ISUZU

WORKSHOP MANUAL

DIESEL ENGINE
4BD1, 4BD1-T MODELS
(FOR AUTOMOTIVE USE)
1986 ~

Part No: IDE2140

ISUZU

WORKSHOP MANUAL
DIESEL ENGINE

4BD1 4BD1-T

FOREWORD

This manual includes special notes, important points, service data, precautions, etc. that are needed for the maintenance, adjustments, service, removal and installation of components of the models titled.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication.

The right is reserved to make changes at any time without notice.

Arrangement of the material is shown by the table of contents on the right-hand side of this page. Black spot on the first page of each section can be seen on the edge of the book below section title. A more detailed table of contents precedes each section.

This manual applies to the 1986 year and later models.

SECTION INDEX

SECTION 1

GENERAL INFORMATION

CONTENTS

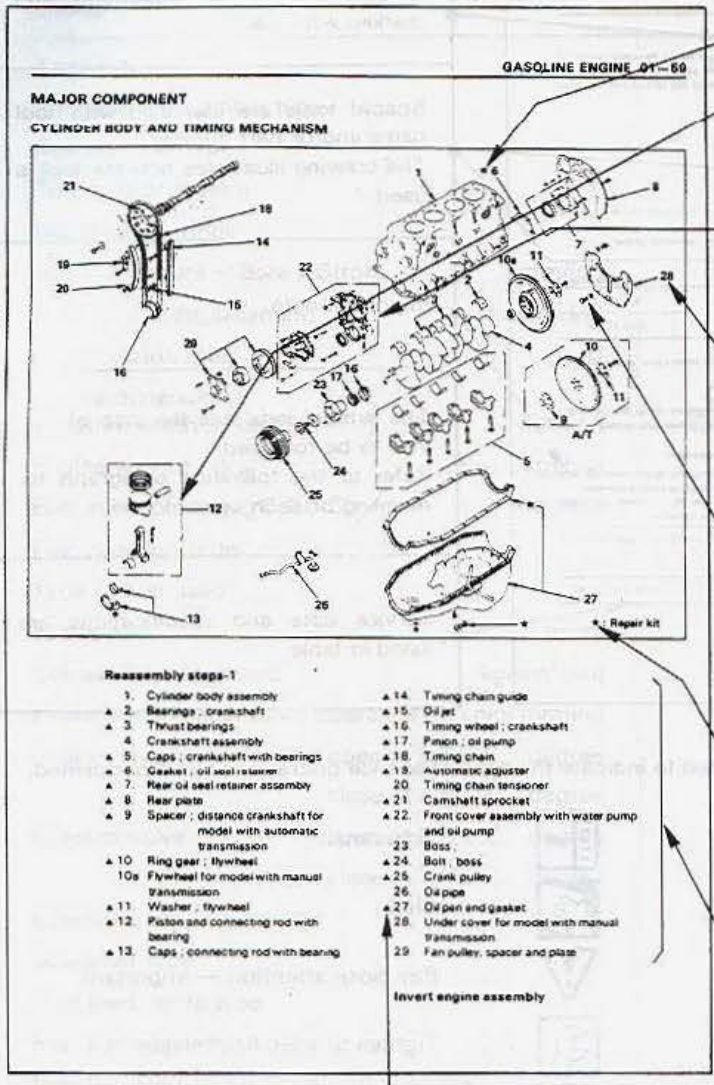
GENERAL REPAIR INSTRUCTIONS

1. Before performing service operations, disconnect ground cable from the battery to reduce the chance of cable damage and burning due to short-circuiting.
2. The use of proper tools and special tools where specified, is important for efficient and reliable service operations.
3. Use genuine Isuzu parts.
4. Used cotter pins, gaskets, O-rings, oil seals, lock washers and self lock nuts should be discarded and new ones used as normal function of the parts can not be maintained if these parts are reused.
5. To facilitate proper and smooth reassembly, keep disassembled parts neatly in groups.
   Keeping bolts and nuts separate is very important as they vary in hardness and design depending on position of installation.
6. Clean the parts before inspection or reassembly. Also clean oil ports, etc. using compressed air to make certain they are free from restrictions.
7. Lubricate rotating and sliding faces of the parts with oil or grease before installation.
8. When necessary, use a sealer on gaskets to prevent leakage.
9. Carefully observe all specifications for bolt and nut torques.
10. When service operation is completed, make a final check to be sure service has been done properly.
11. For assurance of safety, always release air pressure solely from the air tanks before disconnecting pipes, hoses or other parts from any unit under air pressure.

HOW TO USE THIS MANUAL

1. Find the applicable section by referring to the index.
2. This manual includes a "General information" section in which service data, maintenance items and specifications with torques are included.
3. Each section includes, disassembly, inspection and repair and reassembly. When the same service operation applies to more than one unit or equipment, notice is inserted stating, "Refer to manual for other units or equipment".
4. In the removal and installation section, description of self-explanatory items such as removal of individual parts from the unit to be removed, is omitted and important operation such as adjustments, torque specifications, etc. are dealt with mainly.

5. Each service operation section begins with disassembled view of unit or equipment which is useful to find components, service procedure, availability and content of repair kits, etc.



★ parts contained in repair kit.

Parts to be removed or installed as a unit.

All units or parts within frame are to be considered as a "major component".
Each unit or part within frame is to be considered as a "minor component".

The number represents sequence of service operation.

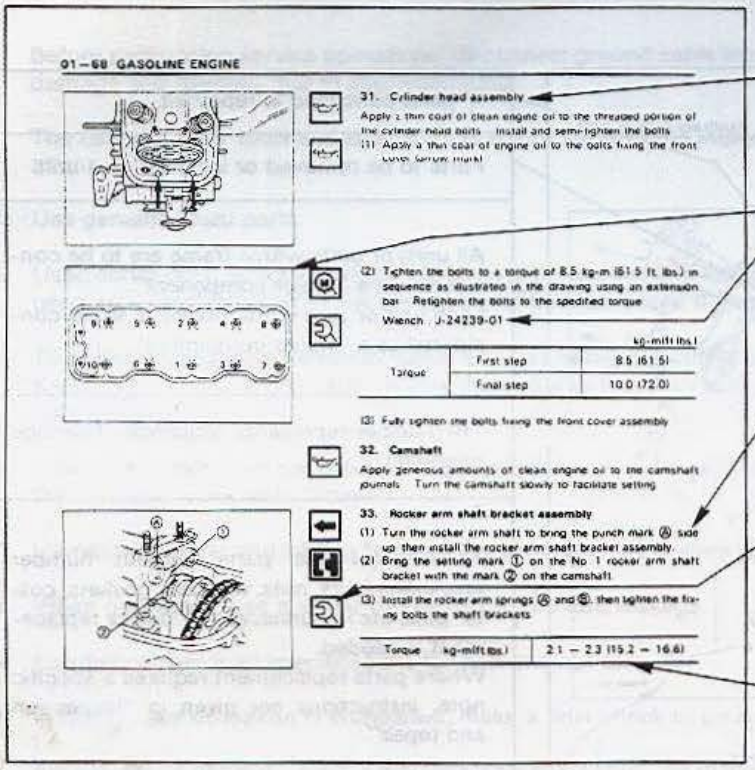
Removal of the parts without number (excluding bolts, nuts, washers, gaskets, cotter pins, etc.) is unnecessary unless replacement is needed.
Where parts replacement requires a specific note, instructions are given in "Inspection and repair".

★ indicates repair kit availability.

Name of parts listed in sequence of service operation.

▲ indicates important operation.
Details of service operation are described in the paragraph "Important operations".

6. The section following illustration(s) deals with important service steps marked with "▲".
This section also includes "notes", "use of special tools", "service data", etc.



Item shown in the illustration and marked with "▲".

Special tools are identified with tool name and/or part number.
The drawing illustrates how the tool is used.

Important note.

The symbol indicates the step of service to be followed.
Refer to the following paragraph for meaning of each symbol.

Service data and specifications are listed in table.

7. In this manual, the following symbols are used to indicate the type of service operations to be performed.

....	Remove	....	Adjustment
....	Install	....	Clean
....	Disassemble	....	Pay close attention — important
....	Reassemble	....	Tighten to specified torque
....	Align the marks	....	Use essential tool(s)
....	Correct direction	....	Use available tool(s)
....	Inspect	....	Lubricate with oil
....	Take measurement	....	Lubricate with grease

8. The service standard is indicated in terms of "Standard" and "Limit".
The "standard" means the assembly standard and standard range within which the parts are considered serviceable.
"Limit" indicates the limit value (Correction or replacement is necessary when measurement is beyond this limit.)

9. In this manual, the components and parts are printed in singular form.

MAIN DATA AND SPECIFICATIONS

Items \ Engine model		4BD1	4BD1-T
Engine type		Water-cooled, 4-cycle in line overhead valve	
Combustion chamber type		Direct injection type	
Cylinder liner type		Dry type (chomard liner)	
Timing gear system		Gear drive	
No. of piston rings		Compression ring 2, Oil ring 1	
No. of cylinders — Bore x Stroke	mm(in.)	4 - 102 x 118	
Total piston displacement	cc(cu.in.)	3856 (235.2)	
Compression ratio	(to 1)	17	
Engine dimensions (length x width x height)	mm(in.)	795 x 701 x 720 (31.3 x 27.6 x 28.3)	806 x 672 x 785 (31.7 x 26.5 x 30.9)
Engine weight : dry	kg(lbs.)	322.5 (711)	327 (721)
Fuel injection timing B.T.D.C.	(Degree)	13°	10°
Fuel injection order		1-3-4-2	
Type of fuel used		High-speed diesel fuel (SAE No. 2)	
Idle speed	(rpm)	555—605	575—625
Compression pressure	kg/cm²(psi)	31 (441) at 200 rpm	
Intake and exhaust valve clearance (at cold)	mm(in.)	0.4 (0.016)	
Intake valve	open at B.T.D.C. degree	28	
	close at A.B.D.C. degree	62	
Exhaust valve	open at B.B.D.C. degree	70	
	close at A.T.D.C. degree	28	
Injection pump type		BOSH in-line A type, with automatic timer	
Governor type		RLD-K Mechanical type	
Fuel feed pump type		KE Mechanical type	
Injection nozzle type		Hole type (with 4 orifices)	
Injection starting pressure[qmkg/cm²(psi)		185 (2631)	
Lubrication method		Pressurized circulation	
Oil pump type		Trochoid	
Oil filter type		Cartridge-paper element	
Lubricating oil capacity	liters(imp.gal)	8.0 (1.8)	
Oil cooler type		Pressurized circulation	
Cooling method		Water cooled	
Cooling water capacity	liters (imp.gal)	14 (3.1)	
Water pump type		Impeller type	
Thermostat type		Waxpellet type (with jiggle valve)	
Turbocharger type			RH-B6A
Compression type			Radial outward-flow

	4BD1	4BD1-T
Maximum permissible speed (continuous) (rpm)	—	130,000
Pressure ratio (Maximum)	—	2.8
*Exhaust gas temperature	—	750
Weight kg(lbs.)	—	4.5 (9.9)
Manufacturer's name	—	Ishikawajima-Harima Heavy Indistries Co., Ltd.

* The exhaust gas temperatue meas maximum allowable temperature measured at turbocharger intake.

Note: The turbocharger uses bolts and nuts based on conventional inch system.

TORQUE SPECIFICATION

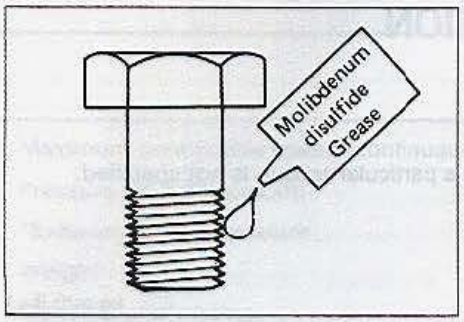
STANDARD BOLTS

The torque values given in the following table should be applied where a particular torque is not specified.

kg·m(ft.lbs.)

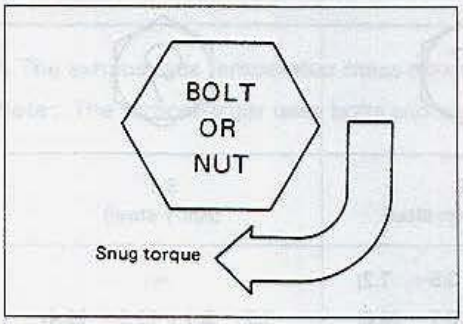
Bolt identification / Bolt diameter x pitch (mm)	4	7	9
	4 T (Low carbon steel)	7 T (High carbon steel)	9 T (Alloy steel)
6 x 1.0	0.4— 0.8 (2.9— 5.8)	0.5— 1.0 (3.6— 7.2)	—
8 x 1.25	0.8— 1.8 (5.8— 13.0)	1.2— 2.3 (8.7— 16.6)	1.7— 3.1 (12.3— 22.4)
10 x 1.25	2.1— 3.5 (15.2— 25.3)	2.8— 4.7 (20.3— 34.0)	3.8— 6.4 (27.5— 46.3)
*10 x 1.5	2.0— 3.4 (14.5— 24.6)	2.8— 4.6 (20.3— 33.3)	3.7— 6.1 (26.8— 44.1)
12 x 1.25	5.0— 7.5 (36.2— 54.2)	6.2— 9.3 (44.8— 67.3)	7.7—11.6 (55.7— 83.9)
*12 x 1.75	4.6— 7.0 (33.3— 50.6)	5.8— 8.6 (42.0— 62.2)	7.3—10.9 (52.8— 78.8)
14 x 1.5	7.8—11.7 (54.6— 84.6)	9.5—14.2 (68.7—102.7)	11.6—17.4 (83.9—125.9)
*14 x 2.0	7.3—10.9 (52.8— 78.8)	9.0—13.4 (65.1— 96.9)	10.9—16.3 (78.8—117.9)
16 x 1.5	10.6—16.0 (76.7—115.7)	13.8—20.8 (99.8—150.4)	16.3—24.5 (117.9—177.2)
*16 x 2.0	10.2—15.2 (73.8—109.9)	13.2—19.8 (95.5—143.2)	15.6—23.4 (112.8—169.3)
18 x 1.5	15.4—23.0 (111.4—166.4)	19.9—29.9 (143.9—216.3)	23.4—35.2 (169.3—254.6)
20 x 1.5	21.0—31.6 (151.9—228.6)	27.5—41.3 (198.9—298.7)	32.3—48.5 (233.6—350.8)
22 x 1.5	25.6—42.2 (185.2—305.2)	37.0—55.5 (267.6—401.4)	43.3—64.9 (313.2—469.4)
24 x 2.0	36.6—55.0 (264.7—397.8)	43.9—72.5 (317.5—524.4)	56.5—84.7 (408.7—612.6)

The asterisk * indicates that the bolts are used for female-threaded parts that are made of soft materials such as casting, etc.

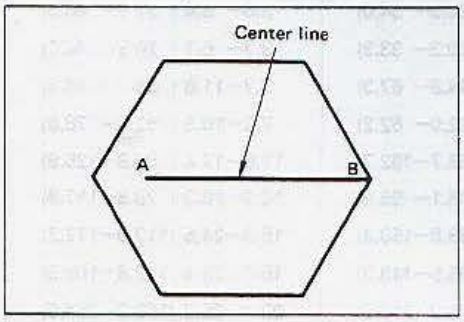


HOW TO TIGHTEN BY ANGULAR TIGHTENING METHOD

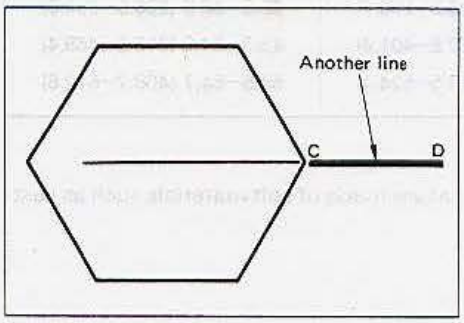
1. Wash bolts and/or nuts clean to remove oil, grease, etc. completely.
2. Apply a coat of molybdenum disulfide grease to threads and setting face of bolts and/or nuts.



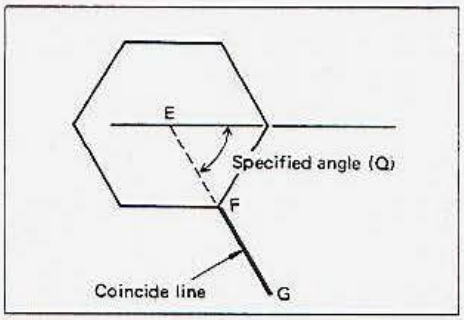
3. With a torque wrench tighten bolts and/or nuts to the specified torque (snug torque).



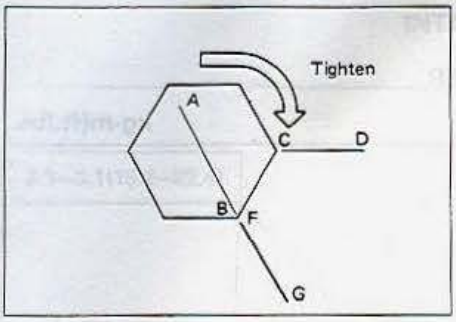
4. Draw a line (A-B) across the center of each bolts.



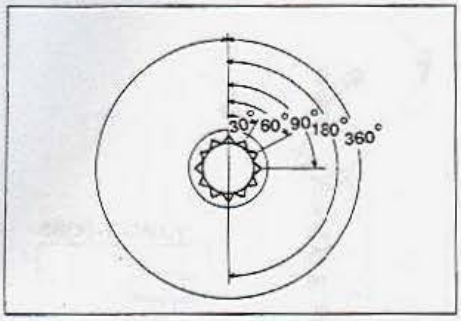
5. On the face of parts to be clamped draw an another line (C-D) extending from the line (A-B).



6. On the face of the parts to be clamped, draw a line (F-G) in direction at the specified angle (Q) to the line (A-B) across the center (E).



7. With a torque wrench, tighten the bolt until the line (A-B) on the bolt head coincides with the line (F-G) drawn on the face of the parts to be clamped.



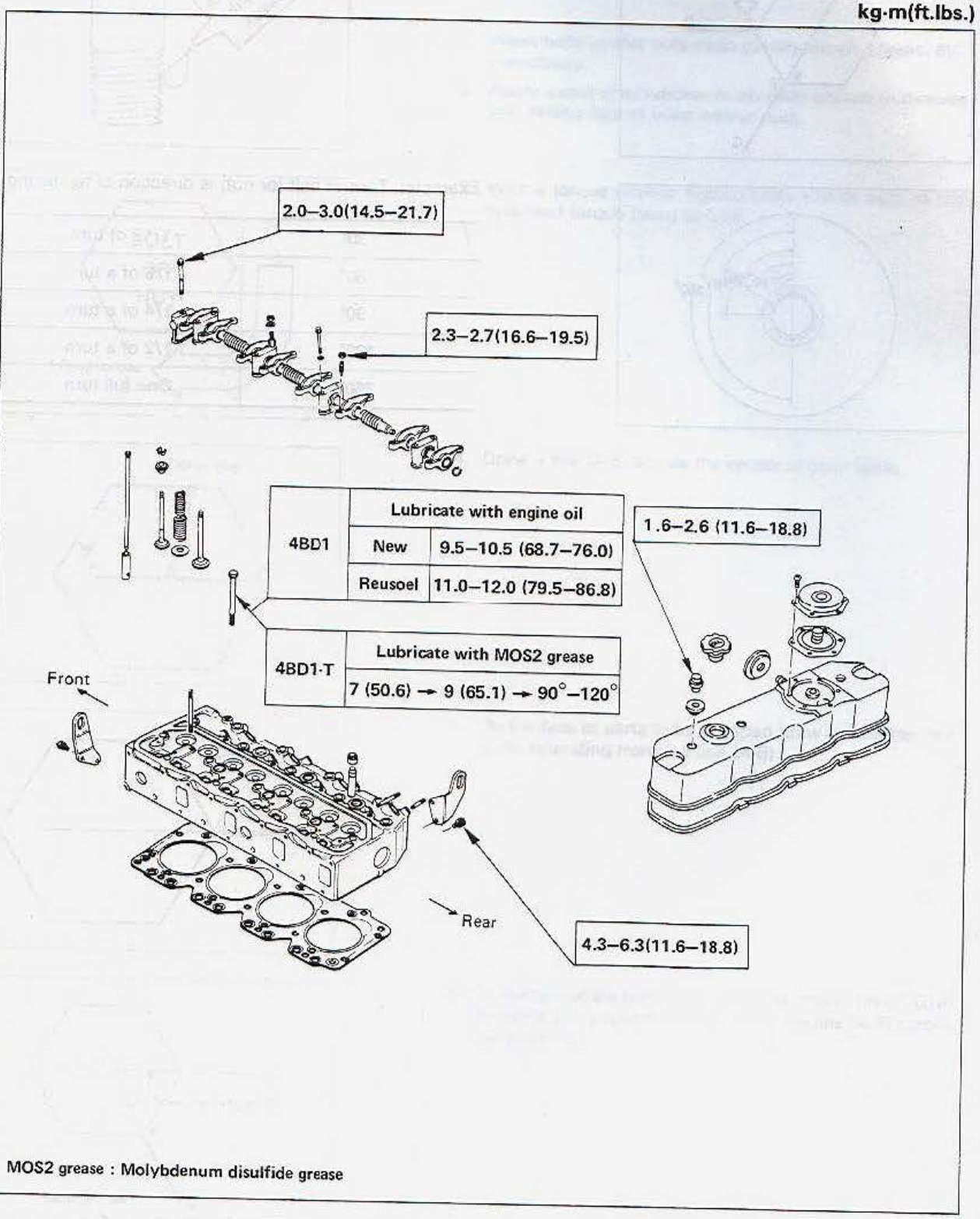
Example: Turn of bolt (or nut) is direction of tightening.

30°	1/12 of turn
60°	1/6 of a turn
90°	1/4 of a turn
180°	1/2 of a turn
360°	One full turn

FIXING TORQUE

CYLINDER HEAD AND COVER

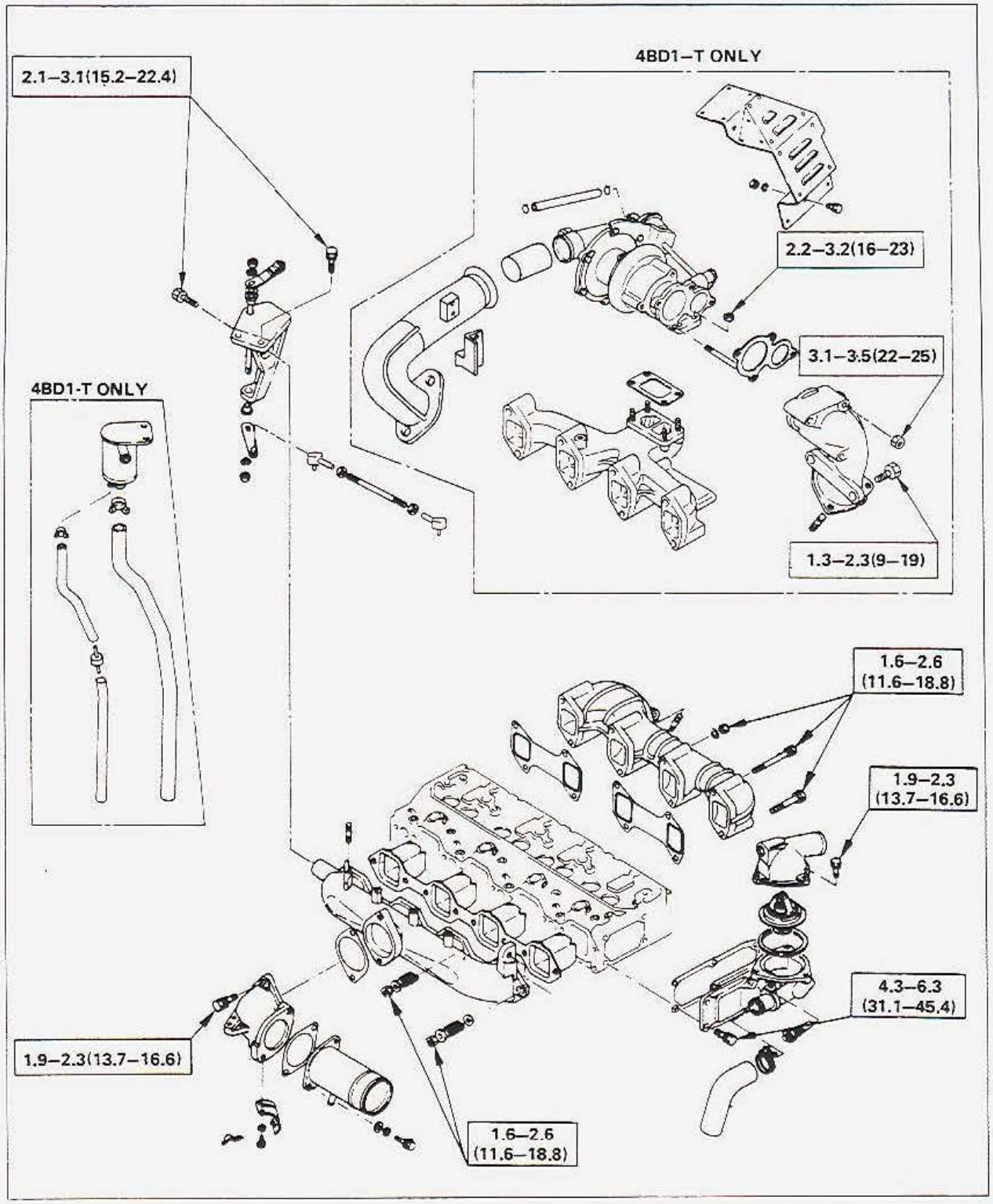
kg·m(ft.lbs.)



MOS2 grease : Molybdenum disulfide grease

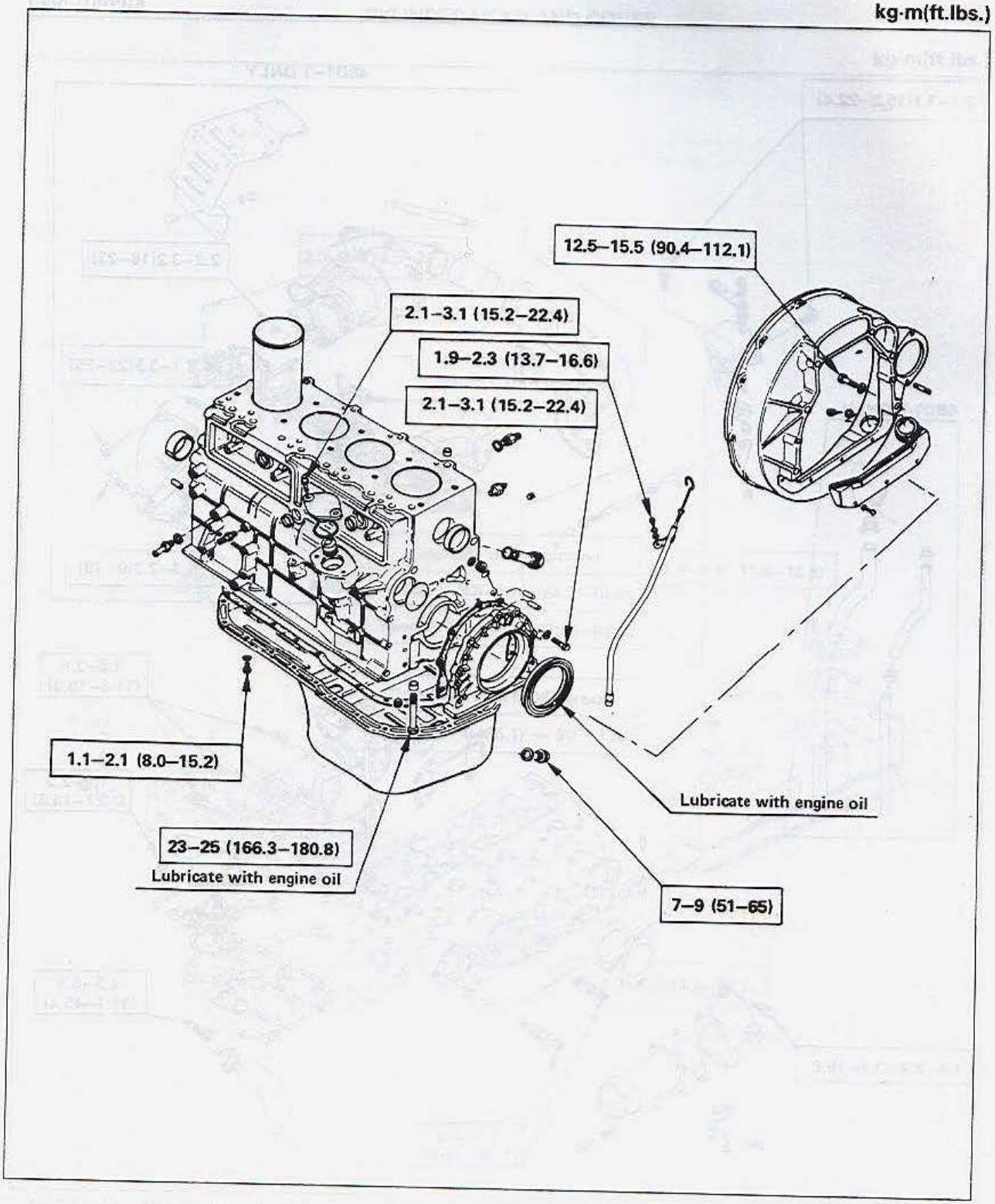
INTAKE AND EXHAUST MANIFOLD

kg·m(ft.lbs.)



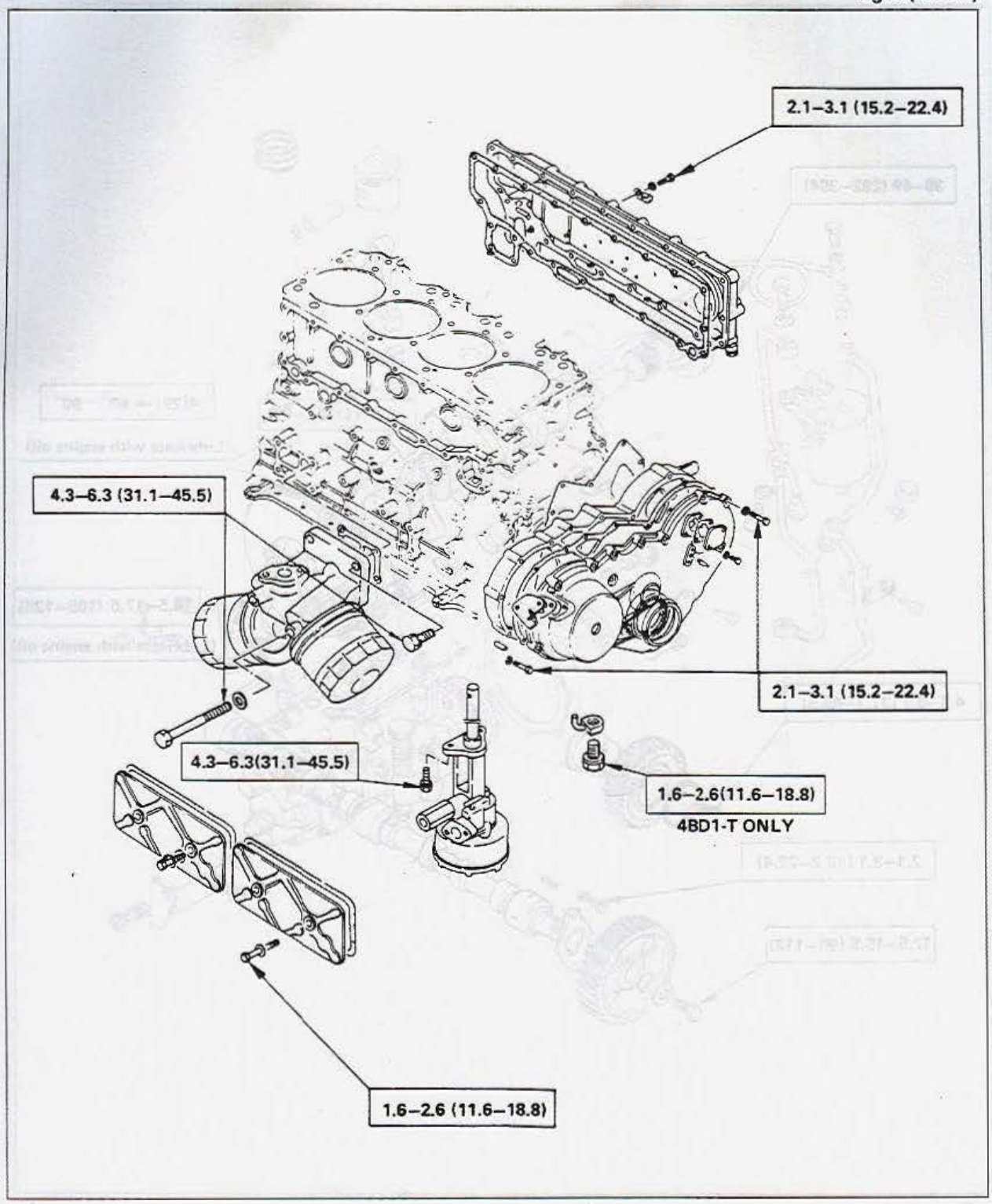
CYLINDER BODY AND OTHERS

kg·m(ft.lbs.)



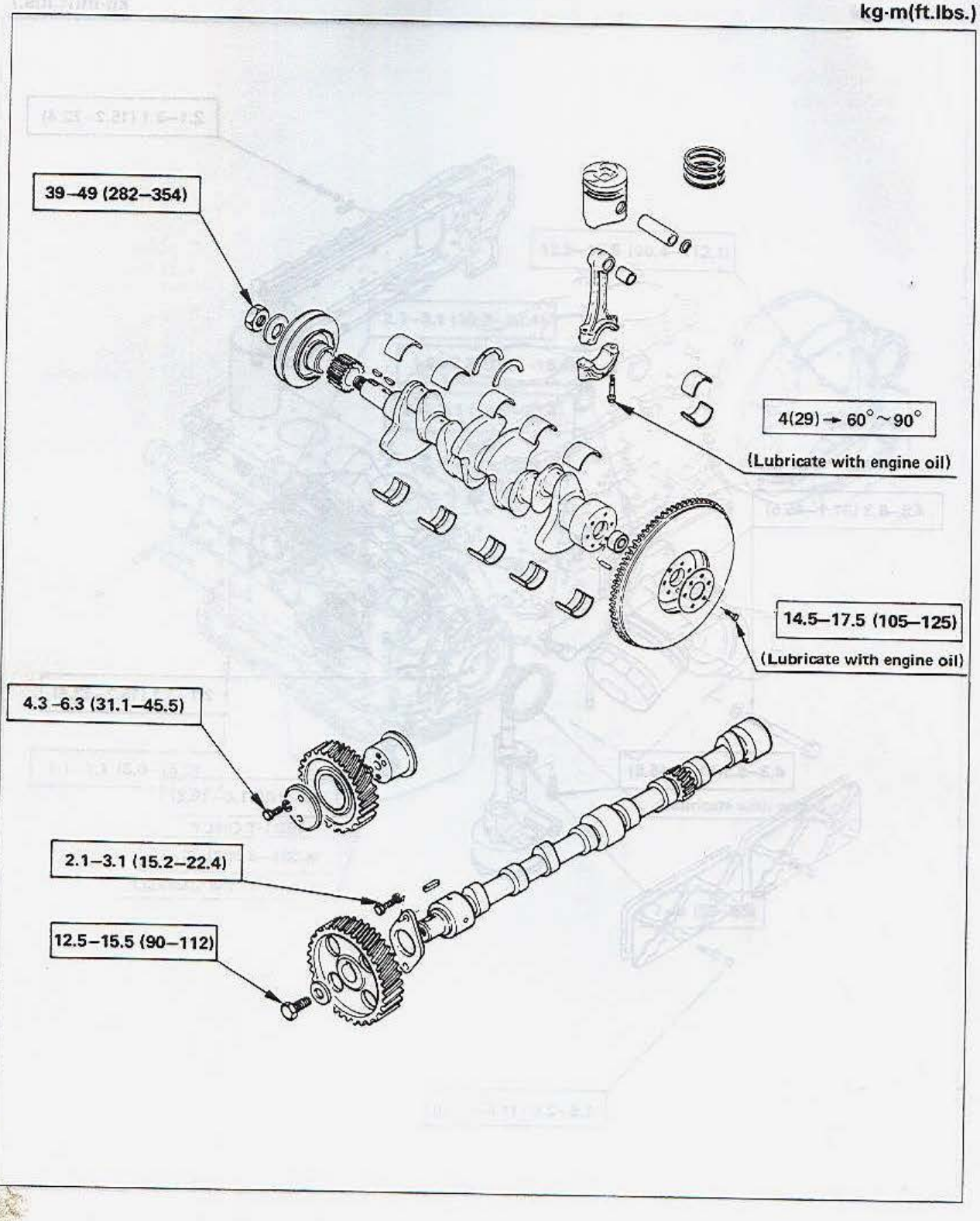
CYLINDER BODY AND OTHERS

kg·m(ft.lbs.)



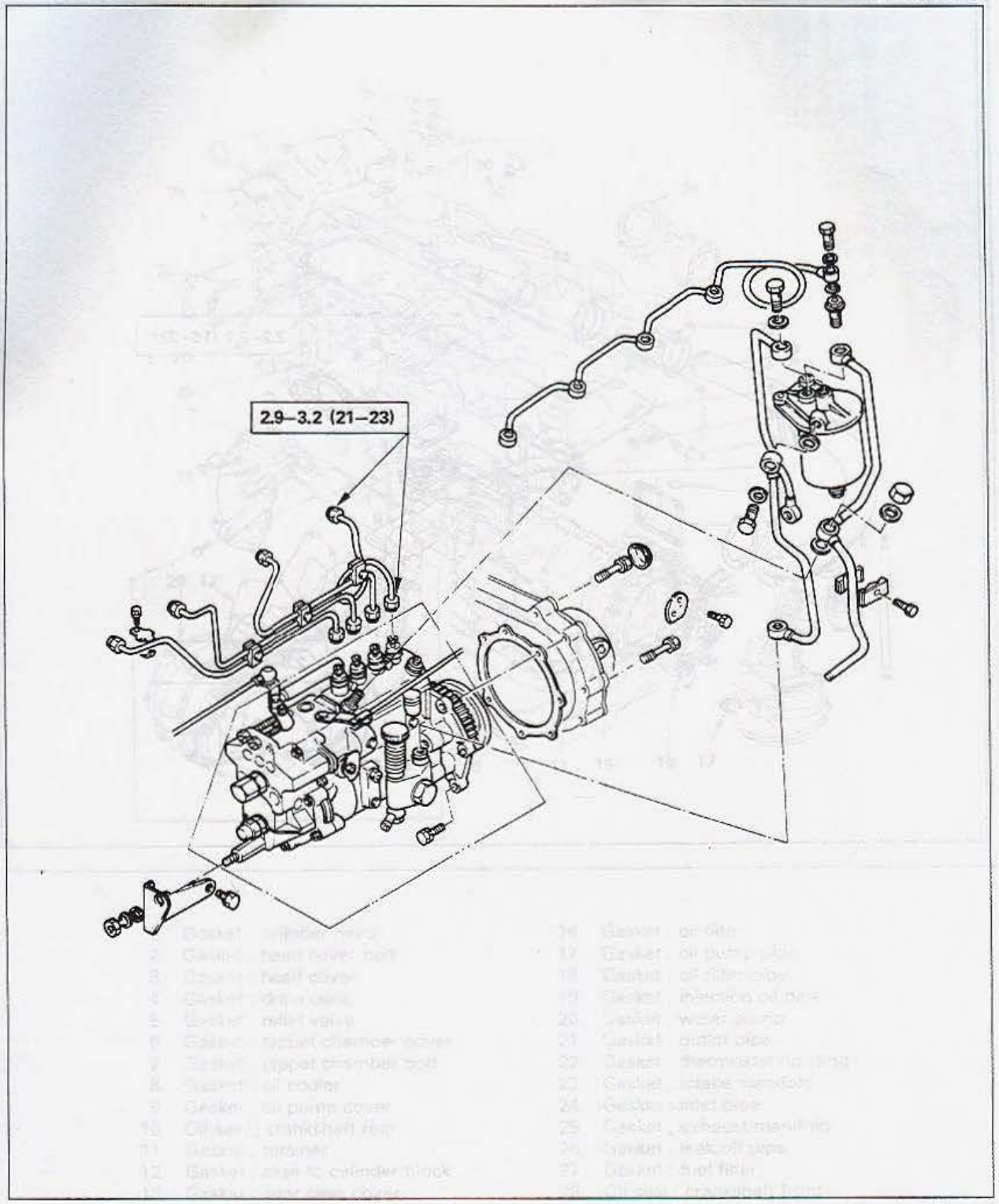
CRANKSHAFT AND CAMSHAFT

kg-m(ft.lbs.)



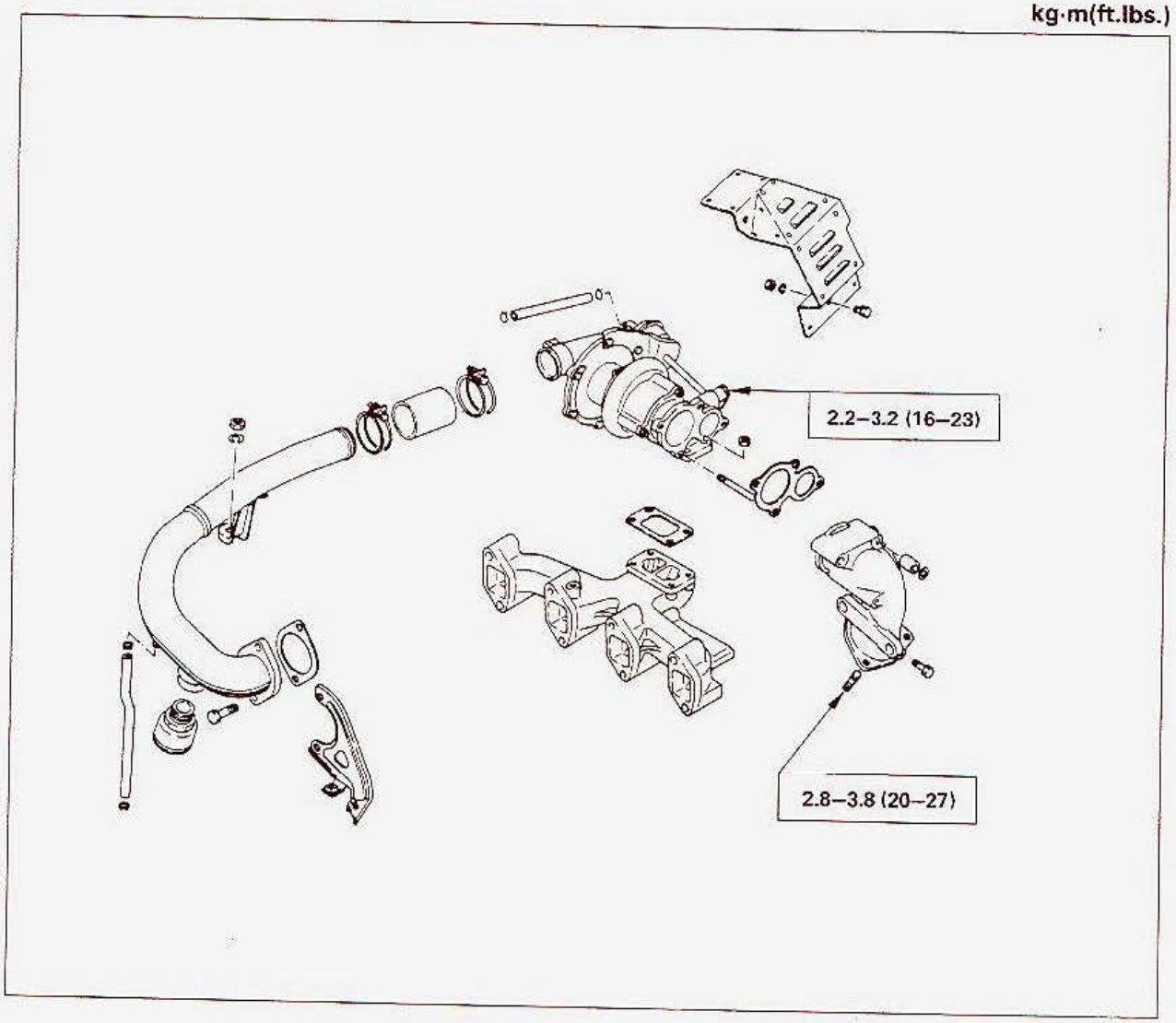
FUEL SYSTEM

kg·m(ft.lbs.)

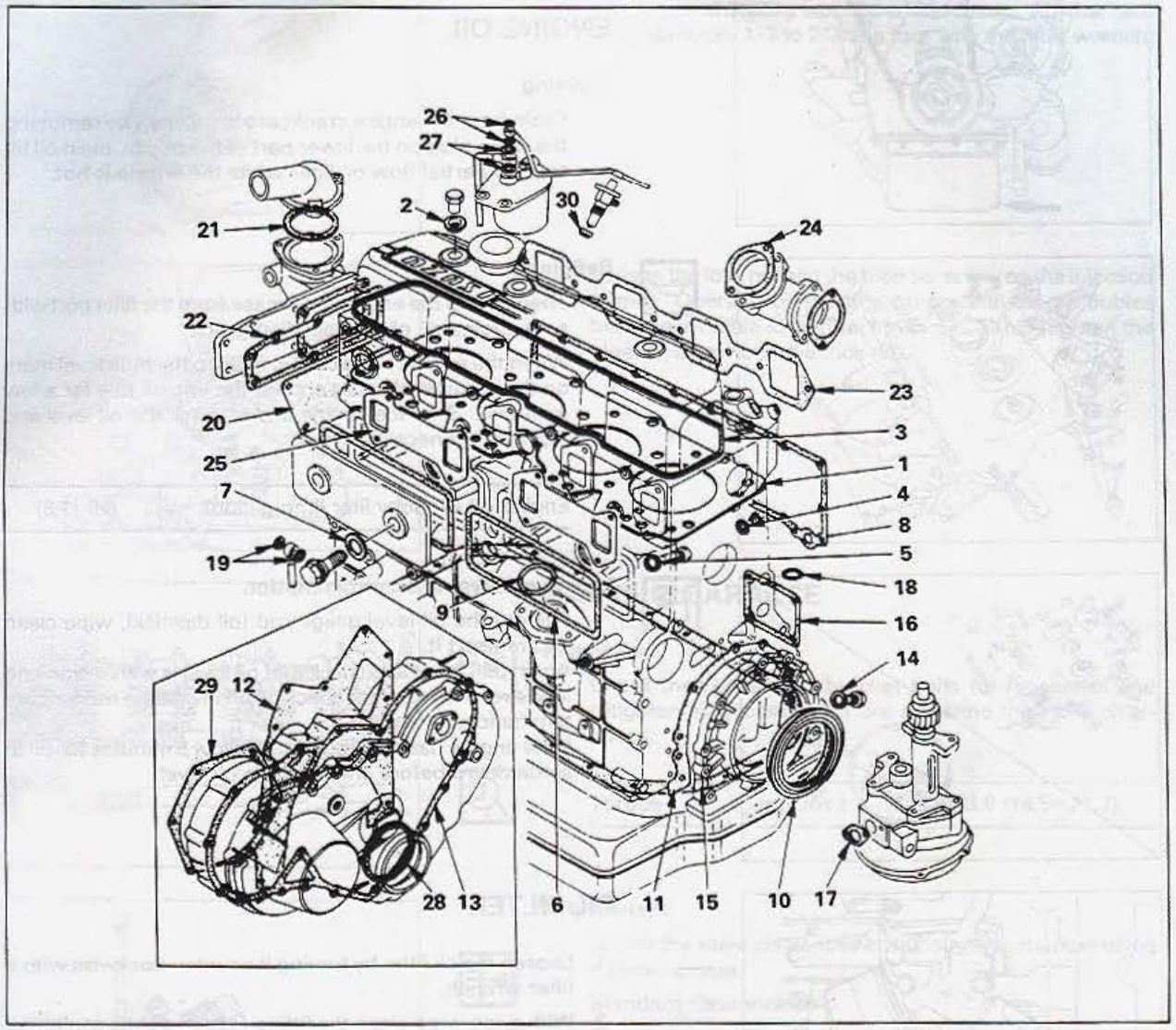


TURBOCHARGER

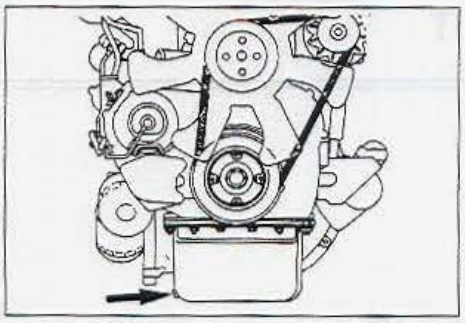
kg·m(ft.lbs.)



ENGINE REPAIR KIT



1. Gasket ; cylinder head
2. Gasket ; head cover bolt
3. Gasket ; head cover
4. Gasket ; drain cock
5. Gasket ; relief valve
6. Gasket ; tappet chamber cover
7. Gasket ; tappet chamber bolt
8. Gasket ; oil cooler
9. Gasket ; oil pump cover
10. Oil seal ; crankshaft rear
11. Gasket ; retainer
12. Gasket ; case to cylinder block
13. Gasket ; gear case cover
14. Gasket ; oil pan drain plug
15. Gasket ; oil pan
16. Gasket ; oil filter
17. Gasket ; oil pump pipe
18. Gasket ; oil filter pipe
19. Gasket ; injection oil pipe
20. Gasket ; water pump
21. Gasket ; outlet pipe
22. Gasket ; thermostat housing
23. Gasket ; intake manifold
24. Gasket ; inlet pipe
25. Gasket ; exhaust manifold
26. Gasket ; leak off pipe
27. Gasket ; fuel filter
28. Oil seal ; crankshaft front
29. Gasket ; injection pump bracket
30. Gasket ; nozzle holder

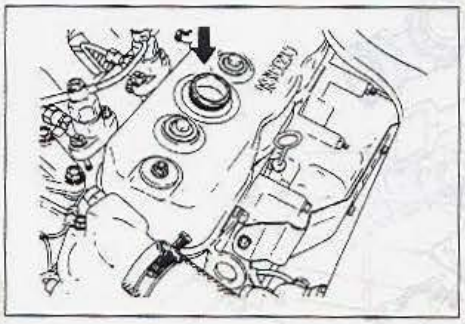


SERVICING

ENGINE OIL

Draining

Drain from the engine crankcase completely by removing the drain plug on the lower part of the oil pan, main oil filter and partial flow oil filter while the engine is hot.

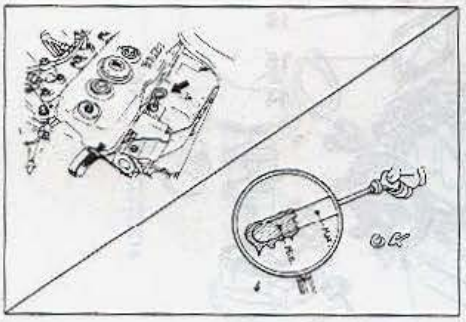


Refilling

Then fill into the engine crankcase from the filler port with new engine oil of the specified grade.

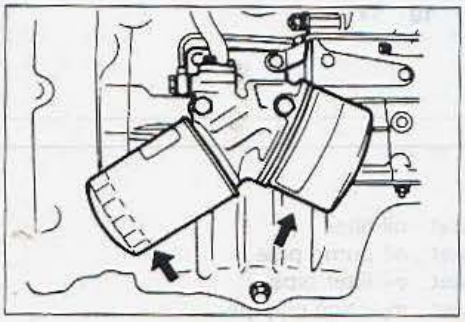
When the engine crankcase is filled to the high level mark on the oil dipstick, start and let the engine idle for a few minutes. Stop the engine and recheck the oil level and replenish, if necessary.

Engine oil capacity liter (Imp gallon)	8.0 (1.8)



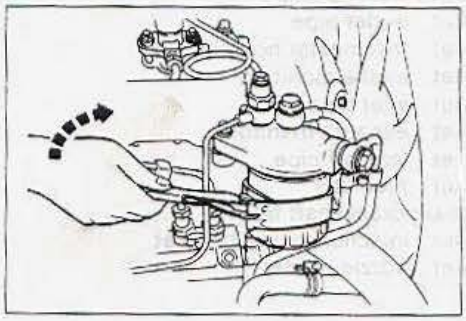
Engine oil level and contamination

Pull out the oil level gauge rod (oil dipstick), wipe clean and reinsert it.
Again pull it out and check that oil level is within high and low level marks. Also check oil on the gauge rod for contamination.
If the engine has been operated, allow 5 minutes for oil to settle down before checking the oil level.



OIL FILTER

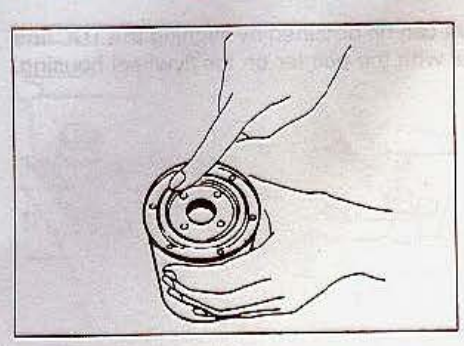
1. Loosen the oil filter by turning it counter-clockwise with a filter wrench.
2. With a rag wipe clean the fitting face of the oil cooler, so that new oil filter can be seated properly.
3. Lightly oil the O-ring and turn in oil filter until sealing face is fitted against the O-ring.
   Turn 1-1/4 turns further with the filter wrench.



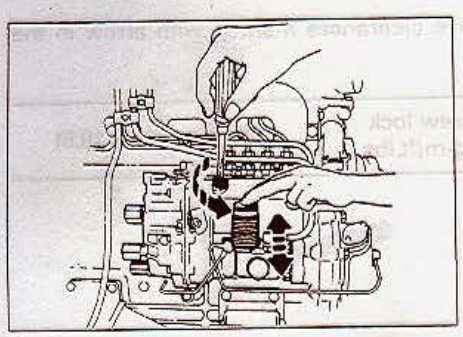
FUEL FILTER

Replacement

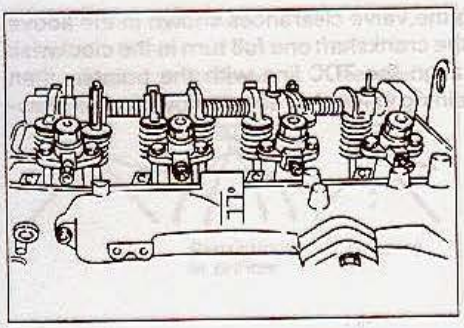
1. Loosen the fuel filter turning it counter-clockwise with a filter wrench.
2. With a rag wipe clean the fitting face on the upper cover, so that new fuel filter can be seated properly.



3. Lightly oil the O-ring. Install and turn in filter assembly clockwise carefully to prevent fuel spillage until O-ring is fitted against sealing face of the filter cover. Further turn filter assembly 1/3 to 2/3 of a turn with the filter wrench.



4. Loosen the lock nut and the bleeder screw on the injection pump. Operate the priming pump until the air bubles become invisible in the fuel flown out. Then tighten the bleeder screw and the lock nut.

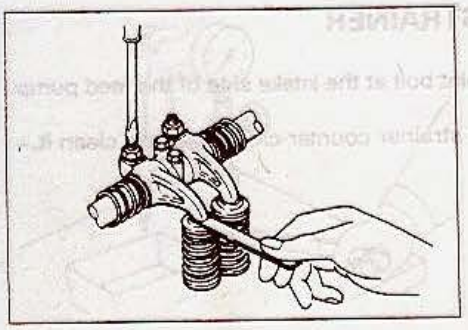


VALVE CLEARANCE

Inspection

Check the rocker arm bracket bolts for looseness and retighten as necessary before adjusting the valve clearances.

Torque	kg·m(ft.lbs.)	2.0—3.0 (14.5—21.7)

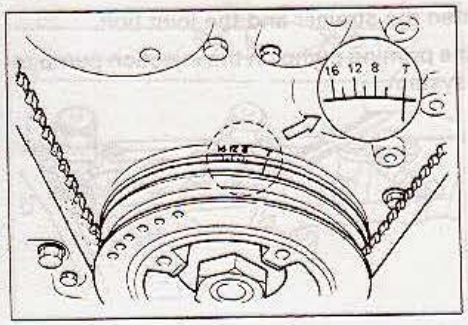


Adjustment

Adjust the valve clearances in the following manner using a feeler gauge.

Standard clearance cold

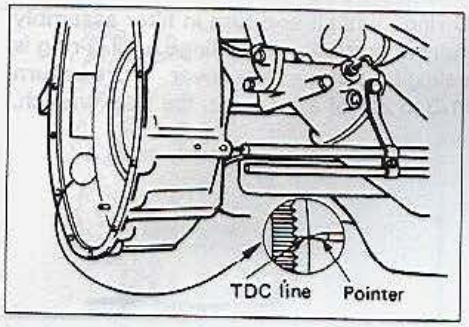
Intake and exhaust	mm(in.)	0.4 (0.016)



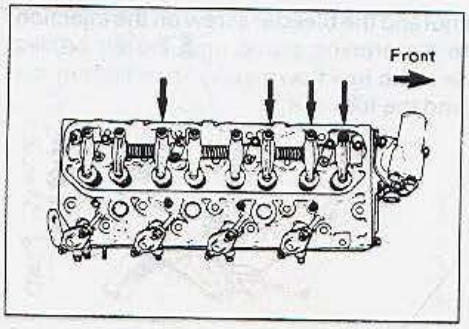
Turn the crankshaft in a clockwise direction to bring the piston in either No. 1 or No. 4 cylinder into Top Dead Center (TDC) on compression stroke by aligning TDC line on the crankshaft pulley with the pointer.

Hand-feel looseness of intake and exhaust valve push rods on the No. 1 cylinder. When both push rods have a play, it indicates that the piston in No. 1 cylinder is at TDC on compression stroke.

When the push rods have not play and those ones on the No. 4 have a play, it indicates that the piston in No. 4 cylinder is at TDC on compression stroke.

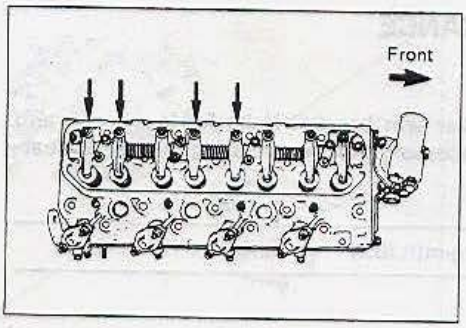


The same result can be obtained by aligning the TDC line on the flywheel with the pointer on the flywheel housing.

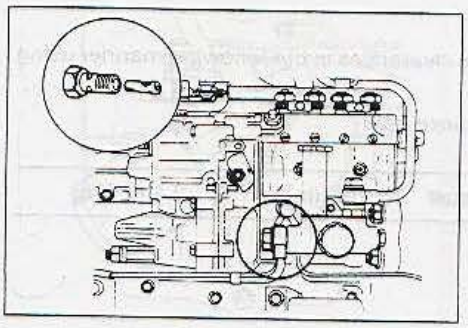


Adjust the valve clearances marked with arrow in the drawing.

Rocker arm screw lock nut torque kg-m(ft.lbs.)	2.3—2.7 (16.6—19.5)

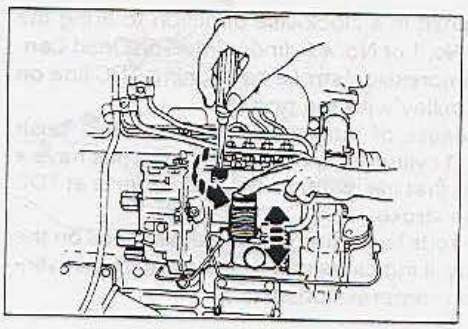


After adjusting the valve clearances shown in the above drawing, turn the crankshaft one full turn in the clockwise direction and align the TDC line with the pointer, then adjust the remaining valve clearances shown in this drawing.

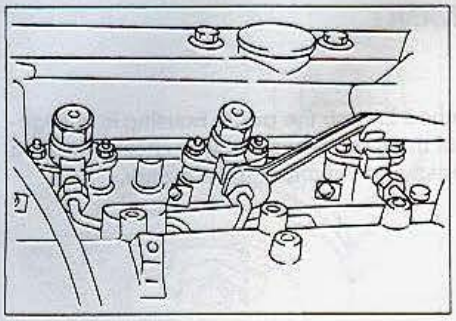


FEED PUMP STRAINER

1. Remove the joint bolt at the intake side of the feed pump.
2. Screw out the strainer counter-clockwise and clean it.



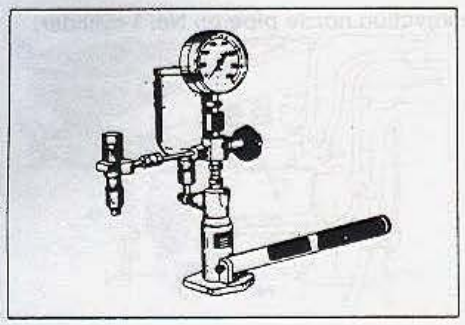
3. Install and tighten the strainer and the joint bolt.
4. Then operate the priming pump on the injection pump to bleed the fuel system.



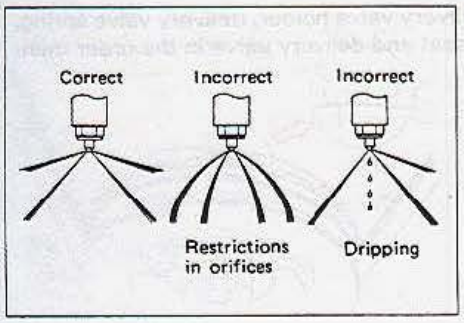
INJECTION PRESSURE AND SPRAYING CONDITION

Preparation

1. Remove 4 injection pipes.
2. Disconnect the leak off pipe.
3. Remove 4 injection nozzles.
4. Set each injection nozzle to the injection nozzle tester.



