A8028

HINO

DIESEL ENGINE FOR INDUSTRIAL USE

13-3
DIESEL

WORKSHOP MANUAL

EK130-T

Hino HINO MOTORS, LTD.

FOREWORD

This workshop manual has been prepared to provide information covering repair procedures on Hino Marine Engine.

Applicable models: EK130-T engine

When marking any repair of your engine, be careful not to be injured through improper procedures.
As for maintenance items, refer to the Operation Hand Book.
All information and specifications in this manual are based upon the latest product information available at the time of printing.
Hino Motors reserves the right to make changes at any time without prior notice.

HINO MOTORS, LTD.

Hino

WORKSHOP MANUAL

INDEX: ENGINE GROUP

HINO MOTORS, LTD.

GI-167E-01

CHAPTER GI

GENERAL INTRODUCTION

GENERAL PRECAUTIONS

Some recommended and standard maintenance services for your engine are mentioned in this section.
When performing maintenance on your engine be careful not to get injured by improper work.
Improper or incomplete work can cause a malfunction of the engine which may result in personal injury and/or property damage.

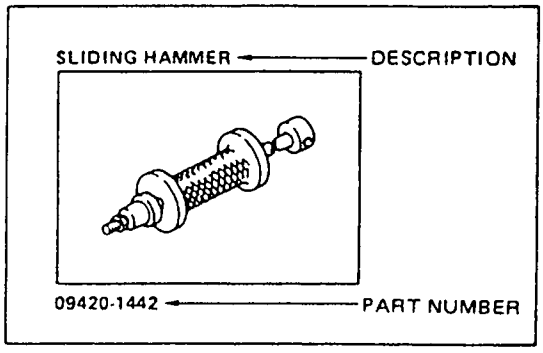
WARNING

When working on your engine, observe the following general precautions to prevent personal injury and/or property damage in addition to the particular NOTES or WARNINGS.
Most threaded fasteners are metric.
Be careful not to mix with threaded fasteners using the inch system.

- **Always wear safety glasses or goggles to protect your eyes.**
- **Remove rings, watches, ties, loose hanging jewelry and loose clothing before starting work on the engine.**
- **Bind long hair securely behind the head.**
- **To avoid serious burns, keep yourself away from hot metal parts such as the engine, exhaust manifold, radiator, muffler, exhaust pipe and tail pipe.**
- **Keep yourself, your clothing and your tools away from moving parts such as the cooling fan and V-belts when the engine is running.**
- **Always stop the engine by pulling out the engine stop knob. Leave the knob pulled out as long as the engine is stopped. And turn off the starter switch, unless the operation requires the engine running. Removing the key from the switch is recommended.**
- **Run the engine only in a well-ventilated area to avoid inhaling of carbon monoxide.**
- **Do not smoke while working on the engine since fuel and gases from the battery are flammable.**
- **Take utmost care when working on the battery. It contains corrosive sulfuric acid.**
- **Large electric current flows through the battery cable and starter cable. Be careful not to cause a short which can result in personal injury and/or property damage.**
- **Be careful not to leave any tool in the engine compartment. The tool may be hit by moving parts and can cause personal injury.**

HOW TO USE THIS WORKSHOP MANUAL.

This workshop manual is designed as a guide for servicing engine.
An INDEX is provided on the first page of each chapter.
TROUBLESHOOTING is dealt with each chapter.
When beginning operations, refer to the sections on for guide to appropriate diagnoses.



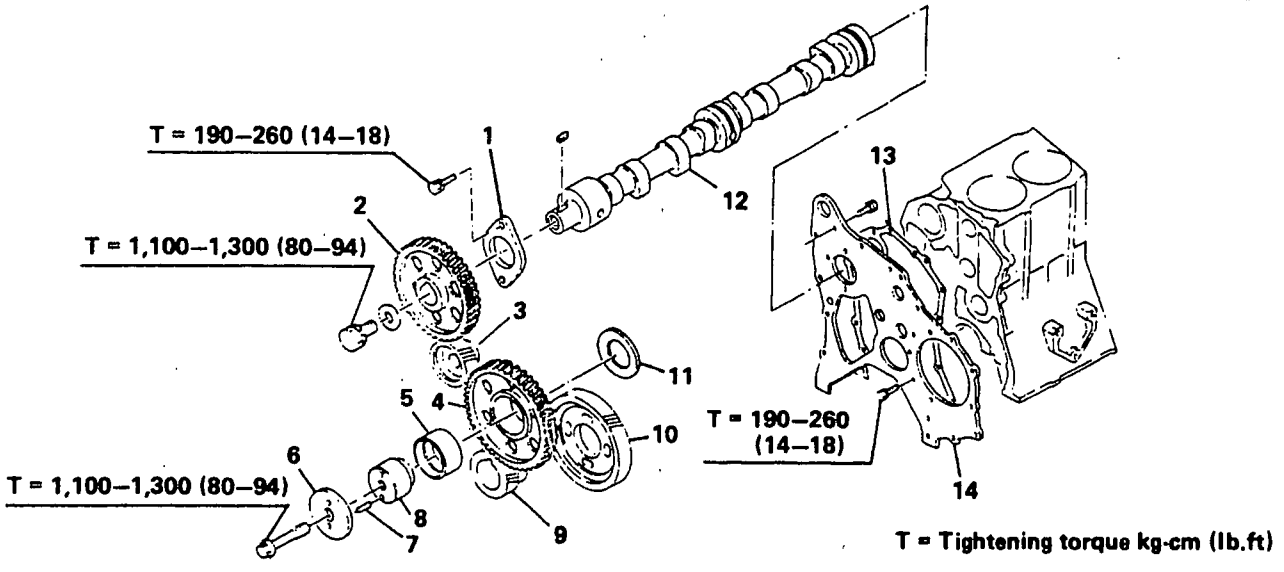
SPECIAL TOOLS are dealt with in each chapter.
When ordering a special tool, make sure that the parts number is correct.

REPAIR PROCEDURES

Repair procedures which are self-explanatory such as simple installation and removal of parts have been omitted. Illustrations such as the one below have been provided to make such simple procedures clear. Only essential procedures requiring directions have been dealt with explicitly.

EXAMPLE:

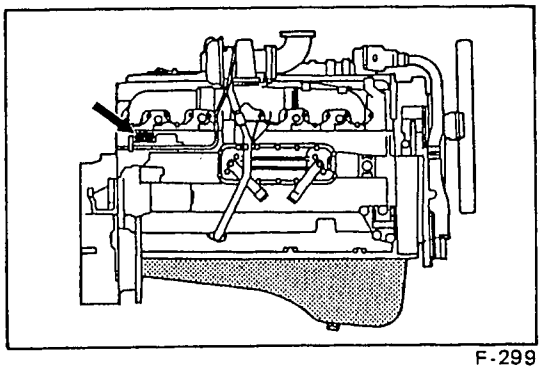
TIMING GEAR AND CAMSHAFT



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

In some cases, illustrations may be of parts which differ in some nonessential way from the parts found on your particular engine. In such cases, however, the principale or procedure being illustrated applies regardless of such nonessential differences.



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IDENTIFICATION INFORMATION

ENGINE SERIAL NUMBERS

Please quote these numbers when ordering spare parts or reporting technical matter as they will give you prompt service attention.

The engine serial number is engraved on the engine cylinder block.

Code No. 4687-E0

SPECIFICATIONS

DIESEL ENGINE FOR INDUSTRIAL USE

HINO EK130-T

13.267 liters, 4-cycle, 6-cyl., water-cooled turbocharged

● PERFORMANCE (STD. specs.)

GENERAL USE (SAE J1349 Gross)				GENERATOR USE (SAE J1349 Gross)			
				Stand-by Power		Prime Power	
Output, intermittent rating kW (HP) at rpm	Output, continuous rating kW (HP) at rpm	Max. torque Nm (lbf·ft) at rpm	Min. fuel consumption g/kWh (lb/HPh) at rpm	Output at 1,500 rpm kW (HP)	Output at 1,800 rpm kW (HP)	Output at 1,500 rpm kW (HP)	Output at 1,800 rpm kW (HP)
193 (260) at 2,000	173 (232) at 2,000	1,050 (774) at 1,400	218 (0.358) at 1,400	171 (230)	193 (260)	162 (217)	183 (246)

Ambient conditions:	SAE	DIN
Intake air temperature	25°C	20°C
Barometric pressure	100 kPa	736 mmHg
Water vapour pressure	1.0 kPa	10.5 mmHg

● ENGINE DESCRIPTION

1.	Type	Diesel, 4-cycle, 6-cyl., in-line, over-head valve, water-cooled Turbocharged
2.	Combustion chamber	Direct injection type
3.	Cylinder Bore x Stroke	137 x 150 mm (5.39 x 5.91 in)
4.	Piston displacement	13.267 liters (809.6 cu.in)
5.	Compression ratio	16.5
6.	Direction of rotation	Counter-clockwise viewed from flywheel
7.	Dimensions without marine gear (L x W x H)	1,544 x 885 x 1,213 mm (60.8 x 34.8 x 47.8 in)
8.	Dry weight	1,050 kg (2,362 lb)

● FEATURES

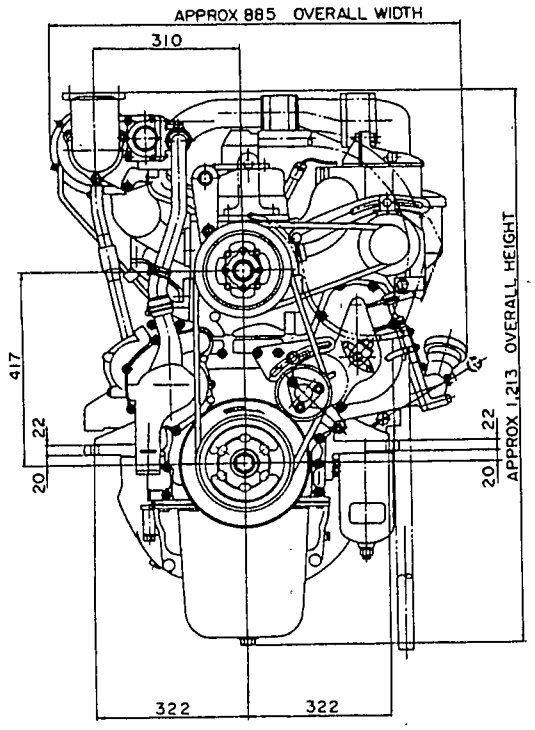
1.	Cylinder block	Mono block cast iron with replaceable wet liner
2.	Cylinder head	In two blocks, each one for three cylinder, cast iron
3.	Crankshaft	Induction-hardened, die forged special steel with counter weights
4.	Piston and rings	Heat-resistance aluminium alloy Three compression rings, chrome plated One oil ring, chrome plated with coil expander
5.	Camshaft	Induction hardened carbon steel
4.	Valves	Heat resistance steel

● STANDARD EQUIPMENT

1. Flywheel housing	HINO own (SAE No. 1 type)
2. Flywheel	HINO own (SAE 14 in. type)
3. Fuel injection pump	BOSCH "P" type
4. Governor	Mechanical, all speed control type
5. Fuel injection nozzle	BOSCH hole type
6. Fuel filter	Paper element type
7. Water separator	
8. Cooling system	Forced-circulation by volute pump
9. Lubricating system	Full forced pressure feed by gear pump
10. Oil filter	Paper element type (Full flow & By-pass flow)
11. Intake manifold	Inlet position at rear
12. Exhaust manifold with flange plate	Upward exhaust
13. Generator	Alternator with integral regulator 24V, 20A
14. Starter	24V, 7kW
15. Safety relay	
16. Connectors of electrical equipments	

● OPTIONAL EQUIPMENT

1. Cooling fan (suction or blowout)
2. Main switch
3. Battery switch
4. Battery relay
5. Starter switch with key
6. Ammeter
7. Fuse box
8. Engine shut off solenoid
9. Emergency relay
10. Coolant temperature switch
11. Coolant temperature gauge sender
12. Coolant temperature gauge
13. Oil pressure switch
14. Oil pressure gauge sender
15. Oil pressure gauge
16. Intake heater
17. Intake heater relay
18. Intake heater indicator
19. Tachometer with hourmeter
20. Tachometer cable
21. Muffler
22. Air cleaner
23. Air cleaner cap
24. Radiator with cooling fan shroud



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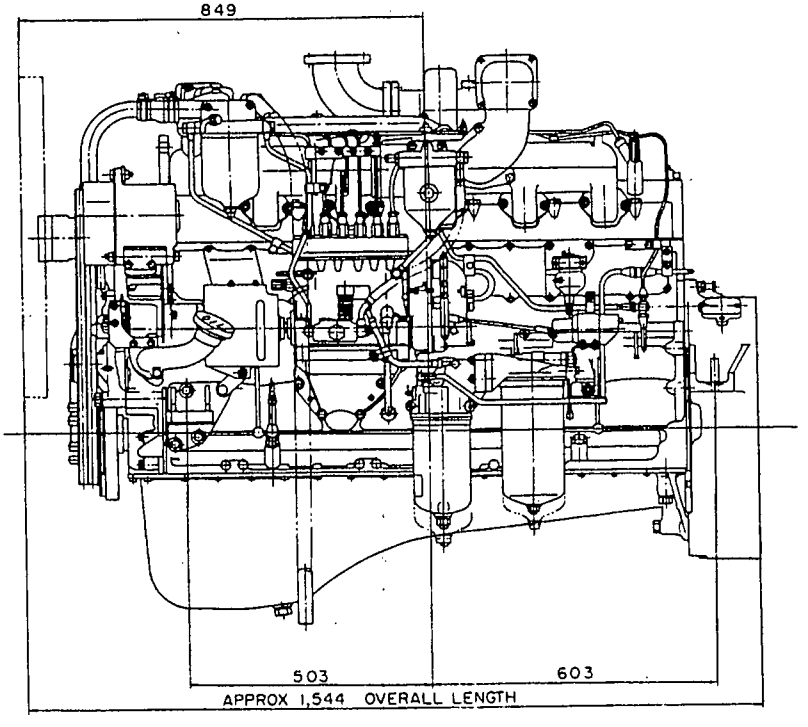

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NOTE: 1) These specifications are subject to change without notice.
2) These specifications are for export models.
3) All specifications of the products are with normal manufacturing allowances and tolerances.
4) The performance and drawings are for standard specifications.

TIGHTENING TORQUE OF STANDARD BOLT

Unit: kg-cm (lb.ft)

Bolt identification	Tightening conditions \ Bolt diameter (mm)	4	6	8	10	12	14	16	18	20	22	24
4	Even tightening area. Bolt nut, coating, naked bolt, lubricant, etc. Optimum conditions.	10 – 15 (0.8 – 1.0)	36 – 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 – 156)	2,030 – 2,980 (147 – 215)	2,560 – 3,750 (186 – 271)
5	Cast iron or aluminum 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	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)	764 – 1,120 (56 – 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)
7	Cast iron or aluminum 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	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 – 267 (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)
9 10	Cast iron or aluminum 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 (564 – 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 – 445 (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.

RECOMMENDED LUBRICANTS FOR ALL HINO ENGINE

HINO MOTORS, LTD.
OVERSEAS OPERATIONS
SERVICE DIV.
TOKYO, JAPAN

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 Beanng			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 Shaft Lever & Reduction Gear			——	Molytex Grease EP2	——	——	——	Mobilgrease 29	Aero Shell Grease 17	——
GENERATOR & STARTER BEARING GREASE	Generator Beanng Starter Beanng			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)

'82-12-200 (T.S.D)

EN-140E-01

CHAPTER EN

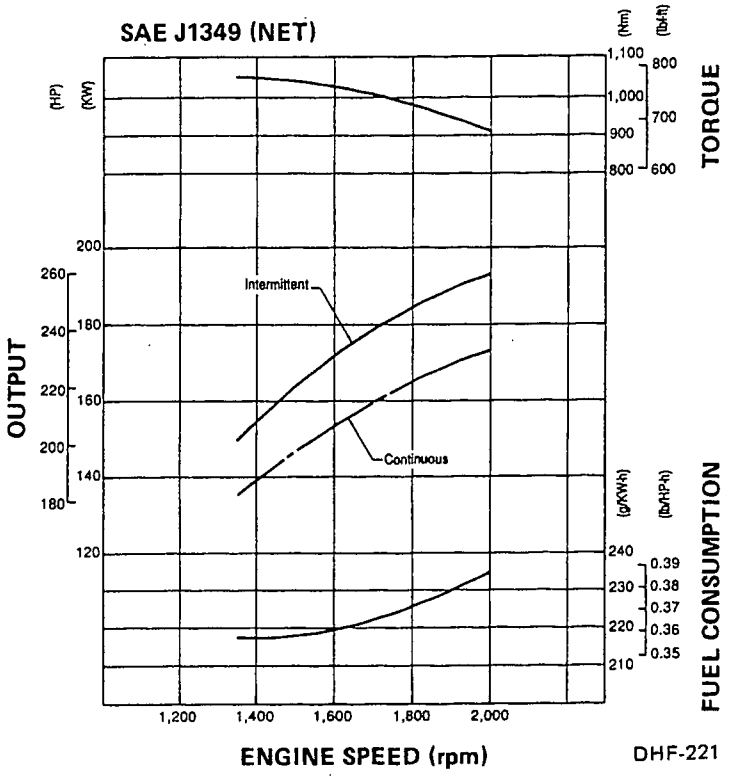
ENGINE

Model EK130-T

DATA AND SPECIFICATIONS

Model		HINO EK130-T
Type		Diesel, 4 cycle, vertical, 6-cylinder, in-line, overhead valve, water-cooled
Aspiration		Turbocharged
Combustion system		Direct injection
Bore and stroke		137 x 150 mm (5.39 x 5.91 in)
Piston displacement		13.267 liters (809.6 cu.in)
Compression ratio		16.5
Compression pressure		29–31 kg/cm^2 (412–441 lb/sq.in) at 200 rpm
Firing order		1–4–2–6–3–5 (A number of a cylinder is to be counted in order from timing gear side)
Direction of rotation		Counter-clockwise viewed from flywheel
Idling revolution		700–750 rpm
Dry weight		Approx. 1,065 kg (2,348 lb)
Valve seat angle;	Intake	30°
	Exhaust	45°
Valve face angle;	Intake	30°
	Exhaust	45°
Valve timing (flywheel travel),	Intake opens	14° before top dead center
	Intake closes	42° after bottom dead center
	Exhaust opens	48° before bottom dead center
	Exhaust closes	16° after top dead center
Valve clearance (when cold)	Intake	0.40 mm (0.0157 in)
	Exhaust	0.40 mm (0.0157 in)
Injection nozzle opening pressure		220 kg/cm^2 (3,129 lb/sq.in)
Injection timing		19° before top dead center for No.1 cylinder on compression stroke

PERFORMANCE CURVE



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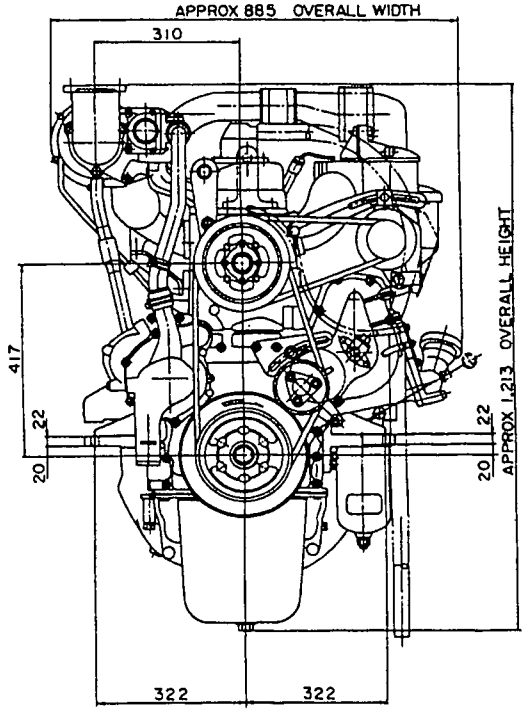
NOTE: Ambient conditions,
Intake air temperature
25°C (77°F)
Barometric pressure
100 kPa (29.61 in.Hg)
Water vapour pressure
1.0 kPa (0.296 in.Hg)

DESCRIPTION



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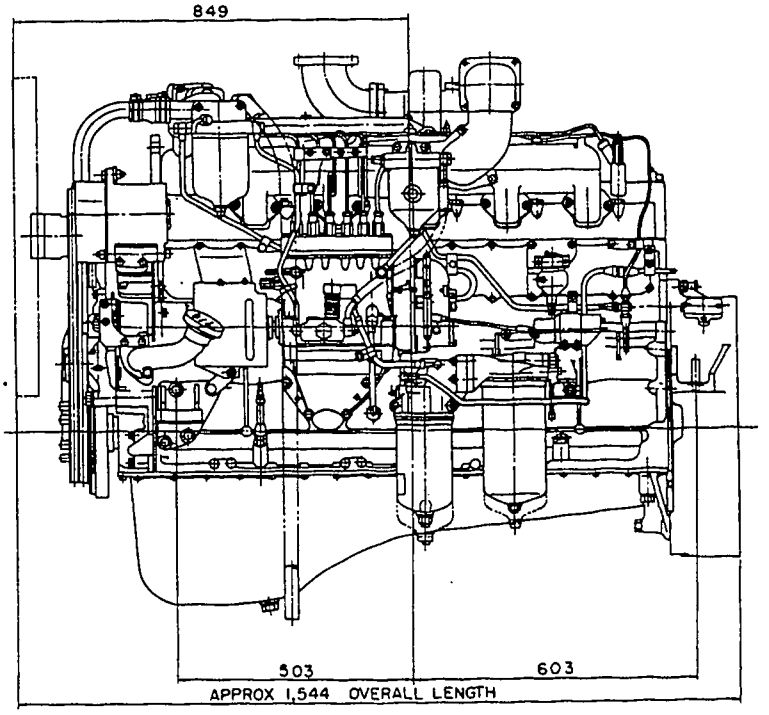

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TROUBLESHOOTING

Symptom	Possible cause	Remedy/Prevention
Engine overheating	**Coolant**	
	• Insufficient coolant	Add coolant.
	• Defective thermostat	Replace the thermostat.
	• Overflow of coolant due to leakage of exhaust into cooling system	Repair.
	• Coolant leakage from cylinder head gasket	Replace gasket.
	• Defective coolant pump	Repair or replace.
	Radiator	
	• Clogged with rust and scale	Clean radiator.
	• Clogged with iron oxide due to leakage of exhaust into cooling system	Clean coolant passage and correct exhaust leakage.
	• Clogged radiator core due to mud or other debris	Clean radiator.
	• Defective radiator cap pressure valve	Replace radiator cap.
	Abnormal combustion	
	• Incorrect injection timing	Adjust injection timing.
	• Reduced injection pressure	Adjust injection pressure.
	• Poor fuel	Use good quality fuel.
	• Poor nozzle spray	Adjust or replace nozzle.
	• Unsatisfactory automatic timer advance angle	Repair or replace timer.
	Other problems	
	• Defective or deteriorated engine oil	Change engine oil.
	• Unsatisfactory operation of oil pump	Replace or repair.
	• Insufficient oil	Add oil.
	• Brake drag	Repair or adjust.
Excessive oil consumption	**Pistons, cylinder liners, and piston rings**	
	• Wear of piston ring and cylinder liner	Replace piston rings and cylinder liner.
	• Worn, sticking or broken piston rings	Replace piston rings and cylinder liner.
	• Insufficient tension on piston rings	Replace piston rings and cylinder liner.
	• Unsatisfactory break-in of piston rings	Replace piston rings and cylinder liner.
	• Unsuitable oil (viscosity too low)	Change oil as required and replace piston rings and cylinder liners.
	• Incorrectly fitted piston rings (upside down)	Replace piston rings.
	• Gaps of piston rings in line with each other	Reassemble piston rings.

Symptom	Possible cause	Remedy/Prevention
Excessive oil consumption	**Valve and valve guides**	
	• Worn valve stem	Replace valve and valve guide.
	• Worn valve guide	Replace valve guide.
	• Incorrectly fitted valve stem seal	Replace the stem seal.
	• Excessive lubricant on rocker arm	Check clearance of rocker arm and shaft.
	Excess oil feed	
	• Defective oil level gauge	Replace oil level gauge.
	• Oil level too high	Drain excess oil.
	Other problems	
	• Overcooled engine (low temperature wear)	Warm up engine before moving vehicle. Check cooling system.
	• Oil leakage from miscellaneous parts	Repair.
Piston seizure	**Operation**	
	• Abrupt stoppage of engine after running at highspeed	Operate engine properly.
	• Hill climbing using unsuitable gear	Select suitable gear.
	Oil	
	• Insufficient oil	Add oil.
	• Dirty oil	Change oil.
	• Poor quality oil	Replace with proper engine oil.
	• High oil temperature	Repair.
	• Low oil pressure	Repair.
	• Defective oil pump	Repair oil pump.
	• Reduced performance due to worn oil pump	Replace oil pump.
	• Suction strainer sucking air	Add oil and/or repair strainer.
	Abnormal combustion	See Symptom: "Engine overheating."
	Coolant	See Symptom: "Engine overheating."
Lack of power	**Injection pump**	Refer to CHAPTER IP, FUEL INJECTION PUMP.
	Intake	
	• Clogged air cleaner	Clean element or replace element.
	Overheating	See Symptom: "Engine overheating."

Symptom	Possible cause	Remedy/Prevention
Lack of power	**Fuel and nozzle**	
	• Poor nozzle spray	Adjust or replace injection nozzle.
	• Clogged nozzle with carbon	Clean nozzle.
	• Wear or seizure of nozzle	Replace nozzle.
	• Air in fuel system	Repair and bleed air from fuel system.
	• Clogged fuel filter	Replace element.
	• Use of poor fuel	Use good quality fuel.
	Abnormal combustion	See Symptom: "Engine overheating."
	Piston, cylinder liners, and piston rings	See Symptom "Engine overheating."
	Other problems	
	• Breakage of turbine or blower	Replace the turbine or blower or turbocharger.
Difficulty starting engine	**Electrical system**	
	• Discharged battery	Charge battery.
	• Defective wiring in starter circuit	Repair wiring of starter.
	• Loose or open-circuit battery cable	Tighten battery terminal connections or replace battery cable.
	• Breakdown of starter	Replace starter.
	• Break of glow plug or intake air heater (If so equipped)	Replace
	Injection pump	Refer to CHAPTER IP, FUEL INJECTION PUMP.
	Air cleaner	
	• Clogged element	Clean the element or replace the element.
	Fuel system	
	• No fuel in tank	Supply fuel and bleed air from fuel system.
	• Clogged fuel line	Clean fuel line.
	• Air sucked into fuel system through fuel line connections	Tighten fuel line connections.
	• Clogged fuel filter	Replace element.
	• Loose connection in high-pressure line	Tighten sleeve nut of high pressure line.
	• Water in fuel	Drain and clean fuel system

Symptom	Possible cause	Remedy/Prevention
Difficulty starting engine	**Nozzles**	
	• Seized nozzle	Replace nozzle.
	• Broken or fatigued nozzle spring	Replace spring.
	Oil system	
	• Oil viscosity too high	Use proper viscosity oil, or install an oil immersion heater and warm up oil.
	Other problems	
	• Seized piston	Replace piston, piston rings, and liner.
	• Seized bearing	Replace bearing and/or crankshaft.
	• Reduced compression pressure	Overhaul engine.
	• Ring gear damaged or worn	Replace the ring gear and/or starter pinion.
	• Improperly adjusted or broken accelerator cable	Adjust or replace the accelerator cable.
Rough idling	**Injection pump**	Refer to CHAPTER IP, FUEL INJECTION PUMP.
	Nozzles	
	• Uneven injection pressure	Adjust.
	• Poor nozzle spray	Adjust or replace nozzle.
	• Carbon deposit on nozzle tip	Remove carbon.
	• Seized needle valve	Replace nozzle.
	Engine proper	
	• Improper valve clearance	Adjust valve clearance.
	• Improper contact of valve seat	Replace or repair valve and valve seat.
	• Idling speed too low	Adjust idling speed.
	• Coolant temperature too low	Warm up engine.
	• Compression pressure of cylinders markedly different from one another	Overhaul engine.
Leakage of exhaust	**Cylinder head gasket**	
	• Fatigued gasket (aging)	Replace gasket.
	• Damage	Replace gasket.
	• Improper installation	Replace gasket.

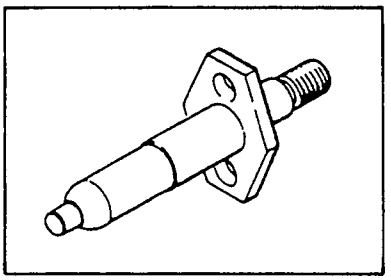
Symptom	Possible cause	Remedy/Prevention
Leakage of exhaust	**Cylinder head bolts**	
	• Loose bolts	Tighten bolt.
	• Elongated bolts	Replace bolt.
	• Improper tightening torque or tightening sequence	Tighten properly.
	Cylinder block	
	• Cracking	Replace cylinder block.
	• Surface distortion	Repair or replace.
	• Fretting of cylinder liner insertion portion (insufficient projection of cylinder liner)	Replace cylinder liner or cylinder block.
	Cylinder head	
	• Cracking	Replace cylinder head.
	• Surface distortion	Repair or replace.
	Cylinder liners	
	• Cracking	Replace cylinder liner.
	• Corrosion	Replace cylinder liner.
	• Insufficient projection of cylinder liner	Replace cylinder liner.
	Other problems	
	• Incorrect injection timing	Adjust injection timing.

ENGINE OVERHAUL CRITERIA

SPECIAL TOOL

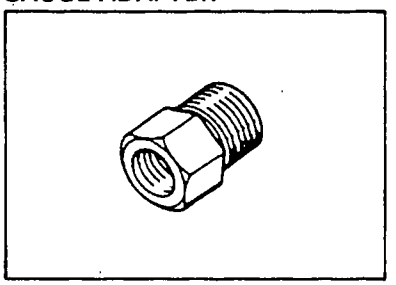
Prior to starting an engine overhaul, it is necessary to have these special tools.

COMPRESSION GAUGE ADAPTER

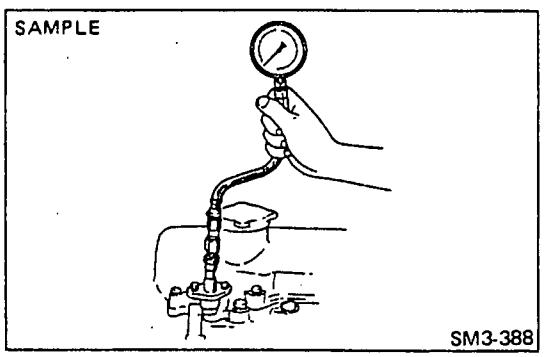


09508-1030

COMPRESSION GAUGE ADAPTER



09552-1030
09552-1060



FACTORS WHICH DETERMINE WHEN AT ENGINE OVERHAUL IS NEEDED.

1. Lowered compression pressure.

a. Before the measurement
   a) Correct the valve clearance.
   b) Warm up engine [Bring the coolant temperature to about 80°C (144°F)].
   c) Charge the battery fully.
   d) Remove the air cleaner.

b. Measurement
   a) Remove the nozzle holders.
   b) Install the gauge adapter in the nozzle holder hole.

Special Tool: Compression Gauge Adapter (09508-1030)
(09552-1030)
(09552-1060)

   c) Connect a compression gauge to the gauge adapter.
   d) Drive the engine with the starter and read the compression pressure.

NOTE: Do not continuously operate the starter for more than 15 seconds at a time.

   e) Measure the compression pressure for each cylinder. If the compression pressure is low, be sure to repeat the measuring.

NOTE: Be sure not to leak through sealing face.

Unit: kg/cm² (lb/sq.in)

Engine model	Compression pressure		Difference between each cylinder	Engine speed (rpm)
	Standard	Limit		
K13C EK130-T	29–31 (412–441)	27 (384)	Less than 3 (43)	200
EK100	32–34 (455–483)	30 (427)		

SAMPLE

SM3-349

S.A.E. GRADE	ATMOSPHERIC TEMPERATURE	
	−10 0 32 50 70 90 100 °F	
	−23 −18 0 10 21 32 39 °C	
40		
30		
20W/20		
15W/40		

2. Decreased oil pressure
   Check the oil pressure warning lamp when the oil and coolant temperature is hot [about 80°C (176°F)].

a. If the warning lamp is lighted, check the oil level.
b. Check oil deterioration.
   If oil quality is poor, replace with a suitable grade oil.
c. Remove the oil pressure switch and install the oil pressure gauge.
d. Measure the oil pressure at coolant temperature 80°C (176°F) or more.

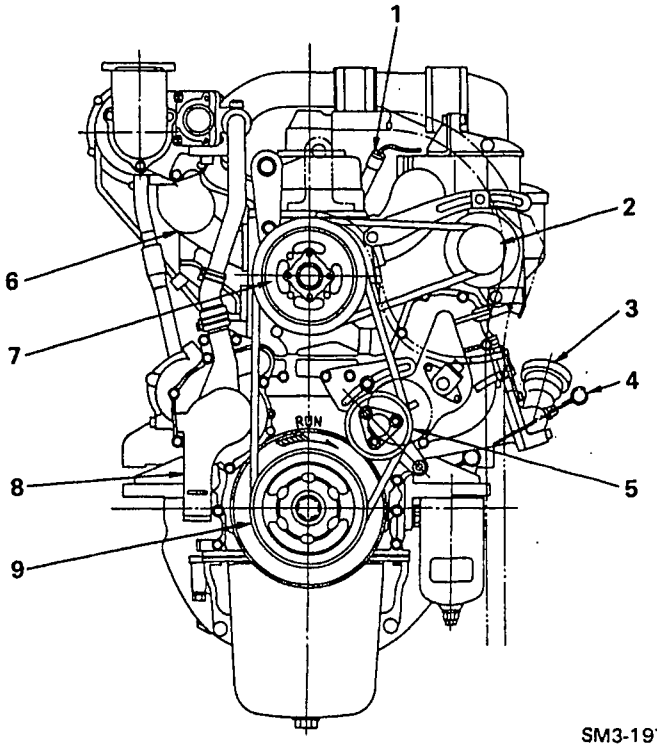
Standard oil pressure: 0.5–5.0 kg/cm^2 (7.11–71.10 lb/sq.in)
Service limit: Less than 0.5 kg/cm^2 (7.11 lb/sq.in)

3. Other factors

a. The blow-by gas increases.
b. The engine does not start easily.
c. Engine output decreases.
d. Fuel consumption increases.
e. Engine makes greater noise.
f. Excessive oil consumption.

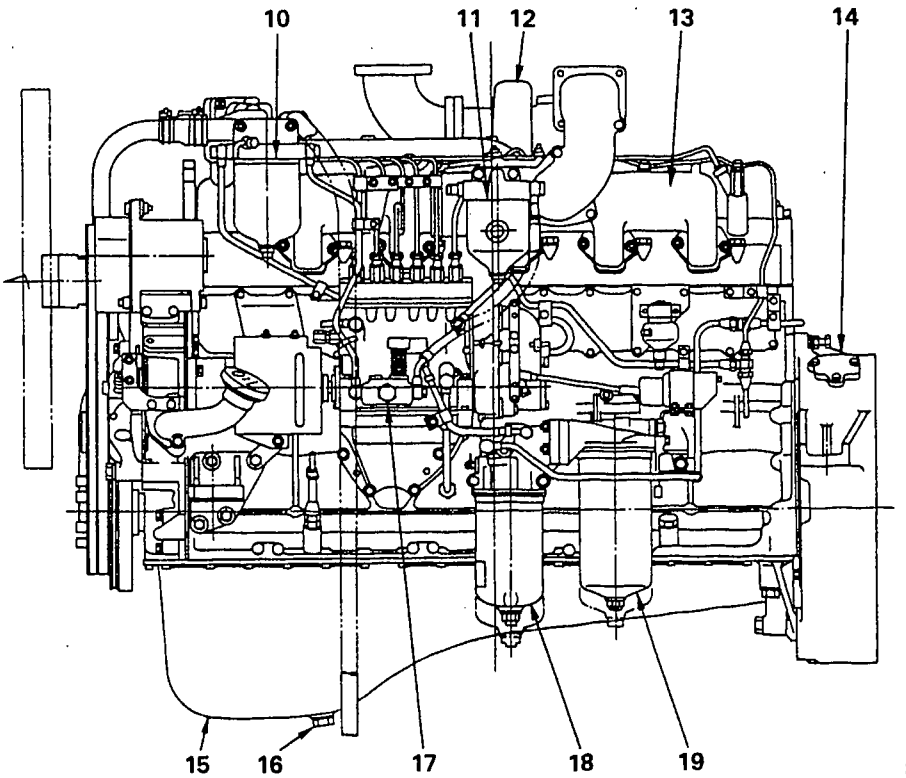
ENGINE MOVING PARTS

DESCRIPTION



SM3-1979

1. Fuel injection nozzle
2. Generator
3. Engine oil filler cap
4. Engine oil level gauge
5. Tension pulley
6. Exhaust manifold
7. Cooling fan pulley
8. Coolant pump
9. Crankshaft pulley
10. Fuel filter
11. Water separator (If so equipped)
12. Turbocharger
13. Intake manifold
14. Inspection hole
15. Oil pan
16. Engine oil drain plug
17. Fuel injection pump
18. Oil filter (Full flow)
19. Oil filter (Bypass)

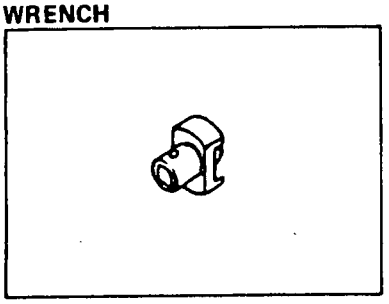


SM3-1980

SPECIAL TOOL

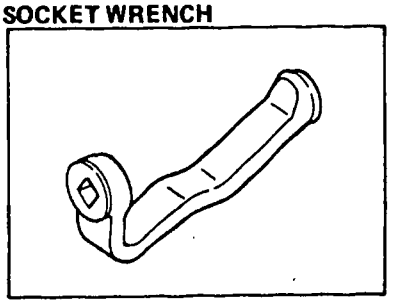
Prior to starting an engine overhaul, it is necessary to have these special tools.

NOZZLE HOLDER ADAPTER WRENCH



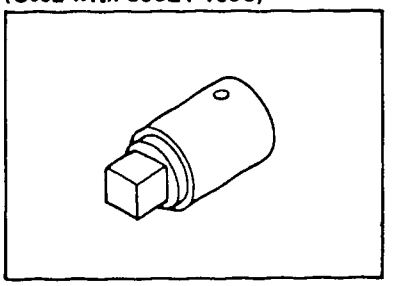
09503-1010

CYLINDER HEAD BOLT SOCKET WRENCH



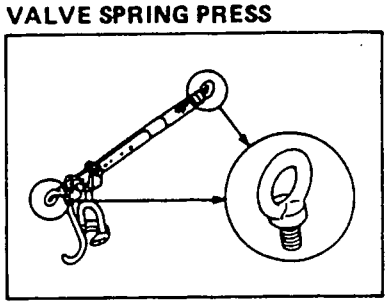
09621-1090

ADAPTER
(Used with 09621-1090)



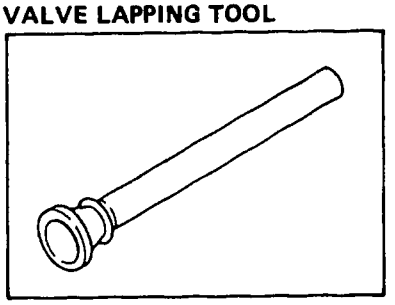
09621-1020

VALVE SPRING PRESS



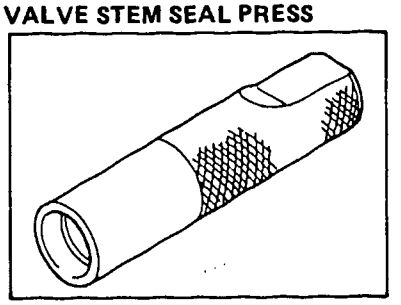
09470-1022

VALVE LAPPING TOOL



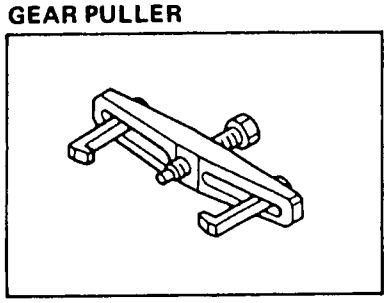
09431-1010

VALVE STEM SEAL PRESS



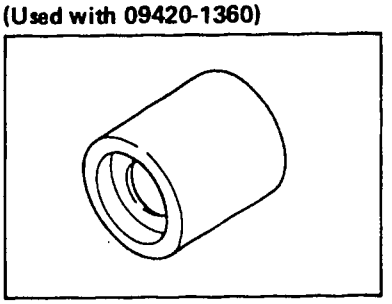
09472-1570

GEAR PULLER



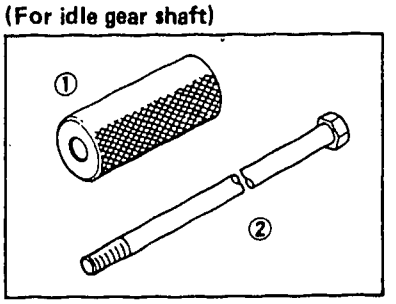
09420-1360

GEAR PULLER ADAPTER
(Used with 09420-1360)



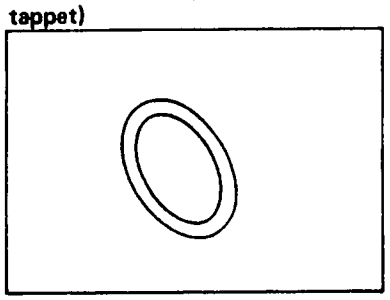
09462-1011

SLIDING HAMMER
(For idle gear shaft)



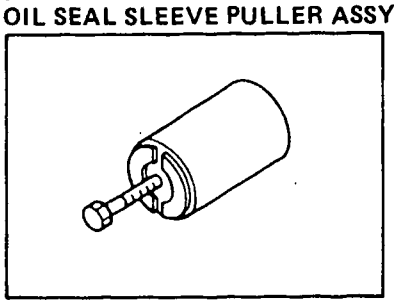
① 09472-1100
② 09472-1090

O-RING (For suspending the tappet)



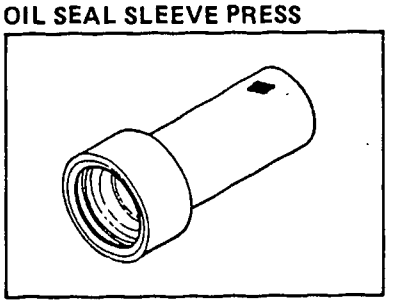
9851-20104

INJECTION PUMP DRIVE SHAFT OIL SEAL SLEEVE PULLER ASSY



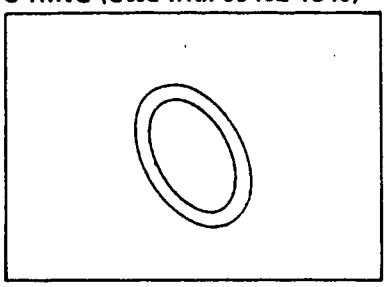
09420-1180

INJECTION PUMP DRIVE SHAFT OIL SEAL SLEEVE PRESS



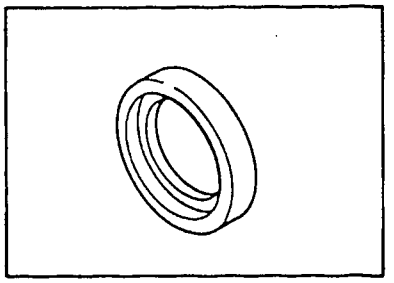
09482-1340

O-RING (Used with 09482-1340)



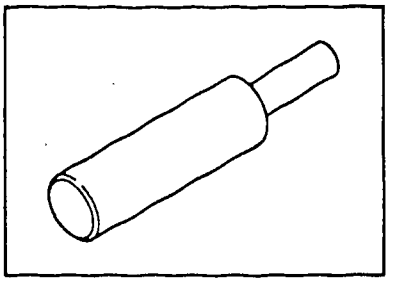
9851-36104

CRANKSHAFT FRONT (TIMING GEAR COVER) OIL SEAL PRESS



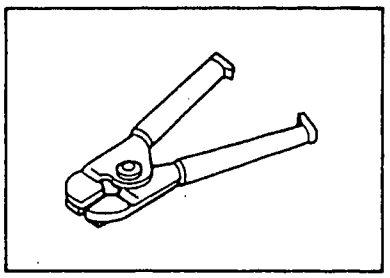
09482-1040

PISTON PIN PRESS



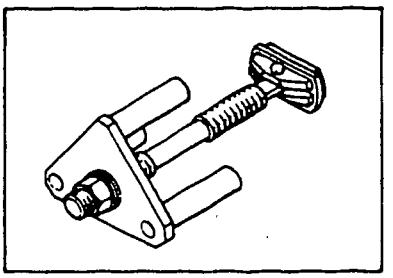
09482-1380

PISTON RING EXPANDER



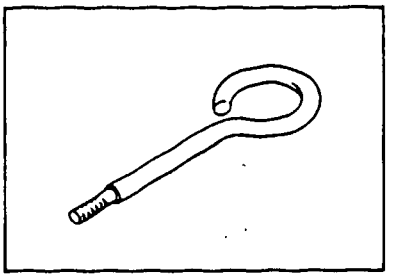
09442-1131

CYLINDER LINER PULLER



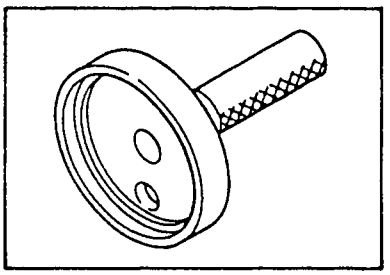
09420-1290

EYE BOLT (For removing the crankshaft front oil seal sleeve)



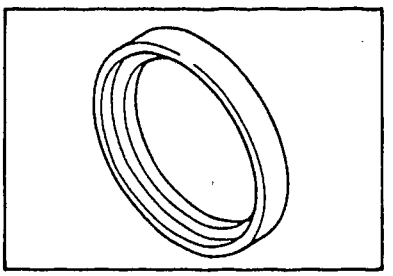
09433-1010

CRANKSHAFT REAR OIL SEAL SLEEVE PRESS



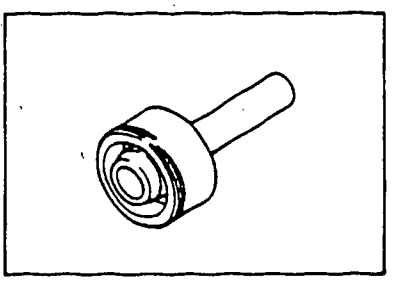
09402-1041

CRANKSHAFT REAR OIL SEAL PRESS



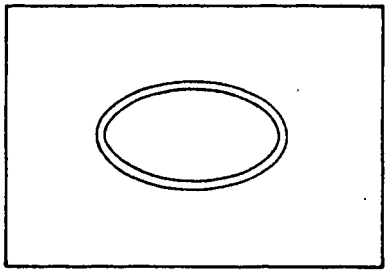
09482-1050

CRANKSHAFT DUST SLINGER PRESS



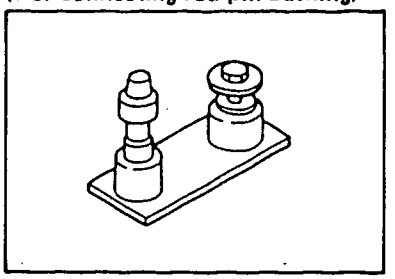
09402-1120

O-RING
(Used with 09402-1120)



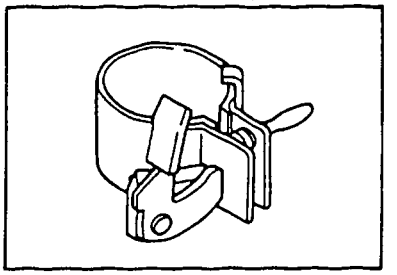
9851-74102

PRESS ASSY
(For connecting rod pin bushing)



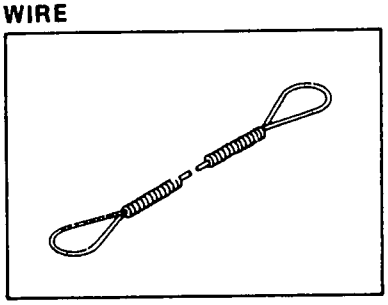
09407-1010

PISTON RING HOLDER



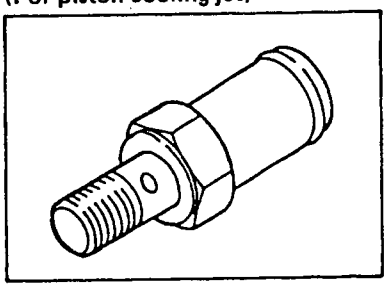
09441-1011

WIRE



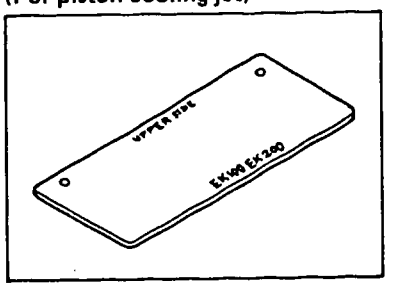
09491-1020 Dia. 12 mm (0.47 in)
09491-1030 Dia. 9 mm (0.35 in)

CONNECTOR BOLT
(For piston cooling jet)



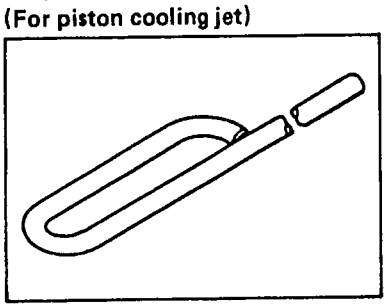
9001-24265

TARGET PLATE
(For piston cooling jet)



09444-1300

ADJUSTER BAR
(For piston cooling jet)

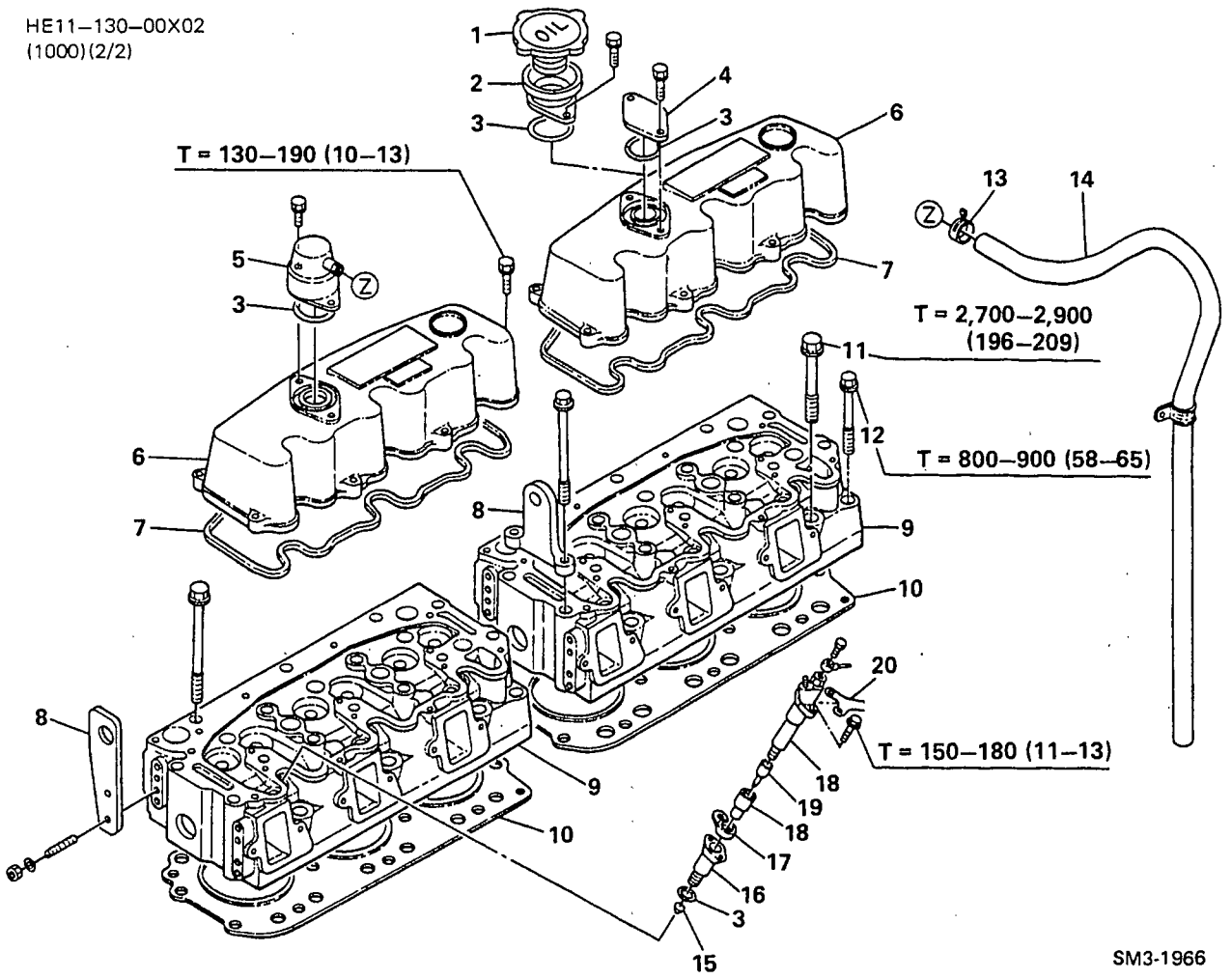


09472-1620

CYLINDER HEAD

OVERHAUL

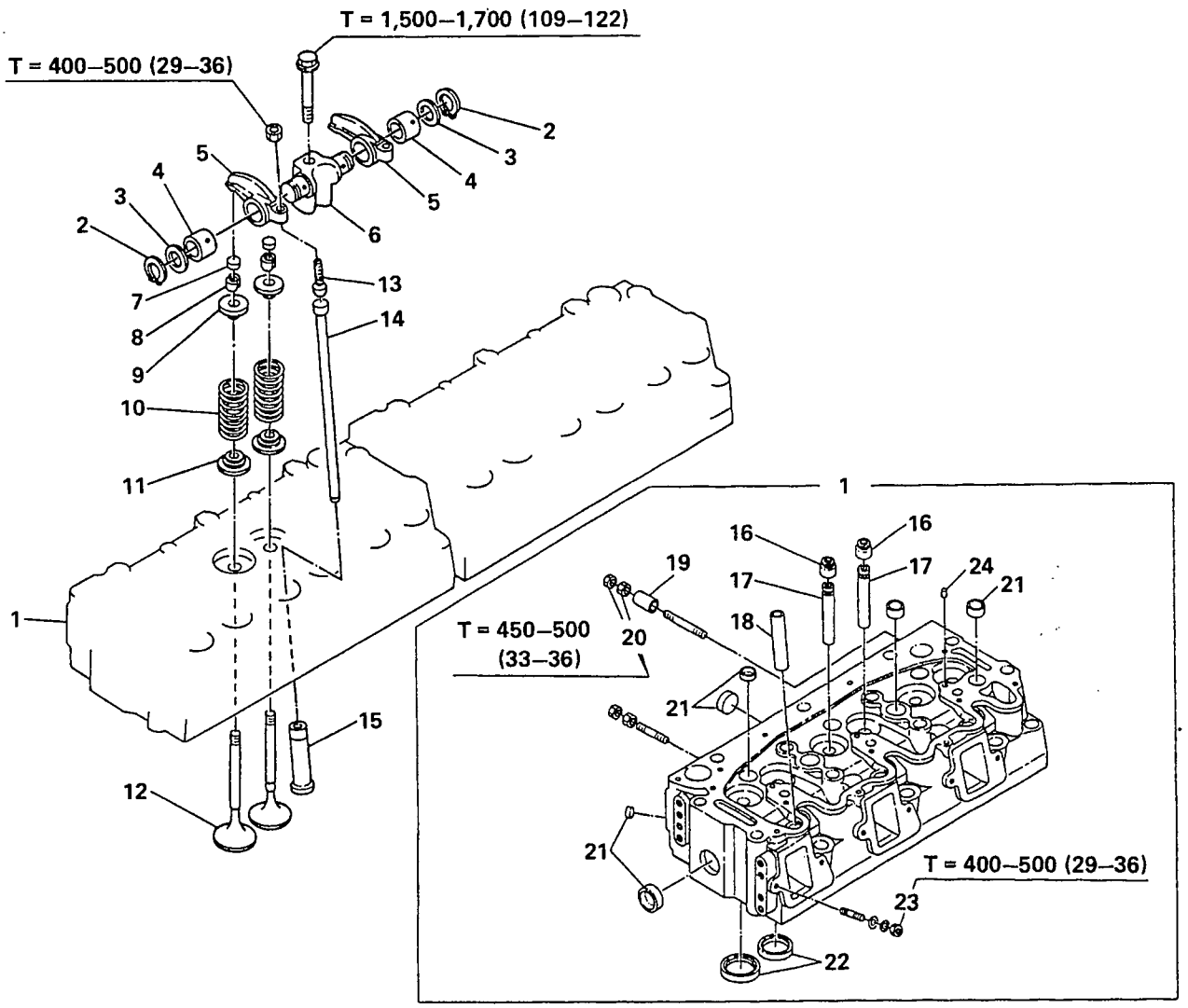
HE11–130–00X02
(1000)(2/2)



T = Tightening torque: kg·cm (lb.ft)

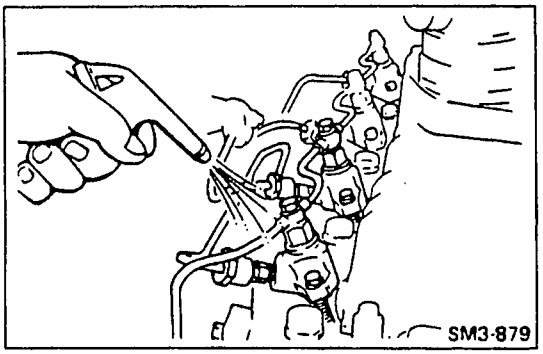
1. Oil filler cap
2. Oil pipe
3. O-ring
4. Plate
5. Ventilator
6. Cylinder head cover
7. Cylinder head cover gasket
8. Engine hanger
9. Cylinder head
10. Cylinder head gasket
11. Cylinder head bolt
    Diameter 16 mm (0.63 in)
12. Cylinder head additional bolt
    Diameter 12 mm (0.47 in)
13. Clip
14. Hose
15. Nozzle holder gasket
16. Nozzle holder adapter
17. Packing ring
18. Nozzle holder
19. Nozzle
20. Nozzle holder gauge

OVERHAUL



T = Tightening torque: kg·cm (lb.ft)

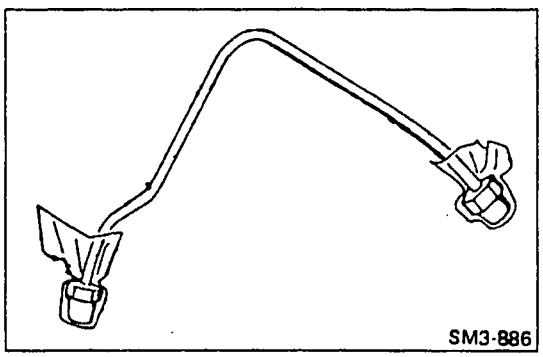
1. Cylinder head
2. Retainer ring
3. Plain washer
4. Bushing
5. Rocker arm
6. Rocker arm support
7. Valve stem cap
8. Valve cotter
9. Valve spring upper seat
10. Valve spring
11. Valve spring lower seat
12. Valve
13. Valve clearance adjusting screw
14. Push rod
15. Tappet
16. Valve stem oil seal
17. Valve guide
18. Pipe
19. Spacer
20. Exhaust manifold fitting nut
21. Plug
22. Valve seat
23. Intake manifold fitting nut
24. Straight pin



IMPORTANT POINTS – DISASSEMBLY

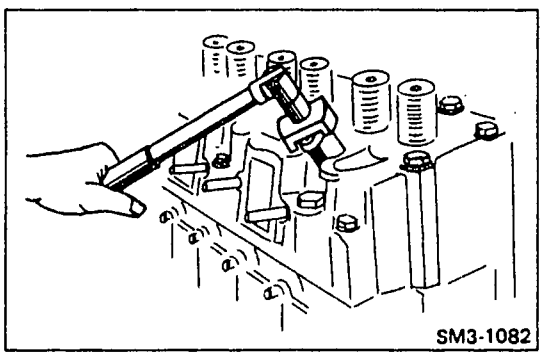
CLEAN OFF SURROUNDING AREA OF THE NOZZLES AND THE FUEL LINE CONNECTORS.

