CATERPILLAR®

99709-66110

Service Manual

S6S Diesel Engine

For use with:
DP40, DPL40, DP45,
DP50, DP60 and DP70

INTRODUCTION

This publication covers the Caterpillar S6S diesel engine. The information, specifications, and illustrations in this publication are on the basis of information that was current at the time this issue was written.

The fuel injection pump and governor are described in the separate volumes of this publication.

The sections and their contents will be found in TABLE OF CONTENTS and the contents of each section in the first page of the section.

1. How To Use This Manual

(1) The parts read in the texts or shown in the illustrations are numbered in the disassembly sequence prescribed for each system or assembly.

(2) What to be inspected for 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 Section 2 in a tabulated form.

(4) Some marks are used in this manual to emphasize important and critical instructions as shown below:

NOTE	Procedures, conditions, etc. which it is essential to highlight.
⚠ CAUTION	Procedures, practices, etc. which will result in damage to or destruction of engine if not strictly observed.
⚠ WARNING	Procedures, practices, etc. which will result in personal injury or loss of life if not correctly followed.

(5) Tightening torque in "wet" condition is indicated as [wet]. Unless indicated as such, the torque is to be considered in "dry" condition.

2. Glossary

NOMINAL SIZE is the named size which has no specified limits of accuracy.

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

STANDARD CLEARANCE is the clearance to be obtained between mating parts at the time of reassembly.

REPAIR LIMIT is the maximum or minimum dimension specified for a part. A part which has reached this limit must be repaired.

SERVICE LIMIT is the maximum or minimum dimension specified for a part. A part which has reached this limit must be replaced.

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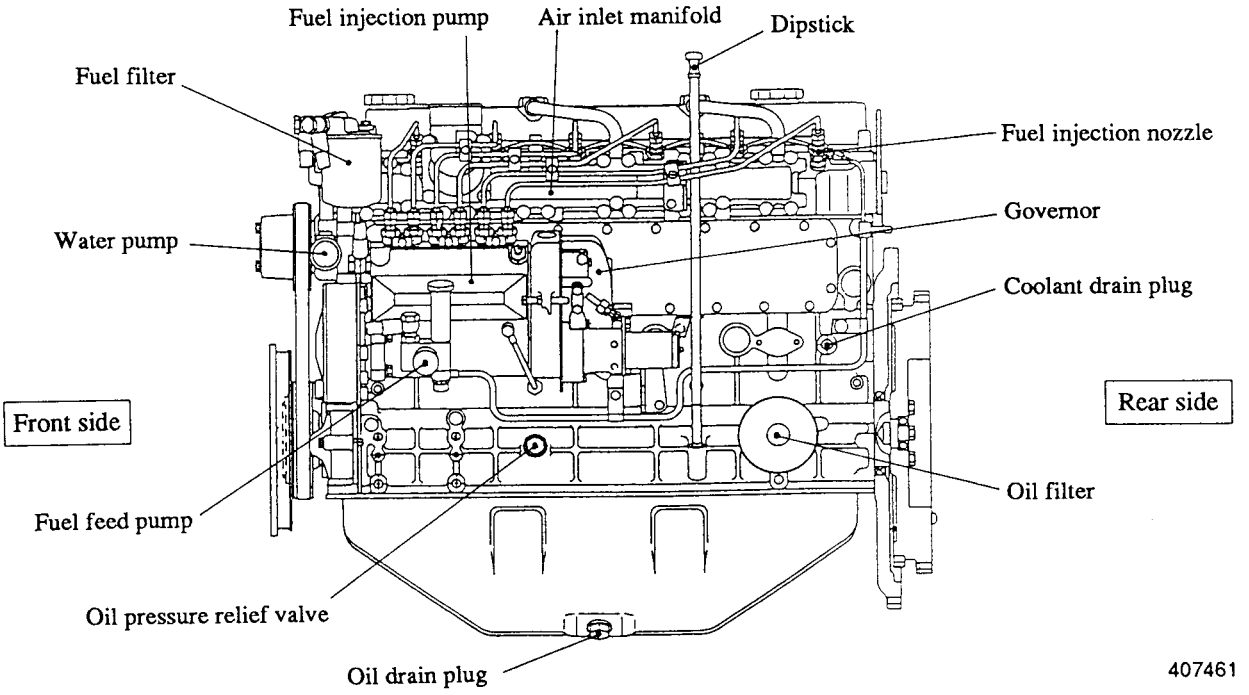
GENERAL INFORMATION

