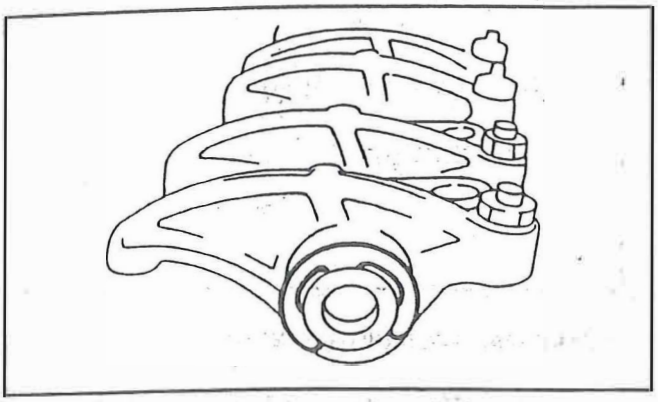
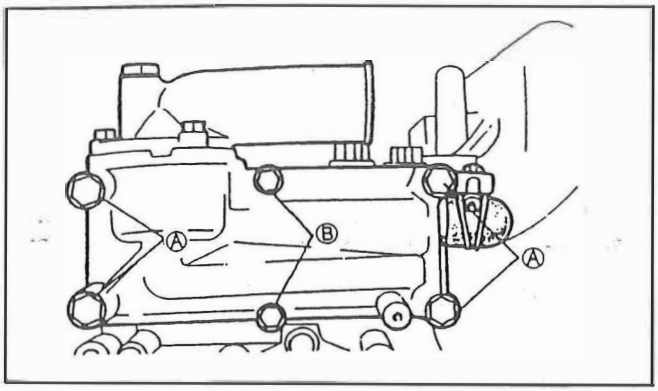
ROCKER ARM INSTALLATION

1. Apply oil on each sliding surface. Install the rocker arms, rocker shaft brackets and springs on the rocker shaft. Install the snap rings.



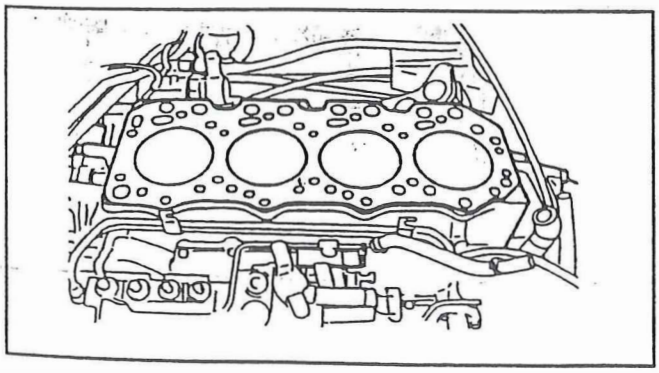
THERMOSTAT HOUSING INSTALLATION

1. Install the thermostat housing, using a new gasket.
   Tightening torque:
   - Ⓐ 1.9-2.6 kgm / (165-226 lbf in) (M8)
   - Ⓑ 0.8-1.1 kgm / (69-95 lbf in) (M6)



