TO THE READER

This Workshop Manual has been prepared to provide servicing personnel with information on the mechanism, service and maintenance of KUBOTA Diesel Engines D782-B. It is divided into two parts, "Mechanism" and "Disassembling and Servicing" for each section.

■ Mechanism

Information on the construction and function are included for each engine section. This part should be understood before proceeding with troubleshooting, disassembling and servicing.

■ Disassembling and Servicing

Under the heading "General" 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 the engines that have been manufactures since January of 1994 are clean exhaust engines.

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

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

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

September '98

© KUBOTA Corporation 1998

01760Z00010

⚠ 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.**

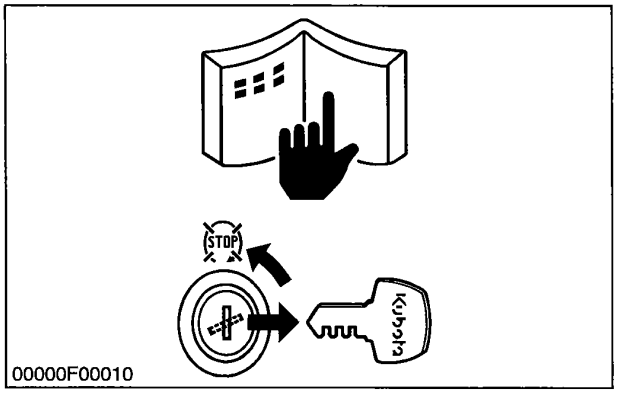
⚠ **WARNING : Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.**

⚠ **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.**

00000Z00011



00000F00010

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.

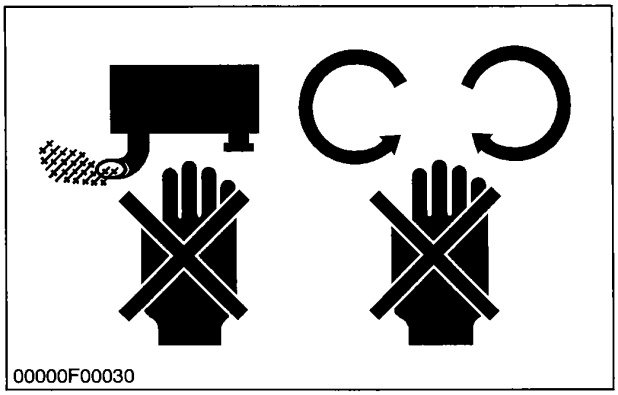
00000Z00021

00000F00021

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.

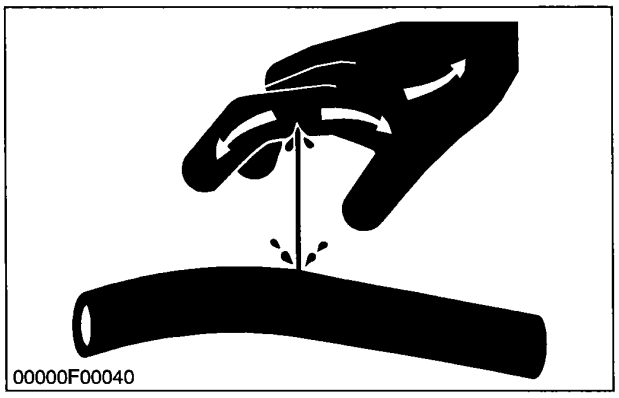
00000Z00031

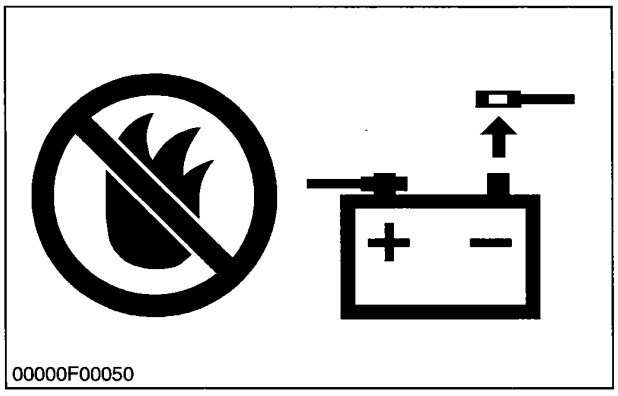

00000F00030

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.

00000Z00041

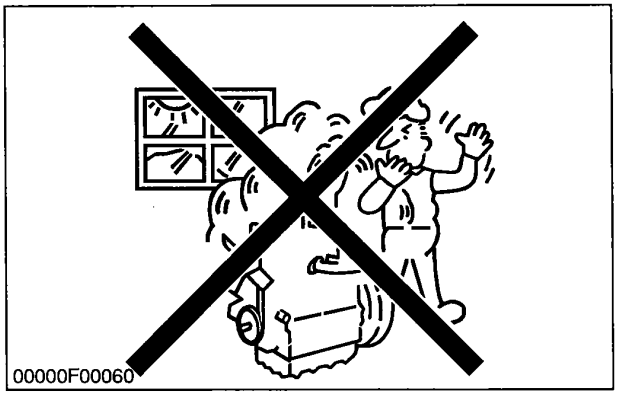

00000F00040


00000F00050

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.

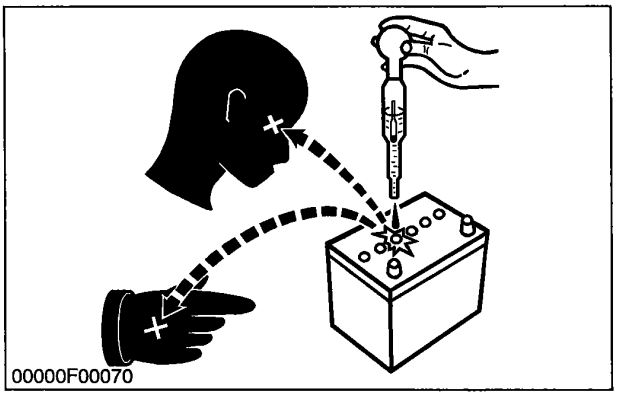
00000Z00050



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.

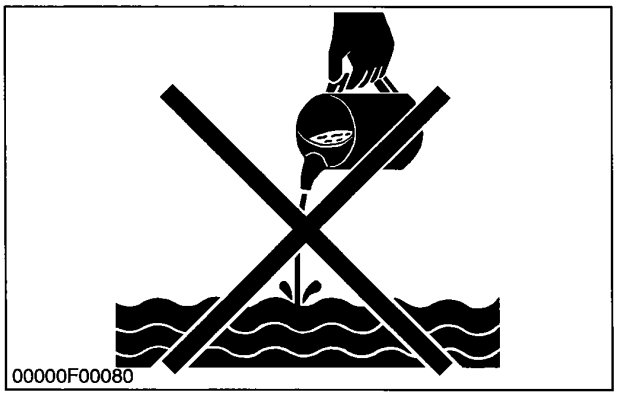
00000Z00060



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.

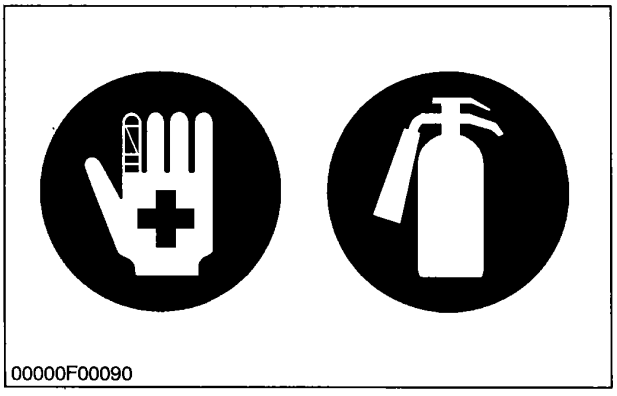
00000Z00070



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.

00000Z00080



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.

00000Z00090

SPECIFICATIONS

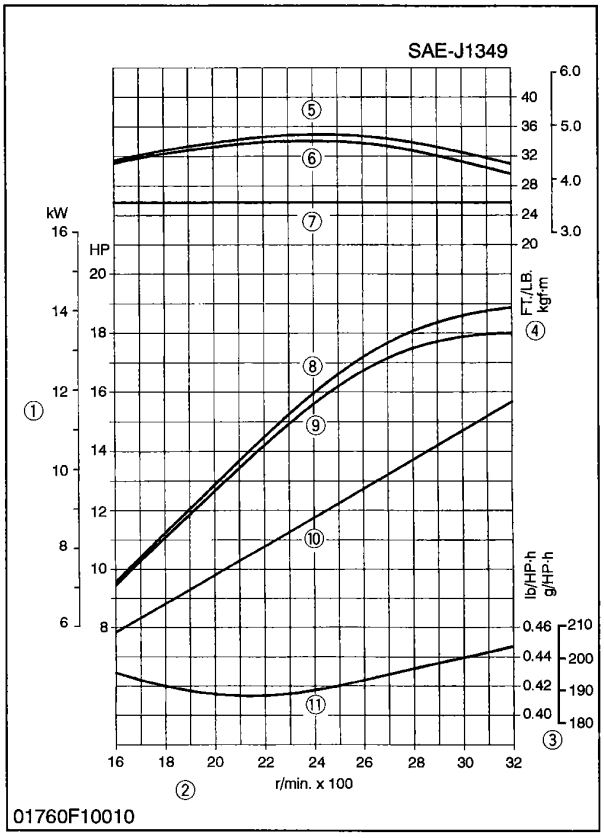
Model		D782-B
Number of cylinders		3
Type		Vertical, water-cooled, 4-cycle diesel engine
Bore × stroke		67 × 73.6 mm (2.64 × 2.90 in.)
Total displacement		778 CC (47.48 cu.in.)
Brake Horsepower	SAE net cont. H.P.	11.7 kW/3200 rpm (15.7 HP/3200 rpm)
	SAE net intermittent H.P.	13.5 kW/3200 rpm (18.1 HP/3200 rpm)
	SAE gross intermittent H.P.	14.1 kW/3200 rpm (18.9 HP/3200 rpm)
	DIN6271-NA	13.0 kW/3200 rpm (17.7 PS/3200 rpm)
	DIN6271-NB	11.7 kW/3200 rpm (15.9 PS/3200 rpm)
	DIN70020	14.0 kW/3200 rpm (19.0 PS/3200 rpm)
Maximum bare speed		3450 rpm
Minimum bare idling speed		950 to 1050 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		0.33 to 0.37 rad. (19 to 21°) before T.D.C.
Injection order		1-2-3
Injection pressure		13.73 MPa (140 kgf/cm^2, 1991 psi)
Compression ratio		23 : 1
Lubricating system		Forced lubrication by pump
Oil pressure 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, 1.0 kW
Starting support device		By glow plug in combustion chamber
Bettery		12 V, 36 AH, equivalent
Generator for charging		12 V, 150 W
Fuel		Diesel fuel No. 2-D (ASTM D975)
Lubricating oil		API service CD or CE
Lubricating oil capacity		3.1 L (3.28 U.S.qts., 2.73 Imp.qts)
Weight (Dry)		63.5 kg (139.7 lbs)
Application		General power source

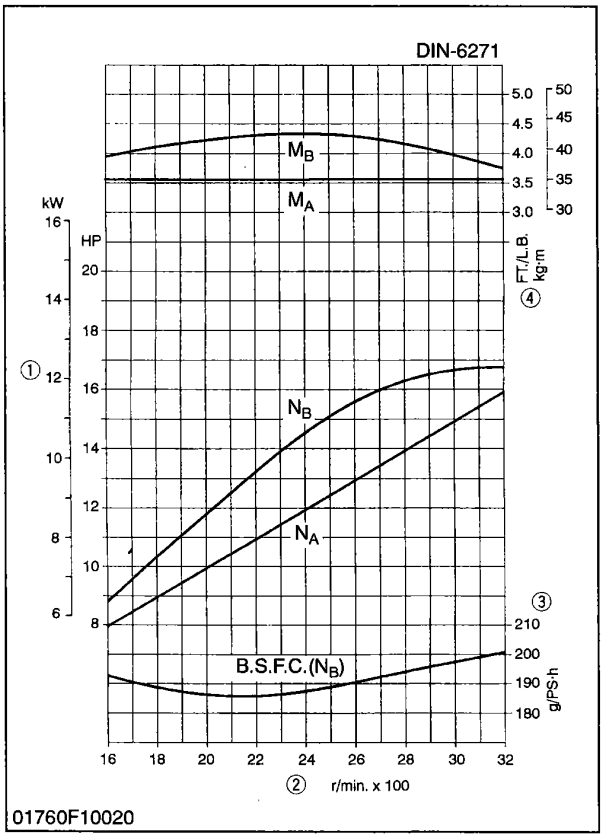
01760Z00020

PERFORMANCE CURVES

COURBES DE PERFORMANCE

LEISTUNGSKURVEN





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

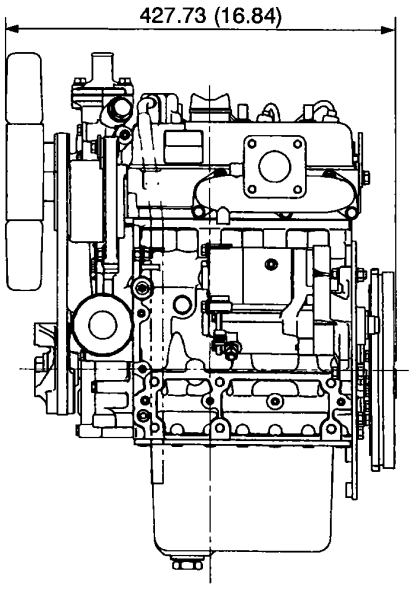
(1) Puissance an frein
(2) Vitesse de moteur
(3) B.S.F.C.
(4) Couple
(5) Couple intermittent brut
(6) Couple intermittent net
(7) Couple continu net
(8) Puissance au frein intermittent brut
(9) Puissance au frein intermittent net
(10) Puissance au frein continue net
(11) Consommation de carburant spécifique pour essai de moteur sur le banc d'essai des freins (B.S.F.C.) (intermittent net)

(1) Bremspferdekraft
(2) Motorendrehzahl
(3) B.S.F.C.
(4) Drehkrafkt
(5) Gesamtes Aussetzdrehmoment
(6) Netto Aussetzdrehmoment
(7) Netto Dauerdrehmoment
(8) Gesamte aussetzende Bremspferdekraft
(9) Netto aussetzende Bremspferdekraft
(10) Netto Dauer-Bremspferdekraft
(11) Spezifischer Treibstoffverbrauch der Bremse (B.S.F.C.) (netto aussetzend)

01760Z00030

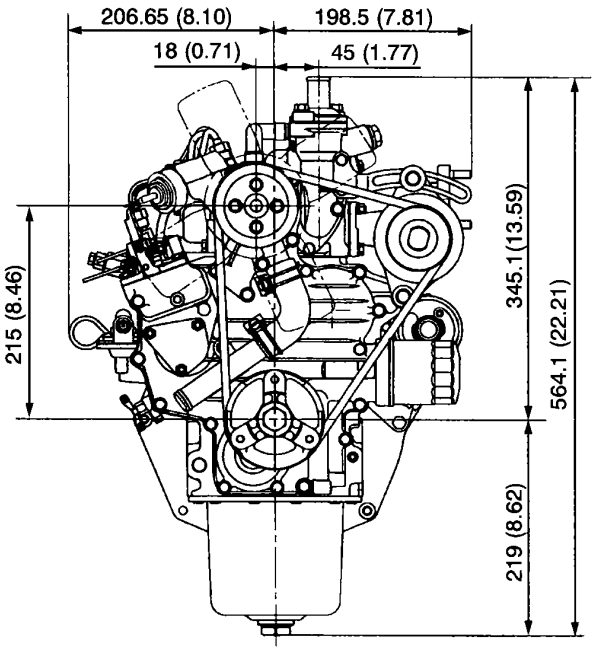
DIMENSIONS DIMENSIONS ABMESSUNGEN

Unit : mm (in.)
Unité : mm
Einheit : mm



01760F10030

Unit : mm (in.)
Unité : mm
Einheit : mm



01760F10040

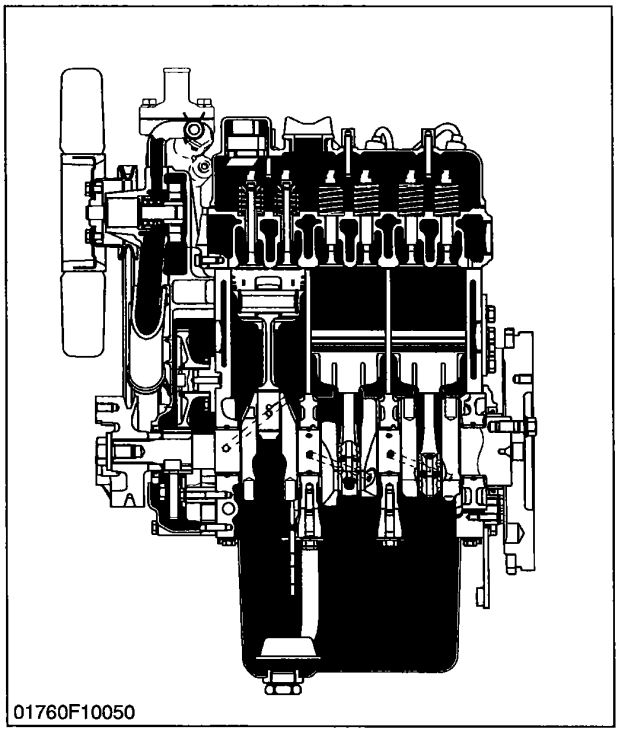
01760Z00040

MECHANISM

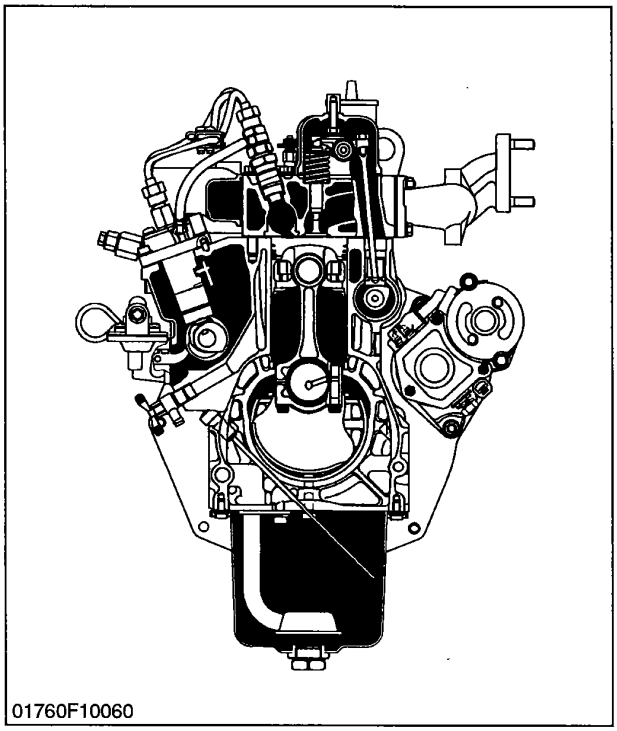
CONTENTS

F FEATURE M-1
1 ENGINE BODY M-3
[1] CYLINDER BLOCK M-3
[2] CYLINDER HEAD M-3
[3] CRANKSHAFT M-5
[4] FLYWHEEL M-5
[5] PISTON AND PISTON RINGS M-7
[6] CONNECTING ROD M-9
[7] ROCKER ARM M-9
[8] CAMSHAFT (IN. AND EXHAUST) M-9
[9] VALVE TIMING M-11
[10] FUEL CAMSHAFT M-11
2 LUBRICATING SYSTEM M-13
[1] GENERAL M-13
[2] PUMP M-15
[3] RELIEF VALVE M-15
[4] OIL FILTER CARTRIDGE M-17
[5] OIL PRESSURE SWITCH M-17
3 COOLING SYSTEM M-19
[1] GENERAL M-19
[2] WATER PUMP M-21
[3] THERMOSTAT M-21
[4] RADIATOR (not included in the basic engine) M-23
[5] RADIATOR CAP M-23
4 FUEL SYSTEM M-25
[1] GENERAL M-25
[2] FUEL FEED PUMP M-27
[3] INJECTION PUMP M-29
(1) Pump Element M-29
(2) Delivery Valve M-31
(3) Dumping Valve M-31
(4) Injection Control M-33
[4] INJECTION NOZZLE M-33
[5] FUEL FILTER (not included in the basic model) M-35
[6] GOVERNOR M-37
5 ELECTRICAL SYSTEM M-41
[1] STARTING SYSTEM M-43
(1) Starter M-43
(2) Glow Plug M-47
[2] CHARGING SYSTEM M-49
(1) Dynamo M-49
(2) Regulator M-49
(3) Charging Mechanism M-51

F FEATURE



01760F10050



01760F10060

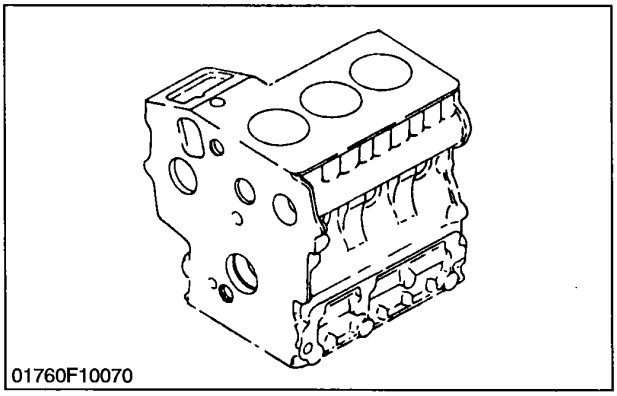
The D782-B is vertical, water-cooled, 4 cycle diesel engines.

It is incorporated KUBOTA's foremost technologies. With KUBOTA's E-TVCS (Three Vortex Combustion System), well-known Bosch MD type injection pump and the well-balanced designs, they give greater power, low fuel consumption, little vibration and quiet operation.

01760M10010

1 ENGINE BODY

[1] CYLINDER BLOCK


01760F10070

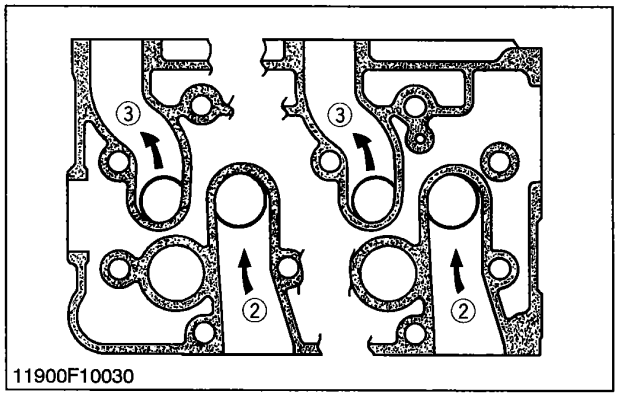
The engine has a high durability tunnel-type cylinder block in which the crank bearing component is a constructed body.

Furthermore, liner less type, allow effective cooling, less distortion, and greater wear-resistance.

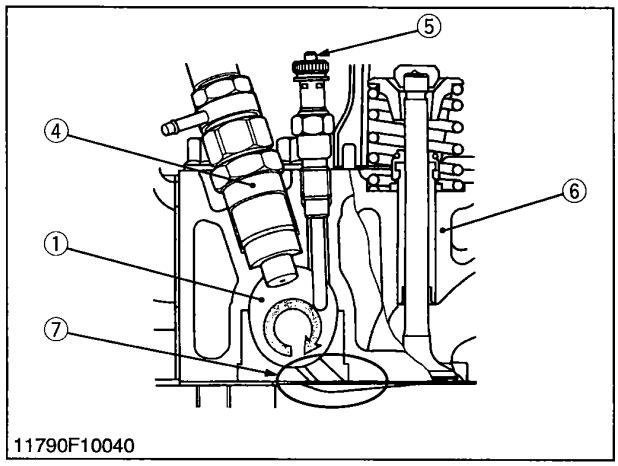
The noise level is reduced to a minimum because each cylinder has its own chamber.

01760M10020

[2] CYLINDER HEAD



11900F10030



11790F10040

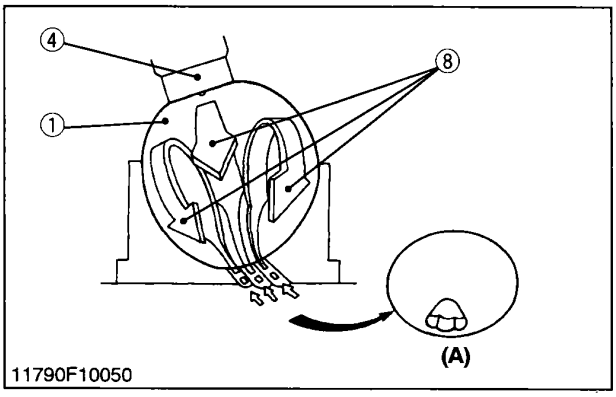
(1) Combustion Chamber
(2) Intake Port
(3) Exhaust Port
(4) Nozzle Assembly
(5) Glow Plug
(6) Cylinder Head
(7) Depression
(8) Compressed Air

(A) Connect to Combustion Chamber

The cross-flow type intake / exhaust ports in this engine have their openings at both sides of the cylinder head. Because overlaps of intake / exhaust ports are smaller than in ports of other types which have openings on one side, the suction air can be protected from being heated and expanded by heated exhaust air. The cool, high density suction air has high volume efficiency and raises the power of the engine. Furthermore, distortion of the cylinder head by heated exhaust gas is reduced because intake ports are arranged alternately.

The combustion chamber is of KUBOTA's exclusive E-TVCS combustion chamber type. Suction air is whirled to be mixed effectively with fuel, prompting combustion and reducing fuel consumption.

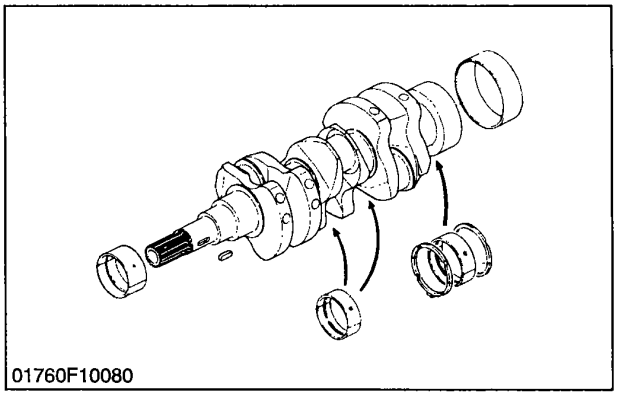
In the combustion chamber are installed throttle type injection nozzle and rapid heating sheathed type glow plug. This glow plug assures easier than ever engine starts even at −15 °C (5 °F).



11790F10050

11900M10031

[3] CRANKSHAFT


01760F10080

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

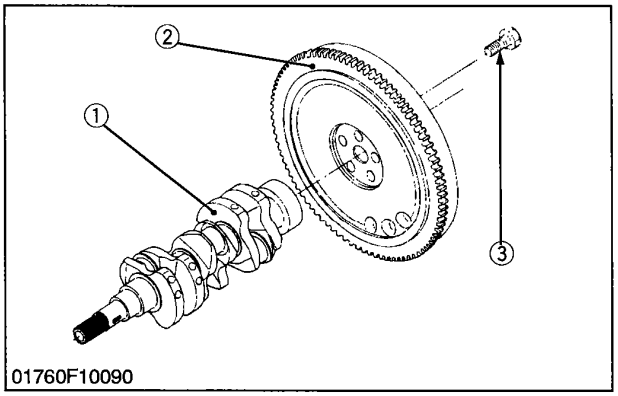
The crankshaft is made of tough special alloy steel, and the journals, pins and oil seal sliding portions are induction hardened to increase the hardness for higher wear resistance.

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

The crankshaft is provided with an oil gallery, through which engine oil is fed to the crankpin portion, and lubricates it.

01760M10030

[4] FLYWHEEL



01760F10090

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

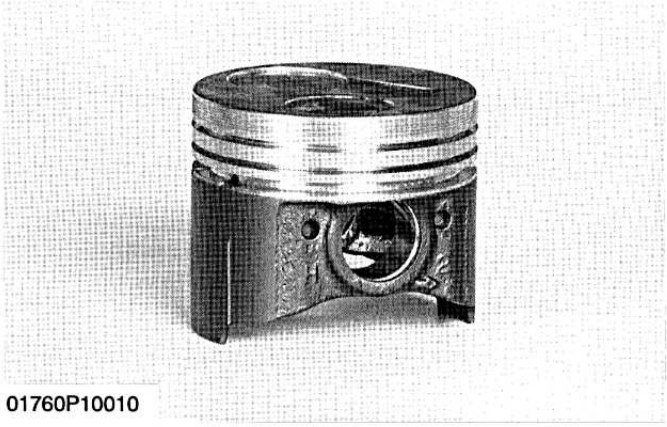
The flywheel periphery is inscribed with the marks showing fuel injection timing angle lines and top dead center mark **TC**.

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

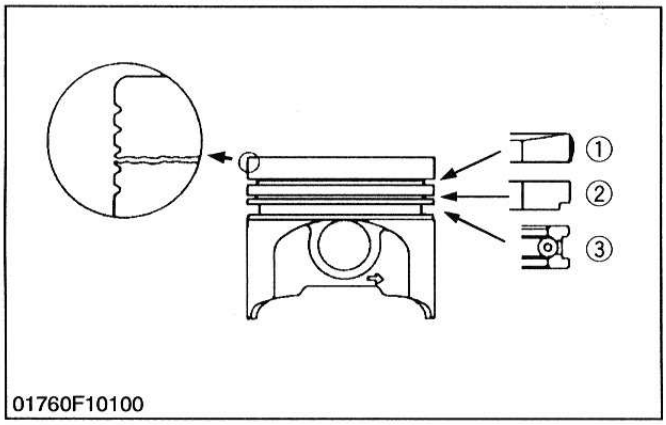
(1) Crankshaft
(2) Flywheel
(3) Flywheel Screw

01760M10040

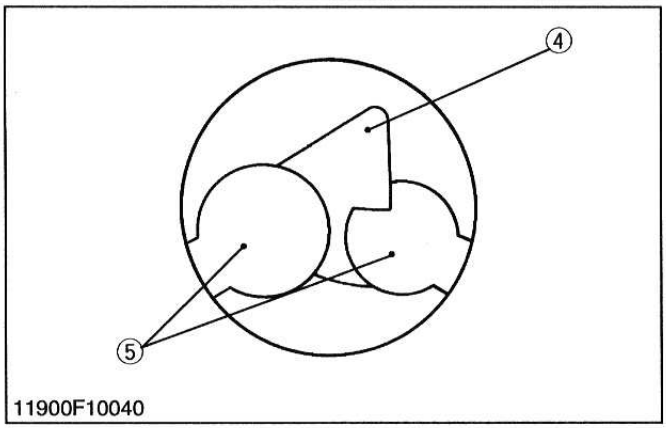
[5] PISTON AND PISTON RINGS



01760P10010



01760F10100



11900F10040

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

The piston has been resin-coated. This coating helps reduce the friction loss and improve the scuff resistance. The clearance between the piston and the cylinder liner can also be minimized to keep down the slapping noise of the piston.

Three rings are installed in grooves in the piston.

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

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

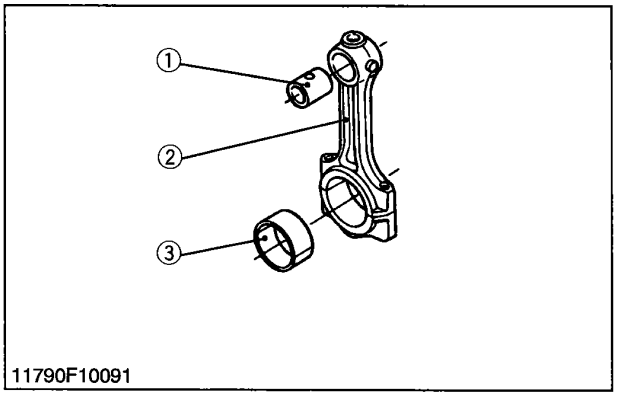
The oil ring (3) has chamfered contact faces and an expander ring, which increase the pressure of the oil ring against the cylinder wall.