1. GENERAL

1.1 Typical engine arrangement (DP40 thru DP50)



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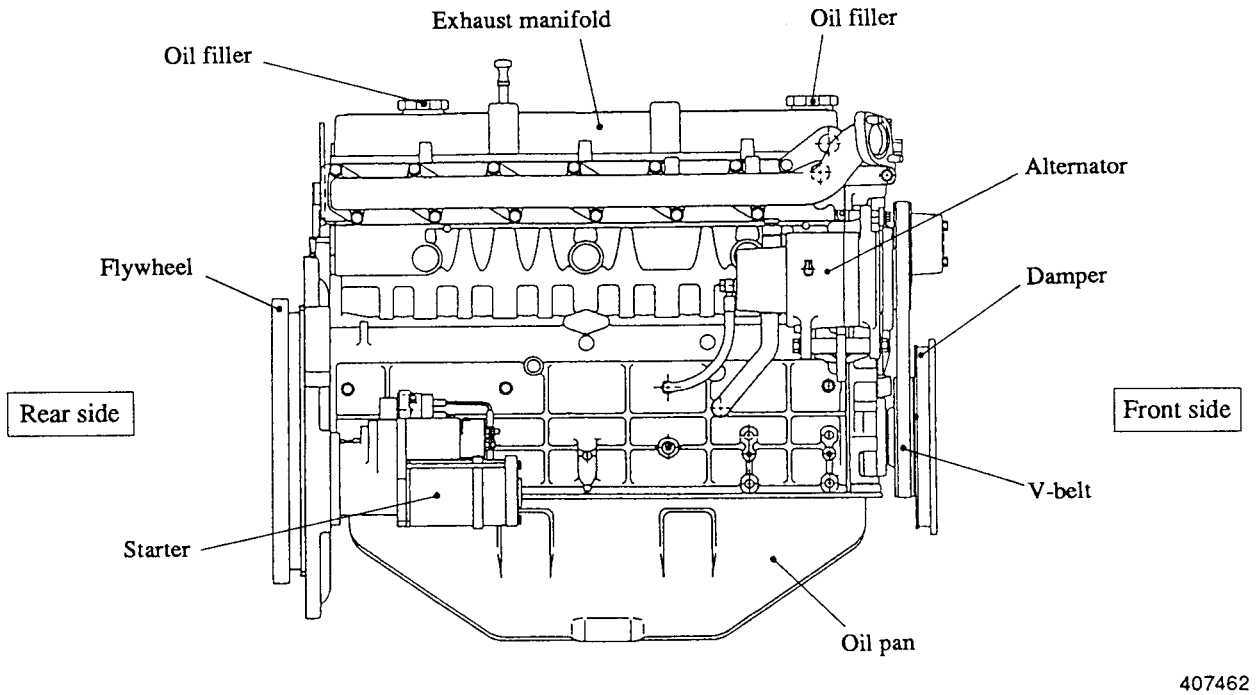
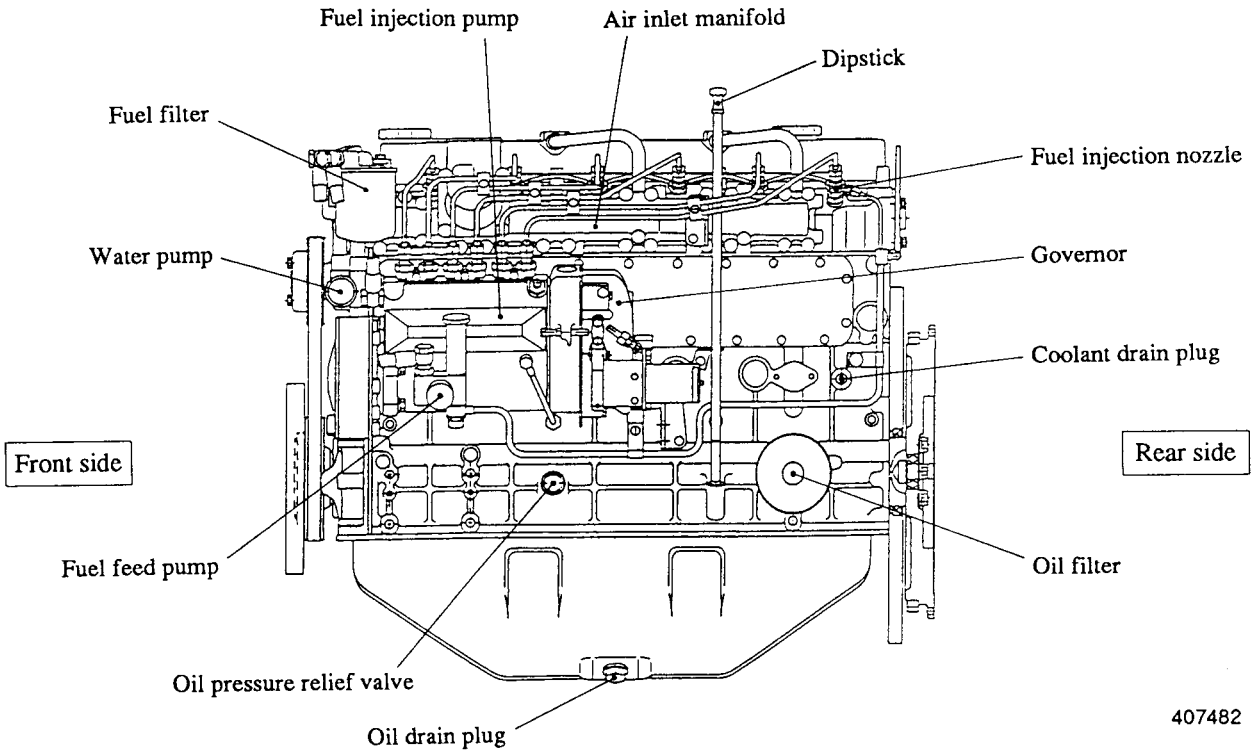


Right side

NOTE: The rotation of crankshaft is counterclockwise when seen from the flywheel end.