CYLINDER HEAD GASKET INSTALLATION

1. Install a new cylinder head gasket on the cylinder block.



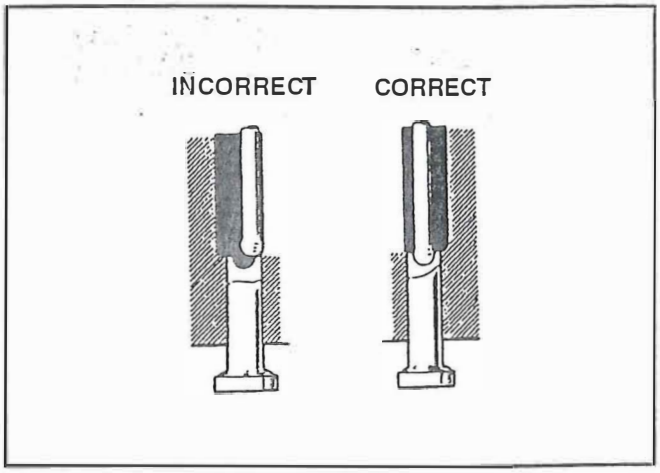
CYLINDER HEAD INSTALLATION

1. Install the cylinder head assembly on the head gasket.

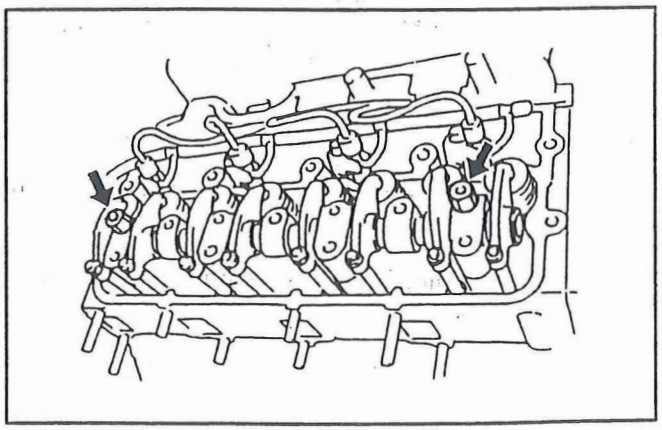
WARNING: The cylinder head is heavy. Be sure that all lifting devices (hoists, cables, chains, slings etc.) are suitable and of adequate capacity to lift the cylinder head. The cylinder head can weigh approximately 33 kg (73 lb).

2. Apply engine oil on the ends of the push rods, and insert them into the tappet followers.

NOTE: Verify that the lower end of the push rod fits properly into the center of the tappet follower as illustrated.



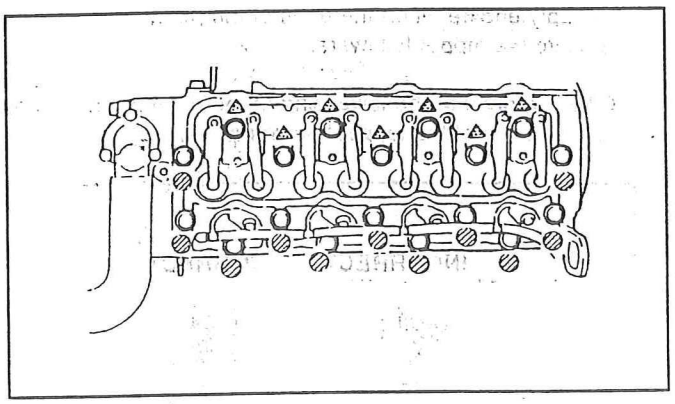
3. Install the rocker arm and shaft assembly on the cylinder head.
   Tightening torque: 1.9-2.6 kgm / (165-226 lbf in)



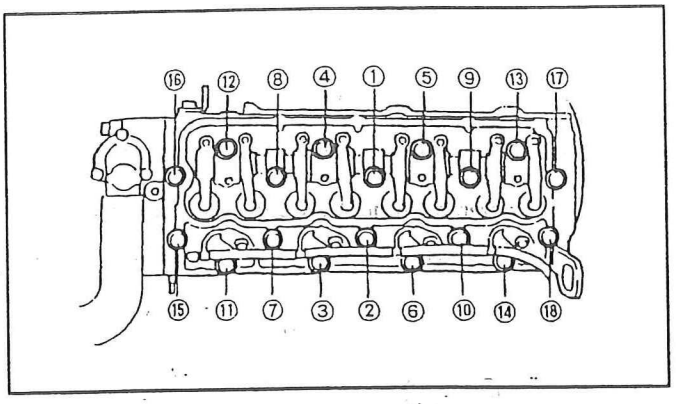
4. Apply engine oil to the seat surface and threads of the cylinder head bolts. Install the cylinder head bolts.

NOTE: Use short bolts for the locations marked: ▨
Use long bolts for the locations marked: △

Reuse the bolt if the cylinder head bolt length is within the limit value. Replace the bolt if the limit value is exceeded.
See: **"CYLINDER HEAD BOLT INSPECTION".**