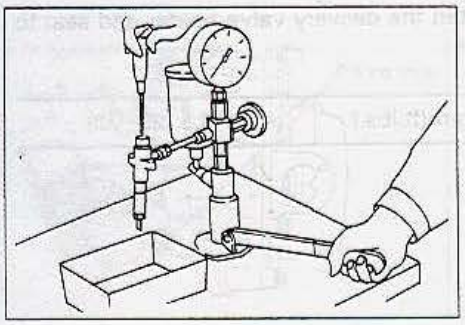
Note: * On removal, mark cylinder No. on the injection nozzles not to interchange.
* Discard O-ring and use new one.



Inspection

Check the spray condition and injection pressure using a nozzle tester.

Injection starting pressure:	kg/cm²(psi)	185 (2630)

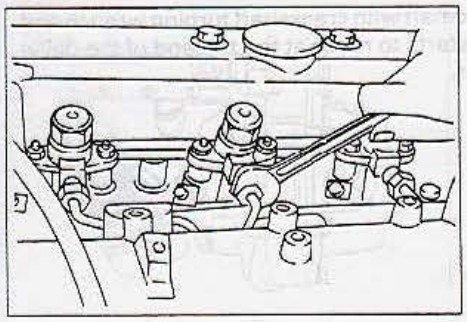


Adjustment

Adjust the injection starting pressure in the manner described below.

1. Remove the cap nut.
2. Turn the adjusting screw to attain the correct injection starting pressure.
3. Tighten the cap nut to specified torque.

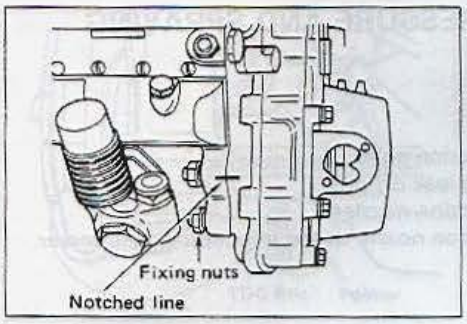
Torque	kg·m(ft.lbs.)	6—8 (43—58)



Installation

1. Install 4 injection nozzles to its home position, and tighten the fixing to the specified torque.
2. Connect the leak off pipe.
3. Install 4 injection pipes and tighten to the specified torque.

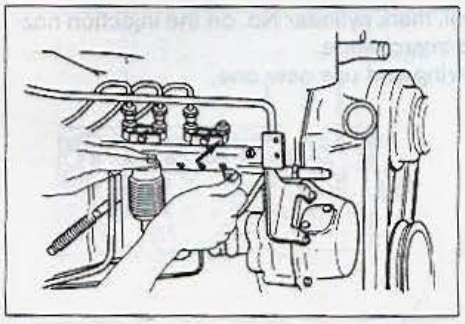
Torque	kg·m(ft.lbs.)
Nozzle fixing nut	2.1—3.1 (15.2—22.4)
Injection pipe	2.9—3.2 (21.0—23.1)



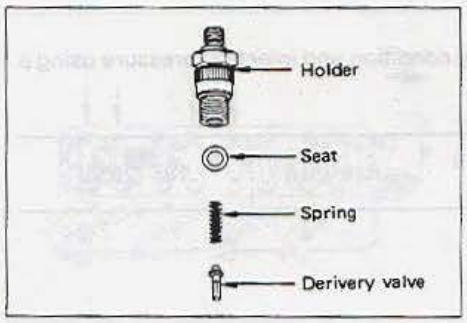
INJECTION TIMING

Inspection

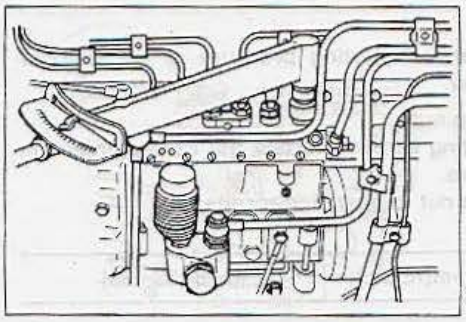
1. Check that notched line on the pump housing is in alignment with that of the timer bracket. Also check the fixing nuts for looseness and retighten if necessary.



2. Disconnect the injection nozzle pipe on No. 1 cylinder.

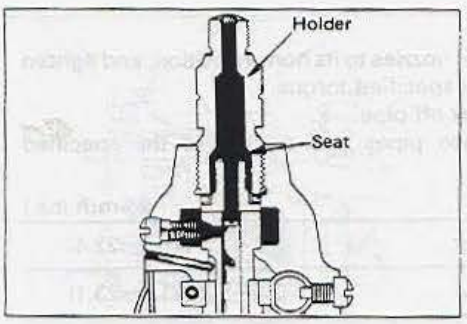


3. Remove the delivery valve holder, delivery valve spring, delivery valve seat and delivery valve in the order mentioned.

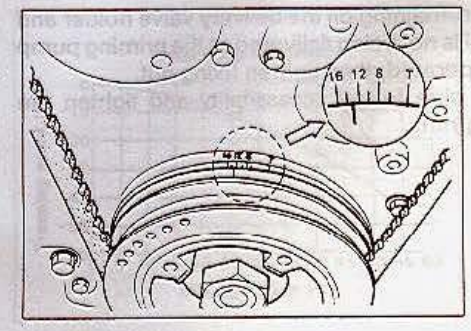


4. Install and tighten the delivery valve holder and seat to specified torque.

Torque	kg·m(ft.lbs.)	4—4.5 (29—33)



5. Rotate the crankshaft with crankshaft turning wrench and stop when fuel starts to move at the top end of the delivery valve holder.

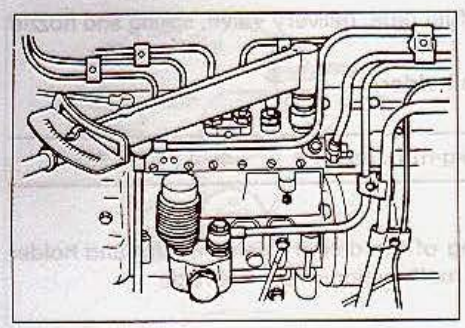


6. Then check if notched line on the crankshaft pulley aligned with specified mark.

(degrees)

Timing (B.T.D.C.)	
4BD1	13°
4BD1-T	10°

Use of mirror is required to see timing marks from below.

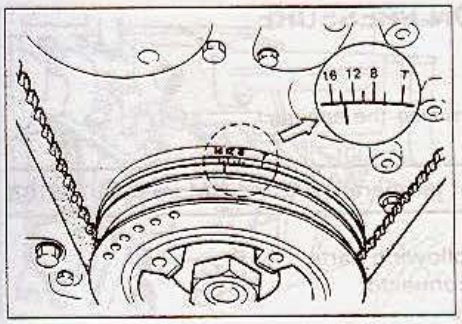


7. When injection timing is correct, re-install the delivery valve, spring and injection nozzle pipe.

Delivery valve holder

Torque	kg·m(ft.lbs.)	4—4.5 (29—33)

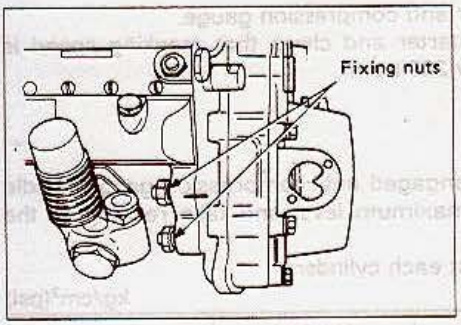
If injection timing is not correct, follow the next procedures without re-installation.



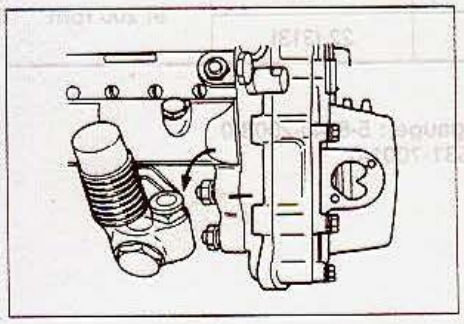
Injection timing adjustment procedure

1. Adjust fuel injection timing by aligning notched line on the or on the pulley with the specified mark (10° or 13°) exactly.

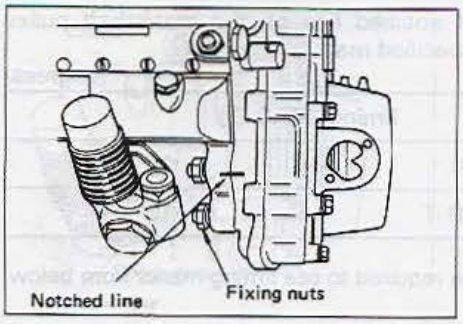
Use of mirror is required to see timing marks from below.



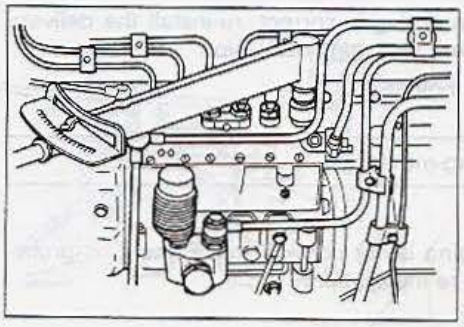
2. Remove fuel pipe connecting fuel feed pump with fuel filter to get access.
Loosen the 4 nuts fixing injection pump housing.
Then re-install fuel pipe connecting fuel feed pump with fuel filter.



3. While operating the priming pump, turn the injection pump housing in opposite direction of engine rotation, until fuel stops flowing from the delivery valve holder.



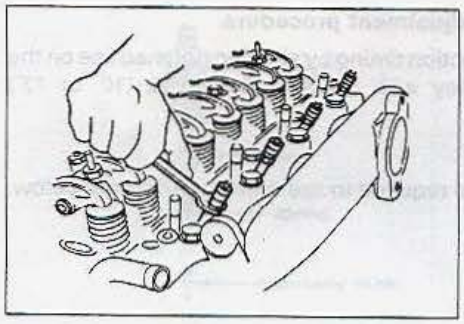
4. Blow out fuel remaining on the delivery valve holder and check that fuel is not being delivered as the priming pump is manually operated, then tighten fixing nut.
Remove fuel pipe to get accessibility and tighten the residual fixing nuts.



5. Re-install the fuel pipe, delivery valve, spring and nozzle pipe.
Delivery valve holder:

Torque	kg·m(ft.lbs.)	4—4.5 (29—33)

Over-tightening of the delivery valve holder and holder clip will invite malfunction of control rack.



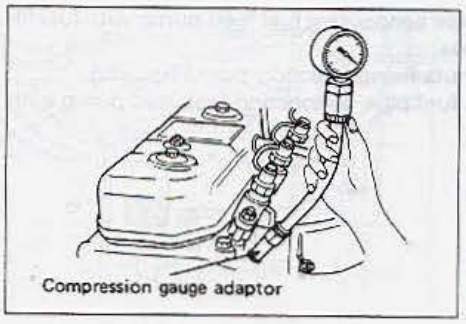
COMPRESSION PRESSURE

Preparation

1. Start and normalize the engine.

Engine coolant temperature C°(F°)	More than 75 (167)

2. Remove the following parts.
   - Glow plug connector
   - 4 glow plugs
3. Install adaptor and compression gauge.
4. Engage the starter and check that cranking speed is approximately 200 r.p.m.



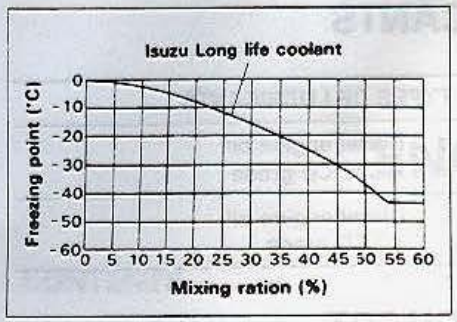
Measurement

1. Keep starter engaged until compression gauge needle reaches the maximum level and take reading of the gauge.
2. Repeat the test each cylinder.

kg/cm²(psi)

Standard	31 (441)	at 200 rpm
Limit	22 (313)	

Compression gauge : 5-8840-2008-0
Adaptor : 5-8531-7001-0

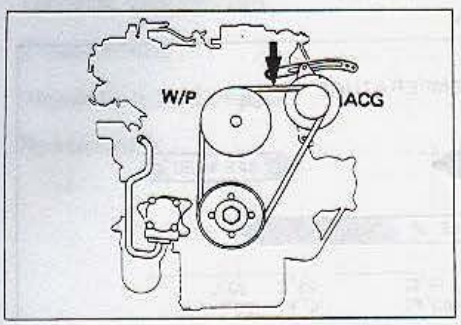


COOLING SYSTEM

Mixing ration

An adequate amount of anti-freeze solution should be added to the cooling system according to lowest temperature anticipated.

Capacity liters (Imp gallon)	14 (3.1)

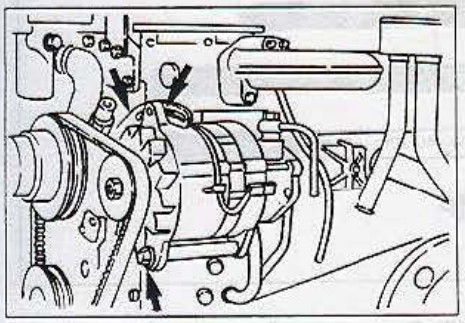


Fan belt

Inspection

Check that the belt gives a specified deflection when the intermediate part of the belt is depressed with finger (when pushed with a force of 10 kg (22 lbs.)

Deflection	mm(in.)	8—12 (0.32—0.47)



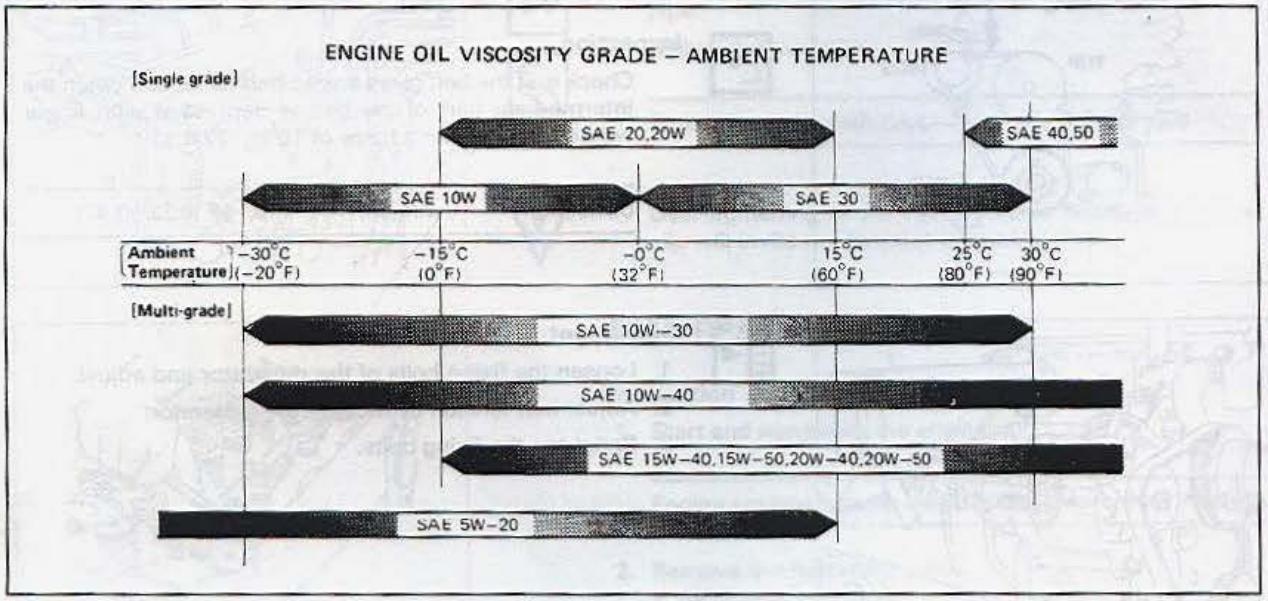
Adjustment

1. Loosen the fixing bolts of the generator and adjust.
2. Adjust belt tension by moving the generator.
3. Retighten the fixing bolts.

RECOMMENDED LUBRICANTS

ENGINE TYPE	TYPES OF LUBRICANTS
Without turbocharger	Diesel engine oil CC or CD grade
With turbocharger	Diesel engine oil CD grade

ENGINE OIL VISCOSITY CHART



ADHESIVE FOR REPAIRS

Liquid gasket, adhesives and other chemicals are used in various parts of the engine to prevent leakage of oil, water and to prevent the bolts and nuts from loosening and these chemicals are available at Isuzu Motors as Isuzu genuine parts.
When servicing the engine, it is recommended to use Isuzu genuine parts or equivalent.

ITEMS	PARTS NAMES
Liquid gasket	BELCOBOND NO. 4 BELCOBOND NO. 5 BELCOBOND No. 201 SEAL END NO. 242
Adhesives and sealant	THREE CEMENT SUPER THREE CEMENT LOCKTITE 242 (Locktite Nutlock) LOCKTITE 262 (Locktite Studlock) LOCKTITE PRIMER "N"

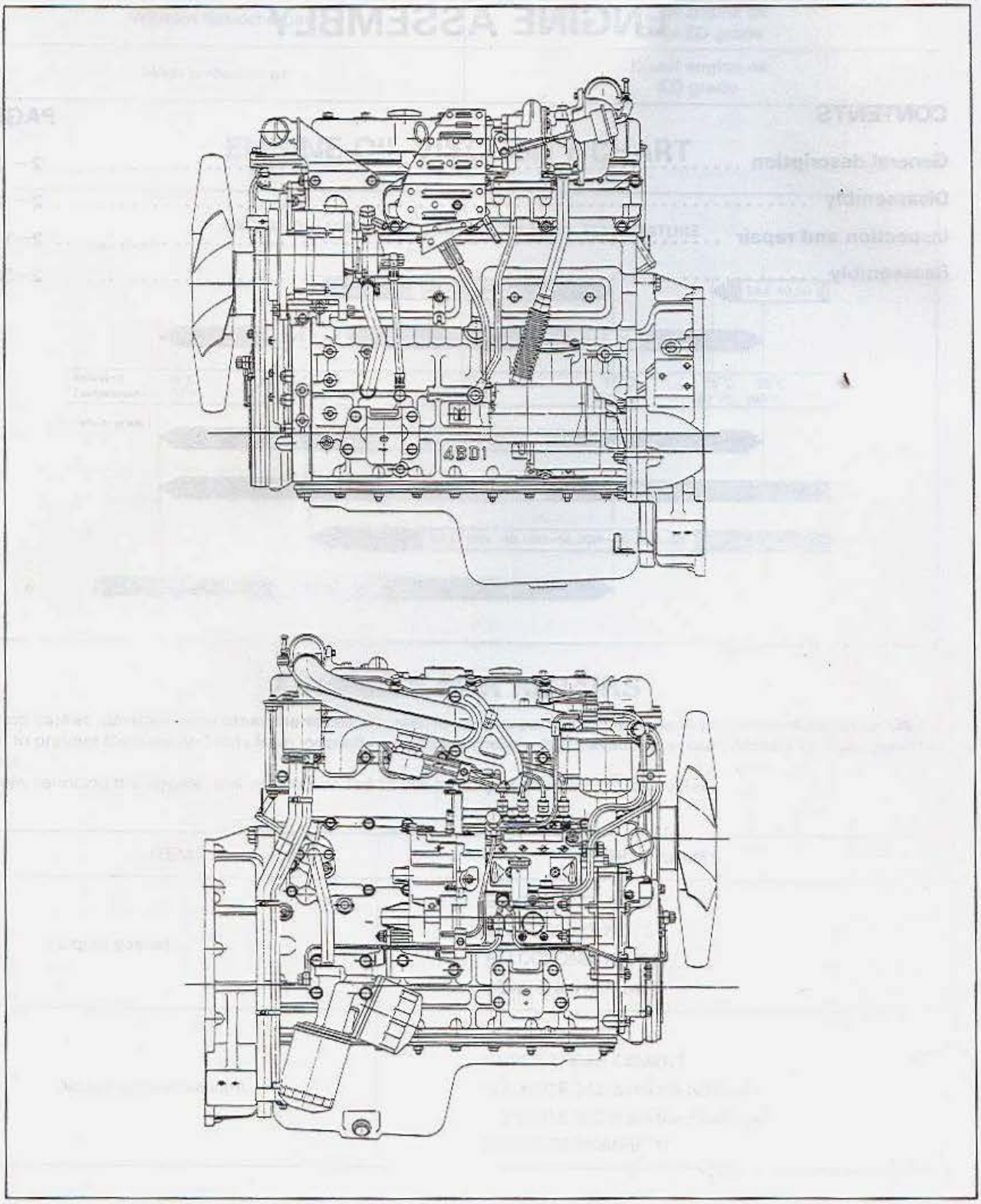
SECTION 2

ENGINE ASSEMBLY

CONTENTS PAGE

GENERAL DESCRIPTION

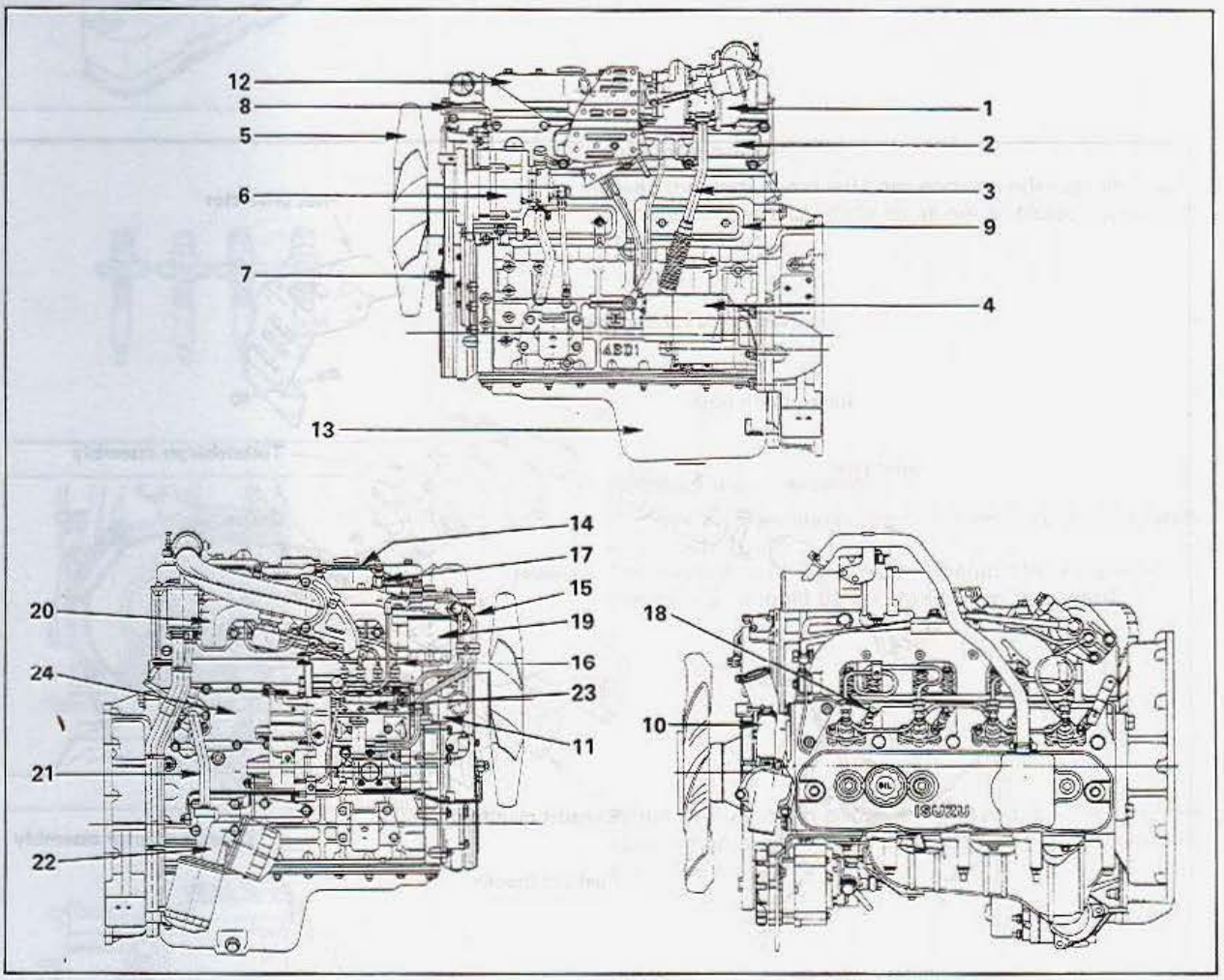
This illustration is based on the 4BD1-T model.



DISASSEMBLY

EXTERNAL PARTS

This illustration is based on the 4BD1-T model.



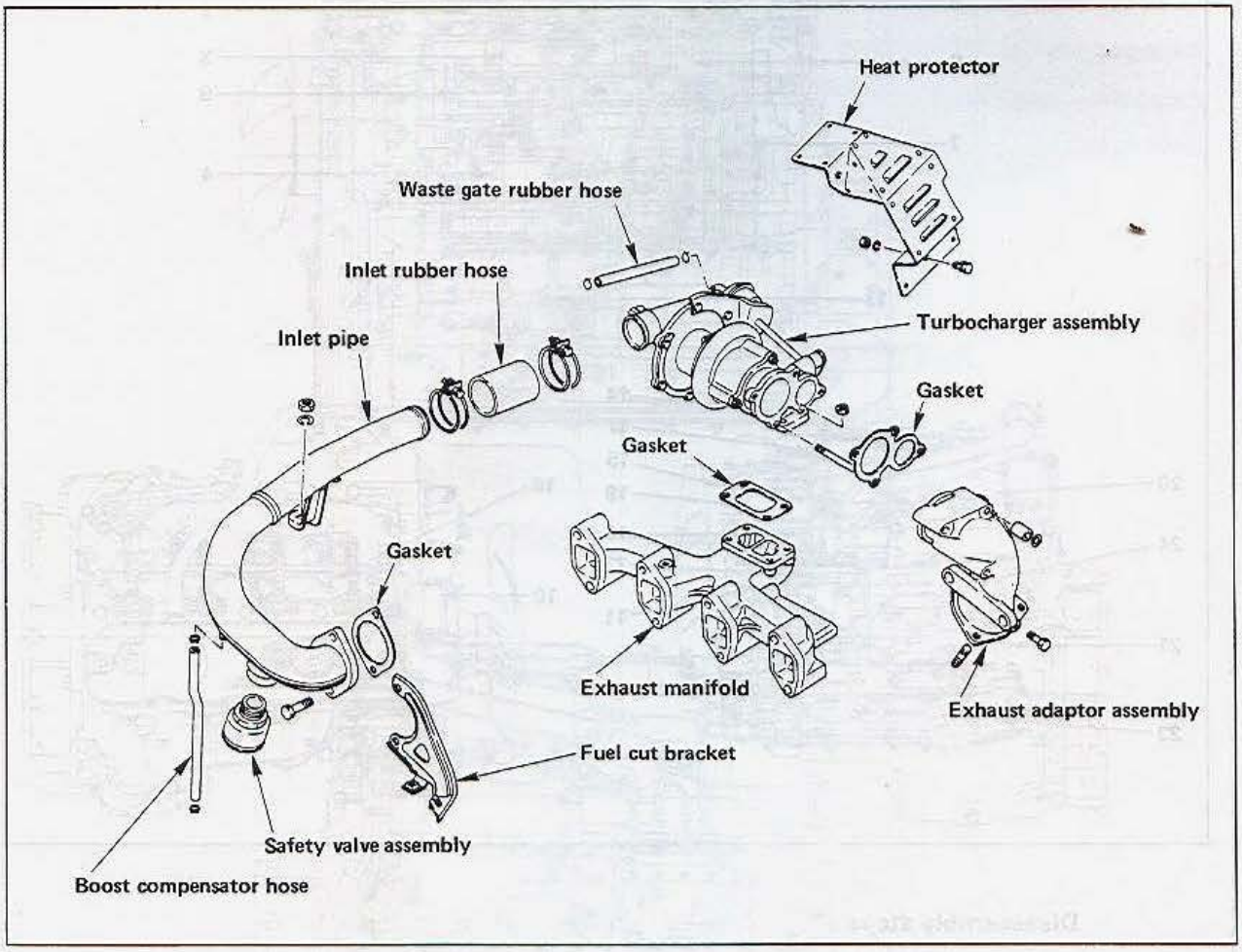
Disassembly steps

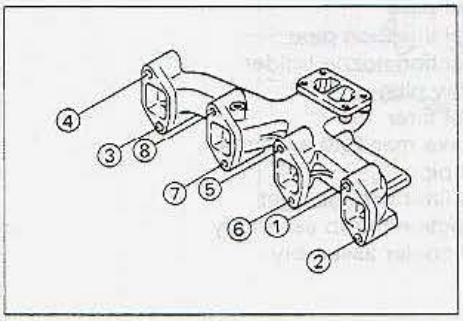
1. Turbocharger related parts (4BD-T only)
▲ 2. Exhaust manifold assembly
3. Oil level gauge with guide tube
4. Starter motor
5. Cooling fan
6. Generator
7. Cooling fan belt
8. Tappet chamber cover
9. Thermostat housing assembly
10. Rubber hose
11. Water pump assembly
▲ 12. Cylinder head cover
▲ 13. Oil pan
14. Fuel injection leak off pipe
15. Fuel pipe
16. Fuel injection pipe
▲ 17. Injection nozzle holder
18. Glow plug
19. Fuel filter
20. Intake manifold assembly
21. Oil pipe
22. Oil filter with bracket
▲ 23. Injection pump assembly
24. Oil cooler assembly

Important operations

1. Turbocharger related parts

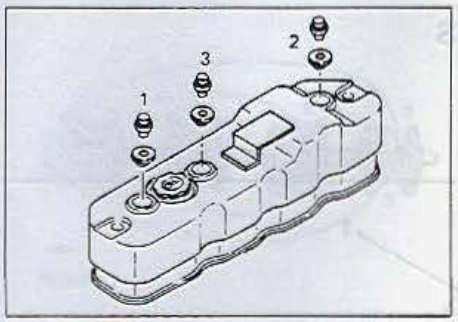
Parts removal steps are related as the following chart.





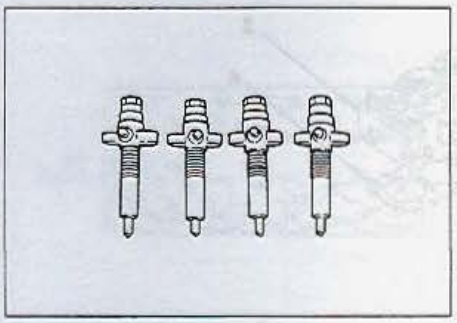
2. Exhaust manifold assembly

Loosen the exhaust manifold bolts in numerical sequence.



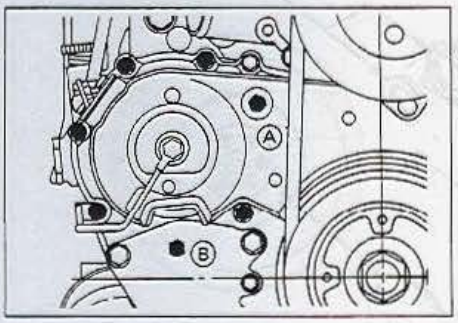
12. Cylinder head cover

Loosen the cylinder head cover bolts in numerical sequence.



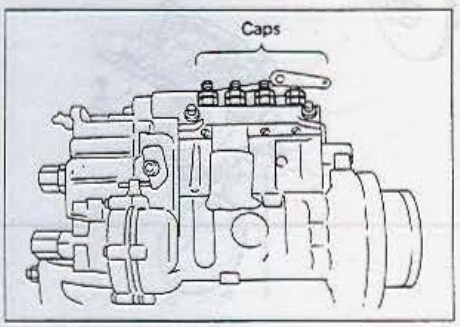
17. Injection nozzle

Keep the parts removed from each cylinder separate and handle the parts carefully so as not to cause damage to the nozzle end.



23. Injection pump assembly

Remove the injection pump by loosening 6 through bolts and a nut.
The through bolt A is hidden behind the hole cover.
The nut B should be accessed from backward.

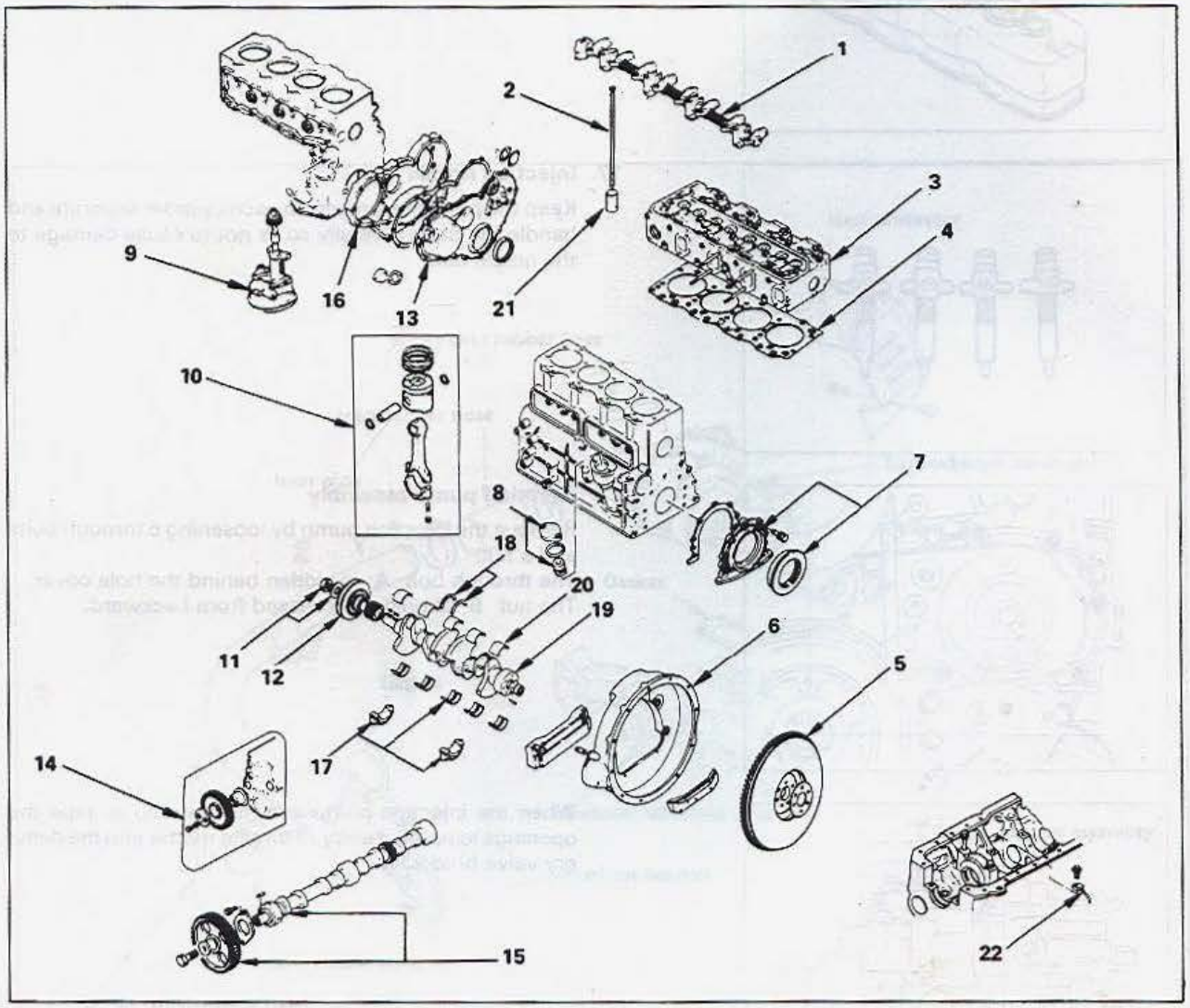


When the injection pump is removed, cap or tape the openings to prevent entry of foreign matter into the delivery valve holder.

INTERNAL PARTS

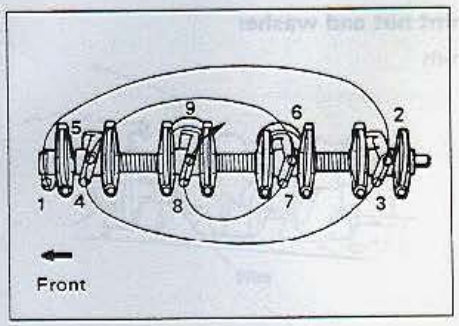
MAJOR COMPONENTS

These illustrations are based on the 4BD1 model.



Disassembly steps

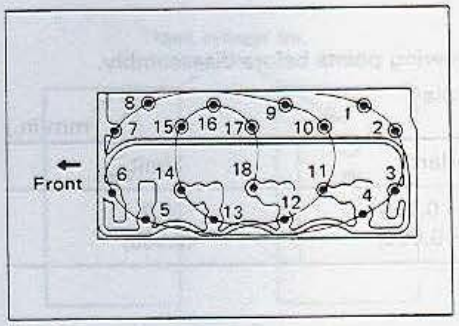
- ▲ 1. Rocker arm shaft assembly
- 2. Push rod
- ▲ 3. Cylinder head assembly
- 4. Cylinder head gasket
- ▲ 5. Flywheel
- 6. Flywheel housing
- 7. Rear oil seal assembly
- 8. Oil pump cover
- 9. Oil pump assembly
- ▲ 10. Piston and connecting rod assembly
- ▲ 11. Crankshaft front nut and washer
- 12. Crankshaft pulley
- 13. Gear case cover
- ▲ 14. Idle gear
- 15. Camshaft assembly
- 16. Timing gear case
- ▲ 17. Crankshaft bearing cap and crankshaft bearing (Lower side)
- ▲ 18. Thrust bearing
- 19. Crankshaft assembly
- 20. Crankshaft bearing (Upper side)
- ▲ 21. Tappet
- 22. Oiling jet (4BD1-T only)



Important operations

1. Rocker arm shaft assembly

Loosen the rocker arm shaft assembly bolts a little at a time in numerical sequence as specified.

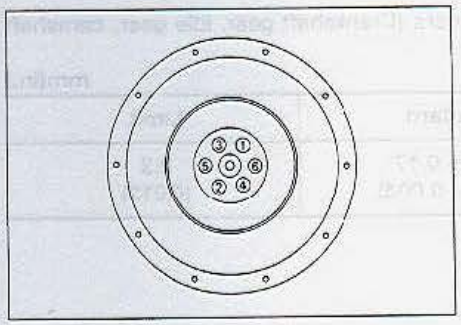


3. Cylinder head assembly

Loosen the cylinder head bolts a little at a time in numerical sequence as specified.

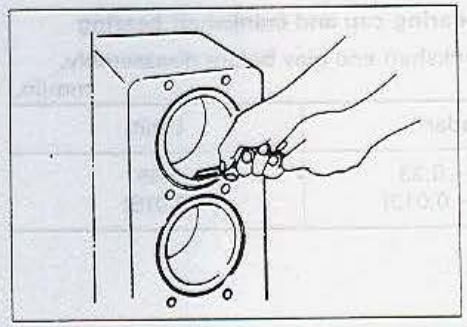
Upon removal of the cylinder head assembly with the rocker arm shaft assembly, use a special tool to loosen the cylinder head bolts.

Wrench : 1-8511-1003-0



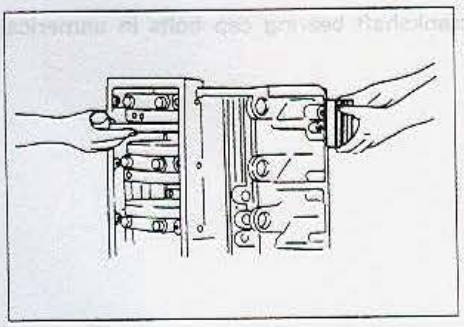
5. Flywheel

Loosen the flywheel bolts a little at a time in numerical sequence as specified.

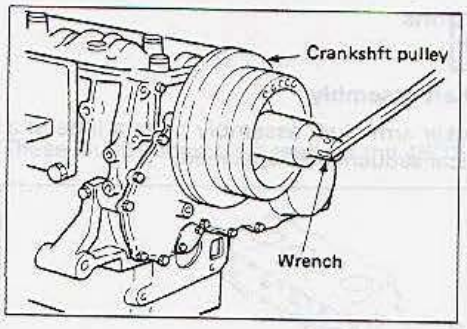


10. Piston and connecting rod assembly

With a scraper remove carbon deposits from the cylinder wall before removing the piston.

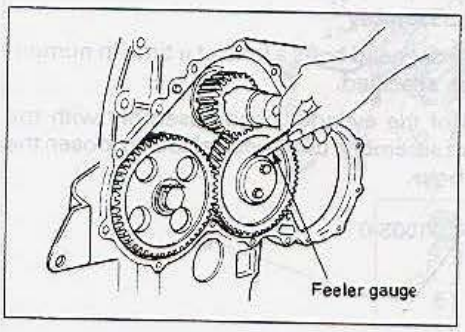


Bring the piston to top dead center by turning the crankshaft, then push out the piston and connecting rod assembly from the cylinder using the handle of a hammer or wood bar.



11. Crankshaft front nut and washer

Wrench : 41 mm



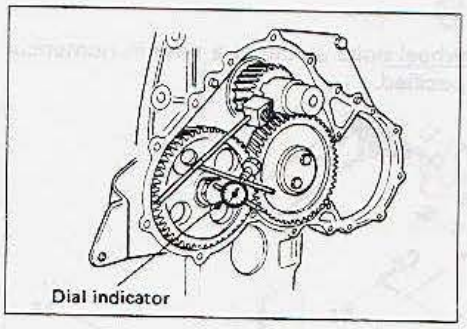
14. Idle gear

Check the following points before disassembly:

Idle gear end play

mm(in.)

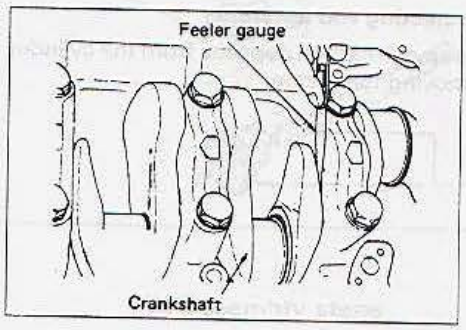
Standard	Limit
0.058 — 0.115 (0.002 — 0.005)	0.2 (0.008)



Backlash in gears (Crankshaft gear, idle gear, camshaft gear).

mm(in.)

Standard	Limit
0.10 — 0.17 (0.004 — 0.004)	0.3 (0.012)

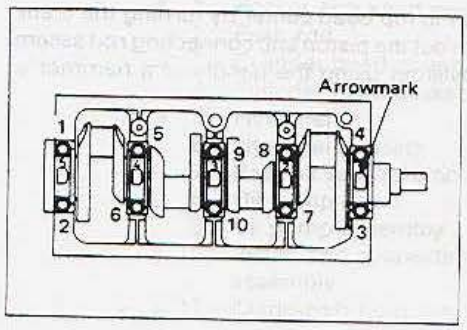


17. Crankshaft bearing cap and crankshaft bearing

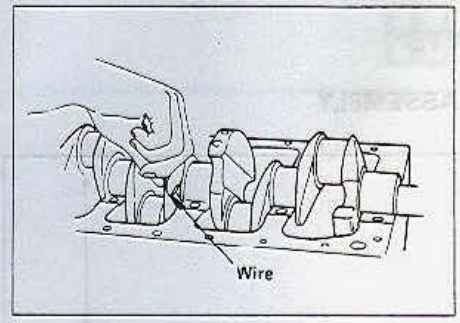
Check the crankshaft end play before disassembly.

mm(in.)

Standard	Limit
0.15 — 0.33 (0.006 — 0.013)	0.45 (0.018)

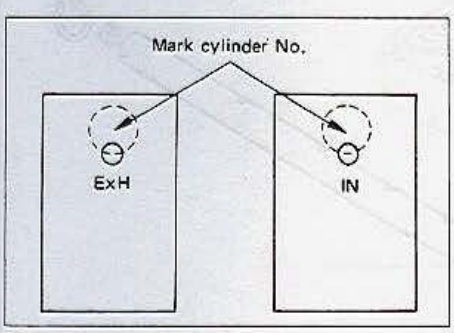


Loosen the crankshaft bearing cap bolts in unmerical order.



18. Thrust bearing

Remove the thrust bearing using a wire.

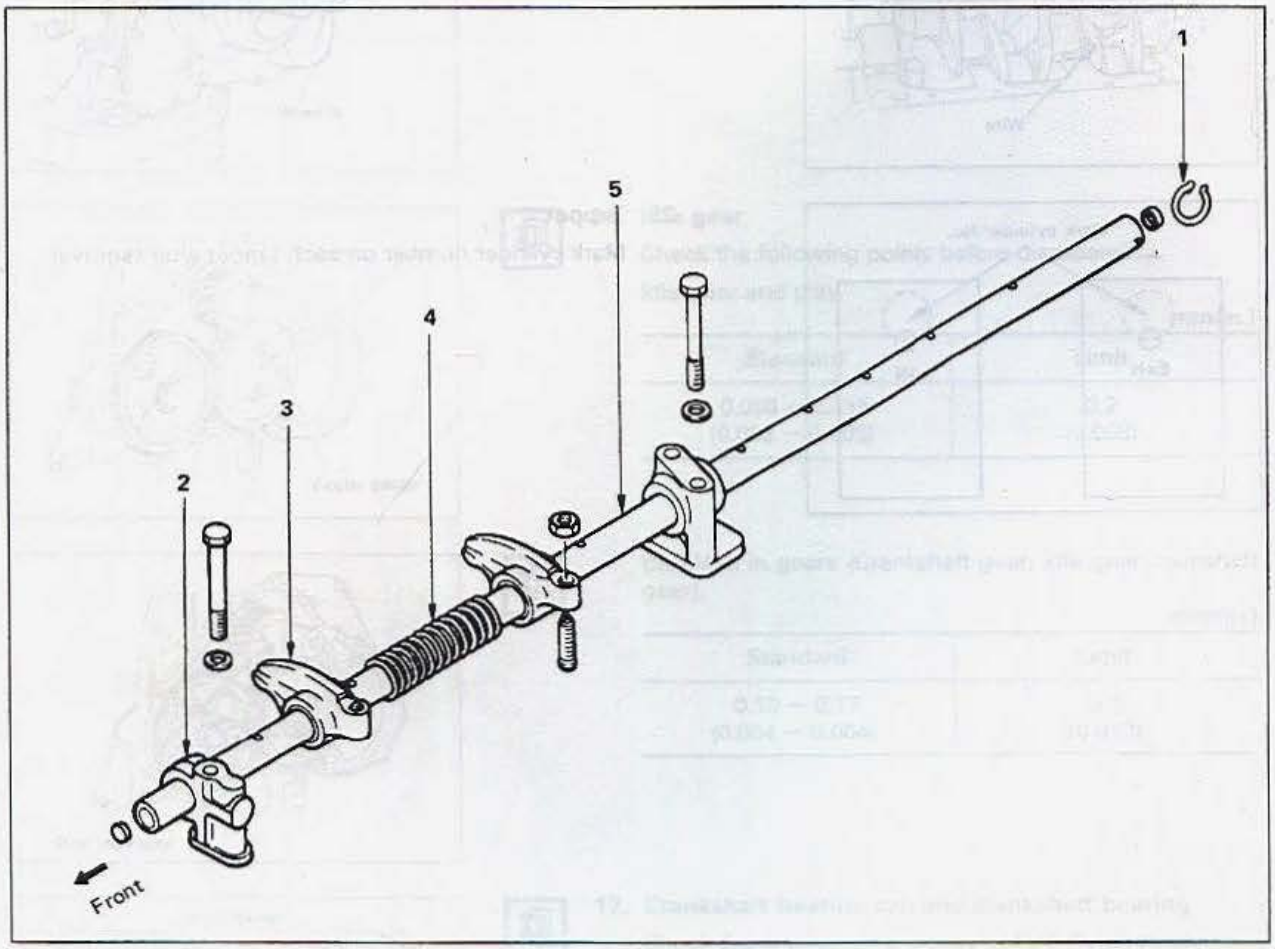


21. Tappet

Mark cylinder number on each tappet after removal.

MINOR COMPONENTS

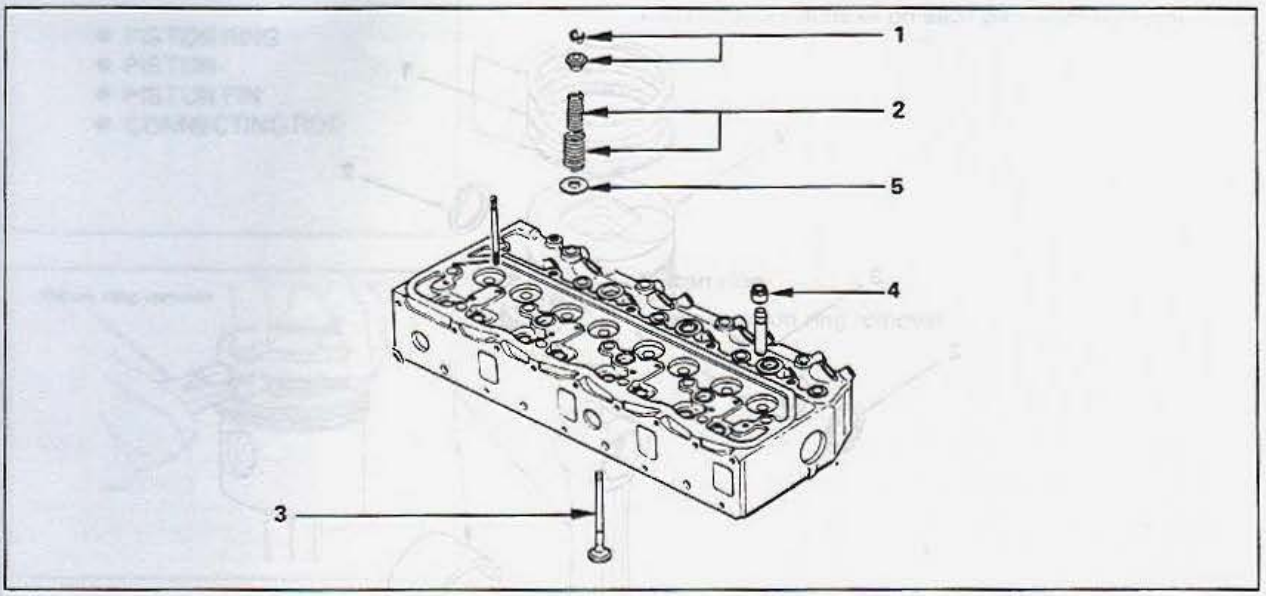
ROCKER ARM, BRACKET AND SHAFT ASSEMBLY



Disassembly steps

1. Snap ring
2. Bracket
3. Rocker arm
4. Spring
5. Rocker arm shaft

CYLINDER HEAD ASSEMBLY



Disassembly steps

▲ 1. Spring cap and split key
2. Spring
3. Valve
4. Valve stem oil seal
5. Spring seat

- VALVE SPRING
- VALVE
- VALVE SEAT

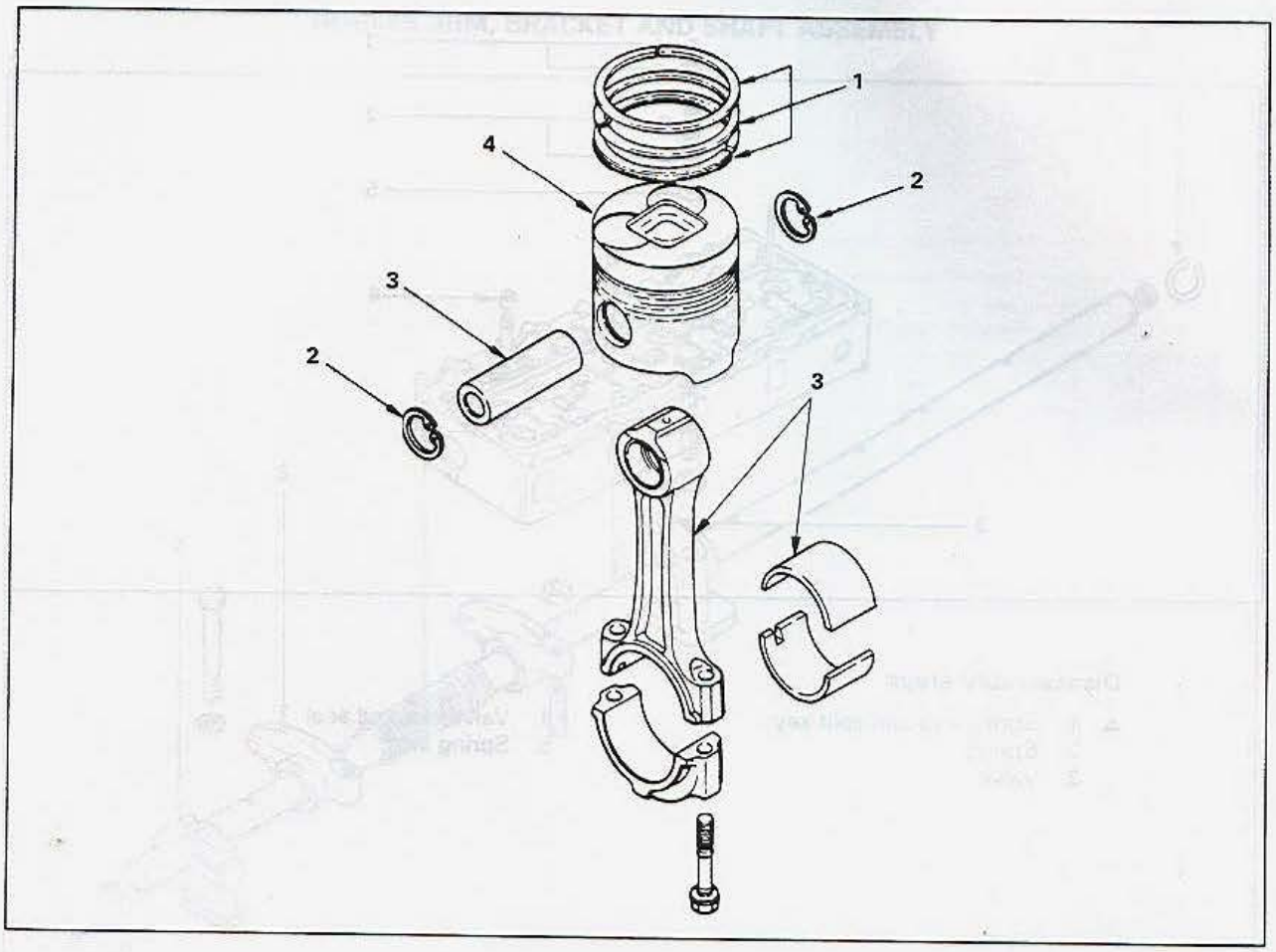
Important operations

Mark cylinder number on each part after removal.

1. Spring cap and split key

Valve spring compressor : 9-8523-14260

PISTON AND CONNECTING ROD ASSEMBLY



Disassembly steps

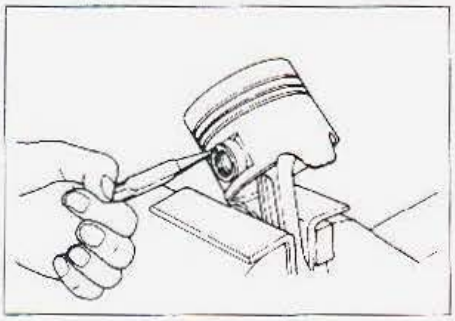
- ▲ 1. Piston ring
- ▲ 2. Snap ring
- ▲ 3. Piston pin, connecting rod and bearing
- 4. Piston

- PISTON RING
- PISTON
- PISTON PIN
- CONNECTING ROD

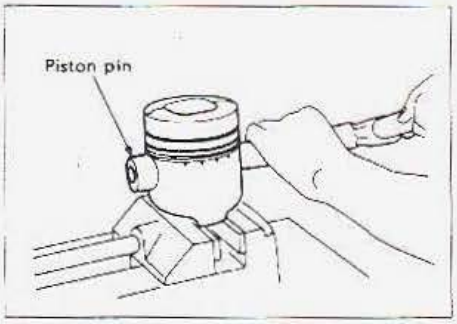
Important operations

Mark cylinder number on each part after removal.

1. **Piston ring**
   Using a piston ring remover



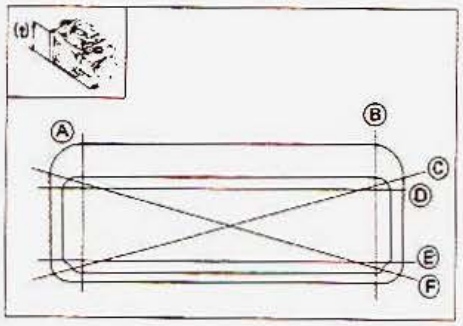
2. **Snap ring**
   Using a snap ring remover.



3. **Piston pin and connecting rod**
   Drive out using a brass rod under normal temperature.

INSPECTION AND REPAIR

Make necessary correction or parts replacement if wear, damage or any other abnormal conditions are found through inspection.



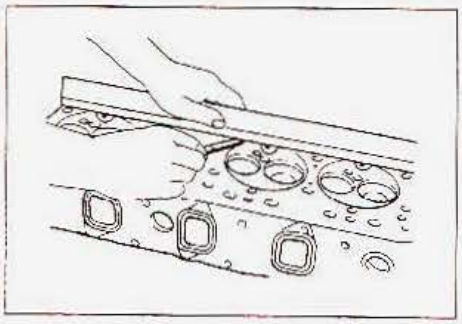
CYLINDER HEAD AND BODY

Distortion at mating face.

Check in six (6) different directions (A — F) using a straight edge and feeler gauge.

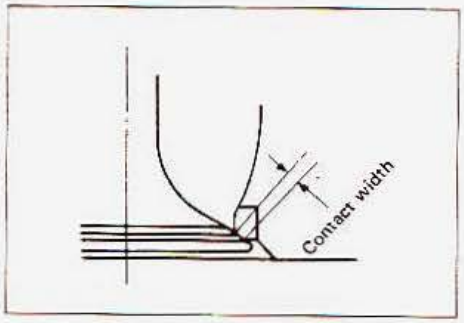
Distortion mm(in.)

Standard	Limit
0.05 (0.020) or less	0.2 (0.08) or less



When the distortion exceecs specified limit, regrind the mating surface within specified limit.
Regrind amount

Limit	mm(in.)	0.30 (0.012)

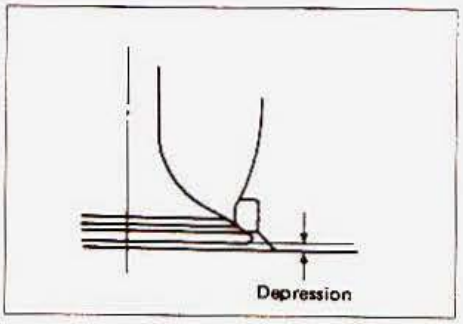


VALVE, VALVE GUIDE AND VALVE SEAT INSERT

Contact width

mm(in.)

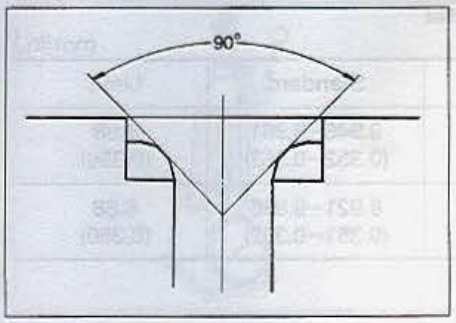
Standard	Limit
1.5 (0.059)	2.0 (0.079)



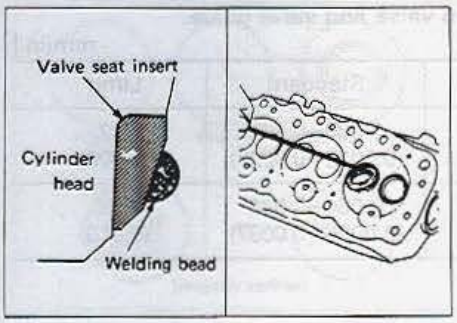
Depression

mm(in.)

Standard	Limit
1.0 (0.039)	2.5 (0.099)



Valve seat angle

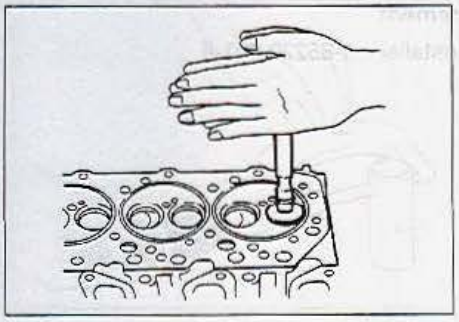


Valve seat insert replacement

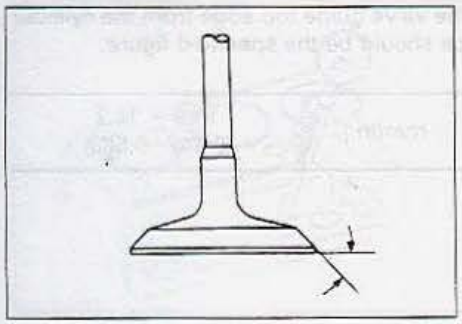
Removal :
Arc-weld excess metal around the inner face of insert and allow to cool off a few minutes, then pry off with a screw driver.

Installation :

Press a new valve seat insert into the bore using a bench press.



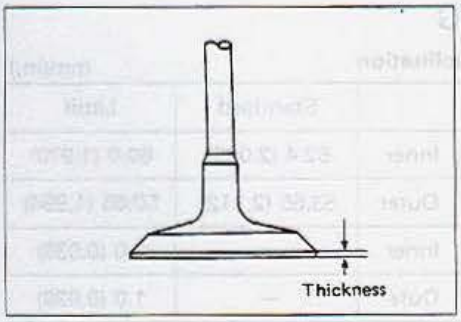
After installation of the valve seat insert, grind finish the seating face with a seat grinder carefully noting the seating angle, contact width and depression. Lap the valve and seat as the final step.



