

INTRODUCTION

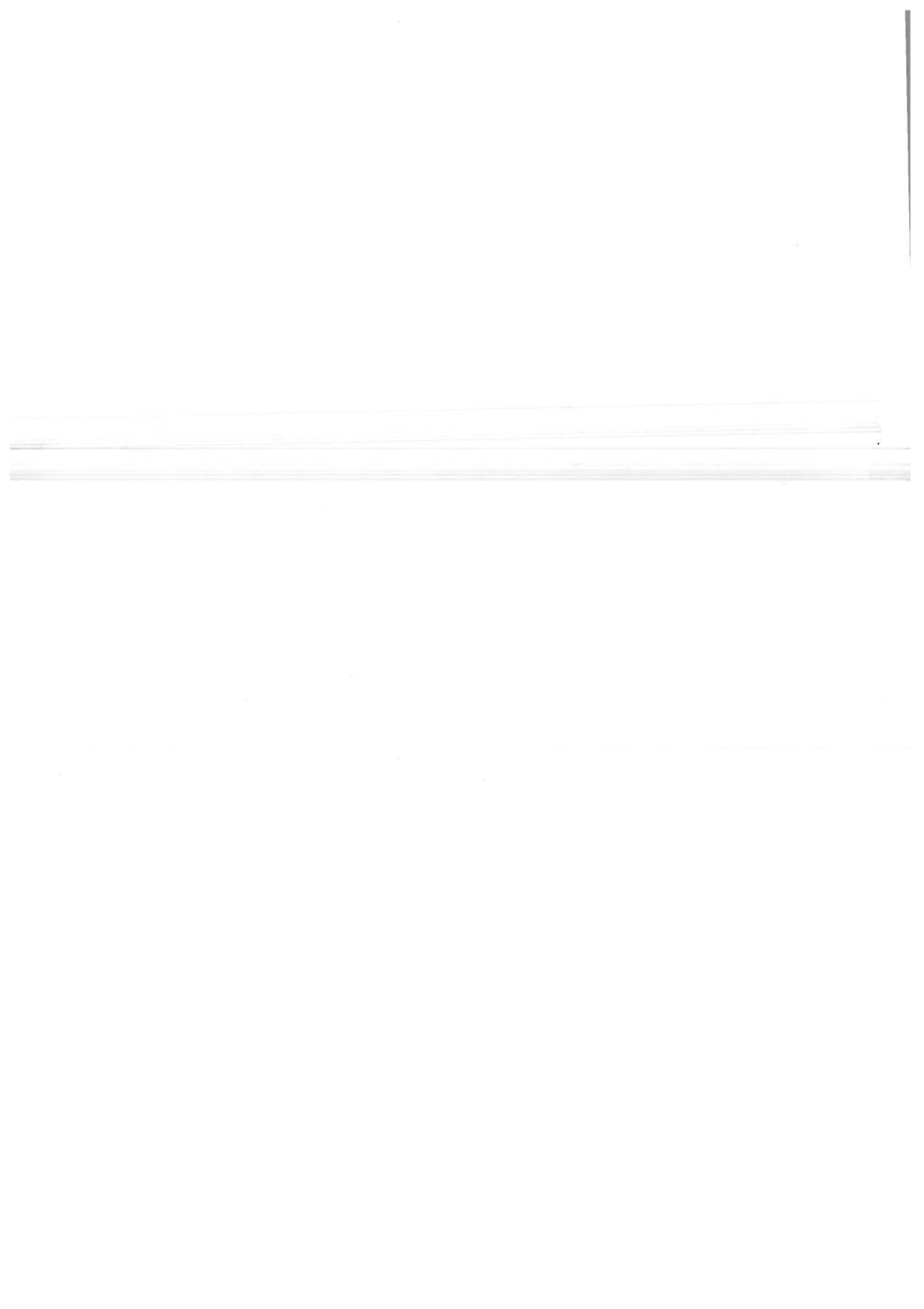
This Service Manual is written to familiarize you with the maintenance of your Mitsubishi SE-, SE2- and SF-series Diesel Engines.

Long productive life and efficient performance are the essential qualities required of the engines if they are to fulfil their function of rationalizing power economy. These qualities depend to a great extent on the care exercised in maintenance of the engines.

We hope you read this manual carefully to get to know your new engines and learn how to service them before starting disassembly, inspection and repair, and reassembly.

The description, illustrations and specifications contained in this manual were of the serial numbers of the engines manufactured at the time this manual was approved for printing.

Mitsubishi reserves the right to change specifications or design without notice and without incurring obligation.



SCOPE

This Service Manual covers the standard-specification models of Mitsubishi SE-, SE2- and SF-series Diesel Engines and describes, group by group, the specifications, maintenance standards, adjustments, disassembly, inspection and repair, and reassembly of these engines.


The fuel injection pump, governor and turbocharger are described in the separate volume of this manual.

For the non-standard-specification engines such as marine propulsion engines, etc., the supplement has been published to be read together with this manual.

The groups and their contents will be found in "Table of Contents" and the contents of each group in the first page of the group.




The operation and periodical maintenance are described in OPERATION & MAINTENANCE MANUAL, the component parts and ordering of service parts in PARTS CATALOGUE and the construction and function in the various training manuals.

HOW TO USE THIS MANUAL

- 1. The parts read in the texts or shown in the illustrations are numbered in the disassembling sequence prescribed for each system or assembly.
- 2. The item to be inspected during disassembly are indicated in  in the disassembled view.
- 3. The maintenance standards to be referred to for inspection and repairs are indicated in easy-to-refer passages of the texts and also in GROUP No. 2 in a tabulated form.
- 4. The sequence in which the parts are to be reassembled are shown in the form of, for example, ⑤→②→④→③→① below the assembled view.
- 5. Marks are used in this manual to emphasize important and critical instructions as shown below:
- 6. Tighten torque in "wet" condition is indicated as [wet]. Unless indicated as such, the torque is to be considered in "dry" condition.

NOTES, CAUTIONS and WARNINGS

NOTES, CAUTIONS and WARNINGS are used in this manual to emphasize important and critical instructions. They are used for the following conditions:

-  An operating procedure, condition, etc., which is essential to highlight.
-  Operating procedures, practices, etc., which if not strictly observed, will result in damage to or destruction of engine.
-  Operating procedures, practices, etc., which if not correctly followed, will result in personal injury or loss of life.

DEFINITION OF TERMS

In this manual, the following terms are used in the dimensional and other specifications:

NOMINAL VALUE Indicates the standard dimension of a part.

ASSEMBLY STANDARD Indicates the dimension of a part, the dimension to be attained at the time of reassembly 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 Indicates the clearance to be obtained between mating parts at the time of reassembly.

REPAIR LIMIT A part which has reached this limit must be repaired.

SERVICE LIMIT A part which has reached this limit must be replaced.

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GENERAL

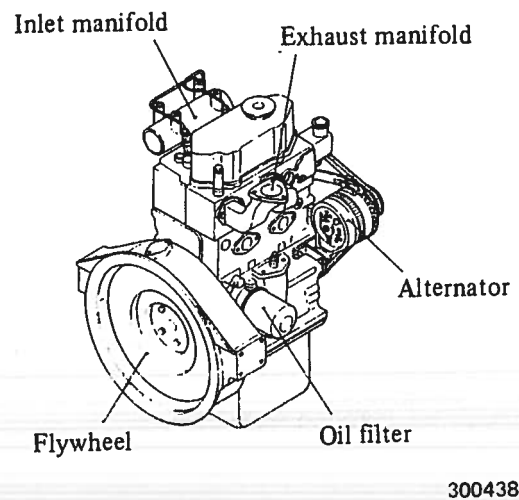
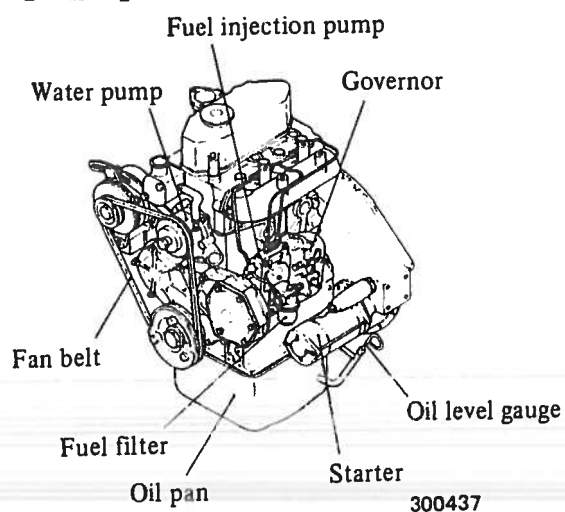
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GENERAL

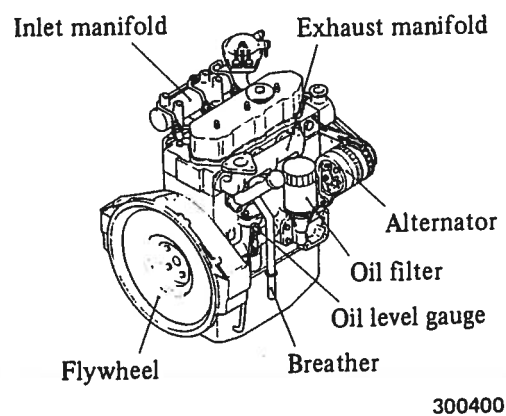
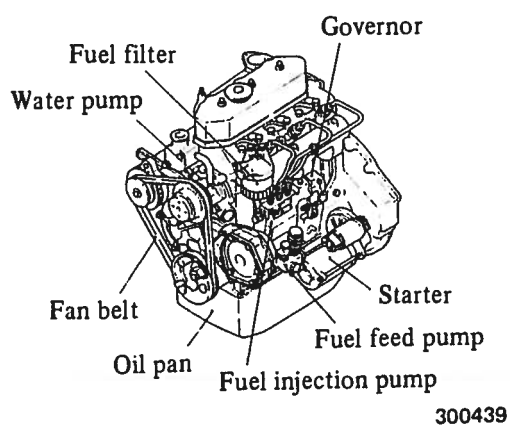
1. GENERAL

1.1 SE-, SE2- and SF-series diesel engines - External views

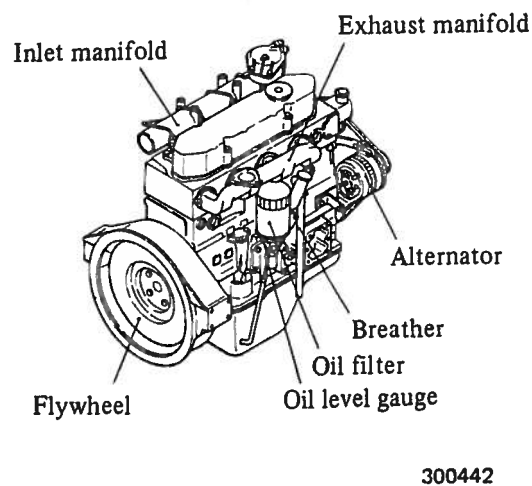
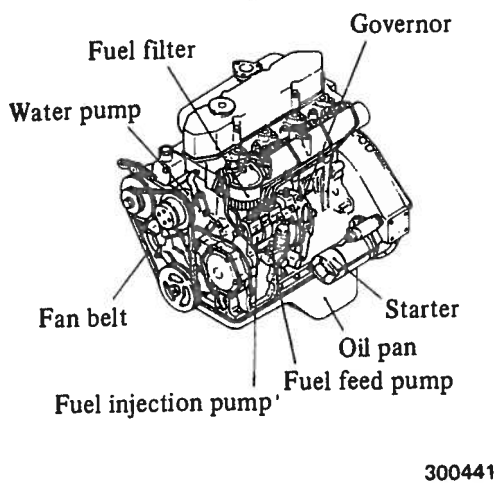
【S2E, S2E2】



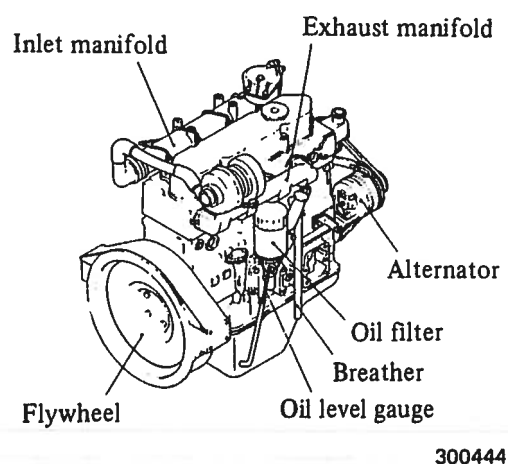
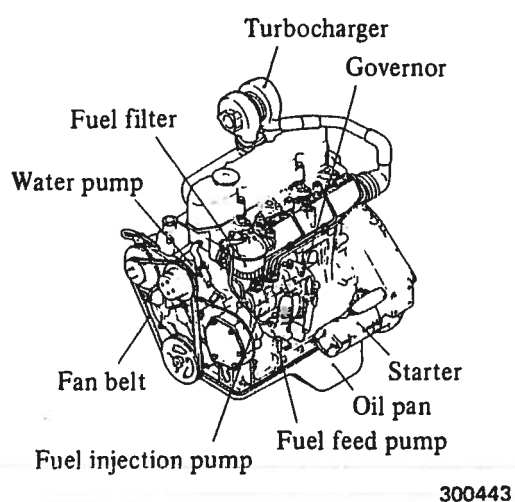
【S3E, S3E2, S3F】



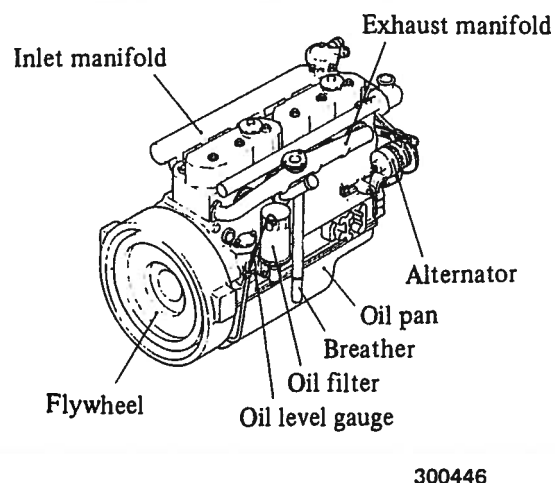
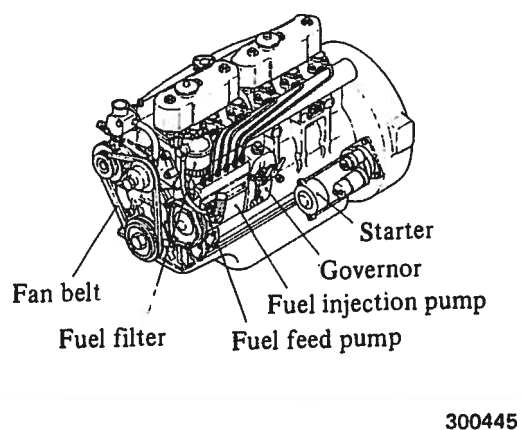
【S4E, S4E2, S4F】



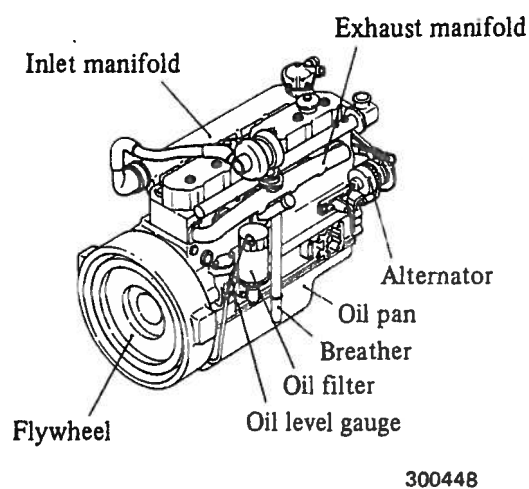
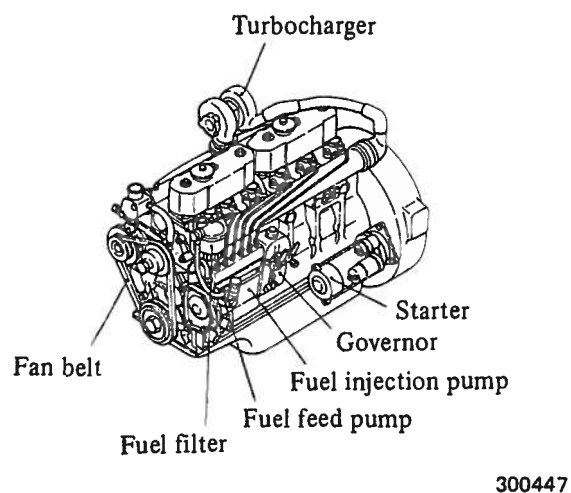
【S4E2-T, S4F-T】



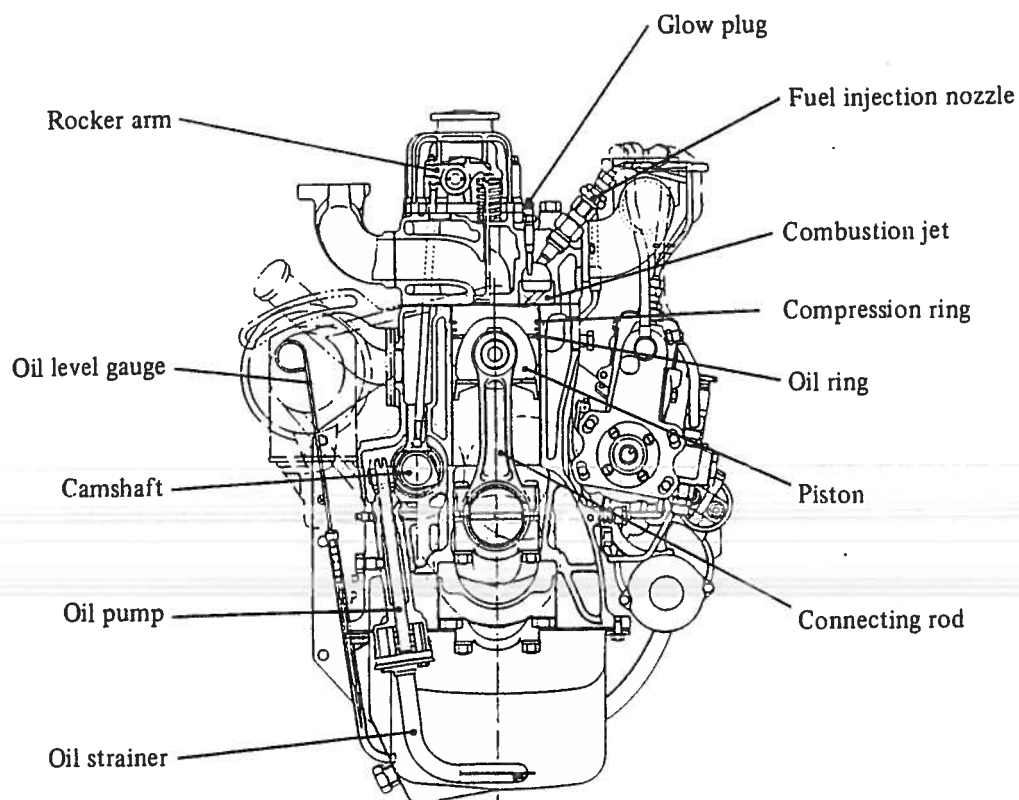
【S6E, S6E2, S6F】



【S6E2-T, S6F-T】

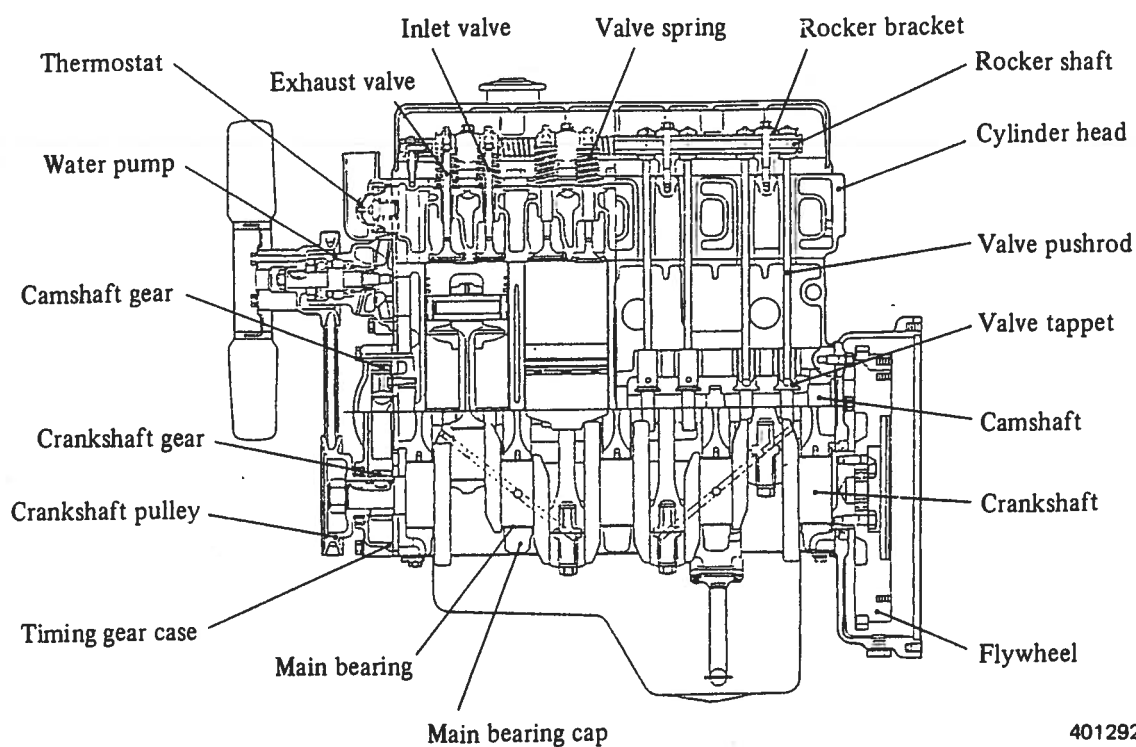


1.2 SE- and SE2-series diesel engines - Sectional views



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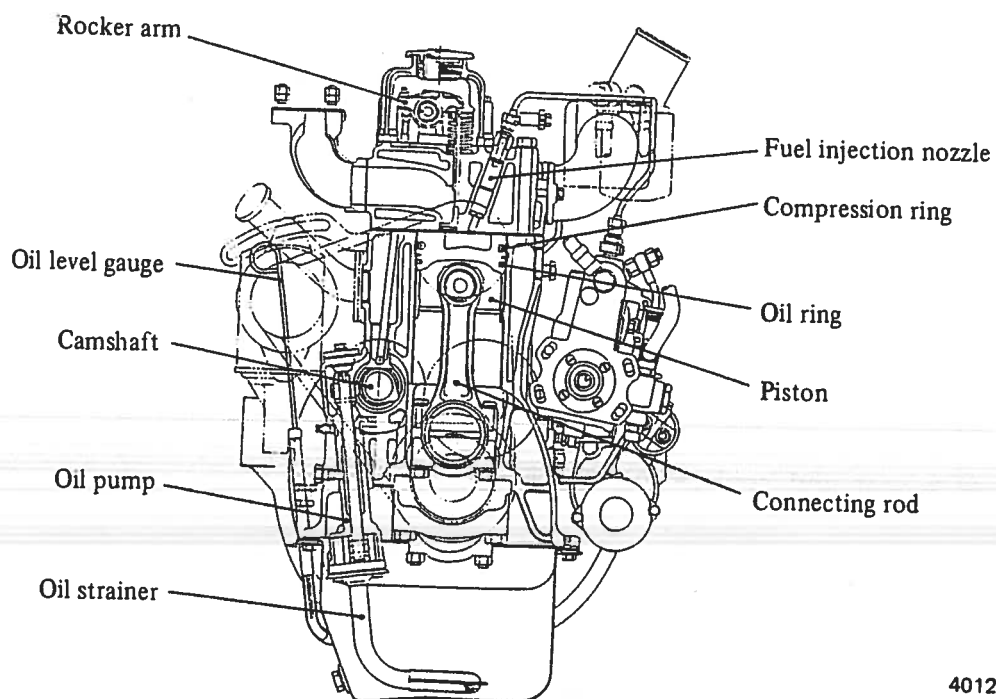
Transverse view [S4E]



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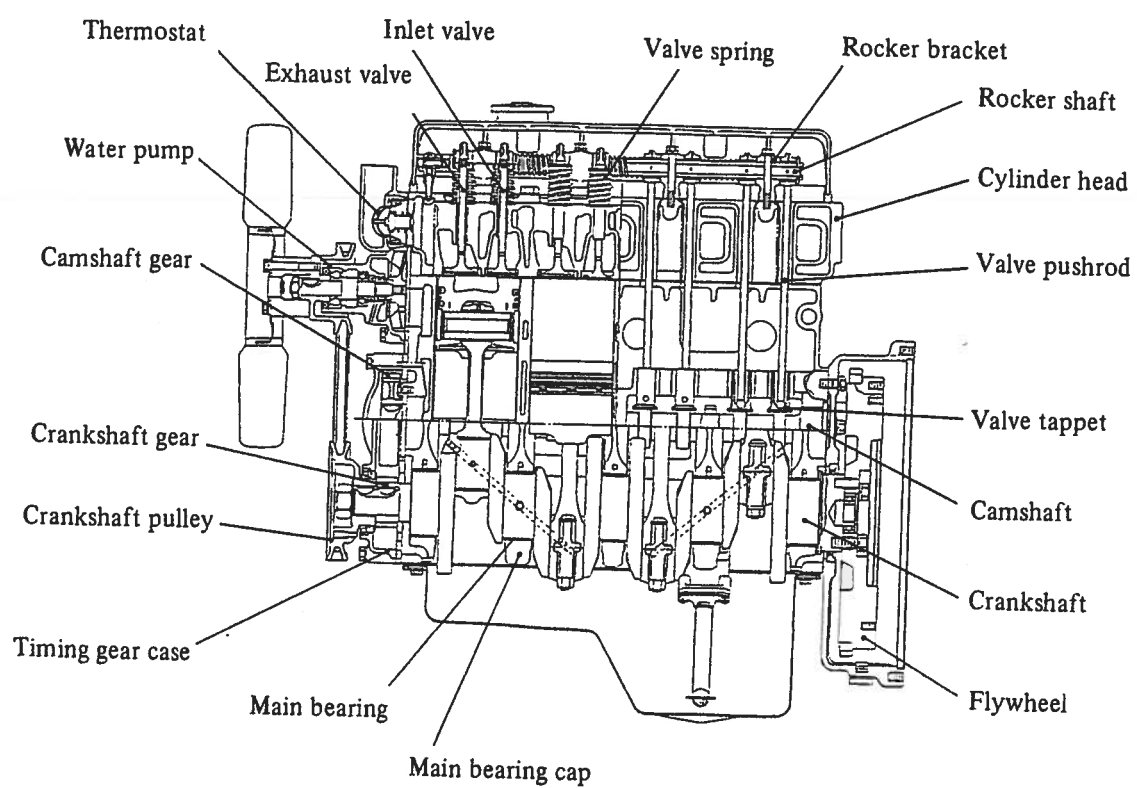
Longitudinal view [S4E]

1.3 SF-series diesel engines - Sectional views



Transverse view [S4F]

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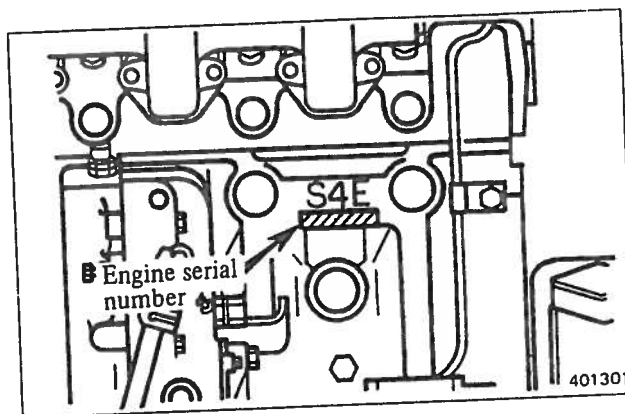
Longitudinal view [S4F]

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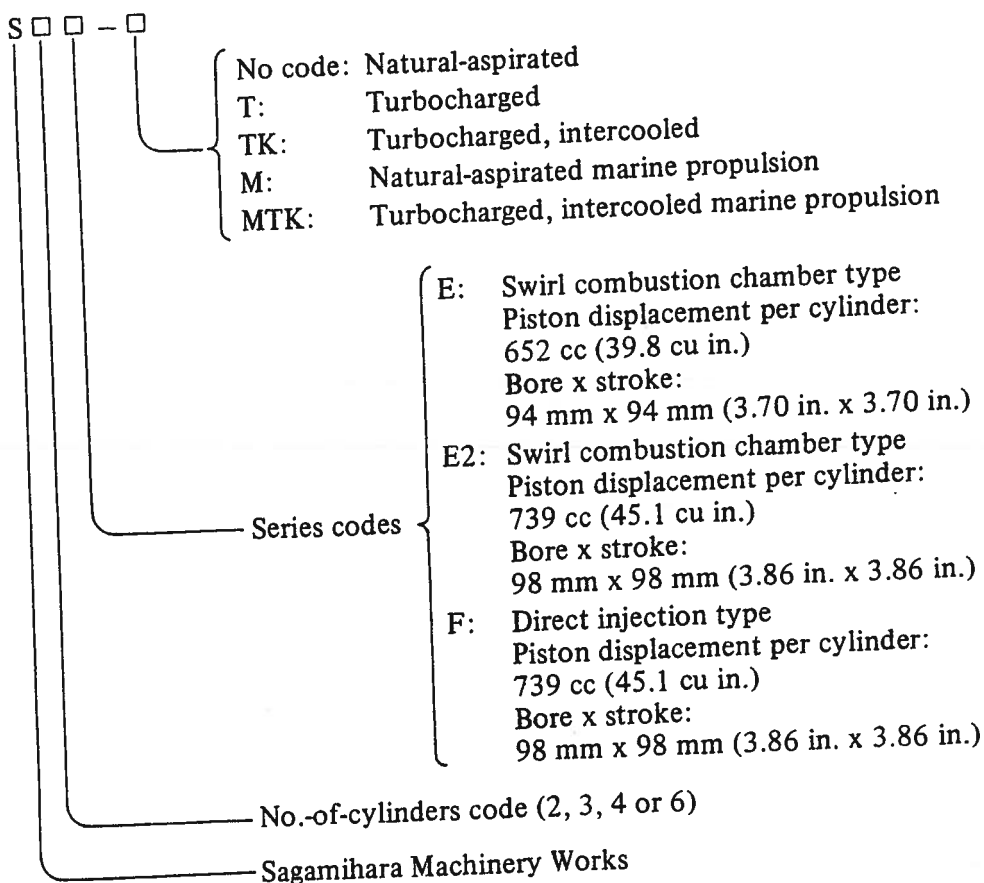
GENERAL

1.4 Engine serial number location

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



1.5 Engine model and application codes



GENERAL

2. SPECIFICATIONS

Model designation				S2E	S3E	S4E	S6E
General	Type			Water-cooled, 4-stroke cycle, diesel			
	No. of cylinders – arrangement			2-in line	3-in line	4-in line	6-in line
	Type of combustion chamber			Swirl chamber			
	Valve mechanism			Overhead			
	Bore x stroke mm (in.)			94 x 94 (3.70 x 3.70)			
	Piston displacement liter (cu in.)			1.30 (79.3)	1.95 (119)	2.61 (159.3)	3.91 (283.6)
	Compression ratio			20 : 1			
	Fuel (ASTM specification)			Grade No. 2D diesel fuel			
	Firing order			1-2	1-3-2	1-3-4-2	1-5-3 -6-2-4
	Direction of rotation			Counterclockwise as viewed from flywheel side			
	Dimensions	Overall length	mm (in.)	573 (22.56)	661 (26.02)	783 (30.83)	1121 (44.13)
		Overall width	mm (in.)	551 (21.69)	515 (20.28)	511 (20.12)	609 (23.98)
		Overall height	mm (in.)	734 (28.90)	729 (28.70)	729 (28.70)	728 (28.66)
	Weight (dry) kg (lb)			180 (397)	230 (507)	270 (595)	360 (794)
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			Medium/low speed type (below 3000 rpm)		High speed type (above 3000 rpm)	
		Inlet valves	Open	B.T.D.C. 30°		B.T.D.C. 30°	
			Close	A.B.D.C. 50°		A.B.D.C. 74°	
		Exhaust valves	Open	B.B.D.C. 74°		B.B.D.C. 74°	
			Close.	A.T.D.C. 30°		A.T.D.C. 30°	
	Starting system			Electric starter			
	Starting aid			Glow plugs			
Inlet/exhaust systems	Air cleaner	Type	Paper element				
	Turbucharger	Type	—				
Lubrication system	Type			Pressure feed by gear pump			
	Engine oil	API service classification		CC			
		Refill capacity (incl. filter) liter (U.S. gal)		5 (1.3)	7 (1.8)	8 (2.1)	12 (3.2)

S2E2	S3E2	S4E2	S4E2-T	S6E2	S6E2-T	S3F	S4F	S4F-T	S6F	S6F-T
Water-cooled, 4-stroke cycle, diesel										
2-in line	3-in line	4-in line		6-in line		3-in line	4-in line		6-in line	
Swirl chamber						Direct injection				
Overhead										
98 x 98 (3.86 x 3.86)										
1.48 (90.3)	2.22 (135.5)	2.96 (180.6)		4.44 (271)		2.22 (135.5)	2.96 (180.6)		4.44 (271)	
20 : 1						17 : 1				
Grade No. 2 diesel fuel										
1-2	1-3-2	1-3-4-2		1-5-3-6-2-4		1-3-2	1-3-4-2		1-5-3-6-2-4	
Counterclockwise as viewed from flywheel side										
573 (22.56)	661 (26.02)	783 (30.83)	783 (30.83)	1121 (44.13)	1160 (45.67)	660.5 (26.00)	806 (31.73)	806 (31.73)	1160 (45.67)	1160 (45.67)
551 (21.69)	515 (20.28)	511 (20.12)	511 (20.12)	609 (23.98)	577 (22.72)	524 (20.63)	524 (20.63)	524 (20.63)	552 (21.73)	577 (22.72)
736 (28.98)	731 (28.78)	731 (28.78)	841 (33.11)	730 (28.74)	900 (35.43)	728.5 (28.68)	717.6 (28.25)	853 (33.58)	727.6 (28.65)	900 (35.43)
180 (397)	230 (507)	270 (595)	275 (606)	360 (794)	365 (805)	230 (507)	270 (595)	275 (606)	360 (794)	365 (805)
Dry, special cast iron										
2										
1 (w/spring expander)										
[Medium/low speed type (below 3000 rpm)]			[High speed type (above 3000 rpm)]							
B.T.D.C. 30°			B.T.D.C. 30°			B.T.D.C. 10°				
A.B.D.C. 50°			A.B.D.C. 74°			A.B.D.C. 50°				
B.B.D.C. 74°			B.B.D.C. 74°			B.B.D.C. 54°				
A.T.D.C. 30°			A.T.D.C. 30°			A.T.D.C. 10°				
Electric starter										
Glow plugs						Air heater				
Paper element										
—		TC05	—	TC06	—		TC05	—	TC06	
Pressure feed by gear pump										
CC		CD	CC	CD	CC		CD	CC	CD	
5 (1.3)	7 (1.8)	8 (2.1)		12 (3.2)		7 (1.8)	8 (2.1)		12 (3.2)	

Model designation			S2E	S3E	S4E	S6E
Lubrication system	Oil pump	Type	Trochoid			
		Speed ratio to crankshaft	0.5			
		Delivery capacity liter (U.S. gal)/min (at 1800 engine rpm)	14 (3.7)			23 (6.1)
	Relief valve	Type	Piston valve			
		Opening pressure kgf/cm ² (psi) [kPa]	3 ± 0.2 (42.7 ± 2.8) [294 ± 19.6]			
	Oil cooler	Type	—			
	Oil filter	Type	Paper element			
	Oil filter relief valve	Opening pressure kgf/cm ² (psi) [kPa]	1.0 ± 0.2 (14.2 ± 2.8) [98.1 ± 19.6]			
Oil jet check valve	Opening pressure kgf/cm ² (psi) [kPa]	—				
Cooling system	Refill capacity (engine water jacket) liter (U.S. gal)		3.0 (0.8)	4.0 (1.1)	4.6 (1.2)	6.5 (1.7)
	Water pump	Type	Centrifugal			
		Speed ratio to crankshaft	1.3			
		Delivery capacity liter (U.S. gal)/min (at 2000 engine rpm)	103 (27.2)	110 (29.0)	115 (30.4)	103 (27.2)
	Fan belt	Type	Low-edge, cog, B type V-belt			
		Manufacturer	MITSUBOSHI			
	Thermostat	Type	Wax pellet			
		Valve opening temperature °C (°F)	76.5 ± 2 (169.7 ± 3.6)			
	Radiator	Type	Corrugated fin			
	Fan	Type	Polypropylene-blade, circular-arc type			
No. of blades		6				
Diameter mm (in.)		325 (12.80)	380 (14.96)		440 (17.32)	
Speed ratio to crankshaft		1.3				
Fuel system	Injection pump	Type	Bosch A			
		Manufacturer	NIPPONDENSO			
		Diameter of plunger mm (in.)	6.5 (0.256)			
	Feed pump	Type	Bosch, piston			
		Manufacturer	NIPPONDENSO			
		Cam lift mm (in.)	1.5 (0.059)			
	Governor	Type	Bosch RSV or RUV, mechanical			
Manufacturer		NIPPONDENSO				

S2E2	S3E2	S4E2	S4E2-T	S6E2	S6E2-T	S3F	S4F	S4F-T	S6F	S6F-T	
Trochoid											
0.5											
14 (3.7)			23 (6.1)		32 (8.4)	14 (3.7)		23 (6.1)		32 (8.4)	
Piston valve											
3 ± 0.2 (42.7 ± 2.8) [294 ± 19.6]											
—			Plate	—	Plate	—		Plate	—	Plate	
Paper element											
1.0 ± 0.2 (14.2 ± 2.8) [98.1 ± 19.6]											
—			1.2 ^{+0.3} _{-0.2} (17 ^{+4.3} _{-2.8}) [118 ⁺²⁹ ₋₂₀]	—	1.2 ^{+0.3} _{-0.2} (17 ^{+4.3} _{-2.8}) [118 ⁺²⁹ ₋₂₀]	—		1.2 ^{+0.3} _{-0.2} (17 ^{+4.3} _{-2.8}) [118 ⁺²⁹ ₋₂₀]	—	1.2 ^{+0.3} _{-0.2} (17 ^{+4.3} _{-2.8}) [118 ⁺²⁹ ₋₂₀]	
3.0 (0.8)	4.0 (1.1)	4.6 (1.2)		6.5 (1.7)		4.0 (1.1)	4.6 (1.2)		6.5 (1.7)		
Centrifugal											
1.3				1.1		1.3				1.1	
103 (27.2)	110 (29.0)	115 (30.4)		103 (27.2)	95 (25.1)	110 (29.0)	115 (30.4)		103 (27.2)	95 (25.1)	
Low-edge, cog, B type V-belt											
MITSUBOSHI											
Wax pellet											
76.5 ± 2 (169.7 ± 3.6)											
Corrugated fin											
Polypropylene-blade, circular-arc type											
6											
325 (12.80)	380 (14.96)		440 (17.32)		500 (19.69)	380 (14.96)		440 (17.32)		500 (19.69)	
1.3				1.1		1.3				1.1	
Bosch A											
NIPPONDENSO											
7.0 (0.276)						9.0 (0.354)					
Bosch, piston											
NIPPONDENSO											
1.5 (0.059)											
Bosch RSV or RUV, mechanical						Bosch RSV, mechanical					
NIPPONDENSO											

Model designation				S2E	S3E	S4E	S6E
Fuel system	Injection nozzles	Type of nozzle holder		Bosch, throttle			
		Type of nozzle tip		Bosch ND-DN0SD			
		Manufacturer		NIPPONDENSO			
		No. of spray holes		1			
		Diameter of spray hole mm (in.)		1.0 (0.04)			
		Spray angle		0°			
		Valve opening pressure kgf/cm ² (psi) [MPa]		120 (1706) [11.8]			
	Fuel filter	Type		Paper element	Cartridge, paper element		
		Manufacturer		TOKYO ROKI	NIPPON ROKAKI		
Electrical system	Voltage – polarity			12V – negative ground		24V – negative ground	
	Starter	Model		M002T56471 or M002T56472 (dry)		M002T65271 or M002T65272 (dry)	M003T56174
		Manufacturer		MITSUBISHI ELECTRIC			
		Type		Pinion shift			
		Output V – kW		12 – 2		24 – 3.2	24 – 5
		No. of pinion teeth/No. of ring gear teeth		11/110			10/110
	Alternator	Type		3-phase, with rectifier			
		Manufacturer		MITSUBISHI ELECTRIC			
		Output V – A		12 – 35		24 – 20	
		Rated voltage generating speed rpm		1050		1100	
		Rated output generating speed rpm		5000			
		Maximum speed rpm		13500			
		Speed ratio to crankshaft		1.7			
	Glow plugs	Type		Sheathed			
		Rated voltage – current V – A		10.5 – 8.3		22.5 – 4.8	
		Resistance at normal temperature		1.25 ± 0.05		4.5 ± 0.5	
	Air heater	Type		–			
		Capacity kW		–			
	Heater relay	Fuse capacity A		–			

S2E2	S3E2	S4E2	S4E2-T	S6E2	S6E2-T	S3F	S4F	S4F-T	S6F	S6F-T
Bosch, throttle						Bosch, hole				
Bosch ND-DN0SD						Bosch DLLA				
NIPPONDENSO										
1						4				
1.0 (0.04)						0.3 (0.01)				
0°						155°				
120 (1706) [11.8]						220 (3128) [21.6] or 180 (2560) [17.7]				
Paper element	Cartridge, paper element					Cartridge, paper element				
TOKYO ROKI	NIPPON ROKAKI					NIPPON ROKAKI				
12V – negative ground		24V – negative ground				12V – negative ground	24V – negative ground			
M002T56471 or M002T56472 (dry)		M002T65271 or M002T65272 (dry)		M003T56174		M002T56471 or M002T56472 (dry)	M002T65271 or M002T65272 (dry)		M003T56174	
MITSUBISHI ELECTRIC										
Pinion shift										
12 – 2		24 – 3.2		24 – 5		12 – 2	24 – 3.2		24 – 5	
11/110				10/110		11/110			10/110	
3-phase, with rectifier										
MITSUBISHI ELECTRIC										
12 – 35		24 – 20				12 – 35	24 – 20			
1050		1100				1050	1100			
5000										
13500										
1.7										
Sheathed						—				
10.5 – 8.3		22.5 – 4.8				—				
1.25 ± 0.05		4.5 ± 0.5				—				
—						Electric heater				
—						0.96	2.1			
—						127				

3. TIPS ON DISASSEMBLY AND REASSEMBLY

This Service manual deals with Mitsubishi's recommended procedures to be followed in servicing the Mitsubishi diesel engines and contains information on the special tools and basic safety precautions.

The safety precautions contained herein, however, are not the whole of 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.

Study this manual carefully and observe the following general precautions to help prevent serious injury to the personnel and damage to the engine.

3.1 Disassembly

- (1) Use only right tools and instruments. Serious injury to the personnel and damage to the engine result from the wrong use of tools and instruments.
- (2) Use an overhaul stand or work bench if necessary. Also, use assembly bins to keep the 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 reassembling work.
- (4) Pay attention to marks on assemblies, components and parts for their positions or directions. Put on marks, if necessary, to aid reassembly.
- (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 chain block.

3.2 Reassembly


- (1) Wash all engine parts, except for oil seals, O-rings, rubber sheets, etc., with cleaning solvent and dry them with pressure air.
- (2) Use only right tools and instruments.
- (3) Use only good-quality lubricating oils and greases. 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 tightening torque is specified. (Refer to 2, Group No. 2.)
- (5) Replace gaskets and packings with new ones. Apply a proper amount of quick-drying cement to gaskets or packings, if necessary.

MAINTENANCE STANDARDS

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1. MAINTENANCE STANDARDS

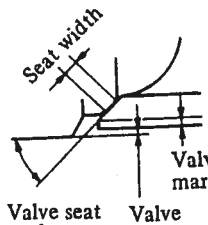
Unit: mm (in.)

Group	Inspection point		Nominal value	Assembly standard [standard clearance]	Repair limit [clearance]	Service limit [clearance]	Remarks
General	Maximum rpm		Varies according to specifications				Adjust governor setting.
	Minimum rpm		650 – 700				
	Compression pressure		27 kgf/cm ² (384 psi) [2.6 MPa] at 150 – 200 rpm		24 kgf/cm ² (341 psi) [2.4 MPa]		Oil and water temp. 20 – 30°C (68 – 86°F)
	Lube oil pressure		3 – 4 kgf/cm ² (43 – 57 psi) [0.3 – 0.4 MPa] at 1500 rpm		2 kgf/cm ² (28.4 psi) [0.2 MPa]		Oil temperature 60 – 70°C (140 – 158°F)
			1 kgf/cm ² (14.2 psi) [0.1 MPa], minimum at idling		0.5 kgf/cm ² (7 psi) [0.05 MPa]		
	Valve timing [with 3-mm clearance on valve side]	In. valves open	Medium/low speed type of SE/SE2 14° A.T.D.C. 3° A.B.D.C. 24° B.B.D.C. 29° B.T.D.C. ±3° (crank angle)	High speed type of SE/SE2 20° A.T.D.C. 15° A.B.D.C. 24° B.B.D.C. 29° B.T.D.C. ±3° (crank angle)	[SF] 28° A.T.D.C. 12° A.B.D.C. 19° B.B.D.C. 25° B.T.D.C. ±3° (crank angle)	Values are only for checking valve timing and are different from actual ones.	
		In. valves close					
		Ex. valves open					
		Ex. valves close					
	Valve clearance (cold)			0.25 [(0.0098)]			Both inlet and exhaust valves
	Fuel injection timing		Specification		B.T.D.C.		Standard injection timing are 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.
			SE-series	1800 rpm	22°		
				2000 rpm	23°		
2200 rpm				24°			
2500 rpm				25°			
3000 rpm				28°			
3600 rpm				31°			
SE2-series			1800 rpm	23°			
			2000 rpm	24°			
	2200 rpm	25°					
	2500 rpm	26°					
	3000 rpm	29°					
	3600 rpm	31°					
SF-series	2000 rpm	13° – 16°					
	2500 rpm	16°					
	3000 rpm	19°					
Fan drive belt tension		12 (1/2), approx				Measure sag at point indicated by arrows 	

In.: Inlet Ex.: Exhaust

Unit: mm (in.)

Group	Inspection point		Nominal value	Assembly standard [standard clearance]	Repair limit [clearance]	Service limit [clearance]	Remarks
Crankcase	Crankcase	Warpage of gasketed surface		0.05 (0.0020), maximum	0.20 (0.0079)		Regrind if warpage is minor.
	Cylinder sleeves	Inside diameter	SE 94 (3.70)	94.000 – 94.035 (3.70078 – 3.70216)	94.200 (3.70865)	95.200 (3.74802)	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
			SE2 SF 98 (3.86)	98.000 – 98.035 (3.85826 – 3.85964)	98.200 (3.86613)	99.200 (3.90550)	
		Out-of-roundness		0.015 (0.00059), maximum			
		Taper		0.05 (0.0020), maximum			
	Main bearings	Clearance on journals		75 (2.95)	0.050–0.115 [(0.00197–0.00453)]	0.200 [(0.00787)]	If repair limit is reached, replace bearings. If service limit is reached, regrind journals and use undersize bearings: Undersize bearings: –0.25 (–0.0098), –0.50 (–0.0197) and –0.75 (–0.0295)
		Thrust journal length (end play)		2.45 (0.0965)	0.100–0.264 [(0.00394–0.01039)]	0.300 [(0.01181)]	Replace thrust plate.
	Tappet guides	Inside diameter			22.000 – 22.021 (0.86614 – 0.86697)	22.100 (0.87008)	
		Clearance on tappets		22 (0.87)	0.035–0.086 [(0.00138–0.00339)]	0.120 [(0.00472)]	+0.10 (+0.0039) as inside diameter If repair limit is reached, replace tappets.
	Camshaft bushings	Clearance on journals			0.04 – 0.09 [(0.0016–0.0035)]	0.15 [(0.0059)]	If repair limit is exceeded, replace bushings. Ream if necessary.
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		1.6 (0.063)	±0.15 (±0.0059)		
	Valves and valve guides	Diameter of valve stems	Inlet valves		7.955 – 7.940 (0.31319 – 0.31260)	7.900 (0.31102)	
			Exhaust valves		7.940 – 7.920 (0.31260 – 0.31181)	7.850 (0.30905)	
		Stem clearance in guide	Inlet valves	8 (0.31)	0.055–0.085 [(0.00217–0.00335)]	0.150 [(0.00591)]	
			Exhaust valves		0.070–0.105 [(0.00276–0.00413)]	0.200 [(0.00787)]	
		As-installed length of guides		17 (0.67)	±0.3 (±0.012)		

Group	Inspection point		Nominal value	Assembly standard [standard clearance]	Repair limit [clearance]	Service limit [clearance]	Remarks		
Cylinder head	Valve seats	Angle	30°				 Valve seat angle Valve sinkage		
		Valve sinkage	SE SE2	0.7 (0.028)	±0.2 (±0.008)	1.3 (0.051)			
			SF	Inlet: 0.4 (0.016) Exhaust: 0.5 (0.020)	±0.2 (±0.008)	1.1 (0.043)			
		Width		1.2 (0.047)	±0.14 (±0.0055)	1.6 (0.063)			
		Valve margin			2.13 (0.0839)	Refacing is permissible up to 1.2 (0.047).			
	Valve springs	Medium/low speed type	Free length	48.85 (1.9232)			47.60 (1.8740)		
			Squareness		1.5°, maximum			Difference in angle between ends with respect to center line	
			Test force/length under test force		19 ± 1 kgf/43 (42 ± 2.2 lbf/1.69) [186 ± 9.8N/1.69]		15 kgf/43 (33 lbf/1.69) [147N/1.69]		
		High speed type	Outer 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		23.9 ± 1.2 kgf/44 (52.7 ± 2.6 lbf/1.73) [234 ± 11.8N/1.73]		21.2 kgf/44 (46.7 lbf/1.73) [208N/1.73]	
			Inner springs	Free length	40.8 (1.606)			39.8 (1.567)	
				Squireness		1.5°, maximum			Difference in angle between ends with respect to center line
				Test force/length under test force		6 ± 0.3 kgf/36.5 (13 ± 0.7 lbf/1.437) [59 ± 2.9N/1.437]		4.6 kgf/36.5 (10 lbf/1.437) 45 N/1.437]	
		Rocker arms	Inside diameter of rocker bushings			20.000 – 20.021 (0.78740 – 0.78823)			
			Diameter of rocker shafts			19.984 – 19.966 (0.78677 – 0.78606)			
			Clearance of bushings on shaft		20 (0.79)	0.016–0.055 [(0.00063–0.00217)]	0.070 (0.00276)		

Unit: mm (in.)

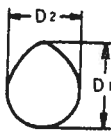
Group	Inspection points			Nominal value	Assembly standard [standard clearance]	Repair limit [clearance]	Service limit [clearance]	Remarks
Cylinder head	Valve pushrods	Runout (bend)			0.4 (0.016), maximum			Rounout measured with pushrod supported at centerlines of its spherical ends
Main moving parts	Crankshaft	Runout			0.02 (0.0008), maximum	0.05 (0.0020)		
		Diameter of journals		75 (2.95)	-0.03 (-0.0012) -0.05 (-0.0020)	-0.15 (-0.0059)	-0.90 (-0.0354)	
		Diameter of crankpins		5.8 (2.28)	-0.035 (-0.00138) -0.055 (-0.00217)	-0.20 (-0.0079)		
		Center to center between journal and crankpin		49 (1.93)	±0.05 (±0.0020)			
		Parallelism between journal and crankpin			Runout: 0.01 (0.0004), maximum (over crankpin length)			
		Out-of-roundness of journals and crankpins			0.01 (0.0004), maximum	0.03 (0.0012)		
		Taper of journals and crankpins			0.01 (0.0004), maximum	0.03 (0.0012)		
		Filler radius of journals and crankpins		3R (0.12)	±0.2 (±0.008)			
		End play		37 (1.46)	[0.100–0.264 (0.00394–0.01039)]	[0.300 (0.01181)]		If repair limit is reached, replace thrust plates. If repair limit is exceeded, use over-size thrust plates. Oversize thrust plates: +0.15 (+0.0059), +0.30 (+0.0118) and +0.45 (+0.0177)
	Pistons	Outside diameter (at skirt)	SE	Standard	94 (3.70)	93.875 – 93.845 (3.69586 – 3.69468)	93.660 (3.68739)	At right angles to piston pin at skirt
				0.25 (0.0098) oversize		94.125 – 94.095 (3.70570 – 3.70452)	93.910 (3.69724)	
				0.50 (0.0197) oversize		94.375 – 94.345 (3.71554 – 3.71436)	94.160 (3.70708)	
		Outside diameter (at skirt)	SE2	Standard	98 (3.86)	97.875 – 97.845 (3.85334 – 3.85216)	97.660 (3.84487)	
				0.25 (0.0098) oversize		98.125 – 98.095 (3.86318 – 3.86200)	97.910 (3.85472)	
				0.50 (0.0197) oversize		98.375 – 98.345 (3.87302 – 3.87184)	98.160 (3.86456)	

Unit: mm (in.)