1.2 Typical engine arrangement (DP60 and DP70)



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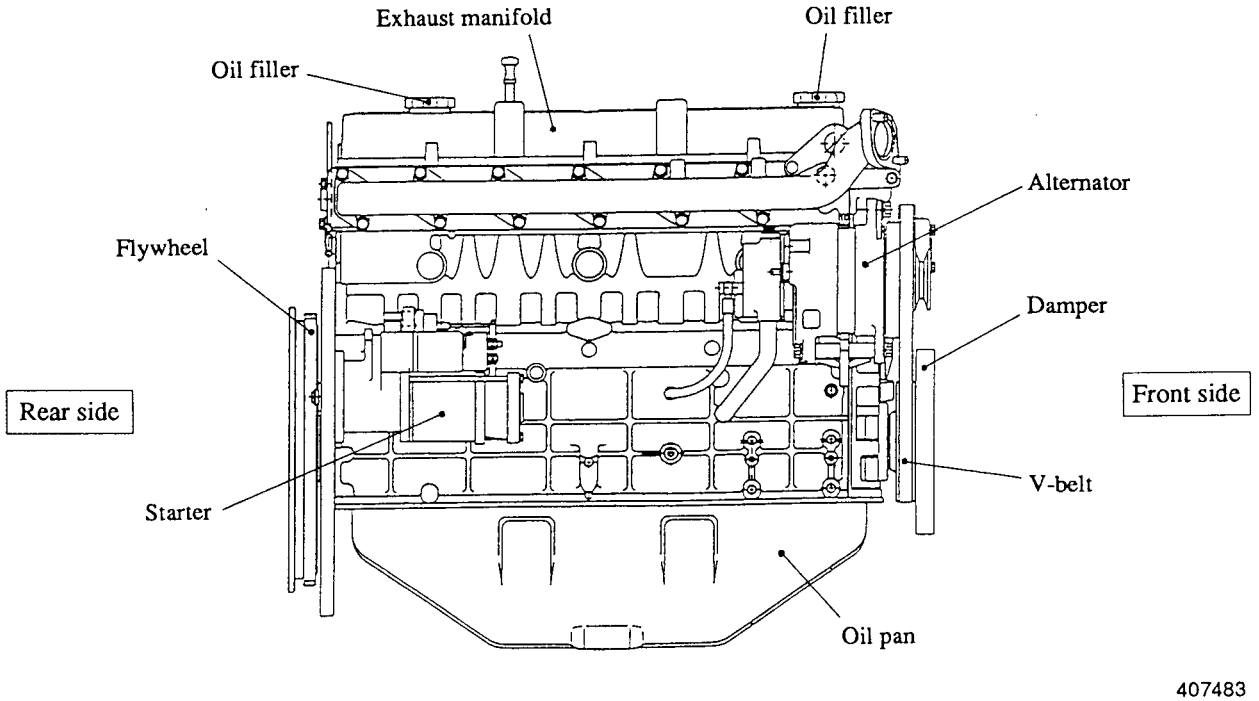

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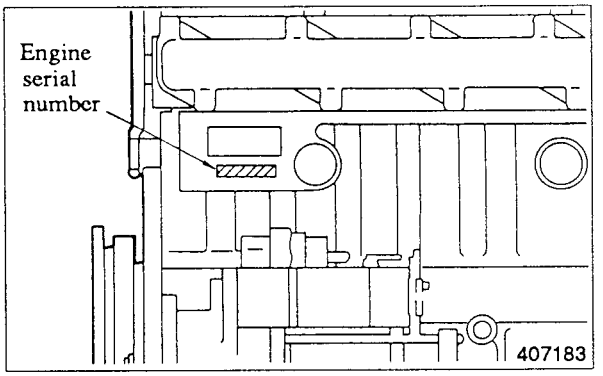
NOTE: The rotation of crankshaft is counterclockwise when seen from the flywheel end.

1.3 Location of engine serial number

The engine serial number is located on the side of the crankcase.



2. SPECIFICATIONS

Model				S6S (DP40 thru DP50)	S6S (DP60 and DP70)
General	Type			Water-cooled, 4-stroke cycle, diesel	
	No. of cylinders – arrangement			6 – in line	
	Combustion chamber, type			Swirl	
	Valve mechanism			Overhead	
	Bore x stroke, mm (in.)			94 x 120 (3.70 x 4.72)	
	Piston displacement, liter (cu in.)			4.996 (305)	
	Compression ratio			22 : 1	
	Firing order			1 – 5 – 3 – 6 – 2 – 4	
	Rotation of crankshaft			Counterclockwise when seen from flywheel end	
	Dimensions	Overall length, mm (in.)		907.5 (35.7)	866 (34.1)
		Overall width, mm (in.)		642 (25.3)	587 (23.1)
		Overall height, mm (in.)		801 (31.5)	
	Weight (dry), kg (lb)			350 (772)	345 (761)
Engine proper	Cylinder sleeves, type			Dry	
	No. of piston rings	Compression rings		2	
		Oil ring		1 (w/spring expander)	
	Valve timing	Inlet valves	Open	30° B.T.D.C.	
			Close	50° A.B.D.C.	
		Exhaust valves	Open	74° B.B.D.C.	
			Close	30° A.T.D.C.	
	Starting system			Electric starter	
	Starting aid			Glow plugs	
Lubrication system	Type			Force feed by oil pump	
	Engine oil	API service classification		CC	
		Refill capacity, liter (U.S. gal.)		Whole engine: 12 (3.2) Oil pan (high level): 11 (2.9), Filter: 1 (0.3)	
	Oil pump	Type		Trochoid	
		Speed ratio to crankshaft		0.74	
		Capacity, liter (U.S. gal.)/min		38.7 (10.2) at 0.3 MPa discharge pressure of pump running at 2230 rpm	
	Oil pressure relief valve	Type		Piston valve	
		Opening pressure, kgf/cm^2 (psi) [kPa]		3.5 ± 0.5 (50 ± 7) [343 ± 49]	
	Oil filter	Type		Paper-element cartridge	