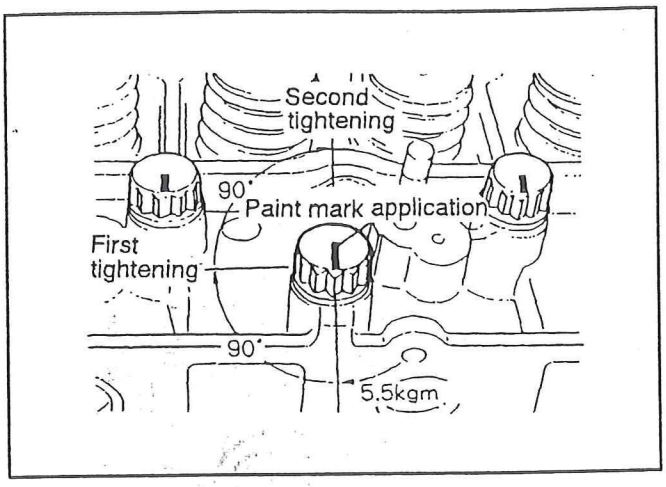
5. Tighten the cylinder head bolts in several stages in the order given in the illustration.
Tightening torque: 5.5 kgm / (40 lbf ft).



6. Apply paint to the head of the cylinder head bolts as shown in the following illustration.

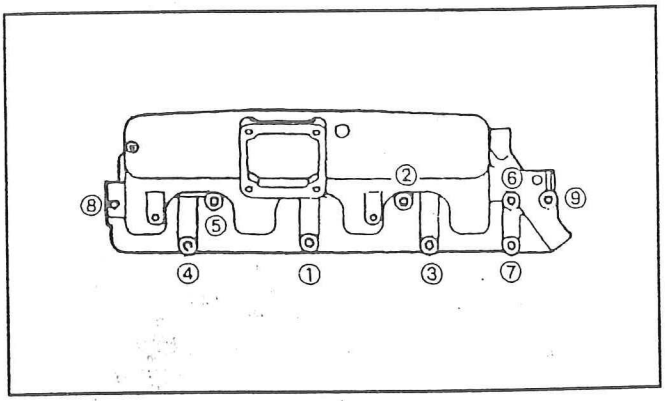
7. Using the paint as a guide, tighten the bolts 90° in the same order used in Step 5.

8. Using the same order, tighten the bolts another 90°.



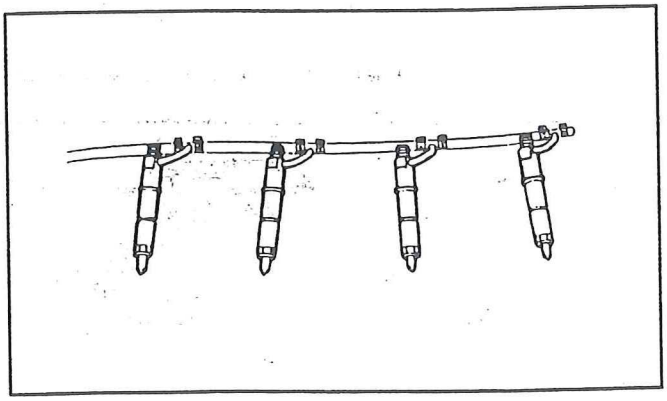
INTAKE MANIFOLD INSTALLATION

1. Install the Intake manifold, using a new gasket. Tighten the bolts using the order given in the illustration.
Tightening torque: 1.9-2.6 kgm / (165-226 lbf in)

