

# **WSM**

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**WORKSHOP MANUAL  
DIESEL ENGINE**

**Z402-EB-ONAN-1**

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**Kubota**



## TO THE READER

This Workshop Manual has been prepared to provide servicing personnel with information on the service and maintenance of KUBOTA Diesel Engine Z402-B.

### ■ Disassembling and Servicing

Under the heading "General" section comes 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 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.

September 2000

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



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



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

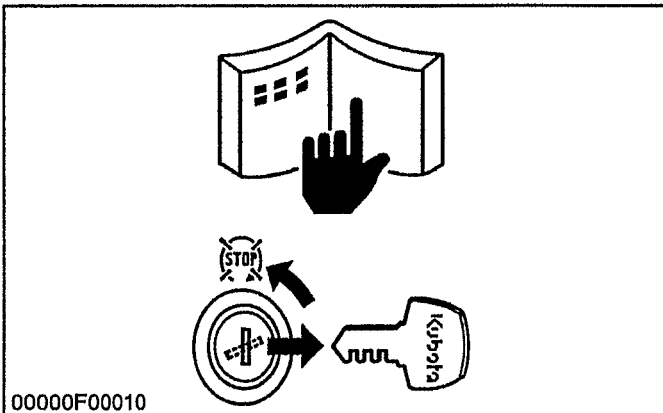


**IMPORTANT** :Indicates that equipment or property damage could result if instructions are not followed.



**NOTE** :Gives helpful information.

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### BEFORE SERVICING AND REPAIRING

- (1) Read all instructions and safety instructions in this manual and on your engine safety decals.
- (2) Clean the work area and engine.
- (3) Place the engine on a firm and level ground.
- (4) allow the engine to cool before proceeding.
- (5) Stop the engine, and remove the key.
- (6) Disconnect the battery negative cable.

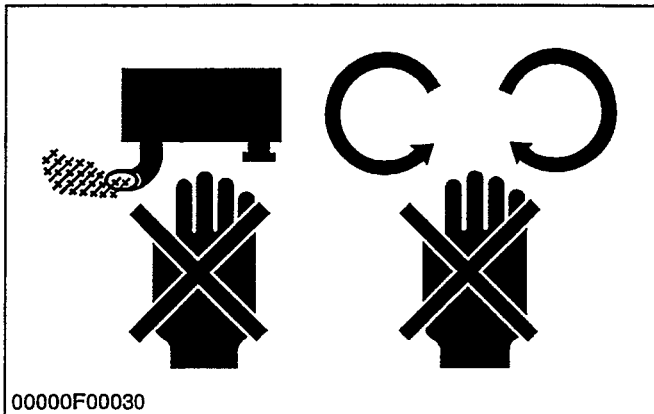
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### SAFETY STARTING

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

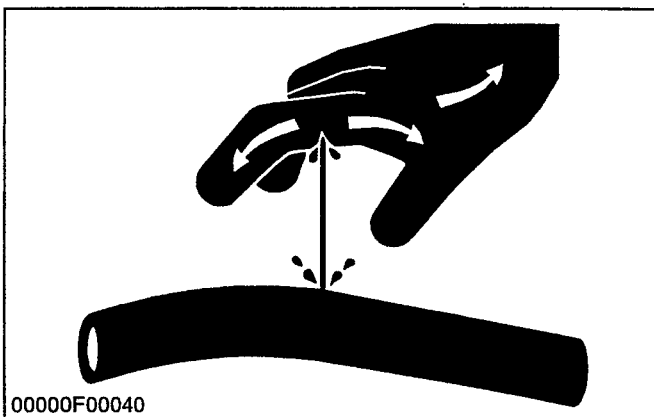
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### SAFETY WORKING

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

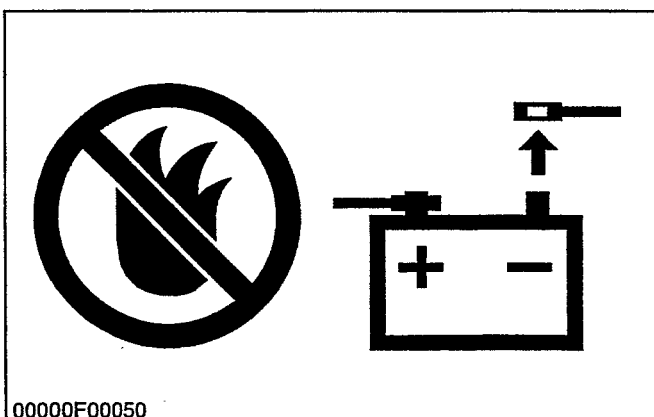
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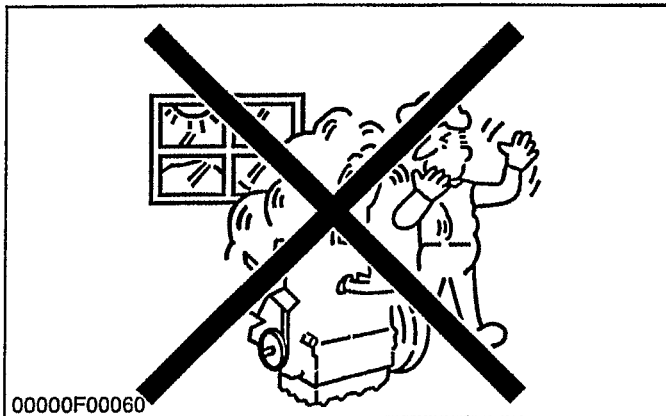


### AVOID FIRES

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

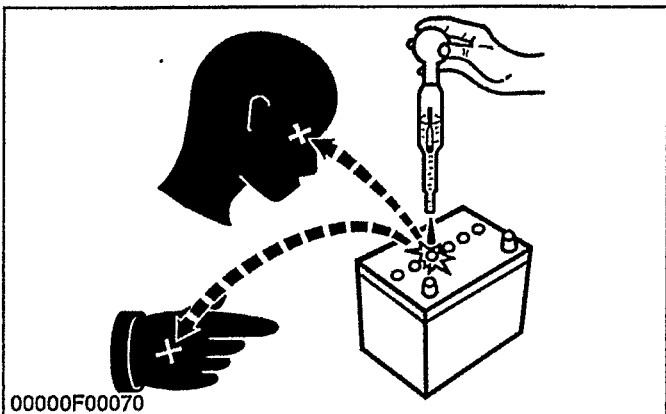
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**VENTILATE WORK AREA**

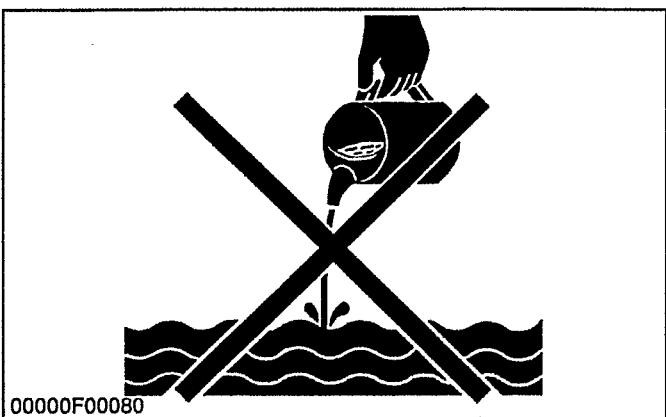
- (1) If the engine must be running to do some work, make sure the area is well ventilated. Never run the engine in a closed area. The exhaust gas contains poisonous carbon monoxide.

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**PREVENT ACID BURNS**

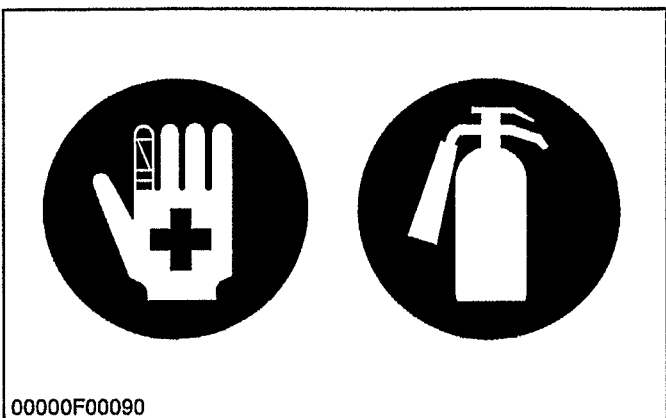
- (1) Sulfuric acid in battery electrolyte is poisonous. It is strong enough to burn skin, clothing and cause blindness if splashed into eyes. Keep electrolyte away from eyes, hands and clothing. If you spill electrolyte on yourself, flush with water, and get medical attention immediately.

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**DISPOSE OF FLUIDS PROPERLY**

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

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**PREPARE FOR EMERGENCIES**

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

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# SPECIFICATIONS

Model	Z402	
Number of cylinders	2	
Type	Vertical, water-cooled, 4-cycle diesel engine	
Bore × stroke	64 × 62.2 mm (2.52 × 2.45 in.)	
Total displacement	400 CC (24.41 cu.in.)	
Brake Horsepower	SAE net cont. H.P.	5.5 kW/3000 rpm (7.4 HP/3000 rpm)
	SAE net intermittent H.P.	6.3 kW/3000 rpm (8.4 HP/3000 rpm)
	SAE gross intermittent H.P.	6.5 kW/3000 rpm (8.7 HP/3000 rpm)
	DIN6270-NA	5.5 kW/3000 rpm (7.5 PS/3000 rpm)
	DIN6270-NB	6.1 kW/3000 rpm (8.3 PS/3000 rpm)
	DIN70020	6.6 kW/3000 rpm (9.0 PS/3000 rpm)
Maximum bare speed	3200 to 3300 rpm	
Combustion Chamber	Spherical type	
Fuel injection pump	Bosch MD type mini pump	
Governor	Centrifugal ball mechanical governor	
Direction of rotation	Counter-clockwise (viewed from flywheel)	
Injection nozzle	Bosch throttle type	
Injection timing	0.31 to 0.35 rad. (18 to 20°) before T.D.C.	
Injection order	1-2	
Injection pressure	13.73 MPa (140 kgf/cm <sup>2</sup> , 1991 psi)	
Compression ratio	23 : 1	
Lubricating system	Forced lubrication by pump	
Oil pressure indicating	Electrical type switch	
Lubricating filter	Full flow paper filter (cartridge type)	
Cooling system	Pressurized radiator, forced circulation with water pump	
Starting system	Electric starting with starter	
	12 V, 1.2 kW	
Starting support device	By glow plug in combustion chamber	
Battery	12 V, CCA 600, equivalent	
Fuel	Diesel fuel No. 2-D (ASTM D975)	
Lubricating oil	API service CD or CE	
Lubricating oil capacity	1.9 L (2.0 U.S.qts., 1.7 Imp.qts.)	
Weight (Dry)	56 kg (123.5 lbs)	
Dimension (L × W × H)	314.5 × 380.4 × 449.1 mm (12.38 × 14.98 × 17.68 in.)	

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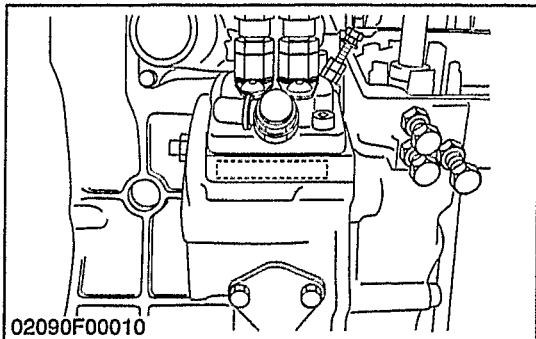
# SERVICING

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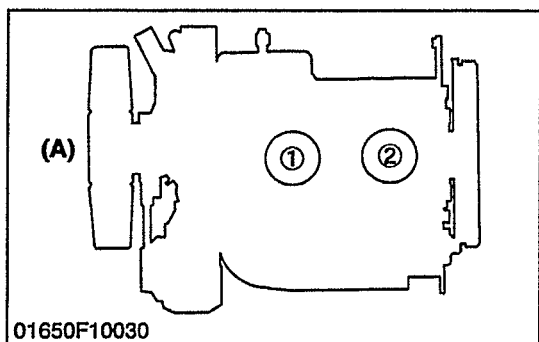


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**G GENERAL****[1] ENGINE IDENTIFICATION****(1) Model Name and Engine Serial Number**

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

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**(2) Cylinder Number**

The cylinder numbers of Z402 diesel engine are designated as shown in the figure.

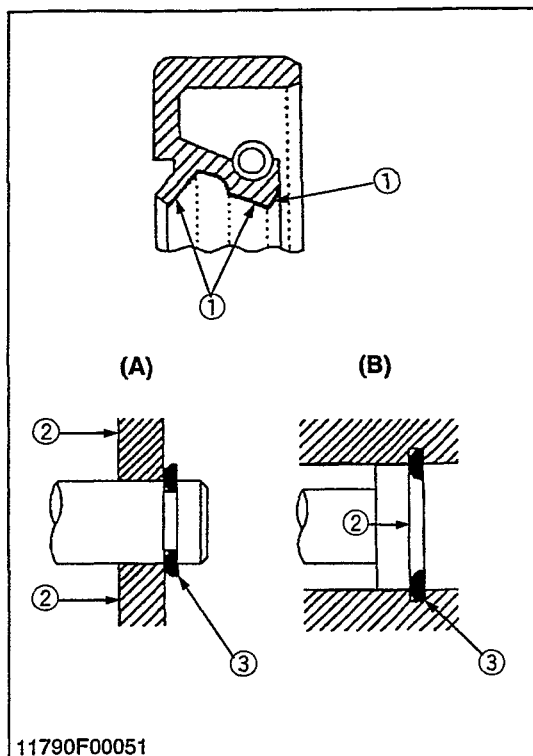
The sequence of cylinder numbers is given as No. 1 and No. 2 starting from the gear case side.

- (1) No. 1 Cylinder
- (2) No. 2 Cylinder

(A) Gear Case Side

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## [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 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

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### [3] TIGHTENING TORQUES

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

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#### (1) Tightening Torques for Special Use Screws, Bolts and Nuts

##### ■ NOTE

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

Item	Size × Pitch	N·m	kgf·m	ft-lbs
* Cylinder head cover cap nuts	M6 × 1.0	3.9 to 5.9	0.4 to 0.6	2.9 to 4.3
* Cylinder head screws	M8 × 1.25	37.2 to 42.1	3.8 to 4.3	27.5 to 31.1
* Main bearing case screws 1	M6 × 1.0	12.7 to 15.7	1.3 to 1.6	9.4 to 11.6
* Main bearing case screws 1 (Flywheel side)	M8 × 1.25	23.5 to 27.4	2.4 to 2.8	17.4 to 20.3
* Main bearing case screws 2	M7 × 1.0	26.5 to 30.4	2.7 to 3.1	19.5 to 22.4
* Flywheel screws	M10 × 1.25	53.9 to 58.8	5.5 to 6.0	39.8 to 43.4
* Connecting rod screws	M7 × 0.75	26.5 to 30.4	2.7 to 3.1	19.5 to 22.4
* Rocker arm bracket nuts	M6 × 1.0	9.8 to 11.3	1.00 to 1.15	7.2 to 8.3
* Idle gear shaft screws	M6 × 1.0	9.8 to 11.3	1.00 to 1.15	7.2 to 8.3
* Crankshaft end bolt	M12 × 1.5	117.6 to 127.4	12.0 to 13.0	86.4 to 93.6
* Bearing case cover screws	M6 × 1.0	9.8 to 11.3	1.00 to 1.15	7.2 to 8.3
Glow plugs	M8 × 1.0	7.8 to 14.7	0.8 to 1.5	5.8 to 10.8
Nozzle holder assembly	M20 × 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 nuts	M12 × 1.5	24.5 to 34.3	2.5 to 3.5	18.1 to 25.3
Overflow pipe assembly retaining nuts	M12 × 1.5	19.6 to 24.5	2.0 to 2.5	14.5 to 18.1
Starter's terminal B mounting nut	M8	8.8 to 11.8	0.9 to 1.2	6.5 to 8.7

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#### (2) Tightening Torques for General Use Screws, Bolts and Nuts

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

Nominal Diameter \ Grade	Standard Screw and Bolt			Special Screw and Bolt		
	④			⑦		
Unit	N·m	kgf·m	ft-lbs	N·m	kgf·m	ft-lbs
M6	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
M8	17.7 to 20.6	1.8 to 2.1	13.0 to 15.2	23.5 to 27.5	2.4 to 2.8	17.4 to 20.3
M10	39.2 to 45.1	4.0 to 4.6	28.9 to 33.3	48.1 to 55.9	4.9 to 5.7	35.4 to 41.2
M12	62.8 to 72.6	6.4 to 7.4	46.3 to 53.5	77.5 to 90.2	7.9 to 9.2	57.1 to 66.5

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

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

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**[4] TROUBLESHOOTING**

Symptom	Probable Cause	Solution	Reference Page
<b>Engine Does Not Start</b>	<ul style="list-style-type: none"> <li>• No fuel</li> <li>• Air in the fuel system</li> <li>• Water in the fuel system</li> </ul>	Replenish fuel Vent air Change fuel and repair or replace fuel system Clean	— S-15 —
	<ul style="list-style-type: none"> <li>• Fuel pipe clogged</li> <li>• Fuel filter clogged</li> <li>• Excessively high viscosity of fuel or engine oil at low temperature</li> <li>• Fuel with low cetane number</li> <li>• Fuel leak due to loose injection pipe retaining nut</li> <li>• Incorrect injection timing</li> <li>• Fuel camshaft worn</li> <li>• Injection nozzle clogged</li> <li>• Injection pump malfunctioning</li> <li>• Seizure of crankshaft, camshaft, piston, cylinder or bearing</li> <li>• Compression leak from cylinder</li> </ul>	Clean or change Use specified fuel or engine oil Use specified fuel Tighten retaining nut Adjust Replace Clean Repair or replace Repair or replace Replace head gasket, tighten cylinder head screw, glow plug and nozzle holder	— S-17 S-16 — — S-54 S-31 S-55 S-30, 54, 55 — S-26, 28
<b>(Starter Does Not Run)</b>	<ul style="list-style-type: none"> <li>• Improper valve timing</li> <li>• Piston ring and cylinder worn</li> <li>• Excessive valve clearance</li> <li>• Battery discharged</li> <li>• Starter malfunctioning</li> <li>• Key switch malfunctioning</li> <li>• Wiring disconnected</li> </ul>	Correct or replace timing gear Replace Adjust Charge Repair or replace Repair or replace Connect	S-31 S-34, 35 S-19 — — — —
<b>Engine Revolution Is Not Smooth</b>	<ul style="list-style-type: none"> <li>• Fuel filter clogged or dirty</li> <li>• Air cleaner clogged</li> <li>• Fuel leak due to loose injection pipe retaining nut</li> <li>• Injection pump malfunctioning</li> <li>• Incorrect nozzle opening pressure</li> <li>• Injection nozzle stuck or clogged</li> <li>• Governor malfunctioning</li> </ul>	Clean or change Clean or change Tighten retaining nut Repair or replace Adjust Repair or replace Repair	S-17 S-17 — S-30, 54, 55 S-55 S-56 S-31
<b>Either White or Blue Exhaust Gas Is Observed</b>	<ul style="list-style-type: none"> <li>• Excessive engine oil</li> <li>• Piston ring and liner worn or stuck</li> <li>• Incorrect injection timing</li> <li>• Deficient compression</li> </ul>	Reduce to specified level Repair or replace Adjust Adjust top clearance	S-16 S-34, 35 S-54 S-26