Model			S6S (DP40 thru DP50)	S6S (DP60 and DP70)
Cooling system	Refill capacity (engine water jacket), liter (U.S. gal.)		8 (2.1)	
	Water pump	Type	Centrifugal	
		Speed ratio to crankshaft	1.4	
		Capacity, liter (U.S. gal.)/min/rpm	160 (42.2) at 0.75 MPa discharge pressure of pump running at 3600 rpm	
	Belt	Type	Low-edge B type V-belt	
	Thermostat	Type	Wax pellet	
		Valve opening temperature, °C (°F)	76.5 ± 1.5 (170 ± 2.7)	
Fuel system	Injection pump	Type	Bosch A	
		Diameter of plunger, mm (in.)	6.5 (0.256)	
	Feed pump	Type	Bosch, piston	
		Camshaft lobe lift, mm (in.)	6 (0.236)	
	Governor	Type	Bosch RSV, centrifugal	
	Injection nozzle	Type	Bosch throttle	
		Diameter of discharge orifice, mm (in.)	1.0 (0.039)	
		Discharge angle	15°	0°
		Valve opening pressure, kgf/cm² (psi) [kPa]	140 (1 991) [13 729]	120 (1 706) [11 768]
	Fuel filter, type		Paper-element cartridge	
Electrical system	Voltage – polarity		24V – negative ground	
	Starter	Model	M003T58771	
		Type	Pinion shift	
		Output, V – kW	24 – 5	
		No. of pinion teeth/flywheel ring gear teeth	10/122	
	Alternator (standard)	Type	3-phase, with rectifier	
		Output, V – A	24 – 35	24 – 30
		Rated voltage generating speed, rpm	1 100	
		Rated output generating speed, rpm	5 000	
		Maximum permissible speed, rpm	8 000	
		Speed ratio to crankshaft	2.0	

Model			S6S (DP40 thru DP50)	S6S (DP60 and DP70)
Electrical system	Alternator (option)	Type	3-phase, with rectifier	
		Output, V – A	24 – 35, 24 – 50	
		Rated voltage generating speed, rpm	1 000, 1 100	
		Rated output generating speed, rpm	5 000, 5 000	
		Maximum permissible speed, rpm	8 000, 8 000	
		Speed ratio to crankshaft	2.0	
	Glow plugs	Type	Sheathed	
		Rated voltage – current, V – A	22 – 4.4 (15 second rating)	

3. SUGGESTIONS FOR DISASSEMBLY AND ASSEMBLY

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

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

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

3.1 Disassembly

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

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

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

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

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

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

3.2 Assembly

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

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

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

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

(5) Replace gaskets and packings with new ones. Apply a proper amount of sealant to gaskets or packings, if necessary.

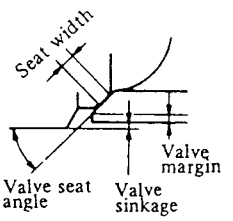
MAINTENANCE STANDARDS

1. MAINTENANCE STANDARDS

Unit: mm (in.)

Group	Item		Nominal size	Assembly standard (standard clearance)	Repair limit (clearance)	Service limit (clearance)	Remarks
General	Maximum rpm, (no-load)		DP40 thru DP50: 2 650 $^{0}_{-50}$ DP60 and DP70: 2 480 $^{0}_{-50}$				Adjust governor setting.
	Minimum rpm, (no-load)		650 $^{+50}_{0}$				
	Compression pressure, kgf/cm² (psi) [kPa]			33 (469) [3 236] at 300 rpm	29 (412) [2 844]		Oil and water temp. 20 to 30°C (68 to 86°F)
	Engine oil pressure, kgf/cm² (psi) [kPa]		3 to 5 (43 to 71) [294 to 490] at 1 500 rpm		1.5 (21.3) [147]		Oil temperature 60 to 70°C (140 to 158°F)
			1 (14.2) [98], minimum at idling		0.5 (7) [49]		
	Valve timing		Inlet valves open 30° B.T.D.C. Inlet valves close 50° A.B.D.C. Exhaust valves open 74° B.B.D.C. Exhaust valves close 30° A.T.D.C. ±3° (crank angle)				
	Valve clearance (cold)			0.25 (0.009 8)			Both inlet and exhaust valves
	Fuel injection timing		19° B.T.D.C.				
	V-belt deflection			12 (0.5), approx.			Push belt inward with thumb pressure and measure deflection.
Crankcase	Crankcase	Warpage of gasket contact surface		0.05 (0.002 0), maximum	0.20 (0.0079)		Re-grind crankcase within the range of retaining specified piston projection.
	Cylinder	Inside diameter	94 (3.70)	94.000 to 94.035 (3.700 78 to 3.702 16)	94.200 (3.708 65)	94.700 (3.728 34)	Refinish cylinder to 0.25 (0.009 8) or 0.50 (0.019 7) oversize of nominal value by honing and use the same oversize pistons and piston rings.
		Out-of-round		0.01 (0.000 4), maximum			
		Taper		0.015 (0.000 59), maximum			
	Main metals	Clearance between bearing and journal		(0.050 to 0.110) ((0.001 97 to 0.004 33))	(0.200) ((0.007 87))	–0.9 (–0.035) as journal diameter which is 78 (3.07)	If repair limit has been reached, replace metals. If it has been exceeded, regrind journals and use undersize metals. Metal undersizes: 0.25 (0.009 8) 0.50 (0.019 7) 0.75 (0.029 5)
		Width of thrust journal		(0.100 to 0.264) ((0.003 94 to 0.010 39))	(0.300) ((0.011 81)) (end play)		Replace thrust plates.

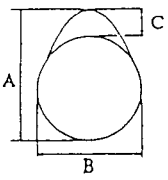
Unit: mm (in.)

