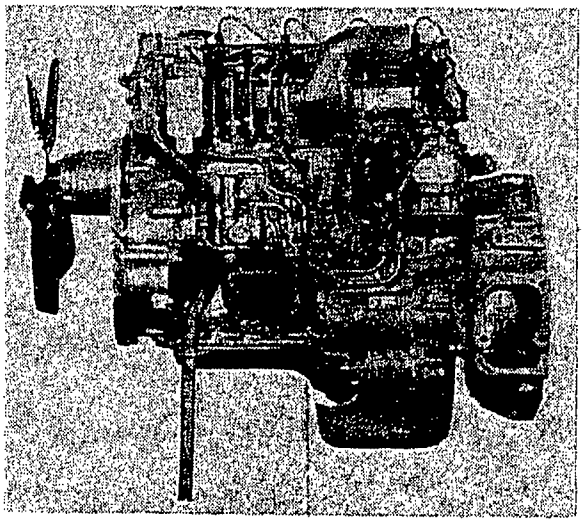
Manual Part No. 92119

SERVICE Manual

4.0 Liter

DIESEL ENGINE

Models 40DT & 40DTA



GENERAC

CORPORATION

P. O. Box 8
Waukesha, WI 53187
Phone: (414) 544-4811
FAX: (414) 544-4851

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Foreword

This Service Manual has been written and published by Generac Corporation to aid our dealers' mechanics and company service personnel in the servicing of the products described herein.

It is assumed that such personnel are familiar with the servicing procedures recommended for these products, or similar products manufactured and marketed by Generac. It is further assumed that they have been trained in the servicing procedures for these products, including the use of mechanic's common hand tools and any special tools that might be required.

We could not possibly know of and advise the service trade of all conceivable procedures by which a service might be performed, nor of the possible hazards and/or results of each method or procedure. We have not undertaken any such wide evaluation. Therefore, anyone who uses a service procedure that is not recommended by Generac must first satisfy himself that neither his nor the product's safety will be endangered by the service method he has selected.

The contents of this manual, including all photographs, drawings and specifications are the latest available at the time of publication. However, Generac reserves the right to change, alter or otherwise improve the product at any time without prior notice.

How to Use the Manual

This SERVICE MANUAL is intended for use as a guide in the disassembly, repair and reassembly of the 4.0 liter diesel engine that powers some Generac standby/prime power generators. Follow the instructions in the manual carefully whenever you are performing service on the engine.

The manual is divided into seven (7) PARTS. Each PART is subdivided into two or more SECTIONS. Each SECTION is divided into PARAGRAPHS.

A main "Table of Contents" page, which lists the seven (7) PARTS of the manual is provided at the front of the Manual.

A DIVIDER page separates each PART of the manual. The DIVIDER page includes a "Table of Contents" which lists each SECTION in that division.

Special Tools

Some service and repair tasks require the use of special tools. The text of the manual identifies each special tool by providing a "Reference Number". A listing of special tools can be found in Part 1, "GENERAL INFORMATION". That listing gives the tool "Reference Number", as well as a Generac Part Number. When ordering a special tool, be sure to include both the PART NUMBER and the REFERENCE NUMBER.

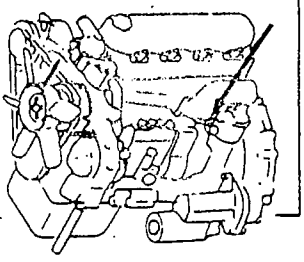
Repair Procedures

Simpler and self-explanatory procedures, such as the installation and removal of parts, are not included in this manual. Illustrations are provided to serve as guides for such simple procedures. Only those essential procedures requiring more complete instructions have been dealt with explicitly.

Engine Serial Number

The engine Serial Number is located as shown in the illustration, engraved on the cylinder block. When ordering replacement parts or specifying technical data, please provide us with that number.

Serial Number Location



SERVICE MANUAL

4.0 Liter

DIESEL ENGINE

Models 40DT & 40DTA

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Part 1 GENERAL INFORMA-TION

4.0 Liter

DIESEL ENGINE

Models 40DT & 40DTA

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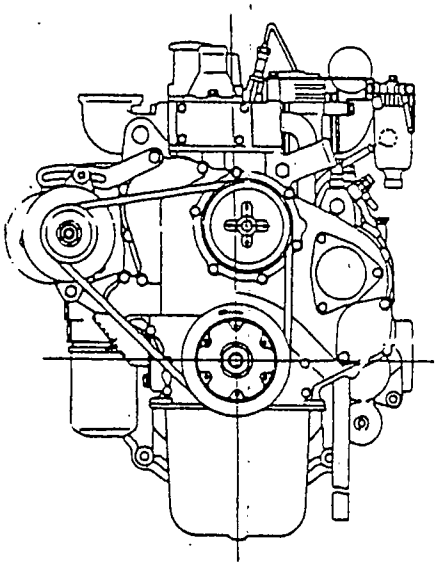
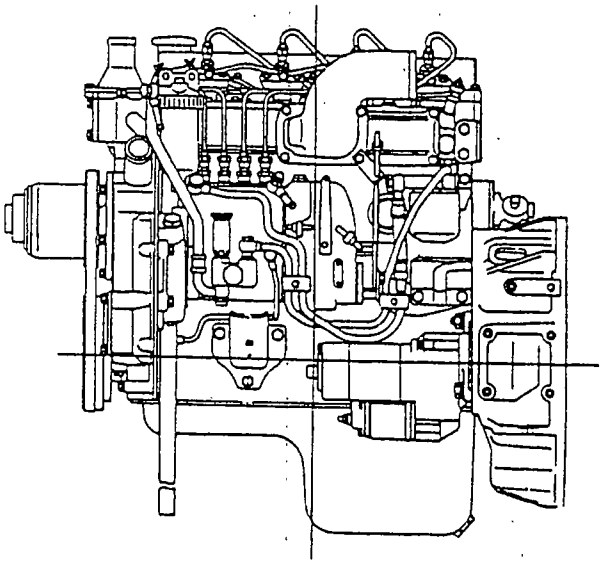
Front & Left Views of Engine



FRONT VIEW



LEFT SIDE VIEW

Data and Specifications

GENERAL SPECIFICATIONS:

Type of Engine	Diesel, Overhead Valve
Cylinders	4, In-Line
Valves	Overhead Valve
Combustion Section	Direct Injection Type
Cylinder Bore	4.09 inches (104mm)
Stroke	4.65 inches (118mm)
Displacement	244 cubic inches (4.009 liters)
Compression Ratio	17.9 to 1
Compression Pressure	450-511 psi (33-36 kg/cm^2) at 350 rpm
Direction of Rotation	Counterclockwise (Viewed from Flywheel End)
Dry Weight	Approximately 782 lbs (355kg)
Cylinder Block Material	Cast Iron with Replaceable dry liner
Cylinder Head Material	Cast Iron
Crankshaft Material	Induction Hardened, die forged special steel
Piston Material	Aluminum Alloy
Compression Rings	Two (2), chrome plated
Oil Ring	One (1), chrome plated with coil expander
Camshaft	Induction Hardened Carbon steel
Valves	Heat Resistant Steel
Firing Order	1-3-4-2
Valve Seat Angles	
Intake Valve	30°
Exhaust Valve	45°
Valve Face Angles	
Intake Valve	30°
Exhaust Valve	45°
Valve Timing	
Intake Valve Opens	16° BTDC
Intake Valve Closes	40° ATDC
Exhaust Valve Opens	55° BTDC
Exhaust Valve Closes	13° ATDC
Valve Clearance (Cold)	
Intake Valve	0.0118 inch (0.30mm)
Exhaust Valve	0.0157 inch (0.40mm)
Fuel Nozzle	
Injection Pressure	3125 psi (220 kg/cm^2)
Oil Capacity	2.77 U.S. Gallons (10.5 liters)
Oil Pressure	22-71 psi (1.5-5.0 kg/cm^2)
Injection Timing	18° BTDC (Flywheel Travel)

Performance

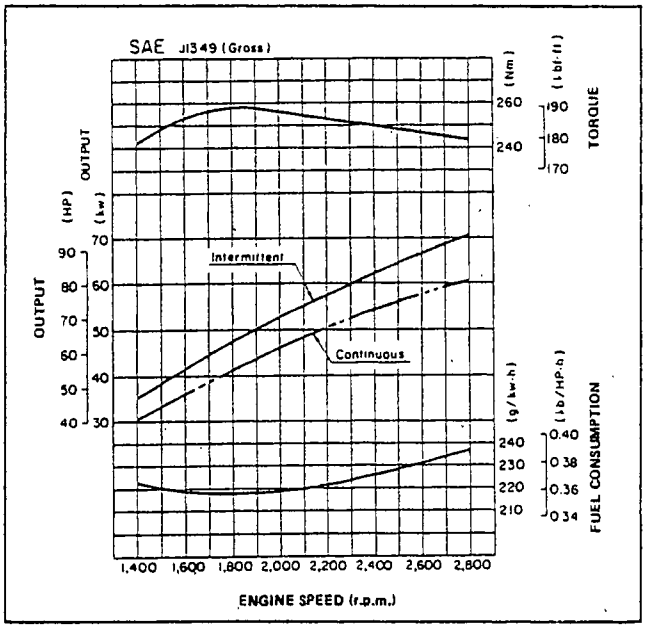
Rated Output . . . . . 87 PS (64 kW) at 2800 rpm
(Intermittent)
DIN 6270B (with Cooling Fan)
79 PS (58 kW) at 2400 rpm
50 PS (68 kW) at 2000 rpm
39 PS (53 kW) at 1600 rpm

Continuous Rated
Output . . . . . 74 PS (54 kW) at 2800 rpm
DIN 6270A (with Cooling Fan)
68 PS (50 kW) at 2400 rpm
58 PS (43 kW) at 2000 rpm
45 PS (33 kW) at 1600 rpm

Maximum Torque . . . 24.5 kgm (240 Nm) at 1800 rpm

NOTE: Outputs are converted to DIN 6270 standard ambient conditions.

Intake Air Temperature . 20° C.
Barometric Presure . . . 735 mmHg
Water Vapor Pressure
in Atmosphere . . . . . 10.5 mmHg



STANDARD TIGHTENING TORQUE

Bolt tightening torque chart—for general purpose

Unit: kg-cm (lb.ft)

Bolt	Tightening conditions \ Bolt diameter (mm)	4	6	8	10	12	14	16	18	20	22	24
4 5	Even tightening area. Bolt nut, coating, naked bolt, lubricant, etc. Optimum conditions.	10 – 15 (0.8 – 1.0)	38 – 53 (2.7 – 3.8)	88 – 128 (7 – 9)	174 – 255 (13 – 18)	304 – 445 (22 – 32)	486 – 712 (36 – 51)	758 – 1,110 (55 – 80)	1,040 – 1,530 (76 – 110)	1,480 – 2,170 (108 – 158)	2,030 – 2,960 (147 – 215)	2,580 – 3,750 (186 – 271)
	Cast iron or aluminium tightening surface. Washers. Medium conditions.	14 – 20 (1.1 – 1.4)	48 – 71 (3.5 – 5.1)	117 – 172 (9 – 12)	232 – 340 (17 – 24)	405 – 592 (30 – 42)	647 – 950 (47 – 68)	1,010 – 1,480 (74 – 107)	1,390 – 2,040 (101 – 147)	1,970 – 2,900 (143 – 209)	2,700 – 3,970 (196 – 287)	3,410 – 5,000 (247 – 361)
	Tightening area having black coarse surface. Rusty. Naked bolt or lubricant unavailable. Poor tightening conditions.	17 – 25 (1.3 – 1.8)	60 – 88 (4.4 – 6.3)	146 – 214 (11 – 15)	290 – 425 (21 – 30)	506 – 742 (37 – 53)	809 – 1,180 (59 – 85)	1,260 – 1,850 (92 – 133)	1,740 – 2,540 (126 – 183)	2,460 – 3,620 (178 – 261)	3,380 – 4,950 (245 – 358)	4,260 – 6,250 (309 – 452)
6 7	Even tightening area. Bolt nut, coating, naked bolt, lubricant, etc. Optimum conditions.	16 – 24 (1.2 – 1.7)	58 – 83 (4.2 – 6.0)	138 – 201 (10 – 14)	273 – 400 (20 – 28)	477 – 700 (35 – 50)	784 – 1,120 (58 – 81)	1,190 – 1,750 (87 – 126)	1,640 – 2,400 (119 – 173)	2,320 – 3,410 (168 – 246)	3,180 – 4,680 (231 – 338)	4,020 – 5,360 (291 – 387)
	Cast iron or aluminium tightening surface. Washers. Medium conditions.	22 – 32 (1.6 – 2.3)	75 – 110 (5.5 – 7.9)	183 – 270 (14 – 19)	364 – 533 (27 – 38)	636 – 932 (47 – 67)	1,020 – 1,500 (74 – 108)	1,590 – 2,330 (116 – 168)	2,180 – 3,200 (158 – 231)	3,100 – 4,550 (225 – 329)	4,250 – 6,210 (308 – 449)	5,360 – 7,850 (388 – 567)
	Tightening area having black coarse surface. Rusty. Naked bolt or lubricant unavailable. Poor tightening conditions.	27 – 40 (2.0 – 2.8)	94 – 138 (6.8 – 9.9)	229 – 336 (17 – 24)	455 – 667 (33 – 48)	795 – 1,165 (58 – 84)	1,270 – 1,870 (92 – 135)	1,990 – 2,920 (144 – 211)	2,730 – 4,000 (198 – 289)	3,870 – 5,680 (280 – 410)	5,310 – 7,800 (385 – 564)	6,700 – 9,850 (485 – 712)
8 9 10	Even tightening area. Bolt nut, coating, naked bolt, lubricant, etc. Optimum conditions.	24 – 32 (1.8 – 2.3)	82 – 110 (6.0 – 7.9)	200 – 287 (15 – 19)	397 – 574 (29 – 41)	694 – 925 (51 – 66)	1,010 – 1,480 (74 – 107)	1,730 – 2,310 (126 – 167)	2,380 – 3,170 (173 – 229)	3,380 – 4,510 (244 – 326)	4,630 – 6,170 (335 – 446)	5,850 – 7,790 (424 – 563)
	Cast iron or aluminium tightening surface. Washers. Medium conditions.	32 – 42 (2.4 – 3.0)	110 – 146 (8.0 – 10.5)	267 – 356 (19 – 25)	529 – 706 (39 – 51)	925 – 1,230 (67 – 88)	1,480 – 1,970 (108 – 142)	2,310 – 3,080 (168 – 222)	3,170 – 4,230 (230 – 305)	4,510 – 6,010 (327 – 434)	6,170 – 8,230 (447 – 595)	7,790 – 10,390 (584 – 751)
11	Tightening area having black coarse surface. Rusty. Naked bolt or lubricant unavailable. Poor tightening conditions.	40 – 53 (2.9 – 3.8)	137 – 183 (10.0 – 13.2)	334 – 446 (25 – 32)	662 – 882 (48 – 63)	1,160 – 1,540 (84 – 111)	1,850 – 2,470 (134 – 178)	2,890 – 3,850 (210 – 278)	3,970 – 5,290 (288 – 382)	5,640 – 7,510 (408 – 543)	7,720 – 10,290 (559 – 744)	9,740 – 12,990 (705 – 939)

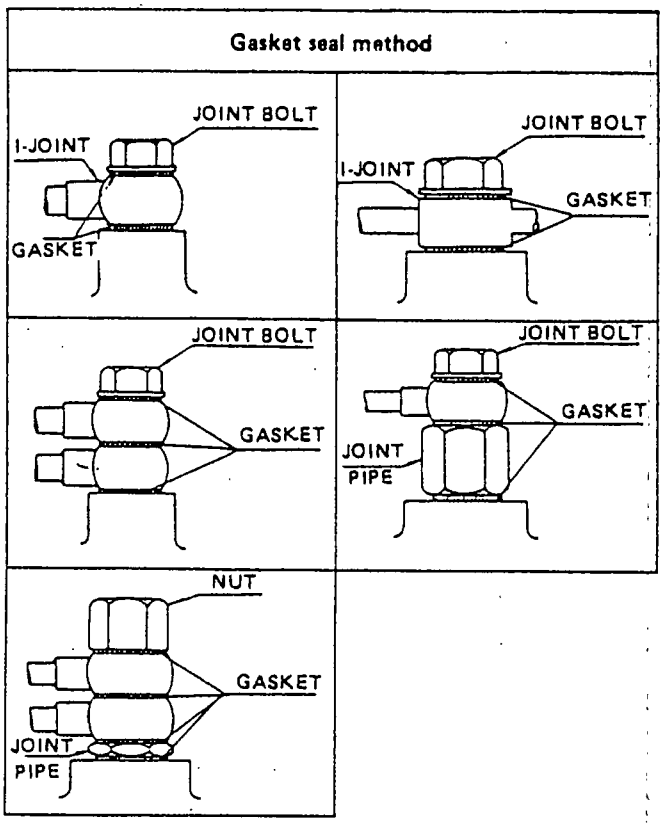
NOTE: The torque values given in this table should be applied where bolt torque is not specified.

LUBRICANTS	POSITIONS	ATMOSPHERIC TEMP.	S.A.E. NO.	BP	CALTEX	CASTROL	ESSO	GULF	MOBIL	SHELL	TOTAL
ENGINE OIL (A.P.I. CD) Previous Classification (A.P.I. DS) (MIL-L-2104C) (MIL-L-45199B)	Cylinder Block Injection Pump Air Cleaner	Above 32°C (90°F)	40	Vanellus C-3 40	RPM DELO 400 Oil SAE 40 or 15W/40 RPM DELO 300 Oil SAE 40	Castrol or Deusol CRD 40 Turbomax Castrol or Deusol RX Super 40, 15W/40	Essolube D-3 40, XD-3 40	Gulf Super Duty Motor Oil 40, 15W-40	Mobil Delvac 1340 Mobil Delvac Super 15W-40	Myrina Oil 40, 20W-40, 15W-40 Rimula X Oil 40 Rimula CT 40	TOTAL Rubia S 40 TOTAL Rubia TM 15W40
		32°–0°C (90°–32°F)	30	Vanellus C-3 30	RPM DELO 400 Oil SAE 30 or 15W/40 RPM DELO 300 Oil SAE 30	Castrol or Deusol CRD 30 Castrol or Deusol RX Super 30, 15W/40	Essolube D-3 30, XD-3 30	Gulf Super Duty Motor Oil 30, 15W-40	Mobil Delvac 1330 Mobil Delvac Super 15W-40	Myrina Oil 30, 20W-40, 15W-40 Rimula X Oil 30, 10W-30 Rimula CT30	TOTAL Rubia S 30 TOTAL Rubia TM 15W40
		0°–-12°C (32°–10°F)	20	Vanellus C-3 20W	RPM DELO 400 Oil SAE 20/20W, 15W/40 RPM DELO 300 Oil SAE 20/20W	Castrol or Deusol CRD 20W/20 Castrol or Deusol RX Super 20W/20, 15W/40	Essolube D-3 20W, XD-3 15W-40	Gulf Super Duty Motor Oil 20, 15W-40	Mobil Delvac 1310 Mobil Delvac Super 15W-40	Myrina Oil 20, 20W-40, 15W-40 Rimula X Oil 20 Rimula CT20	TOTAL Rubia S 20 TOTAL Rubia TM 15W40
ENGINE OIL (A.P.I. CC) Previous Classification (A.P.I. DM) (MIL-L-46152) (MIL-L-2104B)		Above 32°C (90°F)	40	Vanellus M 40	RPM DELO 200 Oil SAE 40 RPM DELO 100 Oil SAE 40	Castrol or Deusol CRX 40 Castrol or Deusol RX Super 40, 15W/40	Essolube HDX 40, HDX Plus 40	Gulflube Motor Oil XHD 40, 15W-40	Mobil Delvac 1240 Mobil Delvac 1140	Rotella TX40, 20W-50 Rotella SX Oil 40, 20W-40	TOTAL Rubia H 40
		32°–0°C (90°–32°F)	30	Vanellus M 30	RPM DELO 200 Oil SAE 30 RPM DELO 100 Oil SAE 30	Castrol or Deusol CRX 30 Castrol or Deusol RX Super 30, 15W/40	Essolube HDX 30, HDX Plus 30	Gulflube Motor Oil XHD 30, 15W-40	Mobil Delvac 1230 Mobil Delvac 1130	Rotella TX30, 20W-50 Rotella SX Oil 30, 20W-40	TOTAL Rubia H 30
		0°–-12°C (32°–10°F)	20	Vanellus M 20W	RPM DELO 200 Oil SAE 20/20W RPM DELO 100 Oil SAE 20/20W	Castrol or Deusol CRX 20W/20 Castrol or Deusol RX Super 20W/20, 15W/40	Essolube HDX 20, HDX Plus 20W-20	Gulflube Motor Oil XHD 20, 15W-40	Mobil Delvac 1220 Mobil Delvac 1120	Rotella TX20, 20W-50 Rotella SX Oil 20/20W, 20W-40	TOTAL Rubia H 20
COOLANT PUMP BEARING GREASE (MIL-G-10924B)	Coolant Pump Bearing			Energrease L-2	Marfak Multipurpose 2 or Marfak All Purpose 2	Castrol LM Grease	Esso Multipurpose Grease	Gulflex Poly	Mobilgrease MP, 77, MS	Retinax A Alvania Grease R2	TOTAL MULTIS 2
STARTER GREASE	Bushing, Clutch, Drive Shaft, Pinion Shift Lever & Reduction Gear			———	Molytex Grease EP2	———	———	———	Mobilgrease 29	Aero Shell Grease 17	———
GENERATOR & STARTER BEARING GREASE	Generator Bearing Starter Bearing			Energrease LT 2	RPM Grease SRI 2	———	———	———	Mobilgrease 28	Aero Shell Grease 7	———
INJECTION PUMP TIMER GREASE (MIL-G-10924B)	Injection Pump Timer			Energrease L-2	Marfak Multipurpose 2 or Marfak All Purpose 2	Castrol LM Grease	Esso Multipurpose Grease	Gulflex Poly	Mobilgrease MP, 77, MS	Retinax A Alvania Grease R2	TOTAL Multis EP 1
ANTI FREEZE (MIL-H-5559A)	Engine, Radiator			Anti Frost	AF Engine Coolant	Castrol Anti-Freeze Castrol Long Life Coolant	Esso Anti Freeze Coolant	Cruise Master Antifreeze And Summer Coolant	Mobil Permazone	Shellzone(U.S.A.) Glycoshell Plus (European Countries) Shellsafe Anti-Freeze P281 Coolguard	TOTAL ANTIGEL

Note: Lubricants were amended according to new classification by A.P.I.(American Petroleum Institute)

Procedures for Installing Pipe Joints & Gaskets

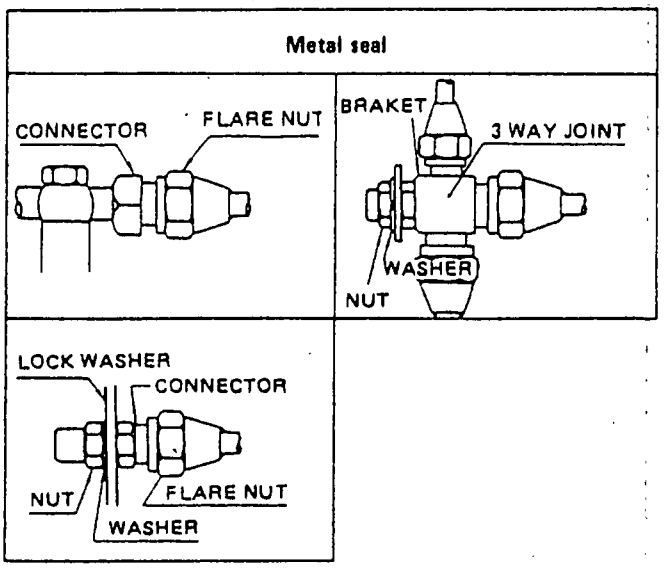
1. Gasket seal type.



Torque chart

Sealing method / Clamping screw size mm (in)	Location of gasket seal (aluminum, rubber + asbestos or copper) kg·cm (lb.ft)
8 (0.314)	120 – 170 (9 – 12)
10 (0.394)	180 – 230 (13 – 17)
12 (0.472)	230 – 280 (17 – 20)
14 (0.551)	230 – 280 (17 – 20)
16 (0.630)	300 – 360 (22 – 26)
18 (0.709)	400 – 450 (29 – 33)
20 (0.787)	400 – 450 (29 – 33)
22 (0.866)	530 – 600 (38 – 43)
24 (0.945)	720 – 800 (52 – 58)
28 (1.102)	1,300 – 1,500 (94 – 108)

2. Metal seal type. (Flares connector)

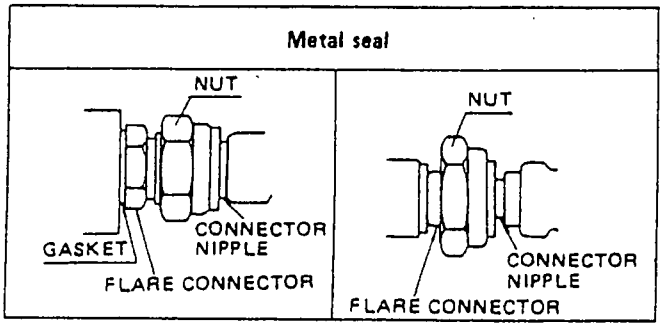


Torque chart

Sealing method / Clamping screw size mm (in)	Location of metal seal kg·cm (lb.ft)
12 (0.472)	200 – 230 (14 – 17)
14 (0.551)	330 – 360 (24 – 26)
16 (0.630)	400 – 500 (29 – 36)
18 (0.709)	600 – 700 (43 – 51)
20 (0.787)	650 – 700 (47 – 51)

Procedures for Installing Pipe Joints & Gaskets (Continued)

3. Metal seal type. (Nipples connectors)



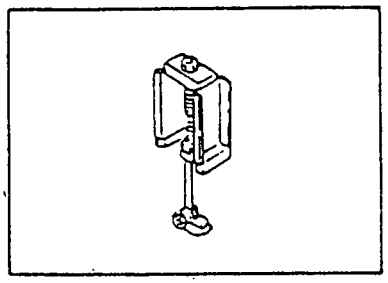
Torque chart

Sealing method / Clamping screw size mm (in)	Location of metal seal kg·cm (lb.ft)
10 (0.394)	100 – 150 (7 – 10)
20 (0.787)	200 – 250 (14 – 18)

NOTE:
- Before installing the joints, ensure that there is no dirt or burrs adhering to the various seat faces (pipe joints, gaskets, etc.)
- Because the pipes can move relatively freely during installation and the seat faces are liable to tilt, first temporarily tighten the pipes, then tighten them to specification and ensure that there is no leakage from them.
- When tightening two pipes together, be very careful that they do not rotate together.
- After installing the pipes, apply the correct pressure to each pipe joint and ensure that there is no leakage.
- Ensure that the various tightening torques conform to the above table.
- If a soft washer # 4840 FR-N (aluminum + rubber and carbon press fit part) is loosened or removed subsequent to being installed, be sure and replace it with a new one.
  There is no need to replace it, however, for normal retightening.

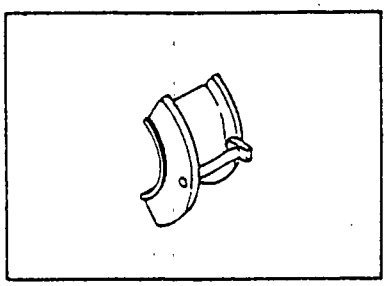
Special Tools

CYLINDER LINER PULLER



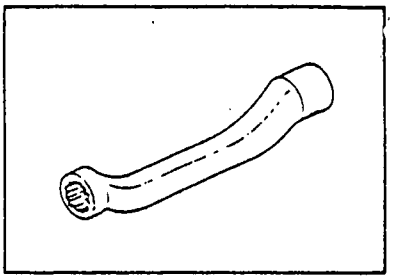
Reference No. 09420-1460
Part No. M-92685

CYLINDER LINER GUIDE



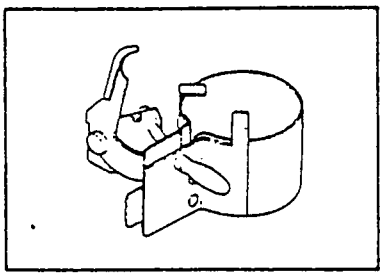
Reference No. 09480-1120
Part No. N-92685

CYLINDER HEAD BOLT WRENCH



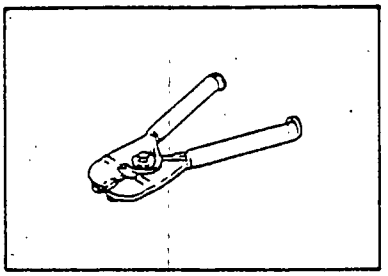
Reference No. 09411-1190
Part No. O-92685

PISTON RING HOLDER



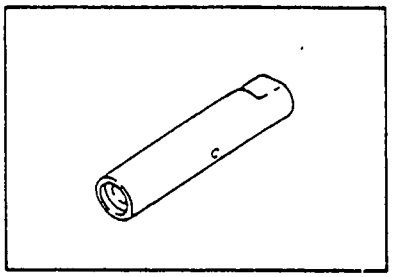
Reference No. 09441-1260
Part No. P-92685

PISTON RING EXPANDER



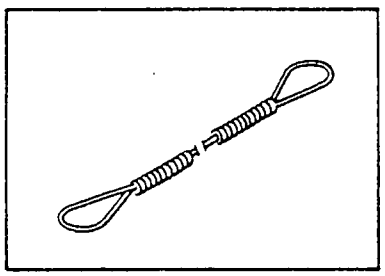
Reference No. 09442-1180
Part No. Q-92685

STEM SEAL PRESS



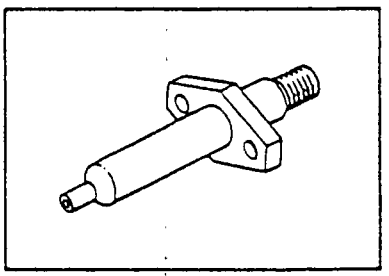
Reference No. 09472-1650
Part No. R-92685

WIRE



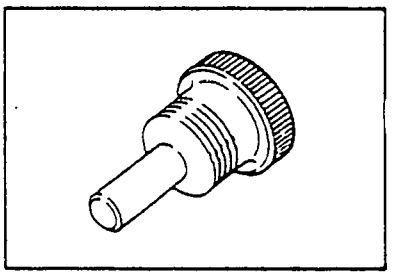
Reference No. 09491-1010
Part No. S-92685

GAUGE ADAPTOR (NOZZLE)



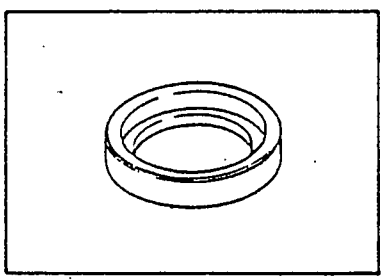
Reference No. 09408-1041
Part No. T-92685

TIMER SETTING TOOL



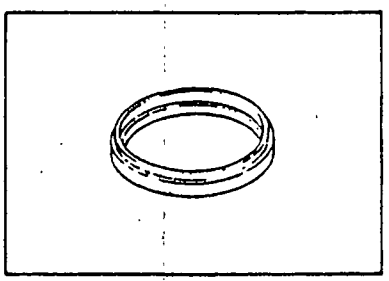
Reference No. 09512-2090
Part No. U-92685

TIMING GEAR CASE OIL SEAL PRESS



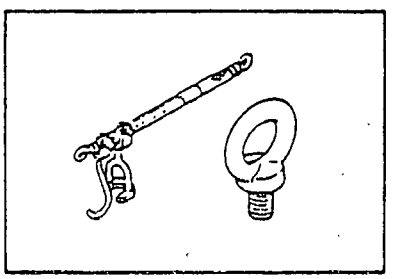
Reference No. 09482-1530
Part No. V-92685

FLY WHEEL HOUSING OIL SEAL PRESS



Reference No. 09482-1540
Part No. W-92685

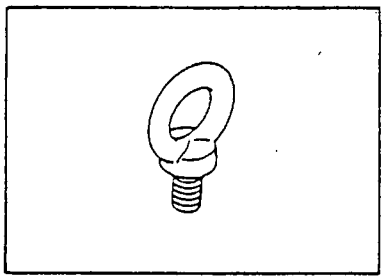
VALVE SPRING PRESS



Reference No. 09470-1022
Part No. X-92685

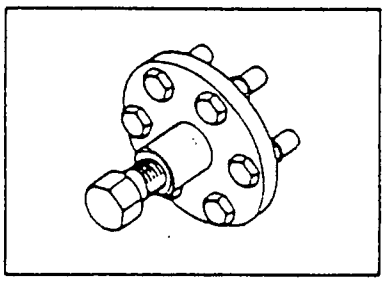
Special Tools (Continued)

EYE BOLT



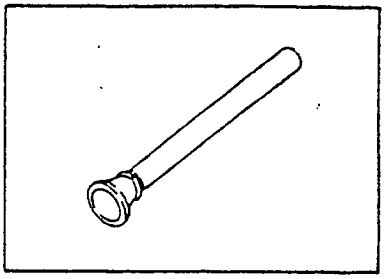
Reference No. 09433-1070
Part No. A92685

CRANK PULLEY PULLER



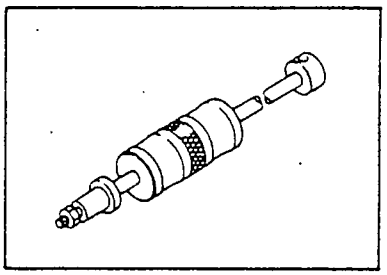
Reference No. 09420-1500
Part No. B92685

VALVE LAPPING TOOL



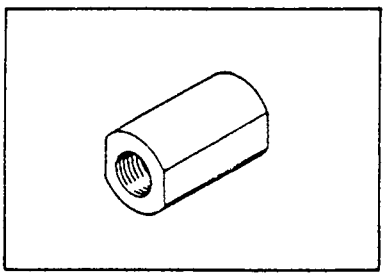
Reference No. 09431-1010
Part No. C-92685

SLIDING HAMMER



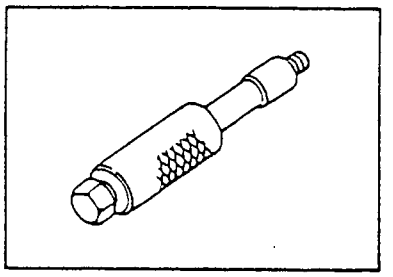
Reference No. 09420-1442
Part No. D-92685

SLIDING HAMMER ADAPTOR FOR NOZZLE



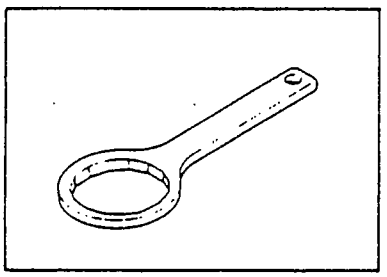
Reference No. 09462-1370
Part No. E-92685

IDLER GEAR SHAFT PULLER



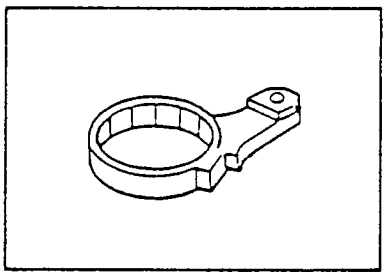
Reference No. 09420-1100
Part No. F-92685

WRENCH (OIL FILTER)



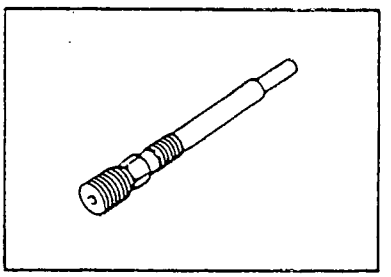
Reference No. 09553-1010
Part No. G-92685

WRENCH (FUEL FILTER)



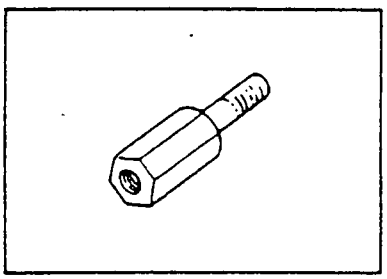
Reference No. 09503-1040
Part No. H-92685

GAUGE ADAPTOR (GLOW PLUG)



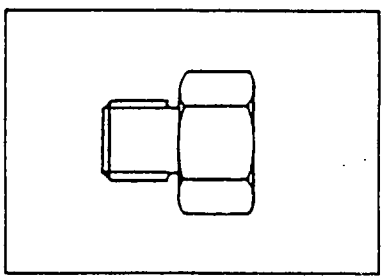
Reference No. 09552-1051
Part No. I-92685

ADAPTOR, NOZZLE HOLDER



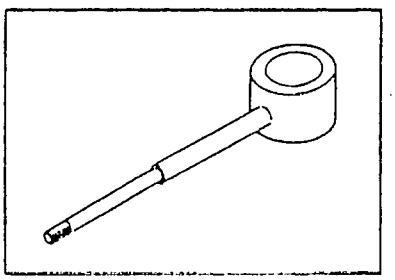
Reference No. 09462-1130
Part No. J-92685

ADAPTOR, COMPRESSION PRESSURE



Reference No. 09552-1070
Part No. K-92685

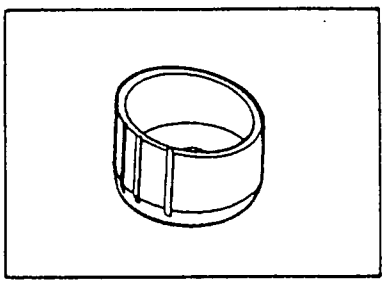
PRESS SUB-ASSEMBLY



Reference No. 09402-1450
Part No. L-92685

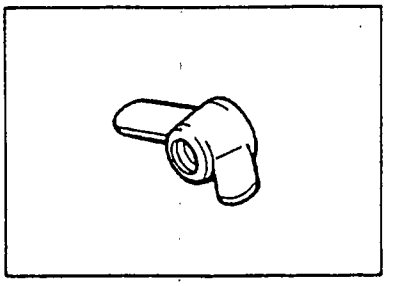
Special Tools (Continued)

GUIDE



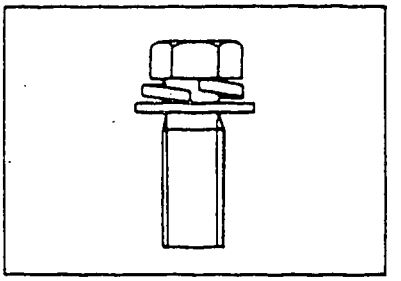
Reference No. 09481-1120
Part No. Y-92685

WING NUT



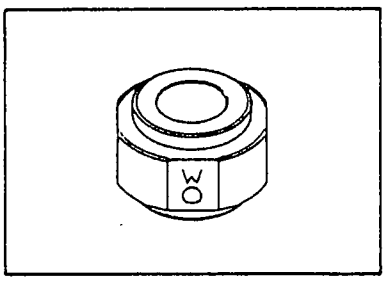
Reference No. 9233-10360
Part No. Z-92685

BOLT



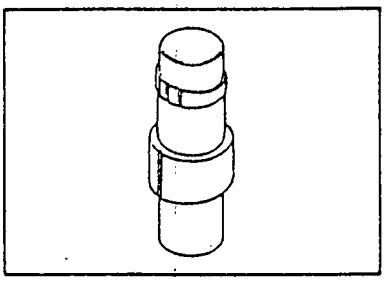
Reference No. 9191-98252
Part No. AA-92685

GUIDE



Reference No. 09481-1130
Part No. AB-92685

SPINDLE



Reference No. 09402-1460
Part No. AC-92685

Part 2
ENGINE

4.0 Liter

DIESEL ENGINE

Models 40DT & 40DTA

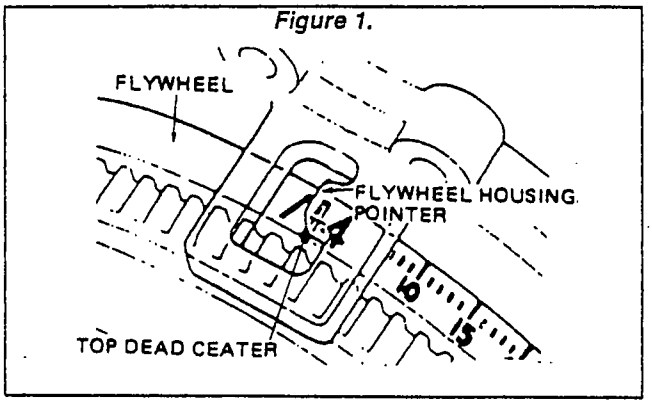
TABLE OF CONTENTS	
SECTION	TITLE
2.1	Engine Tuneup
2.2	Engine Overhaul Criteria
2.3	Cylinder Head
2.4	Timing Gear, Camshaft, Oil Pan
2.5	Cylinder Block & Flywheel Housing
2.6	Oil Pump & Oil Strainer
2.7	Coolant Pump
2.8	Thermostat & Housing
2.9	Fuel Injection Nozzles

Adjust Valve Clearance

CLEARANCE ADJUSTMENT PROCEDURE:

1. Set the No. 1 piston to top dead center (TDC) of its compression stroke.

Figure 1.



2. With No. 1 piston at top dead center of its compression stroke, use a thickness gauge to adjust the No. 1 valve clearance. Clearance is correct when the thickness gauge moves with a very slight pull.