NOTE: If foreign matter is allowed to enter the combustion chamber, engine trouble may result.



REMOVE THE FUEL INJECTION PIPES.

Cover open ends of the pipes and fuel injection pump to prevent entry of dirt.



REMOVE THE INJECTION NOZZLE HOLDER.

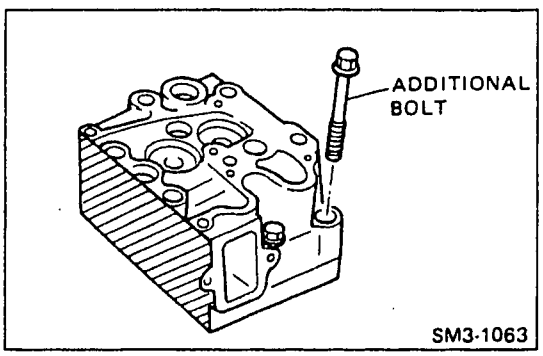
1. Remove the jet locating gauge, dismounted on the nozzle holder flange from each cylinder then nozzle holders.

NOTE: Be careful when handling the gauge so that it is not bent or broken.

2. Remove the nozzle holder adapter from the cylinder head using the adapter wrench, if needs.

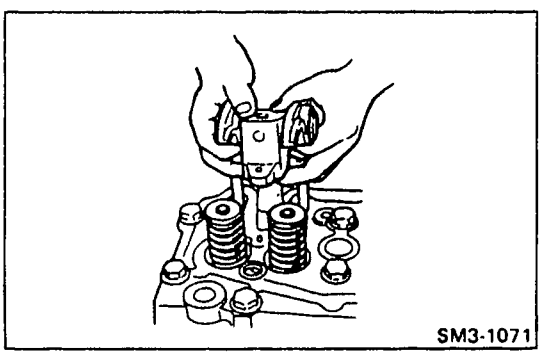
Special Tool: Nozzle holder adapter wrench (09503-1010)

3. Cover open ends of the nozzle holder connectors to prevent of dirt.



REMOVE THE CYLINDER HEAD ADDITIONAL BOLT.

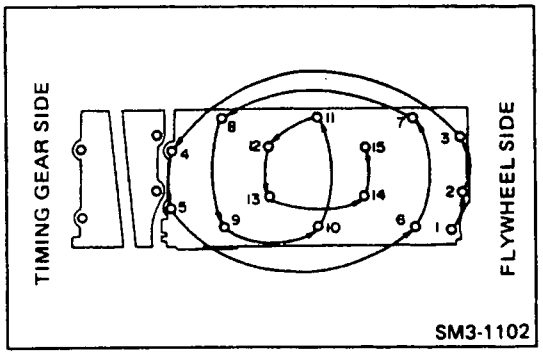
NOTE: Additional bolt is 12 mm (0.47 in) dia.



REMOVE THE ROCKER ARM ASSEMBLY.

Loosen the rocker arm support bolts and remove the rocker arm assembly.

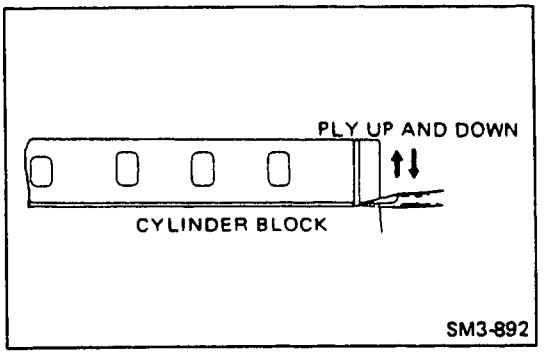
NOTE: Attention should be paid to the fact that the rocker arms of the intake and exhaust valves are mounted different directions. Keep the components in their disassembly order for easy reassembly.



LOOSEN THE CYLINDER HEAD BOLTS AND REMOVE THEM.

Using special tools, loosen the cylinder head bolts little by little in three stages and in the numerical order as shown.

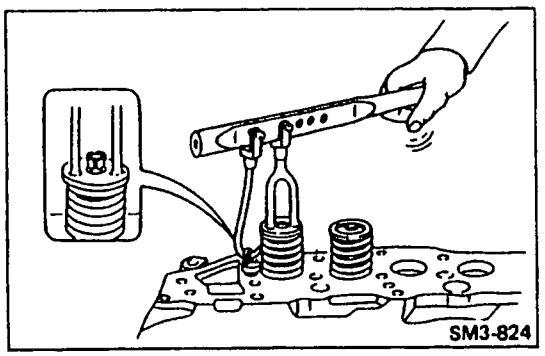
Special Tool: Socket wrench (09621-1090)
Adapter (09621-1020)



LIFT THE CYLINDER HEAD FROM THE DOWEL ON THE CYLINDER BLOCK AND PLACE IT ON WOODEN BLOCKS.

If the cylinder head is difficult to lift off, pry with a chisel between the cylinder head and block.

NOTE: Do not damage the machined surface of the head or block when removng the cylinder head.

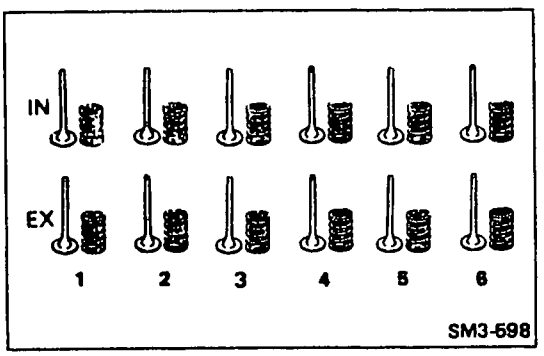


REMOVE THE VALVE SPRINGS.

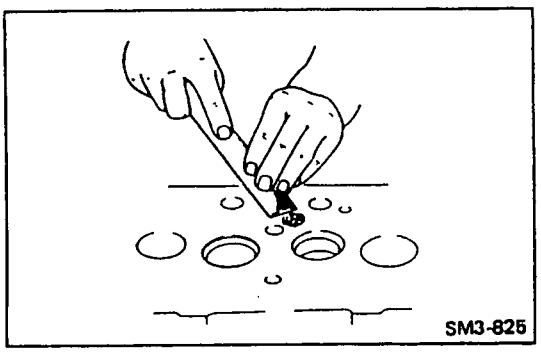
1. Using a special tool, remove the valve stem cotters, upper valve seats, and valve springs from cylinder head.

Special Tool: Valve spring press (09470-1022)

2. Remove the intake and exhaust valves.



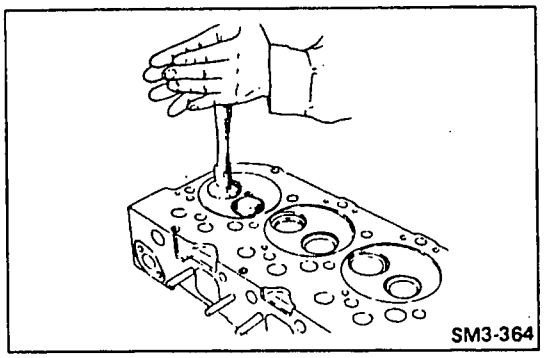
3. Tag valves to identify their cylinder numbers and to eliminate valve lapping.



IMPORTANT POINTS – ASSEMBLY

CLEAN THE CYLINDER HEAD THOROUGHLY WITH A SUITABLE SOLVENT.

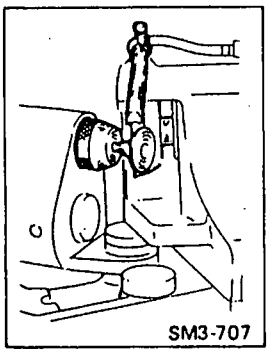
NOTE: Do not damage the cylinder head surface.

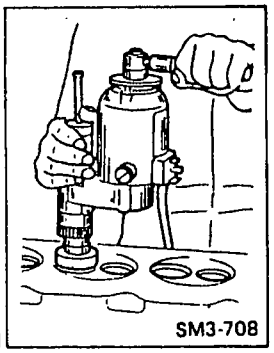

SM3-364

IF NECESSARY, HAND-LAP VALVE AND VALVE SEAT.

Lightly apply lapping compound to the valve face. Install the valve with a special tool, tap and rotate the valve against the seat.

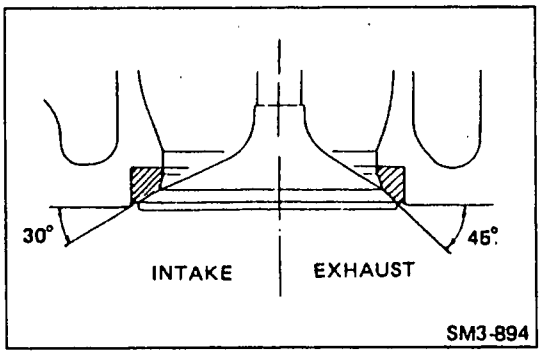
Special Tool: Valve lapping tool (09431-1010)


SM3-707


SM3-708

IF NECESSARY, GRIND THE VALVES AND VALVE SEATS.

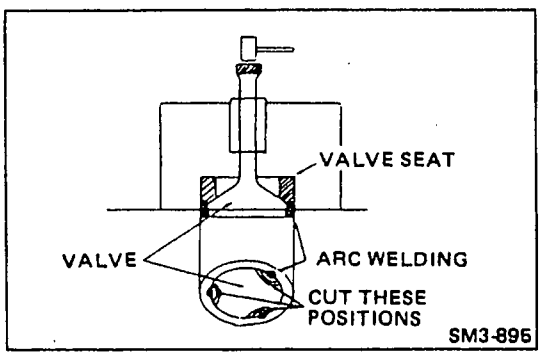
NOTE:
- **Grinding of valves and valve seats should only be performed when hand-lapping does not result in proper seating.**
- **After grinding, always recheck the valve sink.**



SM3-894

Standard:

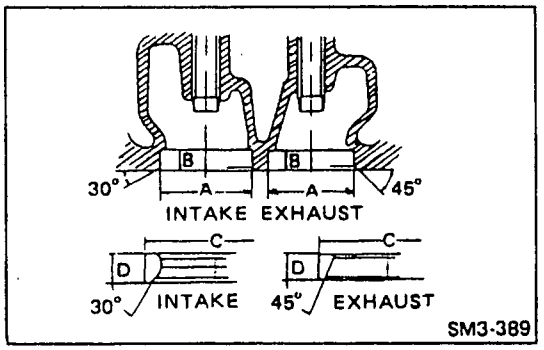
Valve seat (Intake)	:	30°–30°30′
Valve face (Intake)	:	29°30′–30°
Valve seat (Exhaust)	:	45°–45°30′
Valve face (Exhaust)	:	44°30′–45°



SM3-895

IF NECESSARY, REPLACE THE VALVE SEAT.

1. Cut the circumference of a valve head at three places with a grinder and install it into the seat as shown and weld the valve to the seat. Then drive the valve and the seat out with a hammer and a brass bar.

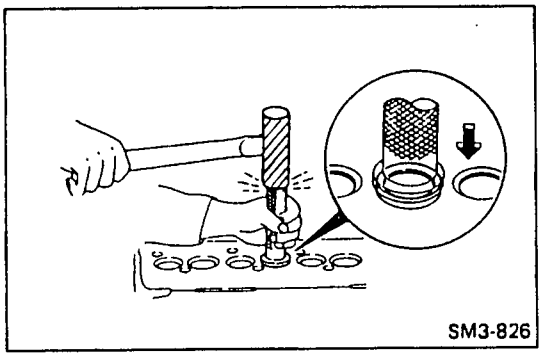


SM3-389

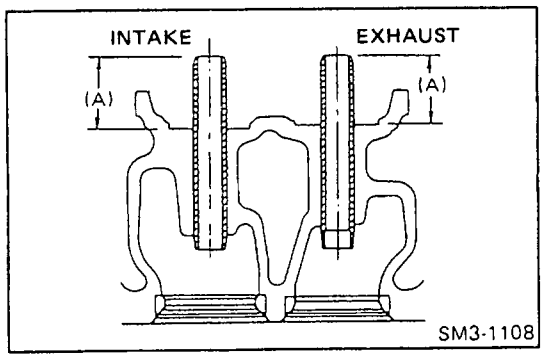
2. Valve seat section machining specifications.

Unit: mm (in)

		Intake	Exhaust
Cylinder head dimension	A	61.00–61.019 (2.4016–2.4023)	55.000–55.019 (2.1654–2.1661)
	B	11.2–11.3 (0.4410–0.4448)	11.2–11.3 (0.4410–0.4448)
Valve seat dimension	C	61.085–61.100 (2.4050–2.4055)	55.085–55.100 (2.1688–2.1692)
	D	9.80–10.0 (0.3859–0.3937)	8.80–9.00 (0.3465–0.3543)


SM3-826

3. Valve seat installation.
   Heat the cylinder head to about 80°–100°C (176–212°F) with hot water. On the other hand, cool the valve seat with liquid nitrogen for about 15 minutes. Hold the seat with pincets and place it into the heated cylinder head.



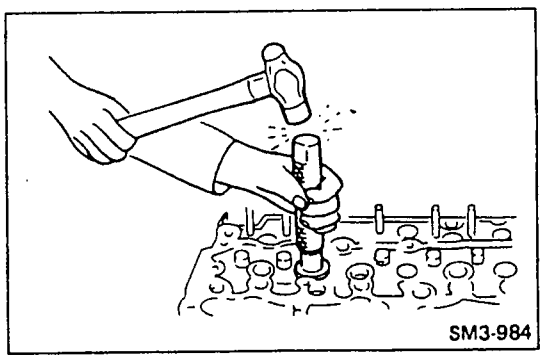
SM3-1108

IF NECESSARY, REPLACE THE VALVE GUIDE.

1. Remove the valve stem seal.
2. Using a brass rod and hammer, drive out the valve guide.
3. Using a brass rod and hammer, install the valve gude as shown.

Valve guide height (A): 22.1–23.1 mm (0.87–0.91 in)

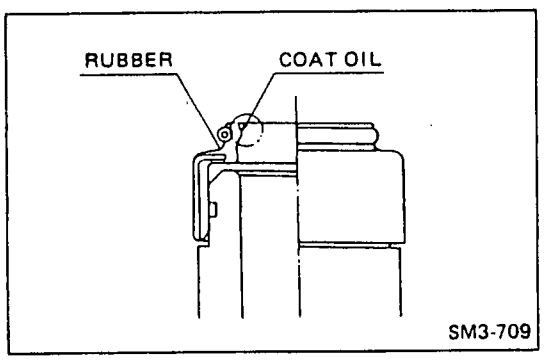
NOTE: Apply engine oil lightly to the valve guide outer circumference before installing.


SM3-984

IF NECESSARY, REPLACE THE VALVE STEM SEAL.

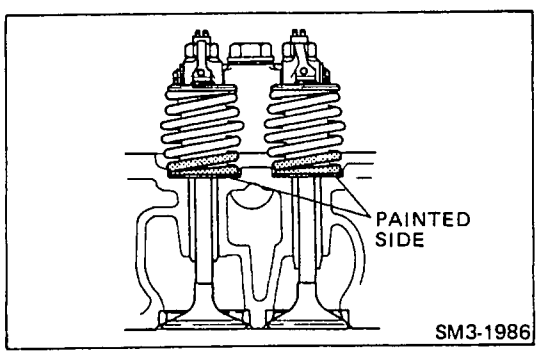
1. Remove the valve stem seal.
2. Install the valve stem seal.
   First, install the lower spring seat and valve. Then apply engine oil to the lip of the stem seal and drive the stem seal with a special tool.

Special tool: Valve stem seal press (09472-1570)



SM3-709

NOTE: o After installing stem seal, make sure that check the rubber
o Do not use the special tool if its tip (surface contacting lower spring seat) is worn or deformed.

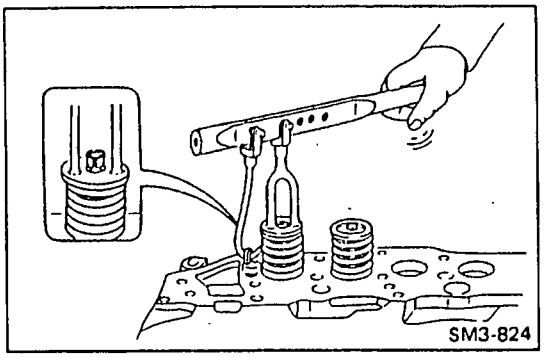


SM3-1986

INSTALL THE VALVE AND VALVE SPRING.

1. Install the valve springs with their painted side down, since they have variable pitches.

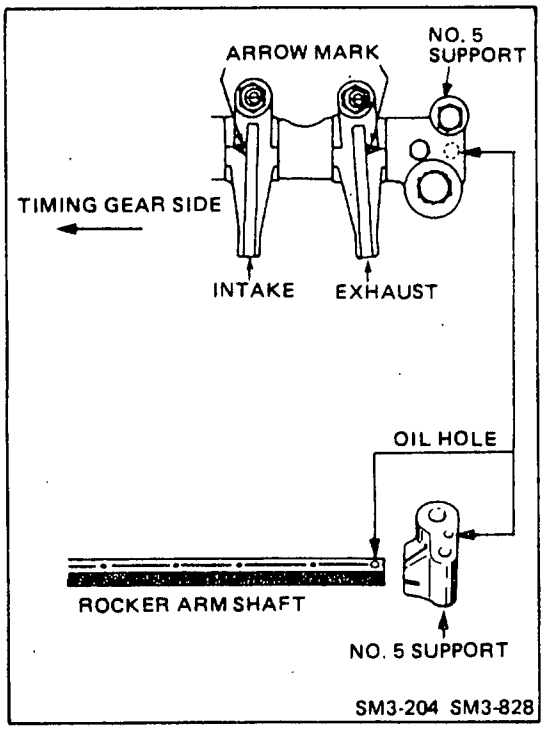
NOTE: o Apply engine oil to contact surfaces of all parts.
o Make sure that the valves are installed in the correct cylinders.



2. Using a special tool, press upper spring seats and install the valve cotters securely in the upper spring seats.

Special Tool: Valve spring press (09470-1022)

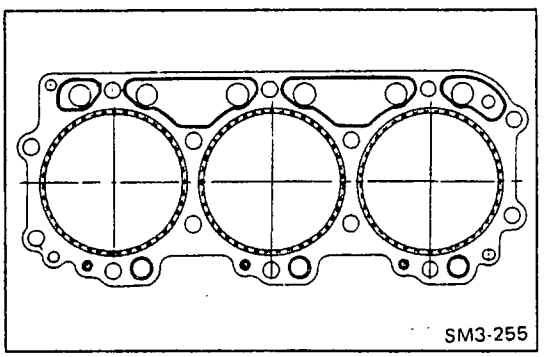
NOTE: o When pressing with the valve spring press, do not damage the stem seals by contacting the upper seats.
o Drive the valve stem lightly with a hammer to assure proper fit te valve cotter.



ASSEMBLE THE ROCKER ARM.

Lubricate the rocker arm shaft and bushing, then assemble the rocker arms and shaft as shown.

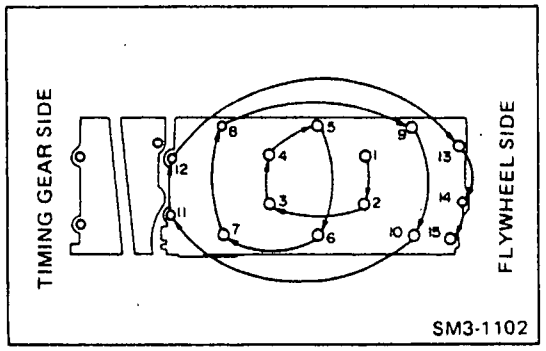
NOTE: Confirm that oil hole of rocker arm assembly No.5 support aligns with shaft oil hole. Improper installation will result in burning of the entire valve assembly.



INSTALL THE CYLINDER HEAD AND ROCKER ARM ASSEMBLY.

1. Install the cylinder head gasket.

NOTE: Always use new cylinder head gasket after cleaning the surfaces of the cylinder head, cylinder block and head gasket free of all dirt, water and grease.

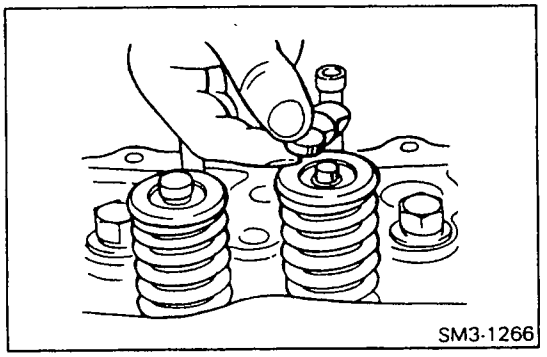


2. Using special tools, tighten the cylinder head bolts in three stages following the tightening order as shown.

NOTE: Apply engine oil to the bolt threads and under the bolt head.
No.15 is 12 mm (0.47 in) dia. bolt and others are 18 mm (0.70 in) dia. bolts.

Special Tool: Socket wrench (09621-1120)
Adapter (09621-1020)

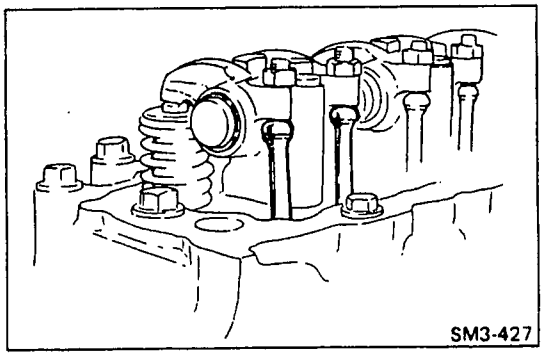
	Tightening torque
1st step	50% of specified torque
2nd step	75% of specified torque
3rd step	100% of specified torque


SM3-1266

INSTALL THE ROCKER ARM.

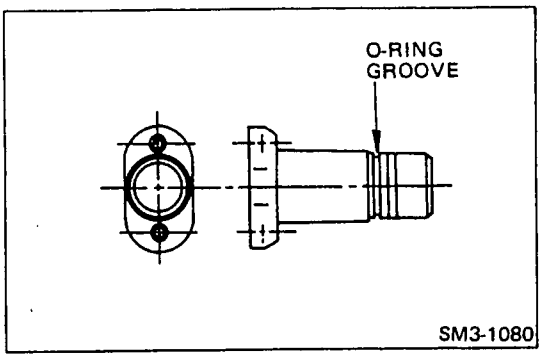
1. Install the stem caps.

NOTE: Make sure that both the end of the valve stem and the inside of the valve stem cap are free from dust.
Apply engine oil to the valve stem ends and put the stem caps on the valve stem ends. Do not drop the caps into the engine.


SM3-427

2. Apply engine oil to both ends and insert the push rods in correct order.
3. Mount the rocker arm assembly on the cylinder head, make sure that the push rods interlock with the adjusting screws.

NOTE: Always loosen the lock nut and raise the adjusting screws fully to the top.



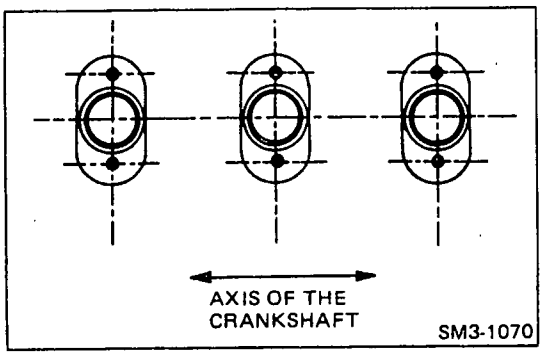
SM3-1080

INSTALL THE NOZZLE HOLDER ADAPTOR.

1. Insert the new O-ring to the nozzle holder adapter.
2. Using a special tool, screw-in into the cylinder head until it is stopped.

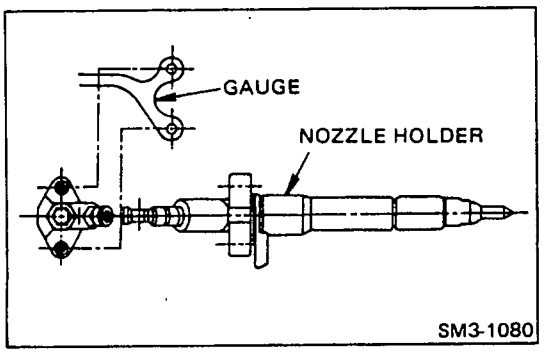
Special Tool: Nozzle holder adapter wrench (09503-1010)

NOTE: When the adapter is removed, replace the O-rng with a new one and apply engine oil.



SM3-1070

2. Loosen and adjust the adapter within 1/2 turns so that the line connecting the tapped holes on the nozzle holder adapter flange meets the crankshaft at a right angle.

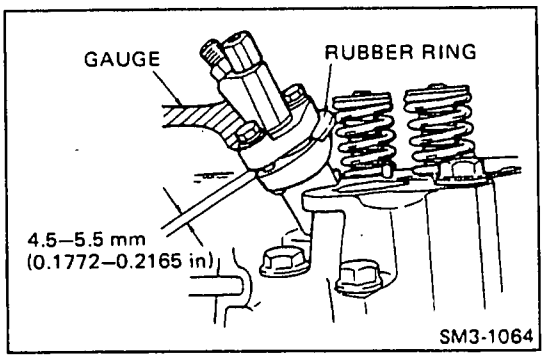


SM3-1080

INSTALL THE NOZZLE HOLDER.

Insert a rubber ring gasket to the underside of the nozzle holder flange, fit a new nozzle holder gasket to the tip of the nozzle holder and insert the nozzle holder into the adapter.

NOTE: ○ When mounting the nozzle holder, direct the high pressure inlet connector towards the engine front side (timing gear side).
○ The projection of the ring packing towards the exhaust manifold side.



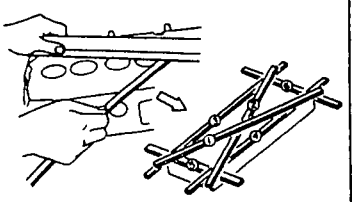
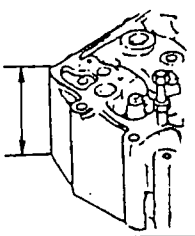
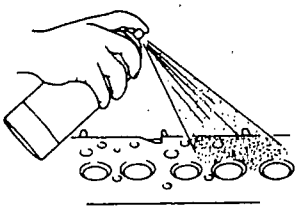
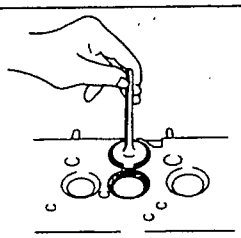
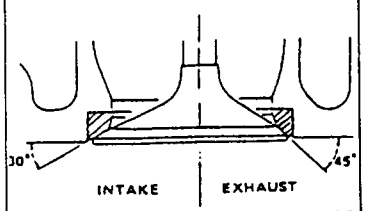
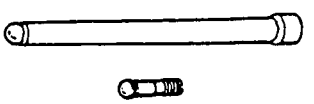
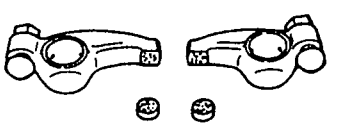
3. Place the gauge on the upper surface of the nozzle holder flange, align holes of the gauge, holder flange and adapter, and tighten the bolt.

Tightening Torque: 150–180 kg·cm (11–13 lb.ft)

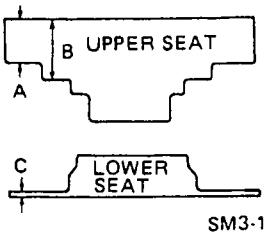
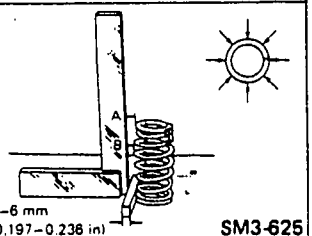
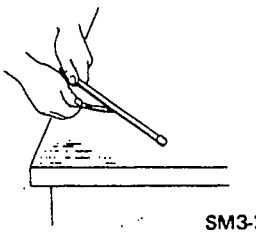
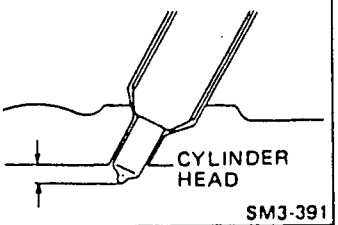
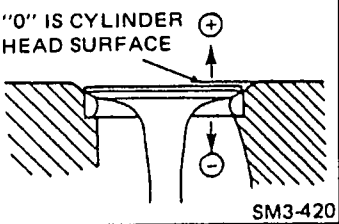
NOTE: After tightening the bolt, confirm that the clearance between the upper surface of the adapter and lower surface of the holder flange is 4.5–5.5 mm (0.1772–0.2165 in), and the gauge is free from deflection and bending. (The gauge is used for locating to the nozzle holes).

INSPECTION AND REPAIR

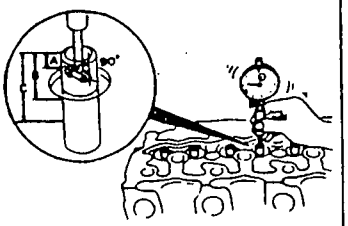
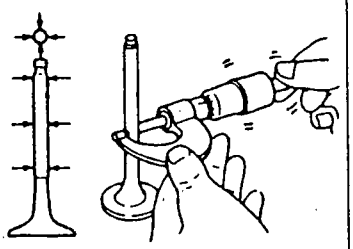
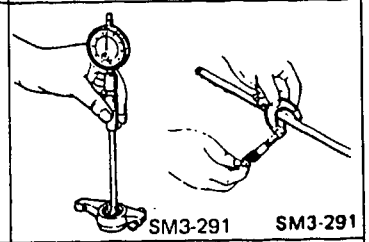
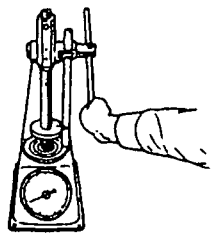
Unit: mm (in)

Inspection Item		Standard	Limit	Remedy	Inspection Procedure
Cylinder Head Flatness		0–0.05 (0–0.019)	0.20 (0.0078)	Regrind	 SM3-831
			0.30 (0.0118)	Replace	
Cylinder Head Height		118.0 (4.646)	117.7 (4.634)	Replace	 SM3-887
Cylinder Head, Cracks and Damage *Using a Dye Panetrant		–	–	Replace, if necessary.	 SM3-832
Valve Seating Condition * Using Red Lead Marking Compound		There should be good contact around entire circumference of valve head.	–	Hand-lap with lapping compound.	 SM3-833
Valve Seat Angle	Intake	30°–30°30′	–	Regrind or replace valve and/or valve seat	 SM3-899
	Exhaust	45°–45°30′			
Valve Angle	Intake	29°30′–30′			
	Exhaust	44°30′–45°			
Adjusting Screws and Push Rods Damage		–	–	Replace, if necessary.	Visual check  SM3-1066
Rocker Arm and Valve Stem Cap Wear or Damage		–	–	Resurface or replace	Visual check  SM3-1103

Unit: mm (in)

Inspection Item		Standard	Limit	Remedy	Inspection Procedure
Upper Spring Seats and Lower Spring seats Wear or Damage	A	3.0 (0.118)	(Wear of A + wear of C) and/or (wear of B+wear of C) is more than 1.0 (0.039)	Resurface or replace	 SM3-1101
	B	6.0 (0.236)			
	C	1.0 (0.039)			
Valve Spring Squareness		–	A MAX – A MIN or B MAX – MIN ≦ 2.0 (0.078)	Replace	 SM3-625
Push Rod Bend		–	0.5 (0.0196)	Replace	 SM3-292
Nozzle Protrusion from Cylinder Head Surface		4.75–5.25 (0.1870–0.2066)	–	Replace nozzle gasket	 SM3-391
Intake Valve Sink		0.75–1.00 (0.0296–0.0393)	0.25 (0.0098)	Replace valve and/or valve	 SM3-420
Exhaust Valve Sink		0.45–0.70 (0.0178–0.0276)	–0.05 (–0.0019)		

Unit: mm (in)

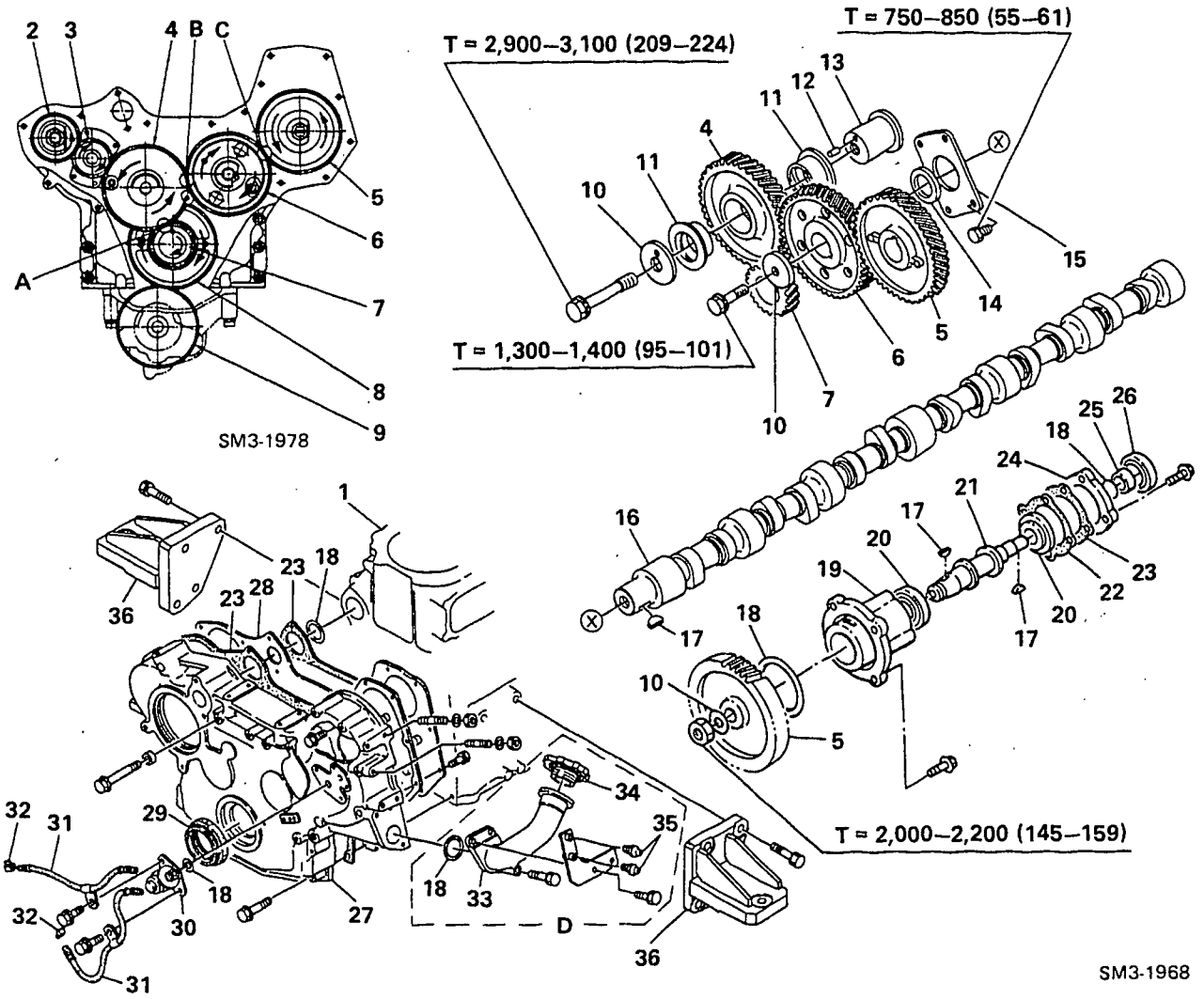
Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Intake Valve Stem Diameter	11.938–11.950 (0.4700–0.4704)	11.85 (0.4665)	Replace valve guide and/or valve	 A : 10 (0.394) B : 30 (1.181) C : 67 (2.638) SM3-834
Exhaust Valve Stem Diameter	11.905–11.930 (0.4688–0.4646)	11.80 (0.4645)		
Intake and Exhaust Valve Guide Diameter	12.000–12.018 (0.4724–0.4732)	–		
Clearance between Valve Stem and Valve Guide (Intake)	0.050–0.080 (0.0020–0.0031)	0.30 (0.0118)		 SM3-835
Clearance between Valve Stem and Valve Guide (Exhaust)	0.070–0.113 0.0028–0.0044)	0.35 (0.0137)		
Rocker Arm Shaft Diameter	27.967–27.980 (1.1011–1.1015)	27.92 (1.0992)	Replace rocker arm bushing and/or shaft	 SM3-291 SM3-291
Clearance between Rocker Arm Shaft and Rocker Am Bushing	0.020–0.054 (0.0008–0.0021)	0.15 (0.0059)		
Outer Valve Spring Setting Load	42.5–46.9 kg (93.695–103.395 lb) at 57.5 (2.264)	40.50 kg (89.303 lb)	Replace	 SM13-024

TIMING GEAR, CAMSHAFT AND OIL PAN

DESCRIPTION

SM3-1978

OVERHAUL



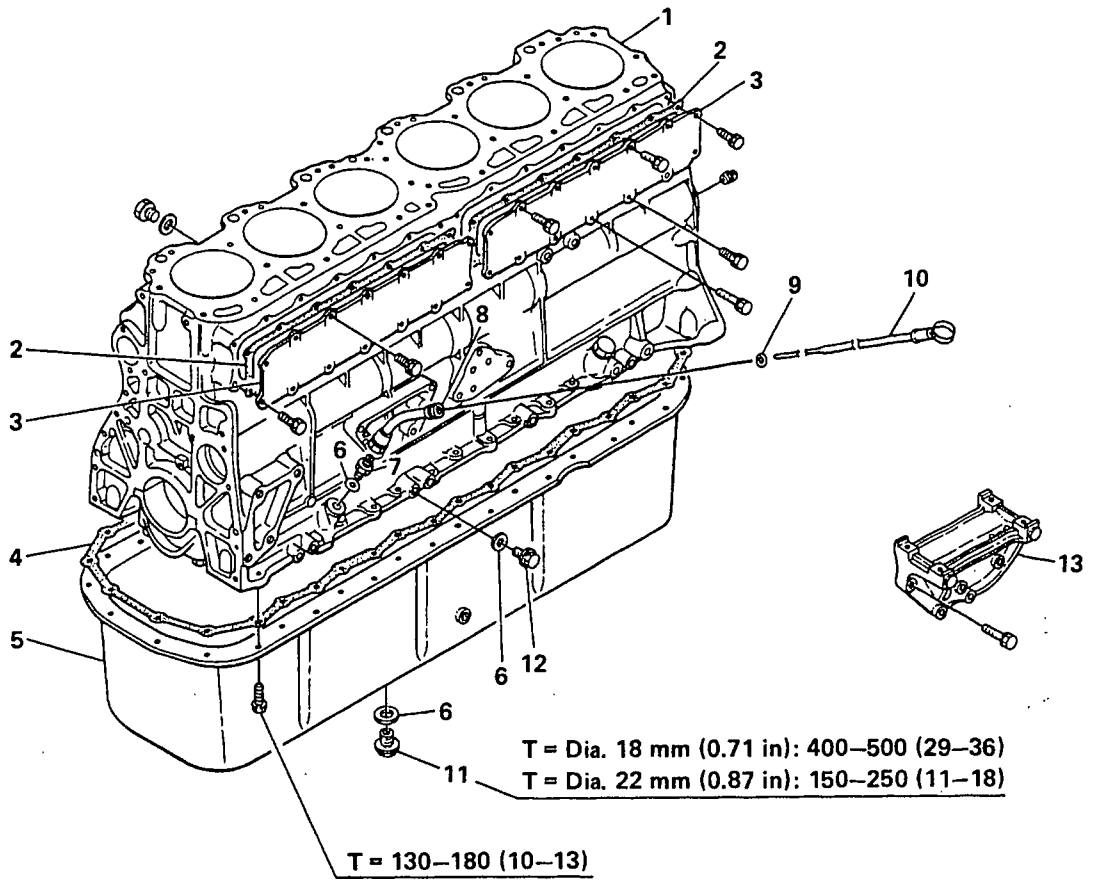
SM3-1968

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

1. Cylinder block
2. Air compressor drive gear (If so equipped)
3. Coolant pump drive gear
4. Idler gear
5. Fuel injection pump drive gear
6. Camshaft gear
7. Crankshaft gear
8. Oil pump drive gear
9. Oil pump driven gear
10. Washer
11. Idler gear bearing
12. Straight pin
13. Idler gear shaft
14. Collar
15. Thrust plate
16. Camshaft
17. Key
18. O-ring
19. Bearing holder case
20. Tapered roller bearing
21. Drive shaft
22. Shim
23. Gasket
24. Bearing retainer
25. Oil seal sleeve
26. Oil seal
27. Timing gear cover
28. Timing gear plate
29. Oil seal
30. Tachometer drive assy
31. Oil hose
32. Elbow
33. Oil pipe
34. Oil filler cap
35. Lubrication fitting
36. Engine mounting bracket

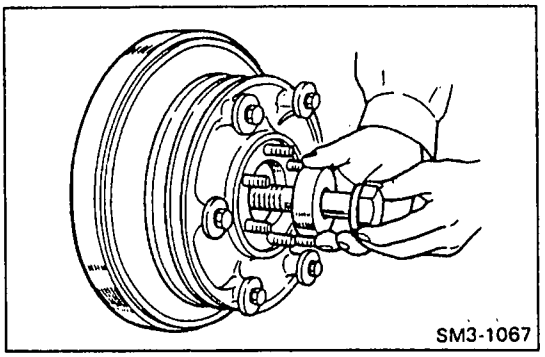
A. Match mark "1"
B. Match mark "2"
C. Match mark "3"
D. If so equipped

OVERHAUL



SM3-1969

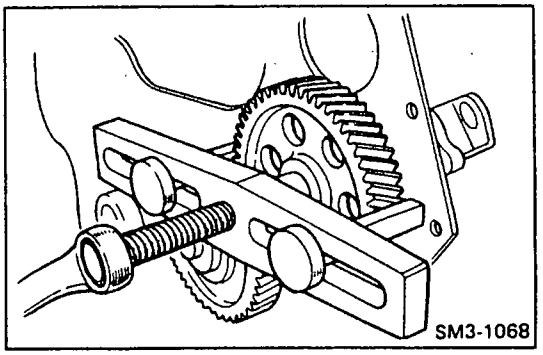
1. Cylinder block
2. Tappet cover gasket
3. Tappet cover
4. Oil pan gasket
5. Oil pan
6. Soft washer
7. Connector
8. Oil level gauge guide
9. O-ring
10. Oil level gauge
11. Drain plug
12. Plug
13. Fuel injection pump bracket


SM3-1067

IMPORTANT POINTS – DISASSEMBLY

REMOVE THE CRANKSHAFT PULLEY.

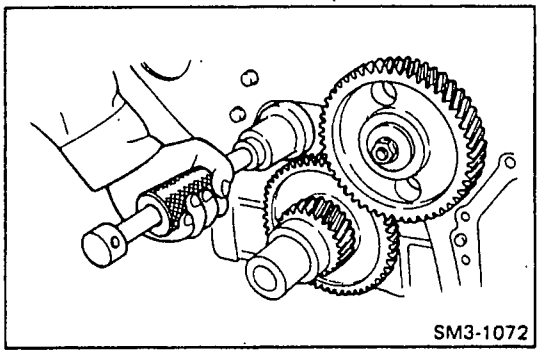
1. Remove the crankshaft pulley.


SM3-1068

REMOVE THE INJECTION PUMP DRIVE GEAR.

1. Remove the lock nut and lock plate.
2. Using special tools, remove the injection pump drive gear.
3. Remove the woodruff key.

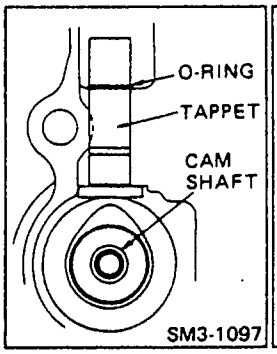
Special Tool: Gear puller (09420-1360)
Gear puller adapter (09462-1011)


SM3-1072

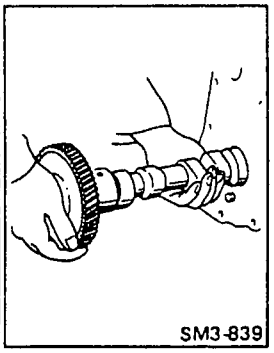
REMOVE THE IDLER GEAR SHAFT.

Using special tools, remove the idler gear shaft.

Special Tool: Sliding hammer (09472-1100 and 09472-1090)



SM3-1097


SM3-839

REMOVE THE CAMSHAFT.

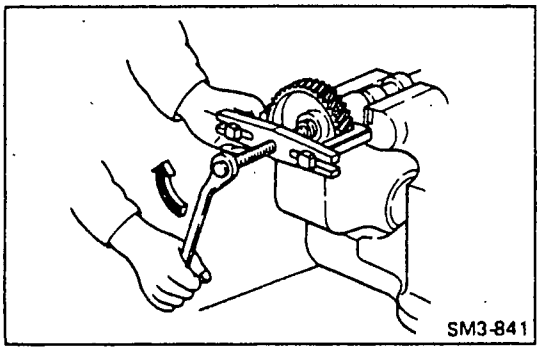
1. Using special tools, suspend the tappets in the cylinder block in correct order.

Special Tool: O-ring (9851-20104)

NOTE: Apply engine oil to the tappets when installing them.

2. Remove the thrust bearing set bolts and pull out the camshaft with gear.

NOTE: Pull the camshaft, slowly turning it so as not to damage the cam bearings.

