ANNEX B

ISUZU DIESEL ENGINE – MODEL 4LE1

WORKSHOP MANUAL

ANNEX B

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CONTENTS

(continued)

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ANNEX B

ISUZU DIESEL ENGINE - MODEL 4LE1 WORKSHOP MANUAL

FOREWORD

This Workshop Manual is designed to help you perform necessary maintenance, service, and repair procedures on applicable Isuzu industrial engines. Information contained in this Workshop Manual is the latest available at the time of publication. Isuzu reserves the right to make changes at any time without prior notice.

SECTION 1 - GENERAL INFORMATION

GENERAL REPAIR INSTRUCTIONS

1 General repair instructions for the 4LE1 engine are as follows:

(1) Before performing any service operation with the engine mounted, disconnect the grounding cable from the battery. This will reduce the chance of cable damage and burning due to short circuiting.

(2) Always use the proper tool or tools for the job at hand. Where specified, use the specially designed tool or tools.

(3) Use genuine ISUZU parts referring ISUZU PARTS CATALOG for the engines.

(4) Never reuse cotter pins, gaskets, O-rings, lock washers, and self locking nuts. Discard them as you remove them. Replace them with new ones.

(5) Always keep disassembled parts neatly in groups. This will ensure a smooth reassembly operation. It is especially important to keep fastening parts separate. These parts vary in hardness and design, depending on their installation position.

(6) All parts should be carefully cleaned before inspection or reassembly. Oil ports and other openings should be cleaned with compressed air to make sure that they are completely free of obstructions.

(7) Rotating and sliding part surfaces should be lubricated with oil or grease before reassembly.

(8) If necessary, use a sealer on gaskets to prevent leakage.

(9) Nut and bolt torque specifications should be carefully followed.

(10) Always release the air pressure from any machine-mounted air tank(s) before dismounting the engine or disconnecting pipes and hoses.

(11) Always check and recheck your work. No service operation is complete until you have done this.

2 Information contained in the "Main Data and Specifications" of the Workshop Manual and the Instruction Manual may differ. In this case, the information contained in the Instruction Manual should be considered applicable.

NOTES ON THE FORMAT OF THIS MANUAL

3 This Workshop Manual is applicable to the 4LB1, 4LC1, 4LE1 family of industrial diesel engines. Unless otherwise specified, these engines have common parts and components as well as data and specifications.

4 Illustrations used in this Workshop Manual are based on the 4LE1 engines.

(1) Find the applicable section by referring to the Table of Contents at the beginning of the Manual.

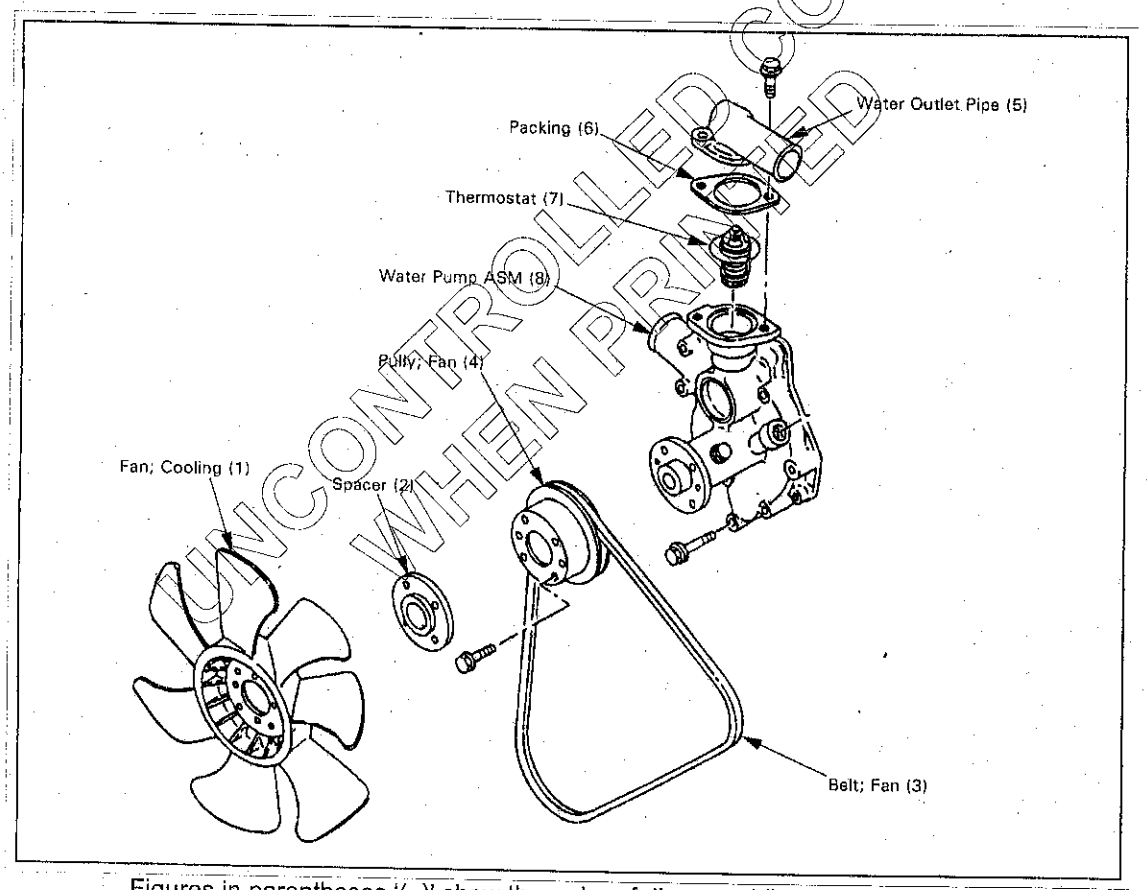
(2) Common technical data such as general maintenance items, service specifications, and tightening torques are included in the "General Information" section.

(3) Each section is divided into sub-sections dealing with disassembly, inspection and repair, and reassembly.

(4) When the same servicing operation is applicable to several different units, the manual will direct you to the appropriate page.

(5) For the sake of brevity, self-explanatory removal and installation procedures are omitted. More complex procedures are covered in detail.

(6) Each service operation section in this Workshop Manual begins with an exploded view of the applicable area.



Figures in parentheses '( )' show the order of disassembling or reassembling.

Fig 1 Typical exploded view

(7) Measurement criteria are defined by the terms "standard" and "limit". A measurement falling within the "standard" range indicates that the applicable part or parts are serviceable. "Limit" should be thought of as an absolute value. A measurement which is outside the "limit" indicates that the applicable part or parts must be either repaired or replaced.

(8) Components and parts are listed in the singular form throughout the Manual.

(9) Directions used in this manual are as follows:

Front	The cooling fan side of the engine viewed from the flywheel.
Right	The injection pump side of the engine.
Left	The exhaust manifold side of the engine.
Rear	The flywheel side of the engine.

Cylinder numbers are counted from the front of the engine.

The front most cylinder is No. 1 and rear most cylinder is No. 4.

The engine's direction of rotation is counterclockwise viewed from the flywheel.

MODEL 4LE1 APPEARANCE

5 Left and right-hand views of the Model 4LE1 engine are shown below.

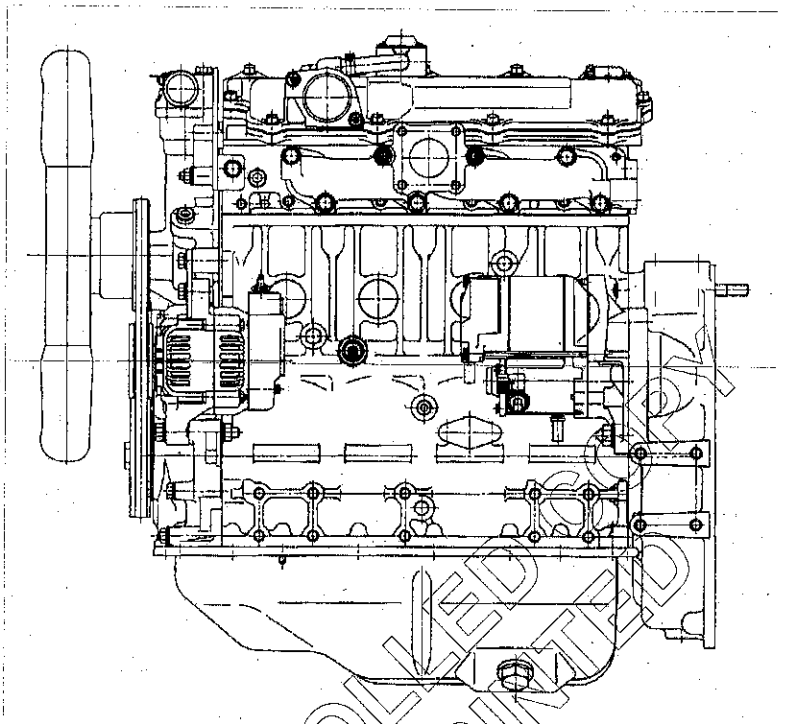


Fig 2 Left side view

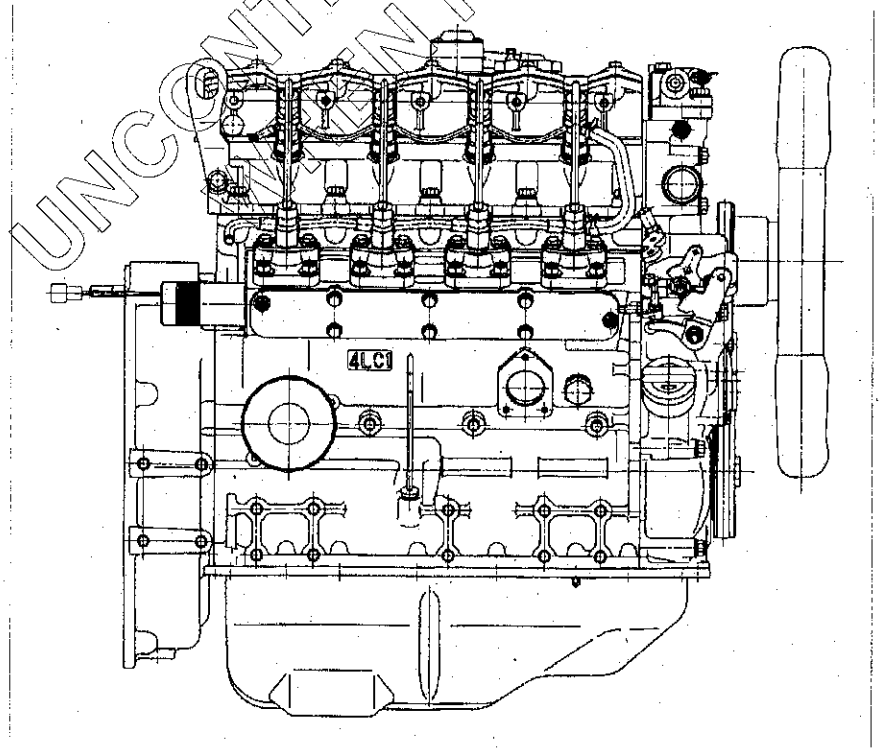


Fig 3 Right side view

MAIN DATA AND SPECIFICATIONS

6 Main data and specifications for the Model 4LE1 engine are shown below.

TABLE 1 MODEL 4LE1 SPECIFICATIONS

Item			4LE1
Type			In-line water cooled 4-cycle type, OHV: diesel engine
Timing drive system			Gear drive
Number of piston rings			Compression rings 2, and oil ring 1
No. of cylinders - Bore x Stroke		mm	4 – 85 x 92
Displacement		cc (cid)	2179 (133)
Compression ratio			21.5 : 1
Type of combustion chamber			Swirl chamber
Overall Length x Width x Height		mm	691 x 449 x 616
Dry weight kg (lb)			155 (342)
Fuel injection timing (BTDC)		(when at stop)	* 16°
Firing order			1 – 3 – 4 – 2
Fuel			Highspeed diesel fuel (SAE No.2)
Idling speed		r.p.m	* 850
Compression pressure		kg/cm² (psi/MPa)	31 (441/3) or more/250 r.p.m.
Valve clearance (cold)		Intake	0.4 (0.0157)
mm (in)		Exhaust	0.4 (0.0157)
Valve operating timing	Intake valve	Open (BTDC)	15°
		Close (ABDC)	29°
	Exhaust valve	Open (BBDC)	40°
		Close (ATDC)	16°
Injection pump			Bosch type
Governor			Mechanical type
Nozzle			Throttle type
Injection pressure		kg/cm² (psi/MPa)	* 135 (1920/13.2)
Oil pump			Trochoid type
Oil filter			Cartridge type
Lubricant capacity: In total		lit (qts)	* About 8.7 (9.2)
Generator output		(V – A)	* 12 – 20
Starter output		(V – KW)	* 12 – 1.0

NOTE

These specifications may be subject to change without notice. Figures in the column with an asterisk (*) are different for each machine. Refer to the specifications provided by the machine manufacturers.

TIGHTENING TORQUE SPECIFICATIONS

7 The tightening torque values given in the table below are applicable to the bolts unless otherwise specified.

TABLE 2 TIGHTENING TORQUE SPECIFICATIONS FOR STANDARD BOLT

kg·m (lb.ft/N·m)

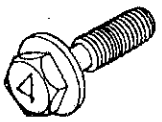
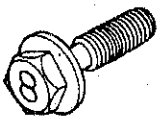
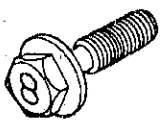
Strength Class / Bolt Identification / Bolt Diameter x Pitch (mm)	4.8 (4T)	(7T)	8.8		9.8 (9T)
			Refined	Non-Refined	
	4	7	8	8	9
	no mark	—			
M6 x 1.0	0.4 0.8 (2.9 5.8/3.9 17.7)	0.5 1.0 (3.6 7.2/4.9 9.8)			
M8 x 1.25	0.8 1.8 (5.8 13.0/7.8 17.7)	1.2 2.3 (8.7 16.6/11.8 22.6)			1.7 3.1 (12.3 22.4/16.7 30.4)
M10 x 1.25	2.1 3.5 (15.2 25.3/20.6 34.3)	2.8 4.7 (20.3 34.0/27.5 46.1)			3.8 6.4 (27.5 46.3/37.3 62.8)
M12 x 1.25	5.0 7.5 (36.2 54.2/49.0 73.6)	6.2 9.3 (44.8 67.3/60.8 91.2)			7.7 11.6 (55.7 83.9/75.5 113.8)
M14 x 1.5	7.8 11.7 (56.4 84.6/78.5 114.7)	9.5 14.2 (68.7 102.7/93.2 139.3)			11.6 17.4 (83.9 125.6/113.8 170.6)
M16 x 1.5	10.6 16.0 (76.7 115.7/103.0 156.9)	9.5 14.2 (68.7 102.7/93.2 139.3)			11.6 17.4 (83.9 125.6/113.8 170.6)
M18 x 1.5	15.4 23.0 (111.1 166.4/151.0 225.6)	19.9 29.9 (143.9 216.3/195.2 391.3)			23.4 35.2 (169.3 254.6/229.5 345.2)
M20 x 1.5	21.0 31.6 (151.9 288.6/205.9 307.9)	27.5 41.3 (198.9 298.7/269.7 405.0)			32.3 48.5 (233.6 350.8/316.8 475.6)
M22 x 1.5	25.6 42.2 (185.2 305.2/251.1 413.8)	37.0 55.5 (267.6 401.4/362.9 544.3)			43.3 64.9 (313.2 469.4/424.6 636.5)
M24 x 2.0	36.6 55.0 (264.7 397.8/358.9 539.4)	43.9 72.5 (317.5 523.9/430.5 711.0)			56.5 84.7 (408.7 612.6/554.1 830.6)
*M10 x 1.5	2.0 3.4 (14.5 24.6/19.6 32.4)	2.8 4.6 (20.3 33.3/27.5 45.1)			3.7 6.1 (26.8 44.1/36.3 59.8)
*M12 x 1.5	4.6 7.0 (33.3 50.6/45.1 68.7)	5.8 8.6 (42.0 62.2/56.9 84.3)			7.3 10.9 (52.8 78.8/71.6 106.9)
*M14 x 2.0	7.3 10.9 (52.8 78.8/71.6 106.9)	9.0 13.4 (65.1 96.9/88.3 131.4)			10.9 16.3 (78.8 118.9/106.9 159.9)
*M16 x 2.0	10.2 15.2 (73.8 110.0/100.0 149.1)	13.2 19.8 (95.5 143.2/129.5 194.2)			15.6 23.4 (112.8 169.3/162.8 229.5)

An asterisk (*) indicates that the bolts are used for female threaded parts that are made of soft materials such as casting. Those shown in parentheses in the Strength Class indicate the classification by the old standard.

8 The tightening torque values given in the table below are applicable to the bolts unless otherwise specified.

TABLE 3 TIGHTENING TORQUE SPECIFICATIONS FOR FLANGED HEAD BOLT

kg·m (lb.ft/N·m)

Bolt head marking / Nominal size (dia. x pitch)			
M6 x 1	0.5 0.9 (3.61 6.50/4.6 8.5)	0.6 1.2 (4.33 8.67/5.88 11.76)	-
M8 x 1.25	1.1 2.0 (7.95 14.46/10.78 19.61)	1.4 2.9 (4.33 8.67/5.88 11.76)	1.9 3.4 (13.74 24.59/18.63 33.34)
M10 x 1.25	2.3 3.9 (17.35 28.20/23.53 38.24)	3.6 6.4 (26.03 44.12/35.30 59.82)	4.3 7.2 (31.10 52.07/42.16 70.60)
*M10 x 1.5	2.3 3.8 (16.63 27.48/22.55 37.26)	3.5 5.8 (25.31 41.95/34.32 56.87)	4.1 6.8 (29.65 49.18/40.20 66.68)
M12 x 1.25	5.6 8.4 (40.50 60.75/54.91 82.37)	7.9 11.9 (57.14 86.07/77.47 116.69)	8.7 13.0 (62.92 94.02/85.31 127.48)
*M12 x 1.75	3.5 9.5 (37.61 56.41/50.99 76.49)	7.3 10.9 (52.80 78.83/71.58 106.89)	8.1 12.2 (58.58 88.24/79.43 119.64)
M14 x 1.5	8.5 12.7 (61.48 91.85/83.35 124.54)	11.7 17.6 (84.62 127.30/114.73 172.59)	12.6 18.9 (91.13 136.70/123.56 185.34)
*M14 x 2	7.6 11.5 (57.14 85.34/77.47 115.71)	11.1 16.6 (80.28 120.06/108.85 162.79)	11.8 17.7 (85.34 128.02/115.71 173.57)
M16 x 1.5	11.8 17.7 (85.34 128.02/115.71 173.57)	17.1 26.5 (125.85 189.50/170.63 256.93)	18.0 27.1 (130.19 196.01/176.52 265.76)
*M16 x 2	11.2 16.7 (81.00 120.79/109.83 163.77)	16.6 24.9 (120.06 180.10/162.79 244.18)	17.2 25.7 (124.40 186.61/168.67 253.01)

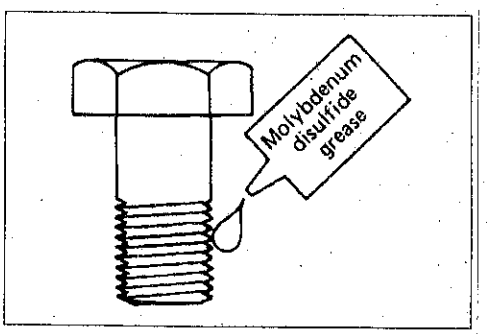
A bolt with an asterisk (*) is used for female screws of soft material such as cast iron.

ANGULAR NUT AND BOLT TIGHTENING METHOD

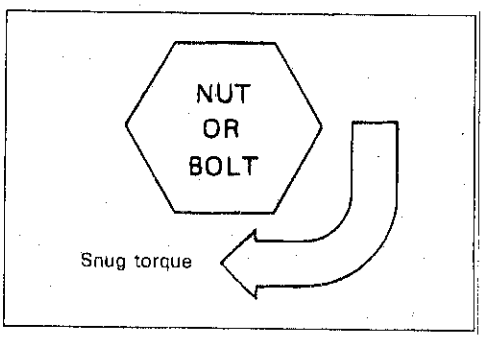
9 The method for angular nut and bolt tightening is as follows:

(1) Carefully wash the nuts and bolts to remove all oil and grease.

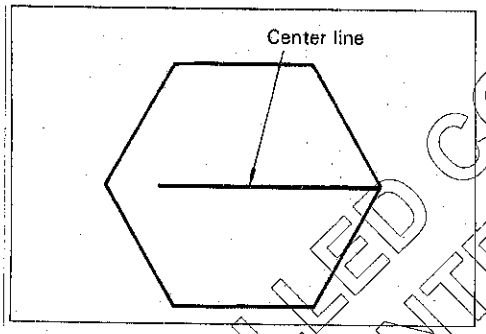
(2) Apply a coat of molybdenum disulphide grease to the threads and setting faces of the nuts and bolts.



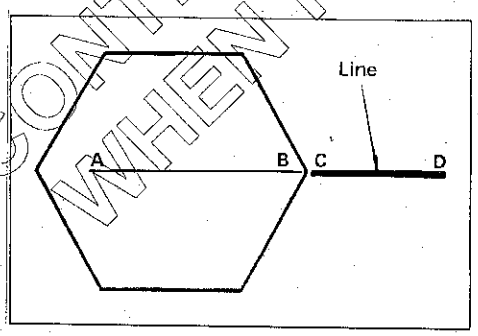
(3) Tighten the nuts and bolts to the specified torque (snug torque) with a torque wrench.



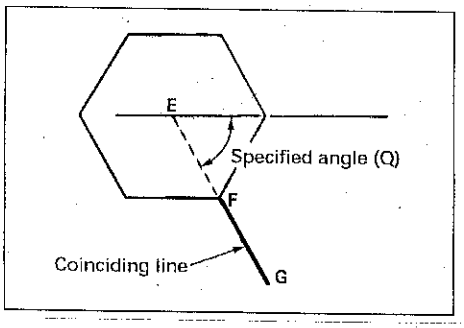
(4) Draw a line [A-B] across the centre of each bolt. Centre line



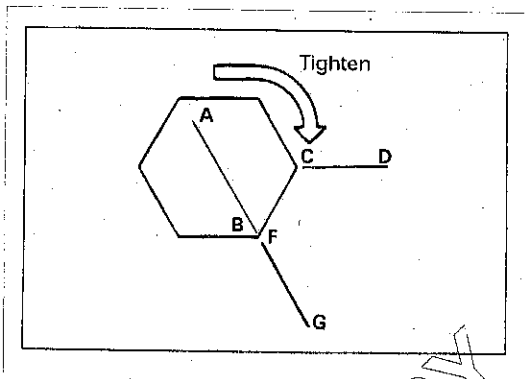
(5) Draw another line [C-D] on the face of each of the parts to be clamped. This line should be an extension of the line [A-B].



(6) Draw another line [F-G] on the face of each of the parts to be clamped. This line will be in the direction of the specified angle [Q] across the centre [E] of the nut or bolt.



(7) Use a socket wrench to tighten each nut or bolt to the point where the line [A-B] is aligned with the line [F-G].



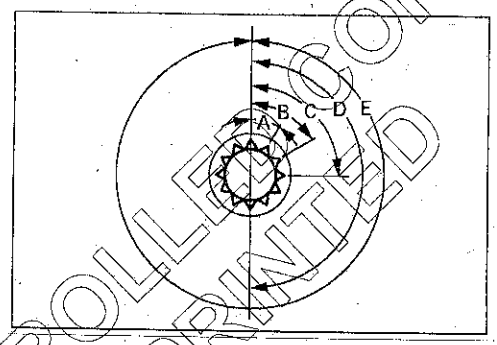


TABLE 4 SPECIFIED ANGLE AND TIGHTENING ROTATION

A	30°	1/12 of a turn
B	60°	1/6 of a turn
C	90°	1/4 of a turn
D	180°	1/2 of a turn
E	360°	One full turn

TIGHTENING TORQUE ON MAJOR COMPONENTS

10 The tightening torques on major components are shown in Figs 4 to 9.

Cooling fan and water pump

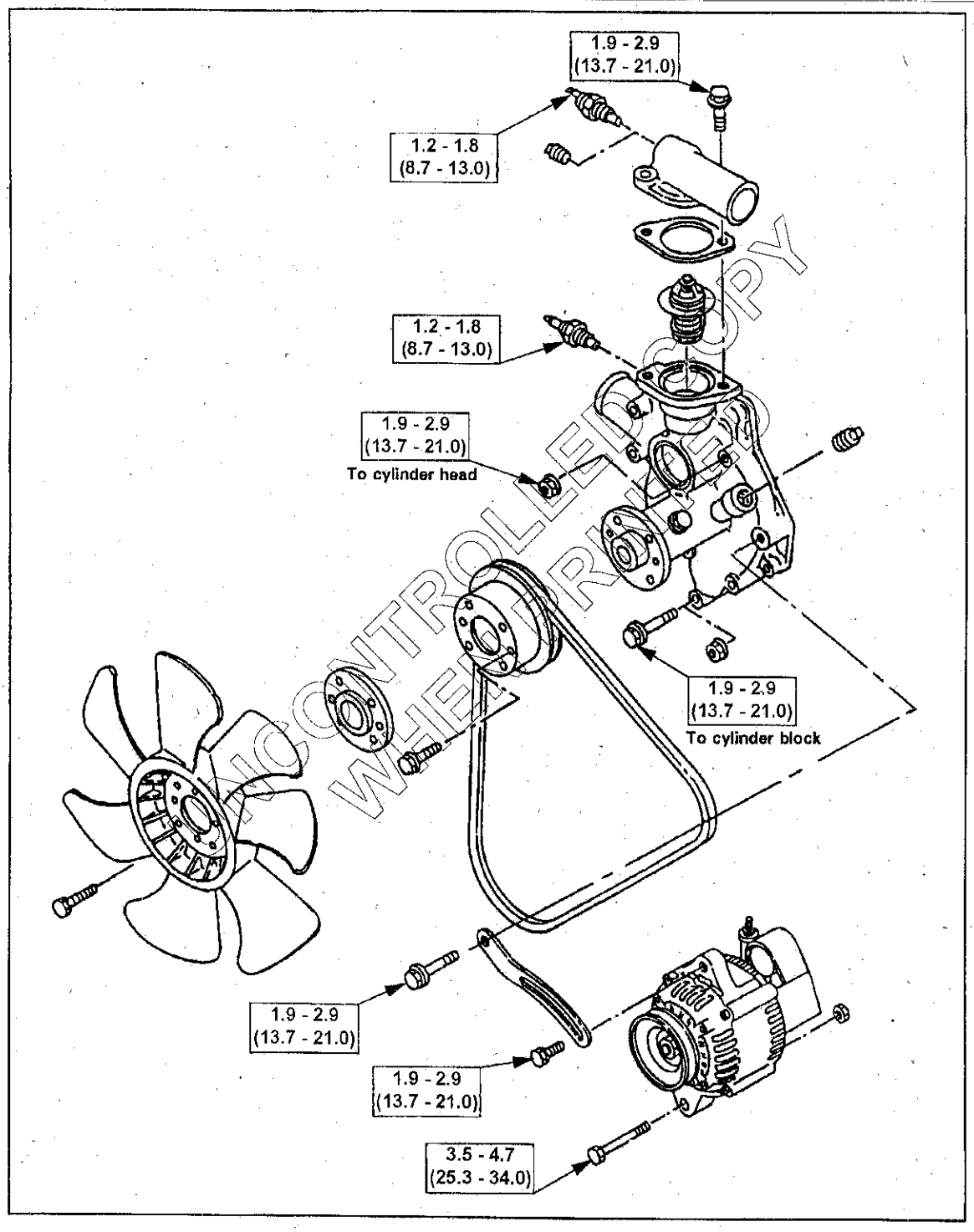


Fig 4 Cooling fan and water pump tightening torque

Cylinder head and cylinder head cover

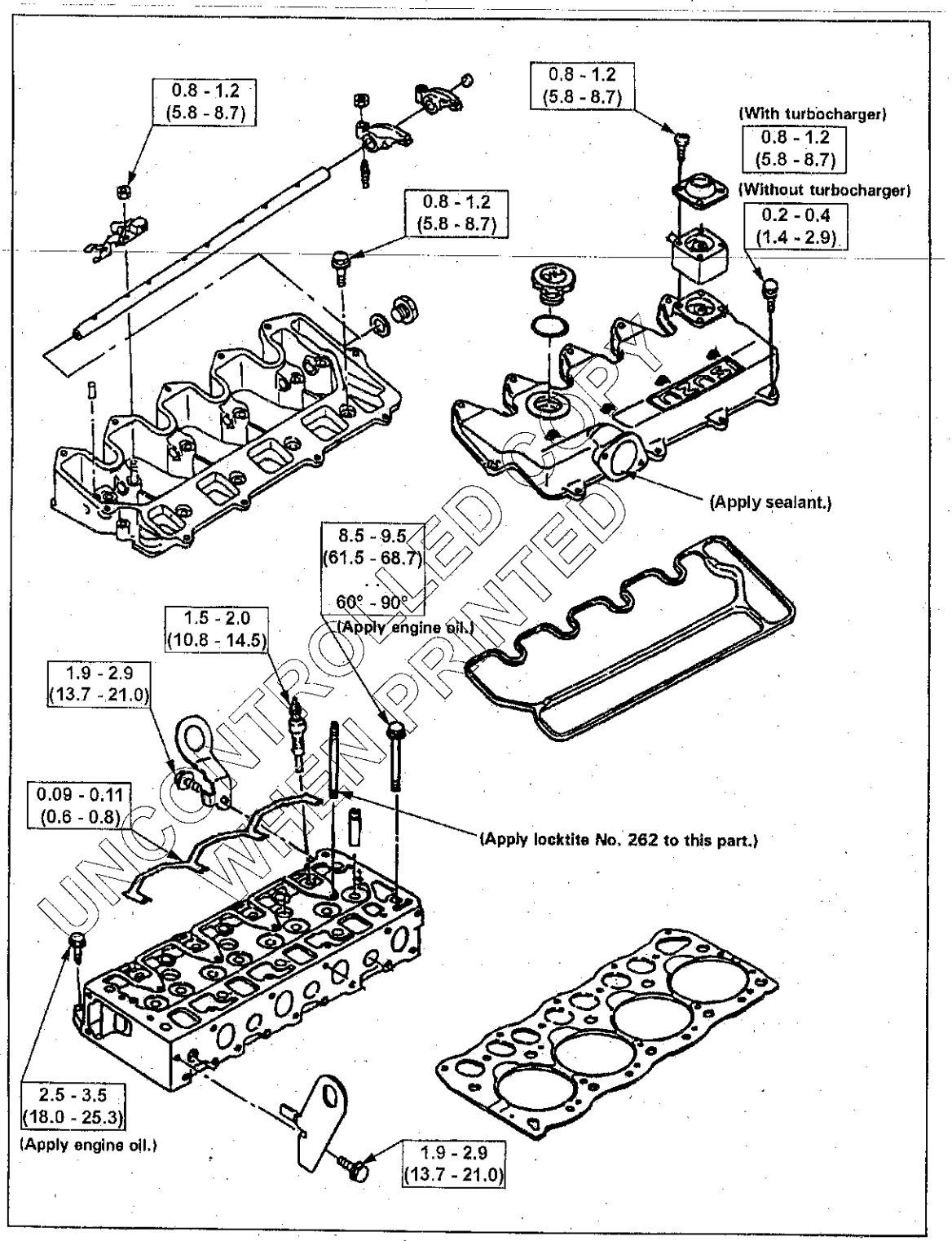


Fig 5 Cylinder head and cylinder head cover tightening torque

Cylinder block and other components

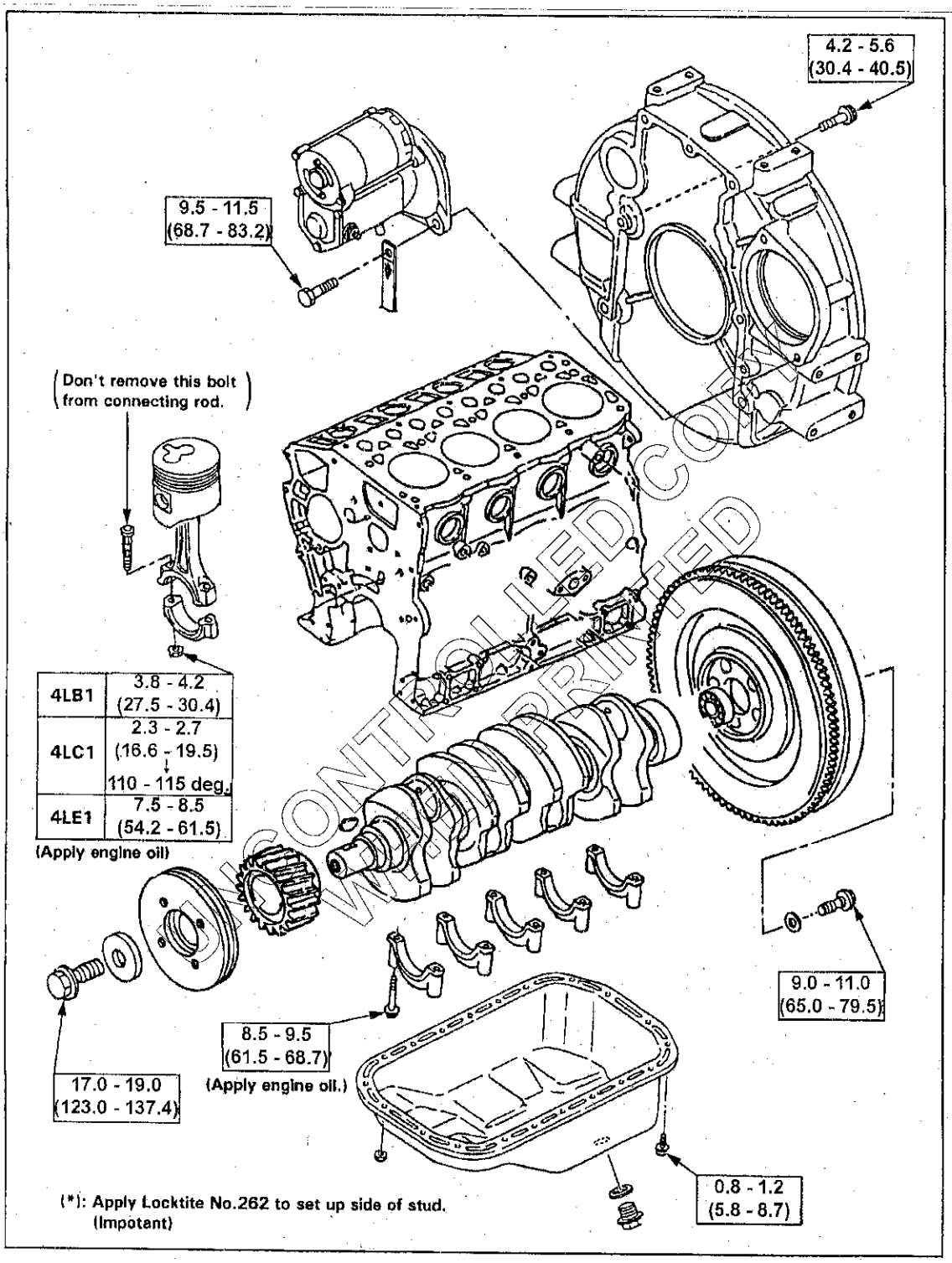


Fig 6 Cylinder block and other components tightening torque (1)

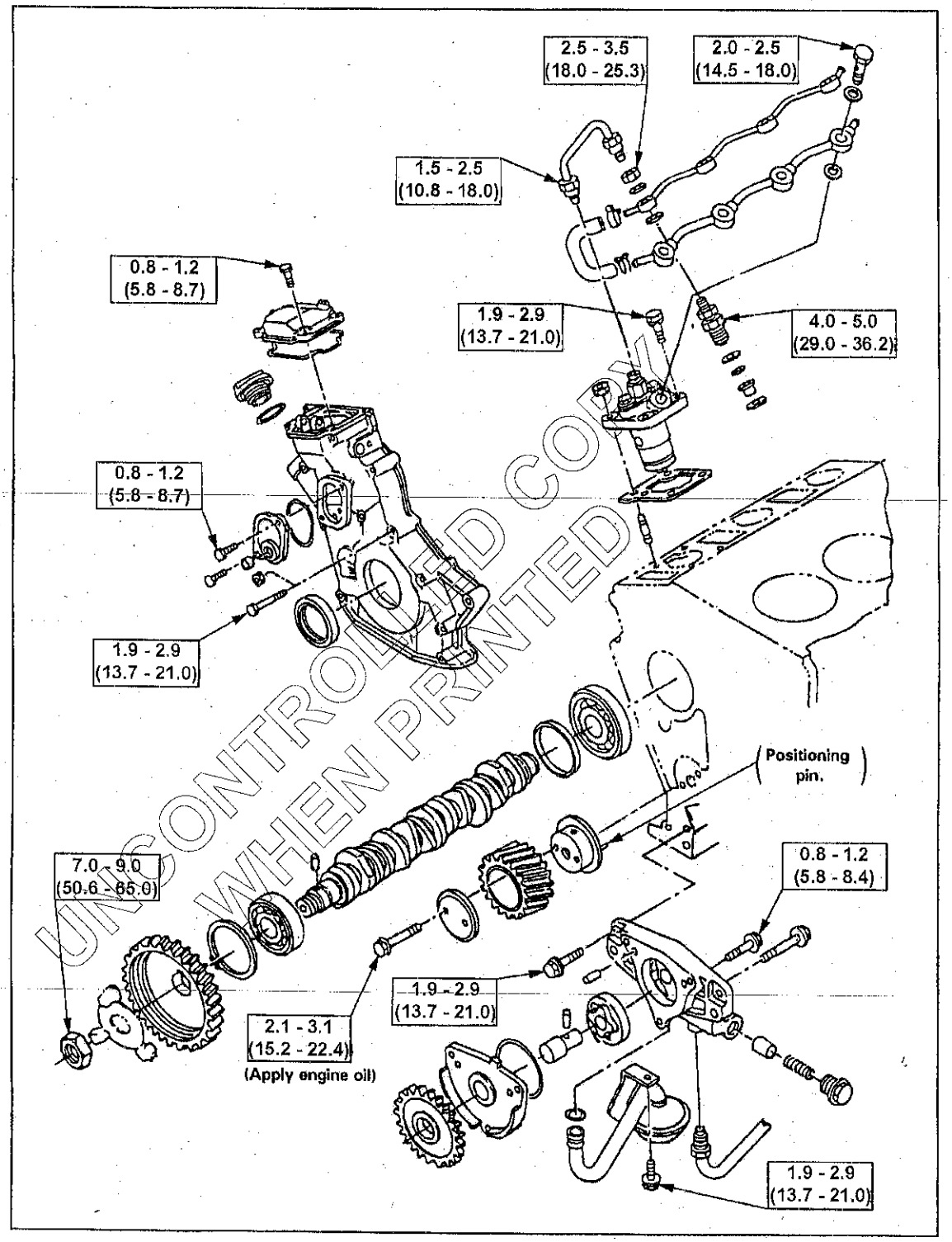


Fig 7 Cylinder block and other components tightening torque (2)

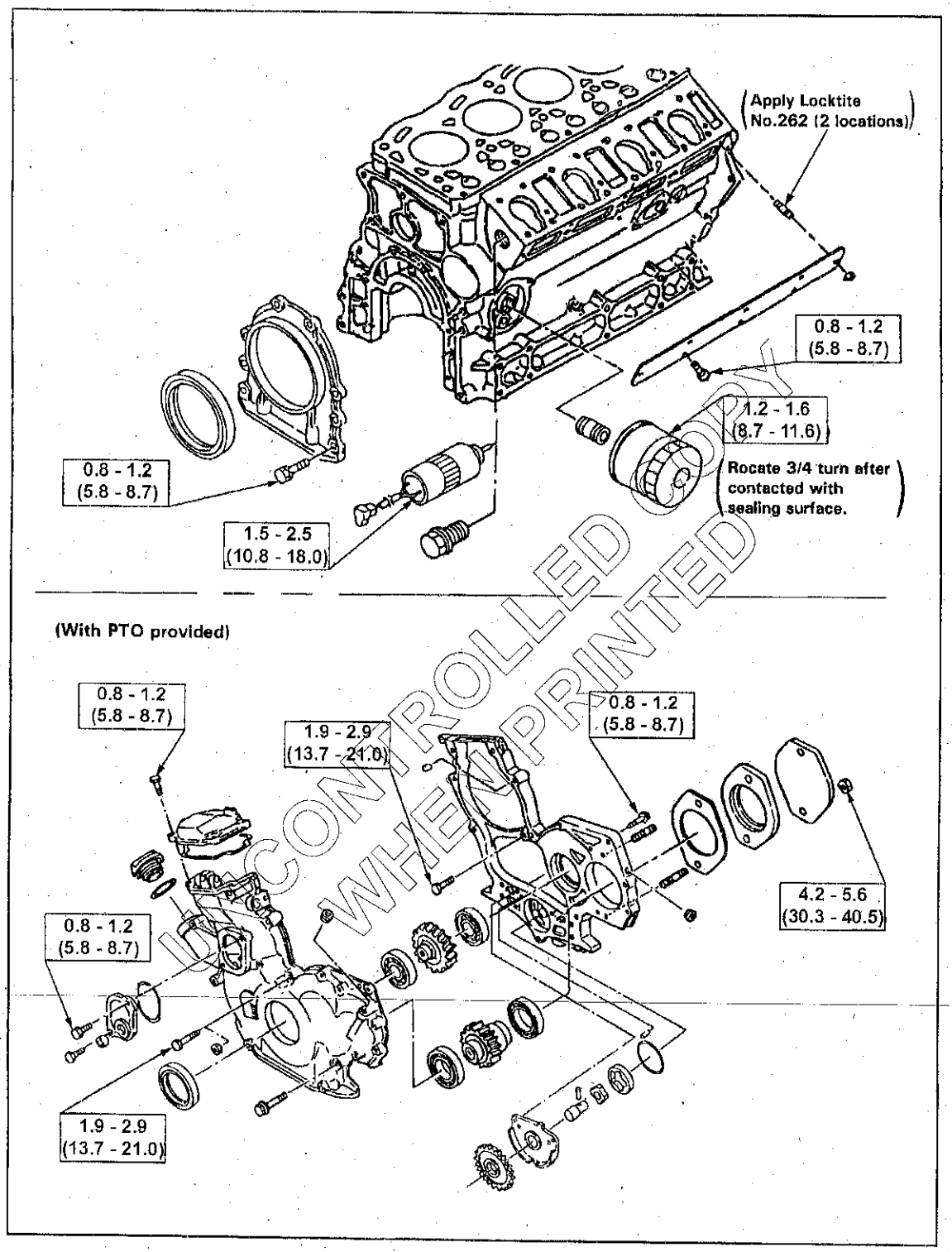


Fig 8 Cylinder block and other components tightening torque (3)

Turbocharger

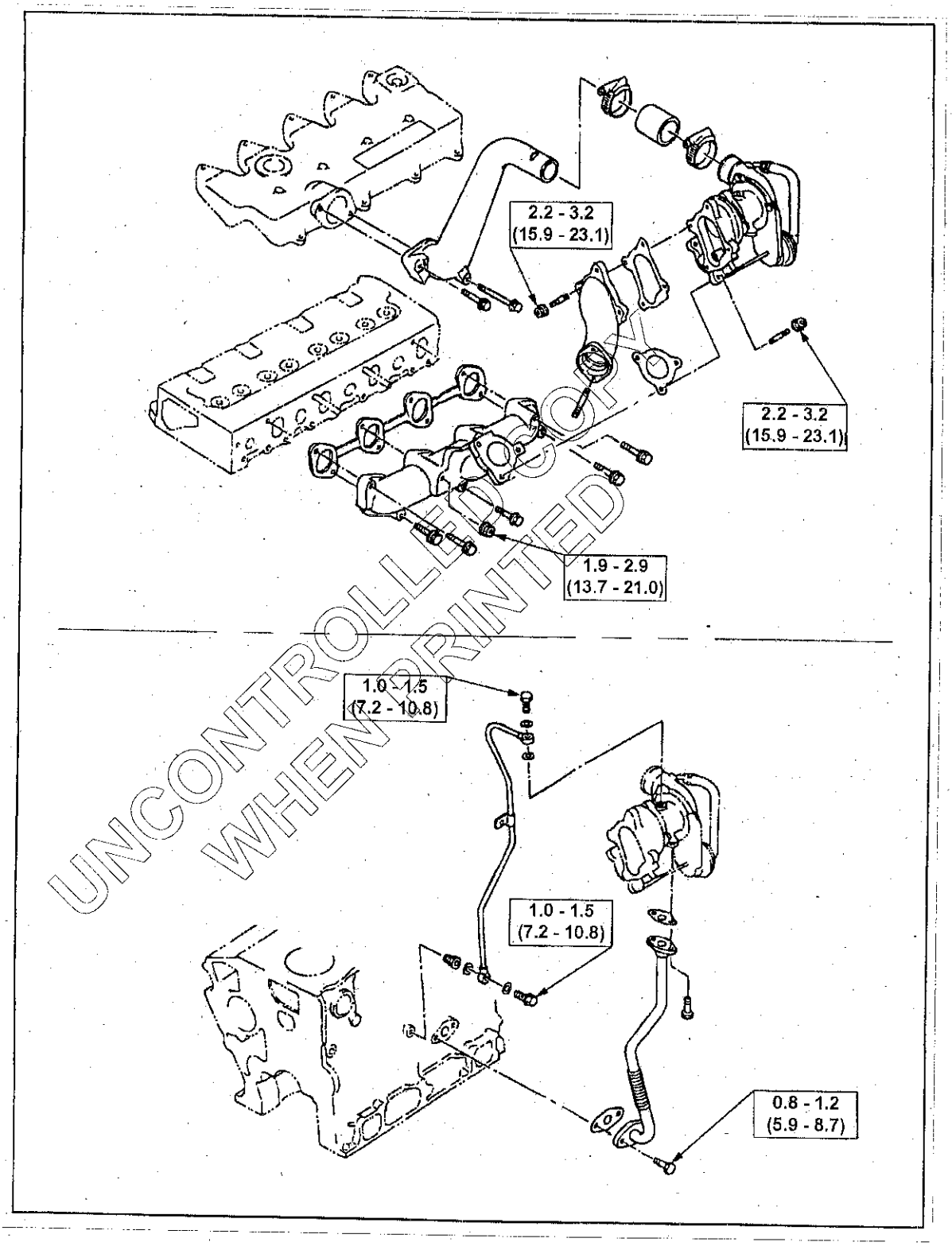


Fig 9 Turbocharger tightening torque

GASKET LOCATION

11 Locations where gaskets are used are shown in Fig 10.

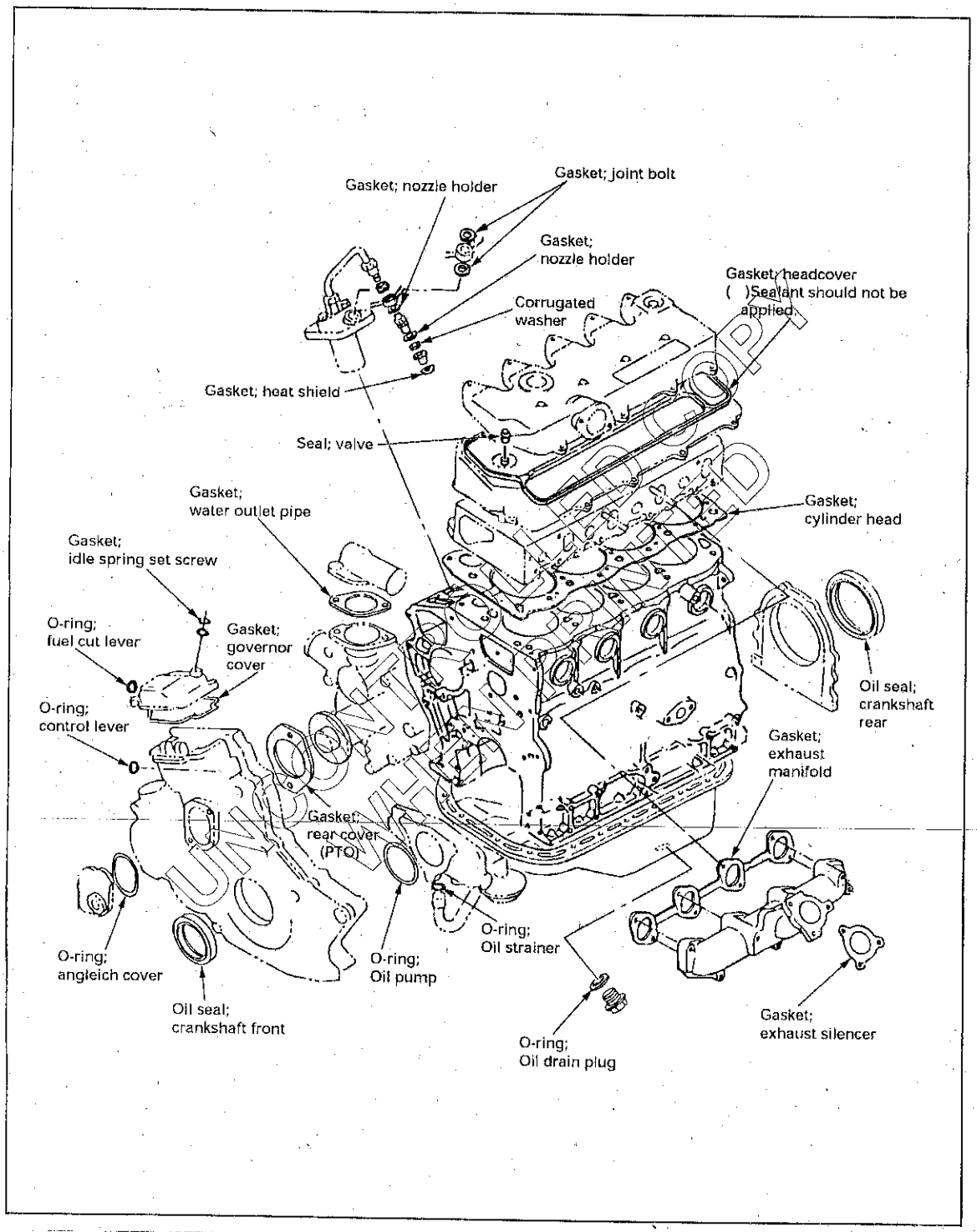


Fig 10 Locations where gaskets are used

Sealant

12 Locations where sealant is applied are given in Table 5.

TABLE 5 LOCATIONS WHERE SEALANT IS APPLIED

	Location		Condition of use		Name of sealant
	Name of part	Name of mating part	Object to be sealed	Groove to be applied	
1	Oil pan	Cylinder block	Engine oil (10W-30)	Not provided	TB1207C
2	Rocker bracket	Cylinder head	Engine oil (10W-30)	Provided	TB1207C
3	Air inlet pipe	Cylinder head cover	Air	Provided	TB1207C
4	Front plate (with PTO provided)	Cylinder block	Engine oil (10W-30)	Provided	TB1207C
5	Timing case (with PTO provided)	Front plate	Engine oil (10W-30)	Provided	TB1207C
6	Timing case (with no PTO provided)	Cylinder block	Engine oil (10W-30)	Provided	TB1207C
7	Water pump ASM	Cylinder block	Cooling water	Not provided	TB1207C
8	Rear cover; water pump	Body; water pump	Cooling water	Provided	TB1207B
9	Housing cover; injection pump	Cylinder block	Engine oil (10W-30)	Provided	TB1207C
10	Solenoid; fuel cut	Cylinder block	Engine oil (10W-30)	Provided	TB1207C
11	Retainer; oil seal	Cylinder block	Engine oil (10W-30)	Provided	TB1207C
12	Indicator; air cleaner	Air cleaner	Air	Not provided	(Sealing tape)

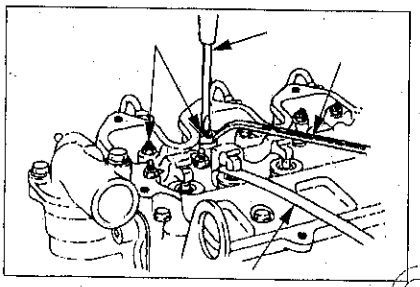
MAINTENANCE

VALVE CLEARANCE AND ADJUSTMENT

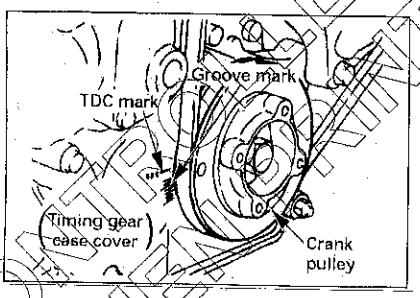
13 Maintenance procedures on the Model 4LE1 engine are set out in Paras 13 to 22.