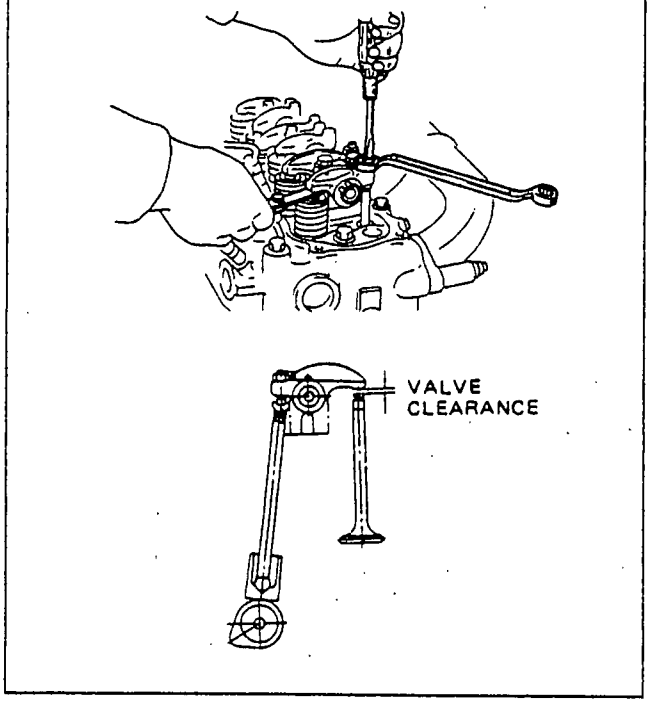
VALVE CLEARANCE
Intake: 0.0118 inch (0.30mm)
Exhaust: 0.0157 inch (0.40mm)

3. Adjust the clearance of the other valves.

a. As viewed from the timing gear cover side, turn the crankshaft clockwise 180°.

b. Adjust the remaining valve clearances in the firing order 1-3-4-2.

Figure 2. Valve Clearance



FINDING TDC OF COMPRESSION STROKE:

To determine if either the No. 1 or No. 4 piston is at top dead center (TDC) of its compression stroke, proceed as follows:

1. Locate the mark "1-4" on the flywheel. Turn the crankshaft until this mark is aligned with the pointer on the flywheel housing. In this position, either the No. 1 or No. 4 piston is at top dead center of its compression stroke.

a. See Figure 3. If the No. 1 intake and exhaust rocker arms can be moved easily by hand, the No. 1 piston is at top dead center (TDC) of its compression stroke. If not, turn the crankshaft one (1) complete revolution and re-align the "1-4" mark again.

b. See Figure 4. If the injection timing mark is nearly aligned with the pointer, the No. 1 piston is at top dead center (TDC) of the compression stroke.

Figure 3.

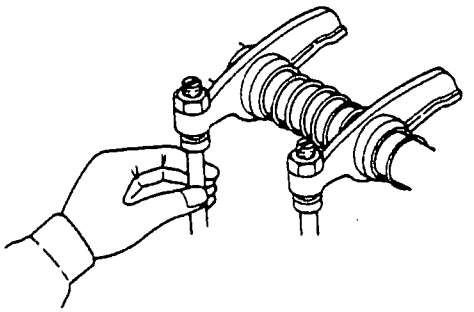


Figure 4.

2. Observe the push rods of the No. 1 and No. 4 pistons. Then, turn the flywheel counterclockwise and clockwise about 30° to 40°. See Figure 5, next page.

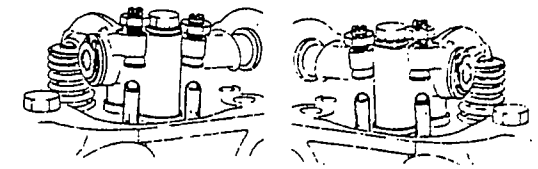
a. Note which intake and exhaust push rods do NOT move while the flywheel is being turned. The piston whose push rods do NOT move is at top dead center (TDC) of its compression stroke.

b. The piston whose push rods moved during flywheel rotation is at the completion of its exhaust stroke and is beginning its intake stroke.

NOTE: If you have followed the preceding instructions carefully, you should have determined which piston (1 or 4) is at top dead center (TDC) of its compression stroke. No. 1 valve clearance must be adjusted with No. 1 piston at top dead center (TDC) of its compression stroke. Repeat the preceding check procedure until you are certain that No. 1 is at top dead center (TDC).

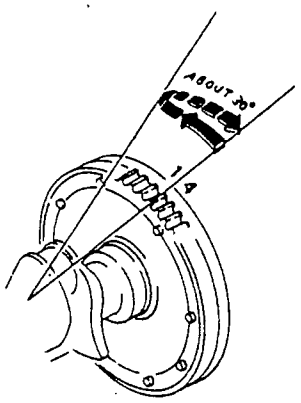
Adjust Valve Clearance (Continued)

Figure 5.



PUSH RODS: STANDING (TDC of compression stroke)

PUSH RODS: MOVE (Overlapping stroke)



Injection Timing

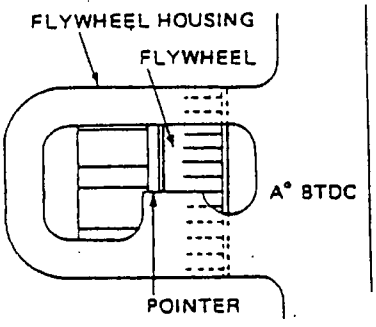
CHECKING INJECTION TIMING:

1. Rotate the crankshaft clockwise (as viewed from timing gear cover side) to align the pointer with the flywheel's injection timing marks at A° before top dead center (BTDC) of No. 1 cylinder's compression stroke. See Figure 6.

INJECTION TIMING MARK (A°)
Pump No. 22030-1650: 18° BTDC
Pump No. 22030-1700: ←

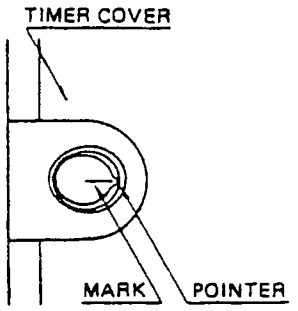
NOTE: The injection pump number can be found on the pump body and should be confirmed.

Figure 6.



2. Check that the injection timing mark on the automatic timer is aligned with the timer cover pointer. If it is not, adjust the injection timing. Refer to Figure 7.

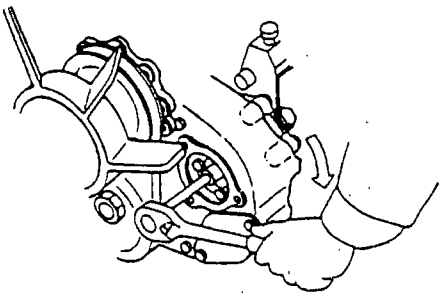
Figure 7.



ADJUSTING INJECTION TIMING:

1. Make sure the injection timing mark on the flywheel is aligned with the flywheel housing pointer. See Figure 6.
2. Remove the timing gear cover seal plate.
3. See Figure 8. Loosen four (4) bolts of the injection pump gear. DO NOT REMOVE THE BOLTS.

Figure 8.



4. Using the timer's round nut, turn the timer clockwise and align the timing mark on the automatic timer with the timing cover pointer. See Figure 7. ALWAYS TURN THE TIMER CLOCKWISE.
5. Tighten the four (4) injection pump gear bolts (Figure 8).

Fuel Injection Nozzle

Refer to Section 2.9, "Fuel Injection Nozzle", and perform the following tests of the injection nozzle.

- ☐ Inspect and adjust fuel injection pressure.
- ☐ Test the spray pattern.
- ☐ Test for fuel leakage.

Bleeding Air From Fuel System

Refer to Figures 9 and 10, next page. To bleed air from the fuel system, proceed as follows:

1. Loosen the fuel filter bleeder plug.
2. Loosen the priming pump handle.
3. Operate the priming pump. Continue priming pump operation until no further air is evident at the filter bleeder plug.

4. Push down on priming pump handle, turn it to the right and lock it.

NOTE: Make sure the priming pump handle is down and locked before tightening the bleeder plug.

5. Tighten the bleeder plug.

BLEEDER PLUG TIGHTENING TORQUE
3-4 ft-lbs (40-60 kg-cm)

6. Wipe up any spilled fuel.

Figure 9. Loosen Bleeder Plug

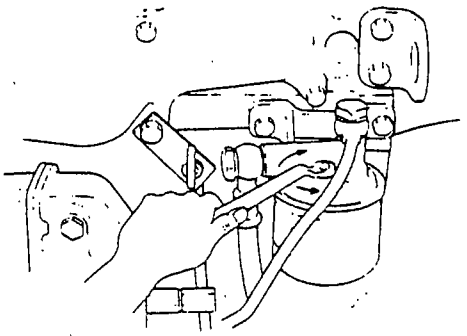
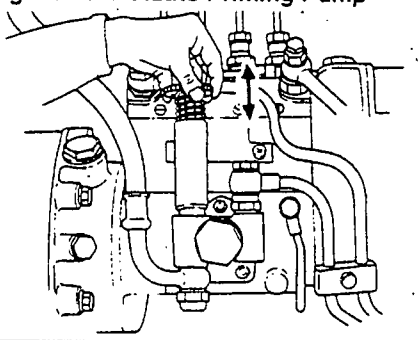


Figure 10. Actuate Priming Pump

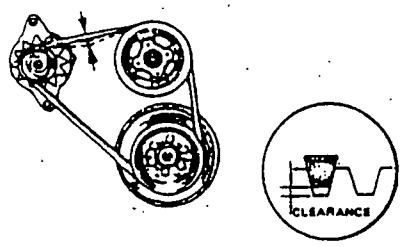


Drive Belts Adjustment

Apply a force of approximately 22 pounds (10kg) with your thumb or finger, midway between pulleys. The belt should deflect about 0.394-0.590 inch. If necessary, adjust belt tension to obtain the stated deflection.

Inspect the v-belt in the pulley groove. The belt should not touch the bottom of the pulley groove.

Figure 11. Drive Belts Inspection



Cooling System Thermostat

1. Place the thermostat in hot water and check the opening temperature and lift. The thermostat should open at 169° F. (76.5° C.).
2. Immerse the thermostat in water at 197° F. (92° C.). Use vernier calipers to measure the lift of the pellet after five (5) minutes. Measure the position of the bottom of the pellet before and after heating the thermostat.

LIFT OF THERMOSTAT
0.4 inch (10mm) at 194° F. (90° C.)

3. Immerse a heated thermostat in water of normal temperature. A thermostat that closes completely within five (5) minutes is satisfactory. If it remains open, even slightly, it is defective and must be replaced.

Figure 12. Testing the Thermostat

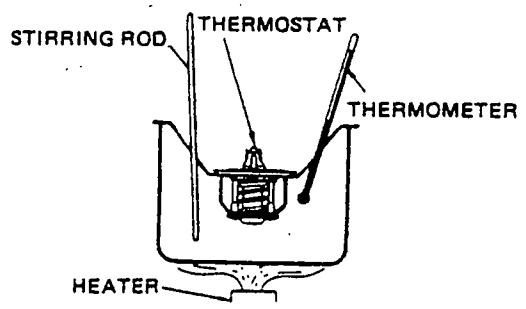
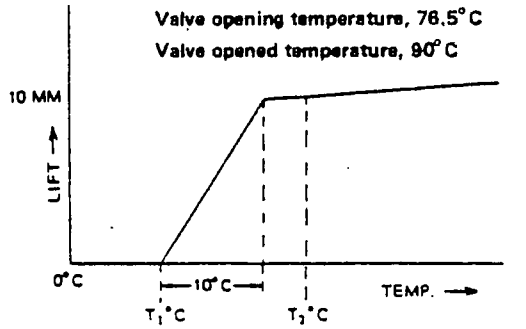


Figure 13.

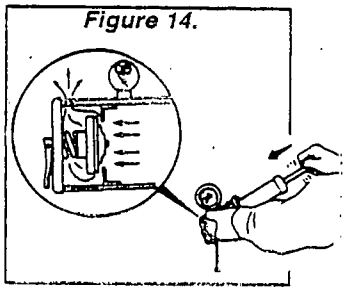


Radiator Cap

Use a pressure cap tester to test the radiator cap. Replace if defective.

RADIATOR CAP PRESSURE
10.66-14.93 psi (0.75-1.05 kg/cm²)

Figure 14.



Section 2.2- ENGINE OVERHAUL CRITERIA

When is Overhaul Needed

Some factors which determine when an engine overhaul is required are as follows:

- ☐ Reduced compression pressure.
- ☐ Decreased engine oil pressure.
- ☐ Engine starts excessively hard.
- ☐ Engine power loss is excessive.
- ☐ High fuel consumption.
- ☐ Engine noise.
- ☐ Excessive oil consumption.

Checking Compression Pressure

BEFORE CHECKING COMPRESSION:

Prior to measuring engine compression, complete the following:

1. Check valve clearance, adjust to correct clearance if necessary. See Section 2.1, "*Engine Tuneup*".
2. Charge the battery fully.
3. Warm up the engine to a coolant temperature of about 176° F. (80° C.).
4. Remove the engine air cleaner.

MEASURING COMPRESSION:

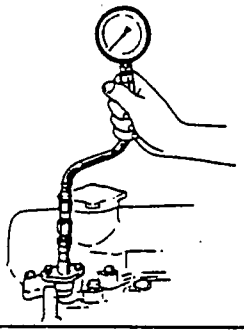
1. Remove the nozzle holders.
2. Install a compression gauge adapter into the nozzle holder hole.

SPECIAL TOOL
Compression Gauge Adapter (Reference No. 09408-1041)

3. Connect a compression gauge to the gauge adapter.
4. Crank the engine and read the compression pressure. Read the compression of all cylinders. If any reading is low, repeat the test.

COMPRESSION PRESSURE
Standard: 470-512 psi (33-36 kg/cm^2) at 350 rpm
Limit: 356 psi (25 kg/cm^2) at 350 rpm

Figure 1. Measuring Compression Pressure



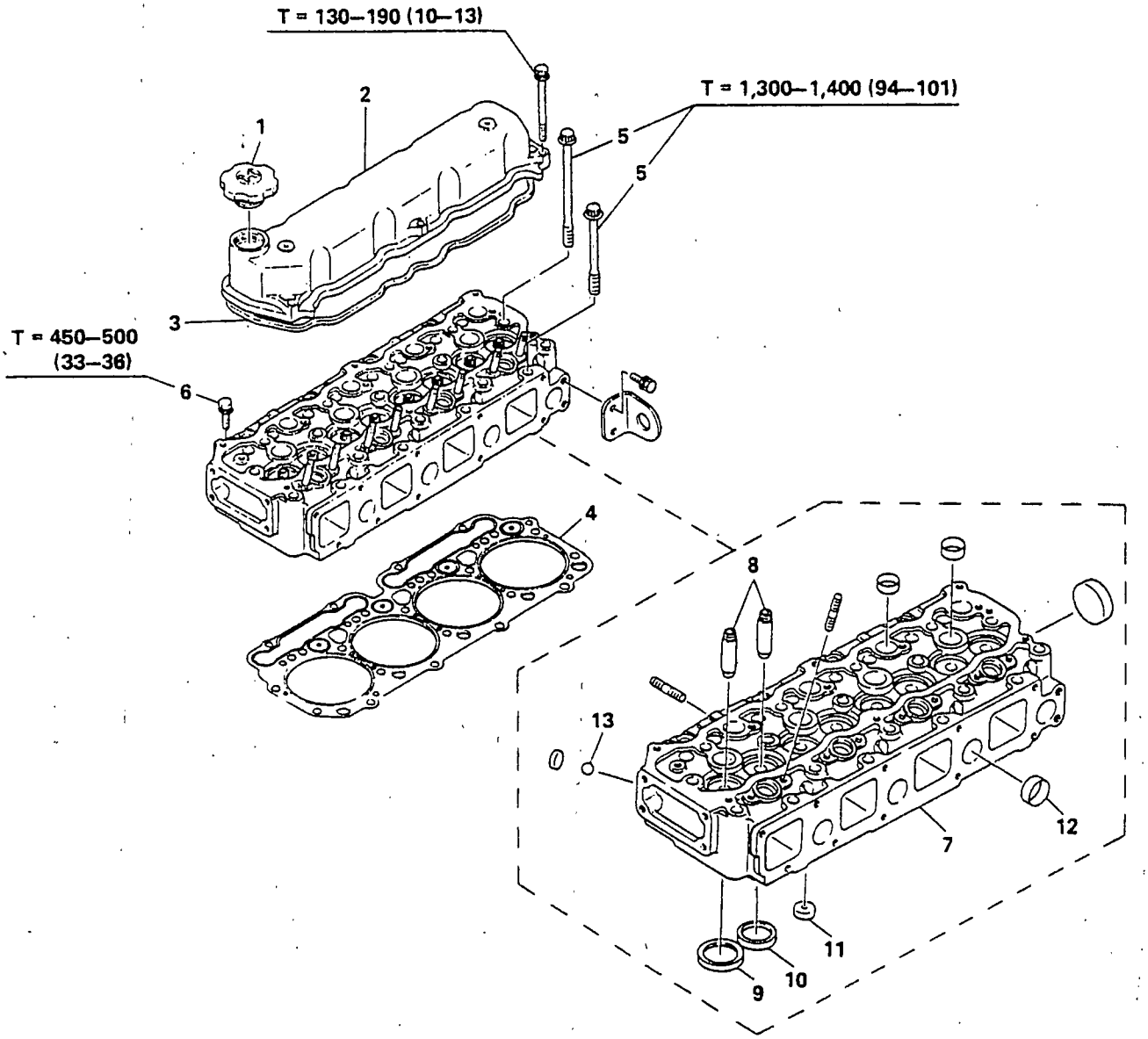
Low Oil Pressure

If oil pressure appears to be low, perform the following:

1. Check oil pressure reading on the equipment gauge when engine is hot, i.e., with coolant temperature about 176° F. (80° C.).
2. If oil pressure appears low, complete the following:
   a. Check oil level. Add oil if necessary.
   b. Check oil for deterioration. If oil quality is poor, drain oil and refill with recommended oil.
   c. Remove the low oil pressure switch and install an oil pressure gauge. With engine running at 176° F. (80° C.) coolant temperature, read the oil pressure.

OIL PRESSURE SERVICE LIMIT
7.11 psi (0.5 kg/cm^2)

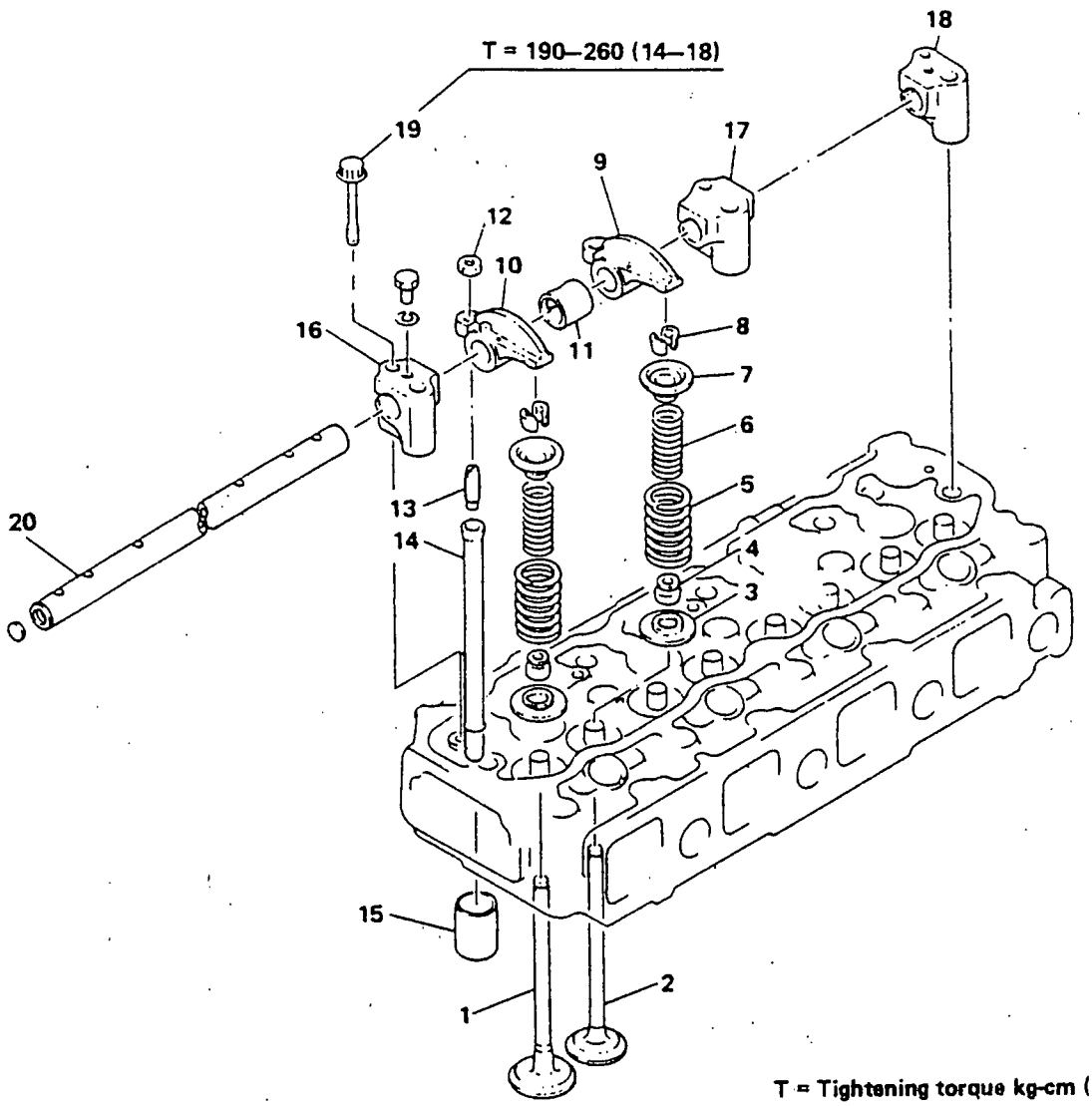
Section 2.3- CYLINDER HEAD



T = Tightening torque kg-cm (lb.ft.)

CYLINDER HEAD AND RELATED PARTS

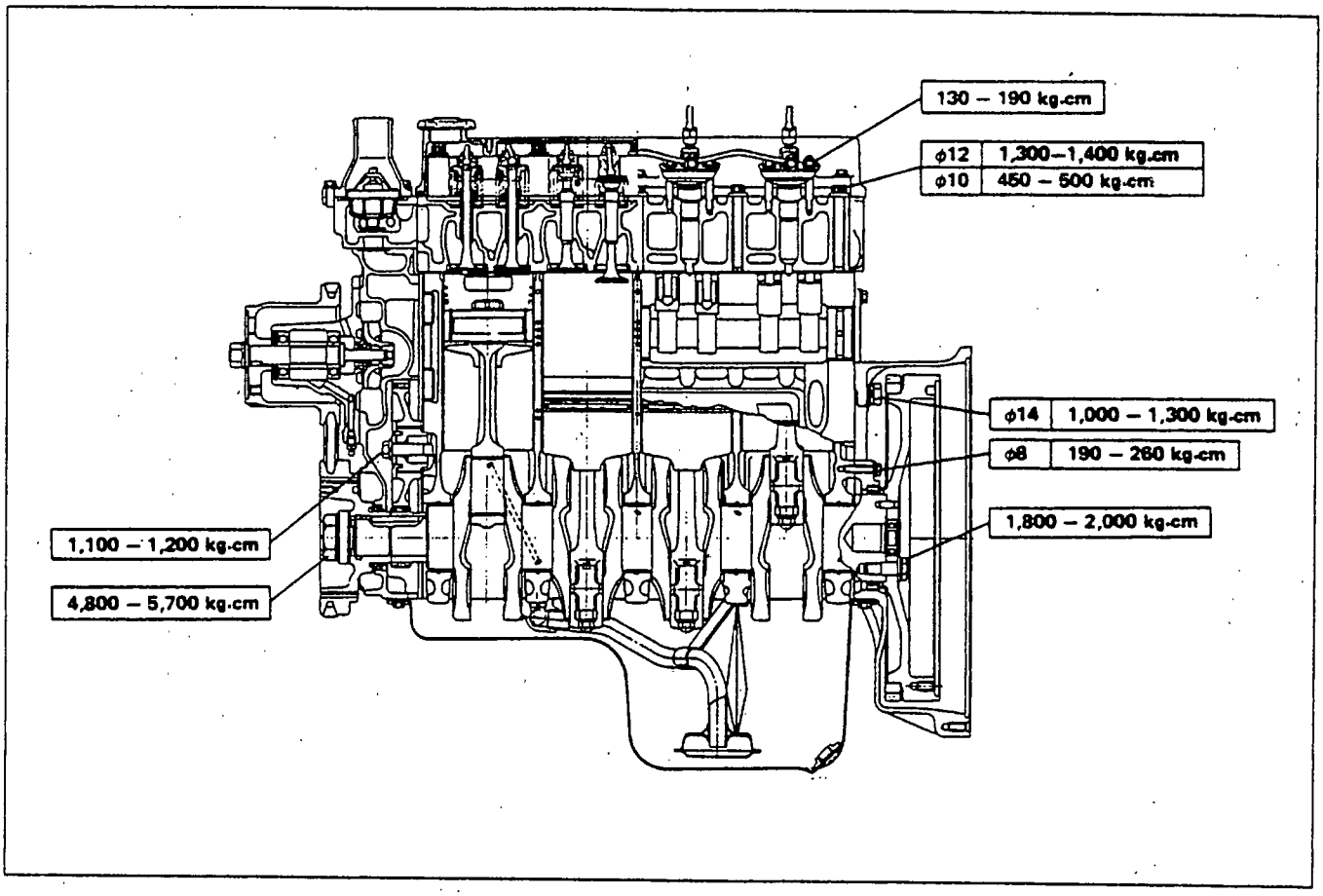
1. Oil filler cap
2. Cylinder head cover
3. Head cover gasket
4. Cylinder had gasket
5. Cylinder head bolt
6. Bolt
7. Cylinder head
8. Valve guide
9. Intake valve seat
10. Exhaust valve seat
11. Expansion plug
12. Expansion plug
13. Steel ball



T = Tightening torque kg-cm (lb.ft.)

VALVE SYSTEM

1. Intake valve
2. Exhaust valve
3. Valve spring lower seat
4. Valve stem seal
5. Outer spring
6. Inner spring (W04D only)
7. Valve spring outer seat
8. Valve stem key
9. Rocker arm
10. Rocker arm
11. Collar
12. Adjusting screw nut
13. Adjusting screw
14. Push rod
15. Tappet
16. Rocker arm support
17. Rocker arm support
18. Rocker arm support
19. Bolt
20. Rocker arm shaft



Important Points- Disassembly

CLEANLINESS:

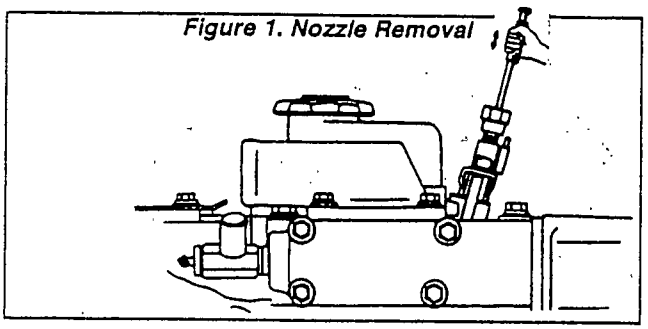
Clean all areas surrounding the nozzles and fuel line conmnections, to prevent entry of dirt into the engine or fuel system. When removing the fuel injection pipes, cover open ends to prevent entry of dirt.

NOZZLE ASSEMBLY REMOVAL:

If the nozzle is difficult to remove by hand, a special tool is available. After the nozzle is removed, cover it with a cloth. Also cover the cylinder head with a cloth, to prevent entry of dirt.

SPECIAL TOOL
Sliding Hammer, Reference No. 09420-1441
Adapter, Reference No. 09462-1370

Figure 1. Nozzle Removal

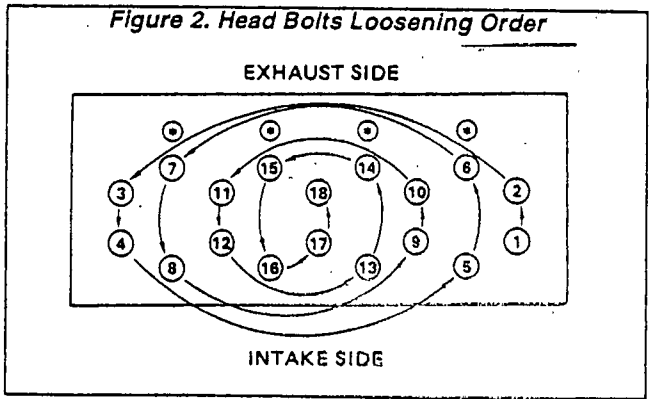


ROCKER ARM/CYLINDER HEAD BOLTS:

1. Loosen the cylinder head's 0.39 inch (10mm) bolt. This bolt position is indicated by an asterisk (*) in Figure 3.
2. Loosen the rocker arm retaining bolts, in the numerical order shown in Figure 2.
3. Loosen the remaining cylinder head bolts in three (3) stages and in the order shown in Figure 3. These bolts are 0.47 inch (12mm) in diameter.

SPECIAL TOOL
Head Bolt Wrench, Reference No. 09411-1190

Figure 2. Head Bolts Loosening Order



** Indicates location of 10mm head bolt*

Important Points- Disassembly (Continued)

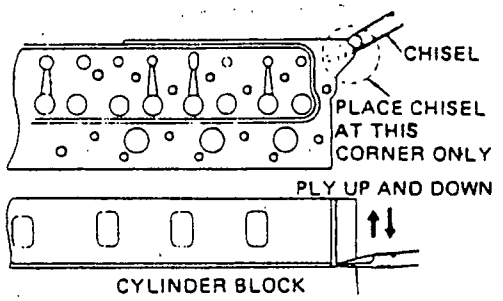
REMOVING THE CYLINDER HEAD:

See Figure 3. If the cylinder head is difficult to remove, use a chisel to pry between the head and the block.

CAUTION: Do NOT damage the machined surface of the head or block during head removal.

SPECIAL TOOL
Eye Bolt, Reference No. 09433-1070
Wire, Reference No. 09491-1010

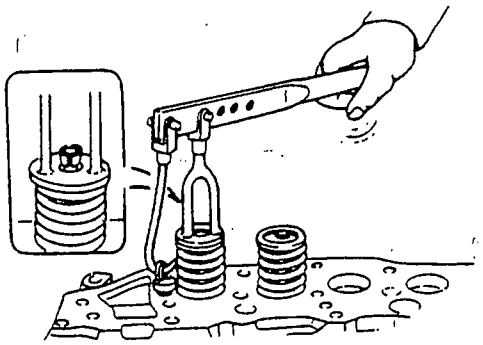
Figure 3. Cylinder Head Removal



REMOVAL OF VALVES:

Remove the valve stem cotters, upper valve seats, and the inner and outer valve springs from the cylinder head. Then, remove the intake and exhaust valves. Tag the valves with the cylinder number from which they were removed, for installation into the same cylinder.

Figure 4. Compressing Valve Springs



SPECIAL TOOL
Valve Spring Compressor, Reference No. 09470-1022

Important Points- Reassembly

CLEAN CYLINDER HEAD:

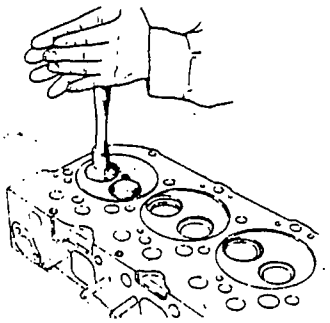
Use a suitable solvent to clean the cylinder head. Use care to avoid damage to the cyolinder head surface or the block to head mating surfaces.

HAND LAPPING VALVE & SEAT:

If necessary, the valve and valve seat may be hand lapped. Apply lapping compound lightly to the valve face. Install the valve with a special tool and rotate it against its seat.

SPECIAL TOOL
Valve Lapping Tool, Reference No. 09431-1010

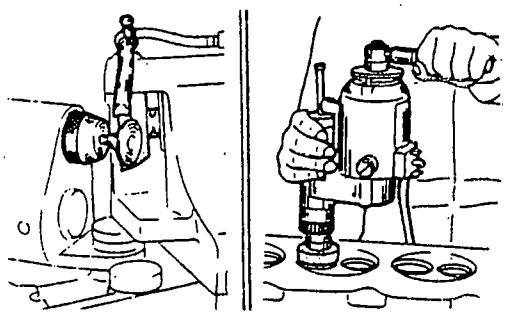
Figure 5. Hand Lapping Valve & Seat



GRINDING VALVES & SEATS:

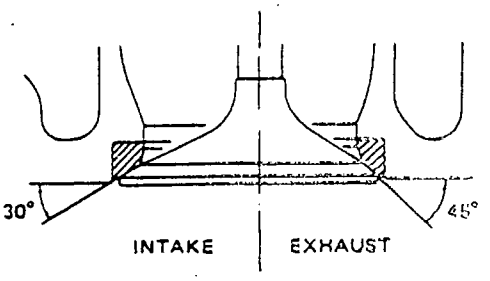
Grinding of valves and valve seats should only be performed when hand lapping does not result in proper seating. If necessary, grind the valves and valve seats. After grinding, always check valve sink.

Figure 6.



VALVE GRINDING ANGLES
Intake Valve Seat: 30° to 30° 30'
Intake Valve Face: 29° 30' to 30°
Exhaust Valve Seat: 45° to 45° 30'
Exhaust Valve Face: 44° 30' to 45°

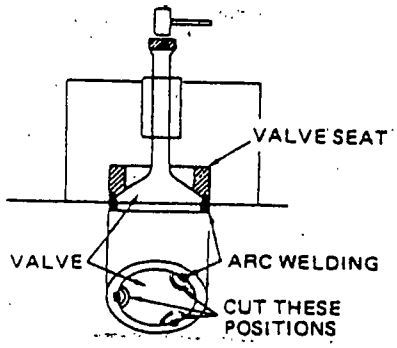
Figure 7.



VALVE SEATS REPLACEMENT:

Removal: If necessary, the valve seats can be replaced. To remove valve seats, first cut a valve head at three (3) places with a grinder. Then, install it into the seat as shown (Figure 8) and weld the valve to the seat. Finally, drive the valve and seat out with a hammer and a brass bar.

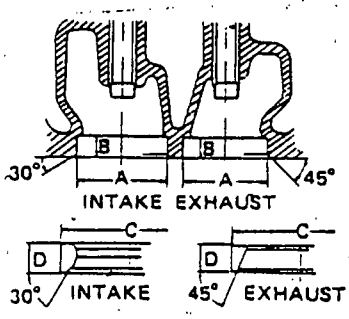
Figure 8. Valve Seats Removal



Valve Seats Machining Specifications: See Figure 9.

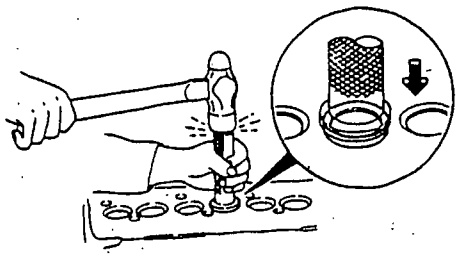
DIMENSION	INTAKE	EXHAUST
A	1.8308-1.8313 inch (46.500-46.516mm)	1.6142-1.6148 inch (41.000-41.016mm)
B	0.3465-0.3543 inch (8.8-9.0mm)	0.2835-0.2874 inch (7.2-7.3mm)
C	1.8341-1.8346 inch (46.585-46.600mm)	1.6193-1.6198 inch (41.130-41.145mm)
D	0,.2953-0.3031 inch (7.5-7.7mm)	0.2363-0.2440 inch (6.0-6.2mm)

Figure 9. Valve Seat Machining Specs



Valve Seat Installation: Heat the cylinder head to about 176°-212° F. (80°-100° C.) with hot water. Cool the valve seat with dry ice or liquid freon for about 30 minutes. Hold the seat with pliers and place it into the heated cylinder head. See Figure 10.

Figure 10. Valve Seat Installation

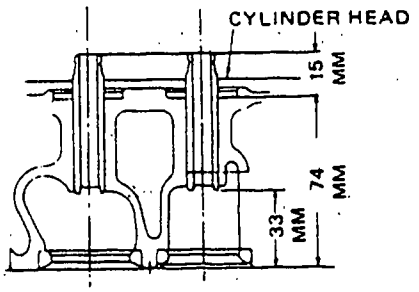


VALVE GUIDE REPLACEMENT:

If necessary, the valve guide(s) can be replaced as follows:

1. Remove the valve stem seal.
2. Use a brass rod and a hammer to drive out the valve guide.
3. Apply a light coating of engine oil to the valve guide outer circumference before installation.
4. Install the valve guide.

Figure 11. Valve Guide Installation



VALVE STEM SEAL REPLACEMENT:

If necessary, the valve stem seal can be replaced. After removing the old stem seal,install the new valve stem seal as follows:

1. Install the lower spring seat, to act as a stopper for the special tool. along with the valve.
2. Apply engine oil to the lip of the stem seal.
3. Use special tool to install the seal until tool hits the lower spring seat.

SPECIAL TOOL
Valve Stem Seal Press, Reference No. 09472-1650

4. After installation, inspect the seal for cracks and other damage.

Figure 12. Valve Stem Seal Installation

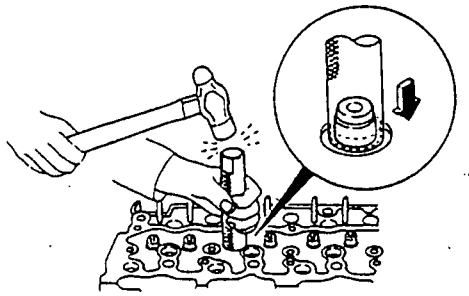
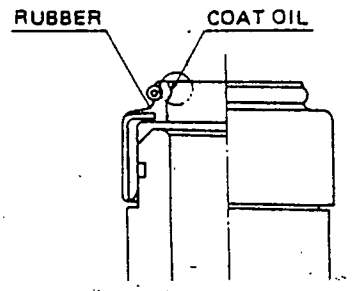


Figure 13. Valve Stem Seal Installation

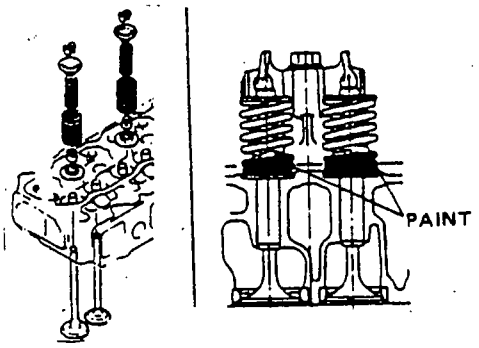


ASSEMBLING THE CYLINDER HEAD:

NOTE: Apply engine oil to sliding and contact surfaces of all parts. The valves should be installed in the same cylinders from which they were removed. Valve springs must be installed with their painted ends down, since they have variable pitches.

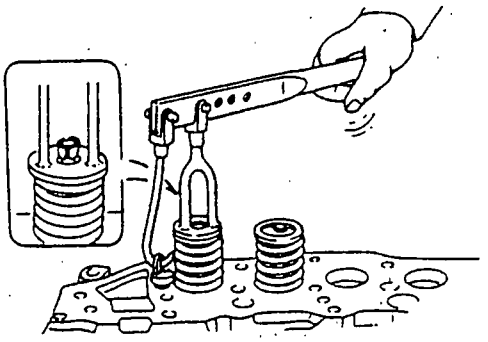
Use special tool to compress valve springs. Install the valve stem keys securely in the upper spring seats. When using the valve spring compressor, use care to avoid damage to the valve stem seals. After installation, strike the valve stems lightly with a hammer to ensure that the valve stem key is correctly installed.

Figure 14. Valves Installation



SPECIAL TOOL
Valve Spring Compressor, Reference No. 09470-1022

Figure 15. Valve Spring Compressor



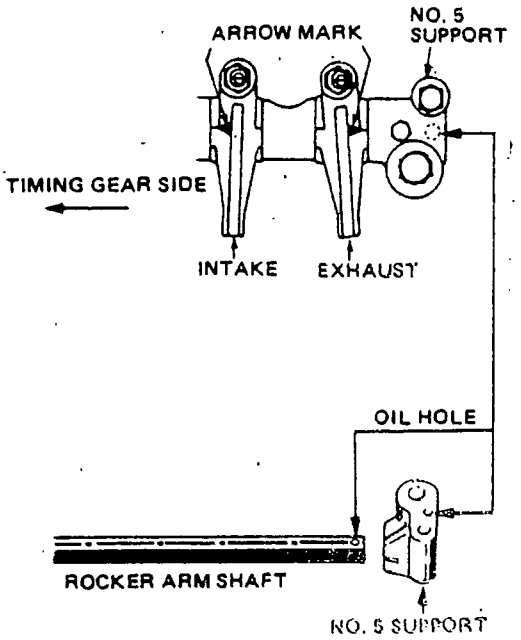
ASSEMBLING THE ROCKER ARM:

See Figure 16. Before assembling the rocker arm, lubricate the rocker arm shaft and the arm bushing with engine oil.

Make sure the oil hole of the rocker arm No. 5 support is aligned with the shaft oil hole.

Apply engine oil to the tappet faces and to the tappet guide when installing them into the block. Install tappets into cylinder block in the correct order.

Figure 16. Rocker Arm Assembly

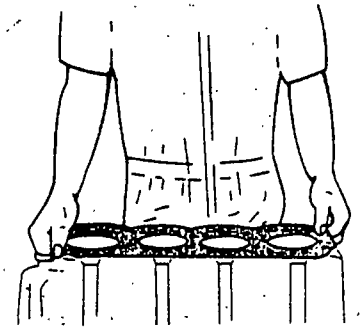


HEAD & ROCKER ARM INSTALLATION:

1. Install the cylinder head gasket.

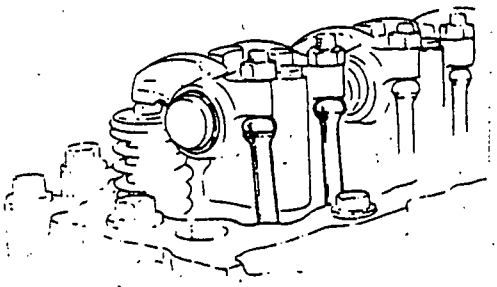
NOTE: Always use a new head gasket. Install the gasket only after all contact surfaces of the cylinder head, cylinder block and gasket are free of dirt, water, grease, etc.

