This service manual has instructions and procedures for the subject on the front cover.

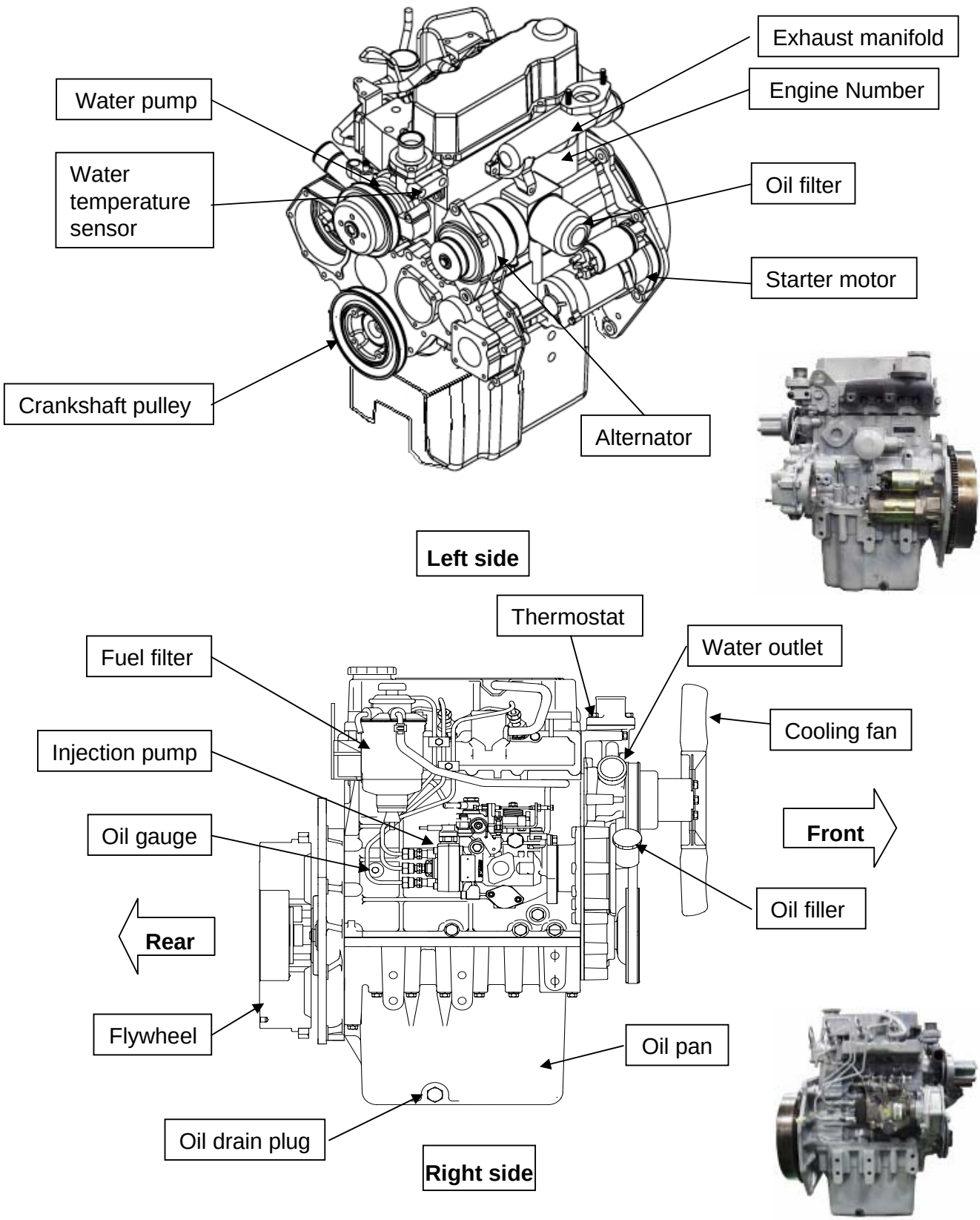
The information, specifications and illustrations I this manual are on the basis of the information that was current at the time this issue was written.

Correct servicing, test and repair procedures will give the engine a long service life. Before starting a test, repair or rebuild job, the serviceman must read the respective sections of this manual to know all the components he will work on.

Continuing improvement of product design may have caused changes to your engine which are not included in this manual.

Whenever a question arises regarding your engine, or this manual, consult your dealer or distributor for the latest available information.

Typical engine arrangements

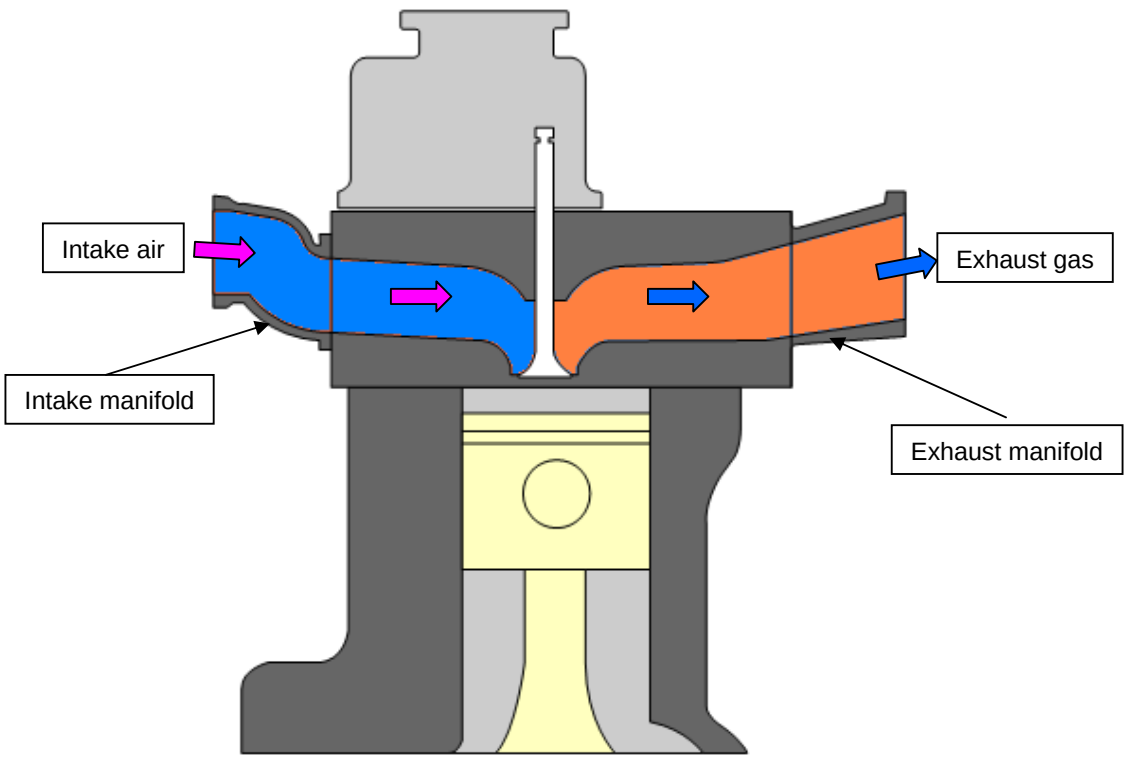


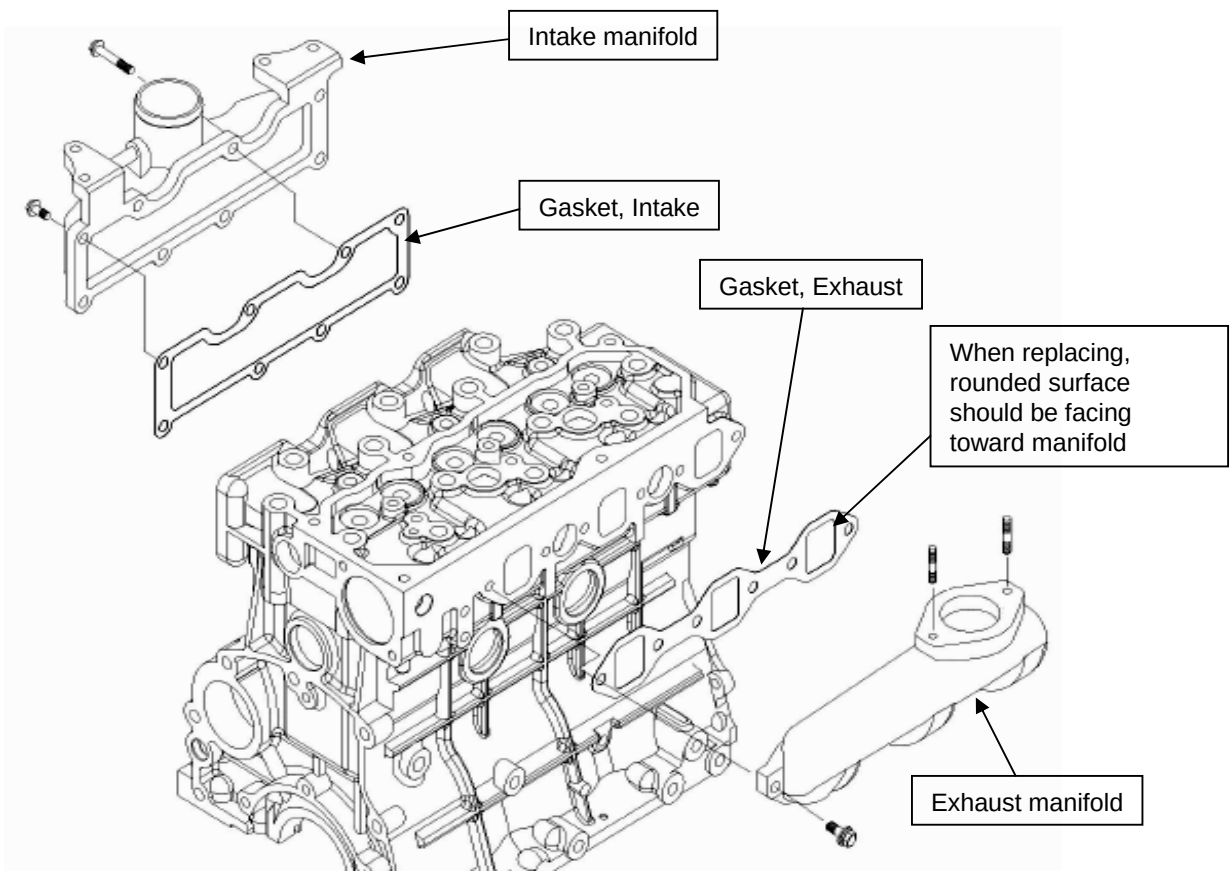
NOTE : Rotation of crankshaft is counterclockwise when seen from flywheel end.

Specifications

Model			L3AL	L3BL	Remark
General Specification	Type		3cy./water cooled/diesel	3cy./water cooled/diesel	
	Bore x Stroke	mm	90 x 105	88 x 105	
	Displacement	cc	2003	1915	
	Fuel Injection Type		IDI	IDI	
	Combustion chamer		Swirl chamber	Swirl chamber	
	Rated Power	ps/rpm	38 / 2600	33/ 2600	
	Max Torque	kgf.m/rpm	12 / 1800	10.4 / 1800	
	Low Idle	rpm	830 (± 20)	830 (± 20)	
	High Idle	rpm	2800 (-10/+30)	2800 (-10/+30)	
Fuel System	Fuel Injection Pump Type		VE	VE	
	Fuel Injection Timing	degree	ATDC 3	ATDC 3	
	Injector Opening Pressure	kgf/cm^2	150	150	
	Fuel		DIESEL	DIESEL	
Lubrication System	Min Oil Pressure	kgf/cm^2	1.0	1.0	
	Relief Pressure	kgf/cm^2	3.5 ± 0.5	3.5 ± 0.5	
	Oil Capacity(High/Low level)	L	6.5 L / 5.0 L	6.5 L / 5.0 L	
	Lubrication Oil		15W/40	15W/40	
	Max Oil Temperature	℃	130	130	
Intake System	Intake Resistance	mmH2O	Max 250	Max 250	
Exhaust System	Exhaust Back Pressure	mmH2O	Max 680	Max 680	

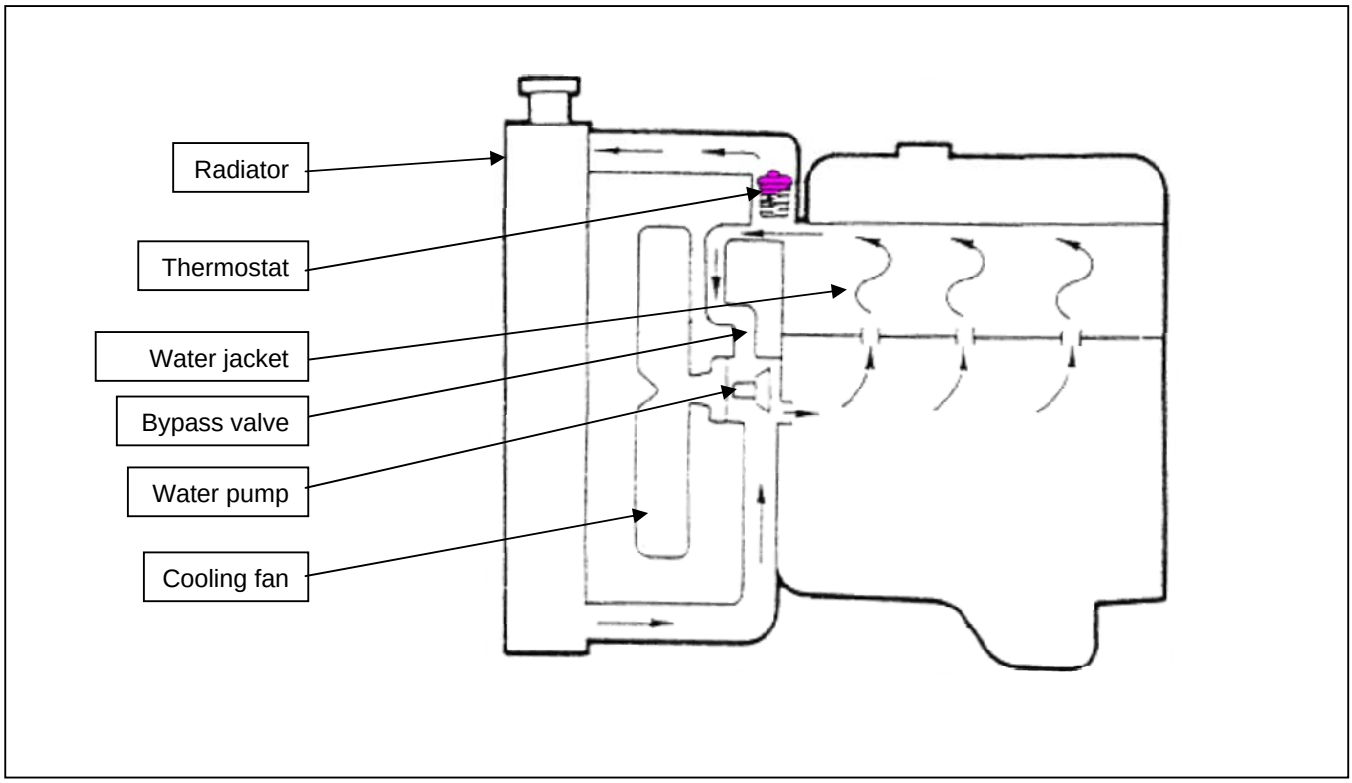
Cooling system





Construction of cooling system

Cooling system consists of water jacket, thermostat, radiator, cooling fan and water pump.



When cold

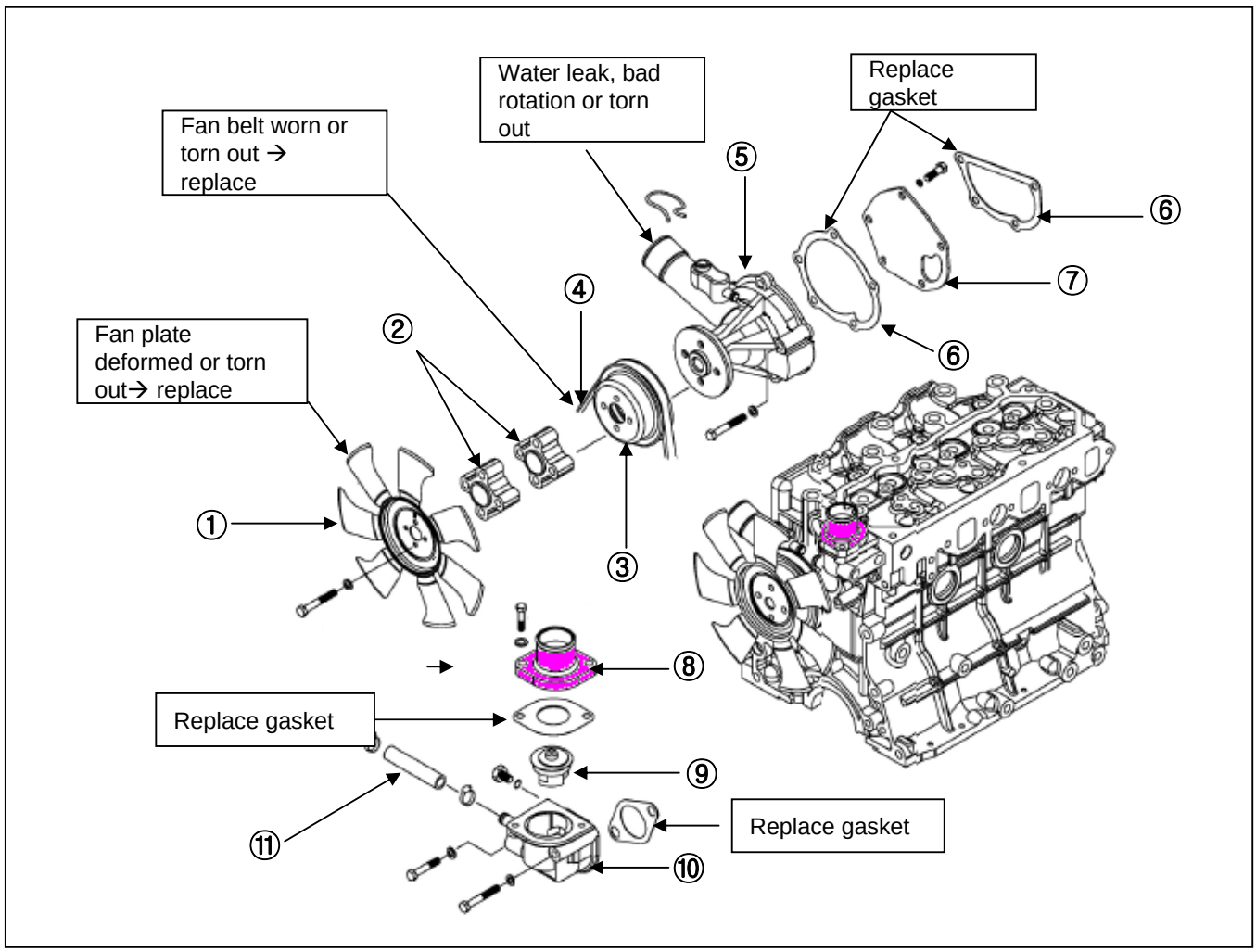
Water jacket → Thermostat → Water pump

When not cold

Water jacket → Thermostat → Radiator → Water pump

Water pump & fan

Inspection – Visually check the water pump and replace it as an assembly if any defect is found.



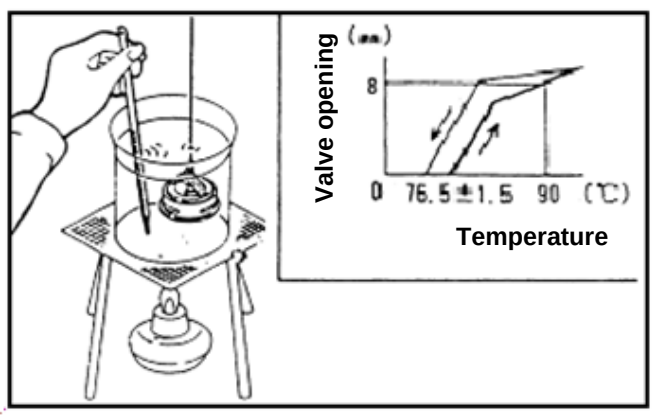
① Cooling fan ② Spacer ③ Water pump pulley ④ Fan belt ⑤ Water pump assembly
⑥ Gasket ⑦ Plate ⑧ Cover ⑨ Thermostat ⑩ Thermostat housing ⑪ By-pass hose

Thermostat - testing

• Remove the thermostat from the engine.

• Hang the thermostat in the pan of water, as shown in the illustration. The thermostat must be below the surface of the water and it must be away from the side of the pan.

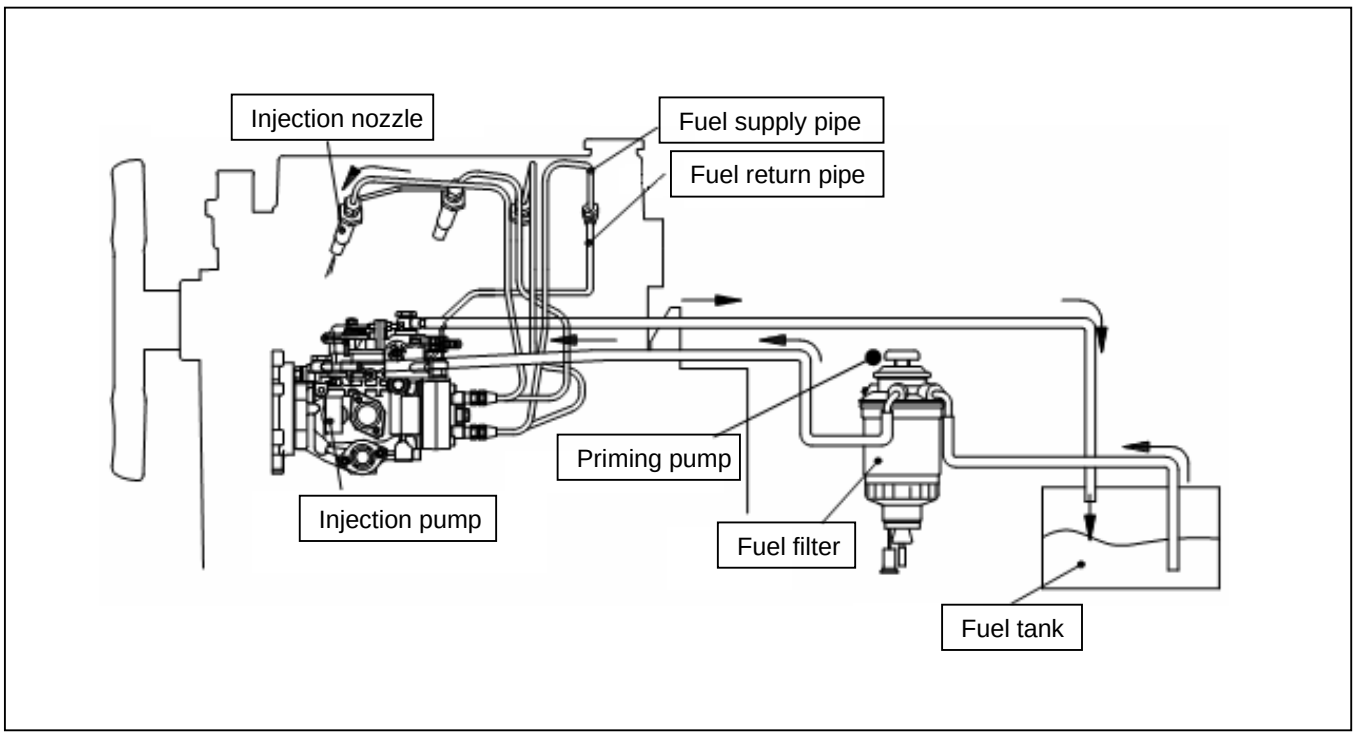
• Heat the water uniformly in the pan and measure a temperature at which the valve starts opening and a temperature at which the valve lift(distance) is more than 8mm(0.3in.). If the valve does not start opening at the correct temperature, or if it does not open to the correct lift, replace the thermostat.



Item	Assembly standard
Valve opens at	76.5±1.5℃
Valve opens more than 8mm	90℃

Construction of fuel system

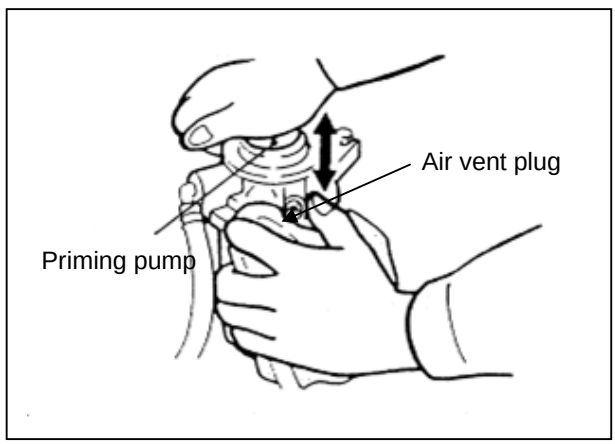
Fuel system consists of fuel tank, filter, injection pump, high pressure pipe and injection nozzle.



Air vent on fuel system

• Uncap the air vent plug on the pump and block it using a cloth. Then push the head of the filter several times.

• Tighten the cap when the fuel is coming out of the plug without any air bubbles.



Notices in air vent:

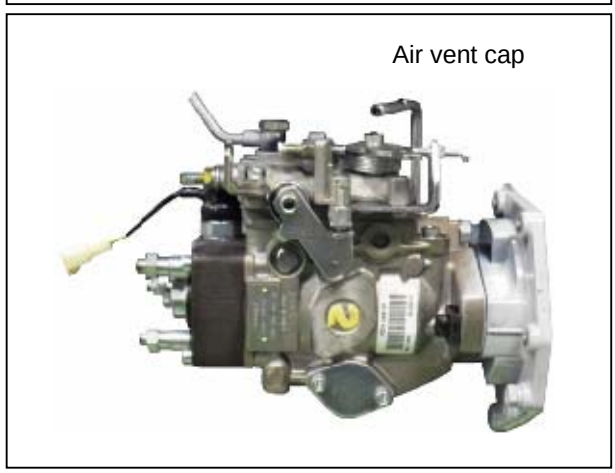
Pressure doesn't reach when something is clogged at the valve. I this case, the valve should be cleaned after disassembling of the filter.

Air vent at injection pump

• Loosen air vent plug on the injection pump.

• Unplug the cap and operate the engine.

• Tighten the air vent plug when the fuel flows free of bubbles. (Torque : 80 kgf-cm)



Caution :

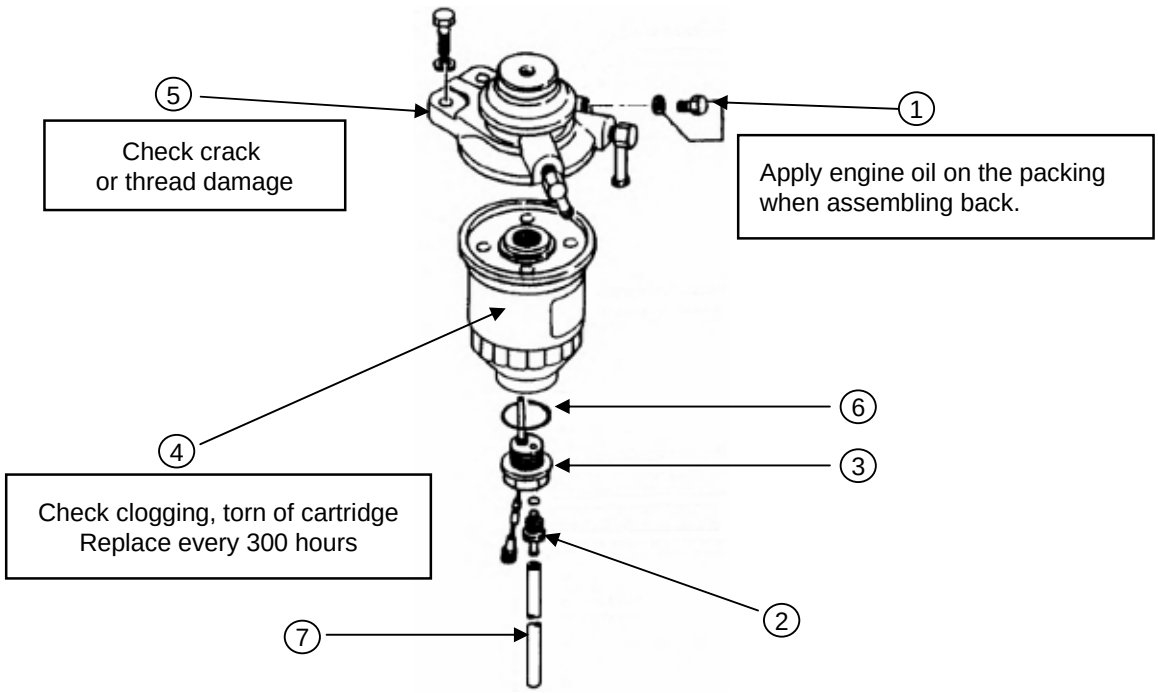
• Be careful of fuel flowing and fire when doing this.

Fuel filter and nozzle

Fuel filter(Water separation included)

• This filter keep the fuel clean by filtering some impurities contained in the fuel. Moreover it senses the water on the bottom and activate the stop solenoid at the injection pump accordingly.

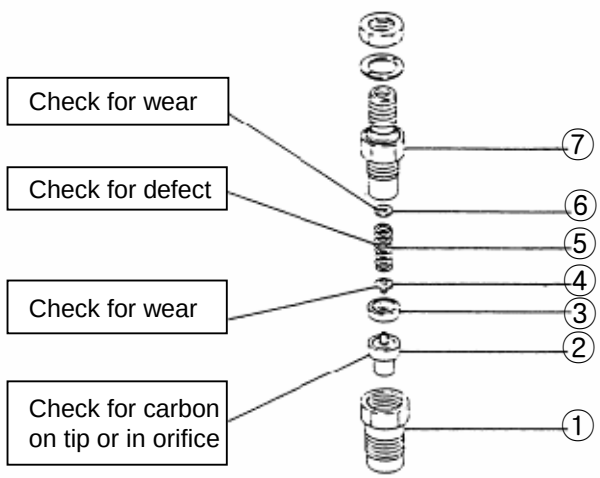
• With this function, engine stalls just after sensing the water immediately.



① Air vent plug ② Plug ③ Sensor ④ Filter cartridge ⑤ Body assembly ⑥ Oil ring ⑦ Hose

NOZZLE

• Injection pressure is 150kg/㎠.

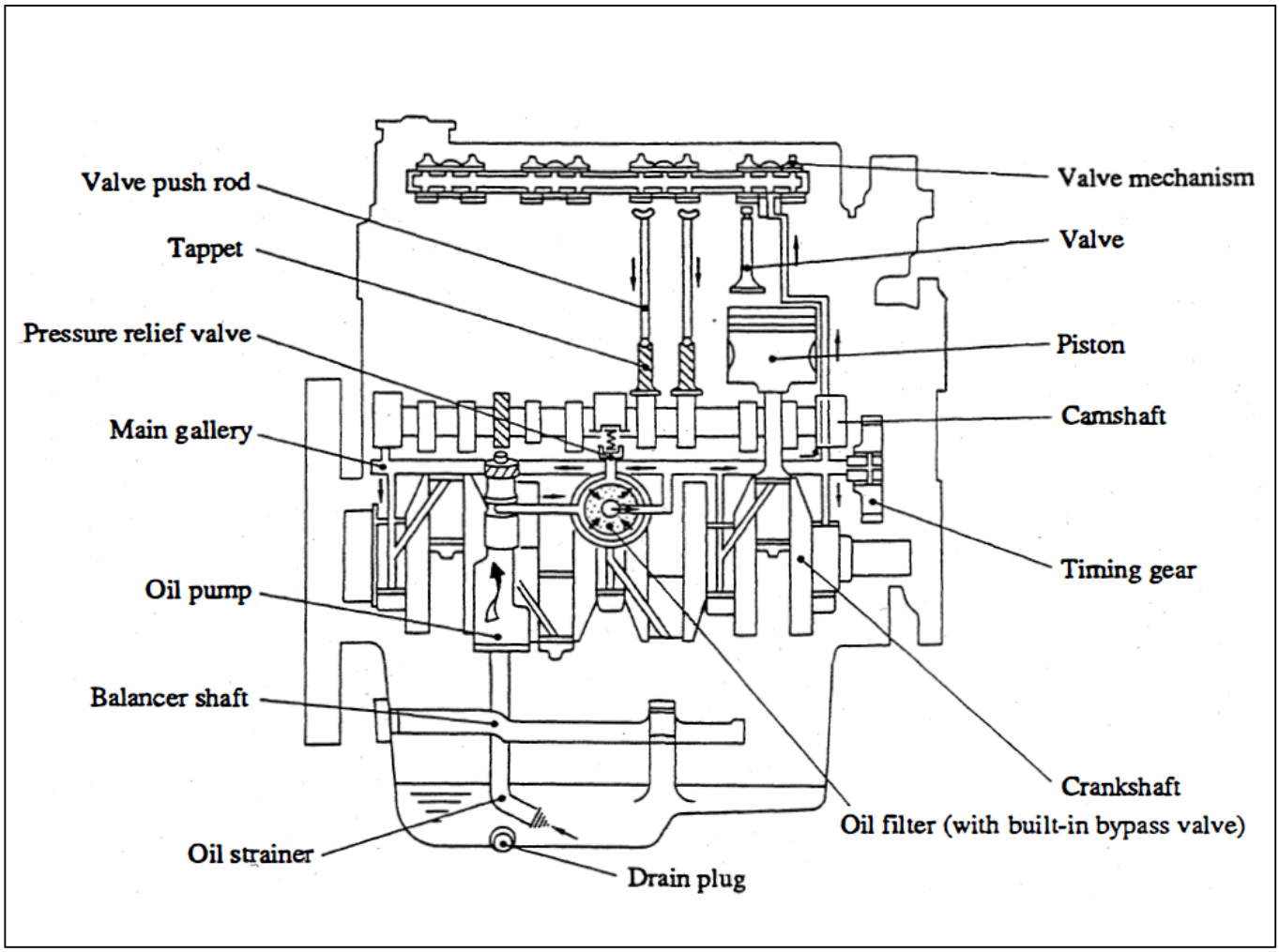


① Retaining nut ② Nozzle tip assembly ③ Piece ④ Pin ⑤ Spring ⑥ Washer ⑦ Nozzle body

Construction of lubrication system

Lubrication system consists of oil pan, oil pump, relief valve and oil filter.

When lubrication system has a problem on it, it may cause a serious damage on the engine.

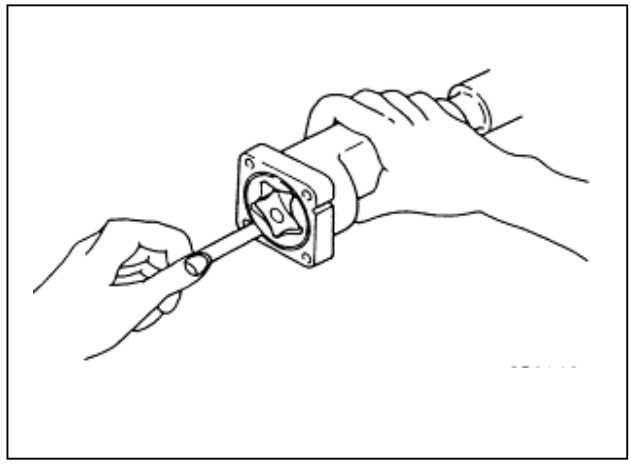


Oil system

Oil pump

1) Clearance between outer rotor and inner rotor

• Check the clearance with a feeler gauge, as shown in the illustration, If the clearance exceeds the service limit, replace the pump assembly.

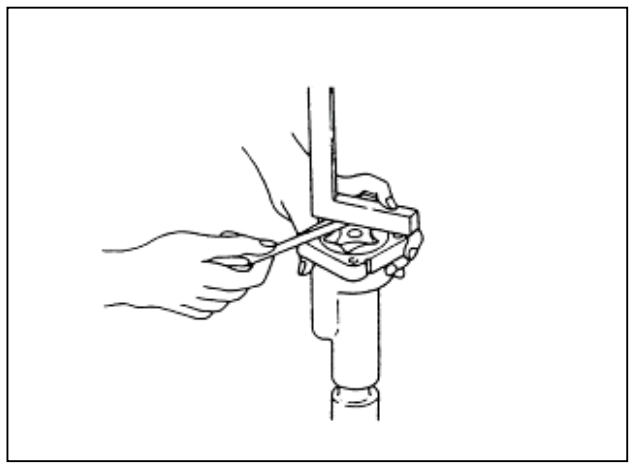


Unit : (mm)

Item	Assembly standard	Service limit
Clearance between outer and inner rotor	0.13 ~ 0.15	0.20

2) Clearance between rotors and cover

• Check the clearance with a feeler gauge and straight edge, as shown in the illustration, If the clearance exceeds the service limit, replace the pump assembly.

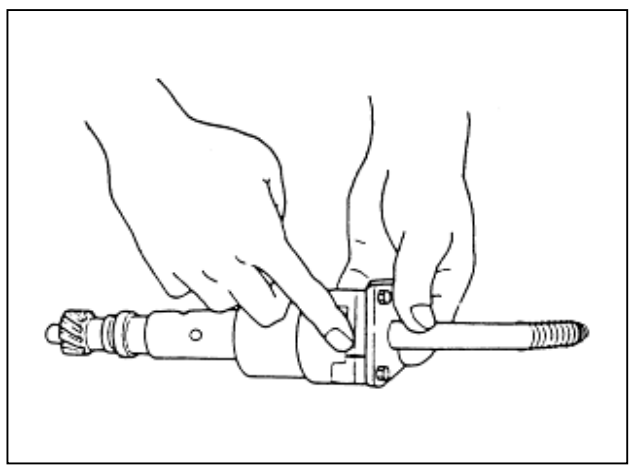


Unit : (mm)

Item	Assembly standard	Service limit
Clearance between rotors and cover	0.04 ~ 0.09	0.15

3) Clearance between outer rotor and case

• Check the clearance with a feeler gauge, as shown in the illustration, If the clearance exceeds the service limit, replace the pump assembly.