NOTE

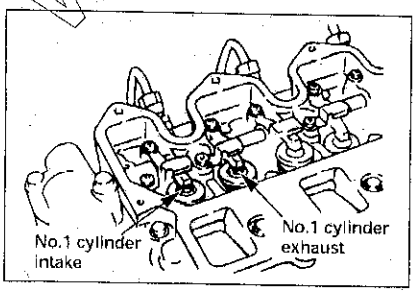
The cylinder head bolts were previously tightened with the "Angular Tightening Method". Therefore, it is not necessary to retighten the cylinder head bolts before adjusting the valve clearance.



(1) Bring the piston in either the No. 1 cylinder or the No. 3 cylinder to Top Dead Centre on the compression stroke by turning the crankshaft until the TDC mark on the front cover aligns with the groove mark on the crankshaft pulley.



(2) Check to see if there is play in the No. 1 intake and exhaust valve rocker arms.



a. If the No. 1 cylinder intake and exhaust valve rocker arms have play, the No. 1 piston is at TDC on the compression stroke.

b. If the No. 1 cylinder intake and exhaust valve rocker arms are depressed, the No. 4 piston is at TDC on the compression stroke.

c. Adjust the circle or double circle marked valves as shown in Table 6, while the No. 1 or the No. 4 cylinder is at TDC on compression stroke.

mm (in.)

Intake and Exhaust Valve Clearance (cold)	0.40 ± 0.05 (0.015 ± 0.002)

TABLE 6 VALVE CLEARANCES

Cylinder No.	1		2		3		4	
Valve arrangement	I	E	I	E	I	E	I	E
No. 1 cylinder TDC for compression	○	○	○			○		
No. 4 cylinder TDC for compression				◎	◎		◎	◎

I = Intake E = Exhaust

(3) Loosen each valve clearance adjusting screw as shown in the illustration.

(4) Insert a 0.40 mm (0.015 in) feeler gauge between the rocker arm and the valve stem end.

(5) Turn the valve clearance adjusting screw until a slight drag can be belt on the feeler gauge.

(6) Tighten the lock nut securely.

(7) Rotate the crankshaft 360°.

a. Realign the crankshaft pulley.

(8) Adjust the clearances for the remaining valves as shown in Table 6.

LUBRICATING SYSTEM

Cartridge (Spin-On) type

Removal

14 Remover and Installer: Filter Wrench.

(1) Loosen the used oil filter by turning it counterclockwise with the filter wrench.

(2) Discard the used oil filter.

Installation

15 Proceed as follows:

(1) Wipe the oil filter mounting face with a clean rag.

a. This will allow the new oil filter to seat properly.

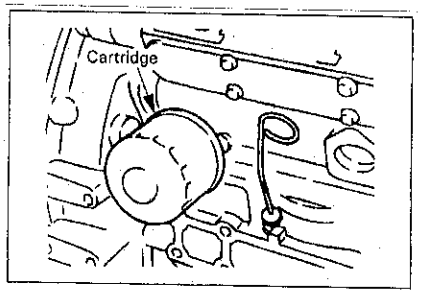
(2) Lightly oil the O-ring.

(3) Turn in the new oil filter until the sealing face is fitted against the O-ring.

(4) Use the filter wrench to turn in the oil filter an additional 3/4 of a turn or one turn.

(5) Check the engine oil level and replenish to the specified level if required.

(6) Start the engine and check for oil leakage from the oil filter.



COOLING SYSTEM

Cooling fan drive belt

Adjustment

16 Check the cooling fan drive belt adjustment as follows:

(1) Check the cooling fan drive belt for cracking and other damage.

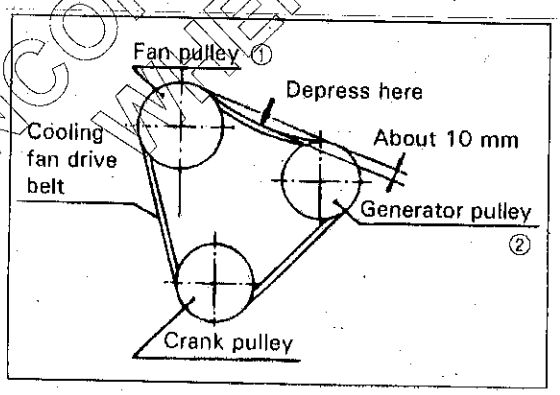
(2) Check the drive belt tension by exerting a force of 10 kg (22 lb) midway between the Fan pulley 1 and the Generator pulley 2.

(3) Adjust the belt tension by loosening the Generator mounting bolt and the Generator adjusting bolt and pivoting the Generator.

a. Be sure to retighten the bolts after adjusting the belt tension.

mm (in.)

Cooling Fan Drive Belt Deflection	8.0 – 12.0 (0.3 – 0.5)



INJECTION TIMING

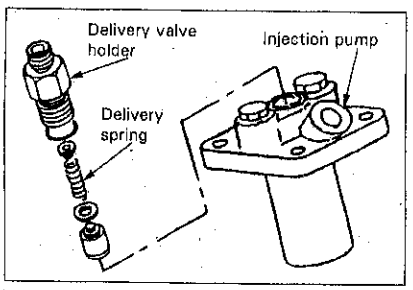
NOTE

Take care to avoid entry of dust or foreign particles into the pump interior when the timing adjustment is made.

17 Check the injection timing as follows:

(1) Remove the injection pipe of the No. 1 cylinder.

(2) Remove the delivery valve holder of the injection pump of the No. 1 cylinder, and then pull out the delivery spring.



(3) With the spring removed, install the delivery valve holder.

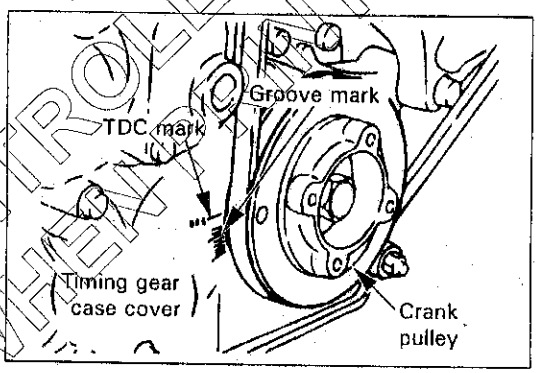
(4) Slowly turn the crankshaft pulley clockwise, at the same time, continue to feed the fuel.

a. When the fuel stop flowing out from the No. 1 delivery valve holder, stop turning the crankshaft.

b. This crank angle position is the starting point of injection.

(5) In the condition at Step (4) above, confirm what degree the "groove mark" of the crank pulley is at, when seen by the "timing mark", provided in the timing gear case.

a. When the value is out of the range of the normal injection timing, adjust it accordingly.



* Injection timing	4LE1	BTDC 16°

NOTE

The injection timing varies according to the specifications of the machine.

(6) Adjust the injection timing with a shim between the injection pump and the cylinder block.

a. Shim is available in the following 9 types, and "identification mark" is stamped (or imprinted) on the top face.

TABLE 7 IDENTIFICATION MARK OF SHIM AND ITS THICKNESS

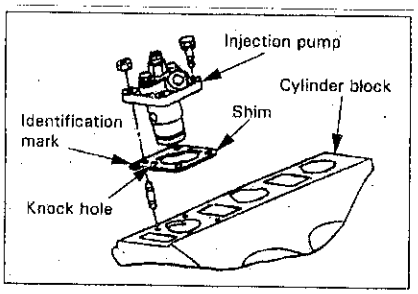
(mm)

Mark	Thickness	Mark	Thickness	Mark	Thickness
2	0.2	5	0.5	8	0.8
3	0.3	6	0.6	10	1.0
4	0.4	7	0.7	12	1.2

NOTE

(1) For each of the injection pumps of three cylinders, the shim adjustment is made at the same time.

(2) When a shim is missing while overhauling the engine and the shim thickness is unknown, assemble the engine with provisional shim inserted. After assembling the engine, check the injection timing and adjust the shim until the normal injection timing is obtained.



Reference: To add the 0.1 mm shim thickness corresponds to the 1 degree of crankshaft angle advance.

Air bleeding from fuel (automatic air-bleeding system)

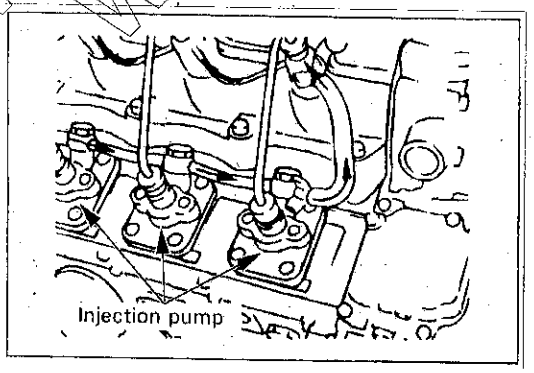
18 To bleed air from the fuel using the automatic air-bleeding system, proceed as follows:

(1) For the automatic air-bleeding system:

a. When the starter switch is set to "OPERATION", the electromagnetic pump is activated to force-feed fuel to the fuel pipe and the leak-off pipe, and air in the fuel system is automatically bled.

(2) For non-automatic air-bleeding system:

a. While sending fuel by means of the force of the electromagnetic pump, the fall from the fuel tank or the feed pump lever, bleed air out of the fuel pipe eye bolt of the No. 1 cylinder injection pump, the leak-off pipe eye bolt of the injection nozzle and the air-bleeder plug of the fuel filter, starting with the one installed the lower most and upward.



COMPRESSION PRESSURE MEASUREMENT

19 To measure the compression pressure, proceed as follows:

(1) Operate the engine to warm-up until the coolant temperature reaches to 75°C (167°F).

(2) Remove all of the glow plugs and the injection pipes.

(3) Attach a compression gauge to the No. 1 cylinder glow plug installation threads.

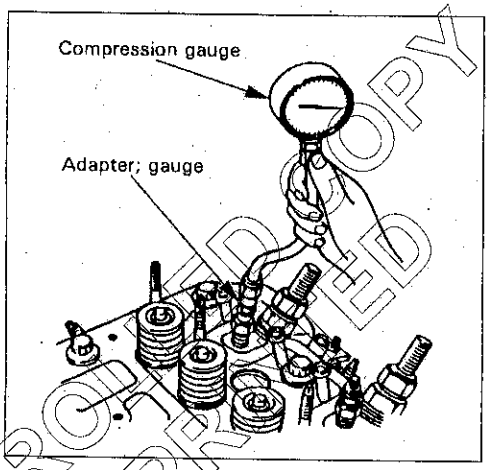
NOTE

(1) Compression pressure may be measured starting at any cylinder and in no particular cylinder order. However, it is very important that the compression pressure be measured in each cylinder.

(2) Therefore, start at the No. 1 cylinder and work back. In this way, you will be sure to measure the compression pressure in each cylinder.

Compression Gauge: 5-8840-2675-0

Compression Gauge Adaptor: 5-8840-9026-0



(4) Crank the engine with the starter motor and take the compression gauge reading.

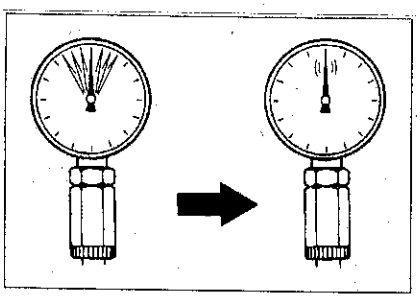
kg/cm 2 (psi) at 250 rpm

Standard	Limit
31.0 (441)	26.0 (370)

(5) Repeat the procedure (Steps 3 and 4) for the remaining cylinders.

a. Compression pressure should be approximately the same for each cylinder. A variation exceeding 2.0 kg/cm² (28 psi) is unacceptable.

b. If the measured value exceeds the specified limit, the related parts must be checked.



FUEL SYSTEM

Fuel filter replacement

Cartridge (Spin-On) Type

Removal

20 To replace the fuel filter, proceed as follows:

(1) Loosen the fuel filter by turning it counterclockwise with the filter wrench or your hand. Discard the used filter.

a. Filter Wrench.

(2) Wipe the fuel filter fitting face clean with a rag.

a. This will allow the new fuel filter to seat properly.

Installation

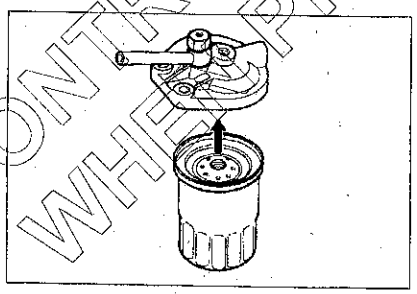
21 (1) Apply a light coat of engine oil to the O-ring.

(2) Supply fuel to the new filter.

a. This will facilitate air bleeding.

(3) Turn in the new fuel filter until the filter O-ring is fitted against the sealing face.

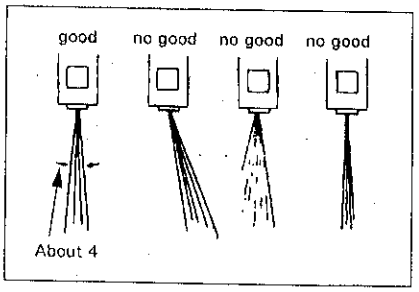
(4) Use the filter wrench to turn in the fuel filter an additional 2/3 of a turn.



Injection nozzle

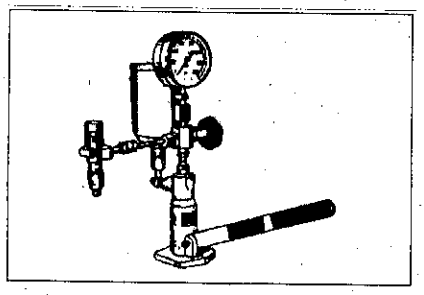
22 Check to see if the spray condition and the injection pressure are normal. Adjust them to the specified value respectively when they do not meet the standard valve.

		kg/cm² (psi)
Injection pressure	4LE1	135 (1920)



(1) Using a nozzle tester, adjust the injection pressure with a shim.

Special tool: Nozzle tester:



RECOMMENDED LUBRICATING OIL

23 The recommended lubricating oils for the 4LE1 engine are detailed in Fig 11.

TYPE OF LUBRICANTS (API)	DIESEL ENGINE OIL; CC OR CD GRADE

ENGINE OIL VISCOSITY CHART

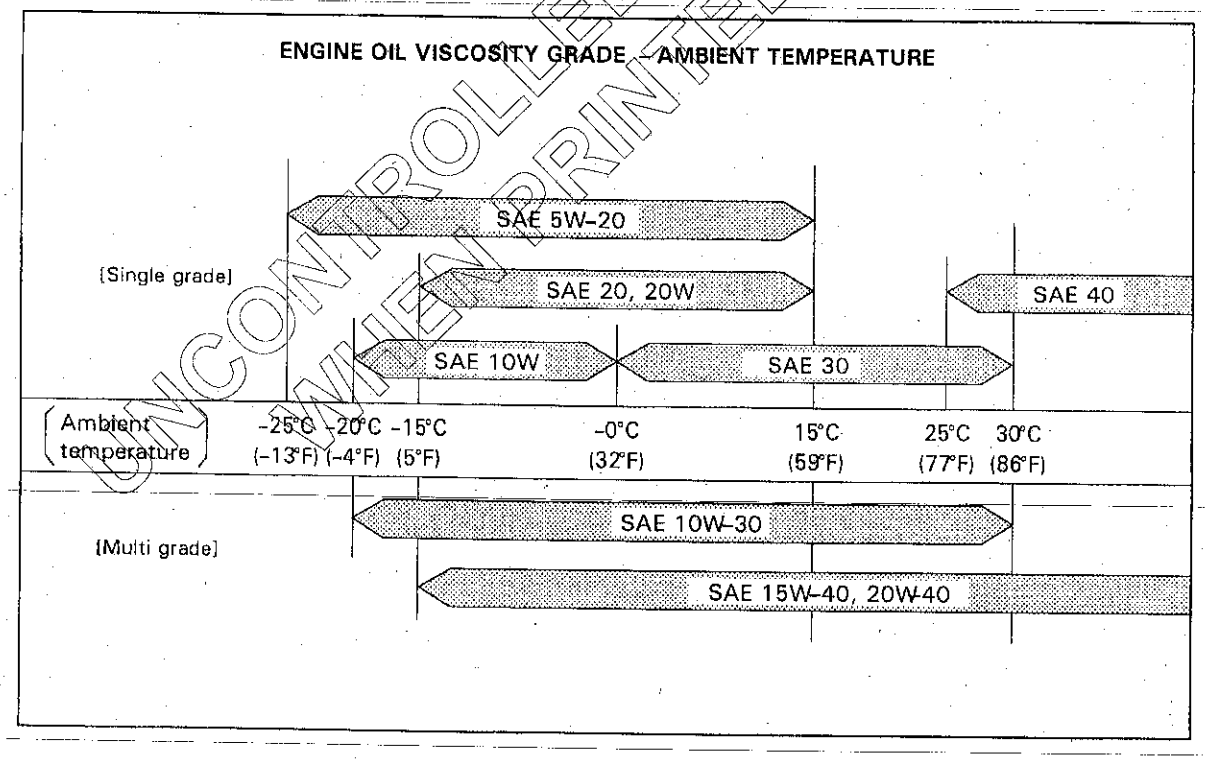


Fig 11 Engine oil viscosity chart

SECTION 2 - ENGINE

DISASSEMBLY OF EXTERNAL PARTS

External parts (left-hand side)

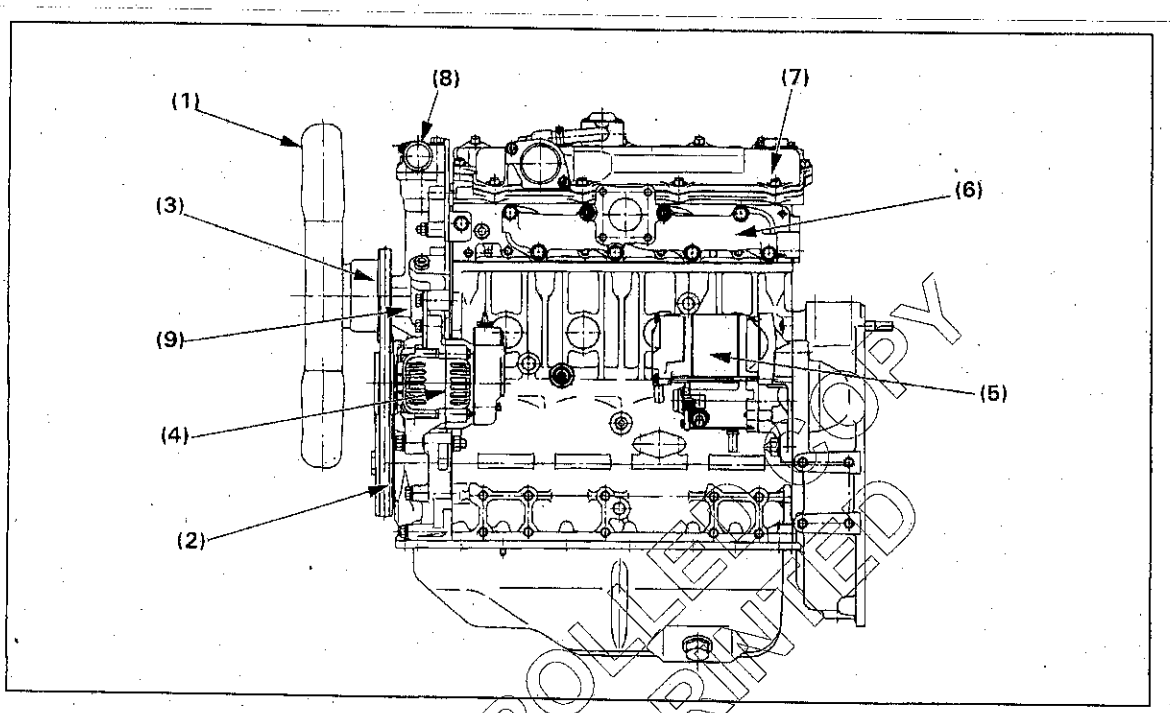


Fig 12 External parts (left-hand side)

24 The external parts on the left-hand side of the engine are shown in Fig 12.

(1) Cooling fan and spacer.

(2) Fan belt.

(3) Fan pulley.

(4) Generator.

(5) Starter.

(6) Exhaust manifold and gasket.

(7) Cylinder head cover and air intake pipe.

(8) Water outlet pipe and thermostat.

(9) Water pump assembly.

External parts (right-hand side)

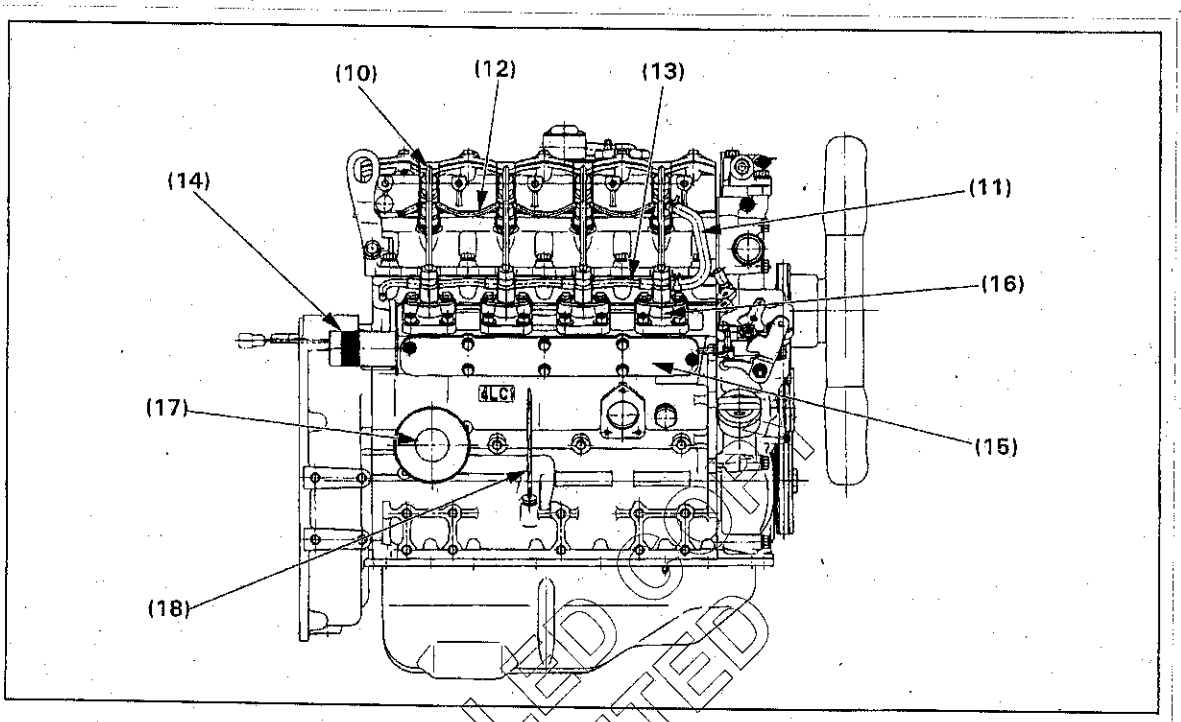


Fig 13 External parts (right-hand side)

25 The external parts on the right-hand side of the engine are shown in Fig 13.

(10) Injection pipe (4 pcs).

(11) Fuel hose.

(12) Fuel leak off pipe.

(13) Fuel pipe.

(14) Engine stop solenoid.

(15) Injection pump housing cover.

(16) Injection pump and shim (4 set).

(17) Oil filter.

(18) Oil level gauge.

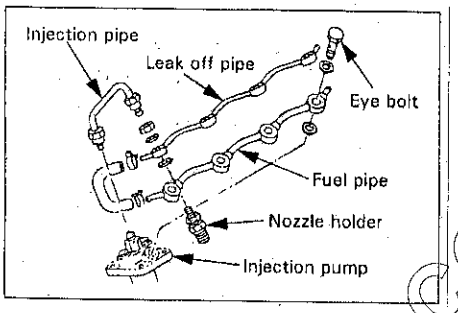
Injection pipe - Leak off pipe - Fuel pipe

26 Proceed as follows:

(1) Loosen the sleeve nuts on the nozzle holder side and on the injection pump side, and then disconnect the injection pipes.

(2) Disconnect the leak off pipe together with gaskets.

(3) Remove the eye bolt, and then disconnect the fuel pipe.



Injection pump

27 Proceed as follows:

(1) Align the hole of the fuel cut lever with the hole of the governor cover, and then insert a pin (6ø) into this hole to hold the fuel cut lever.

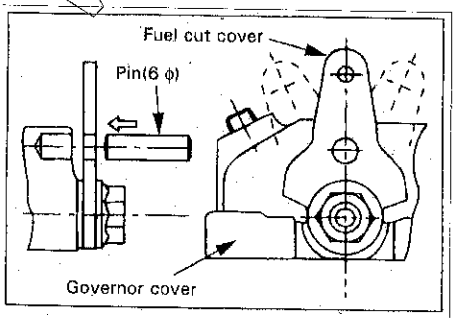
(2) Check to see if the pin groove of the control link is at the center of the injection pump.

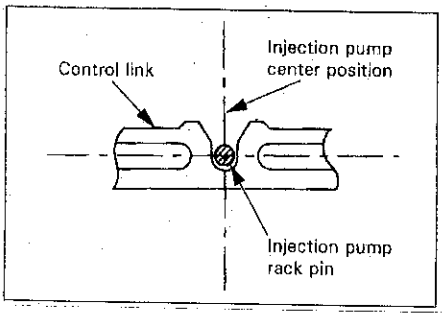
(3) Remove the injection pump, and then take out the shim.

NOTE

(1) Mark each injection pump as to which cylinder it was removed from.

(2) Do not reuse the shim, replace it with the same thickness that was removed.





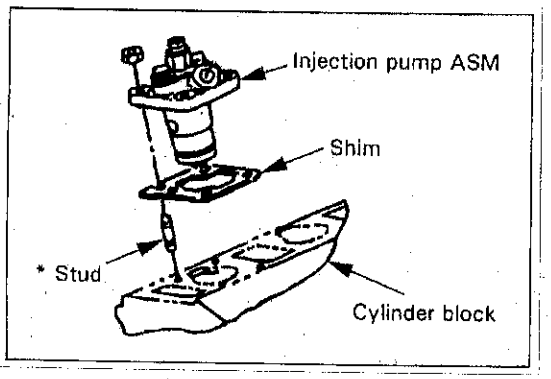


TABLE 8 BACKLASH OF TIMING GEAR

mm (in)

	Standard	Limit
Crank Gear/ Idler Gear	0.04 (0.0017)	0.2 (0.0079)
Cam Gear/ Idler Gear	0.03 (0.0012)	0.2 (0.0079)

TABLE 9 IDLER GEAR END PLAY

mm (in)

Standard	Limit
0.058 – 0.115 (0.0023 – 0.0045)	0.2 (0.0079)

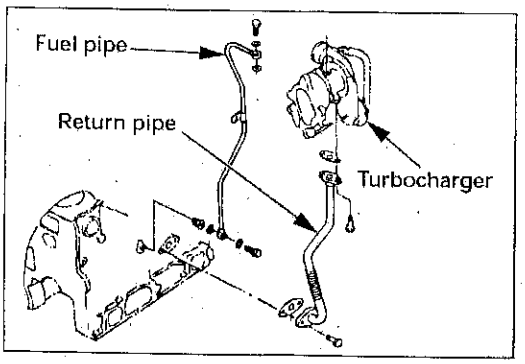
TABLE 10 CRANKSHAFT END PLAY

mm (in)

Standard	Limit
0.058 – 0.208 (0.0023 – 0.0082)	0.3 (0.0118)

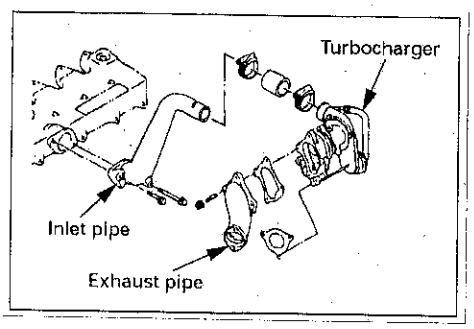
Return pipe - Feed pipe

28 Remove the return pipe and the feed pipe.



Exhaust pipe - Inlet pipe - Turbocharger

29 Remove the exhaust pipe, the inlet pipe and turbocharger.



DISASSEMBLY OF INTERNAL PARTS

30 Disassembly steps for the internal parts of the engine (Figs 14 to 16) are as follows:

(1) Rocker Bracket Assembly.
(2) Push Rods.
(3) Rear Hanger.
(4) Front Hanger.
(5) Cylinder Head Assembly.
(6) Cylinder Head Gasket.
(7) Tappets.
(8) Oil Pan.
(9) Oil Strainer.
(10) Oil Pipe.
(11) Crank Pulley.
(12) Flywheel.
(13) Flywheel Housing.
(14) Timing Gear Case (without PTO).
(15) Oil Pump Assembly.
(16) Idler Gear and Shaft.
(17) Cam Gear.
(18) Camshaft.
(19) Rear Seal Retainer.
(20) Piston Assemblies.
(21) Crankshaft.

Internal parts (1/3)

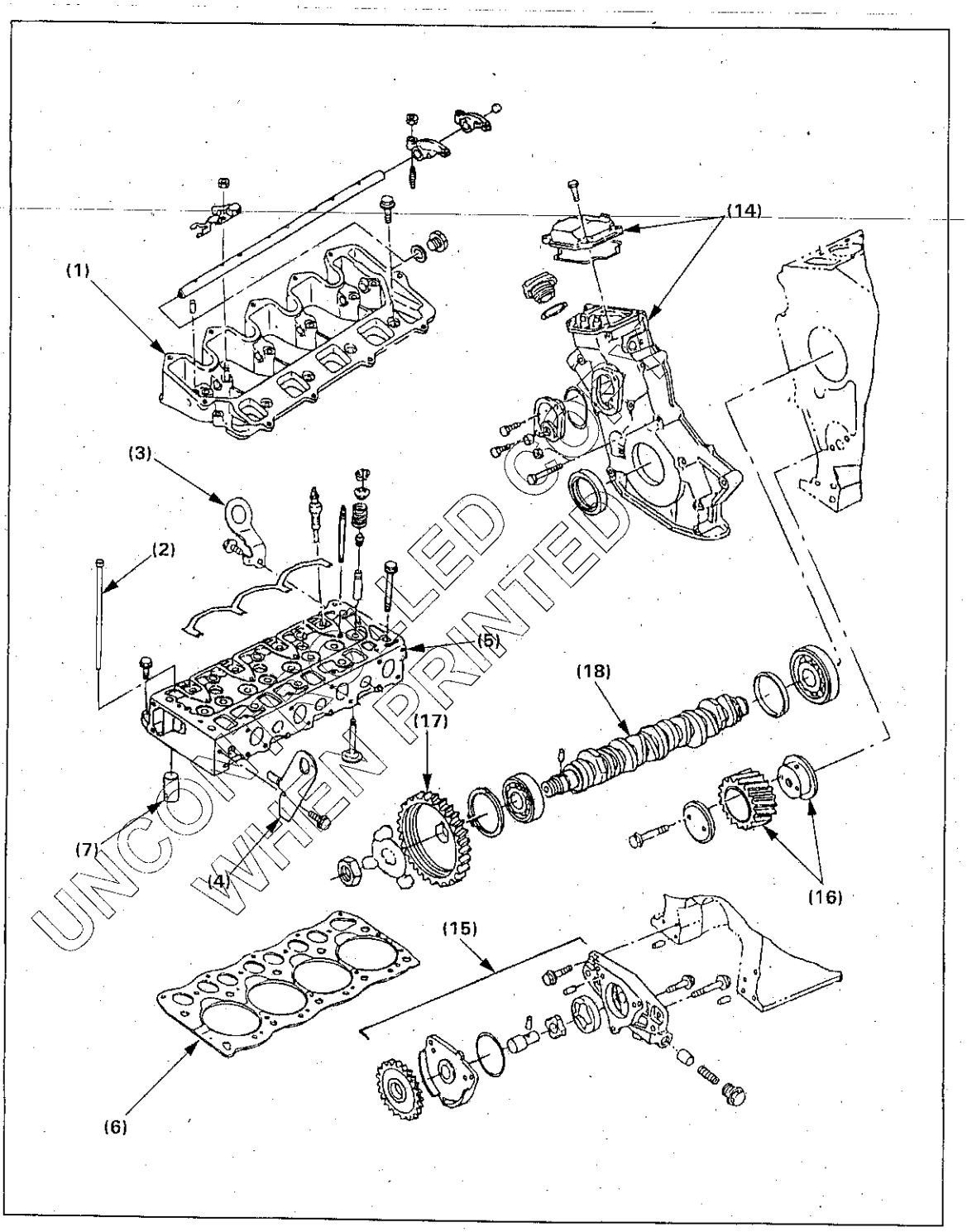


Fig 14 Disassembly internal parts (sheet 1 of 3)

Internal parts (2/3)

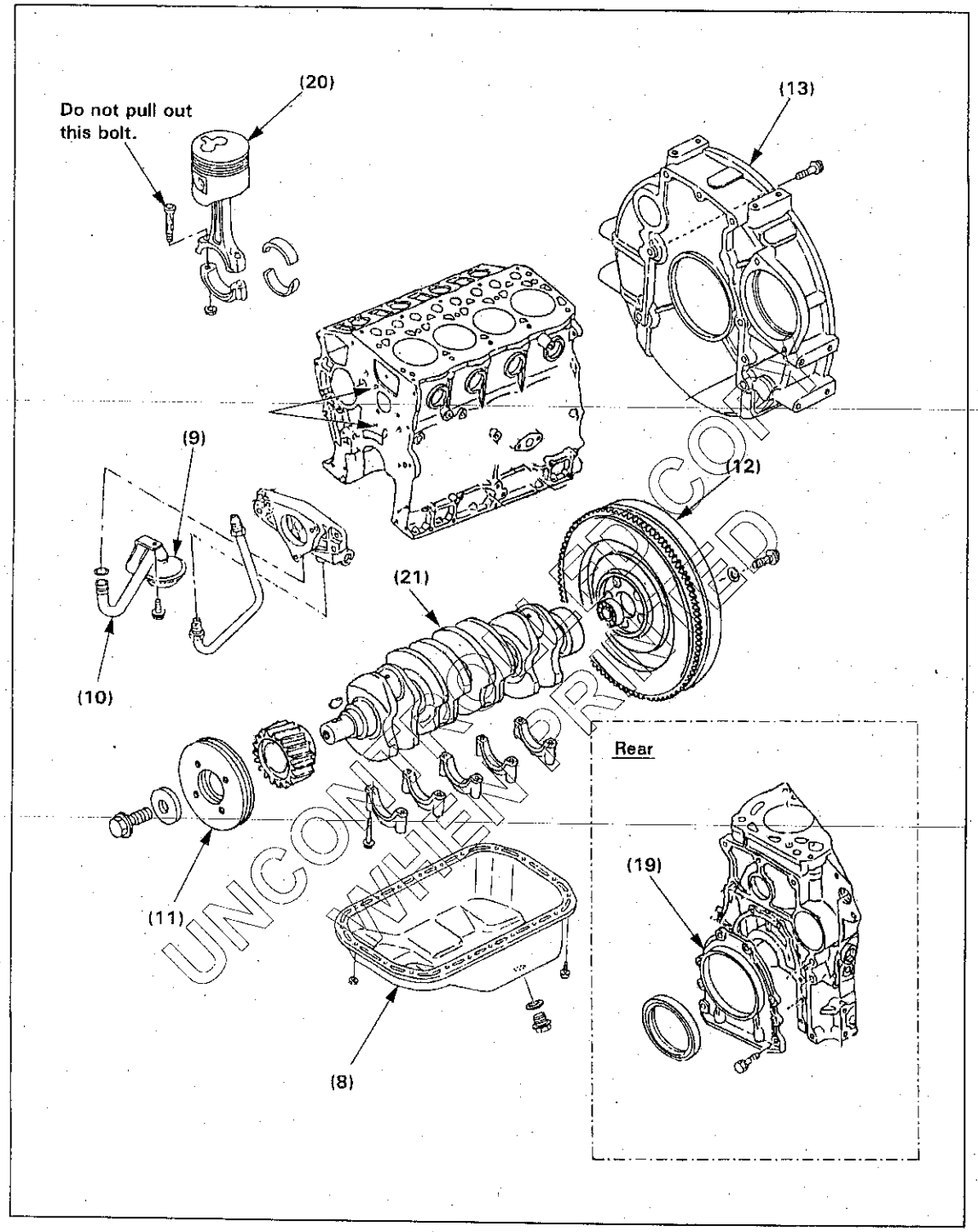


Fig 15 Disassembly internal parts (sheet 2 of 3)

Internal parts (3/3)

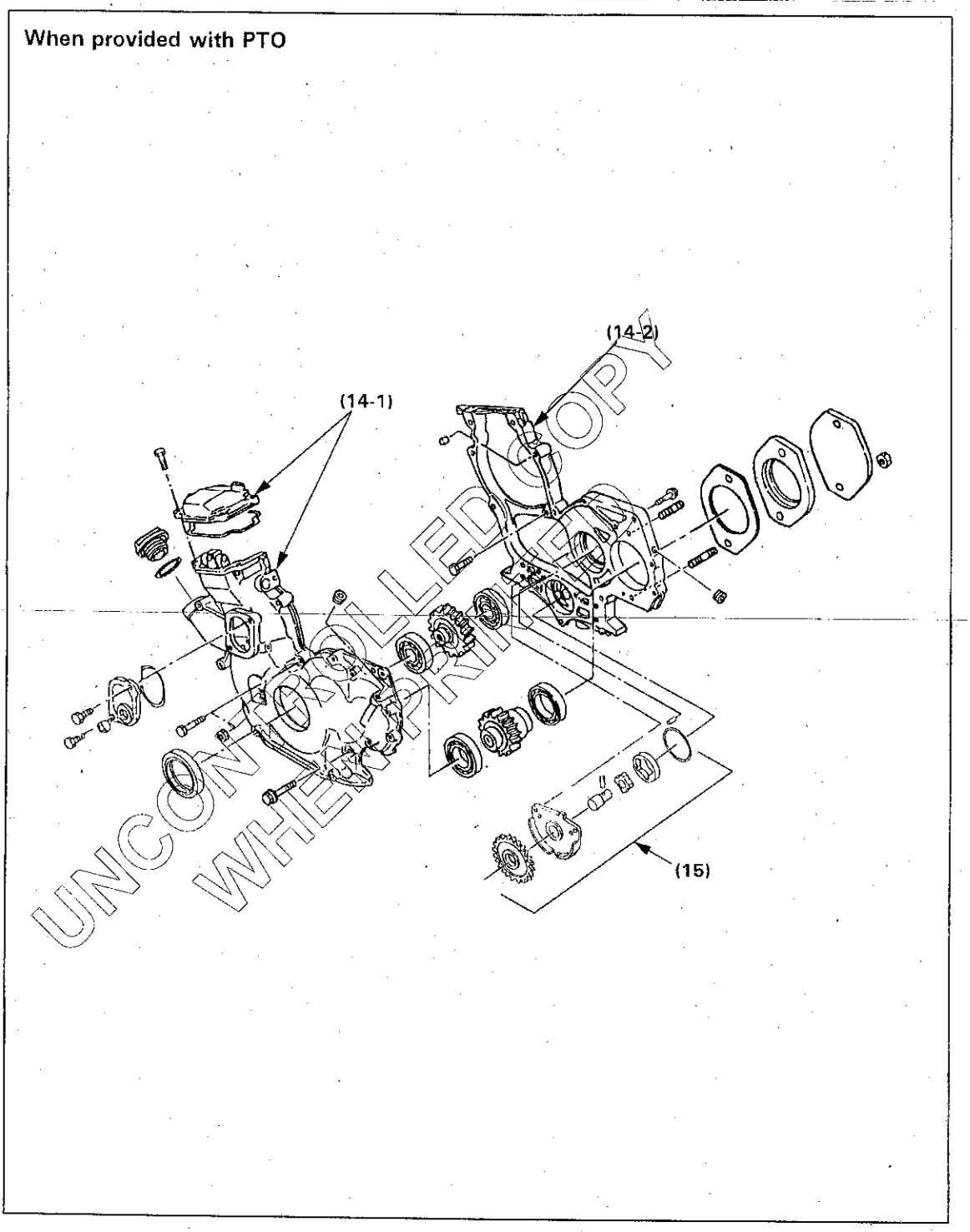


Fig 16 Disassembly internal parts (sheet 3 of 3)

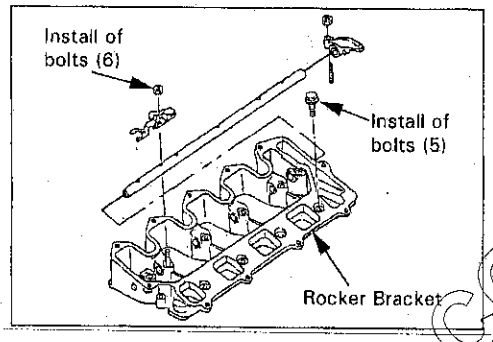
Rocker bracket

Push rod

31 Proceed as follows:

(1) Remove the rocker bracket assembly. (M6 x 1 . . . . . 5 bolts and 6 nuts.)

(2) Pull out the push rods (8 pcs.).



Cylinder head assembly

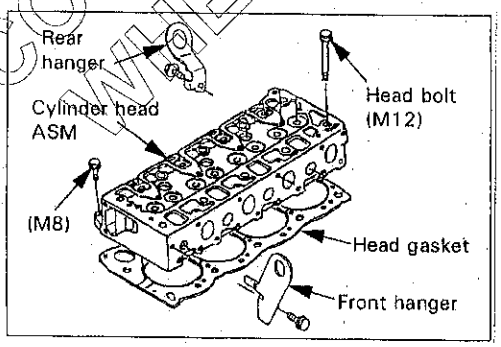
32 Proceed as follows:

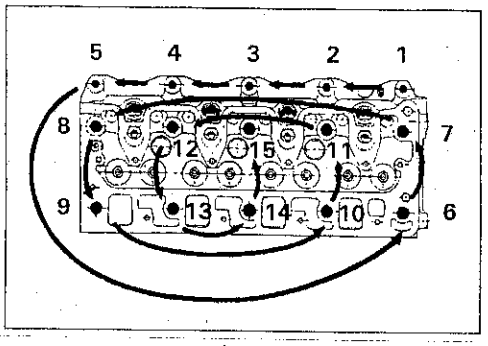
(1) Remove the rear and front hangers.

(2) When removing the cylinder head bolts, loosen them slowly, a little at a time, starting with the outside, working in a circular pattern inward.

(3) Remove the cylinder head assembly and the head gasket.

(4) Pull out the tappet from the cylinder body.





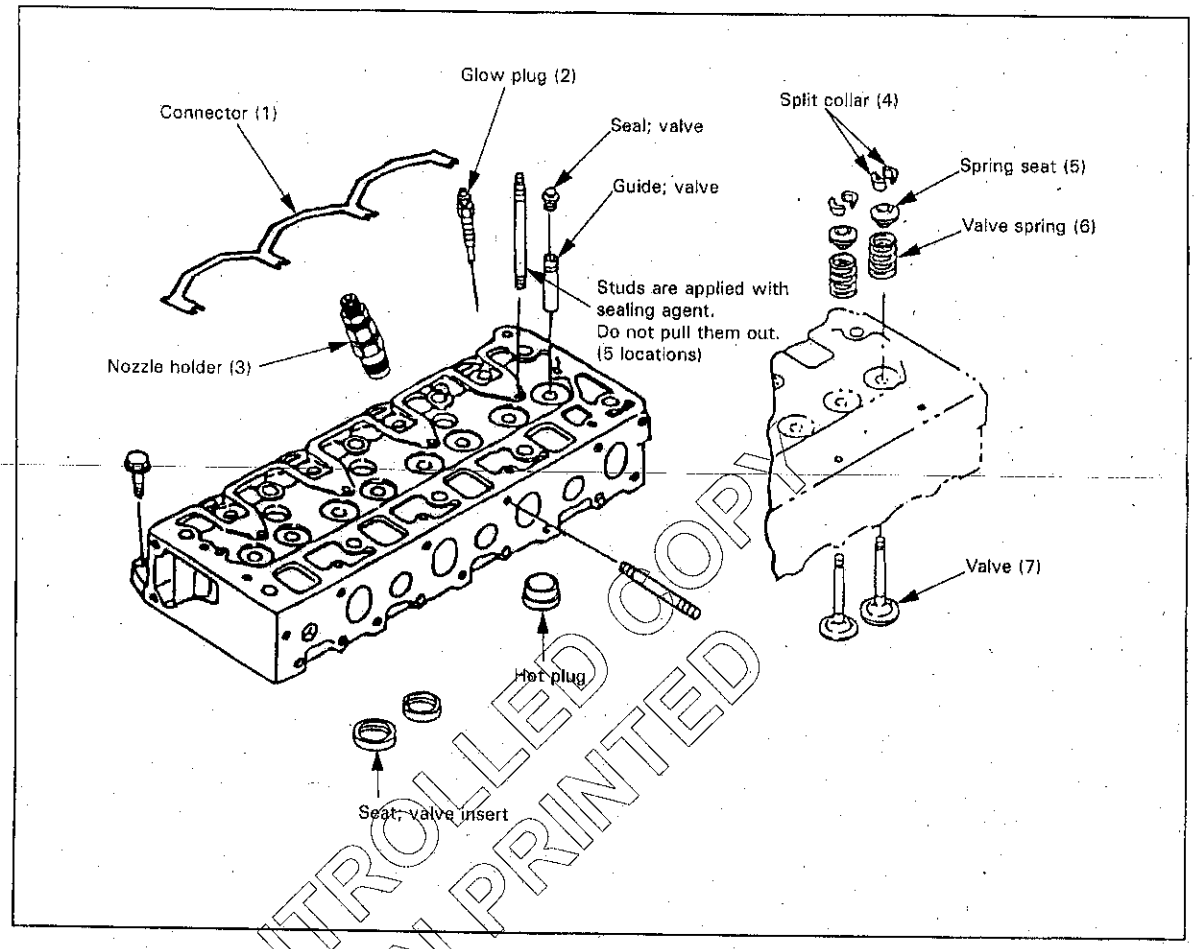


Fig 17 Cylinder head assembly

Valve mechanism

33 Proceed as follows:

(1) Before disassembling the valve mechanism, remove the connector, glow plug and nozzle holder assembly.

(2) Compressing the valve spring, remove the split collar, spring seat, valve spring and valve.

Timing gear

34 Proceed as follows:

(1) Remove the idle gear and the idle gear shaft.

(2) Pull out the sleeve from the tip end of the camshaft.

(3) Remove the lock nut of the camshaft gear, and then remove the flyweight assembly and the cam gear.