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Symptom	Probable Cause	Solution	Reference Page
<b>Either Black or Dark Gray Exhaust Gas Is Observed</b>	<ul style="list-style-type: none"> <li>• Overload</li> <li>• Low grade fuel used</li> <li>• Fuel filter clogged</li> <li>• Air cleaner clogged</li> <li>• Deficient nozzle injection</li> </ul>	Lessen load Use specified fuel Clean or change Clean or change Repair or replace nozzle	— — S-17 S-17 S-55
<b>Deficient Output</b>	<ul style="list-style-type: none"> <li>• Incorrect injection timing</li> <li>• Engine's moving parts seem to be seizing</li> <li>• Uneven fuel injection</li> <li>• Deficient nozzle injection</li> <li>• Compression leak</li> </ul>	Adjust Repair or replace Repair or replace injection pump Repair or replace nozzle Replace head gasket, tighten cylinder head screw, glow plug and nozzle holder	S-54 — S-30, 54, 55 S-56 S-26, 28
<b>Excessive Lubricant Oil Consumption</b>	<ul style="list-style-type: none"> <li>• Piston ring's gap facing the same direction</li> <li>• Oil ring worn or stuck</li> <li>• Piston ring groove worn</li> <li>• Valve stem and valve guide worn</li> <li>• Crankshaft bearing, and crank pin bearing worn</li> <li>• Oil leaking due to defective seals or packing</li> </ul>	Shift ring gap direction Replace Replace piston Replace Replace Replace	S-33 S-33, 34 S-44 S-37 S-46 —
<b>Fuel Mixed into Lubricant Oil</b>	<ul style="list-style-type: none"> <li>• Injection pump's plunger worn</li> <li>• Deficient nozzle injection</li> <li>• Injection pump broken</li> </ul>	Replace pump element or injection pump Repair or replace nozzle Replace	S-54, 55 S-56 S-30
<b>Water Mixed into Lubricant Oil</b>	<ul style="list-style-type: none"> <li>• Head gasket defective</li> <li>• Cylinder block or cylinder head flawed</li> </ul>	Replace Replace	S-28 S-36, 37
<b>Low Oil Pressure</b>	<ul style="list-style-type: none"> <li>• Engine oil insufficient</li> <li>• Oil strainer clogged</li> <li>• Relief valve stuck with dirt</li> <li>• Relief valve spring weaken or broken</li> <li>• Excessive oil clearance of crankshaft bearing</li> <li>• Excessive oil clearance of crankpin bearing</li> <li>• Excessive oil clearance of rocker arm bearing</li> <li>• Oil passage clogged</li> <li>• Different type of oil</li> <li>• Oil pump defective</li> </ul>	Replenish Clean Clean Replace Replace Replace Replace Clean Use specified type of oil Repair or replace	— S-32 — — S-47, 48 S-46 S-40 — — S-50
<b>High Oil Pressure</b>	<ul style="list-style-type: none"> <li>• Different type of oil</li> <li>• Relief valve defective</li> </ul>	Use specified type of oil Replace	— —

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Symptom	Probable Cause	Solution	Reference Page
<b>Engine Overheated</b>	• Engine oil insufficient	Replenish	—
	• Fan belt broken or elongated	Replace or adjust	S-16
	• Cooling water insufficient	Replenish	—
	• Radiator net and radiator fin clogged with dust	Clean	—
	• Inside of radiator corroded	Clean or replace	—
	• Cooling water flow route corroded	Clean or replace	—
	• Radiator cap defective	Replace	S-53
	• Overload running	Loosen load	—
	• Head gasket defective	Replace	S-28
	• Incorrect injection timing	Adjust	S-54
	• Unsuitable fuel used	Use specified fuel	—
<b>Battery Quickly Discharge</b>	• Battery electrolyte insufficient	Replenish distilled water and charge	—
	• Fan belt slips	Adjust belt tension or change	S-16
	• Wiring disconnected	Correct	—
	• Rectifier defective	Replace	—
	• Alternator defective	Replace	S-27
	• Battery defective	Change	—

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## [5] SERVICING SPECIFICATIONS

### (1) Engine Body

#### Cylinder Head

Item	Factory Specification	Allowable Limit
Cylinder Head Surface Flatness	—	0.05 mm 0.0019 in.
Top Clearance	0.50 to 0.70 mm 0.0197 to 0.0276 in.	—
Compression Pressure	2.84 to 3.23 MPa 29.0 to 33.0 kgf/cm <sup>2</sup> 412 to 469 psi	2.25 MPa 23 kgf/cm <sup>2</sup> 327 psi
Variance Among Cylinders	—	10 % or less

#### Valves

Valve Clearance (Cold)	0.145 to 0.185 mm 0.0057 to 0.0072 in.	—
Valve Seat Angle	0.785 rad. 45°	—
Valve Face Angle	0.785 rad. 45°	—
Valve Recessing	— 0.10 to 0.10 mm — 0.0039 to 0.0039 in.	0.3 mm 0.0118 in.
Clearance between Valve Stem and Valve Guide	0.030 to 0.057 mm 0.00118 to 0.00224 in.	0.1 mm 0.0039 in.
Valve Stem O.D.	5.968 to 5.980 mm 0.23496 to 0.23543 in.	—
Valve Guide I.D.	6.010 to 6.025 mm 0.23661 to 0.23720 in.	—

#### Valve Timing

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

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**Valve Spring**

Item	Factory Specification	Allowable Limit
Free Length	31.6 mm 1.244 in.	28.4 mm 1.118 in.
Setting Load / Setting Length	64.7 N / 27 mm 6.6 kgf / 27 mm 14.6 lbs / 1.063 in.	54.9 N / 27 mm 5.6 kgf / 27 mm 12.3 lbs / 1.063 in.
Tilt	—	1.2 mm 0.047 in.

**Rocker Arm**

Clearance between Rocker Arm Shaft and 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.	10.473 to 10.484 mm 0.41232 to 0.41276 in.	—
Rocker Arm I.D.	10.500 to 10.518 mm 0.41339 to 0.41410 in.	—

**Tappet**

Clearance between Tappet and Guide	0.016 to 0.052 mm 0.00063 to 0.00205 in.	0.10 mm 0.0039 in.
Tappet O.D.	17.966 to 17.984 mm 0.70732 to 0.70803 in.	—
Tappet Guide I.D.	18.000 to 18.018 mm 0.70866 to 0.70939 in.	—

**Camshaft**

Camshaft Side Clearance	0.15 to 0.31 mm 0.0059 to 0.01220 in.	0.5 mm 0.020 in.
Cam Height	27.00 mm 1.0630 in.	26.97 mm 1.0618 in.
Oil Clearance of Camshaft	0.050 to 0.091 mm 0.0020 to 0.0036 in.	0.15 mm 0.0059 in.
Camshaft Journal O.D.	32.934 to 32.950 mm 1.2966 to 1.2972 mm	—
Camshaft Bearing I.D.	33.000 to 33.025 mm 1.2992 to 1.3002 in.	—

01650S10060

**Timing Gear**

Item	Factory Specification	Allowable Limit
Timing Gear Backlash		
Crank Gear-Idle Gear	0.043 to 0.124 mm 0.00169 to 0.00488 in.	0.15 mm 0.0059 in.
Idle Gear-Cam Gear	0.047 to 0.123 mm 0.00185 to 0.00484 in.	0.15 mm 0.0059 in.
Idle Gear-Injection Pump Gear	0.046 to 0.124 mm 0.00181 to 0.00488 in.	0.15 mm 0.0059 in.
Crank Gear-Oil Pump Drive Gear	0.041 to 0.123 mm 0.00161 to 0.00484 in.	0.15 mm 0.0059 in.
Clearance between Idle Gear Shaft and Idle Gear Bushing	0.020 to 0.084 mm 0.0008 to 0.00331 in.	0.10 mm 0.0039 in.
Idle Gear Bushing I.D.	20.000 to 20.051 mm 0.78740 to 0.78941 in.	—
Idle Gear Shaft O.D.	19.967 to 19.980 mm 0.78610 to 0.78661 in.	—
Idle Gear Side Clearance	0.20 to 0.51 mm 0.0079 to 0.0200 in.	0.60 mm 0.0236 in.

**Piston • Piston Ring**

Piston Pin Bore	20.000 to 20.013 mm 0.78740 to 0.78791 in.	20.05 mm 0.7894 in.
Clearance between Compression Ring 2 and Ring Groove	0.085 to 0.112 mm 0.0033 to 0.0044 in.	0.15 mm 0.0059 in.
Clearance between Oil Ring and Ring Groove	0.04 to 0.08 mm 0.0016 to 0.0031 in.	0.15 mm 0.0059 in.
Ring Gap		
Compression Ring 1, Compression Ring 2	0.25 to 0.40 mm 0.0098 to 0.0157 in.	1.25 mm 0.0492 in.
Oil Ring	0.15 to 0.30 mm 0.0059 to 0.0177 in.	1.25 mm 0.0492 in.

01650S10070

**Connecting Rod**

Item	Factory Specification	Allowable Limit
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.	0.10 mm 0.0039 in.
Piston Pin O.D.	20.002 to 20.011 mm 0.78748 to 0.78783 in.	—
Small End Bushing I.D.	20.025 to 20.040 mm 0.78839 to 0.78897 in.	—

**Crankshaft**

Crankshaft Alignment	—	0.02 mm 0.0008 in.
Oil Clearance between Crankshaft and Crankshaft Bearing 1	0.034 to 0.106 mm 0.0013 to 0.0042 in.	0.20 mm 0.0079 in.
Crankshaft O.D.	39.934 to 39.950 mm 1.57221 to 1.57281 in.	—
Crankshaft Bearing 1 I.D.	39.984 to 40.040 mm 1.57428 to 1.57648 in.	—
Oil Clearance between Crankshaft and Crankshaft Bearing 2	0.034 to 0.092 mm 0.0013 to 0.0036 in.	0.20 mm 0.0079 in.
Crankshaft O.D.	43.934 to 43.950 mm 1.7297 to 1.7303 in.	—
Crankshaft Bearing 2 I.D.	43.984 to 44.026 mm 1.7317 to 1.7333 in.	—
Oil Clearance between Crankshaft and Crankshaft Bearing 3	0.028 to 0.059 mm 0.0011 to 0.0023 in.	0.20 mm 0.0079 in.
Crankshaft O.D.	39.934 to 39.950 mm 1.5722 to 1.5728 in.	—
Crank bearing 3 I.D.	39.978 to 39.993 mm 1.5739 to 1.5745 in.	—
Oil Clearance between Crank Pin and Crank Pin Bearing	0.02 to 0.051 mm 0.0008 to 0.0020 in.	0.15 mm 0.0059 in.
Crank Pin O.D.	33.959 to 33.975 mm 1.3370 to 1.3376 in.	—
Crank Pin Bearing I.D.	33.995 to 34.010 mm 1.3384 to 1.3390 in.	—
Crankshaft Side Clearance	0.15 to 0.25 mm 0.0059 to 0.0098 in.	0.50 mm 0.0197 in.

01650S10080

**Cylinder Liner**

Item	Factory Specification	Allowable Limit
Cylinder Liner I.D.	64.000 to 64.019 mm 2.5199 to 2.5204 in.	64.169 mm 2.52634 in.
Oversized Cylinder Liner I.D.	+ 0.5 mm + 0.0197 in.	+ 0.15 mm 0.0059 in.

01650S10090

**(2) Lubricating System****Oil Pump**

Engine Oil Pressure At Idle Speed	98 kPa 1.0 kgf/cm <sup>2</sup> , 14 psi	—
At Rated Speed	196.0 to 441.0 kPa 2.0 to 4.5 kgf/cm <sup>2</sup> 28.0 to 64.0 psi	98 kPa 1.0 kgf/cm <sup>2</sup> 14 psi
Clearance between Inner Rotor and Outer Rotor	0.03 to 0.14 mm 0.0012 to 0.0055 in.	—
Clearance between Outer Rotor and Pump Body	0.07 to 0.15 mm 0.0028 to 0.0059 in.	—
End Clearance between Inner Rotor and Cover	0.075 to 0.135 mm 0.0029 to 0.0053 in.	—

01640S10511

**(3) Cooling System****Thermostat**

Thermostat's Valve Opening Temperature	69.5 to 72.5 °C 157.1 to 162.5 °F	—
Temperature at Which Thermostat Completely Opens	85 °C 185 °F	—

**Radiator**

Radiator Water Tightness	Water tightness at specified pressure 157 kPa 1.6 kgf/cm <sup>2</sup> , 23 psi	—
Radiator Cap Air Leakage	10 seconds or more 88 → 59 kPa 0.9 → 0.6 kgf/cm <sup>2</sup> 13 → 9 psi	—
Fan Belt Tension	10 to 12 mm / 10 kgf 0.394 to 0.472 in. / 10 kgf (22.1 lbs.)	—

01640S10521

**(4) Fuel System****Injection Pump**

Item	Factory specification	Allowable Limit
Injection Timing	0.31 to 0.35 rad. (18 to 20°) Before T.D.C.	—
Fuel Tightness of Pump Element	—	14.7 MPa 150 kgf/cm <sup>2</sup> 2133 psi
Fuel Tightness of Delivery Valve	—	5 seconds 14.7 → 13.7 MPa 150 → 140 kgf/cm <sup>2</sup> 2133 → 1990 psi

**Injection Nozzle**

Fuel Injection Pressure	13.73 to 14.71 MPa 140 to 150 kgf/cm <sup>2</sup> 1991 to 2133 psi	—
Fuel Tightness of Nozzle Valve Seat	When the pressure is 12.75 MPa (130 kgf/cm <sup>2</sup> , 1849 psi), the valve seat must be fuel tightness	—

02090S10220

## [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 100 hrs	Every 200 hrs	Every 400 hrs	Every 800 hrs	Every 1000 hrs	Every one year	Every two years
Checking fuel pipes and clamps	☆							
* Changing engine oil		☆						
Cleaning air filter element		☆						
Cleaning fuel filter element		☆						
Checking fan belt tension and damage		☆						
Checking water pipes and clamps			☆					
* Changing oil filter element			☆					
Changing fuel filter cartridge				☆				
Checking valve clearance					☆			
Changing radiator coolant (L.L.C)								☆
Changing air filter element							☆	
Checking nozzle injection pressure						☆		
Changing water pipes and clamps								☆
Changing fuel pipes and clamps								☆

\* 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.

01650S10230

## [7] CHECK AND MAINTENANCE

### (1) Daily Check Points

#### Checking Engine Oil Level

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

#### ■ IMPORTANT

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

01640S10050

#### Checking and Replenish Cooling Water

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



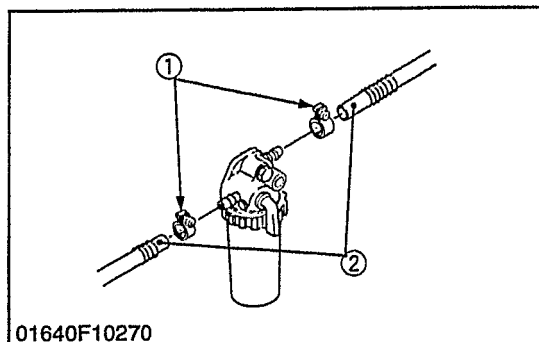
#### CAUTION

- 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.

01640S10060

**(2) Check Point of Every 50 Hours****Checking Fuel Pipe**

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

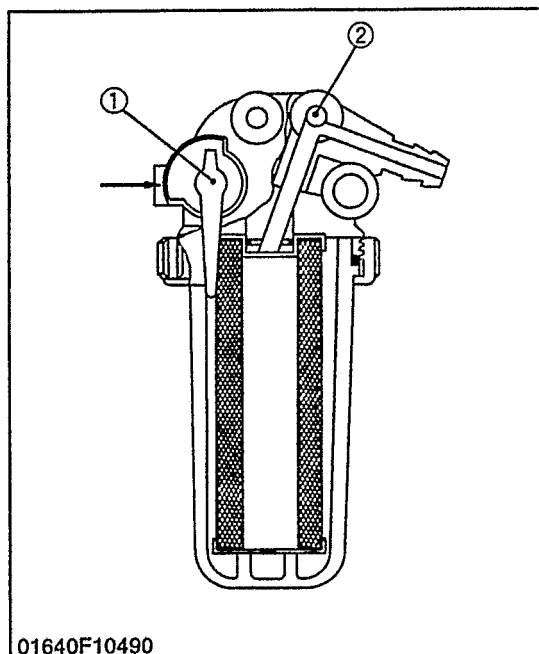
**CAUTION**

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

(1) Clamp

(2) Fuel Pipe

01640S10070

**(When bleeding fuel system)**

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

**NOTE**

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

(1) Fuel Cock

(2) Air Vent Plug

01640S10080



### (3) Check Points of Every 100 Hours

#### Changing Engine Oil

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

#### ■ IMPORTANT

- Engine oil should be MIL-L-46152 / MIL-L-2104C or have properties of API classification CD / CE grades.
- Change the type of engine according to the ambient temperature.

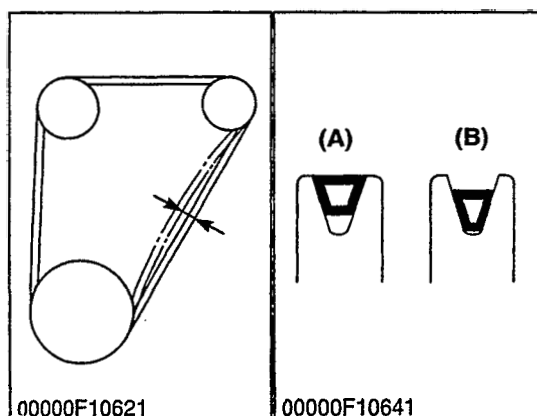
Above 25 °C (77 °F) .....SAE 30 or 10W-30

0 °C to 25 °C (32 °F to 77 °F) .....SAE 20 or 10W-30

Below 0 °C (32 °F).....SAE 10W or 10W-30

Model	Capacity
Z402-B	1.9 L 2.0 U.S.qts. 1.7 Imp.qts.

02090S10230



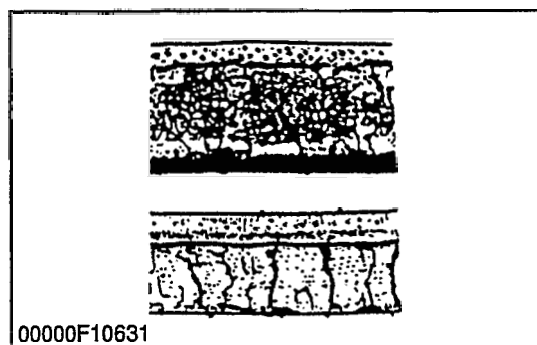
#### Checking Fan Belt Tension

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, adjust with the tension pulley adjusting bolts.

(A) Good

(B) Bad

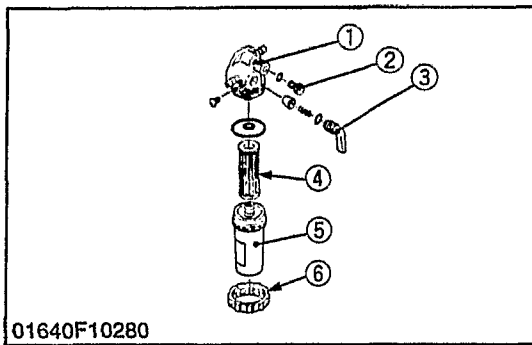
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#### Fan Belt Damage and Wear

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.

00000S10462



### Cleaning Fuel Filter

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

### ■ IMPORTANT

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

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

01640S10120

### Cleaning Air Cleaner

1. The air cleaner uses a dry element. Never apply oil to it.
2. Remove and clean out the dust cup before it becomes half full with dust.
3. When the air filter element is dusty, clean it.