Figure 17. Head Gasket Installation



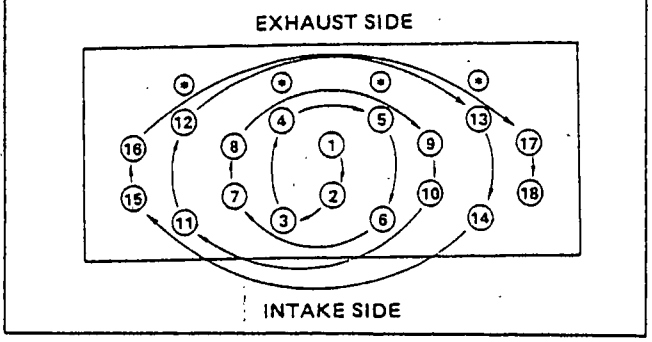
2. Install the cylinder head over the dowels on the cylinder block.
3. Install the push rods in their correct order, after applying engine oil to both ends of each push rod.
4. Install the rocker arm assembly onto the cylinder head. Make sure the push rods interlock with the adjusting screws. Always loosen the lock nut and raise the adjusting screws all the way to the top.

Figure 18. Install Push Rods & Rocker Arm



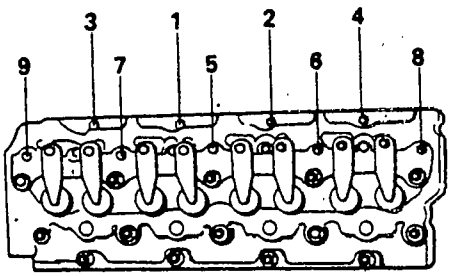
5. Apply engine oil to the bolt threads and under the bolt heads. Install head bolts. One head bolt, indicated in Figure 19 by an asterisk [*]) is 0.39 inch (10mm) in diameter. Other head bolts are 0.47 inch (12mm) in diameter.
6. Tighten head bolts to the specfied torque in three (3) stages, in the sequence shown in Figure 19. See Page 2.3-1 for head bolts torque specification.

Figure 19. Head Bolts Tightening Sequence



7. Tighten the cylinder head 10mm bolt (see Page 2.3-1).
8. Tighten the rocker arm support bolts in three (3) stages and in the order shown in Figure 20. See Page 2.3-2 for torque of rocker arm support bolts.

Figure 20. Tightening Sequence of Rocker Arm Bolts



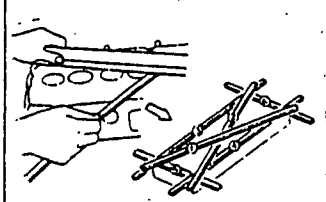
Inspection & Repair

CYLINDER HEAD FLATNESS:

Check cylinder head flatness. If flatness is in excess of stated limit, replace or regrind the cylinder head as necessary.

CYLINDER HEAD FLATNESS
Standard: 0.0019 inch (0.05mm)
Limit: 0.0039 inch (0.1mm)

Figure 21.

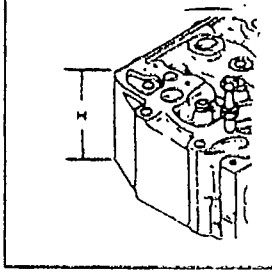


CYLINDER HEAD HEIGHT:

Replace cylinder head if its height is below the limit.

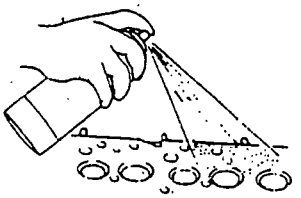
HEAD HEIGHT
Standard: 3.425 inch (87.0mm)
Limit: 3.417 inch (86.8mm)

Figure 22.



CYLINDER HEAD VISUAL INSPECTION:

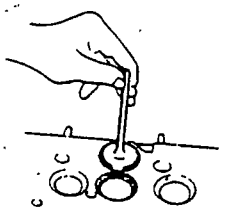
Figure 23.



Use a dye penetrant to check the cylinder head for cracks and damage. Replace the cylinder head, if necessary.

CHECK VALVE SEATING:

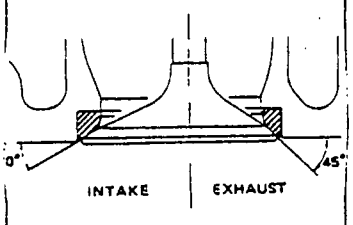
Figure 24.



Use red lead compound to check valve seating conditions. There should be good contact around the entire circumference of the valve head. If not, hand lap with lapping compound. See "*Hand Lapping Valve & Seat*" on Page 2.3-4.

CHECK VALVE & VALVE SEAT ANGLE:

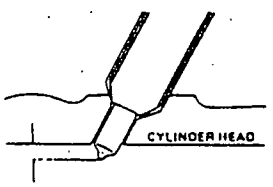
Figure 25.



Check valve seat angle. If not within the stated limits, regrind or replace the valve and/or valve seat. See "Grinding Valves & Seats" on Page 2.3-4.

CHECK NOZZLE PROTRUSION:

Figure 26.



Check nozzle protrusion from the cylinder head surface. If not within the stated limits, replace the nozzle gasket.

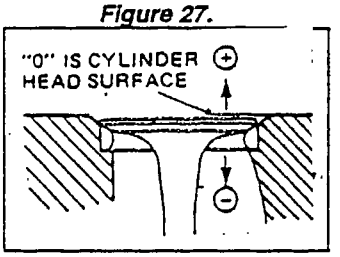
NOZZLE PROTRUSION FROM HEAD SURFACE
0.1083-0.1279 Inch (2.75-3.25mm)

CHECK INTAKE & EXHAUST VALVE SINK:

See Figure 27. If valve sink is beyond the stated limit, replace the valve and/or valve seat.

Intake Valve Standard: 0.0079-0.0157 Inch (-0.2- -0.4mm)
Intake Valve Limit: 0.0196 Inch (-0.5mm)
Exhaust Valve Standard: -0.0205 to -0.0283 Inch (-0.52 to -0.72mm)
Exhaust Valve Limit: 0,.0322 Inch (-0.82mm)

Figure 27.



CHECK INTAKE & EXHAUST VALVES:

Check the diameters of the valve stems and the valve guides. If necessary, replace the valve guide(s) and/or the valve stem(s).

INTAKE VALVE STEM DIAMETER
Standard: 0.3524-0.3531 Inch (8.95-8.97mm)
Limit: 0.3903 Inch (8.90mm)

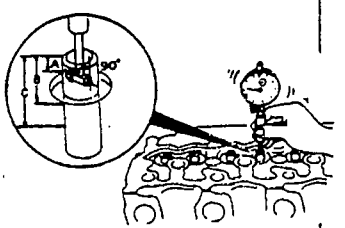
EXHAUST VALVE STEM DIAMETER
Standard: 0.3516-0.3524 Inch (8.93-8.95mm)
Limit: 0.3464 Inch (8.80mm)

INTAKE/EXHAUST VALVE GUIDE DIAMETER
Standard: 0.3544-0.3549 Inch (9.000-9.015mm)
Limit: A & B= 0.3562 Inch (9.05mm); C= 0.0071 Inch (0.18mm)

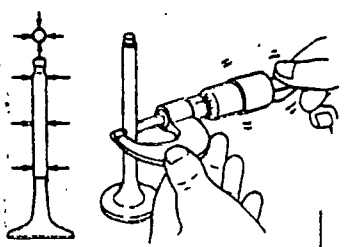
CLEARANCE- INTAKE VALVE STEM TO VALVE GUIDE
Standard: 0.0004-0.0026 Inch (0.035-0.068mm)
Limit: A & B= 0.0040 Inch (0.10mm); C= 0.0071 Inch (0.18mm)

CLEARANCE- EXHAUST VALVE STEM TO VALVE GUIDE
Standard: 0.0020-0.0032 Inch (0.050-0.083mm)
Limit: A & B= 0.0047 Inch (0.12mm); C= 0.0078 Inch (0.2mm)

Figure 28.



A: 5 (0.197)
B: 25 (0.984)
C: 45 (1.771)



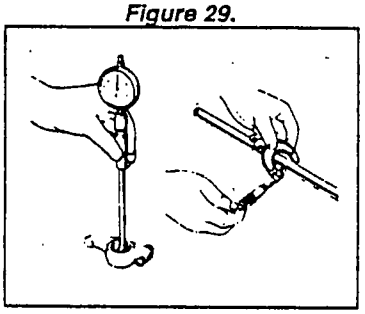
ROCKER ARM SHAFT & BUSHING:

Check rocker arm shaft diameter. Then, check rocker arm bushing inside diameter. Calculate the clearance between the shaft and bushing. If limits are exceeded, replace the shaft and/or the bushing.

ROCKER ARM SHAFT DIAMETER
Standard: 0.7469-0.7472 Inch (18.97-18.98mm)
Limit: 0.7461 Inch (18.95mm)

ROCKER ARM SHAFT TO BUSHING CLEARANCE
Standard: 0.0015-0.0031 Inch (0.036-0.079mm)
Limit: 0.0039 Inch (0.1mm)

Figure 29.



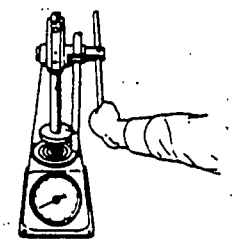
VALVE SPRINGS LENGTH UNDER LOAD:

Check the amount of force needed to compress inner and outer valve springs to a known length. Replace spring(s) if stated limits are exceeded.

INNER VALVE SPRING
Standard: 19.4 lbs (8.8 kg) at 1.69 Inch (43.0mm)
Limit: 17.6 lbs (8.0 kg)

OUTER VALVE SPRING
Standard: 54.5 lbs (27.4kg) at 1.79 Inch (45.5mm)
Limit: 56.2 lbs (25.5kg)

Figure 30.

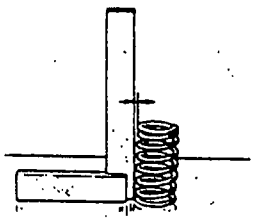


VALVE SPRINGS STRAIGHTNESS:

Check straightness of inner and outer valve sporings. Replace spring(s), if beyond stated limit.

INNER/OUTER VALVE SPRING STRAIGHTNESS
Limit: 0.0787 Inch (2.0mm)

Figure 31.

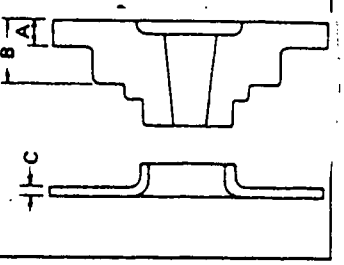


CHECK VALVE SPRING SEAT:

Check the valve spring seat for excessive wear. Replace if stated dimension(s) are exceeded.

VALVE SPRING SEAT
Dimension "A": 0.0984 Inch (2.5mm)
Dimension "B": 0.1969 Inch (5.0mm)
Dimension "C": 0.0394 Inch (1.0mm)

Figure 32.

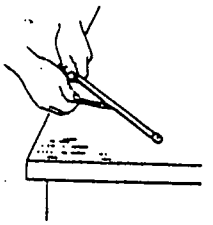


CHECK FOR BENT PUSH RODS

Replace push rod(s) if bent beyond limit.

PUISH ROD BEND
Limit: 0.0118 Inch (0.3mm)

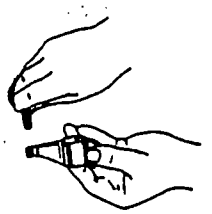
Figure 33.



INSPECT VALVE STEM TIP:

Visually inspect valve stem tip for excessive wear. Also inspect valve stem contact surface on rocker arm for wear. Resurface or replace as necessary.

Figure 34.



INSPECT TAPPETS:

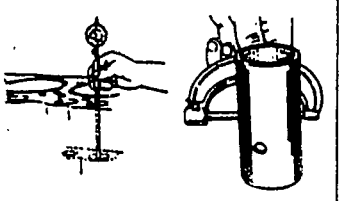
Inspect tappets diameter, tappet guide inside diameter. Calculate the clearance between the tappet and tappet guide. Replace tappet(s), if necessary.

TAPPET DIAMETER
1.0611-1.0618 Inch (26.95-26.97mm)

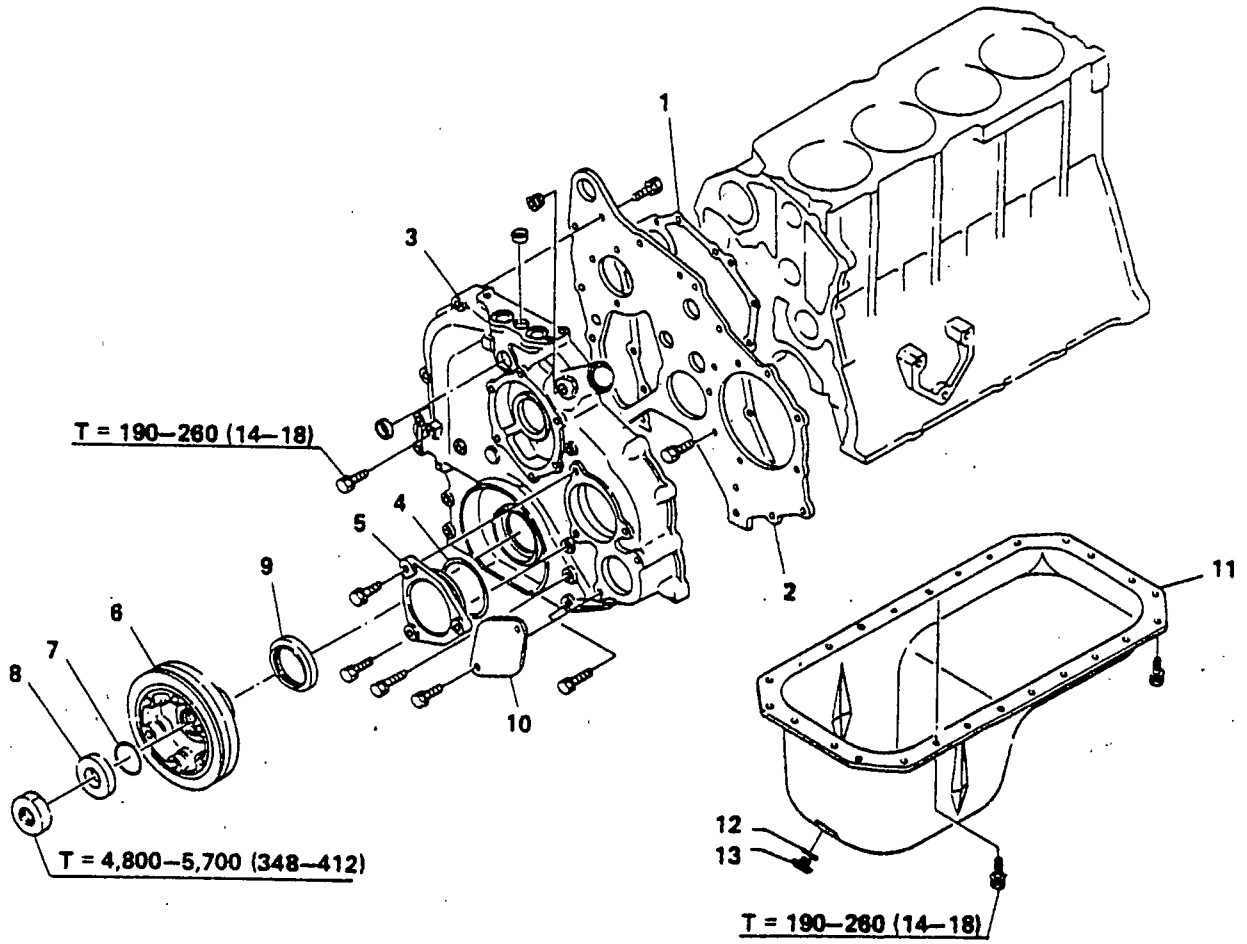
TAPPET GUIDE IN-SIDE DIAMETER
1.0630-1.0637 Inch (27.00-27.02mm)

TAPPET TO TAPPET GUIDE CLEARANCE
Standard: 0.0010-0.0029 Inch (0.025-0.071mm)
Limit: 0.0039 Inch (0.1mm)

Figure 35.

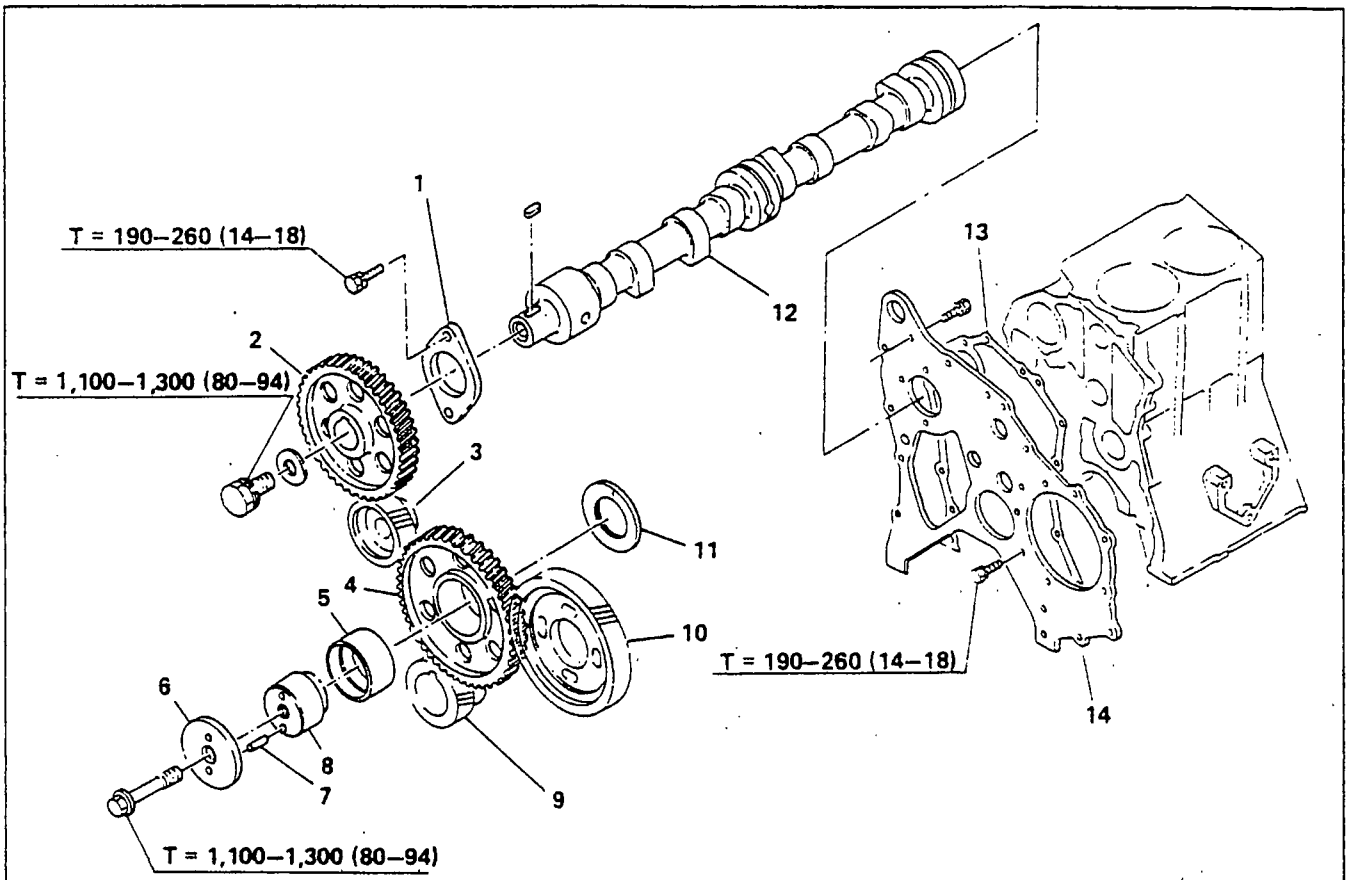


Section 2.4- TIMING GEAR, CAMSHAFT & OIL PAN



T = Tightening torque kg-cm (lb.ft.)

1. Front end plate gasket
2. Front end plate
3. Timing gear cover
4. O-ring
5. Seal plate
6. Crankshaft pulley
7. O-ring
8. Plain washer
9. Oil seal
10. Seal plate
11. Oil pan
12. Oil drain plug gasket
13. Oil drain plug



T = Tightening torque kg·cm (lb.ft.)

1. Thrust bearing
2. Camshaft gear
3. Oil pump drive gear
4. Idler gear
5. Bushing
6. Idler gear thrust plate
7. Straight pin
8. Idler gear shaft
9. Crankshaft gear
10. Injection pump drive gear
11. Idler gear thrust plate
12. Camshaft
13. Front end plate gasket
14. Front end plate

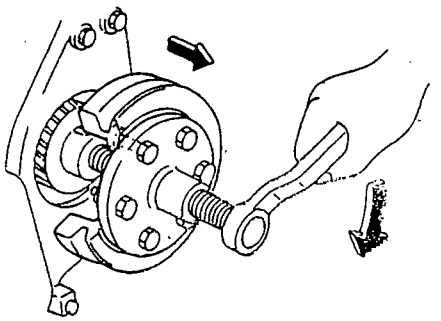
Important Points- Disassembly

CRANKSHAFT PULLEY REMOVAL:

Remove the nut and spacer. Then, use a special tool to remove the pulley.

SPECIAL TOOL
Crank Pulley Puller, Reference No. 09420-1500

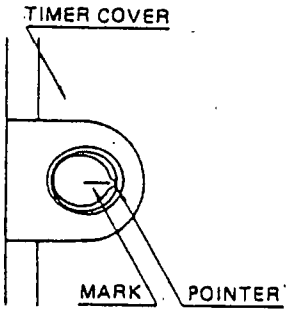
Figure 1. Removing the Crank Pulley



INJECTION PUMP REMOVAL:

1. Remove the dust cover from the timer's inspection hole.
2. Turn the crankshaft clockwise (viewed from timing gear end) to align the injection timing mark.

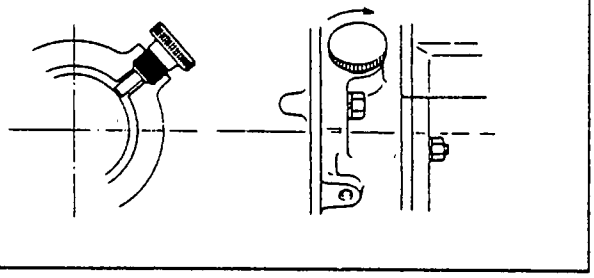
Figure 2. Alignment of Injection Timing Mark



3. Install the timer setting tool. DO NOT LOOSEN THE INJECTION PUMP DRIVE GEAR BOLTS.

SPECIAL TOOL
Timer Setting Tool, Reference No. 09512-2090

Figure 3. Install the Timer Setting Tool

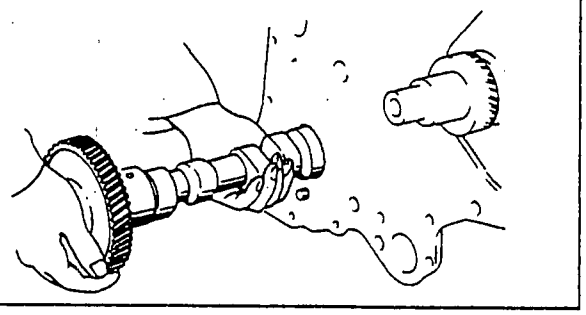


4. Remove the injection pump assembly.

CAMSHAFT REMOVAL:

Hold the tappets above the camshaft. Then, pull the camshaft out slowly while rotating it to prevent damage to bearings.

Figure 4. Camshaft Removal

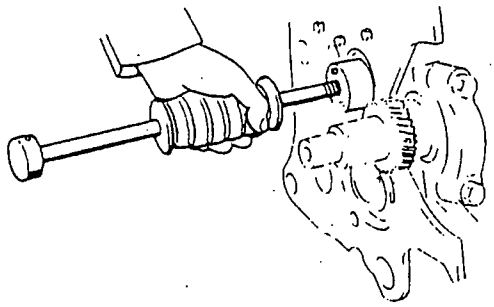


IDLER GEAR SHAFT REMOVAL:

See Figure 5. A special tool is required to remove the idler gear shaft.

SPECIAL TOOL
Sliding Hammer, Reference No. 09420-1442

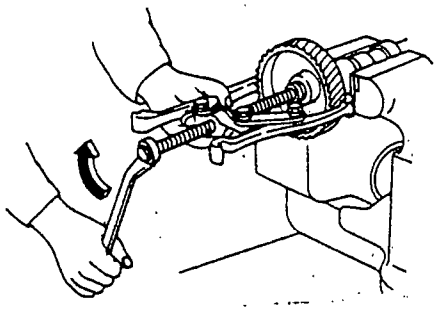
Figure 5. Idler Gear Shaft Removal



IF THE CAMSHAFT GEAR MUST BE REMOVED:

Place the camshaft between wooden blocks in a vise. Then, use a gear puller to remove the camshaft gear.

Figure 6. Removal of Camshaft Gear



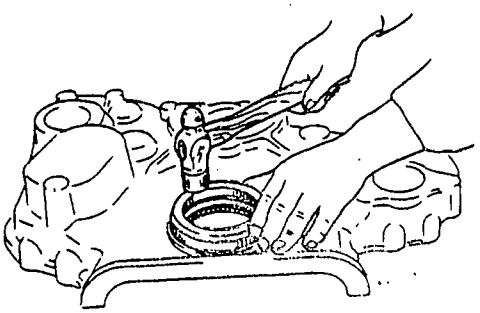
Important Points- Reassembly

TIMING GEAR CASE OIL SEAL:

If necessary, replace the timing gear case oil seal. Use a screwdriver to pry out the old seal. Use special tool to install the new seal.

SPECIAL TOOL
Oil Seal Press, Reference No. 09482-1530

Figure 7. Installing Timing Gear Case Cover Oil Seal

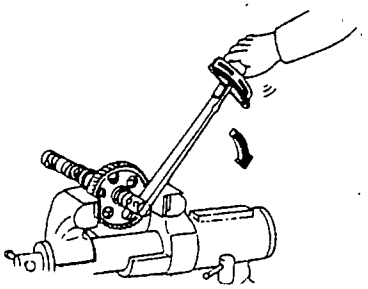


Important Points - Reassembly (Continued)

CAMSHAFT GEAR INSTALLATION:

If the camshaft gear was removed, it must be replaced with thrust bearing. Heat the gear in hot water at about 212° F. (100° C.), then press the gear onto the shaft. Apply engine oil to bolt threads and to bearing surfaces of bolts.

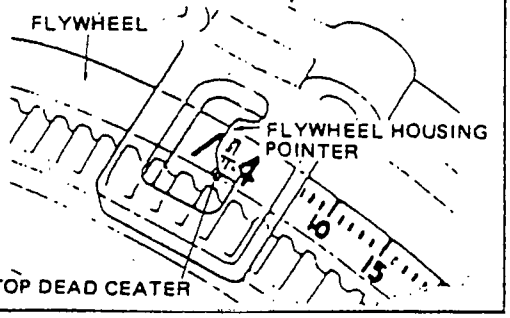
Figure 8. Installing the Camshaft Gear



CAMSHAFT INSTALLATION:

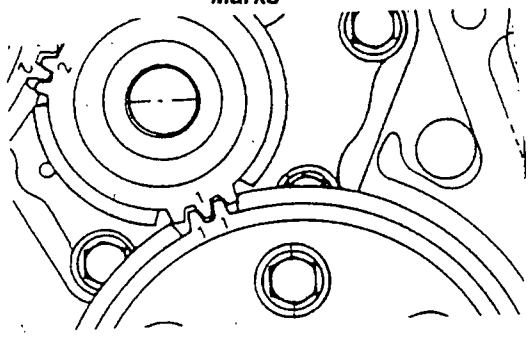
1. Set the No. 1 piston to top dead center (TDC) of its compression stroke. See "FINDING TDC OF COMPRESSION STROKE" on Page 2.1-1.

Figure 9. Set No. 1 Piston to Top Dead Center



2. Lubricate all camshaft journals with engine oil. Then, install the camshaft as follows:
   a. Slowly rotate the camshaft during installation, to prevent damage to bearings.
   b. Align the match marks on the timing gear with the mark on the oil pump gear.

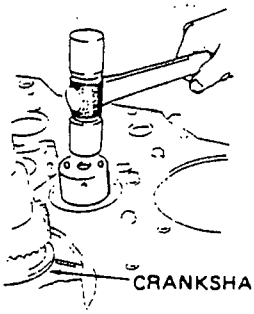
Figure 10. Camshaft Gear to Oil Pump Gear Match Marks



IDLER GEAR SHAFT INSTALLATION:

When installing the idler gear shaft, make sure the oil holes face downward. This will help prevent clogging that might be caused by sludge and other foreign material in the oil.

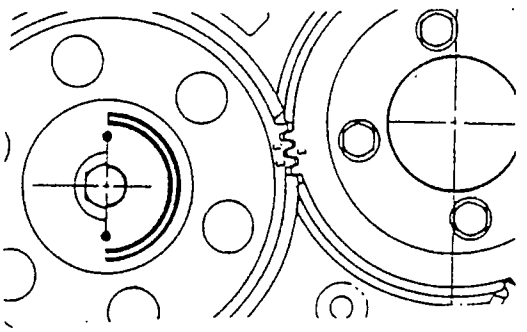
Figure 11. Idler Gear Shaft Installation



INJECTION PUMP:

Install the injection pump temporarily. The match marks on the idler gear and injection pump drive gear must be aligned properly.

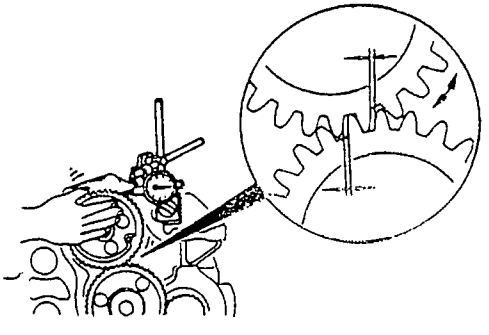
Figure 12. Idler Gear/Pump Drive Gear Match Marks



CHECK GEAR BACKLASH:

Use a dial indicator to measure gear backlash. Refer to "Inspection and Repair" portion of this Section.

Figure 13. Check Gear Backlash

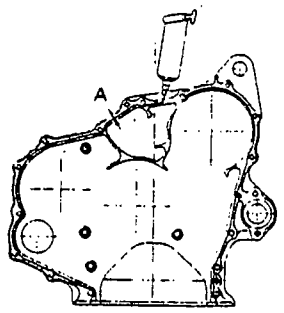


TIMING GEAR CASE:

Before installing the timing gear case, clean mounting surfaces thoroughly. Apply liquid gasket, then tighten the case within 20 minutes. If the liquid gasket is applied longer than 20 minutes before tightening, clean the liquid gasket off completely and reapply.

SEAL DIAMETER "A"
0.06-0.10 Inch (1.5-2.5mm)

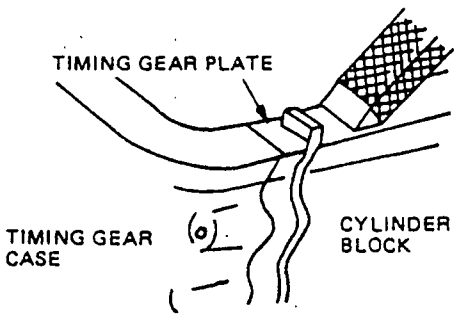
Figure 14. Timing Gear Case



OIL PAN INSTALLATION:

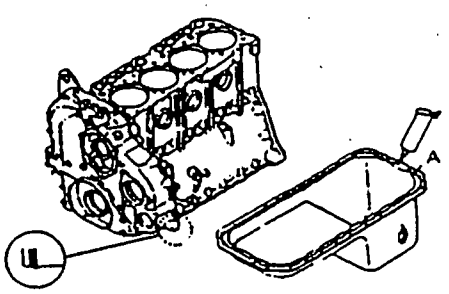
1. The timing gear plate gasket extrudes above the oil pan mounting surface. Cut this gasket protrusion.

Figure 15. Cut Timing Gear Plate Gasket Protrusion



2. Clean all mounting surfaces.
3. Apply liquid gasket to oil pan mounting surface to the approximate diameter given below.

Figure 16. Applying Liquid Gasket



SEAL DIAMETER "A"
0.12-0.15 Inch (3-4mm)

The oil pan must be installed and tightened within 20 minutes after the liquid gasket is applied. If longer than 20 minutes, clean the liquid gasket completely off, then reapply.

Inspection and Repair

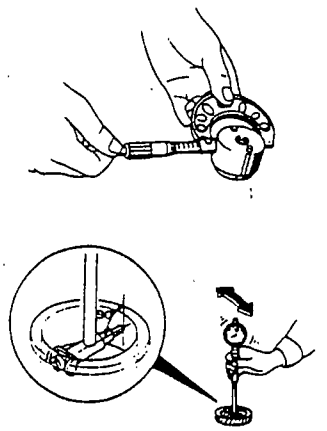
IDLER GEAR:

IDLER GEAR SHAFT DIAMETER
Standard: 0.9311-1.9318 Inch (49.95-49.97mm)
Limit: 1.9307 Inch (49.94mm)

IDLER GEAR BISHING INSIDE DIAMETER
Standard: 1.9685-1.9686 Inch (50.00-50.03mm)
Limit: 1.9705 Inch (50.05mm)

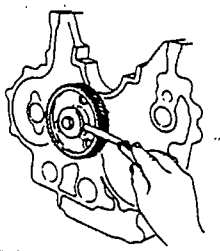
SHAFT TO BUSHING CLEARANCE
Standard: 0.0012-0.0031 Inch (0.03-0.08mm)
Limit: 0.039 Inch (0.1mm)

Figure 17.



IDLER GEAR END PLAY
Standard: 0.0016-0.0039 Inch (0.04-0.10mm)
Limit: 0.0059 Inch (0.15mm)

Figure 18.



CAMSHAFT:

CAMSHAFT BEND
Limit: 0.0020 Inch (0.05mm)

CAM HEIGHT (INTAKE)
Standard: 1.9465 Inch (49.44mm)
Limit: 1.9251 Inch (48.90mm)

CAM HEIGHT (EXHAUST)
Standard: 1.9488 Inch (49.50mm)
Limit: 1.9271 Inch (48.95mm)

Figure 19.

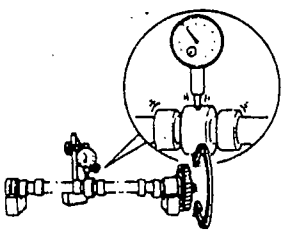
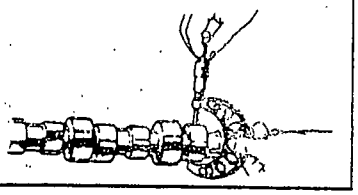
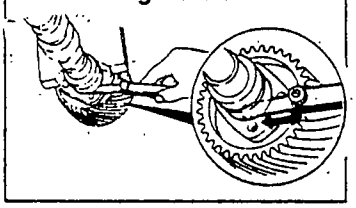


Figure 20.



CAMSHAFT END PLAY
Standard: 0.0040-0.0070 Inch (0.10-0.18mm)
Limit: 0.0118 Inch (0.3mm)

Figure 21.



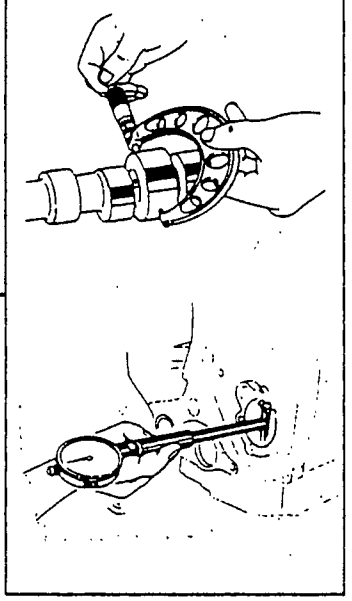
CAMSHAFT JOURNAL DIAMETER

Journal	Standard	Limit
No. 1	2.441 In. (57.0mm)	2.2382 In. (56.85mm)
No. 2	2.2362 In. (56.8mm)	2.2303 In. (56.65mm)
No. 3	2.2283 In. (56.6mm)	2.2224 In. (56.45mm)

CAMSHAFT JOURNAL BEARING INSIDE DIAMETER

Journal	Standard	Limit
No. 1	2.2441 In. (57.00mm)	2.2500 In. (57.15mm)
No. 2	2.2362 In. (56.8mm)	2.2421 In. (56.95mm)
No. 3	2.2283 In. (56.6mm)	2.2342 In. (56.75mm)

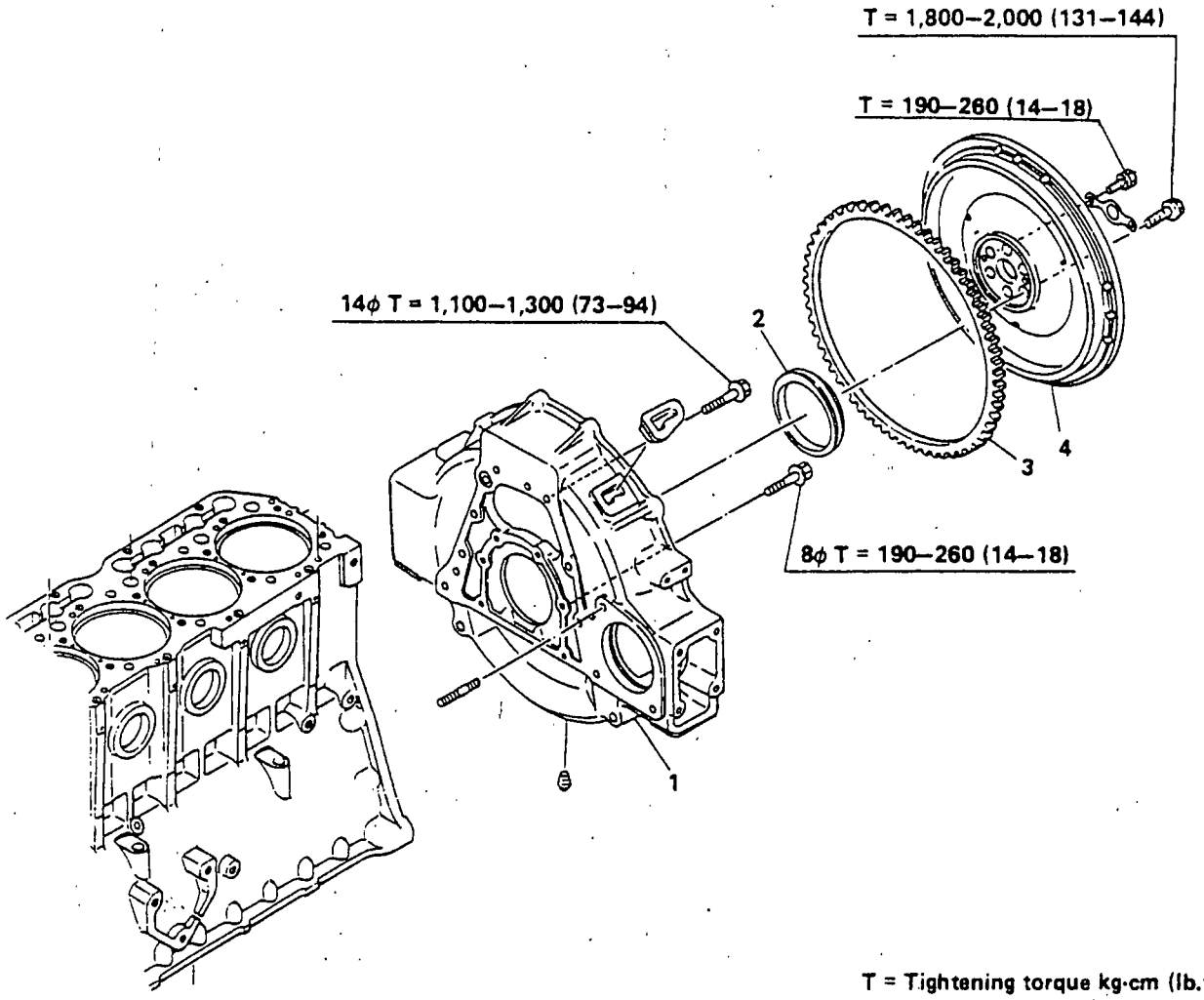
Figure 22.



CAMSHAFT JOURNAL TO BEARING OIL CLEARANCE
Standard: 0.0012-0.0047 Inch (0.03-0.12mm)
Limit: 0.0059 Inch (0.15mm)

Section 2.5- CYLINDER BLOCK & FLYWHEEL HOUSING

Figure 1.



T = Tightening torque kg·cm (lb.ft.)

1. Flywheel housing
2. Oil seal
3. Ring gear
4. Flywheel

Important Points- Disassembly

PISTONS & CONNECTING RODS:

Before attempting to remove the pistons, remove carbon from upper end of cylinder with emery cloth (No. 150 recommended). Move the emery cloth in a circular direction.