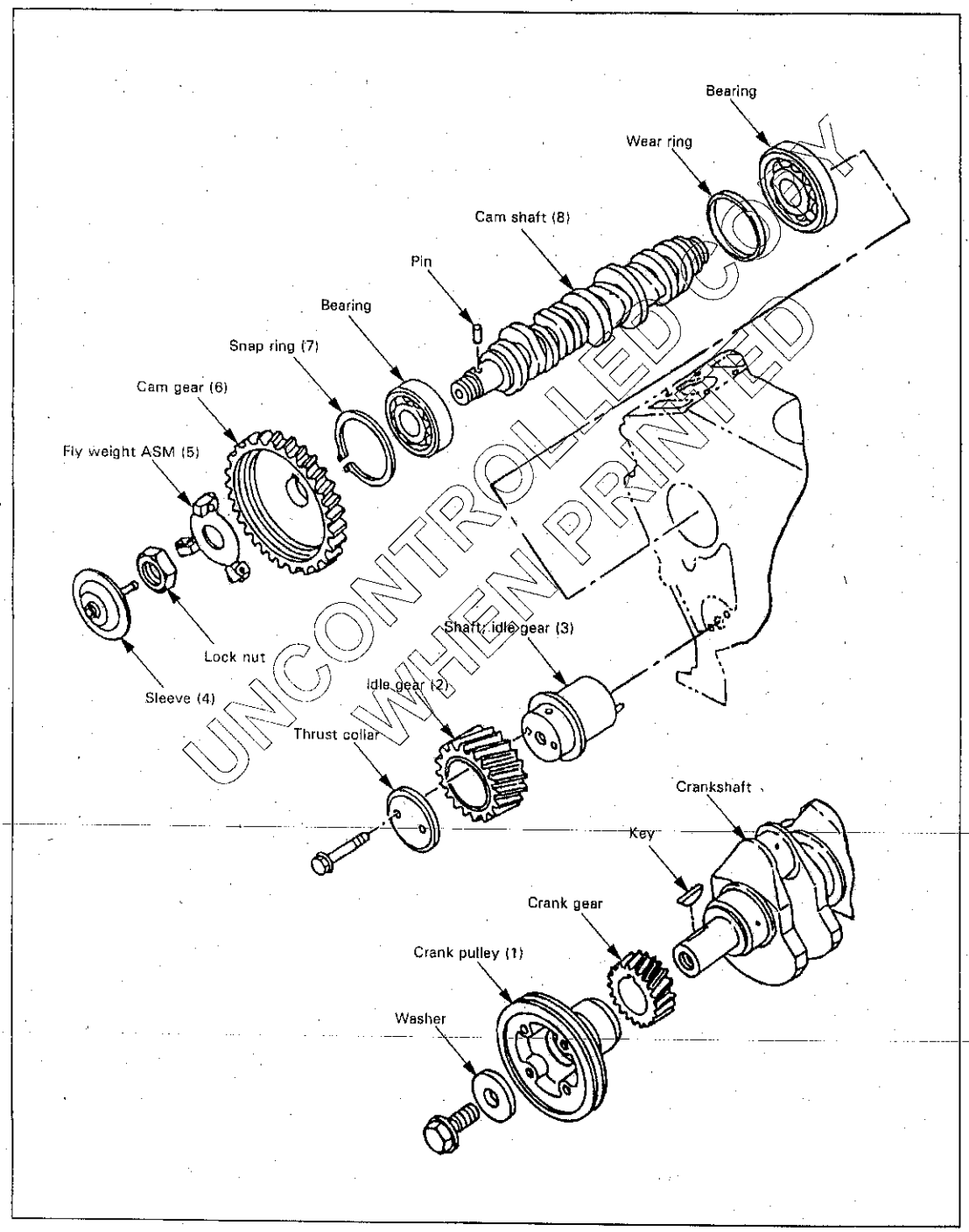


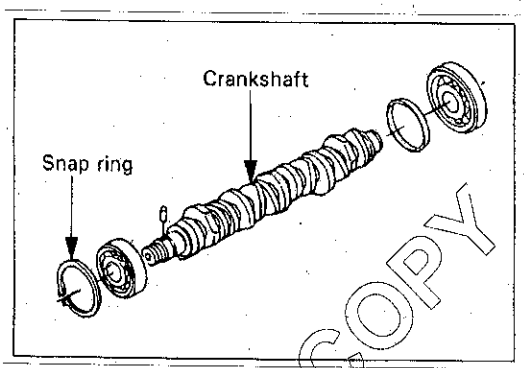
Fig 18 Timing gear

Camshaft

35 Proceed as follows:

(1) Remove the snap ring that holds down the front bearing of the camshaft from the ring groove of the cylinder block.

(2) Pull out the camshaft from the cylinder block, together with the bearing.



Piston and connecting rod

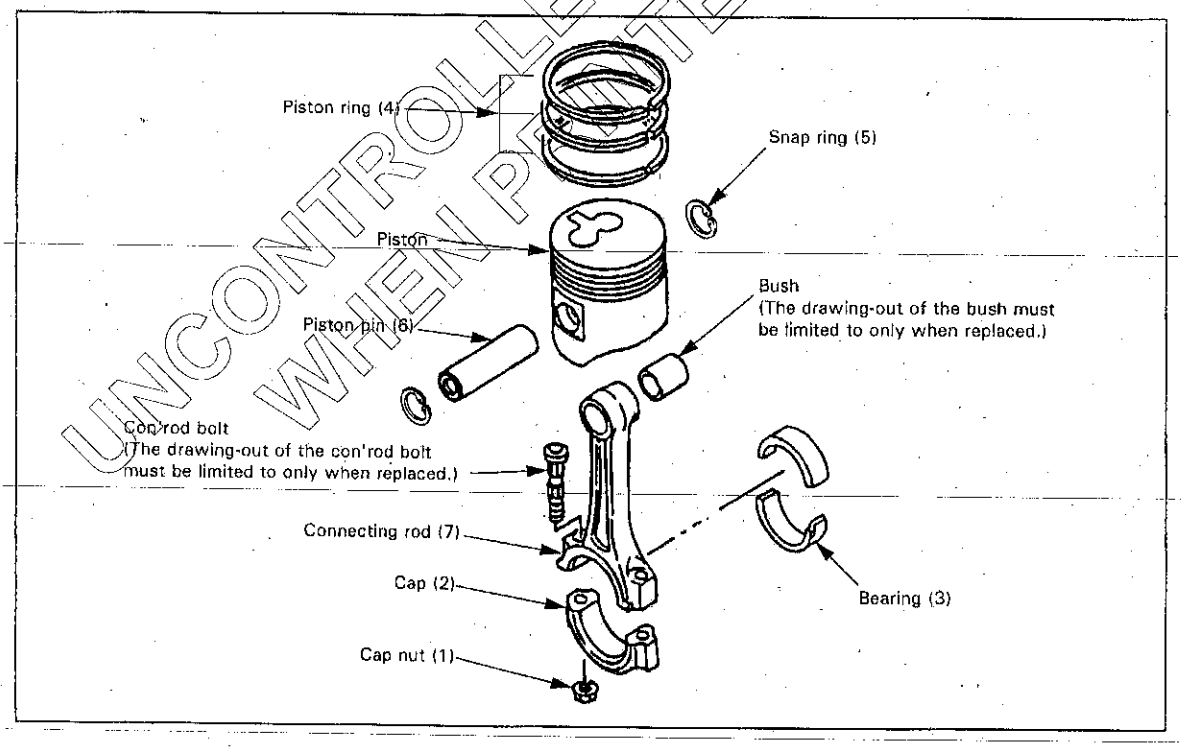


Fig 19 Piston and connecting rod

36 Proceed as follows:

(1) Turning the crankshaft, position the piston to be removed at the bottom dead centre.

(2) Loosen the cap nut of the connecting rod, and then remove it.

(3) Give another rotation to the crankshaft to position the piston at the top dead centre.

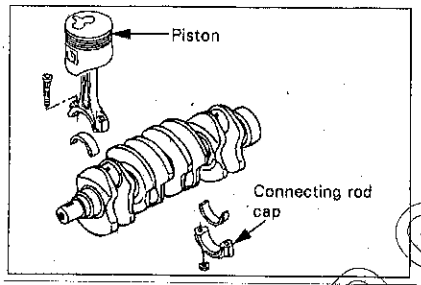
(4) With the handle of a hammer placed at the bottom of the connecting rod, push the piston assembly upward out of the cylinder block.

NOTES

(1) Before removing the piston, scrape the carbon deposit off the cylinder wall.

(2) When pushing out the piston assembly, care should be taken not to damage the cylinder wall.

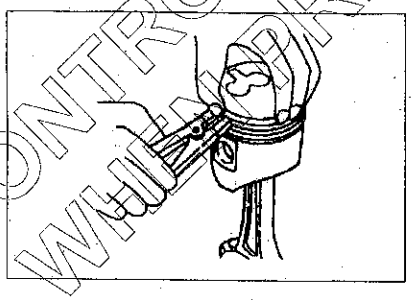
(3) Attach a tag with a cylinder number to the removed caps and bearings to keep them in order.



Piston ring

37 Proceed as follows:

(1) Remove the piston ring with ring pliers. (Pliers: piston ring: 1-85221-029-0.)



Piston pin

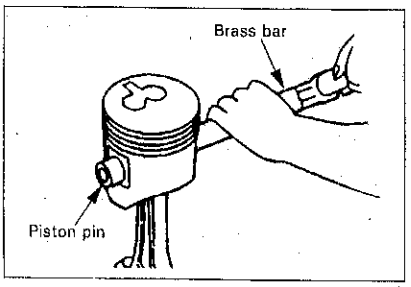
38 Proceed as follows:

(1) Remove the snap rings with a commercially available tool.

(2) With a brass bar attached to the piston pin, push it out by hammering it lightly.

NOTE

Keep the pistons, piston pins and connecting rods in order for each cylinder.



INSPECTION AND REPAIR

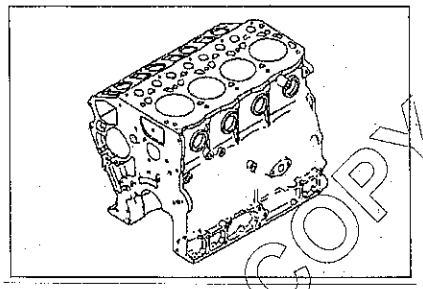
Cylinder block

39 Proceed as follows:

(1) Check the cylinder block for wear, damage or any other defects.

(2) Use the hydraulic gauge to check the water jacket water pressure.

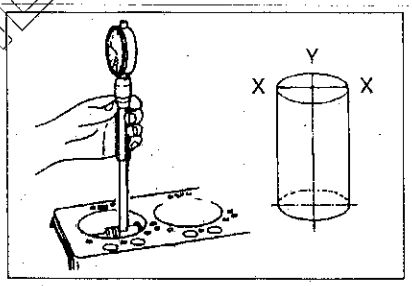
(3) Apply water pressure to the water jacket at 5 kg/cm^2 (71.1 psi) for three minutes.



Cylinder bore

Measurement position: 13 mm below the top
(Measure in X-X and Y-Y directions)
(Near the No. 1 compression ring)

Engine	Limit mm (in.)	Repair method
4LE1	0.2 (0.0079)	Perform boring and honing of the inner diameter



Cylinder bore diameter and grade mark

40 The grade mark is stamped on the top surface of the cylinder block (on the mating face with the cylinder head).

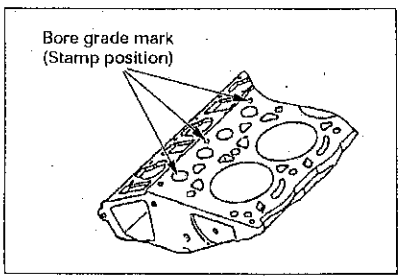


TABLE 11 CYLINDER BORE DIAMETER AND GRADE MARK

mm (in.)

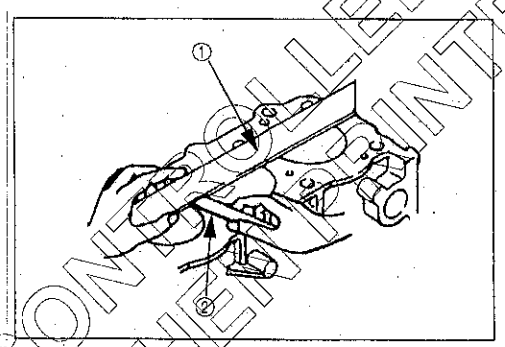
Engine	Bore Diameter mm (in.)	Grade
4LE1	85.000-85.010 (3.3464-3.3468)	A
	85.011-85.020 (3.3468-3.3472)	B
	85.021-85.030 (3.3472-3.3476)	C

Cylinder body upper face warpage

41 Proceed as follows:

(1) Use a straight edge ① and a feeler gauge ② to measure the four sides and the two diagonals of the cylinder body upper face.

(2) Regrind the cylinder body upper face if the measured values are greater than the specified limit but less than the maximum grinding allowance.

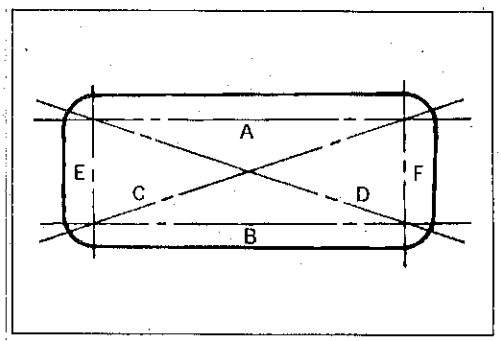


(3) If the measured values exceed the maximum grinding allowance, the cylinder body must be replaced.

Cylinder Body Upper Face Warpage mm (in.)

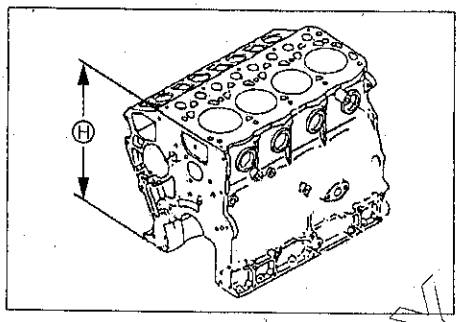
Standard	Limit mm (in.)	Maximum Grinding Allowance
0.075 (0.0029)	0.15 (0.0059)	0.3 (0.0118)

(4) If the measured value is less than the limit, the cylinder body may be reground.



Cylinder Body Height Ⓗ (Reference) mm (in.)

Engine	Standard
4LE1	307.94 – 308.06 (12.123 – 12.128)

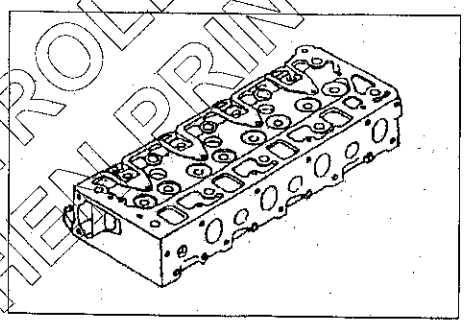


Cylinder head inspection

42 Proceed as follows:

(1) Remove carbon deposit on the bottom surface of the head with care not to damage the valve seat.

Leakage: Water pressure test 5kg/cm^2 (for 3 minutes)

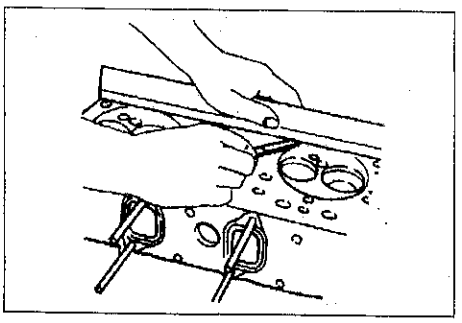


Cylinder head lower face warpage

43 Proceed as follows:

(1) Use a straight edge and a feeler gauge to measure the four sides and the two diagonals of the cylinder head lower face.

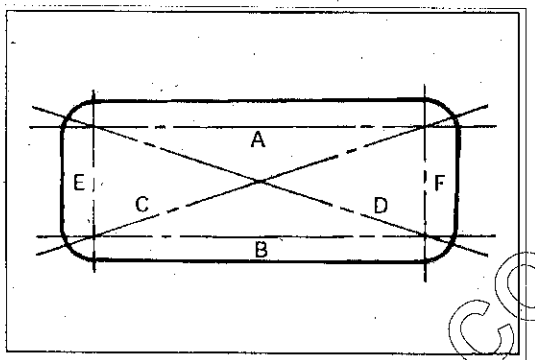
(2) Regrind the cylinder head lower face if the measured values are greater than the specified limit but less than the maximum grinding allowance.



(3) If the measured values exceed the maximum grinding allowance, the cylinder head must be replaced.

Cylinder Head Lower Face Warpage mm (in.)

Standard	Limit	Maximum Grinding Allowance
0.075 (0.0029)	0.15 (0.0059)	0.3 (0.0118)

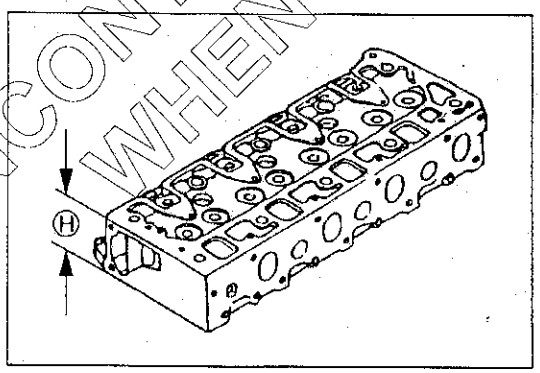


Cylinder Head Height Ⓗ(Reference) mm (in.)

Engine	Standard
4LE1	63.90 – 64.10(2.515 – 2.523)

NOTE

If the cylinder head lower face is reground, valve depression must be checked.



Hot plug

Hot plug depression

44 Proceed as follows:

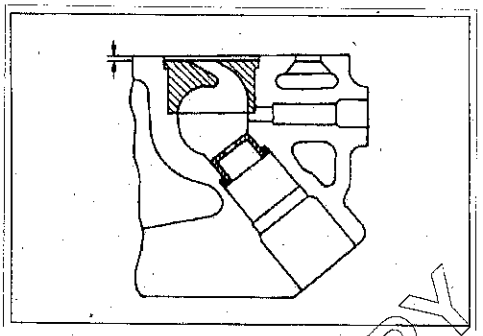
(1) Clean the cylinder head lower face, taking care not to damage the hot plug surfaces.

(2) Use a straight edge and a feeler gauge to measure the hot plug depression in a straight line from the No. 1 hot plug to the No. 3 hot plug.

(3) If the measured value exceeds the specified limit, the hot plugs must be replaced.

mm (in.)

Limit
0.05 (0.002)



Combustion chamber inspection

45 Proceed as follows:

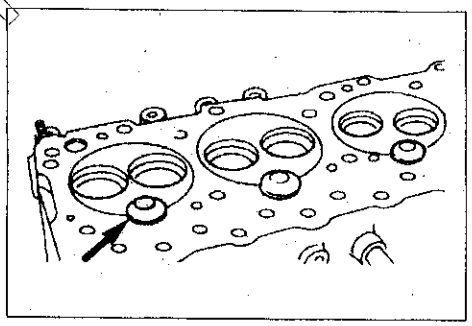
(1) Remove the carbon adhering to the inside of the combustion chamber. Take care not to damage the hot plug fitting positions.

(2) Inspect the combustion chamber, the hot plug hole, and the hot plug machined faces for cracking and other damage.

(3) If cracking or damage is present, the cylinder head must be replaced.

NOTE

Be absolutely certain that there are no scratches or protuberances on the combustion chamber surfaces which will be in contact with the hot plug after it is in-stalled. These flaws will prevent the hot plug from seating correctly.



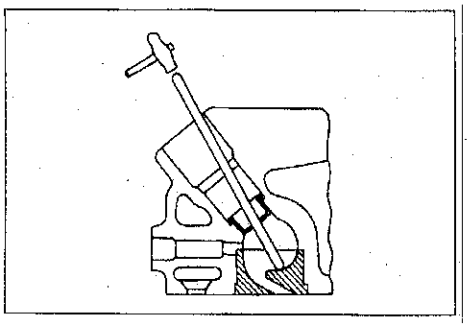
Hot plug replacement

Removal

46 Proceed as follows:

(1) Insert a 3.0 – 5.0 mm (0.12 – 0.20 in) diameter brass bar into the nozzle holder fitting hole until it makes contact with the hot plug.

(2) Lightly tap the bar with a hammer to drive the hot plug free.



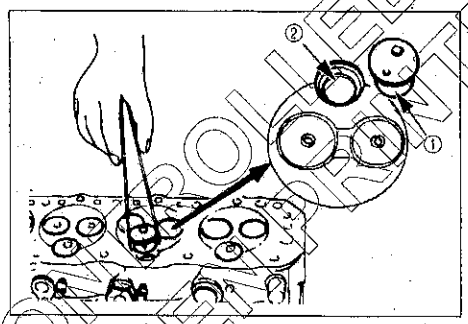
Inspection

47 Inspect the hot plugs for excessive wear and other damage. Replace the hot plugs if either of these conditions are discovered.

Installation

48 Proceed as follows:

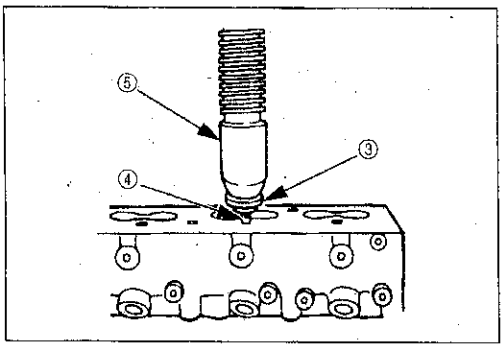
(1) Align the hot plug knock ball ← with the cylinder head groove ↑ to and tap it temporarily into position with a plastic hammer.



(2) Place a metal plate shield → approximately 25 mm (1 in) thick over the hot plug upper surface ↓.

(3) Use a bench press ° to exert a pressure of 4,000 – 5,000 kg (8,819 – 11,023 lb/39,227 – 49,033 N) on the metal plate covering the hot plug upper surface. This will drive the hot plug into position.

(4) Lightly tap the hot plug head to make sure that it is firmly seated.



(5) Repeat the procedure Steps (1) – (4) for the remaining hot plugs.

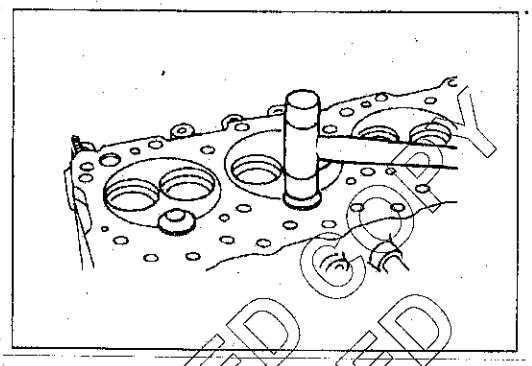
NOTE

Do not apply pressure greater than that specified. Damage to the cylinder head will result.

(6) Use a surface grinder to grind off any hot plug surface protuberances.

The hot plug surfaces must be perfectly flush with the cylinder head lower face.

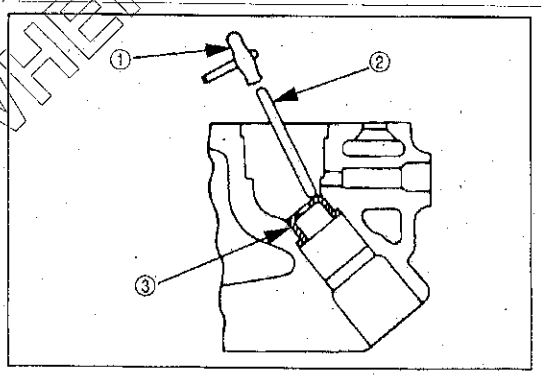
(7) After grinding, make sure that the hot plug surfaces are completely free of protuberances. The hot plug surfaces must also be free of depressions. Once again, lightly tap the hot plug heads to make sure that they are firmly seated.



Heat shield replacement

Removal

49 After removing the hot plugs, use a hammer ← and a brass bar ↑ to lightly tap the lower side of the heat shield → and drive it free.



Installation

50 Install the heat shield to the cylinder head from the nozzle holder installation hole side. Lightly tap the heat shield flange into place with a hammer and a brass bar. The heat shield flange side must be facing up.

NOTE

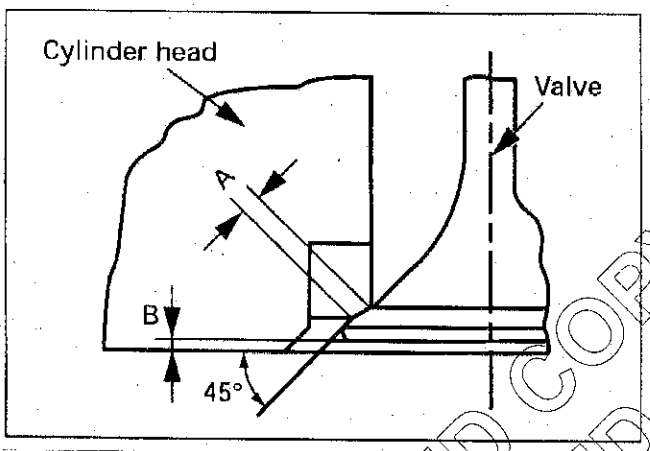
Always install a new heat shield. Never reuse the old heat shield.

VALVE, VALVE SEAT INSERT AND VALVE SEAL

Inspection of valve seat

51 A = Contact width.

B = Valve depression.



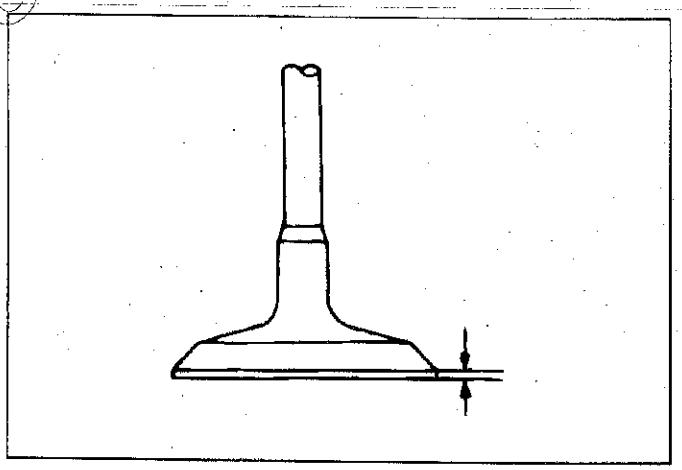
Valve Seat Limits mm (in.)

	Standard	Limit
Contact width	2.0 (0.0787)	2.5 (0.0984)
Valve depression	0.7 (0.0276)	1.2 (0.0427)

Valve thickness

Valve Thickness mm (in.)

Normal	Limit	Repair method
1.0 (0.03937)	0.7 (0.0276)	Replace

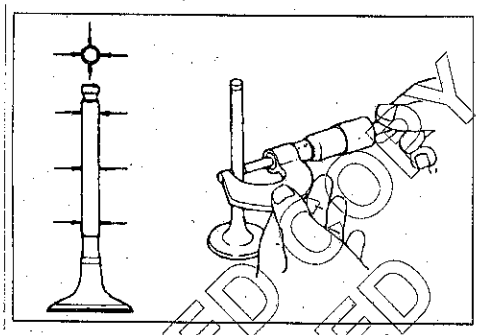


Valve stem outside diameter

52 Measure the valve stem diameter at three points. If the measured value is less than the specified limit, the valve must be replaced.

Valve Stem Outside Diameter mm (in.)

	Standard	Limit
Intake Valve	7.0 (0.2756)	6.85 (0.2697)
Exhaust Valve	7.0 (0.2756)	6.8 (0.2677)



Valve seat insert replacement

Removal

53 Proceed as follows:

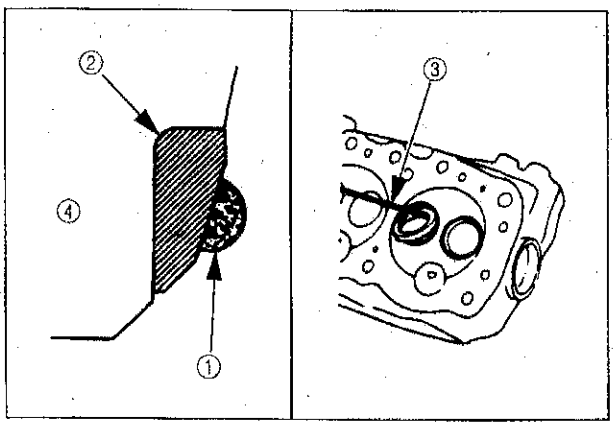
(1) Arc weld the entire inside circumference ← of the valve seat insert ↑.

(2) Allow the valve seat insert to cool for a few minutes. This will invite contraction and make removal of the valve seat insert easier.

(3) Use a screwdriver → to pry the valve seat insert free.

Take care not to damage the cylinder head ↓.

(4) Carefully remove carbon and other foreign material from the cylinder head insert bore.



Installation

54 Proceed as follows:

(1) Carefully place the attachment ← (having a smaller outside diameter than the valve seat insert) on the valve seat insert ↑.

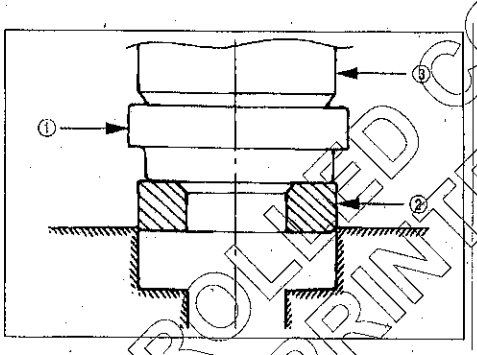
NOTE

The smooth side of the attachment must contact the valve seat insert.

(2) Use a bench press → to gradually apply pressure to the attachment and press the valve seat insert into place. 4,000 kg (8,819 lbs.)

NOTE

Do not apply an excessive amount of pressure with the bench press. Damage to the valve seat insert will result.

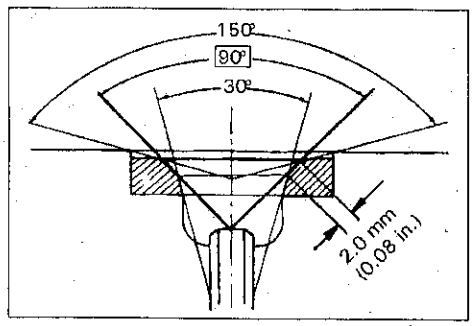


Valve seat insert correction

55 Proceed as follows:

(1) Remove the carbon from the valve seat insert surface.

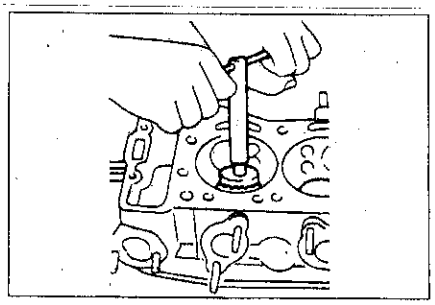
(2) Use a valve cutter (15°, 45°, and 75° blades) to minimize scratches and other rough areas. This will bring the contact width back to the standard value. Remove only the scratches and rough areas. Do not cut away too much. Take care not to cut away unblemished areas of the valve seat surface.



Valve Seat Angle (Degree)
45

NOTE

Use an adjustable valve cutter pilot. Do not allow the valve cutter pilot to wobble inside the valve guide.



(3) Apply abrasive compound to the valve seat insert surface.

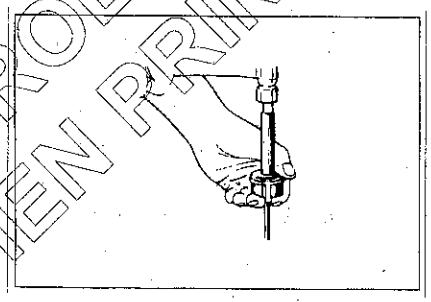
(4) Insert the valve into the valve guide.

(5) Apply light pressure to the valve while turning it to fit the valve seat insert.

(6) Check that the valve contact width is correct.

(7) Check that the valve seat insert surface is in contact with the entire circumference of the valve.

(8) Clean the head and valves to remove the abrasive compound and metal particles.



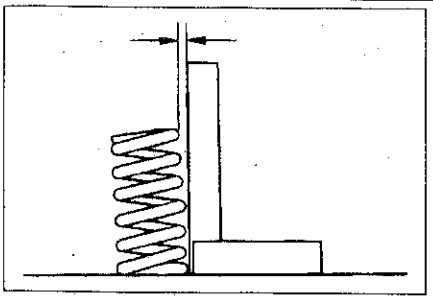
VALVE SPRING

Valve spring inclination

56 Use a surface plate and a square to measure the valve spring inclination. If the measured value exceeds the specified limit, the valve spring must be replaced.

Valve Spring Inclination mm (in.)

	Standard	Limit
Valve Spring Inclination	1.8 (0.0709)	2.5 (0.0984)

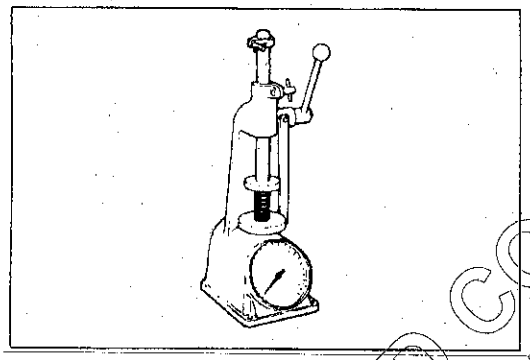


Valve spring tension

57 Use a spring tester to measure the valve spring tension. If the measured value is less than the specified limit, the valve spring must be replaced.

Valve Spring Tension kgf (lb)

	Standard	Limit
Valve Spring Tension at 29.9 mm Set Length	17.0 (37.479)	15.0 (33.069)

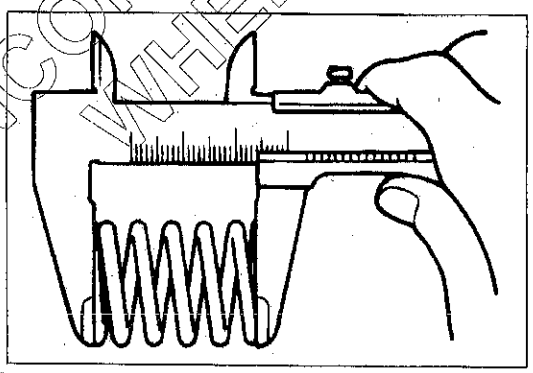


Valve spring free length

58 Use a vernier caliper to measure the valve spring free length. If the measured value is less than the specified limit, the valve spring must be replaced.

Valve Spring Free Length mm (in.)

	Standard	Limit
Exhaust and Intake Valve Spring Free Length	42.1 (1.6575)	40.0 (1.5748)

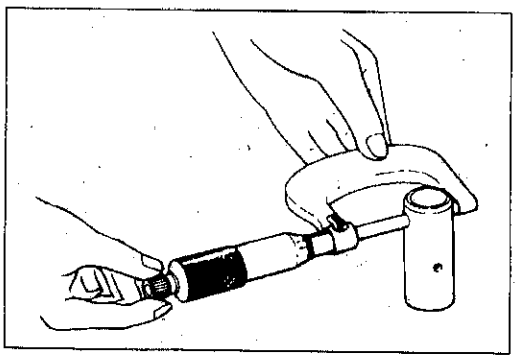


TAPPET (Cam Follower or Valve Lifter) AND PUSH ROD

59 Inspect the tappets for excessive wear, damage and any abnormalities. Use a micrometer to measure the tappet diameter.

Tappet Diameter mm (in.)

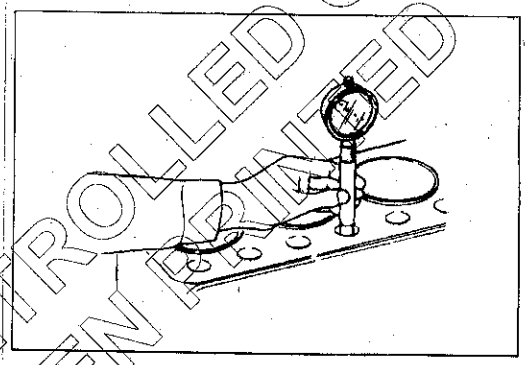
	Standard
Tappet Diameter	20.967 – 20.980 (0.82547 – 0.82598)



60 Use a dial indicator to measure the clearance between the tappet and cylinder body tappet travelling bore.

Tappet and Tappet Travelling Bore Clearance mm (in.)

	Standard	Limit
Tappet and Tappet Travelling Bore Clearance	0.020 – 0.054 (0.00079 – 0.00213)	0.08 (0.00315)

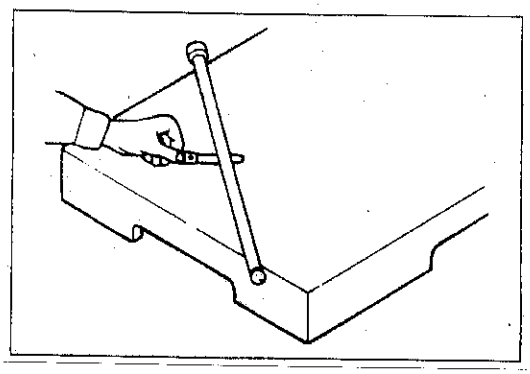


PUSH ROD

61 Use a filler gauge to measure the valve push rod runout. Roll the push rod along a smooth flat surface (illustration).

Push Rod Run-Out mm (in.)

	Limit
Push Rod Run-Out	0.3 (0.0118)



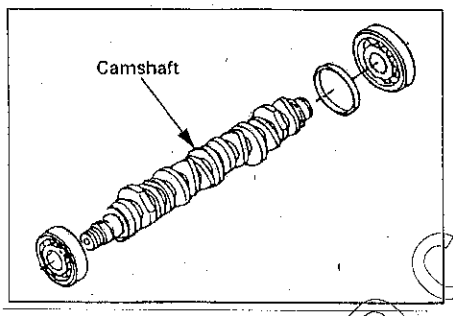
CAMSHAFT

Inspection of cam shaft

62 Check the journal and the cam for evidence of wear, damage or any other defect.

NOTE

With the front and rear parts of camshaft pressed in with ball bearings, and with the cylinder block pressed in with roller bearings as the centre bearing, check to see if the camshaft rotates smoothly with no play at each bearing.



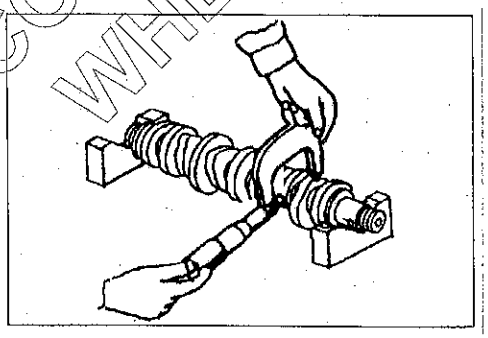
Measurement of journal and cam

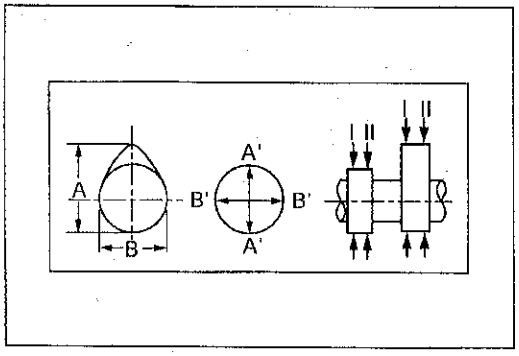
63 Proceed as follows:

(1) Cam height (A – B) mm:

Cam Height (A – B) mm (in.)

	Standard	Limit	Repair method
Intake	6.13 (0.2413)	5.83 (0.2295)	Replace
Exhaust	6.43 (0.2531)	6.13 (0.2413)	Replace





(2) Centre journal diameter:

Centre Journal Diameter mm (in.)

Nominal	Limit	Repair method
52 ø (2.0472)	51.92 ø (2.0441)	Replace

(3) Uneven wear of journal

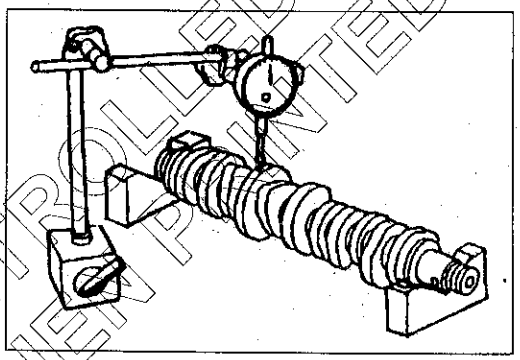
Uneven Wear of Journal mm (in.)

Nominal	Limit	Repair method
52 ø (2.0472)	0.05 (0.002)	Replace

(4) Runout of camshaft

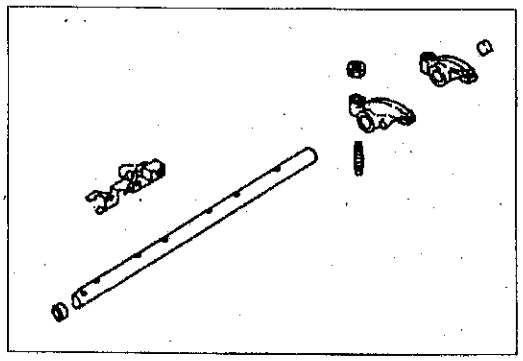
Runout of Camshaft mm (in.)

Nominal	Limit	Repair method
0.02 (0.008)	0.1 (0.004)	Replace



ROCKER ARM SHAFT AND ROCKER ARM

64 Inspect all disassembled parts for wear, damage and any abnormalities.



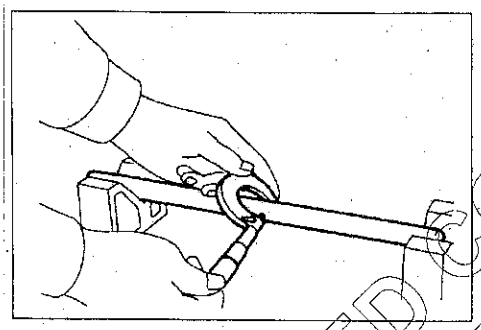
Rocker arm shaft outside diameter

65 Use a micrometer to measure the rocker arm outside diameter.

66 If the measured value is less than the specified limit, the shaft must be replaced.

Rocker Arm Shaft Diameter mm (in.)

	Standard
Rocker Arm Shaft Diameter	11.935 – 11.955 (0.4699 – 0.4707)



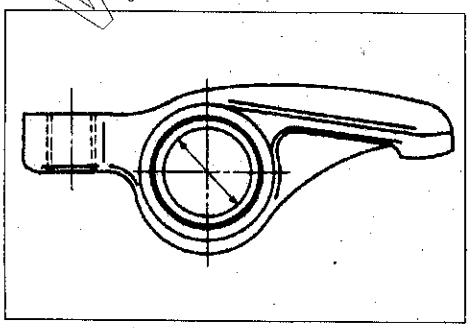
Rocker Arm Shaft and Rocker Arm Clearance

67 Proceed as follows:

(1) Use a vernier caliper to measure the rocker arm bushing inside diameter.

Rocker Arm Bushing Inside Diameter mm (in.)

	Standard
Rocker Arm Bushing Inside Diameter	11.960 – 11.980 (0.4709 – 0.4717)

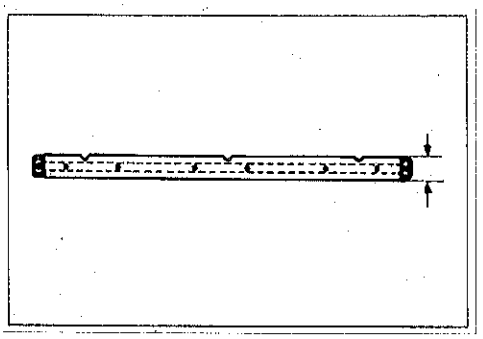


(2) Measure the rocker arm shaft outside diameter. Replace either the rocker arm or the rocker arm shaft if the clearance exceeds the specified limit.

Rocker Arm Shaft Outside Diameter mm (in.)

	Standard	Limit
Rocker Arm Bushing and Rocker Arm Shaft Clearance	0.005 – 0.045 (0.0002 – 0.0018)	0.2 (0.0079)

(3) Check that the rocker arm oil port is free of obstructions. If necessary, use compressed air to clean the rocker arm oil port.



PISTON, PISTON PIN AND PISTON RING

Clearance between piston and cylinder bore

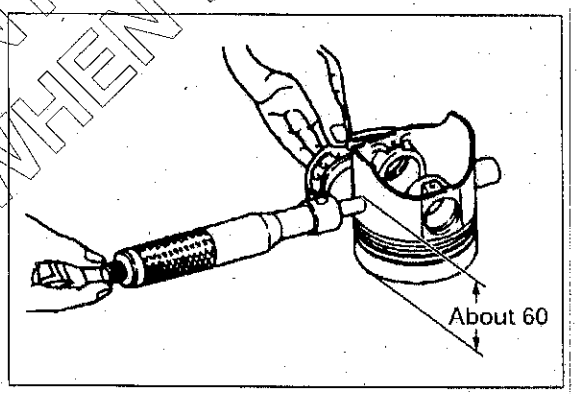
68 Proceed as follows:

(1) Measure the outside diameter of the piston at about 60 mm from the top in a right angle to the piston pin (in the unit of 1/1,000 mm).

(2) Calculate the clearance based on the measurements of the cylinder bore and the outside diameter of the piston.

mm (in.)

Clearance	0.015 – 0.035 (0.0006 – 0.0014)

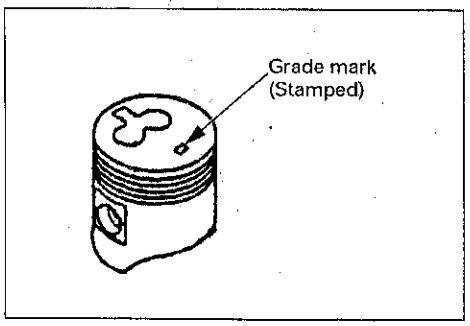


Outside diameter of piston and grade mark

69 The grade mark is stamped on the top surface of the piston.

mm (in.)

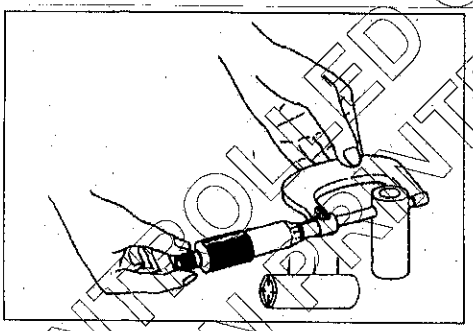
Model	Outside diameter of piston	Grade
4LE1	84.975 –84.985 (3.3454 – 3.3458)	A
	84.986 –84.995 (3.3459 – 3.3462)	B
	84.996 –85.005 (3.3463 – 3.3466)	C



Wear of piston pin (outside diameter)

Wear of Piston Pin (outside diameter) mm (in.)

Model	Nominal	Limit	Remarks
4LE1	25.0 (0.9843)	24.97 (0.9831)	



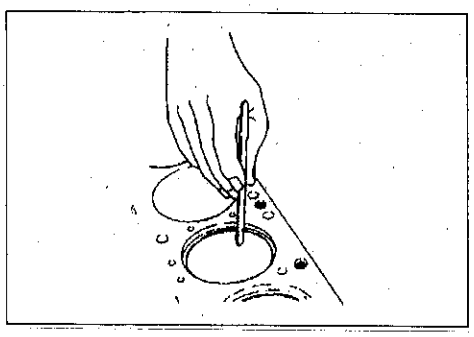
Clearance between piston pin and piston pin hole

mm (in.)

	Standard
4LE1	0.002 – 0.012 (0.00008 – 0.00047)

Piston ring gap

70 With the ring inserted into the cylinder bore, push it in with the piston head so that it becomes a right angle to the cylinder, and then measure the gap of the piston ring. If worn beyond the limit, replace the rings.



Piston Ring Gap mm (in.)

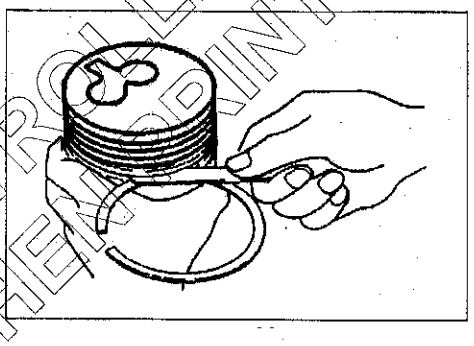
4LE1	Standard	Limit
1st compression ring	0.2 – 0.35 (0.0079 – 0.0138)	1.5 (0.0590)
2nd compression ring	0.35 – 0.5 (0.0138 – 0.0197)	
Oil ring	0.2 – 0.4 (0.0079 – 0.0157)	1.0 (0.03937)

Clearance between piston ring groove and ring

71 Measure clearance at several places on the circumference. If worn beyond the limit, replace the rings or piston.

4LE1 mm (in.)

	Standard	Limit
1st compression ring	0.085 – 0.105 (0.0033 – 0.0041)	2.0 (0.0078)
2nd compression ring	0.050 – 0.085 (0.0020 – 0.0033)	0.15 (0.0059)
Oil ring	0.030 – 0.070 (0.0011 – 0.0027)	



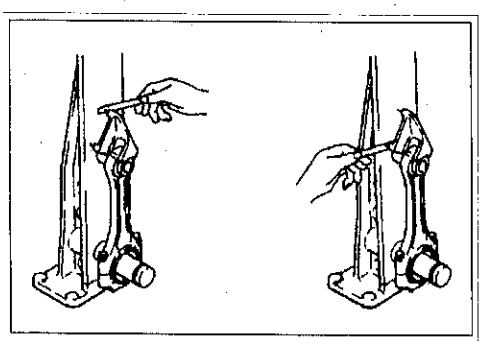
CONNECTING ROD AND CONNECTING ROD BEARING

Torsion and parallelism of connecting rod

72 If worn beyond the limit, repair or replace.

Torsion and Parallelism of Connecting Rod mm (in.)