Group	Item			Nominal size	Assembly standard (standard clearance)	Repair limit (clearance)	Service limit (clearance)	Remarks
Crankcase	Tappet bore	Inside diameter			14.000 to 14.018 (0.551 18 to 0.551 89)		14.100 (0.555 12)	
		Clearance between tappet and bore			(0.016 to 0.052) ((0.000 63 to 0.002 05))	(0.08) ((0.003 1))		If repair limit has been reached, replace tappets.
	Camshaft	Clearance between bushing and camshaft journal			(0.040 to 0.119) ((0.001 57 to 0.004 69))	(0.15) ((0.005 9))		If repair limit has been exceeded, replace bushing or camshaft.
Cylinder head	Cylinder head	Warpage of gasket contact surface			0.05 (0.002 0), maximum	0.20 (0.007 9)		Regrind if warpage is minor.
		Compressed thickness of gasket		1.2 (0.05)	±0.05 (±0.002)			
	Valves and valve guides	Diameter of valve stem	Inlet valve	8 (0.31)	7.940 to 7.955 (0.312 60 to 0.313 19)		7.900 (0.31102)	
			Exhaust valve		7.920 to 7.940 (0.311 81 to 0.312 60)		7.850 (0.309 05)	
		Clearance between guide and stem	Inlet valve		(0.055 to 0.085) ((0.002 17 to 0.003 35))		(0.150) ((0.005 91))	
			Exhaust valve		(0.070 to 0.105) ((0.002 76 to 0.004 13))		(0.200) ((0.007 87))	
		Height to top of valve guide		14 (0.55)	±0.3 (±0.012)			
	Valve seats	Angle		30°				
		Valve sinkage	Inlet valve	0.4 (0.016)	±0.2 (±0.008)		1.0 (0.039)	
			Exhaust valve	0.5 (0.020)				
		Width		1.4 (0.055)	±0.14 (±0.005 5)		1.8 (0.071)	
		Valve margin			2.13 (0.083 9)		Up to 1.83 (0.072 0) by refacing	
	Valve spring	Free length		48.85 (1.92)			47.60 (1.87)	
		Squareness			1.5°			Squareness of ends with respect to center line
		Length under test force			43 (1.69)		43 (1.69)	
		Test force, kgf (lbf) [N]			18 to 20 (40 to 44) [177 to 196]		15 (33) [147]	

Unit: mm (in.)

Group	Item		Nominal size	Assembly standard (standard clearance)	Repair limit (clearance)	Service limit (clearance)	Remarks
Cylinder head	Rocker arm	Inside diameter of rocker bushing	19 (0.75)	19.010 to 19.030 (0.748 42 to 0.749 21)			
		Diameter of rocker shaft		18.980 to 19.000 (0.747 24 to 0.748 03)			
		Clearance between bushing and shaft		(0.010 to 0.050) ((0.000 39 to 0.001 97))		(0.070) ((0.002 76))	
	Valve push rod	Runout		0.3 (0.012), maximum			Dial indicator reading with both ends supported in V-blocks
Main moving parts	Crankshaft	Runout		0.02 (0.000 8), maximum	0.05 (0.002 0)		
		Diameter of journal	78 (3.07)	77.955 to 77.970 (3.069 09 to 3.069 68)	77.850 (3.064 95)	77.100 (3.035 43)	
		Diameter of crankpin	58 (2.28)	57.955 to 57.970 (2.281 69 to 2.282 28)	57.100 (2.248 03)		
		Distance from center of journal to center of crankpin	60 (2.36)	±0.04 (±0.001 6)			
		Parallelism between journal and crankpin		Runout: 0.01 (0.004), maximum (over crankpin length)			
		Out-of-round of journal and crankpin		0.01 (0.000 4), maximum	0.03 (0.001 2)		
		Taper of journal and crankpin					
		Fillet radius of journal and crankpin	3 (0.12)	±0.2 (±0.008)			
		End play	33 (1.30)	(0.100 to 0.264) ((0.003 94 to 0.010 39))	(0.300) ((0.011 81))		If repair limit has been reached, replace thrust plates. If it has been exceeded, use oversize thrust plates. Thrust plate oversizes: 0.15 (0.005 9) 0.30 (0.011 8) 0.45 (0.017 7)
	Pistons	Outside diameter (at skirt) Standard	94 (3.70)	93.955 to 93.985 (3.699 01 to 3.700 19)		93.770 (3.691 72)	
		Outside diameter (at skirt) 0.25 (0.009 8) oversize		94.205 to 94.235 (3.708 85 to 3.710 03)		94.020 (3.701 57)	
		Outside diameter (at skirt) 0.50 (0.019 7) oversize		94.455 to 94.485 (3.718 69 to 3.719 87)		94.270 (3.711 41)	
		Projection		–0.25 to 0.15 (–0.009 8 to 0.005 9)			Check metal clearance.
		Clearance between piston pin and bore		(0.000 to 0.016) ((0.000 00 to 0.000 63))		(0.050) ((0.001 97))	

Unit: mm (in.)

Group	Item			Nominal size	Assembly standard (standard clearance)	Repair limit (clearance)	Service limit (clearance)	Remarks
Main moving parts	Piston rings	Clearance between groove and ring	No. 1 ring		(0.07 to 0.11) ((0.002 8 to 0.004 3))		(0.200) ((0.007 87))	
			No. 2 ring	2.0 (0.079)	(0.045 to 0.085) ((0.001 77 to 0.003 35))		(0.150) ((0.005 91))	
			Oil ring	4.0 (0.157)	(0.025 to 0.065) ((0.000 98 to 0.002 56))		(0.150) ((0.005 91))	
		Clearance between ends	No. 1, 2 rings		0.30 to 0.50 (0.011 8 to 0.019 7)		1.50 (0.059 1)	
			Oil ring					
	Piston pin	Diameter		30 (1.18)	29.994 to 30.000 (1.180 86 to 1.181 10)			
		Clearance between pin and connecting rod bushing			(0.020 to 0.051) ((0.000 79 to 0.002 01))		(0.080) ((0.003 15))	
	Connecting rod	Inside diameter of bushing		30 (1.18)	30.020 to 30.045 (1.181 89 to 1.182 87)			
		Twist/bend			0.10/100 (0.003 9/3.94), maximum	0.15 (0.005 9)		
		Clearance between crankpin and connecting rod metal			(0.030 to 0.090) ((0.001 18 to 0.003 54))		(0.200) ((0.007 87))	If repair limit has been reached, replace metals. If it has been exceeded, regrind crankpins and use undersize metals.
		End play		35 (1.38)	(0.15 to 0.35) ((0.005 9 to 0.013 8))		(0.50) ((0.020))	Replace connecting rod.
	Fly-wheel	Flatness			0.15 (0.005 9), maximum	0.50 (0.020)		
		Face/bore runout						
Timing gears	Camshaft	Runout			0.02 (0.000 8), maximum	0.05 (0.002 0)		Straighten by cold working or replace.
		Lobe lift C (A – B)	Inlet valve	A = $46.916^{+0.1}_{-0.3}$ ($1.847\,08^{+0.004}_{-0.012}$)	6.684 (0.263 15)		6.184 (0.243 46)	
			Exhaust valve	A = $46.880^{+0.1}_{-0.3}$ ($1.845\,67^{+0.004}_{-0.012}$)	6.720 (0.264 57)		6.220 (0.244 88)	
		Diameter of journals	No. 1, 2, 3	54 (2.13)	53.94 to 53.96 (2.123 6 to 2.124 4)		53.90 (2.122 0)	
			No. 4	53 (2.09)	52.94 to 52.96 (2.084 2 to 2.085 0)		52.90 (2.082 7)	
		End play		5 (0.20)	(0.10 to 0.25) ((0.003 9 to 0.009 8))		(0.30) ((0.011 8))	Replace thrust plates.