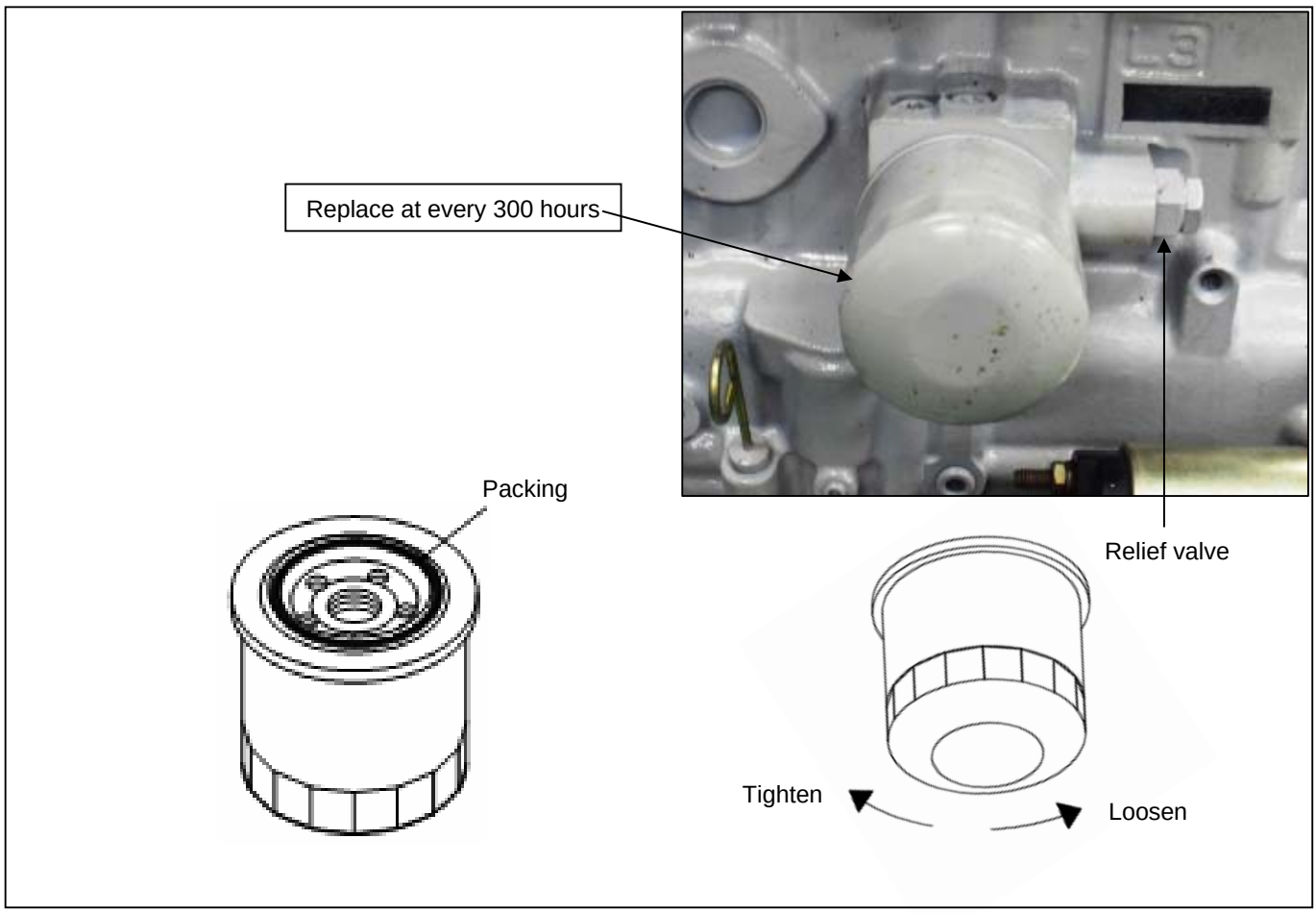
Unit : (mm)

Item	Assembly standard	Service limit
Clearance between Outer rotor and case	0.20 ~ 0.275	0.50

Notices in assembling:

• Be sure to mach the mark both on the upper case and low case of the oil pump when assembling.

Oil filter

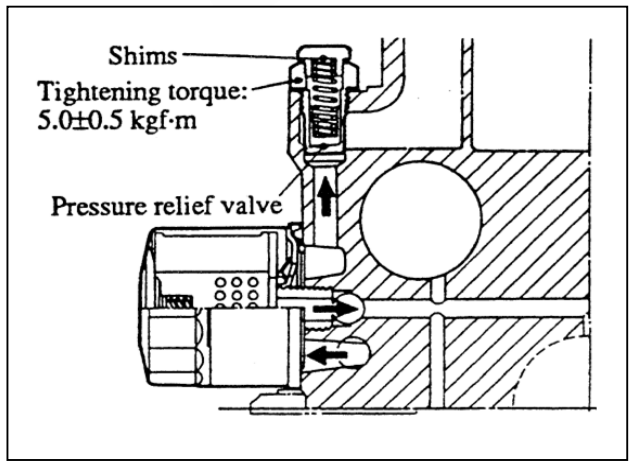


Pressure relief valve

[Inspection}

• Check the valve and valve seat for condition. Also, check the spring for damage.

• Check the valve opening pressure (the oil pressure when the engine is running at the rated rpm). If the pressure is not correct, make an adjustment by adding or removing shim. The pressure tap (RP 1/8 thread) is located near the oil filter.



(Unit : kgf/㎠)

Item	Assembly standard
Valve opening pressure	3.5±0.5

	Complaint / Cause	Hard starting: Engine will turn: No exhaust smoke	Hard starting: Engine will turn: Little exhaust smoke	Hard starting: Engine will turn: Excessive exhaust smoke	Hard starting: Cranking speed low	Hard starting: Engine will not turn: Engine can be cranked manually	Hard starting: Engine will not turn: Engine cannot be cranked manually	Glow plug indicator does not glow red	Glow plug indicator glows red	Not enough power: Little exhaust smoke	Not enough power: Excessive white exhaust smoke	Not enough power: Excessive black exhaust smoke	Exhaust smoke abnormal: During idling	Exhaust smoke abnormal: During operation: White	Exhaust smoke abnormal: During operation: Black	Engine knocks excessively	Engine noisy	Engine runs rough	Engine hunts: During idling	Engine hunts: During operation
Fuel system	No fuel to injection pump	O	O	—	—	—	—	—	—	O	—	—	—	—	—	—	—	—	—	
	Greater variance of fuel injection quantity	—	—	O	—	—	—	—	—	—	O	O	—	O	O	—	O	O	O	
	Injection pump oil seals defective	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Insufficient injection quantity	O	O	—	—	—	—	—	—	O	—	—	—	—	—	—	—	—	—	
	Excessive injection quantity	—	—	—	—	—	—	—	—	—	—	—	—	O	—	—	—	—	—	
	Injection nozzle defective	—	—	O	—	—	—	—	—	—	—	O	O	O	O	—	O	O	O	
	Excessive fuel return from injection nozzles	—	O	—	—	—	—	—	—	O	—	—	—	—	—	—	O	O	—	
	Injection timing advanced	—	—	O	—	—	—	—	—	—	O	—	—	O	O	—	—	—	—	
	Injection timing retarded	—	—	O	—	—	—	—	—	—	—	O	O	—	—	—	O	O	—	
	Engine speed too low	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O	—	
	Failure to stop	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Bad quality fuel	—	—	O	—	—	—	—	—	—	—	O	O	O	O	—	—	—	—	
	Fuel oil viscosity high	O	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Lubrication system	Bad quantity oil	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Oil viscosity high	—	—	—	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Oil viscosity low	—	—	—	—	—	—	—	—	—	—	—	O	—	—	—	—	—	—	
	Oil pressure low	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Oil leaks	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Excessive pumping up of oil	—	—	—	—	—	—	—	—	—	—	—	O	O	O	—	—	—	—	
	Oil filter clogged	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Oil pressure switch or lamp defective	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Air intake system	Not enough air for combustion	—	—	O	—	—	—	—	—	—	—	O	—	O	—	—	—	—	—	
	Poor compression	—	—	O	—	—	—	—	—	—	O	O	O	O	O	—	O	O	O	
	High temperature or low barometric pressure at high altitude	—	—	—	—	—	—	—	—	—	—	O	—	O	—	—	—	—	—	

Engine vibrates excessively	Engine stalls	Poor response for deceleration	Engine does not pick up speeds	Engine runs at high speeds and fails to stop	Engine turns in reverse direction	Fuel consumption high	Oil consumption high	Fuel in oil	Water in oil	Excessive blow-by	Lubrication system defective: Indicator light does not come on when engine stops	Lubrication system defective: Indicator light comes on at low speeds	Lubrication system defective: Indicator light comes on at high speeds	Coolant temperature abnormal: Overheating	Coolant temperature abnormal: Low	Alternator defective: Indicator light does not come on when engine stops	Alternator defective: Indicator light come on at high speeds	Correction
–	O	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–		●
O	O	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–		●
–	–	–	–	–	–	–	–	O	–	–	–	–	–	–	–	–		Check and replace part (s) if necessary.
–	O	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–		●
–	–	–	–	–	–	O	–	O	–	–	–	–	O	–	–	–		●
O	O	–	–	–	–	O	–	O	–	–	–	–	–	–	–	–		●
–	O	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–		Replace nozzle tip (s).
O	O	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–		●
–	O	–	–	–	–	O	–	–	–	–	–	–	O	–	–	–		●
O	O	–	–	–	–	–	–	–	–	–	O	–	–	–	–	–		
–	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–	–		
–	O	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–		●
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		Use fuel for cold weather.
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		Use good quality oil.
–	–	–	–	–	–	–	–	–	–	–	–	O	–	–	–	–		Use oil of proper viscosity.
–	–	–	–	–	–	–	O	–	O	–	O	–	–	–	–	–		Use oil of proper viscosity.
–	–	–	–	–	–	–	–	–	–	–	O	–	–	–	–	–		●
–	–	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–		Retighten and replace packing (s) if necessary.
–	–	–	–	–	–	–	O	–	–	–	–	–	–	–	–	–		●
–	–	–	–	–	–	–	–	–	–	–	–	O	–	–	–	–		Change element and oil.
–	–	–	–	–	–	–	–	–	–	O	O	–	–	–	–	–		Change element and oil.
–	O	–	O	–	–	O	–	–	–	–	–	–	–	–	–	–		●
–	O	–	–	–	–	O	–	–	–	–	–	–	–	–	–	–		●
–	–	–	–	–	–	O	–	–	–	–	–	–	O	–	–	–		(Adjust full-load setting of governor.)

	Complaint / Cause	Hard starting: Engine will turn: No exhaust smoke	Hard starting: Engine will turn: Little exhaust smoke	Hard starting: Engine will turn: Excessive exhaust smoke	Hard starting: Cranking speed low	Hard starting: Engine will not turn: Engine can be cranked manually	Hard starting: Engine will not turn: Engine cannot be cranked manually	Glow plug indicator does not glow red	Glow plug indicator glows red	Not enough power: Little exhaust smoke	Not enough power: Excessive white exhaust smoke	Not enough power: Excessive black exhaust smoke	Exhaust smoke abnormal: During idling	Exhaust smoke abnormal: During operation: White	Exhaust smoke abnormal: During operation: Black	Engine knocks excessively	Engine noisy	Engine runs rough	Engine hunts: During idling	Engine hunts: During operation
Cooling system	Engine not warm	—	—	O	O	—	—	—	—	—	—	O	—	—	O	—	—	—	—	
	Radiator dissipating heat excessively	—	—	—	—	—	—	—	—	—	O	—	O	O	—	O	—	—	—	—	
	Not enough coolant	—	—	—	—	—	—	—	—	—	—	O	—	—	O	—	—	—	—	—	
	Radiator not dissipating heat properly	—	—	—	—	—	—	—	—	—	—	O	—	—	O	—	—	—	—	—	
	Cylinder head gasket leaks	—	—	—	—	—	—	—	—	—	O	—	O	O	—	—	—	O	—	—	
	Cranks in crankcase water jacket	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Electrical system	Starter switch defective	—	—	—	—	O	—	O	—	—	—	—	—	—	—	—	—	—	—	—	
	Starter magnetic switch defective	—	—	—	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Starter defective	—	—	—	O	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Starter free wheel defective	—	—	—	O	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Flywheel ring gear and pinion defective	—	—	—	—	O	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Battery voltage low	—	—	O	O	O	—	O	—	—	—	—	—	—	—	—	—	—	—	—	
	Glow plus (s) or indicator open circuited	—	—	O	—	—	—	O	—	—	—	—	—	—	—	—	—	—	—	—	
	Glow plus (s) short circuited	—	—	O	—	—	—	—	O	—	—	—	—	—	—	—	—	—	—	—	
	Alternator defective	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Relay defective	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Wiring defective	—	—	O	O	O	—	—	O	—	—	—	—	—	—	—	—	—	—	—	
Mechanical system	Running parts seized	—	—	—	O	—	O	—	—	—	—	O	—	—	O	—	O	O	—	—	
	Cylinder (s), piston (s) or piston ring (s) worn	—	—	O	—	—	—	—	—	—	O	—	O	O	—	O	O	—	—	—	
	Piston ring (s) worn	—	—	O	—	—	—	—	—	—	O	—	O	O	—	O	—	—	—	—	
	Excessive oil clearance	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O	—	—	—	
	Connecting rod cap bolts loose	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O	—	—	—	
	Interference between valve (s) and piston (s)	—	—	—	—	—	O	—	—	—	—	—	—	—	—	—	O	—	—	—	
	Valve spring (s) broken	—	—	O	—	—	—	—	—	—	O	—	O	O	—	—	O	O	O	O	
	Excessive valve clearance	—	—	O	—	—	—	—	—	—	—	O	—	—	O	—	O	O	O	O	
	Foreign material in cylinder(s)	—	—	—	—	—	O	—	—	—	—	—	—	—	—	—	O	—	—	—	
	Excessive gear backlash	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	O	—	—	—	

Engine vibrates excessively	Engine stalls	Poor response for deceleration	Engine does not pick up speeds	Engine runs at high speeds and fails to stop	Engine turns in reverse direction	Fuel consumption high	Oil consumption high	Fuel in oil	Water in oil	Excessive blow-by	Lubrication system defective: Indicator light does not come on when engine stops	Lubrication system defective: Indicator light comes on at low speeds	Lubrication system defective: Indicator light comes on at high speeds	Coolant temperature abnormal: Overheating	Coolant temperature abnormal: Low	Alternator defective: Indicator light does not come on when engine stops	Alternator defective: Indicator light come on at high speeds	Correction
—	○	—	—	—	—	—	—	—	—	—	—	○	—	—	—	—		Heat oil pan starting. After starting warm of engine through.
—	—	—	—	—	—	○	—	—	—	—	—	—	—	—	○	—	—	●
—	—	—	—	—	—	—	○	—	—	○	—	○	—	○	—	—	—	●
—	—	—	—	—	—	—	○	—	—	○	—	○	—	○	—	—	—	●
—	—	—	—	—	—	—	—	—	○	—	—	—	—	—	—	—	—	Retighten and replace gasket if necessary.
—	—	—	—	—	—	—	—	—	○	—	—	—	—	—	—	—	—	Replace crankcase.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Check and repair. Replace part (s) if necessary.
—	—	—	—	—	○	—	—	—	—	—	—	—	—	—	—	—	—	Repair or replace.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Repair or replace.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Repair or replace starter if necessary.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Repair or replace ring gear. Replace pinion.
—	—	—	—	—	○	—	—	—	—	—	○	—	—	—	—	○	—	Recharge or replace battery. Heat it if necessary.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Replace part (s).
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Replace copper packing (s) and, if necessary, glow plug (s).
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	○	Replace alternator if necessary.
—	—	—	—	—	○	—	—	—	—	—	—	—	—	—	—	○	○	Adjust or replace.
—	—	—	—	—	—	—	—	—	—	—	○	—	—	—	—	○	—	Connect wires properly.
—	○	—	—	—	—	○	○	—	—	○	—	—	—	○	—	—	—	●
—	○	—	—	—	—	○	○	○	—	○	—	—	—	—	—	—	—	Repair of replace.
—	○	—	—	—	—	○	○	○	—	○	—	○	○	—	—	—	—	Repair or replace.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Check and replace bearings with undersize ones if necessary.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Retighten.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Reinstall timing gears or adjust valve sinkage.
○	○	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Replace part (s).
○	○	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Readjust valve clearance to 0.25㎜ (0.0098in.).
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Repair.
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Replace gear (s) or idler gear bushing.

Cause		Correction
Fuel injection pump not delivering fuel properly	Fuel tank supply valve closed No fuel in tank Fuel lines restricted Air in fuel system Leak in fuel lines or connections Fuel filter clogged Air in fuel system	Open the valve. Refuel. Repair or clean fuel pipes with air. Retighten connections or replace fuel pipes. Retighten connections. Clean or replace element. Prime.
Greater variance of fuel Injection quantity	Fuel injection pump plunger (s) jammed Fuel injection pump plunger (s) worn Bearing (s) worn Fuel injection pump plunger spring (s) broken Fuel injection pump plunger pinion (s) loose Delivery valve (s) defective Delivery valve spring (s) broken	Replace. Replace. Replace. Replace. Reinstall by matching marks. Replace. Replace.
Not enough fuel injection quantity (injection pump)	Governor stop lever link binding Control rack sticking Fuel injection pump plunger (s) jammed Fuel injection pump plunger (s) worn Bearing (s) worn Fuel injection pump plunger pinion (s) loose Full-load setting of governor improper	Repair link properly and place lever in neutral position. Re-lubricate or repair. Replace. Replace. Replace. Reinstall by matching marks. Readjust governor setting on bench.
Too much fuel injection quantity	Stop lever sticking in “increase” position Full-load setting of governor improper Fuel injection pump plunger pinion (s) loose	Repair link properly and place lever in neutral position. Readjust governor setting on bench. Reinstall by matching marks.
Fuel injection nozzle (s) defective	Needle valve in nozzle tip (s) sticking Nozzle tip seat (s) defective Nozzle spring (s) broken Fuel injection pressure low Carbon on packing at nozzle tip (s)	Repair or replace. Repair or replace. Replace. Shim adjust fuel injection pressure on tester. Remove carbon.
Fuel injection timing advanced	Fuel injection pump improperly installed Timing gears incorrectly installed	Retime by moving fuel injection pump away from engine. Reinstall timing gears.

Cause		Correction
Fuel injection timing retarded	Fuel injection pump improperly installed Timing gears incorrectly installed Fuel injection pump bearings worn	Retime by moving fuel injection pump toward engine. Reinstall timing gears. Replace.
Bad quality fuel		Use good quality fuel.
Pumping up of oil	Not enough oil un oil pan Air in oil strainer Oil pump defective Oil lines restricted Relief valve defective Oil filter clogged Leak in oil lines	Add oil to correct level. Replace damaged pipe (s) or packing (s). Retighten loose part (s). Repair. Flush. Repair or replace. Replace element and oil. Repair.
Not enough intake air	Air cleaner clogged Intake manifold clogged	Clean or replace element Clean.
Poor compression	Valve seat (s) defective Valve stem (s) sticking Rocker arm (s) not lifting valve (s) Cylinder (s), piston (s) or piston ring (s) worn Piston ring (s) sticking Exhaust gas leak in cylinder head gasket Valve spring (s) broken Not enough torque of starter (at starting)	Repair or replace. Repair or place. Readjust valve clearance to 0.25㎜(0.0098in.) Repair or replace. Repair or replace. Retighten. Replace gasket if necessary. Repair or replace. Repair or replace.
Not enough coolant	Overheating Leak in unit seal of water pump Cracks in crankcase water jacket Leak in other part (s)	Add coolant to correct level. Repair or replace. Replace crankcase. Repair or replace.

Cause		Correction
Radiator not dissipating heat properly	Air in cooling system	Bleed air by loosening air bleed plug, drain plug or hose clamp.
	Rust or scale deposits in radiator	Flush.
	Dust and dirt build-up on radiator	Flush.
	Fan belt slipping	Adjust belt tension.
	Thermostat defective (stuck closed)	Replace.
Radiator dissipating heat excessively	Atmospheric temperature low	Cover radiator.
	Radiator uncovered	
	Thermostat defective (stuck open)	Replace.
Running part (s) seized	Cylinder (s), piston (s) or piston ring (s) sticking	Repair or replace.
	Main or connecting rod bearing (s) sticking	Repair or replace.
	Idler gear bushing sticking	Repair or replace.

1. MAINTENANCE STANDARDS

Unit : ㎜

Group	Item	Normal size	Assembly standard (Standard clearance)	Repair limit (Clearance)	Service limit (Clearance)	Remarks
General	Maximum speed, (no-load)	Vary according to specifications.				Adjust governor setting.
	Minimum speed, (no-load)					
	Compression pressure, ㎏f/㎠ (psi) [kpa]	30 (427) [2940] At 150 to 200 rpm		26 (370) [2550]	20~30	Oil and water temp. 20 to 30℃(68 to 86°F)
	Engine oil pressure, ㎏f/㎠ (psi) [kpa]	2 to 4 (28 to 57) [196 to 392] at rated rpm		1.5 (21.3) [147]		Oil temperature 70 to 90℃(158 to 194°F)
		1 (14.2) [98], minimum at low idle speed		0.5 (7) [49]		
	Valve timing	Inlet valves open 30° B.T.D.C. Inlet valves close 50° A.T.D.C. Exhaust valves open 74° B.T.D.C. Exhaust valves close 30° A.T.D.C. ±3° (crank angle)				
	Valve clearance (cold)		0.25			Both inlet and exhaust valves
	Fuel injection timing	L3AS:BTDC5	L3AL:ATDC3	L3BL:ATDC3		Standard injection timing is indicated here. The timing for each model of engine varies according to its specification. Be sure to verify the timing by referring to the specifications of each model. L3AL,L3BL:Tier3
	Fan (water pump) and alternator drive belt tension		13 approx			When belt is pushed inward with 10㎏f (22lbf) [98N] pressure exerted midway between crankshaft and alternator pulleys
Crankcase	Warpage of top face		0.05 maximum	0.20		Regrind if warpage is minor.
	Inside diameter of bore (cylinder)		0~+0.035			Increase bore to 0.25(0.0098) or 0.50(0.0197) oversize and use oversize piston.
	Out-of -round of bore (cylinder)		0.01 Maximum			
	Taper of bore (cylinder)		0.015 maximum			
	Main bearings / Bore for main bearings / Inside diameter	Φ74	74.092			With main bearing cap installed (bolts tightened)
	Main bearings / Bore for main bearings / Out-of-round		0.02 Maximum			
	Main bearings / Bore for main bearings / Concentricity		0.05 Maximum			

Unit : mm

Group	Item			Normal size	Assembly standard (Standard clearance)	Repair limit (Clearance)	Service limit (Clearance)	Remarks
Crankcase	Main bearings	Oil clearance (clearance between crankshaft journal and main bearing)			0.035 to 0.100		0.200	
		Width of thrust journals		23	22.979 to 23.000			
	Tappet bore	Inside diameter		14	14.000 to 14.018		14.100	
		Clearance between Tappet and bore			0.016 to 0.052		0.080	
	Camshaft	Inside diameter of bushing (No.1)		54	54.030 to 54.050			
		Inside diameter of bores for camshaft	No.1 and No.2	54	54.030 to 54.050			
			No.3	53	53.030 to 53.050			
		Out-of-round			0.02 Maximum			
		Concentricity			0.05 Maximum			
		Clearance between camshaft and journal			0.07 to 0.11		0.15	
Cylinder head	Cylinder head	Warpage of bottom face			0.05 Maximum	0.20		Regrind if warpage is minor.
		Compressed thickness of gasket		1.3	1.27 to 1.35			
	Valves and valve guides	Diameter of valve stem	Inlet valve	8	7.940 to 7.955		7.900	
			Exhaust valve		7.920 to 7.940		7.850	
		Clearance between guide and stem	Inlet valve		0.065 to 0.095		0.200	
			Exhaust valve		0.080 to 0.115			
		Height to top of valve guide		18	17.9~18.1			
	Valve seats	Angle		30°				
		Valve sinkage		0.8	0.7 to 0.9		1.3	
		Width		1.18	1.04 to 1.32		1.6	
		Valve margin			1.70			

Unit : ㎜

Group	Item		Normal size	Assembly standard (Standard clearance)	Repair limit (Clearance)	Service limit (Clearance)	Remarks
Cylinder head	Valve springs	Free length		48.85		47.60	
		Squareness (distortion)		1.5° Maximum			Squareness of ends with respect to center line
		Length when assembled		43			
		Assembled load kgf (lbf) [N]		18 to 20 (40 to 44) [177 to 196]		15 (33) [147]	
	Rocker arms	Inside diameter of rocker arm (bushing)	19	19.010 to 19.030			
		Diameter of rocker shaft		18.980 to 19.00			
		Clearance between rocker arm and shaft		0.010 to 0.050 (0.00039 to 0.00197)			
	Valve push rods	Bending		0.3 Maximum			Dial indicator reading
Main moving parts	Crankshaft	Runout		0.02 Maximum	0.05		
		Diameter of journal	70	69.840 to 69.855			
		Diameter of crankpin	58	57.955 to 57.970			
		Distance from center of journal to center of crankpin	48.5	48.46 to 48.54			
		Parallelism between journal and crankpin		Runout : 0.01 Maximum			
		Out-of-round of journal and crankpin		0.01 Maximum	0.03		
		Taper of journal and crankpin					
		Fillet radius of journal and crankpin	3	± 0.2			
		End play		0.100 to 0.204		0.300	

Unit : ㎜

Group	Item			Normal size	Assembly standard (Standard clearance)	Repair limit (Clearance)	Service limit (Clearance)	Remarks
Main moving parts	Pistons	Outside diameter (at skirt)	Standard	89.970	89.955 to 89.985		89.770	L3BL:87.970
			0.25 Oversize	90.220	90.205 to 90.235		90.020	L3BL:88.220
			0.50 Oversize	90.470	90.455 to 90.485		90.270	L3BL:88.470
		Projection			0.13 to 0.60			Check bearing clearance.
		Maximum permissible difference between average weight of all pistons in one engine			5g (0.2 oz) Maximum			
	Piston rings	Clearance between groove and ring	No.1 ring		0.060 to 0.100		0.200	Replace piston rings if service limit is not exceeded. Replace piston if service limit is exceeded.
			No.2 ring		0.045 to 0.085		0.150	
			Oil ring		0.025 to 0.065			
		Clearance between ends of piston ring	No.1 and No.2 ring	0.2~0.35 0.4~0.6	0.25 to 0.40		1.50	
			Oil ring	0.2~0.4	0.30 to 0.50			
	Piston pins	Diameter		28	27.994 to 28.000			
		Clearance between pin and bore			0.000 to 0.016		0.050	Replace pin if service limit is not exceeds. Replace piston if service limit is exceeds.
		Clearance between pin and bushing			0.020 to 0.051		0.080	Replace pin or bushing. Ream if necessary.
	Connecting rods	Inside diameter of bushing		28	28.020 to 28.045			
		Twist / bend			0.05 / 100 maximum	0.15 / 100		
		Clearance between crankpin and connecting rod bearing (oil clearance)			0.03 to 0.09	0.20		
		End play			0.15 to 0.35		0.50	Replace connecting rod.
		Maximum permissible difference between average weight of all connecting rods in one engine			10g (0.4 oz) maximum			
	Flywheel	Flatness			0.15 Maximum	0.50		
		Face run-out			0.25 Maximum			

Unit : ㎜

Group	Item			Normal size	Assembly standard (Standard clearance)	Repair limit (Clearance)	Service limit (Clearance)	Remarks
Timing gears	camshafts	Bending			0.02 Maximum	0.05		Straighten by cold working or replace.
		Lobe lift C	Intake valves		6.684		6.184	
			Exhaust valves		7.344		6.844	
		Diameter of journals	No.1 and No.2	54	53.94 to 53.96		53.90	
			No.3	53	52.94 to 52.96		52.90	
		End play		5	0.10 to 0.25		0.30	Replace thrust plates.
	Idler gear	Clearance between shaft and bushing			0.025 to 0.075		0.100	Replace bushing.
		End play			0.05 to 0.20		0.35	Replace thrust plates.
		Fit (interference) of shaft in crankcase bore			−0.038 to −0.076			
	Backlash	Crankshaft gear and idler gear			0.05 to 0.15		0.25	Replace gears.
		Idler gear and camshaft gear						
		Injection pump drive gear and idler gear			0.04 to 0.16			
Lubrication system	Oil pump	Clearance between rotors and cover			0.04 to 0.09		0.15	
		Clearance between outer rotor and case			0.200 to 0.275		0.500	
		Shaft diameter		13	12.985 to 13.000			
		Clearance between shaft and case			0.032 to 0.074			
		Relief valve opening pressure, kgf/㎠ (psi) [kpa]		3.5 (50) [343]	3.0 to 4.0 (43 to 57) [294 to 392]			

Unit : ㎜

Group	Item		Normal size	Assembly standard (Standard clearance)	Repair limit (Clearance)	Service limit (Clearance)	Remarks
Cooling system	Water pump	Fit (interference) of bearing unit in case		-0.026~-0.064			
	Thermostat	Temp. at which valve starts opening		76.5±1.5			
		Temp. at which valve lifts more than 8 (0.3)		90℃			
Fuel system	Injection nozzles	Valve opening pressure, ㎏f/㎠ (psi) [kpa]	150	150~160			
		Discharge angle	0°				Test by means of hand tester, using diesel fuel at 20℃ (68°F). If discharge pattern is bad even after nozzle is washed in clean diesel fuel, replace nozzle tip.
		Oil-tightness of needle valve seat	Seat shall hold a test pressure 20㎏f/㎠ (284psi) [1961 kpa] lower than valve opening pressure For 10 seconds.				Wash or replace nozzle tip.
Electrical system	Starter	Commu-Tator — Diameter		32		31.4	
		Commu-Tator — Runout		0.03		0.10	
		Mica undercut		0.4 to 0.6	0.2		
		Brushes — Length		18		11	
		Brushes — Spring tension, ㎏f		3.1 to 3.9		2	
		Thrust gap of pinion shaft		0 to 0.5			
		Pinion clearance		0.1 to 2.5			

No-load characteristics			Magnetic switch operating voltage
Voltage, V	Current, A	Speed, rpm	8 volts, maximum, with pinion held at 2㎜ (0.08 in.) position from cranking position
11	130, max	3750, min.	

Alternator	Brush length		18.5 (0.73)		5 (0.20)	
	Resistance between slip rings		3.4Ω			At 20℃

2. TIGHTENING TORQUES

2.1 Major bolts and nuts

Parts to be fastened	Thread dia x pitch, ㎜	Width across flats, ㎜	Torque		
			kgf・m	lbf・ft	N・m
Cylinder head	M12 x 1.75	19	12.0 ± 0.5	87 ± 4	118 ± 5
Rocker cover	M8 x 1.25	12	1.2 ± 0.1	9 ± 1	12 ± 1
Rocker shaft bracket (long bolt)	M8 x 1.25	12	1.5 ± 0.2	11 ± 1	15 ± 2
Main bearing cap	M12 x 1.75	12	8.5 ± 0.5	61 ± 4	83 ± 5
Connecting rod cap	M10 x 1	14	5.5 ± 0.5	40 ± 4	54 ± 5
Flywheel	M12 1.25	17	8.5 ± 0.5	61 ± 4	83 ± 5
Camshaft thrust plate	M8 x 1.25	12	1.2 ± 0.1	9 ± 1	1.2 ± 0.1
Front end plate	M8 x 1.25	12	1.2 ± 0.1	9 ± 1	1.2 ± 0.1
Timing gear case and cover	M8 x 1.25	12	1.2 ± 0.1	9 ± 1	1.2 ± 0.1
Crankshaft pulley	M24 x 1.5	34	40 ± 1	289 ± 7	392 ± 10
Rear housing	M10 x 1.25	14	5.5~6.7	39.8~48.5	54~66
Oil pan	M8 x 1.25	12	1.7 ± 0.2	12 ± 1	7 ± 2
Oil pan drain plug	M14 x 1.5	22	4.0 ± 0.4	29 ± 3	39 ± 4
Oil filter shaft	M20 x 1.5	—	5.0 ± 0.5	36 ± 4	49 ± 5
Oil filter	M20 x 1.5	—	1.2 ± 0.1	9 ± 1	12 ± 1
Fuel injection nozzle	M20 x 1.5	21	6.0 ± 0.6	43 ± 4	59 ± 6
Fuel leak-off pipe	M12 x 1.5	17	2.3 ± 0.2	17 ± 1	23 ± 2
Fuel injection pump gear (distributor type)	M14 x 1.5	22	8.3 ± 0.5	60 ± 4	81 ± 5
B terminal of starter	M8 x1.25	12	1.1 ± 0.1	8 ± 1	11 ± 1
Glow plug (body) (terminal)	M10 x 1.25 M4 x 0.7	12 8	1.8 ± 0.2 0.13 ± 0.02	13 ± 1 0.94 ± 0.14	18 ± 2 1.3 ± 0.2
Pressure relief valve	M22 x 1.5	27	5.0 ± 0.5	36 ± 4	49 ± 5
Coolant drain plug	1/4-1/8, NPTF	14	4.0 ± 0.4	29 ± 3	39 ± 4
Fuel injection pipe	M12 x 1.5	19	3.0±0.3	22 ± 2	29 ± 3
Fuel return pipe	M10 x 1.25	14	2.0 ± 0.2	14 ± 1	20 ± 2
Oil pump set bolt	M12 x 1.75	17	3.5 ± 0.4	25 ± 3	34 ± 4
Overheat warning unit (thermo switch)	M16 x 1.5	19	2.3 ± 0.2	17 ± 1	23 ± 2
Drain plug	M16 x 1.5	24	4.5 ± 0.5	33 ± 4	44 ± 5

2.2 Standard bolts

Thread dia. x pitch	Torque					
	4T			7T and larger		
	kgf · m	lbf · ft	N · m	kgf · m	lbf · ft	N · m
M6 x 1.0	0.4 ± 0.1	3 ± 1	4 ± 1	0.7 ± 0.1	5 ± 1	7 ± 1
M8 x 1.25	1.2 ± 0.1	9 ± 1	12 ± 1	1.7 ± 0.2	12 ± 1	17 ± 2
M10 x 1.25	2.2 ± 0.3	16 ± 2	22 ± 3	3.4 ± 0.3	25 ± 2	33 ± 2
M12 x 1.25	3.6 ± 0.6	35 ± 6	35 ± 6	6.1 ± 0.6	44 ± 4	60 ± 6

2.3 Standard studs

Thread dia. x pitch	Torque					
	For driving in aluminum materials			For driving in ferrous materials		
	kgf · m	lbf · ft	N · m	kgf · m	lbf · ft	N · m
M8 x 1.25	0.75 ± 0.1	5.4 ± 0.6	7.4 ± 08	1.3 ± 0.1	9 ± 1	13 ± 1
M10 x 1.5	1.4 ± 0.1	10 ± 1	14 ± 1	2.4 ± 0.2	17 ± 1	24 ± 2

2.4 Standard plugs

Thread dia. x pitch	Torque					
	For driving in aluminum materials			For driving in ferrous materials		
	kgf · m	lbf · ft	N · m	kgf · m	lbf · ft	N · m
PT 1/8	1.0 ± 0.1	7 ± 1	10 ± 1	1.8 ± 0.2	13 ± 1	18 ± 2
PT1/8, NPTF 1/4	2.5 ± 0.3	18 ± 2	25 ± 3	4.0 ± 0.4	29 ± 3	39 ± 4
PT 3/8	—	—	—	6.5 ± 0.7	47 ± 5	64 ± 7

3. THREAD SEALANTS

Applied to	Mating parts	Sealant	Remarks
Cylinder head coolant hole plug	Cylinder head	Three Bond 1386D	Apply to hole and install plug.
Crankcase coolant hole plug	Crankcase	Three Bond 1386D	Apply to hole and install plug.
Crankcase oil gallery plug	Crankcase	Three Bond 1386D	Apply to hole and install plug.
Crankcase oil return pipe	Crankcase	Three Bond 1344	Apply to pipe and tighten.
Crankcase No.1 and No.5 bearing cap grooves	Oil pan gasket and U-seal	Three Bond 1207C or 1211	See pages 49 and 50.
Balancer shaft drive gear	Crankshaft	Three Bond 1215	Apply to the inside of gar and install.

4. MAINTENANCE SCHEDULE

(1) Use the service meter to determine servicing intervals.

(2) The servicing intervals in the schedule are for an average operating conditions.

Service the engine earlier than the scheduled intervals if necessary. (The intervals depends on application, operating conditions and fuel oil and lube oil used in the engine. Adjust the intervals to meet the actual operating conditions.)

(3) Perform service on items at multiples of the original requirement. For example, at every 250 service hours, also service those items listed under Every 50 service hours and every 10 service hours.

○ Check, clean, wash or adjust.
● Change.
Ⓢ Relay on LS dealer if necessary.
* Items to be services after initial 50 hours of operation of a new, reconditioned or long-stored engine.

Group	Item		Interval					Remarks
			Every 10 service hours	Every 50 service hours	Every 300 service hours	Every 600 service hours	Every 900 service hours	
General	Walk-around Inspection	Check	○					
	Valve clearance	Check				○		Ⓢ
	Bolts and nuts (cylinder head bolts)	Retighten		*			○	Ⓢ
Lubrication system	Oil pan	Check oil level	○					
		Change oil		*	●			Ⓢ
	Oil filter (Cartridge)	Change		*	●			
Fuel system	Fuel tank	Check oil level	○					
		Drain moisture		○				
	Fuel filter	Change				●		
	Injection nozzles	Check				○		Ⓢ
Cooling system	Radiator	Check coolant level	○					
		Change coolant	Every 2 years					
	Radiator fins	Clean			○			
	Fan belt	Check tension				○		
Air inlet system	Air cleaner (paper-element type)	Check indicator		○				Ⓢ
		Clean element				○		
		Change element					●	
Electrical system	Battery	Check electrolyte level and specific gravity		○				Check specific gravity from time to time
	Alternator	Check					○	Ⓢ
	Starter	Check					○	Ⓢ

ENGINE(GENERAL)

1. Decision of the repairing

Generally, when to overhaul the engine is to be determined by taking into consideration a drop in compression pressure as well as an increase in lube oil consumption and excessive blow-by.

Lack of power, increase in fuel consumption, drop in lube oil pressure, hard starting and abnormal sound are also engine troubles. These troubles, however are not always the result of low compression pressure and give no valid reason for overhauling the engine.

The engine develops troubles of widely different varieties when the compression pressure drops in it. Following are the list of typical troubles caused by this compression pressure fault :

1) Lack of power

2) Increase in fuel consumption

3) Increase in lube oil consumption

4) Excessive blow-by through breather due to worn cylinders, pistons, etc.

5) Excessive blow-by due to poor seating of worn inlet and exhaust valves

6) Hard starting

7) Abnormal sound

In most cases, these troubles occur concurrently. Some of them are directly caused by low compression pressure, but others are not. Among the troubles listed above, (2) and (6) are caused by a fuel injection pump improperly adjusted with respect to injection quantity or injection timing, faulty injection nozzles, or poor care of the battery, starter and alternator.

The trouble to be considered as the most valid reason for overhauling the engine is (4) in actually determining when to overhaul the engine, it is reasonable to take this trouble into consideration in conjunction with the other troubles.

2. Measuring the compression pressure

Start by :

(a) Make sure the engine oil, air cleaner, starter and battery are normal.

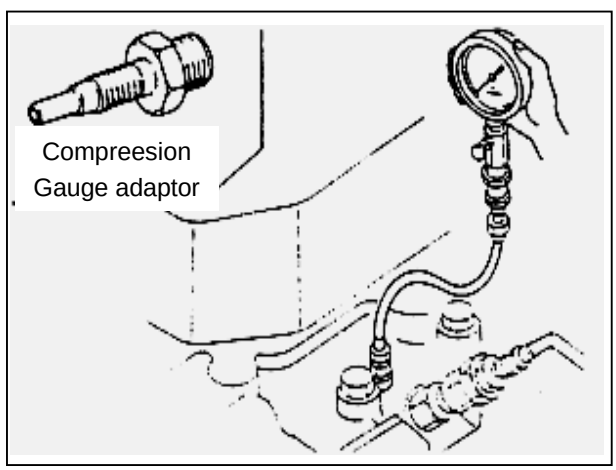
(b) Start the engine and allow it to warm up thoroughly.