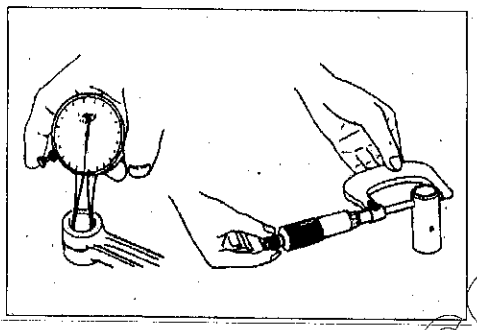
Per 100 mm (3.94)	Standard	Limit
Torsion	0.05 (0.002)	2.0 (0.0079)
Parallelism	0.05 (0.002)	0.15 (0.0059)



73 Clearance between small end pin hole of connecting rod and piston pin, inside diameter of bushing.

mm (in.)

4LE1	Standard	Limit
Clearance	0.008 – 0.020 (0.0003 – 0.0008)	0.05 (0.0020)
Inside diameter	25 (0.8268)	-



Connecting rod bearing inspection

74 Proceed as follows:

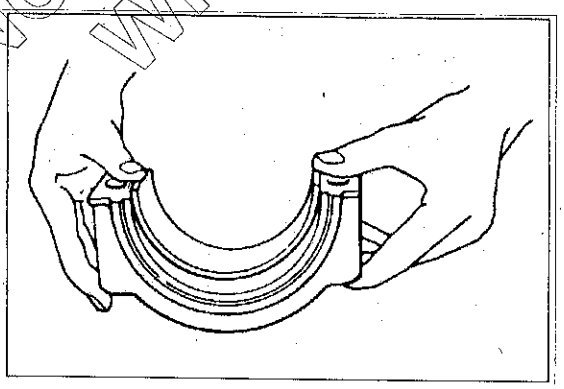
(1) Fit the connecting rod bearing lower half into the connecting rod bearing cap.

(2) Check the connecting rod bearing lower half tension. If the tension is insufficient, the bearing must be replaced.

(3) Tighten the torque and the bearing cap to the specified torque.

kg m (ft.lbs.)

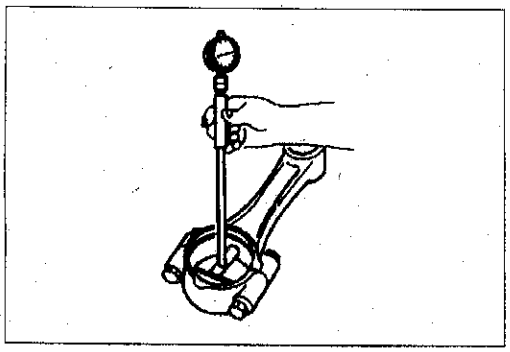
Connecting rod tightening torque	4LE1	7.5 – 8.5 (54 - 61)



75 Clearance between bearing and crank pin, inside diameter with bearing installed and without.

mm (in.)

	Standard	Limit
Clearance	0.035 – 0.073 (0.0014 – 0.0029)	0.10 (0.0039)



CRANKSHAFT AND CRANKSHAFT BEARING

Outside diameters of journal and pin

76 If worn beyond the limits, replace

Crank journal

mm (in.)

	Standard	Limit
4LE1	60.0 (2.2047)	59.86 (2.3567)

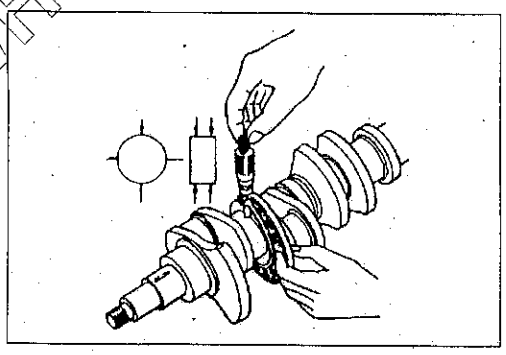
Crank pin

mm (in.)

	Standard	Limit
4LE1	49.0 (1.9291)	48.87 (1.9240)

NOTE

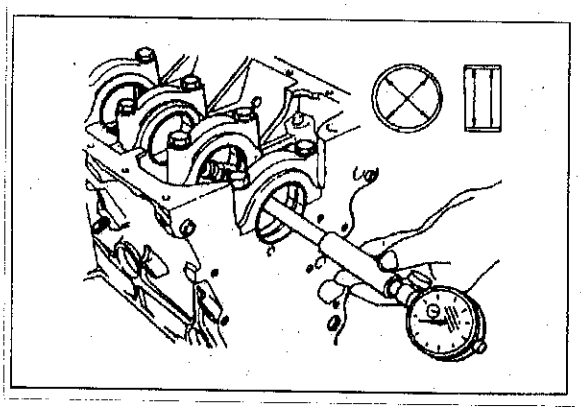
When there occurs an uneven wear to the crankshaft, replace it with a new one without grinding it for reuse.



Clearance between journal and bearing inside diameter with bearing installed and without

mm (in.)

	Standard	Limit
Clearance	0.029 – 0.072 (0.0011 – 0.0028)	0.11 (0.0043)

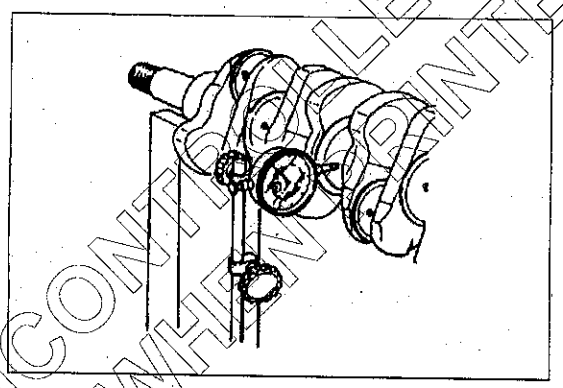


Runout of crankshaft

77 Replace if beyond limit.

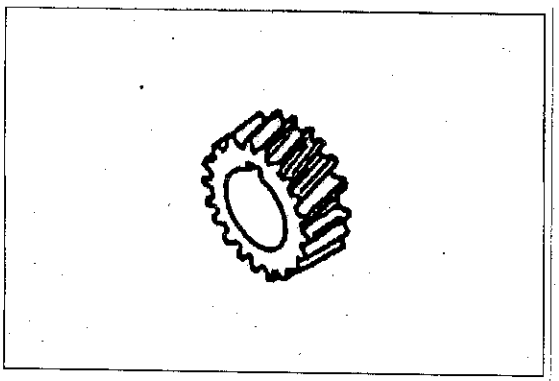
Runout of Crankshaft mm (in.)

Standard	Limit
0.025 (0.001)	0.05 (0.002)



Crankshaft gear

78 Check the crankshaft gear visually for damage and any other defects.

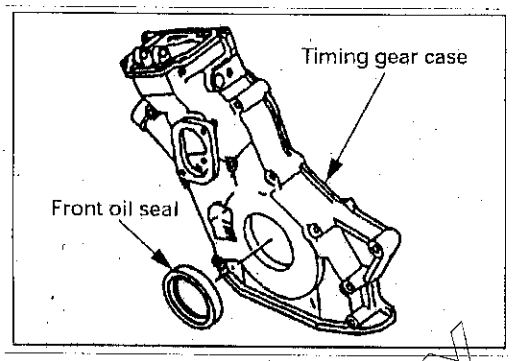


Oil seal

79 When the lip of an oil seal is found defective, replace it with a new one.

Installation

80 Use the crankshaft front oil seal installer to install the crankshaft front oil seal.



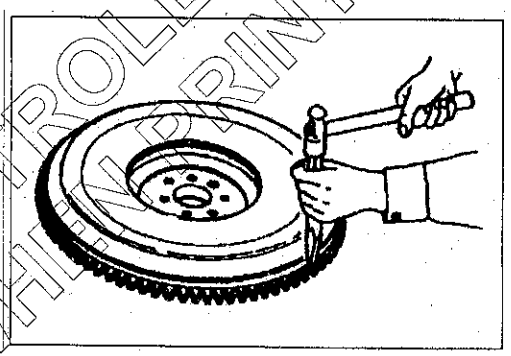
FLYWHEEL AND RING GEAR

Ring gear replacement

81 Inspect the ring gear. If the ring gear teeth are broken or excessively worn, replace the ring gear.

Removal

82 Strike around the edges of the ring gear with a hammer and chisel to remove it.

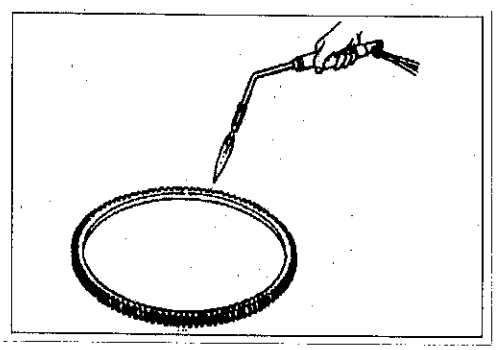


Installation

83 Proceed as follows:

(1) Heat the ring gear evenly with a gas burner to invite thermal expansion. Do not allow the temperature of the gas burner to exceed 200°C (390°F).

(2) Use a hammer to install the ring gear when it is sufficiently heated.

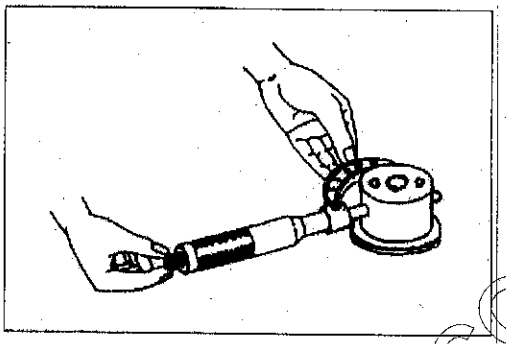


TIMING GEAR

Uneven wear of idle gear shaft

Idle gear shaft mm (in.)

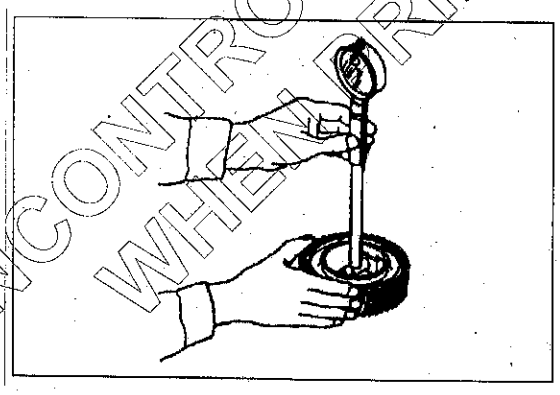
Nominal	Limit
45.0 (1.7717)	0.1 (0.0039)



Clearance between idle gear bushing and shaft

mm (in.)

Standard	Limit
0.025 – 0.085 (0.001 –0.0033)	0.2 (0.0079)



REASSEMBLY

CYLINDER HEAD ASSEMBLY

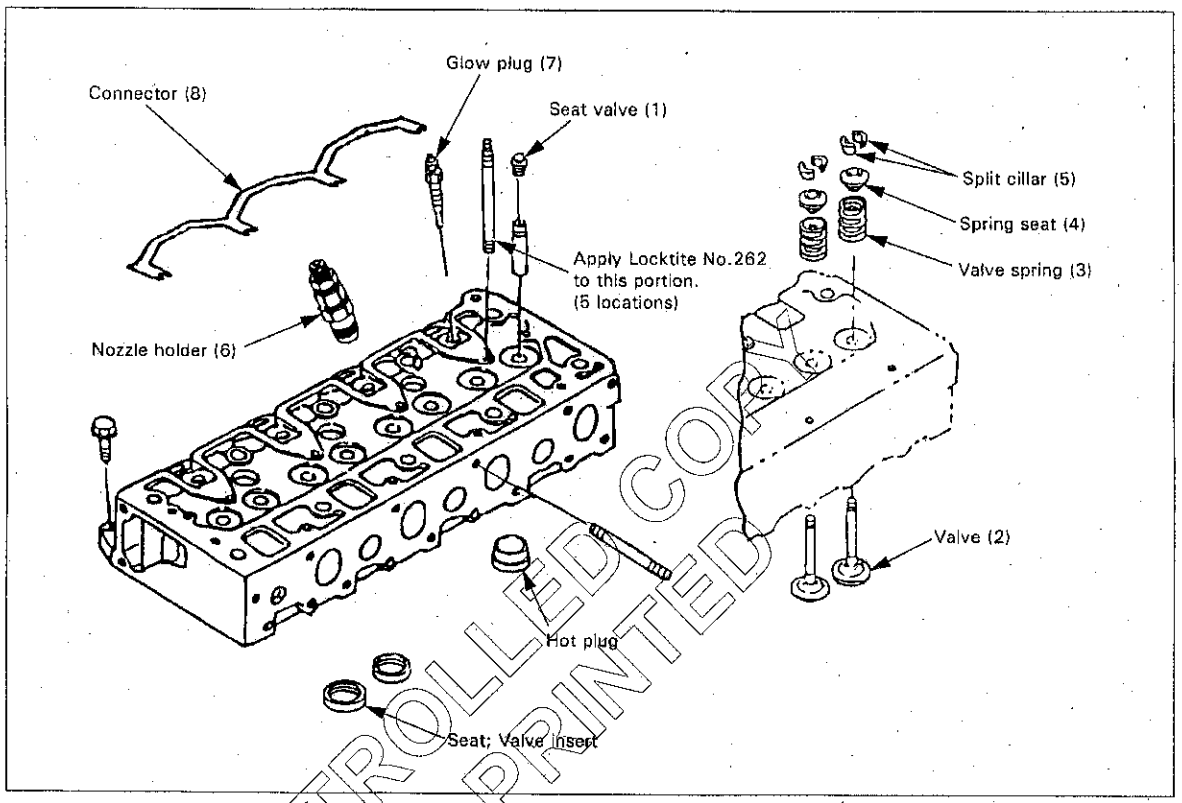


Fig 20 Cylinder head assembly

Important operations

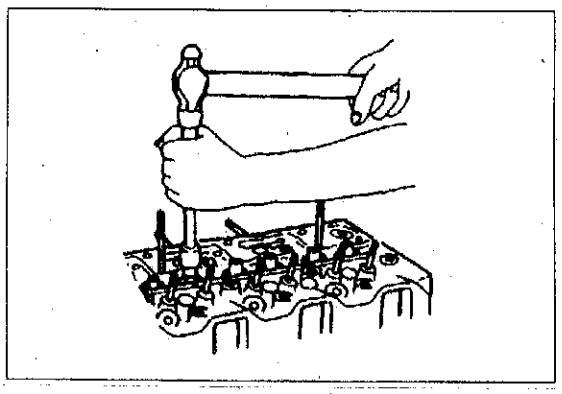
Valve stem oil seal

84 Proceed as follows:

(1) Lubricate the oil seals and valve stem sealing area with engine oil.

(2) Use a valve stem oil seal installer to install the oil seal.

Valve Stem Oil Seal Installer: 5-8840-9033-0



Intake and exhaust valves

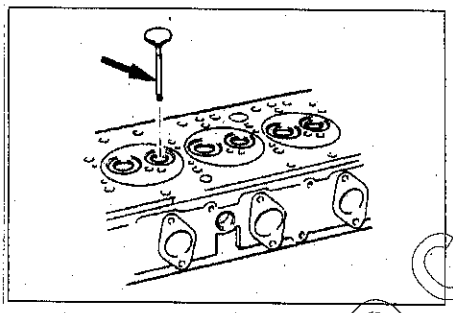
85 Proceed as follows:

(1) Place the cylinder head on a flat wooden surface.

(2) Lubricate valve stems with engine oil.

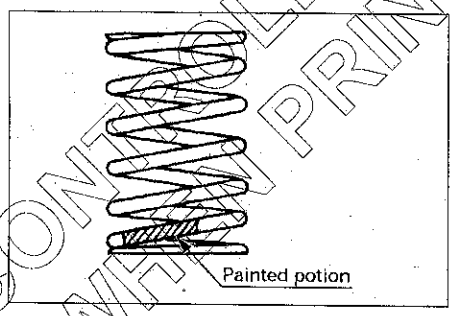
(3) Install the valves to the intake or exhaust guides.

(4) Install the valves to their original lapped valve seats.



Intake and exhaust valve springs

86 Install the valve springs with their painted end (the close pitched end) facing down.



Spring seat split collar

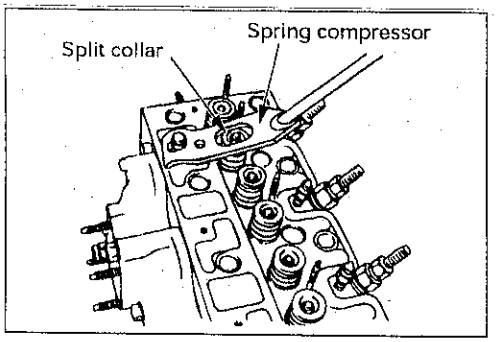
87 Proceed as follows:

(1) Use a spring compressor to push the valve spring into position.

(2) Install the spring seat split collar.

(3) Set the spring seat split collar by tapping lightly around the head of the collar with a rubber hammer.

Spring Compressor: 5-8840-9030-0



Nozzle holder assembly

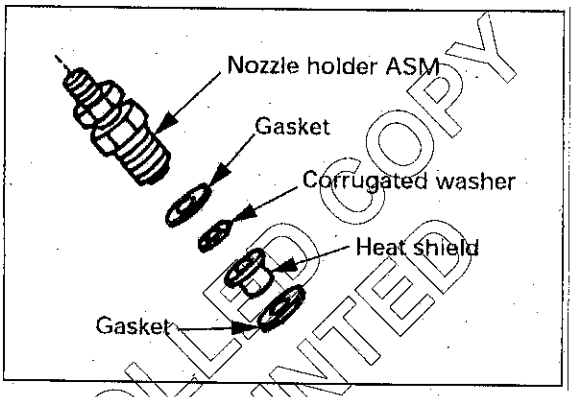
88 Before assembling the nozzle holder assembly, check to see if the spray condition and the spray pressure of the injection nozzle are appropriate, (Refer to "INSPECTION AND SERVICE.")

89 Assemble to the cylinder head the gasket (heat shield), heat shield, corrugated washer and gasket (nozzle holder) in this order.

90 Install the nozzle holder assembly, and then tighten it to the specified torque.

kg m (ft. lbs.)

Nozzle holder assembly tightening torque	4.0 – 5.0 (29.0 – 36.0)



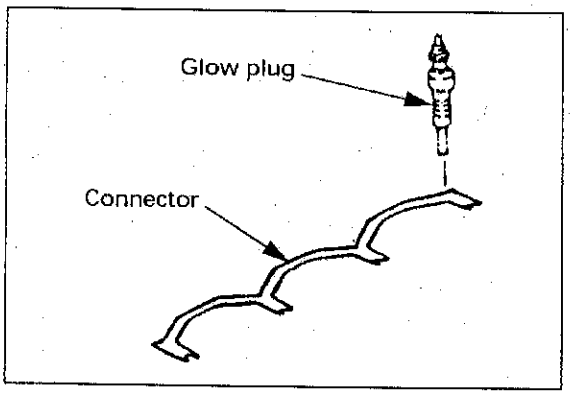
Glow plug and connector

91 Assemble the glow plug to the cylinder head, and then tighten it to the specified torque.

92 Install the connector to the glow plug, and then tighten until snug.

kg m (ft. lbs.)

Parts	Tightening torque
Glow plug	1.5 – 2.0 (11.0 – 14.0)



PISTON AND CONNECTING ROD

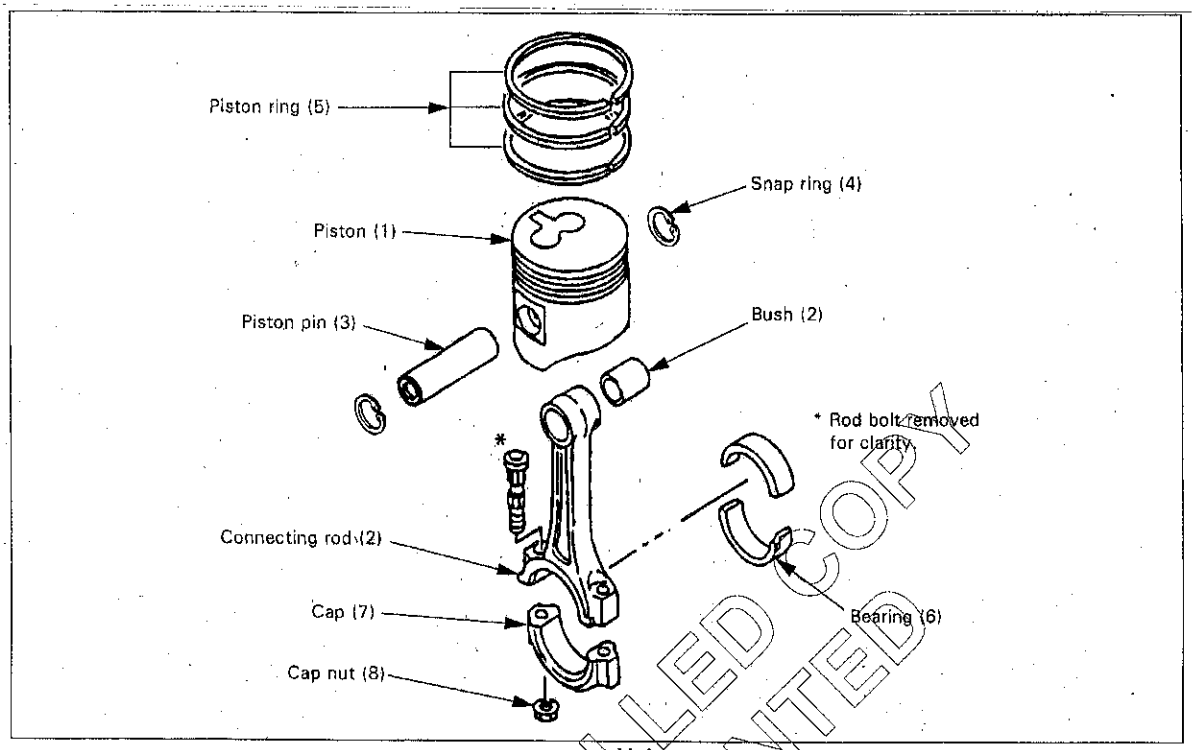
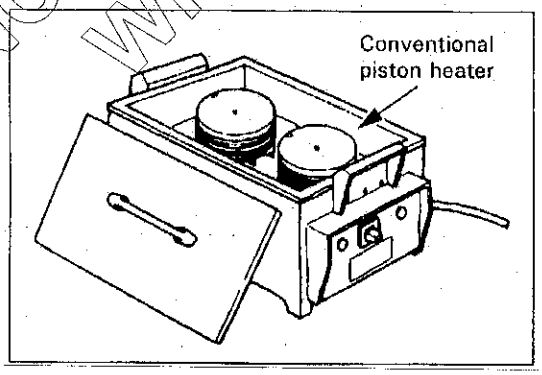


Fig 21 Piston and connecting rod

Important operations

Piston

93 Use a piston heater to heat the pistons to approximately 100°C (212°F).

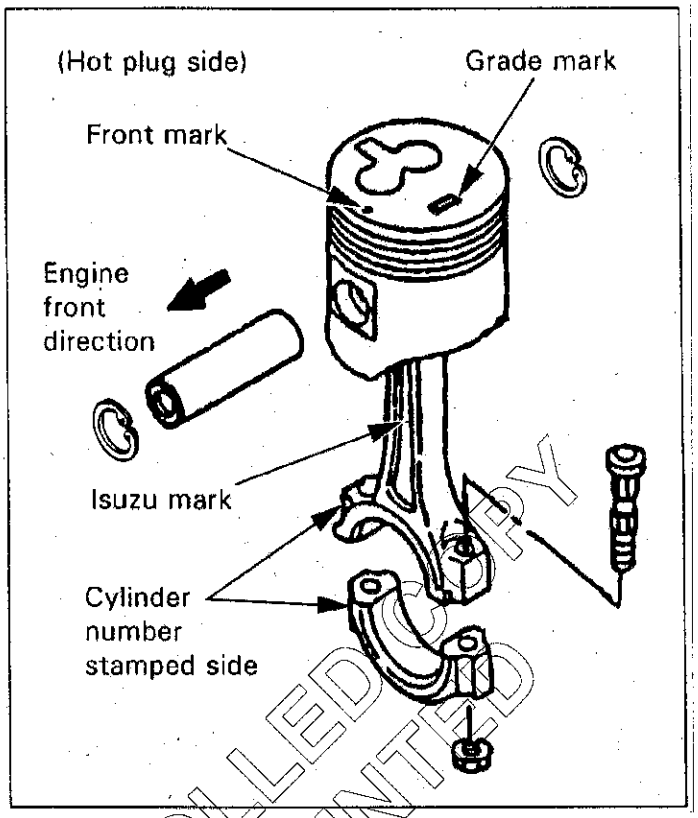


Connecting rod

94 Proceed as follows:

(1) Install the connecting rod to the piston with setting the marks as illustrated.

(2) Install the piston pin into the piston and the connecting rod bushing.

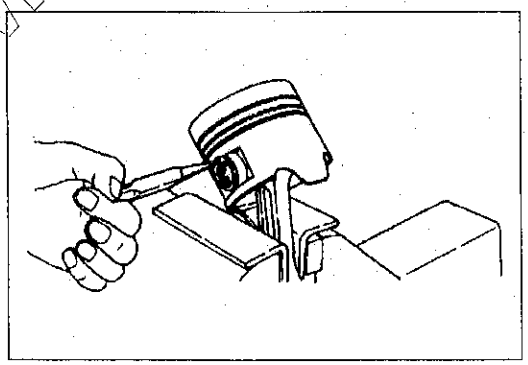


Piston pin snap ring

95 Proceed as follows:

(1) Use a pair of snap ring pliers to install the piston pin snap ring.

(2) Check that the piston moves smoothly on the piston pin.



Piston Ring

96 Proceed as follows:

(1) Use a piston ring installer to install the three piston rings.

Piston Ring Installer.

(2) Install the piston rings in the following order.

a. Oil ring.

b. 2nd compression ring.

c. 1st compression ring.

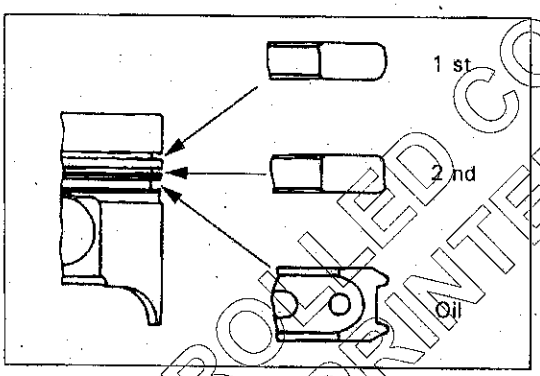
The marked side of the two compression rings must be facing up.

The undercut side of the second compression ring will be facing down.

As the oil ring has no any facing mark, it may face in either direction.

(3) Lubricate the piston ring surfaces with engine oil.

(4) Check that the piston rings rotate smoothly in the piston ring grooves.



REASSEMBLY OF INTERNAL PARTS

97 The reassembly steps for the internal parts of the engine are shown in Fig 22 to 24.

(1) Crankshaft.

(2) Piston Assembly.

(3) Rear Seal Retainer.

(4) Camshaft.

(5) Cam Gear.

(6) Idler gear and Shaft.

(7) Oil Pump Assembly.

(8) Timing Gear Case (Without PTO).

(9) Flywheel Housing.

(10) Flywheel.

(11) Crank Pulley.

(12) Oil Pipe.

(13) Oil Strainer.

(14) Oil Pan.

(15) Tappets.

(16) Cylinder Head Gasket.

(17) Cylinder Head Assembly.

(18) Push Rods.

(19) Rocker Bracket Assembly.

(20) Engine Hangers.

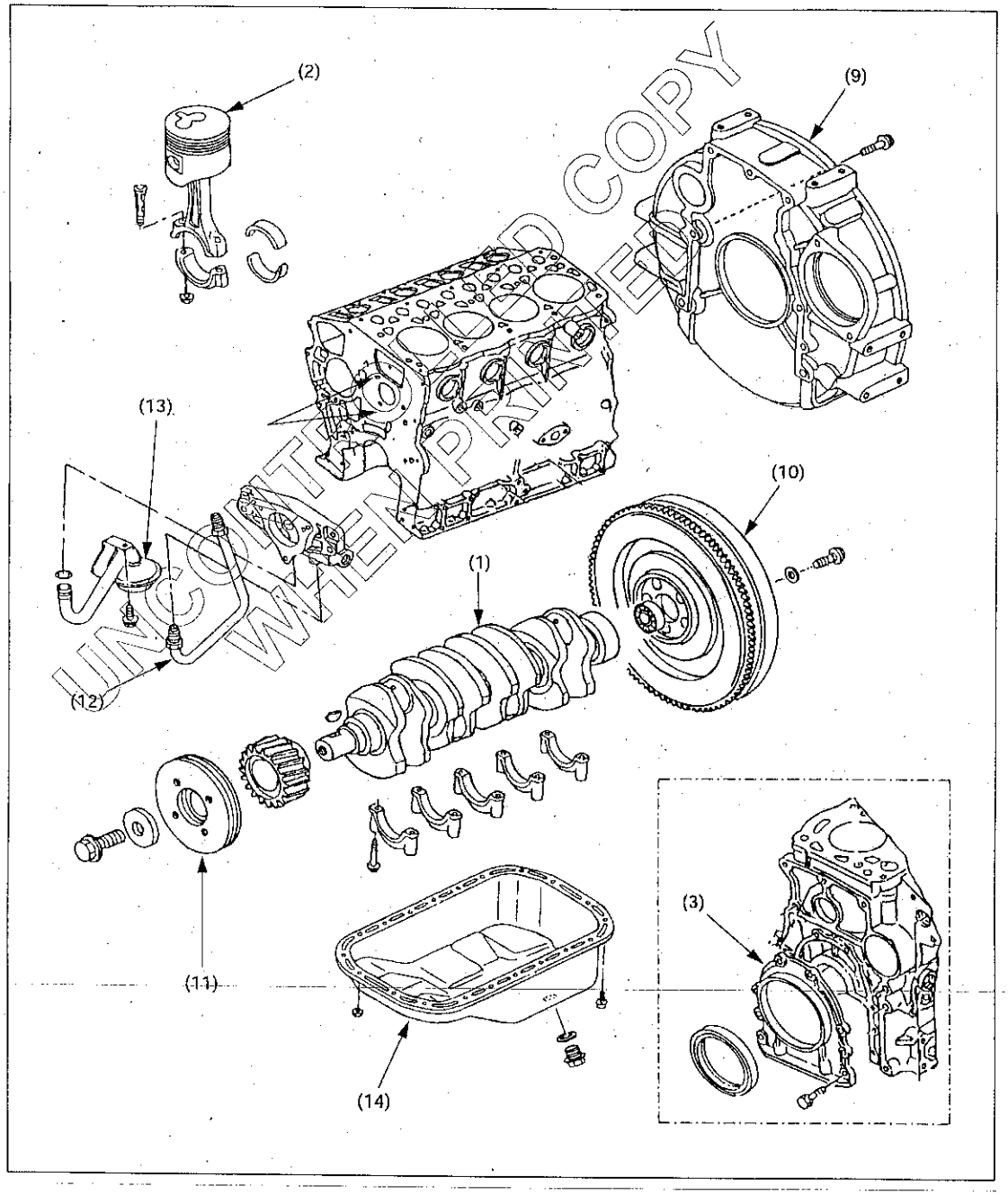


Fig 22 Reassembly internal parts (sheet 1 of 3)

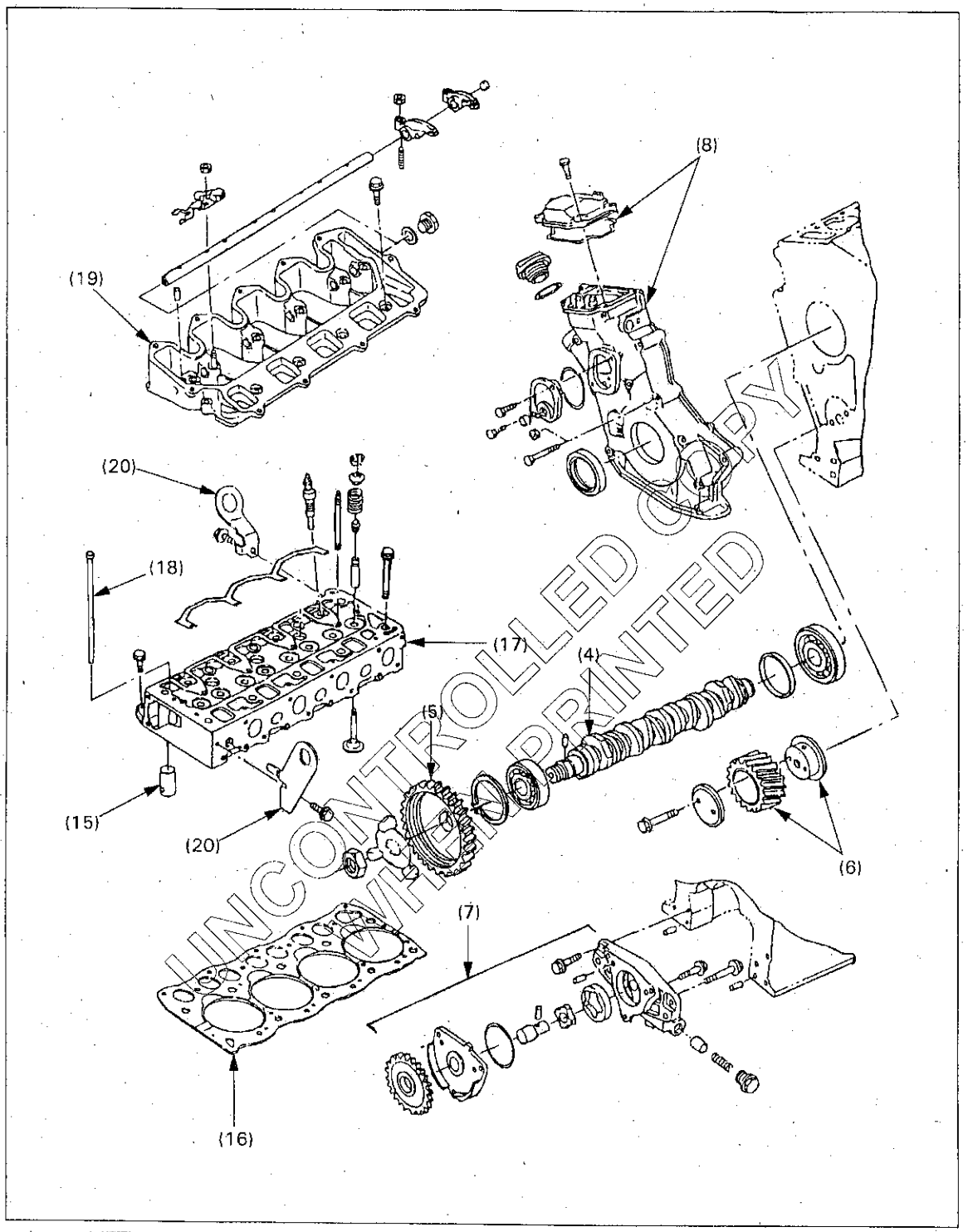


Fig 23 Reassembly internal parts (sheet 2 of 3)

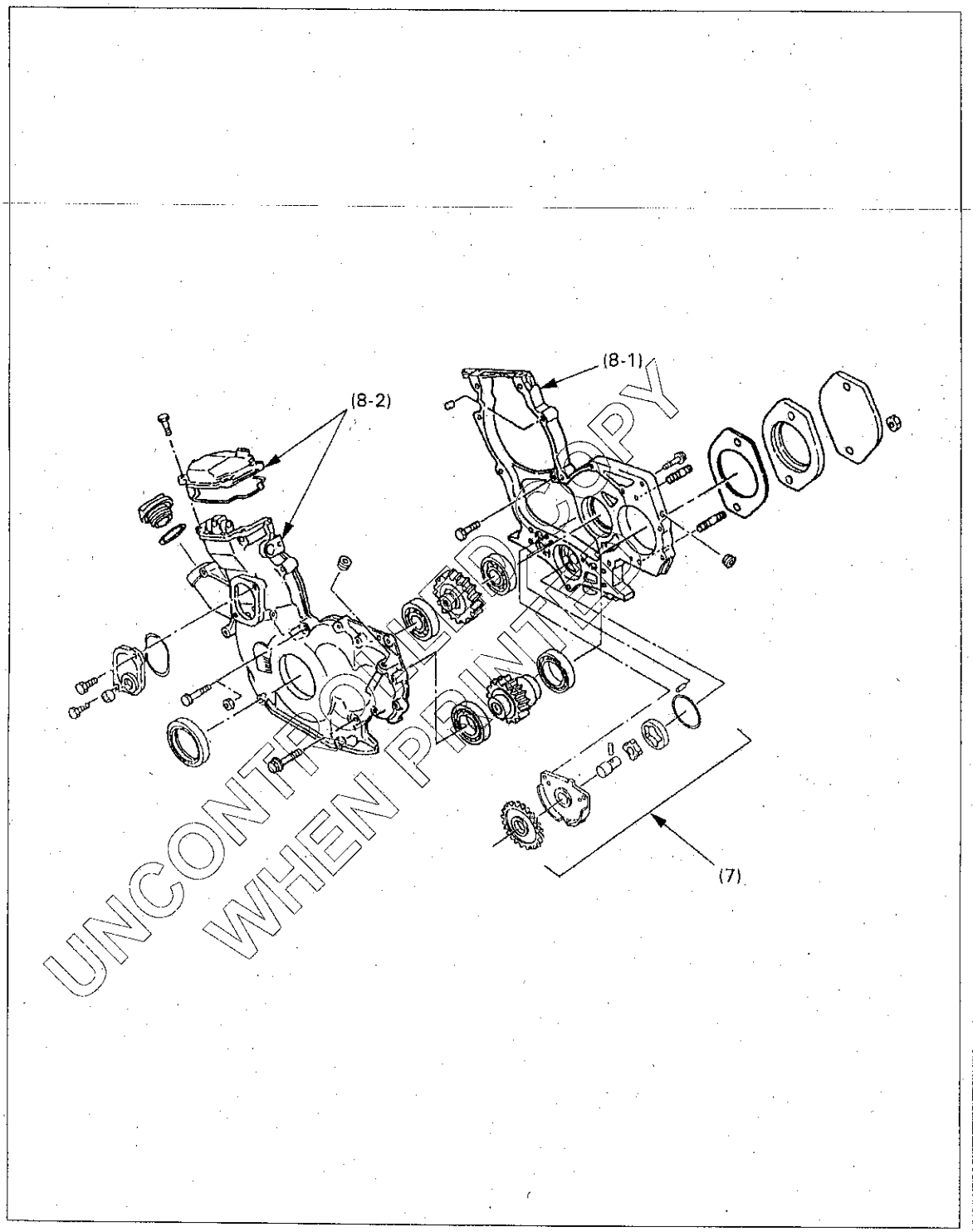
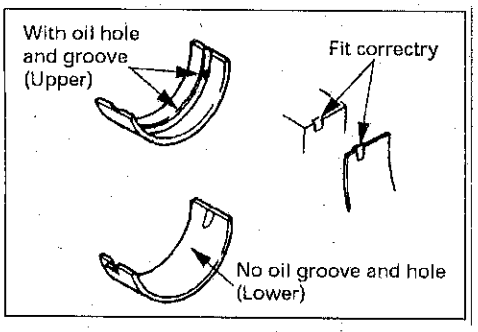


Fig 24 Reassembly internal parts (sheet 3 of 3)

Crankshaft bearing

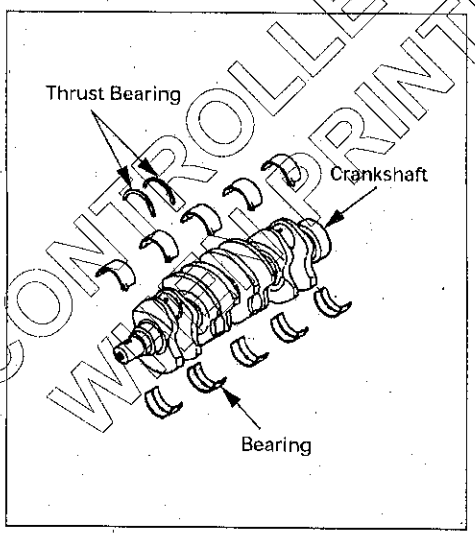
98 Note that there is an oil hole and an oil groove in the upper bearing (on the block side), but not in the lower bearing (on the bearing cap side).

99 Fit the bearing tang firmly into the slot machined on the cylinder body bearing arches.



Crankshaft and bearing

100 Lubricate the bearings with engine oil, install the crankshaft, install the thrust bearings with the groove facing the crankshaft.



Crankshaft bearing cap

101 Proceed as follows:

(1) Lubricate the bearing cap bolts with engine oil.

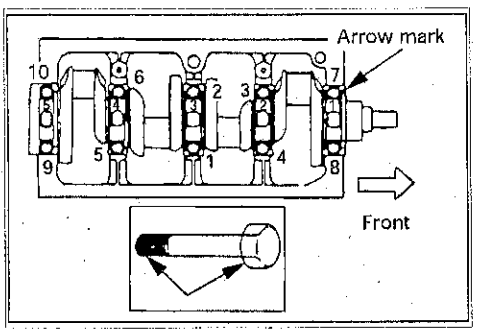
(2) Install the bearing caps to the crankshaft.

The arrow mark must be pointing to the front of the engine.

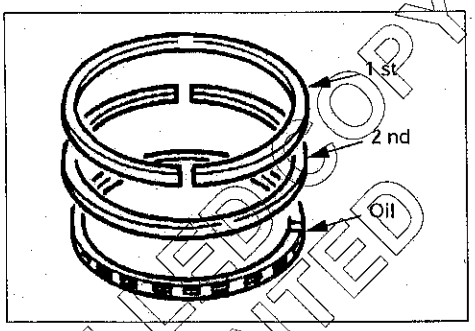
(3) Tighten the bearing cap bolts to the specified torque a little at a time in the numerical order shown in the illustration.

	kg m (ft. lbs.)
Crankshaft bearing cap bolt tightening torque	8.5 – 9.5 (61.0 – 69.0)

(4) Check that the crankshaft turns smoothly by manually rotating it.



102 Position the rings as shown making sure the ring gaps are away from the thrust side.



Piston and connecting rod

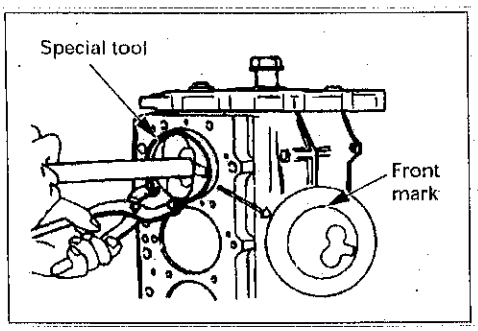
103 Lubricate the piston, the piston rings, and the connecting rod bearings with engine oil.

104 Position the piston front mark towards the front of the engine.

105 Use the piston ring compressor to compress the piston rings.

106 Use a hammer grip to push the piston in until it makes contact with the crank pin.

107 At the same time, rotate the crankshaft until the crankpin reaches its highest point.



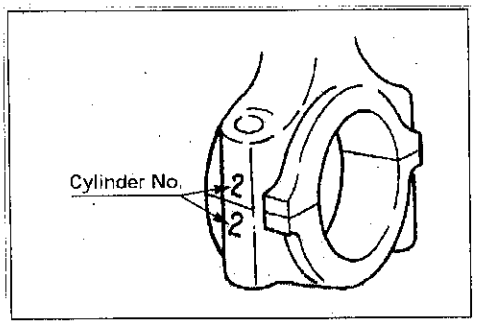
108 Set the bearing cap cylinder number marks and the connecting rod cylinder number marks.

109 The marks must be facing the injection pump side.

		kg m (ft.lbs.)
Tightening torque	4LE1	7.5 – 8.5 (54 - 61)

NOTE

After installation, confirm that the crankshaft rotates smoothly.

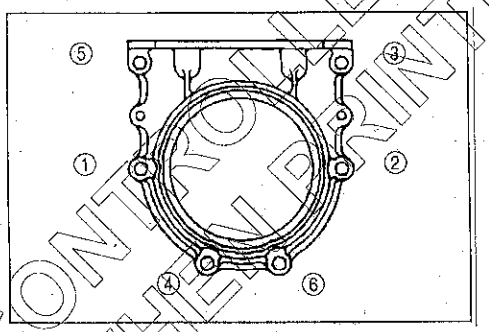


Installation of retainer

110 After applying engine oil to the lip of the oil seal, install the retainer. Apply sealant.

111 Tighten bolts on the retainer to the specified torque in the order as shown in the figure left.

	kg m (ft. lbs.)
Retainer tightening torque	0.8 – 1.2 (6.0 – 9.0)



Camshaft assembly

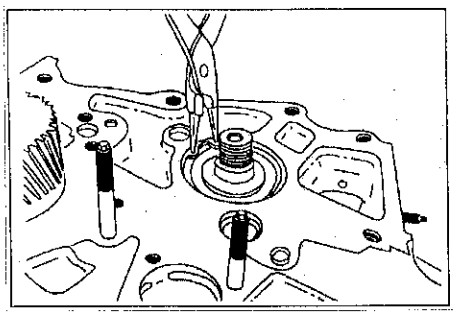
112 Proceed as follows:

(1) Apply engine oil to the inside of the bearing of the cylinder block, and then install the camshaft assembly.

NOTE

When installing the assembly, care should be taken not to damage the bearing.

(2) After installation of the snap ring to the outside of the front bearing, check to see if the camshaft rotates smoothly.



Cam gear and sleeve

113 Proceed as follows:

(1) Install the cam gear to the camshaft so that the timing point (a dot mark "·") comes to the front side.

(2) With the flyweight installed, tighten the cam gear with a lock nut.

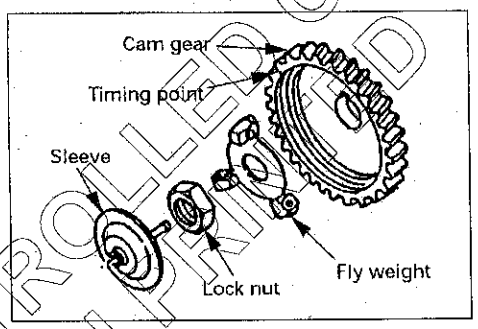
	kg m (ft. lbs.)
Cam gear tightening torque	7.0 – 9.0 (51.0 – 65.0)

(3) Apply engine oil to the shaft of the sleeve and the slide of the flyweight.

(4) With the lip of the sleeve placed in the cavity of the flyweight, insert the shaft of the sleeve into the tip end of the camshaft.

NOTE

Check to see if the sleeve moves smoothly.



Idle gear

114 Install the idler gear shaft with the oil hole facing up-ward.

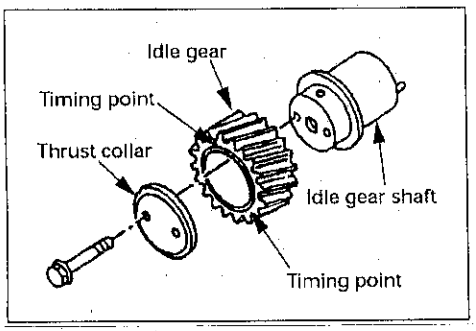
115 Lubricate the shaft with oil.

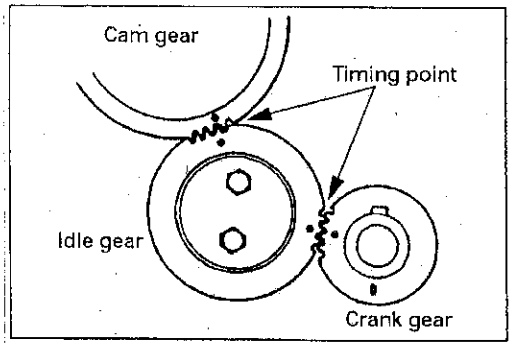
116 Install the idler gear.

117 Align the timing marks as shown in the illustration.

118 Install the thrust collar and tighten the bolts to the specified torque.

	kg m (ft. lbs.)
Thrust collar tightening torque	2.1 – 3.1 (15.2 – 22.4)





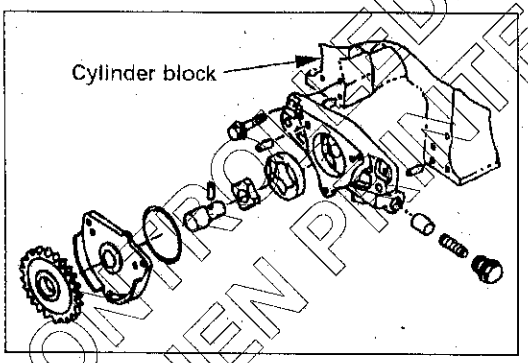
Oil pump assembly

119 Proceed as follows:

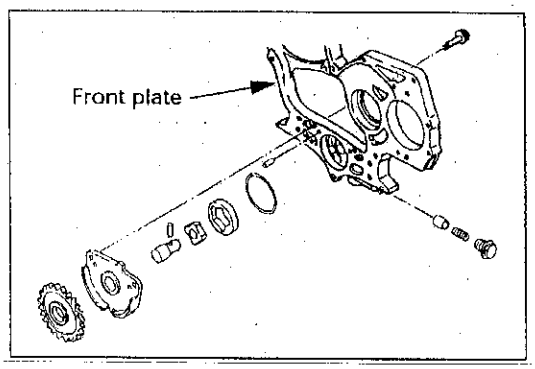
(1) When PTO is not provided, install the oil pump assembly to the cylinder block.

kg m (ft. lbs.)

Oil pump tightening torque	1.9 – 2.9 (14.0 – 21.0)



(2) When PTO is provided, install the oil pump to the front plate.



kg m (ft. lbs.)