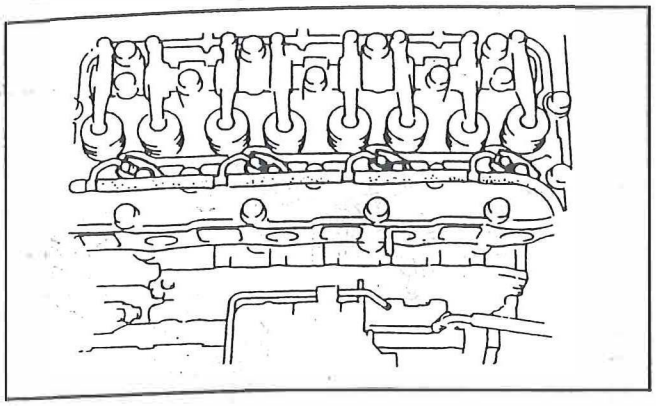


INJECTION NOZZLE INSTALLATION

1. Install a new O-ring and gasket on each injection nozzle and insert them into the cylinder head.

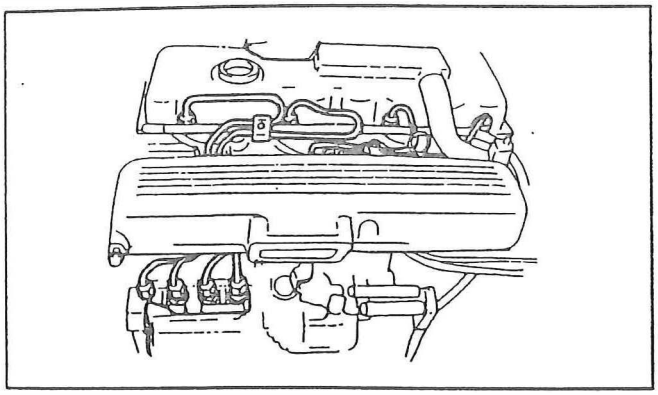


2. Install the injection nozzle holders.
   Tightening torque: 4.7-5.5 kgm / (34-40 lbf ft)



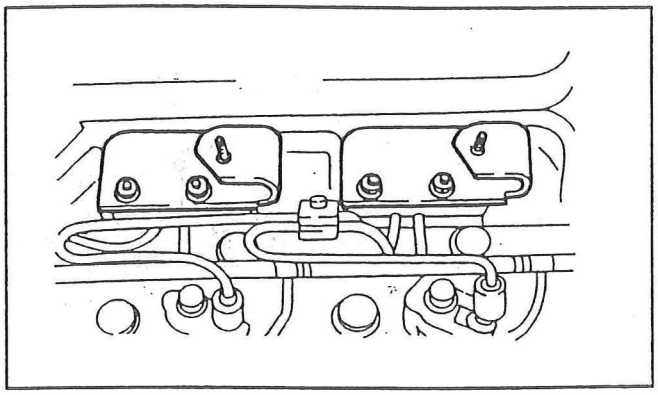
FUEL INJECTOR LINE INSTALLATION

1. Install the injector lines.
   Tightening torque: 2.5-3.0 kgm / (217-260 lbf in)



INJECTOR LINE CLIP INSTALLATION

1. Install the injector line clips.
   Tightening torque: 0.8-1.1 kgm / (69-95 lbf in)

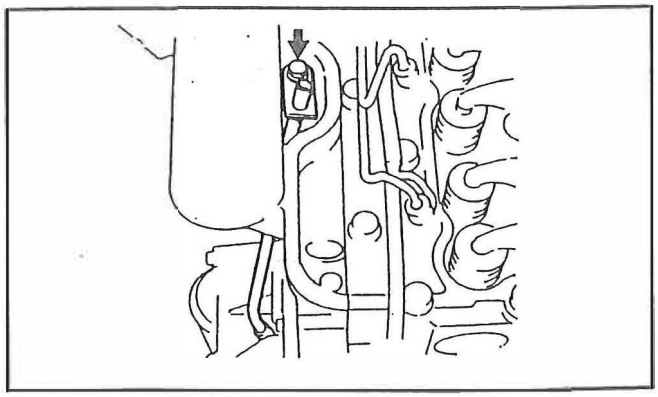


OIL LEVEL GAUGE (DIPSTICK) AND GUIDE PIPE INSTALLATION

1. Install a new O-ring on the oil level gauge guide pipe (dipstick tube). Insert the dipstick tube into the cylinder block and install the retaining bolt.
   Tightening torque: 1.9-2.6 kgm / (165-226 lbf in)

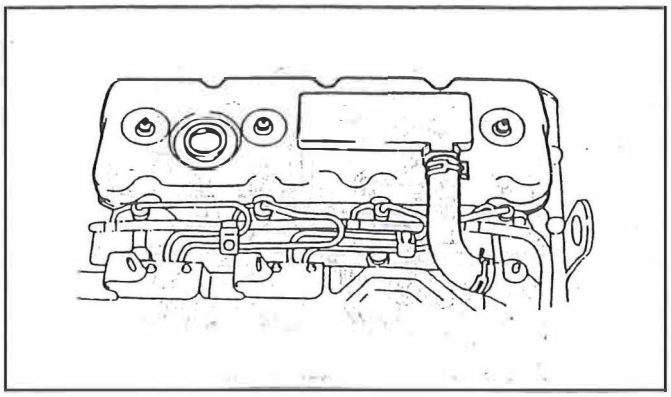
NOTE: Coat the new O-Ring with engine oil before installation.