(1) Move the control lever to the stop position.

(2) Remove the glow plugs from all cylinders.

Connect compression gauge (33391-02100) to the cylinder on which the compression is to be measured with compression gauge adaptor (30691-21100).

(3) Crank the engine with the starter and after the gauge pointer stops moving take a pressure reading from the gauge.



(4) If the reading on the gauge is lower than the repair limit, overhaul the engine.

※**CAUTION** : a) Be sure to measure the compression on all cylinders.

b) The compression pressure may vary depending on engine rpm. This makes it necessary to check the engine rpm when measuring the compression.

Unit : kgf/㎠(psi)[kpa]

Item	Assembly standard	Repair limit
Compression	30 (427) [2940]	26 (370) [2550]

※**NOTE** : Measure the compression with the engine running at 150 to 200 rpm.

※**CAUTION** : a) Measure the compression at regular intervals to obtain the data on the gradual change of compression .

b) The compression would be slightly higher than the assembly standard in a new or overhaul engine but it will drop after break-in period.

3. Precautions for disassembly and assembly

This section outlines basic recommended procedures, some of which require special tools, devices or work methods and contains basic safety precautions.

The safety precautions contained herein, however are not for the whole of service work. It is the responsibility of the service personnel to know that specific requirements, precautions and work hazards exist and to discuss

These with his foreman or supervisor.

Following is a list of basic precautions that should always be observed :

3.1 Disassembly

(1) Always use tools that are in good condition and be sure you understand how to use them before performing any service work.

(2) Use an overhaul stand or a work bench, if necessary. Also, use bins to keep engine parts in order of removal.

(3) Lay down the disassembled and cleaned parts in the order in which they were removed to save time for assembly.

(4) Pay attention to marks on assemblies, components and parts for their positions or directions. Put on marks if necessary to aid assembly.

(5) Carefully check each part for any sign of faulty condition during removal or cleaning. The part will tell you how it acted or what was abnormal about it more accurately during removal or cleaning.

(6) When lifting or carrying a part too heavy or too awkward for one person to handle, get another person's help and if necessary use a jack or a hoist.

3.2 Assembly

(1) Wash all parts, except for oil seals, o-rings, rubber sheets, etc., with cleaning solvent and dry them with pressure air.

(2) Always use tools that are in good condition and be sure you understand how to use them before performing any service work.

(3) Use only good quality lubricants. Be sure to apply a coat of oil, grease or sealant to parts as specified.

(4) Be sure to use a torque wrench to tighten parts for which torques are specified.

(5) Replace gaskets and packing with new ones.

4. Oil seal, o-ring and bearing installation

4.1 Oil seals

When installing a lip type seal, observe the following basic precautions :

Installing oil seal in housing

(1) Check the lip of the seal for damage before installing the seal. When installing the seal, position it so that the lip is toward the inside of a housing.

(2) Apply a thin coat of cement to the surface of the outer case of the seal.

(3) Using a special tool (oil seal installer) for guiding the lip of the seal, install the seal squarely in the housing. Do not hit the seal with a hammer. Damage to the seal can be the result.

Installing oil seal on shaft

(1) Apply a thin coat of grease to the lip of the seal.

(2) When installing the seal on a shaft having splines, threads or keyway use a special tool (oil seal guide) to prevent damage to the lip fo the seal.

4.2 O-rings

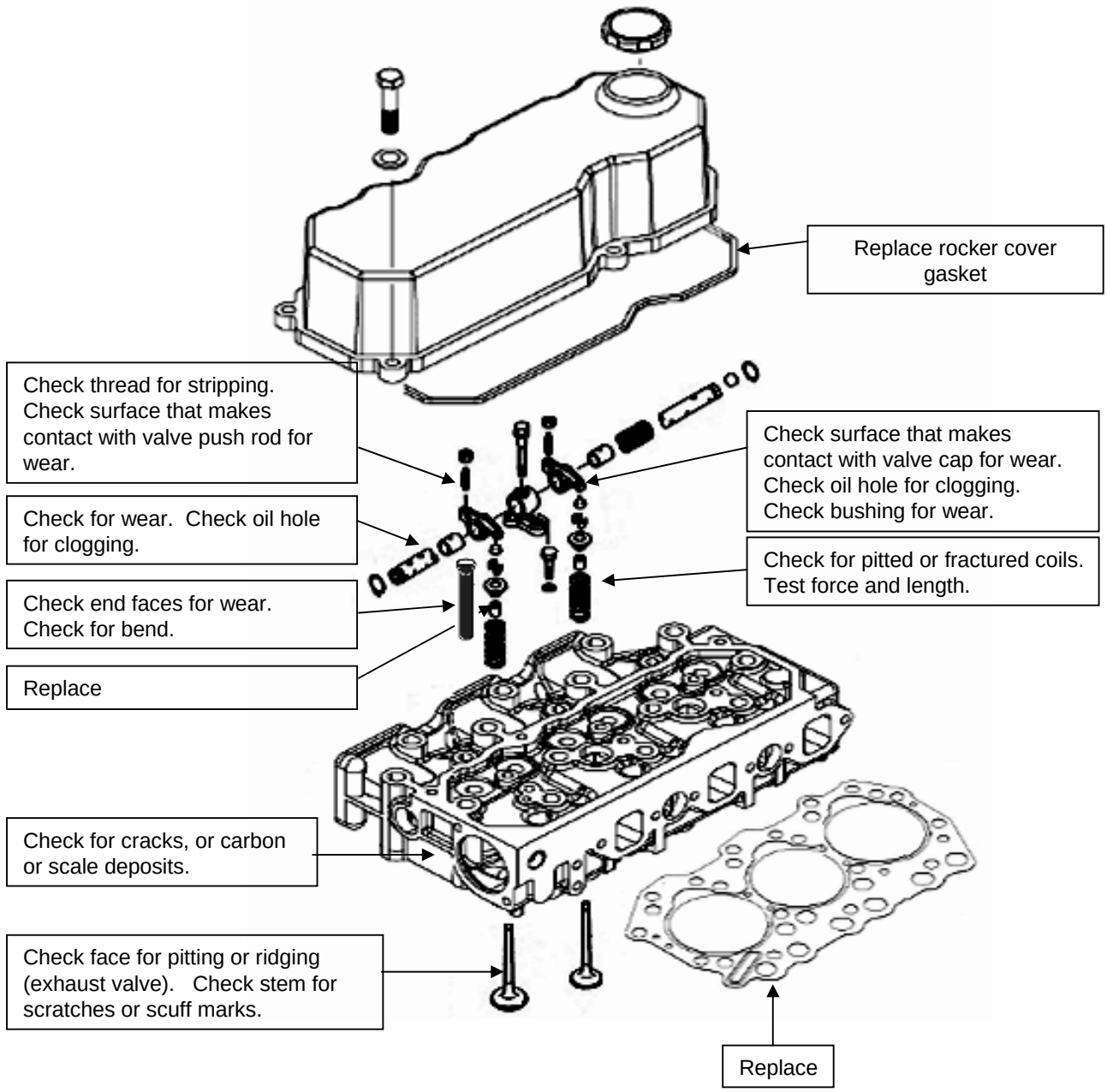
When installing an o-ring on a shaft having splines, threads or keyway use a special tool (o-ring guide) to prevent damage to the o-ring. Apply a thin coat of grease to the o-ring before installing it.

4.3 Bearing

(1) When installing a bearing be sure to push the inner or outer race by which the bearing is fitted, with a special tool (bearing installer).

(2) The use of a hydraulic pusher will facilitate bearing installation and help prevent damage to the bearing.

1. DISASSEMBLY



Notice : 1. Every part should be handled carefully.

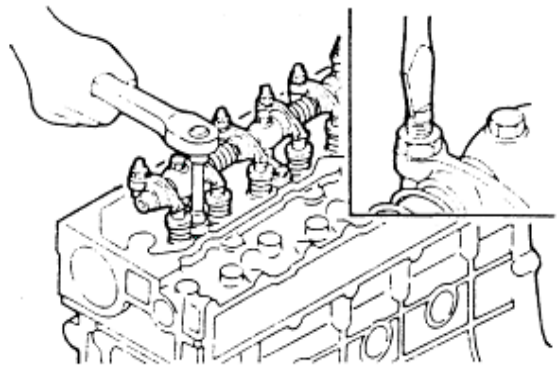
2. Every tool should be used properly and wear a safety glasses and gloves.

(1) Removing rocker shaft assemblies

(a) Loosen the adjusting screw one turn.

(b) Loosen the bolts, long and short, that hold the rocker shaft bracket to the cylinder head. Be sure to loosen the short bolt first. Remove the rocker shaft assembly from the cylinder head.

※ **CAUTION** : If the long bolt is loosened first the rocker shaft bracket might suffer damage.



Removing rocker shaft assembly

(2) Disassembling rocker shaft assemblies

The rocker arms must be restored to the rocker shafts from which they were removed during disassembly.

After removing the rocker arms, mark them for their rocker shafts to insure the original clearance between the arm and shaft at time of assembly.

(3) Removing cylinder head

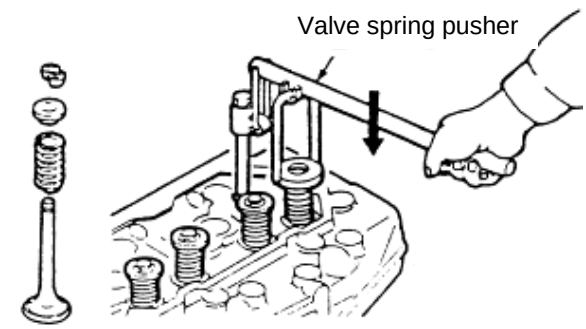
Remove the bolts that hold the cylinder head. Lift off the cylinder head from the crankcase.

※ **NOTE** : If any parts of the cylinder head are faulty, check the cylinder head bolts for torque with a torque wrench before removing them.

(4) Removing valves and springs

Compress the valve spring with valve spring pusher (30691-04500) and remove the valve cotters.

※ **NOTE** : If the existing valves are to be reused, put a mark on each valve for its location.



Removing valves and valve springs

(5) Removing valve stem seals

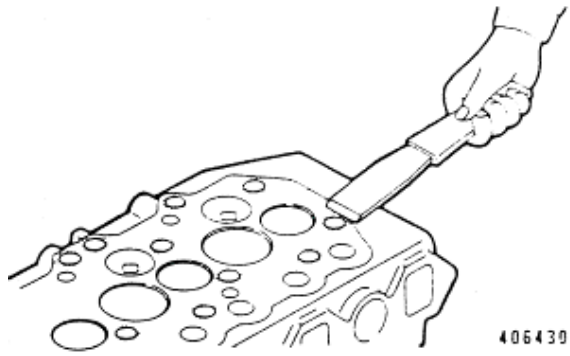
Remove the stem seals with a pliers as shown in the illustration.

※ NOTE : Do not reuse the stem seals.

(6) Cleaning cylinder head

Clean the machined surface of the cylinder head that makes contact with the gasket.

※ **NOTE** : Remove the gasket with a scraper, then clean the machined surface with an oil-stone and engine oil.



Cleaning cylinder head

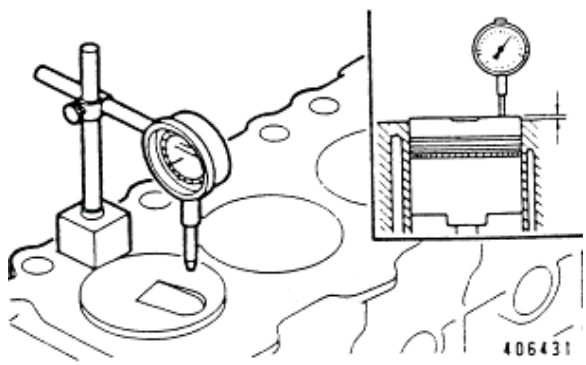
(7) Measuring piston projection

(a) Determine the top dead center of the piston with a dial indicator.

(b) Install a dial indicator on the crankcase with its point on the top of the piston. Set the indicator to read 0㎜(0.0000 in.)

(c) Check the piston projection at three points on the top of the piston as shown in the illustration and average the three measurements to determine the projection. Subtract the projection from the compressed thickness of the gasket to determine the clearance between the piston top and the cylinder head.

If the piston projection is not correct, check the various parts for clearance.



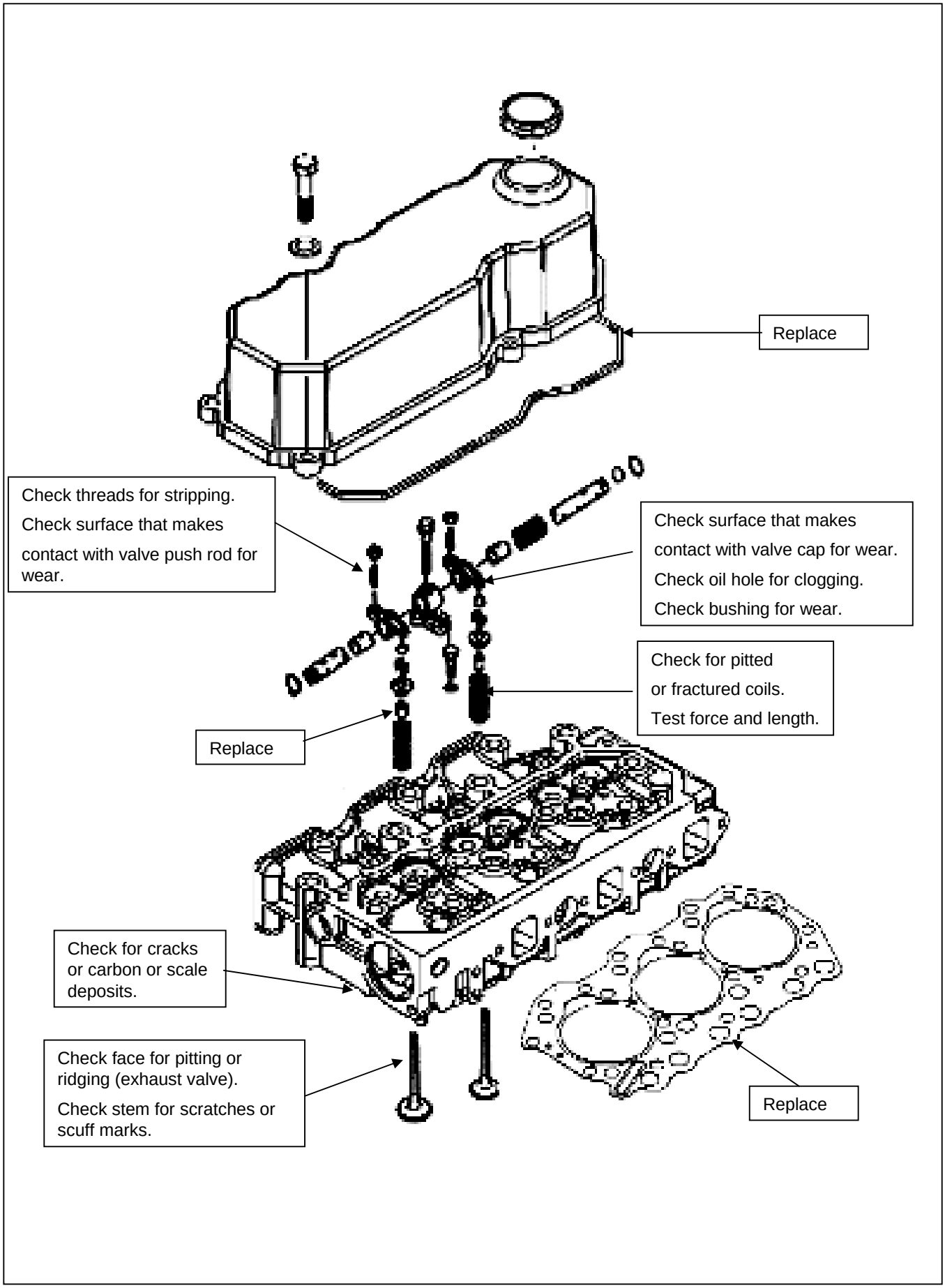
Checking piston projection

Unit : ㎜ (in.)

Item	Assembly standard
Piston projection	0.13 ~ 0.60 (0.0051 ~ 0.0236)
Compressed thickness of gasket	1.27 ~ 1.35 (0.0500 ~ 0.0531)

※ **CAUTION** : Incorrect piston projection affects engine performance and causes valve interference with piston.

2. Inspection

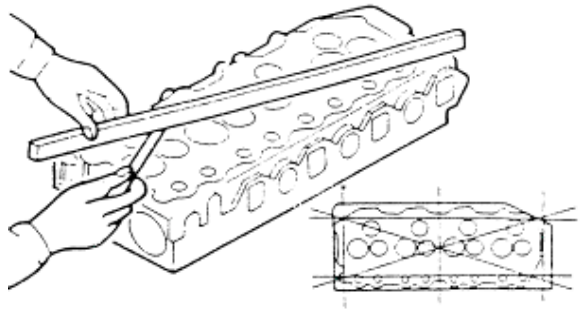


Cylinder head

Using a heavy accurate straight edge and a feeler gauge Check for warpage in three positions lengthwise, two crosswise and two widthwise, as shown in the illustration. If warpage exceeds the repair limit, reface the head with a surface grinder.

Unit : ㎜ (in.)

Item	Assembly standard	Repair limit
Warpage of bottom face	0.05maximum (0.0020)	0.20(0.0079)

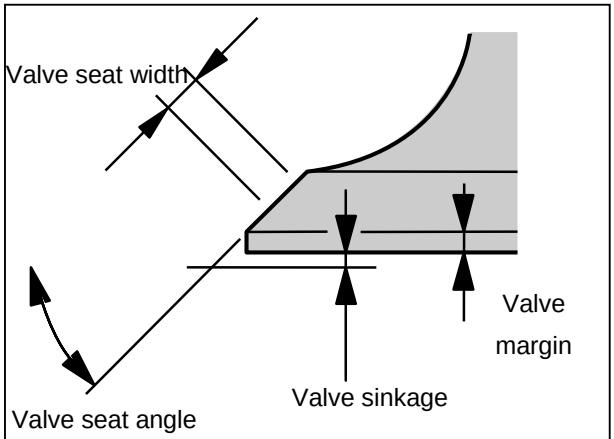


Checking cylinder head for warpage

Valve seat

Unit : mm (in.)

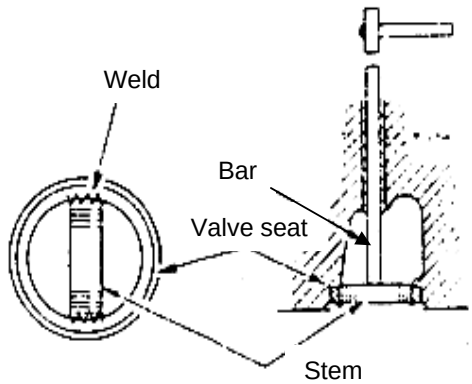
Item		Normal size	Assembly standard	Service limit
Valve seat	Angle	30°		
	Width	1.18 (0.0465)	1.04~1.32 (0.0409~0.0520)	1.6 (0.063)
	Valve sinkage	0.8 (0.031)	0.7~0.9 (0.028~0.035)	1.3 (0.051)
Valve margin			1.70 (0.0669)	1.20 (0.0472)



(1) Replacing valve seats

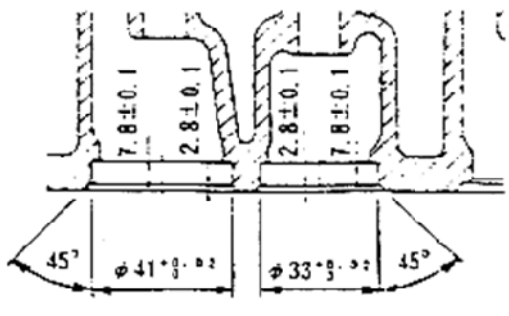
(a) Weld a stud to the valve seat. Insert a bar through the the valve guide from the upper side of the cylinder head to put its end on the stud as shown in the illustration. Then, drive the seat off the head.

※ **NOTE** : When welding the stud to the valve seat, avoid contact of any spatter with the machined surf ace of the cylinder head.



Removing valve seat

(b) Before installing a replacement valve seat, measure the bores in the cylinder head for the valve seats to mark sure they are correct in dimension.



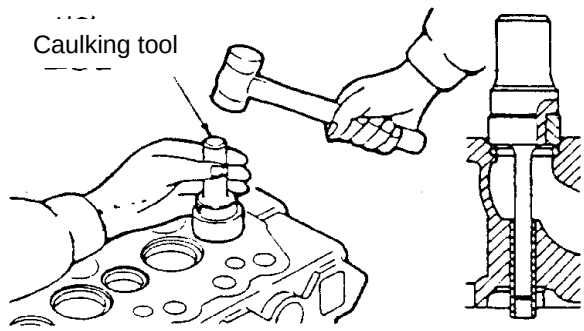
Inlet Exhaust

Valve seat bore dimensions

(c) Chill the valve seat in liquid nitrogen of -170℃(-274˚F) for more than 4 minutes with the cylinder head kept at normal temperature or heat the cylinder head up to 80℃ to 100℃(176˚F to 212˚F) with the valve seat chilled in ether or alcohol containing dry ice.

(d) Using a caulking tool, drive the seat into.

	Part number
Caulking tool (for inlet valve seat)	30691-02700
Caulking too l(for exhaust valve seat)	30691-02800



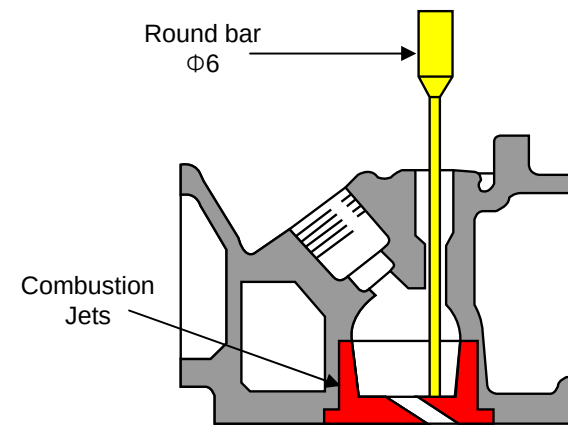
Installing valve seat

Combustion jets

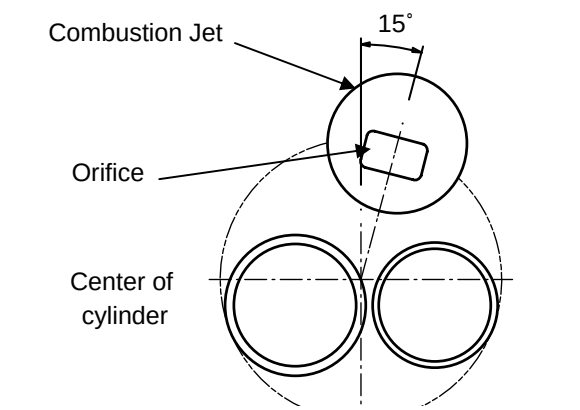
- **Replacing**

Replace the combustion jets when they are cracked or otherwise faulty.

(a) To remove the combustion jet, tap the jet off the cylinder head with a 6㎜(0.24 in.) diameter round bar inserted through the glow plug hole as shown in the illustration.



(b) To install a replacement jet, position the jet so that the orifice is toward the center of the cylinder and drive it into position with a plastic hammer.



3. Assembly

(1) Installing valve stem seals

(a) Apply engine oil to the valve stem and put the valve in the valve guide.

(b) Put a new stem seal on the valve guide.

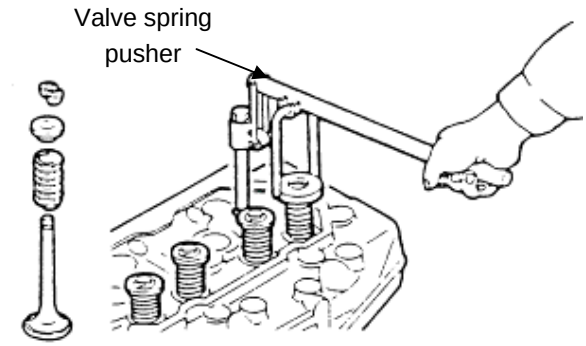
(c) Using stem seal installer (21c81-10400), install the stem seal to the valve guide, making use of the valve stem as a guide.

(2) Installing valves and valve springs

- Put the valve spring and retainer on the valve guide.

  Using valve spring pusher(30691-04500), compress the valve spring and install the valve cotters to the valve.

※ **CAUTION :** Compressing the valve spring excessively will cause the retainer to make contact with and damage the stem seal.



Installing valve and valve spring

(b) Tap the top of the valve with a soft-faced hammer several times to make sure the valve spring and valve cotters are properly installed.

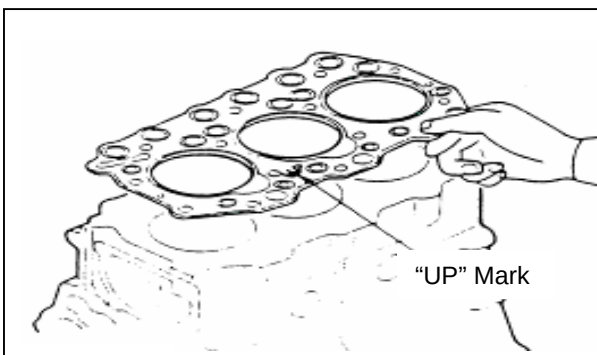
Testing valve cotter installation

(3) Installing cylinder head gasket

(a) Make sure the machined surface of the crankcase and the top of the pistons are clean.

(b) Put a new gasket on the crankcase with “UP” mark side up. Make sure the locating dowels enter their holes in the gasket.

※ **CAUTION** : Do not use any sealant.



Installing cylinder head gasket

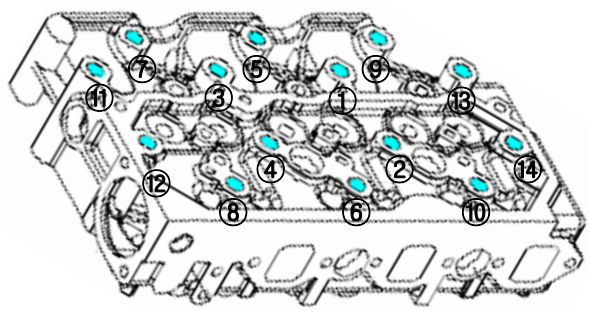
(4) Installing cylinder head

Put the cylinder head on the crankcase. Make sure the locating dowels enter their holes in the cylinder head.

(5) Tightening cylinder head bolts

Tighten the cylinder head bolts to the specified torque in two or three steps in the sequence shown in the illustration.

Tightening torque	12±0.5 kgf.m (87±4 lbf・ft) (118±5 N・m)



Cylinder head bolt tightening sequence

(6) Assembling rocker arms and rocker shafts

When installing the rocker arms to the rocker shaft, position the arms with their assembly marks pointing forward.

After installing the arms, make sure they move smoothly.

Assembling rocker arms and rocker shaft

(7) Installing valve push rods

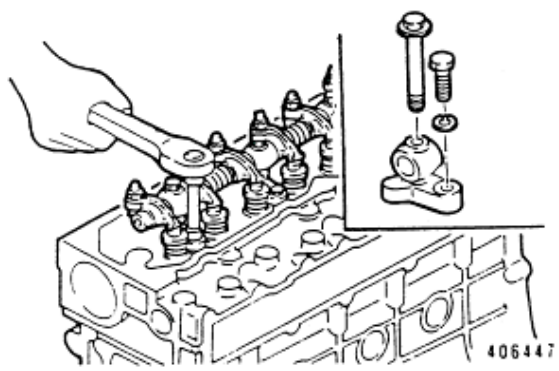
(a) Insert the push rod into position through the push rod hole in the cylinder head.

(b) Make sure the ball end of the push rod is in the socket formed of the tappet.

(8) Installing rocker shaft assembly

Tighten the long bolts and short bolts in that order to the specified torque.

Tightening torque	Long bolts	1.5±0.2kgf・m (11±1.4 lbf・ft) [15±2 N・m]
	Short bolts	1.2±0.1kgf・m (8.7±0.7 lbf・ft) [12±1 N・m]

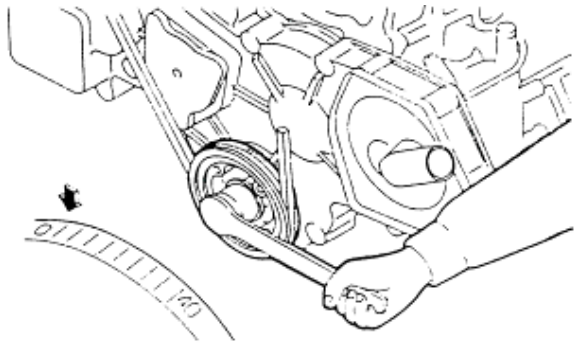


Installing rocker shaft assembly

4. Valve clearance adjusting

(1) Find the top dead center on the compression stroke for No.1 piston as outlined below :

(a) Put turning handle(30691-21800) on the crankshaft pulley nut. Turn the crankshaft in the normal direction (as seen from the front end) until the “0” mark scribed on the crankshaft pulley is aligned with the pointer on the timing gear case as shown in the illustration.



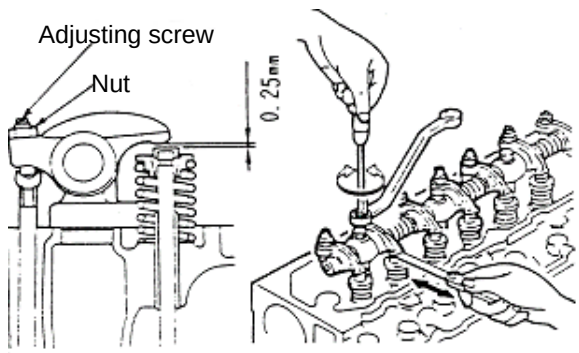
Finding top dead center on compression Stroke for No.1 piston (1)

(b) Try to move up and down the inlet and exhaust valve rocker arms of the No.1 cylinder to make sure they are not being pushed up by the push rods. The No.1 piston is at the top dead center on the compression stroke when the rocker arms are not being pushed up by the push rods. If the rocker arms are being pushed up, turn crankshaft one turn.

Finding top dead center on compression Stroke for No.1 piston (1)

(2) Insert a 0.25㎜ (0.0098in.) feeler gauge into between the rocker arm and valve cap.

(3) Loosen the lock nut for the adjusting screw and turn the adjusting screw in either direction until the feeler gauge is slightly gripped between the rocker arm and valve cap.



Adjusting valve clearance

Unit : ㎜ (in.)

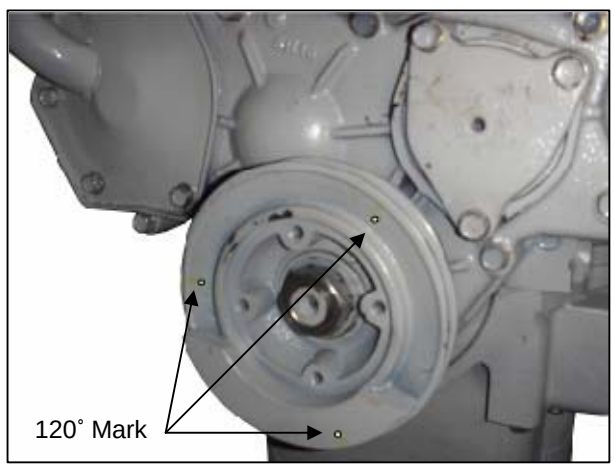
Item		Assembly standard
Valve clearance (cold setting	Inlet valves	0.25 (0.0098)
	Exhaust valves	

(4) After adjusting , tighten the lock nut and recheck the clearance.

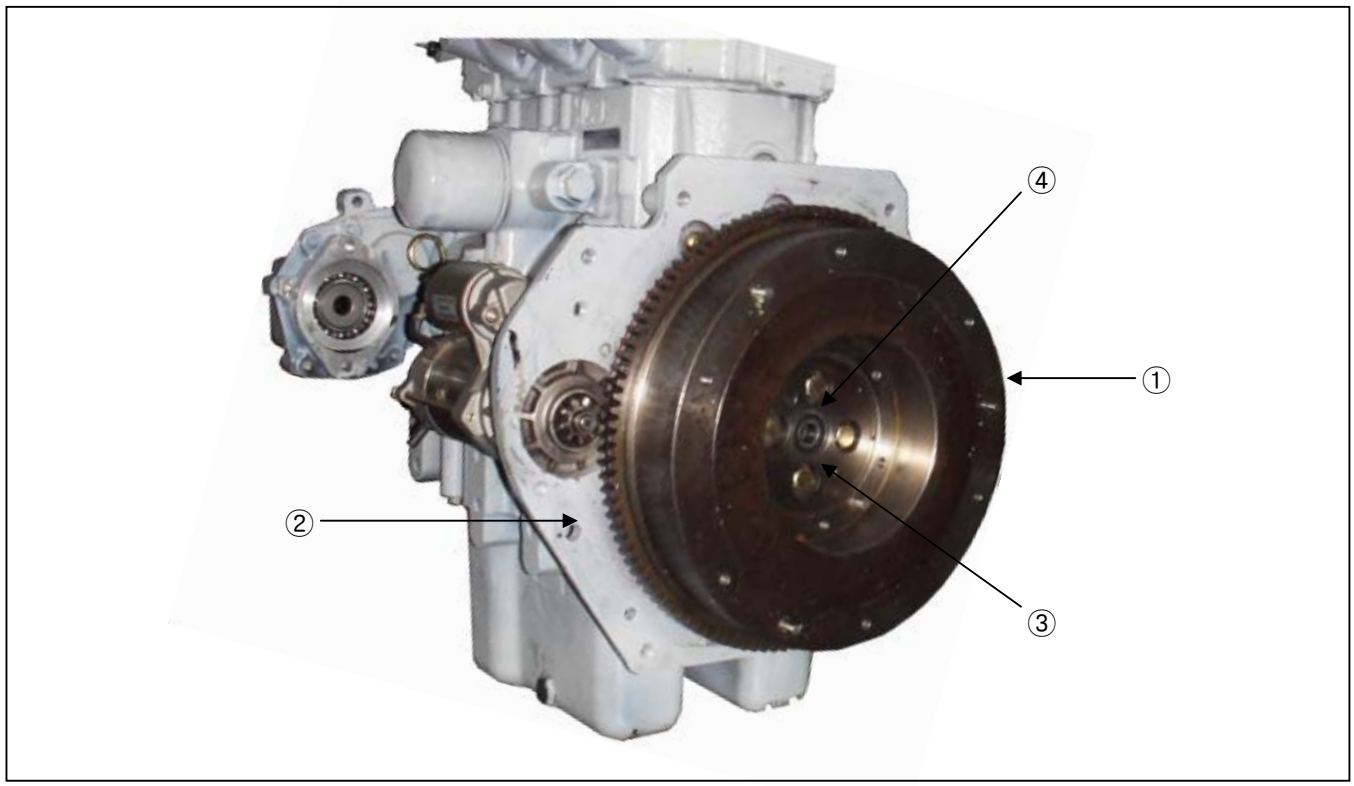
(5) Adjust the valve clearance on the remaining cylinders by turning the crankshaft 180˚ at a time in the firing order.

Sequence (cylinder No.)	Turning angle
1-3-4-2	180˚

※ **CAUTION** : After adjusting the valve clearance on all cylinders turn the crankshaft two or three turns and recheck the clearance.



1. Disassembly



(1) FLYWHEEL (2) REAR HOUSING (3) BOLT (4) BEARING

(1) Removing flywheel

(a) Have someone hold the crankshaft pulley with a wrench to prevent the flywheel from turning during removal.

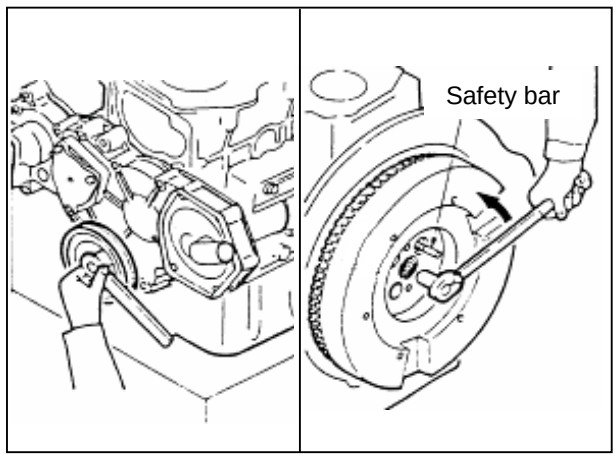
(b) Remove one of the bolts that hold the flywheel.

※ CAUTION

During removal, signal each other to avoid personal injury.

(c) Screw safety bar (M12 x 1.25) in the bolt hole and remove the remaining bolts.

(d) Remove the flywheel from the crankshaft by pulling it straight.



Removing flywheel

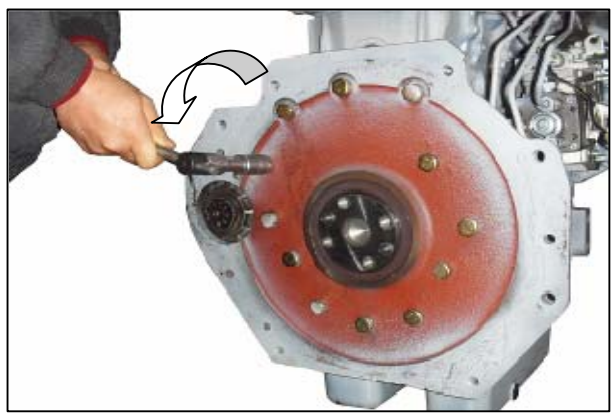
※ CAUTION

When removing the flywheel, wear heavy gloves to protect your hands.

