

ENGINE BASE

SERVICE MANUAL

mitsubishi
S4K,S6K

REFERENCE ONLY
- EXCAVATOR(10TON, -7SERIES)

HYUNDAI

INTRODUCTION

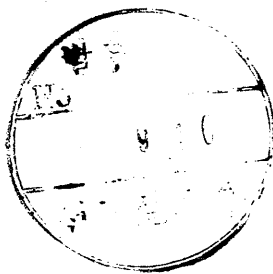
This service manual has instructions and procedures for the subject on the front cover.

The information, specifications and illustrations in 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 Mitsubishi dealer for the latest available information.



HOW TO USE THIS MANUAL

This service manual covers standard specifications for the Mitsubishi Diesel Engine, and describes specifications, maintenance standards, adjustments, disassembly inspection and repair, and reassembly.

Following is a brief summary of the system used in compiling this service manual.

1. The fuel injection pump, governor, and turbocharger are covered in the supplement of this manual.
2. The sections of the manual and their contents are listed in the index furnished at the beginning of the manual. The contents of each section are listed in the index furnished at the beginning of the section.
3. For operation and periodic maintenance, refer to OPERATION MAINTENANCE MANUAL; for component parts and ordering of replacement parts, refer to PARTS CATALOGUE; for systems operation, refer to TRAINING MANUALS.
4. The parts read in the texts or shown in the disassembled views are numbered in the disassembly sequence.
5. What to be inspected for during disassembly are indicated in in the disassembled views.
6. The maintenance standards or specifications to be referred to for inspection and repair are indicated in easy-to-refer passages of the texts and also in Section 2 in a tabulated form.
7. The following symbols are used in this manual to emphasize important and critical instructions:

NOTE Indicates a condition that is essential to highlight.

CAUTION Indicates a condition that can cause engine damage.

WARNING Indicates a condition that can cause personal injury or death.

8. Tighten Torque in "wet" condition is indicated as [wet]. Unless indicated as such, the torque is to be considered in "dry" condition.

9. The following terms are used in the dimensional and other specifications:

Nominal size Is the named size which has no specified limits of accuracy.

Assembly standard Is the dimension of a part to be attained at the time of assembly, or the standard performance. Its value is rounded to the nearest whole number needed for inspection and is different from the design value.

Standard clearance Is the clearance to be obtained between mating parts at the time of assembly.

Repair limit Is the maximum or minimum dimension specified for a part. A part which has reached this limit must be repaired.

Service limit Is the maximum or minimum dimension specified for a part. A part which has reached this limit must be replaced.

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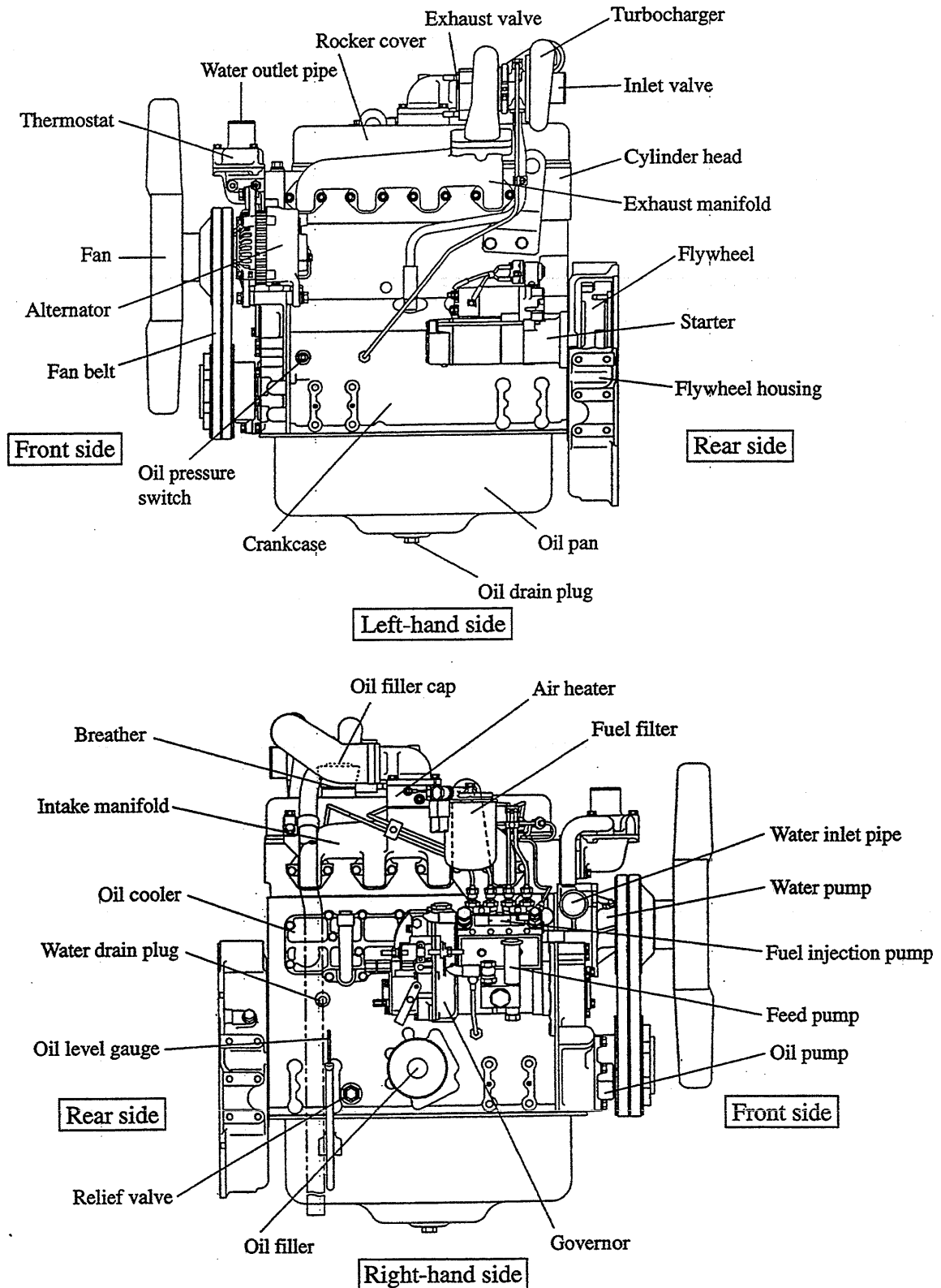
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GENERAL INFORMATION

1. GENERAL

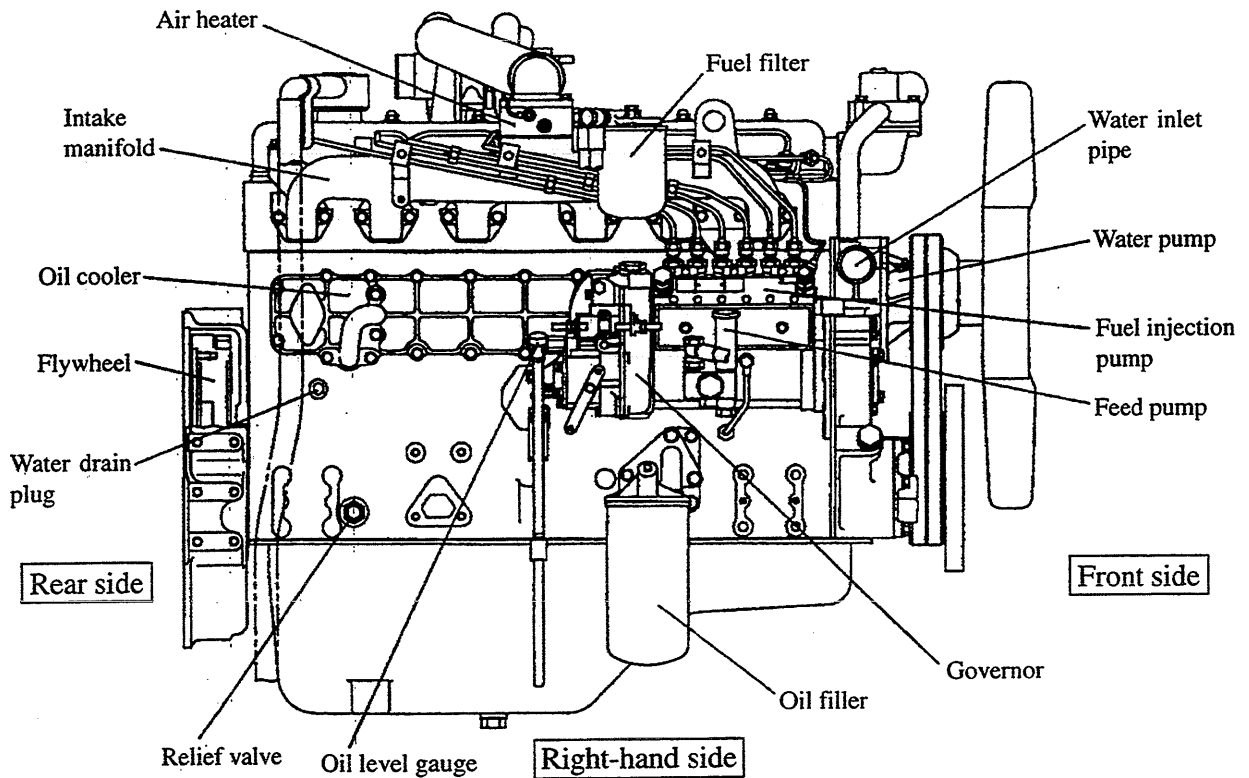
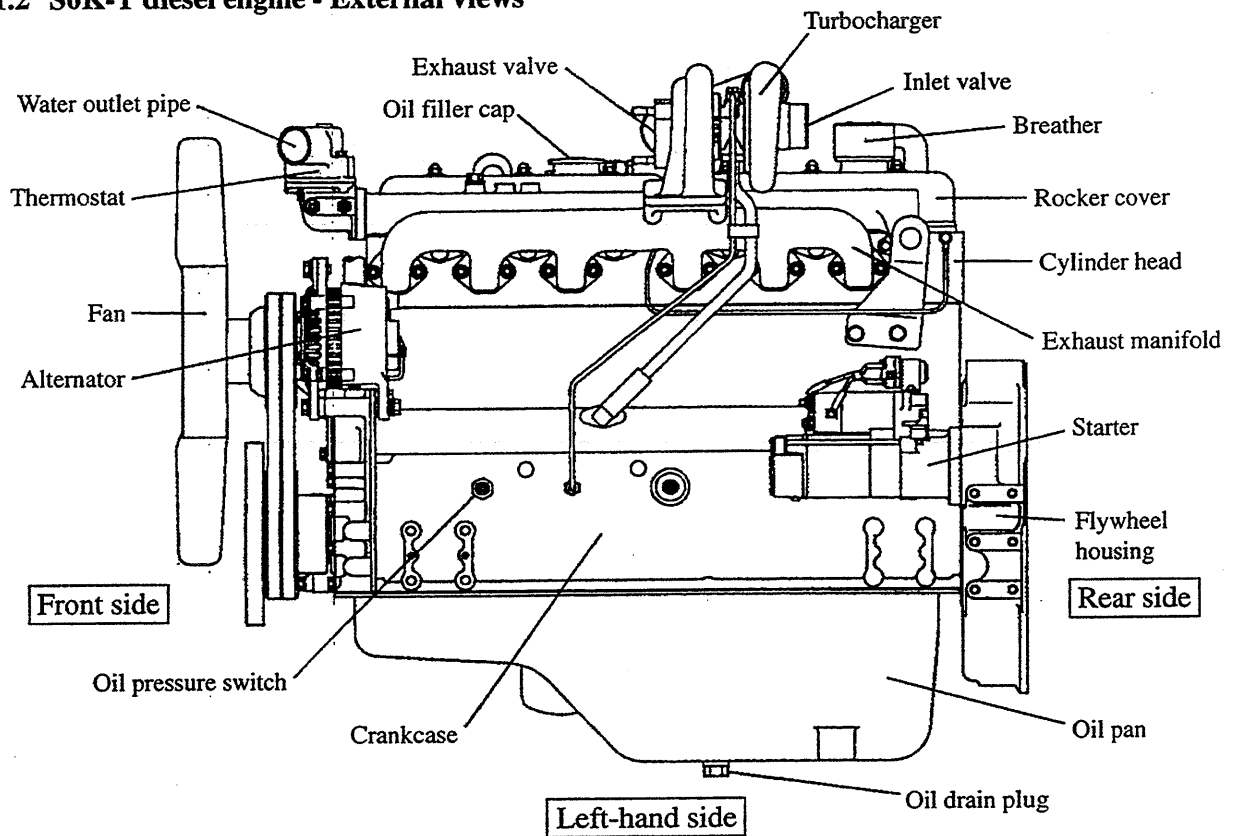
1.1 S4K-T diesel engine - External views



NOTE

Direction of rotation when viewed from the flywheel side is to the rear left (counterclockwise).

1.2 S6K-T diesel engine - External views



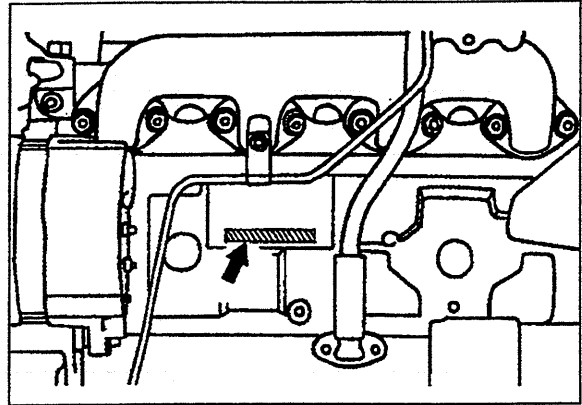
NOTE

Direction of rotation when viewed from the flywheel side is to the rear left (counterclockwise).

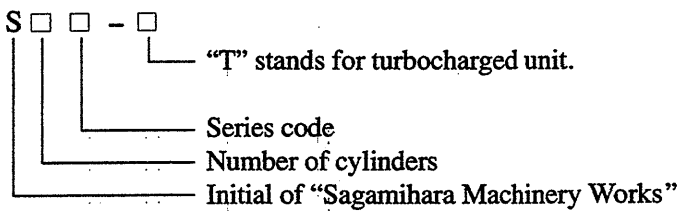
GENERAL INFORMATION

1.3 Engine serial number location

The engine serial number is stamped on the left side face of crankcase.



1.4 Engine model and application codes



2. SPECIFICATIONS [Sections marked with ☆ indicate Mitsubishi Standard specifications (external diagram).]

Model designation			S4K	S4K-T	S6K	S6K-T	
General	Type		Diesel	Diesel engine with turbocharger	Diesel	Diesel engine with turbocharger	
	Cooling system		Watercooled				
	Cycle		4-stroke cycle				
	No. of cylinders – arrangement		4-in line		6-in line		
	Type of combustion chamber		Direct injection				
	Valve mechanism		Overhead				
	Bore × stroke		mm (in.) 102 × 130 (4.02 × 5.12)				
	Piston displacement		liter (cu in.) 4.249 (259.3)		6.373 (388.9)		
	Compression ratio		17:1				
	Fuel (ASTM specification)		Diesel fuel (JIS K2204 Special Grade 2)				
	Firing order		1-3-4-2		1-5-3-6-2-4		
	Direction of rotation		Counterclockwise as viewed from flywheel side				
	Dimensions (☆)	Overall length	mm (in.)	857 (33.74)	873 (34.37)	1143 (45)	1143 (45)
		Overall width	mm (in.)	631 (24.84)	634 (24.96)	634 (24.96)	634 (24.96)
Overall height		mm (in.)	868 (34.17)	929 (36.57)	918 (36.14)	976 (38.43)	
Weight (dry)		kg (lb)	340 (750)	350 (770)	465 (1025)	475 (1047)	
Engine proper	Type of cylinder sleeves		Dry, special cast iron				
	No. of piston rings	Compression ring	2				
		Oil ring	1 (w/spring expander)				
	Valve timing	Inlet valves	Open	10° B.T.D.C.			
			Close	50° A.B.D.C.			
		Exhaust valves	Open	54° B.B.D.C.			
			Close	10° A.T.D.C.			
Starting system		Electric starter					
Starting aid		Air heater					
Inlet/exhaust systems	Air cleaner	Type	Paper element				
	Turbocharger	Type	-	TD06H or TD04H	-	TD06H	
Lubrication system	Type		Pressure feed by oil pump				
	Engine oil	API service classification	CD	CD	CD	CD	
		Refill capacity (incl. filter) liter (U.S. gal)	13 (3.4)		20.5 (5.4)		
	Oil pump	Type		Gear			
		Speed ratio to crankshaft		1.0			
Delivery capacity liter (U.S. gal)/min/rpm		40 (10.57)/2000		66 (17.44)/1800			

GENERAL INFORMATION

Model designation		S4K	S4K-T	S6K	S6K-T	
Lubrication system	Relief valve	Type	Piston valve			
		Opening pressure kgf/cm ² (psi) [MPa]	3.5 ± 0.2 (49.79 ± 2.85) [0.34 ± 0.02]			
	Oil cooler	Type	Water-cooled multi-plate type			
	Oil filter	Type	Cartridge type paper element			
	Safety valve (primary)	Opening pressure kgf/cm ² (psi) [MPa]	—		12 ± 1(170.7±14.225)[1.2 ± 0.1]	
Safety valve (secondary)	Opening pressure kgf/cm ² (psi) [MPa]	10 ± 1(142.25±14.225) [1.0 ± 0.1]				
Cooling system	Refill capacity (engine water jacket) liter (U.S. gal)		6 (1.6)		9 (2.4)	
	Water pump	Type	Centrifugal			
		Delivery capacity liter (U.S. gal)/min/rpm	130 (34.3)/ 1800	145 (38.3)/ 1800	174 (45.9)/1800	
	Water pump pulley	Speed ratio to crankshaft	1.26	1.0	1.0	1.15
	Fan belt	Type	Low-edge cog B type V-belt			
	Thermostat	Type	Wax pellet			
		Valve opening temperature °C (°F)	71 ± 2 (159.8 ± 35.6)			
	Fan	Type	Polypropylene-blade circular arc			
No. of blades		7				
Diameter mm (in.)		600 (23.6)				
Fuel system	Injection pump	Type	Bosch A or AD			
		Diameter of plunger mm (in.)	9.5 (0.374) or 10.5 (0.413)			
	Feed pump	Type	Bosch, piston			
		Cam lift mm (in.)	1.5 (0.06)			
	Governor	Type	Centrifugal			
	Injection nozzles	Type of nozzle holder	Bosch RSV			
		Type of nozzle tip	KBAL-P			
		No. of spray holes	4			
		Diameter of spray hole mm (in.)	0.3 (0.012)			
		Spray angle	155°			
	Valve opening pressure kgf/cm ² (psi) [MPa]	220 (3128) [21.6]				
Fuel filter	Type	Cartridge of paper element				

GENERAL INFORMATION

Model designation		S4K	S4K-T	S6K	S6K-T	
Electrical system	Voltage – polarity		24V – negative ground			
	Starter	Model	M008T60471 or M008T60871			
		Type	Pinion shift			
		Output V – kW	24 – 5			
		No. of pinion teeth/ No. of ring gear teeth	10/127			
	Alternator	Type	3-phase, w/rectifier			
		Output V – A	24 – 35			
		Rated voltage generating speed rpm	1100			
		Rated output generating speed rpm	5000			
		Maximum speed rpm	8000			
		Speed ratio to crankshaft	2.16			
	Air heater	Type	Electric			
		Capacity kW	2.1			
	Heater relay	Fuse capacity A	127			

GENERAL INFORMATION

3. SUGGESTIONS ON DISASSEMBLY AND REASSEMBLY

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 Reassembly

- (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.
(Refer to 2, Group No. 2.)
- (5) Replace gaskets and packings with new ones. Apply sealant as necessary. When using sealant, be careful not to apply an excessive amount.

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MAINTENANCE STANDARDS

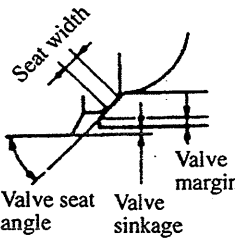
1. MAINTENANCE STANDARDS

Unit: mm (in.)

Group	Item	Nominal Size	Assembly Standard (standard clearance)	Repair Limit (clearance)	Service Limit (clearance)	Remarks	
General	Maximum speed, (rpm)	Vary according to specifications.				Adjust governor setting.	
	Minimum speed, (rpm)						
	Compression pressure, kgf/cm ² (psi) [MPa]	30 (427) [2.9] at 300 rpm		27 (384) [2.6]		Oil and water temp. 20 to 30°C (68 to 86°F)	
	Engine oil pressure, kgf/cm ² (psi) [MPa]	2 to 4 (28 to 57) [0.2 – 0.4] at 1500 rpm		1.5(21.3) [0.15]		Oil temperature 70 to 90°C (158 to 194°F)	
		1 (14.2) [0.1], minimum at low idle speed		0.5 (7) [0.05]			
	Valve timing	Inlet valves open Inlet valves close Exhaust valves open Exhaust valves close	10° B.T.D.C. 50° A.B.D.C. 54° B.B.D.C. 10° A.T.D.C. ±3° (crank angle)				
	Valve clearance (cold)			0.25 (0.0098)			Both inlet and exhaust valves
	Fuel injection timing		16° B.T.D.C.				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.
Fan drive belt tension			12 (0.473), approx.			Push belt inward with thumb pressure and measure sag.	
Crankcase	Warpage of top face			0.20 (0.0079)		Regrind if warpage is minor.	
	Inside diameter of bore (cylinder)	102 (4.02)	102.010 – 102.045 (4.01614 – 4.01752)	102.200 (4.02361)	102.700 (4.04330)	Refinish sleeves to 0.25 (0.0098) or 0.50 (0.0197) oversize of nominal value by honing and use the same oversize pistons and piston rings.	
	Out-of-round of bore (cylinder)		0.01 (0.0004), maximum				
	Taper of bore (cylinder)		0.015 (0.00059), maximum				

MAINTENANCE STANDARDS

Unit: mm (in.)

Group	Item		Nominal Size	Assembly Standard (standard clearance)	Repair Limit (clearance)	Service Limit (clearance)	Remarks	
Crankcase	Main metals	Oil clearance (clearance between crankshaft journal and main bearing)		(0.050 to 0.118) ((0.00197 to 0.00465))	(0.200) ((0.00787))	-0.9 (-0.035) as journal diameter	If repair limit is reached, replace metals. If it is exceeded, regrind journals and use undersize metals: Undersize metals: -0.25 (-0.0098) -0.50 (-0.0197) -0.75 (-0.0295)	
		Width of thrust journals (end play)		(0.100 to 0.264) ((0.00394 to 0.01039))	Play in thrust direction (0.300) ((0.011811))		Replace thrust plate	
	Tappet bore	Inside diameter	22 (0.87)	22.000 to 22.021 (0.86614 to 0.86697)		22.100 (0.87008)		
		Clearance between tappet and bore	22 (0.87)	(0.035 to 0.086) ((0.001378 to 0.003386))	(0.120) ((0.00472))	+0.10 (+0.0039) as inside diameter	If repair limit is reached, replace tappets.	
	Camshaft bushing (S6K)	Clearance on journals		(0.04 to 0.09) ((0.0016 to 0.0035))	(0.15) ((0.0059))		If repair limit is exceeded, replace bushings. Ream if necessary.	
	Crankcase cam bushing (S4K)							
	Cylinder head	Cylinder head	Warpage of gasketed surface		0.05 (0.0020), maximum	0.20 (0.0079)		Regrind if warpage is minor.
As-installed thickness of gasket			1.7 (0.067)	±0.10 (±0.0039)				
Valves and valve guides		Diameter of valve stem	Inlet valves		7.940 to 7.955 (0.31260 to 0.31319)		7.900 (0.31102)	
			Exhaust valves		7.920 to 7.940 (0.31181 to 0.31260)		7.850 (0.30905)	
		Clearance between guide and stem	Inlet valve	ø0.8 (0.03)	(0.055 to 0.085) ((0.00217 to 0.00335))		(0.150) ((0.00591))	
			Exhaust valve	ø0.8 (0.03)	(0.070 to 0.105) ((0.00276 to 0.00413))		(0.200) ((0.00787))	
As-installed depth of valve guide		17 (0.67)	±0.3 (±0.012)					
Valve seats		Angle		30°				
		Valve sinkage	Inlet	0.4 (0.016)	±0.1 (±0.00394)		1.1 (0.043)	
			Exhaust	0.5 (0.020)				
		Width		1.4 (0.055)	±0.2 (±0.008)		1.8 (0.071)	
Valve margin			2.13 (0.0839)		Up to 1.20 (0.047) by refacing			

MAINTENANCE STANDARDS

Unit: mm (in.)

Group	Item	Nominal Size	Assembly Standard (standard clearance)	Repair Limit (clearance)	Service Limit (clearance)	Remarks	
Cylinder head	Valve springs	Free length	56.40 (2.2205)		55.00 (2.1654)		
		Squareness		2°, maximum		Difference in angle between ends with respect to center line	
		Test force/length under test force, kgf(lbf)/N/mm(in.)		22.7 to 25.1 (50.1 to 55.3) [222.6 to 246.1] /44 (1.73)		21.2 (46.7) [208] /44(1.73)	
	Rocker arms	Inside diameter of rocker arm (bushing)	20 (0.79)	20.011 to 20.094 (0.78784 to 0.79110)			
		Diameter of rocker shaft	20 (0.79)	19.984 to 19.966 (0.78677 to 0.78606)			
		Clearance of bushing on shaft	20 (0.79)	(0.027 to 0.128) ((0.00106 to 0.00504))	(0.15) ((0.0059))		
	Valve pushrods	Runout (bend)		0.4 (0.016), maximum			Runout measured with pushrod supported at centerlines of its spherical ends (Dial gauge reading)
Main moving parts	Crankshaft	Runout		0.02 (0.0008), maximum	0.05 (0.0020)		
		Diameter of journal	90 (3.54)	-0.03 (-0.0012) -0.05 (-0.0020)	-0.15 (-0.0059)	-0.90 (-0.0354)	
		Diameter of crankpin	60 (2.36)	-0.035 (-0.00138) -0.055 (-0.00217)		-0.20 (-0.0079)	
		Distance from center of journal to center of crankpin	65 (2.56)	±0.05 (±0.0020)			
		Parallelism between journal and crankpin		Runout: 0.01 (0.0004), maximum			
		Out-of-round of journal and crankpin		0.01 (0.0004), maximum	0.03 (0.0012)		
		Taper of journal and crankpin					
		Fillet radius of journal and crankpin	3R (0.12)	±0.2 (±0.008)			
		End play		(0.100 to 0.264) ((0.00394 to 0.01039))		(0.300) ((0.01181))	If repair limit is reached, replace thrust plates. If it is exceeded, use oversize thrust plates. Oversize thrust plates: +0.015 (+0.0059) +0.30 (+0.0118) +0.45 (+0.0177)

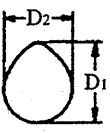
MAINTENANCE STANDARDS

Unit: mm (in.)

Group	Item		Nominal Size	Assembly Standard (standard clearance)	Repair Limit (clearance)	Service Limit (clearance)	Remarks	
Main moving parts	Pistons	Outside diameter (at skirt)	Standard	101.915 to 101.945 (4.01239 to 4.01357)		101.730 (4.00511)		
			0.25 (0.0098) oversize	102 (4.02)	102.165 to 102.195 (4.02224 to 4.02343)		101.980 (4.01495)	
			0.50 (0.0197) oversize		102.415 to 102.445 (4.03209 to 4.03327)		102.230 (4.02480)	
		Projection			0.55 to 1.15 (0.0217 to 0.0453)			Check metal clearance.
		Maximum permissible difference between average weight of all pistons in one engine			5 g (0.2 oz), maximum			
		Clearance between groove and ring	No. 1 ring	3.0 (0.118)	(0.08 to 0.12) ((0.0031 to 0.0047))		(0.200) ((0.00787))	
			No. 2 ring	2.0 (0.079)			(0.150) ((0.00591))	
			Oil ring	4.0 (0.157)	(0.025 to 0.065) ((0.00098 to 0.00256))			
		End gap	No. 1, 2 rings		0.30 to 0.45 (0.0118 to 0.0177)		1.50 (0.0591)	
			Oil ring		0.30 to 0.50 (0.0118 to 0.0197)			
	Piston pins	Diameter		34 (1.34)	33.993 to 34.000 (1.33830 to 1.33858)			
		Clearance between pin and bore			(0.002 to 0.019) ((0.00008 to 0.00075))		(0.050) ((0.00197))	
		Clearance between pin and bushing			(0.023 to 0.054) ((0.00091 to 0.00213))		(0.080) ((0.00315))	Replace pin or bushing. Ream if necessary.
	Connecting rods	Inside diameter of bushing		34 (1.34)	34.020 to 34.045 (1.33937 to 1.34035)			
		Twist/bend			0.05/100 (0.0020/3.94), maximum	0.15 (0.0059)		
		Clearance between crankpin and connecting rod metal (oil clearance)			(0.035 to 0.100) ((0.00138 to 0.00394))		(0.200) ((0.00787))	Replace connecting rod metal.
		End play			(0.15 to 0.35) ((0.0059 to 0.0138))		(0.50) ((0.020))	Replace connecting rod.
		Maximum permissible difference between average weight of all connecting rods in one engine			10g (±0.35 oz), maximum			

MAINTENANCE STANDARDS

Unit: mm (in.)

Group	Item		Nominal Size	Assembly Standard (standard clearance)	Repair Limit (clearance)	Service Limit (clearance)	Remarks		
Main moving parts	Flywheel	Flatness		0.15 (0.0059), maximum	0.50 (0.020)				
		Face runout							
Timing gears	Camshaft	Bending			0.02 (0.0008), maximum	0.05 (0.0020)		Straighten by cold working or replace.	
		Cam profile	Inlet valves	D_1 46.911 $\begin{smallmatrix} +0.1 \\ -0.3 \\ (1.84689 \end{smallmatrix}$ $\begin{smallmatrix} +0.004 \\ -0.012 \end{smallmatrix}$	$D_1 - D_2$ = 6.689 (0.26335)		$D_1 - D_2$ = 6.189 (0.24366)		
			Exhaust valves	D_1 46.256 $\begin{smallmatrix} +0.1 \\ -0.3 \\ (0.82110 \end{smallmatrix}$ $\begin{smallmatrix} +0.004 \\ -0.012 \end{smallmatrix}$	$D_1 - D_2$ = 7.344 (0.28913)		$D_1 - D_2$ = 6.844 (0.26945)		
		Diameter of journals	S4K S4K-T	No. 1, 2	54 (2.13)	53.94 to 53.96 (2.1236 to 2.1244)		53.90 (2.1220)	
				No. 3	53 (2.09)	52.94 to 52.96 (2.0842 to 2.0850)		52.90 (2.0827)	
			S6K S6K-T	No. 1, 2, 3	54 (2.13)	53.94 to 53.96 (2.1236 to 2.1244)		53.90 (2.1220)	
				No. 4	53 (2.09)	52.94 to 52.96 (2.0842 to 2.0850)		52.90 (2.0827)	
		End play		5 (0.20)	(0.10 to 0.25) ((0.0039 to 0.0098))		(0.300) ((0.01181))	Replace thrust plates.	
		Idler gear	Clearance between shaft and bushing			(0.009 to 0.080) ((0.00035 to 0.00315))		(0.100) ((0.00394))	Replace bushing.
			End play		26 (1.02)	(0.05 to 0.20) ((0.0020 to 0.0079))		(0.35) ((0.0138))	Replace thrust plates.
	Fit (interference) of shaft in crankcase bore		35 (1.37)	(-0.009 to -0.045) ((-0.00035 to -0.00177))					
	Backlash			(0.03 to 0.17) ((0.0012 to 0.0067))		(0.25) ((0.0098))	Replace gears.		
	Lubrication system	Oil pump	Backlash of oil pump gear and idler gear			(0.10 to 0.19) ((0.0039 to 0.0075))	(0.35) ((0.0138))		
End clearance of pump gears in case			S4K S4K-T	22 (0.87)	(+0.02 to -0.034) ((+0.0008 to -0.00134))	(0.15) ((0.0059))			
			S6K S6K-T	36 (1.42)					
Radial clearance of pump gears in case				(0.05 to 0.098) ((0.0020 to 0.00386))		(0.10) ((0.0039))			
Clearance of gear shaft in case and cover				(0.04 to 0.07) ((0.0016 to 0.0028))		(0.15) ((0.0059))			
Diameter of spindle			25 (0.98)	24.939 to 24.960 (0.98185 to 0.98268)					
Inside diameter of idler gear bushing		25 (0.98)	25.000 to 25.021 (0.98425 to 0.98508)						

MAINTENANCE STANDARDS

Unit: mm (in.)

Group	Item		Nominal Size	Assembly Standard (standard clearance)	Repair Limit (clearance)	Service Limit (clearance)	Remarks	
Lubrication system	Relief valve	Opening pressure,		3.5 ± 0.5 (49.8 ± 2.8) [0.34 ± 0.05]				
	Safety valve	kgf/cm ² (psi) [MPa]		10 ± 1.0 (142 ± 14.2) [1 ± 0.1]				
Cooling system	Water pump	Fit (interference) of pump shaft in flange	25 (0.98)	(0.035 to 0.065) ((0.00138 to 0.00256))			Parts may be reassembled 2 times.	
		Fit (interference) of pump shaft in impeller	13 (0.51)	(0.032 to 0.065) ((0.00126 to 0.00256))				
		Clearance of impeller in case		1.4 to 1.6 (0.055 to 0.063)				
	Thermostat	Temp. at which valve starts opening		71±2°C (159.8±3.6°F)				
		Temp. at which valve lifts more than 10 (4)		85°C (185°F)				
Fuel system	Injection nozzles	Valve opening pressure, kgf/cm ² (psi) [MPa]	220 (3128) [21.6]	225 – 235 (3200 – 3342) [22.1 – 23.0]			Make shim adjustment. Pressure varies by 14 (199) [1.4] per 0.1mm (0.004 in.) thickness of shim.	
		Discharge angle	155° (311°F)				Test by means of hand tester, using diesel fuel, at 20°C (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 kgf/cm ² (284.4 psi) [2.0 MPa] lower than valve opening pressure for 10 seconds.				Wash or replace nozzle tip.	
Electrical system	Commutator	Diameter	32.0 (1.260)			31.4 (1.24)		
		Runout		0.03 (0.0012)		0.05 (0.0020)		
	Mold depth between segments				0.2 (0.008) maximum			
	Brushes	Length	18 (0.71)				11 (0.43)	
		Spring tension, kgf (lbf) [N]	3.0 to 4.0 (6.6 to 8.8) [29 to 39]				1.4 (3.1) [13.7]	
	Thrust gap of pinion shaft				0.4 to 1.1 (0.016 to 0.043)			

MAINTENANCE STANDARDS

Unit: mm (in.)

Group	Item	Nominal Size	Assembly Standard (standard clearance)	Repair Limit (clearance)	Service Limit (clearance)	Remarks			
Electrical system	Starter	Pinion clearance	0.5 - 2.0 (0.020 - 0.079)						
		No-load characteristics		Locked rotor characteristics			Magnetic switch operating voltage		
		Voltage, V	Current, A	Speed, rpm	Voltage, V	Current, A	Speed, rpm	Switch-in, V	Switching off
		23	85, max.	3300	9	1400, max.	9.0, min.	16, max.	Shall turn off upon turning off of starter switch.
	Alternator	Brush spring tension, gf (lbf) [N]	640 (1.41) [6.3]	580 - 700 (1.28 - 1.54) [5.7 - 6.9]		290 (0.45) [2.8]			
		Brush length	21.5 (0.846)			8 (0.31)			
		Resistance between slip rings		9 - 10.5Ω			At 20°C (68°F)		

2. TIGHTENING TORQUE

2.1 Important bolts and nuts

Secured part or component	Thread dia. – pitch mm	Width across flats mm	Tightening torque			Remarks
			kgf-m	lbf-ft	N-m	
Cylinder head bolts	12 – 1.75	19	12±0.5	87±8.6	118±5	[Wet]
Rocker cover nuts	8 – 1.25	14	0.85±0.15	6.15±1.08	8.35±1.45	
Rocker shaft bracket bolts	8 – 1.25	12	1.5±0.5	11±3.6	14.9±5.1	
Main metal cap bolts	14 – 2	22	14±0.5	101±3.6	137±0.5	[Wet]
Connecting rod cap nuts	12 – 1.25	17	10.5±0.5	76±3.6	103±5	[Wet]
Flywheel bolt	12 – 1.25	17	8.5±0.5	61±3.6	83.3±4.9	
Camshaft thrust plate bolt	8 – 1.25	12	1.15±0.15	8.3±1.08	11.4±1.6	
Front plate bolt	10 – 1.5	14	3.6±0.6	26±4	35.25±5.85	
Timing gear case bolt	10 – 1.5	14	3.6±0.6	26±4	35.3±5.9	
Crankshaft pulley nut	30 – 1.5	46	50±1	362±7	490±10	
Idler thrust plate bolt	10 – 1.25	14	3.5±0.5	25±3.6	34.3±4.9	
Oil pan bolt	8 – 1.25	12	1.85±0.35	13.4±2.5	18.15±3.45	
Oil drain valve	24 – 1.5	—	5±0.5	36±3.6	49.05±4.95	
Oil pan drain plug	14 – 1.5	22	4±0.5	29±3.6	39.2±4.9	S4K
	24 – 1.5	27	6±0.5	43±3.6	59±5	S6K
Nozzle gland (direct injection type)	8 – 1.25	12	2.2±0.2	16±1.45	21.75±1.75	
Injection pump delivery valve holders	A type	22	4.25±0.25	31±1.81	41.65±2.54	
	AD type		5.25±0.25	38±1.81	51.5±2.5	
Fuel leak-off pipe mounting nuts	12 – 1.5	17	2.3±0.2	17±1.45	25.55±1.95	
Injection pump gear nut	14 – 1.5	19	8.5 – 10.0	61 – 72	83 – 98	
Air heater terminal nuts	6 – 1	10	1.3±0.1	9±0.72	12.75±0.95	
Intake manifold bolts	8 – 1.25	12	1.85±0.35	13±2.53	18.15±3.45	
Exhaust manifold bolts	8 – 1.25	12	1.85±0.35	13±2.53	18.15±3.45	
Relief valve	22 – 1.5	27	5±0.5	36±3.6	49±4.9	
Safety valve	18 – 1.5	24	4.5±0.5	33±3.6	44.1±4.9	
Injection pipe nuts	12 – 1.5	19	3±0.3	21.7±2.2	29.45±2.95	
Overheat warning unit (thermoswitch)	16 – 1.5	19	2.3±0.2	17±1.45	22.55±1.95	
Lifting bolts	12 – 1.75	19	8.5±0.5	62±3.6	83.4±4.9	
Starter B terminal	8 – 1.25	12	1.0 – 1.2	7 – 9	10 – 12	
Plugs	16 – 1.5	24	4.5±0.5	32.5±3.6	44.1±4.9	
Balancer	8 – 1.25	12	5.4±0.5	39±3.6	52.9±5	
Injection pump oil supply pipe (flare)	12 – 1.0	17	1.95±0.35	14.10±2.53	19.15±3.45	
Injection pump eyebolt	14 – 1.5	22	2.5±0.5	18.1±3.6	24.7±4.7	
Injection pump overflow valve		17	2.25±0.25	16.27±1.81	22.25±2.25	

Remarks: Apply engine oil to threads of parts specified as [Wet] in Remarks column.

MAINTENANCE STANDARDS

2.2 Standard bolts

Thread diameter mm	Tightening torque					
	4T			7T		
	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft
M6	4±1	0.4±0.1	2.95±0.74	9±1	0.9±0.1	59.74±0.74
M8	11±1.5	1.15±0.15	8.11±1.11	18±3	1.85±0.35	13.28±2.21
M10	21±3	2.15±0.35	15.44±2.21	35±6	3.6±0.6	25.81±4.43
M12	35±6	3.6±0.6	25.81±4.43	64±10	6.5±1	47.2±7.38

2.3 Standard stud bolts

Thread diameter mm	Embedding torque					
	When embedding in aluminum			When embedding in iron		
	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft
M8	7.4±1	0.75±0.1	5.46±0.74	13±1	1.3±0.1	9.59±0.74
M10	14±1	1.4±0.1	10.33±0.74	24±2	2.4±0.2	17.7±1.48

2.4 Standard plugs

Thread diameter mm	Tightening torque					
	When installing in aluminum			When installing in iron		
	N·m	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft
NPTF 1/16	6.4±1.5	0.65±0.15	4.72±1.11	10±2	1.0±0.2	0.74±0.15
PT 1/8	10±2	1.0±0.2	7.38±1.48	18±3	1.85±0.35	1.364±2.12
PT 1/4, NPTF 1/4	25±5	2.5±0.5	18.44±3.69	39±5	4.0±0.5	28.76±3.69
PT 3/8	—	—	—	64±10	6.5±1	47.2±7.38

- NOTE: (a) The indicated tightening torque values are for standard bolts and nuts.
 (b) The indicated values are tightening torque for bolts with spring washers.
 (c) The indicated values are standard tightening torque, with an allowed range of ±10%.
 (d) Use the indicated tightening torque, unless otherwise specified.
 (e) Do not apply oil on bolt threads (dry).

3. SEALANTS

Application point	Mating parts	Sealant	How to use
Oil pan gasket	<ul style="list-style-type: none"> • Rear metal cap seat of crankcase • Lower side of front plate 	ThreeBond 1104 (No. 4)	Apply to lower rear end of crankcase and lower side of front plate (metal cap seat).
<ul style="list-style-type: none"> • Water hole sealing cap for crankcase and sealing cap for main oil gallery • Water hole sealing cap for cylinder head 	<ul style="list-style-type: none"> • Crankcase • Cylinder head 	ThreeBond 1307N Hermeseal S-2	Apply to holes before installing plugs.
Screw plug (taper plug) for crankcase main oil gallery	Crankcase	Loctite 271	Apply to threads.
Water bypass hose and pipe	Thermostat cover, elbow and water pump	Loctite 271	Apply to threads.
Rear metal cap side seal of crankcase	Metal cap (rear side seal contact surface)	ThreeBond 1105D (No. 5)	Apply to crankcase before installing rear bearing cap.
Timing gear case gasket	Timing gear case	ThreeBond 1102 (No. 2)	Apply to gasket surface of timing gear case.
Oil pump cover	Timing gear case	ThreeBond 1205	Apply to gasket surface of timing gear case.
Front oil seal sleeve	Crankshaft pulley	ThreeBond 1205	Apply to sleeve mounting surface of crankshaft pulley.

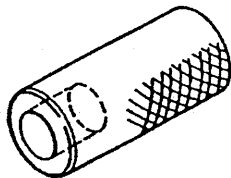
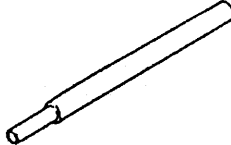
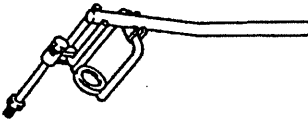
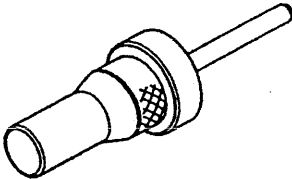
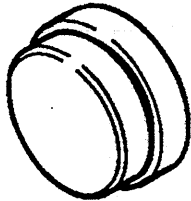
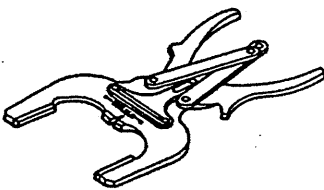
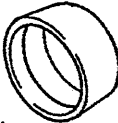
SPECIAL TOOLS

SPECIAL TOOLS LIST 3-2

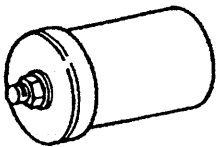
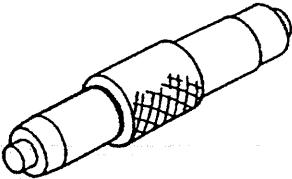
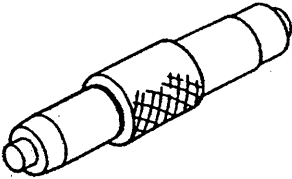
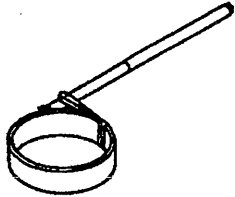
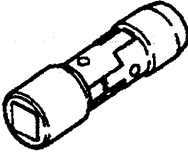
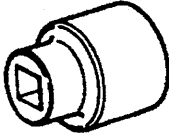
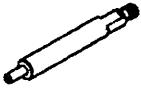


SPECIAL TOOLS

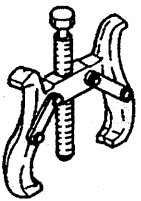
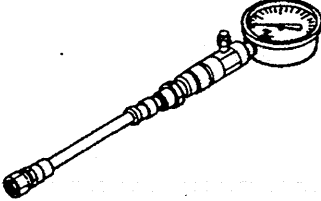
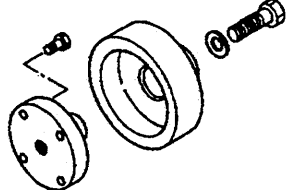
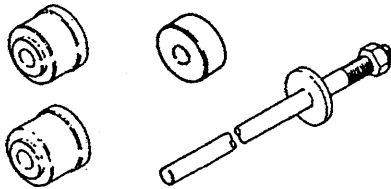
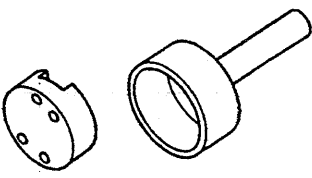
SPECIAL TOOL LIST

Tool name	Part No.	Shape	Use
Valve guide installer	34491-00400		Valve guide installation
Valve guide remover	31391-10500		Valve guide removal
Valve spring pusher	30691-04500		Valve spring removal/ installation
Valve seat insert caulking tool	Inlet 36791-00200 Exhaust 36791-00300		Valve seat installation
Sleeve installer	34291-00200		Cylinder sleeve installation
Piston ring pliers	30091-07100		Piston ring removal/ installation
Piston guide	34291-00100		Piston installation

SPECIAL TOOLS

Tool name	Part No.	Shape	Use
Idler shaft puller	MH061077		Idler gear shaft removal
Idler gear bushing installer	30091-07300		Idler gear bushing removal/ installation
Connecting rod bushing puller	MH061296		Connecting rod bushing removal/installation
Oil filter wrench	34591-00100		Oil filter and fuel filter removal/installation
Universal extension	30091-01101		Fuel injection pump removal/installation
Socket	58309-73100		Engine cranking
Gauge adaptor	36791-00100		Engine compression pressure measurement

SPECIAL TOOLS

Tool name	Part No.	Shape	Use
Puller assembly	64309-12900		Crankshaft gear and crankshaft pulley removal
Compression gauge	33391-02100		Compression pressure testing
Rear oil seal installer	34291-00020		Installation of oil seal slinger in rear side of crankshaft
Camshaft pushing installer set	30691-00010		Camshaft bushing removal/installation (S6K/S6K-T only)
Crankshaft sleeve installer	34291-00010		Installation of double-lip oil seal sleeve on crankshaft rear side

GENERAL INSTRUCTIONS

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2. MEASURING THE COMPRESSION PRESSURE 4-3

GENERAL INSTRUCTIONS

1. DETERMINING WHEN TO OVERHAUL THE ENGINE

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 blowby.

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:

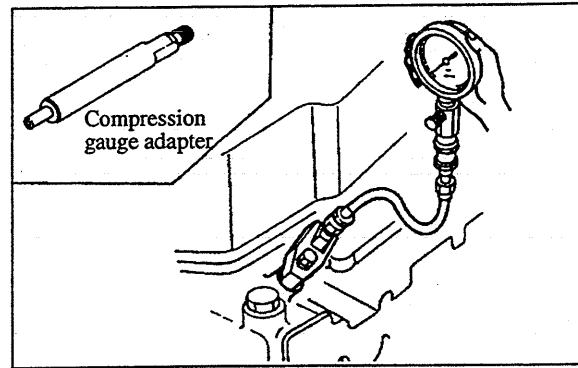
- (1) Lack of power
- (2) Increase in fuel consumption
- (3) Increase in lube oil consumption
- (4) Excessive blowby through breather due to worn cylinders, pistons, etc.
- (5) Excessive blowby due to poor seating of worn inlet and exhaust valves
- (6) Hard starting
- (7) Abnormal sound
- (8) Abnormal color of exhaust gas from engine after warm-up.

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

- (1) Remove the injection nozzle from a cylinder on which the compression pressure is to be measured.
- (2) Attach the gauge adaptor (36791-00100) to the cylinder, and connect the compression gauge to the adaptor.
- (3) Crank the engine by means of the starter, and read the compression gauge indication when the engine begins to run at the specified speed.
- (4) If the compression pressure is lower than the repair limit, overhaul the engine.