### ■ NOTE

- Change the element once a year or every 6th cleaning.

02090S10050

### Cleaning Air Filter Element

#### ● When dry dust adheres

Use clean dry compressed air on the inside of the element.

Air pressure at the nozzle must not exceed 690 kPa (7 kgf/cm<sup>2</sup>, 100 psi).

Maintain reasonable distance between the nozzle and the filter.

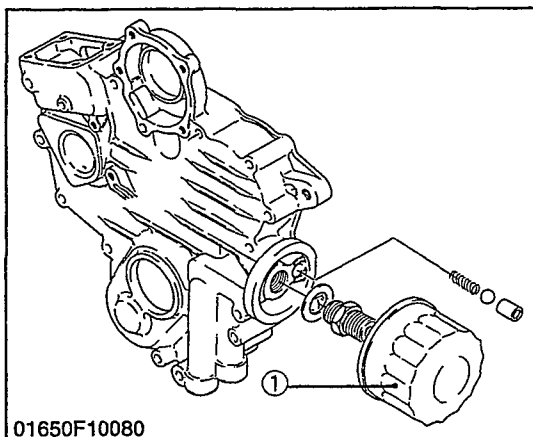
02090S10060

#### (4) Check Points of Every 200 Hours

##### Checking Radiator Hoses (Water Pipes)

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

02090S10070



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##### Changing Engine Oil Filter Cartridge

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

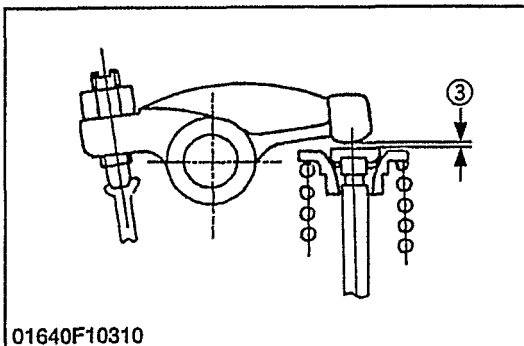
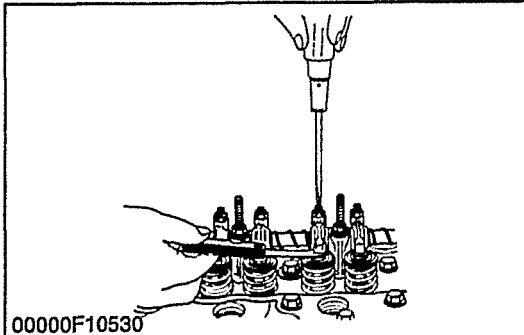
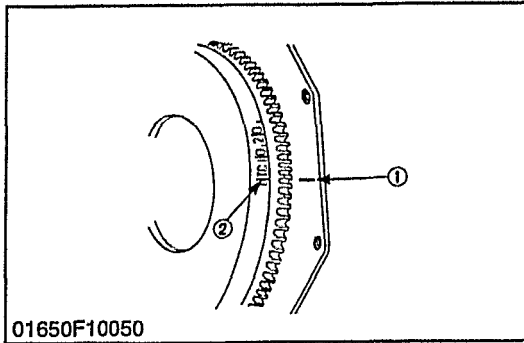
##### ■ NOTE

- Over-tightening may cause deformation of rubber gasket.
- After cartridge has been replaced, engine oil normally decreases a little.

Check the oil level and add new oil to the specified level.

(1) Oil Filter Cartridge

01650S10440

**(5) Check Points of Every 800 Hours****Checking Valve Clearance****IMPORTANT**

- Valve clearance must be checked and adjusted when engine is cold.
- 1. Remove the head cover.
- 2. Align the "1TC" mark on the flywheel and punch mark (1) on the plate so that the No. 1 piston comes to the compression or overlap top dead center.
- 3. Check the following valve clearance marked with "☆" using a feeler gauge.
- 4. If the clearance, adjust with the adjusting screw.

Valve clearance	Factory spec.	0.145 to 0.185 mm 0.0059 to 0.0073 in.
-----------------	---------------	---

**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 punch mark of the rear end plate. Turn the flywheel 0.26 rad. (15°) clockwise and counter-clockwise to see if the piston is at the compression top dead center or the overlap position. Now referring to the table below, readjust the valve clearance. (The piston is at the top dead center when both the IN. and EX. valves do not move; it is at the overlap position when both the valves move.
- Finally turn the flywheel 6.28 rad. (360°) to mark sure the "TC" marking and the punch mark are perfectly aligned. Adjust 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.

Number of cylinders Valve arrangement Adjustable cylinder Location of piston		2 cylinder	
		IN.	EX
(1) When No. 1 piston is at top dead center compression	1st	☆	☆
	2nd		☆
(1) When No. 1 piston is at the overlap position	1st		
	2nd	☆	

(1) Punch Mark  
(2) TC Mark Line

(3) Valve Clearance

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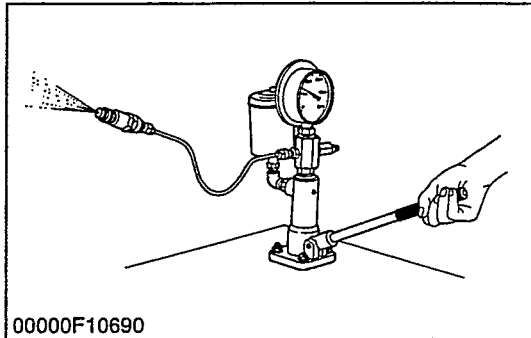
## (6) Check Points of Every 1000 Hours



### 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.

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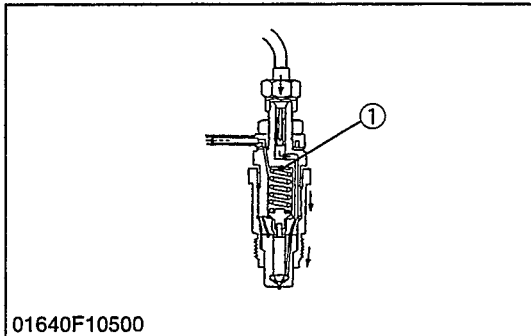
### Checking Nozzle Injection Pressure

1. Set the injection nozzle to the nozzle tester (Code No: 07909-31361).
2. Slowly move the tester handle to measure the pressure at which fuel begins jetting out from the nozzle.
3. If the measurement is not within the factory specifications, disassemble the injection nozzle, and change adjusting washer (1) until the proper injection pressure is obtained. (See page S-55.)
4. If the spraying condition is defective, replace the nozzle piece.

#### (Reference)

- Pressure variation with 0.025 mm (0.001 in.) difference of adjusting washer thickness.  
Approx. 59 kPa (6 kgf/cm<sup>2</sup>, 85 psi)

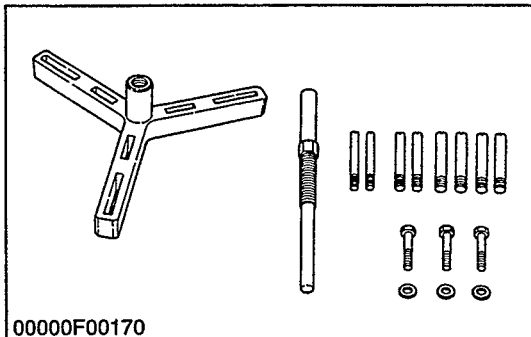
(1) Adjusting Washer



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02090S10080

## [8] SPECIAL TOOLS



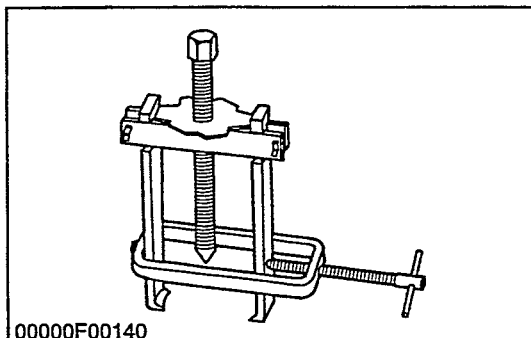
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### Flywheel Puller

Code No: 07916-32011

Application: Use to remove the flywheel.

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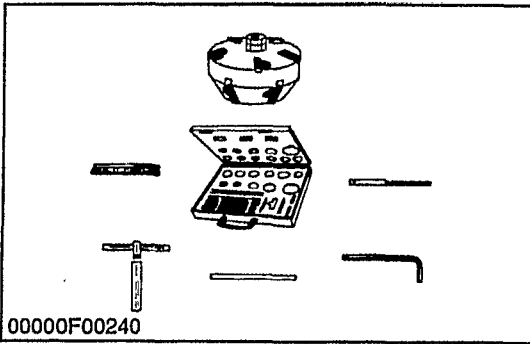
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### Special-use Puller Set

Code No: 07916-09032

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

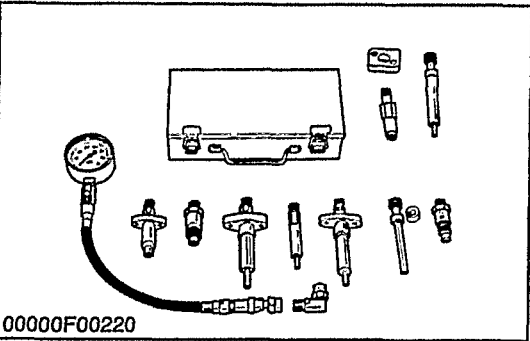
01640S10190

**Valve Seat Cutter Set**

Code No: 07909-33102

Application: Use for correcting valve seats.

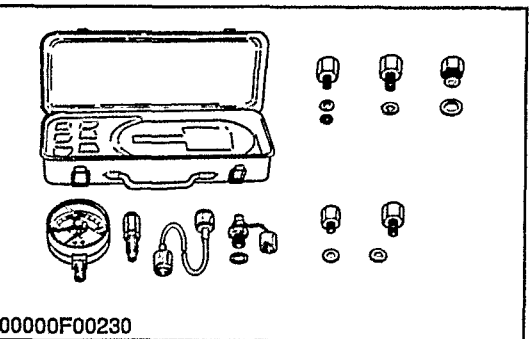
01640S10200

**Diesel Engine Compression Tester**

Code No: 07909-30207

Application: Use for measuring diesel engine compression pressure.

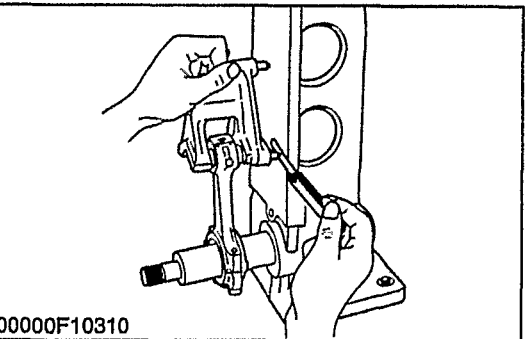
01640S10210

**Oil Pressure Tester**

Code No: 07916-32031

Application: Use for measuring lubricating oil pressure.

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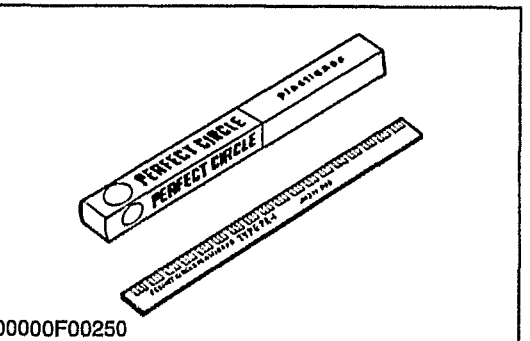
**Connecting Rod Alignment Tool**

Code No: 07909-31661

Application: Use for checking the connecting rod alignment.

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

01640S10230

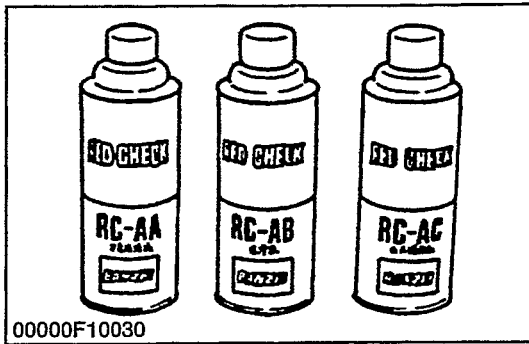
**Press Gauge**

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.)

01640S10240

**Red Check (Crack Check Liquid)**

Code No: 07909-31371

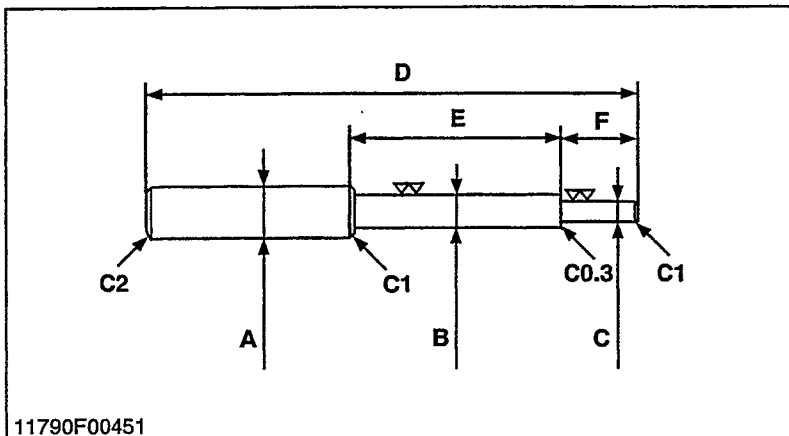
Application: Use for checking cracks on cylinder head, cylinder block, etc.

01640S10250

**NOTE**

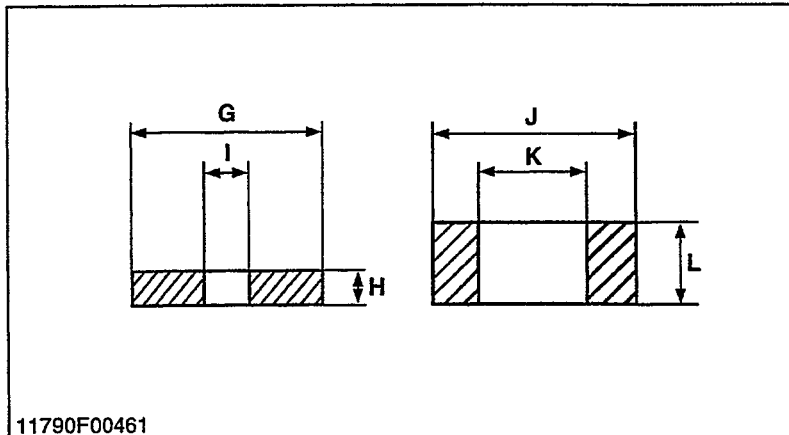
- The following special tools are not provided, so make them referring to the figure.

01640S10910

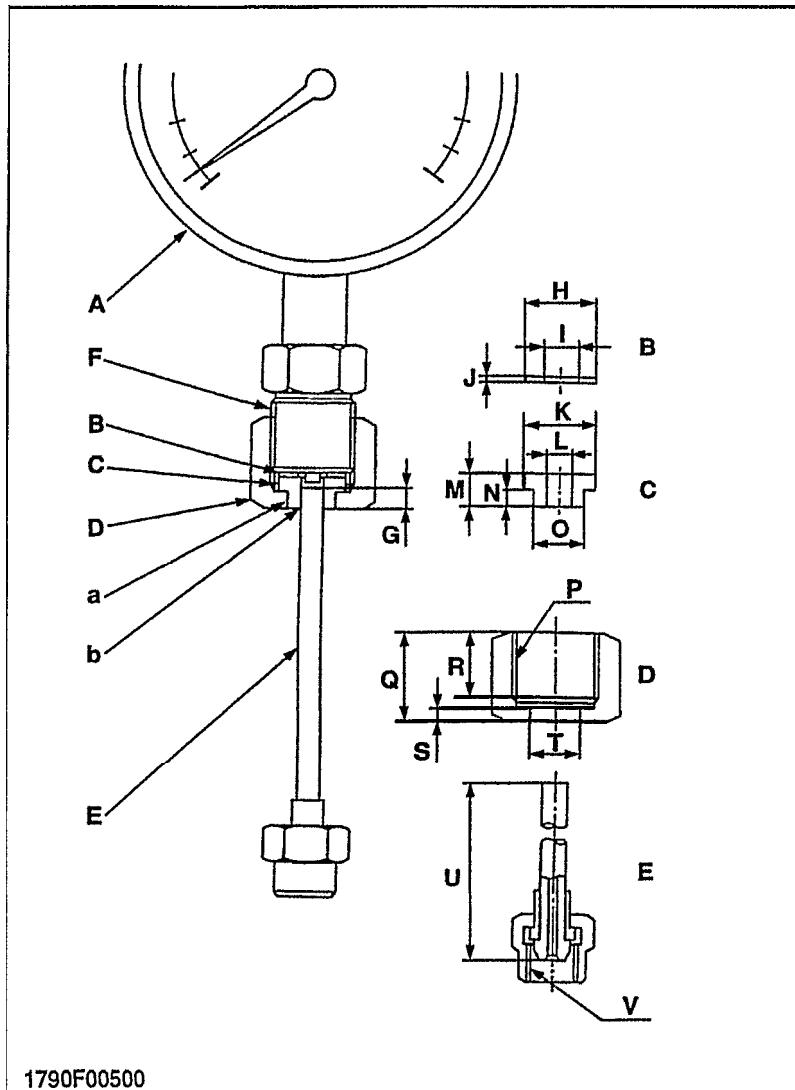
**Valve Guide Replacing Tool**

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

A	20 mm dia. (0.79 in. dia.)
B	9.96 to 9.98 mm dia. 0.3921 to 0.3929 in. dia.
C	5.5 to 5.7 mm dia. 0.2165 to 0.2244 in. dia.
D	200 mm (7.87 in.)
E	80 mm (3.15 in.)
F	40 mm (1.58 in.)
G	15 mm (0.59 in.)
H	5 mm (0.197 in.)
I	6.0 to 6.1 mm dia. (0.236 to 0.240 in. dia.)
J	18 mm dia. (0.71 in. dia.)
K	10.6 to 10.7 mm dia. (0.417 to 0.421 in. dia.)
L	7 mm (0.276 in.)
C1	Chamfer 1.0 mm (0.039 in.)
C2	Chamfer 2.0 mm (0.079 in.)
C0.3	Chamfer 0.3 mm (0.012 in.)



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**Injection Pump Pressure Tester**

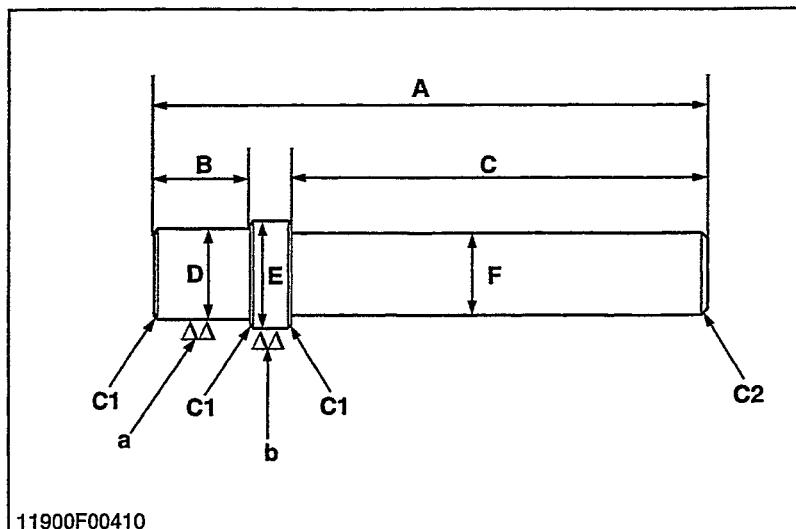
Application: Use to check fuel tightness of injection pumps.