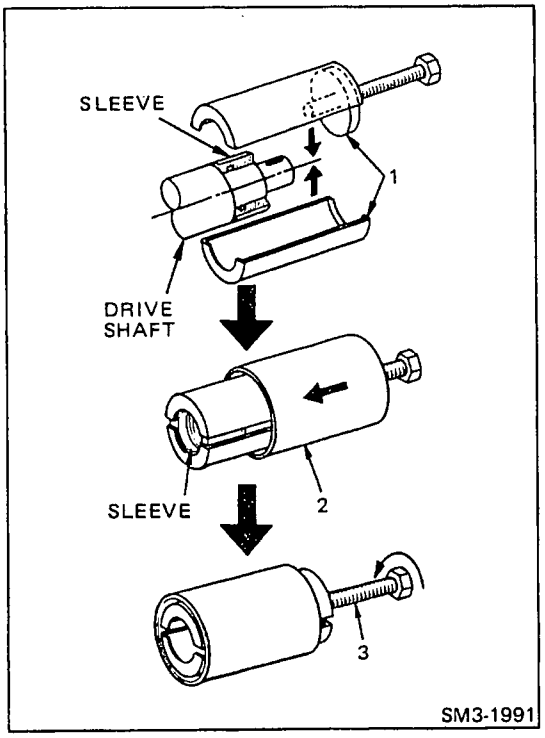

SM3-841

IF NECESSARY, REMOVE THE CAMSHAFT GEAR.

Hold the camshaft assembly with a vice through wooden plates.

Remove the bolt and washer, then using a special tool, remove the gear.

Special Tool: Gear puller (09420-1360)

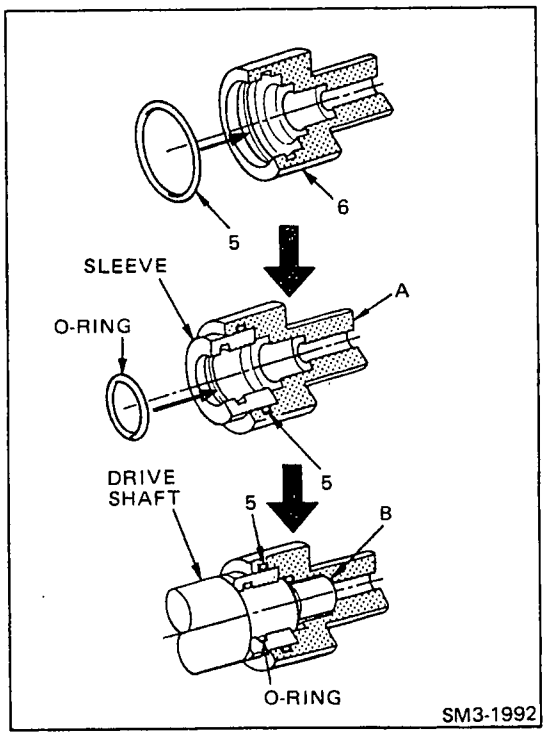


IMPORTANT POINTS – ASSEMBLY

IF NECESSARY, REPLACE THE INJECTION PUMP DRIVE SHAFT OIL SEAL SLEEVE'

1. Using a special tool, remove the sleeve.
a. Put the puller (1) onto the sleeve.
b. Insert the hook portion of the puller between shaft and sleeve.
c. Insert the puller (2).
d. After inserting the puller, screw in the center bolt (3), them remove the sleeve.

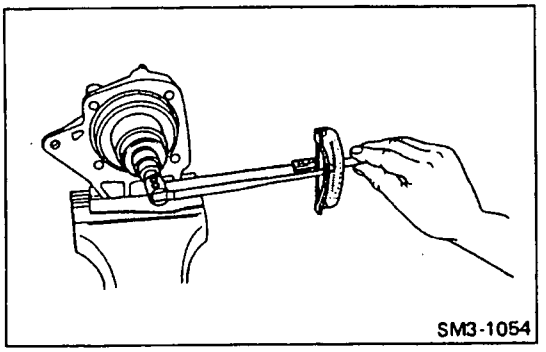
Special Tool: Puller assy (09420-1180)



2. Using special tools, install the shaft sleeve with a new O-ring.
a. Put the O-ring (5) into the press (6).
b. Insert the new oil seal sleeve with new O-ring into the press and then insert them into the drive shaft.
c. Hitting the "A" lightly by hammer, contact the press end and the shaft end "B", with this determine the oil seal sleeve position.

NOTE:
- **Be sure to fit an O-ring on the sleeve and also apply a liberal coating of oil to the shaft.**
- **When driving on the shaft sleeve, taking care that the O-ring does not get cut or torn.**
- **Once a sleeve has been removed, it cannot be reused.**

Special Tool: Press (09482-1340)
O-ring (9851-36104)

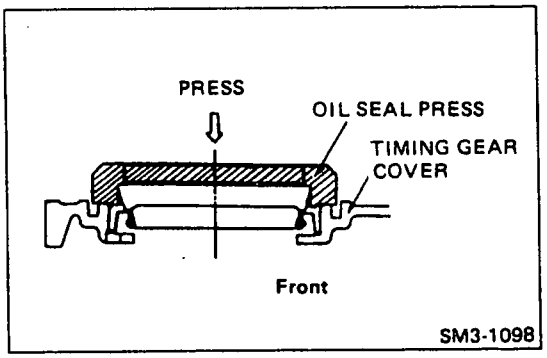


ASSEMBLE THE INJECTION PUMP DRIVE GEAR SHAFT ASSEMBLY.

Adjust the preload of drive gear shaft by shims.

Starting Torque: 4-12 kg·cm (0.290–0.867 lb.ft)

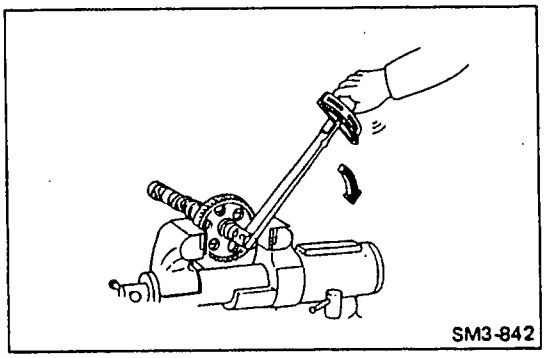
NOTE: Be sure that there is no loose rattling in the axis direction of the drive shaft.



IF NECESSARY, REPLACE THE TIMING GEAR COVER OIL SEAL.

1. Using a screwdriver, remove the oil seal.
2. Using a special tool, install the new oil seal.

Special Tool: Front oil seal press (09482-1040)

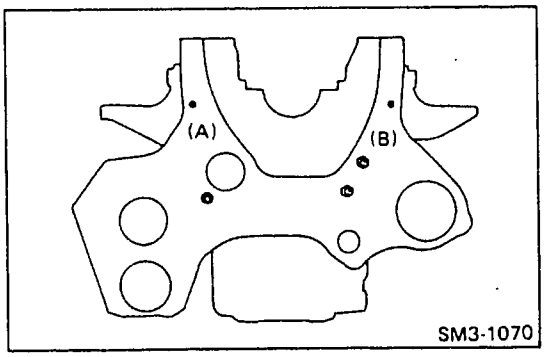


INSTALL THE CAMSHAFT GEAR TO THE SHAFT.

1. Install the camshaft gear with thrust bearing with a press.

NOTE: Heat the gear in hot water [Approx. 100°C (212°F)], before installing the gear to the camshaft.

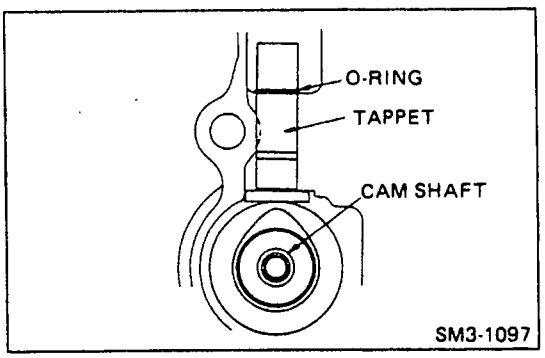
2. Apply engine oil to the threads and bearing surface of the bolt, then tighten the bolt with washer.



INSTALL THE TIMING GEAR PLATE.

Fit the O-ring to the cylinder block water gallery and install the timing gear plate with a gasket.

NOTE: Align the cylinder block and timing gear plate using dowel pin (A) and (B).



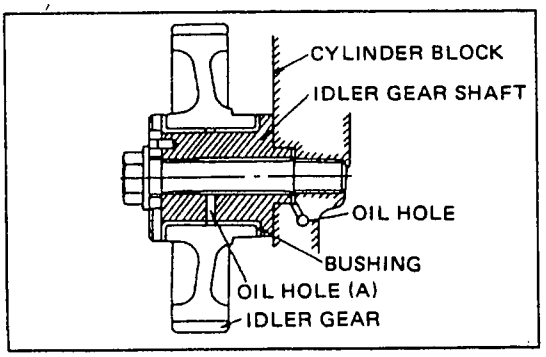
INSTALL THE CAMSHAFT.

1. Using special tools, lift up the tappets and suspend them above the camshaft.

Special Tool: O-ring (9851-20104)

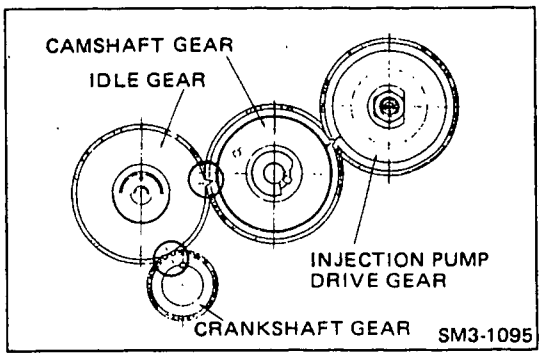
2. Lubricate all journals of the camshaft and insert the camshaft assembly into the cylinder block.

NOTE: Insert the camshaft, slowly turning while inserting so that the bearing will not be damaged.



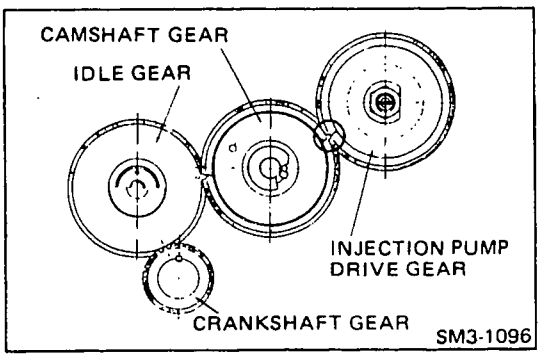
INSTALL THE IDLER GEAR.

1. Install the idler gear shaft with oil hole (A) positioned oil pan side.



2. Align the idler gear match marks with the crankshaft gear and camshaft gear.

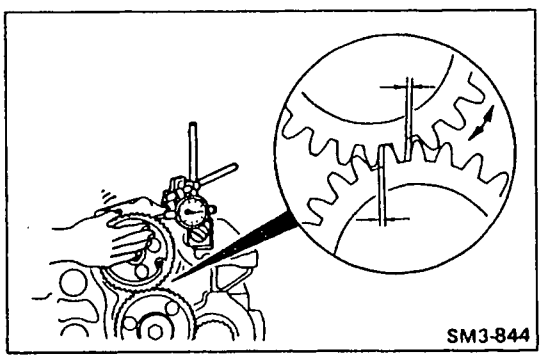
NOTE: Incorrect installation can result in engine damage or lowering of engine performance by causing improper injection timing.



INSTALL THE INJECTION PUMP DRIVE GEAR.

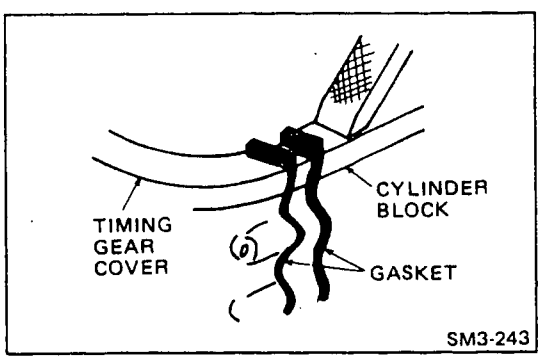
Align the injection pump drive gear match mark with the camshaft gear.

NOTE: Incorrect installation can results in engine damage or lowering of engine performance by causing improper injection timing.



MEASURE THE GEAR BACKLASH.

Measure the backlash of each gear using a dial indicator.
Replace the gear if necessary.
Refer to INSPECTION AND REPAIR.



INSTALL THE OIL PUMP AND OIL STRAINER.

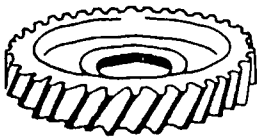
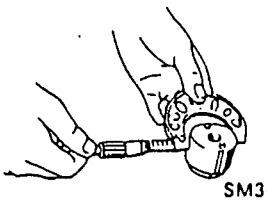
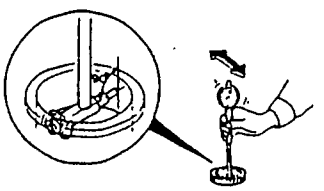
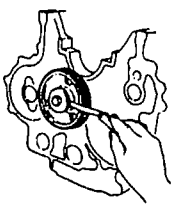
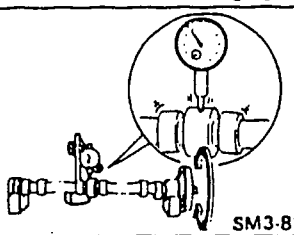
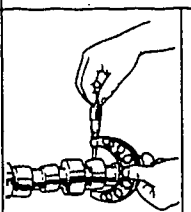
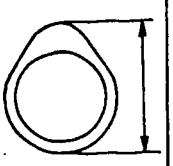
Refer to SECTION LUBRICATING SYSTEM.

INSTALL THE OIL PAN.

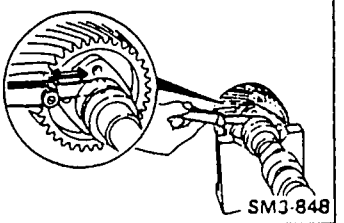
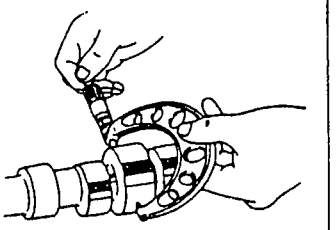
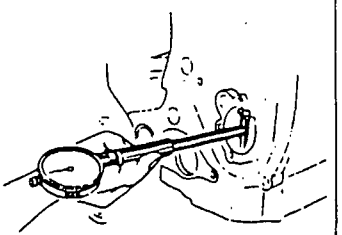
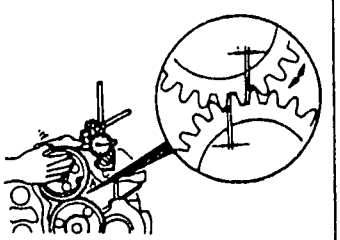
Cut the protrusion of the timing gear plate gasket and timing gear cover gasket from the oil pan mounting surface.

INSPECTION AND REPAIR

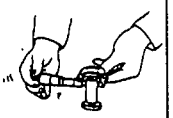
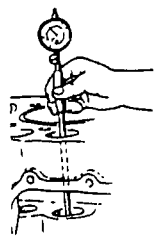
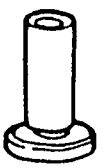
Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Gear Teeth for Pitting or Wear	–	–	Replace, if necessary.	Visual check  SM3-845
Idle Gear Shaft Diameter	47.950–47.975 (1.887–1.888)	–	Replace bushing and/or shaft	 SM3-846
Idler Gear Bushing Inside Diameter	48.013–48.038 (1.890–1.891)	–		
Oil Clearance Between Idler Gear Shaft and Gear Bushing	0.038–0.088 (0.0015–0.0034)	0.20 (0.0078)		 SM3-847
Idler Gear End Play	0.07–0.17 (0.0028–0.0067)	0.30 (0.0118)	Replace thrust bearing.	 SM3-421
Camshaft Bend	–	0.05 (0.0019)	Replace	 SM3-858
Camshaft Cam Height (Intake)	55.90 (2.2008)	55.10 (2.1693)	Replace	 SM3-374  SM3-563
Camshaft Cam Height (Exhaust)	55.36 (2.1799)	54.56 (2.1484)		

Unit: mm (in)

Inspection Item		Standard	Limit	Remedy	Inspection Procedure
Camshaft End Play		0.10–0.26 (0.0039–0.0102)	0.50 (0.0196)	Replace thrust bearing	 SM3-848
Camshaft Journal Diameter	Journal No.: 1.	65.95–65.97 (2.5886–2.5894)	65.90 (2.5945)	Replace shaft and/or bearing	 SM3-849
	2.	65.75–65.77 (2.5880–2.5894)	65.70 (2.5867)		
	3.	65.55–65.57) (2.5807–2.5815)	65.50 (2.5788)		
	4.	65.35–65.37 (2.5728–2.5736)	65.30 (2.5709)		
	5.	65.15–65.17 (2.5650–2.5657)	65.10 (2.5630)		 SM3-850
	6.	64.95–64.97 (2.5571–2.5579)	64.90 (2.5552)		
	7.	64.75–64.77 (2.5492–2.5500)	64.70 (2.5473)		
Oil Clearance between Camshaft Journal and Bearing		0.03–0.12 (0.0012–0.0047)	0.20 (0.0078)		
Gear Backlash	Crankshaft Gear and Idler Gear	0.09–0.22 (0.0035–0.0087)	0.40 (0.0157)	Replace gear, if necessary.	 SM3-844
	Camshaft Gear and Injection Pump Drive Gear	0.07–0.25 (0.0028–0.0098)			
	Oil Pump Drive Gear and Oil Pump Driven Gear	0.12–0.26 (0.0047–0.0102)			
	Idler Gear and Camshaft Gear	0.10–0.22 (0.0039–0.0087)			
	Idle Gear and Coolant Pump Drive Gear	0.10–0.26 (0.0039–0.0102)			

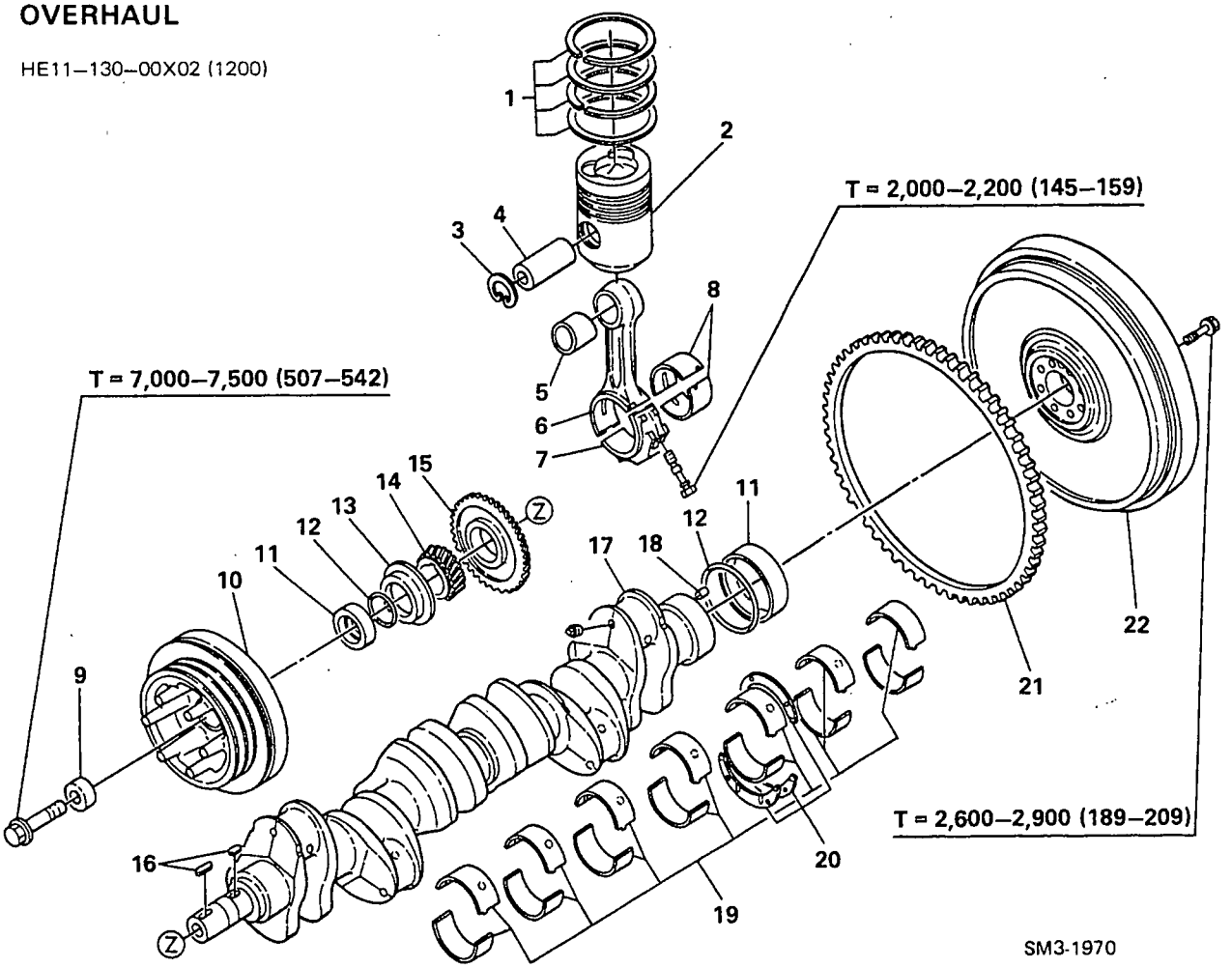
Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Tappet Outside Diameter	22.95–22.98 (0.9035–0.9047)	–	Replace tappet	 SM3-949  SM3-420
Tappet Guide Inside Diameter	23.00–23.02 (0.9055–0.9063)	–		
Clearance between Tappet and Tappet Guide	0.020–0.062 (0.0008–0.0024)	0.20 (0.0078)		
Tappet for Wear	Should not be worn unevenly.	–	Replace, if necessary.	Visual check  SM3-949

PISTON, CRANKSHAFT, CYLINDER BLOCK AND FLYWHEEL HOUSING

OVERHAUL

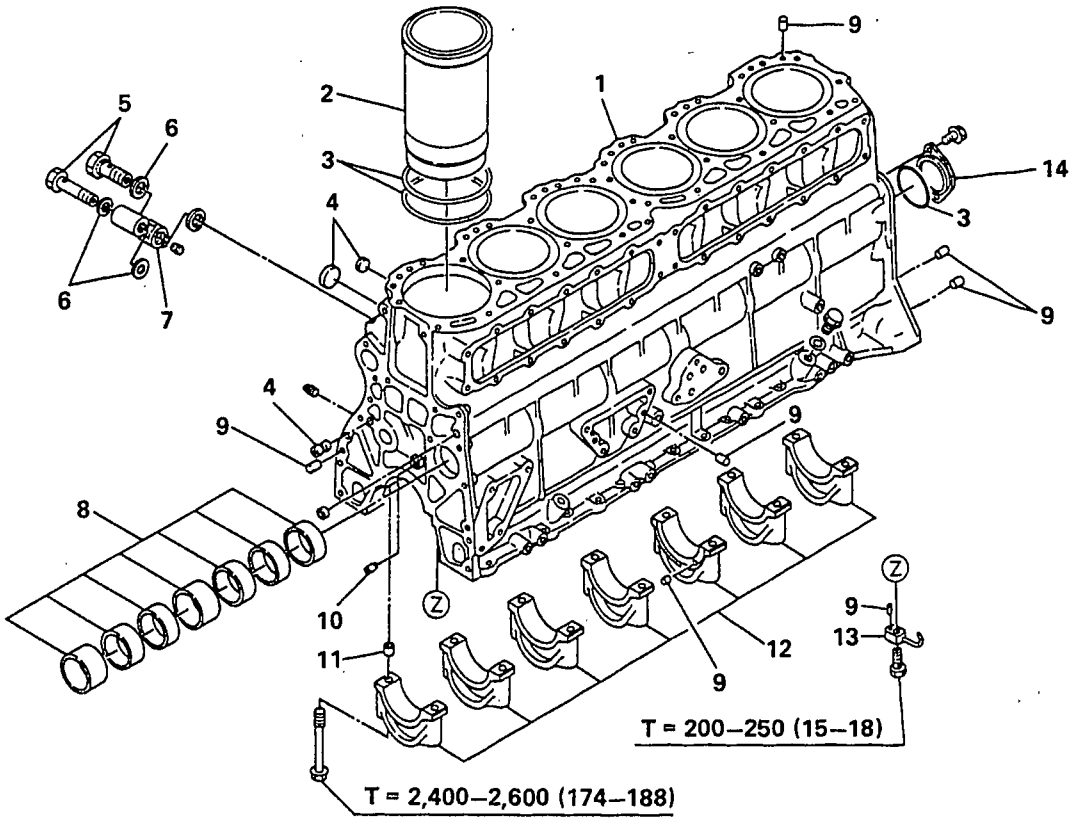
HE11–130–00X02 (1200)



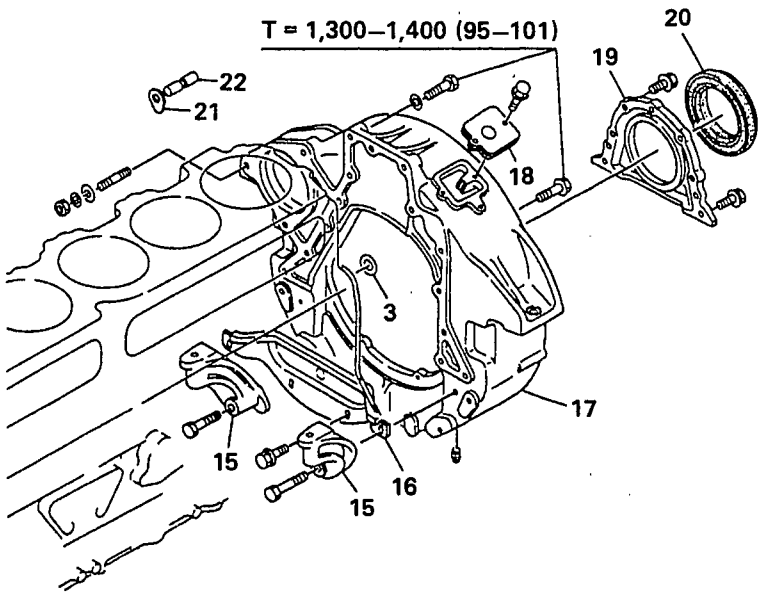
T = Tightening torque: kg·cm (lb.ft)

1. Piston ring
2. Piston
3. Retainer ring
4. Piston pin
5. Piston pin bushing
6. Connecting rod
7. Connecting rod cap
8. Connecting rod bearing
9. Collar
10. Crankshaft pulley
11. Oil seal sleeve
12. O-ring
13. Dust slinger
14. Crankshaft gear
15. Oil pump drive gear
16. Key
17. Crankshaft
18. Straight pin
19. Crankshaft bearing
20. Thrust bearing
21. Ring gear
22. Flywheel

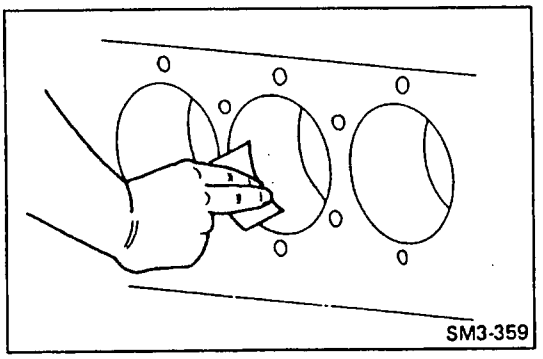
OVERHAUL



T = Tightening torque: kg·cm (lb.ft)



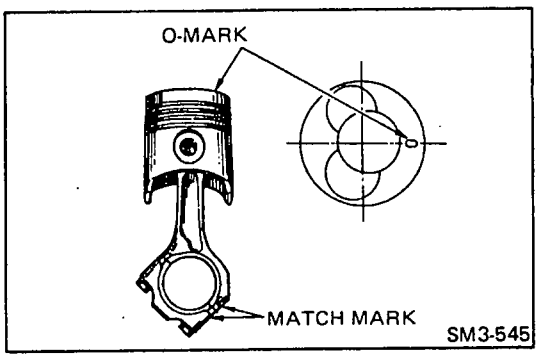
1. Cylinder block
2. Cylinder liner
3. O-ring
4. Plug
5. Connector bolt
6. Soft washer
7. Oil pipe
8. Camshaft bearing
9. Straight pin
10. Oil jet pipe
11. Collar
12. Main bearing cap
13. Piston cooling jet
14. Camshaft end plate
15. Flywheel housing stay
16. Dust cover
17. Flywheel housing
18. Inspection hole cover
19. Oil seal retainer
20. Oil sseal
21. Shim (For flywheel housing angular alignment)
22. Straight pin (For flywheel housing parallel alignment)


SM3-359

IMPORTANT POINTS – DISASSEMBLY

REMOVE THE PISTONS WITH CONNECTING RODS.

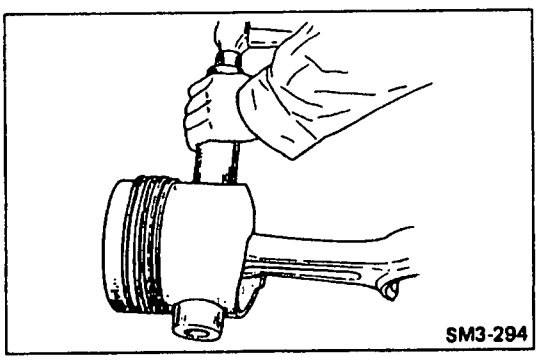
1. Remove the carbon from the upper end of the cylinder liner with a scraper or emery paper (recommended: No. 150) in a circular direction.



SM3-545

2. Extract the piston with connecting rod out through the top of the cylinder.

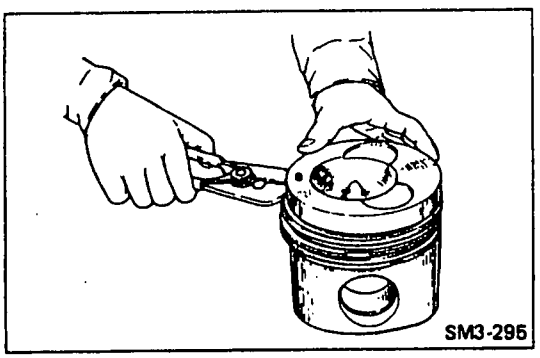
NOTE: ○ **Do not damage the piston cooling jet.**
○ **Arrange the piston and connecting rod caps in order.**


SM3-294

DISASSEMBLE THE PISTON AND CONNECTING ROD.

1. Remove the retainer ring installed on both ends of the piston pin, by means of retainer ring pliers.
2. Using a special tool, remove the piston pin.

Special Tool: Piston pin press (09482-1380)

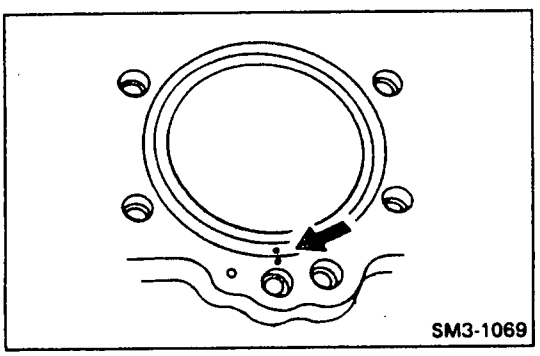

SM3-295

REMOVE THE PISTON RINGS.

Using a special tool, remove the piston rings.

Special Tool: Piston ring expander (09442-1131)

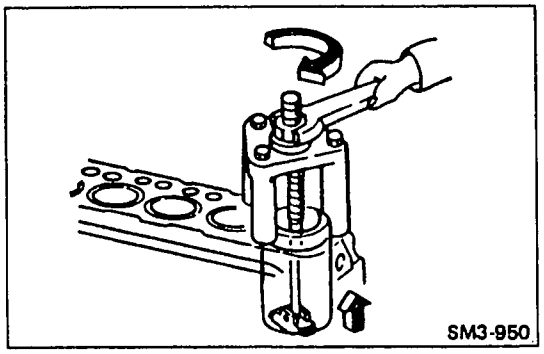
NOTE: ○ **Handle the piston rings carefully because they are made of a special casting which is easily broken.**
○ **Keep the rings for each cylinder separate.**


SM3-1069

REMOVE THE CYLINDER LINER.

1. Before removing the cylinder liners, place the match marks on the cylinder block and liner flange with a pen.

NOTE: Do not put the match marks with a punch.



2. Using a special tool, pull the cylinder liner towards the head.

Special Tool: Cylinder liner puller (09420-1290)

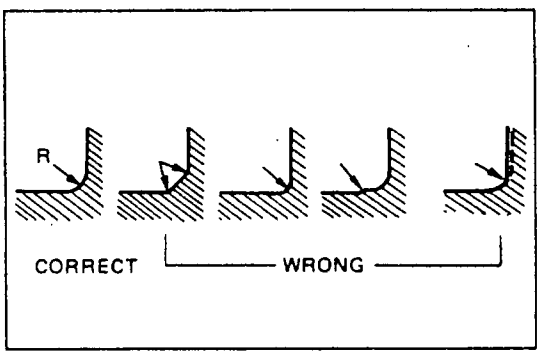
NOTE: After removing the cylinder liners, put numbers on their periphery or arrange them in sequence.

IF NECESSARY, REGRIND THE CRANKSHAFT.

NOTE:
- **If the wear of the crankshaft pin or journal matches an undersize bearing 4 types 0.25 mm (0.0098 in), 0.50 mm (0.0197 in), 0.75 mm (0.0295 in), 1.00 mm (0.0394 in), replace the bearing with an undersized one.**
- **The bearing is a set consisting of upper and lower halves. Consequently, be sure to replace the bearing as a set.**

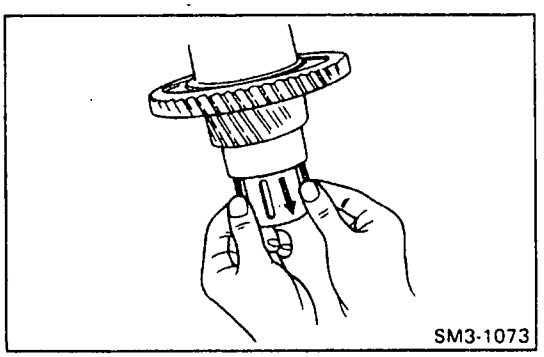
Unit: mm (in)

Bearing size	Outside diameter	
	Crank pin	Journal
0.25 US	83.695–83.715 (3.2951–3.2958)	89.66–89.68 (3.5400–3.5307)
0.50 US	83.445–83.465 (3.2853–3.2860)	89.41–89.43 (3.5201–3.5208)
0.75 US	83.195–83.215 (3.2754–3.2761)	89.16–89.18 (3.5103–3.5110)
1.00 US	82.945–82.965 (3.2656–3.2663)	88.91–88.93 (3.5004–3.5011)



INSPECT THE FILLET OF THE CRANK PIN AND JOURNAL.

Dimension of fillet (R): 5.0–5.5 mm (0.196–0.216 in)



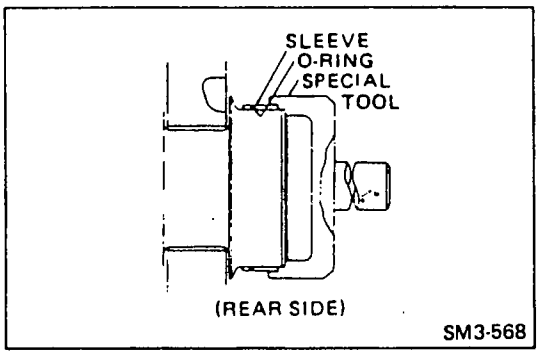
IMPORTANT POINTS – ASSEMBLY

IF NECESSARY, REPLACE THE CRANKSHAFT OIL SEAL SLEEVE.

1. Using a special tool, remove the crankshaft sleeve.

Special Tool: Eye bolt (09433-1010) for front sleeve

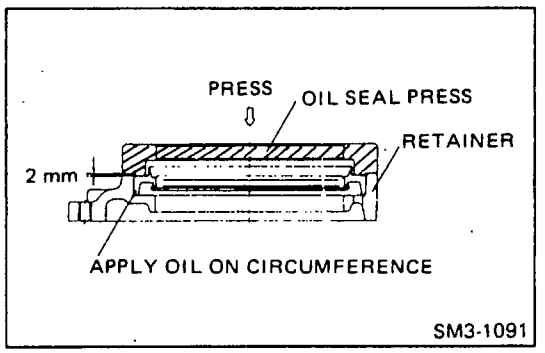
NOTE: Do not remove the crankshaft gear unless it considered absolutely necessary.



2. Be sure to fit a new O-ring on the sleeve and also apply a liberal coating of oil to the pulley center side at the front, and the crankshaft side at the rear.
3. Using a special tool, drive on the crankshaft sleeve.

Special Tool: Rear oil seal sleeve press (09402-1041)

NOTE: Take care that the O-ring does not get cut or torn.

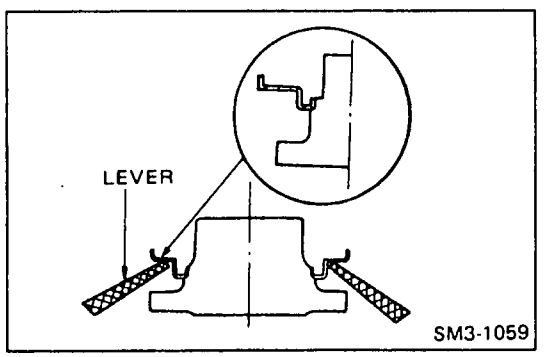


IF NECESSARY, REPLACE THE REAR OIL SEAL.

1. Remove the oil seal.
2. Using a special tool, insert the oil seal to the oil seal retainer, ensuring that it is flush with the end of the oil seal retainer.

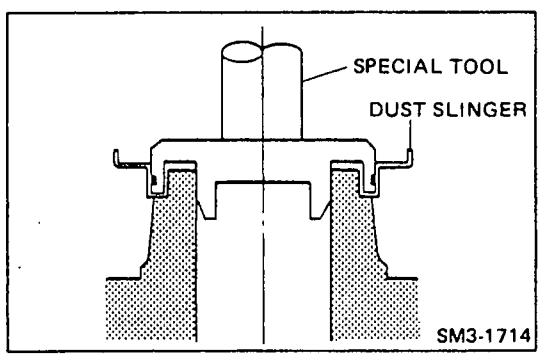
Special Tool: Rear oil seal press (09482-1050)

NOTE: Ensure that the lip of the oil seal is coated with oil seal lubricating grease (lithium-based).



IF NECESSARY, REPLACE THE DUST SLINGER.

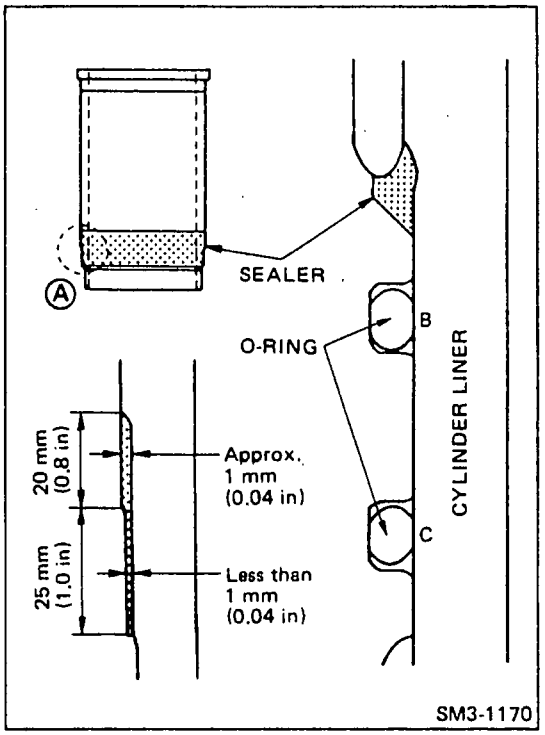
1. Remove the dust slinger with a lever.



2. Using special tools, install the dust slinger.

Special Tool: Dust slinger press (09402-1120)
O-ring (9851-74102)

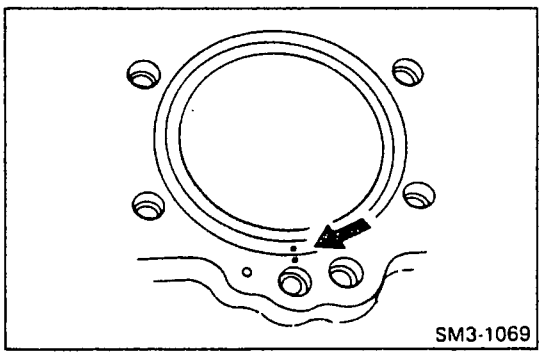
NOTE: To prevent wear of the side of the oil seal, inject about 0.5 to 1 cc of grease (lithium-based) into the "U" groove of the dust slinger.



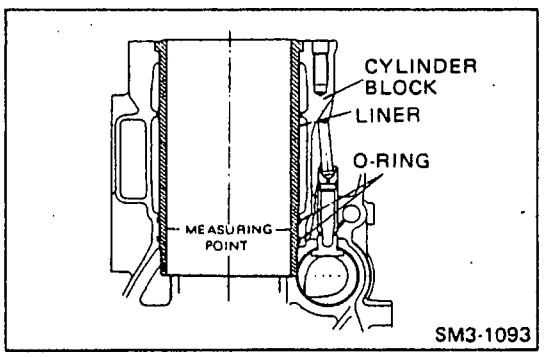
INSERT THE CYLINDER LINER INTO THE CYLINDER BLOCK.

1. Install the O-ring to the cylinder block as shown.

NOTE:
- **Apply the silicon rubber sealer (Room Temperature Vulcanizer as of THREE BOND No. 1211 or equivalent) to the position Ⓐ to the cylinder liners.**
- **Replace the O-rings with new ones.**
  Upper O-ring (B) : Light Green color
  Lower O-ring (C) : Black color

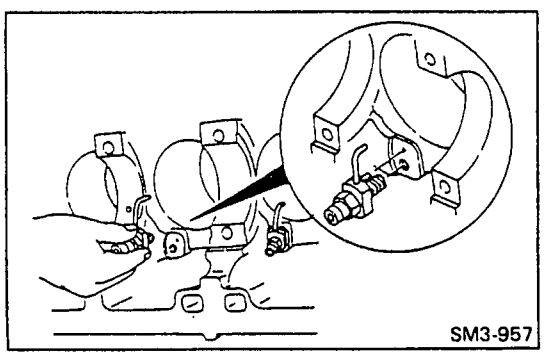


2. Insert the liner its original position aligning the marking marked before disassembling.



3. Measurement of cylinder liner deformation.
   After inserting the cylinder liner into the cylinder block, measure the inside diameter of the liner again at the O-ring position.

Service Limit: 0.03 mm (0.001 in)

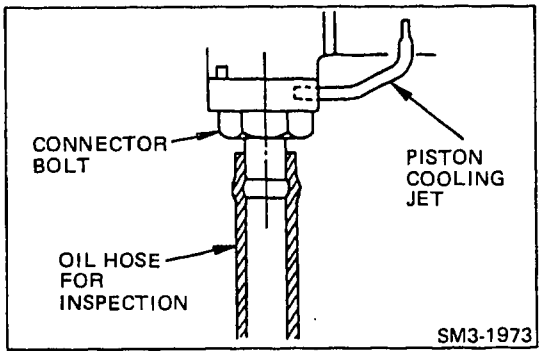


INSPECT THE PISTON COOLING JET POSITIONING.

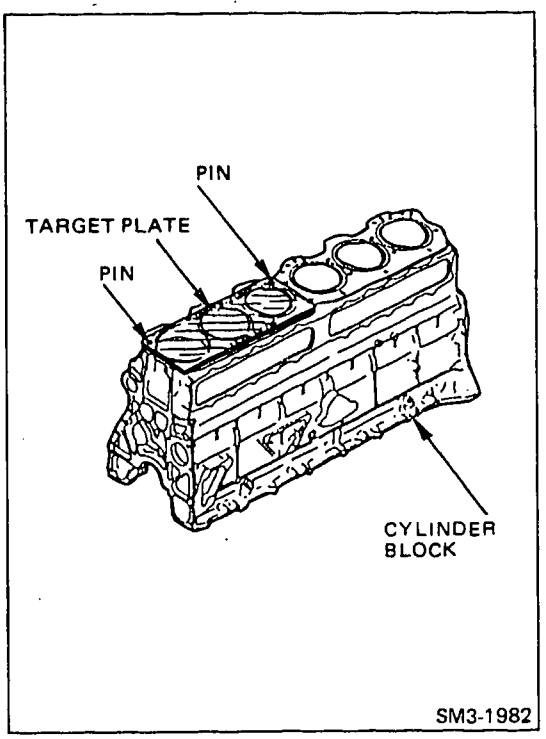
Inspection of the piston cooling jet positioning procedure are as follows.

1. Remove the piston cooling jet connector bolt and install a special tool.

Special Tool: Connector bolt (9001-24265)

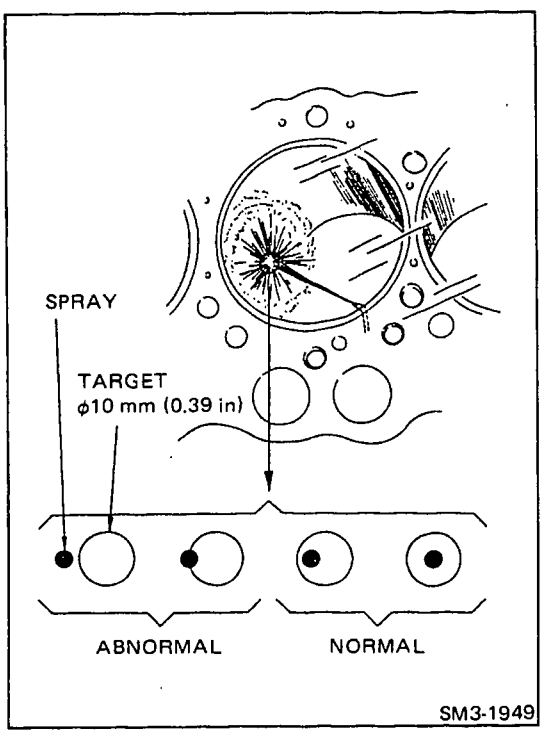


2. Use a commercially available oil pump [pressure about 2 kg/cm^2 (28.44 lb/sq.in), flow rate about 3ℓ/min (0.72 US.gal/min)].
3. Prepare fresh engine oil.
4. Connect the oil lines.
   Connect the oil pump outlet to a special tool (connector bolt).



5. Install a special tool on the cylinder block with locating pins.

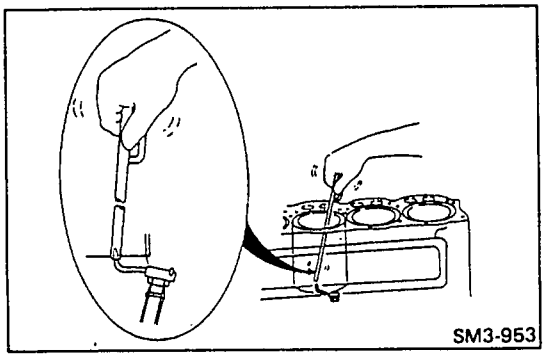
Special Tool: Target plate (09444-1310)



6. Operate the oil pump, and with pressure at about 2 kg/cm^2 (28.44 lb/sq.in), pump fresh oil from the jet, and perform a spray test. Conditions are normal if the center of stream hits a cooling jet check gauge of ϕ10mm (0.39 in).

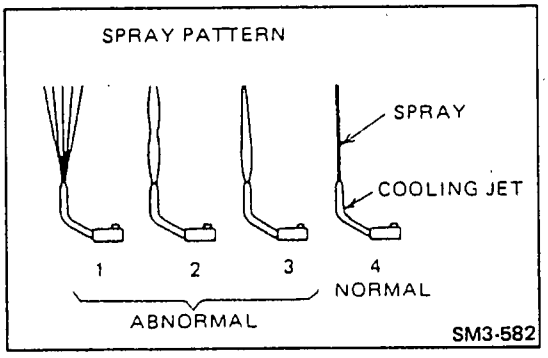
WARNING

Engine oil is flamable.
This spray test should be done in a well ventilated room and away from any open flames or electric sparks.


SM3-953

7. If the spray of the cooling jet messes the circle on the cooling jet, check gauge, realign the nozzle using a special tool.

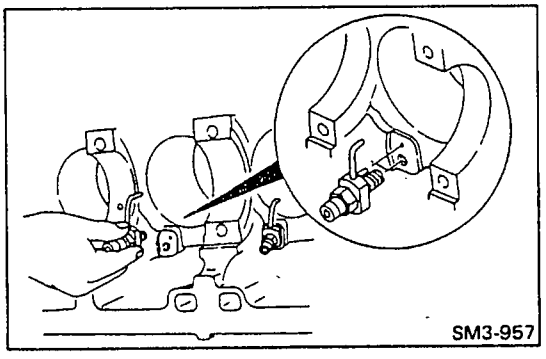
Special Tool: Adjusting bar (09472-1620)



SM3-582

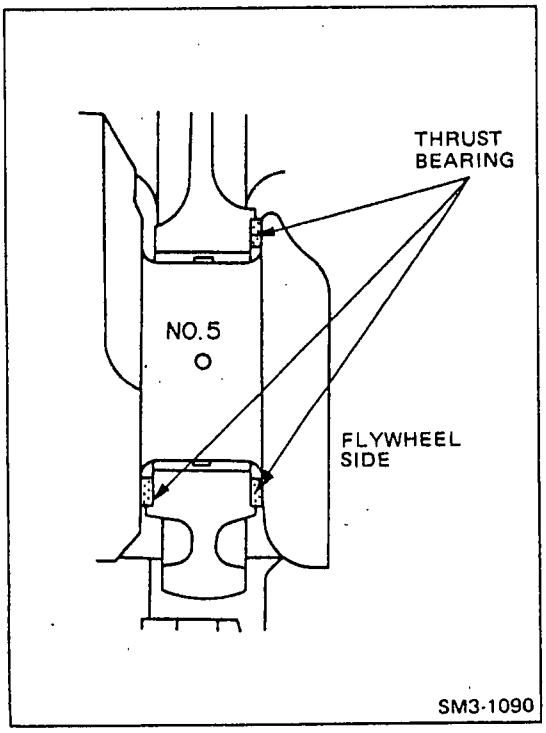
8. Spray pattern
When inspecting the piston cooling jet positioning, check that the spray is dispersed as shown in (4) and not as in (1), (2), or (3) in the illustration at left.
Check that the spray is not a thin muddy color.

WARNING
If the tip of the jet is damaged so that the spray pattern is bad, replace the jet with a new one. When replacing the cooling jet, always inspect the new piston cooling jet's positioning.


SM3-957

9. After inspecting the piston cooling jet positioning.
Remove the special tool (connector bolt), then install the cooling jet on the cylinder block using the correct mounting bolt.

Tightening Torque: 200–250 kg·cm (15–18 lb.ft)



SM3-1090

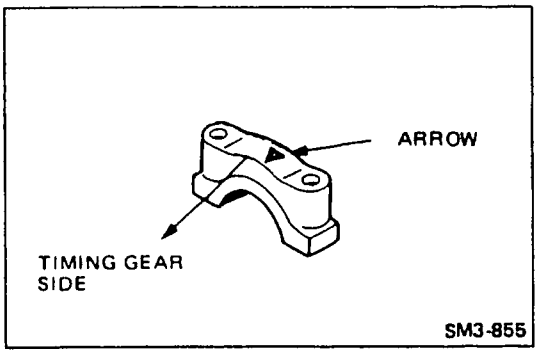
MOUNT THE CRANKSHAFT.

1. Install the crankshaft bearings on the cylinder block and bearing cap.

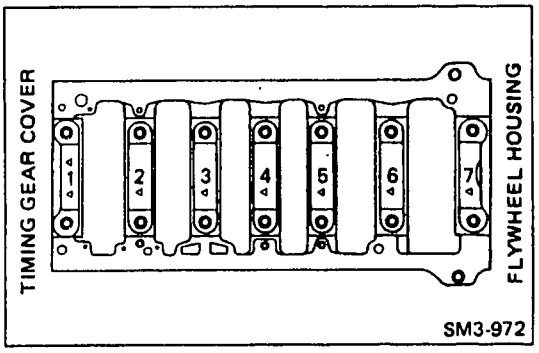
NOTE: ○ **Install the bearing with the oil hole on the block side, and the bearing without the oil hole on the cap side.**
○ **Apply fresh engine oil to sliding and each bearing and surface of the crankshaft.**

2. Insert the crankshaft thrust bearings along the groove of the cylinder block.
3. Install the crankshaft on the cylinder block.
4. Install the thrust bearing on the No.5 bearing cap sides.

NOTE: Apply fresh engine oil to sliding surface and each thrust bearing and crankshaft.



5. Install the crankshaft bearing caps.
   Install the bearing caps in numbered order form timing gear side with the arrow point toward the timing gear side.



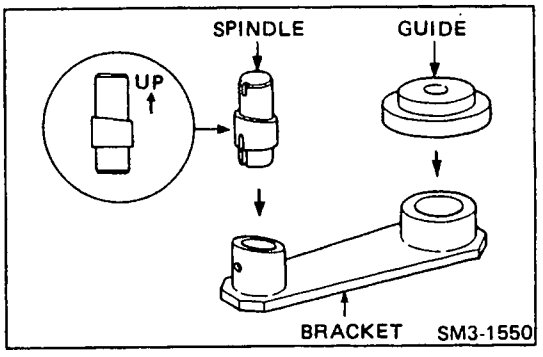
6. Tighten the cap bolts in three stages following the tightening order.

NOTE: Apply engine oil to the threads and bearing cap surface of the bolts.