Group	Inspection point			Nominal value	Assembly standard [standard clearance]	Repair limit [clearance]	Service limit [clearance]	Remarks
Main moving parts	Pistons	Outside diameter (at skirt)	SF	Standard	97.975 – 97.945 (3.85728 – 3.85609)		97.760 (3.84881)	At right angles to piston pin at skirt
				0.25 (0.0098) oversize	98.225 – 98.195 (3.86712– 3.86594)		98.010 (3.85865)	
				0.50 (0.0197) oversize	98.475 – 98.445 (3.87696 – 3.87578)		98.260 (3.86850)	
		Protrusion above crankcase		SE SE2	0.35 – 0.75 (0.0138 – 0.0295)			Check bearing clearance.
				SF	0.65 – 1.05 (0.0256 – 0.0413)			
		Variance in weight per engine				±3 g (±0.1 oz)		
		Piston rings	Side clearance in ring grooves	No. 1 ring		2.5 (0.098)	0.030 – 0.070 [(0.00118 – 0.00276)]	0.200 [(0.00787)]
	No. 2 ring			2.0 (0.079)	0.025 – 0.060 [(0.00098 – 0.00236)]	0.150 [(0.00591)]		
	Oil ring		SE	4.0 (0.157)	0.025 – 0.060 [(0.00098 – 0.00236)]	0.150 [(0.00591)]		
			SE2 SF	4.5 (0.177)	0.025 – 0.060 [(0.00098 – 0.00236)]	0.150 [(0.00591)]		
	End gap				0.35 – 0.50 (0.0138 – 0.0197)		1.50 (0.0591)	
	Piston pins	Outside diameter	SE SE2		28.000 – 27.984 (1.10236 – 1.10173)			
			SE2-T SF		32.000 – 31.984 (1.25984 – 1.25921)			
		Clearance in piston	SE SE2	28 (1.10)	0 – 0.016 [(0 – 0.00063)]	0.050 [(0.00197)]	If repair limit is reached, replace pin. If repair limit is exceeded, replace piston.	
			SE2-T SF	32 (1.26)	0 – 0.016 [(0 – 0.00063)]	0.050 [(0.00197)]		
		Clearance in bushing	SE SE2	28 (1.10)	0.020 – 0.051 [(0.00079 – 0.00201)]	0.080 [(0.00315)]	Replace pin or bushing. Ream if necessary.	
			SE2-T SF	32 (1.26)	0.020 – 0.051 [(0.00079 – 0.00201)]	0.080 [(0.00315)]		
	Connecting rod	Inside diameter of bushings	SE SE2		28.045 – 28.020 (1.10413 – 1.10315)			
			SF		32.048 – 32.020 (1.26173 – 1.26063)			
		Twist/bend				0.05/100 (0.0020/3.94), maximum	0.15 (0.0059)	
	Clearance of connecting rod bearings on crankpins			58 (2.28)	0.035 – 0.100 [(0.00138 – 0.00394)]	0.200 [(0.00787)]		If repair limit is reached, replace bearings. If repair limit is exceeded, regrind crankpins and use undersize bearings.

Unit: mm (in.)

Unit: mm (in.)

Group	Inspection point		Nominal value	Assembly standard [standard clearance]	Repair limit [clearance]	Service limit [clearance]	Remarks		
Main moving parts	Connecting rod	End play	40 (1.57)	[0.15–0.35 (0.0059–0.0138)]		[0.50 (0.020)]	Replace connecting rod.		
		Variance in weight per engine		±5 g (±0.2 oz)					
	Flywheel	Radial runout		0.15 (0.0059), maximum	0.50 (0.020)				
		Face runout		0.15 (0.0059), maximum	0.50 (0.020)				
Timing gears	Camshaft	Runout			0.02 (0.0008), maximum	0.05 (0.0020)		Straighten by cold working or replace.	
		SE, SE2	Inlet	D_1 $46.916^{+0.1}_{-0.3}$ (1.84708 ^{+0.004} _{-0.012})	$D_1 - D_2$ = 6.684 (0.26315)		$D_1 - D_2$ = 6.184 (0.24346)		
			Inlet (high-speed engine)	D_1 $45.944^{+0.1}_{-0.3}$ (1.80882 ^{+0.004} _{-0.012})	$D_1 - D_2$ = 7.344 (0.28913)		$D_1 - D_2$ = 6.844 (0.26945)		
			Exhaust						
		SF	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)		
		Diameters of journals	2-cylinder engines	No. 1	54 (2.13)	53.96 – 53.94 (2.1244 – 2.1236)		53.90 (21.220)	
				No. 2	53 (2.09)	52.96 – 52.94 (2.0850 – 2.0842)		52.90 (2.0827)	
			3-/4-cylinder engines	No. 1, 2	54 (2.13)	53.96 – 53.94 (2.1244 – 2.1236)		53.90 (2.1220)	
				No. 3	53 (2.09)	52.96 – 52.94 (2.0850 – 2.0842)		52.90 (2.0827)	
			6-cylinder engine	No. 1, 2, 3	54 (2.13)	53.96 – 53.94 (2.1244 – 2.1236)		53.90 (2.1220)	
				No. 4	53 (2.09)	52.96 – 52.94 (2.0850 – 2.0842)		52.90 (2.0827)	
		End play		5 (0.20)	[0.050 – 0.112 (0.00197 – 0.00441)]	[0.300 (0.01181)]		Replace thrust plates.	
	Idle	Clearance of shaft in bushing		36 (1.42)	[0.025 – 0.075 (0.00098 – 0.00295)]	[0.100 (0.00394)]		Replace bushing.	
		End play			[0 – 0.10 (0 – 0.0039)]	[0.35 (0.0138)]			
		Length of thrust journal of shaft and boss		26 (1.02)	[0.05 – 0.20 (0.0020 – 0.0079)]	[0.40 (0.0157)]		Replace thrust plates.	

Unit: mm (in.)

Group	Inspection point		Nominal value	Assembly standard [standard clearance]	Repair limit [clearance]	Service limit [clearance]	Remarks
Timing gears	Idle	Fit of shaft in crankcase bore	30 (1.18)	0.009T–0.045T [(0.00035T–0.00177T)]			
	Backlash			0.03 – 0.17 [(0.0012 – 0.0067)]	0.25 [(0.0098)]		Replace gears.
Lubrication system	Oil pump	Outer rotor to inner rotor clearance		0.013–0.150 [(0.00051–0.00591)]		0.250 [(0.00984)]	
		Rotor to cover clearance		0.04–0.09 [(0.0016–0.0035)]	0.15 [(0.0059)]		
		Outer rotor to case clearance		0.20–0.28 [(0.0079–0.0110)]		0.50 [(0.0197)]	
		Diameter of main shaft		13.000 – 12.985 (0.51181 – 0.51122)			
		Clearance of main shaft in pump case		0.032–0.074 [(0.00126–0.00291)]		0.150 [(0.00591)]	
	Relief valve	Opening pressure	3.0 kgf/cm ² (42.7 psi) [294 kPa]	±0.2 kgf/cm ² (±2.8 psi) [±19.6 kPa]			Make shim adjustment. Pressure varies by 0.15 kgf/cm ² (2.1 psi [14.7 kPa] per 1 mm (0.04 in.) thickness of shim.
Cooling system	Water pump	Fit of bearing inner races on pump shaft	Front	17 (0.67)	0.01T–0.017T [(0.0004T–0.00067T)]		Replace pump case or pump assembly.
			Rear				
		Fit of bearing outer races in pump case	Front	47 (1.85)	0.011L–0.025L [(0.00043L–0.00098L)]		
			Rear	40 (1.57)			
		Radial clearance of bearings		17 (0.67)	0.010 – 0.025 0.010 – 0.022 (0.00039 – 0.00098) (0.00039 – 0.00087)	0.045 (0.00177)	Replace bearings if they fail to rotate smoothly when slowly turned.
		Inside diameter of spacer for shaft		17 (0.67)	0.001–0.017 [(0.00004–0.00067)]		
		Clearance of impeller on both sides		0.5 – 1.0 (0.020 – 0.039)			Replace impeller if any sign of rubbing contact is noted.
	Unit seal	Protrusion of carbon		1.5 (0.059)		0	
		Height (free state)		21.8 (0.858)	±1 (±0.04)		
Thermo-stat		Valve opening temp./valve lift [at 90°C (194°F)]		76.5°C (169.7°F) 9 (0.35)	±2°C (±3.6°F)		

Unit: mm (in.)

Group	Inspection point		Nominal value	Assembly standard [standard clearance]	Repair limit [clearance]	Service limit [clearance]	Remarks
Fuel system	Injection nozzles	Valve opening pressure	SE SE2	120 kgf/cm ² (1706 psi) [11.8 MPa]	+5 – +15 kgf/cm ² (+71 – +213 psi) [+0.5 – +1.5 MPa]		Make shim adjustment. Pressure varies by 10 kgf/cm ² (142.2 psi) [1.0 MPa] per 0.1 mm (0.004 in.) thickness of shim.
			SF	220 or 180 kgf/cm ² (3128 or 2560 psi) [21.6 or 17.7 MPa]	+5 – +15 kgf/cm ² (+71 – +213 psi) [+0.5 – +1.5 MPa]		
		Spray angle	SE SE2	0°			Test by means of hand tester, using diesel fuel, at 20°C (68°F). If spray pattern is poor even after nozzle is washed in clean diesel fuel, replace nozzle tip.
			SF	155°			
		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	Starter	Diameter of commutator		32 (1.26) [38.7 (1.524)]		31 (1.22) [37.7 (1.484)]	
		Brush	Length	18 (0.71) [17 (0.67)]		11 (0.43)	
			Spring pressure kgf(lbf) [N]	3.5 (7.7) [34.3] [2.5 (5.5) [24.5]]		2.3 (5.1) [22.6] [1.8 (4.0) [18.7]]	
		Thrust gap of pinion shaft		0.5 (0.020)	0, minimum		
		Pinion gap		0.5 – 2.0 (0.020 – 0.079) [0.1 – 2.5 (0.004 – 0.098)]			
		Values in [] indicate those of M003T56174.					

	No-load characteristics			Locked characteristics			Magnetic switch operating voltage	
	Voltage V	Current A	Speed rpm	Voltage V	Current A	Torque kgf·m (lbf·ft) [N·m]	Switch-in voltage V	Switching off
M002T56471 or M002T56472 (dry)	11	130, max.	4000	3	1000, max.	2.8 (20.3) [27.5], min.	8, max.	Shall turn off upon turning off of starter switch.
M002T65271 or M002T65272 (dry)	23	80, max.	3400	8	730, max.	4.5 (32.5) [44.1], min.	16, max.	
M003T56174	23	85, max.	3300	10	1370, max.	9.0 (65.1) [88.3], min.	16, max.	

MAINTENANCE STANDARDS

Unit: mm (in.)

Group	Inspection point		Nominal value	Assembly standard [standard clearance]	Repair limit [clearance]	Service limit [clearance]	Remarks
Electrical system	Alternator	Brush length	18 (0.71)			8 (0.31)	
		Brush spring tension				210 gf (0.5 lbf) [2.1 N]	
		Outside diameter of slip ring	33 (1.30)			32.4 (1.276)	

2. TIGHTENING TORQUE

2.1 Important bolts and nuts

Secured part or component		Thread dia.-pitch	Width across flats	Tightening torque			Remarks
				kgf·m	lbf·ft	N·m	
Cylinder head bolts		12 – 1.75	19	12 ± 0.5	87 ± 4	118 ± 5	[Wet]
Rocker shaft brackets		8 – 1.25	12	1.5 ± 0.5	11 ± 4	15 ± 5	
Main bearing caps		14 – 2	22	10.4 ± 0.5	75 ± 4	102 ± 5	[Wet]
Connecting rod caps		12 – 1.25	17	8.5 ± 0.5	61 ± 4	83 ± 5	[Wet]
Flywheel		12 – 1.25	17	8.5 ± 0.5	61 ± 4	83 ± 5	
Camshaft thrust plate		8 – 1.25	12	1.8	13	18	
Front plate		10 – 1.5	14	1	7	10	
Timing gear case bolts		10 – 1.5	14	1	7	10	
Timer cover		8 – 1.25	12	1.3 ± 0.3	9 ± 2	13 ± 3	
Crankshaft pulley		24 – 1.5	36	40 ± 0.5	289 ± 4	392 ± 5	
Idler thrust plate		10 – 1.25	14	3.5	25	34	
Oil pan		8 – 1.25	12	0.7	5	7	
Oil pan drain plug		12 – 1.25	19	10 ± 0.5	72 ± 4	98 ± 5	
Oil pump mounting bolts		12 – 1.75	17	5.5 ± 0.5	40 ± 4	54 ± 5	
Nozzle gland	SF	8 – 1.25	12	2.2	16	22	
Injection nozzle retaining nuts	SE SE2	24 – 2	—	5 ± 0.5	36 ± 4	49 ± 5	
	SF	15 – 0.5	14	3	22	29	
Injection pump delivery valve holders		10 – 1.5	14	3.5 – 4.0	25 – 29	34 – 39	
Injection pump gear				8.5 – 10.0	61 – 72	83 – 98	
Starter B terminal		8 – 1.25	12	1.0 – 1.2	7 – 9	10 – 12	

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

MAINTENANCE STANDARDS

2.2 General bolts and nuts

Screw thread		Tightening torque					
Diameter	Pitch	With spring washer			Without spring washer		
		kgf·m	lbf·ft	N·m	kgf·m	lbf·ft	N·m
8	1.0	1.8	13	18	2.2	16	22
	1.25	1.8	13	18	2.1	15	21
10	1.25	3.6	26	35	4.2	30	41
	1.5	3.4	25	33	4.0	29	39
12	1.25	6.5	47	64	7.6	55	75
	1.75	6.0	43	59	7.1	51	70
14	1.5	10.4	75	102	12.2	88	120
	2.0	9.8	71	96	11.5	83	113
16	1.5	15.8	114	155	18.6	135	182
	2.0	15.0	108	147	17.6	127	173
18	1.5	22.9	166	225	26.9	195	264
	2.5	20.7	150	203	24.4	176	239

3. SEALANTS

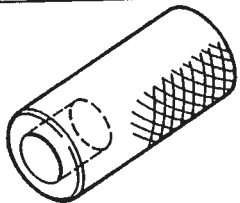
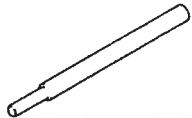
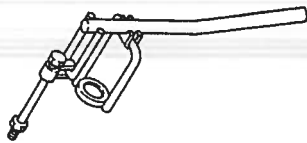
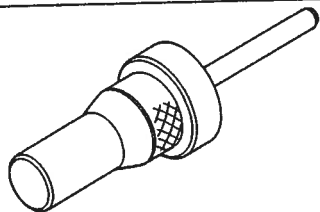
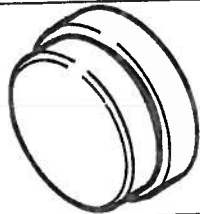
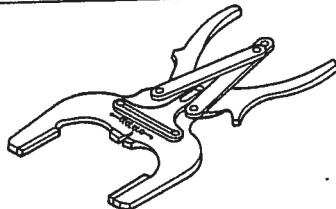
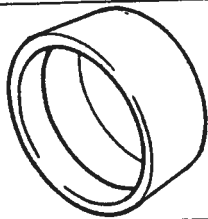
Application point	Mating parts	Sealant	How to use
Oil pan gasket	Front and rear bearing cap seats of crankcase	ThreeBond 1104	Apply to front and rear lower sides (bearing cap seats).
<ul style="list-style-type: none"> Plugs for water and oil holes in crankcase Plug for water hole in cylinder head 	<ul style="list-style-type: none"> Crankcase Cylinder head 	Hermeseal H-1	Apply to holes before installing plugs.
Screw plug for crankcase main oil gallery (taper plug)	Crankcase	Loctite 271	Apply to threads.
Water bypass hose and pipe	Thermostat cover, elbow and water pump	Loctite 271	Apply to threads.
Front and rear bearing cap side seals of crankcase	Bearing caps (front and rear side seal contact surfaces)	ThreeBond 1105D	Apply to crankcase before installing front and rear bearing caps.
Timing gear case gasket	Timing gear	ThreeBond 1102	Apply to gasket surface of timing gear case.

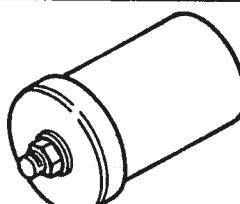
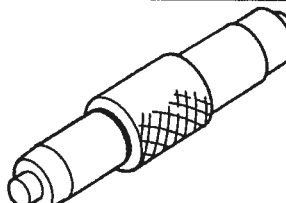
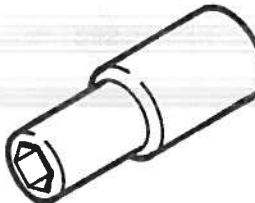
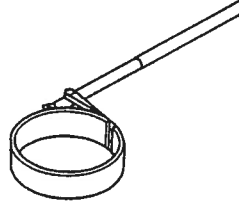
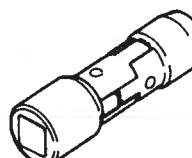
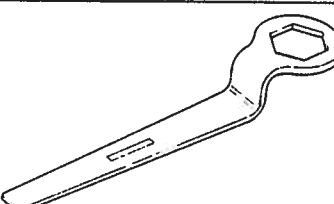
SPECIAL TOOLS

SPECIAL TOOL LIST	30
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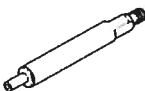
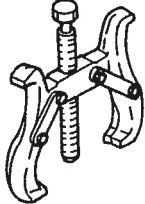
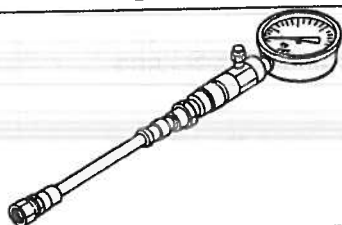
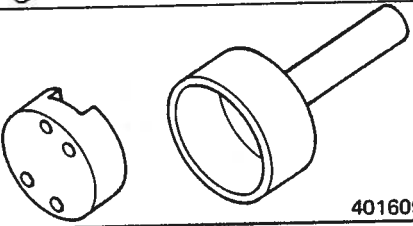
SPECIAL TOOLS

SPECIAL TOOL LIST

Tool name	Part No.	Applicable engine model	Shape	Use
Valve guide installer	34491-00400	SE SE2 SF	 670228	Valve guide installation
Valve guide remover	31391-10500	SE SE2 SF	 670230	Valve guide removal
Valve spring pusher	30691-04500	SE SE2 SF	 401793	Valve spring removal/installation
Insert caulking tool	31391-13010 (For inlet)	SE SE2	 670232	Valve seat installation
	34491-01300 (For exhaust)	SF		
Sleeve installer	34491-00100	SE	 670236	Cylinder sleeve installation
	34491-02100	SE2 SF		
Piston ring pliers	31391-12900	SE SE2 SF	 670240	Piston ring removal/installation
Piston guide	34491-00200	SE	 670234	Piston installation
	34491-02200	SE2 SF		

Tool name	Part No.	Applicable engine model	Shape	Use
Idler shaft puller	34491-02300	SE SE2 SF	 670237	Idler shaft removal
Idler bushing puller	30091-07300	SE SE2 SF	 670242	Idler bushing removal/installation
Socket	34491-00300	SE SE2 SF	 670235	Camshaft thrust plate removal/installation
Oil filter wrench	30691-53301	S3E S4E S6E S3E2 S4E2 S6E2	 401822	Cartridge type oil filter removal/installation
Universal extension	30091-01101	SE SE2 SF	 670239	PE-A type fuel injection pump removal/installation
Cranking handle	30691-11800	SE SE2 SF	 670238	Engine cranking

SPECIAL TOOLS

Tool name	Part No.	Applicable engine model	Shape	Use
Adaptor	30691-21100	SE SE2	 670233	Engine compression pressure measurement
	36791-00100	SF	 401821	
Puller assembly	64309-12900	SE SE2 SF	 670241	Crankshaft gear, camshaft gear, crankshaft pulley and water pump pulley removal
Compression gauge	33391-02100	SE SE2 SF	 401823	Compression pressure measurement
Crankshaft sleeve installer	30691-13010	SE SE2 SF	 401609	Oil seal sleeve on crankshaft rear side installation

OVERHAUL INSTRUCTIONS

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OVERHAUL 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 lubricating oil consumption and excessive blowby gases.

Low power or loss of power, increase in fuel consumption, drop in lubricating oil pressure, hard starting and excessive abnormal noise 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 typical troubles caused by this compression pressure failure:

- (a) Low power or loss of power
- (b) Increase in fuel consumption
- (c) Increase in lubricating oil consumption
- (d) Excessive blowby through breather due to worn cylinder sleeves, pistons, etc.
- (e) Excessive blowby due to poor seating of worn inlet and exhaust valves
- (f) Hard starting
- (g) Excessive abnormal noise

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, (b) and (f) are caused by a fuel injection pump improperly adjusted with respect to injection quantity or injection timing, worn

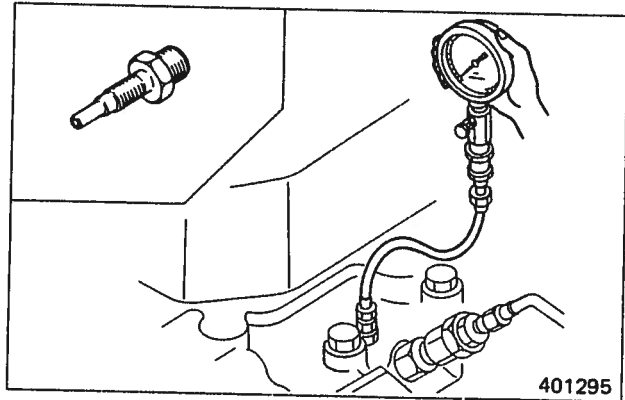
injection pump plungers, faulty injection nozzles, or poor care of the battery, starter and alternator.

The trouble to be considered as the most valid reason for overhauling the engine is (d) Excessive blowby through breather due to worn cylinder sleeves, pistons, etc.; in actually determining when to overhaul the engine, it is reasonable to take this trouble into consideration in conjunction with the other troubles.

2. TESTING THE COMPRESSION PRESSURE

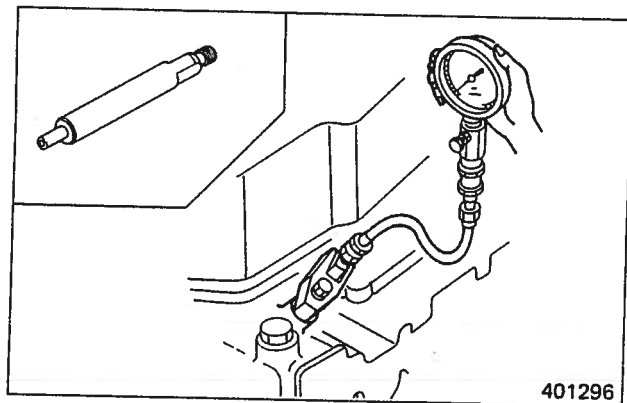
[SE-/SE2-series]

- (1) Remove the glow plug from a cylinder on which the compression pressure is to be measured.
- (2) Attach the adaptor (30691-21100) to the threaded glow plug hole, and connect compression gauge (33391-02100) 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.



[SF-series]

- (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 compression gauge (33391-02100) 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 pressure 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 varies with change of engine rpm. This makes it necessary to check engine rpm at the time of measuring the compression pressure.

Unit: kgf/cm² (psi) [kPa]

Item	Assembly standard	Repair limit
Compression pressure	27 (384) [2.6]	24 (341) [2.4]

NOTE

Measure the compression pressure with the engine running at 150 -200 rpm.

**CAUTION**

- (a) It is important to measure the compression pressure at periodical intervals to obtain the data on the gradual change of the pressure.
- (b) The compression pressure would be slightly higher than the Assembly standard in a new or overhauled engine owing to breaking-in of the piston rings, valve seats, etc. It drops as the engine parts wear down.

ADJUSTMENTS, BENCH TEST, PERFORMANCE TESTS

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1. ADJUSTMENTS

1.1 Valve clearance

Inspect 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

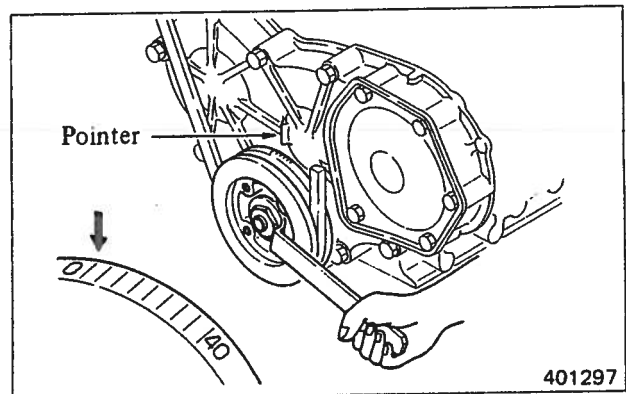
- (a) Inspect the valve clearance by the firing order, by turning the crankshaft by the specified crank angle in normal direction at a time to bring the piston to its top dead center on compression stroke.

No. of cylinders	Firing order	Crank angle
2	1-2	180°
3	1-3-2	240°
4	1-3-4-2	180°
6	1-5-3-6-2-4	120°

- (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

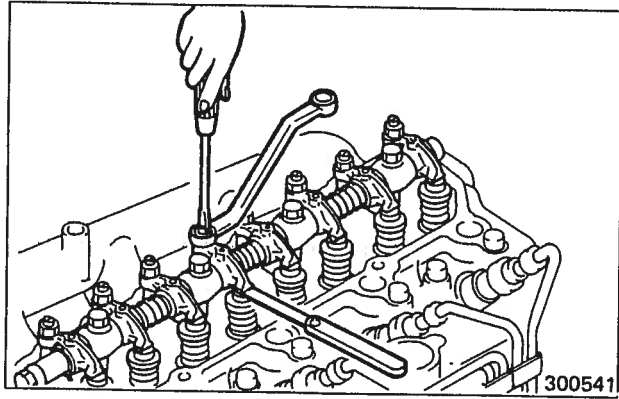
On the 6-cylinder engines equipped with a vibration damper, align the timing mark on the damper with the pointer on the gear case.



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

(2) Adjusting valve clearance

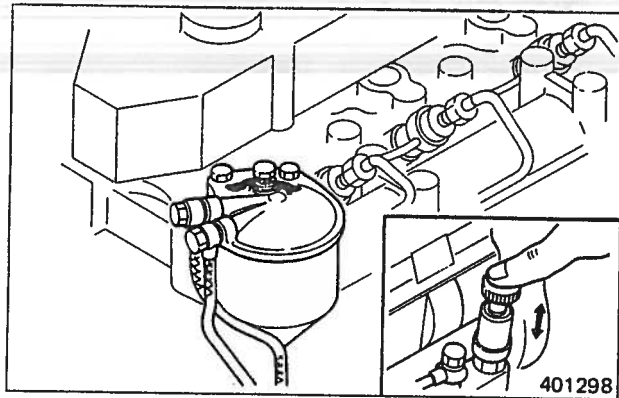
- (a) Loosen the lock nut for adjusting screw, and adjust the clearance by turning the screw in either direction to the extent that the gauge is slightly gripped between the rocker arm and valve cap.
- (b) After adjusting the clearance, tighten the lock nut, and again inspect the clearance, making sure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



1.2 Fuel system priming

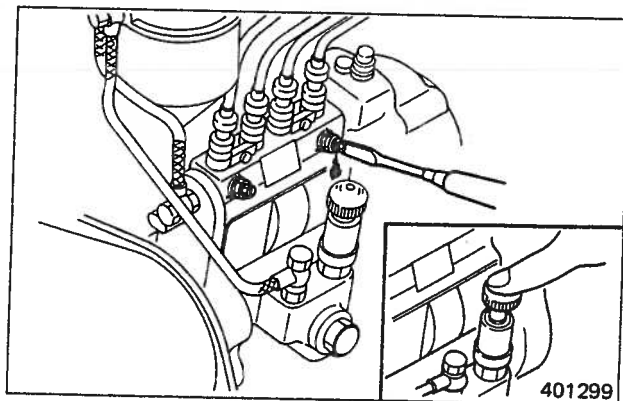
(1) Fuel filter

- (a) Loosen air vent plug at the top of the filter (by turning it about 1.5 rotations).
- (b) Unlock priming pump handle 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 on the injection pump (by turning it about 1.5 rotations). If the pump has two air vent plugs, prime at these plugs.
- (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.

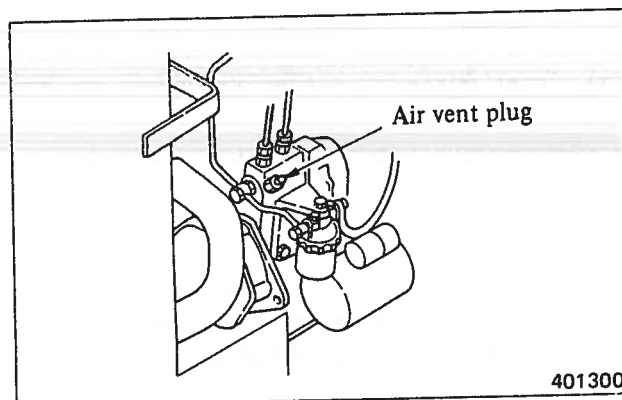


NOTE

- (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 cloth.

[S2E/S2E2 engines]

Prime the fuel system by gravity-feeding fuel from the fuel tank.



Air vent plug on S2E/S2E2 engines

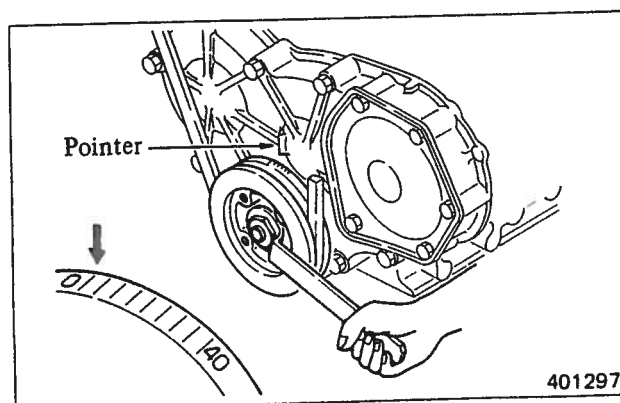
1.3 Fuel injection timing inspection and adjustment

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) Using turning bar (30691-11800) at the crankshaft pulley, 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.



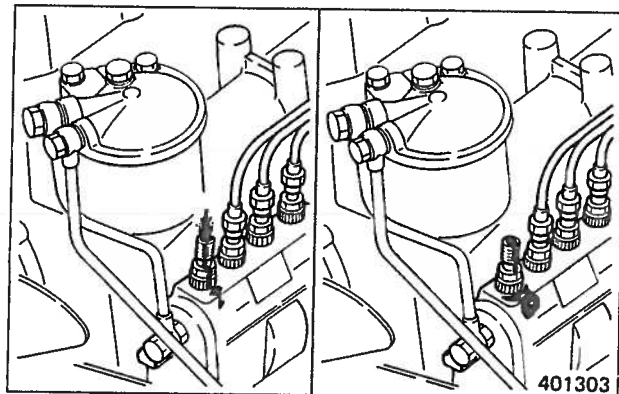
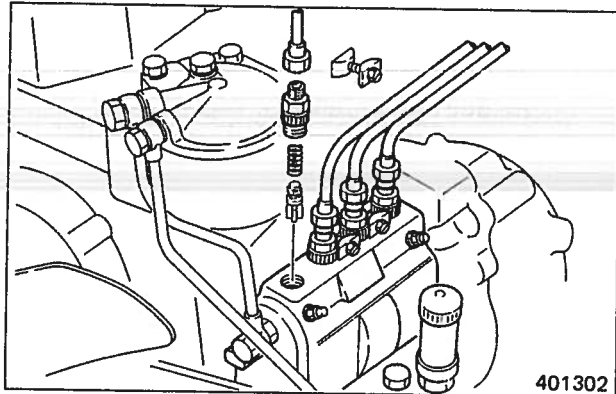
NOTE

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) 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.

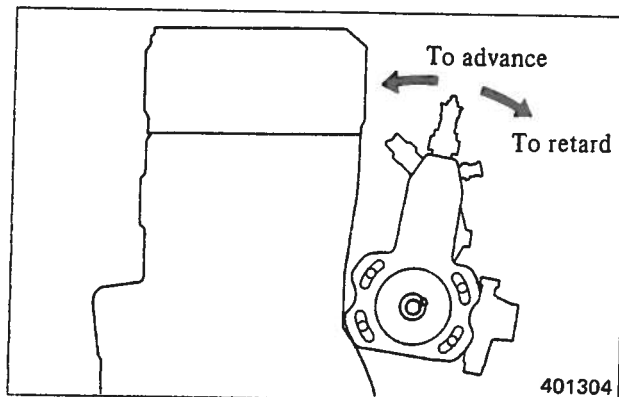
(2) Inspecting fuel injection timing

- (a) Remove the delivery valve holder from No. 1 pumping element of injection pump. Take delivery valve and spring out of the holder, and restore the holder to the pump.
- (b) Turn the crankshaft to bring No. 1 piston to about 60° position before top dead center on compression stroke.
- (c) While operating the priming pump to allow fuel to flow from the delivery valve holder, crank the engine in normal direction. Reduce cranking speed when the fuel just starts to stop flowing. Stop cranking when the fuel stops flowing.
- (d) 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 retarded, tilt the injection pump toward the crankcase. If it is advanced, tilt the pump away from the crankcase.



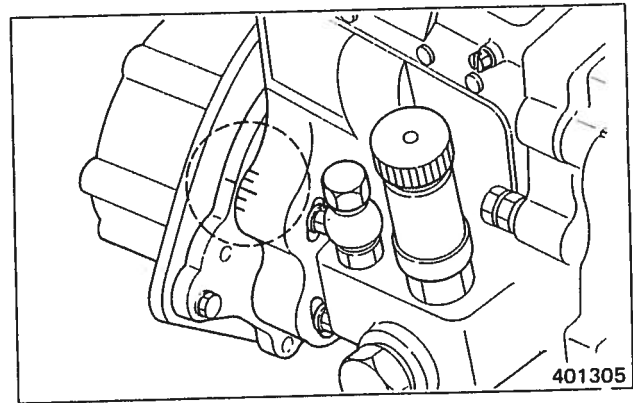
- (b) One graduation of the scale on the injection pump coupling changes the timing by 6° in terms of crank angle.

1.4 No-load minimum (idling) speed and maximum speed setting inspection and adjustment



CAUTION

- (a) No-load minimum (idling) speed and maximum speed are set for each engine on the test bench at the factory and the set bolts are sealed. These settings are to be inspected and adjusted at Mitsubishi-authorized service shop only.
- (b) When inspecting and adjusting these settings, be on standby to operate the engine stop lever manually in the event of engine overrun.

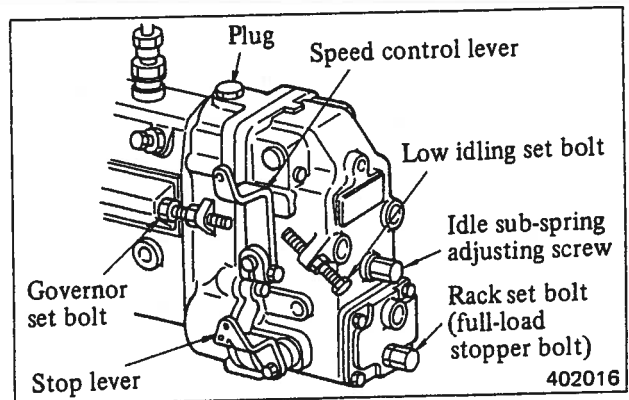


For inspection and adjustment, warm up the engine thoroughly until the coolant and oil temperature rises to 70°C (158°F).

RSV-type governor

(1) Engine starting

- (a) Pull speed control lever to high-speed side. Operate starter switch to crank the engine.
- (b) At about 150 rpm of cranking speed, the engine will fire up to pick up speed. Immediately after the engine fires, move back speed control lever to hold the speed anywhere between 800 and 1000 rpm.
- (c) When the engine is noted to be running with a steady speed, move speed control lever back to low idling speed position.



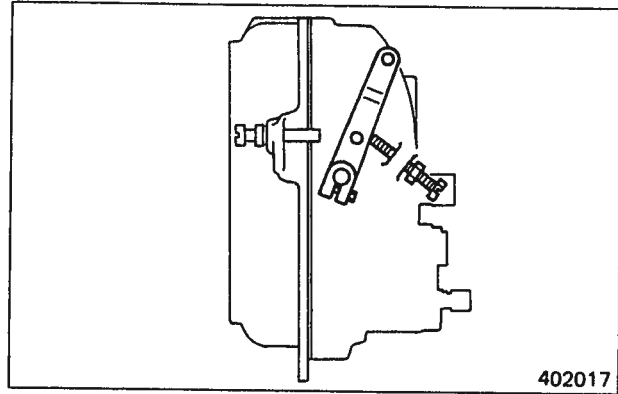
(2) Idling set (The setting for keeping the no-load minimum engine speed)

- (a) Hold speed control lever at the position for permitting the engine to run at 600 to 700 rpm, and set the low idling set bolt.



CAUTION

If a critical speed (the speed at which the engine exhibits excessive vibration due to torsional resonance) might exist, shift the idling set to a lower or higher idling level.



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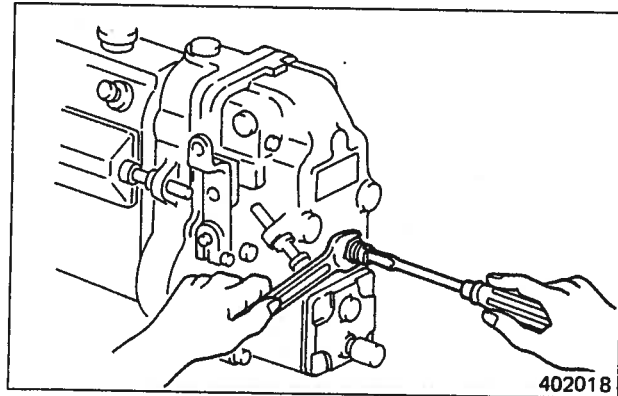
- (b) Turning the set bolt clockwise raises the idling speed.

- (c) If engine speed tends to fluctuate at a lowest idling speed set as above, turn the idle sub-spring adjusting screw clockwise to push in this spring, making it come in slight contact with tension lever. With 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 result in engine overspeeding when, during duty operation, the load is dumped. When tightening the adjusting screw, be sure to tighten it just enough to eliminate the unstable condition.



402018

(3) Rack set (The setting for limiting the maximum engine output)

- (a) Hold 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 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.

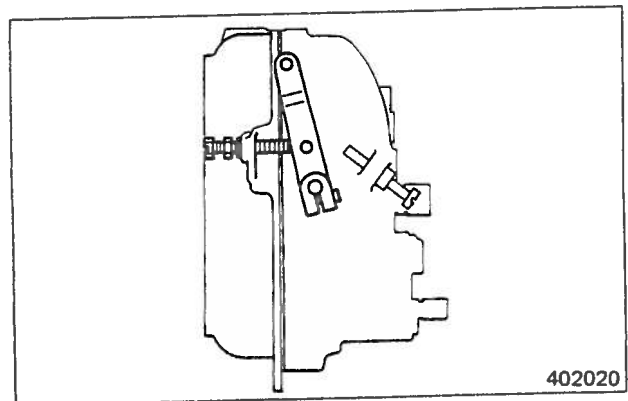
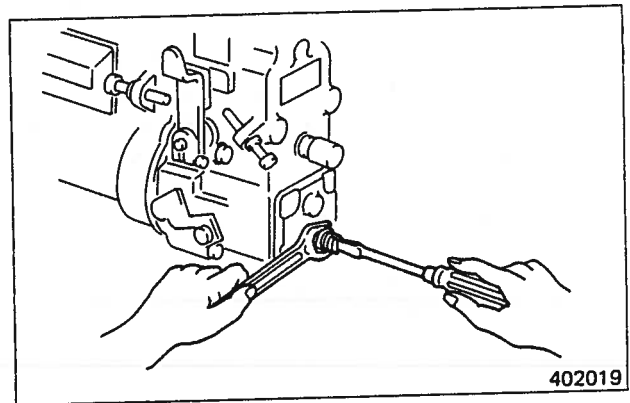
(e) Having positioned the stopper bolt properly (for the rated output), back it off slowly while observing the speed (which will be above the rated speed). Stop backing it off just when the speed begins to fall from the rated level. Secure the stopper bolt (rack set bolt) in that position with its lock nut.

(f) At that time, the speed control lever should be at the position mentioned in (a), above.

(g) Turning the full-load stopper bolt clockwise will increase the injection quantity (engine output), and vice verse.

(4) Governor set (The setting for limiting the maximum engine speed)

- (a) Hold speed control lever at the indicated maximum speed position while applying full load to the engine.



- (b) Run in governor set bolt (maximum speed set bolt) slowly until its forward end comes in contact with speed control lever held as above. Secure the bolt right there by tightening its lock nut.

(5) Determination of the speed regulation (speed droop)

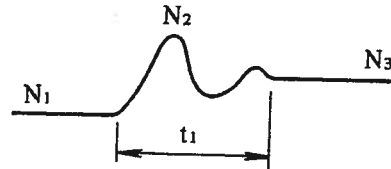
[1] Speed regulation upon removing load

- (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 speed control lever.
- (c) The speed will increase once and decrease, as shown and settle at a new steady level. Read the highest speed (N_2) occurring in this transition and the speed (N_3) after settling, 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 subsequent to the condition mentioned in (b), [1], 5 above, and with the speed control lever left in the same position as above, put the prescribed load instantaneously on the engine: the speed will decrease once and increase, as shown, and settle at a new steady level. Read the lowest speed (N_5) occurring in this transition and the speed (N_6) after settling, and the time (t_2) from N_4 to N_6 .

Speed regulation upon removing load



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

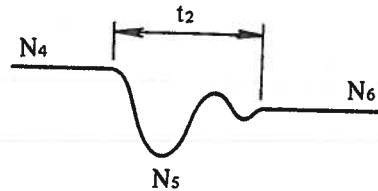
N_1 = initial speed, rpm, before load is removed

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

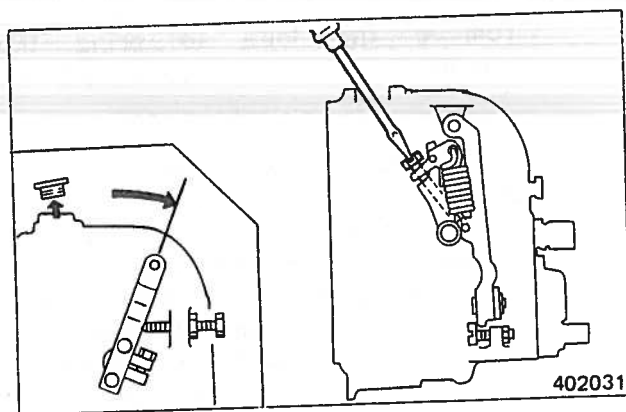
[3] Computing the speed regulation

From the values obtained in [1] and [2], above, compute the speed regulation for each load change. A total of four percent values of speed regulation are to be determined by using the indicated formulas.

If the computed values are at variance with the prescribed values, "governor notch adjustment" must be carried out to eliminate the variance.

(6) Adjustment of speed regulation (governor notch adjustment)

- (a) This adjustment is to be made by turning the adjusting screw for swivel lever to increase or decrease the pre-tension of governor spring.
- (b) To gain access to the adjusting screw, remove the plug at the top of governor housing, and turn 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 pre-tension of governor spring to narrow the speed regulation; loosening it decreases the governor spring pre-tension 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 set (for limiting the maximum engine speed). After making a governor notch adjustment, be sure to re-adjust the governor set, as explained in (4), above.



- (e) Tightening the adjusting screw, mentioned above, will increase the maximum speed, and vice versa.

**CAUTION**

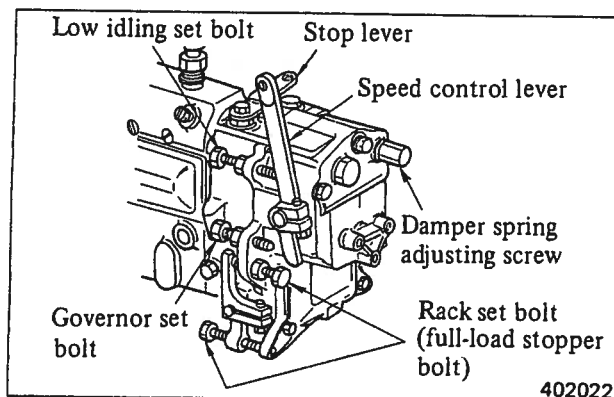
The adjustable range is 20-notch (5 rotations) long. Never loosen the screw by more than 20 notches from the fully tightened position or the control action of the governor will become hazardous.

(7) Sealing

- (a) The stoppers on the injection pump and its governor are adjusted and set through testing by using an injection pump tester or an engine test bench in the final stage of manufacture prior to shipment from the factory. All these stoppers visible on the injection pump are sealed with wires and punched pellets.
- (b) After authorized adjustment of the governor, which has to be effected by breaking the seals, be sure to re-seal all visible stoppers, making them appear as if they were sealed at the factory.
- (c) The stoppers to be sealed are specified. Whether the seals are intact or not has important bearing on the validity of claims, if any, under warranty.

RUV-type governor**(1) Engine starting**

- (a) Pull speed control lever to high-speed side. Operate starter switch to crank the engine.



ADJUSTMENTS, BENCH TEST, PERFORMANCE TESTS

(b) At above 150 rpm of cranking speed, the engine will fire up to pick up speed. Immediately after the engine fires, move back speed control lever to hold the speed anywhere between 800 and 1,000 rpm.

(c) When the engine is noted to be idling steady, move speed control lever back to low idling speed position.

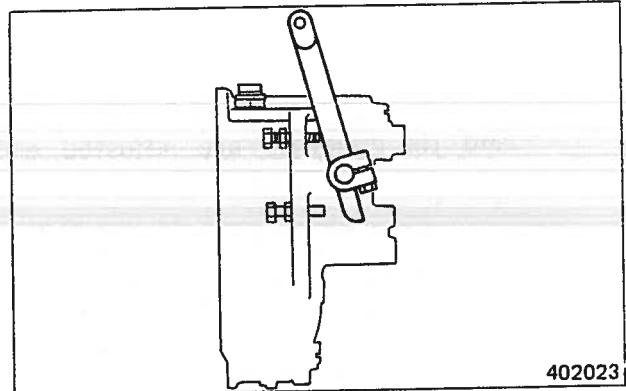
(2) Idling set (The setting for keeping no-load minimum engine speed)

(a) Position low idling set bolt so that the engine will idle at 600 to 700 rpm.



CAUTION

If a critical speed (the speed at which the engine exhibits excessive vibration due to torsional resonance) might exist, shift the idling set to a lower or higher idling level.



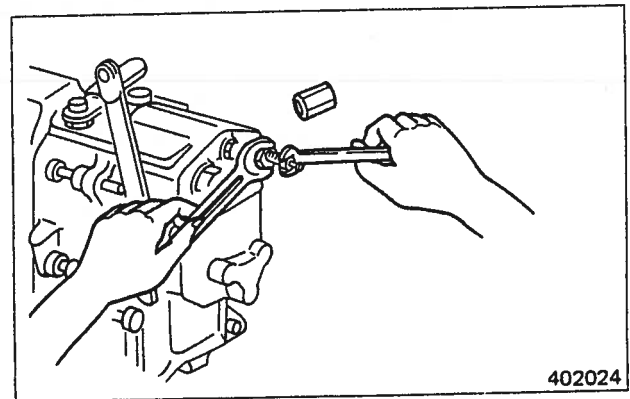
(b) Turning the set bolt clockwise raises the idling speed.

(c) If engine speed tends to fluctuate at a low idling speed set as above, turn damper spring adjusting screw clockwise to push in this spring, making it come in slight contact with floating lever. With the spring exerting some force to the lever, the speed will rise slightly but will stop fluctuating.



CAUTION

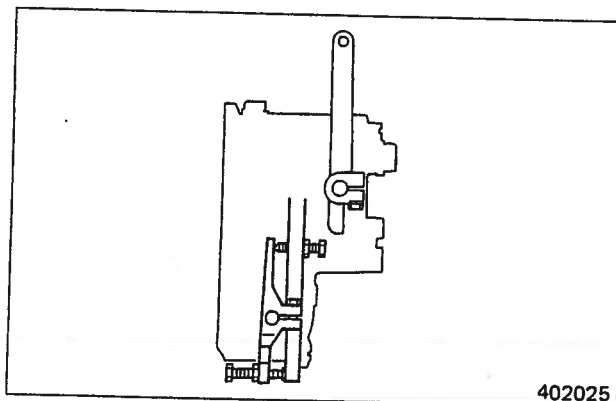
If damper spring set apart from floating lever, the engine will stop when the speed is decreased suddenly.



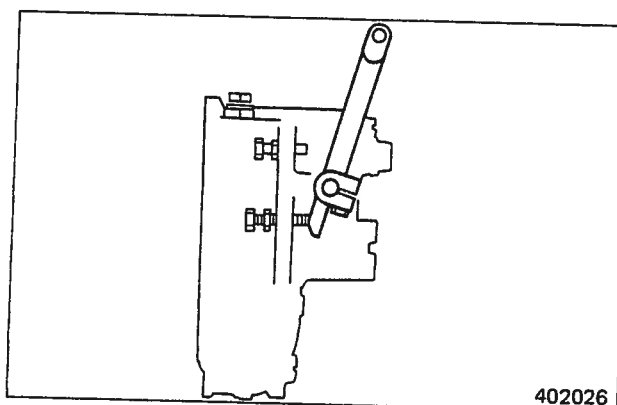
(3) Rack set (The setting for limiting the maximum engine output)

- (a) Hold speed control lever at the position for the indicated output and speed (specified for the 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 state, adjust full-load stopper bolts (2 pcs), as follows:
 - (d) After loosening the stopper bolts, turn stop lever in either direction to find the rack position at which the engine runs at the rated speed.
 - (e) After positioning the rack properly, slightly turn stop lever counterclockwise and then turn it clockwise slowly while observing the speed. Stop turning the lever just when the speed begins to fall from the rated level, secure the stopper bolts in that position with lock nuts.
 - (f) Turning the stop lever counterclockwise (toward the injection pump) will increase the injection quantity (engine output), and vice versa.
- (4) Governor set (The setting for limiting the maximum engine speed)

- (a) Hold speed control lever at the indicated maximum speed position while applying full load to the engine.
- (b) Under this condition, reposition governor set bolt to set the position for the maximum engine speed.



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(5) Sealing

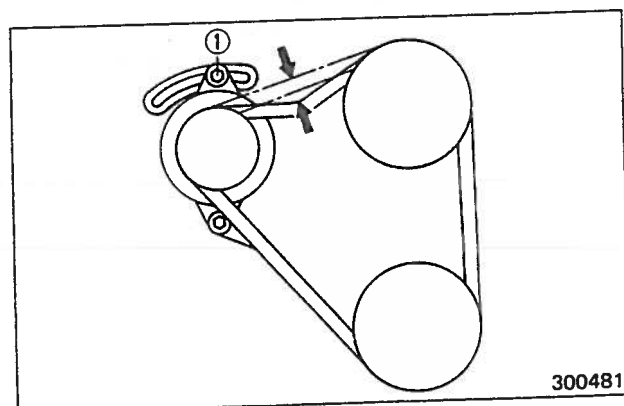
- (a) The stoppers on the injection pump and its governor are adjusted and set through testing by using an injection pump tester or an engine test bench in the final stage of manufacture prior to shipment from the factory. All these stoppers visible on the injection pump are sealed with wires and punched pellets.
- (b) After authorized adjustment of the governor, which has to be effected by breaking the seals, be sure to re-seal all visible stoppers, making them appear as if they were sealed at the factory.
- (c) The stoppers to be sealed are specified. Whether the seals are intact or not has important bearing on the validity of claims, if any, under warranty.

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 bolt (1).

Unit: mm (in.)

Item	Assembly standard
Fan drive belt tension (deflection)	12 (1/2), approx.



2. BENCH TEST

An overhauled engine should be tested for performance on a dynamometer. This test is also for "breaking-in" of the major running parts of the engine. To test the engine, proceed as follows:

2.1 Starting up

- (1) Check the levels in the radiator, oil pan and fuel tank. Prime the fuel and cooling systems to bleed air out.

- (2) Crank the engine with the starter for about 15 seconds to permit lubricating 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 fuel injection, and turn the starter switch to START for starting the engine. (Do not move the control lever to "full injection" position.)
- (4) After the engine starts, let it idle by operating the speed control lever.

2.2 Inspection after starting up

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

- (1) Lubricating oil pressure: It should be 3 to 4 kgf/cm² (42.7 to 56.9 psi) [294 to 392 kPa] at rated speed or 1 kgf/cm² (14.2 psi [98 kPa] at idling speed.
- (2) Coolant temperature: It should be 75°C to 85°C (167°F to 185°F).
- (3) Lubricating oil temperature: It should be 60°C to 80°C (140°F to 176°F) when measured in oil pan.
- (4) Leakage of oil, coolant and fuel, especially oil leakage from turbo-charger lubricating oil pipe connections.
- (5) Knocking: It should die away as the coolant temperature rises. No other defects should be noted.
- (6) Exhaust color and abnormal 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	2000	25%	60
4	Rated (varies according to specifications)	25%	10
5		50%	10
6		75%	30
7		100%	20

2.4 Inspection and adjustment after bench test

- (1) Retightening of cylinder head bolts
- (2) Adjustment of valve clearance
- (3) Adjustment of injection timing

3. PERFORMANCE TESTS

3.1 Standard equipment

The cooling fan, air cleaner and alternator are the standard equipment of an engine to be tested.

3.2 Test items

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

ADJUSTMENTS, BENCH TEST, PERFORMANCE TESTS

3.3 Test methods

(1) Fuel consumption test

- (a) Engine speed (rpm)
- (b) Fuel injection quantity
- (c) Engine output

where H = atmospheric pressure
(mmHg)

Hw = water vapor partial pressure (mmHg)

t = room temperature (°C)

(2) No-load maximum speed test

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

(3) No-load minimum speed test

- (a) The control lever should be set to the stable minimum speed position. By "stable minimum speed" is meant a minimum speed to which the engine rpm can be quickly dropped from the maximum rpm without stalling.
- (b) The no-load minimum speed is specified to be 650 to 700 rpm.

(4) Others

During the performance test, inspect for leakage of gases, coolant, lubricating oil and fuel, noise or hunting.