Valve seating angle

(degree)

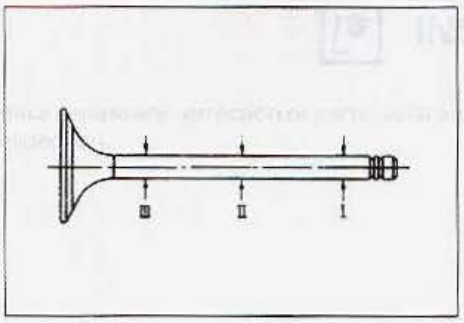
Intake valve	45°
Exhaust valve	45°



Valve head thickness

mm(in.)

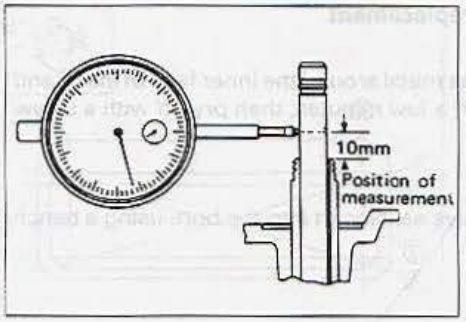
Standard	Limit
1.5 (0.059)	1.0 (0.039)



Valve stem diameter

mm(in.)

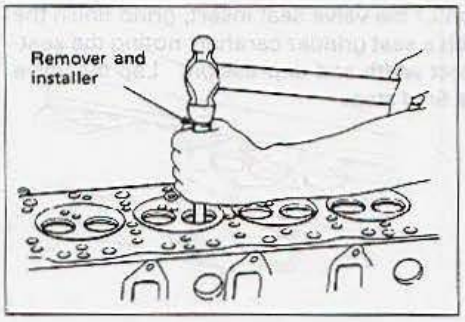
	Standard	Limit
Intake	8.946—8.961 (0.352—0.353)	8.88 (0.350)
Exhaust	8.921—8.936 (0.351—0.352)	8.88 (0.350)



Clearance between valve and valve guide.

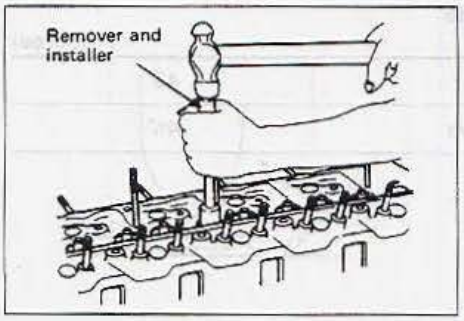
mm(in.)

	Standard	Limit
Intake	0.039—0.068 (0.0015—0.0027)	0.2 (0.008)
Exhaust	0.064—0.093 (0.0025—0.0037)	0.25 (0.010)



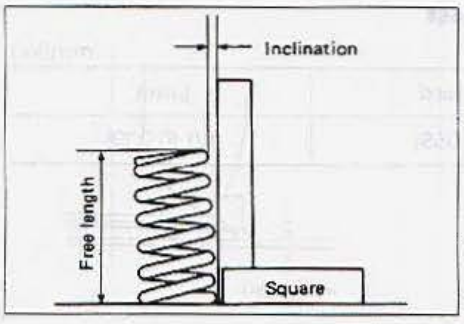
Valve guide replacement

Remover and installer : 1-85220-001-0



The height of the valve guide top edge from the cylinder head upper face should be the specified figure.

Height	mm(in.)	13.9 — 14.3 (0.547—0.563)

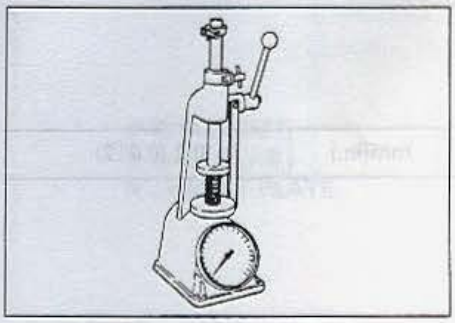


VALVE SPRING

Free length and inclination

mm(in.)

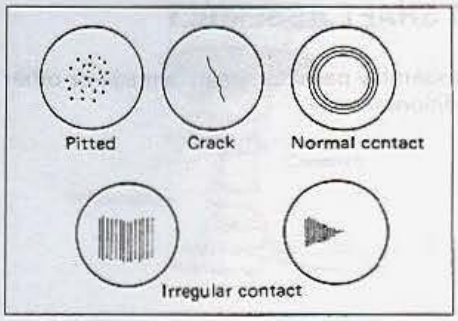
		Standard	Limit
Free length	Inner	52.4 (2.065)	50.0 (1.970)
	Outer	53.65 (2.112)	50.65 (1.994)
Inclination	Inner	—	1.0 (0.039)
	Outer	—	1.0 (0.039)



Tension

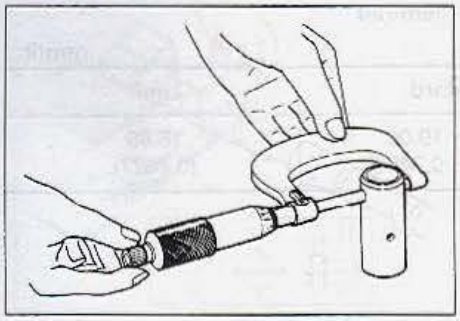
kg(lbs.)

	Set length	Standard	Limit
Inner	42.0 mm (1.65 in.)	10.9 (24.03)	9.9 (21.83)
Outer	44.0 mm (1.73)	23.0 (50.72)	20.0 (44.10)



TAPPET

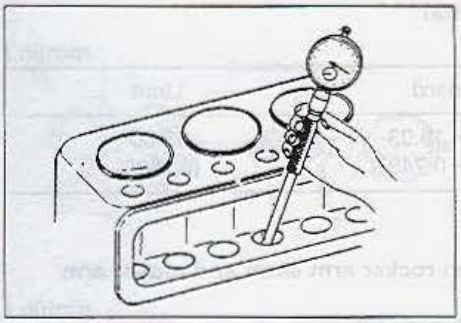
Inspect tappets for wear, damage or other abnormal conditions.



Diameter

mm(in.)

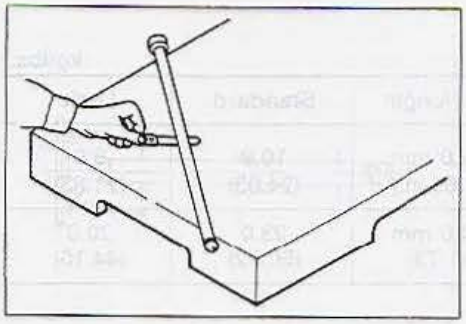
Standard	Limit
27.97 — 27.98 (1.1020 — 1.1024)	27.92 (1.1000)



Clearance between tappet and body.

mm(in.)

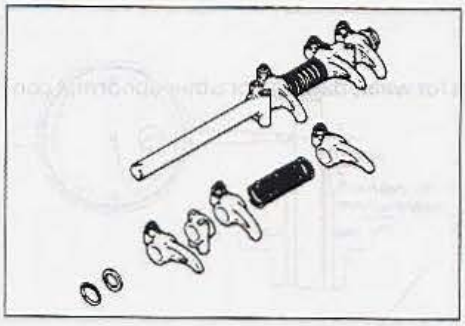
Standard	Limit
0.02 — 0.054 (0.0007 — 0.0021)	0.1 (0.0039)



PUSH ROD

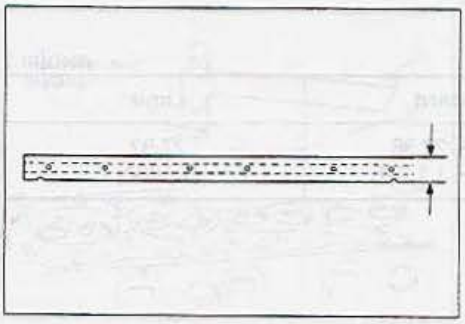
Run-out

Limit	mm(in.)	0.3 (0.012)



ROCKER ARM SHAFT ASSEMBLY

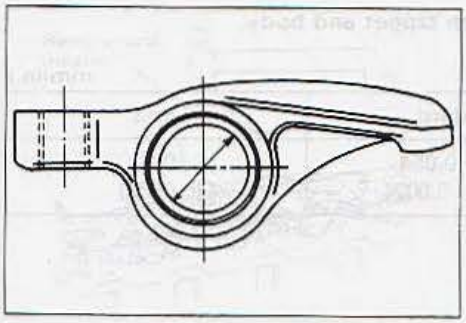
Inspect all disassembly parts for wear, damage or other abnormal conditions.



Rocker arm shaft diameter

mm(in.)

Standard	Limit
18.98 — 19.00 (0.7478 — 0.7486)	18.85 (0.7427)



Rocker arm diameter

mm(in.)

Standard	Limit
19.01 — 19.03 (0.7489 — 0.7497)	19.05 (0.7505)

Clearance between rocker arm shaft and rocker arm

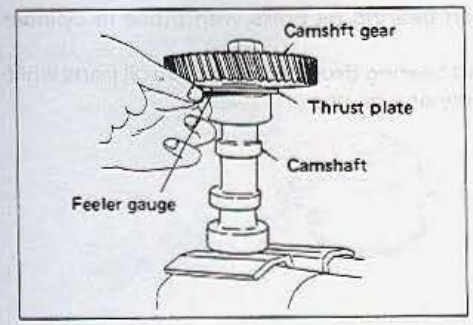
mm(in.)

Standard	Limit
0.014 — 0.062 (0.00055 — 0.0024)	0.2 (0.0079)

CAMSHAFT ASSEMBLY

- CAMSHAFT
- CAM GEAR
- THRUST PLATE

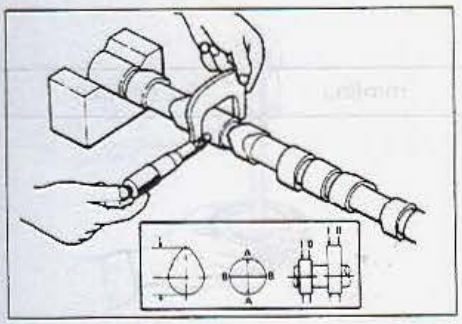
Inspect all disassembly parts for wear, damage or other abnormal conditions.



End play

mm(in.)

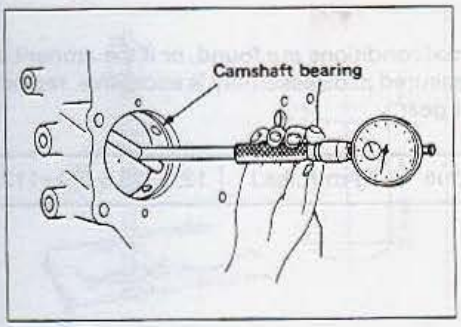
Standard	Limit
0.050 — 0.114 (0.0002 — 0.0045)	0.2 (0.0079)



Camshaft journal diameter

mm(in.)

Standard	Limit
55.94 — 55.97 (2.2040 — 2.2052)	55.60 (2.1906)



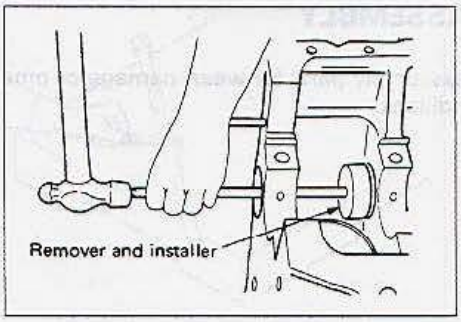
Camshaft bearing inside diameter

Standard	mm(in.)	56.00 — 56.03 (2.2064—2.2076)

Clearance between camshaft journal and bearing

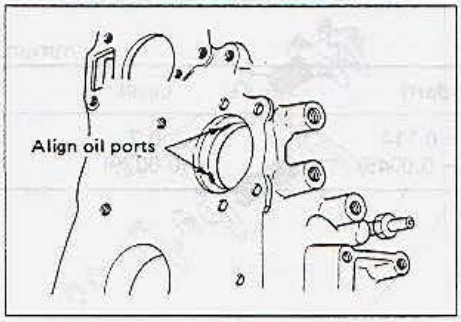
mm(in.)

Standard	Limit
0.03 — 0.09 (0.0012 — 0.0035)	0.15 (0.0059)

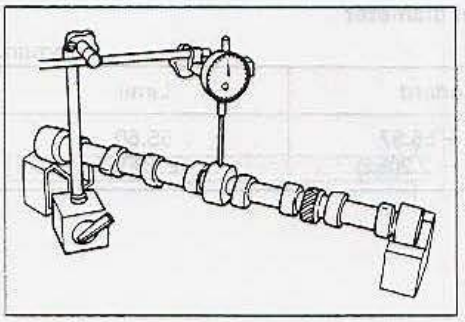


Camshaft bearing replacement

Remover & intaller : 9-8523-1818-0



Align camshaft bearing oil ports with those in cylinder body.
No. 1 camshaft bearing (front side) has two oil ports while other have only one oil port.



Run-out

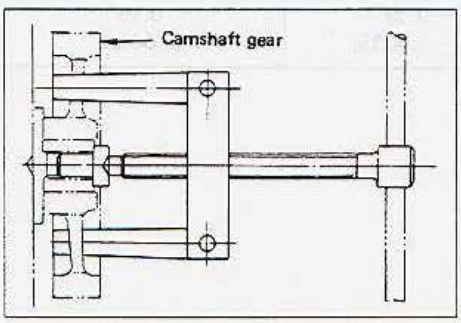
Limit	mm(in.)	0.1 (0.0039)

Refer to "DISASSEMBLY OF MAJOR COMPONENT" for the backlash measurement.

Camshaft gear

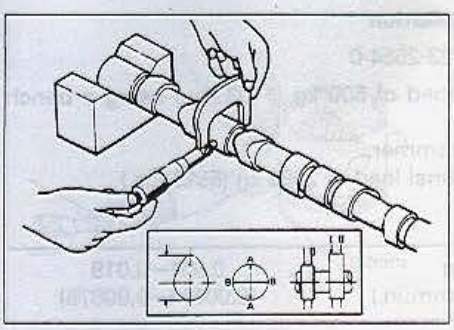
If any abnormal conditions are found, or if the amount of back-lash measured at disassembly is excessive, replace the camshaft gear.

Gear bolt torque	kg·m(ft.lbs.)	12.5—15.5 (90—112)



Gear and thrust plate replacement

Removal : 5-8840-0086-0
Installation : Use a bench press or a hammer.

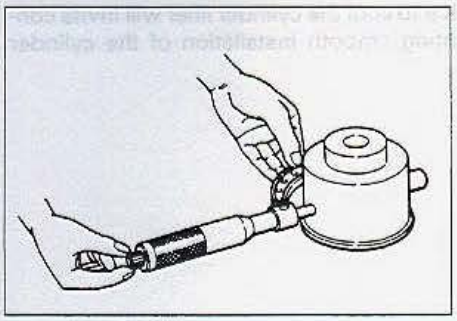


Cam lobe height

mm(in.)

Standard	Limit
47.7 (1.879)	46.5 (1.832)

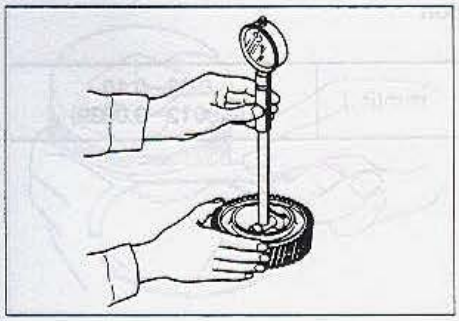
IDLE GEAR AND IDLE GEAR SHAFT



Shaft outside diameter

mm(in.)

Standard	Limit
44.94—44.97 (1.7706—1.7718)	44.84 (1.7667)

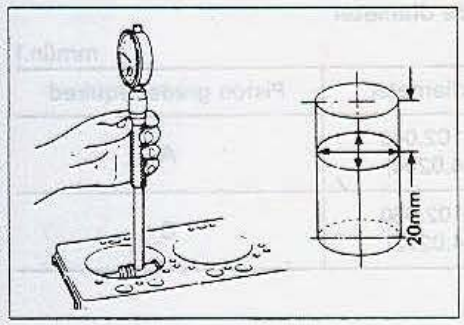


Clearance between shaft and gear

mm(in.)

Standard	Limit
0.009—0.060 (0.00035—0.0024)	0.2 (0.0079)

CYLINDER LINER

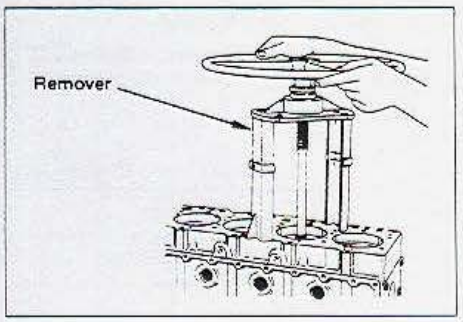


Cylinder liner inside diameter

Measuring point : Approx. 20 mm below top end.

mm(in.)

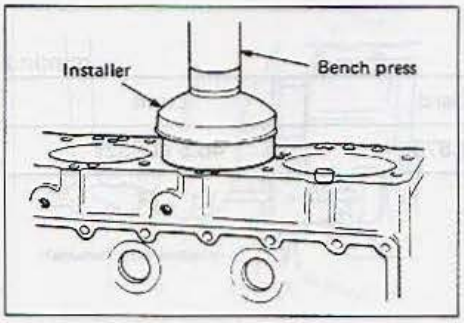
Standard	Limit
102.021—102.060 (4.0196—4.0212)	102.2 (4.0267)



Cylinder liner removal

Remover : 9-8523-1169-0

Remover ankle : 9-8523-2557-0



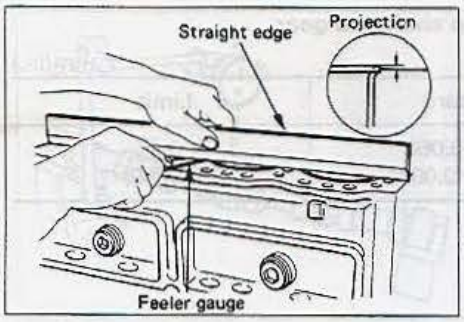
Cylinder liner installation

Installer : 9-8523-2554-0

First, apply a load of 500 kg (1103 lbs.) using a bench press.
Do not use a hammer.
Then, apply a final load of 2500 kg (5513 lbs.).

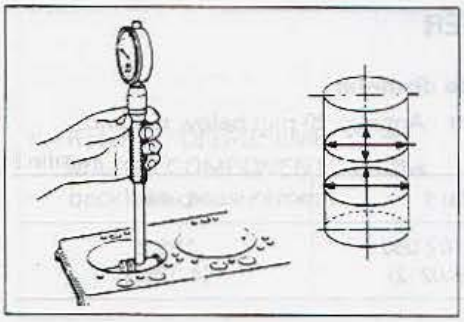
Standard fitting interference mm(in.)	0.001—0.019 (0.00004—0.00075)

The use of dry ice to cool the cylinder liner will invite contraction, facilitating smooth installation of the cylinder liner.



Amount of projection

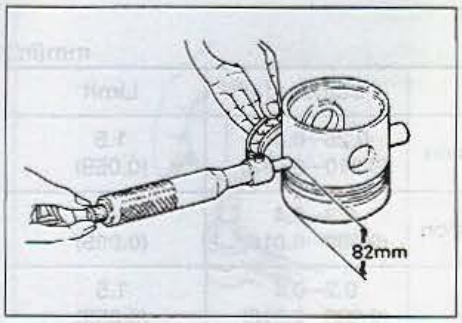
Standard	mm(in.)	0.03—0.10 (0.0012—0.0039)



Cylinder liner inside diameter

mm(in.)

Minimum diameter	Piston grade required
102.021—102.040 (4.0196—4.0204)	A
102.041—102.060 (4.0204—4.0212)	C



PISTON, PISTON PIN AND PISTON RING

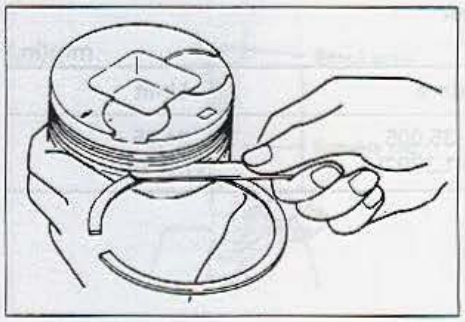
Piston diameter

mm(in.)

Piston grade	
A	101.955—101.974 (4.0140—4.0147)
C	101.975—101.994 (4.0148—4.0155)

Piston clearance

Standard	mm(in.)	0.057—0.075 (0.0022—0.0030)



Piston ring

Clearance between piston ring and ring groove.

4BD1 model

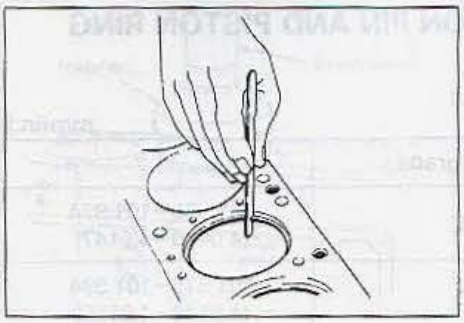
mm(in.)

	Standard	Limit
1st compression	0.085—0.11 (0.0033—0.0043)	0.2 (0.008)
2nd compression	0.030—0.055 (0.0012—0.0022)	0.15 (0.006)
Oil	0.03—0.07 (0.001—0.003)	0.15 (0.006)

4BD1-T model

mm(in.)

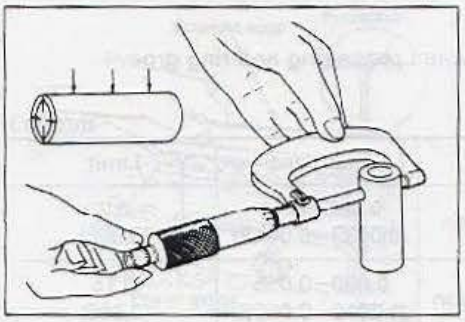
	Standard	Limit
1st compression	0.105—0.13 (0.0041—0.0051)	0.2 (0.008)
2nd compression	0.040—0.075 (0.0016—0.0030)	0.15 (0.006)
Oil	0.03—0.07 (0.001—0.003)	0.15 (0.006)



Piston ring gap

mm(in.)

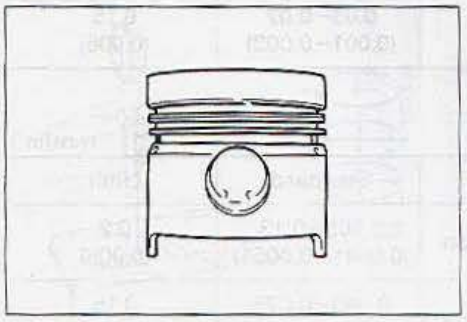
	Standard	Limit
1st compression	0.25—0.45 (0.010—0.018)	1.5 (0.059)
2nd compression	0.2—0.4 (0.008—0.016)	1.5 (0.059)
Oil	0.2—0.4 (0.008—0.016)	1.5 (0.059)



Piston pin diameter

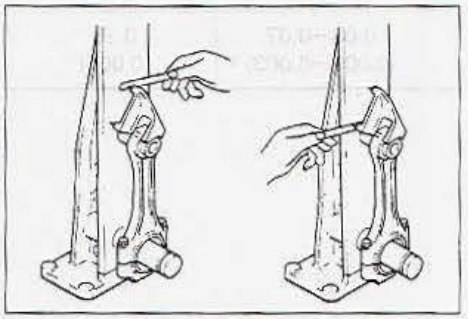
mm(in.)

Standard	Limit
35.000—35.005 (1.3790—1.3792)	34.95 (1.3770)



Interference between piston pin and piston pin hole.

Clearance	mm(in.)	0.005 (0.0002) or less



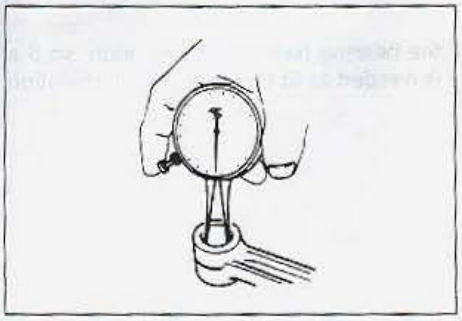
CONNECTING ROD AND BEARING

Distortion or misalignment

Connecting rod aligner.

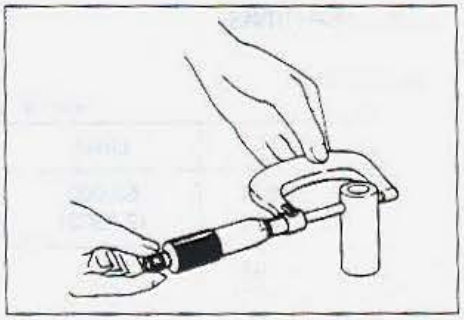
(per 100 mm)mm(in.)

Standard	Limit
0.05 (0.0002) or less	0.2 (0.0079)



Bushing inside diameter

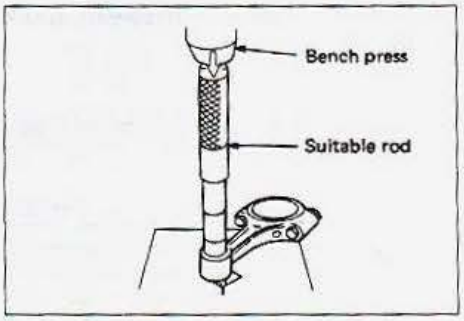
Standard	mm(in.)	35.017—35.025 (1.3797—1.3800)



Clearance between piston pin and connecting-rod.

mm(in.)

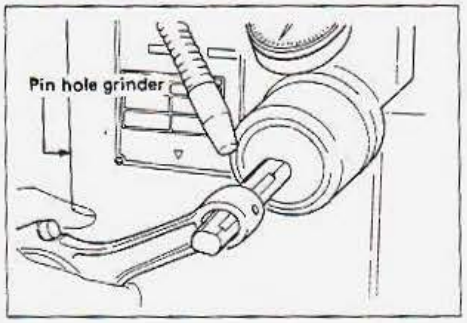
Standard	Limit
0.012—0.025 (0.00047—0.00098)	0.05 (0.0002)



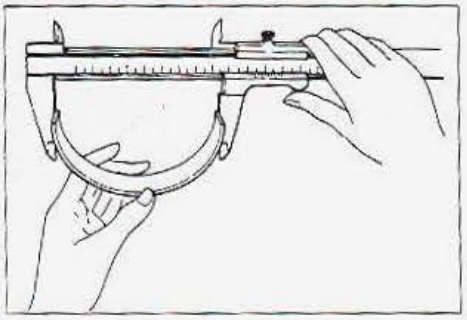
Bushing replacement

Removal : Use a suitable bar and bench press or hammer.

Installation : Use a suitable bar and bench press.

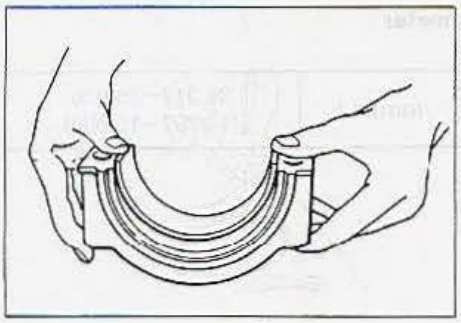


After installing a new bushing, finish the bushing bore with a pin hole grinder.



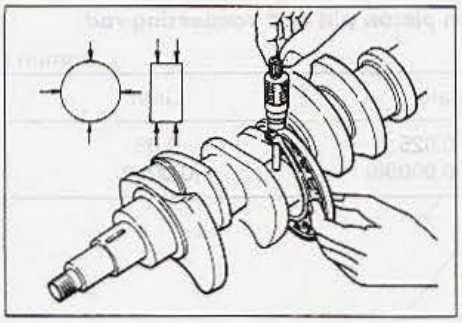
Bearing spread

Limit	mm(in.)	68.0 (2.68)



Tension

Check to see if the bearing has enough tension, so that finger pressure is needed to fit the bearing into position.

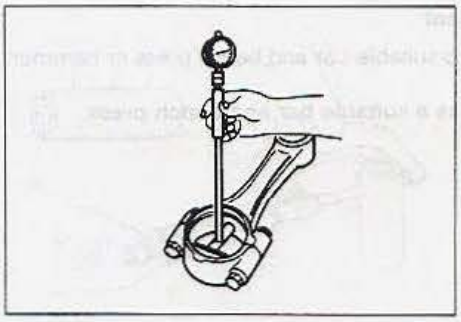


CRANKSHAFT AND BEARING

Crankshaft pin outside diameter

mm(in.)

	Standard	Limit
4BD1	63.932—63.944 (2.5189—2.5194)	63.000 (2.4803)
4BD1-T	63.924—63.944 (2.5167—2.5175)	—



Procedure for measuring the clearance between crank shaft pin and connecting rod.

Install bearings and cap
Tighten the connecting rod bearing cap bolts to the specified angle.

mm(in.)

	1st step kg·m(ft.lbs.)	2nd step (degree)
Torque	4.0 (29)	60° — 90°

Inside diameter

Apply engine oil to bearing, then measure the connecting rod big end inside diameter.

Nominal diameter	mm(in.)	64 φ (2.52)

Clearance between crankshaft pin and connecting rod.

mm(in.)

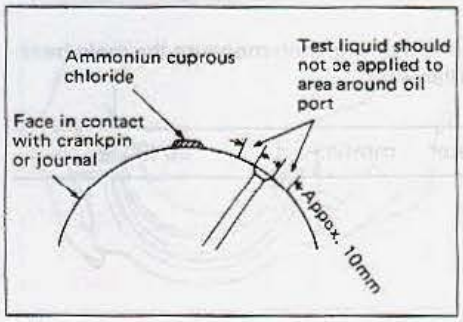
	Standard	Limit
4BD1	0.030—0.073 (0.0012—0.0029)	0.10 (0.004)
4BD1-T	0.030—0.081 (0.0012—0.0032)	

Crankshaft for 4BD1-T engine can not be reground because it is finished with tufftride method.
For the crankshaft on 4BD1-T, no attempt should be made to grind finish the faces of the journals and crankpins as they are tufftrided (Special hardening teatment).
Therefore, the undersize bearings are not prepared.

Except 4BD1-T

mm(in.)

Under size bearing availability for crankshaft regrinding mm(in.)	0.25, 0.50, 0.75, 1.00 (0.010, 0.020, 0.030, 0.040)



Crankshaft Tufftriding

Inspection

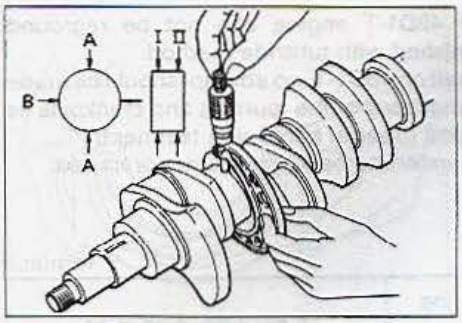
1. Use an organic cleaner to thoroughly clean the crankshaft. There must be no traces of oil on the surfaces to be inspected.
2. Prepare a 5 — 10% solution of ammonium cuprous chloride (dissolved in distilled water).
3. Use a spot glass rod to apply the solution to the surface to be inspected.
   Hold the surface to be inspected perfectly horizontal to prevent the solution from running.

Note: Do not allow the solution to come in contact with the oil ports and their surrounding area.

Judgement

1. Wait for thirty to forty seconds.
   If there is no discoloration after thirty or forty seconds, the crankshaft is useable.
   If discoloration appears (the surface being tested will become the color of copper), the crankshaft must be replaced.
2. Clean the surface being tested with clean water of steam immediately after completing the test.

Note: The ammonium cuprous chloride solution is highly corrosive. Because of this, it is imperative that the surfaces being tested be cleaned immediately after completing the test.



Crankshaft journal outside diameter

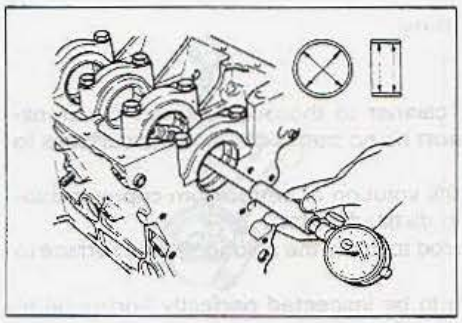
mm(in.)

	Standard	Limit
4BD1	79.913—79.925 (3.1462—3.1467)	79.000 (3.1102)
4BD1-T	79.905—79.925 (3.1459—3.1467)	—

Procduer for measuring the clearance between crank shaft journal and crankshaft bearing cap.

Install bearings and cap

Torque	kg·m(ft.lbs.)	23—25 (166—181)



Inside diameter

Apply engine oil to bearing, then measure the main bearing cap inside diameter.

Nominal diameter	mm(in.)	80 (3.15)

Clearance between crankshaft journal and bearing.

mm(in.)

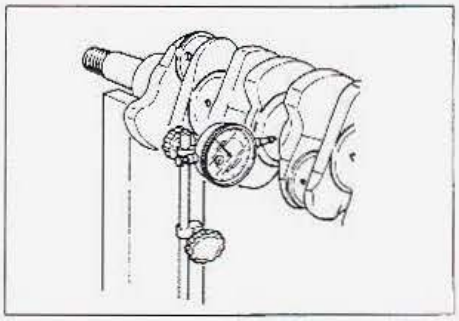
	Standard	Limit
4BD1	0.039—0.090 (0.0015—0.0035)	0.11 (0.0043)
4BD1-T	0.025—0.076 (0.0010—0.0030)	

Crankshaft for 4BD1-T engine can not be reground because it is finished with tufftride method.
For the crankshaft on 4BD1-T, no attempt should be made to grind finish the faces of the journals and crankpins as they are tufftrided (Special hardening teatment).
Therefore, the undersize bearings are not prepared.

Except 4BD1-T

mm(in.)

Under size bearing availability for crankshaft regrinding mm(in.)	0.25, 0.50, 0.75, 1.00 (0.010, 0.020, 0.030, 0.040)

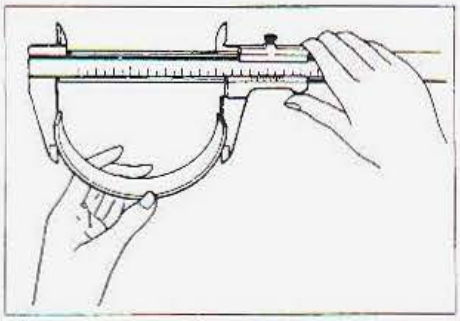


Run-out

mm(in.)

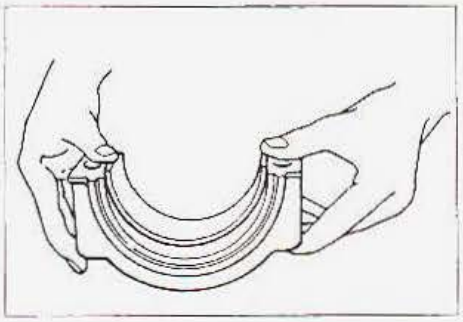
Standard	Limit
0.05 (0.020) or less	0.30 (0.012)

If the crankshaft generated crack after repair, replace the crankshaft.
Crankshaft for 4BD1-T engine can not be bench pressed, because it is finished with tufftride method.



Bearing spread

Limit	mm(in.)	85.0 (3.35)



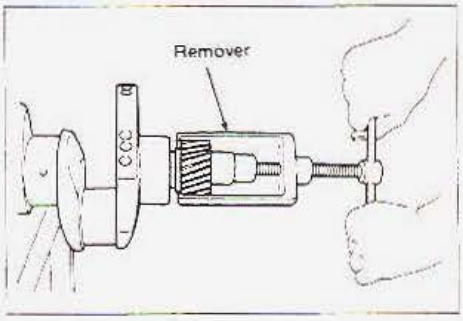
Tension

Check to see if the bearing has enough tension, so that finger pressure is needed to fit the bearing into position.

Refer to "DISASSEMBLY OF MAJOR COMPONENTS" for the backlash measurement.

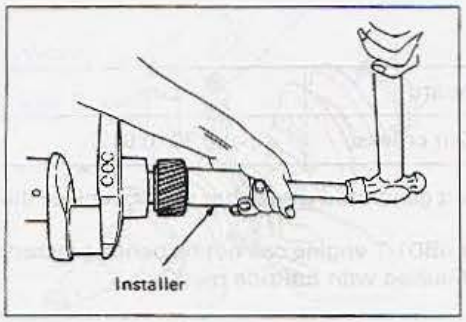
Crankshaft gear

If any abnormal conditions are found, or if the amount of backlash measured at disassembly is excessive, replace the crankshaft gear.

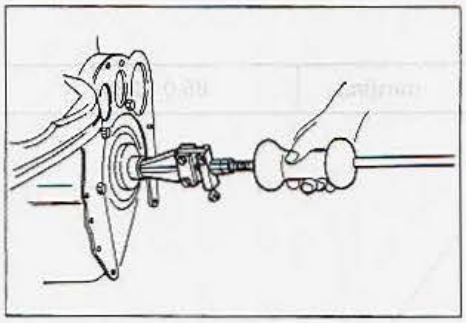


Crankshaft gear replacement

Removal ; Remover : 9-8521-0141-0



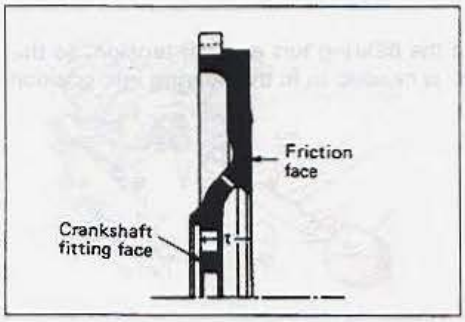
Installation ; Installer : 9-8522-0033-0



Pilot bearing replacement

Removal ; Remover : 9-8523-1812-0

Installation ; Installer : 5-8522-0024-0

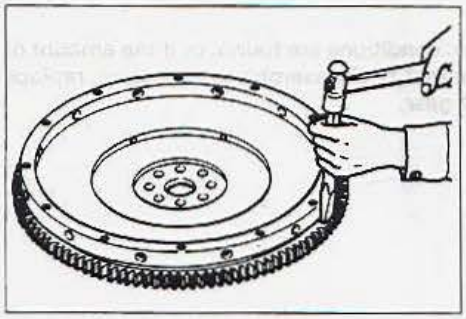


FLYWHEEL AND HOUSING (REAR OIL SEAL)

Thickness

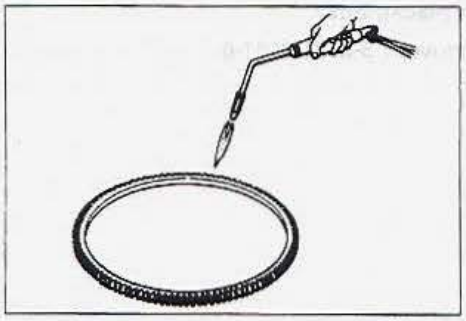
mm(in.)

Standard	Limit
30.9—31.1 (1.217—1.225)	30 (1.182)

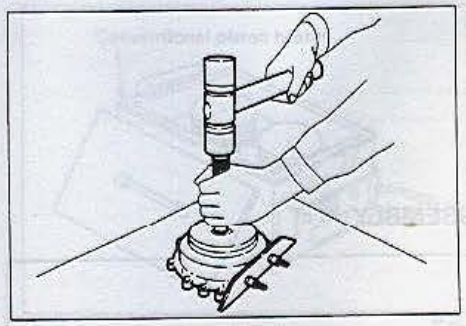


Ring gear replacement

Removal ; Use a suitable brass rod and a hammer.

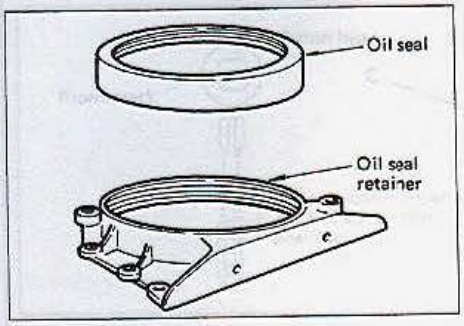


Installation ;
With a gas burner, heat the ring gear until heat expansion takes place, then install it using a hammer.

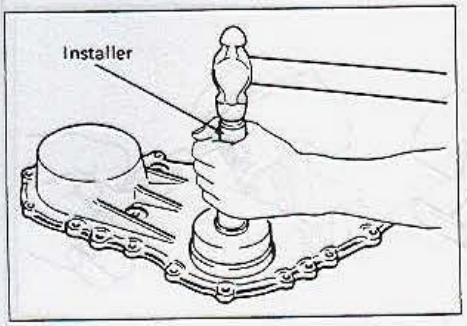


Oil seal replacement

Removal ; pry off or pull out.
Installation ;
Installer : 9-8522-1254-0



When the crankshaft face in contact with the oil seal is worn, the contact portion on the crankshaft can be changed by driving into the deeper position.



GEAR CASE COVER

Oil seal replacement

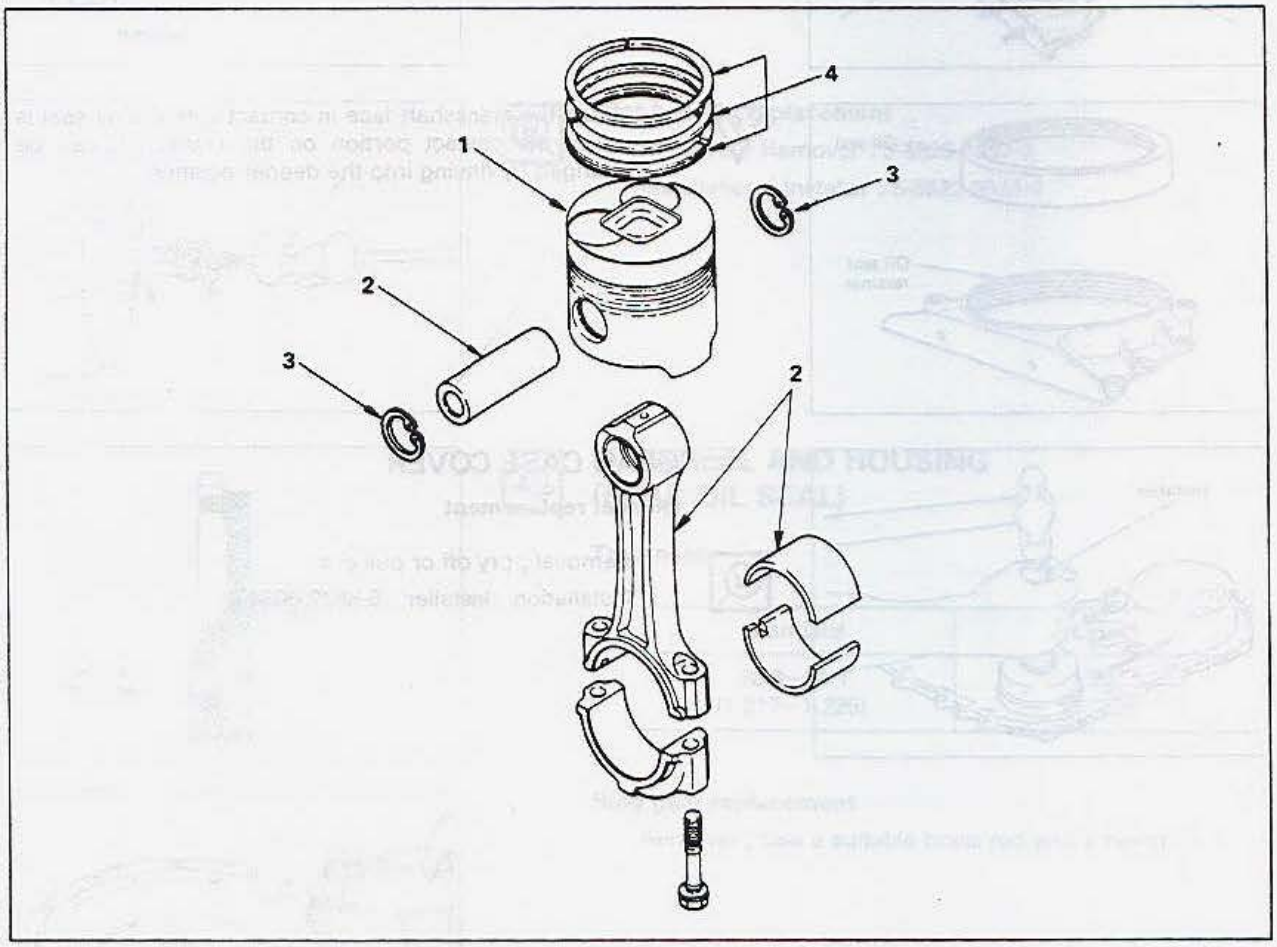
Removal ; pry off or pull out.
Installation ; Installer : 9-8522-0034-0

REASSEMBLY

INTERNAL PARTS

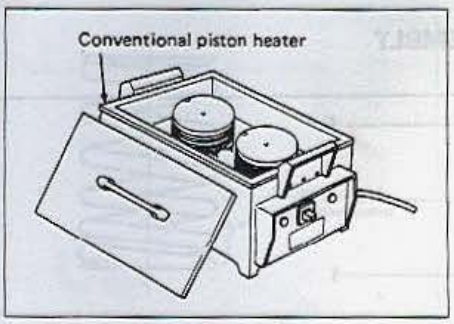
MINOR COMPONENTS

PISTON AND CONNECTING-ROD ASSEMBLY



Reassembly steps

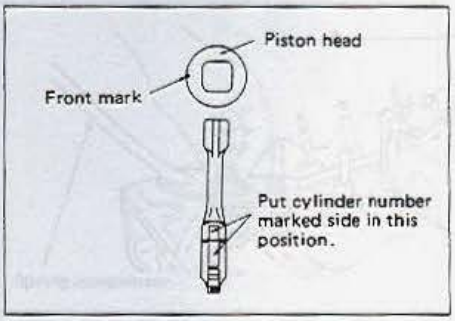
- ▲ 1. Piston
- ▲ 2. Piston pin, connecting-rod and bearing
- ▲ 3. Snap ring
- ▲ 4. Piston ring



Important operations

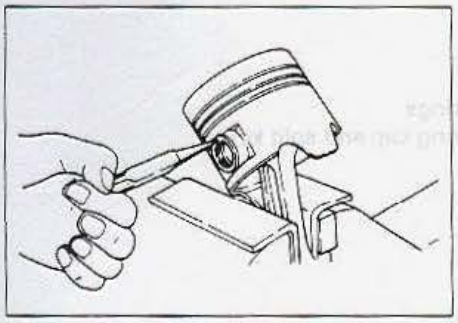
1. Piston

Heat the piston to about 60°C using a piston heater or equivalent.



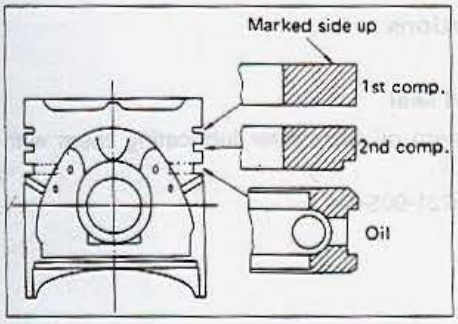
2. Piston pin and connecting rod

Refer to the alignment instructions given in the left figure.



3. Snap ring

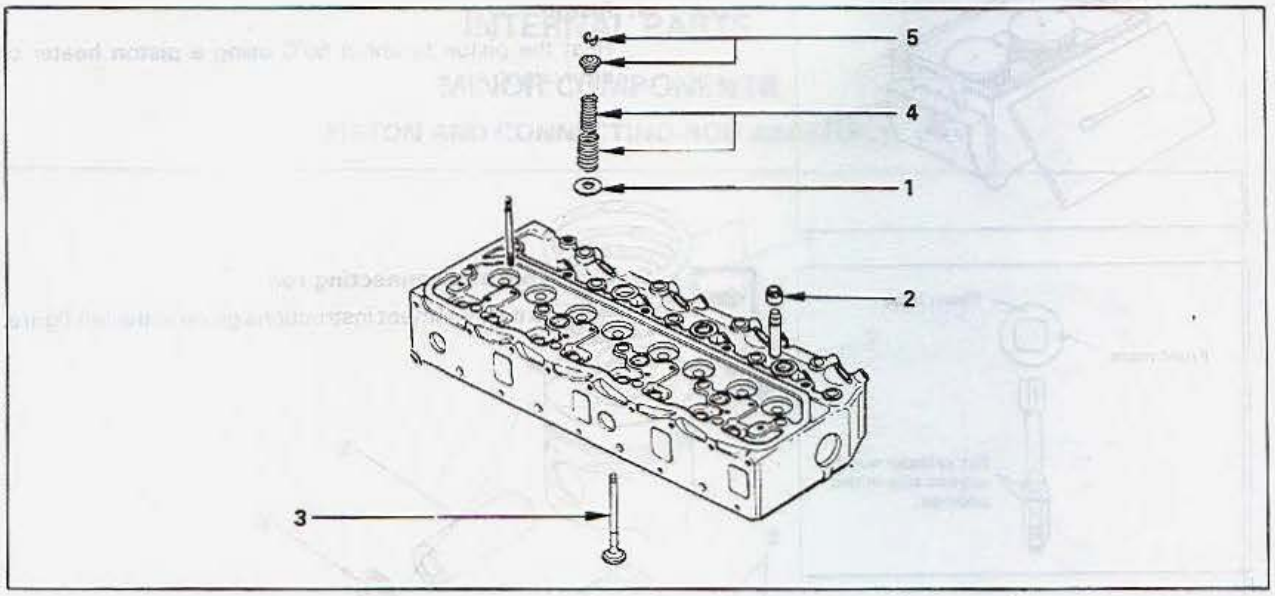
Install the snap ring using a snap ring installer.



4. Piston ring

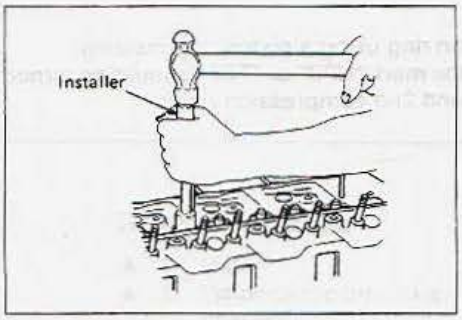
Install the piston ring using a piston ring installer.
The face with the mark "NPR" or "TOP" should be turned up for the 1st and 2nd compression rings.

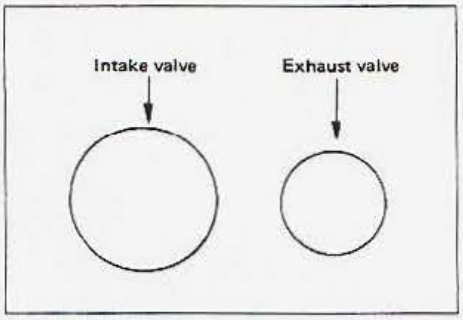
CYLINDER HEAD ASSEMBLY



Reassembly steps

1. Spring seat
▲ 2. Valve stem oil seal
▲ 3. Valve
▲ 4. Springs
▲ 5. Spring cap and split key





Important operations

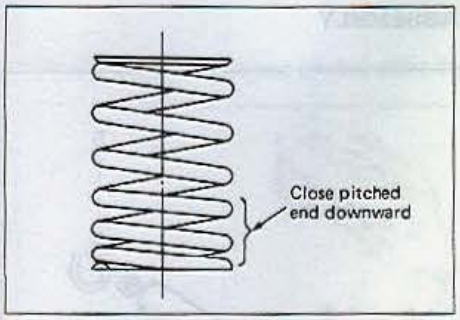
2. Valve stem oil seal

Install valve stem oil seals after lubricating them with clean engine oil.

Installer : 1-85221-005-0

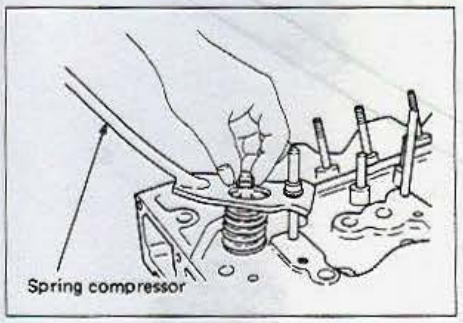
3. Valve

Install the intake and exhaust valves in the proper positions. Take care not to interchange the valves.



4. **Springs**

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

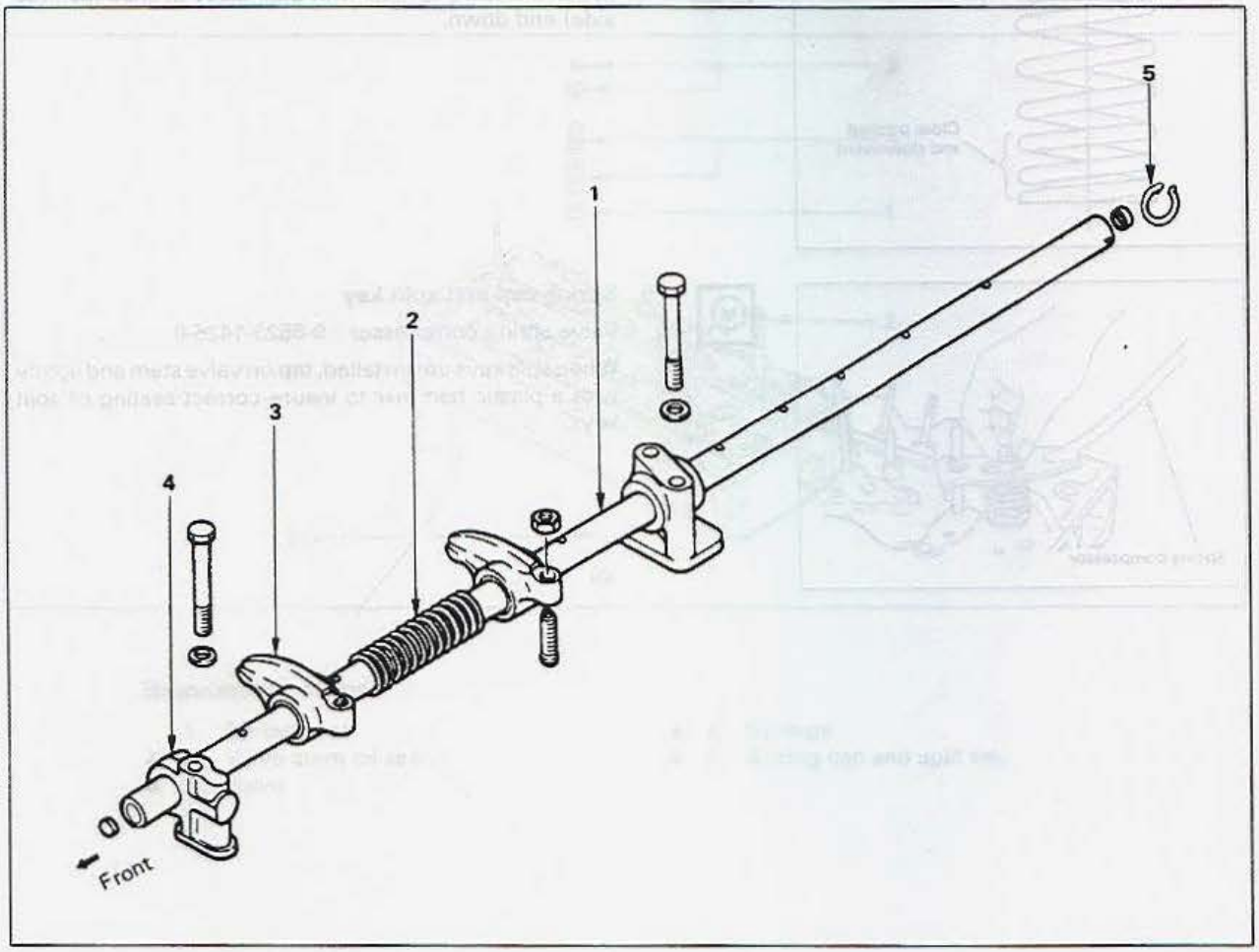


5. **Spring cap and split key**

Valve spring compressor : 9-8523-1426-0

When split keys are installed, tap on valve stem end lightly with a plastic hammer to insure correct seating of split keys.

ROCKER ARM, BRACKET AND SHAFT ASSEMBLY

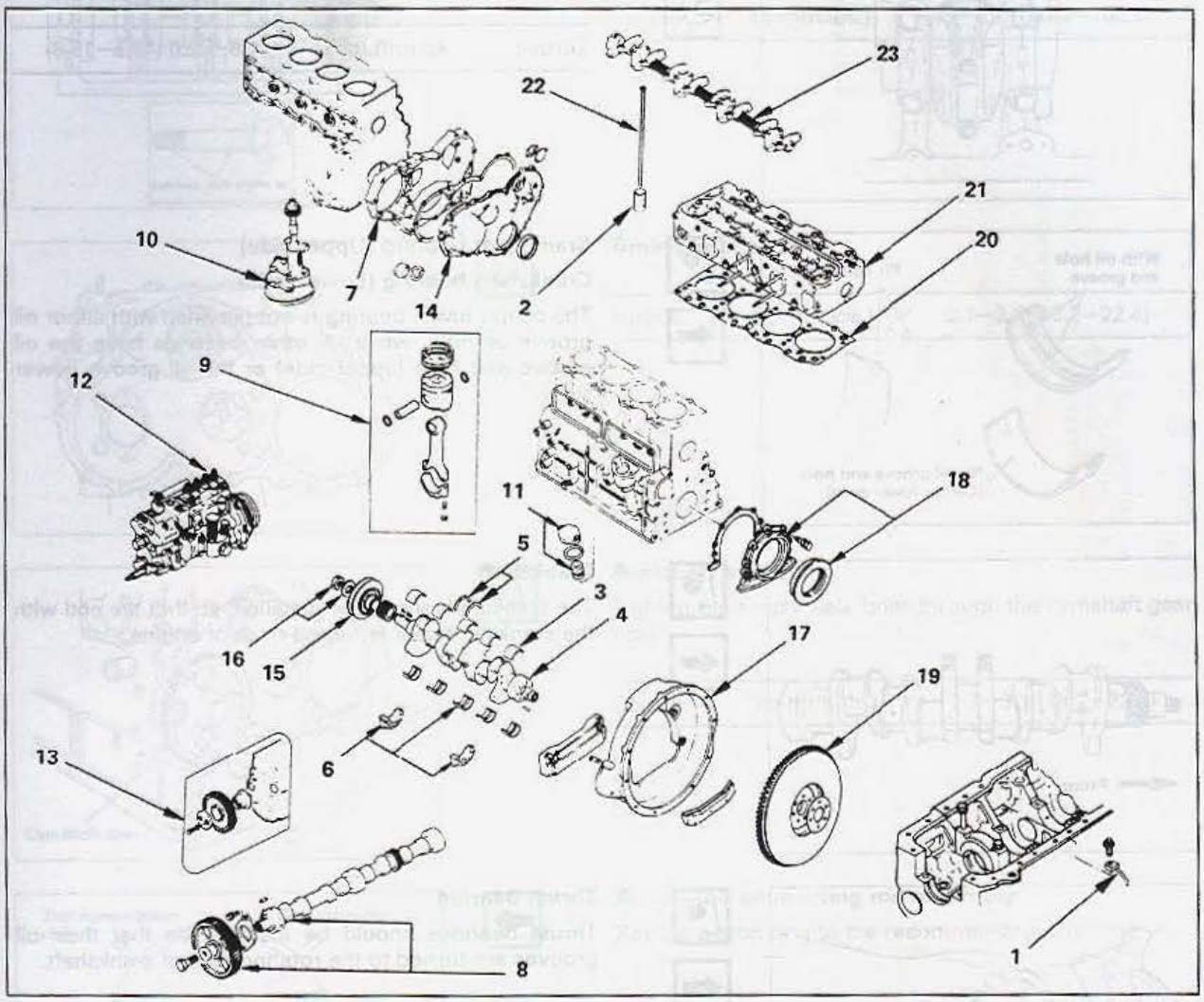


Reassembly steps

▲ 1. Rocker arm shaft
2. Spring
3. Rocker arm
4. Bracket
5. Snap ring

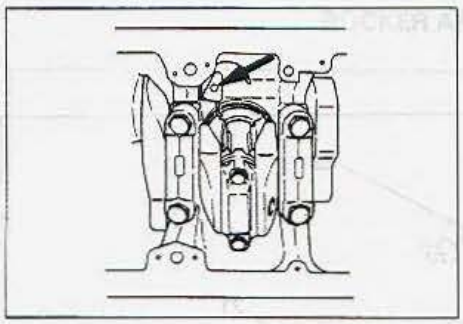
MAJOR COMPONENTS

This illustration is based on the 4BD1-T model.



Reassembly steps

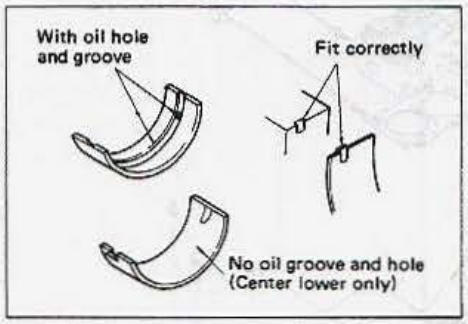
- ▲ 1. Oil jet (4BD1-T only)
- 2. Tappet
- ▲ 3. Crankshaft bearing (Upper side)
- ▲ 4. Crankshaft
- ▲ 5. Thrust bearing
- ▲ 6. Crankshaft bearing cap and crankshaft bearing (Lower side)
- ▲ 7. Timing gear case
- ▲ 8. Camshaft assembly
- ▲ 9. Piston and connecting rod assembly
- ▲ 10. Oil pump assembly
- 11. Oil pump cover
- ▲ 12. Idle gear
- 13. Timing gear case cover
- 14. Crankshaft pulley
- ▲ 15. Crankshaft front nut and washer
- ▲ 16. Flywheel housing
- ▲ 17. Rear oil seal assembly
- ▲ 18. Flywheel
- ▲ 19. Cylinder head gasket
- ▲ 20. Cylinder head assembly
- 21. Push rod
- ▲ 22. Rocker arm shaft assembly



Important operations

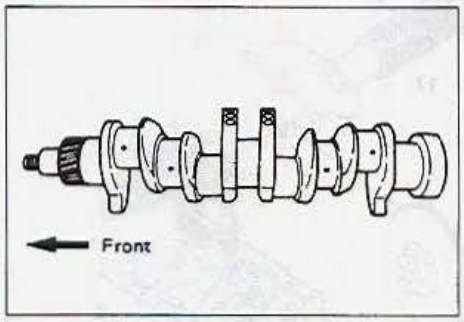
1. Oiling jet (4BD1-T only)

Torque	kg·m(ft.lbs.)	1.6 — 2.6 (11.5—18.8)



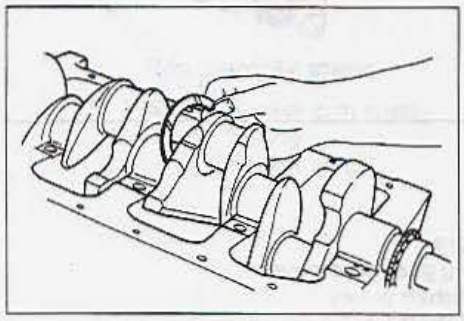
3. Crankshaft bearing (Upper side)
Crankshaft bearing (Lower side)

The center lower bearing is not provided with either oil groove or hole, while all other bearings have the oil groove and hole (upper side) or the oil groove (lower side).