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

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

01760M10050

[6] CONNECTING ROD



11790F10091

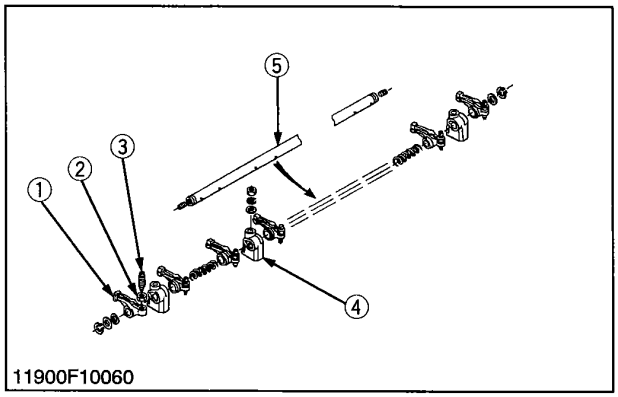
The connecting rod (2) is used to connect the piston with the crankshaft.

The big end of the connecting rod has a crankpin bearing (3) (split type) and the small end has a small end bushing (1) (solid type).

(1) Small End Bushing
(2) Connecting Rod
(3) Crankpin Bearing

11790M10061

[7] ROCKER ARM



11900F10060

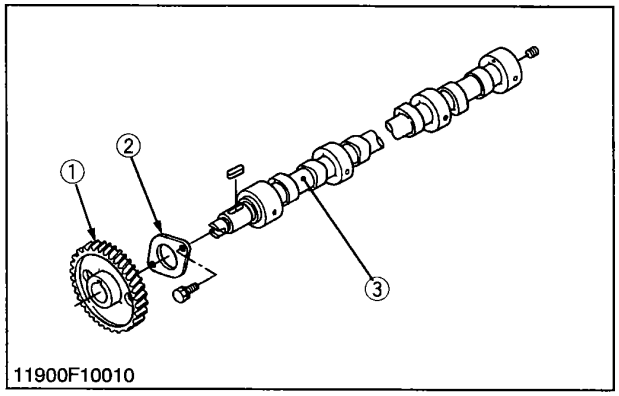
The rocker arm assembly includes the rocker arms (1), rocker arm brackets (4) and rocker arm shaft (5), and converts the reciprocating movement of the push rods to an open / close movement of the intake and exhaust valves.

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

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

11900M10070

[8] CAMSHAFT (IN. AND EXHAUST)



11900F10010

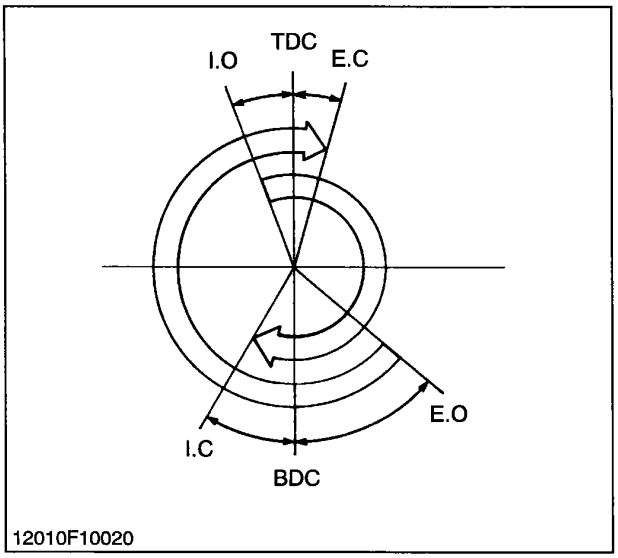
The camshaft (3) is made of special cast iron, and the journal and cam sections are chilled to resist wear.

The journal sections are force-lubricated.

(1) Cam Gear
(2) Camshaft Stopper
(3) Camshaft

11900M10050

[9] VALVE TIMING



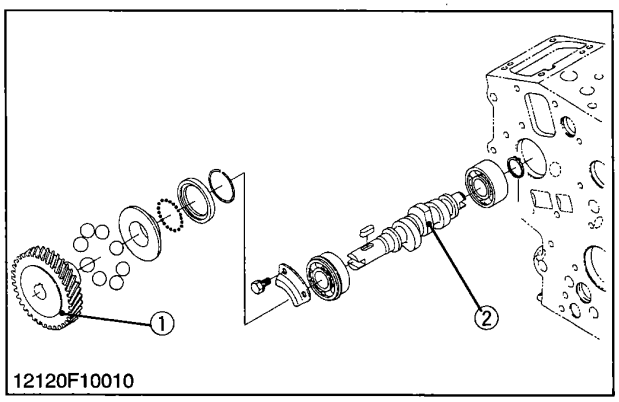
12010F10020

The valve opening and closing timing is extremely important for effectively intaking air into the cylinder and sufficiently exhaust gas. An appropriate timing can be obtained by aligning the alignment marks on the crank gear and cam gear.

Inlet valve open (I.O)	0.35 rad. (20°) before T.D.C.
Inlet valve close (I.C)	0.79 rad. (45°) after B.D.C.
Exhaust valve open (E.O)	0.89 rad. (50°) Before B.D.C.
Exhaust valve close (E.C)	0.26 rad. (15°) after T.D.C.

12120M10030

[10] FUEL CAMSHAFT



12120F10010

The fuel camshaft (2) controls the reciprocating movement of the injection pump.

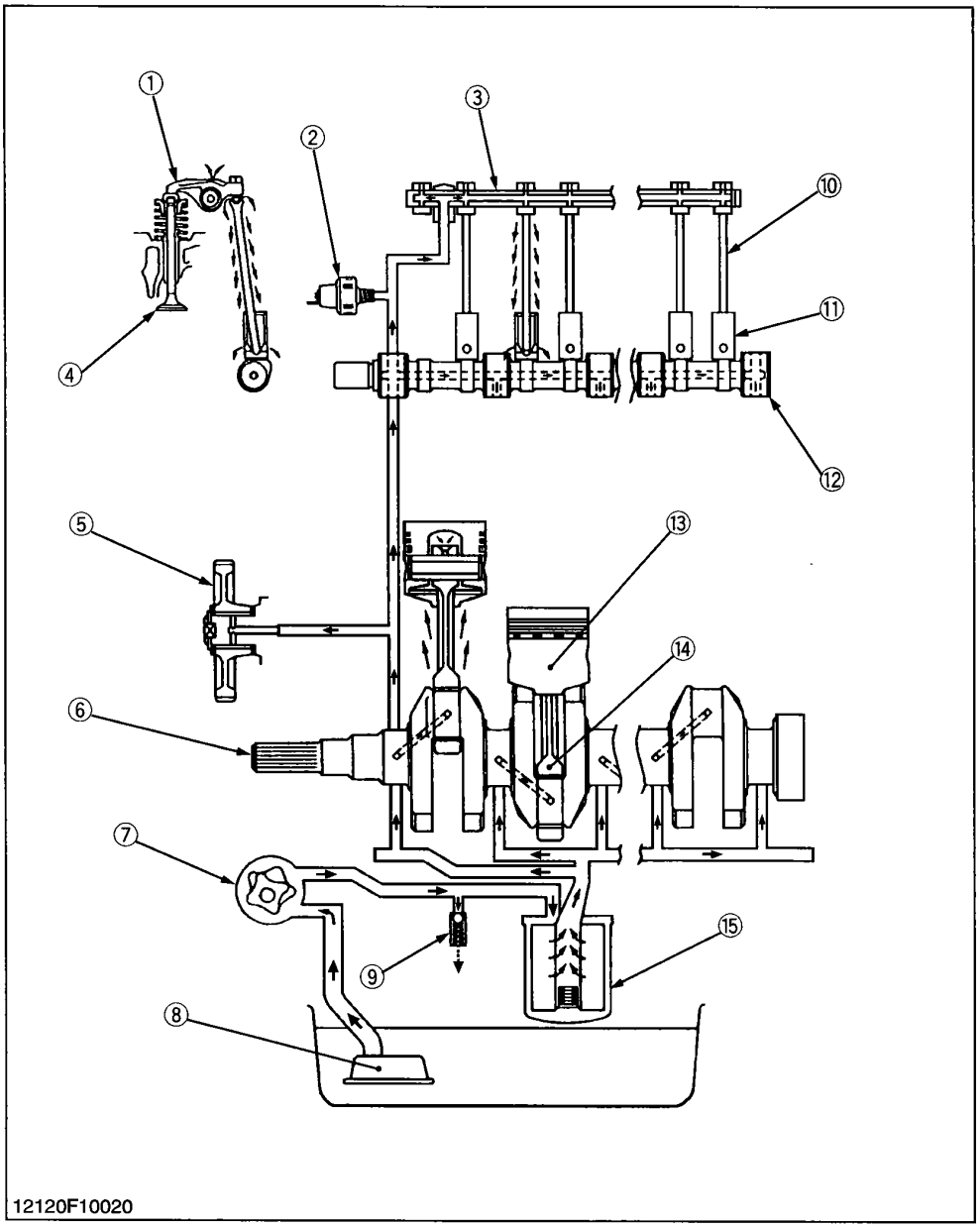
The fuel camshaft is made of carbon steel and the cam sections are quenched and tempered to provide greater wear resistance.

(1) Injection Pump Gear (2) Fuel Camshaft

12120M10020

2 LUBRICATING SYSTEM

[1] GENERAL



(1) Rocker Arm
(2) Oil Pressure Switch
(3) Rocker Arm Shaft
(4) Valve
(5) Idle Gear
(6) Crankshaft
(7) Oil Pump
(8) Oil Strainer
(9) Relief Valve
(10) Push Rod
(11) Tappet
(12) Camshaft
(13) Piston
(14) Connecting Rod
(15) Oil Filter Cartridge

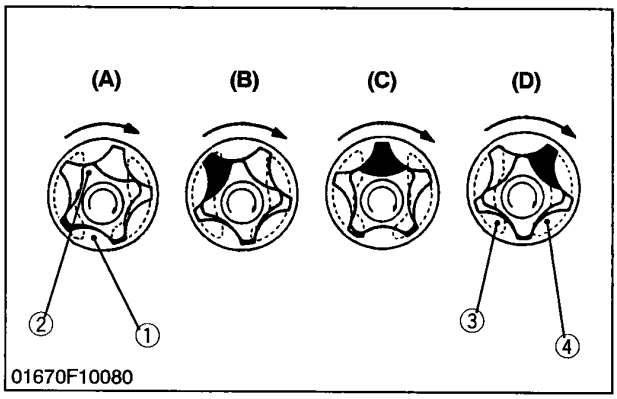
This engine's lubricating system consists of oil strainer (8), oil pump (7), relief valve (9), oil filter cartridge (15) and oil pressure switch (2).

The oil pump sucks lubricating oil from the oil pan through the oil strainer and the oil flows down to the filter cartridge, where it is further filtered. Then the oil is forced to crankshaft (6), connecting rods (14), idle gear (5), camshaft (12) and rocker arm shaft (3) to lubricate each part.

Some part of oil, splashed by the crankshaft or leaking and dropping from gaps of each part, lubricates these parts : pistons (13), cylinders, small ends of connecting rods, tappets (11), push rods (10), inlet and exhaust valves (4) and timing gears.

12120M10040

[2] OIL PUMP



01670F10080

The oil pump in this engine is a trochoid pump.

Inside the pump body, the 4 lobe inner rotor (2) is eccentrically engaged with the 5 lobe outer rotor (1). The inner rotor is driven by the crankshaft, which in turn rotate the outer rotor.

When the inner rotor rotates, the outer rotor also rotates in the same direction. The two rotors have differences in lobe number and center, which generates space between lobes as shown in the figure.

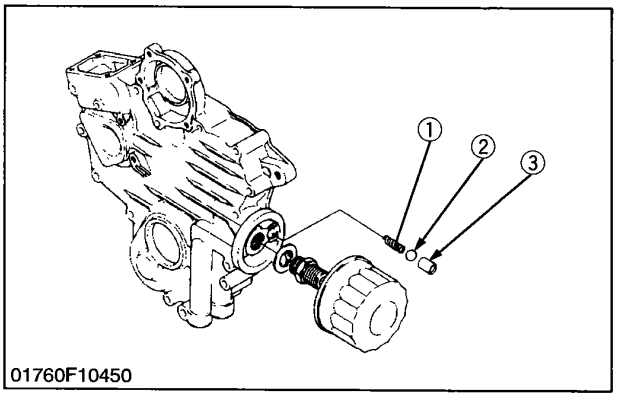
At position **(A)**, there is little space between lobes in the inlet port. As the rotor rotates towards position **(B)**, the space between the lobes becomes larger, creating a negative pressure which sucks in oil.

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

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

01760M10060

[3] RELIEF VALVE



01760F10450

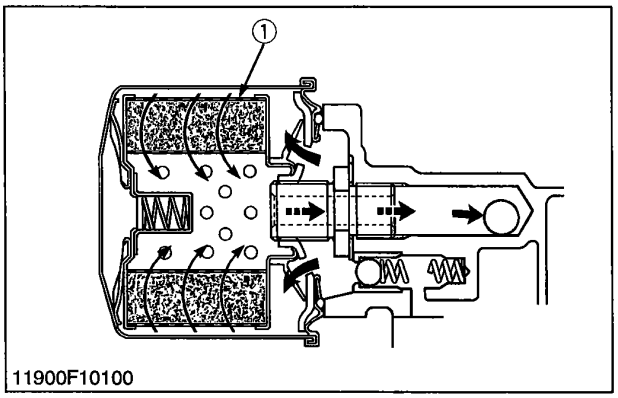
The relief valve prevents the damage of the lubricating system due to high oil pressure. This relief valve is a ball type direct acting relief valve, and is best suited for low pressures.

When oil pressure exceeds the upper limit, the ball (2) is pushed back by the pressure oil and the oil escapes.

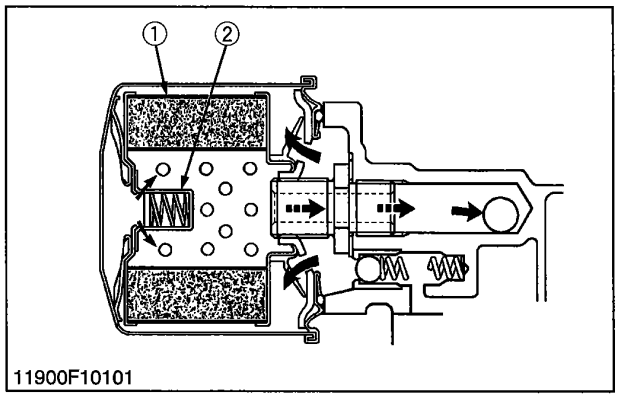
(1) Spring
(2) Steel Ball
(3) Valve Seat

01760M10280

[4] OIL FILTER CARTRIDGE



11900F10100



11900F10101

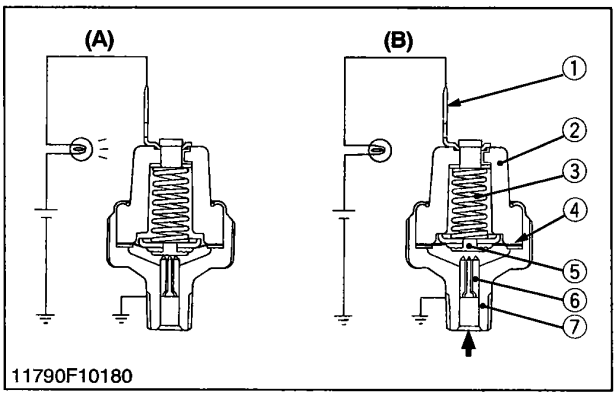
Impurities in engine oil can cause to wear and seize components as well as impairing the physical and chemical properties of the oil itself. Impurities contained in force-fed engine oil are absorbed on the filter paper for removal as they pass through the filter element (1).

When the filter element is clogged and the oil pressure in inlet line builds up by 98 kPa (1.0 kgf/cm^2, 14 psi) more than the outlet line, the bypass valve (2) opens and the oil flows from inlet to outlet bypassing the filter element.

(1) Filter Element
(2) Bypass Valve

11900M10120

[5] OIL PRESSURE SWITCH



11790F10180

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

If the oil pressure falls below 49 kPa (0.5 kgf/cm^2, 7 psi), the oil warning lamp will light up, warning the operator. In this case, stop the engine immediately and check the cause of pressure drop.

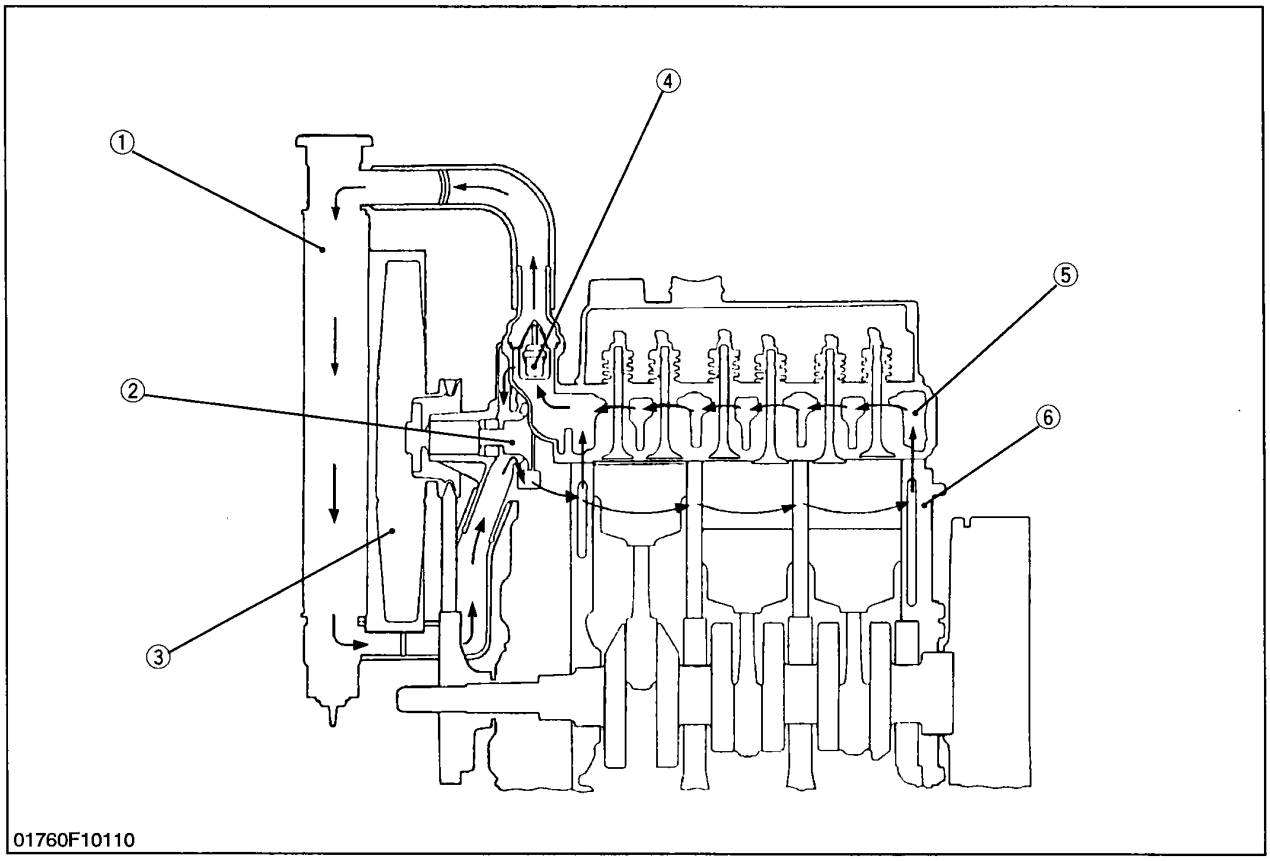
(1) Terminal
(2) Insulator
(3) Spring
(4) Rubber Gasket
(5) Contact Rivet
(6) Contact
(7) Oil Switch Body

(A) At Oil Pressures of 49 kPa (0.5 kgf/cm^2, 7 psi) or Less
(B) At Proper Oil Pressure

11790M10152

3 COOLING SYSTEM

[1] GENERAL



01760F10110

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

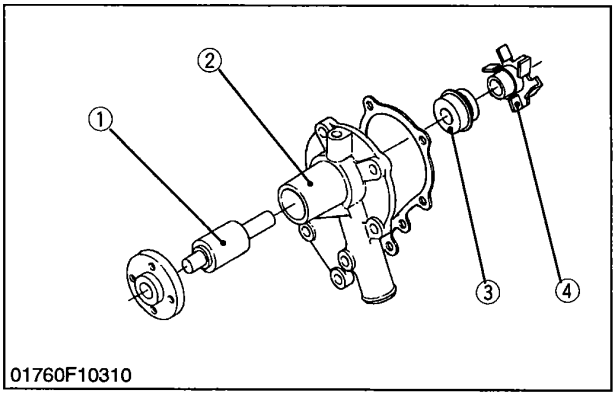
The cooling system consists of a radiator (1) (not included in the basic engine), centrifugal water pump (2), suction fan (3) and thermostat (4).

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

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

01760M10070

[2] WATER PUMP

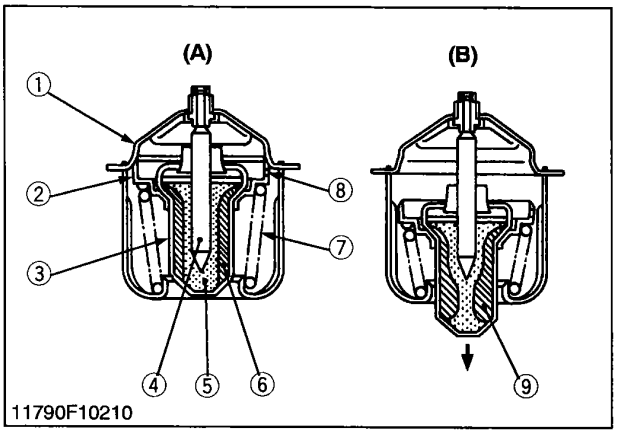


The water pump is driven by the crankshaft via a V belt. Water cooled in the radiator is sucked into the water pump from its lower portion and is sent from the center of the water pump impeller (4) radially outward into the water jacket in the crankcase.

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

01760M10080

[3] THERMOSTAT



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

(A) At low temperature (lower than 71 °C, 160 °F)

As the thermostat is closed, cooling water circulates in the engine through the water return pipe without running to the radiator.

Air in the water jacket escapes to the radiator side through leak hole (8) of the thermostat.

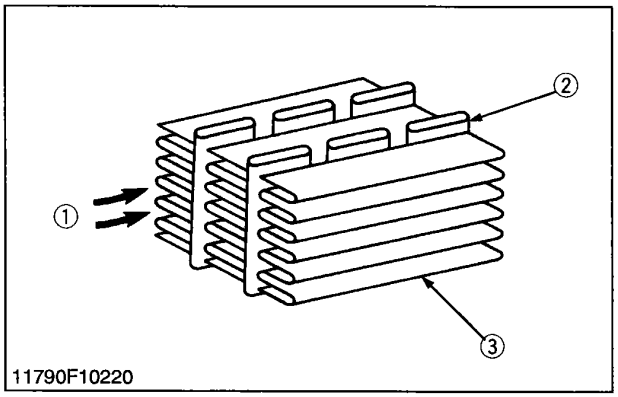
(B) At high temperature (higher than 71 °C, 160 °F)

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

(1) Seat
(2) Valve
(3) Pellet
(4) Spindle
(5) Synthetic Rubber
(6) Wax (Solid)
(7) Spring
(8) Leak Hole
(9) Wax (Liquid)

11790M10182

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



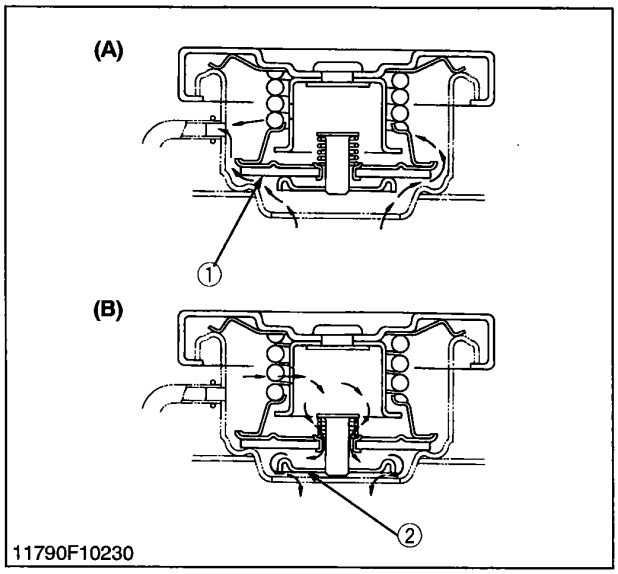
11790F10220

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

(1) Cooling Air
(2) Tube
(3) Fin

11790M10191

[5] RADIATOR CAP



11790F10230

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

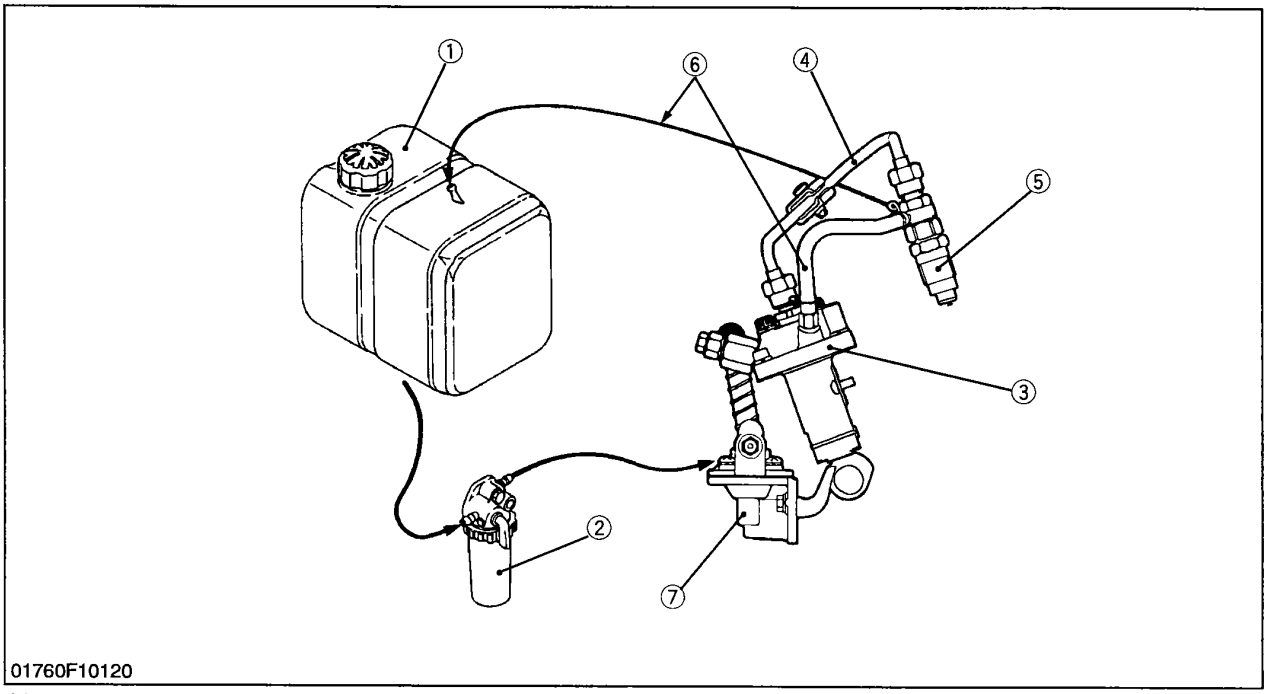
Cooling water is pressurized by thermal expansion of steam, and as its boiling temperature rises, generation of air bubbles will be suppressed. (Air bubbles in cooling water lowers the cooling effect.)

(1) Pressure Valve
(2) Vacuum Valve
(A) When radiator internal pressure is high
(B) When radiator internal pressure is negative

11790M10201

4 FUEL SYSTEM

[1] GENERAL



01760F10120

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

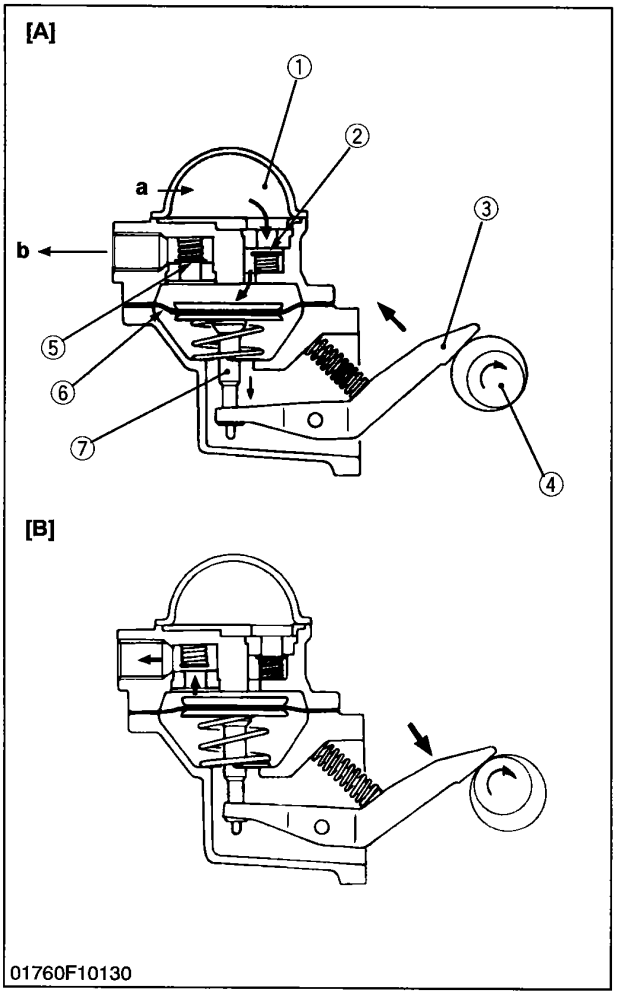
Fuel from the fuel tank (1) passes through the fuel filter (2), and then enters the injection pump (3) after impurties such as dirt, water, etc. are removed.

The fuel pressurized by the injection pump to the opening pressure (13.73 to 14.71 MPa, 140 to 150 kgf/cm^2, 1991 to 2133 psi), of the injection nozzle (5) is injected into the combustion chamber.