⚠ CAUTION

- a) Be sure to measure the compression on all cylinders. It is not a good practice to measure the compression pressure on two or three cylinders and judge the compression pressure of the remaining cylinders therefrom.
- 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/cm² (psi) [MPa]

Item	Assembly Standard	Repair Limit
Compression	30 (427) [2.9]	27 (384) [2.6]

NOTE

It is important to measure compression pressure regularly to obtain data of the gradual change in compression pressure.

Compression pressure is usually higher when the engine is new and immediately after an overhaul due to tight clearances of piston rings and valve seats, and gradually decreases as the engine breaks in.

ADJUSTMENTS, BENCH TEST, PERFORMANCE TESTS

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TESTING AND ADJUSTING

1. ADJUSTMENTS

1.1 Valve clearance inspection and adjustment

Check and adjust the valve clearance when the engine is cold or when it is warm in whole.

Unit: mm (in.)

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

(1) Inspecting valve clearance

- (a) Check the valve clearance by the firing order, by turning the crankshaft by the specified crank angle in normal direction at a time to bring the piston to its top dead center on compression stroke.

No. of cylinders	Firing order	Crank angle
4	1-3-4-2	180°
6	1-5-3-6-2-4	120°

NOTE

To turn the crankshaft, disconnect the universal joint from the damper on the engine and rotate the crankshaft pulley nut using a socket and ratchet handle.

Unit: mm (in.)

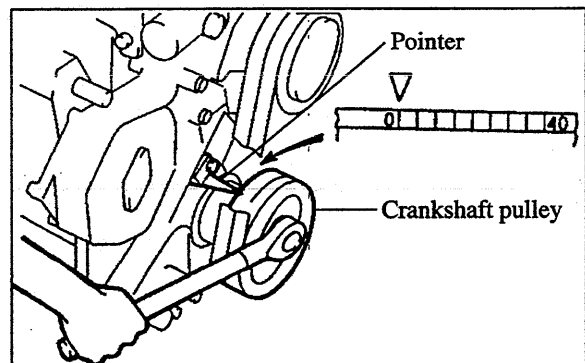
Width across flats of crankshaft pulley nut	46 (1.81)
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- (b) The top dead center on compression stroke of the piston is identified by the timing mark "0" (on the crankshaft pulley) being aligned with the pointer on the gear case. With the piston so located, either inlet and exhaust valve rocker arms are not being pushed up by their pushrods.

NOTE

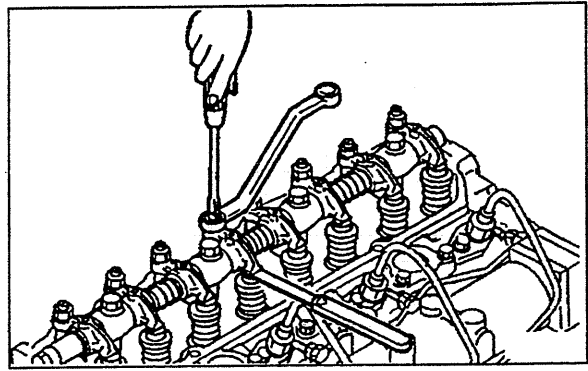
On the 6-cylinder engines equipped with a vibration damper, align the timing mark on the damper with the pointer on the gear case.

- (c) Insert a feeler gauge into between the rocker arm and valve cap, and check the valve clearance.



(2) Adjusting valve clearance

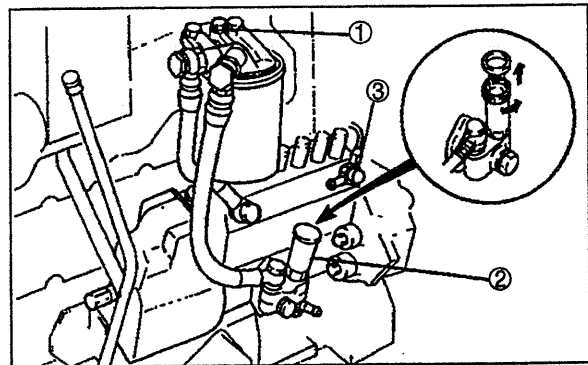
- (a) Loosen the lock nut for adjusting screw, and adjust the clearance by turning the screw in either direction to the extent that the gauge is slightly gripped between the rocker arm and valve cap.
- (b) After adjusting the clearance, tighten the lock nut, and again check the clearance, making sure that it is correct.



1.2 Fuel system priming

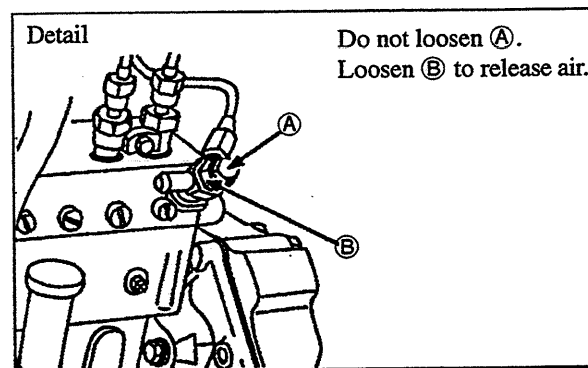
(1) Fuel filter

- (a) Loosen air vent plug ① at the top of the filter (by turning it about 1.5 rotations).
- (b) Unlock priming pump handle ② by turning it counterclockwise, and operate the priming pump.
- (c) Tighten the air vent plug when fuel flows from the vent hole without bubbles.



(2) Fuel injection pump

- (a) Loosen air vent plug ③ on the injection pump (by turning it about 1.5 rotations).
- (b) Operate the priming pump handle.
- (c) Tighten the air vent plug when fuel flows from the vent hole without bubbles. Lock the priming pump by turning its handle clockwise while pushing it down before tightening the last vent plug.



NOTE

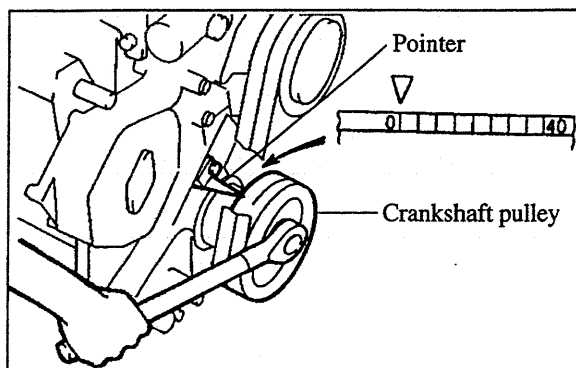
- (a) If all vent plugs are tightened before the priming pump handle is locked, fuel pressure acts on the feed pump, making it impossible to restore the handle.
- (b) Wipe off fuel spilt from the vent holes with a cloth.

TESTING AND ADJUSTING

1.3 Fuel injection timing inspection and adjustment

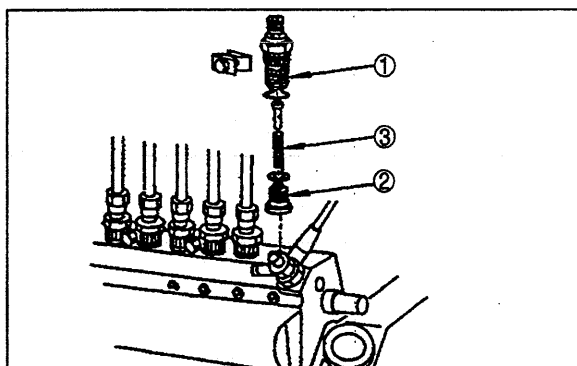
The injection timing for each model of the engine varies according to its output, speed and specification. Be sure to verify the timing by referring to the specifications of each model.

- (1) Bringing No. 1 piston to top dead center on compression stroke
 - (a) Put socket (58309-73100) to the crankshaft pulley, and turn the crankshaft in normal direction (clockwise as viewed from the front side of the engine).
 - (b) Stop cranking the engine when the timing mark "0" on the crankshaft pulley is aligned with the pointer.
 - (c) Move the inlet and exhaust valve rocker arms for the No. 1 cylinder up and down to make sure that they are not being pushed up by their pushrods. Now the inlet and exhaust valves should have a clearance to be checked.

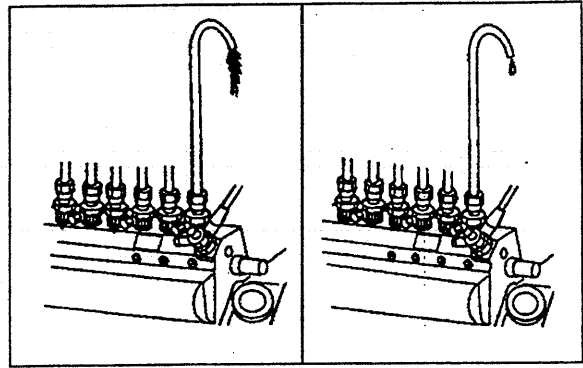


(2) Inspecting fuel injection timing

- (a) Remove the delivery valve holder from No. 1 pumping element of injection pump. Take delivery valve, spring and stopper out of the holder, and restore the holder to the pump.
- (b) Attach a spare injection pipe to No. 1 pumping element, with its free end held downward to that you can see fuel flow from that end.
- (c) Turn the crankshaft to bring No. 1 piston to about 60° position before top dead center on compression stroke.

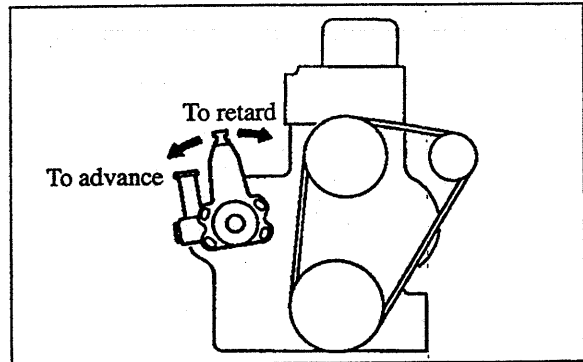


- (d) While operating the priming pump to allow fuel to flow from the injection pipe, crank the engine in normal direction. Reduce cranking speed when the fuel just starts to stop flowing. Stop cranking when the fuel stops flowing.
- (e) Make sure that the timing mark on the crankshaft pulley is aligned with the pointer.

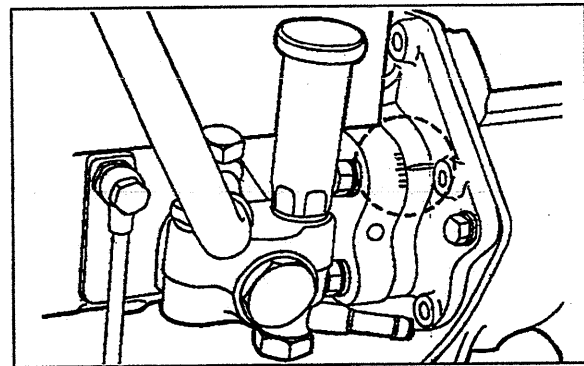


(3) Adjusting fuel injection timing

- (a) If the timing is advanced, tilt the injection pump toward the crankcase. If it is retarded, tilt the pump away from the crankcase.



- (b) One graduation of the scale on the injection pump coupling changes the timing by 6° in terms of crank angle.



TESTING AND ADJUSTING

1.4 No-load minimum (low idle) speed and no-load maximum speed setting inspection and adjustment

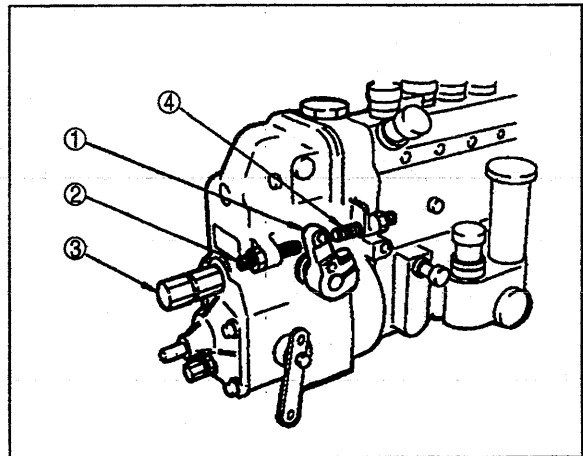
⚠ CAUTION

- a) The no-load minimum (low idle) speed and no-load maximum speed are set for each engine on the test bench at the factory. The set bolts are sealed. Inspection and adjustment of these speeds are to be made at the Mitsubishi-authorized service shop only.
- b) After adjusting the governor by breaking the seals, be sure to re-seal all stoppers, making them appear as if they were sealed at the factory.
- c) Whether the stopper seals are intact or not has important bearing on the validity of claims under warranty.
- d) When inspecting and adjusting these speeds, be on the standby to operate the engine stop lever manually in the event of engine over-run.

For inspection and adjustment, warm up the engine thoroughly until the coolant and oil temperatures are above 70°C (158°F).

(1) Starting engine

- (a) Move speed control lever to the high speed position and turn the starter switch to START position to crank the engine.
- (b) The engine will fire up at a speed of approximately 150 rpm. When the engine fires, hold the engine speed between 800 and 1000 rpm by operating the speed control lever.
- (c) When the engine runs with a steady speed, move the speed control lever back to the low idle speed position.

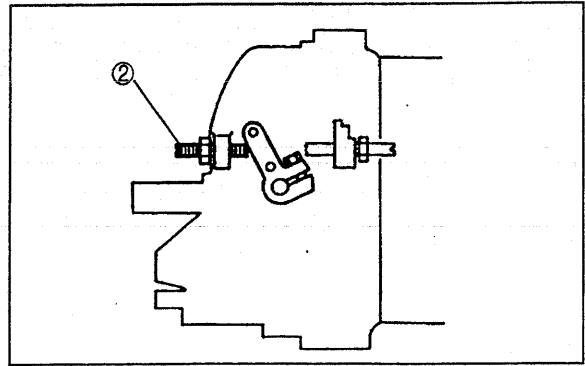


(2) Setting no-load minimum (low idle) speed

- (a) Set the speed control lever at the position for no-load minimum (low idle) speed with the low idle speed set screw ②.

CAUTION

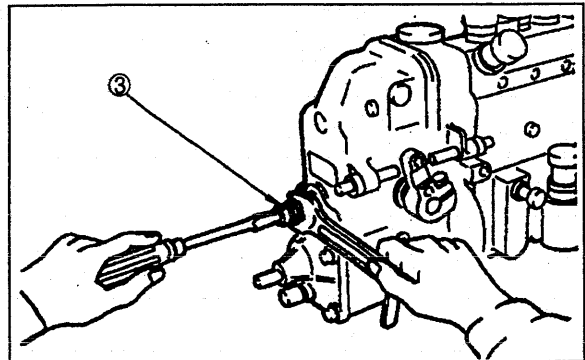
If a critical speed (the speed at which the engine excessively vibrates due to torsional resonance) might exist, shift the setting to a lower or high idle speed level.



- (b) Turning the low idle set screw clockwise raises the idling speed.
- (c) If engine speed tends to fluctuate, turn the idle sub-spring adjusting screw ③ clockwise to push in this spring, making it come in slight contact with the tension lever. With the idle sub-spring exerting some force to the lever, the speed will rise slightly but will stop fluctuating.

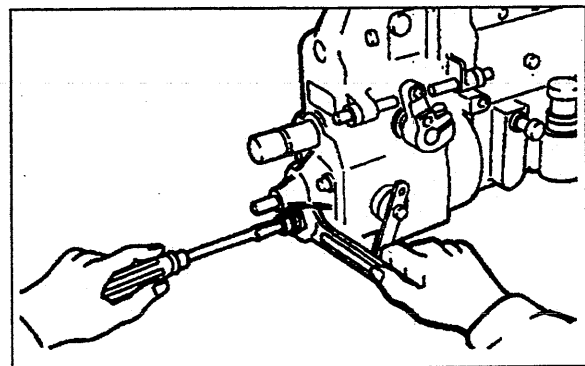
CAUTION

Tightening the idle sub-spring adjusting screw is likely to cause the engine to overspeed when the load is dumped during duty operation. When tightening the adjusting screw, be sure to tighten it just enough to eliminate the unstable condition.



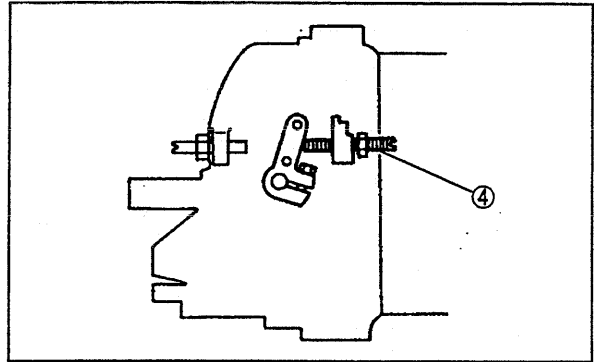
(3) Rack setting (setting no-load maximum speed)

- (a) Hold the speed control lever at the position for the indicated output and speed (specified for purpose of governor adjustment).
- (b) Under this condition, check to be sure that the engine is running in a steady state.
- (c) With the engine running in a steady condition, adjust the full-load stopper bolt, as follows:
- (d) Reposition the full-load stopper bolt by tightening or loosening (to push or pull out the fuel control rack through the levers) in order to find out just where the engine produces the rated output.



TESTING AND ADJUSTING

- (e) Having positioned the stopper bolt properly (for the rated output), back it off slowly while observing the speed (which will be above the rated speed). Stop backing it off just when the speed begins to fall from the rated level. Secure the stopper bolt (rack set bolt) in that position with its lock nut.
 - (f) At that time, the speed control lever should be at the maximum speed side.
 - (g) Turning the full-load stopper bolt clockwise will increase the injection quantity (engine output), and vice versa.
- (4) Governor setting (setting for limiting the maximum engine speed)
- (a) Hold the speed control lever at the indicated maximum speed position while applying full load to the engine.
 - (b) Set the governor set bolt ④ (maximum speed set bolt) at the indicated speed position.



(5) Determining the speed regulation (speed droop)

[1] Speed regulation upon removing load

- (a) Run the engine with the speed control lever set for the rated condition of load and speed.
- (b) With the control lever held there, remove the load to bring the engine into no-load condition. Do not move the speed control lever.
- (c) The speed will increase once and decrease, as shown and settle at a new steady state level. Read the highest speed (N_2) occurring in this transition and the speed (N_3) after setting, and the time (t_1) from the moment of removing the load at initial speed (N_1) to the speed settling at the new level (N_3).

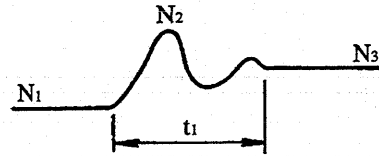
[2] Speed regulation upon applying load

With the engine running in no-load condition, apply specified load momentarily, and record the peak engine speed, the engine speed after settling, and the time from the moment of load application to the time the speed settles.

[3] Computing the speed regulation

From the values obtained above, compute the speed regulation for each load change. If the computed values are at variance with the prescribed values, "governor notch adjustment" must be made to eliminate the variance.

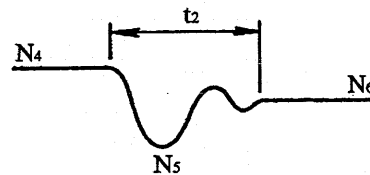
Speed regulation upon removing load



Instantaneous speed regulation (%)	Steady-state speed regulation (%)
$\frac{N_2 - N_1}{N_1} \times 100$	$\frac{N_3 - N_1}{N_1} \times 100$

- N_1 = initial speed, rpm, before load is removed
- N_2 = highest speed, rpm, during transitional period
- N_3 = speed, rpm, at which the engine settles after load is removed
- t_1 = stabilization time

Speed regulation upon applying load



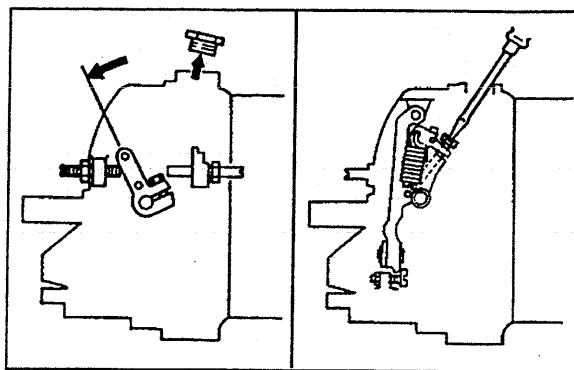
Instantaneous speed regulation (%)	Steady-state speed regulation (%)
$\frac{N_4 - N_5}{N_4} \times 100$	$\frac{N_4 - N_6}{N_4} \times 100$

- N_4 = initial speed, rpm, before load is applied
- N_5 = lowest speed, rpm, during transitional period
- N_6 = speed, rpm, at which the engine settles after load is applied
- t_2 = stabilization time

TESTING AND ADJUSTING

(6) Speed regulation adjustment (governor notch adjustment)

- (a) This adjustment is to be made by turning the adjusting screw for swivel lever to increase or decrease the preload of governor spring.
- (b) To gain access to the adjusting screw, remove the plug at the top of governor housing, and turn the speed control lever all the way to the low idling set bolt: this will turn up the swivel lever, pointing the head of the adjusting screw toward the plug hole. Insert a flat-tip screwdriver through the hole to catch the screw head.
- (c) Tightening the adjusting screw increases the preload of governor spring to narrow the speed regulation; loosening it decreases the governor spring preload to widen the regulation. One notch corresponds to 1/4 turn of adjusting screw and to 3 to 5 rpm change of engine speed.
- (d) Changing the setting of this adjusting screw changes the governor setting (for limiting the maximum engine speed). After making a governor notch adjustment, be sure to readjust the governor setting.
- (e) Tightening the adjusting screw, mentioned above, will increase the maximum speed, and vice versa.



CAUTION

The adjustable range is 20/notch (5 rotations) long. Never loosen the screw by more than 20 notches from the fully tightened position or the control action of the governor will become hazardous.

(7) Sealing

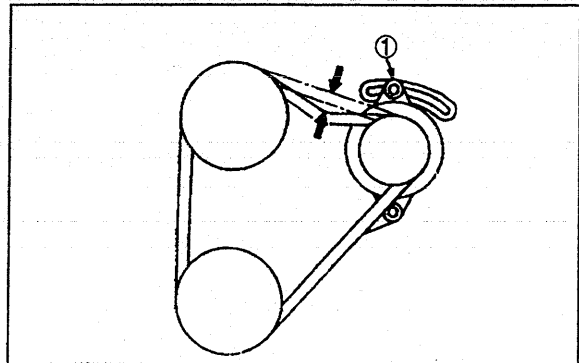
Seal each set bolt.

1.5 Fan drive belt inspection and adjustment

Apply thumb pressure to the belt midway between the pulleys to inspect the belt tension. If the tension is incorrect, make an adjustment by means of bolts (1).

Unit : mm (in.)

Item	Assembly standard
Fan drive belt tension (deflection)	12 (0.5), approx.



2. BENCH TEST

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

2.1 Starting up

- (1) Check the fluid levels in the radiator, oil pan and fuel tank. Bleed the fuel and cooling systems.
- (2) 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.
- (3) 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.)
- (4) After the engine starts, allow it to idle by operating the speed control lever.

2.2 Inspection after starting up

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

- (1) Lube oil pressure — Should be 2 to 4 kgf/cm² (28 to 57 psi) [0.2 to 0.4 MPa] when the engine is running at rated speed. It should be 1 kgf/cm² (14.2 psi) [0.1 MPa] when the engine is running at low idle speed.
- (2) Coolant temperature — Should be 75°C to 85°C (167°F to 185°F).
- (3) Lube oil temperature — Should be 70°C to 90°C (158°F to 194°F).

- (4) Oil, coolant or fuel leaks.
- (5) Knocking — Should die away as the coolant temperature increases. No other defects should be noted.
- (6) Abnormal exhaust smoke and smell.

2.3 Bench test (dynamometer test) conditions

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

2.4 Inspection and adjustment after bench test

- (1) Adjust the valve clearance.
- (2) Check and adjust the injection timing.
- (3) Check under and around the engine for loose bolts or nuts.

3. PERFORMANCE TESTS

There are various testing methods to evaluate the performance of an engine. The following describes the diesel engine performance test method [JIS D1005 (1986)]. Other test items must also be added according to the particular use of the engine. Evaluate all test results to determine the performance level of the engine.

3.1 Standard equipment

The engine should be equipped with fan, air cleaner and alternator.

3.2 Test items

- (1) Fuel consumption test
- (2) No-load maximum speed test
- (3) No-load minimum speed test

3.3 Test methods

- (1) Fuel consumption test
 - (a) Speed (rpm)
 - (b) Fuel injection quantity
 - (c) Output
- (2) No-load maximum speed test
- (3) No-load minimum speed test

For this test, the governor must be set for no-load maximum speed.

- (a) The speed control lever must be set for stable minimum speed. By "stable minimum speed" is meant a minimum level to which the engine speed can be quickly dropped from the maximum level without stalling.
- (b) Specified no-load minimum speed
- (4) Others

During the performance tests, check for gas, coolant or oil leaks, abnormal sound and hunting.

(5) Engine output correction calculation

The output of a diesel engine varies depending on atmospheric pressure, temperature and humidity. Therefore, it is necessary to correct the measured output values to obtain output performance values under the standard ambient conditions (atmospheric pressure: 750 mmHg, temperature: 25°C, atmospheric steam partial pressure: 11.4 mmHg).

Use the correction coefficients obtained from the following equations to convert the measured shaft output and torque values.

$$k = \left\{ \left(\frac{P_0}{P} \right) \cdot \left(\frac{\theta}{\theta_0} \right)^{0.7} \right\}^{fm} \quad (\text{natural aspiration engine})$$

$$k = \left\{ \left(\frac{P_0}{P} \right)^{0.7} \cdot \left(\frac{\theta}{\theta_0} \right)^{1.5} \right\}^{fm'} \quad (\text{turbocharged engine})$$

P_0 : Measured atmospheric pressure (mmHg)

P : Standard dry atmospheric pressure (743 mmHg, 99 kPa)

θ : Measured temperature (°C +273)

θ_0 : Standard air temperature (298 K, 25°C)

fm, fm' : air/fuel consumption coefficients

$$fm = 0.036 \frac{q}{r} - 1.14 \quad (40 \leq \frac{q}{r} \leq 65)$$

$$= 0.3 \left(\frac{q}{r} \leq 40 \right)$$

$$= 1.2 \left(65 \leq \frac{q}{r} \right)$$

q : Amount of fuel supply per 1 liter of cylinder volume and per 1 cycle (mg/l cycle)

r : Compression ratio of turbocharger ($r = 1$ for natural aspiration)

Application range of k shall be

$$600 \leq p \leq 825 \text{ mmHg } \{ 80 \leq p \leq 110 \text{ KPa} \}$$

$$10 \leq \theta - 273 \leq 40^\circ\text{C } \{ 283 \leq \theta \leq 313 \text{ K} \}$$

and k shall also be $0.9 \leq k \leq 1.1$. When k is not within the range and also when p and θ are within the limit range, indicate the values converted by using the correction coefficients and record the test conditions on the test record sheet.

ENGINE ACCESSORY REMOVAL AND INSTALLATION

1. PREPARATORY STEPS	6-2
2. ENGINE ACCESSORY REMOVAL	6-2
3. ENGINE ACCESSORY INSTALLATION	6-7



ENGINE ACCESSORY REMOVAL AND INSTALLATION

This section explains the procedures and suggestions for removal and installation of the accessories - the preparatory steps to go through for overhauling the engine.

1. PREPARATORY STEPS

- (a) Shut off fuel supply, and disconnect the starting system from the engine.
- (b) Loosen the drain cock, on the left rear side of crankcase, and drain coolant.
- (c) Loosen the oil pan drain plug, and drain engine oil.

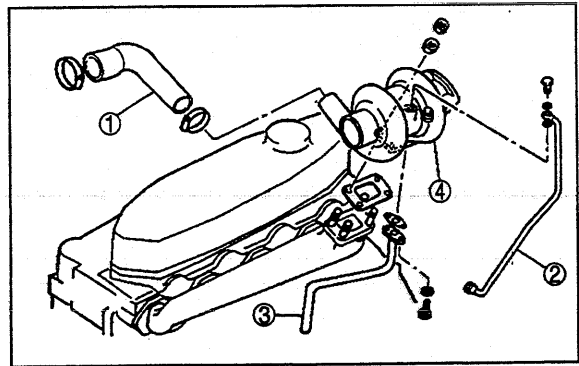
WARNING

Hot engine oil can cause personal injury if it contacts the skin. Use caution when draining the oil.

2. ENGINE ACCESSORY REMOVAL

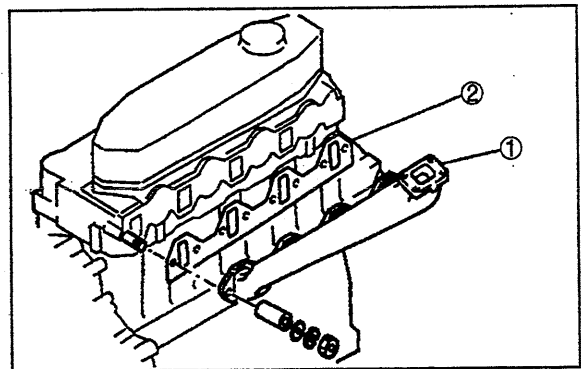
(1) Removing turbocharger [turbocharged engines]

- (a) Disconnect pipe ① between the turbocharger and inlet manifold.
- (b) Disconnect turbocharger lubricating oil pipe ② and drain pipe ③.
- (c) Remove turbocharger ④ from the exhaust manifold.



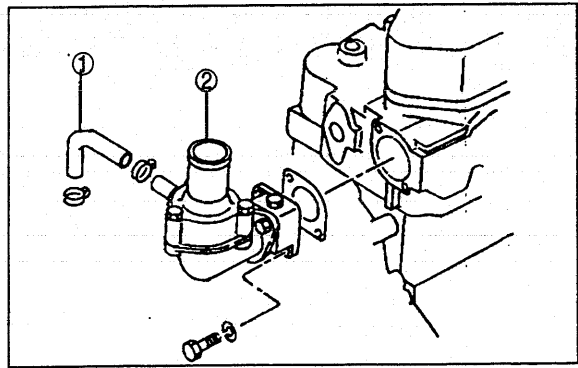
(2) Removing exhaust manifold

Unscrew bolts securing exhaust manifold ①, and remove the manifold and gasket ②.



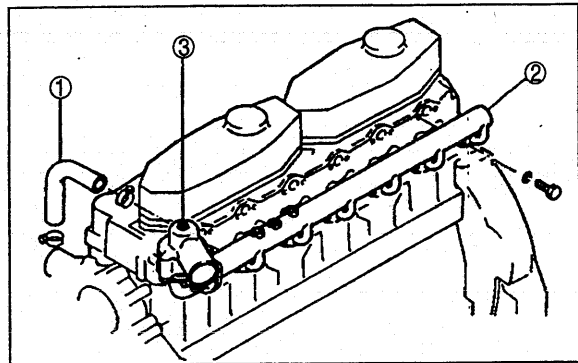
(3) Removing thermostat (S4K, S4K-T)

- (a) Disconnect water bypass hose ①.
- (b) Remove thermostat case ②.



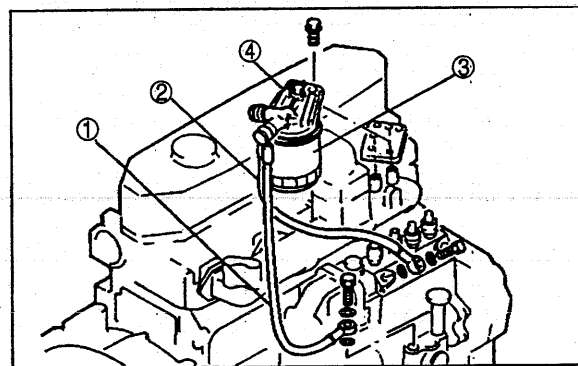
(4) Removing water outlet pipe and thermostat (S6K, S6K-T)

- (a) Disconnect water bypass hose ①.
- (b) Remove water outlet pipe ② and thermostat case ③ as an assembly.



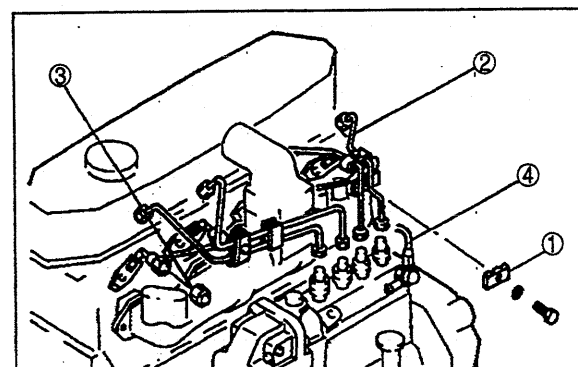
(5) Removing fuel filter

- (a) Disconnect fuel pipes ① and ②.
- (b) Remove fuel filter ③ and bracket ④ as an assembly.



(6) Removing fuel injection pipes

- (a) Remove pipe clamp ①, and disconnect injection pipes ②.
- (b) Unscrew lock nut ③, and remove leak-off pipe ④.



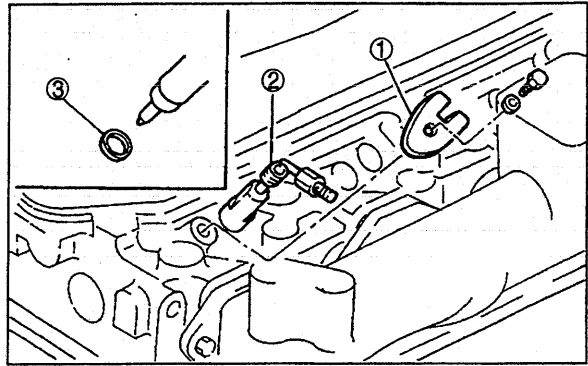
CAUTION

Be sure to fit rubber caps to the openings of the injection pumps and nozzle holders to prevent dust from getting inside the fuel system.

ENGINE ACCESSORY REMOVAL AND INSTALLATION

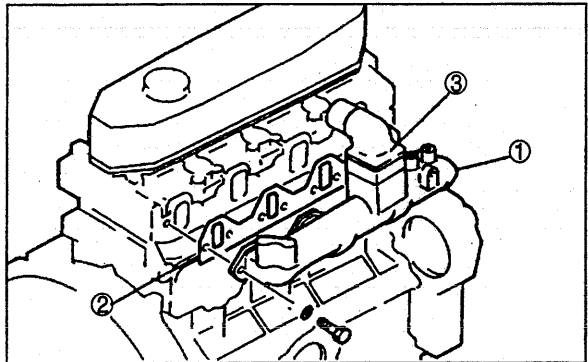
(7) Removing fuel injection nozzle

Take off nozzle gland ①, and remove injection nozzle ② and gasket ③.



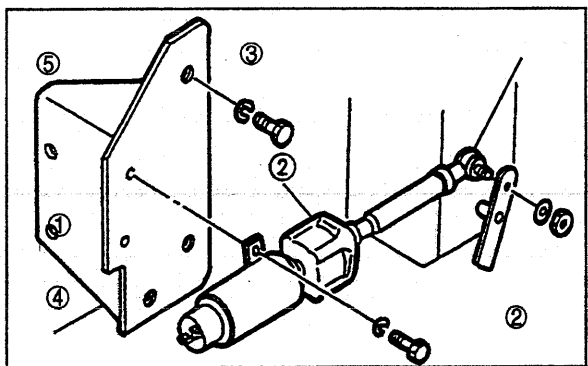
(8) Removing inlet manifold and air heater

Unscrew the bolts securing inlet manifold ①, and remove the manifold and gasket ② complete with air heater ③.



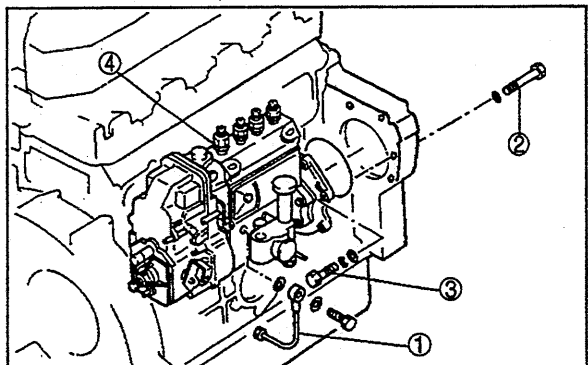
(9) Removing stop solenoid (for engine equipped with stop solenoid)

- (a) Disconnect the governor stop lever and rod ①.
- (b) Remove the mounting bolt, and dismount stop solenoid ②.
- (c) Remove bracket ③.



(10) Removing fuel injection pump

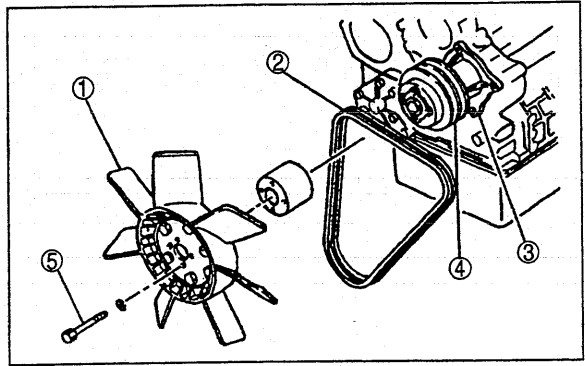
- (a) Disconnect oil pipe ①, and remove cover ②.
- (b) Unscrew bolts ③, and remove injection pump ④ complete with gear and mounting flange from the front plate.



ENGINE ACCESSORY REMOVAL AND INSTALLATION

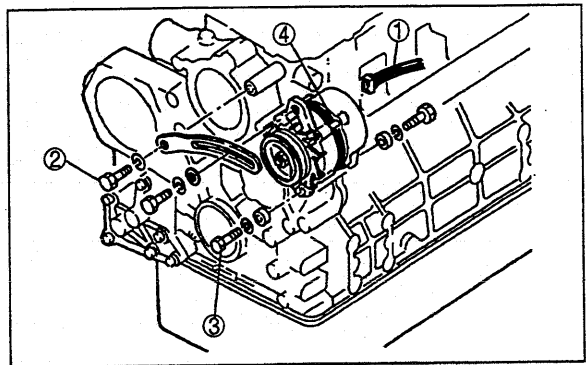
(11) Removing fan and water pump.

- (a) Remove fan mounting bolt ① and fan ②.
- (b) Loosen the alternator holding bolt and adjusting plate holding bolt, then remove fan belt ③.
- (c) Remove the mounting bolts of pulley ④, and remove the pulley.
- (d) Remove the mounting bolts of water pump ⑤, and dismount the water pump.



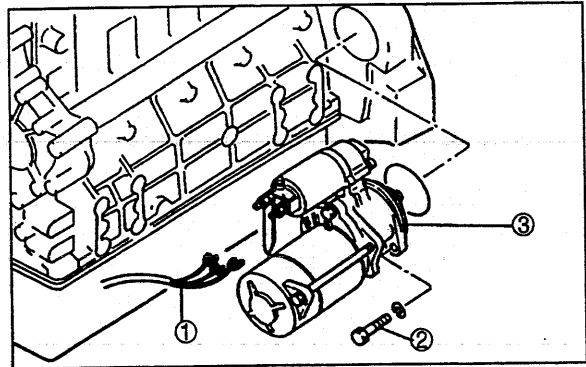
(12) Removing alternator

- (a) Disconnect harness ①, and unscrew bolt ② securing the belt adjusting plate.
- (b) Unscrew bolts ③, and remove alternator ④.



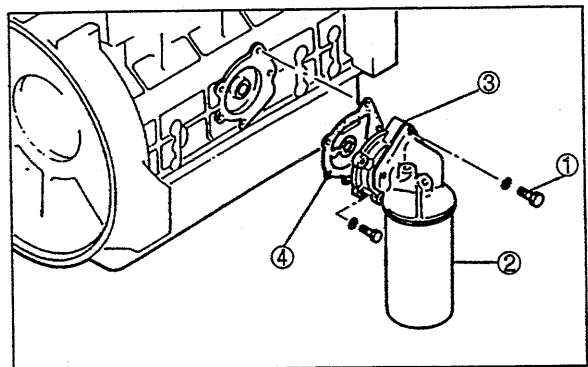
(13) Removing starter

- (a) Disconnect harness ①. Unscrew nuts ②, and remove starter ③.



(14) Removing oil filter

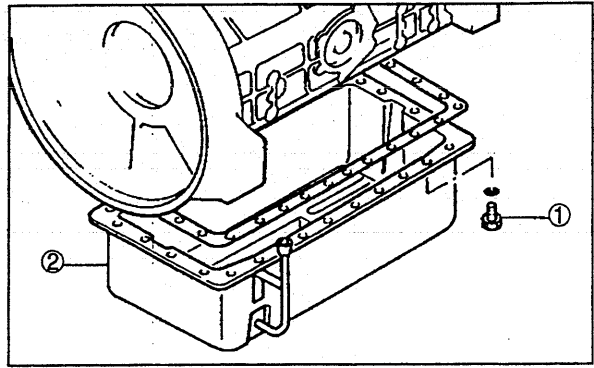
- Unscrew bolts ①, and remove oil filter ② and filter bracket ③ with gasket ④.



ENGINE ACCESSORY REMOVAL AND INSTALLATION

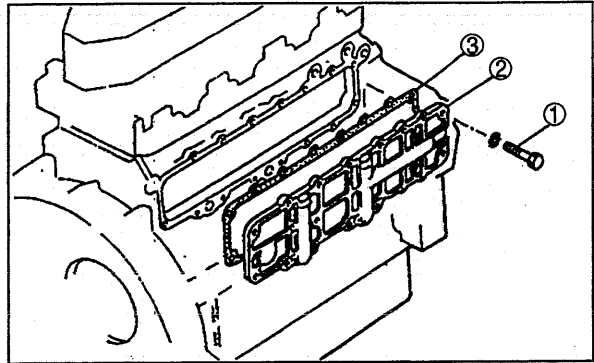
(15) Removing oil pan

Unscrew bolts ①, and remove oil pan ②.



(16) Removing oil cooler

Unscrew bolts ①, and remove the oil cooler attached to cover ②. Remove gasket ③.

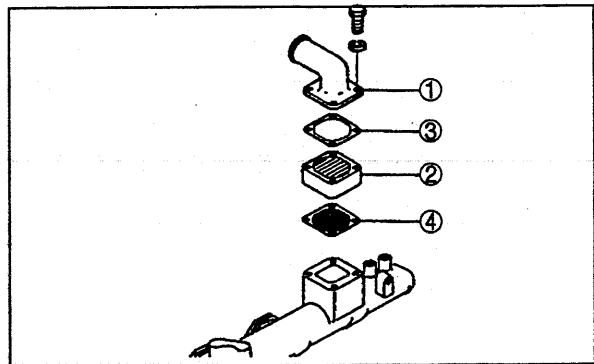


(17) Removing air heater

Unscrew the bolts securing air inlet elbow ①, and remove the elbow, air heater ② and gaskets ③ ④.

NOTE

When installing gaskets ③ and ④, make sure gasket ④ faces the manifold.

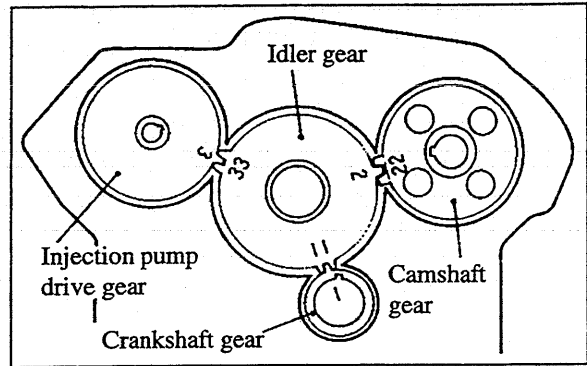


3. ENGINE ACCESSORY INSTALLATION

To install the accessories, follow the reverse of removal procedure, and take the following steps:

(a) Installing fuel injection pump

When installing the pump, make sure that matching marks on pump drive gear and other gears are aligned with those on idler gear respectively, as shown.



Matching marks on timing gears

NOTE

With these matching marks are all aligned, No. 1 cylinder piston is at top dead center on compression stroke.

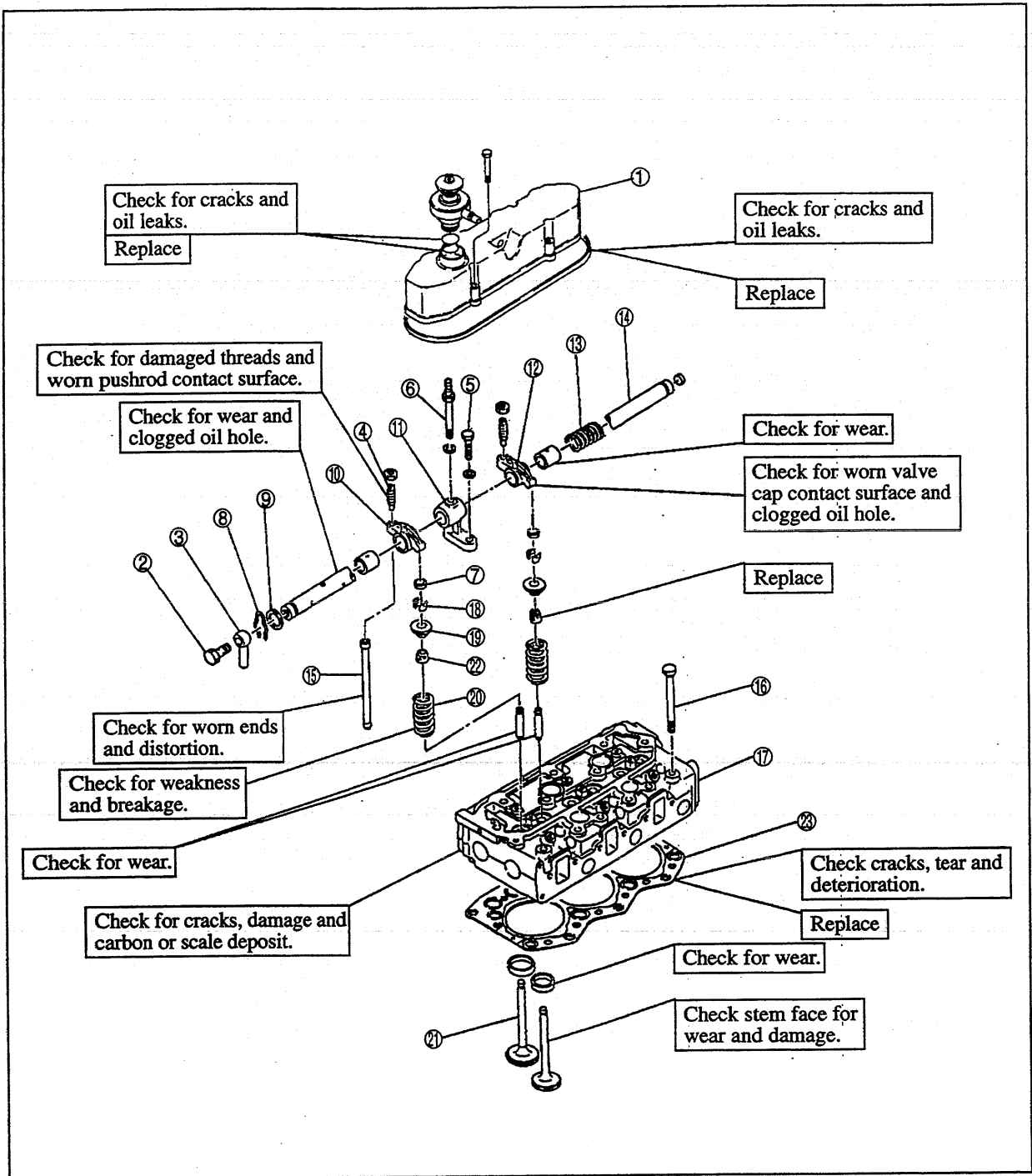
- (b) Refill the engine with recommended oil up to the specified level.
- (c) Refill the cooling system with coolant.
- (d) Check each pipe connection for oil or coolant leaks.
- (e) Prime the fuel system.
- (f) After installing the fuel injection pumps, inspect and adjust the injection timing. (Refer to 1.3, Group No. 5.)

ENGINE PROPER

1. CYLINDER HEADS AND VALVE MECHANISM	7- 2
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2. FLYWHEEL, TIMING GEARS AND CAMSHAFT	7-13
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3. PISTONS, CONNECTING RODS, CRANKSHAFT AND CRANKCASE	7-25
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1. CYLINDER HEADS AND VALVE MECHANISM

1.1 Disassembly



- ① Rocker cover
- ② Eye bolt
- ③ Oil pipe
- ④ Adjusting screw
- ⑤ Bolt (short)
- ⑥ Bolt (long)
- ⑦ Valve cap
- ⑧ Snap ring

- ⑨ Washer
- ⑩ Inlet rocker arm
- ⑪ Rocker shaft bracket
- ⑫ Exhaust rocker arm
- ⑬ Rocker shaft
- ⑭ Rocker shaft spring
- ⑮ Valve pushrod
- ⑯ Cylinder head bolt

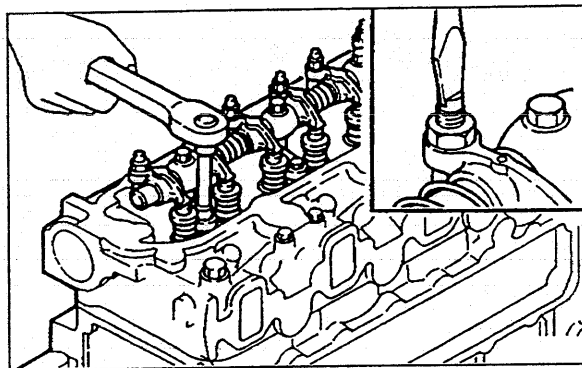
- ⑰ Cylinder head
- ⑱ Valve cotter
- ⑲ Valve retainer
- ⑳ Valve spring
- ㉑ Valve
- ㉒ Valve stem seal
- ㉓ Cylinder head gasket

(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.