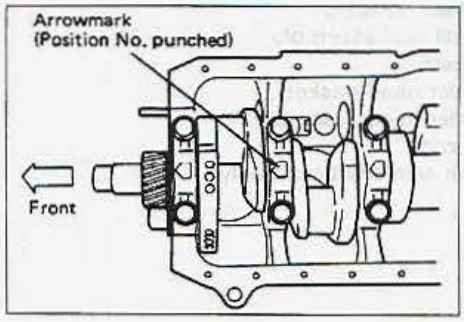
4. Crankshaft

The crankshaft should be installed, so that the end with the crankshaft gear is turned front of engine.



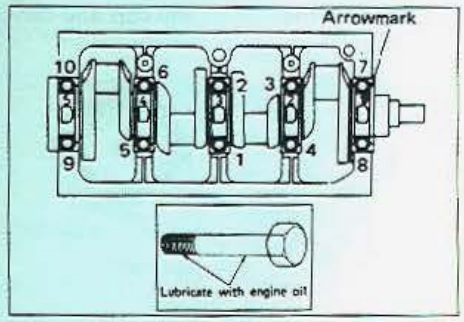
5. Thrust bearing

Thrust bearings should be installed so that their oil grooves are turned to the rotating face of crankshaft.



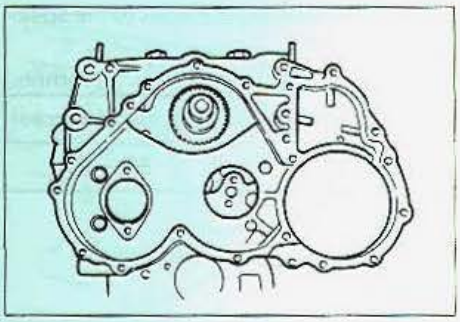
6. Crankshaft bearing cap and crankshaft bearing (Lower side)

Each bearing cap has a position number which is punched onto the arrow mark.
The arrow mark should be pointed to the front of engine.



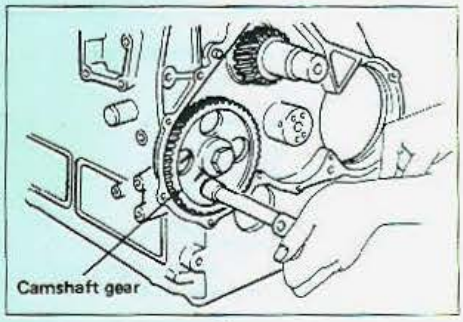
Tighten the crankshaft bearing cap bolts in the sequence specified.

Torque	kg·m(ft.lbs.)	23—25 (166.3—180.8)



7. Timing gear case

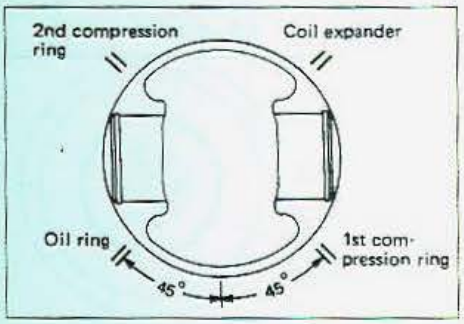
Torque	kg·m(ft.lbs.)	2.1—3.1 (15.2—22.4)



8. Camshaft assembly

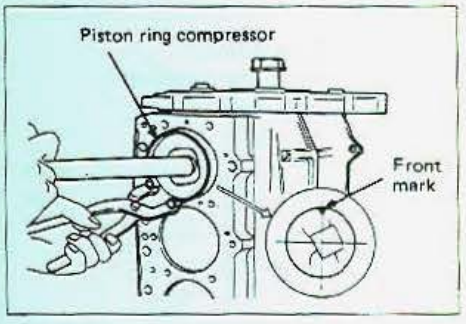
Tighten the thrust plate bolts through the camshaft gear hole

Torque	kg·m(ft.lbs.)	2.1—3.1 (15.2—22.4)



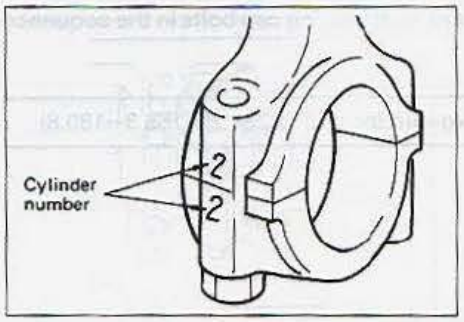
9. Piston and connecting rod assembly

Set the piston ring to the recommended positions.

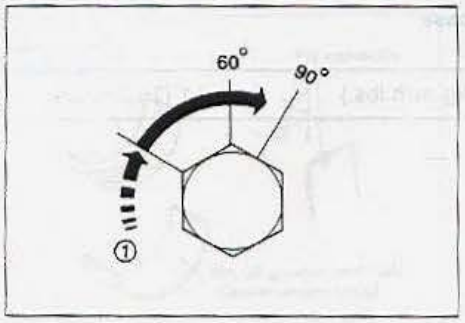


The piston front mark should be turned to the front of the block.

Piston ring compressor : 9-8522-1251-0



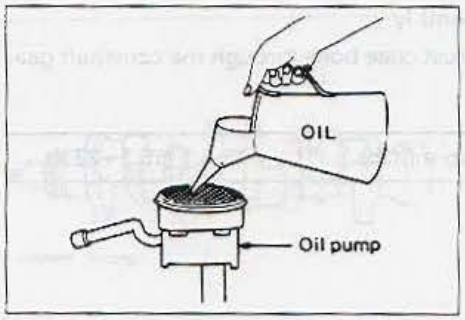
Align the cylinder numbers marked on the cap and connecting rod.



Tighten the connecting rod bearing cap bolts to the specified angle.

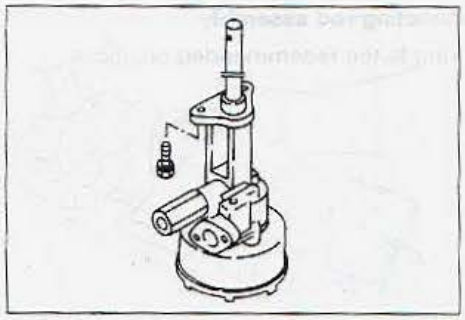
mm(in.)

	1st step kg·m(ft.lbs.)	2nd step (degree)
Torque	4.0 (29)	60 — 90

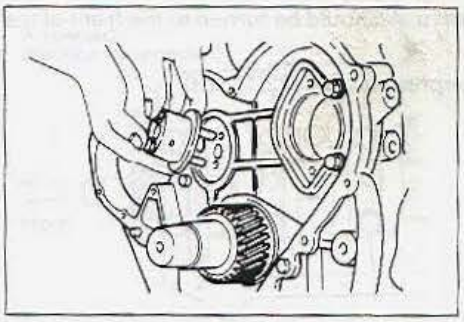


10. Oil pump assembly

Install the oil pump after filling it with engine oil.

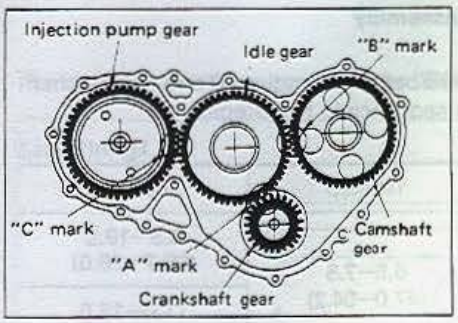


Torque	kg·m(ft.lbs.)	4.3—6.3 (31.1—45.5)



12. Idle gear

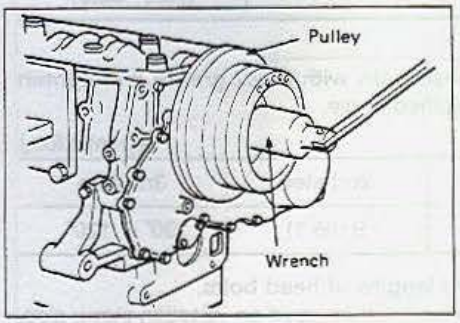
Use thrust collar fixing bolts as guide.
The oil port should be turned to the camshaft.



Align the timing marks ("A", "B" and "C") on the gears.

Torque	kg·m(ft.lbs.)	4.3—6.3 (31.1—45.5)

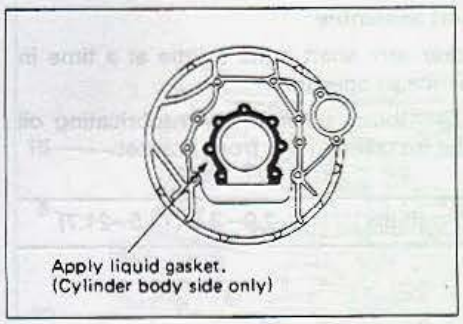
The thrust collar should be installed so that the chamfer side is turned to the front.



15. Crankshaft front nut

Wrench : 41 mm

Torque	kg·m(ft.lbs.)	39—49 (282—354)

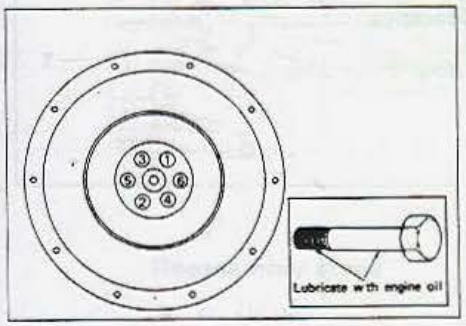


16. Flywheel housing

17. Rear oil seal assembly

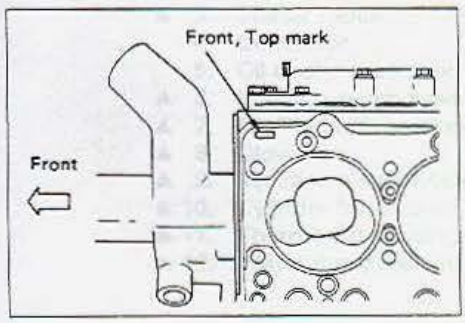
Apply a liquid gasket Belco Bond No. 4 (or equivalent) to the shaded area in the drawing.

Torque	kg·m(ft.lbs.)
Flywheel housing	12.5—15.5 (90.4—112.1)
Rear oil seal assembly	2.1—3.1 (15.2—22.4)



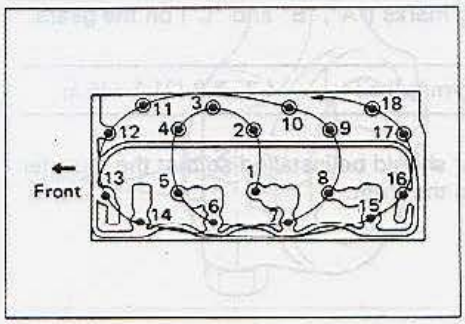
18. Flywheel

Torque	kg·m(ft.lbs.)	14.5—17.5 (105—125)



19. Cylinder head gasket

The "TOP" mark should be up and the "FRONT" mark to the front.



20. Cylinder head assembly

4BD1:

Lubricate the head bolts with engine oil and tighten them in the following sequence in two steps.

Torque kg·m(ft.lbs.)

	1st step	2nd step
New	6.5—7.5 (47.0—54.2)	9.5—10.5 (68.7—76.0)
Reused		11.0—12.0 (79.5—86.8)

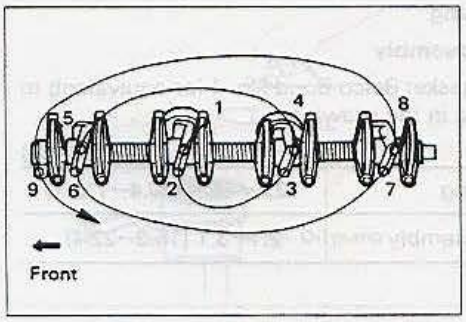
4BD1-T:

Lubricate the head bolts with Mos2 grease and tighten them to the specified angle.

Torque kg·m(ft.lbs.)

1st step	2nd step	3rd step
7 (50.6)	9 (65.1)	90° — 120°

Note: There are two lengths of head bolts.
The shorter ones must be used on injection pump side.



22. Rocker arm shaft assembly

Tighten the rocker arm shaft bolts a little at a time in numerical sequence as specified.

Note that the bolt (black colored) with lubricating oil groove should be installed to the front bracket.

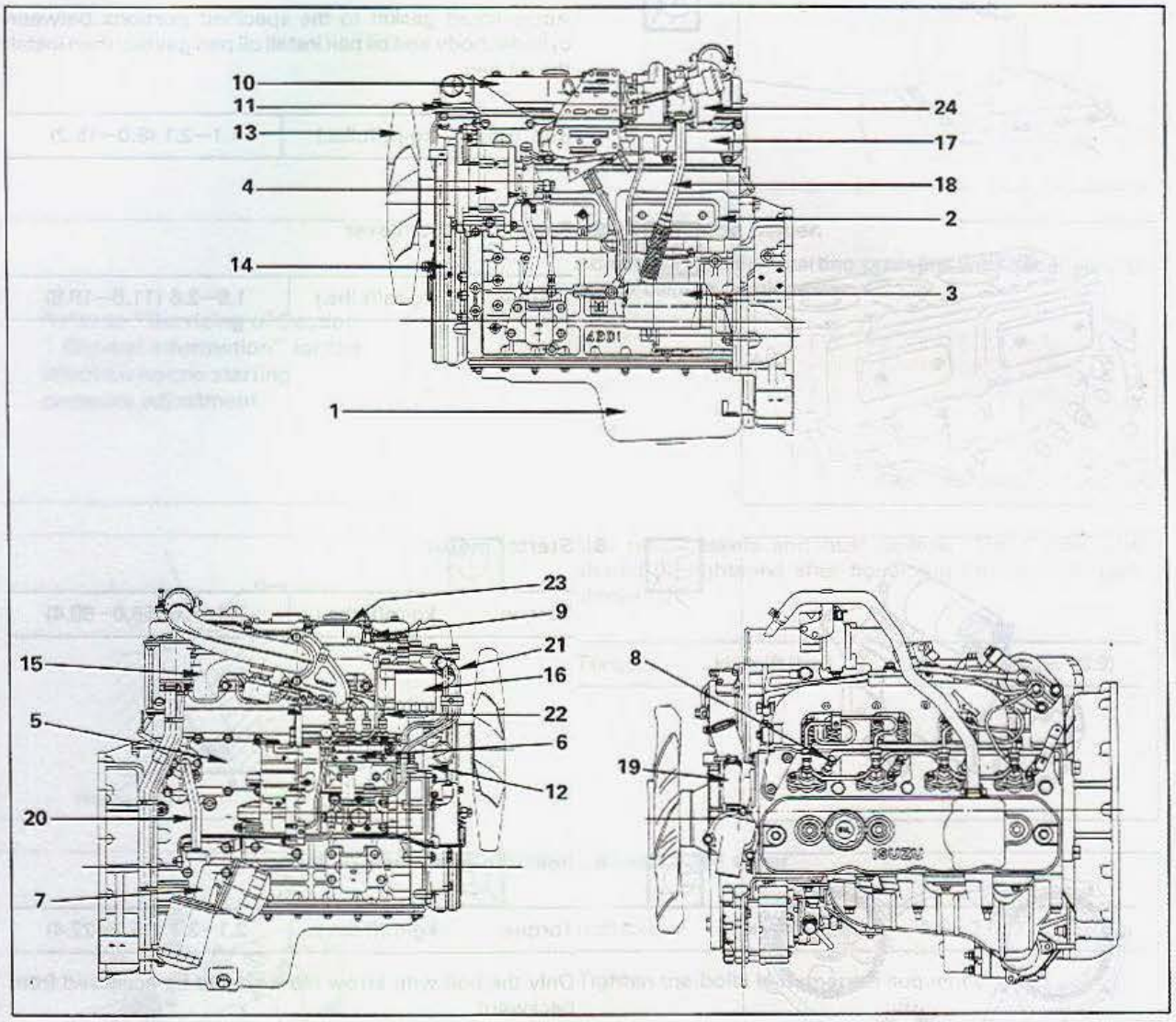
Torque	kg·m(ft.lbs.)	2.0—3.0 (14.5—21.7)

Refer to "Servicing of Section 1 General Information" for the valve clearance adjustment.

Adjust the valve clearance.

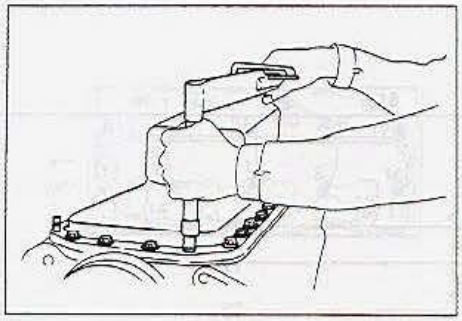
EXTERNAL PARTS

These illustrations are based on the 4BD1-T model.



Reassembly steps

- ▲ 1. Oil pan
- ▲ 2. Tappet chamber cover
- ▲ 3. Starter motor
- 4. Generator
- 5. Oil cooler assembly
- ▲ 6. Injection pump assembly
- ▲ 7. Oil filter with bracket
- ▲ 8. Glow plug
- ▲ 9. Injection nozzle holder
- ▲ 10. Cylinder head cover
- ▲ 11. Thermostat housing assembly
- ▲ 12. Water pump assembly
- ▲ 13. Cooling fan belt
- 14. Cooling fan
- ▲ 15. Intake manifold assembly
- 16. Fuel filter
- ▲ 17. Exhaust manifold assembly
- 18. Oil level gauge with guide tube
- 19. Rubber hose
- 20. Oil pipe
- ▲ 21. Fuel pipe
- ▲ 22. Fuel injection pipe
- 23. Fuel injection leak off pipe
- ▲ 24. Turbo charger related parts (4BD1-T only)

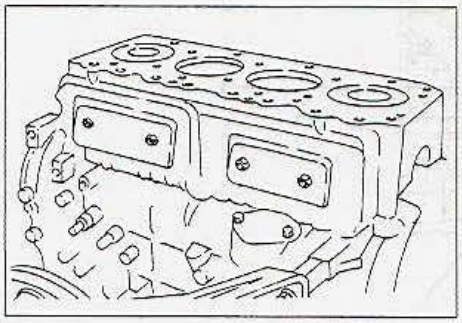


Important operations

1. **Oil pan**

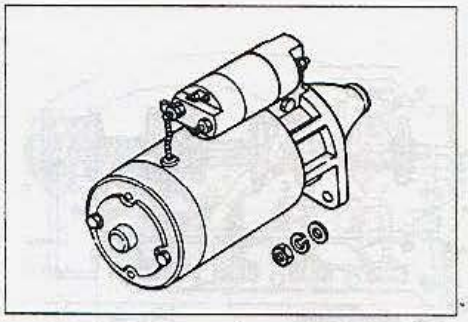
   Apply liquid gasket to the specified portions between cylinder body and oil pan install oil pan gasket, then install the oil pan.

Bolt torque	kg·m(ft.lbs.)	1.1—2.1 (8.0—15.2)



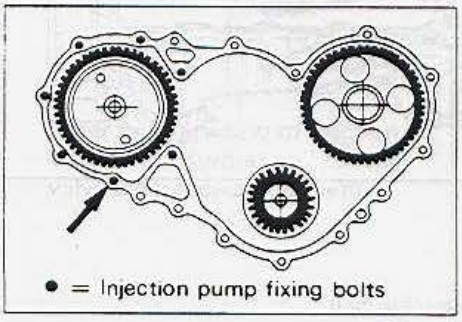
2. **Tappet camber cover**

Torque	kg·m(ft.lbs.)	1.6—2.6 (11.6—18.8)



3. **Starter motor**

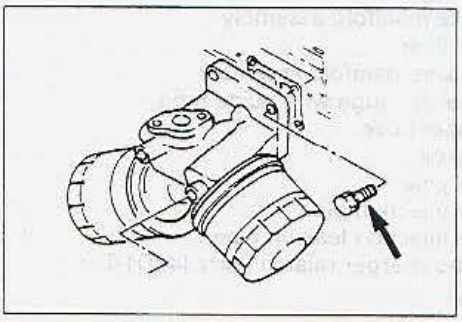
Torque	kg·m(ft.lbs.)	7.6—9.6 (55.0—69.4)



6. **Injection pump assembly**

Torque	kg·m(ft.lbs.)	2.1—3.1 (15.2—22.4)

Only the bolt with arrow mark should be accessed from backward.



7. **Oil filter with bracket**

Torque	kg·m(ft.lbs.)	4.3—6.3 (31.1—45.5)

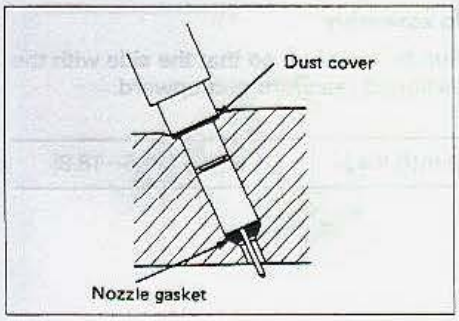
8. Glow plug

Torque	kg·m(ft.lbs.)	2.25—2.75 (16.3—19.9)

Refer to "Servicing of Section 1 General Information" for the injection nozzle starting pressure adjustment.

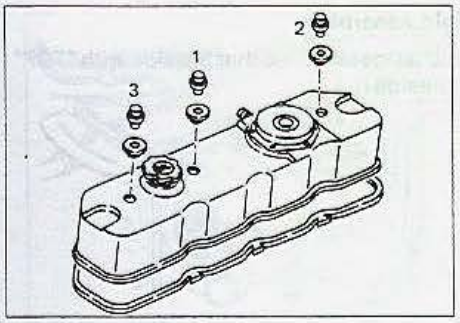
9. Injection nozzle holder.

Adjust the injection starting pressure with the adjusting screw using a nozzle tester.



Use new gaskets and dust covers. The flange nuts should be tightened after tightening the injection pipe sleeve nuts.

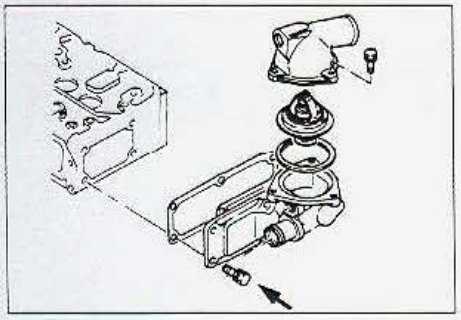
Torque	kg·m(ft.lbs.)	2.25—2.75 (16.3—19.9)



10. Cylinder head cover

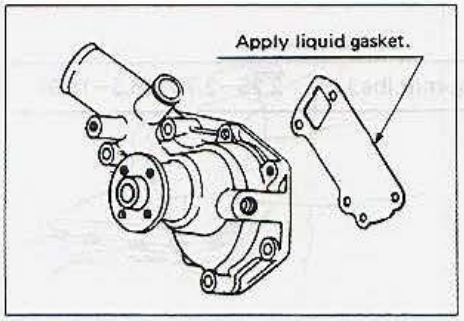
Bolt torque	kg·m(ft.lbs.)	1.6—2.6 (11.6—18.8)

Tighten the bolts in numerical sequence.



11. Thermostat housing assembly

Torque	kg·m(ft.lbs.)	4.3—6.3 (31.1—45.5)



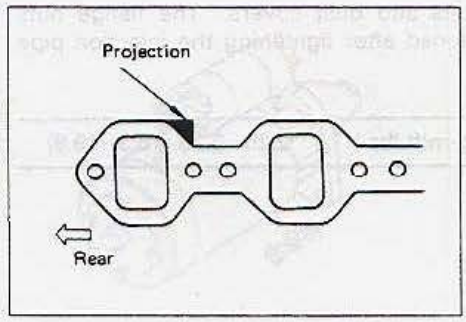
12. Water pump assembly

Apply liquid gasket Belco Bond No. 4 (or equivalent) to the gasket before installation.

Refer to "Servicing of Section 1 General Information" for the fan belt tension adjustment.

13. Cooling fan belt

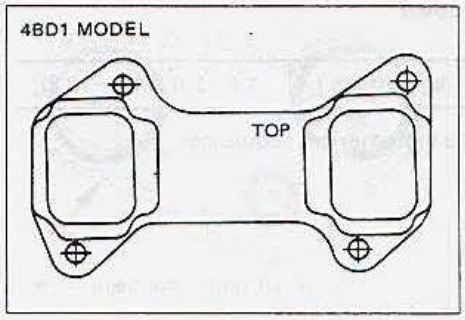
Adjust the fan belt tension.



15. Intake manifold assembly

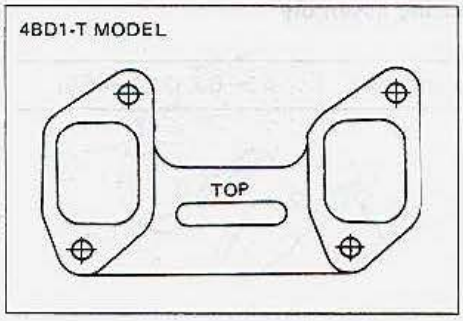
The gasket sholud be installed, so that the side with the projection is positioned rearward and upward.

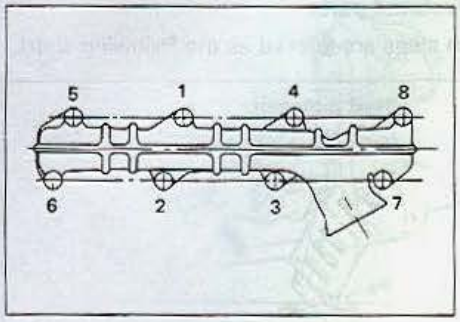
Torque	kg·m(ft.lbs.)	1.6—2.6 (11.6—18.8)



17. Exhaust manifold assembly

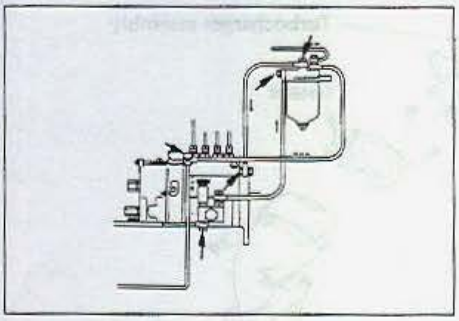
The gasket should be installed, so that the side with "TOP" mark is turned outside.





Tighten the exhaust manifold bolts a little at a time in numerical sequence as specified.

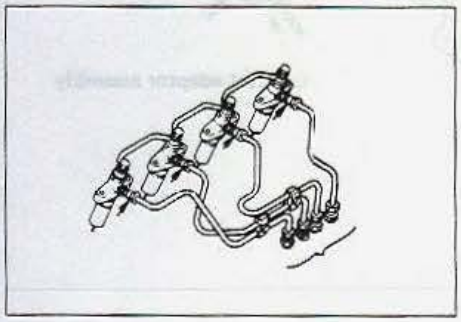
Torque	kg·m(ft.lbs.)	1.6—2.6 (11.6—18.8)



21. Fuel pipe

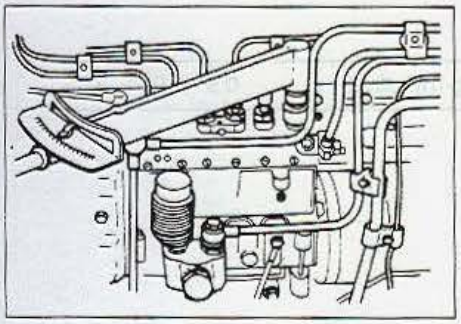
When installing the fuel pipes, avoid interchanging the check valve and joint bolts.

Torque	kg·m(ft.lbs.)	2.0—2.5 (14—18)



22. Fuel injection pipe

Torque	kg·m(ft.lbs.)	2.9—3.2 (21.0—23.1)

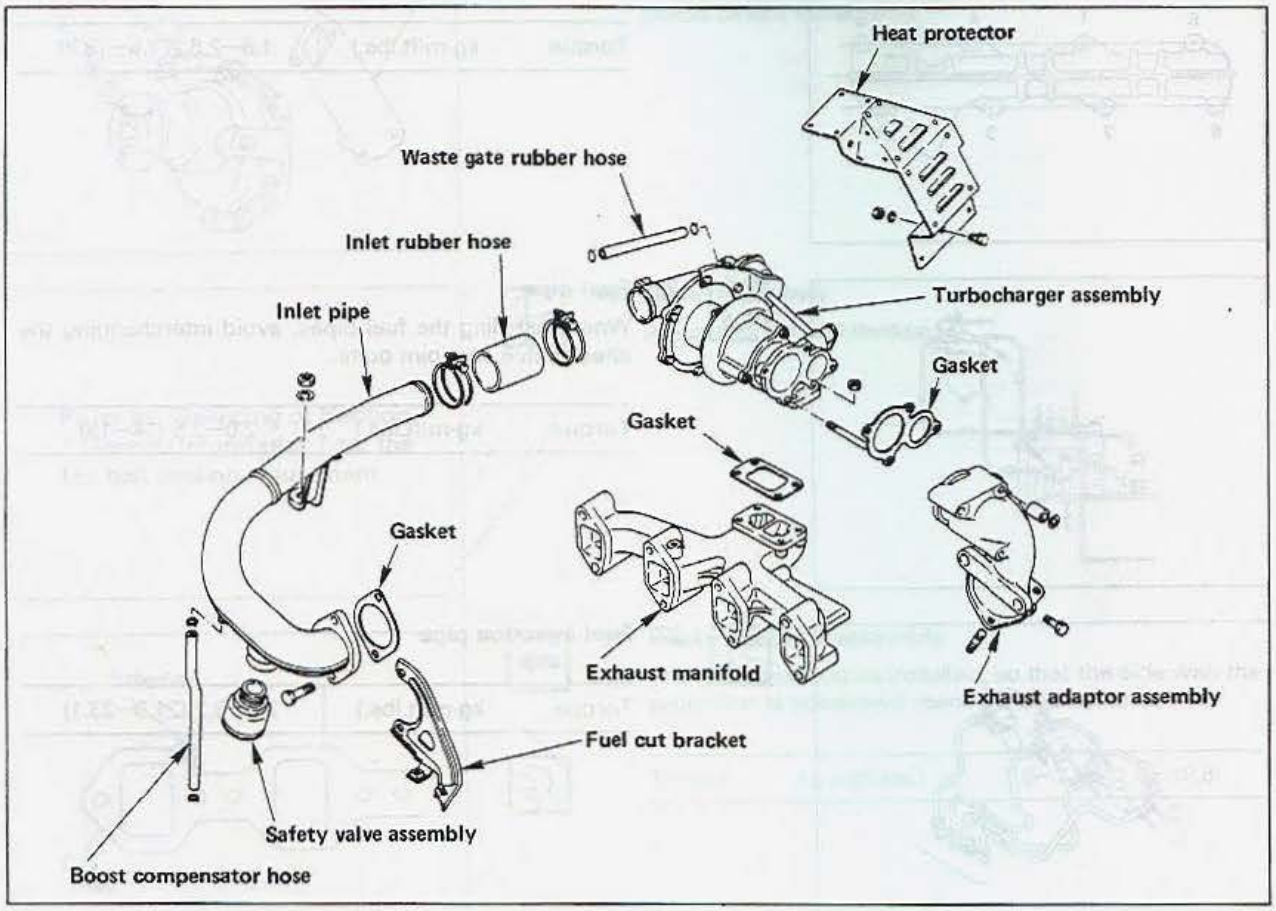


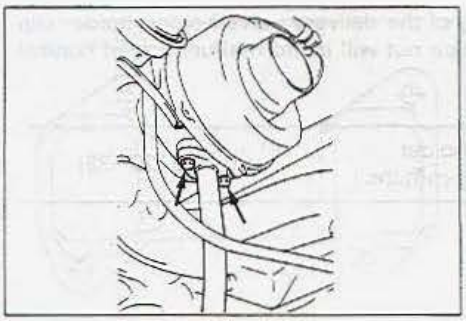
Over-tightening of the delivery valve holder, holder clip and injection pipe nut will invite malfunction of control rack.

Delivery valve holder torque	kg·m(ft.lbs.)	4.0—4.5 (29—33)

23. Turbo charger related parts

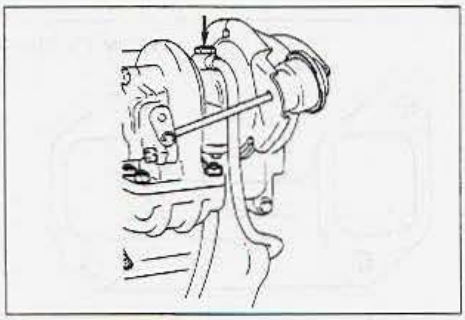
Parts installation steps are refered as the following chart.





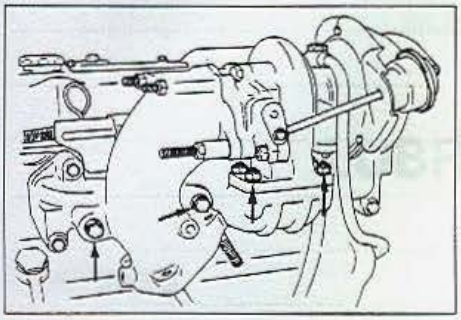
Oil drain pipe

Torque	kg·m(ft.lbs.)	0.5—1.0 (4—7)



Oil feed pipe

Torque	kg·m(ft.lbs.)	1.2—1.6 (8.7—11.6)



Turbocharger assembly

Torque kg·m(ft.lbs.)	A	3.1—3.5 (22—25)
	B	2.2—3.2 (16—23)
	C	1.3—2.3 (9—17)

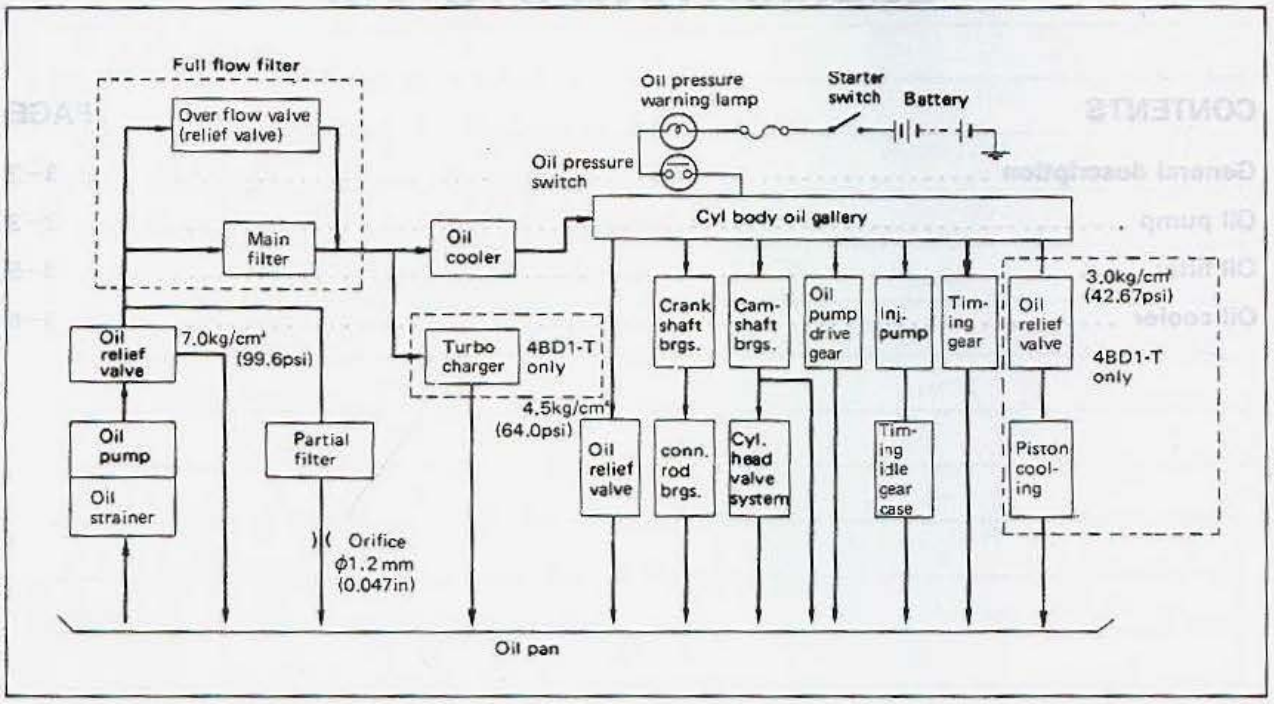
SECTION 3

LUBRICATING SYSTEM

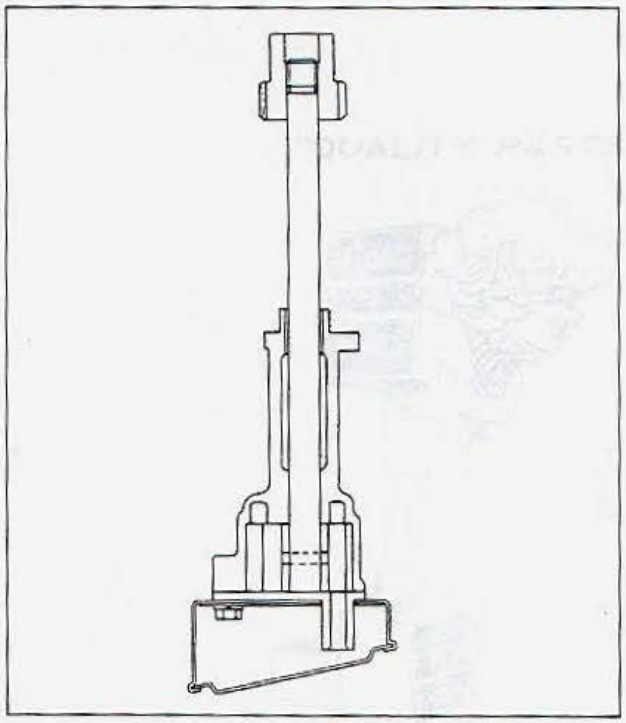
CONTENTS PAGE

LUBRICATING SYSTEM

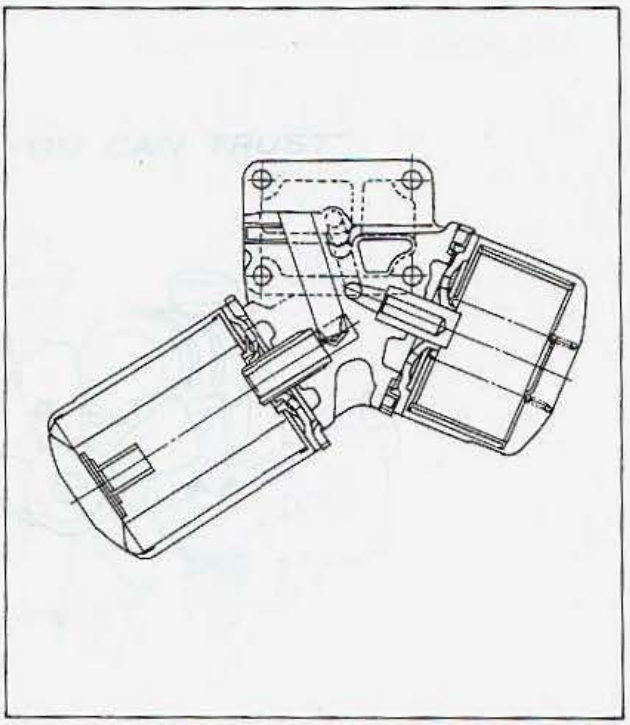
GENERAL DESCRIPTION



OIL PUMP

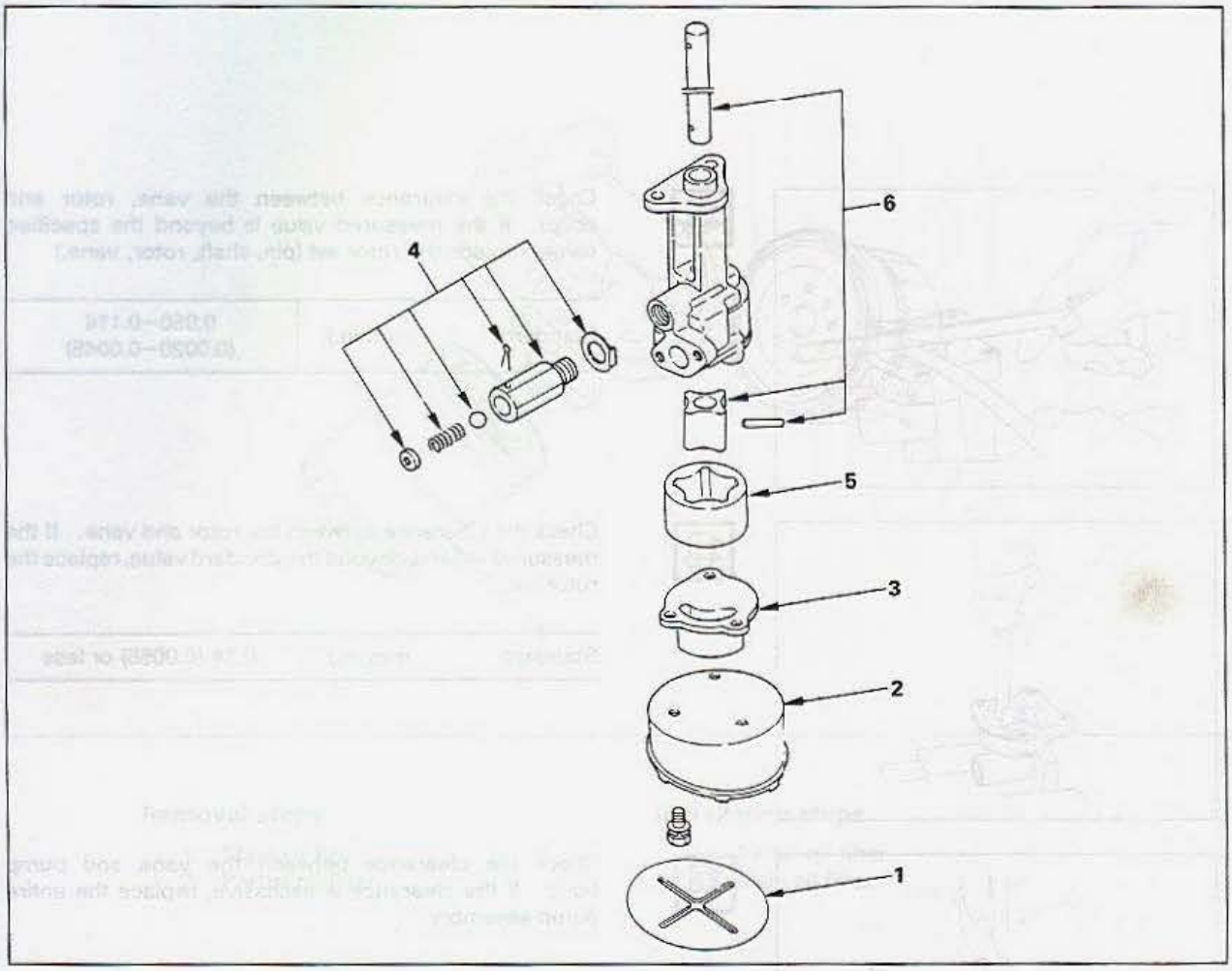


OIL FILTER



OIL PUMP

DISASSEMBLY AND REASSEMBLY



Disassembly steps

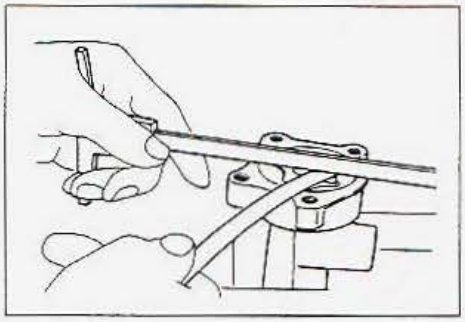
1. Strainer
2. Strainer case
3. Cover
4. Relief valve assembly
5. Vane
6. Rotor assembly

Reassembly steps

To reassemble, follow the disassembly procedures in reverse order.

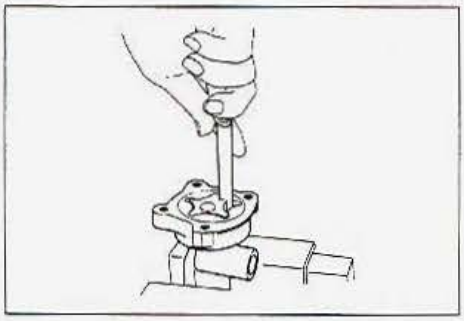
INSPECTION AND REPAIR

Make necessary correction or parts replacement if wear, damage or any other abnormal conditions, are found through inspection.



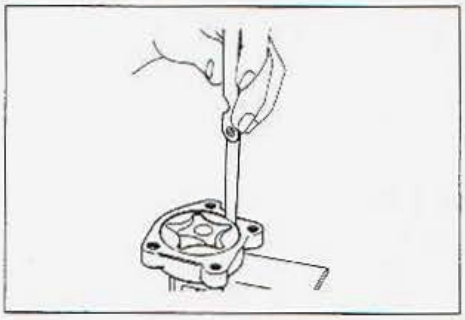
Check the clearance between the vane, rotor and cover. If the measured value is beyond the specified value, replace the rotor set (pin, shaft, rotor, vane.)

Standard	mm(in.)	0.050—0.114 (0.0020—0.0045)



Check the clearance between the rotor and vane. If the measured value is beyond the standard value, replace the rotor set.

Standard	mm(in.)	0.14 (0.0055) or less



Check the clearance between the vane and pump body. If the clearance is excessive, replace the entire pump assembly.

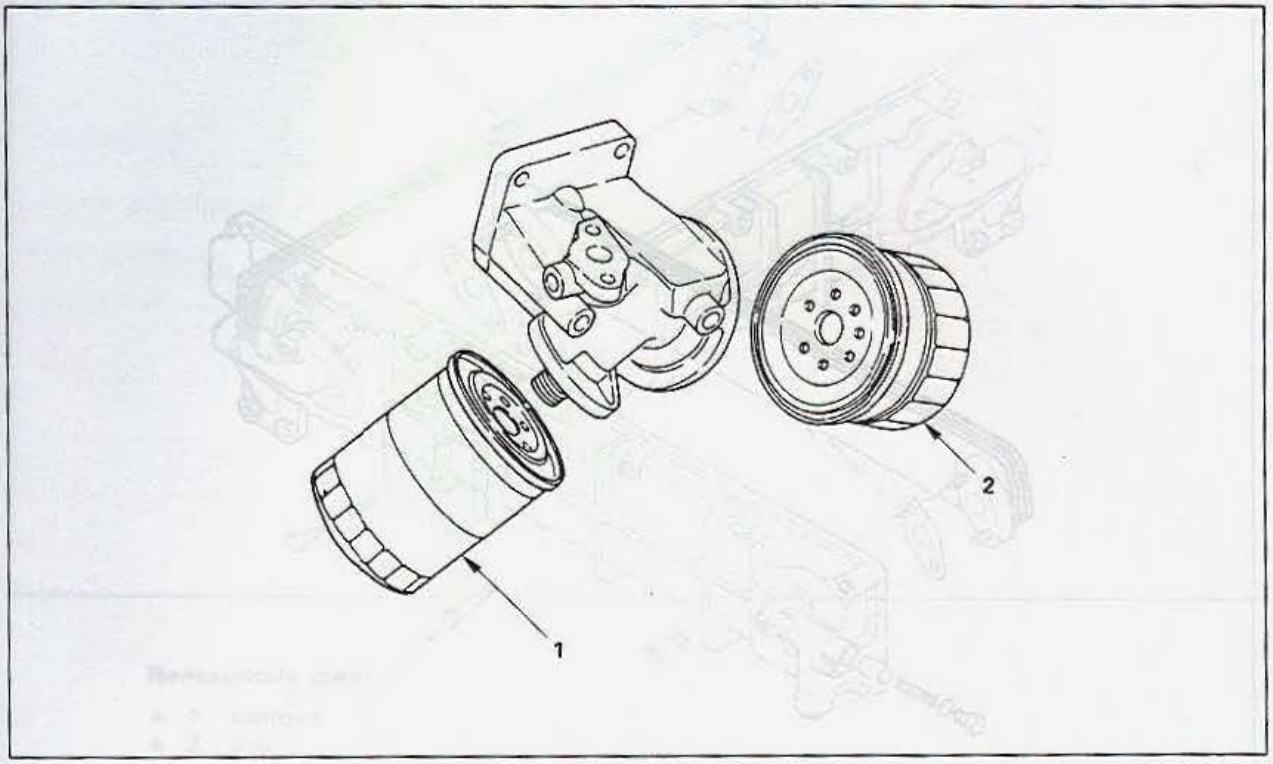
Standard	mm(in.)	0.20—0.30 (0.008—0.012)

Check the clearance between the rotor shaft and pump body. If the measured value is beyond the specified value, replace the entire pump assembly.

Standard	mm(in.)	0.032—0.070 (0.0013—0.0028)

OIL FILTER

REMOVAL AND INSTALLATION



Removal steps

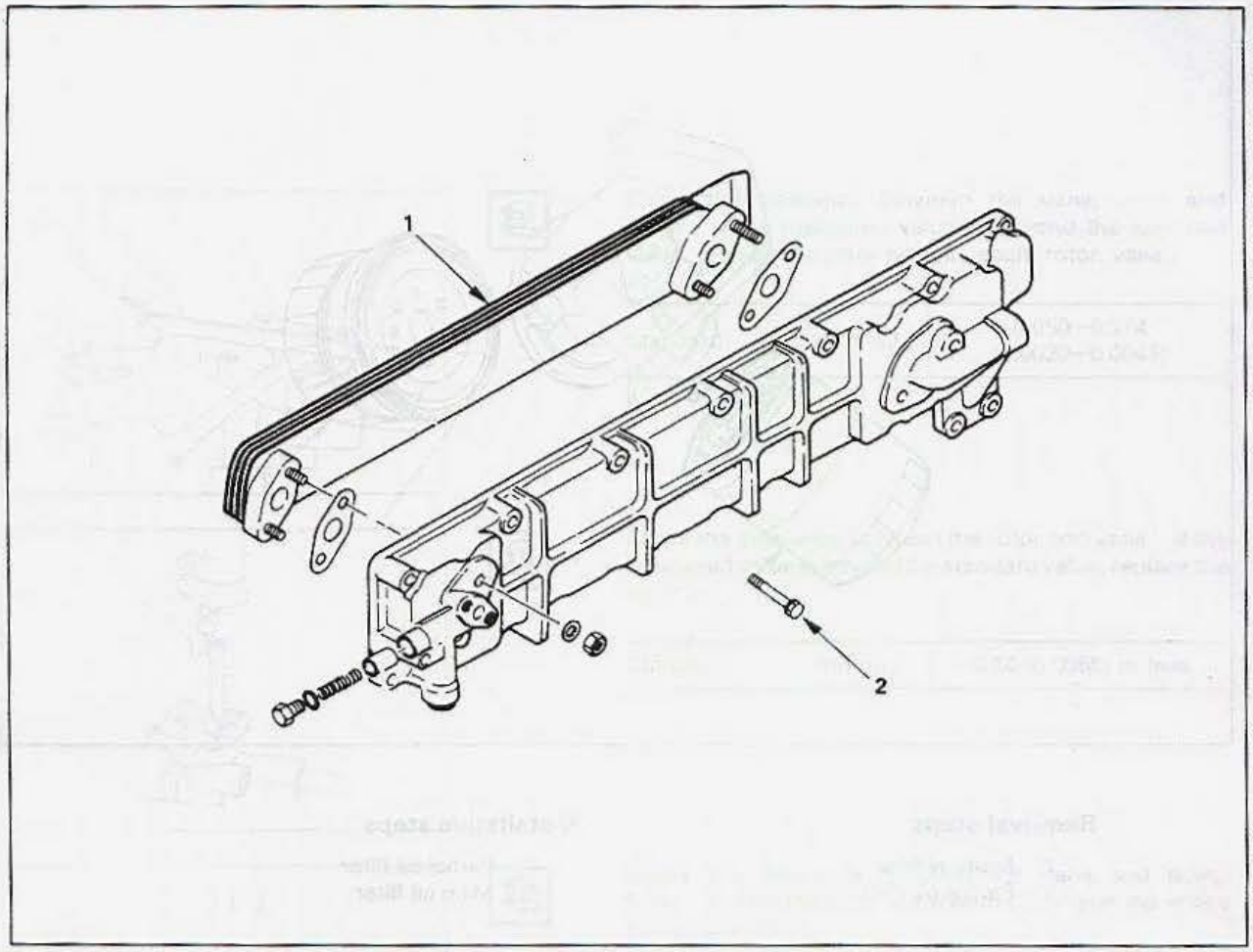
1. Main oil filter
2. Partial oil filter

Installation steps

2. Partial oil filter
1. Main oil filter

OIL COOLER

DISASSEMBLY



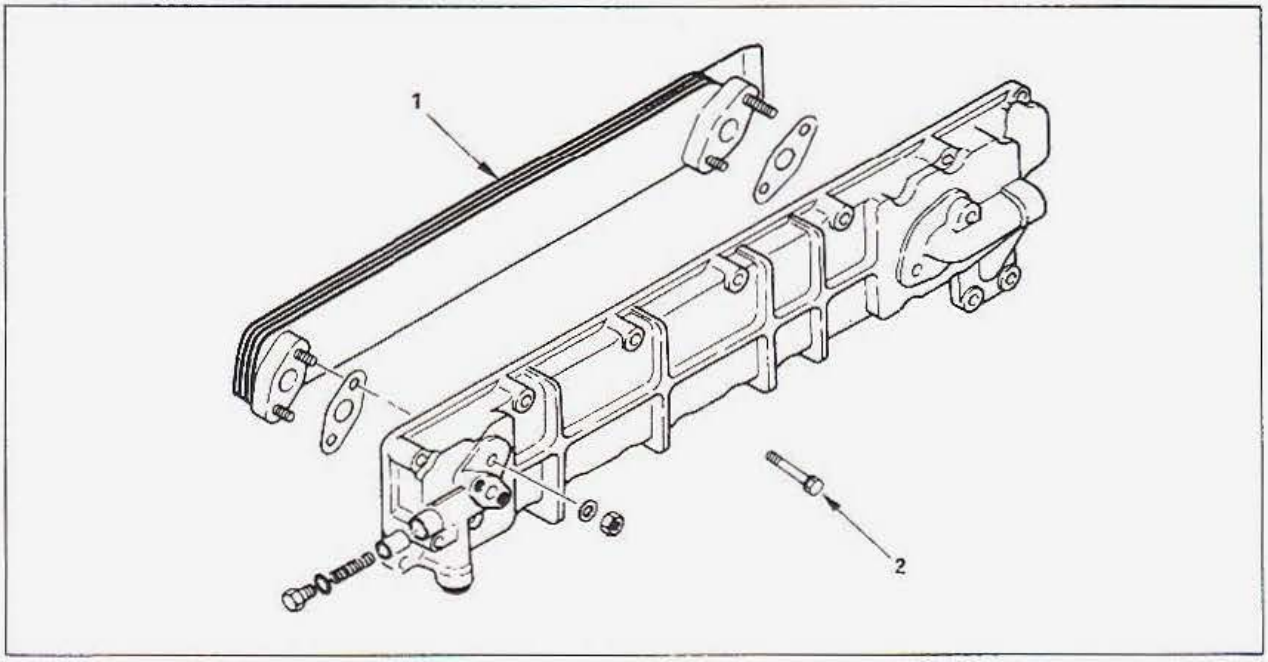
Disassembly steps

1. Element
2. Bolt

INSPECTION AND REPAIR

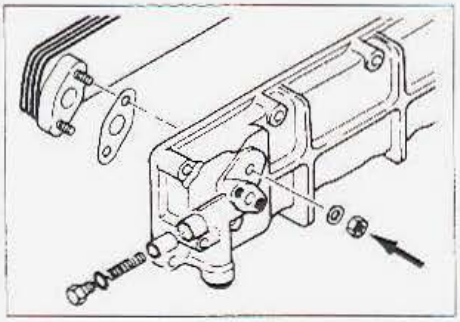
Make necessary correction or parts replacement if wear damage or any other abnormal conditions are found through inspection.

REASSEMBLY



Reassembly steps

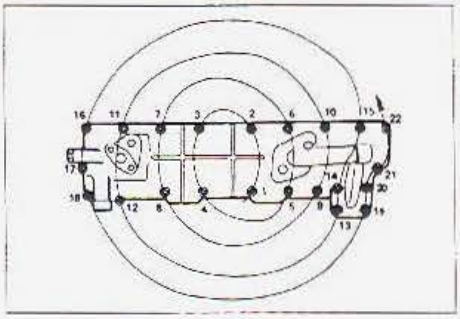
▲ 1. Element
▲ 2. Bolt



Important operation — Installation

1. Element

Torque	kg·m(ft.lbs.)	2.1—3.1 (15.2—22.4)



2. Bolt

Tighten the bolts in numerical sequence as specified.