Unit: mm (in.)

Group	Item		Nominal size	Assembly standard (standard clearance)	Repair limit (clearance)	Service limit (clearance)	Remarks
Timing gears	Idler gear	Clearance between shaft and bushing		(0.009 to 0.050) ((0.000 35 to 0.001 97))		(0.100) ((0.003 94))	Replace bushing.
		End play	30 (1.18)	(0.05 to 0.20) ((0.002 0 to 0.007 9))		(0.35) ((0.013 8))	Replace thrust plate.
		Fit (interference) of shaft in crankcase bore	30 (1.18)	(0.035T to 0.076T) ((0.001 38T to 0.002 99T))			
	Backlash			(0.03 to 0.18) ((0.001 2 to 0.007 1))		(0.25) ((0.009 8))	Replace gears.
Lubrication system	Oil pump	Clearance between outer rotor and case		(0.20 to 0.30) ((0.007 9 to 0.011 8))		(0.50) ((0.019 7))	
		Diameter of main shaft (case side)	16 (0.63)	15.985 to 16.000 (0.629 33 to 0.629 92)			
		Diameter of main shaft (bushing side)	14 (0.55)	13.957 to 13.975 (0.549 49 to 0.550 20)			
		Clearance between main shaft and case		(0.032 to 0.074) ((0.001 26 to 0.002 91))		(0.150) ((0.005 91))	Replace pump case or pump assembly.
		Clearance between main shaft and bushing		(0.025 to 0.111) ((0.000 98 to 0.004 37))		(0.200) ((0.007 87))	Replace bushing or pump assembly.
		Clearance between inner rotor and outer rotor		(0.13 to 0.15) ((0.005 1 to 0.005 9))		(0.20) ((0.007 9))	
		Clearance between rotors and cover		(0.04 to 0.09) ((0.001 6 to 0.003 5))		(0.15) ((0.005 9))	Repair case or cover.
	Relief valve	Opening pressure, kgf/cm² (psi) [kPa]		3.5 ± 0.5 (50 ± 7) [343 ± 49]			
Cooling system	Thermostat	Temp. at which valve starts opening		76.5 ± 1.5°C (170 ± 2.7°F)			
		Temp. at which valve lift is more than 8 (0.3)		90°C (194°F)			
Fuel system	Injection nozzles	Valve opening pressure, kgf/cm² (psi) [kPa] — FD35 thru FD50	140 (1 991) [13 729]	145 to 151 (2 062 to 2 147) [14 220 to 14 808]			Make shim adjustment. Pressure varies by 10 (142) [980] per 0.1 mm (0.004 in.) thickness of shim.
		Valve opening pressure, kgf/cm² (psi) [kPa] — FD60 and FD70	120 (1 706) [11 768]	120 to 130 (1 706 to 1 849) [11 768 to 12 749]			
		Discharge angle	0°				Test by means of hand tester, using diesel fuel, at 20°C (68°F). If discharge pattern is bad even after nozzle is washed in clean diesel fuel, replace nozzle tip.
		Oil-tightness of needle valve seat	Seat shall hold a test pressure 20 kgf/cm² (284 psi) [1 961 kPa] lower than valve opening pressure for 10 seconds.				Wash or replace nozzle tip.

Unit: mm (in.)

Group	Item		Nominal size	Assembly standard (standard clearance)	Repair limit (clearance)	Service limit (clearance)	Remarks
Electrical system	Starter	Diameter of commutator	38.7 (1.52)			37.7 (1.48)	
		Brush – Length	17 (0.67)			11 (0.43)	
		Brush – Spring force, kgf (lbf) [N]	3.0 (6.6) [29.4]			1.8 (4.0) [17.7]	
		Thrust clearance of pinion shaft	0.5 (0.020)	0, minimum			
		Pinion clearance	0.1 to 2.5 (0.004 to 0.098)				

No-load characteristics			Locked characteristics			Magnetic switch
Voltage V	Current A	Speed rpm	Voltage V	Current A	Torque kgf·m (lbf·ft) [N·m]	Switch-in voltage V
23	85, max.	3 300	9	1 400, max.	9.0 (65) [88], min.	16, max.