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

01760M10090

[2] FUEL FEED PUMP



01760F10130

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

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

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

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

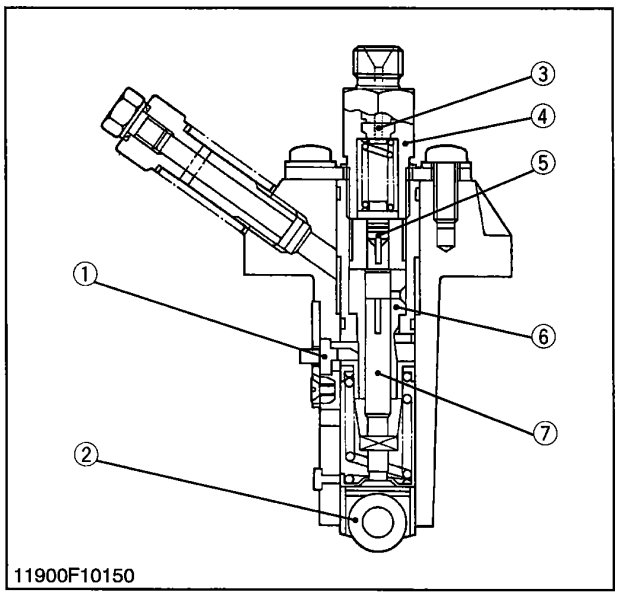
(1) Chamber
(2) Inlet Valve
(3) Rocker Arm
(4) Fuel Camshaft
(5) Outlet Valve
(6) Diaphragm
(7) Pull Rod

(a) From Fuel Filter
(b) To Injection Pump

(A) Inlet Stroke
(B) Discharge Stroke

01760M10100

[3] INJECTION PUMP



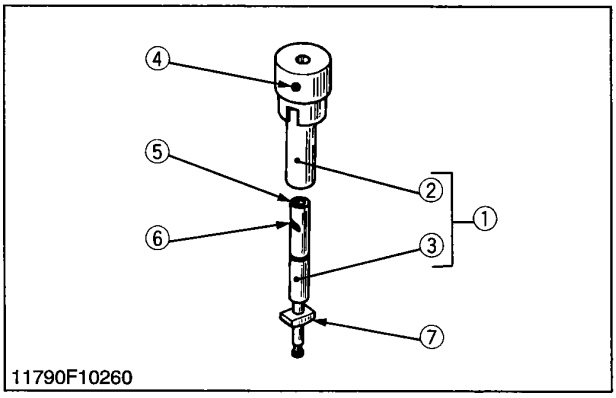
A Bosch MD type mini pump is used for the injection pump. It is small, lightweight and easy to handle.

The plunger (7) with a left-hand lead reciprocates via the tappet roller (2) by means of the fuel camshaft, causing the fuel to be delivered into the injection nozzle.

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

11900M10170

(1) Pump Element



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

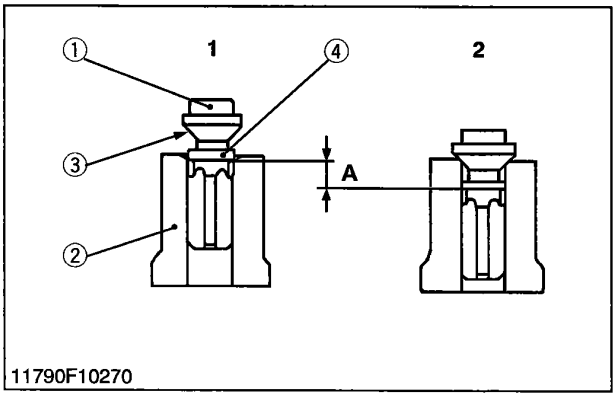
The sliding surfaces are super-precision machined to maintain injection pressure at engine low speeds. Since the driving face (7) fits in the control sleeve, the plunger (3) is rotated by the movement of the control rack to increase or decrease of fuel delivery.

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

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

11790M10231

(2) Delivery Valve



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

The delivery valve performs the following functions.

1. Reverse flow preventing function

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

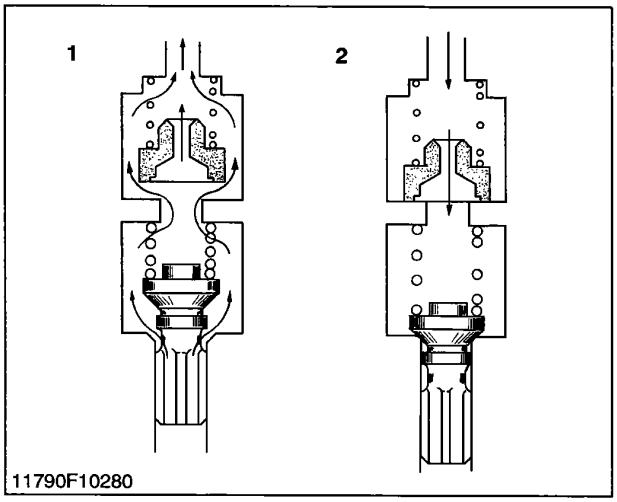
2. Suck-back function

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

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

11790M10241

(3) Dumping Valve



1. At fuel injection

Since dumping valve is pushed up to press the spring, fuel is pressure-fed to injection nozzle the same as without dumping valve.

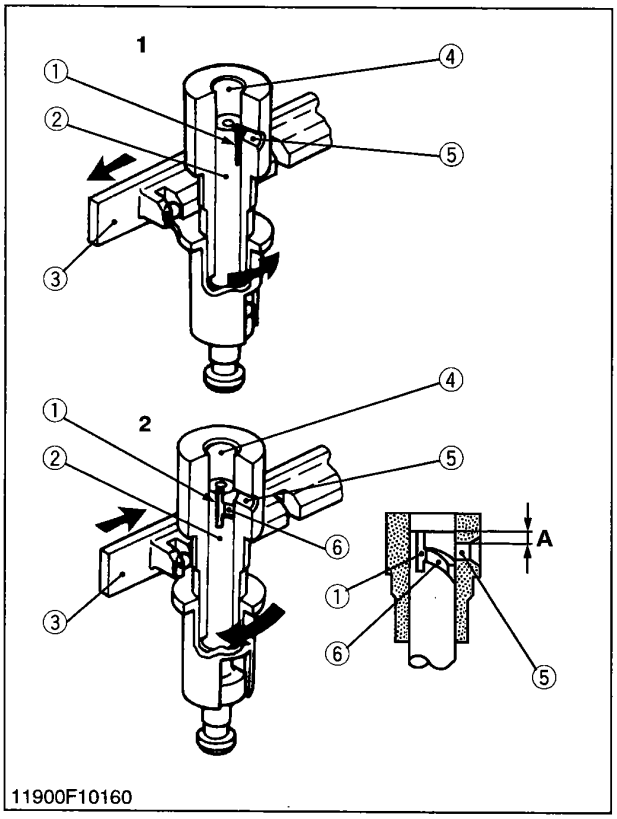
2. At suck-back

At suck-back by delivery valve after fuel injection fuel returns through dumping valve orifice. Generally second injection is apt to occur by reflex pressure due to reaction of sudden pressure drop when changing into suck-back by delivery valve from high injection pressure.

As a result of preventing this second injection perfectly by dumping valve and dissolving nozzle clogging, durability of injection nozzle is improved.

11790M10251

(4) Injection Control



11900F10160

1. No fuel delivery

At the engine stop position of the control rack (3), the lengthwise slot (1) on the plunger (2) aligns with the feed hole (5). And the delivery chamber (4) is led to the feed hole during the entire stroke of the plunger.

The pressure in the delivery chamber does not build up and no fuel can be forced to the injection nozzle.

2. Fuel delivery

The plunger (2) is rotated (see figure) by the control rack (3).

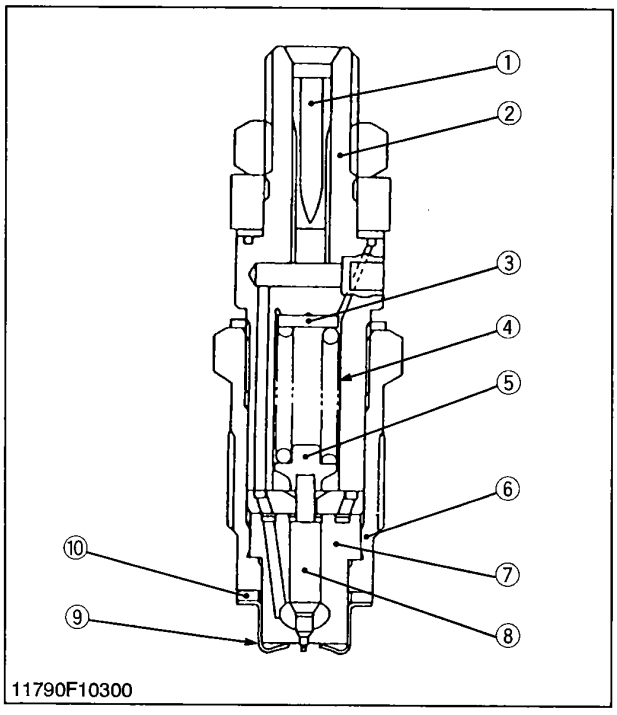
When the plunger is pushed up, the feed hole (5) is closed. The pressure in the delivery chamber (4) builds up and forcefeeds the fuel to the injection nozzle until the control groove (6) meets the feed hole (5).

The amount of the fuel corresponds to the distance "**A**".

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

11900M10181

[4] INJECTION NOZZLE



11790F10300

This nozzle is throttle-type. The needle valve (8) is pushed against the nozzle body (7) by the nozzle spring via the push rod (5). Fuel pressurized by the injection pump pushes the needle valve up and then is injected into the sub-combustion chamber.

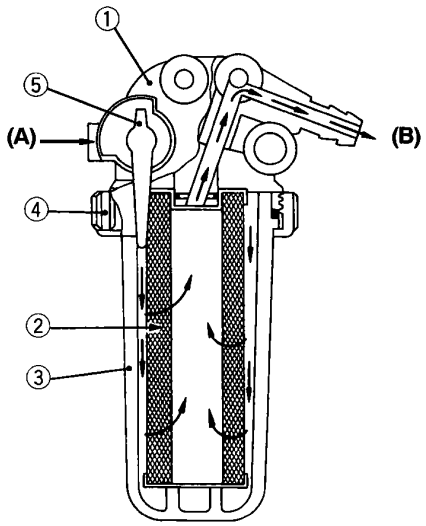
Excessive flow passes from nozzle holder center through the eye joint and the fuel overflow pipe to the fuel tank.

The injection pressure is 13.73 to 14.71 MPa (140 to 150 kgf/cm^2, 1991 to 2133 psi), and is adjusted with adjusting washers (3).

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

11790M10272

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



01640F10120

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

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

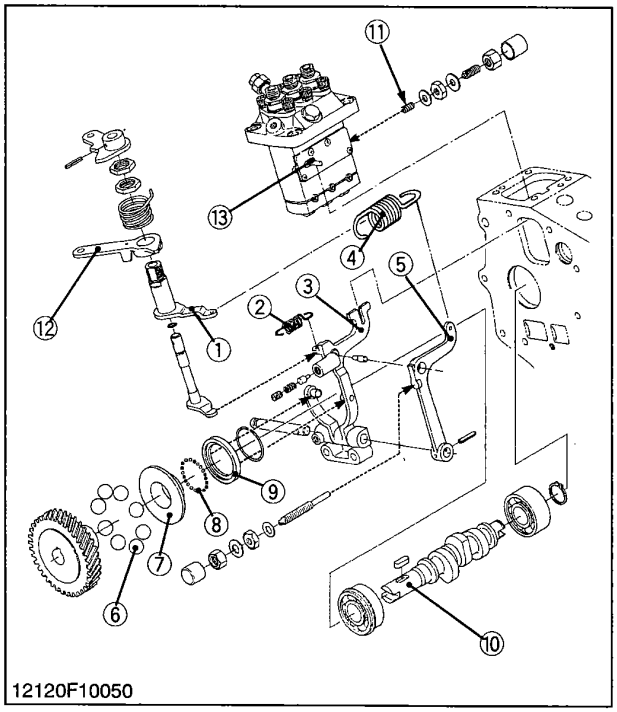
Air vent plug is fitted to the cock body. Before starting or after disassembling and reassembling, loosen this plug and bleed the air in the fuel system.

(1) Cock Body
(2) Filter Element
(3) Filter Cup
(4) Retaining Ring
(5) Fuel Cock

(A) Inlet
(B) Outlet

01640M10030

[6] GOVERNOR



12120F10050

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

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

■ At start

The steel ball (6) has no centrifugal force.

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

■ At idling

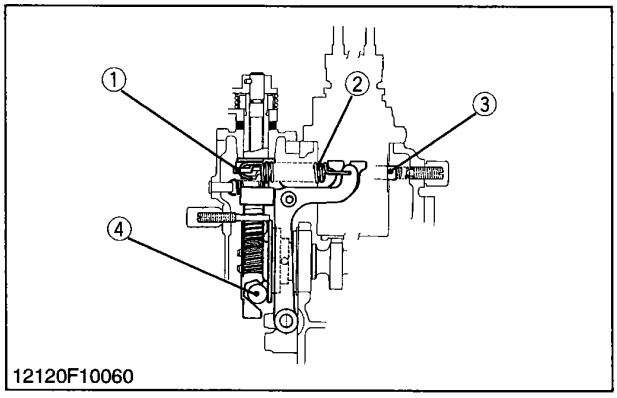
When the speed control lever (12) is set at the idling position, the governor spring (4) is pulled slightly.

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

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

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

12120M10080



12120F10060

■ At medium or high speed running

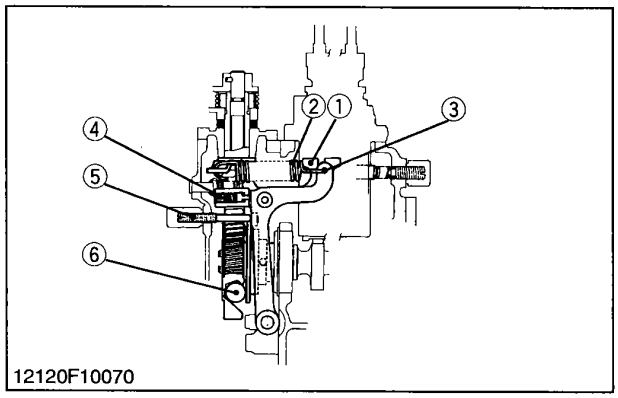
When the speed control lever (1) is turned further, the governor spring (2) increases the tension and the control rod (3) is pulled to increase the engine speed.

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

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

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

12120M10090



12120F10070

■ At maximum speed running with an overload

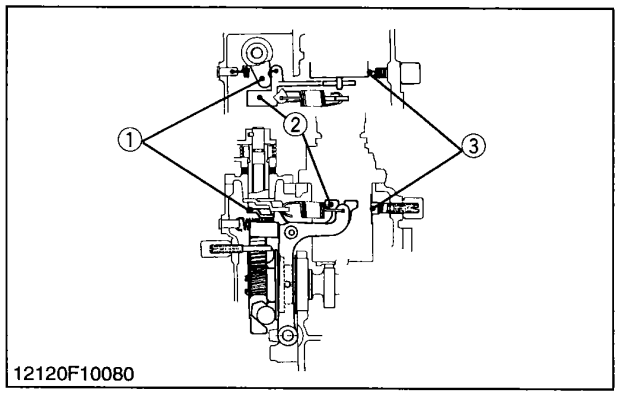
When the engine is overloaded at the high speeds and the engine speed drops, the centrifugal force of the steel ball (6) decreases and the governor spring (2) pulls fork lever 1 (1) and 2 (3).

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

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

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

12120M10100



12120F10080

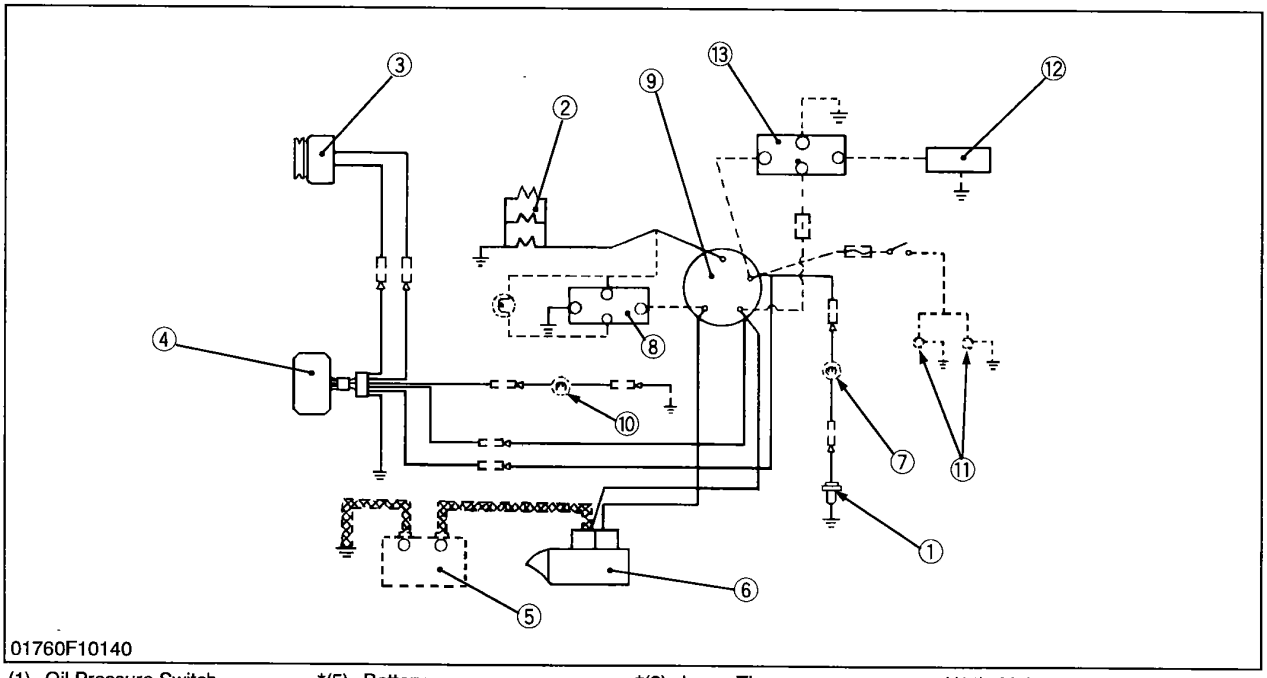
■ To stop the engine

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

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

12120M10110

5 ELECTRICAL SYSTEM



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

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

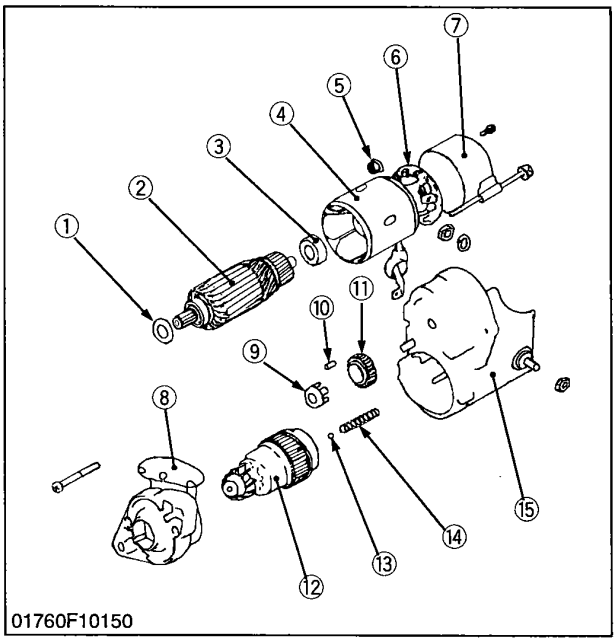
■ **NOTE**

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

01760M10110

[1] STARTING SYSTEM

(1) Starter



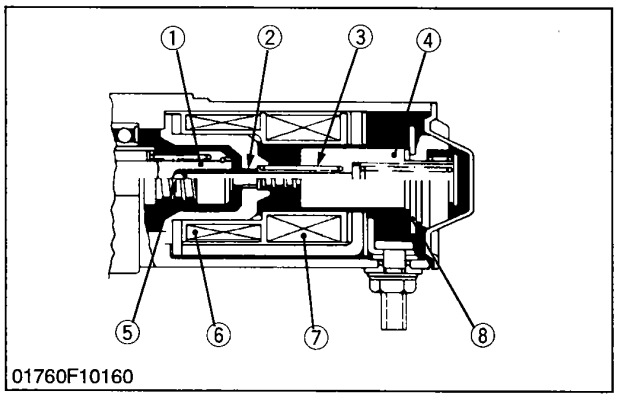
The starter for this engine is of the reduction type that has a small, high-speed motor.

The speed of the pinion gear is reduced to approx. one third of motor one.

Type of motor	DC, Series-wound reduction type
Nominal voltage	12 V
Nominal output	1.0 kW
Timer rating	30 seconds (Do not rotate continuously for longer peroids)
Direction of rotation	Clockwise viewed from the pinion side
Number of pinion teeth	9

(1) Felt Washer
(2) Armature
(3) Ball Bearing
(4) Yoke
(5) Brush Spring
(6) Brush Holder
(7) End Frame
(8) Housing
(9) Retainer
(10) Roller
(11) Idle Gear
(12) Overrunning Clutch
(13) Steel Ball
(14) Return Spring
(15) Solenoid Switch

01760M10120

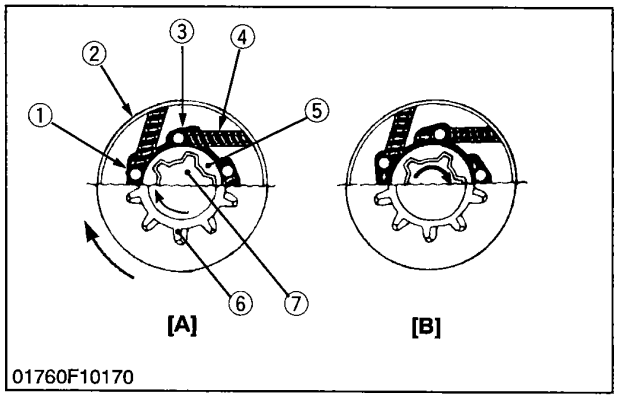


1) Solenoid Switch

The plunger (4), contact plate (8) and plunger shaft (2) are made as one unit. When the key switch is turned to **"START"** position, the plunger is drawn in and thus clutch pinion shaft (1) is forced out. This meshes the pinion gear and the ring gear, and causes the contact plate to close the contacts, causing the main current to flow into the armature. When releasing the key switch, the plunger is returned to its former position by a return spring (3).

(1) Clutch Pinion Shaft
(2) Plunger Shaft
(3) Return Spring
(4) Plunger
(5) Steel Ball
(6) Holding Coil
(7) Pull-in Coil
(8) Contact Plate

01760M10130



01760F10170

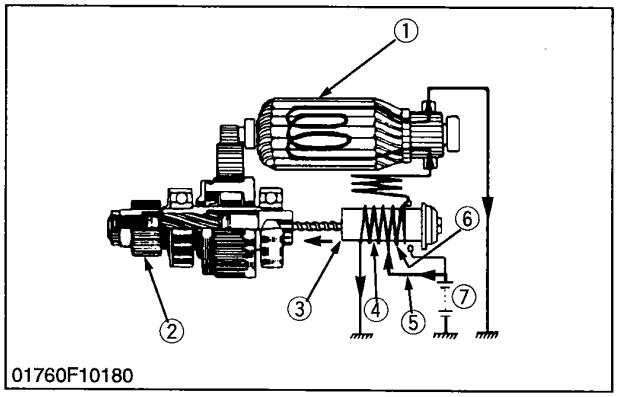
2) Overrunning Clutch

The overrunning clutch is so constructed that the power transmission relationship is automatically severed when the clutch pinion shaft (7) speed exceeds the clutch gear outer (2) speed at increased engine speeds. Therefore, the armature drives the ring gear and is never driven by the engine.

(1) Locked Position
(2) Clutch Gear Outer
(3) Roller
(4) Roller Spring
(5) Spline Tube Inner
(6) Pinion Gear
(7) Clutch Pinion Shaft

(A) When power is transmitted
(B) Idling rotation with clutch pinion shaft speed exceed that of clutch gear outer

01760M10140


01760F10180

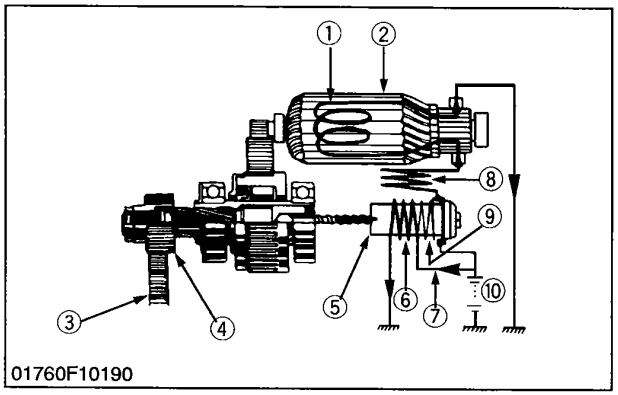
3) Operation of Starter

When Key Switch is Turned to "START" Position

With the key switch (5) in the **"START"** position, current flows from the battery (7) to the holding coil (4), which moves the plunger (3) electromagnetically and pushes out the pinion gear (2). At the same time, current flowing through the pull-in coil (6) rotates the armature (1) at low speed.

(1) Armature
(2) Pinion Gear
(3) Plunger
(4) Holding Coil
(5) Key Switch
(6) Pull-in Coil
(7) Battery

01760M10150

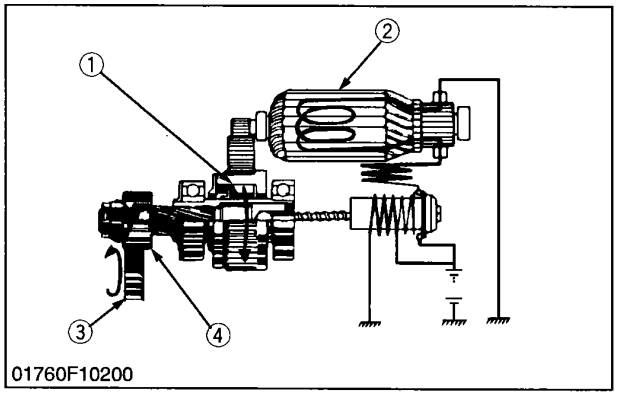

01760F10190

■ When Pinion Gear Meshes with Ring Gear

When the pinion gear (4) meshes with the ring gear (3) on the flywheel, current flows from the battery (10) directly into the field coil (8) and armature coil (1), but not through the pull-in coil (9). This rotates the armature (2) at a high speed, which in turn drives the ring gear through the pinion gear at 200 to 300 rpm.

(1) Armature Coil
(2) Armature
(3) Ring Gear
(4) Pinion Gear
(5) Plunger
(6) Holding Coil
(7) Key Switch
(8) Field Coil
(9) Pull-in Coil
(10) Battery

01760M10160



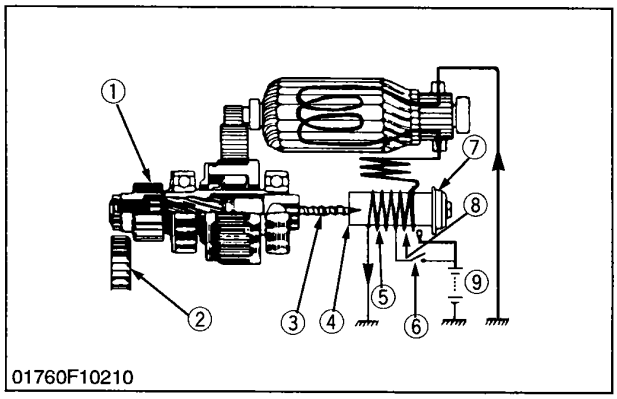
01760F10200

■ When Engine is Running

When the engine starts and drives the pinion gear (4) with the ring gear (3), the roller clutch (1) disengages to prevent an armature (2) from being driven by the engine.

(1) Roller Clutch
(2) Armature
(3) Ring Gear
(4) Pinion Gear

01760M10170



01760F10210

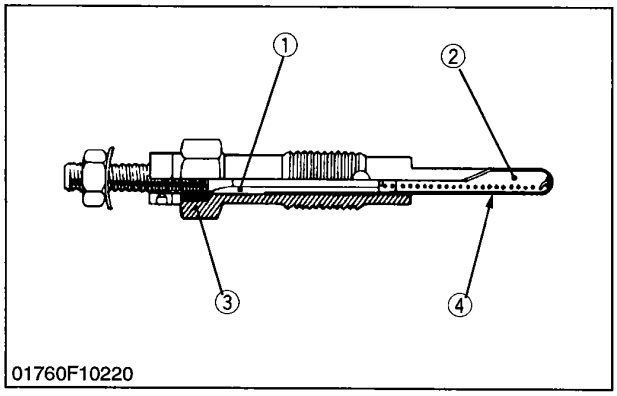
■ When Releasing Key Switch

When releasing the key switch (6), it returns from **"START"** to **"ON"** position and the starter circuit opens. Then, current flows from the battery (9) to the pull-in coil (8) and the holding coil (5) through the contact plate (7). Since the magnetic force is generated in each coil in the opposite direction, the magnetic field collapses and the plunger (4) is returned to its former position by a return spring (3). This opens the contacts on the contact plate (7) and separates pinion gear (1) from ring gear (2), whereupon the pinion gear stops rotating.

(1) Pinion Gear
(2) Ring Gear
(3) Return Spring
(4) Plunger
(5) Holding Coil
(6) Key Switch
(7) Contact Plate
(8) Pull-in Coil
(9) Battery

01760M10180

(2) Glow Plug



01760F10220

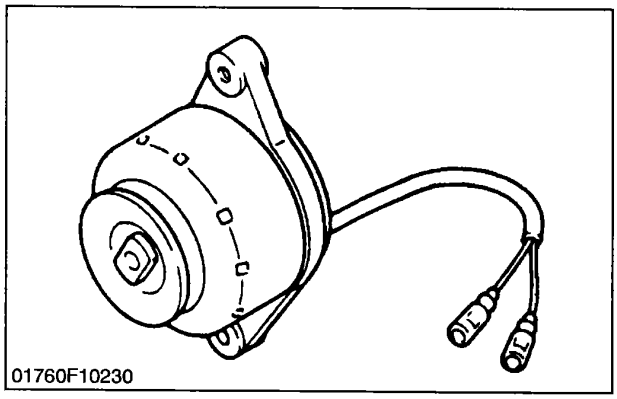
Each sub-combustion chamber has a glow plug for easy starting. The glow plug is of the quick-heating type.

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

01760M10190

[2] CHARGING SYSTEM

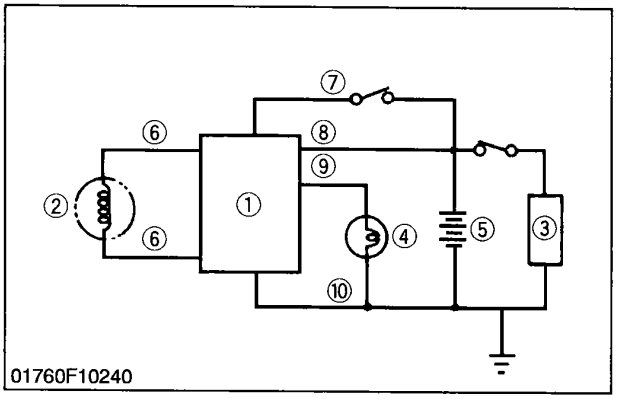
(1) Dynamo


01760F10230

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

01760M10200

(2) Regulator



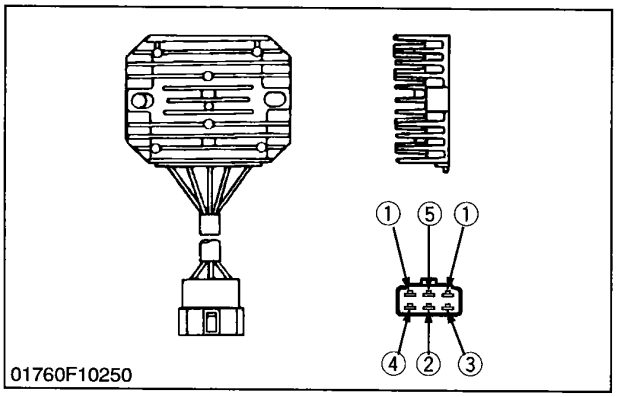
01760F10240

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

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

(A) General Wiring Diagram

01760M10210



01760F10250

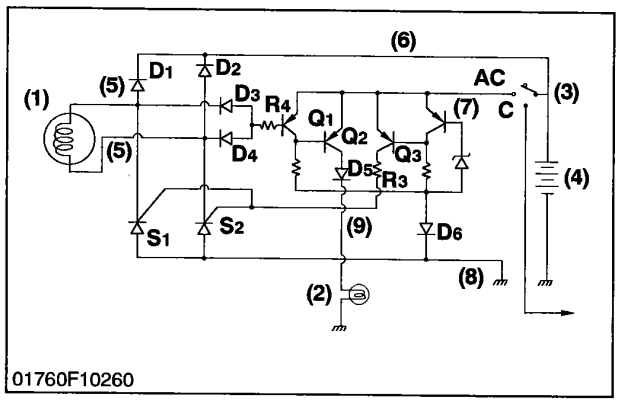
■ Features

1. This small-sized regulator can control large output current because charging current is supplied and stopped by thyristor (Series system).
2. Built-in AC diode generation detecting circuit permits a charge indication lamp (12 V, 3.4 W) to be easily connected.
3. Protection diode protects regulator when battery is wrongly connected.