(2) Removing rear housing (rear end plate)

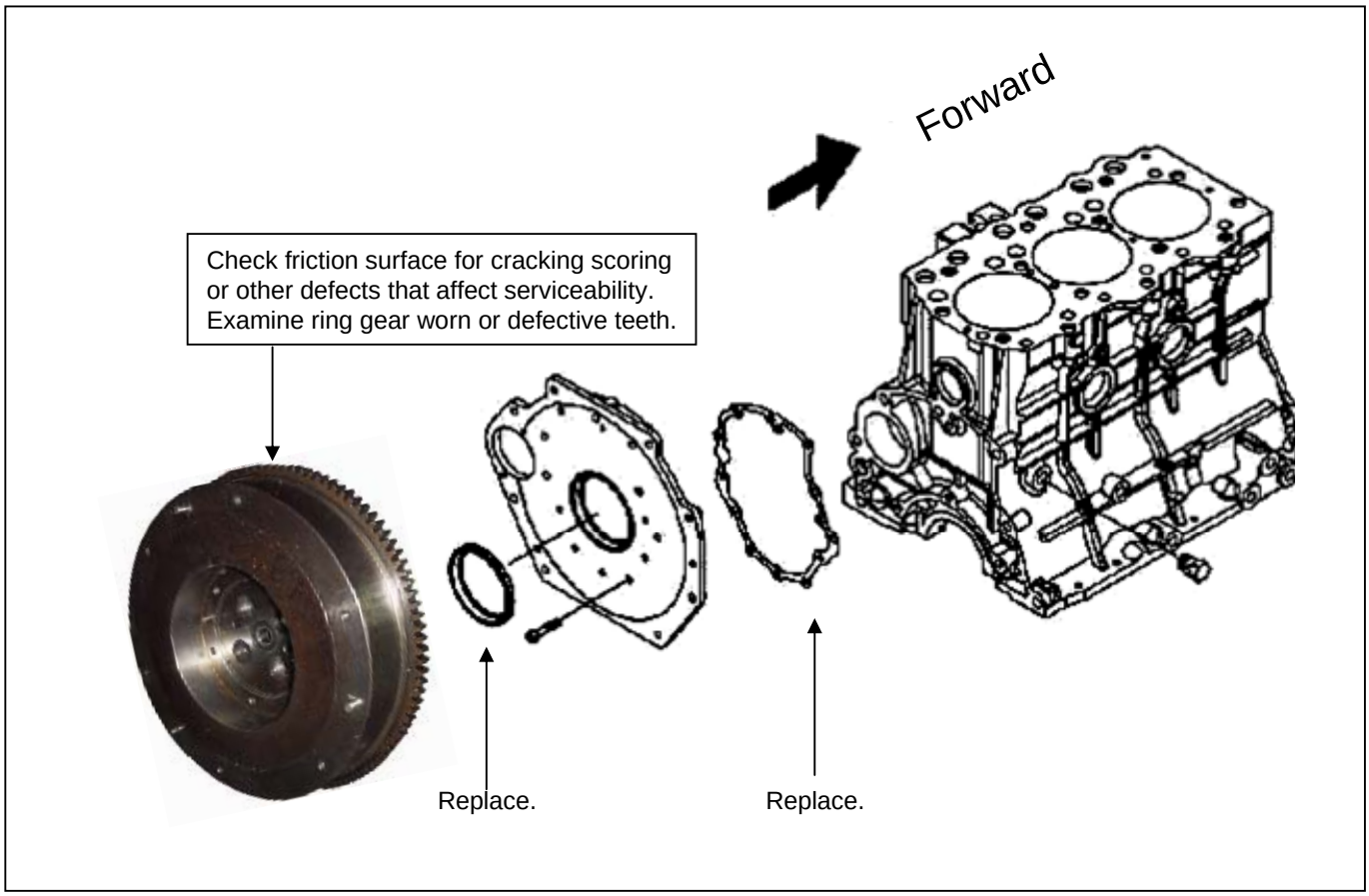
The rear housing (rear end plate) is doweled.

To remove the housing, pull it as straight as possible.



Removing rear end plate

2. Inspection



Inspection points

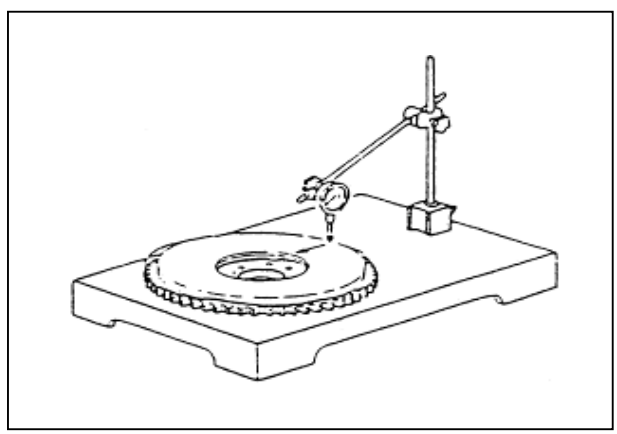
Flywheel and ring gear

(1) Flatness of flywheel

Put the flywheel on the surface plate. Set a dial indicator at one side of the friction surface and move it over to the opposite side of the surface, as shown in the illustration. If the friction surface is not flat over the repair limit, regrind it.

Unit : ㎜ (in.)

Item	Assembly standard	Repair Limit
Flatness of flywheel	0.15maximum (0.0059)	0.50 (0.0020)



Checking flywheel

(2) Replacing ring gear

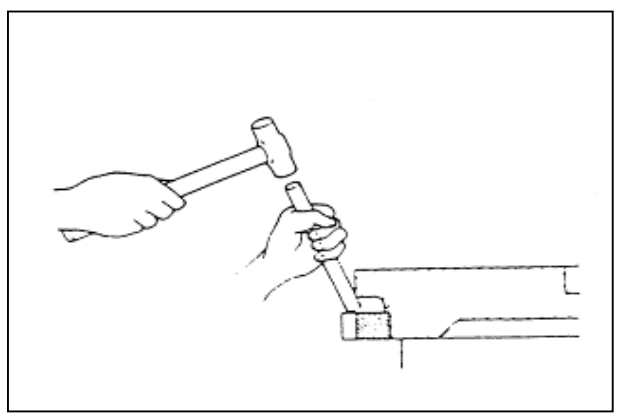
(Removal)

(a) Heat the ring gear evenly with an acetylene torch.

(b) Tap the ring gear all the way around with a bar and a hammer to remove it from the flywheel.

(Installation)

Heat a replacement ring gear up to 150℃ (302°F) with a piston heater and install it to the flywheel with the unchamfered side of the gear teeth foremost.

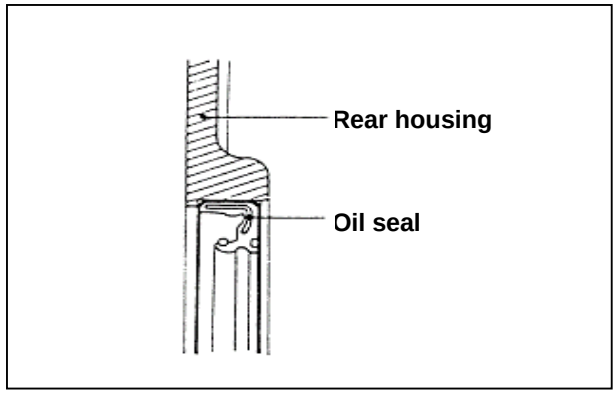


Removing ring gear

3 Assembly

(1) Installing rear housing (rear end plate) oil seal

Install the seal to the rear housing from the chamfered side of the housing.



Installing oil seal

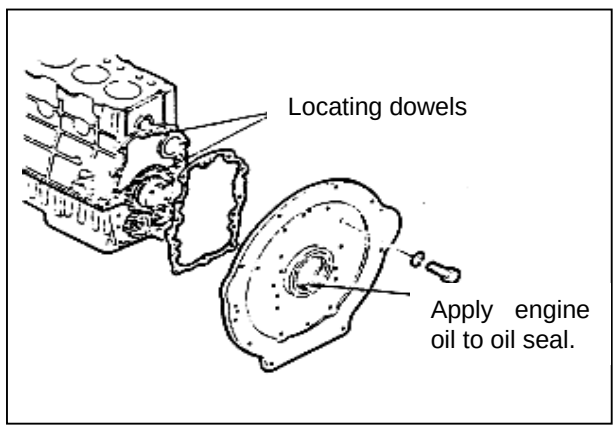
(2) Installing rear housing

(a) Apply engine oil to the lip of the seal.

(b) Install the rear housing and a new gasket to the rear face of the crankcase. Make sure the locating dowels enter their holes in the gasket and housing.

(c) Tightening 14 bolts to the specified torque.

Tightening torque	3.4±0.3 kgf-m (25±2 lbf-ft) [33±3 N-M]



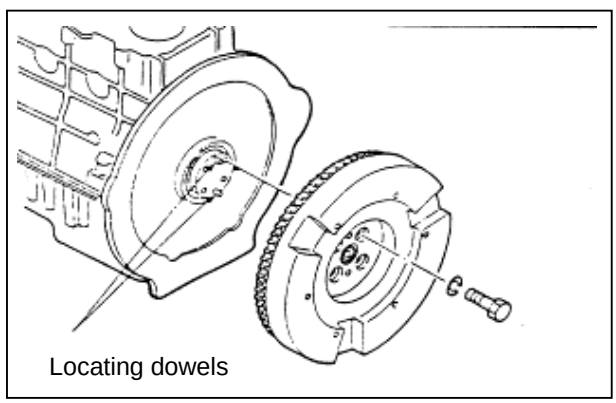
Installing rear plate

(3) Installing flywheel

(a) Install the flywheel to the rear end of the drive gear (which is doweled to the crankshaft). Make sure the locating dowels enter their holes in the flywheel.

(b) Tighten four bolts with washers to the specified torque.

Tightening torque	8.5±0.5 kgf-m (61±4 lbf-ft) [83±5 N-M]



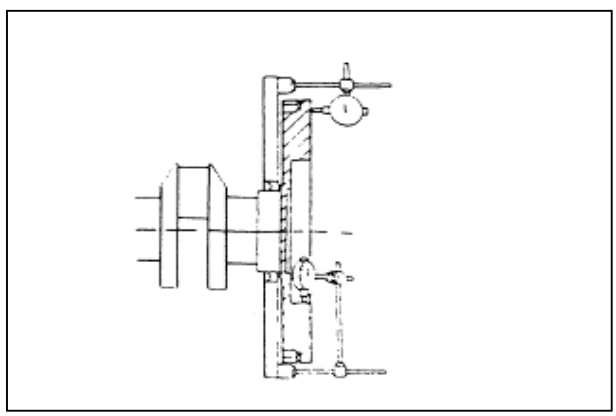
Installing flywheel

(4) Checking face run-out and pilot bearing bore run-out of flywheel

Set a dial indicator at the friction (vertical) surface and turn the flywheel one full revolution to check the face run-out (axial eccentricity). Set a dial indicator at the horizontal surface of the pilot bearing bore and turn the flywheel one full revolution to check the bore run-out. Excessive run-out of the flywheel in either position will probably be caused by dirt in the mounting face or improper tightening of the bolts.

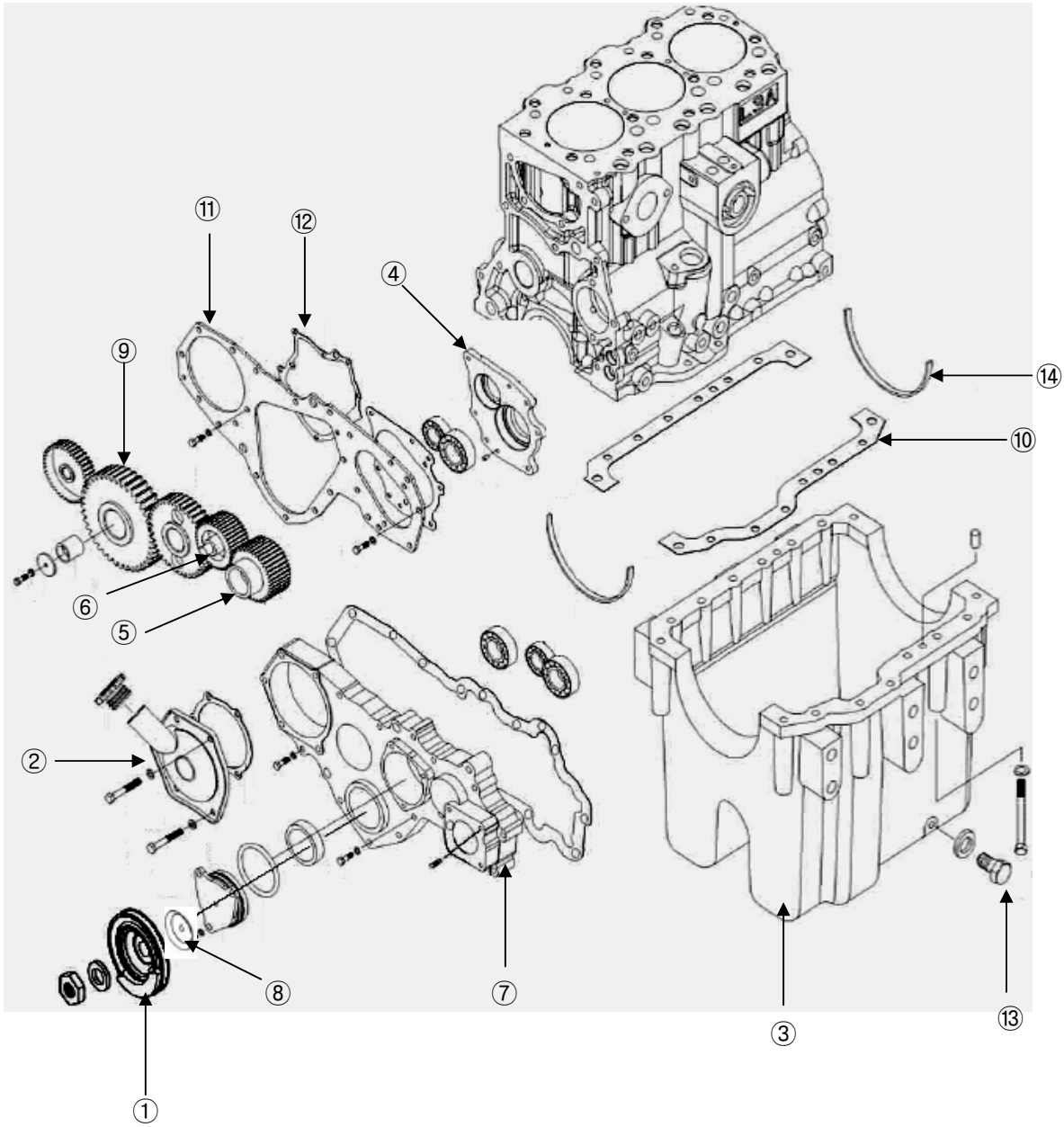
Unit : ㎜ (in.)

Item	Assembly Standard	Repair limit
Face and pilot bearing bore run-out	0.25 (0.0098)	0.50 (0.0197)



Checking flywheel run-out

1. Disassembly

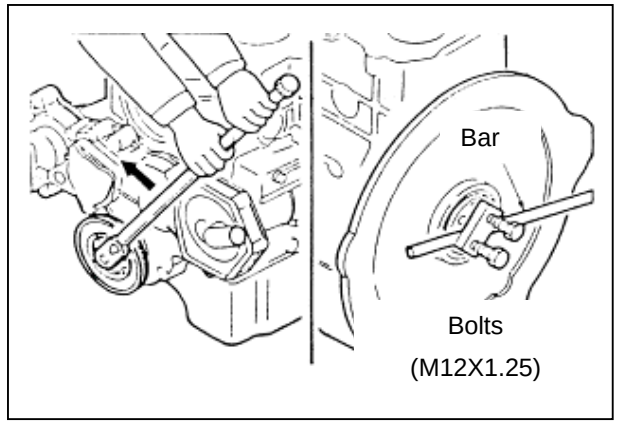


(1) Crankshaft pulley (2) Cover (3) Oil pan (4) Bearing case (5) Pump drive gear (6) P.T.O Idler gear (7) Timing gear case (8) Plate (9) Idler gear (10) Oil pan gasket (11) Plate (12) Gasket
(13) Drain plug (14) U seal

(1) Removing crankshaft pulley

(a) Install two bolts (M12 x 1.25) to the rear end of the crankshaft and put a bar between the bolts to hold the crankshaft, as shown in the illustration.

(b) Remove the pulley from the crankshaft.



Removing crankshaft pulley

※ WARNING

Make sure the bar will not come off when removing the pulley.

(2) Removing timing gear case

Remove the timing gear case with the oil pump drive gear and idler gear from the crankcase.

Pull the case straight off the locating dowels.

※ CAUTION

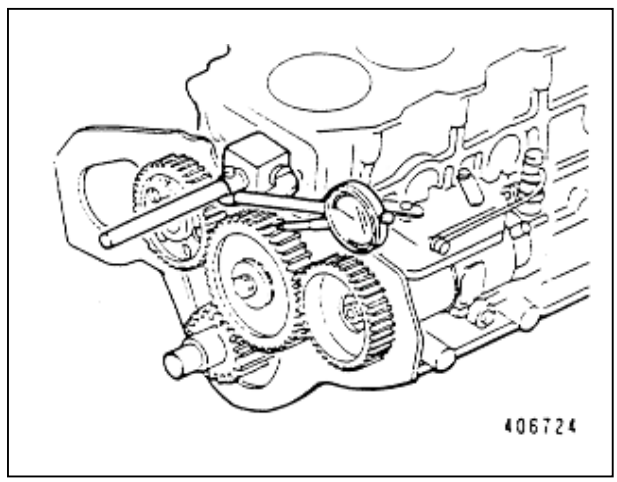
The front plate is bolted inside the gear case. Do not attempt to remove the plate with the case by tapping

(3) Removing timing gear case

Measure the backlash between the gears and make a record of the measurements to be referred to at the time of assembly. If the backlash exceeds the service limit, replace the gears.

Unit: mm (in.)

Item	Assembly standard	Service limit
Backlash between crankshaft gear and idler gear	0.05 to 0.15 (0.0020 to 0.0059)	0.25 (0.0098)
Backlash between idler gear and camshaft gear		
Backlash between injection pump drive gear and idler gear	0.04 to 0.16 (0.0016 to 0.0063)	



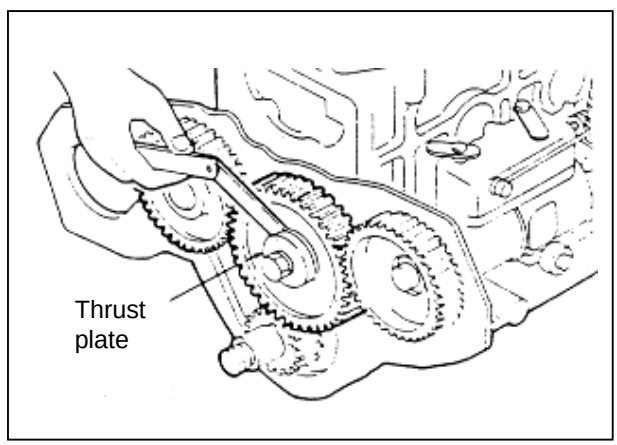
Checking timing gear backlash

(4) Checking end play of idler gear

Check the end play with a feeler gauge or a dial indicator. If the end play exceeds the service limit, replace the thrust plate.

Unit: mm (in.)

Item	Assembly standard	Service limit
End play of gear	0.05 to 0.20 (0.0020 to 0.0079)	0.35 (0.0138)



Checking end play of idler gear

(5) Removing idler gear

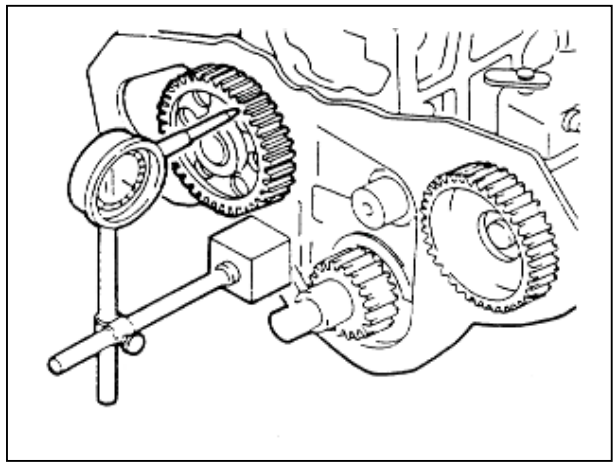
Unscrew the bolt and washer and remove the idler gear.

(6) Checking end play of camshaft

Check the end plat with a dial indicator, as shown in the illustration. If the end plat exceeds the service limit, replace the thrust plate.

Unit: mm (in.)

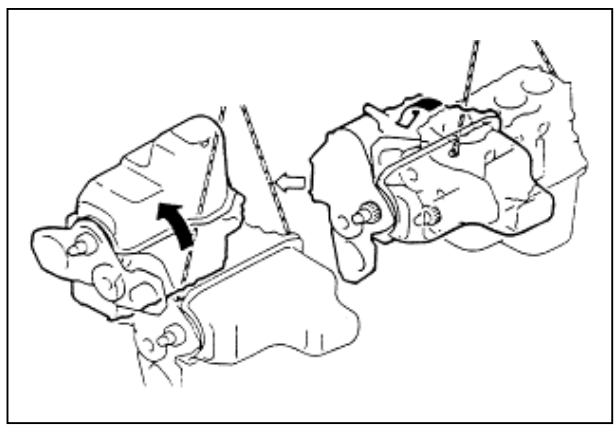
Item	Assembly standard	Service limit
End play of camshaft	0.10 to 0.25 (0.0039 to 0.0098)	0.30 (0.0118)



Checking end play of camshaft

(7) Removing oil pan and gasket

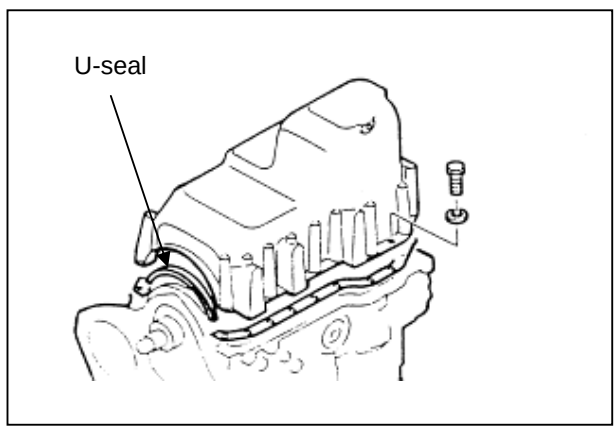
(a) Turn the crankcase upside down.



Turning crankcase upside down

(b) Unscrew the bolts that hold the oil pan to the crankcase. Remove the oil pan.

(c) Remove the gasket and U-seal.



Removing oil pan and gasket

(8) Removing balancer shafts

(a) Unscrew the bolts that hold balancer shafts, and remove the washers.

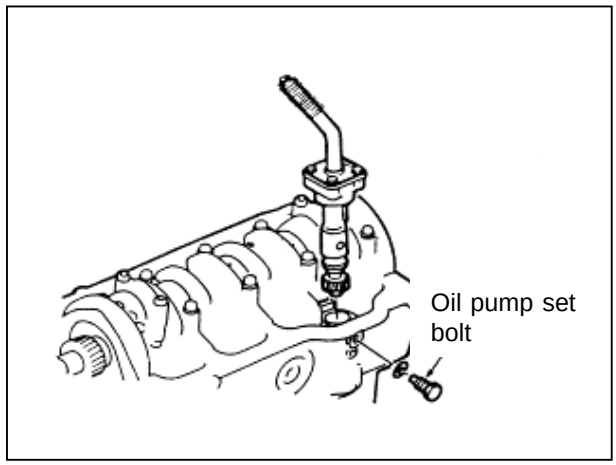
(b) Remove the gears from the balancer shafts with a gear puller.

(c) Remove the keys and snap rings from the balancer shafts.

(d) Remove the balancer shafts with bearings by, tapping their read ends with a plastic hammer.

(9) Removing oil pump

Unscrew the set bolt and remove the oil pump from the crankcase.



Removing oil pump

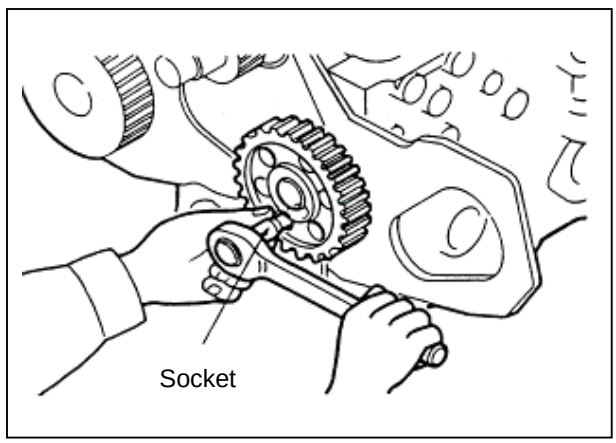
(10) Removing camshaft

(a) Position the camshaft gear so that its lightening holes are on the top and bottom sides. Unscrew the bolts that hold the thrust plate with socket (34491-00300).

(b) Pull the camshaft from the crankcase.

※ CAUTION

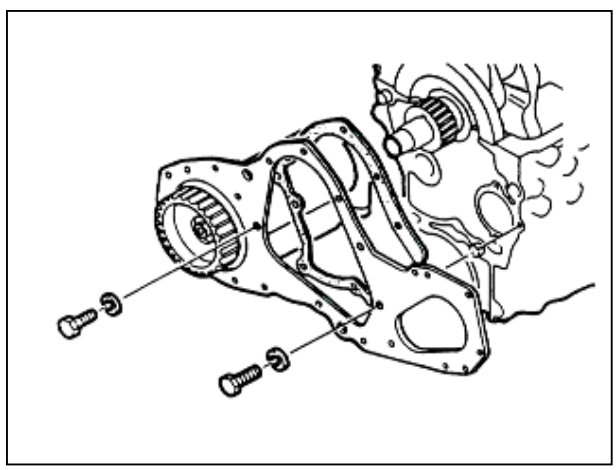
Do not cause damage to the lobes or bushing journals when removing the camshaft.



Removing camshaft

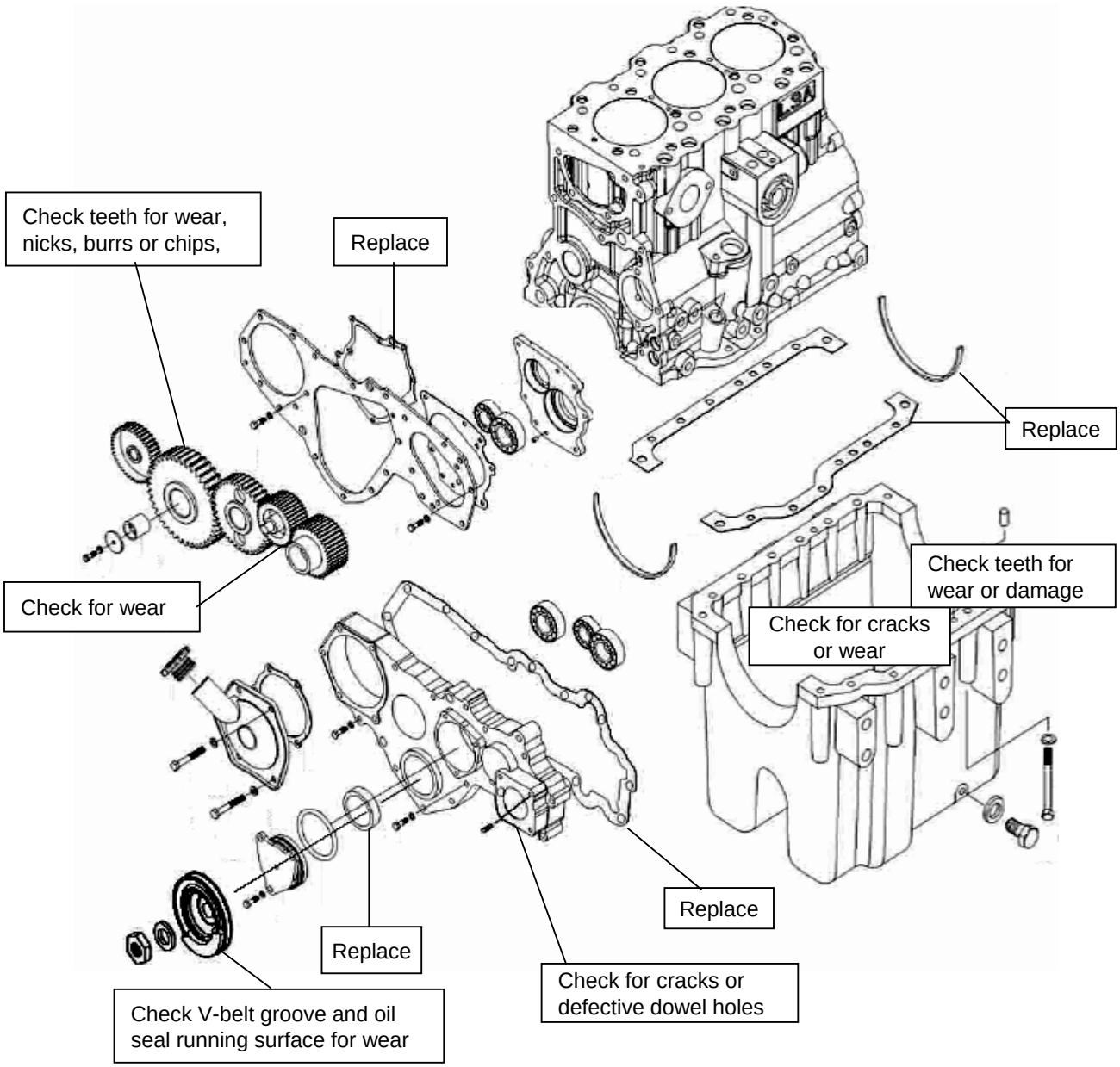
(11) Removing from plate

Unscrew the bolts that hold the front plate to the crankcase. Remove the plate (with the injection pump) from the crankcase.



Removing front plate

2. Inspection



Crankshaft pulley

Check the V-belt groove for wear. To do so, wrap a new V-belt around the pulley and press it in the groove to see if the top of the belt is above the groove of the pulley. If the belt top is uniformly above the groove all the way around the pulley is serviceable. If the top sinks into the groove more than 1.6㎜(0.1in.) replace the pulley.

Check the oil seal running surface of the pulley for wear. If the surface is badly worn, replace the pulley.

Idler gear

(1) Checking clearance between idler gear and shaft

Measure the inside diameter of the idler gear and the diameter of the shaft, as shown in the illustration, to check the clearance. If the clearance exceeds the service limit, replace the gear or shaft whichever is badly worn.

Unit: mm (in.)

Item	Assembly standard	Service limit
Clearance between idler gear and shaft	0.025 to 0.075 (0.00098 to 0.00295)	0.100 (0.00394)

(2) Replacing idler gear bushing

(a) To replace the bushing, use idler gear bushing installer (30691-51900).

(b) When installing a replacement bushing, press it into position until its end is flush with the end of the gear boss.

(c) After installing the bushing, finish its inside diameter to 36(1.42) H7.

(3) Replacing idler gear shaft

To remove the shaft for replacement, use idler gear shaft puller(MH061077).

※ **NOTE** : When installing a replacement shaft to the crankcase, make sure the oil hole in the shaft points upward.

Camshaft

(1) Checking lobe lift

To fine the lobe lift, use the procedure that follows :

(a) Measure lobe height (A).

(b) Measure base circle (B).

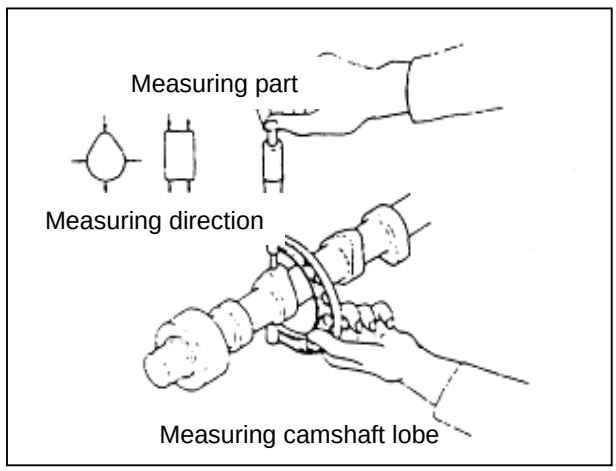
(c) Subtract base circle (B) from lobe height (A).

The difference is lobe lift (C).

If the lobe lift is less than the service limit, replace the camshaft.

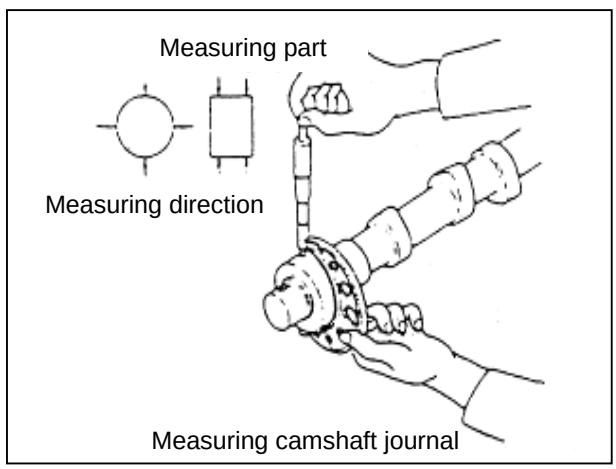
Unit: mm (in.)

Item		Nominal Size	Assembly standard	Service limit
Lobe life	Inlet Valves	46.916(1.84708) [lobe height]	6684 (0.26315)	6.184 (0.24346)
	Exhaust valves	45.944(1.80882) [lobe height]	7.344 (0.28913)	6.844 (0.26945)



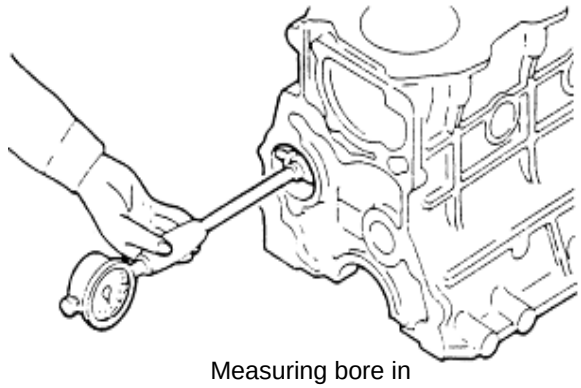
(2) Checking clearance between camshaft journal and bore in crankcase (or bushing)

Measure the diameter of the camshaft journal and the inside diameter of the bore in the crankcase (or bushing) for camshaft as shown in the illustration to check the clearance. If the clearance exceeds the service limit, replace the camshaft.



Unit : ㎜(in.)

Item		Normal size	Assembly standard	Service Limit
Diameter of camshaft journal	No.1 and No.2	54(2.13)	53.94~53.96 (2.1236~2.1244)	53.90 (2.1220)
	No.3	53(2.09)	52.94~52.96 (2.0842~2.0850)	52.90 (2.0827)
Clearance between camshaft journal and bore in crank –case (or bushing) for camshaft)		–	0.07~0.11 (0.0028~0.0043)	0.15 (0.0059)
Inside diameter of bushing	No.1	54(2.13)	54.03~54.05 (2.1272~2.1280)	–
Inside diameter of bore for camshaft	No.2	54(2.13)	54.03~54.05 (2.1272~2.1280)	–
	No.3	53(2.09)	53.03~53.05 (2.0878~2.0886)	–

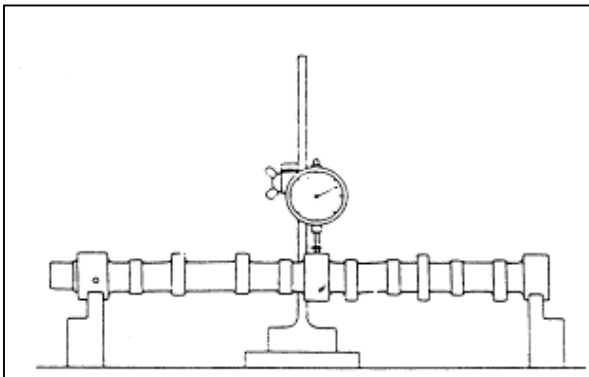


Measuring bore in crankcase (bushing) for camshaft

(3) Checking bend

Support the camshaft on its front and rear journals in V–blocks. With the dial indicator set at 0.00㎜(0.0000 in.) at the center journal, turn the camshaft full one revolution and read the indicator as shown in the illustration. 1/2 of the reading on the indicator is bend of the camshaft.

If the reading exceeds the repair limit, straighten the camshaft by cold working or replace it.



Checking camshaft for bend

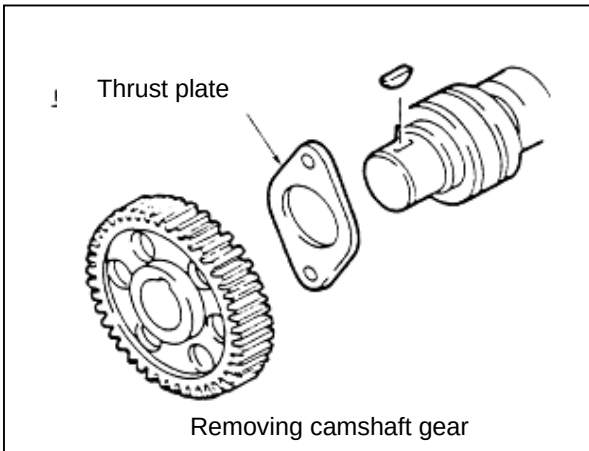
Unit : ㎜(in.)

Item	Assembly standard	Repair limit
Camshaft bend	0.02(0.0008) maximum	0.05 (0.0020)

(4) Removing camshaft gear

To remove the camshaft gear use a hydraulic press.

※ **NOTE** : Do not remove the camshaft, thrust place or gear unless it requires replacement.



Removing camshaft gear

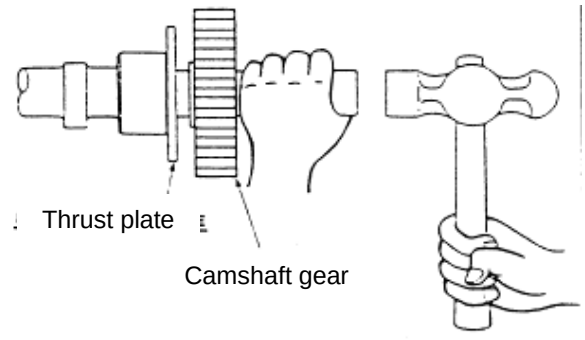
(5) Installing camshaft gear and thrust plate

(a) Install the key and thrust plate to the camshaft.

(b) Heat the gear up to a temperature of 250℃(482°F).

(c) Drive the gear onto the camshaft.

※ **NOTE** : Install the thrust plate before installing the gear to the camshaft.



Installing camshaft gear and thrust plate

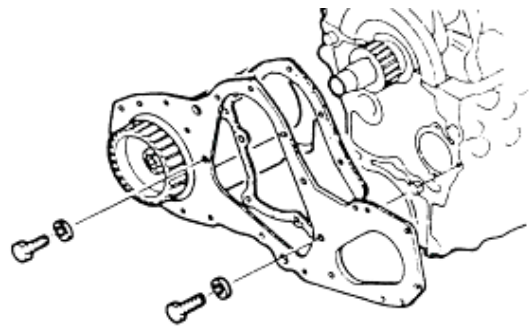
ASSEMBLY

(1) Installing front end plate

(a) Put the front end plate and gasket on the front face of the crankcase. Make sure the locating dowels enter their holes in the plate and gasket.

(b) Tighten two bolts to the specified torque.

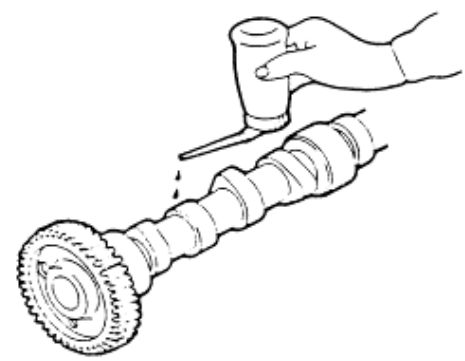
Tightening torque	1.2±0.1 kgf・m (8.7±0.7 lbf・ft) [12±1 N・m]



Installing front end plate

(2) Installing camshaft

(a) Apply engine oil to the journals and lobes of the camshaft.