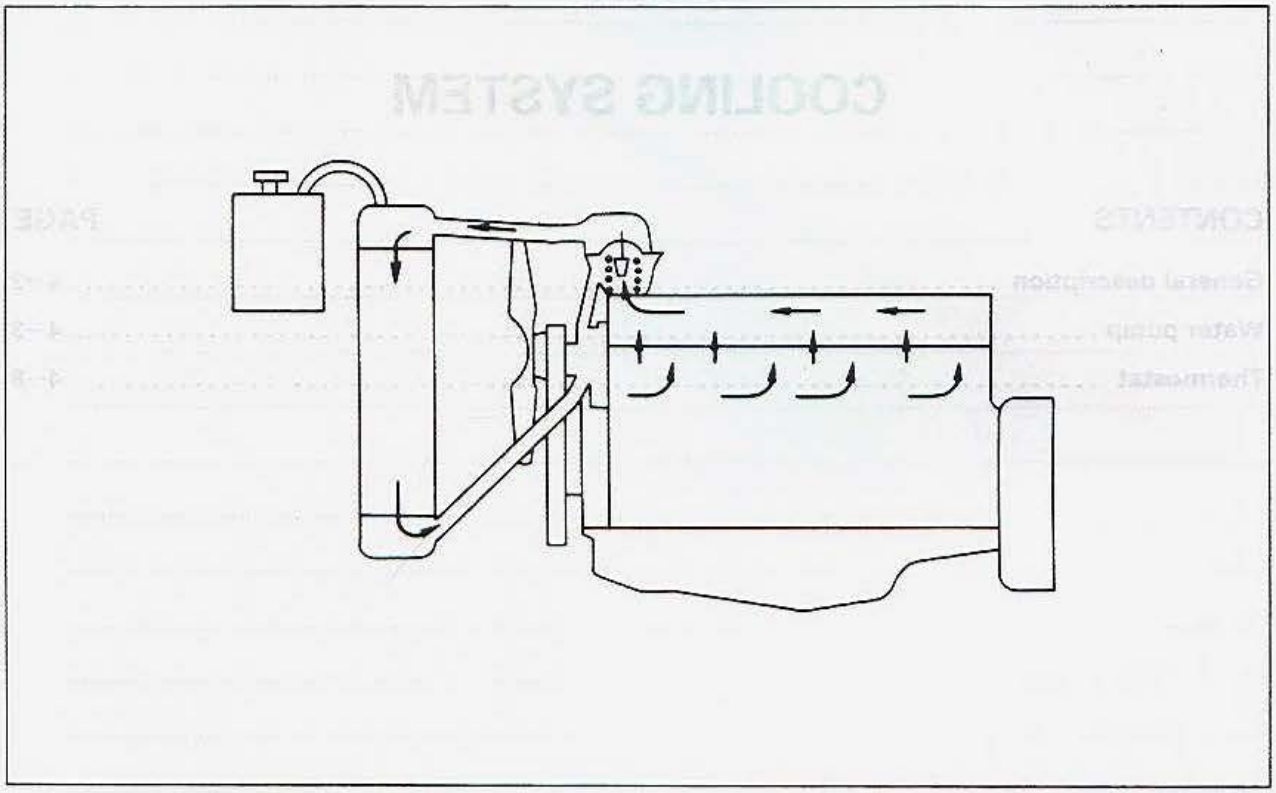
Torque	kg·m(ft.lbs.)	2.1—3.1 (15.2—22.4)

SECTION 4

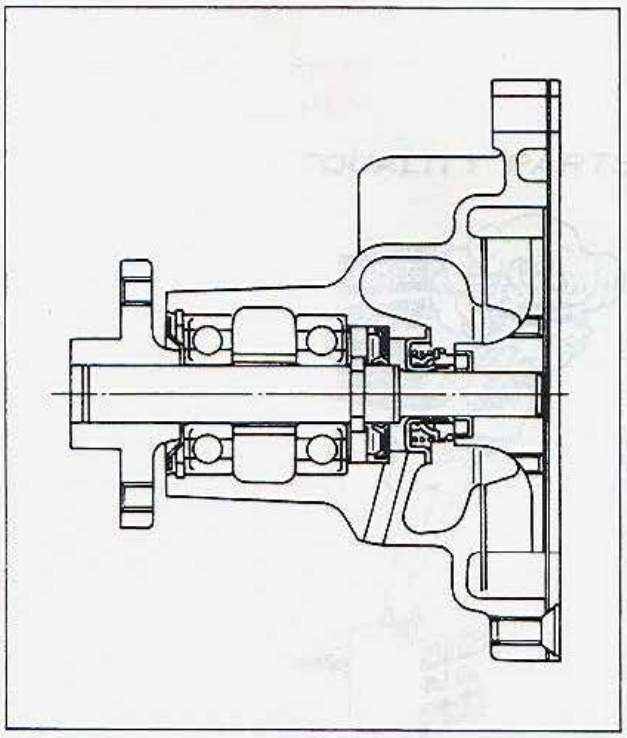
COOLING SYSTEM

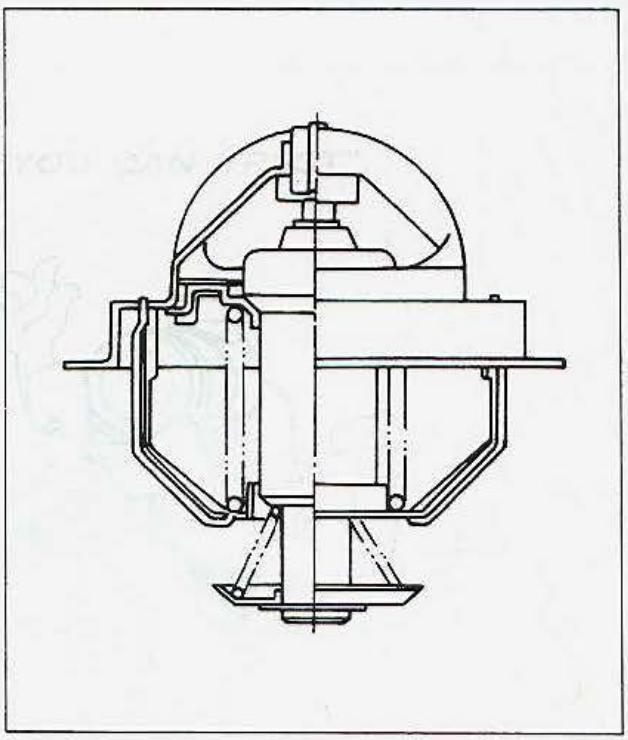
CONTENTS

GENERAL DESCRIPTION



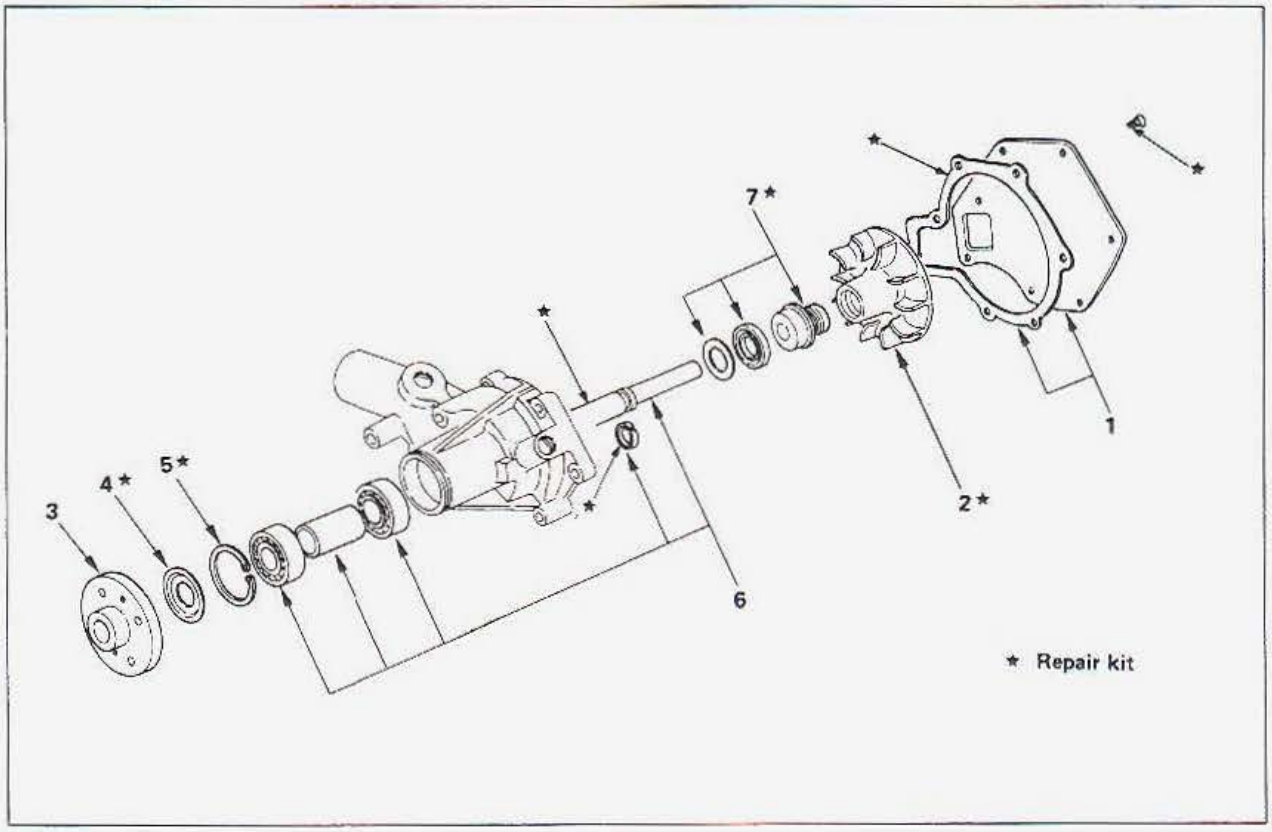
THERMOSTAT





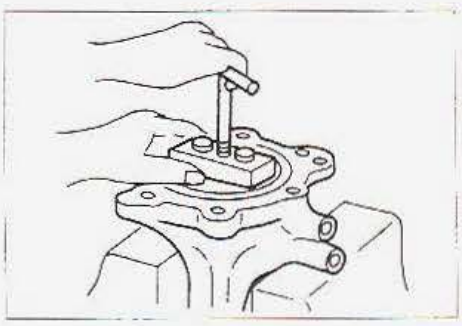
WATER PUMP

DISASSEMBLY



Disassembly steps

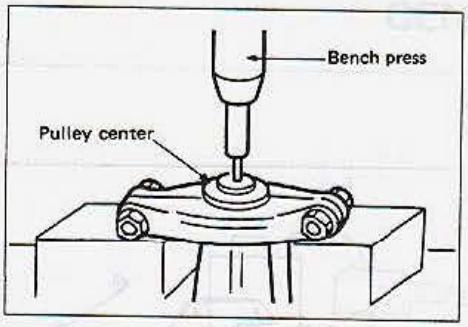
1. Cover
▲ 2. Impeller
▲ 3. Pulley center
4. Dust thrower
▲ 5. Snap ring
▲ 6. Spindle, bearing and spacer
▲ 7. Seal unit, washer and seal



Important operations

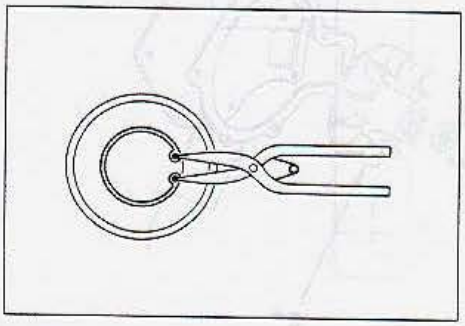
2. Impeller

Remover : 9-8521-0097-0



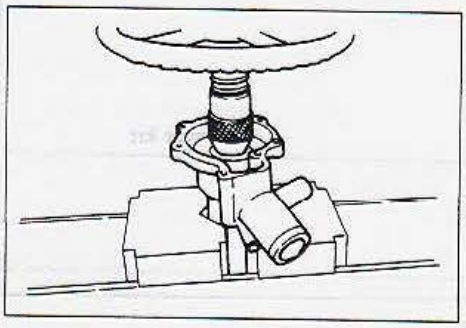
3. Pulley center

Use a bench press and a suitable rod.



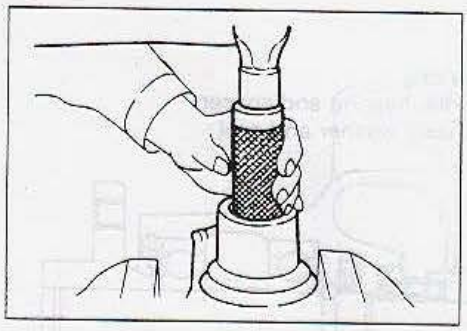
5. Snap ring

Remove the snap using a snap ring pliers.



6. Spindle, bearing and spacer

Remove the spindle with bearings using a bench press and suitable remover.

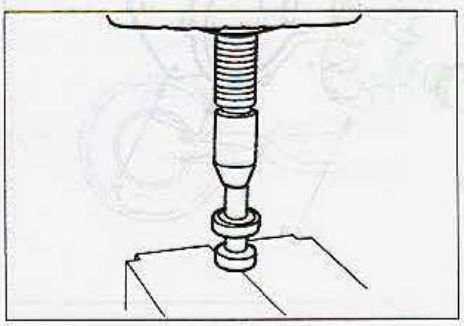


7. Seal unit, washer and seal

Remove the seal unit using a bench press and suitable remover.

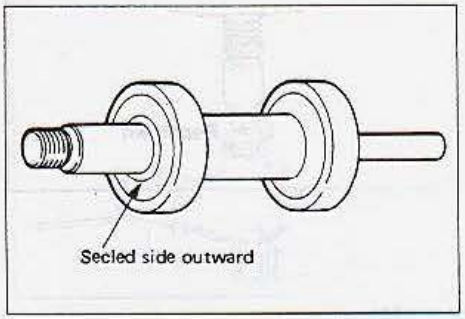
INSPECTION AND REPAIR

Make necessary correction or parts replacement if wear, damage or any other abnormal conditions are found through inspection.



Bearing replacement procedure

Removal :
Use a bench press.

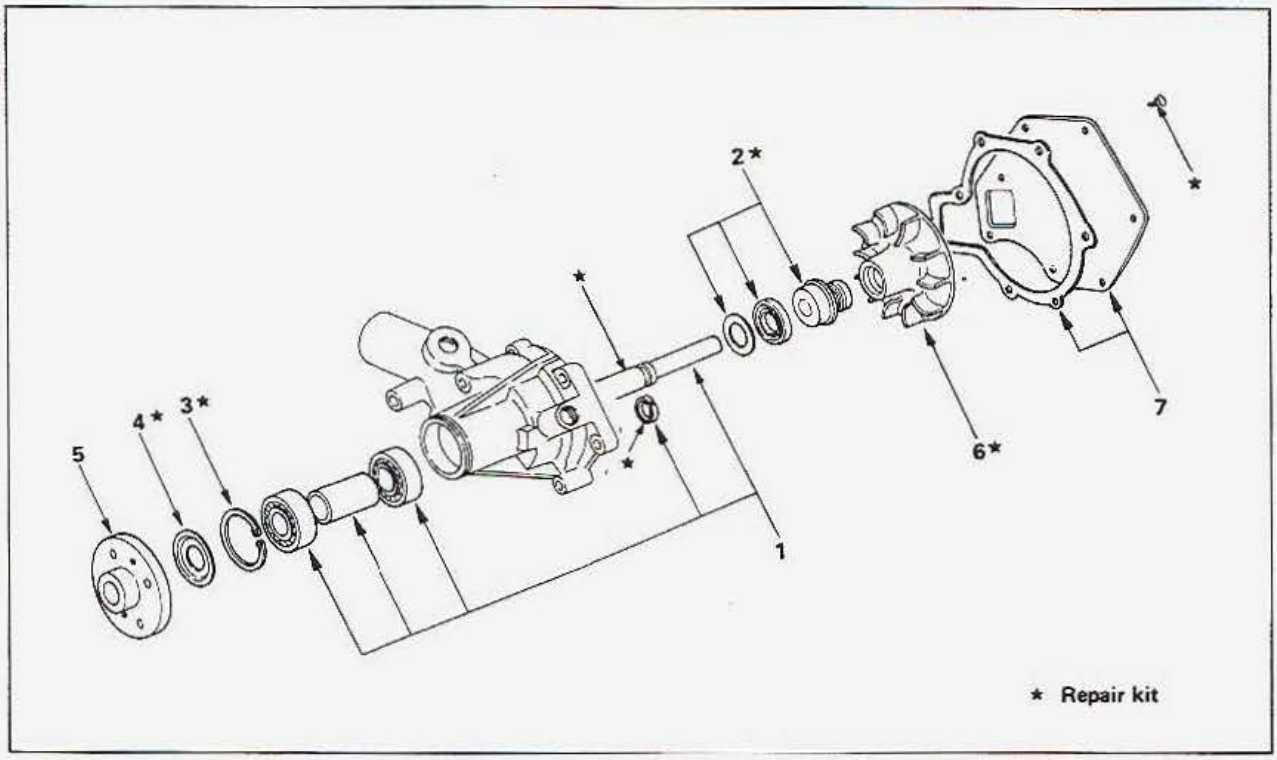


Installation :
Use a bench press for the front and rear bearings installation.

The bearings should be so installed that their sealed side are turned outwards.

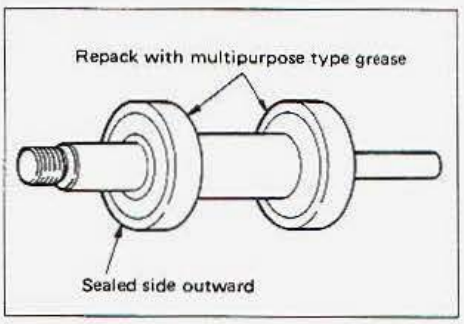
REASSEMBLY

This illustration bassed on 4BD1 model.



Reassembly steps

- ▲ 1. Spindle, bearing and spacer
- ▲ 2. Washer, seal and seal unit
- 3. Snap ring
- 4. Dust thrower
- ▲ 5. Pulley center
- ▲ 6. Impeller
- 7. Cover

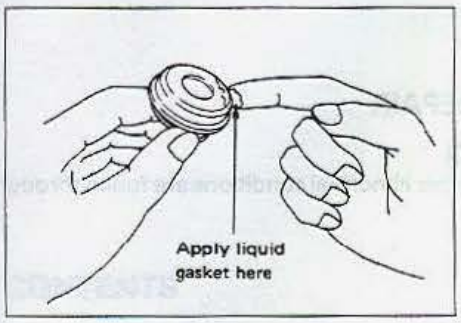


Important operations

1. Spindle, bearing and spacer

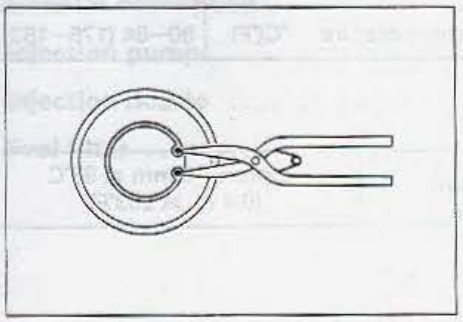
Repack the bearings with multipurpose type grease before installing into the pump body.

Install the above assembly using a bench press.
Installer : 9-8522-1140-0



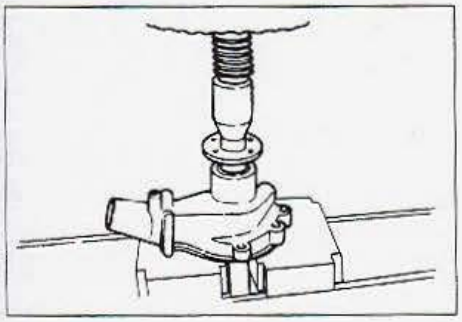
2. Washer, seal and seal unit

Apply liquid gasket (Belco Bond No. 4) to the surface in contact with the pump body.



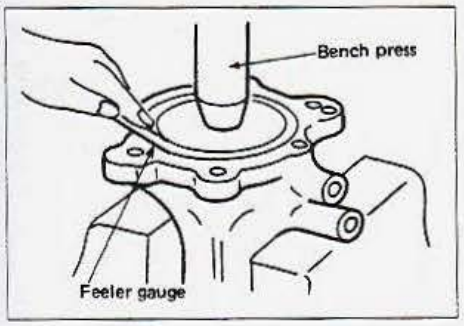
3. Snap ring

Install the snap ring using a snap ring pliers.



5. Pulley center

Use a bench press. Press in until it stops.



6. Impeller

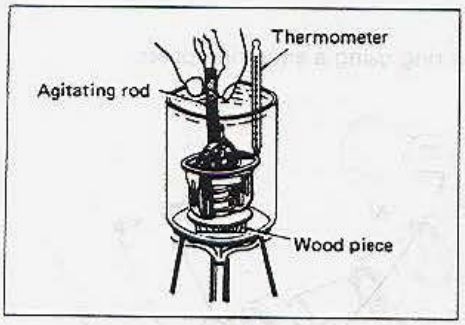
Install the impeller using a bench press so that the clearance between the impeller and body is held within the specified value.

Standard	mm(in.)	0.3—0.8 (0.012—0.031)

THERMOSTAT

INSPECTION AND REPAIR

Make necessary correction or parts replacement if wear damage or any other abnormal conditions are found through inspection.



Valve opening temperature	°C(°F)	80—84 (176—183)

Valve lift

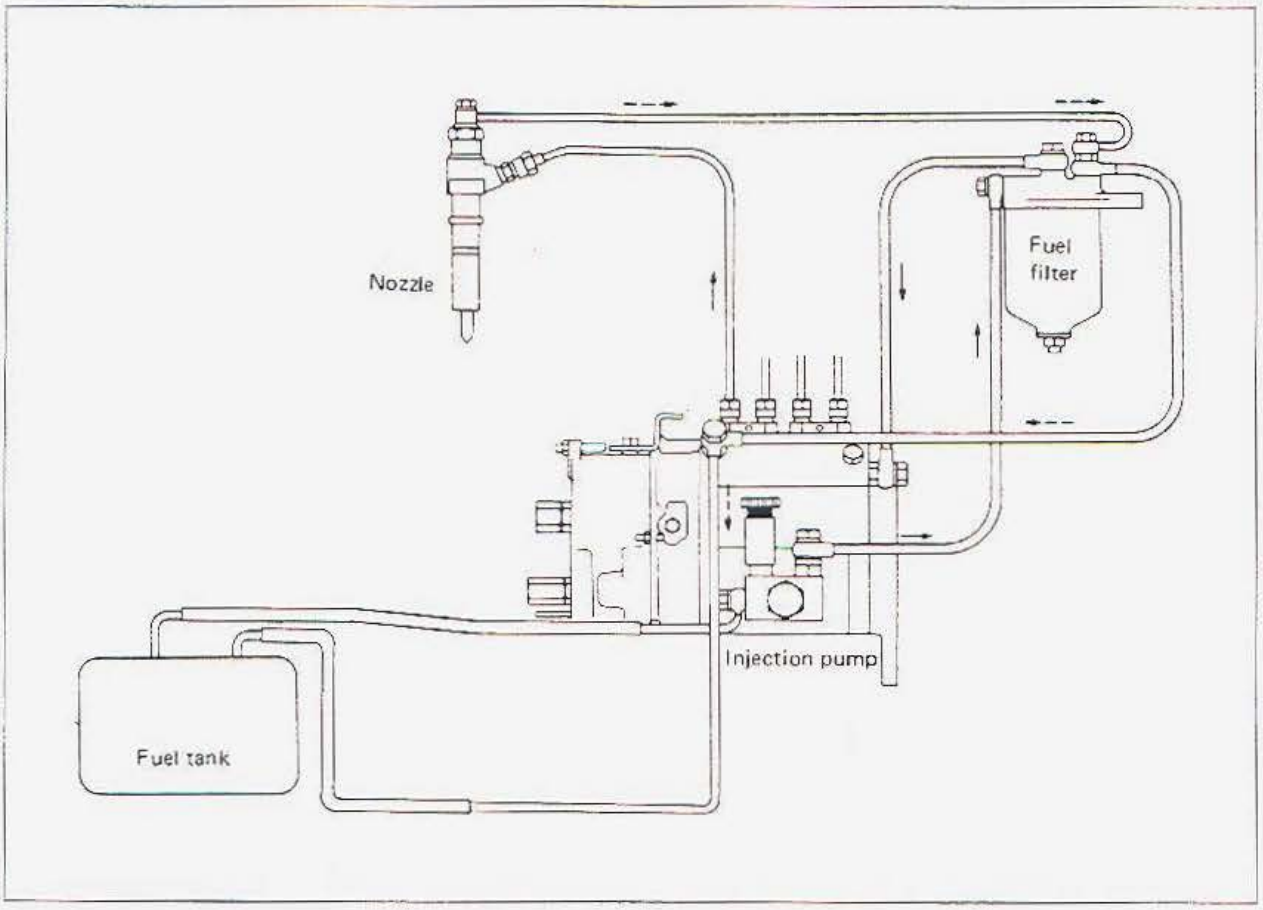
Standard	Approx. 10 mm at 95°C (0.4 in. at 203°F)

SECTION 5

FUEL SYSTEM

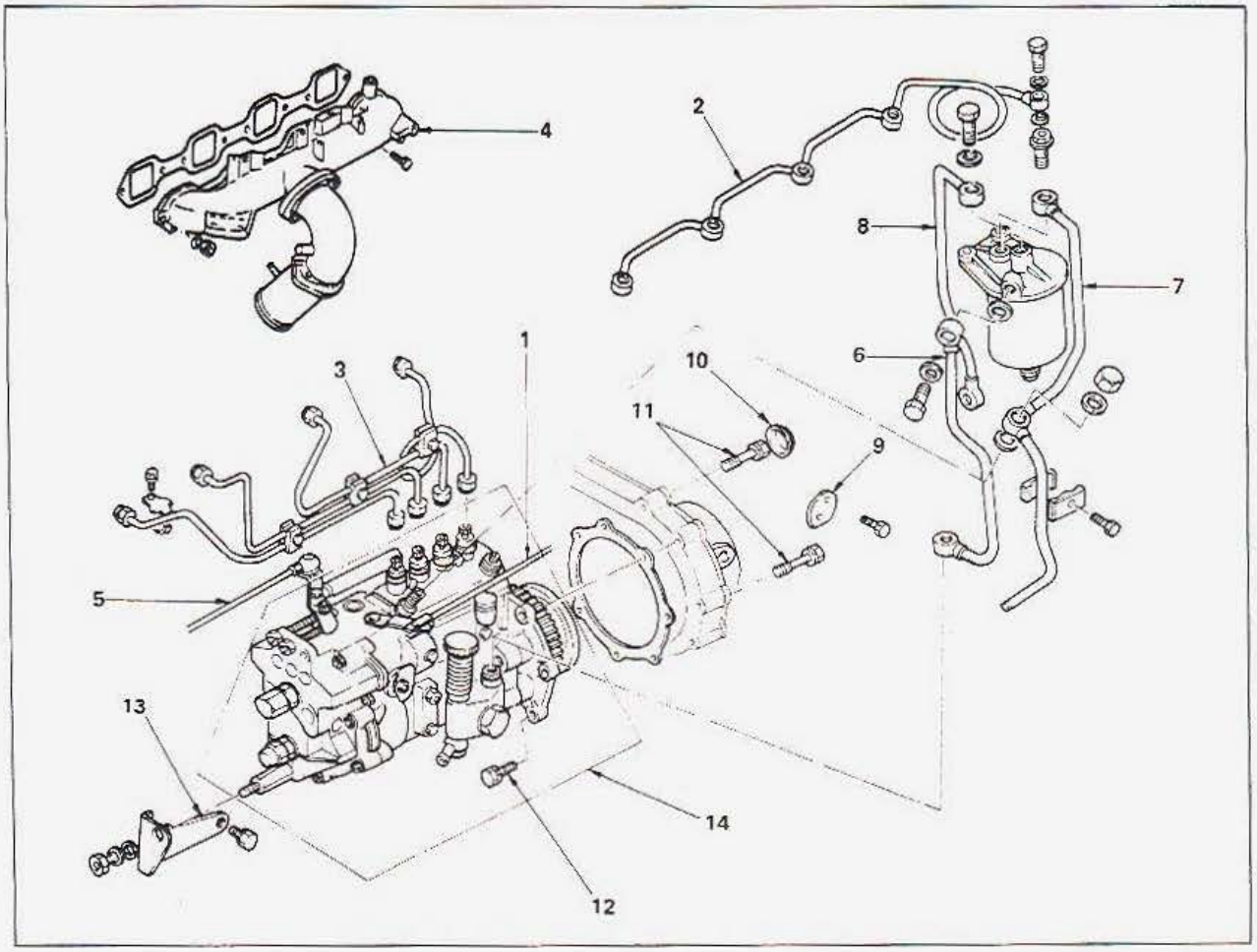
CONTENTS PAGE

GENERAL DESCRIPTION



INJECTION PUMP

REMOVAL AND INSTALLATION

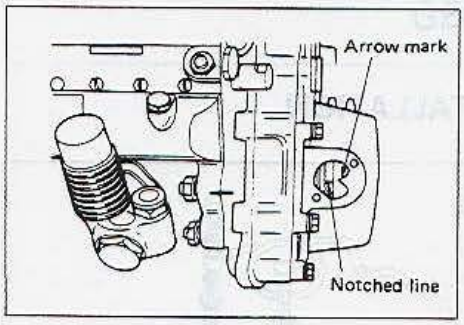


Removal steps

1. Engine stop cable
2. Fuel leakoff pipe
3. Fuel injection pipe
4. Intake manifold
5. Engine control cable
6. Fuel pipe; feed pump to filter
7. Fuel return pipe
8. Fuel pipe; filter to injection pump
▲ 9. Hole cover
10. Grommet
▲ 11. Bolt; front side (six)
▲ 12. Bolt; rear side (one)
13. Bracket
14. Injection pump assembly

Installation steps

14. Injection pump assembly
12. Bolt; rear side (one)
11. Bolt; front side (six)
10. Grommet
13. Bracket
8. Fuel pipe; filter to injection pump
7. Fuel return pipe
6. Fuel pipe; feed pump to filter
5. Engine control cable
▲ 4. Intake manifold
3. Fuel injection pipe
2. Fuel leakoff pipe
1. Engine stop cable
9. Hole cover

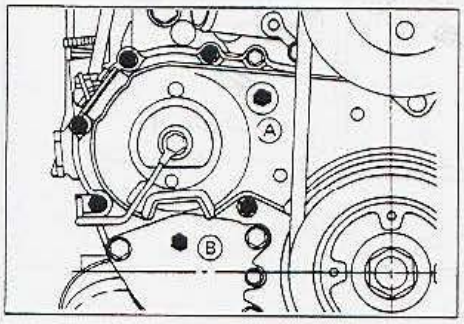


Important operations — Removal

9. Hole cover

Align the notched line on the automatic timer with the arrow mark on the timing gearcase cover by rotating the crankshaft using the crankshaft turning wrench.

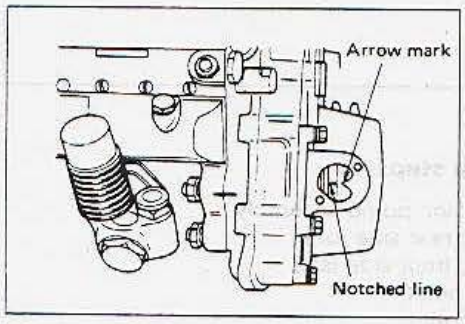
Crankshaft should not be rotated from this alignment for ease of reinstallation.



11. Bolt; front side (six)

12. Bolt; rear side (one)

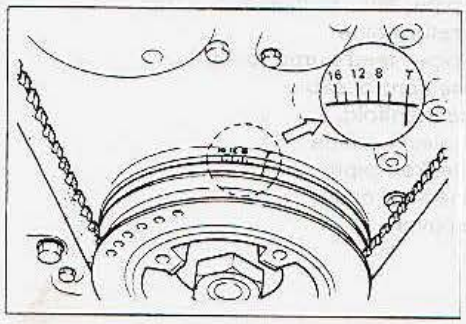
Remove the injection pump by loosening 6 through bolts and a nut.
The through bolt Ⓐ is hidden behind the hole cover.
The nut Ⓑ should be accessed from backward.



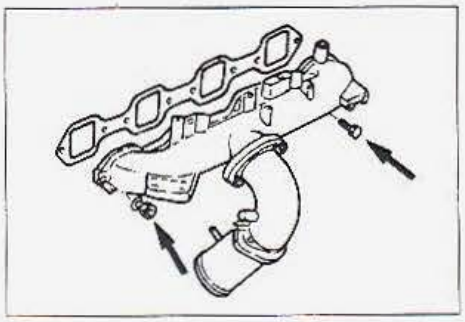
Important operations — Installation

14. Injection pump

Install the injection pump assembly so that the notched line on the automatic timer align with the arrow mark on the timing gearcase cover.



If timing gear train gets misalignment, turn the crankshaft in a clockwise direction to bring the piston in No. 1 cylinder into Top Dead Center (TDC) on compression stroke by aligning notched line on the crankshaft pulley with the specified mark exactly.
After this adjustment, install the injection pump assembly by following the procedure above.



4. **Intake manifold**

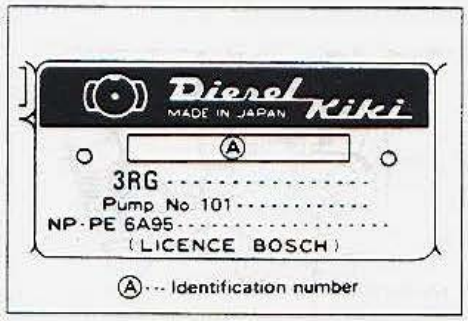
Torque	kg·m(ft.lbs.)	1.6—2.6 (11.6—18.8)

INJECTION PUMP DATA

INJECTION VOLUME ADJUSTMENT

Test condition	
Injection nozzle	D.K.K.C. P.No. 105780-0000 Bosch type No. DN12SD12T
Injection nozzle holder	D.K.K.C. P.No. 105780-2080 Bosch type No. EF8511/9A
Injection starting pressure	175 kg/cm² (2489 psi)
Injection line	Outside dia. 6mm (0.236 in.) x Inside dia. 2mm (0.078 in.) — Length 600 mm (24 in.)
Over flow valve opening pressure	1.6 kg/cm² (23 psi)
Test oil	SAE standard test diesel fuel (SAE J967d, or ISO4113)
Temperature of in use	35° — 45°C (95° — 113°F)

IDENTIFICATIONS PLATE AND NUMBER



When adjusting the volume of fuel delivery, use the correct data following the injection pump assembly number.

Pre-stroke : No. 1 plunger 3.6 ± 0.05 mm

Injection order :

1 — 3 — 4 — 2 (interval 90° ± 30")

Plunger are numbered from the drive side

Tappet clearance:

More than 0.3 mm with all cylinder

INJECTION VOLUME AND GOVERNOR PERFORMANCE DIAGRAM

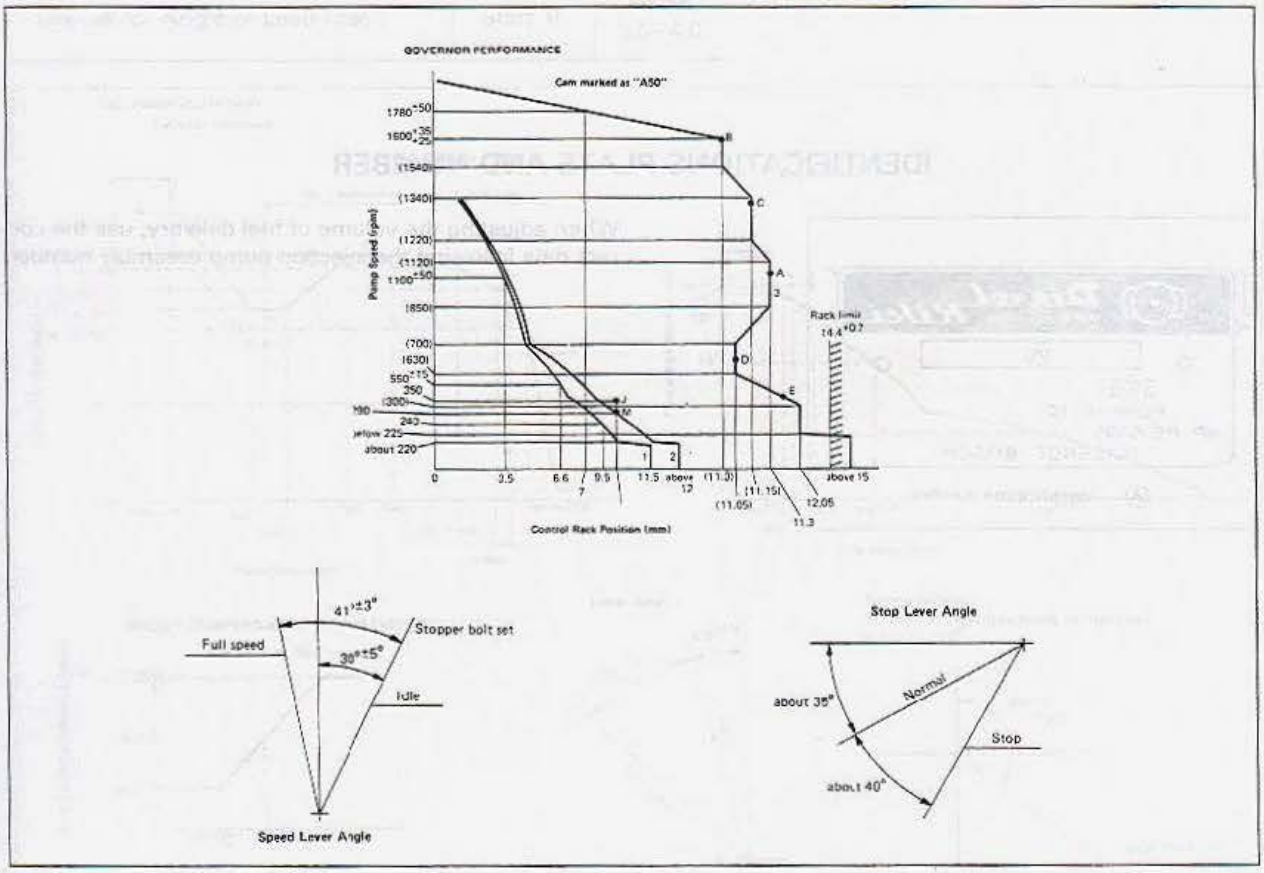
4BD1 (Identification number : 101401-0290) ADR Spec.

Injection Quantity

Adjusting point	Control rack position (mm)	Pump speed (r.p.m.)	Strokes	Injection volume (cc/1000 st.)	Variance (%)	Fixed	Remarks
A	11.3	950	1000	67.3 — 70.3	± 2.5	Rack	Basic
H	About 9.5	290	1000	6.7 — 9.3	±14.0	Rack	
A	R1 11.3	950	1000	67.8 — 69.8	—	Lever	Basic
B	10.95	1600	1000	67.0 — 70.2	—	Lever	
C	11.15	1300	1000	70.9 — 74.1	—	Lever	
D	11.05	650	1000	48.7 — 51.9	—	Lever	
E	11.4	500	1000	49.9 — 53.9	—	Lever	

Timing Advance Specification

Pump Speed (rpm)	1250	1350	1400	1600
Degree for Angle of Lead (deg.)	below 0.5	below 1.1	below 1.6	$5\ ^{0}_{-1}$

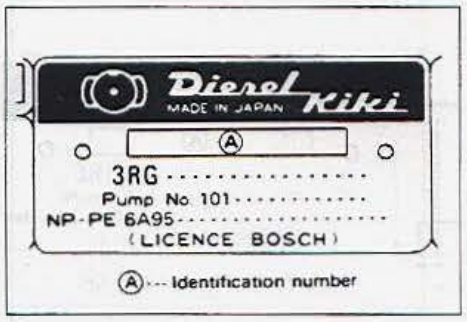


INJECTION PUMP DATA

INJECTION VOLUME ADJUSTMENT

Test condition	
Injection nozzle	D.K.K.C. P.No. 105780-0000 Bosch type No. DN12SD12T
Injection nozzle holder	D.K.K.C. P.No. 105780-2080 Bosch type No. EF8511/9A
Injection starting pressure	175 kg/cm² (2489 psi)
Injection line	Outside dia. 6mm (0.236 in.) x Inside dia. 2mm (0.078 in.) — Length 600 mm (24 in.)
Over flow valve opening pressure	1.3 kg/cm² (18 psi)
Test oil	SAE standard test diesel fuel (SAE J967d, or ISO4113)
Temperature of in use	40° — 45°C (104° — 113°F)

IDENTIFICATIONS PLATE AND NUMBER



When adjusting the volume of fuel delivery, use the correct data following the injection pump assembly number.

Pre-stroke : No. 1 plunger 3.4 ± 0.05 mm

Injection order :

1 — 3 — 4 — 2 (interval 90° ± 30°)

Plunger are numbered from the drive side

Tappet clearance:

More than 0.3 mm with all cylinder

INJECTION VOLUME AND GOVERNOR PERFORMANCE DIAGRAM

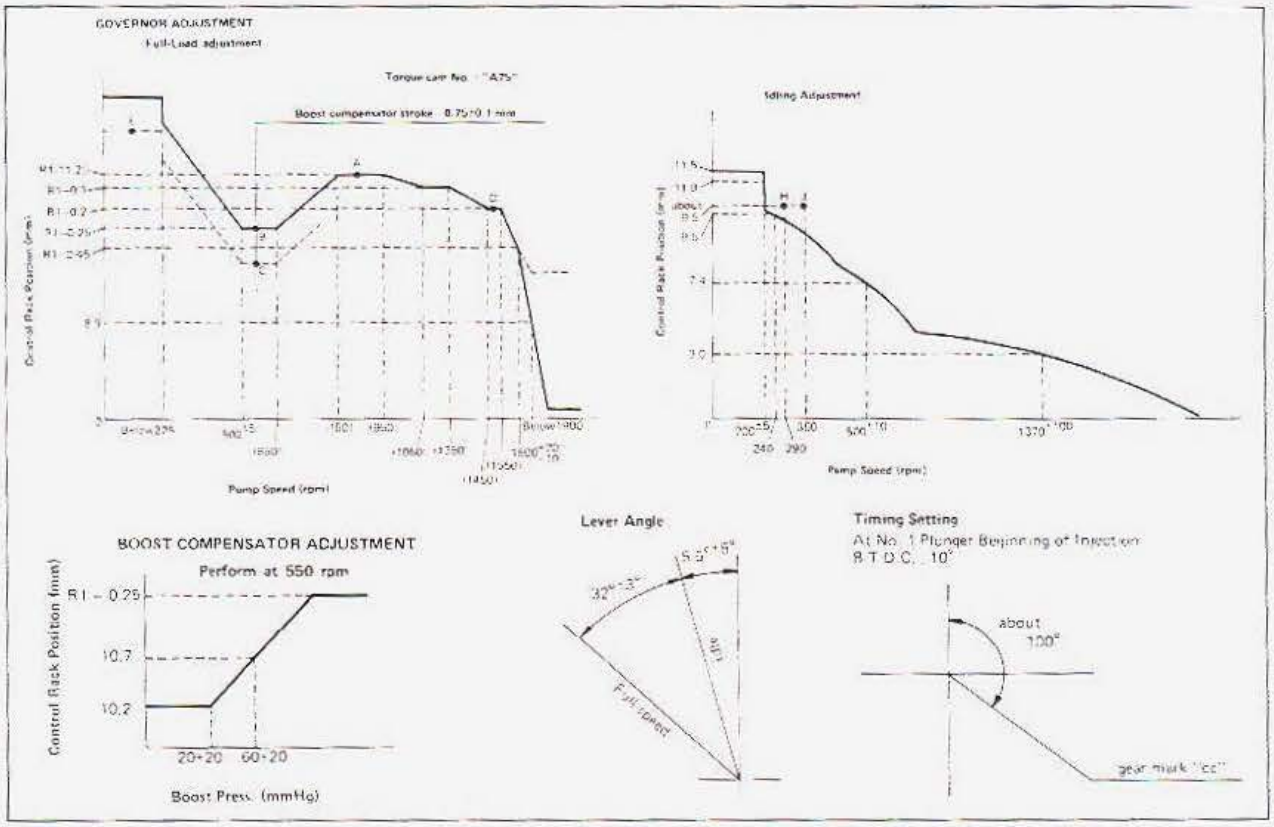
4BD1-T (Identification number : 101401-0660) with Boost compresator

Injection Quantity

Adjusting point	Control rack position (mm)	Pump speed (r.p.m.)	Strokes	Injection volume (cc/1000 st.)	Variance (%)	Fixed	Remarks
A	11.3	900	1000	69.6 — 72.8	± 2.5	Rack	Basic
H	About 9.5	290	1000	6.7 — 9.3	±14.0	Rack	
A	R1 11.2	900	1000	70.2 — 72.2	—	Lever	Boost pressure Above 110mmHg
B	R1 — 0.25	550	1000	(49.7)	—	Lever	Boost pressure Above 110mmHg
C	10.2	550	1000	(29.7)	—	Lever	
D	R1 — 0.2	1500	1000	78.0	—	Lever	Boost pressure Above 110mmHg
E	—	150	1000	Above 90.0	—	Lever	

Timing Advance Specification

Pump Speed (rpm)	1200—1300	1500
Degree for Angle of Lead (deg.)	Start 0	Finish 3.0—4.0



INJECTION NOZZLE

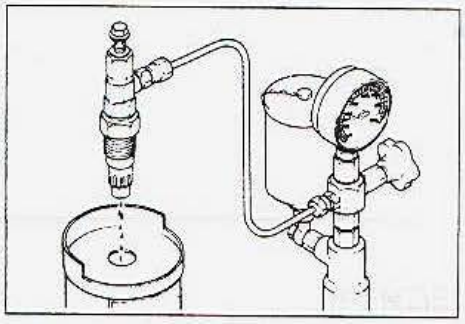
INSPECTION

Be sure to perform the following inspections before disassembly.

Nozzle opening pressure

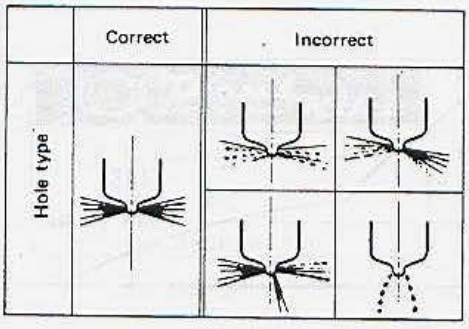
Measure the nozzle opening pressure using nozzle tester.

Nozzle opening pressuire is 185 kg/cm² (2630 psi).



Check for leakage

Using nozzle tester, maintain a pressure of 165 kg/cm² (2346 psi). if there is no leakage, the nozzle is satisfactory.



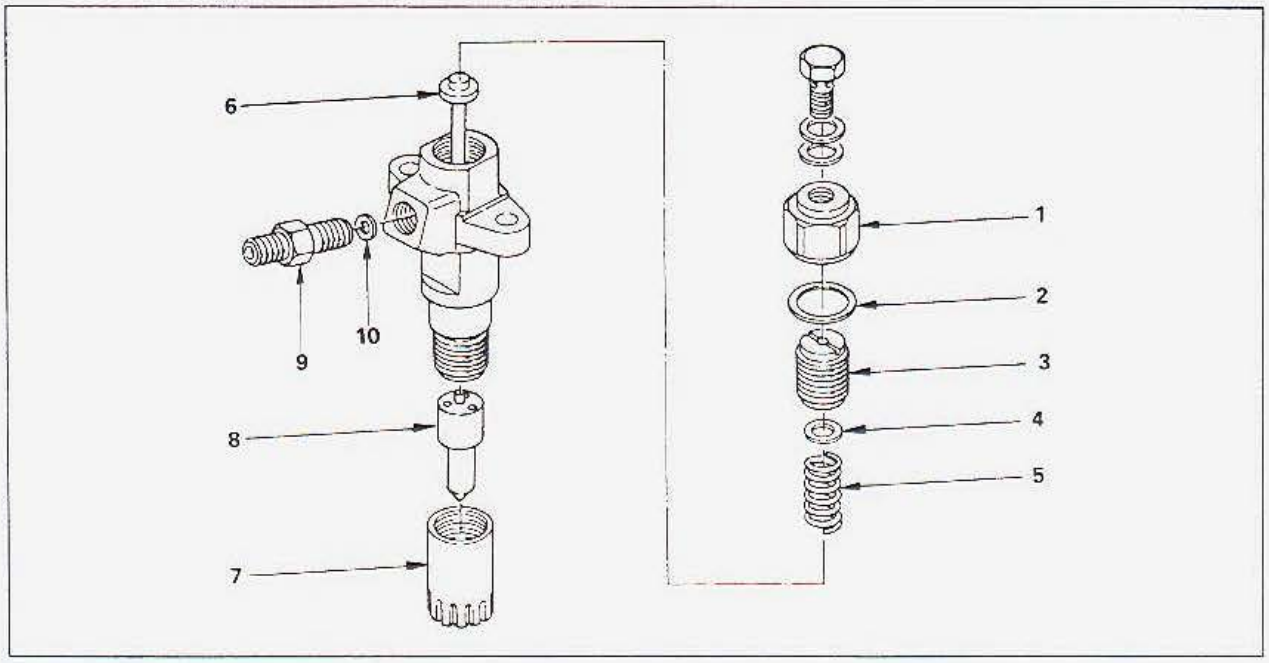
Nozzle spray pattern

Turn the handle of tester clockwise until it is seated. Having moved the nozzle tester lever several times abruptly, check the spray pattern at a lever speed of 4-6 times per second or more.

CAUTION: When using the nozzle tester, test fluid will spray out of injection nozzle at great pressure which can easily puncture worker's skin.

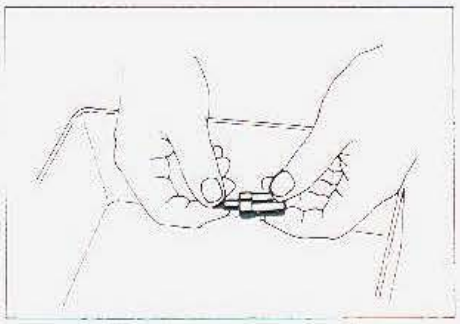
Since a defective injection nozzle and nozzle holder assembly may spray in any direction, make sure worker's hands are placed away from the nozle outlet when using the nozzle tester.

DISASSEMBLY



Disassembly steps

1. Cap nut
2. Gasket
3. Adjusting screw
4. Washer
5. Nozzle spring
6. Push rod
7. Retaining nut
▲ 8. Injection nozzle
9. Connector
10. Gasket



Important operation

8. Injection nozzle

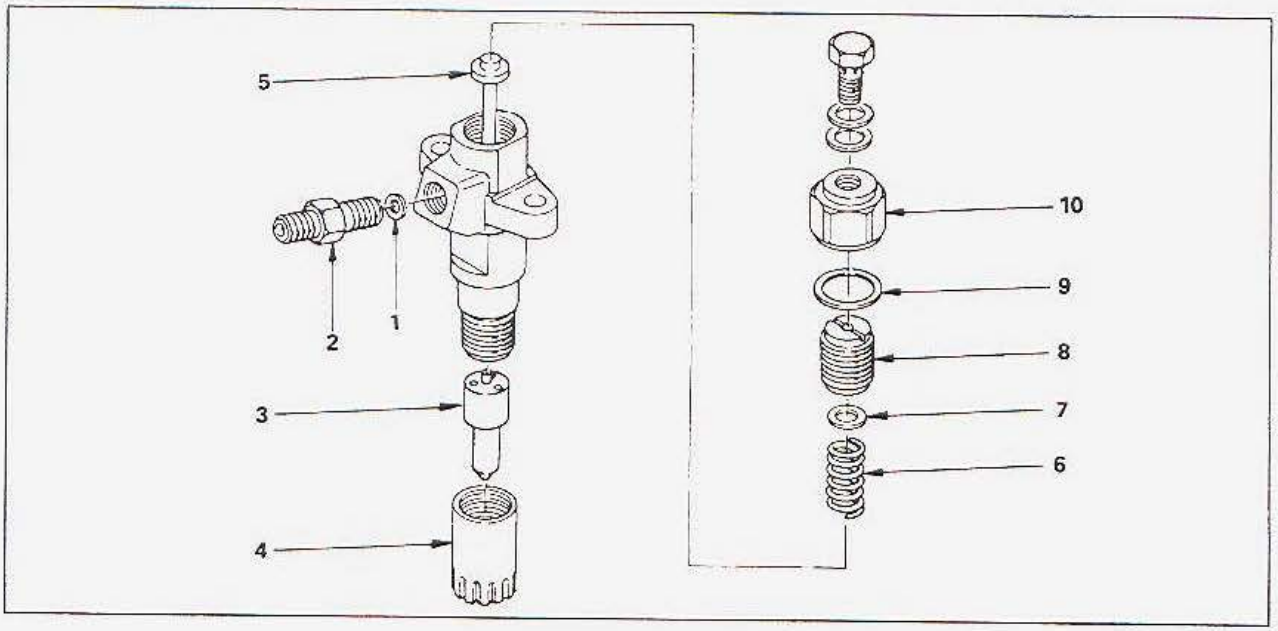
Keep nozzle assembly removed from the nozzle body separate from other units to maintain proper needle valve and body combinations.

INSPECTION AND REPAIR

Make necessary correction or parts replacement if wear damage or any other abnormal conditions are found through inspection.

Discard the used gaskets and install new one.
Clean the nozzle and nozzle holder with clean diesel fuel. Check them for worn out, corrosion and damage, and replace if necessary.
Carbon deposit on the tip end of the needle valve and injection holes should be cleaned using nozzle cleaning kit.

REASSEMBLY

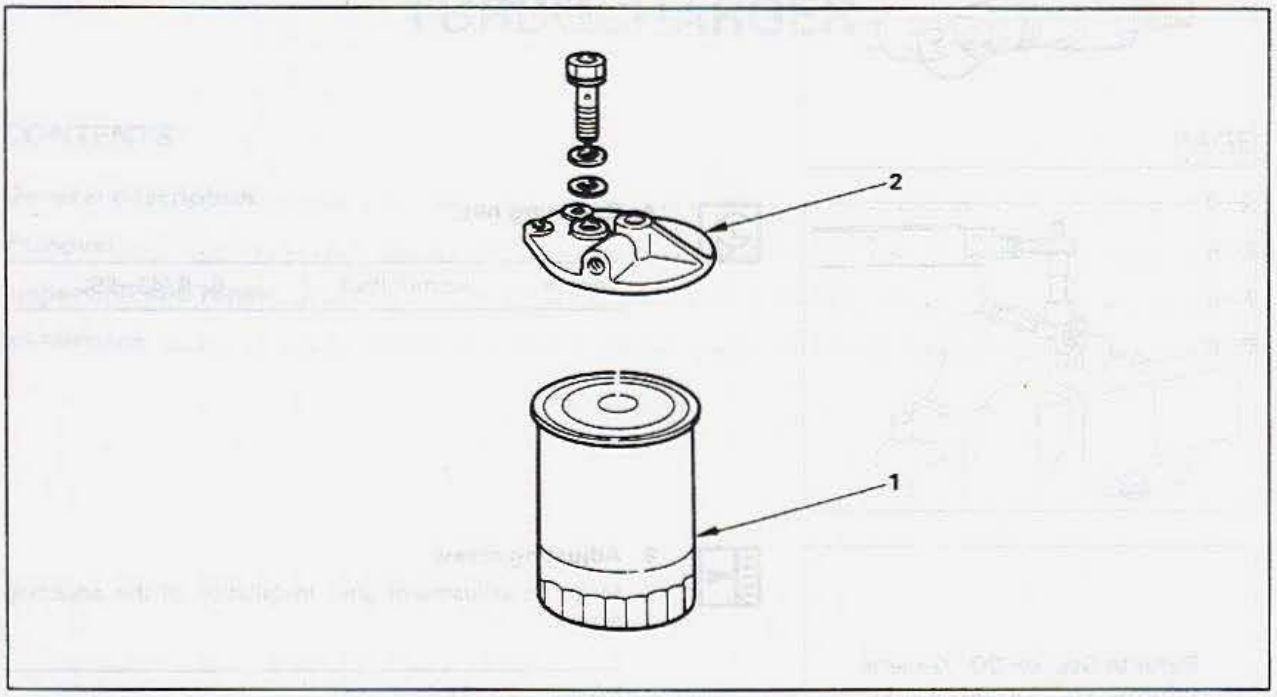


Disassembly steps

1. Gasket
2. Connector
▲ 3. Injection nozzle
▲ 4. Retaining nut
5. Push rod
6. Nozzle spring
7. Washer
▲ 8. Adjusting screw
9. Gasket
▲ 10. Cap nut

FUEL FILTER

DISASSEMBLY



Removal steps

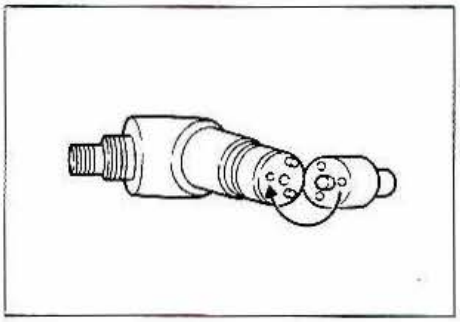
1. Fuel filter cartridge
2. Fuel filter body

INSPECTION AND REPAIR

Make necessary correction or parts replacement if wear damage or any other abnormal conditions are found through inspection.

REASSEMBLY

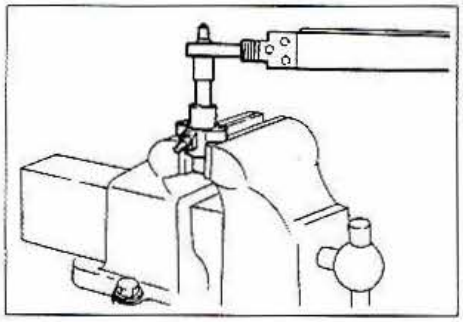
To reassemble, follow the disassembly procedure in reverse order.



Important operations

3. Injection nozzle

The locating pin on nozzle must be aligned with the hole in nozzle holder body.



4. Retaining nut

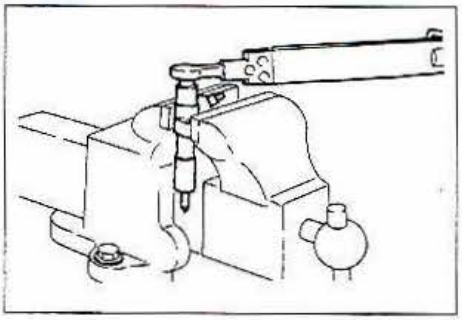
Torque	kg·m(ft.lbs.)	6—8 (43—58)

Refer to Section 00 "General information" for the injection nozzle starting pressure adjustment.

8. Adjusting screw

Make an adjustment after installation of the adjusting screw.

Injection starting pressure kg/cm²(psi)	185 (2630)



10. Cap nut

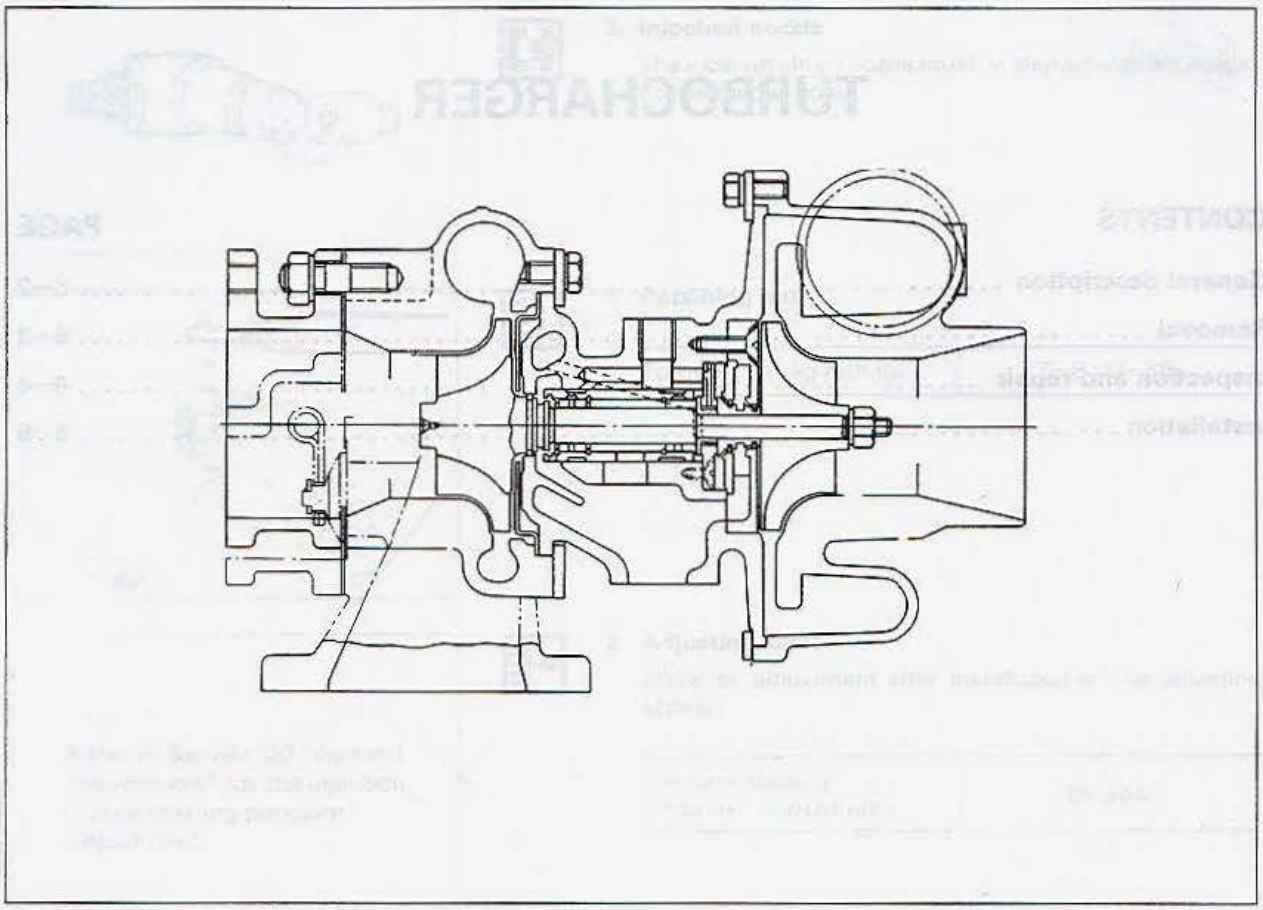
Torque	kg·m(ft.lbs.)	4—5 (29—36)

SECTION 6

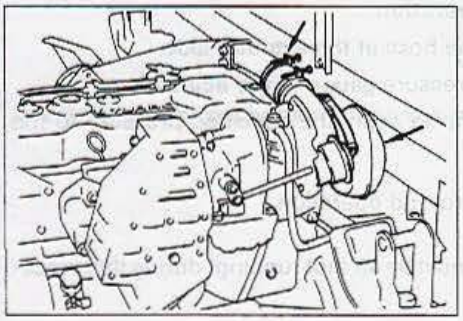
TURBOCHARGER

CONTENTS PAGE

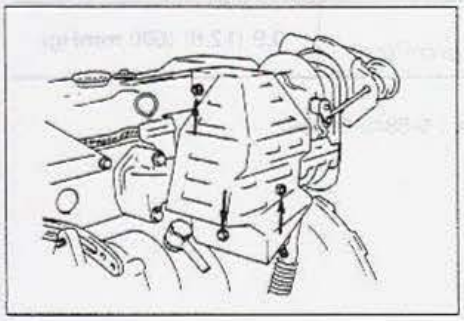
GENERAL DESCRIPTION



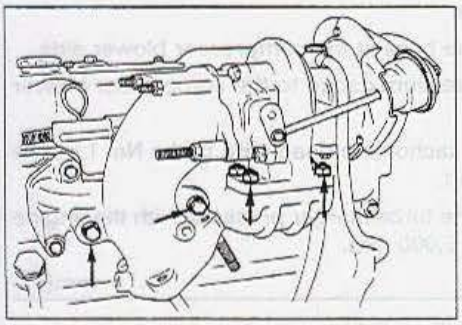
REMOVAL



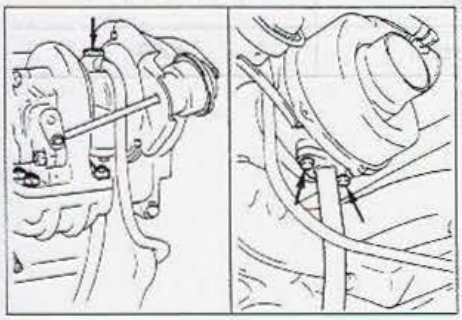
1. Intake duct
2. Intake rubber hose



3. Heat protector



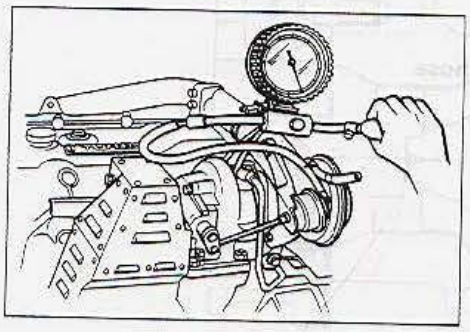
4. Fixing nuts and bolts



5. Oil pipe

INSPECTION AND REPAIR

Make necessary correction or parts replacement if wear damage or any other abnormal conditions are found through inspection.



1. Waste gate operation

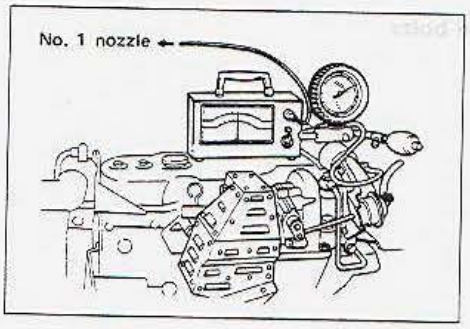
(1) Remove the hose at the actuator side.
(2) Attach a pressure gauge to the actuator.
(3) Use a pump to apply the specified pressure to the actuator.

Check the control rod operation.

Note: The engine must be off (not running) during this procedure.