(5) Output correction

The output is influenced by atmospheric pressure, ambient temperature and humidity. This makes it necessary to correct the output to the standard conditions [atmospheric pressure: 760 mmHg (30 in. Hg), room temperature: 20°C (68°F) and water vapor partial pressure: 11.4 mmHg (0.45 in. Hg)]. This can be accomplished by multiplying the output value obtained in the test by the coefficient of correction "K," which may be found by the formula:

$$K = \frac{760 - 11.4}{H - H_w} \sqrt{\frac{273 + t}{293}}$$

ENGINE ACCESSORY REMOVAL AND INSTALLATION

1. PREPARATORY STEPS	54
2. ENGINE ACCESSORY REMOVAL	54
3. ENGINE ACCESSORY INSTALLATION	58

ENGINE ACCESSORY REMOVAL AND INSTALLATION

This section explains the procedures and tips for removal and installation of the accessories - the preliminary process 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 left rear side of crankcase, and drain coolant.
- (c) Loosen the oil pan drain plug, and drain engine oil.



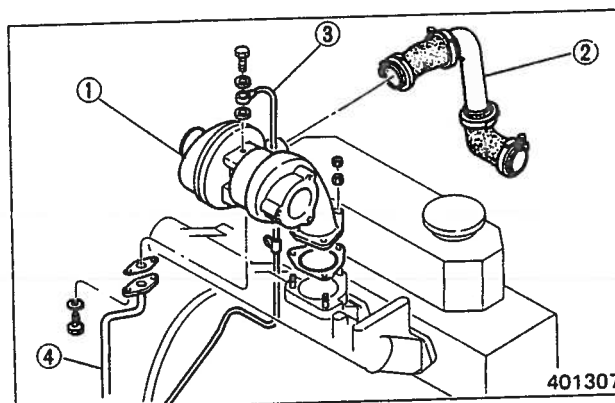
WARNING

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

2. ENGINE ACCESSORY REMOVAL

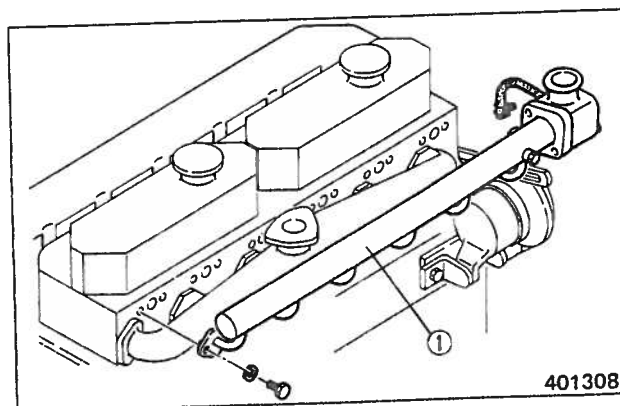
(1) Removing turbocharger [turbocharged engines]

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



(2) Removing water outlet pipe [6-cylinder engines]

After disconnecting water bypass hose, remove water outlet pipe (1) from cylinder head by unscrewing mounting bolts.



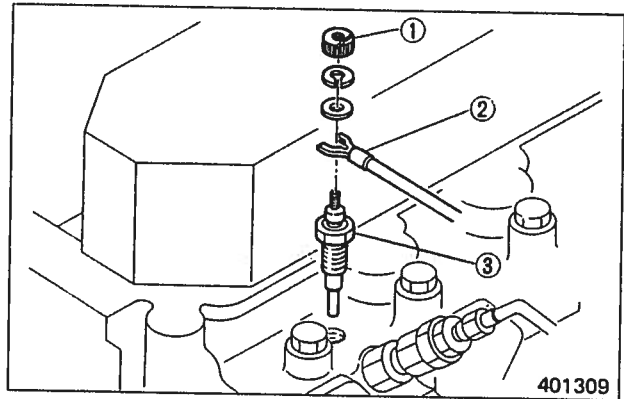
(3) Removing glow plugs [SE-/SE2-series]

Disconnect wire (2) by loosening nut (1), and remove glow plug (3).



CAUTION

After removing each glow plug, cover the opening by taping to prevent dust from getting inside.



(4) Removing fuel injection pipes

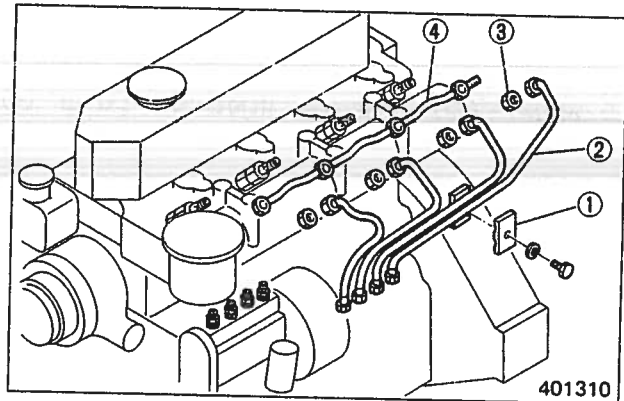
(a) Remove pipe clamp (1), and disconnect injection pipes (2).

(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.

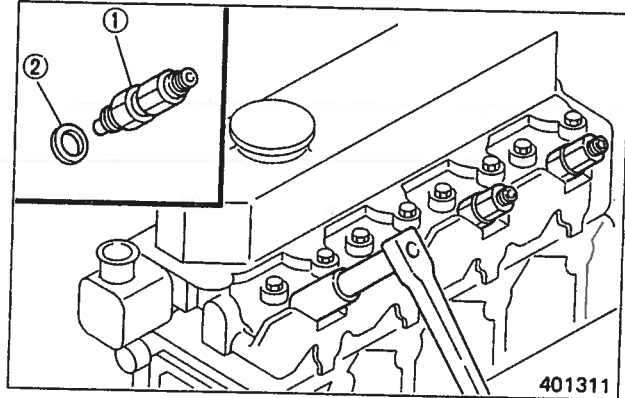


(5) Removing fuel injection nozzles [SE-/SE2-series]

Using a box wrench, loosen nozzle retaining nut, and remove nozzle (1) complete with gasket (2).

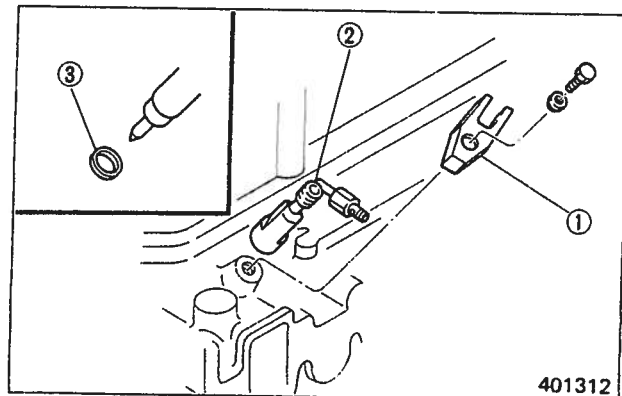
NOTE

Remove nozzle gaskets from the cylinder head, using a piece of wire or screwdriver, and discard them if damaged.



(6) Removing fuel injection nozzles [SF-series]

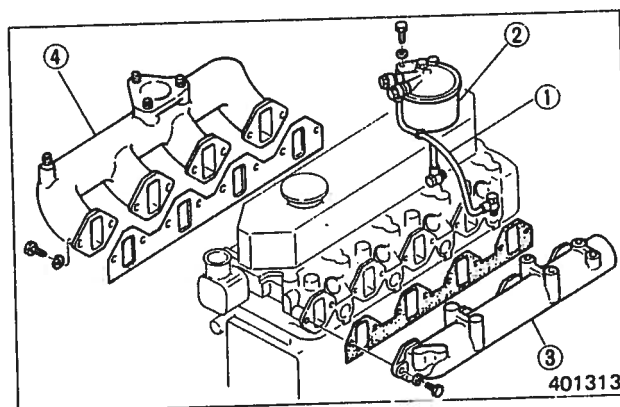
Take off nozzle gland (1), and remove nozzle (2) complete with gasket (3).



ENGINE ACCESSORY REMOVAL AND INSTALLATION

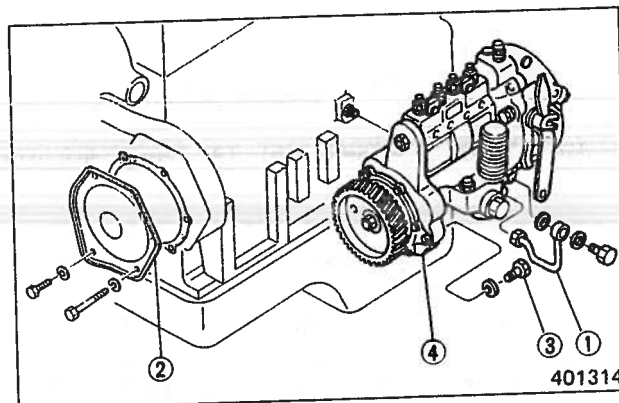
(7) Removing fuel filter and inlet and exhaust manifolds

- (a) Disconnect fuel hose (1) from fuel filter (2). Remove filter (2) by unscrewing its mounting bolts.
- (b) Remove inlet manifold (3) and exhaust manifold (4) by unscrewing mounting bolts.



(8) Removing fuel injection pump

Disconnect oil feed pipe (1) and remove cover (2). Remove injection pump (4) from the timing gear case by unscrewing two mounting bolts (3).

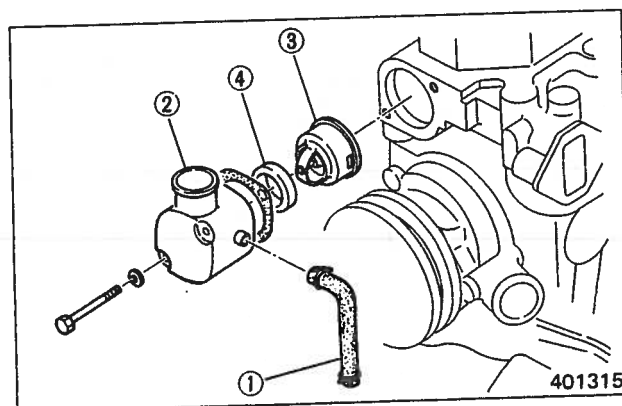


(9) Removing thermostat

- (a) Disconnect bypass hose (1).
- (b) Unscrew elbow attaching bolts, and remove elbow (2), thermostat (3) and gasket (4).

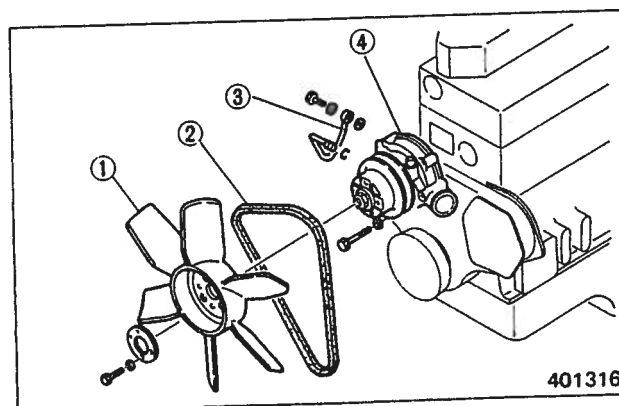
NOTE

At reassembly, install thermostat with its air vent hole facing upward.



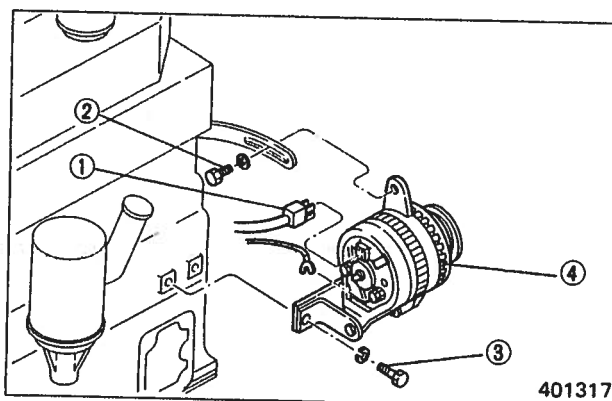
(10) Removing water pump

- (a) Remove fan (1). Slacken fan belt (2), and remove it from water pump (4).
- (b) Disconnect oil pipe (3).
- (c) Remove water pump by unscrewing its mounting bolts.



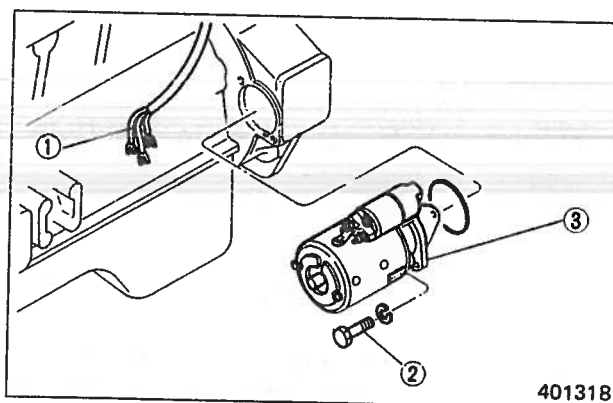
(11) Removing alternator

- (a) Disconnect harness (1), and unscrew belt adjusting plate bolt (2).
- (b) Remove alternator (4) by unscrewing mounting bolts (3).



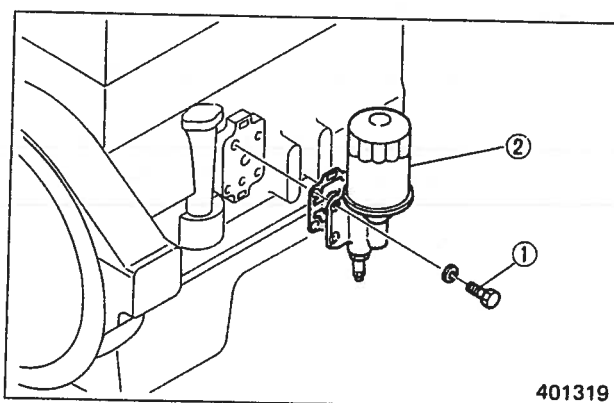
(12) Removing starter

Disconnect harness (1), and remove starter (3) by unscrewing mounting bolts (2).



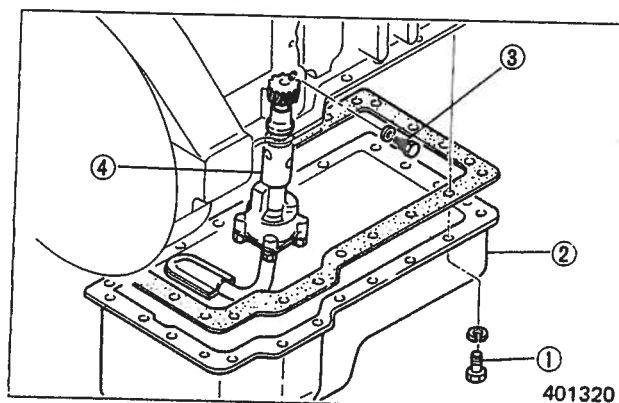
(13) Removing oil filter

Remove oil filter (2) complete with its bracket by unscrewing mounting bolts (1).



(14) Removing oil pan and oil pump

- (a) Remove oil pan (2) by unscrewing mounting bolts (1).
- (b) Remove oil pump (4) by unscrewing mounting bolt (3).



NOTE

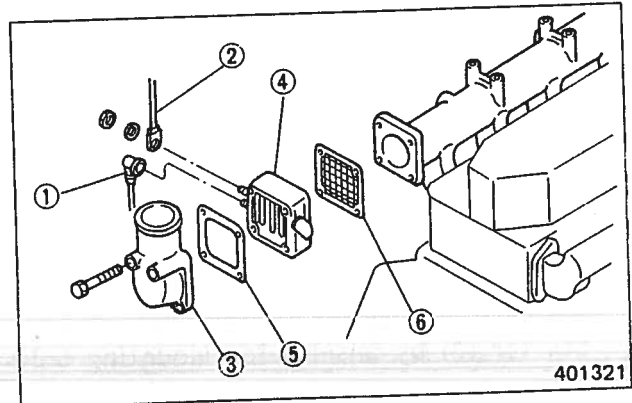
Camshaft skew gear might interfere with pump drive gear. Remove pump by turning crankshaft slightly.

(15) Removing air heater [SF-series]

- (a) Disconnect harnesses (1)(2).
- (b) Unscrew elbow mounting bolts, and remove air inlet elbow (3), air heater (4) and gaskets (5)(6).

NOTE

Gasket (6) is to come to manifold side when installed.



3. ENGINE ACCESSORY INSTALLATION

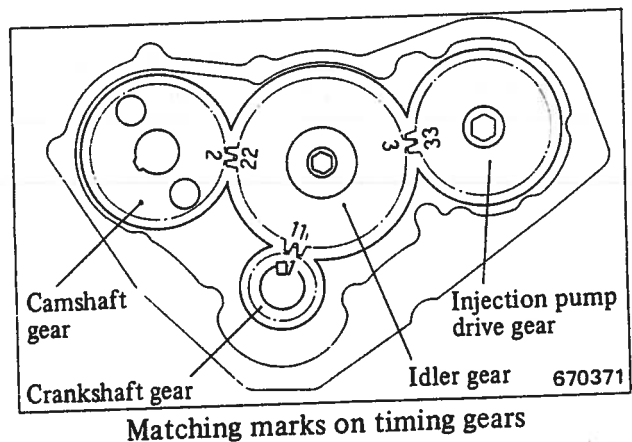
To install the engine accessories, use reverse of the removal procedures. After installing them, take the following steps:

(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.

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.

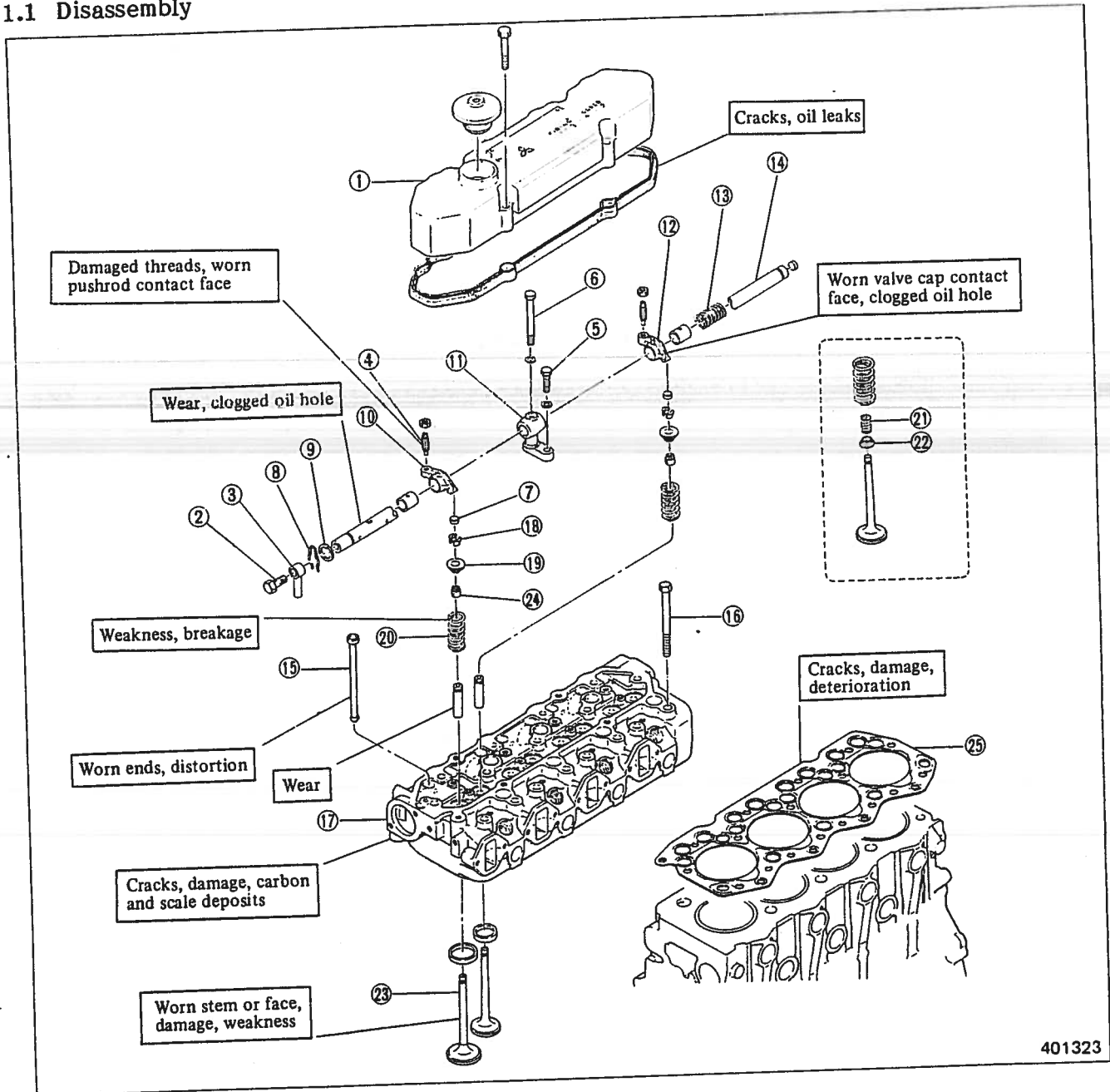
- (e) Prime the fuel system.
- (f) After installing the fuel injection pumps, inspect and adjust the injection timing. (Refer to 1.3, Group No. 5.)

ENGINE PROPER

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1. CYLINDER HEADS AND VALVE MECHANISM

1.1 Disassembly



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- | | | |
|-------------------|------------------------|------------------------|
| ① Rocker cover | ⑩ Inlet rocker arm | ⑲ Upper retainer |
| ② Eye bolt | ⑪ Rocker shaft bracket | ⑳ Outer valve spring |
| ③ Oil pipe | ⑫ Exhaust rocker arm | ㉑ Inner valve spring |
| ④ Adjusting screw | ⑬ Rocker shaft spring | ㉒ Lower retainer |
| ⑤ Bolt (short) | ⑭ Rocker shaft | ㉓ Valve |
| ⑥ Bolt (long) | ⑮ Valve pushrod | ㉔ Valve stem seal |
| ⑦ Valve cap | ⑯ Cylinder head bolt | ㉕ Cylinder head gasket |
| ⑧ Snap ring | ⑰ Cylinder head | |
| ⑨ Washer | ⑱ Valve cotter | |

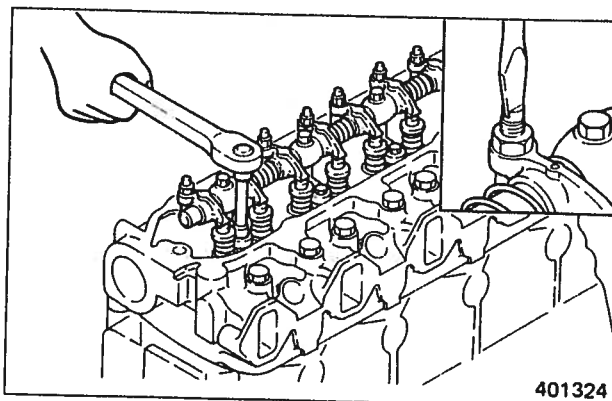
Remarks: Inner valve spring (21) and lower retainer (22) are for high-speed (above 3000 rpm) type.

(1) Removing rocker shaft assemblies

- (a) Loosen the adjusting screw of each rocker about one rotation.
- (b) Loosen the rocker bracket short bolt and long bolt in that order, and remove the rocker shaft assembly from the cylinder head.

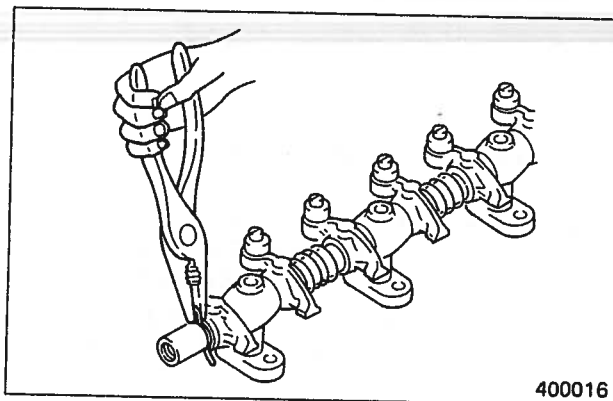
**CAUTION**

If these bolts are loosened in reverse order, the rocker shaft bracket might suffer damage.



(2) Disassembling rocker shaft assemblies

Lay the disassembled rockers in the order removed, and install them in that order at the time of reassembly. This is for reproducing the same rocker shaft-to-rocker arm clearance as before.

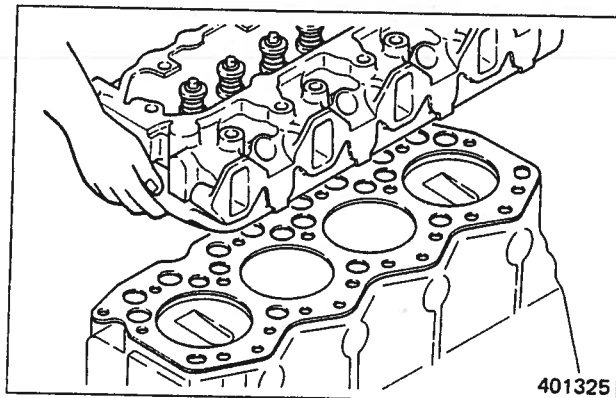


(3) Removing cylinder head

Unscrew the cylinder head bolts, and lift the head off the crankcase.

NOTE

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

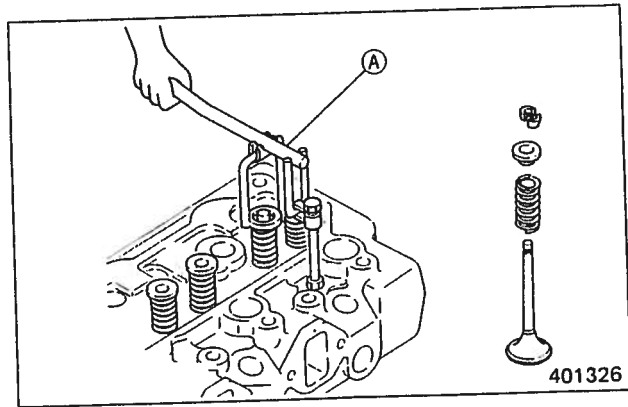


(4) Removing valves and valve springs

Using valve spring pusher (A) (30691-04500), compress the valve spring squarely, and remove the valve cotter.

NOTE

If the valves are to be reused, mark them for their locations to aid installation at the time of reassembly.



1.2 Inspection and repair

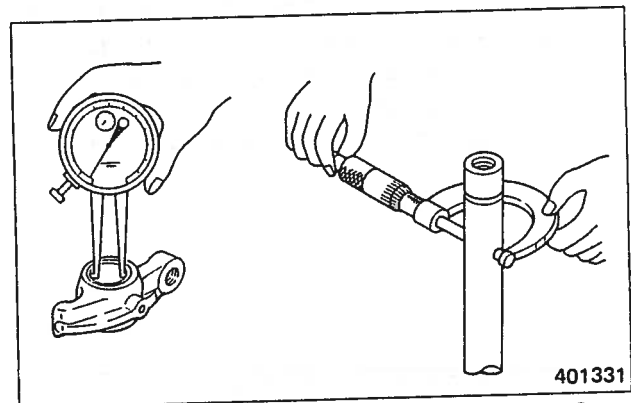
Rocker arms, rocker bushings and rocker shafts

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

Compute the clearance between the bushing and shaft on the basis of the measurements. If the Repair limit is reached, replace the bushing. If it is exceeded, replace both bushing and shaft.

Unit: mm (in.)

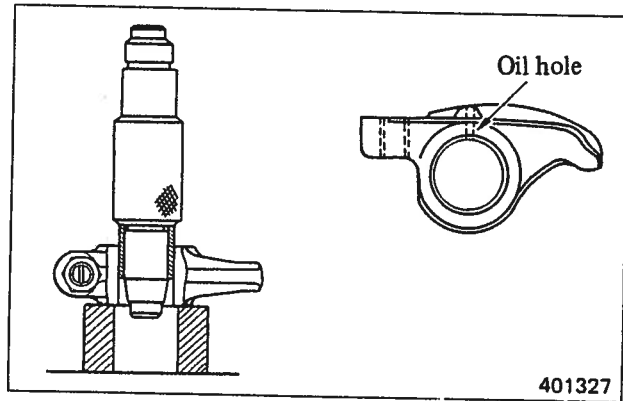
Item	Nominal value	Assembly standard	Repair limit
Rocker bushing inside diameter		20.000 – 20.021 (0.78740 – 0.78823)	
Rocker shaft diameter		19.984 – 19.966 (0.78677 – 0.78606)	
Rocker shaft-to-bushing clearance	20 (0.79)	0.016 – 0.055 (0.00063 – 0.00217)	0.070 (0.00276)



Measuring rocker bushing and rocker shaft

(2) Replacing rocker bushings

When installing a replacement bushing, align the oil holes in the bushing and rocker arm.



Replacing rocker bushing

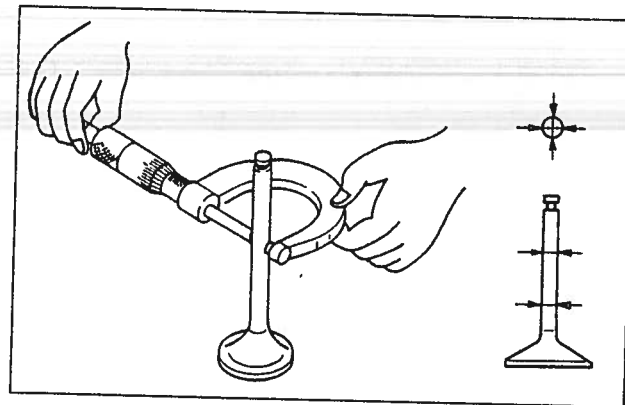
Valves, valve guides and valve seats

(1) Measuring valve stem diameter

If the Service limit is exceeded, or if the stem is abnormally worn excessively, replace the valve.

Unit: mm (in.)

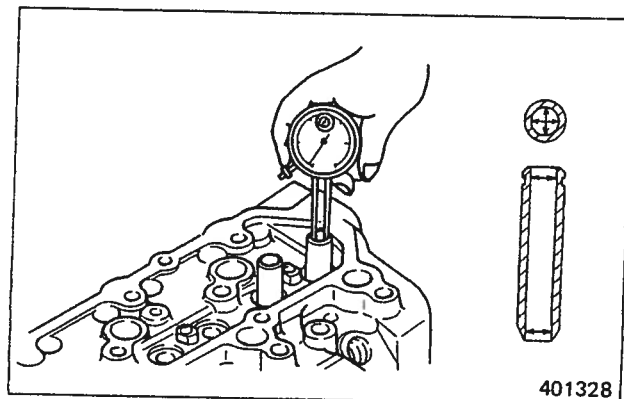
Item		Assembly standard	Service limit
Valve stem diameter	Inlet	7.955 – 7.940 (0.31319 – 0.31260)	7.900 (0.31102)
	Exhaust	7.940 – 7.920 (0.31260 – 0.31181)	7.850 (0.30905)



Measuring valve stem

(2) Measuring valve stem-to-guide clearance

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. If the Service limit is exceeded, replace the guide.



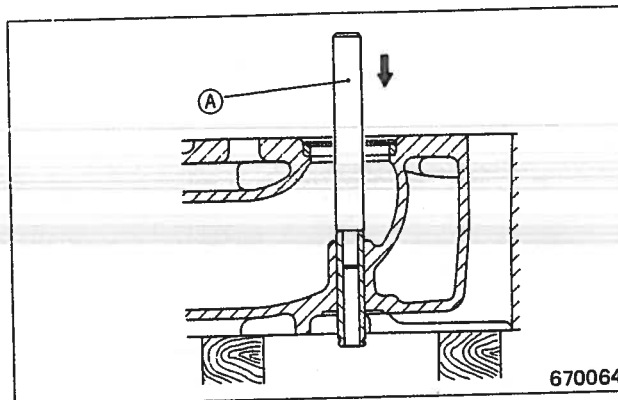
Measuring valve guide

Unit: mm (in.)

Item		Nominal value	Assembly standard	Service limit
Valve stem-to-guide clearance	Inlet	8 (0.31)	0.055 - 0.085 (0.00217 - 0.00335)	0.150 (0.00591)
	Exhaust		0.070 - 0.105 (0.00276 - 0.00413)	0.200 (0.00787)
As-installed depth of valve guide		17 (0.67)	±0.3 (±0.012)	

(3) Replacing valve guides

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

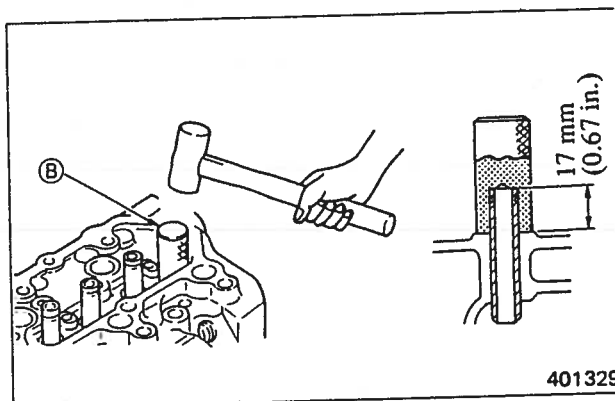


Removing valve guide

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

**CAUTION**

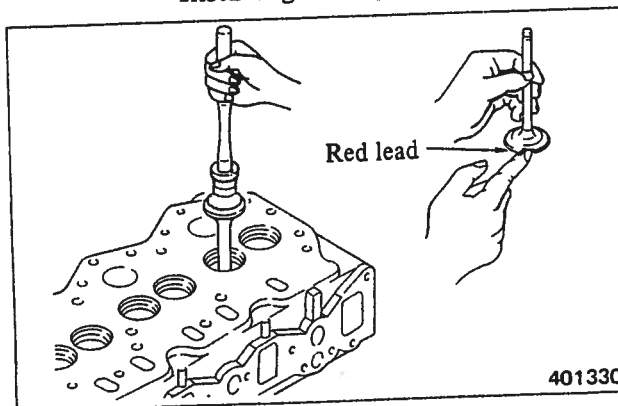
As-installed depth of the valve guide is specified; be sure to use the valve guide installer to insure this depth.



Installing valve guide

(4) Inspecting valve face

Coat the valve face lightly with red lead and, using valve lapper, check the valve contact with its seat. If the contact is not uniform, or if the valve is defective or the Repair limit is exceeded, repair or replace the valve and valve seat.



Inspecting valve face

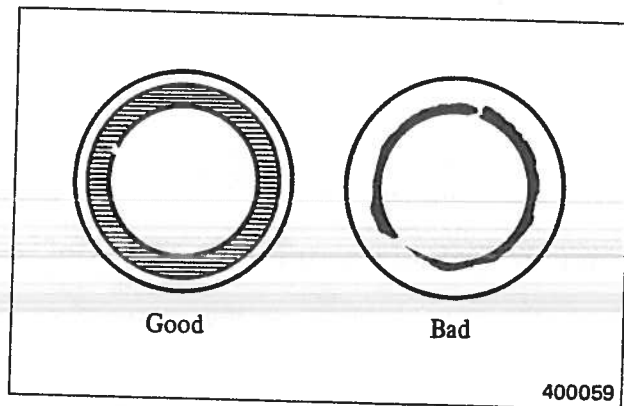
NOTE

- (a) Check the valve face after inspecting or replacing the valve guide.
- (b) Press the valve into the seat without rotating it.

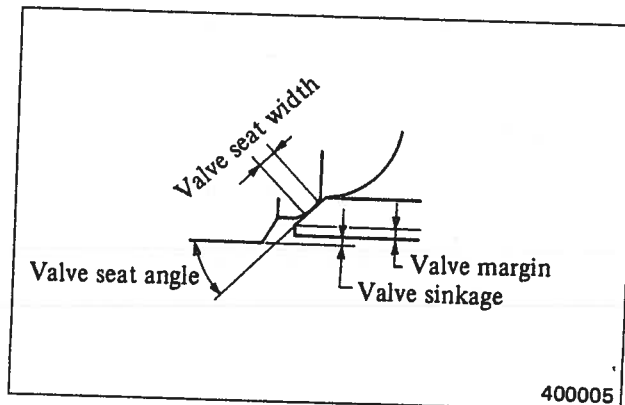
Unit: mm (in.)

Unit: mm (in.)

Item			Assembly standard	Repair limit
Valve seat	Angle	deg	30	
	Valve sinkage	SE SE2	0.7 ± 0.2 (0.028 ± 0.008)	1.3 (0.051)
		SF	0.4 ± 0.2 (0.016 \pm 0.008) [IN] 0.5 ± 0.2 (0.020 \pm 0.008) [EX]	1.1 (0.043)
	Width		1.2 ± 0.14 (0.047 ± 0.0055)	1.6 (0.063)
Valve margin			2.13 (0.0839)	Up to 1.2 (0.047) by refacing



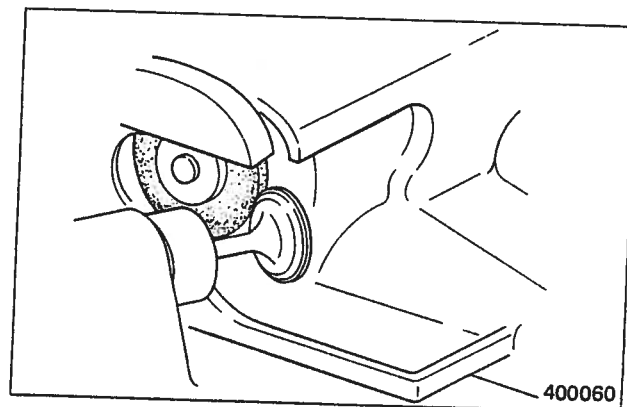
Valve contact with its seat

**(5) Refacing valves**

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

NOTE

- (a) Set a valve refacer at an angle of 30°.
- (b) If the valve margin seems to be less than the Repair limit when ground, replace the valve.



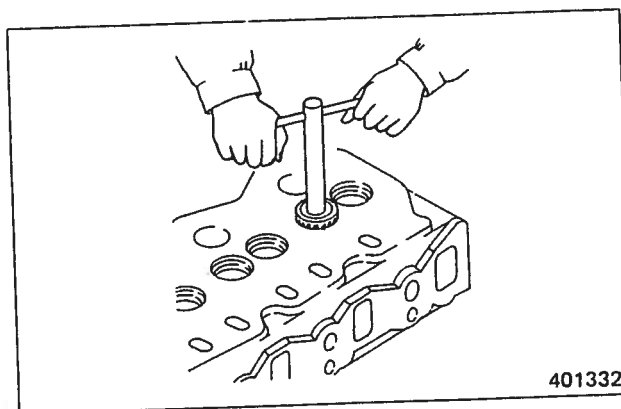
Refacing valve

(6) Refacing valve seats

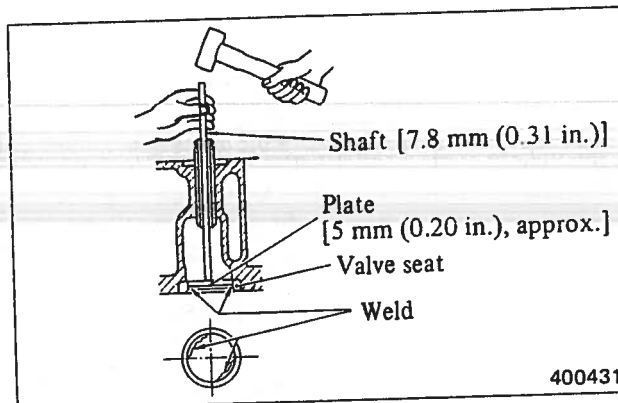
- (a) Using a valve seat cutter or valve seat grinder, cut the valve seat. After cutting, grind the seat lightly by using a sandpaper of #400 grade or so, inserted between the cutter and seat.
- (b) Lap the valve in the seat.

NOTE

- (a) Cut or grind the valve seat only as necessary for refacing.
- (b) If the seat width is in excess of the Repair limit as a result of wear or cutting, replace the valve seat.
- (c) If the valve sinkage exceeds the Repair limit after refacing, replace the valve seat.



Refacing valve seat



Removing valve seat

(7) Replacing valve seats

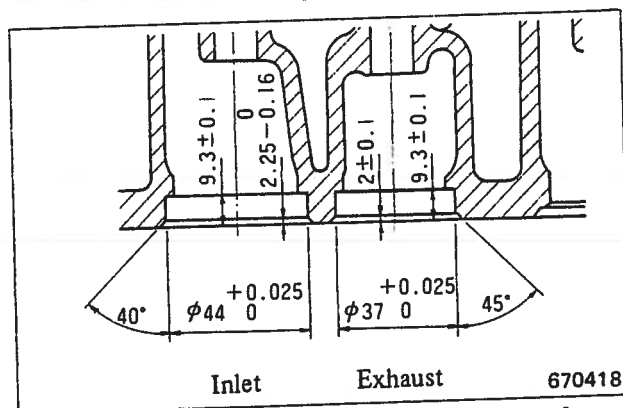
- (a) Weld a plate of about 5 mm (0.20 in.) thickness to the valve seat. Insert a shaft into the valve guide hole from the upper side of cylinder head, and drive the seat off the head as shown.



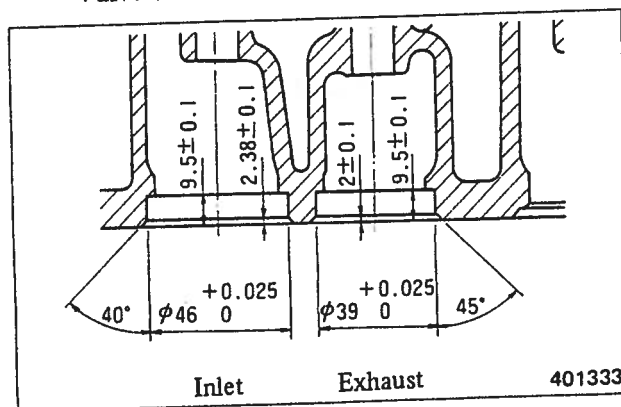
CAUTION

When welding the plate, be careful not to permit spatters to come in contact with the machined surfaces of cylinder head.

- (b) Measure dimensions of valve seat holes in the cylinder head before installing valve seats and make sure that they are as specified.



Valve seat dimensions [SE-/SE2-series]

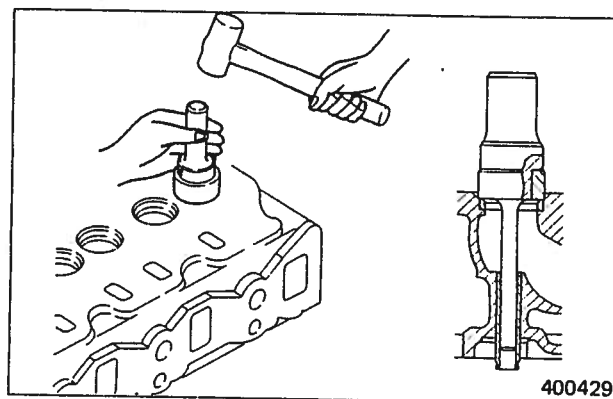


Valve seat dimensions [SF-series]

- (c) Chill the valve seat in liquid nitrogen [about -170°C (-274°F)] for more than 4 minutes with the cylinder head kept at normal temperature, or heat the cylinder head 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 valve insert caulking tool (A), install the valve seat by caulking it there.

Valve insert caulking tool

Applicable model		Part No.
Inlet	SE, SE2	31391-13010
	SF	36791-00200
Exhaust	SE, SE2	34491-01300
	SF	36791-00300



Installing valve seat

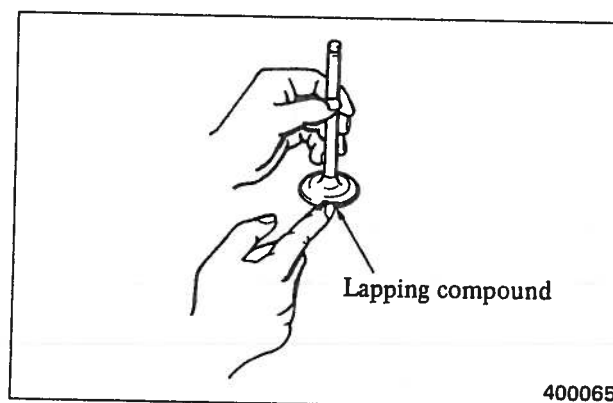
(8) Lapping valves in valve seats

Be sure to lap the valves in the valve seats after the seats have been replaced.

- (a) Coat the valve face lightly with a lapping compound.

NOTE

- (a) Do not permit the compound to come in contact with the valve stem.
- (b) Use the compound of 120 to 150 mesh for initial lapping and the compound of finer than 200 mesh for finish lapping.
- (c) Mixing the compound with a small amount of engine oil will facilitate coating.



Coating valve with lapping compound

ENGINE PROPER

- (b) Using a valve lapper, lap the valve in the seat. To lap, press the valve against the seat, then raise the valve off the seat, rotating it only a part of turn to a new position.
- (c) Wash off the compound with diesel fuel.
- (d) Coat the valve face with engine oil, and again lap the valve.
- (e) Check the valve face for contact.

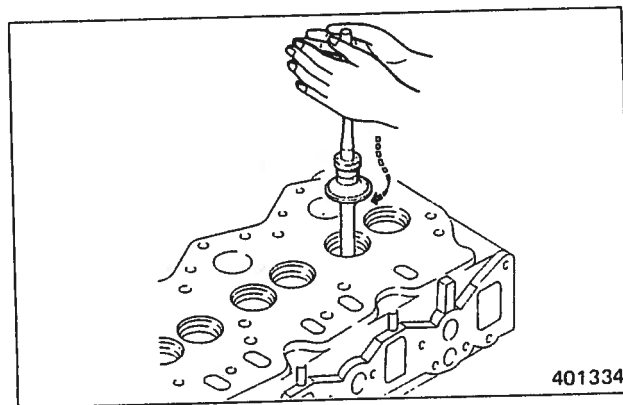
Valve springs

Measuring squareness and free length

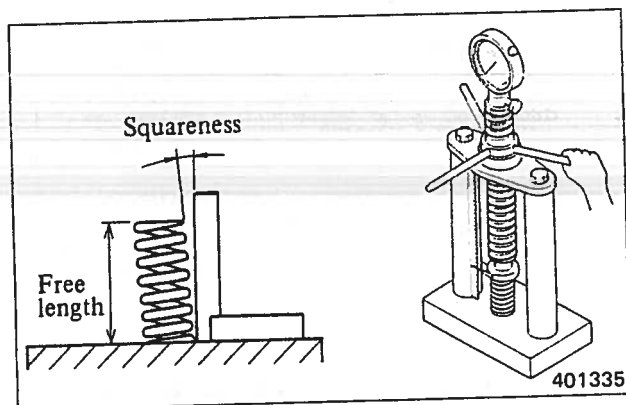
If the squareness or free length exceeds the Service limit, replace the spring.

Unit: mm (in.)

Item		Assembly standard	Service limit
Medium/low-speed type	Free length	48.85 (1.9232)	47.60 (1.8740)
	Squareness deg	1.5, maximum	
	Test force/length under test force kgf (lbf) [N] / mm (in.)	19 ± 1 (42 ± 2.2) [186 ± 9.8] / 43 (1.69)	15 (33) [147] / 43 (1.69)
High-speed type	Outer spring	Free length	56.40 (2.2205)
		Squareness deg	2, maximum
		Test force/length under test force kgf (lbf) [N] / mm (in.)	23.9 ± 1.2 (52.7 ± 2.6) [234 ± 11.8] / 44 (1.73)
	Inner spring	Free length	40.8 (1.606)
		Squareness deg	1.5, maximum
		Test force/length under test force kgf (lbf) [N] / mm (in.)	6 ± 0.3 (13 ± 0.7) [59 ± 2.9] / 36.5 (1.437)



Lapping valve in valve seat



Measuring valve spring

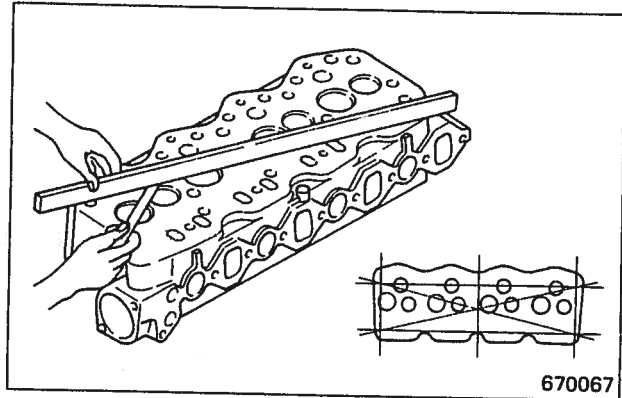
Cylinder head

Measuring gasketed surface warpage

Measure warpage with a straightedge and a feeler gauge. If the warpage exceeds the Repair limit, reface the gasketed surface with a surface grinder.

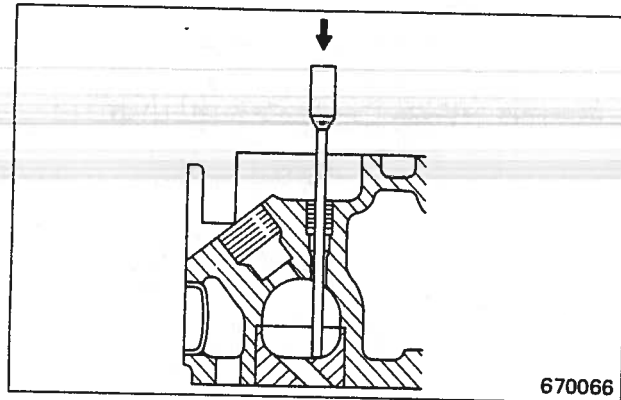
Unit: mm (in.)

Item	Assembly standard	Repair limit
Cylinder head gasketed surface warpage	0.05 (0.0020), maximum	0.20 (0.0079)



670067

Measuring cylinder head gasketed surface warpage



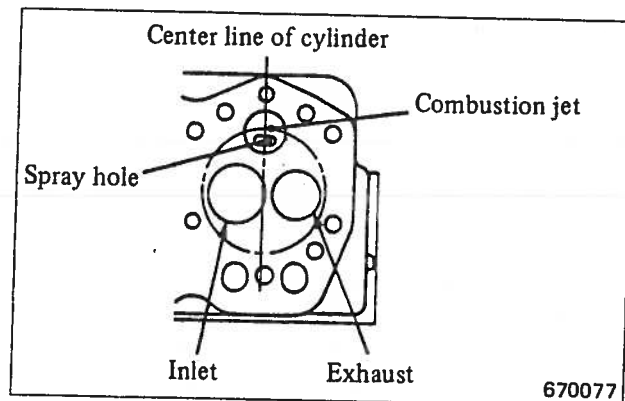
670066

Removing combustion jet

Combustion jets [SE-/SE2-series]

Replacing combustion jets

- Replace the jets only when they are cracked. To remove, insert a round rod of about 6 mm (0.24 in.) diameter into the glow plug hole, and give light blows to the periphery of the jet through the rod.
- To install, align the spray hole of the jet with the center line of cylinder.



670077

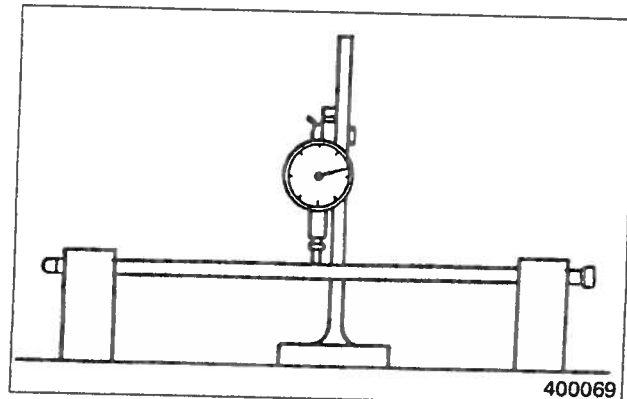
Installing combustion jet

Valve pushrods

If the runout exceeds the Assembly standard, replace the pushrods.

Unit: mm (in.)