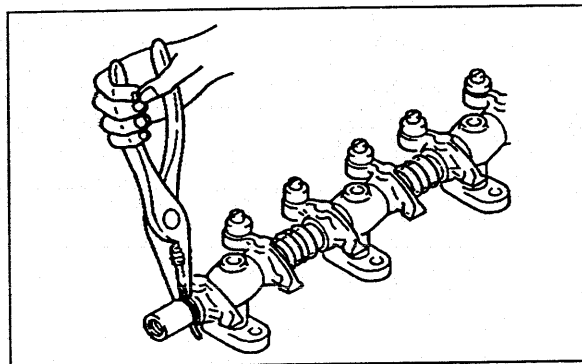
CAUTION

If the long bolt is loosened first, the rocker shaft bracket might suffer damage.



(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 the time of assembly.

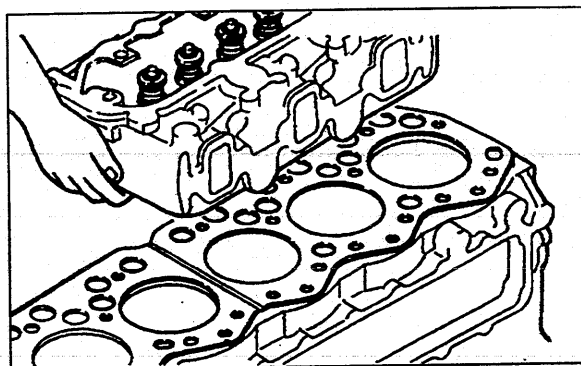


(3) Removing cylinder head

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

NOTE

- (a) When removing the gasket from the crankcase, be careful not to damage the mounting face of crankcase.
- (b) If any parts of the cylinder head are faulty, check the cylinder head bolts for torque with a torque wrench before removing them.

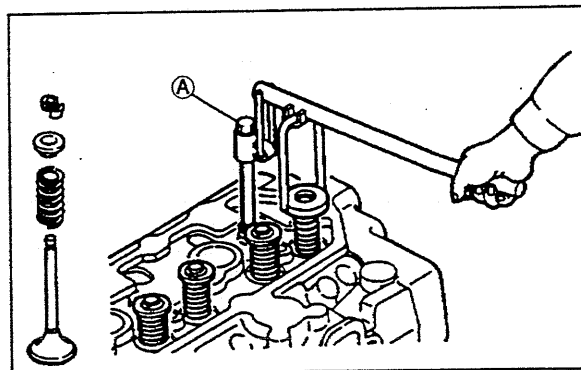


(4) Removing valves and valve springs

Compress the valve spring squarely with valve spring pusher (A) (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 to aid installation at the time of reassembly.



1.2 Inspection and repair

Rocker arms, rocker bushings and rocker shafts

(1) Measuring inside diameter rocker of arm bushing and diameter of rocker shaft

Measure the inside diameter of the rocker bushings and the diameter of the rocker shaft, as shown in the illustration, to check the clearance between the rocker bushing and shaft. If the clearance is not correct, within the repair limit, replace the rocker bushing. If it exceeds the repair limit, replace both rocker shaft and bushing.

Unit: mm (in.)

Item	Nominal Size	Assembly Standard	Repair Limit
Inside diameter of rocker arm bushing)	2.0 (0.79)	20.011 to 20.094 (0.78784 to 0.79110)	—
Diameter of rocker shaft	2.0 (0.79)	19.984 to 19.966 (0.78677 to 0.87606)	—
Clearance between rocker bushing and shaft		0.027 to 0.128 (0.00106 to 0.00504)	0.15 (0.0059)

(2) Replacing rocker arm bushing

When replacing the bushing, align the oil hole of the bushing with the hole on the rocker arm.

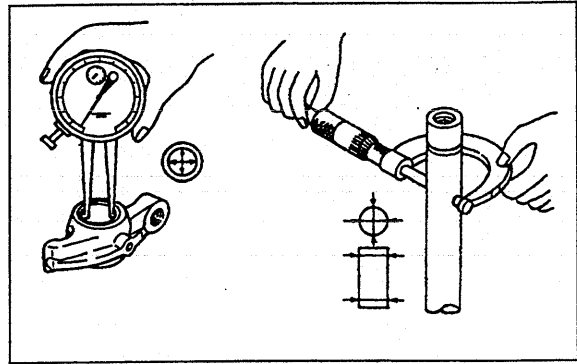
Valves, valve guides and valve seats

(1) Measuring valve stem

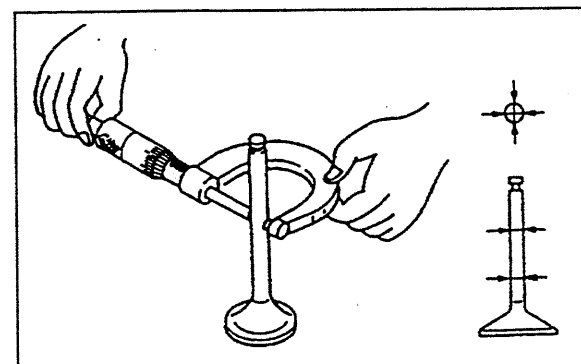
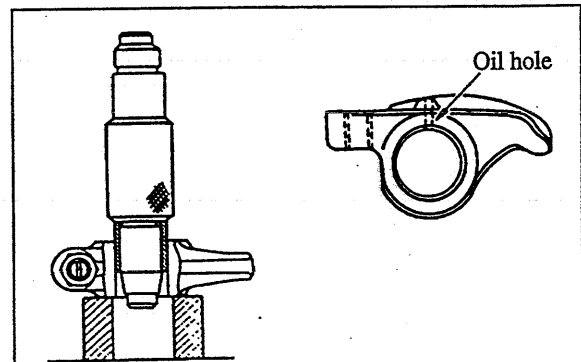
Measure the diameter of the valve stem, as shown in the illustration. If the stem is worn beyond the service limit, replace the valve.

Unit: mm (in.)

Item	Assembly Standard	Service Limit
Diameter of valve stem	Inlet valves 7.940 to 7.955 (0.31260 to 0.31319)	7.900 (0.31102)
	Exhaust valves 7.920 to 7.940 (0.31181 to 0.31260)	7.850 (0.30905)



Measuring rocker bushing and rocker shaft



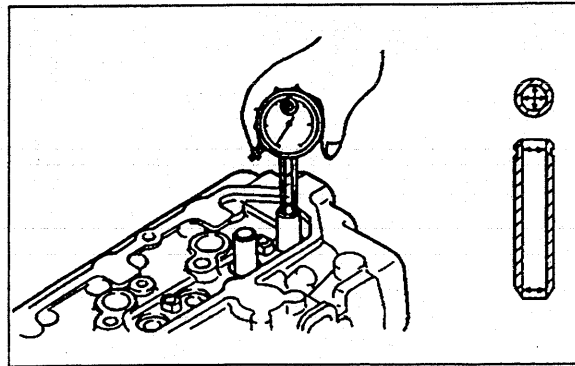
Measuring valve stem

(2) Checking clearance between valve stem and guide

The valve guide wears more rapidly at its both ends than at any other parts. Measure the guide at its ends and in two directions at right angles to each other, to check the clearance. If the clearance exceeds the service limit, replace the guide.

Unit: mm (in.)

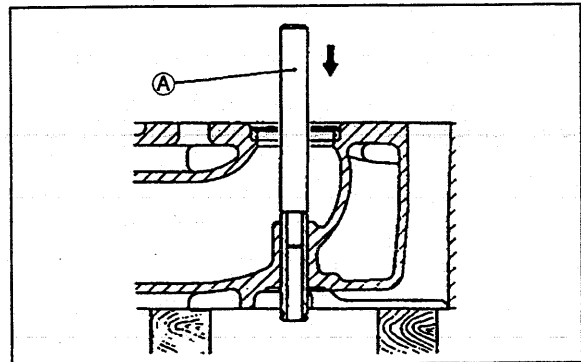
Item		Nominal Size	Assembly Standard	Service Limit
Clearance between valve stem and guide	Inlet valves	ø8	0.055 to 0.085 (0.00217 to 0.00335)	0.150 (0.00591)
	Exhaust valves	ø8	0.070 to 0.105 (0.00276 to 0.00413)	0.200 (0.00787)
Height to top of valve guide		17 (0.67)	±0.3 (±0.012)	—



Measuring valve guide

(3) Replacing valve guides

- (a) To remove the valve guide for replacement, use valve guide remover (A) (31391-10500).

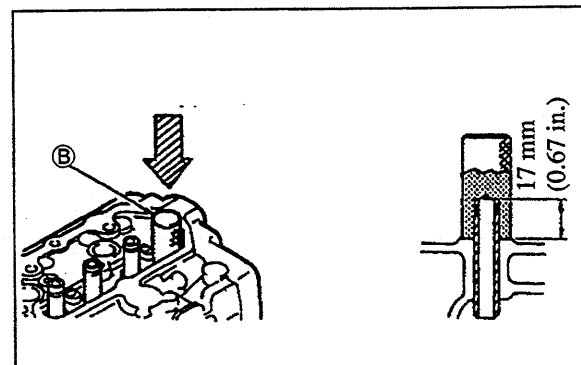


Removing valve guide

- (b) To install a replacement valve guide, use valve guide installer (B) (34491-00400).

CAUTION

The height to top of valve guide is specified; be sure to use the valve guide installer to insure the correct height.

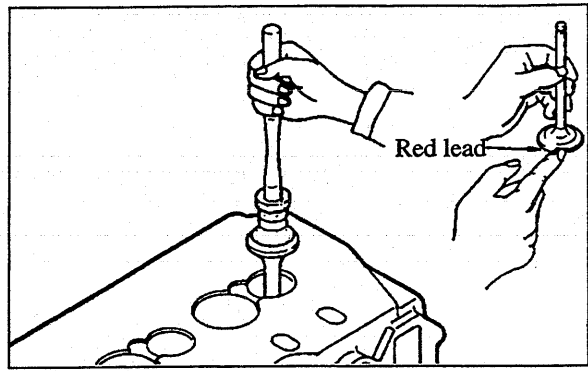


Installing valve guide

ENGINE PROPER

(4) Checking valve face

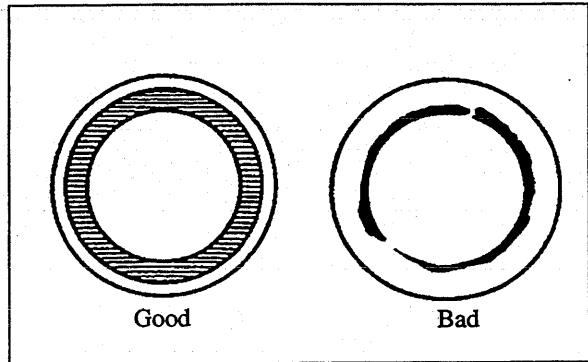
Coat the valve face lightly with red lead and, using a valve lapping tool, check the valve contact with the seat, as shown in the illustration. If the contact is not uniform, repair or replace the valve and valve seat. Check the valve seat angle, valve seat width, valve sinkage and valve margin. If any of these items exceeds the service limit, replace the valve.



Inspecting valve face

NOTE

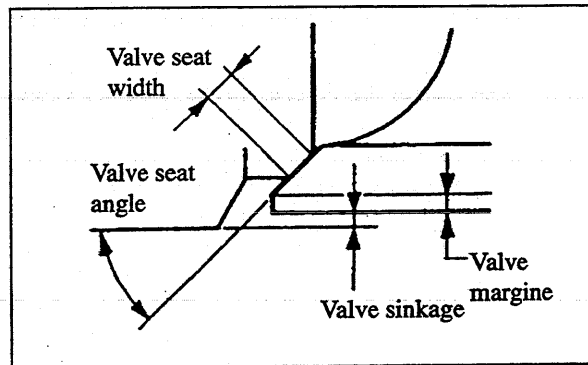
- a) Check the valve contact after checking or replacing the valve guides.
- b) Press the valve coated with red lead into the seat without rotating it.
- c) After refacing or replacing the valve or valve seat, lap the valve in the valve seat. (See Group 1, Section (8) regarding the method of lapping valve in valve seat.)



Valve contact pattern

Unit: mm (in.)

Item		Assembly Standard	Service Limit
Valve seat	Angle	30°	
	Valve sinkage	0.4 ± 0.1 (0.016 ± 0.004) (inlet)	1.1 (0.043)
		0.5 ± 0.1 (0.020 ± 0.004) (exhaust)	
Width	1.4 ± 0.2 (0.055 ± 0.008)	1.8 (0.071)	
Valve margin		2.13 (0.0839)	Up to 1.2 (0.047) by refacing

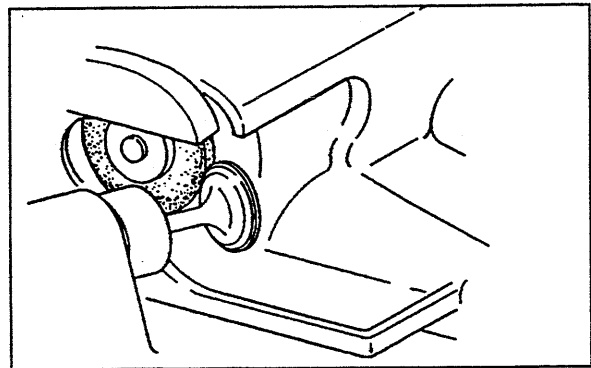


(5) Refacing valve face

If the valve face is badly worn, reface the valve with a valve refacer.

NOTE

- a) Set the valve refacer at an angle of 30°.
- b) The valves have a stellite facing. If the valve margin seems to be less than the service limit, when ground, replace the valve.



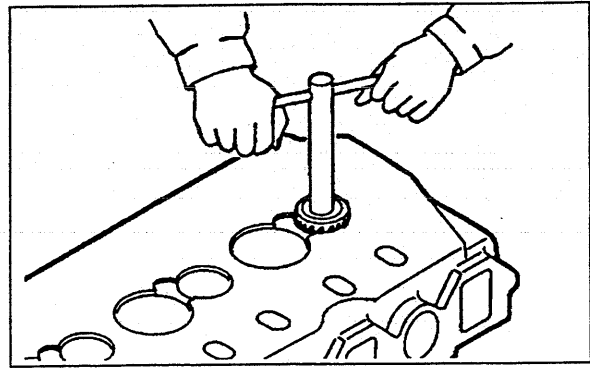
Refacing valve face

(6) Refacing valve seats

Using a valve seat cutter or a valve seat grinder, cut the valve seat. After cutting, grind the seat with a sandpaper of #400 grade or so inserted between the cutter and valve seat.

NOTE

- a) Do not cut or grind the valve seat more than is necessary for refacing.
- b) If the seat width seems to be greater than the service limit when refaced, replace the valve seat.



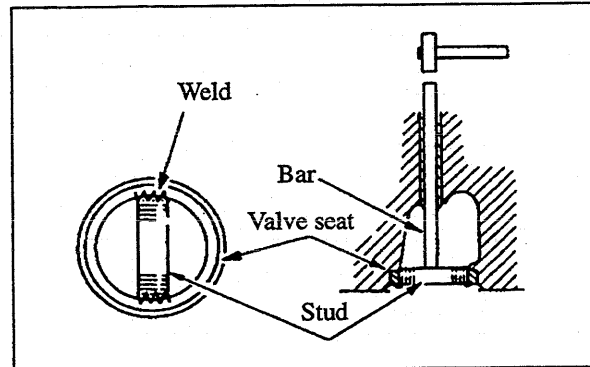
Refacing valve seat

(7) Replacing valve seats

- (a) Weld a stud or bar to the valve seat. Insert a bar through 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.

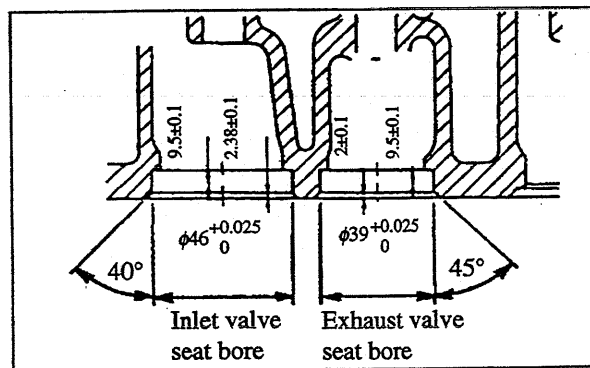
NOTE

When welding the stud to the valve seat, avoid contact of any spatter with the machined surface 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 make sure they are correct in dimension.

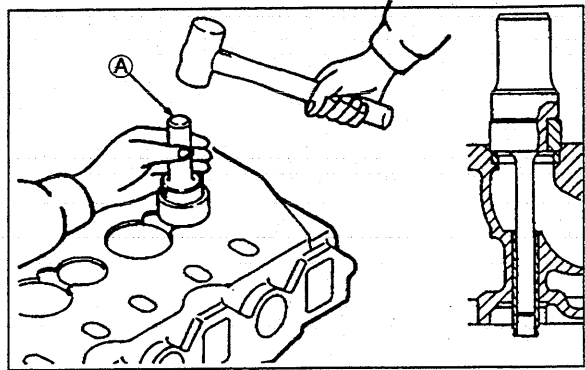


Valve seat bore dimensions

ENGINE PROPER

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

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



Installing valve seat

Tools needed

Applicable model	Part number
Caulking tool (for inlet valve seat)	36791-00200
Caulking tool (for exhaust valve seat)	36791-00300

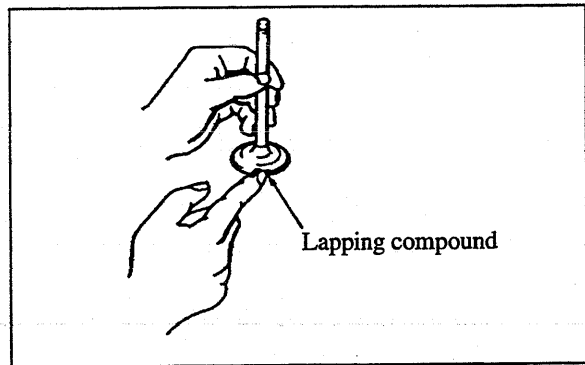
(8) Lapping valves

After refacing or replacing the valves and/or valve seats, be sure to lap the valve in the valve seat.

- (a) Put a small amount of lapping compound on the valve face.

NOTE

- a) Do not put the lapping compound on the valve stem.
- b) Use a compound of 120 to 150 mesh for initial lapping and a compound of finer than 200 mesh for finish lapping.
- c) Mixing the compound with a small amount of engine oil will facilitate putting the compound on the valve face.



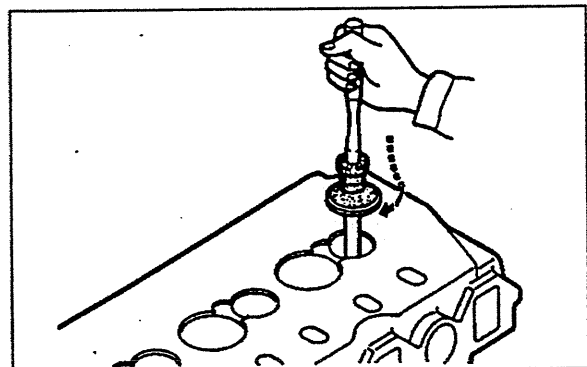
Coating valve with lapping compound

- (b) Using a lapping tool, hold the valve against the seat and rotate it only a part of a turn, then raise the valve off the seat, rotating it to a new position. Then press the valve against the seat for another part of a turn. Repeat this operation until the compound wears and loses its cutting property.

- (c) Wash the valve and valve seat with dry cleaning solvent.

- (d) Put engine oil on the valve seat and lap the valve in the seat.

- (e) Check the valve face for contact with the seat.



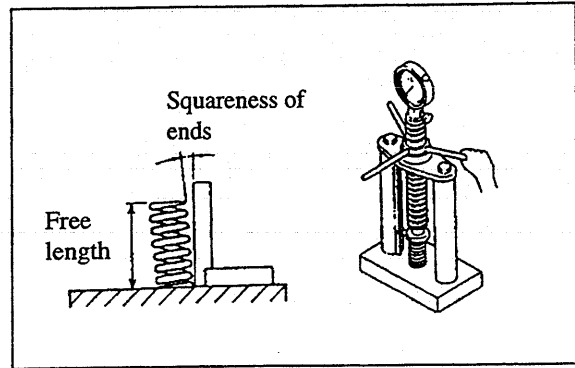
Lapping valve in valve seat

Valve springs

Check the squareness of ends and the free length, as shown in the illustration. If the squareness of ends is not correct, or if the free length is less than the service limit, replace the spring.

Unit: mm (in.)

Item	Assembly Standard	Service Limit
Free length	56.40 (2.2205)	55.00 (2.1654)
Squareness of ends	2°, maximum	—
Length under test force	43 (1.69)	
Test force, kgf (lbf) [N]	22.7 to 25.1 (50.1 to 55.3) [222.6 to 246.1] /44 (1.73)	21.2 (46.7) [208] /44 (1.73)



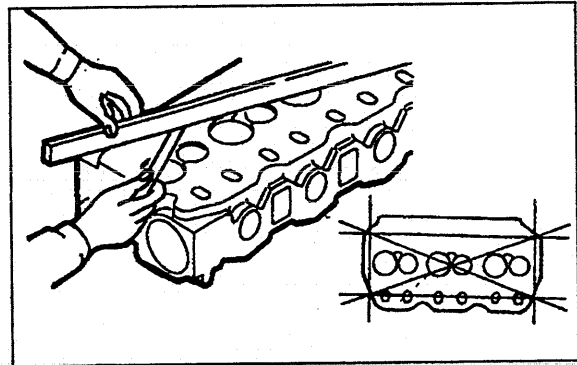
Checking valve spring

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: mm (in.)

Item	Assembly Standard	Repair Limit
Warpage of bottom face	0.05 (0.0020), maximum	0.20 (0.0079)



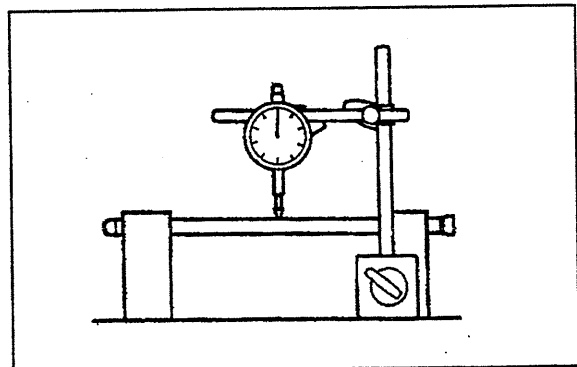
Checking cylinder head for warpage

Valve push rods

Using V-blocks and a dial indicator, check for bending, as shown in the illustration. If bending exceeds the assembly standard, replace the push rod.

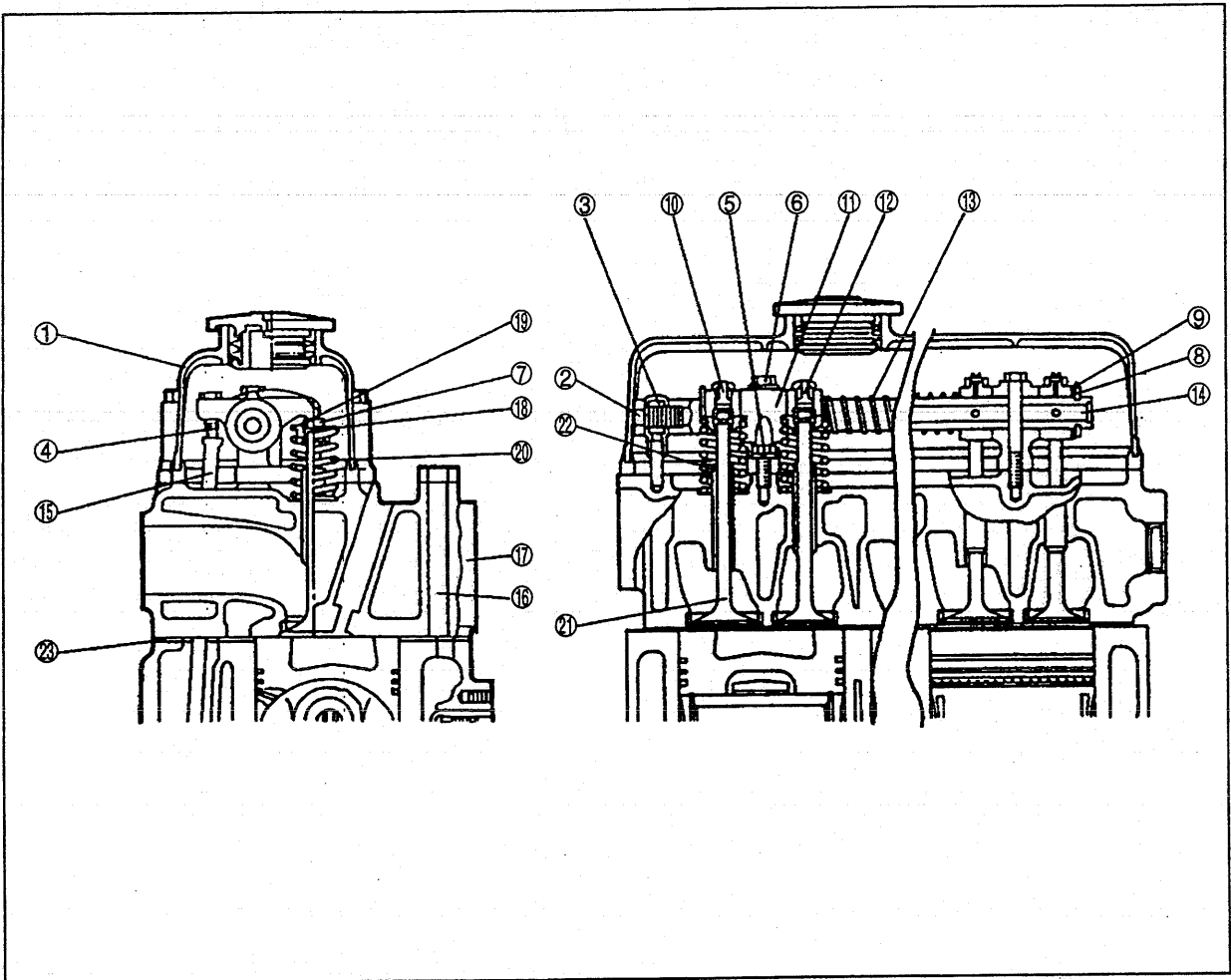
Unit: mm (in.)

Item	Assembly Standard
Bending (dial indicator reading) of valve push rod	0.4 (0.016), maximum

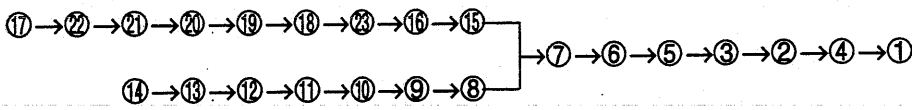


Checking valve push rod

1.3 Reassembly



Reassembling sequence

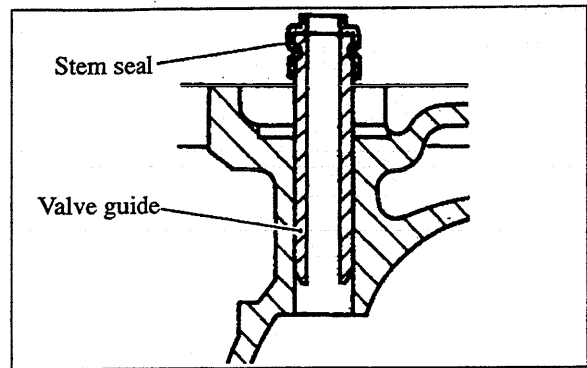


(1) Installing valve stem seals

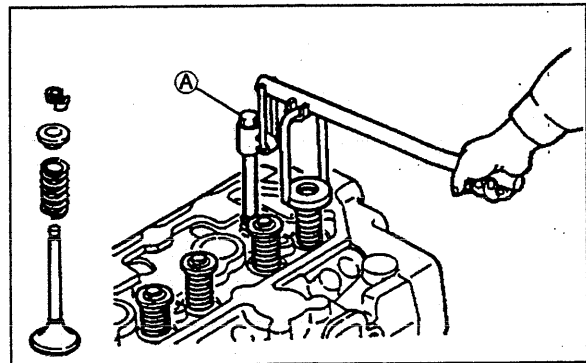
After installing the stem seal to the valve guide, make sure that the seal is properly fitted in the groove of the guide.

CAUTION

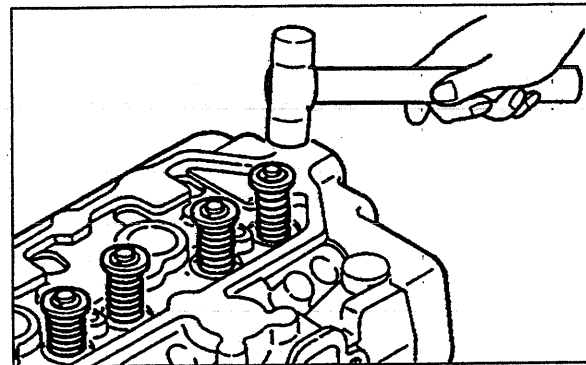
Do not apply any oil or sealant to the mating face of stem seal that comes in contact with the valve guide. When installing the stem seal, coat the seal rubbing surface of the stem with engine oil to insure initial lubrication of the stem lip.

**(2) Installing valves and valve springs**

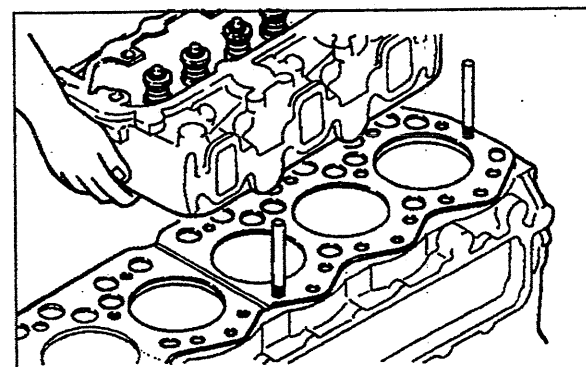
- (a) Put the valve spring and retainer on the valve guide. Using valve spring pusher (A) (30691-04500), compress the valve spring and install the valve cotters to the valve.



- (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.

**(3) Installing cylinder head**

- (a) Screw two guide bolts into the crankcase to hold the gasket in place.
- (b) Place the cylinder head on the crankcase as guided by the two guide bolts. Apply engine oil to the threads of cylinder head bolts, and insert the bolts into the head.

**CAUTION**

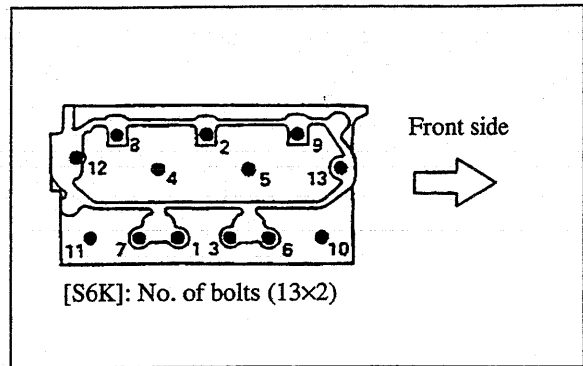
Do not use liquid gasket.
Inspect the upper face of the crankcase to make sure there is no dent.

ENGINE PROPER

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

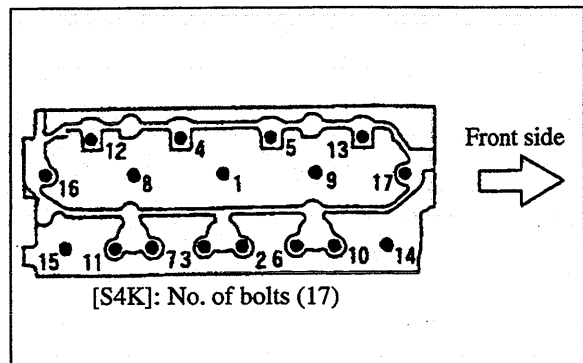
Unit : kgf·m (lbf·ft) [N·m]

Tightening torque	12±0.5 (87±3.6) [118±5]	[Wet]
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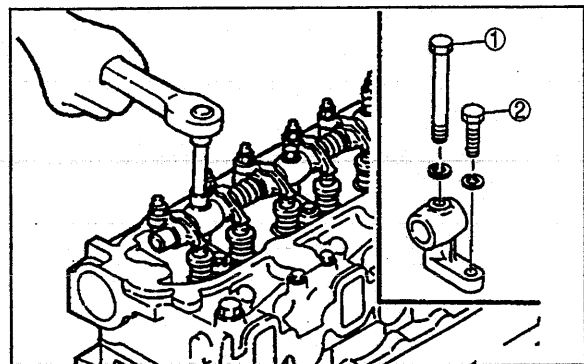
(4) Assembling rocker arms and rocker shafts

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.



(5) Installing rocker shaft assembly

When tightening bolts on the rocker shaft bracket, tighten long bolt ① first, then tighten short bolt ②.

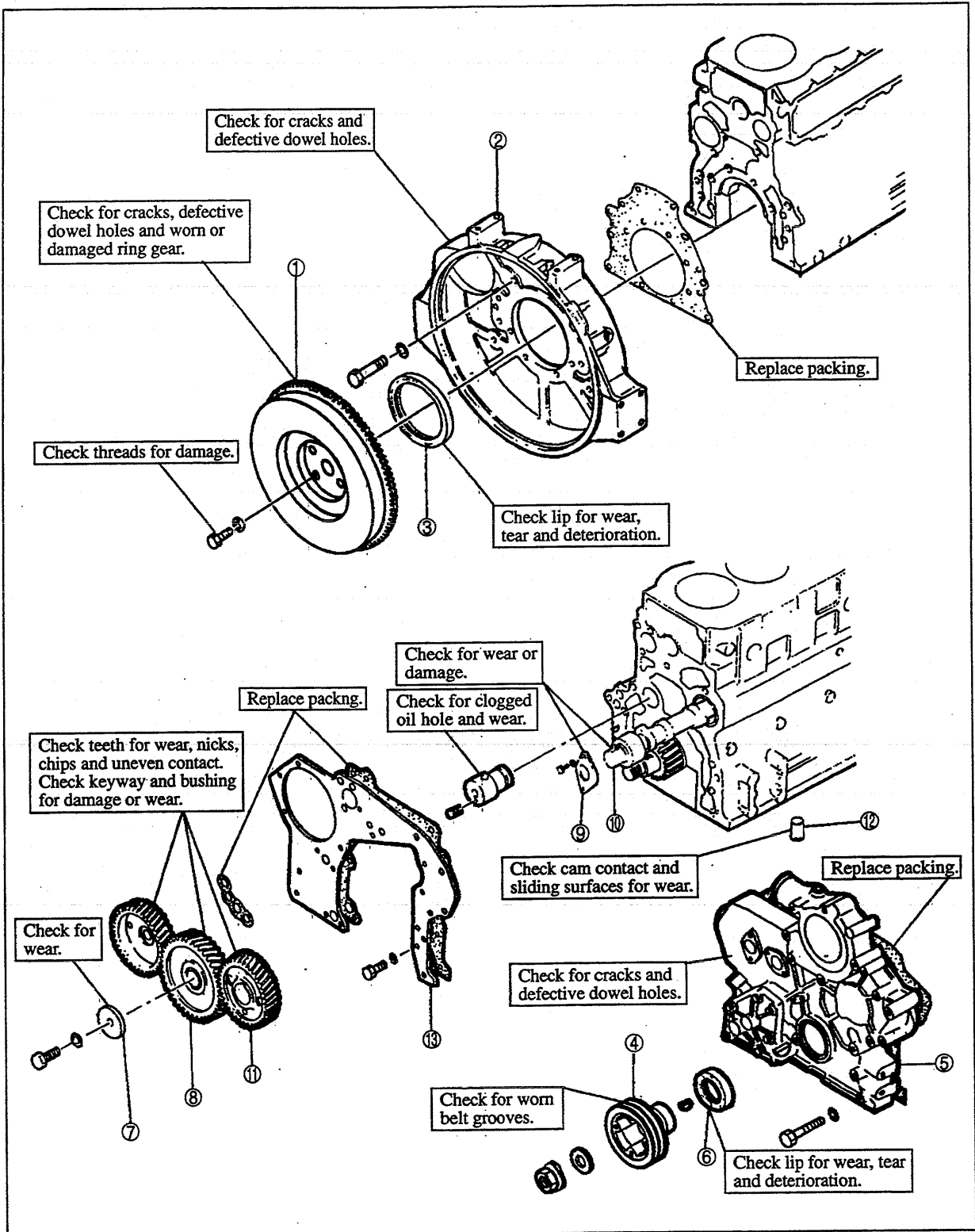


(6) Adjusting valve clearance

Refer to 1.1, Group No. 5.

2. FLYWHEEL, TIMING GEARS AND CAMSHAFT

2.1 Disassembly



- ① Flywheel
- ② Flywheel housing
- ③ Oil seal
- ④ Crankshaft pulley
- ⑤ Timing gear case assembly

- ⑥ Oil seal
- ⑦ Thrust plate
- ⑧ Idler gear
- ⑨ Thrust plate
- ⑩ Camshaft

- ⑪ Camshaft gear
- ⑫ Valve tappet
- ⑬ Front plate

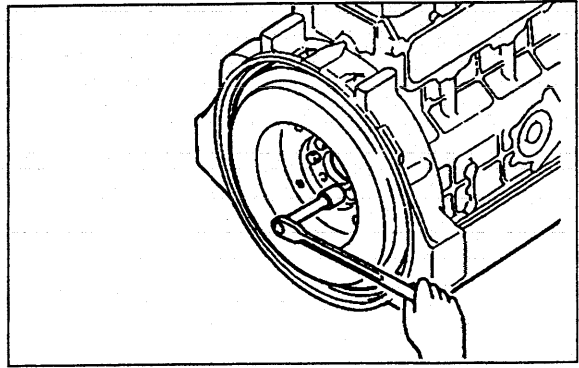
ENGINE PROPER

(1) Removing flywheel

- (a) Unscrew the flywheel mounting bolts.
- (b) Screw the jacking bolts (M10 × 1.5 or M16 × 2) into the holes provided in the flywheel uniformly, and remove the flywheel.

⚠ CAUTION

When removing the flywheel, be careful not to get injured by the ring gear.

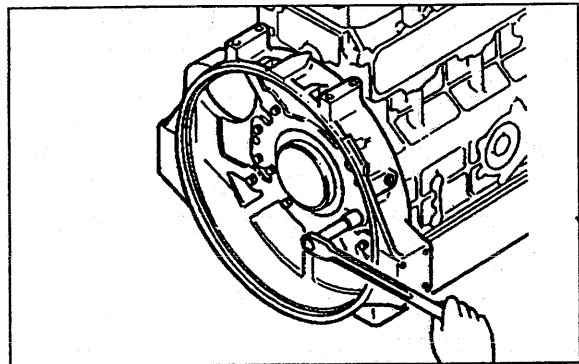


(2) Removing flywheel housing

Unscrew the housing mounting bolts, and remove the housing.

⚠ CAUTION

Oil seals cannot be reused. Be sure to install new oil seals during reassembly.

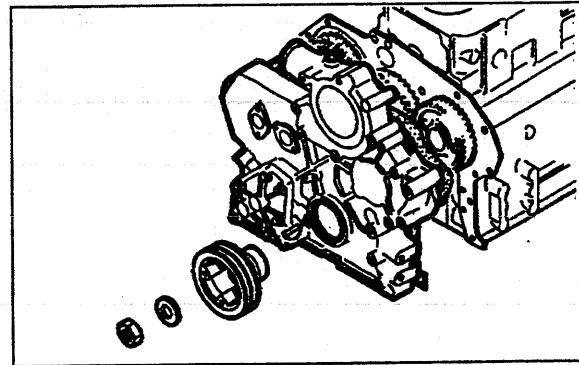


(3) Removing timing gear case assembly

Remove the crankshaft pulley and timing gear case assembly.

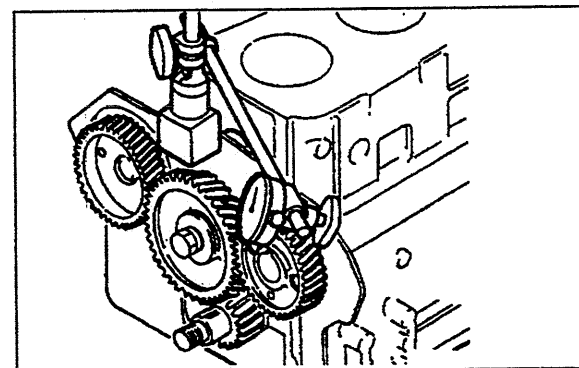
⚠ CAUTION

Take care not to damage the oil pump idler gear and crankshaft gear.



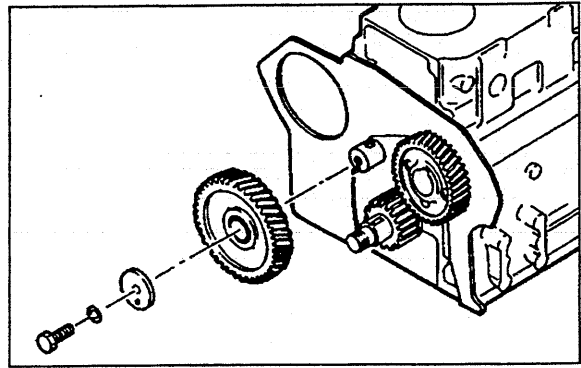
(4) Measuring backlash and end play

Measure the backlash and end play on each gear to obtain the data for parts replacement. (Refer to 2.2, Group No. 7.)



(5) Removing idler gear

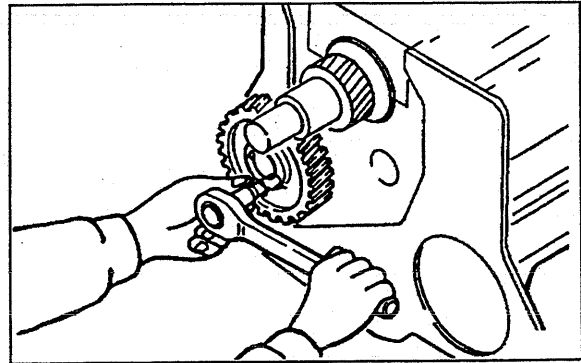
Remove the thrust plate mounting bolt. Remove the idler gear by turning it in the direction of helix of gear teeth.



(6) Removing camshaft

- (a) Turn the crankcase upside down.
- (b) Position the camshaft gear so that its two jacking bolt holes come to top and bottom. Unscrew the thrust plate bolts, and remove the camshaft from the crankcase.

After removing the camshaft, remove the tappets.

**CAUTION**

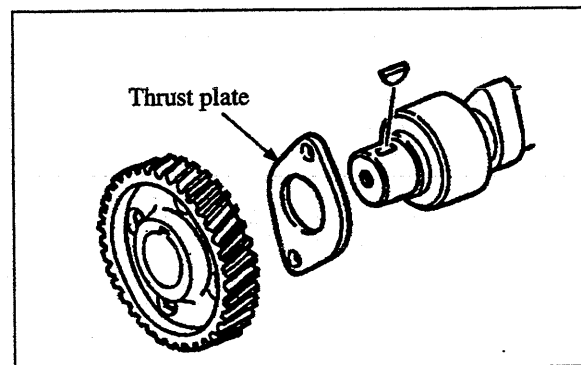
Take care not to damage the cam faces of camshaft and the bushings.

(7) Removing camshaft gear

Using a hydraulic press, remove the gear from the camshaft. Now, the thrust plate can be removed.

NOTE

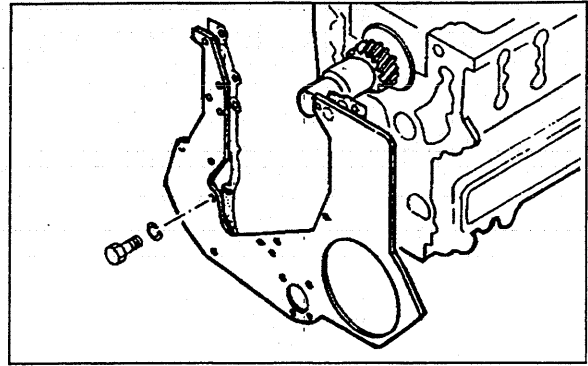
It is not necessary to remove camshaft gear unless camshaft gear and thrust plate is defective.



ENGINE PROPER

(8) Removing front plate

Unscrew the front plate mounting bolt, and remove the plate from the crankcase.



2.2 Inspection and repair

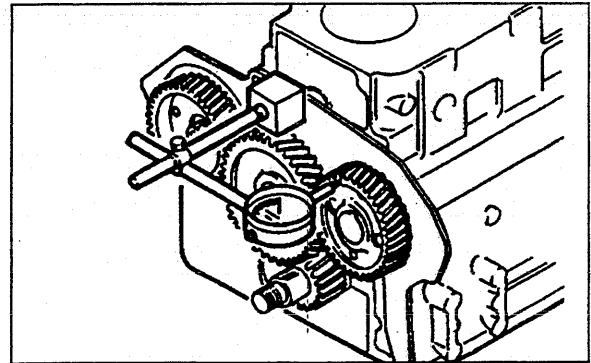
Camshaft and camshaft bushings

(1) Measuring end play of camshaft

If the end play exceeds the Service limit, replace the thrust plate.

Unit: mm (in.)

Item	Assembly Standard	Service Limit
End play of camshaft	0.10 – 0.25 (0.0039 – 0.0098)	0.300 (0.01181)



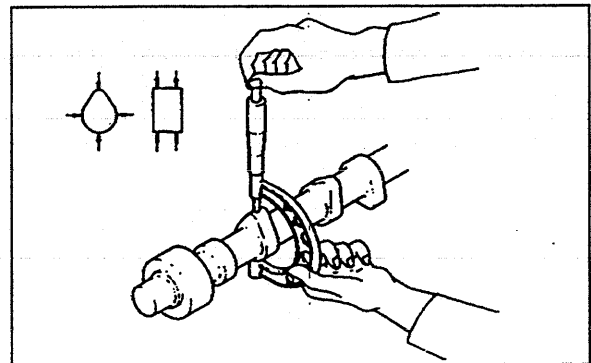
Measuring camshaft end play

(2) Measuring cam profile

Using a micrometer, measure each cam in two directions and at two positions as shown. If the measurement exceeds the Service limit, replace the camshaft.

Unit: mm (in.)

Item		Nominal Value	Assembly Standard	Service Limit
Cam profile	Inlet	D ₁ 46.911 ^{+0.1} _{-0.3} (1.84689 ^{+0.004} _{-0.012})	D ₁ – D ₂ = 6.689 (0.26335)	D ₁ – D ₂ = 6.189 (0.24366)
	Exhaust	D ₁ 46.256 ^{+0.1} _{-0.3} (1.82110 ^{+0.004} _{-0.012})	D ₁ – D ₂ = 7.344 (0.28913)	D ₁ – D ₂ = 6.844 (0.26945)



Measuring cam lift

(3) Measuring runout of camshaft

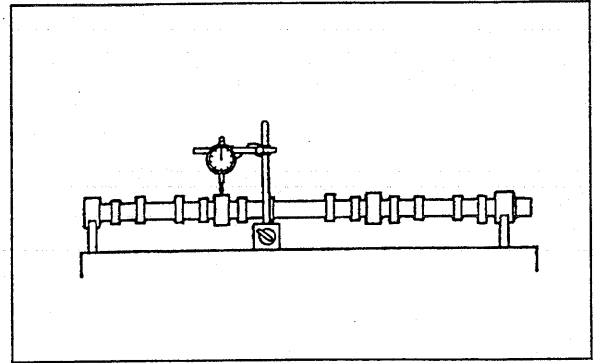
If the runout exceeds the Repair limit, straighten the camshaft by means of a press, or replace it with a new one.

CAUTION

Set up a dial gauge on the camshaft, and turn the camshaft. Take one half (1/2) of the gauge indication as the runout.

Unit mm (in.)