A	Pressure gauge full scale : More than 29.4 MPa (300 kgf/cm <sup>2</sup> , 4267 psi)
B	Copper gasket
C	Flange (Material : Steel)
D	Hex. nut 27 mm (1.06 in.) across the plat
E	Injection pipe
F	PF 1/2
G	5 mm (0.20 in.)
H	17 mm dia. (0.67 in. dia.)
I	8 mm dia. (0.31 in. dia.)
J	1.0 mm (0.039 in.)
K	17 mm dia. (0.67 in. dia.)
L	6.10 to 6.20 mm dia. (0.2402 to 0.2441 in. dia.)
M	8 mm (0.31 in.)
N	4 mm (0.16 in.)
O	11.97 to 11.99 mm dia. (0.4713 to 0.4721 in. dia.)
P	PF 1/2
Q	23 mm (0.91 in.)
R	17 mm (0.67 in.)
S	4 mm (0.16 in.)
T	12.00 to 12.02 mm dia. (0.4724 to 0.4732 in. dia.)
U	100 mm (3.94 in.)
V	M12 x P1.5
a	Adhesive application
b	Fillet welding on the enter circumference

1790F00500

11790G00811



**Bushing Replacing Tool**

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

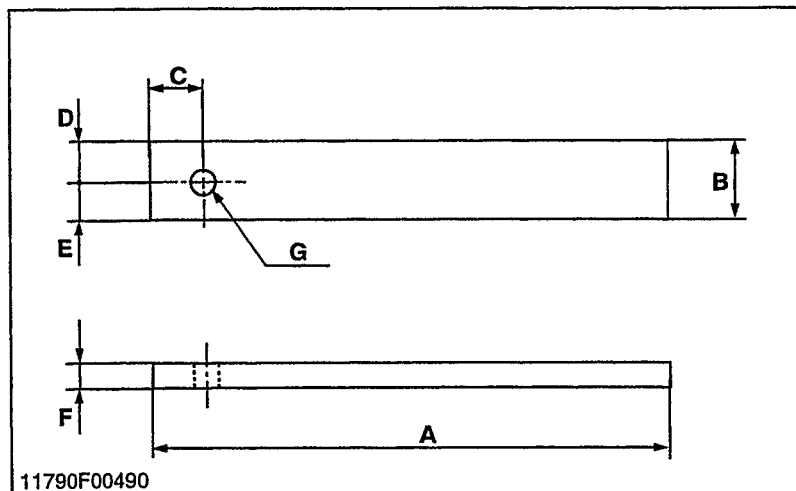
## 1. For small end bushing

A	145 mm (5.71 in.)
B	20 mm (0.79 in.)
C	100 mm (3.94 in.)
D	19.90 to 19.95 mm (0.7835 to 0.7854 in.)
E	21.90 to 21.95 mm (0.8622 to 0.8642 in.) DIA.
F	25 mm (0.98 in.)
a	6.3 $\mu$ m (250 $\mu$ in.)
b	6.3 $\mu$ m (250 $\mu$ in.)

## 2. For idle gear bushing

A	150 mm (5.91 in.)
B	20 mm (0.79 in.)
C	100 mm (3.94 in.)
D	19.90 to 19.95 mm (0.7835 to 0.7854 in.)
E	21.90 to 21.95 mm (0.8622 to 0.8642 in.) DIA.
F	25 mm (0.98 in.)
a	6.3 $\mu$ m (250 $\mu$ in.)
b	6.3 $\mu$ m (250 $\mu$ in.)

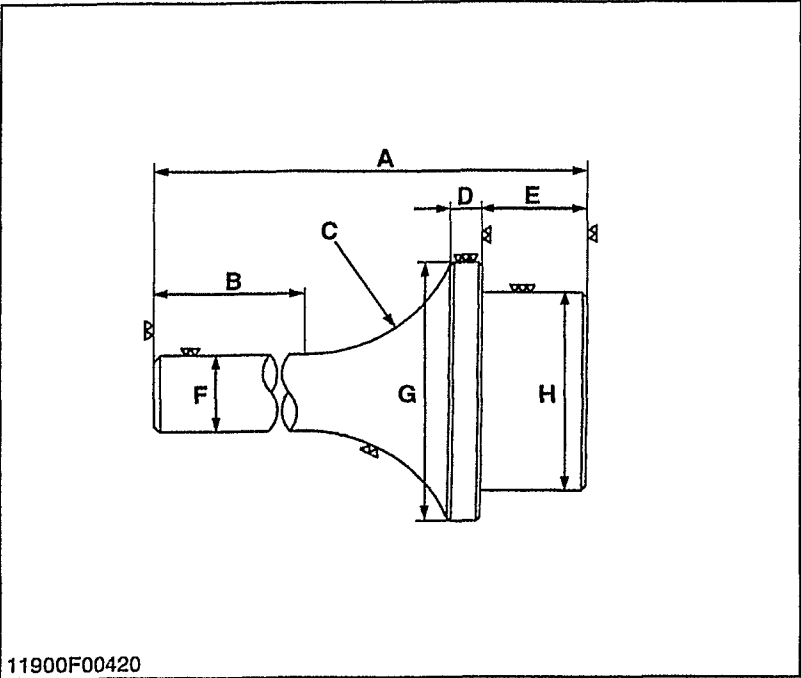
11900G00442

**Flywheel Stopper**

Application: Use to loosen and tighten the flywheel screw.

A	200 mm (7.87 in.)
B	30 mm (1.18 in.)
C	20 mm (0.79 in.)
D	15 mm (0.59 in.)
E	15 mm (0.59 in.)
F	8 mm (0.31 in.)
G	10 mm DIA. (0.39 in. DIA.)

11790G00801



**Crankshaft Bearing 1 Replacing Tool**

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

**[Press Out]**

A	135 mm (5.31 in.)
B	72 mm (2.83 in.)
C	1.57 rad. (40°)
D	10 mm (0.39 in.)
E	22 mm (0.87 in.)
F	20 mm (0.79 in.)
G	48.90 to 48.95 mm dia. (1.9251 to 1.9271 in. dia.)
H	43.90 to 43.95 mm dia. (1.7283 to 1.7303 in. dia.)

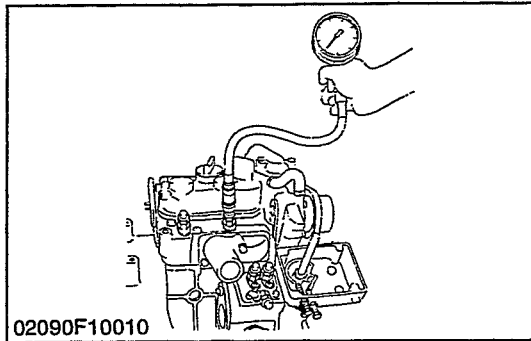
**[Press Fit]**

A	130 mm (5.12 in.)
B	72 mm (2.83 in.)
C	1.57 rad. (40°)
D	9 mm (0.35 in.)
E	24 mm (0.95 in.)
F	20 mm dia. (0.79 in. dia.)
G	68 mm dia. (2.68 in. dia.)
H	39.90 to 39.95 mm dia. (1.5709 to 1.5728 in. dia.)

11900G00452

# 1 ENGINE BODY

## CHECKING AND ADJUSTING



### Compression Pressure

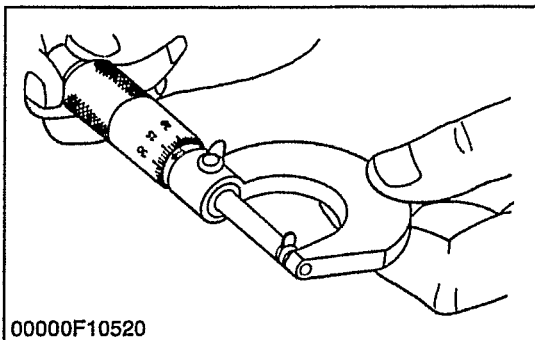
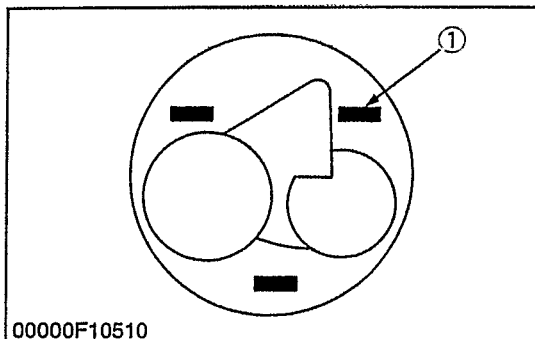
1. After warming up the engine, stop it and remove the air cleaner, the muffler and all nozzle holders.
2. Install a compression tester (Code No: 07909-30204) for diesel engines to nozzle holder hole.
3. After making sure that the speed control lever is set at the stop position (Non-injection), run the 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.
6. If the measurement is below the allowable limit, apply a small amount of oil to the cylinder wall through the nozzle hole and measure the compression pressure again.
7. If the compression pressure is still less than the allowable limit, check the top clearance, valve and cylinder head.
8. If the compression pressure increases after applying oil, check the cylinder wall and piston rings.

### NOTE

- Check the compression pressure with the specified valve clearance.
- Always use a fully charged battery for performing this test.
- Variances in cylinder compression values should be under 10 %.

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

02090S10090



### Top Clearance

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

Top clearance	Factory spec.	0.50 to 0.70 mm 0.0197 to 0.0276 in.
Tightening torque	Cylinder head mounting bolts	37.2 to 42.1 N·m 3.8 to 4.3 kgf·m 27.5 to 31.1 ft-lbs

(1) Fuse

01640S10271

## DISASSEMBLING AND ASSEMBLING

### [1] DRAINING WATER AND OIL

#### Draining Cooling Water and Engine Oil



#### CAUTION

- Never remove radiator cap until cooling water temperature is below its boiling point. Then loosen cap slightly to the stop to relieve any excess pressure before removing cap completely.
1. Prepare a bucket. Open the drain cock to drain cooling water.
  2. Prepare an oil pan. Remove the drain plug to drain engine oil in the pan.

01640S10290

### [2] EXTERNAL COMPONENTS

#### Air Cleaner and Muffler

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

#### (When reassembling)

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

01640S10300

#### Alternator and Fan Belt

1. Remove the alternator.
2. Remove the fan belt.

#### (When reassembling)

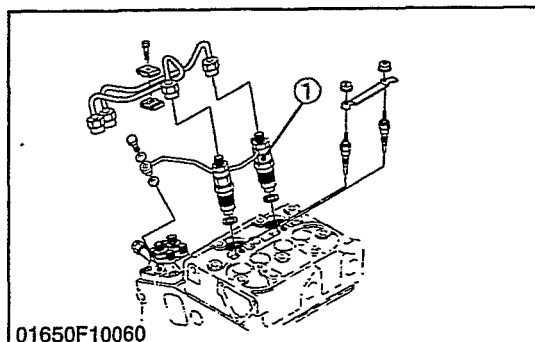
- Check to see that there are no cracks on the belt surface.

#### ■ IMPORTANT

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

02090S10100

### [3] CYLINDER HEAD AND VALVES

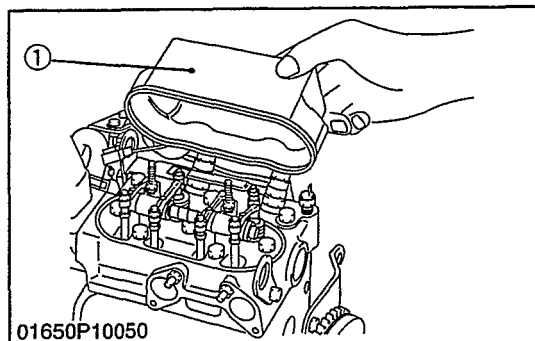


#### Nozzle Holder Assembly

1. Loosen the screws on the pipe clamps.
2. Remove the injection pipes.
3. Remove the fuel overflow pipes.
4. Loosen the lock nuts, and remove the nozzle holder assemblies.
5. Remove the copper gaskets on the seats.

(1) Nozzle Holder Assembly

01640S10321



#### Cylinder Head Cover

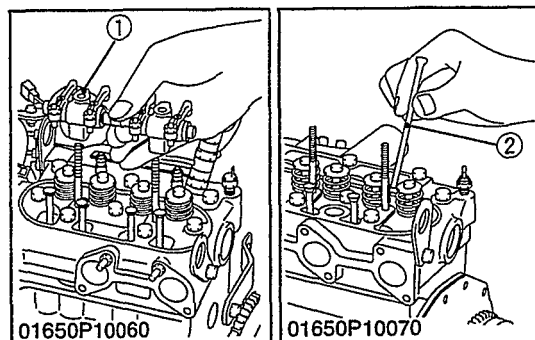
1. Remove the head cover cap nuts.
2. Remove the cylinder head cover (1).

#### (When reassembling)

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

(1) Head Cover

01640S10331



#### Rocker Arm and Push Rod

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

#### ■ IMPORTANT

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

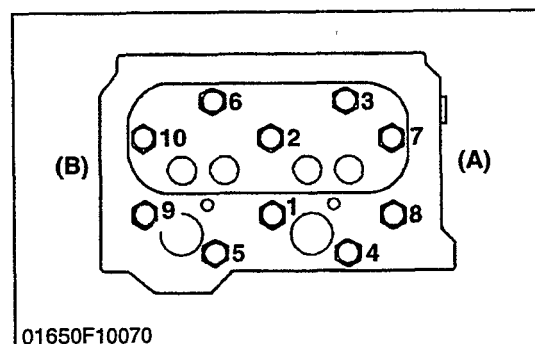
#### (When reassembling)

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

(1) Rocker Arm Assembly

(2) Push Rod

11900S10062



#### Cylinder Head

1. Loosen the pipe band, and remove the water return pipe.
2. Remove the cylinder head screws in the order of (10) to (1), and remove the cylinder head.
3. Remove the cylinder head gasket and O-ring.

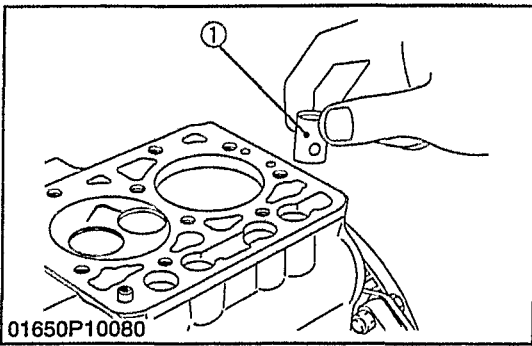
#### (When reassembling)

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

(A) Gear Case Side

(B) Flywheel Side

11900S10073



### Tappets

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

#### **(When reassembling)**

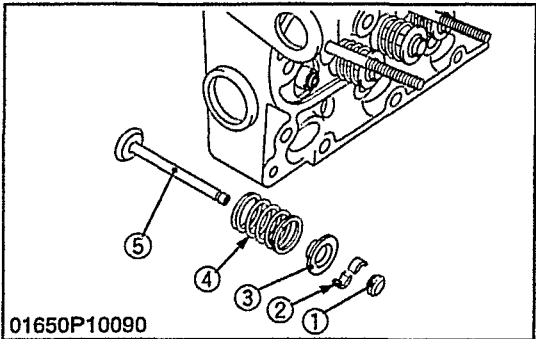
- Before installing the tappets, apply engine oil thinly around them.

#### **■ IMPORTANT**

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

(1) Tappet

11900S10082



### Valves

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

#### **(When reassembling)**

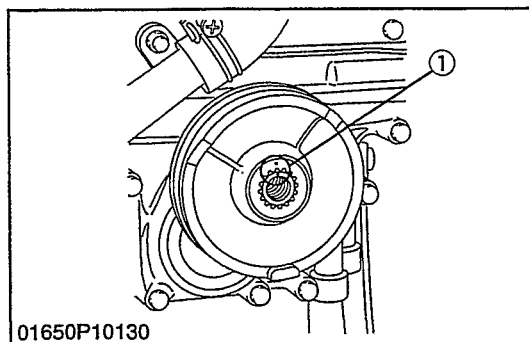
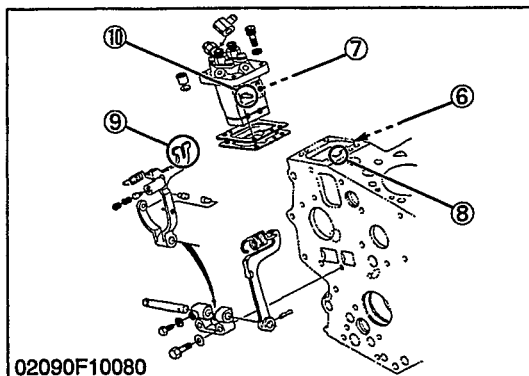
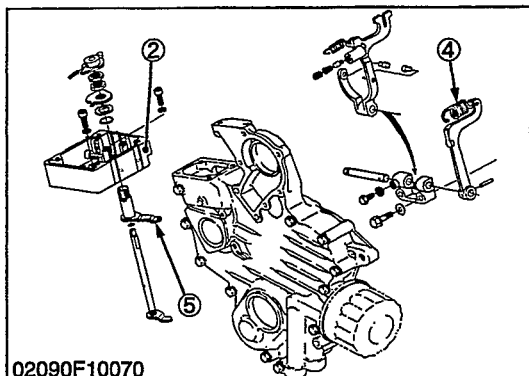
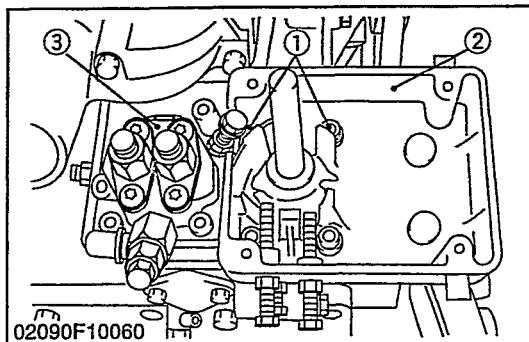
- Wash the valve stem and valve guide hole, and apply engine oil sufficiently
- After installing the valve spring collets, lightly tap the stem to assure proper fit with a plastic hammer.

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

(4) Valve Spring  
(5) Valve

11900S10092

## [4] TIMING GEAR AND CAMSHAFT



### Injection Pump and Speed Control Plate

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

### (When reassembling)

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

### NOTE

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

Tightening torque	Injection pump retaining screw and nut	9.81 to 11.3 N·m 1.00 to 1.15 kgf·m 7.23 to 7.32 ft-lbs
-------------------	--	---

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

02090S10110

### Fan Drive Pulley

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

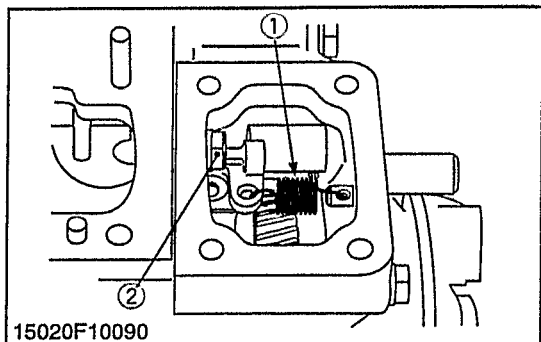
### (When reassembling)

- Install the pulley to the crankshaft, aligning the mark (1) on them.

Tightening torque	Crankshaft screw	117.6 to 127.4 N·m 12.0 to 13.0 kgf·m 86.4 to 93.6 ft-lbs
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- (1) Aligning Marks

01650S10310

**Gear Case**

1. Unscrew the screw (2) and disconnect the start spring (1) in the speed control plate mounting hole.
2. Remove the gear case.