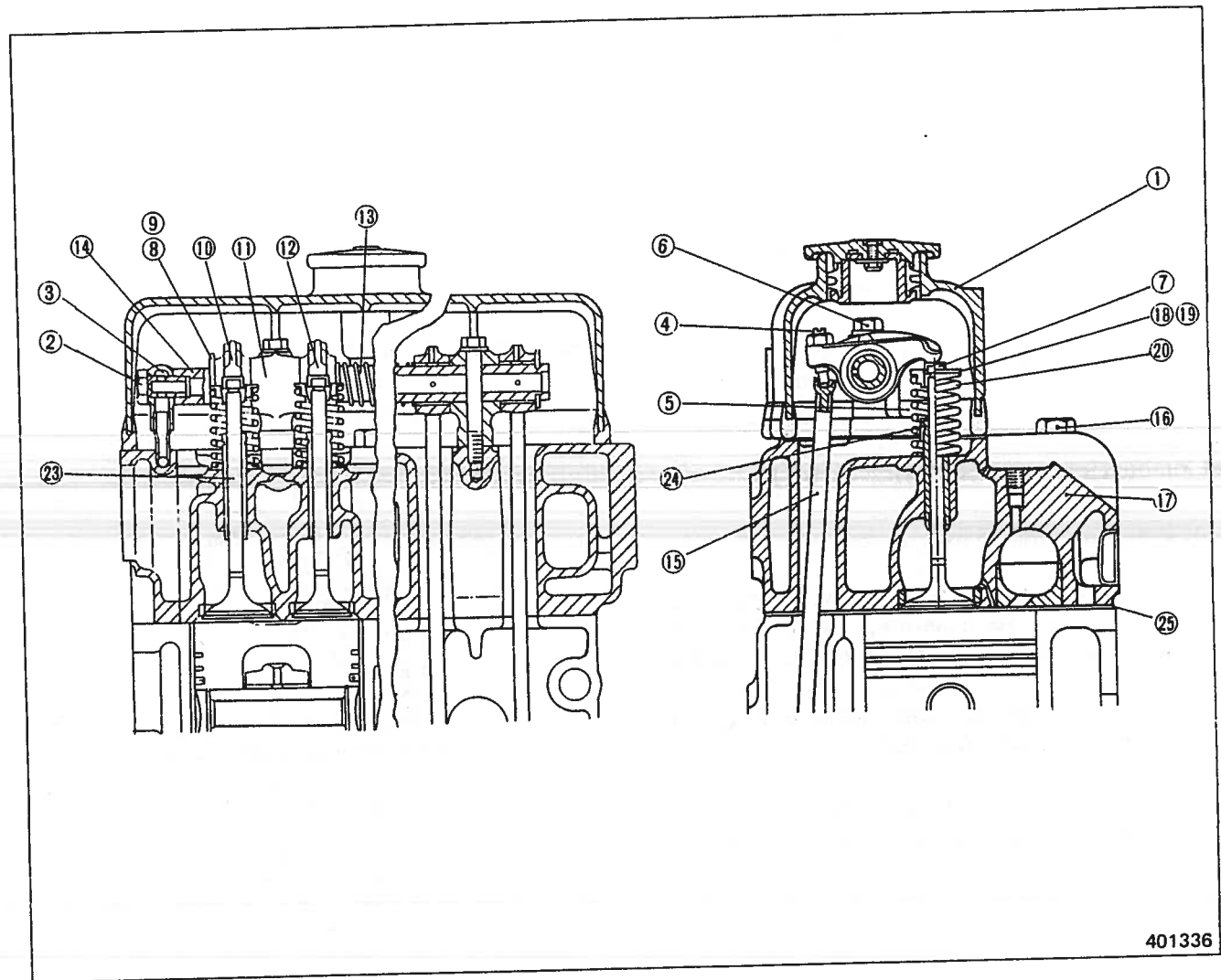
Item	Assembly standard
Valve pushrod runout	0.4 (0.016), maximum



400069

Measuring pushrod runout

1.3 Reassembly



401336

Reassembling sequence

17 → 24 → 23 → 22 → 21 → 20 → 19 → 18 → 25 → 16 → 15
 14 → 13 → 12 → 11 → 10 → 9 → 8

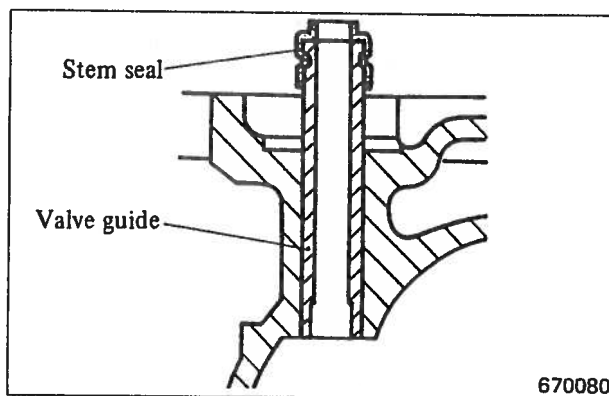
7 → 6 → 5 → 3 → 2 → 4 → 1

(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 seal lip.

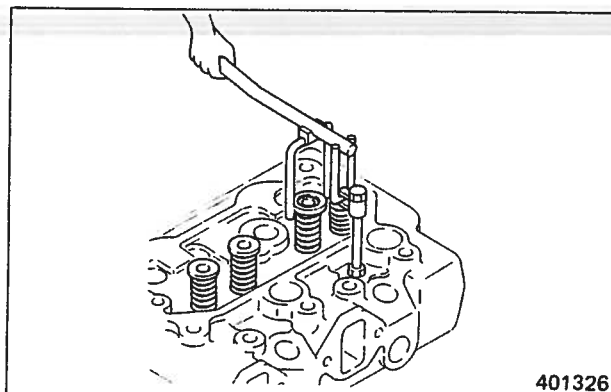


(2) Installing valves and valve springs

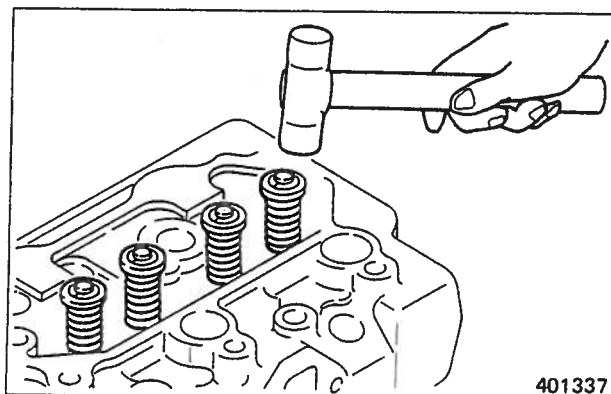
- (a) Install the valve spring and retainer to the valve guide. Using valve spring pusher (A) (30691-04500), install the valve cotters.

NOTE

In case of the double spring (comprising inner and outer springs), install the outer spring with its smaller-coil-pitch end on the cylinder head side.

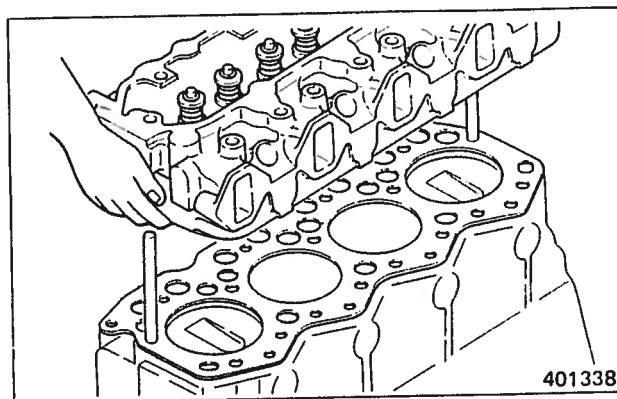


- (b) Using a soft hammer, give light blows to the valve stem top several times to make sure that the spring and valve cotter are properly installed.



(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.



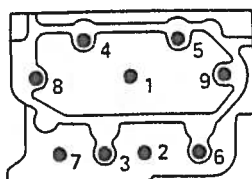
CAUTION

Do not apply any sealant to the cylinder head bolts.

- (c) Tighten the cylinder head bolts to the specified torque in the sequence shown.

[S2E, S2E2]

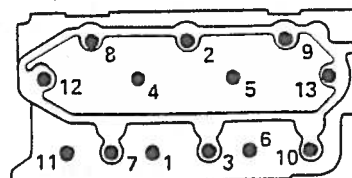
Front side ←



S2E, S2E2 : No. of bolts: 9

[S3E, S3E2, S6E, S6E2]

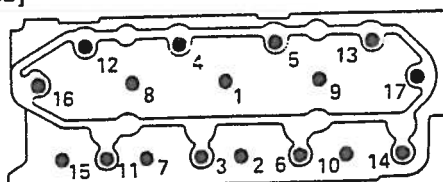
Front side ←



S3E, S3E2, S3F : No. of bolts: 13
S6E, S6E2, S6F : No. of bolts: 13 x 2

[S4E, S4E2]

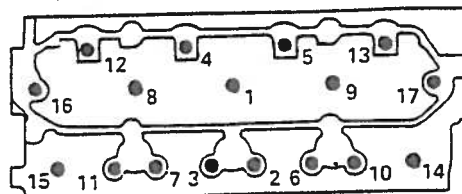
Front side ←



S4E, S4E2, S4F : No. of bolts: 17

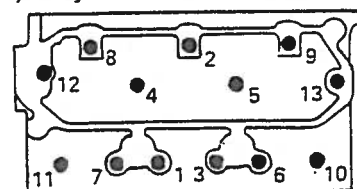
[S4F]

Front side ←



[S3F, S6F]

Front side ←



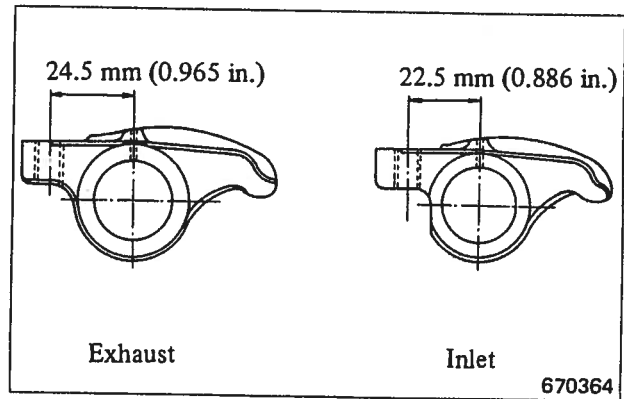
Unit: kgf·m (lbf·ft) [N·m]

Tightening torque	12 ± 0.5 (87 ± 4) [118 ± 5]
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401339

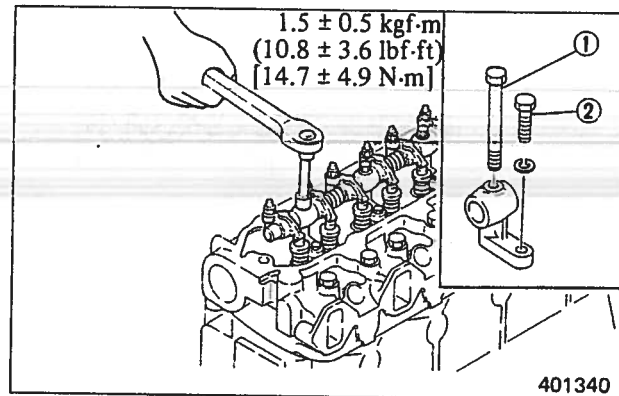
(4) Reassembling rocker shafts

The rocker arms for inlet valves are different in dimension from those for exhaust valves. After installing the arms, make sure that they move freely.



(5) Installing rocker shaft assemblies

Tighten the long bolt and short bolt in that order (by following reverse of loosening order).

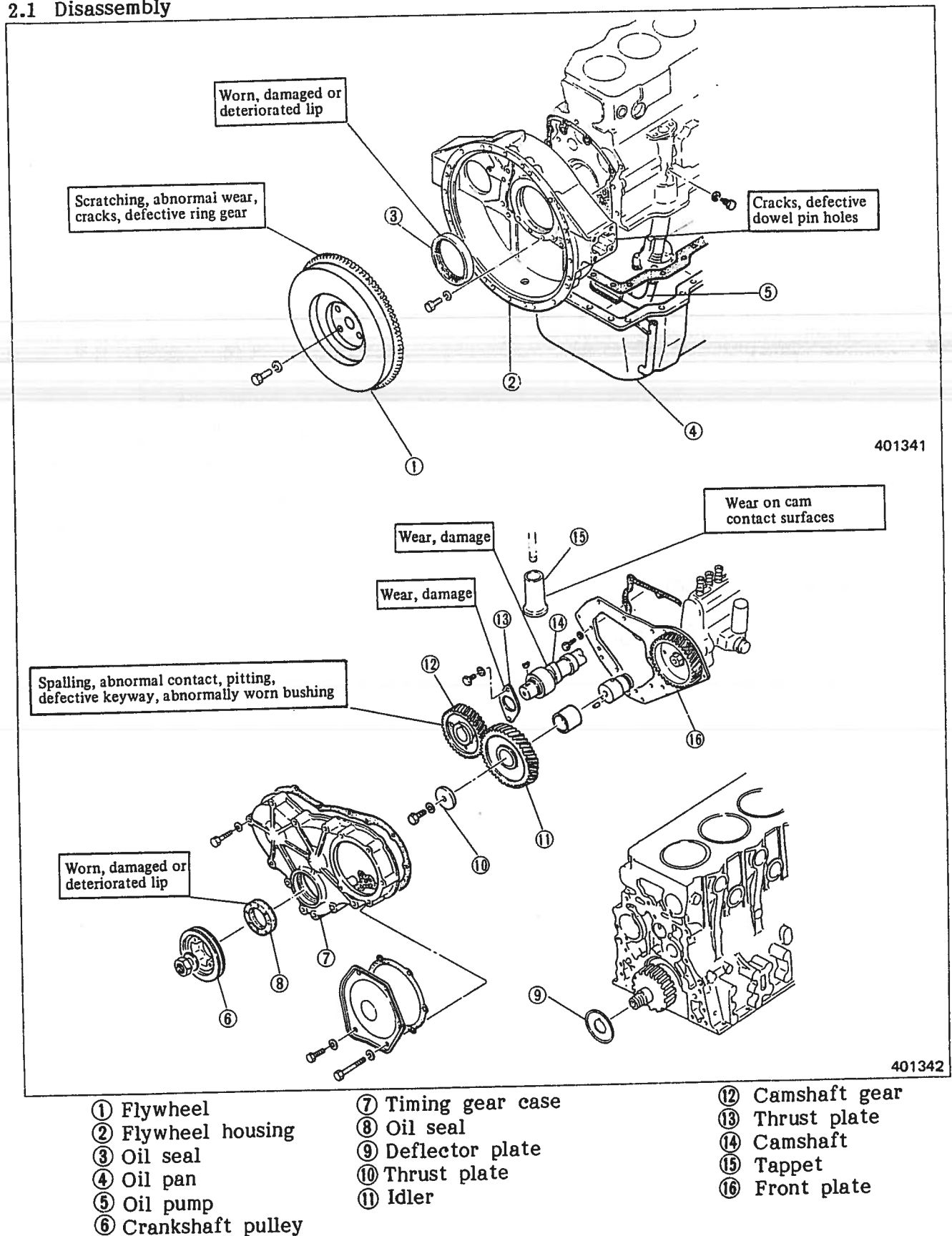


(6) Adjusting valve clearance

Refer to 1.1, Group No. 5.

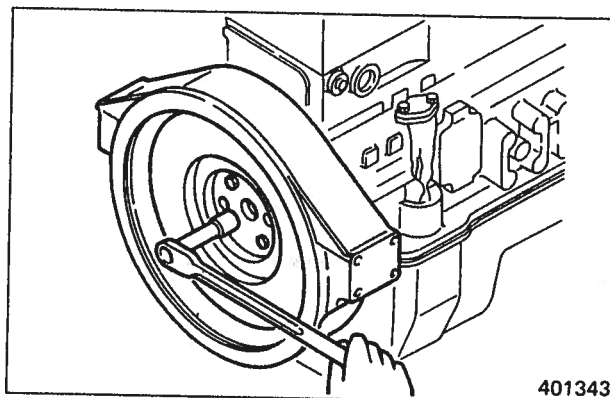
2. FLYWHEEL, TIMING GEARS AND CAMSHAFT

2.1 Disassembly



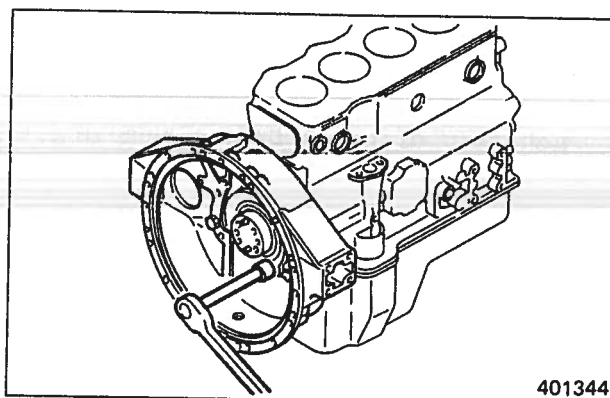
(1) Removing flywheel

- (a) Unscrew the flywheel mounting bolts.
- (b) Screw the jacking bolts into the holes provided in the flywheel uniformly, and remove the flywheel.



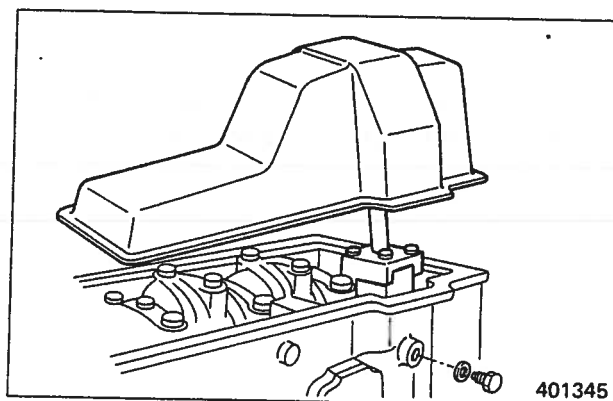
(2) Removing flywheel housing

Unscrew the housing mounting bolts, and remove the housing.



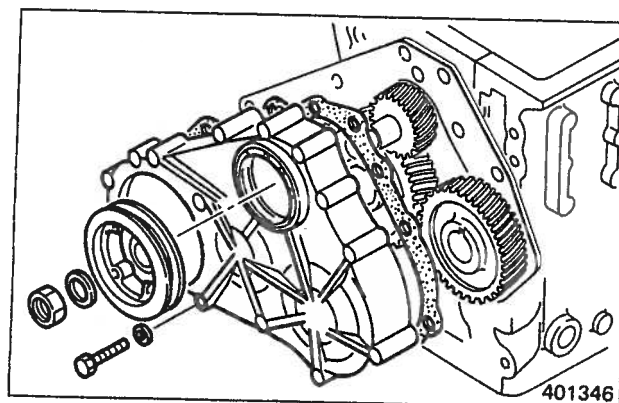
(3) Removing oil pan and oil pump

Unscrew the oil pan mounting bolts, and remove the oil pan. Then, remove the oil pump by unscrewing its bolt. (Refer to 2, Group No. 6.)



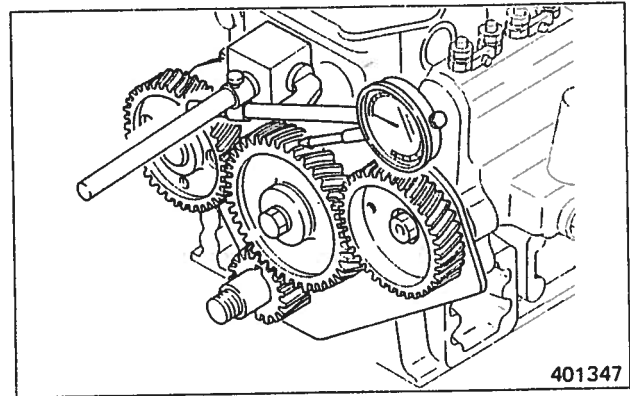
(4) Removing timing gear case

Remove the crankshaft pulley and timing gear case.



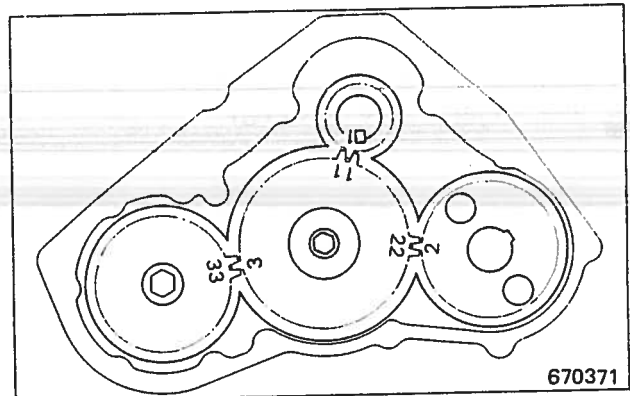
(5) Measuring backlash and end play

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



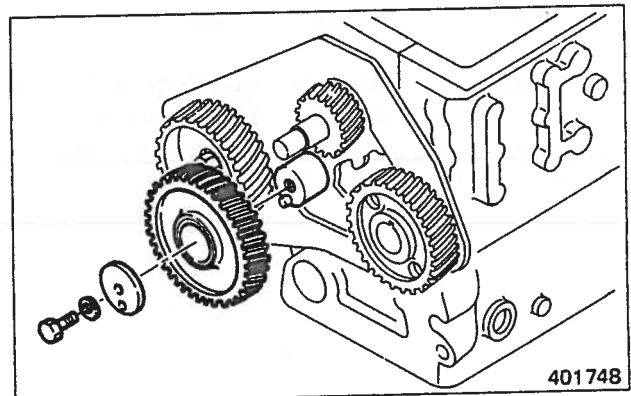
(6) Removing timing gears

Be sure to align the timing marks for each pair of gears before removing or installing the gears.



(7) Removing idler

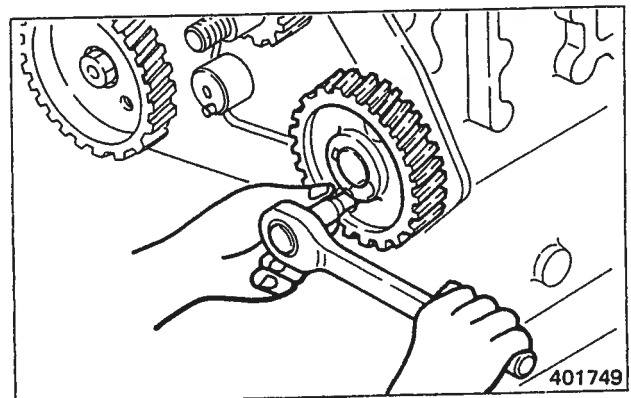
Remove the idler by turning it in the direction of helix of gear teeth.



(8) Removing camshaft

Position the camshaft gear so that its two jacking bolt holes come to top and bottom. Using socket A (34491-00300), unscrew the thrust plate bolts, and remove the camshaft from the crankcase.

After removing the camshaft, remove the tappets.

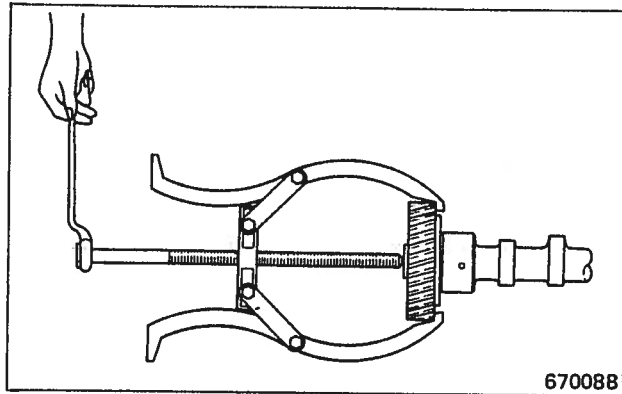


(9) Removing camshaft gear

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

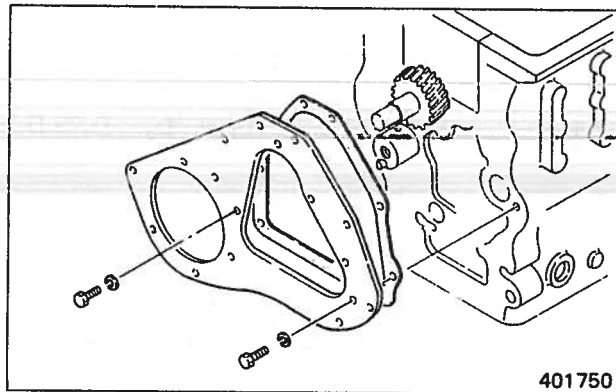
NOTE

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



(10) Removing front plate

Unscrew two front plate mounting bolts, and remove the plate from the crankcase.



2.2 Inspection and repair

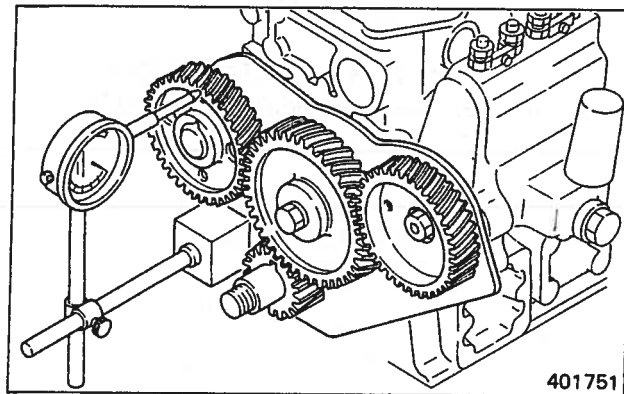
Camshaft and camshaft bushings

(1) Measuring camshaft end play

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

Unit: mm (in.)

Item	Assembly standard	Repair limit
Camshaft end play	0.050 – 0.112 (0.00197 – 0.00441)	0.300 (0.01181)



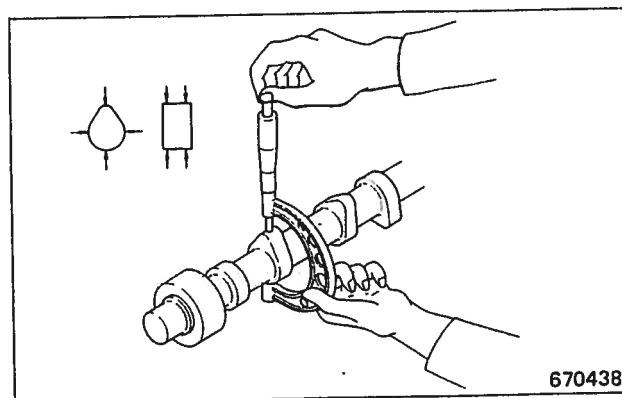
Measuring camshaft end play

(2) Measuring cam lift

Using a micrometer, measure the cam lift. If it exceeds the Service limit, replace the camshaft.

Unit: mm (in.)

Item			Nominal value	Assembly standard	Service limit
Cam lift	SE	Inlet	D_1 46.916 ^{+0.1} _{-0.3} (1.84708 ^{+0.004} _{-0.012})	$D_1 - D_2$ = 6.684 (0.26315)	$D_1 - D_2$ = 6.184 (0.24346)
		Inlet (high-speed engine)	D_1 45.944 ^{+0.1} _{-0.3} (1.80882 ^{+0.004} _{-0.012})	$D_1 - D_2$ = 7.344 (0.28913)	$D_1 - D_2$ = 6.844 (0.26945)
		Exhaust			
	SF	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)



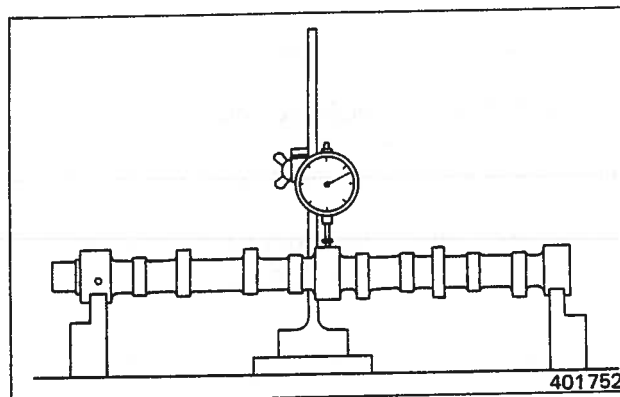
Measuring cam lift

(3) Measuring camshaft runout

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.



Measuring camshaft runout

Unit: mm (in.)

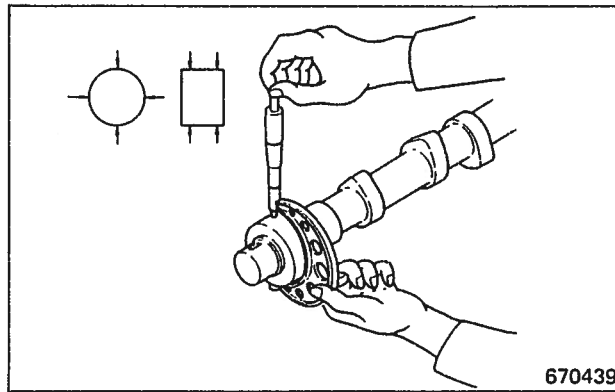
Item	Assembly standard	Repair limit
Camshaft runout	0.02 (0.0008), maximum	0.05 (0.0020)

(4) Measuring camshaft journal diameter

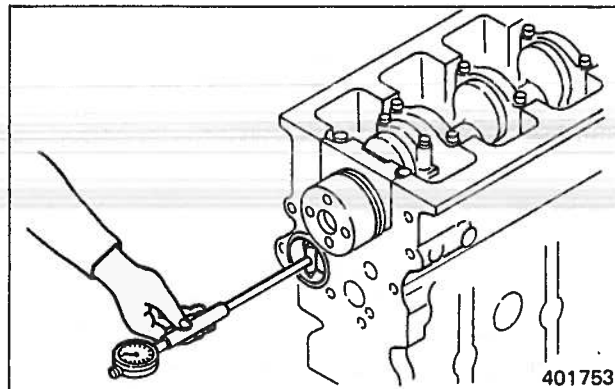
If the journals exceed the Service limit, replace the camshaft bushings.

Unit: mm (in.)

Item			Assembly standard	Service limit
Camshaft journal diameter	2-cylinder engines	No. 1	53.96 – 53.94 (2.1244 – 2.1236)	53.90 (2.1220)
		No. 2	52.96 – 52.94 (2.0850 – 2.0842)	52.90 (2.0827)
	3-/4-cylinder engines	No. 1, 2	53.96 – 53.94 (2.1244 – 2.1236)	53.90 (2.1220)
		No. 3	52.96 – 52.94 (2.0850 – 2.0842)	52.90 (2.0827)
	6-cylinder engines	No. 1, 2, 3	53.96 – 53.94 (2.1244 – 2.1236)	53.90 (2.1220)
		No. 4	52.96 – 52.94 (2.0850 – 2.0842)	52.90 (2.0827)
Camshaft journal-to-bushing clearance			0.04 – 0.09 (0.0016 – 0.0035)	0.15 (0.0059) (Repair limit)



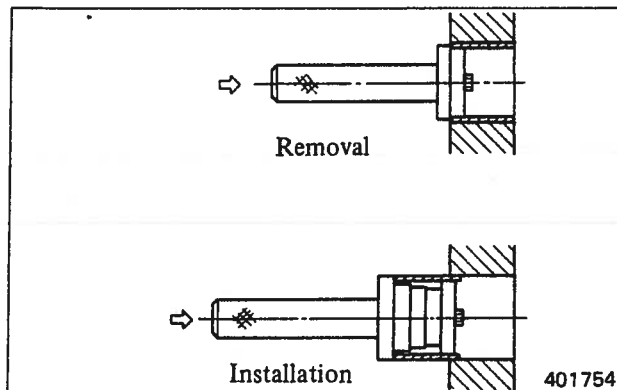
Measuring camshaft journal diameter



Measuring camshaft bushing inside diameter

(5) Replacing camshaft bushings

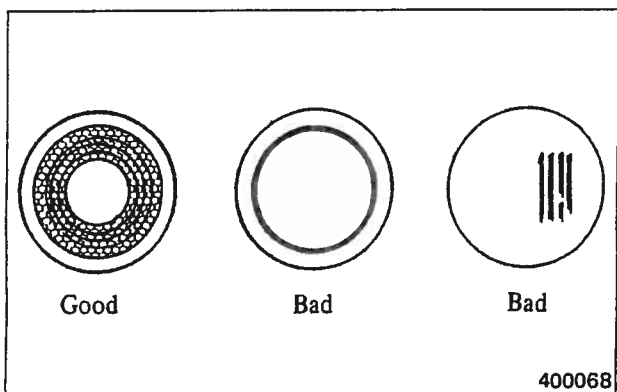
To install bushings, align their oil holes with those from oil gallery and drive bushings in.



Replacing camshaft bushing

Tappets**(1) Inspection**

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



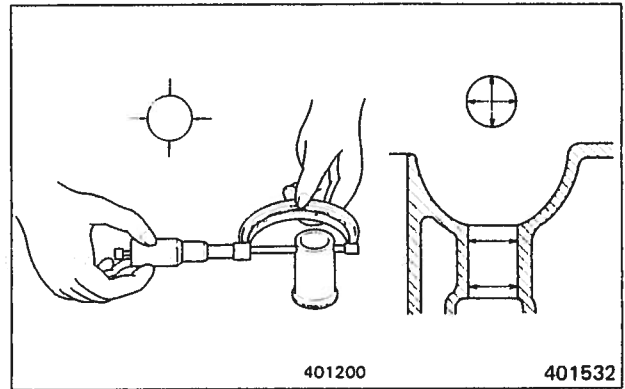
Cam contact face of tappet

(2) Measuring tappet-to-guide clearance

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

Unit: mm (in.)

Item	Assembly standard	Repair limit	Service limit
Tappet hole diameter	22.000 – 22.021 (0.86614 – 0.86697)		22.100 (0.87008)
Tappet-to-guide clearance	0.035 – 0.086 (0.00138 – 0.00339)	0.12 (0.0047)	



Measuring tappet and guide

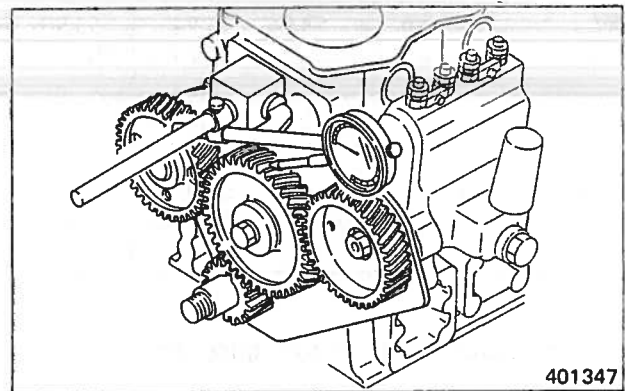
Timing gears

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 Repair limit, replace the gears.

Unit: mm (in.)

Item	Assembly standard	Repair limit
Timing gear backlash	0.03 – 0.17 (0.0012 – 0.0067)	0.25 (0.0098)



Measuring timing gear backlash

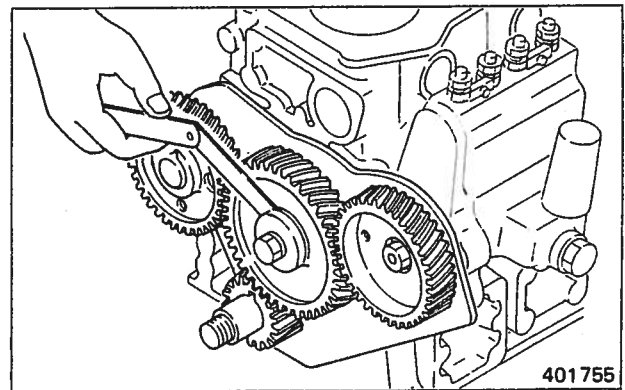
Idler, idler bushing and idler shaft

(1) Measuring idler end play

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

Unit: mm (in.)

Item	Assembly standard	Repair limit
Idler end play	0 – 0.10 (0 – 0.0039)	0.35 (0.0138)



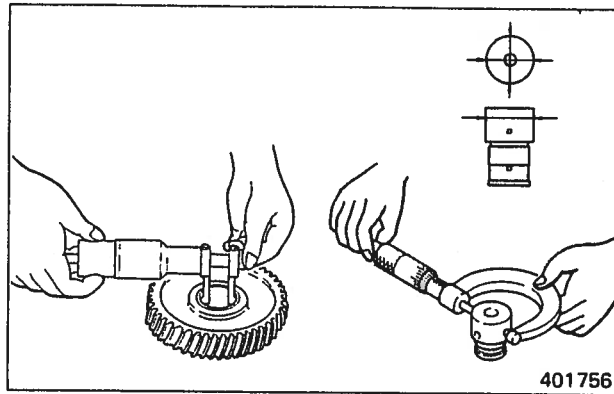
Measuring idler end play

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

If the idler shaft-to-bushing clearance exceeds the Standard clearance, replace the bushing.

Unit: mm (in.)

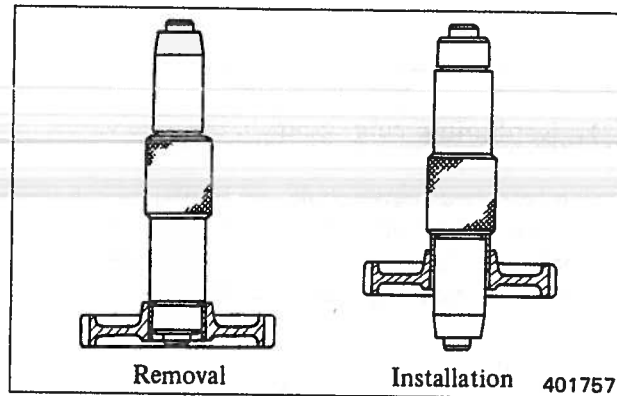
Item	Nominal value	Standard clearance	Repair limit
Idler shaft-to-bushing clearance	36 (1.42) [Diam.]	0.025 - 0.075 (0.00098 - 0.00295)	0.100 (0.00394)



Measuring idler shaft and bushing

(3) Replacing idler bushing

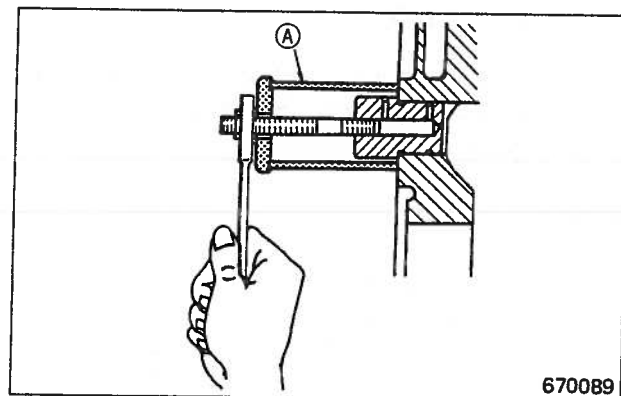
When installing the bushing, press it in until its end face is flush with that of gear boss.



Replacing idler bushing

(4) Replacing idler shaft

To remove the idler shaft for replacement, use idler shaft puller (A) (34491-02300).

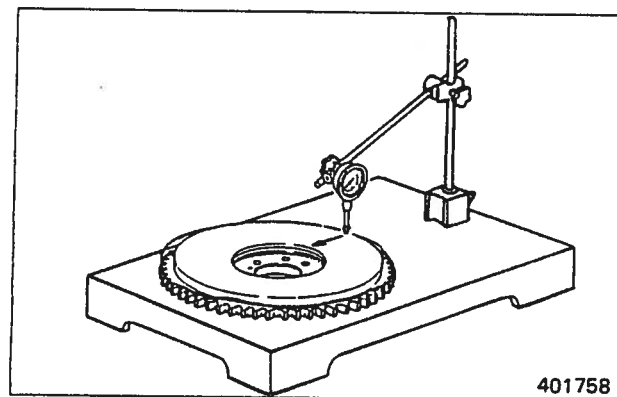


Removing idler shaft

Flywheel and ring gear

(1) Measuring flywheel flatness

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



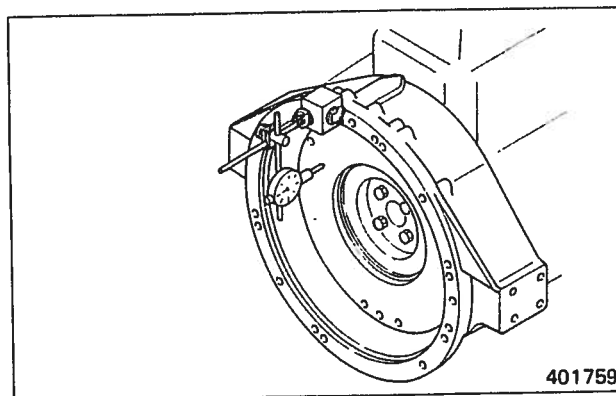
Measuring flywheel flatness

(2) Measuring flywheel runout

With the flywheel installed on the engine, measure its 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	Repair limit
Flatness	0.15 (0.0059), maximum	0.50 (0.020)
Runout		



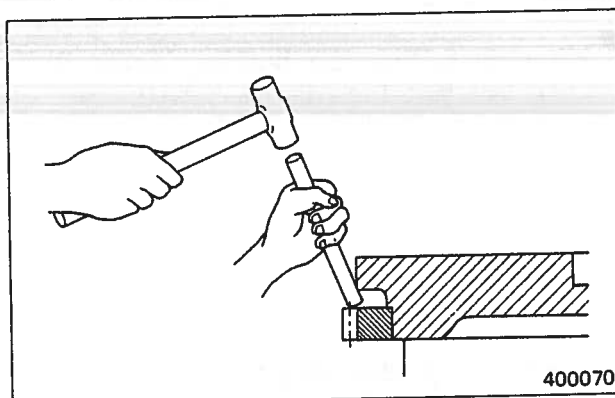
Measuring flywheel runout

(3) Replacing ring gear

Check the ring gear for broken teeth, corrosive 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.



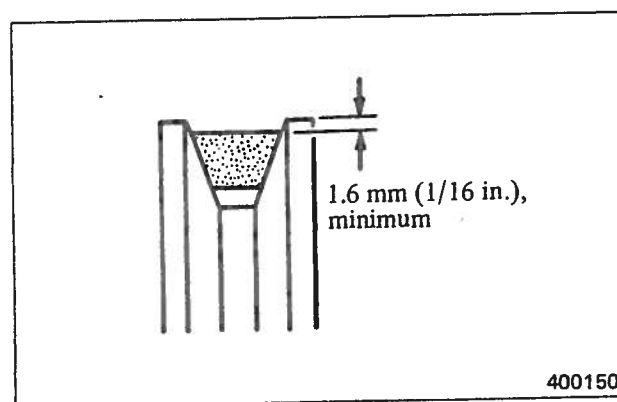
Replacing ring gear

(Installation)

Heat a replacement ring gear up to about 100°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**

Inspect 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.

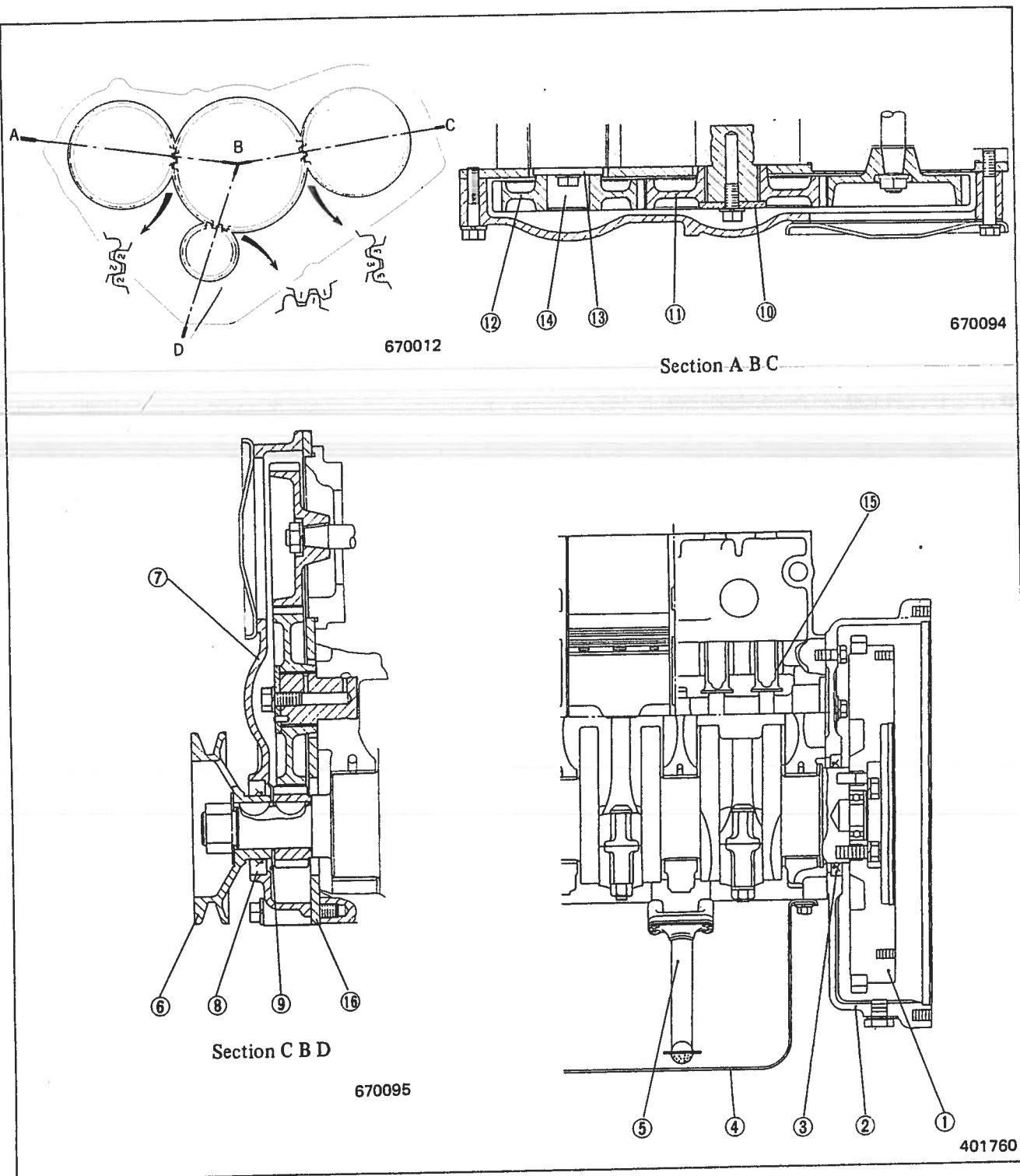


Inspecting V-belt groove in crankshaft pulley

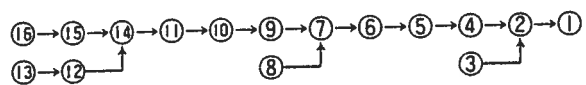
If the top surface of the belt is uniformly above the top of the pulley all the way around, it is not necessary to replace the pulley.

If the top surface of the belt sinks into the groove more than 1.6 mm (1/16 in.), replace the pulley.

2.3 Reassembly

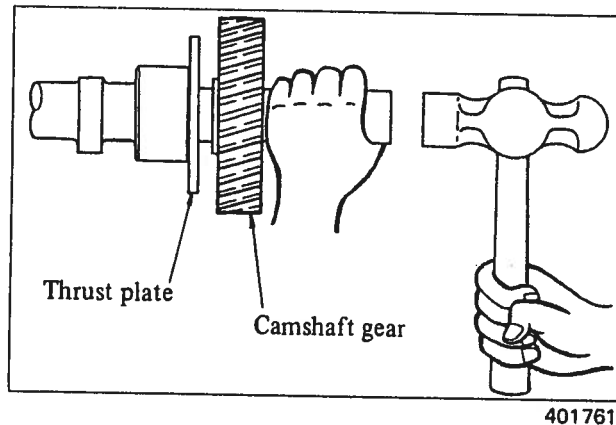


Reassembling sequence



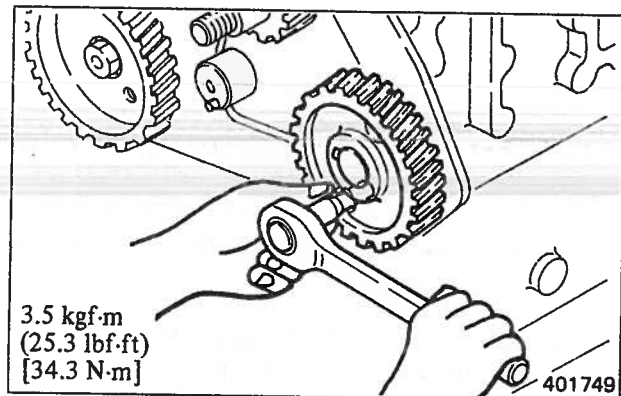
(1) Installing camshaft gear and thrust plate

Heat the gear for installation. Have the thrust plate installed in advance.



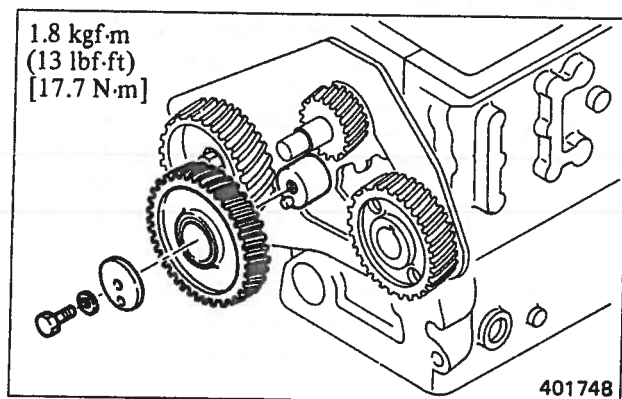
(2) Installing camshaft

Carefully insert the camshaft into the crankcase.



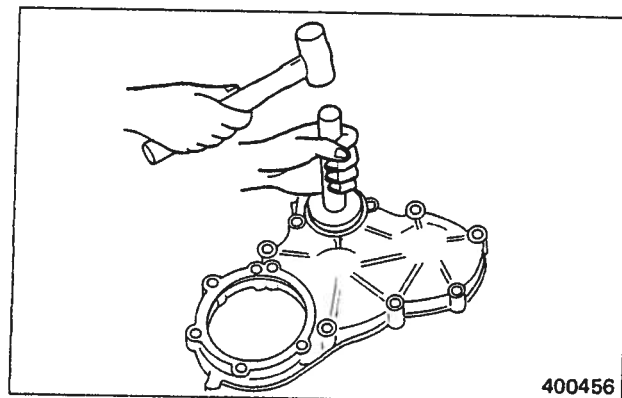
(3) Installing idler

Install the idler while aligning the timing marks each pair of gears, and install the thrust plate with bolt.



(4) Installing oil seal

To install the oil seal, use the installer.



ENGINE PROPER

- (5) Inspecting and adjusting timing gears after installation.

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

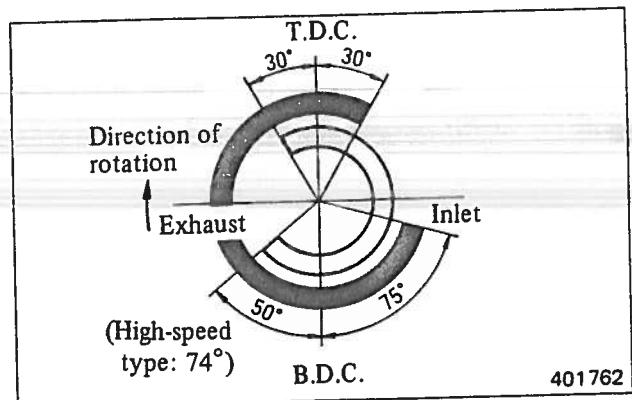
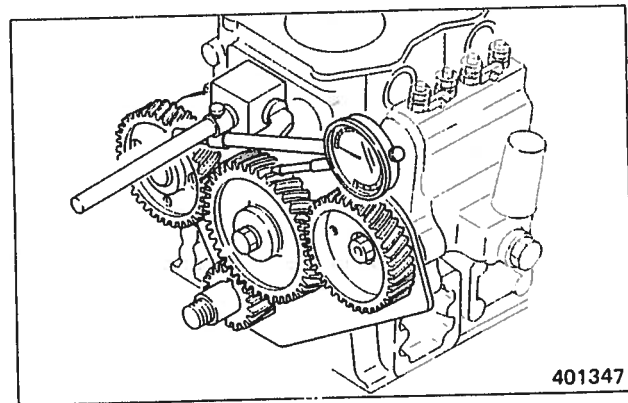
(Inspecting timing gear backlash and end play)

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.)

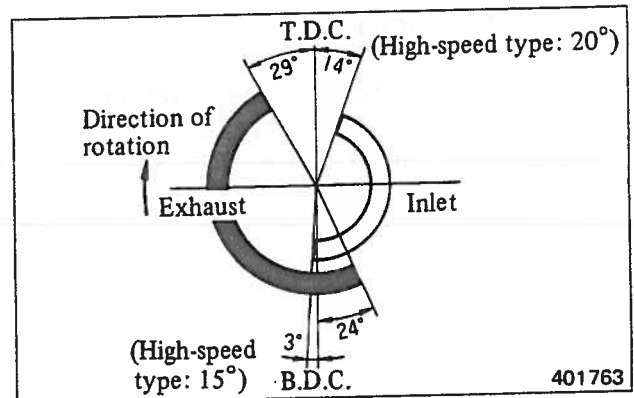
(Inspecting valve timing)

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:

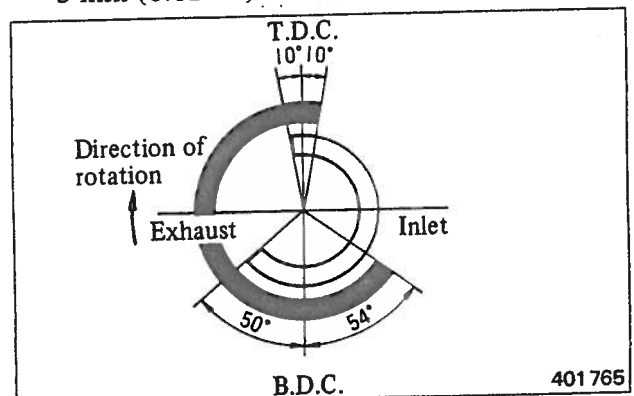
Using a 3 mm (0.12 in.) thick smooth steel plate, add 3 mm (0.12 in.) clearance to the inlet and exhaust valves of No. 1 cylinder. Then, insert a 0.05 mm (0.0020 in.) feeler gauge into between the top of valve cap and rocker, and slowly turn the crankshaft, trying to find a position where the feeler gauge is firmly gripped (the valve starts opening) and a position where the gauge is just ungripped (the valve starts closing). Check to make sure that these positions coincide with the angular positions shown in the valve timing diagram with 3 mm (0.12 in.) clearance added to valves.