Tightening Order: 4–3–5–2–6–1–7

NOTE:
- **Make sure that the crankshaft rotates smoothly.**
- **Inspect the crankshaft end play.**

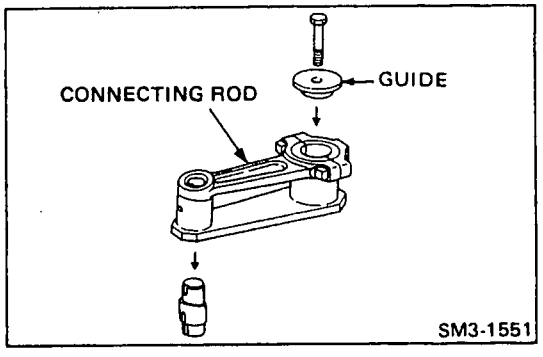
IF NECESSARY, REPLACE THE CONNECTING ROD BUSHING.



1. Install the spindle and the guide on the bracket.

Special Tool: Press assy (09407-1010)

NOTE: The tapered face on the spindle should be upward.



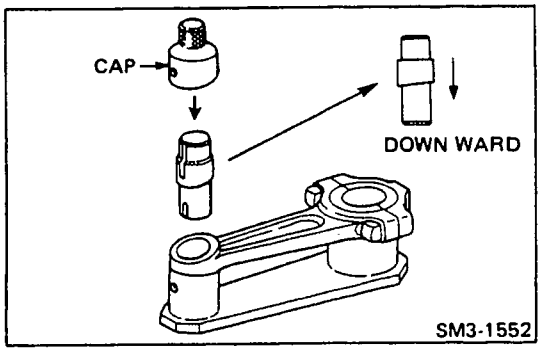
2. Mount the connecting rod and install the guide on the connecting rod housing, and tighten a second the bolt.

Tightening Torque: 1,000–1,200 kg-cm (72–86 lb.ft)

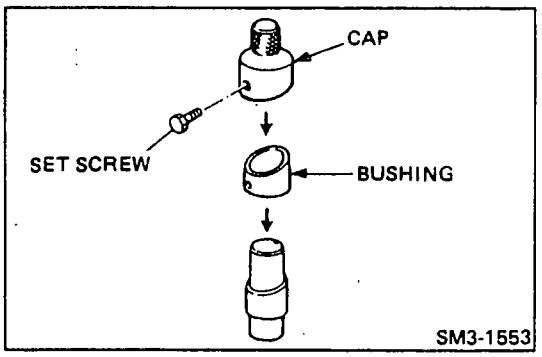
NOTE: Use following bolt:
Length: 178 mm for EK engine

3. Remove the spindle from the bottom.
4. Reinsert the spindle from the top on the connecting rod bushing.

NOTE: The tapered face on the spindle should be downward.



5. Install the cap on the spindle and push the bushing out using a press.



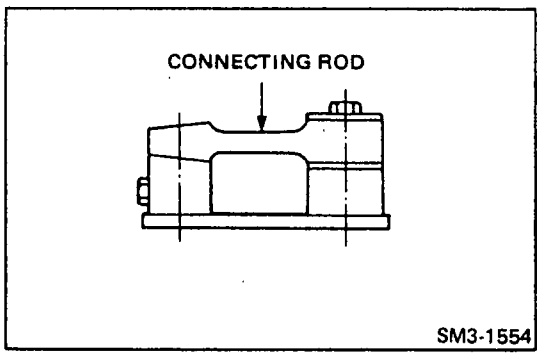
6. Using a special tool, install a new connecting rod bushing.

Special Tool: Press assy (09407-1010)

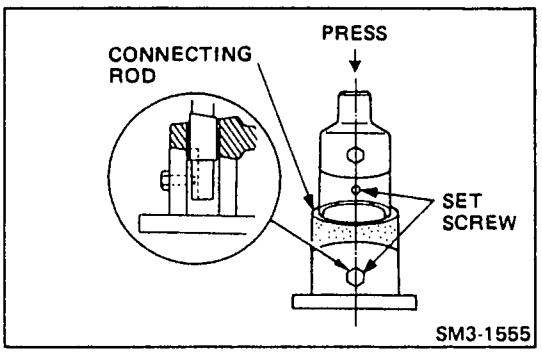
a) Deburr and clean the connecting rod bushing insert bore (small end).

b) Mount a new connecting rod bushing on the spindle and mount the cap, tighten the cap's set screw.

c) Make sure that the bushing oil hole coincides with the oil hole in the connecting rod.



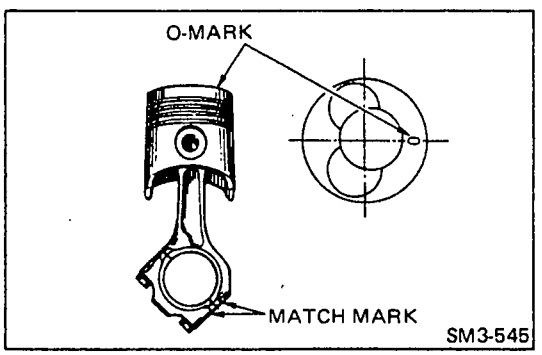
d) Install the bracket set screw in the bracket.



e) Press in the new bushing using a press.

NOTE: Make sure that the spindle groove coincides with the bracket set screw.

f) Remove the spindle, and dismount the connecting rod from the special tool.

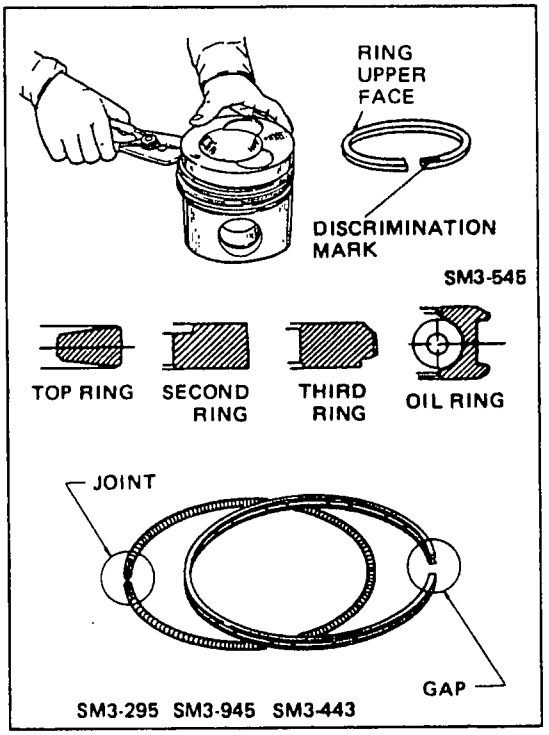


ASSEMBLE THE PISTON AND CONNECTING ROD.

1. Make sure that the O-mark at the top of the piston in the same direction of the match mark on the connecting rod.

NOTE: Replace the retainer rings with new ones.

2. Apply fresh engine oil to the piston pin then fix the piston and connecting rod by inserting the piston pin.

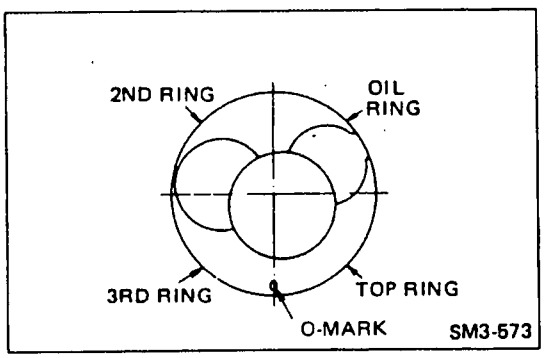


INSTALL THE PISTON RING.

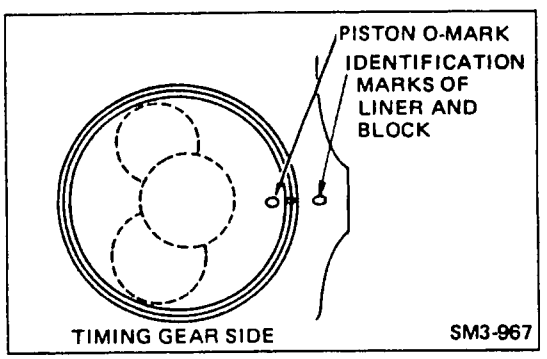
1. Connect the ends of the coil expander and then fit the coil inside the piston ring after ensuring that the gap of the piston ring is 180° away from the joint of the coil.
2. Using a special tool, install the piston rings in the sequence oil ring, third ring, second ring and top ring with the identification mark at the top of the ring facing up.

Special Tool: Piston ring expander (09442-1121)

NOTE: Apply oil to the piston ring.



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

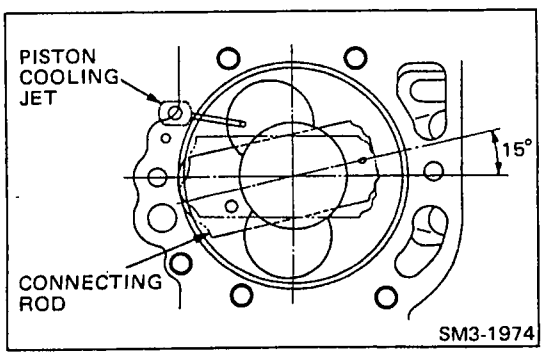


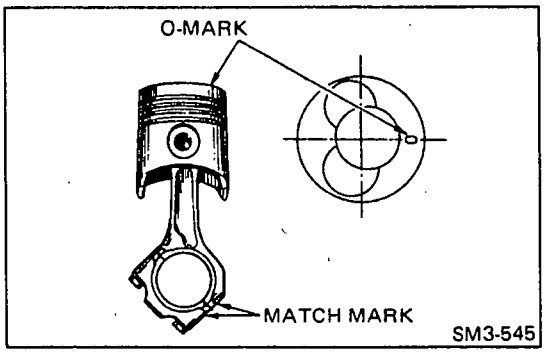
INSTALL THE PISTON WITH CONNECTING ROD IN THE CYLINDER LINER.

1. Apply engine oil to the piston, cylinder liner and connecting rod bearing surface.
2. Using a special tool, hold the piston rings and push the piston with connecting rod with a wooden rod.

Special Tool: Piston ring holder (09441-1151)

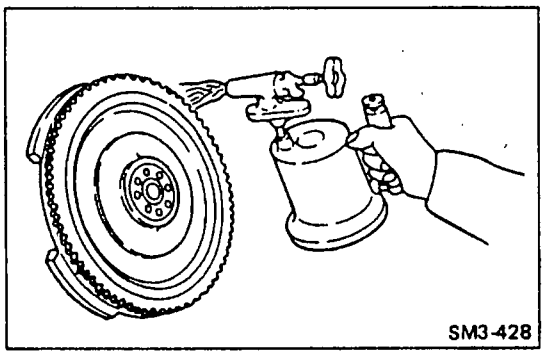
NOTE:
- **Be sure that the O-mark on the top of the piston is nearest the identification marks of cylinder block and liner side.**
- **When installing the piston with connecting rod, be careful that the cooling jet is not struck by the connecting rod. If the cooling jet is struck, adjust or replace it.**
- **Rotate the crankshaft slowly, make sure that the pistons do not contact with the piston cooling jets.**





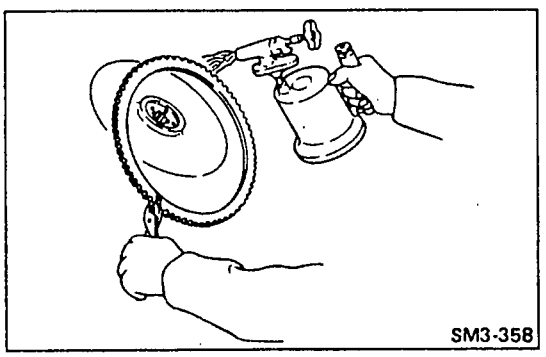
INSTALL THE CONNECTING ROD CAP.

1. Apply engine oil to the cap bearing surface.
2. Align the match marks on the connecting rod and cap.
3. Apply engine oil to the threads of the bolt and cap surface of the nut.
4. Tighten the cap bolt in three stages.



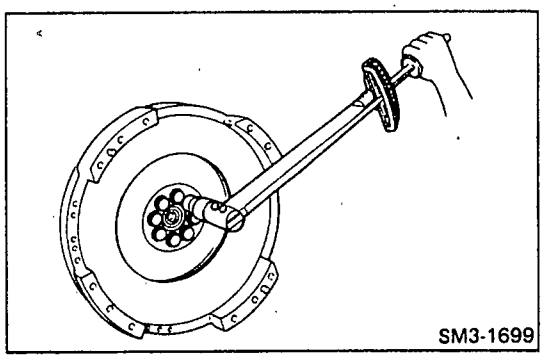
IF NECESSARY, REPLACE THE RING GEAR.

1. Heat the ring gear with a blow torch in a uniform manner [Approx. 100°C (212°F)].
2. Using a metal rod as a pad and strike all around the ring gear in a uniform manner and remove the ring gear.



3. Heat the ring gear uniformly using a blow torch [Approx. 100°C (212°F)].
4. Drive the ring gear with its chamfered gear teeth facing the block onto the flywheel using a metal rod.

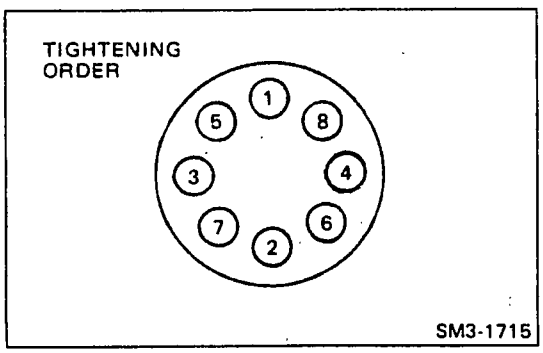
NOTE: Do not overheat the ring gear.



INSTALL THE FLYWHEEL.

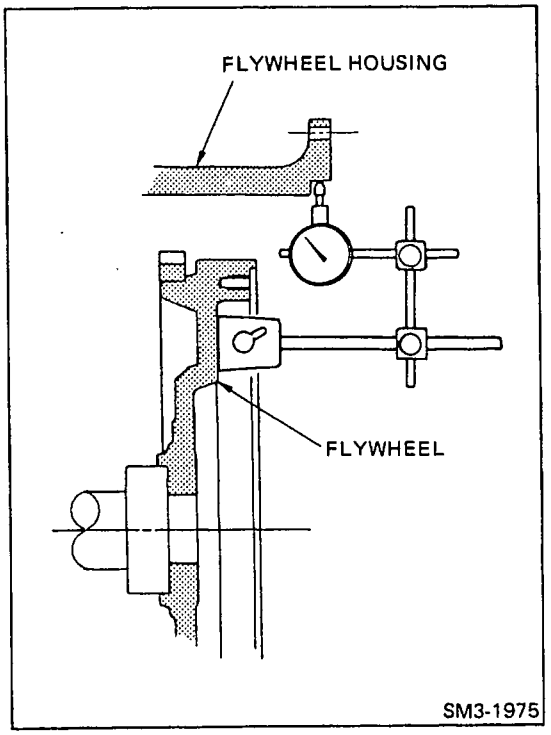
Install the flywheel and tighten the bolts through several repetitions of the tightening order so as to reach specified torque evenly and gradually, then slacken and tighten them one by one to the specified torque.

WARNING
The flywheel is heavy. When installing, be careful not to drop it on your feet.



NOTE:
- **Align the "O" mark on the flywheel and crankshaft collar knock-in.**
- **When tightening the bolt, apply engine oil to the threads and flywheel surface of the bolts.**

Tightening Torque: 2,600–2,900 kg·cm (189–209 lb.ft)



IMPORTANT POINTS – ADJUSTMENT

GENERATOR USE ONLY

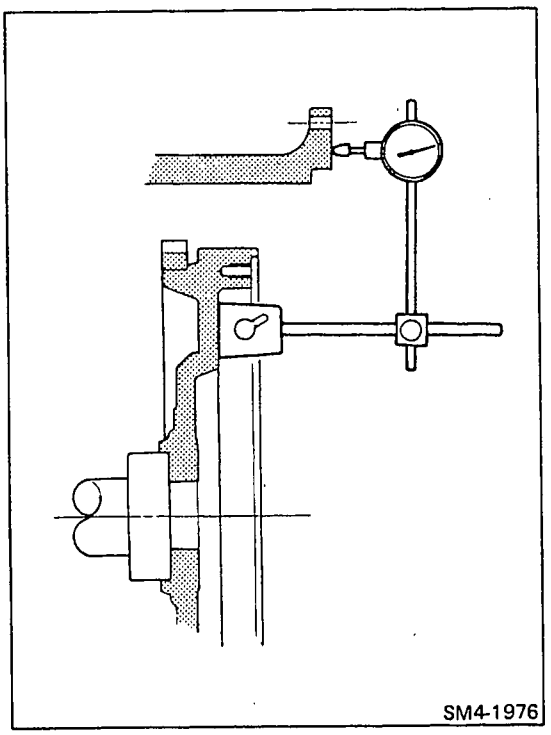
ANGULAR AND PARALLEL ALIGNMENT.

1. Checking angular (face) alignment.
a. Attach the dial indicator stand to the flywheel.
b. Apply the dial indicator at right angle to plane surface of flywheel housing.
c. Pretension the gauge and set to "0".
d. Turn the flywheel slowly and measure the angular alignment.

Repair limit: 0.20 mm (0.0078 in)

e. If the angular alignment exceeds the limit, install the shim between the cylinder block and flywheel housing.

NOTE: The following shims are available.
Thickness;
0.05 mm (0.0020 in): 9001-11186
0.10 mm (0.0039 in): 9001-11187
0.20 mm (0.0079 in): 9001-11188

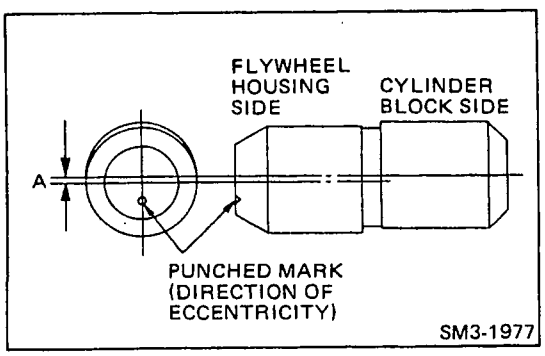


2. Checking parallel (bore) alignment.
a. Attach the dial indicator stand to the flywheel.
b. Apply the dial indicator at right angle to entering surface of flywheel housing.
c. Pretension the gauge and set to "0".
d. Turn the flywheel slowly and measure the parallel alignment.

Repair limit: 0.20 mm (0.0078 in)

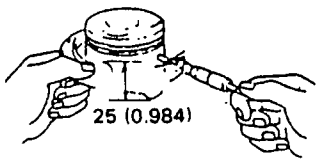
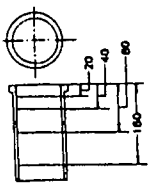
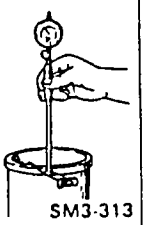
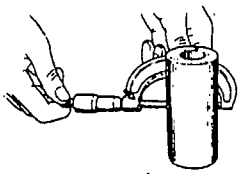
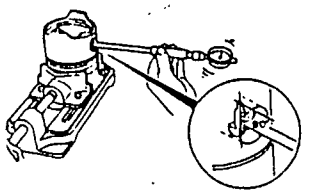
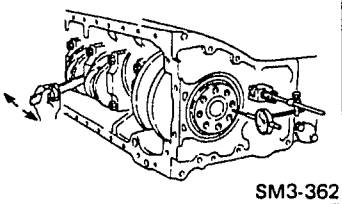
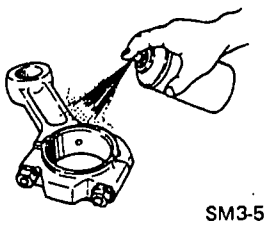
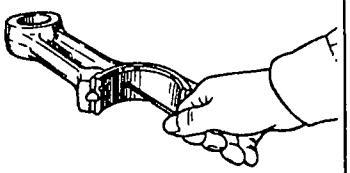
e. If the parallel alignment exceeds the limit, change the straight pins.

NOTE: The following straight pins are available.
Eccentricity (A);
0.05 mm (0.0020 in): 9002-12110
0.10 mm (0.0039 in): 9002-12111
0.20 mm (0.0079 in): 9002-12112

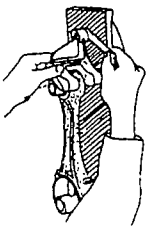
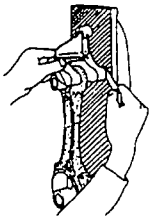
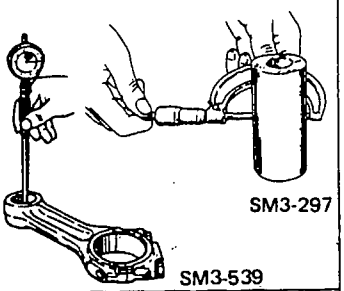
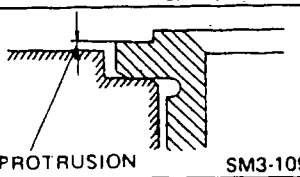
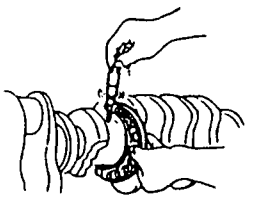
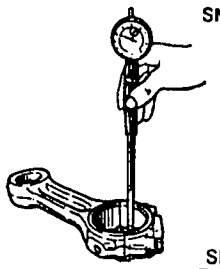
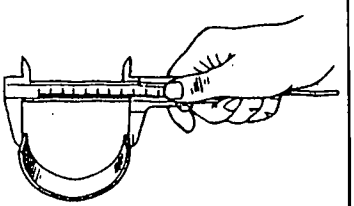


INSPECTION AND REPAIR

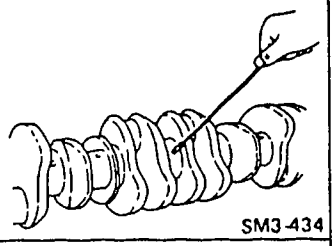
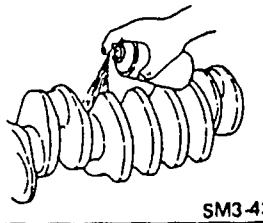
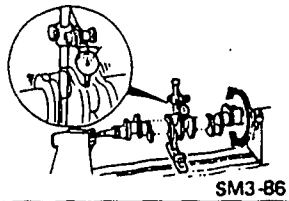
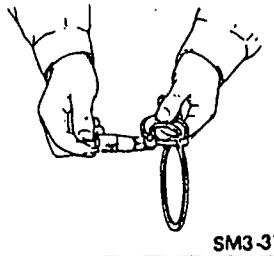
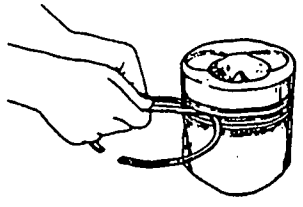
Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Cylinder Liner Inside Diameter	137 (5.393)	138.3 (5.444)	Replace piston and/or liner oversize pistons 0.50 (0.0197) 0.75 (0.0295) 1.00 (0.0394)	 SM3-910
Clearance between Piston and Cylinder Liner	0.211–0.230 (0.0083–0.0091)	–		 SM3-432  SM3-313
Piston Pin Diameter	49.995–50.000 (1.9683–1.9685)	49.80 (1.9606)	Replace piston and/or piston pin	 SM3-297
Piston Pin Hole Inside Diameter	50.001–5.007 (1.9685–1.9687)	–		
Clearance between Piston Pin and Piston Pin Hole	0.001–0.012 (0.00004–0.00047)	0.05 (0.0019)		 SM3-859
Crankshaft end Play	0.110–0.265 (0.0044–0.0104)	0.50 (0.0196)	Replace thrust bearing	 SM3-362
Connecting Rod Wear or Damage Using a dye penetrate	–	–	Replace	 SM3-537
Connecting Rod Oil Hole Clogged	–	–	Clean	 SM3-538

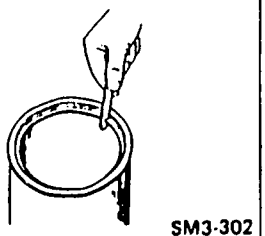
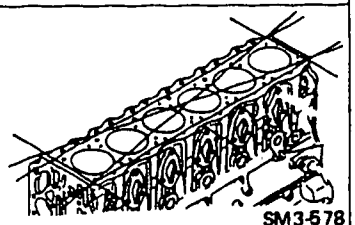
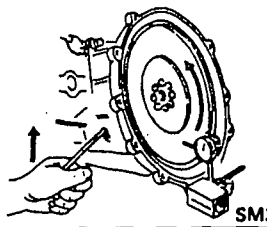
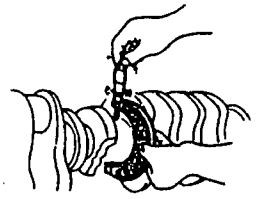
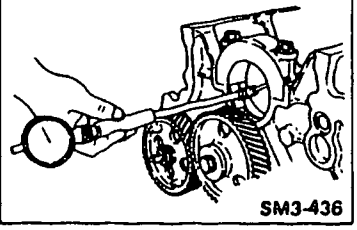
Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Connecting Rod Straightness	–	0.05 (0.0019) Per 200 (0.7874)	Repair or replace	 SM3-330
Connecting Rod Twist	–	0.05 (0.0019) Per 200 (0.7874)	Repair or replace	 SM3-331
Piston Pin Diameter	49.99–50.00 (1.968–1.969)	49.90 (1.9645)	Replace bushing and/or piston pin	 SM3-297 SM3-539
Clearance between Piston Pin and Connecting Rod Small End Bushing	0.025–0.049 (0.0010–0.0019)	0.10 (0.0039)		
Projection of the Cylinder liner	0.08–0.14 (0.0031–0.0055)	–	Replace	 PROTRUSION SM3-1092
Crank Pin Diameter	83.945–83.965 (3.3050–3.3057)	-0.20 (-0.0078)	Regrind crankshaft and use undersize bearing	 SM3-860
		82.8 (3.2599)	Replace	
Clearance between Connecting Rod and Crank Pin	0.050–0.101 (0.0020–0.0039)	0.30 (0.0118)	Replace bearing	 SM3-540
Main Bearing Spread	96.75–98.00 (3.8091–3.8582)	–	Replace bearing	 SM3-298
Connecting Rod Bearing Spread	89.75–90.75 (3.5335–3.5728)	–		

Unit: mm (in)

Inspection Item		Standard	Limit	Remedy	Inspection Procedure
Crankshaft Oil Hole Clogged		–	–	Clean	 SM3-434
Crankshaft Cracks and Damage Using a dyd penetrate		–	–	Replace	 SM3-435
Crankshaft Bend		–	0.05 (0.0019)	Replace	 SM3-861
Piston Ring Breadth Ring No.	Top:	–	–	–	 SM3-379
	2nd: 3rd:	3.47–3.49 (0.1366–0.1374)	3.25 (0.1280)	Replace	
	Oil:	5.97–5.99 (0.2351–0.2358)	5.95 (0.2343)		
Piston Ring Groove Breadth Ring No.	Top:	–	–	–	 SM3-301
	2nd: 3rd:	3.56–3.58 (0.1402–0.1409)	3.35 (0.1319)	Replace piston	
	Oil:	6.03–6.05 (0.2375–0.2381)	6.10 (0.2401)		
Clearance between Piston Ring and Piston Ring Breadth Ring No.	Top:	–	–	–	
	2nd: 3rd:	0.07–0.11 (0.0028–0.0043)	0.20 (0.0078)	Replace piston ring and/or piston	
	Oil:	0.04–0.08 (0.0015–0.0052)	0.10 (0.0039)		

Unit: mm (in)

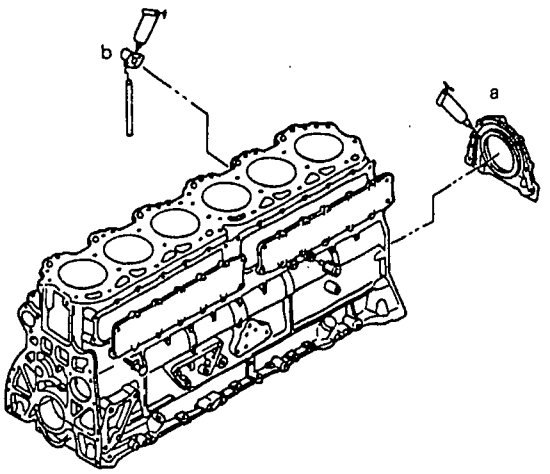
Inspection Item		Standard	Limit	Remedy	Inspection Procedure
Piston Ring Gap Ring No. *Insert the Piston Rings Where the Wear of the Liner is Small	Top:	0.45–0.65 (0.0178–0.0255)	1.50 (0.0590)	Replace	 SM3-302
	2nd: 3rd:	0.45–0.65 (0.0178–0.0255)	1.50 (0.0590)		
	Oil:	0.35–0.55 (0.0138–0.0217)	1.00 (0.0393)		
Cylinder Block Flatness		0.0–0.05 (0.0–0.0019)	0.10 (0.0039)	Regrind	 SM3-578
			0.15 (0.0059)	Replace	
Flywheel Face Alignment		–	0.20 (0.0078)	Regrind and/or replace	 SM3-908
Crankshaft Journal Diameter		89.910–89.930 (3.5398–3.5405)	–0.20 (–0.0078)	Regrind crankshaft and use undersize bearing	 SM3-860
			88.80 (3.4961)	Replace	
Clearance between Crankshaft Journal and Main Bearing		0.070–0.121 (0.0028–0.0047)	0.30 (0.0118)	Replace bearing	 SM3-436

LIQUID GASKET AND APPLICATION POINTS

The EK130-T type engine use liquid gasket (Three Bond TB1207C : 04132-1207) instead of conventional sheet gaskets. Apply liquid gasket, therefore, taking the following items into account.

1. LIQUID GASKET APPLICATION POINTS AND COATING WIDTH

Unit: mm (in)

Parts name	Application point	Coating width 
a. Rear oil seal retainer b. Coolant drain cock	 SM3-1965	1.5–2.5 (0.06–0.10)

2. COATING LIQUID GASKET AND PARTS ASSEMBLY PROCEDURE

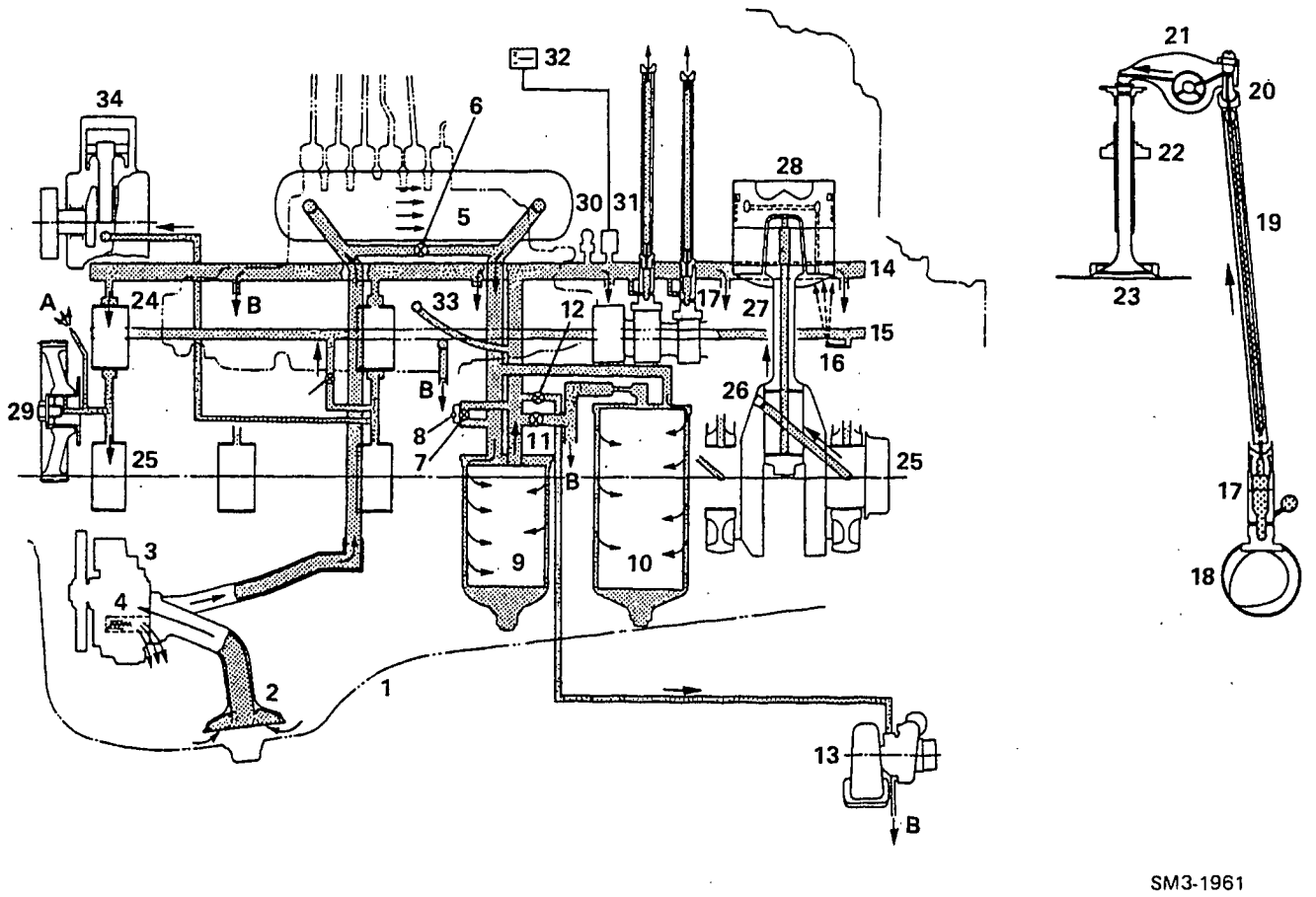
1. Completely remove old liquid gasket from each part and the respective mating part, and remove oil, water, and dirt using a cloth.
2. Be careful not to apply excessive or insufficient liquid gasket. Also, be sure to overlap the start and end of each coating.
3. When assembling coated parts, be careful that there is no misalignment between mating parts. If there is any misalignment, coat the parts again.
4. Assemble the various parts within 20 minutes after applying liquid gasket. If more than 20 minutes have elapsed, remove the liquid gasket and apply it again.
5. After assembling the various parts, wait for at least 15 minutes before starting the engine.

3. REMOVING PARTS

When removing each part, do not attempt to pry one portion of the flange alone but use the flange collar or clearance to pry the flange at several points alternately.

LUBRICATING SYSTEM

LUBRICATING SYSTEM DIAGRAM



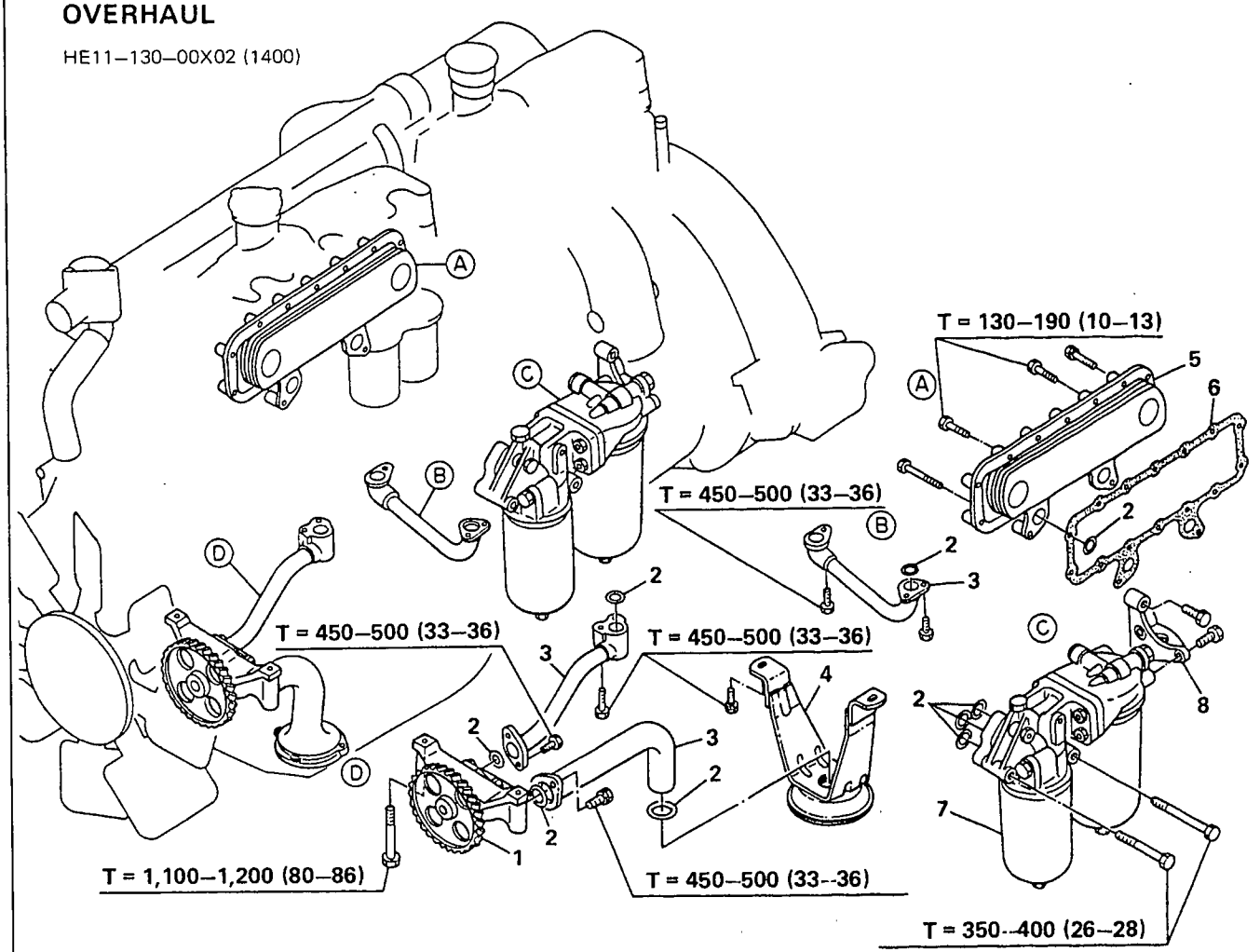
SM3-1961

1. Oil pan
2. Oil strainer
3. Oil pump
4. Oil pump safety valve
   $8.0^{+1.5}_{-0}$ kg/cm^2
   ($113.76^{+21.33}_{-0}$ lb/sq.in)
5. Oil cooler
6. Oil cooler safety valve
   4.0 ± 0.3 kg/cm^2
   (56.88 ± 4.26 lb/sq.in)
7. Oil filter safety valve
   1.5 ± 0.2 kg/cm^2
   (21.33 ± 2.84 lb/sq.in)
8. Warning device for clogging of oil filter
9. Oil filter (Full flow)
10. Oil filter (Bypass)
11. Regulator valve
    4.0 ± 0.3 kg/cm^2
    (56.88 ± 4.26 lb/sq.in)
12. Check valve for turbocharger
13. Turbocharger
14. Main oil hole
15. Sub oil hole
16. Piston cooling jet
17. Tappet
18. Camshaft cam
19. Push rod
20. Adjusting screw
21. Rocker arm
22. Rocker arm shaft
23. Valve
24. Camshaft journal
25. Crankshaft journal
26. Crankshaft pin
27. Connecting rod
28. Piston
29. Idler gear
30. Oil pressure switch
31. Oil pressure gauge unit
32. Oil pressure gauge
33. Fuel injection pump
34. Air compressor
    (If so equipped)

A. To timing gear
B. To oil pan

OVERHAUL

HE11–130–00X02 (1400)



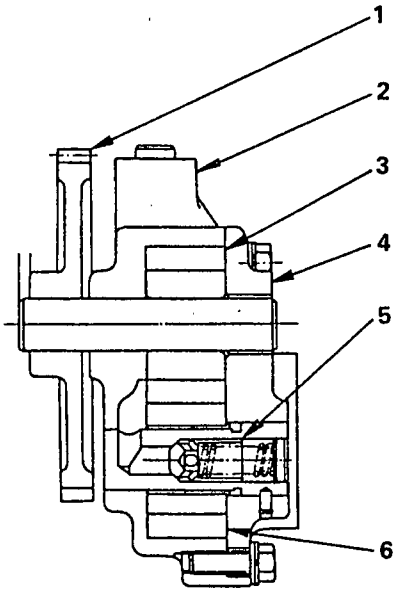
SM3-1962

T = Tightening torque: kg·cm (lb.ft)

1. Oil pump
2. O-ring
3. Oil pipe
4. Oil strainer
5. Oil cooler
6. Gasket
7. Oil filter
8. Bracket

OIL PUMP

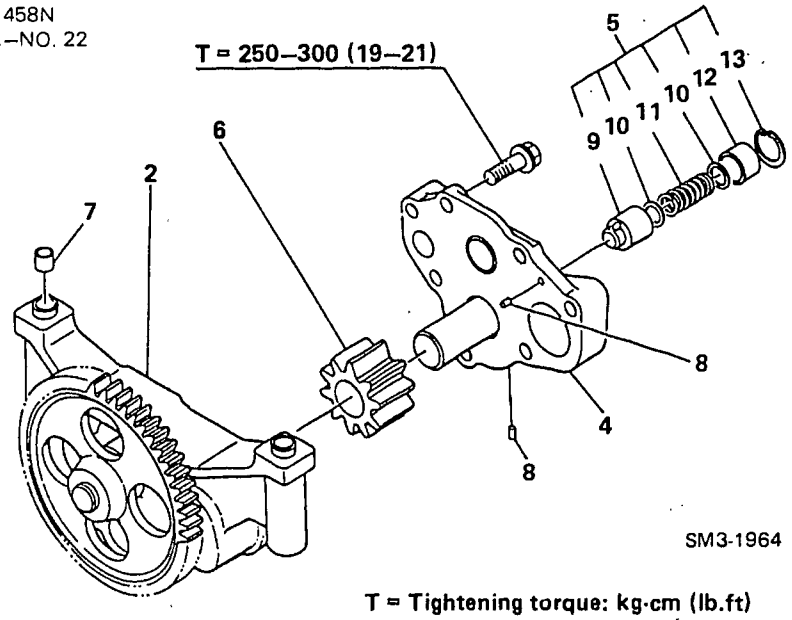
DESCRIPTION



SM3-1963

OVERHAUL

1458N
I–NO. 22



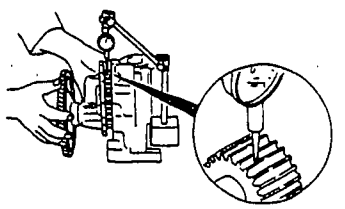
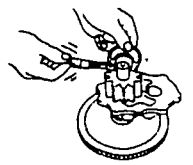
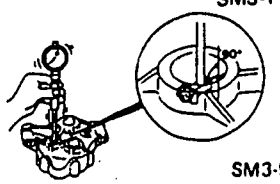
SM3-1964

T = Tightening torque: kg·cm (lb.ft)

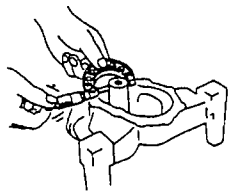
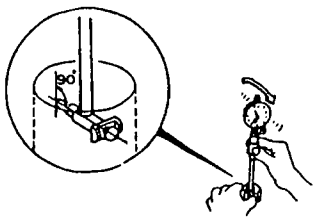
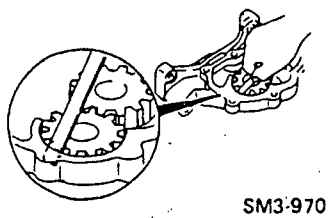
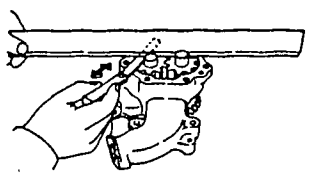
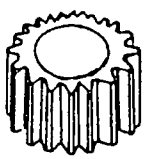
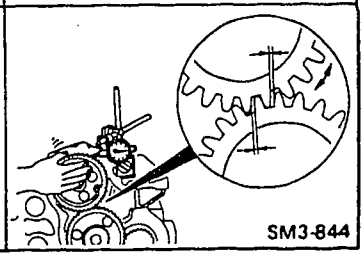
1. Oil pump gear
2. Oil pump case
3. Drive gear
4. Oil pump cover
5. Oil pump safety valve
6. Driven gear
7. Collar
8. Pin
9. Valve
10. Shim
11. Spring
12. Spring seat
13. Retainer ring

INSPECTION AND REPAIR

Unit: mm (in)

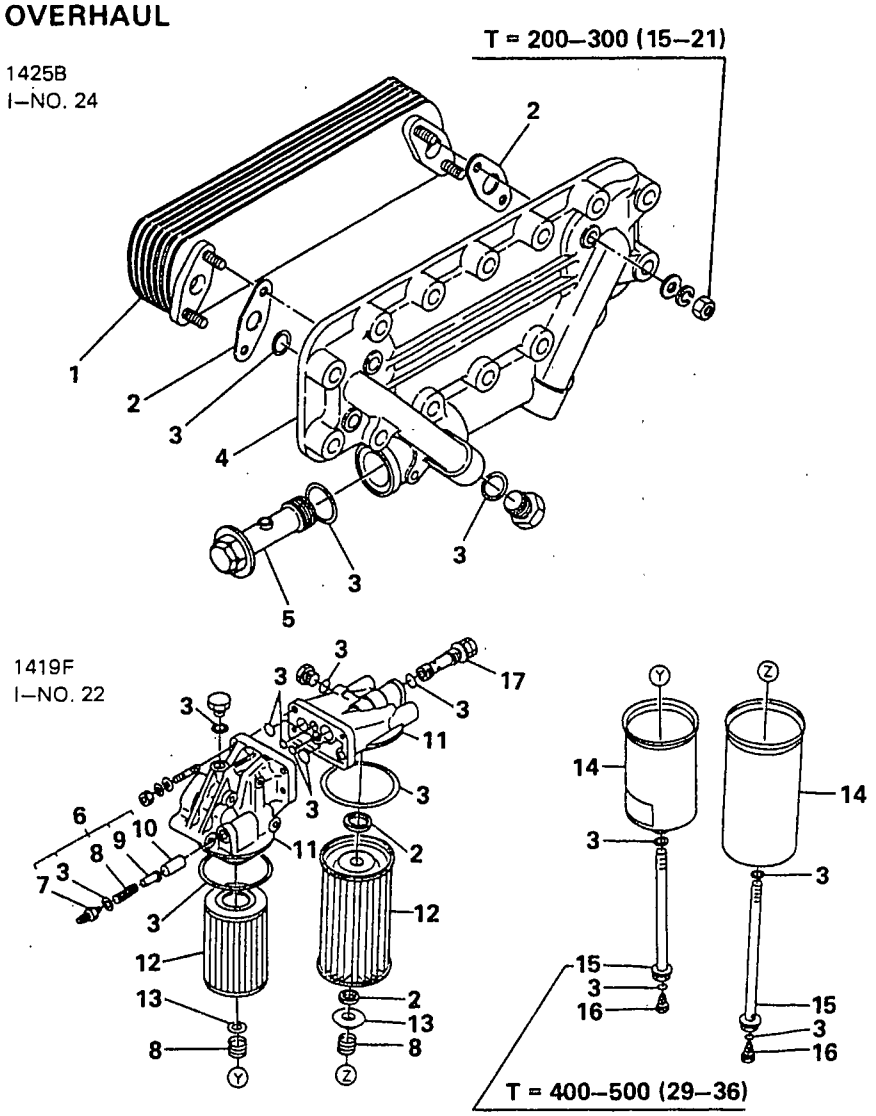
Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Gear Backlash	0.14–0.26 (0.0055–0.0102)	0.40 (0.0157)	Replace	 SM3-1117
Drive Gear Shaft Diameter	21.967–21.980 (0.8649–0.8653)	–	Replace shaft and/or pump body	 SM3-1123
Pump Body Inside Diameter	22.023–22.044 (0.8671–0.8678)	–		
Clearance between Drive Shaft and Oil Pump Body	0.043–0.077 (0.0016–0.0030)	0.19 (0.0074)		 SM3-971

Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Driven Gear Shaft Diameter	25.959–25.980 (1.0221–1.0228)	–	Replace	 SM3-1124
Driven Gear Inside Diameter	26.025–26.050 (1.0247–1.0255)	–	Replace	
Clearance between Driven Gear and Shaft	0.045–0.091 (0.0018–0.0035)	0.19 (0.0074)	Replace driven gear and/or shaft	 SM3-869
Clearance between Gear and Case	0.05–0.13 (0.0020–0.0051)	0.18 (0.0070)	Replace gear and/or case	 SM3-970
Gear End Play	0.06–0.105 (0.0024–0.0041)	0.15 (0.0059)	Replace gear and/or case	 SM3-927
Gear Teeth Pitting or Wear	–	–	Replace, if necessary	Visual check  SM3-845
Oil pump safety valve Wear or Damage	–	–	Replace, if necessary	Visual check
Gear Backlash Oil Pump Drive Gear and Oil Pump Driven Gear	0.089–0.289 (0.0035–0.0113)	0.40 (0.0157)	Replace gear	 SM3-844

OIL COOLER AND OIL FILTER

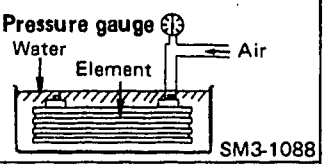
OVERHAUL



1. Oil cooler element
2. Gasket
3. O-ring
4. Oil cooler case
5. Oil cooler safety valve
   4.0±0.3 kg/cm^2
   (56.88±4.26 lb/sq.in)
6. Oil filter safety valve
   1.5±0.2 kg/cm^2
   (21.33±2.84 lb/sq.in)
7. Warning device for clogging of oil filter
8. Spring
9. Holder
10. Valve
11. Oil filter upper cover
12. Oil filter element
13. Washer
14. Oil filter lower cover
15. Center bolt
16. Drain plug
17. Regulator valve
    4.0 ± 0.3 kg/cm^2
    (56.88 ± 4.26 lb/sq.in)

T = Tightening torque: kg·cm (lb.ft)

INSPECTION AND REPAIR

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Oil Cooler Air Tightness Air Pressure: 10 kg/cm^2 (142 lb/sq.in)	–	–	Replace, if necessary.	
Valve and Springs of Oil Cooler and Oil Filter Wear or Damage	–	–	Replace, if necessary	1. Sliding face of valve for possible damage. 2. Valve move smoothly.

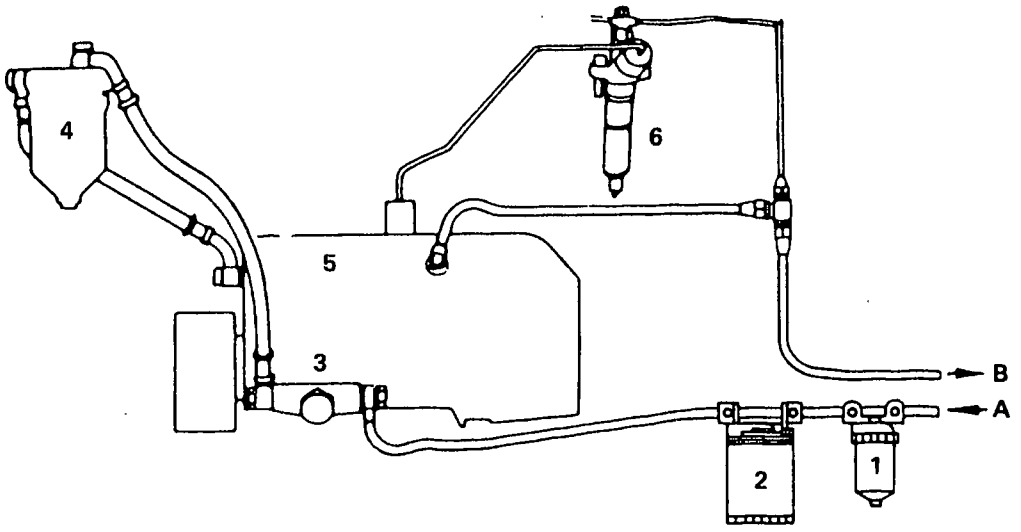
FUEL SYSTEM

DATA AND SPECIFICATIONS

Injection nozzle

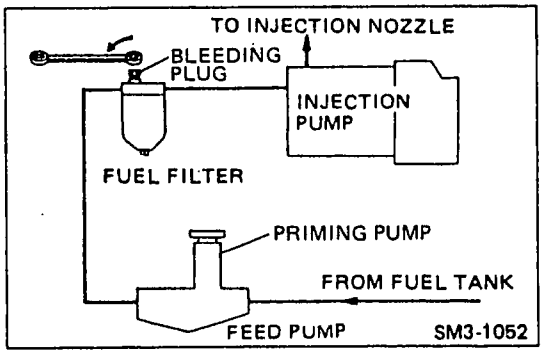
Type	Multi-hole nozzle type
Opening pressure	220 kg/cm^2 (3,129 lb/sq.in)

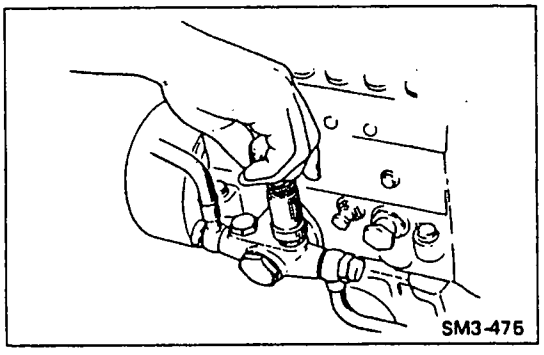
FUEL SYSTEM DIAGRAM



1. Water separator (If so equipped)
2. Fuel filter (If so equipped)
3. Fuel feed pump
4. Fuel filter
5. Injection pump
6. Injection nozzle

A. From fuel tank
B. To fuel tank





AIR BLEEDING FROM FUEL SYSTEM.