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

01760M10220

(3) Charging Mechanism



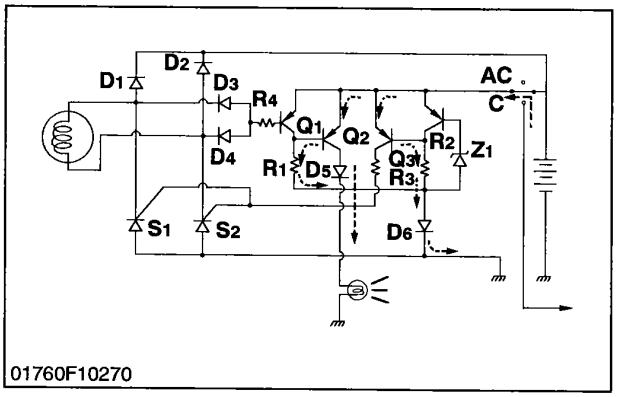
01760F10260

The charging mechanism is described in four sections:

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

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

01760M10230

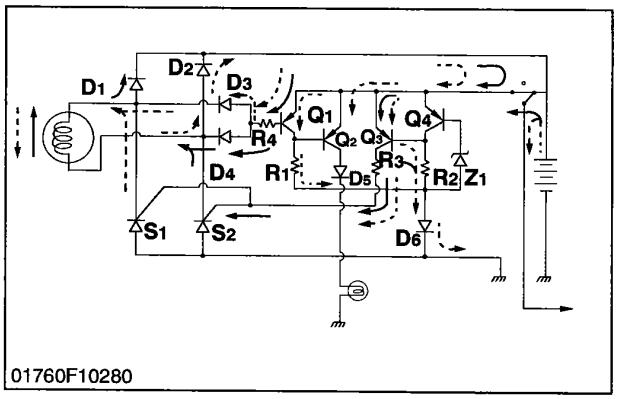


01760F10270

1) When Key Switch is "ON"

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

01760M10240



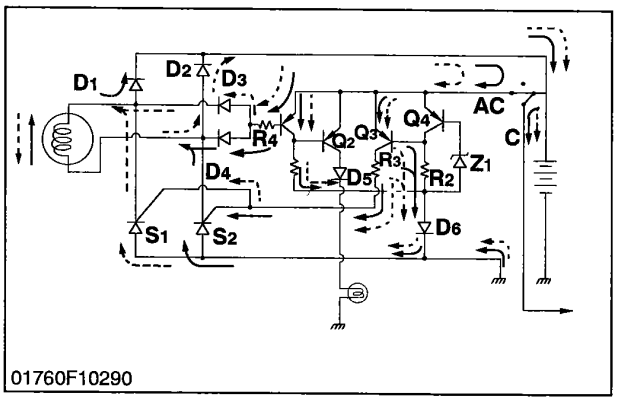
01760F10280

2) At Starting

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

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

01760M10250



01760F10290

3) In Charging

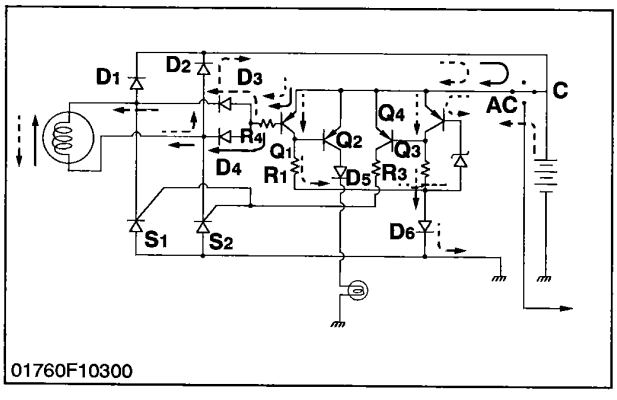
Because **BATT** terminal voltage just after engine start is lower than setting value (14 to 15 V), or lower than zener lever of Z_1, current is not supplied to base of Q_4 and Q_4 is off, as shown in Fig. 2. Q_3 is on with base current which flows through the route of **BATT**---> emitter / base of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

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

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

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

01760M10260



01760F10300

4) Over-Charge Protection

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

01760M10270

SERVICING

CONTENTS

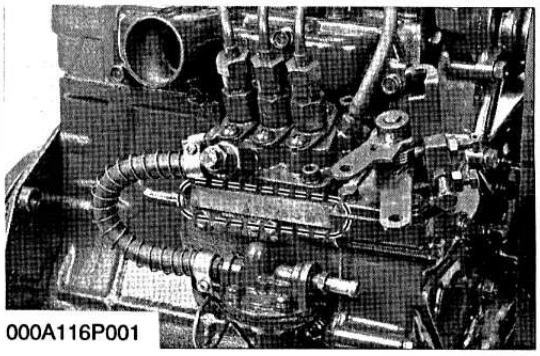
G GENERAL S-1
[1] ENGINE IDENTIFICATION S-1
(1) Model Name and Engine Serial Number S-1
(2) Cylinder Number S-1
[2] GENERAL PRECAUTION S-3
[3] TIGHTENING TORQUES S-5
(1) Tightening torques for special use screws, bolts and nuts S-5
(2) Tightening torques for general use screws, bolts and nuts S-5
[4] TROUBLESHOOTING S-8
[5] SERVICING SPECIFICATIONS S-18
(1) Engine Body S-18
(2) Lubricating System S-22
(3) Cooling System S-22
(4) Fuel System S-23
(5) Electrical System S-23
[6] MAINTENANCE CHECK LIST S-34
[7] CHECK AND MAINTENANCE S-37
(1) Daily Check Points S-37
(2) Check Point of Every 50 hours S-39
(3) Check Point of Every 100 hours S-41
(4) Check Point of Every 200 hours S-43
(5) Check Point of Every 800 hours S-45
(6) Check Point of 1500 hours S-45
[8] SPECIAL TOOLS S-47
1 ENGINE BODY S-61
CHECKING AND ADJUSTING S-61
DISASSEMBLING AND ASSEMBLING S-67
[1] DRAINING WATER AND OIL S-67
[2] EXTERNAL COMPONENTS S-67
[3] CYLINDER HEAD AND VALVES S-69
[4] TIMING GEAR AND CAMSHAFT S-75
[5] PISTON AND CONNECTING ROD S-81
[6] FLYWHEEL AND CRANKSHAFT S-87
SERVICING S-91
[1] CYLINDER HEAD S-91
[2] TIMING GEAR AND CAMSHAFT S-105
[3] PISTON AND CONNECTING ROD S-109
[4] CRANKSHAFT S-117
[5] CYLINDER S-127
2 LUBRICATING SYSTEM S-131
CHECKING S-131
SERVICING S-131
[1] OIL PUMP S-131
3 COOLING SYSTEM S-135
CHECKING S-135
[1] FAN BELT S-135
[2] RADIATOR S-135

DISASSEMBLING AND ASSEMBLING S-137
4 FUEL SYSTEM S-141
CHECKING AND ADJUSTING S-141
[1] INJECTION PUMP S-141
[2] INJECTION NOZZLE S-143
DISASSEMBLING AND ASSEMBLING S-147
[1] INJECTION NOZZLE S-147
5 ELECTRICAL SYSTEM S-149
CHECKING S-149
[1] STARTER S-149
[2] GLOW PLUG S-151
[3] DYNAMO AND REGULATOR S-151
[4] OIL PRESSURE SWITCH S-153
[5] COOLANT TEMPERATURE SWITCH S-155
[6] ENGINE STOP SOLENOID S-155
DISASSEMBLING AND ASSEMBLING S-157
[1] STARTER S-157
SERVICING S-159
[1] STARTER S-159

G GENERAL

[1] ENGINE IDENTIFICATION

(1) Model Name and Engine Serial Number

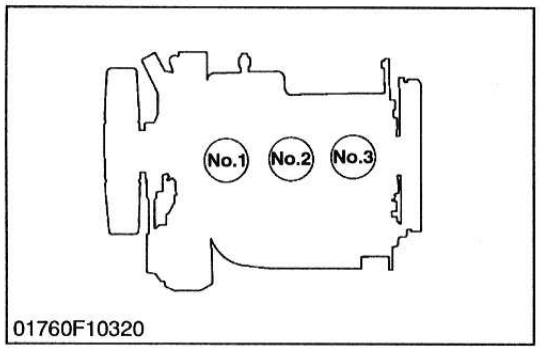


000A116P001

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

01760G10010

(2) Cylinder Number



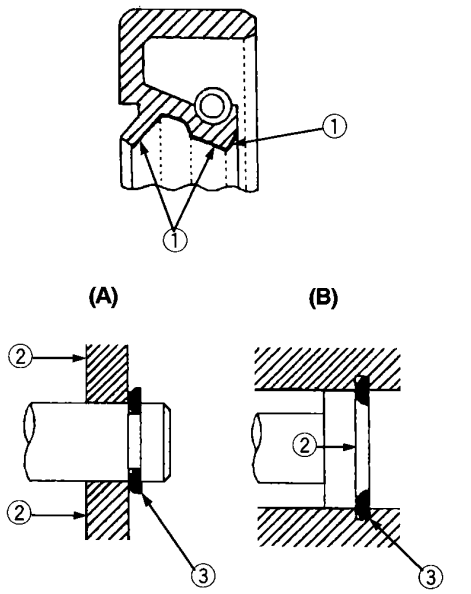
01760F10320

The cylinder numbers of D782-B diesel engine are designated as shown in the figure.

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

01760G10020

[2] GENERAL PRECAUTION



11790F00051

- 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 make 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

01760G10030

[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.

01760G10040

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

■ NOTE

- **In removing and applying the bolts and nuts marked with "*", a pneumatic wrench or similar pneumatic tool, if employed, must be used with enough care not to get them seized.**
- **For "*" marked screws, bolts and nuts on the table, apply engine oil to their threads and seats before tightening.**
- **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
* Bearing case screws 1	M6 × 1.0	12.7 to 15.7	1.3 to 1.6	9.4 to 11.6
* 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 screw	M12 × 1.5	98 to 107.8	10.0 to 11.0	72 to 79.2
* 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 to11.8	0.9 to 1.2	6.5 to 8.7

01760G10050

(2) Tightening torques for general use screws, bolts and nuts

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

Grade / Nominal Diameter / Unit	Standard Screw and Bolt ④			Special Screw and Bolt ⑦		
	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)

01760G10060

[4] TROUBLESHOOTING

Symptom	Probable Cause	Solution	Reference Page
Engine Does Not Start	• No fuel	Replenish fuel	–
	• Air in the fuel system	Vent air	S-39
	• Water in the fuel system	Change fuel and repair or replace fuel system	–
	• Fuel pipe clogged	Clean	–
	• Fuel filter clogged	Clean or change	S-43
	• Excessively high viscosity of fuel or engine oil at low temperature	Use specified fuel or engine oil	S-41
	• Fuel with low cetane number	Use specified fuel	–
	• Fuel leak due to loose injection pipe retaining nut	Tighten retaining nut	–
	• Incorrect injection timing	Adjust	S-141
	• Fuel camshaft worn	Replace	S-79
	• Injection nozzle clogged	Clean	S-143
	• Injection pump malfunctioning	Repair or replace	S-75, 143
	• Seizure of crankshaft, camshaft, piston, cylinder or bearing	Repair or replace	–
	• Compression leak from cylinder	Replace head gasket, tighten cylinder head screw, glow plug and nozzle holder	S-61, 69, 71
	• Improper valve timing	Correct or replace timing gear	S-77
	• Piston ring and cylinder worn	Replace	S-85, 113, 127
	• Excessive valve clearance	Adjust	S-65
(Starter Does Not Run)	• Battery discharged	Charge	–
	• Starter malfunctioning	Repair or replace	–
	• Key switch malfunctioning	Repair or replace	–
	• Wiring disconnected	Connect	–
Engine Revolution Is Not Smooth	• Fuel filter clogged or dirty	Clean or change	S-43
	• Air cleaner clogged	Clean or change	S-43
	• Fuel leak due to loose injection pipe retaining nut	Tighten retaining nut	–
	• Injection pump malfunctioning	Repair or replace	S-75, 143
	• Incorrect nozzle opening pressure	Adjust	S-143
	• Injection nozzle stuck or clogged	Repair or replace	S-143
	• Governor malfunctioning	Repair	S-79
Either White or Blue Exhaust Gas Is Observed	• Excessive engine oil	Reduce to specified level	S-41
	• Piston ring and liner worn or stuck	Repair or replace	S-85, 113, 127
	• Incorrect injection timing	Adjust	S-141
	• Deficient compression	Adjust top clearance	S-61

01760G10070

Symptom	Probable Cause	Solution	Reference Page
Either Black or Dark Gray Exhaust Gas Is Observed	• Overload	Lessen load	–
	• Low grade fuel used	Use specified fuel	–
	• Fuel filter clogged	Clean or change	S-43
	• Air cleaner clogged	Clean or change	S-43
	• Deficient nozzle injection	Repair or replace nozzle	S-143
Deficient Output	• Incorrect injection timing	Adjust	S-141
	• Engine's moving parts seem to be seizing	Repair or replace	–
	• Uneven fuel injection	Repair or replace injection pump	S-75, 143
	• Deficient nozzle injection	Repair or replace nozzle	S-143, 145
	• Compression leak	Replace head gasket, tighten cylinder head screw, glow plug and nozzle holder	S-61, 69, 71
Excessive Lubricant Oil Consumption	• Piston ring's gap facing the same direction	Shift ring gap direction	S-83
	• Oil ring worn or stuck	Replace	S-85, 113
	• Piston ring groove worn	Replace piston	S-83, 113
	• Valve stem and valve guide worn	Replace	S-73, 95, 99
	• Carnkshaft bearing, and crank pin bearing worn	Replace	S-83, 119
	• Oil leaking due to defective seals or packing	Replace	–
Fuel Mixed into Lubricant Oil	• Injection pump's plunger worn	Replace pump element or injection pump	S-143
	• Deficient nozzle injection	Repair or replace nozzle	S-143, 145
	• Injection pump broken	Replace	S-75
Water Mixed into Lubricant Oil	• Head gasket defective	Replace	S-71
	• Cylinder block or cylinder head flawed	Replace	S-93
Low Oil Pressure	• Engine oil insufficient	Replenish	–
	• Oil strainer clogged	Clean	S-81
	• Relief valve stuck with dirt	Clean	–
	• Relief valve spring weaken or broken	Replace	–
	• Excessive oil clearance of crankshaft bearing	Replace	S-121, 125
	• Excessive oil clearance of crankpin bearing	Replace	S-119
	• Excessive oil clearance of rocker arm bearing	Replace	S-101
	• Oil passage clogged	Clean	–
	• Different type of oil	Use specified type of oil	–
	• Oil pump defective	Repair or replace	S-131, 133
High Oil Pressure	• Different type of oil	Use specified type of oil	–
	• Relief valve defective	Replace	–

01760G10080

Symptom	Probable Cause	Solution	Reference Page
Engine Overheated	• Engine oil insufficient	Replenish	–
	• Fan belt broken or elongated	Replace or adjust	S-41
	• 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-137
	• Overload running	Loosen load	–
	• Head gasket defective	Replace	S-71
	• Incorrect injection timing	Adjust	S-141
	• Unsuitable fuel used	Use specified fuel	–
Battery Quickly Discharge	• Battery electrolyte insufficient	Replenish distilled water and charge	–
	• Fan belt slips	Adjust belt tension or change	S-41
	• Wiring disconnected	Correct	–
	• Dynamo defective	Replace	S-151
	• Battery defective	Change	–

01760G10090

[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^2 412 to 469 psi	2.25 MPa 23 kgf/cm^2 327 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.	–

01760G10170

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.	–

Push Rod

Push Rod Alignment	–	0.5 mm 0.020 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	26.88 mm 1.0583 in.	26.83 mm 1.0563 in.
Oil Clearance of Camshaft	0.050 to 0.091 mm 0.0020 to 0.0036 in.	0.15 mm 0.0059 in.
Camshaft Journal O.D.	32.934 to 32.950 mm 1.2966 to 1.2972 mm	–
Camshaft Bearing I.D.	33.000 to 33.025 mm 1.2992 to 1.3002 in.	–

01760G10180

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 Shaft O.D.	19.967 to 19.980 mm 0.78610 to 0.78661 in.	–
Idle Gear Bushing I.D.	20.000 to 20.051 mm 0.78740 to 0.78941 in.	–
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	0.090 to 0.120 mm 0.0035 to 0.0047 in.	0.15 mm 0.0059 in.
Clearance between Oil Ring and Ring Groove	0.040 to 0.080 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.

01760G10190

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 1.57284 in.	–
Crankshaft Bearing 1 I.D.	39.984 to 40.040 mm 1.57428 to 1.57638 in.	–
Oil Clearance between Crankshaft and Crankshaft Bearing 2 (Flywheel Side)	0.028 to 0.059 mm 0.0011 to 0.0023 in.	0.20 mm 0.0079 in.
Crankshaft O.D.	43.978 to 43.993 mm 1.7314 to 1.7320 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 (Intermediate)	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 0.31 mm 0.0059 to 0.0122 in.	0.50 mm 0.0197 in.

01760G10200

Cylinder Liner

Item	Factory Specification	Allowable Limit
Cylinder Liner I.D.	67.000 to 67.019 mm 2.63779 to 2.63854 in.	67.169 mm 2.64444 in.
Oversized Cylinder Liner I.D.	67.250 to 67.269 mm 2.64764 to 2.64839 in.	67.419 mm 2.65429 in.

01760G10210

(2) Lubricating System

Oil Pump

Engine Oil Pressure At Idle Speed	68 kPa 0.7 kgf/cm^2, 10 psi	–
At Rated Speed	196.0 to 441.0 kPa 2.0 to 4.5 kgf/cm^2 28.0 to 64.0 psi	98 kPa 1.0 kgf/cm^2 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.	0.30 mm 0.0118 in.
End Clearance between Inner Rotor and Cover	0.075 to 0.135 mm 0.0029 to 0.0053 in.	0.20 mm 0.0078 in.

01760G10220

(3) Cooling System

Thermostat

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

Radiator

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

01760G10230

(4) Fuel System

Injection Pump

Item	Factory specification	Allowable Limit
Injection Timing	0.33 to 0.37 rad. (19 to 21°) Before T.D.C.	–
Fuel Titghtness of Pump Element	–	14.7 MPa 150 kgf/cm^2 2133 psi
Fuel Tightness of Delivery Valve	–	5 seconds 14.7 → 13.7 MPa 150 →140 kgf/cm^2 2133 → 1990 psi

Injection Nozzle

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

01760G10240

(5) Electrical System

Starter

Commutator O.D.	30.0 mm 1.1811 in.	29.0 mm 1.1417 in.
Mica Undercut	0.5 to 0.8 mm 0.0197 to 0.0315 in.	0.2 mm 0.079 in.
Brush Length	13.0 mm 0.5118 in.	8.5 mm 0.3346 in.

Dynamo

No-load voltage	AC 20 V or more at 5200 rpm	–

Glow Plug

Glow Plug Resistance	Approx. 0.9 Ω	–

Coolant Temperature Switch

Coolant Temperature Switch Continuity	Infinity less than 112 °C 233 °F Continuity 112 to 118 °C 233 to 280 °F	– –

01760G10250

[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 1500 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 element				☆				
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.

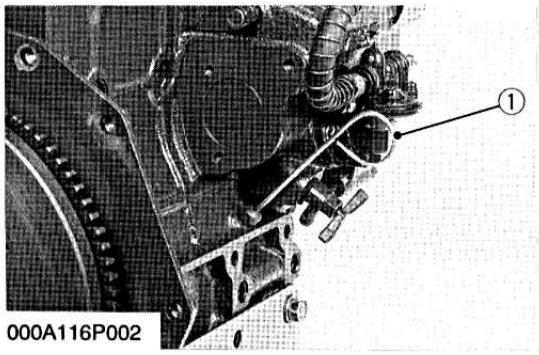
CAUTION

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

01760G10410

[7] CHECK AND MAINTENANCE

(1) Daily Check Points



000A116P002

Checking Engine Oil Level

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

■ IMPORTANT

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

(1) Dipstick

01760G10420

Checking and Replenish Cooling Water

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

⚠ CAUTION

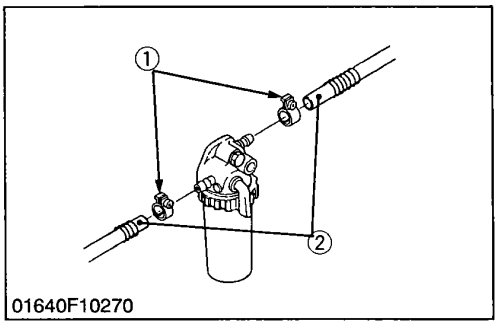
- **Do not remove the radiator cap until cooling water temperature is below its boiling point. Then loosen the cap slightly to relieve any excess pressure before removing the cap completely.**

■ 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.**

01760G10430

(2) Check Point of Every 50 hours



01640F10270

Checking Fuel Pipe

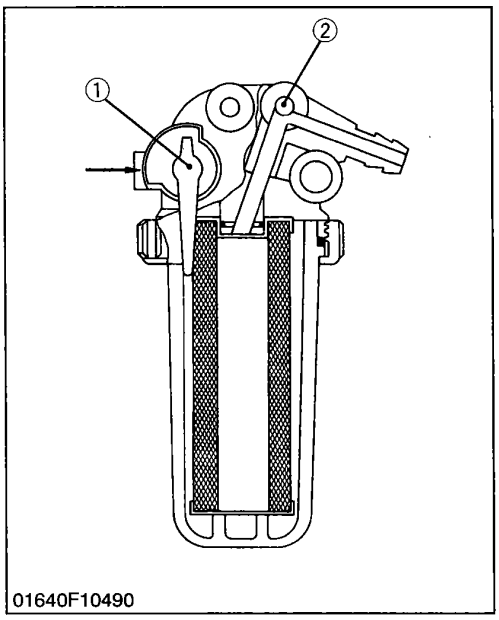
1. If the clamp (1) is loose, apply oil to the threads and securely retighten it.
2. The fuel pipe (2) is made of rubber and ages regardless of the period of service.
   Change the fuel pipe together with the clamp every two years.
3. However, if the fuel pipe and clamp are found to be damaged or deteriorate 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

01760G10440



01640F10490

(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.

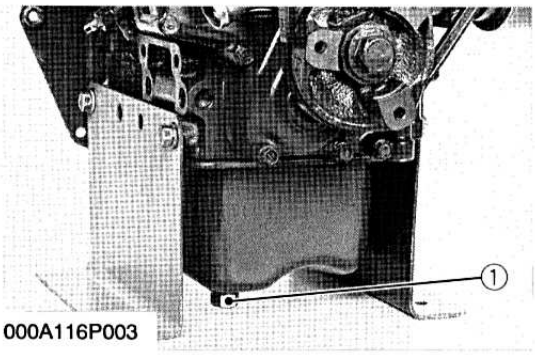
■ NOTE

- **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

01760G10450

(3) Check Point of Every 100 hours



000A116P003

Changing Engine Oil

1. After warming up, stop the engine.
2. To change the used oil, remove the drain plug (1) 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.

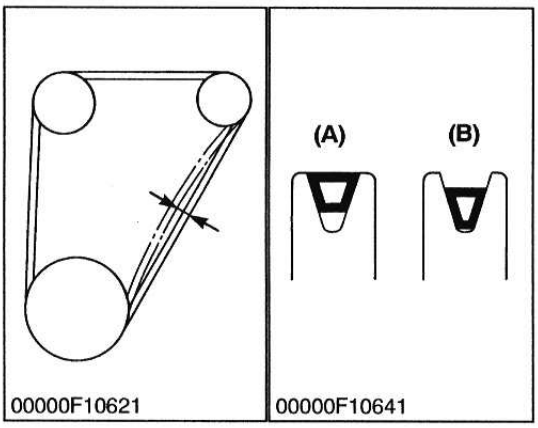
■ IMPORTANT

- **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
D782-B	3.1 L 3.28 U.S.qts. 2.73 Imp.qts

(1) Drain Plug

01760G10460



00000F10621 00000F10641

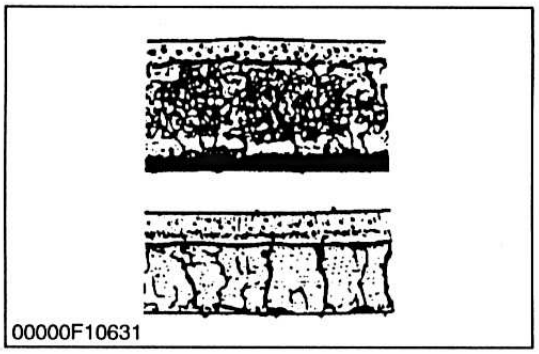
Checking Fan Belt Tension

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 approx. 10 mm (0.394 in.).
2. If the deflection is not within the factory specifications, adjust with the tension pulley adjusting bolts.

Fan belt tension	Factory spec.	approx. 10mm 0.394 in.

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

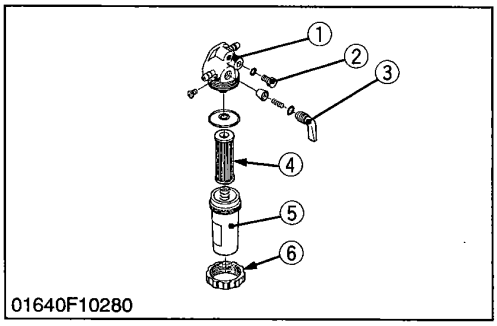
01760G10470


00000F10631

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.

01760G10480



01640F10280

Cleaning Fuel Filter

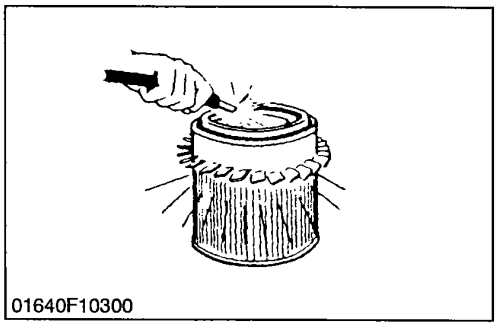
1. Close the fuel filter cock (3).
2. Unscrew the retaining ring (6) and remove the cup (5), and rinse the inside with kerosene.
3. Take out the element (4) and dip it in the kerosene to rinse.
4. After cleaning, reassemble the fuel filter, keeping out dust and dirt.
5. Bleed the fuel system.

■ **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
(2) Air Vent Plug
(3) Filter Cock
(4) Filter Element
(5) Filter Cup
(6) Retaining Ring

01760G10490

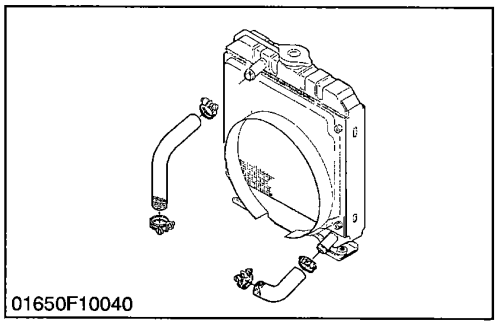

01640F10300

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^2, 100 psi).
  Maintain reasonable distance between the nozzle and the filter.

01760G10500

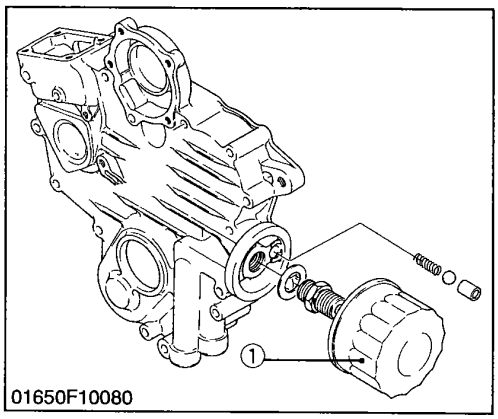
(4) Check Point of Every 200 hours


01650F10040

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.

01760G10510



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.

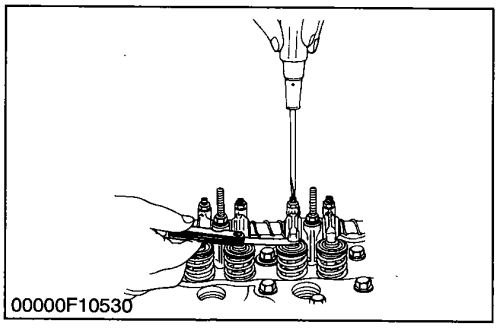
■ NOTE

- **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

01760G10520

(5) Check Point of Every 800 hours



Checking Valve Clearance

1. See page S-65.

■ IMPORTANT

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

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

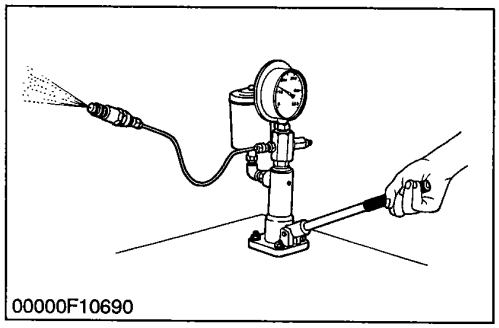
01760G10530

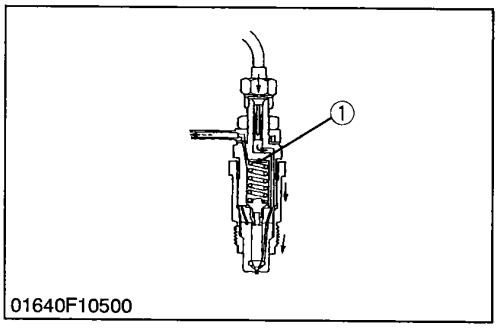
(6) Check Point of 1500 hours

⚠ 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.**

01760G10540


00000F10690



01640F10500

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-135.)
4. If the spraying condition is defective, replace the nozzle piece.

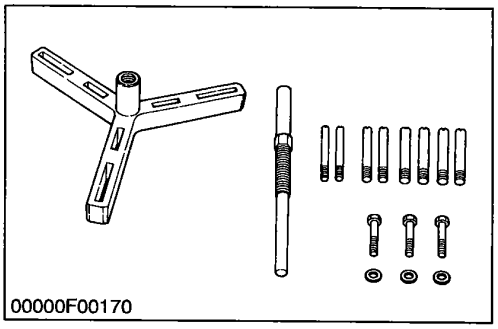
(Reference)

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

(1) Adjusting Washer

01760G10550

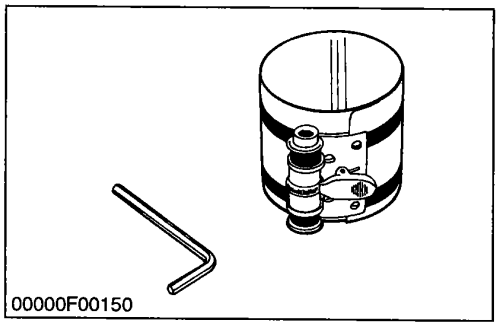
[8] SPECIAL TOOLS


00000F00170

Flywheel Puller

Code No: 07916-32011
Application: Use to remove the flywheel.