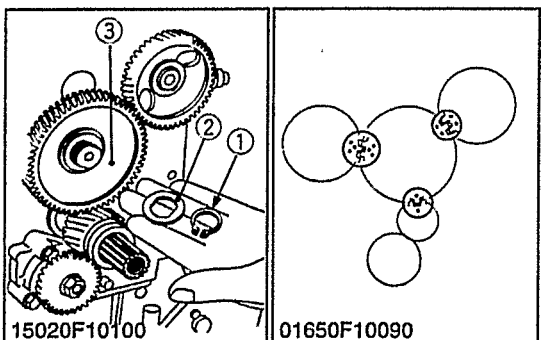
**(When reassembling)**

- 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.

(1) Start Spring

(2) Screw

01650S10320

**Idle Gear**

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

**(When reassembling)**

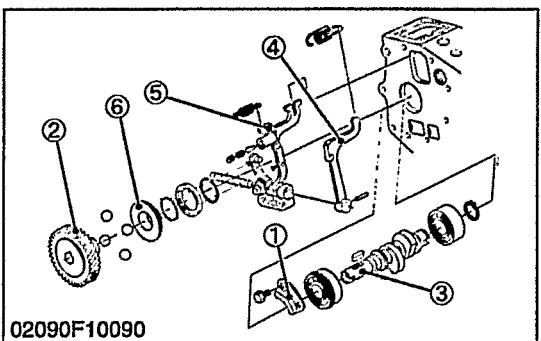
- Install the idle gear, aligning the mark on the gears referring to the figure.

(1) External Snap Ring

(3) Idle Gear

(2) Idle Gear Collar

01650S10330

**Fuel Camshaft**

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

**(When reassembling)**

- Hook the spring to the fork lever 2 (4) as shown in the figure before installing the fork lever assembly to the crankcase.

(1) Retaining Plate

(4) Fork Lever 2

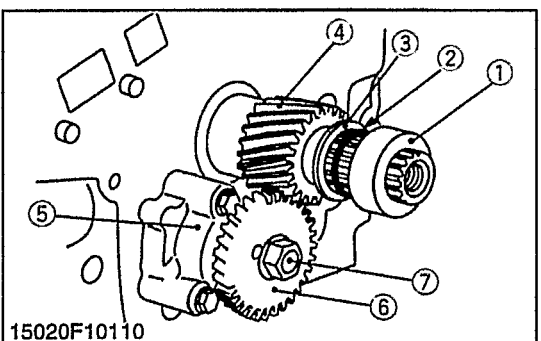
(2) Injection Pump Gear

(5) Fork Lever 1

(3) Fuel Camshaft

(6) Governor Sleeve

02090S10200

**Oil Pump and Crankshaft Gear**

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

**(When reassembling)**

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

(1) Crankshaft Collar

(5) Oil Pump

(2) O-ring

(6) Oil Pump Gear

(3) Crankshaft Oil Slinger

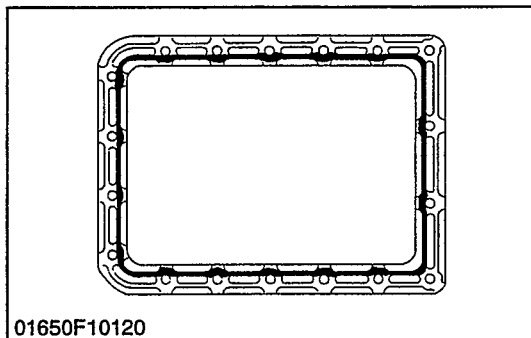
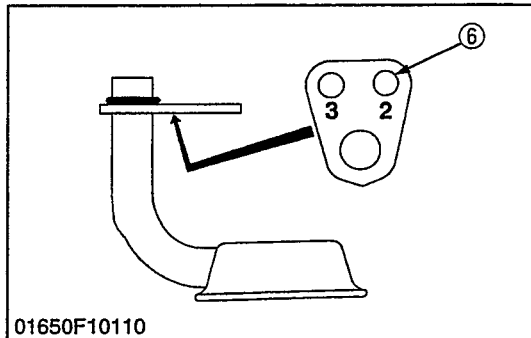
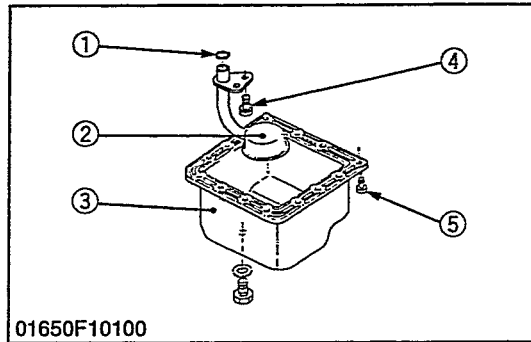
(7) Flange Nut

(4) Crankshaft Gear

01650S10350



## [5] PISTON AND CONNECTING ROD



### Oil Pan and Oil Strainer

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

### (When reassembling)

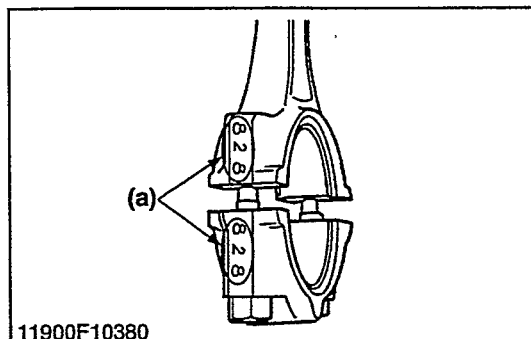
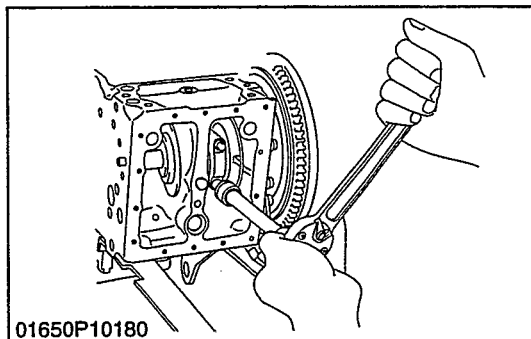
- Install the oil strainer, using care not to damage the O-ring (1).
- Using the hole (6) numbered "2", install the oil strainer by mounting screw.
- Apply liquid gasket (Three Bond 1270D or 1270C) to the oil pan as shown in the figure.

### ■ IMPORTANT

- Scape off the oil adhesive completely. Wipe the sealing surface clean using waste cloth soaked with gasoline. Now apply new adhesive 3 ~ 5 mm thick all over the contact surface. Apply the adhesive also on the center of the flange as well as on the inner wall of each bolt hole.
- Cut the nozzle of the "fluid sealant" container at its second notch. Apply "fluid sealant" about 5 mm thick. Within 20 minutes after the application of fluid sealant, reassemble the components. Wait then for about 30 minutes, and pour oil in the crankcase.

- |                  |                             |
|------------------|-----------------------------|
| (1) O-ring       | (4) Screw                   |
| (2) Oil Strainer | (5) Oil Pan Mounting Screws |
| (3) Oil Pan      | (6) Hole                    |

01650S10360



### Connecting Rod Cap

1. Remove the connecting rod screws from connecting rod cap.
2. Remove the connecting rod caps.

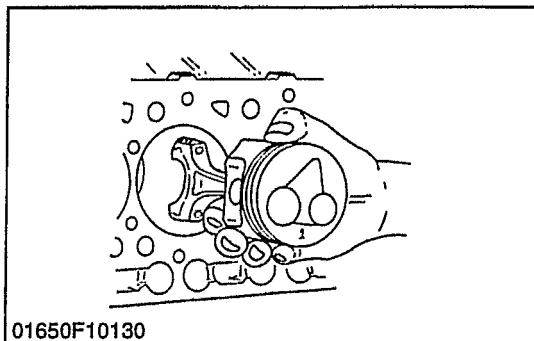
### (When reassembling)

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

Tightening torque	Connecting rod screw	26.5 to 30.4 N·m 2.7 to 3.1 kgf·m 19.5 to 22.4 ft·lbs
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(a) Mark

11900S10192



### Piston

1. Turn the flywheel and bring the No. 1 piston to the top dead center.
2. Pull out the piston upward by lightly tapping it from the bottom of the crankcase with the grip of a hammer.

#### **(When reassembling)**

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

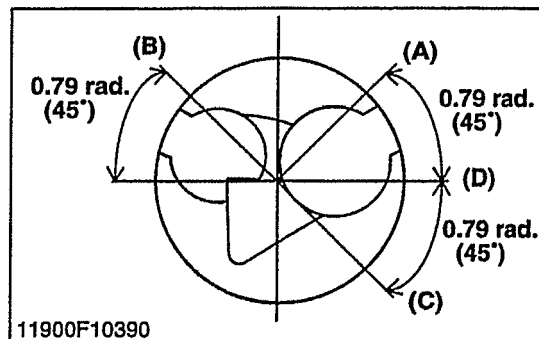
#### **IMPORTANT**

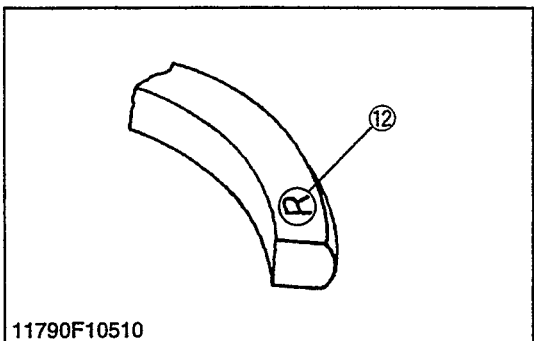
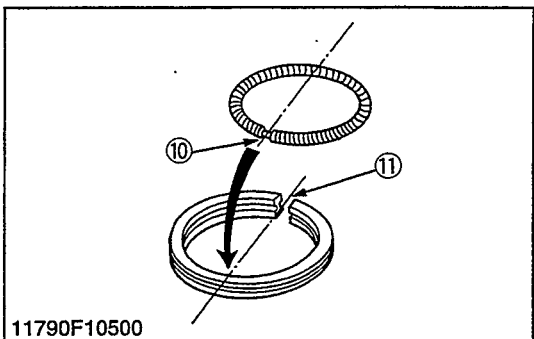
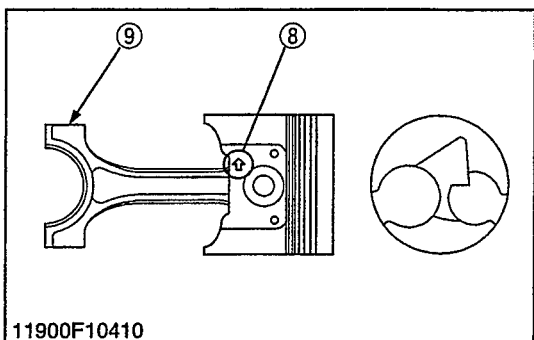
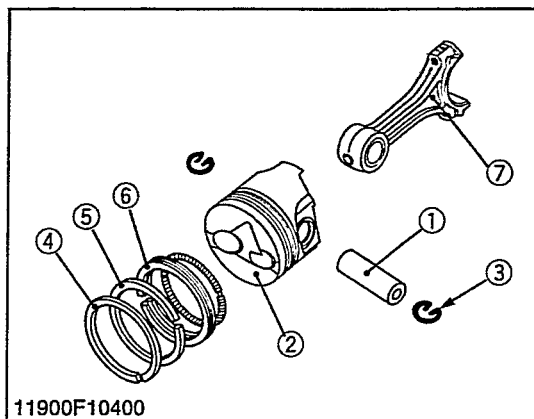
- Do not change the combination of cylinder and piston. Make sure of the position of each piston by marking. For example, mark "1" on the No.1 piston.
- When inserting the piston into the cylinder, place the gap of the compression ring 1 on the opposite side of the combustion chamber and stagger the gaps of the compression ring 2 and oil ring making a right angle from the gap of the compression ring 1.
- Carefully insert the pistons using a piston ring compressor. Otherwise, their chrome-plated section may be scratched, causing trouble inside the liner.

(A) Top Ring Gap  
(B) Second Ring Gap

(C) Oil Ring Gap  
(D) Piston Pin Hole

11900S10202





### Piston Ring and Connecting Rod

1. Remove the piston rings using a piston ring tool.
2. Put the casting mark (↑) (8) on the piston as shown in figure.
3. 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 (12) near the gap faces the top of the piston.
- When installing the oil ring onto the piston, place the expander joint (10) on the opposite side of the oil ring gap (11).
- Apply engine oil to the piston pin.
- When installing the piston pin, immerse the piston in 80 °C (176 °F) oil for 10 to 15 minutes and insert the piston pin to the piston.
- When installing the connecting rod to the piston, align the mark (9) on the connecting rod to the casting mark (8).

#### **■ IMPORTANT**

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

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

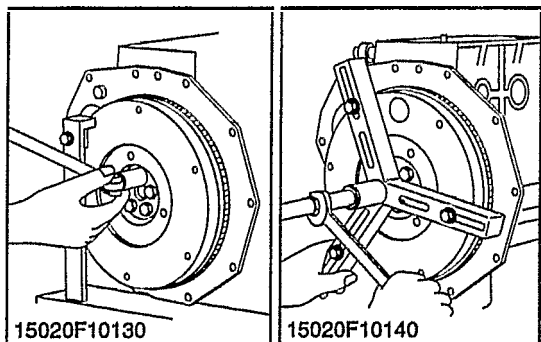
11900S10211

## [6] FLYWHEEL AND CRANKSHAFT

### Starter

1. Remove the starter.

02090S10240



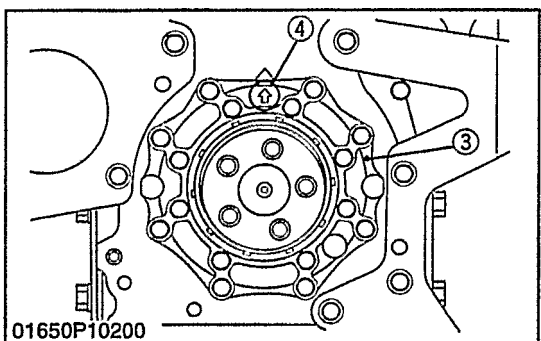
### Flywheel

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 screws.

01640S10400



01650P10200

### Bearing Case Cover and Crankshaft

#### ■ NOTE

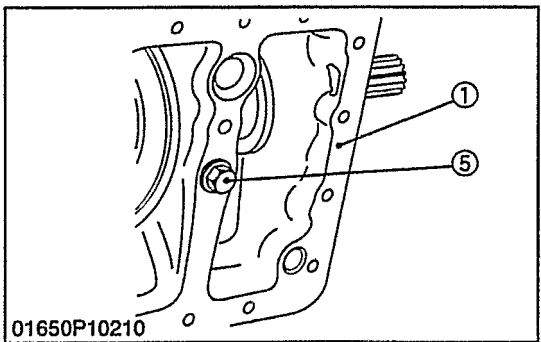
- Before disassembling, check the side clearance of crankshaft. Also check it during reassembly.

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

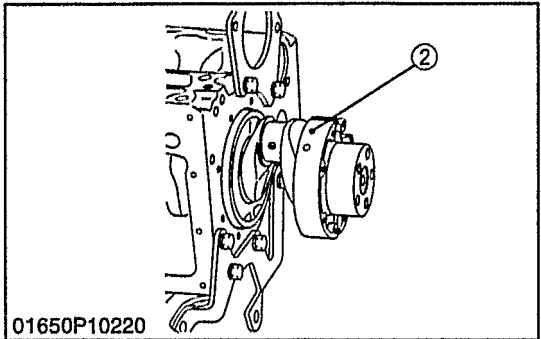
### (When reassembling)

#### ■ 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 "↑" (4) on it upward.
- Tighten the bearing case cover mounting screws with even force on the diagonal line.



01650P10210

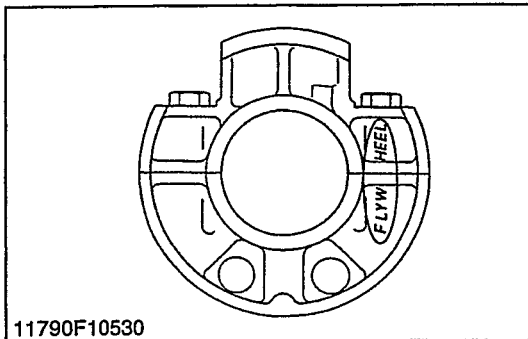
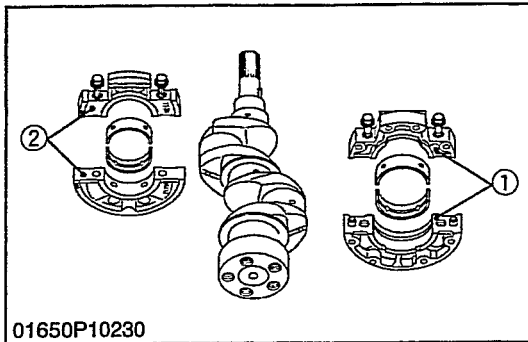


01650P10220

- (1) Cylinder Block  
(2) Main Bearing Case 2  
(3) Bearing Case Cover

- (4) Top Mark "↑"  
(5) Bearing Case Screw 2

01650S10370



### Main Bearing Case Assembly

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

#### (When reassembling)

- Clean the oil passage in the main bearing case.
- Apply clean engine oil on the crankshaft bearing 2 and main bearing case assembly 1.
- When installing the main bearing case assemblies 1, face the mark "FLYWHEEL" to the flywheel.

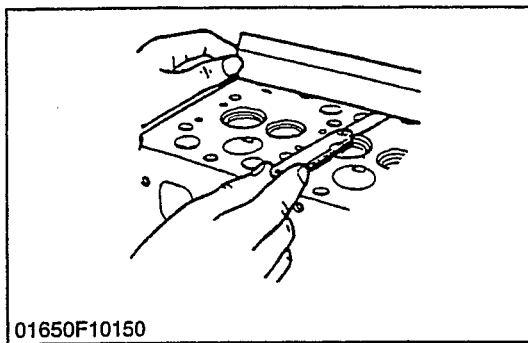
(1) Main Bearing Case Assembly

(2) Main Bearing Case Assembly 1

01650S10380

## SERVICING

### [1] CYLINDER HEAD

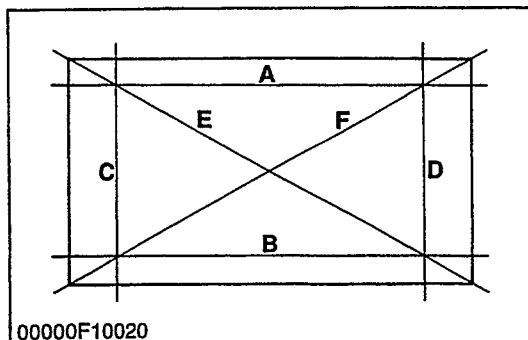


#### Cylinder Head Surface Flatness

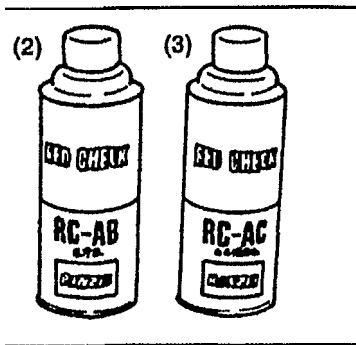
1. Thoroughly clean the cylinder head surface.
2. Place a straightedge on the cylinder head's four sides and two diagonal as shown in the figure. Measure the clearance with a feeler gauge.
3. If the measurement exceeds the allowable limit, correct it with a surface grinder.