1. Loosen the bleeder plug on the fuel filter.
2. Loosen the priming pump knob.
3. Operate the priming pump knob until the air will not come out from the bleeder plug.
4. Tighten the bleeder plug.

Tightening Torque: 40–60 kg·cm (3–4 lb.ft)

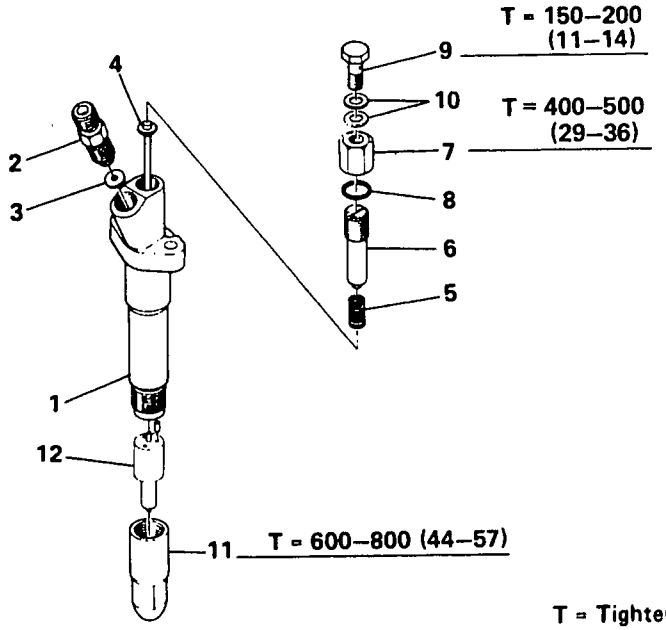
NOTE: The bleeder plug should be tightened while the priming pump knob is operated.

5. Once again, operate the pump knob several times.
6. Push back the priming pump knob and tighten it.

NOTE: Wipe off any splashed fuel.

INJECTION NOZZLE

OVERHAUL



T = Tightening torque: kg·cm (lb.ft)

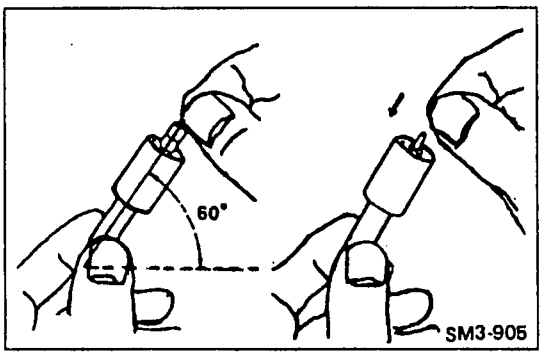
SM3-1132

1. Nozzle body
2. Connector
3. Gasket
4. Stem
5. Spring
6. Adjust screw
7. Cap nut
8. Gasket
9. Joint bolt
10. Gasket
11. Nozzle adapter
12. Nozzle

IMPORTANT POINTS – DISMOUNTING AND MOUNTING

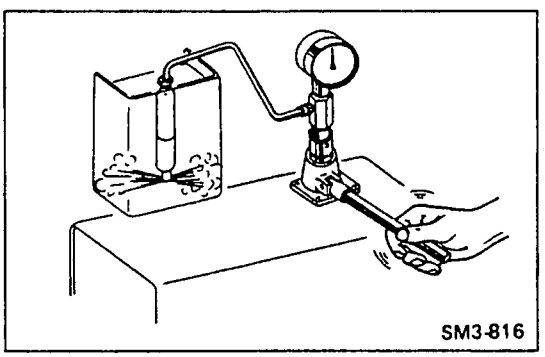
WHEN REMOVING OR INSTALLING THE INJECTION NOZZLE, REFER TO SECTION CYLINDER HEAD.

IMPORTANT POINTS – ASSEMBLY



TEST THE NOZZLE SINKING.

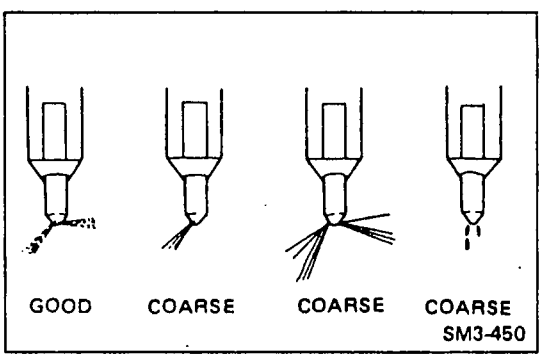
Wash the nozzle proper with diesel fuel oil, them immerse it in diesel fuel oil.
Next slide the needle inside the nozzle proper and ensure that it move smoothly. The needle valve should fall under its own weight when withdrawn vertically about 1/3 and released. If its motion is luggish, replace the nozzle with a new one.



ADJUST THE INJECTION PRESSURE.

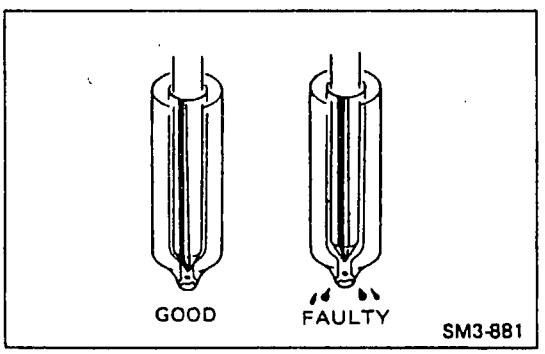
1. Connect the nozzle holder with a nozzle tester and move the lever at the rate of about 50 to 60 times per minute.
   If not correct, adjust the injection pressure with adjusting screw.

Injection Pressure: 220 kg/cm^2 (3,129 lb/sq.in)



TEST THE SPRAY PROFILE.

In the case of the new nozzle, operate the lever at the rate of 30 to 60 strokes per minute, and for a used nozzle, operate the lever at the rate of 15 to 60 strokes per minute.
In the spray profile is unsatisfactory, clean or replace the nozzle with a new one.



TEST THE FUEL LEAKAGE.

When checking for fuel leakage from the nozzle, apply a pressure of about 20 kg/cm^2 (284 lb/sq.in) lower than the correct injection pressure to the nozzle by means of the nozzle tester. If there is no fuel leakage, the nozzle is normal.

COOLING SYSTEM

DATA AND SPECIFICATIONS

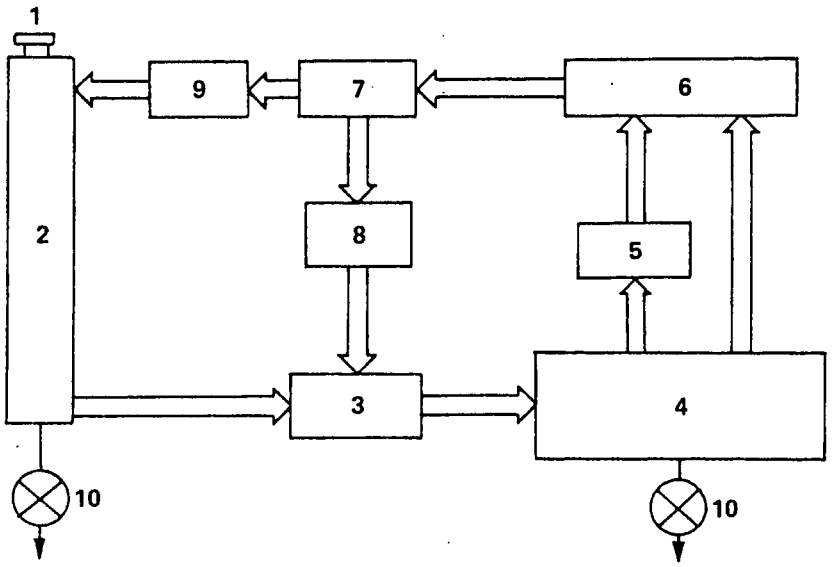
Coolant pump

Type	Forced circulation by volute pump
Drive	By Gear

Thermostat

Type	Wax type, bottom bypass type

COOLING SYSTEM DIAGRAM

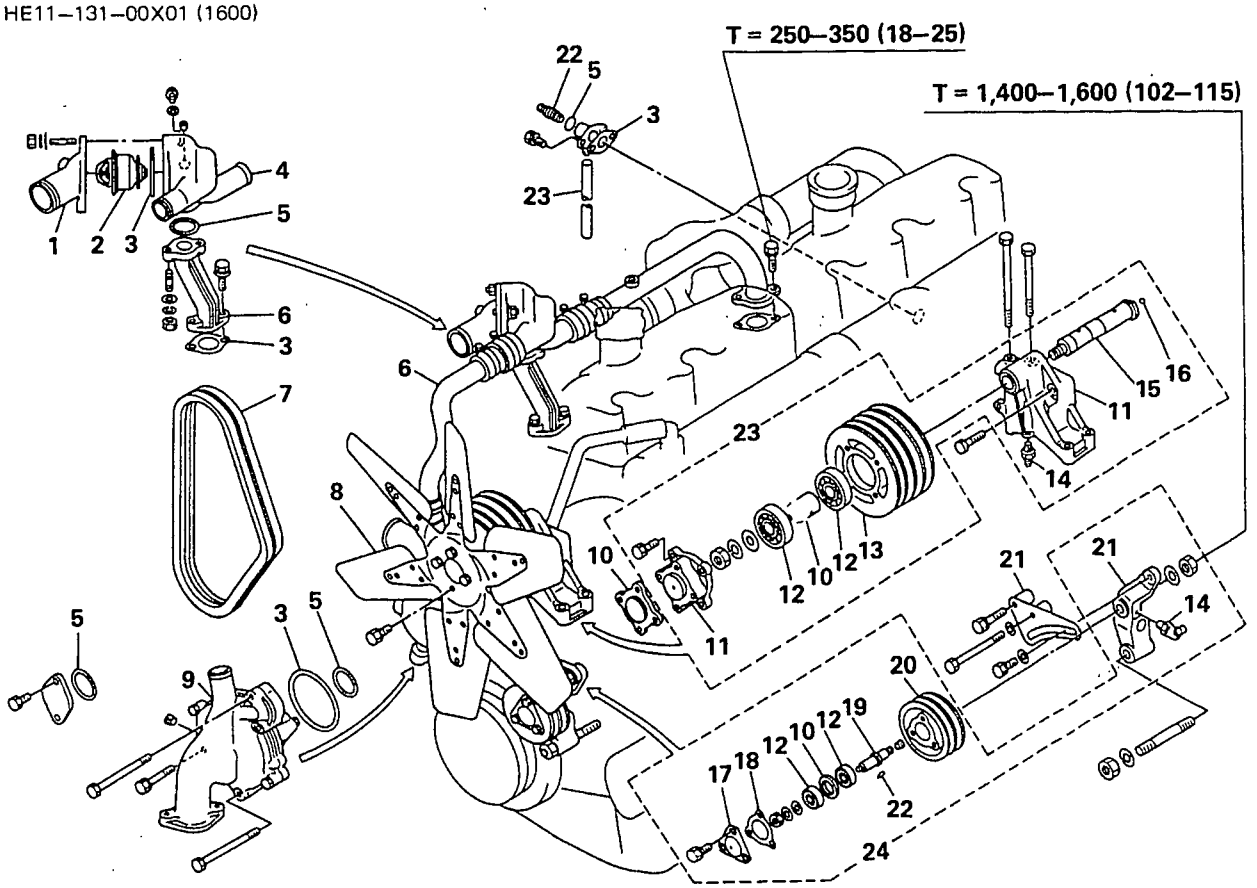


SM3-1872

1. Radiator cap
2. Radiator
3. Coolant pump
4. Cylinder block
5. Oil cooler
6. Cylinder head
7. Thermostat case
8. Bypass hose
9. Thermostat cover
10. Drain cock

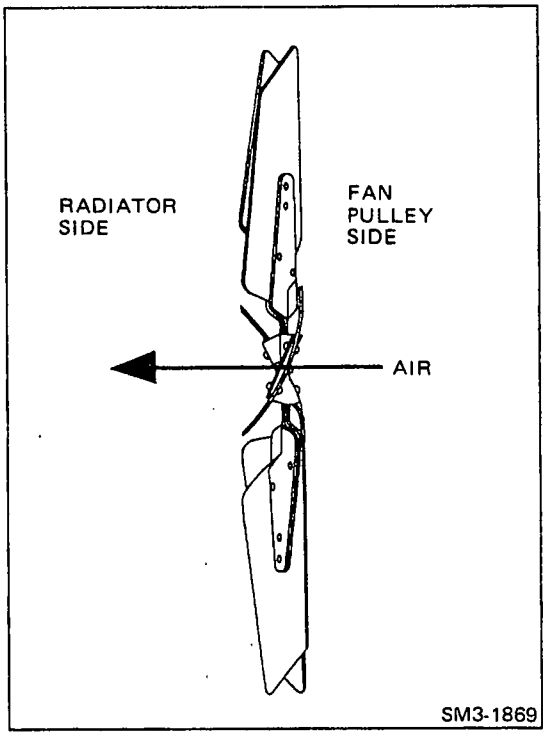
OVERHAUL

HE11–131–00X01 (1600)



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

1. Thermostat cover
2. Thermostat
3. Gasket
4. Thermostat case
5. O-ring
6. Pipe
7. V-belt
8. Cooling fan
9. Coolant pump
10. Spacer
11. Fan drive holder
12. Ball bearing
13. Fan pulley
14. Lubrication fitting
15. Fan drive shaft
16. Steel ball
17. Tension pulley cover
18. Shim
19. Tension pulley shaft
20. Tension pulley
21. Tension pulley holder
22. Key
23. Fan drive assy
24. Tension pulley assy

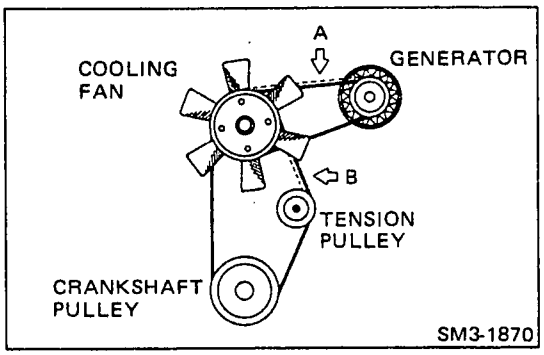


IMPORTANT POINT – ASSEMBLY

INSTALL THE COOLING FAN.

Install the cooling fan as shown.

NOTE: Do not drop or strike the fan. The resulting damage may lower the performance of the fan.



IMPORTANT POINT – MOUNTING

V-BELT ADJUSTMENT.

1. Install the V-belts, and adjust the belt tension.

NOTE:
- **Do not under any circumstances apply the lever directly against the generator body owing to the risk of damaging the generator.**
- **When installing a new V-belt or adjusting the tension, be sure to repeat the adjustment two or three times, after running the engine for several minutes each time.**

2. V-belt deflection
   Apply a load of about 10 kg (22 lb) by pressing with your finger or a special tool.

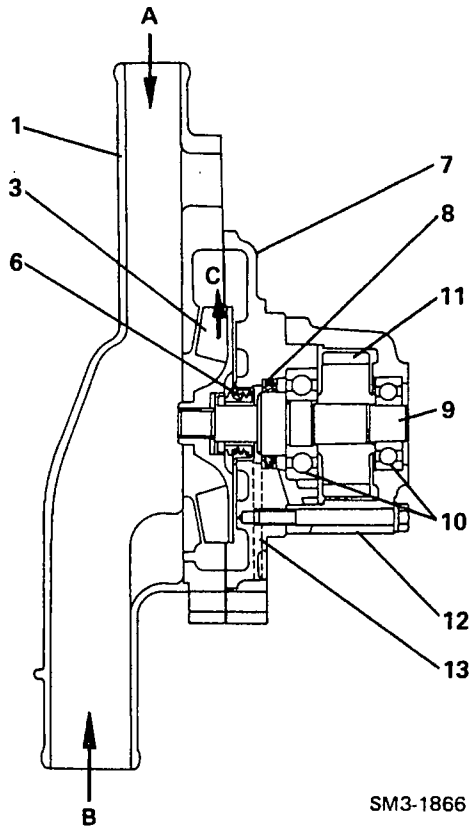
Assembly Standard (A) : 15–20 mm (0.60–0.78 in)
(B) : 10–15 mm (0.40–0.59 in)

Special Tool: V-belt tension gauge (09444-1210)

NOTE: If the belt is excessively tensioned, there is a risk of damaging the bearings of the generator and also shorting the life of the V-belt.
Conversely, if there is insufficient tension on the V-belt, the belt will slip, unusual noise will be emitted, the battery may run down and the engine may overheat.

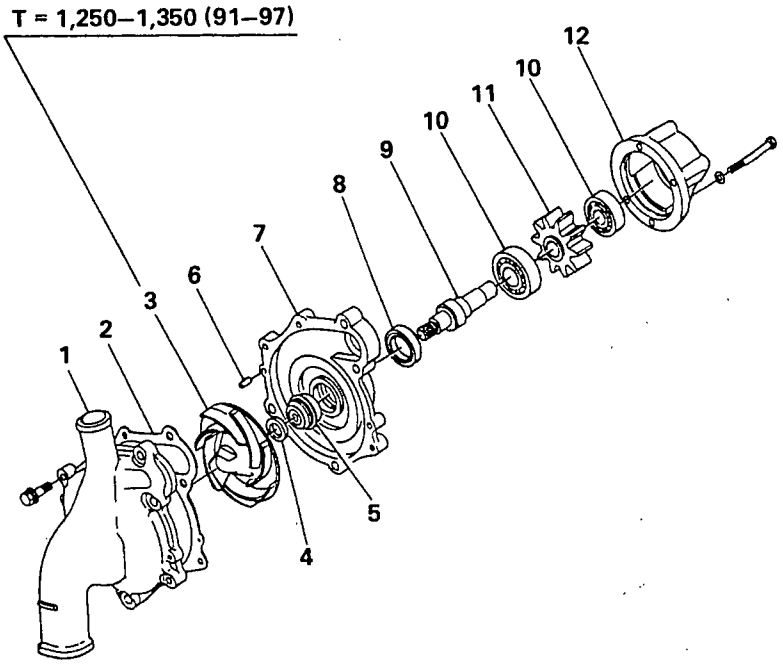
COOLANT PUMP

DESCRIPTION



SM3-1866

OVERHAUL



SM3-1871

T = Tightening torque: kg·cm (lb.ft)

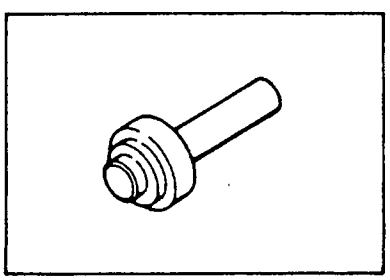
1. Pump case cover
2. Gasket
3. Vane
4. Spacer
5. Coolant seal
6. Straight pin
7. Pump case
8. Oil seal
9. Shaft
10. Ball bearing
11. Coolant pump gear
12. Bearing retainer
13. Coolant drain hole

A. From thermostat (Bypass)
B. From radiator
C. To cylinder block

SPECIAL TOOL

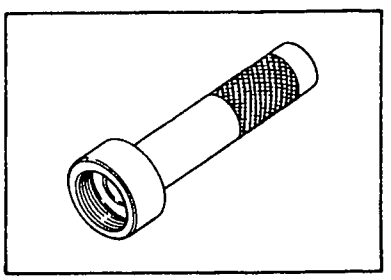
Prior to starting an engine overhaul, it is necessary to have these special tools.

OIL SEAL PRESS

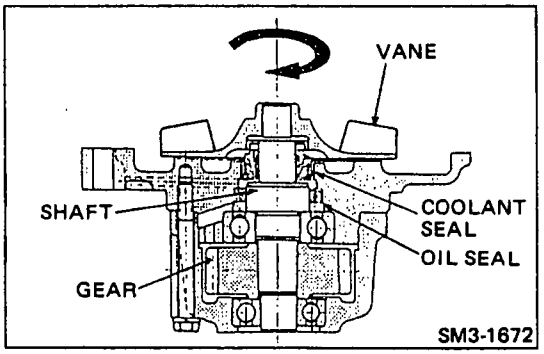


09482-1160

COOLANT SEAL PRESS



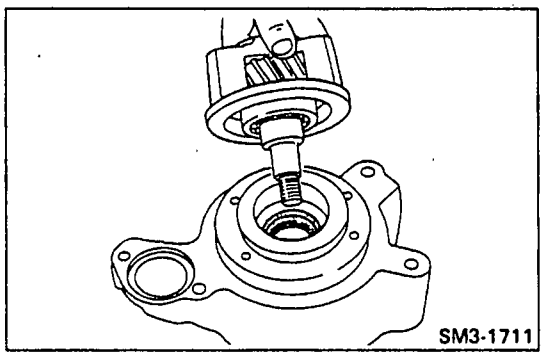
09482-1690



IMPORTANT POINTS – DISASSEMBLY

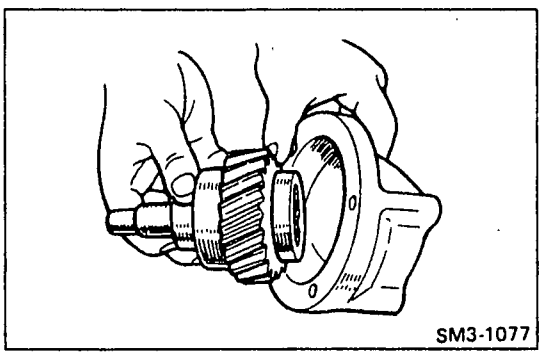
REMOVE THE VANE FROM THE SHAFT.

The vane is a screw in type, so it is removed by turning the vane clockwise.



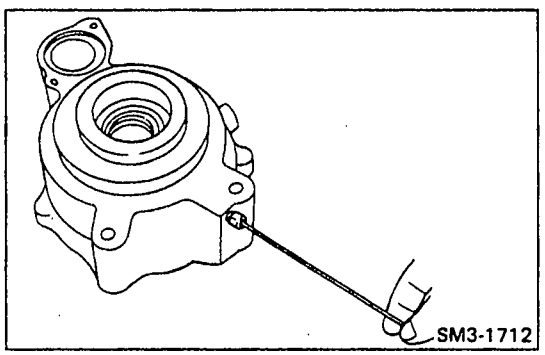
REMOVE THE BEARING RETAINER.

Remove the bearing retainer with shaft from the pump case.

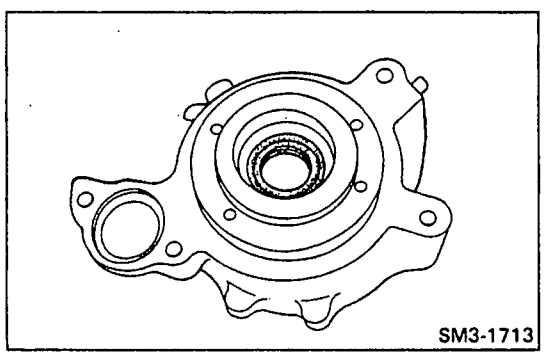


REMOVE THE SHAFT.

Press to the end of the shaft on the retainer side and remove the ball bearing.



CLEAN THE WATER DRAIN HOLE OF THE PUMP CASE.



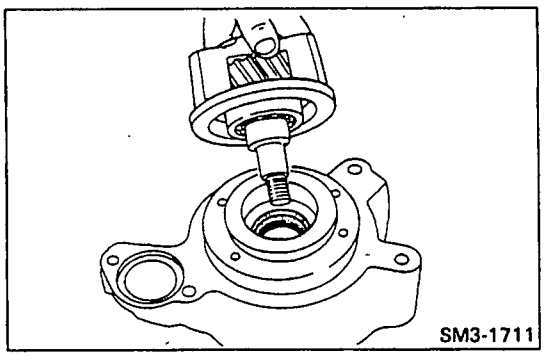
IMPORTANT POINTS – ASSEMBLY

INSTALL THE OIL SEAL.

Apply engine oil to the pump case side and then using a special tool, install the oil seal to the case.

Special Tool: Oil seal press (09482-1160)

NOTE:
- **Install the oil seal with the lip positioned to the retainer side.**
- **Apply grease to the main lip and between main and sub lips.**

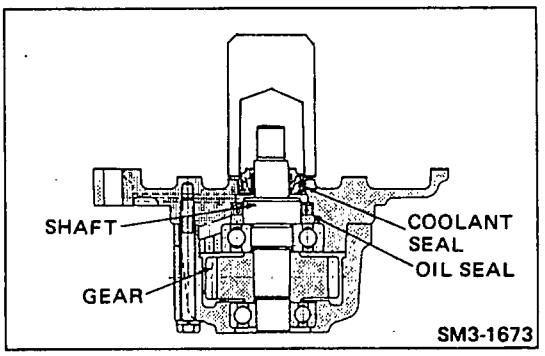

SM3-1711

INSTALL THE SHAFT.

Install the shaft to the case and fasten the retainer with four bolts.

Tightening torque: 180–220 kg·cm (13–16 lb.ft)

NOTE: Before installing the shaft to the case, apply engine oil to the shaft to prevent the oil seal from damage.



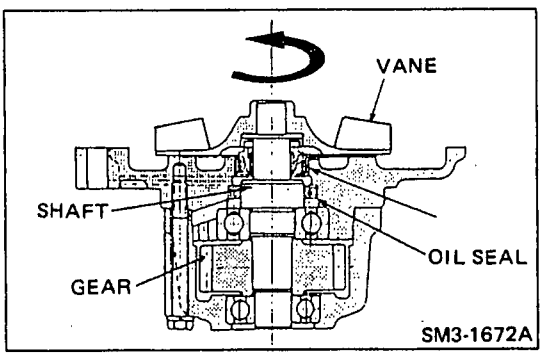
SM3-1673

INSTALL THE COOLANT SEAL.

Using a special tool, install the coolant seal to the case.

Special Tool: Coolant seal press (09482-1690)

NOTE: Before installing the coolant seal, apply the liquid gasket (Three Bond No. 1104 or equivalent) to the outer and circumference of the coolant seal cage.



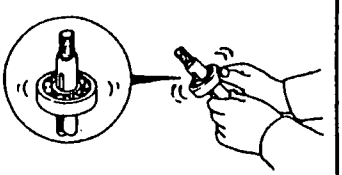
SM3-1672A

INSTALL THE VANE TO THE SHAFT.

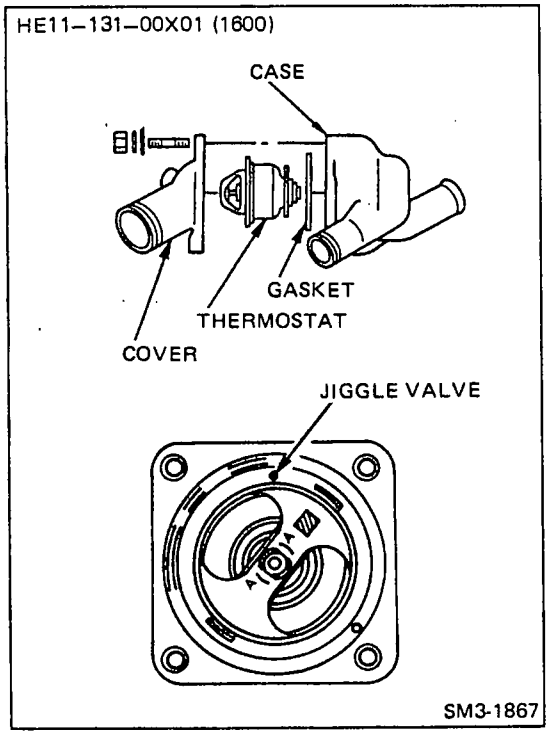
Install the vane to the shaft by turning the vane counter-clockwise.

NOTE: Make sure that the vane rotates smoothly.

INSPECTION AND REPAIR

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Bearing Wear and Damage	–	–	Replace, if necessary	 SM3-946

THERMOSTAT



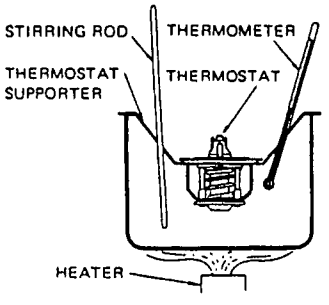
IMPORTANT POINT – MOUNTING

INSTALL THE THERMOSTAT.

1. Clean the thermostat and thermostat case.
2. Be sure to that the jiggle valve faces upwards when installing.
3. Be sure to place corroded, scared or permanently strained O-rings with new ones.
4. Apply liquid gasket to the coolant pipe outer surface and thermostat seal before connecting hoses.

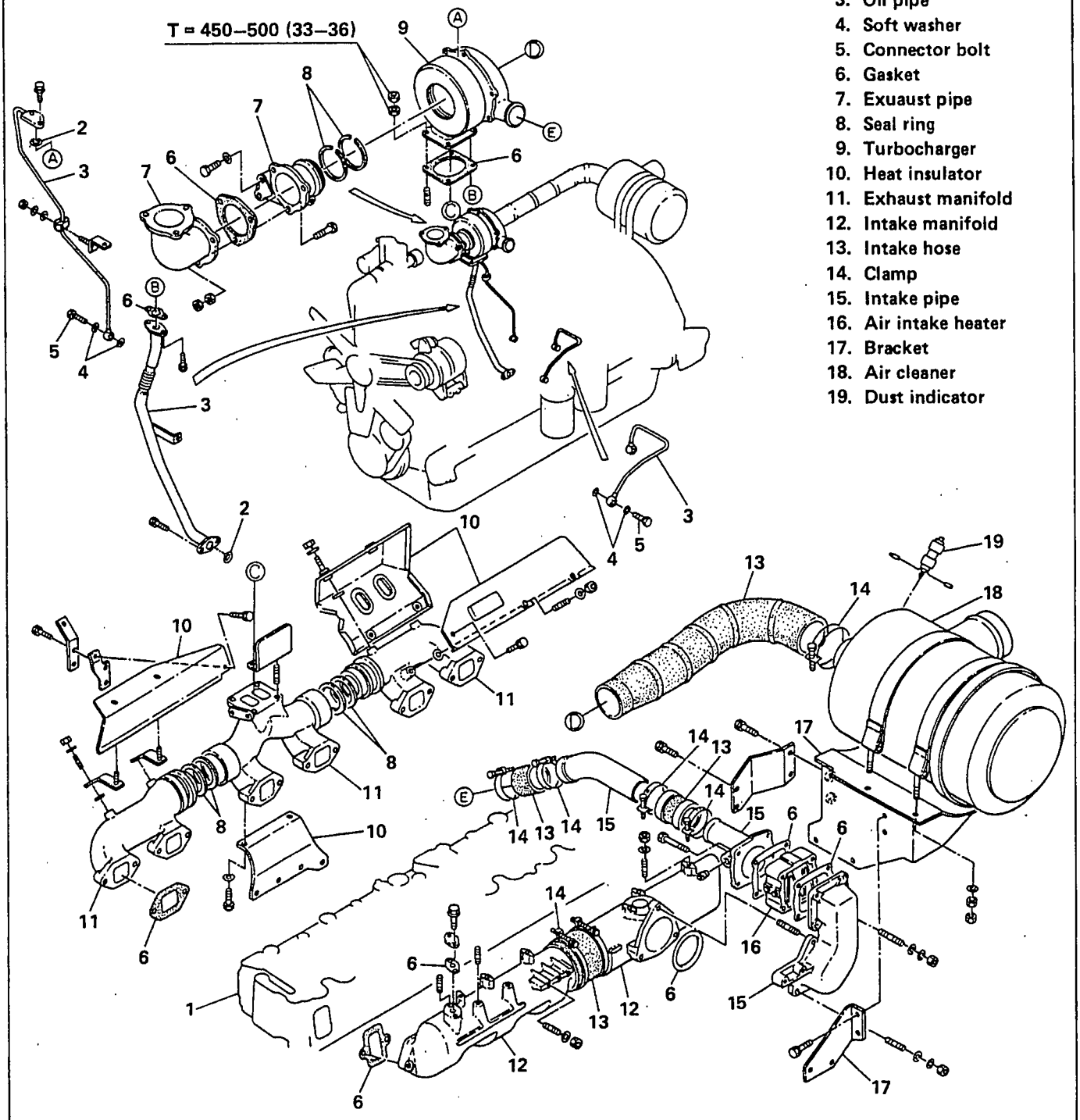
INSPECTION AND REPAIR

Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Thermostat Valve Opening Temperature	74.5–78.5°C (166–173°F)	–	Replace thermostat	
Thermostat Valve Lift	At least 10 (0.4) at 90°C (194°F)	–		
Thermostat Closing Condition	Fully opened valve should close completely within 5 minutes when thermostat is immersed in water of normal temperature.	–		

AIR INTAKE AND EXHAUST SYSTEM

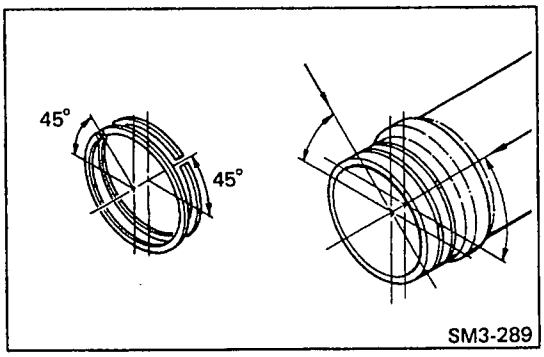
OVERHAUL



1. Cylinder head
2. O-ring
3. Oil pipe
4. Soft washer
5. Connector bolt
6. Gasket
7. Exuaust pipe
8. Seal ring
9. Turbocharger
10. Heat insulator
11. Exhaust manifold
12. Intake manifold
13. Intake hose
14. Clamp
15. Intake pipe
16. Air intake heater
17. Bracket
18. Air cleaner
19. Dust indicator

SM3-1972

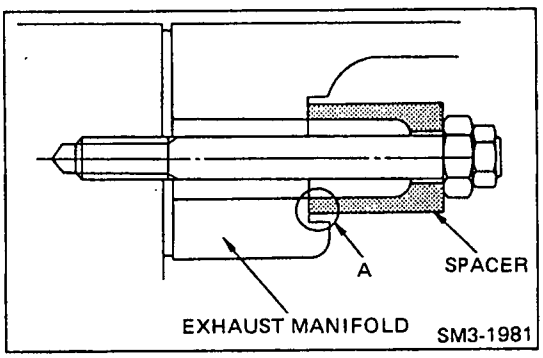
T = Tightening torque: kg·cm (lb.ft)



IMPORTANT POINTS – ASSEMBLY

INSTALL THE EXHAUST MANIFOLD.

1. When installing seal rings on the exhaust manifold, fit new seal rings in such a way that the gaps are equally spaced, as shown, to prevent gas and oil leakage.



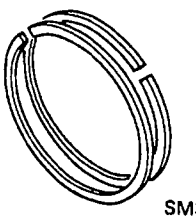
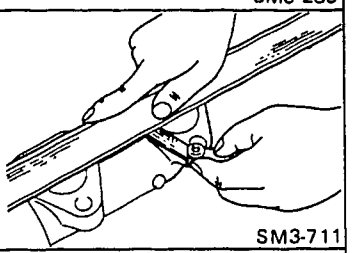
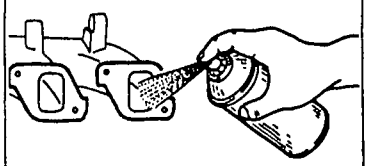
2. Install the exhaust manifold as shown.

NOTE:
- **Tighten the exhaust manifold with nut, putting the spacer beneath it.**
- **Before tightening, make sure that the spacer do not slip out from the spot facing refer to A section.**
- **Fit the spacer positioning the small inside diameter side (with white paint) at the nut side.**

Tightening Torque: 450–500 kg·cm (33–36 lb.ft)

INSPECTION AND REPAIR

Unit: mm (in)

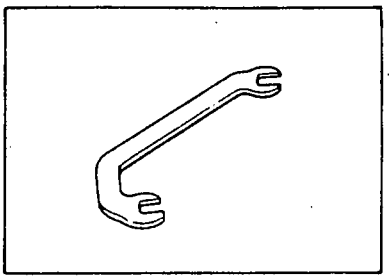
Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Exhaust Seal Ring Wear or Damage	–	–	Replace	Visual check  SM3-289
Intake and Exhaust Manifolds Flatness	Less than 0.10 (0.0039)	0.50 (0.0197)	Resurface or replace Resurface Limit: 0.10 (0.0039) par flange	 SM3-711
Intake and Exhaust Manifolds Crack or Damage *Using a Dye penetrant	–	–	Replace	 SM3-710

ENGINE COMPONENT PARTS DISMOUNTING AND MOUNTING

SPECIAL TOOL

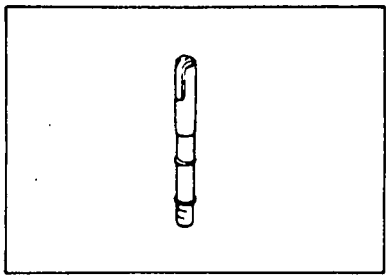
Prior to starting an engine overhaul, it is necessary to have these special tools.

INJECTION PUMP COUPLING WRENCH

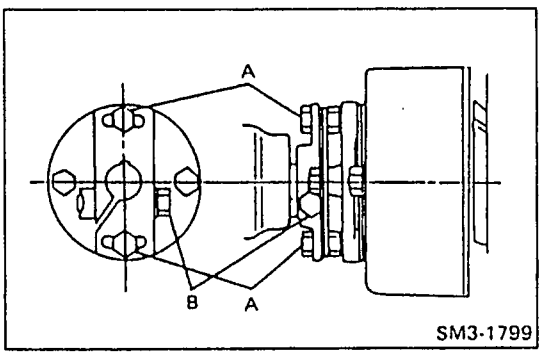


08919-1705

V-BELT TENSION GAUGE



09444-1210



FUEL INJECTION PUMP

IMPORTANT POINTS – DISMOUNTING

REMOVE THE FUEL INJECTION PUMP.

1. Disconnect the fuel lines, oil lines and engine control lines.

NOTE: Cover open end of the pipes and pump to prevent entry of dirt.

2. Remove the through bolt "B" and flange bolts "A".
3. Remove the pump mounting bolts and then dismount the pump.

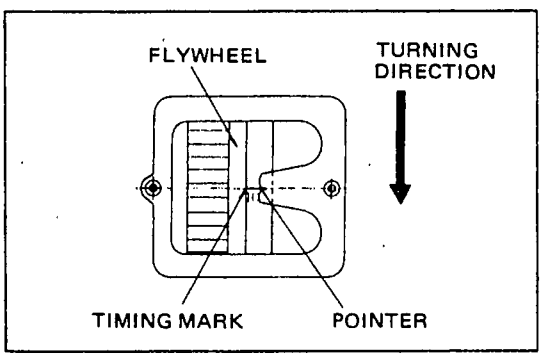
Special Tool: Wrench (09819-1705)

IMPORTANT POINTS – MOUNTING

INSTALL THE INJECTION PUMP.

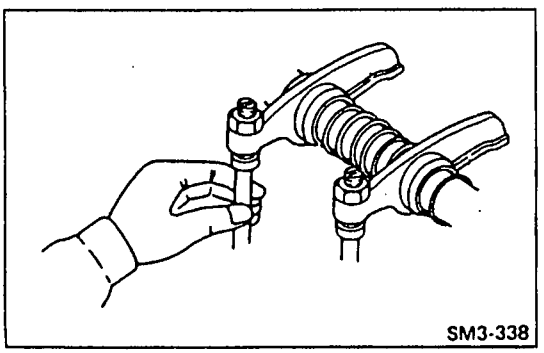
1. Adjust the injection timing.
   Turn the crankshaft counter-clockwise viewed from flywheel side to align the injection timing marks on the flywheel at A° before top dead center for No. 1 cylinder on compression stroke with pointer on the flywheel housing.

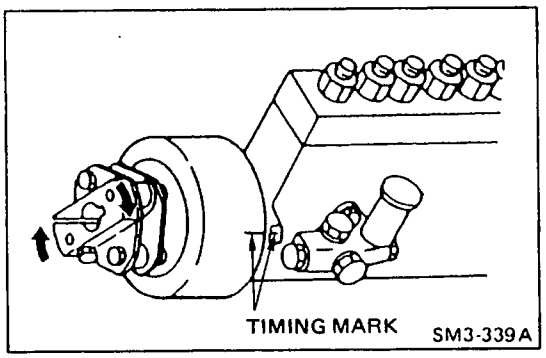
Injection Timing (A°): Refer to SECTION DATA AND SPECIFICATION.



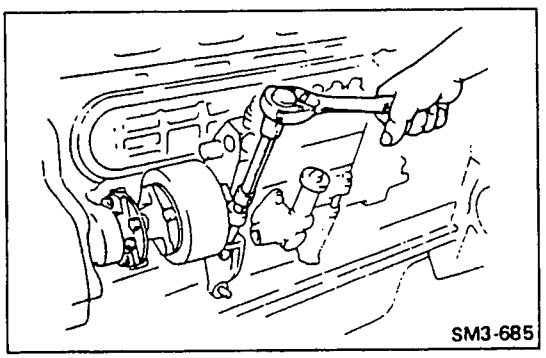
2. Check the push rods on No. 1 cylinder are loose and push rods on No. 6 are tight.

NOTE: If not, turn the crankshaft one complete revolution and align marks as above.

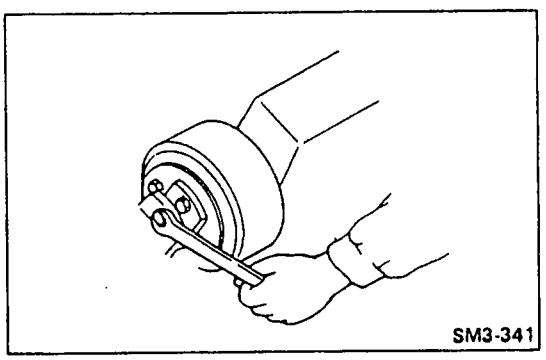




3. Slowly turn the automatic timer flange coupling to clockwise viewed from coupling side to align the timing mark on the automatic timer and pump body pointer.



4. Position the pump on the pump bracket and adjust the position of the pump so that its mounting holes align with those of the bracket and then tighten the mounting bolts evenly.

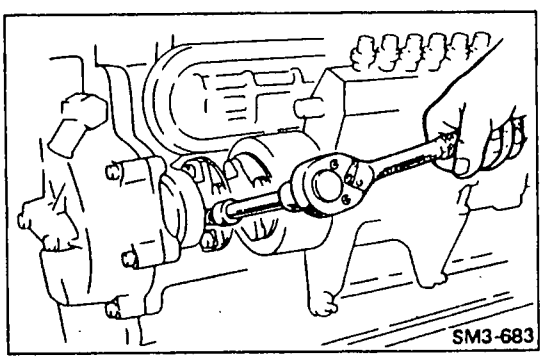


5. Using a special tool, tighten the two flange bolts (in slotted holes) at the coupling.

NOTE: There should not be any gap between the laminated plates or be any deformation of the flange due to pressure the laminated.

Special Tool: Wrench (09819-1705)

Tightening Torque: 600—650 kg·cm (44—47 lb.ft)



6. Tighten the through bolt at the flange.

NOTE: Do not tighten the through bolt before tightening the two flange bolts.

Tightening Torque: 600—650 kg·cm (44—47 lb.ft)

7. Connect the fuel lines, oil lines and engine control cables.

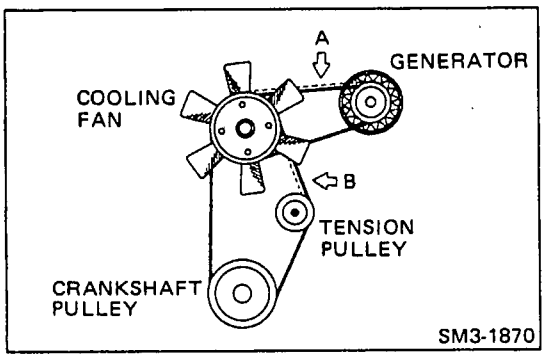
GENERATOR

IMPORTANT POINT – MOUNTING

V-BELT ADJUSTMENT.

1. Install the V-belts, and adjust the belt tension.

NOTE: ○ **Do not under any circumstances apply the lever directly against the generator body owing to the risk of damaging the generator.**
○ **When installing a new V-belt or adjusting the tension, be sure to repeat the adjustment two or three times, after running the engine for several minutes each time.**



2. V-belt deflection
Apply a load of about 10 kg (22 lb) by pressing with your finger or a special tool.

Assembly Standard (A) : 15–20 mm (0.60–0.78 in)
(B) : 10–15 mm (0.40–0.59 in)

Special Tool: V-belt tension gauge (09444-1210)

NOTE: If the belt is excessively tensioned, there is a risk of damaging the bearings of the generator and also shorting the life of the V-belt.
Conversely, if there is insufficient tension on the V-belt, the belt will slip, unusual noise will be emitted, the battery may run down and the engine may overheat.

Through Bolt Tightening Torque;
10 mm (0.39 in) Dia.: 380–500 kg·cm (28–36 lb.ft)
14 mm (0.55 in) Dia.: 700–900 kg·cm (51–65 lb.ft)

STARTER

IMPORTANT POINT – DISMOUNTING

REMOVE THE STARTER FROM THE ENGINE.

1. Turn off the battery switch (If so equipped).
2. Put the match marks on the starter terminals and harness with a pen and then disconnect the harness.
3. Remove the starter from the engine.

IMPORTANT POINT – MOUNTING

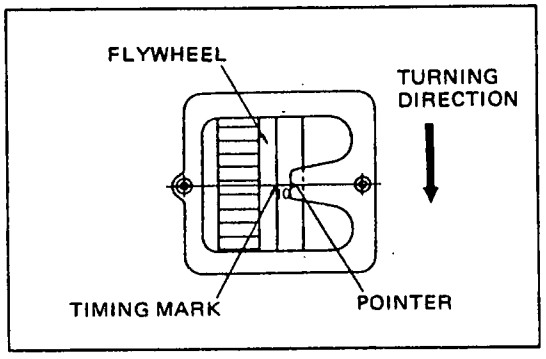
INSTALL THE STARTER ON THE ENGINE.

1. Install the starter on the engine.

Fitting Nuts Tightening Torque: 1,100–1,500 kg·cm (80–108 lb.ft)

2. Connect the harness to match the marks.

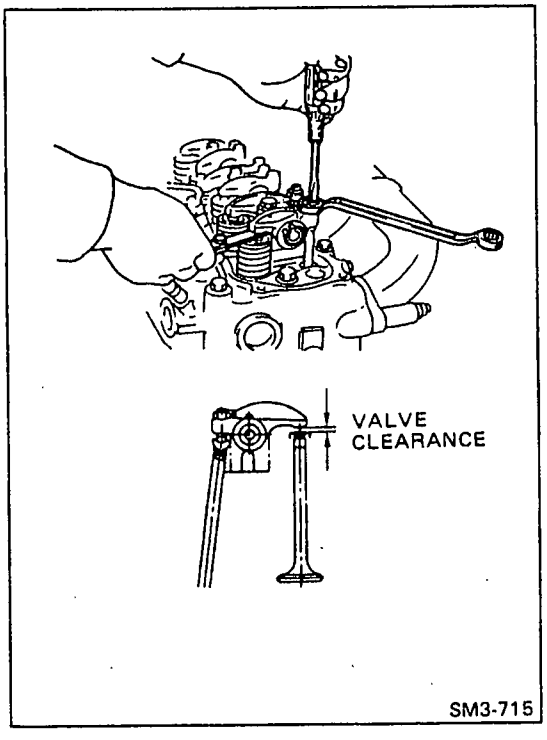
ENGINE TUNE-UP



VALVE CLEARANCE

INSPECTION AND ADJUSTMENT OF THE VALVE CLEARANCE

1. Set the No.1 piston to top dead center on compression stroke.

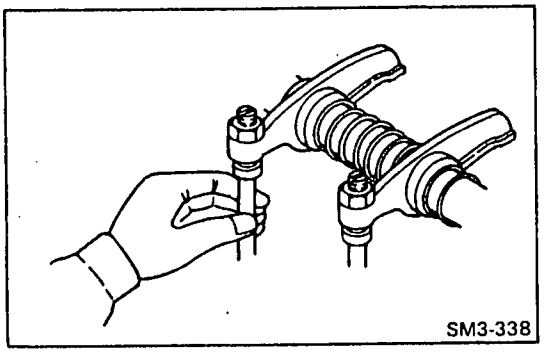


2. With the No.1 piston positioned at top dead center on compression stroke, adjust the No.1 valve clearance using a thickness gauge.
   The thickness gauge should move with a very slight pull.

Valve Clearance (When cold);
Intake: 0.40 mm (0.0157 in)
Exhaust: 0.40 mm (0.0157 in)

3. Adjust the other valves.
   Turn the crankshaft counter-clockwise 120° viewed from flywheel side. Adjust the valve clearance for each cylinder in the firing order.

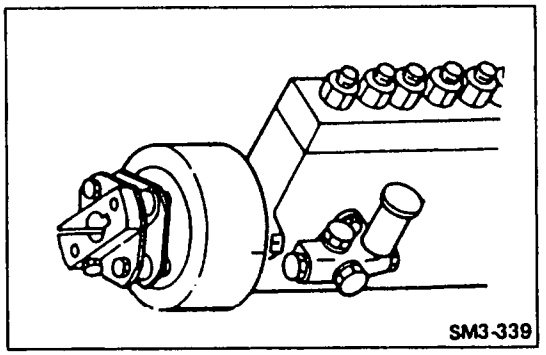
Firing order: 1–4–2–6–3–5



METHOD FOR DETERMINING IF THE NO. 1 OR NO. 6 PISTON IS AT THE TOP DEAD CENTER ON COMPRESSION STROKE.

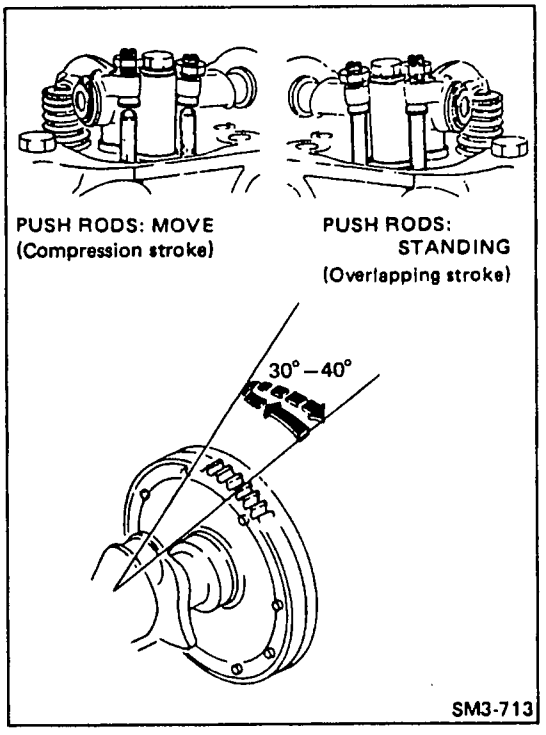
NOTE:
- **Turning the crankshaft, align the mark "1–6" on the flywheel with the pointer on the flywheel housing.**
- **In this position either the No.1 or No.6 piston is at the top dead center on compression stroke.**

1. If both No.1 intake and exhaust rocker arms can be moved easily by hand, the No.1 piston is at top dead center on compression stroke.


SM3-339

2. If the injection timing mark is nearly aligned with the pointer, the No. 1 piston is at top dead center on compression stroke.

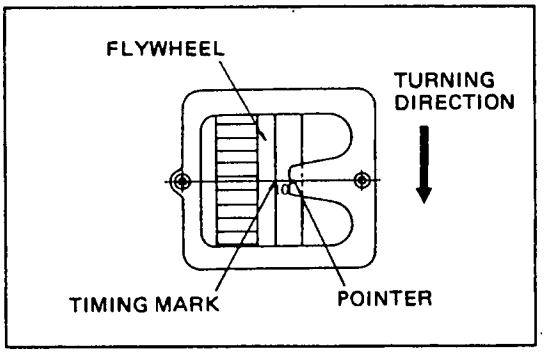
NOTE: **If not, turn the crankshaft one complete revolution and align marks as above.**



SM3-713

3. While locking at the push rods of No. 1 and No. 6 piston, turn the crankshaft unticlockwise and clockwise about 30° to 40° (see left figure).
If the piston whose exhaust and inlet push rods do not move during the interval, it is at the top dead center on compression stroke.
If the piston whose push rods have moved, it is at the completion of the exhaust and begun of the intake stroke (overlapping stroke).

NOTE: **Always loosen the lock nut and raise the adjusting screws fully to the top. If the adjusting screws are too low, the piston and valves may strike each other during valve clearance adjustment.**

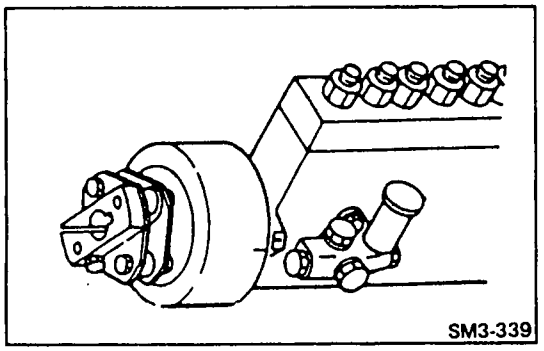


INJECTION TIMING

INSPECT THE INJECTION TIMING.