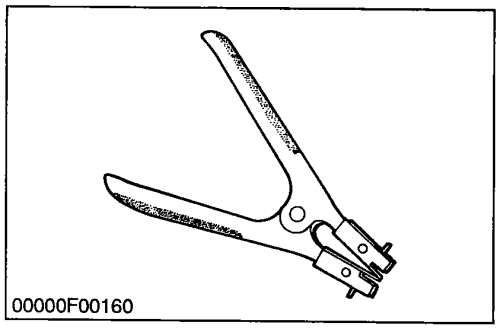
01760G10570


00000F00150

Piston Ring Compressor

Code No : 07909-32111
Application: Use exclusively for pushing in the piston with piston rings into the cylinder.

00000G00020

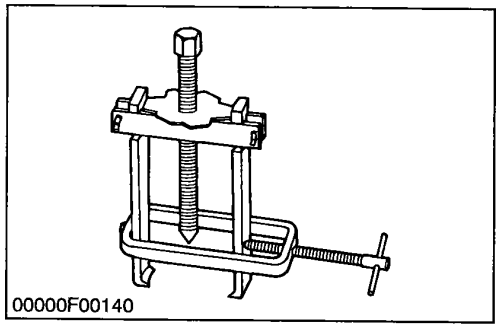

00000F00160

Piston Ring Tool

Code No : 07909-32121

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

00000G00030

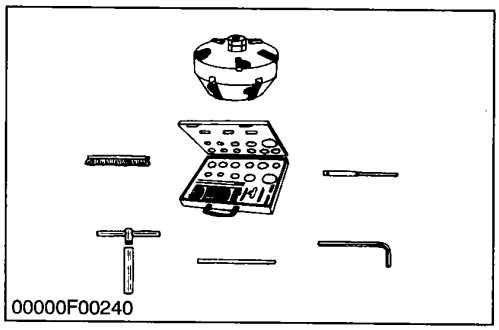

00000F00140

Special-use Puller Set

Code No: 07916-09032

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

01760G10580

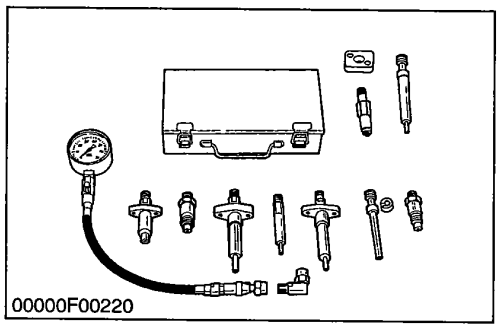

00000F00240

Valve Seat Cutter Set

Code No: 07909-33102

Application: Use for correcting valve seats.

01760G10590

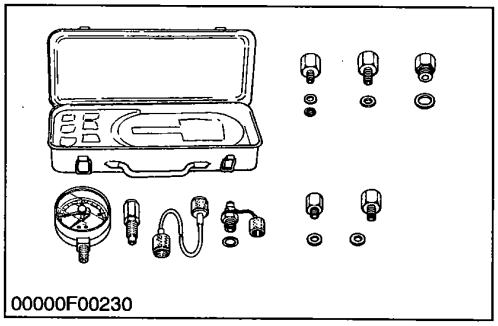

00000F00220

Diesel Engine Compression Tester

Code No: 07909-30208

Application: Use for measureing diesel engine compression pressure

01760G10600

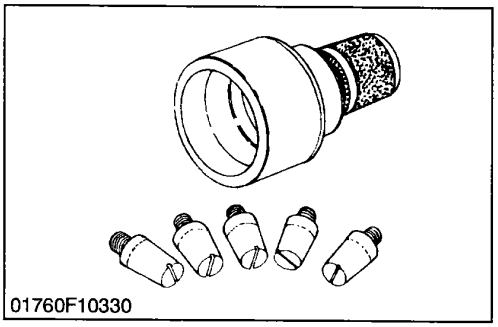

00000F00230

Oil Pressure Tester

Code No: 07916-32031

Application: Use for measureing lubricating oil pressure.

01760G10610

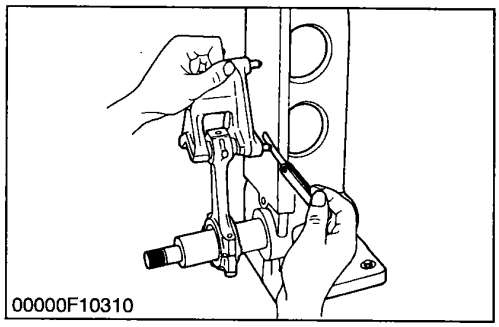

01760F10330

Crank Sleeve Setter

Code No: 07916-34041

Application: Use to fix the crankshaft sleeve.

01760G10560


00000F10310

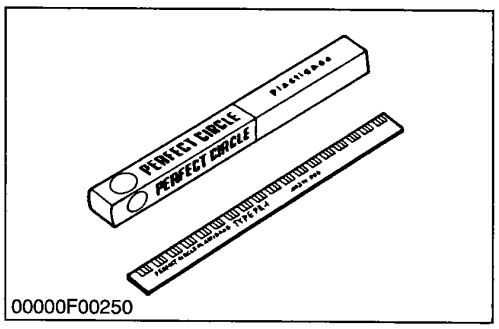
Connecting Rod Alignment Tool

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.).

01760G10620



00000F00250

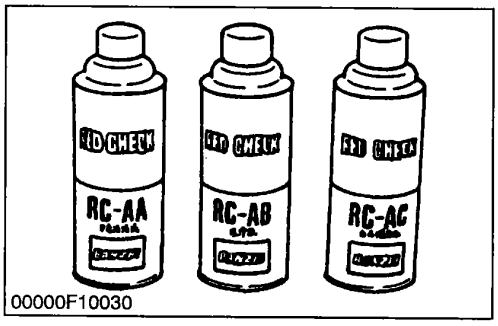
Press Gauge

Code No: 07909-30241

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

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

01760G10630



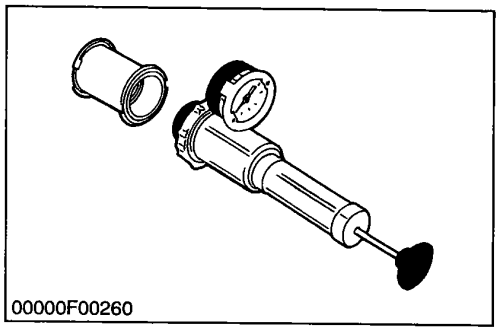
00000F10030

Red Check (Crack Check Liquid)

Code No: 07909-31371

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

01760G10640

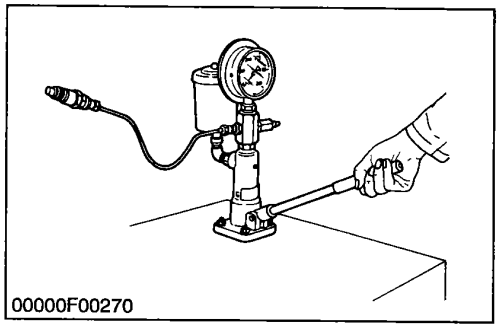

00000F00260

Radiator Tester

Code No : 07909-31551

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

01760G10650


00000F00270

Nozzle Tester

Code No : 07909-31361

Application : Use to check the fuel injection pressure and spray pattern of nozzle.

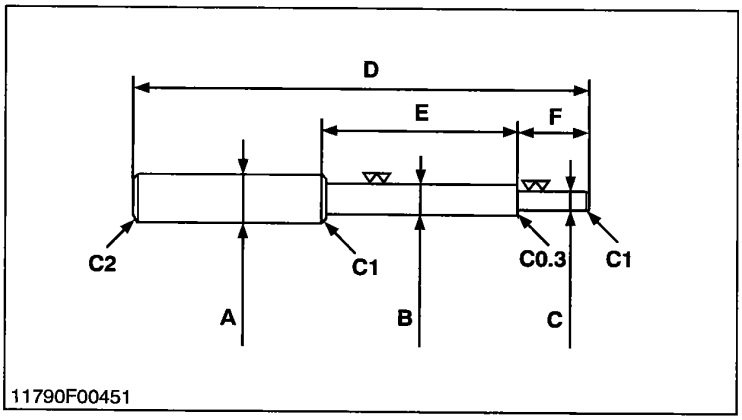
Measuring range : 0 to 50 MPa (0 to 500 kgf/cm^2, 0 to 7000 psi)

00000G00140

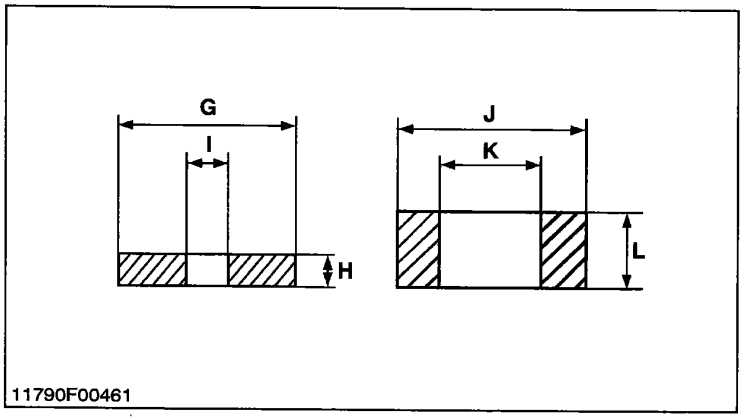
■ **NOTE**

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

01640S10910



11790F00451



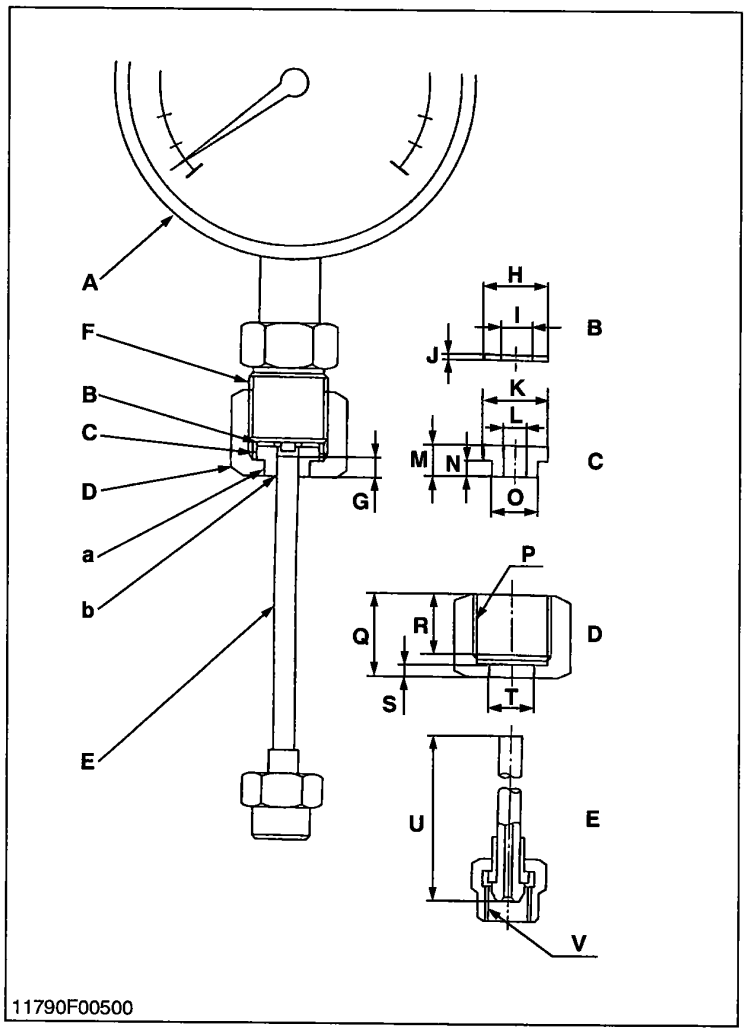
11790F00461

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.)

11790G00623



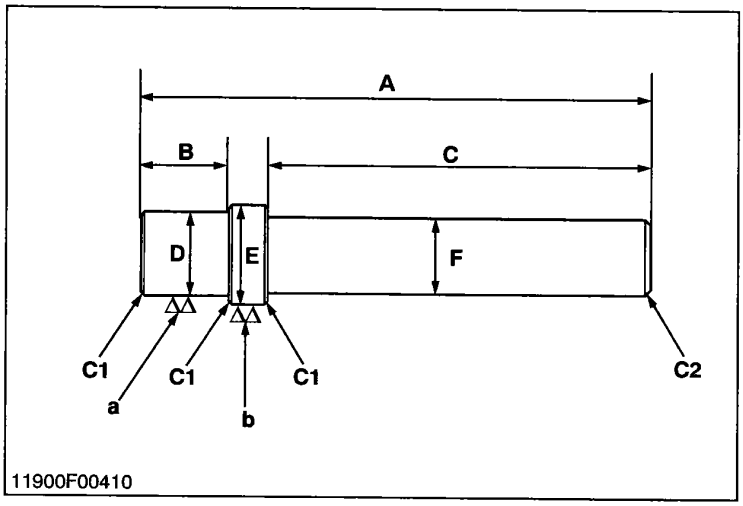
11790F00500

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^2, 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 × P1.5
a	Adhesive application
b	Fillet welding on the enter circumference

11790G00811



11900F00410

Bushing Replacing Tool

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

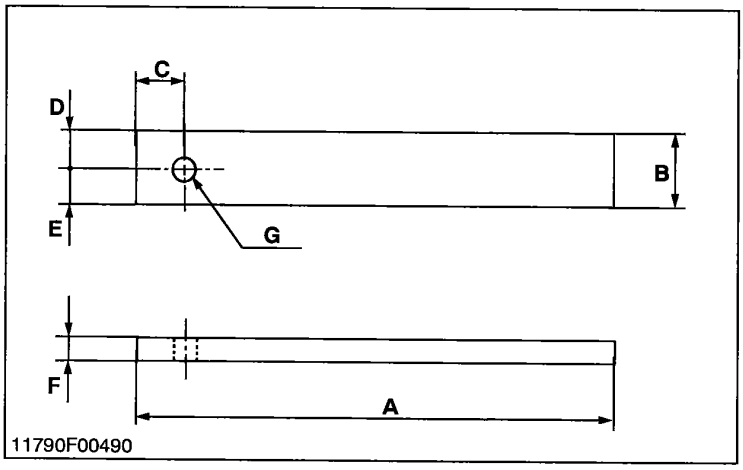
1. For small end bushing

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 μm (250 μin.)
b	6.3 μm (250 μin.)

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 μm (250 μin.)
b	6.3 μm (250 μin.)

11900G00442



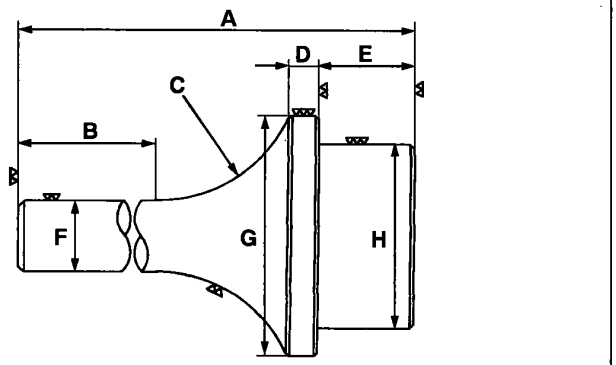
11790F00490

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



11900F00420

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.

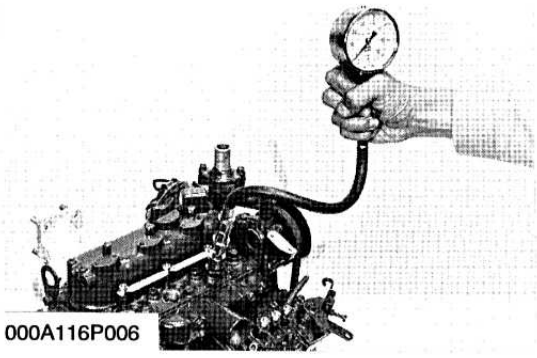
[Press Fit]

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.

11900G00453

1 ENGINE BODY

CHECKING AND ADJUSTING



000A116P006

Compression Pressure

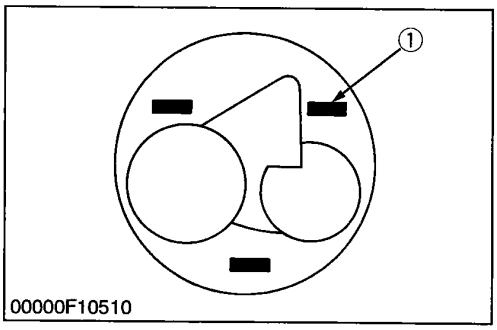
1. After warming up the engine, stop it and remove the air cleaner, the muffler and all nozzle holders.
2. Install a compression tester (Code No: 07909-30204) for diesel engines to nozzle holder hole.
3. After making sure that the speed control lever is set at the stop position (Non-injection), run the 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**

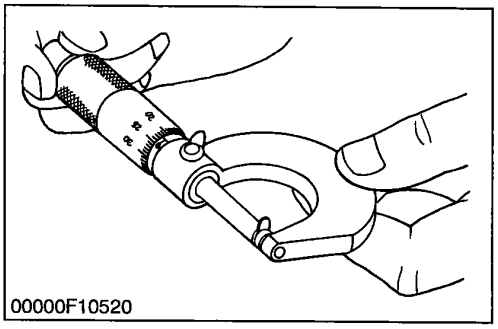
- **Check the compression pressure with the specified valve clearance.**
- **Always use a fully charged battery for performing this test.**
- **Variances in cylinder compression values should be under 10 %.**

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

01760S10690



00000F10510


00000F10520

Top Clearance

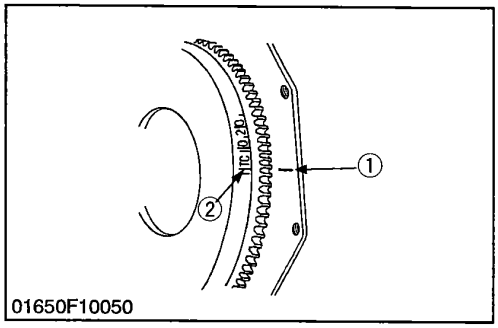
1. Remove the cylinder head (remove the cylinder head gasket completely).
2. Bring the piston to its top dead center fasten 1.5 mm dia. 5 to 7 mm long fuse wires to 3 to 4 spots on the piston top with grease so as to avoid the intake and exhaust valves and the combustion chamber ports.
3. Bring the piston 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.

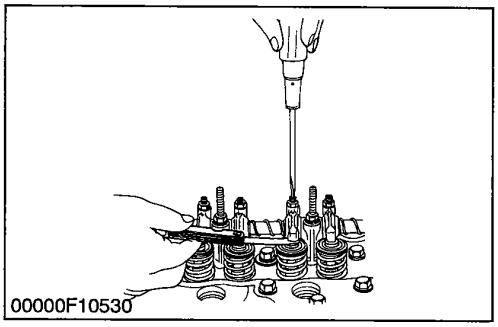
Tightening torque	Cylinder head screw	37.2 to 42.1 N·m 3.8 to 4.3 kgf·m 27.5 to 31.1 ft-lbs

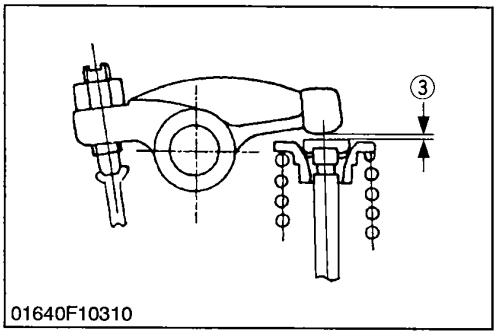
(1) Fuse

01640S10273



01650F10050


00000F10530



01640F10310

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 0.0057 to 0.0072 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, recheeck the valve clearance.**
- **After adjusting the valve clearance, firmly tighten the lock nut of the adjusting screw.**

Engine model Valve arrangement Adjustable cylinder Location of piston		D782-B	
		IN.	EX
When No. 1 piston is compression top dead center	1st	☆	☆
	2nd		☆
	3rd	☆	
When No. 1 piston is overlap position	1st		
	2nd	☆	
	3rd		☆

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

01650S10292

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

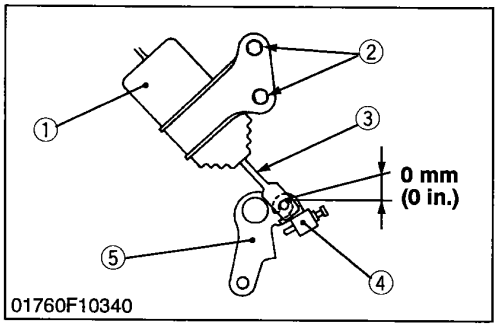
Air Cleaner and Muffler

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



01760F10340

Engine Stop Solenoid

1. Unscrew the solenoid mounting screws, and remove the engine stop solenoid (1).

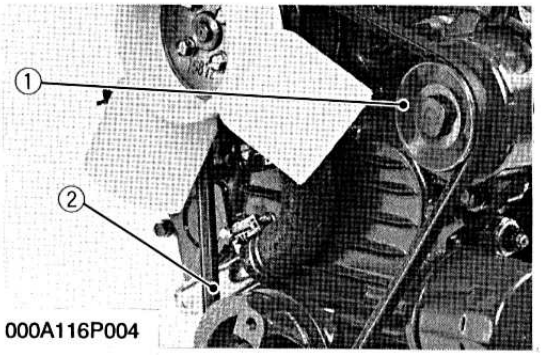
(When reassembling)

■ IMPORTANT

- **Keep the engine stop lever (5) to touch the stopper (4). Tighten the engine stop solenoid mounting screw (2) so that there be no gap between the engine stop lever and the engine stop solenoid plunger.**

(1) Engine Stop Solenoid
(2) Engine Stop Solenoid Mounting Screw
(3) Plunger
(4) Stopper
(5) Engine Stop Lever

01760S10010



000A116P004

Dynamo and Fan Belt

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

(When reassembling)

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

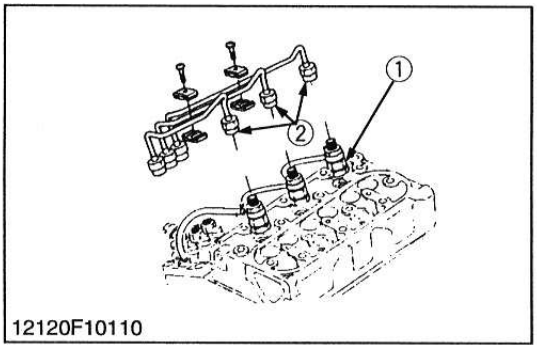
■ IMPORTANT

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

(1) Dynamo (2) Fan Belt

01760S10020

[3] CYLINDER HEAD AND VALVES



12120F10110

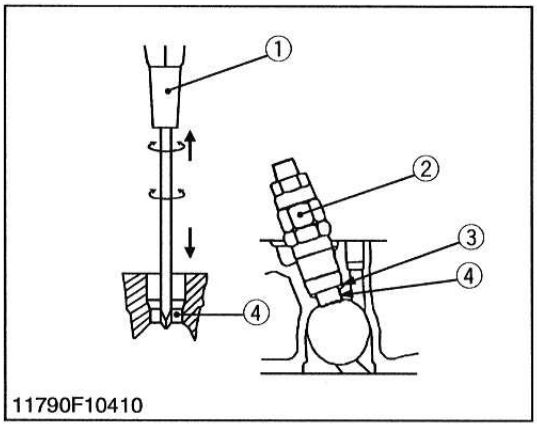
Nozzle Holder Assembly

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.

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

(1) Nozzle Holder Assembly (2) Injection Pipes

01760S10030



11790F10410

Nozzle Heat Seal Service Removal Procedure

■ IMPORTANT

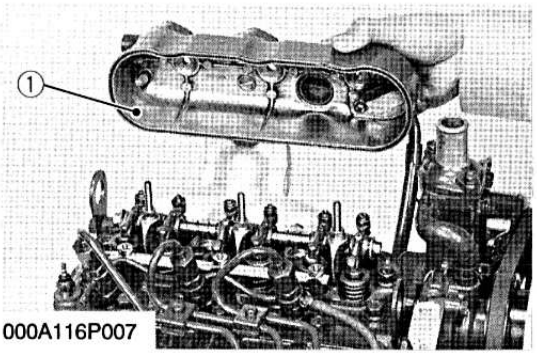
- **Use a plus (phillips head) screwdriver that has a Dia. which is bigger than the heat seal hole. (Approx. 6 mm) 1/4 in.**

1. Drive screwdriver lightly into the heat seal hole.
2. Turn screwdriver three or four times each way.

   While turning the screwdriver, slowly pull the heat seal out together with the injection nozzle gasket.
   If the heat seal drops, repeat the above procedure. Heat seal and injection nozzle gasket must be changed when the injection nozzle is removed for cleaning or for service.

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

01760S10040



000A116P007

Cylinder Head Cover

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

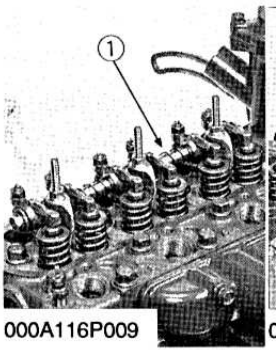
(When reassembling)

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

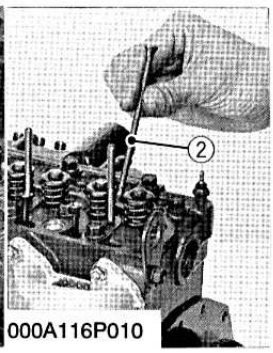
Tightening torque	Cylinder head cover cap nut	3.9 to 5.9 N·m 0.4 to 0.6 kgf·m 2.9 to 4.3 ft-lbs

(1) Head Cover

01760S10050



000A116P009



000A116P010

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)

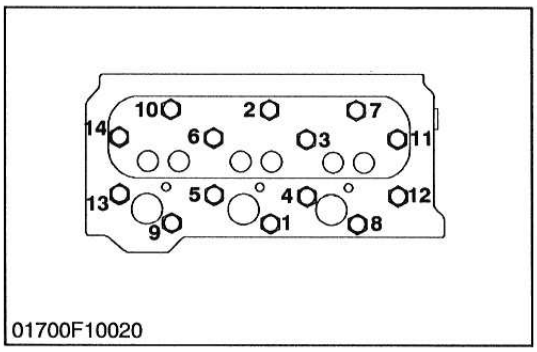
- When putting the push rods onto the tappets, check to see if their ends are properly engaged with the grooves.

Tightening torque	Rocker arm bracket mounting nut	9.8 to 11.3 N·m 1.00 to 1.15 kgf·m 7.2 to 8.3 ft-lbs

Valve clearance	Factory spec.	0.145 to 0.185 mm 0.0059 to0.0072 in.

(1) Rocker Arm Assembly (2) Push Rod

01760S10060



01700F10020

Cylinder Head

1. Loosen the pipe band, and remove the water return pipe.
2. Remove the cylinder head screws in the order of (14) to (1), and remove the cylinder head.
3. Remove the cylinder head gasket and O-ring.

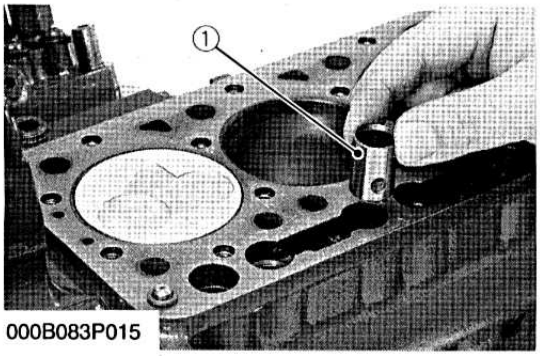
(When reassembling)

- 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 (14) after applying engine oil.
- Retighten the cylinder head screws after running the engine for 30 minutes.

Tightening torque	Cylinder head screw	39.2 to 44.1 N·m 4.0 to 4.5 kgf·m 27.5 to 31.1 ft-lbs

(A) Gear Case Side **(B) Flywheel Side**

01760S10070



000B083P015

Tappets

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

(When reassembling)

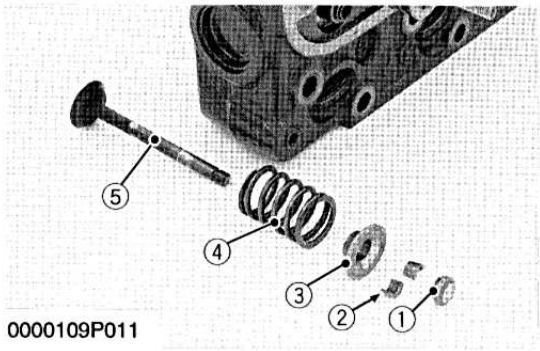
- Before installing the tappets, apply engine oil thinly around them.

■ IMPORTANT

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

(1) Tappet

01760S10700



0000109P011

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).

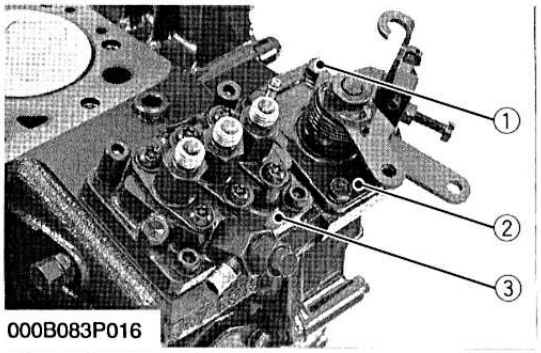
(When reassembling)

- 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.

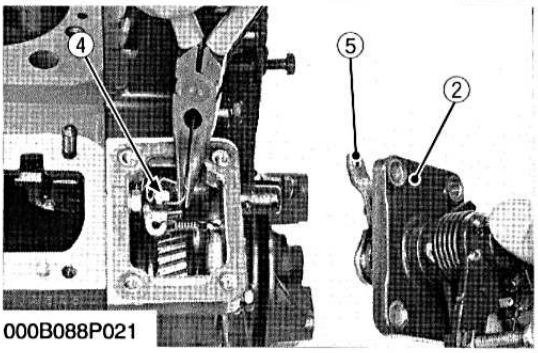
(1) Valve Cap
(2) Valve Spring Collet
(3) Valve Spring Retainer
(4) Valve Spring
(5) Valve

01760S10710

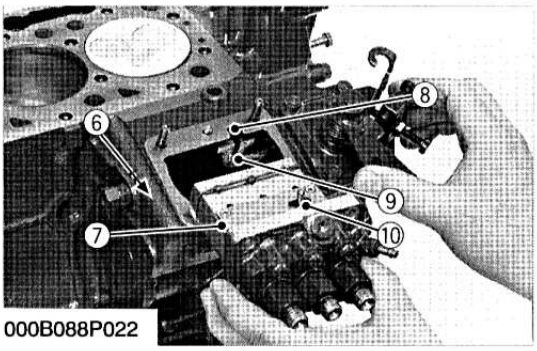
[4] TIMING GEAR AND CAMSHAFT



000B083P016



000B088P021



000B088P022

Injection Pump and Speed Control Plate

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

(When reassembling)

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

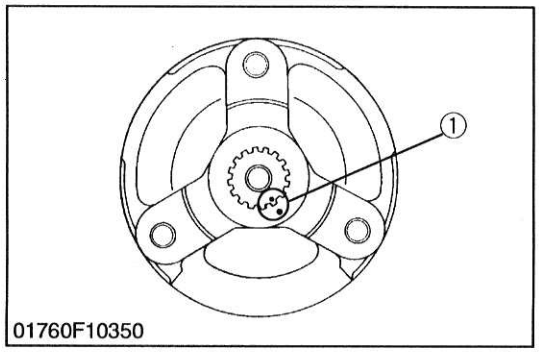
■ **NOTE**

- **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	9.8 to 11.3 N·m 1.00 to 1.15 kgf·m 7.23 to 7.32 ft-lbs

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

01760S10080



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.