#### ■ IMPORTANT

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



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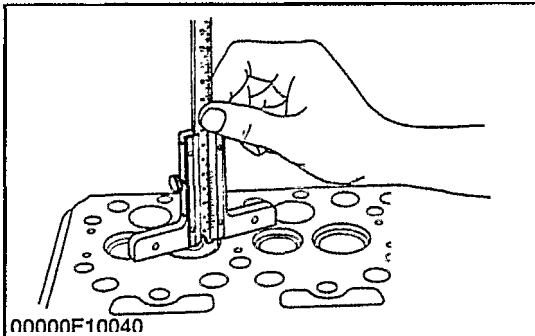
**Cylinder Head Flaw**

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

(1) Red Permeative Liquid  
(2) Detergent

(3) White Developer

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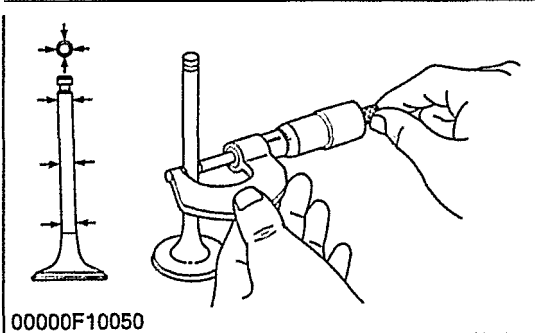
**Valve Recessing**

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

If it still exceeds the allowable limit after replacing the valve, correct the valve seat face of the cylinder head with a valve seat cutter (Code No. 07909-33102) or valve seat grinder.

Then, correct the cylinder head surface with a surface grinder, or replace the cylinder head.

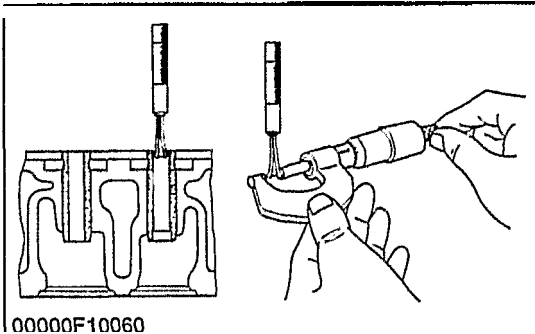
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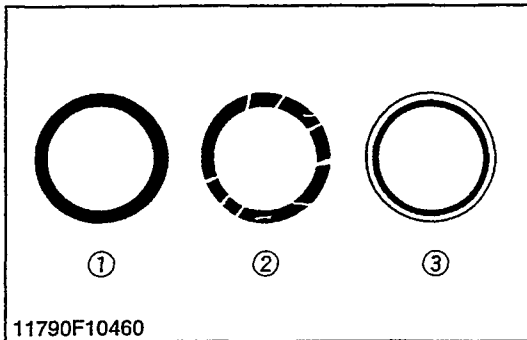
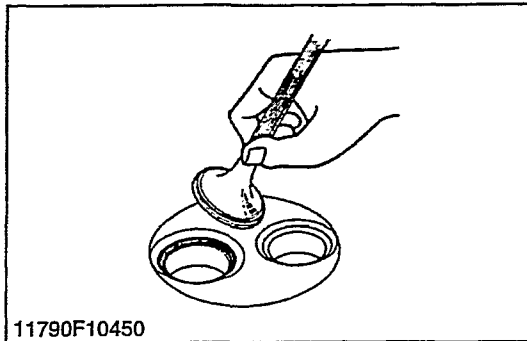
**Clearance between Valve Stem and Valve Guide**

1. Remove carbon from the valve guide section.
2. Measure the valve stem O.D. with an outside micrometer.
3. Measure the valve guide I.D. 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.



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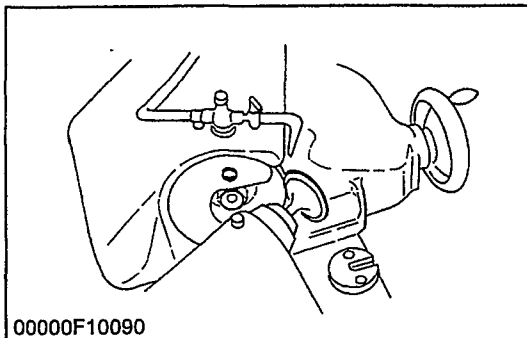
### Valve Seating

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

(1) Correct  
(2) Incorrect

(3) Incorrect

11790S10230



### Correcting Valve and Valve Seat

#### NOTE

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

#### 1) Correcting Valve

1. Correct the valve with a valve refacer.

Valve face angle	Factory spec.	0.79 rad. 45.0°
------------------	---------------	--------------------

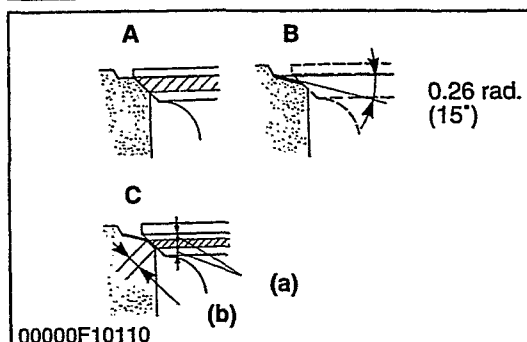
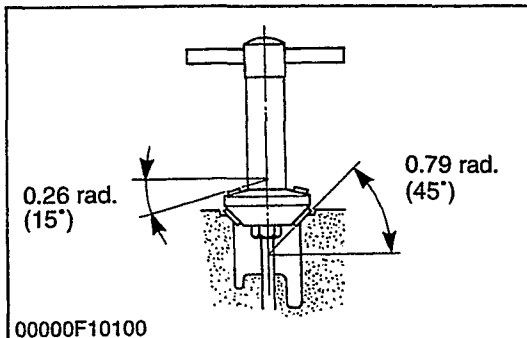
#### 2) Correcting Valve Seat

1. Slightly correct the seat surface with a 0.79 rad. (45°) valve seat cutter (Code No. 07909-33102).
2. Fitting the valve, check the contact position of the valve face and seat surface with red lead. (Visual check) [If the valve has been used for a long period, the seat tends to come in contact with the upper side of the valve face.]
3. Grind the upper surface of the valve seat with a 0.26 rad. (15°) valve seat cutter until the valve seat touches to the center of the valve face (so that a equals b as shown in the figure).
4. Grind the seat with a 0.79 rad. (45°) valve seat cutter again, and visually recheck the contact between the valve and seat.
5. Repeat steps 3 and 4 until the correct contact is achieved.
6. Continue lapping until the seated rate becomes more than 70 % of the total contact area.

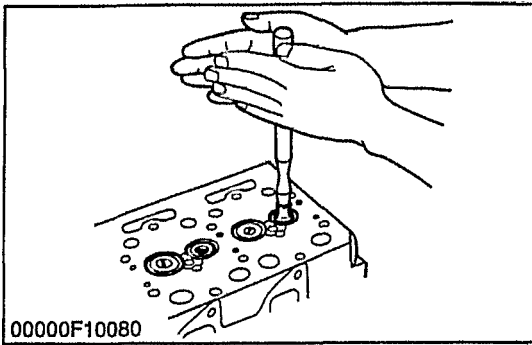
Valve seat angle	Factory spec.	0.79 rad. 45.0°
------------------	---------------	--------------------

(a) Identical Dimensions  
(b) Valve Seat Width

(A) Check Contact  
(B) Correct Seat Width  
(C) Check Contact



01650S10390



### Valve Lapping

1. Apply compound evenly to the valve lapping surface.
2. Insert the valve into the valve guide. Lap the valve onto its seat with a valve flapper or screwdriver.
3. After lapping the valve, wash the compound away and apply oil, then repeat valve lapping with oil.
4. Apply prussian blue to the contact surface to check the seated rate. If it is less than 70 %, repeat valve lapping again.

#### ■ IMPORTANT

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

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### Replacing Valve Guide

#### (When removing)

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

#### (When installing)

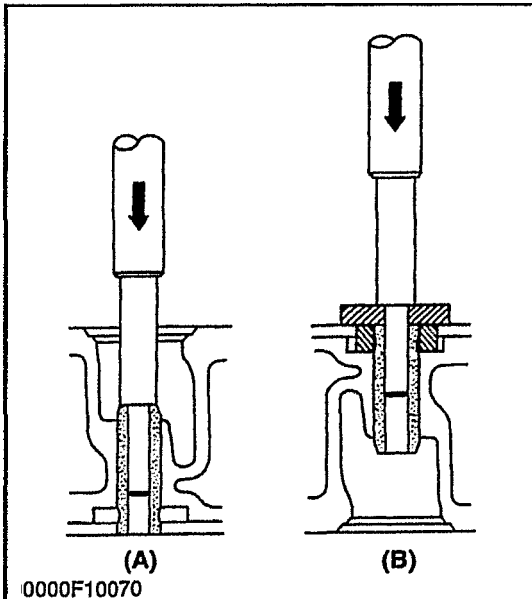
1. Clean a new valve guide, and apply engine oil to it.
2. Using a valve guide replacing tool, press in a new valve guide until it is flush with the cylinder head as shown in the figure.
3. Ream precisely the I.D. of the valve guide to the specified dimension.

#### ■ IMPORTANT

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

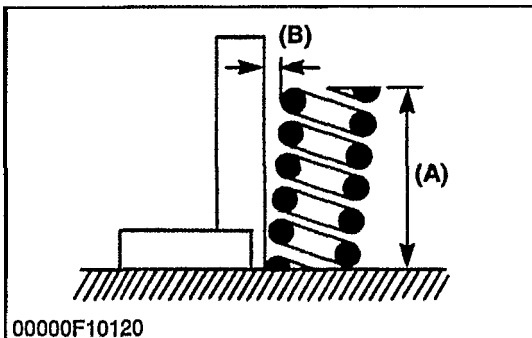
(A) When Removing

(B) When Installing



### Free Length and Tilt of Valve Spring

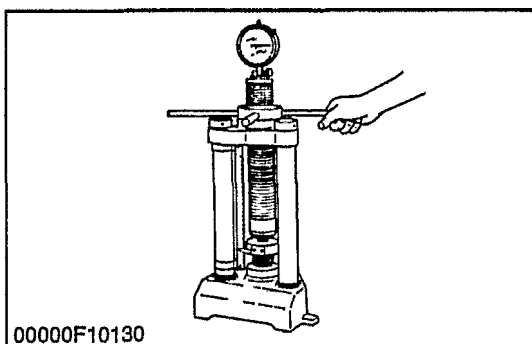
1. Measure the free length (A) with vernier calipers. If the measurement is less than the allowable limit, replace it.
2. Put the spring on a surface plate, place a square on the side of the spring, and check to see if the entire side is in contact with the square. Rotate the spring and measure the maximum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



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### Valve Spring Setting Load

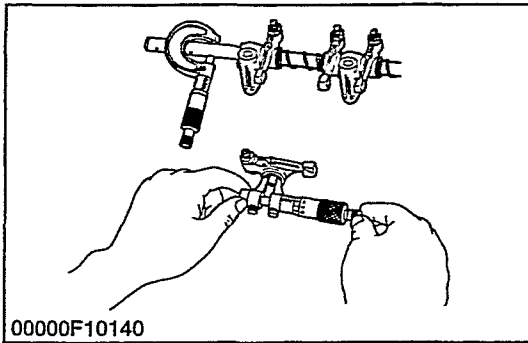
1. Place the valve spring on a tester and compress it to the same length it is actually compressed in the engine.
2. Read the compression load on the gauge.
3. If the measurement is less than the allowable limit, replace it.



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00000S10092

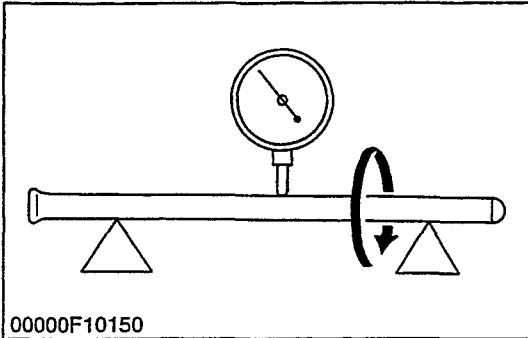




#### Oil Clearance between Rocker Arm Shaft and Bearing

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

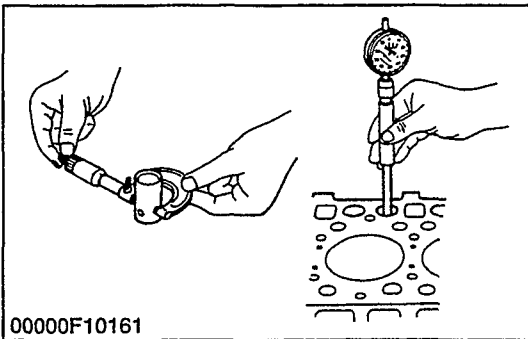
00000S10102



#### Push Rod Alignment

1. Check the both end of the push rod for cracks, damage and unusual wear.
2. Measure the bending of the push rod with a dial indicator.
3. If the measurement exceeds the allowable limit, replace the push rod.

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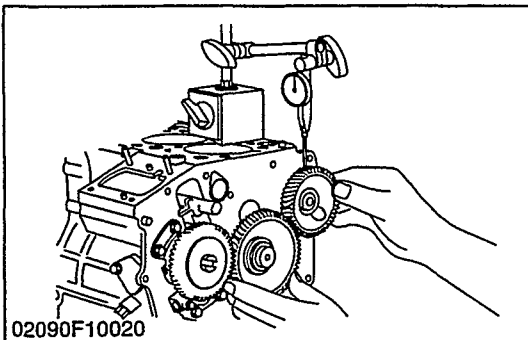


#### Oil Clearance between Tappet and Tappet Guide Bore

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

00000S10123

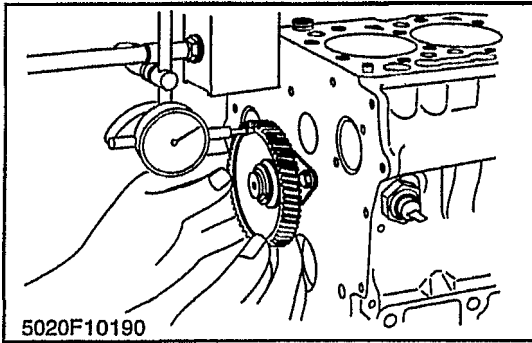
## [2] TIMING GEAR AND CAMSHAFT



#### Timing Gear Backlash

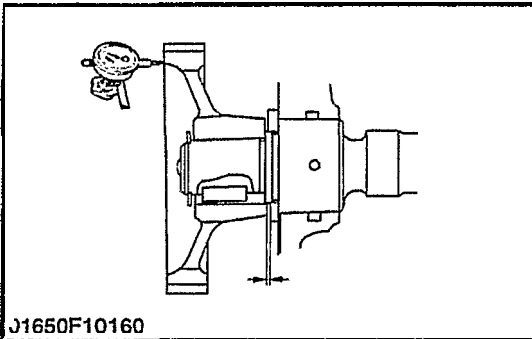
1. Set a dial indicator (lever type) with its tip on the gear tooth.
2. Move the gear to measure the backlash, holding its mating gear.
3. If the backlash exceeds the allowable limit, check the oil clearance of the shafts and the gear.
4. If the oil clearance is proper, replace the gear.

02090S10130

**Idle Gear Side Clearance**

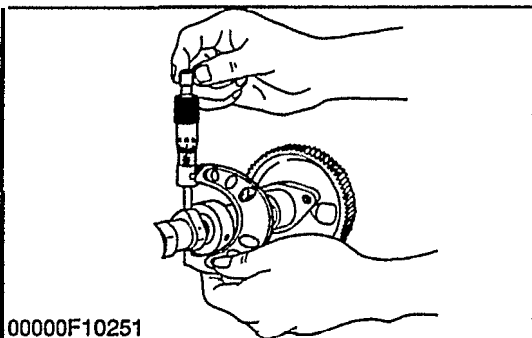
1. Set a dial indicator with its tip on the idle gear.
2. Measure the side clearance by moving the idle gear to the front and rear.
3. If the measurement exceeds the allowable limit, replace the idle gear collar.

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**Camshaft Side Clearance**

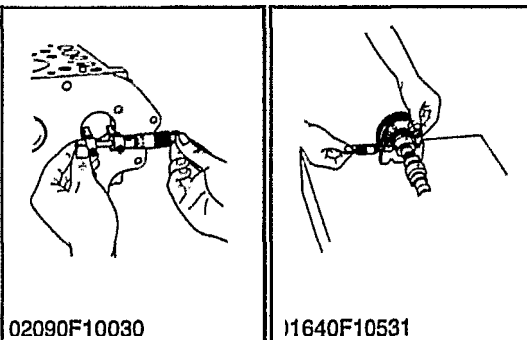
1. Set a dial indicator with its tip on the camshaft.
2. Measure the side clearance by moving the cam gear to the front and rear.
3. If the measurement exceeds the allowable limit, replace the camshaft stopper.

00000S10183

**Cam Height**

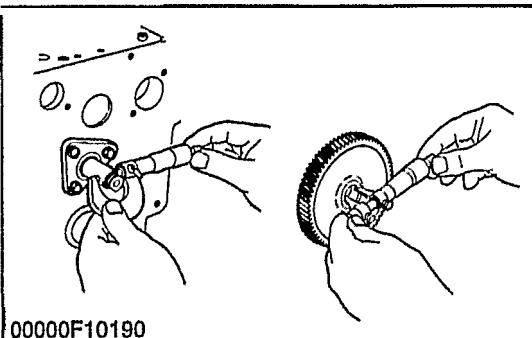
1. Measure the height of the cam at its highest point with an outside micrometer.
2. If the measurement is less than the allowable limit, replace the camshaft.

00000S10203

**Oil Clearance of Camshaft Journal**

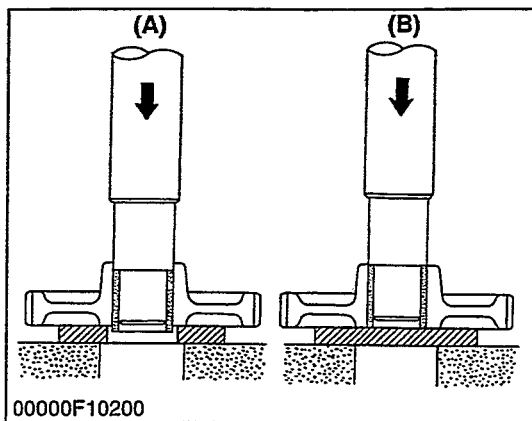
1. Measure the camshaft journal O.D. with an outside micrometer
2. Measure the cylinder block bore I.D. for camshaft with an inside micrometer.  
Calculate the oil clearance.
3. If the clearance exceeds the allowable limit, replace the camshaft.

02090S10140

**Oil Clearance between Idle Gear Shaft and Idle Gear Bushing**

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

00000S10152



### Replacing Idle Gear Bushing

#### **(A) (When removing)**

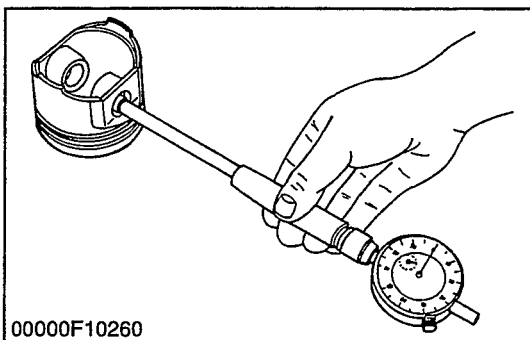
1. Using an idle gear bushing replacing tool (see page S-24), press out the used bushing.