Item	Assembly Standard	Service Limit
Runout of camshaft	0.02 (0.0008), maximum	0.05 (0.0020)



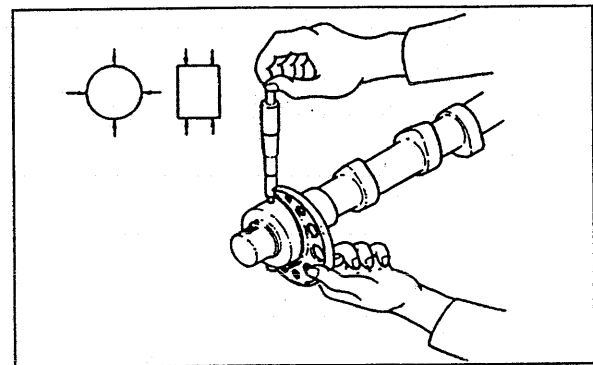
Removing crankshaft pulley

(4) Measuring diameters of camshaft journals

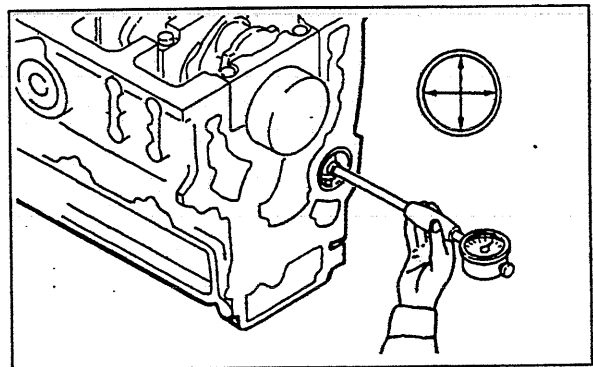
If the journals exceed the Service limit, replace the camshaft bushings.

Unit mm (in.)

Item			Assembly Standard	Service Limit
Diameters of camshaft journals	S4K	No. 1, 2	53.94 – 53.96 (2.1236 – 2.1244)	53.90 (2.1220)
		S4K-T	No. 3	52.94 – 52.96 (2.0842 – 2.0850)
	S6K	No. 1, 2, 3	53.94 – 53.96 (2.1236 – 2.1244)	53.90 (2.1220)
		S6K-T	No. 4	52.94 – 52.96 (2.0842 – 2.0850)
Camshaft journal clearance in bushing			0.04 – 0.09 (0.0016 – 0.0035)	0.15 (0.0059) (Repair limit)



Measuring camshaft journal diameter

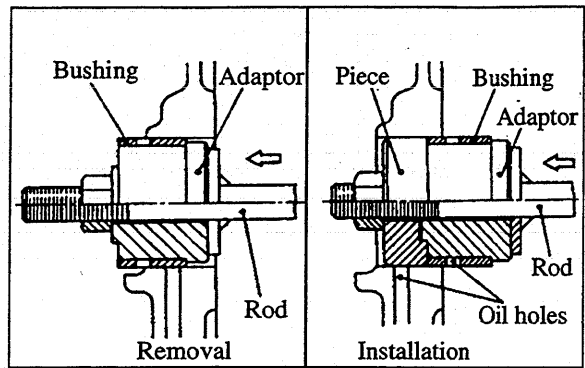


Measuring camshaft bushing inside diameter

ENGINE PROPER

(5) Replacing camshaft bushings

- (a) To replace the bushings, use camshaft bushing installer set (30691-00010).
- (b) To install replacement bushings, align their oil holes with those from oil gallery and drive the bushings in.

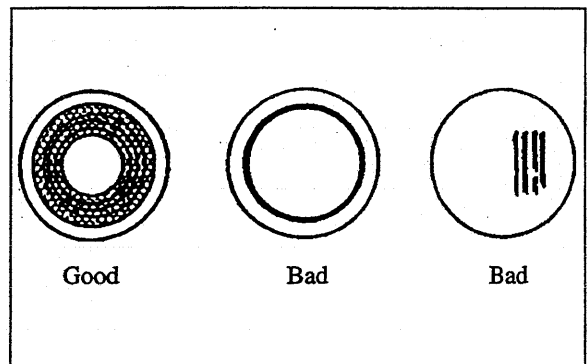


Replacing camshaft bushing

Valve tappets

(1) Inspection

Check the cam contact face of each tappet for abnormal wear, and replace it if necessary.



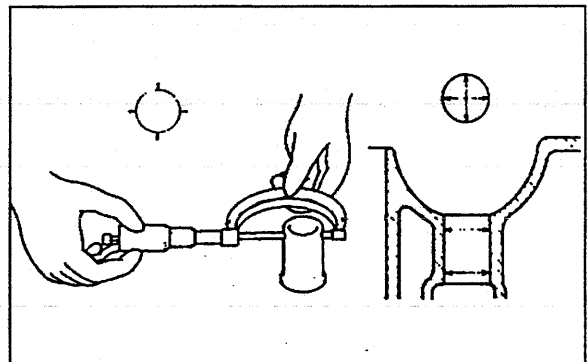
Cam contact face of tappet

(2) Measuring tappet clearance in tappet hole

If the clearance exceeds the Assembly standard, replace the tappet.

Unit mm (in.)

Item	Assembly Standard	Repair Limit	Service Limit
Inside diameter of tappet hole	22.000 - 22.021 (0.86614 - 0.86697)		22.100 (0.87008)
Tappet clearance	0.035 - 0.086 (0.00138 - 0.00339)	0.12 (0.0047)	



Measuring tappet clearance

Timing gears

Measuring backlash

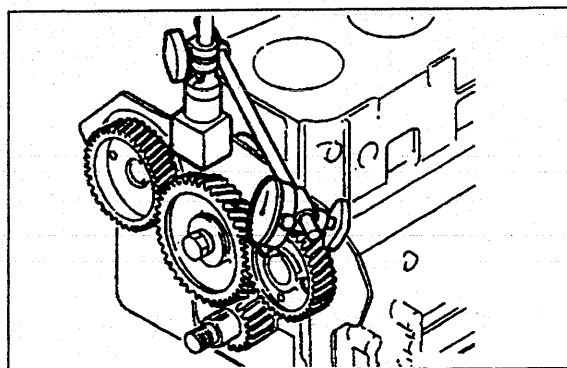
Set up a dial gauge so that it contacts the pitch circle of the gear, and move one gear back and forth to measure the backlash between the gears. If the backlash exceeds the Service limit, replace the gears.

Unit mm (in.)

Item	Standard Clearance	Service Limit
Backlash of timing gears	0.03 – 0.17 (0.0012 – 0.0067)	0.25 (0.0098)

NOTE

Install the injection pump gear to the front plate in the state of being installed on the injection pump.



Measuring timing gear backlash

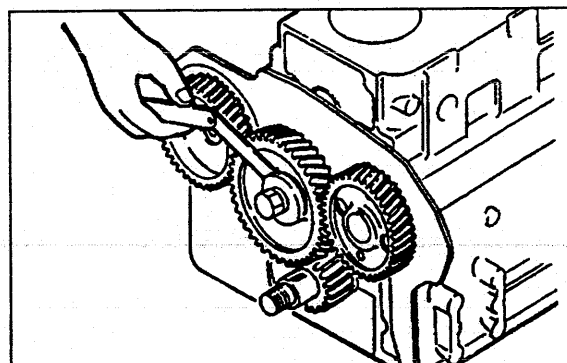
Idler, idler bushing and idler shaft

(1) Measuring end play of idler

Measure the end play with a feeler gauge or dial gauge. If the end play exceeds the Service limit, replace the thrust plate.

Unit mm (in.)

Item	Standard Clearance	Service Limit
End play of idler	0.05 – 0.20 (0.0020 – 0.0079)	0.35 (0.0138)



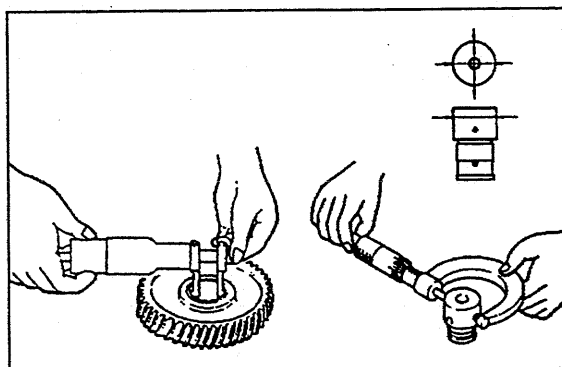
Measuring idler end play

(2) Measuring inside diameter of idler bushing and diameter of idler shaft

If the idler shaft clearance in bushing exceeds the Service limit, replace the bushing.

Unit mm (in.)

Item	Assembly Standard	Service Limit
Idler shaft clearance in bushing	0.009 – 0.080 (0.00035 – 0.00315)	0.100 (0.00394)

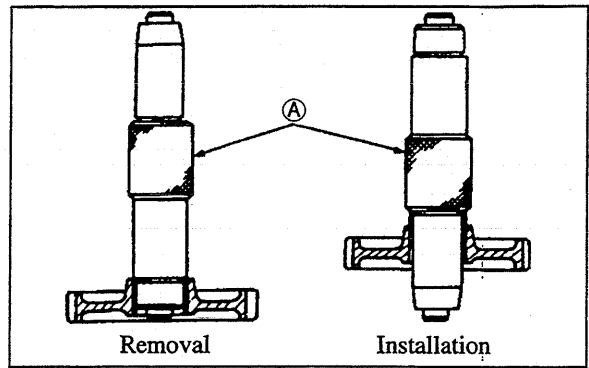


Measuring idler shaft and bushing

ENGINE PROPER

(3) Replacing idler bushings

- (a) To replace the bushing, use idler bushing puller (A) (30091-07300).
- (b) When installing replacement bushing, press it in until its end face is flush with that of gear boss.



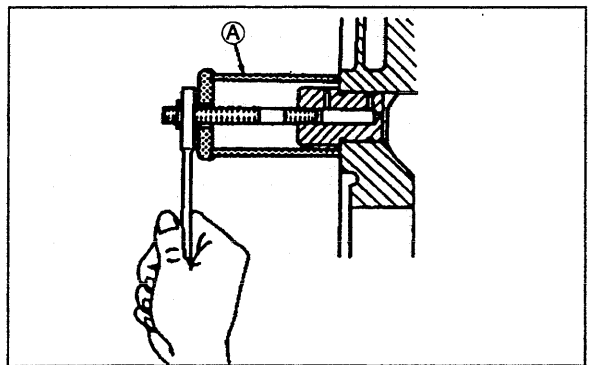
Replacing idler bushing

(4) Replacing idler shaft

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

NOTE

Install the idler shaft to the crankcase with its oil holes positioned upward.



Removing idler shaft

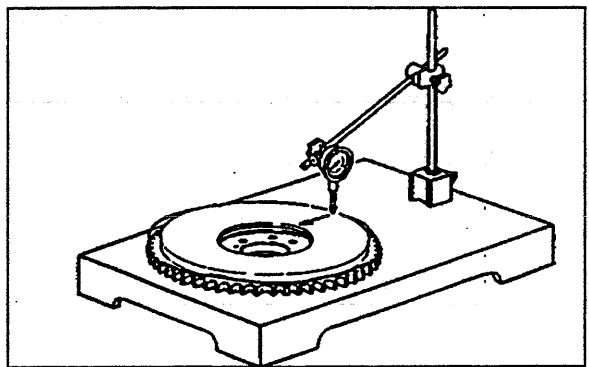
Flywheel and ring gear

(1) Measuring flatness of flywheel

Set the flywheel on the surface plate and, measure the flatness of the friction surface by moving a dial gauge on the along that surface. If the flatness exceeds the Repair limit, refinish the friction surface.

Unit mm (in.)

Item	Assembly Standard	Service Limit
Flatness of flywheel	0.15 (0.0059), maximum	0.50 (0.020)



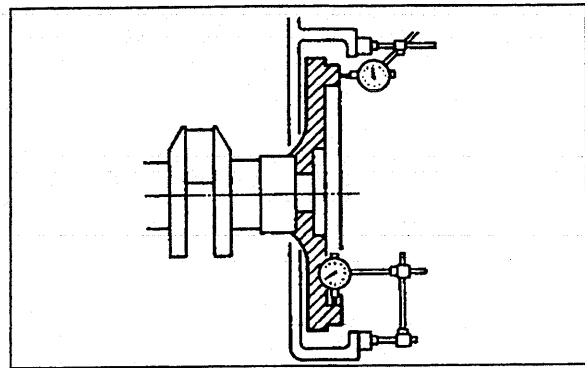
Measuring flywheel flatness

(2) Measuring face runout of flywheel

With the flywheel installed on the engine, measure its face runout. If the runout exceeds the Assembly standard, check for improper installation or foreign matter lodged in the mounting face.

Unit: mm (in.)

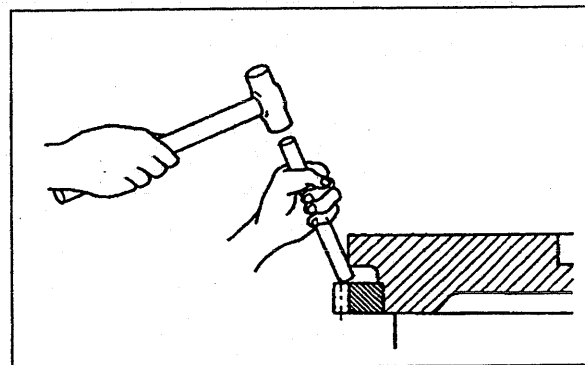
Item	Assembly Standard	Service Limit
Face runout of flywheel	0.15 (0.0059) maximum	0.50 (0.020)

**Measuring flywheel face runout****(3) Replacing ring gear**

Check the ring gear teeth for wear or other defects, and replace the gear if defective. To remove, proceed as follows:

(Removal)

- (a) Heat the ring gear uniformly with an acetylene torch.
- (b) Using a bar, give light hammer blows to the periphery of ring gear.

**Replacing ring gear****(Installation)**

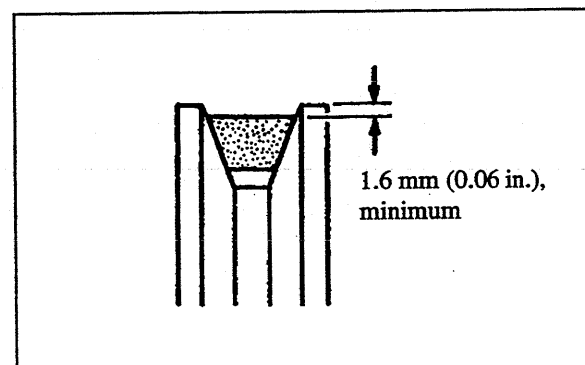
Heat a replacement ring gear up to about 150°C (212°F) in a piston heater, and press the gear onto the flywheel with its unchamfered teeth foremost.

Crankshaft pulley**Inspecting V-belt groove**

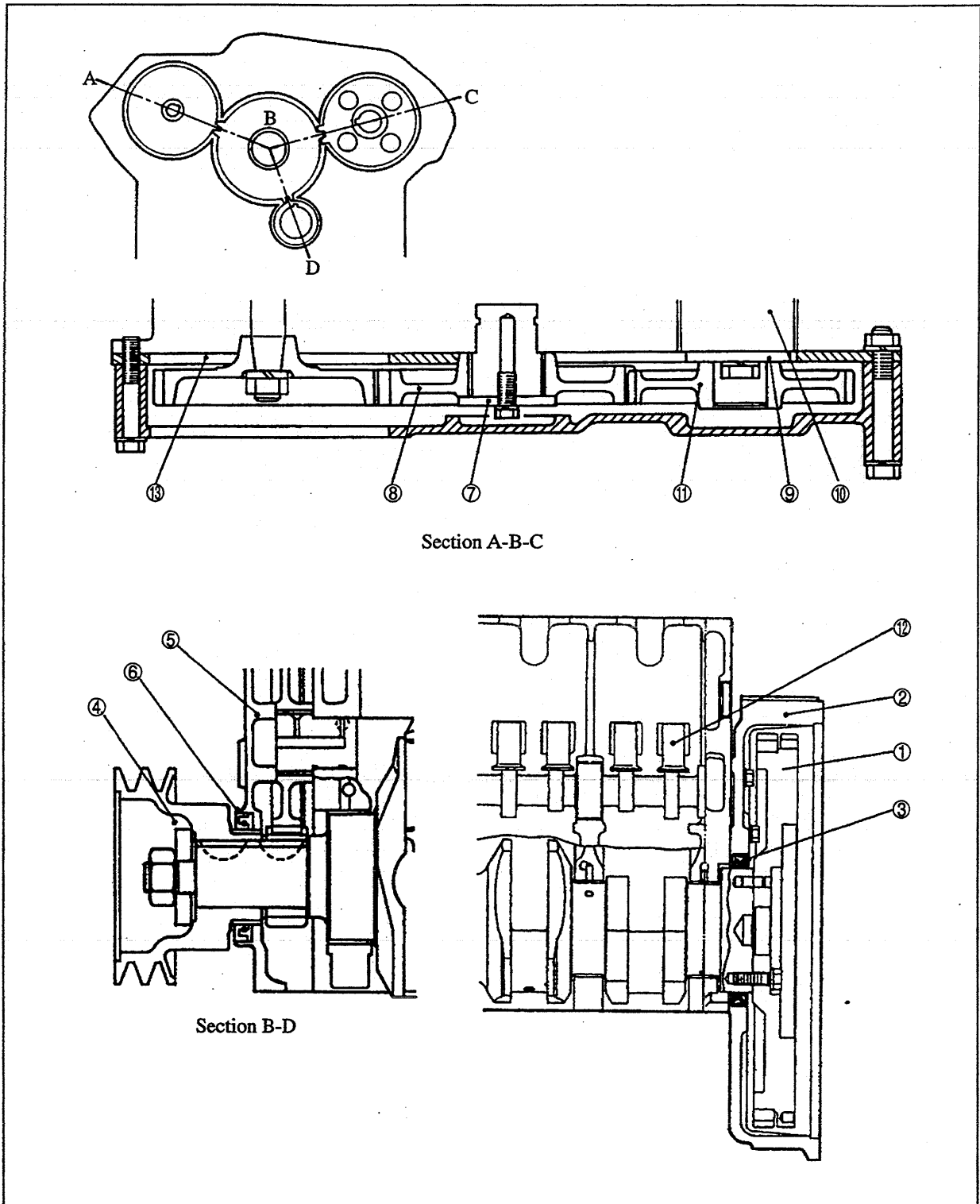
Check the groove for wear. Wrap a new belt around the pulley, pressing it in the groove as far as it goes, and see if the top surface of the belt is above the top of the pulley.

If the top surface of the belt is uniformly above the top of the pulley all the way around, it is not necessary to replace the pulley.

If the top surface of the belt sinks into the groove more than 1.6 mm (0.06 in.), replace the pulley.

**Inspecting V-belt groove in crankshaft pulley**

2.3 Reassembly



Reassembling sequence

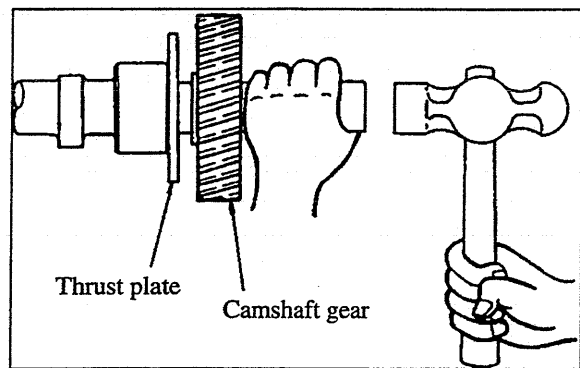
13 → 12 → 10 → 9 → 11 → 8 → 7 → 5 → 6 → 4 → 2 → 3 → 1

(1) Installing camshaft gear and thrust plate

Heat the gear for installation.

CAUTION

Have the thrust plate installed in advance.



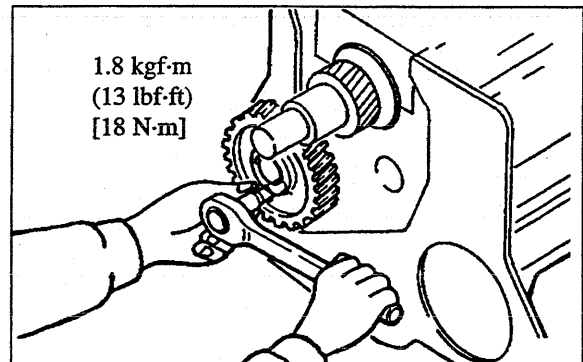
(2) Installing camshaft

(a) Carefully insert the camshaft into the crankcase.

(b) Tighten the mounting bolts to the specified torque.

Unit: kgf·m (lbf·ft) [N·m]

Tightening torque	1.8 (13) [18]
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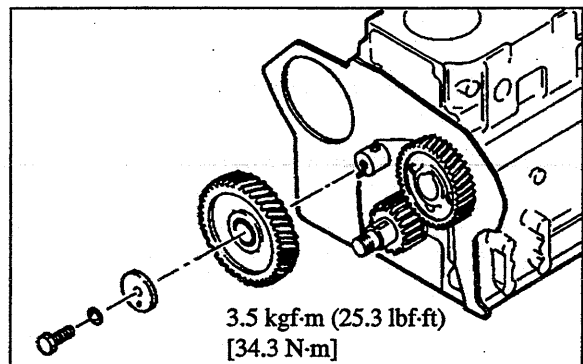
(3) Installing idler

(a) Install the idler while aligning the matching marks each pair of gears.

(b) Tighten the thrust plate mounting bolt to the specified torque.

Unit: kgf·m (lbf·ft) [N·m]

Tightening torque	3.5 (25.3) [34]
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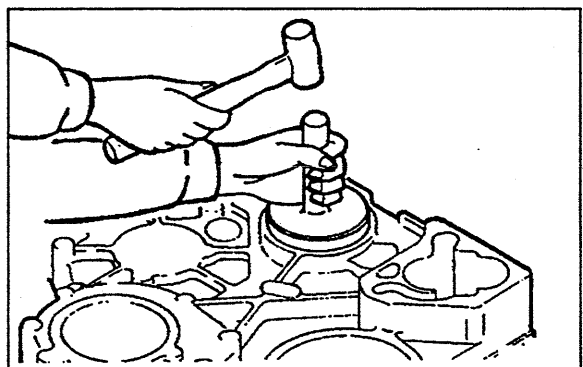


(4) Installing oil seal

To install the oil seal, use the installer.

(5) Installing rear oil seal

Install the rear oil seal after mounting the flywheel housing to the crankcase. For installation procedure, see page 7-35.



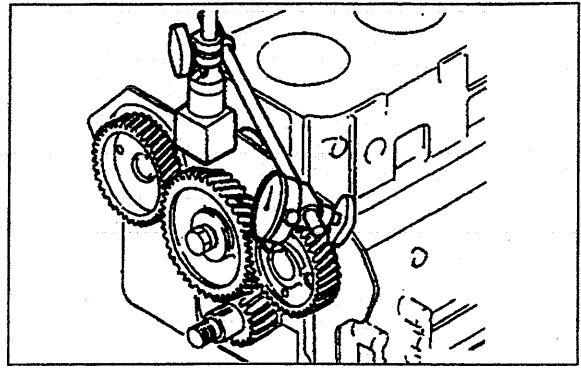
ENGINE PROPER

Inspecting and adjusting timing gears after installation

After installing the timing gears, be sure to inspect and adjust them as follows:

(Inspecting timing gear backlash and end play)

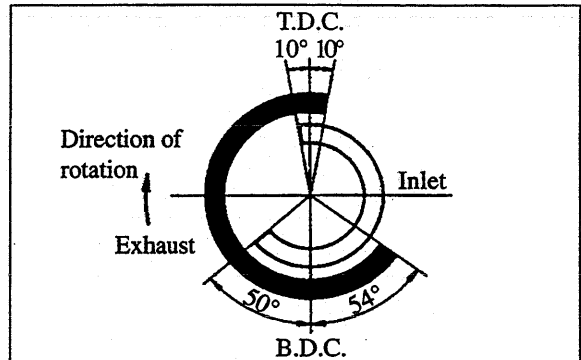
After installing the timing gears, inspect the backlash between the gears in mesh and the end play of each gear. (Refer to 2.2, Group No. 7.)



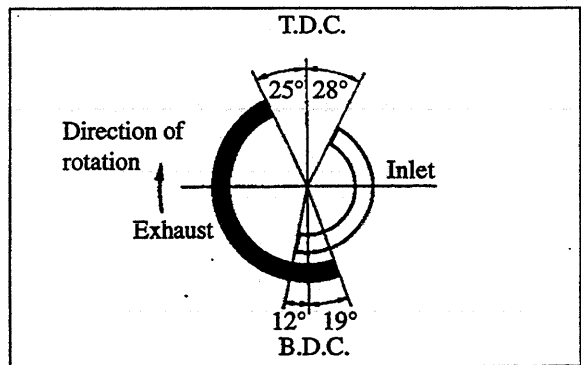
(Inspecting valve timing)

It is not necessary to inspect the valve timing, provided that all matching marks on the timing gears are aligned. Inspect the timing for verification as follows:

- (a) Using a flat plate with thickness of 3 mm, adjust the valve clearances of the inlet and exhaust valves for cylinder No. 1.
- (b) Insert a 0.05-mm feeler gauge between the top of the valve cap and the rocker arm, and slowly turn the crankshaft.
- (c) Find a position where the feeler gauge is firmly gripped (valve opening position) and a position where the gauge becomes loose (valve closing position).
- (d) Check to make sure these positions correspond to the angular positions shown in the valve timing diagram (with 3 mm clearance on valve side).



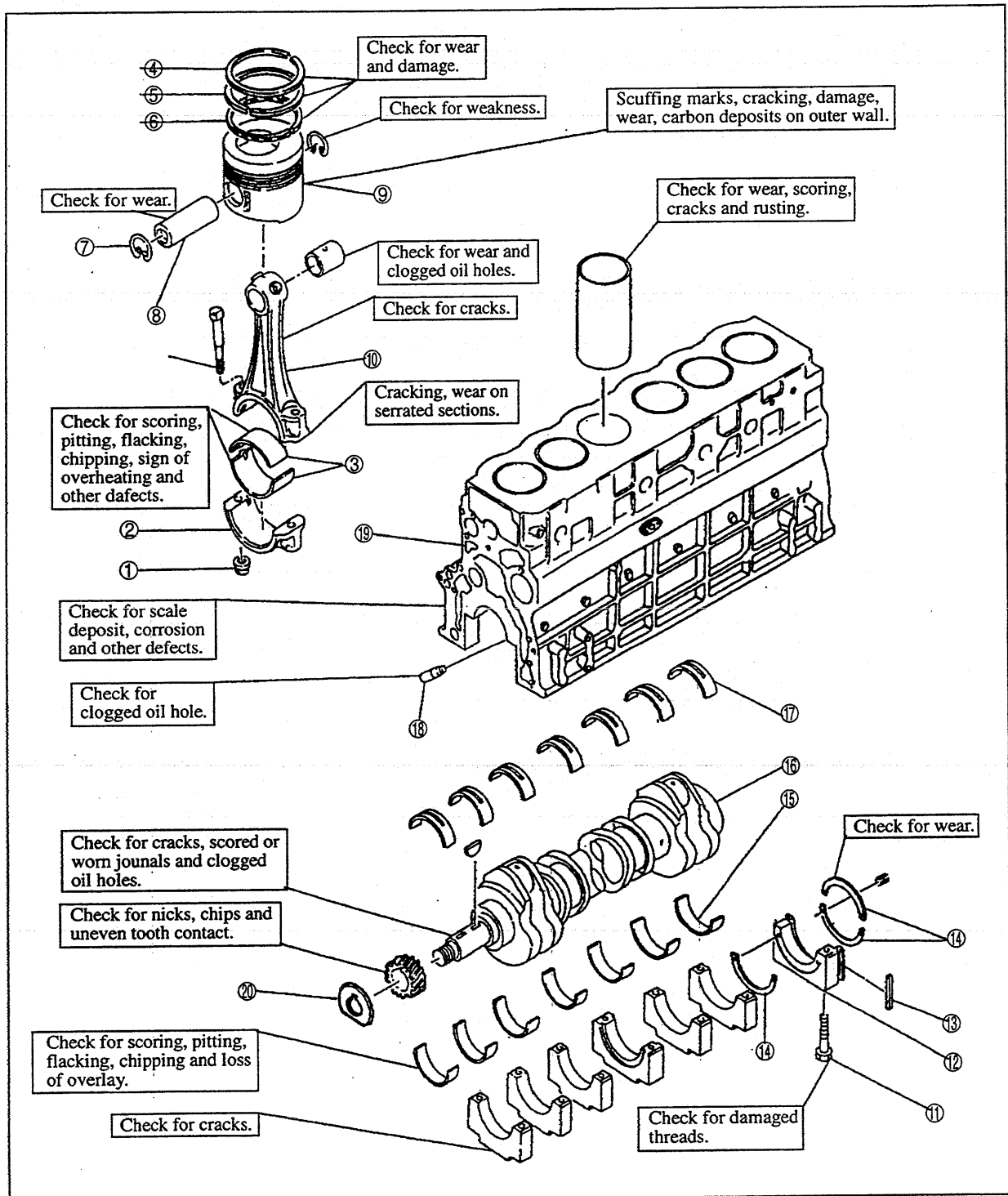
Valve timing diagram
(with 0.25 mm clearance on valve side)



Valve timing diagram
(with 3 mm clearance on valve side)

3. PISTONS, CONNECTING RODS, CRANKSHAFT AND CRANKCASE

3.1 Disassembly



- ① Nut
- ② Connecting rod cap
- ③ Connecting rod metal
- ④ Top compression ring
- ⑤ Second compression ring
- ⑥ Oil ring
- ⑦ Snap ring

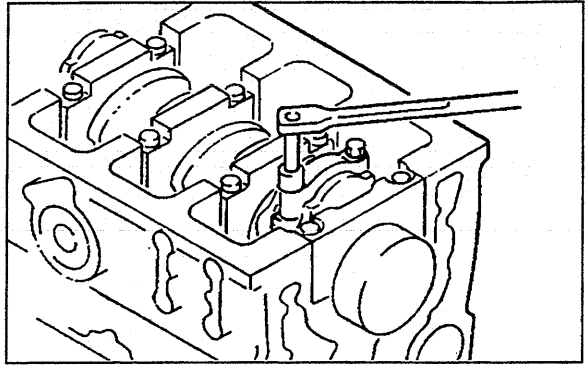
- ⑧ Piston pin
- ⑨ Piston
- ⑩ Connecting rod
- ⑪ Metal cap bolt
- ⑫ Main metal cap
- ⑬ Side seal
- ⑭ Thrust plate

- ⑮ Main metal (lower shell)
- ⑯ Crankshaft
- ⑰ Main metal (upper shell)
- ⑱ Check valve
- ⑲ Crankcase
- ⑳ Baffle plate

ENGINE PROPER

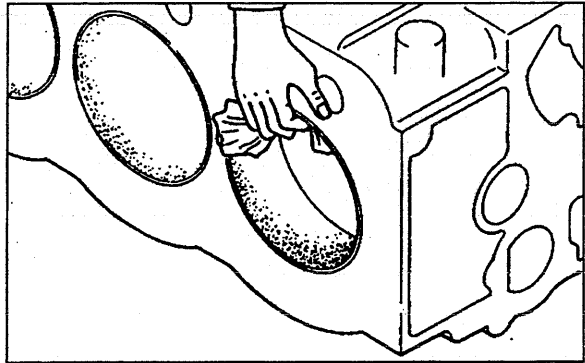
(1) Removing connecting rod caps

- (a) Unscrew the nuts securing the cap. Give hammer blows to the bolts squarely and evenly and, after the cap comes off the reamer bolt, take off the cap.
- (b) Mark the removed connecting rod metals for identification of cylinder numbers and kinds, upper shells and lower shells.



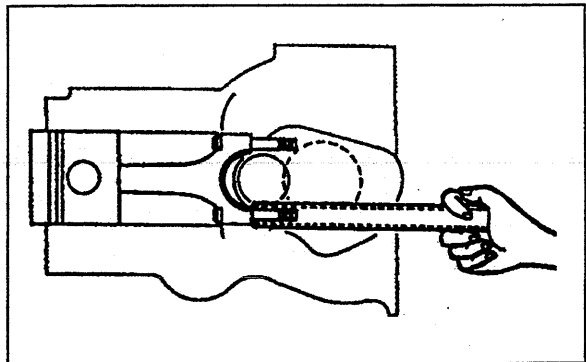
(2) Preparatory step for removing pistons

- (a) Lay the crankcase on its side.
- (b) Remove all carbon deposits from the upper areas of cylinder sleeves with a cloth or oil paper. Carbon deposits, if any, will make it difficult to pull the pistons upward.



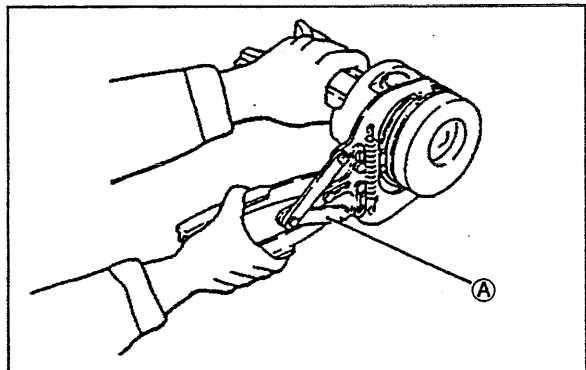
(3) Removing pistons

- (a) Bring the piston assembly (from which the connecting rod cap has been removed) to top dead center position.
- (b) Put the hollow pipe to the big end of the rod, and push the assembly off the crankcase.



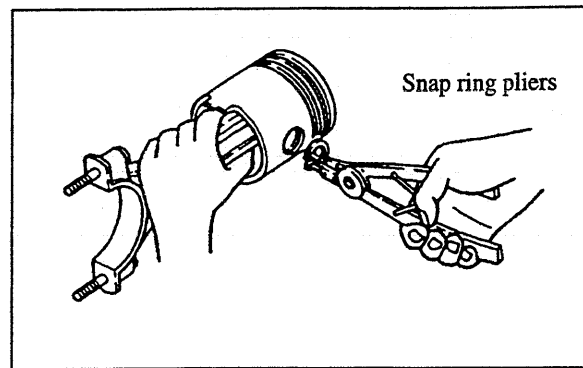
(4) Removing piston rings

Remove the piston rings with piston ring pliers (A) (30091-07100).



(5) 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.
- (c) When it is difficult to remove the piston pin, heat the piston in an oven or in hot water.

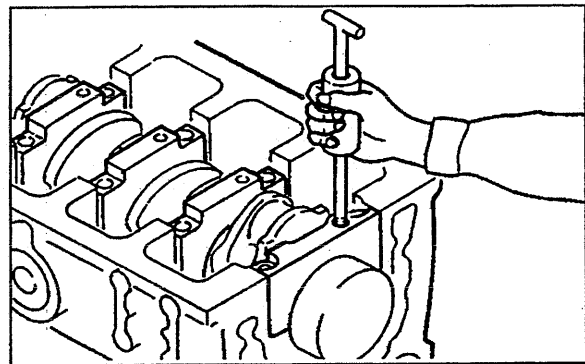


(6) Removing main metal caps

Unscrew the bolts securing the cap, and remove the cap complete with main metal. To remove the rear-end main metals, use a puller.

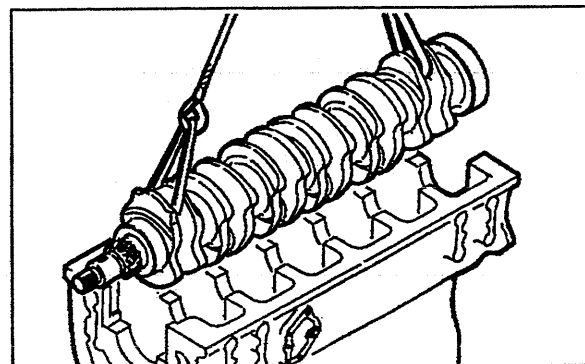
NOTE

Be careful not to cause damage to the main metals. Put a mark on each metal cap so it can be installed in the same position from which it was removed.



(7) Removing crankshaft

Suspend the crankshaft horizontally using slings, then gently remove it by lifting upward.



ENGINE PROPER

3.2 Inspection and repair

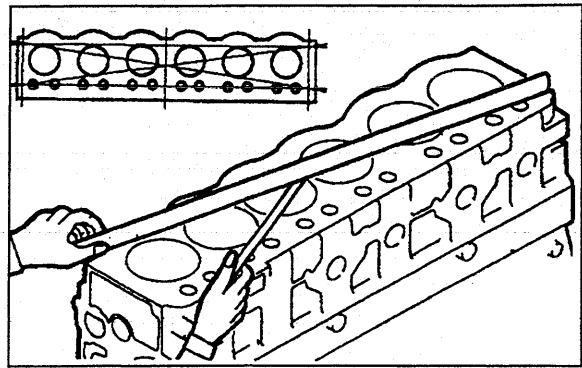
Crankcase and cylinder sleeves

(1) Measuring warpage of crankcase gasketed surface

Measure the warpage with a straightedge and feeler gauge. If the warpage exceeds the Repair limit, grind the surface with a surface grinder. Grind the crankcase only enough to remove the warpage.

Unit: mm (in.)

Item	Assembly Standard	Repair Limit
Warpage of crankcase gasketed surface	0.05 (0.0020), maximum	0.20 (0.0079)



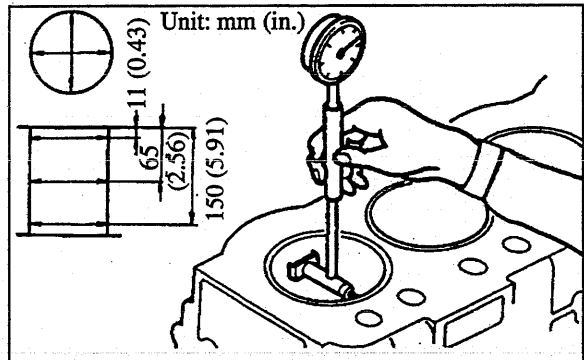
Measuring crankcase gasketed surface

(2) Measuring inside diameter of cylinder sleeves

- (a) Measure the sleeve in two directions, parallel and transverse to the crankshaft, at three positions, top (ridged area), middle and bottom as shown.

Unit mm (in.)

Item	Assembly Standard	Repair Limit	Service Limit
Cylinder sleeve	102.010 - 102.045 (4.01614 - 4.01752)	102.200 (4.02361)	102.700 (4.04330)
	0.01 (0.0004), maximum		
	0.015 (0.00059), maximum		



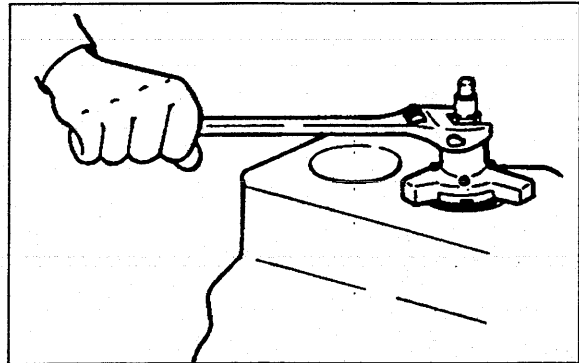
Measuring cylinder sleeve diameter

- (b) If the inside diameter reaches the Repair limit within the Service limit, bore the sleeve to the specified oversize.
- (c) Hone the sleeve to +0.25 mm (+0.0098 in.) or +0.5 mm (+0.0197 in.) oversize accurate within 0.010 to 0.045 mm (0.00039 to 0.00177 in.). Use the piston and piston rings of the same oversize.

- (d) If any sleeve is unevenly worn, determine the oversize on the basis of the maximum wear noted to ensure perfect roundness in the oversized bore.

NOTE

- (a) Refinish all sleeves to the same oversize.
- (b) If the sleeve is found in good condition, with the wear far less than the Repair limit, replace the piston rings, and ream off "ridge" at the top of the sleeve. Hone the bore if necessary.



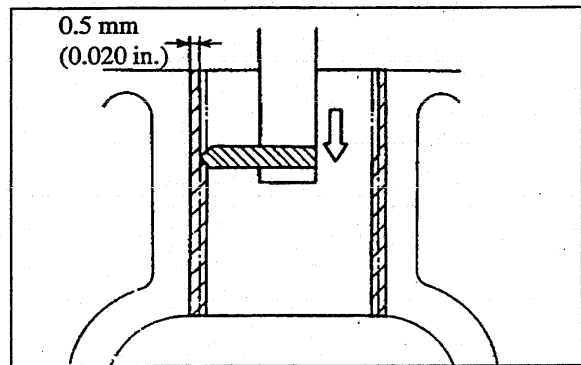
Ridge-reaming cylinder sleeve

(3) Replacing cylinder sleeve

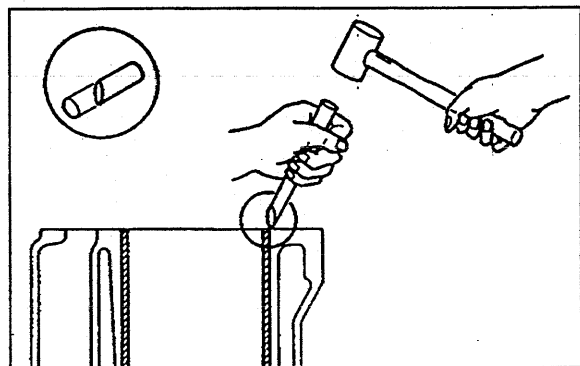
If one sleeve exceeds the Service limit in inside diameter, or it is defective, with the other sleeves in good condition, replace that sleeve only.

(Removing cylinder sleeve)

- (a) Set up a boring machine on the crankcase by aligning it with the center of the less-worn area of the sleeve at the bottom.
- (b) Bore the sleeve until its stock thickness is about 0.5 mm (0.020 in.).
- (c) Break and remove the sleeve, being careful not to damage the inside surface of the crankcase.



Removing cylinder sleeve (1)

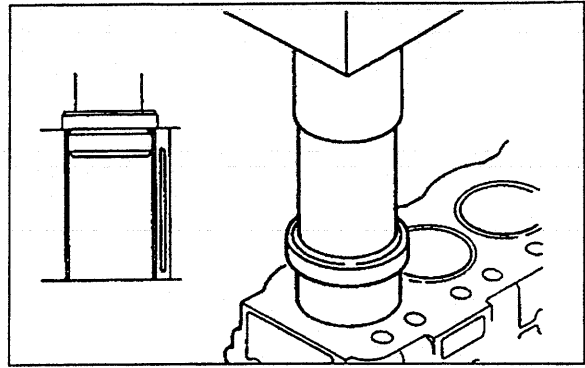


Removing cylinder sleeve (2)

ENGINE PROPER

(Installing replacement cylinder sleeve)

- (a) Use cylinder sleeve installer (34291-00200) to install a replacement sleeve.
- (b) Press the sleeve into the crankcase, leaving a protrusion of 0.3 to 0.5 mm (0.012 to 0.020 in.) at the top. Then make it flush with the crankcase top.
- (c) Bore and hone the sleeve to $102^{+0.045}_0$ mm ($4.02^{+0.00138}_0$ in.) diameter.

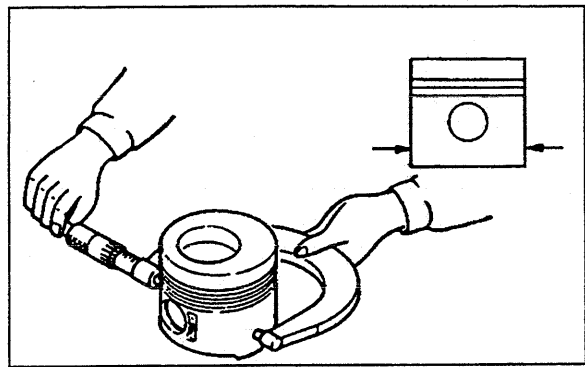


Installing cylinder sleeve

Pistons and piston rings

(1) Checking diameter of pistons

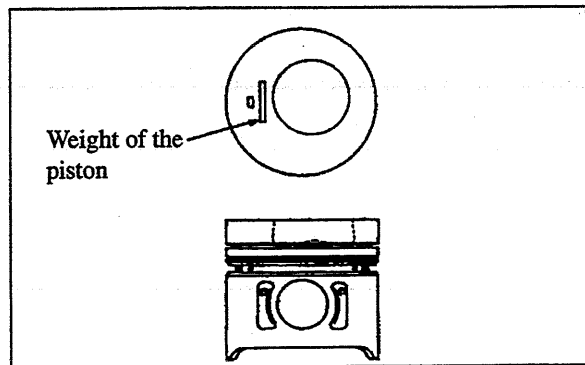
- (a) Measure the diameter of the piston at skirt in the direction transverse to the piston pin with a micrometer, as shown in the illustration. If the piston is worn beyond the service limit, replace it. When replacing the piston, select a new piston so that the difference between average weight of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



Checking diameter of piston

Unit: mm (in.)

Item		Assembly Standard	Service Limit
Diameter of piston	Standard	101.915 to 101.945 (4.01239 to 4.01357)	101.730 (4.00511)
	0.25 (0.0098) oversize	102.165 to 102.195 (4.02224 to 4.02343)	101.980 (4.01495)
	0.50 (0.0197) oversize	102.415 to 102.445 (4.03209 to 4.03327)	102.230 (4.02480)
Maximum permissible difference between average weight of all pistons in one engine		5 g (0.2 oz), maximum	—



The weight of the piston

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

(2) Checking clearance between ends of piston ring

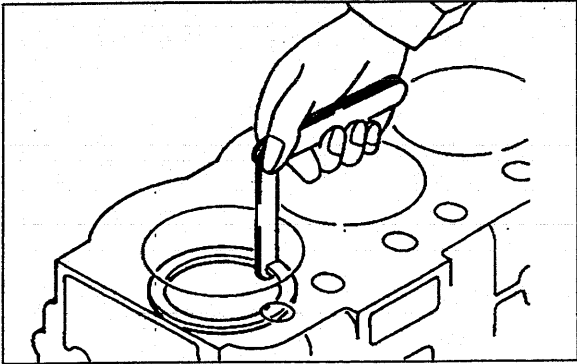
Install the piston ring in a new cylinder or a gauge and measure the clearance between the ends of the ring with a feeler gauge. If the clearance exceeds the service limit, replace all piston rings.

Inside diameters of gauges

$$102^{+0.045}_0 \text{ mm } (4.02^{+0.00177}_0 \text{ in.})$$

NOTE

Install the piston ring in the cylinder squarely with a piston.



Checking clearance between ends of piston ring

Unit: mm (in.)

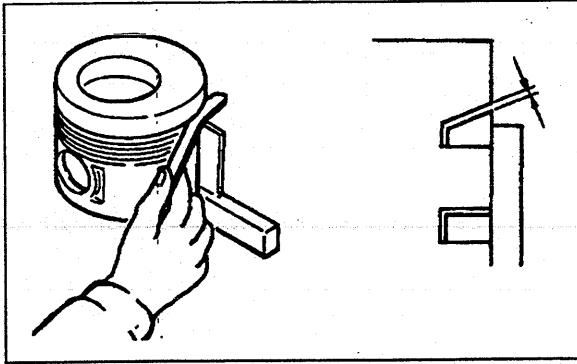
Item		Assembly Standard	Service Limit
Clearance between ends of piston ring	No. 1, 2 rings	0.30 to 0.45 (0.0118 to 0.0177)	1.50 (0.0591)
	Oil ring	0.30 to 0.50 (0.0118 to 0.0197)	

(3) Checking pistons and piston rings

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: mm (in.)

Item		Assembly Standard	Service Limit
Clearance between groove and piston ring	No. 1 ring	0.08 to 0.12 (0.0031 to 0.0047)	0.150 (0.00591)
	No. 2 ring		
	Oil ring	0.025 to 0.065 (0.00098 to 0.00256)	



Measuring piston pin and bore

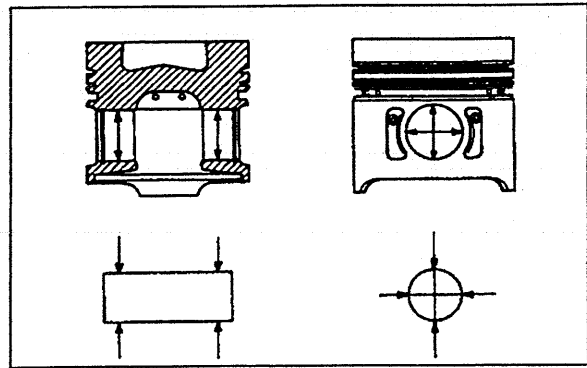
ENGINE PROPER

(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: mm (in.)

Item	Nominal Size	Assembly Standard	Service Limit
Diameter of piston pin	34 (1.34)	33.993 to 34.000 (1.33830 to 1.33858)	
Clearance between piston pin and bore		0.002 to 0.019 (0.00008 to 0.00075)	0.050 (0.00197)



Measuring piston pin and bore

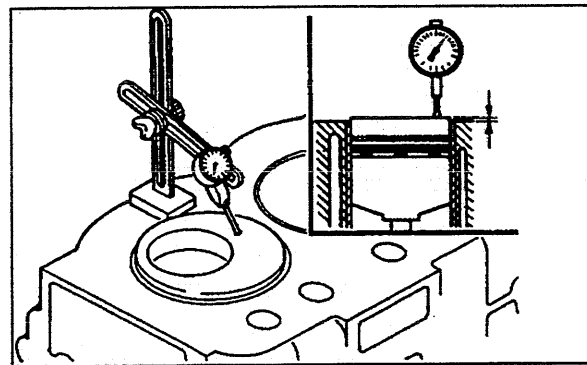
(5) Measuring protrusion of piston

Measure protrusion of each piston and, if it is not within the Assembly standard, inspect the various parts for clearance.