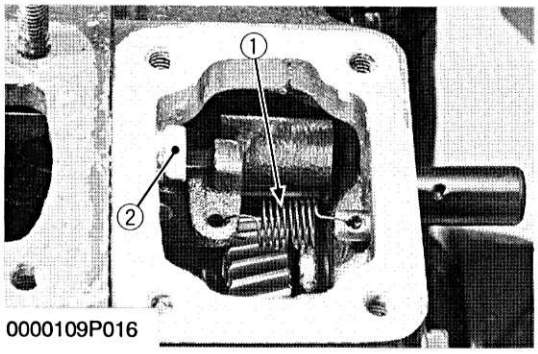
(When reassembling)

- Install the pulley to the crankshaft, aligning the mark (1) on them.
- Apply engine oil to the crankshaft screw.

Tightening torque	Crankshaft screw	98 to 107.8 N·m 10.0 to 11.0 kgf·m 72.0 to 79.2 ft-lbs

(1) Aligning Marks

01760S10090



Gear Case

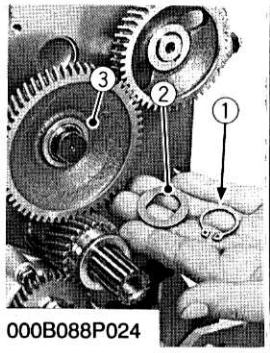
1. Unscrew the screw (2) and disconnect the start spring (1) in the speed control plate mounting hole.
2. Remove the gear case.

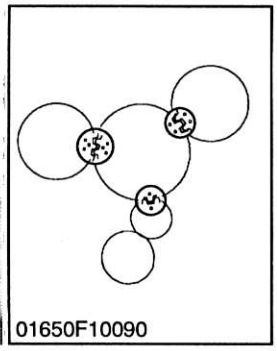
(When reassembling)

- Be sure to set three O-rings inside the gear case.
- 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

01760S10720





Idle Gear

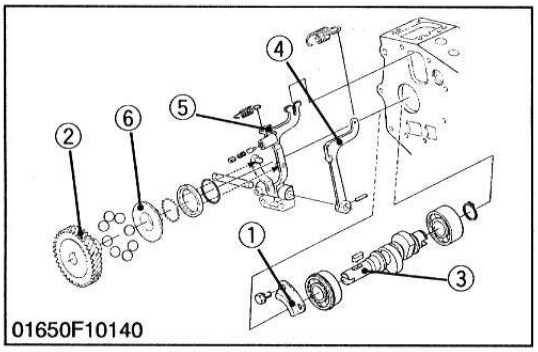
1. Remove the external snap ring (1), the collar (2) and the idle gear (3).

(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

01760S10740



01650F10140

Fuel Camshaft

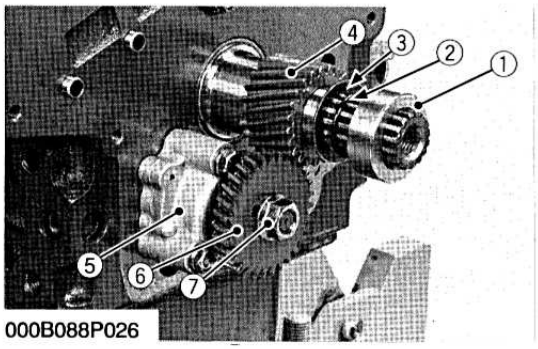
1. Remove the screws and draw out the camshaft with the gear on it.
2. Remove the retaining plate (1).
3. Remove the screws, then draw out the injection pump gear (2) and fuel camshaft (3) with the governor fork assembly.

(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
(2) Injection Pump Gear
(3) Fuel Camshaft
(4) Fork Lever 2
(5) Fork Lever 1
(6) Governor Sleeve

01650S10340



000B088P026

Oil Pump and Crankshaft Gear

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

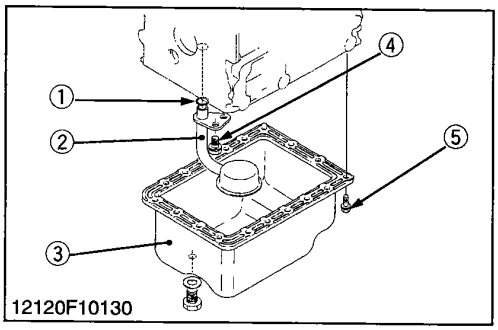
(When reassembling)

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

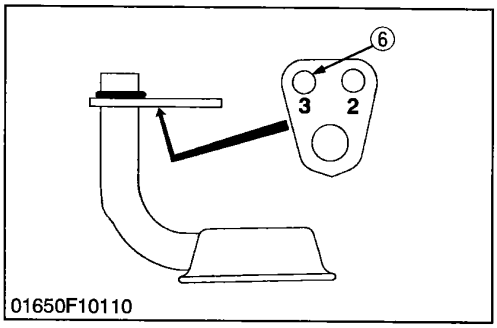
(1) Crankshaft Collar
(2) O-ring
(3) Crankshaft Oil Slinger
(4) Crankshaft Gear
(5) Oil Pump
(6) Oil Pump Gear
(7) Flange Nut

01760S10730

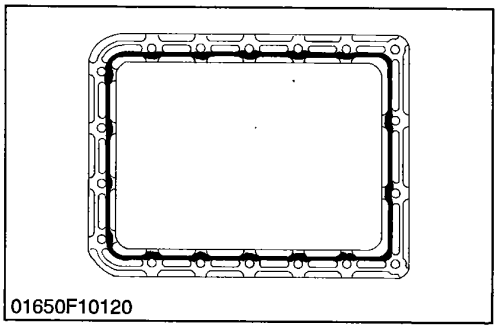
[5] PISTON AND CONNECTING ROD



12120F10130



01650F10110


01650F10120

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 **"3"**, install the oil strainer by mounting screw.
- Apply liquid gasket (Three Bond 1270D or 1270C) to the oil pan as shown in the figure.

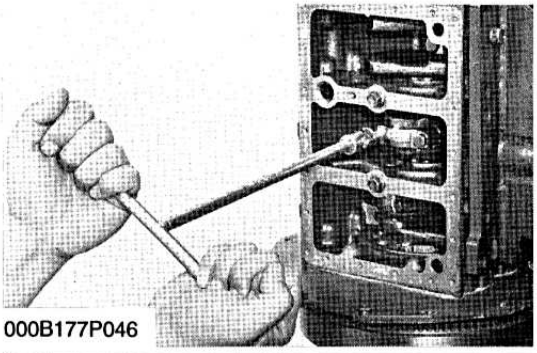
■ IMPORTANT

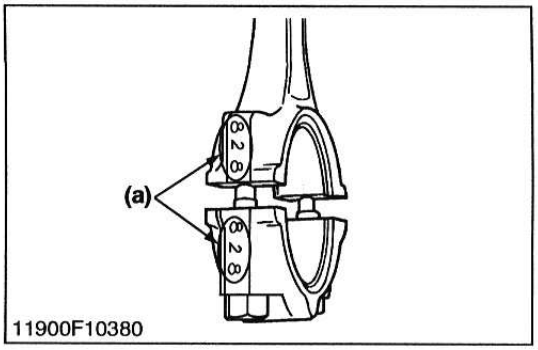
- **Scape off the oil adhesive completely. Wipe the sealing surface clean using waste cloth soaked with gasoline. Now apply new adhesive 3 to 5 mm thick all over the contact surface. Apply the adhesive also on the center of the flange as well as on the inner wall of each bolt hole.**
- **Cut the nozzle of the "fluid sealang" 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.**

Tightening torque	Oil pan mounting screw	9.8 to 11.3 N·m 1.00 to 1.15 kgf·m 7.23 to 8.32 ft-lbs

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

01760S10100


000B177P046



11900F10380

Connecting Rod Cap

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

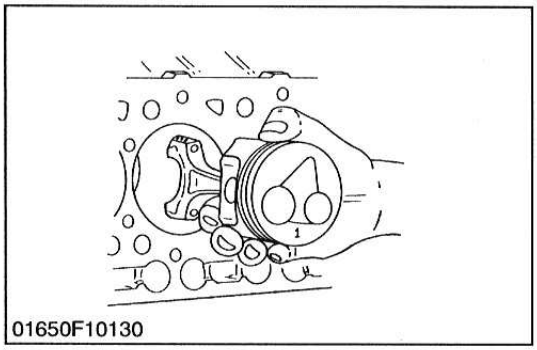
(When reassembling)

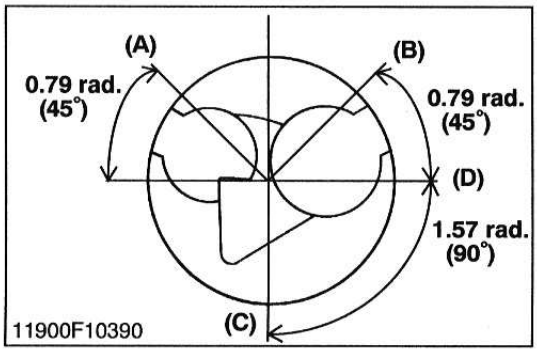
- Align the marks **(a)** with each other. (Face the marks toward the injection pump.)
- Apply engine oil to the connecting rod screws and lightly screw it in by hand, then tighten it to the specified torque.
  If the connecting rod screw won't be screwed in smoothly, clean the threads.
  If the connecting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

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

(a) Mark

01760S10110


01650F10130



11900F10390

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)

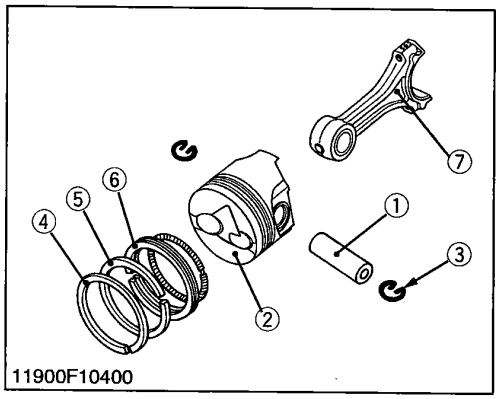
- Before inserting the piston into the cylinder, apply enough engine oil to the cylinder.
- When inserting the piston into the cylinder, face the mark **(a)** on the connecting rod to the injection pump.

■ IMPORTANT

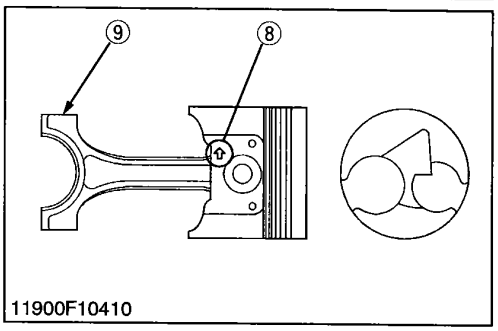
- **Do not change the combination of cylinder and piston. Make sure of the position of each piston by marking. For example, mark "1" on the No.1 piston.**
- **When inserting the piston into the cylinder, place the gap of the compression ring 1 on the opposite side of the combustion chamber and stagger 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

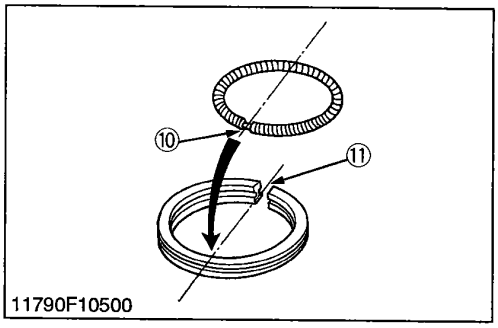
01760S10120



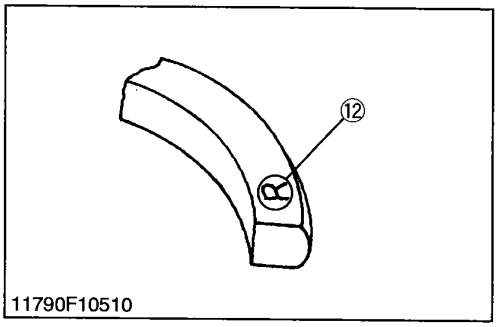
11900F10400



11900F10410



11790F10500



11790F10510

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).

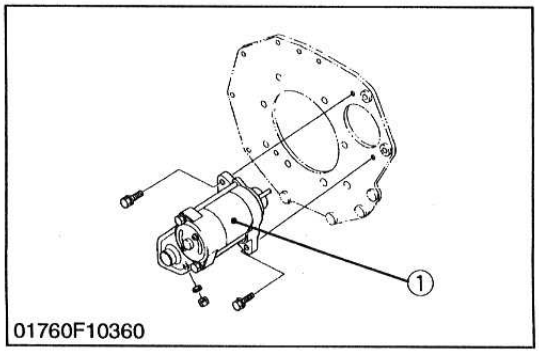
■ IMPORTANT

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

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

11900S10211

[6] FLYWHEEL AND CRANKSHAFT



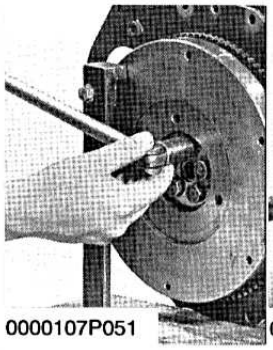
01760F10360

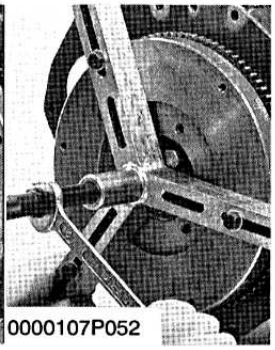
Starter

1. Remove the starter (1).

(1) Starter

01760S10130


0000107P051


0000107P052

Flywheel

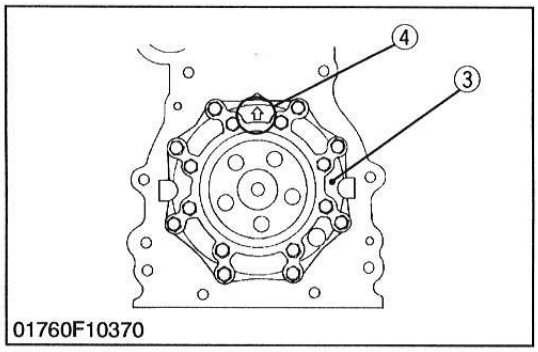
1. Lock the flywheel not to turn using the flywheel stopper.
2. Remove the flywheel screws, except for two which must be loosened and left as they are.
3. Set a flywheel puller (Code No: 07916-32011), and remove the flywheel.

(When reassembling)

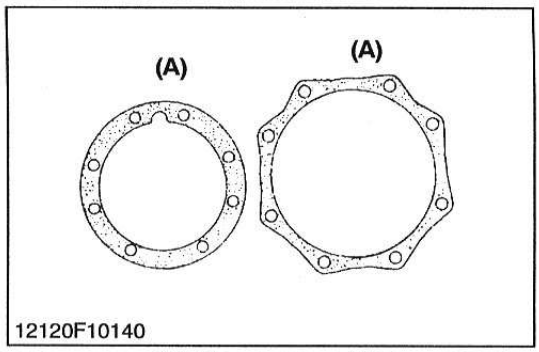
- Apply engine oil to the flywheel screws.

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

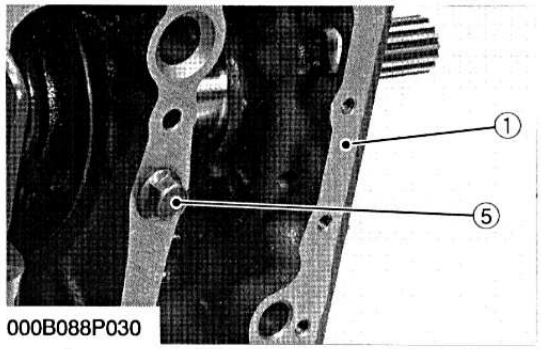
01760S10140



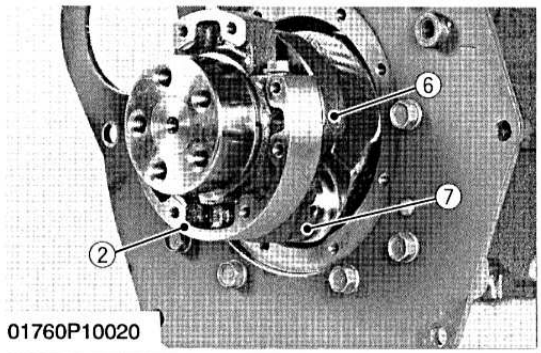
01760F10370



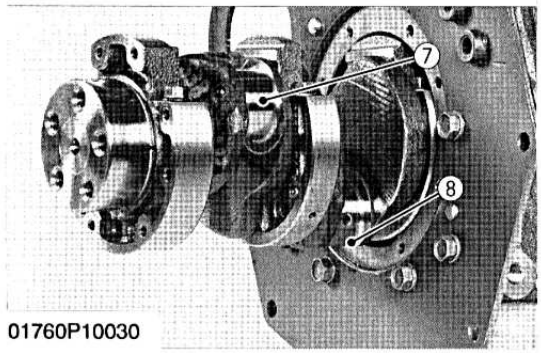
12120F10140



000B088P030



01760P10020



01760P10030

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).
3. Remove the bearing case screw 2 (5).
4. Turn the crankshaft (6) to set the crank pin (7) of the third cylinder to the bottom dead center. Then draw out the crankshaft until the crank pin of the second cylinder comes to the center of the third cylinder.
5. Turn the crankshaft by 2.09 rad. (120°) counterclockwise to set the crank pin (8) of the second cylinder to the bottom dead center. Draw out the crankshaft until the crank pin of the first cylinder comes to the center of the third cylinder.
6. Repeat the above steps to draw out all the crankshafts.

(When reassembling)

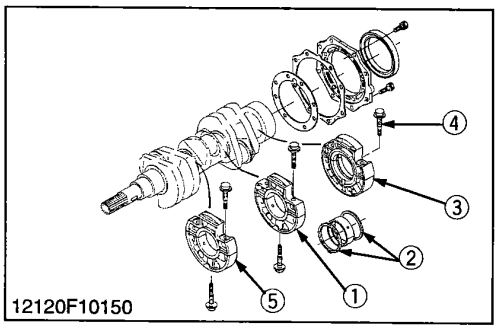
■ **IMPORTANT**

- **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.**
- **Fit the bearing case gasket and the bearing case cover gasket with correct directions (A).**
- **Apply liquid-type gasket (Three Bond 1215 or its equivalent) to both sides of a new bearing case cover gasket.**
- **Install the bearing case cover (3) to position the casting mark "↑" (4) on it upward.**
- **Tighten the bearing case cover mounting screws with even force on the diagonal line.**

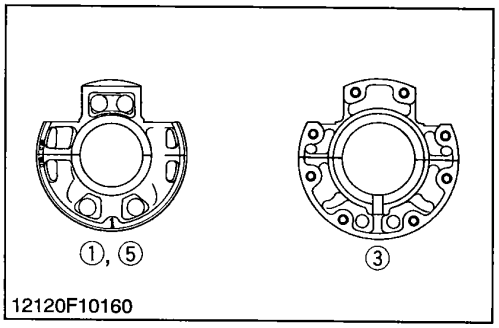
Tightening torque	Bearing case cover mounting screw	9.8 to 11.3 N·m 1.00 to 1.15 kgf·m 7.2 to 8.3 ft-lbs
	Bearing case screw 2	26.5 to 30.4 N·m 2.7 to 3.1 kgf·m 19.5 to 22.4 ft-lbs

(1) Cylinder Block
(2) Main Bearing Case 2
(3) Bearing Case Cover
(4) Top Mark "↑"
(5) Bearing Case Screw 2
(6) Crankshaft
(7) Crank Pin
(8) Crank Pin
(A) Up Side

01760S10150



12120F10150



12120F10160

Main Bearing Case Assembly

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

(When reassembling)

- Clean the oil passage in the main bearing case.
- Apply clean engine oil on the crankshaft bearing 2 and thrust bearings.
- Install the main bearing case assemblies in the original positions. Since diameters of main bearing case vary, install them in order of makings (1, 2) from the gear case side.
- When installing the main bearing case assemblies 1 (5), 2 (1), face the mark **"FLYWHEEL"** to the flywheel.
- Be sure to install the thrust bearing with its oil groove facing outward.
- Do not change the combination of crankshaft bearing and main bearing case.

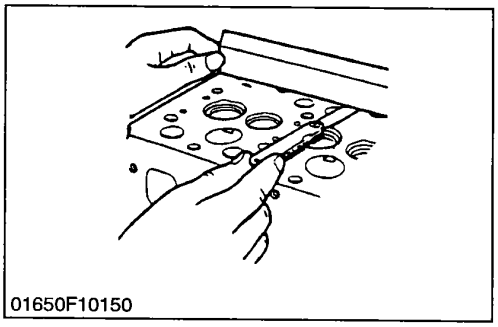
Tightening torque	Bearing case screw 1	12.7 to 15.7 N·m 1.3 to 1.6 kgf·m 9.4 to 11.6 ft-lbs

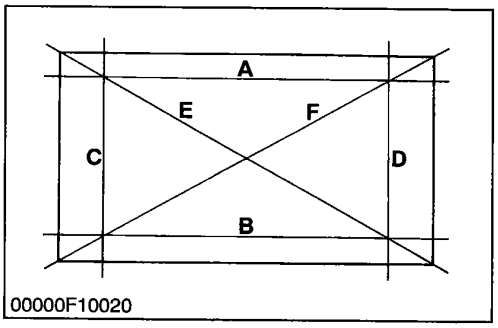
(1) Main Bearing Case Assembly 2
(2) Thrust Bearing
(3) Main Bearing Case Assembly
(4) Bearing Case Screw 1
(5) Main Bearing Case Assembly 1

01760S10160

SERVICING

[1] CYLINDER HEAD


01650F10150



00000F10020

Cylinder Head Surface Flatness

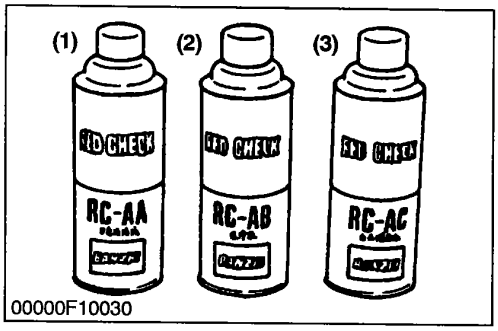
1. Thoroughly clean the cylinder head surface.
2. Place a straightedge on the cylinder head's four sides and two diagonal as shown in the figure.
   Measure the clearance with a feeler gauge.
3. If the measurement exceeds the allowable limit, correct it with a surface grinder.

■ IMPORTANT

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

Cylinder head surface flatness	Allowable limit	0.05 mm 0.0019 in.

01760S10170



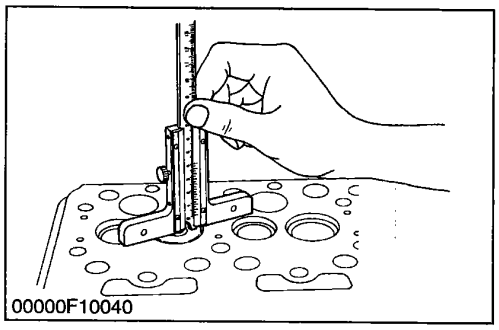
00000F10030

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

00000S10020

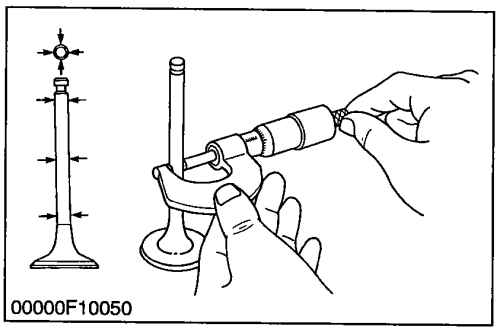

00000F10040

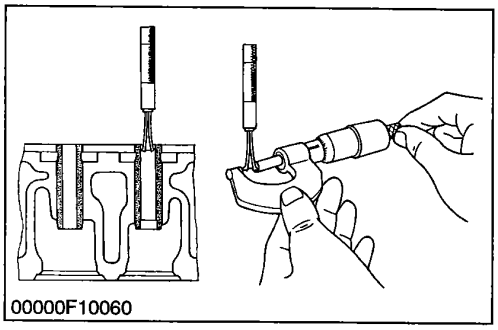
Valve Recessing

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.

Valve recessing (Intake and exhaust)	Factory spec.	– 0.10 to 0.10 mm – 0.0039 to 0.0039 in.
	Allowable limit	0.30 mm 0.0118 in.

01760S10180


00000F10050

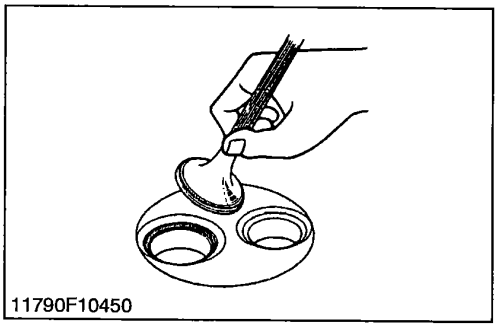

00000F10060

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.

Clearance between valve stem and valve guide	Factory spec.	0.030 to 0.057 mm 0.00118 to 0.00224 in.
	Allowable limit	0.1 mm 0.0039 in.
Valve stem O.D.	Factory spec.	5.968 to 5.980 mm 0.23496 to 0.23543 in.
Valve guide I.D.	Factory spec.	6.010 to 6.025 mm 0.23661 to 0.23720 in.

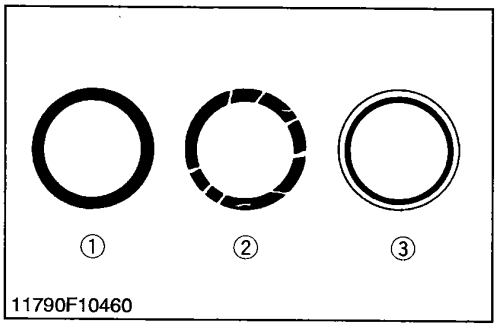
01760S10190


11790F10450

Valve Seating

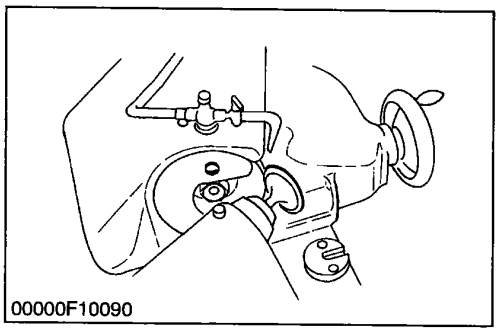
1. Coat the valve face lightly with prussian blue and put the valve on its seat to check the contact.
2. If the valve does not seat all the way around the valve seat or the valve contact is less than 70 %, correct the valve seating as follows.
3. If the valve contact does not comply with the reference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

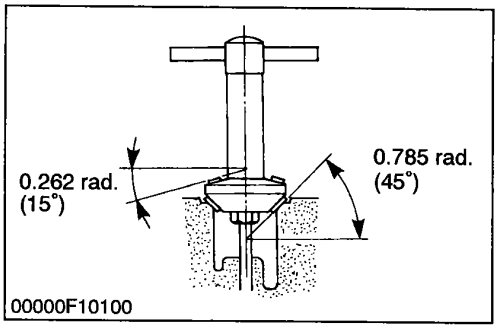
(1) Correct
(2) Incorrect
(3) Incorrect



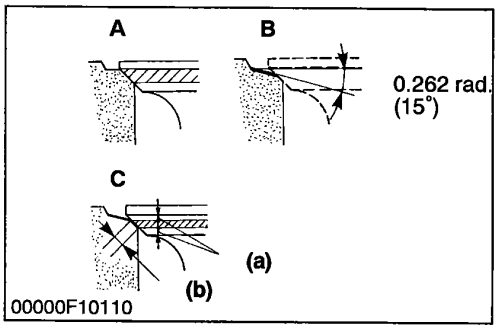
11790F10460

11790S10230


00000F10090



00000F10100



00000F10110

Correcting Valve and Valve Seat

■ **NOTE**

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

1) Correcting Valve

1. Correct the valve with a valve refacer.

Valve face angle	Factory spec.	0.785 rad. 45.0°

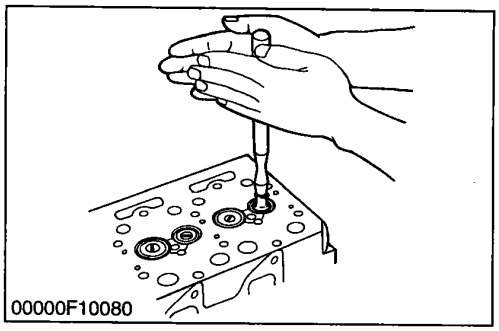
2) Correcting Valve Seat

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

Valve seat angle	Factory spec.	0.785 rad. 45.0°

(a) Identical Dimensions
(b) Valve Seat Width
(A) Check Contact
(B) Correct Seat Width
(C) Check Contact

01650S10390


00000F10080

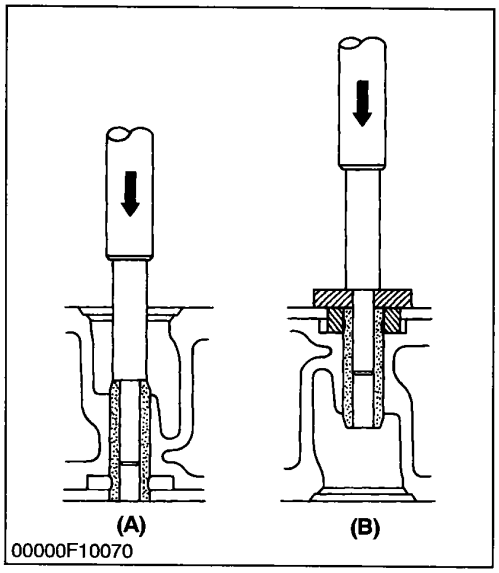
Valve Lapping

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.**

00000S10060



00000F10070

Replacing Valve Guide

(When removing)

1. Using a valve guide replacing tool (see page S-55), 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.

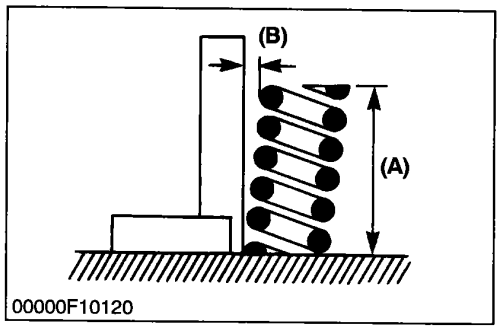
■ IMPORTANT

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

Valve guide I.D. (Intake and exhaust)	Factory spec.	6.010 to 6.025 mm 0.23661 to 0.23720 in.

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

01760S10200

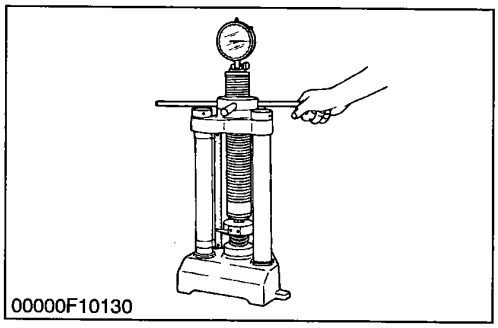


Free Length and Tilt of Valve Spring

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. Replac it, if any.