Alternator, 24V–30A (standard)	Brush spring force, gf (lbf) [N]		320 to 440 (0.71 to 0.97) [3.1 to 4.3]		200 (0.44) [2.0]	
	Brush length		23 (0.91)		8 (0.31)	
	Resistance in slip rings		8.8Ω			at 20°C (68°F)
Alternator, 24V–35A (standard)	Brush spring force, gf (lbf) [N]		590 to 710 (1.3 to 1.6) [5.8 to 7.0]		330 (0.73) [3.2]	
	Brush length		21.5 (0.85)		8 (0.31)	
	Resistance in slip rings		9 to 10.4Ω			at 20°C (68°F)
Alternator, 24V–35A (option)	Brush spring force, gf (lbf) [N]		320 to 440 (0.71 to 0.97) [3.1 to 4.3]		200 (0.44) [2.0]	
	Brush length		19 (0.75)		6 (0.24)	
	Resistance in slip rings		40Ω			at 20°C (68°F)
Alternator, 24V–50A (option)	Resistance in slip rings		5 to 6Ω			at 20°C (68°F)

2. TIGHTENING TORQUES

2.1 Major bolts and nuts

Secured part or component	Thread dia. x pitch, mm	Width across flats, mm	Tightening torque			Remarks
			kgf·m	lbf·ft	N·m	
Cylinder head	M12 x 1.75	19	12 ± 0.5	87 ± 4	118 ± 5	
Rocker shaft brackets	M8 x 1.25	12	1.5 ± 0.5	11 ± 4	15 ± 5	
Main metal caps	M14 x 2	22	10.5 ± 0.5	76 ± 4	103 ± 5	
Connecting rod caps	M10 x 1.25	14	5.5 ± 0.5	40 ± 4	54 ± 5	
Flywheel	M12 x 1.25	17	8.5 ± 0.5	61 ± 4	83 ± 5	
Camshaft thrust plate	M8 x 1.25	12	1.0 to 1.3	7 to 9	10 to 13	
Front plate	M8 x 1.25	12	1.0 to 1.3	7 to 9	10 to 13	
Timing gear case	M8 x 1.25	12	1.0 to 1.3	7 to 9	10 to 13	
Crankshaft pulley	M30 x 1.5	46	50 ± 1	362 ± 7	490 ± 10	
Idler gear thrust plate	M10 x 1.25	14	3.5 ± 0.5	25 ± 4	34 ± 5	
Oil pan	M8 x 1.25	12	1.0 to 1.3	7 to 9	10 to 13	
Oil pan drain plug	M20 x 1.5	24	8 ± 0.5	58 ± 4	78 ± 5	
Fuel injection nozzles	M20 x 1.5	21	5 to 7	36 to 51	49 to 69	
Fuel leak-off pipe nuts	M12 x 1.5	17	2.0 to 2.5	14 to 18	20 to 25	
Fuel injection pump delivery valve holders	M20 x 1.5	14	3.75 ± 0.25	27 ± 2	37 ± 2.5	
Fuel injection pump gear	M14 x 1.5	22	8.5 to 10	62 to 72	83 to 98	
B teminal of starter	M8 x 1.25	12	1.1 ± 1	8 ± 1	11 ± 1	
Alternator pulley	M20 x 1.5	27	15 ± 1.5	108.5 ± 11	147 ± 15	
Oil pump gear	M10 x 1.25	14	3.4 ± 0.5	25 ± 4	33 ± 5	
Glow plug (body) (terminal)	M10 x 1.25 M4 x 0.7	12 8	1.5 to 2.0 0.10 to 0.15	11 to 14 0.7 to 1.1	15 to 20 1 to 1.5	
Exhaust manifold	M8 x 1.25	12	3.1 ± 0.5	22 ± 4	30 ± 5	
Oil pressure relief valve	M22 x 1.5	27	5 ± 0.5	36 ± 4	49 ± 5	
Blind plug on lower side of crankcase	M18 x 2	24	7 ± 0.5	51 ± 4	69 ± 5	
Coolant drain plug	1/4 x 18NPTF	14	4.5 ± 0.5	33 ± 4	44 ± 5	
Fuel injection pipe nuts	M12 x 1.5	19	2.5 to 3.5	18 to 25	25 to 34	
Fuel return pipe nuts	M10 x 1.25	14	1.6 to 2.4	12 to 17	16 to 24	

2.2 Standard bolts

Thread dia. x pitch, mm	Torque					
	4T			7T and larger		
	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft	N·m
M6 x 1.0	0.4	3	4	0.7	5	7
M8 x 1.25	1.2	9	12	1.7	12	17
M10 x 1.25 M10 x 1.5	2.2	16	22	3.4	25	33
M12 x 1.25 M12 x 1.75	3.6	26	35	6.1	44	60
M14 x 1.5	6.0	43	59	9.9	72	97

2.3 Standard studs

Thread dia. x pitch, mm	Torque (tap end)					
	For driving in aluminum materials			For driving in ferrous materials		
	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft	N·m
M8 x 1.25	0.75	5.4	7.4	1.3	9	13
M10 x 1.5	1.4	10	14	2.4	17	24

2.4 Standard plugs

Thread dia. x pitch, mm	Torque					
	For aluminum materials			For ferrous materials		
	kgf·m	lbf·ft	N·m	kgf·m	lbf·ft	N·m
R1/8 (PT1/8)	1.0	7	10	1.8	13	18
R1/4 (PT1/4)	2.5	18	25	4.0	29	39
R3/8 (PT3/8)	—	—	—	6.5	47	64

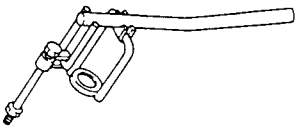
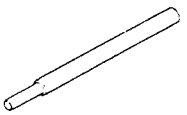
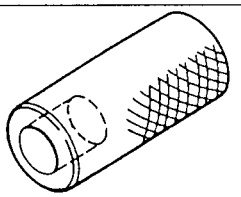
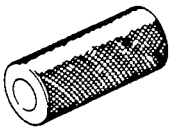
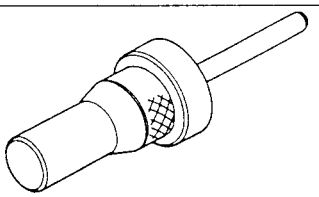
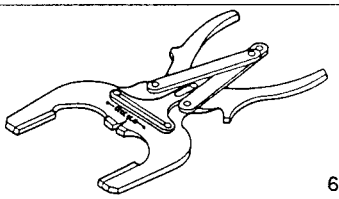
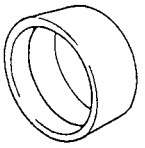
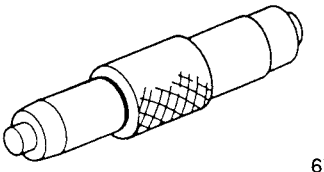
Remarks: 1. The torque values shown above are for the bolts with spring washers.
2. Tolerance on the torque values shown above is ±10%.
3. Unless otherwise specified, use the torque values shown above.
4. Do not apply any oil to the bolt threads.