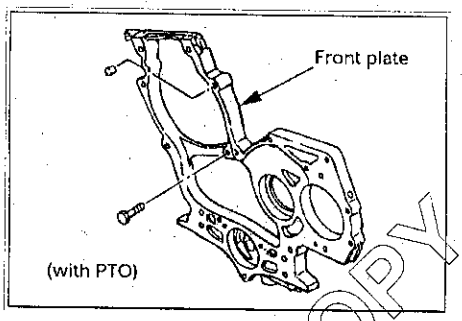
Oil pump tightening torque (PTO Provided)	0.8 – 1.2 (6.0 – 9.0)

Front plate (only for those provided with PTO)

120 Apply liquid gasket to the front plate incorporated with the oil pump before installing it to the cylinder block.

kg·m (ft. lbs.)

Front plate tightening torque	1.9 – 2.9 (14.0 – 21.0)



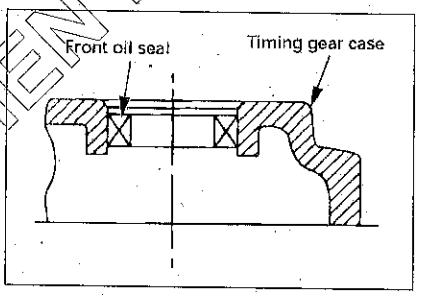
Front oil seal

121 Install the front oil seal to the timing gear case.

122 Installation is made according to the "L" dimension shown in the figure.

mm (in.)

	L dimension
PTO not provided	60.2 – 60.8 (2.370 – 2.384)
PTO provided	40.2 – 40.8 (1.582 – 1.606)



Timing gear case (with governor)

123 When not provided with PTO, install the timing gear case to the cylinder block. When provided with PTO, install it to the front plate.

(1) Put the link plate of the governor incorporated in the gear case through the connecting hole of the injection pump in advance.

(2) Apply engine oil to the bushes provided on both ends of the main spring lever of the governor.

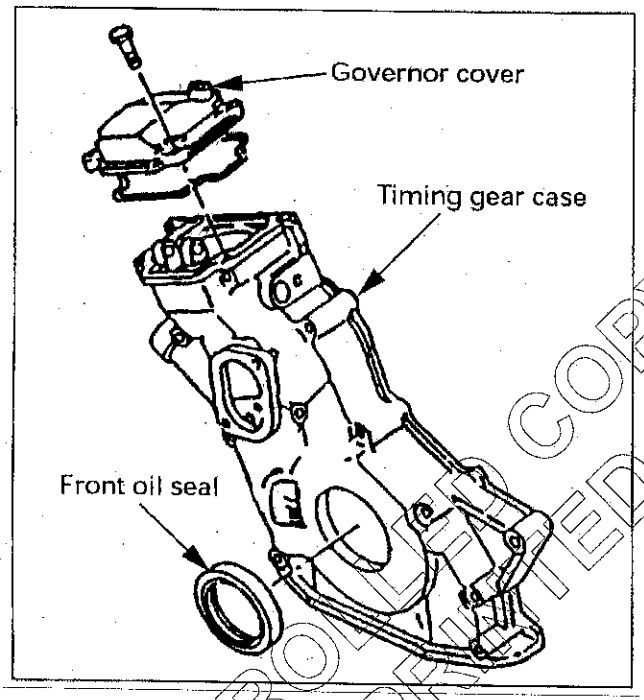
(3) Apply sealant to the gear case, and then install it to the cylinder block or the front plate.

kg·m (ft. lbs.)

Case tightening torque	1.9 – 2.9 (14.0 – 21.0)

(4) Assemble the gasket and the governor cover to the top of the gear case, and then tighten them to the specified torque.

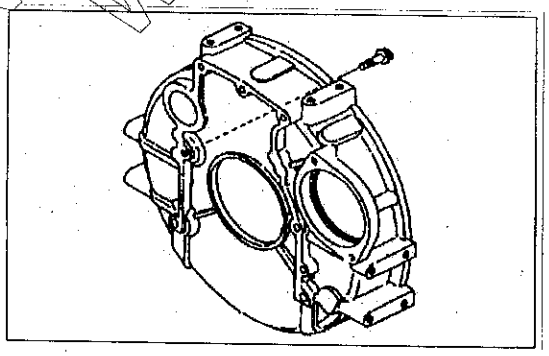
	kg·m (ft. lbs.)
Cover tightening torque	0.8 – 1.2 (6.0 – 9.0)



Flywheel housing

124 Install the flywheel housing to the cylinder body.

	kg·m (ft. lbs.)
Flywheel housing tightening torque	4.2 – 5.6 (30.0 – 40.0)

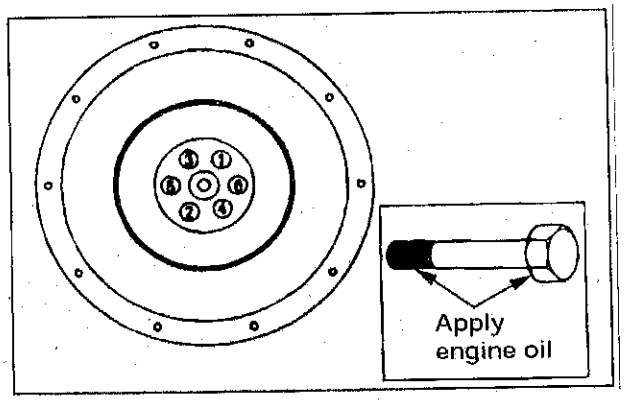


Flywheel

125 Lubricate bolts with engine oil.

126 Tighten a little at a time in the sequence shown in the illustration.

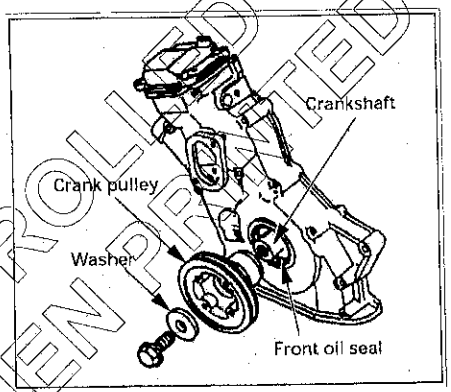
	kg·m (ft. lbs.)
Flywheel tightening torque	9.0 – 11.0 (65.0 – 80.0)



Crank pulley

127 Lubricate the lip of the front, seal with oil. Install the crank pulley, lock the crankshaft and tighten the front bolt.

	kg·m (ft. lbs.)
Crank pulley tightening torque	17.0 – 19.0 (123.0 – 137.0)



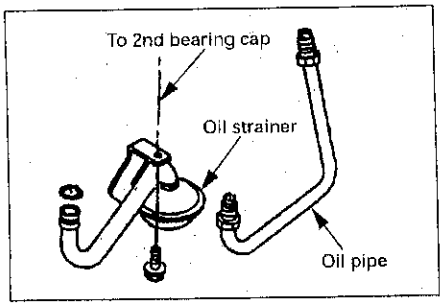
Oil pipe and oil strainer

128 Proceed as follows:

(1) Install the oil pipe from the oil pump assembly to cylinder block and tighten the sleeve nuts.

(2) Install the oil strainer to the oil pump, and then tighten the bracket of the strainer to the No. 2 bearing cap.

	kg·m (ft. lbs.)
Oil pipe and oil strainer tightening torque	1.9 – 2.9 (14.0 – 21.0)



Oil pan

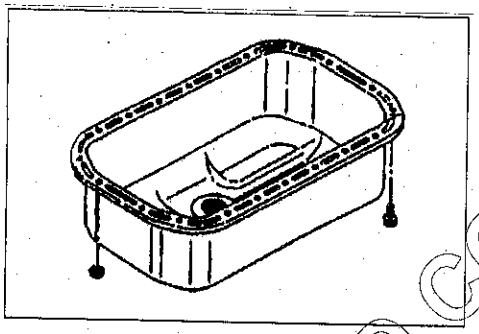
129 Proceed as follows:

(1) Apply sealant to the oil pan.

(2) Install the oil pan to the cylinder block and tighten fixing bolts evenly.

kg·m (ft. lbs.)

Oil pan tightening torque	0.8 – 1.2 (6.0 – 9.0)

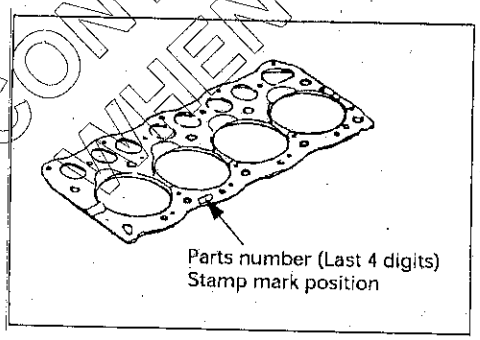


Tappet and head gasket

130 Proceed as follows:

(1) Install the tappet to the cylinder block.

(2) When installing the head gasket, turn up the stamp mark of the parts number (last 4 digits) which is between the No. 2 and No. 3 cylinders of the gasket.



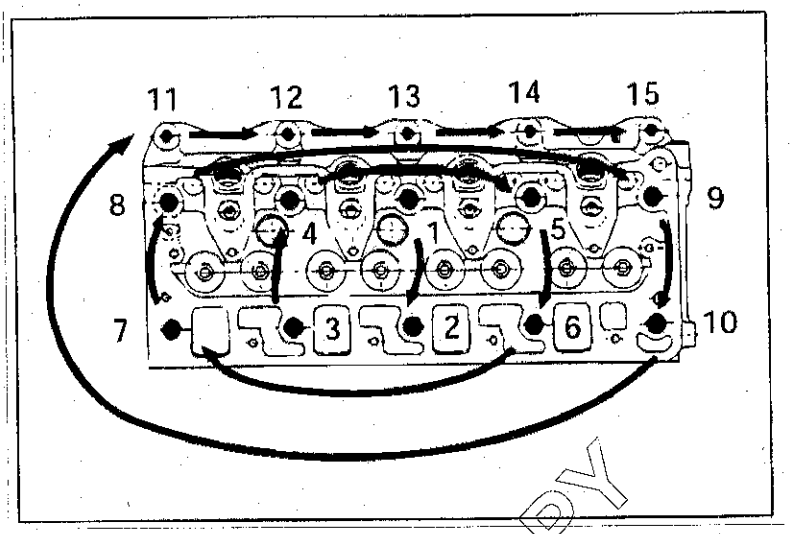
Cylinder head assembly

131 Lubricate the bolts with oil.

132 Tighten the bolts in the sequence shown in the illustration to the specified torque.

kg m (ft. lbs.)

Bolt size	Cylinder head assembly tightening torque
M12 x 1.5 (8 each)	8.5 – 9.5 (61 - 69) 60° 90°
M8 x 1.25	2.5 – 3.5 (18 - 25)



Push rod

133 Install the push rods.

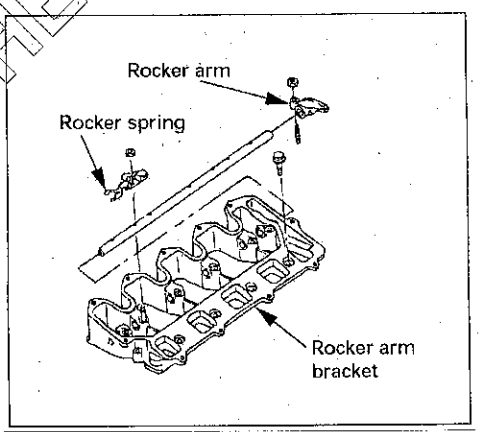
Rocker arm bracket assembly

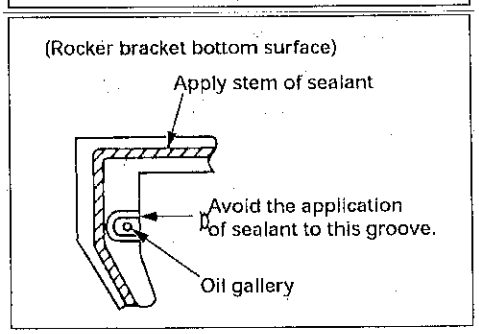
134 Apply liquid gasket to the bottom of the rocker arm bracket assembly, being careful not to get any in the groove around the oil galley as shown in the illustration.

135 Install the rocker arm bracket assembly making sure the push rods align with the rocker arms and tighten to the specified torque.

kg·m (ft. lbs.)

Rocker arm bracket assembly tightening torque	0.8 – 1.2 (6.0 – 9.0)





Adjustment of valve clearance

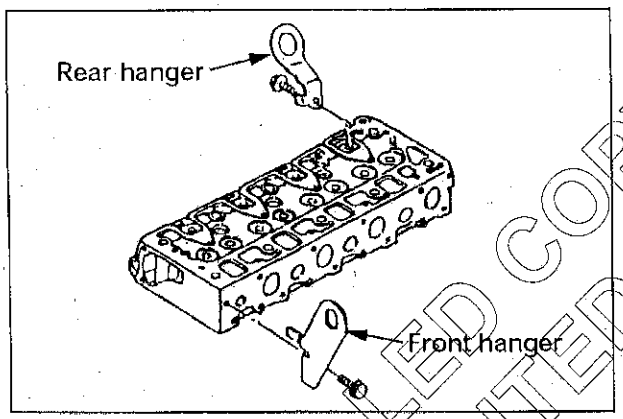
136 Refer to Page 20.

Front hanger and rear hanger

137 Tighten them to the specified torque shown below.

kg·m (ft. lbs.)

Front hanger and rear hanger tightening torque	1.9 – 2.9 (14.0 – 21.0)



REASSEMBLY OF EXTERNAL PARTS

External parts (right-hand side)

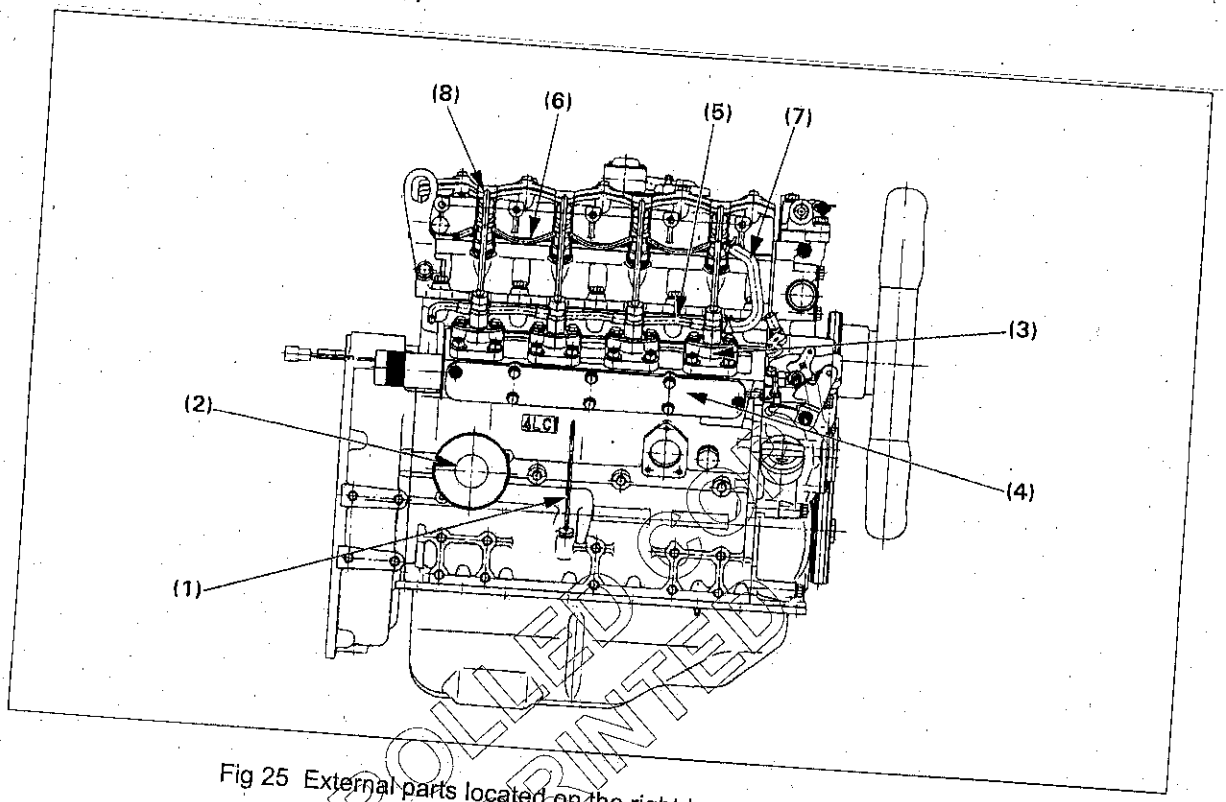


Fig 25 External parts located on the right-hand side of the engine

138 The following external parts are located on the right-hand side of the engine:

(1) Dipstick.

(2) Oil Filter.

(3) Injection Pump.

(4) Injection Pump Housing Cover.

(5) Fuel Pipe.

(6) Leak Off Pipe.

(7) Fuel Hose.

(8) Injection Pipe.

External parts (left-hand side)

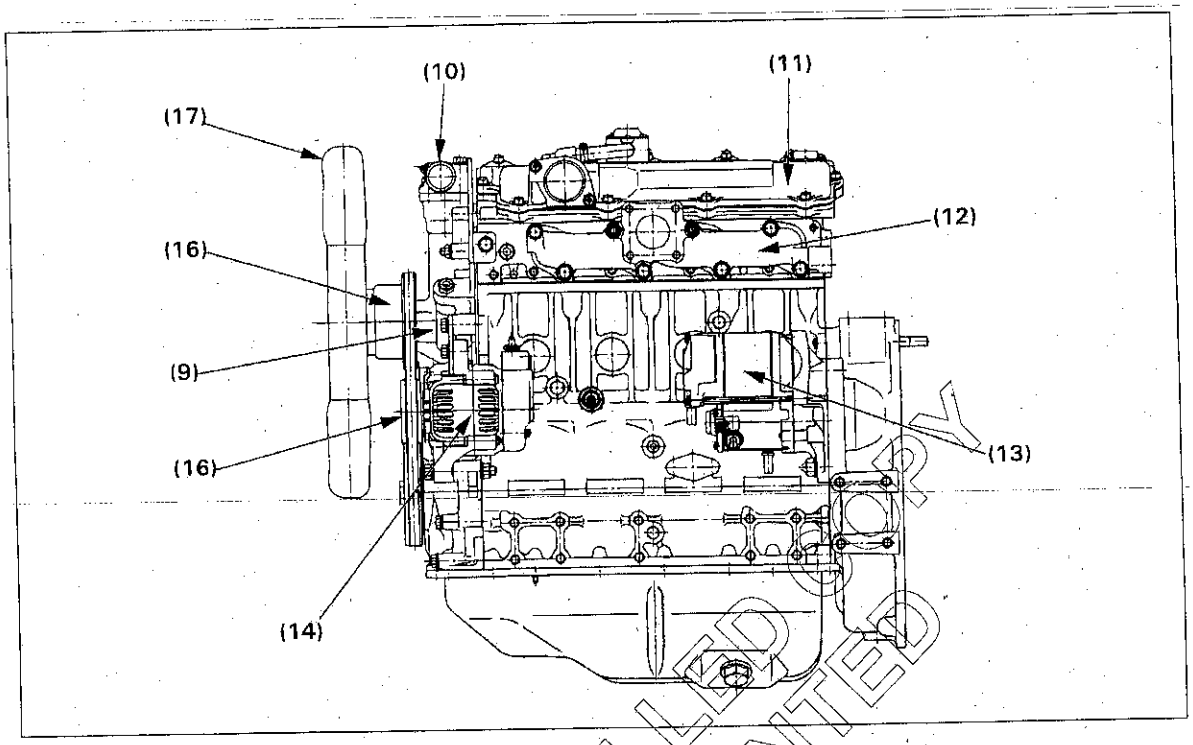


Fig 26 External parts located on the left-hand side of the engine

139 The following external parts are located on the left-hand side of the engine:

(9) Water Pump.

(10) Thermostat and Water Outlet Pipe.

(11) Cylinder Head Cover.

(12) Exhaust Manifold.

(13) Starter.

(14) Generator.

(15) Fan Pulley.

(16) Fan Belt.

(17) Cooling Fan.

Dipstick

Oil filter (cartridge)

140 Proceed as follows:

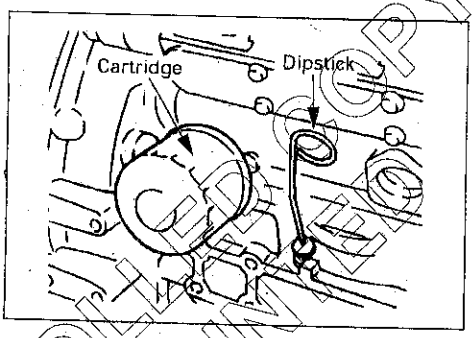
(1) Insert the dipstick.

(2) Install the cartridge with a filter wrench (commercially available).

a. Apply engine oil thinly to the gasket of the cartridge.

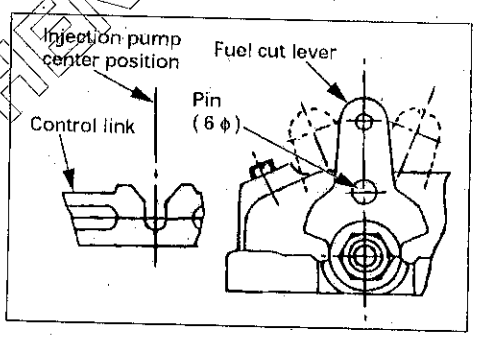
b. Screw in the cartridge until the gasket comes into contact with the seal, and then tighten it by giving it about 3/4 turns.

(Reference: Tightening torque 1.2 to 1.6 kg·m (8.6 – 11.6 ft. lbs.)

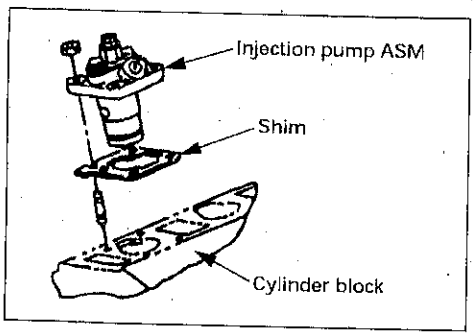


Injection pump

141 Align the two (2) holes in the fuel cut lever and the governor and lock into place with a pin. This will center and hold the control link for the installation of the injection pumps.



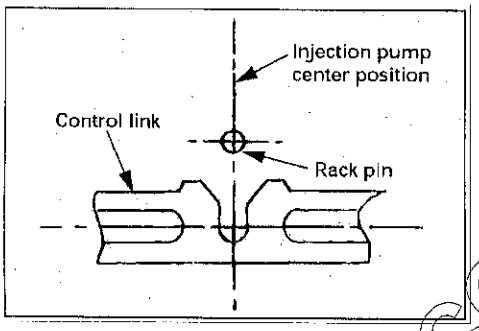
142 Install a new shim with the same thickness as the one that was removed. (Refer to the maintenance section on shim selection).



143 Install the injection pump making sure the rack pin is in the groove of the control rack before tightening the injection pump to the specified torque.

	kg·m (ft. lbs.)
Injection pump tightening torque	1.9 – 2.9 (14.0 – 21.0)

144 Remove the rack pin (6ø) which is inserted into the fuel cut lever, and then confirm that the fuel cut lever moves smoothly.



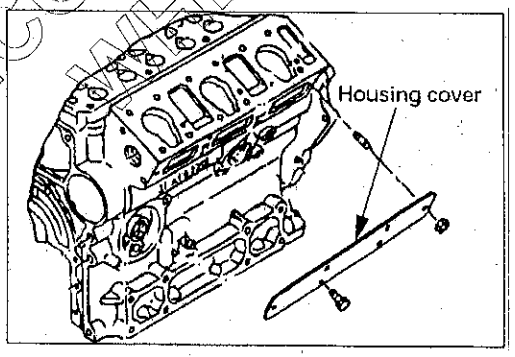
Injection pump housing cover

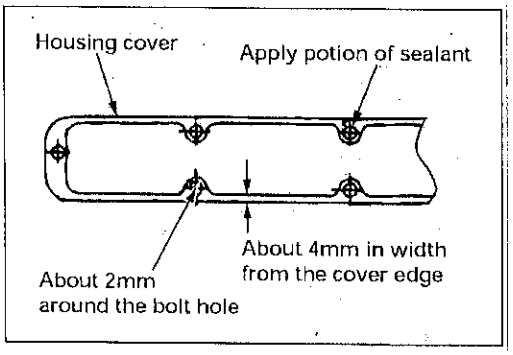
145 After applying sealant (TB1207C) to the housing cover, install it to the cylinder block by the side of the injection pump.

	kg·m (ft. lbs.)
Injection pump housing tightening torque	0.8 – 1.2 (6.0 – 9.0)

NOTE

The areas of the housing cover to which liquid gasket is applied are about 4 mm in width from the cover edge and about 2 mm around the bolts.





Solenoid assembly

146 Proceed as follows:

(1) Apply sealant (TB1207C) to the surface (bite groove) in which the solenoid is installed.

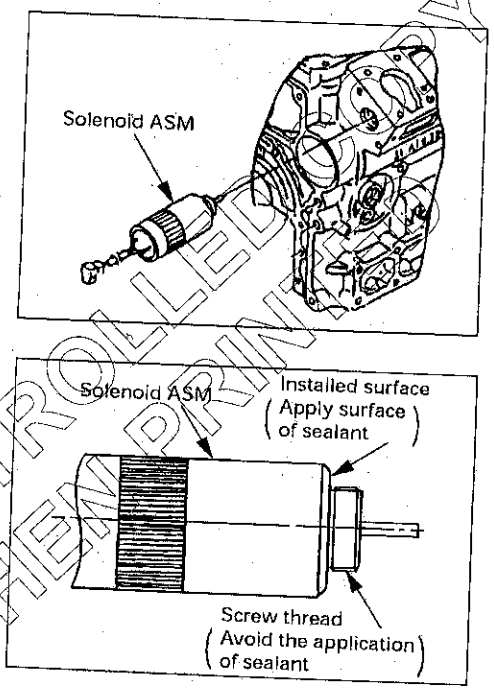
NOTE

Avoid the application of sealant to the screw thread.

(2) Screw in the solenoid from the rear of the cylinder block (the rear of the No. 3 injection pump rack), and then tighten it to the specified torque.

kg·m (ft. lbs.)

Solenoid tightening torque	1.5 – 2.5 (11.0 – 18.0)



Fuel pipe

Leak off pipe

147 Proceed as follows:

(1) Install the fuel pipe to the injection pump and then tighten it to the specified torque.

(2) Install the leak off pipe to the nozzle holder and then tighten it to the specified torque.

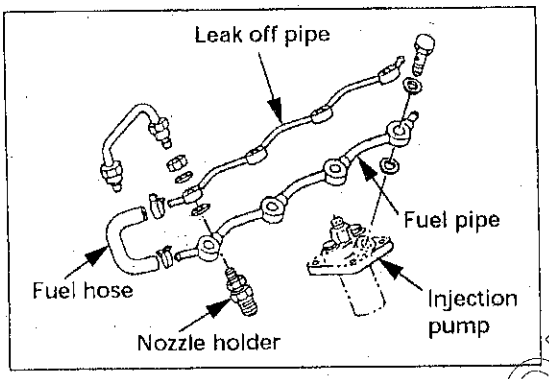
kg·m (ft. lbs.)

Fuel pipe and leak off pipe tightening torque	
Fuel pipe	2.0 – 2.5 (14.0 – 18.0)
Leak off pipe	2.5 – 3.5 (18.0 – 25.0)

NOTE

When tightening it, hold the pipe securely by hand so that it will not rotate.

(3) Connect the fuel pipe and the leak off pipe with the fuel hose and fix them with clips.



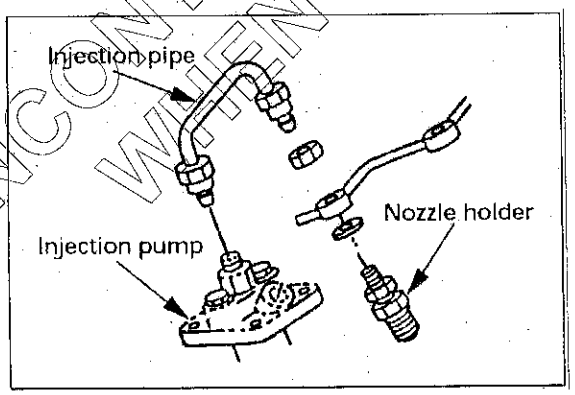
Injection pipe

148 Install the injection pipe to the injection pump and the nozzle holder and tighten them up with sleeve nuts.

	kg·m (ft. lbs.)
Injection pipe tightening torque	1.5 – 2.5 (11.0 – 18.0)

NOTE

Set the thread of the sleeve nut securely before tightening it up.



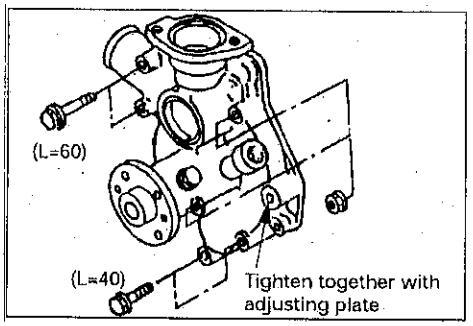
Water pump assembly

149 Proceed as follows:

(1) Put sealant on the water pump where it contacts the block and head.

(2) Tighten to the specified torque.

	kg·m (ft. lbs.)
Water pump tightening torque	1.9 – 2.9 (14.0 – 21.0)

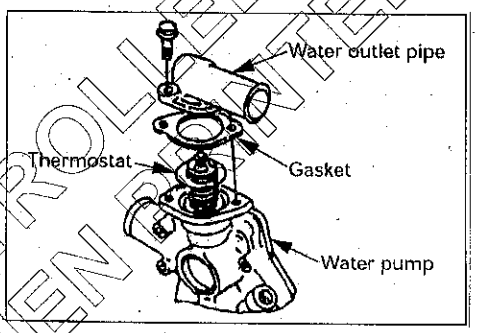


Thermostat

Water outlet pipe

150 Assemble the thermostat, install the gasket and the water outlet pipe, and then tighten it to the specified torque.

	kg·m (ft. lbs.)
Water outlet pipe tightening torque	1.9 – 2.9 (14.0 – 21.0)



Adjustment of valve clearance

151 Refer to Section 1 "GENERAL INFORMATION – MAINTENANCE".

Cylinder head cover

152 Proceed as follows:

(1) Install the gasket to the cylinder head cover.

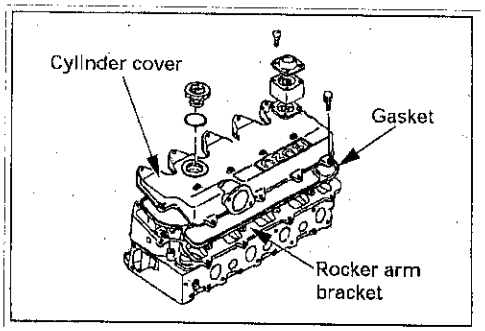
NOTES

(1) Much care should be taken for the gasket not to get dislocated or twisted when installing the head cover.

(2) Avoid the application of sealant to the rubber gasket.

(2) Install the cylinder head cover to the rocker arm bracket, and tighten it to the specified torque.

	kg·m (ft. lbs.)
Cylinder head cover tightening torque	0.2 – 0.4 (1.4 – 2.9)



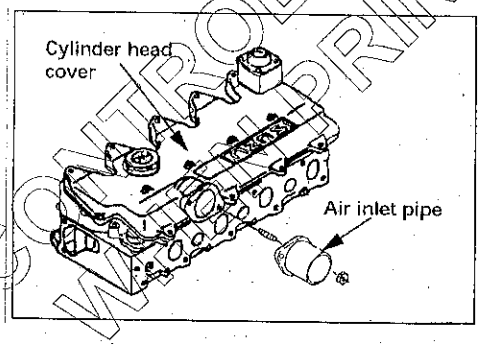
Air inlet pipe

153 Proceed as follows:

(1) Apply sealant (TB1207C) to the surface in which the air inlet pipe is installed.

(2) Install the air inlet pipe to the cylinder head cover, and tighten it to the specified torque.

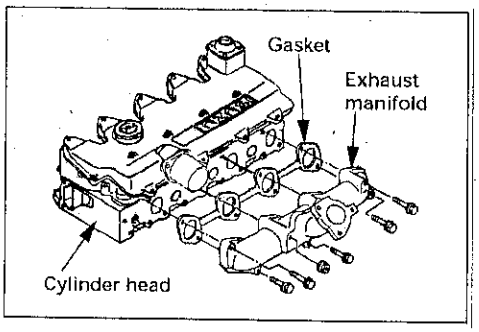
	kg·m (ft. lbs.)
Air inlet pipe tightening torque	0.8 – 1.2 (6.0 – 9.0)



Exhaust manifold

154 Assemble the gasket to the cylinder head, install the exhaust manifold along the stud bolts and tighten it to the specified torque.

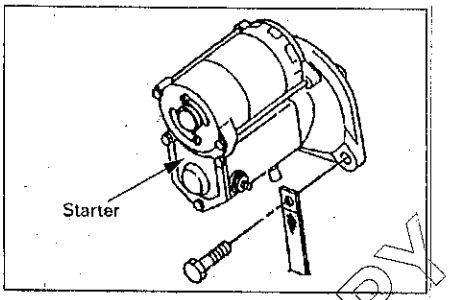
	kg·m (ft. lbs.)
Exhaust manifold tightening torque	1.9 – 2.9 (14.0 – 21.0)



Starter

155 Install the starter to the flywheel housing, and tighten it to the specified torque.

	kg·m (ft. lbs.)
Starter tightening torque	9.5 – 11.5 (68.7 – 83.2)



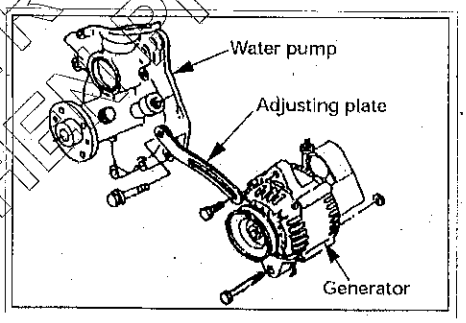
Generator

156 Proceed as follows:

(1) Tighten the adjust plate together with the water pump, and then install them temporarily.

(2) Install the bottom of the generator to the timing gear case, and then tighten it temporarily with bolts and nuts.

(3) Install the fixing bolts onto the top of the generator through the adjusting plate. (Temporary tightening.)

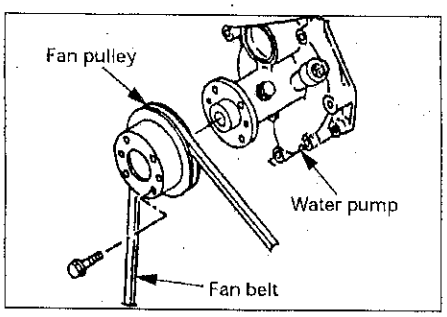


Fan pulley and fan belt

157 Proceed as follows:

(1) Install the fan pulley to the water pump and then tighten it up. (2 locations)

(2) Set the fan belt to each pulley.



Fan belt tension

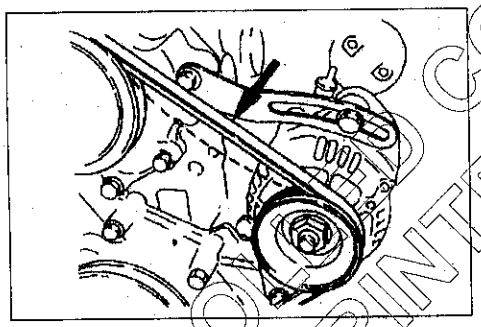
158 Adjust the alternator as specified and tighten to the specified torque.

mm (in.)

Deflection amount (Press the belt at its centre between the pulleys with 10 kg (22 lbs.) force.)	8 to 10 (0.315 – 0.3937)

kg·m (ft. lbs.)

Generator upper tightening torque	1.9 – 2.9 (14.0 – 21.0)
Generator lower tightening torque	3.5 – 4.7 (25.0 – 34.0)
Adjust plate tightening torque	1.9 – 2.9 (14.0 – 21.0)

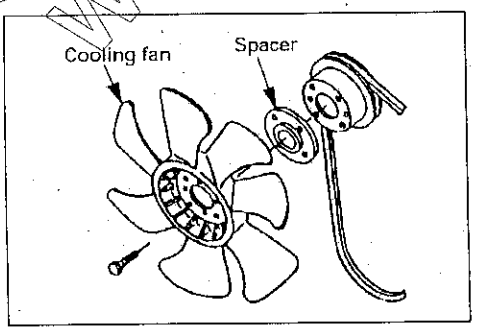


Cooling fan

159 Proceed as follows:

(1) Assemble the spacer before tightening the cooling fan.

(2) Tighten it to the specified torque. (4 locations.)



SECTION 3 - LUBRICATING SYSTEM

LUBRICATING OIL CIRCULATION DIAGRAM

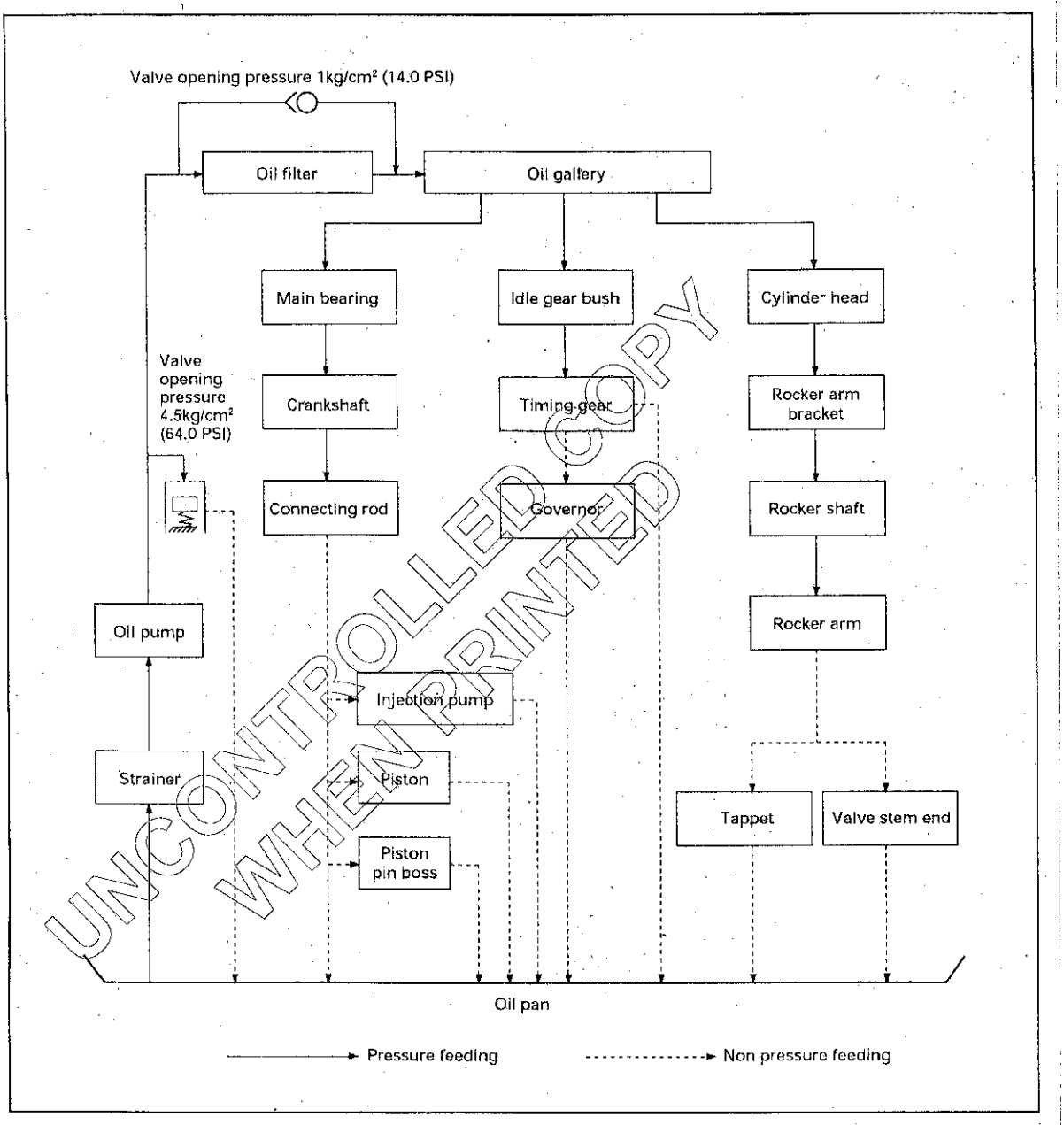


Fig 27 Lubricating oil circulation diagram

OIL PUMP

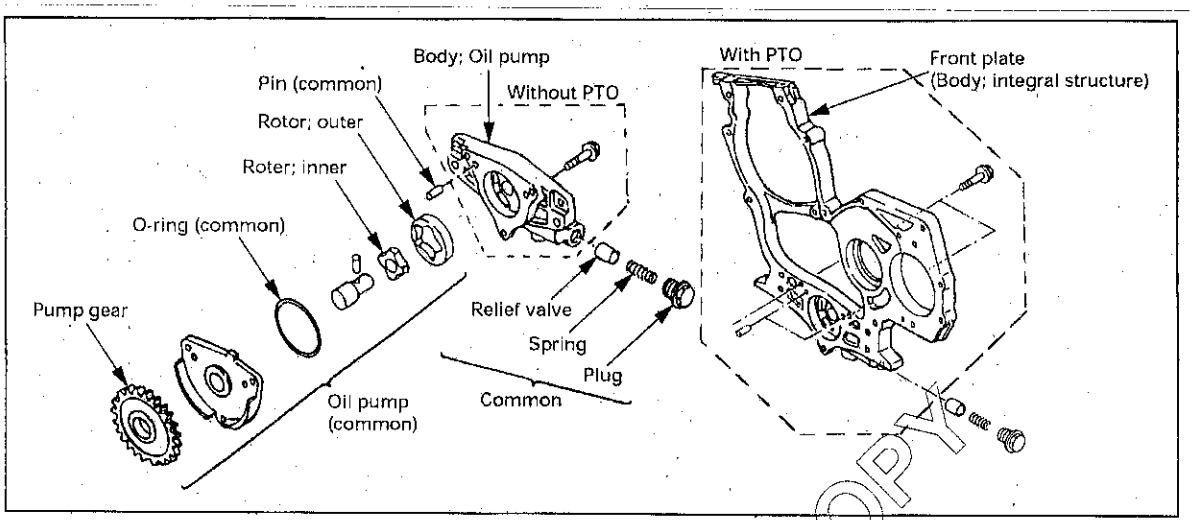


Fig 28 Oil pump exploded view

Inspection and replacement

160 When there is wear, damages or any other defects found, repair or replace the rotor.

(1) Clearance between the outer rotor or inner rotor and the pump cover:

mm (in.)

Standard	Limit
0.040 – 0.085 (0.0016 – 0.0033)	0.15 (0.0059)

(2) Clearance between the periphery of the outer rotor and the pump body:

mm (in.)

Standard	Limit
0.10 – 0.185 (0.0039 – 0.0073)	0.4 (0.0157)

(3) Clearance between the inner rotor and the outer rotor:

mm (in.)

Standard	Limit
0.17 (0.0067)	0.2 (0.0079)

SECTION 4 - COOLING SYSTEM

COOLING WATER CIRCULATION SYSTEM DIAGRAM

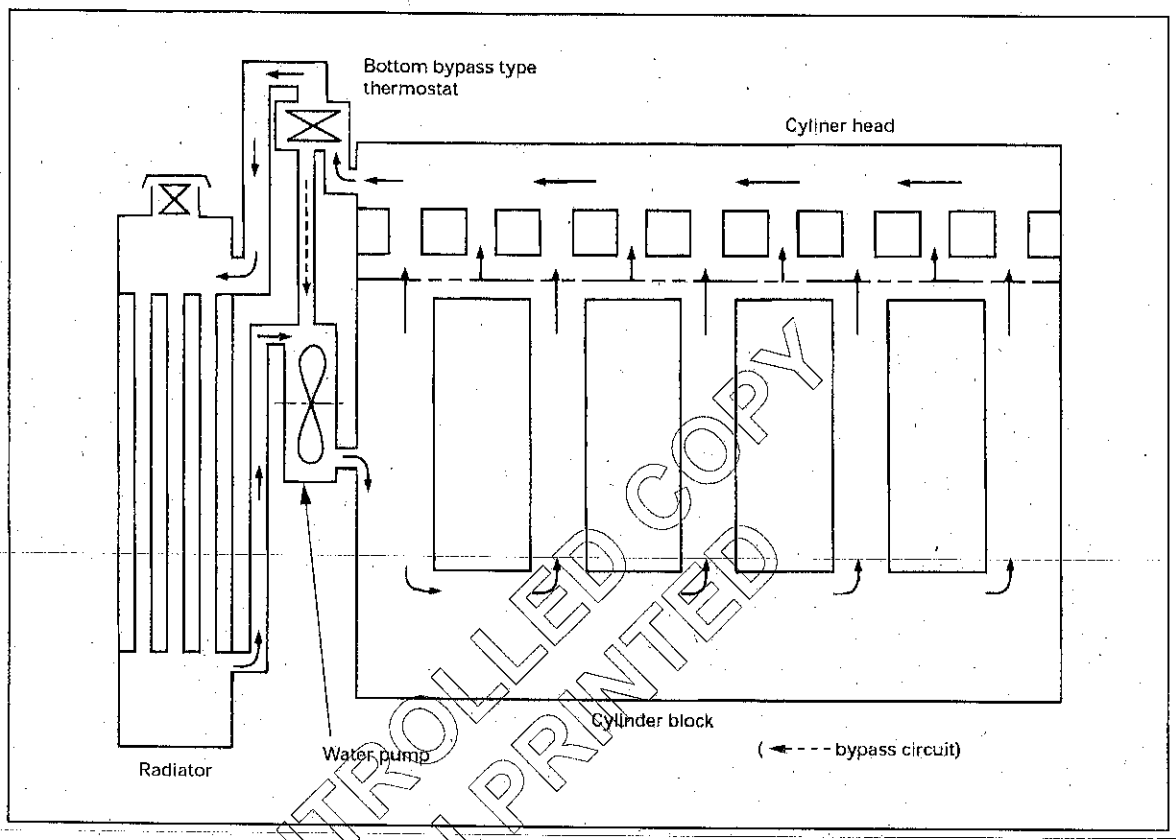


Fig 29 Cooling water circulation system diagram

WATER PUMP DISASSEMBLY

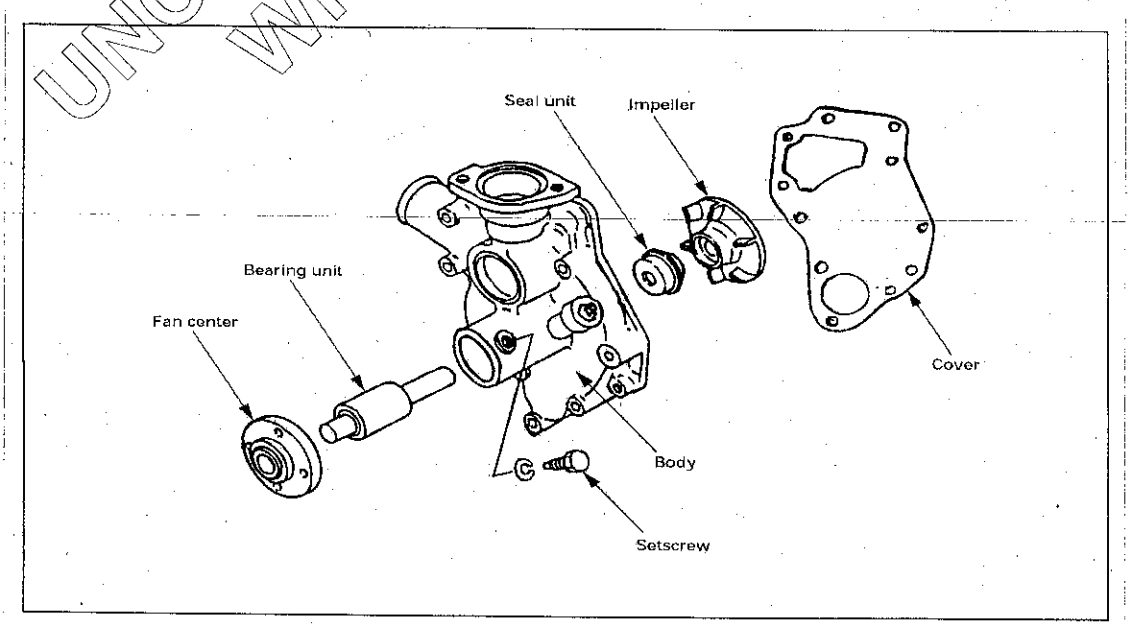


Fig 30 Water pump

Fan centre

Cover

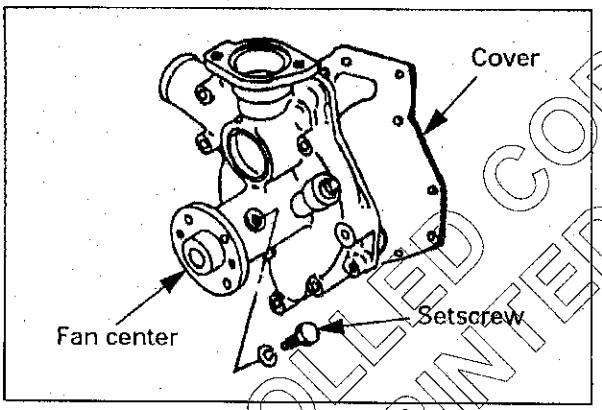
161 Proceed as follows:

(1) Loosen the set screw.

(2) Remove the cover.