Free length **A**	Factory spec.	31.6 mm 1.244 in.
	Allowable limit	28.4 mm 1.118 in.
Tilt **B**	Allowable limit	1.2 mm 0.047 in.

01760S10210

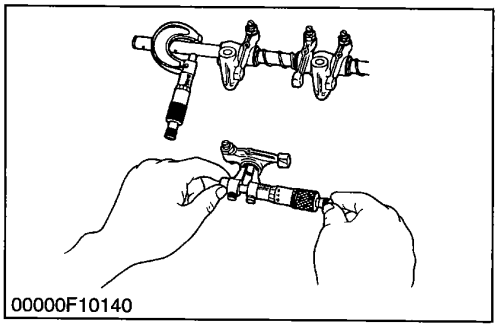


Valve Spring Setting Load

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

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

01760S10220

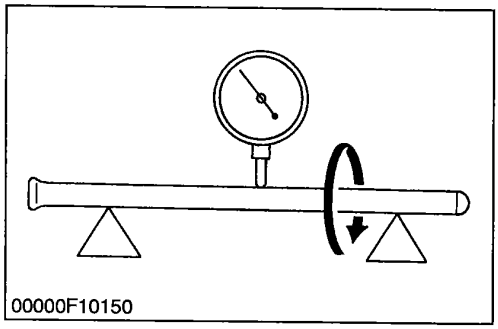


Oil Clearance between Rocker Arm Shaft and Beraing

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.

Oil clearance between rocker arm and rocker arm shaft	Factory spec.	0.016 to 0.045 mm 0.0006 to 0.0018 in.
	Allowable limit	0.15 mm 0.0059 in.
Rocker arm shaft O.D.	Factory spec.	10.437 to 10.484 mm 0.41232 to 0.41276 in.
Rocker arm I.D.	Factory spec.	10.500 to 10.518 mm 0.41339 to 0.41410 in.

01760S10230

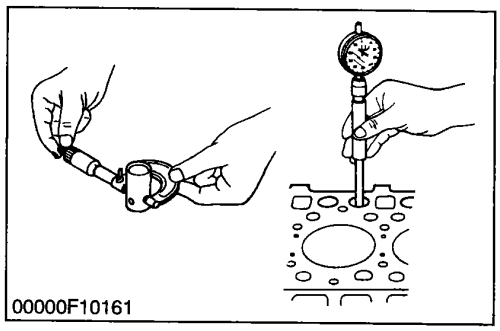

00000F10150

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.

Push rod alignment	Allowable limit	0.5 mm 0.020 in.

01760S10240


00000F10161

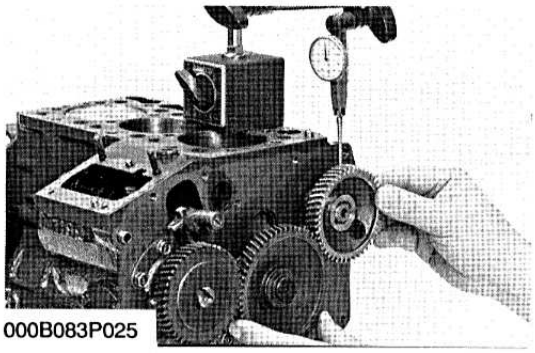
Oil Clearance between Tappet and Tappet Guide Bore

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.

Clearance between tappet and guide	Factory spec.	0.016 to 0.052 mm 0.00063 to 0.00205 in.
	Allowable limit	0.10 mm 0.0039 in.
Tappet O.D.	Factory spec.	17.966 to 17.984 mm 0.70732 to 0.70803 in.
Tappet guide I.D.	Factory spec.	18.000 to 18.018 mm 0.70866 to 0.70939 in.

01760S10250

[2] TIMING GEAR AND CAMSHAFT

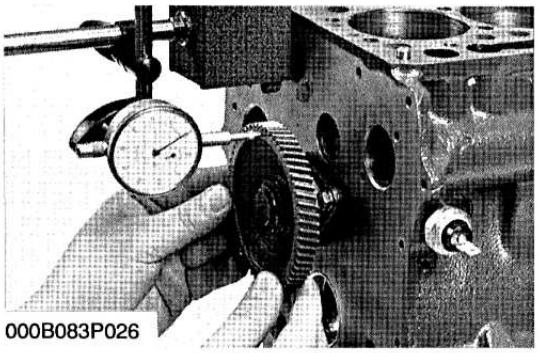

000B083P025

Timing Gear Backlash

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

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

01760S10260

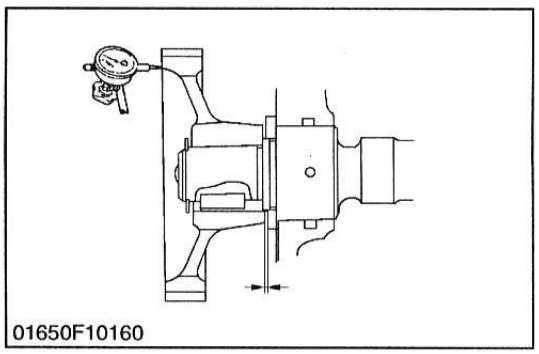

000B083P026

Idle Gear Side Clearance

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

Idle gear side clearance	Factory spec.	0.20 to 0.51 mm 0.0079 to 0.0200 in.
	Allowable limit	0.60 mm 0.0236 in.

01760S10270

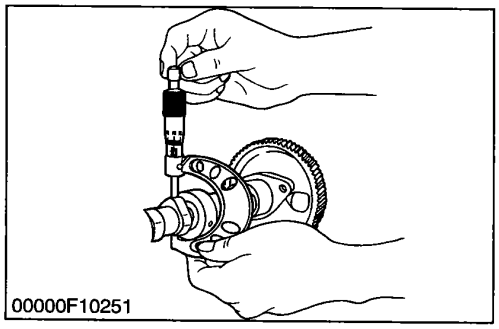

01650F10160

Camshaft Side Clearance

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

Camshaft side clearance	Factory spec.	0.15 to 0.31 mm 0.0059 to 0.0122 in.
	Allowable limit	0.50 mm 0.020 in.

01760S10280

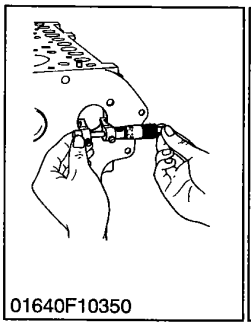

00000F10251

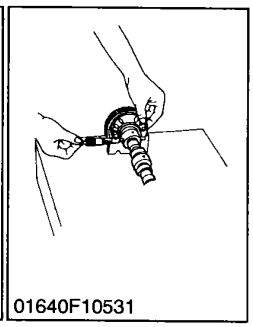
Cam Height

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

Cam height of intake and exhaust	Factory spec.	26.88 mm 1.0583 in.
	Allowable limit	26.83 mm 1.0563 in.

01760S10290


01640F10350

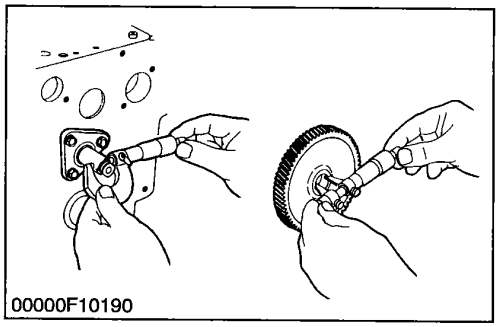

01640F10531

Oil Clearance of Camshaft Journal

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

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

01760S10300

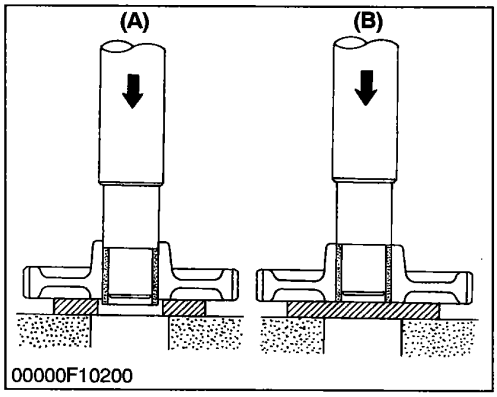

00000F10190

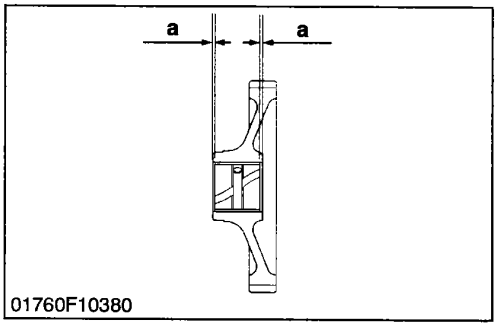
Oil Clearance between Idle Gear Shaft and Idle Gear Bushing

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.

Oil clearance between idle gear shaft and idle gear bushing	Factory spec.	0.020 to 0.084 mm 0.00080 to 0.00331 in.
	Allowable limit	0.10 mm 0.0039 in.
Idle gear shaft O.D.	Factory spec.	19.967 to 19.980 mm 0.78610 to 0.78661 in.
Idle gear bushing I.D.	Factory spec.	20.000 to 20.051 mm 0.78740 to 0.78941 in.

01760S10310





Replacing Idle Gear Bushing

(A) (When removing)

1. Using an idle gear bushing replacing tool (see page S-59), press out the used bushing.

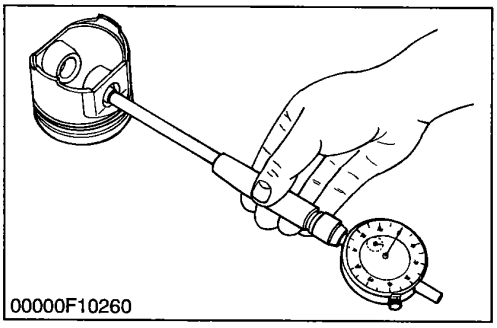
(B) (When installing)

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.)

Dimension (a)	Factory spec.	0 to 0.2 mm 0 to 0.7874 in.

01760S10320

[3] PISTON AND CONNECTING ROD

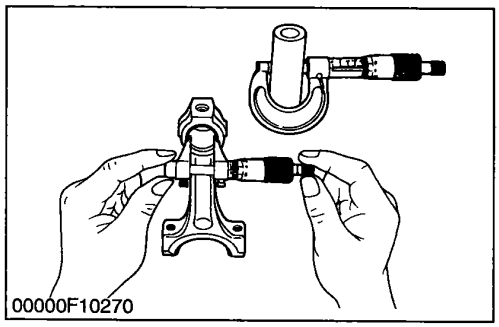


Piston Pin Bore I.D.

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

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

01760S10330

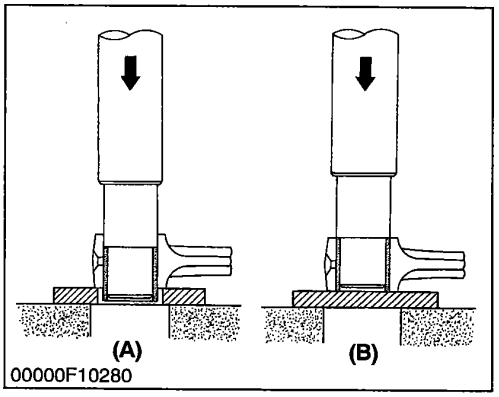

00000F10270

Oil Clearance between Piston Pin and Small End Bushing

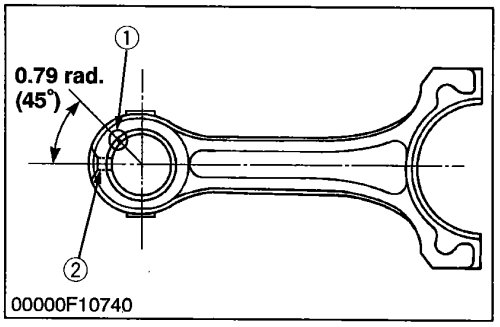
1. Measure the O.D. of the piston pin where it contacts the bushing with an outside micrometer.
2. Measure the I.D. of the piston pin bushing at the connecting rod small end with a cylilnder gauge.
   Calculate the oil clearance.
3. If the clearance exceeds the allowable limit, replace the bushing. If it still exceeds the allowable limit, replace the piston pin.

Oil clearance between piston pin and small end bushing	Factory spec.	0.014 to 0.038 mm 0.0006 to 0.0015 in.
	Allowable limit	0.10 mm 0.0039 in.
Piston pin O.D.	Factory spec.	20.002 to 20.011 mm 0.78748 to 0.78783 in.
Small end bushing I.D.	Factory spec.	20.025 to 20.040 mm 0.78839 to 0.78897 in.

01760S10340



00000F10280



00000F10740

Replacing Small End Bushing

(When removing)

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

(When installing)

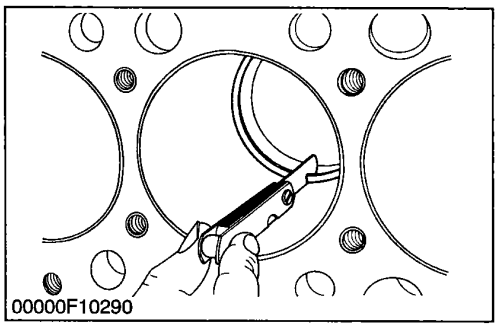
1. Clean a new small end bushing and bore, and apply engine oil to them.
2. Insert a new bushing onto the tool and press-fit it with a press so that the seam (1) of bushing positions as shown in the figure, until it is flash with the connecting rod.
3. Drill a hole to the bushing with aligning the oil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


00000F10290

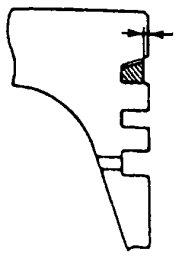
Piston Ring Gap

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.

Piston ring gap	Top compression ring and second compression ring	Factory spec.	0.25 to 0.40 mm 0.0098 to 0.0157 in.
		Allowable limit	1.25 mm 0.0492 in.
	Oil ring	Factory spec.	0.15 to 0.30 mm 0.0059 to 0.0177 in.
		Allowable limit	1.25 mm 0.0492 in.

01760S10350

[A]


01640F10360

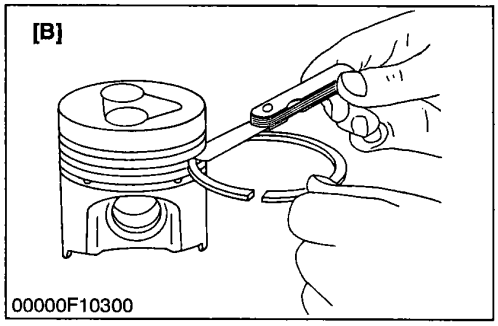
Clearance between Piston Ring and Groove

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.

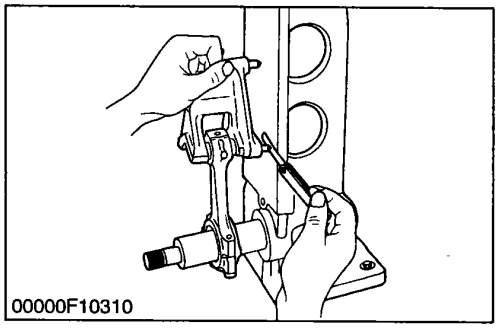
Clearance between piston ring and groove	Second compression ring	Factory spec.	0.090 to 0.120 mm 0.0035 to 0.047 in.
		Allowable limit	0.15 mm 0.0059 in.
	Oil ring	Factory spec.	0.0040 to 0.080 mm 0.0016 to 0.0031 in.
		Allowable limit	0.15 mm 0.0059 in.

[B]


00000F10300

(A) Top Ring (Key Stone Type) **(B) 2nd, Oil Ring**

01760S10360


00000F10310

Connecting Rod Alignment

■ **NOTE**

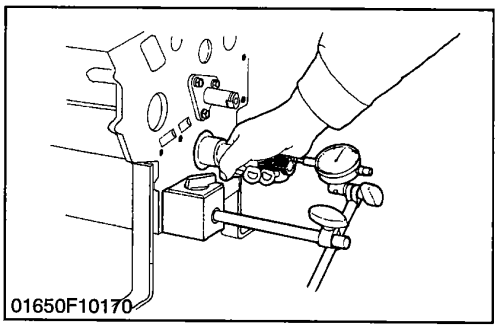
- **Since the I.D. of the connecting rod small end bushing is the basis of this check, check the bushing for wear beforehand.**

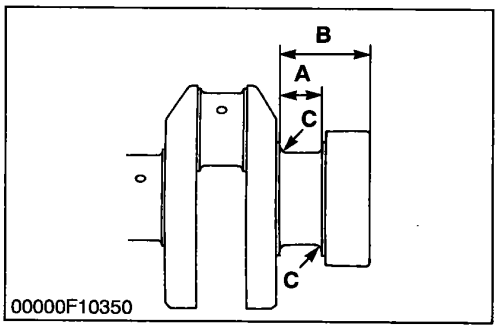
1. Remove the crankpin bearing, and install the connecting rod cap.
2. Install the piston pin in the connecting rod.
3. Install the connecting rod on the connecting rod alignment tool (Code No. 07909-31661).
4. Put a gauge over the piston pin, and move it against the face plate.
5. If the gauge does 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.

Bend of connecting rod	Allowable limit	0.05 per 100 mm 0.0020 per 3.9370 in.

01760S10370

[4] CRANKSHAFT


01650F10170



00000F10350

Crankshaft Side Clearance

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

Crankshaft side clearance	Factory spec.	0.15 to 0.31 mm 0.0059 to 0.0122 in.
	Allowable limit	0.50 mm 0.0197 in.

(Reference)

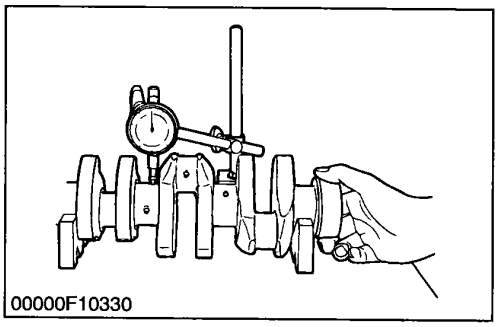
- Oversize thrust bearing

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

- Oversize dimensions of crankshaft journal

Oversize	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
The crankshaft journal must be fine-finished to higher than ∇∇∇∇ (0.8-S).		

01760S10380

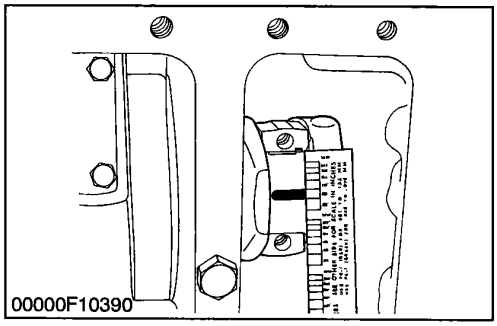

00000F10330

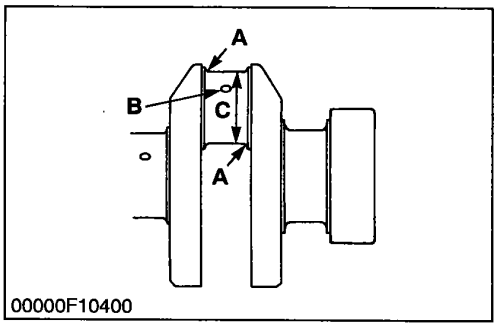
Crankshaft Alignment

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.

Circle runout	Allowable limit	0.02 mm 0.0008in.

01760S10390


00000F10390



00000F10400

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.	0.020 to 0.051 mm 0.0008 to 0.0020 in.
	Allowable limit	0.15 mm 0.0059 in.
Crankpin O.D.	Factory spec.	33.959 to 33.975 mm 1.3370 to 1.3376 in.
Crankpin bearing I.D.	Factory spec.	33.995 to 34.010 mm 1.3384 to 1.3389 in.

(Reference)

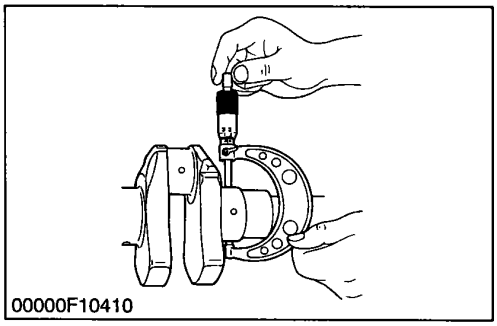
- Undersize crankpin bearing

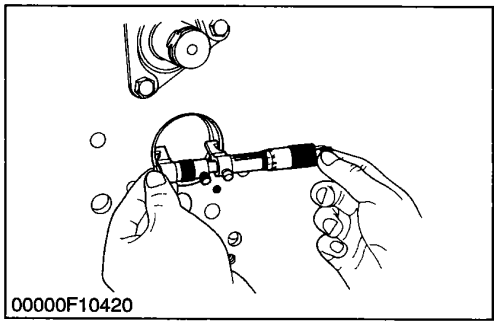
Undersize	Bearing	Code Number	Marking
0.2 mm 0.008 in.	Crankpin bearing 02	15861-22971	020 US
0.4 mm 0.016 in.	Crankpin bearing 04	15861-22981	040 US

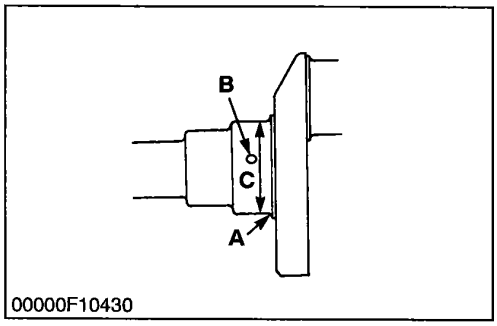
- Undersize dimensions of crankpinl

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.
The crankpin must be fine-finished to higher than ▽▽▽▽ (0.8-S).		

01760S10400


00000F10410


00000F10420



00000F10430

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)

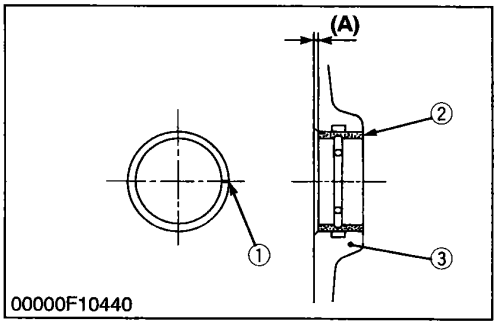
- Undersize crankshaft bearing 1

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

00000S10332



00000F10440

Replacing Crankshaft Bearing 1

(When removing)

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

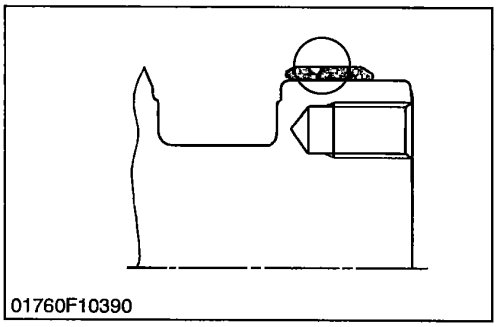
(When installing)

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.

(1) Seam
(2) Crankshaft Bearing 1
(3) Cylinder Block

00000S10341

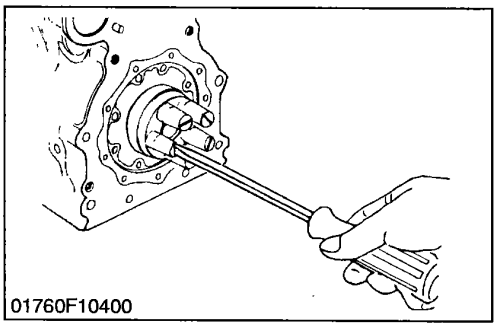

01760F10390

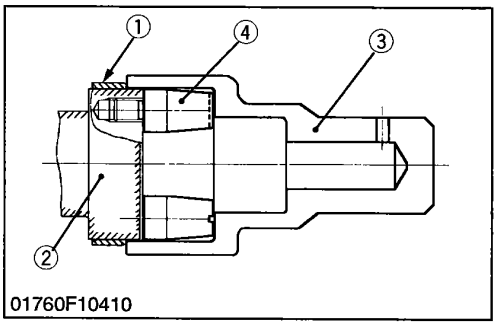
Crankshaft Sleeve Wear

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

Wear of sleeve	Allowable limit	0.1 mm 0.004 in.

01760S10410


01760F10400



01760F10410

Replacing Crankshaft Sleeve

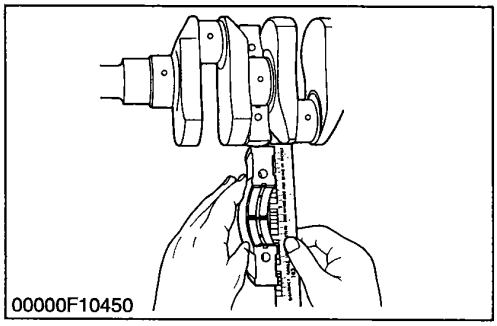
1. Remove the used crankshaft sleeve.
2. Set the sleeve guide (4) to the crankshaft.
3. Heat a new sleeve to a temperature between 150 and 200 °C (302 and 392 °F), and fix the sleeve to the crankshaft as shown in figure.
4. Press fit the sleeve using the auxiliary socket for pushing (3).

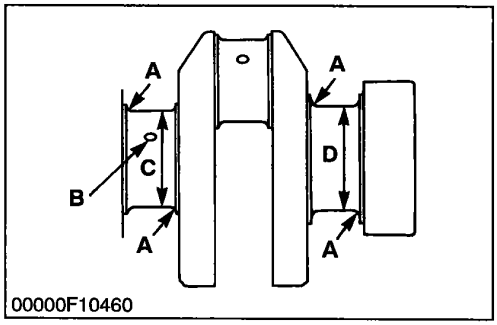
■ **NOTE**

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

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

01760S10420


00000F10450



00000F10460

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 0.0011 to 0.0023 in.
	Allowable limit	0.20 mm 0.0079 in.
Crankshaft journal O.D. (Intermediate)	Factory spec.	39.934 to 39.950 mm 1.5722 to 1.5728 in.
Crankshaft bearing 3 I.D.	Factory spec.	39.978 to 39.993 mm 1.5739 to 1.5745 in.

Oil clearance between crankshaft journal and crankshaft bearing 2	Factory spec.	0.028 to 0.059 mm 0.0011 to 0.0023 in.
	Allowable limit	0.20 mm 0.0079 in.
Crankshaft journal O.D. (Flywheel side)	Factory spec.	43.978 to 43.993 mm 1.7314 to 1.7320 in.
Crankshaft bearing 2 I.D.	Factory spec.	43.984 to 44.026 mm 1.7317 to 1.7333 in.

01760S10430

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

(Reference)

- Undersize crankshaft bearing 2 and 3

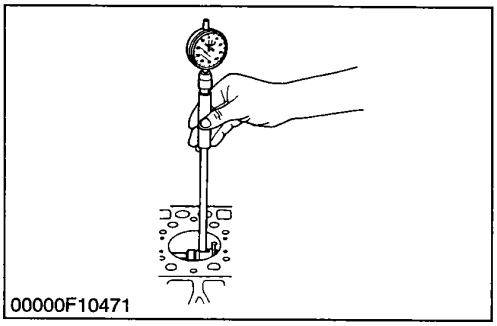
Undersize	Bearing	Code Number	Marking
0.2 mm 0.008 in.	Crankshaft bearing 2 02	15694-23931	020 US
	Crankshaft bearing 3 02	15861-23861	020 US
0.4 mm 0.016 in.	Crankshaft bearing 2 04	15694-23941	040 US
	Crankshaft bearing 3 04	15861-23871	040 US

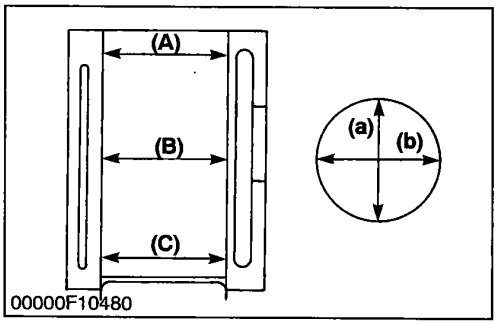
- Undersize dimensions of crankshaft journal

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 ▽▽▽▽ (0.8 S).		

00000S10354

[5] CYLINDER


00000F10471



00000F10480

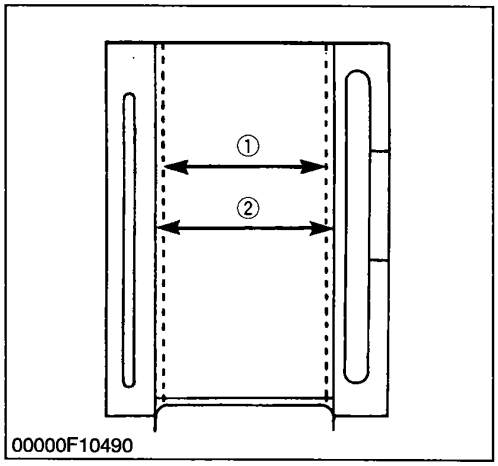
Cylinder Wear

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"**.)

Cylihnder I.D.	Factory spec.	67.000 to 67.019 mm 2.63779 to 2.63854 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

01760S10440



00000F10490

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.	67.250 to 67.269 mm 2.64764 to 2.64839 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	1E051-21901	025 OS
Piston ring assembly	16853-21091	025 OS

■ **NOTE**

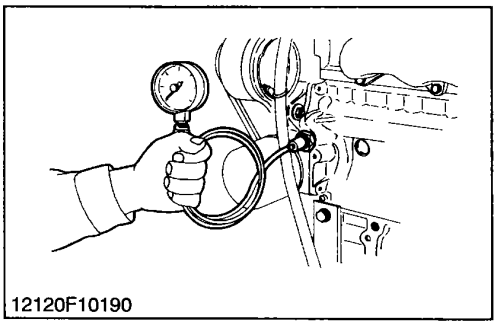
- **When the oversize cylinder is worn beyond the allowable limit, replace the cylinder block with a new one.**

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

01760S10450

2 LUBRICATING SYSTEM

CHECKING


12120F10190

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

Engine oil pressure	Factory spec.	At idle speed	68 kPa 0.7 kgf/cm^2 10.0 psi
		At rated speed	196 to 441 kPa 2.0 to 4.5 kgf/cm^2 28.0 to 64.0 psi
	Allowable limit	At rated speed	98 kPa 1.0 kgf/cm^2 14 psi

(When reassembling)

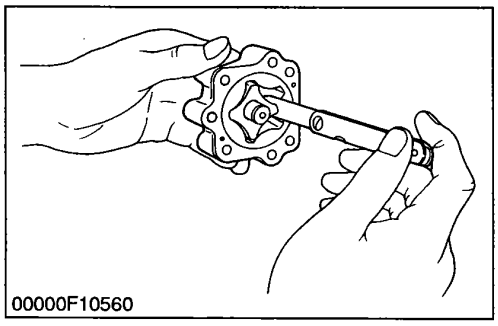
- After checking the engine oil pressure, tighten the engine oil pressure switch to the specified torque.

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

01760S10460

SERVICING

[1] OIL PUMP

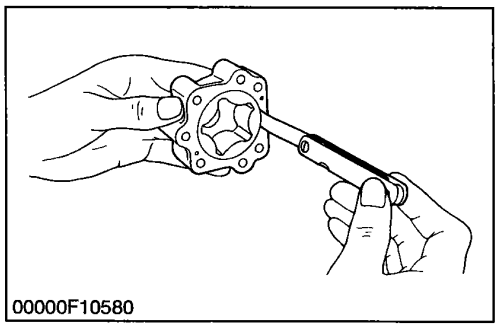

00000F10560

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.