Applying engine oil to camshaft

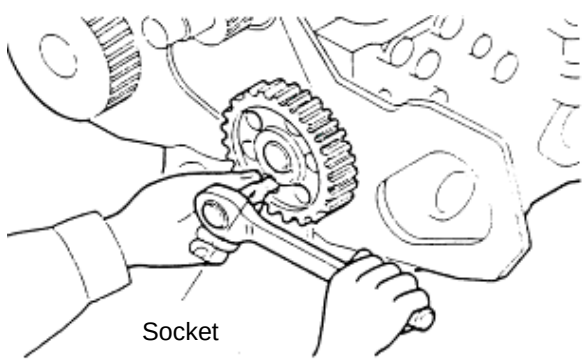
(b) Install the camshaft (with gear) in the crankcase.

※ **NOTE** : Do not cause damage to the journals and lobes.

(c) Tighten the thrust plate bolts to the specified torque with a torque wrench and socket(34491-0030).

Tightening torque	1.2±0.1 kgf・m (8.7±0.7 lbf・ft) [12±1 N・m]

(d) Make sure the camshaft rotates smoothly. Move the



Installing camshaft

camshaft back and forth in the axial direction to make sure it has correct end play.

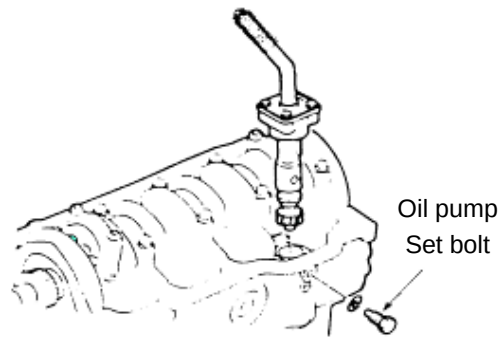
(3) Installing oil pump

(a) Install the oil pump in position in the crankcase.

Make sure the oil pump gear is meshing with the oil pump drive gear of the camshaft.

(b) Install the oil pump set bolt with gasket and tighten it to the specified torque.

Tightening torque	3.5±0.4 kgf・m (25±3 lbf・ft) [34±4 N・m]

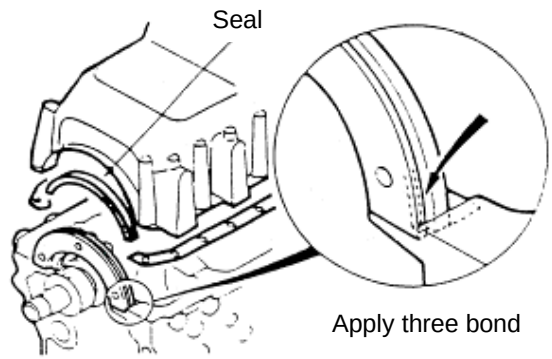


Installing oil pump

(4) Installing oil pan

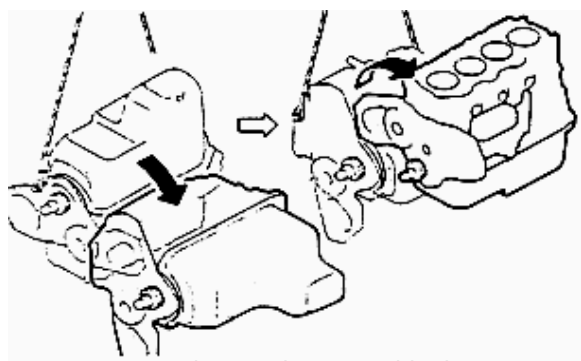
(a) Install a new gasket on the oil pan. Apply three bond 1207C or 1211 or equivalent to the seats formed of the crankcase for the No.1 and No.5 main bearing caps just enough to be forced out of the seats slightly when the U-seals are installed.

(b) Install the U-seals to the bottom of the crankcase by fitting them into the grooves in the main bearing caps while forcing their ends into the seats to which three bond was applied in step (a) as shown in the illustration.

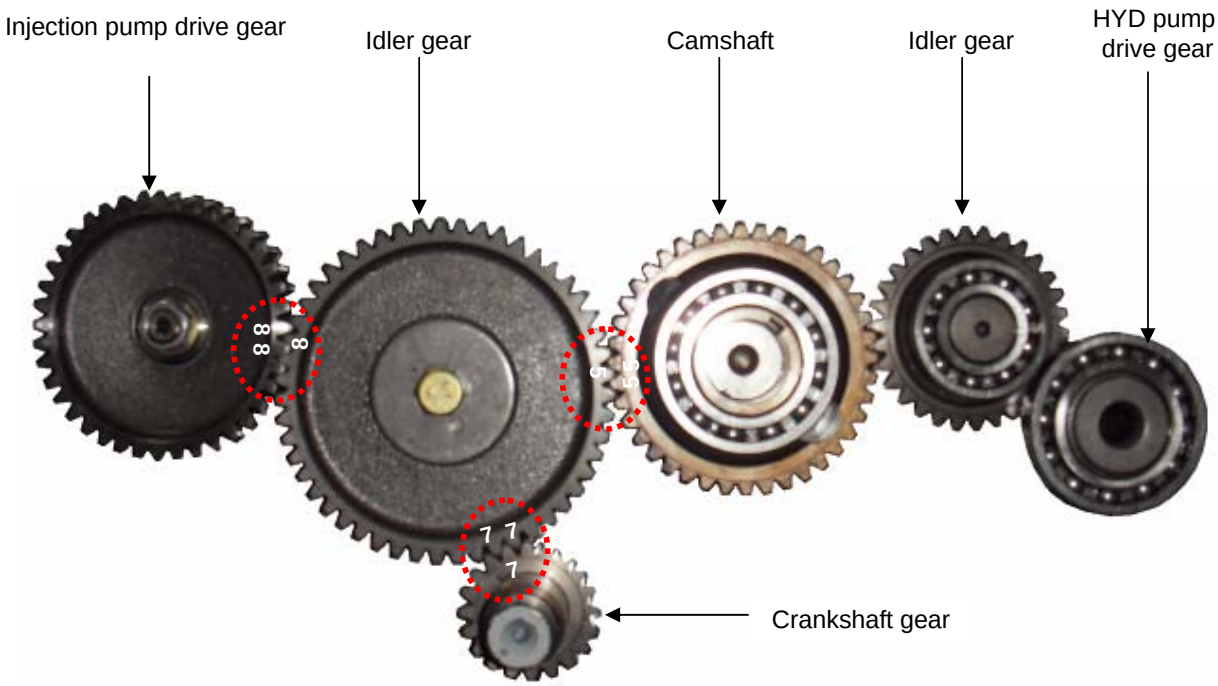


Installing oil pan

(5) Turn the crankcase upside down for the steps that follow.


Turning crankcase upside down

(6) Installing idler gear

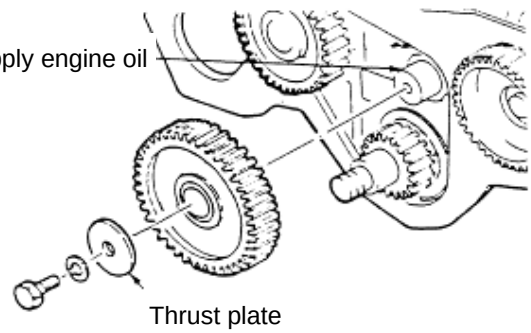


(a) Apply engine oil to the idler gear shaft.

(b) Install the idler gear with its marks in alignment with the marks on the injection pump drive gear, camshaft gear and crankshaft gear as shown in the illustration.

(c) Put the thrust plate on the idler gear and tighten the bolt with washer to the specified torque.

(d) Move the idler gear back and forth in the axial direction to make sure it has correct end play.



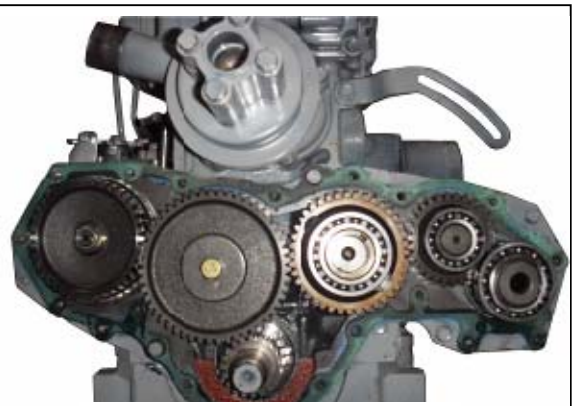
Installing idler gear

(7) Checking timing gear backlash

After installing the timing gear, check them for backlash, as shown in the illustration.

Unit : ㎜(in.)

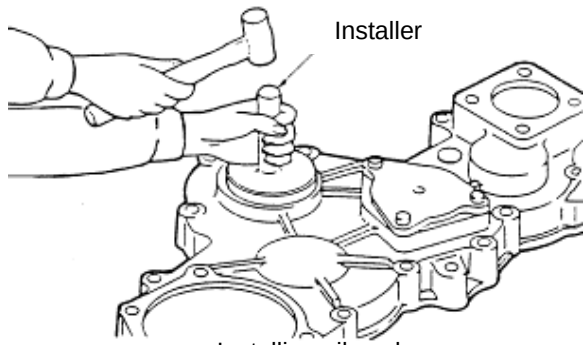
	Assembly standard	Service Limit
Crankshaft gear ~ idler gear	0.05~0.15 (0.0020~0.0059)	0.25 (0.0098)
Idler gear ~ camshaft gear		
Idler gear ~injection pump drive gear	0.04~0.16 (0.0016~0.0063)	



Checking timing gear backlash

(8) Installing oil seal

Using an installer, install a new oil seal to the timing gear case until it is flush with the end face of the case as shown in the illustration. The lip of the seal must be toward the inside of the gear case.



Installing oil seal

(9) Installing timing gear case

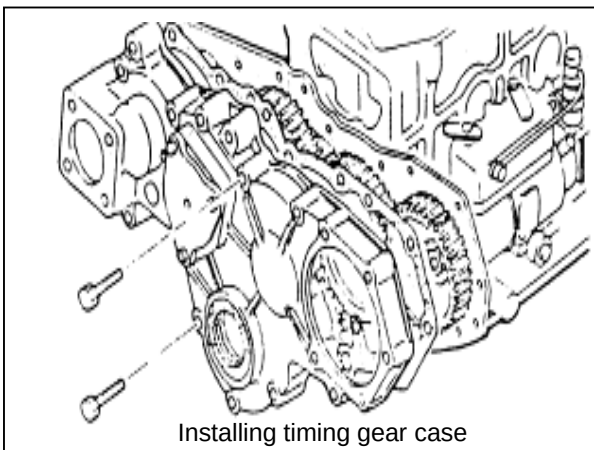
(a) Install the oil pump drive gear and idler gear to the timing gear case. Install the cover in position.

(b) Install the baffle plate to the crankshaft.

(c) Install the timing gear case and gasket to the front face of the crankcase. Make sure the locating dowels enter their holes in the case and gasket.

(d) Tighten the bolts to the specified torque.

Tightening torque	1.2±0.1 kgf・m (8.7±0.7 lbf・ft) [12±1 N・m]


Installing timing gear case

(10) Installing crankshaft pulley

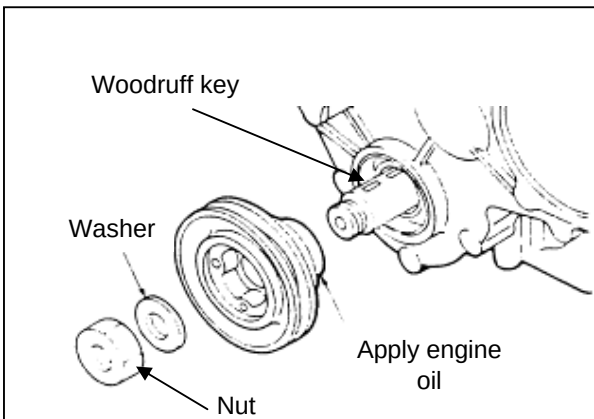
(a) Apply engine oil to the oil seal running surface of the pulley.

(b) Push the pulley on to the crankshaft in alignment with the keys.

(c) Install two lock bolts (M12 X 1.25) to the rear end of the crankshaft and insert a bar between the bolts to hold the crankshaft.

(d) Tighten the nut with washer to the specified torque.

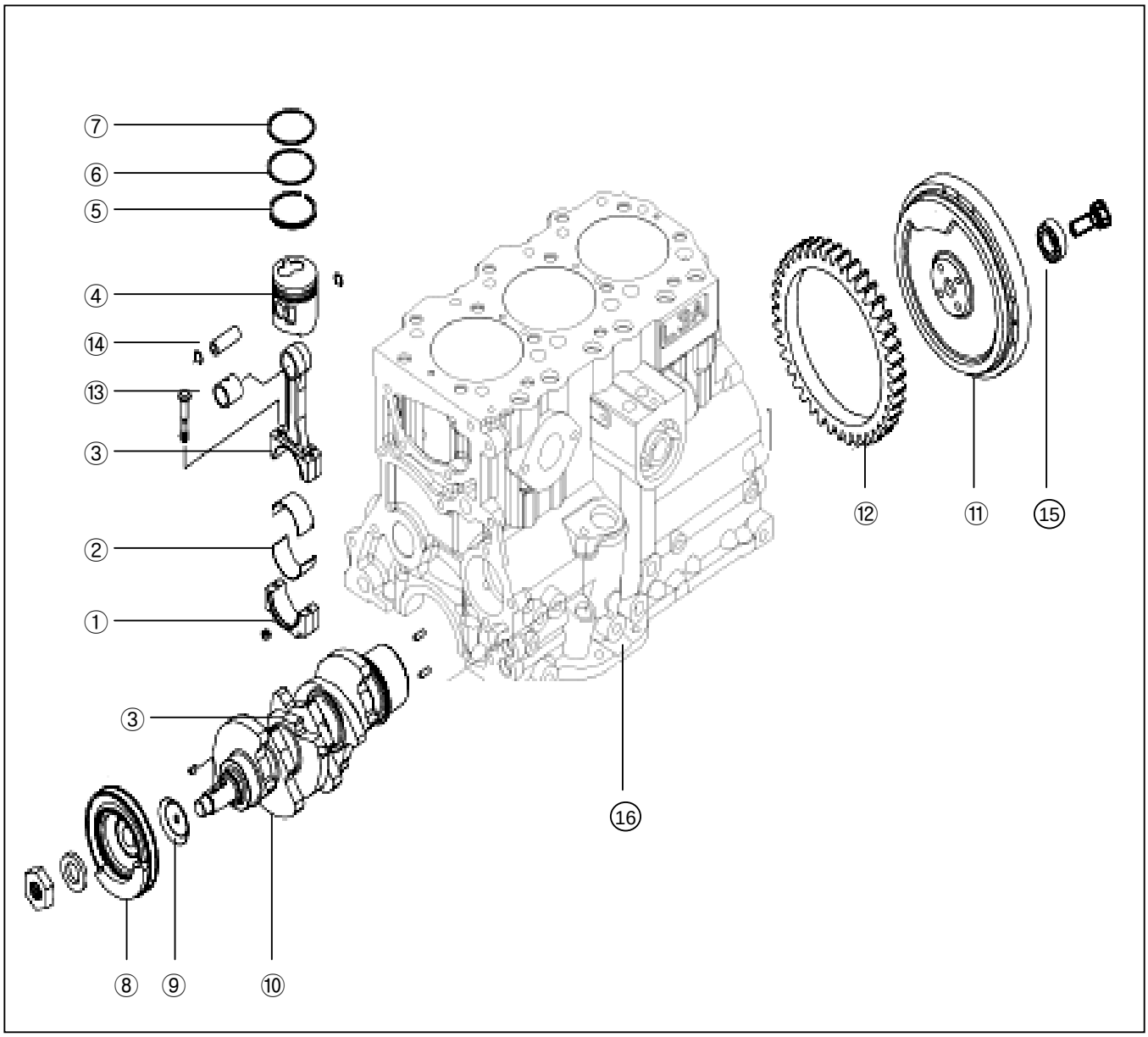
Tightening torque	40±1 kgf・m (289±7 lbf・ft) [392±10 N・m]



Installing crankshaft pulley

※ **CAUTION :** Use a strong bar to hold the crankshaft.

Disassembly

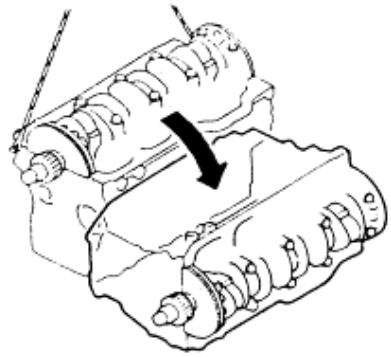


(1) Connecting rod cap (2) Connecting rod bearing (lower half) (3) Main bearing cap (4) Main bearing (lower half)
(5) Crankshaft (6) Main bearing (upper half) (7) Connecting rod (8) Connecting rod bearing (upper half)
(9) Snap ring (10) Piston pin (11) Piston (12) No.1 ring (13) No.2 ring (14) Oil ring (15)Tappet
(16) Crankcase (17) Drive gear

※ **NOTE** : When replacing the crankcase, carefully remove the parts (such as the relief valve, etc.) from the crankcase to reuse them at the time of assembly.

(1) Checking thrust clearance of connecting rod big end

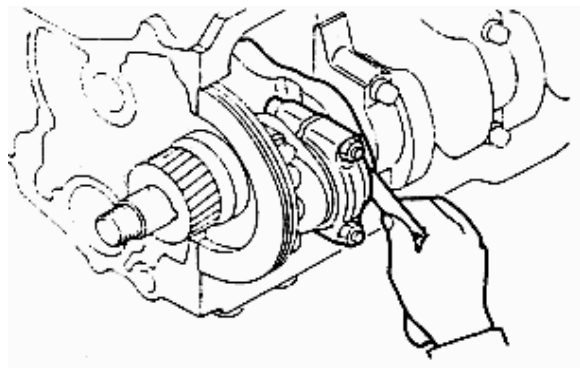
(a) Carefully lay the crankcase on its side.



Laying crankcase on its side

(b) Check the clearance between the connecting rod big end and the crankpin with a feeler gauge, as shown in the illustration.

(c) If the thrust clearance exceeds the service limit, replace the connecting rod.



Checking thrust clearance of connecting rod big end

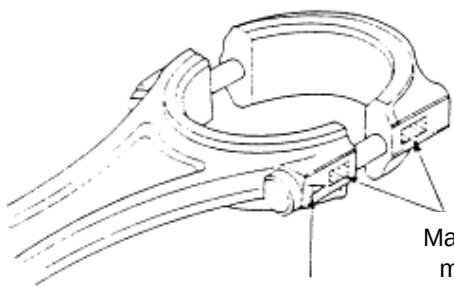
Unit : ㎜(in.)

Item	Assemble standard	Service Limit
Thrust clearance of connecting rod big end	0.15~0.35 (0.0059~0.0138)	0.50 (0.0197)

(2) Maximum permissible difference between average weight of all connecting rod assemblies in one engine.

When replacing the connecting rods, select new connecting rods having the same weight rank marks so that the difference between average weight of all connecting rod assemblies in one engine does not exceeds the maximum permissible limit.

Maximum permissible difference between average weight of all connecting rod assemblies in one engine	10g (0.35 oz)



Weight rank mark on connecting rod

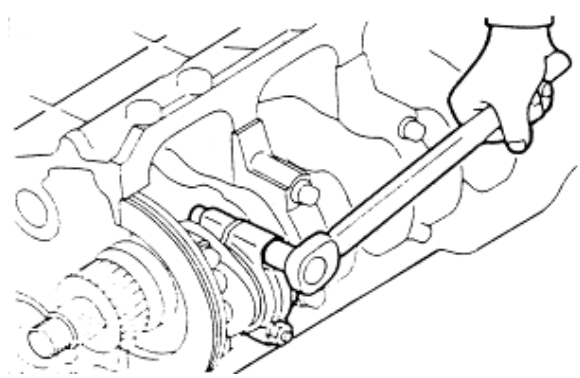
(3) Removing connecting rod caps

(a) Put a mark on each cap so it can be installed in the same position from which it was removed.

(b) Remove the caps and the lower halves of the connecting rod bearings.

(c) Put a mark on each connecting rod bearing (lower half) so it can be installed in the same position from which it was removed.

※**NOTE** : Be careful not to cause damage to the bearings.



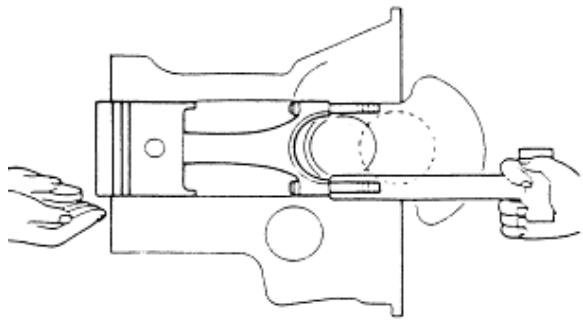
Removing connecting rod caps

(4) Removing pistons

(a) Remove carbon from the inner surface of the cylinders with a rag and sandpaper.

(b) Turn the crankshaft to bring the piston to the top dead center.

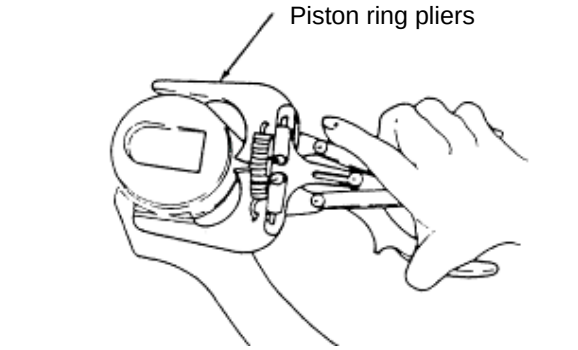
(c) Push the piston and connecting rod away from the crankshaft with the handle of a hammer until the piston rings are above the cylinder. Then remove the piston and connecting rod from the crankcase.



Removing carbon from cylinders

(5) Removing piston rings

Remove the piston rings with piston ring pliers.



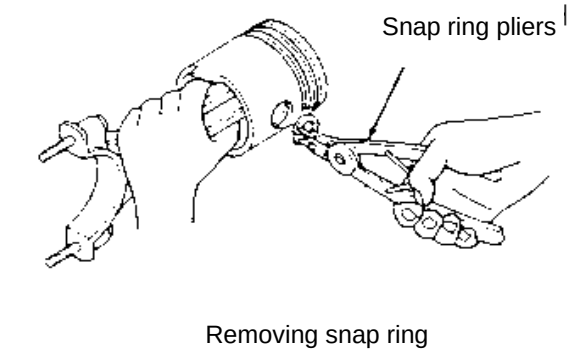
Removing piston rings

(6) Removing piston pins

(a) Remove the snap rings with a snap ring pliers.

(b) Remove the piston pin to separate the connecting rod from the piston.

※ **NOTE** : When it is difficult to remove the piston pin, heat the piston in an oven or in hot water.



Removing snap ring

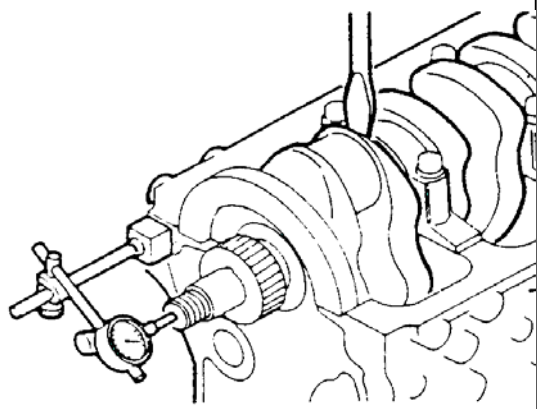
(7) Checking end play of crankshaft

(a) Turn the crankcase upside down with the oil pan side up.

(b) With a dial indicator at the end of the crankshaft check the end play as shown in the illustration. If the end play exceeds the service limit, replace the thrust bearings.

Unit : ㎜(in.)

Item	Assembly standard	Service limit
End play of crankshaft	0.100~0.204 (0.00394~0.00803)	0.300 (0.01181)

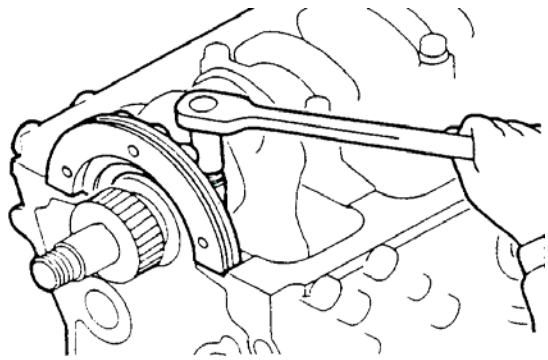


Measuring end play of crankshaft

(8) Removing main bearing caps

Remove the main bearing caps with lower halves of the main bearings.

※ **NOTE** : Be careful not to cause damage to the main bearings. Put a mark on each bearing cap so it can be installed in the same position from which it was removed.

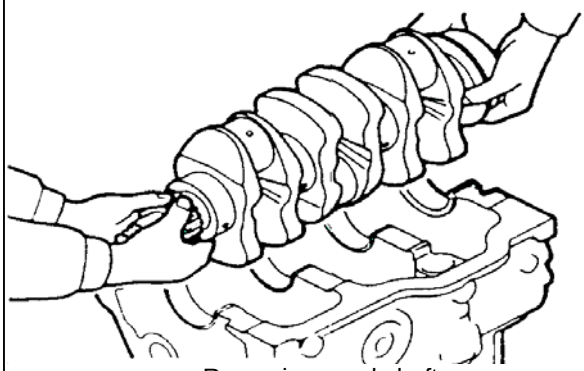


Removing main bearings caps

(9) Removing crankshaft

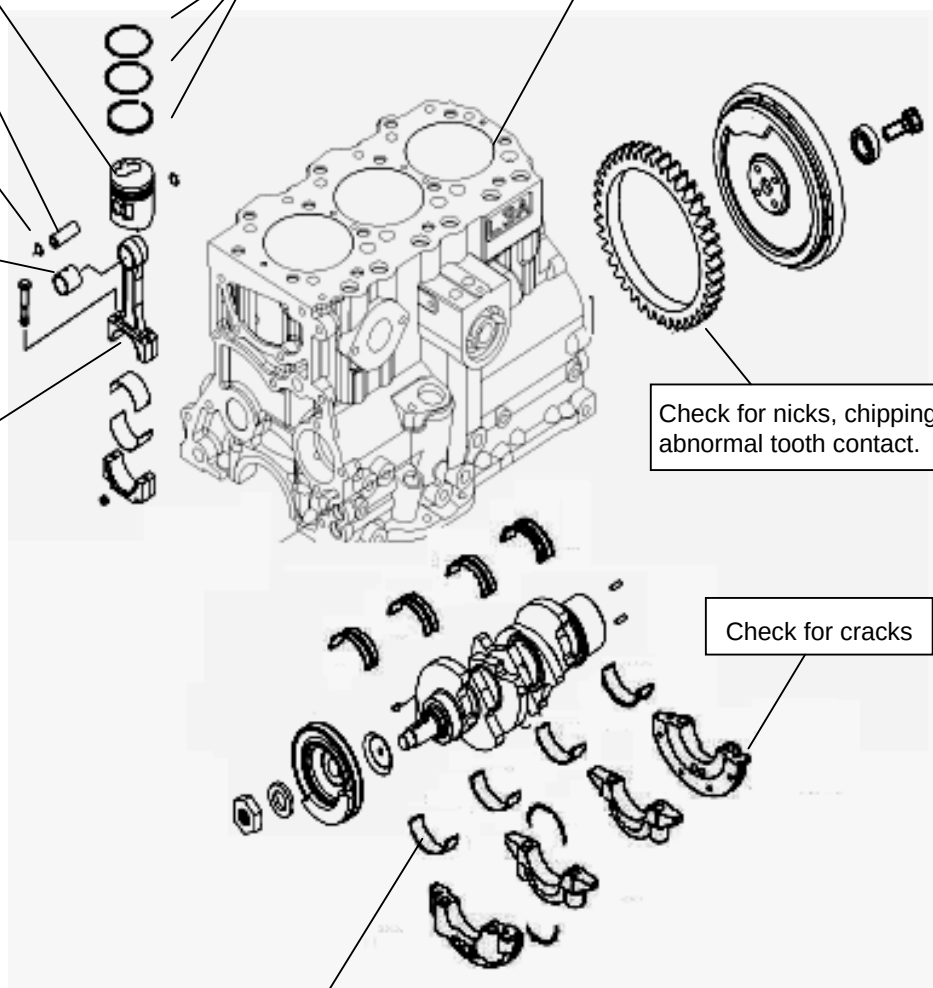
Carefully remove the crankshaft.

※ **NOTE :** Be careful not to cause damage to the main journals and crankpins. Put a mark on each bearing.



Removing crankshaft

Inspection



Typical failures for which main bearings are to be checked are scratches due to dirt embedded Into bearing material, loss of overly due to lack of oil, craters or pockets due to fatigue failure, Failure due to poor seating, radius ride, etc.

Pistons, piston rings and piston pins

(1) Checking diameter of pistons

(a) Measure the diameter of the piston at shirt in the direction transverse to the piston pin with a micrometer as shown in the illustration. If the piston is worn beyond the service limit, replace it. When replacing the piston select a new piston so that the difference between average weight of all pistons in one engine does not exceeds the maximum permissible limit.

Unit : ㎜(in.)

■ L3AL, L3AS

Item		Normal size	Assembly standard	Service limit
Diameter of piston	Standard	89.970 (3.4634)	89.955~89.985 (3.4628~3.4640)	89.770 (3.4555)
	0.25(0.0098) oversize	90.220 (3.4732)	90.205~88.235 (3.4726~3.4738)	90.020 (3.4654)
	0.50(0.0197) oversize	90.470 (3.4831)	90.445~88.485 (3.4825~3.4837)	90.270 (3.4752)
Maximum permissible diff-erence between average weight of all pistons in one engine.			5g(0.2oz) maximum	

■ L3BL

Item		Normal size	Assembly standard	Service limit
Diameter of piston	Standard	87.970	87.955~87.985	87.770
	0.25(0.0098) oversize	88.220	88.205~88.235	88.020
	0.50(0.0197) oversize	88.470	88.445~88.485	88.270
Maximum permissible diff-erence between average weight of all pistons in one engine.			5g(0.2oz) maximum	

(b) The weight of the piston is stamped on the top of the piston.

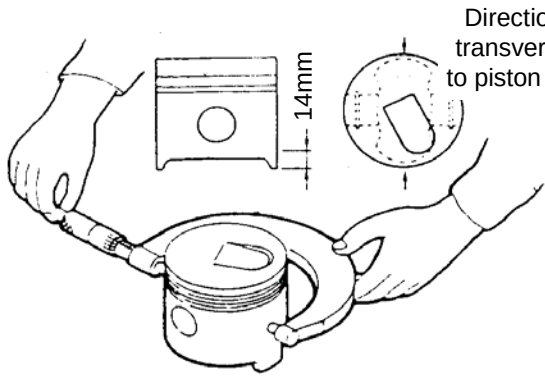
(2) Checking pistons and piston rings

(a) Check the clearance between the groove and the piston ring with a feeler gauge as shown in the illustration. If the clearance exceeds the service limit, replace the piston ring.

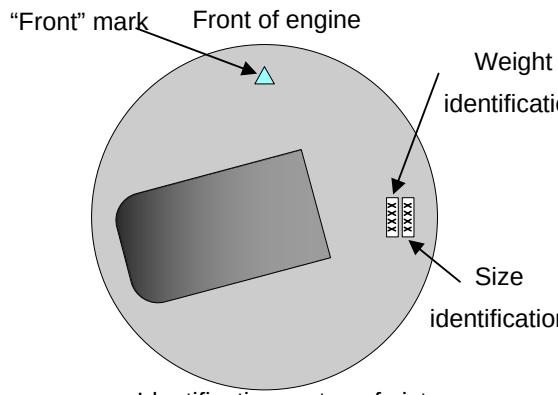
Unit : ㎜(in.)

Item		Assembly standard	Service Limit
Clearance between groove and piston ring	No.1 ring	0.060~0.100 (0.0024~0.0040)	0.200 (0.0079)
	No.2 ring	0.045~0.085 (0.0018~0.0032)	0.150 (0.0059)
	Oil ring	0.025~0.065 (0.0010~0.0026)	

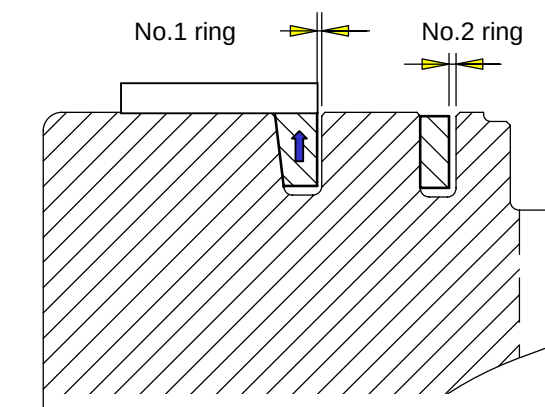
(b) Install a new piston rings and recheck the clearance. If the clearance still exceeds the service limit, replace the piston.



Checking diameter of piston



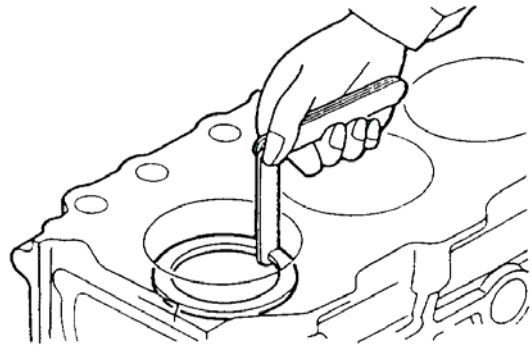
Identification on top of piston



Checking between groove and piston ring

(3) Checking clearance between ends of piston ring

Install the piston ring in a new cylinder or a gauge and measure the clearance between the ends of the ring with a feeler gauge. If the clearance exceeds the service limit, replace all piston rings.



Checking clearance between ends of piston ring

Inside diameter of gauges

	Item	L3BL	L3AL, L3AS
Inside diameter of crankcase	Standard	88.00 $^{+0.35}_{0}$ mm	90.00 $^{+0.35}_{0}$ mm
	0.25 O.S	88.25 $^{+0.35}_{0}$ mm	90.25 $^{+0.35}_{0}$ mm
	0.50 O.S	88.50 $^{+0.35}_{0}$ mm	90.50 $^{+0.35}_{0}$ mm

※**NOTE** : Install the piston ring in the cylinder squarely with a piston.

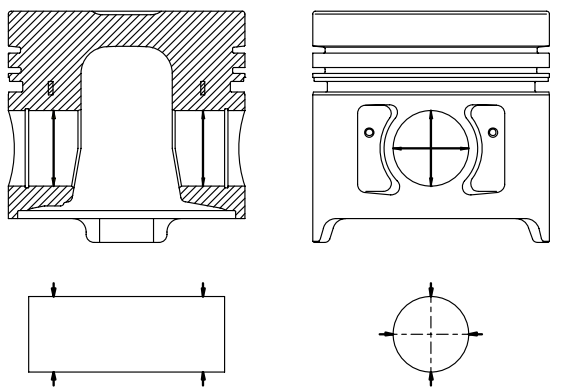
Unit : ㎜(in.)

Item		Assembly standard	Service Limit
Clearance between ends of piston ring	No.1, No. 2 ring	0.20 ~ 0.35 (0.0099~0.0158)	1.50 (0.0591)
	Oil ring	0.20 ~ 0.40 (0.0118~0.0197)	

(4) Checking clearance between piston pin and bore

Measure the inside diameter of the pin bore of the piston and the diameter of the pin as shown in the illustration, to check the clearance. If the clearance exceeds the service limit, replace the parts.

Unit : ㎜(in.)



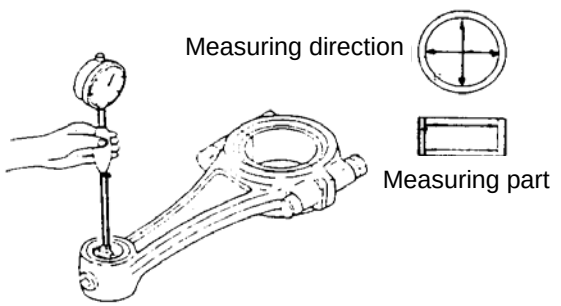
Measuring piston pin and bore

Item	Normal size	Assembly standard	Service limit
Diameter of piston pin	28 (1.10)	27.994~28.000 (1.1021~1.10234)	—
Clearance between piston pin and bore	—	0.000~0.016 (0.0000~0.0006)	0.050 (0.0020)

(5) Checking clearance between connecting rod bushing and piston pin

Measure the inside diameter of the connecting rod bushing bore and the diameter of the piston pin as shown in the illustration to check the clearance. If the clearance exceeds the service limit, replace the parts.

Unit : ㎜(in.)



Measuring connecting rod bushing

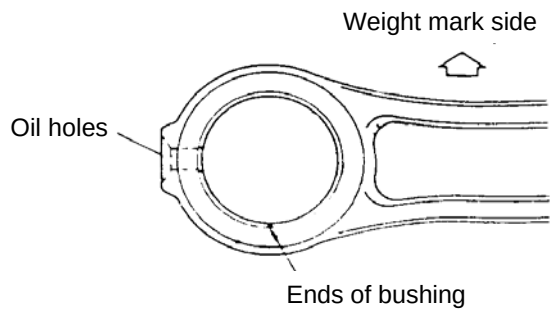
Item	Normal size	Assembly standard	Service limit
Inside diameter of bushing	28 (1.10)	28.020~28.045 (1.1032~1.1041)	—
Clearance between bushing and piston pin	—	0.020~0.051 (0.0008~0.0020)	0.080 (0.0032)

(6) Replacing connecting rod bushings

(a) Use a connecting rod bushing puller to replace the replace the connecting rod bushings.

(b) When installing a new bushing, align the oil holes in the bushing and connecting rod. Position the ends of the bushing at the location shown in the illustration.

(c) After installing the bushing, insert the piston pin into position and make sure it rotates smoothly.



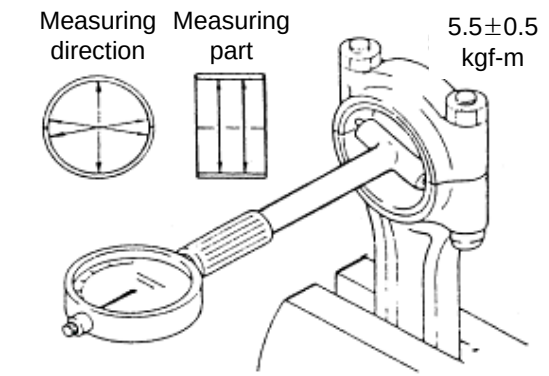
Installing connecting rod

Crankshaft

(1) Checking oil clearance of connecting rod bearings

(a) Install the upper and lower halves of the bearings and the cap to the connecting rod and tighten the cap nuts to the specified torque. Measure the inside diameter of the bearing as shown in the illustration.