Figure 3. Clean Carbon from Cylinder Bores

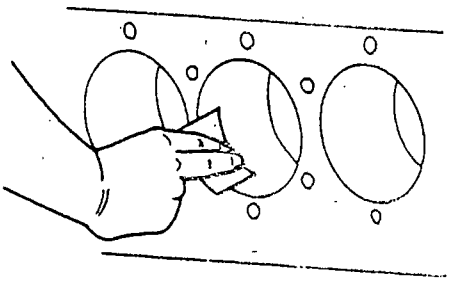
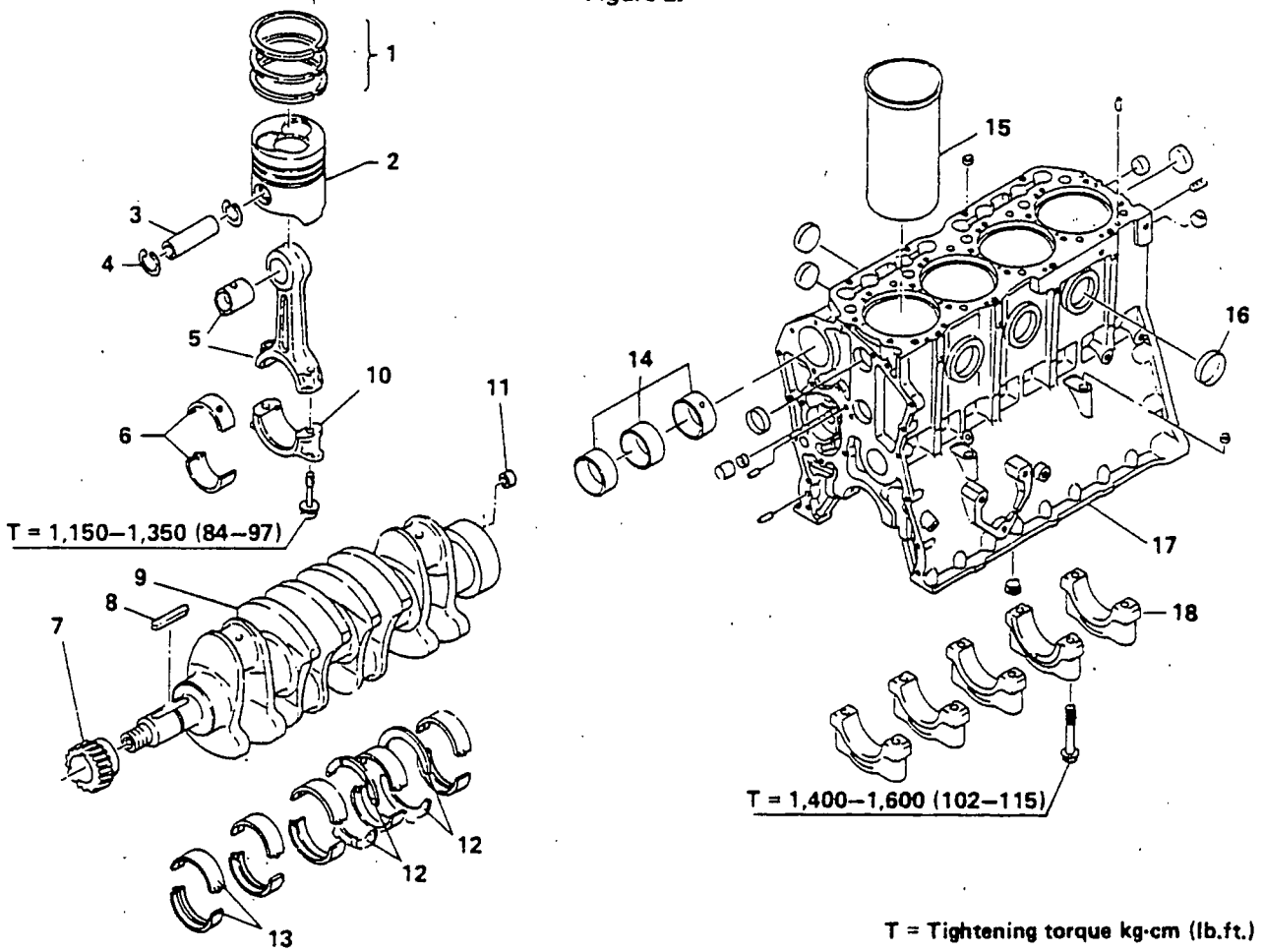


Figure 2.



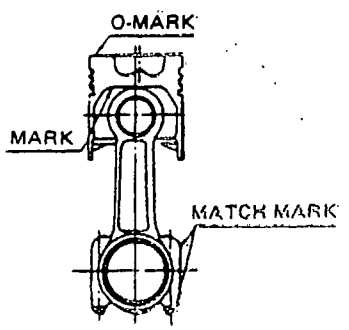
T = Tightening torque kg·cm (lb.ft.)

1. Piston ring	7. Crankshaft gear	13. Crankshaft bearing
2. Piston	8. Key	14. Camshaft bearing
3. Piston pin	9. Crankshaft	15. Cylinder liner
4. Retainer ring	10. Connecting rod cap	16. Expansion plug
5. Connecting rod	11. Collar	17. Cylinder block
6. Connecting rod bearing	12. Crankshaft thrust washer	18. Bearing cap

Important Points- Disassembly

Remove the pistons and connecting rods out through the top of the cylinder. Arrange the pistons and connecting rod caps in order by cylinder number.

Figure 4. Piston & Connecting Rod

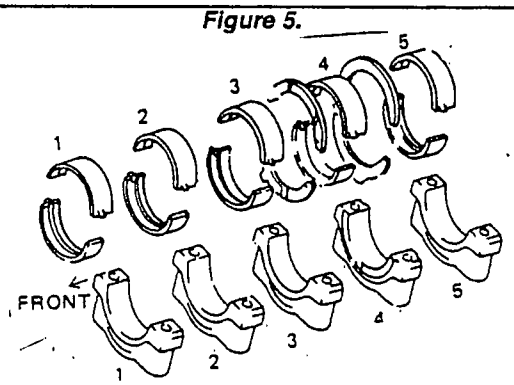


Important Points- Disassembly (Continued)

CRANKSHAFT:

Remove the crankshaft. Arrange the caps, bearings and thrust washers in order as shown in Figure 5.

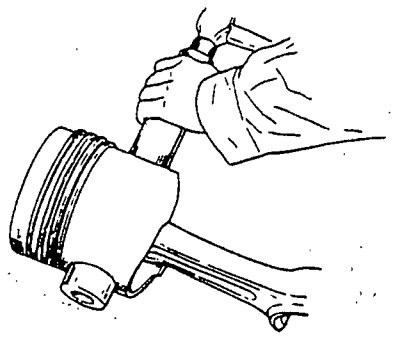
Figure 5.



CONNECTING ROD REMOVAL:

First, warm the piston in hot water (176°-194° F., or 80°-90° C.) for about five (5) minutes. Use snap ring pliers to remove the snap rings at each end of the piston pin. Finally, drive out the piston pin and separate the connecting rod from the piston.

Figure 6. Removal of Connecting Rod



PISTON RINGS REMOVAL:

See Figure 7. Use a special tool to remove the piston rings. Handle rings with care. They are made of a special alloy that breaks easily./

SPECIAL TOOL
Piston Ring Expander, Reference No. 09442-1180

CYLINDER LINER REMOVAL:

Use a pencil (NOT a punch or scribe) to place alignment marks on the cylinder liner flange and the cylinder block, for easier reassembly. Number the liners in order, by cylinder number as they should be reinstalled back into the same cylinder from which they were removed. Use a special tool to remove the cylinder liner.

SPECIAL TOOL
Cylinder Liner Puller, Reference No. 09420-1460

Figure 7. Removing Piston Rings

Figure 8. Cylinder Liner

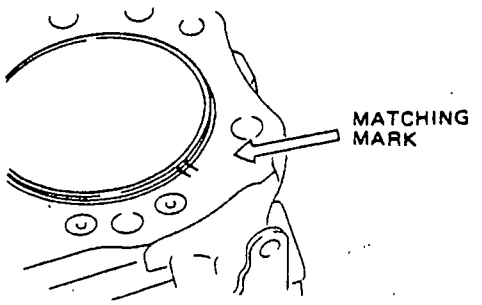
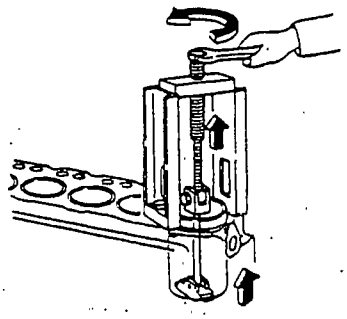


Figure 9. Cylinder Liner Puller

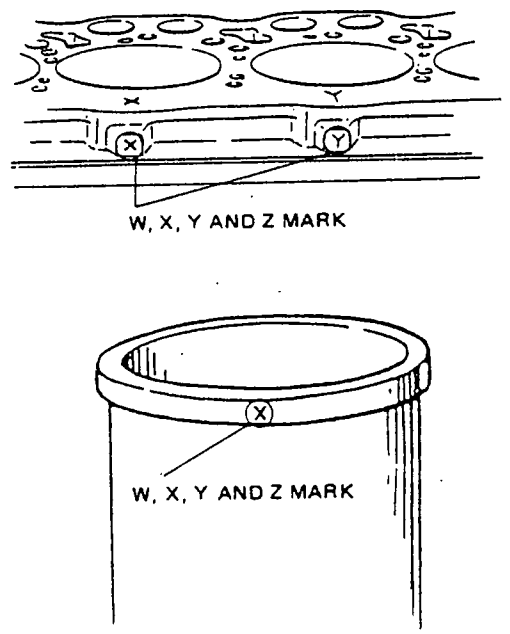


Important Points- Reassembly

CYLINDER LINER:

The cylinder liner MUST have the same mark as the mark on the cylinder block (W, X, Y and Z). If using a new liner, install it with the mark on the liner toward the mark on the block. See Figure 10, next page.

Figure 10. Marks on Cylinder Block & Liner

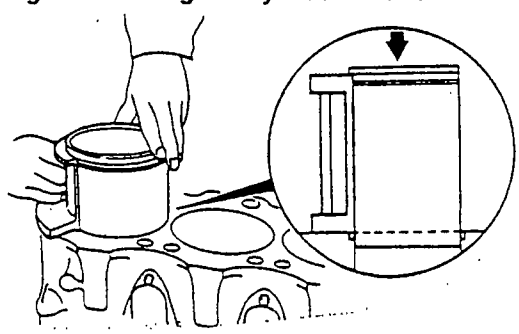


To install the cylinder liner, proceed as follows:

1. Apply a small amount of clean engine oil to the outside diameter of the cylinder liner.
2. Use a cylinder liner guide (Special Tool) to install the cylinder liner as the liner is thin and easily damaged.

SPECIAL TOOL
Cylinder Liner Guide, Reference No. 09480-1120

Figure 11. Using the Cylinder Liner Guide



3. If you are re-using a cylinder liner, install it in its original position, by using the alignment marks placed on the liner and block during disassembly. See Figure 12.
4. When the cylinder liners are installed, measure the projection of the cylinder liner flange (Figure 13).

SPECIAL TOOL
Cylinder Liner Puller, Reference No. 09420-1460

TIGHTENING TORQUE
7.23 foot-pounds (100 kg-cm

CYLINDER LINER PROJECTION
Standard: 0.0004-0.0064 inch (0.01-0.08mm)

Figure 12. Cylinder Liner Alignment Marks

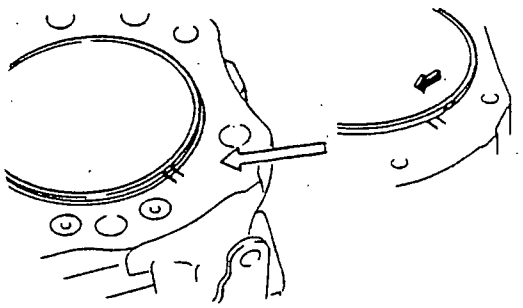
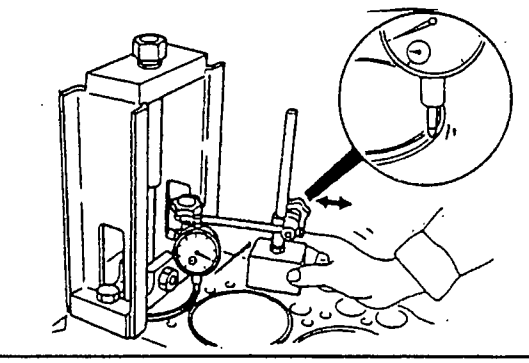
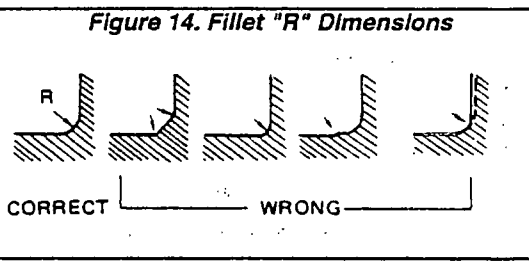


Figure 13. Check Liner Flange Projection



DIMENSION OF FILLET "R":
Crankpin: 0.1378-0.1574 inch (3.50-4.00mm)
Journal: 0.1201-0.1377 inch (3.05-3.50mm)

Figure 14. Fillet "R" Dimensions



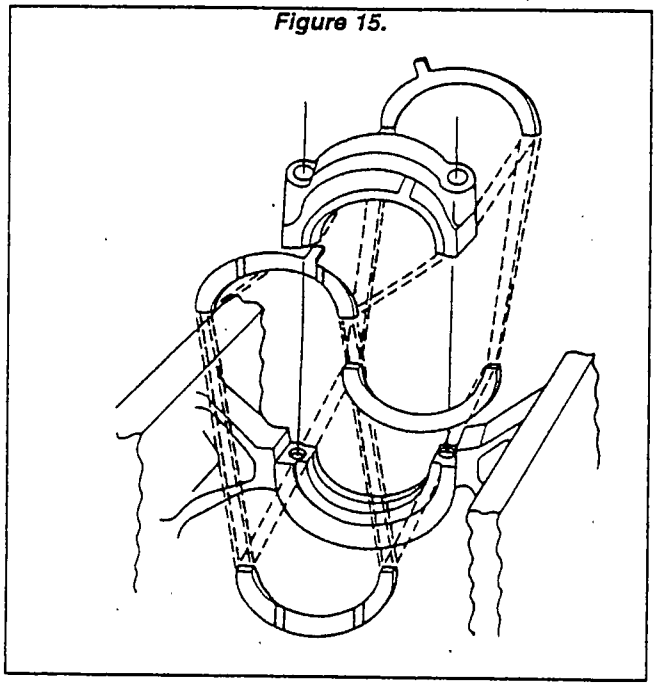
UNDERSIZE CRANKSHAFT BEARINGS:

UNDER SIZE	OUTSIDE DIAMETER	
	CRANKPIN	JOURNAL
0.25	2.4288-2.4295 inch (61.69-61.71mm)	2.8619-2.8625 inch (72.69-72.71mm)
0.50	2.4189-2.4196 inch (61.44-61.46mm)	2.8520-2.8527 inch (72.44-72.46mm)
0.75	2.4091-2.4098 inch (61.19-61.21mm)	2.8422-2.8429 inch (72.19-72.21mm)
1.00	2.3992-2.4000 inch (60.94-60.96mm)	2.8230-2.8330 inch (71.94-71.96mm)

MOUNTING THE CRANKSHAFT:

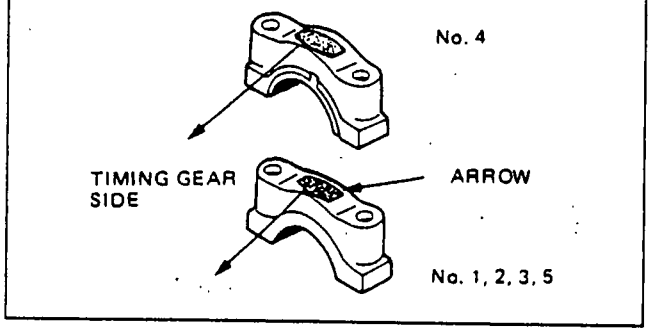
1. Apply fresh engine oil to all bearing surfaces. Then, install the crankshaft bearings on the cylinder block and bearing cap.

Figure 15.



2. Install the crankshaft onto the cylinder block.
3. Apply engine oil to each thrust bearing surface. Install the crankshaft thrust bearings along the groove of the cylinder block.
4. Install the thrust bearings on the No. 4 bearing cap sides.
5. Install the crankshaft bearing caps in numbered order (from timing gear side), with the arrow pointing toward the timing gear side.

Figure 16. Crankshaft Bearing Caps

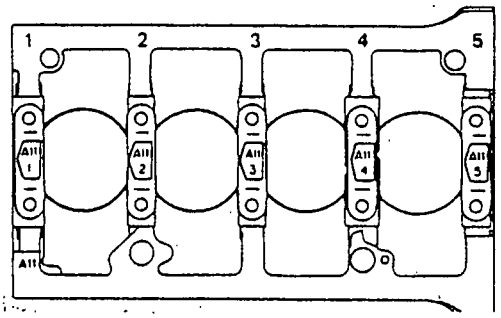


6. Apply engine oil to the cap bolt threads and under the bolt head. Install the cap bolts. Tighten them in the order shown below (see Figure 17) and to the recommended tightening torque.

TIGHTENING ORDER
3-2-4-1-5

CAP BOLTS TIGHTENING TORQUE
102-115 foot-pounds (1400-1600 kg-cm)

Figure 17. Cap Bolts Tightening Order



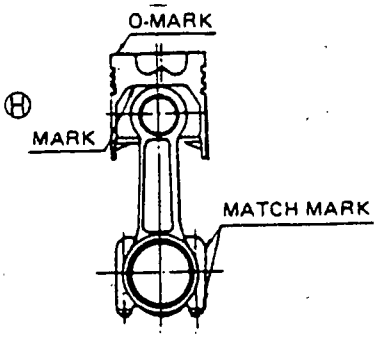
ASSEMBLE PISTON & CONNECTING ROD:

When assembling the pistons to the connecting rods, use new snap rings to retain the piston pins.

Make sure the "0" mark at top of piston is opposite (away from) the connecting rod match marks.

To install piston pins, first heat the piston in hot water to about 176°-194° F. (80°-90° C.) for about five (5) minutes. Apply engine oil to piston pins.

Figure 18.



PISTON RINGS INSTALLATION:

See Figure 19, next page. Install the piston rings onto pistons as follows:

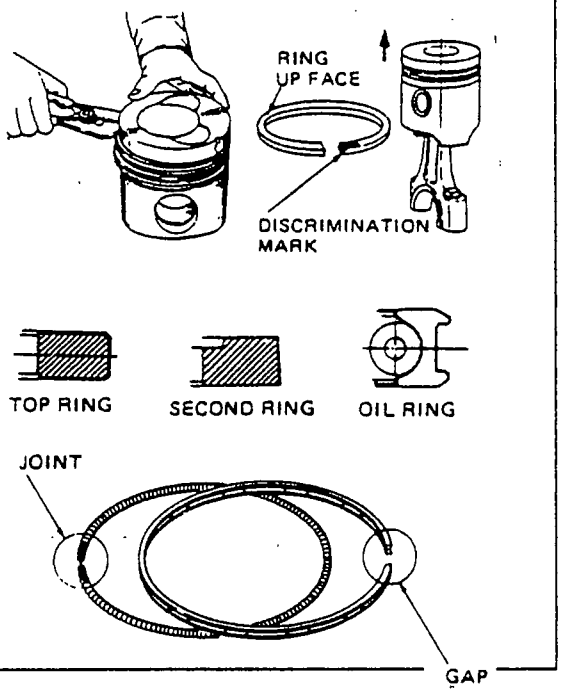
1. Install the oil ring, followed by the second ring, and then the top ring. The identification mark at top of each ring must face upward, toward top of piston. Use a special tool to install rings.

SPECIAL TOOL
Piston Ring Expander, Reference No. 09442-1180

NOTE: The identification marks on the second ring and on the oil ring are applied with gold paint.

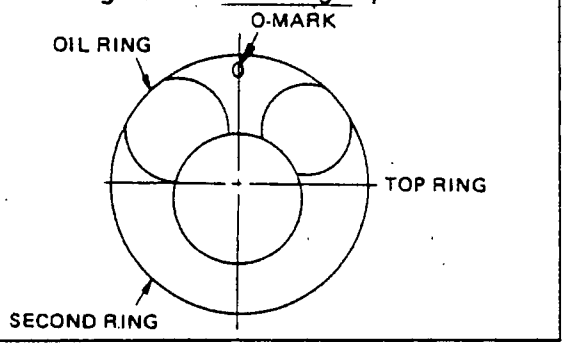
2. Connect the ends of the coil expander, then fit the coil inside the piston ring. Make sure the piston ring gap is 180° away from the coil joint as shown in Figure 19.

Figure 19. Installing the Piston Rings



3. Arrange the piston rings on each piston so their gaps are equally spaced.

Figure 20. Piston Ring Gaps



INSTALLING PISTONS:

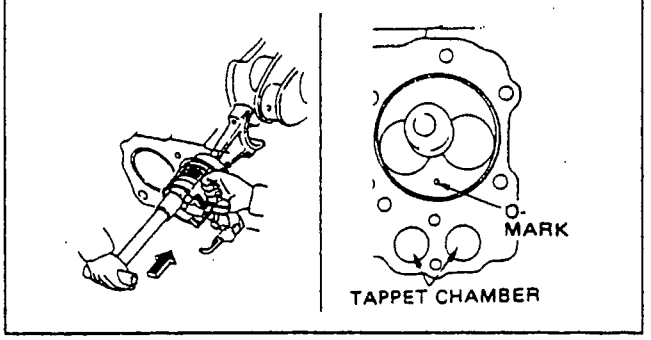
Apply engine oil to the piston, to the cylinder liner and to the connecting rod bearing surface.

The "0" mark at top of each pistion must be on the tappet chamber side.

Use a special tool to protect the rings while installing the pistons into the cylinder liners.

SPECIAL TOOL
Piston Ring Compressor, Reference No. 09441-1260

Figure 21. Pistons Installation

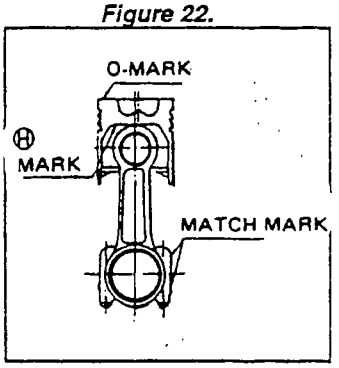


CONNECTING RODS INSTALLATION:

1. Apply engine oil to all bearing cap surfaces.
2. Align the match marks on the connecting rods and caps.
3. Apply engine oil to cap bolt threads and under the bolt head.
4. Tighten the cap bolts in three (3) stages, to the following torque:

CAP BOLTS TIGHTENING TORQUE
84-97 foot-pounds
(1150-1350 kg-cm)

Figure 22.

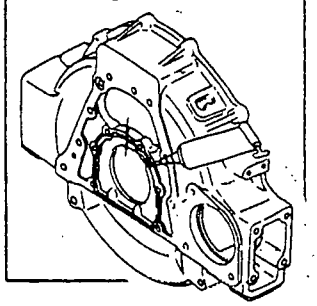


FLYWHEEL HOUSING INSTALLATION:

1. Clean the mating surfaces.
2. Apply liquid gasket to form a gasket bead about 0.06-0.10 inch (1.5-2.5mm) in diameter.

NOTE: The flywheel housing bolts must be tightened within 20 minutes after applying the liquid gasket. If longer then 20 minutes, clean liquid gasket from housing and reapply.

Figure 23.



TO REPLACE CONNECTING ROD BUSHING:

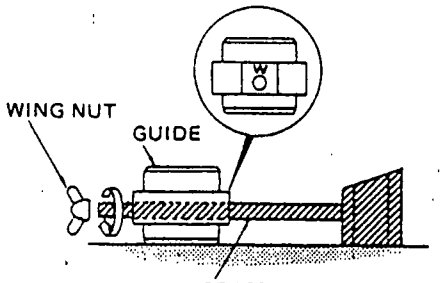
SPECIAL TOOLS
Guide, Reference No. 09481-1130
Press Subassembly, Reference No. 09402-1450
Wing Nut, Reference No. 9233-10360

If it is necessary to replace the connecting rod bushing(s), proceed as follows:

1. First, prepare the special tools.
   a. Insert the pin of the press subassembly into the guide hole and lock the guide with the wing nut.
   b. Guide must be up as shown (Figure 24) and the letter engraved on guide must be above the pin hole.

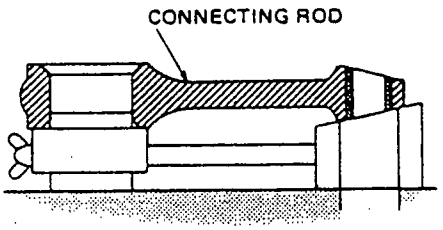
c. After the tools have been set up, make sure the assembly is flush with its supporting surface.

Figure 24. Setting up the Special Tools



2. Second, remove the connecting rod bushing.
   a. Remove the large end bearing.
   b. Install the connecting rod onto the guide.

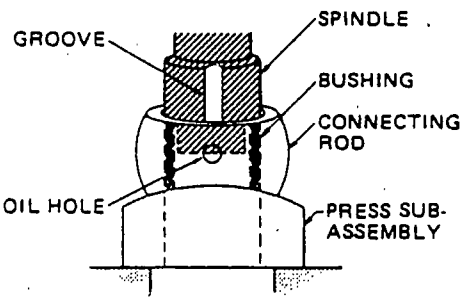
Figure 25.



c. Install the spindle into the bushing. Align the spindle grooving with the oil hole of the bushing.

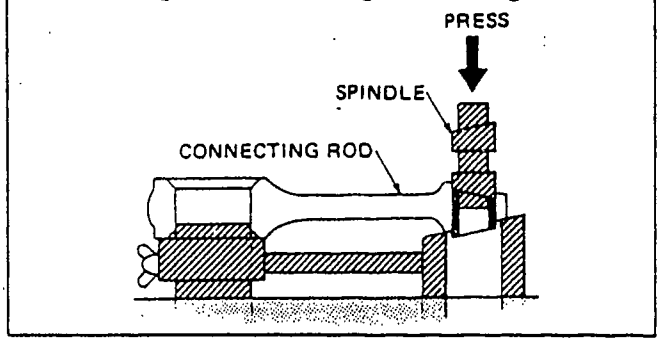
SPECIAL TOOL
Spindle, Reference No. 09402-1460

Figure 26. Installing Spindle into Bushing



d. Use a hydraulic press to remove the bushing (Figure 27).

Figure 27. Removing the Bushing

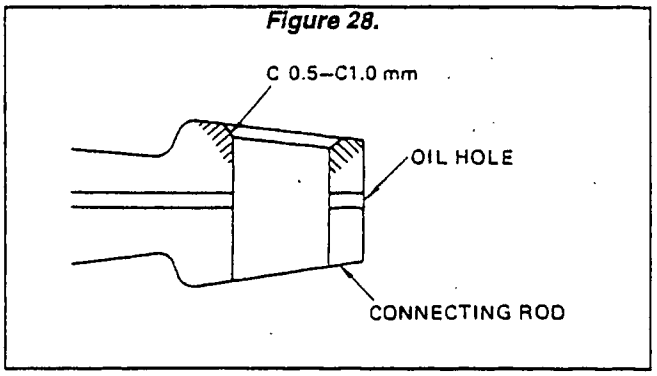


3. Install the Connecting Rod Bushing.
   a. Uniformly chamfer one edge of the bushing hole at the small end of the connecting rod, to the circumference recommended below. Remove dust from the inner surface of the small end hole.

CHAMFER CIRCUMFERENCE
0.0196-0.0393 inch (0.5-1.0mm)

NOTE: Irregular chamfering can result in out-of-roundness of the bushing, which may result in jamming during installation.

Figure 28.



4. Mount the bushing onto the spindle.

SPECIAL TOOLS
Spindle, Reference No. 09402-1460
Guide, Reference No. 09481-1140
Bolt, Reference No. 9191-08252

a. See Figure 29, next page. Set the bushing onto the spindle with oil hole ("A") of the bushing is aligned over the spindle groove, then lock the guide and bolt.
b. Apply engine oil around the bushing and guide.

GUIDE BOLT TIGHTENING TORQUE
3.61-5.06 foot-pounds (50-70 kg-cm)

5. Refer to Figure 30, next page. Coat the connecting rod hole with engine oil. Align the inner oil hole of the connecting rod with the groove of the guide.

Important Points- Reassembly (Continued)

Figure 29. Mounting Bushing to Spindle

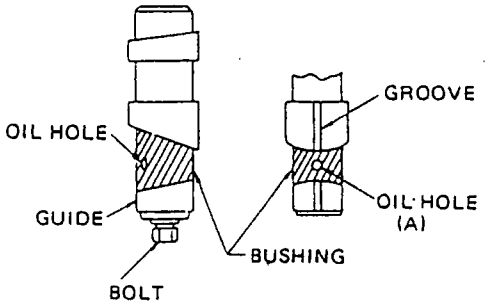
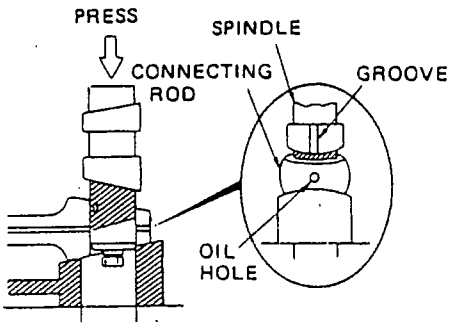


Figure 30. Installing the Bushing



6. Following its installation, inspect the bushing for proper positioning.

a. Oil holes in the bushing and connecting rod must be aligned.

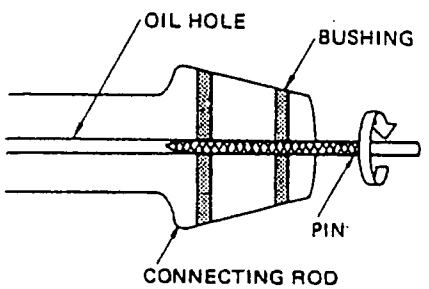
b. Insert a length of wire or a pin having a diameter of 0.1102 inch (2.8mm) into hole at end of connecting rod. Make sure the pin or wire penetrates fully.

c. If the oil holes do NOT align perfectly, correct the deviation with a 0.1102 inch (2.8mm) drill.

d. Install a new piston pin and rotate it slowly to make sure there is no looseness or play.

CAUTION: Misalignment of the oil holes will lead to inadequate lubrication and possible seizure of the connecting rod bushings.

Figure 31. Checking Oil Holes Alignment



Inspection & Repair

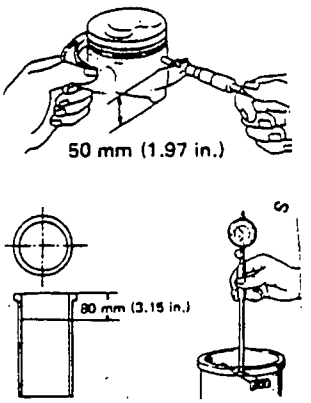
PISTON & CYLINDER LINER:

PISTON DIAMETER
4.0890-4.0896 inch
(103.860-103.876mm)
Limit: 4.1003 inch
(104.15mm)

CYLINDER LINER I.D.
4.0949-4.0960 inch
(104.008-104.040mm)
Limit: 4.1003 inch
(104.15mm)

PISTON TO LINER CLEARANCE
0.0056-0.0067 inch
(0.140-0.172mm)

Figure 32.



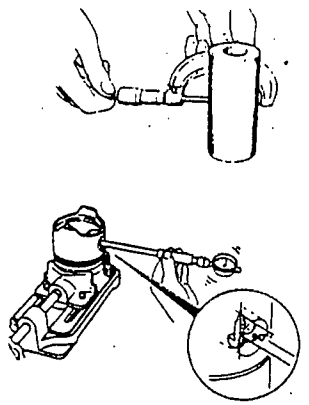
PISTON PIN:

PISTON PIN DIAMETER
1.3776-1.3779 inch
(34.989-35.000mm)
Limit: 1.3771 inch
(34.980mm)

PISTON PIN HOLE I.D.
1.3775-1.3780 inch
(34.987-35.003mm)
Limit: 1.3787 inch
(35.02mm)

PISTON PIN TO PISTON PIN HOLE CLEARANCE
0.00052T-0.00055L inch
(0.013T-0.014L mm)
T: Tight L: Clearance
Limit: 0.0015 inch
(0.4mm)

Figure 33.

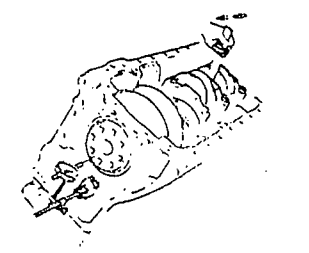


CRANKSHAFT END PLAY:

If crankshaft end play is not within the stated limits, replace thrust bearing.

CRANKSHAFT END PLAY
Standard: 0.0020-0.0086 inch (0.05-0.22mm)
Limit: 0.0157 inch
(0.4mm)

Figure 34.



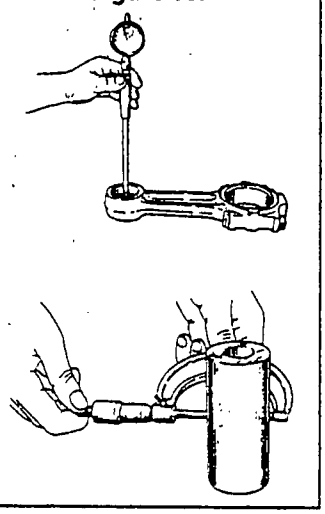
CONNECTING ROD & PISTON:

CONNECTING ROD SMALL END BUSHING I.D.
1.3786-1.3789 Inch (35.015-35.025mm)
Limit: 1.3811 Inch (35.080mm)

PISTON PIN DIAMETER
1.3776-1.3779 Inch (34.989-35.000mm)
Limit: 1.3771 Inch (34.980mm)

PISTON PIN TO CONNECTING ROD SMALL END BUSHING CLEARANCE
0.00016-0.0014 Inch (0.0039 Inch (0.1mm)

Figure 35.

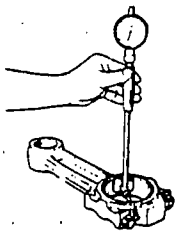


CONNECTING ROD:

CONNECTING ROD LARGE END I.D.
Standard: 2.5979-2.5984 Inch (65.985-66.000mm)

CONNECTING ROD LARGE END ROUNDNESS
0.0023 Inch (0.06mm)

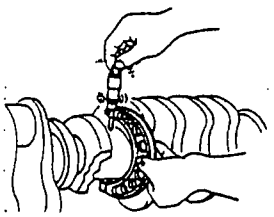
Figure 36.



CRANKPIN:

CRANKPIN DIAMETER
2.4386-2.4393 Inch (61.94-61.96mm)
Limit: 2.3921 Inch (60.76mm)

Figure 37.



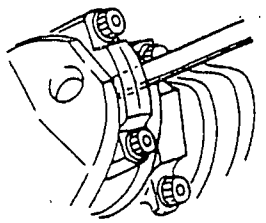
CONNECTING ROD TO CRANKPIN CLEARANCE:

Standard: 0.0013-0.0032 Inch (0.031-0.082mm)
Limit: 0.0047 Inch (0.12mm)

CONNECTING ROD END PLAY:

0.0079-0.0204 Inch (0.20-0.52mm)
Limit: 0.0236 Inch (0.6mm)

Figure 38.

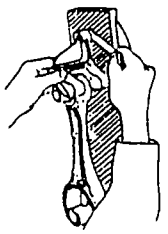


CONNECTING ROD STRAIGHTNESS:

Limit: 0.0039 Inch (0.1mnm) per 0.7874 Inch (200mm)

CONNECTING ROD TWIST:
Limit: 0.0039 Inch (0.1mm) per 0.7874 Inch (200mm)

Figure 39.

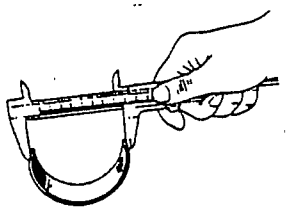


CONNECTING ROD & CRANKSHAFT BEARINGS:

CONNECTING ROD BEARING SPREAD
2.6398-2.6594 Inch (67.05-67.55mm)

CRANKSHAFT BEARING SPREAD
3.1102-3.1339 Inch (79.00-79.60mm)

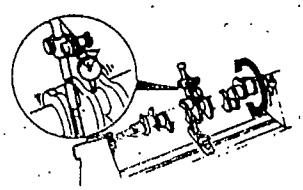
Figure 40.



CRANKSHAFT BEND:

CRANKSHAFT BEND LIMIT
0.0156 Inch
0.04mm

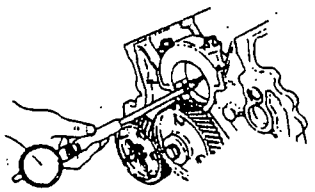
Figure 41.



CRANKSHAFT CHECKS:

CRANKSHAFT MAIN BEARING CAP ROUNDNESS 0.0023 inch (0.06mm)

Figure 42.

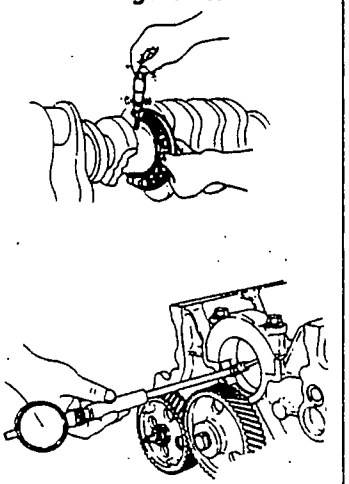


CRANKSHAFT JOURNAL DIAMETER Standard: 2.8717-2.8724 inch (72.94-72.96mm) Limit: 2.8521 inch (71.76mm)

CRANKSHAFT MAIN BEARING I.D. 3.0703-3.0708 inch (77.985-78.000mm)

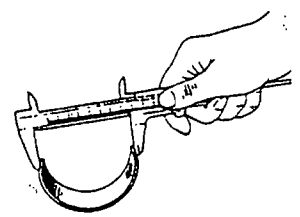
JOURNAL TO MAIN BEARING CLEARANCE Standard: 0.0016-0.0035 inch (0.039-0.090mm) Limit: 0.0051 inch (0.13mm)

Figure 43.



CRANKSHAFT MAIN BEARING SPREAD 3.1103-3.1125 inch (79.00-79.06mm)

Figure 44.



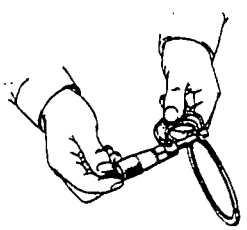
PISTON RINGS:

PISTON RING WIDTH Top Ring Standard: 0.0973-0.0980 inch (2.47-2.49mm) Top Ring Limit: 0.0913 inch (2.32mm)

2nd Ring Standard: 0.0776-0.0783 inch (1.97-1.99mm) 2nd Ring Limit: 0.0716 inch (1.82mm)

Oil Ring Standard: 0.1957-0.1964 inch (4.97-4.99mm) Oil Ring Limit: 0.1948 inch (4.95mm)

Figure 45.



WIDTH OF PISTON RING GROOVE Top Ring Standard: 0.1012-0.1019 inch (2.57-2.59mm) Top Ring Limit: 0.1078 inch (2.74mm)

2nd Ring Standard: 0.0800-0.0807 inch (2.03-2.05mm) 2nd Ring Limit: 0.0866 inch (2.2mm)

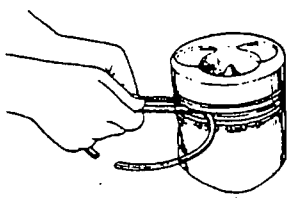
Oil Ring Standard: 0.1973-0.1980 inch (5.01-5.03mm) Oil Ring Limit: 0.2000 inch (5.08mm)

RING TO GROOVE CLEARANCE Top Ring Standard: 0.0032-0.0047 inch (0.08-0.12mm) Top Ring Limit: 0.0118 inch (0.3mm)

2nd Ring Standard: 0.0016-0.0031 inch (0.04-0.08mm) 2nd Ring Limit: 0.0118 inch (0.3mm)

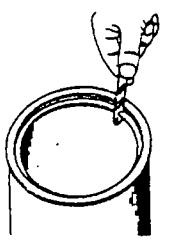
Oil Ring Standard: 0.0008-0.0023 inch (0.02-0.06mm) Oil Ring Limit: 0.0031 inch (0.08mm)

Figure 46.



RING GAP (ALL RINGS) Standard: 0.0119-0.0177 inch (0.30-0.45mm) Limit: 0.0472 inch (1.2mm) Insert ring where liner wear is least

Figure 47.

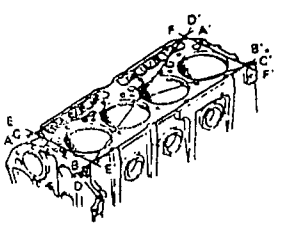


CYLINDER BLOCK FLATNESS:

Standard: 0.0019 inch (0.05mm) Limit: 0.0039 inch (0.1mm)

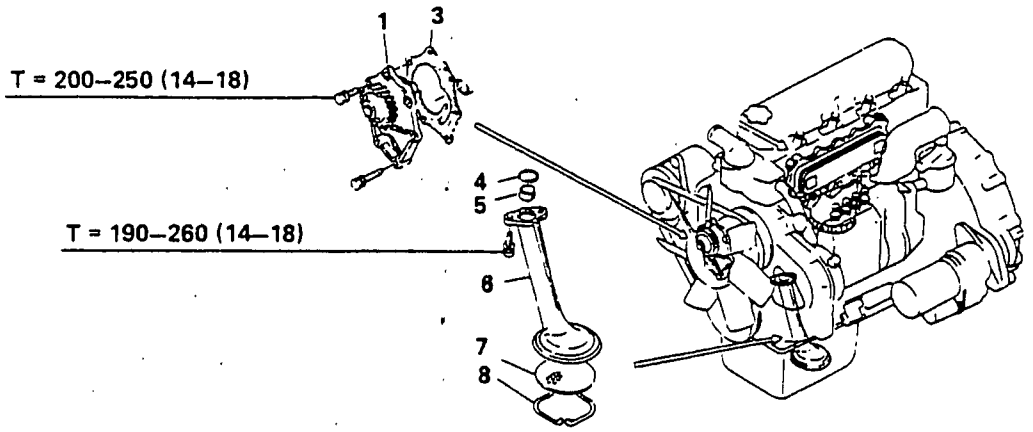
If not within tolerance, regrind or replace cylinder block.