- Determine the top dead center of piston with a dial gauge.
- Set up the dial gauge at the top of crankcase, and set the gauge pointer to zero (0).
- Measure the protrusion at three places on the piston head, and average the three measurements to determine the protrusion. Subtract the protrusion from the as-installed thickness of cylinder head gasket to determine the clearance between the piston top and cylinder head.

Unit: mm (in.)

Item	Assembly Standard
Piston protrusion	0.55 – 1.15 (0.0217 – 0.0453)
As-installed thickness of cylinder head gasket	1.7 ± 0.10 (0.067 ± 0.0039)



Measuring piston protrusion

CAUTION

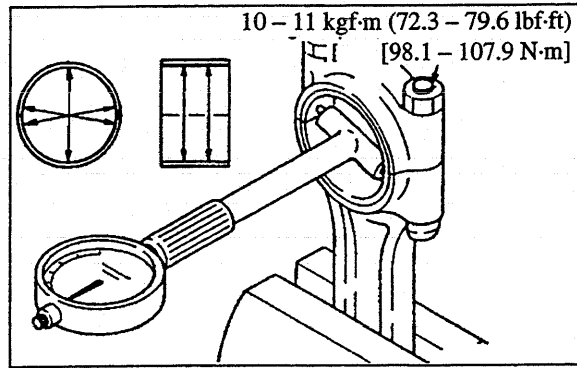
Keeping the piston protrusion within the Assembly standard is important not only for engine performance but also for prevention of interference of the valve with the piston.

Connecting rods, connecting rod metals and small-end bushings

(1) Measuring connecting rod metal clearance on crankpin

Measure the crankpin diameter and metal inside diameter to determine the clearance between the two. If the clearance exceeds the Repair limit, replace the metal. If the crankpin is worn excessively or unevenly, grind the crankpin, and use undersize metal.

The three metal undersizes are -0.25 mm (-0.0098 in.), -0.50 mm (-0.0197 in.) and -0.75 mm (0.0295 in.).



Measuring connecting rod metal inside diameter

NOTE

To measure the metal inside diameter, install upper and lower shells to the connecting rod properly, and tighten the cap bolts to the specified torque.

Unit: mm (in.)

Item	Nominal Value	Assembly Standard	Service Limit
Diameter of crankpin	60 (2.36)	-0.035 to -0.055 (-0.00138 to 0.00217)	-0.20 (-0.0079)
Connecting rod metal clearance on crankpin		0.035 to 0.100 (0.00138 to 0.00394)	0.200 (0.00787)

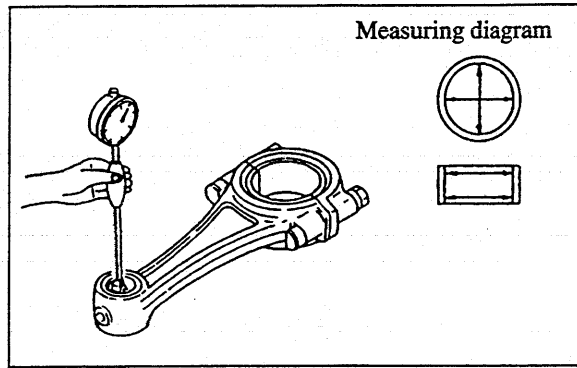
ENGINE PROPER

(2) 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: mm (in.)

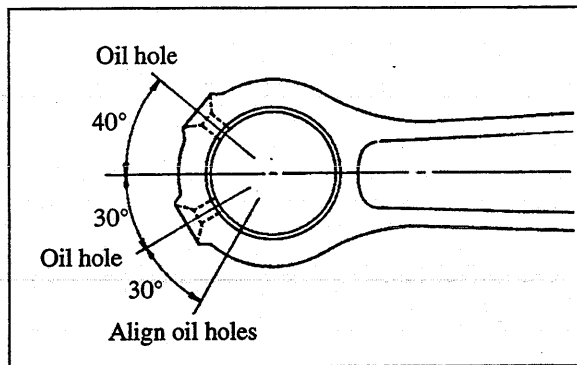
Item	Nominal Size	Assembly Standard	Service Limit
Inside diameter of bushing	34 (1.34)	34.020 to 34.045 (1.33937 to 1.34035)	
Clearance between bushing and piston pin		0.023 to 0.054 (0.00091 to 0.00213)	0.080 (0.00315)



Measuring connecting rod bushing

(3) Replacing connecting rod bushings

- (a) Use a connecting rod bushing puller (MH061296) to 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.



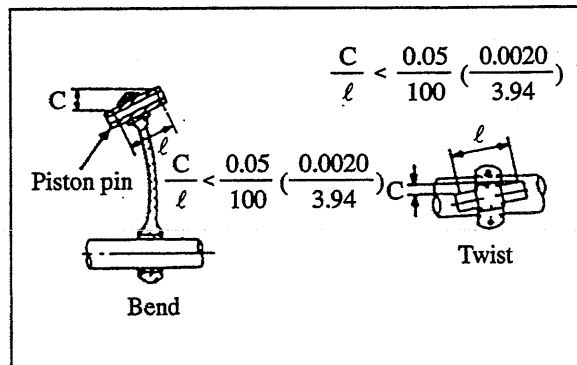
Installing connecting rod bushing

(4) Inspecting connecting rods for bend and twist

- (a) Measure "C" and "l" to check the rod for twist and/or bend. If "C" exceeds 0.05 mm (0.0020 in.) per 100 mm (3.94 in.) of "l," straighten the rod with a press.

Unit: mm (in.)

Item	Assembly Standard	Repair Limit
Twist or bend of connecting rod	0.05/100 (0.0020/3.94), maximum	0.15/100 (0.0059/3.94)



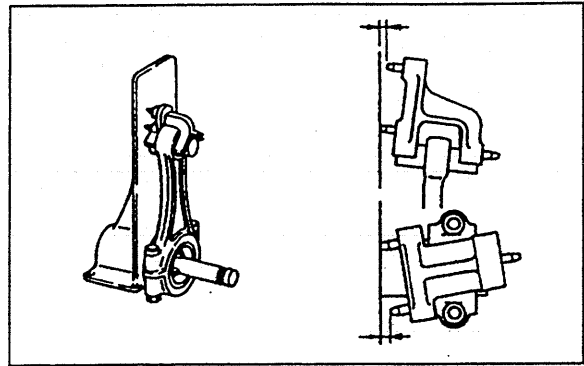
Checking connecting rod

- (b) A connecting rod aligner is generally used for checking the connecting rod for twist and/or bend.

To check the connecting rod for bend, install the cap to the rod and tighten the cap nuts to the specified torque.

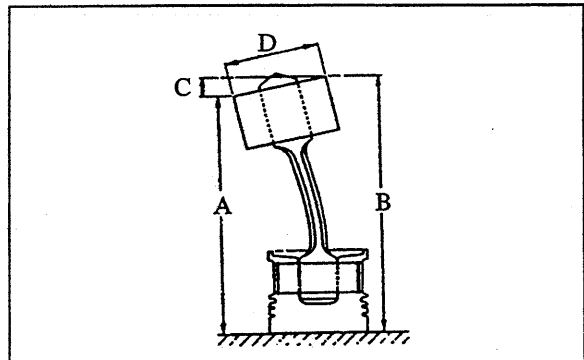
Unit: kgf-m (lbf-ft) [N-m]

Tightening torque	10.5±0.5 (76±3.6) [103±5] [Wet]
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Checking connecting rod with a connecting rod aligner

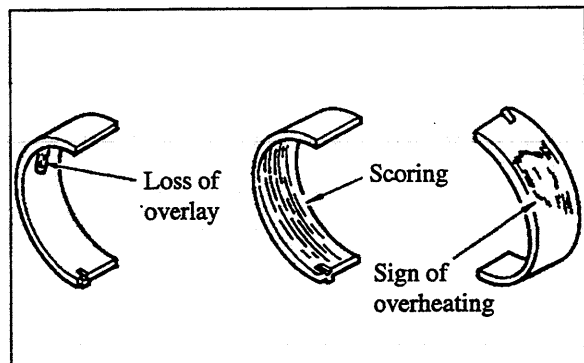
- (c) To check the connecting rod installed to the piston for bend, put the piston and connecting rod on the surface plate, insert a round bar identical with the crankpin in diameter into the big end bore and measure the heights "A" and "B" of the bar with a dial indicator, as shown in the illustration. The difference between the heights "A" and "B" of the bar is bend of the connecting rod.



Checking connecting rod with a dial indicator

(5) Inspecting connecting rod metals

Inspect each metal shell for loss of overlay, scoring, sign of overheating, pitting and other defects. If any of these defects is present, replace the shell.

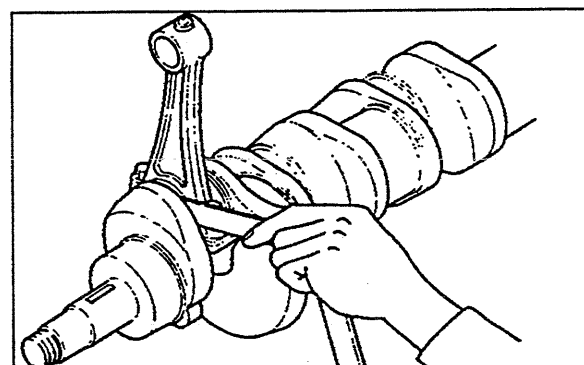


(6) Measuring end play of connecting rod

Install the connecting rod to the mating crankpin, and tighten its cap to the specified torque. Then, using a feeler gauge, measure the end play. If the end play exceeds the Service limit, replace the connecting rod.

Unit: mm (in.)

Item	Standard Clearance	Service Limit
End play of connecting rod	0.15 – 0.35 (0.0059 – 0.0138)	0.50 (0.0197)



Measuring connecting rod end play

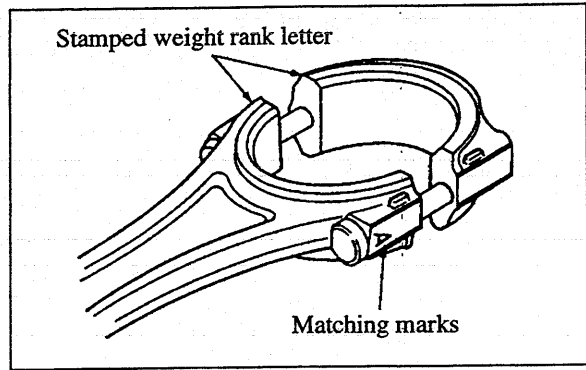
ENGINE PROPER

(7) Variance in weight among connecting rods per engine

When replacing connecting rods, make sure that the variance in weight among connecting rods per engine is within the Assembly standard shown below.

Unit: mm (in.)

Item	Assembly Standard
Variance in weight per engine	10g (0.35 oz), maximum



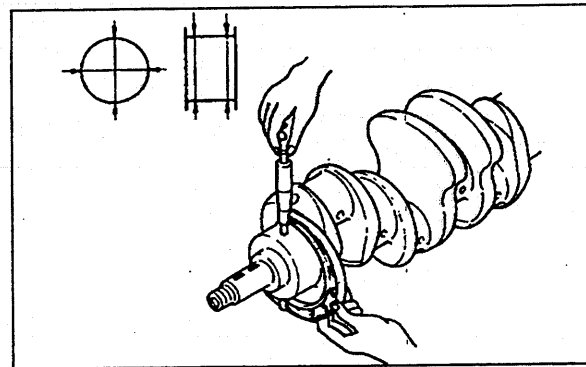
Crankshaft

(1) Measuring diameter of journal

Using a micrometer, measure the journal in two positions and in two directions to determine the wear, out of round and taper. If any of the Repair limits is exceeded, regrind the journal to the undersize or replace the crankshaft.

Unit: mm (in.)

Item	Nominal Value	Assembly Standard	Repair Limit	Service Limit
Diameter	90 (3.54)	-0.03 -0.05 (-0.0012) (-0.0020)	-0.15 (-0.0059)	-0.90 (-0.0354)
Out of round		0.01 (0.0004), maximum	0.03 (0.0012)	
Taper				



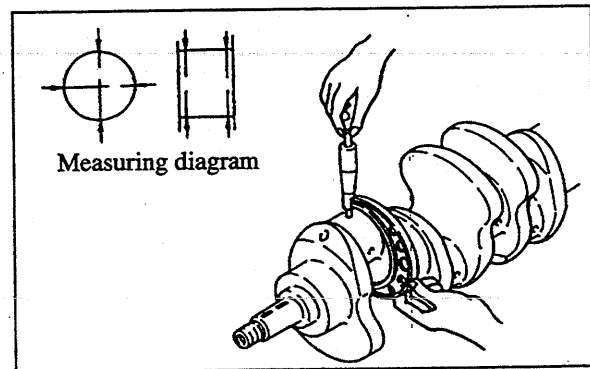
Measuring crankshaft journals

(2) Measuring diameter of crankpin

Using a micrometer, measure the outside diameter of the crankpin in vertical and horizontal directions, and check the out-of-roundness, taper and bearing clearance. If any of the repair limits is exceeded, regrind the crankpin to the undersize or replace the crankshaft.

Unit: mm (in.)

Item	Nominal Size	Assembly Standard	Repair Limit
Diameter of crankpin (standard)	60 (2.36)	-0.035 to -0.055 (-0.00138 to -0.00217)	-0.20 (-0.0079)
Out of round	—	0.01 (0.004), maximum	0.03 (0.0012)
Taper			



Measuring crankpin

(3) Grinding crankshaft

If the crankshaft is ground to any of the undersizes and refinished to a dimension which is 0.100 to 0.120 mm (0.00394 to 0.00472 in.) smaller than the undersize, it is not necessary to check the metal contact pattern.

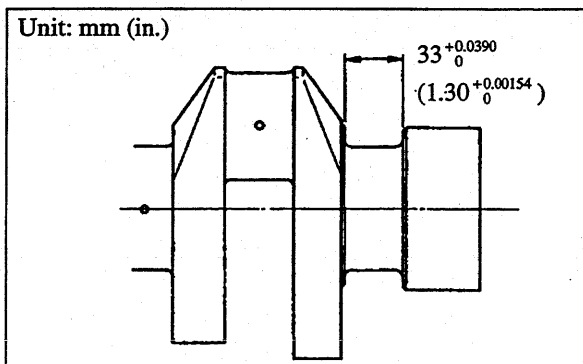
When grinding the journals and crankpins, be sure to produce the same fillet radius as the original one. They should have a hardness of 620 or more in terms of vickers hardness number. If necessary, reharden the journals and crankpins, and inspect them for cracks by conducting a magnalux (magnetic particle) test.

Crankshaft grinding dimensions Unit: mm (in.)

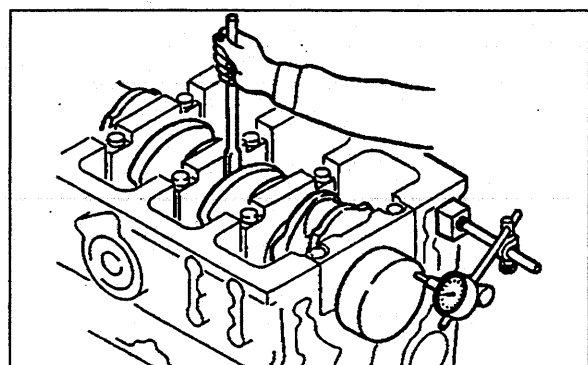
	Undersize	Refinishing dimension
Journal	0.25 (0.0098)	89.70 – 89.72 (3.5315 – 3.5323)
	0.50 (0.0197)	89.45 – 89.47 (3.5216 – 3.5224)
	0.75 (0.0295)	89.20 – 89.22 (3.5118 – 3.5126)
Crankpin	0.25 (0.0098)	59.695 – 59.715 (2.35019 – 2.35098)
	0.50 (0.0197)	59.445 – 59.465 (2.34035 – 2.34114)
	0.75 (0.0295)	59.195 – 59.215 (2.33051 – 2.33129)

(4) Measuring end play of crankshaft

- (a) Install the thrust plates in position, and secure the main metal caps. Under this condition, measure the end play (the end clearance of thrust plates in the journal). If the end play exceeds the Assembly standard, replace the thrust plates.
- (b) If the end play still exceed the Repair limit even after new thrust plates have been installed, replace the plates with the next oversize ones. There are three oversizes for the thrust plates; namely, +0.15 mm (+0.0059 in.), +0.30 mm (+0.0118 in.) and +0.45 mm (+0.0177 in.). Generally, the rear journal is likely to be worn more rapidly than the front journal. This means that replacement of the rear thrust plates will, in most cases, gain the purpose.



Measuring crankshaft end play



Measuring crankshaft end play

Unit: mm (in.)

Item	Standard Clearance	Service Limit
End play of crankshaft	0.100 – 0.264 (0.00394 – 0.01039)	0.300 (0.0118)

ENGINE PROPER

Crankshaft journal grinding dimensions for oversize thrust plates Unit: mm (in.)

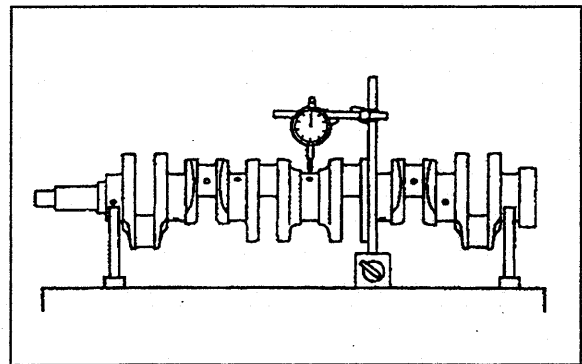
Item	Oversizes for journal or thrust plates	Oversizes for journal and thrust plates	Tolerance
+0.15 (+0.0059) oversize	33.15 (1.3051)	33.30 (1.3110)	
+0.30 (+0.0118) oversize	33.30 (1.3110)	33.45 (1.3169)	+0.039 0 (+0.00154) 0
+0.45 (+0.0177) oversize	33.45 (1.3169)	33.60 (1.3228)	

(5) Checking runout

Support the crankshaft on its front and rear journals in V-blocks, and measure the runout (eccentricity) at the center journal using a dial gauge. Compared the measured value with the standard value. If the amount of runout is small, correct the runout by grinding. If the amount of runout is large, use a press. If the repair limit is exceeded, replace the crankshaft.

Unit: mm (in.)

Item	Assembly Standard	Repair Limit
Crankshaft runout	0.02 (0.0008), maximum	0.05 (0.0020)



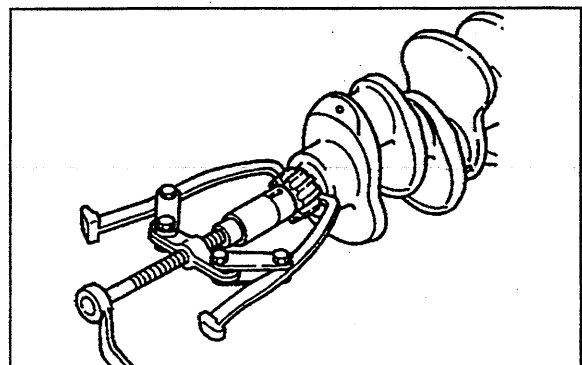
Checking crankshaft runout

(6) Removing crankshaft gear

- (a) Remove the crankshaft gear with a gear puller, as shown in the illustration.

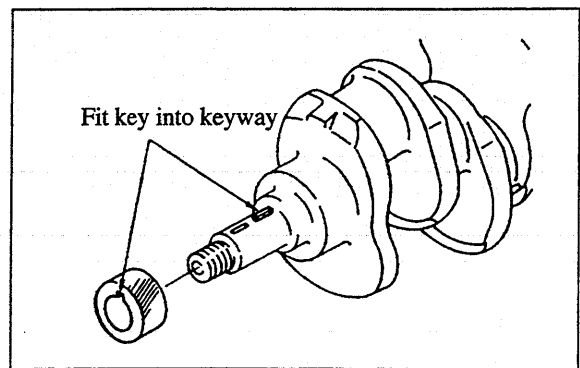
NOTE

Do not remove the gear unless it requires replacement.



Removing crankshaft gear

- (b) Heat the gear in an oven to a temperature of 100°C to 150°C (212°F to 302°F).
- (c) Install the key to the crankshaft. Install the gear by fitting the key into the keyway in the gear.



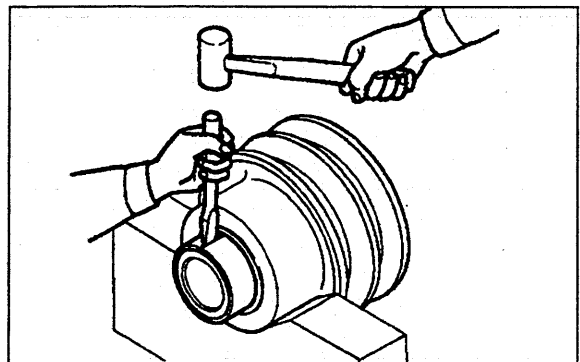
(7) Replacing front oil seal on crankshaft

If oil leaks from the oil seal, replace both sleeve and oil seal with replacement parts.

(Removal of sleeve)

Place a chisel at a right angle to the sleeve surface and strike with a hammer. Repeat this at two other locations on the sleeve. When the sleeve becomes loose, remove the sleeve.

If the sleeve cannot be removed by the above method, place the chisel on the sleeve in the direction of the shaft, and tap lightly to expand the sleeve so that the sleeve becomes dislodged from its position.



Removing front sleeve

⚠ CAUTION

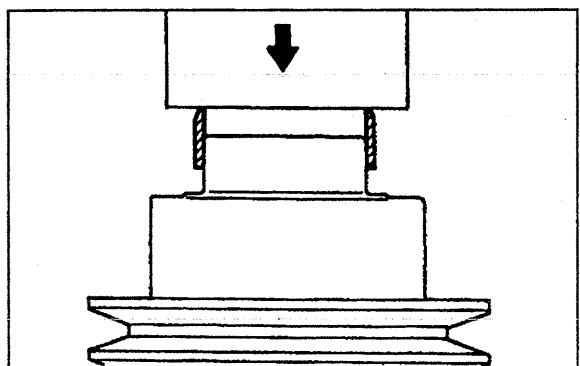
When removing the sleeve with a chisel, be careful not to damage the crankshaft.

(Installation of sleeve)

Apply ThreeBond 1205 to the inside surface of the sleeve, and install the sleeve using a press, making sure that the edge of the sleeve is flush with the pulley end face.

⚠ CAUTION

Be careful not to dent or scratch the outer surface of the sleeve.



Press-fitting front sleeve

ENGINE PROPER

(8) Replacing rear oil seal on crankshaft rear side

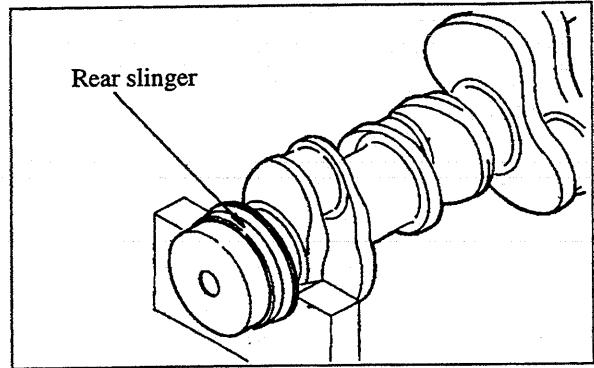
If oil leaks from the oil seal, replace the oil seal and slinger with replacement parts.

(Removal of rear oil seal)

Use a puller to remove the slinger.

CAUTION

Be careful not to damage the crankshaft when removing the rear oil seal.

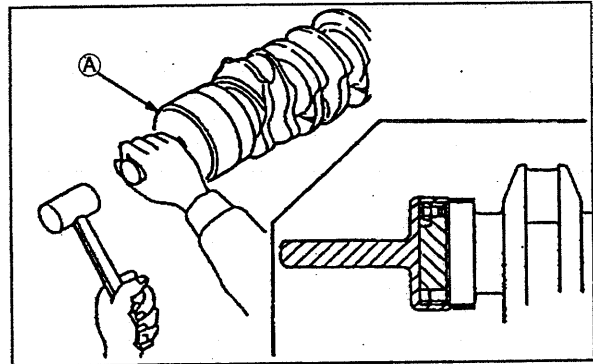


Removing rear slinger

(Double-lip rear oil seal)

When oil leaks from the double-lip rear oil seal, replace with a sleeved oil seal supplied as a replacement part.

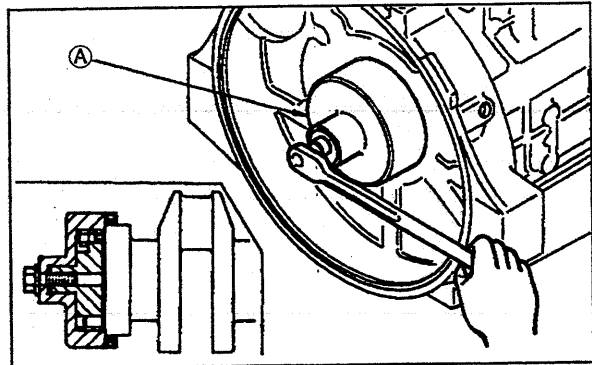
To install the sleeve, apply ThreeBond 1205 to the inner surface of the sleeve, and use crankshaft sleeve installer **A** (34291-00010) and a hammer to fit into place.



Installation of oil seal sleeve

(Installation of slinger)

Install the oil seal on the slinger. Apply oil to the inside surface of the slinger, and apply ThreeBond 1212 to the mounting surface. Use special oil seal installer **A** (34291-00020) to install the oil seal and slinger.



Installing oil seal and slinger

Main metals

(1) Inspection

Inspect each metal shell for abnormal contact, scratching, corrosion, wiped overlay and other defects. Also check for a sign of poor seating in the bore of the crankcase or metal cap.

(2) Measuring main metal clearance on journal

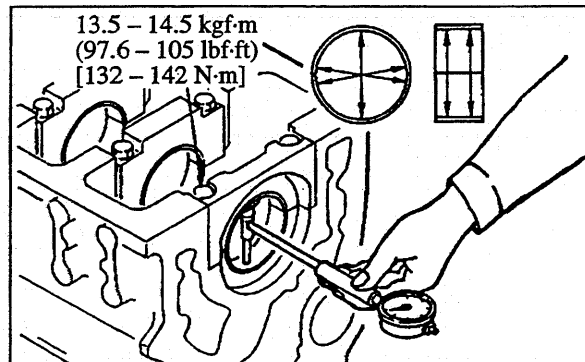
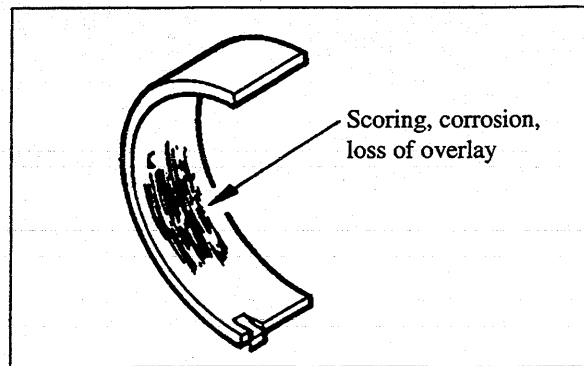
Fit the metal shells to the crankcase and metal cap, and tighten the cap bolts to the specified torque. Measure the inside diameter of the metal in two positions, front and back along the longitudinal axis of crankshaft, in the criss-cross directions to take an average. Obtain the difference between the journal diameter and this inside diameter to determine the clearance.

Unit: mm (in.)

Item	Assembly Standard	Repair Limit
Main metal clearance on journal	0.050 – 0.118 (0.00197 – 0.00465)	0.200 (0.00787)

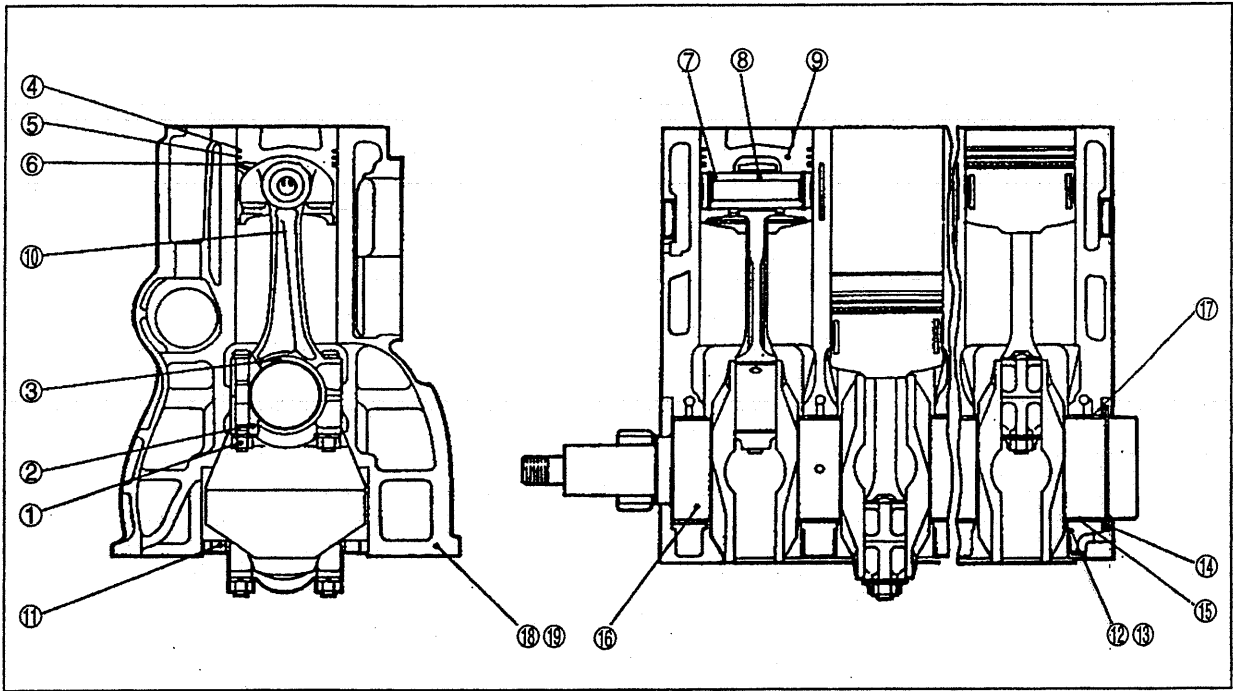
(3) Inspection

If the clearance exceeds the Repair limit, replace the metals, or refinish the crankshaft and use undersize metals. If the crankshaft is refinished in compliance with any of the undersizes, it is not necessary to check the metal contact pattern.

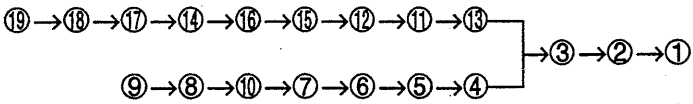


Measuring main metal inside diameter

3.3 Reassembly

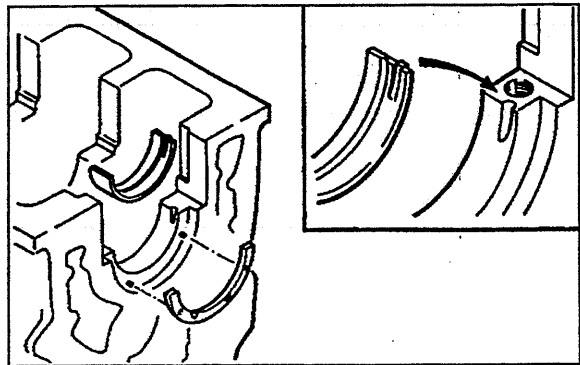


Reassembling sequence



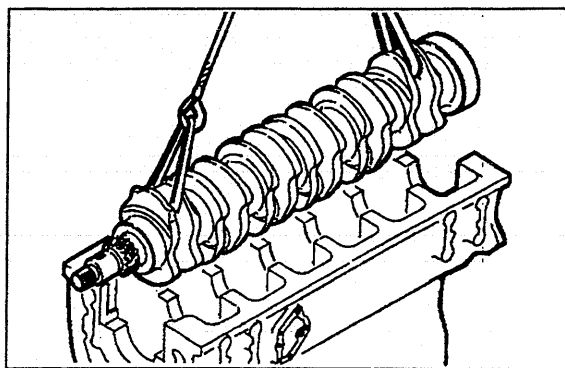
(1) Installing main metals

- (a) Install each upper shell in the crankcase by fitting its locking lip in the recess. The oil holes in the shell and crankcase will be aligned when the shell is so installed.
- (b) Apply a thin coat of engine oil to the inside surface of each shell.
- (c) Install the thrust plate to the rear face of crankcase with its oil groove facing outside.



(2) Installing crankshaft

- (a) Wash the crankshaft with cleaning solvent, and dry it by directing pressure air.
- (b) Hold the crankshaft in horizontal position, and carefully put it on the crankcase.
- (c) Apply a thin coat of engine oil to the journals of crankshaft.

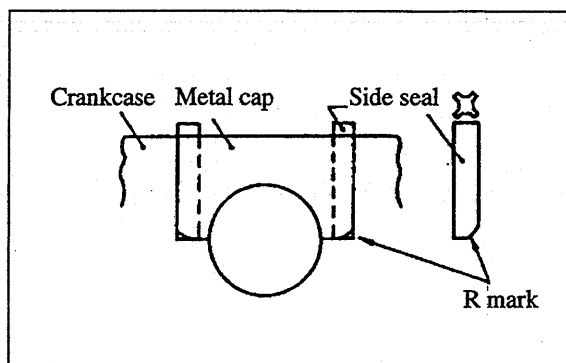


(3) Installing main metal caps

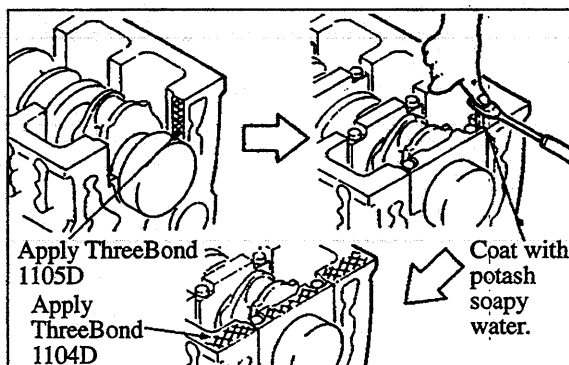
- (a) Apply engine oil to each lower shell, and fit it to the metal cap.
- (b) Apply ThreeBond 1105D to the mating faces of front cap, rear caps and crankcase before installing the caps.

NOTE

Do not apply ThreeBond 1105D to any surface other than those mating faces of the caps and crankcase.



- (c) Install the metal caps to the crankcase, making sure that they are flush with the crankcase walls on the front and rear sides.
- (d) Coat the side seals with potash soapy water, and insert them into the grooves in each metal cap. Using the face of a screwdriver, push in the seals, bringing their rounded corners on the outer side and taking care not to twist the seals.
- (e) Apply ThreeBond 1104 (grey in color) to the side seal joint.

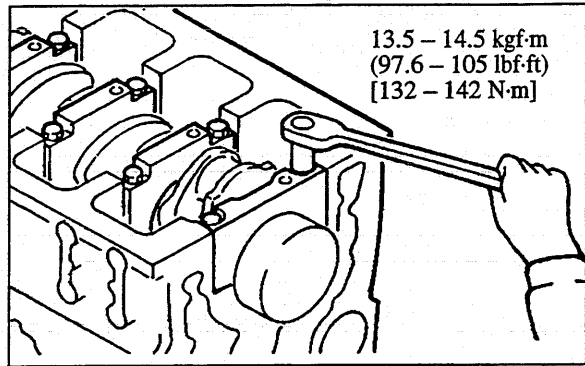
**NOTE**

The metal caps have metal numbers stamped on them. Install the caps in that order from the front side of the engine.

ENGINE PROPER

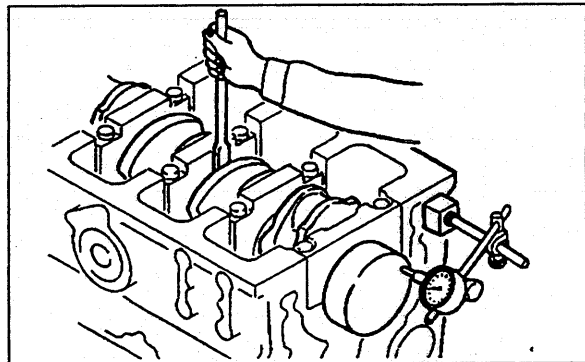
(4) Installing metal cap bolts

Apply engine oil to the bolts, and tighten them to the specified torque.



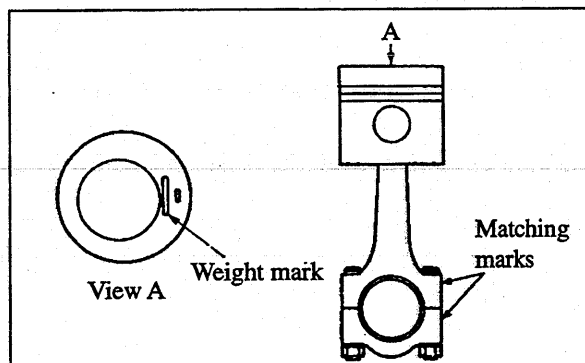
(5) Measuring end play of crankshaft

After installing the metal caps, measure the end play to make sure that it is correct. (Refer to 3.2, Group No. 7.)



(6) Assembling piston and connecting rod

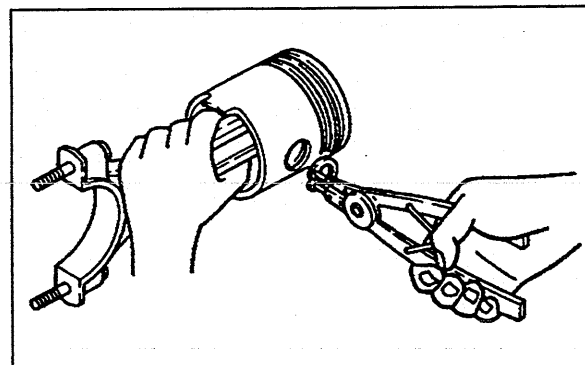
- (a) Assemble the piston and connecting rod with their weight and matching marks on the same side.
- (b) Apply engine oil to the piston, and connect it to the connecting rod.



- (c) Using a snap ring pliers, fit the snap rings to the grooves in the piston, making sure that they are not weakened.

NOTE

Position the ends of the snap rings on the lower side of the piston.

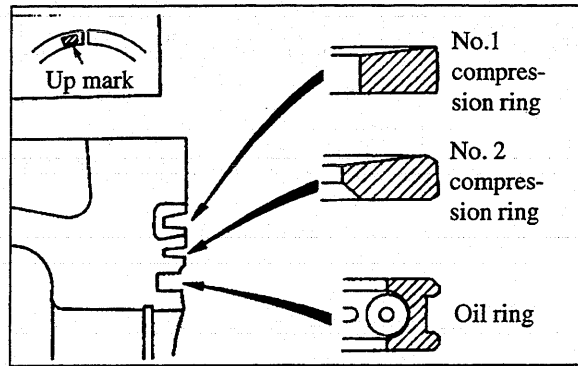


(7) Installing piston rings

- (a) Using piston ring pliers (30091-07100), install the compression (No. 1 and No. 2) rings and oil ring on the piston.

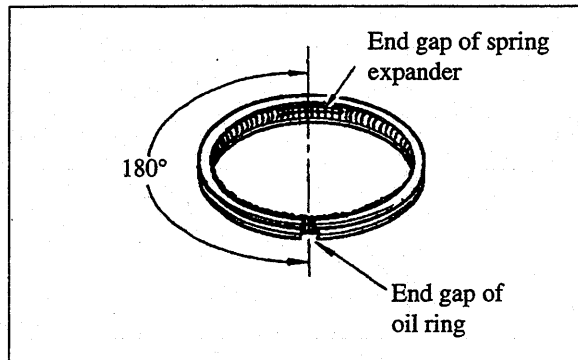
NOTE

When installing piston rings, position the rings so that either "R" or "T" mark faces up.



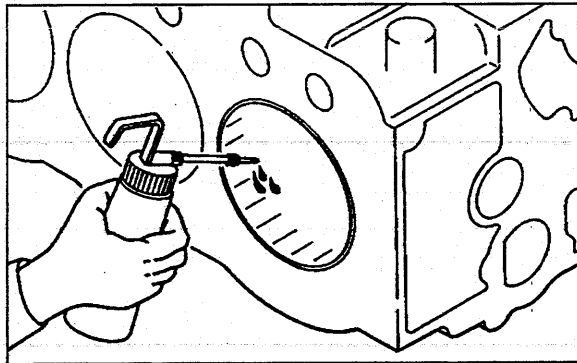
Piston and piston rings

- (b) The oil ring must be installed on the piston with the ring end gap 180° from that of spring expander. Attach teflon tube to the expander close to the oil ring end gap.



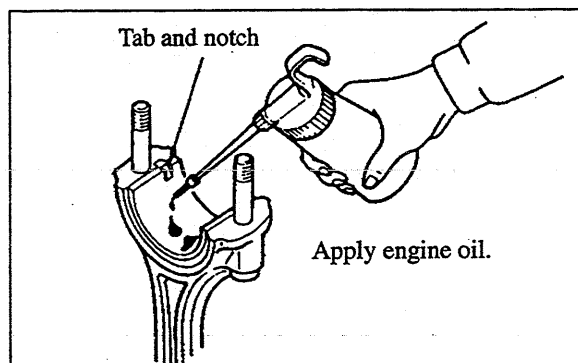
(8) Preparatory steps for installing piston assemblies

- (a) Lay the crankcase on its side.
- (b) Clean the bores with a clean rag and apply engine oil to the bores.



(9) Installing connecting rod bolts and metal

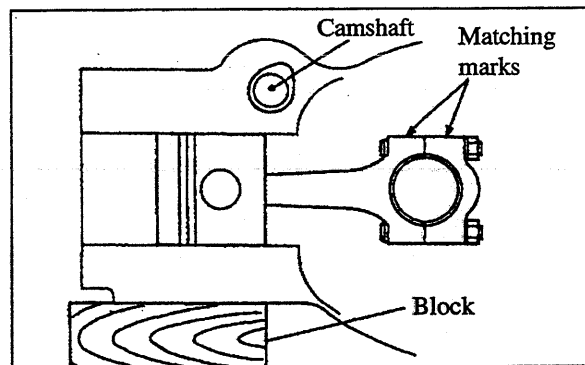
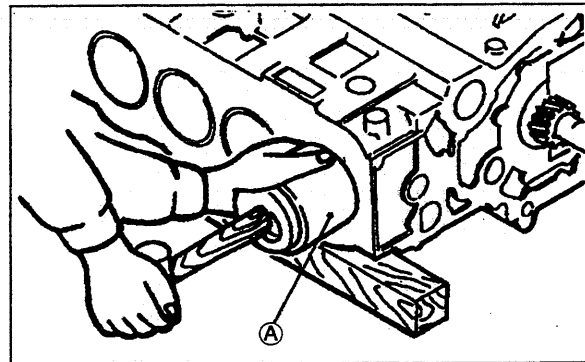
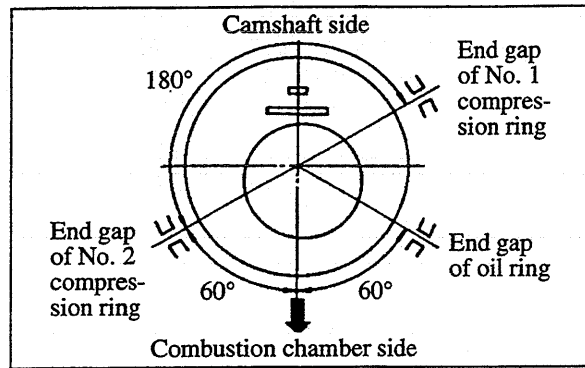
- (a) Install the connecting rod cap bolts in the big end of the connecting rod so the flats of their heads fit on the connecting rod properly.
- (b) Install the upper half of the connecting rod metal in the big end of the connecting rod. Make sure the tab on the back of the metal is in the notch of the connecting rod.



ENGINE PROPER

(10) Installing pistons

- (a) Apply engine oil to the piston rings, and reposition the rings by keeping their end gaps away from the direction of piston pin and thrust side.
- (b) Bring the crankpin to which the piston is to be installed to top dead center position. Using piston installer (A) (34291-00100), insert the piston assembly into the cylinder sleeve.
- (c) After resting the big end of connecting rod on the crankpin, turn crankshaft by 180° while pressing down on the piston head to bring the big end to a position where the cap can be installed easily.

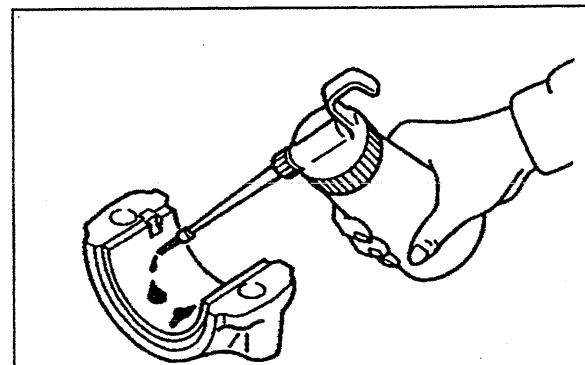


(11) Installing connecting rod cap

- (a) Install the lower shell of the metal in the cap by fitting its locking lip in the recess of the cap, apply engine oil to the inside surface of the shell.
- (b) Install the cap, and apply oil to the threads and seats of the nuts. Then, tighten the nuts to the specified torque.

Unit: kgf·m (lbf·ft) [N·m]

Tightening torque	10.5±0.5 (76±3.6) [103±5]
-------------------	---------------------------



CAUTION

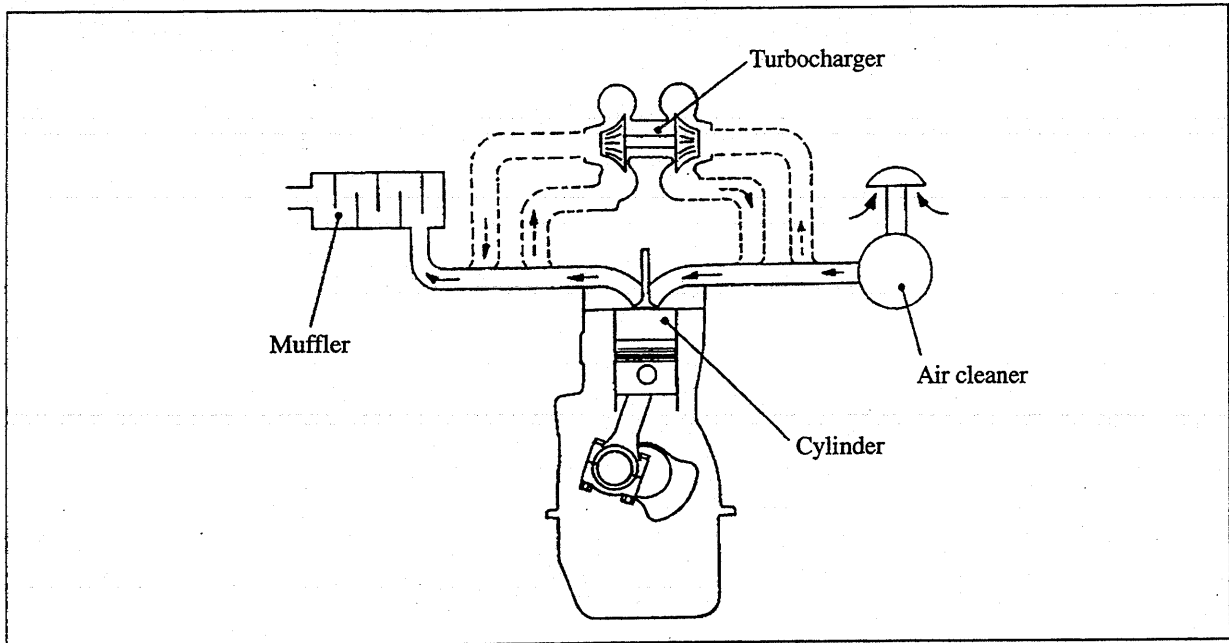
Make sure that the matching marks of the cap and rod are on the same side.