2. Insert the oil level gauge (dipstick).



CYLINDER HEAD COVER INSTALLATION

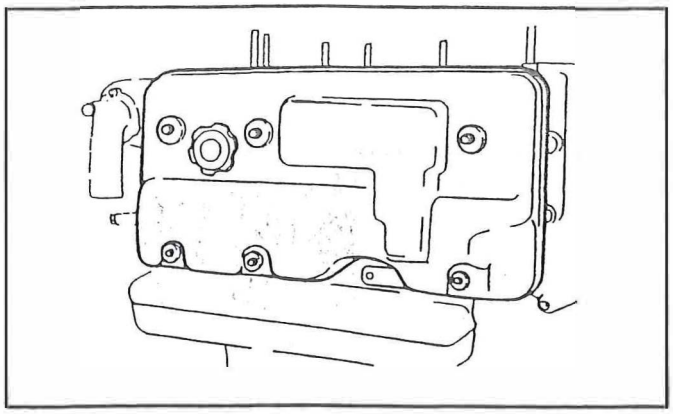
1. Install the cylinder head cover, using a new gasket.
   Tightening torque: 0.35-0.55 kgm / (30-48 lbf in)



SEAL COVER INSTALLATION

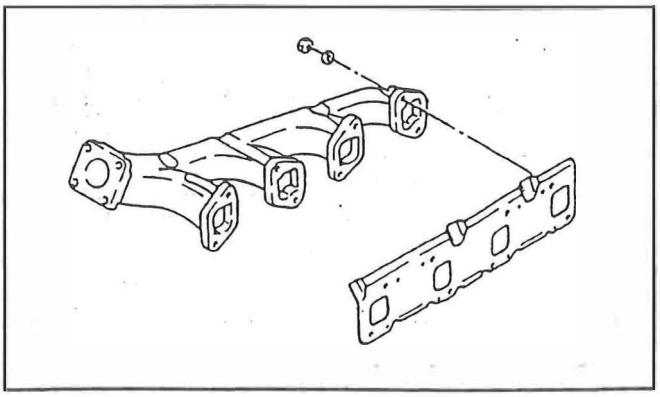
1. Install the seal cover.
   Tightening torque: 0.35-0.55 kgm / (30-48 lbf in)

2. Install the oil filler cap.



EXHAUST MANIFOLD INSTALLATION

1. Install the exhaust manifold, using a new gasket.
   Tightening torque: 4.5-4.9 kgm / (33-35 lbf ft)



ENGINE OVERHAUL WEAR LIMITS

Engine model	TM
Number and arrangement of cylinders	Four vertically aligned cylinders
Bore and stroke mm / (in)	109.0 × 122.0 (4.29 × 4.80)
Total displacement cc / (cu in)	4,553 / (277.8)
Compression ratio	18:1

Valve opening/closing timing			
Intake	Opening (BTDC)		18.4°
	Closing (ABDC)		45°
Exhaust	Opening (BBDC)		49.4°
	Closing (ATDC)		17.3°
Compression Pressure kg/cm² @ rpm / (psi @ rpm)		Standard	30 @ 270 (426.7 @ 270)
		Limit	27 @ 270 (384 psi @ 270)
		Difference between cylinders	3.0 @ 270 (43 psi @ 270)
Valve clearance cold mm / (in)		Intake	0.30 / (0.012)
		Exhaust	0.45 / (0.018)
Cylinder head Distortion limit (longitudinal direction) mm / (in)			0.1-0.25 (.0039-.0098)

Valve seat			
Valve stem protruding length. (With lower valve spring seat installed) mm / in	Intake	Standard	48.40 / (1.906)
		Limit	49.90 / (1.925)
	Exhaust	Standard	48.40 / (1.906)
		Limit	49.90 / (1.925)
Valve seat angle		Intake	45°
		Exhaust	30°
Valve seat width mm / (in)		Intake	1.7 / (.0669)
		Exhaust	1.7 / (.0669)

Valve guide, valve and valve spring			
Clearance valve stem to guide mm / (in)	Standard	Intake	0.038-0.068 (.0015-.0027)
		Exhaust	0.058-0.088 (.0023-.0035)
	Limit Intake / Exhaust		0.127 / (.0050)
Valve guide inner diameter			9.018-9.033
Valve stem diameter mm / (in)	Intake	Standard	8.965-8.980 (.3530-.3535)
		Limit	8.884 / (.3498)
	Exhaust	Standard	8.945-8.960 (.3522-.3528)
		Limit	8.864 / (.3490)
Valve head thickness mm / (in)		Intake	1.0 / (.0394)
		Exhaust	1.0 / (.0394)
Valve face angle		Intake	45°
		Exhaust	30°
Outer valve spring free length mm / (in)		Standard	59.47 / (2.3413)
		Limit	58.47 / (2.3020)
Inner valve spring free length mm / (in)		Standard	53.84 / (2.1197)
		Limit	52.84 / (2.0804)
Valve spring squareness limit mm / (in)		Inner	1.88 / (.0740)
		Outer	2.08 / (.0819)