NOTE

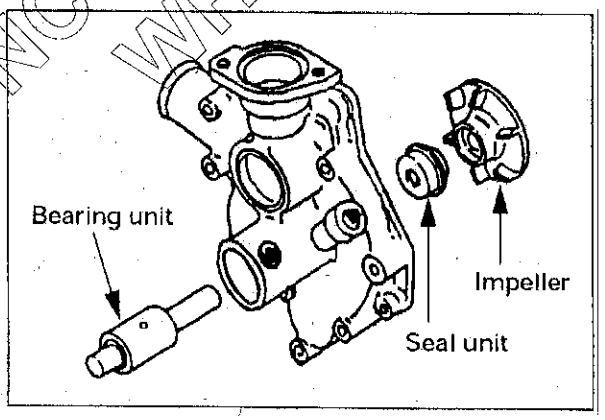
The cover is applied with sealant (TB1207B). When removing the cover, much care should be taken not to deform it by applying an excessive force to it.



Impeller

Seal unit

Bearing unit

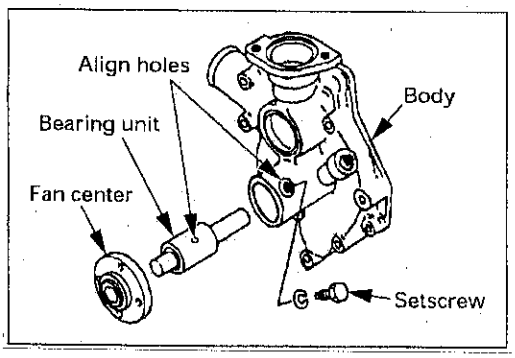


WATER PUMP REASSEMBLY

Bearing unit

162 With a hole in the bearing unit set in line with one in the body, lock the bearing unit with a setscrew.

	kg·m (ft. lbs.)
Set screw tightening torque	0.8 – 1.2 (6.0 – 9.0)



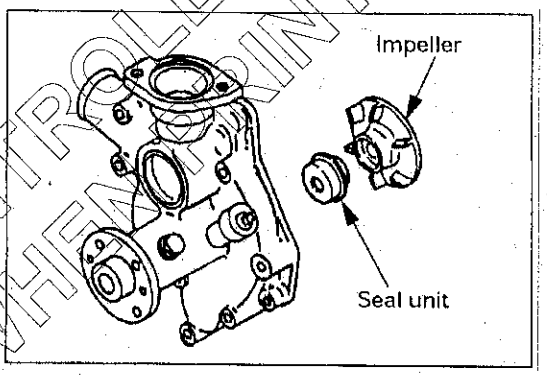
Seal unit

Impeller

163 Proceed as follows:

(1) Apply BELCO bond No. 4 to the surface where the seal unit comes into contact with the body, and then assemble the seal unit.

(2) Press in the impeller with a press until the clearance between the pump impeller and the body gets to the specified value.

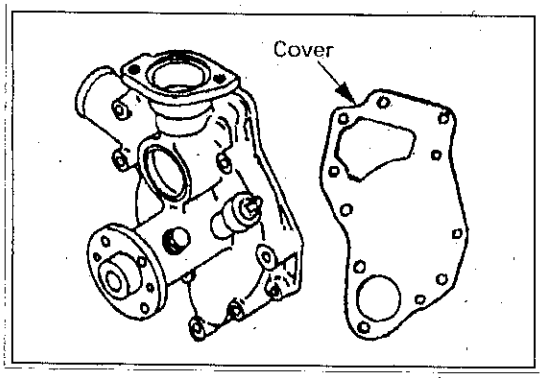


Cover

164 Proceed as follows:

(1) Apply liquid gasket to the surface to which the cover is installed, and then install the cover.

(2) Apply Screw-lock to the cover installation screws, and then tighten them.



Clearance, play and tightening allowance between parts

165 Proceed as follows:

(1) Clearance between the pump impeller and the body.

mm (in.)

Standard	0.53 – 2.17 (0.0209 – 0.0854)

(2) Play in the water pump ball bearing.

mm (in.)

Standard	Limit
0.008 – 0.010 (0.0003 – 0.0004)	0.2 (0.0079)

(3) Tightening allowance between the fan center and the bearing shaft.

mm (in.)

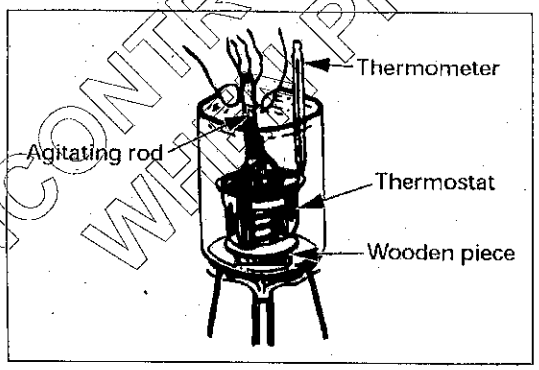
Standard	0.026 – 0.061 (0.001 – 0.0024)

THERMOSTAT

Inspection and replacement

166 Replace the thermostat when there is wear, damages or any other defects found.

Opening temp.	74.5 – 78.5°C (166 – 174°F)
Valve lift mm (in.)	8 mm or more at 90°C (0.315 inch or more at 194°F)



SECTION 5 - FUEL SYSTEM

FUEL CIRCULATION SYSTEM DIAGRAM

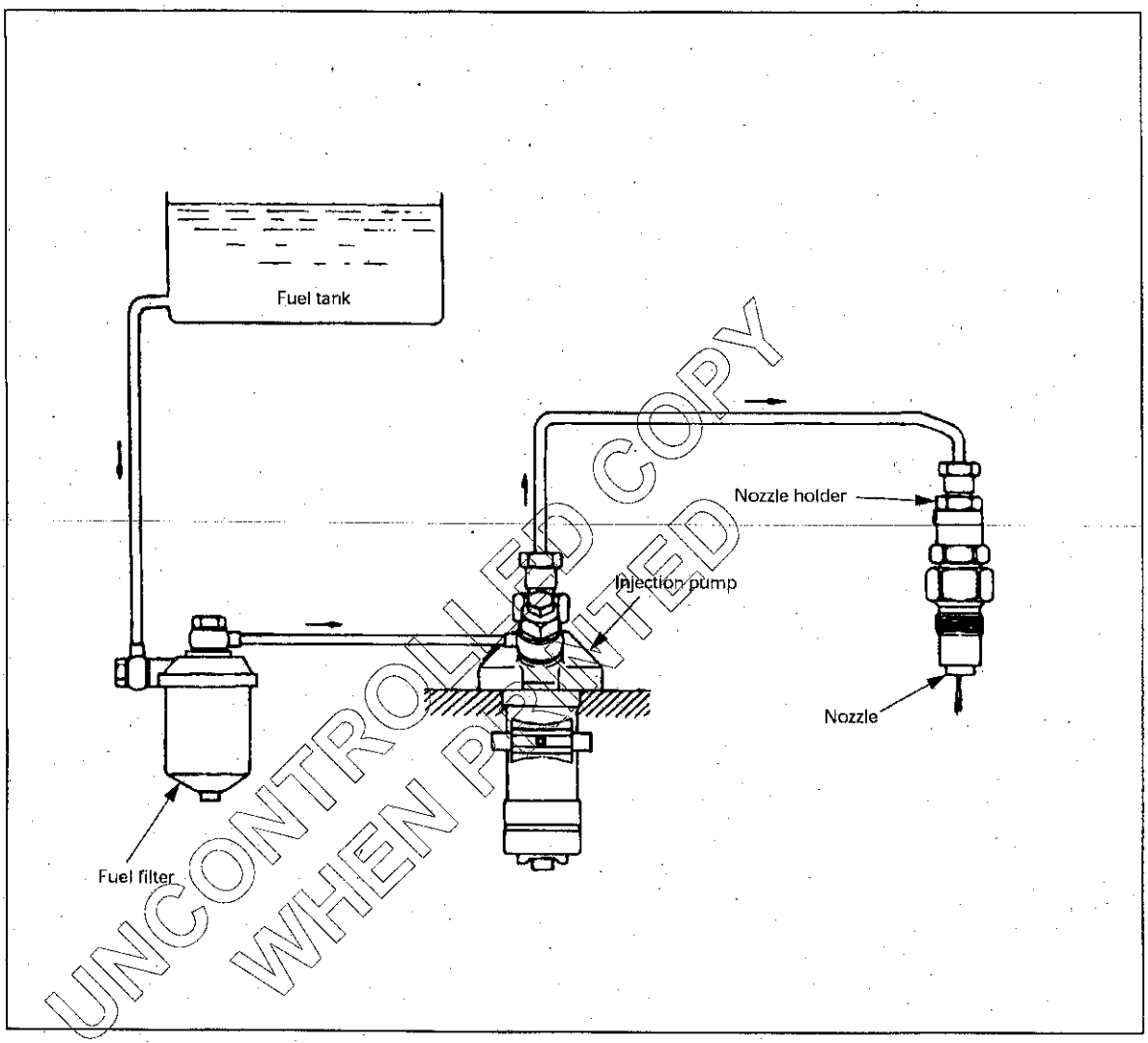


Fig 31 Fuel circulation system diagram

GOVERNOR

167 Proceed as follows:

(1) The adjustments of the governor-related parts require the engine performance test.

(2) Before disassembling the governor, measure the dimensions "A" and "B" given in the structural drawing to ensure the same dimensions in reassembly.

(3) Do not disassemble the governor when the performance test cannot be conducted after reassembly.

STRUCTURAL DRAWING OF GOVERNOR (1)

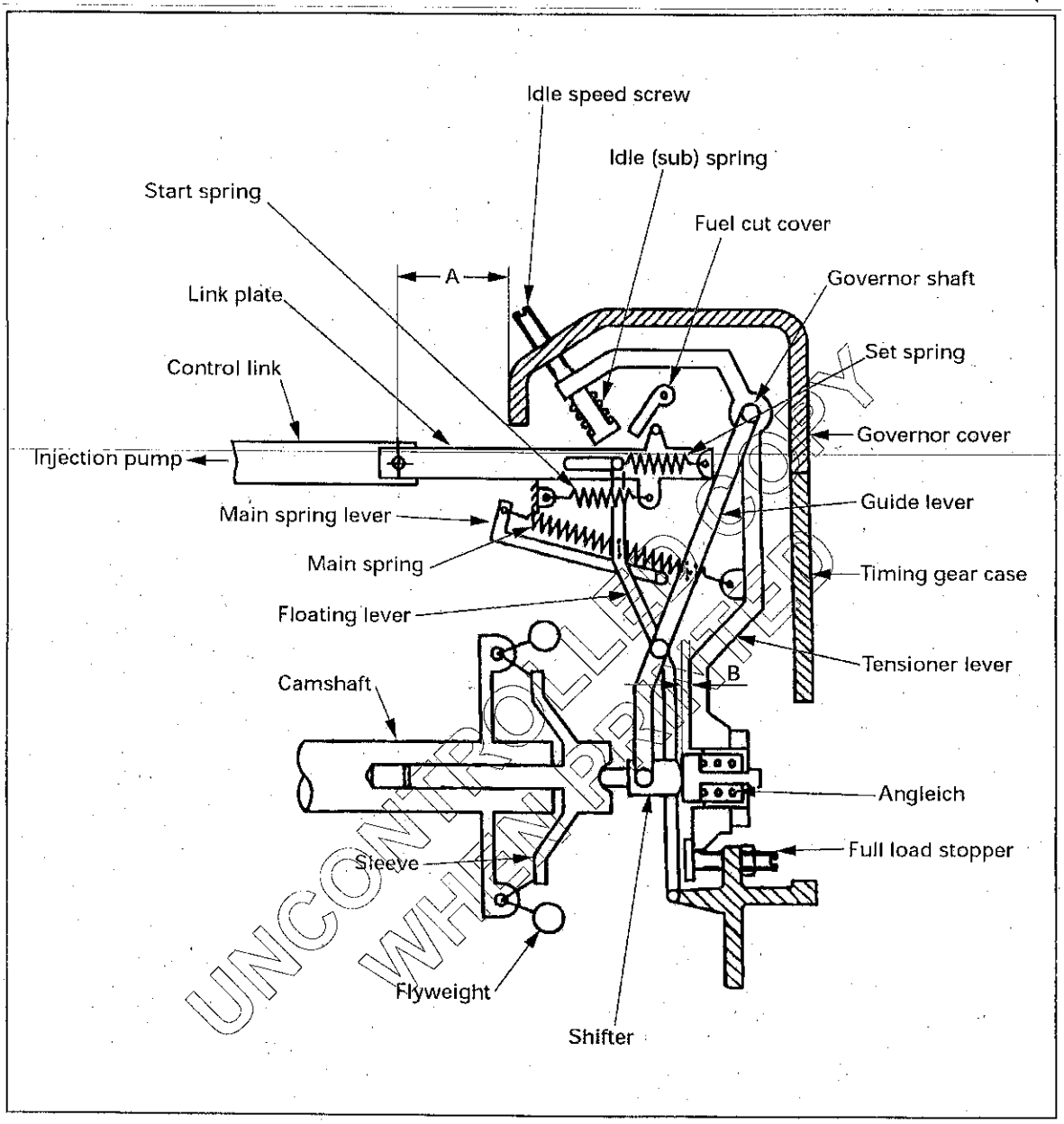


Fig 32 Structural drawing of governor (1)

STRUCTURAL DRAWING OF GOVERNOR (2)

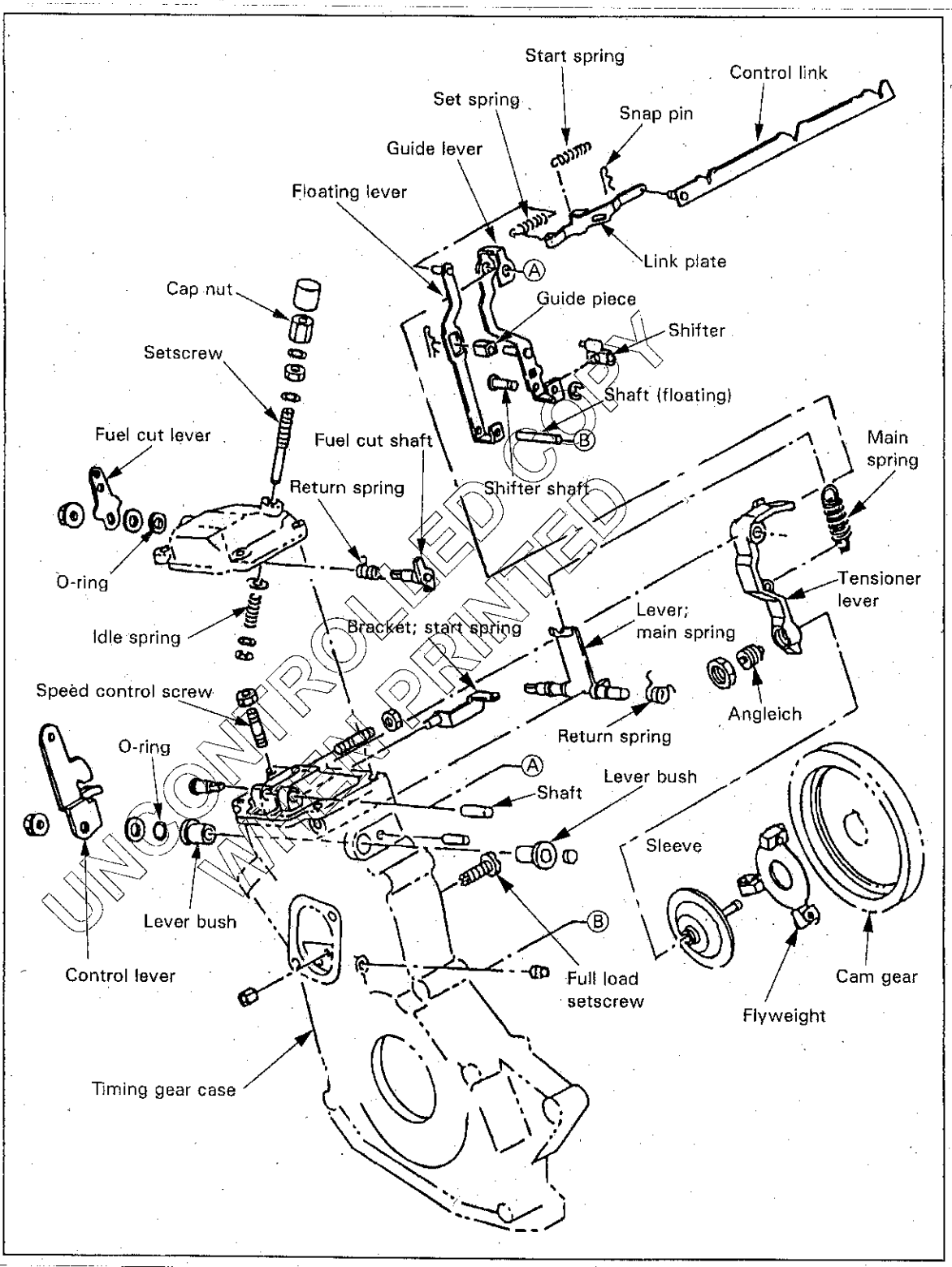


Fig 33 Structural drawing of governor (2)

REASSEMBLY OF CONTROL LEVER RELATED PARTS

168 Proceed as follows:

(1) Put the lever (main spring) through the hole of the timing gear case lever.

NOTE

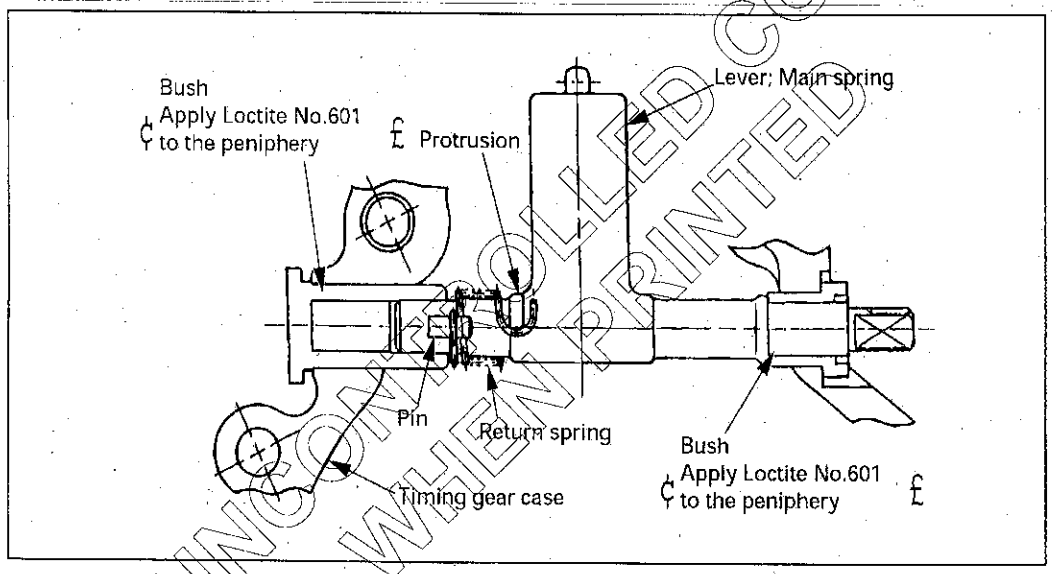
Before hammering in the bushes, put both shafts of the lever through the holes of the timing gear case lever respectively.

(2) Put the return spring of the control lever through the shaft of the lever (main spring).

(3) Assemble the bushes. Assemble the bush of the lever (main spring) first, and then the control lever bush.

NOTE

When assembling the bushes, apply Loctite (#601) to the periphery of the bushes.

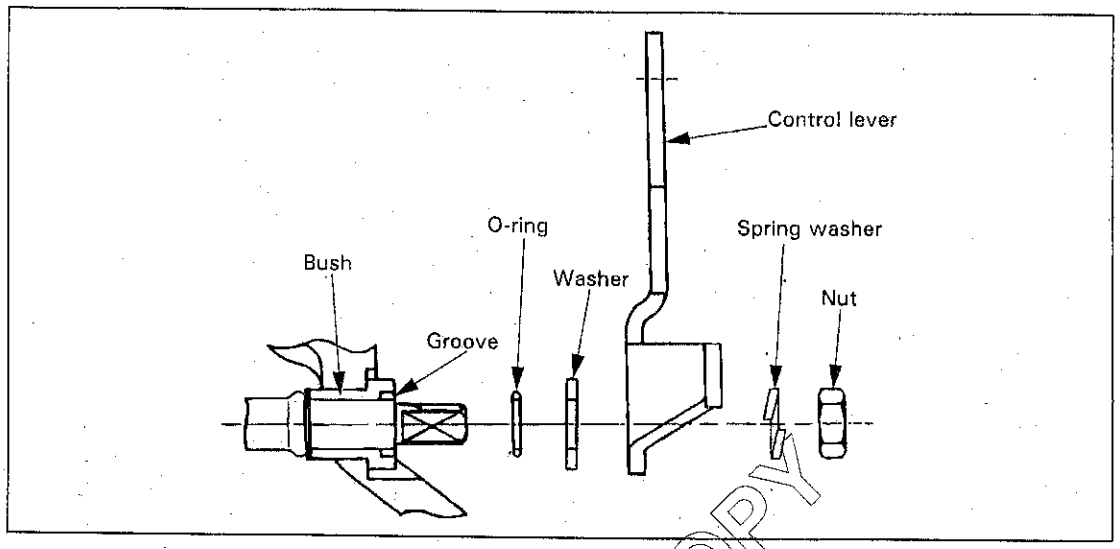


(4) Hook both ends of the return spring (control lever) securely to the protrusion and the pin of the lever (main spring) respectively.

(5) Assemble the control lever. Assemble the O-ring to the groove of the bushes (control lever) first, and then assemble the washers and the control lever before tightening up the control lever with a nut.

kg·m (ft. lbs.)

Control lever tightening torque	1.2 – 1.8 (9.0 – 13.0)



NOTES

(1) Tighten the control lever after locking the control lever firmly. (Do not tighten the control lever after locking the main spring lever.)

(2) After assembly, confirm that the control lever moves smoothly.

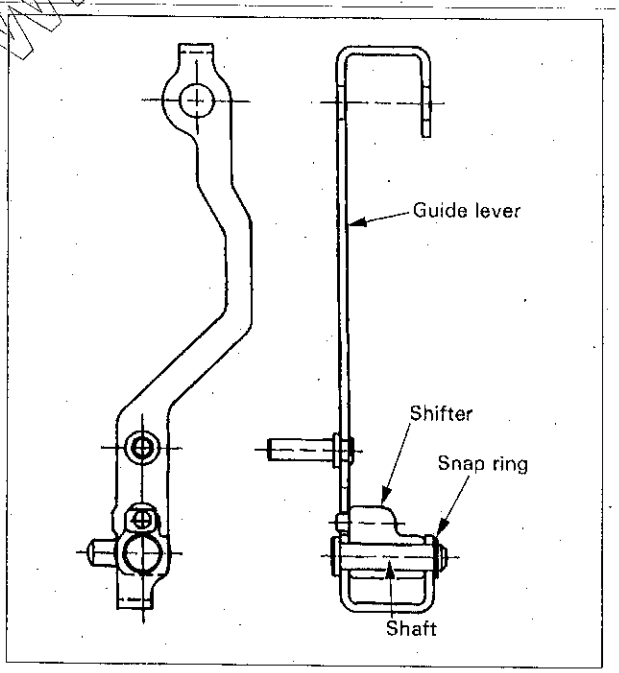
Reassembly of shifter

169 Proceed as follows:

(1) Assemble the shifter to the guide lever, put the shaft through it, and then assemble the snap ring.

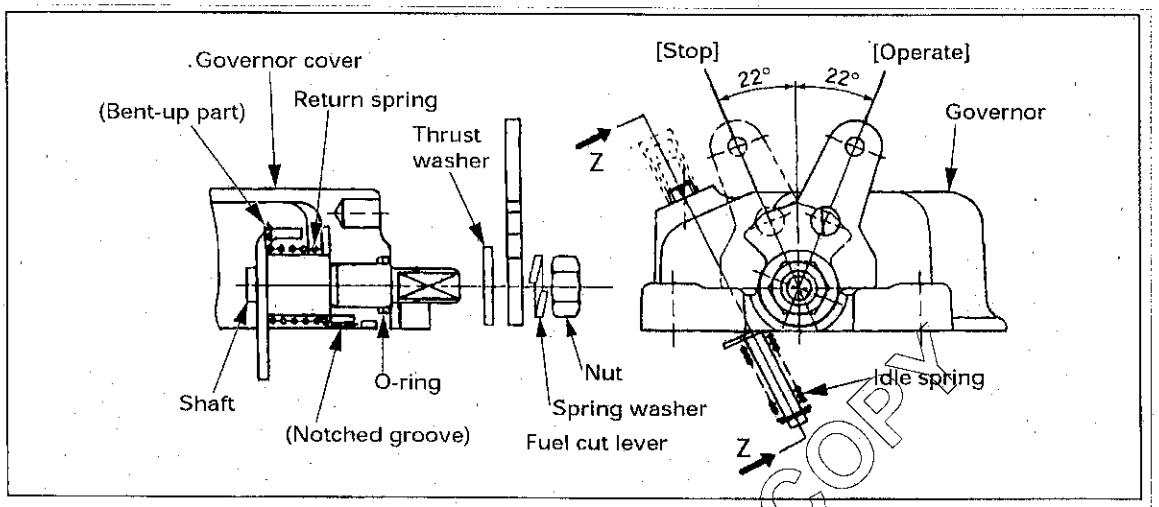
(2) After assembly, confirm that the shaft moves smoothly.

(3) Also, confirm that the shifter shakes smoothly.



Reassembly of governor cover

170 Assemble the related parts such as the fuel cut lever and the idle spring to the governor cover.



(1) When assembling the shaft, apply engine oil to the sliding portion with the governor cover.

(2) Set both ends of the return spring securely to the notched groove at the bottom of the cover and the bent-up arm of the lever respectively.

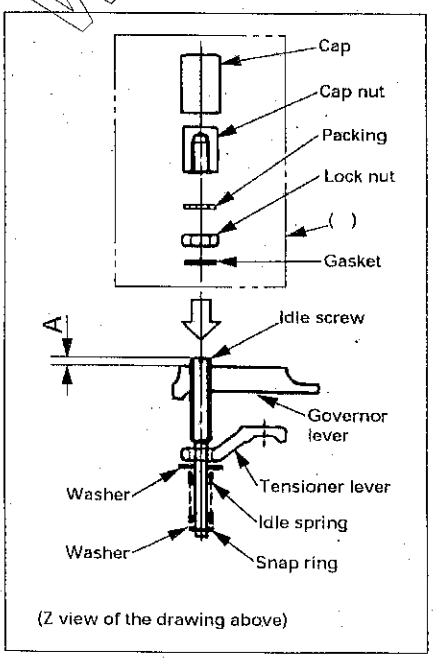
(3) After reassembling the governor cover, confirm that the governor moves smoothly.

(4) When assembling the timing gear case to the governor cover, tighten the "A" dimension shown in the illustration to 2 – 3 mm temporarily.

The parts given in the square indicated by ( ) are assembled after performance test.

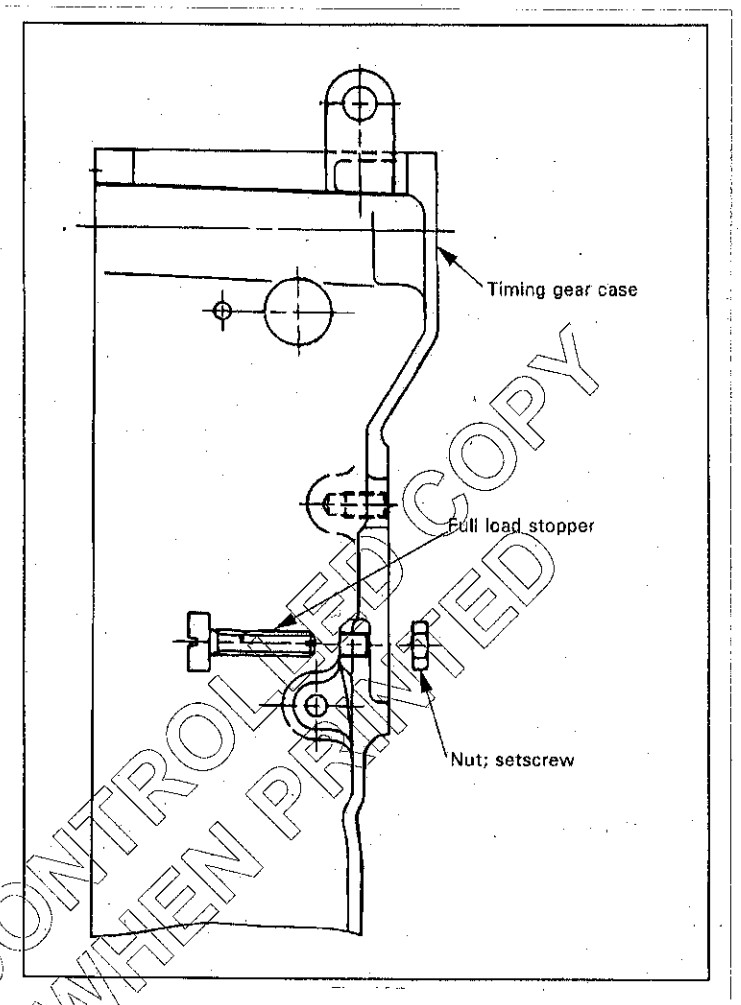
mm (in.)

"A" dimension	(When assembling temporarily) 2 – 3 (0.0787 – 0.0118)



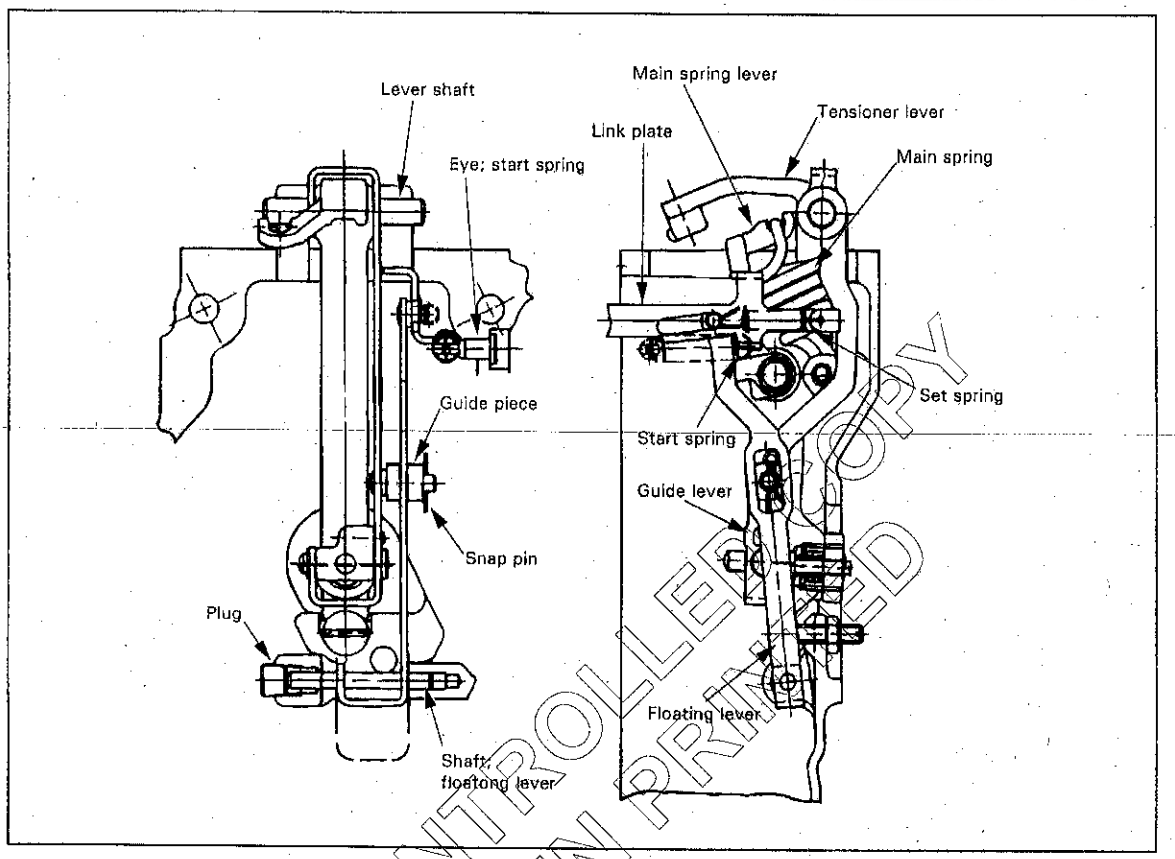
Reassembly of full-load stopper

171 Install the full-load stopper to the timing gear case, and then tighten it with a nut temporarily.



Reassembly of governor lever related components

172 Assemble each lever and spring to the timing gear case.



Notes when assembling governor related components

173 Proceed as follows:

(1) When assembling components, apply engine oil to each slide (such as the end face of the lever, the hole in the shaft, and the periphery of the shaft).

(2) Install the set spring securely to the groove of the pin connecting the floating lever, taking care with the assembling direction.

(3) Confirm that each lever moves by its dead weight before installing the start spring.

(4) After assembly, confirm that each lever moves smoothly. Also confirm that each spring operates properly.

NOZZLE HOLDER ASSEMBLY

DISASSEMBLY

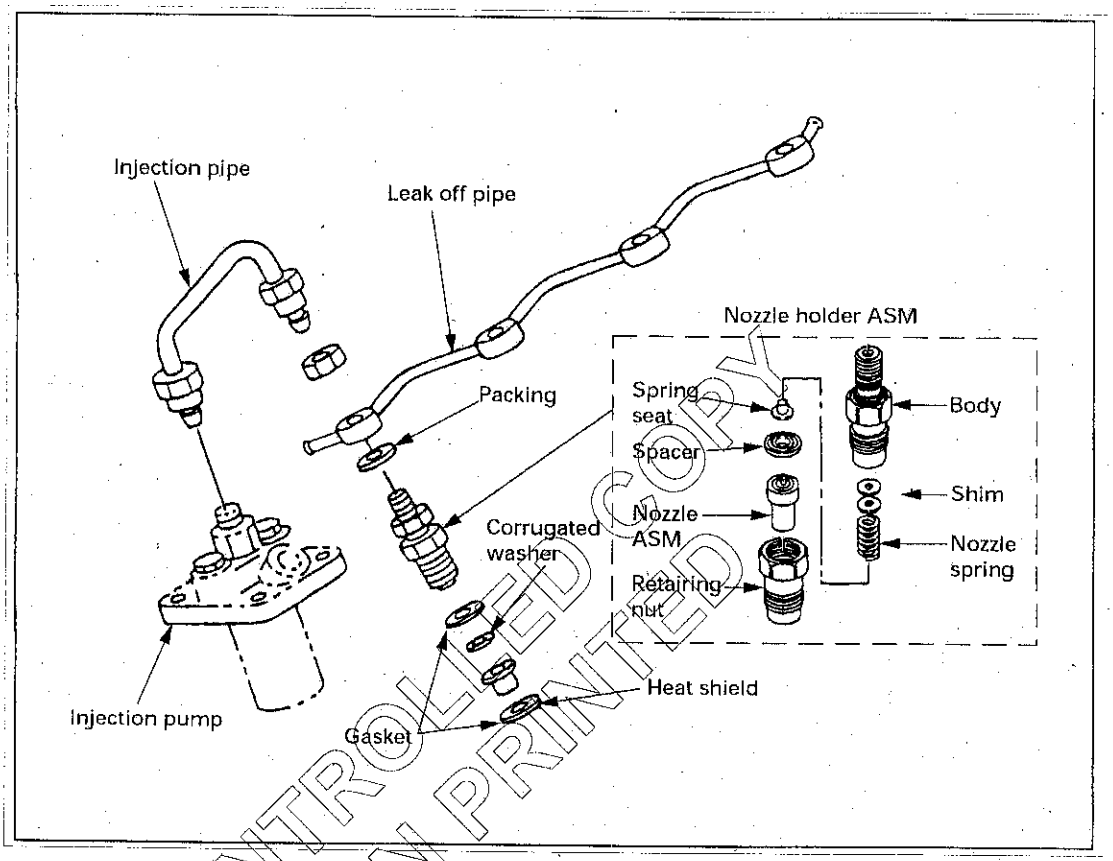


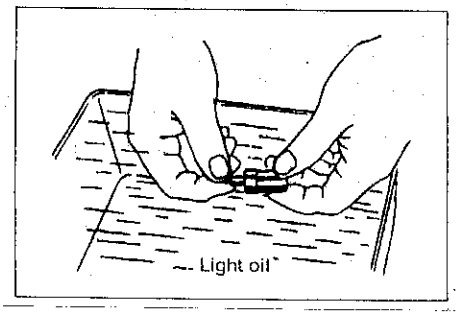
Fig 34 Nozzle holder assembly

NOZZLE ASSEMBLY

Inspection and replacement

174 Place the removed nozzle in the clean light oil, disassemble it into the nozzle body and the needle valve and clean them thoroughly. Then check to see if the valve moves smoothly in the body.

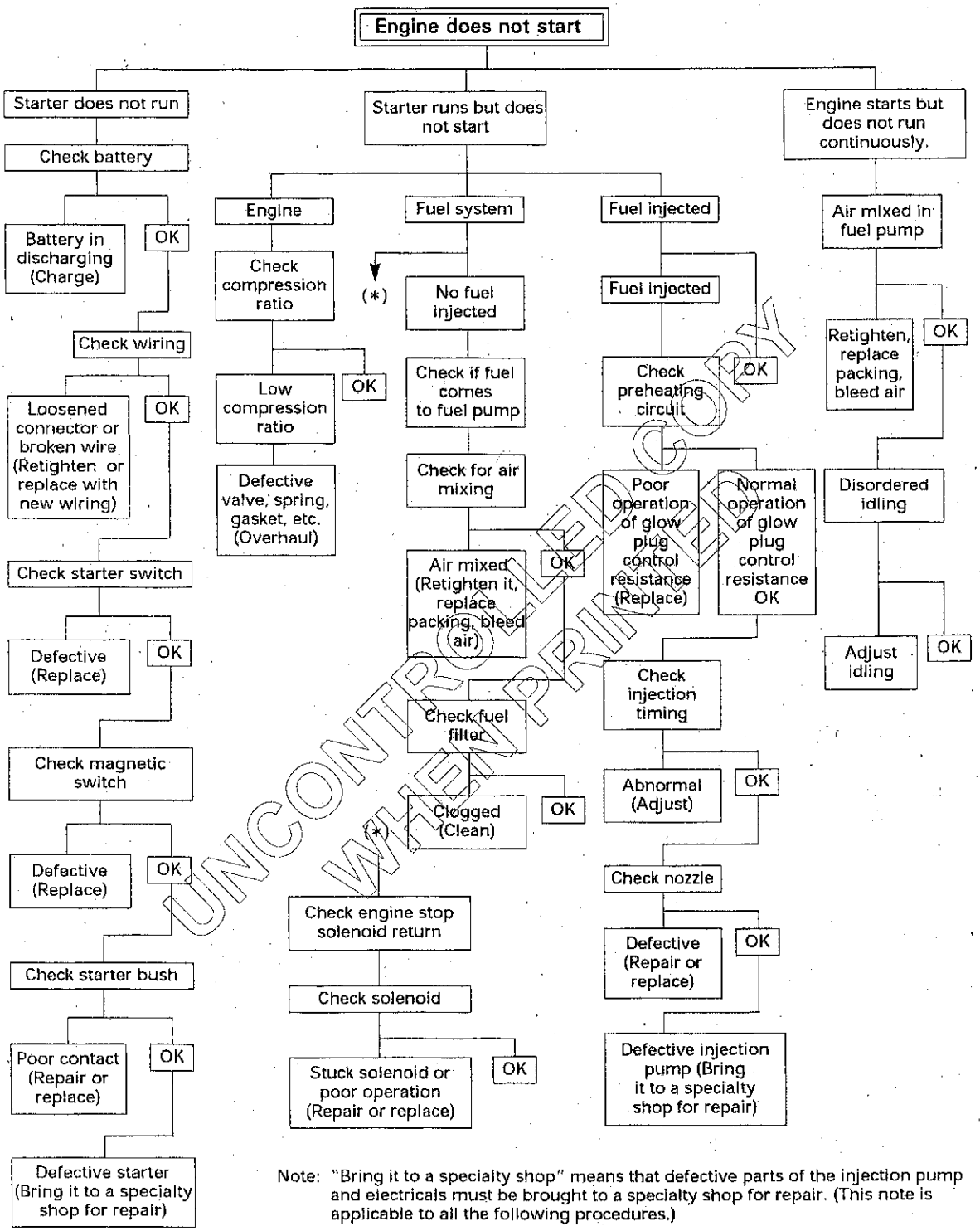
175 When it does not move smoothly, repair or replace the nozzle.



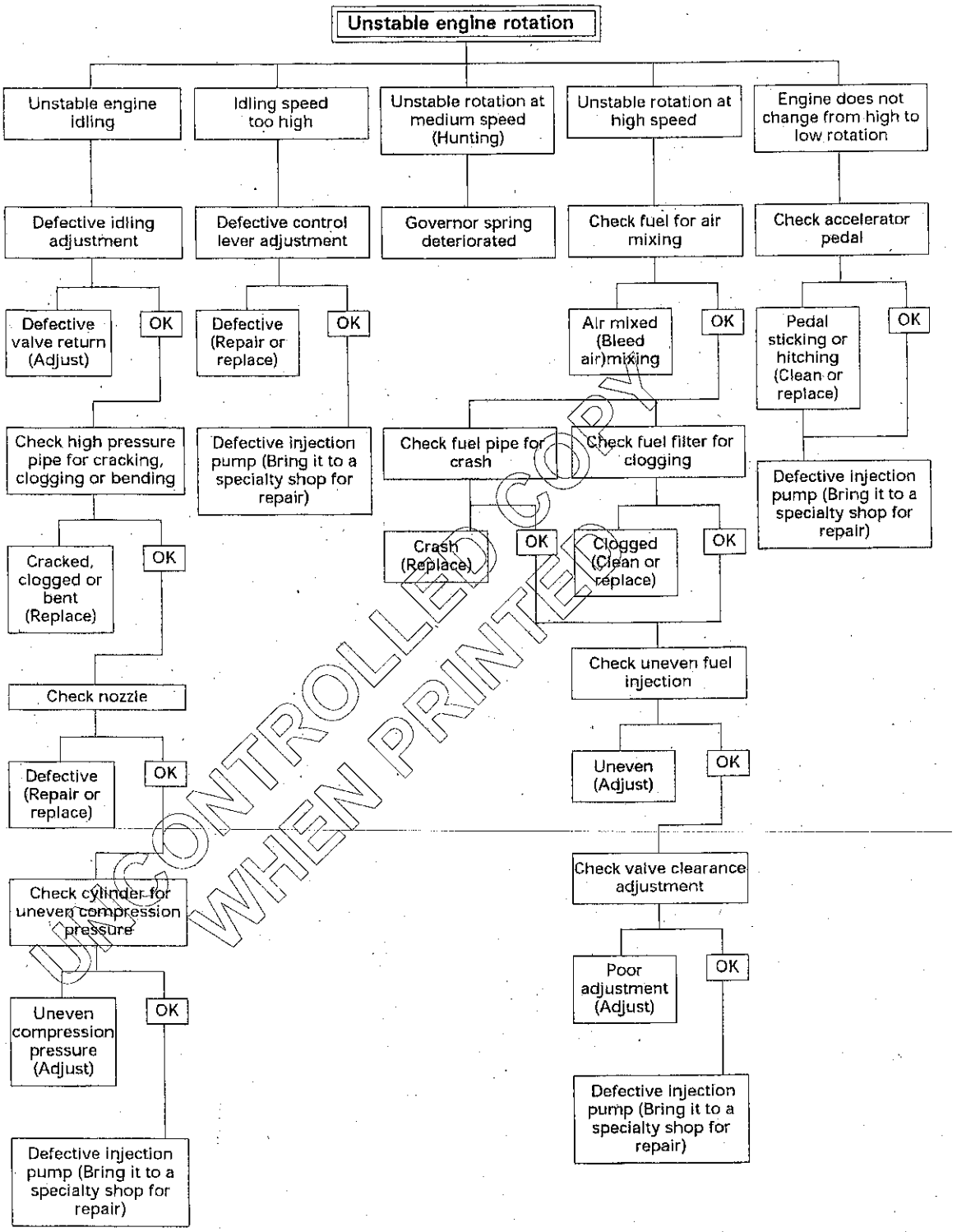
Adjustment

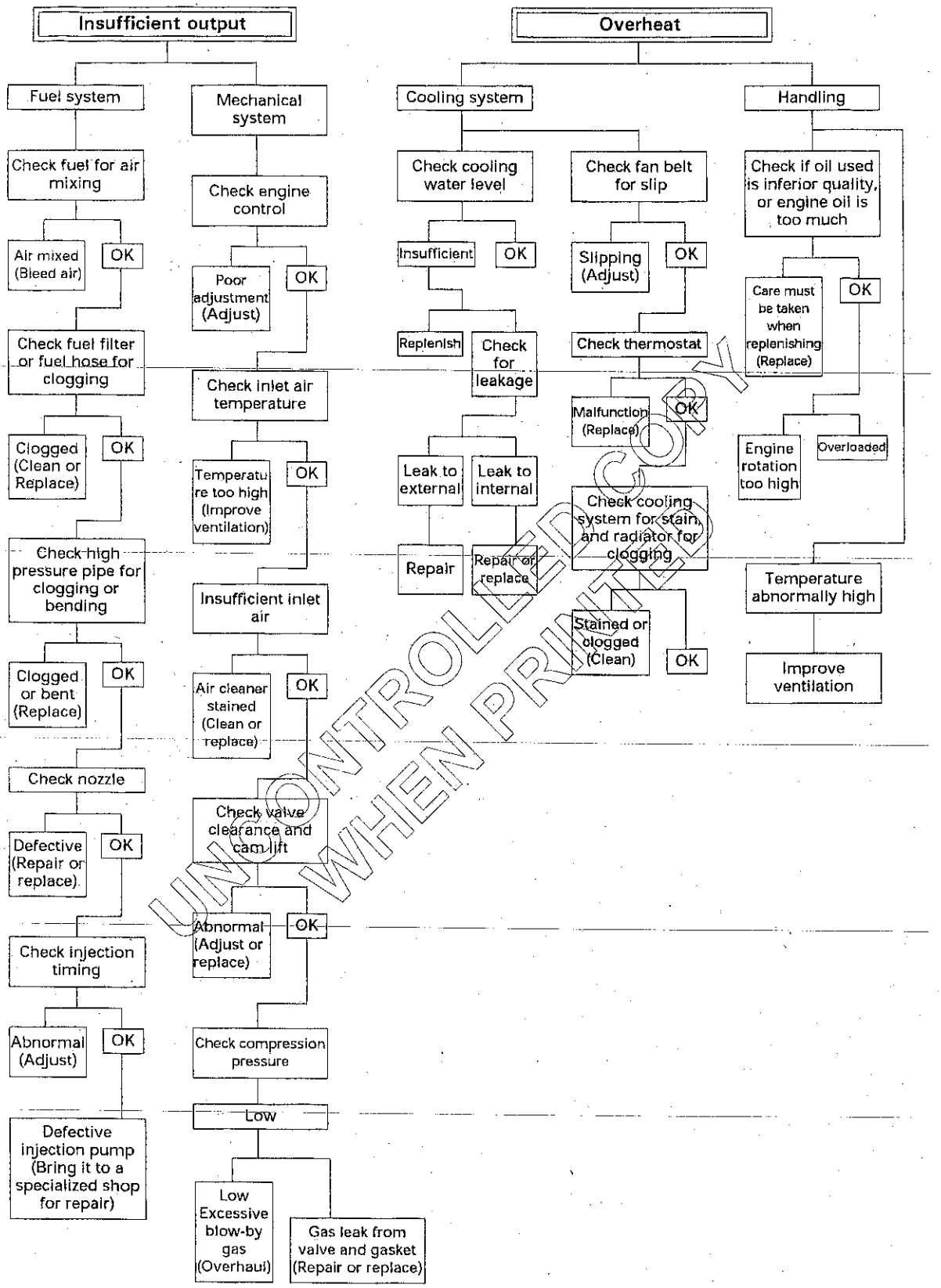
176 For the adjustment of the injection pressure and the spray condition of fuel, refer to Section 1 "INSPECTION AND SERVICE."