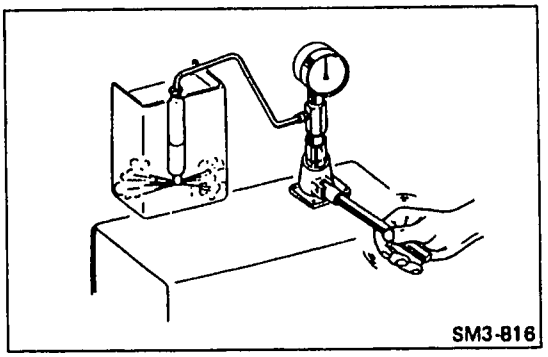
1. Turn the crankshaft counter-clockwise viewed from flywheel side to align the injection timing marks on the flywheel or crankshaft pulley damper at A° before top dead center for No. 1 cylinder on compression stroke.

Injection Timing A°: Refer to section DATA AND SPECIFICATIONS.


SM3-339

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

NOTE: **When adjusting the injection timing, refer to "FUEL INJECTION PUMP" in section ENGINE COMPONENT PARTS DISMOUNTING AND MOUNTING for details.**


SM3-816

INJECTION NOZZLE

INSPECT AND ADJUST THE INJECTION PRESSURE.

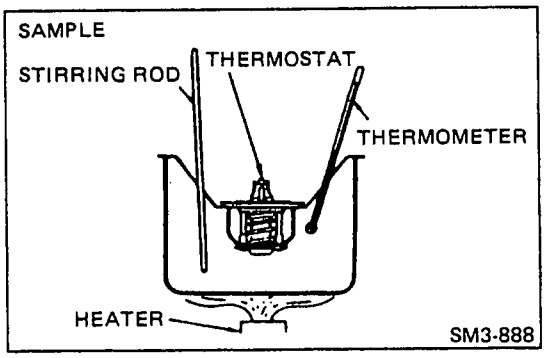
Refer to "INJECTION NOZZLE" in section FUEL SYSTEM.

TEST THE SPRAY PROFILE.

Refer to "INJECTION NOZZLE" in section FUEL SYSTEM.

TEST THE FUEL LEAKAGE.

Refer to "INJECTION NOZZLE" in section FUEL SYSTEM.



SM3-888

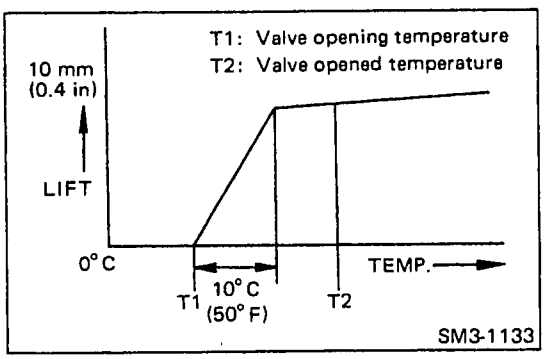
THERMOSTAT

INSPECT THE THERMOSTAT FUNCTION.

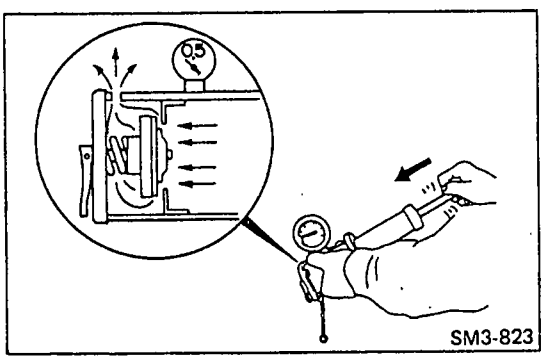
1. Place the thermostat in hot water and check the opening temperature and the lift.
2. Using a thermometer, check to see the thermostat opens at the specified temperature: 74.5–78.5°C (166–173°F).
3. Immerse the thermostat in hot water of a temperature of 90°C (194°F), and measure the lift of the pellet after a period of 5 minutes using vernier calipers. Measure the position of the bottom of the pellet before and after heating the thermostat.

Lift: At least 10 mm (0.4 in) [90°C (194°F)]

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



SM3-1133



SM3-823

COOLANT FILLER CAP

INSPECT THE COOLANT FILLER CAP FUNCTION.

Check the coolant filler cap using a cap tester.

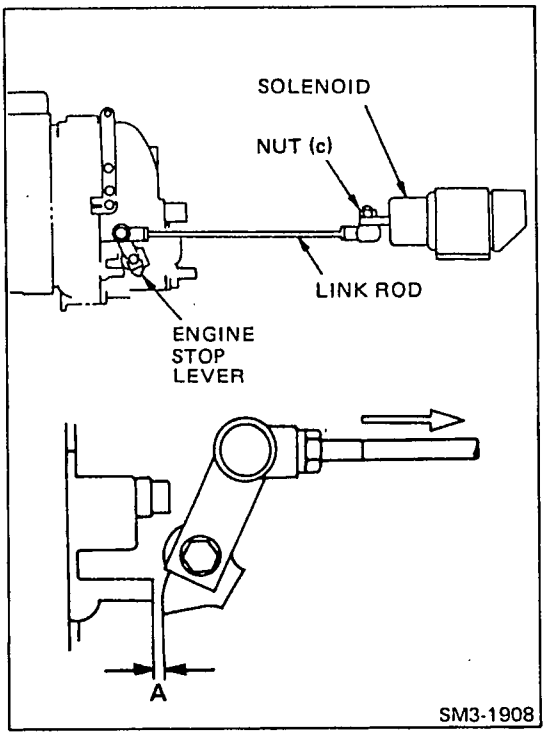
Cap Pressure:

0.5 : 0.4–0.6 kg/cm² (5.69–8.53 lb/sq.in)
0.0 : 0.75–1.05 kg/cm² (10.67–14.93 lb/sq.in)

NOTE:
- **The cap pressure is shown on the coolant filler cap, and it should be confirmed.**
- **If the cap pressure is incorrect, there is a risk of abnormally high pressure being generated in the cooling system, which may cause the hose to drop off or burst and, in turn, damage the engine.**

WARNING

Do not remove the cap while the engine and cooling system are still hot.
If the cap is removed while the engine and cooling system are still hot, scalding water and steam under pressure can be blown out. This can result in personal injury.



ENGINE STOP CONTROL

ADJUST THE SOLENOID (ENGINE STOP) LINK ROD.

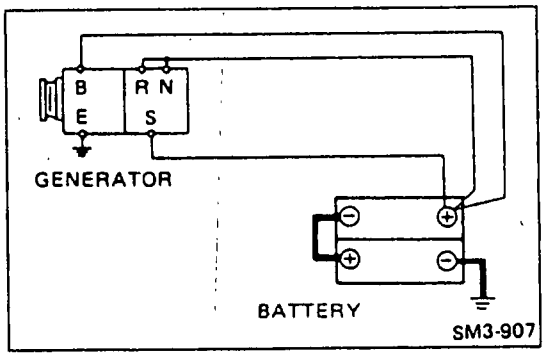
1. Adjust the link rod length so that the clearance between the stopper of the governor case and the engine stop lever becomes "A" when the solenoid plunger is fully pushed in.

Assembly Standard "A": 2–3 mm (0.08–0.11 in)

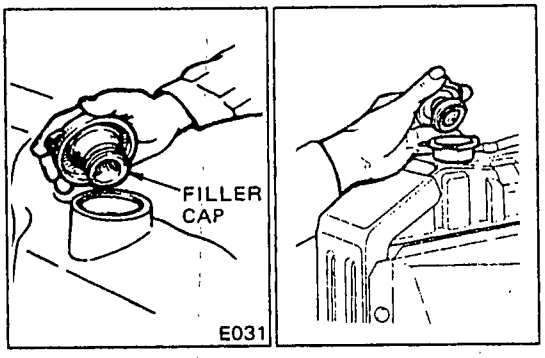
NOTE: ○ **Install the link rod with the nut(c) at the top.**
○ **If the clearance adjustment is unsatisfactory or the action of the solenoid is sluggish, solenoid seizure, insufficient output or engine stoppage may result.**

2. After the above adjustment is over, move the link rod by hand and make sure that it moves lightly.

ENGINE TUNE-UP ON TEST BENCH



NOTE: Starting the engine when the generator is not connected to the battery may damage the generator. Always connect to the battery.



SET THE ENGINE ASSEMBLY ON A TEST BENCH.

1. Add the proper amount of the specified engine oil through the oil filler cap on the cylinder head cover.
2. Add coolant.
   Bleed out air from inside the coolant gallery through the cylinder block drain plug.

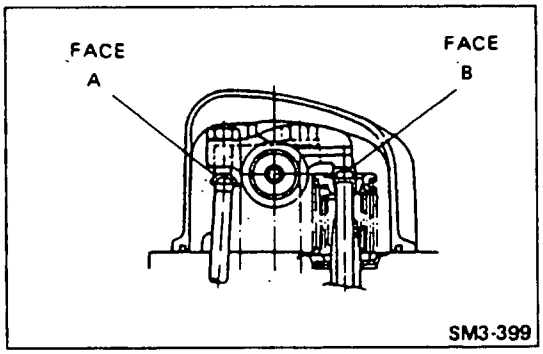
BLEED AIR FROM FUEL SYSTEM.

Refer to section FUEL SYSTEM.

CHECK THE INJECTION TIMING.

Refer to "FUEL INJECTION PUMP" in section ENGINE COMPONENT PARTS DISMOUNTING AND MOUNTING.

CHECK THE VALVE CLEARANCE.



START THE ENGINE.

NOTE: Before starting the engine, make sure that the fuel cut lever of the fuel injection pump is operating normally.

1. Check the oil feed to rocker arms.

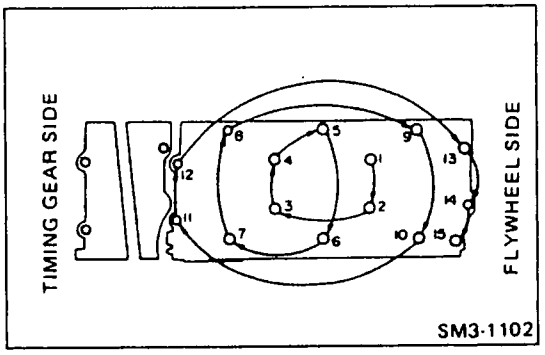
a. Set the engine idling speed.

Engine Idling Speed: Refer to SECTION DATA AND SPECIFICATIONS.

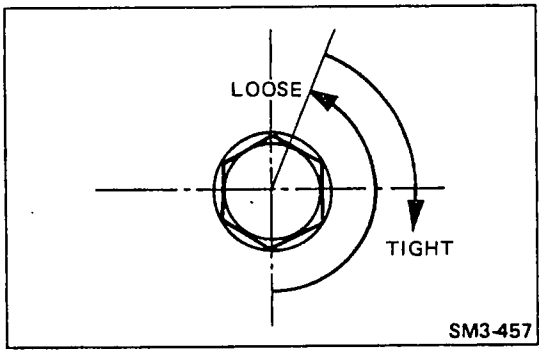
b. When one minute after starting the engine, oil should flow to the head (Face A) of all push rods and the head (Face B) of all valves. If the time required for the oil to flow to the rocker arms is long, various troubles such as seizing, abnormal wear and unusual noize may occur.

2. Retightening cylinder head bolt.
Retighten the cylinder head bolts according to the following instructions.

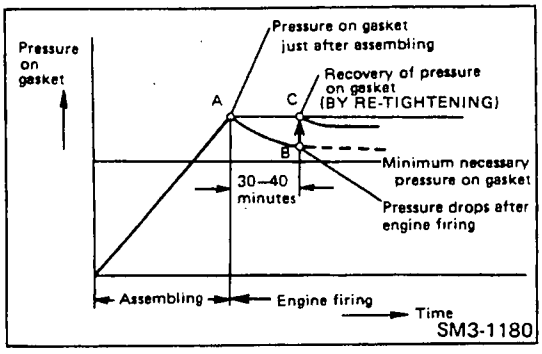
(1) Retightening schedule
Retighten at the first 30 hours following servicing which involves the loosening or removal of any cylinder head bolt. Such servicing includes replacement of the cylinder head gasket, servicing of the valve gear parts, and the like.



(2) Retightening procedure
Step 1: Warm up the engine in the same way as in engine turning.
Step 2: Following the cylinder head bolt tightening order as shown (SM3-1102), loosen the first cylinder head bolt by 1/4 to 1/2 turns as shown (SM3-457), then tighten it to its specified torque.
Repeat until all the bolts have been retightened.



NOTE: ○ Be sure to loosen one bolt at a time, then retighten it before going on to the next bolt.
○ By retighten, face pressure of cylinder head is restored from point B to C as shown.

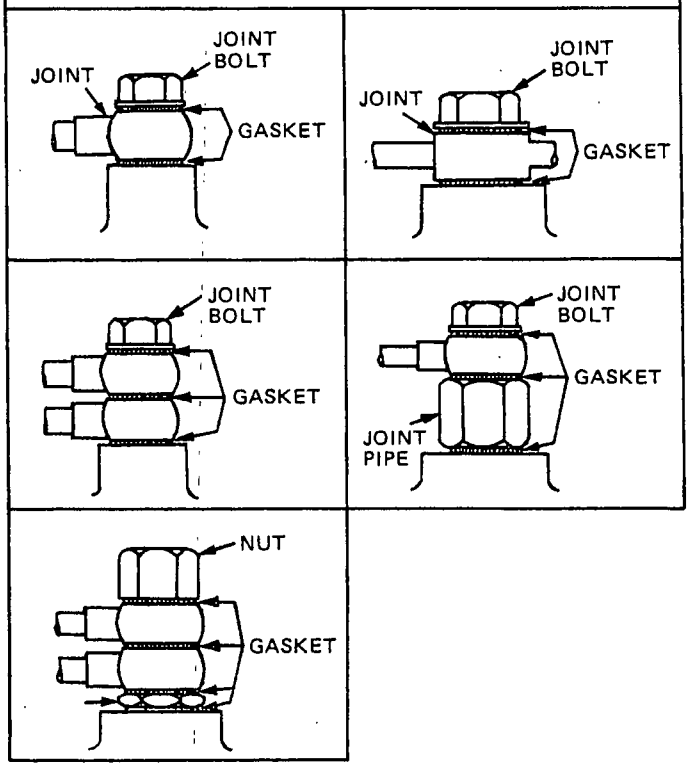


RECHECK THE VALVE CLEARANCE, WHEN ENGINE IS COLD.

PROCEDURE FOR INSTALLING JOINTS AND GASKETS OF ENGINE PIPES

1. Gasket seal type (aluminum + rubber, asbestos or copper).

Location of gasket seal

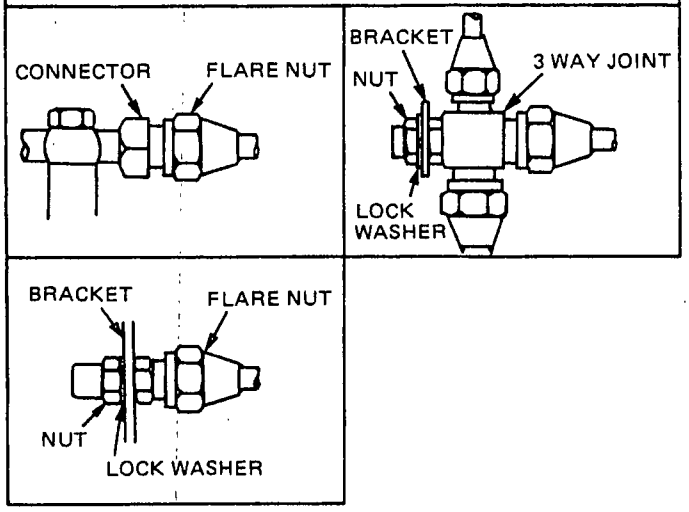


Tightening torque chart

Clamping screw size (Diameter) mm (in)	Tightening torque kg·cm (lb.ft)
8 (0.315)	120–170 (9–12)
10 (0.394)	180–230 (13–16)
12 (0.472)	230–280 (17–20)
14 (0.551)	230–280 (17–20)
16 (0.630)	300–350 (22–25)
18 (0.709)	400–450 (29–32)
20 (0.787)	400–450 (29–32)
22 (0.866)	530–600 (38–43)
24 (0.945)	720–800 (52–57)
28 (1.102)	1,300–1,500 (94–108)

2. Metal seal type (Flares connector type).

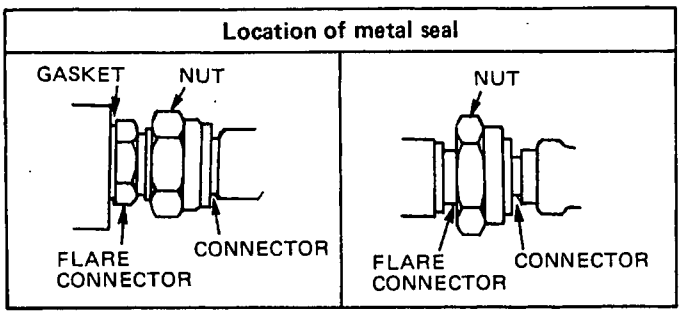
Location of metal seal



Tightening torque chart

Clamping screw size (Diameter) mm (in)	Tightening torque kg·cm (lb.ft)
12 (0.472)	200–220 (15–16)
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)

3. Metal seal type (Nipples connectors type)



Tightening torque chart

Clamping screw size (Diameter) mm (in)	Tightening torque 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 free 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.

EE-202E-01

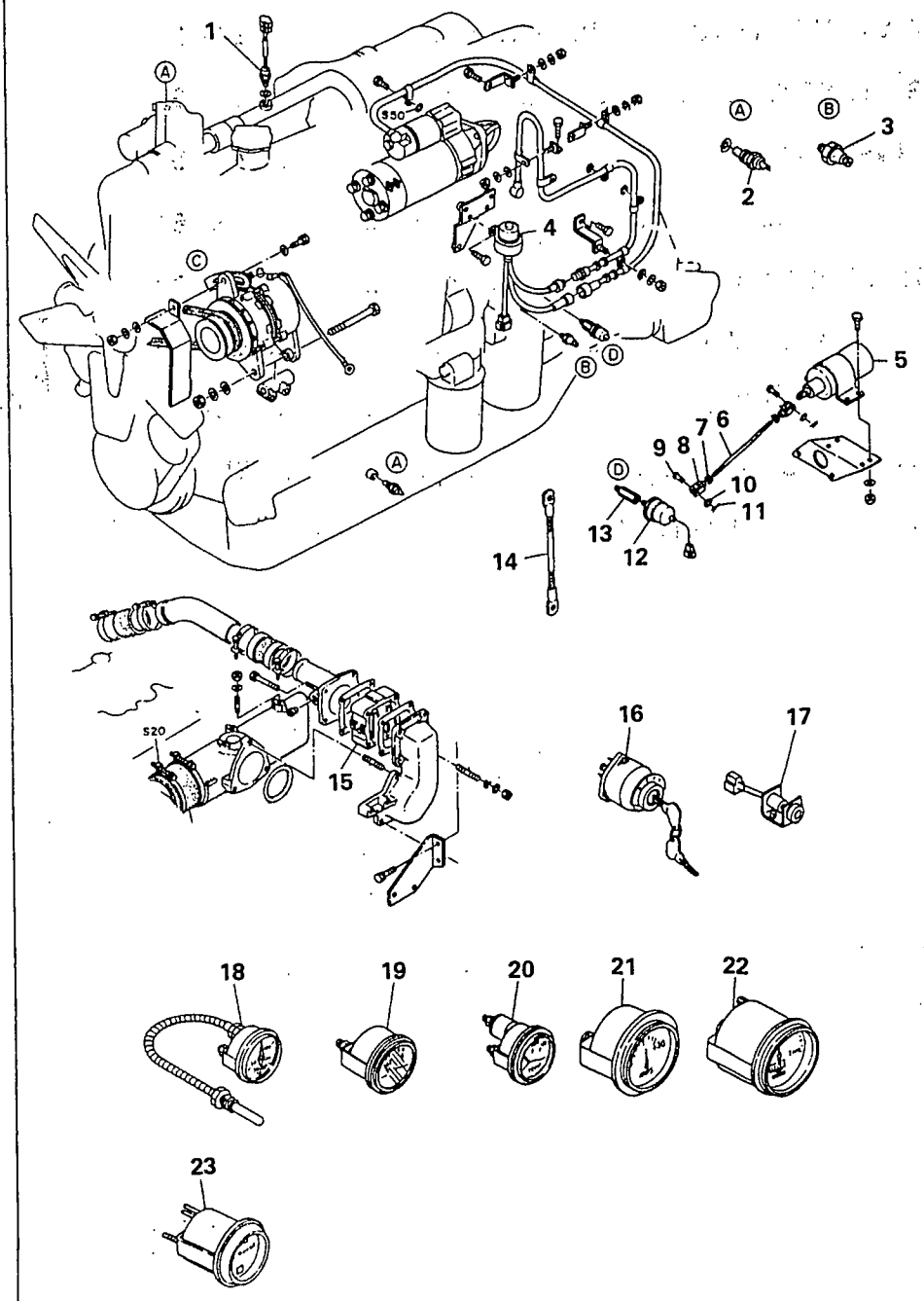
CHAPTER EE

ELECTRICAL EQUIPMENT

DATA AND SPECIFICATIONS

Electrical system	
Voltage	Direct current 24 volts
Ground	Negative (–) ground

LOCATION OF ELECTRICAL EQUIPMENT



1. Water temperature switch
2. Water temperature sender gauge
3. Oil pressure switch
4. Intake air heater relay
5. Solenoid
6. Link rod
7. Lock nut
8. Clevis
9. Clevis pin
10. Plain washer
11. Cotter pin
12. Oil pressure sender gauge
13. Pipe joint
14. Band strap
15. Intake air heater
16. Starter switch
17. Glow plug controller
18. Water temperature gauge
19. Oil pressure receiver gauge
20. Oil temperature receiver gauge
21. Ammeter
22. Engine tachometer
23. Engine hourmeter

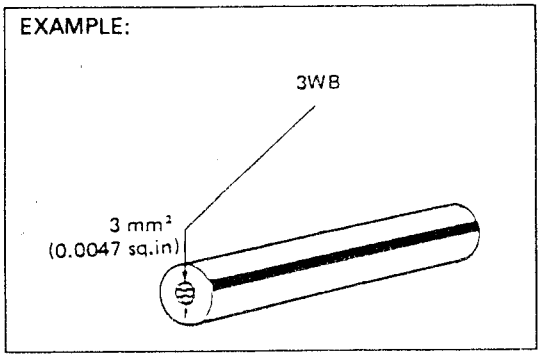
TROUBLESHOOTING

Symptom	Possible cause	Remedy/Prevention
A lot of exhaust is emitted but the engine does not start or is difficult to start. (Auxiliary starting device: Standard specifications)	**Auxiliary starting device**	
	• Loose wiring of heater signal or defective heater signal.	Repair or replace.
	• Defective heater plug	Replace.
	• Defective wiring between heater and plug	Repair.
(Auxiliary starting device: Option specifications)	• Defective power relay	Repair or replace
	• Defective heater plug	Replace.
	• Defective wiring between heater and plug	Repair.
	• Defective sensing resistor	Replace.
	• Defective heater control timer	Replace.
Solenoid does not operate when engine is running, even if abnormal signal is input. (Engine does not stop.)	**Emergency stop relay**	
	• Alternator malfunctions	Repair or replace.
	• Insufficient battery voltage	Charge or replace.
	• Faulty connection at N terminal of emergency relay	Repair.
	• Defective solenoid	Replace.
Solenoid operates with starter switch is turned ON	**Emergency stop relay**	
	• Faulty connection at R1 terminal	Repair.
	• Faulty connection at B and C terminals	Repiar.
When the strater switch is turned OFF, the battery relay switch goes OFF and the solenoid fails to operate.	**Battery**	
	• Insufficient voltage	Charge or replace.
	Alternator	
	• Malfunctions	Repair or replace.
Starter chattering or improper plunging	**Battery**	
	• Insufficient voltage	Charge or replace.
	Starter block relay	
	• Faulty connection at terminals	Repair.
	• Internal circuit abnormal	Replace.
	• Relay switch abnormality (faulty contacts), improper sliding between rod and moving core, or open-circuit or burnt out coil.	Replace.
	Starter switch	
	• Faulty connection at terminals	

Symptom	Possible cause	Remedy/Prevention
Improper disengagement of starter or defective hold function when engine is rotating	Alternator	
	• Defective (correct voltage not generated)	Repair or replace.
	Starter block relay	
	• Improper terminal connection	Repair.
	• Reverse connections to terminals B and C	Repair.
Re-plunging during inertial rotation	Starter block relay	
	• Reverse connections to terminals B and C	Repair.

GENERAL INSTRUCTION

WARNING
Be sure to disconnect the ground cable before servicing the electrical circuits except for on-vehicle testing.

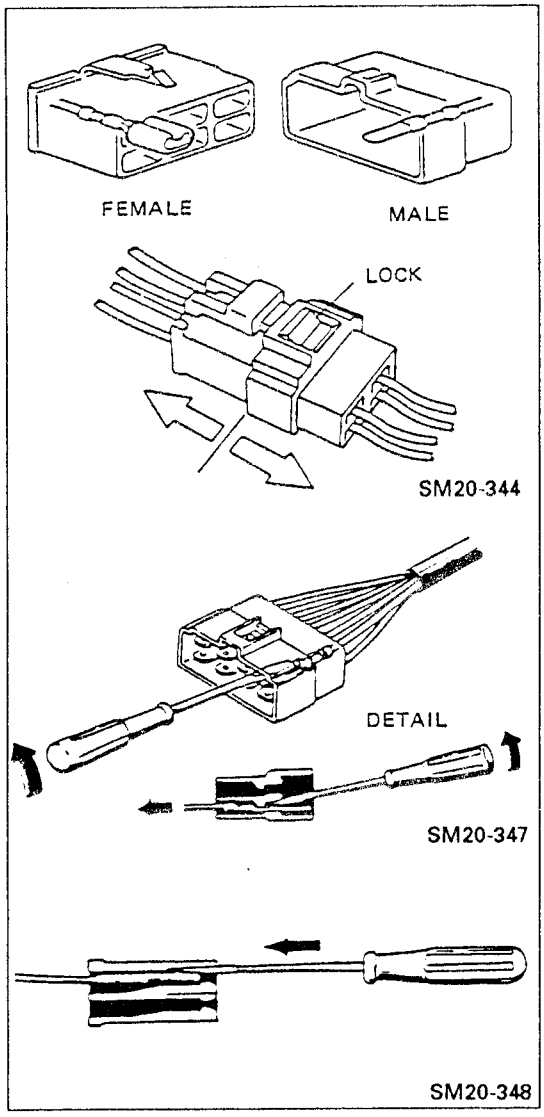


WIRING CODE

1. Wiring colors are indicated by a code.

B	: Black	Lg	: Light green
Br	: Brown	R	: Red
G	: Green	W	: White
L	: Blue	Y	: Yellow

2. The first letter indicates the ground wire color and second letter indicates the stripe color.
3. Arabic numerals indicates the cross sectional area of wire.
   3: 3 mm² (0.0047 sq.in)



CONNECTOR

- The connectors exist as male and female connectors.
- Male and female connectors are classified according to the shape of the terminals in the connector (refer to the figure on the left).
- Male and female connectors are provided with a lock, so that they can not be separated easily.
- For connector separation, hold the connector, unlock the lock and separate the connector.

NOTE: **When the connector is pulled by pulling the wires, the connection between the terminals and the wires will be damaged.**

1. Remove the terminal from the connector.
a. Insert a minature screwdriver or a terminal puller between terminal and connector and unlock the lock between terminal and connector.
b. When the lock has been released, pull the wire to remove the terminal.
2. Install the terminal in the connector.
a. Insert the terminal into the connector until the clicking sound of lock engagement can be heard.
b. Pull the wire to confirm correct lock engagement.

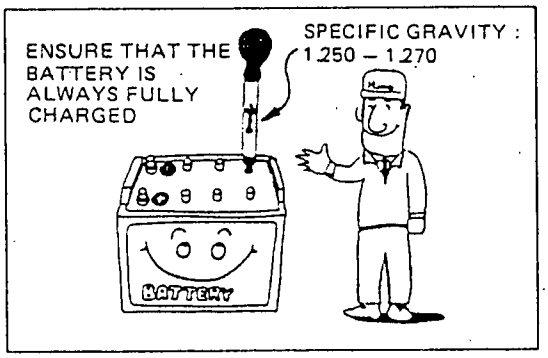
FUSE

- The power supply must be switched off for fuse replacement.
- Use a fuse with a suitable amperage.

NOTE: **Wire burning may be caused when a fuse with an excessively large current capacity is used.**

- If the fuse should blow frequently, investigate the cause and remove it.

BATTERY



CONVERSION FORMULA FOR SPECIFIC GRAVITY.

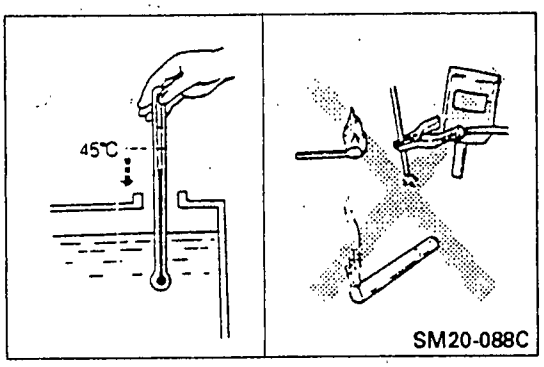
- The specific gravity of electrolyte changes according to the temperature of the electrolyte itself, hence it is based on a temperature of 20°C (68°F).
  Consequently, if the temperature is not 20°C when the specific gravity is measured, it is necessary to convert the measured value to the equivalent value at 20°C.

Temperature conversion formula: S20 = St + 0.0007 (t – 20)

Where,

- S20 is the specific gravity at 20°C (reference temperature)
- St is the specific gravity at the measuring temperature
- t is the temperature during mesurement
- 0.0007 is the temperature coefficient of the electrolyte

NOTE: **As a rough guide, if the temperature of the electrolyte rises or falls by 15°C (59°F), the specific gravity of the electrolyte will vary by about 0.01.**



BATTERY CHARGING

- Be careful of the following points.

1) While the battery is being charged, ensure that the temperature of the electrolyte does not rise above 45°C (113°F).
2) While the battery is being charged, be particularly careful to keep it away from sources of fire.
3) The amount of electrolyte must be within the specified level.

Specific gravity when battery is fully charged:
1.250 – 1.270 at 20°C (68°F)

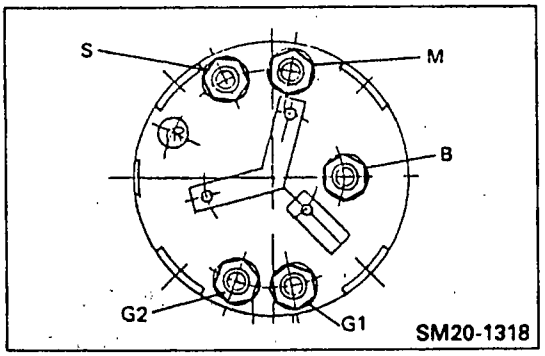
CLEANING THE BATTERY

- If the terminals at the top of the battery are dirty, clean them with cold water or lukewarm water.
- Apply a light coating of grease to the terminals to prevent them from rusting so as to prevent faulty contact.

CONNECTING THE BATTERY CABLES

- Clamp the cables securely to prevent improper contact between the cables and the battery terminals.
- Be very careful not to connect the (+) and (–) leads in reverse. (Because this may cause equipment run off the battery to be damaged.)

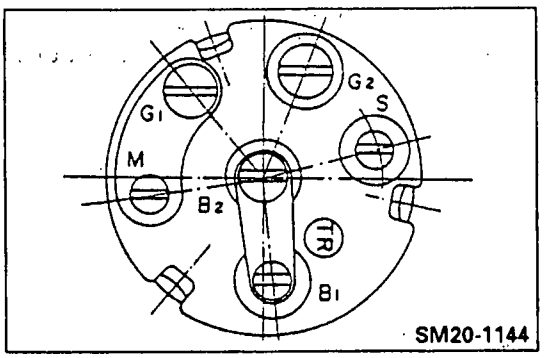
ENGINE STARTING CIRCUIT



CHECK THE CONTINUITY OF THE STARTER SWITCH.

Check the continuity between terminals.
If continuity is not correct, replace the starter switch.

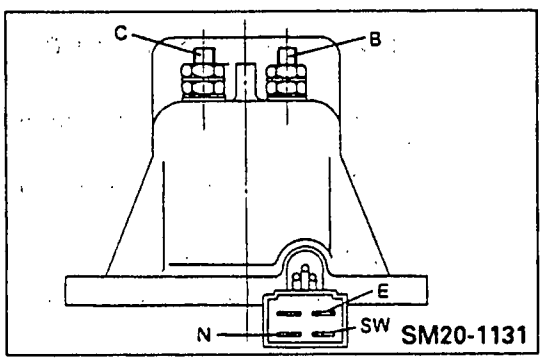
Switch position \ Terminal	B	M	G_1	G_2	S
PRE-HEAT	○		○		
OFF					
ON	○	○			
START	○			○	○



CHECK THE CONTINUITY OF THE STARTER SWITCH.

Check the continuity between terminals.
If continuity is not correct, replace the starter switch.

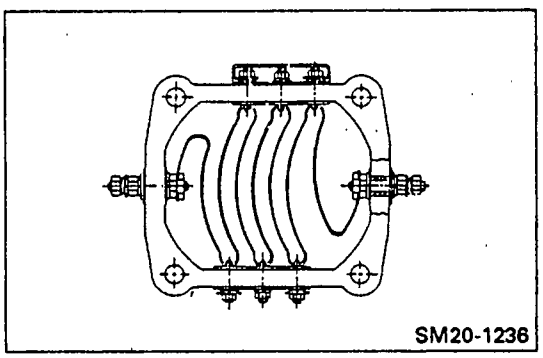
Switch position \ Terminal	B_1	B_2	G_1	G_2	M	S
PRE-HEAT	○	○	○		○	
OFF						
ON	○	○			○	
START	○	○		○	○	○



CHECK THE OPERATION OF THE STARTER BLOCK RELAY.

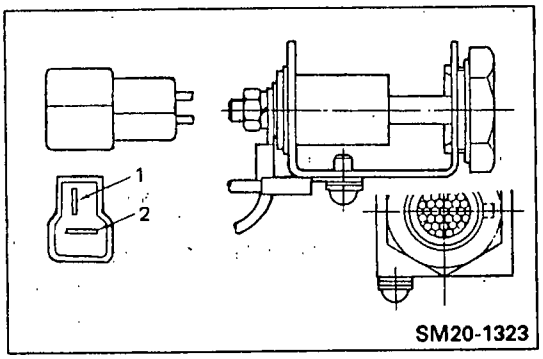
1. Check that there is no continuity between terminals C and B.
2. Connect the positive (+) lead from the battery to terminal SW. Connect the negative (–) lead to terminal E. Check that there is continuity between terminals C and B.
3. Then connect the positive (+) lead from the battery (12 volts) to terminal N. Check that there is no continuity between terminals C and B.
4. If operation is not correct, replace the relay.

INTAKE AIR HEATER CIRCUIT



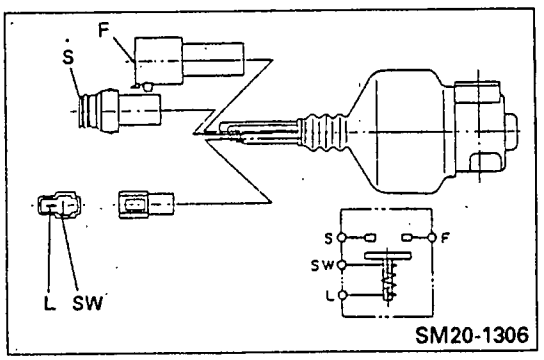
CHECK THE CONTINUITY OF THE INTAKE AIR HEATER.

1. Check that there is no continuity between terminal and body ground.
2. Check that there is continuity between terminals.
3. If continuity is not correct, replace the intake air heater.



CHECK THE CONTINUITY OF THE GLOW CONTROLLER.

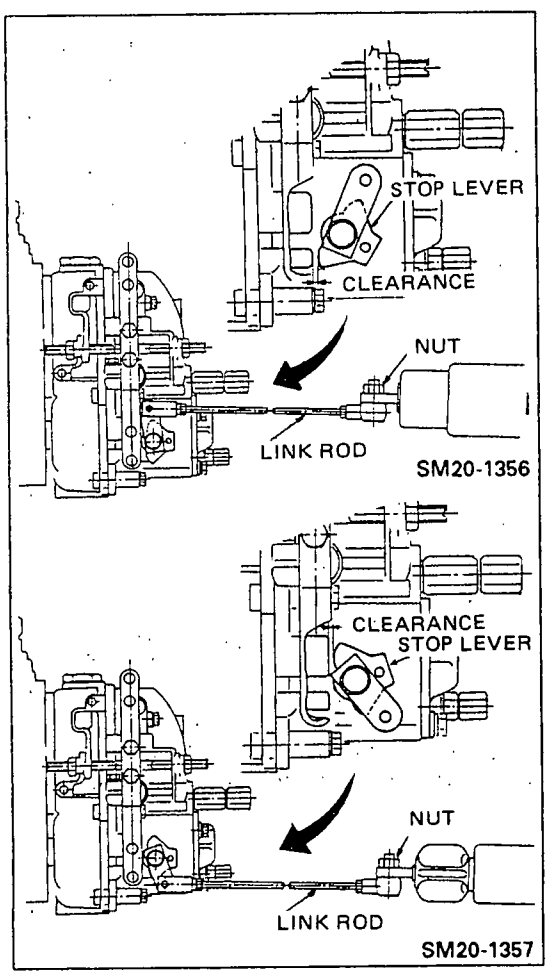
Check that there is continuity between terminal 1 and 2.
If continuity is not correct, replace the controller.



CHECK THE OPERATION OF THE INTAKE AIR HEATER RELAY.

1. Check that there is continuity between terminals SW and L.
2. Check that there is no continuity between terminals S and F.
3. Connect the positive (+) lead from the battery to terminal SW. Connect the positive (–) lead to terminal L. Check that there is continuity between terminal S and F.
4. If operation is not correct, replace the relay.

ENGINE STOP CIRCUIT



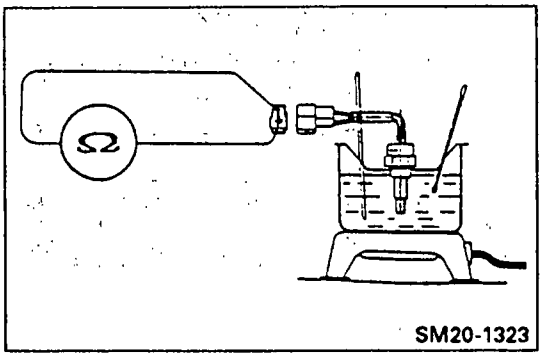
CHECK THE OPERATION OF THE SOLENOID AND ADJUST THE LINK ROD.

1. Connect the battery to the solenoid terminals and confirm that the solenoid is drawn in.
2. Push in the plunger by hand and confirm that there is a clearance between the stopper and the stop lever.

Standard clearance: 2 – 3 mm (0.01188 – 0.1181 in)

If there is no clearance, perform adjustment with the link rod.

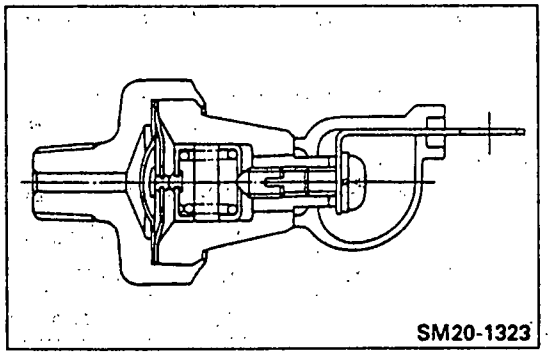
NOTE: ○ **If the clearance adjustment is unsatisfactory or the action of the solenoid is sluggish, solenoid burnout, insufficient output or insufficient engine stoppage may result.**
○ **Install the link rod with the nut at the top.**



CHECK THE CONTINUITY OF THE WATER TEMPERATURE SWITCH.

Check the continuity between terminals.
If continuity is not correct, replace the temperature switch.

Terminal / Water temperature: °C (°F)	1	2
Not less than 102±2 (212–219)	o	o
Between 95 (203) and 102±2 (212–219)		

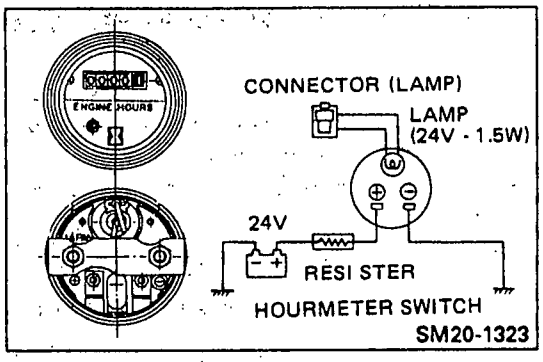


CHECK THE OPERATION OF THE PRESSURE SWITCH.

1. Check the continuity between terminal and body ground.
   a. Check that there is continuity when engine is stopped.
   b. Check that there is no continuity when engie is running.
2. If continuity is not correct, replace the oil pressure switch.

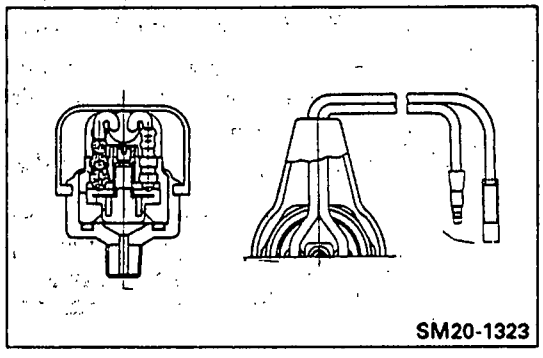
NOTE: Engine oil pressure should be more than 0.5 kg/cm².

METER AND GAUGE CIRCUIT



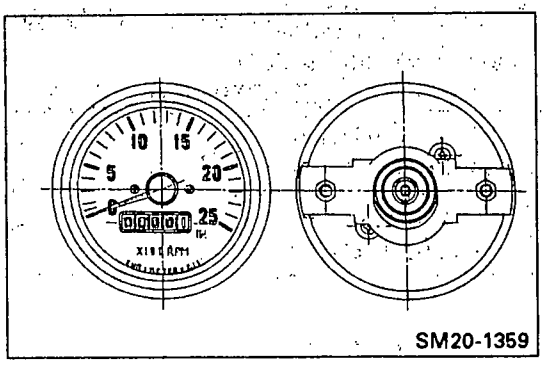
CHECK THE OPERATION OF THE ENGINE HOUR METER.

1. Wire the hourmeter, battery and resister as shown in the figure at left. Check the operation the hourmeter.
2. If operation is not correct, replace the hourmeter.



CHECK THE OPERATION OF THE PRESSURE SWITCH. (HOURMETER CONTROL SWITCH).

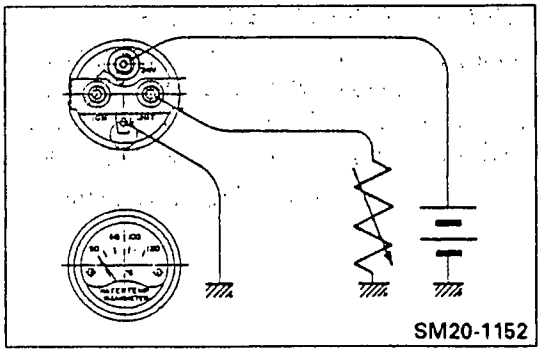
1. Check the continuity between terminals.
   a. Check that there is no continuity when engine is stopped.
   b. Check that there is continuity when engine is running.
2. If continuity is not correct, replace the oil pressure switch.



CHECK THE OPERATION OF THE TACHOMETER.

1. Connect a turn-up test tachometer, and start the engine. Check the tester and tachometer indications.
2. If the indicated value of tachometer is not correct, replace the tachometer.

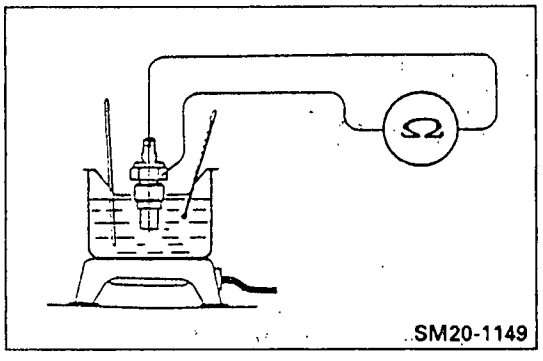
Standard revolution (rpm)	500	1,000	1,500	2,000
Allowable value (rpm)	±25	±50	±45	±100



CHECK THE OPERATION OF THE WATER TEMPERATURE RECEIVER GAUGE.

1. Wire the receiver gauge, variable resistor and battery, as shown in the figure at left. Check the indicated value on the receiver gauge at the reference resistance value.
2. If indicated value is not correct, replace the receiver gauge.

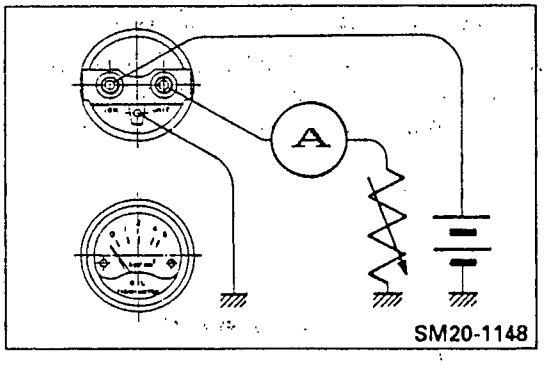
Resistance: Ω	65^{+6}_{-1}	36.5^{+3}_{-1}
Standard gauge reading: °C (°F)	80 (176)	100 (212)
Allowable value: °C (°F)	±5 (41)	±3 (37.4)



CHECK THE OPERATION OF THE WATER TEMPERATURE SENDER GAUGE.

1. Wire the sender gauge and ohmmeter as shown in the figure at left. Check the resistance value of the sender gauge at the reference water temperature.
2. If the indicated value is not correct, replace the sender gauge.

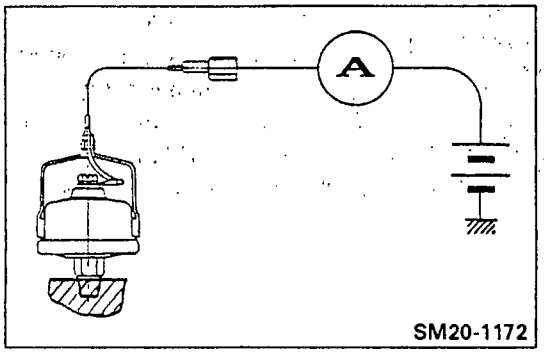
Water temperature: °C (°F)	80 (176)	100 (212)
Standard resistance: Ω	65	36.5
Allowable value: Ω	$^{+6}_{-1}$	$^{+3}_{-1}$



CHECK THE OPERATION OF THE OIL PRESSURE RECEIVER GAUGE.

1. Wire the receiver gauge, ammeter, variable resistor and battery as shown in the figure as left. Check the indicated value on the receiver gauge at the reference current value.
2. If the indicated value is not correct, replace teh receiver gauge.

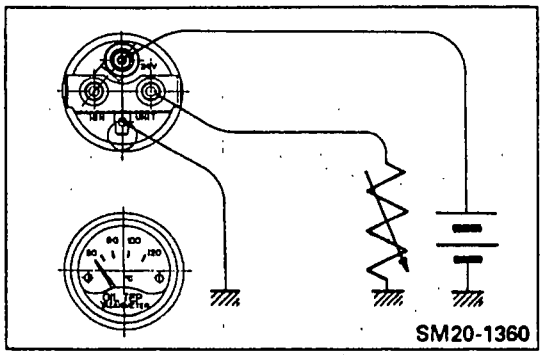
Current: mA	24	48	80.5
Gauge reading: kg/cm² (lb/sq.in)	0	1 (0.070)	4 (0.281)
Allowable value: kg/cm² (lb.sq.in)	±0.1 (0.007)	±0.1 (0.007)	±0.42(0.029)



CHECK THE OPERATION OF THE OIL PRESSURE SENDER GAUGE.

1. Wire the sender gauge, ammeter and battery as shown in the figure at left. Check the current between the sender gauge and the battery at the reference oil pressure.
2. If the indicated value is not corrent, replace the sender gauge.

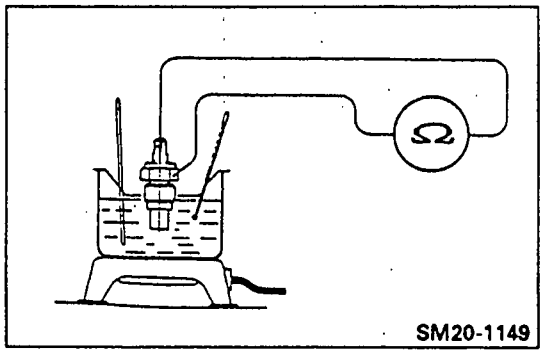
Oil pressure: kg/cm² (lb/sq.in)	0	1 (14)	4 (57)
Standard current: mA	24	48	80.5


SM20-1360

CHECK THE OPERATION OF THE OIL TEMPERATURE RECEIVER GAUGE.

1. Wire the receiver gauge, variable resistor and battery, as shown in the figure at left. Check the indicated value on the receiver gauge at the reference resistance value.
2. If indicated value is not correct, replace the receiver gauge.

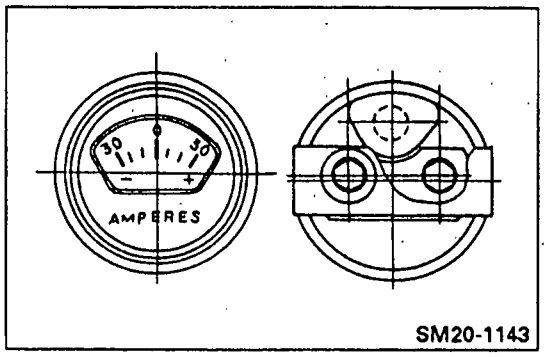
Resistance: Ω	65^{+6}_{-1}	36.5^{+3}_{-1}
Standard gauge reading: °C (°F)	80 (176)	100 (212)
Allowable value: °C (°F)	±5 (41)	±3 (37.4)


SM20-1149

CHECK THE OPERATION OF THE OIL TEMPERATURE SENDER GAUGE.

1. Wire the sender gauge and ohmmeter as shown in the figure at left. Check the resistance value of the sender gauge at the reference water temperature.
2. If the indicated value is not correct, replace the sender gauge.

Water temperature: °C (°F)	80 (176)	100 (212)
Standard resistance: Ω	65	36.5
Allowable value: Ω	$^{+6}_{-1}$	$^{+3}_{-1}$

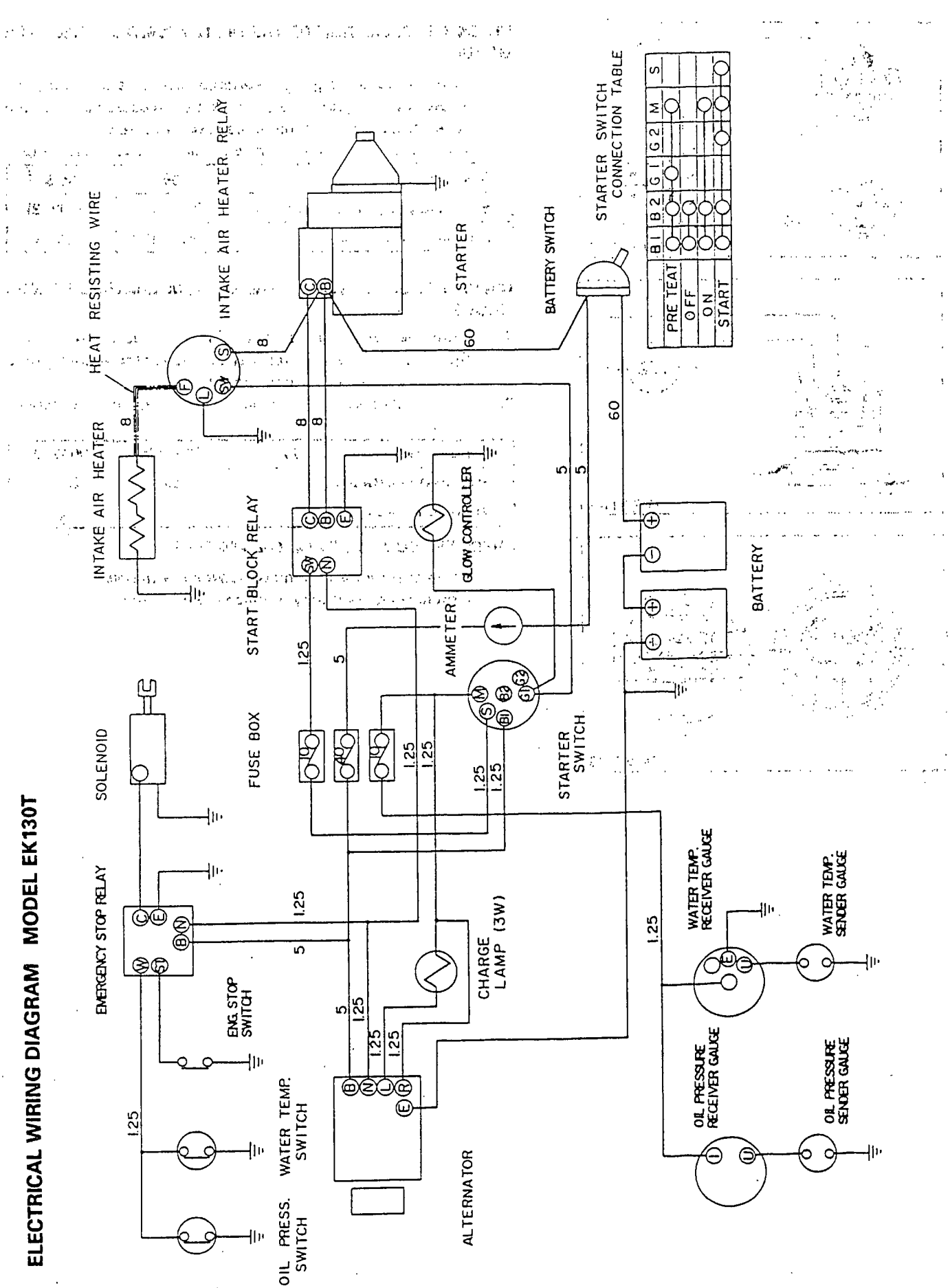


SM20-1143

CHECK THE CONTINUITY OF THE AMMETER.