Rocker arm and shaft		
Clearance rocker arm t o shaft mm / (in)	Standard	0.020-0.062 (.0008-.0024)
	Limit	0.07 / (.0028)
Rocker arm shaft inner diameter mm / (in)		20.959-20.980 (.8252-.8260)
Rocker arm inner diameter mm / (in)		21.000-21.021 (.8268-.8276)
Tappet		
Tappet diameter mm / (in)		15.518-15.533 (.6109-.6115)
Tappet bore diameter (cylinder block) mm / (in)		15.588-15.619 (.6137-.6149)
Clearance tappet to bore mm / (in)	Standard	0.055-0.101 (.0022-.0040)
Clearance tappet to bore mm / (in)	Limit	0.15 / (.0059)

Camshaft			
Camshaft deflection limit mm / (in)			0.08 / (.0031)
Camshaft end play mm / (in)		Standard	0.020-0.180 (.0008-.0071)
		Limit	0.30 / (.0118)
Journal diameter standard diameter mm / (in)		No. 1	58.410-58.440 (2.2996-2.3008)
		No. 2	58.160-58.190 (2.2898-2.2909)
		No. 3	57.910-57.940 (2.2799-2.2811)
		No. 4	57.660-57.690 (2.2701-2.2713)
Journal diameter limit diameter			0.08 / (.0031)
Camshaft bore standard diameter mm / (in)		No. 1	58.500-58.530 (2.3031-2.3043)
		No. 2	58.250-58.280 (2.2933-2.2945)
		No. 3	58.000-58.030 (2.2835-2.2846)
		No. 4	57.750-57.780 (2.2736-2.2748)
Journal oil clearance mm / (in)		Standard	0.06-0.12 (.0024-.0047)
		Limit	0.145 / (.0057)
Cam height mm / (in)	Intake	Standard	48.415 / (1.9061)
		Limit	47.886 / (1.8853)
	Exhaust	Standard	48.547 / (1.9113)
		Limit	47.996 / (1.8896)

Timing gear		
Gear backlash mm / (in)	Standard	0.06-0.18 (.0024-.0071)
	Limit	0.30 / (.0118)
Idle gear end play mm / (in)		0.05-0.22 (.0020-.0087)
Idle gear bushing inner diameter mm / (in)		44.009-44.034 (1.7326-1.7336)
Idle gear spindle diameter mm / (in)		43.950-43.975 (1.7303-1.7313)
Clearance bushing to spindle mm / (in)	Standard	0.034-0.084 (.0013-.0033)
	Limit	0.15 / (.0059)

Connecting rod and bearings		
Length (between hole centers) mm / (in)		187.000-187.050 (7.3622-7.3642)
Bending limit mm / (in)		0.1 per 100 mm (.0039 per 3.937 in)
Inner diameter of small end mm / (in)		38.000-38.039 (1.4961-1.4976)
Clearance small end bushing to piston pin mm / (in)	Standard	0.012-0.040 (.0005-.0016)
	Limit	0.05 / (.0020)
End play Large end mm / (in)	Standard	0.200-0.400 (.0079-.0157)
	Limit	0,50 / (.0197)
Oil clearance Large end mm / (in)	Standard	0.040-0.062 (.0016-.0024)
	Limit	0.10 / (.0039)
Bearings Undersize available mm / (in)		0.254 / (.0100) 0.508 / (.0200) 0.762 / (.0300)