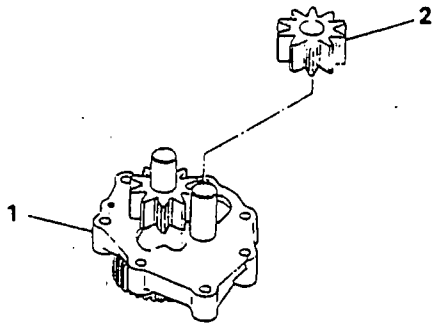
Figure 48.



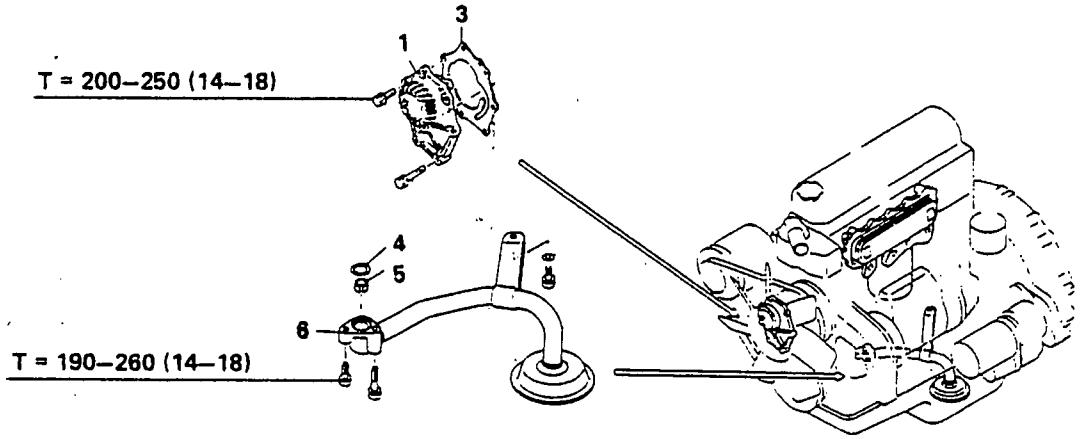
Section 2.6- OIL PUMP & OIL STRAINER

FRONT SUMP





REAR SUMP



T = Tightening torque: kg·cm (lb.ft)

1. Oil pump case sub-assembly
2. Driven gear
3. Gasket
4. O-ring
5. O-ring guide
6. Oil strainer
7. Oil strainer screen
8. Snap ring

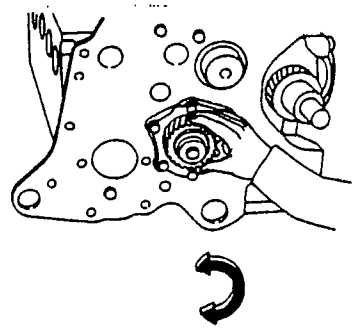
Pump & Strainer Installation

PUMP INSTALLATION:

Prior to installing the oil pump, apply a liberal quantity of oil to the cylinder block pump case and bearing. Install the pump, tighten the bolts to the recommended torque. Finally, make sure the pump rotates smoothly.

PUMP BOLTS TIGHTENING TORQUE
14-18 foot-pounds (200-250 kg-cm)

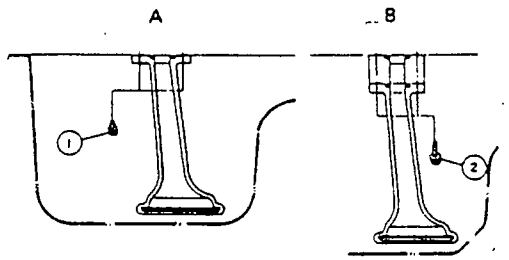
Figure 1.



INSTALLING FRONT SUMP OIL STRAINER:

Be sure to install o-ring guide and o-ring onto the adapter. Insert the adapter between the bottom surface of the cylinder block and strainer.

Figure 2.

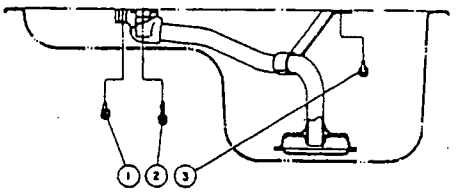


INSTALLING REAR SUMP OIL STRAINER:

See Figure 3. Tighten bolts 1 and 2 temporarily. Then, align the bolt holes of the cylinder block and bracket. Finally, tighten bolts 1, 2 and 3 to the specified torque. BE SURE TO INSTALL O-RING.

TIGHTENING TORQUE
14-18 foot-pounds (190-260 kg-cm)

Figure 3.



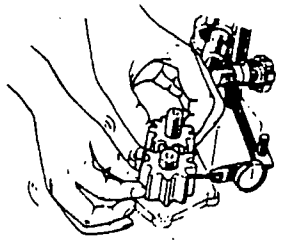
Inspection & Repair

GEAR BACKLASH:

Check gear for proper backlash. If backlash exceeds the stated limit, replace the gear.

GEAR BACKLASH
Standard: 0.0036-0.0082 inch (0.09-0.21mm)
Limit: 0.0118 inch (0.30mm)

Figure 4.



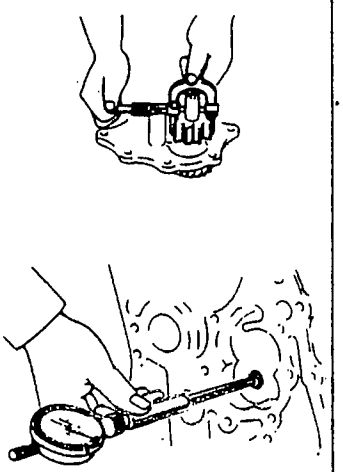
DRIVE GEAR SHAFT & BUSHING:

DRIVE GEAR SHAFT DIAMETER
Standard: 0.7122-0.7128 inch (18.088-18.106mm)
Limit: 0.7110 inch (18.060mm)

DRIVE SHAFT BUSHING I.D.
Standard: 0.7145-0.7154 inch (18.146-18.173mm)
Limit: 0.7165 inch (18.20mm)

DRIVE SHAFT TO BUSHING CLEARANCE
Standard: 0.0080-0.0033 inch (0.040-0.085mm)
Limit: 0.0039 inch (0.1mm)

Figure 5.



DRIVE GEAR SHAFT DIAMETER
Standard: 0.7079-0.7085 inch (17.979-17.997mm)
Limit: 0.7074 inch (17.970mm)

DRIVEN GEAR I.D.
Standard: 0.7102-0.7107 inch (18.037-18.054mm)
Limit: 0.7114 inch (18.070mm)

DRIVEN GEAR TO SHAFT CLEARANCE
Standard: 0.0080-0.0023 inch (0.040-0.075mm)
Limit: 0.0039 inch (0.1mm)

Figure 6.

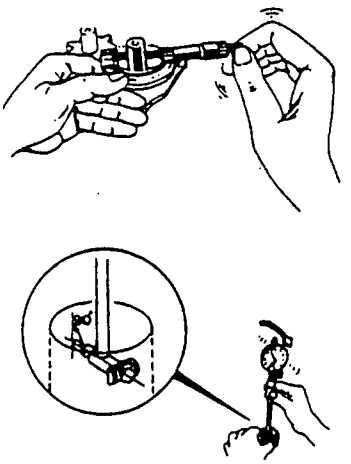
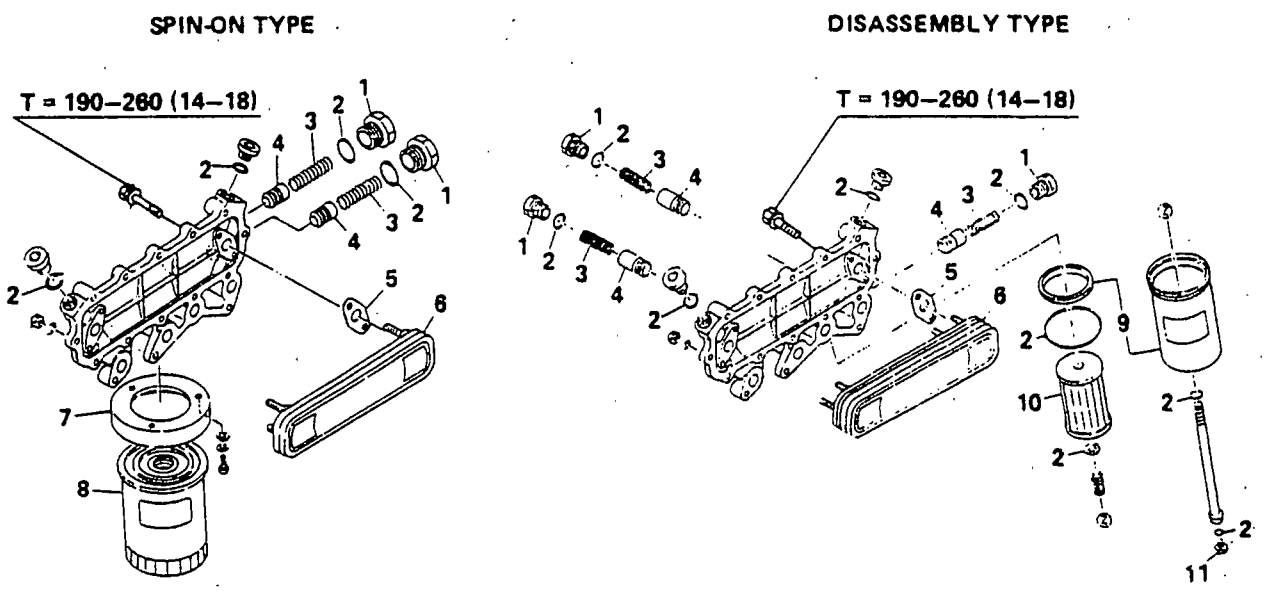
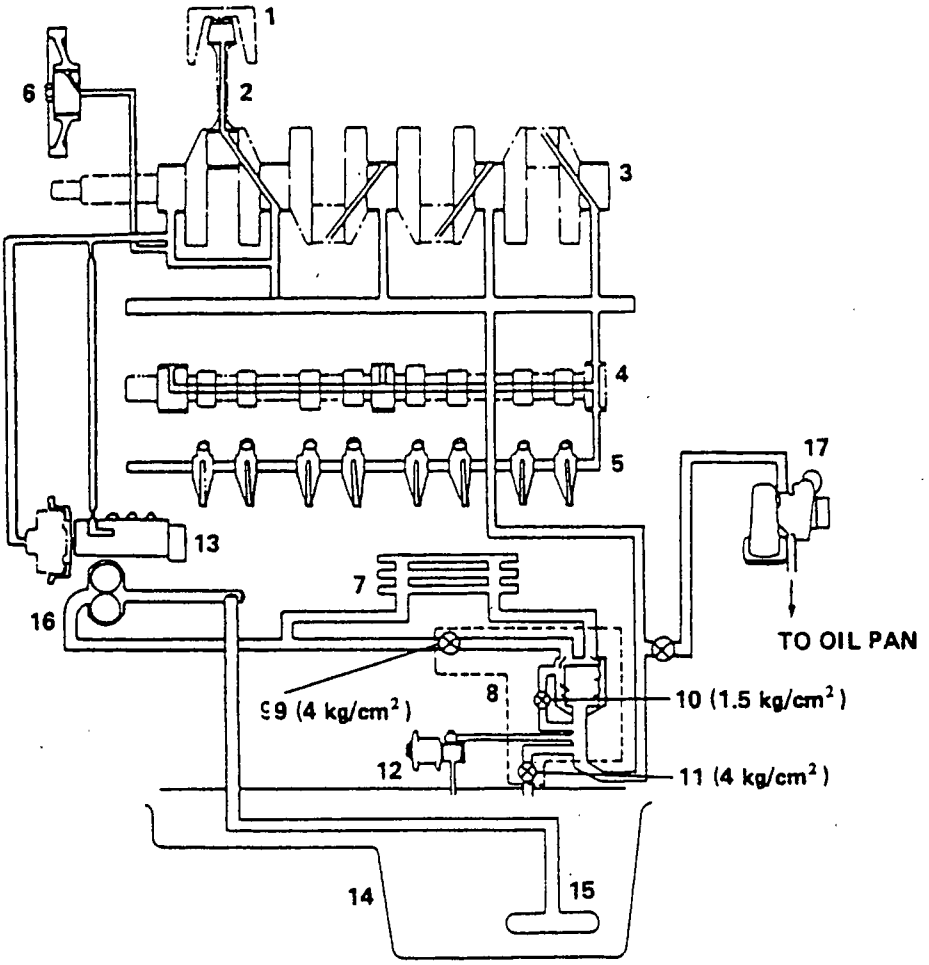


Figure 7. Oil Cooler & Oil Filter



T = Tightening torque: kg·cm (lb.ft)

1. Valve spring plug
2. O-ring
3. Oil valve spring
4. Valve
5. Element gasket
6. Oil cooler element
7. Oil filter plate
8. Oil filter element set
9. Element lower cover
10. Oil filter element
11. Drain plug

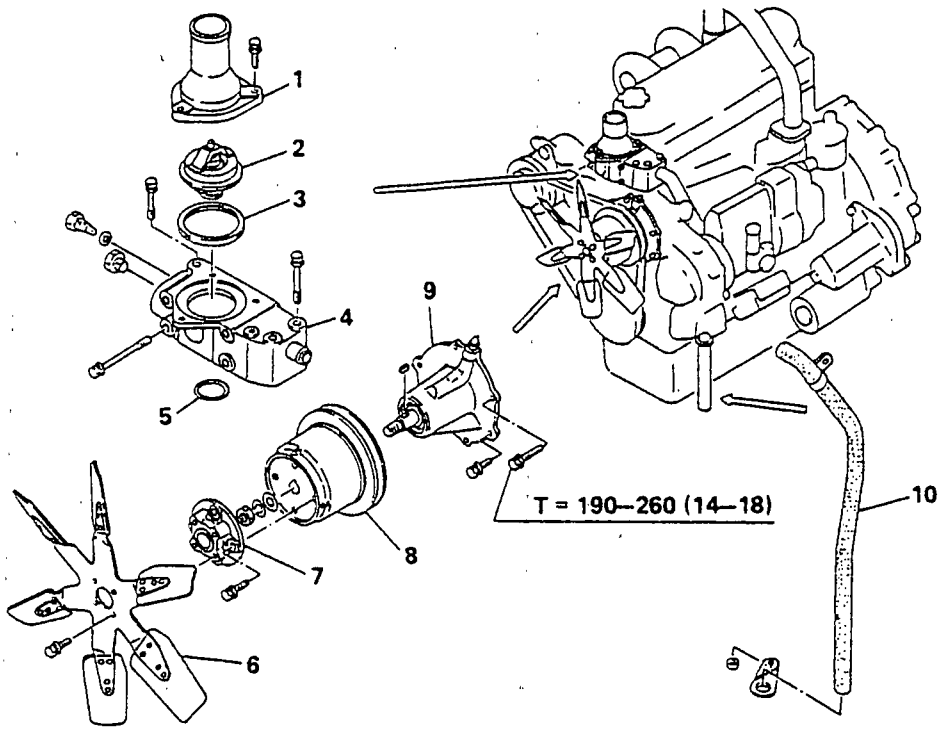


LUBRICATING SYSTEM

1. Piston
2. Connecting rod
3. Crankshaft
4. Camshaft
5. Rocker arm shaft
6. Idle gear
7. Oil cooler
8. Oil filter
9. Cooler safety valve
10. Filter safety valve
11. Regulator valve
12. Vacuum pump
13. Injection pump
14. Oil pan
15. Oil strainer
16. Oil pump
17. Turbo charger

Section 2.7- COOLANT PUMP

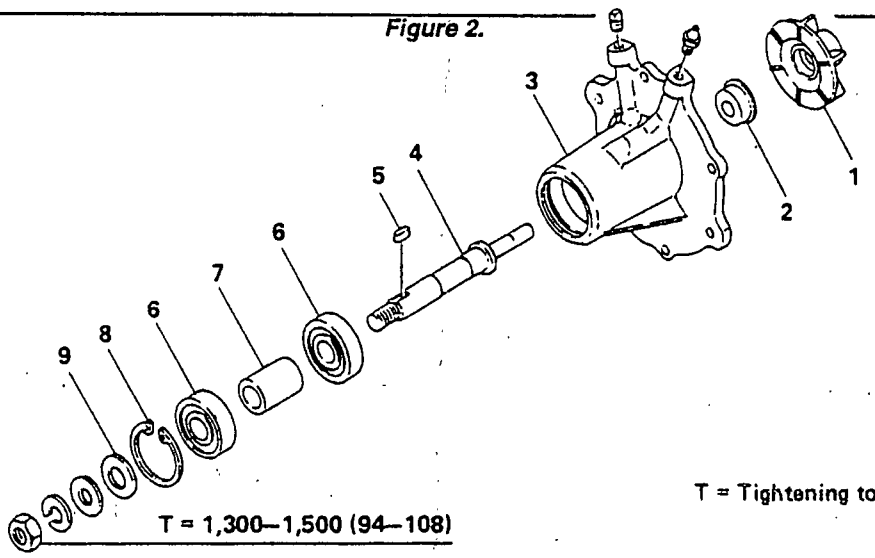
Figure 1.



T = Tightening torque kg-cm (lb.ft)

1. Thermostat case cover
2. Thermostat
3. Thermostat gasket
4. Thermostat case
5. O-ring
6. Cooling fan
7. Fan pulley spacer
8. Coolant pump pulley
9. Coolant pump assembly
10. Vent hose

Figure 2.



T = Tightening torque kg-cm (lb.ft)

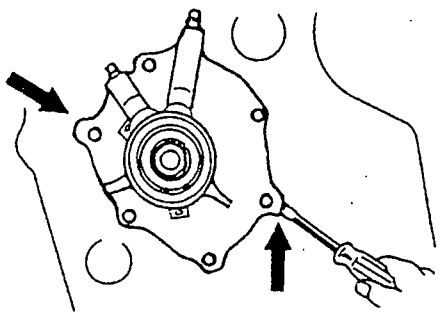
1. Coolant pump vane
2. Coolant pump seal
3. Coolant pump case
4. Coolant pump shaft
5. Key
6. Ball bearing
7. Collar
8. Retainer ring
9. Spacer

Important Points- Removal & Disassembly

REMOVAL:

After the retaining bolts are removed, the coolant pump can be removed by prying with a screwdriver at the two points on the flange as shown in Figure 3, below.

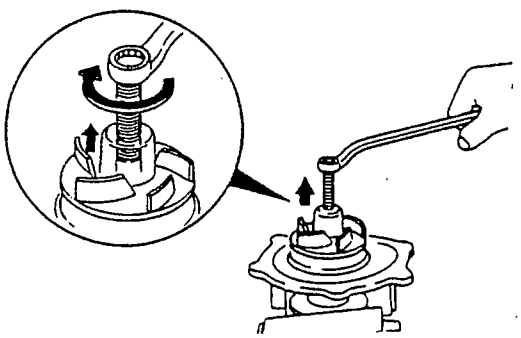
Figure 3. Prying the Coolant Pump Loose



DISASSEMBLY:

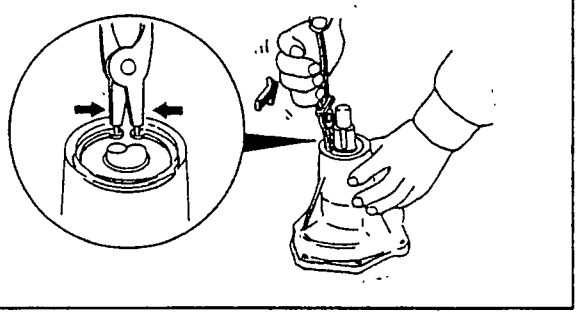
1. To remove the vane from the shaft, screw in a bolt having a 10mm diameter and a 1.5mm pitch. See Figure 4.

Figure 4. Removing the Vane



2. Use snap ring pliers to remove the snap ring (Figure 5).

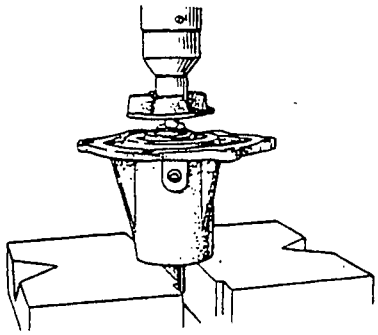
Figure 5.



3. Press out the bearings, collar and shaft. See Figure 6.

CAUTION: If the snap ring is not removed, any attempt to press out components will damage the pump case.

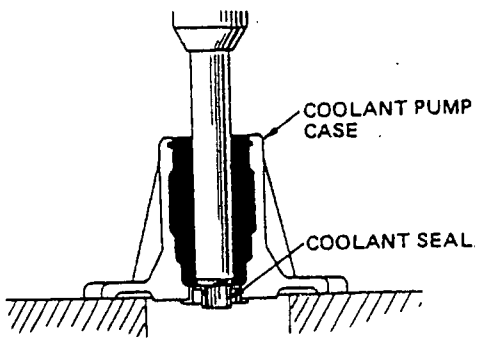
Figure 6.



4. Remove the coolant seal from the case. Use a copper rod to strike the seal. See Figure 7.

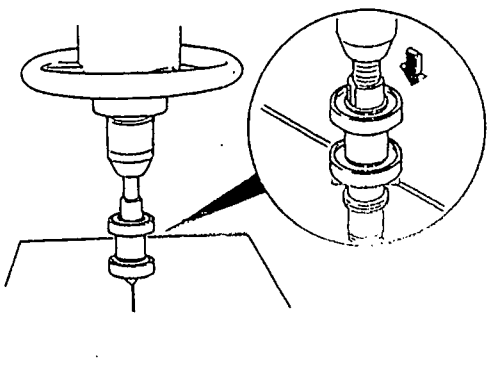
CAUTION: Once the coolant seal is removed, it must be replaced with a new one.

Figure 7.



5. Use a press to remove the bearings and collar (Figure 8).

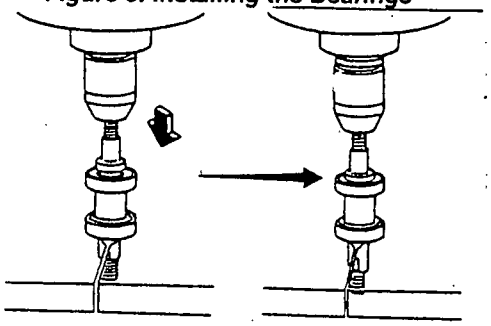
Figure 8.



Important Points- Reassembly

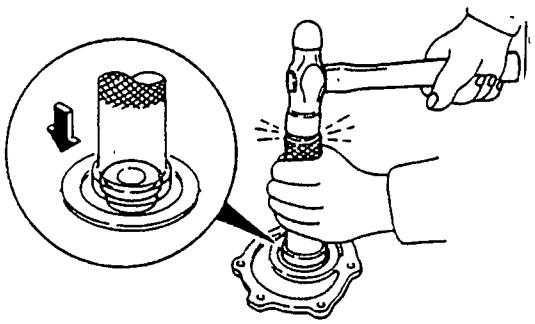
1. See Figure 9. Use a press to install the bearings onto the shaft. Use grease-packed bearings. Do NOT strike the shaft with a hammer.

Figure 9. Installing the Bearings



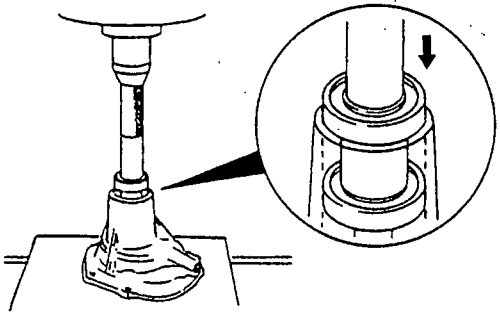
2. Apply liquid gasket (such as Three Bond No. 1104) around the periphery of the coolant seal cage. Install the seal using a press (Figure 10).

Figure 10. Installing the Coolant Seal



3. Press the shaft into the case (Figure 11).

Figure 11.



4. After pressing the shaft into the case, install the flat washer and then install the snap ring (see Figure 12).

5. Apply engine oil onto the coolant seal face. Press the vane onto the shaft so that Dimension "L" is as follows (Figure 13):

DIMENSION "L"
0.016-0.035 inch (0.4-0.9mm)

Figure 12. Press the Shaft into the Case

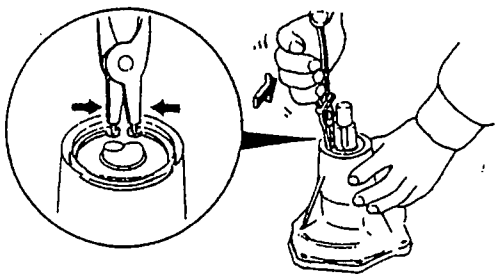
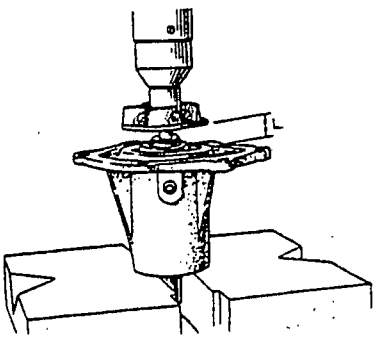


Figure 13. Installing the Vane

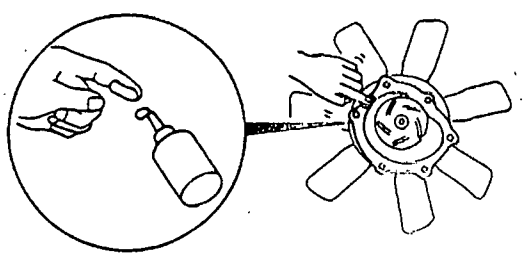


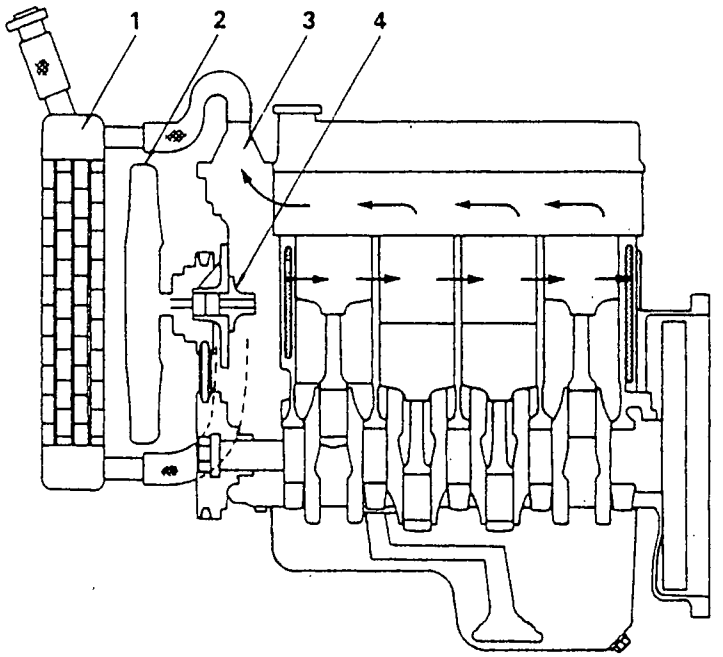
NOTE: After assembling the coolant pump, make sure the shaft rotates smoothly, without binding.

6. When installing the pump, clean the contacting surfaces of both the pump and the timing gear cover. These surfaces must be completely free of old sealer, oil, water, etc. When contact surfaces are clean, apply oliquid gasket and install the pump.

NOTE: The pump must be installed within 20 minutes after the liquid gasket has been applied. If longer than 20 minutes, completely remove all old liquid gasket and reapply new liquid gasket.

Figure 14. Pump Installation



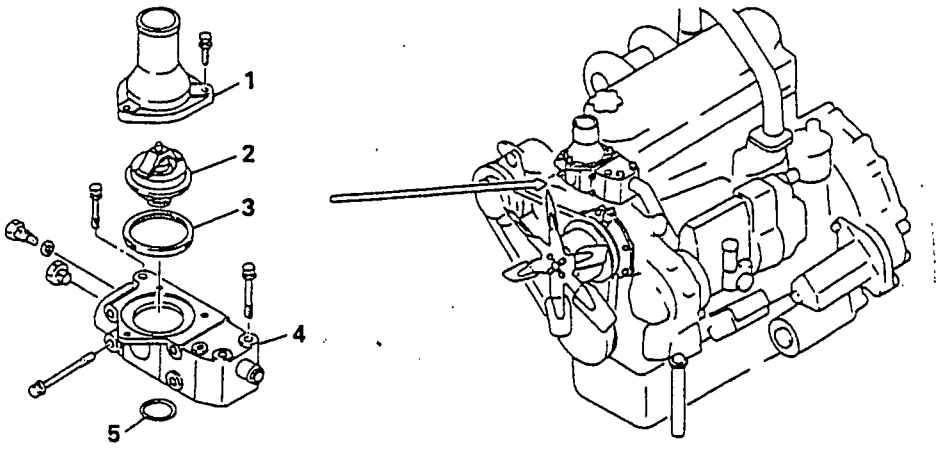


COOLING SYSTEM

1. Radiator
2. Cooling fan
3. Thermostat
4. Coolant pump

Section 2.8- THERMOSTAT AND HOUSING

Figure 1.

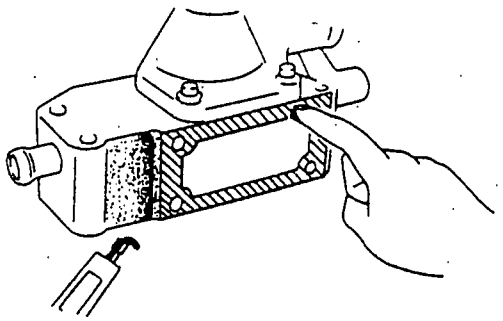


1. Thermostat case cover
2. Thermostat
3. Thermostat gasket
4. Thermostat case
5. O-ring

Installing the Thermostat Case

Before installing the thermostat case, clean the mounting flanges. After applying liquid gasket, install and tighten the case within 20 minutes. If more than 20 minutes elapses before the case is tightened, clean away all liquid gasket material completely. Then, apply new liquid gasket and install the case within 20 minutes.

Figure 2.



Testing the Thermostat

GENERAL:

The thermostat can be removed and tested for (a) opening temperature, (b) valve lift, and (c) closing condition. Immerse the thermostat in a 50-50 solution of soft water and anti-freeze (Figure 2), along with a thermometer and a stirring rod.

OPENING TEMPERATURE:

Heat the 50-50 mixture. The thermostat valve should open at about 176°-183° F. (80°-84° C.).

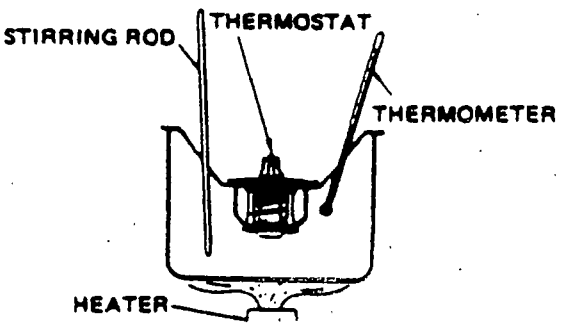
VALVE LIFT:

At about 197° F. (92° C.), thermostat valve lift should be 0.4 inch (10mm).

CLOSING CONDITION:

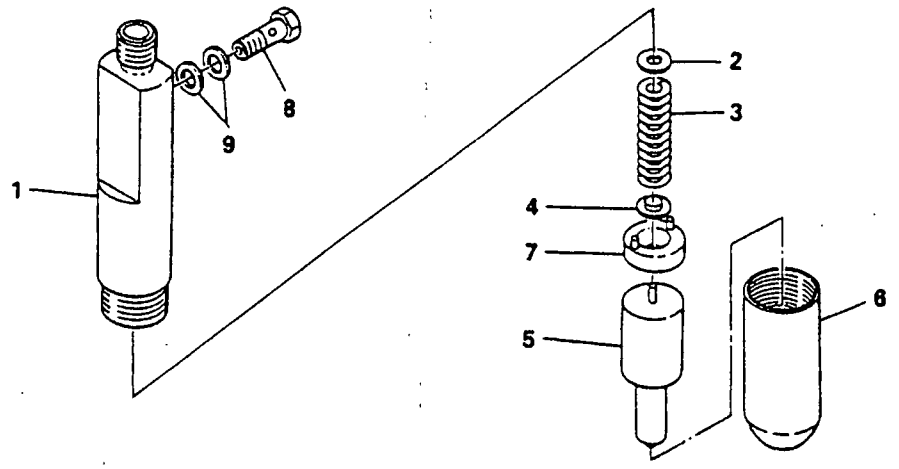
With the thermostat valve fully open, immerse the thermostat in water at normal room temperature. The valve should close within five (5) minutes.

Figure 3. Testing the Thermostat



Section 2.9- FUEL INJECTION NOZZLES

Figure 1. Injection Nozzle



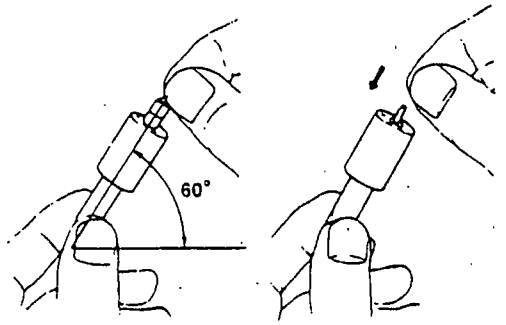
1. Nozzle holder assembly
2. Shim
3. Pressure spring
4. Nozzle holder pressure pin
5. Nozzle
6. Nozzle retaining nut
7. Distance piece
8. Joint bolt
9. Plain washer

Checking Needle Valve Movement

Test the needle valve for freedom of movement as follows:

1. Wash the nozzle in diesel fuel.
2. Immerse the nozzle in diesel fuel.
3. Slide the needle inside the nozzle and check that it moves smoothly.
   a. With the nozzle held at a 60° angle (Figure 2), the needle valve should fall under its own weight when withdrawn vertically about 1/3 of the distance and released.
   b. If needle valve movement is sluggish, the nozzle should be replaced.

Figure 2. Checking Needle Valve Movement



Adjustment of Injection Pressure

1. See Figure 3. Connect a nozzle tester to the nozzle. Then, actuate the tester lever at a rate of about 50 to 60 times per minute. Fuel injection should occur at the correct pressure.

INJECTION PRESSURE
3129 psi (220 kg/cm²)

2. If injection pressure is not within specification, change the adjusting shim (see Figure 4).

Figure 3. Checking Injection Pressure

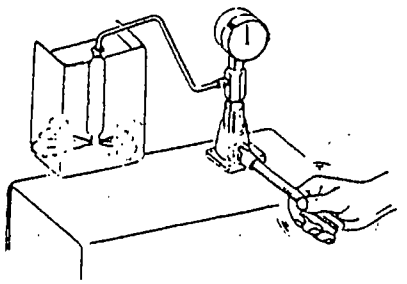
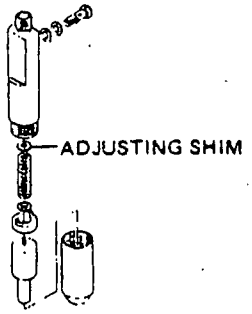


Figure 4. Injection Pressure Adjusting Shim

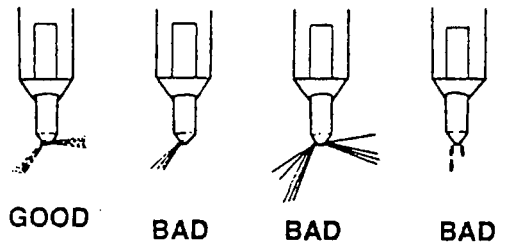


Testing the Spray Pattern

For a NEW nozzle, operate the nozzle tester lever at a rate of about 30 to 60 strokes per minute. If nozzle is USED, actuate the tester lever at about 15 to 60 strokes per minute. Spray pattern should be "GOOD" as shown in Figure 5 on next page.

Testing the Spray Pattern (Continued)

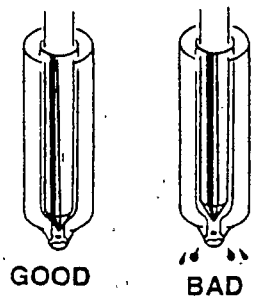
Figure 5. Spray Pattern Test



Testing for Leakage

Use a nozzle tester to apply a pressure of about 2841 psi (200-210 kg/cm^2) to the injection nozzle. There must be no fuel leakage.

Figure 6. Nozzle Leakage Test



Part 3

TURBO-CHARGER

4.0 Liter

DIESEL ENGINE

Models 40DT & 40DTA

TABLE OF CONTENTS

Section 3.1- TURBOCHARGER FAMILIARIZATION

DANGER: TURBOCHARGERS OPERATE AT EXTREMELY HIGH SPEEDS AND TEMPERATURES. DO NOT OPERATE THE ENGINE UNLESS ALL INLET AND EXHAUST PIPING IS PROPERLY INSTALLED. OPERATION OF THE ENGINE WITH PIPING AND OTHER COMPONENTS REMOVED COULD RESULT IN PERSONAL INJURY AND/OR DAMAGE TO THE ENGINE-GENERATOR.

Note: When fasteners are removed from any part of the turbocharger system, always reinstall them in the same location from which they were removed. If any fastener requires replacement, use the correct part number for the application. If the correct part number is NOT available, a fastener of equal size and strength (or stronger) may be used. When installing any fastener for which a torque value is called out, those fasteners must be tightened properly.

Turbocharger Operation

A turbocharger is used to increase the volume of air that enters the engine cylinders. The increase in air volume permits a proportional increase in the ratio of fuel to be injected into the cylinders and offers the following benefits:

- ☐ Increased engine power output.
- ☐ More complete combustion of the fuel.
- ☐ Cooling of the cylinder head, pistons, valves and exhaust gases which, in turn, extends engine life.

Heat energy and pressure in the engine exhaust gases are used to drive the turbocharger turbine. Heated gases from the exhaust manifold are directed upward into the turbocharger housing. The housing acts as a "nozzle" to direct the flow of exhaust gases against the turbine wheel. This imparts a spinning motion to the turbine wheel and to a turbine shaft. A compressor, attached to the opposite end of the turbine shaft, will then spin at the same speed as the turbine.

Air from the engine air cleaner is drawn into the compressor wheel. The compressor wheel compresses the air and delivers it to the engine's air intake manifold

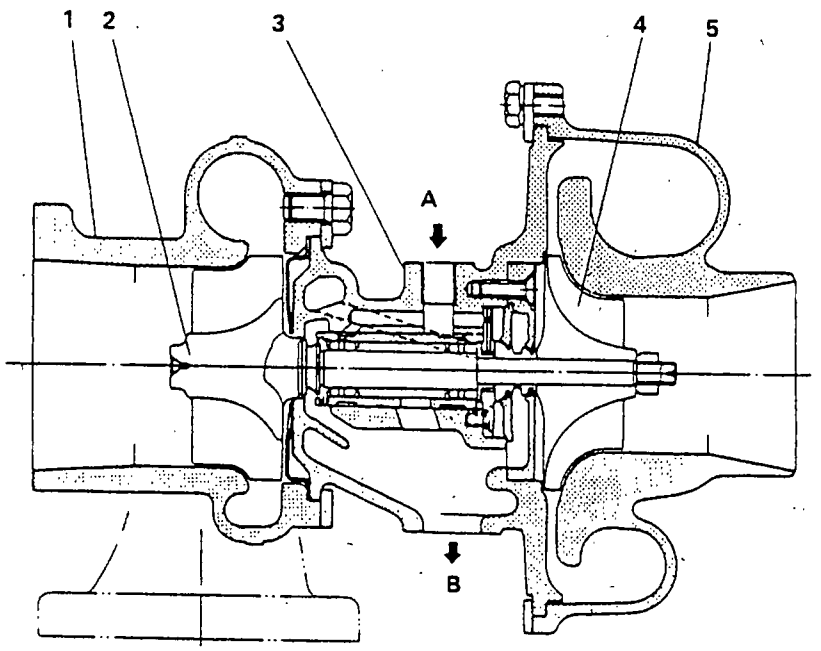
Exhaust gases that imparted the spinning motion to the turbine flow out of the turbocharger, through the exhaust piping and muffler, and into the atmosphere.

Turbocharger Lubrication

The turbocharger's turbine and compressor bearings are lubricated by engine oil. Oil enters the turbocharger at the top oil inlet fitting. After lubricating the bearings, the oil is returned to the engine via an oil return line.

NOTE: Newly installed turbochargers and installed turbochargers that have been idle for a long time should be pre-oiled before the engine is cranked and started. This can be done by disconnecting the oil inlet line and pouring engine oil into the turbocharger.