AIR INLET AND EXHAUST SYSTEM

1. DESCRIPTION	8-2
2. PAPER-ELEMENT TYPE AIR CLEANER	8-2
Disassembly and inspection	8-2
3. EXHAUST MANIFOLD	8-3
Inspection	8-3

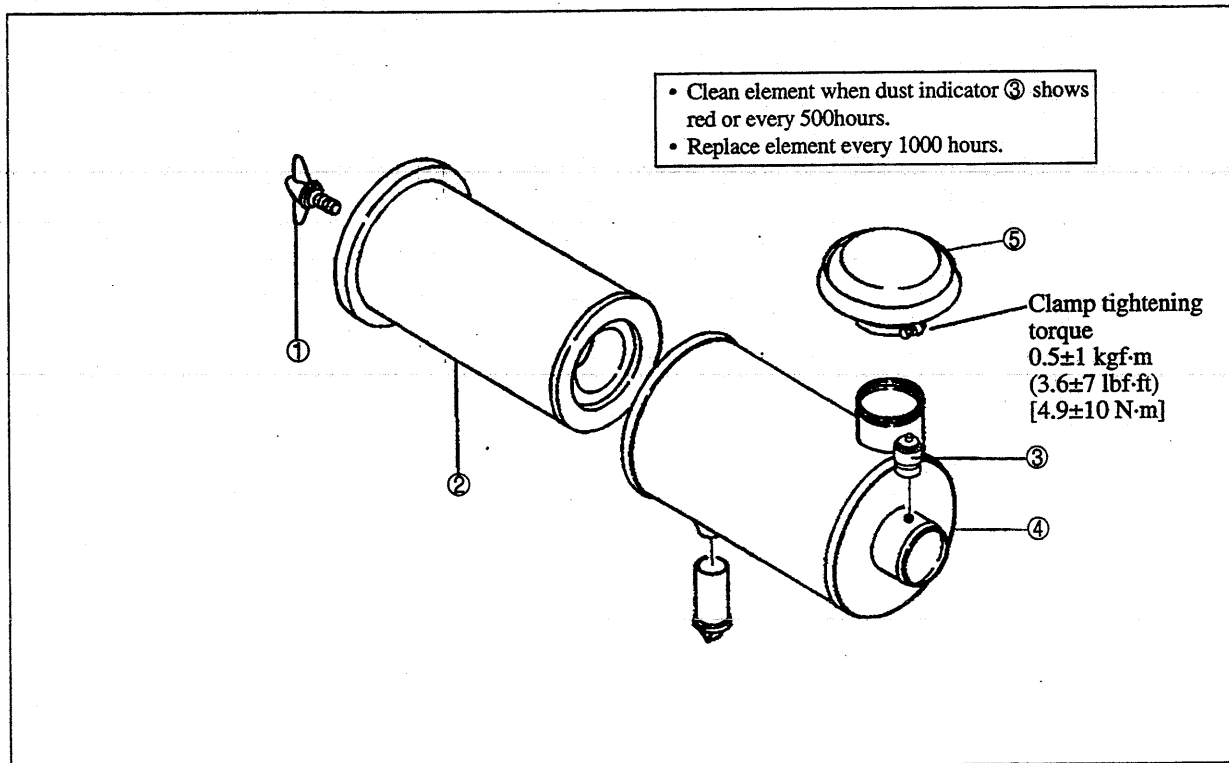
AIR INLET AND EXHAUST SYSTEM

1. DESCRIPTION



2. PAPER-ELEMENT TYPE AIR CLEANER

Disassembly and inspection



- ① Wing nut
- ② Element
- ③ Dust indicator
- ④ Air cleaner body

- ⑤ Air cleaner cap

CAUTION

When removing the air cleaner for servicing, be sure to stop the engine and cover the air inlet port to prevent dirt from entering the engine.

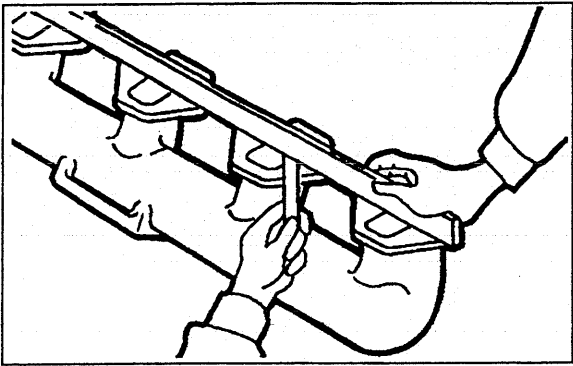
3. EXHAUST MANIFOLD

Inspection

- (a) Check each flange for cracks.
- (b) Check each flange for warpage. If the warpage exceeds the Assembly standard, repair the flanges.

Unit: mm (in.)

Item	Assembly standard
Warpage of exhaust manifold flanges	0.2 (0.008), maximum



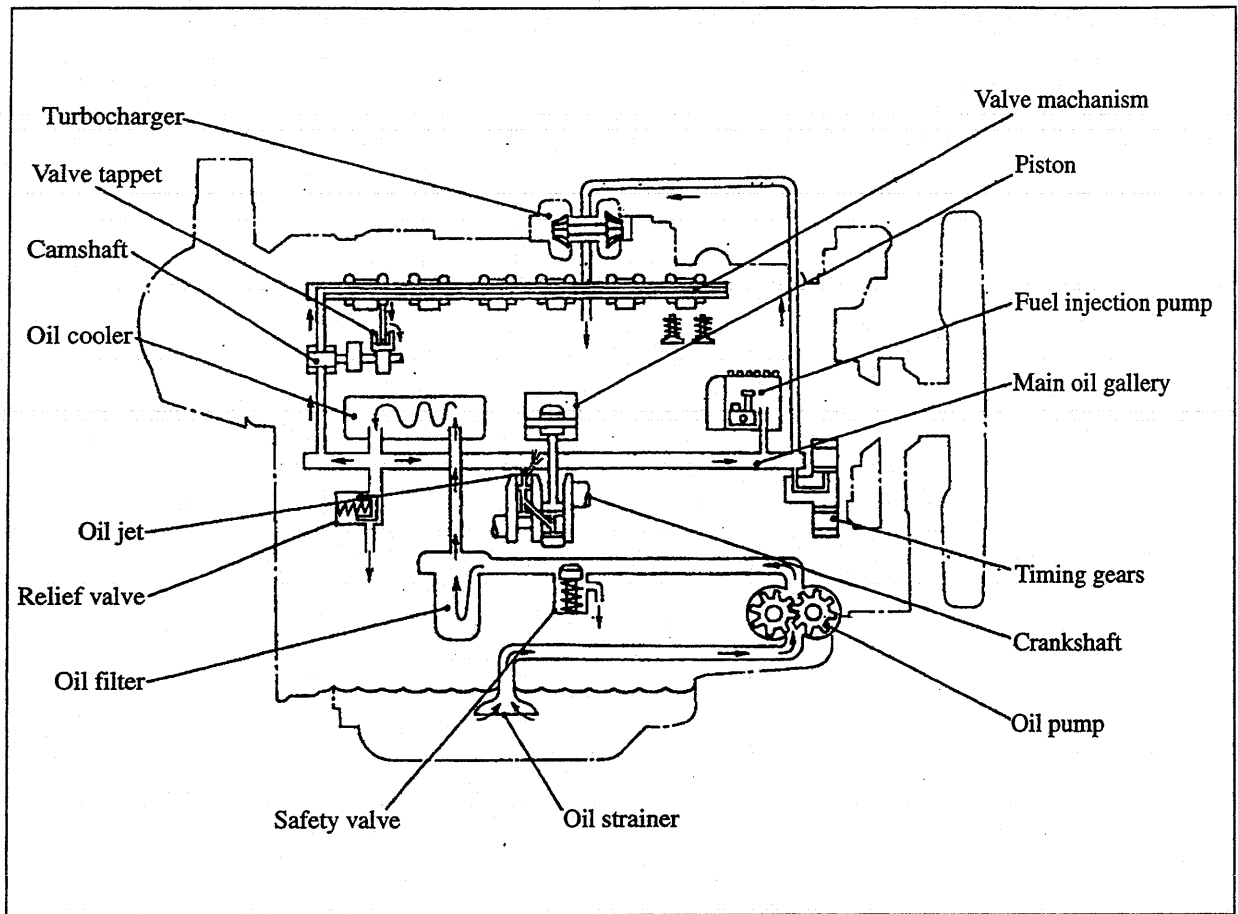
Checking exhaust manifold flanges for warpage

LUBRICATION SYSTEM

1. DESCRIPTION	9-2
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Inspection	9-9
6. SAFETY VALVE (PRIMARY)	9-9
Inspection	9-9
7. SAFETY VALVE (SECONDARY)	9-9

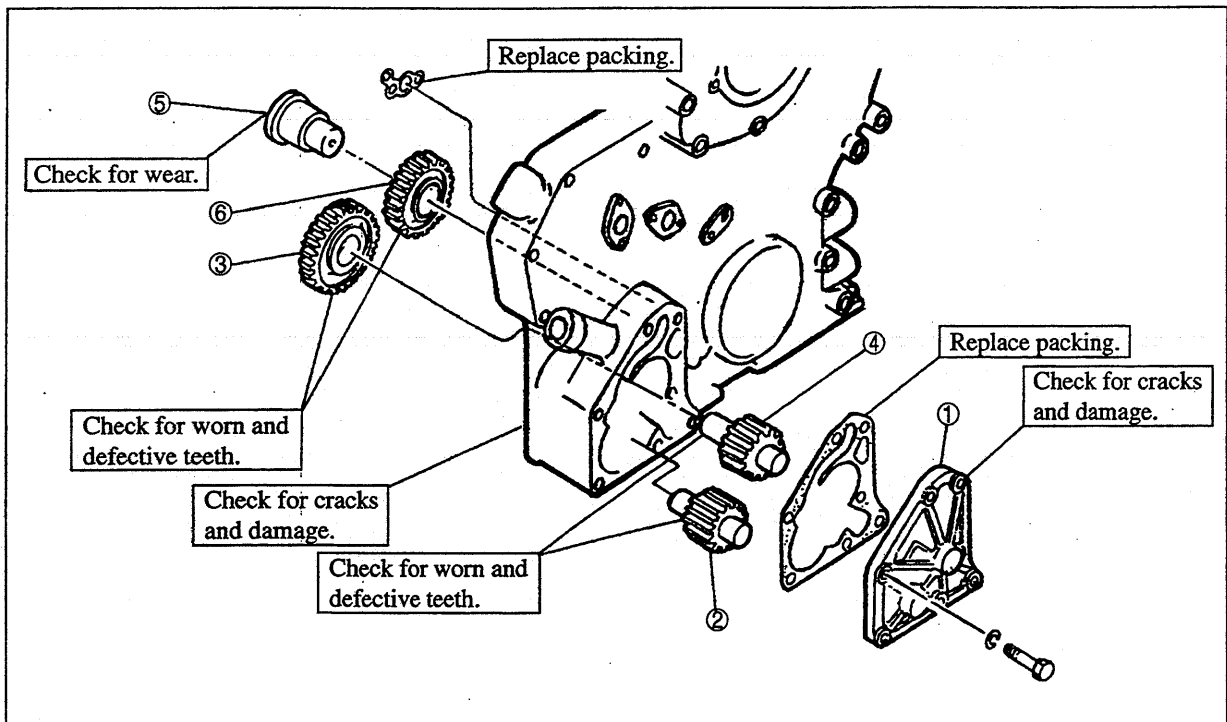
LUBRICATION SYSTEM

1. DESCRIPTION



2. OIL PUMP

2.1 Disassembly



- | | | |
|---------------------------|------------------------|-----------------------|
| ① Cover assembly, packing | ③ Oil pump gear | ⑤ Spindle |
| ② Driven gear assembly | ④ Driven gear assembly | ⑥ Idler gear assembly |

NOTE

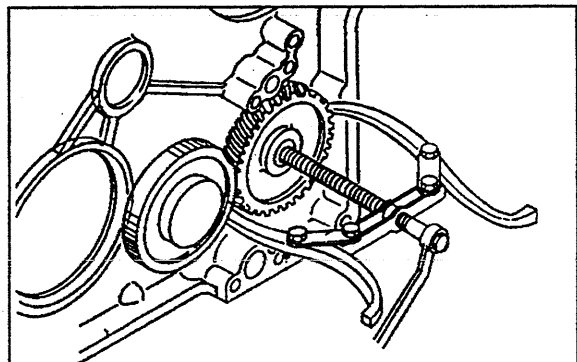
Before removing the gears, check and repair the pump parts by referring to 2.2.

(1) Removing oil pump gear

Using a puller, remove the gear.

NOTE

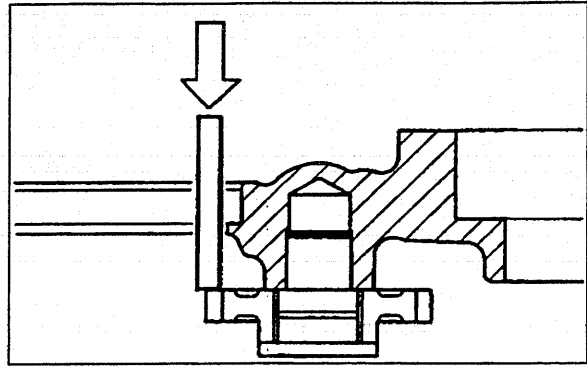
Removal of the pump gear makes the pump gear and drive gear unserviceable: replace these gears with new ones.



LUBRICATION SYSTEM

(2) Removing spindle and idler gear

Remove the spindle and idler gear as an assembly by pushing the gear with a wood bar through oil seal mounting hole. Rotate the gear while pushing it.

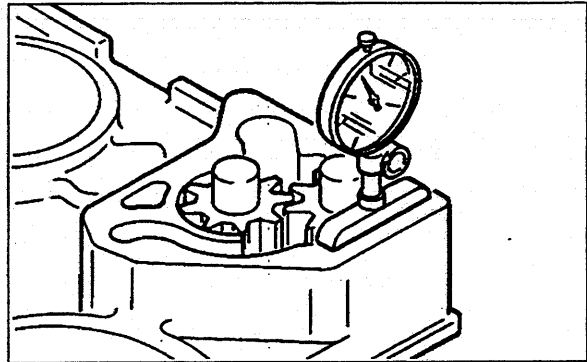


2.2 Inspection and repair

Drive gear and driven gear

(1) End clearance of gears in case

Using a dial gauge, measure the clearance. If the clearance exceeds the Service limit, replace the gear assembly.

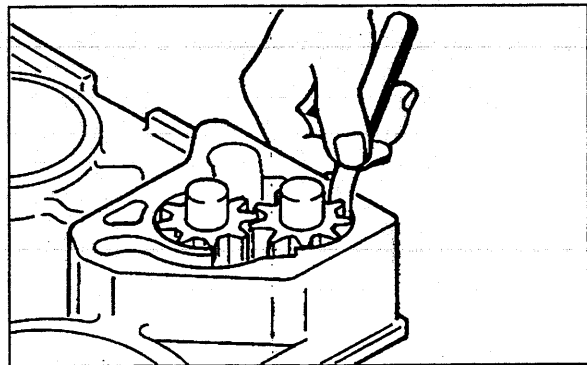


Unit: mm (in.)

Item	Standard clearance	Service limit
End clearance of pump gears in case	+0.02 -- -0.034 (+0.0008 -- -0.00134)	-0.15 (0.0059)

(2) Radial clearance of gears in case

Using a feeler gauge, measure the clearance. If the clearance exceeds the Service limit, replace the gear assembly.



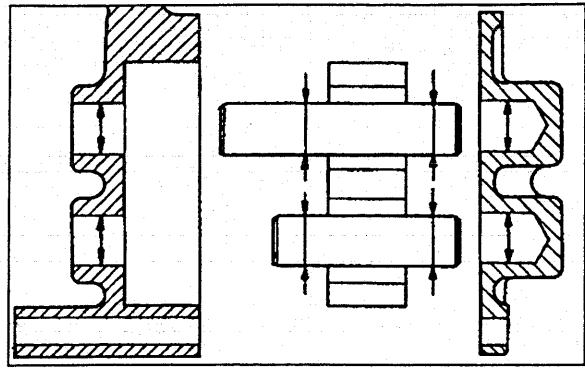
Unit: mm (in.)

Item	Standard clearance	Service limit
Radial clearance of pump gears in case	0.05 - 0.098 (0.0020 - 0.00386)	0.10 (0.0039)

Cover, timing gear case and gear shafts

Measuring clearance of gear shaft in case and cover

- (a) Check the gear teeth for condition, and replace the gear assembly if they are defective.
- (b) Measure the diameter of the gear shaft and the inside diameter of the cover and case to determine clearance. If the clearance exceeds the Service limit, replace the gear assembly, cover or case whichever is badly worn.



Clearance of gearshaft in case and cover

Unit: mm (in.)

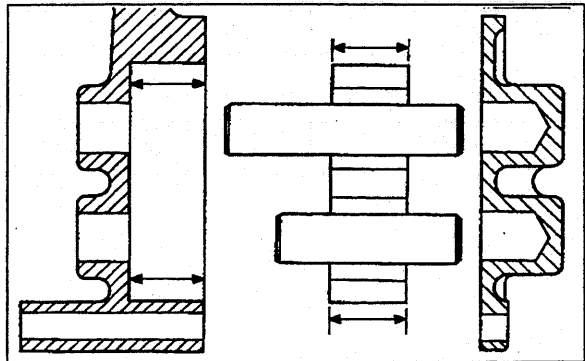
Item		Standard clearance	Service limit
Clearance of gearshaft in case and cover	S4K S4K-T	+0.02 -- 0.034 (+0.00079 - -0.00013)	0.15 (0.0059)
	S6K S6K-T	+0.01 -- 0.0054 (+0.000394 - -0.000213)	0.15 (0.0059)



Replace the drive and driven gear as an assembly.

Unit: mm (in.)

Item	Standard clearance	Service limit
Clearance inside diameter of gearshaft in case and cover	0.04 - 0.07	0.15



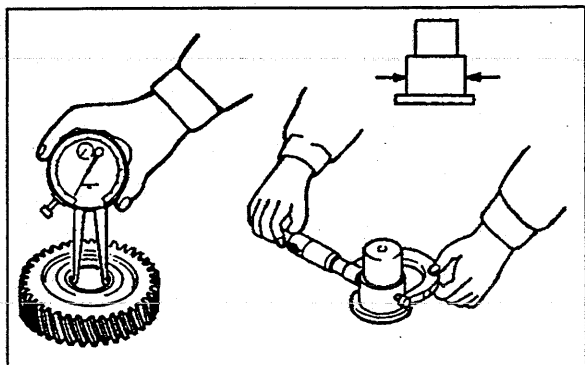
Clearance inside diameter of gearshaft in case and cover

Spindle and idler gear

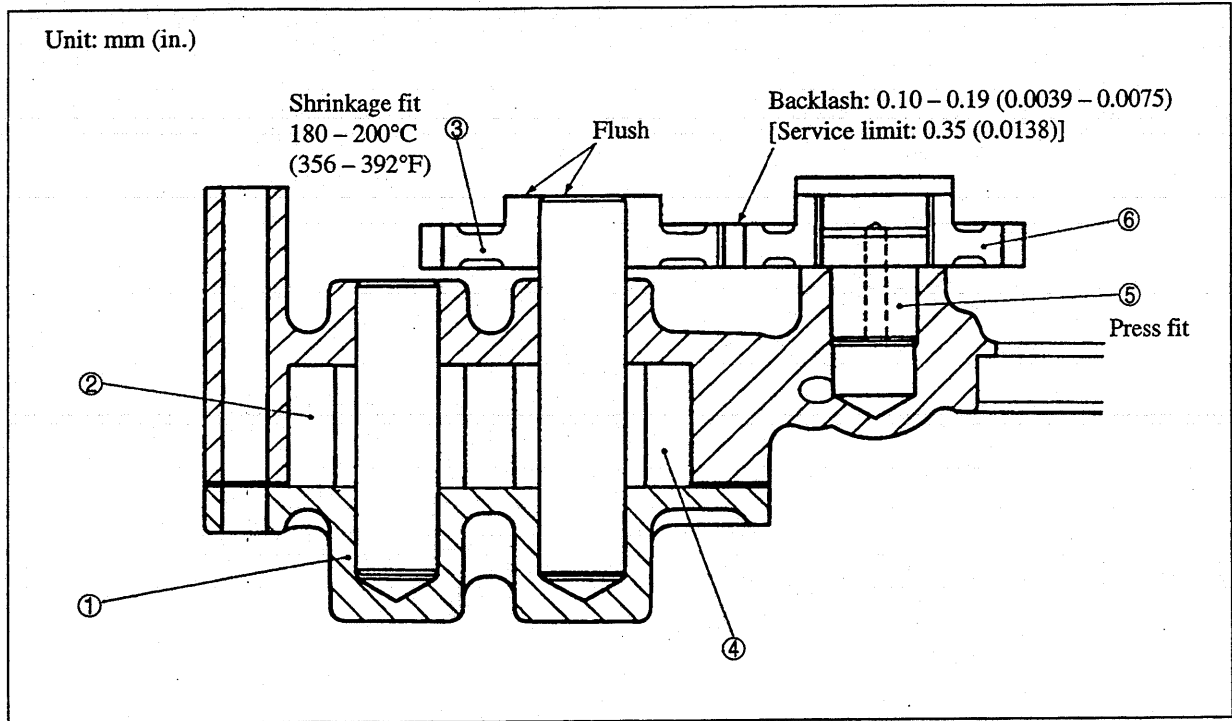
Measure the diameter of the spindle and the inside diameter idler gear bushing. Replace the parts if they are badly worn.

Unit: mm (in.)

Item	Nominal value	Assembly standard
Diameter of spindle	25 (0.98)	24.939 - 24.960 (0.98185 - 0.98268)
Inside diameter of idler gear bushing		25.000 - 25.021 (0.98425 - 0.98508)



2.3 Reassembly

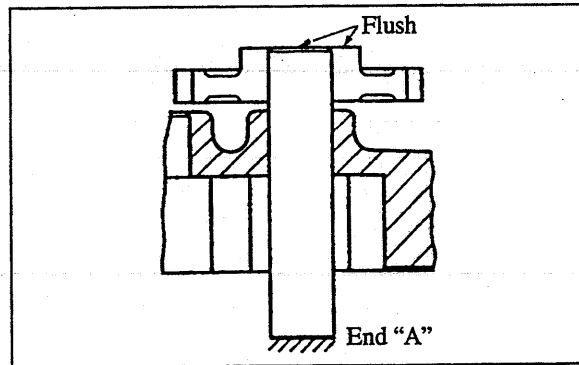


Reassembling sequence

② → ④ → ③ → ⑥ → ⑤ → ①

(1) Assembling oil pump gear and drive gear assembly

- (a) Heat the oil pump gear up to 180 to 220°C (356 to 428°F).
- (b) Support the end (A) of the shaft, and fit the gear to the shaft until their ends are flush.

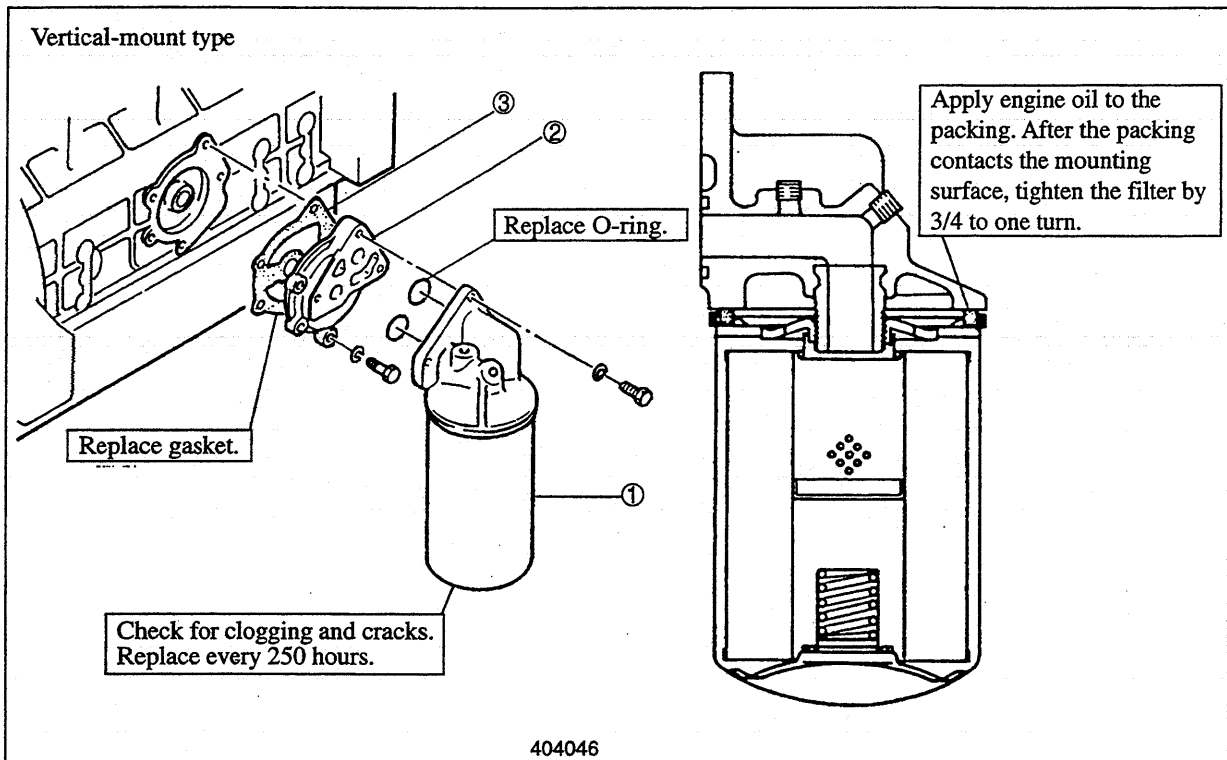


CAUTION

Replace the oil pump gear and drive gear assembly (which are unserviceable) with new ones.

3. OIL FILTER

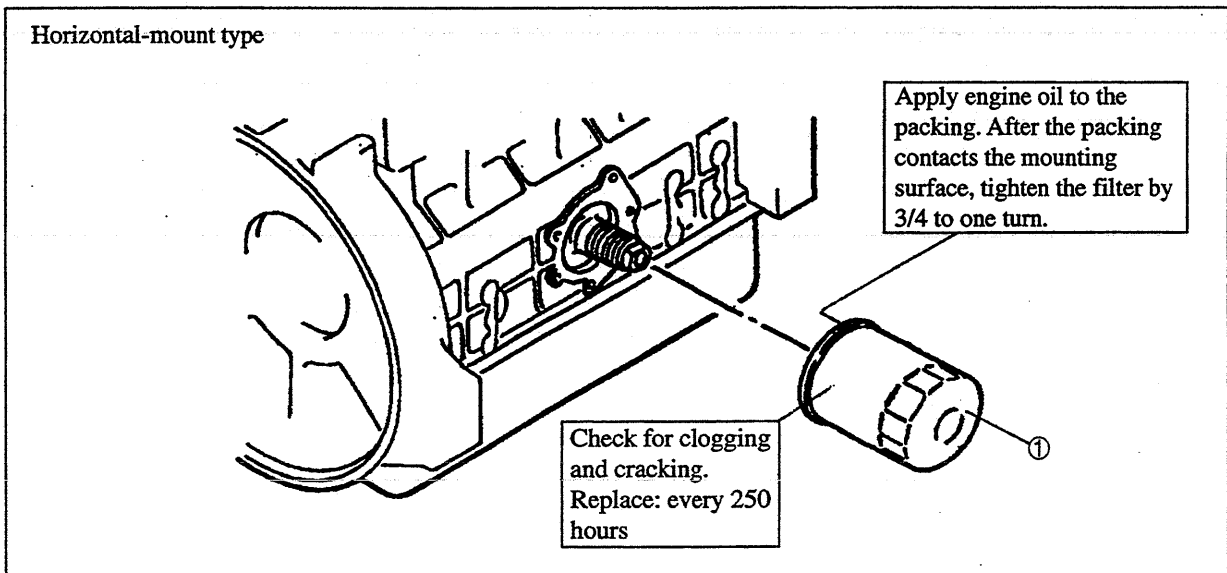
Disassembly and inspection



① Filter element

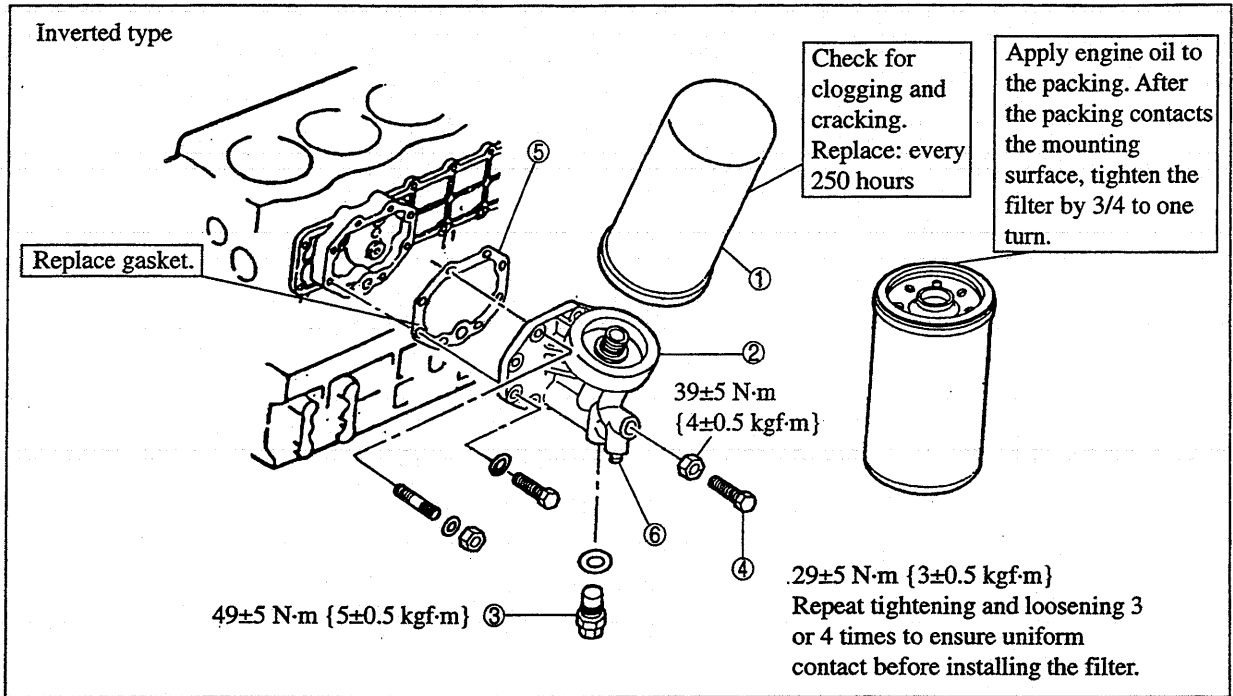
② Bracket

③ Gasket



① Filter element

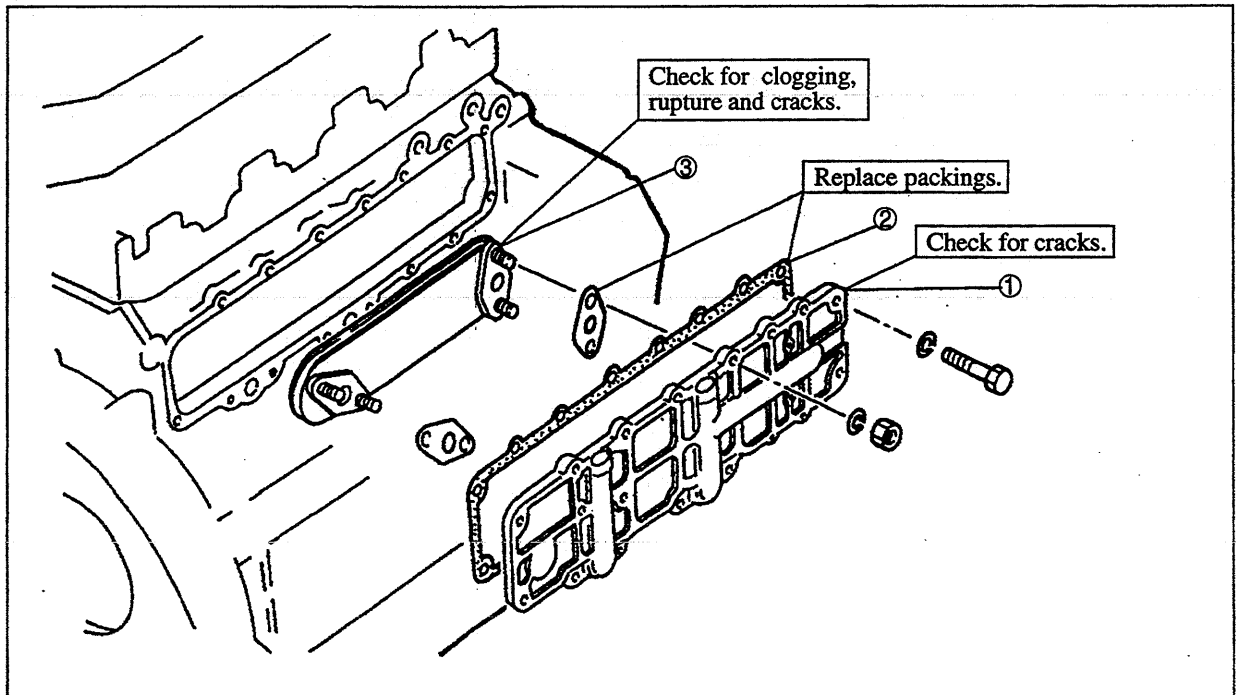
LUBRICATION SYSTEM



- ① Filter element ② Bracket ③ Bypass valve ④ Drain valve ⑤ Gasket ⑥ Oil outlet

4. OIL COOLER

Inspection



- ① Cover ② Gasket ③ Element

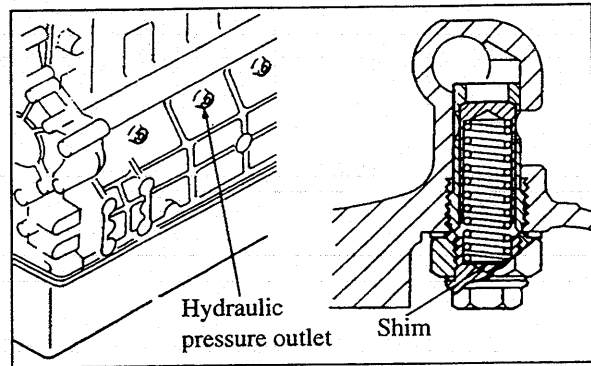
5. RELIEF VALVE

Inspection

- (1) Check the valve seat for abnormal contact. Also check the spring for weakness and breakage.
- (2) Measure the relief valve opening pressure. If it exceeds the Assembly standard, make an adjustment by shimming.

Unit: kgf/cm² (psi) [MPa]

Item	Assembly standard
Relief valve opening pressure	3.5 ± 0.5 (49.8 ± 7.1) [0.34 ± 0.02]

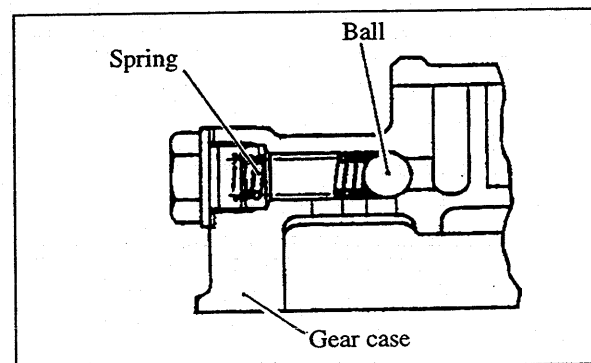


6. SAFETY VALVE (PRIMARY) (EQUIPPED ON S6K AND S6K-T)

Inspection

Check the valve seat for abnormal contact. Also check the spring for weakness and breakage.

Item	Assembly standard
Valve opening pressure	12 ± 1.0 kgf/cm ² (171 ± 14.2 psi) [1.2 ± 0.1 MPa]

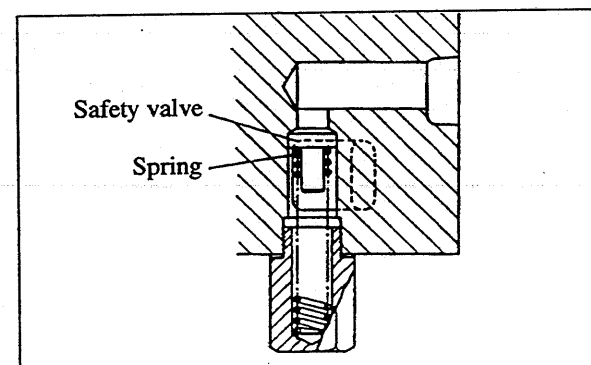


7. SAFETY VALVE (SECONDARY)

Inspection

Check the valve seat for abnormal contact. Also check the spring for weakness and breakage.

Item	Assembly standard
Valve opening pressure	10 ± 1.0 kgf/cm ² (142 ± 14.2 psi) [1.0 ± 0.1 MPa]

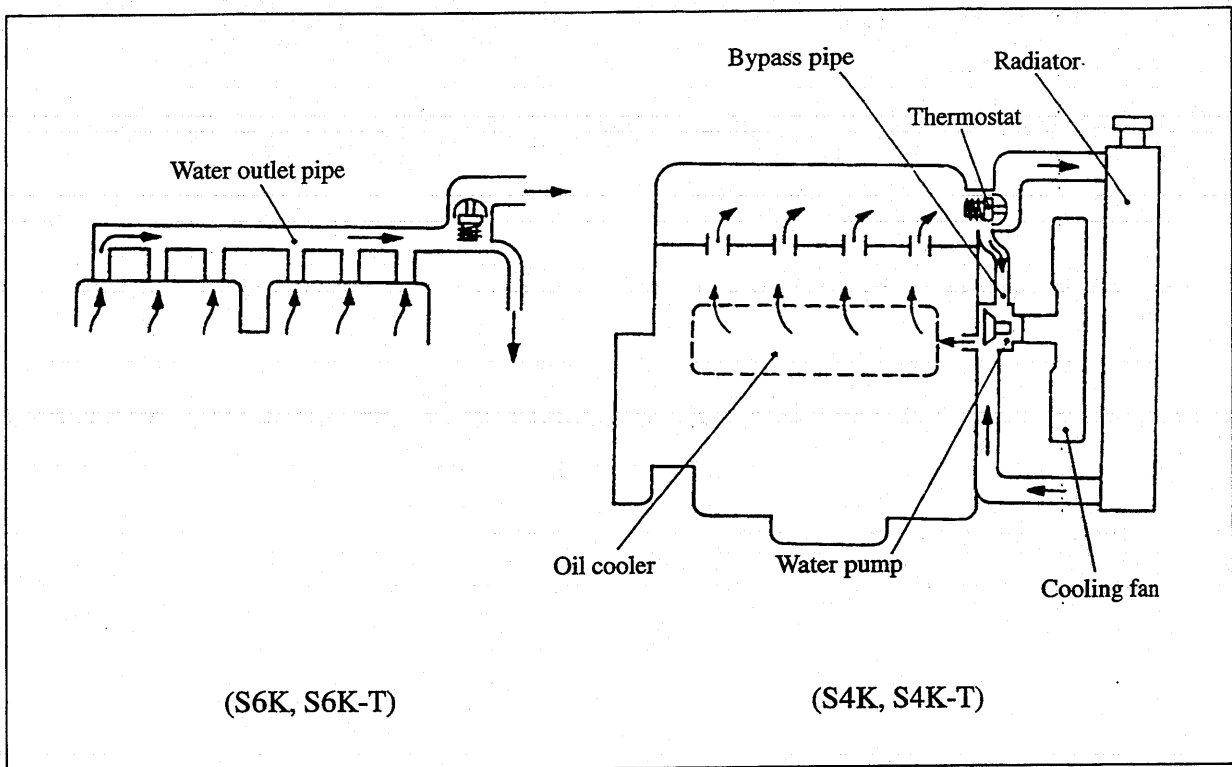


COOLING SYSTEM

1. DESCRIPTION	10-2
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2.2 Inspection	10-3
2.3 Reassembly	10-5
3. THERMOSTAT	10-6
Inspection	10-6
4. RADIATOR, FAN AND FAN BELT	10-7
Inspection	10-7

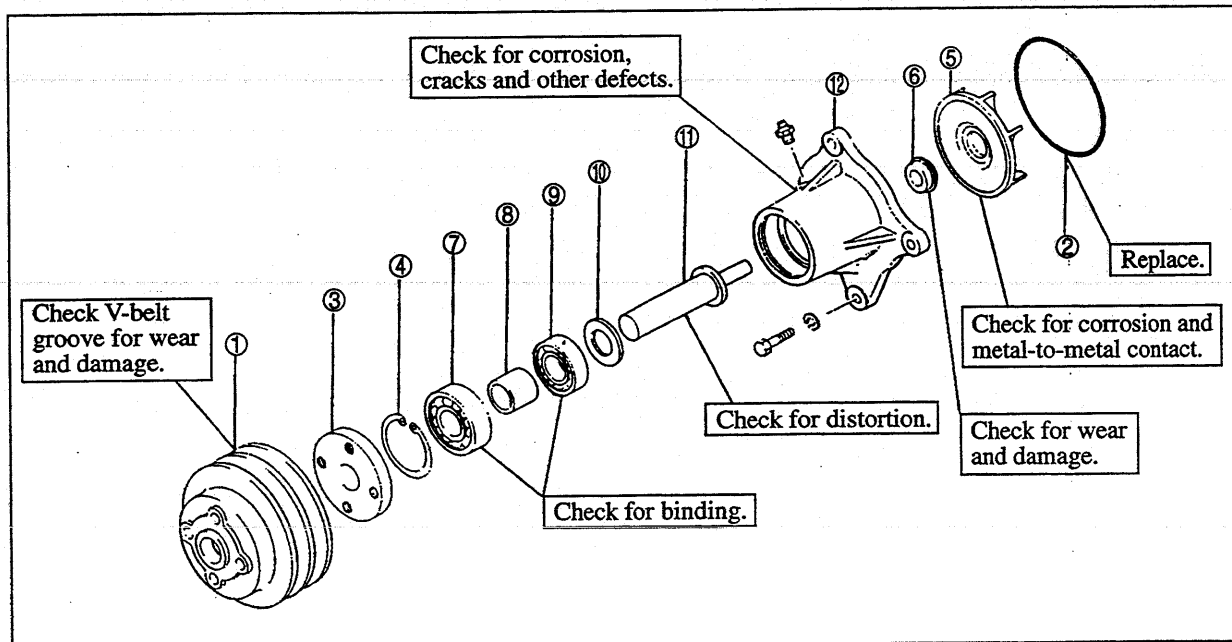
COOLING SYSTEM

1. DESCRIPTION



2. WATER PUMP

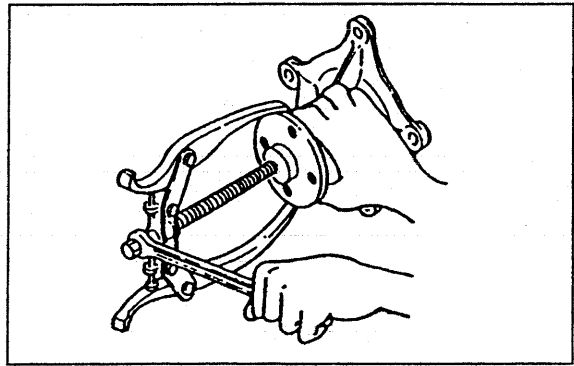
2.1 Disassembly



- | | | |
|---------------------|-------------|-----------|
| ① Water pump pulley | ⑤ Impeller | ⑨ Bearing |
| ② O-ring | ⑥ Unit seal | ⑩ Washer |
| ③ Flange | ⑦ Bearing | ⑪ Shaft |
| ④ Snap ring | ⑧ Spacer | ⑫ Case |

(1) Removing flange

Using a puller, remove the flange.

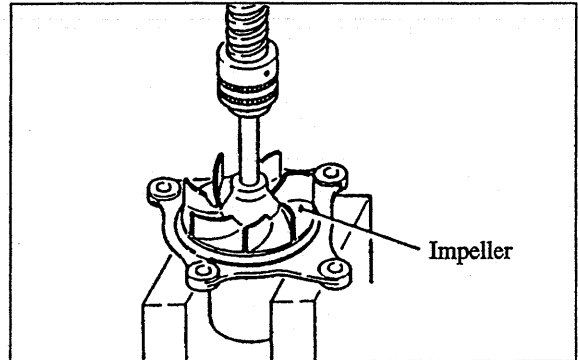


(2) Removing impeller and shaft

- (a) Remove the snap ring.
- (b) Using a press, remove the shaft complete with the bearings. Remove the impeller.

NOTE

If the case is heated up to 80°C (176°F), the parts can be removed easily.



2.2 Inspection

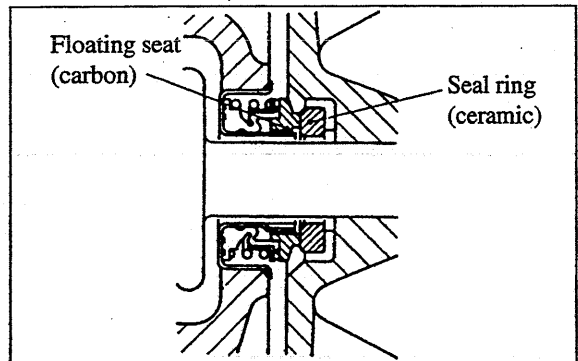
Unit seal

Checking for water leakage

Check the unit seal for condition. Replace the seal if any sign of leakage is noted during operation.

Unit: mm (in.)

Item	Assembly Standard	Service limit
Carbon protrusion	1.5 (0.059)	0
Free-state height	21.8 ± 1 (0.858 ± 0.04)	



Unit seal

COOLING SYSTEM

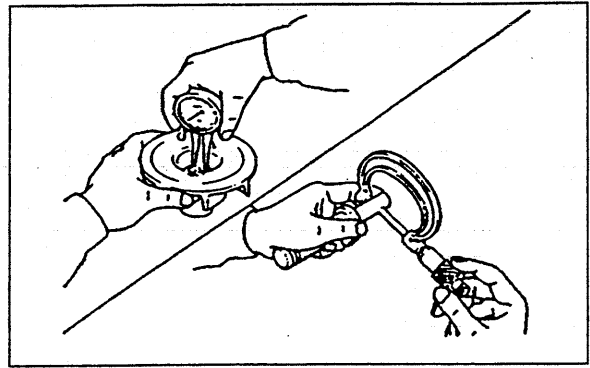
Water pump shaft

Checking fit (interference) of pump shaft in flange

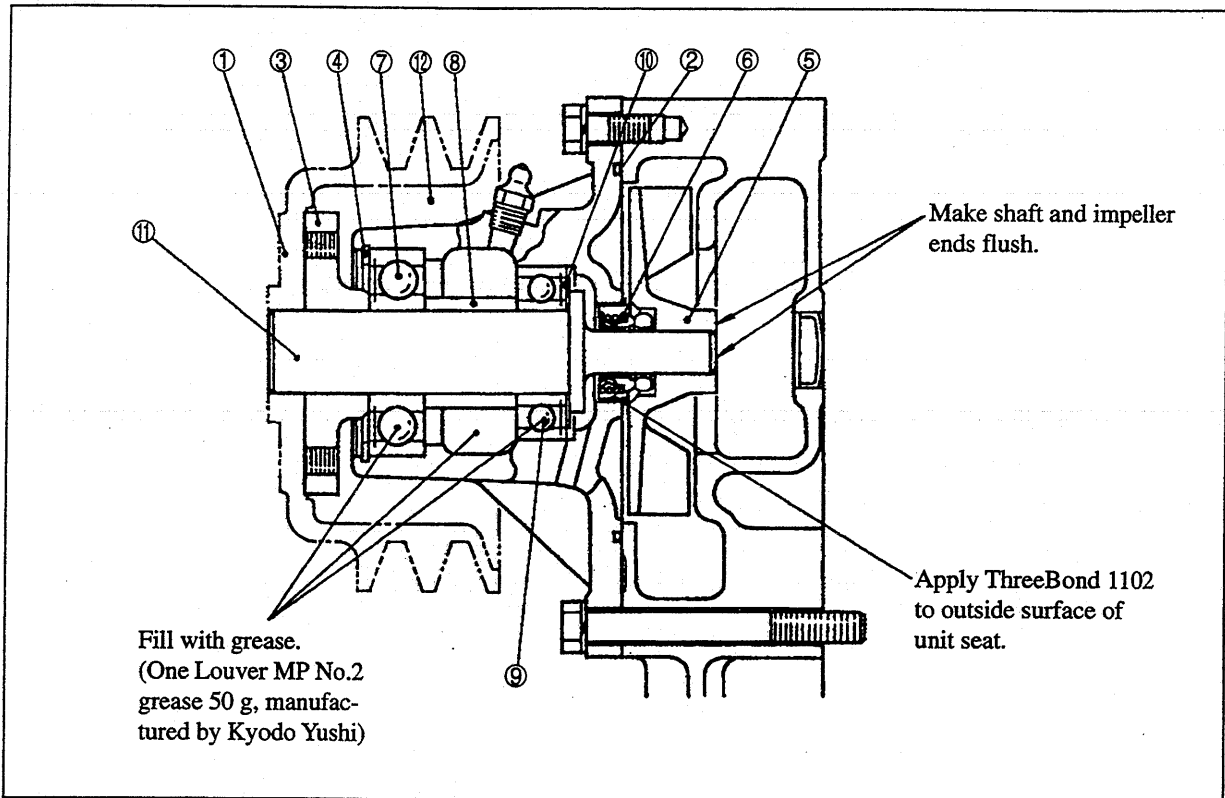
Removal of the flange or impeller from the pump shaft affects the fit between the two. Replace the parts with new ones if the fit is out of specification even if the pump has not been reassembled 2 times.