Crankshaft and bearing		
Crank pin diameter (Standard bearings) mm / (in)	Standard	63.987-64.000 (2.5192-2.5197)
	Minimum	63.75 / (2.5098)
Maximum variation min. O.D. to max. O.D. (crank pin runout)		0.05 (.0020)
Main journal diameter (Standard bearings) mm / (in)	Standard No. 1,2,4,5	78.980-79.000 (3.1094-3.1102)
	Minimum No. 1,2,4,5	78.306 (3.0829)
	Standard No. 3	78.954-78.974 (3.1084-3.1092)
	Minimum No. 3	78.280 (3.0819)
Maximum variation min. O.D. to max. O.D. (main journal runout)		0.05 (.0020)
Main journal oil clearance mm / (in)	Standard No. 1,2,4,5	0.058-0.092 (.0023-.0036)
	Limit No. 1,2,4,5	0.12 (.0047)
	Standard No. 3	0.084-0.118 (.0033-.0046)
	Limit No. 3	0.15 (.0059)
Bearings Undersize available mm / (in)		0.254 / (.0100) 0.508 / (.0200) 0.762 / (.0300)
Crankshaft deflection limit (runout) mm / (in)		0.05 (.0020)
Crankshaft end play mm / (in)	Standard	0.14-0.39 (.0055-.0154)
	Limit	0.40 / (.0157)

Cylinder block, piston and piston ring		
Block surface distortion limit Left to right mm / (in) Front to rear mm / (in)		0.1 / (.0039) 0.25 / (.0098)
Cylinder liner standard inner diameter mm / (in)		109.005-109.031 (4.2915-4.2926)
Cylinder liner wear limit mm / (in)		0.2 / (.0079)
Cylinder liner projection amount mm / (in)		0-0.090 (0-0.0035)
Piston diameter mm Measurement location: Vertical toward piston pin, 22 mm / (.8661 in) above piston bottom end.		Y: 108.945-108.958 (4.2892-4.2897) Z: 108.932-108.945 (4.2887-4.2892)
Clearance piston to liner Maximum mm / (in)		0.060-0.086 (.0024-.0034)
Width of piston ring groove mm / (in)	Top	3.170-3.190 (.1248-.1256)
	Second	2.030-2.050 (.0799-.0807)
	Oil	3.020-3.040 (.1189-.1197)
Piston ring width mm / (in)	Top	2.970-2.990 (.1169-.1177)
	Second	1.970-1.990 (.0776-.0783)
	Oil	2.970-2.990 (.1169-.1177)
Clearance piston ring to piston ring groove mm / (in)	Top	0.130-0.220 (.0051-.0087)
	Second	0.04-0.08 (.0016-.0031)
	Oil	0.03-0.07 (.0012-.0028)
	Limit	0.30 / (.0118)
Piston ring gap mm / (in)	Top	0.30-0.40 (.0118-.0157)
	Second	0.40-0.55 (.0157-.0217)
	Oil	0.20-0.40 (.0079-.0157)
	Limit	1.5 / (.0591)
Piston pin diameter mm / (in)		34.993-35.000 (1.3777-1.3780)
Piston pin hole diameter (in piston) mm / (in)		34.996-35.008 (1.3778-1.3783)

TORQUE SPECIFICATIONS

NOTE: Follow instructions in "Engine Reassembly" during assembly and torque procedures.