Tightening torque	5.5±0.5 kgf・m (40±4 lbf・ft) [54±5 N・m]

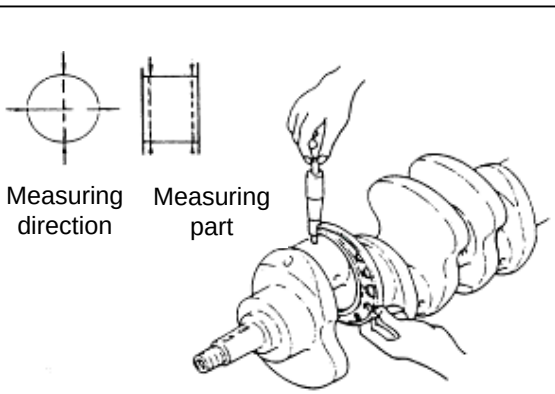


Measuring connecting rod bearing

(b) Measure the diameter of the crankpin of the crankshaft as shown in the illustration and subtract the diameter of the crankpin from the inside diameter of the bearing (Step (a)). The difference is the oil clearance of the connecting rod bearing

Unit : ㎜(in.)

Item	Normal size	Assembly standard	Service limit
Diameter of crankpin (standard)	58 (2.28)	57.955~57.970 (2.2817~2.2823)	—
Oil clearance	—	0.03~0.09 (0.0012~0.0035)	0.20 (0.0079)



Measuring crankpin

(c) If the oil clearance exceeds the repair limit, replace the bearing and recheck the oil clearance.

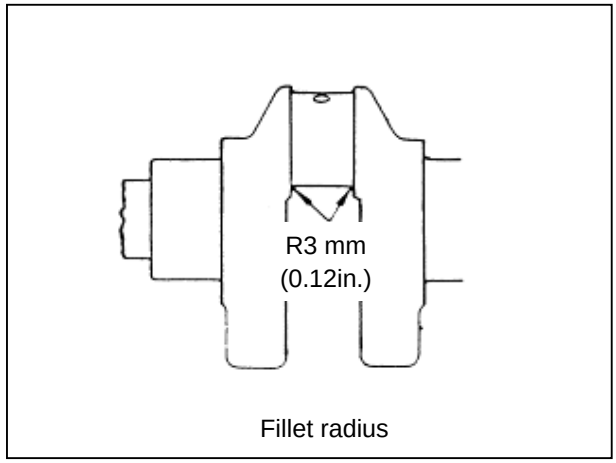
(d) If the oil clearance still exceeds the repair limit, use 0.25㎜(0.0098in.), 0.50㎜(0.0197in.) or 0.75㎜(0.02 95in.) undersize bearings. When using undersize bearings, refinish the crankpins to any of the undersize listed below.

Unit : ㎜(in.)

		Finishing dimension
Undersize of crankpin	0.25 (0.0098)	$57.75^{-0.030}_{-0.045}$ ($2.2736^{-0.00118}_{-0.00177}$)
	0.50 (0.0197)	$57.50^{-0.030}_{-0.045}$ ($2.2638^{-0.00118}_{-0.00177}$)
	0.75 (0.0295)	$57.25^{-0.030}_{-0.045}$ ($2.2539^{-0.00118}_{-0.00177}$)

※**NOTE** : a) Grind all crankpins to the same undersize.

b) Finish the fillet radius to 3㎜(0.12in.)

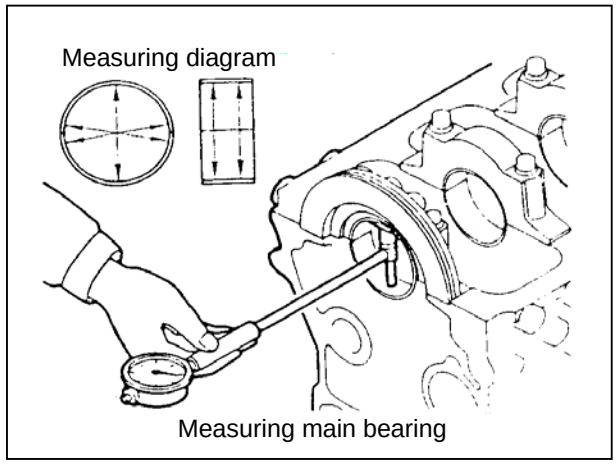


Fillet radius

(2) Checking oil clearance of main bearings

(a) Install the upper and lower halves of the bearings and the cap to the crankcase and tighten the cap nuts to the specified torque. Measure the inside diameter of the bearing as shown in the illustration.

Tightening torque	8.5±0.5 ㎏f・m (61±4 lbf・ft) [83±5 N・m]

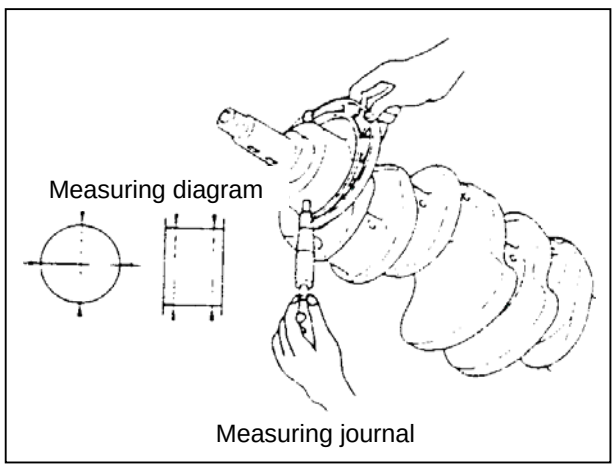


Measuring main bearing

(b) Measure the diameter of the journal of the crankshaft as shown in the illustration and subtract the diameter of the journal from the inside diameter of the bearing (Step (a)). The difference is the oil clearance of the main bearing.

Unit : ㎜(in.)

Item	Normal size	Assembly Standard	Service limit
Diameter of Journal (standard)	65 (2.56)	69.840~69.855 (2.5577~2.5585)	—
Oil clearance	—	0.035~0.100 (0.0014~0.0039)	0.200 (0.0079)



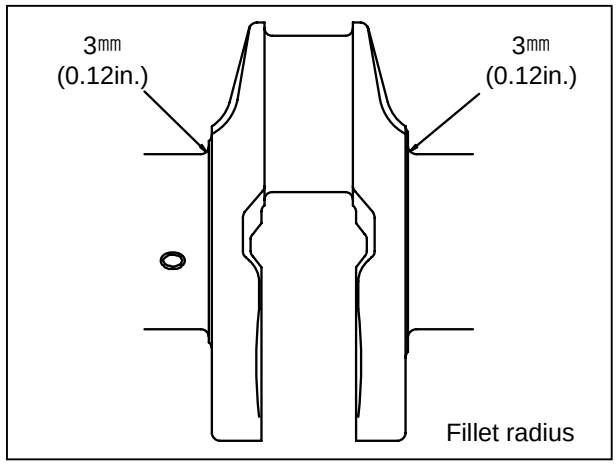
Measuring journal

(c) If the oil clearance exceeds the service limit, replace the bearing and recheck the oil clearance.

(d) If the oil clearance still exceeds the service limit, use 0.25㎜(0.0098in.), 0.50㎜(0.0197in.) or 0.75㎜(0.0295in.) undersize bearings, refinish the journals to any of the undersize listed below.

Unit : ㎜(in.)

		Finishing dimension
Undersize of journal	0.25 (0.0098)	$64.75^{-0.015}_{-0.035}$ ($2.5492^{-0.00058}_{-0.00138}$)
	0.50 (0.0197)	$64.50^{-0.015}_{-0.035}$ ($2.5394^{-0.00058}_{-0.000138}$)
	0.75 (0.0295)	$64.25^{-0.015}_{-0.035}$ ($2.5295^{-0.00058}_{-0.00138}$)



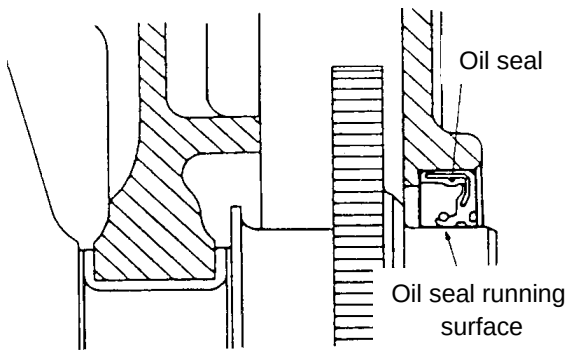
Fillet radius

※**NOTE** : a) Grind all crankpins to the same undersize.

b) Finish the fillet radius to 3㎜(0.12in.)

(3) Checking oil seal running surface

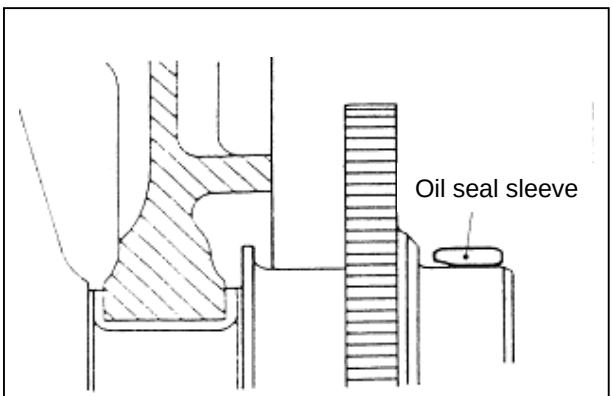
Check the oil seal running surface of the balancer shaft drive gear for wear at the rear end of the crankshaft. If the drive gear is badly worn, replace the oil seal with replacement oil seal and oil seal sleeve.



Checking oil seal running surface

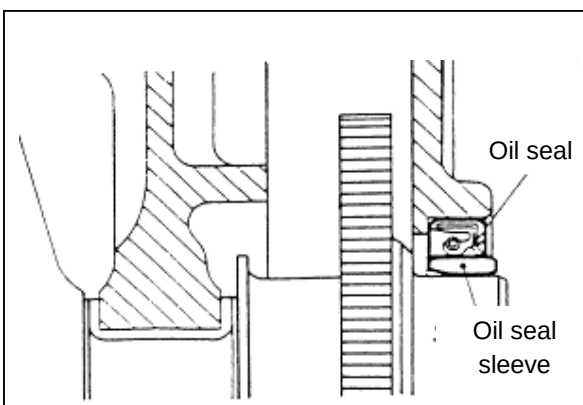
(a) Installing oil seal sleeve

Heat an oil seal sleeve in an oven to a temperature of 100℃ to 150℃(212°F to 302°F) and install it by tapping uniformly with a hammer.



Installing oil seal sleeve

When the oil seal sleeve is worn after the engine has been operated, replace both oil seal and oil seal sleeve.

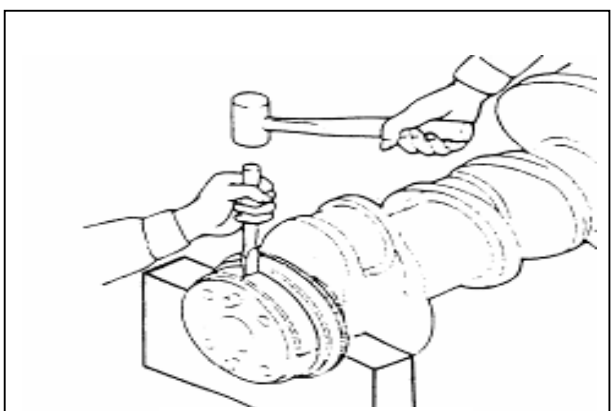


Oil seal running surface

(b) Removing oil seal sleeve

Hold a flat cold chisel at right angles to the sleeve and cut the sleeve at three places to loosen it, as shown in the illustration. If it is impossible to remove the sleeve in this method, hold the chisel in the axial direction and lightly tap the sleeve to loosen it.

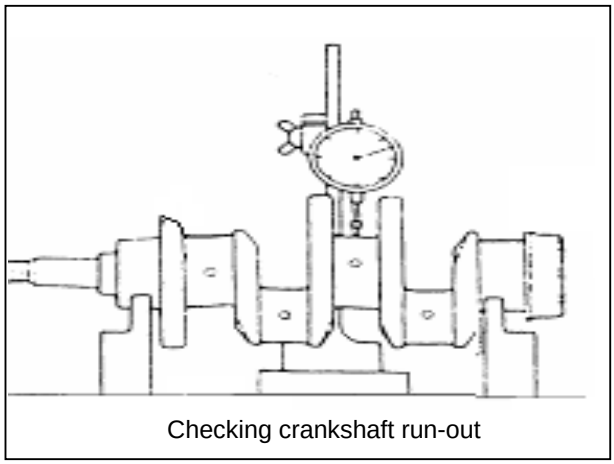
※**CAUTION** : Be extra careful not to cause damage to the drive gear when removing the sleeve.


Removing oil seal sleeve

(4) Checking run-out

Support the crankshaft on its front and rear journals in V-blocks. With the dial indicator set at 0.00㎜(0.0000in.) at the center journal, turn the camshaft full one revolution and read the indicator as shown in the illustration.

If run-out is out of the assembly standard but does not exceeds the repair limit, repair the crankshaft by grinding. If run-out exceeds the repair limit, repair the crankshaft by cold working. Replace the crankshaft of run-out exceeds the repair limit excessively.



Checking crankshaft run-out

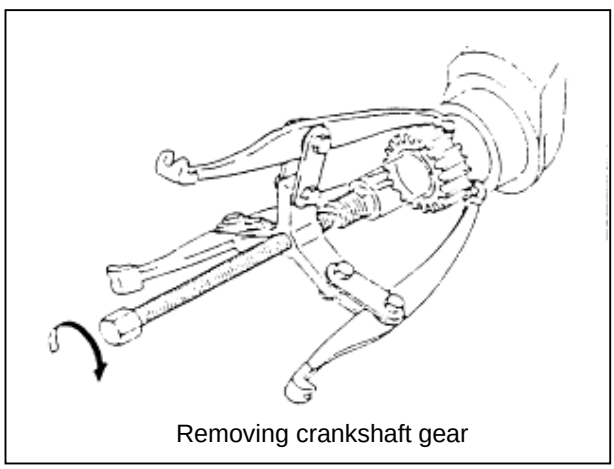
Unit : ㎜(in.)

Item	Assembly standard	Repair limit
Crankshaft run-out	0.02(0.0008) Maximum	0.05 (0.0020)

(5) Removing crankshaft gear

Remove the crankshaft gear with a gear puller as shown in the illustration.

※ **NOTE** : Do not remove the gear unless it requires replacement.



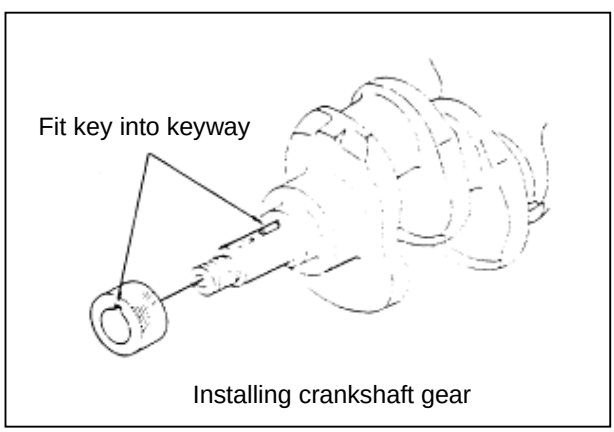
Removing crankshaft gear

(6) Installing crankshaft gear

(a) Heat the gear in an oven to a temperature of 100℃ to 150℃(212°F to 302°F).

(b) Install the key to the crankshaft.

(c) Install the gear by fitting the key into the keyway in the gear.



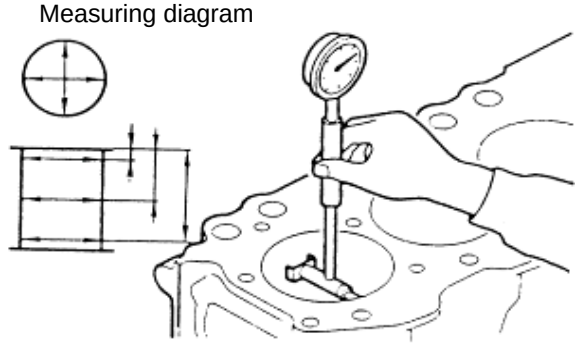
Installing crankshaft gear

Crankcase

(1) Checking bores

(a) Measure the engine bore with a cylinder bore gauge having a dial indicator. Take measurements as A, B and C positions in the bore on axes 90˚ apart as shown in the illustration to check the diameter, out-of-round and taper. If the bores exceeds the service limit for diameter, out-of-round and taper, increase them for oversize pistons.

Measuring diagram



Checking crankcase bore

• L3AS,L3AL

Unit : ㎜(in.)

		Assembly standard	Service Limit
Cylinder inner size	Standard	$90.00\ ^{+0.035}_{0}$ ($3.46\ ^{+0.00138}_{0}$)	Standard +0.2 (+0.008)
	0.25 (0.0098)	$90.25\ ^{+0.035}_{0}$ ($3.4744^{+0.00138}_{0}$)	
	0.50 (0.0197)	$90.50\ ^{+0.035}_{0}$ ($3.4842^{+0.00138}_{0}$)	
Out-of-round and taper of bores		0.015(0.00059) Maximum	

• L3BL

Unit : ㎜(in.)

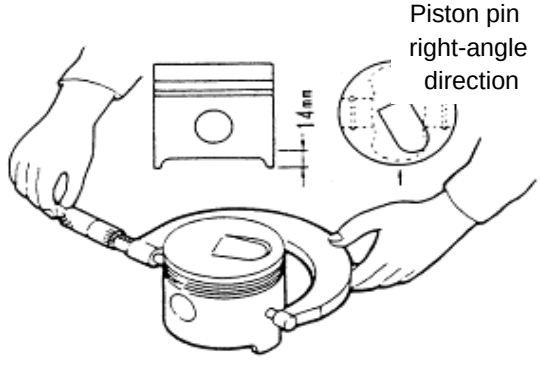
		Assembly standard	Service Limit
Cylinder inner size	Standard	$88.00\ ^{+0.035}_{0}$ ($3.46\ ^{+0.00138}_{0}$)	Standard +0.2 (+0.008)
	0.25 (0.0098)	$88.25\ ^{+0.035}_{0}$ ($3.4744^{+0.00138}_{0}$)	
	0.50 (0.0197)	$88.50\ ^{+0.035}_{0}$ ($3.4842^{+0.00138}_{0}$)	
Out-of-round and taper of bores		0.015(0.00059) Maximum	

(b) Boring and honing

1) Determine an oversize to which the bores are to be increased by boring and honing on the basis of the maximum measurement taken on the bores.

2) Bore, then finish hone the bores to the oversize determined in (Step 1).

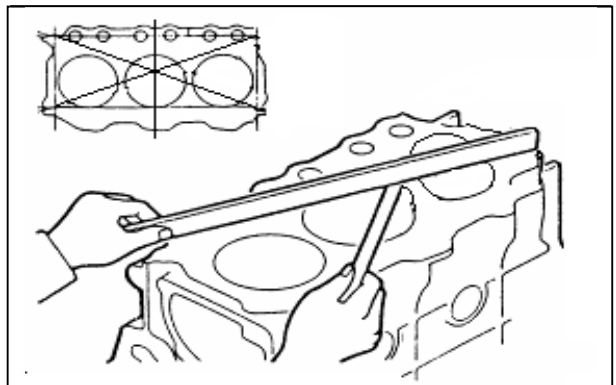
Piston pin right-angle direction



(2) Checking top face

Check the top face warpage, using an accurate straight edge and a feeler gauge, in three positions lengthwise, two crosswise and two widthwise as shown in the illustration.

If warpage exceeds the repair limit, grind the crankcase.



Checking crankcase top face

Unit : ㎜(in.)

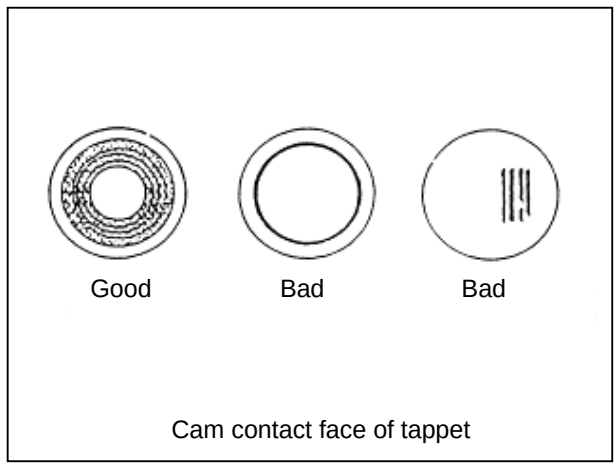
Item	Assembly standard	Repair Limit
Warpage of crankcase top face	0.05(0.0020) maximum	0.20 (0.0079)

※ **NOTE** : The maximum limit of stock to be removed from the crankcase and cylinder head grinding is 0.2 ㎜(0.008in.) in all.

Tappets

(1) Checking for wear

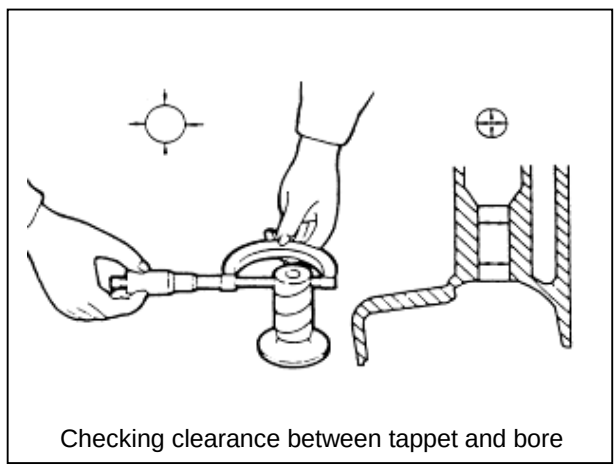
Check the cam contact face of each tappet for wear. Replace badly worn tappets if any.



Cam contact face of tappet

(2) Checking clearance between tappet and bore

Measure the diameter of the tappet and the inside diameter of the bore in the crankcase for the tappet as shown in the illustration, to check the clearance. If the clearance exceeds the service limit, replace the tappets. If the bores are worn beyond the service limit, replace the crankcase.



Checking clearance between tappet and bore

Unit : ㎜(in.)

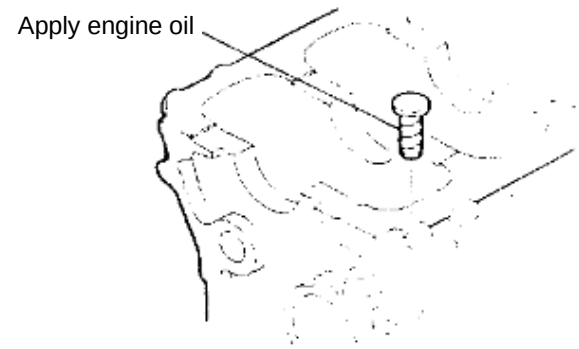
Item	Normal size	Assembly standard	Service limit
Inside diameter of bore for tappet	14 (0.55)	14.000~14.018 (0.5512~0.5519)	14.100 (0.5551)
Clearance between tappet and bore	—	0.016~0.052 (0.0006~0.0021)	0.080 (0.0032)

Assembly

(1) Installing tappets

(a) Apply engine oil to the tappets and install them in the bores in the crankcase.

(b) Make sure the tappets rotate smoothly.



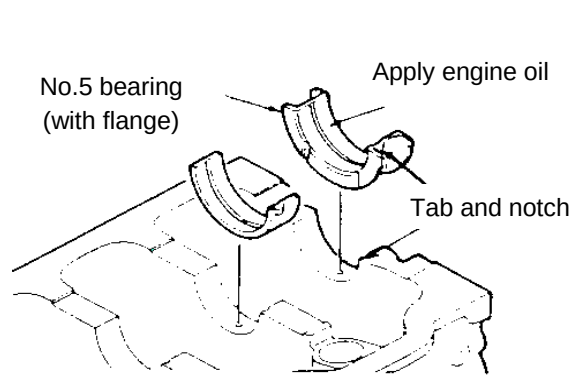
Installing tappet

(2) Installing crankshaft

(a) Install the lower halves of the main bearings in the main bearing caps. Install the upper halves of the main bearings in the crankcase.

※ **NOTE** : a) Make sure the upper and lower halves of the main bearings are installed so the bearing tabs fit into the notch in the crankcase and main bearing caps.

b) Only the upper halves of the main bearings to be installed in the crankcase has an oil groove.



Installing main bearings

(b) Install the upper and lower halves of the main bearing having flange in the crankcase and main bearing cap for No.5 journal of he crankshaft.

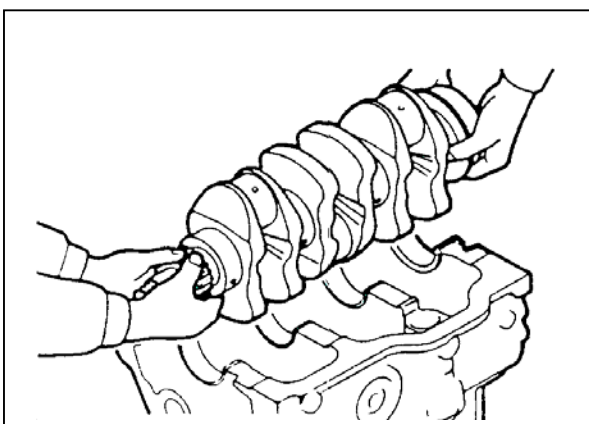
(c) Apply a small amount of engine to the inside of the main bearings.

(d) Wash the crankshaft with cleaning solvent and blow dry with compressed air. Make sure all oil holes in the crankshaft are clean. Check the oil holes for condition.

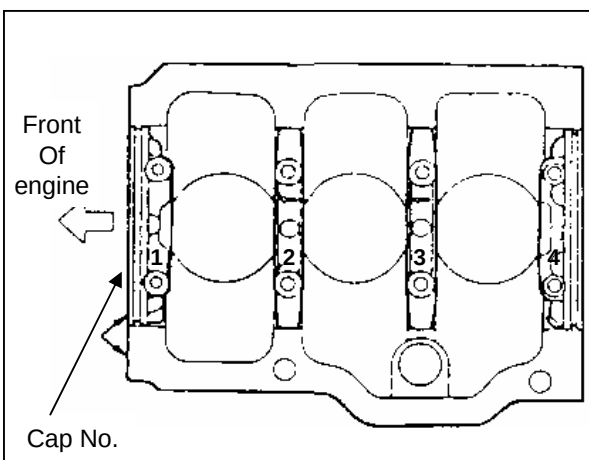
(e) Fasten a hoist to the crankshaft and carefully install it in the crankcase.

(f) Apply a small amount of engine oil to the journals of the crankshaft.

(g) Install the main bearing caps in position so the “Front” mark (arrow) on the cap is toward the front of the engine and the number on the cap is the same as the number on the crankcase on the left side of each main bearing cap.

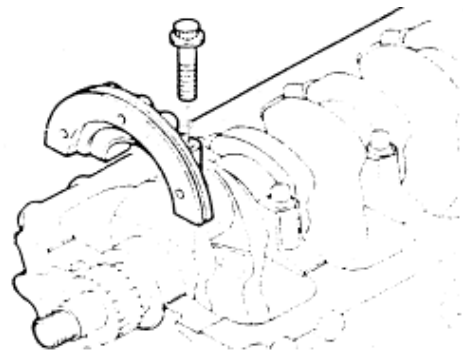

Installing crankshaft

※ **NOTE** : The end faces No.1 and No.5 bearing caps must be flush with the end faces of the crankcase.



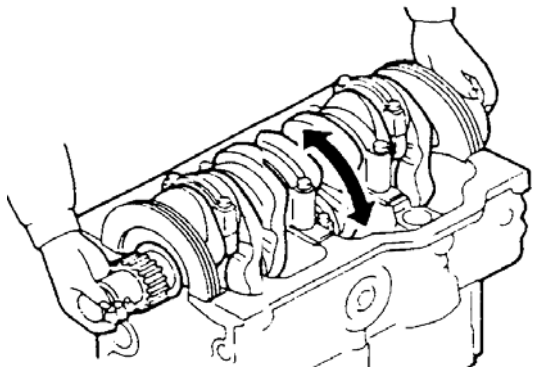
(h) Tighten the main bearing cap bolts evenly to the specified torque.

Tightening torque	8.5±0.5 kgf・m (61±4 lbf・ft) [83±5 N・m]



Tightening main bearing cap bolts

(i) Make sure the crankshaft rotates smoothly.



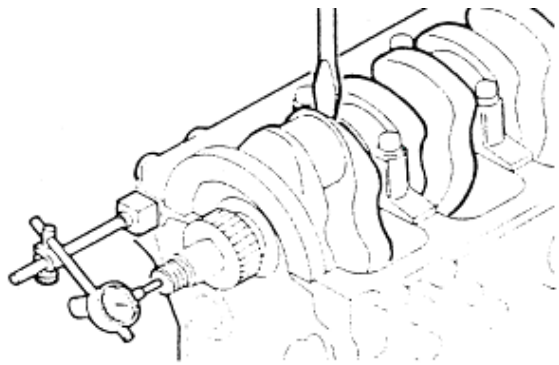
Checking crankshaft for rotation

(j) Check the crankshaft end play with a dial indicator as shown in the illustration.

Unit : ㎜(in.)

Item	Assembly standard	Repair limit
End play of crankshaft	0.100 to 0.204 (0.0039 to 0.0080)	0.300 (0.0118)

If the end play is less than the assembly standard, retighten the main bearing cap bolts. If it exceeds the service limit, replace the flanged bearings.

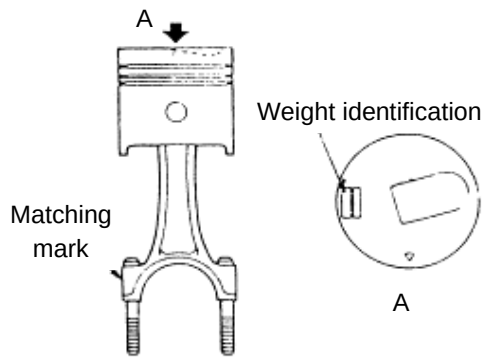


Checking crankshaft end play

(3) Assembling pistons

(a) Put the connecting rod in position in the piston with the matching mark of the rod on the same side as the weight identification on the top of the piston.

(b) Apply engine oil to the piston pin and install it in position.



Assembling piston (1)

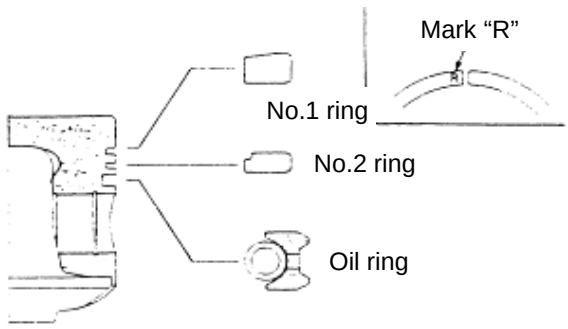
(c) Install the snap rings in the grooves in the piston with a pliers. Make sure the snap rings fit in the grooves properly.

※ **NOTE** : The snap ring ends must be toward the bottom of piston.

Assembling piston (2)

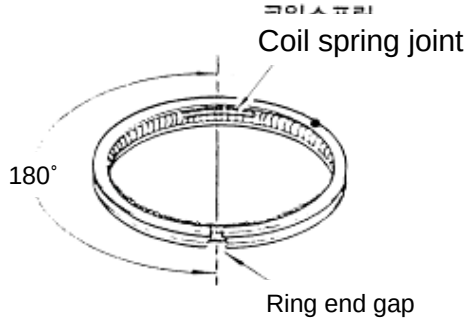
(4) Installing piston rings

Using piston ring pliers (31391-12900), install the compression (No.1 and No.2) rings and oil ring on the piston with the mark “R” toward the top of the piston.



Piston and piston rings

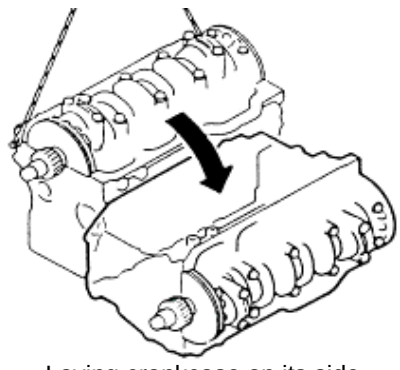
※ **NOTE :** The oil ring must be installed on the piston with the ring end gap 180˚ from the oil ring spring joint.



Oil ring end gap and spring joint

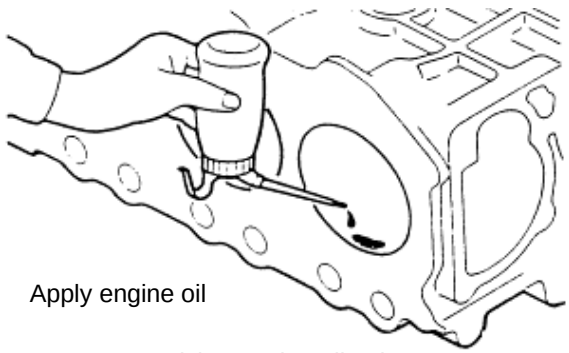
(5) Installing piston assemblies

(a) Lay the crankcase on its side.



Laying crankcase on its side

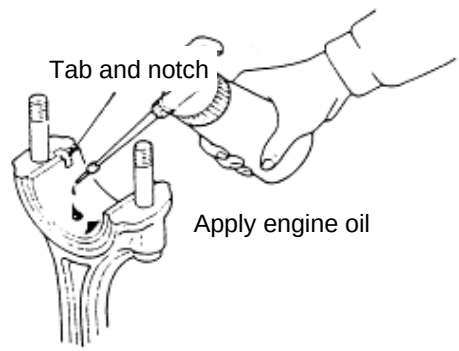
(b) Clean the bores with a clean rag and apply engine oil to the bores.



Applying engine oil to bores

(c) Install the connecting rod cap bolts in the big end of the connecting rod so the flats of their heads fit on the connecting rod properly.

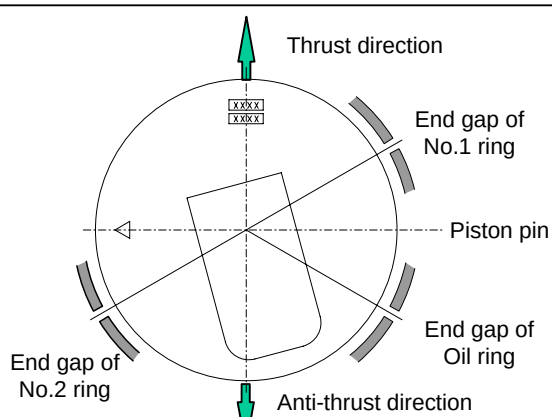
(d) Install the upper half of the connecting rod bearing in the big end of the connecting rod. Make sure the tab on the back of the bearing is in the notch of the connecting rod.



Installing connecting rod bearings

(e) Apply engine oil to the piston rings.

(f) Make sure the piston ring end gaps are arranged on the piston as shown in the illustration.



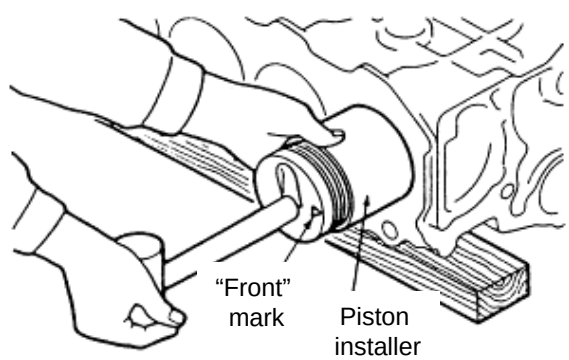
Arrangement of piston ring end gaps on piston

(g) Turn the crankshaft to bring the No.1(or No.4) crankpin to the center.

(h) Put piston installer (30691-58100) on the top of the crankcase in alignment with the bore center. Hold the installer in position by one hand.

(i) Put the piston Assembly in the crankcase through the installer. Make sure the “Front” mark on the top of the piston is toward the front of the engine.

※ **NOTE** : Make sure the big end of the connecting rod fits on the crankpin properly.



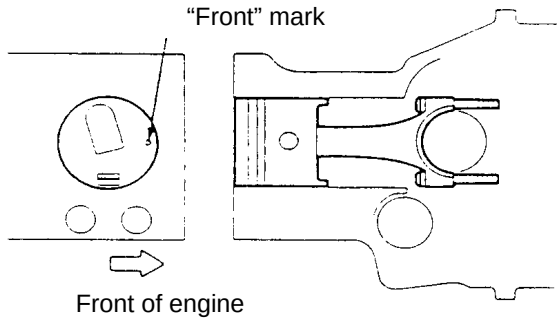
Installing piston assembly (1)

※**NOTE** : Be careful not to cause damage to the crankpin when putting the connecting rod on the crankpin.

(j) Lightly tap the top of the piston with the handle of a hammer to put the big end of the connecting rod on the crankpin.

(k) Install the lower half of the connecting rod bearing in the connecting rod cap. Make sure the tab on the back of the bearing is in the notch of the connecting rod cap. Apply engine oil to the inside of the bearing.(l) Install the connecting rod cap (with the bearing) to the connecting rod (over the crankpin) with the matching mark of the cap on the same side as the mark of the rod.

(m) Tighten the connecting rod cap nuts finger tight.

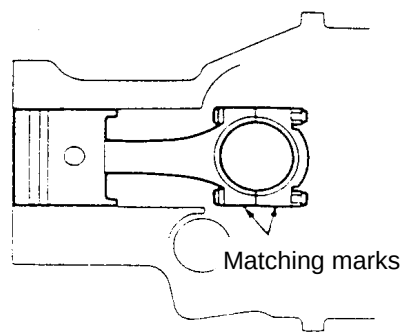


Installing piston assembly (2)

※**NOTE** : Do steps (a) through (m) are for the installation of the piston assemblies in the No.1 and No.4 cylinders. Turn the crankshaft 180˚ and install the piston assemblies in the No.2 and No.3 cylinders.

(n) Tighten the connecting rod cap nuts evenly to the specified torque with a torque wrench.

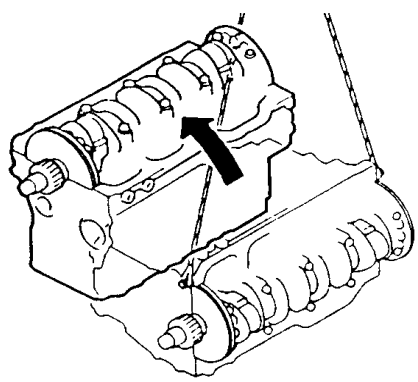
Tightening torque	5.5±0.5 kgf・m (40±4 lbf・ft) [54±5 N・m]



Installing connecting rod cap

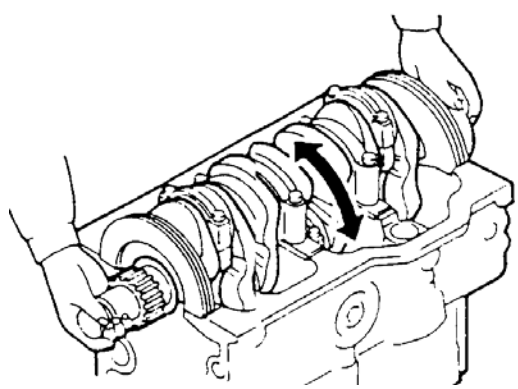
(o) Check the thrust clearance of the connecting rod big end. If the thrust clearance is less than the assembly standard, retighten the cap nuts.