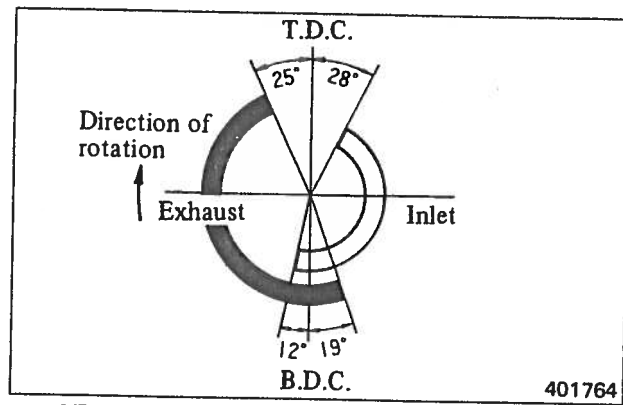
SE-, SE2-series valve timing diagram



SE-, SE2-series valve timing diagram with 3 mm (0.12 in.) clearance added to valves



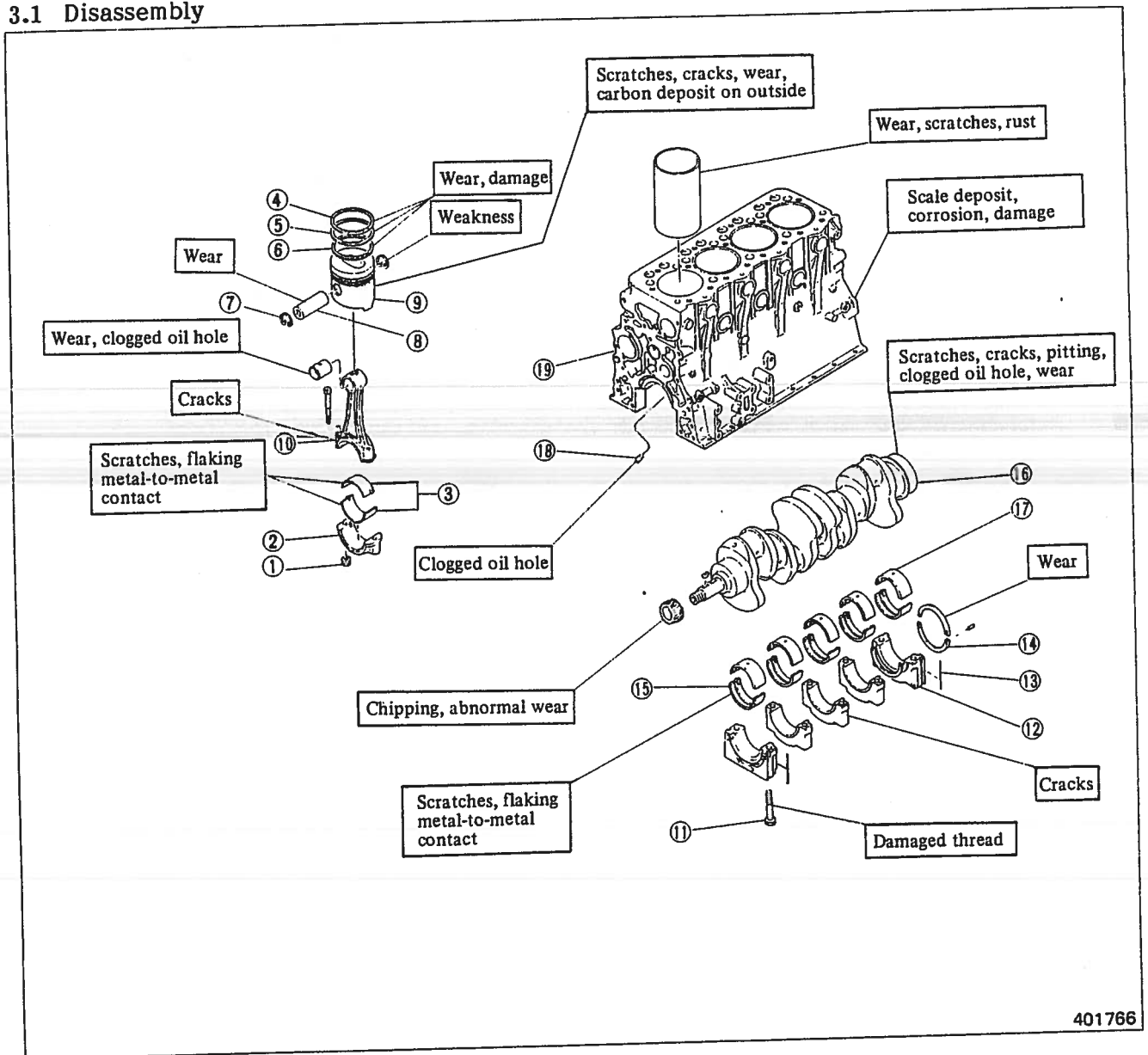
SF-series valve timing diagram



SF-series valve timing diagram with
3 mm (0.12 in.) clearance added to valves

3. PISTONS, CONNECTING RODS, CRANKSHAFT AND CRANKCASE

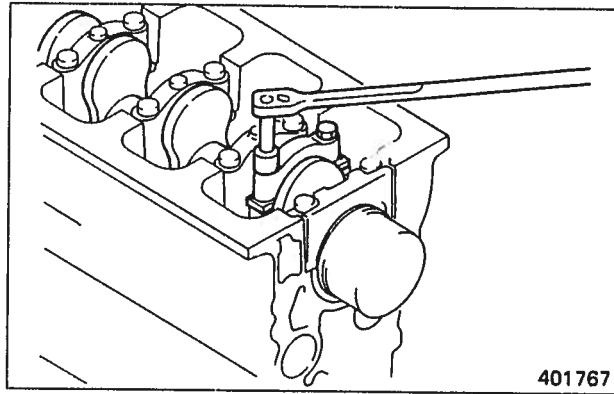
3.1 Disassembly



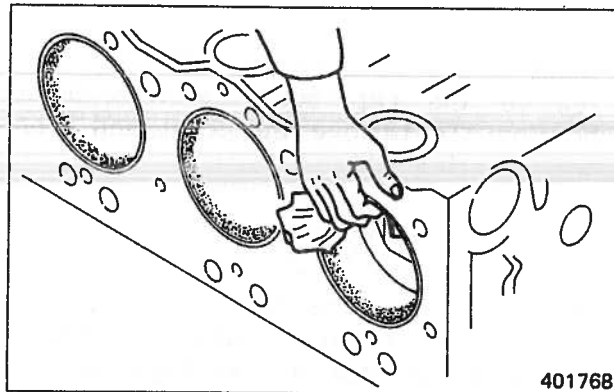
- | | | |
|---------------------------|--------------------|--------------------------------|
| ① Nut | ⑧ Piston pin | ⑮ Main bearing (lower shell) |
| ② Connecting rod cap | ⑨ Piston | ⑯ Crankshaft |
| ③ Connecting rod bearing | ⑩ Connecting rod | ⑰ Main bearing (upper shell) |
| ④ Top compression ring | ⑪ Bearing cap bolt | ⑱ Check valve (w/turbocharger) |
| ⑤ Second compression ring | ⑫ Main bearing cap | ⑲ Crankcase |
| ⑥ Oil ring | ⑬ Side seal | |
| ⑦ Snap ring | ⑭ Thrust plate | |

(1) Removing connecting rod caps

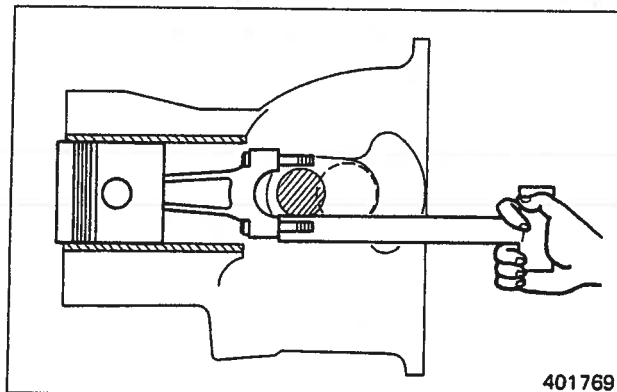
- (a) Unscrew the nuts securing the cap. Give hammer blows to the bolts squarely and evenly and, after the cap comes off the reamer bolt, take off the cap.
- (b) Mark the removed connecting rod bearings for identification of cylinder numbers and kinds, upper shells and lower shells.

**(2) Preparatory step for removing pistons**

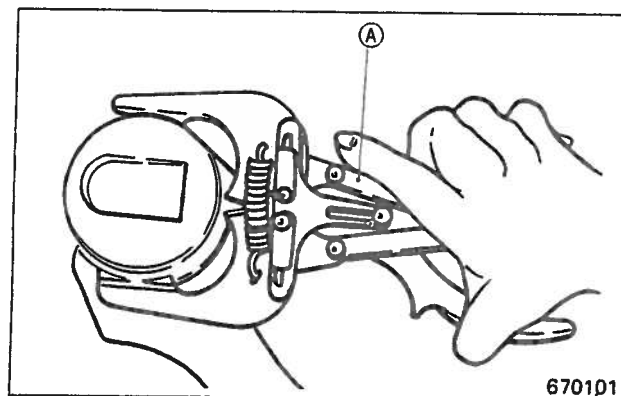
- (a) Lay the crankcase on its side.
- (b) Remove all carbon deposits from the upper areas of cylinder sleeves with cloth or oil paper. Carbon deposits, if any, will make it difficult to pull the pistons upward.

**(3) Removing pistons**

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

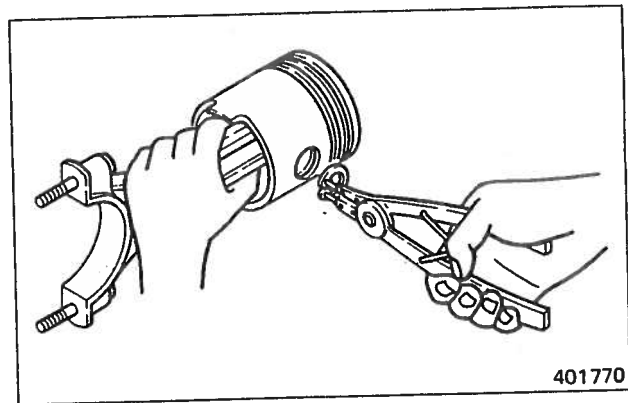
**(4) Removing piston rings**

To remove the rings, use piston ring pliers (A) (31391-12900).



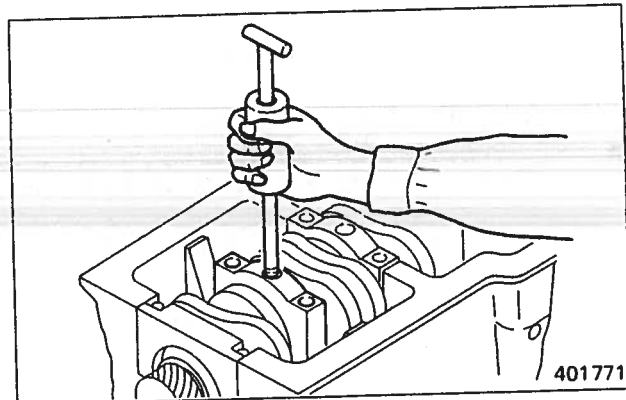
(5) Removing piston pin

- (a) Using snap ring pliers, remove the snap rings.
- (b) Remove the piston pin, and separate the piston from the connecting rod.
- (c) If it is difficult to pull out the pin, heat the piston in a piston heater or hot water to expand the pin bore.



(6) Removing main bearing caps

Unscrew the bolts securing the cap, and remove the cap complete with main bearing. To remove the front and rear main bearings, use a puller.

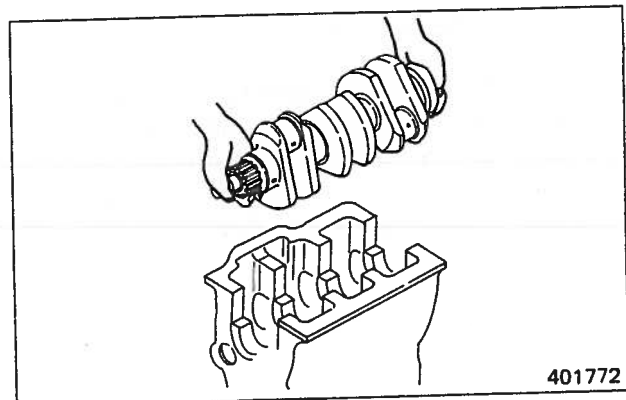


CAUTION

When removing the caps, be careful not to damage the bearings. After removing the caps and bearings, mark each combination for its location so that it is installed to the same crankshaft journal as before at the time of reassembly.

(7) Removing crankshaft

Slowly lift the crankshaft off the crankcase.



3.2 Inspection and repair

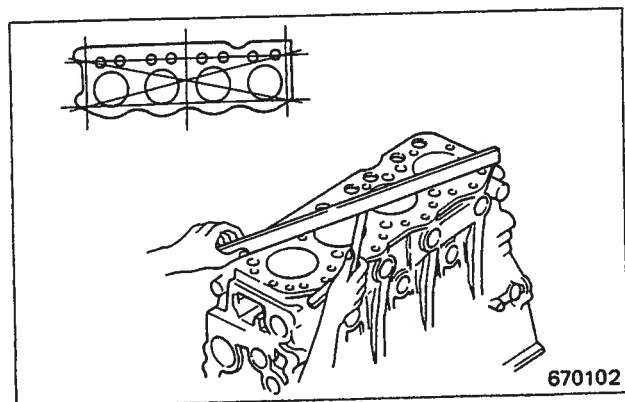
Crankcase and cylinder sleeves

(1) Measuring warpage of crankcase gasketed surface

Measure the warpage with a straightedge and feeler gauge. If the warpage exceeds the Assembly standard, 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)



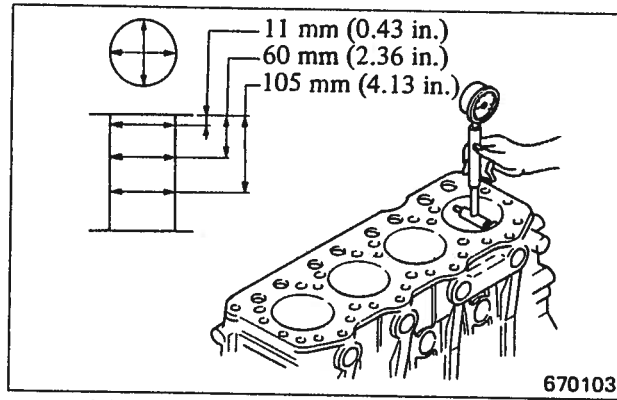
Measuring crankcase gasketed surface

(2) Measuring cylinder sleeve inside diameter

- (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 inside diameter	SE	94.000 - 94.035 (3.70078 - 3.70216)	94.200 (3.70865)	95.200 (3.74802)
	SE2 SF	98.000 - 98.035 (3.85826 - 3.85964)	98.200 (3.86613)	99.200 (3.90550)
Out of round		0.015, maximum		
Taper		0.05, maximum		

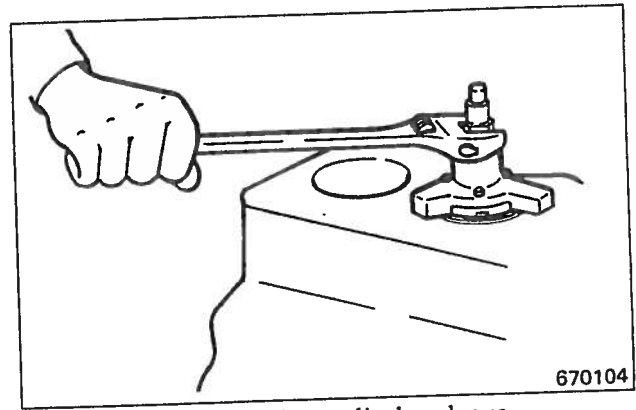


Measuring cylinder sleeve diameter

- (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 to 0.035 mm (0.00138 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.



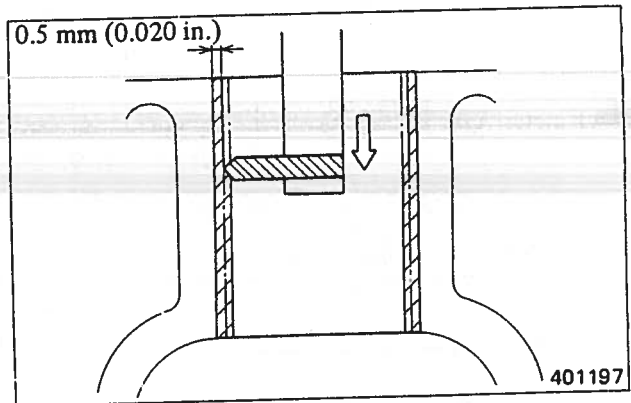
Ridge-reaming cylinder sleeve

(3) Replacing cylinder sleeve

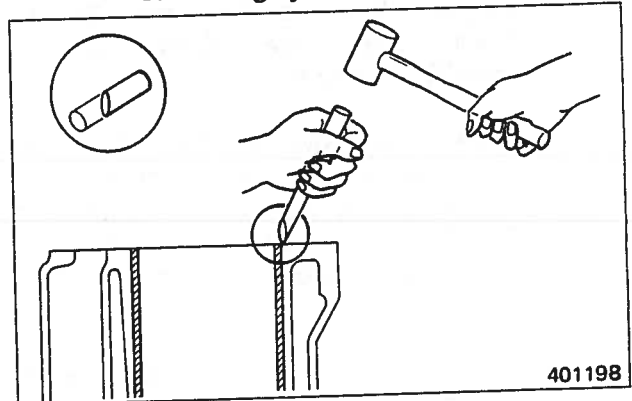
If one sleeve exceeds the Service limit in inside diameter or it is defective, with the other sleeves in good condition, replace that sleeve only.

(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 (0.02 in.).
- (c) Break and remove the sleeve, being careful not to damage the inside surface of the crankcase.



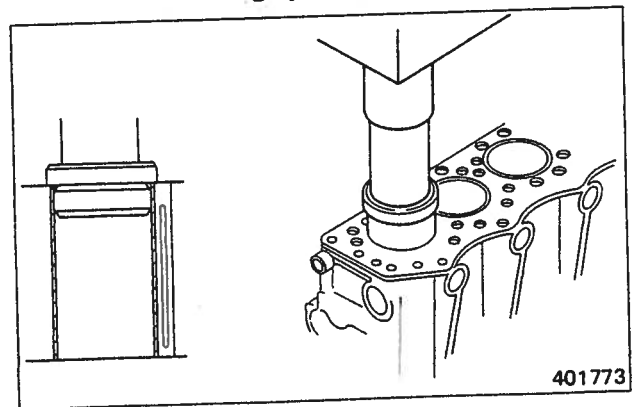
Removing cylinder sleeve (1)



Removing cylinder sleeve (2)

(Installing a new cylinder sleeve)

- (a) Use cylinder sleeve installer (34491-00100 for SE-series, 34491-02100 for SE2-/SF-series).
- (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 $94^{+0.035}_0$ mm ($3.70^{+0.00138}_0$ in.) for SE-series or $98^{+0.035}_0$ mm ($3.86^{+0.00138}_0$ in.) for SE2-/SF-series.

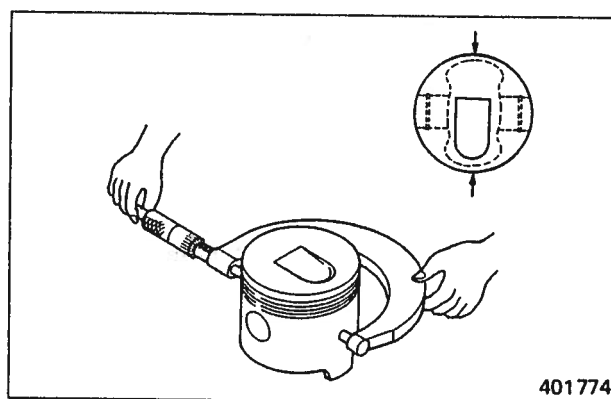


Installing cylinder sleeve

Pistons and piston rings

(1) Measuring piston diameter

- (a) Using a micrometer, measure each piston in the direction transverse to the piston pin. If the diameter exceeds the Service limit, replace the piston. If any pistons have to be replaced, select new pistons so that the variance in weight among pistons per engine is within the Assembly standard.

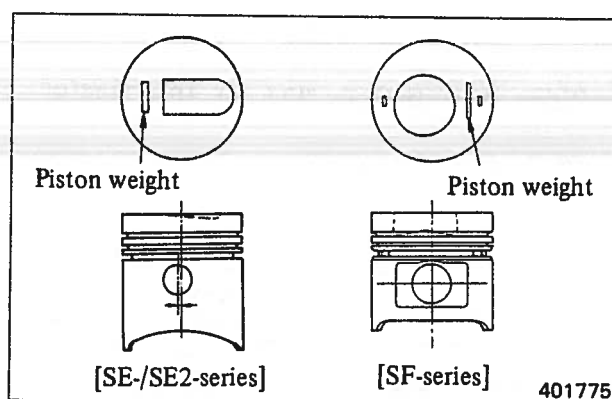


Measuring piston diameter

Unit: mm (in.)

Unit: mm (in.)

Item			Assembly standard	Service limit
Piston diameter	SE	Standard	93.875 – 93.845 (3.69586 – 3.69468)	93.660 (3.68739)
		0.25 (0.0098) oversize	94.125 – 94.095 (3.70570 – 3.70452)	93.910 (3.69724)
		0.50 (0.0197) oversize	94.375 – 94.345 (3.71554 – 3.71436)	94.160 (3.70708)
	SE2	Standard	97.875 – 97.845 (3.85334 – 3.85216)	97.660 (3.84487)
		0.25 (0.0098) oversize	98.125 – 98.095 (3.86318 – 3.86200)	97.910 (3.85472)
		0.50 (0.0197) oversize	98.375 – 98.345 (3.87302 – 3.87184)	98.160 (3.86456)
	SF	Standard	97.975 – 97.945 (3.85728 – 3.85609)	97.760 (3.84881)
		0.25 (0.0098) oversize	98.225 – 98.195 (3.86712 – 3.86594)	98.010 (3.85865)
		0.50 (0.0197) oversize	98.475 – 98.445 (3.87696 – 3.87578)	98.260 (3.86850)
Variance in weight per engine gram (oz)			±3 (±0.1)	



Piston weight marking

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

ENGINE PROPER

(2) Measuring piston ring end gap

Place the ring in a new or master sleeve, and measure the gap. If the gap exceeds the Service limit, replace all rings as a set.

Inside diameter of master cylinder sleeve:

94 $^{+0.035}_{0}$ mm (3.70 $^{+0.00138}_{0}$ in.) [SE-series]

98 $^{+0.035}_{0}$ mm (3.86 $^{+0.00138}_{0}$ in.) [SE2-/SF-series]

NOTE

Place the piston ring in the master sleeve by pushing it squarely with the use of piston.

Unit: mm (in.)

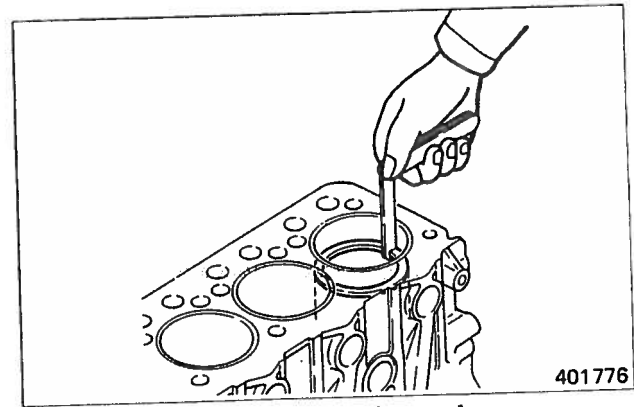
Item	Assembly standard	Service limit
Piston ring end gap	0.30 – 0.50 (0.0118 – 0.0197)	1.50 (0.0591)

(3) Measuring piston ring side clearance

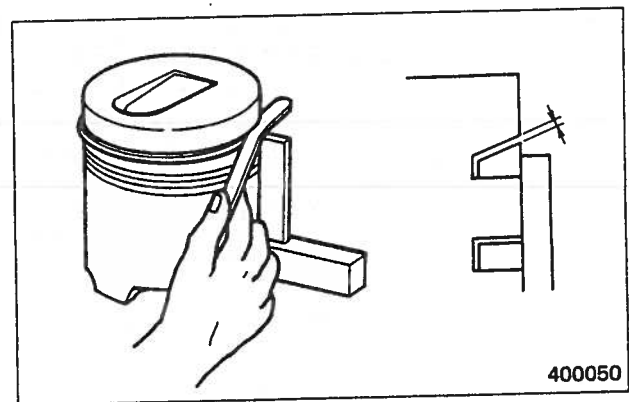
Insert new piston rings into the ring grooves in the piston, and measure the clearance of each ring with a feeler gauge and straightedge as shown.

Unit: mm (in.)

Item		Nominal value	Assembly standard	Repair limit
Piston ring side clearance	No. 1 ring	2.5 (0.098)	0.030 – 0.070 (0.00118 – 0.00276)	0.200 (0.00787)
	No. 2 ring	2.0 (0.079)	0.025 – 0.060 (0.00098 – 0.00236)	0.150 (0.00591)
	Oil ring	SE 4.0 (0.157)		
		SE2 4.5 SF (0.177)		



Measuring piston ring end gap



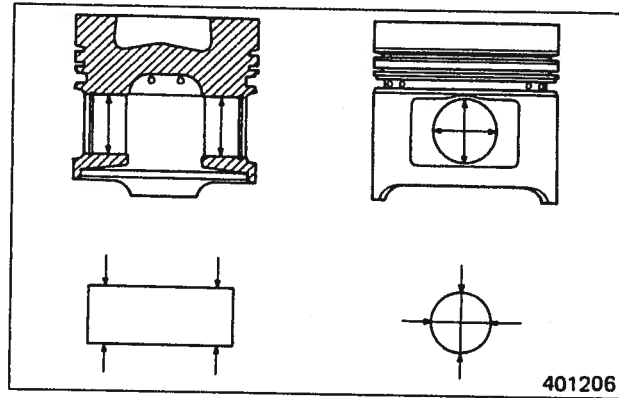
Measuring piston ring side clearance

(4) Measuring piston pin and hole diameters

If the Repair limit is reached, replace the piston pin. If it is exceeded, replace the piston.

Unit: mm (in.)

Item		Assembly standard	Repair limit
Piston pin diameter	SE SE2	28.000 – 27.984 (1.10236 – 1.10173)	
	SF	32.000 – 31.984 (1.25984 – 1.25921)	
Piston pin-to-hole clearance		0 – 0.016 (0 – 0.00063)	0.050 (0.00197)

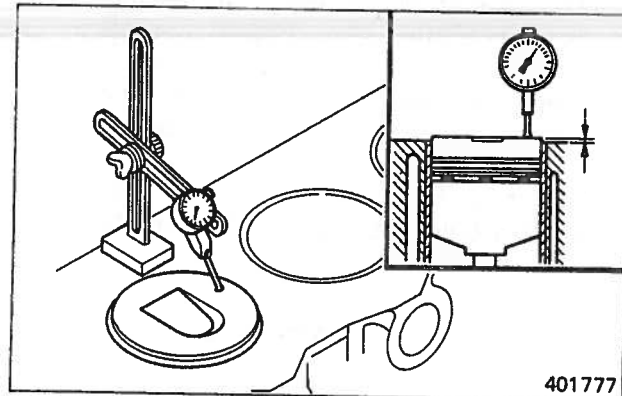


Measuring piston pin and hole

(5) Measuring piston protrusion

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.



Measuring piston protrusion

Unit: mm (in.)

Item		Assembly standard
Piston protrusion	SE SE2	0.35 – 0.75 (0.0138 – 0.0295)
	SF	0.65 – 1.05 (0.0256 – 0.0413)
"As-installed" thickness of cylinder head gasket		1.6 ± 0.15 (0.063 ± 0.0059)



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 bearings and small-end bushings

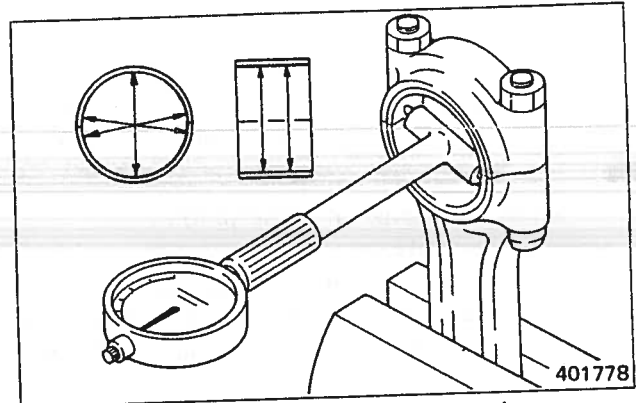
(1) Measuring connecting rod bearing-to-crankpin clearance

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

The two bearing undersizes are -0.25 mm (-0.0098 in.) and -0.50 mm (-0.0197 in.).

NOTE

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



Measuring connecting rod bearing inside diameter

Unit: mm (in.)

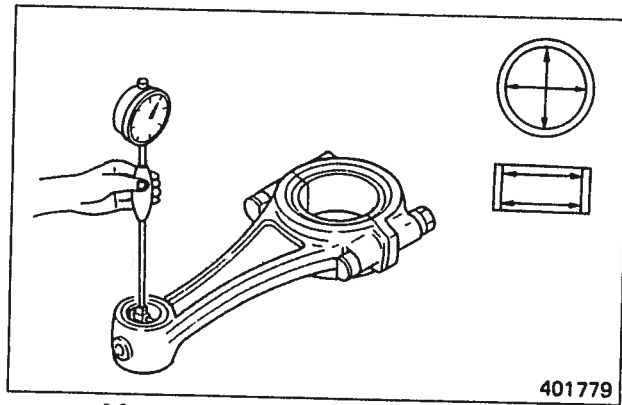
Item	Assembly standard	Repair limit
Crankpin diameter	58 $\begin{smallmatrix} -0.035 \\ -0.055 \end{smallmatrix}$ (2.28 $\begin{smallmatrix} -0.00138 \\ -0.00217 \end{smallmatrix}$)	-0.20 (-0.0079)
Connecting rod bearing-to-crankpin clearance	0.035 - 0.100 (0.00138 - 0.00394)	0.200 (0.00787)

(2) Measuring connecting rod bushing-to-piston pin clearance

Measure the piston pin diameter and bushing inside diameter to determine the clearance between the two. If the clearance exceeds the Repair limit, replace the pin or bushing whichever is badly worn.

Unit: mm (in.)

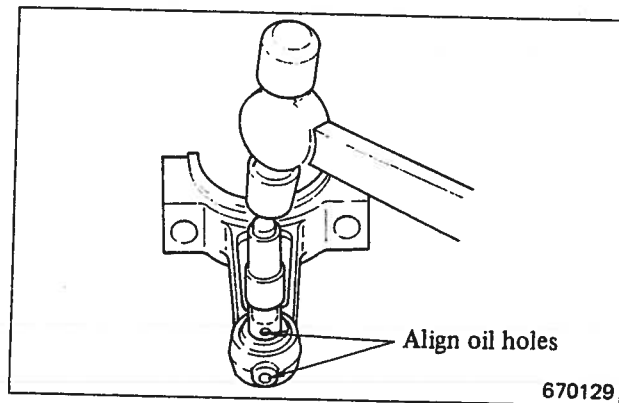
Item		Assembly standard	Repair limit
Piston pin bushing inside diameter	SE	28.045 – 28.020	
	SE2	(1.10413 – 1.10315)	
	SF	32.048 – 32.020	
		(1.26173 – 1.26063)	
Connecting rod bushing-to-piston pin clearance		0.020 – 0.051 (0.00079 – 0.00201)	0.080 (0.00315)



Measuring connecting rod bushing inside diameter

(3) Replacing connecting rod bushing

- To remove the bushing for replacement, use a connecting rod bushing puller as shown.
- Align the oil holes in the bushing and connecting rod.
- Press the bushing from the chamfered side of connecting rod.
- After installing the bushing, insert the piston pin to make sure that the pin rotates freely.



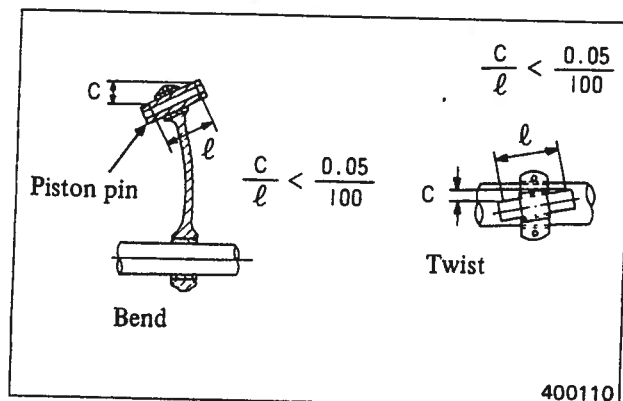
Installing connecting rod bushing

(4) Inspecting connecting rods for bend and twist

- Measure "C" and "l." If the measurement at "C" is larger than 0.05 mm (0.0020 in.) per 100 mm (3.9 in.) of "l," straighten the rod with a press.

Unit: mm (in.)

Item	Assembly standard	Repair limit
Connecting rod bend and twist	0.05/100 (0.0020/3.9), maximum	0.15 (0.0059)

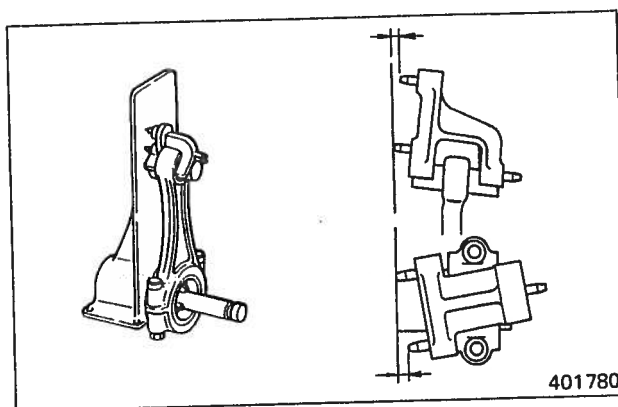


Inspecting connecting rod

- (b) For inspecting connecting rod for bend and twist, the connecting rod aligner is generally used.

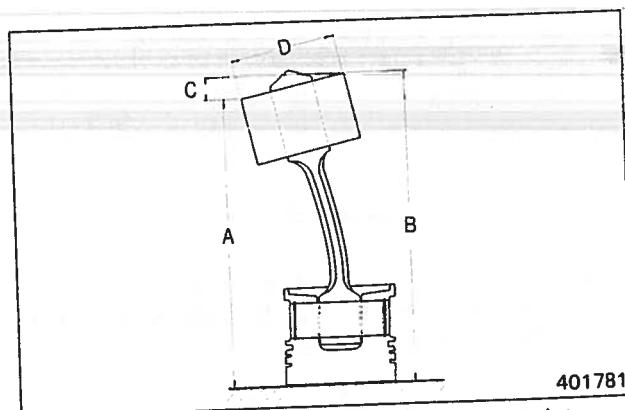
NOTE

To inspect for bend, install the bearing cap to connecting rod, and tighten the cap bolts to the specified torque.



Checking connecting rod on aligner

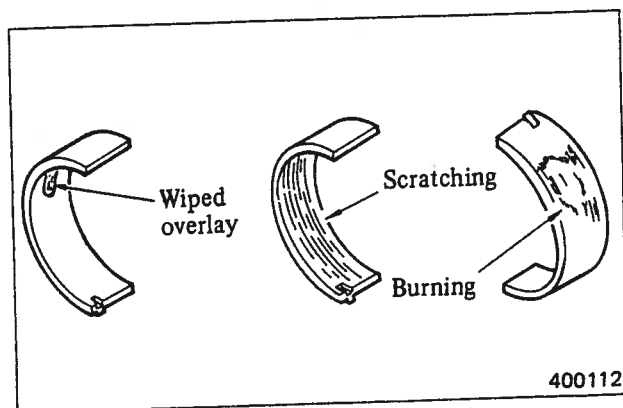
- (c) To inspect the rod installed to the piston, place the piston on a surface plate, insert a round bar corresponding to the crankpin in diameter into the big end bore, and measure the heights "A" and "B" of the bar.



Inspecting connecting rod installed to piston

(5) Inspecting connecting rod bearings

Inspect each bearing shell for wiped overlay, scratching, burning, pitting and other defects. If any of these defects is present, replace the shell.

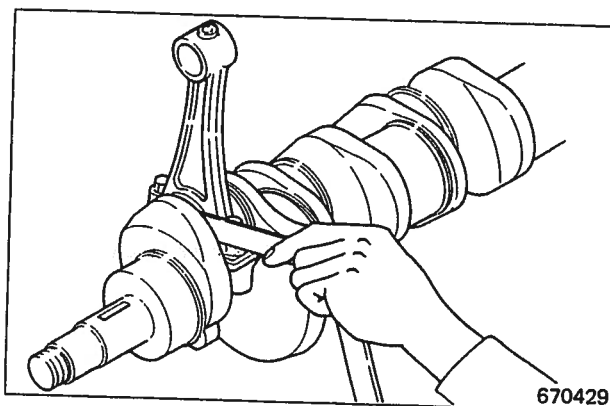


(6) Measuring connecting rod end play

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	Nominal value	Standard clearance	Service limit
Connecting rod end play [widths of connecting rod and crankpin]	40 (1.57)	0.15 - 0.35 (0.0059 - 0.0138)	0.50 (0.0197)



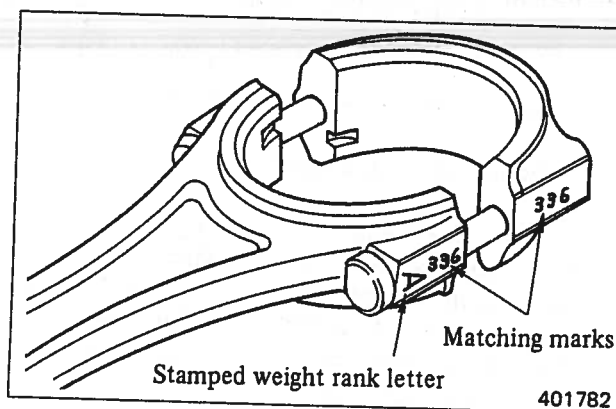
Measuring connecting rod end play

(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	±5 g (±0.2 oz), maximum



Stamped weight rank letter

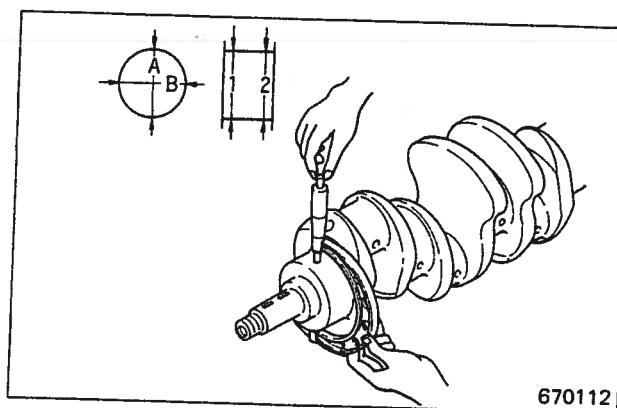
Crankshaft

(1) Measuring journal diameter

Using a micrometer, measure the journal in two positions, 1 and 2, and in two directions, A and B, 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	Assembly standard	Repair limit	Service limit
Crankshaft journals	Diameter 75 -0.03 -0.05 (2.95 -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		



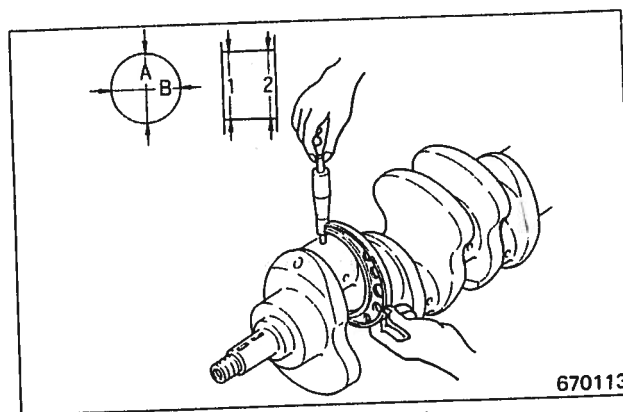
Measuring crankshaft journals

(2) Measuring crankpin diameter

Using a micrometer, measure the crankpin in two positions, 1 and 2, and in two directions, A and B, to determine the war, out of round and taper. If any of the Repair limits is exceeded, regrind the crankpin to the undersize or replace the crankshaft.

Unit: mm (in.)

Item		Assembly standard	Repair limit
Crankpins	Diameter	58 -0.035 -0.055 (2.28 0.00138 -0.00217)	-0.20 (-0.0079)
	Out of round	0.01 (0.0004), maximum	0.03 (0.0012)
	Taper		



Measuring crankpins

(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 bearing contact pattern.

Crankshaft grinding dimensions

Unit: mm (in.)

	Undersize	Refinishing dimension
Crankshaft journal	0.25 (0.0098)	74.65 – 74.63 (2.9390 – 2.9382)
	0.50 (0.0197)	74.40 – 74.38 (2.9291 – 2.9283)
Crankpin	0.25 (0.0098)	57.65 – 57.63 (2.2697 – 2.2689)
	0.50 (0.0197)	57.40 – 57.38 (2.2598 – 2.2591)

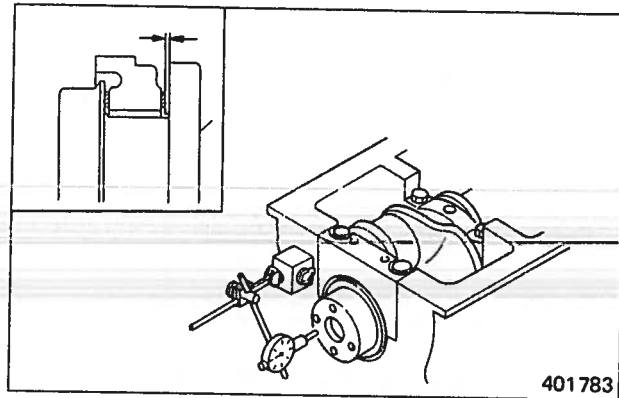
When grinding the journals and crankpins, be sure to produce the same fillet radius as the original one. They should have a hardness of 620 or more in terms of Vickers Hardness Number. If necessary, reharden the journals and crankpins, and inspect them for cracks by conducting a magnalux (magnetic particle)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

(4) Measuring crankshaft end play

Install the thrust plates in position, and secure the main bearing 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.

Unit: mm (in.)

Item	Nominal value	Assembly standard	Repair limit
Crankshaft end play	37 (1.46)	0.100 - 0.264 (0.00394 - 0.01039)	0.300 (0.01181)



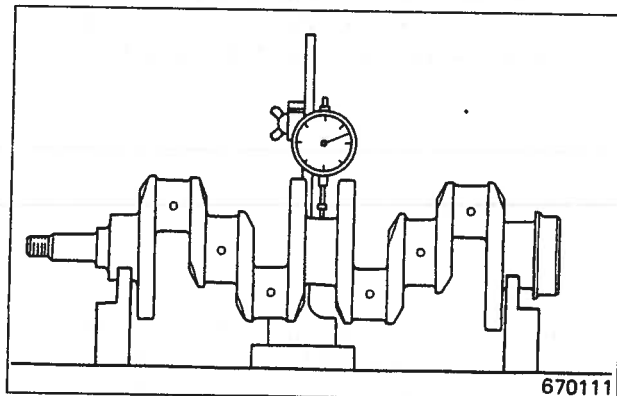
Measuring crankshaft end play

(5) Measuring crankshaft runout

Support the crankshaft on its front and rear journals in V-blocks, and measure the runout at the center journal, using a dial gauge. Depending on the amount of runout, repair the crankshaft by grinding or straightening with a press. If the runout exceeds the Repair limit, replace the crankshaft.

Unit: mm (in.)

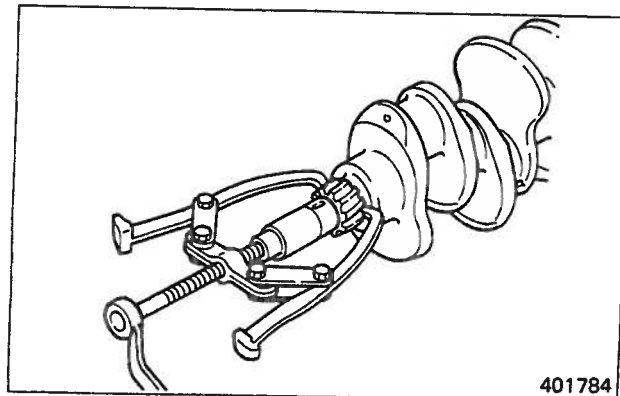
Item	Assembly standard	Repair limit
Crankshaft runout	0.02 (0.0008), maximum	0.05 (0.0020)



Measuring crankshaft runout

(6) Replacing crankshaft gear

- (a) Using gear puller, remove the gear from the crankshaft.

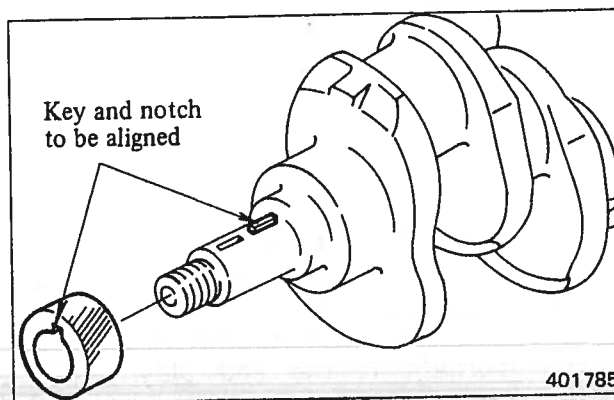


Replacing crankshaft gear

NOTE

Do not remove the gear by driving with a hammer.

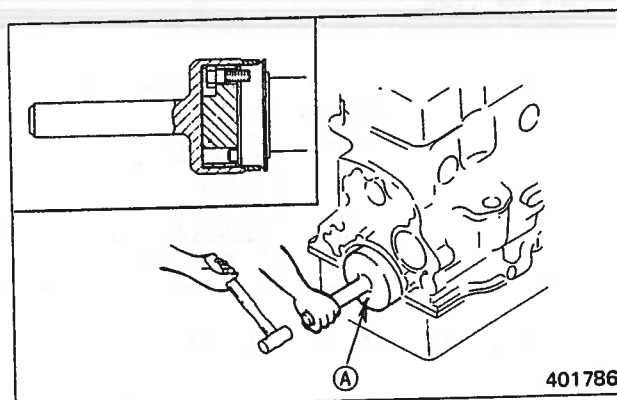
- (b) To install, heat the gear up to about 100°C (212°F) with the heater. Place the new gear on the crankshaft by aligning the key with the notch of the gear and give light blows of a copper hammer to the end face of the gear.



(7) Replacing rear oil seal

If the seal shows a sign of oil leaks, replace it with a replacement oil seal with sleeve.

To install the sleeve, apply oil to the inside surface of the sleeve, and drive it onto the crankshaft, using crankshaft sleeve installer (A) (30691-13010), as shown.

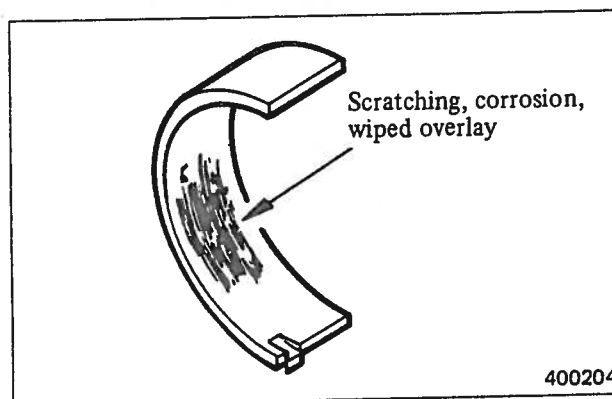


Replacing rear oil seal

Main bearings

(1) Inspection

Inspect each bearing 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 bearing cap.

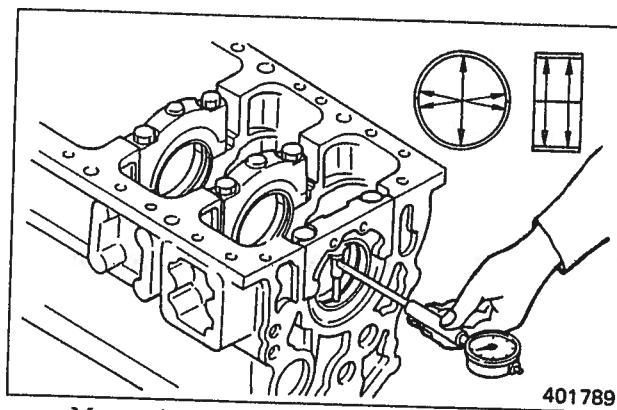


(2) Measuring main bearing clearance

Fit the bearing shells to the crankcase and bearing cap, and tighten the cap bolts to the specified torque. Measure the inside diameter of the bearing 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 bearing-to-journal clearance	0.050 – 0.115 (0.00197 – 0.00453)	0.200 (0.00787)

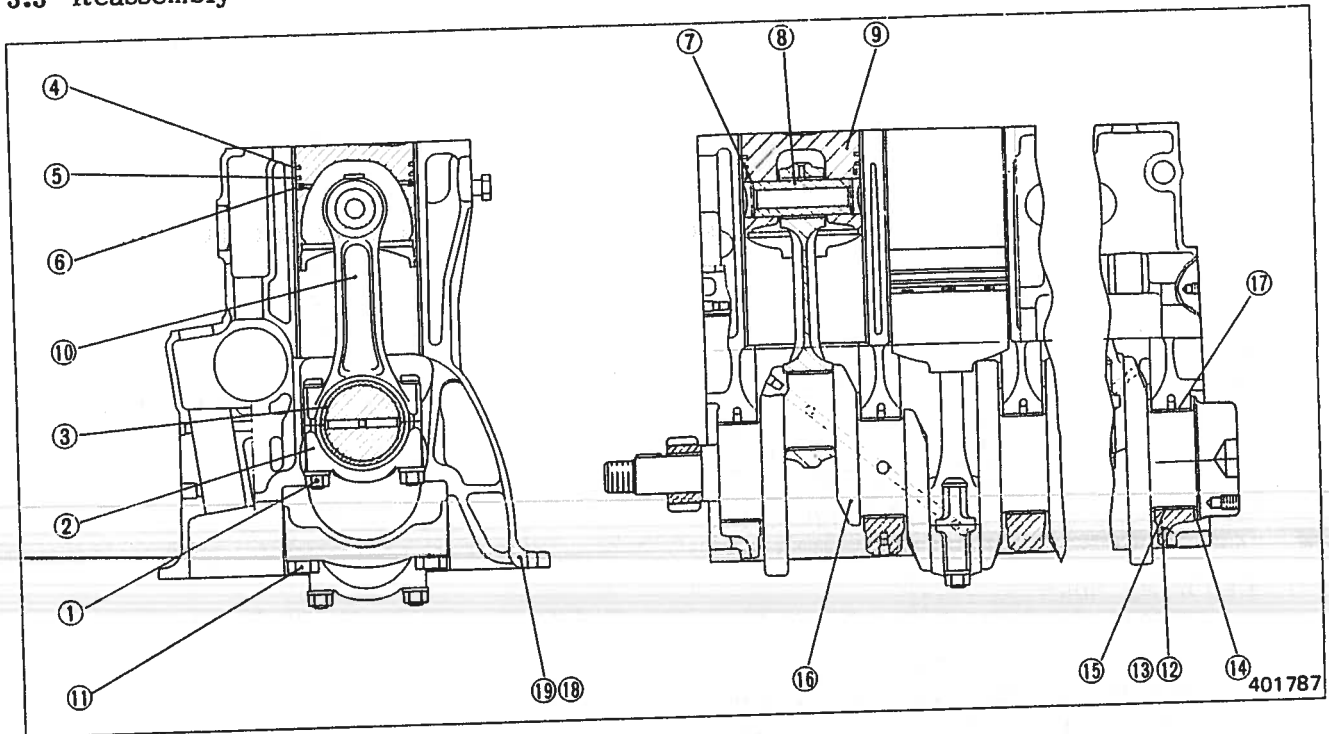


Measuring main bearing inside diameter

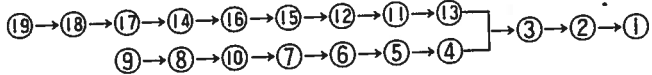
(3) Replacing main bearings

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

3.3 Reassembly

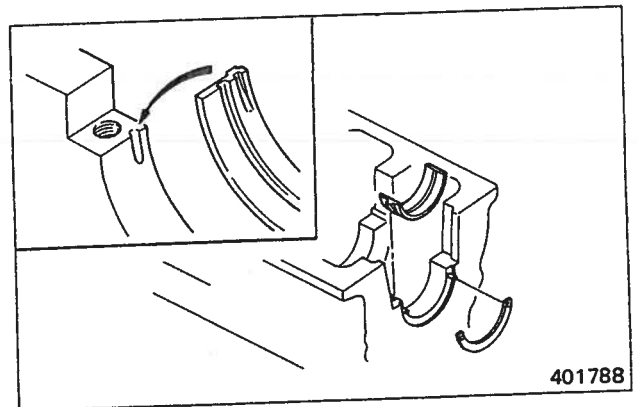


Reassembling sequence



(1) Install main bearings

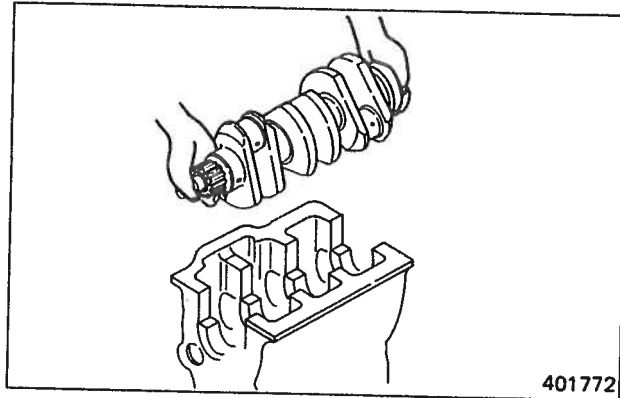
- (a) Install each upper shell in the crankcase by fitting its locking lip in the recess. The oil holes in the shell and crankcase will be aligned when the shell is so installed.
- (b) Apply a thin coat of engine oil to the inside surface of each shell.
- (c) Install the thrust plate in position.



Installing main bearing upper shell

(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.

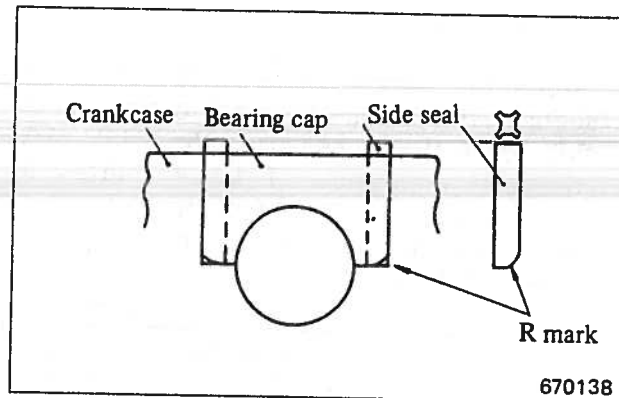


(3) Installing main bearing caps

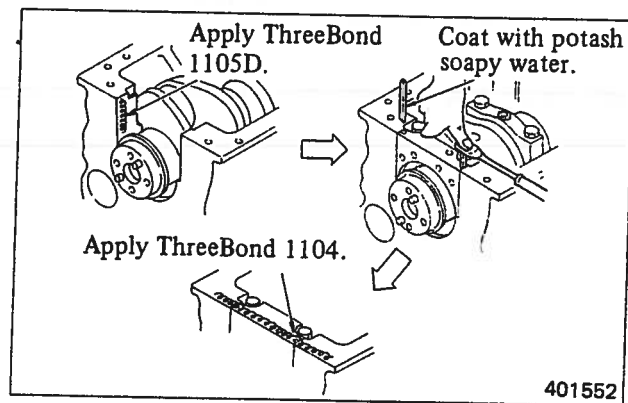
- (a) Apply engine oil to each lower shell, and fit it to the bearing cap.
- (b) Apply ThreeBond 1105D to the mating face of the front and rear caps.