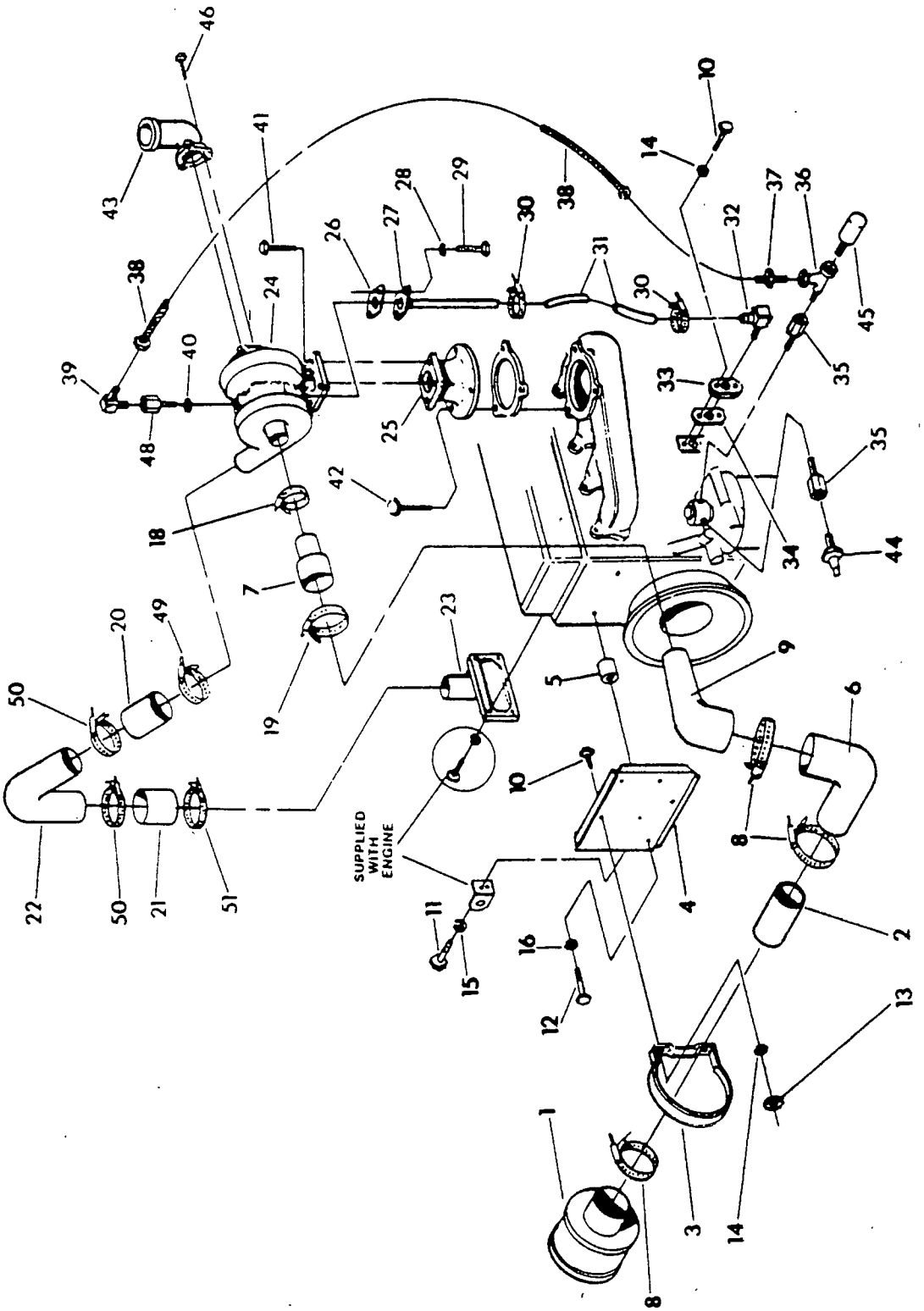
Figure 1. Turbocharger



1. Turbine case
2. Turbine rotor
3. Bearing case
4. Blower impeller
5. Blower case

A: Oil inlet
B: Oil outlet

Figure 2. Exploded View of Turbocharger System (Typical)



Drawing No. 90795

Parts List for Figure 2

ITEM	QTY	DESCRIPTION		ITEM	QTY	DESCRIPTION
1	1	Air Cleaner		26	1	Oil Return Line Gasket
2	1	Steel Tube		27	1	Oil Return Line
3	1	Air Cleaner Strap		28	2	M6 Lockwasher
4	1	Air Cleaner Mounting Bracket		29	2	M6-1.00 x 16mm Capscrew
5	2	Spacer		30	2	Hose Clamp
6	1	90° Reducer Elbow		31	1	5/8" ID Hose
7	1	Reducer Coupling		32	1	90° Barbed Elbow
8	3	Hose Clamp		33	1	Flange Cover
9	1	Inlet Tube		34	1	Gasket
10	2	M8-1.25 x 20mm Capscrew		35	2	Adapter
11	2	M10-1.50 x 16mm Capscrew		36	1	1/8" NPT Tee Fitting
12	2	M12-1.75 x 45mm Capscrew		37	1	1/8" NPT Adapter
13	2	M8 Hex Nut		38	1	Oil Inlet Line
14	4	M8 Lockwasher		39	1	90° Elbow
15	2	M10 Lockwasher		40	1	Copper Washer
16	2	M12 Lockwasher		41	4	M8-1.25 x 20mm Capscrew
18	1	Hose Clamp		42	3	M10-1.50 x 20mm Capscrew
19	1	Hose Clamp		43	1	Exhaust Outlet Elbow
20	1	Turbocharger to Manifold Connector		44	1	Low Oil Pressure Switch
21	1	Reducer Coupling		45	3	Oil Pressure Sending Unit
22	1	Reducer Coupling		46	3	M8-1.25 x 20mm Socket Head Capscrew
23	1	Intake Manifold Adapter		47*	1	Intake Manifold Adapter Gasket (For Item 23)
24	1	Turbocharger Assembly		48	1	Adapter
25	1	Turbocharger to Exhaust Manifold Adapter		49	1	High Torque Clamp
				50	2	High Torque Clamp
				51	1	High Torque Clamp

* Item 47 is not shown on the exploded view.

Section 3.2- TURBOCHARGER DIAGNOSIS

Troubleshooting Chart

PROBLEM	POSSIBLE CAUSE	CORRECTION
Engine lacks power	1. Restricted air cleaner. 2. Obstructed air intake duct to turtbocharger compressor wheel. 3. Air leak in compressor wheel inlet/outlet duct. 4. Obstructed intake manifold. 5. Air leak between intake manifold and engine. 6. Restricted exhaust system. 7. Exhaust gas leakage between cylinder head exhaust ports and turbine inlet. 8. Turbocharger center housing siudged or coked. 9. Turbocharger is damaged. 10. Fuel system problem.	1. Clean or replace air cleaner. 2. Remove obstruction(s). 3. Check inlet/outlet ducts for loose connections. Tighten connections and/or replace damaged duct work. 4. Inspect manifold & remove obstructions. 5. Locate and repair. 6. Locate and remove obstruction. 7. Repair leaks. 8. Replace turbocharger and change engine oil and oil filter. 9. Locate and correct cause of damage. Replace turbocharger, if necessary. 10. Refer to correct section.
Turbocharger noise	1. Restriction and/or leak in the compressor inlet ducting and/or outlet ducting. 2. Rotating parts of turbocharger are out-of-balance. 3. Compressor and/or turbine are contacting the housing.	1. Inspect ducting and remove any restrictions. Tighten connectors and replace any damaged duct work. 2. Replace the turbocharger. 3. Find reason for damage and replace the turbocharger.
Black exhaust smoke	1. Lack of intake air causing improper fuel/air ratio.	1. Refer to "Engine lacks power".
Blue exhaust smoke	1. Lack of intake air. 2. Restricted oil return tube. 3. Oil leakage past turbine side seal. 4. Oil leakage past the compressor side seal.	1. See "Engine lacks power". 2. Clean or replace oil return tube. 3. Replace the turbocharger. 4. Replace the turbocharger.
Abnormal oil consumption	1. See "Blue exhaust smoke".	1. See "Blue exhaust smoke".

Inspection

GENERAL:

Turbochargers are typically very reliable units. Most problems with the turbocharger are caused by dirty oil, inadequate flow of oil, foreign object damage to the turbocharger, and plugged or restricted air cleaner systems.

Low engine power, black smoke , blue smoke (excess oil consumption), and other performance problems are often blamed on the turbocharger when the actual fault lies with some other engine part. For that reason, the turbocharger should not be replaced until (a) the turbocharger has been thoroughly inspected, and (b) other possible causes of a problem are investigated. The following steps and the preceding "Troubleshooting Chart" will aid in helping diagnose problems caused by a turbocharger. If it is determined that the turbocharger is the cause of a problem, it must be replaced. Servicing of the turbocharger is NOT recommended.

LISTEN:

- A high pitched whine may indicate an exhaust leak or a leak in the air intake system.
- A cycling up and down in pitch often indicates blockage in the air intake ducting, a restricted air cleaner, or a buildup of dirt on the turbocharger compressor wheel.
- A sharp, high pitched scream may indicate that the turbocharger bearings have deteriorated and one (or both) of the wheels is rubbing on the housing.

Inspection (Continued)

LOOK:

- Inspect the compressor wheel. There should not be any bent, broken, cracked or eroded wheel blades. See Figures 1, 2, 3 and 4.
- Carefully inspect the turbocharger housing for evidence of rubbing.
- Check the compressor wheel for buildup of dirt.
- Check for oil leakage into the turbocharger housing.

Some possible causes of excessive oil leakage into the turbocharger housing are:

1. Obstructed air intake ducting or a clogged air cleaner.
2. A plugged or kinked turbocharger oil return line. This is the oil line attached to the bottom of the turbocharger.
3. Sludged oil accumulations in the turbocharger center housing.
4. Damaged turbocharger bearings, turbine wheel or compressor wheel.

FEEL:

DANGER: DO NOT TOUCH ANY TURBOCHARGER COMPONENTS WHILE THE ENGINE IS RUNNING. ROTATING PARTS OF EXTREME HEAT MAY RESULT IN SERIOUS PERSONAL INJURY. MAKE SURE THE TURBOCHARGER HAS STOPPED TURNING AND THE TURBOCHARGER AND ENGINE HAVE COOLED DOWN BEFORE HANDLING ANY OF THESE COMPONENTS.

- Grasp the turbocharger's compressor wheel and rotate the wheel in a clockwise direction. It should turn freely, with no evidence of binding or scraping.
- Rotate the turbocharger wheels while pushing in and out on the compressor wheel. It should rotate freely without contacting the turbocharger housing.
- Grasp the compressor wheel nut and rotate the wheel while moving the wheel up and down. There should be no contact of the compressor wheel with the turbocharger housing.

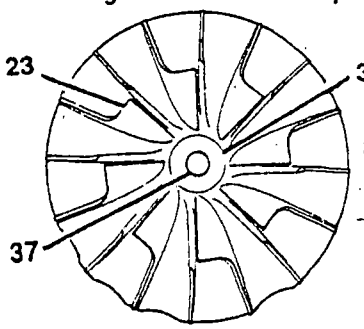
NOTE: Radial and axial play are normal, even on a new turbocharger. Contact of the wheel with the housing will be very evident when rotating the wheel. The wheel will scrape on the housing surface. In addition, visual evidence will probably be seen on the wheel blades and on the housing surface.

ANALYZE THE RESULTS:

If the turbocharger fails any one of the preceding tests or inspections, it should be replaced.

NOTE: If it is determined that the turbocharger is the cause of a problem, it must be replaced. Repair of the turbocharger is NOT recommended.

Figure 1. Normal Compressor Wheel



23. COMPRESSOR WHEEL
36. NUT FACE
37. BORE

Figure 2. Damage by a Soft Object

A. DAMAGED COMPRESSOR WHEEL BLADES
23. COMPRESSOR WHEEL

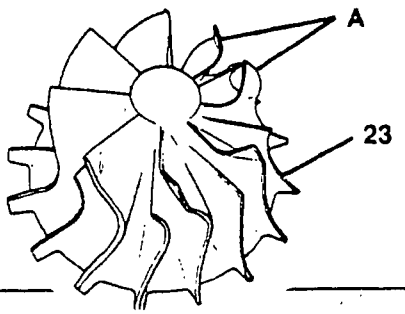


Figure 3. Damage by a Hard Object

8. BLADE DAMAGE FROM FOREIGN MATERIAL
23. COMPRESSOR WHEEL
36. NUT FACE
37. BORE

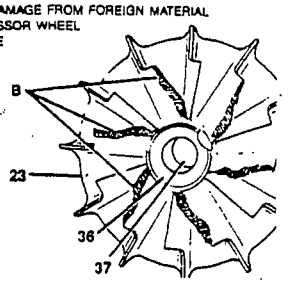
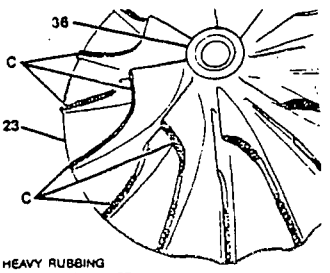


Figure 4. Compressor Blades Show Heavy Rubbing



C. HEAVY RUBBING
23. COMPRESSOR WHEEL
36. NUT FACE

Section 3.3- TURBOCHARGER SERVICE

Pre-Oiling the Turbocharger

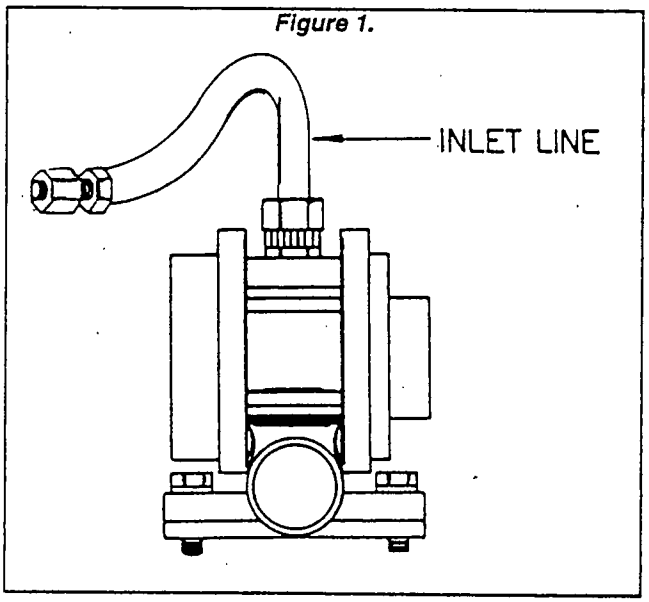
The turbocharger should be pre-oiled if any of the following conditions exist:

- Following installation of a new turbocharger.
- Following the re-installation of a turbocharger that has been removed for any reason.
- If the engine has not been operated for longer than thirty (30) days.

To pre-oil the turbocharger, proceed as follows:

1. Disconnect the turbocharger oil inlet line.
2. Use an oil can to inject engine oil into the turbocharger oil inlet opening. Use the same type and grade of oil that is used in the engine crankcase.
3. Install and tighten the oil inlet line.

Figure 1.



Turbocharger Removal

See Figure 2. To remove the turbocharger, proceed as follows:

1. Remove two clamps (Item 1) and remove the turbocharger to manifold connector (Item 2) .
2. Remove two clamps (Item 3) and remove the reducer coupling (Item 4).
3. Remove three socket head capscrews (Item 5) and remove the exhaust outlet elbow (Item 6).
4. Disconnect the oil inlet line (Item 7) at the turbocharger.
5. Remove the two capscrews (Item 8) and disconnect the oil return line (Item 9) from the turbocharger.
6. Remove four capscrews (Item 10) and remove the turbocharger.

Turbocharger Installation

BEFORE INSTALLATION:

Prior to installing a turbocharger, perform the following:

- Inspect the intake and exhaust piping leading to and from the turbocharger for foreign objects. Be thorough. Even very small pieces of debris can inflict serious damage during high speed turbocharger operation.
- Make sure the turbocharger and exhaust manifold flanges are clean and free of foreign material.
- Use a high temperature anti-seize compound of good quality on all threaded fasteners of the turbocharger (turbocharger mounting bolts and exhaust outlet elbow bolts, Items 5 and 6).
- If the turbocharger to exhaust manifold adapter was removed, use high temperature anti-seize compound on its retaining bolts.

TURBOCHARGER INSTALLATION:

Install the turbocharger in the reverse order of removal. The following tightening torques apply during installation:

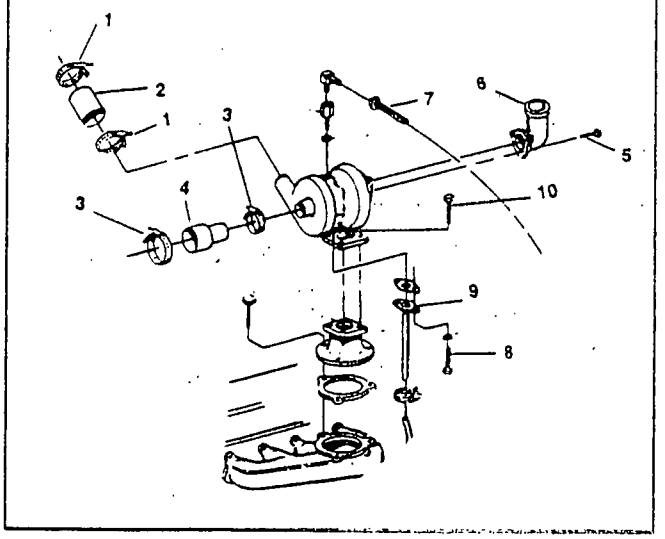
TURBOCHARGER TO EXHAUST MANIFOLD ADAPTER
M10-1.50 Capscrews (3)
Tighten to 37 Ft-Lbs (50 N-m)

TURBOCHARGER MOUNTING BOLTS
M8-1.25 Capscrews (4)
Tighten to 19 Ft-Lbs (26 N-m)

OIL RETURN LINE BOLTS
M6-1.00 Capscrews (2)
Tighten to 13 Ft-Lbs (17 N-m)

EXHAUST OUTLET ELBOW BOLTS
M8-1.25 Socket Head Capscrews (3)
Tighten to 19 Ft-Lbs (26 N-m)

Figure 2. Turbocharger Mounting (Typical)



NOTE: Figure 2 shows typical mounting details only. Some mounting/installation methods may be different, but will be similar.

Part 4

FUEL INJECTION PUMP

4.0 Liter

DIESEL ENGINE

Models 40DT & 40DTA

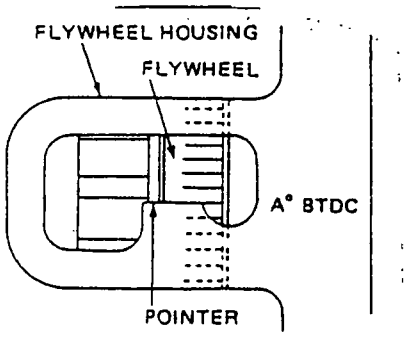
TABLE OF CONTENTS

Section 4.1- PUMP REMOVAL & INSTALLATION

Pump Removal

1. Rotate the crankshaft clockwise as viewed from the timing gear cover side, to align the injection timing marks on the flywheel at 18° BTDC (A°) of No. 1 cylinder's compression stroke.

Figure 1. Aligning Injection Timing

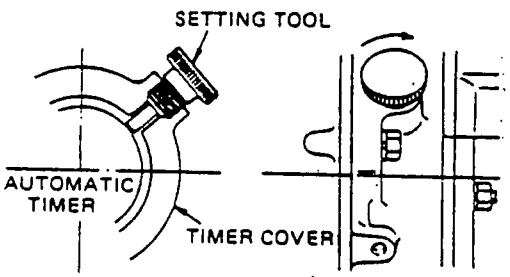


2. Check that the injection timing mark on the automatic timer is aligned with the timer cover pointer. If it is not, adjust the injection timing.

3. Install the timer setting tool.

SPECIAL TOOL
Timer Setting Tool, Reference No. 09512-2090

Figure 2. Timer Setting Tool



NOTE: Do NOT loosen the four bolts of the injection pump drive gear when removing the injection pump.

4. Remove the injection pump assembly.

Pump Installation

1. Check that the injection timing mark on the flywheel is aligned with the flywheel housing pointer. See Figure 1.

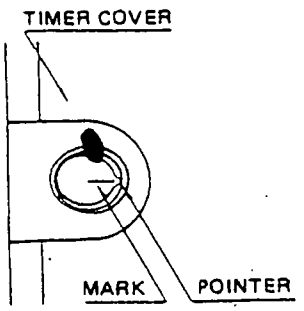
INJECTION TIMING
18° BTDC of No. 1 Cylinder
Compression Stroke

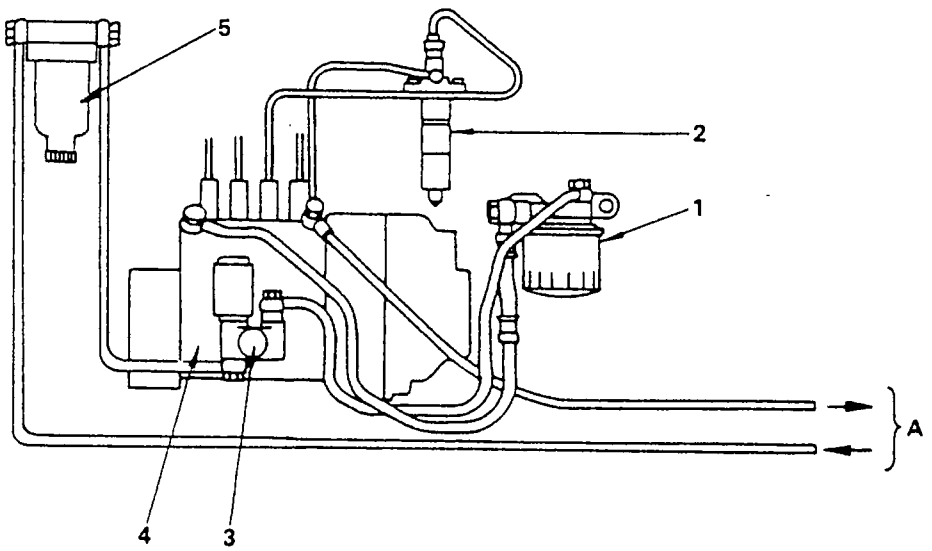
2. Check that the injection timing mark on the automatic timer is aligned with the timer cover pointer. If not, adjust the injection timing using the timer setting tool (Reference No. 09512-2090).

3. Install the injection pump assembly.

4. Remove the timer setting tool.

Figure 3.





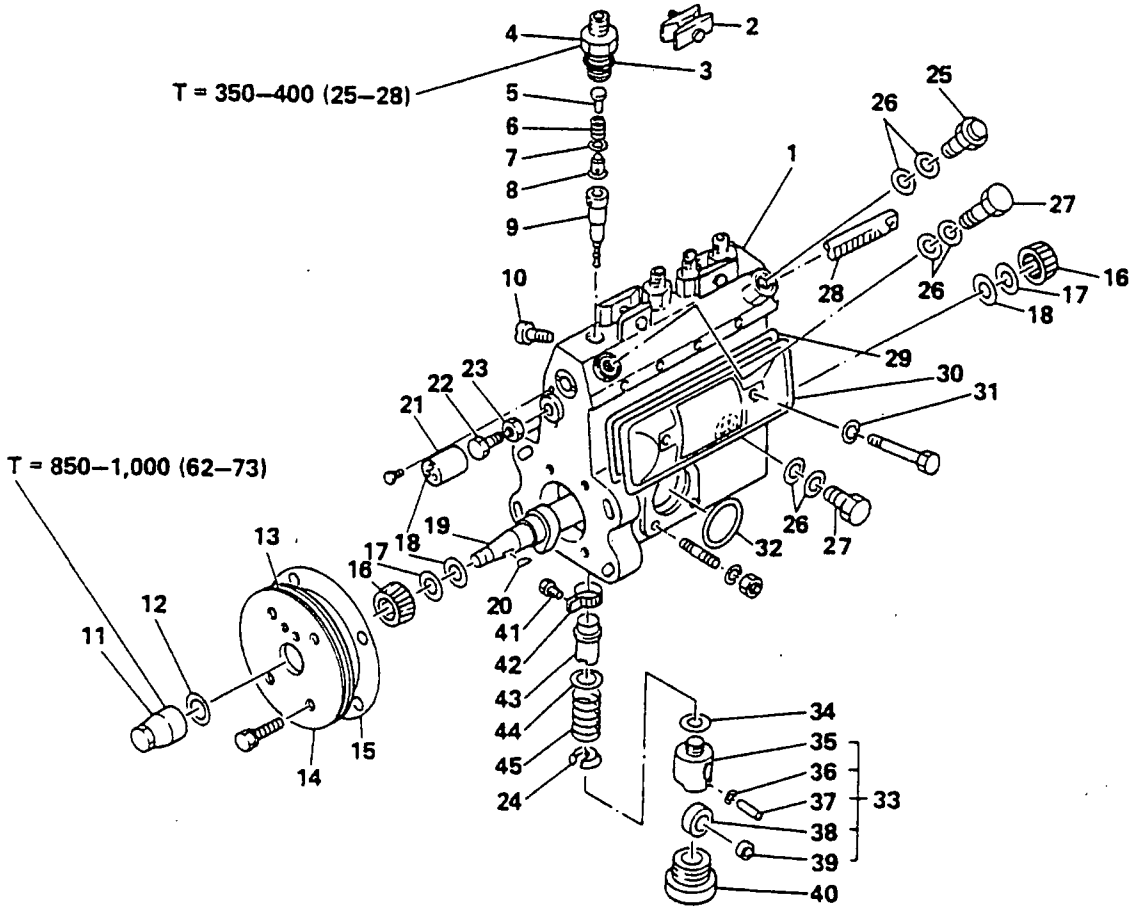
FUEL SYSTEM

1. Fuel Filter
2. Nozzle holder
3. Feed pump
4. Injection pump
5. Water separater (Sedimenter)

A. Fuel tank

Section 4.2- INJECTION PUMP, GOVERNOR, FEED PUMP

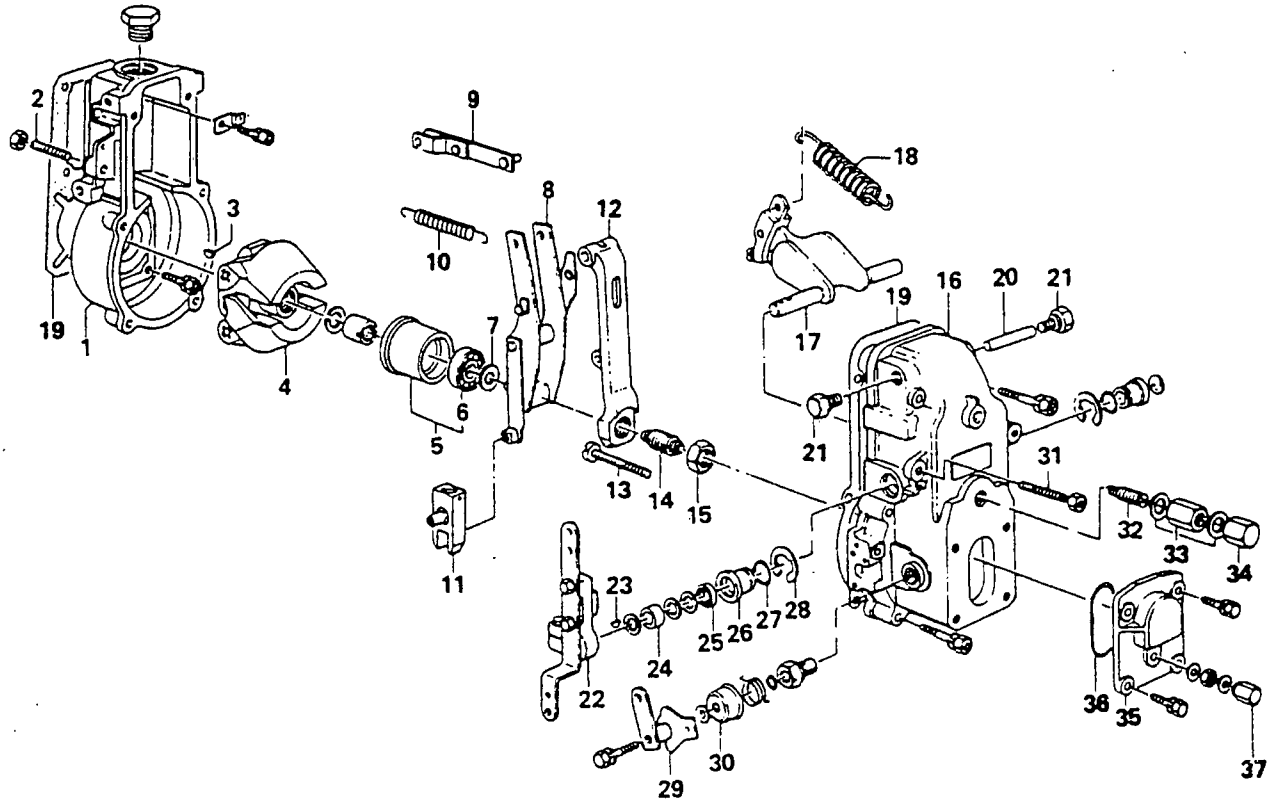
Figure 1. Fuel Injection Pump



T = Tightening torque kg·cm (lb.ft)

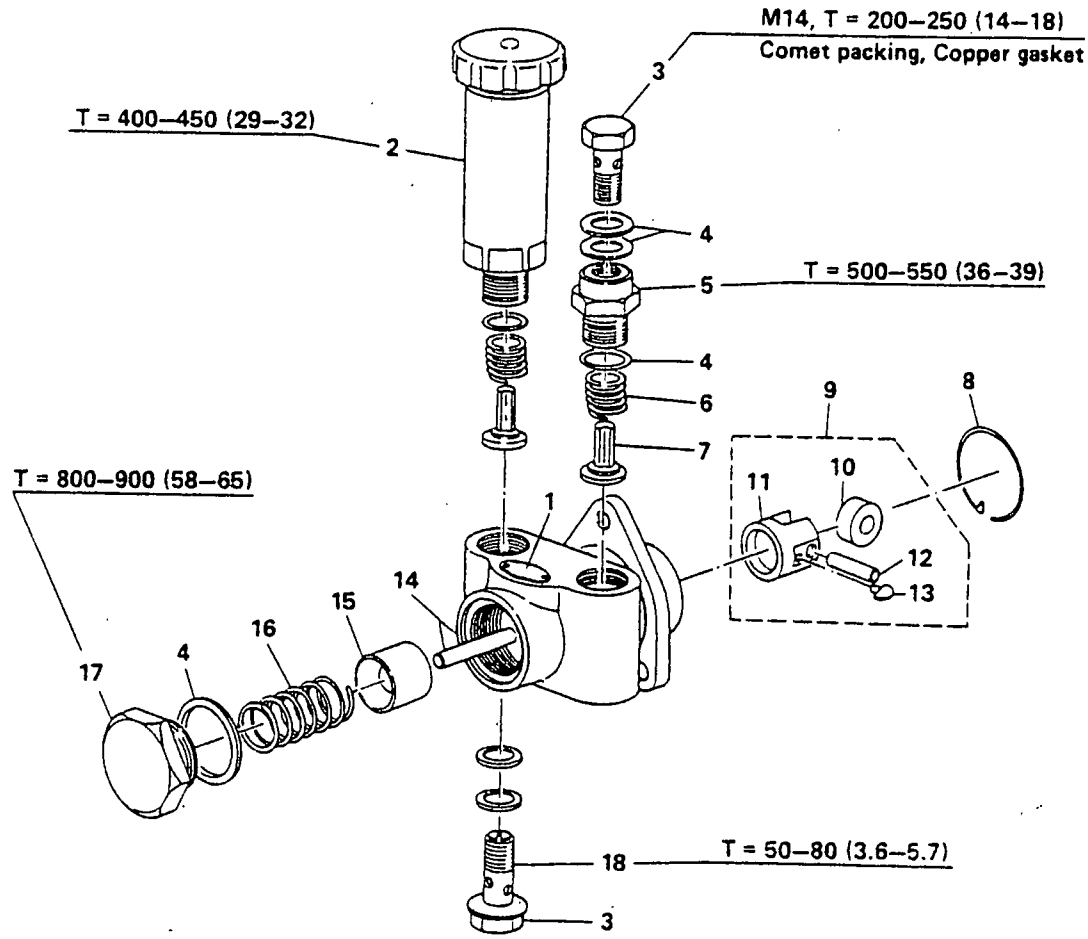
1. Injection pump housing
2. Lock plate
3. O-ring
4. Delivery valve holder
5. Stopper
6. Delivery valve spring
7. Gasket
8. Delivery valve
9. Plunger
10. Screw
11. Nut
12. O-ring
13. O-ring
14. Bearing cover
15. Gasket
16. Taper roller bearing
17. Shim
18. Adjusting ring
19. Camshaft
20. Woodruff key
21. Control rod cover
22. Bolt
23. Nut
24. Plunger spring seat, lower
25. Overflow valve sub-assembly
26. Special washer
27. Joint bolt
28. Control rod
29. Cover gasket
30. Cover
31. Plain washer
32. O-ring
33. Tappet assembly
34. Shim
35. Tappet
36. Retainer ring
37. Tappet roller pin
38. Tappet roller
39. Roller bushing
40. Plug
41. Screw
42. Control pinion
43. Control sleeve
44. Plunger spring seat, upper
45. Plunger spring

Figure 2. Governor



1. Governor housing
2. Stopper bolt
3. Woodruff key
4. Flyweight
5. Sleeve
6. Bearing
7. Shim
8. Guide lever assy
9. Link
10. Start spring
11. Supporting lever
12. Tension lever
13. Full load stopper
14. Idling spring
15. Lock nut
16. Governor cover
17. Swivel lever
18. Governor spring
19. Gasket
20. Pin
21. Plug
22. Control lever
23. Woodruff key
24. Coller
25. Oil seal
26. Bush
27. O-ring
28. Snap ring
29. Stop lever
30. Cap
31. Idle stopper bolt
32. Idling sub spring
33. Nut
34. Cap nut
35. Closing cover
36. O-ring
37. Cap nut

Figure 3. Feed Pump



T = Tightening torque: kg·cm (lb.ft)

1. Feed pump serial No.
2. Priming pump
3. Joint bolt
4. Gasket
5. Connector
6. Check valve spring
7. Check valve
8. Retainer ring
9. Tappet assembly
10. Roller
11. Tappet
12. Pin
13. Sliding block
14. Feed pump housing, push rod & oil seal
15. Piston
16. Spring
17. Plug
18. Filter

Section 4.3- INJECTION PUMP ADJUSTMENT

General

This section will outline the correct procedures for adjustment of the injection pump and governor with the pump installed on an injection pump tester.

WARNING

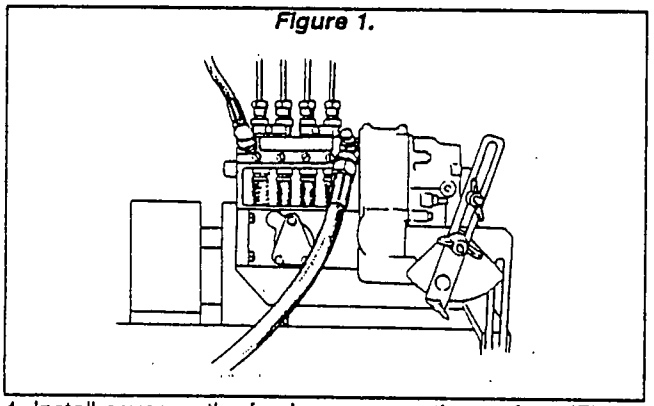
The lead seals and crimp caps on the injection pump should be broken only by Generac authorized service stations or by service stations authorized by the injection pump manufacturer. If injection pump or governor problems are suspected, consult with Generac authorized service facilities or service facilities authorized by the injection pump manufacturer. Service facilities authorized by Generac or by the pump manufacturer can correct the problem(s) and reinstall lead seals and crimp caps as required.

Adjustments on a Pump Tester

INITIAL SETUP:

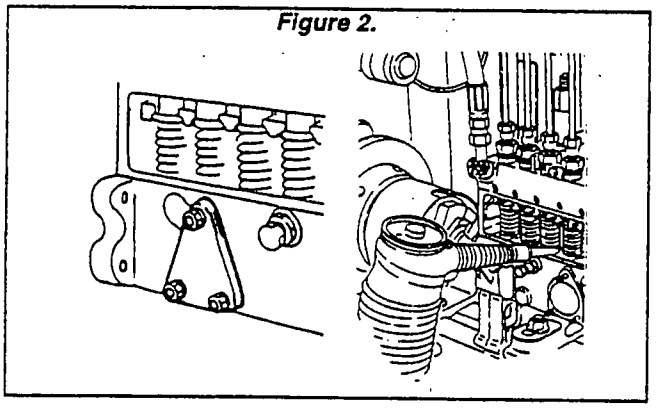
1. Mount the fuel injection pump on an injection pump tester.
2. Attach a rack measuring device to the control rack and set it at "0".
3. Install calibration nozzles and lines (see chart in Section 4.5, "CALIBRATION").

Figure 1.



4. Install cover on the feed pump mounting surface (Figure 2). Fill the pump camshaft chamber and governor chamber with engine oil.

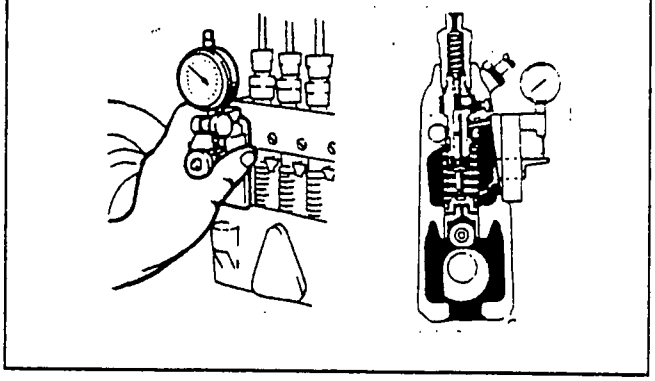
Figure 2.



ADJUSTING INJECTION TIMING:

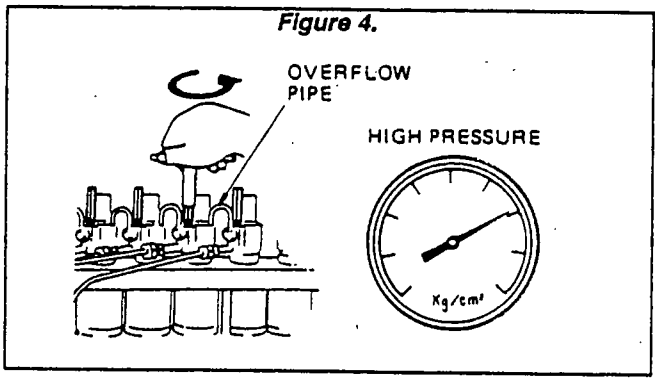
1. Prepare to measure PRE-STROKE as follows:
   a. Remove the plate cover.
   b. Install the pre-stroke measuring instrument.
   c. Bring the tappet of the first cylinder to its bottom dead center (B.D.C.) and set the pointer tip on the tappet.

Figure 3.



2. Measure the pre-stroke of No. 1 plunger as follows:
   a. Set the control rack at "Full Load" position.
   b. Loosen the overflow screw of each nozzle holder.
   c. Operate the pump tester's high pressure pump and allow fuel to run out of the overflow line.

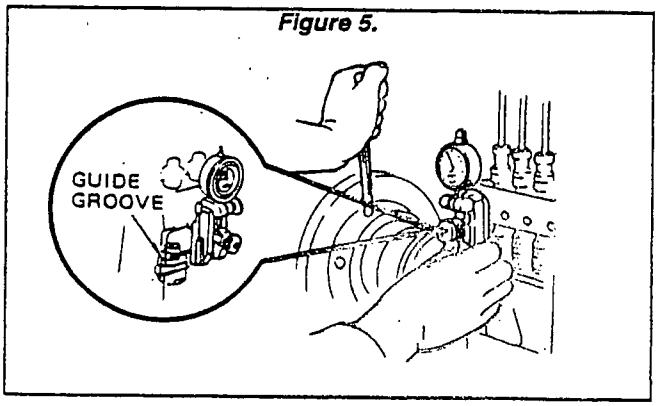
Figure 4.



   d. Move the angle dial to set the pump's first cylinder to bottom dead center (B.D.C.) and adjust the pre-stroke gauge to zero.

NOTE: Bottom dead center is the point at which the pointer of the dial gauge does not move, even when the angle dial is rotated while fuel is flowing from the overflow line.

Figure 5.

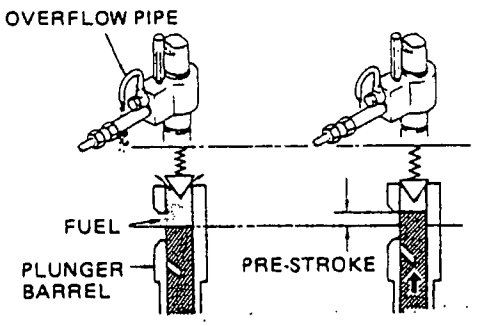


ADJUSTING INJECTION TIMING (CONT'D):

e. Turn the camshaft clockwise with the angle dial and read the dial gauge when fuel stops running out of the overflow line. This reading is the "Pre-Stroke" value of the pump.

PRE-STROKE
0.122 Inch (plus or minus 0.0011 Inch)
(3.1mm (plus or minus 0.03mm)

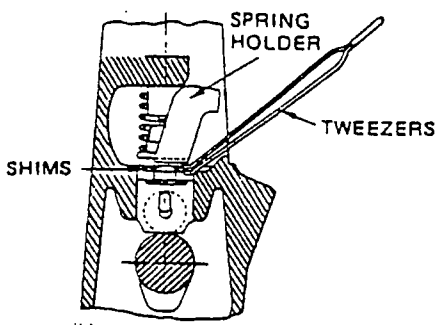
Figure 6.



f. If the pre-stroke value obtained is not within the stated specification, adjust by changing the tappet adjusting shim.