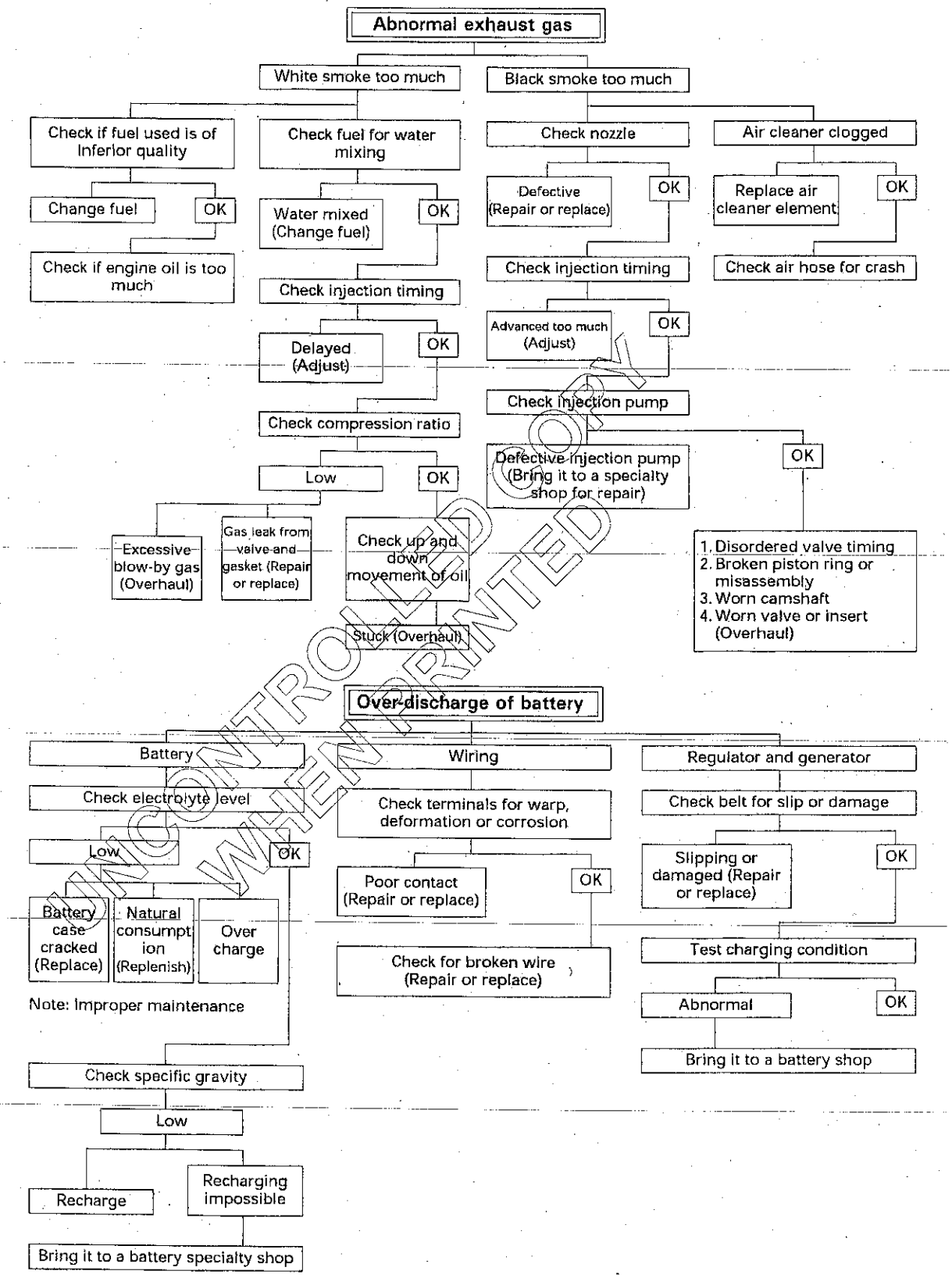
SECTION 6 - TROUBLESHOOTING

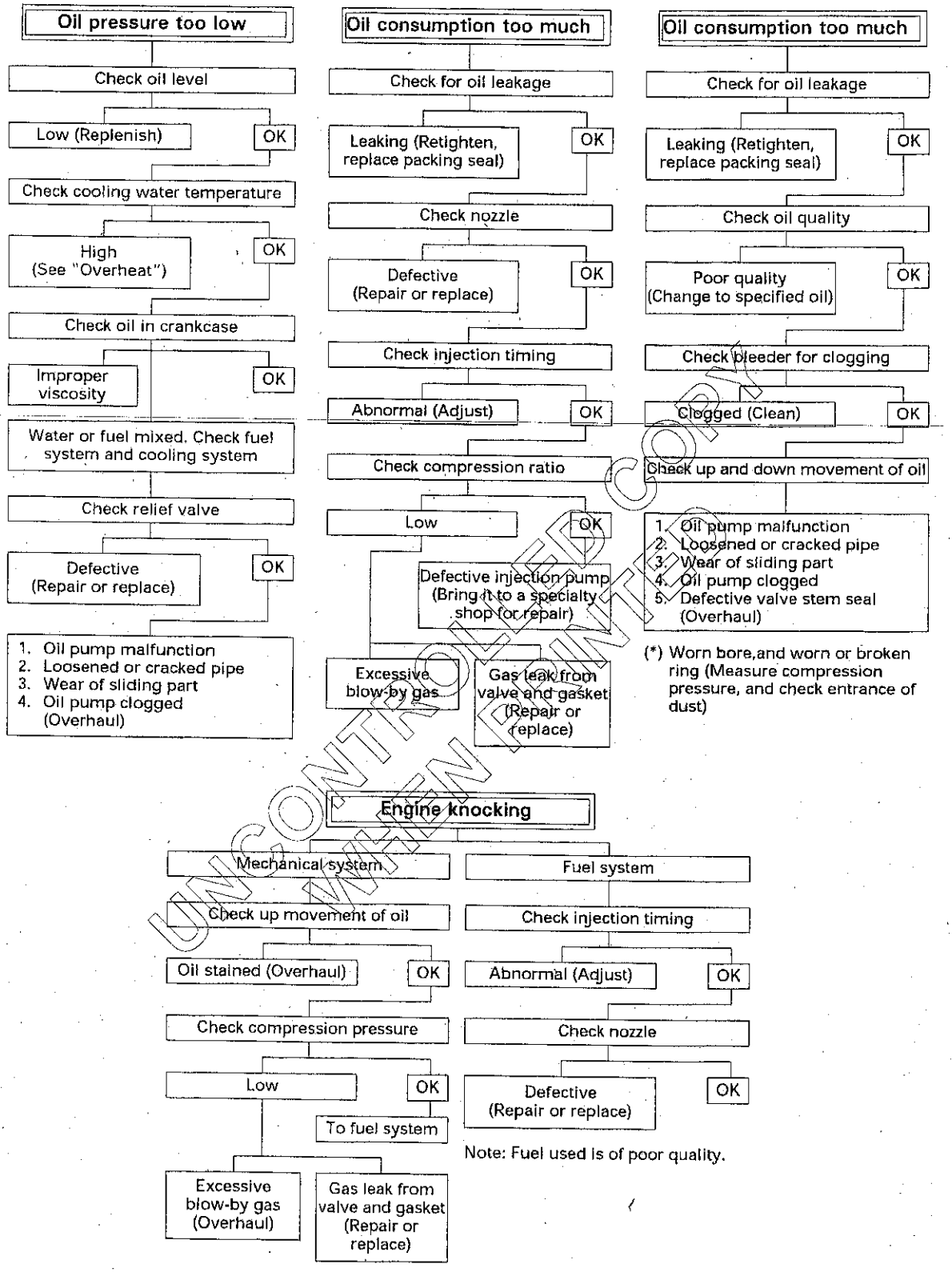


Note: "Bring it to a specialty shop" means that defective parts of the injection pump and electricals must be brought to a specialty shop for repair. (This note is applicable to all the following procedures.)



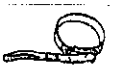
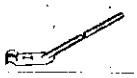
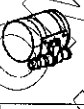
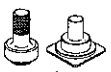
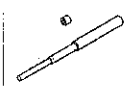
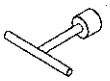






SECTION 7 - SPECIAL TOOLS

The alphanumeric codes in parentheses ( ) are part numbers assigned by special tool manufacturers.

No.	Illustration	Part number	Part name	Page
1.		5-8840-2675-0	Compression gauge	25
2.		5-8840-9026-0	Compression gauge adaptor	25
3.		5-8840-9016-0 (J28829)	Nozzle tester	27
4.		5-8840-9015-0 (JKM-9004)	Oil filter wrench	-
5.		5-8840-9030-0	Valve spring compressor	66
6.		1-852211-029-0	Piston ring pliers	40
7.		5-8840-9018-0 (J-8037)	Piston ring compressor	-
8.		5-8840-9031-0	Front oil seal installer	-
9.		5-8840-9032-0	Rear oil seal installer	-
10.		5-8840-9034-0	Camshaft bearing installer	-
11.		5-8840-9035-0	Valve guide installer	-
12.		5-8840-9033-0	Valve stem seal installer	65

SECTION 8 - CONVERSION TABLES

LENGTH

MILLIMETERS TO INCHES

mm	in.	mm	in.	mm	in.	mm	in.
1	0.0394	35	1.3780	69	2.7165	103	4.0551
2	0.0787	36	1.4173	70	2.7559	104	4.0945
3	0.1181	37	1.4567	71	2.7953	105	4.1339
4	0.1575	38	1.4961	72	2.8346	106	4.1732
5	0.1969	39	1.5354	73	2.8740	107	4.2126
6	0.2362	40	1.5748	74	2.9134	108	4.2520
7	0.2756	41	1.6142	75	2.9528	109	4.2913
8	0.3150	42	1.6535	76	2.9921	111	4.3701
9	0.3543	43	1.6929	77	3.0315	112	4.4094
10	0.3937	44	1.7323	78	3.0709	113	4.4488
11	0.4331	45	1.7717	79	3.1102	114	4.4882
12	0.4724	46	1.8110	80	3.1496	115	4.5276
13	0.5118	47	1.8504	81	3.1890	116	4.5669
14	0.5512	48	1.8898	82	3.2283	117	4.6063
15	0.5906	49	1.9291	83	3.2677	118	4.6457
16	0.6299	50	1.9685	84	3.3071	119	4.6850
17	0.6693	51	2.0079	85	3.3465	121	4.7638
18	0.7087	52	2.0472	86	3.3858	122	4.8031
19	0.7480	53	2.0866	87	3.4252	123	4.8425
20	0.7874	54	2.1260	88	3.4646	124	4.8819
21	0.8268	55	2.1654	89	3.5039	125	4.9213
22	0.8661	56	2.2047	90	3.5433	126	4.9606
23	0.9055	57	2.2441	91	3.5827	127	5.0000
24	0.9449	58	2.2835	92	3.6220	128	5.0394
25	0.9843	59	2.3228	93	3.6614	129	5.0787
26	1.0236	60	2.3622	94	3.7008	131	5.1575
27	1.0630	61	2.4016	95	3.7402	132	5.1969
28	1.1024	62	2.4409	96	3.7795	133	5.2362
29	1.1417	63	2.4803	97	3.8189	134	5.2756
30	1.1811	64	2.5197	98	3.8583	135	5.3150
31	1.2205	65	2.5591	99	3.8976	136	5.3543
32	1.2598	66	2.5984	100	3.9370	137	5.3937
33	1.2992	67	2.6378	101	3.9764	138	5.4331
34	1.3386	68	2.6772	102	4.0157	139	5.4724

INCHES TO MILLIMETERS

in.	mm.	in.	mm.
1/64	0.3969	33/64	13.0969
1/32	0.7938	17/32	13.4938
3/64	1.1906	35/64	13.8906
1/16	1.5875	9/16	14.2875
5/64	1.9844	37/64	14.6844
3/32	2.3813	19/32	15.0813
7/64	2.7781	39/64	15.4781
1/8	3.1750	5/8	15.8750
9/64	3.5719	41/64	16.2719
5/32	3.9688	21/32	16.6688
11/64	4.3656	43/64	17.0656
3/16	4.7625	11/16	17.4625
13/64	5.1594	45/64	17.8594
7/32	5.5563	23/32	18.2563
15/64	5.9531	47/64	18.6531
1/4	6.3500	3/4	19.0500
17/64	6.7469	49/64	19.4469
9/32	7.1438	25/32	19.8438
19/64	7.5406	51/64	20.2406
5/16	7.9375	13/16	20.6375
21/64	8.3344	53/64	21.0344
11/32	8.7313	27/32	21.4313
23/64	9.1281	55/64	21.8281
3/8	9.5250	7/8	22.2250
25/64	9.9219	57/64	22.6219
13/32	10.3188	29/32	23.0188
27/64	10.7156	59/64	23.4156
7/16	11.1125	15/16	23.8125
29/64	11.5094	61/64	24.2094
15/32	11.9063	31/32	24.6063
31/64	12.3031	63/64	25.0031
1/2	12.7000	1	25.4000

LENGTH

FEET TO METERS

ft.	0	1	2	3	4	5	6	7	8	9	ft.
	m	m	m	m	m	m	m	m	m	m	
---	---	0.305	0.610	0.914	1.219	1.524	1.829	2.134	2.438	2.743	---
10	3.048	3.353	3.658	3.962	4.267	4.572	4.877	5.182	5.486	5.791	10
20	6.096	6.401	6.706	7.010	7.315	7.620	7.925	8.230	8.534	8.839	20
30	9.144	9.449	9.754	10.058	10.363	10.668	10.973	11.278	11.582	11.887	30
40	12.192	12.497	12.802	13.106	13.411	13.716	14.021	14.326	14.630	14.935	40
50	15.240	15.545	15.850	16.154	16.459	16.764	17.069	17.374	17.678	17.983	50
60	18.288	18.593	18.898	19.202	19.507	19.812	20.117	20.422	20.726	21.031	60
70	21.336	21.641	21.946	22.250	22.555	22.860	23.165	23.470	23.774	24.079	70
80	24.384	24.689	24.994	25.298	25.603	25.908	26.213	26.518	26.822	27.127	80
90	27.432	27.737	28.042	28.346	28.651	28.956	29.261	29.566	29.870	30.175	90
100	30.480	30.785	31.090	31.394	31.699	32.004	32.309	32.614	32.918	33.223	100

METERS TO FEET

m	0	1	2	3	4	5	6	7	8	9	
	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	
---	---	3.2808	6.5617	9.8425	13.1234	16.4042	19.6850	22.9659	26.2467	29.5276	---
10	32.8084	36.0892	39.3701	42.6509	45.9318	49.2126	52.4934	55.7743	59.0551	62.3360	10
20	65.6168	68.8976	72.1785	75.4593	78.7402	82.0210	85.3018	88.5827	91.8635	95.1444	20
30	98.4252	101.7060	104.9869	108.2677	111.5486	114.8294	118.1102	121.3911	124.6719	127.9528	30
40	131.2336	134.5144	137.7953	141.0761	144.3570	147.6378	150.9186	154.1995	157.4803	160.7612	40
50	164.0420	167.3228	170.6037	173.8845	177.1654	180.4462	183.7270	187.0079	190.2887	193.5696	50
60	196.8504	200.1312	203.4121	206.6929	209.9738	213.2546	216.5354	219.8163	223.0971	226.3780	60
70	229.6588	232.9396	236.2205	239.5013	242.7822	246.0630	249.3438	252.6247	255.9055	259.1864	70
80	262.4672	265.7480	269.0289	272.3097	275.5906	278.8714	282.1522	285.4331	288.7139	291.9948	80
90	295.2756	298.5564	301.8373	305.1181	308.3990	311.6798	314.9606	318.2415	321.5223	324.8032	90
100	328.0840	331.3648	334.6457	337.9265	341.2074	344.4882	347.7690	351.0499	354.3307	357.6116	100

MILES TO KILOMETERS

miles	0	1	2	3	4	5	6	7	8	9	
	km	km	km	km	km	km	km	km	km	km	
---	---	1.609	3.219	4.828	6.437	8.047	9.656	11.265	12.875	14.484	---
10	16.093	17.703	19.312	20.921	22.531	24.140	25.749	27.359	28.968	30.577	10
20	32.187	33.796	35.405	37.015	38.624	40.234	41.843	43.452	45.062	46.671	20
30	48.280	49.890	51.499	53.108	54.718	56.327	57.936	59.546	61.155	62.764	30
40	64.374	65.983	67.592	69.202	70.811	72.420	74.030	75.639	77.248	78.858	40
50	80.467	82.076	83.686	85.295	86.904	88.514	90.123	91.732	93.342	94.951	50
60	96.560	98.170	99.779	101.388	102.998	104.607	106.216	107.826	109.435	111.044	60
70	112.654	114.263	115.872	117.482	119.091	120.701	122.310	123.919	125.529	127.138	70
80	128.747	130.357	131.966	133.575	135.185	136.794	138.403	140.013	141.622	143.231	80
90	144.841	146.450	148.059	149.669	151.278	152.887	154.497	156.106	157.715	159.325	90
100	160934	162.543	164.153	165.762	167.371	168.981	170.590	172.199	173.809	175.418	100

KILOMETERS TO MILES

km	0	1	2	3	4	5	6	7	8	9	
	miles	miles	miles	miles	miles	miles	miles	miles	miles	miles	
---	---	0.621	1.243	1.864	2.485	3.107	3.728	4.350	4.971	5.592	---
10	6.214	6.835	7.456	8.078	8.699	9.321	9.942	10.563	11.185	11.806	10
20	12.427	13.049	13.670	14.292	14.913	15.534	16.156	16.777	17.398	18.020	20
30	18.641	19.262	19.884	20.505	21.127	21.748	22.369	22.991	23.612	24.233	30
40	24.855	25.476	26.098	26.719	27.340	27.962	28.583	29.204	29.826	30.447	40
50	31.069	31.690	32.311	32.933	33.554	34.175	34.797	35.418	36.039	36.661	50
60	37.282	37.904	38.525	39.146	39.768	40.389	41.010	41.632	42.253	42.875	60
70	43.496	44.117	44.739	45.360	45.981	46.603	47.224	47.845	48.467	49.088	70
80	49.710	50.331	50.952	51.574	52.195	52.816	53.438	54.059	54.681	55.302	80
90	55.923	56.545	57.166	57.787	58.409	59.030	59.652	60.273	60.894	61.516	90
100	62.137	62.758	63.380	64.001	64.622	65.244	65.865	66.487	67.108	67.729	100

Connecting rod

36 A forged steel I-beam connecting rod is used for all L-series engines. They are full floating design with bushed wrist pin ends (Fig 24).

NOTE

When removing and replacing the connecting rod assemblies, be sure to install the connecting rod with the Isuzu Logo facing the same direction as the piston's forward notch.

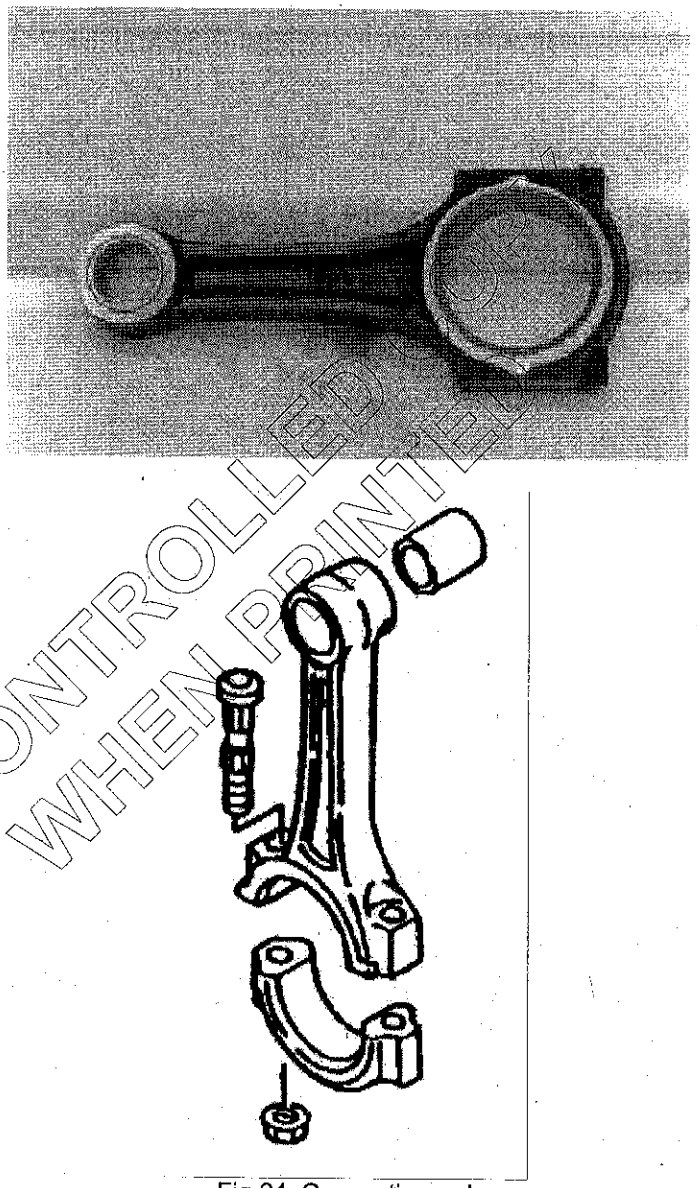


Fig 24 Connecting rod

IMPORTANT: The rod cap bolts are not to be removed. It is shown only for clarity, but is not a standard rod cap bolt. These bolts have serrations (to prevent the bolts from turning) and are pressed onto the rod. When servicing, the entire rod must be replaced.

Cylinder head gasket

37 The L-series engines use a three-layer ultra thin laminated steel head gasket that requires no re-torqueing after the engine break-in period. Holes for coolant are drilled between the valve seats for effective cooling of the combustion area.

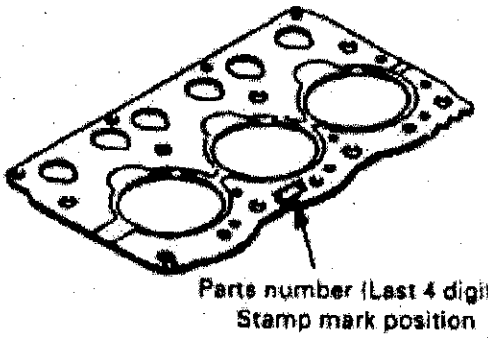


Fig 25 Cylinder head gasket

IMPORTANT: The head gasket must be installed with the flat side of the sealing bead facing up. Also the large flat end of the gasket must face forward.

38 The sealing bead surrounding the cylinders of the gasket is stainless steel. It protects the head gasket from the high cylinder pressures. The sealing bead also protects the gasket from the high temperatures released by the hot plugs.

39 The gasket comes pre-coated with a silicon material. Therefore, no additional application of sealers or gasket adhesives is necessary, and no re-torqueing of the head bolts is required if the prescribed angular tightening method is used.

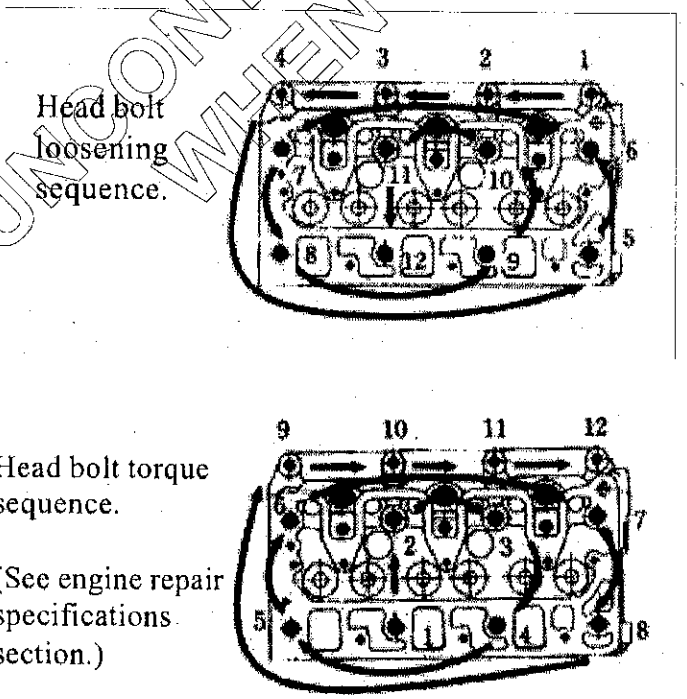


Fig 26 Head bolt loosening and torque sequences

40 To identify the gallies, use Fig 27 and the legend below.

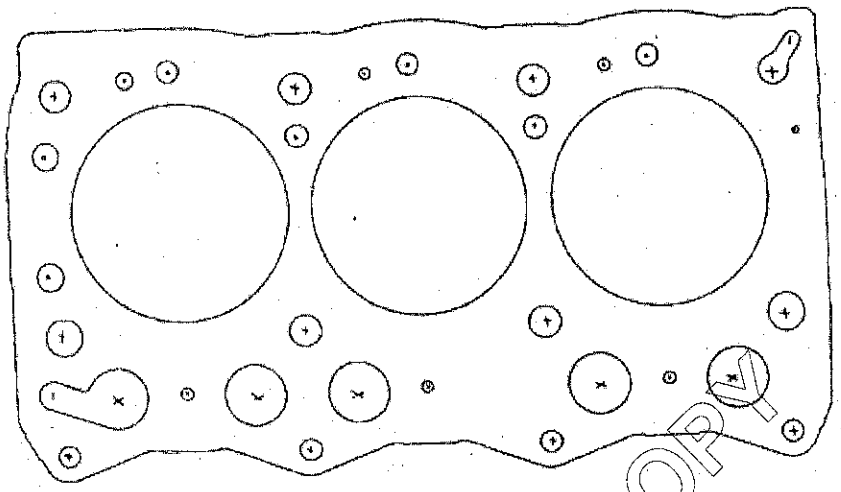


Fig 27 Gasket detail

Cylinder head

41 The L-series cylinder heads are cast iron with replaceable valve guides and valve seats. The head casting number is embossed at the front of the head's casting just below the injector nozzle bore (Fig 28).

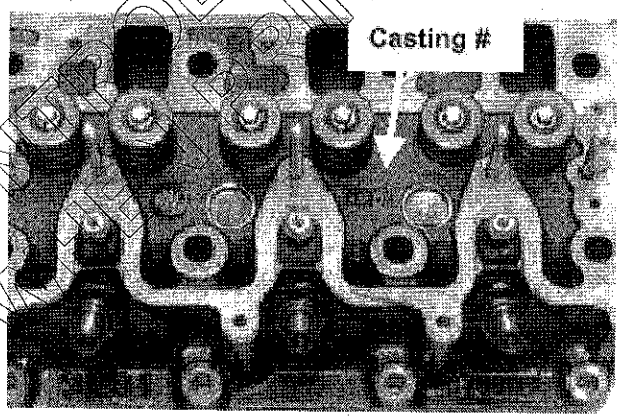


Fig 28 Head casting number

42 Compression tests are conducted using a compression gauge adaptor used as a glow plug insert, special tool number 5-88402-656-0. Refer to the workshop manual for procedure.

43 The service limit for this engine is 370 psi (26.0 kg/cm^2). Standard pressure is 441 psi (31.0 kg/cm^2). Isuzu allows an 8% variance between cylinders on compression tests, but there can be no more than a 15% difference between any two cylinders.

44 Letters A - F represent the different measurements that need to be taken to determine head warpage. See Fig 29.

Upper and Lower face warpage specifications:

Standard:	0.075 mm. (0.0029 in.)
Limit:	0.15 mm. (0.0059 in.)
Max Grinding Allowance:	0.3 mm. (0.0118 in.)

Head Height:

Standard: 64 mm. (2.5197 in.)
Limit: 63.7 mm. (2.5079 in.)

IMPORTANT: Valve depression must be checked to ensure that it is still within specification.

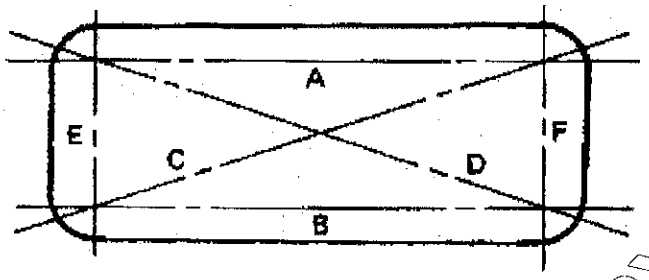


Fig 29 Head warpage measurements

LUBRICATION

45 Lubrication is achieved with a conventional wet sump oiling system. Internally, the trochoid oil pump uses a set of rotors instead of spur gears. Refer to Fig 30.

46 It is a very efficient and smooth operating pump. Compared with the spur gear type pump, the trochoid pump gives practically continuous flow, due to less leakage on the discharge side of the pump.

47 The pump is mounted to the front of the engine block and driven by the crankshaft.

48 On the pump's exterior housing, there are two lugs machined for dowel pins. This enables the pump to be repositioned in exactly the same location without having to set pump gear backlash.

49 The pump is a serviceable unit. Internal components are interchangeable between PTO (Fig 31) and non-PTO versions.

TIP: Always remove the pump's pressure relief valve during a rebuild. Look for a cocked pressure spring, burred relief valve or burred pump housing that would cause the pressure valve to fail. (If housing is burred, it must be replaced.

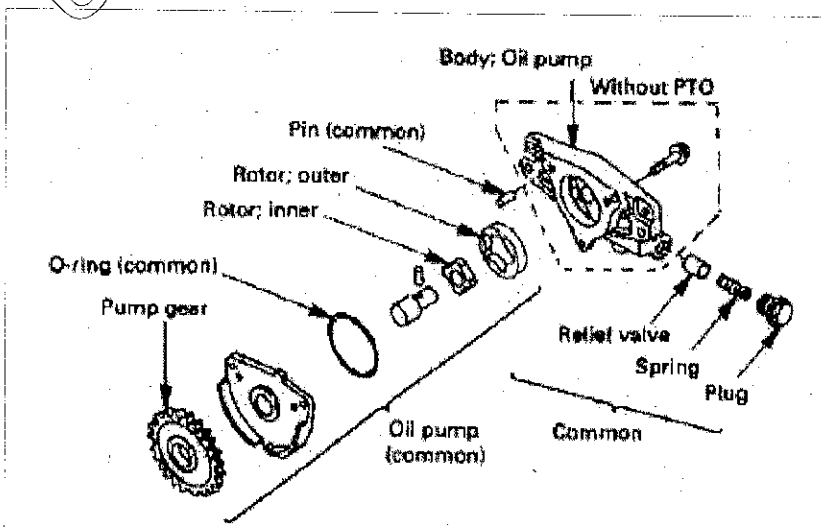


Fig 30 Oil pump

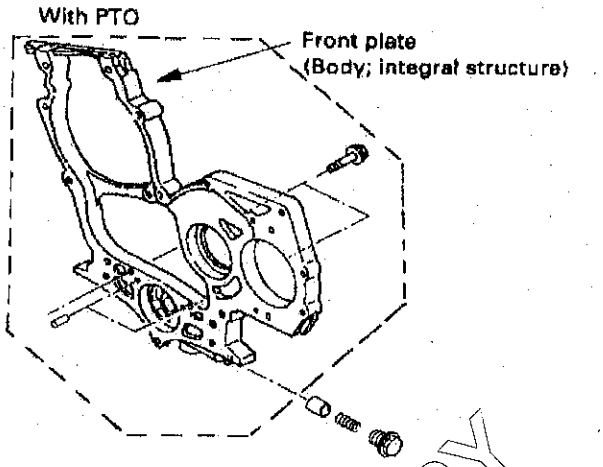


Fig 31 Oil pump housing

50 Below is the oil full flow diagram (Fig 32). Note the valve opening pressure for the oil filter bypass valve (14 PSI) is where the valve begins to open. The same is true for the oil pump relief valve, which begins to open at 64 PSI.

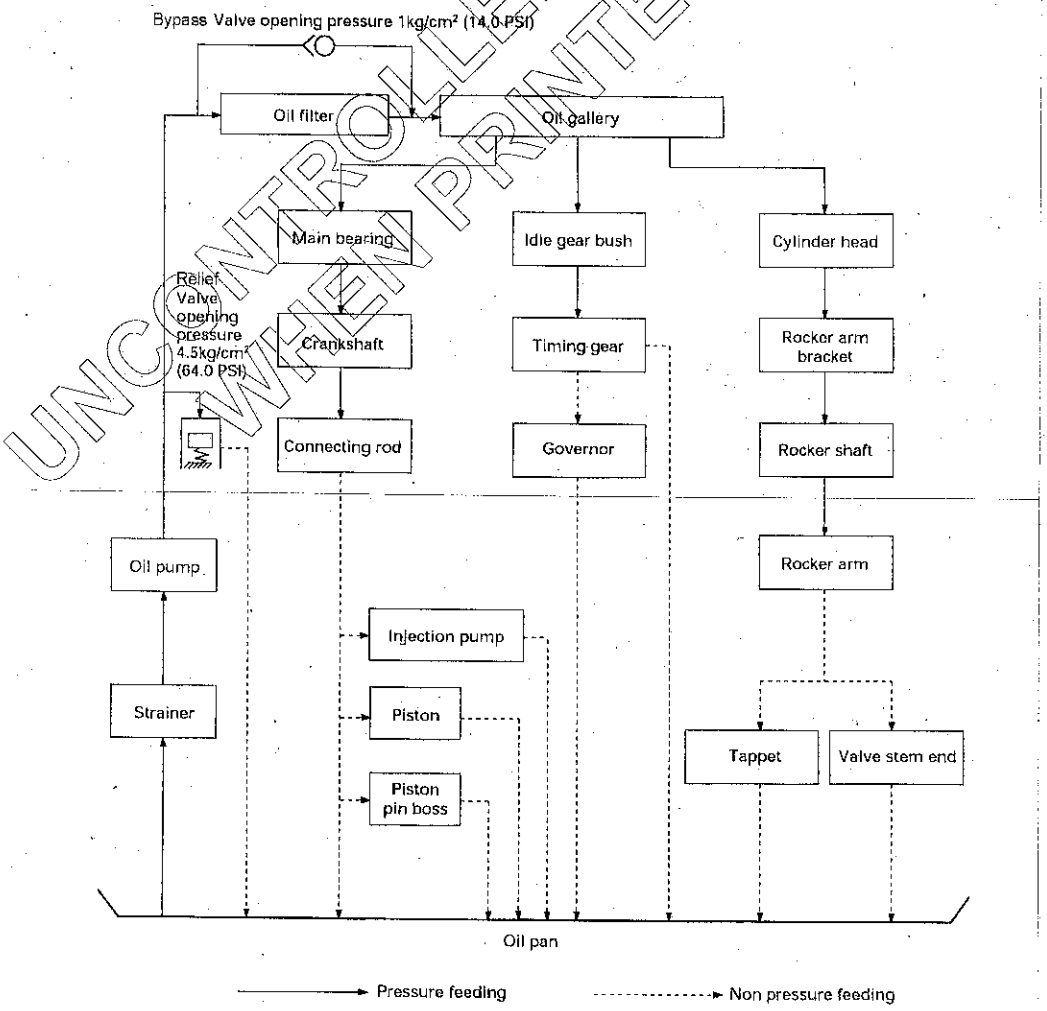


Fig 32 Oil flow diagram

COOLING SYSTEM

51 Below is the coolant flow diagram (Fig 33). Good coolant circulation is ensured by utilizing water jackets formed with a one-piece casting core, which eliminates burrs in the water passage.

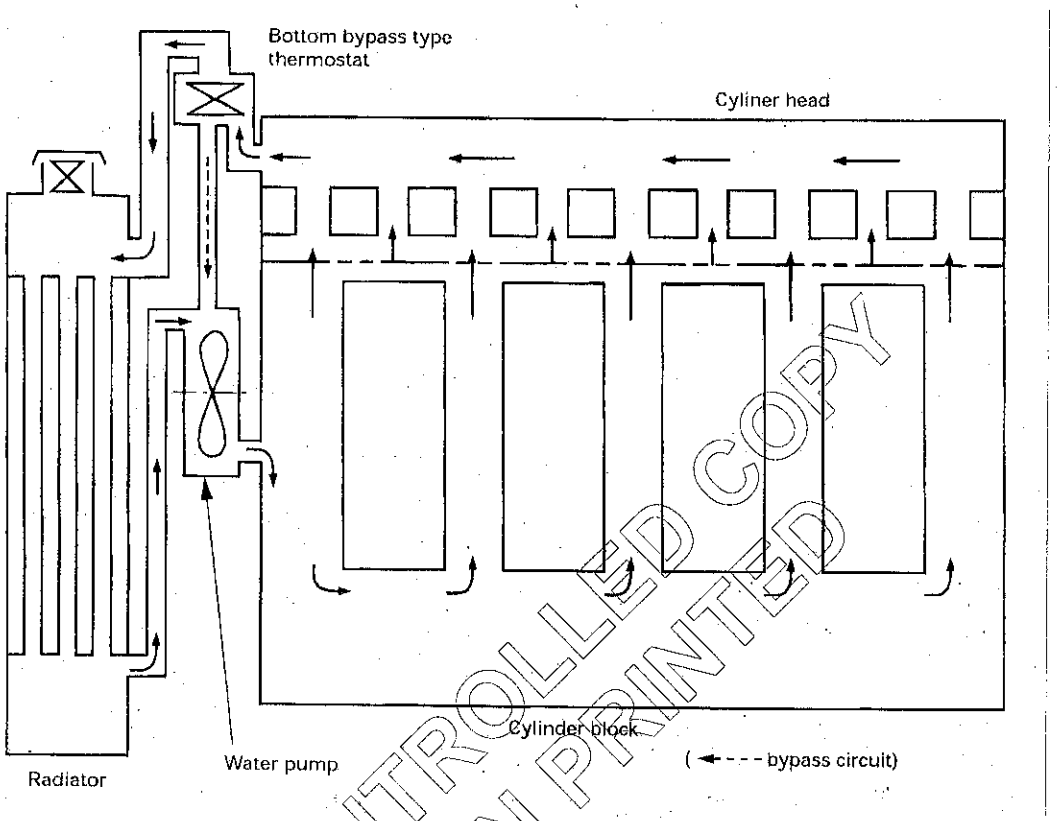


Fig 33 Coolant flow diagram

52 Maintain a coolant/water solution concentration ratio of 50 /50. Use only de-mineralized (soft) water, since hard water tends to neutralize the corrosion inhibitors in the antifreeze and add scale (particularly in hot spots) to the cooling system. It is absolutely **required** that you use a low-silicate formula anti-freeze. Do not add any additional water pump lubricants to the cooling system. Refer to the Workshop Manual for radiator cap and cooling system testing and specifications.

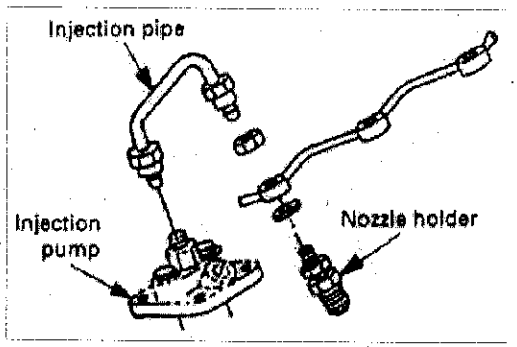
53 Use a commercially available antifreeze tester when testing for coolant/water mixture. Testing for pH is essential, as too high an acidity or alkalinity can cause severe damage to the engine and cooling systems. The pH readings should be 7.5-8.5 (SAE J1034 allows for 7.5-11.0). Litmus test paper is available from most commercial tool suppliers and product distributors.

SECTION 3 - ENGINE SERVICING PROCEDURES

SPILL-PORT TIMING

54 Spill-port timing is a precise method of measuring the initial injection of fuel by the pump and the duration of injection. It is a standard procedure used by Isuzu when timing Zexel pumps. This procedure is a very precise method of timing fuel because it shuts off fuel to the high-pressure chambers relative to the position of the piston.

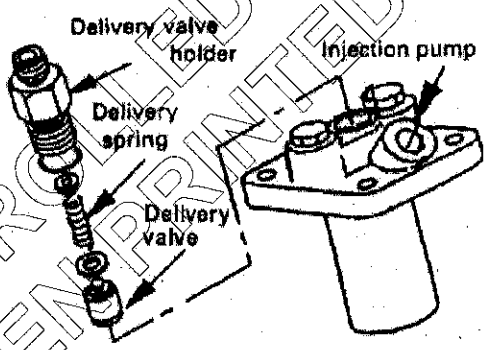
(1) Disconnect the injection pipe from the nozzle holder.



(2) Remove the nozzle delivery valve holder from the pump. Reinstall the holder without the delivery spring and delivery valve. Pressurize the pump. Then rotate the engine clockwise until fuel quits flowing out of the holder. (This is the beginning of the injection).

NOTE

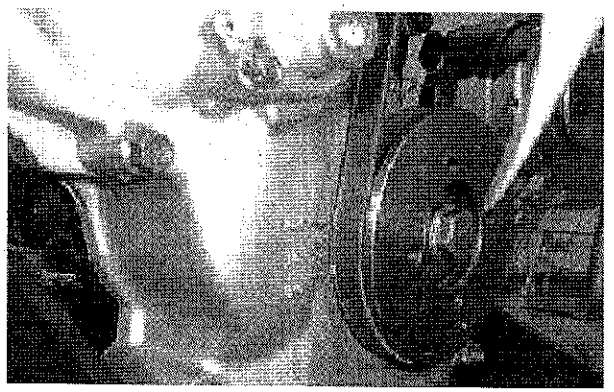
Remember that the injection pump uses shims to advance or retard injection. Thicker retards the timing, thinner advances it).



(3) Observe the reading on the crank pulley in relation to the timing marks on the gear case cover. If this value is out of range, change the thickness of the shims from underneath the pump. Each shim varies in thickness by .1mm (.004"), creating a 1° change in timing (thicker=retard, thinner=advance). The shims are a "crush" design and must not be reused.

NOTE

Refer to the proper specification sheet for timing adjustment information.



55 After spill port is performed, be sure to reassemble all components and install correctly for proper operation.

VALVE ADJUSTMENT

56 Bring the engine up on number one compression stroke. Verify the position by checking for clearance in-between the valve stem tip and the rocker arm.

NOTE

Valves can be adjusted beginning with #1 or #4 (4L). This adjustment can only be made with a cold engine.

TABLE 3 VALVE ADJUSTMENT - COMPRESSION STROKE

4L Engines								
Cylinder Number	1		2		3		4	
Valve Arrangement	I	E	I	E	I	E	I	E
Valve Numbers	4	4	4	--------	--------	4	--------	--------

57 Loosen the adjuster jam nut; insert a 0.40 mm (0.016") feeler gauge in-between the rocker tips and the valve stems to adjust the valves.

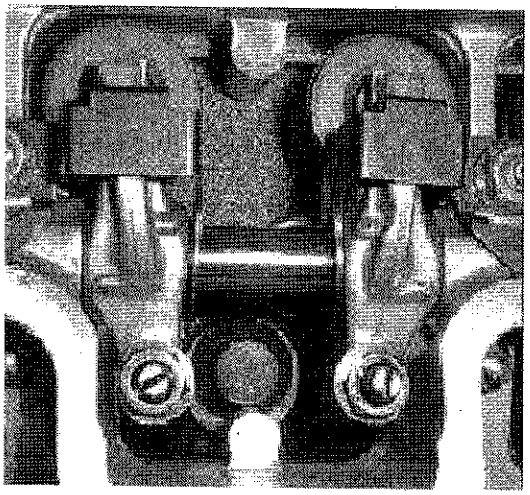
NOTE

Proper adjustment is obtained when there is a slight drag against the feeler gauge. Jam nut torque is 5.8-8.7 lbs. ft (0.8-1.2 kg m)

58 Rotate the crankshaft 360° (so that the opposing piston is now on its exhaust stroke) and adjust the remaining valves.

TABLE 4 VALVE ADJUSTMENT - EXHAUST STROKE

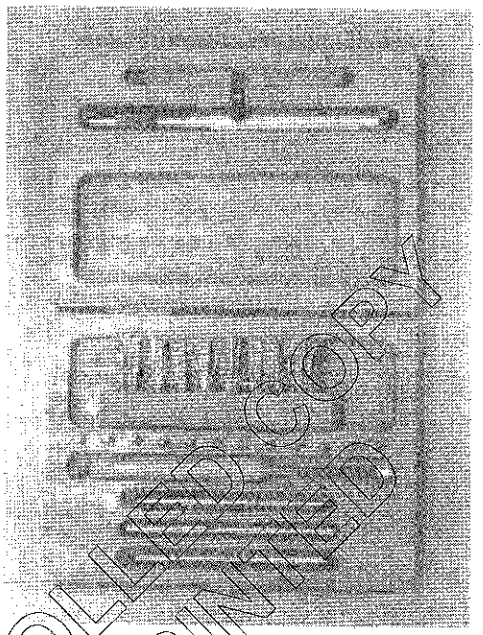
4L Engines								
Cylinder Number	1		2		3		4	
Valve Arrangement	I	E	I	E	I	E	I	E
Valve Numbers	--------	--------	--------	4	4	--------	4	4



INJECTOR SERVICE

59 The following procedures are service recommendations from Zexel:

(1) Thoroughly clean all carbon residue and carbon build–up on the surface of the nozzle using Zexel cleaning kit #1057790010.

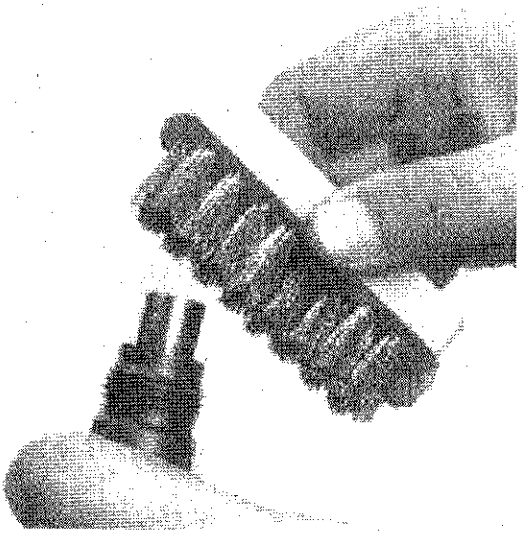


(2) Soak all parts other than the nozzle in cleaning oil.

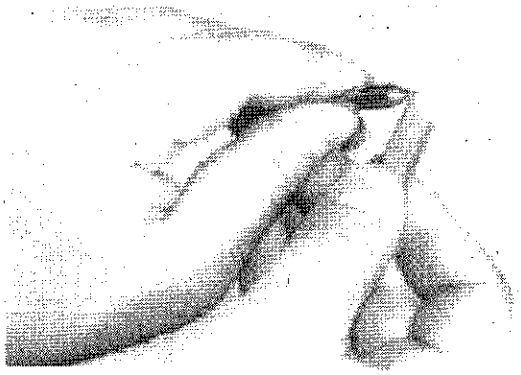
(3) Use a soft wire brush to clean excessively dirty parts.

CAUTION

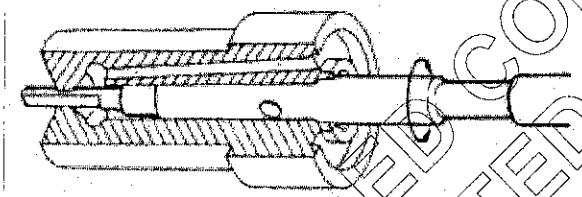
EQUIPMENT DAMAGE: Do not use metal or abrasive cleaning media to clean the nozzle holder. Their abrasive nature will leave scars on the ground surface and may cause fuel leaks



(4) Remove the needle valve from the nozzle. Clean the seat's surface and shaft section using the piece of hardwood from the cleaning kit or a clean soft cloth dipped in oil.

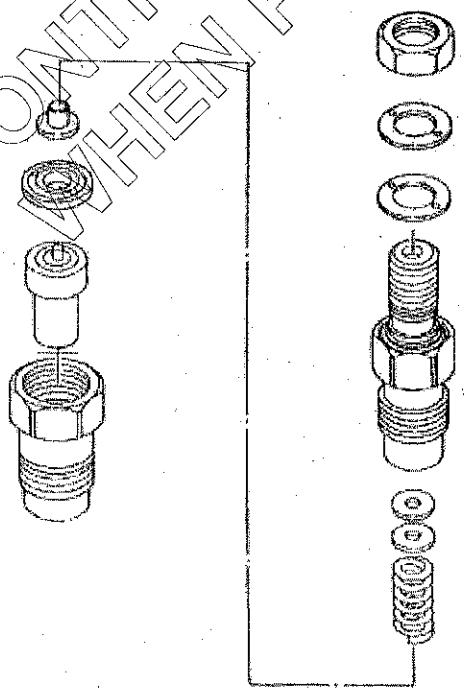


(5) Likewise, clean the spray hole with the special needle also supplied with the cleaning kit.



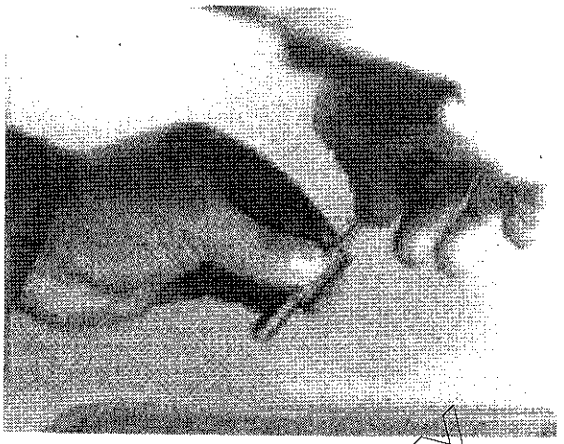
(6) Re-wash the injector components to remove any final debris.

(7) Reassemble the injector.



NOTE

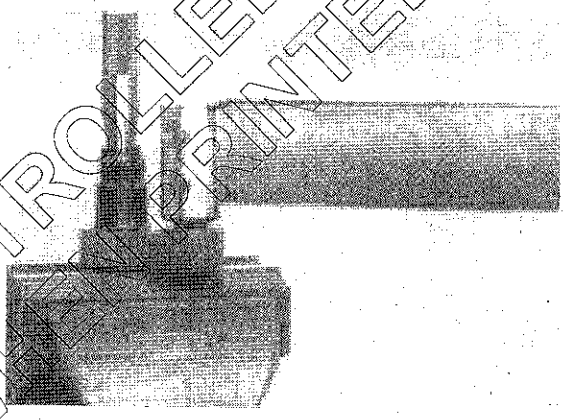
Before assembling the injector, perform a needle slide test to ensure that there is no obstruction that could cause a fuel leak.



(8) Insert the body nozzle holder to center the nozzle in the retaining nut. For reassembly torque specifications, see Appendix 1 'Nozzle Holder Tightening Standards'.

NOTE

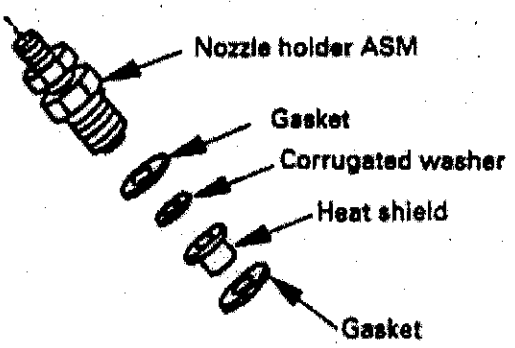
Use a flare nut/crowfoot socket on the torque wrench.