NOTE

Apply ThreeBond 1105D to only front and rear caps to which side seals are to be installed.

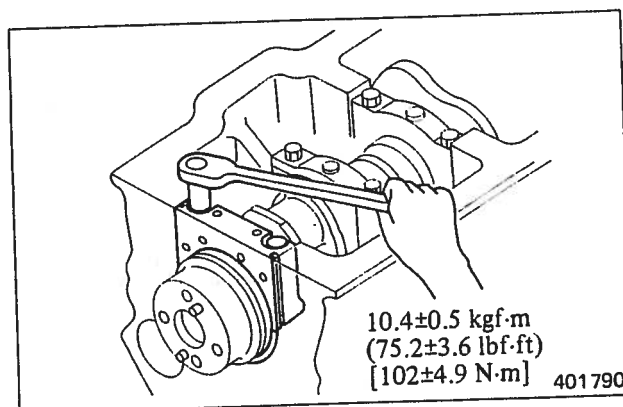


- (c) Install the bearing caps to the crankcase, making sure that they are flush with the crankcase walls on the front and rear sides.
- (d) Coat the side seals with potash soapy water, and insert them into the grooves in each bearing cap. Using the face of a screwdriver, push in the seals, bringing 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.



(4) Installing bearing cap bolts

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

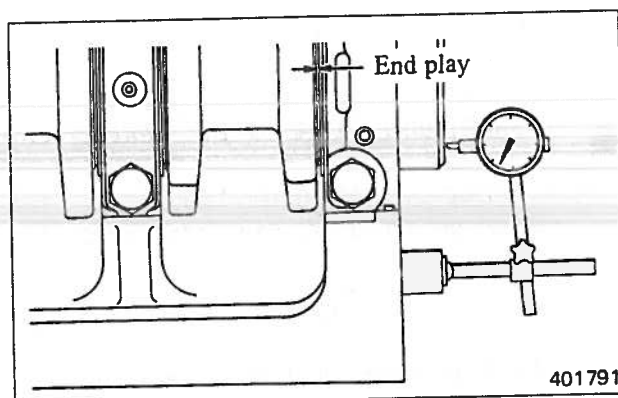


(5) Measuring crankshaft end play

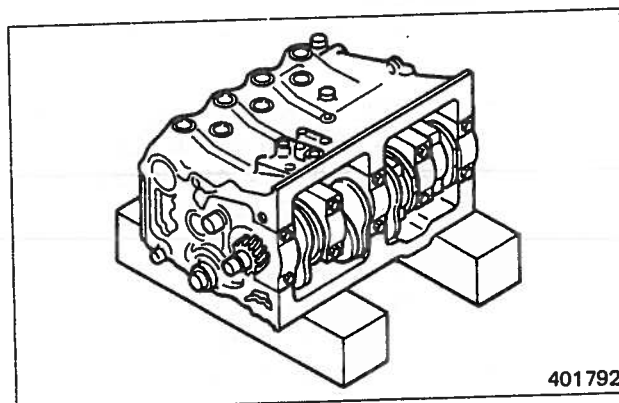
Install the thrust plates in position, and secure the main bearing caps. Under this condition, measure the end play (the end clearance of thrust plates in the journal). If the end play exceeds the Assembly standard, replace the thrust plates.

Unit: mm (in.)

Item	Assembly standard	Repair limit
Crankshaft end play	0.100 - 0.264 (0.00394 - 0.01039)	0.300 (0.01181)



(6) Lay the crankcase on its side

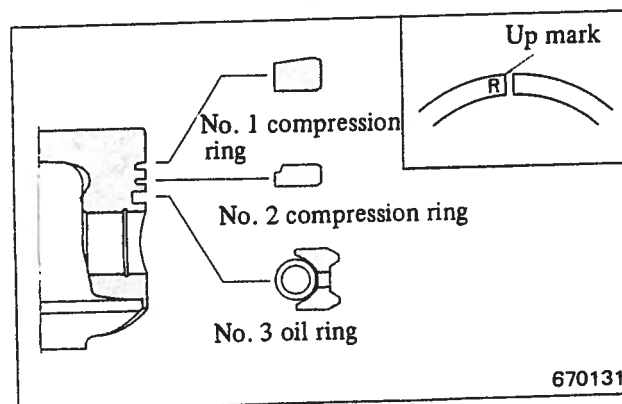


(7) Installing piston rings

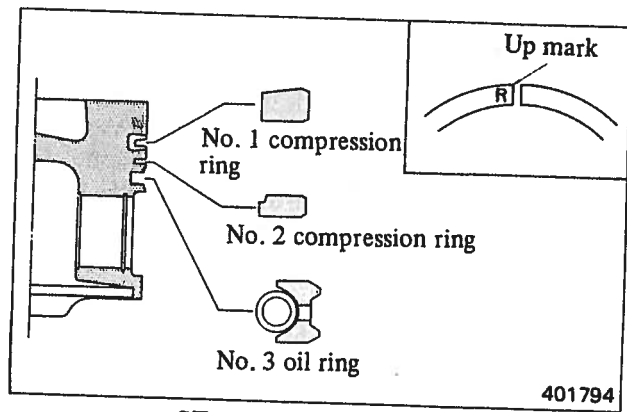
- (a) Using piston ring pliers (31391-12900), install the piston rings on the piston.

NOTE

Each piston ring is marked "R" on the side to be up when installed on the piston.

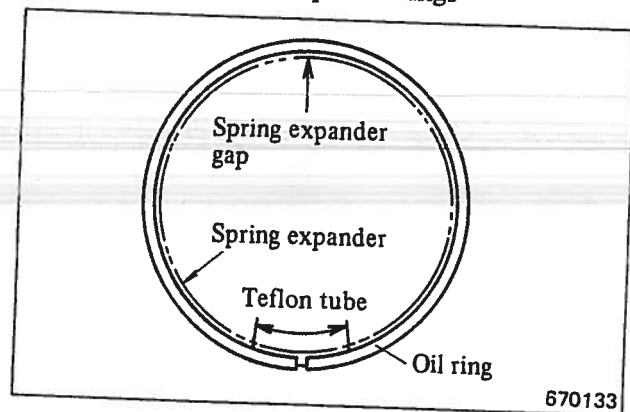


SE-/SE2-series piston rings



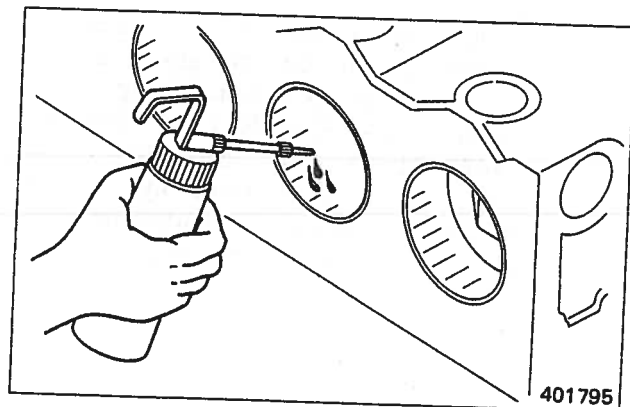
SF-series piston rings

- (b) Install the oil ring with its end gap positioned at 180° to that of spring expander. Attach teflon tube to the expander close to the oil ring end gap.



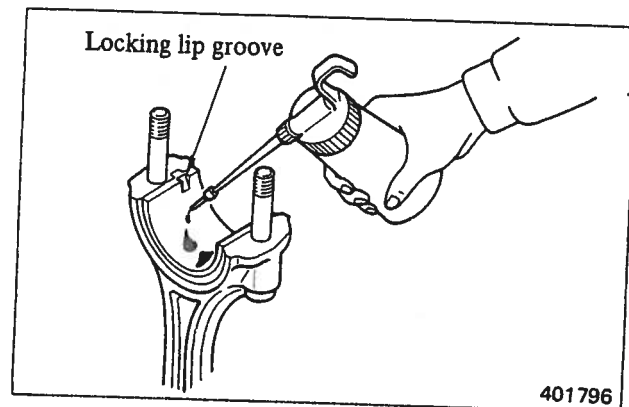
(8) Preparatory steps for installing pistons

Clean the cylinder sleeve bore surface with a clean cloth, and apply engine oil to that surface.



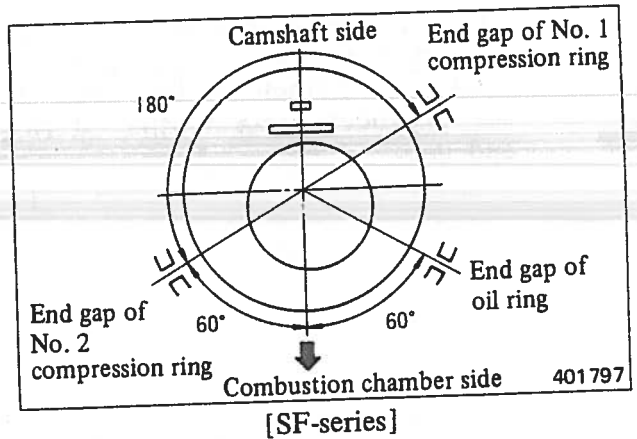
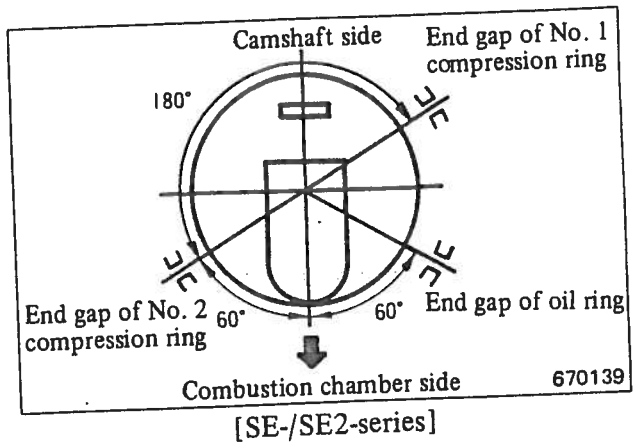
(9) Installing connecting rod bearings and caps

- (a) Insert the bolts into the cap by settling the flat of bolt head in place on the cap.
- (b) Install the upper shell of the bearing in the rod by fitting its locking lip in the groove, and apply engine oil to the inside surface of the shell.

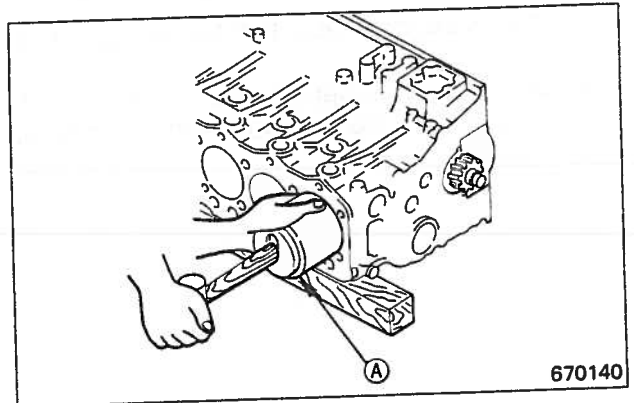


(10) Installing pistons

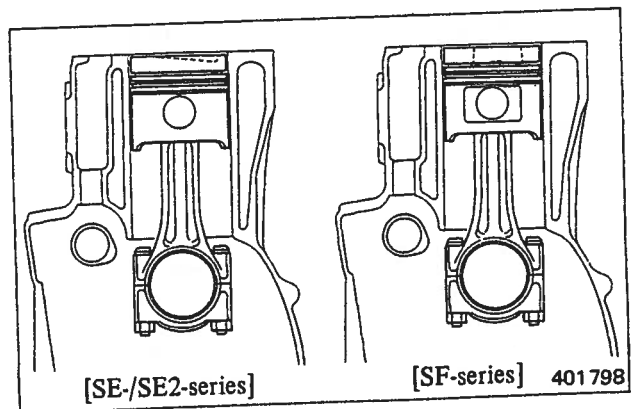
- (a) Apply engine oil to the piston rings, and reposition the rings by keeping their end gaps away from the direction of piston pin and thrust side.



- (b) Bring the crankpin to which the piston is to be installed to top dead center position. Using piston installer (34491-00200 for SE-series, 34491-02200 for SE2-/SF-series), insert the piston assembly into the crankcase, with the matching mark of the connecting rod on the camshaft side.

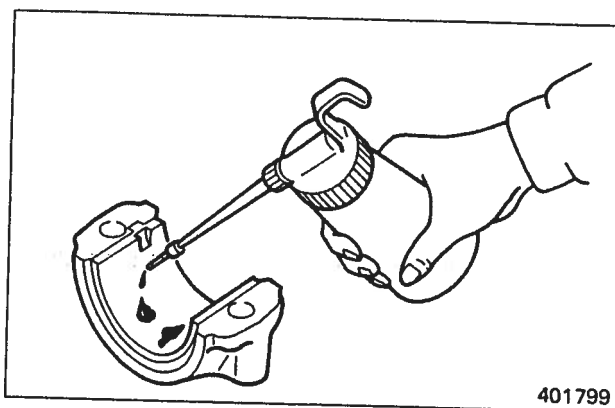


- (c) After resting the big end of connecting rod on the crankpin, turn crankshaft by 180°, and install the cap.



(11) Installing connecting rod caps

- (a) Install the lower shell of the bearing in the cap, apply engine oil to the inside surface of the shell.
- (b) Install the cap by tightening the nuts to the specified torque.

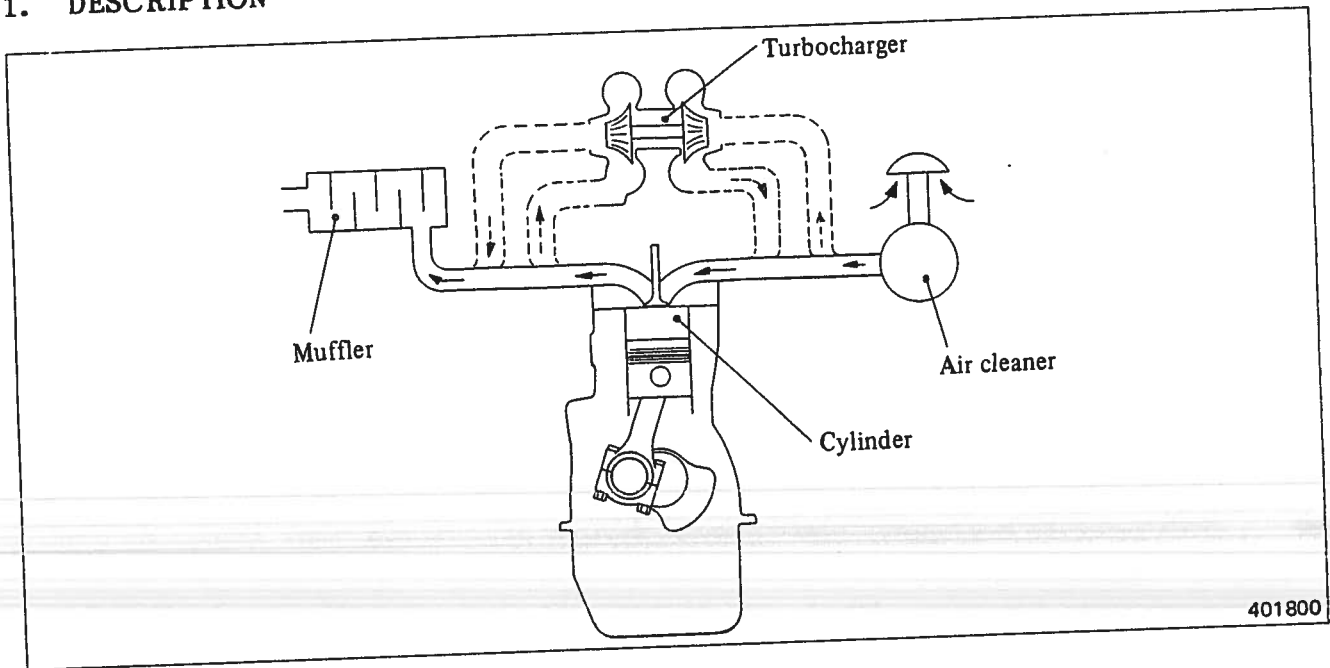


401799

INLET & EXHAUST SYSTEMS

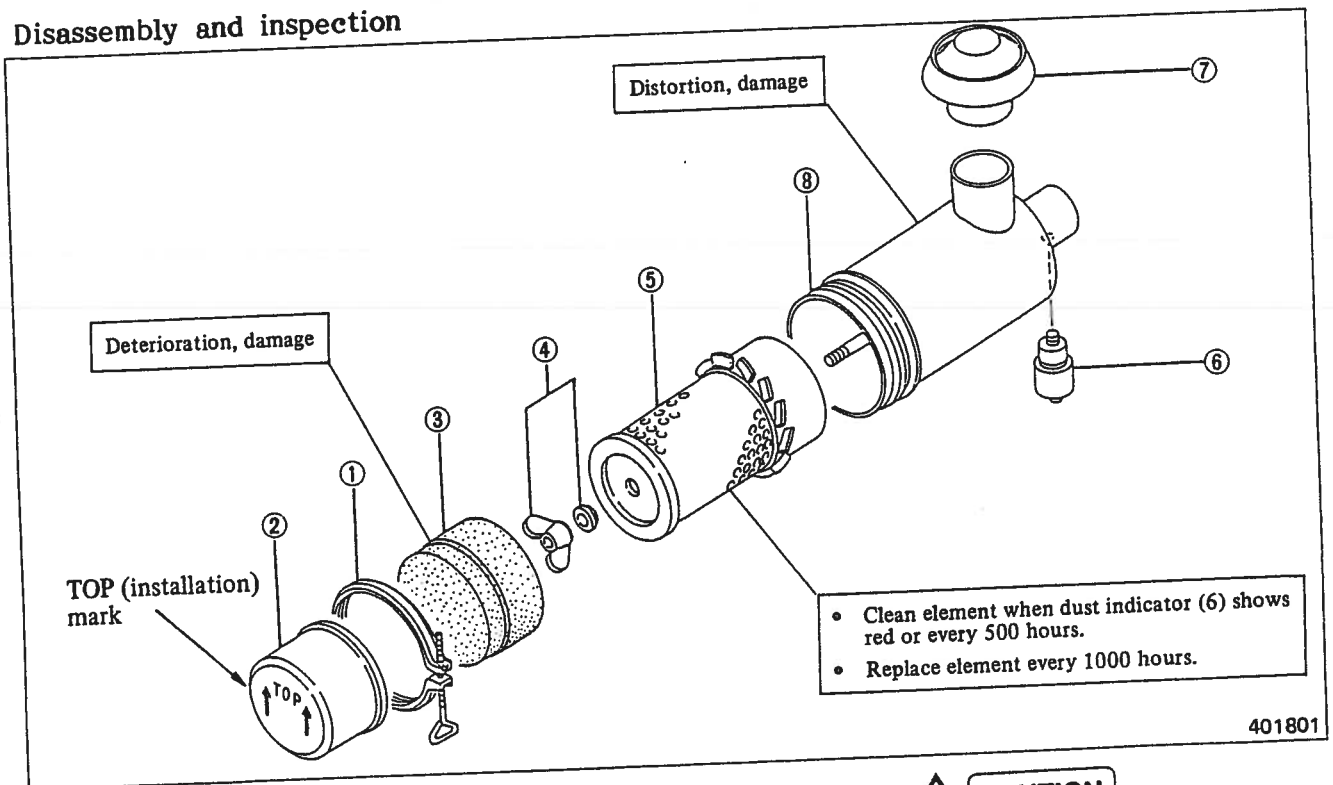
1. DESCRIPTION	114
2. PAPER-ELEMENT TYPE AIR CLEANER	114
Disassembly and inspection	114
3. EXHAUST MANIFOLD	115
Inspection	115

1. DESCRIPTION



2. PAPER-ELEMENT TYPE AIR CLEANER

Disassembly and inspection



- | | |
|--------------------|--------------------|
| ① Clamp | ⑤ Element |
| ② Cap | ⑥ Dust indicator |
| ③ Baffle scarf | ⑦ Cap |
| ④ Wing nut, gasket | ⑧ Air cleaner body |



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.

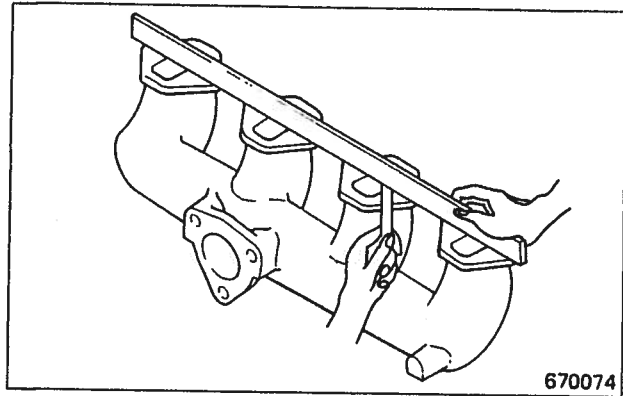
3. EXHAUST MANIFOLD

Inspection

- (a) Inspect flanges for cracks.
- (b) Inspect flanges 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



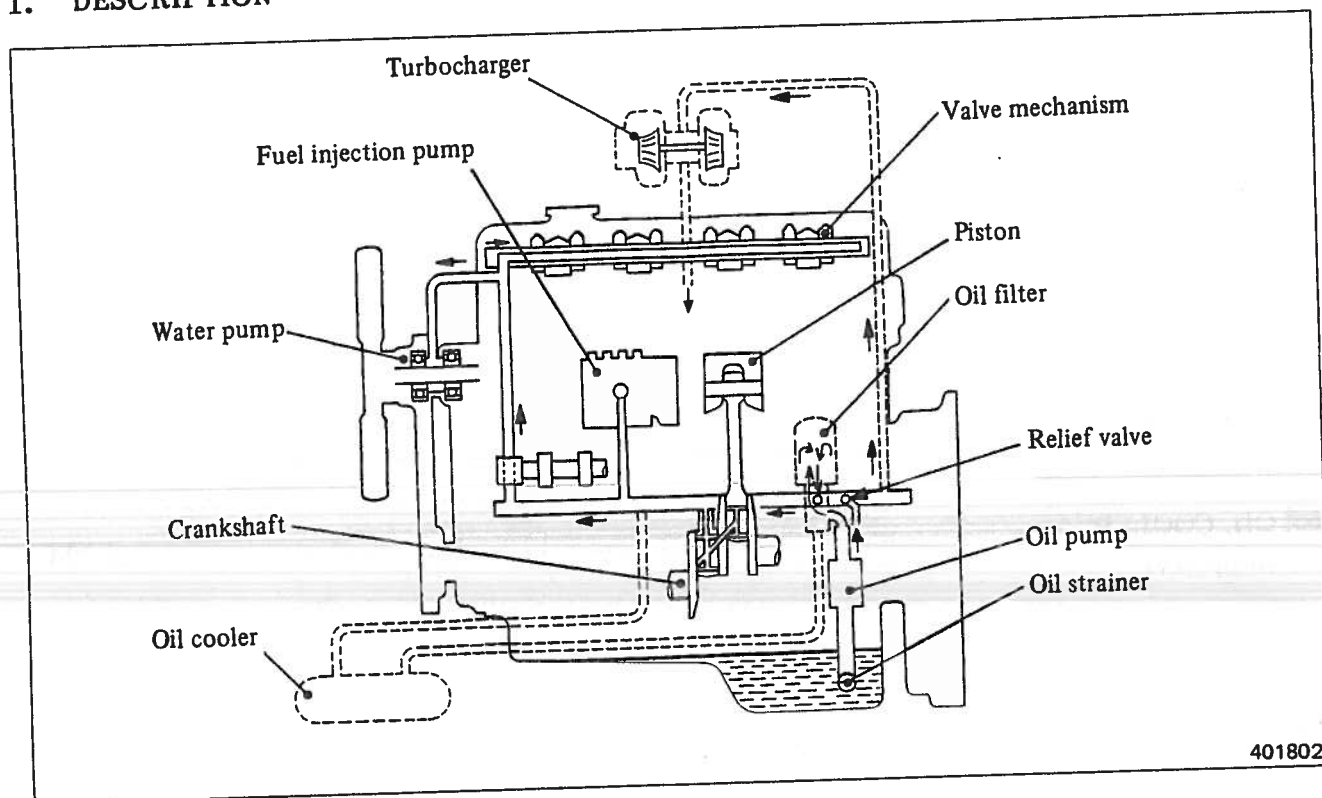
Inspecting exhaust manifold flanges for warpage

LUBRICATION SYSTEM

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Disassembly and inspection	123
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Inspection	123
5. OIL COOLER	124
Inspection	124

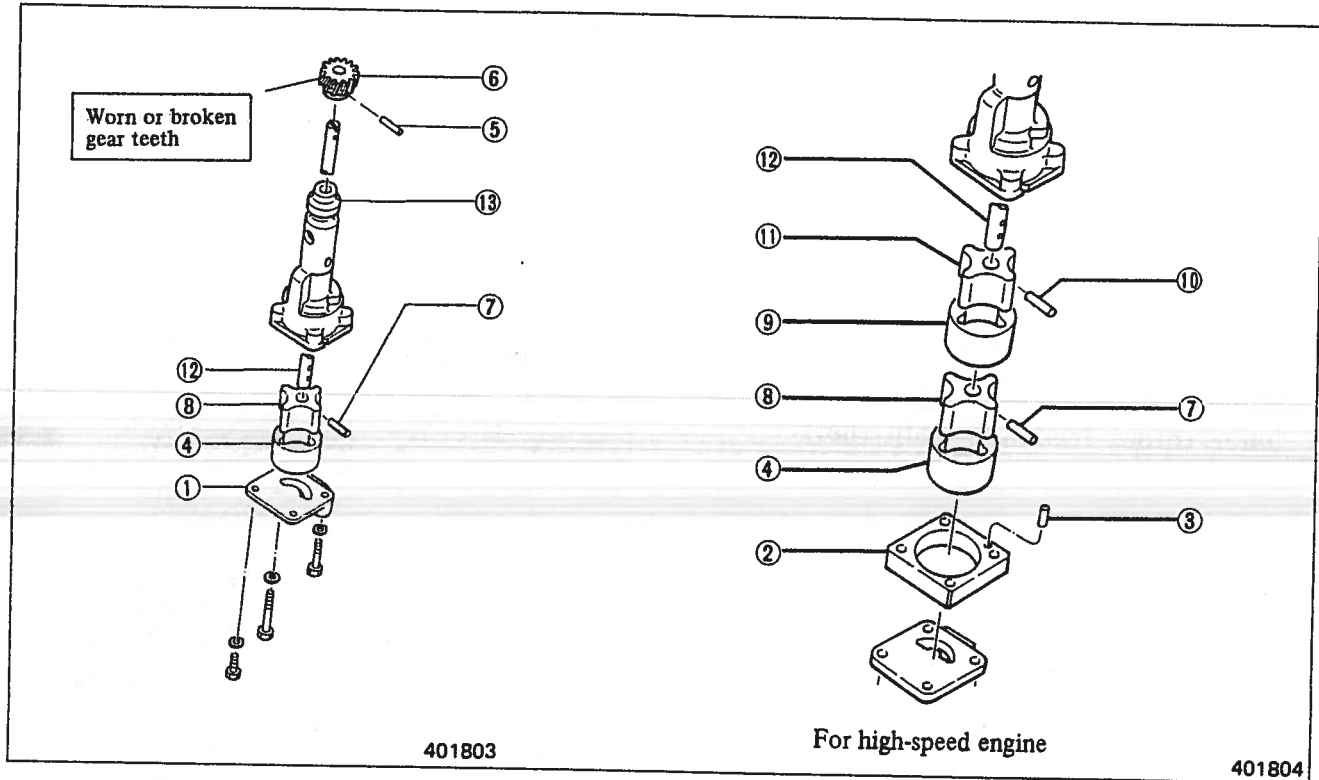
LUBRICATION SYSTEM

1. DESCRIPTION



2. OIL PUMP

2.1 Disassembly



- ① Oil pump case cover
- ② Spacer
- ③ Pin
- ④ Outer rotor
- ⑤ Taper pin

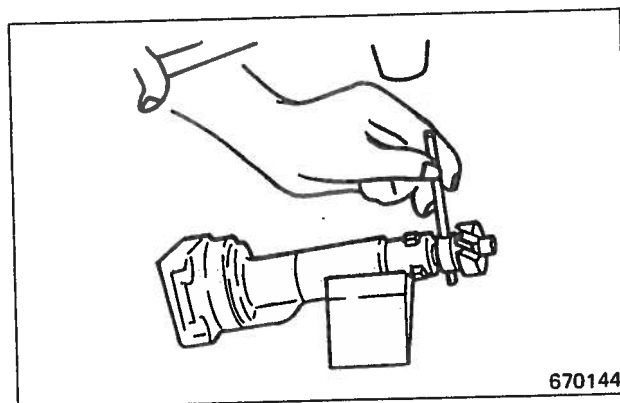
- ⑥ Pump drive gear
- ⑦ Pin
- ⑧ Inner rotor
- ⑨ Outer rotor
- ⑩ Pin

- ⑪ Inner rotor
- ⑫ Main shaft
- ⑬ Oil pump case

LUBRICATION SYSTEM

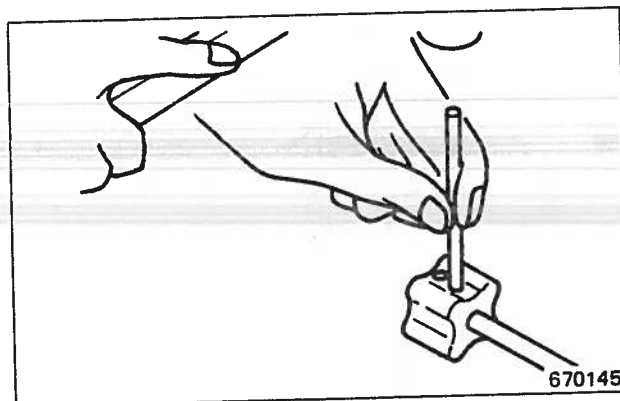
(1) Removing main shaft

Take off the taper pin, and remove the drive gear from the main shaft. Then, pull the main shaft complete with the inner rotors from the pump case.



(2) Removing inner rotors

Take off the pin, and separate the inner rotors from the main shaft.



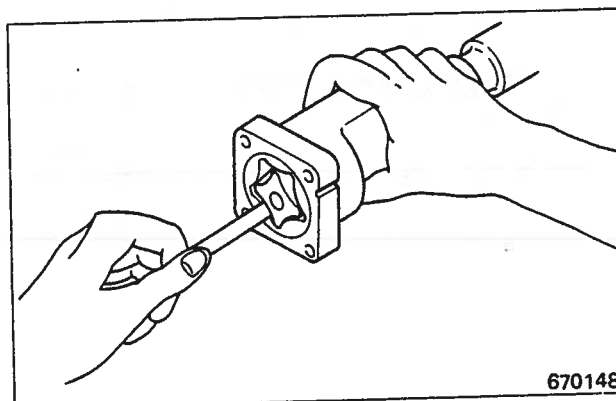
2.2 Inspection and repair

(1) Measuring outer rotor-to-inner rotor clearance

If the clearance exceeds the Service limit, replace the outer and inner rotors as an assembly.

Unit: mm (in.)

Item	Assembly standard	Service limit
Outer rotor-to-inner rotor clearance	0.013 - 0.150 (0.00051 - 0.00591)	0.250 (0.00984)



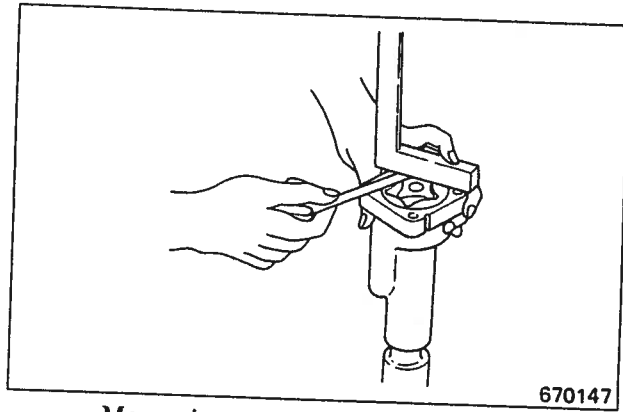
Measuring outer rotor-to-inner rotor clearance

(2) Measuring rotor-to-cover clearance
(end play of rotors)

If the clearance exceeds the Repair limit, replace the rotors or grind the mating faces of the case and cover.

Unit: mm (in.)

Item	Assembly standard	Repair limit
Rotor-to-cover clearance (end play of rotors)	0.04 -0.09 (0.0016 - 0.0035)	0.15 (0.0059)



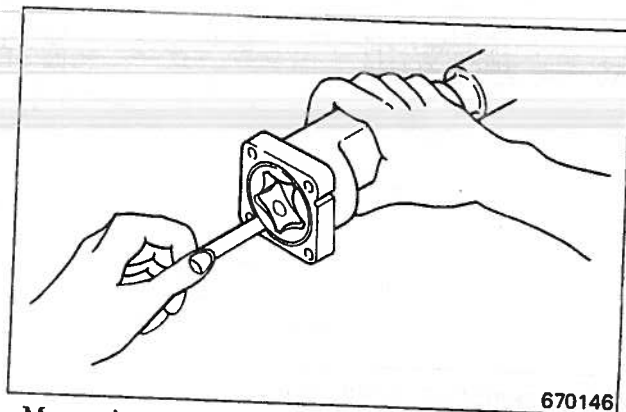
Measuring rotor-to-cover clearance

(3) Measuring outer rotor-to-pump case clearance

If the clearance exceeds the Service limit, replace the rotor or case whichever is badly worn.

Unit: mm (in.)

Item	Assembly standard	Service limit
Outer rotor-to-pump case clearance	0.20 - 0.28 (0.0079 - 0.0110)	0.50 (0.0197)



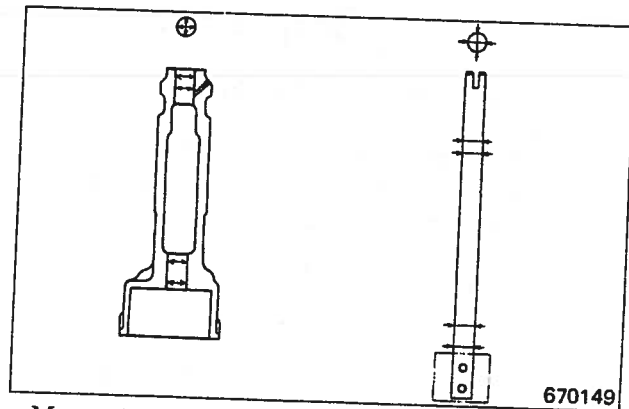
Measuring outer rotor-to-pump case clearance

(4) Measuring main shaft-to-pump case clearance

Measure the diameter of main shaft and the inside diameter of pump case to determine the clearance between the two. If the clearance exceeds the Service limit, replace the main shaft or the pump assembly.

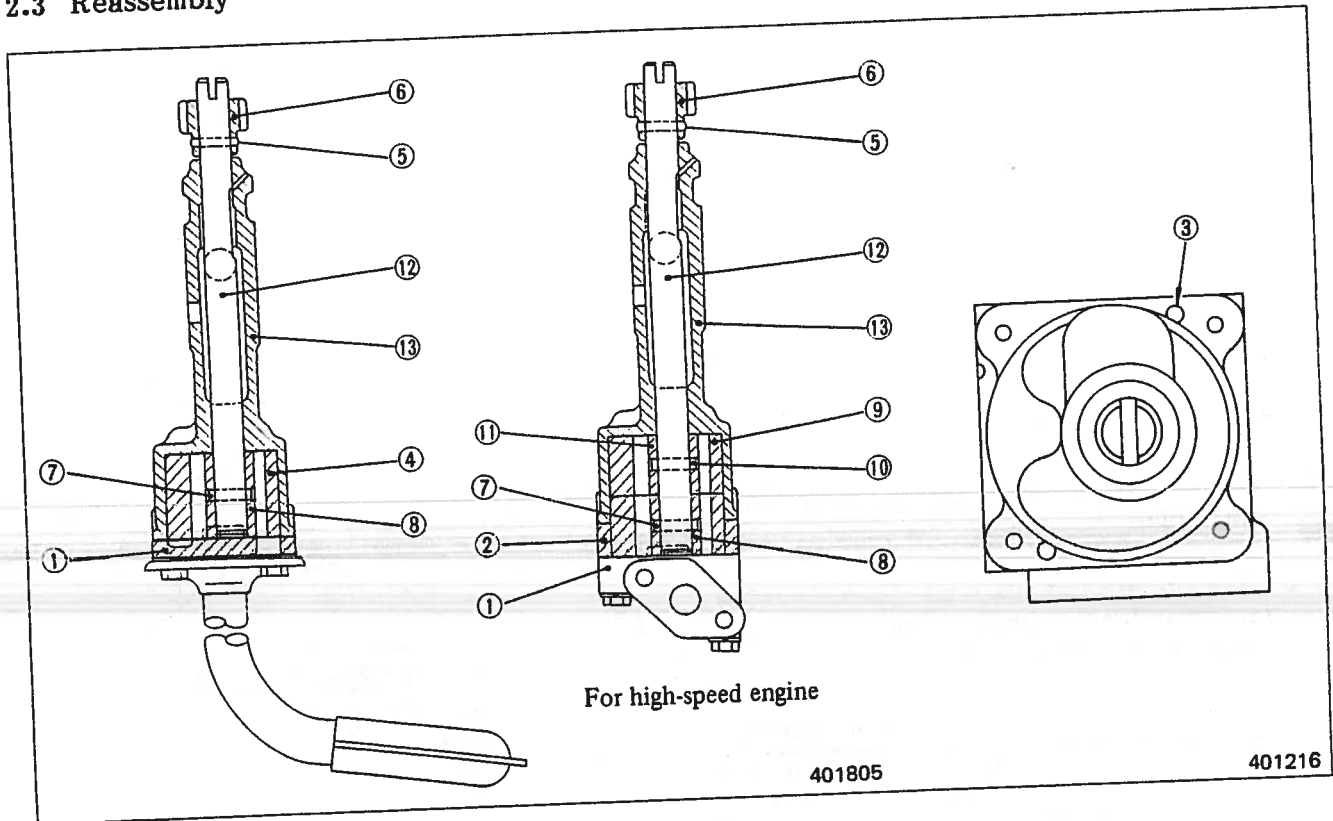
Unit: mm (in.)

Item	Assembly standard	Service limit
Diameter of main shaft	13.000 - 12.985 (0.51181 - 0.51122)	
Main shaft-to-pump case clearance	0.032 - 0.074 (0.00126 - 0.00291)	0.150 (0.00591)



Measuring main shaft-to-pump case clearance

2.3 Reassembly

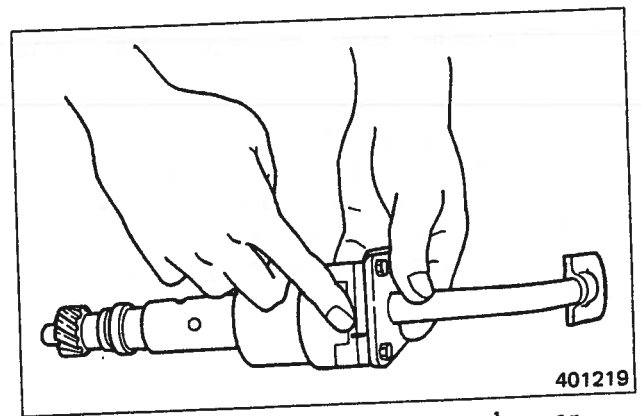


Reassembling sequence

⑫→⑪→⑩→⑧→⑦→⑬→⑨→⑥→⑤→④→③→②→①

NOTE

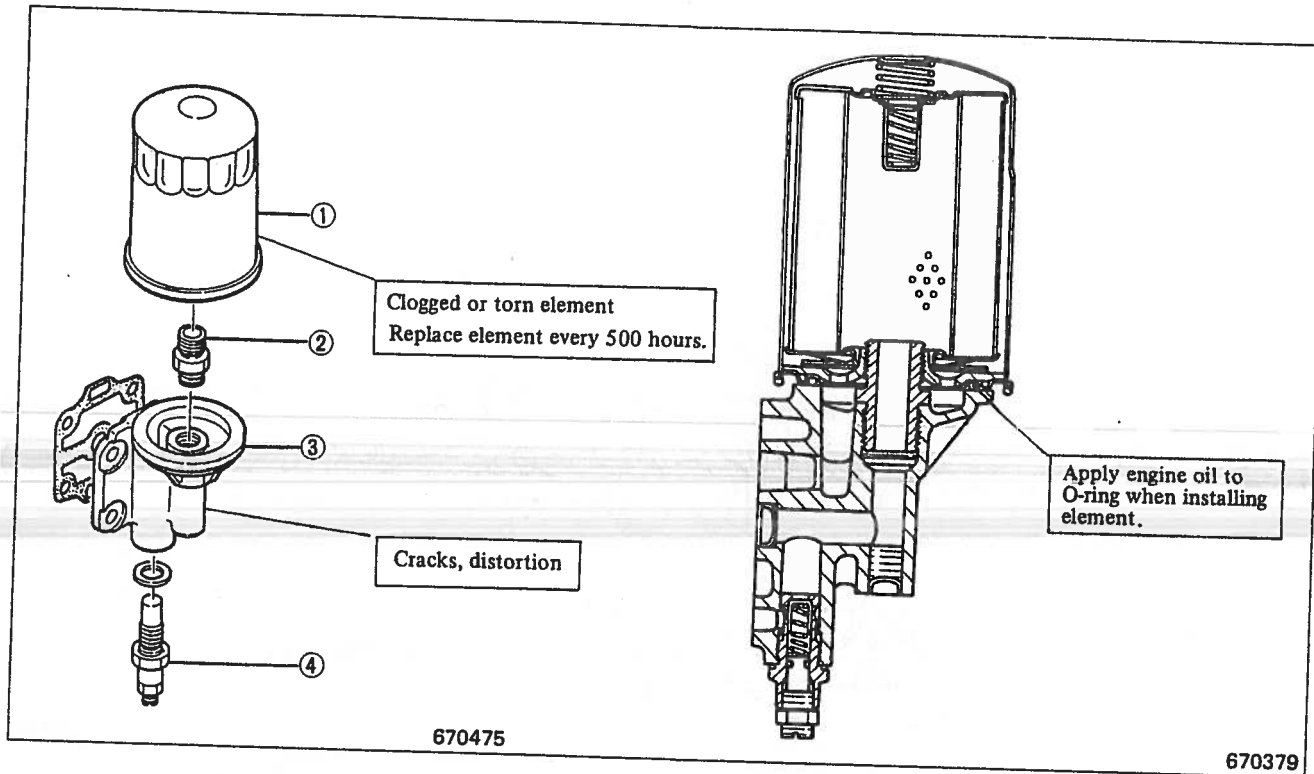
- When using replacement (new) main shaft and drive gear at the time of reassembling the pump, drill dowel pin hole in and through the shaft and gear.
- When tightening the cover bolts, be sure to make sure that the matching marks on the cover and case are aligned. A failure to match the marks will result in malfunction.



Matching marks on pump case and cover

3. OIL FILTER

Disassembly and inspection



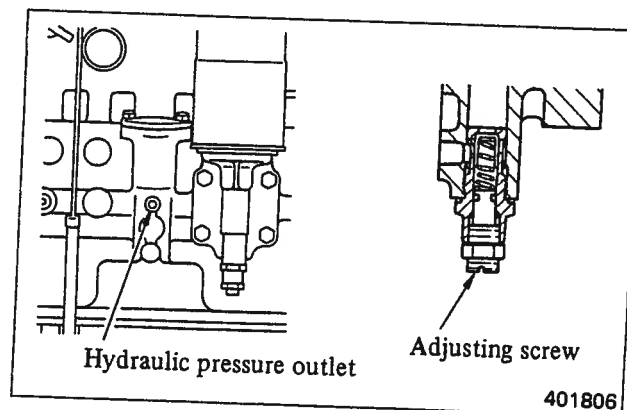
① Filter element
② Center screw

③ Filter case
④ Relief valve

4. 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 tightening or loosening the adjusting screw (varying the setting of the spring).



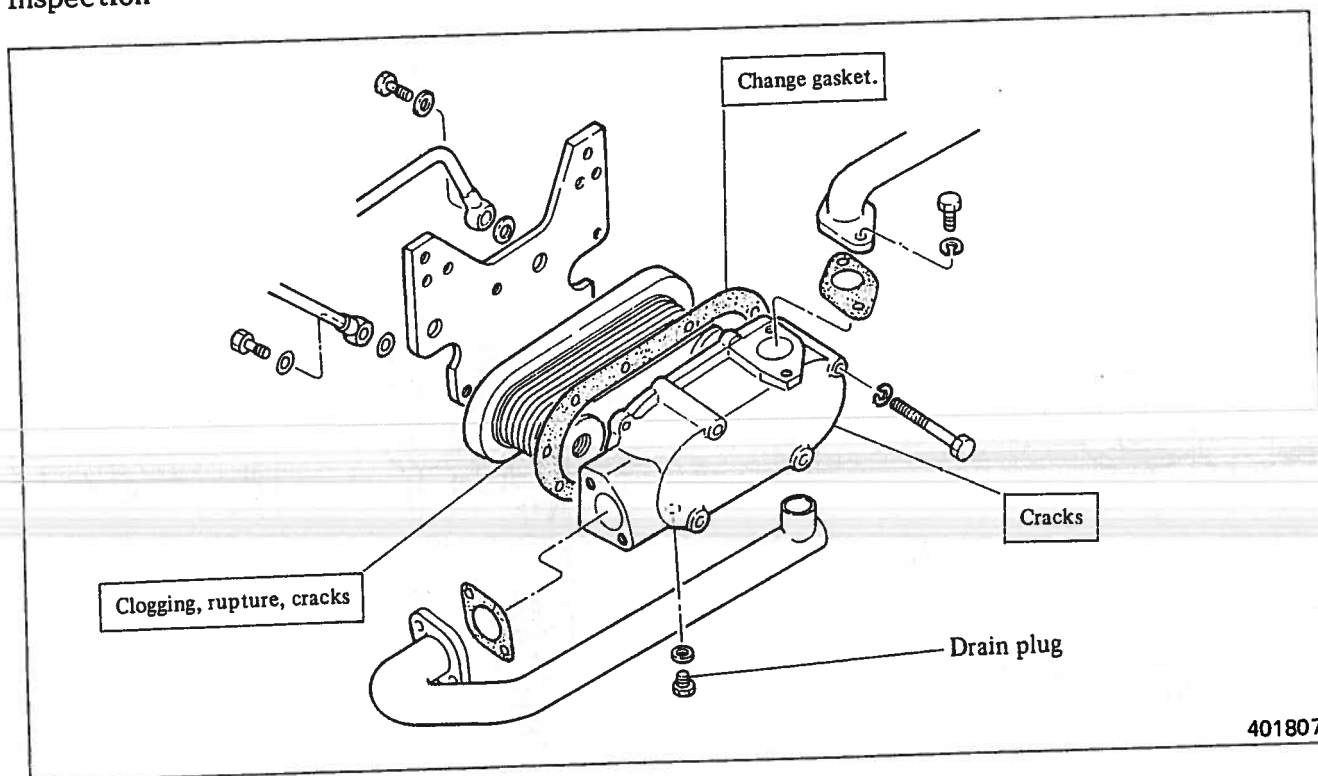
Unit: kgf/cm² (psi) [MPa]

Item	Assembly standard
Relief valve opening pressure	3 ± 0.2 (42.7 ± 2.8) $[0.3 \pm 0.02]$

LUBRICATION SYSTEM

5. OIL COOLER

Inspection

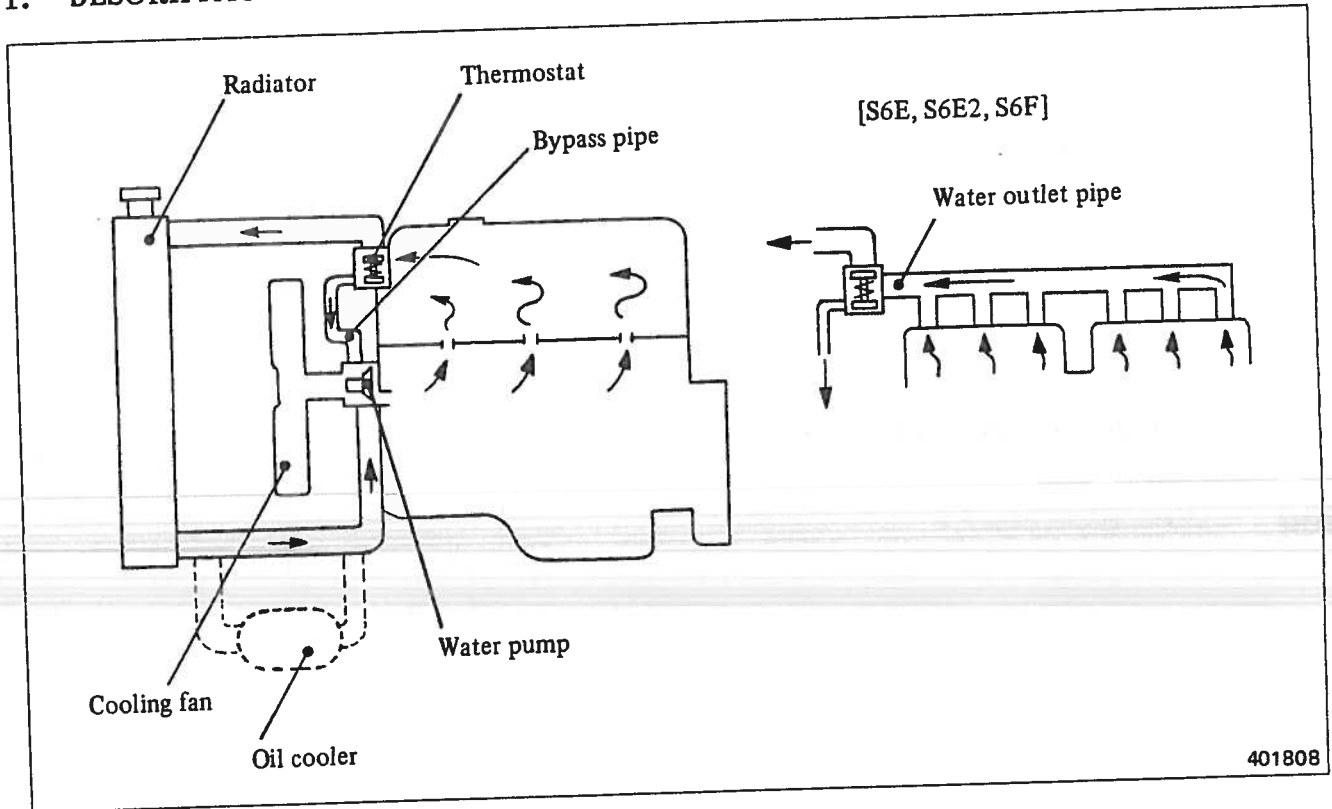


COOLING SYSTEM

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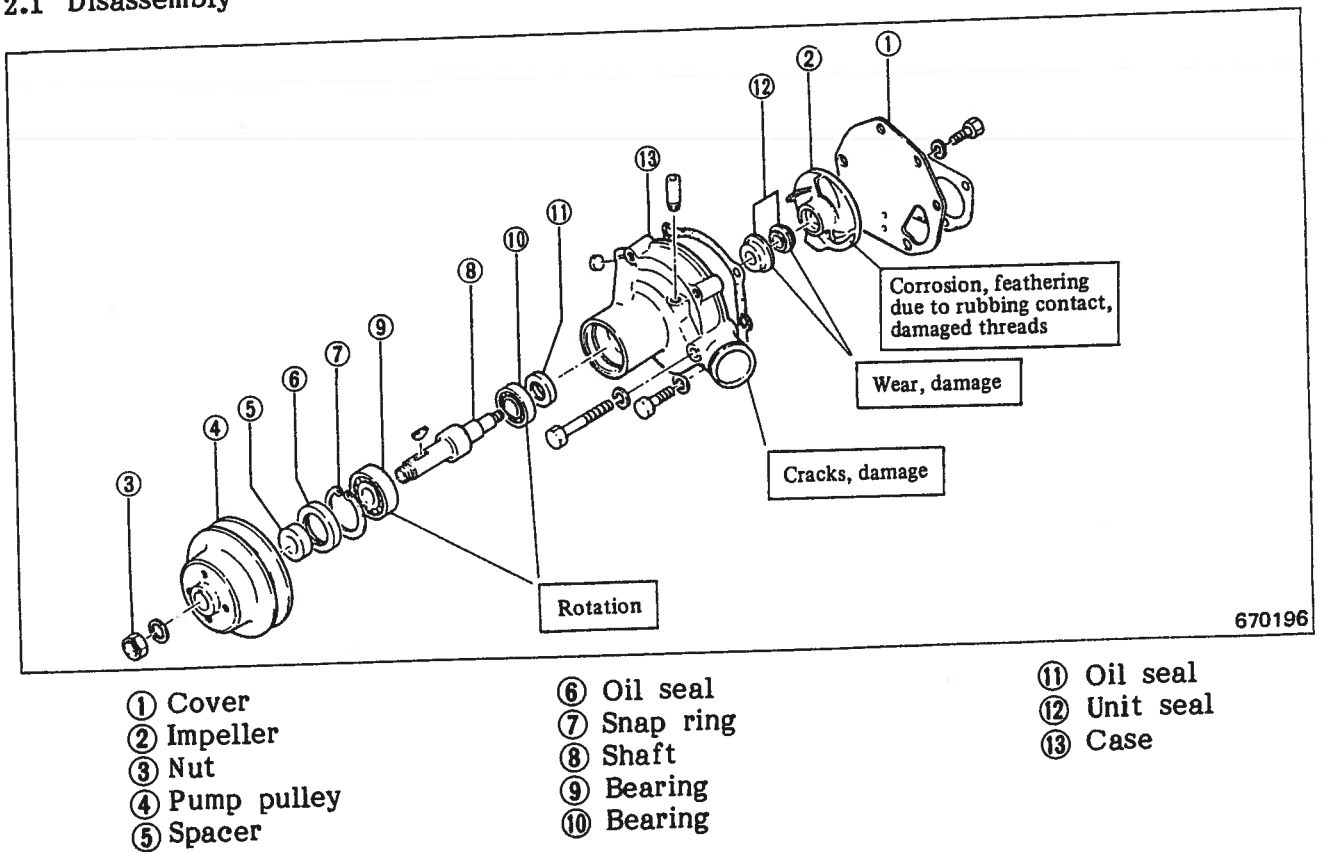
COOLING SYSTEM

1. DESCRIPTION



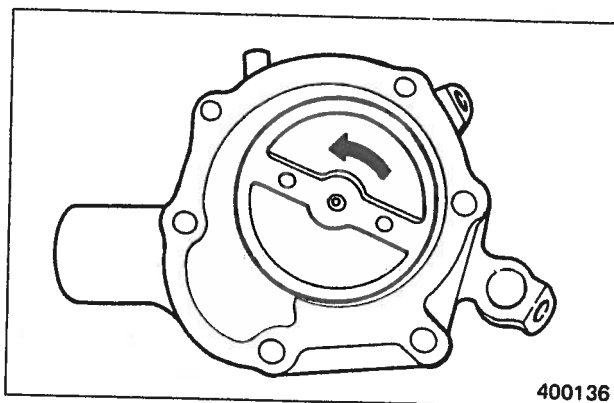
2. WATER PUMP

2.1 Disassembly

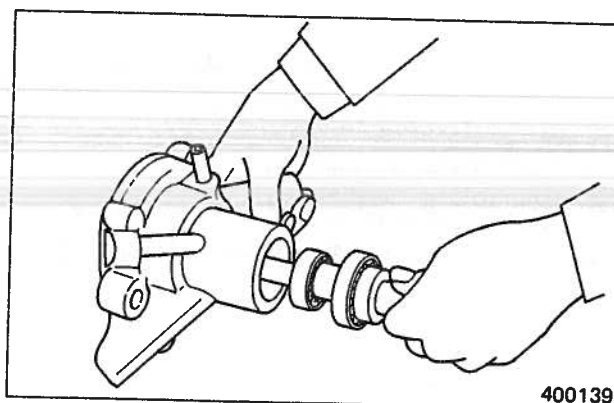


(1) Removing impeller

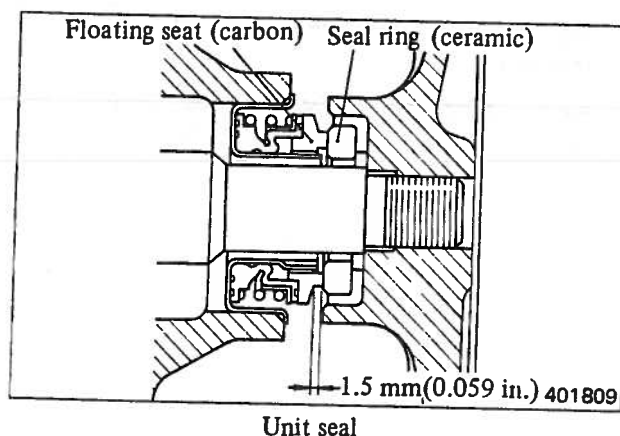
The impeller is right hand-threaded. To remove the impeller, turn it counterclockwise (in the direction of arrow).