SPECIAL TOOL
Spring Holder, Reference No. 09512-1370

Figure 7.



ADJUSTING INJECTION INTERVAL:

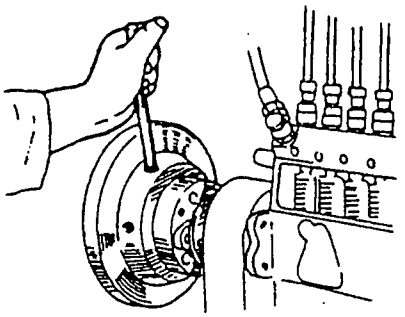
1. Using the No. 1 cylinder's injection starting point as a base, inspect and adjust the injection interval in the given injection order. See Figure 8.

INJECTION INTERVAL
89° 45' to 90° 45'

INJECTION ORDER
1-3-4-2

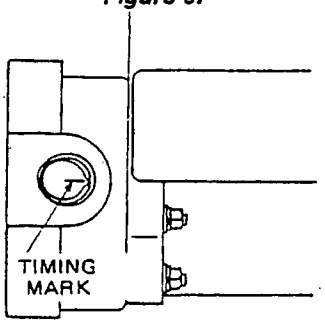
2. If the injection intervals are not within specifications, adjust by using the same procedure as for pre-stroke adjustment (Figure 7).

Figure 8.



3. Set the No. 1 cylinder at the injection starting point. Check that the marks on the timer and pump body are aligned. If they are NOT aligned, make a new mark on the timer and erase the old mark. See Figure 9.

Figure 9.



CHECK TAPPET CLEARANCE:

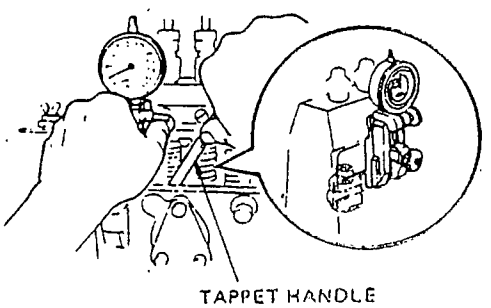
1. See Figure 10, below. Set the No. 1 cylinder at top dial center point, then move the tappet with the handle.

TAPPET TOP CLEARANCE
0.0079 Inch (0.2mm)

SPECIAL TOOL
Tappet Handle, Reference No. 09512-1410

2. Check the other cylinders (No. 2 through No. 4).
3. If tappet clearance is less than 0.0079 inch (0.2mm), recheck the pre-stroke.

Figure 10.

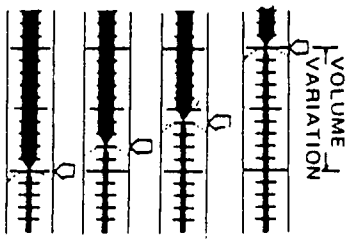


CHECK/ADJUST INJECTION VOLUME:

Measure the injection volume for each control rack position and pump revolution.

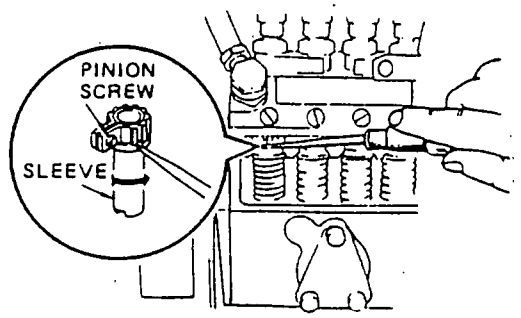
INJECTION VOLUME
See Section 4.5, "CALIBRATION"

Figure 11.



To adjust injection volume, loosen the pinion screwand insert the adjusting pin into the hole in the control sleeve. Then, move the sleeve slightly.

Figure 12.



Section 4.4- GOVERNOR ADJUSTMENT

Introduction

This section will cover adjustment of the diesel engine governor under the following conditions:

- With the unit Installed on a pump tester.
- With the with the unit installed on the engine.

> ***Important***
> ***Adjusting devices on the injection pump governor are wired and lead sealed as a protection for the customer. This helps prevent unauthorized readjustment which might result in engine malfunction and/or engine failure. Periodically check that these seals are not broken.***

Testing and adjustment of the governor will be done in the following sequence. The values of "N" and "R" will be given in the appropriate adjustment procedure, as well as in Section 4.5, "CALIBRATION".

- Adjustment of medium speed control.
- Adjustment of maximum speed control.
- Adjustment of speed droop.

Adjustments with Unit on a Pump Tester

PREPARATION:

1. Connect the rack measuring device to the control rack and set to "0".
2. Connect the fuel line.
3. Refill the camshaft chamber with engine oil.
4. Install the angle gauge on the adjusting lever.

NOTE: Before testing the governor on the test stand, adjust the injection timing and fuel delivery quantity (Section 4.3).

ADJUSTING MEDIUM SPEED CONTROL:

See Figure 2. Adjust the medium speed control as follows:

1. Make sure the control lever is in its "Full Load" position.
2. At a pump speed of "Na" (600 rpm), adjust the rack position "Ra" (7.6 plus or minus 0.2mm) with the FULL LOAD STOPPER BOLT.
3. Adjust the IDLING SPRING as follows:

a. Operate the pump at Na rpm (300 rpm) and adjust the IDLING SPRING so the rack position will start moving from the full load position.

b. When the rack starts to move from its full load position, secure the idling spring stop nut.

NOTE: See Section 4.5. Rod position at 300 rpm should be 10.6 (plus or minus 0.3) mm. Rod position at 400 rpm should be 9.6 (plus or minus 0.3) mm.

ADJUSTING MAXIMUM SPEED CONTROL:

See Figure 3. At a pump speed of "Nb" rpm (900 rpm), adjust the rod position to 6.4 mm (plus or minus 0.2mm) with the MAXIMUM SPEED STOPPER BOLT (Figure 1). The control rack should start to be pulled.

Figure 1. Governor Adjustments

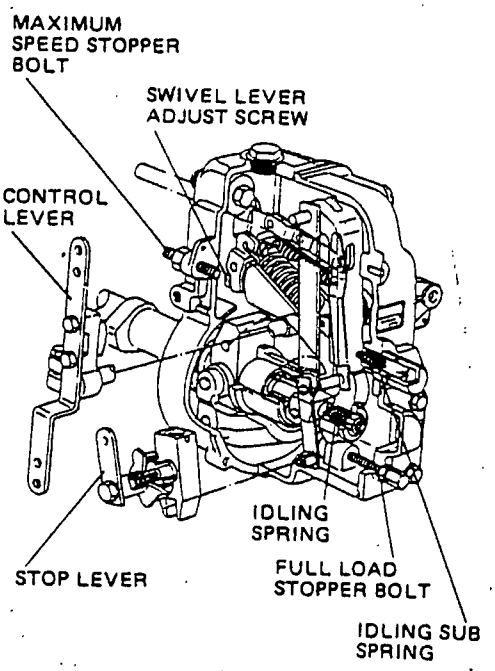


Figure 2. Medium Speed Control Adjust

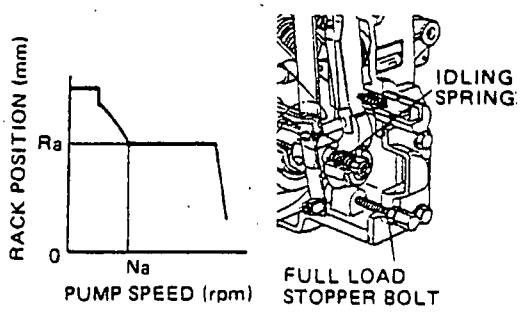
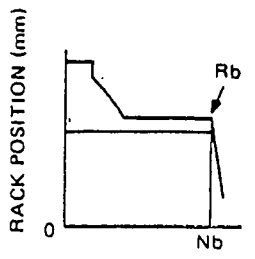


Figure 3. Maximum Speed Control



SPEED DROOP ADJUSTMENT:

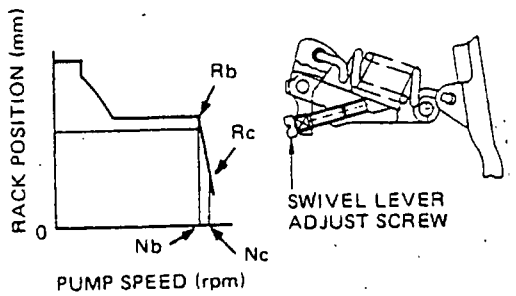
See Figures 1 and 4. At a pump speed of 940 rpm, rod position should be 6.4 mm (plus or minus 0.2). If rod position is not correct , adjust the SWIVEL LEVER ADJUSTING SCREW.

Adjustments with Unit on a Pump Tester (Continued)

SPEED DROOP ADJUSTMENT (CONT'D):

NOTE: After adjusting the SWIVEL LEVER ADJUSTING SCREW, readjust the MAXIMUM SPEED STOPPER BOLT. Then, check that the control lever angle is correct as specified in the "CALIBRATION CHART".

Figure 4.



At a pump speed of "Nd" rpm (940 rpm), adjust the rack position to 4.5mm (plus or minus 0.2) with the IDLING SUB-SPRING (Figure 5).

CAUTION: Do NOT turn the IDLING SUBSPRING too far. If turned too far, the no-load maximum speed will increase and overrun will occur.

Figure 5. Idling Subspring

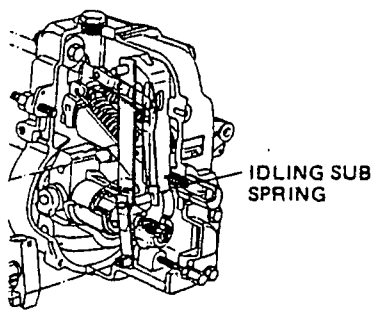
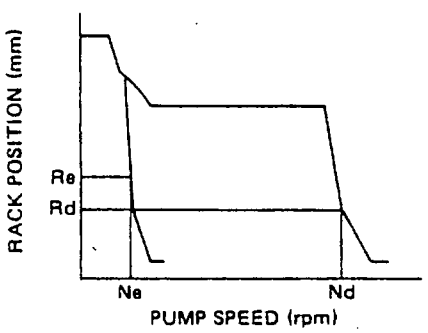


Figure 6. Rack Position Vs. Pump Speed



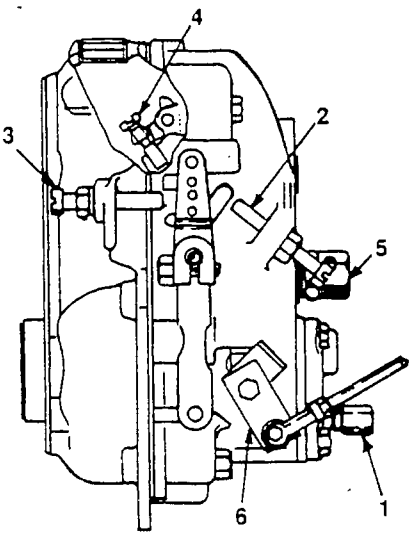
Adjustments- Unit Mounted on Engine

INTRODUCTION:

See Figure 7. The governor provides the following adjustments:

- Item 1, Full Load Stopper Bolt.
- Item 2, Stop Adjust Screw.
- Item 3, Maximum Speed Stopper Bolt.
- Item 4, Swivel Lever Adjust Screw.
- Item 5, Idling Subspring.
- Item 6, Stop Lever.

Figure 7.



FULL LOAD STOPPER BOLT:

Use this stopper bolt to eliminate excessive rpm and frequency droop when electrical loads are applied to the generator. If generator AC output frequency drops too low when the generator's rated maximum load is applied, remove the cap and turn the adjust screw in (clockwise) to increase control rod travel as follows:

NOTE: It is assumed that the engine is being used to drive an AC generator. In this type of application, the generator's AC output frequency becomes an indicator of engine-generator operating speed. On AC generators rated 60 Hertz, that frequency will be obtained at 1800 rpm (units with 4-pole rotor); or at 3600 rpm (units with 2-pole rotor). If rated 50 Hz, that speed will be obtained at 1500 rpm (4-pole rotor); or 3000 rpm (2-pole rotor).

1. With the engine-generator set running at its correct no-load rated AC frequency, apply an electrical load to the generator set equal to the unit's rated capacity.
2. With the rated load applied to the generator, turn the stopper bolt in (clockwise) to increase AC frequency. Then, turn the bolt out (counterclockwise) until AC frequency starts to drop off.
3. Finally, turn the stopper bolt in (clockwise) to recover frequency. The full load AC frequency should be 59-60 Hz (never below 58 Hz).

STOP ADJUST SCREW:

Use this screw to establish a governed no-load speed equal to the unit's rated no-load speed and the rated AC frequency of the generator set.

MAXIMUM SPEED SCREW:

Adjustment of this screw should not be required on an installed pump.

GOVERNOR ADJUST SCREW:

Normally, this screw will require adjustment only on new replacement fuel injection pumps. Adjust the screw with the engine shut down as follows:

1. Remove the engine intake adapter to gain access to the adjust screw.
2. Back the full load adjust screw (Item 1) all the way out (counterclockwise).
3. Move the stop lever (Item 6) to the right (shutdown position) to allow adjustment of the governor adjust screw.
4. Turn the governor adjust screw in (clockwise) for better and more stable governing.

NOTE: The GOVERNOR ADJUST SCREW (Item 4) is adjusted by counting the number of "clicks" as the screw is turned. There is no hard and fast rule as to the number of clicks that will provide optimum, stable governing. After adjustment, start the engine and let it run at the unit's rated no-load speed. If governing is unstable, shut engine down and adjust the GOVERNOR ADJUST SCREW in (clockwise) one or two clicks. Restart the engine, let it run at rated no-load speed and check agains for unstable governing. Continue this process until stable governing is obtained. If governing is unstable at no-load but instability occurs when partial loads are applied, turn the screw out (counterclockwise) to eliminate the problem.

IDLING SUBSPRING:

Idle speed is increased by turning the subspring screw (Item 5) clockwise. This adjustment should never be needed in the field. If the screw is turned in too far, maximum governed rpm will be changed.

STOP LEVER:

An electrically actuated fuel solenoid is connected to the STOP LEVER. Movement of the STOP LEVER to the right will terminate fuel flow and engine shutdown will occur. Proper adjustment of the solenoid linkage is critical. When the solenoid is de-energized, positive fuel shutoff must occur. Conversely, when the solenoid energizes, fuel flow must be positively turned on.

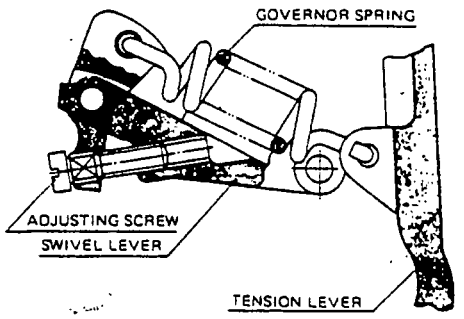
Installed Governor Adjustment Procedure

1. If necessary, bleed air from the fuel system.
2. Start the engine, let it warm up for a few minutes at no-load.
3. With engine running at no-load, turn the STOP ADJUST SCREW (Figure 7, Item 2) to obtain correct no-load AC frequency.

IF ENGINE SPEED IS ERRATIC OR HUNTING OCCURS, GO TO STEP 4. IF NOT ERRATIC, GO TO STEP 5.

4. If hunting or erratic operation occur at no-load governed speed, adjust the SWIVEL LEVER ADJUST SCREW (Item 4) as follows:
   a. Stop the engine.
   b. Turn the STOP ADJUST SCREW (Item 2) all the way out.
   c. Remove the engine air intake adapter, to gain access to the SWIVEL LEVER ADJUST SCREW.
   d. At top of the governor housing, remove the plug to gain access to the SWIVEL LEVER ADJUST SCREW (Item 4).
   e. Hold the STOP LEVER (Item 6) all the way to its right. Then, insert a screwdriver into the access hole and turn the SWIVEL LEVER ADJUST SCREW in about four (4) clicks.
   f. Install and tighten the plug into the access hole.
   j. Turn the STOP ADJUST SCREW (Item 2) back to its original position.
   k. Start the engine, let it warm up. If hunting or erratic operation is present, repeat Steps (a) through (j).
   l. Continue the above procedure until hunting or erratic operation are no longer present.

Figure 8. Swivel Lever Adfjust Screw



5. With engine running at its correct no-load speed, apply a light electrical load then increase the load gradually, in increments of about 10 percent. If hunting or erratic operation occur under light loading, it will be necessary to adjust the SWIVEL LEVER ADJUST SCREW (repeat Step 4).
6. With the engine running at its correct rated no-load speed, apply electrical loads equal to 100 percent of the AC generator's rated wattage/amperage capacity.
   a. With generator running at its full rated load, check the generator's AC output frequency. Reading should not be less than about 59-60 Hertz.
   b. If reading is about 59-60 Hertz at full rated load, no further adjustment is necessary.
   c. If reading is less than 58 Hertz, go on to Step 7.
7. If the AC frequency (engine speed) is low, adjust the FULL LOAD STOPPER BOLT as follows:
   a. Remove the cap from the FULL LOAD STOPPER BOLT.
   b. With engine running and full rated load applied, turn the FULL LOAD STOPPER BOLT clockwise until the speed increases as close to 60 Hertz as possible. Then, back the screw out until speed (AC frequency) just starts to drop off. Finally, turn the SCREW clockwise until speed (frequency) recovers.
   c. When engine is running at its best speed (frequency) under full rated load, install the cap over the STOPPER BOLT.

NOTE: The engine speed (frequency) obtained under full rated load should be as close as possible to the unit's rated speed (frequency). This manual assumes that the engine is being used to drive an AC generator. Rated speed of a 60 Hertz AC generator with 4-pole rotor is 1800 rpm (60 Herz; for a 50 Hertz AC generator with 4-pole rotor is 1500 rpm (50 Hertz). Rated speed of a 60 Hertz AC generator with 2-pole rotor is 3600 rpm (60 Hertz); for a 50 Hertz unit with 2-pole rotor is 3000 rpm (50 Hertz).

Section 4.5- CALIBRATION

TEST CONDITION

Turning direction	Right hand seen from drive side	Injection order	1–3–4–2	Injection interval	90° ± 30′
Pre-stroke	3.1 ± 0.03	Tappet clearance	More than 0.2 mm	Camshaft clearance	0.03 – 0.05 mm
Nozzle valve opening pressure	175 kg/cm³			Injection timing	B.T.D.C.
Oil temperature	40 – 45° C	Calibration nozzle		12SD12	

INJECTION RATE ADJUSTMENT

Pump speed	Rod position	Injection volume		Unequal volume	
900 r.p.m.	6.4 mm	8 ± 0.4 cc (200 stroke)	40 ± 2 mm³/rev.cyl	≦ 0.004 cc/st.cyl	≦ 4 mm³/rev.cyl
350 r.p.m.	about 3.0 mm	4.5 ± 0.5 cc (500 stroke)	9 ± 1 mm³/rev.cyl	≦ 0.003 cc/st.cyl	≦ 3 mm³/rev.cyl

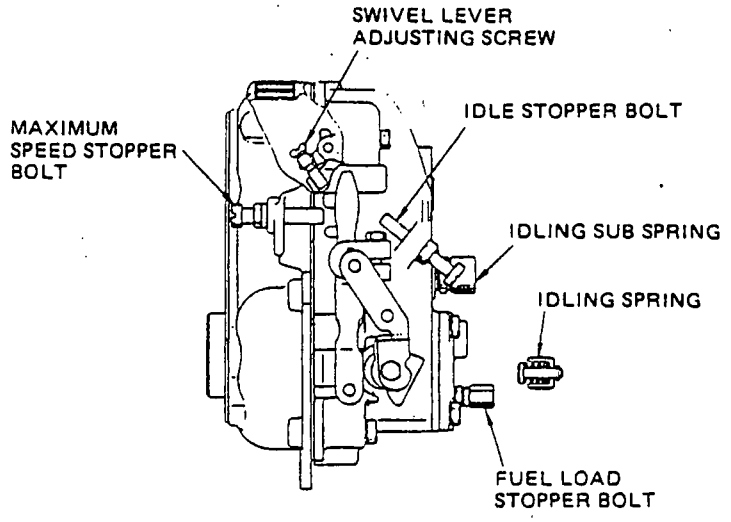
Oil feed pressure	2.0 kg/cm²	High pressure pipe φ2 x φ6 x 600 mm	Test oil: Diesel fuel oil (JIS) ASTM No. 2 diesel fuel oil
Plunger diameter	φ9.5 right-hand 15 + 38 mm lead	Delivery valve diameter	φ6, suction volume 51 mm³
Cam profile	Lift rate 8 mm	Control Resistance to slide	0 r.p.m. ≦ 120 g 1,000 r.p.m. ≦ 50 g

FEED PUMP

Suction capacity		Discharge capacity	
Hand pump	At 150 r.p.m. of pump speed	Discharge pressure at 600 r.p.m. of pump speed	Through nozzle at 1,000 r.p.m. of pump speed
≦ 25 stroke	≦ 40 sec.	3 ± 0.5 kg/cm²	≧ 900 cc/min.

Suction pipe φ9 x 2,000 mm	Height from oil level 1,000 mm
Cam lift 6 mm	Discharge pressure indicates the pressure when discharge side is closed.

ADJUSTING POSITION

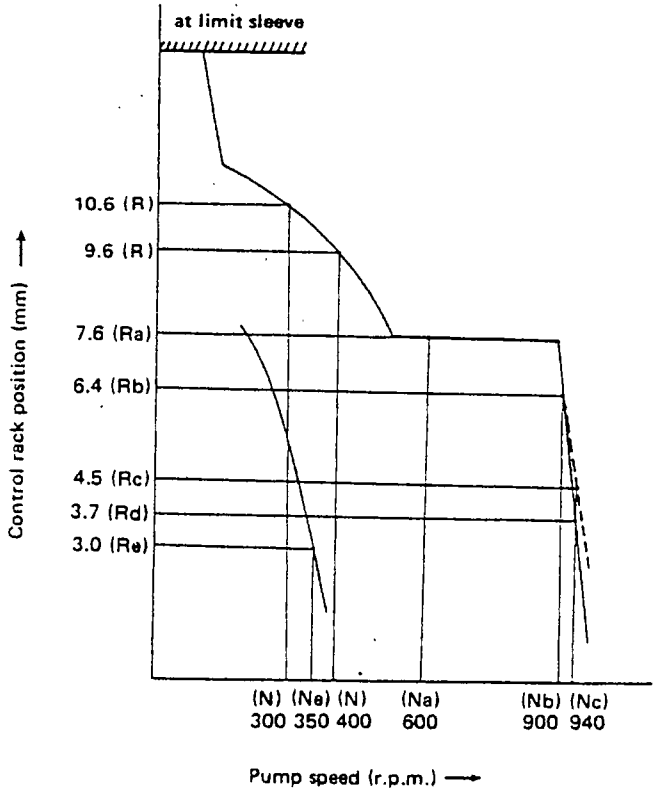


GOVERNOR ADJUSTMENT

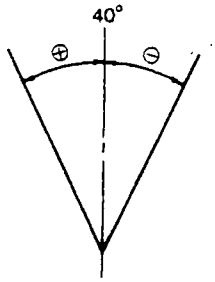
Medium speed control			Maximum speed control			Low speed adjustment		
Adjusting lever angle	Pump speed (r.p.m.)	Rod position (mm)	Adjusting lever angle	Pump speed (r.p.m.)	Rod position (mm)	Adjusting lever angle	Pump speed (r.p.m.)	Rod position (mm)
55° ± 5°	600	7.6 ± 0.2	55° ± 5°	900	6.4 ± 0.2	Free	350	3.0 ± 0.7
	(Full load stopper set)			(Max. speed stopper bolt)			(Lever free)	
	300	10.6 ± 0.3		940	6.4 ± 0.2	–	0	1.0
	(Idling spring set)			(Swivel adjusting screw set)			(Idle stopper bolt)	
	400	9.6 ± 0.3		940	4.5 ± 0.2			
	(Idling spring set)			(Idling sub spring set)				

Governing range: 200–1,100 r.p.m. | Speed droop: 4%

NOTE: ○ Do not back out the adjusting screw more than 24 clicks from the position where the adjusting screw is screwed all the way in.
○ Recommended setting of swivel adjusting screw: 19 clicks.



The angle of adjusting lever in vertical position is 40°.



SM4-119

Part 5

DC GENERATOR

4.0 Liter

DIESEL ENGINE

Models 40DT & 40DTA

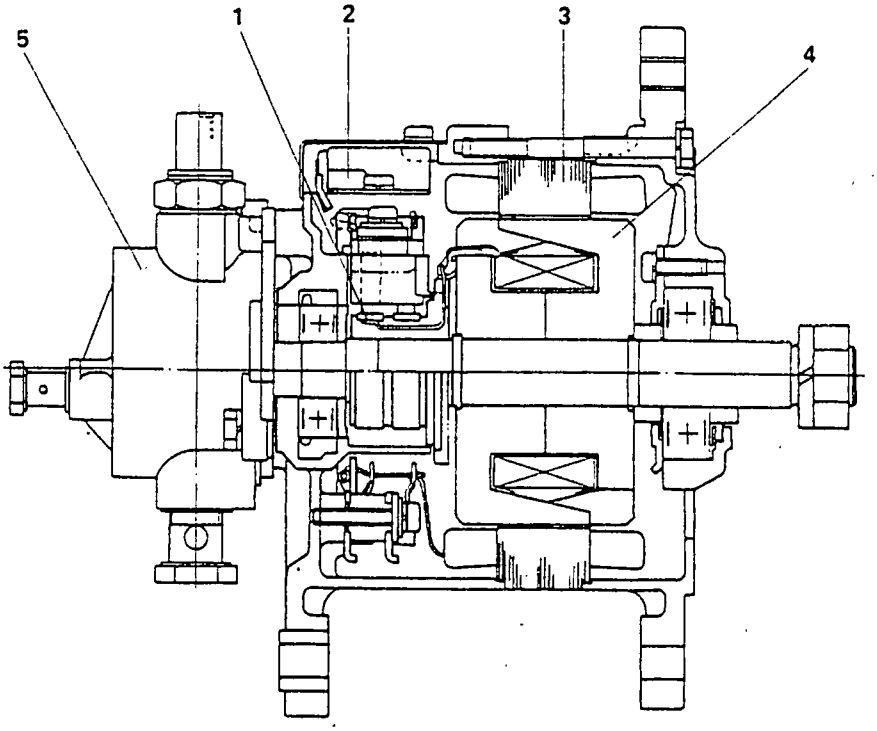
TABLE OF CONTENTS

Section 5.1- GENERATOR DESCRIPTION

Generator Specifications

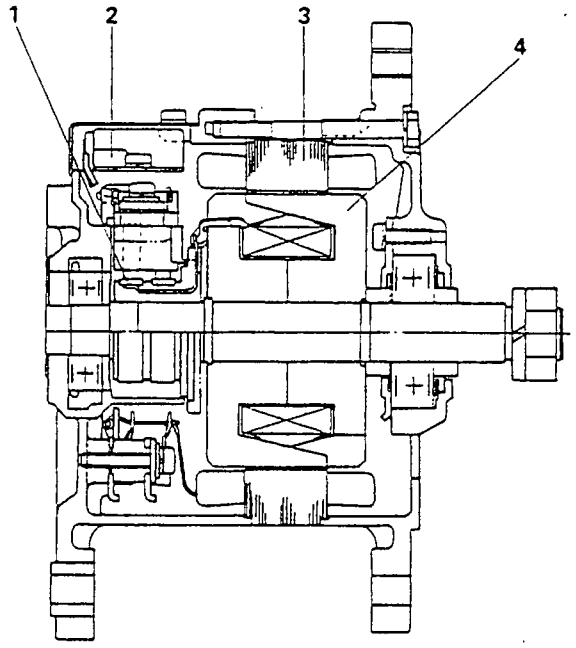
Type	DC Alternator
Output	24 volts, 20 amp
Normal Voltage	24 volts
Charging Rotation & Voltage	900 rpm, 27 volts
Direction of Rotation	Clockwise (viewed from Pulley Side)
Allowable Maximum Speed	7200 rpm
Power & Rotating Speed	28 Volts, 20 amp at 5000 rpm
Voltage Regulator	Built-in
Rotor Windings Resistance	
Standard	Approx. 12.5 ohms
Limit	11 ohms or infinity

Generator Description



GENERATOR WITH VACUUM PUMP

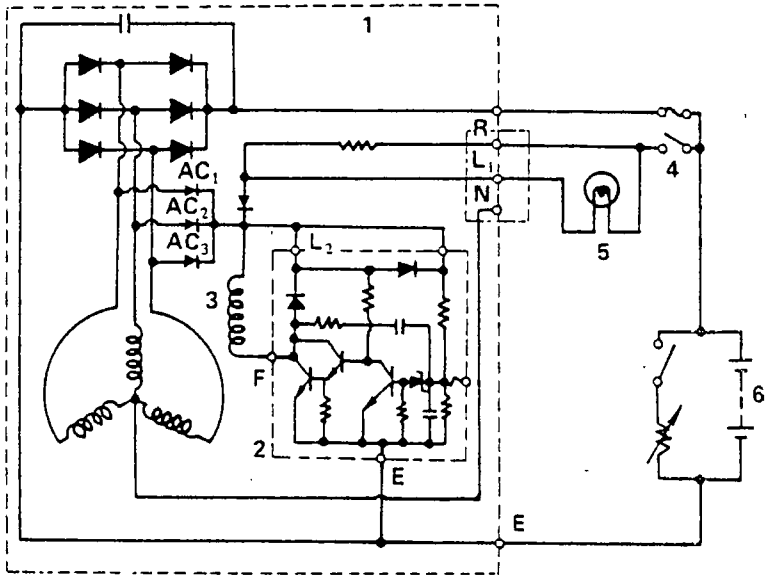
1. Brush
2. I.C. Regulator
3. Stator
4. Rotor
5. Vacuum pump assembly



GENERATOR WITHOUT VACUUM PUMP

1. Brush
2. I.C. Regulator
3. Stator
4. Rotor

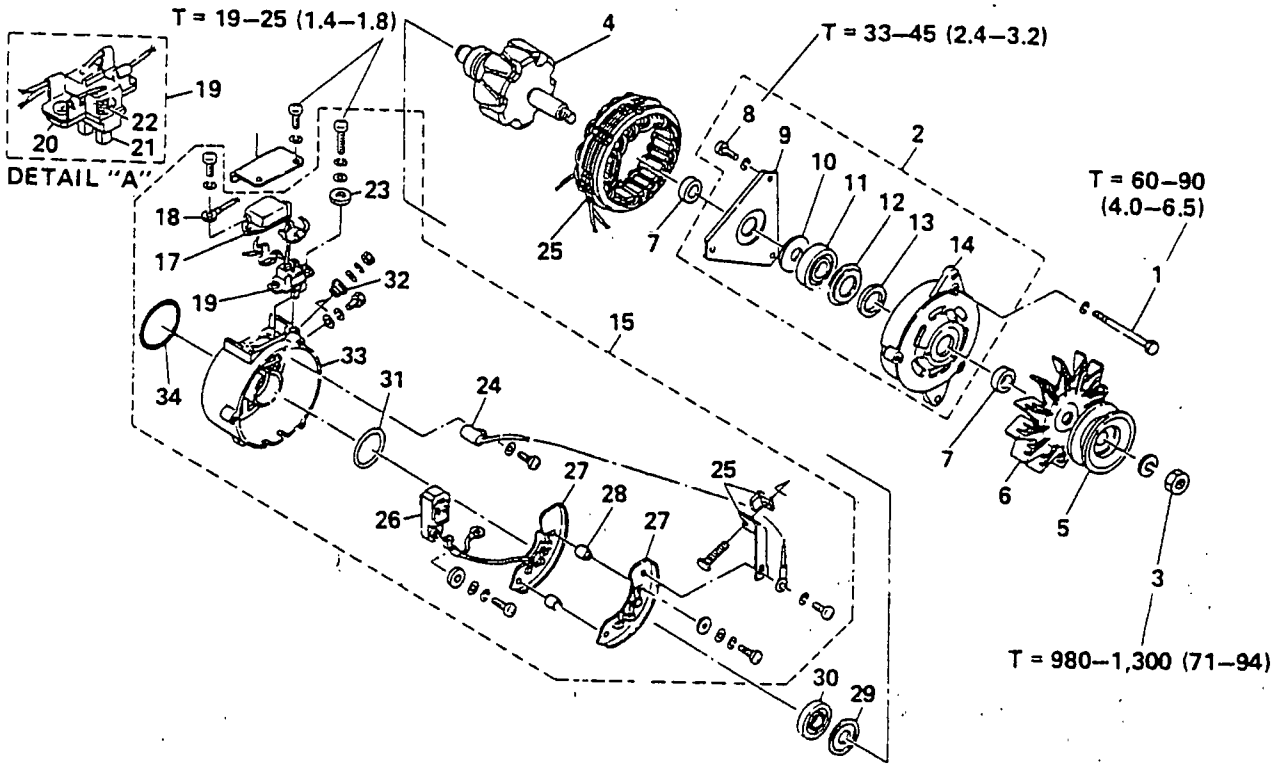
For standby/prime power generator applications, refer to "DIAGNOSTIC REPAIR MANUAL-STANDBY/PRIME ELECTRIC POWER SYSTEMS" (Manual Part No. 79247).



CHARGING SYSTEM CIRCUIT

1. Generator
2. I.C. regulator
3. Field coil
4. Starter switch
5. Charging warning lamp
6. Battery

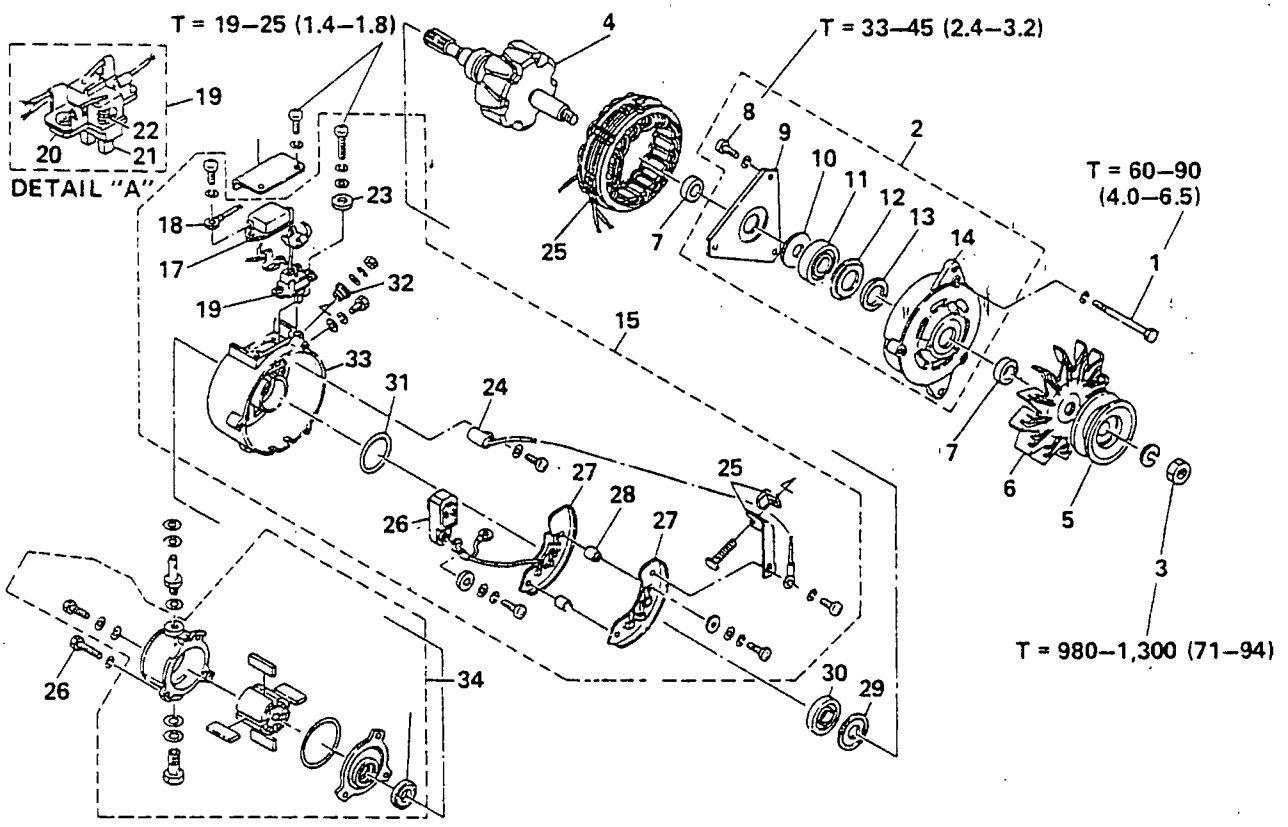
Section 5.2- COMPONENTS



GENERATOR WITHOUT VACUUM PUMP

T = Tightening torque: kg·cm (lb-ft)

1. Through bolt
2. Front bracket assembly
3. Nut
4. Rotor
5. Pulley
6. Fun
7. Collar
8. Bolt
9. Bearing retainer
10. Retainer plate
11. Ball bearing
12. Felt cover
13. Felt
14. Front bracket
15. Rear bracket assembly
16. Cover
17. Regulator assembly
18. Terminal with lead wire
19. Brush holder assembly
20. Brush holder
21. Brush
22. Brush spring
23. Stator coil
24. Condenser
25. Insulator
26. Connector with lead wire
27. Rectifier
28. Insulator
29. Gasket
30. Ball bearing
31. O-ring
32. Insulator
33. Rear bracket
34. Cover



GENERATOR WITH VACUUM PUMP

T = Tightening torque: kg·cm (lb-ft)

1. Through bolt
2. Front bracket assembly
3. Nut
4. Rotor
5. Pulley
6. Fun
7. Collar
8. Bolt
9. Bearing retainer
10. Retainer plate
11. Ball bearing
12. Felt cover
13. Felt
14. Front bracket
15. Rear bracket assembly
16. Cover
17. Regulator assembly
18. Terminal with lead wire
19. Brush holder assembly
20. Brush holder
21. Brush
22. Brush spring
23. Stator coil
24. Condenser
25. Insulator
26. Connector with lead wire
27. Rectifier
28. Insulator
29. Gasket
30. Ball bearing
31. O-ring
32. Insulator
33. Rear bracket
34. Vacuum pump assembly
35. Through bolt

Section 5.3- DISASSEMBLY INFORMATION

General

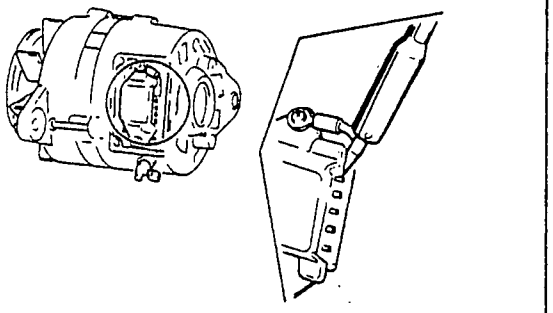
Routine disassembly tasks can be performed using the pictorial aids in Section 5.2, "COMPONENTS". This section will provide special information required for the disassembly of the DC generator.

Disassembly

REGULATOR & BRUSH HOLDER:

1. Unsolder the lead wire from the regulator.
2. Remove the regulator and brush holder assembly.

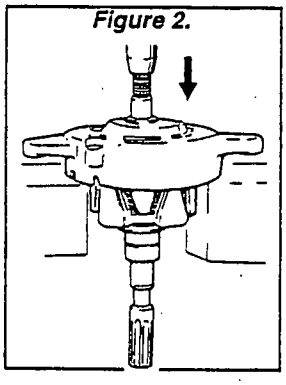
Figure 1.



ROTOR REMOVAL:

Use a press to remove the Rotor.

Figure 2.



FRONT & REAR BEARINGS:

1. Use a press to remove the front ball bearing (Figure 3).
2. Use a PULLER to remove the rear ball bearing (Figure 4).

Figure 3. Front Bearing

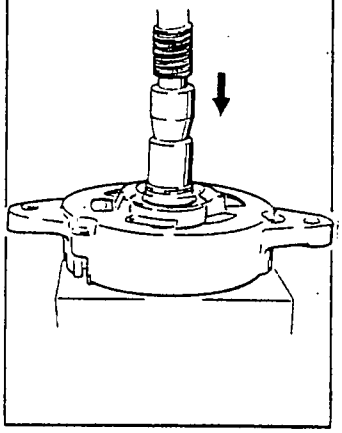
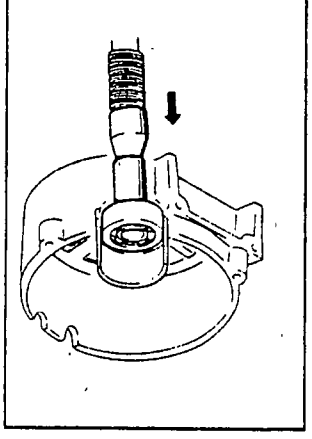


Figure 4. Rear Bearing



STATOR ASSEMBLY:

1. Unsolder the regulator lead wire (Figure 5).
2. Unsolder each terminal of the stator coil (Figure 6).
3. Remove the stator assembly.

Figure 5.

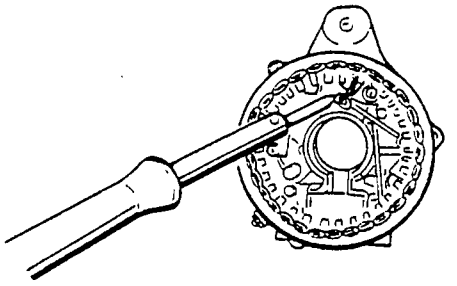


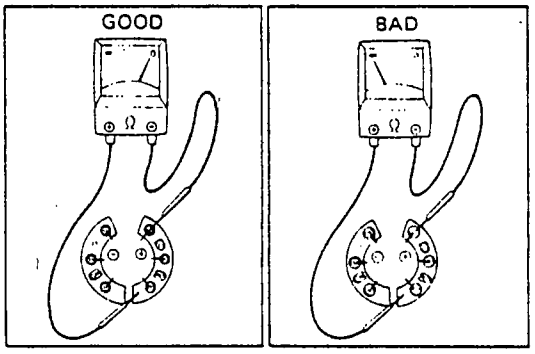
Figure 6.