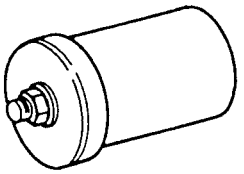
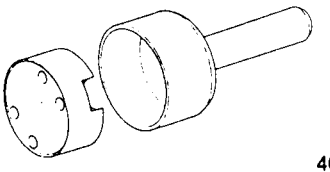
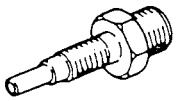
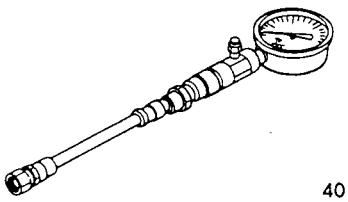
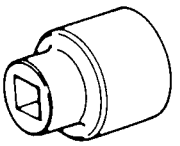
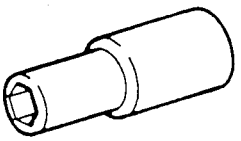
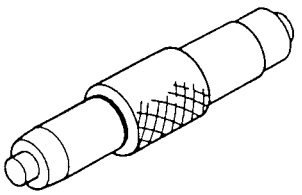
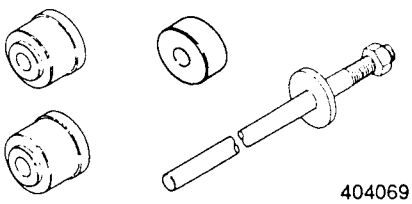
3. SEALANTS

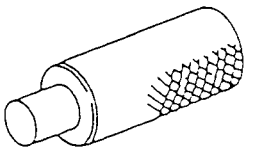
Apply to	Mating part	Sealant	Remarks
Oil pan	Crankcase	Three Bond 1207C	Apply to sealing surfaces of oil pan.
Rear metal cap seat on crankcase	Rear metal cap	Three Bond 1212	Apply to corners of cap before installing cap.
Side seals	Crankcase rear metal cap	Three Bond 1212	Apply to side seals before installing them.
Plug for coolant hole in cylinder head	Cylinder head	Three Bond 1386D	Apply to hole before installing plug.
Plug for coolant hole in crankcase	Crankcase	Three Bond 1386D	Apply to hole before installing plug.
Plug for oil gallery in crankcase	Crankcase	Three Bond 1386D	Apply to hole before installing plug.
Oil return hole blind plug or pipe of crankcase	Crankcase	Three Bond 1344	Apply to plug or pipe before tightening it.
Starter mounting studs	Rear plate	Three Bond 1344	Apply to studs before tightening them.
Crankshaft threads	Crankshaft pulley nut	Three Bond 1212	Apply to threads before tightening nut.
Rear plate	Crankcase	Three Bond 1104	Apply to rear plate and crankcase.

SPECIAL TOOLS

SPECIAL TOOL LIST

Tool name	Part No.	Shape	Application
Valve spring pusher	30691-04500	 401793	Valve spring removal and installation
Valve guide remover	32A91-00300	 670230	Valve guide removal
Valve guide installer	32A91-00100	 670228	Valve guide installation
Stem seal installer	32A91-10200	 405736	Valve stem seal installation
Valve seat insert caulking tool	Inlet valve: 36791-00200 Exhaust valve: 34491-03020	 670232	Valve seat installation
Piston ring pliers	31391-12900	 670240	Piston ring removal and installation
Piston installer	34491-00200	 670234	Piston installation
Idler bushing installer	30091-07300	 670242	Idler gear bushing removal and installation

Tool name	Part No.	Shape	Application
Idler shaft puller	MH061077	 670237	Idler gear shaft removal
Oil seal sleeve installer set	30691-13010	 405733	Crankshaft rear oil seal sleeve installation
Adaptor	30691-21100	 670233	Compression pressure measurement
Compression gauge	33391-02100	 401823	Compression pressure measurement
Turning socket	58309-73100	 400903	Engine turning
Socket	34491-00300	 670235	Camshaft thrust plate and rocker bracket installation
Connecting rod bushing puller	MH061236	 670242	Connecting rod bushing removal and installation
Camshaft bushing installer set	30691-00010	 404069	Camshaft bushing removal and installation

Tool name	Part No.	Shape	Application
Oil pump bushing installer	32A91-00400	 407215	Oil pump bushing installation

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 lube oil consumption and excessive blowby.

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

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

(a) Lack of power

(b) Increase in fuel consumption

(c) Increase in lube oil consumption

(d) Excessive blowby through breather due to worn cylinders, piston rings, etc.

(e) Excessive blowby due to poor seating of worn inlet and exhaust valves

(f) Hard starting

(g) Abnormal sound

In most cases, these problems occur concurrently. Some of them are directly caused by low compression pressure, but others are not. Among the problems 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 problem to be considered as the most valid reason for overhauling the engine is (d); in actually determining when to overhaul the engine, it is reasonable to take this problem into consideration in conjunction with the other problems.