Unit: mm (in.)

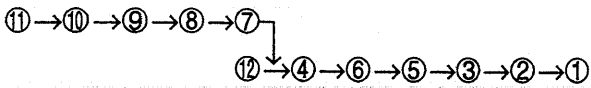
Item	Standard clearance
Fit (interference) of pump shaft in flange	0.035 – 0.065 (0.00138 – 0.00256)
Fit (interference) of pump shaft in impeller	0.032 – 0.065 (0.00126 – 0.00256)



2.3 Reassembly



Reassembling sequence



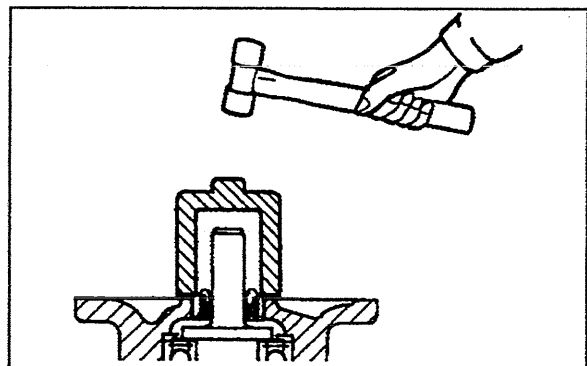
CAUTION

- (a) Install the water pump to the timing gear case, and make sure that the impeller does not touch the case.
- (b) Do not reassemble the flange and impeller more than 2 times.

(1) Installing unit seal

To install the seal, use a unit seal installer.

Whenever removing the unit seal from the pump case, be sure to replace it with new one.



COOLING SYSTEM

3. THERMOSTAT

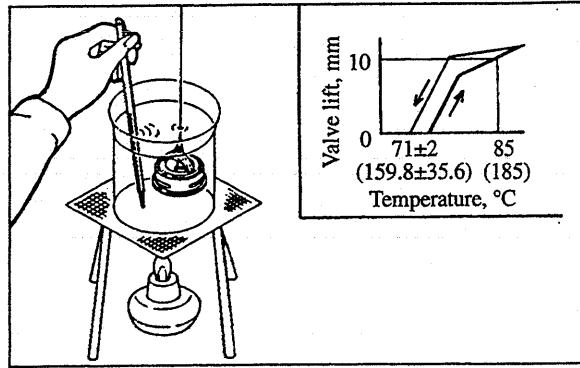
Inspection

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 10 mm (0.4 in.). 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
Temperature at which valve starts opening	76.5±2°C (169.7±3.6°F)
Temperature at which valve life is more than 10 mm (0.4 in.)	90°C (194°F)

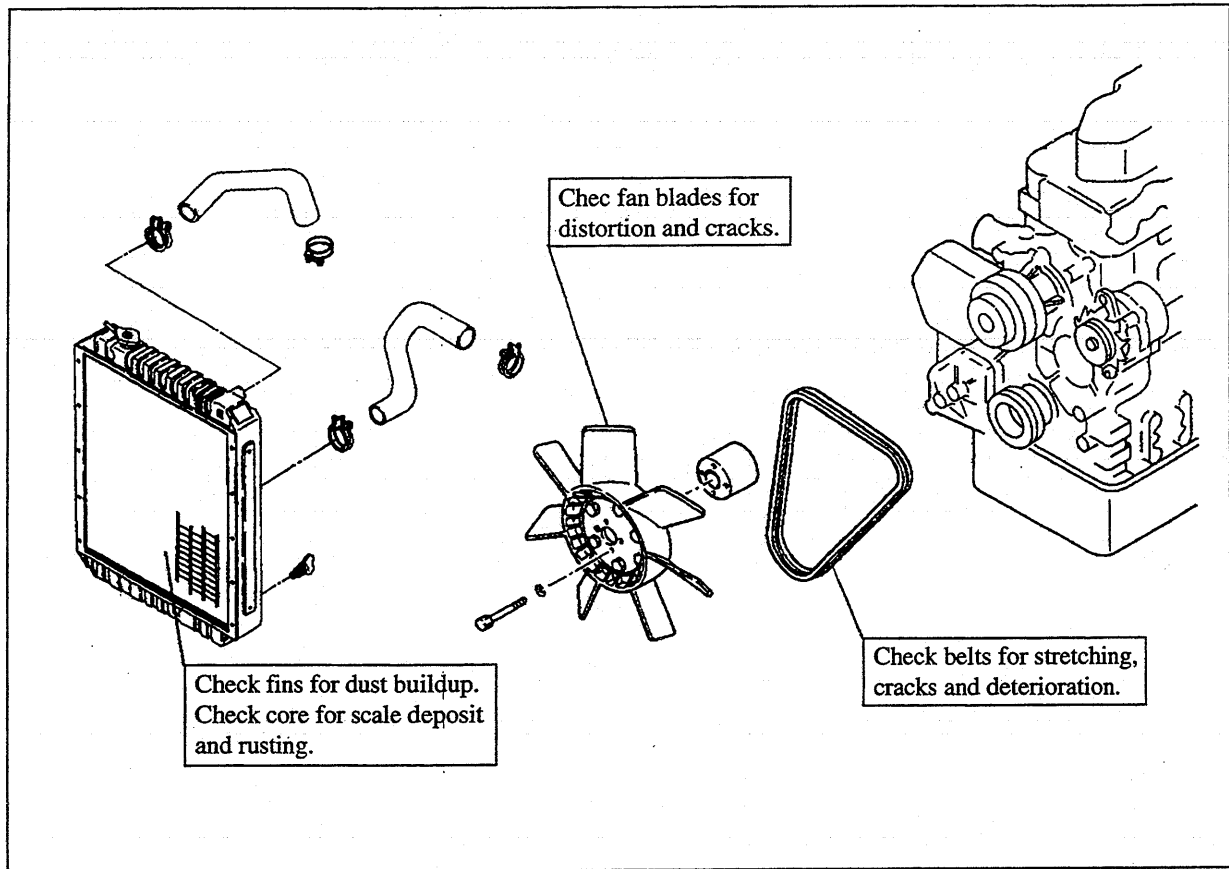
CAUTION

- a) Stir up the water with a stick to keep the temperature uniform.
- b) Install the thermostat with its air vent hole up.



4. RADIATOR, FAN AND FAN BELT

Inspection

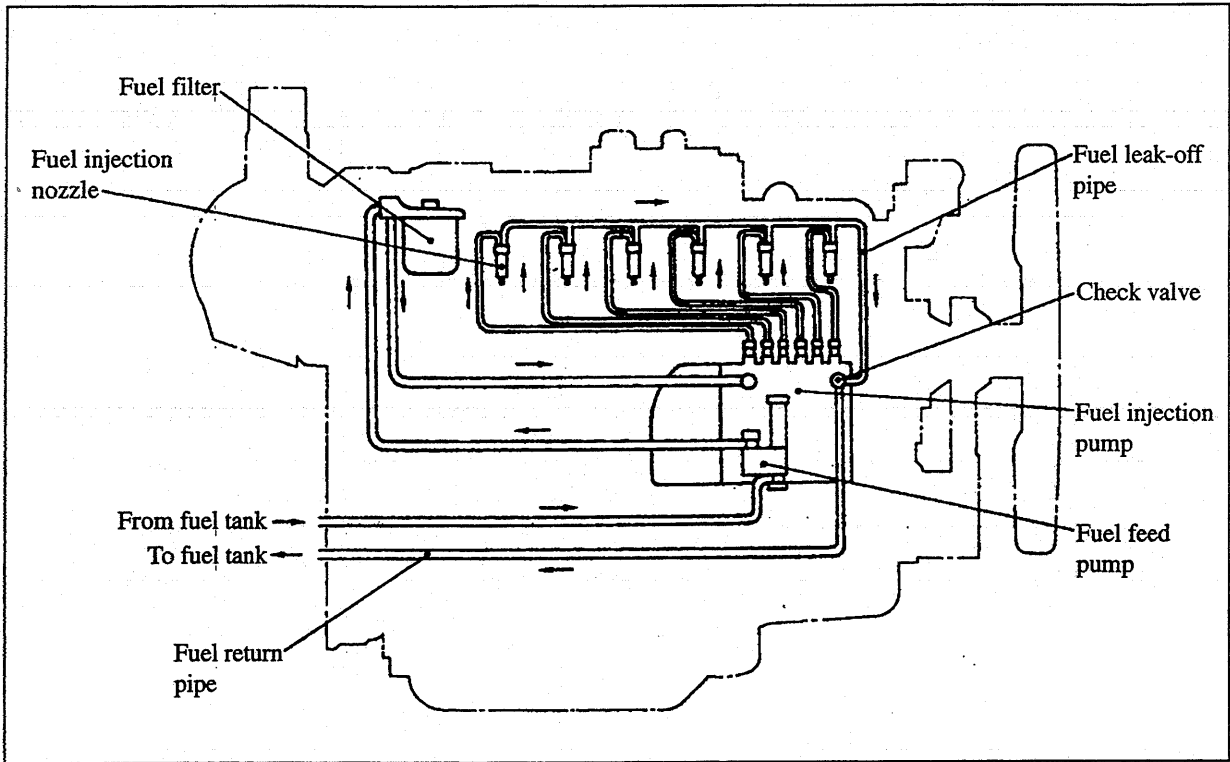


FUEL SYSTEM

1. DESCRIPTION	11-2
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3. FUEL INJECTION NOZZLES	11-3
3.1 Disassembly	11-3
3.2 Inspection and repair	11-3
3.3 Reassembly	11-5

FUEL SYSTEM

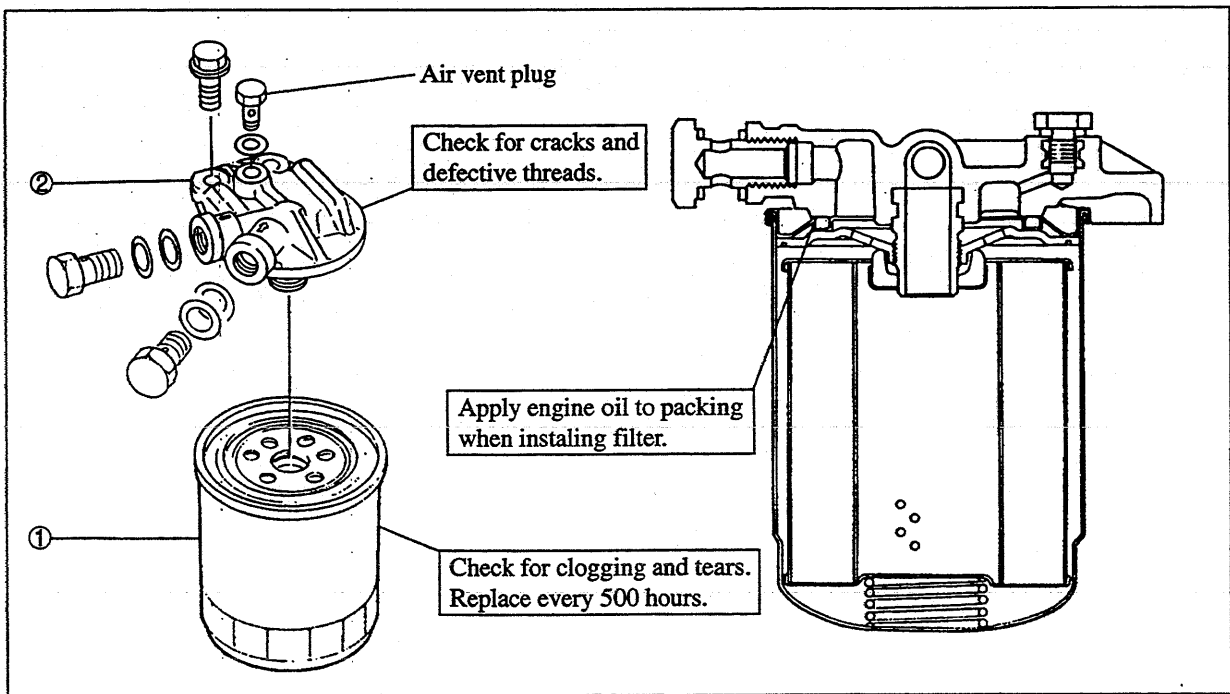
1. DESCRIPTION



2. FUEL FILTER

Disassembly and inspection

Cartridge type paper element

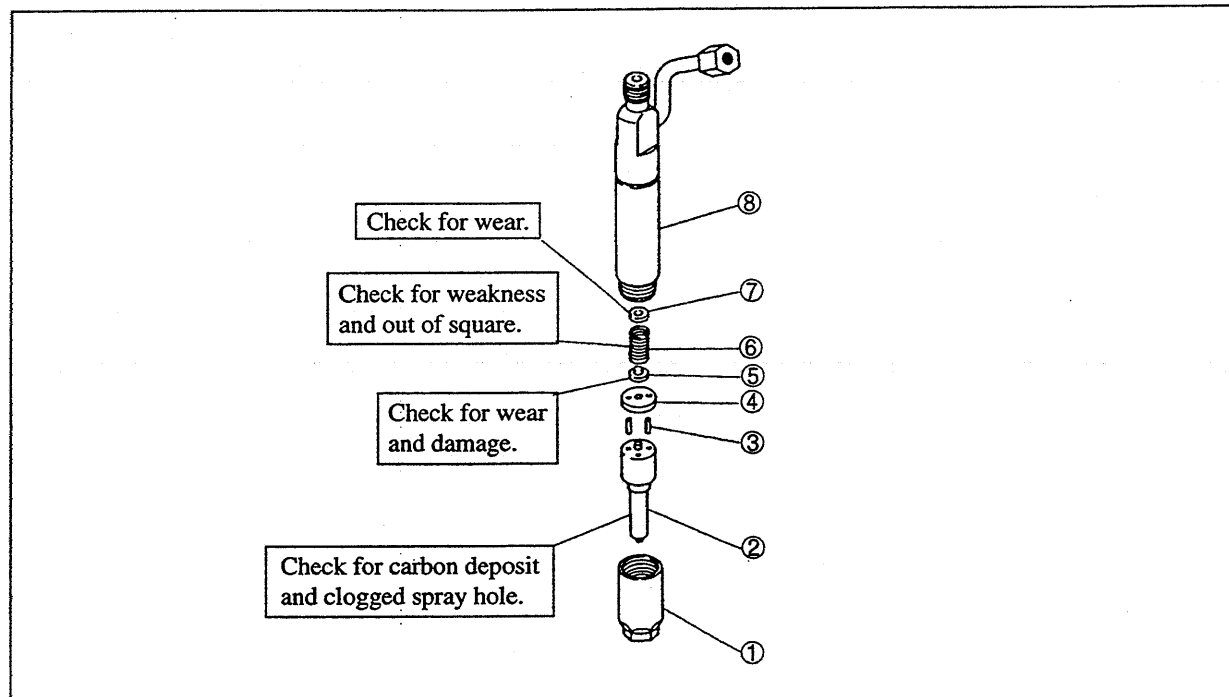


① Element assembly

② Bracket

3. FUEL INJECTION NOZZLES

3.1 Disassembly

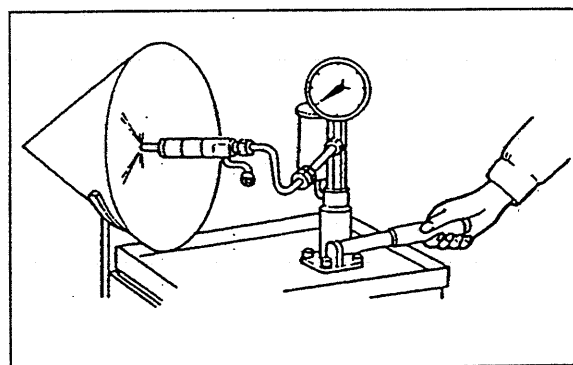


- ① Retaining nut
- ② Nozzle tip
- ③ Straight pin
- ④ Tip packing
- ⑤ Pressure pin
- ⑥ Pressure spring
- ⑦ Shim
- ⑧ Nozzle body

3.2 Inspection and repair

(1) Injection pressure

- (a) Install the injection nozzle on the tester. Slowly operate the tester handle full strokes to bleed (remove) air from the pipe and nozzle.
- (b) Make a slow increase in pressure by operating the tester handle at a speed of more than one stroke per second while observing the pressure gauge.
- (c) The pressure gauge reading will slowly increase and, when the nozzle starts discharging fuel, it will go down fast. Take the gauge reading right then as the injection pressure



Testing injection nozzle

CAUTION

When testing the injection nozzle, keep its tip pointed away from the operator. Fuel from the orifices in the tip of the nozzle is under high pressure and can cause injury to the operator.

Unit: kgf/cm² (psi) [MPa]

Item	Nominal Value	Assembly Standard
Injection pressure (Valve opening pressure)	220 (3128) [21.6]	225 - 235 (3200 - 3342) [22 - 23]

FUEL SYSTEM

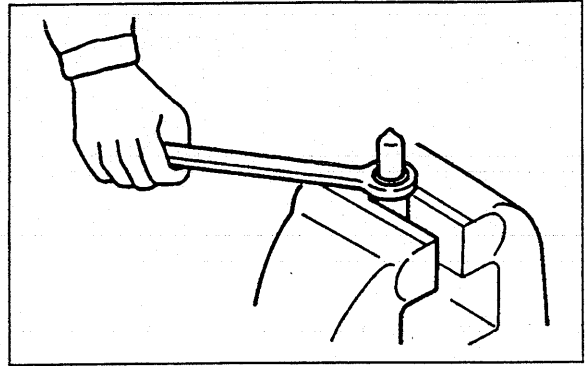
- (d) If the injection pressure is not correct, make an adjustment of the nozzle by adding or removing the shims inside the nozzle holder.

NOTE

An increase or decrease of the shim thickness by 0.1 mm (0.004 in.) will vary the injection pressure by 14 kgf/cm² (199 psi) [1.4 MPa]. The shims are available in nine sizes from 0.1 mm (0.004 in.) to 0.58 mm (0.0228 in.).

Unit: mm (in.)

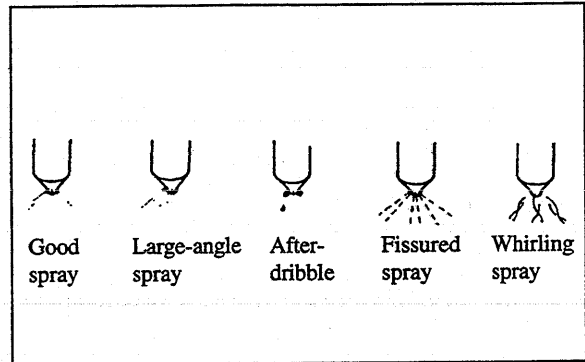
Shim thickness				
0.1 (0.0039)	0.2 (0.0079)	0.3 (0.0118)	0.4 (0.0157)	0.5 (0.0197)
Shim thickness				
0.52 (0.0205)	0.54 (0.0213)	0.56 (0.0220)	0.58 (0.0228)	



Removing nozzle tip

(2) Orifice discharge pattern

- (a) When a nozzle tester is used for inspection of a fuel spray condition, check the nozzle for injection hole clogging, spray condition and fuel leakage at the same time.



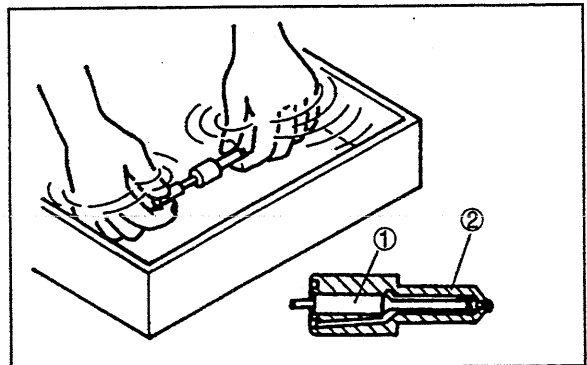
- (b) Check to make sure a fuel mist spreads from each of the four holes to form a uniform cone shape having an angle of approximately 155°.

(3) Washing or replacing nozzle tip

- (a) Loosen the retaining nut, and remove the nozzle tip. Wash the needle ① valve and body ②.

CAUTION

Be careful not to cause damage to the tip when removing it from the nozzle body.



- (b) Wash the nozzle tip in clean gasoline. After washing, assemble the needle valve and body in clean diesel fuel.

NOTE

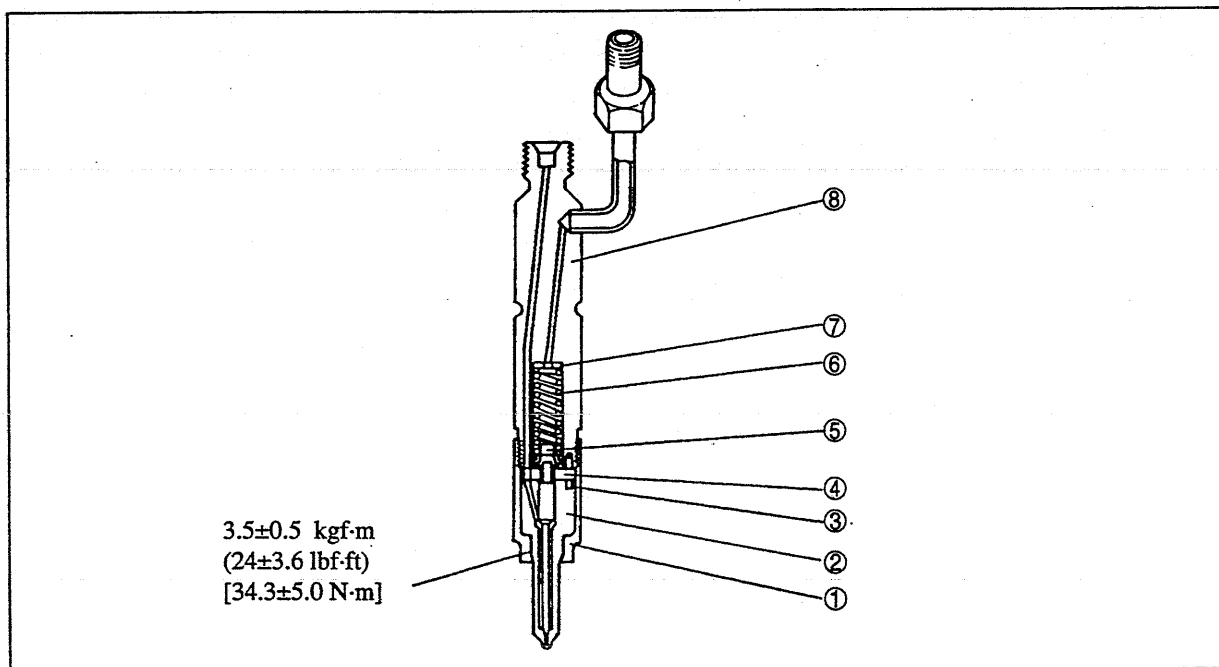
The needle valve and body are precision parts. Therefore, handle them with care, and never change the combination of the original needle valve and body set.

- (c) After cleaning the nozzle tip, install it to the nozzle body and tighten the retaining nut to the specified torque.
- (d) If the discharge pattern (nozzle) is still bad after the nozzle tip has been washed, replace the tip.

NOTE

- a) Do not touch the sliding surface of the needle valve.
- b) When installing a new nozzle tip, remove resin film from the tip and slide the needle valve in the body in clean diesel fuel to wash off inhibitor completely.

3.3 Reassembly



Reassembling sequence

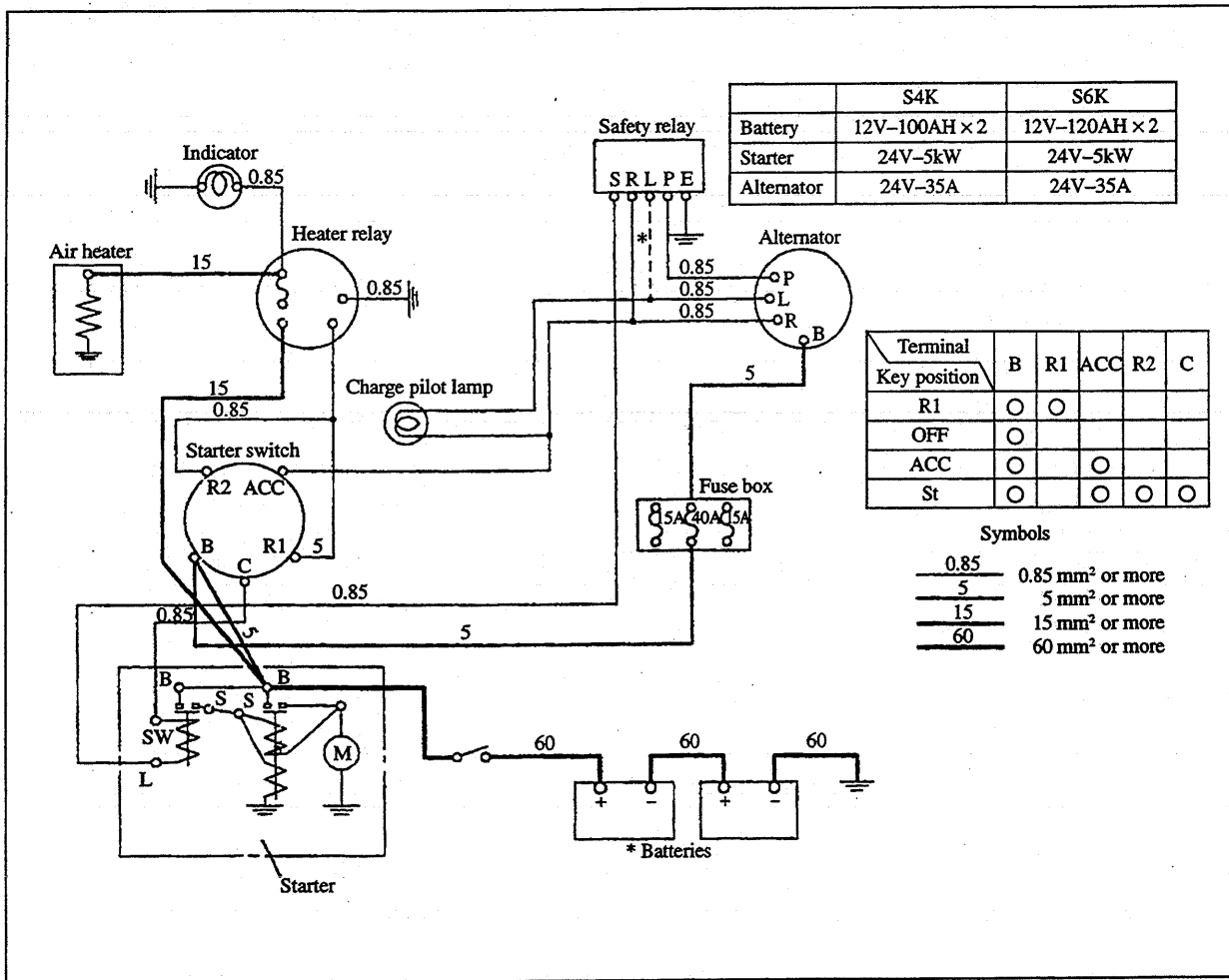
⑧→⑦→⑥→⑤→④→③→②→①

ELECTRICAL SYSTEM

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2.1 Disassembly	12- 3
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2.3 Reassembly	12- 8
3. ALTERNATOR	12-11
3.1 Disassembly	12-11
3.2 Inspection	12-12
3.3 Reassembly	12-13
4. HEATER RELAY	12-13
5. AIR HEATER	
Inspection	12-14

ELECTRICAL SYSTEM

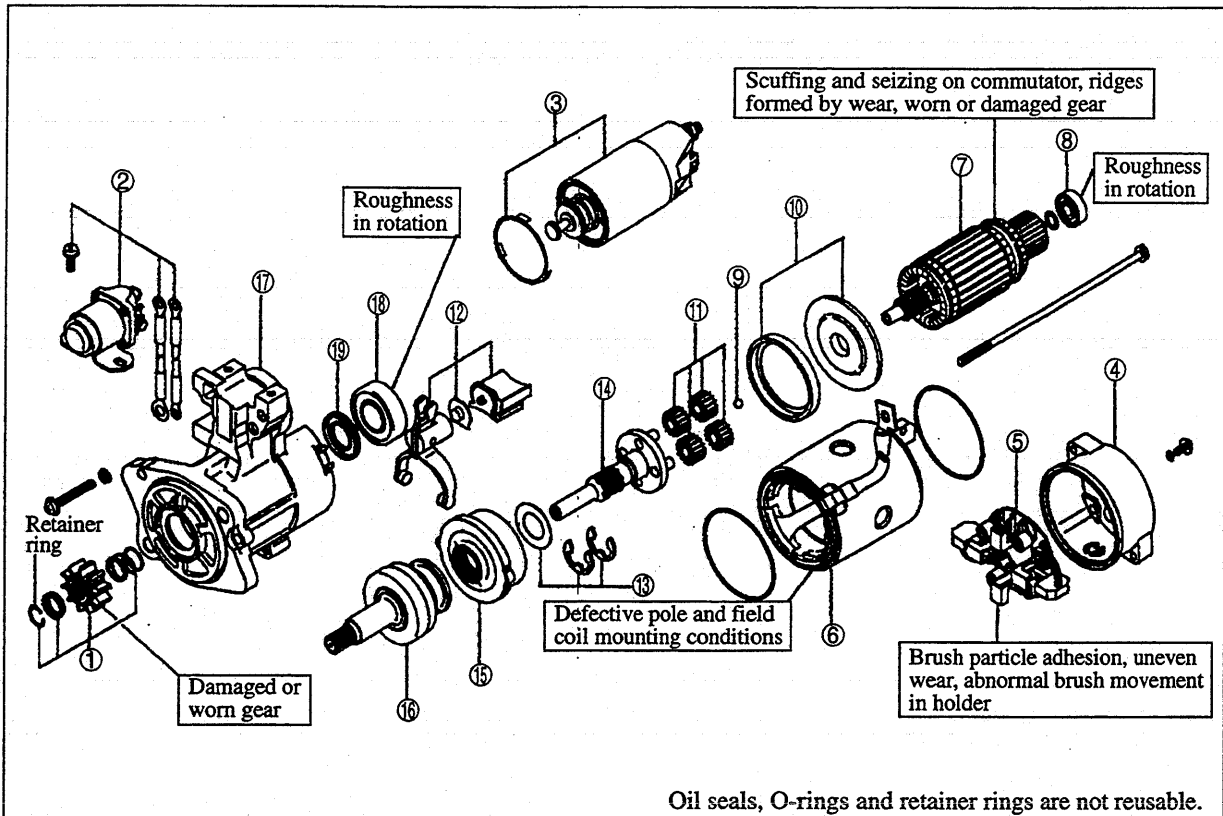
1. DESCRIPTION



- Remarks:
1. The standard circuit is shown. The circuit varies according to the specification and application of the engine.
 2. If the battery charge pilot lamp is not used, or if a 3-watt or smaller battery charge pilot lamp is used, connect a circuit (*).
 3. Parts marked with "*" were manufactured by companies not affiliated with Mitsubishi Heavy Industries.

2. STARTER

2.1 Disassembly



- | | | |
|--------------------|----------------|----------------------|
| ① Pinion set | ⑧ Ball bearing | ⑮ Internal gear |
| ② Auxiliary switch | ⑨ Ball | ⑯ Overrunning clutch |
| ③ Switch | ⑩ Packing set | ⑰ Front bracket |
| ④ Rear bracket | ⑪ Gear | ⑱ Bearing |
| ⑤ Brush holder | ⑫ Lever | ⑲ Oil seal |
| ⑥ Yoke | ⑬ Washer set | |
| ⑦ Armature | ⑭ Gear shaft | |

CAUTION

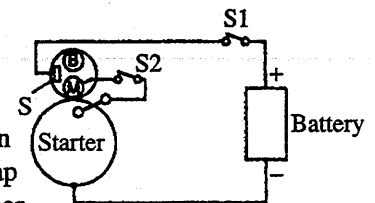
Before disassembling or replacing the following parts, remove the pinion.

Remove the pinion before disassembling:

1. Front bracket, or bracket bearing and oil seal
2. Reduction gears
3. Overrunning clutch

(1) Removing pinion

Supply electric current to the switch to set the pinion in the protruded condition. Remove the M-terminal connector, and connect the battery and starter, as shown in the diagram. Close switches S1 and S2 to set the pinion in the protruded condition. Then, open switch S2 to stop the pinion rotation. Set a pipe-shape



tool on the pinion stopper, and lightly tap the tool with a hammer to remove the pinion.

In some cases, the stopper does not dislodge from the position and the pinion retracts into the original position. When this happens, repeat the procedure.

(2) Ball

The ball serving as the bearing in the armature thrust direction may be stuck to grease on the tip of the shaft when the armature is removed. Do not loose this bearing ball.

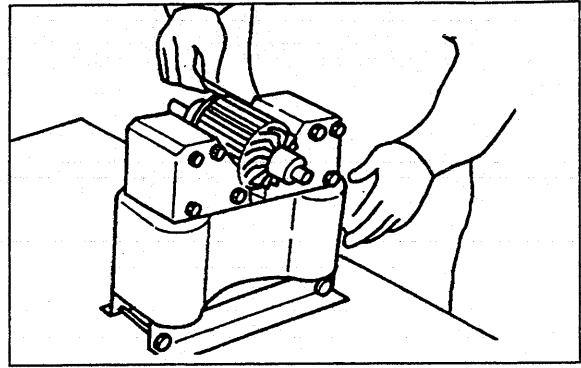
ELECTRICAL SYSTEM

2.2 Inspection and repair

(1) Armature

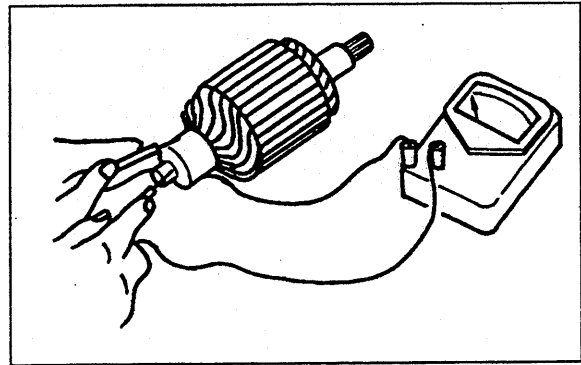
(a) Testing for short circuits

Place the armature on a growler, and slowly revolve it with a hacksaw blade held above the armature core. The hacksaw blade vibrates against the core when it is above a slot containing a shorted winding. Replace the armature if shorted.



(b) Testing for grounded circuits

If there is continuity between the commutator and shaft (or core), the armature is grounded and should be replaced.

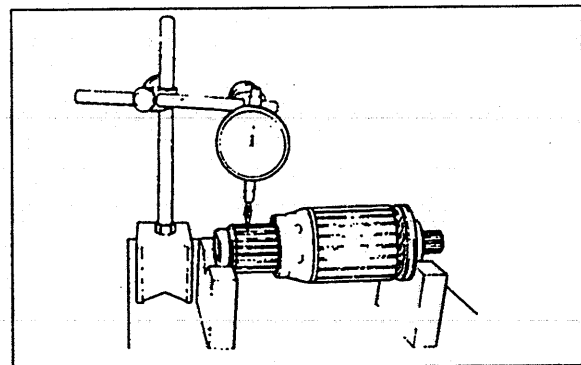


(c) Inspecting commutator

- 1) Measure the runout of commutator with a dial gauge. If the runout exceeds the Repair limit, repair the commutator by turning it in a lathe within Service limit for the outside diameter. If the commutator surface is rough, smoothen it with a sandpaper of #300 to #500.

Unit: mm (in.)

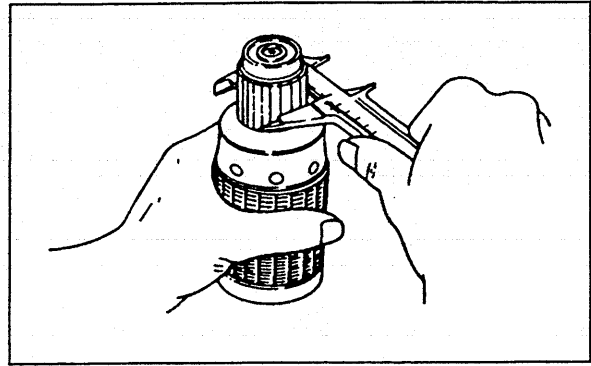
Item	Assembly standard	Service limit
Runout of commutator	0.03 (0.0012)	0.1 (0.0039)



- 2) Measure the outside diameter of commutator. If it is smaller than the Service limit, replace the armature.

Unit: mm (in.)

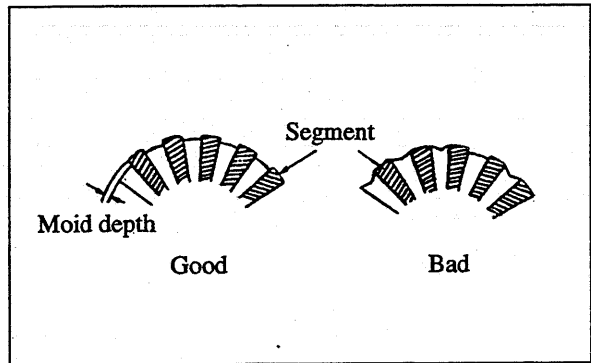
Item	Assembly standard	Service limit
Diameter of commutator	32.0 (1.260)	31.4 (1.24)



- 3) Measure the depth of each mold between segments with a depth gauge. If the depth exceeds the Repair limit, recondition the mold.

Unit: mm (in.)

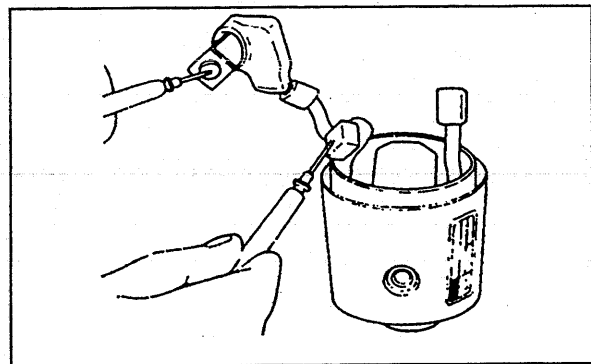
Item	Repair limit
Depth of commutator mold	0.2 (0.008), maximum



(2) Field coil

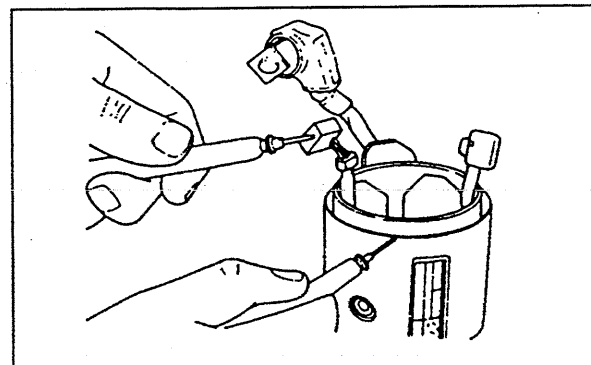
- (a) Testing for open circuits

If there is no continuity between the lead wire and positive brush, the field coil is open and the yoke assembly should be replaced.



- (b) Testing for grounded circuits

If there is no continuity between the yoke and positive brush, check the insulation, and repair or replace the yoke assembly.



ELECTRICAL SYSTEM

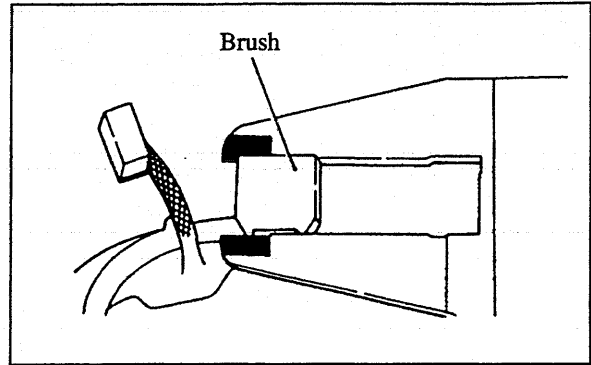
(3) Brushed and holders

(a) Wear of brushes

Measure the brush length and, if it is less than the Service limit, replace the brushes. If the brushes are unevenly worn or rough, recondition them with a sandpaper of #300 to #500.

Unit: mm (in.)

Item	Assembly standard	Service limit
Length of brush	18 (0.71)	11 (0.43)

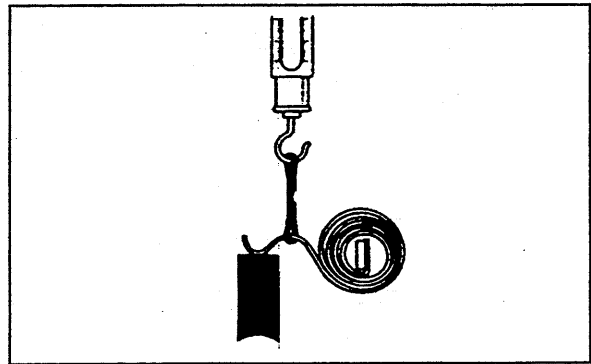


(b) Brush spring tension

Test the spring tension (test force) using a new brush. In this test, read the load at the moment that the spring moves off the brush. If the tension is below the Service limit, replace the spring.

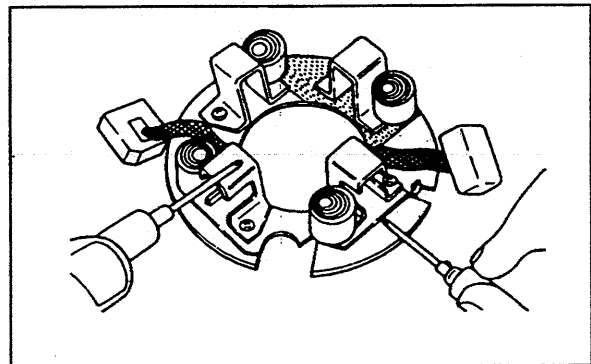
Unit: kgf (lbf) [N]

Item	Assembly standard	Service limit
Pressure of brush spring	3.0 to 4.0 (6.6 to) [29 to 39]	1.4 (3.1) [13.7]



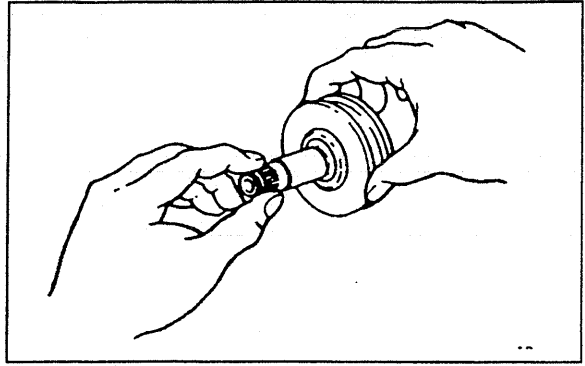
(c) Testing brush holders for insulation

If there is continuity between the positive (+) brush holder and negative (-) holder plate, replace the brush holder assembly.



(4) Overrunning clutch

Make sure that the pinion shaft turns smoothly when turned in the direction of driving (clockwise) and that it locks when turned in the opposite direction. If not, replace the overrunning clutch.

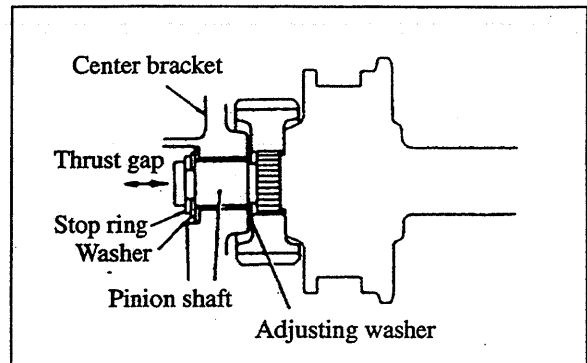


(5) Gear shaft thrust gap

The pinion shaft thrust gap is the play exhibited by the pinion shaft when it is moved in the thrust direction.

Unit: mm (in.)

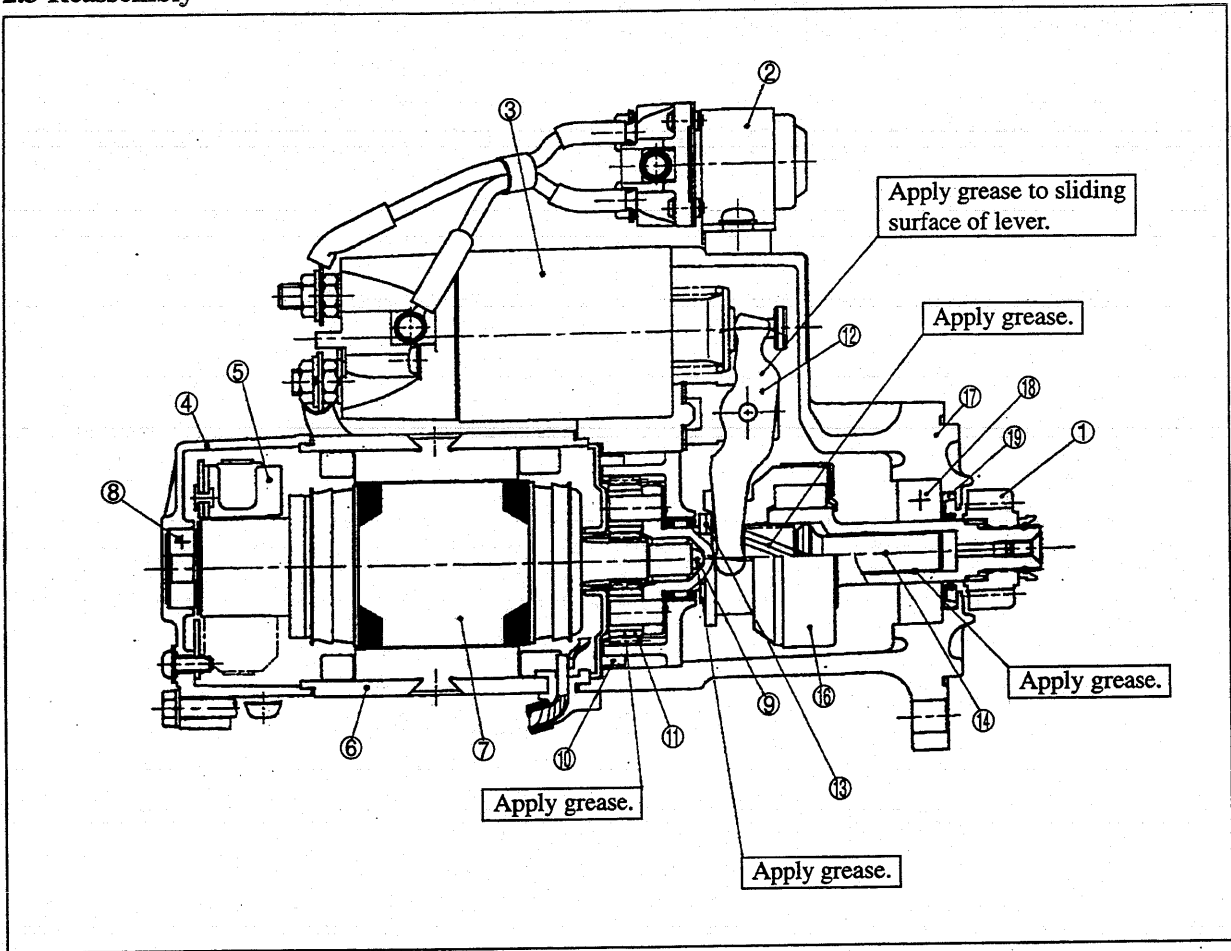
Item	Assembly standard
Thrust gap of pinion shaft	0.4 – 1.1 (0.016 – 0.043)



(6) There is no need to adjust the armature thrust gap.