Testing the Rectifiers

POSITIVE RECTIFIER CONDITION:

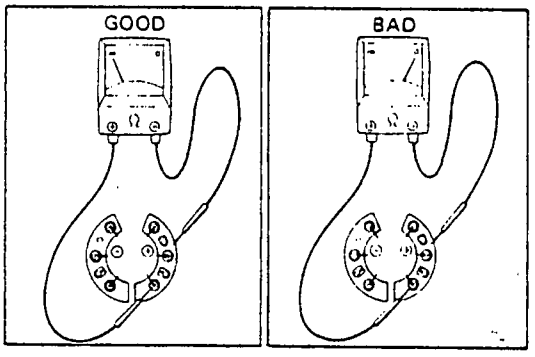
See Figure 1. Connect the positive (+) lead of a circuit tester to the rectifier holder; the common (-) test lead to the rectifier terminal. The meter needle should swing upscale. If the meter reads "Infinity", rectifier is open and should be replaced.

Figure 1.



See Figure 2. Now, connect the positive (+) test lead to the rectifier terminal; the common (-) test lead to the rectifier holder. The tester should read "Infinity". If tester needle swings upscale, the rectifier is bad and should be replaced.

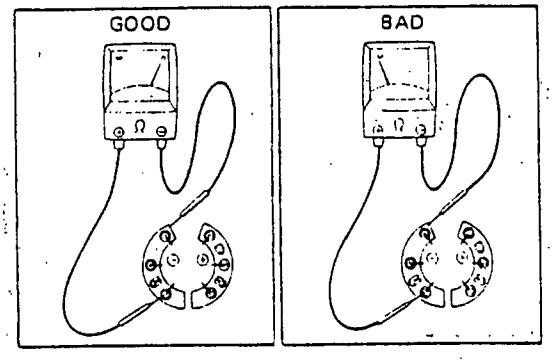
Figure 2.



NEGATIVE RECTIFIER CONDITION:

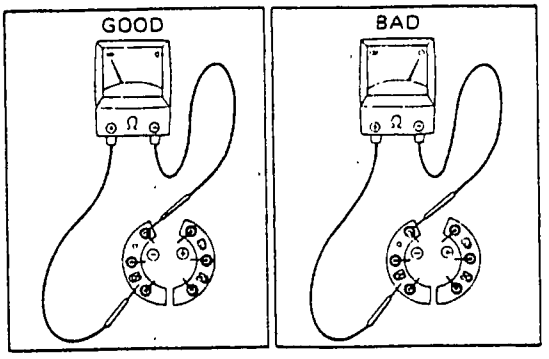
Connect the positive lead of the circuit tester to the rectifier terminal; the common (-) test lead to the rectifier holder. Tester should indicate a reading. If tester reads "Infinity", replace the rectifier.

Figure 3.



Now, connect the positive test lead to the rectifier holder; the common (-) test lead to the rectifier holder. The tester should read "Infinity".

Figure 4.



Performance Test

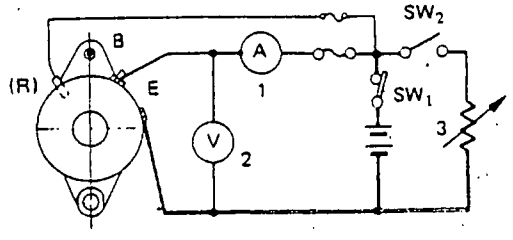
CAUTION: Battery cables must be properly connected to ensure correct polarity. If connections are reversed, the diodes (rectifiers) can short the circuit and allow a large current flow. Such a large current flow can damage diodes and/or the voltage regulator, and can also damage the wiring harness.

CAUTION: Do NOT perform tests with a high voltage insulation resistance tester while the DC generator is assembled. Damage to the voltage regulator will result.

CAUTION: Never disconnect the battery cables while the engine is running.

To test the performance of the charging system, connect a test harness as shown in Figure 5. Then, proceed as follows:

Figure 5.



1. Close Switch SW1 and open Switch SW2. Increase the alternator rotational speed slowly.
2. When voltage reaches 28 VDC, close Switch SW2 and regulate load resistance. Increase rpm while keeping voltage at 28 VDC.

Performance Test (Continued)

PERFORMANCE TEST RESULTS
Generator Speed= Less than 5000 rpm
at 28 VDC, 20 amps

VOLTAGE REGULATION TEST:

See Figure 5 on previous page. Close Switch SW1 and open Switch SW2, to increase rotor rotational speed to 5000 rpm. Standard voltage should be indicated.

STANDARD VOLTAGE
28.5 to 29.5 VDC

Inspection and Repair

BRUSH LENGTH:

Check brush length. Replace brush(es), if worn excessively.

BRUSH LENGTH
Standard: 0.630 inch (16mm)
Limit: 0.2755 inch (7.0mm)

Figure 6.

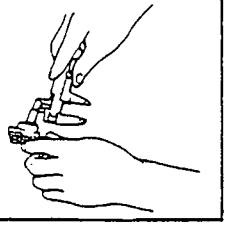
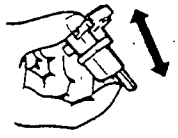


Figure 7.



CHECK BRUSH HOLDER:

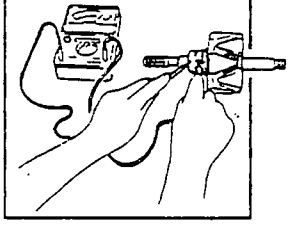
Perform a visual check of the brush holder. Replace, if necessary.

ROTOR COIL RESISTANCE:

Test the resistance of the Rotor coil.

ROTOR RESISTANCE
Standard: 12.5 ohms
Limit: 11.0 ohms or "Infinity"

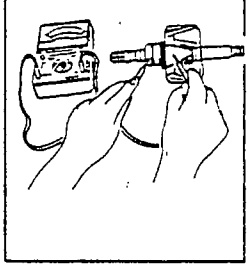
Figure 8.



SLIP RING TO CORE INSULATION RESISTANCE:

SLIP RING TO CORE INSULATION RESISTANCE
Standard: More than 1.0 meg-ohms
Limit: Less than 0.5 meg-ohms

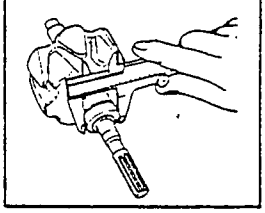
Figure 9.



SLIP RING DIAMETER:

SLIP RING DIAMETER
Standard: 1.3583 inch (34.5mm)
Limit: 1.3188 inch (33.5mm)

Figure 10.

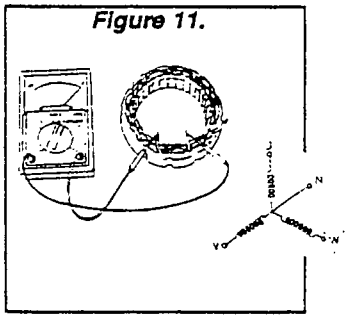


STATOR COIL RESISTANCE:

Check stator coil resistance across N-U; across N-V; and across N-W. Replace stator if bad.

STATOR RESISTANCE
About 0.4 ohm

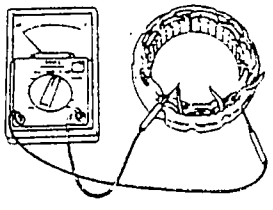
Figure 11.



STATOR COIL INSULATION RESISTANCE:

STATOR INSULATION RESISTANCE
Standard: Above 1.0 meg-ohm
Limit: Less than 0.5 meg-ohm

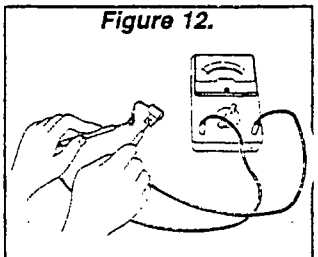
Figure 12.



CONDENSOR:

Check the condensor capacity. Condensor is rated at 0.5 micro-Farad.

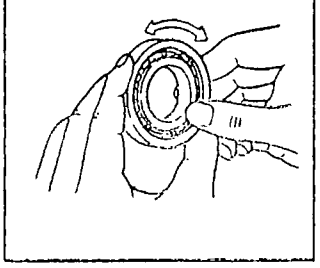
Figure 12.



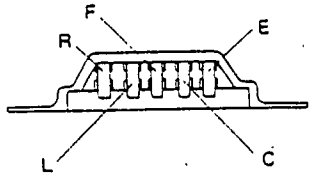
VISUAL CHECKS:

Inspect bearings for damage or wear. Also inspect oil seal and O-ring. Replace, if necessary.

Figure 13.



Resistance Between Voltage Regulator Terminals
Replace the Regulator if any test is not within tolerance.

METER LEAD CONNECTIONS			
+ TEST LEAD	- TEST LEAD	READING	
R	L	Approximately 10 ohms	
R	F	Approximately 10 ohms	
R	C	Infinity	
R	E	Approximately 1.5k ohms	
L	F	Approximately 10 ohms	
L	C	Approximately 90 ohms	
L	E	Approximately 100 ohms	
F	C	Approximately 10 ohms	
F	E	Approximately 180 ohms	
C	E	Approximately 40 ohms	
L	R	Infinity	
F	R	Infinity	
C	R	Infinity	
E	R	Infinity	
F	L	Approximately 2k ohms	
C	L	Infinity	
E	L	Approximately 1.5 k ohms	
C	F	Infinity	
E	F	Infinity	
E	C	Infinity	

Section 5.5- REASSEMBLY INFORMATION

Installing the Stator

1. After installing the stator coil, solder each terminal of the coil. See Figure 6, Page 5.3-1.
2. Solder the regulator lead wire (Figure 5, Page 5.3-1).

Install Bearings

1. Use a press to install the rear ball bearing (Figure 4, Page 5.3-1).
2. Use a press to install the front ball bearing (Figure 3, Page 5.3-1).
3. Use a press to install the rotor assembly into the front bracket. See Figure 2 on Page 5.3-1.

Regulator and Brush Holder

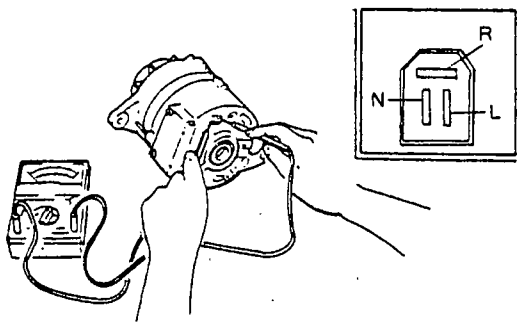
1. Install the brush holder assembly and the regulator (Figure 1, Page 5.3-1).
2. Solder the lead wire to the regulator.

Check Resistance Between Terminals

After the generator has been assembled, measure the resistance between each terminal as follows (Figure 1):

TESTER			TESTER		
+ LEAD	- LEAD	OHMS	+ LEAD	- LEAD	OHMS
B	R	Infinity	N	E	7-10
B	N	7-10	N	B	Infinity
R	L	400-500	E	R	Infinity
R	E	Infinity	E	L	Infinity
L	E	Infinity	E	N	Infinity

Figure 1. Resistance Between Terminals



Part 6
STARTER

4.0 Liter

DIESEL ENGINE

Models 40DT & 40DTA

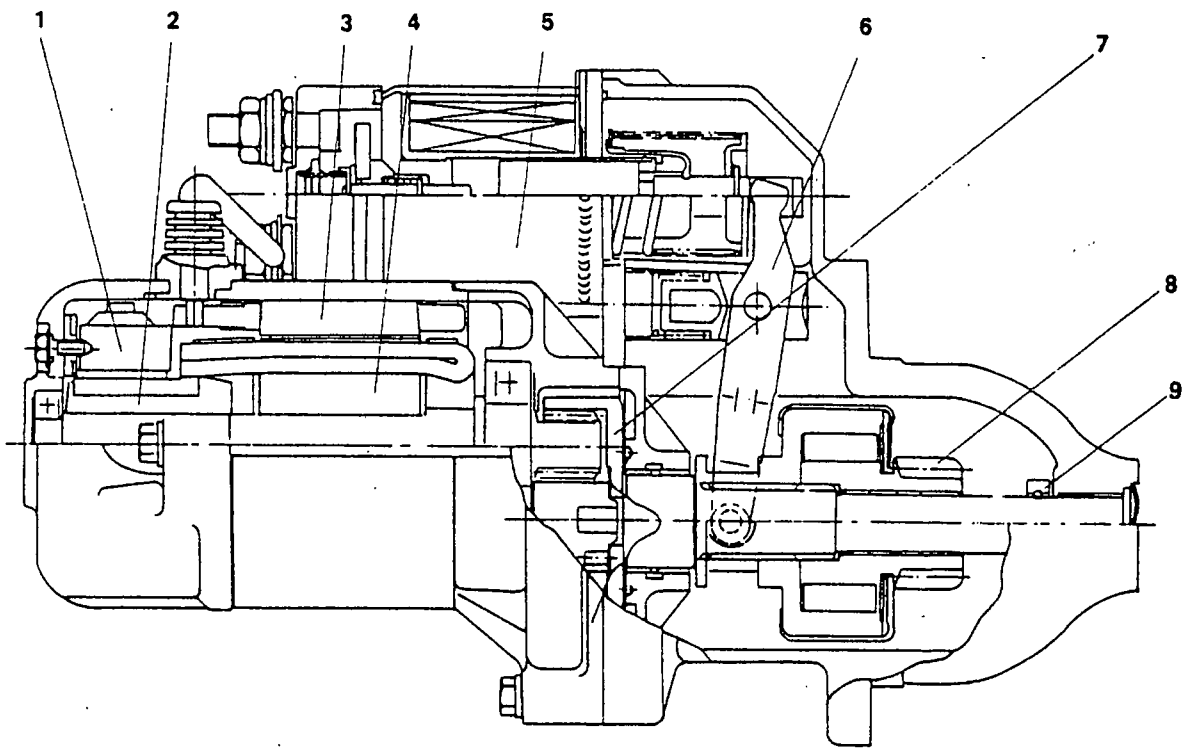
TABLE OF CONTENTS

Section 6.1- STARTER DESCRIPTION

Data & Specifications

Type	Reduction Gear Type
Rated Output	4.5 kW at 24 VDC
No. of Pinion Teeth	11
Direction of Rotation	Clockwise (Viewed from Pinion Side)

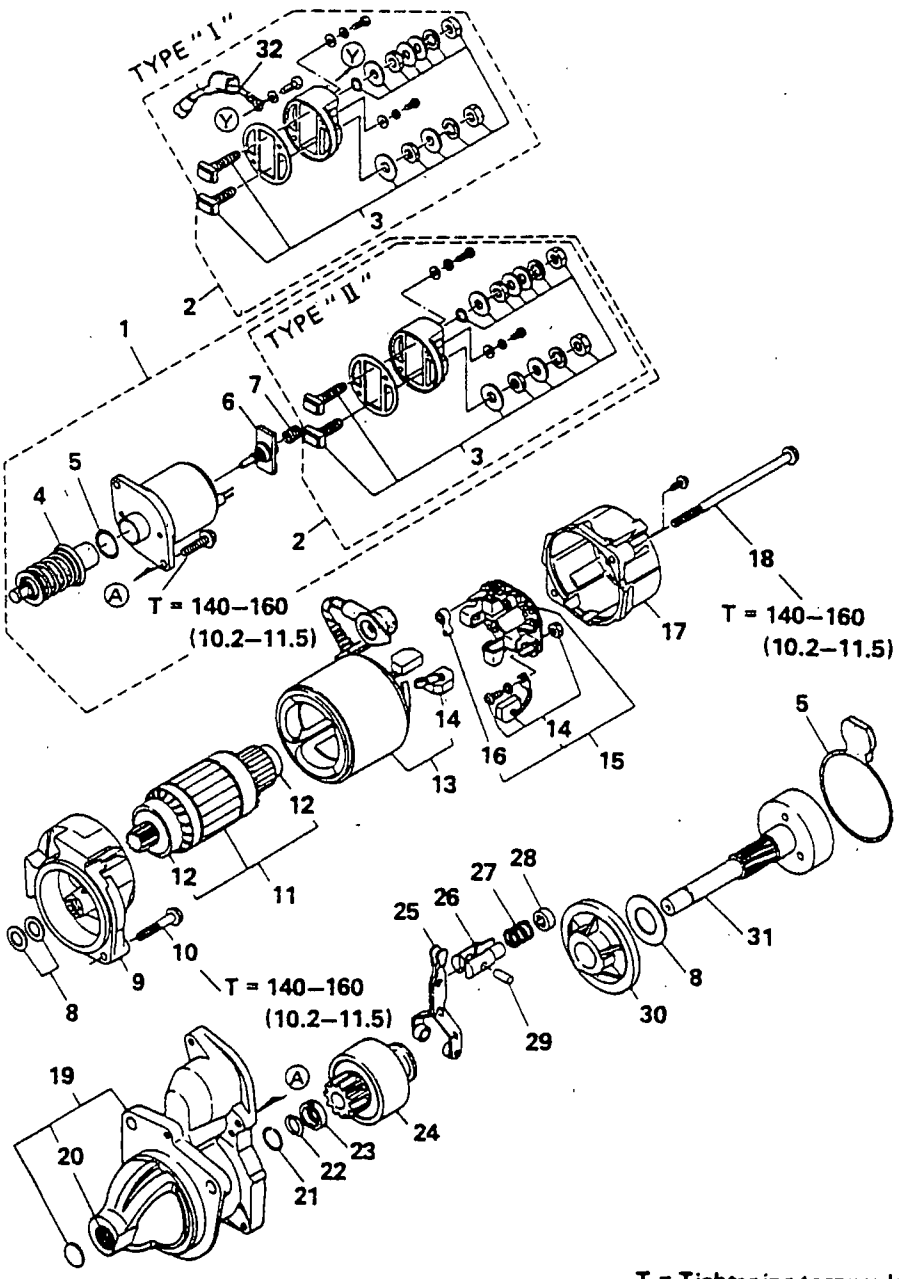
Description



1. Brush
2. Commutator
3. Field coil
4. Armature
5. Magnetic switch
6. Pinion shift lever
7. Reduction gear
8. Clutch and pinion
9. Pinion stopper

Section 6.2- STARTER COMPONENTS

Figure 1. Exploded View of Starter



T = Tightening torque: kg-cm (lb.ft)

1. Magnetic switch assembly
2. Terminal cover assembly
3. Terminal assembly
4. Moving core assembly
5. O-ring
6. Moving contactor assembly
7. Spring
8. Shim
9. Gear housing
10. Set bolt
11. Armature assembly
12. Ball bearing
13. Yoke assembly
14. Brush
15. Brush holder assembly
16. Brush spring
17. Commutator end frame assembly
18. Through bolt
19. Drive housing
20. Bushing
21. Retainer ring
22. Hook
23. Pinion stopper
24. Clutch and pinion assembly
25. Pinion shift lever
26. Holder
27. Spring
28. Collar
29. Pin
30. Center holder
31. Drive shaft
32. Harness

Section 6.3- DISASSEMBLY INFORMATION

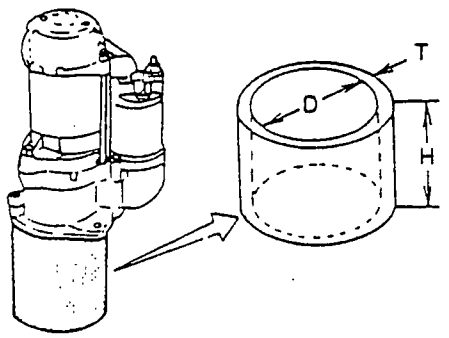
Introduction

This section is not intended to provide detailed, step-by-step instructions for the dosassembly of the starter. Routine disassembly can be accomplished using the exploded view in Section 6.2. This section will provide special instructions to aid you in the disassembly process.

A Starter Work Stand

If desired, a simple starter work stand can be constructed locally. See Figure 1, below.

Figure 1. A Starter Work Stand



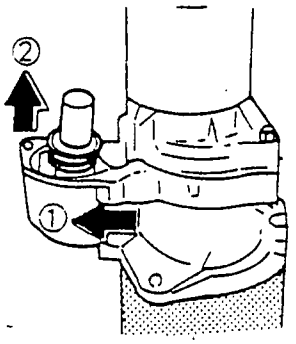
WORK STAND DIMENSIONS
D (Diameter) = 4.331 inch (110mm)
T (Thickness) = 0.394 inch (10mm)
H (Height) = 4.724 inch (120mm)

Important Disassembly Points

REMOVAL OF MOVING CORE:

To remove the moving core, first move it in the direction of arrow "1"; then, in the direction of arrow "2".

Figure 2. Moving Core Removal



ARMATURE:

Use a press to remove the armature (Figure 3).

DRIVE HOUSING PLUG:

Use a press to remove the drive housing plug. See Figure 4.

MAGNETIC SWITCH:

To remove the magnetic switch, unsolder the "COIL" and the "C" terminals. Refer to Figure 5.

Figure 3. Armature Removal

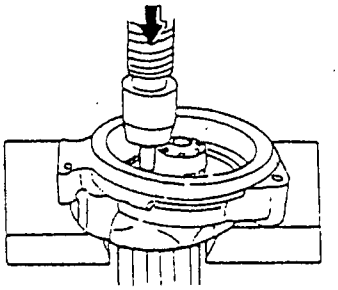


Figure 4. Drive Housing Plug Removal

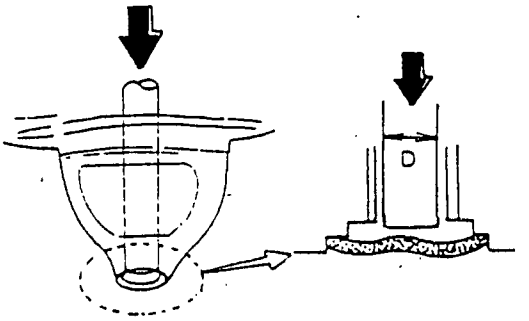
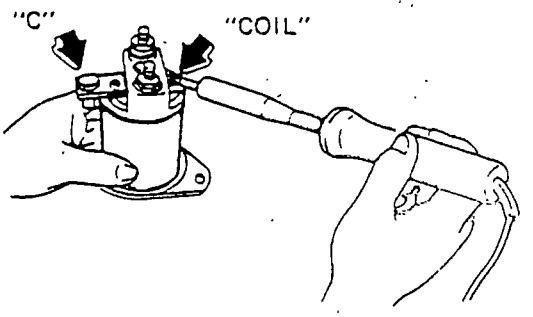


Figure 5. Magnetic Switch Removal



Section 6.4- REASSEMBLY INFORMATION

Introduction

It is not intended that this section should provide detailed, step-by-step instructions for the reassembly of the starter. Some special instructions pertaining to starter reassembly will be provided. Routine assembly can be accomplished using the exploded view of Page 6.2-1.

NOTE: Always install NEW o-rings when reassembling the starter.

Lubrication

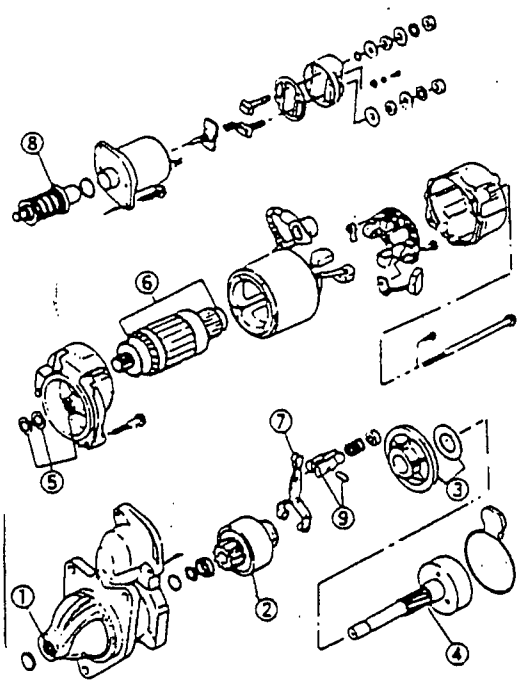
Prior to reassembly of starter components, apply grease to the starter components listed below and shown in Figure 1. Use one of the following types of grease on starter parts:

RECOMMENDED GREASE FOR STARTER
Molytex Grease EP2 from Caltex
OR
Mobilgrease 29 from Mobil
OR
Aero Shell Grease 17 from Shell

The recommended grease should be applied to the following starter components (Figure 1):

ITEM	NOMENCLATURE	ITEM	NOMENCLATURE
1	Bushing	6	Bearing
2	Clutch & Pinion	7	Drive Pinion Lever
3	Bushing & Shim	8	Moving Core
4	Drive Shaft	9	Lever Holder & Pin
5	Gear Housing & Shim		

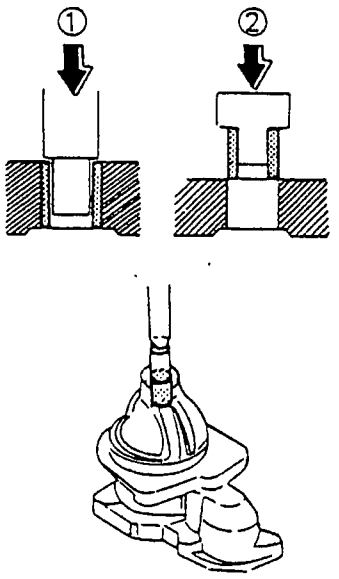
Figure 1. Areas on Starter to be Greased



Replacement of Bushings

Use a press to remove bushings (Figure 2). Press a new bushing into place.

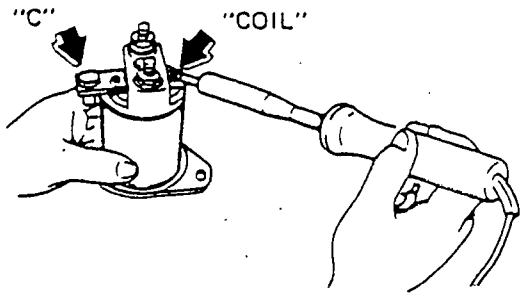
Figure 2. Bushings Replacement



Magnetic Switch

The "COIL" and the "C" terminal of the magnetic switch must be soldered into place.

Figure 3. Soldered Terminals on Magnetic Switch



Other Reassembly Points

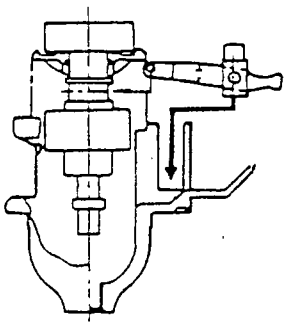
The starter can be reassembled in the reverse order of disassembly. During reassembly, perform the following tasks:

DRIVE PINION LEVER INSTALLATION:

When installing the drive pinion lever on the shaft, install the lever in the direction shown in Figure 4.

Other Reassembly Points (Continued)

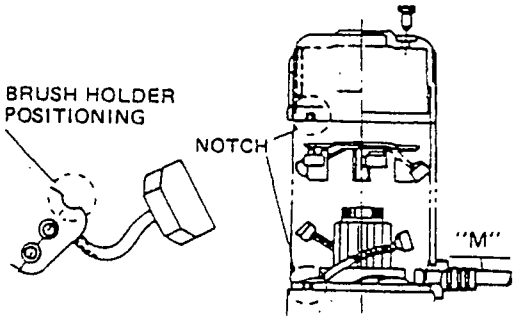
Figure 4. Drive Pinion Lever Installation



BRUSH HOLDER POSITIONING:

Match the positioning of the brush holder with the "M" lead. Match the end frame positioning guide with the notch of the brush holder positioning guide.

Figure 5. Brush Holder/End Frame Positioning

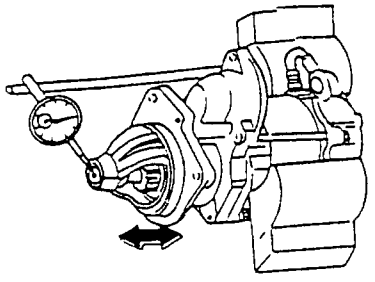


MEASURE THRUST GAP:

After assembling the starter and without the magnetic switch (starter solenoid), use a dial indicator to measure the thrust gap as you move the drive shaft in and out by hand. If the thrust gap exceeds the standard given below, adjust by increasing or decreasing the shim.

THRUST GAP
Standard: 0.004-0.0196 inch (0.1-0.5mm)

Figure 6. Checking Thrust Gap

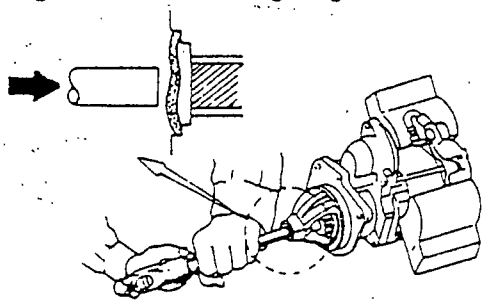


INSTALLING THE DRIVE HOUSING PLUG:

Do NOT install the drive housing plug until AFTER the "NO-LOAD TEST" of the starter has been completed. See Section 6.6, "OPERATIONAL TESTS", for no-load test procedure.

NOTE: Always install a new plug.

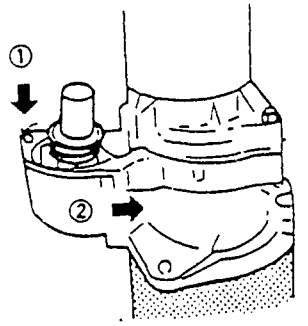
Figure 7. Drive Housing Plug Installation



MOVING CORE INSTALLATION:

See Figure 8. Install the moving core in the direction indicated by arrows and in the order shown.

Figure 8. Moving Core Installation



MEASURING THE TIMING GAP:

After the starter has been properly assembled, measure the timing gap as follows:

1. Connect the starter and starter solenoid into a circuit as shown in Figure 9.
2. Closes Switches SW1 and SW2.
3. When the pinion pops out, open Switch SW2.
4. Maintain the above conditions, push the pinion back in to measure the gap.

STARTER TIMING GAP
Standard: 0.020-0.118 inch (0.5-3.0mm)

If the gap exceeds the standard value, check the following parts and replace as required (Figure 10):

1. Lever Holder
2. Lever Pin
3. Drive Pinion Lever
4. Gasket
5. Insert

Figure 9. Timing Gap Test Circuit

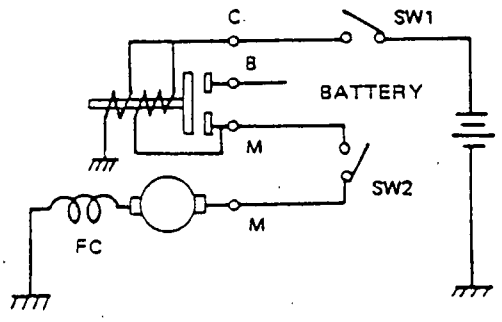
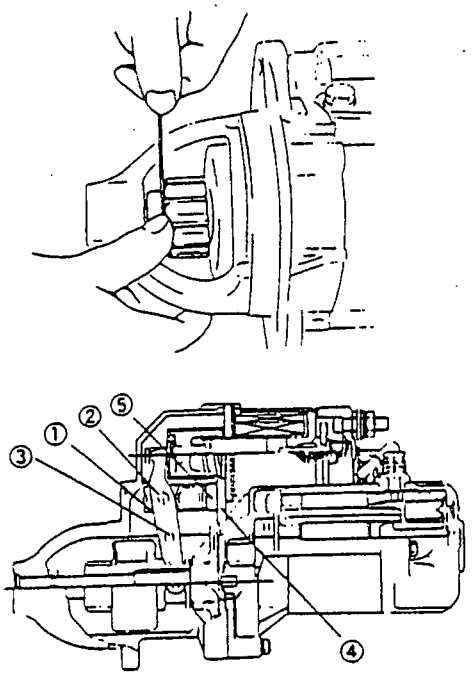
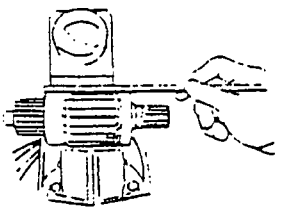
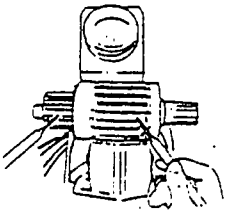
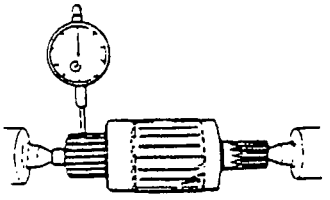
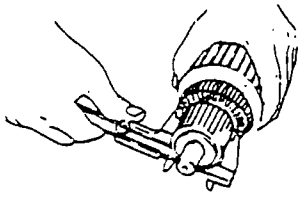
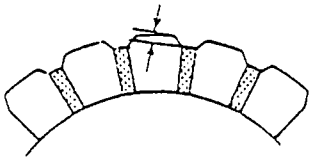
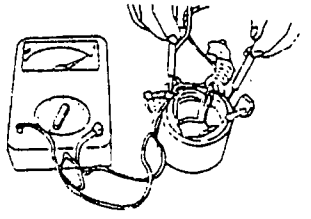
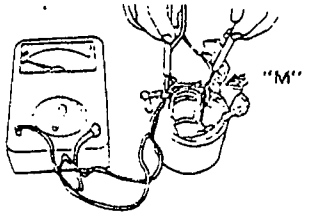
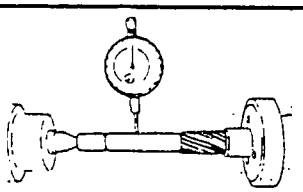
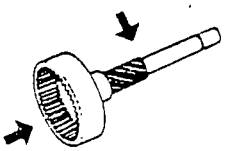
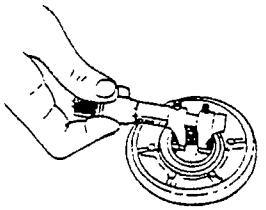
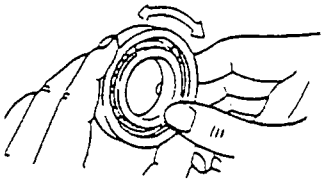
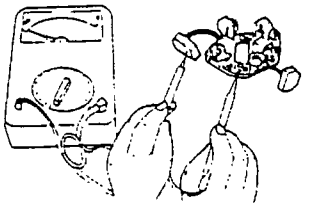
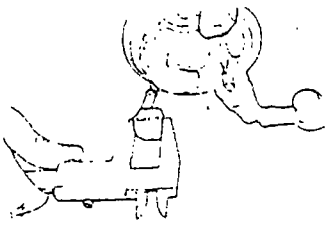


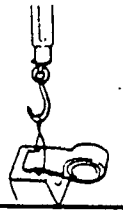
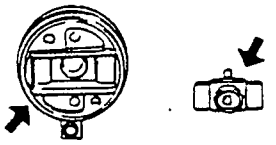
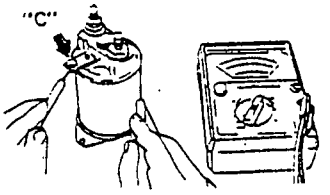
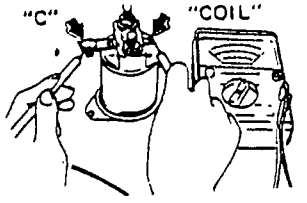
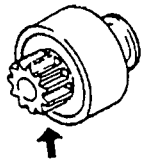
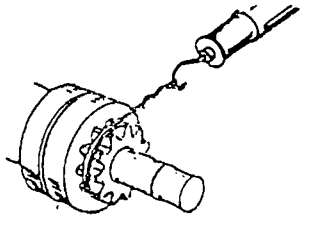
Figure 10. Measuring Starter Timing Gap



Section 6.5- INSPECTION AND REPAIR

INSPECTION ITEM	STANDARD	LIMIT	REMEDY	INSPECTION PROCEDURE
Armature Short Circuit Test	-	If the iron piece does not vibrate, the armature is good.	Replace	
Armature Insulation	Greater than 1 meg-ohm	Less than 0.5 meg-ohm	Replace	
Wear of the Commutator	0.002 inch (0.05mm)	0.0039 inch (0.1mm)	Replace	
Commutator Outside Diameter	0.0197-0.0315 inch (0.5-0.8mm)	0.0078 inch (0.2mm)	Replace	
Depth of Undercut of the Mica	0.0197-0.0315 inch (0.5-0.8mm)	0.0078 inch (0.2mm)	Replace	COMMUTATOR UNDERCUT 
Resistance Between Brush and Yoke Body	-	Should Indicate "Continuity"	Replace	
Insulation Resistance Between Brush and the "M" Terminal	More than 1 meg-ohm	Less than 0.5 meg-ohm	Replace	

INSPECTION ITEM	STANDARD	LIMIT	REMEDY	INSPECTION PROCEDURE
Drive Shaft Bending	0.0019 inch (0.05mm)	0.0039 inch (0.1mm)	Replace	
Internal Gear and the spline	-	-	Replace, if necessary	VISUAL CHECK 
Drive Housing Bushing Inside Diameter	0.669 inch (17.0mm)	0.677 inch (17.2mm)	Replace	
Bearing Housing Inside Diameter	1.102 inch (28.0mm)	1.110 inch (28.2mm)	Replace	
Bearing Wear or Damage	-	-	Replace, if necessary	
Brush Holder to Bracket Insulation	Greater than 1 meg-ohm	Less than 0.5 meg-ohm	Replace	
Brush Length	0.709 inch (18.0mm)	0.472 inch (12.0mm)	Replace	

INSPECTION ITEM	STANDARD	LIMIT	REMEDY	INSPECTION PROCEDURE
Brush Spring Tension	3.0 lbs (1.4 kg)	2.0 lbs. (1.0 kg)	Replace	
Wear or damage to the moving core, spring, seal rubber and seat	-	-	Replace, if necessary	
Damage to Contactor Point	-	-	Replace, if necessary	VISUAL CHECK 
Resistance Between "C" terminal and the Body (Holding Coil)	0.5-2.0 ohms		Replace	
Resistance Between "C" Terminal and the Coil Terminal (Pulling Terminal)	0.1-0.3 ohm		Replace	
Damage to Pinion Gear Teeth	-	-	Replace, if necessary	VISUAL CHECK 
Rotational Torque of the Pinion	0.3-0.4 lb-ft (4-6 kg-cm	-	Replace	

Section 6.6- OPERATIONAL TESTS

Magnetic Switch (Starter Contactor) Test

GENERAL:

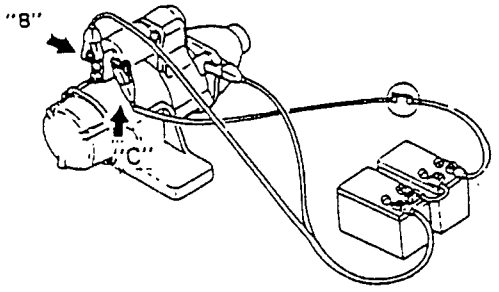
To perform this test, the starter must be assembled without the "M" terminal lead. The specified voltage must be applied.

CAUTION: Each test should be performed as quickly as possible, not to exceed about 3 to 5 seconds. Excessively long test times can result in burning of the magnetic switch (starter contactor).

PULL-IN TEST:

Connect a test harness as shown in Figure 1, below. When the switch is closed, the pinion should move outward (actuate) quickly and smoothly.

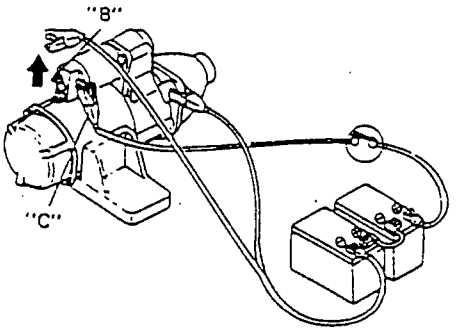
Figure 1. Connections for Pull-In Test



HOLD-IN TEST:

Use the same procedure as in the "Pull-In" test, but disconnect the "B" terminal. The pinion should remain in its outward (actuated) position.

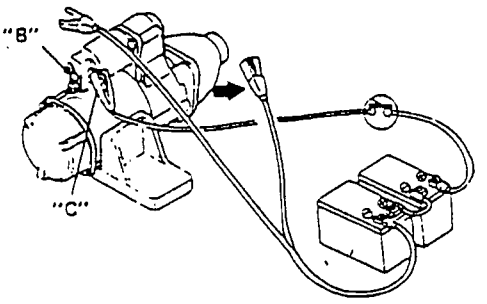
Figure 2. The Hold-In Test



RETURN TEST:

See Figure 3. Use the same procedure as for the "Hold-In" test, but disconnect the "EARTH" (grounding) jumper wire. The pinion should return to its non-actuated position quickly and smoothly.

Figure 3. The "Return" Test



Performance Test

Perform this test when the starter has been reassembled, as follows:

1. Clamp the starter securely in a vise.
2. Use two (2) fully charged 12 volt batteries and a suitable ammeter, connected as shown in Figure 4 below.
3. Connect the positive (+) battery lead to the ammeter, and to the "B" and "C" terminal as shown.
4. Connect the battery negative (-) lead to the starter body as shown.

The pinion should actuate (move outward). As soon as the pinion has actuated, the starter motor should operate with a smooth and steady rotation. Starter rpm and current draw should be as specified below.

PERFORMANCE TEST REQUIREMENTS
Starter rpm: Greater than 4000 rpm
Current (amperes): Less than 100 amperes

Figure 4. Performance Test