Rotor lobe clearance	Allowable limit	0.03 to 0.14 mm 0.0012 to 0.0055 in.

01760S10470

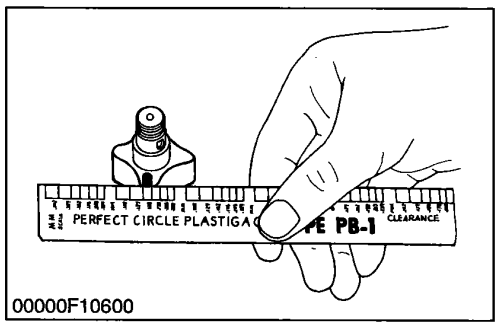

00000F10580

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.

Clearance between outer rotor and pump body	Factory spec.	0.07 to 0.15 mm 0.0028 to 0.0059 in.
	Allowable limit	0.30 mm 0.0118 in.

01760S10480



00000F10600

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.

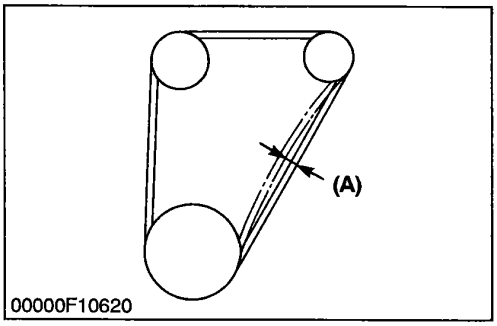
Clearance between rotor and cover	Factory spec.	0.075 to 0.135 mm 0.0029 to 0.0053 in.
	Allowable limit	0.20 mm 0.0078 in.

01760S10490

3 COOLING SYSTEM

CHECKING

[1] FAN BELT



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 nut.

Fan belt tension (Deflection A)	Factory spec.	Approx. 10 mm 0.394 in.

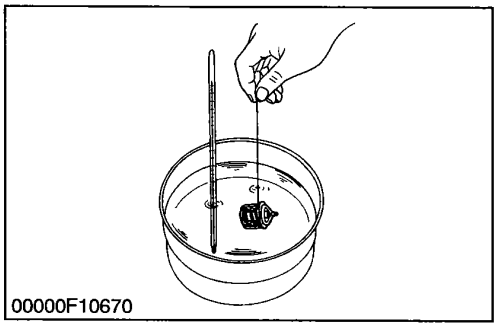
01760S10500

[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.**

01640S10430

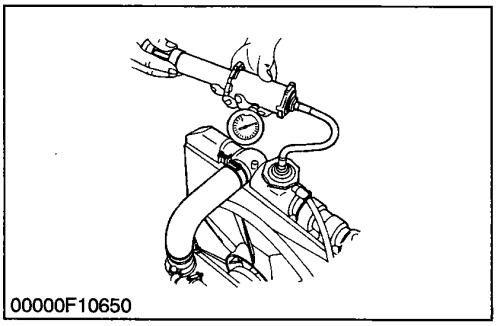


Thermostat Valve Opening Temperature

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

00000S10492

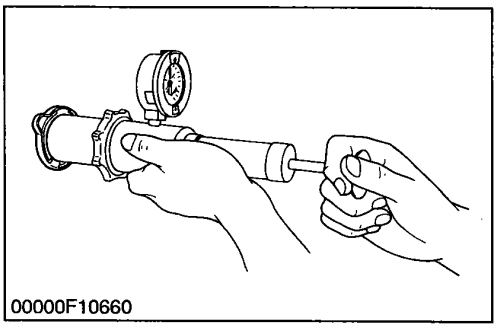

00000F10650

Radiator Water Leakage

1. Pour a specified amount of water into the radiator.
2. Set a radiator tester (Code No. 07909-31551).
   Increase water pressure to the specified pressure of 157 kPa (1.6 kgf/cm^2, 23 psi).
3. Check the radiator for water leaks.
4. When water leakage is excessive, replace the radistor. If water leakage is caused by a small pinhole, correct the radiator with radistor cement.

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

01760S10510


00000F10660

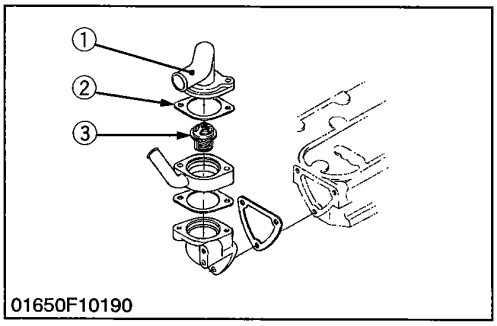
Radiator Cap Air Leakage

1. Set a radiator tester (Code No. 07909-31551) on the radiator cap.
2. Apply the specified pressure of 88.2 kPa (0.9 kgf/cm^2, 12.8 psi).
3. ,Check if the pressure drop to less than 59 kPa (0.6 kgf/cm^2, 9 psi) in 10 seconds.
4. If the pressure is less than the factory specification, replace it.

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

01760S10520

DISASSEMBLING AND ASSEMBLING



01650F10190

Thermostat Assembly

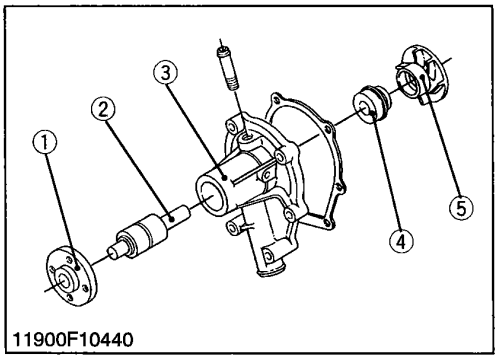
1. Remove the thermostat cover mounting screws, and remove the thermostat cover (1).
2. Remove the thermostat assembly (3).

(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



11900F10440

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.

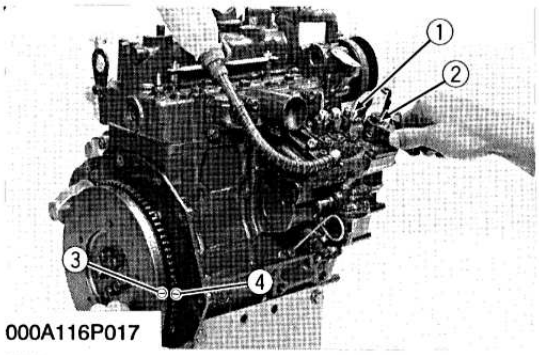
(1) Water Pump Flange
(2) Water Pump Shaft
(3) Water Pump Body
(4) Mechanical Seal
(5) Impeller

11900S10280

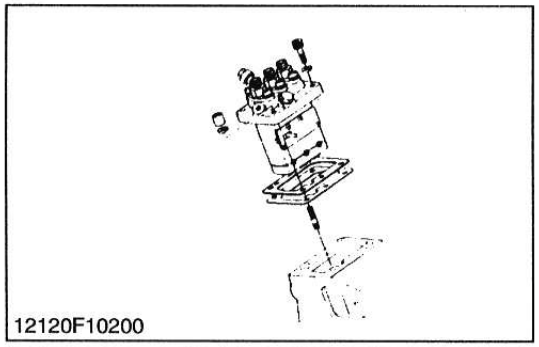
4 FUEL SYSTEM

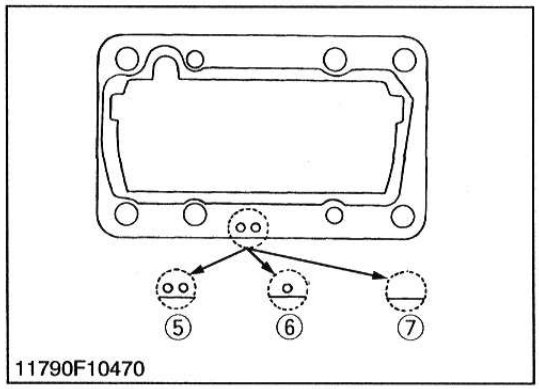
CHECKING AND ADJUSTING

[1] INJECTION PUMP



000A116P017


12120F10200



11790F10470

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

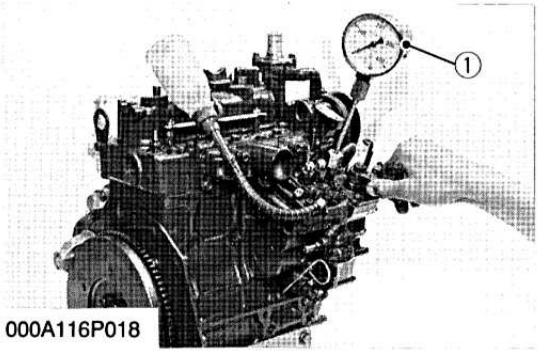
Injection timing	Factory spec.	0.33 to 0.37 rad. (19 to 21°) before T.D.C.

■ **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) Speed Control Lever
(3) Punch Mark
(4) Timing Mark
(5) Two-holes : 0.20 mm (0.0079 in.)
(6) One-hole : 0.25 mm (0.0098 in.)
(7) Without hole : 0.30 mm (0.0118 in.)

01760S10530



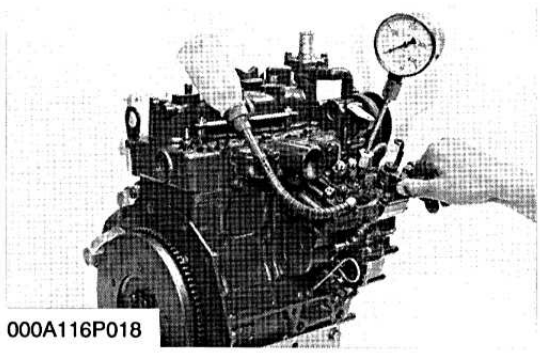
Fuel Tightness of Pump Element

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

Pump element fuel tightness (Fuel pressure)	Allowable limit	14.71 MPa 150 kgf/cm^2 2133 psi

(1) Injection Pump Pressure Tester

01760S10540



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^2, 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^2, 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^2, from 2133 to 1990 psi).
6. If the measurement is less than allowable limit, replace the delivery valve.

Pressure falling time	Allowable limit	5 seconds

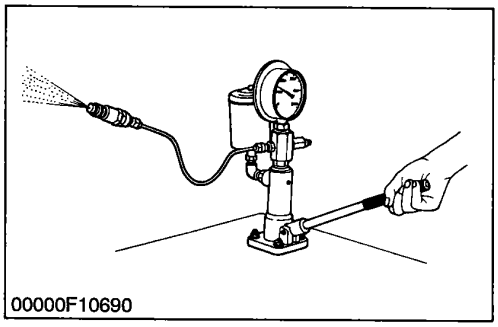
01760S10550

[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.

11790S10690


00000F10690

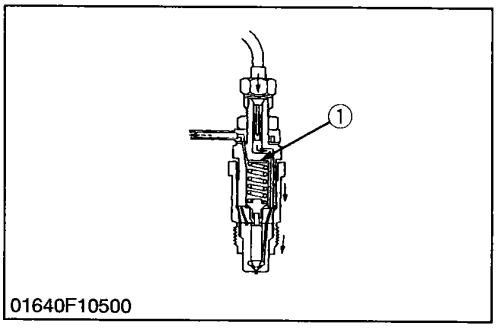
Nozzle Injection Pressure

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

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

(Reference)

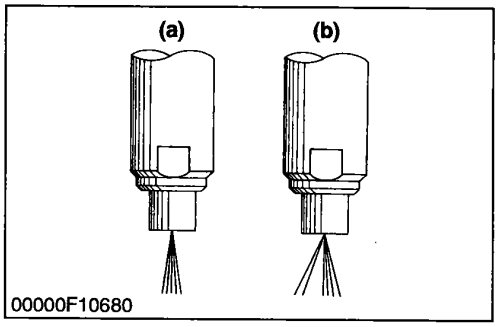
- Pressure variation with 0.025 mm (0.001 in.) difference of adjusting washer thickness.
  Approx. 59 kPa (6 kgf/cm^2, 85 psi)



01640F10500

(1) Adjusting Washer

01760S10560



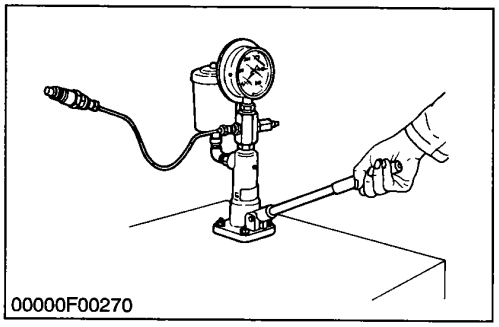
00000F10680

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**

00000S10500


00000F00270

Valve Seat Tightness

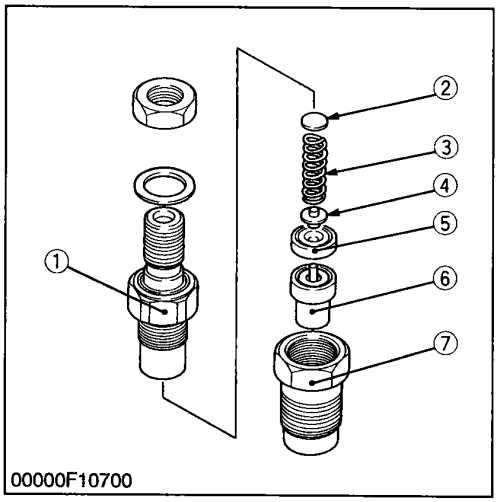
1. Set the injection nozzle to a nozzle tester (Code No. 07909-31361).
2. Raise the fuel pressure, and keep at 12.75 MPa (130 kgf/cm^2, 1849 psi) for 10 seconds.
3. If any fuel leak is found, replace the nozzle piece.

Valve seat tightness	Factory spec.	No fuel leak at 12.75 Mpa (130 kgf/cm^2, 1849 psi)

01760S10570

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.

Tightening torque	Fuel overflow pipe nut	19.6 to 24.5 N·m 2.0 to 2.5 kgf·m 14.5 to 18.1 ft-lbs
	Nozzle holder to nozzle retaining nut	34.3 to 39.2 N·m 3.5 to 4.0 kgf·m 25.3 to 28.8 ft-lbs
	Injection nozzle to cylinder head	49.0 to 68.6 N·m 5.0 to 7.0 kgf·m 36.2 to 50.6 ft-lbs

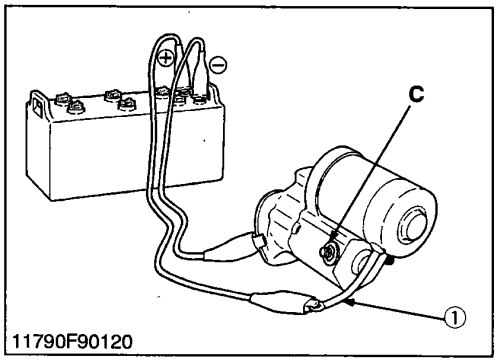
(1) Nozzle Holder
(2) Adjusting Washer
(3) Nozzle Spring
(4) Push Rod
(5) Distance Piece
(6) Nozzle Piece
(7) Nozzle Retaining Nut

01760S10580

5 ELECTRICAL SYSTEM

CHECKING

[1] STARTER



11790F90120

Motor Test

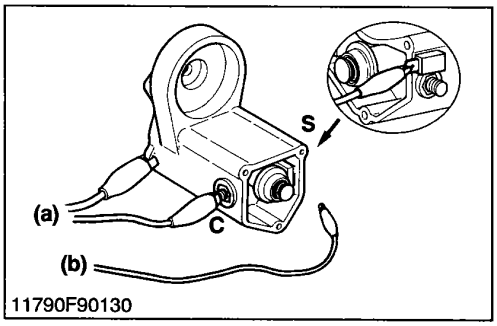
CAUTION

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

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

(1) Connecting Lead

11790S90180



11790F90130

Magnet Switch Test (Pull-in, Holding Coils)

1. Remove the motor from the starter housing.
2. Preparate a 6 V battery for the test.
3. Connect jumper leads from the battery negative terminal to the housing and the starter **C** terminal.
4. The plunger should be attached and the pinion gear should pop out when a jumper lead is connected from the battery positive terminal to the **S** terminal. It's a correct.
5. Disconnect the jumper lead to the starter **C** terminal. Then the pinion gear should remain popped out. It's a correct.

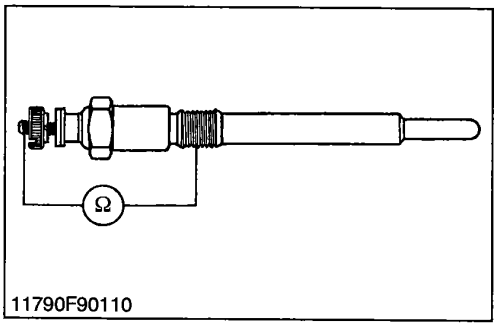
IMPORTANT

- **Testing time must be 3 to 5 sec.**

(a) To Negative Terminal **(b) To Positive Terminal**

11790S90190

[2] GLOW PLUG



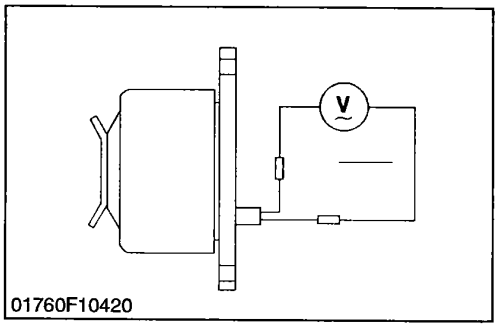
Glow Plug

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

Glow plug resistance	Factory spec.	Approx. 0.9 ohms

01650S90020

[3] DYNAMO AND REGULATOR

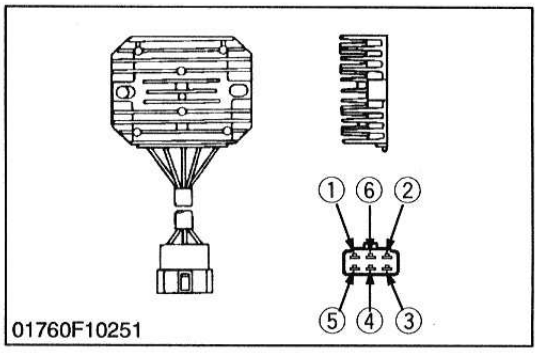


Dynamo No-load Voltage

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

No load dynamo voltage	Factory spec.	AC 20 V or more at 5200 rpm

01760S10590



01760F10251

Continuity across Regulator's Terminals

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

■ NOTE

- **For this test, use only Analog Meter and do not use a high voltage tester such as a MΩ meter.**
- **This check sheet shows the results of the test conducted by using the "Sanwa-made testers SP-10 and SP-15D" (Analog Meter).**
- **Use of other testers than those above may show different measured results. Ω shall be used as the unit for the measuring range.**
- **The judgement shoule be as below table. "ON" if the indicator moves, otherwise "OFF".**

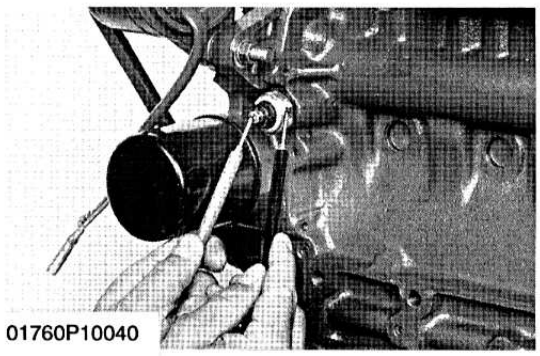
■ Check Table

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

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

01760S10600

[4] OIL PRESSURE SWITCH


01760P10040

Oil Pressure Switch Continuity

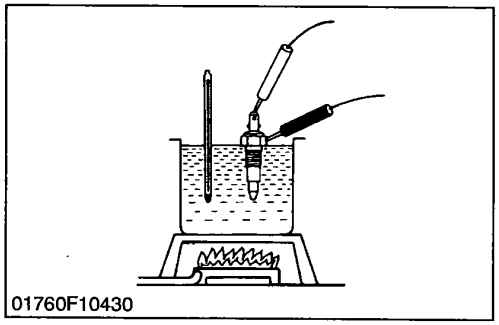
1. Using an ohmmeter, check that there is continuity between the switch terminal and switch body when the engine is stopped.
2. If there is no continuity, the oil pressure switch is faulty.
3. Start the engine, and check that there is no continuity between the switch terminal and the chassis.
4. If there is continuity, the oil pressure switch is faulty.

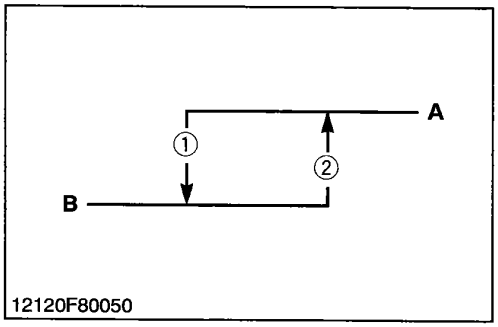
■ IMPORTANT

- **Before performing the oil pressure switch continuity, be sure to check that the engine oil pressure is more than allowable limit.**

01760S10610

[5] COOLANT TEMPERATURE SWITCH


01760F10430



12120F80050

Coolant Temperature Switch Continuity

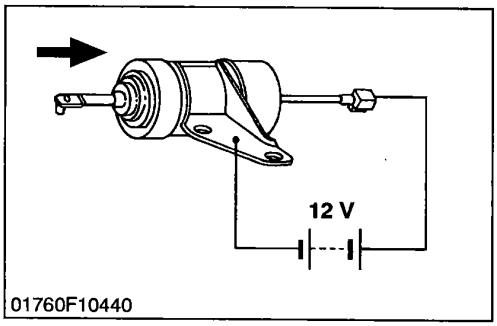
1. Disconnect the **1P** connector, and remove the coolant temperature switch.
2. Immerse the coolant temperature switch in the oil as shown in the figure.
3. Heating the oil gradually, measure the resistance with an ohmmeter between the switch terminal and its body.
4. If the factory specification is not indicated, the coolant temperature switch is faulty.

Coolant temperature switch resistance	Factory spec.	Infinity [less than 112 °C, 233 °F]
		Continuity [112 to 118 °C, 233 to 280 °F]

(1) 112 °C (233 °F) or more
(2) 112 to 118 °C (233 to 280 °F)
(A) ON
(B) OFF

01760S10620

[6] ENGINE STOP SOLENOID



01760F10440

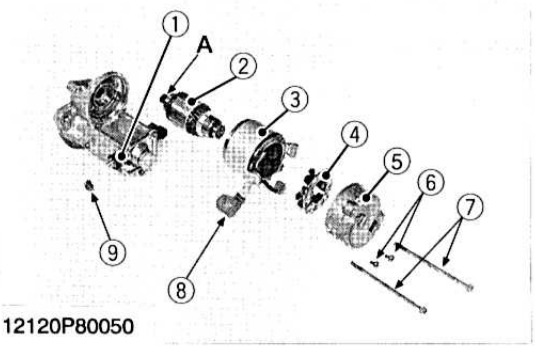
Solenoid Test

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

01760S10630

DISASSEMBLING AND ASSEMBLING

[1] STARTER



12120P80050

Disassembling Motor

1. Disconnected the connecting lead (8) from the magnet switch (1).
2. Remove the through screws (6), and then separate the end frame (5), yoke (3) and armature (2).
3. Remove the two screws (7), and then take out the brush holder (4) from the end frame (5).

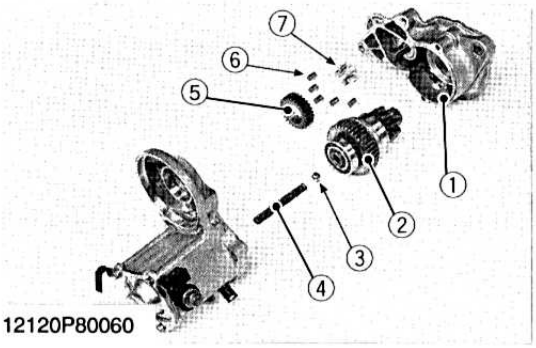
(When reassembling)

- Apply grease to the spline teeth **(A)** of the armature (2).

(1) Magnet Switch
(2) Armature
(3) Yoke
(4) Brush Holder
(5) End Frame
(6) Screws
(7) Screws
(8) Connecting Lead
(9) Nut

(A) Spline Teeth

01760S10640



12120P80060

Disassembling Magnet Switch

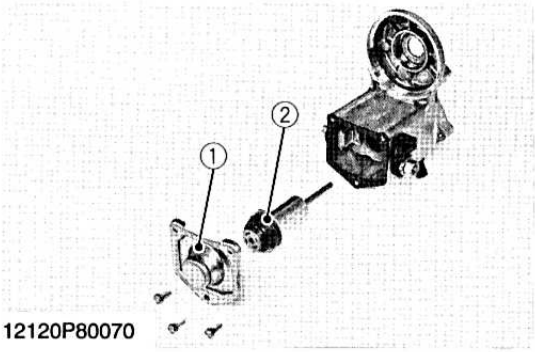
1. Remove the drive end frame (1) mounting screws.
2. Take out the over running clutch (2), ball (3), spring (4), gear (5), rollers (6) and retainer (7).

(When reassembling)

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

(1) Drive End Frame
(2) Over Running Clutch
(3) Ball
(4) Spring
(5) Gear
(6) Roller
(7) Retainer

01760S10650



12120P80070

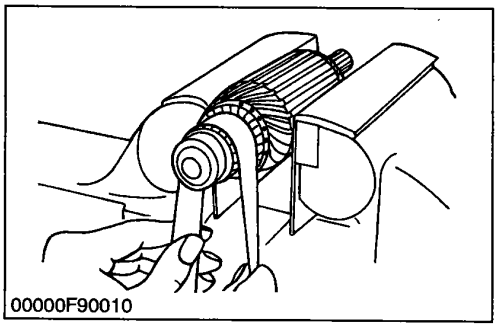
Plunger

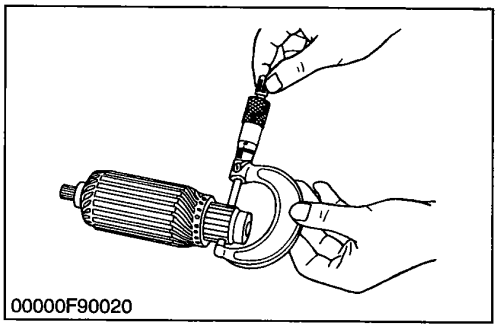
1. Remove the end cover (1).
2. Take out the plunger (2).

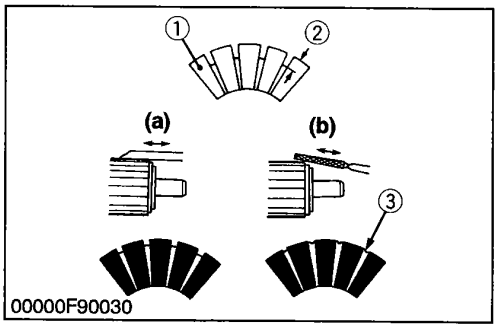
(1) End Cover
(2) Plunger

01760S10660

SERVICING
[1] STARTER


00000F90010


00000F90020



00000F90030

Commutator and Mica

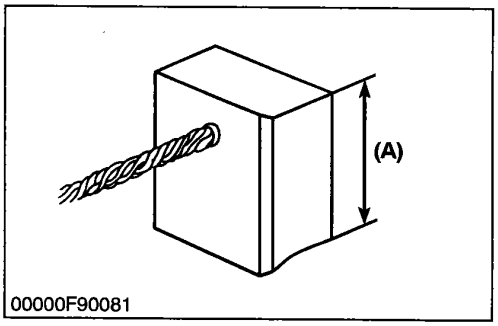
1. Check the contact face of the commutator for wear, and grind the commutator with emery paper if it is slightly worn.
2. Measure the commutator O.D. with an outside micrometer at several points.
3. If the minimum O.D. is less than the allowable limit, replace the armature.
4. If the difference of the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

Commutator O.D.	Factory spec.	30.0 mm 1.1811 in.
	Allowable limit	29.0 mm 1.1417 in.
Difference of O.D.'s	Factory spec.	Less than 0.05 mm 0.00197 in.
	Allowable limit	29.0 mm 1.1417 in.
Mica undercut	Factory spec.	0.5 to 0.8 mm 0.0197 to 0.0315 in.
	Allowable limit	0.2 mm 0.079 in.

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

(a) Good
(b) Bad

01760S10670



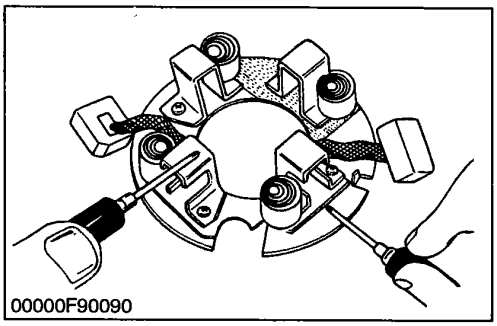
00000F90081

Brush Wear

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

Brush length	Factory spec.	13.0 mm 0.5118 in.
	Allowable limit	8.5 mm 0.3346 in.

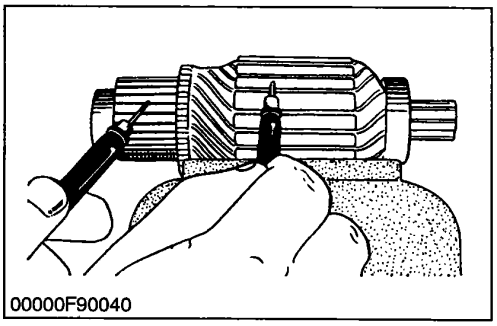
01760S10680


00000F90090

Brush Holder

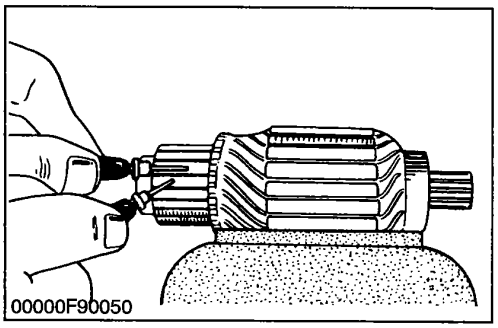
1. Check the continuity across the brush holder and the holder support with an ohmmeter.
2. If it conducts, replace the brush holder.

00000S90050

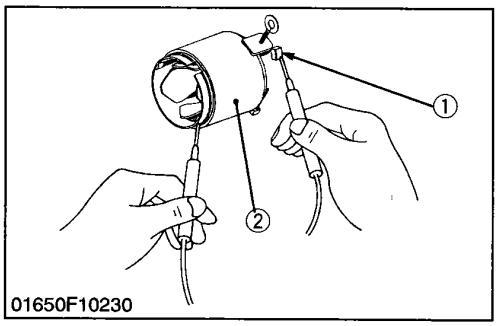

00000F90040

Armature Coil

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


00000F90050

00000S90020



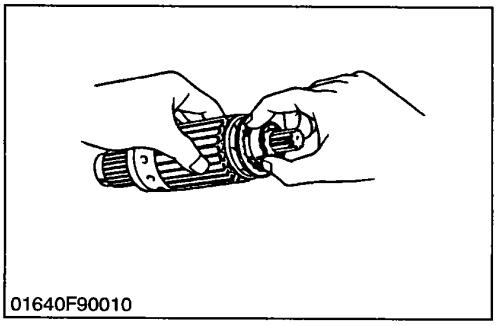
01650F10230

Field Coil

1. Check the continuity across the brush (1) and yoke (2) with an ohmmeter.
2. If it conducts, replace the yoke assembly.

(1) Brush (2) Yoke

01650S90040


01640F90010

Armature Bearing

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

01640S90010

Overrunning Clutch

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

00000S90061