#### **(B) (When installing)**

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

02090S10150

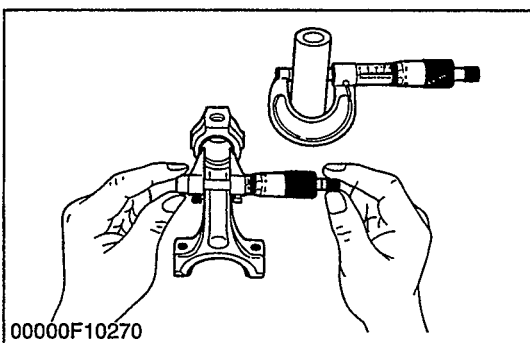
## **[3] PISTON AND CONNECTING ROD**



### Piston Pin Bore I.D.

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

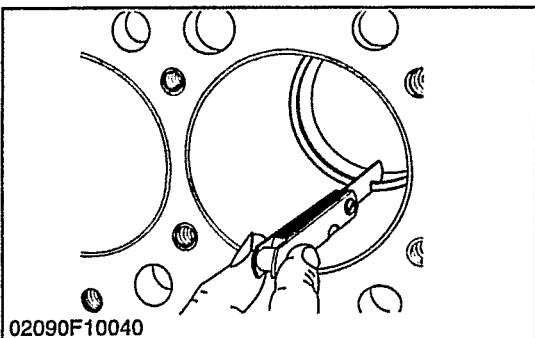
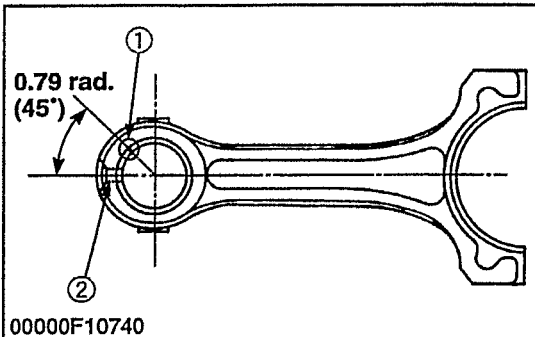
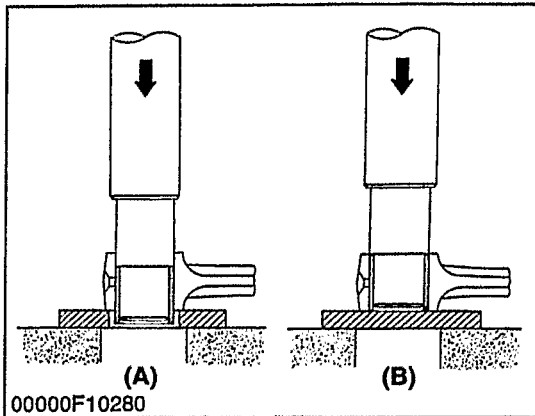
00000S10212



### 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.

00000S10222



### Replacing Small End Bushing

#### **(When removing)**

1. Press out the used bushing using a small end bushing replacing tool.

#### **(When installing)**

1. Clean a new small end bushing and bore, and apply engine oil to them.
2. Insert a new bushing onto the tool and press-fit it with a press so that the seam (1) of bushing positions as shown in the figure, until it is flush with the connecting rod.
3. Drill a hole to the bushing with aligning the oil hole (2) of connecting rod using 3.5 mm dia. (0.138 in. dia.) drill.

#### **NOTE**

- Be sure to chamfer the oil hole circumference with an oil stone.

- (1) Seam  
(2) Oil Hole

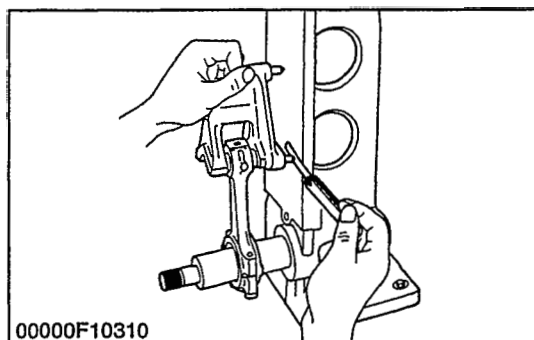
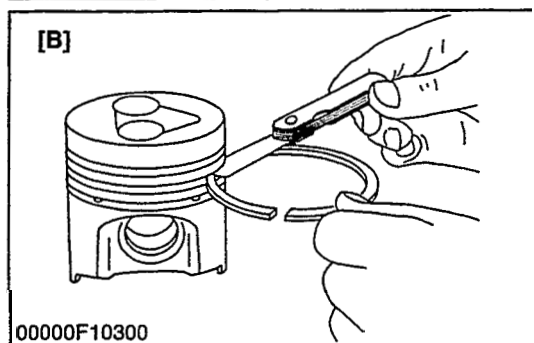
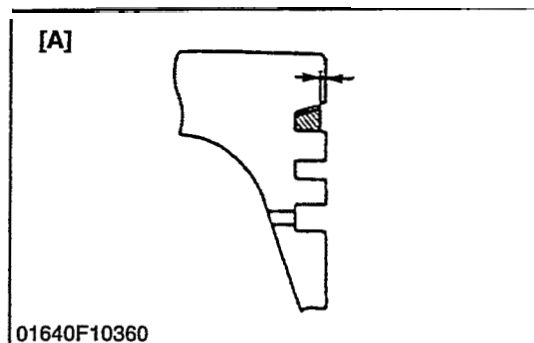
- (A) When Removing  
(B) When Installing

00000S10232

### 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 piston ring.

02090S10160



### 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 : A	More than 0.2 mm 0.079 in.
------------------	-------------------------------

(A) Top Ring (Key Stone Type)

(B) 2nd, Oil Ring

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### Connecting Rod Alignment

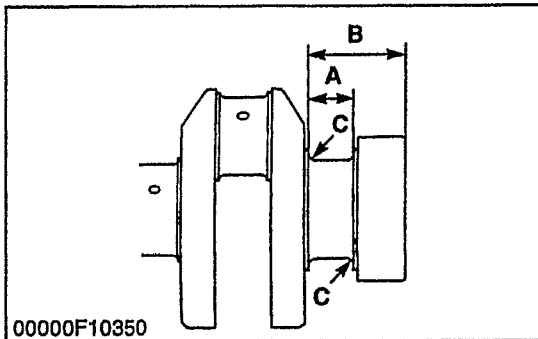
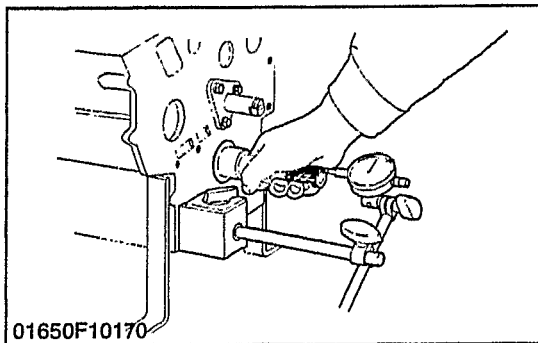
#### ■ NOTE

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

1. Remove the crankpin bearing, and install the connecting rod cap. -
2. Install the piston pin in the connecting rod.
3. Install the connecting rod on the connecting rod alignment tool (Code No. 07909-31661).
4. Put a gauge over the piston pin, and move it against the face plate.
5. If the gauge does not fit squarely against the face plate, measure the space between the pin of the gauge and the face plate.
6. If the measurement exceeds the allowable limit, replace the connecting rod.

00000S10261

#### [4] CRANKSHAFT



### Crankshaft Side Clearance

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

Crankshaft side clearance	Factory spec.	0.15 to 0.25 mm 0.0059 to 0.0098 in.
	Allowable limit	0.50 mm 0.0197 in.

**(Reference)**

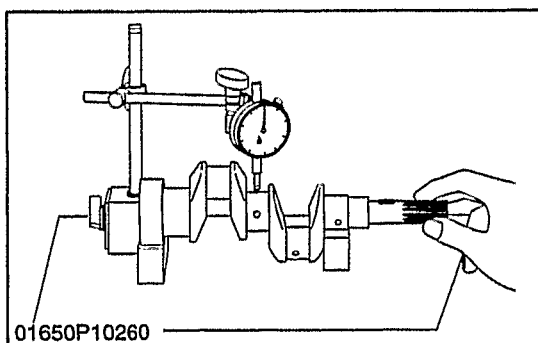
- Oversize main bearing case assembly

Oversize	Bearing	Code Number	Marking
0.2 mm 0.008 in.	Main bearing case assembly 02	15821-07201	020 OS
0.4 mm 0.016 in.	Main bearing case assembly 04	15821-07211	040 OS

- **Oversize dimensions of crankshaft journal**

Oversize	0.2 mm 0.008 in.	0.4 mm 0.016 in.
Dimension A	23.40 to 23.45 mm 0.9134 to 0.9154 in.	23.80 to 23.85 mm 0.9213 to 0.9232 in.
Dimension B	46.1 to 46.3 mm 1.815 to 1.823 in.	46.3 to 46.5 mm 1.823 to 1.831 in.
Dimension C	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius
(0.8-S) The crankshaft journal must be fine-finished to higher than VVVV.		

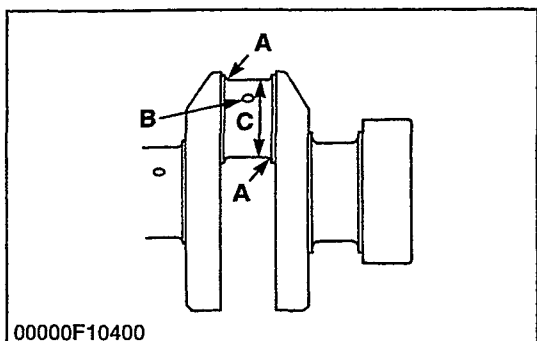
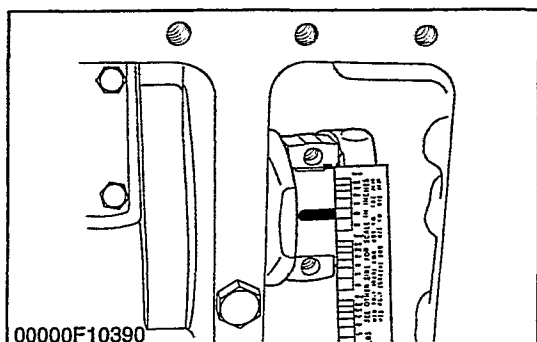
01650S10400



## 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.

00000S10282



### Oil Clearance between Crankpin and Crankpin Bearing

1. Clean the crankpin and crankpin bearing.
2. Put a strip of plastigage (Code No. 07909-30241) on the center of the crankpin.
3. Install the connecting rod cap and tighten the connecting rod screws to the specified torque, and remove the cap again.
4. Measure the amount of the flattening with the scale, and get the oil clearance.
5. If the oil clearance exceeds the allowable limit, replace the crankpin bearing.
6. If the same size bearing is useless because of the crankpin wear, replace it with an undersize one referring to the table and figure.

## NOTE

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

Oil clearance between crankpin and crankpin bearing	Factory spec.	0.019 to 0.081 mm 0.00075 to 0.00319 in.
	Allowable limit	0.15 mm 0.0059 in.
Crankpin O.D.	Factory spec.	33.959 to 33.975 mm 1.33679 to 1.33760 in.
Crankpin bearing I.D.	Factory spec.	33.995 to 34.010 mm 1.33839 to 1.33898 in.

**(Reference)**

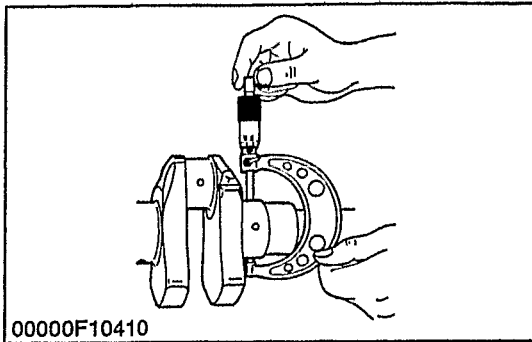
- Undersize crankpin bearing

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

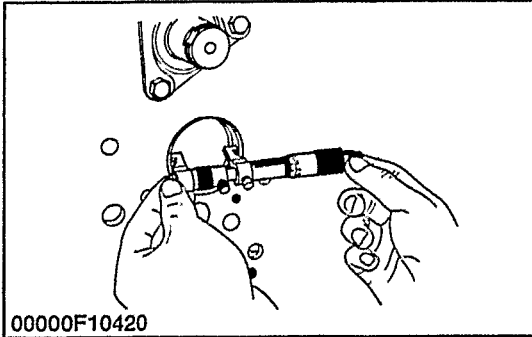
- Undersize dimensions of crankpin

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

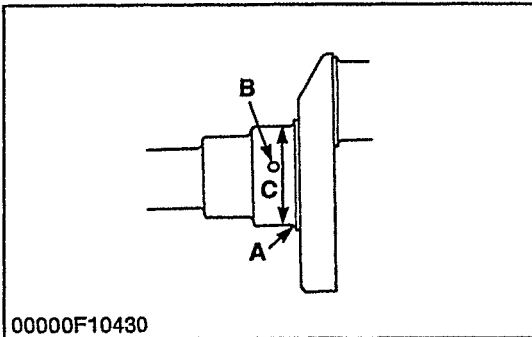
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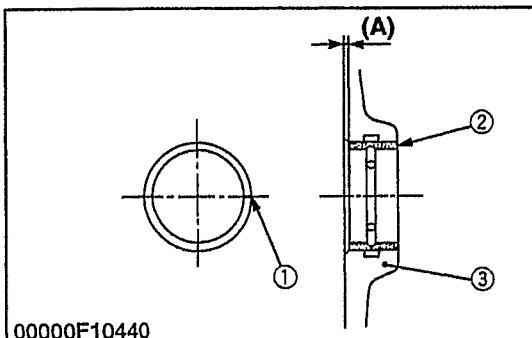
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## Oil Clearance between Crankshaft Journal and Crankshaft

### Bearing 1

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

Oil clearance between crankshaft journal and crankshaft bearing 1	Factory spec.	0.034 to 0.106 mm 0.0013 to 0.0042 in.
	Allowable limit	0.20 mm 0.0079 in.

Crankshaft journal O.D.	Factory spec.	39.934 to 39.950 mm 1.57221 to 1.57284 in.
Crankshaft bearing 1 I.D.	Factory spec.	39.984 to 40.040 mm 1.57148 to 1.57638 in.

### (Reference)

- Undersize crankshaft bearing 1

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

- Undersize dimensions of crankshaft journal

Undersize Dimension	0.2 mm 0.008 in.	0.4 mm 0.016 in.
A	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius
B	5 mm dia. 0.20 in. dia.	5 mm dia. 0.20 in. dia.
C	39.734 to 39.750 mm 1.56433 to 1.56496 in.	39.534 to 39.550 mm 1.55646 to 1.55709 in.
(0.8-S) The crankshaft journal must be fine-finished to higher than $\nabla\nabla\nabla\nabla$ .		

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## Replacing Crankshaft Bearing 1

### (When removing)

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

### (When installing)

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

Dimension (A)	Factory spec.	0 to 0.3 mm 0 to 0.0118 in.
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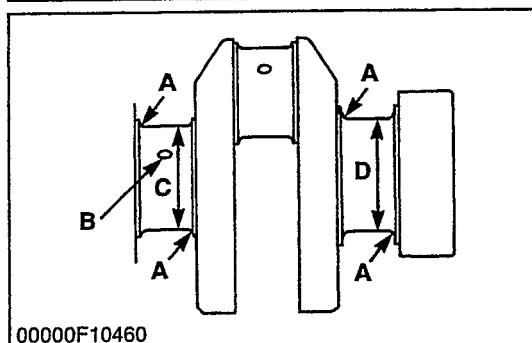
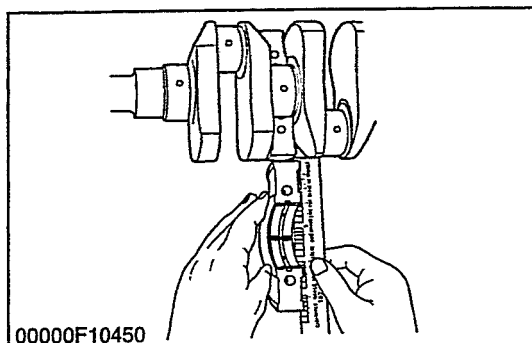
(1) Seam

(2) Crankshaft Bearing 1

(3) Cylinder Block

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### **Oil Clearance between Crankshaft Journal and Crankshaft Bearing 2 and Crankshaft Bearing 3**

1. Put a strip of plastigage (Code No. 07909-30241) on the center of the journal.
2. Install the bearing case and tighten the bearing case screws 1 to the specified torque, and remove the bearing case again.
3. Measure the amount of the flattening with the scale, and get the oil clearance.
4. If the oil clearance exceeds the allowable limit, replace the crankshaft bearing 2 or 3.
5. If the same size bearing is useless because of the crankshaft journal wear, replace it with an undersize one referring to the table and figure.

#### **NOTE**

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

Oil clearance between crankshaft journal and crankshaft bearing 3	Factory spec.	0.028 to 0.059 mm 0.0014 to 0.00232 in.
	Allowable limit	0.20 mm 0.0079 in.

Crankshaft journal O.D. (Intermediate)	Factory spec.	39.934 to 39.950 mm 1.57221 to 1.57284 in.
Crankshaft bearing 3 I.D.	Factory spec.	39.978 to 39.993 mm 1.57394 to 1.57453 in.

Oil clearance between crankshaft journal and crankshaft bearing 2	Factory spec.	0.034 to 0.092 mm 0.00134 to 0.00362 in.
	Allowable limit	0.20 mm 0.0079 in.

Crankshaft journal O.D. (Flywheel side)	Factory spec.	43.934 to 43.950 mm 1.72969 to 1.73032 in.
Crankshaft bearing 2 I.D.	Factory spec.	43.984 to 44.026 mm 1.73166 to 1.73331 in.

#### **(Reference)**

- Undersize crankshaft bearing 2 and 3

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

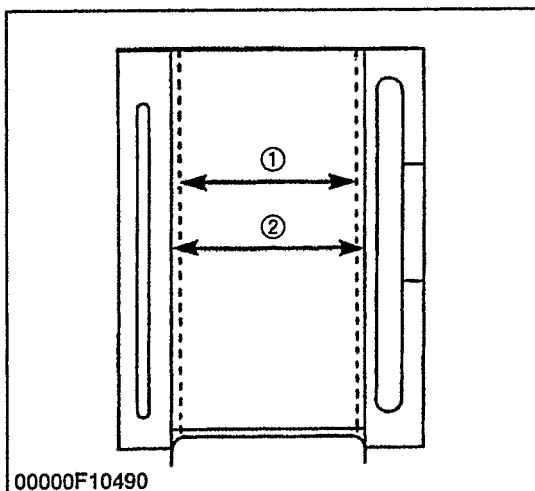
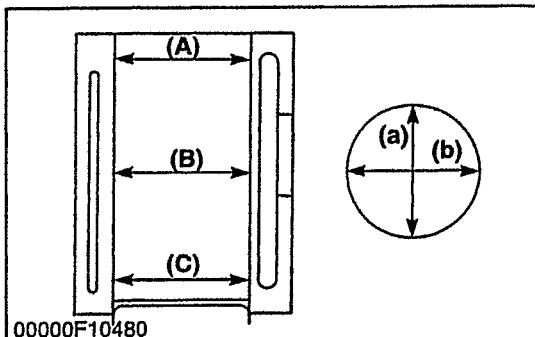
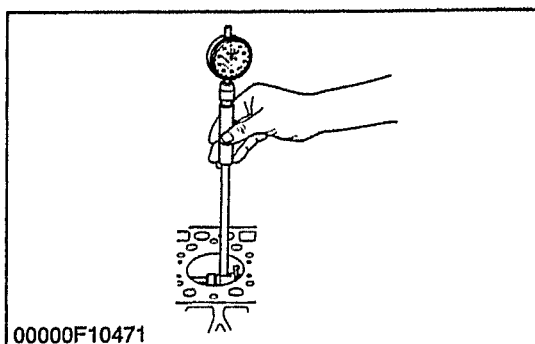
- Undersize dimensions of crankshaft journal

Undersize Dimension	0.2 mm 0.008 in.	0.4 mm 0.016 in.
A	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius
B	3 mm dia 0.12 in. dia	3 mm dia 0.12 in. dia
C	39.734 to 39.750 mm 1.56433 to 1.56496 in.	39.534 to 39.550 mm 1.55646 to 1.55709 in.
D	43.734 to 43.750 mm 1.72181 to 1.72244 in.	43.534 to 43.550 mm 1.71394 to 1.71457 in.