Control rod operation	kg/cm²(psi)	0.9 (12.8) (680 mmHg)

Pressure gauge : 5-8840-0075-0

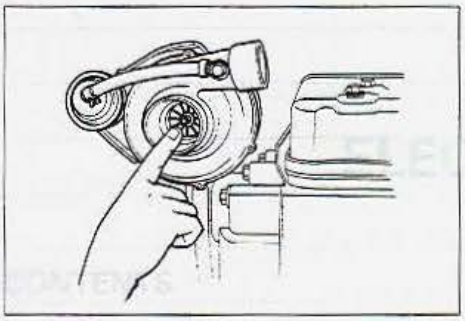


2. Boost pressure

(1) Remove the hose at the compressor blower side.
(2) Attach a pressure gauge to the compressor blower side.
(3) Attach the tachometer lead wire to the No. 1 nozzle holder head.
(4) Measure the turbocharger pressure with the engine running at 3,000 rpm.

mm(in.)

Boost pressure (engine at no load) kg/cm²	About 0.4 (5.7)
Engine speed (rpm)	3000



3. **Abnormal noise, excessive play, and oil leakage**
   (1) Remove the intake duct.
   (2) Rotate the turbine shaft by hand to check for abnormal noise and excessive play.
   (3) Check each of the flange and oil pipe connections on the turbine, the center, and the compressor housing for oil leaks.

Note: The engine must be off (not running) and cold during this inspection procedure.

INSTALLATION

To install the turbocharger, follow the removal procedure in the reverse order.

SECTION 7

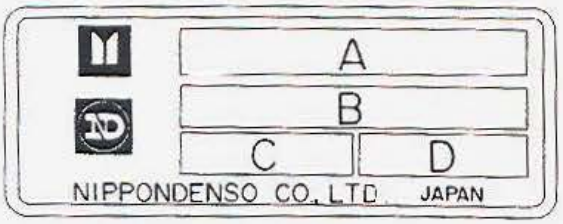
ELECTRICAL SYSTEM

CONTENTS PAGE

STARTER MOTOR

IDENTIFICATION OF UNIT OR EQUIPMENT

Nippondenso starter motor is identified with the name plate attached to the yoke as illustrated.



Isuzu part no.	Manufacturer's code no.
1-81100-169-0	028000-6640

A : Isuzu part number
B : Manufacturer's code number
C : Rated voltage
D : Manufacturer's production mark

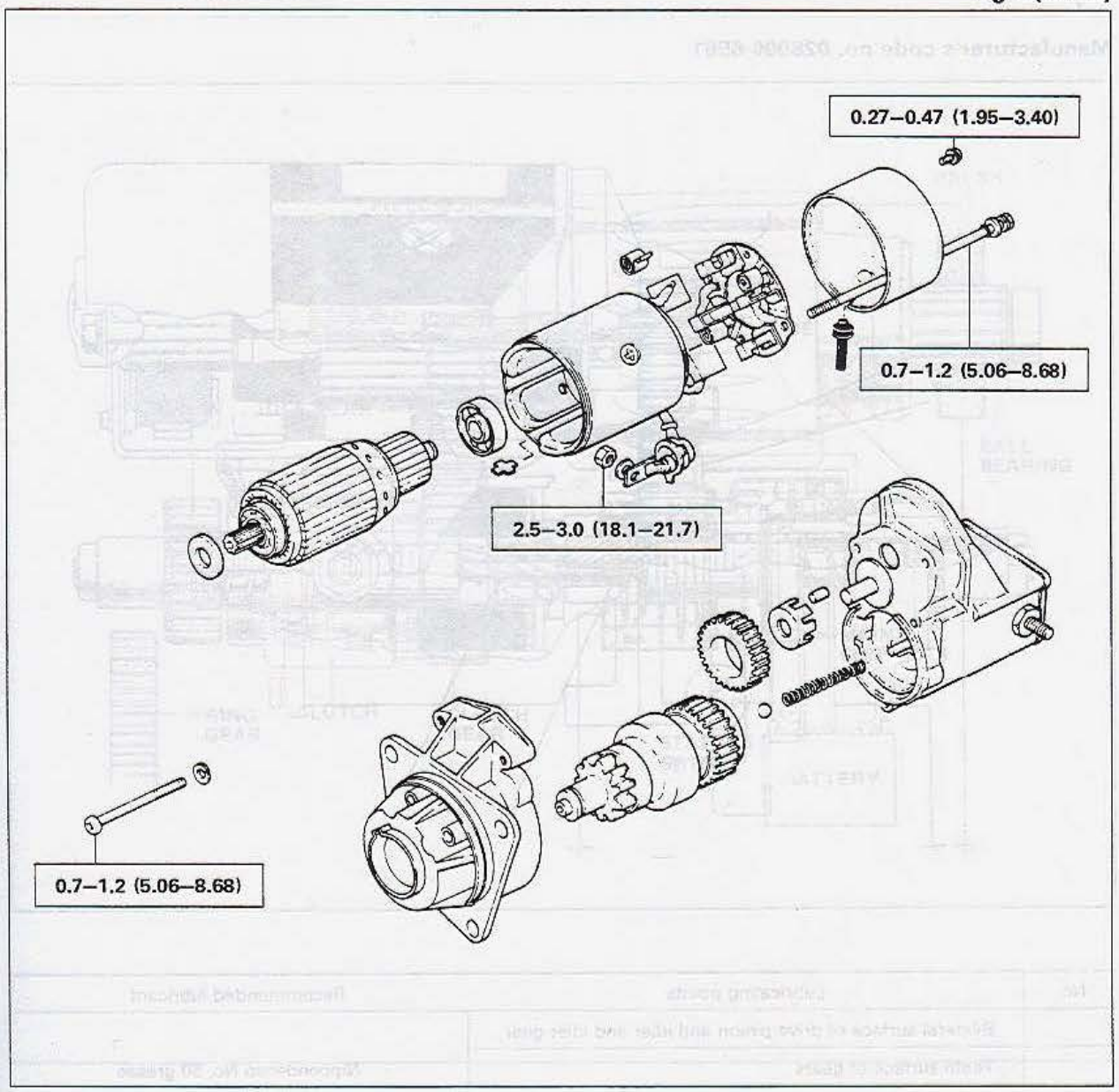
MAIN DATA AND SPECIFICATIONS

Isuzu part no.			1-81100-169-0
Manufacturer's code no.			028000-6561
Rated voltage		(V)	12
Rated output		(kW)	2.5
Rating		(Sec.)	30
Direction of rotation As viewed from pinion side			Clockwise
Type of clutch			Roller
Terminal voltage : (No load)		(V)	11
No-load current : Max.		(A)	170
Number of revolutions : Min : (No-load)		(rpm)	3,800
Pinion gear Module			
Number teeth			11
Outside diameter		mm(in.)	40.5 (1.59)
Distance of travel		mm(in.)	0.81 (0.032)
Yoke Outside diameter		mm(in.)	90 (3.54)
Armature Outside diameter		mm(in.)	60 (2.36)
Number of poles			4
Brush length Standard		mm(in.)	20.5 (0.79)
Limit		mm(in.)	13.0 (0.51)
Bush springs Standard fitting load		kg(lbs.) kg(lbs.)	3.4 (7.5)
Commutator	Outside diameter Standard	mm(in.)	36 (1.42)
	Limit	mm(in.)	35 (1.38)
	Run-out Standard	mm(in.)	0.05 (0.0020)
	Limit	mm(in.)	0.4 (0.016)
	Depth of undercut mica Standard	mm(in.)	0.5—0.8 (0.02—0.03)
	Limit	mm(in.)	0.2 (0.0078)

TORQUE SPECIFICATIONS

Manufacturer's code no. 028000-6561

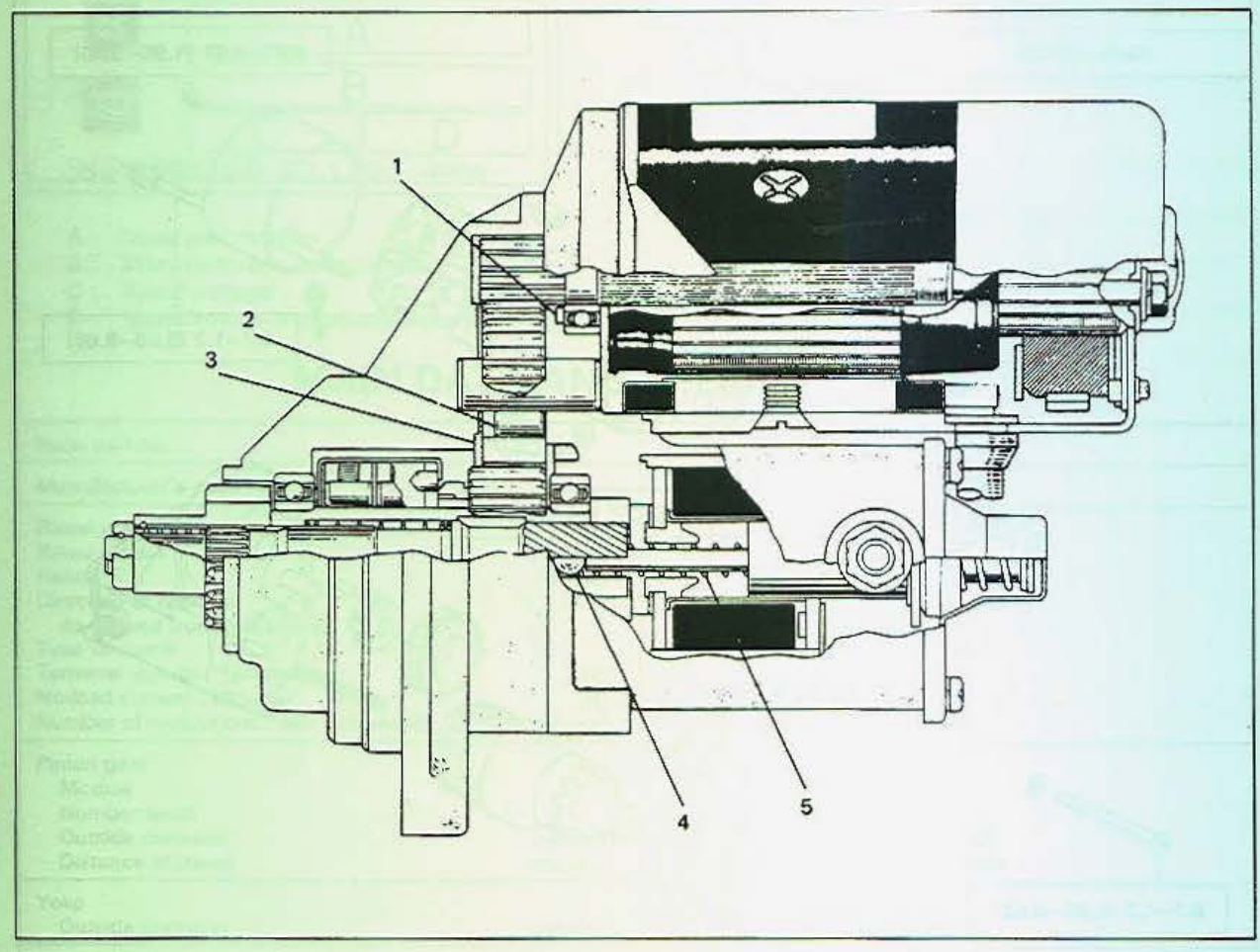
kg·m(ft.lbs.)



RECOMMENDED LUBRICANTS

Grease of different types should never be blended, or characteristics will be deteriorated.

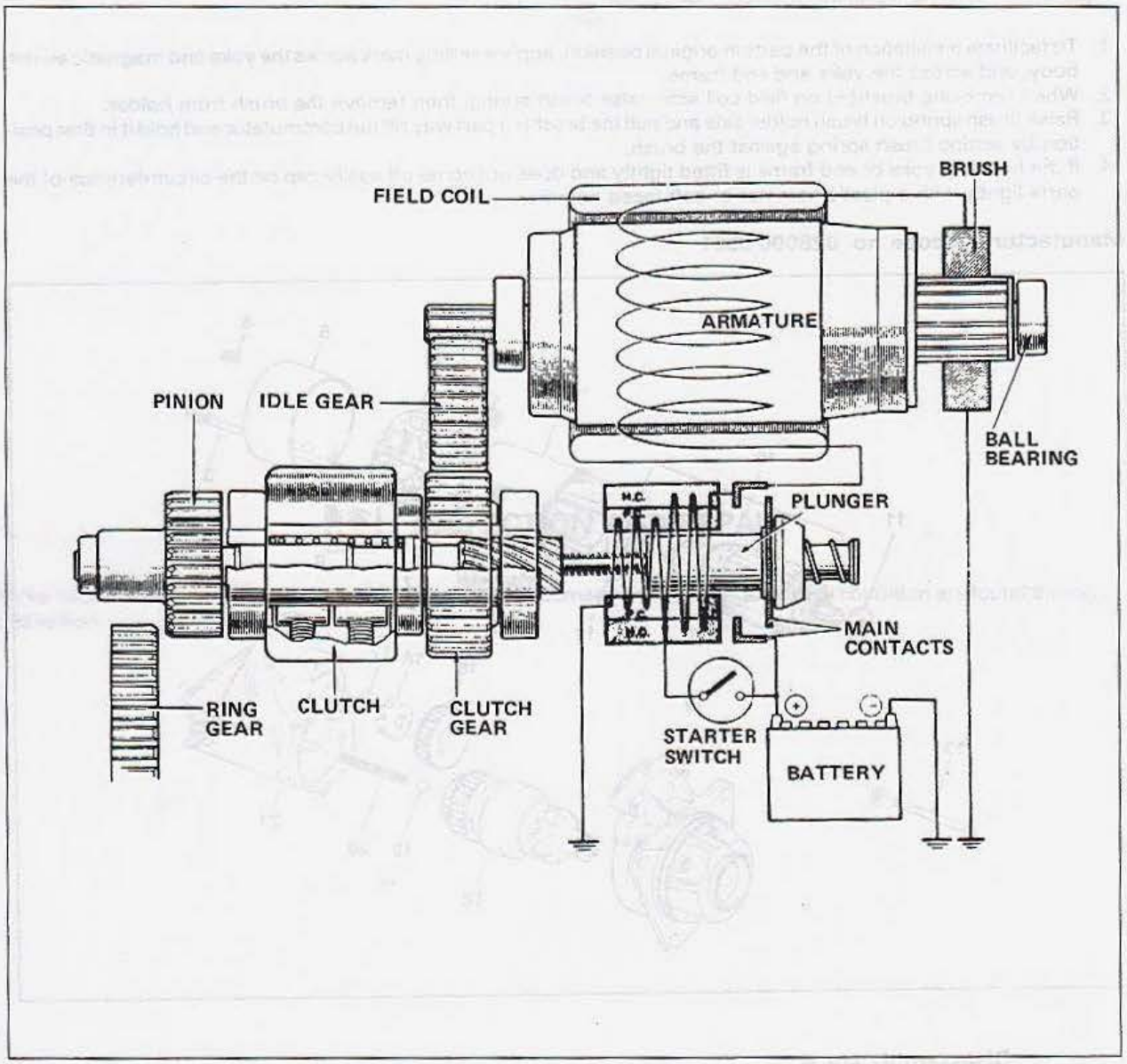
Manufacturer's code no. 028000-6561



No.	Lubricating points	Recommended lubricant	
	Bilateral surface of drive pinion and idler and idler gear		
	Teeth surface of gears	Nippondenso No. 50 grease	
	Ball bearings	Aeroshell 1	(SHELL)
1	Felt washer		
2	Roller	Aeroshell 7A	(SHELL)
3	Retainer		
4	Steel ball	Beacon 325	(ESSO)
5	Return spring		

CIRCUIT ARRANGEMENT

Manufacturer's code no. 028000-6561

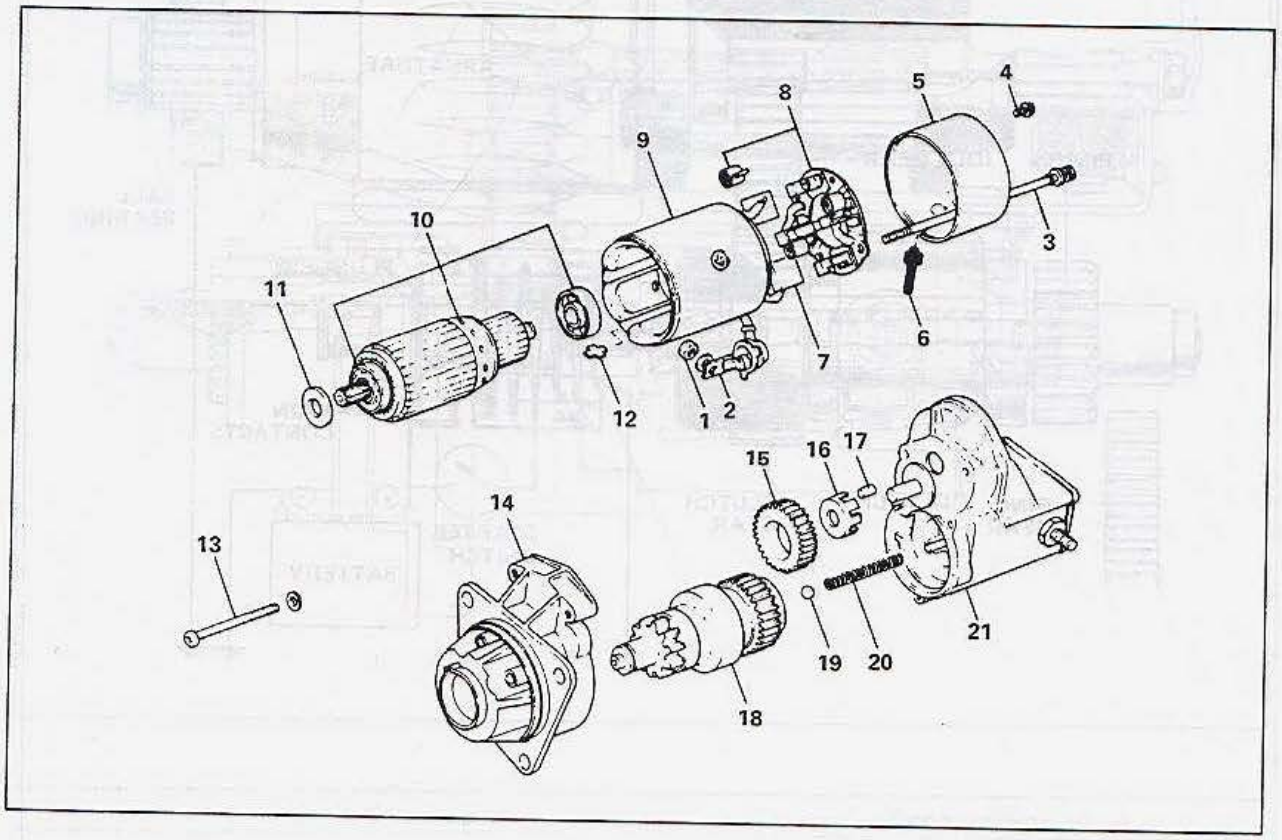


DISASSEMBLY

Note the following points when disassembling the starter motor:

1. To facilitate installation of the parts in original position, apply a setting mark across the yoke and magnetic switch body, and across the yoke and end frame.
2. When removing brush(+) on field coil side, raise brush spring, then remove the brush from holder.
3. Raise brush spring on brush holder side and pull the brush(—) part way off the commutator and hold it in that position by setting brush spring against the brush.
4. If the housing, yoke or end frame is fitted tightly and does not come off easily, tap on the circumference of the parts lightly with a plastic hammer or soft faced hammer.

Manufacturer's code no. 028000-6561



Disassembly steps

1. Nut
2. Connecting lead
3. Through bolt
4. Screw
5. End frame
6. Cover
7. Brush
8. Brush holder
9. Yoke
10. Armature
11. Felt washer
12. Lock plate
13. Screw
14. Housing
15. Idler gear
16. Retainer
17. Roller
18. Clutch
19. Steel ball
20. Return spring
21. Magnetic switch

Important operation

21. Magnetic switch

(1) The hexagonal nuts on terminal bolts must not be loosened.

INSPECTION AND REPAIR

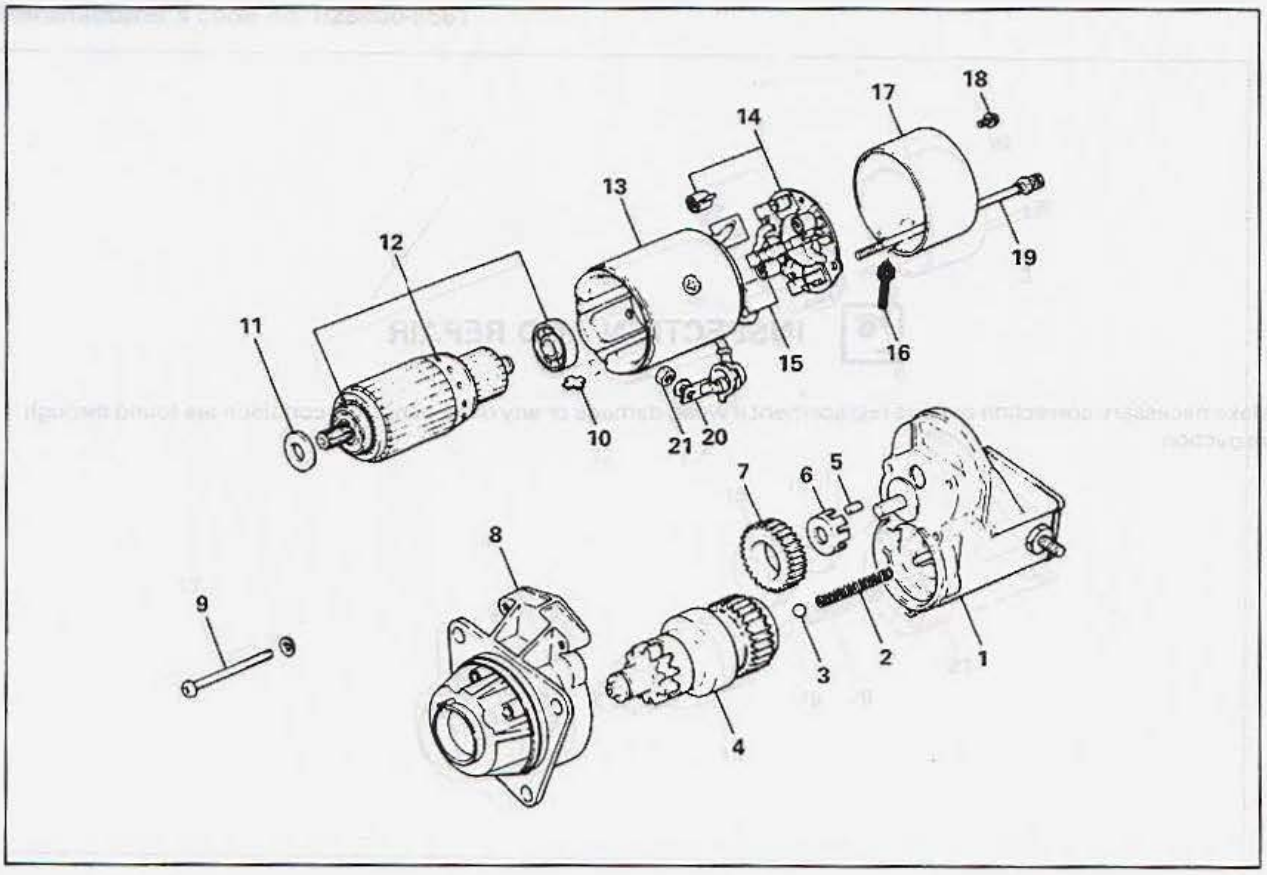
Make necessary correction or parts replacement if wear, damage or any other abnormal condition are found through inspection.

REASSEMBLY

Note the following points when disassembling the starter motor:

1. When installing rotating or sliding parts, check to make sure they operate smoothly before proceeding to the following steps.
2. When installing brush holder, exercise care so as not to cause damage to the brushes.
3. Properly align the setting marks applied to the yoke or end frame at disassembly before tightening.
4. Tighten fixing bolts, screws and nuts to the specified torques.

Manufacturer's code no. 028000-6561



Reassembly steps

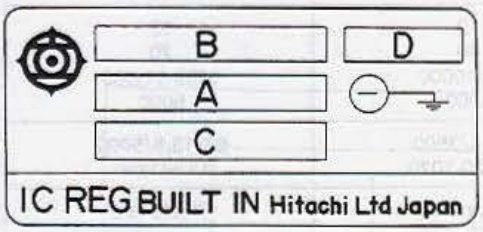
1. Magnetic switch
2. Return spring
3. Steel ball
4. Clutch
5. Roller
6. Retainer
7. Idler gear
8. Housing
9. Screw
10. Lock plate
11. Felt washer
12. Armature
13. Yoke
14. Brush holder
15. Brush
16. Cover
17. End frame
18. Screw
19. Through bolt
20. Connecting lead
21. Nut

ALTERNATOR AND REGULATOR

IDENTIFICATION OF UNIT OR EQUIPMENT

ALTERNATOR

Hitachi alternator is identified with the name plate attached to the rear end frame as illustrated.

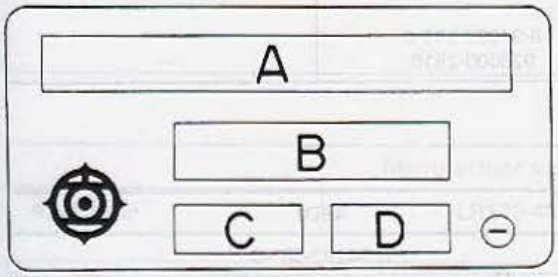


Isuzu part no.	Manufacturer's code no.
5-81200-132-0	100210-1150
8-94175-448-1	LR170-401

A : Isuzu part number
B : Manufacturer's code number
C : Rated voltage
D : Manufacturer's production mark

REGULATOR

Hitachi regulator is identified with the mark printed on the cover as illustrated.



Isuzu part no.	Manufacturer's code no.
8-94202-581-0	026000-2510

A : Isuzu part number
B : Manufacturer's code number
C : Rated voltage
D : Manufacturer's production mark

MAIN DATA AND SPECIFICATIONS

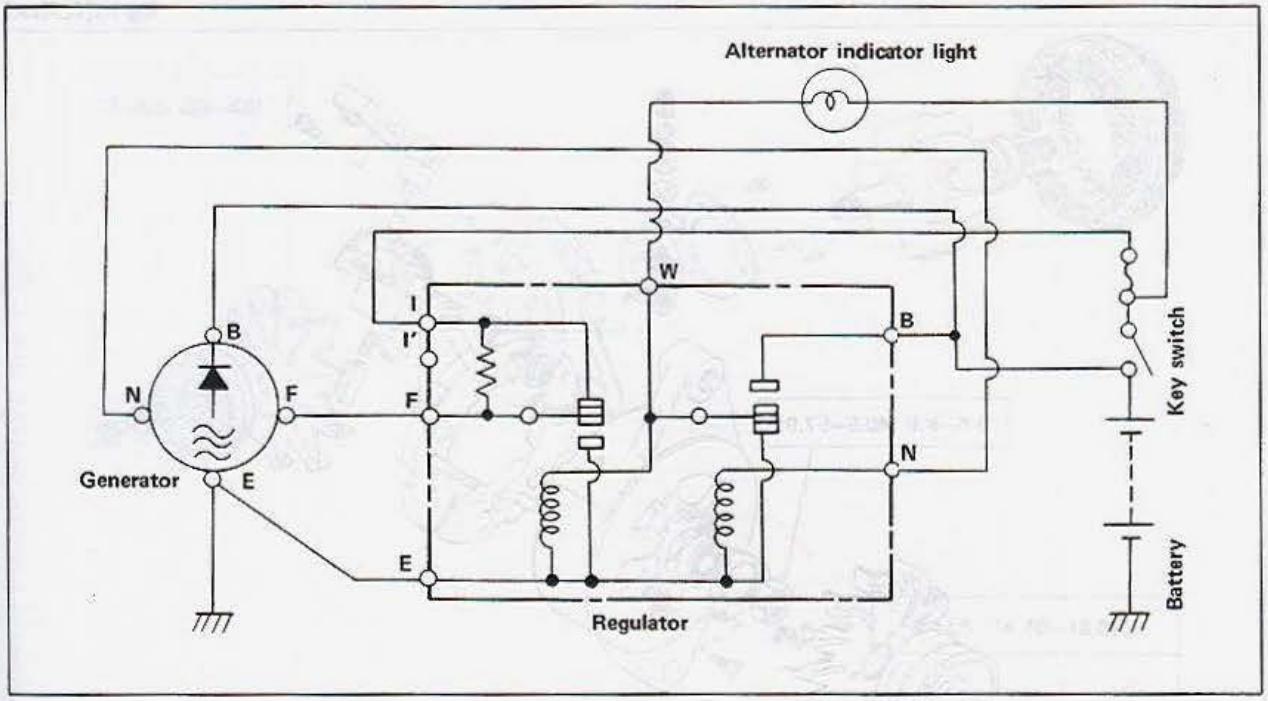
ALTERNATOR

Engine model		4BD1	4BD1T
Isuzu part no.		5-81200-132-0	8-94175-448-1
Manufacturer's code no.		100210-1150	LR170-401
Rated voltage	(V)	12	12
Rated output	(A)	40	70
Operating speed	(rpm)	850-10000	1000-11,000
Rated speed	(rpm)	5000	5000
Rated output at r.p.m.	(Amp./Volt/rpm)	40/14/3500	67/13.5/5000
No-load output at 0 Amp	(Volt/rpm)	14/820-1020	13.5/1250
Direction of rotation as viewed from pulley side		Clockwise	Clockwise
Polarity grounded		Negative	Negative
Pulley diameter	mm(in.)	90 (3.54)	82 (3.23)
Coil resistance at 20°C			
Rotor coil	(Ω)	4.0 (0.16)	3.8 (0.15)
Brush length			
Standard	mm(in.)	12.5 (0.49)	20.0 (0.79)
Limit	mm(in.)	5.5 (0.22)	14.0 (0.55)
Slip ring diameter			
Standard	mm(in.)	42.0 (1.65)	34.6 (1.36)
Limit	mm(in.)	41.6 (0.16)	33.6 (1.32)
Regulator's applicable			
Isuzu part no.		8-94202-581-0	—
Manufacturer's no.		026000-2510	—

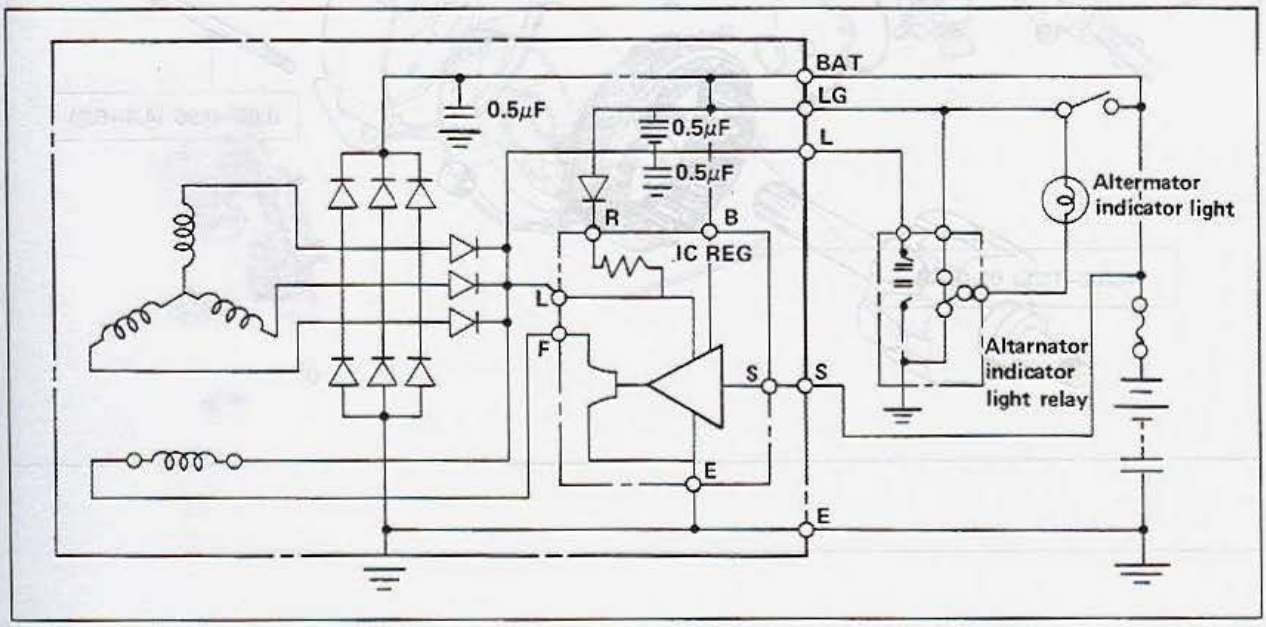
REGULATOR

Engine model		4BD1
Isuzu part no.		8-94202-581-0
Voltage regulator		
Regulated voltage	(V)	13.7 — 14.3
Yoke gap	mm(in.)	0.2 (0.0078)
Core gap	mm(in.)	0.3 (0.0118)
Point gap	mm(in.)	0.3—5.6 (0.0118—0.220)
Relays		
Yoke gap	mm(in.)	0.1—1.0 (0.0039—0.039)
Core gap	mm(in.)	0
Point gap	mm(in.)	0.4—1.2 (0.0016—0.0472)

	Manufactuer's code no.
Alternator	100210-1150
Combined regulator	026000-2510



	Manufactuer's code no.
Alternator	LR170-401

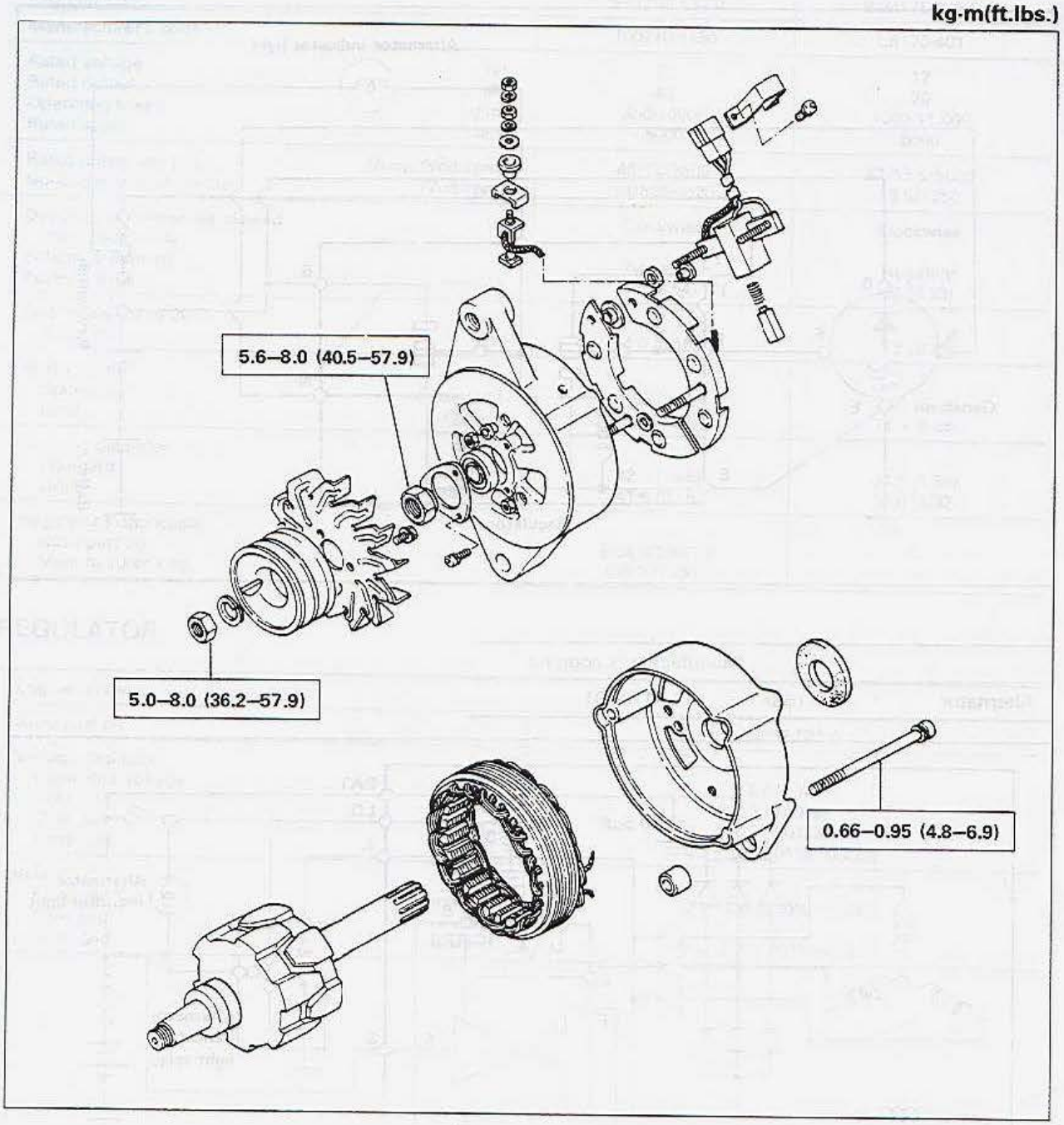


TORQUE SPECIFICATIONS

ALTERNATOR

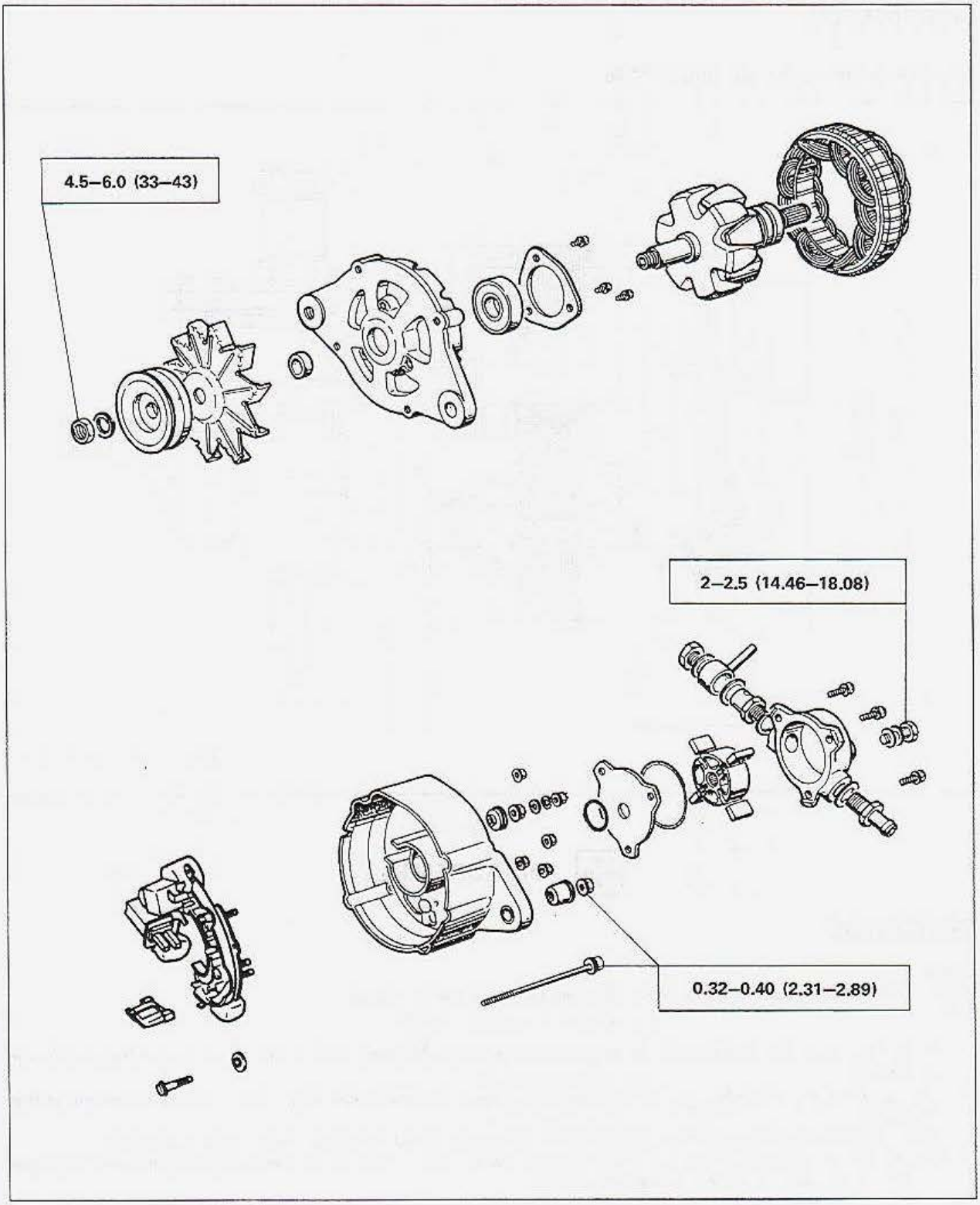
Manufacturer's code no. 100210-1150

kg·m(ft.lbs.)



Manufacturer's code no. LR170-401

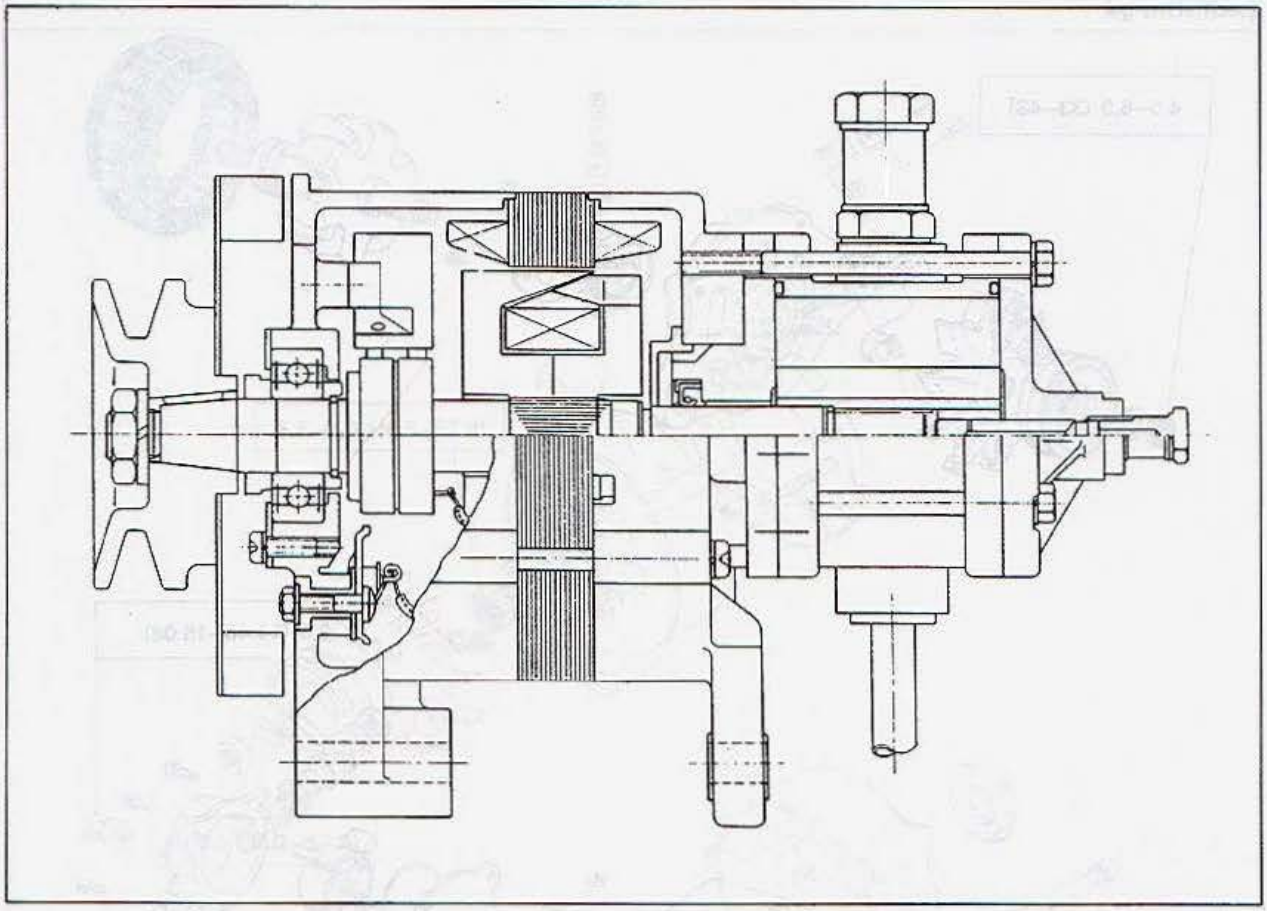
kg·m(ft.lbs.)



SECTIONAL VIEW

ALTERNATOR

Manufacturer's code no. 100210-1150



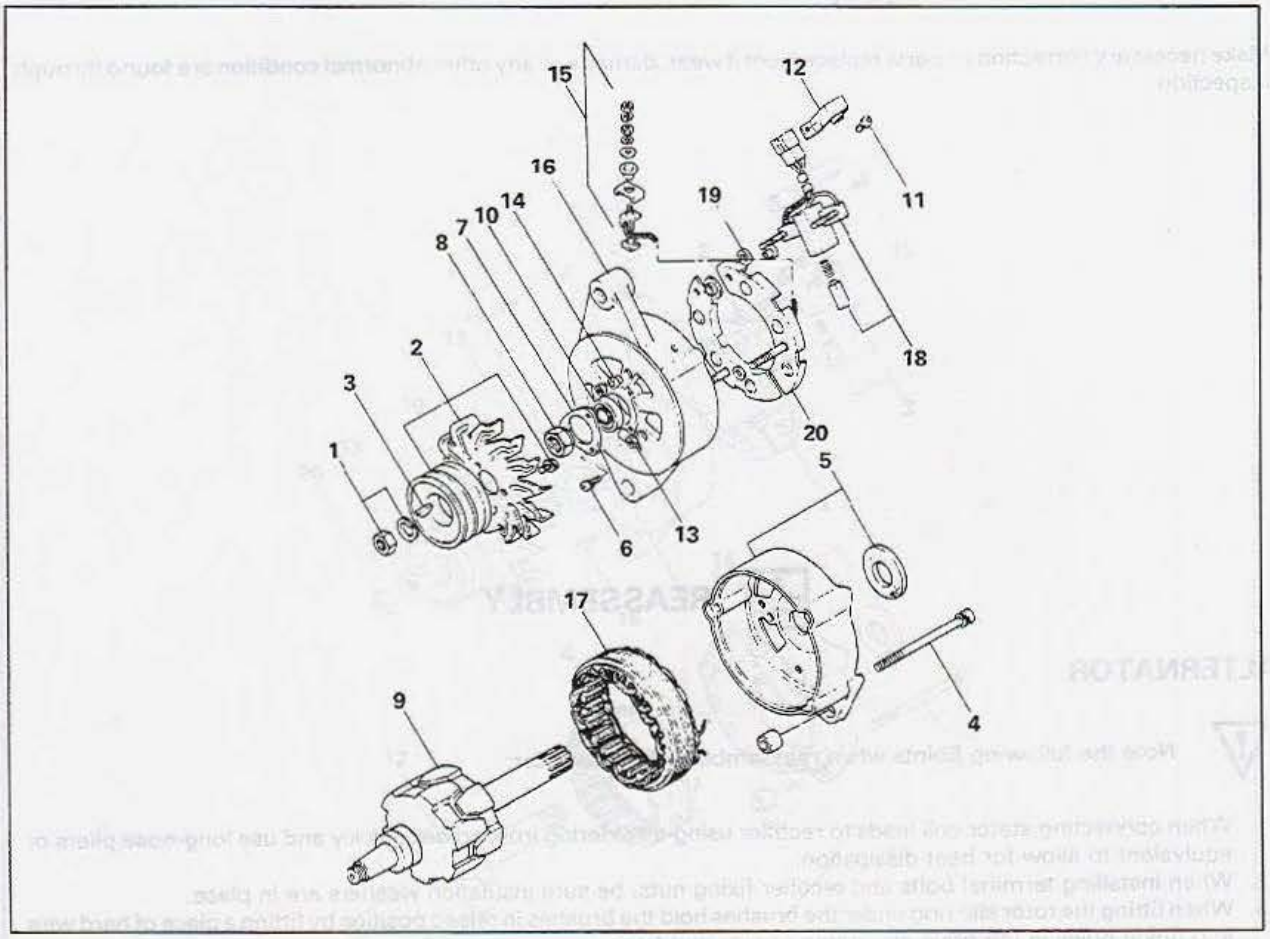
DISASSEMBLY

GENERATOR

Note the following points when disassembling the starter motor:

1. To facilitate installation of the parts in original position, apply a setting mark across the drive end frame and rear end frame.
2. Clamp the rotor in vise when removing pulley nut. Use a soft-jawed vise to prevent to prevent damaging rotor assembly.
3. Keep insulation washers neatly in sequence of removal to avoid installing them in wrong position.
4. When disconnecting stator coil leads from rectifiers using a soldering iron, melt solder quickly and use long-nose pliers or equivalent to allow for heat dissipation.

Manufacturer's code no. 100210-1150



Disassembly steps

1. Pulley
2. Pulley and fan
3. Key
4. Through bolt
5. Rear end frame
6. Screw
7. Retainer plate
▲ 8. Bearing lock nut
9. Rotor
10. Ball bearing
11. Screw
12. Cord clip
13. Nut
14. Insulator
15. Terminal
16. Drive end frame
17. Stator
18. Brush holder
19. Insulator
20. Rectifier

Important operation

8. Bearing lock nut

Remove bearing lock nut by turning clockwise. The lock nut has left-hand thread.

INSPECTION AND REPAIR

Make necessary correction or parts replacement if wear, damage or any other abnormal condition are found through inspection.

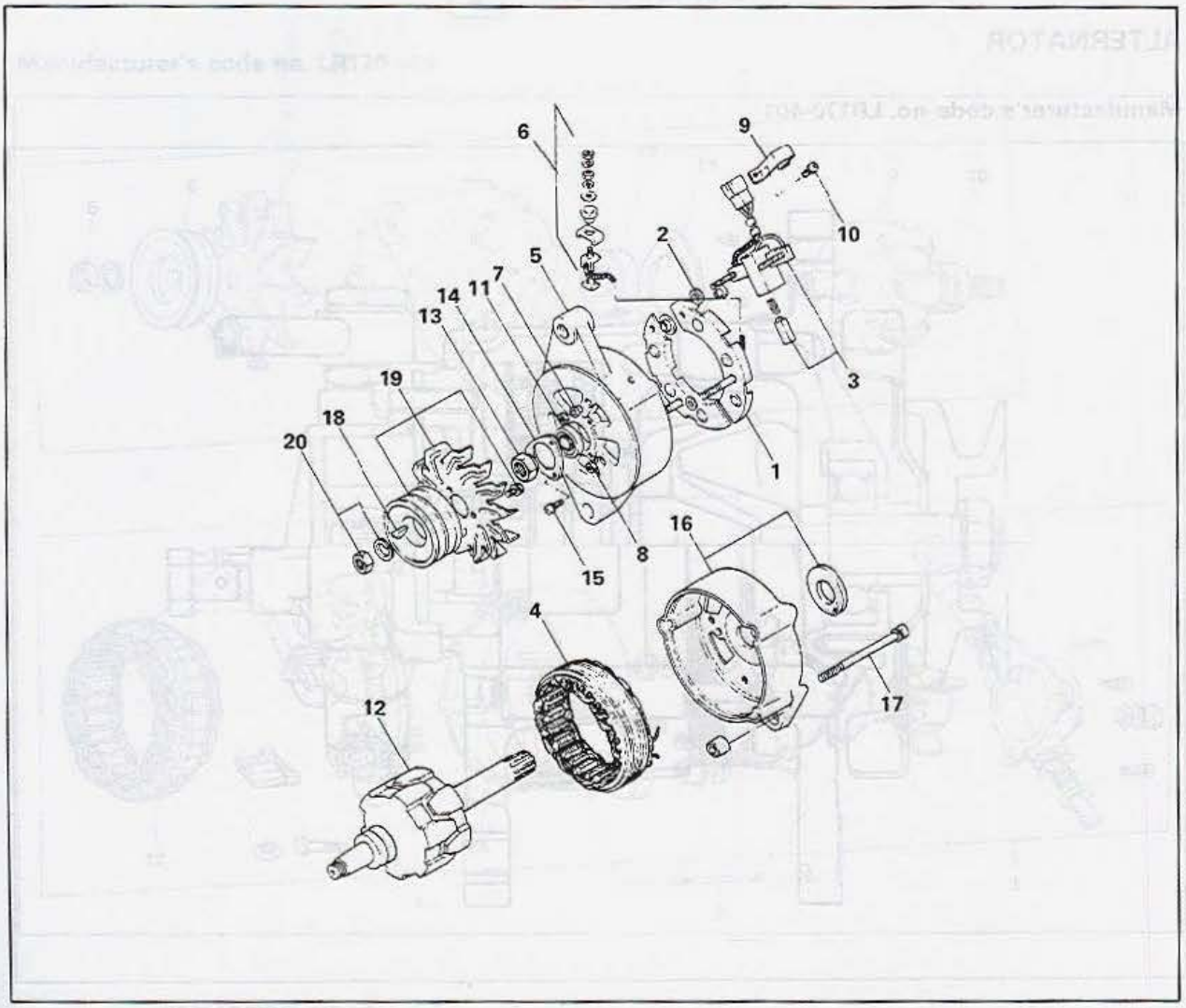
REASSEMBLY

ALTERNATOR

Note the following points when reassembling the alternator:

1. When connecting stator coil leads to rectifier using a soldering iron, solder quickly and use long-nose pliers or equivalent to allow for heat dissipation.
2. When installing terminal bolts and rectifier fixing nuts, be sure insulation washers are in place.
3. When fitting the rotor slip ring under the brushes hold the brushes in raised position by fitting a piece of hard wire into guide holes in the drive and frame or rear end frame.
4. Install a guide bar through holes in drive end frame and rear end frame for alignment of setting marks, then install through bolts.
5. Tighten fixing bolts, screws and nuts to the specified torques.

Manufacturer's code no. 100210-1150



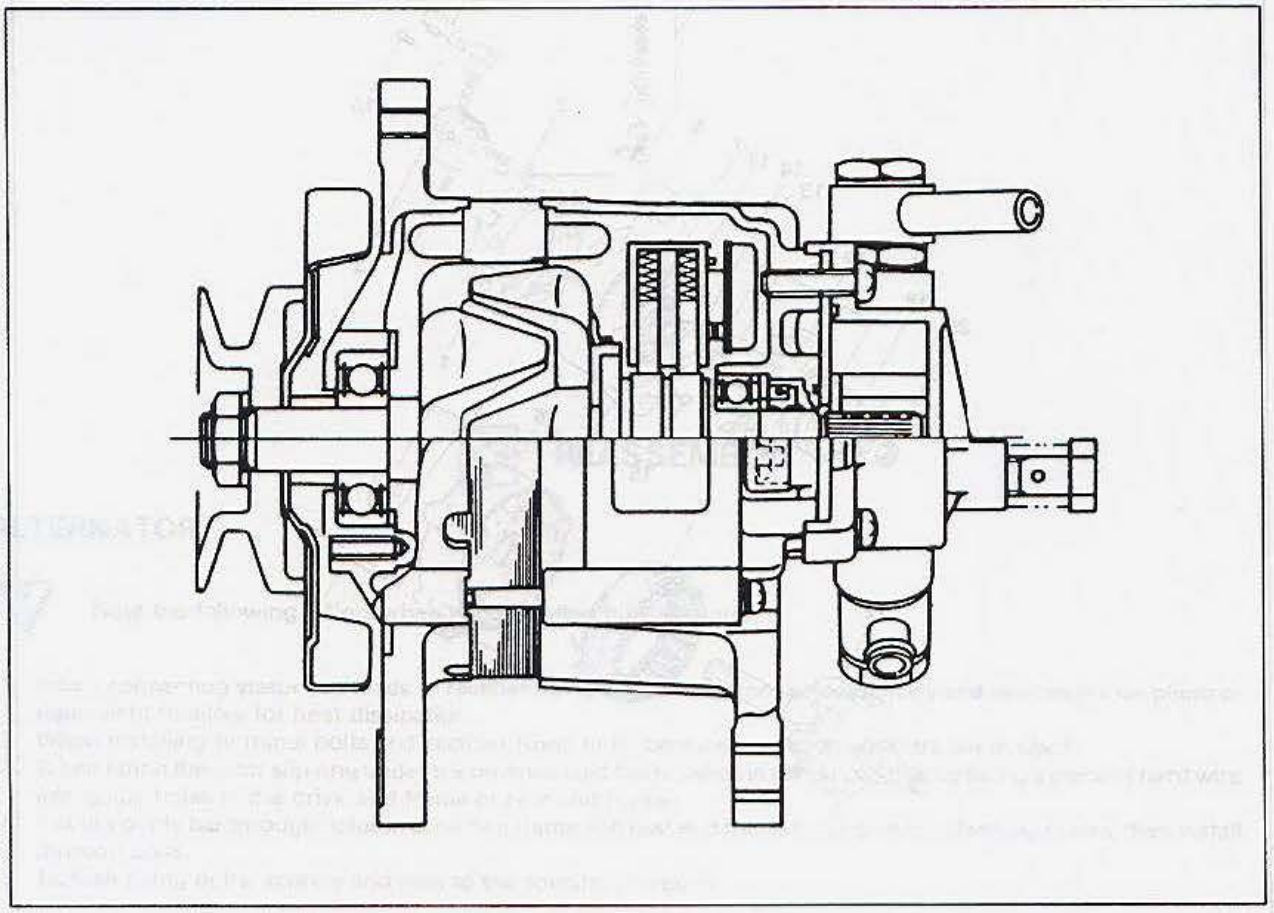
Reassembly steps

1. Rectifier
2. Insulator
3. Brush holder
4. Stator
5. Drive end frame
6. Terminal
7. Insulator
8. Nut
9. Cord clip
10. Screw
11. Ball bearing
12. Rotor
13. Bearing lock nut
14. Retainer plate
15. Screw
16. Rear end frame
17. Through bolt
18. Key
19. Pulley and fan
20. Pulley nut

SECTIONAL VIEW

ALTERNATOR

Manufacturer's code no. LR170-401



DISASSEMBLY

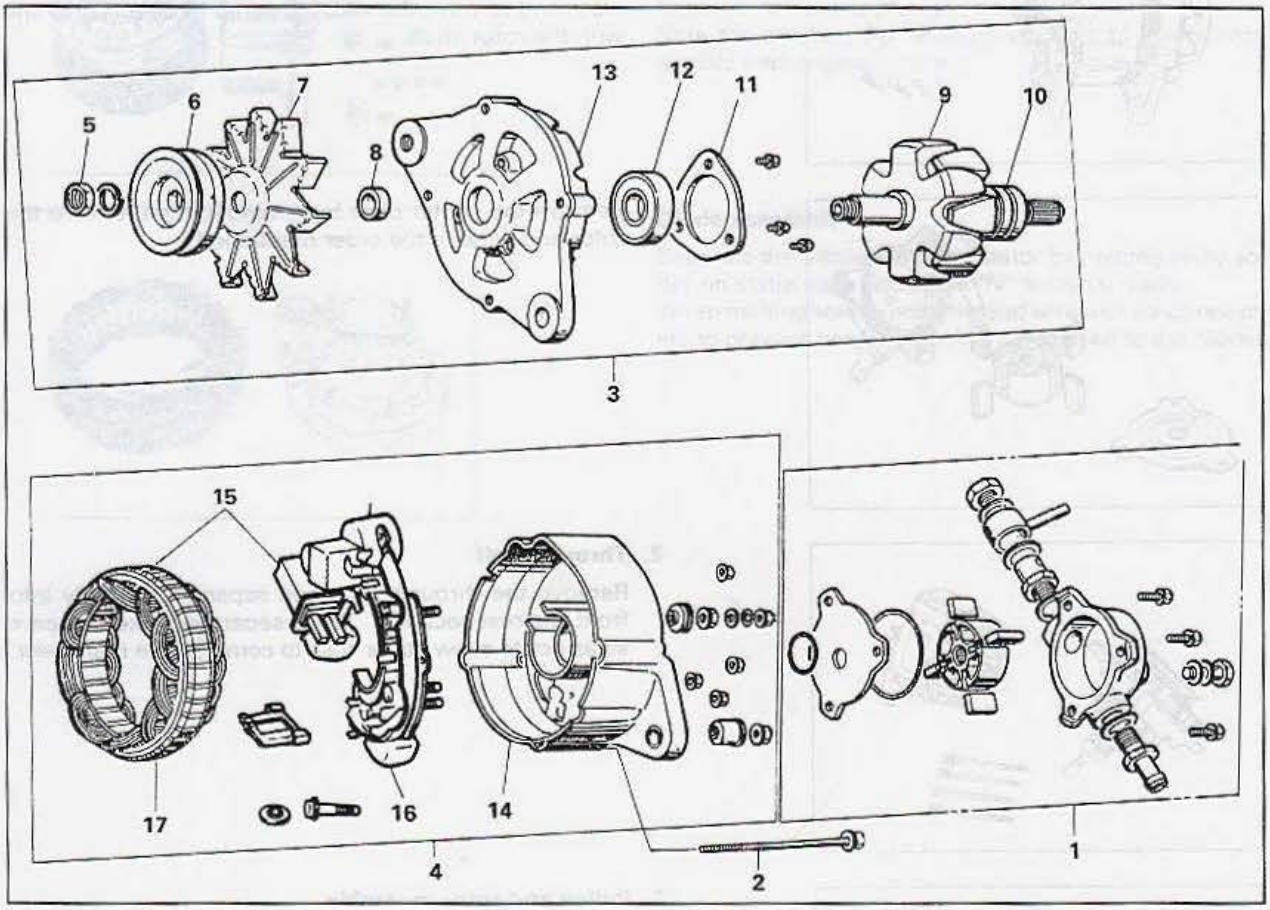
GENERATOR

Note the following points when disassembling the starter motor:

1. To facilitate installation of the parts in original position, apply a setting mark across the drive end frame and rear end frame.
2. Clamp the rotor in vise when removing pulley nut. Use a soft-jawed vise to prevent to prevent damaging rotor assembly.
3. Keep insulation washers neatly in sequence of removal to avoid installing them in wrong position.
4. When disconnecting stator coil leads from rectifiers using a soldering iron, melt solder quickly and use long-nose pliers or equivalent to allow for heat dissipation.