**(2) Removing shaft**

Remove the oil seal and snap ring, and pull out the shaft complete with bearings to the pulley side.

**2.2 Inspection**

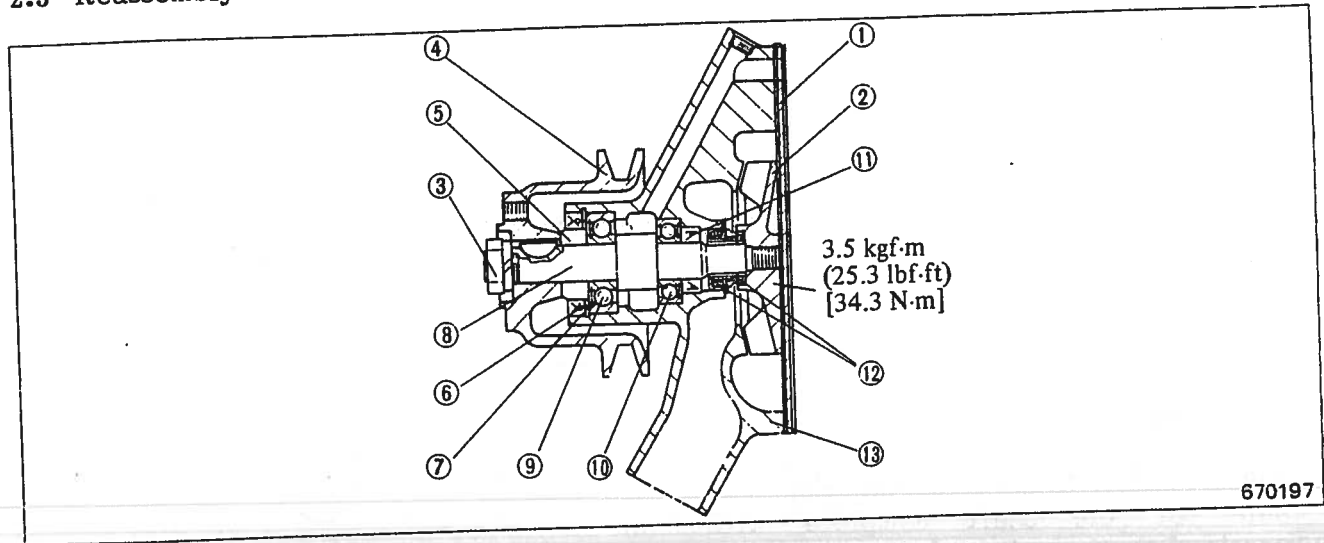
- (a) Inspect the pump operation by slowly rotating it. If it is erratic in rotation, replace the bearings.
- (b) Visually inspect the impeller for corrosion or broken blade. Replace the impeller if defective. Also check the impeller for sign of rubbing contact with the pump case and rear cover. If such a contact is evident, replace the impeller and bearings.
- (c) Inspect 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)	

2.3 Reassembly



Reassembling sequence

⑬→⑫→⑪→⑩→⑨→⑧→⑦→⑥→⑤→④→③→②→①

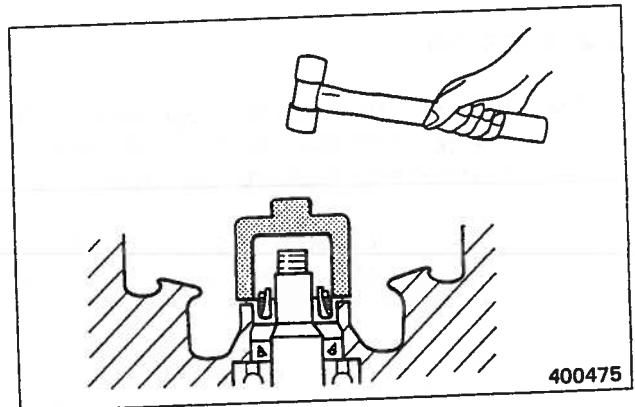
NOTE

After reassembling the pump, operate it by means of the pulley and belt, making sure that it runs smoothly without any sign of rubbing contact with the pump case or cover.

(1) Installing unit seal

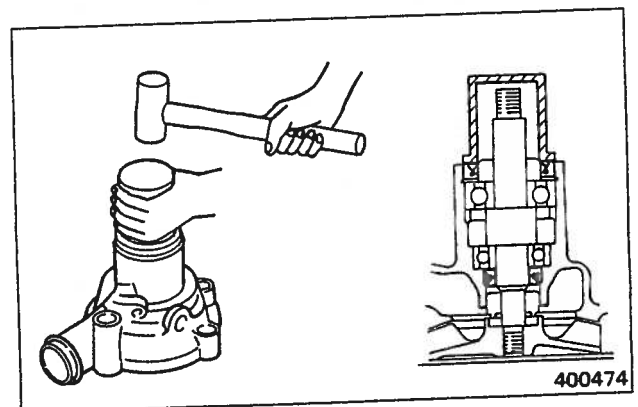
To install the seal, use a unit seal installer.

Do not reuse a unit seal which has been removed from the pump case.



(2) Installing oil seal

To install the seal, use an oil seal installer.



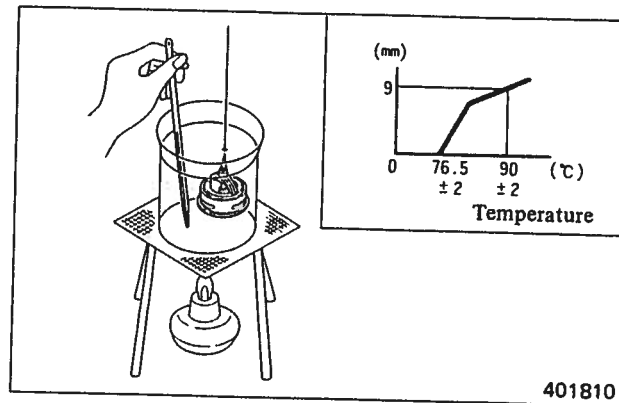
3. THERMOSTAT

Inspection

Immerse the thermostat in a water bath, and test it for thermostatic action by heating the bath to raise the water temperature. If the valve fails to operate properly, replace the thermostat.

Unit: mm (in.)

Item	Assembly standard
Temperature at which valve starts opening	$76.5 \pm 2^{\circ}\text{C}$ ($169.7 \pm 3.6^{\circ}\text{F}$)
Temperature at which valve opens fully	$90 \pm 2^{\circ}\text{C}$ ($194 \pm 3.6^{\circ}\text{F}$)
Valve stroke	9 (0.35)

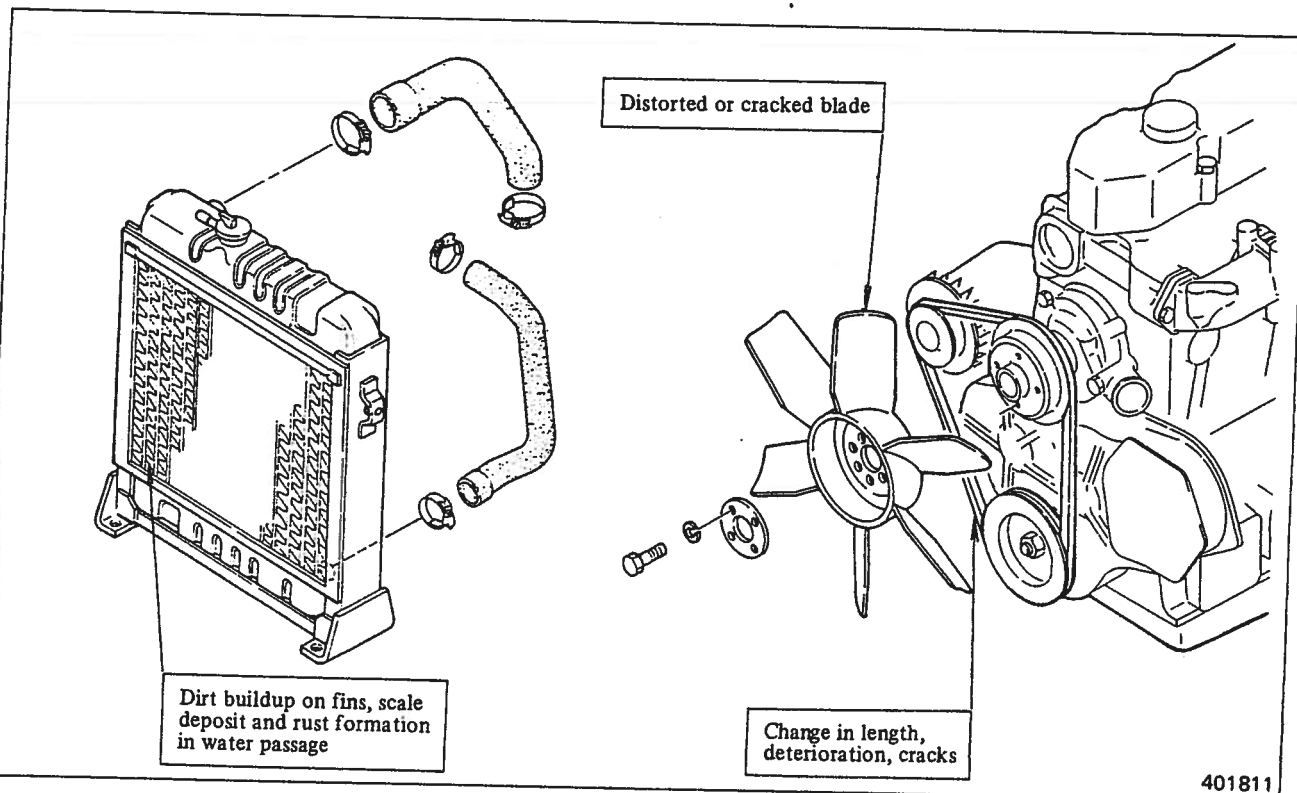


NOTE

Stir the water in the bath with a stick to maintain its temperature uniform during test.

4. RADIATOR, FAN AND FAN BELT

Inspection

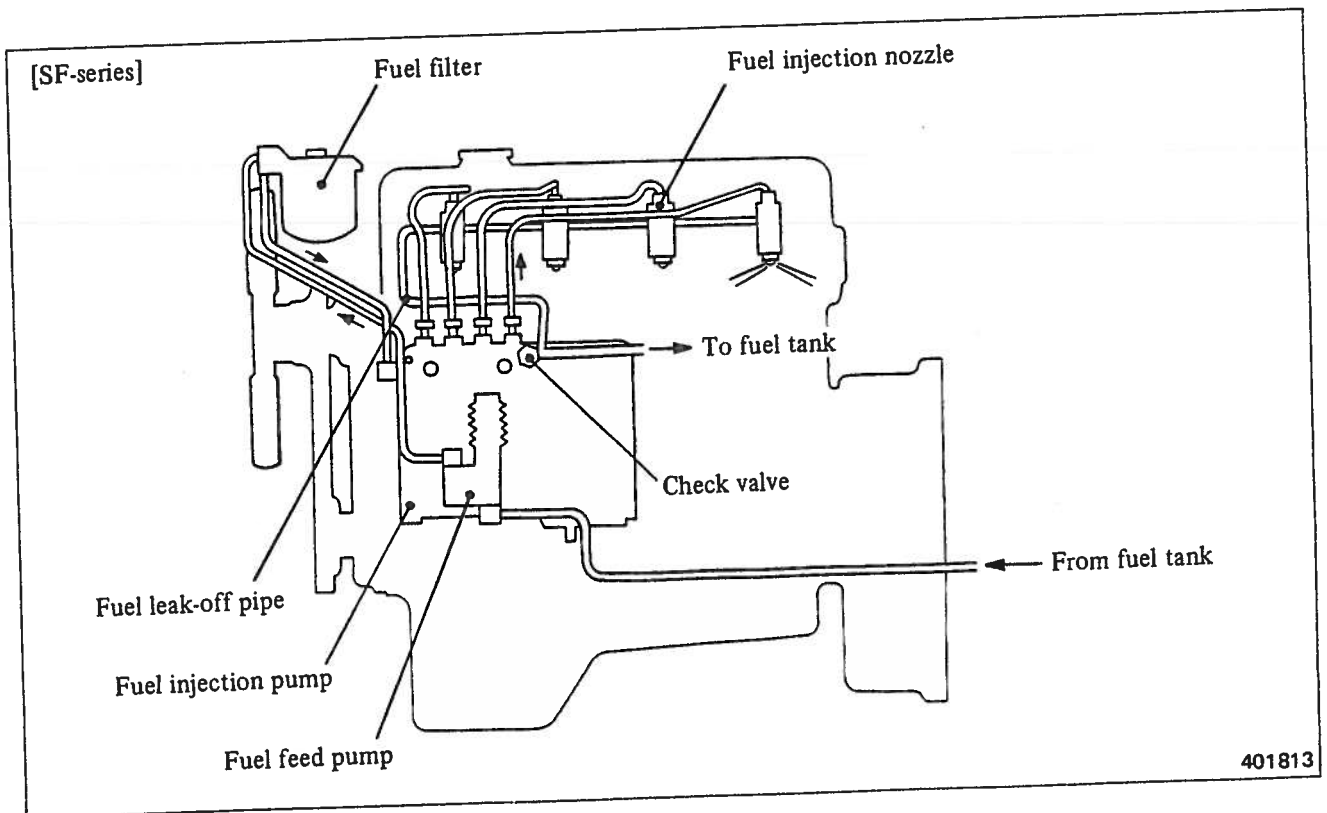
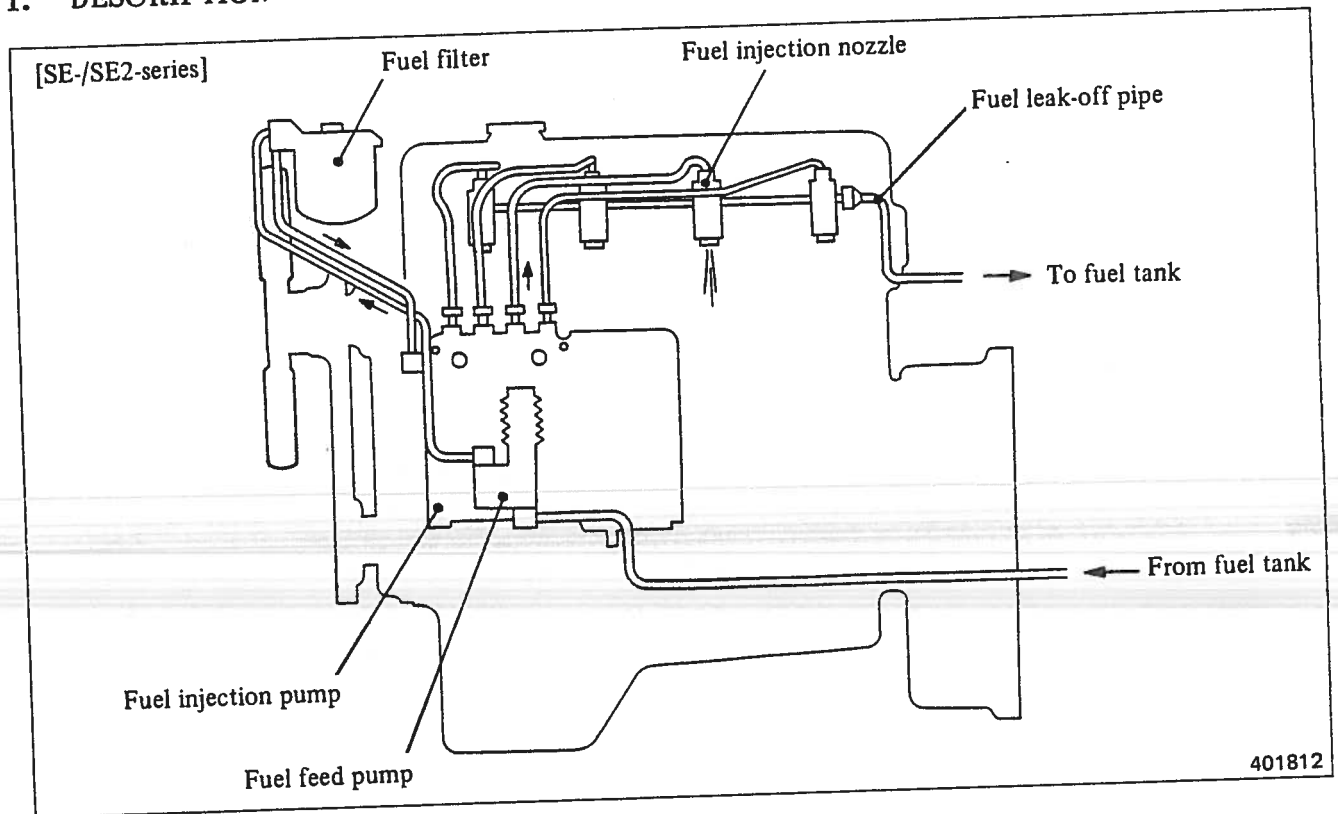


FUEL SYSTEM

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FUEL SYSTEM

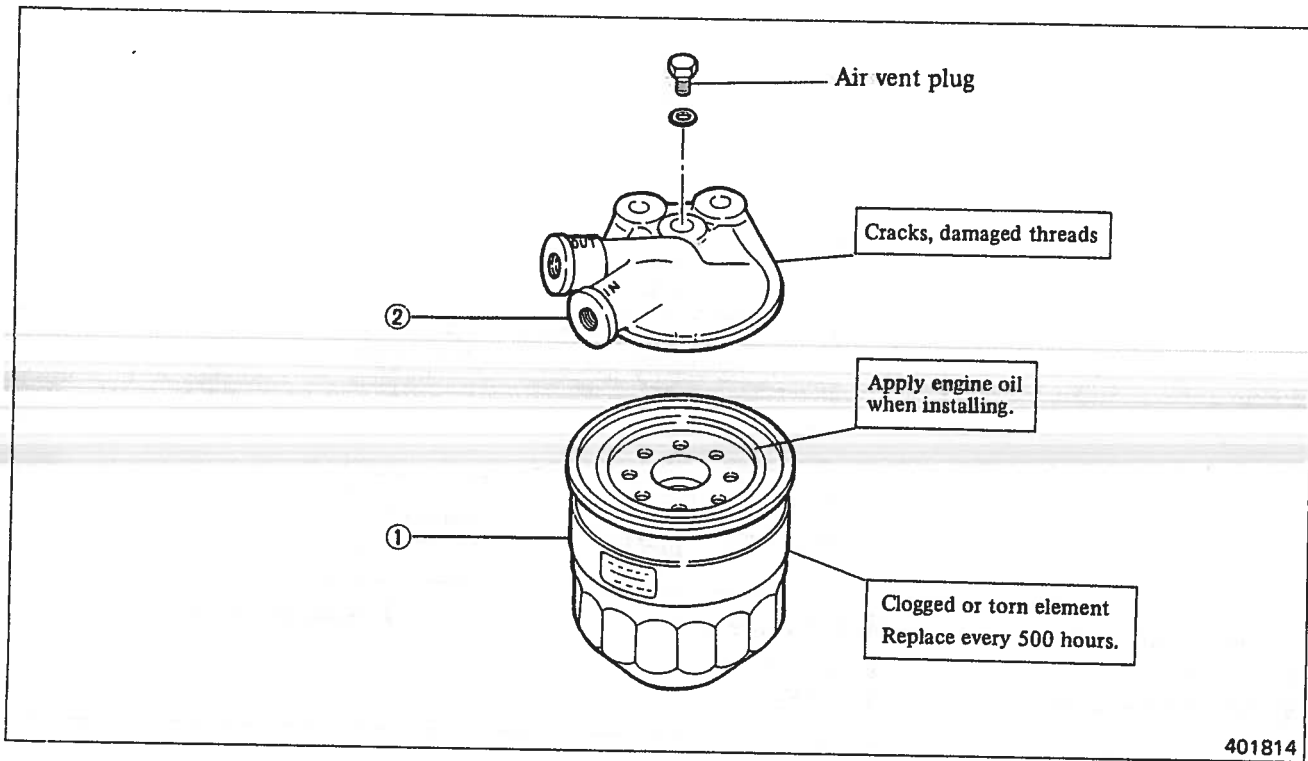
1. DESCRIPTION



2. FUEL FILTER

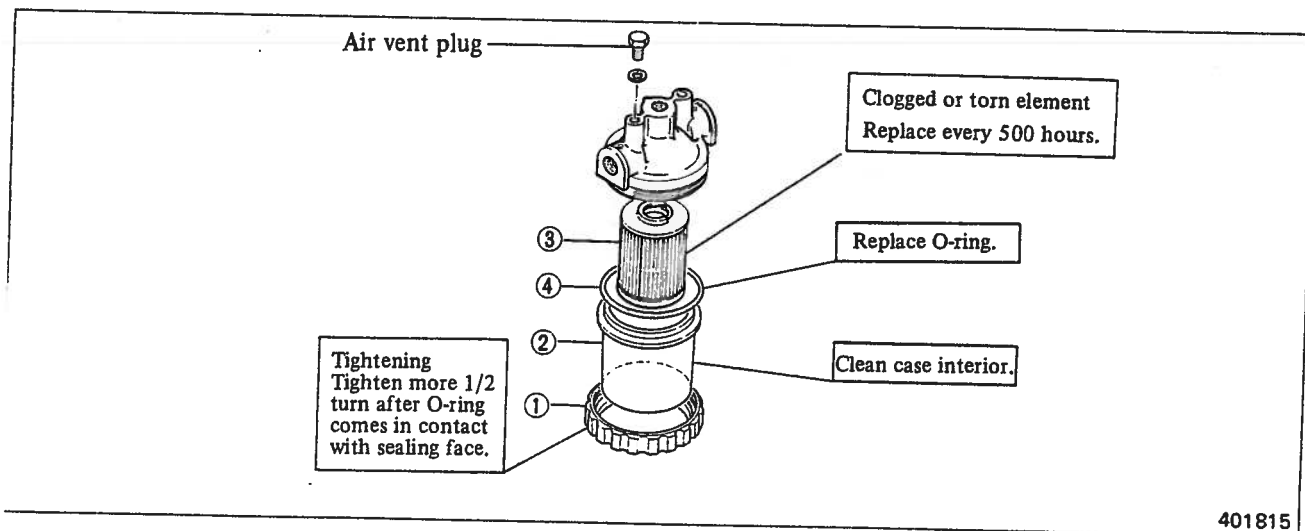
Inspection

Cartridge type paper-element filter



- ① Element assembly ② Bracket

Paper-element filter



401815

- ① Ring ③ Element
② Filtercase ④ O-ring

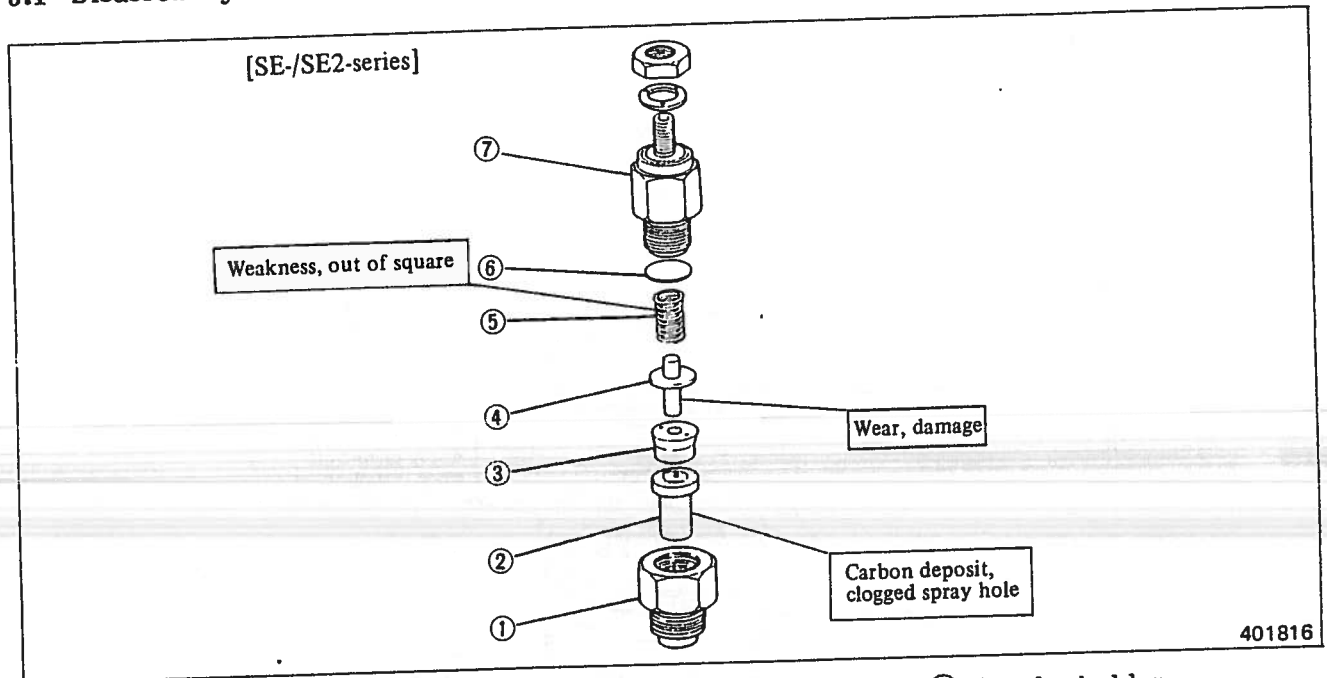


CAUTION

Do not reuse a dirty element by washing.

3. FUEL INJECTION NOZZLES

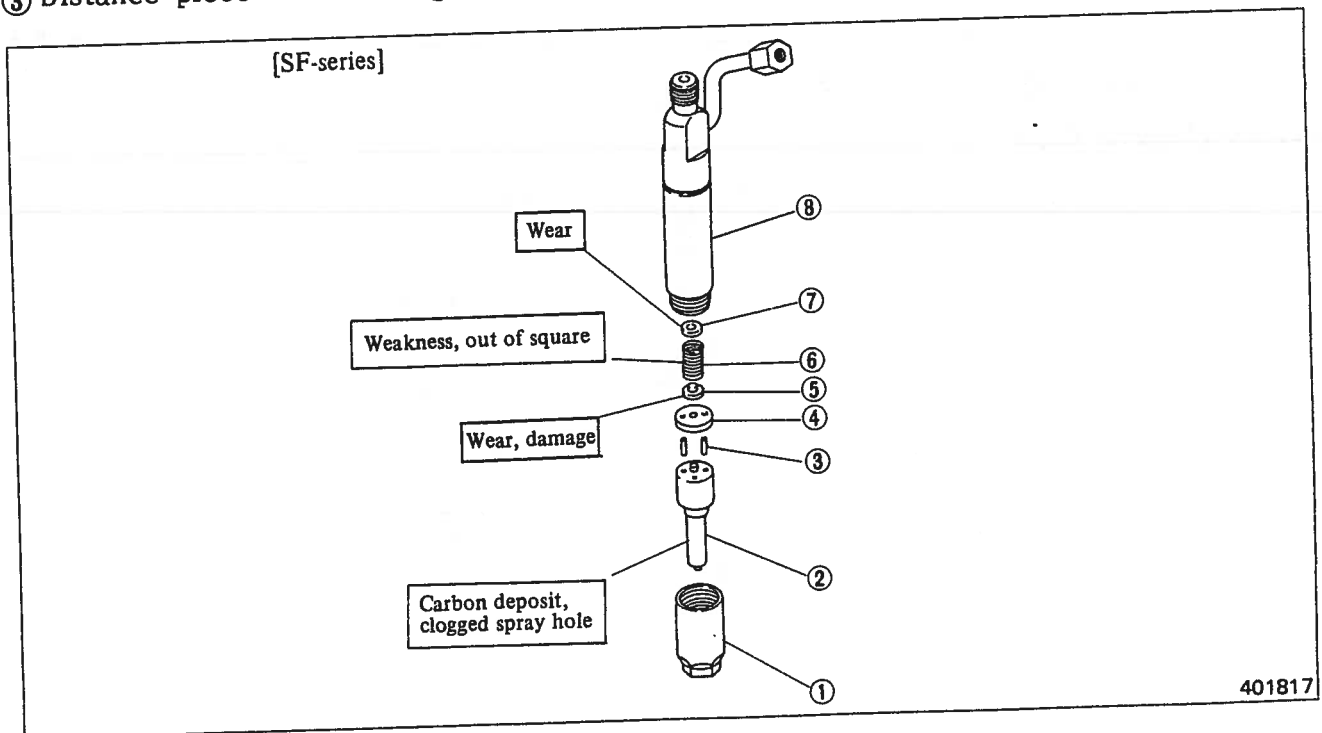
3.1 Disassembly



- ① Retaining nut
- ② Nozzle tip
- ③ Distance piece

- ④ Pressure pin
- ⑤ Spring
- ⑥ Washer

- ⑦ Nozzle holder



- ① Retaining nut
- ② Nozzle tip
- ③ Straight pin

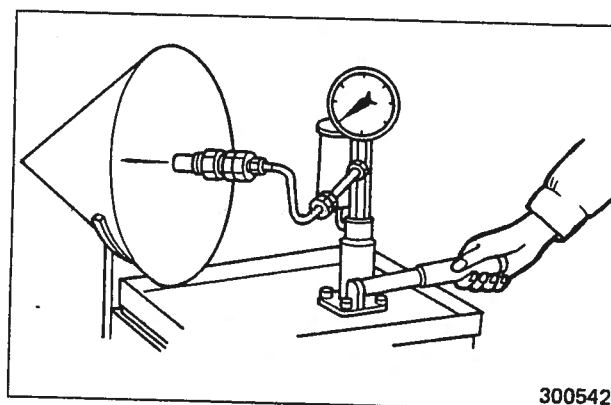
- ④ Tip packing
- ⑤ Pressure pin
- ⑥ Pressure spring

- ⑦ Washer
- ⑧ Nozzle body

3.2 Inspection and repair

(1) Injection pressure

- (a) Set up the nozzle on the tester. Operate the tester handle several times to prime the pipe and nozzle.
- (b) Slowly operate the handle all the way up and down, completing each cycle in about a second, while observing the pressure gauge indication.
- (c) As the nozzle begins to spray fuel, the needle of the gauge being deflected will start oscillating. Read the pressure right then as the injection pressure.



Testing injection nozzle

Unit: kgf/cm² (psi) [MPa]

Item		Assembly standard
Injection pressure (valve opening pressure)	SE SE2	120 (1706) [11.8]
	SF	220 or 180 (3128 or 2560) [21.6 or 17.7]



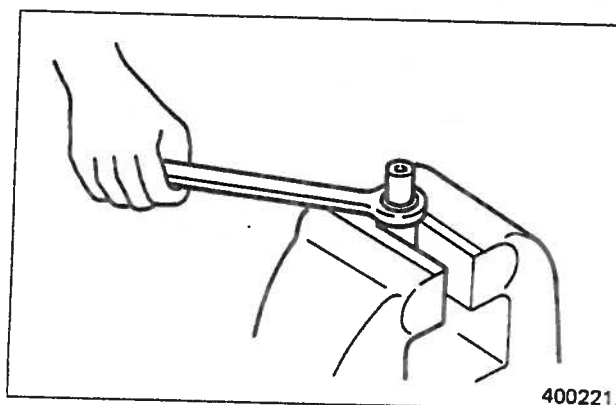
WARNING

Never expose the hand or other part of the body to fuel spray nor to touch the spray hole during the test.

- (d) If the pressure is out of specification, make a shim adjustment.

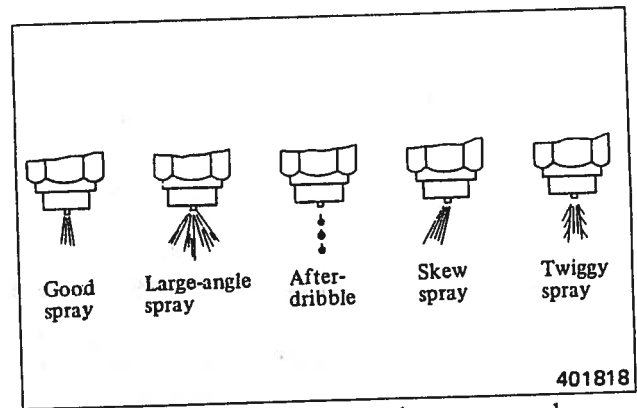
NOTE

Increasing or decreasing shim thickness by 0.1 mm (0.004 in.) raise or drops injection pressure by about 10 kgf/cm² (142 psi) [0.98 MPa]. Shims for this adjustment are available in 20 sizes, from 1.0 mm (0.039 in.) up to 1.95 mm (0.0768 in.) in an increment of 0.05 mm (0.0020 in.)

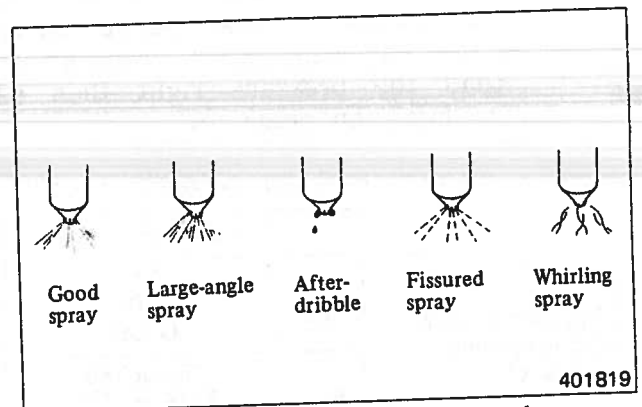


(2) Spray pattern

- (a) At the time of testing the injection pressure, inspect each nozzle for clogged spray hole and fuel leaks from the hole. Also examine spray pattern.
- (b) To test the nozzles for SE- and SE2-series, move the tester handle at a rate of about 1 stroke per second to make sure that it sprays fuel in good straight pattern.
- (c) The nozzle for SF-series should spray fuel from its four orifices at the same time in a good straight cone of 155°, consisting of finely atomized fuel particles.



Spray patterns of throttle type nozzle
[SE-/SE2-series]



Spray patterns of hole type nozzle
[SF-series]

(3) Washing or replacing nozzle tip

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



CAUTION

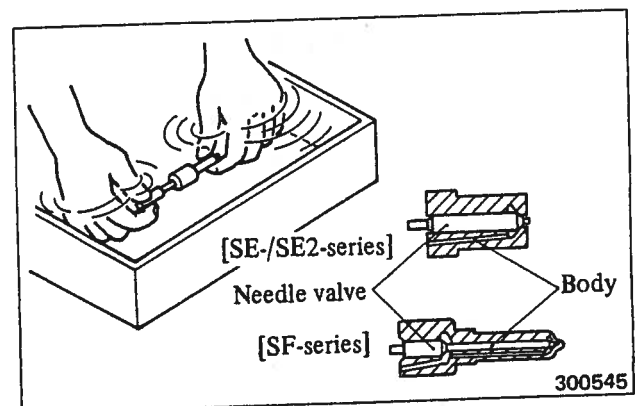
When pulling out the nozzle tip, be careful not to damage it.

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



CAUTION

The needle valve and body are finely finished. Do not change the combination or set of the valve and body.



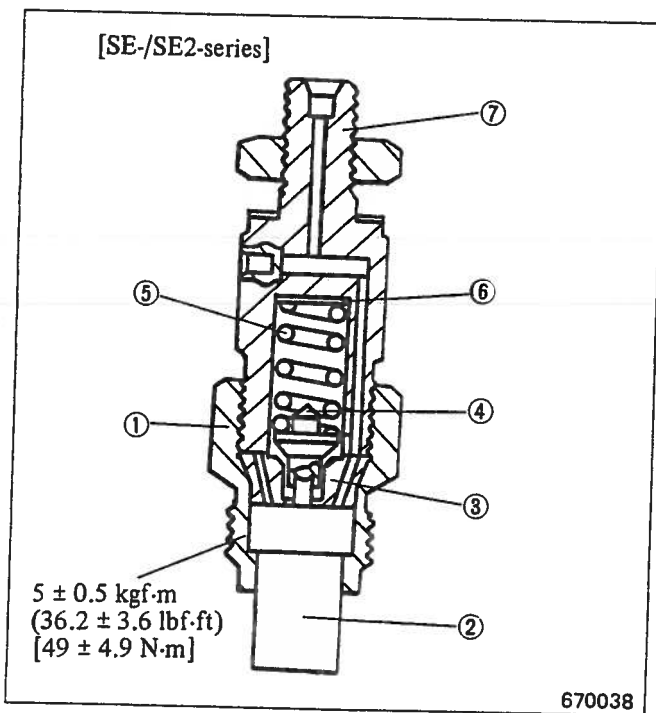
- (c) Tighten the retaining nut to the specified torque.
- (d) If the spray pattern is still bad after the nozzle has been adjusted and cleaned, replace the nozzle tip.

**CAUTION**

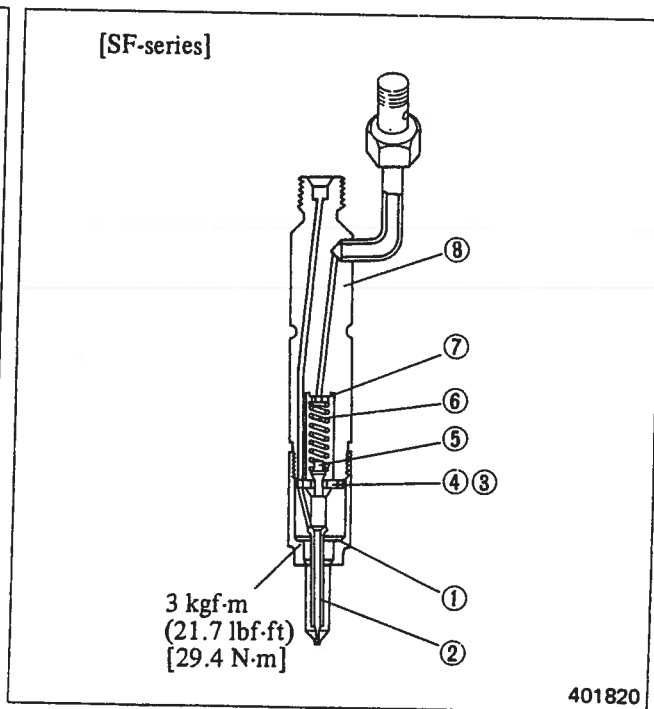
Never attempt to touch the sliding surface of needle valve.

NOTE

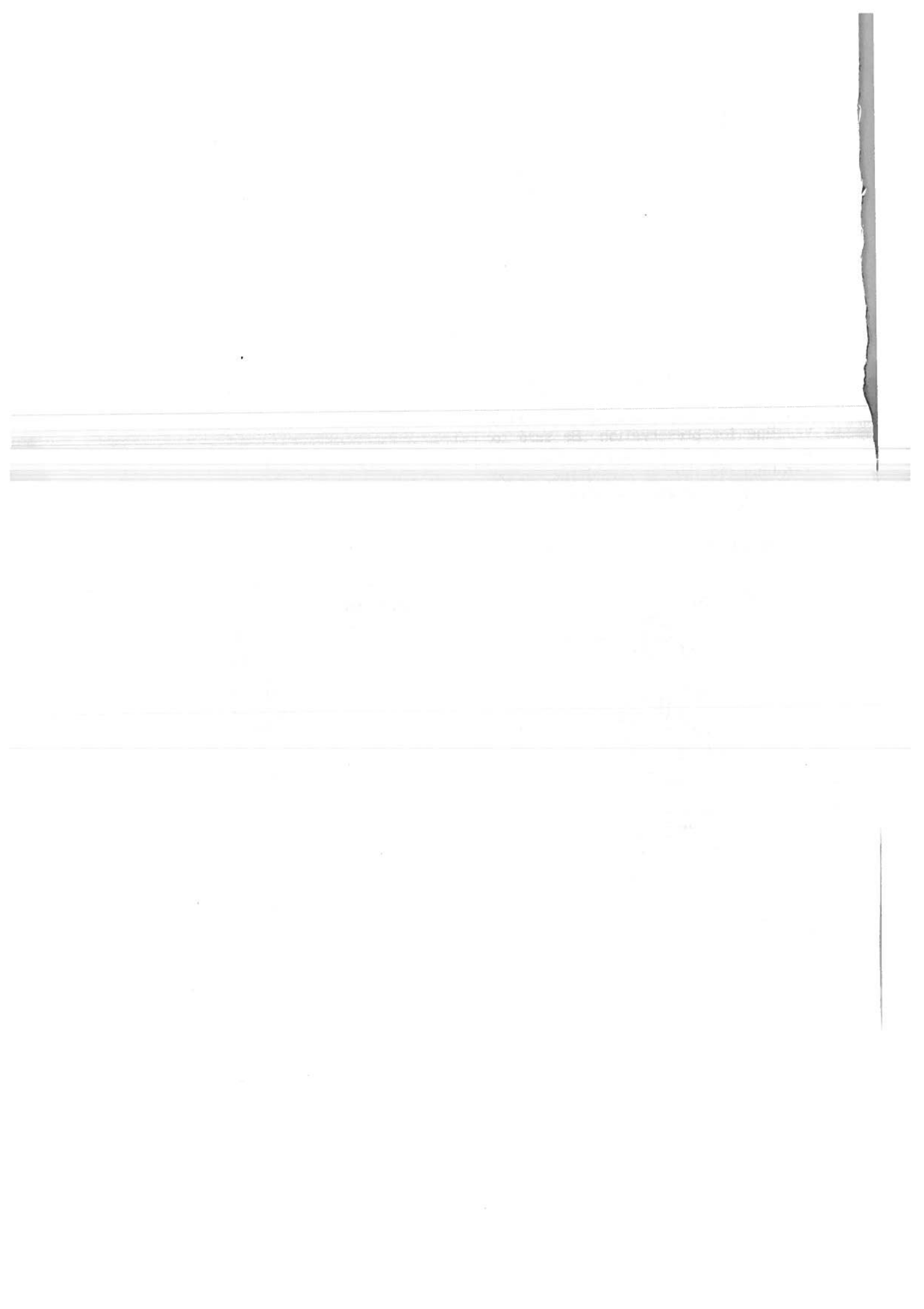
New nozzle tips are coated with vaseline for preservation. Be sure to wash them two times, first in gasoline and then in diesel fuel to be used, before assembling them.

3.3 Reassembly**Reassembling sequence**

⑦→⑥→⑤→④→③→②→①

**Reassembling sequence**

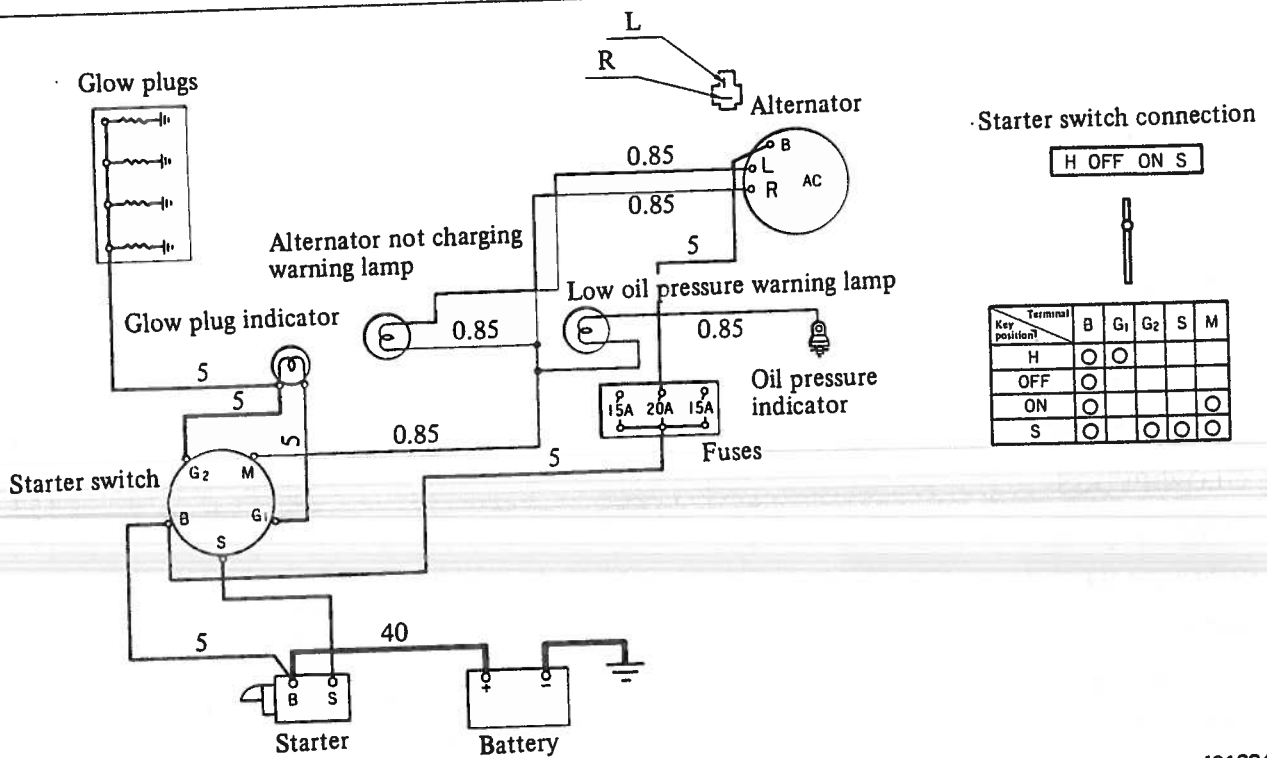
⑧→⑦→⑥→⑤→④→③→②→①



ELECTRICAL SYSTEM

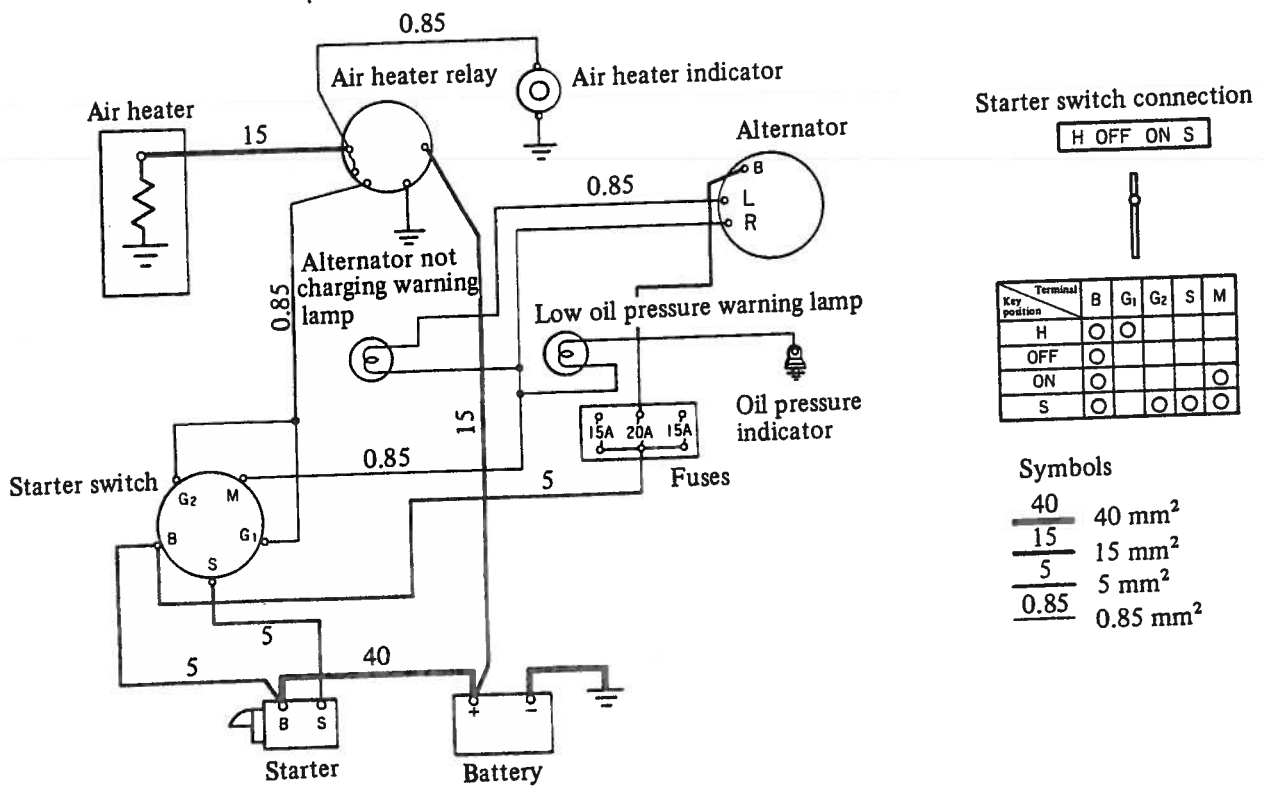
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5. HEATER RELAY	153
Inspection	153
6. AIR HEATER	153
Inspection	153

1. DESCRIPTION



401824

Wiring diagram [SE-/SE2-series]