• The crankpin journal must be fine-finished to higher than VVVV (0.8 S).

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## [5] CYLINDER



### Cylinder Wear

1. Measure the I.D. of the cylinder at the six positions (see figure) with a cylinder gauge to find the maximum and minimum I.D.'s.
2. Get the difference (Maximum wear) between the maximum and the minimum I.D.'s.
3. If the wear exceeds the allowable limit, bore and hone to the oversize dimension. (Refer to "**Correcting Cylinder**".)
4. Visually check the cylinder wall for scratches. If deep scratches are found, the cylinder should be bored. (Refer to "**Correcting Cylinder**".)

Cylinder I.D.	Factory spec.	64.000 to 64.019 mm 2.51968 to 2.52043 in.
Maximum wear	Allowable limit	0.15 mm 0.0059 in.

- (A) Top  
(B) Middle  
(C) Bottom (Skirt)

- (a) Right-angled to Piston Pin  
(b) Piston Pin Direction

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### Correcting Cylinder

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

Cylinder I.D.	Factory spec.	64.500 to 64.519 mm 2.5394 to 2.5401 in.
Maximum wear	Allowable limit	0.15 mm 0.0059 in.
Finishing	Hone to 1.2 to 2.0 mR max. ▽▽▽ (0.000047 to 0.0079 in.R max.)	

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

Part Name	Code Number	Marking
Piston	15821-21911	05 OS
Piston ring assembly	15821-21091	05 OS

### NOTE

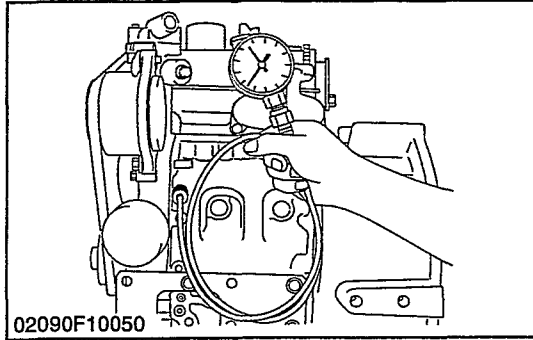
- When the oversize cylinder is worn beyond the allowable limit, replace the cylinder block with a new one.

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

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## 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 filter cartridge
  - Oil gallery clogged
  - Excessive oil clearance of bearing
  - Foreign matter in the relief valve

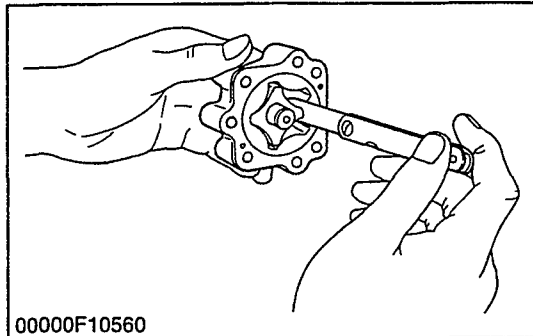
#### (When reassembling)

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

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### SERVICING

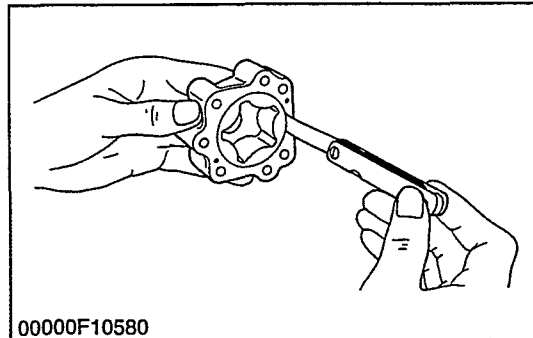
#### [1] OIL PUMP



#### Rotor Lobe Clearance

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

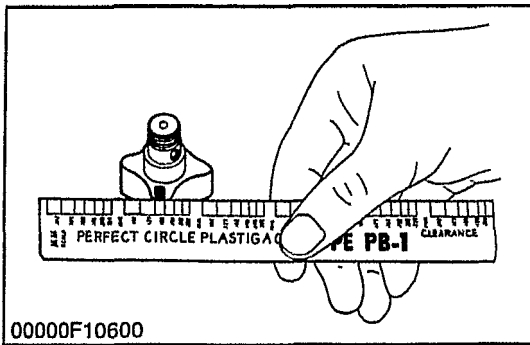
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#### Clearance between Outer Rotor and Pump Body

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

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**Clearance between Rotor and Cover**

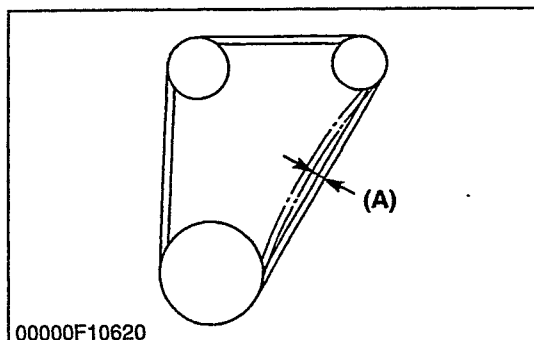
1. Put a strip of plastigage (Code No. 07909-30241) onto the rotor face with grease.
2. Install the cover and tighten the screws.
3. Remove the cover carefully, and measure the amount of the flattening with the scale and get the clearance.
4. If the clearance exceeds the factory specifications, replace oil pump rotor assembly.

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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 (98 N, 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, adjust with the tension pulley adjusting nut.

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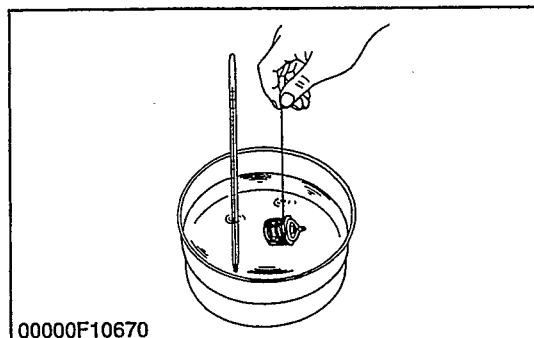
##### [2] RADIATOR



##### 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.

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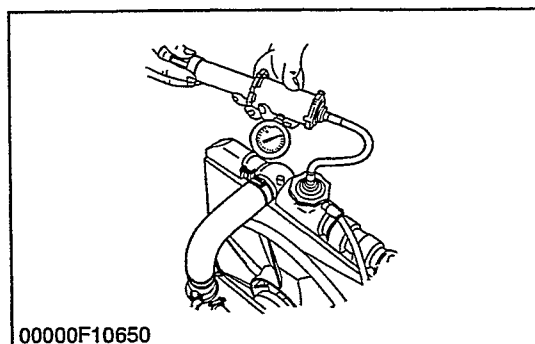


##### Thermostat Valve Opening Temperature

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 6 mm (0.236 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 °F

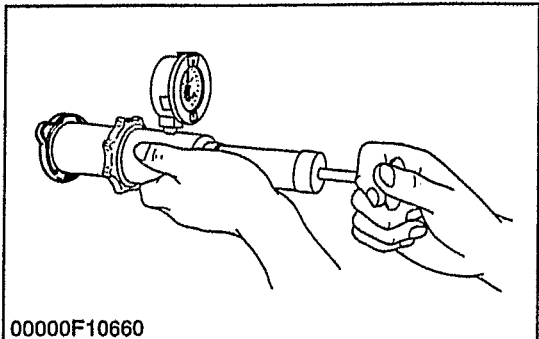
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##### Radiator Water Leakage

1. Pour a specified amount of water into the radiator.
2. Set a proper radiator tester and joints.  
Increase water pressure to the specified pressure of 157 kPa (1.6 kgf/cm<sup>2</sup>, 23 psi).
3. Check the radiator for water leaks.
4. When water leakage is excessive, replace the radiator. If water leakage is caused by a small pinhole, correct the radiator with radiator cement.

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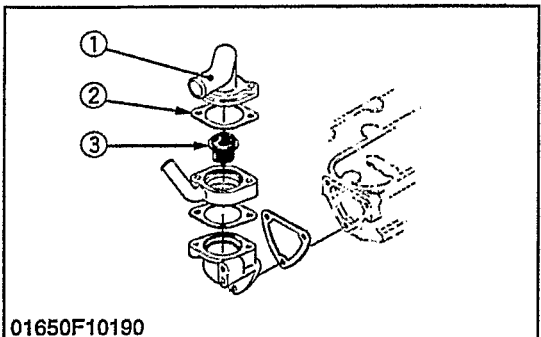


### **Radiator Cap Air Leakage**

1. Set a proper radiator tester and an adapter on the radiator cap.
2. Apply the specified pressure of 88.2 kPa (0.9 kgf/cm<sup>2</sup>, 12.8 psi).
3. Check if the pressure drop to less than 59 kPa (0.6 kgf/cm<sup>2</sup>, 9 psi) in 10 seconds.
4. If the pressure is less than the factory specification, replace it.

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## **DISASSEMBLING AND ASSEMBLING**



### **Thermostat Assembly**

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

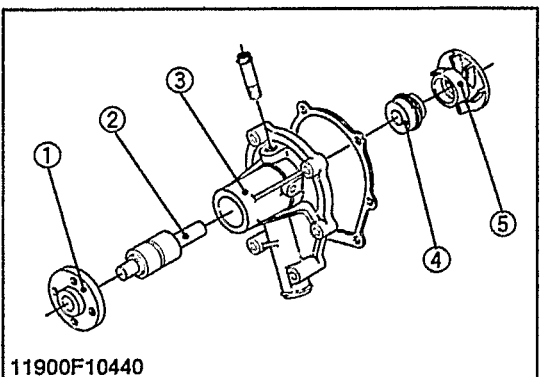
#### **(When reassembling)**

- Apply a liquid gasket (Three Bond 1215 or equivalent) only at the thermostat cover side of the gasket (2).

- (1) Thermostat Cover  
(2) Thermostat Cover Gasket

- (3) Thermostat Assembly

11900S10271



### **Water Pump Assembly**

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

#### **(When reassembling)**

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

- (1) Water Pump Flange  
(2) Water Pump Shaft  
(3) Water Pump Body

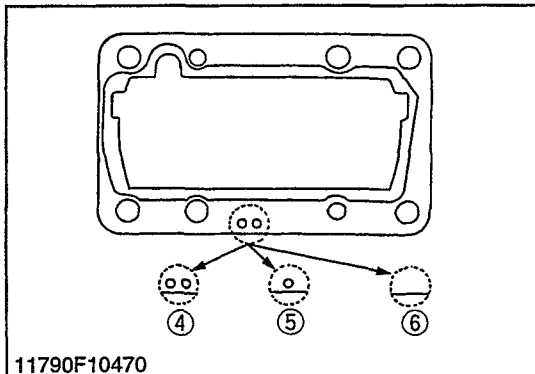
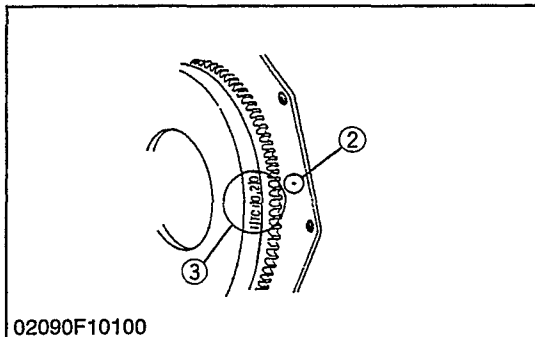
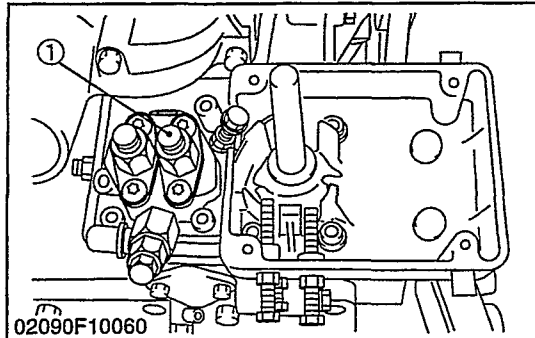
- (4) Mechanical Seal  
(5) Impeller

11900S10280

## 4 FUEL SYSTEM

### CHECKING AND ADJUSTING

#### [1] INJECTION PUMP



#### Injection Timing

##### ■ IMPORTANT

- When inspecting the fuel injection timing, the timing control actuates during starting and the correct fuel injection timing cannot be measured.
1. Remove the injection pipes.
  2. Set the speed control lever to the maximum fuel discharge position.
  3. Turn the flywheel until the fuel fills up to the hole of the delivery valve holder (1).
  4. Turn the flywheel further to check the injection timing, and stop turning when the fuel begins to flow over again.
  5. Check to see if the mark or punch mark (2) on the flywheel is aligned with the timing mark (3).
  6. If the timing is out of adjustment, readjust the timing with shims.

##### ■ NOTE

- 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 (0.0079 in.), 0.25 mm (0.0098 in.) and 0.30 mm (0.0118 in.). Combine these shims for adjustments.
- Addition or reduction of shim (0.05 mm, 0.0020 in.) delays or advances the injection timing by approx. 0.0087 rad. (0.5°).
- In disassembling and replacing, be sure to use the same number of new gasket shims with the same thickness.

- (1) Delivery Valve Holder
- (2) Punch Mark
- (3) Timing Mark

- (4) Two-holes : 0.20 mm (0.0079 in.)
- (5) One-hole : 0.25 mm (0.0098 in.)
- (6) Without hole : 0.30 mm (0.0118 in.)

02090S10210

#### Fuel Tightness of Pump Element

1. Remove the injection pipes and glow plugs.
2. Install the injection pump pressure tester 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.

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**Fuel Tightness of Delivery Valve**

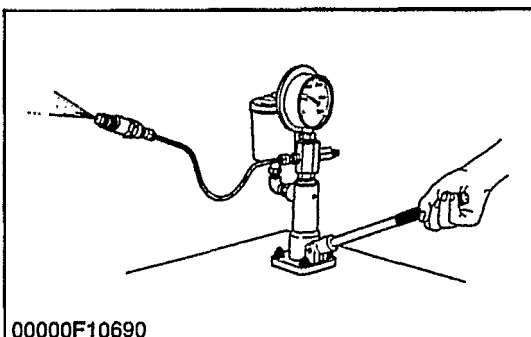
1. Remove the injection pipes and glow plugs.
2. Set a pressure tester to the fuel injection pump.
3. Turn the flywheel and raise the pressure to approx. 14.7 MPa (150 kgf/cm<sup>2</sup>, 2133 psi).
4. Now turn the flywheel back about half a turn (to keep the plunger free). Maintain the flywheel at this position and clock the time taken for the pressure to drop from 14.7 to 13.7 MPa (from 150 to 140 kgf/cm<sup>2</sup>, from 2133 to 1990 psi).
5. Measure the time needed to decrease the pressure from 14.7 to 13.7 MPa (from 150 to 140 kgf/cm<sup>2</sup>, from 2133 to 1990 psi).
6. If the measurement is less than allowable limit, replace the delivery valve.

02090S10190

**[2] INJECTION NOZZLE****⚠ CAUTION**

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

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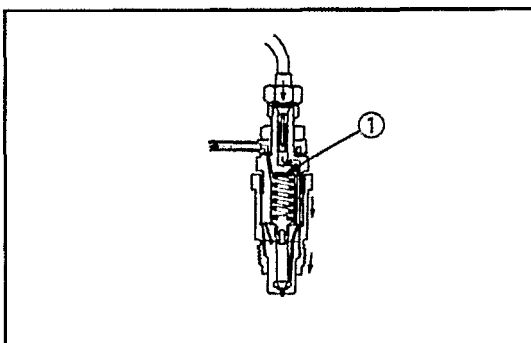
**Nozzle Injection Pressure**

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.

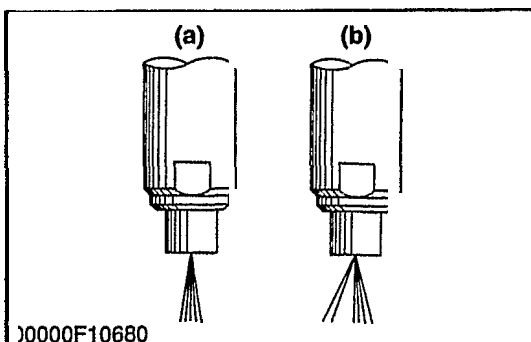
**(Reference)**

- Pressure variation with 0.025 mm (0.001 in.) difference of adjusting washer thickness.  
Approx. 59 kPa (6 kgf/cm<sup>2</sup>, 85 psi)

(1) Adjusting Washer



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**Nozzle Spraying Condition**

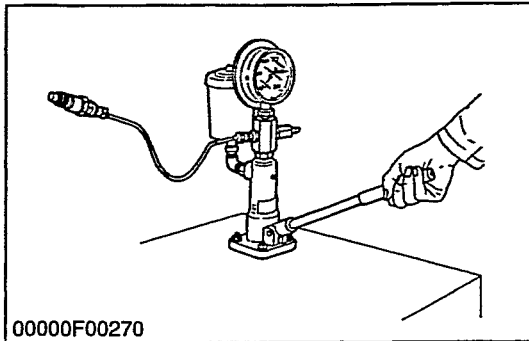
1. Set the injection nozzle to a nozzle tester (Code No. 07909-31361), and check the nozzle spraying condition.
2. If the spraying condition is defective, replace the nozzle piece.

(a) Good

(b) Bad

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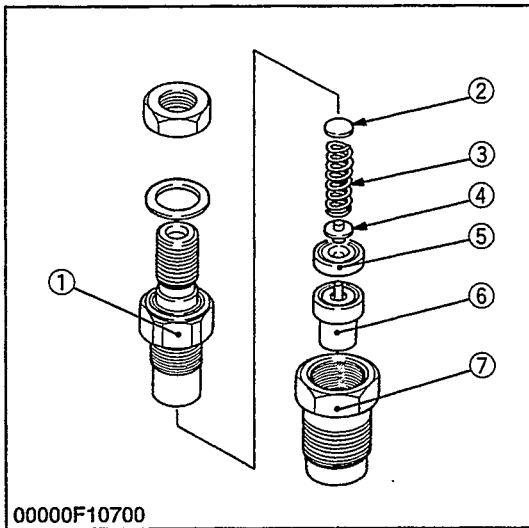
### Valve Seat Tightness

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

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## DISASSEMBLING AND ASSEMBLING

### [1] 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

00000S10531





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