(9) When installing nozzle assembly into the cylinder head, be sure to replace the gaskets and washers, as they can only be used once.

NOTE

The blue side on the corrugated washer faces the nozzle.



(10) Tighten the retaining nut with a torque wrench to 29-36 lb. ft. (39-49 Nm).

INJECTOR POP-OFF TEST

WARNING

PERSONNEL INJURY. FLUID FROM THE NOZZLE TESTER WILL SPRAY OUT UNDER GREAT PRESSURE. IT CAN EASILY PUNCTURE A PERSON'S SKIN. KEEP YOUR HANDS AWAY FROM THE NOZZLE TESTER AT ALL TIMES.

60 Use the following procedure to check nozzle opening pressure, spray pattern, chatter and leakage:

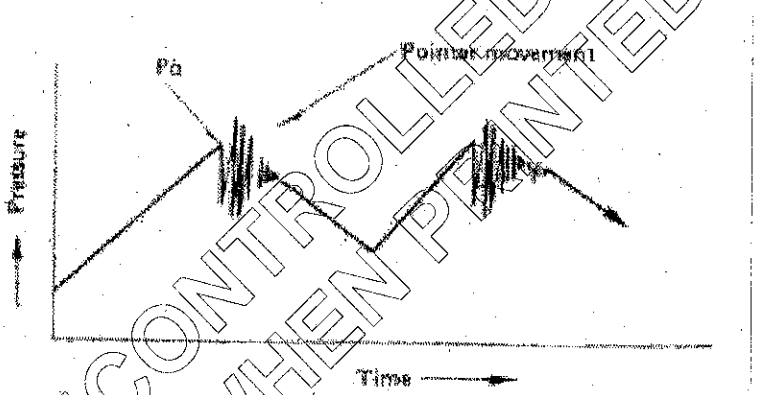
(1) Mount the nozzle and holder assembly to the gauge (J28829) and bleed the system of air.

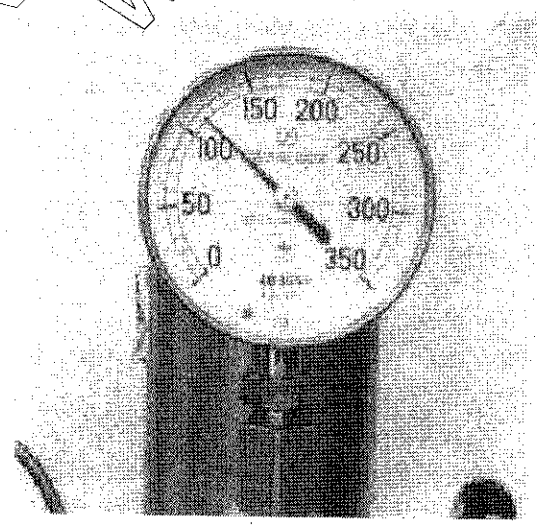
(2) Open the pressure gauge valve and pump the lever at a rate of one stroke per second.

(3) Then check the opening pressure. When the pressure gauge pointer decreases rapidly, read pop-off value. (Refer to engine's specification sheet for values. An Indirect Injection will have lower readings than a Direct Injection engine.)

NOTE

If the nozzle opening pressure is not steady or cannot be checked, the trouble is with the nozzle assembling procedure.





61 If the nozzle 'pop-off' pressure does not meet factory pressures, disassemble the nozzle and make a shim adjustment. The following size shims are available through AIPDN.

Shim Part Number	Shim Size (mm)
894176-9620	0.10
894176-9630	0.20
894176-9640	0.30
894176-9650	0.40
894176-9660	0.50
894176-9670	0.52
894176-9680	0.54
894176-9690	0.56
894176-9700	0.58
894176-9710	0.60

INJECTOR LEAK TEST

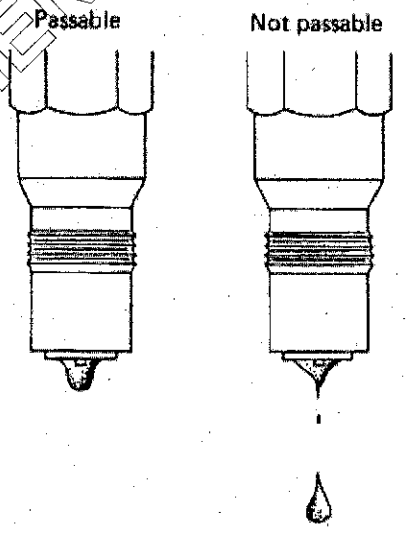
62 The leak test should be conducted immediately following the nozzle opening pressure adjustment check.

(1) Wipe the nozzle with a clean shop towel.

(2) Decrease the tester pressure about 20 kg/cm^2 less than the pop-off pressure and maintain the position.

(3) There should be no fuel discharge from the nozzle for at least 10 seconds.

(4) Re-clean or replace any nozzle that does not meet the criteria.

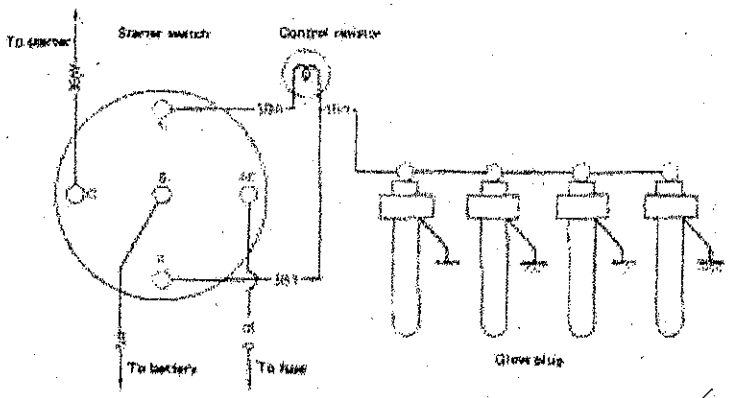


GLOW PLUG INSPECTION

63 The following procedure tests the resistance value of the glow plug.

NOTE

The test can be performed on or off the engine.



64 Total glow plug resistance value should be ≤ 0.9 ohms.

On engine service:

(1) Remove the buss bar from the glow plug.

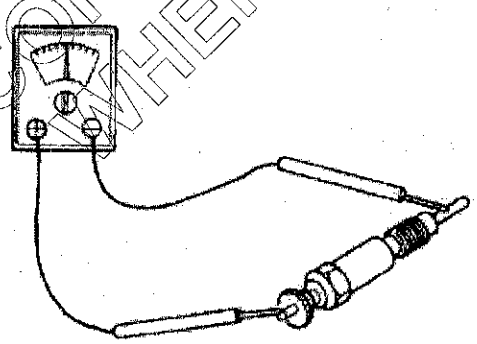
(2) Attach the DVOM red lead to the to the tip of the glow plug.

(3) Attach the DVOM black lead to a good ground source. Verify the ground integrity by testing it with the DVOM.

Off engine service:

(1) Disconnect and remove glow plug.

(2) Place DVOM leads across glow plug (one lead at each end) to obtain resistance reading

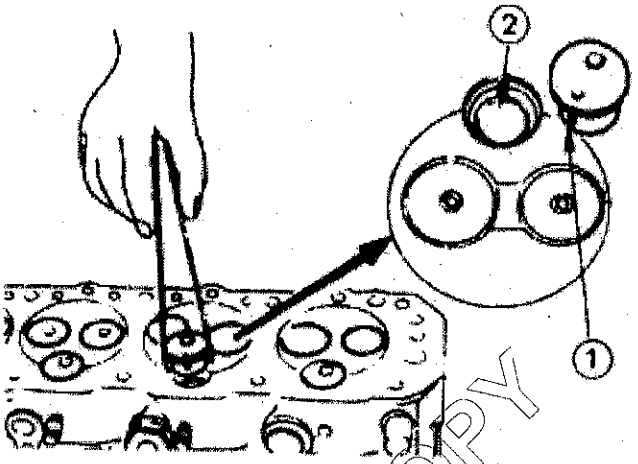


HOT PLUG REPLACEMENT

65 Hot plugs for the L-series are similar to other Isuzu diesel engines.

66 If the plug needs to be replaced, knock out the old plug from behind, though the injector nozzle hole.

67 Always remember that the plug groove in the cylinder head needs to be clean and free of any burrs that would prevent proper seating. With reference to the figure overpage, align the hot plug knock ball (1) with the cylinder head groove (2) and tap it temporarily into position with a plastic hammer.



NOTE

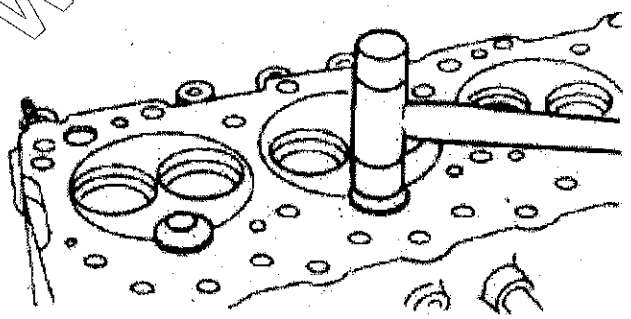
Illustration is generic and does not precisely represent the L-Series hot plugs.

68 New plug. Place a 1" thick metal plate over the top of the hot plug and press fit the plug using 4 to 5 tons of force on the metal plate.

69 Old plug. When re-using plugs, be sure to place the plug in the same hole that it came out of originally. Tap the plug head into place and ensure that the plug is firmly seated. Grind off any surface protrusions so that it is completely flush with the surface of the head.

NOTE

Most current/newer model surfacing machines do not require hot plug removal before head refinishing. Consult your particular equipment manual.



SECTION 4 - ENGINE REPAIR SPECIFICATIONS - 4L

MAINTENANCE SPECIFICATIONS

70 Maintenance specifications are as follows:

TABLE 5 4L MAINTENANCE SPECIFICATIONS

Item	Metric Measure	US Measure
Engine Oil Capacity (see Note 1) 4LB1/LC1 4LE1	 7.3 Litres 8.7 Litres	 7.7 quarts 9.2 quarts
Engine Oil Pressure (see Note 5)	4-5 Kg/cm^2	43-51 lbs
Compression Pressure (see Note 2)	31 Kg/cm^2	441 psi
Valve Adjustment	.40 ±0.05 mm	0.015 ± .002 in
Coolant Capacity (see Note 3) 4LB1 4LC1 4LD1	 2.5 Litres 2.7 Litres 2.8 Litres	 2.6 quarts 2.8 quarts 3.0 quarts
Injection Starting Pressure	12.7-13.7 Mpa	1850-1990 psi
Injection Timing (see Note 4)	16° BTDC	
Fan Belt Deflection Tension	8.0 mm-12 mm	0.3-0.5 in
Glow Plug Resistance	0.7-0.9 Ω	

NOTES

(1) These specifications vary depending upon the type of equipment in which the engine is being installed. Only use API class CC or CD. On 4LB1 with turbocharger, use only API grade CD.

(2) First warm up the engine until coolant temperature reaches 167° F (75° C). Measured at 250 rpm. Service Limit is 26 Kg/cm^2 (370 psi).

(3) Use only an Ethylene glycol based anti-freeze/water mixture. A 50/50 concentration ratio provides maximum protection to -37° C or -34° F. Never exceed a 60/40 concentration ratio, which provides protection to ≈ -50° C or -58° F.

(4) Timing may vary depending on engine specification.

(5) Pressure may be lower at engine idle.

MECHANICAL SPECIFICATIONS

71 Mechanical specifications are as follows:

TABLE 6 4L MECHANICAL SPECIFICATIONS - CYLINDER HEAD/VALVE TRAIN

Cylinder Head/Valve Train	Standard	Service Limit
Valve Clearance (see Note 1)	0.40 mm/0.01575 in	----------
Cylinder Head Warpage (see Note 2)	0.075 mm/0.0029 in	0.15 mm/0.0059 in
Cylinder Head Height (see Note 3)	63.9 mm/2.515 in	64.1 mm/2.523 in
Valve Depression (see Note 4)	0.7 mm/0.0276 in	1.2 mm/0.0427 in
Hot Plug Description	0.05 mm/0.002 in	0.05 mm/0.002 in

Valve Margin Thickness (see Note 5)	1.0 mm/0.3937 in	.7 mm/ .0276 in
Valve Stem Diameter	7.0 mm/ .2756 in (Int) 7.0 mm/ .2756 in (Exh.)	6.85 mm/ .2697 in (Int) 6.80 mm/ .2677 in (Exh.)
Valve Spring Installed Height	29.9 mm	----------
Valve Seat Angle	45°	

NOTES

(1) Valve adjustment clearances are established cold.

(2) Maximum grinding allowance is 0.3 mm/0.0118 in.

(3) Measurement is established by measuring from the head's sealing surface to the rocker bracket surface area.

(4) Dimension taken from the cylinder head surface to the top of the valves.

(5) Specification is for both intake and exhaust valves.

TABLE 7 4L MECHANICAL SPECIFICATIONS - SHORT BLOCK SPECIFICATIONS

Short Block Specifications	Standard	Service Limit
Main Bearing Bore Diameter	55.98 mm/2.2039 in	56.0 mm/2.2047 in
Cylinder Block Height 4LB1 4LC1/4LD1	 280394 mm/11.060 in 307.94 mm/12.123 in	 281.06 mm/11.065 in 308.06 mm/12.128 in
Main Bearing Journal Diameter 4LB1/4LC1 4LD1	 56.0 mm/2.2047 in 60.0 mm/2.3622 in	 55.86 mm/2.1992 in 59.86 mm/2.3567 in
Crank Pin Diameter 4LB1 4LC1 4LE1	 43.0 mm/1.6929 in 46.0 mm/1.8110 in 49.0 mm/1.9291 in	 42.87 mm/1.6878 in 45.87 mm/1.8059 in 48.87 mm/1.9240 in
Piston Protrusion	.400 mm/ .0158 in	----------
Piston to Cylinder Clearance	0.015-.035 mm/0.0006-.0014 in	
Main Bearing Clearance	0.029-0.072 mm/ 0.0011-0.0028 in	.0127 mm/0.005 in
Connecting Rod Bearing Clearance	0.035-0.073 mm/ 0.0014-0.0029 in	0.10 mm/0.0039 in
Crank Gear/Idler Gear Backlash	0.04 mm/0.0017 in	0.2 mm/0.0079 in
Cam Gear/Idler Backlash	0.03 mm/0.0012 in	0.2 mm/0.0079 in
Crankshaft End Play	0.058-.208 mm (0.0023-0.0082 in)	0.30 mm/0.0118 in

TORQUE SPECIFICATIONS

72 Torque specifications are as follows:

TABLE 8 4L TORQUE SPECIFICATIONS - CYLINDER HEAD/VALVE TRAIN

Cylinder Head/Valve Train	kg m	lb/ft
Cylinder Head Torque (see Notes 1 and 2) M12 x 1.5	8.5-9.5 + 60°~90° (see Note 3)	61-69 + 60°~90° (see Note 3)
M8 x 1.25	2.5-3.5	18-25
Valve lash adjusting jamb nut	0.8-1.2	5.8-8.7
Valve cover bolts	0.2-0.4	1.4-2.9
Exhaust Manifold	1.9-2.9	13.7-21.0
Rocker Arm Bracket Assembly	0.8-1.2	5.8-8.7
Exhaust Manifold	1.9-2.9	13.7-21.0
Nozzle Holder Assembly	4.0-5.0	29.0-36.2
Glow Plug	1.5-2.0	10.8-14.5

NOTES

(1) Torque using the following sequence.

(2) Bolts must not be reused. New bolts only.

(3) Clarification: On the second step, turn 60° to 90°.

TABLE 9 4L TORQUE SPECIFICATIONS - SHORT BLOCK SPECIFICATIONS

Short Block Specifications	kg m	lb/ft
Crankshaft Bearing Cap	8.5-9.5	61.0-69.0
Rod Bearing Cap 4LB1 4LC1 4LE1	 3.8-4.2 2.3-2.7 + 100°-115° 7.5-8.5	 27-30 17-20 + 100°-115° 54-61
Camshaft Gear Nut	7.0-9.0	50.6-65.0
Idler Gear	2.7-3.5	19.5-25.3
Oil Pump w/o PTO w PTO	1.9-2.9 0.8-1.2 (see Note)	13.7-21.0 5.8-8.7 (see Note)
Front Plate	1.9-2.9	13.7-21.0
Timing Gear Case	2.1-3.1	15.2-22.4
Starter	9.5-11.5	68.7-83.2
Flywheel Housing	4.2-5.6	30.4-40.5
Flywheel	9.0-11.0	65.0-79.5
Crank Pulley	17.0-19.0	123.0-137.4
Oil Strainer Bolt	1.9-2.9	13.7-21.0

NOTE: When PTO is provided, install the oil pump to the front plate.

LUBRICATION AND SEALANT SPECIFICATIONS

73 Lubrication and sealant specifications are as follows:

TABLE 10 4L LUBRICATION AND SEALANT SPECIFICATIONS

Application	Thread Lockers	Lubricants	Sealant
Flywheel Bolts	----------	Engine Oil	----------
Oil Pan	----------	----------	TB1207C
Rocker Bracket (see Note)	----------	----------	TB1207C
Air Inlet Pipe	----------	----------	TB1207C
Front Plate (PTO only)	----------	----------	TB1207C
Timing Case w/wo PTO	----------	----------	TB1207C
Water Pump	----------	----------	TB1207C
Core Plugs	----------	----------	TB1207C
Injection Pump Housing Cover	----------	----------	TB1207C
Fuel Cut Solenoid	----------	----------	TB1207C
Oil Seal Retainer	----------	----------	TB1207C
Connecting Rod Bolts	----------	Engine Oil	----------
Cylinder Head Bolts	----------	Engine Oil	----------
Main Cap Bolts	----------	Engine Oil	----------
Head Gasket	----------	----------	----------
Exhaust Gasket	----------	----------	----------
Oil Pump O-ring	----------	Engine Oil	----------
Oil Strainer O-ring	----------	Engine Oil	----------
Drain Plug O-ring	----------	Engine Oil	----------
Head Cover Gasket	----------	----------	----------
Oil Pump Back Cover	----------	----------	----------
Camshaft	----------	Extreme Pressure Lubricant	----------
Lifters	----------	Extreme Pressure Lubricant	----------
Engine Bearings	----------	Engine Oil	----------
Piston Pin	----------	Engine Oil	----------
Pistons	----------	Engine Oil	----------
Piston Rings	----------	Engine Oil	----------
Valve Guides	----------	Engine Oil	----------
Valves	----------	Engine Oil	----------

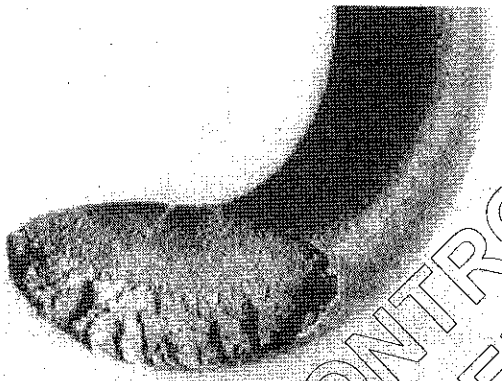
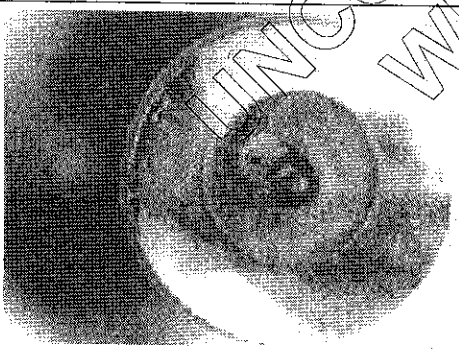
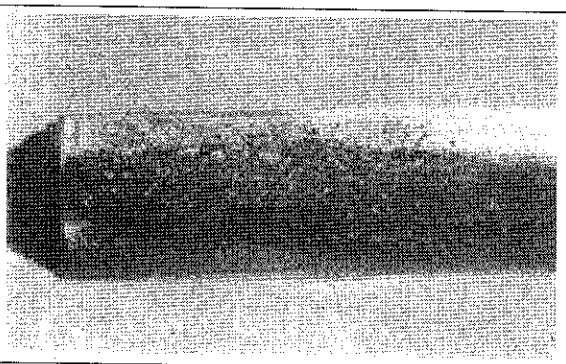
NOTE

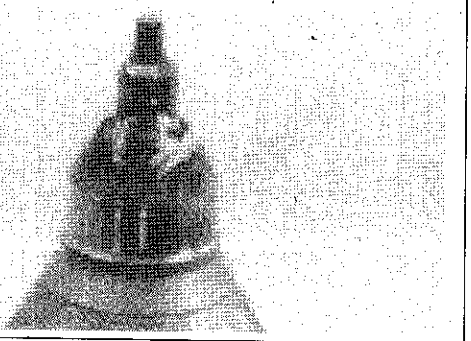
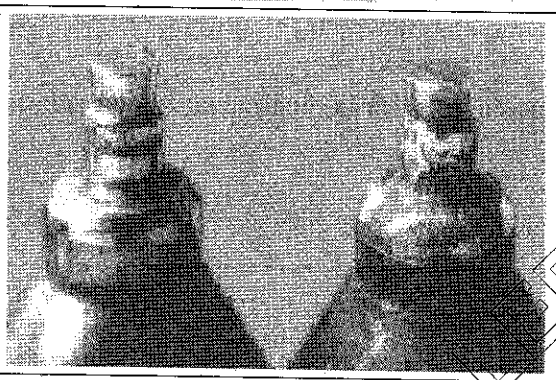
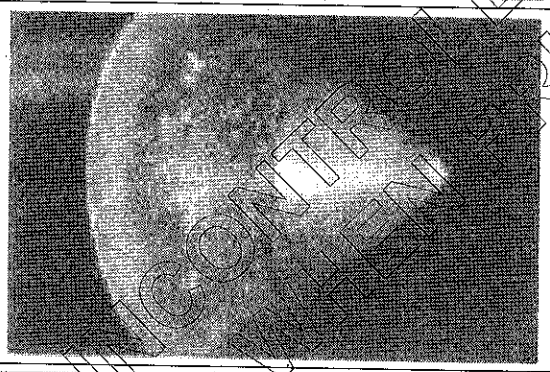
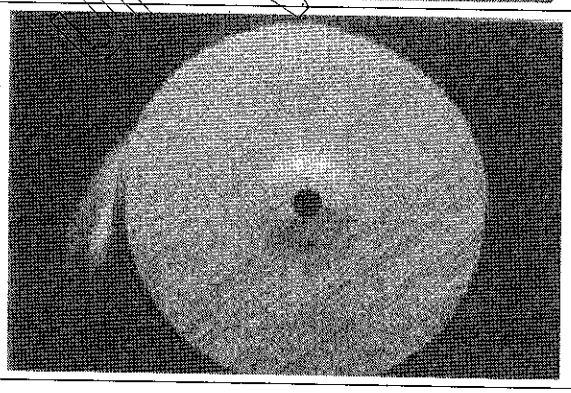
During Installation of the rocker arm bracket, be sure not to cover the rocker shaft oil galley.

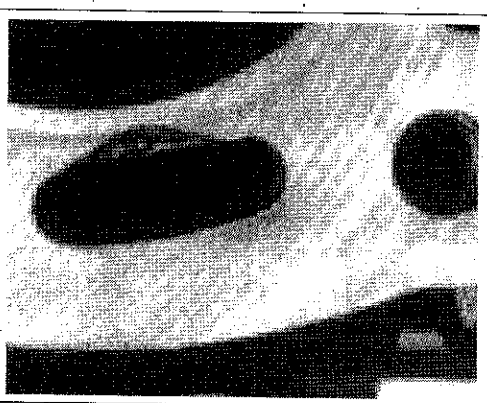
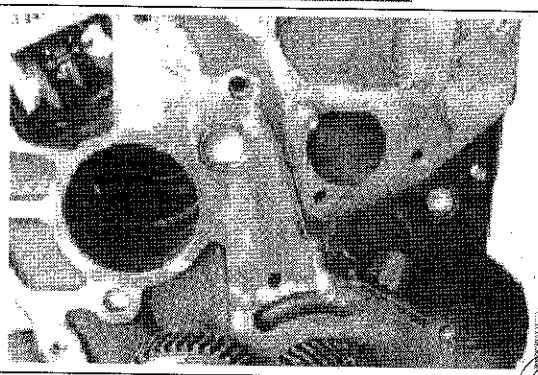
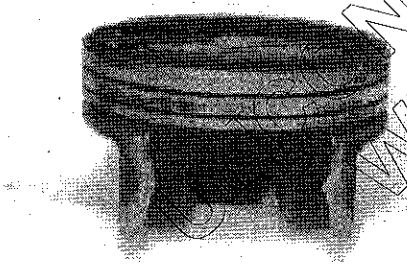
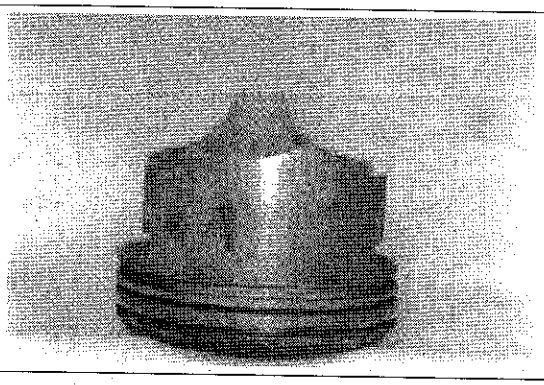
SECTION 5 - COMPONENT FAILURE ANALYSIS

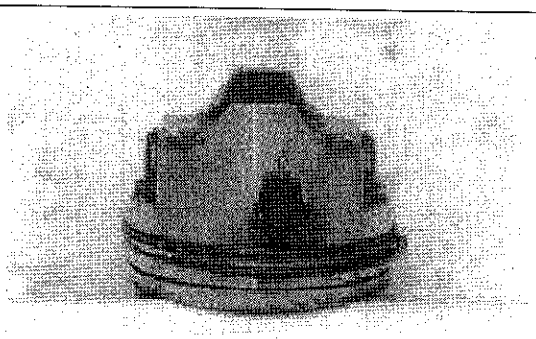
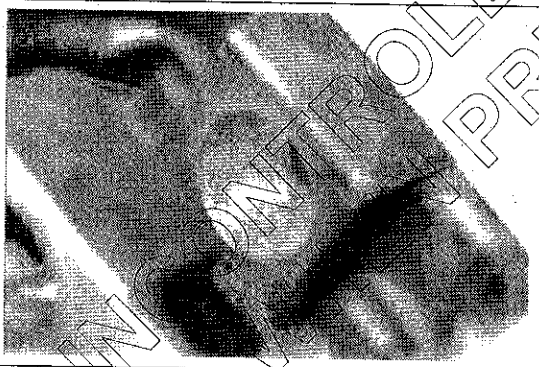
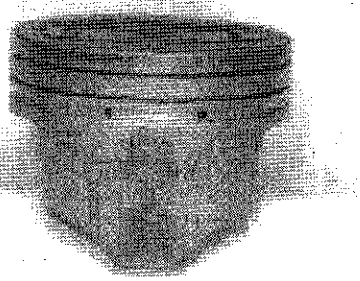
74 Table 11 illustrates examples of component failure.

TABLE 11 COMPONENT FAILURE ANALYSIS

Example	Description
FUEL SYSTEM – Nozzle holder component failure	
	Broken coil on the holder spring directly related to large amounts of carbon build-up on the nozzle spring. Carbon build-up can also be seen on the push rod. This condition is directly related to combustion gases passing through the nozzle holder spring chamber. Problems can be avoided by routine inspection of the nozzles.
	Broken coil due to oxidation caused by moisture or high sulphur content in the fuel. Condition can be prevented through routine inspection of the fuel and filter.
	Sulphuric acid corrosion at the pintal caused by high sulphur content in the fuel. This is a result of water reacting with the sulphur to form sulphuric acid.
	Corrosive abrasion of the pintal nozzle edge caused by direct contact with blow-by of the combustion gases in the combustion chamber.

	Nozzle seat damage caused by metal contaminants in the fuel that pressed onto the seat area. The condition can cause leaks or distorted spray patterns from improper nozzle seating.
	Pintal valve abrasion caused by sulfuric acid. This condition will cause the nozzle to stop functioning.
	Foreign material build-up on the nozzle seat surface. This condition will cause an injector leak.
	Damage to the nozzle seat and spray hole sections when the nozzle holder is over tightened.

CYLINDER BLOCK	
	Damaged head gasket, cylinder head, pistons, connecting rods and crankshaft caused by poor cylinder block casting, cooling system cavitation, or cooling system electrolysis.
	Low oil pressure readings or premature engine bearing wear due to missing internal oil galley plugs.
PISTON	
	Piston failure due to reusing a previously cracked piston skirt.
	Broken piston skirt tang due to excessive piston to wall clearance. (Creates piston slap sound).

	Seized piston skirt due to insufficient piston to wall clearance. (aka piston galling).
	Failed piston due to lack of oil in the engine at the time of the failure. (Heat failure can be identified by '4 point' scoring resulting in vertical scoring on the sides of the pin boss on both sides of the piston.)
PISTON FAILURE	
	A wrist pin seized in this bore due to a previously used bent wrist pin or damaged piston pin bore.
	(Normal piston skirt wear)

APPENDIX 1

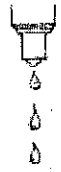
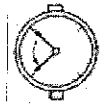
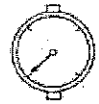
MISCELLANEOUS SERVICE INFORMATION

Para

NOZZLE TROUBLESHOOTING GUIDE

Condition / Cause	Nozzle opening pressure too low	Nozzle opening pressure too high	Unsatisfactory chatter	Oil leak from nozzle seat	Improper spray pattern	Excessive pressure drop	External oil leak
Improper adjustment of nozzle opening pressure	●	●					
Clogged pintle nozzle hole and spray hole (carbon residue, foreign matter)		●	●		●		
Needle valve sticking		●	●	●	●	●	
Abrasion, damage or accumulation of foreign matter at seat section	●		●	●	●	●	
Damage to pintle section of needle valve (pintle type nozzle)			●		●		
Broken needle valve holding shaft	●		●		●		
Corrosion of sliding section			●			●	
Damage to nozzle spring	●		●				
Damage to push rod	●		●				
Scars or wear to nozzle's high pressure surface					●	●	●
Scars or wear to spacer's high pressure surface					●	●	●
Scars or wear to holder's high pressure surface					●	●	●
Foreign matter accumulation in each mating surface of nozzle, spacer and holder					●	●	●
Insufficient tightening of inlet connector					●	●	●
Defective gasket of each seal section					●	●	●
Damage or excessive wear to nozzle hole area				●			
Defective retaining nut (deformation caused by corrosion or insufficient cleaning)			●	●			●

PERFORMANCE EXAMPLES OF USED NOZZLES

Judgement Rank	A	B	C	D	E
Spray pattern example					
Pressure gauge pointer movement					
	Continuously moves in the neighbourhood of nozzle opening pressure	The same as "A"	Stabilizes and does not move in the neighborhood of nozzle opening pressure.	Rises to nozzle opening pressure, but the pressure markedly drops.	Pressure does not rise even when the tester handle is operated.
Spray pattern	Almost uniform	Extremely non-uniform	Atomizes, but no pulsation of needle.	Incorrect atomization with extreme after-drip.	Dripping.
Possible cause of malfunction	(Normal)	(1) The common cause is carbon residue sticking to the nozzle edge. (2) Occasionally the needle edge is damaged or broken.	(1) A large quantity of carbon residue is sticking to the nozzle edge. (2) Occasionally caused by foreign materials caught in the spray hole.	(1) Damage to the seat section. (2) Fine foreign matter caught in the seat section. (3) The seat section has worn excessively.	(1) Needle stick. (2) The seat section has been damaged or worn excessively. (3) Foreign matter caught in the seat section. (4) Damage to nozzle holder internal parts.
Judgement after nozzle cleaning (removal of carbon residue and foreign matter, etc.)	Useable as is.	Replace with a new nozzle if the "A" performance is not restored after cleaning.	The same as "B"	The same as "B"	The same as "B" NOTE Replace with a new nozzle holder or parts (in the case of Item 4 above).

NOZZLE HOLDER TIGHTENING STANDARDS

Unit: kg-m

Parts / Type	Retaining Nut	Nozzle holder plug	Adjusting screw lock nut	Cap nut	Leak off pipe joint bolt	Eye lock nut	Inlet connector
KB-S	M20x1.5 ZMC2 6-8 " Br 8-10 3/4-16UNF ZMC2 6-8 " ZMC2 8-10 M22x15 ZMC2 6-8 " Br 8-10 M24x1.5 Br 9-11	M22x1.5 Br 5-6	M8x0.75 Br 2.5	M22x1.5 ZMC2 4-5 " Br 5-6	M8x1 ZMC2 1-1.5 " Br 1-1.5 M8x1.25 ZMC2 1-1.5 " Br 1-1.5 M10x1 ZMC2 1.5-2 " Br 1.5-2		M12x1.5 ZMC2 5-6 " Br 6-7 M14x1.5 ZMC2 6-7 " Br 7-8 M16x1.5 Br 8-10 M18x1.5 Br 10-12
KBA . . S	M22x1.5 Br 10-12				M8x1 Br 1-1.5		M14x1.5 Br 7-8
KBL . . S	M20x1.5 ZMC2 6-8 " Br 8-10 3/4-16UNF ZMC2 6-8 " Br 8-10 M22x15 ZMC2 6-8 " Br 8-10 M24x1.5 Br 9-11			M14x1 ZMC2 3-4 " Br 4-5 M20x1 ZMC2 4-5 " Br 5-6 M22x1 ZMC2 4-5 M22x1.5 ZMC2 4-5 " Br 5-6	M8x1 Br 1-1.5 M8x1.25 ZMC2 1-1.5 " Br 1-1.5 M10x1 ZMC2 1.5-2 " Br 1.5-2		M12x1.5 ZMC2 5-6 " Br 6-7 M14x1.5 ZMC2 6-7 " Br 7-8 M16x1.5 Br 8-10 M18x1.5 Br 10-12
KB . . . T	M24 x1.5 Br 18-20	M22x1.5 Br 5-6	M8x0.75 Br 2.5-3.5	M22x1.5 Br 4-5	M10x1 Br 1.5-2.0		029301-0090 M18x1.5 Br 10-12 029300-4030 M18x1.5 Br 1.5-17 150604-1420 M18x1.5 Br 150604-3820 M20 x1.5 1.5-17
KB . . . U	M36x3 Br 24-27	M36x3 Br 12-14	M12x1.5 Br 2.5-3.5	M36x3 Br 10-12	M14x15 Br 5-6		M22x1.5 B4 20-23

NOTE

ZMC2 Galvanizing and chrome treatment
Br Black oxide coating

(continued)

NOZZLE HOLDER TIGHTENING STANDARDS (continued)

Unit: kg-m

Parts / Type	Retaining Nut	Nozzle holder plug	Adjusting screw lock nut	Cap nut	Leak off pipe joint bolt	Eye lock nut	Inlet connector
KBF . . T	M24x1.5 Br 18-20	M22x1.5 Br 5-6	M8x0.75 Br 2.5-3.5	M22x1.5 Br 4-5	M10x1 Br 1.5-2.0		029301-0090 M18x1.5 Br 10-12 029300-4030 M18x1.5 Br 1.5-17 150604-1420 M18x1.5 Br 150604-3820 M20 x1.5 1.5-17
KBF . . U	M36x3 Br 24-27	M36x3 Br 12-14	M12x1.5 Br 2.5-3.5	M36x3 Br 10-12	M14x15 Br 5-6		M22x1.5 Br 20-23
KCA . . S	M22x1.5 ZMC2 8-10 " Br 10-12					M12x1.5 ZMC2 4- 5 " Br 4-5 M14z1.5 ZMC2 5-6 " Br 5-6	
KCA SD	M22x1.5 ZMC2 8-10 " Br 10-12					M12x1.5 ZMC2 4- 5 " Br 4-5 M14z1.5 ZMC2 5-6 " Br 5-6	
KD . . . S	M20x1.5 ZMC2 6-8 " Br 8-10 3/4-16UNF ZMC2 6-8 " Br 8-10 M22x1.5 ZMC2 6-8 " Br 8-10 M24x1.5 Br 9-11		M22x1 ZMC2 5-6 M22x1 Br 6-7	M22x1 ZMC2 5-6 " Br 5-6	M8x1 ZMC2 1-1.5 M8x1.25 ZMC2 1-1.5 " Br 1-1.5 M10x1 ZMC2 1.5-2 " Br 1.5-2		M12x1.5 ZMC2 5-6 " Br 6-7 M14x1.5 ZMC2 6-7 " Br 7-8 M16x1.5 Br 8-10 M18x1.5 Br 10-12
KD L . S	M20x1.5 ZMC2 6-8 " Br 8-10 3/4-16UNF ZMC2 6-8 " Br 8-10 M22x1.5 ZMC2 6-8 " Br 8-10 M24x1.5 Br 9-11		M22x1 ZMC2 5-6 M22x1 Br 6-7	M22x1 ZMC2 5-6 " Br 5-6	M8x1 ZMC2 1-1.5 M8x1.25 ZMC2 1-1.5 " Br 1-1.5 M10x1 ZMC2 1.5-2 " Br 1.5-2		M12x1.5 ZMC2 5-6 " Br 6-7 M14x1.5 ZMC2 6-7 " Br 7-8 M16x1.5 Br 8-10 M18x1.5 Br 10-12

NOTE

ZMC2 Galvanizing and chrome treatment
Br Black oxide coating

TURBOCHARGER BOOST PRESSURE DIAGNOSIS

1 Listed below are suggested checks for determining the cause of lowered turbo boost pressure (in the sequence they should be performed). To obtain maximum boost pressure, the engine must be operated at rated RPM under a full load condition. Boost pressure is measured with a mercury manometer. A pressure gauge may be substituted.

2 One of the following checks will uncover the reason for low boost pressure. (Normal pressure is 11-16 psi.)

(1) Check the throttle linkage for travel to full fuel position.

(2) Measure the maximum no load engine RPM. Adjust if necessary.

(3) Inspect the manifolds and turbo for cracks, loosened mounting bolts or leaking gaskets.

(4) Check the intake and exhaust systems for restriction, ie dirty air cleaner, collapsed hose or crushed exhaust pipe.

(5) Check the fuel system, ie air in the fuel, dirty fuel inlet screen (rock stopper), dirty fuel filter, contaminated fuel or reduce fuel delivery to the injection pump.

(6) Check the valve clearance adjustment.

(7) Check the injection nozzles, ie popping pressure, spray pattern or leakage.

(8) While the injection nozzles are removed, check the compression pressure.

(9) With the turbo mounted to the manifold inspect the following:

It is necessary to remove the intake and exhaust piping from the turbo.

a. The wastegate (if used) does not close completely.

b. Check the compressor wheel for damage.

c. Check the turbine side for heavy carbon deposits or damage.

d. Measure the wheel shaft end play and bearing clearance.

(10) Have the injection pump tested by an authorized Zexel dealer for proper calibration.

EXHAUST TEMPERATURE TEST

3 Exhaust temperature is measured with a pyrometer, thermo coupler, or infrared meter.

4 The temperature probe is installed in a straight section of the exhaust pipe approximately 6 inches from the turbo flange or manifold flange for naturally aspirated engines.

5 The reading is taken with the engine operating at rated output.

6 When the exhaust temperature is high, check the following:

(1) Retarded timing.

(2) Air intake system restriction.

(3) Excessive exhaust system back pressure.

7 When exhaust temperature is low, check the following:

(1) Low compression.

(2) Inadequate fuel delivery from injection pump.

CRANKCASE PRESSURE TEST

8 Crankcase pressure is measured with a water manometer.

NOTE

2 in. of water (or less) is normal. Pressure should never measure more than 2 in.

9 The manometer pickup tube is inserted into the oil level gauge tube, from which the level gauge has been removed. Do not insert the tube into the oil. Do not attempt to seal engine openings.

10 The reading is taken with the engine operating at rated output.

INLET MANIFOLD PRESSURE (BOOST PRESSURE) TEST

11 Boost pressure is to be measured with a mercury manometer. A pressure gauge may be used when a manometer is not available. 1 inch of mercury =.49 PSI

12 The measuring device is to be installed in or straight run of the inlet air pipe. The most desirable location is 6 inches from the inlet manifold flange.

13 The reading is taken with the engine operating at its peak rated output.

SPECIFICATIONS FOR THESE TESTS

14 The results of all three of these tests will vary between engine models and between specifications of the same model. To find specifications for your particular engine, reference American Isuzu Motors Inc. Engine & Components Operations Publication #SV-5013-00 ('Engine Service Specifications Manual').

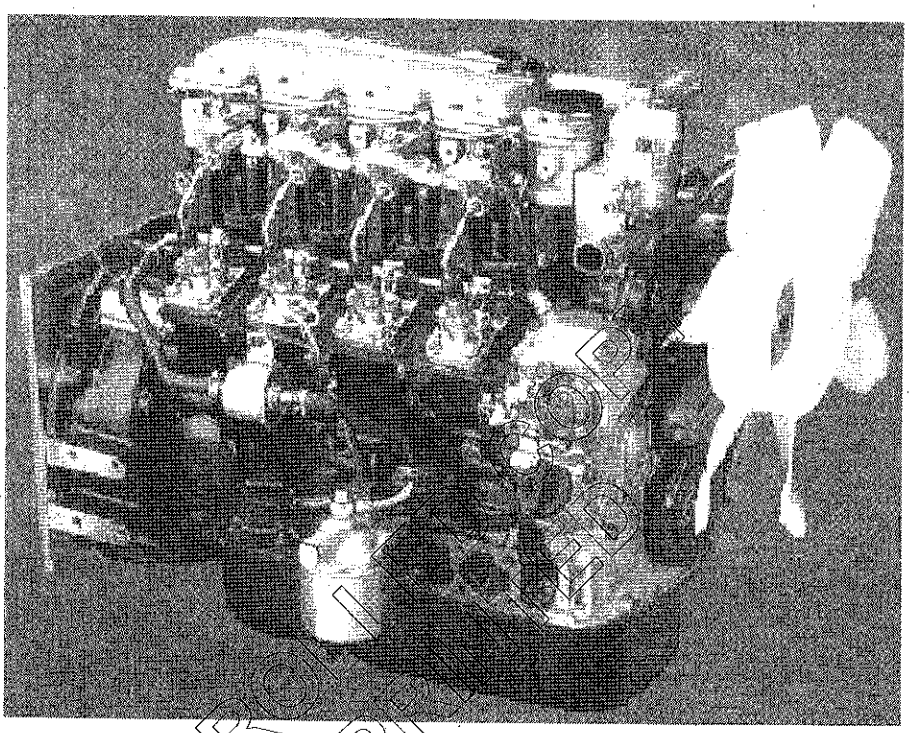
USED OIL SAMPLE DATA (LIMITS)

Item	Unit of Measurement	Limit
Kinematic Viscosity	(@98.9°C (CST)/210°F	-20 to 50% of new oil
Total Base No.	KOH mG/G	1 (min.)
Total Acid No.	KOH mG/G	3 (max.)
B-Heptane Insoluble	Wt%	3 (max.)
Resin Insoluble	Wt%	Reference [1 (max.)]
Ash Sulphate	Wt%	Reference [0.5 (max.)]
Diesel Fuel Content	Wt%	5 (max.)
Water Content	Wt%	.5 (max.)
Worn Metal particle: Fe	PPM	150
Worn Metal particle: Cu	PPM	50
Worn Metal particle: PB	PPM	50
Worn Metal particle: Cr	PPM	20 (or 80..Cr-plated liner)
Worn Metal particle: Al	PPM	20-40
Worn Metal particle: Si	PPM	20

Based on testing a new oil sample of exact same kind as used oil.

APPENDIX 2

ISUZU TECHNOLOGY: L-SERIES DIRECT INJECTION



1 Re-engineering equipment for a new engine model is typically an expensive proposition and stepping up to EPA's Tier 2 regulations in 2004 for off-highway engines in the 25 to 100 hp range will mean just that, but not if the envelope of the replacement engine is identical with the present engine. Current and prospective users of Isuzu's L-Series engines will be pleased to learn that the new direct-injection (DI) versions have the same physical footprint as the current IDI models.

2 The industrial engines are developed from the technology of well-proven automotive engines. It is certainly the automotive sector that represents the leading edge in gaseous emissions, but that is also true of customer expectations with respect to noise, vibration and ease of use. Isuzu produces more than 800,000 diesel engines per year and plans to produce 1.8 million by 2005.

3 The L-Series diesels will still be in the picture at that time and that was always the plan from the time they were introduced by American Isuzu to the U.S. market back in 1993, replacing the well-known K-Series. The three cylinder L-Series engines were joined by four cylinder versions in 1995. These engines were conceived to be among the quietest, most compact, lightweight, water-cooled engines in their class and the plan was that this basic platform would meet CARB, EPA and other applicable emission standards well into the future.

4 If one looks at the global automotive picture, it is estimated that fully 90 percent of the vehicular diesel engines will be direct injected after 2000 and the percentage would be even higher were it not for Third World production. The main motivations are the reduction of CO, and particulate matter emissions and the improvement of fuel economy.

5 So this is the battleground and direct injection appears to be the weapon of choice. And from this massive automotive capital base flows the technology base that will then be applied to other engine applications. Virtually all automotive diesel engines above 3.5 L displacement already use DI technology and many smaller automotive engines are also DI.

6 Many of Isuzu's engines were developed for automotive as well as industrial use. Included would be the J-Series and the B-Series in the under 100 hp range. The L-Series, however, was developed strictly for industrial use, yet it too makes use of the tools of automotive engine design.

7 With the new DI three cylinder model 3LD2 displacing 1499 cc and the four cylinder 4LE2 displacing 2179 cc, the L-Series is the smallest series that Isuzu manufactures today. The 3LD2 has a bore and stroke of 83.1 x 92 mm and a maximum output of 34.8 hp at 3000 rpm, with peak torque of 73.5 lb.ft. at 1800 rpm. The 4LE2 has a bore and stroke of 85 x 96 mm and a maximum output of 54.4 hp at 3000 rpm, with peak torque of 113.4 lb.ft. at 1800 rpm. All ratings are SAE J1995 gross hp. Dry weight of the 3LD2 and 4LE2 is given at 290 and 396 lb. respectively.

8 Despite the very small differences in bore and stroke, the engines are virtually identical in other respects. Isuzu insists new DI L-Series still offers OEMs a single engine family with high component commonality in both three and four cylinder configurations.

9 The compact and lightweight L-Series feature one-piece, cast iron blocks and heads, and overhead valve design with two valves per cylinder. The block is deep skirted for strength, rigidity and durability. Unit injection pump housings are cast into the blocks. The engine water jacket is formed with a one-piece casting core to eliminate irregular cooling passages.

10 The ductile iron crankshaft is underslung to the block with five main bearings for the 4LE2 and four main bearings for the 3LD2. The flame-hardened, chilled casting camshaft is mid-mounted in the block and it is gear driven. The camshaft is a one-piece design.

11 Low noise and vibration were very active design themes for the L-Series. A single camshaft actuates unit pump injectors as well as intake and exhaust valves. Valves are actuated through forged steel push rods and aluminum die cast rocker arms. Gears are helical and the number of gears in the gear train is only three and this permits a smaller gear cover with a lower profile and reduced forward noise emissions.

12 Finite element analysis (FEA), modal analysis and acoustic intensity techniques were used to evaluate every engine component and determine the contribution to the overall noise level. FEM was used to develop spherical cylinder block sidewalls and to optimize bulkhead ribs. Integral camshaft journal bearings featured on the L-Series had a tendency to lower rigidity of the engine block but this was overcome by numerous FEMJ iterations.

13 Other L-Series noise reduction features include the use of auto thermatic type pistons, an oil pan constructed of vibration damped steel sheet on the 3LD2, crankshaft balancers and an optimized fuel injection system. There is no difference in noise level comparing the DI and IDI at no load and only a 2 dB(A) difference at full load. Fuel injection lines from the unit pumps to the injectors are short and all the same length. Additionally, the fan or blower speed can also be lowered for an extra measure of noise reduction. Isuzu feels it has accomplished something with respect to sound quality as well as sound level.

14 Both the 3LD2 and the 4LE2 direct injected diesels are naturally aspirated and feature Isuzu's new 'Cobra' combustion chamber, which uses an interesting high swirl conservation strategy. The aim is twofold. First, reduce the peak temperature in the premixed combustion stage to lower combustion noise and NOx emissions. A two-spring injector is vital to achieving this part of the rate shaping. Second, promote vigorous, fast mixing in the diffusion combustion stage - after top dead center - to lower smoke and particulate matter emission and to improve fuel consumption.

15 The unit injection pump is driven by the camshaft lobes that have a concave-shaped cam profile and this determines rate shaping throughout the combustion cycle. A lower initial injection rate in the premix stage and a higher rate in the diffusion stage provides a more complete and efficient burn.

16 So most of the fuel is actually injected during the combustion diffusion stage via a high-pressure nozzle with small holes to minimize fuel particle size and new combustion chamber design optimized through the use of computational fluid dynamics (CFD) analysis. The entire combustion cycle is reduced in length, but it is characterized by relatively higher swirl in the later stages.

17 Tier 2 compliance is the real driving force here, but fuel consumption should be lower 10 to 15 percent. The overall efficiency of the DI L-Series engines is demonstrated by a heat rejection rate that is 20 to 25 percent lower than the comparable IDI engines. Users may be less interested in fuel consumption lately, but the overall improvement in efficiency cannot be overlooked.

18 The engine lube oil filler and level gauge, oil filter cartridge, unit injection pumps, and injection nozzles are all located on the right side of the engines. The L-Series reputation for leak-free operation should be continued, always a strong point for Isuzu. The fuel system is also self-bleeding and self-priming, meaning that should the operator run out of fuel, he can just add fuel and restart the engine.

19 Summing up features of the new DI L-Series, high engine performance and efficiency, compliant with Tier 2 regulations; low noise and pleasant sound quality, low fuel consumption, low heat rejection, compact envelope size, one side service access, high reliability. And don't forget, the same footprint as the IDI versions.