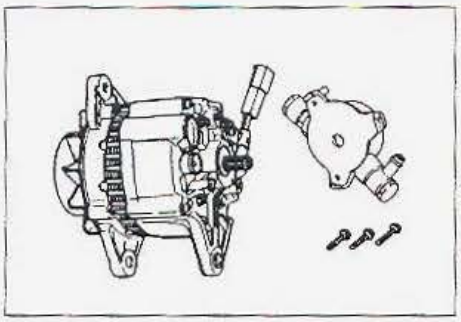
DISASSEMBLY

Manufacturer's code no. LR170-401



Disassembly steps

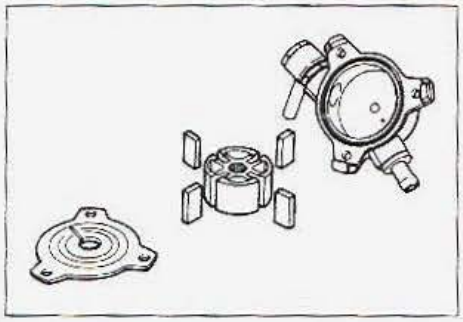
▲ 1. Vacuum pump assembly
▲ 2. Through bolt
▲ 3. Pulley and rotor assembly
▲ 4. Rear cover and stator assembly
▲ 5. Pulley nut
6. Pulley
7. Fan
8. Spacer
9. Rotor
10. Rear ball bearing
11. Bearing retainer
12. Front ball bearing
13. Front cover
▲ 14. Rear cover
▲ 15. Stator and diode assembly
▲ 16. Diode assembly
17. Stator



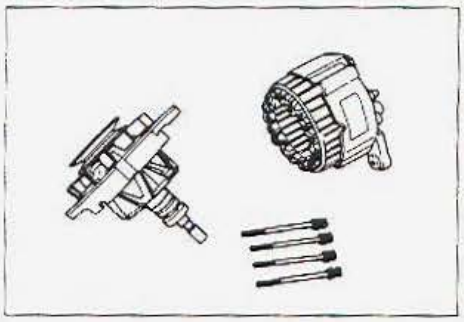
Important operations

1. Vacuum pump assembly

Remove the vacuum pump fixing bolts. Hold the center plate and remove the vacuum pump in direction in line with the rotor shaft.

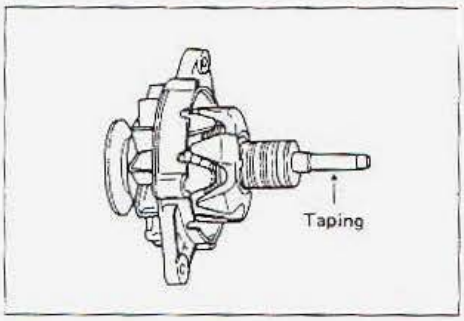


Remove the center plate by turning it, then remove the rotor and vane in the order mentioned.



2. Through bolt

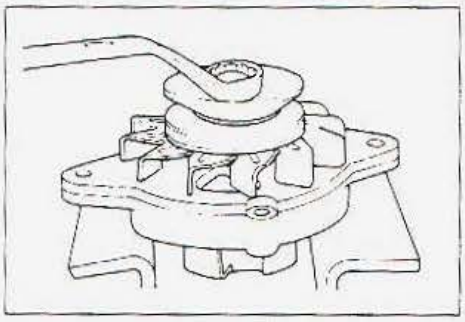
Remove the through bolts and separate the body into front and rear sections. When separating, *exercise care* so as not to allow stator coils to come off the rear cover.



3. Pulley and rotor assembly

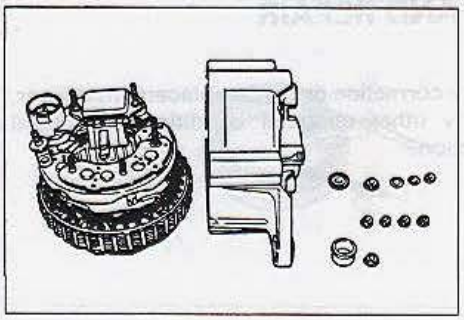
4. Rear cover and stator assembly

Take care not to damage the oil seal when removing the rear cover.
Taping the splines will provide some protection.



5. Pulley nut

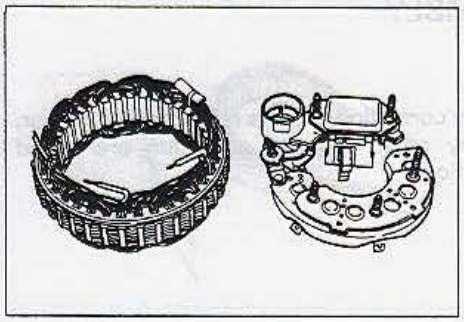
Clamp the rotor assembly in a vise and remove the pulley nut, then remove the pulley, front cover and rotor.



14. Rear cover

15. Stator and diode assembly

Remove the nuts fixing the B terminal and diode holder, then remove the screw inside the stator.
Separate the stator and rear cover.
Note the position of insulation washers to insure reassembly into original position.



16. Diode assembly

Separate the diodes from the stator by melting away solder on stator coil, diode and "N" terminal leads.
When melting solder, hold the lead wire with longnose pliers to prevent heat from being transferred to the diodes.

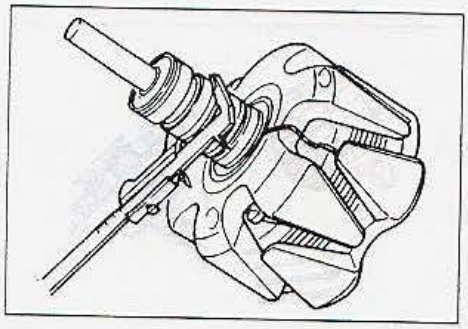
INSPECTION AND REPAIR

Make necessary correction or parts replacement if wear, damage or any other abnormal condition are found through inspection.

ROTOR ASSEMBLY

Visual check

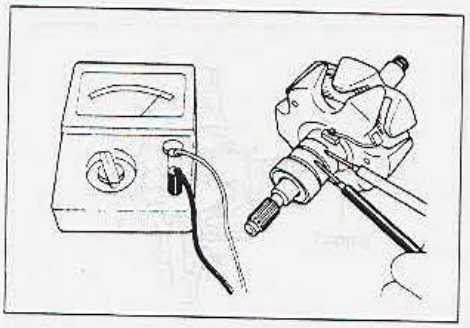
Make necessary correction or parts replacement if wear, damage or any other abnormal condition are found through inspection.



Measure the outside diameter of the slip rings.

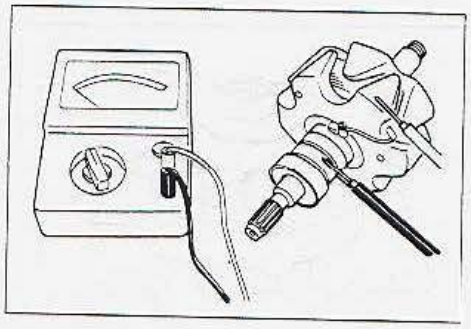
mm(in.)

Standard	Limit
34.6 (1.362)	33.6 (1.323)



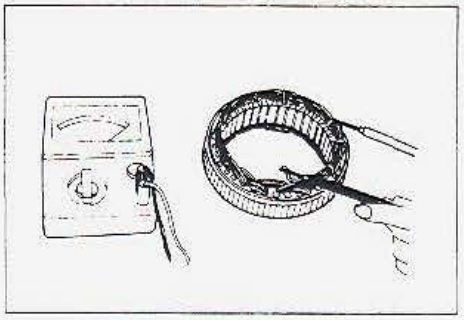
Continuity test

Check the rotor coil resistance across the slip rings. If no continuity exists, replace the rotor.



Ground test

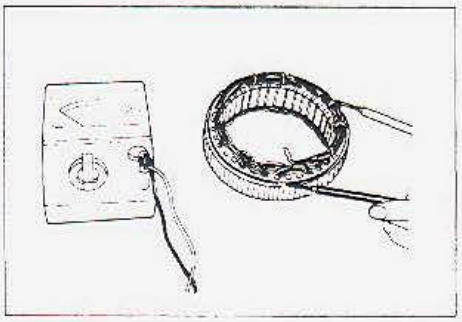
Check for continuity across the slip ring and rotor core or shaft. If a continuity exists, the parts should be replaced. Check front and rear ball bearings for abnormal noise and binding. Replace as necessary.



STATOR COIL ASSEMBLY

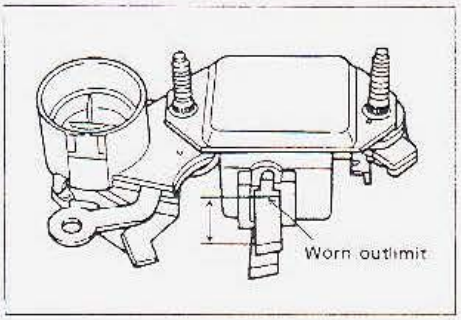
Continuity test

Check for continuity across the stator coils. If no continuity exists, replace the coils.



Ground test

Check for continuity across one of the stator coils and stator core. If a continuity exists, replace the coil.



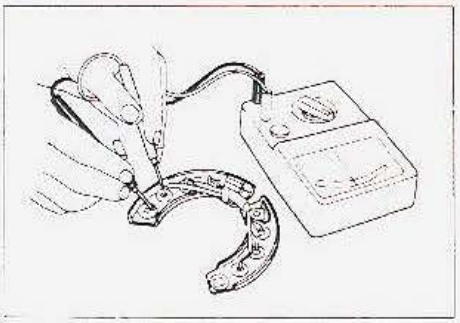
BRUSH

Measure length of brushes.
Brush length

mm(in.)

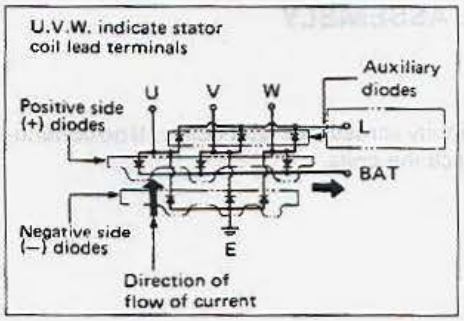
Standard	Limit
20 (0.787)	6 (0.24)

Brushes are provided with a line which indicates the limit of usage.



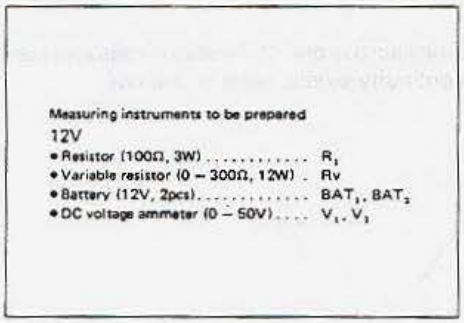
DIODE

Check for continuity across the terminals (example: across BAT and U). If a continuity exists the diode is in satisfactory condition. If no continuity exists the diode is defective.
Make a test with the polarities reversed. If no continuity exists the diode is in satisfactory condition.
If a continuity exists at any point, the diode is defective and should be replaced.
Auxiliary diodes are not provided with the terminal and a continuity test should be made across the terminals of the conventional diodes.



Across terminals		B.A.T. (Positive side(+) diodes)	
	Tester pin	Positive side	Negative side
V.V.W.	Positive side		No continuity
	Negative side	Continuity	

Across terminals		E (Negative side(—) diodes)	
	Tester pin	Positive side	Negative side
V.V.W.	Positive side		Continuity
	Negative side	No continuity	

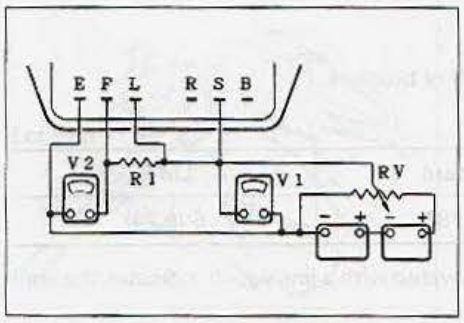


IC REGULATOR

Measuring instruments to be prepared.

Battery standard voltage

12V, 2 pcs	20V — 26V



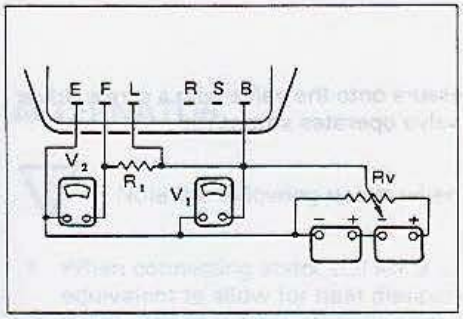
Take the following measurements with the instruments connected as shown in the illustration.

V2: Measure the voltage across the terminals E — F while varying resistance gradually from zero using variable resistor.
Then check that abrupt voltage increase from less to more around 2V. If increase in voltage is interrupted at any point, replace the regulator.

V1: Measure the voltage across the terminals L/S — E while varying resistance gradually from zero using variable resistor.
Then check it when voltage increase abruptly by 2 — 6V.

Standard voltage at 20°C (68°F) (V)	14.4—15.0

If measured value deviates from the standard, replace the regulator.

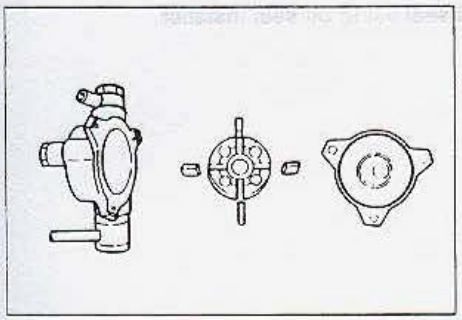


Change connection of the instruments as illustrated.

V1: Measure the voltage across the terminals B/L — E while varying resistance gradually from zero using variable resistor.
Then check it when voltage increases abruptly.

Standard voltage at 20°C (68°F) (V)	14.9—16.5

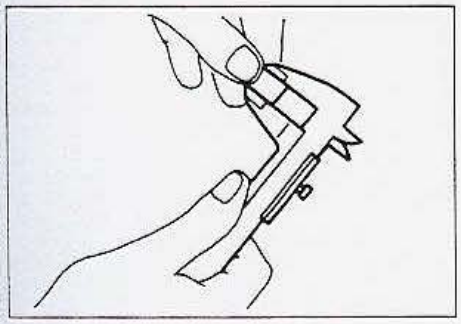
If measured voltage deviates from the standard value, replace the regulator.



VACUUM PUMP

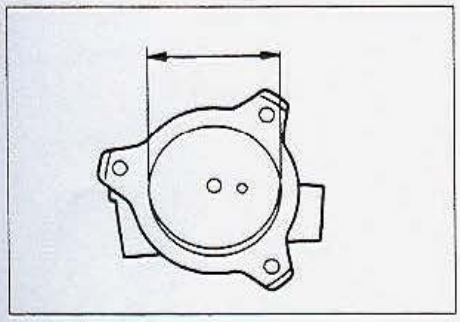
Visual check

Inspect the following parts for wear, damage or other abnormal conditions.



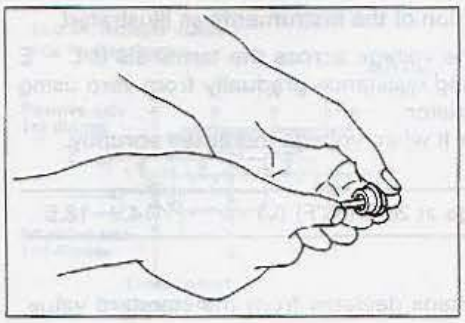
Measure the length of vanes.

Standard	mm(in.)	12.5—13.5 (0.492—0.531)



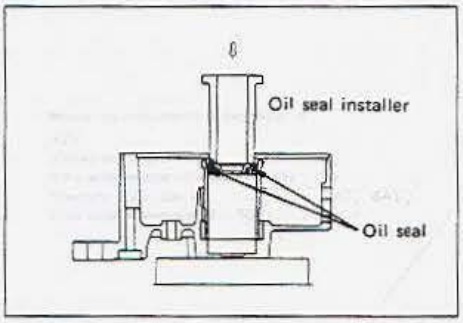
Measure the inside diameter of housing.

Standard	mm(in.)	57.0—57.1 (2.2440—2.2441)



CHECK VALVE

Apply a light pressure onto the valve with a screw driver and check that valve operates smoothly.



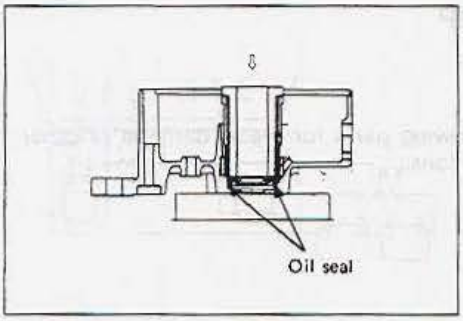
OIL SEAL

Inspection

Check inner face of the rear cover for traces of oil leakage. Also check inner face of the oil seal for wear or damage.

Replacement

1. Using a screw driver, remove oil seal from rear cover side.



2. Install a new oil seal using oil seal installer.

REASSEMBLY

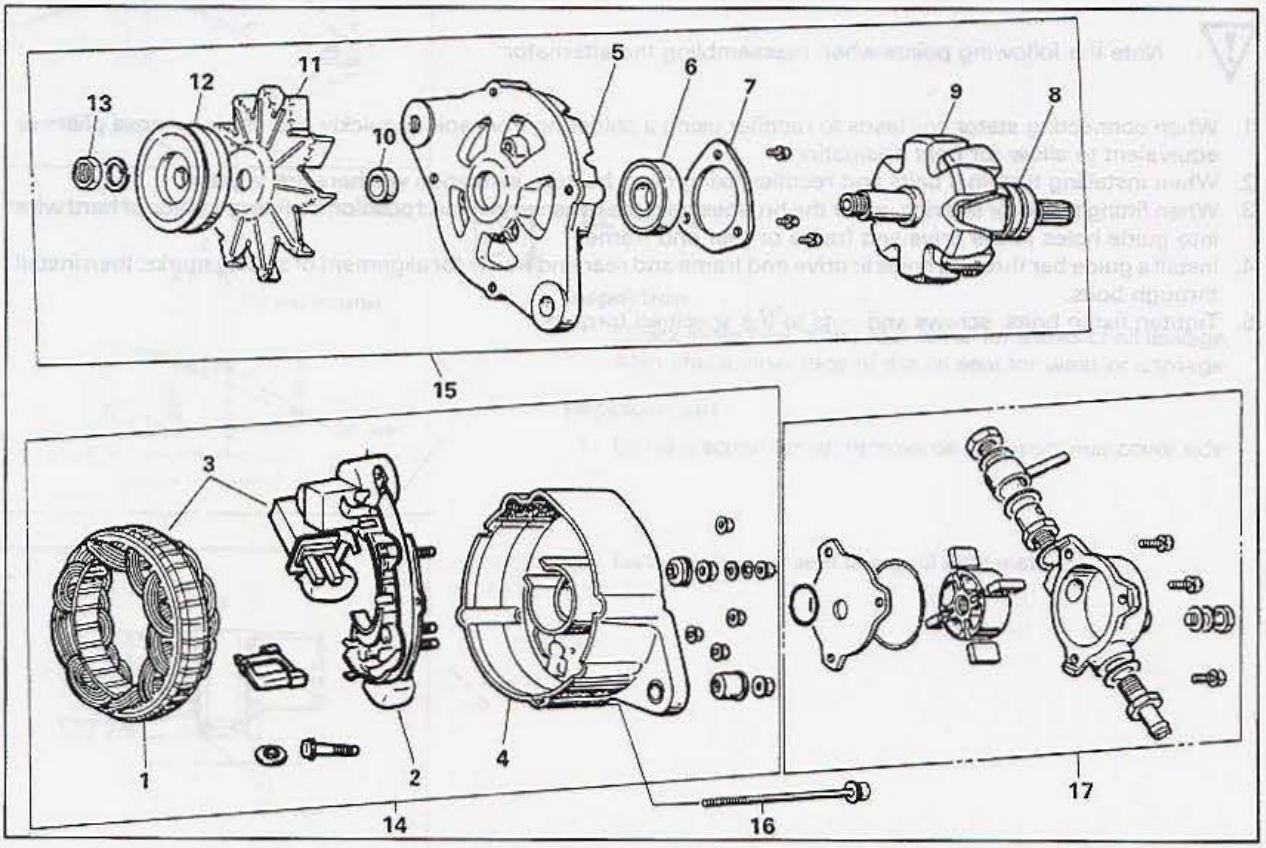
ALTERNATOR

Note the following points when reassembling the alternator:

1. When connecting stator coil leads to rectifier using a soldering iron, solder quickly and use long-nose pliers or equivalent to allow for heat dissipation.
2. When installing terminal bolts and rectifier fixing nuts, be sure insulation washers are in place.
3. When fitting the rotor slip ring under the brushes hold the brushes in raised position by fitting a piece of hard wire into guide holes in the drive and frame or rear end frame.
4. Install a guide bar through holes in drive end frame and rear end frame for alignment of setting marks, then install through bolts.
5. Tighten fixing bolts, screws and nuts to the specified torques.

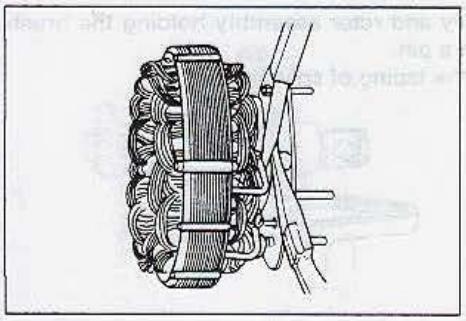
REASSEMBLY

Manufacturer's code no. LR170-401



Reassembly steps

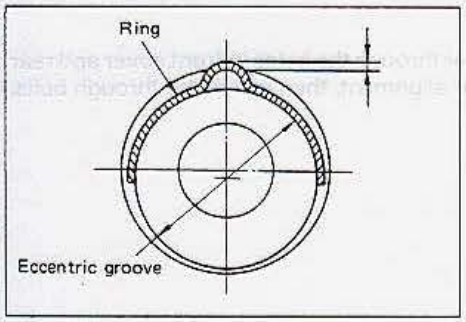
- ▲ 1. Stator
- ▲ 2. Diode assembly
- 3. Starter and diode assembly
- 4. Rear cover
- 5. Front cover
- 6. Front ball bearing
- 7. Bearing retainer
- ▲ 8. Rear ball bearing
- 9. Rotor
- 10. Spacer
- 11. Fan
- 12. Pulley
- ▲ 13. Pulley nut
- ▲ 14. Rear cover and stator assembly
- ▲ 15. Pulley and rotor assembly
- ▲ 16. Through bolt
- ▲ 17. Vacuum pump assembly



Important operations

1. **Stator**
2. **Diode assembly**

When connecting stator coil leads and diode leads using solder, use long-nose pliers and finish the work as quickly as possible to prevent the heat from being transferred to the diodes.

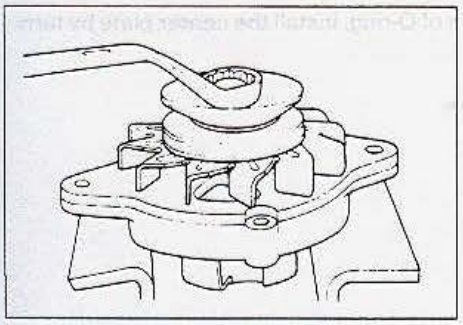


8. **Rear ball bearing**

The dowel of the rear side bearing protrudes from the outer ring, as the ring is mounted on the eccentric groove of the outer ring.
Upon assembling, rotate the ring to a position where this protrusion is at a minimum, then assemble the ring.

Limit	mm(in.)	0.65 (0.0256)

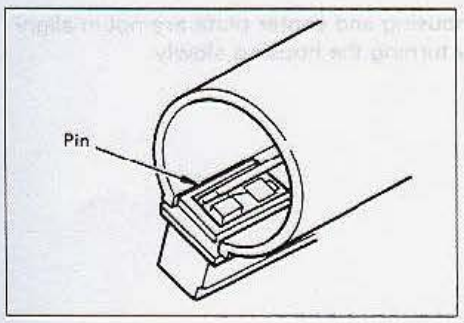
In addition, inspect the bearing of the rear cover.
Should any irregularity be present, replace the rear cover at the same time.



13. **Pulley nut**

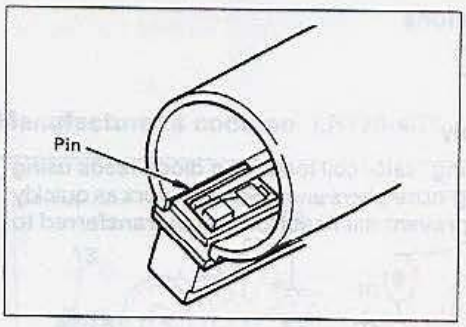
Clamp the rotor in a vise and install the pulley nut.

Torque	kg·m(ft.lbs.)	4.5—6.0 (33—43)

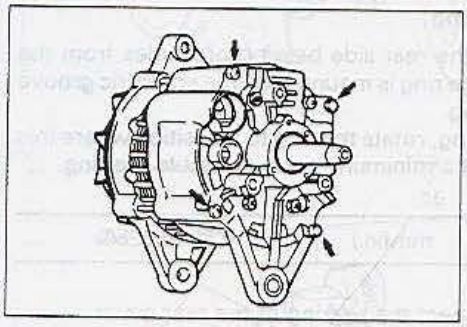


14. **Rear cover and stator assembly**
15. **Pulley and rotor assembly**

Position the projected portion of ring on the bearing so that the projection becomes minimum.

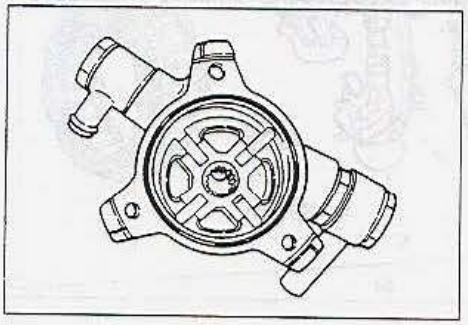


Install the pulley and rotor assembly holding the brush pushed-in with a pin.
Then remove the taping of splines.



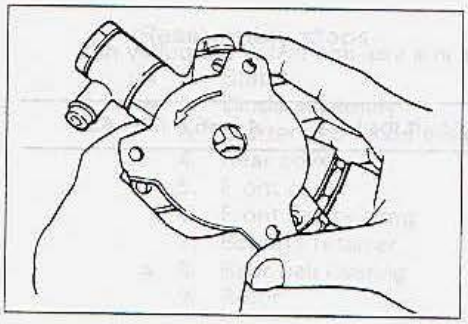
16. Through bolt

Place a guide bar through the holes in front cover and rear cover flange for alignment, then install the through bolts.

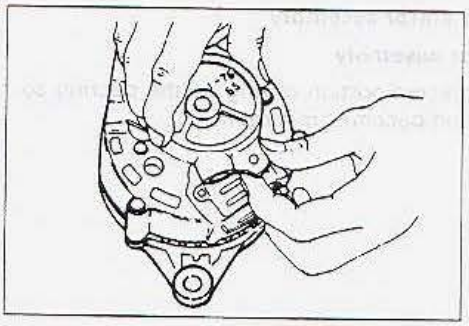


17. Vacuum pump assembly

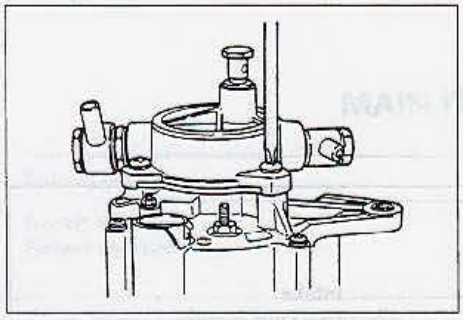
Position the rotor, with the serrated boss turned up, on the center plate and housing.
Align the holes in center plate and rotor.
Install vanes into slits in rotor.
The vanes should be installed with round side turned outward.



After installation of O-ring, install the center plate by turning it.



If the holes in housing and center plate are not in alignment, adjust by turning the housing slowly.

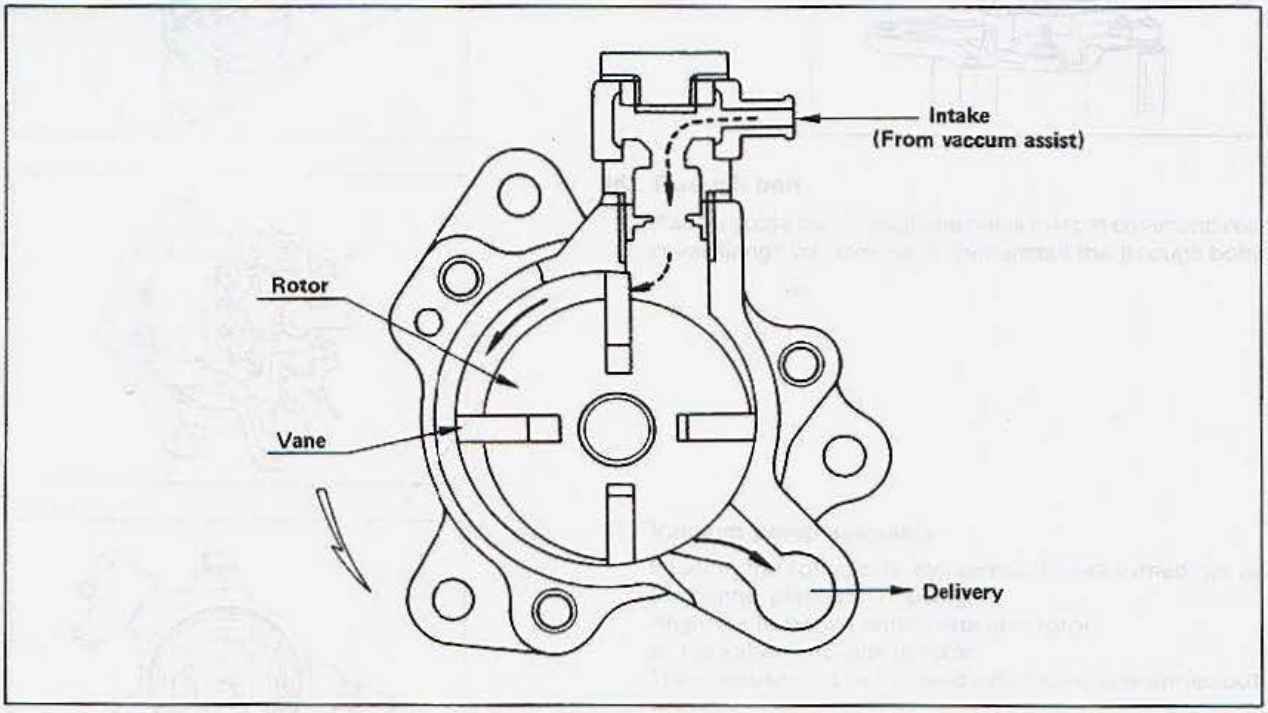


Install and fix the housing to the generator using 3 volts. Pour engine oil (5cc or so) in through the filler port, then check that generator pulley can be turned smoothly with hand.

VACUUM PUMP

GENERAL DESCRIPTION

This illustration is based on the 4BD1 engine.



MAIN DATA AND SPECIFICATONS

Engine model		4BD1	4BD1T
Pump type		Oil-cooled vane type pump	
Theretical derively	cc/rev.(in³/rev.)	31 (1.89)	30 (1.83)
Maximum allowable speed	(rpm)	10,000	11,000
Direction of rotation		Clockwise as viewed from coupling side	
Weight	kg(lbs.)	2.2 (4.85)	0.9 (1.98)

GLOW PLUGS

MAIN DATA AND SPECIFICATIONS

Isuzu part no.		5-81410-023-0
Rated voltage Rated current	(V) (A) (Ω)	10.5 6 — 7.5 1.8
Time taken before 800°C is reached	(Sec.)	20 — 25

CONTROL RESISTOR

MAIN DATA AND SPECIFICATIONS

Isuzu part no.		9-8253-0041-0
Rated voltage Rated current Internal resistance	(V) (A) (Ω)	12 26 0.028—0.032
Time taken before 800°C is reached	(Sec.)	20 — 25
Insulaton resistance Saturation temperature	(MΩ) (°C)	1 or higher 1000 or lower

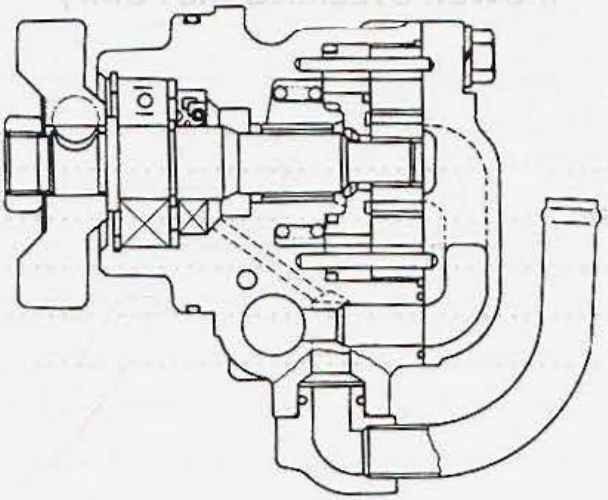
SECTION 8

AUXILIARIES

(POWER STEERING OIL PUMP)

CONTENTS PAGE

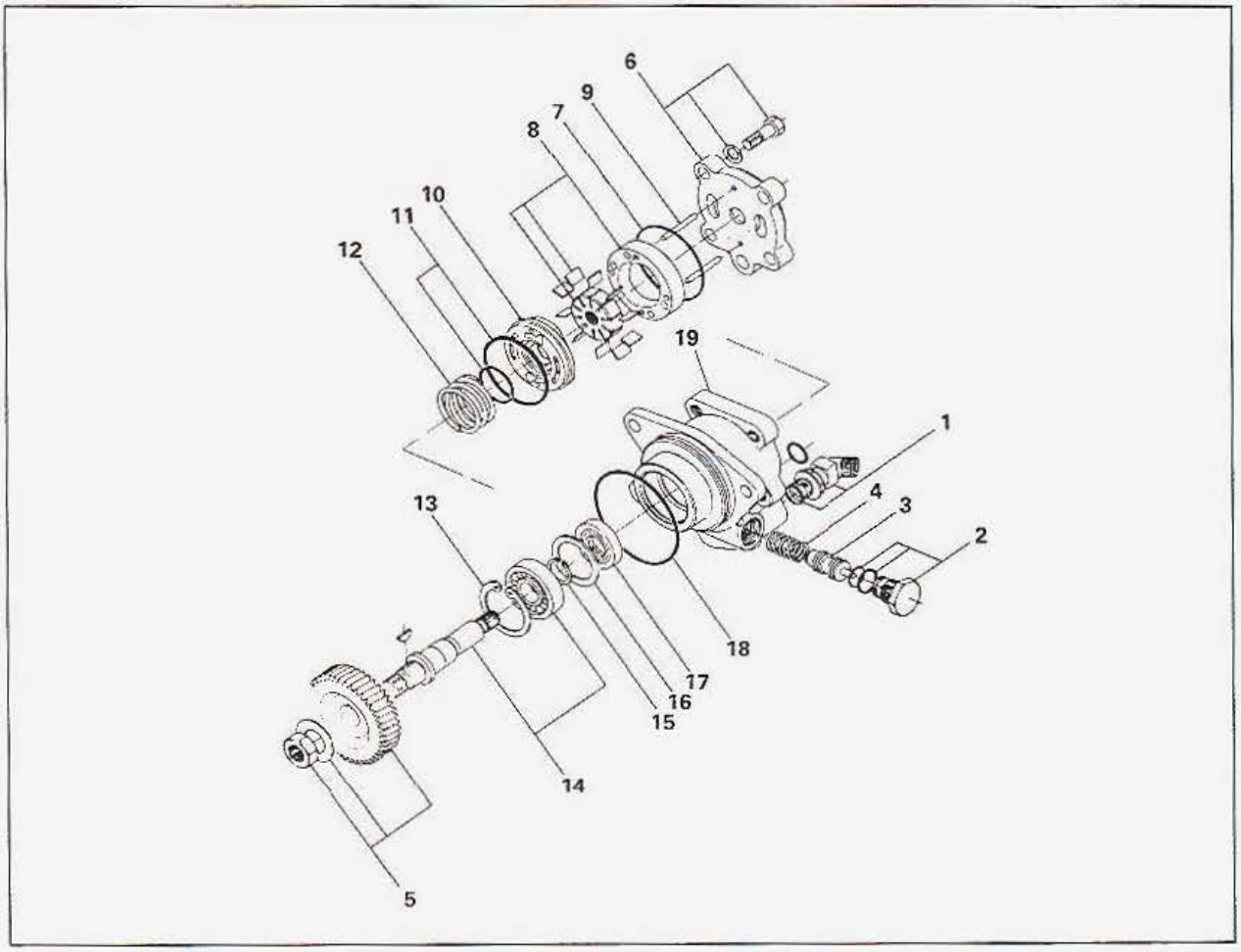
GENERAL DESCRIPTION



MAIN DATA AND SPECIFICATION

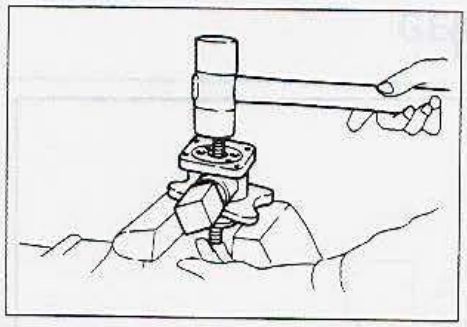
Item		
Pump type	(V)	Centifugal vane
Theoritical delivery volume	cc/rev.(in^3/rev)	12.2 (0.732)
Relief valve preset pressure	kg/cm^2(psi)	85 (1208)
Preset delivery volume at 200 rpm	liter/min.(UK gallon/min)	8 (1.8)
Pump operating speed	(rpm)	450 — 4000
Pump to crankshaft speed ratio to 1		0.89 (25/28)
Weight (dry)	kg(lbs.)	4.3 (9.48)

DISASSEMBLY



Disassembly steps

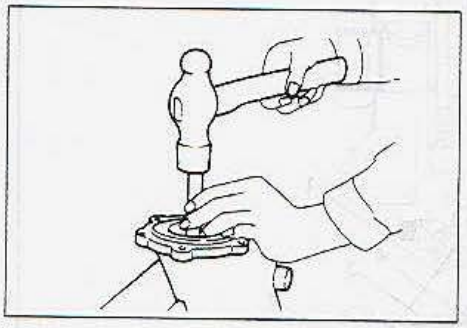
1. Outer connector and O-ring
2. Plug and O-ring
3. Relief valve
4. Spring
5. Gear
6. Cover
7. O-ring
8. Cartridge assembly
9. Knock pin
10. Side plate
11. O-rings
12. Spring
13. Snap ring
14. Shaft with bearing
15. Snap ring
16. Collar
17. Oil seal
18. O-ring
19. Body



Important operations

14. Shaft with ball bearing

Use a mallet for removal.

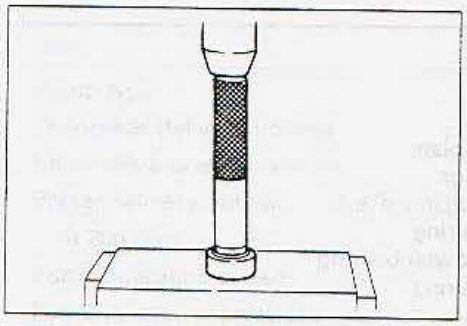


17. Oil seal

Use a suitable brass drift.

INSPECTION AND REPAIR

Make necessary correction or parts replacement if wear, damage or any other abnormal conditions are found through inspection.



Bearing replacement procedure

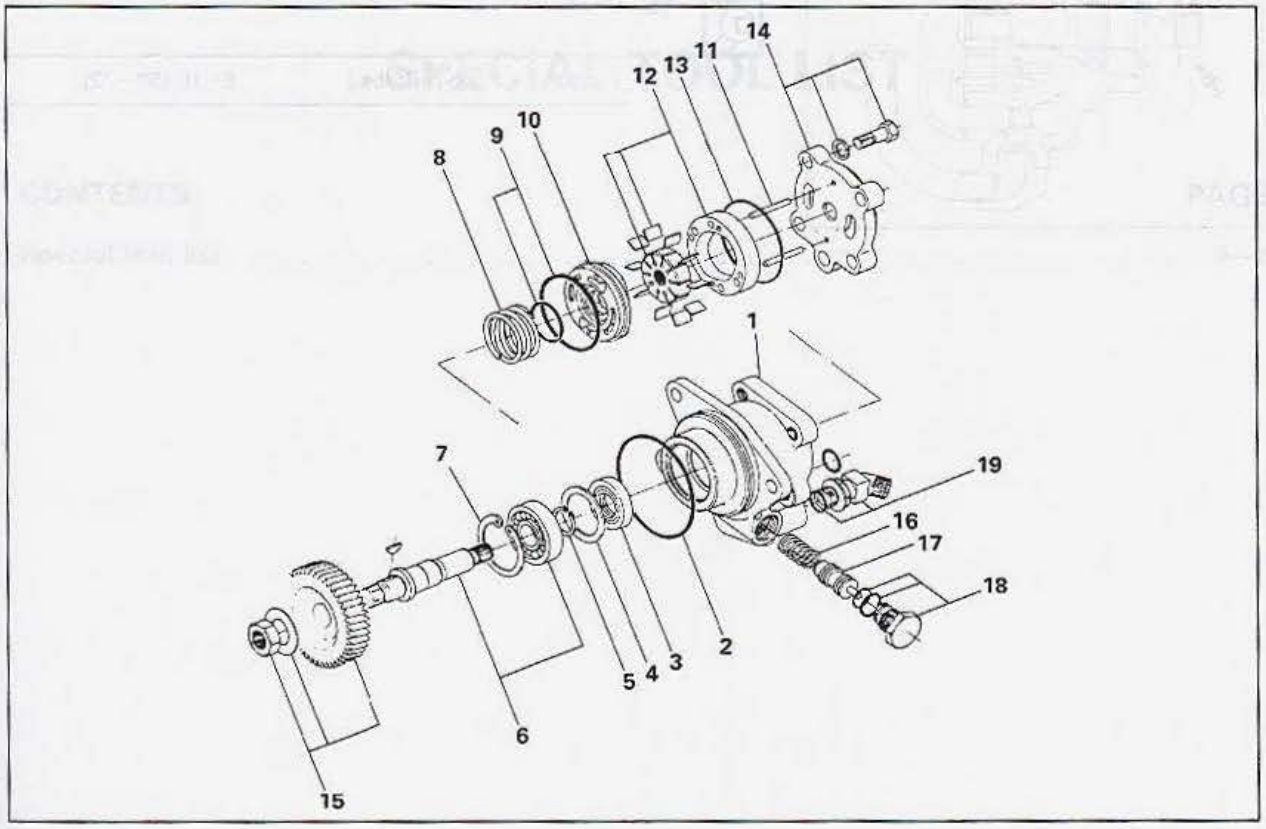
Removal:

Remove the snap ring and then, remove the bearing using a bench press and a suitable rod.

Installation:

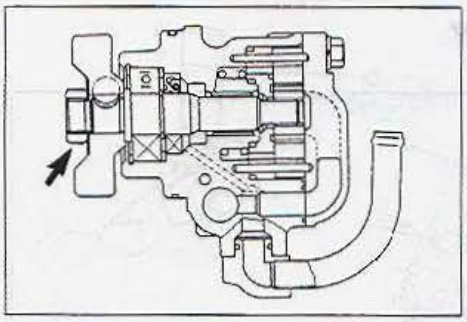
Use a bench press and a suitable rod.

REASSEMBLY



Reassembly steps

1. Body
2. O-ring
3. Oil seal
4. Collar
5. Snap ring
6. Shaft with bearing
7. Snap ring
8. Spring
9. Oil seals
10. Side plate
11. Knock pin
12. Cartridge assembly
13. O-ring
14. Cover
▲ 15. Gear
16. Spring
17. Relief valve
18. Plug and O-ring
19. Outer connector and O-ring



Important operation

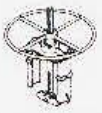
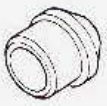
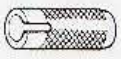
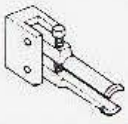
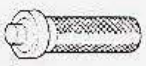
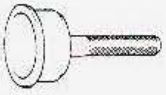
15. Gear

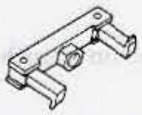
Torque	kg·m(ft.lbs.)	8—10 (58—72)

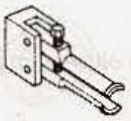
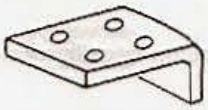
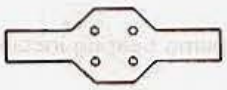
SECTION 9

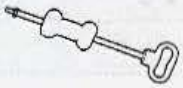
SPECIAL TOOL LIST

CONTENTS PAGE

ITEM NO.	ILLUSTRATION	PART NO.	PART NAME
1		9-8523-1426-0 JKM-1033	Valve spring compressor
2		1-8522-0001-0 JKM-1019	Valve guide remover & installer
3		9-8523-1169-0 JKM-1021	Cylinder liner remover
4		9-8523-2557-0 +(EN-8) JKM-1022	Cylinder liner remover ankle
5		9-8523-2554-0 JKM-1024	Cylinder liner installer
6		9-8521-0141-0 +(OT-3) JKM-1026	Crankshaft gear remover
7		9-8522-0033-0 JKM-1027	Crankshaft gear installer
8		5-8840-2000-0 +(OT-6) JKM-1026	Crankshaft pilot bearing remover
9		5-8522-0024-0 JKM-3035	Crankshaft gear installer
10		9-8522-1254-0 JKM-1028	Crankshaft rear oil seal installer

ITEM NO.	ILLUSTRATION	PART NO.	PART NAME
11		9-8522-0034-0 JKM-1029	Crankshaft front oil seal installer
12		5-8840-0086-0 JKM-1035	Camshaft gear remover
13		9-8521-0063-0 JKM-3222	Crankshaft pulley remover
14		9-8521-0063-0 JKM-3222	Crankshaft pulley remover
15		1-85221-005-0 JKM-1030	Valve stem oil seal installer
16		9-8522-1251-0 JKM-1102	Piston ring compressor
17		9-8521-0097-0 JKM-1031	Water pump impeller remover
18		9-8522-1140-0 JKM-1032	Water pump bearing installer
19		1-85111-0030 JKM-1002	Cylinder head bolt wrench
20		5-8840-2008-0 J-29762	Compression gauge

ITEM NO.	ILLUSTRATION	PART NO.	PART NAME
21		5-8531-7001-0 JKM-1018	Compression gauge adapter
22		9-8511-3703-0 JKM-1017	Injection pump wrench
23		J-33895	ACG checker (Built-in IC regurator)
24		5-85253-001-0 J-24547	Clutch pilot aligner
25		5-8840-2000-0 +(OT-7) J-5822	Crankshaft pilot bearing remover
26		5-8522-0024-0 JKM-3035	Crankshaft pilot bearing installer
27		5-8840-2058-0 JKM-20580	Servo unit support plate
28		9-8523-1733-0 JKM-3250	Handle
OT-3		9-8511-4307-0 JKM-3146	Handle
OT-6		5-8840-0019-0 J-23907	Sliding hammer (Small)

ITEM NO.	ILLUSTRATION	PART NO.	PART NAME
OT-7		5-8840-0084-0 J-2619-01	Sliding hammer (Big)

SECTION 10

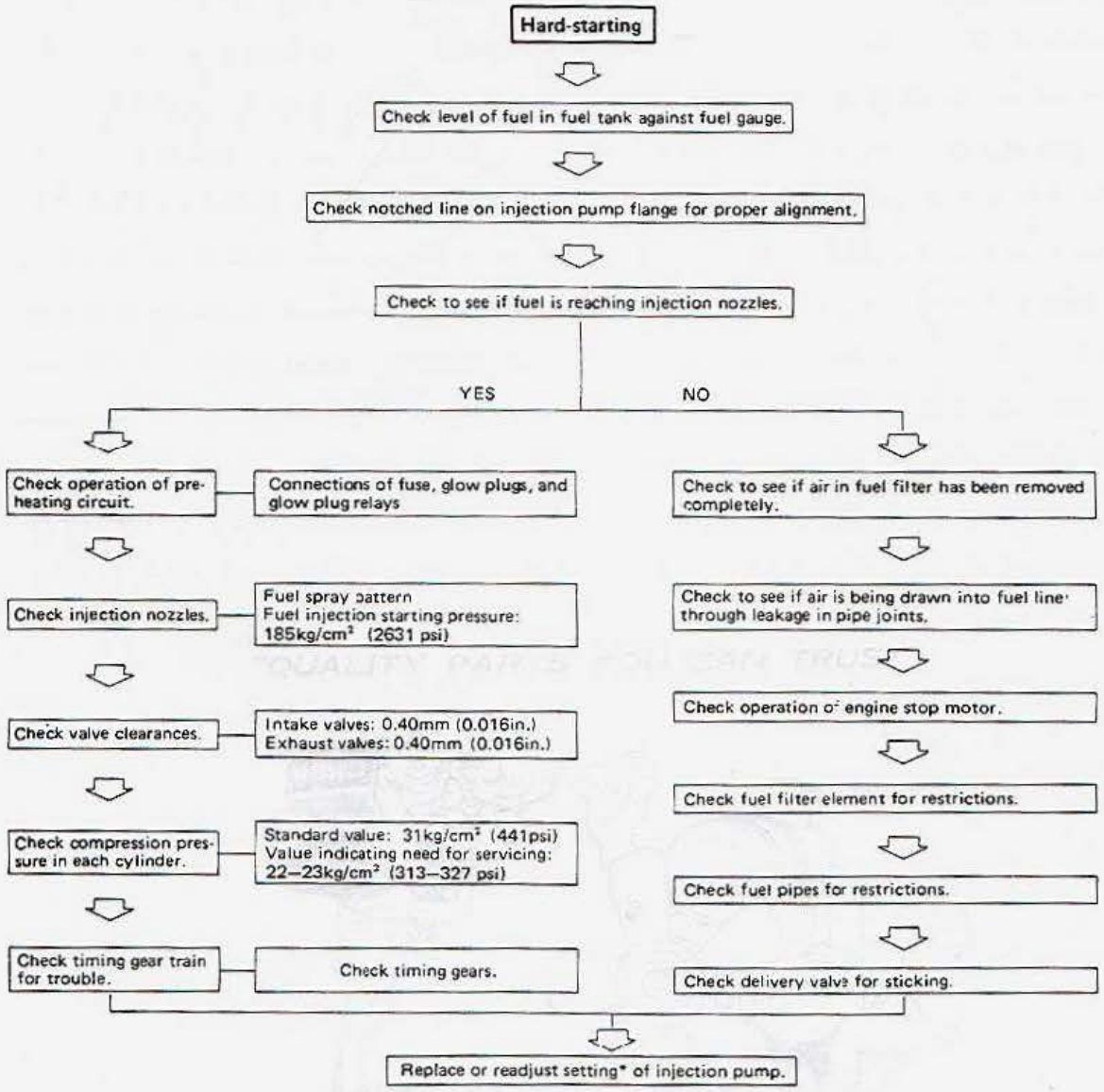
TROUBLESHOOTING

CONTENTS PAGE

ENGINE ASSEMBLY

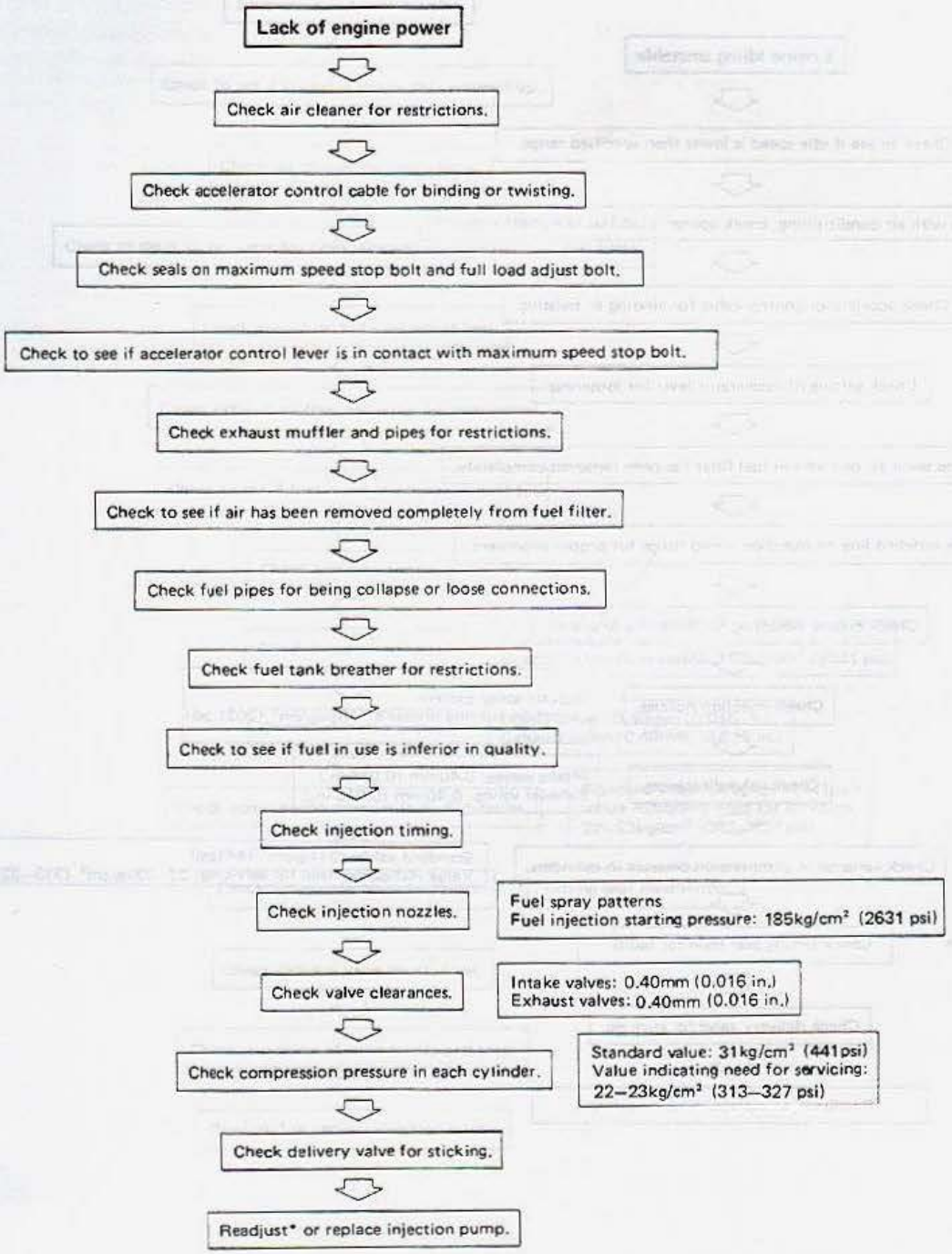
HARD-STARTING

Difficulty will not be experienced in starting a diesel engine provided sufficient power is supplied for cranking, compression pressure is sufficiently high, preheating system is operating normally and an appropriate volume of fuel is supplied. As an initial step for checking the cause of hard-starting, loosen the pipe joint at the nozzle end and see if fuel is being supplied. In some instances, it may be necessary to check nozzle spray conditions and fuel injection timing. If these checks do not disclose any problems, measure the compression pressure to determine the condition of valves and piston rings.
If the engine starts but stalls suddenly and can not be restarted, presence of air in the fuel system is likely.
Engine startability is more or less affected by the environmental temperature conditons.



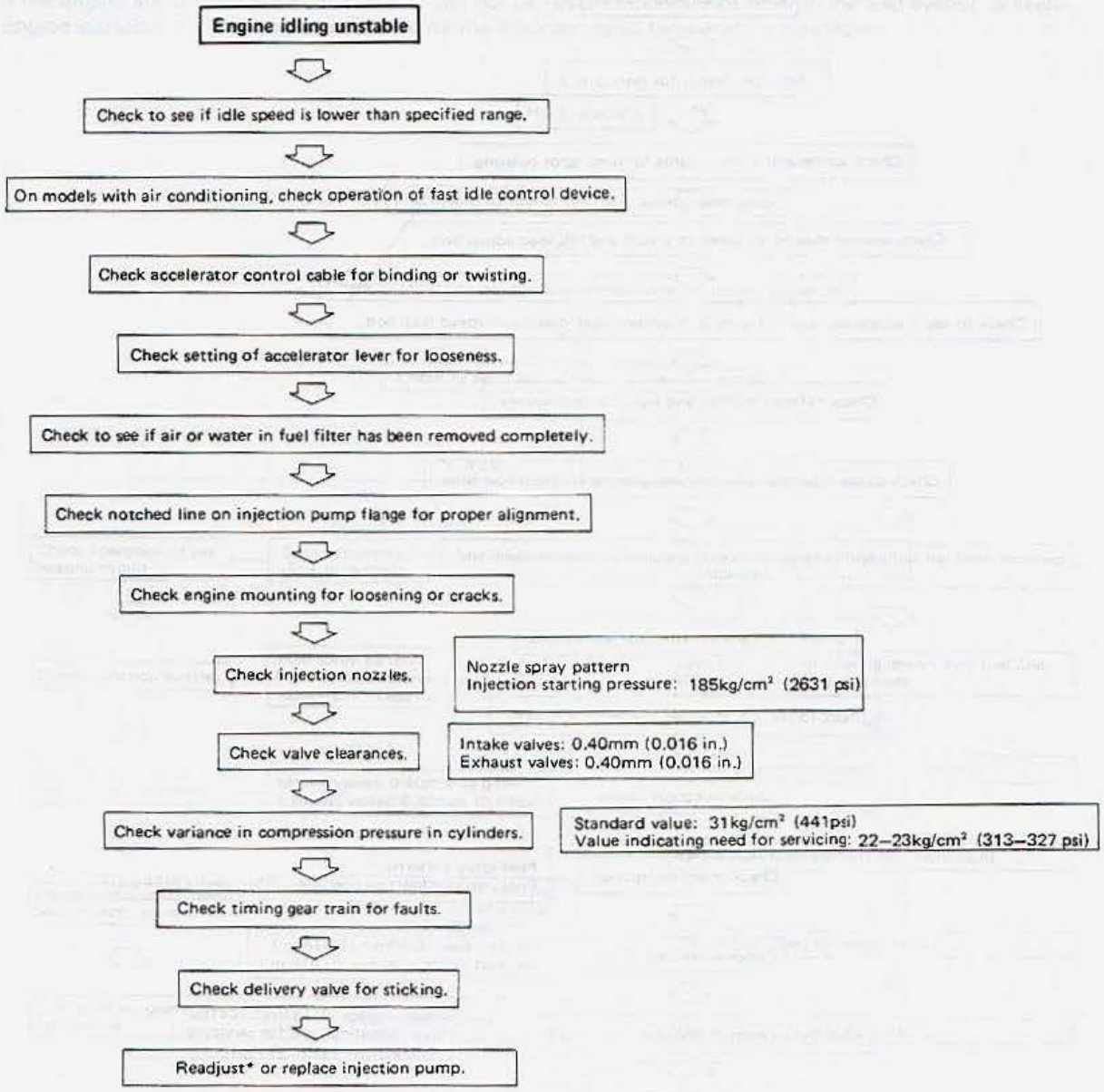
ENGINE IDLING ROUGH

Lack of engine power may be caused by insufficient injection volume, insufficient volume of intake air, lowered compression pressure, etc. If the trouble is due to lack of volume of fuel injection, check fuel filter element for restrictions and fuel system for presence of air.
If the above checks do not disclose any troubles, make a test on the fuel injection pump and governor, using a pump tester.*
If the volume of intake air is insufficient, check air cleaner element for restrictions and exhaust pipe(s) for clogging.