Item	Tightening torque lbf ft	Tightening torque lbf in	Tightening torque kgm
Cylinder head (when cold)	40 + 90° + 90°	477 +90° + 90°	5.5 +90° + 90°
Cylinder head cover and head seal cover	3-4	30-48	0.35-0.55
Connecting rod cap	65 → Loosen → 25 +90°	781→Loosen→304 +90°	9.0 → Loosen → 3.5 +90°
Main baring cap	87 → Loosen → 33 +90°	1042→Loosen→391+90°	12.0 → Loosen → 4.5 +90°
Camshaft thrust plate	14-19	165-226	1.9-2.6
Camshaft gear	77-99	929-1189	10.7-13.7
Idle gear	14-19	165-226	1.9-2.6
Fuel injection pump assembly	14-19	165-226	1.9-2.6
Injection pump timer	43-51	521-608	6.0-7.0
Rocker arm assembly	40 + 90° + 90°	477 + 90° + 90°	5.5 + 90° + 90°
Timing gear case	14-19	165-226	1.9-2.6
Timing gear cover	14-19	165-226	1.9-2.6
Oil pump	14-19	165-226	1.9-2.6
Oil pump strainer	M6:6-8 M8:14-19	M6:69-85 M8:165-226	M6: 0.8-1.1 M8: 1.9-2.6
Oil pan	14-19	165-226	1.9-2.6
Water pump	14-19	165-226	1.9-2.6
Crankshaft pulley	282-318	———	39.0-44.0
Coolant temperature sending unit (water temperature, air heater)	4-7	52-78	0.6-0.9
Oil pressure switch	7-11	87-130	1.0-1.5
Air heater and air intake elbow	14-19	165-226	1.9-2.6
Injection nozzle holder	34-40	408-477	4.7-5.5
Injection pipe flare nut	18-22	217-260	2.5-3.0
Cooling fan	14-19	165-226	1.9-2.6
Intake manifold	14-19	165-226	1.9-2.6
Exhaust manifold	33-35	391-425	4.5-4.9
Pump drive plate	23-34	278-408	3.2-4.7
Piston cooling jet	9-13	104-156	1.2-1.8
Oil cooler	14-19	165-226	1.9-2.6
Oil filter body	14-19	165-226	1.9-2.6
Main oil filter	13-17	156-200	1.8-2.3
	After tightening by hand, tighten another 1/4 turn with a filter wrench		
Bypass oil filter	14-18	174-217	2.0-2.5
End plate	M8: 12-17 M14: 56-76	M8: 139-200 M14: 668-911	M8: 1.6-2.3 M14: 7.7-10.5
Flywheel	152-166	———	21.0-23.0
Alternator bracket	27-38	330-460	3.8-5.3
Alternator strap	14-19	165-226	1.9-2.6
Fuel pipe (eye bolt)	14-18	174-217	2.0-2.5
Oil pipe (eye bolt)	7-9	87-113	1.0-1.3
Fuel filter	After tightening by hand, tighten another 1/4 turn with a filter wrench		
Fuel filter hose clamp	———	13-16.5	0.15-0.19
Engine mount	30-36	362-434	4.17-5.0

TROUBLESHOOTING GUIDE

Problems	Possible causes	Remedy
Low output, Improper, sluggish acceleration	**Low compression pressure** * The valve clearance is incorrect * The compression pressure is leaking past the valve seat. * Seizure of the valve stem * Fatigue or damage of the valve spring * Failure of the cylinder head gasket * Cracks or strain in the cylinder head * Stuck, damaged or worn piston rings * Worn or cracked piston	 Adjust Repair (fit the valve) Replace Replace Replace Replace Replace Replace
	Improper fuel system operation	Refer to fuel system section
Excessive engine oil consumption	* Worn or stuck piston ring or worn piston ring grooves * Worn piston or cylinder * Valve seal defective * Worn valve stem and / or guide	Replace Replace or repair Replace Replace
	Oil leakage	Refer to lubrication system section
Hard starting	**Defect in engine main body** * Burnt valves * Worn piston, piston ring and / or cylinder * Damaged or cracked cylinder head	 Replace Replace or repair Replace
	Defect in fuel system	Refer to fuel system section
	Defect in electrical system	Refer to electrical part section
Irregular engine operation (Engine missing)	**Defect in engine main body** * Incorrect valve clearance * Sticking or burning of valves * Fatigued or broken valve springs * Carbon accumulation in combustion chamber	 Adjust Replace Replace Remove
	Defect in fuel system	Refer to fuel system section
Rough idling, stalling	**Defect in engine main body** * Incorrect valve clearance * Sticking or leaking valves * Leaking cylinder head gasket	 Adjust Repair or replace Replace
	Defect in fuel system	Refer to fuel system section
Engine noise	**Crankshaft and bearing system** * Excessive main bearing oil clearance * Seized or spun main bearings * Excessive crankshaft end play * Excessive oil clearance for connecting rod bearings * Seized or spun connecting rod bearings * Wear or seizure of connecting rod bushing	 Replace or repair Replace Replace or repair Replace Replace Replace

Problems	Possible causes	Remedy
Engine noise	**Piston system**	
	* Cylinder wear	Replace
	* Wear of piston or piston pin	Replace
	* Seized piston	Replace
	* Stuck or broken piston ring	Replace
	* Bent connecting rod	Replace
	Valve and timing system	
	* Excessive valve clearance	Adjust
	* Broken valve spring	Replace
	* Excessive gap between valve stem and guide	Replace
	Others	
	* Defective water pump bearings	Replace
	* Incorrect alternator belt tension or worn belt	Adjust
	* Defective alternator bearings	Replace
	* Exhaust gas leakage	Repair
	* Compression leak past fuel injection nozzle	Repair