(p) Raise up the crankcase with the oil pan side up.



Raising crankcase

(q) Make sure the crankshaft rotates smoothly.



Checking crankshaft rotation

Testing and adjusting (Break in)

Break in

An engine should be tested on a dynamometer. This test is also for “break in” of the major running parts of the engine.

Start-up procedure

• Check the fluid levels in the radiator, oil pan and fuel tank. Bleed the fuel and cooling system.

• Crank the engine with the starter for 15 seconds to permit lube oil to circulate through the engine. For this cranking, do not supply fuel to the engine.

• Slightly move the speed control lever in the direction of increasing the injection quantity and turn the starter switch to the START position. (Do not move the speed control lever to the full injection position).

• After the engine starts, allow it to idle by operating the speed control lever.

Inspection after starting the engine

After starting the engine, check the following items. Upon discovery of any faulty condition, immediately stop the engine and investigate for this cause.

• Lube oil pressure – should be 2 to 4kgf/㎠ when the engine is running at the rated speed. It should be 1 kgf/㎠ when the engine is running at low idle speed.

• Coolant temperature – should be 75℃ to 85℃.

• Lube oil temperature – Should be 70℃ to 90℃.

• Oil, coolant or fuel leaks.

• Knocking – Should die away as the coolant temperature increases. No other defects should be noted.

• Abnormal exhaust smoke and smell.

Test condition

Follow the table shown below.

Step	Speed(rpm)	Load(PS)	Time(min.)
1	1000 1500 Rated (varies according to specifications)	No-load	30
2		25%	30
3		25%	10
4		50%	10
5		75%	30
6		100%	20

Inspection after break-in

• Check under and around the engine for loose bolts or nuts.

• Check and adjust the valve clearance.

• Check the adjust the injection timing.

Adjustment

Adjustment and inspection should be carried out at both the low idle speed and maximum speed with no load.

Notices in adjustments :

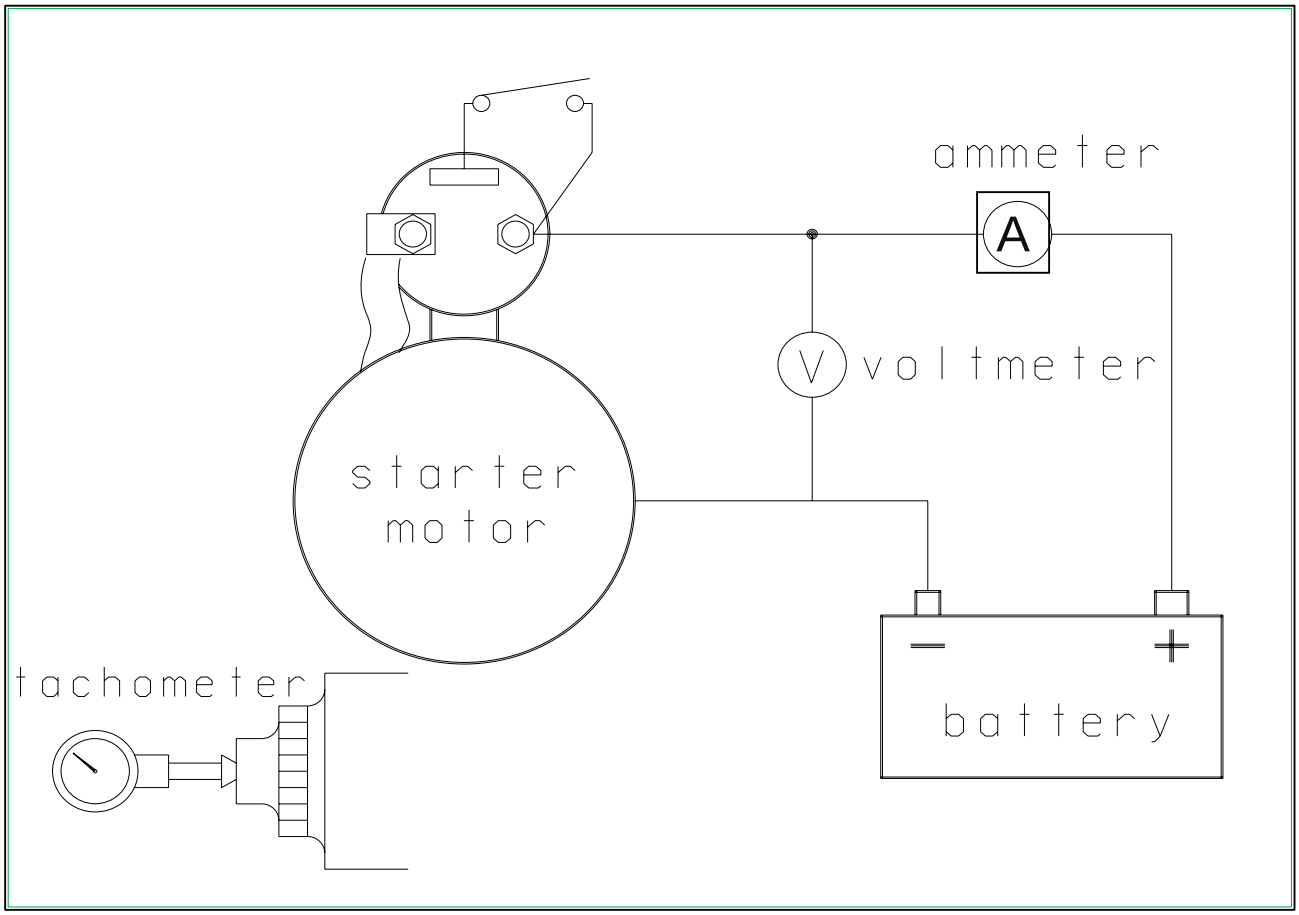
• This adjustments must be carried out at the authorized service network by LS Mtron. However this service can be available when the seal on the injection pump keep its condition as same as the beginning from the factory.

• Make a same seal on the pump after adjustment of the governor.

• This seal can be using an evidence of warrantable.

• Adjustment should be carried when engine oil reaches at or over 70℃.

1. Inspection before disassembly



Before disassembling starter motor, check the following articles.

(1) Test without load

Connect ammeter, voltmeter, tachometer and battery as shown in figure above to check the values listed below. When switch is "ON", the pinion is projected and the starter motor is rotated. If the speed measured is equal to or over the prescribed speed, it is normal. However, if not, disassemble the starter motor and overhaul.

Caution: Use a heavy gauge wire and thoroughly tighten each terminal. When measuring speed in front of pinion, be careful of the pinion being projected during operation. When safety shield is removed, operation of starter motor will be noisy.

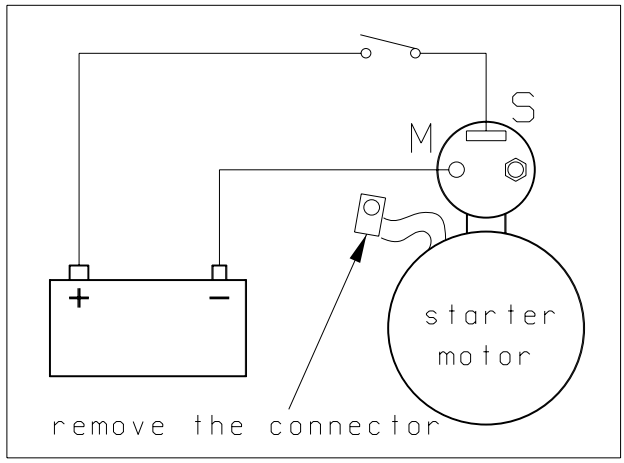
Items		Standard value
Characteristics without load	Model name of starter motor	LS Mtron
	Rating power	12V-2.2kw
	Terminal voltage	11V
	Current	130A or more
	Speed	4500rpm or more

(2) Checking of magnetic switch

Check the magnetic switch through three steps. First remove the wire from the terminal ⓜ.

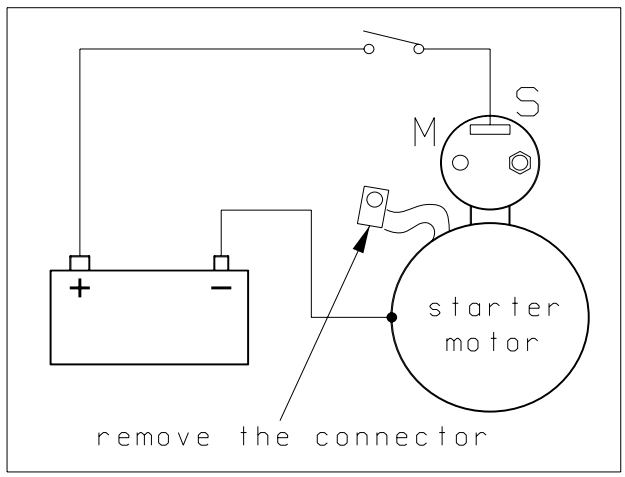
1) Test the current flow between terminal ⓢ and ⓜ

Connect a wire from the battery ground to terminal ⓜ and connect a wire from the positive post through a switch to terminal ⓢ. Turn the switch "ON" and if the pinion is projected, the connection is correct.



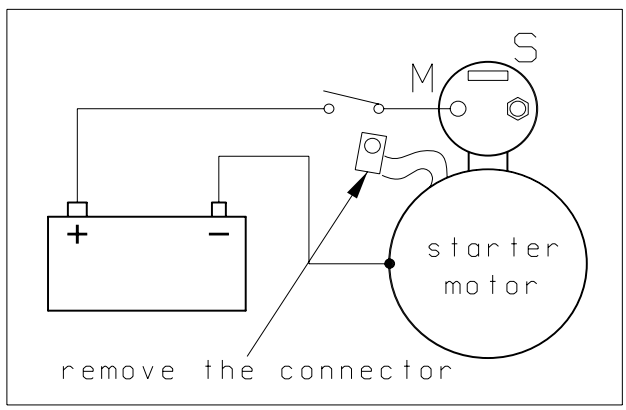
2) Test the current flow between terminal ⓢ and the body

By using the same battery and switch as above, connect the battery ground to the body and connect the wire from the switch to terminal ⓢ. Turn the switch "ON" and if the pinion is projected, the connection is correct.

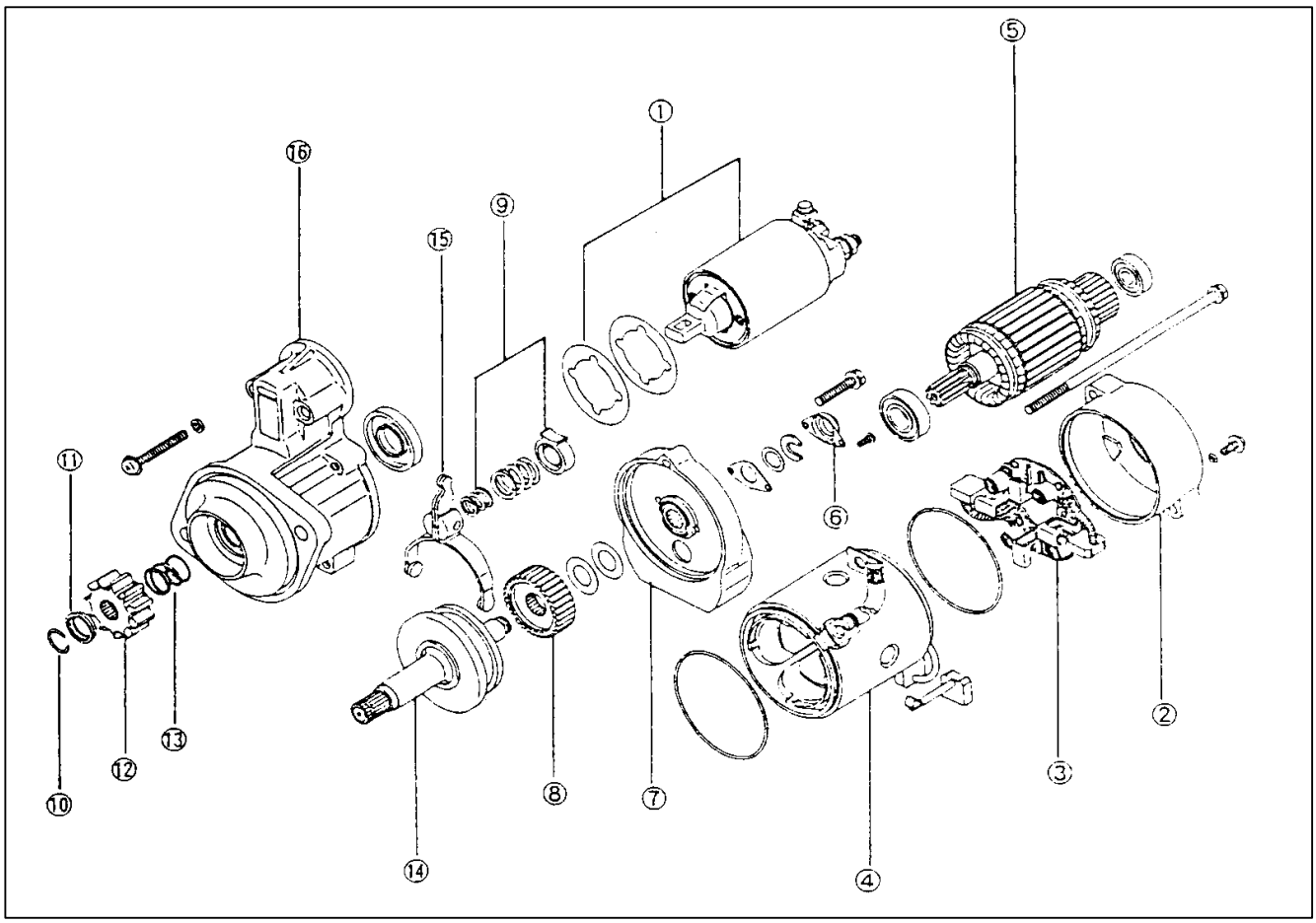


3) Test the current flow between terminal ⓜ and the body

By using the same battery and switch as above, connect the battery ground to the body and connect the wire from the switch to terminal ⓜ. Turn the switch "ON" and if the pinion is projected, the connection is correct.



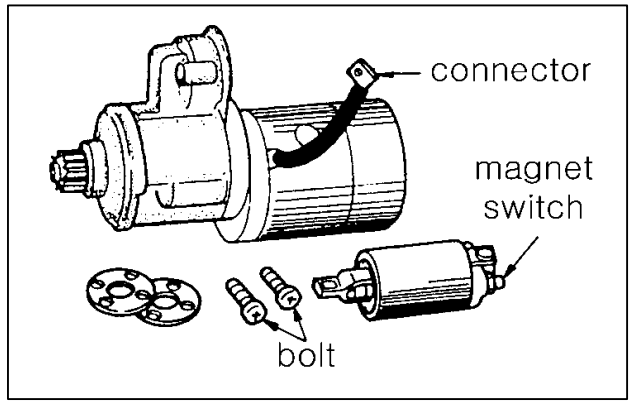
2. Disassembly



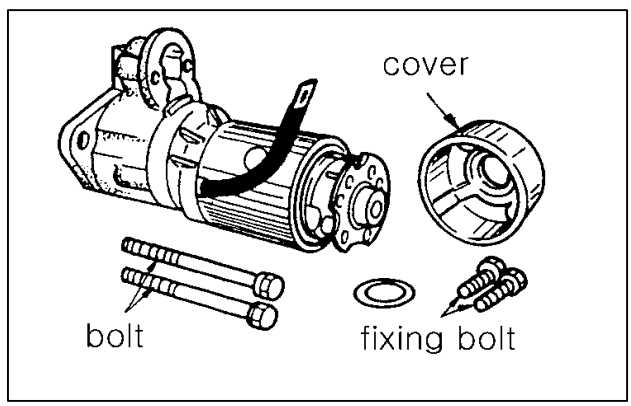
(1) magnet switch
(2) rear bracket
(3) brush holder assembly
(4) yoke assembly
(5) armature
(6) cap
(7) middle bracket
(8) reduction gear
(9) spring
(10) "C" spring
(11) pinion stop
(12) pinion
(13) spring
(14) pinion shaft
(15) lever
(16) front bracket

(1) Main point of disassembly

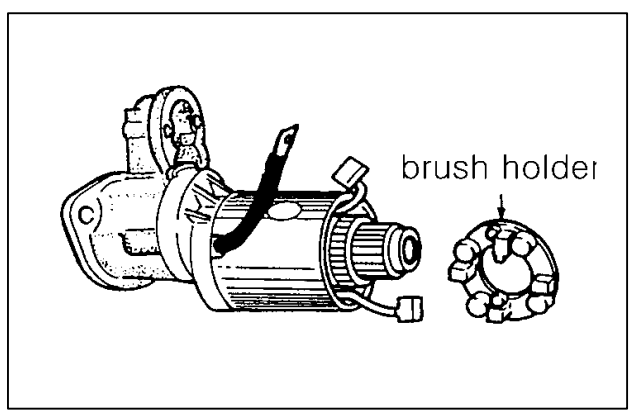
1) Undo nuts of terminal (M) and remove connector. Remove the two bolts holding magnetic switch and remove it.



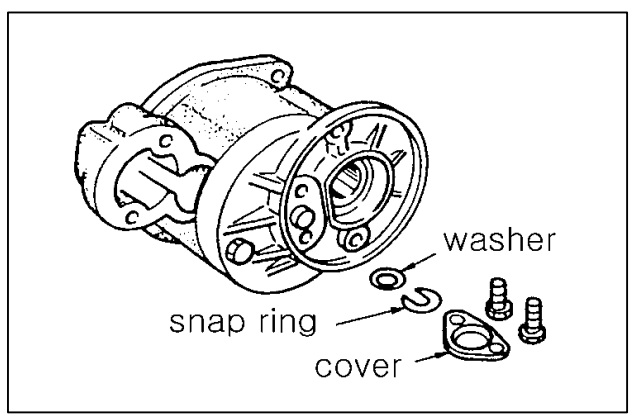
2) Remove two bolts attaching the rear bracket. Remove the rear bracket and the two smaller bolts attaching the brush holder, being careful not to lose the adjusting washer in side of the bracket,



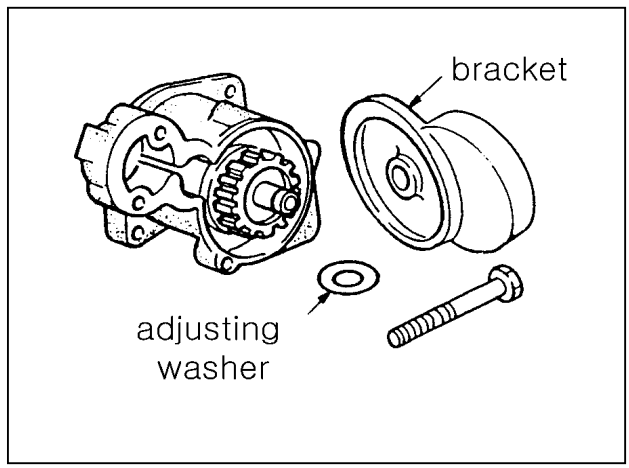
3) Remove the two brushes. Remove the yoke assembly and brush holder assembly from the armature.



4) Remove the cover, snap-ring and washer.



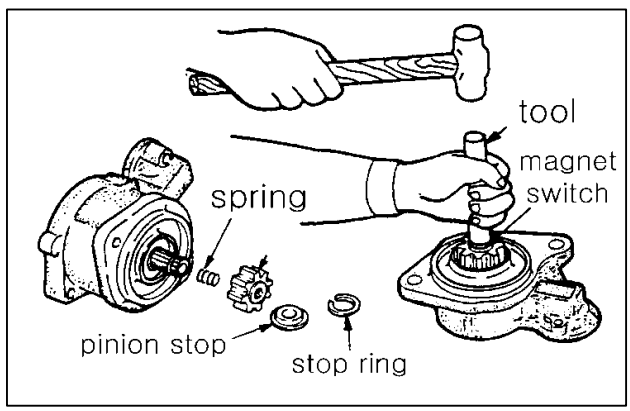
5) Undo bolts and remove the center bracket. At the same time, remove the pinion shaft end adjusting washer.



6) Place a round hollow object, such as a pipe, on the pinion stop. Tapping with a hammer, separate from clutch shaft and expose the stop ring.

Remove the stop ring with pliers and then remove the pinion

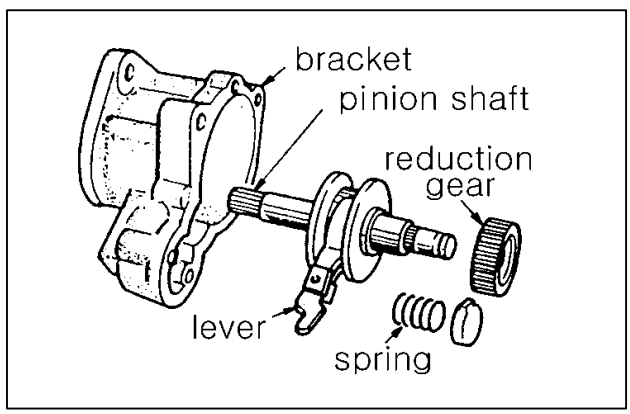
Note: when reassembling, do not re-use the stop ring.



7) Remove the pinion shaft and separate the spring, lever, reduction gear and pinion shaft from the bracket.

Note: Note the direction of offset in the lever for re-assembly.

Remove the ball bearing in both ends of the armature with bearing pliers. It is not possible to replace the ball bearing pressed into the front bracket. Replace the front bracket assembly if worn.

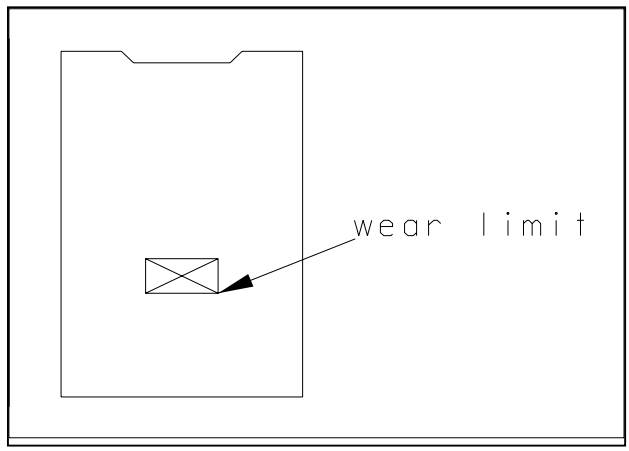


(2) Inspecting of each component

1) Checking the wear limit of brushes

Check the brushes and replace if they have reached the wear limit line. This is below a mark surrounded with a trademark.

Replace the brush holder assembly if over the limit.

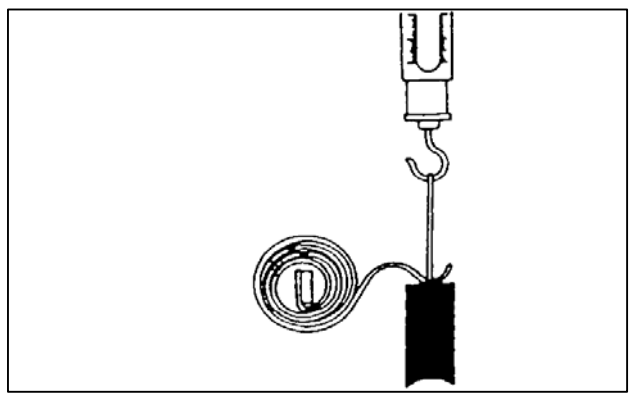


2) Brush spring test

Assemble the new brush in the holder and attach a hand scale to the spring. While gradually pulling, read the weight of the movement where the spring is separated from the brush.

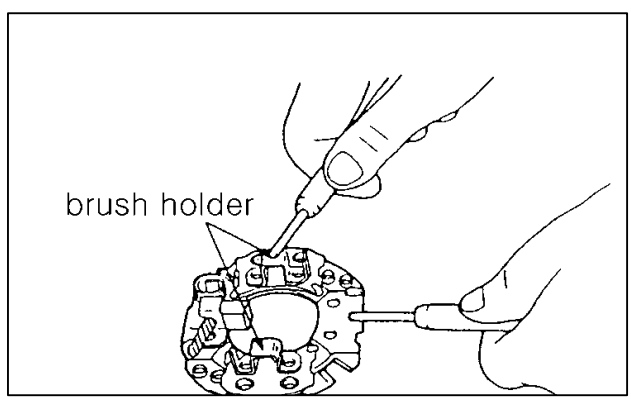
If below the minimum limit, replace the spring.

	Assembly standard	Minimum limit
Scale reading	3.1～3.9 kg	2 kg



3) Check the insulation between the brush holder and body

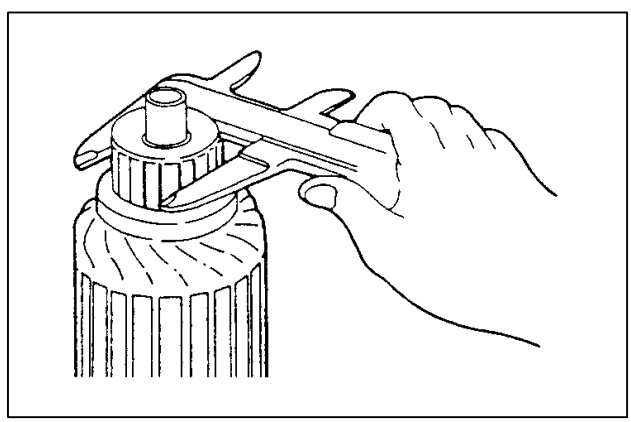
Replace the holder assembly if not insulated.



4) Measure the outer diameter of the armature assembly in contact with the brush

If below the minimum limit, replace the armature.

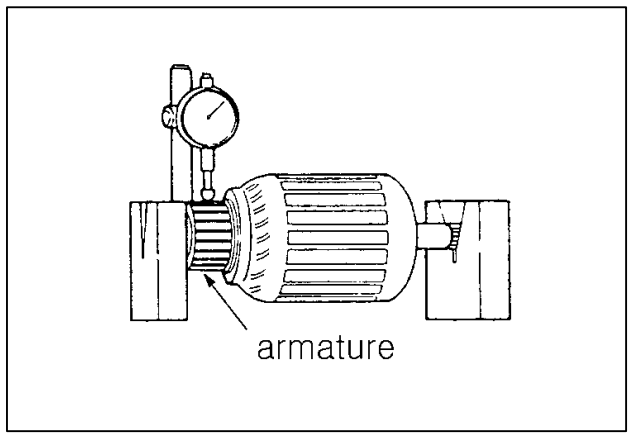
	Assembly standard	Minimum limit
Outer diameter	32 mm	31 mm



5) Check the shaking in the contact face of the brush

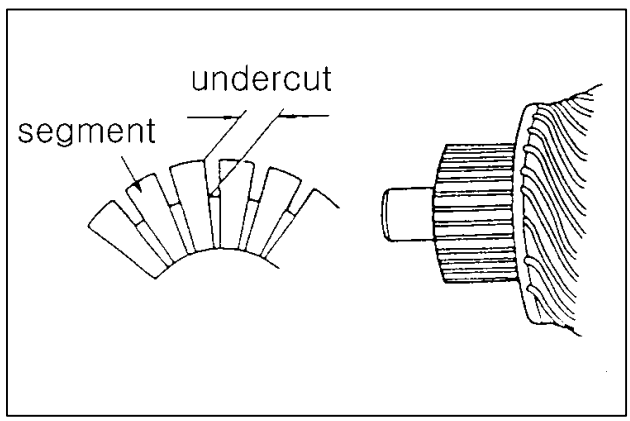
If above the maximum limit, repair is necessary.

	Assembly standard	Maximum limit
Eccentricity	0.03 mm	0.10 mm



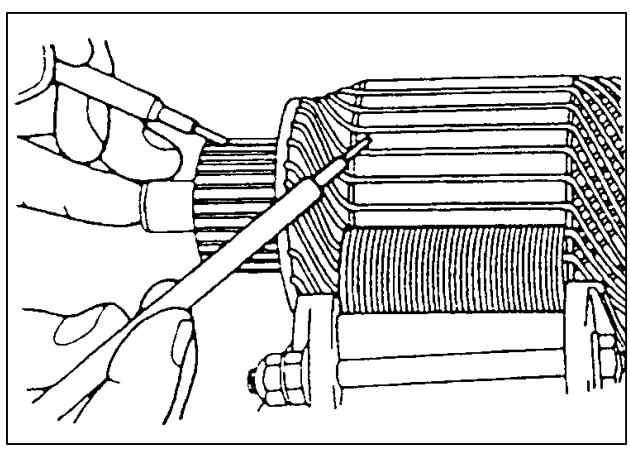
6) Measuring the depth in the contact face of brush

	Assembly standard	Maximum limit
Depth	0.50 mm	0.10 mm



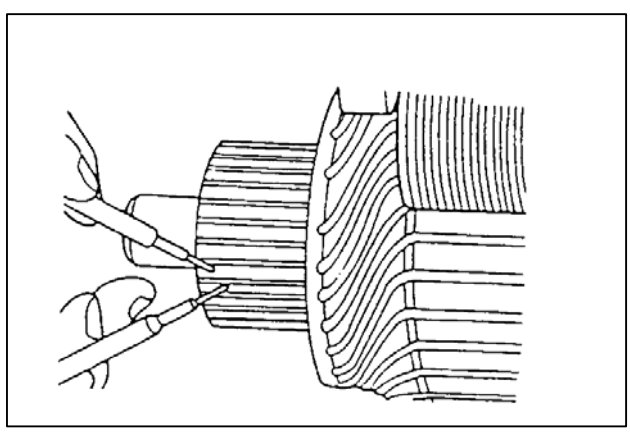
7) Check for current flow between each terminal and body of the armature or coil

Replace the armature assembly if current flows.



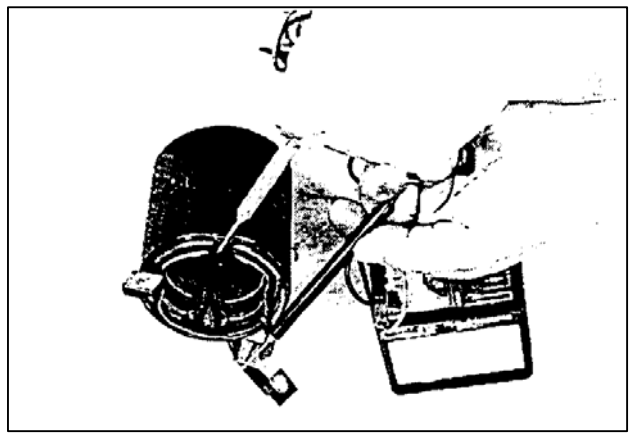
8) Check for a short circuit between each of the terminals

If current does not flow, the coil of the armature is short-circuited and needs to be replaced



9) Check for a short circuit between coil and yoke assembly

If current flows between them, the yoke assembly needs to be replaced.

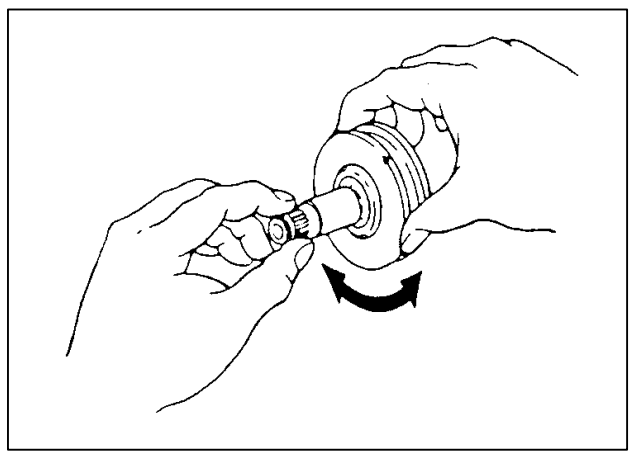


(3) Check of over-running clutch

1) If the bearing does not rotate smoothly or it is noisy, replacement with a new one is necessary.

2) Hold the outside of the over-running clutch by hand. Looking into the shaft end turn the shaft clockwise. Only the shaft should rotate. Turn the shaft counter-clockwise. The shaft and over-running clutch should rotate together.

Caution: Do not clean over-running clutch with oil.



(4) Reduction gear

Replace if worn or defective.

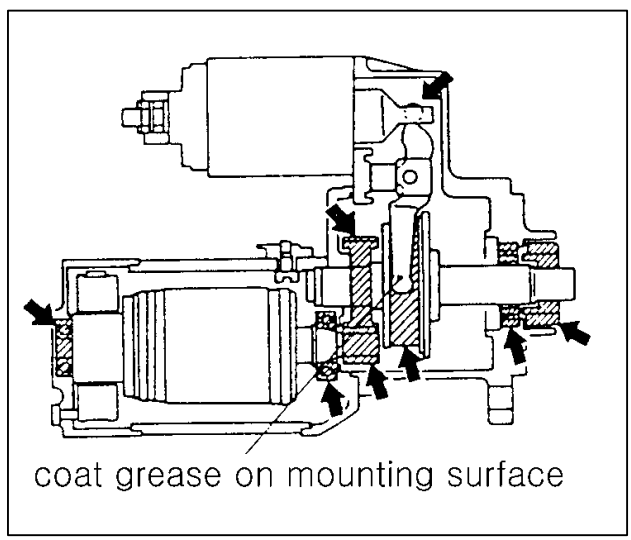
3. Assembly

Assemble by reversing the disassembly procedure. Be sure to grease the starter motor assembly by applying grease to the area noted by arrows in the drawing below.

(1) Lubrication points

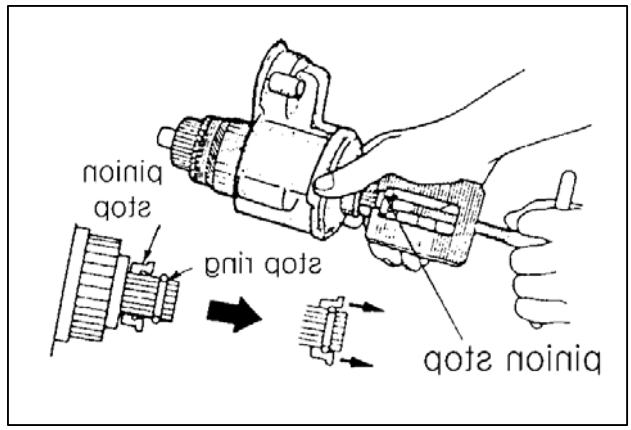
Grease	multi purpose grease

Caution: Do not allow grease to come in contact with the brushes or armature.



(2) Assembly of stop ring

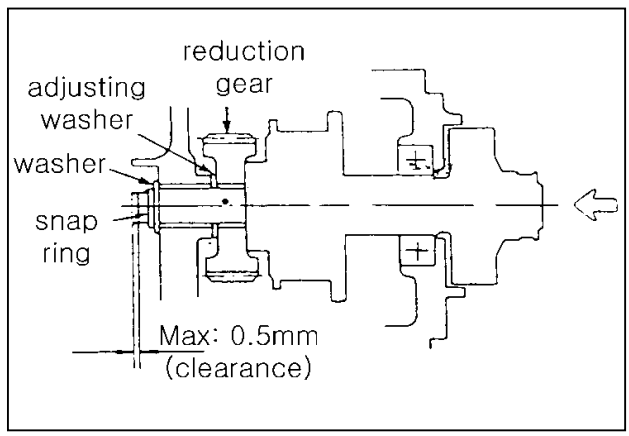
Install stop ring in the ring groove of pinion shaft. Pull the pinion stop out until it is locked into the stop ring.



(3) Adjusting the movement of the end of pinion

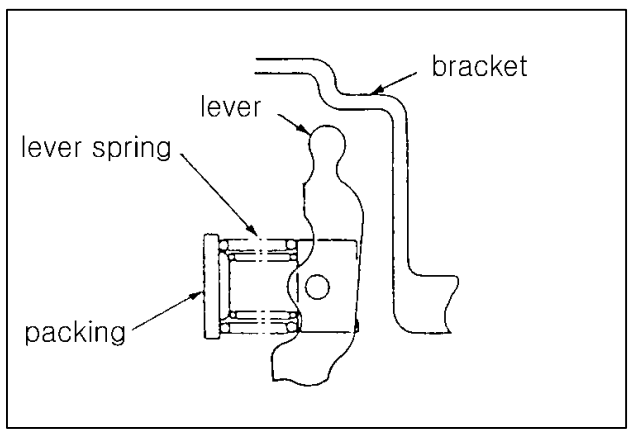
1) Insert the adjustment shims and secure with snap-ring. Check the clearance of the end of pinion.

2) If the clearance is above 0.5 mm, adjust by inserting more shims.



(4) Assembly of lever

Insure proper direction of offset in the lever.

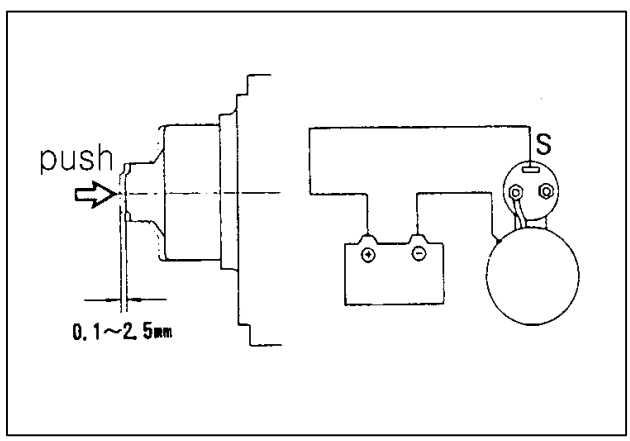


(5) Check of pinion gap

1) In the position where the pinion is completely projected, push it completely in and release, allowing the shaft to freely come out to a shorter length than previously at.

2) Measure the length of projection from the end of the pinion to the front bracket. If the length is less than 0.1 mm or longer than 2.5 mm, adjustment is necessary.

3) Increase or decrease the number of shims in the area where the magnetic switch is installed for adjustment.



1. Inspection before disassembly

(1) The main point of checking

Determine detective parts by checking the charging system for the following problems. Some disassembly may be required for checking.

1) Over-charging

-high current
-weak battery

2) Discharging

-low current
-low output of alternator
-excessive power consumption

(2) Precautions in checking

Observe the following precautions.

1) Do not reverse connections to the battery.

2) Do not use a high current tester.

3) When re-charging battery, always remove from the tractor.

4) While running the engine, never remove the positive cable from of alternator.

5) Never allow the positive cable on terminal (B) to come in contact with a ground or negative lead.

6) When using a steam cleaner, use care not to touch the alternator.

(3) Checking the voltage of alternator

1) Using a heavy gauge wire, connect the positive terminal of the battery to an ammeter. Connect the cable from the ammeter to the terminal (B) of the alternator as shown in the figure above.

2) Connect a voltmeter between terminal (L) and a negative terminal.

3) When the starter switch is placed in the “OFF” position, the voltmeter reads 0 V.