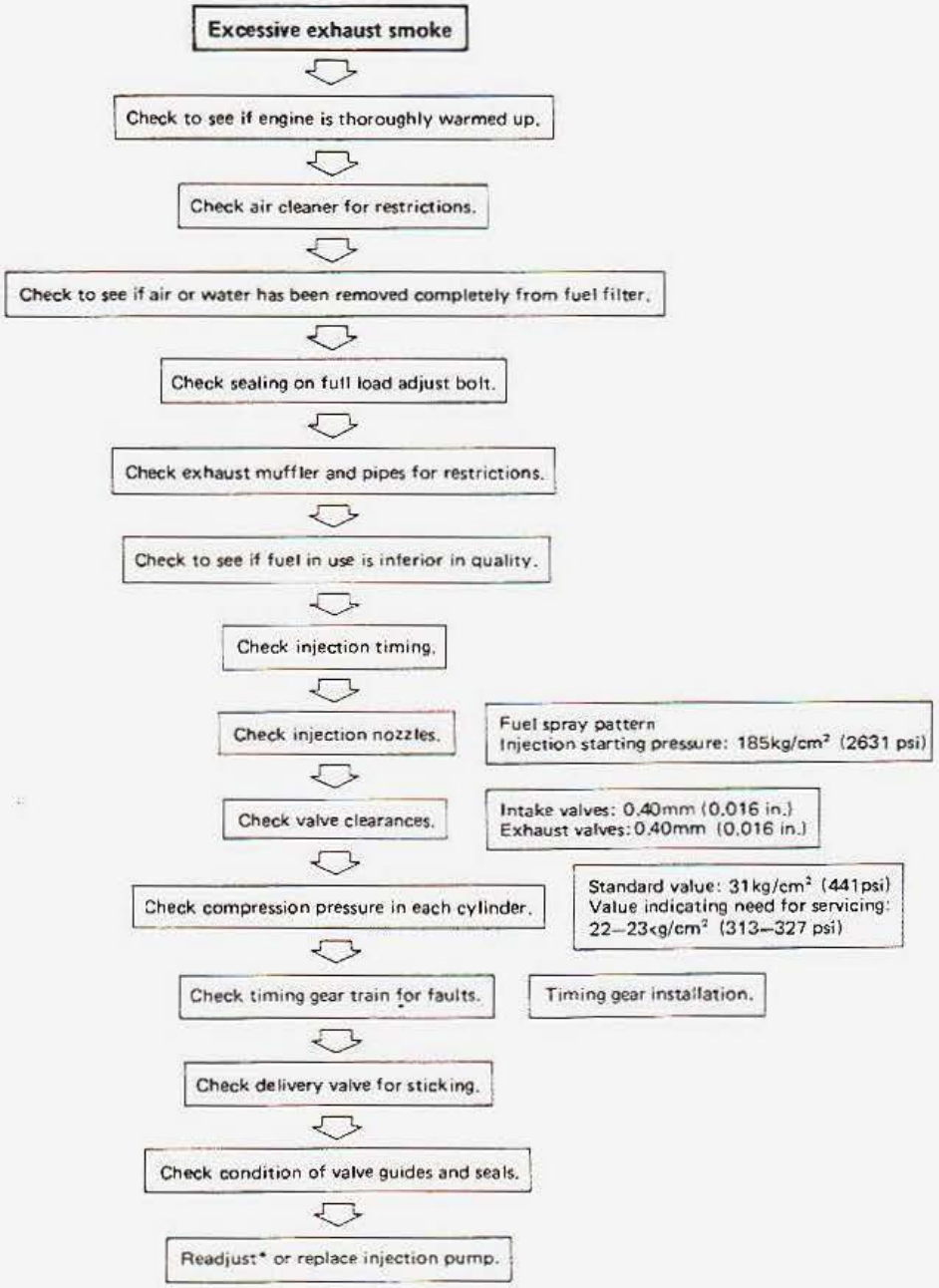
ENGINE LACKS POWER

Rough engine idling can cause engine surging and sudden engine stalling at quick deceleration. If the engine operates normally at medium and high speeds, perform diagnostic checks on the injection pump and related components, then check engine idling speed.
Engine hunting may be caused by too low an idling speed, rough plunger operation, over-tightened delivery valve holder, etc.
If the engine stalls at quick deceleration, idling speed might have been set too low.



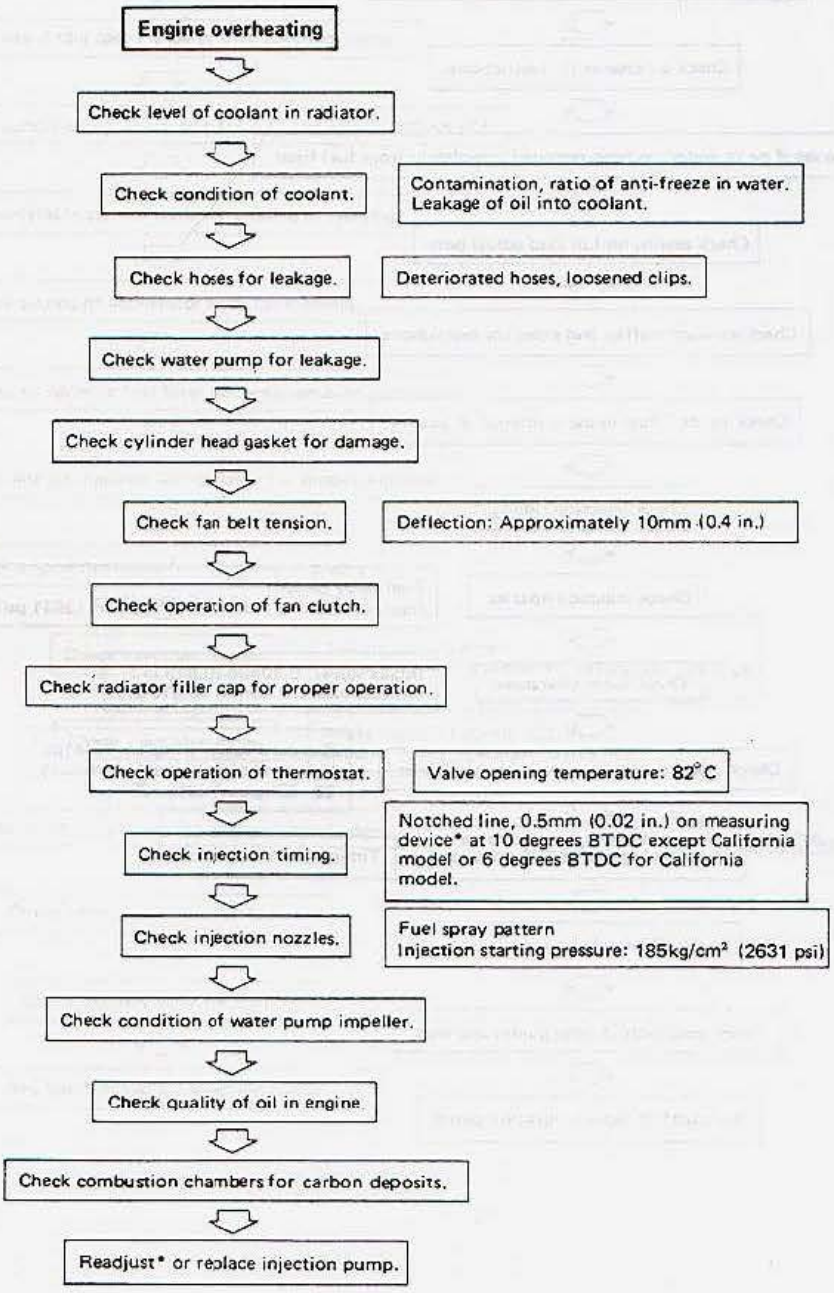
DARK OR WHITE EXHAUST SMOKE

A considerable amount of dark smoke in the exhaust gases is due to incomplete fuel combustion caused by excessive volume of fuel injection, insufficient volume of intake air, poor spray condition, excessively advanced injection timing, etc.
To determine the cause, check seals on the injection pump, check compression pressure, condition of air cleaner and injection nozzle spray conditons, then check fuel injection timing.



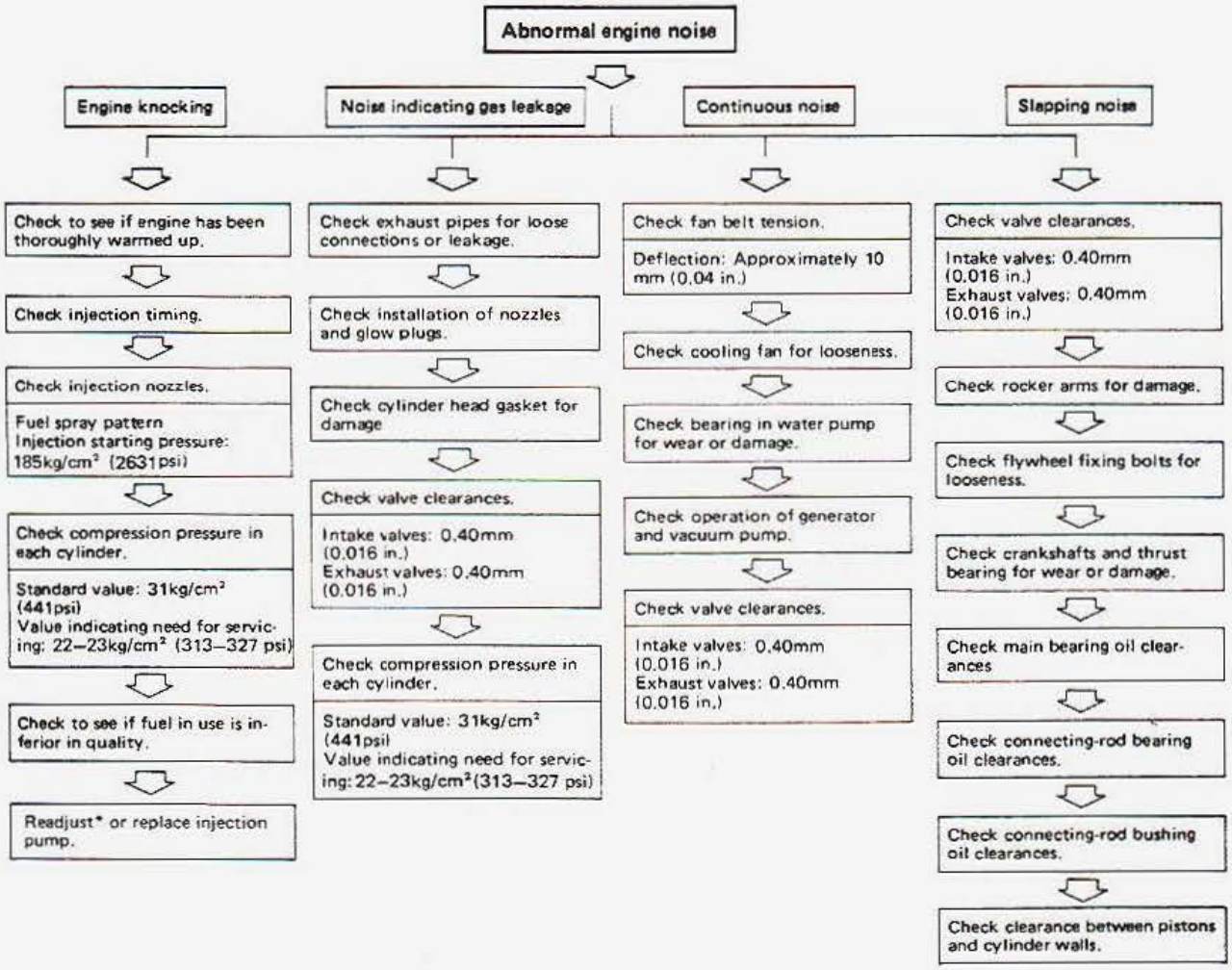
ENGINE OVERHEATING

When locating the cause of engine overheating, it is necessary to find whether the engine is actually overheating or the temperature gauge is giving a false indication.
To determine the true cause, measure the temperature of engine coolant at the upper part of the radiator with the engine running and compare the measured value with the reading of the temperature gauge on the instrument panel to check the accuracy of gauge indication.
Then check the following causes, starting with the item which can be checked easily.
Common causes of engine overheating will be as follows when listed in sequence of frequency: Leakage of coolant from water pump, radiator and hoses which causes a reduction in coolant level, defective thermostat, formation of scales in water passages. etc.
Leakage of gases into cooling water circuit due to defective gasket, excessive volume of fuel injection, incorrect injection timing, deposit of carbon within the combustion chambers are but some of the causes of engine overheating which are often overlooked.



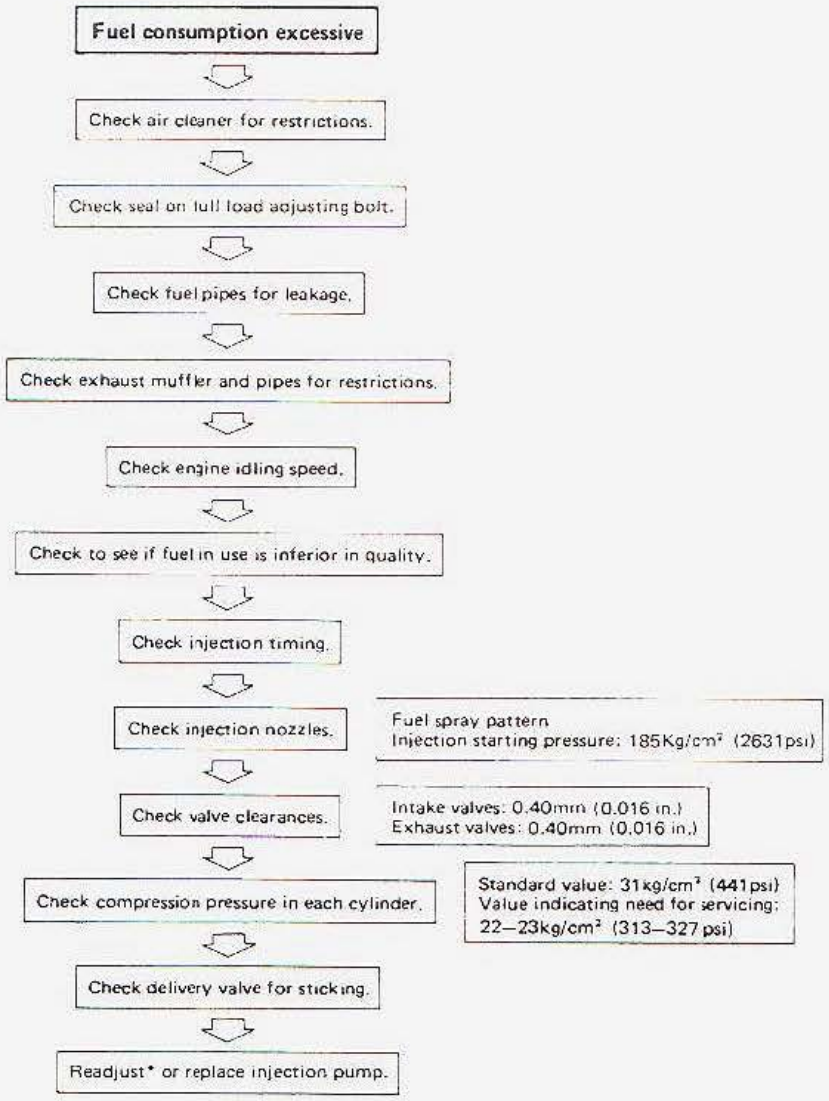
ENGINE NOISY

Abnormal noise of engine includes knocking sound, piston slap, etc.
Engine knocking is a result of rapid fuel combustion and is due mainly to excessively advanced fuel injection timing or detriorated fuel spray conditions.
Engine may produce slight knocking immediately after starting which normally diminishes as the engine temperature increases.
If engine produces a continuous noise, systematic checks are usually performed to determine the source of the noise, and noise from the auxiliaries such as generator, water pump, etc. can be shut-off by removing the belt to make checks on the engine easier.
If the engine produces slapping noise such as piston slap, piston pins and connecting-rod bearing noise, cylinder from which the noise comes can be checked by interrupting flow of fuel with the injection pipe joints loosened in sequence.
Engine crankshaft noise can be diagnosed by moving the clutch pedal in and out.
If noise is caused by crankshaft movement, noise will change as the clutch is operated.



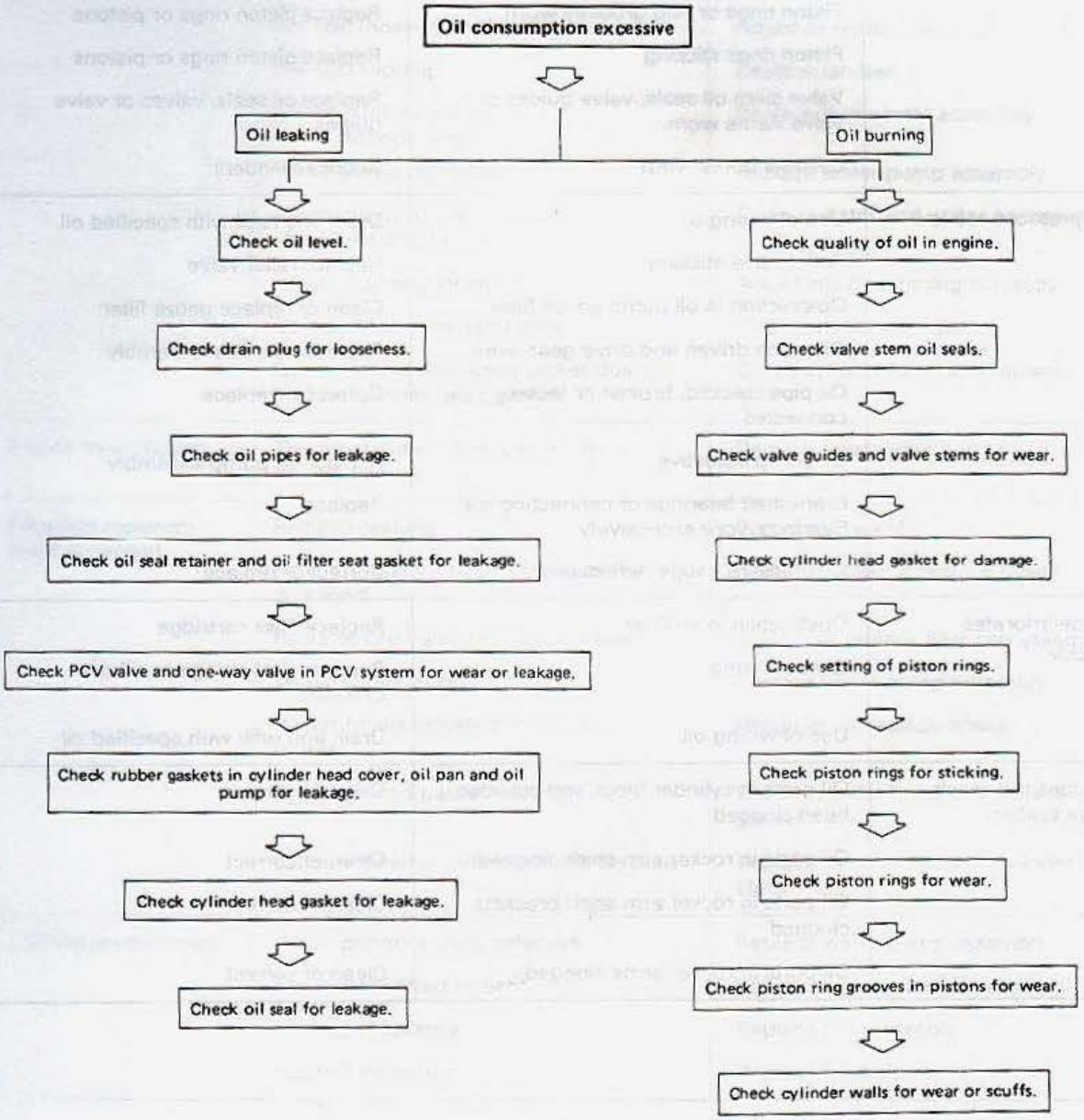
EXCESSIVE ENGINE OIL CONSUMPTION

It is necessary to find under which driving conditions the rate of fuel consumption is registered before following the diagnosis procedure since the fuel consumption varies greatly with the driving habits, load the vehicle carries and general condition of the roads and streets.
As a first step check the air cleaner and exhaust muffler for restrictions, then check the compression pressure in the cylinders. Road test the vehicle to see if the engine operates normally, giving reasonable acceleration.
If the results of road test are satisfactory, trouble in the fuel system is suspected.
To determine the condition of the fuel system, check fuel spray condition and injection starting pressure using a nozzle tester.



EXCESSIVE FUEL CONSUMPTION

Major causes of excessive oil consumption include external oil leakage, oil burning and internal leakage of oil past the piston can be detected with relative ease through visual checks.
To find whether oil is burning or leaking past the piston, start and let the engine idle for a few minutes, then check with the cylinder head removed. Oil burning is indicated by the traces of oil around the circumference of pistons. A trace of oil is normally found around the valve head£is localized to that area when internal oil leakage is present.



LUBRICATING SYSTEM

Complaint	Cause	Correction
Oil consumption too high	Use of wrong oil	Drain and refill with specified oil
	One-way valve leakage in PCV system	Clean or replace one-way valve
	Oil seals for gaskets defective	Correct
	Piston rings or ring grooves worn	Replace piston rings or pistons
	Piston rings sticking	Replace piston rings or pistons
	Valve stem oil seals, valve guides or valve stems worn	Replace oil seals, valves or valve guides
	Cylinder bores worn	Rebore cylinders
Oil pressure too low	Use of wrong oil	Drain and refill with specified oil
	Relief valve sticking	Replace relief valve
	Obstruction in oil pump gauze filter	Clean or replace gauze filter
	Oil pump driven and drive gear worn	Replace oil pump assembly
	Oil pipe cracked, broken or loosely connected	Correct or replace
	Oil pump defective	Replace oil pump assembly
	Crankshaft bearings or connecting-rod Bearings worn excessively	Replace
	Oil pressure gauge defective	Correct or replace
Oil deteriorates quickly	Obstruction in oil filter	Replace filter cartridge
	Gases leaking	Replace piston rings or rebore cylinders
	Use of wrong oil	Drain and refill with specified oil
Oil does not reach valve system	Oil ports in cylinder block and cylinder head clogged	Clean or correct
	Oil ports in rocker arm shaft clogged	Clean or correct
	Oil ports in rocker arm shaft brackets clogged	Clean or correct
	Oil ports in rocker arms clogged	Clean or correct

COOLING SYSTEM

Complaint	Cause	Correction
Engine overheating	Cooling water level too low	Replenish, check for leakage and correct as necessary
	Radiator cap pressure valve spring weakened	Replace filler cap assembly
	Fan belt loosened or broken	Adjust or replace fan belt
	Fan belt slipping	Replace fan belt
	Thermostat defective (valve not opening)	Replace thermostat assembly
	Water pump defective	Replace water pump assembly
	Obstructions in water passages due to accumulation of scale	Clean radiator and water passages
	Injection timing incorrect	Adjust injection timing correctly
	Obstructions in radiator core	Clean exterior of radiator
	Gases leaking into water jacket due to broken cylinder head gasket	Check cylinder head and replace gasket
Engine over-cooling	Thermostat defective (valve not closing completely)	Replace thermostat
Frequent replenishment is needed	Radiator leaking	Correct or replace
	Radiator hoses loosely connected or damaged	Retighten clips or replace hoses
	Radiator cap valve spring weakened	Correct or replace filler cap assembly
	Water pump leaking	Replace water pump assembly
	Heater hoses loosely connected or broken	Retighten or replace hoses
	Cylinder head gasket leaking	Check cylinder head and replace gasket
	Cylinder head or cylinder block cracked	Replace cylinder head or cylinder block
Cooling system noisy	Water pump bearing defective	Replace water pump assembly
	Fan loosely fitted or bent	Retighten or replace fan assembly
	Fan out of balance	Replace fan assembly
	Fan belt defective	Replace fan belt

SECTION 11

CONVERSION TABLE

CONTENTS

LENGTH

MILLIMETERS TO INCHES

mm	in.	mm	in.	mm	in.	mm	in.
1	0.0394	26	1.0236	51	2.0079	76	2.9921
2	0.0787	27	1.0630	52	2.0472	77	3.0315
3	0.1181	28	1.1024	53	2.0866	78	3.0709
4	0.1575	29	1.1417	54	2.1260	79	3.1102
5	0.1969	30	1.1811	55	2.1654	80	3.1496
6	0.2362	31	1.2205	56	2.2047	81	3.1890
7	0.2756	32	1.2598	57	2.2441	82	3.2283
8	0.3150	33	1.2992	58	2.2835	83	3.2677
9	0.3543	34	1.3386	59	2.3228	84	3.3071
10	0.3937	35	1.3780	60	2.3622	85	3.3465
11	0.4331	36	1.4173	61	2.4016	86	3.3858
12	0.4724	37	1.4567	62	2.4409	87	3.4252
13	0.5118	38	1.4961	63	2.4803	88	3.4646
14	0.5512	39	1.5354	64	2.5197	89	3.5039
15	0.5906	40	1.5748	65	2.5591	90	3.5433
16	0.6299	41	1.6142	66	2.5984	91	3.5827
17	0.6693	42	1.6535	67	2.6378	92	3.6220
18	0.7087	43	1.6929	68	2.6772	93	3.6614
19	0.7480	44	1.7323	69	2.7165	94	3.7008
20	0.7874	45	1.7717	70	2.7559	95	3.7402
21	0.8268	46	1.8110	71	2.7953	96	3.7795
22	0.8661	47	1.8504	72	2.8346	97	3.8189
23	0.9055	48	1.8898	73	2.8740	98	3.8583
24	0.9449	49	1.9291	74	2.9134	99	3.8976
25	0.9843	50	1.9685	75	2.9528	100	3.9370
101	3.9764	111	4.3701	121	4.7638	131	5.1575
102	4.0157	112	4.4094	122	4.8031	132	5.1968
103	4.0551	113	4.4488	123	4.8425	133	5.2362
104	4.0945	114	4.4882	124	4.8819	134	5.2756
105	4.1339	115	4.5276	125	4.9213	135	5.3150
106	4.1732	116	4.5669	126	4.9606	136	5.3543
107	4.2126	117	4.6063	127	5.0000	137	5.3937
108	4.2520	118	4.6457	128	5.0394	138	5.4331
109	4.2913	119	4.6850	129	5.0787	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

11—2 CONVERSION TABLES

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	m
	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	175.4803	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	miles
	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	25.750	27.359	28.968	30.578	10
20	32.187	33.796	35.406	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	77.249	78.858	40
50	80.467	82.077	83.686	85.295	86.905	88.514	90.123	91.733	93.342	94.951	50
60	96.561	98.170	99.779	101.389	103.000	104.607	106.217	107.826	109.435	111.045	60
70	112.654	114.263	115.873	117.482	119.091	120.700	122.310	123.919	125.529	127.138	70
80	128.748	130.357	131.966	133.576	135.185	136.794	138.404	140.013	141.622	143.232	80
90	144.841	146.450	148.060	149.669	151.278	152.888	154.497	156.106	157.716	159.325	90
100	160.934	162.544	164.153	165.762	167.372	168.981	170.590	172.200	173.809	175.418	100

KILOMETERS TO MILES

km	0	1	2	3	4	5	6	7	8	9	km
	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	22.370	22.990	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	31.065	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	49.711	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	57.187	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

AREA

SQUARE INCHES TO SQUARE CENTIMETERS

in^2	0	1	2	3	4	5	6	7	8	9	in^2
	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	
—		6.452	12.903	19.355	25.806	32.258	38.710	45.161	51.613	58.064	—
10	64.516	70.968	77.419	83.871	90.322	96.774	103.226	109.677	116.129	122.580	10
20	129.032	135.484	141.935	148.387	154.838	161.290	167.742	174.193	180.645	187.096	20
30	193.548	200.000	206.451	212.903	219.354	225.806	232.258	238.709	245.161	251.612	30
40	258.064	264.515	270.967	277.419	283.870	290.322	296.774	303.225	309.677	316.128	40
50	322.580	329.032	335.483	341.935	348.386	354.838	361.290	367.741	374.193	380.644	50
60	387.096	393.548	399.999	406.451	412.902	419.354	425.806	432.257	438.709	445.160	60
70	451.612	458.064	464.515	470.967	477.418	483.870	490.322	496.773	503.225	509.676	70
80	516.128	522.580	529.031	535.483	541.934	548.386	554.838	561.289	567.741	574.192	80
90	580.644	587.096	593.547	599.999	606.450	612.902	619.354	625.805	632.257	638.708	90
100	645.160	651.612	658.063	664.515	670.966	677.418	683.870	690.312	696.773	703.224	100

SQUARE CENTIMETERS TO SQUARE INCHES

cm^2	0	1	2	3	4	5	6	7	8	9	cm^2
	in^2	in^2	in^2	in^2	in^2	in^2	in^2	in^2	in^2	in^2	
—		0.155	0.310	0.465	0.620	0.775	0.930	1.085	1.240	1.395	—
10	1.550	1.705	1.860	2.015	2.170	2.325	2.480	2.635	2.790	2.945	10
20	3.100	3.255	3.410	3.565	3.720	3.875	4.030	4.185	4.340	4.495	20
30	4.650	4.805	4.960	5.115	5.270	5.425	5.580	5.735	5.890	6.045	30
40	6.200	6.355	6.510	6.665	6.820	6.975	7.130	7.285	7.440	7.595	40
50	7.750	7.905	8.060	8.215	8.370	8.525	8.680	8.835	8.990	9.145	50
60	9.300	9.455	9.610	9.765	9.920	10.075	10.230	10.385	10.540	10.695	60
70	10.850	11.005	11.160	11.315	11.470	11.625	11.780	11.935	12.090	12.245	70
80	12.400	12.555	12.710	12.865	13.020	13.175	13.330	13.485	13.640	13.795	80
90	13.950	14.105	14.260	14.415	14.570	14.725	14.880	15.035	15.190	15.345	90
100	15.500	15.655	15.810	15.965	16.120	16.275	16.430	16.583	16.740	16.895	100

VOLUME

CUBIC INCHES TO CUBIC CENTIMETERS

in^3	0	1	2	3	4	5	6	7	8	9	in^3
	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	
		16.387	32.774	49.161	65.548	81.935	98.322	114.709	131.097	147.484	—
10	163.871	180.258	196.645	213.032	229.419	245.806	262.193	278.580	294.967	311.354	10
20	327.741	344.128	360.515	376.902	393.290	209.677	426.064	442.451	458.838	475.225	20
30	491.612	507.999	524.386	540.773	557.160	573.547	589.934	606.321	622.708	639.095	30
40	655.483	671.870	688.257	704.644	721.031	737.418	753.805	770.192	786.579	802.966	40
50	819.353	835.740	852.127	868.514	884.901	901.289	917.676	934.063	950.450	966.837	50
60	983.224	999.611	1015.998	1032.385	1048.772	1065.159	1081.546	1097.933	1114.320	1130.707	60
70	1147.094	1163.482	1179.869	1196.256	1212.643	1229.030	1245.417	1261.804	1278.191	1294.578	70
80	1310.965	1327.352	1343.739	1360.126	1376.513	1392.900	1409.288	1425.675	1442.062	1458.449	80
90	1474.836	1491.223	1507.610	1523.997	1540.384	1556.771	1573.158	1589.545	1605.932	1622.319	90
100	1638.706	1655.093	1671.481	1687.868	1704.255	1720.642	1737.029	1753.416	1769.803	1786.190	100

CUBIC CENTIMETERS TO CUBIC INCHES

cm^3(cc)	0	1	2	3	4	5	6	7	8	9	cm^3(cc)
	in^3	in^3	in^3	in^3	in^3	in^3	in^3	in^3	in^3	in^3	
—		0.0610	0.1220	0.1831	0.2441	0.3051	0.3661	0.4272	0.4882	0.5492	—
10	0.6102	0.6713	0.7323	0.7933	0.8543	0.9153	0.9764	1.0374	1.0984	1.1594	10
20	1.2205	1.2815	1.3425	1.4035	1.4646	1.5256	1.5866	1.6476	1.7086	1.7697	20
30	1.8307	1.8917	1.9527	2.0138	2.0748	2.1358	2.1968	2.2579	2.1389	2.3799	30
40	2.4409	2.5020	2.5630	2.6240	2.6850	2.7460	2.8071	2.8681	2.9291	2.9901	40
50	3.0512	3.1122	3.1732	3.2342	3.2952	3.3563	3.4173	3.4783	3.5393	3.6004	50
60	3.6614	3.7224	3.7834	3.8444	3.9055	3.9665	4.0275	4.0885	4.1496	4.2106	60
70	4.2716	4.3326	4.3937	4.4547	4.5157	4.5767	4.6377	4.6988	4.7598	4.8208	70
80	4.8818	4.9429	5.0039	5.0649	5.1259	5.1870	5.2480	5.3090	5.3700	5.4310	80
90	5.4921	5.5531	5.6141	5.6751	5.7362	5.7972	5.8582	5.9192	5.9803	6.0413	90
100	6.1023	6.1633	6.2243	6.2854	6.3464	6.4074	6.4684	6.5295	6.5905	6.6515	100

VOLUME

GALLONS (U. S.) TO LITERS

U.S. gal.	0	1	2	3	4	5	6	7	8	9	U.S. gal.
	liters	liters	liters	liters	liters	liters	liters	liters	liters	liters	
—		3.7854	7.5709	11.3563	15.1417	18.9271	22.7126	26.4980	30.2834	34.0633	—
10	37.8543	41.6397	45.4251	49.2105	52.9960	56.7814	60.5668	64.3523	68.1377	71.9231	10
20	75.7085	79.4940	83.2794	87.0648	90.8502	94.6357	98.4211	102.2065	105.9920	109.7774	20
30	113.5629	117.3482	121.1337	124.9191	128.7045	132.4901	136.2754	140.0608	143.8462	147.6316	30
40	151.4171	155.2025	158.9879	162.7734	166.5588	170.3442	174.1296	177.9151	181.7005	185.4859	40
50	189.2713	193.0568	196.8422	200.6276	204.4131	208.1985	211.9839	215.7693	219.5548	223.3402	50
60	227.1256	230.9110	234.6965	238.4819	242.2673	246.0527	249.8382	253.6236	257.4090	261.1945	60
70	264.9799	268.7653	272.5507	276.3362	280.1216	283.9070	287.6924	291.4779	295.2633	299.0487	70
80	302.8342	306.6196	310.4050	314.1904	317.9759	321.7613	325.5467	329.3321	333.1176	336.9030	80
90	340.6884	344.4738	348.2593	352.0447	355.8301	359.6156	363.4010	367.1864	370.9718	374.7573	90
100	378.5427	382.3281	386.1135	389.8990	393.6844	397.4698	401.2553	405.0407	408.8261	412.6115	100

LITERS TO GALLONS (U.S.)

liters	0	1	2	3	4	5	6	7	8	9	liters
	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	
—		0.2642	0.5283	0.7925	1.0567	1.3209	1.5850	1.8492	2.1134	2.3775	—
10	2.6417	2.9059	3.1701	3.4342	3.6984	3.9626	4.2268	4.4909	4.7551	5.0193	10
20	5.2834	5.5476	5.8118	6.0760	6.3401	6.6043	6.8685	7.1326	7.3968	7.6610	20
30	7.9252	8.1893	8.4535	8.7177	8.9818	9.2460	9.5102	9.7743	10.0385	10.3027	30
40	10.5669	10.8311	11.0952	11.3594	11.6236	11.8877	12.1519	12.4161	12.6803	12.9444	40
50	13.2086	13.4728	13.7369	14.0011	14.2653	14.5295	14.7936	15.0578	15.3220	15.5861	50
60	15.8503	16.1145	16.3787	16.6428	16.9070	17.1711	17.4354	17.6995	17.9637	18.2279	60
70	18.4920	18.7562	19.0204	19.2846	19.5487	19.8129	20.0771	20.3412	20.6054	20.8696	70
80	21.1338	21.3979	21.6621	21.9263	22.1904	22.4546	22.7188	22.9830	23.2471	23.5113	80
90	23.7755	24.0397	24.3038	24.5680	24.8322	25.0963	25.3605	25.6247	25.8889	26.1530	90
100	26.4172	26.6814	26.9455	27.2097	27.4739	27.7381	28.0022	28.2664	28.5306	28.7947	100

GALLONS (IMP.) TO LITERS

Imp gal.	0	1	2	3	4	5	6	7	8	9	Imp gal.
	liters	liters	liters	liters	liters	liters	liters	liters	liters	liters	
—		4.5459	9.0918	13.6377	18.1836	22.7295	27.2754	31.8213	36.3672	40.9131	—
10	45.4590	50.0049	54.5508	59.0967	63.6426	68.1885	72.7344	77.2803	81.8262	86.3721	10
20	90.9180	95.4639	100.0098	104.5557	109.1016	113.6475	118.1934	122.7393	127.2852	131.8311	20
30	136.3770	140.9229	145.4688	150.0147	154.5606	159.1065	163.6524	168.1983	172.7442	177.2901	30
40	181.8360	186.3819	190.9278	195.4737	200.0196	204.5655	209.1114	213.6573	218.2032	222.7491	40
50	227.2950	231.8409	236.3868	240.9327	245.4786	250.0245	254.5704	259.1163	263.6622	268.2081	50
60	272.7540	277.2999	281.8458	286.3917	290.9376	295.4835	300.0294	304.5753	309.1212	313.6671	60
70	318.2130	322.7589	327.3048	331.8507	336.8966	340.9425	345.4884	350.0343	354.5802	359.1261	70
80	363.6720	368.2179	372.7638	377.3097	381.8556	386.4015	390.9474	395.4933	400.0392	404.5851	80
90	409.1310	413.6769	418.2228	422.7687	427.3146	431.8605	436.4064	440.9523	445.4982	450.0441	90
100	454.5900	459.1359	463.6818	468.2277	472.7736	477.3195	481.8654	486.4113	490.9572	495.5031	100

LITERS TO GALLONS (IMP.)

liters	0	1	2	3	4	5	6	7	8	9	liter
	gal.	gal.	ga	gal.	gal.	gal	gal.	gal.	gal.	gal.	
—		0.2200	0.4400	0.6599	0.8799	1.0999	1.3199	1.5399	1.7598	1.9798	—
10	2.1998	2.4198	2.6398	2.8597	3.0797	3.2997	3.5197	3.7397	3.9596	4.1796	10
20	4.3996	4.6196	4.8396	5.0595	5.2795	5.4995	5.7195	5.9395	6.1594	6.3794	20
30	6.5994	6.8194	7.0394	7.2593	7.4793	7.6993	7.9193	8.1393	8.3592	8.5792	30
40	8.7992	9.0192	9.2392	9.4591	9.6791	9.8991	10.1191	10.3391	10.5590	10.7790	40
50	10.9990	11.2190	11.4390	11.6590	11.8789	12.0989	12.3189	12.5389	12.7588	12.9788	50
60	13.1988	13.4188	13.6388	13.8587	14.0787	14.2987	14.5187	14.7387	14.9586	15.1786	60
70	15.3986	15.6186	15.8386	16.0585	16.2785	16.4985	16.7185	16.9385	17.1584	17.3784	70
80	17.5984	17.8184	18.0384	18.2583	18.4783	18.6983	18.9183	19.1383	19.3582	19.5782	80
90	19.7982	20.0182	20.2382	20.4581	20.6781	20.8981	21.1181	21.3381	21.5580	21.7780	90
100	21.9980	22.2180	22.4380	22.6579	22.8779	23.0979	23.3179	23.5379	23.7578	23.9778	100

MASS

POUNDS TO KILOGRAMS

lbs.	0	1	2	3	4	5	6	7	8	9	lbs.
	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	
—		0.454	0.907	1.361	1.814	2.268	2.722	3.175	3.629	4.082	—
10	4.536	4.990	5.443	5.897	6.350	6.804	7.257	7.711	8.165	8.618	10
20	9.072	9.525	9.979	10.433	10.886	11.340	11.793	12.247	12.701	13.154	20
30	13.608	14.061	14.515	14.969	15.422	15.876	16.329	16.783	17.237	17.690	30
40	18.144	18.597	19.051	19.504	19.958	20.412	20.865	21.319	21.772	22.226	40
50	22.680	23.133	23.587	24.040	24.494	24.948	25.401	25.855	26.308	26.762	50
60	27.216	27.669	28.123	28.576	29.030	29.484	29.937	30.391	30.844	31.298	60
70	31.751	32.205	32.659	33.112	33.566	34.019	34.473	34.927	35.380	35.834	70
80	36.287	36.741	37.195	37.648	38.102	38.555	39.009	39.463	39.916	40.370	80
90	40.823	41.277	41.731	42.184	42.638	43.091	43.545	43.998	44.452	44.906	90
100	45.359	45.813	46.266	46.720	47.174	47.627	47.081	48.534	48.988	49.442	100

KILOGRAMS TO POUNDS

kg	0	1	2	3	4	5	6	7	8	9	kg
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
—		2.205	4.409	6.614	8.818	11.023	13.228	15.432	17.637	19.842	—
10	22.046	24.251	26.455	28.660	30.865	33.069	35.274	37.479	39.683	41.888	10
20	44.092	46.297	48.502	50.706	52.911	55.116	57.320	59.525	61.729	63.934	20
30	66.139	68.343	70.548	72.753	74.957	77.162	79.366	81.571	83.776	85.980	30
40	88.185	90.390	92.594	94.799	97.003	99.208	101.413	103.617	105.822	108.026	40
50	110.231	112.436	114.640	116.845	119.050	121.254	123.459	125.633	127.868	130.073	50
60	132.277	134.482	136.687	138.891	141.096	143.300	145.505	147.710	149.914	152.119	60
70	154.324	156.528	158.732	160.937	163.142	165.347	167.551	169.756	171.961	174.165	70
80	176.370	178.574	180.780	182.984	185.188	187.393	189.597	191.802	194.007	196.211	80
90	198.416	200.621	202.825	205.030	207.234	209.439	211.644	213.848	216.053	218.258	90
100	220.462	222.667	224.871	227.076	229.281	231.485	233.690	235.895	238.099	240.304	100

KILOGRAMS TO NEWTON

kg	0	1	2	3	4	5	6	7	8	9	kg
	N	N	N	N	N	N	N	N	N	N	
—	—	9.81	19.61	29.42	39.23	49.03	58.84	68.65	78.45	88.26	—
10	98.07	107.87	117.68	127.49	137.29	147.10	156.91	166.71	176.52	186.33	10
20	196.13	205.94	215.75	225.55	235.36	245.17	254.97	264.78	274.59	284.39	20
30	294.20	304.01	313.81	323.62	333.43	343.23	353.04	362.85	372.65	382.46	30
40	392.27	402.07	411.88	421.69	431.49	441.30	451.11	460.91	470.72	480.53	40
50	490.33	500.14	509.95	519.75	529.56	539.37	549.17	558.98	568.79	578.59	50
60	558.40	598.21	608.01	617.82	627.63	637.43	647.24	657.05	666.85	676.66	60
70	686.47	696.27	706.08	715.89	725.69	735.50	745.31	755.11	764.92	774.73	70
80	784.53	794.34	804.15	813.95	823.76	833.57	843.37	853.18	862.99	872.79	80
90	882.60	892.41	902.21	912.02	921.83	931.63	941.44	951.25	961.05	970.86	90
100	980.67	990.47	1000.28	1010.08	1019.89	1029.70	1039.50	1049.31	1059.12	1068.92	100

NEWTON TO KILOGRAMS

N	0	10	20	30	40	50	60	70	80	90	N
	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	
—	—	1.020	2.039	3.059	4.079	5.099	6.118	7.138	8.158	9.177	—
100	10.197	11.217	12.237	13.256	14.276	15.296	16.316	17.335	18.355	19.375	100
200	20.394	21.414	22.434	23.453	24.473	25.493	26.513	27.532	28.552	29.572	200
300	30.592	31.611	32.631	33.651	34.670	35.690	36.710	37.730	38.749	39.769	300
400	40.789	41.809	42.828	43.848	44.868	45.887	46.907	47.927	48.947	49.966	400
500	50.986	52.006	53.025	54.045	55.065	56.085	57.104	58.124	59.144	60.163	500
600	61.183	62.203	63.223	64.242	65.262	66.282	67.302	68.321	69.341	70.361	600
700	71.380	72.400	73.420	74.440	75.459	76.479	77.499	78.518	79.538	80.558	700
800	81.578	82.597	83.617	84.637	85.656	86.676	87.696	88.716	89.735	90.755	800
900	91.775	92.795	93.814	94.834	95.854	96.873	97.893	98.913	99.933	100.952	900
1000	101.972	102.992	104.011	105.031	106.051	107.071	108.090	109.110	110.130	111.149	1000

11—6 CONVERSION TABLES

PRESSURE

POUNDS PER SQUARE INCHES TO KILOGRAMS PER SQUARE CENTIMETERS

lb/in² (psi)	0 kg/cm²	1 kg/cm²	2 kg/cm²	3 kg/cm²	4 kg/cm²	5 kg/cm²	6 kg/cm²	7 kg/cm²	8 kg/cm²	9 kg/cm²	lb/in² (psi)
—		0.0703	0.1406	0.2109	0.2812	0.3515	0.4218	0.4921	0.5625	0.6328	—
10	0.7031	0.7734	0.8437	0.9140	0.9843	1.0546	1.1249	1.1952	1.2655	1.3358	10
20	1.4061	1.4764	1.5468	1.6171	1.6874	1.7577	1.8280	1.8983	1.9686	2.0389	20
30	2.1092	2.1795	2.2498	2.3201	2.3904	2.4607	2.5311	2.6014	2.6717	2.7420	30
40	2.8123	2.8826	2.9529	3.0232	3.0935	3.1638	3.2341	3.3044	3.3747	3.4450	40
50	3.5154	3.5857	3.6560	3.7263	3.7966	3.8669	3.9372	4.0075	4.0778	4.1481	50
60	4.2184	4.2887	4.3590	4.4293	4.4996	4.5700	4.6403	4.7106	4.7809	4.8512	60
70	4.9215	4.9918	5.0621	5.1324	5.2027	5.2730	5.3433	5.4136	5.4839	5.5543	70
80	5.6246	5.6947	5.7652	5.8355	5.9058	5.9761	6.0464	6.1167	6.1870	6.2573	80
90	6.3276	6.3979	6.4682	6.5386	6.6089	6.6792	6.7495	6.8198	6.8901	6.9604	90
100	7.0307	7.1010	7.1713	7.2416	7.3119	7.3822	7.4525	7.5228	7.5932	7.6635	100

KILOGRAMS PER SQUARE CENTIMETERS TO POUNDS PER SQUARE INCHES

kg/cm²	0 lb/in²(psi)	1 lb/in²(psi)	2 lb/in²(psi)	3 lb/in²(psi)	4 lb/in²(psi)	5 lb/in²(psi)	6 lb/in²(psi)	7 lb/in²(psi)	8 lb/in²(psi)	9 lb/in²(psi)	kg/cm²
—		14.22	28.45	42.67	56.89	71.12	85.34	99.56	113.78	128.01	—
10	142.23	156.45	170.68	184.90	199.12	213.35	227.57	241.79	256.01	270.24	10
20	284.46	298.68	312.91	327.13	341.35	355.58	369.80	384.02	398.24	412.47	20
30	426.69	440.91	455.14	469.36	483.58	497.81	512.03	526.25	540.47	554.70	30
40	568.92	583.14	597.37	611.59	625.81	640.04	654.26	668.48	682.70	696.93	40
50	711.16	725.37	739.60	753.82	768.04	782.27	795.49	810.71	824.93	839.16	50
60	853.38	867.60	881.83	896.05	910.27	924.50	938.72	952.94	967.16	981.39	60
70	995.61	1009.83	1024.06	1038.28	1052.50	1066.73	1080.95	1095.17	1109.39	1123.62	70
80	1137.84	1152.06	1166.27	1180.51	1194.73	1208.96	1223.18	1237.40	1251.62	1265.85	80
90	1280.07	1294.20	1308.52	1322.74	1336.96	1351.19	1365.41	1379.63	1393.85	1408.08	90
100	1422.30	1436.52	1450.75	1464.97	1479.19	1493.42	1507.64	1521.86	1536.08	1550.31	100

KILOGRAMS PER SQUARE CENTIMETERS TO KILO PASCAL

kg/cm²	0 KPa	1 KPa	2 KPa	3 KPa	4 KPa	5 KPa	6 KPa	7 KPa	8 KPa	9 KPa	kg/cm²
—	—	98.1	196.1	294.2	392.3	490.3	588.4	686.5	784.5	882.6	—
10	980.7	1078.7	1176.8	1274.9	1372.9	1471.0	1569.1	1667.1	1765.2	1863.3	10
20	1961.3	2059.4	2157.5	2255.5	2353.6	2451.7	2549.7	2647.8	2745.9	2843.9	20
30	2942.0	3040.1	3138.1	3236.2	3334.3	3432.3	3530.4	3628.5	3726.5	3824.6	30
40	3922.7	4020.7	4118.8	4216.9	4314.9	4413.0	4511.1	4609.1	4707.2	4805.3	40
50	4903.3	5001.4	5099.5	5197.5	5295.6	5393.7	5491.7	5589.8	5687.9	5785.9	50
60	5584.0	5982.1	6080.1	6178.2	6276.3	6374.3	6472.4	6570.5	6668.5	6766.6	60
70	6864.7	6962.7	7060.8	7158.9	7256.9	7355.0	7453.1	7551.1	7649.2	7747.3	70
80	7845.3	7943.4	8041.5	8139.5	8237.6	8335.7	8433.7	8531.8	8629.9	8727.9	80
90	8826.0	8924.1	9022.1	9120.2	9218.3	9316.3	9414.4	9512.5	9610.5	9708.6	90
100	9806.7	9904.7	10002.8	10100.8	10198.9	10297.0	10395.0	10493.1	10591.2	10689.2	100

KILO PASCAL TO KILOGRAMS PER SQUARE CENTIMETERS

KPa	0 kg/cm²	100 kg/cm²	200 kg/cm²	300 kg/cm²	400 kg/cm²	500 kg/cm²	600 kg/cm²	700 kg/cm²	800 kg/cm²	900 kg/cm²	KPa
—	—	1.020	2.039	3.059	4.079	5.099	6.118	7.138	8.158	9.177	—
1000	10.197	11.217	12.237	13.256	14.276	15.296	16.316	17.335	18.355	19.375	1000
2000	20.394	21.414	22.434	23.453	24.473	25.493	26.513	27.532	28.552	29.572	2000
3000	30.592	31.611	32.631	33.651	34.670	35.690	36.710	37.730	38.749	39.769	3000
4000	40.789	41.809	42.828	43.848	44.868	45.887	46.907	47.927	48.947	49.966	4000
5000	50.986	52.006	53.025	54.045	55.065	56.085	57.104	58.124	59.144	60.163	5000
6000	61.183	62.203	63.223	64.242	65.262	66.282	67.302	68.321	69.341	70.361	6000
7000	71.380	72.400	73.420	74.440	75.459	76.479	77.499	78.518	79.538	80.558	7000
8000	81.578	82.597	83.617	84.637	85.656	86.676	87.696	88.716	89.735	90.755	8000
9000	91.775	92.794	93.814	94.834	95.854	96.873	97.893	98.913	99.933	100.952	9000
10000	101.972	102.992	104.011	105.031	106.051	107.071	108.090	109.110	110.130	111.149	10000

TORQUE

FOOT POUNDS TO KILOGRAMMETERS

ft. lbs.	0	1	2	3	4	5	6	7	8	9	ft. lbs.
	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	
—		0.138	0.277	0.415	0.553	0.691	0.830	0.968	1.106	1.244	—
10	1.383	1.521	1.659	1.797	1.936	2.074	2.212	2.350	2.489	2.627	10
20	2.765	2.903	3.042	3.180	3.318	3.456	3.595	3.733	3.871	4.009	20
30	4.148	4.286	4.424	4.562	4.700	4.839	4.977	5.115	5.253	5.392	30
40	5.530	5.668	5.807	5.945	6.083	6.221	6.360	6.498	6.636	6.774	40
50	6.913	7.051	7.189	7.328	7.466	7.604	7.742	7.881	8.019	8.157	50
60	8.295	8.434	8.572	8.710	8.848	8.987	9.125	9.263	9.401	9.540	60
70	9.678	9.816	9.954	10.093	10.231	10.369	10.507	10.646	10.784	10.922	70
80	11.060	11.199	11.337	11.475	11.613	11.752	11.890	12.028	12.166	12.305	80
90	12.442	12.581	12.719	12.858	12.996	13.134	13.272	13.410	13.549	13.687	90
100	13.826	13.964	14.102	14.240	14.379	14.517	14.655	14.793	14.932	15.070	100

KILOGRAMMETERS TO FOOT POUNDS

kg-m	0	1	2	3	4	5	6	7	8	9	kg-m
	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	
—		7.23	14.47	21.70	28.93	36.17	43.40	50.63	57.86	65.10	—
10	72.33	79.56	86.80	94.03	101.26	108.50	115.73	122.96	130.19	137.43	10
20	144.66	151.89	159.13	166.36	173.59	180.83	188.06	195.29	202.52	209.76	20
30	217.00	224.22	231.46	238.69	245.92	253.16	260.39	267.62	274.85	282.09	30
40	289.32	296.55	303.79	311.02	318.25	325.49	332.72	339.95	347.18	354.42	40
50	361.65	368.88	376.12	383.35	390.58	397.82	405.05	412.28	419.51	426.75	50
60	433.98	441.21	448.45	455.68	462.91	470.15	477.38	484.61	491.84	499.08	60
70	506.31	513.54	520.78	528.01	535.24	542.48	549.71	556.94	564.17	571.41	70
80	578.64	585.87	593.11	600.34	607.57	614.81	622.04	629.27	636.50	643.74	80
90	650.97	658.20	665.44	672.67	679.90	687.14	694.37	701.60	708.83	716.07	90
100	723.30	730.53	737.77	745.00	752.23	759.47	766.70	773.93	781.16	788.40	100

KILOGRAMMETERS TO NEWTONMETERS

kg-m	0	1	2	3	4	5	6	7	8	9	kg-m
	N-m	N-m	N-m	N-m	N-m	N-m	N-m	N-m	N-m	N-m	
—	—	9.81	19.61	29.42	39.23	49.03	58.84	68.65	78.45	88.26	—
10	98.07	107.87	117.68	127.49	137.29	147.10	156.91	166.71	176.52	186.33	10
20	196.13	205.94	215.75	225.55	235.36	245.17	254.97	264.78	274.59	284.39	20
30	294.20	304.01	313.81	323.62	333.43	343.23	353.04	362.85	372.65	382.46	30
40	392.27	402.07	411.88	421.69	431.49	441.30	451.11	460.91	470.72	480.53	40
50	490.33	500.14	509.95	519.75	529.56	539.37	549.17	558.98	568.79	578.59	50
60	588.40	598.21	608.0*	617.82	627.63	637.43	647.24	657.05	666.85	676.66	60
70	686.47	696.27	706.08	715.89	725.69	735.50	745.31	755.11	764.92	774.73	70
80	784.53	794.34	804.15	813.95	823.76	833.57	843.37	853.18	862.99	872.79	80
90	882.60	892.41	902.21	912.02	921.83	931.63	941.44	951.25	961.05	970.86	90
100	980.67	990.47	1000.28	1010.08	1019.89	1029.70	1039.50	1049.31	1059.12	1068.92	100

NEWTONMETERS TO KILOGRAMMETERS

N-m	0	10	20	30	40	50	60	70	80	90	N-m
	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	
—	—	1.020	2.039	3.059	4.079	5.099	6.118	7.138	8.158	9.177	—
100	10.197	11.217	12.236	13.256	14.276	15.296	16.315	17.335	18.355	19.374	100
200	20.394	21.414	22.433	23.453	24.473	25.493	26.512	27.532	28.552	29.571	200
300	30.591	31.611	32.630	33.650	34.670	35.690	36.710	37.729	38.749	39.768	300
400	40.789	41.808	42.827	43.847	44.867	45.887	46.906	47.926	48.946	49.965	400
500	50.986	52.005	53.024	54.044	55.064	56.084	57.103	58.123	59.143	60.162	500
600	61.183	62.202	63.221	64.241	65.261	66.281	67.300	68.320	69.340	70.359	600
700	71.380	72.399	73.418	74.438	75.458	76.478	77.497	78.517	79.537	80.556	700
800	81.577	82.596	83.615	84.635	85.655	86.675	87.694	88.714	89.734	90.753	800
900	91.774	92.793	93.812	94.832	95.852	96.872	97.891	98.911	99.931	100.950	900
1000	101.972	102.990	104.009	105.029	106.049	107.069	108.088	109.108	110.128	111.147	1000

TEMPERATURE

FAHRENHEIT TO CENTIGRADE

°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
-60	-51.1	-2	-18.9	56	13.3	114	45.6	172	77.8	230	110.0	288	142.2	346	174.4
-58	-50	0	-17.8	58	14.4	116	46.7	174	78.9	232	111.1	290	143.3	348	175.6
-56	-48.9	2	-16.7	60	15.6	118	47.8	176	80.0	234	112.2	292	144.4	350	176.7
-54	-47.8	4	-15.6	62	16.7	120	48.9	178	81.1	236	113.3	294	145.6	352	177.8
-52	-46.7	6	-14.4	64	17.8	122	50.0	180	82.2	238	114.4	296	146.7	354	178.9
-50	-45.6	8	-13.3	66	18.9	124	51.1	182	83.3	240	115.6	298	147.8	356	180.0
-48	-44.4	10	-12.2	68	20.0	126	52.2	184	84.4	242	116.7	300	148.9	358	181.1
-46	-43.3	12	-11.1	70	21.1	128	53.3	186	85.6	244	117.8	302	150.0	360	182.2
-44	-42.2	14	-10.0	72	22.2	130	54.4	188	86.7	246	118.9	304	151.1	362	183.3
-42	-41.1	16	-8.9	74	23.3	132	55.6	190	87.8	248	120.0	306	152.2	364	184.4
-40	-40.0	18	-7.8	76	24.9	134	56.7	192	88.9	250	121.1	308	153.3	366	185.6
-38	-38.9	20	-6.7	78	25.6	136	57.8	194	90.0	252	122.2	310	154.4	368	186.7
-36	-37.8	22	-5.6	80	26.7	138	58.9	196	91.1	254	123.3	312	155.6	370	187.8
-34	-36.7	24	-4.4	82	27.8	140	60.0	198	92.2	256	124.4	314	156.7	372	188.9
-32	-35.6	26	-3.3	84	28.9	142	61.1	200	93.3	258	125.6	316	157.8	374	190.0
-30	-34.4	28	-2.2	86	30.0	144	62.2	202	94.4	260	126.7	318	158.9	376	191.1
-28	-33.3	30	-1.1	88	31.1	146	63.3	204	95.6	262	127.8	320	160.0	378	192.2
-26	-32.2	32	-0	90	32.2	148	64.4	206	96.7	264	128.9	322	161.1	380	193.3
-24	-31.1	34	1.1	92	33.3	150	65.6	208	97.8	266	130.0	324	162.2	382	194.4
-22	-30.0	36	2.2	94	34.4	152	66.7	210	98.9	268	131.1	326	163.3	384	195.6
-20	-28.9	38	3.3	96	35.6	154	67.8	212	100.0	270	132.2	328	164.4	386	196.7
-18	-27.8	40	4.4	98	36.7	156	68.9	214	101.1	272	133.3	330	165.6	388	197.8
-16	-26.7	42	5.6	100	37.8	158	70.0	216	102.2	274	134.4	332	166.7	390	198.9
-14	-25.6	44	6.7	102	38.9	160	71.1	218	103.3	276	135.6	334	167.8	392	200.0
-12	-24.4	46	7.8	104	40.0	162	72.2	220	104.4	278	136.7	336	168.9	400	204.4
-10	-23.3	48	8.9	106	41.1	164	73.3	222	105.6	280	137.8	338	170.0	410	210.0
-8	-22.2	50	10.0	108	42.2	166	74.4	224	106.7	282	138.9	340	171.1	420	215.6
-6	-21.1	52	11.1	110	43.3	168	75.6	226	107.8	284	140.0	342	172.2	430	221.1
-4	-20.0	54	12.2	112	44.4	170	76.7	228	108.9	286	141.1	344	173.3	440	226.7

CENTIGRADE TO FAHRENHEIT

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
-50	-58.0	-18	- 0.4	14	57.2	46	114.8	78	172.4	110	230.0	142	287.6	174	345.2
-49	-56.2	-17	1.4	15	59.0	47	116.6	79	174.2	111	231.8	143	289.4	175	347.0
-48	-54.4	-16	3.2	16	60.8	48	118.4	80	176.0	112	233.6	144	291.2	176	348.8
-47	-52.6	-15	5.0	17	62.6	49	120.2	81	177.8	113	235.4	145	293.0	177	350.6
-46	-50.8	-14	6.8	18	64.4	50	122.0	82	179.6	114	237.2	146	294.8	178	352.4
-45	-49.0	-13	8.6	19	66.2	51	123.8	83	181.4	115	239.0	147	296.6	179	354.2
-44	-47.2	-12	10.4	20	68.0	52	125.6	84	183.2	116	240.8	148	298.4	180	356.0
-43	-45.4	-11	12.2	21	69.8	53	127.4	85	185.0	117	242.6	149	300.2	181	357.8
-42	-43.6	-10	14.0	22	71.6	54	129.2	86	186.8	118	244.4	150	302.0	182	359.6
-41	-41.8	-9	15.8	23	73.4	55	131.0	87	188.6	119	246.2	151	303.8	183	361.4
-40	-40.0	-8	17.6	24	75.2	56	132.8	88	190.4	120	248.0	152	305.6	184	363.2
-39	-38.2	-7	19.4	25	77.0	57	134.6	89	192.2	121	249.8	153	307.4	185	365.0
-38	-36.4	-6	21.2	26	78.8	58	136.4	90	194.0	122	251.6	154	309.2	186	366.8
-37	-34.6	-5	23.0	27	80.6	59	138.2	91	195.8	123	253.4	155	311.0	187	368.6
-36	-32.8	-4	24.8	28	82.4	60	140.0	92	197.6	124	255.2	156	312.8	188	370.4
-35	-31.0	-3	26.6	29	84.2	61	141.8	93	199.4	125	257.0	157	314.6	189	372.2
-34	-29.2	-2	28.4	30	86.0	62	143.6	94	201.2	126	258.8	158	316.4	190	374.0
-33	-27.4	-1	30.2	31	87.8	63	145.4	95	203.0	127	260.6	159	318.2	191	375.8
-32	-25.6	0	32.0	32	89.6	64	147.2	96	204.8	128	262.4	160	320.0	192	377.6
-31	-23.8	1	33.8	33	91.4	65	149.0	97	206.6	129	264.2	161	321.8	193	379.4
-30	-22.0	2	35.6	34	93.2	66	150.8	98	208.4	130	266.0	162	323.6	194	381.2
-29	-20.2	3	37.4	35	95.0	67	152.6	99	210.2	131	267.8	163	325.4	195	383.0
-28	-18.4	4	39.2	36	96.8	68	154.4	100	212.0	132	269.6	164	327.2	196	384.8
-27	-16.6	5	41.0	37	98.6	69	156.2	101	213.8	133	271.4	165	329.0	197	386.6
-26	-14.8	6	42.8	38	100.4	70	158.0	102	215.6	134	273.2	166	330.8	198	388.4
-25	-13.0	7	44.6	39	102.2	71	159.8	103	217.4	135	275.0	167	332.6	199	390.2
-24	-11.2	8	46.4	40	104.0	72	161.6	104	219.2	136	276.8	168	334.4	200	392.0
-23	-9.4	9	48.2	41	105.8	73	163.4	105	221.0	137	278.6	169	336.4	210	410.0
-22	-7.6	10	50.0	42	107.6	74	165.2	106	222.8	138	280.4	170	338.0	220	428.0
-21	-5.8	11	51.8	43	109.4	75	167.0	107	224.6	139	282.2	171	339.8	230	446.0
-20	-4.4	12	53.6	44	111.2	76	168.8	108	226.4	140	284.0	172	341.6	240	464.0
-19	-2.2	13	55.4	45	113.0	77	170.6	109	228.2	141	285.8	173	343.4	250	482.0