Check that ther is continuity between terminals.
If there is no continuity, replace the ammeter.

ELECTRICAL WIRING DIAGRAM MODEL EK130T



TU-22E-01

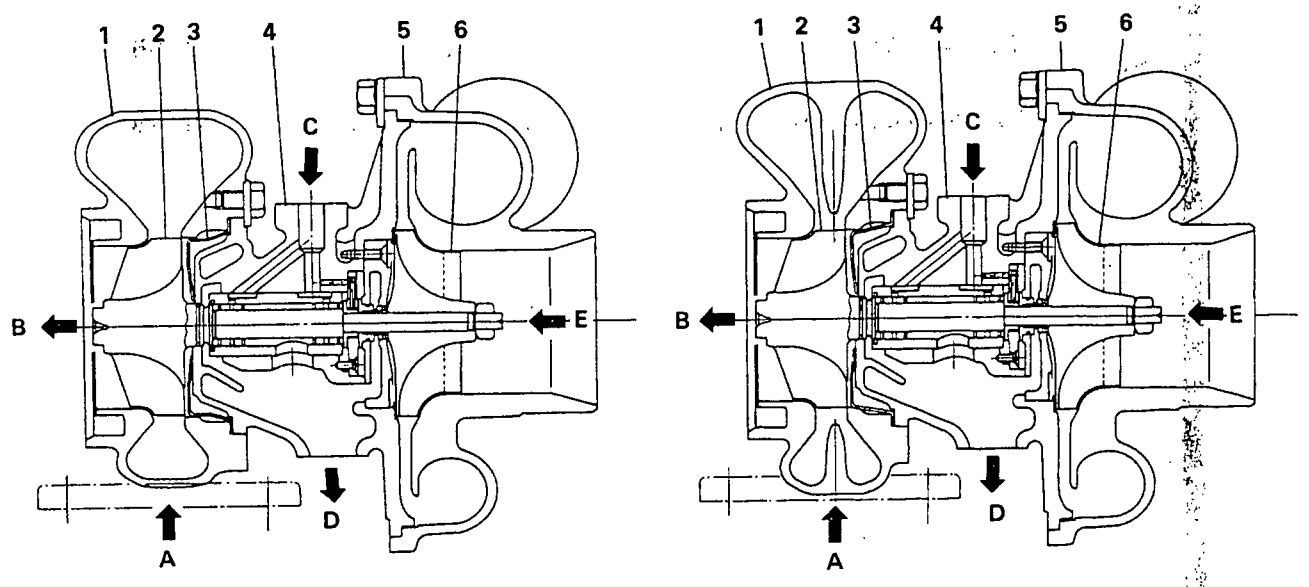
CHAPTER TU

TURBOCHARGER

DATA AND SPECIFICATIONS

Type	RHC 7
External dimensions (Length x Width x Height)	229 mm x 215 mm x 215 mm
Turbine type	Radial flow type
Blower type	Centrifugal type
Lubricating method	External lubrication type
Bearing type	Full floating type
Maximum allowable continuous revolution	132.000 rpm
Direction of rotation	Counterclockwise as seen from the turbine side
Maximum allowable continuous inlet termperature	730°C

DESCRIPTION



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

A. Exhaust gas inlet
B. Exhaust gas outlet
C. Oil inlet
D. Oil outlet
E. Air inlet

TROUBLESHOOTING

Symptom	Possible cause	Remedy/Prevention
Dense black smoke	**Insufficient air intake**	
	• Air cleaner is choked with dust, causing greater intake air resistance.	Disassemble and clean or replace the air cleaner element.
	• Air inlet is choked	Repair.
	• Air is leaking from intake menifold	Repair.
	Turbocharger does not rotate smoothly.	
	• Engine oil impurities deposited on rotor, resulting in heavy rotation or sticking.	Overhaul and clean turbocharger and/or change engine oil.
	Bearing sticking	
	• Insufficient lubrication or blockalge of lubricating oil lines.	Check lubricating oil system, and/or repair.
	• Abnormal wear or damage of seal ring caused by wear of journal bearing, due to insufficient lubrication.	Repair.
	• Temperature of lubricating oil too high	Check cooling system.
	• Unbalanced rotating parts	Change rotating parts.
	• Incomplete warming-up, failure to idle before stopping engine, or jack rabbit starts.	Operate vehicle properly.
	Loose or damaged turbine rotor or blower impeller.	
	• Over-rotation	Check and adjust the engine.
	• Temperature of exhaust gas too high	Check and adjust the engine.
	• Foreign matter present	Remove foreign material. Inspect the air cleaner and air intake manifold. Repair if necessary.
	• Worn thrust bearing	Overhaul and repair.
	• Incomplete assembly	Reassembly.
High volume exhaust like noise.	Exhaust gas leaking before turbocharger, therefore insufficient revolution.	Check and repair connections.
	Deformed or blocked exhaust gas lines therefore insufficient revolution.	Repair.
White smoke	Choking defects, or deformation of oil return lines so that oil leaks around blower or turbine sides.	Repair and replace the lines.
	Seal ring may be broken or worn due to abnormal wear of thrust washer.	Replace the thrust washer.

Symptom	Possible cause	Remedy/Prevention
Loss of power	Gas leakage from exhaust system	Repair.
	Air leakage from air manifold	Repair.
	Clogged air cleaner element	Clean or replace.
	Turbocharger dirty or damaged	Repair or replace.
Poor response of turbocharger	Carbon accumulation on the turbine side seal ring and heavy rotation.	Change engine oil, clean turbocharger.
	Poor combustion	Check fuel system and improve combustion.
High pitched noise and vibration	**Noise**	
	• So called "surging" Surging sometimes occurs when the gas passage at the nozzle of the turbine housing is choked or when compressed air does not flow in proper responses to acceleration.	Overhaul and clean turbocharger.
	• Loosen rotating parts	Replace.
	Vibration	
	• Joints loose between turbocharger and intake, exhaust manifold or oil lines.	Check the mounting and repair.
	• Damaged bearing, loose rotating parts, imbalanced rotating parts, etc.	Repair.

OVERHAUL CRITERIA

CONDITIONS WHICH DETERMINE WHEN A TURBOCHARGER OVERHAUL MAY BE NEEDED.

THE ENGINE LACKS POWER OR ENGINE EXHAUST EMITS BLACK SMOKE.

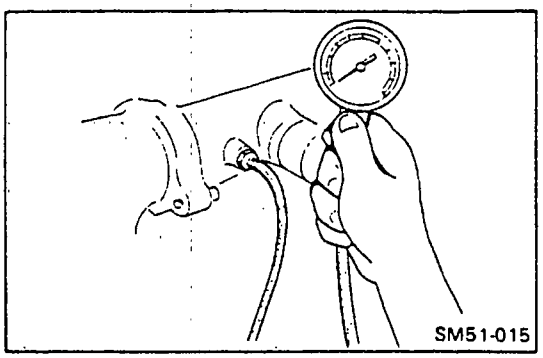
BOOST PRESSURE IS BELOW THE NORMAL VALUE.

Inspect the turbocharger boost pressure according to the following procedures.

NOTE: **Before measurement**
- **Coolant temperature should approximately 80°C.**
- **Air cleaner element should be clean.**

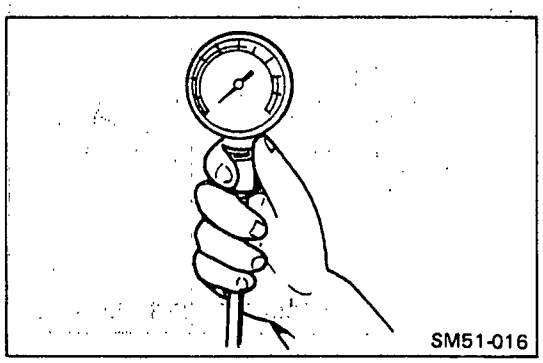
WARNING

When making a pressure test, be sure that personnel are adequately protected against any stream of pressurized air that might be released by a leak or the rupture of a hose.


SM51-015

1. Remove the blind plug on the intake pipe and install the hose and pressure gauge.

Special Tools: Pressure Gauge (09444-1250)
Hose (17108-1040)


SM51-016

2. Read boost pressure.
If the boost pressure is below the specified value, turbocharger overhaul is needed.

Boost Pressure: Less than 0.16 kg/cm^2 (2.28 lb/sq.in) at no load with maximum revolution.

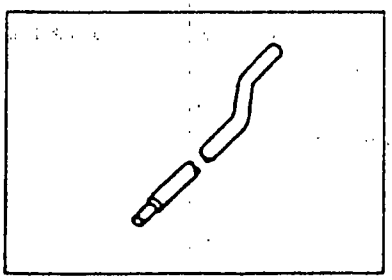
OTHER FACTORS

1. Noisy of excessive vibration of the turbocharger.
2. Excessive engine oil consumption.
3. Gas leakage at the turbine end or blower end.
4. Oil leakage from the turbocharger.

SPECIAL TOOL

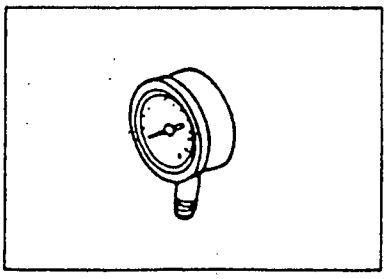
Prior to starting an turbocharger overhaul, it is necessary to have these special tools.

ATTACHMENT FOR MEASURING TURBINE SHAFT RADIAL PLAY



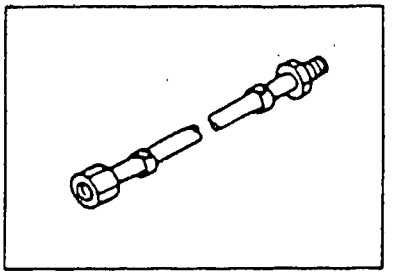
09444-1230

BOOST PRESSURE GAUGE



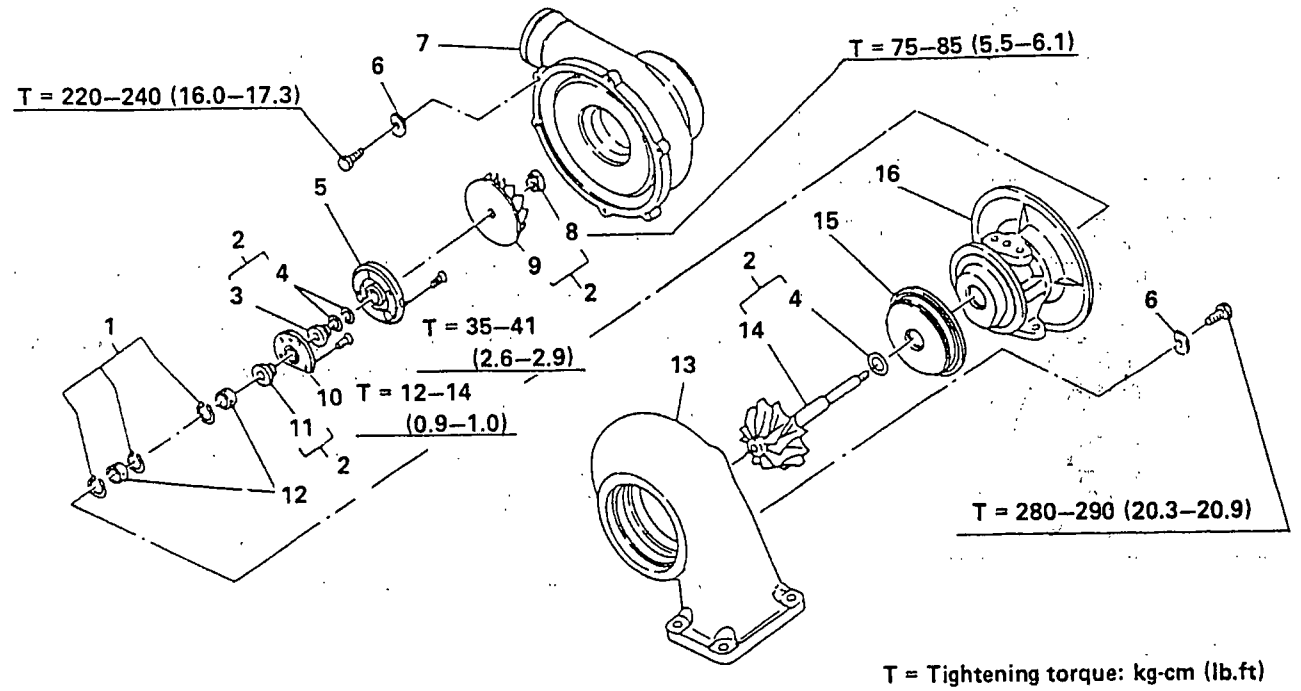
09444-1250

BOOST PRESSURE GAUGE HOSE



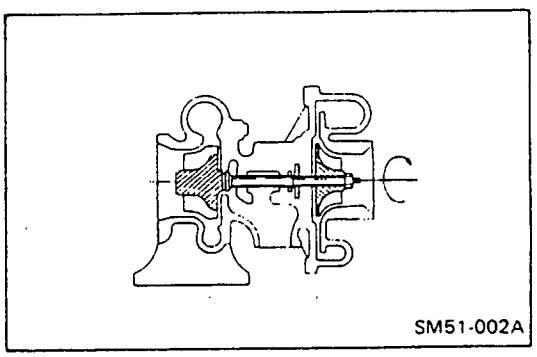
17108-1040

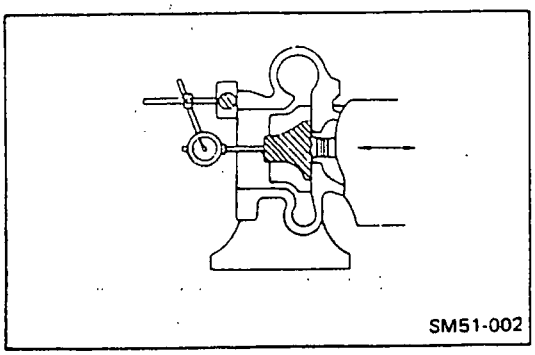
TURBOCHARGER



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

1. Retainer ring
2. Turbine rotor assembly
3. Oil thrower
4. Seal ring
5. Back plate
6. Lock plate
7. Blower case
8. Lock nut
9. Blower impeller
10. Thrust bearing
11. Thrust bush
12. Journal bearing
13. Turbine case
14. Turbine shaft
15. Heat protector
16. Bearing case





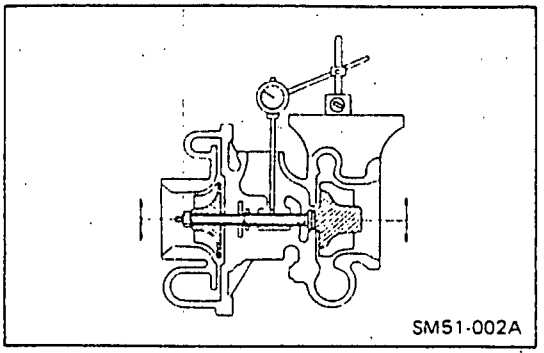
IMPORTANT POINT (S) – INSPECTION

INSPECT THE TURBINE ROTOR.

1. Rotate the blower impeller by hand to see if it turns smoothly. If it does not turn smoothly, clean and inspect the bearing and turbine rotor.

2. Check the turbine rotor axial play (A).
   If the axial play is greater than the service limit, replace the thrust bearing and/or thrust bush.

Standard: 0.06 – 0.09 mm (0.0023 – 0.0035 in)
Service Limit: 0.11 mm (0.0043 in)

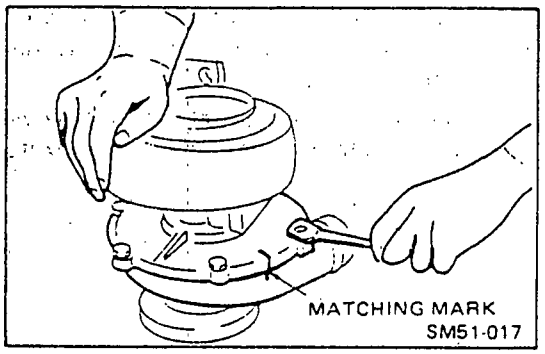

SM51-002A

3. Using a special tool, check the turbine rotor radial play.
   If the radial play is greater than the service limit, replace the bearings and/or turbine rotor.

Special Tool: 09444-1230

Standard Play: 0.11 – 0.18 mm (0.004 – 0.007 in)

Service Limit: 0.215 mm (0.0085 in)

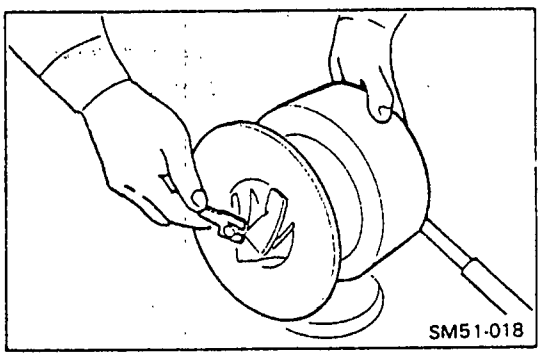


SM51-017

IMPORTANT POINT (S) – DISASSEMBLY

REMOVE THE BLOWER CASING.

NOTE: ○ Make matching marks on the blower case and bearing case to aid alignment during reassembly.
○ If the blower casing cannot easily be removed by hand, tap it carefully all around using a plastic hammer and carefully remove it.
○ Be careful not to damage the blower impeller.

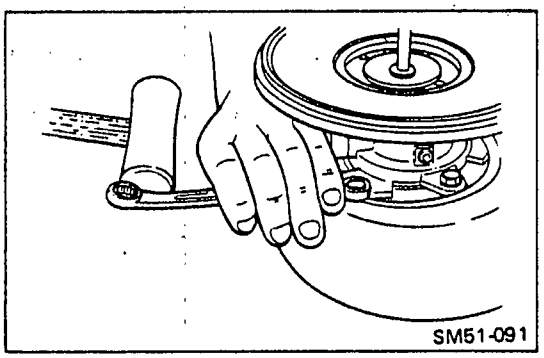

SM51-018

REMOVE THE BLOWER IMPELLER.

1. Remove the blower impeller fitting nut.

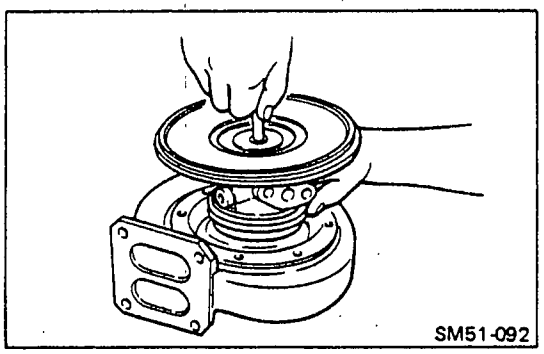
NOTE: Turn the lock nut clockwise to loosen the nut (left-hand threads).

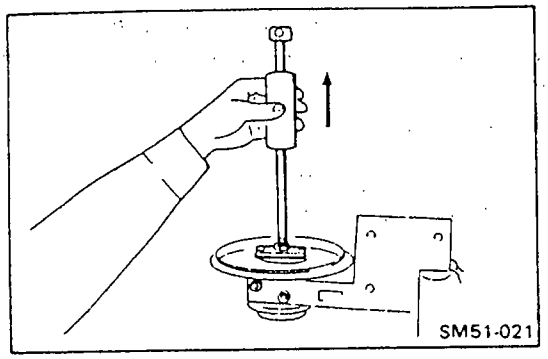
2. Remove the blower impeller by hand.


SM51-091

REMOVE THE TURBINE CASING.

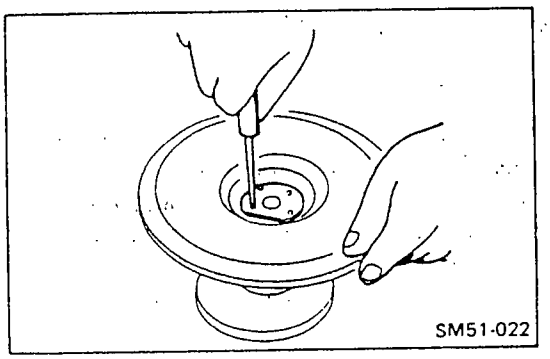
NOTE ○ Make matching marks on the turbine case and bearing case to aid alignment druing reassembly.
○ Because the bolts on the turbine side are exposed to high temperature, if they have seized, do not apply an unreasonable force to remove them because they may brake. Spray a lubricant onto them, then wait for about 15 minutes and loosen them.
○ Be careful not to damage the turbine blades and shaft.
○ If the turbine casing cannot easily be removed by hand, tap it carefully all round using a plastic hammer and carefully remove it.
○ Be careful not to drop the turbine shaft when remove the bearing case and turbine shaft.


SM51-092


SM51-021

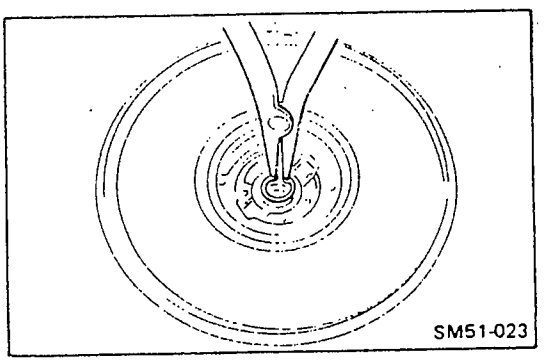
DISASSEMBLY THE BEARING CASE.

1. Remove the back plate. Pull out the back plate using the attachment and a sliding hammer.
2. Remove the oil thrower from the back plate.


SM51-022

3. Remove the thrust bearing and thrust bush. Loosen the bolt, then remove the thrust busing using a 10 dia. copper rod by tapping a hammer from turbine case side.

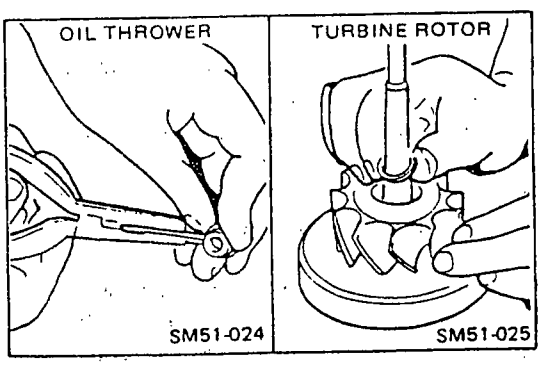
NOTE: **When removing the thrust bearing and thrust bush be careful not to damage the thrust bearing hole in the bearing case.**


SM51-023

4. Remove the retainer rings of each bearing.

NOTE: **When removing the retainer ring, be careful not to damage the front face of the hole in the bearing case.**

5. Remove the bearings.



REMOVE THE SEAL RINGS.

NOTE: **When removing the seal ring, be very careful not to damage the groove of the seal ring.**

IMPORTANT POINT (S) – ASSEMBLY

CLEAN ALL PARTS.

1. Before cleaning, the disassembled parts should be visually inspected to check for burning, abrasion, carbon deposits, gas and oil leakage.
2. Thoroughly clean all the parts with diesel fuel, using a soft brush, and dry with compressed air.

NOTE: ○ **Never use a caustic cleaning solution, as it may attack aluminum.**
○ **Never use a wire brush.**

ASSEMBLE THE JOURNAL BEARINGS.

1. Install the first retainer ring in the bearing casing.

NOTE: ○ **Bevelled edge of the retainer ring should be towards the bearing.**
○ **Make sure that the retainer ring is securely fitted in the groove.**
○ **Install the retainer ring with the gap facing as shown in the drawing.**

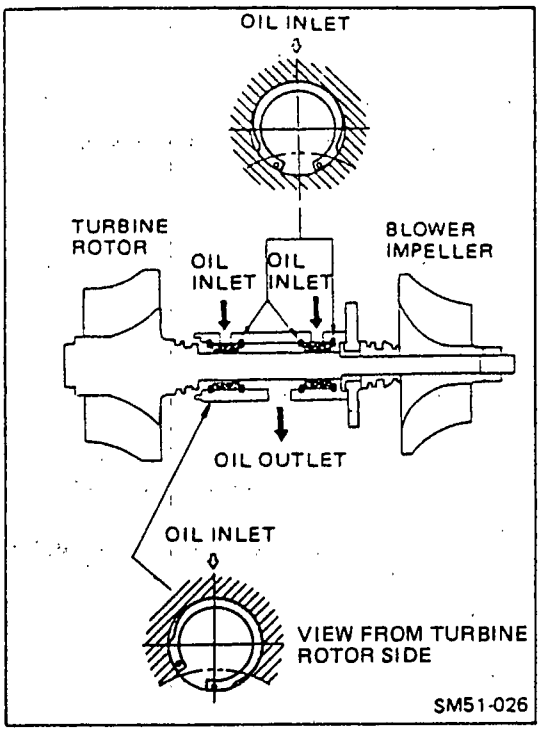
2. Install the bearing in the bearing case.

NOTE: **Apply clean engine oil.**

3. Install the other retainer ring.

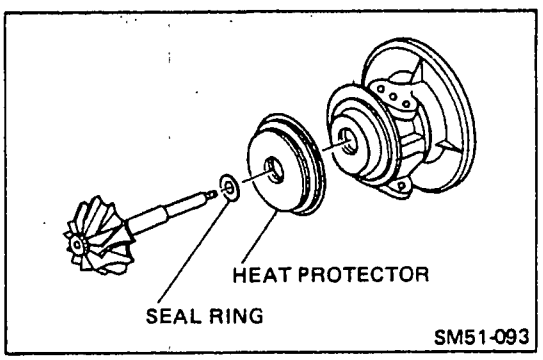
NOTE: **The only nearest turbine side of the retainer ring should be installed according to the figure on the left.**

4. Repeat step 1) through 4) to install the second bearing.



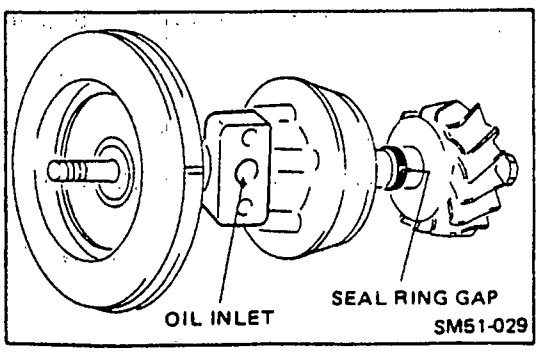
ASSEMBLE THE TURBINE ROTOR.

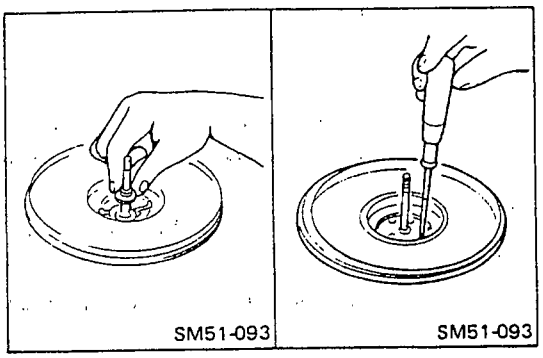
1. Install a new seal ring in the seal ring groove of the turbine shaft.
2. Position the heat protector on the bearing case.



3. Coat the journals of the tuebine rotor with clean engine oil and install the turbine rotor in the bearing case.

NOTE: ○ **The gap in the seal ring of the turbine shaft must face towards the oil inlet.**
○ **Insert the seal ring concentric with the turbine shaft. If it is inserted with unreasonable force, it may be damaged.**
○ **When inserting the turbine shaft, be very careful not to damage the journal bearing.**





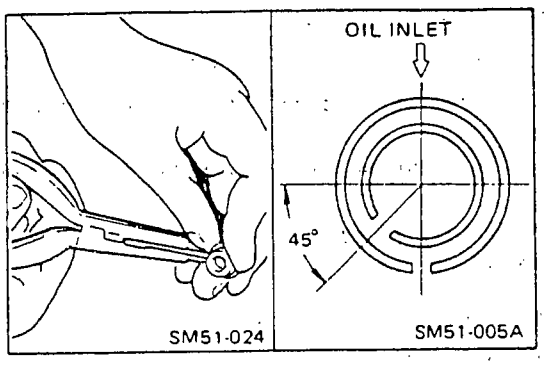
ASSEMBLE THE THRUST BEARING.

1. Install the thrust bush on the turbine shaft.

NOTE: **Lubricate thrust bush surface.**

2. Coat the thrust bearing with clean engine oil and install the thrust bearing.

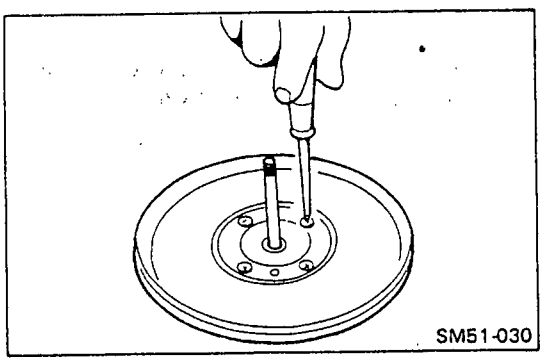
NOTE: **Always use new screws and lock washers.**



INSTALL THE BACK PLATE.

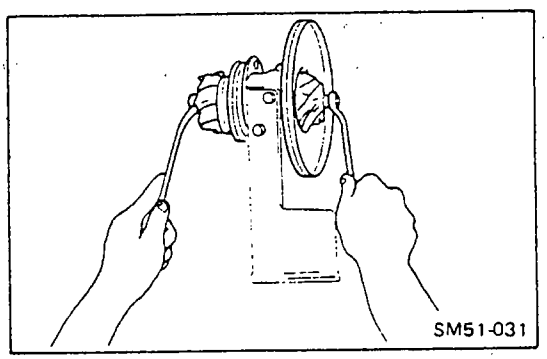
1. Insert two new seal rings on the oil thrower.
2. Install the oil thrower in the back plate.

NOTE: **The openings of seal rings should be positioned as shown.**



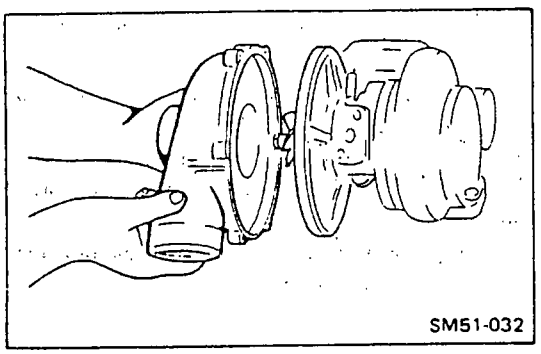
3. Install the back plate in the bearing plate.

NOTE: **o The oil return hole should face the oil outlet side. Apply silicone R.T.V. sealer to the flanged surface of the back plate.**
o Take care that the cilicone sealer does not protrude from the flange.



FIT THE BLOWER IMPELLER ON THE TURBINE ROTOR AND TIGHTEN THE LOCK NUT.

NOTE: **Remember that this nut has left-hand threads.**



INSTALL THE TURBINE CASE TO THE BEARING CASE, BEING SURE TO ALIGN THE MATCHING MARKS.

NOTE: **Always use new lock plates.**

ASSEMBLE THE BLOWER CASE.

1. Install the blower case to the bearing case referring to the matching marks.

NOTE: **Coat the flange face of the blower case with silicone R.T.V. sealant.**

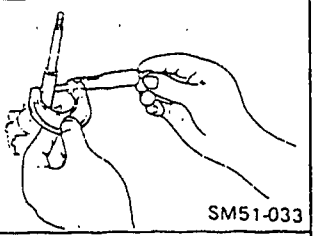
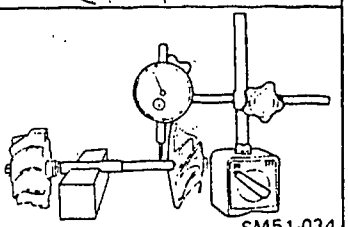
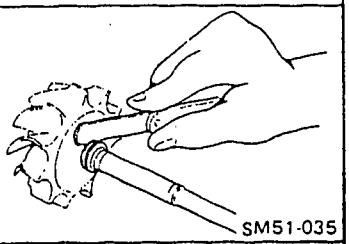
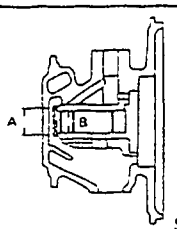
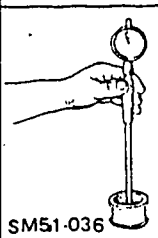
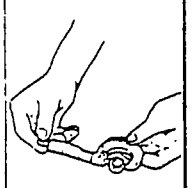
2. Tighten the six fitting bolts.

ASSEMBLY TEST

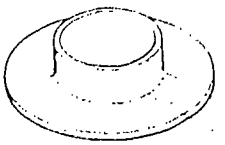
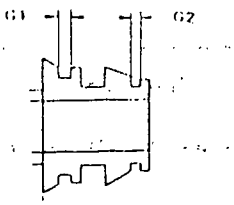
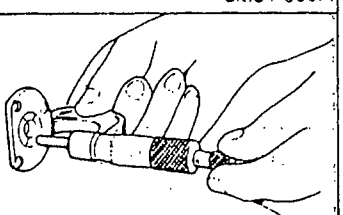
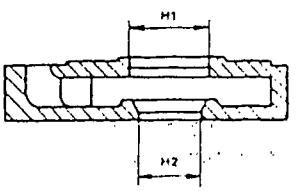
1. Rorate the blower impeller by hand to see if it turns smoothly.
   Refer to page TU-6.
2. Check the turbine rotor for axial play (A).
   Refer to page TU-6.
3. Check the turbine rotor for radial play using a special tool.
   Refer to page TU-7.

INSPECTION AND REPAIR

Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Turbine Shaft Diameter	–	12.28 (0.4835)	Replace	 SM51-033
Turbine Shaft Bend	–	0.011 (0.0004)	Replace	 SM51-034
Seal Ring Groove Width of Turbine Shaft	–	1.63 (0.0642)	Replace shaft assembly.	 SM51-035
Bearing Case Inside Diameter	–	A: 18.55 (0.7303) B: 17.11 (0.6736)	Replace	 SM51-006
Journal Bearing Inside Diameter	–	12.36 (0.4866)	Replace	 SM51-036
Journal Bearing Outside Diameter	–	16.98 (0.6685)	Replace	 SM51-037

INSPECTION AND REPAIR

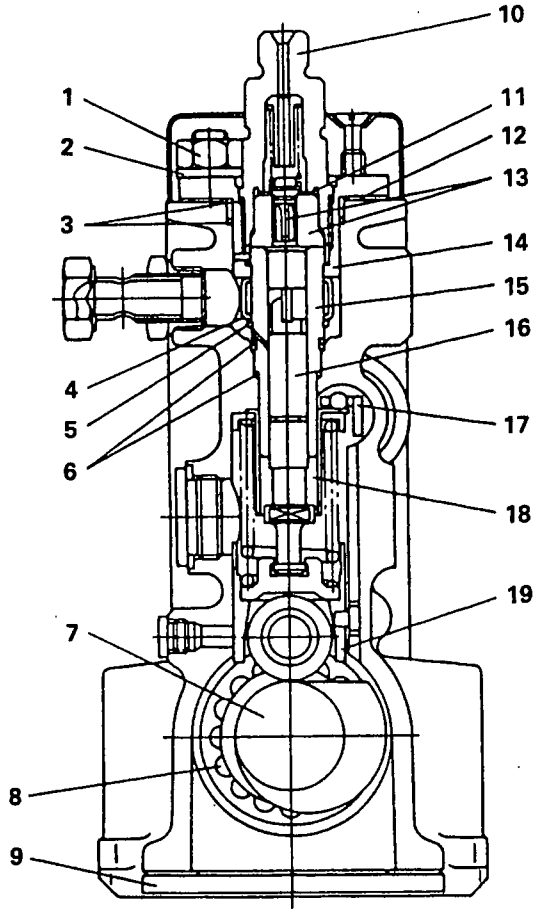
Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Thrust Spacer Height	–	4.68 (0.1843)	Replace	 SM51-007
Seal Ring Groove Width of Oil Thrower	–	G1: 1.75 (0.0689) G2: 1.52 (0.0598)	Replace	 SM51-006A
Thrust Bearing Thickness	–	4.48 (0.1764)	Replace	 SM51-038
Sealing Bore of Seal Plate	–	H1: 16.05 (0.6319) H2: 14.05 (0.5531)	Replace	 SM51-006B

IP-122E-01

CHAPTER IP

FUEL INJECTION PUMP

DESCRIPTION



SM4-342

FUEL INJECTION PUMP

1. Nut
2. Washer
3. O-ring
4. Deflector
5. Snap ring
6. O-ring
7. Camshaft
8. Bearing
9. Cover
10. Delivery valve holder
11. Delivery valve gasket
12. Adjusting shim
13. Delivery valve
14. Flange sleeve
15. Plunger barrel
16. Plunger
17. Control rack
18. Control sleeve
19. Tappet

TROUBLESHOOTING

Symptom	Possible cause	Remedy/Prevention
Engine does not start	**Fuel not reaching injection pump**	
	• Fuel lines clogged or damaged	Clean or replace fuel lines.
	• Fuel filter clogged	Clean or replace the filter element.
	• Air in fuel caused by improper connections of fuel line between fuel tank and feed pump	Repair connections.
	• Filter incorporated in inlet side of feed pump clogged	Remove foreign material.
	• Faulty feed pump check valve	Repair or replace it.
	• Feed pump piston spring broken	Replace it.
	• Feed pump push rod or tappet sticking	Repair or replace it.
	Fuel reaching injection pump	
	• Faulty connection of accelerator wire to pump adjusting lever.	Repair connection.
	• Control rack faulty or sticking	Repair it.
	• Damaged camshaft bearing	Repair it.
	• Plunger worn or sticking	Correct or replace it.
	• Faulty connection of engine stop wire to pump stop lever.	Repair it.
	Nozzle faulty	
	• Fuel leakage caused by loosened nozzle holder.	Inspect and tighten it.
	• Low opening pressure of nozzle	Adjust it.
	• Nozzle pressure spring broken	Replace it.
	• Nozzle needle sticking to nozzle body	Correct or replace it.
	Pump out of timing	
	• Improperly retarded injection timing	Correct injection timing.
	• Incorrect timing caused by improper Installation of pump.	Check engine timing and correct it.
	• Woodruff key for pump camshaft cut off.	Replace it.
	• Improper pre-stroke adjustment	Correct it to obtain specified injection timing.

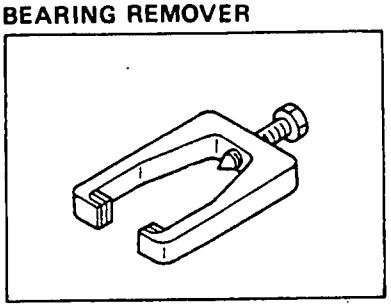
Symptom	Possible cause	Remedy/Prevention
Excessive smoke	Black smoke	
	• Excessive fuel delivery caused by incorrect adjustment of fuel load stopper screw.	Adjust fuel delivery on test stand.
	• Excessively advanced injection timing.	Correct it.
	• Large spread in fuel delivery	Adjust it.
	• Bad nozzle fuel spray characteristics	Check and correct them.
	White smoke	
	• Improperly retarded injection timing.	Advance injection timing.
	• Water in fuel	Check and clean fuel lines.
Low idle speed irregular	Improper adjustment of idle button	Correct it.
	Bad fuel spray characteristic of nozzles.	Check and repair them.
	Incorrect injection timing	Correct it.
	Incorrect initial tension setting of idling spring or the spring broken.	Adjust or replace it.
	Control rack not smoothly move	Disassemble pump and repair it.
	Large spread in fuel delivery	Adjust it.
	Plunger worn	Replace it.
	Governor linkage not smoothly move.	Correct it.
	Defective feed pump	Disassemble and repair it.
Engine always runs at hig speed	Accelerator cable sticking	Check and correct it.
	Governor linkage sticking	Disassemble and repair the governor.
	Control rack sticking	Check and correct it.
Engine starts and stops	Fuel lines clogged	Clean or replace fuel lines.
	Air in fuel caused by damaged fuel lines or improper connection of fuel lines.	Repair fuel lines or replace fuel lines and gaskets.

Symptom	Possible cause	Remedy/Prevention
Engine has low power	**Pump out of timing**	
	• Excessive advanced timing, resulting in loud knocking.	Check and correct it.
	• Excessively retarded timing resulting in black smoke.	Check and correct it.
	• Defective injection pump overflow valve.	Repair or replace it.
	• Feed pressure too low	Repair the feed pump.
	• Inproper accelerator cable adjustment	Adjust it.
	Nozzle faulty	
	• Fuel leakage from nozzle holder	Check and repair nozzle holder.
	• Bad nozzle spray characteristic	Repair or replace it.
	• Loosened adjusting screw in nozzle holder, resulting in low opening pressure.	Adjust it.
	• Nozzle pressure spring broken	Replace it.
	Pump faulty	
	• Fuel leakage from delivery valve holder.	Retighten the delivery valve holder if it is loosened or replace O-ring if the O-ring is defective.
	• Defective seat of delivery valve assembly.	Repair or replace it.
	• Delivery valve spring broken	Replace the spring.
	• Plunger worn	Replace it.
	• Large spread in fuel delivery	Adjust it.
	• Wear of tappet roller	Replace the roller.
	• Camshaft bearing worn or broken	Replace it.
	• Improper adjustment of governor fuel load stopper screw.	Adjust it.
Loud knocking	— Imprlper injection timing	Correct it.
	— Bad fuel nozzle spray pattern after-dribble.	Check and correct it.
	— High nozzle opening pressure	Adjust the opening pressure.
	— Incorrect fuel deliveries to some nozzles.	Readjust the fuel deliveries.

SPECIAL TOOL

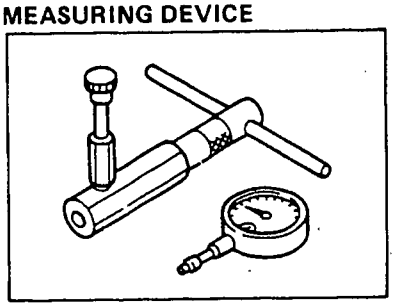
Prior to starting a fuel injection pump overhaul, it is necessary to have these special tools.

BEARING REMOVER



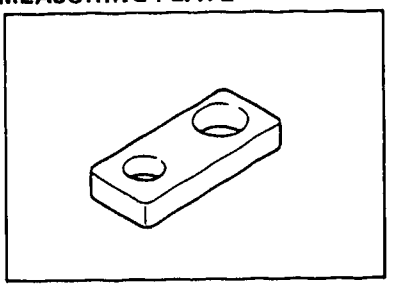
09500-1160

MEASURING DEVICE



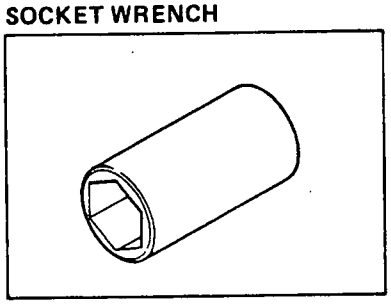
09500-1310

MEASURING PLATE



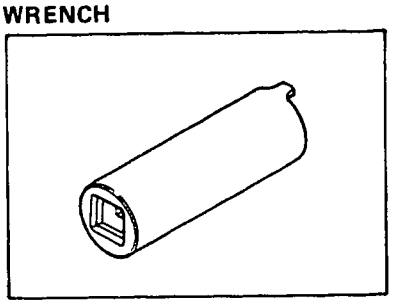
09511-1330

SOCKET WRENCH



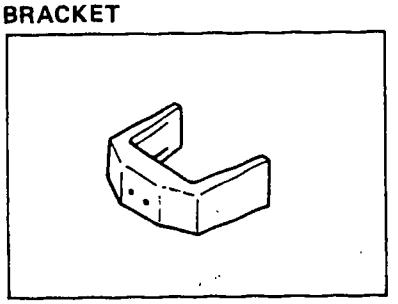
09511-1340

WRENCH



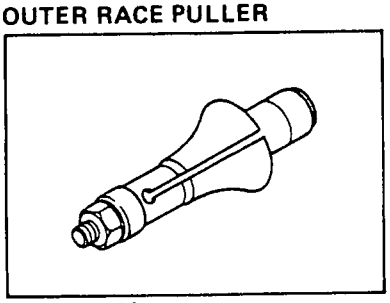
09511-1350

BRACKET



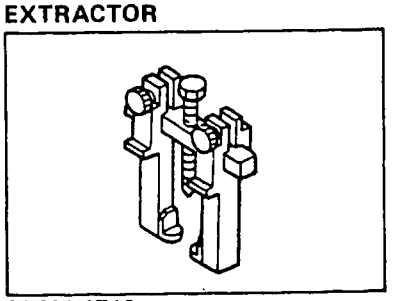
09511-1380

OUTER RACE PULLER



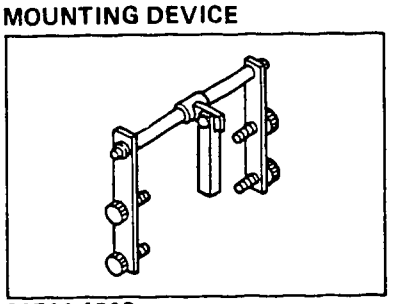
09511-1700

EXTRACTOR



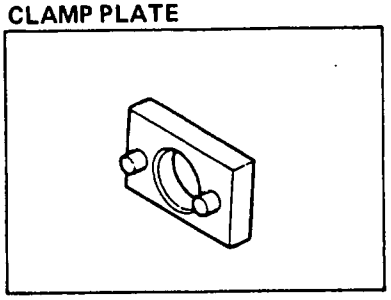
09511-1710

MOUNTING DEVICE



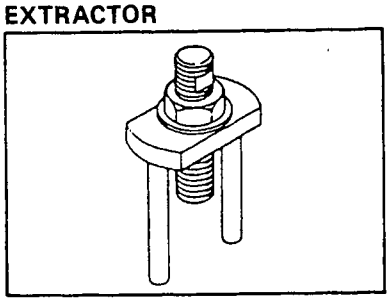
09511-1800

CLAMP PLATE



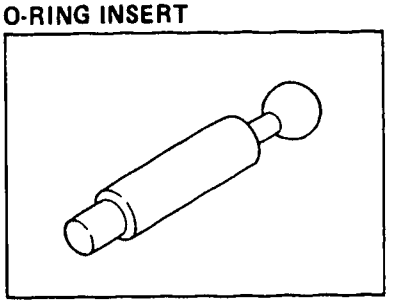
09511-1820

EXTRACTOR



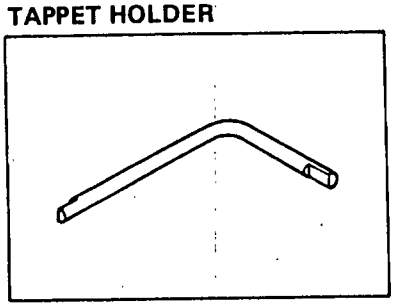
09511-1830

O-RING INSERT



09511-1850

TAPPET HOLDER

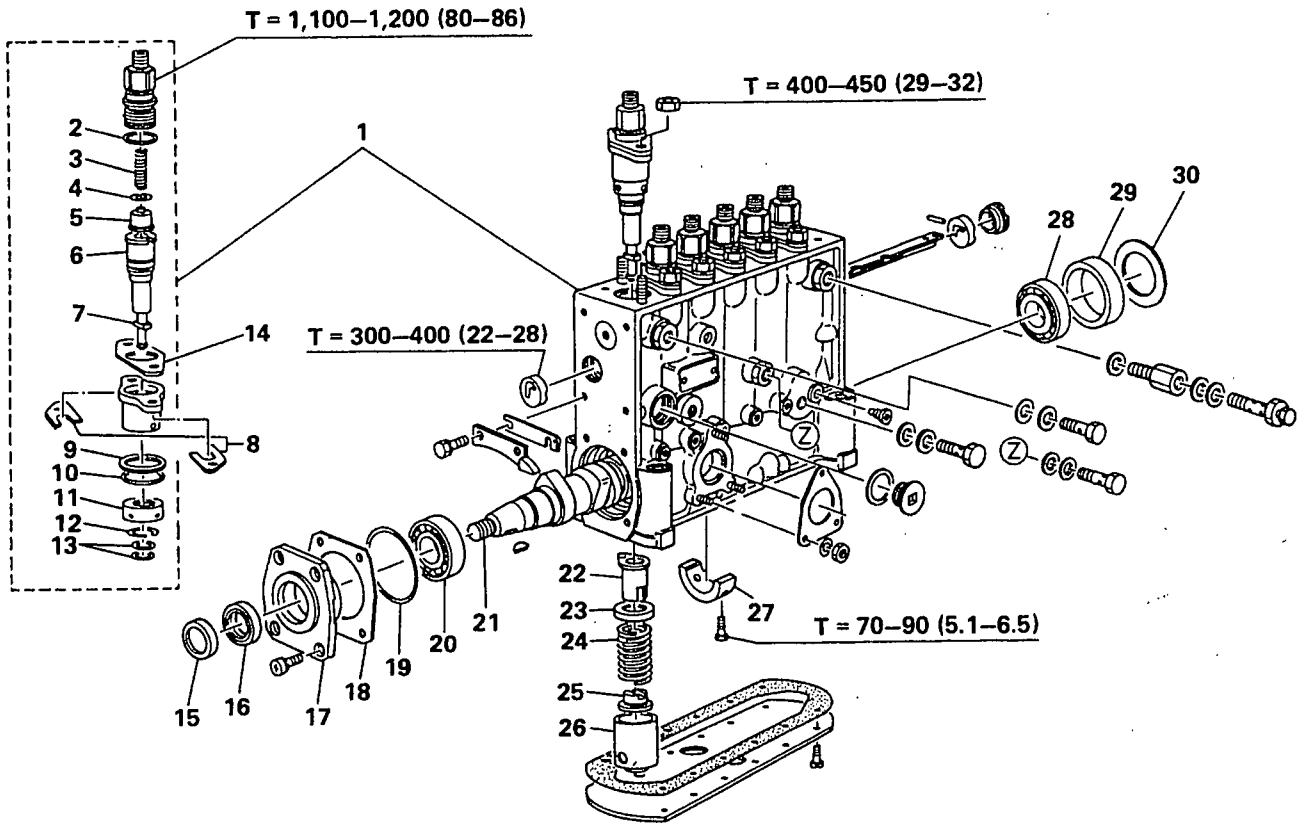


09511-2040

INJECTION PUMP

P-TYPE PUMP

1556B
I–NO. 32



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

1. Plunger block assembly
2. O-ring
3. Delivery valve spring
4. Gasket
5. Delivery valve
6. Plunger barrel
7. Plunger
8. Shim
9. Collar
10. O-ring
11. Deflector
12. Snap ring
13. O-ring
14. Valve holder lock plate
15. Sleeve
16. Oil seal
17. Bearing cover
18. Shim
19. O-ring
20. Taper roller bearing
21. Cam shaft
22. Control sleeve
23. Upper plunger spring seat
24. Plunger spring
25. Lower plunger spring seat
26. Tappet
27. Center bearing
28. Taper roller bearing
29. Bearing holder
30. Shim

IMPORTANT POINT (S) – DIASSEMBLY

WARNING

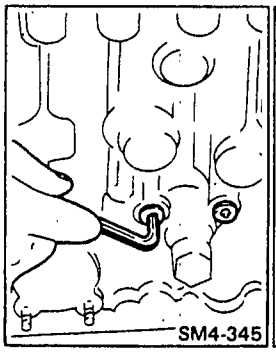
- **Breaking of the lead seals or crimp caps by anyone other than HINO or pump manufacture authorized service stations to make these adjustment will void the warranty.**
- **If fuel pump or governor difficulties are suspected, consult only HINO or pump manufacture authorized service stations, where the problem can be corrected and the injection pump lead seals and crimp caps can be reinstalled as required.**
- **Measure and record the fuel delivery characteristics of the pump before disassembling it.**
- **Keep the parts for each cylinder in separate groups and in an orderly arrangement. Parts to be replaced and parts to be used again must be kept separately.**

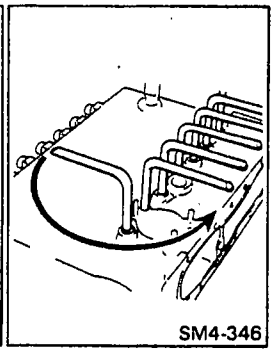
REMOVE THE TIMER ASSEMBLY.