ELECTRICAL SYSTEM

2.3 Reassembly



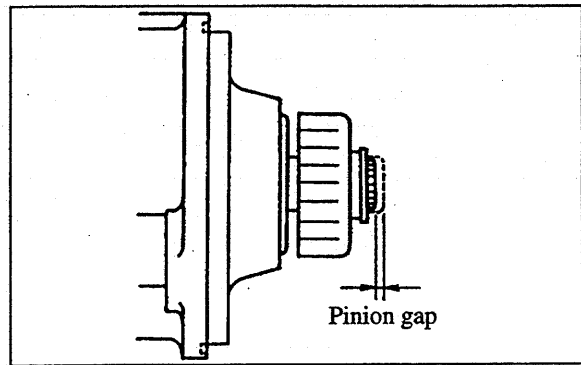
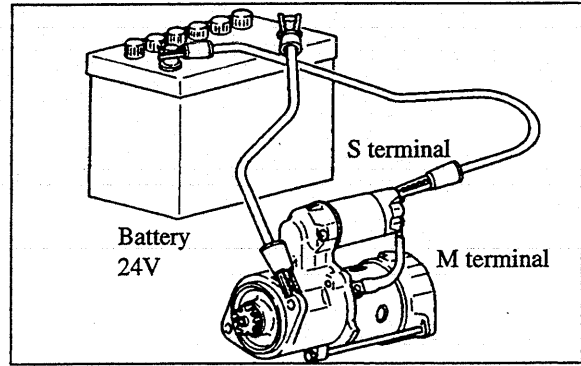
Reassembling sequence

- 19 → 18 → 17 → 13 → 14 → 16 → 1 → 11 → 12 → 10 → 9 → 6 → 7 → 8 → 5 → 4 → 3 → 2

Inspection and testing after reassembly

(1) Pinion gap adjustment

- (a) If the assembled starter is wired as shown, the pinion will shift and turn slowly. Remove the connector from the M terminal to stop the pinion.
- (b) Under this condition, lightly push in the shaft toward the armature, and measure the movement (gap) of the pinion.
- (c) If the assembly standard is exceeded, replace the lever.



Unit: mm (in.)

Item	Assembly standard
Pinion gap	0.5 – 2.0 (0.020 – 0.079)

NOTE

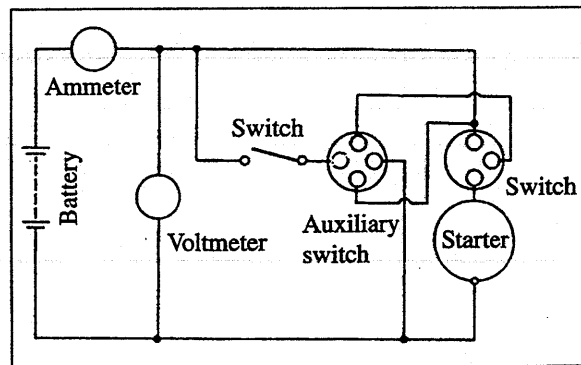
Do not test the starter continuously for more than 10 seconds to prevent the switch coil from overheating.

(2) No-load test

After adjusting the pinion gap, hook up the starter as shown, and test it for no-load characteristics.

CAUTION

Use wire as thick as possible and tighten each terminal securely.



Starter	Voltage (V)	Current (A)	Speed (rpm)
No-load characteristic	23	85, maximum	3300, minimum

ELECTRICAL SYSTEM

(3) Magnetic switch

(a) Testing coil for open circuits

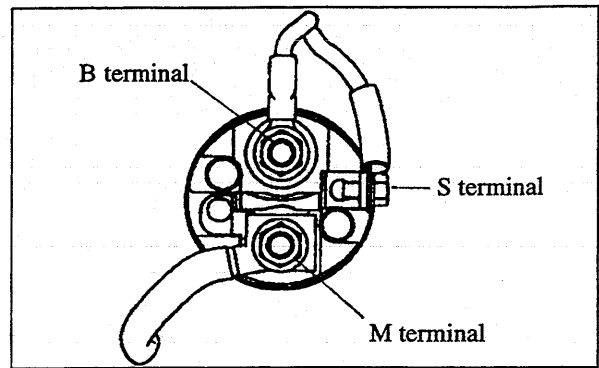
If there is no continuity between S and M terminals and between S terminal and body (ground), replace the switch.

(b) Checking contactors for fusion

If there is continuity between B and M terminals, replace the switch.

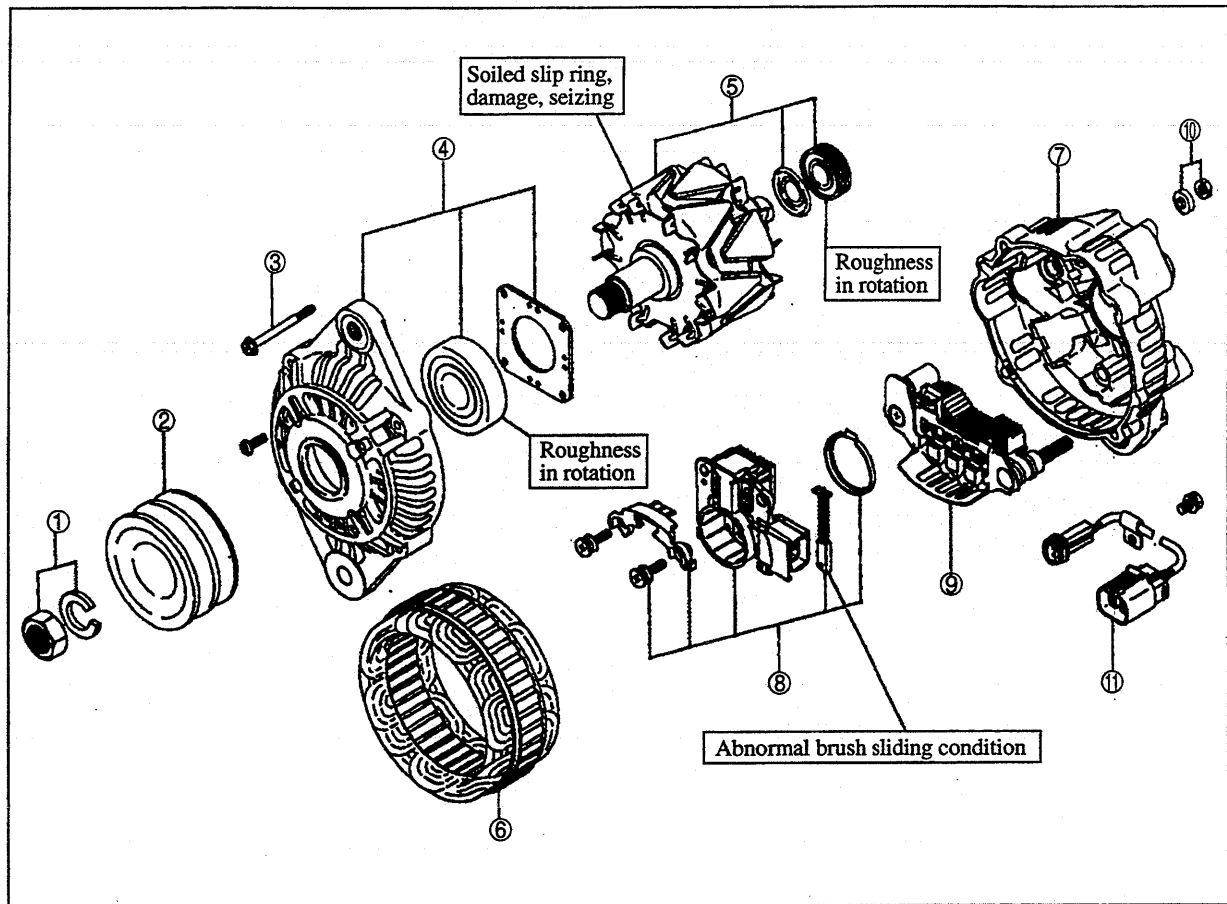
(c) Checking contactors for poor contact action

Check for voltage drop. If voltage drop is excessive, the contactors are defective.



3. ALTERNATOR

3.1 Disassembly



- ① Nut, washre
- ② Pulley
- ③ Screw
- ④ Front bracket assembly

- ⑤ Rotor assembly
- ⑥ Stator
- ⑦ Rear bracket
- ⑧ Regulator assembly

- ⑨ Rectifier assembly
- ⑩ Nut set
- ⑪ Connector assembly

ELECTRICAL SYSTEM

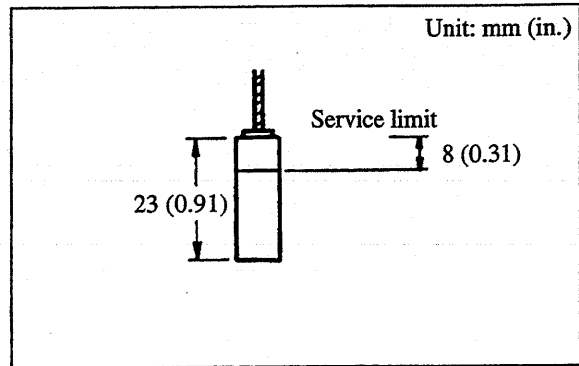
3.2 Inspection

(1) Brushes

Replace the brushes if they are worn down to the wear limit line.

Unit: mm (in.)

Item	Assembly standard	Service limit
Brush length	21.5 (0.846)	8 (0.31)

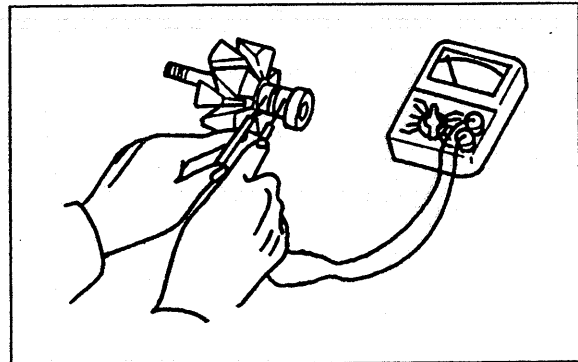


(2) Field coil

Measure the resistance between the slip rings. If the resistance is out of Assembly standard, replace the rotor.

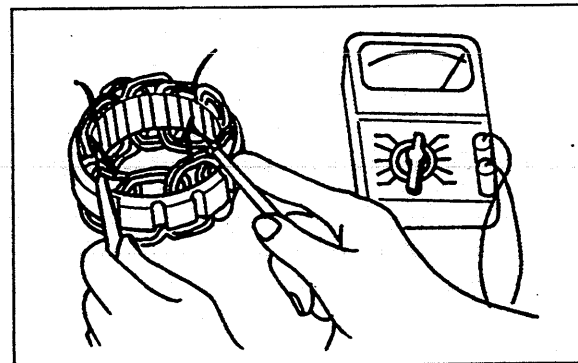
Unit: ohm

Item	Assembly standard
Resistance between slip rings	9.0 – 10.5 (at 20°C – 68°F)



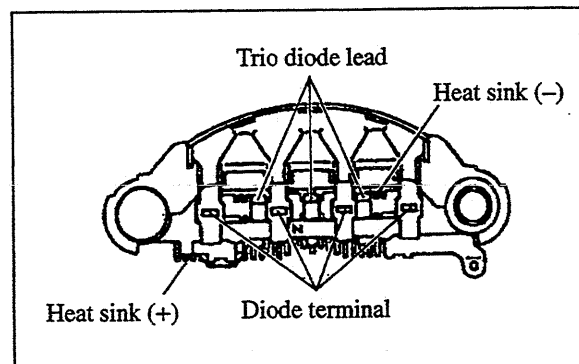
(3) Stator coil

Check for continuity between the lead wires. If no continuity is noted, the coil is open-circuited. Also check for continuity between the lead wire and coil. If any continuity is noted, the coil is grounded. If the coil is open-circuited or grounded, replace the stator.

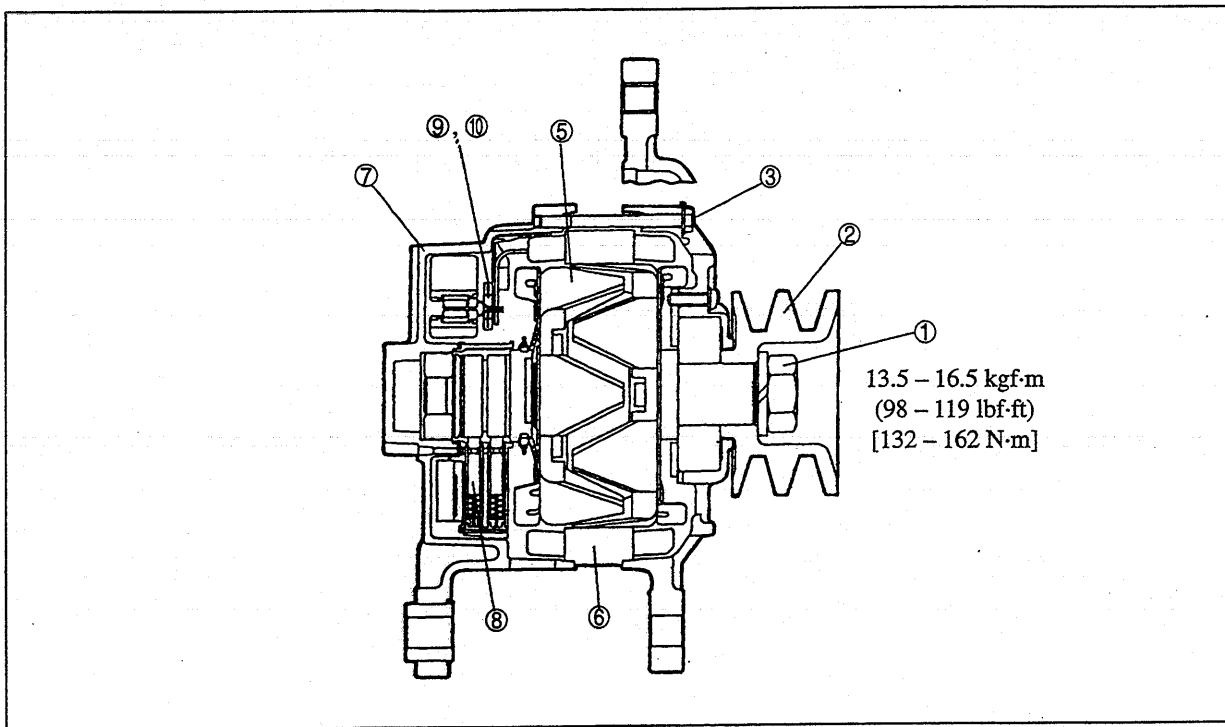


(4) Rectifier

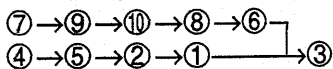
Test the resistance between the diode lead wire and heat sink. To test, connect the positive (+) lead wire of the tester to the diode and then the negative (-) lead wire of the tester to the diode. If the resistance is infinite in both cases, the diode is open-circuited. If it is nearly zero in both cases, the diode is short-circuited. If the diode is open- or short-circuited, replace the rectifier.



3.3 Reassembly

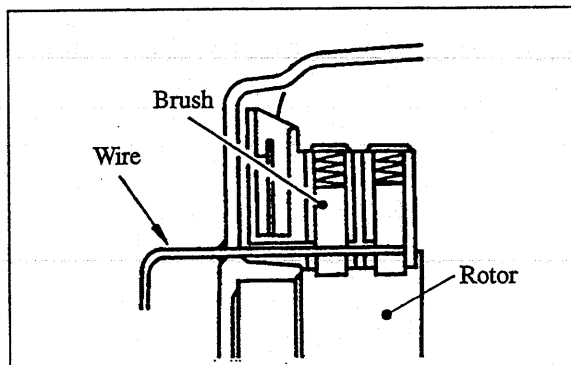


Reassembling sequence



(1) Holding brush

Push the brush into the holder, and hold it there by inserting a 2 mm (0.08 in.) diameter wire into the hole in the brush. Then, install the rotor. Remove the wire after installing the rotor.

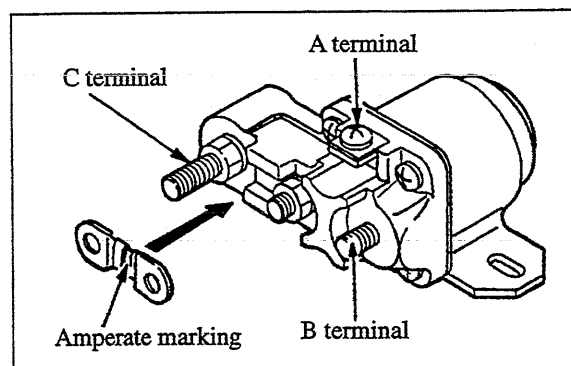


4. HEATER RELAY

Inspection

Check for continuity between the B and C terminals by flowing exciting current through A terminal and ground (body).

Also check the fuse. If the fuse is burnt out, investigate the cause before installing a replacement fuse. Be sure to use a replacement fuse of the same amperage.



ELECTRICAL SYSTEM

5. AIR HEATER

Inspcetion

Check the terminals for looseness. Also check the heater element for any signs of defects.

WORKSHOP THEORY

1. SUGGESTIONS ON DISASSEMBLY AND REASSEMBLY	13-2
1.1 Oil seals	13-2
1.2 O-rings	13-3
1.3 Bearings	13-3
1.4 Lock plates	13-4
1.5 Split pins and spring pins	13-4

WORKSHOP THEORY

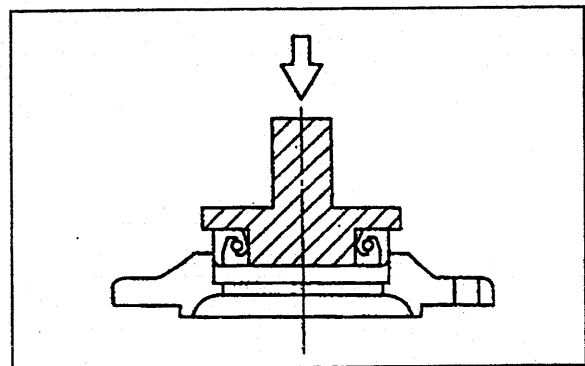
1. SUGGESTIONS ON DISASSEMBLY AND REASSEMBLY

1.1 Oil seals

When installing oil seals, carefully observe the following points:

(1) Driving oil seals into housings

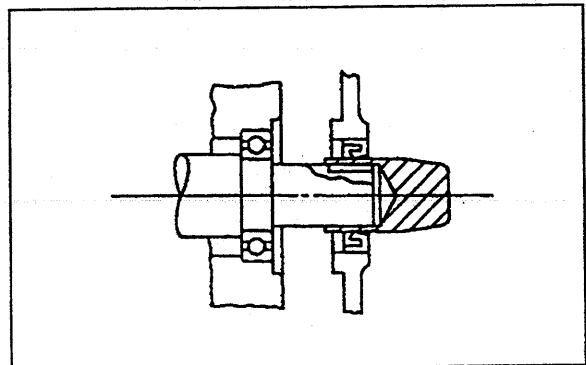
- (a) Make sure that seal lip is not damaged, and position it correctly with respect to oil compartment.
- (b) Apply a small amount of grease (ThreeBond 1212) to the surface of oil seal to be fitted into housing bore.
- (c) Using a tool of the type shown to guide seal lip, drive oil seal squarely. Never give any hammer blows directly to oil seal since this will damage the seal, resulting in oil leakage.



Oil seal driver

(2) Driving oil seals onto shafts

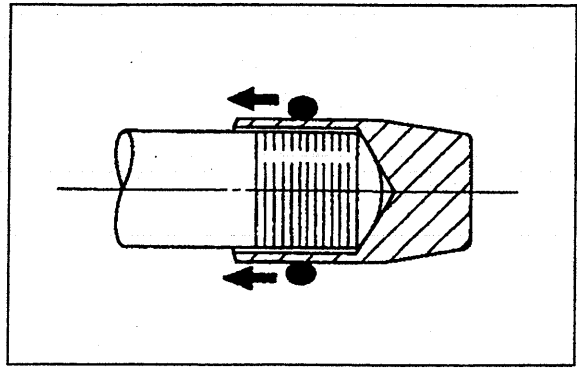
- (a) Apply a thin coat of grease to oil seal lip.
- (b) Use an oil seal guide of the type shown when driving oil seal over stepped portion, splines, threads or keyway to prevent damage to seal lip.



Oil seal guide

1.2 O-ring

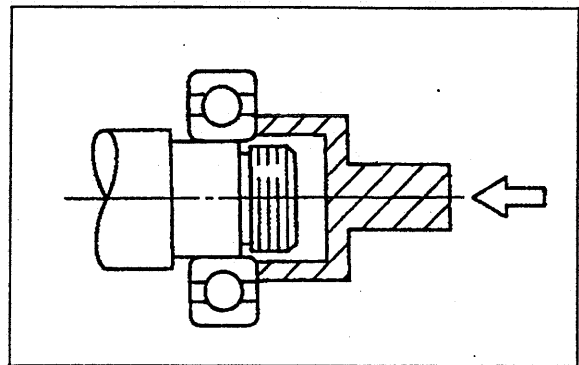
Use an O-ring guide of the type shown when installing O-ring over stepped portion, splines, threads or keyway to prevent damage to the ring. Apply a thin coat of grease to O-ring.



O-ring guide

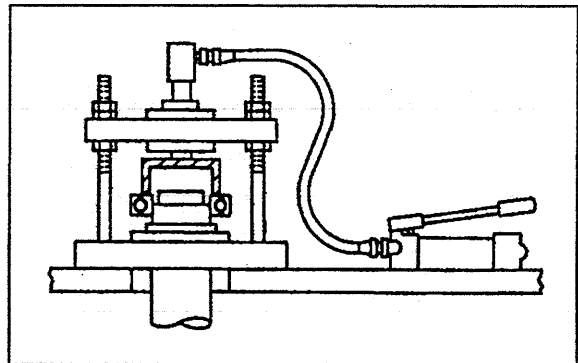
1.3 Bearings

(1) When installing a rolling bearing, be sure to give a push to the race, inner or outer, by which the bearing is fitted. Be sure to use a bearing driver of the type shown.



Bearing driver

(2) Use a press whenever possible to minimize shock to bearing and to assure proper installation.

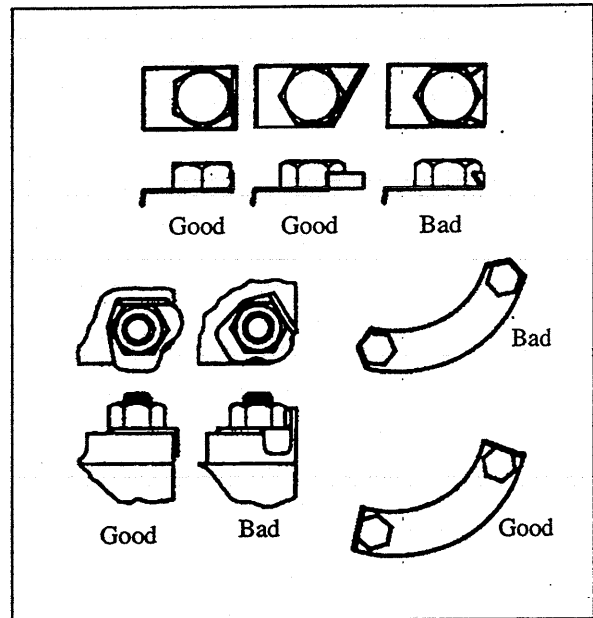


Bearing installation by a press

WORKSHOP THEORY

1.4 Lock plates

Bend lock plate against one of the flats of nut or bolt head as shown.



1.5 Split pins and spring pins

Generally, spring pins are to be replaced at the time of disassembly. Drive each spring pin into position so that it may not get out of place after subsequent installation of parts has been completed.

Bending lock plates

MAINTENANCE CHART

*** Regular maintenance is important to prolong the service life of the engine and to ensure safety. Be sure to conduct inspections according to the maintenance chart.**

1. The maintenance chart shows the standard service intervals. When you think the engine should be serviced more frequently due to particular operating conditions, adjust the intervals accordingly.

NOTE: Appropriate service intervals vary depending on the usage and operating conditions as well as the fuel, oil and cooling water used. Check the operating record of the engine to determine the most appropriate service intervals.

2. Perform service items with shorter intervals that correspond to the interval of the service being conducted.

(Example)

During inspection conducted at "Every 500 Service Hours," also include service items listed under "Every 50 Service Hours" and "Every 250 Service Hours."

3. Items marked with an asterisk (*) require special tools and large equipment. For inspection of these items, consult your Mitsubishi dealer.

Interval	Service item	Remarks (service data)	Page
Every 50 service hours	Drain water from fuel tank.	Amount of fuel to drain: 1-2 ℓ [0.26-0.52 U.S. gal.]	26
First 50 service hours for new or overhauled engine	Re-tighten bolts and nuts on engine.		-
	Change engine oil and change oil filter.	Engine oil capacity: approx. 13 ℓ [3.4 U.S. gal.] (S4K) approx. 20.5 ℓ [5.4 U.S. gal.] (S6K) Recommended oil: Class CD (API Service Classification)	27
Every 250 service hours	Clean radiator fins.		27
	Change engine oil and change oil filter.	Engine oil capacity: approx. 13 ℓ [3.4 U.S. gal.] (S4K) approx. 20.5 ℓ [5.4 U.S. gal.] (S6K) Recommended oil: Class CD (API Service Classification)	27
	Add grease to link joints, etc.		-
Every 500 service hours	* Check valve clearance.	Valve clearance (intake and exhaust valves): 0.25 mm [0.0098 in.]	-
	Change fuel filter.	Cartridge type	29
	Check and adjust V-belt tension.	Belt tension (amount of deflection): approx. 12 mm [0.47 in.]	29
	Clean air cleaner element.		30
	Clean gauze filter.	Bleed air after cleaning.	30
	* Inspect and adjust fuel injection nozzles.	Fuel injection start pressure: 21.57 MPa {220 kgf/cm ² } [3130 psi]	-
Every 1000 service hours	Re-tighten bolts and nuts on engine.		-
	Inspect turbocharger		31
	Change air cleaner element.		31
	* Inspect starter.		31
	* Inspect alternator.		31
Every 2 years	Change cooling water.	Cooling water capacity: approx. 6 ℓ [1.6 U.S. gal.] (S4K) approx. 9 ℓ [2.4 U.S. gal.] (S6K)	32
As required	Bleed fuel system.		34
	Check specific gravity of battery fluid.		35

MAINTENANCE

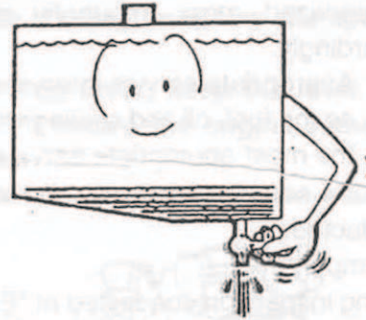
[Every 50 Service Hours]

■ Draining water from fuel tank



**Make sure flames are not used near the engine.
Wipe spilled fuel to prevent a fire.**

If water or dust mixes in the fuel, it can not only reduce the output power but also cause malfunctioning of the fuel system. Open the drain valve of the fuel tank to drain water and dust collected on the bottom of the tank. Drain at least 1 to 2 l [0.3 to 0.6 U.S. gal.] of fuel to make sure water and dust are removed together with the fuel.

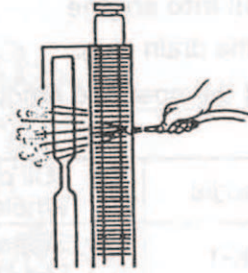


Interval	Service Item	Interval
Every 50 service hours	Check and adjust the engine oil level.	Every 50 service hours
Every 100 service hours	Check and adjust the engine oil level.	Every 100 service hours
Every 200 service hours	Check and adjust the engine oil level.	Every 200 service hours
Every 300 service hours	Check and adjust the engine oil level.	Every 300 service hours
Every 400 service hours	Check and adjust the engine oil level.	Every 400 service hours
Every 500 service hours	Check and adjust the engine oil level.	Every 500 service hours
Every 600 service hours	Check and adjust the engine oil level.	Every 600 service hours
Every 700 service hours	Check and adjust the engine oil level.	Every 700 service hours
Every 800 service hours	Check and adjust the engine oil level.	Every 800 service hours
Every 900 service hours	Check and adjust the engine oil level.	Every 900 service hours
Every 1000 service hours	Check and adjust the engine oil level.	Every 1000 service hours

[Every 250 Service Hours]

■ **Cleaning radiator fins**

Check the radiator fins for holes and cracks.
To clean the radiator fins, blow compressed air in the direction opposite the normal air flow. Be sure to wear protective goggles and dust protective mask when cleaning the radiator fins.



■ **Changing engine oil and oil filter**



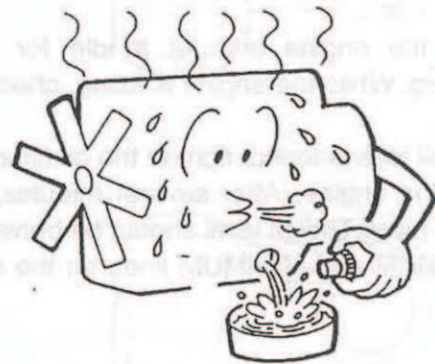
Wear gloves when draining oil and changing oil filter. Hot oil and parts can cause burns.

● **Draining engine oil**

While the oil is still warm after the engine is operated, remove the drain plug on the oil pan to drain the oil.

NOTE: (1) Oil drains smoother when it is still warm after engine operation.

(2) Waste oil must be disposed of in accordance with local regulations. Consult your Mitsubishi dealer for disposal of waste oil.

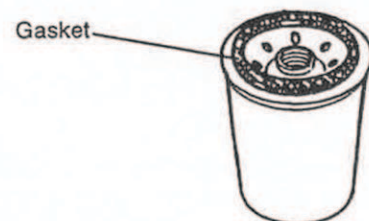
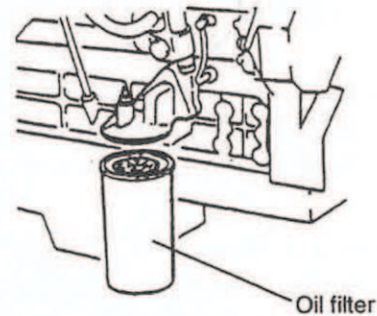


● **Changing oil filter**

1. Place a container under the oil filter. Using an oil filter wrench, loosen and remove the oil filter.
2. Apply a thin coat of clean engine oil to the gasket on a new oil filter.
3. Clean the oil filter mounting surface.
4. Install the new oil filter to the filter mounting position on the crankcase.

The oil filter should be turned about 3/4 to 1 turn after the oil filter gasket contacts the mounting surface.

NOTE: If the element in the removed filter has collected metallic particles, consult your Mitsubishi dealer.



[Every 250 Service Hours]

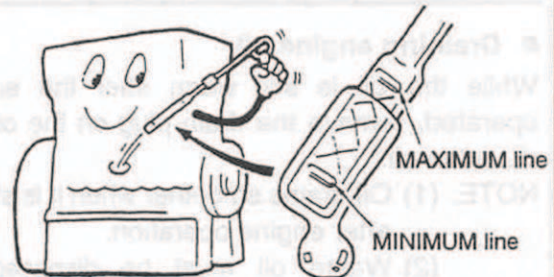
● **Pouring oil into engine**

1. Reinstall the drain plug.
2. Pour oil of the specified amount through the oil filler.

Engine model	Oil capacity (Whole engine)
S4K, S4K-T	Approx. 13 ℓ [3.4 U.S. gal.]
S6K, S6K-T	Approx. 20.5 ℓ [5.4 U.S. gal.]



3. Start the engine and let it idle for several minutes. While the engine is idling, check for oil leaks.
If an oil leak is found, tighten the oil filter.
4. Stop the engine. After several minutes, check the oil level. The oil level should be between the MAXIMUM and MINIMUM lines on the oil level gage.



Changing oil filter

1. Place a container under the oil filter. Undo an oil filter wrench, loosen and remove the oil filter.
2. Apply a thin coat of clean engine oil to the gasket on a new oil filter.
3. Clean the oil filter mounting surface.
4. Install the new oil filter to the filter mounting position on the engine.

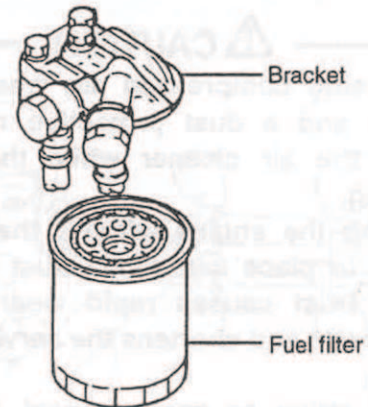
The oil filter should be tightened about 1/2 to 1 turn after the oil filter gasket contacts the mounting surface.

NOTE: If the element is removed after the collected metallic particles, consult your distributor dealer.

[Every 500 Service Hours]

■ Changing fuel filter

- Remove the fuel filter using a filter wrench.
- Apply a coat of fuel to the O-ring of the new fuel filter.
- Tighten the new filter by hand to install. Do not use a filter wrench for tightening.
- The filter should be dry.
- Do not add fuel in the fuel filter before installation. If fuel is poured in the filter, unfiltered fuel enters the fuel pump.
- Bleed air out of the filter.



■ Checking and adjusting V-belt tension

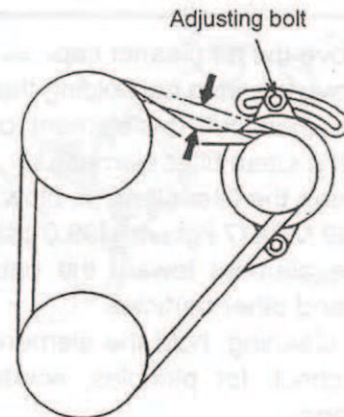


Do not make the V-belt too tight. Excessive belt tension damages the bearing and belt.

Keep the V-belt free of oil and grease to prevent slippage that can shorten the service life of the belt.

If the V-belt is loose, it can cause insufficient battery charge and engine overheating. Be sure to maintain proper belt tension.

- Press hard on the center section of the V-belt using a thumb. If the belt deflects approximately 12 mm [0.47 in.], the tension is appropriate.
- To adjust the V-belt tension, loosen the retaining bolt of the alternator and adjusting plate, then loosen and move the adjusting bolt.



[Every 500 Service Hours]

■ Cleaning air cleaner element

⚠ CAUTION

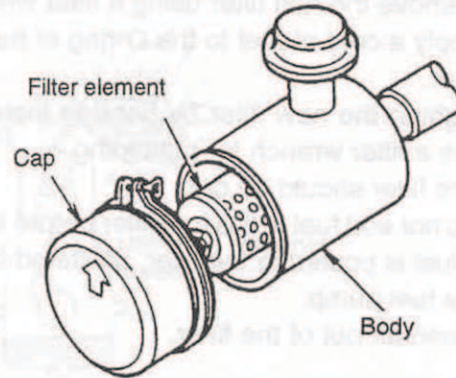
When using compressed air, wear protective goggles and a dust protective mask. Never service the air cleaner while the engine is operating.

Operating the engine without the air cleaner element in place can cause dust to enter the engine. Dust causes rapid wear of internal engine parts and shortens the service life of the engine.

Do not strike or apply impact to the filter element.

1. Remove the air cleaner cap.
2. Remove the wing nut holding the filter element in place, then pull the element out of the body. Install a clean filter element.
3. To clean the filter element, blow compressed air of 0.69 MPa {7 kgf/cm²} [99.6 psi] from the inside of the element toward the outside to remove dust and other particles.
4. After cleaning, hold the element against a light and check for pinholes, scratches and worn sections.

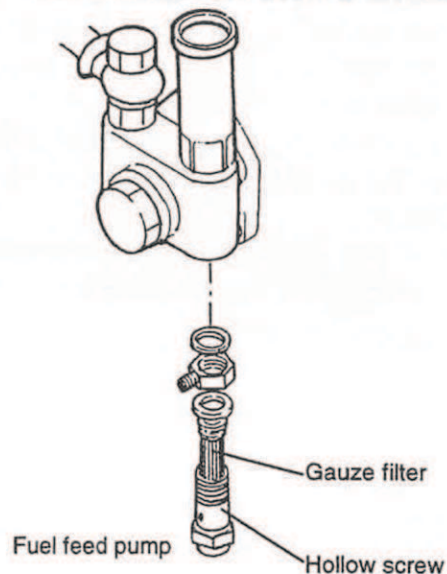
If the dust indicator remains red after the filter element is cleaned, it indicates that the element is clogged. Replace it with a new filter element.



■ Cleaning gauze filter

When the gauze filter is clogged, it reduces the fuel supply, thus causing the engine to produce less output and stop suddenly during operation in some cases.

1. Remove the hollow screw located at the inlet side of the fuel feed pump.
2. Remove the gauze filter from the hollow screw using a screwdriver.
3. Immerse the gauze filter in a cleaning solvent and clean with a brush.
4. After cleaning, install the gauze filter on the hollow screw using a screwdriver.
5. Install the hollow screw to the fuel feed pump.
6. Bleed air out of the fuel filter.



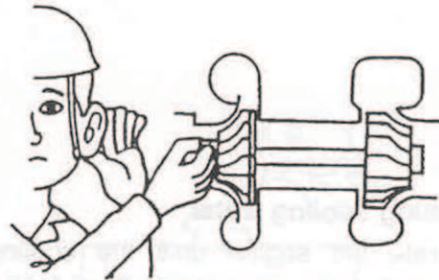
[Every 1000 Service Hours]

■ Inspecting turbocharger

CAUTION

Be sure to inspect the turbocharger when the engine is cooled. Also inspect the turbocharger when abnormal color is found in exhaust smoke. Do not start the inspection before confirming that the wheel rotation has stopped.

Replace the bearings if you find some excessive play on the unit by holding the tightening nut of the compressor wheel by hand, or a vibration sound by rotating the wheel.

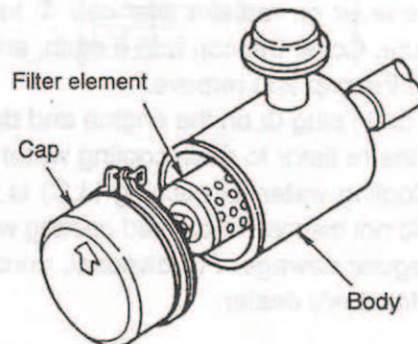


■ Changing air cleaner element

CAUTION

When using compressed air, wear protective goggles and a dust protective mask. Never service the air cleaner while the engine is operating. Operating the engine without the air cleaner element in place can cause dust to enter the engine. Dust causes rapid wear of internal engine parts and shortens the service life of the engine.

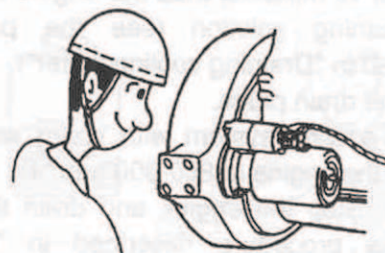
Do not strike or apply impact to the filter element.



1. Remove the air cleaner cap.
2. Remove the wing nut holding the filter element in place, then pull the element out of the body. Install a new filter element.

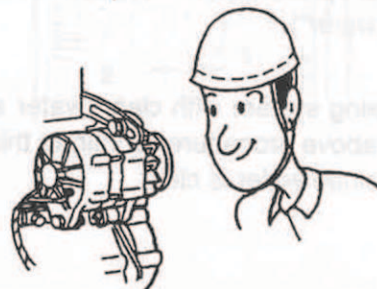
■ Inspecting starter

1. Inspect the exterior of the starter for abnormalities.
2. Check to make sure the pinion gear works properly. If there is an abnormality, consult your Mitsubishi dealer.



■ Inspecting alternator

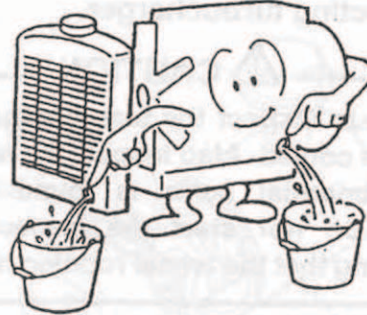
1. Inspect the exterior of the alternator for abnormalities.
2. Remove the V-belt. Turn the pulley by hand to check if it rotates smoothly. If there is an abnormality, consult your Mitsubishi dealer.



[Every 2 Years]

■ Changing cooling water

LLC used in the cooling system retains its efficacy for two years. Change the cooling water every 2 years.



● Draining cooling water

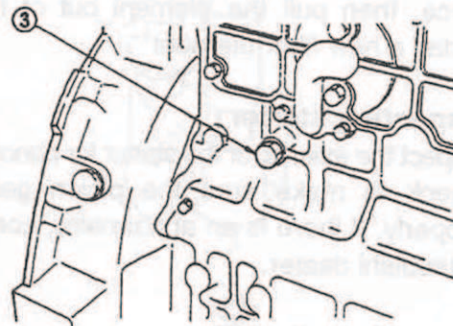
1. Operate the engine until the cooling water temperature increases to 70-85°C [158-185°F].
2. Allow the engine to cool to room temperature. Lift the lever on radiator filler cap ① to release pressure. Cover the cap with a cloth, and slowly loosen the cap and remove.
3. Open drain plug ③ on the engine and drain plug ② on the radiator to drain cooling water.

NOTE: Cooling water (containing LLC) is harmful. Do not dispose of drained cooling water into regular sewage. For disposal, consult your Mitsubishi dealer.



● Flushing cooling system

1. Close drain plug ③ on the engine and drain plug ② on the radiator.
2. Fill the cooling system with a cleaning solution (containing no chemicals that damage rubber or metals), and operate the engine at 800-900 min⁻¹ for about 15 minutes. Stop the engine and drain the cleaning solution (see the procedure described in "Draining cooling water").
3. Close the drain plugs.
4. Fill the cooling system with clean water and operate the engine at 800-900 min⁻¹ for about 10 minutes. Stop the engine and drain the water (see the procedure described in "Draining cooling water").

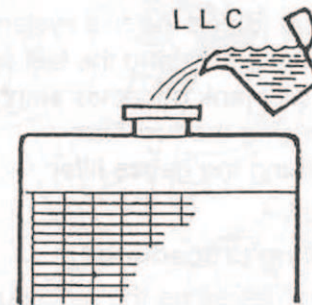


Fill the cooling system with clean water again and repeat the above procedure. Continue this process until the drained water is clear.

[Every 2 Years]

● Filling radiator with cooling water

1. Close the drain plugs on the engine and radiator tightly.
2. Remove the radiator filler cap. Pour antifreeze (LLC) into the radiator.
3. Add clean water (soft water containing minimum impurities, such as drinkable tap water) slowly until the radiator is full.
4. When the radiator is filled with water, tighten the radiator filler cap securely.
5. Crank the engine for less than 10 seconds using the starter. Wait for about one minute, and crank the engine again. Repeat this process to bleed air out of the water pump.
6. Operate the engine until the cooling water temperature reaches 70-85°C [158-185°F]. Stop the engine.
7. Allow the engine to cool to room temperature. Check the cooling water level. Remove the radiator filler cap and make sure the cooling water surface is up to the filler mouth. If the cooling water level is low, add cooling water having the same LLC concentration. If the engine is equipped with a reservoir, add cooling water containing LLC into the reservoir to the FULL line when the engine is cold.



Engine model	Cooling water capacity (in engine only)
S4K, S4K-T	Approx. 6ℓ [1.6 U.S. gal.]
S6K, S6K-T	Approx. 9ℓ [2.4 U.S. gal.]

NOTE: (1) Cooling water added to the reservoir should have the same LLC concentration as the cooling water originally poured.

- (2) When cooling water is changed, the cooling system is mixed with air. After air is dispersed and discharged during operation, the cooling water level decreases gradually over a period of several days. Therefore, after the cooling water has been changed, check the cooling water level frequently and add cooling water if necessary.



[As Required]

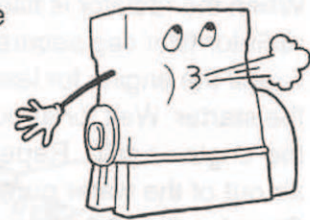
■ Bleeding fuel system



Wipe fuel spilled from the air vent plug thoroughly with a cloth. Spilled fuel can cause a fire.

If air enters the fuel system, it can cause improper operation of the fuel injection pump and disallow engine startup. Bleed the fuel system in the following cases.

- After adding fuel during the test operation of a newly installed engine
- After the fuel tank becomes empty
- After changing the fuel filter
- After cleaning the gauze filter



● Air bleeding procedures

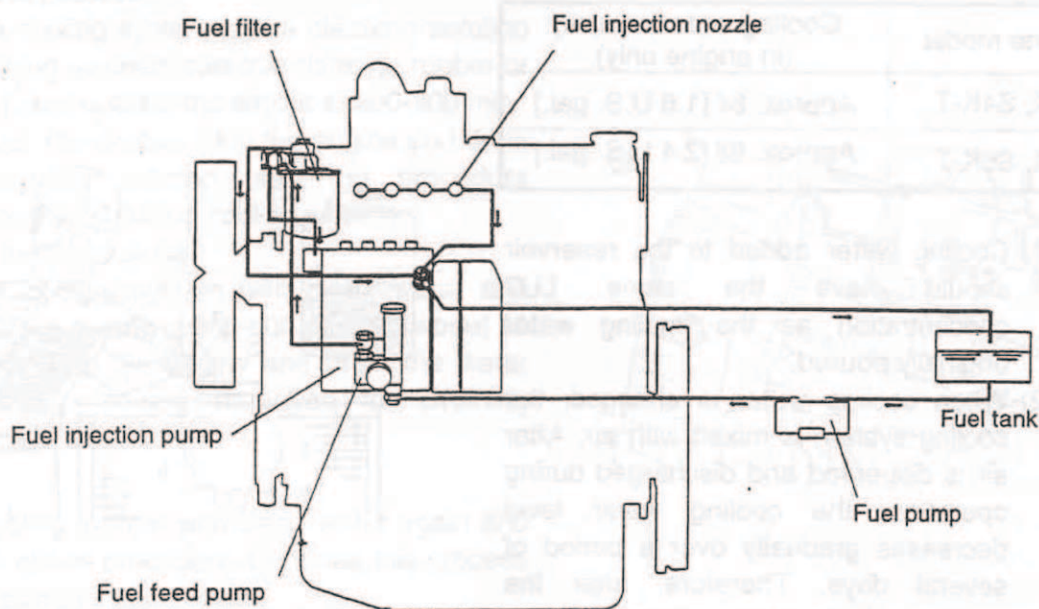
The following describes the procedures for bleeding the entire fuel system. After changing the fuel filter, bleed air from the fuel filter only.

After cleaning the gauze filter, bleed air from the fuel filter.

Start the bleeding operation for the component closest to the fuel tank, then move toward the engine in order (fuel filter → fuel injection pump).

● Automatic air bleed when a fuel pump is installed

Operate the fuel pump to eliminate air from the pipe.



Fuel flow during automatic air bleed

[As Required]

● Fuel filter

1. Loosen the air vent plug of the fuel filter by turning about 1.5 turns.

NOTE: Cover the vent with a cloth to prevent fuel from splashing.

2. Turn the priming pump cap of the fuel feed pump counterclockwise to unlatch. Move the priming pump cap up and down.
3. When fuel flowing from the air vent plug hole contains no air bubbles, close the air vent plug.

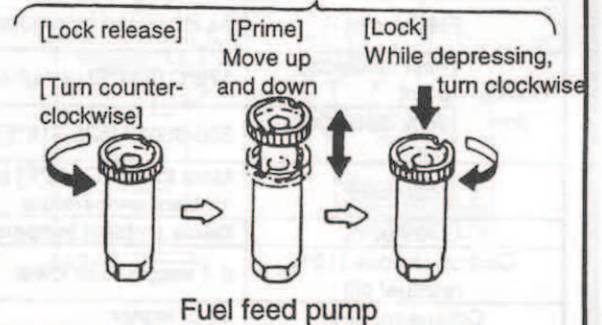
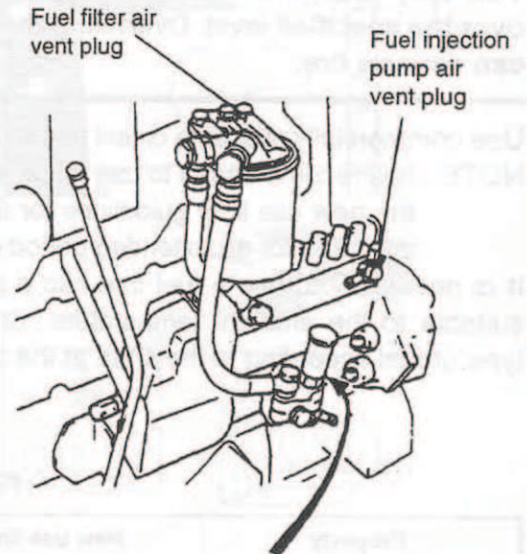
● Fuel injection pump

1. Loosen the air vent plug of the fuel injection pump by turning about 1.5 turns.

NOTE: Cover the vent with a cloth to prevent fuel from splashing.

2. Move the priming pump cap of the fuel feed pump up and down.
3. When fuel flowing from the air vent plug hole contains no air bubbles, depress the priming pump cap and turn clockwise to lock in place.
4. Close the air vent plug.

NOTE: Do not close the air vent plug before locking the priming pump cap in place, otherwise internal pressure prevents the priming pump cap from returning to the original position.



■ Inspecting specific gravity of battery fluid

Check the specific gravity of the electrolyte in the battery. If the specific gravity is less than 1.22 at 20°C [68°F], charge the battery immediately.

Specific gravity (at 20°C [68°F])	Condition	Remedy
From 1.26 to 1.28	Good	-
From 1.22 to less than 1.26	Acceptable	Charge
Less than 1.22	Not acceptable	Charge