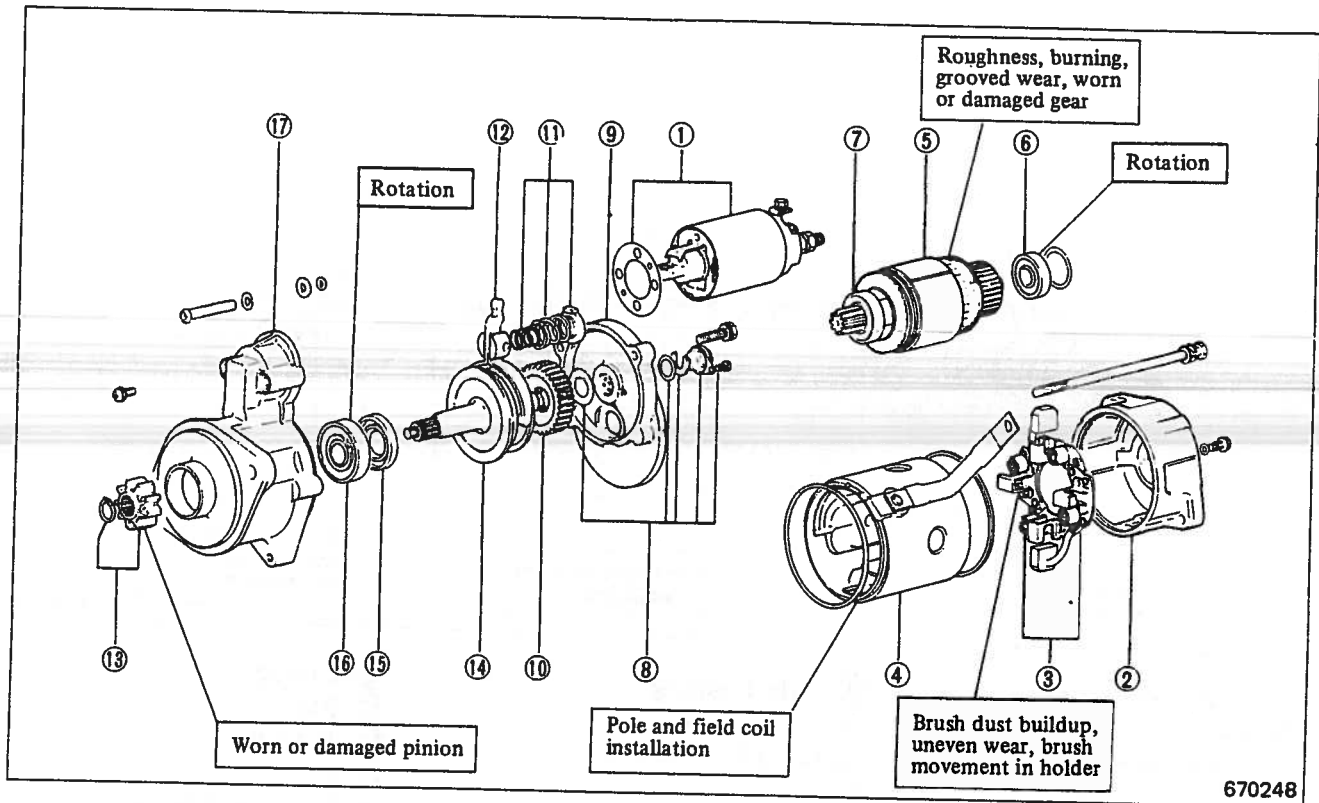
401825

Wiring diagram [SF-series]

2. STARTER

2.1 Disassembly

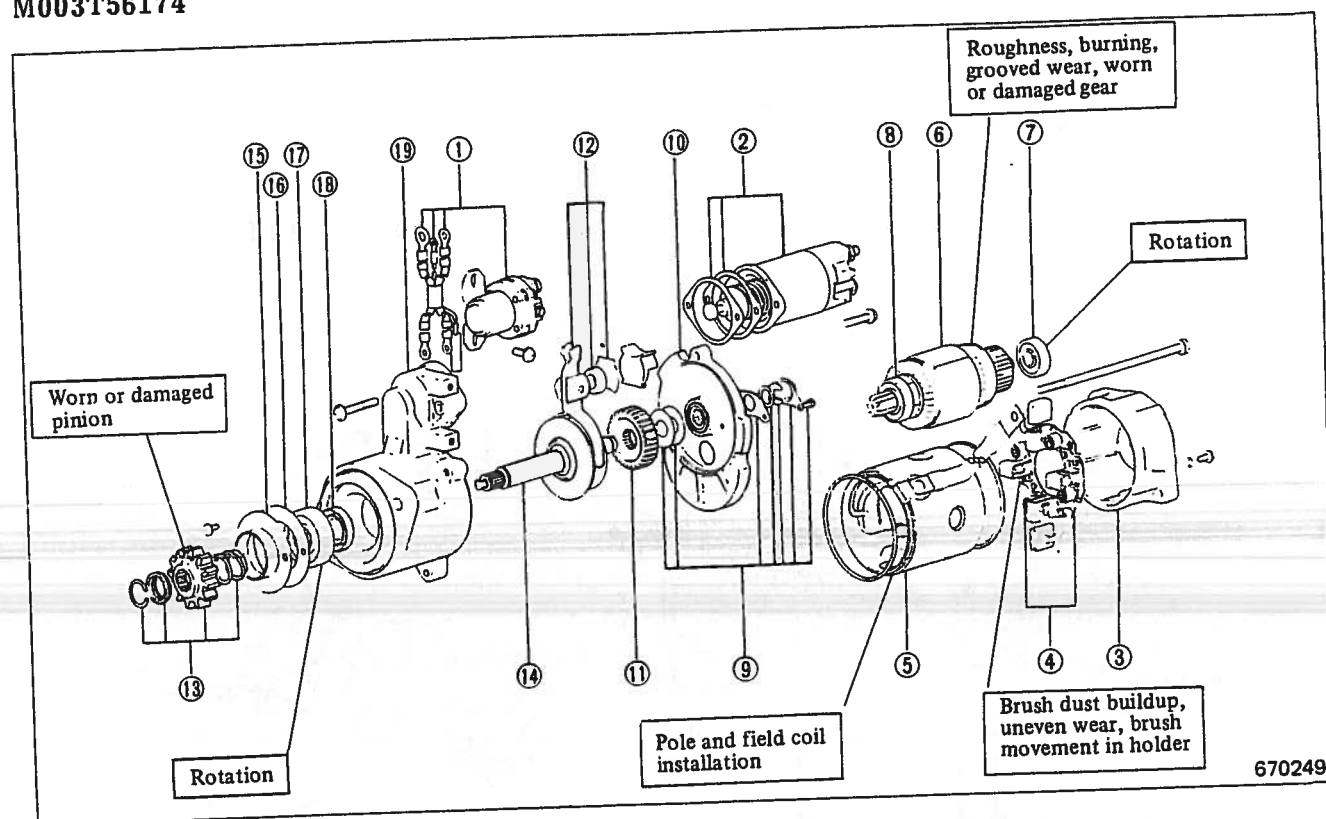
M002T56471 or M002T56472 (dry type)
M002T65271 or M002T65272 (dry type)



670248

- | | | |
|----------------|------------------|-----------------|
| ① Switch | ⑦ Ball bearing | ⑬ Pinion set |
| ② Rear bracket | ⑧ Cover set | ⑭ Pinion shaft |
| ③ Brush holder | ⑨ Center bracket | ⑮ Oil seal |
| ④ Yoke | ⑩ Gear | ⑯ Ball bearing |
| ⑤ Armature | ⑪ Spring set | ⑰ Front bracket |
| ⑥ Ball bearing | ⑫ Lever | |

M003T56174



- ① Auxiliary switch
- ② Switch
- ③ Rear bracket
- ④ Brush holder
- ⑤ Yoke
- ⑥ Armature
- ⑦ Ball bearing

- ⑧ Ball bearing
- ⑨ Cover set
- ⑩ Center bracket
- ⑪ Gear
- ⑫ Lever
- ⑬ Pinion set
- ⑭ Pinion shaft

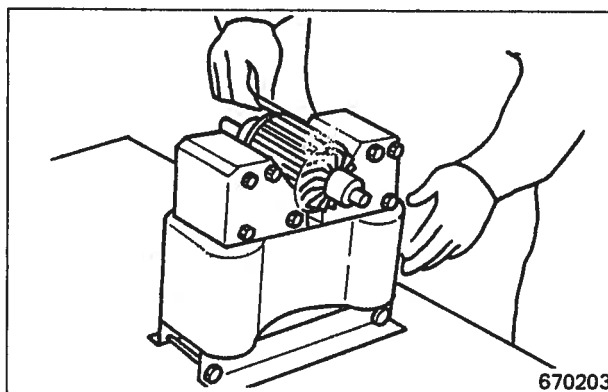
- ⑮ Cover
- ⑯ Plate
- ⑰ Bearing
- ⑱ Oil seal
- ⑲ Front bracket

2.2 Inspection and repair

(1) Armature

(a) Testing armature for short circuits

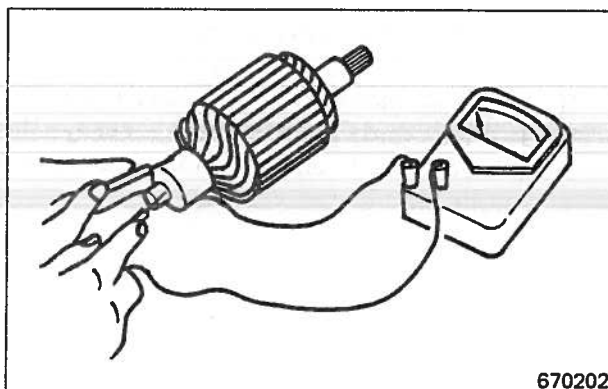
Place the armature on a growler, and slowly revolve it with a hacksaw blade held above the armature core. The hacksaw blade vibrates against the core when it is above a slot containing a shorted winding. Replace the armature if shorted.



670203

(b) Testing armature for grounded circuits

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



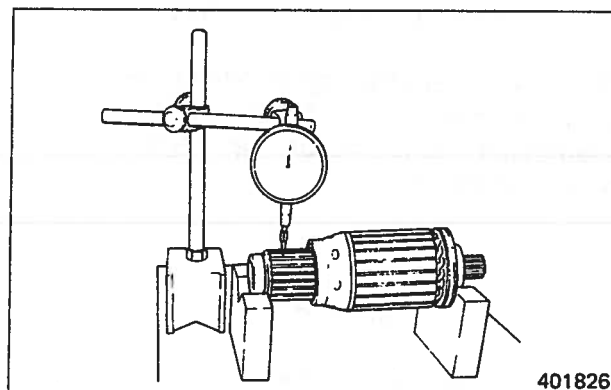
670202

(c) Inspecting commutator

- 1) Support the armature in V-blocks, and 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	Repair limit	Service limit
Commutator runout	0.03 (0.0012)	0.05 (0.0020)	0.05 (0.0020)

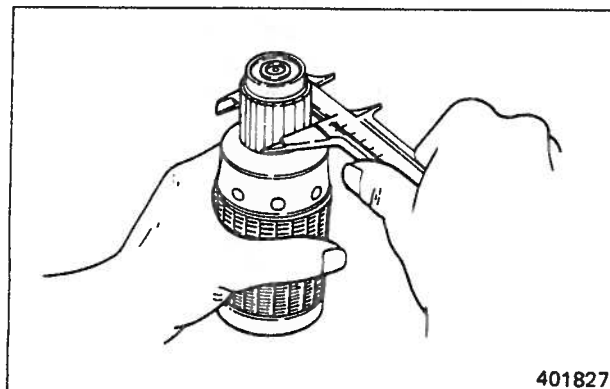


401826

- 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
Outside diameter of commutator	32 (1.26) [38.7 (1.524)]	31 (1.22) [37.7 (1.484)]



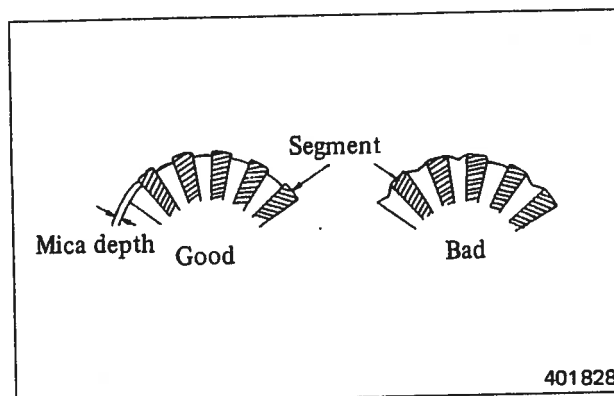
401827

Values in [] are for M003T56174.

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

Unit: mm (in.)

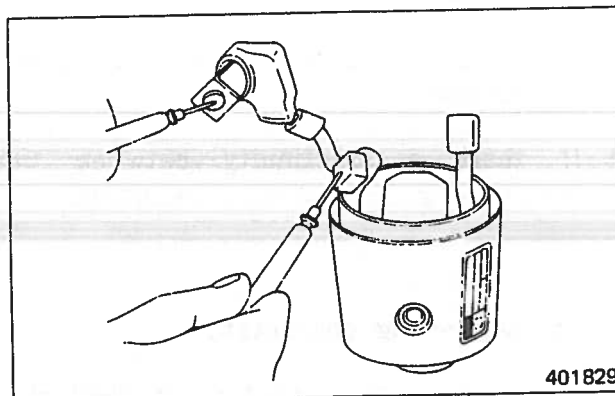
Item	Repair limit
Commutator mica depth	0.2 (0.008), maximum



(2) Field coil

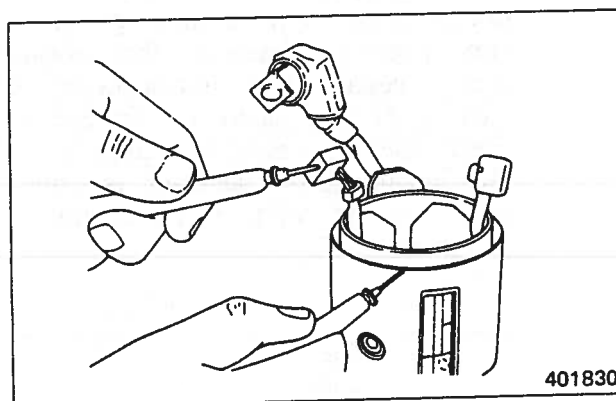
(a) Testing for open circuits

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 continuity between the yoke and positive (+) brush, check the insulation, and repair or replace the yoke assembly.



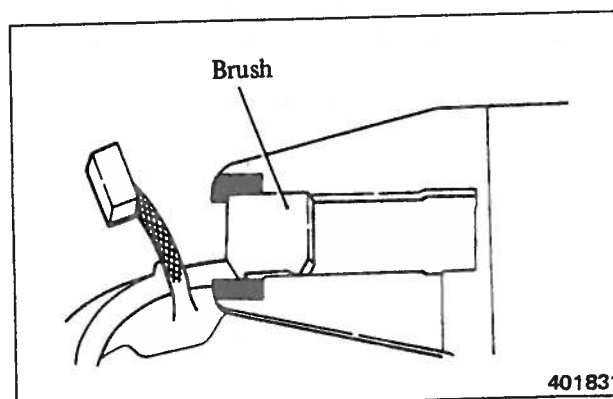
(3) Brushes and holders

(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
Brush length	18 (0.71) [17 (0.67)]	11 (0.43)



Values in [] are for M003T56174.

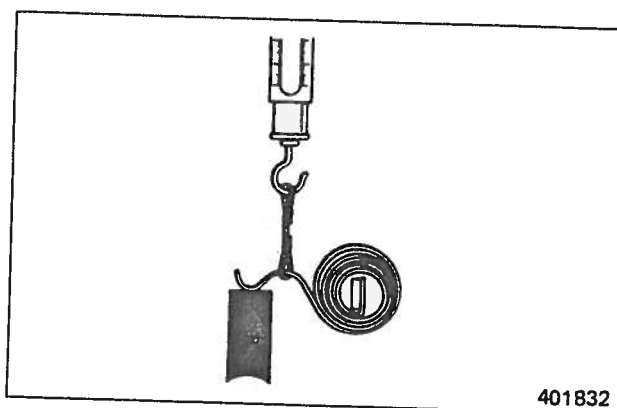
(b) Brush spring tension

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: mm (in.)

Item	Assembly standard	Service limit
Brush spring tension	3.5 (0.138) [2.5 (0.098)]	2.3 (0.091) [1.8 (0.071)]

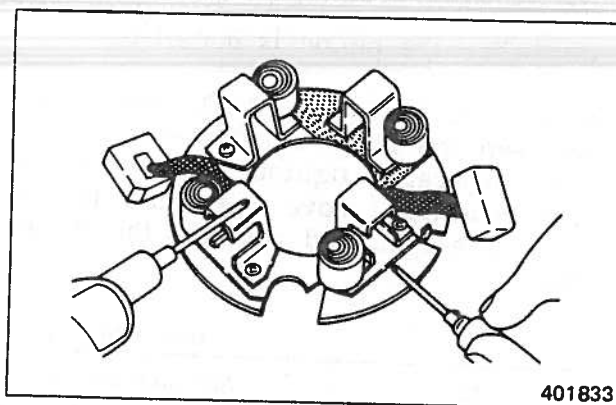
Values in [] are for M003T56174.



401832

(c) Testing brush holders for insulation

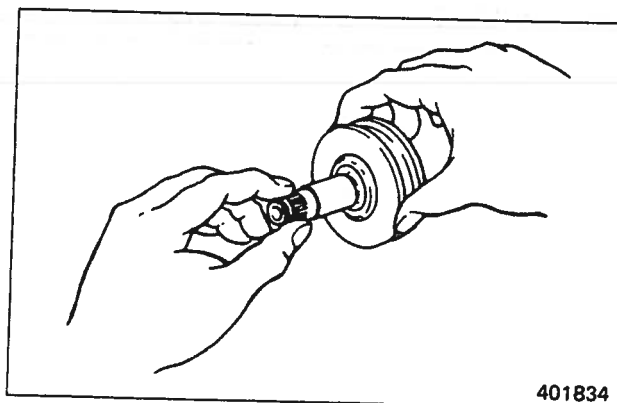
If there is continuity between the positive (+) brush holder and negative (-) holder plate, replace the brush holder assembly.



401833

(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.



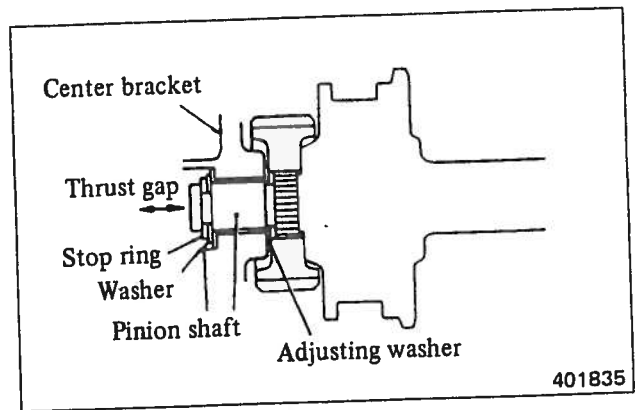
401834

(5) Pinion thrust gap

The pinion shaft thrust gap is the play exhibited by the pinion shaft when it is moved in the thrust direction. Measure the thrust gap in the following manner. If it is out of specification, select the adjusting washer and adjust the gap.

(a) When the pinion is removed:

Install the gear on the pinion shaft, insert the shaft into the center bracket, and lock the shaft with the washer and ring. Under this condition, move the shaft in the axial direction, and measure the thrust gap.



(b) When the pinion is installed:

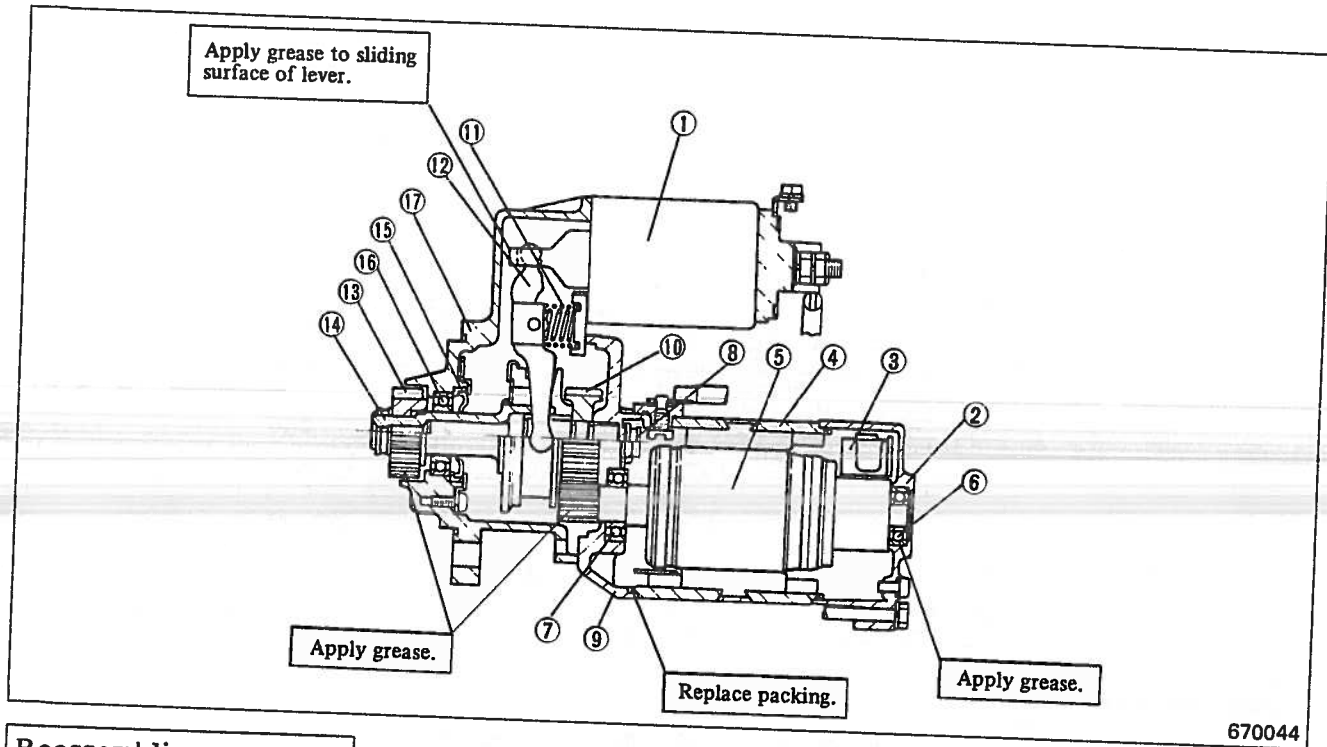
Install the pinion shaft and gear between the front and center brackets, and temporarily tighten the bolt. Under this condition, move the shaft in the axial direction, and measure the thrust gap.

Unit: mm (in.)

Item	Assembly standard
Pinion thrust gap	0.5 (0.020), maximum [Below 0 not permissible]

2.3 Reassembly

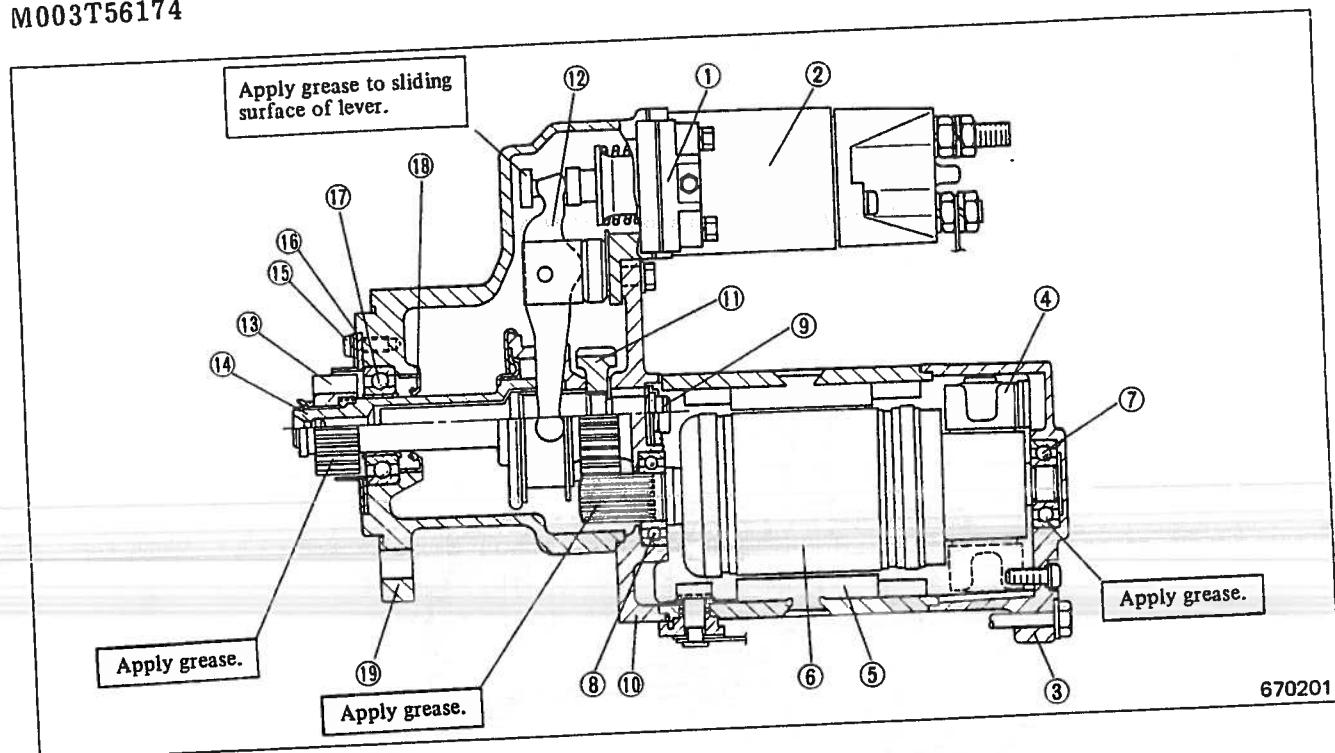
M002T56471 or M002T56472 (dry type)
M002T65271 or M002T65272 (dry type)



Reassembling sequence

17 → 16 → 15 → 11 → 12 → 14 → 10 → 13 → 9 → 8 → 7 → 6 → 5 → 4 → 3 → 2 → 1

M003T56174



Reassembling sequence

19 → 17 → 18 → 12 → 14 → 13 → 16 → 15 → 11 → 10 → 9 → 8 → 7 → 6 → 5 → 4 → 3 → 2 → 1

Inspection and testing after reassembly

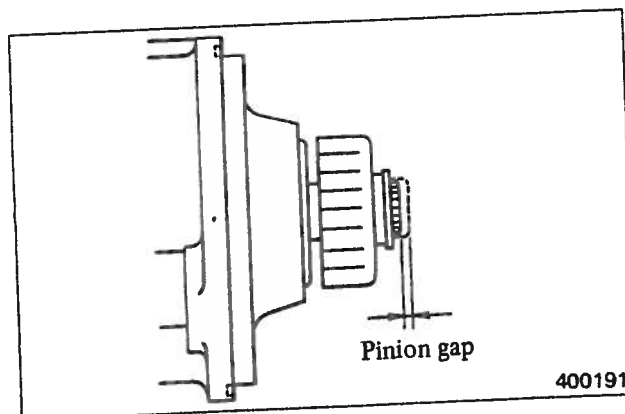
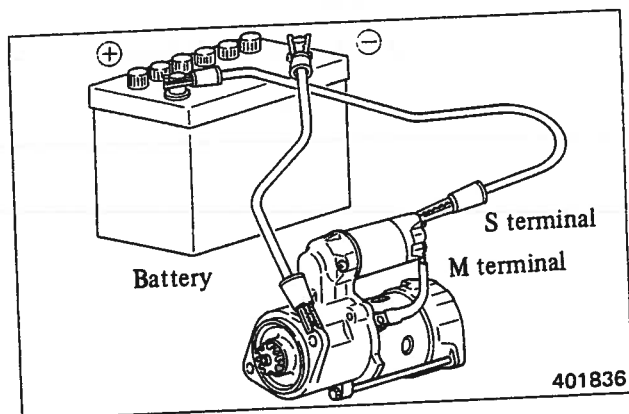
(1) Pinion gap adjustment

- 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.
- Under this condition, lightly push in the pinion toward the armature, and measure the movement (gap) of the pinion.
- To adjust the gap, increase or decrease the packings fitted to the magnetic switch. Increasing the packings decreases the pinion gap.

Unit: mm (in.)

Item	Assembly standard
Pinion gap	0.5 - 2.0
	(0.025 - 0.079)
	0.1 - 2.5
	[(0.004 - 0.098)]

Values in [] are for M003T56174.



**CAUTION**

Do not test the starter continuously for more than 20 seconds to prevent the switch coil from overheating.

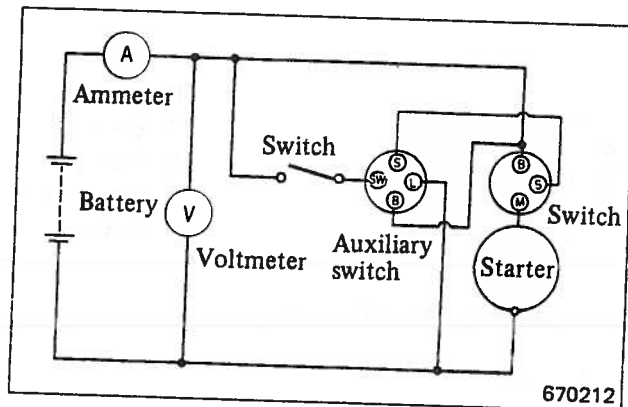
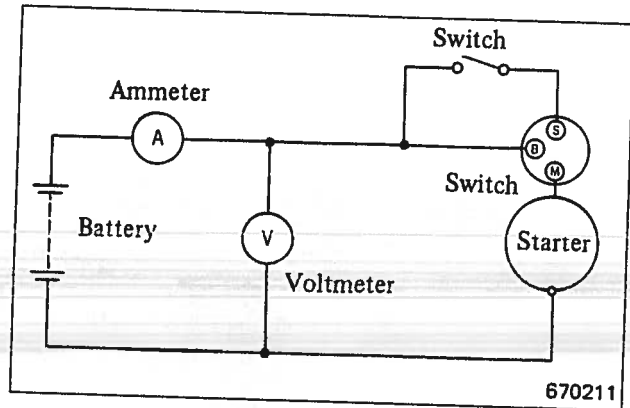
(2) No-load test

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

NOTE

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

Starter	Voltage (V)	Current (A)	Speed (rpm)
M002T56471 or M002T56472	11	130, maximum	4000
M002T65271 or M002T65272	23	80, maximum	3400
M003T56174	23	85, maximum	3300



For M003T56174 starter

(3) Magnetic switch**(a) Testing coil for open circuits**

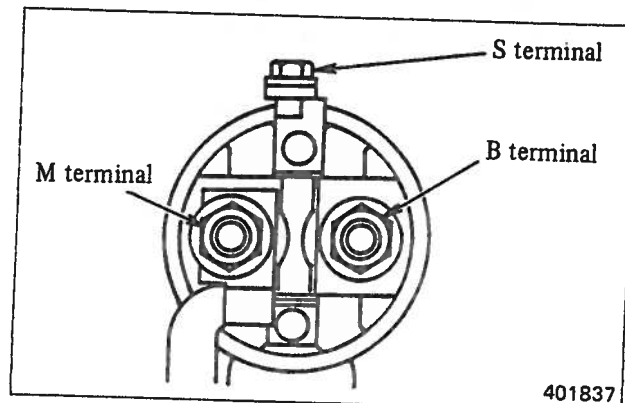
If there is no continuity between S and M terminals and between S terminal and body (ground), replace the switch.

(b) Inspecting contactors for fusion

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

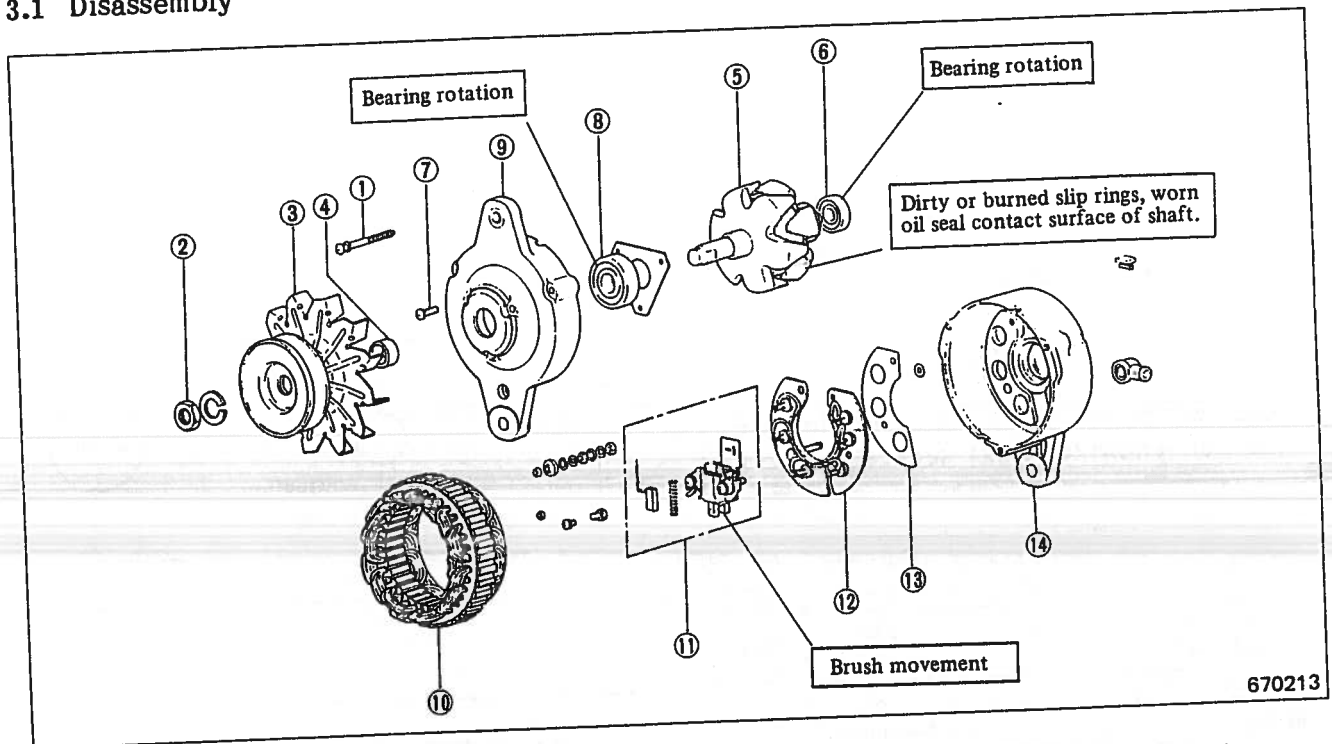
(c) Inspecting contactors for poor contact action

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



3. ALTERNATOR

3.1 Disassembly



670213

① Screw

② Nut

③ Pulley (with fan)

④ Spacer

⑤ Rotor

⑥ Bearing

⑦ Screw

⑧ Bearing

⑨ Front bracket

⑩ Stator

⑪ Brush holder set

⑫ Rectifier assembly

⑬ Plate

⑭ Rear bracket

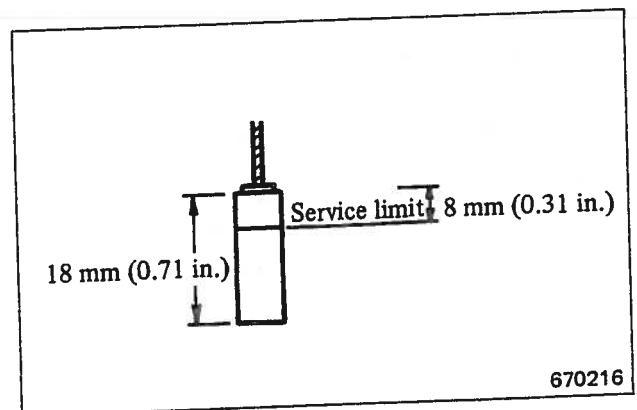
3.2 Inspection and repair

(1) Brushes

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

Unit: mm (in.)

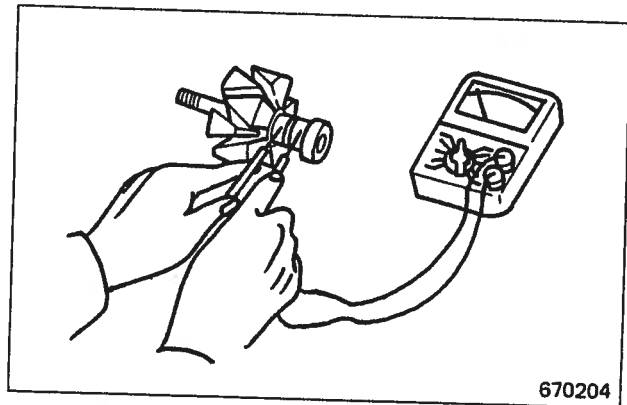
Item	Assembly standard	Service limit
Brush length	18 (0.71)	8 (0.31)



670216

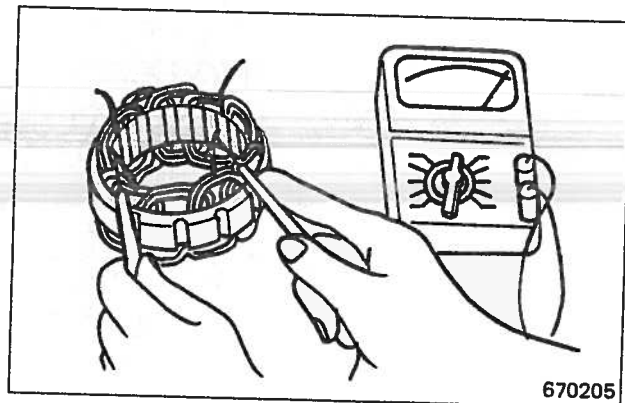
(2) Field coil

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



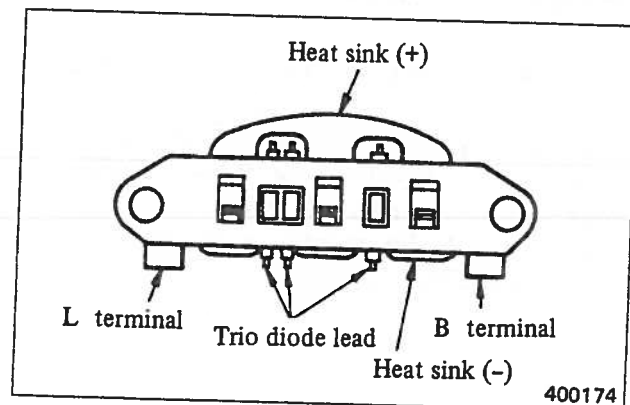
(3) Stator coil

Inspect 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.

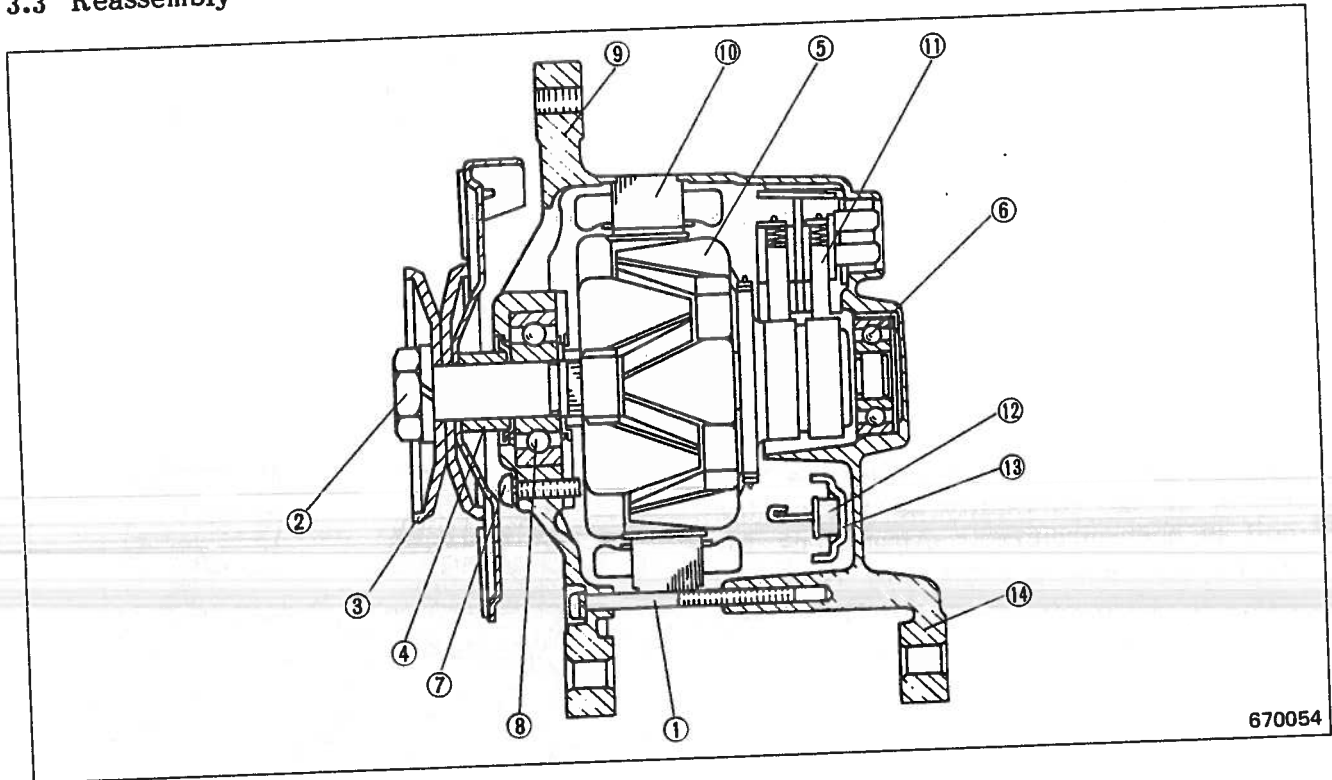


(4) Rectifier

Inspect the resistance between the lead wire and heat sink on each diode by connecting the positive (+) side lead wire and negative (-) side 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.



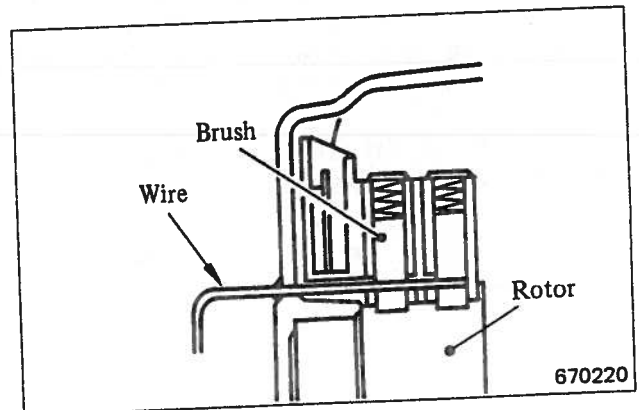
3.3 Reassembly



Reassembling sequence

⑭→⑬→⑫→⑪→⑩→⑨→⑧→⑦→⑥→⑤→④→③→②→①

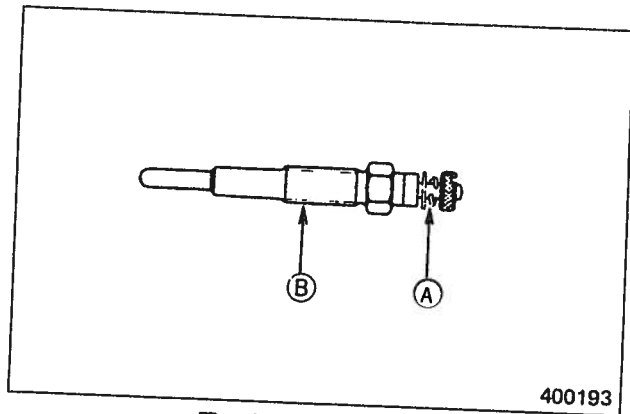
Push the brush into the holder, and hold it there by inserting a 2 mm (0.08 in.) diameter wire into the hole in the brush. Then, install the rotor. Remove the wire after installing the rotor.



4. GLOW PLUGS

Inspection

If the glow plug glows red when the positive (+) wire is connected to the portion (A) with the portion (B) grounded, the plug is in satisfactory condition.



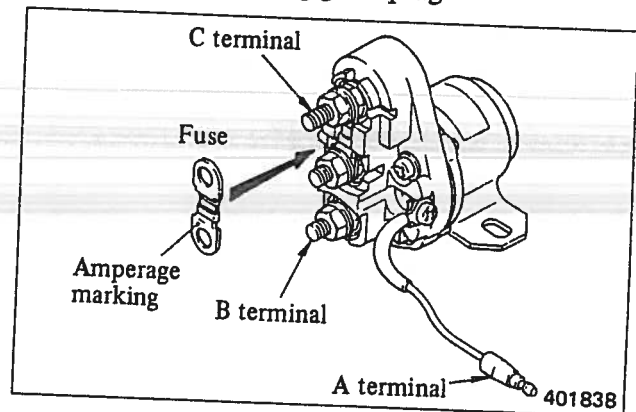
Testing glow plug

5. HEATER RELAY

Inspection

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

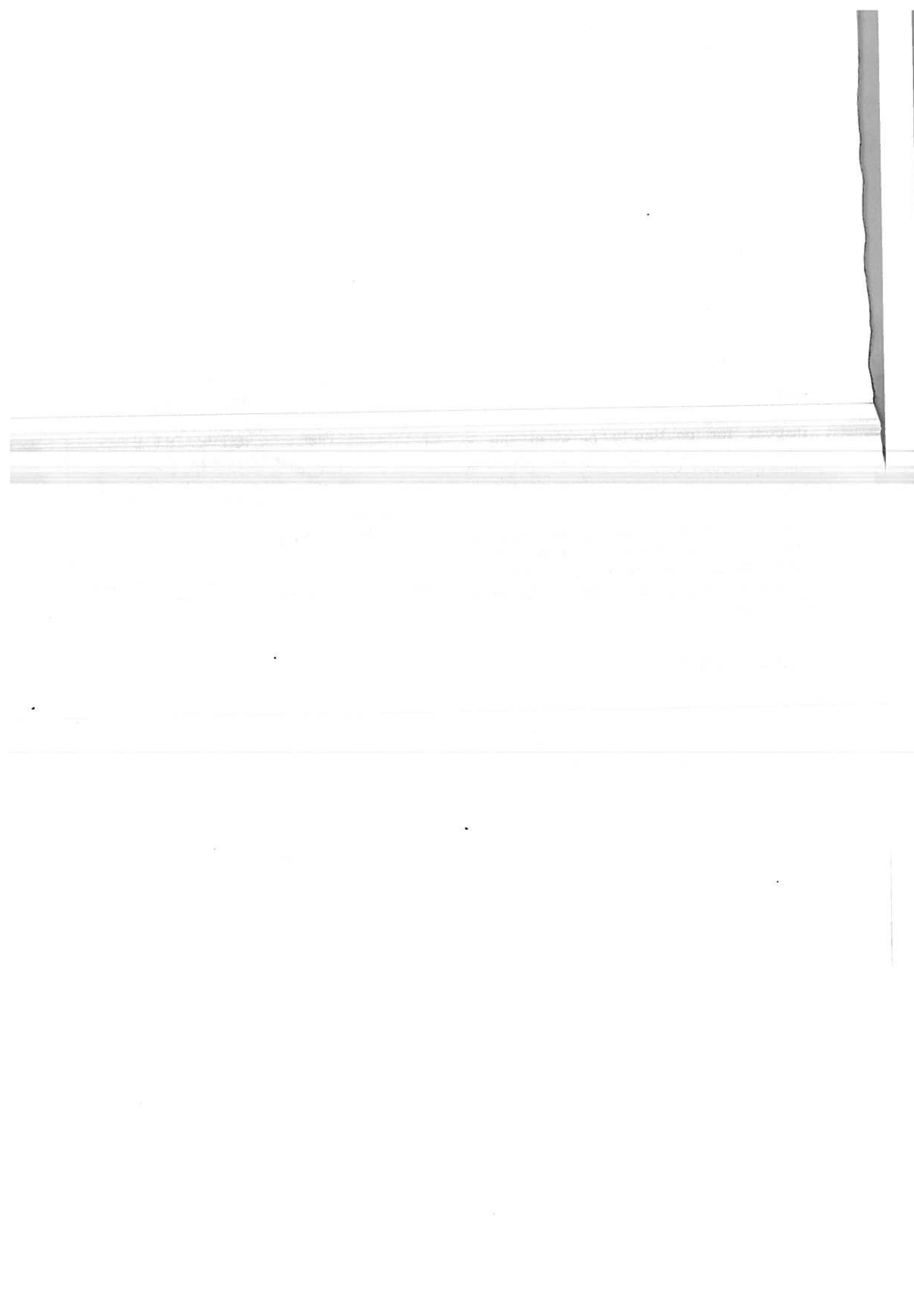
Also inspect the fuse. If the fuse is burnt out, inspect for the cause before installing a replacement fuse. Be sure to use a replacement fuse of the same amperage.



6. AIR HEATER

Inspection

Inspect the terminals for looseness. Also inspect the heater element for any signs of defects.



WORKSHOP THEORY

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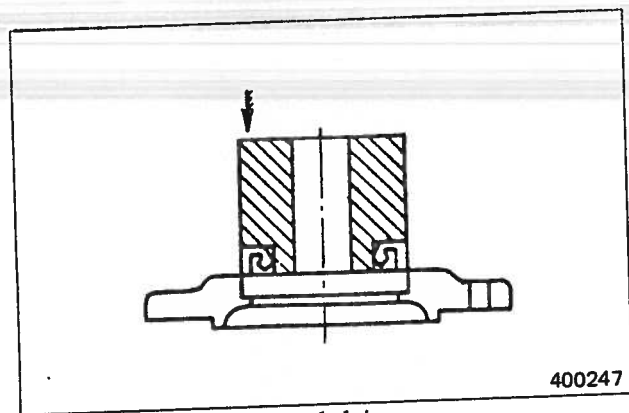
1. PRECAUTIONS FOR DISASSEMBLY AND REASSEMBLY

1.1 Oil seals

When installing oil seals, carefully observe the following points:

(1) Driving oil seals into housings

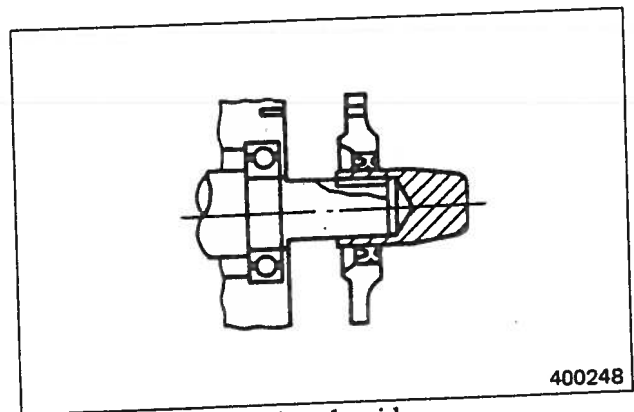
- (a) Make sure that seal lip is not damaged, and position it correctly with respect to oil compartment.
- (b) Apply a small amount of grease to the surface of oil seal to be fitted into housing bore.
- (c) Using a tool of the type shown to guide seal lip, drive oil seal squarely. Never give any hammer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



Oil seal driver

(2) Driving oil seals onto shafts

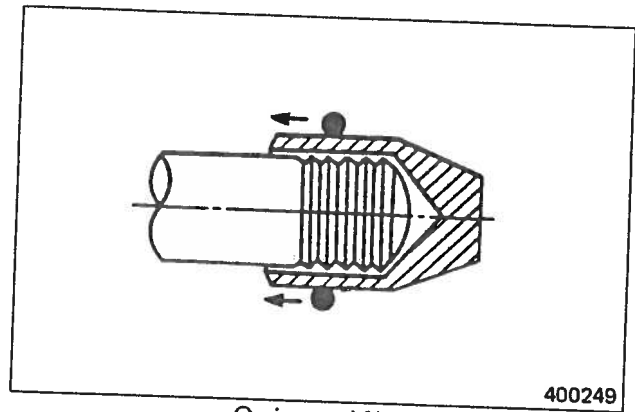
- (a) Apply a thin coat of grease to oil seal lip.
- (b) Use an oil seal guide of the type shown when driving oil seal over stepped portion, splines, threads or keyway to prevent damage to seal lip.



Oil seal guide

1.2 O-rings

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.

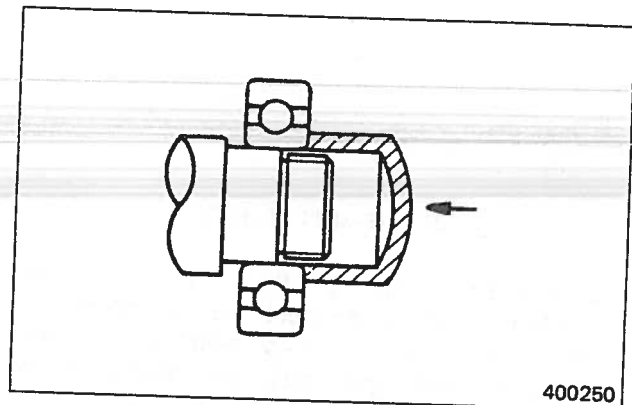


O-ring guide

400249

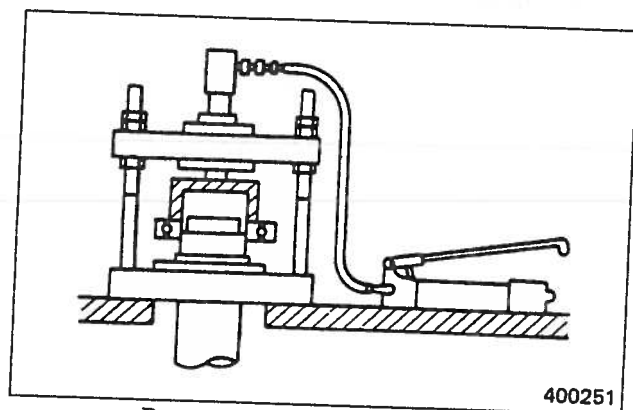
1.3 Bearings

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



Bearing driver

400250

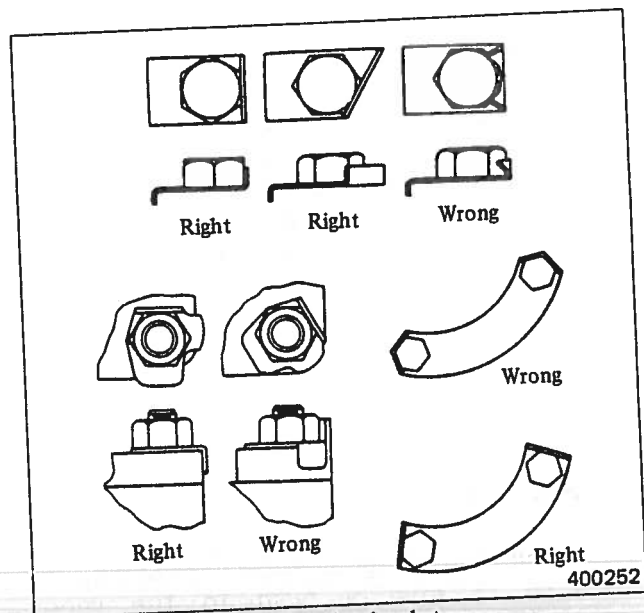


Bearing installation by a press

400251

1.4 Lock plates

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



Bending lock plates

1.5 Split pins and spring pins

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