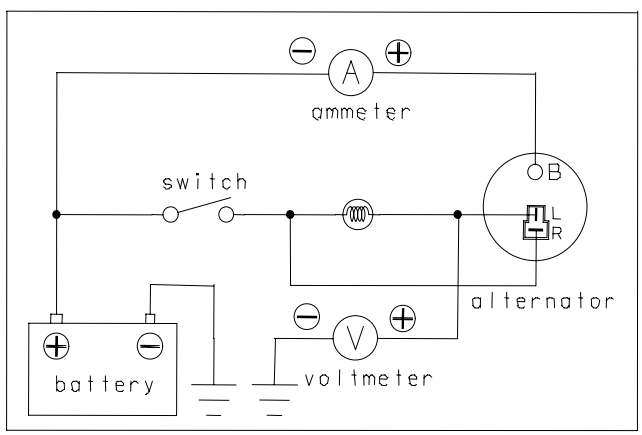
4) Without starting the engine, turn the switch to the “ON” position and read the voltmeter value. Make sure that the voltage reading is below battery voltage.

5) Disconnect the amp meter and start the engine. After the engine has started, reconnect the ammeter.

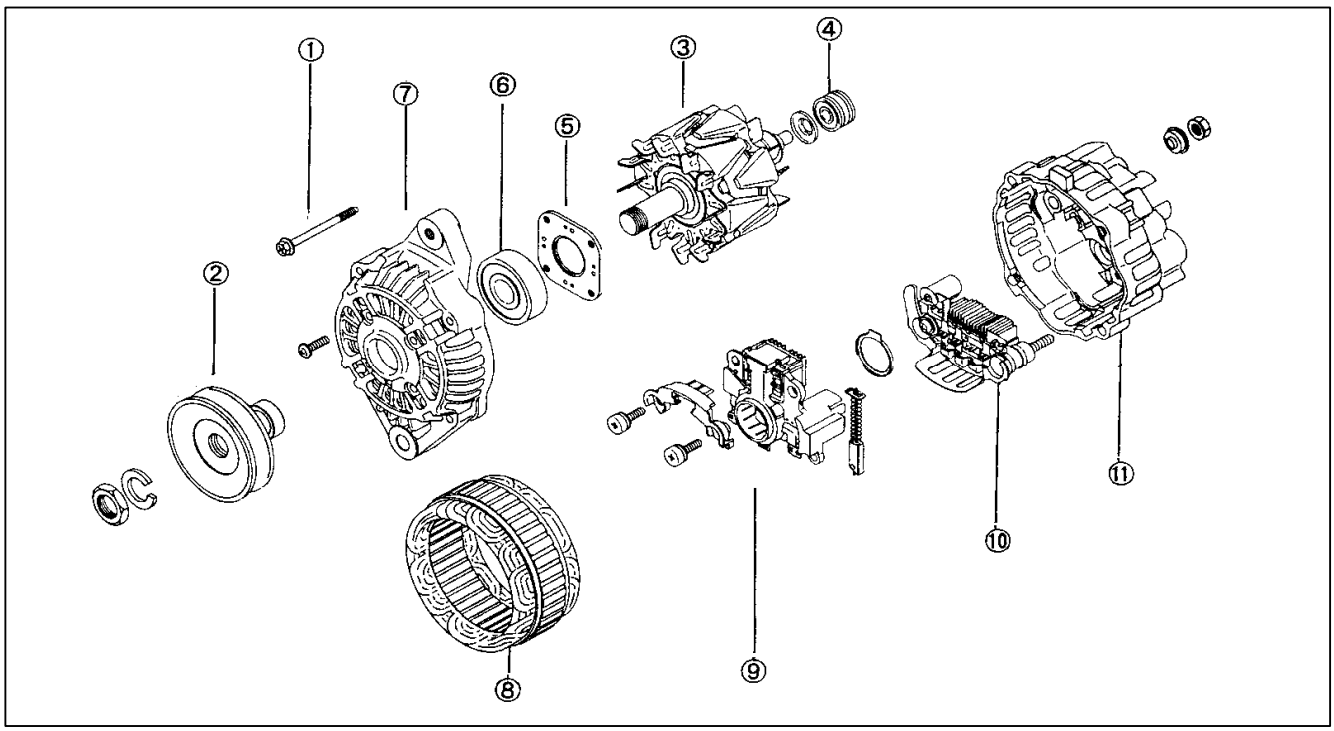
6) The ammeter reading should be below 5A when the engine is at 1800 rpm. When the engine is turning at 1800 rpm, the alternator is turning at 2500 rpm.

7) After starting the engine, turn all the lights and electrical accessories off. Read the voltmeter. The voltage reading is affected by ambient temperature. The higher the temperature, the lower the voltage reading.

	Standard
Voltage reading (at 20° C)	14.7±0.3 (V)



2. Disassembly

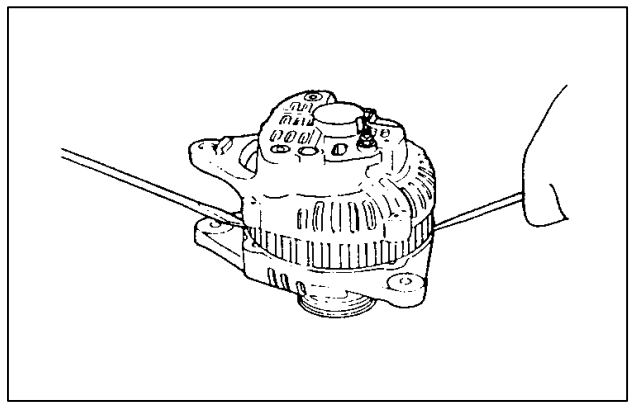


① bolt
② pulley
③ rotor
④ rear bearing
⑤ bearing retainer
⑥ front bearing
⑦ front bracket
⑧ stator
⑨ regulator
⑩ rectifier
⑪ rear bracket

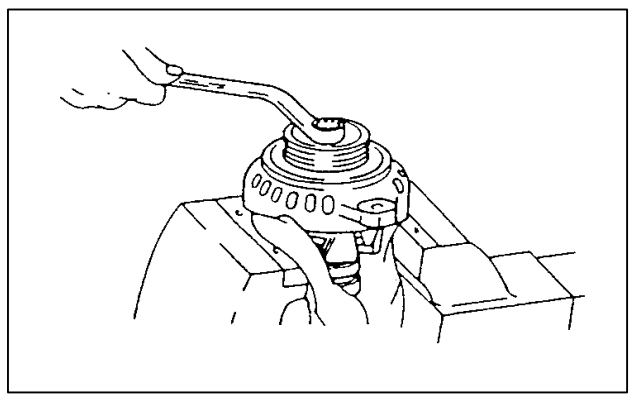
3. The main point of disassembly

1) Remove the two bolts mounting the front bracket to the stator. Using the end of a flat screw driver inserted in the gap between the stator and front bracket, pry them apart and remove the front bracket.

Caution: If the screw driver is inserted too deep, stator core damage may occur.



2) Put a piece of cloth around the rotor and grip in a vice. Undo the nut and remove the pulley.

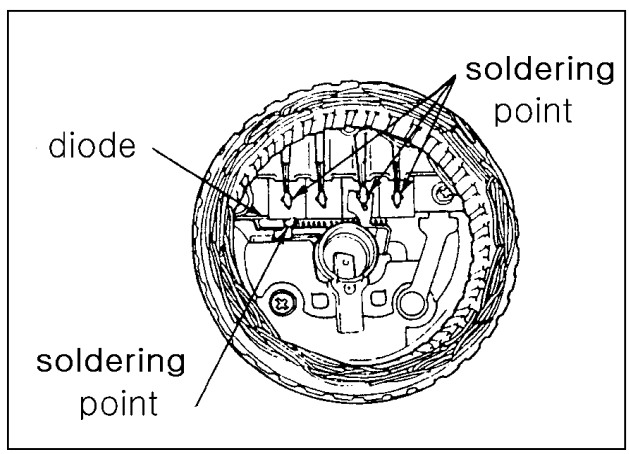


3) Removing stator and rectifier.

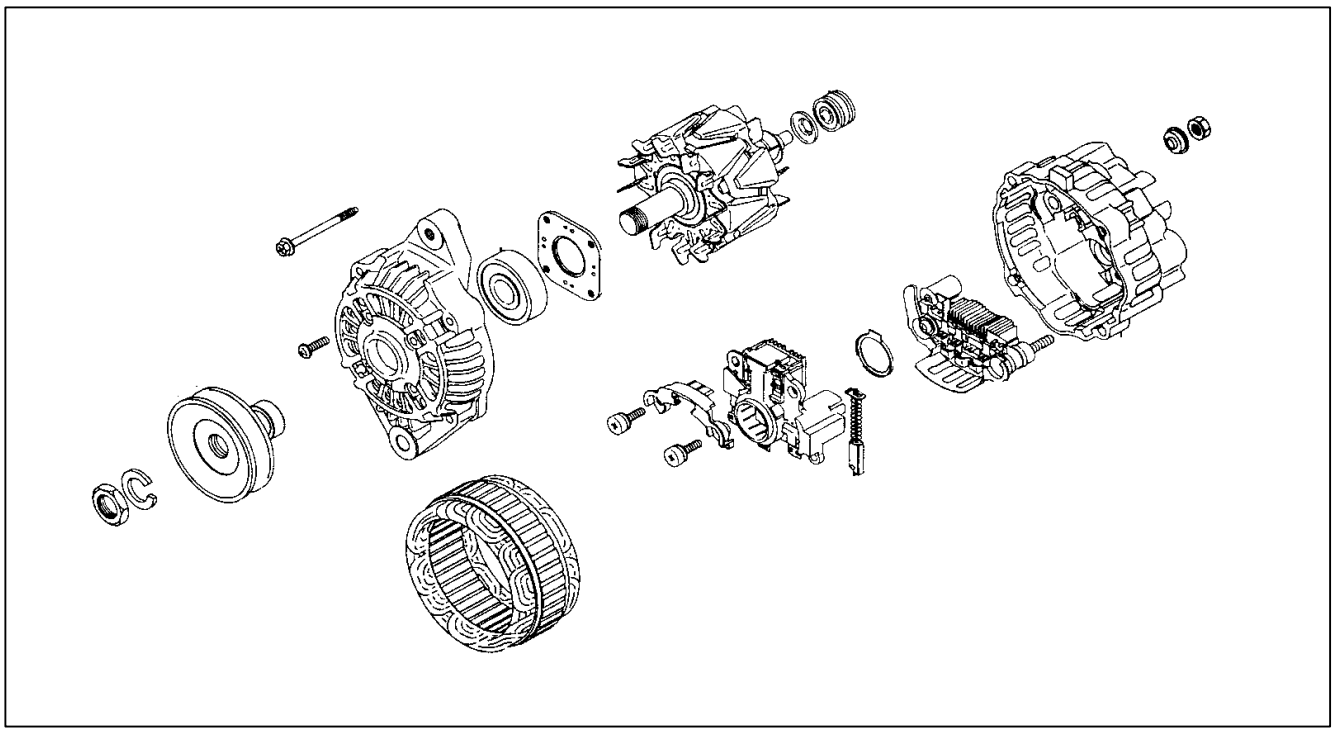
-Heat the three soldered connections to remove the wire leads. Remove stator.

Caution: Use care in removing the soldered connections. Excessive heat may cause damage to the components.

-Remove the nut attached to rectifier and remove rectifier.



4. Overhaul and inspection

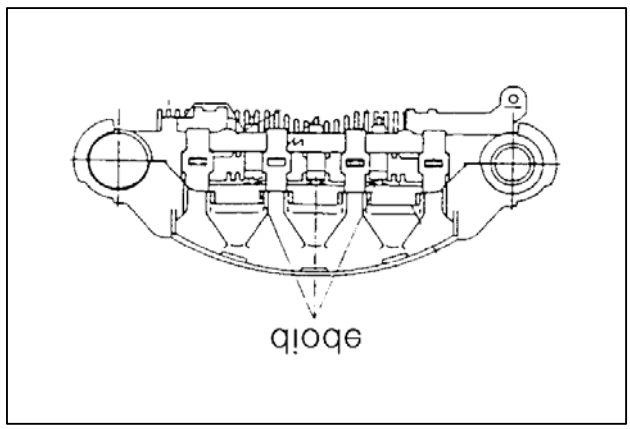


(1) The main point of checking

1) Check of diodes

-Check whether or not current flows between the lead wire from the diode and the case of the diode. Resistance reading should be small in one direction and larger in the other direction.

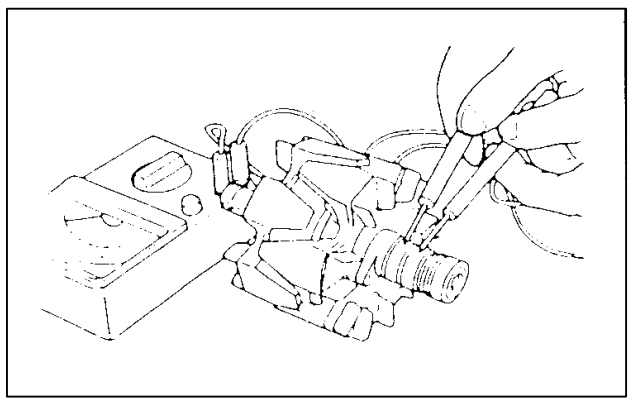
-Check all diodes and if the resistance reading is the same in both directions, replace the rectifier.



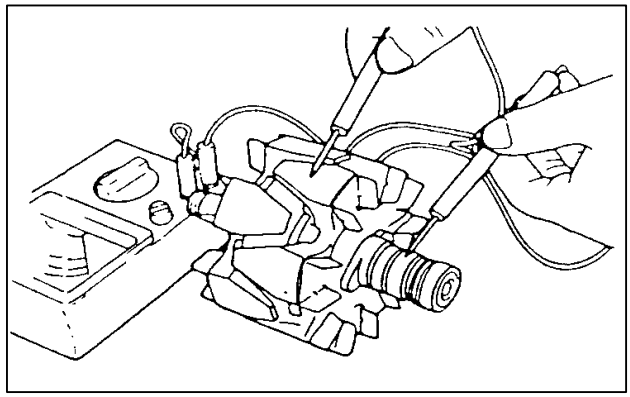
2) Check of field coil

-Check for current flow between rings of the sleeve. If no current flow, replace the rotor assembly.

-Check for current flow between sleeve rings and body. If no current flow, replace the rotor assembly.

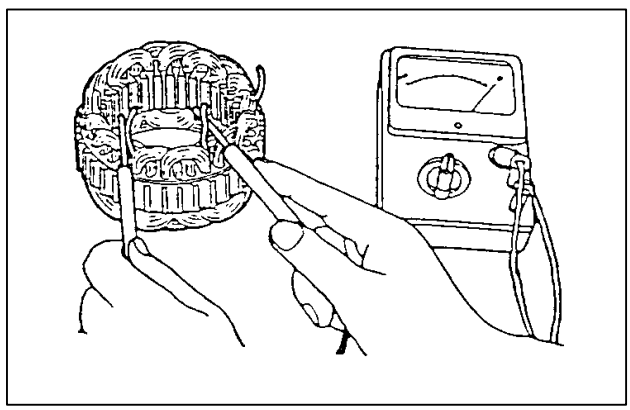


-Check for current flow between sleeve rings and body. If no current flow, replace the rotor assembly.

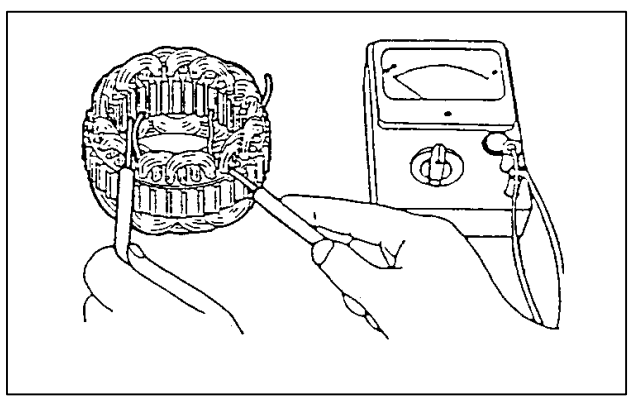


3) Check of stator core

-Check for current flow between each of the lead wires of the stator core. If no current flow, replace the stator core.

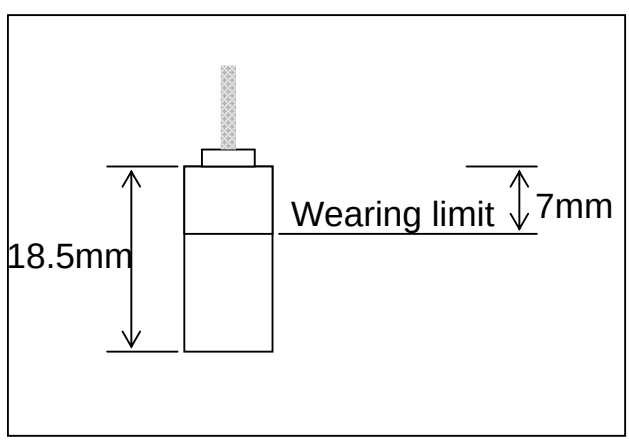


-Check for current flow between each of the lead wires and stator core. If no current flow, replace the stator core.

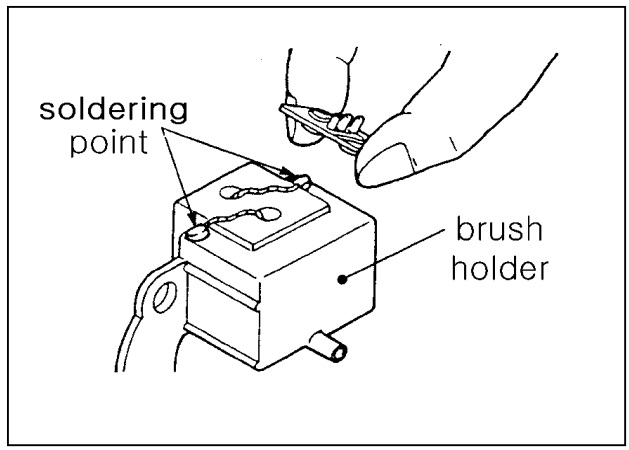


4) Check of brush

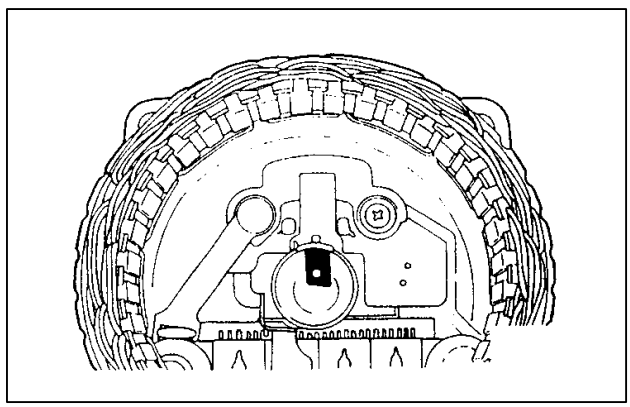
-Replace the brushes if they are worn to shorter than 7 mm.



-The brush and spring can be removed if the connection is unsoldered.



-When replacing the brushes, push them into the holder and solder connections.

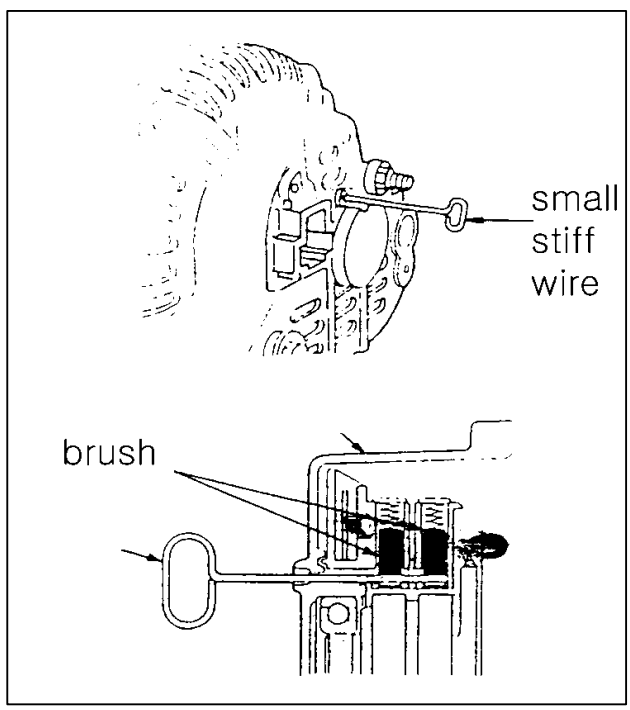


5. Assembly

Assembly opposite of the disassembly procedure, paying special attention to the following :

1) When pressing the rear bearing to the rotor shaft, heat the bearing and press on the shaft.

2) When attaching the rotor to the rear bracket, use a small stiff wire inserted through the small hole in the rear of bracket to hold the brushes in place during assembly.



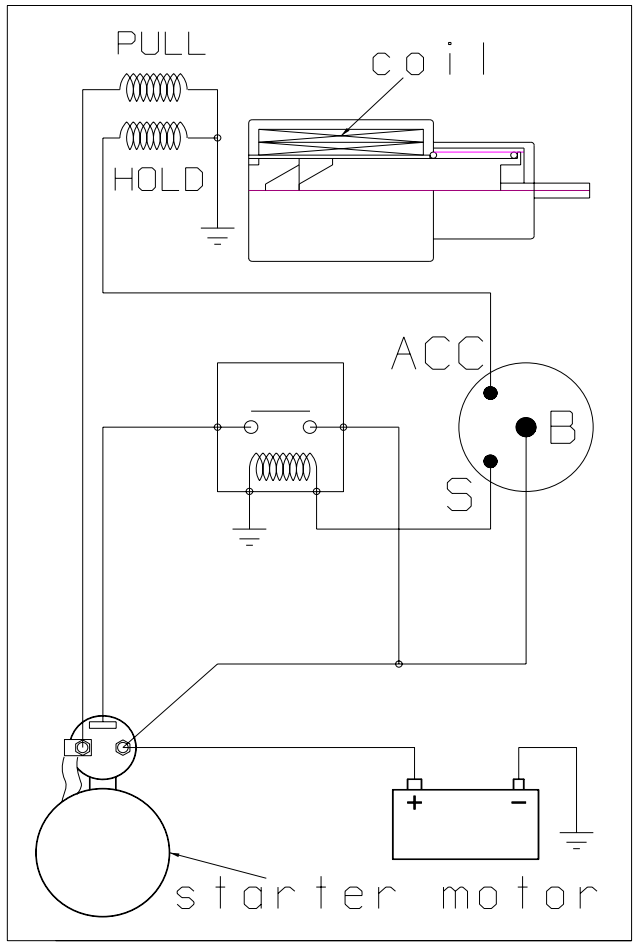
(1) Outline

Voltage 12V
Pull coil 50A
Hold coil 1A

(2) Operation

When starting the engine, high current is supplied to the pull coil of the fuel solenoid through the starter motor, opening the fuel valve. Once the engine has started, current is supplied to the hold coil through the ignition switch, continuing to hold the fuel valve open. With the switch in off position, no current is supplied to either of the coils; therefore fuel is no longer supplied to the engine.

Caution: If the wire lead from starter motor to pull coil is removed, the fuse will be blown due to high current required during starting.



(3) Assembly of fuel solenoid

1) Remove the tie rod cover.

2) Coat the screw threads of fuel solenoid with a sealant.

3) After temporarily mounting the fuel solenoid and nut, move the speed adjustment lever of the injection pump to the maximum stop position.

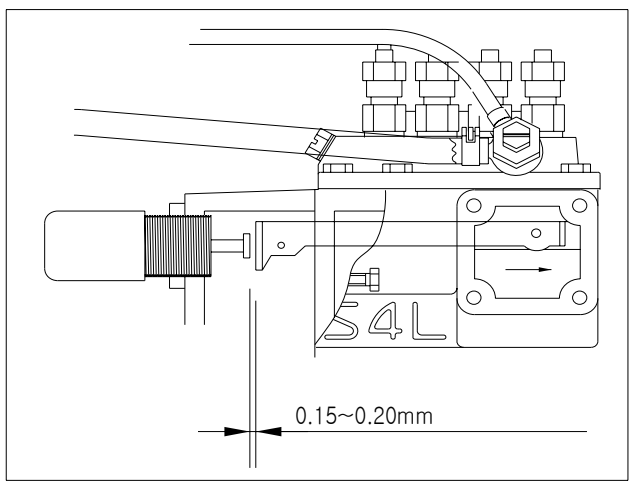
Caution1: Take care not to allow any sealant to come in contact with any working part of solenoid.

Caution2: Be careful when cleaning the solenoid with cleaner not to infiltrate the wiring connection.

4) Screw in the fuel solenoid until solenoid valve shaft touches tie rod.

5) Unscrew the fuel solenoid about 30。～45。 and tighten nut.

6) Start the engine and push the rear of solenoid to make sure that the engine stops.



Specification

Item	Specification
Number of cylinders	2, 3, 4, 5 or 6
Direction of rotation	Clockwise/counterclockwise (viewed from the drive side)
Maximum allowable speed (pump)	3000 r.p.m (2. 4. 5 cylinders) 2500 r.p.m (3. 6 cylinders)
Plunger diameters	8,9, 10, 11 or 12mm
Injection timing control	Speed timer 2, 4, 5 cylinders: 110 Maximum 3, 6 cylinders: 7° Maximum Load Timer Maximum: 3° to 4° Speed-load timer 2, 4. 5 cylinders: 11° Maximum 3. 6 cylinders: 7° Maximum
Speed governing	Variable speed governor (All speed governor) Minimum-maximum speed governor (limited speed governor) Combination governor (Half-all speed governor)
Speed drop	4% (750 r.p.m.)
Weight	Approx. 5.5 kg
Lubrication system	Fuel oil lubrication
Control lever position	Right or Left side of governor cover (viewed from the drive side)
Stop lever position	Right or Left side of governor cover (viewed from the drive side)
Maximum allowable in-pipe pressure	Approx. 550 kg/cm2
Engine reverse rotation prevention	Because the inlet port opens during the compression stroke if the engine rotates in the reverse direction, fuel cannot be delivered and injection cannot occur.
Additional devices	Installation of boost compensator, pump speed sensor, cold start device etc. is possible.

Furl system

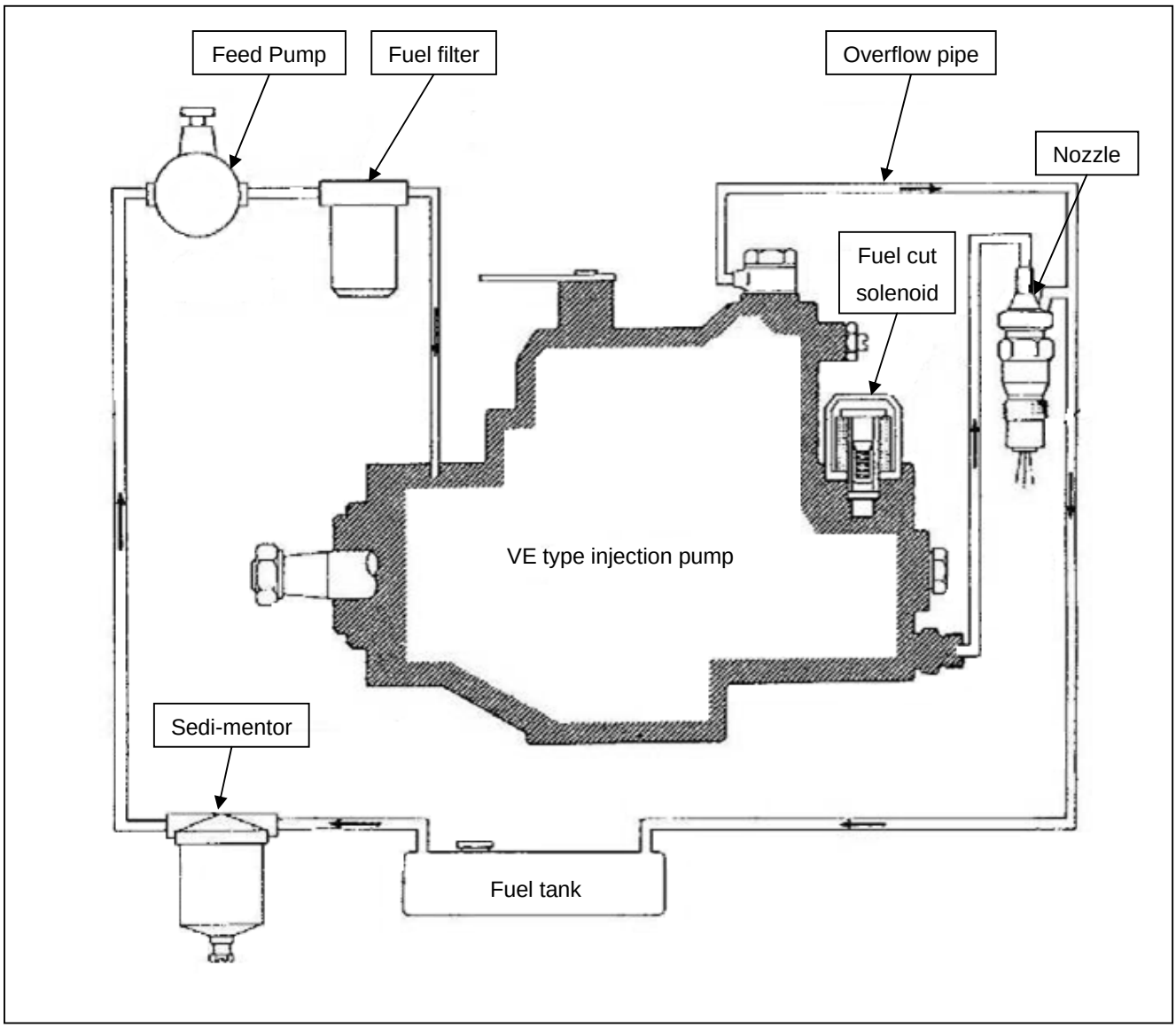


Figure sows an example of a fuel system. The injection pump drive shaft is turned by the engine's timing gear and fuel is drawn by the injection pump's feed pump through the sedimentor and fuel filter to the injection pump's fuel inlet.

The fuel filter acts to filter the fuel, and the sedimentor is located in the lower portion of the fuel filter to remove moisture from the fuel system.

With drive shaft rotation the fuel oil sucked into the feed pump is pressurized by the feed pump and fills the injection pump chamber. The fuel oil pressure is proportional to drive shaft speed, and when it exceeds a specified pressure excess fuel again returns to the inlet side through a regulating valve located at .the feed pump's fuel oil outlet.

The fuel oil in the injection pump chamber flows through the distributor head inlet into the pressure chamber, where plunger rotation and reciprocating motion increase its pressure. The fuel oil is then delivered through the injection pipe to the nozzle and nozzle holder.

An overflow valve located at the top of the injection pump functions to maintain a constant fuel oil temperature in the pump chamber by returning excess fuel oil to the fuel tank.

Fuel Delivery

The drive shaft, rotated by the engine's timing belt (or gear), rotates the cam disk through a cross coupling. The cam disk's press-fitted pin fits into a groove in the plunger to rotate the plunger. To reciprocate the plunger, the cam disk is also equipped with raised face cams, arranged uniformly around the circumference of the cam disk. The cam disk's face cams are always in contact with the roller holder assembly's rollers because the cam disk and the plunger are pressed against the roller holder assembly by the set force of the two plunger springs. Because of this the plunger can follow cam disk movement. Therefore, as the cam disk is rotated on the roller holder assembly by the drive shaft. simultaneous plunger rotation and reciprocating movement is possible.

The roller holder assembly construction is such that it can only rotate in a certain angle range in accordance with timer operation.

Because the plunger rotates and reciprocates simultaneously, suction of the fuel oil into the pressure chamber, pressurization in the pressure chamber delivery into the engine cylinder are possible.

Speed Governing

The governor is located in the upper part of the injection pump chamber. Four flyweights and a governor sleeve are held in the flyweight holder, which is mounted on the governor shaft.

The flyweight holder is rotated and accelerated by the drive shaft gear, through rubber dampers.

The governor lever assembly is supported by pivot bolts in the pump housing, and the ball joint at the bottom of the lever assembly is inserted into the control sleeve, which slides over the outside surface of the plunger The top of the lever assembly (the tension lever) is connected to the governor spring by a retaining pin, while the opposite end of the governor spring is connected to the control lever shaft. The control lever shaft is inserted into the governor cover and a control lever is attached to the control lever shaft. The accelerator pedal is connected directly to the control lever by a linkage, and the governor spring set force changes in response to the control lever position (i.e. accelerator pedal position).

Injection quantity control is governed by the mutually opposing forces of the flyweights' centrifugal force and the governor spring's set force.

The flyweights' centrifugal force, which changes in response to engine speed, acts on the governor lever through the governor sleeve.

The governor spring's set force, which is dependant on control lever position, i.e. accelerator pedal position, acts on the governor lever through the retaining pin.

Injection Timing Control

In the lower part of the injection pump is the timer, in the centre of which the timer piston is positioned.

On the low pressure side of the timer piston is a timer spring with a predetermined set force; the pump chamber fuel oil pressure acts on the opposite side (high pressure side). The timer piston position changes in accordance with the balance of these two forces, to rotate the roller holder via the roller holder pin. When the timer piston compresses the timer spring, the injection timing is advanced (the roller holder rotates in the reverse rotation direction), and through timer piston movement in the opposite direction the injection timing is retarded. Injection timing is controlled by the above.

Feed Pump

The feed pump comprises a rotor, blades and liner. Drive shaft rotation is transmitted through a key to the rotor to rotate the rotor

The inside circumference of the liner is eccentric to the centre of rotor rotation. Four blades are installed in the rotor. Centrifugal force forces the blades outwards during rotation to contact the inside surface of the liner and form four fuel oil chambers. Therefore, the volume of these four chambers increases through rotor rotation to suck fuel oil from the fuel tank. Conversely, when the volume of these four chambers decreases fuel oil is pressurized.

Regulating Valve

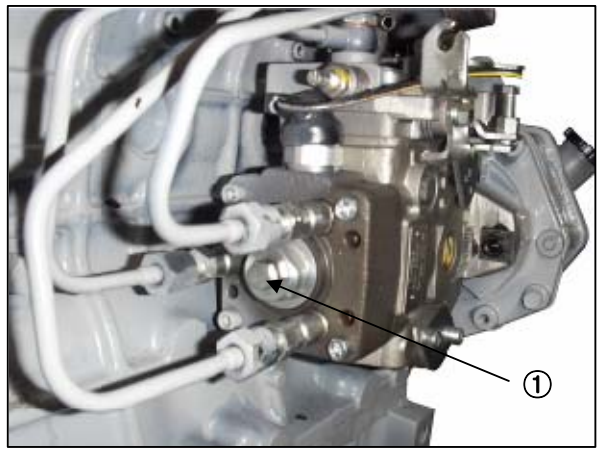
Feed pump fuel oil delivery pressure increases proportionately with an increase in injection pump speed.

However, the total fuel oil injection quantity necessary for the engine is considerably less than that delivered by the feed pump. Therefore, in order to prevent an excessive increase in the pump chamber pressure caused by the excess fuel oil, and to adjust the pump chamber pressure so that it is usually within the specified limit, a regulating valve is installed near the feed pump outlet. The timer performs timing control using the pump chamber pressure, which is regulated by the regulating valve.

INJ PUMP timing setting

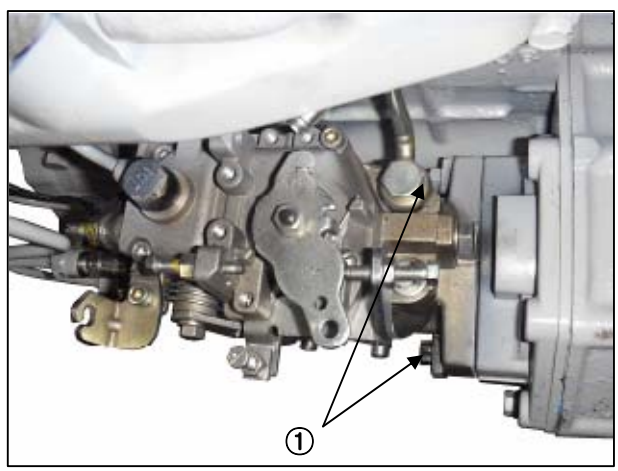
☞ How to set BTDC 5degree

▶ Firstly remove a gauge bolt ① on the rear side of the pump then install dial gauge.

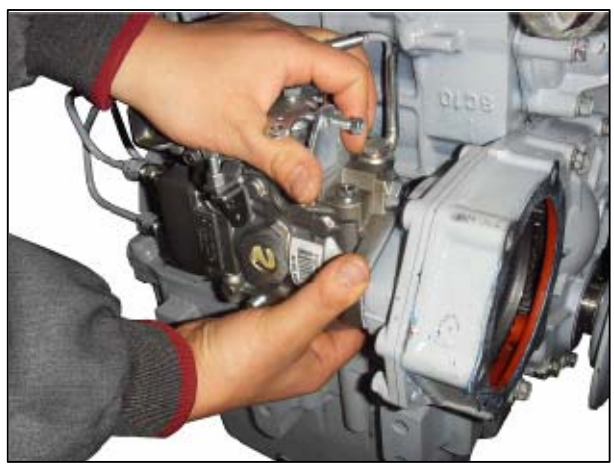


▶ Be secure whether the end of the needle contact pump inside.

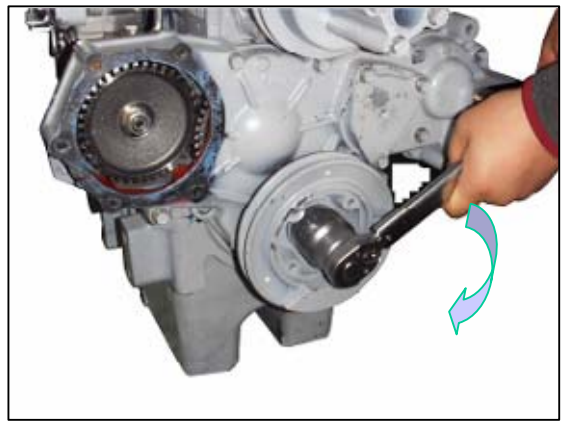
▶ Loosen the blot ① around three threads.



▶ Turn the injection pump counterclockwise like a photo then tighten it prematurely when the pump hits the block.

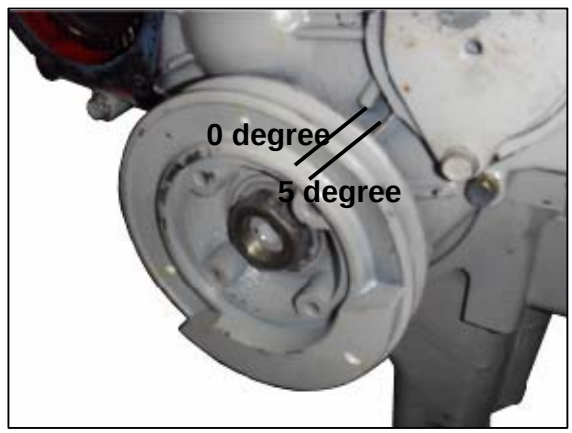


▶ Rotate the crankshaft clockwise viewed from front, find the position where the dial gauge stops and set the “0”.



▶ Rotate the crankshaft clockwise, match the mark on the pulley with 5 degree.

For fine setting of BTDC 5 degree, install a dial gauge on the upper side of the block.



▶ Turn the injection pump until dial gauge shows “0” after loosen the bolt slightly.

▶ Tighten the bolt completely.

▶ Completed timing set of BTDC 5degree.