Refer to "TIMER AND COUPLING".

REMOVE THE GOVERNOR.

Refer to "GOVERNOR".

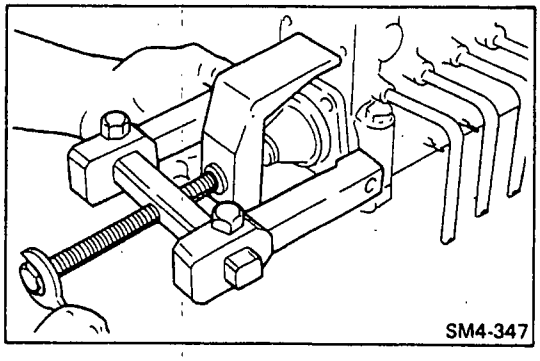

SM4-345


SM4-346

REMOVE THE CAMSHAFT FROM PUMP BODY.

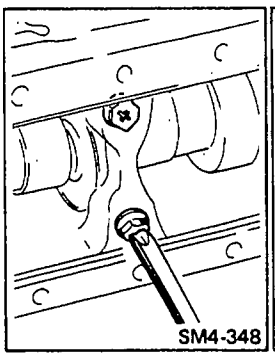
1. Remove the screw plug.
2. Turn the camshaft and when the tappet reaches top dead center, insert the tappet holder into the screw plug hole.

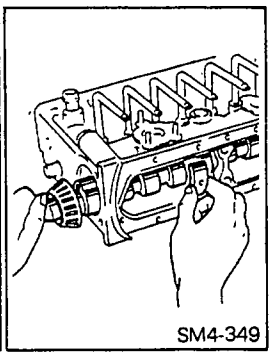
Special tool: Tappet holder (09511-2040)


SM4-347

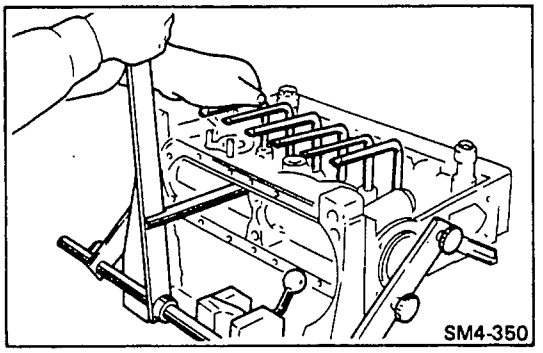
3. Remove the cover setting bolt.
4. Using a special tools, takeout the bearing cover.

Special tools: Bracket (09511-1380)
Eextractor (09511-1710)


SM4-348


SM4-349

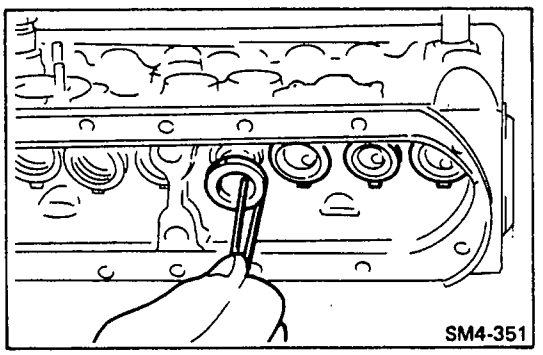
5. Remove the center bearing bolt and pull out the camshaft with the center bearing.


SM4-350

REMOVE THE TAPPET ASSEMBLY.

1. Set up the mounting device on bottom of the pump housing.
2. Operate the lever to push up the tappet and pull out tappet holder.

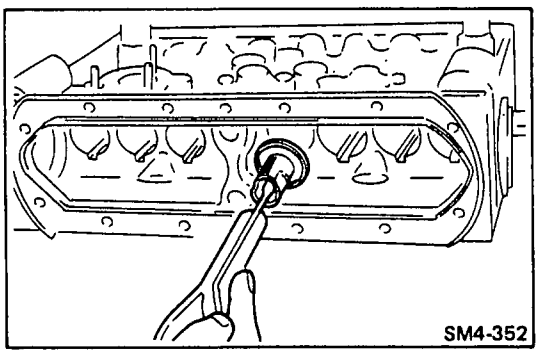
Special tools: Mounting device (09511-1800)


SM4-351

REMOVE THE SPRING SEAT WITH PLUNGER.

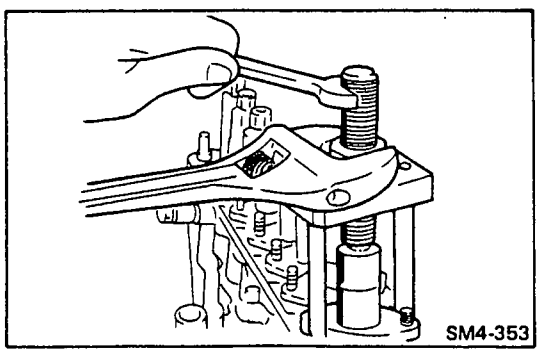
3. Using small pincers, pull out lower spring seat together with plunger.

NOTE: Put the plunger in order in a tray containing clean diesel fuel.


SM4-352

REMOVE THE CONTROL SLEEVE UPPER SPRING SEAT.

NOTE: To do this, it is essential to line up the sleeve ball with the groove in the pump housing; otherwise the control sleeve will not come out.


SM4-353

REMOVE THE PLUNGER BLOCK ASSEMBLY.

Fasten extractor to the delivery valve holder, and withdraw plunger block assembly.

Special tool: Extractor (09511-1830)

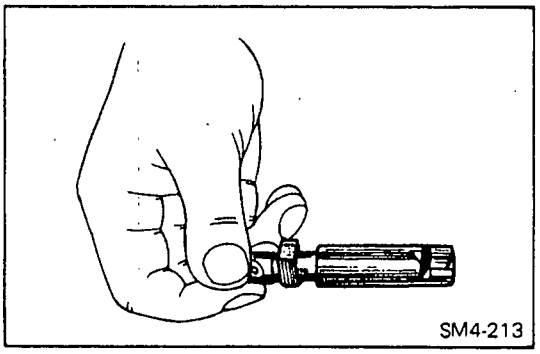
NOTE: Put the plunger block assembly and adjusting shims in a tray containing clean diesel fuel.

IMPORTANT POINT (S) – ASSEMBLY

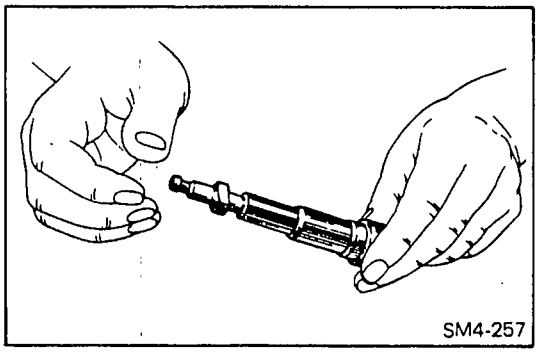
WARNING

- **Wash all parts with clean diesel fuel before installing them, and any defective or damaged parts must be replaced.**
- **Do not allow dust or other foreign matter to enter the pump during assembly.**
- **Apply grease to O-rings and oil seals before installing them.**
- **Assemble the parts in correct order and to correct tightening torques, assembled dimensions etc.**
- **Assembly takes place in the reverse order of disassembly.**

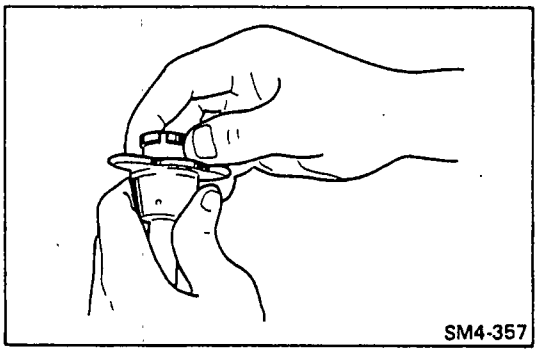
ASSEMBLING THE PLUNGER BLOCK


SM4-213

1. Before install the plunger barrel should be inspect the plunger barrel and plungers for wear, scratches, or discoloration.

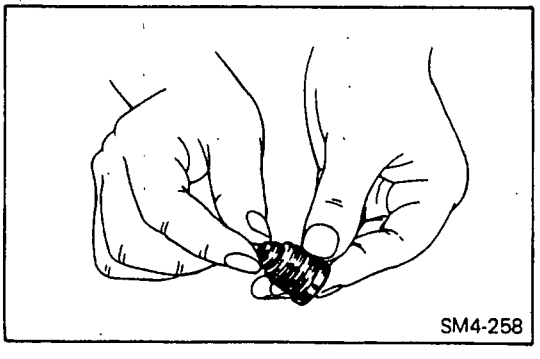

SM4-257

2. Tilt the plunger to about 60°. Pull the plunger out approximately 10 to 15 mm (0.39–0.59 in) and release it to see if it slides down smoothly from its own weight.


SM4-357

3. Assemble the plunger barrel into the flange sleeve.

NOTE: Be sure that the knock pin of the flange sleeve is fitted into the guide groove on the plunger barrel.


SM4-258

4. Install the delivery valve, delivery valve gasket, delivery spring and delivery valve holder on the flange sleeve in this order.

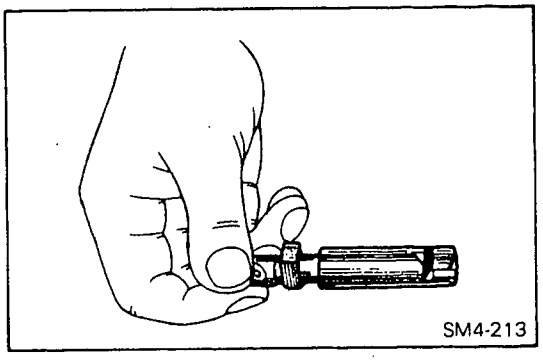
NOTE: Before install the delivery valves, inspect the delivery valves for scratches on the valve seat or the piston sections.

IMPORTANT POINT (S) – ASSEMBLY

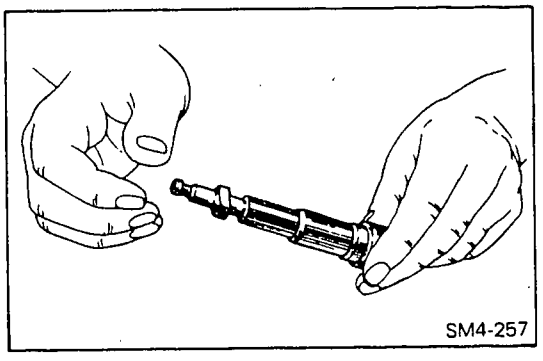
WARNING

- **Wash all parts with clean diesel fuel before installing them, and any defective or damaged parts must be replaced.**
- **Do not allow dust or other foreign matter to enter the pump during assembly.**
- **Apply grease to O-rings and oil seals before installing them.**
- **Assemble the parts in correct order and to correct tightening torques, assembled dimensions etc.**
- **Assembly takes place in the reverse order of disassembly.**

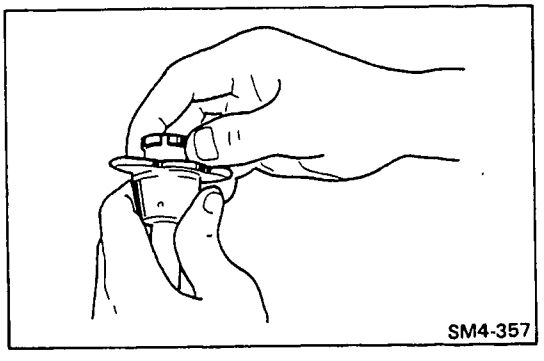
ASSEMBLING THE PLUNGER BLOCK


SM4-213

1. Before install the plunger barrel should be inspect the plunger barrel and plungers for wear, scratches, or discoloration.

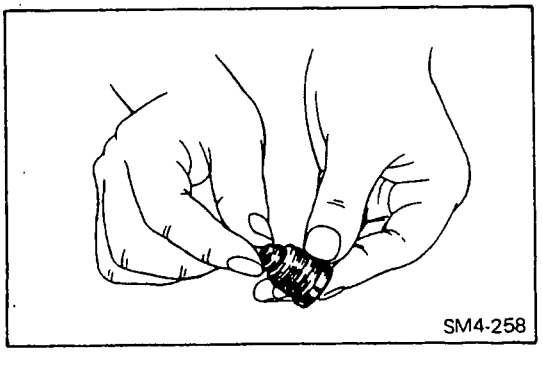

SM4-257

2. Tilt the plunger to about 60°. Pull the plunger out approximately 10 to 15 mm (0.39–0.59 in) and release it to see if it slides down smoothly from its own weight.


SM4-357

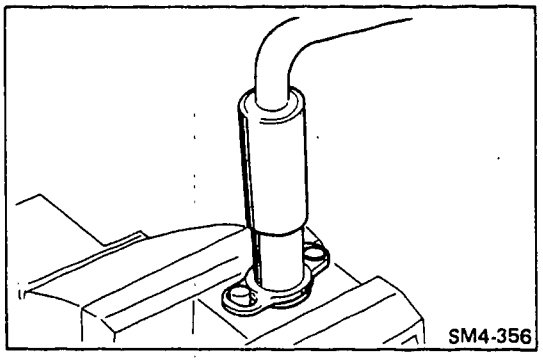
3. Assemble the plunger barrel into the flange sleeve.

NOTE: **Be sure that the knock pin of the flange sleeve is fitted into the guide groove on the plunger barrel.**


SM4-258

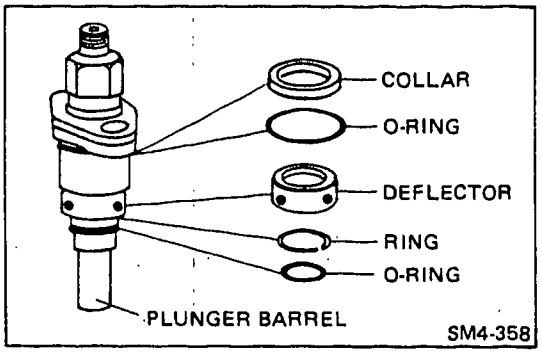
4. Install the delivery valve, delivery valve gasket, delivery spring and delivery valve holder on the flange sleeve in this order.

NOTE: **Before install the delivery valves, inspect the delivery valves for scratches on the valve seat or the piston sections.**


SM4-356

5. Tighten the delivery valve holder.

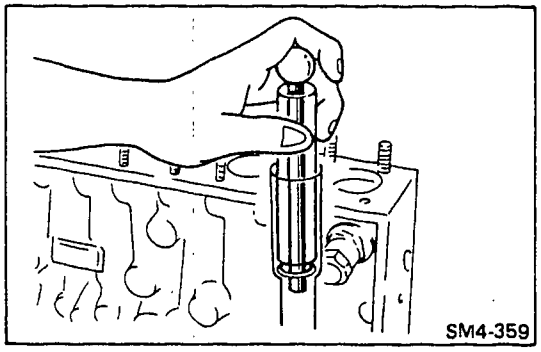
NOTE: O-ring should first be assembled in the delivery valve holder. In doing this, be sure that O-ring is coated with grease to prevent it from being damaged.



SM4-358

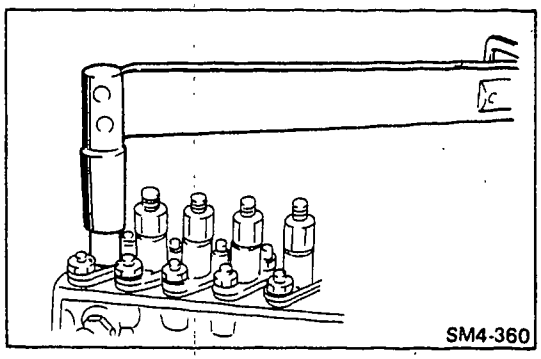
6. Install the collar, O-ring, deflector, ring and O-ring.

NOTE: The deflector should not be installed upside down with the hole near to its lower edge.


SM4-359

7. Install the small O-ring in the housing by with the inserter.

Special tool: O-Ring inserter (09611-1850)

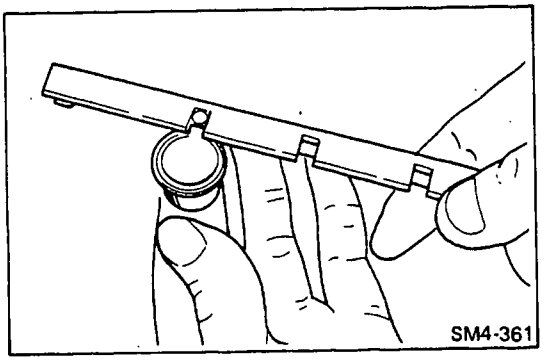

SM4-360

INSTALL THE PLUNGER BLOCK ASSEMBLY TO THE PUMP BODY.

1. Tighten the delivery valve holder using a socket wrench and a torque wrench.

Special tool: Socket wrench (09511-1340)

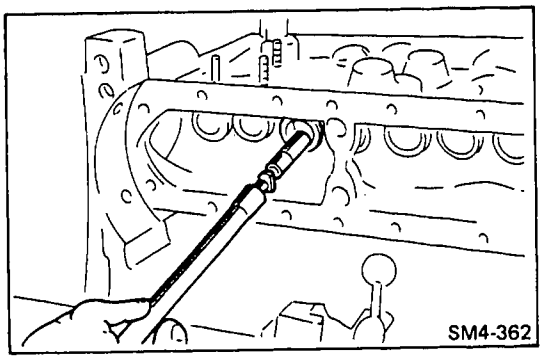
NOTE: Tightening should be made in three steps in the order of
1,200 → 0 → 1,200 → 0 → 1,200 kg·cm
(87) (87) (87) lb.ft


SM4-361

INSTALL THE CONTROL RACK AND THE CONTROL SLEEVE.

Assemble the control sleeve, inserting it until the ball on the sleeve is parfectly fitted in the notch of the control rod.

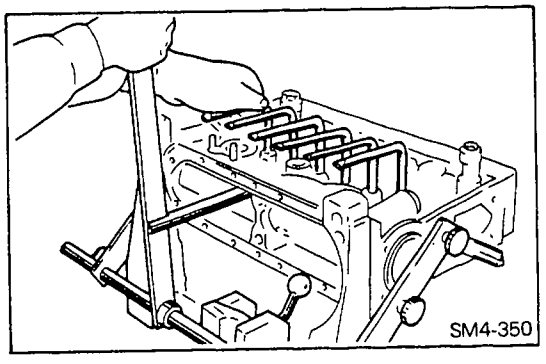
NOTE: **Make sure that the ball of the control sleeve is well fitted in the groove on the control rack; otherwise the ball section of the control sleeve will be bent when the next associated parts are assembled.**


SM4-362

INSTALL THE UPPER SPRING SEAT, THE PLUNGER SPRING AND THE PLUNGER.

Insert the plunger in the barrel. Make sure that the aligning mark on the plunger vane is pointing toward the front of the pump housing. Install the lower spring seat on the plunger.

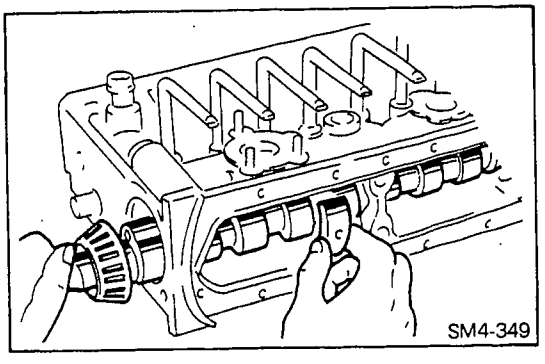
NOTE: **Do not interchange plungers with barrels.**


SM4-350

INSTALL THE TAPPET.

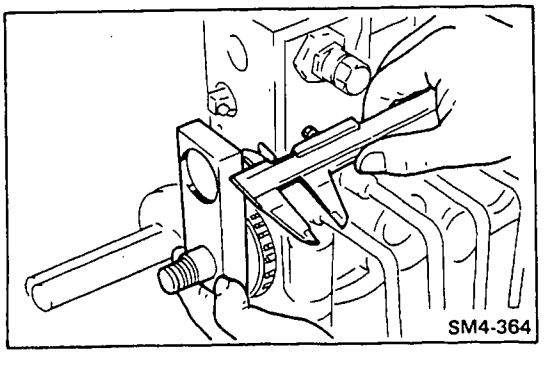
Using the mounting device to press in the tappet and hold it in with the tappet holder.

Special tool: Mounting device (09511-1800)
Tappet holder (09511-2040)


SM4-349

INSTALL THE CAMSHAFT.

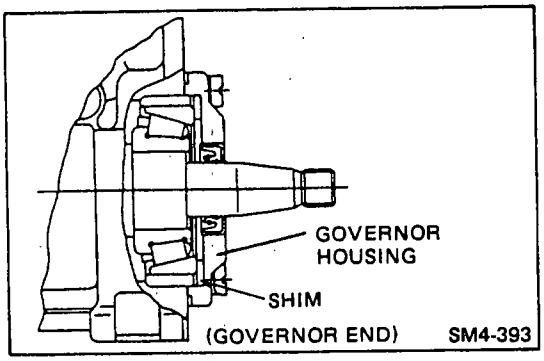
Place the center bearing on the camshaft and insert the cam-shaft into the pump housing.


SM4-364

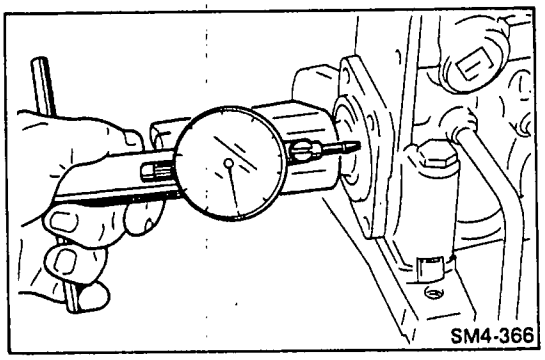
MEASURE THE PROTRUDING LENGTH OF THE CAMSHAFT.

1. Measure the distance from the surface of the end of the pump housing to the surface of the end of the measuring plate (where the tapered section of the cam-shaft starts).

Special tool: Measuring plate (09511-1300)
Standard length: 13.3–14.3 mm (0.524–0.563 in)



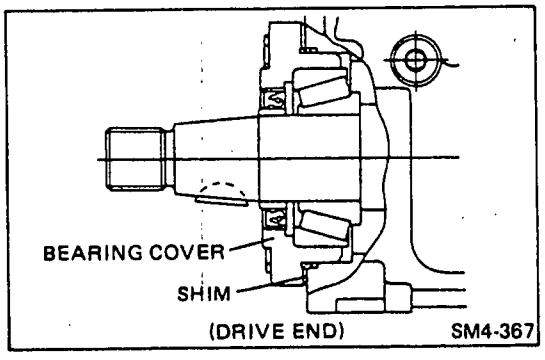
2. If the specification is not met, use appropriate shim plates at the governor end of camshaft until the specification is met.



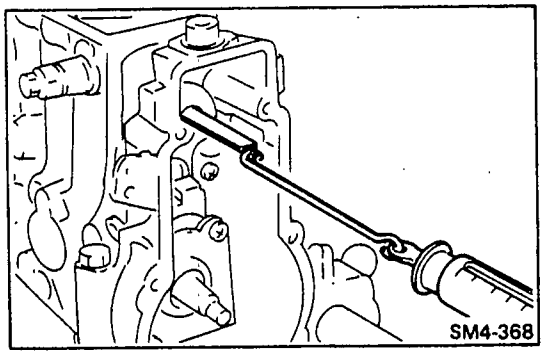
MEASURE THE CAMSHAFT END PLAY.

1. Attach the special tool onto the camshaft drive end and measure the thrust clearance of the camshaft with a dial gauge.

Special tool: Camshaft end play gauge (09500-1310)
Standard end play: 0.02–0.06 mm (0.0008–0.0023 in)



2. If the specification is not met, use appropriate shim plates at the drive end of camshaft until the specification is met.



MEASURE THE SLIDING RESISTANCE OF THE CONTROL RACK.

After the pump body has been assembled, attach a spring scale to the control rack and check that the control rack slides smoothly through its entire stroke.

Assembly standard: Less than 130 g (4.59 oz)

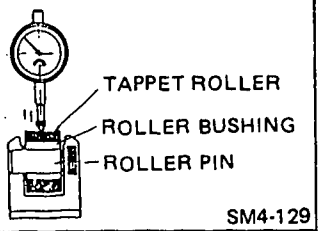
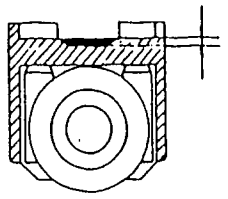
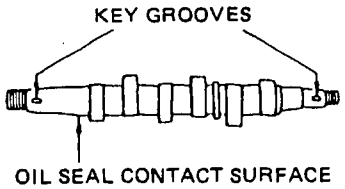
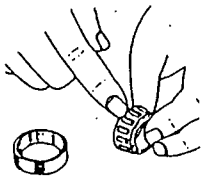
INSTALL THE TIMER ASSEMBLY.

Refer to "TIMER".

INSTALL THE GOVERNOR.

Refer to "GOVERNOR".

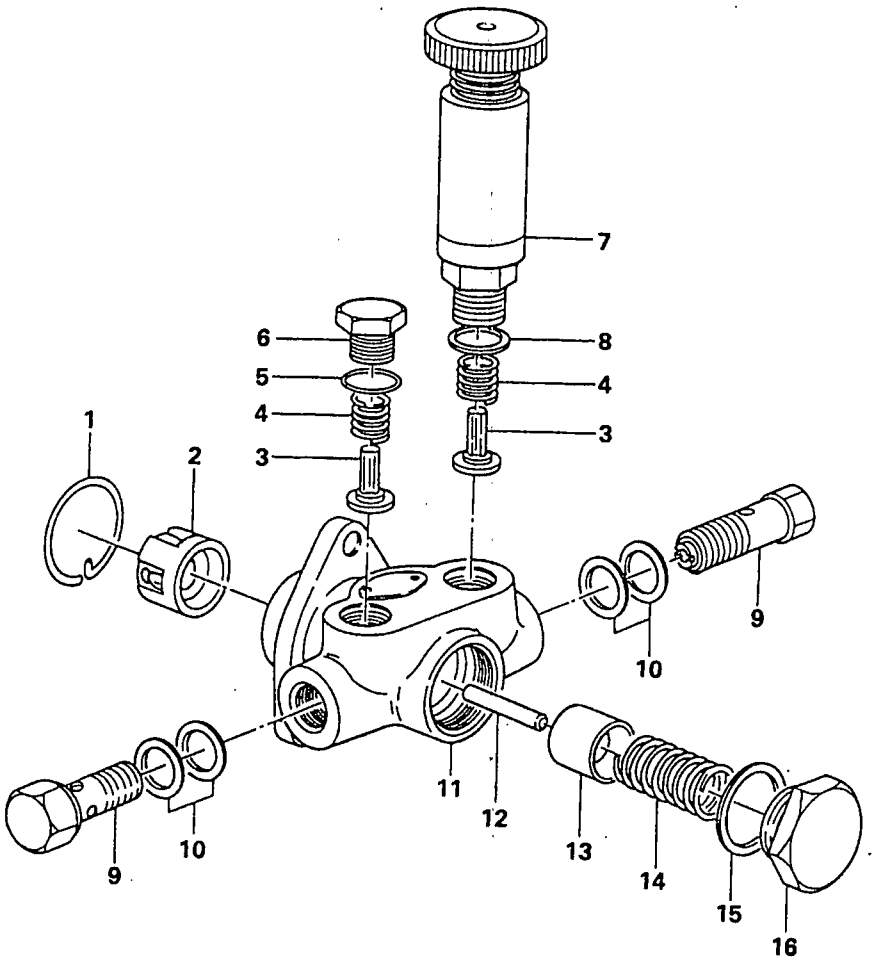
INSPECTION AND REPAIR

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Tappet wear.		0.2 mm (0.008 in)	Replace, tappet assembly.	 SM4-129
Tappet surface wear.		0.2 mm (0.008 in)	Replace, tappet.	
Camshaft wear		–	Replace, camshaft.	 SM4-131
Roller and center bearing wear, any other damage.		–	Replace, if necessary.	Visual check 

FEED PUMP

FP/K-P

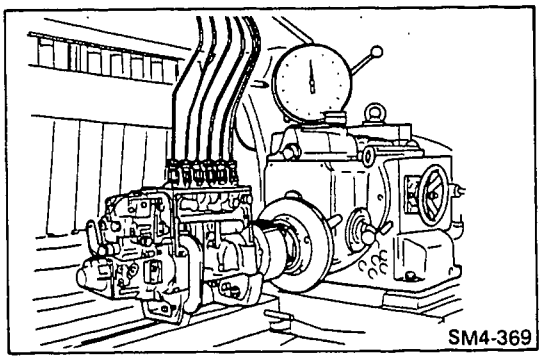
1561Z
I—NO. 21



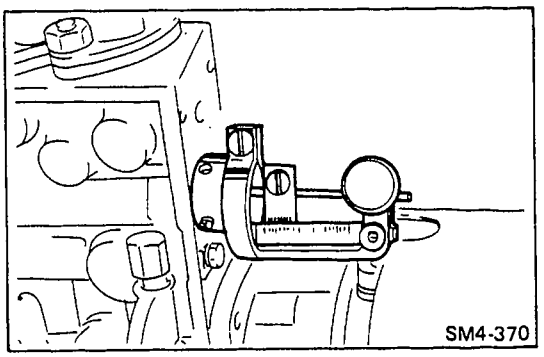
1. Retainer ring
2. Tappet
3. Check valve
4. Spring
5. O-ring
6. Plug
7. Priming pump
8. Gasket
9. Joint bolt
10. Gasket
11. Housing
12. Push rod
13. Piston
14. Spring
15. Gasket
16. Plug

ADJUSTMENT

PREPARATION


SM4-369

1. Mount the injection pump correctly on the pump tester.

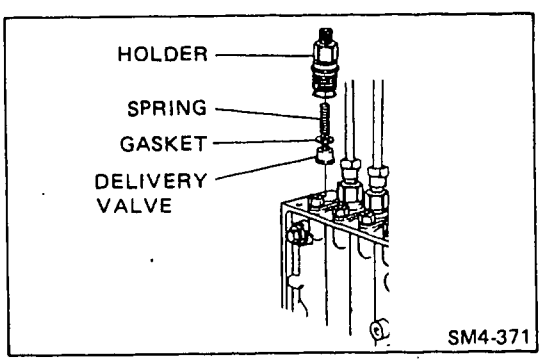

SM4-370

2. Attach a rack measuring device to the control rack and set to "0".
3. Install calibration nozzles and lines of the following specifications.

a) Nozzle
Nozzle holder assembly: 105780-8140
Opening pressure: 175 kg/cm (2,489 lb.ft)

b) Line
Outside diameter: 8.0 mm (0.3150 in)
Inner diameter: 3.0 mm (0.1181 in)
Length: 600 mm (23.6 in)

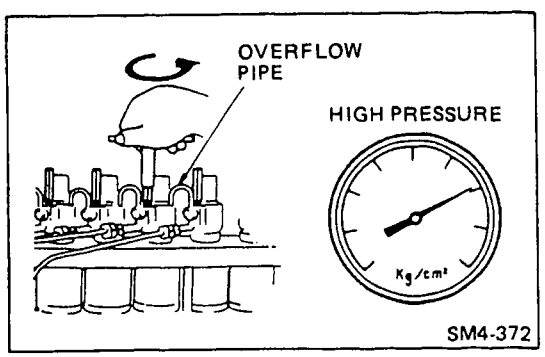
4. Calibration oil
a) Calibration oil: SAE J967C
b) Oil temperature: 40–45°C (104–113°F)



SM4-371

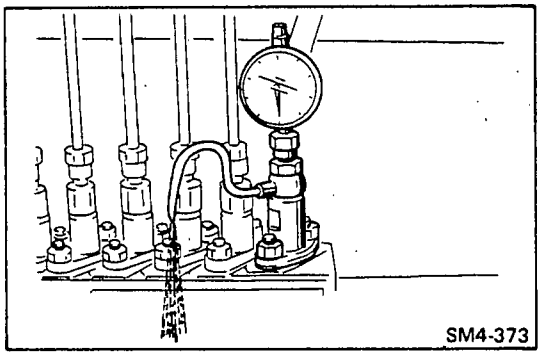
ADJUSTING THE PRE-STROKE OF NO.1 PLUNGER.

1. Remove the 1st cylinder delivery valve holder, spring delivery valve and gasket.
2. Install the plunger stroke measuring gauge to the flange sleeve by turning it as far as it will go.
3. Bring the tappet of the first cylinder to its bottom dead center, and set the dial indial indicator zero.

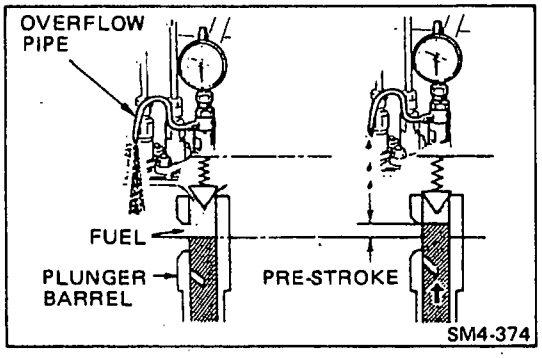


SM4-372

4. Measure the pre-stroke
a) Set the control rack at full-load position.
b) Loosen the overflow screw of each nozzle holder.
c) Operate the high-pressure pump of the pump tester and let fuel run out of the overflow line.


SM4-373

d) Move the angle dial to set the first cylinder of the pump to bottom dead center and adjust the pre-stroke gauge to zero.

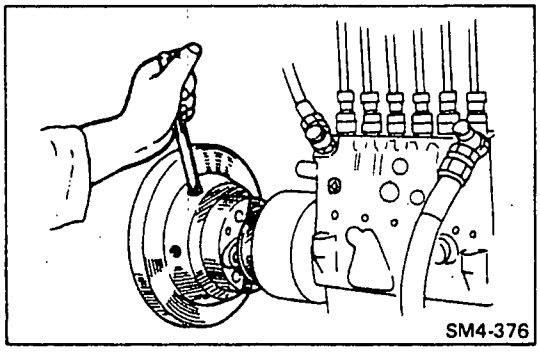


SM4-374

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

Pre-stroke: 3.20–3.30 mm (0.1260–0.1299 in)

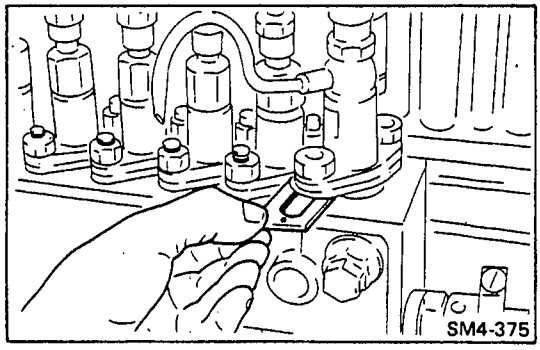
f) If the pre-stroke value is not within specification, adjust by changing the adjusting shim.
The shims can be replaced by pulling up the plunger block slightly.


SM4-376

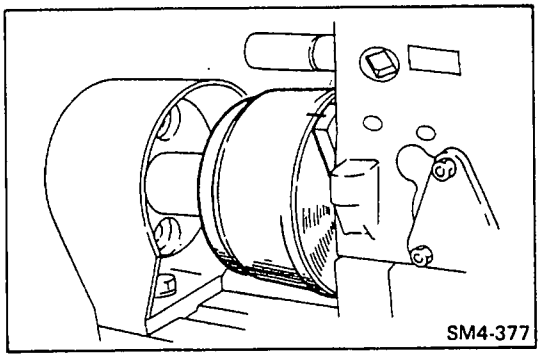
ADJUST THE INJECTION INTERVAL.

1. Using the No.1 cylinder injection starting point as a base, inspect and adjust the injection interval in the order of injection.

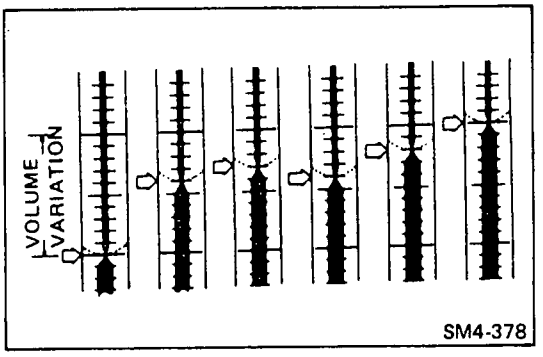
Injection interval: 59°30′ – 60°30′
Injection order: 1–4–2–6–3–5


SM4-375

2. If the injection intervals are not within specification, adjust by using the same procedure as for pre-stroke adjustment.


SM4-377

3. Set the No.1 cylinder at the injection starting point, and check that the marks on the coupling and the marks on the pump body are aligned.
If the timing marks are not aligned, make a new mark on the coupling and erase the old mark.

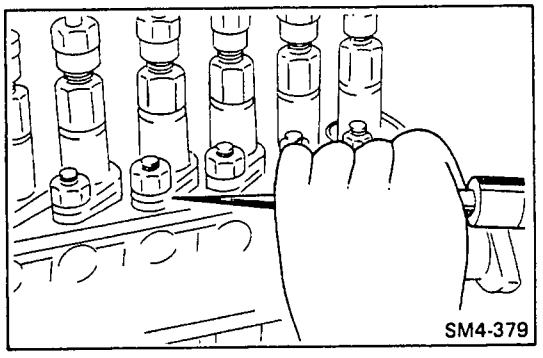


SM4-378

MEASURING AND ADJUSTING THE INJECTION VOLUME.

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

Injection volume: Refer to "CALIBRATION chart."


SM4-379

2. To adjust the injection volume, loose the flare nut of injection pipe and the lock nut of the plunger block assembly and turn to left or right the plunger block assembly.

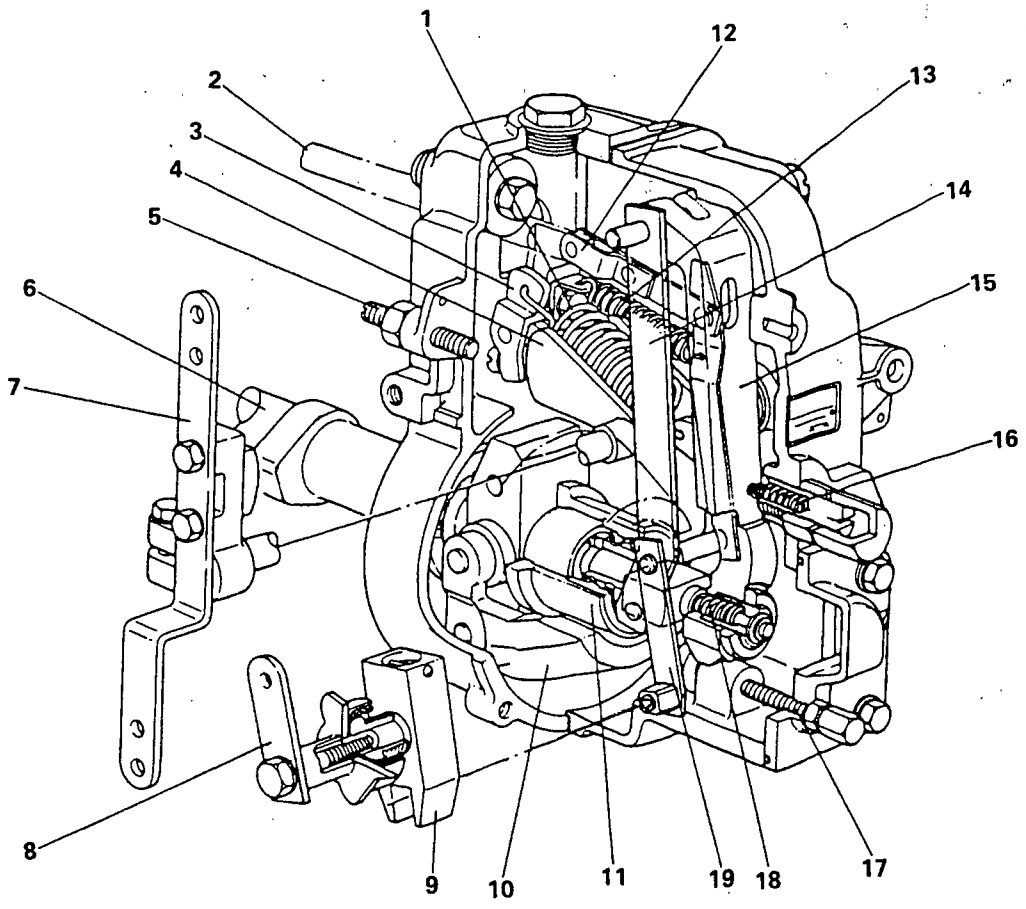
GV-06E-03

CHAPTER GV

INJECTION PUMP GOVERNOR
(MODEL: RSV)

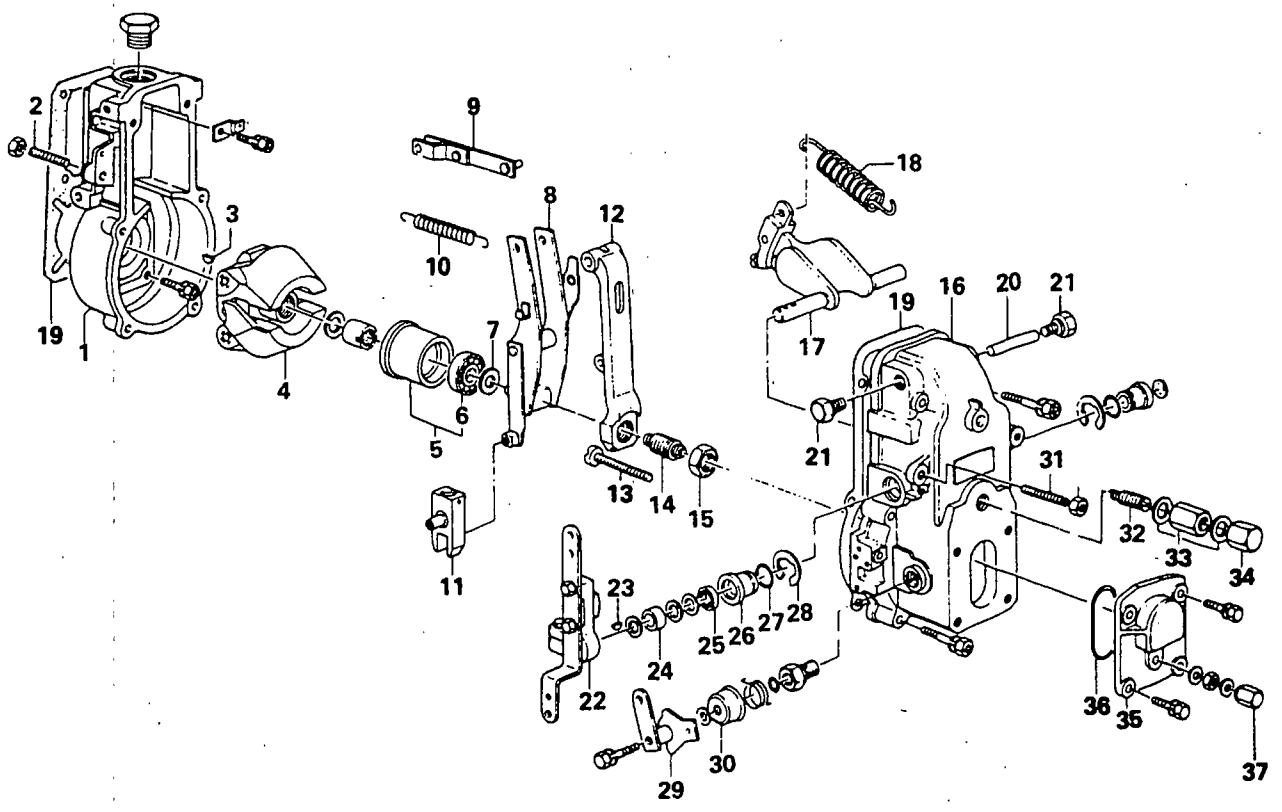
DESCRIPTION

[MODEL: RSV]



1. Governor spring
2. Control rod
3. Knuckle
4. Swivel lever
5. Maximum speed stopper bolt
6. Camshaft
7. Control lever
8. Stop lever
9. Supporting lever
10. Flyweight
11. Sleeve
12. Link
13. Start spring
14. Guide lever
15. Tension lever
16. Idle sub spring
17. Full load stopper bolt
18. Idle spring
19. Floating lever

GOVERNOR

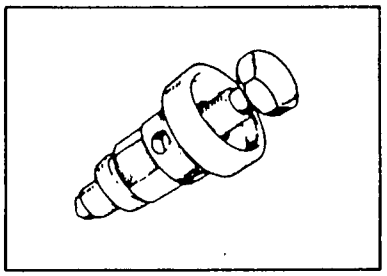


1. Governor housing
2. Stopper bolt
3. Woodruff key
4. Flyweight
5. Sleeve
6. Bearing
7. Shim
8. Guide lever assy
9. Link
10. Start spring
11. Supporting lever
12. Tension lever
13. Full load stopper
14. Idle spring
15. Lock nut
16. Governor cover
17. Swivel lever
18. Governor spring
19. Gasket
20. Pin
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. Idle sub spring
33. Nut
34. Cap nut
35. Closing cover
36. O-ring
37. Cap nut

SPECIAL TOOL

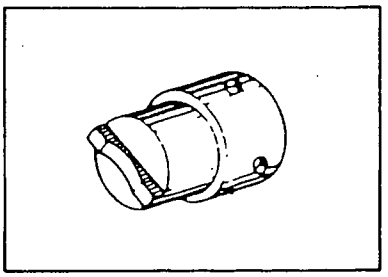
Prior to starting an injection pump governor overhaul, it is necessary to have these special tools.

FLYWEIGHT EXTRACTOR



09511-1900

ROUND NUT WRENCH

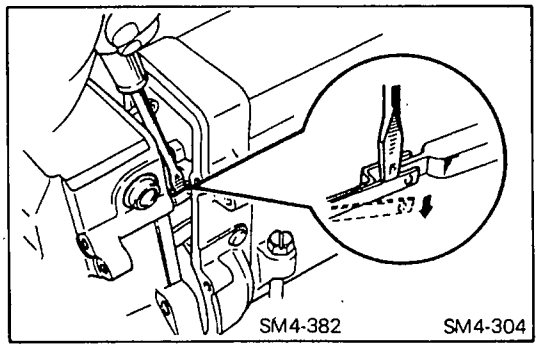


09511-1500

IMPORTANT POINT (S) – DISASSEMBLY

WARNING

- **Breaking of the lead seals or crimp caps by anyother other than HINO or pump manufacture authorized service stations to make these adjustment will void the warranty.**
- **If fuel pump or governor difficulties are suspected, consult only HINO or pump manufacture authorized service stations, where the problem can be corrected and the injection pump lead seals and crimp caps can be rainstalled as required.**

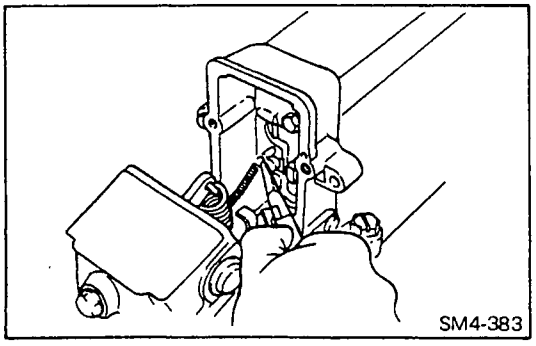


SM4-382 SM4-304

DISASSEMBLY THE GOVERNOR COVER FROM PUMP BODY.

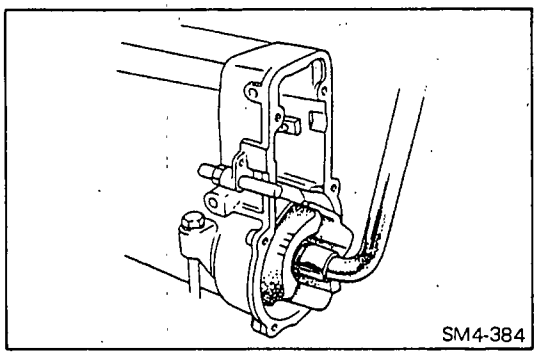
1. Disconnect the shackle from the control rack.

NOTE: When remove the governor cover fitting bolt, hold the governor cover.



SM4-383

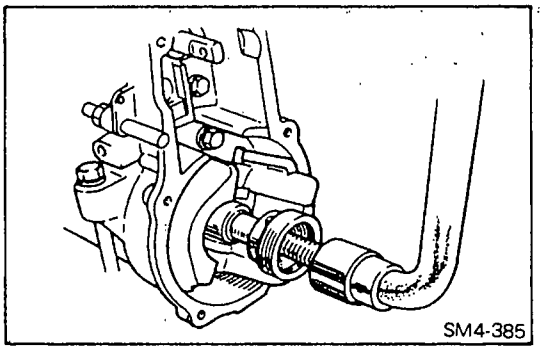
2. Disconnect the start spring.


SM4-384

REMOVE THE FLYWEIGHT ROUND NUT.

NOTE: Use the holding spanner to keep the camshaft from rotating.

Special Tools: Round Nut Wrench (09511-1500)


SM4-385

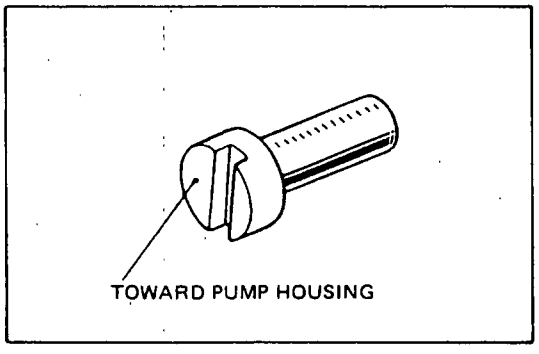
REMOVE THE FLYWEIGHT, USING THE FLYWEIGHT EXTRACTOR.

Special Tool: Flyweight Extractor (09511-1900)

IMPORTANT POINT (S) – Assebmly

WARNING

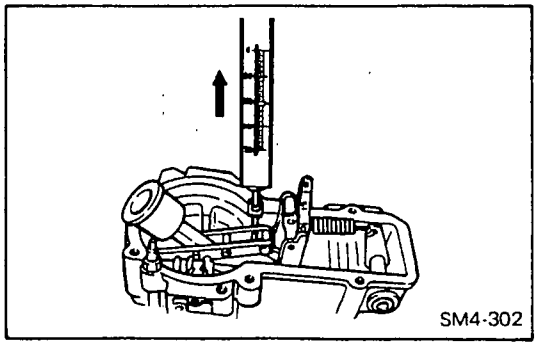
- **Wash all parts with clean diesel fuel before installing them, and any defective or damaged parts must be replaced.**
- **Do not allow dust or other foreign matter to enter the pump during assembly.**
- **Apply grease to O-rings and oil seals before installing them.**
- **Assemble the parts in correct order and to correct tightening torque, assembled dimensions etc.**
- **Assembly takes place in the reverse order of disassembly.**



INSTALL THE ADJUSTING LEVER

1. Install the shaft of the adjusting lever so that wide side of the shaft head surface is toward the pump body.

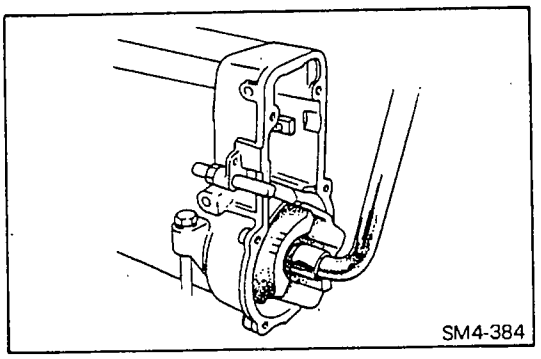
NOTE: Installing in reverse may cause the floating lever to contact the speed control spring, resulting in operational malfunction.


SM4-302

CHECK THE GOVERNOR LINKAGE FOR SMOOTH OPERATION.

Hook under the guide lever, and pull upwards, using a spring balance.

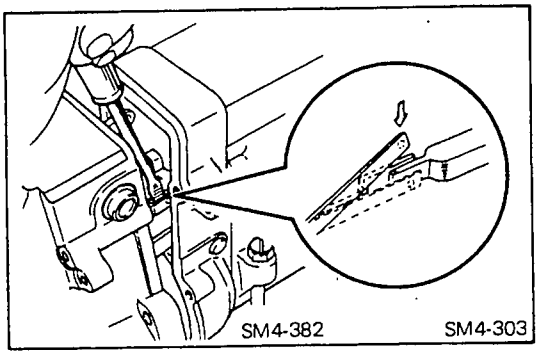
Starting force: 140–180 g (4.9–6.3 oz)


SM4-384

INSTALL THE FLYWEIGHT TO PUMP CAMSHAFT.

Using a special tools, tighten the round nut.

Special Tools: Round Nut Wrench (09511-1500)


SM4-382 SM4-303

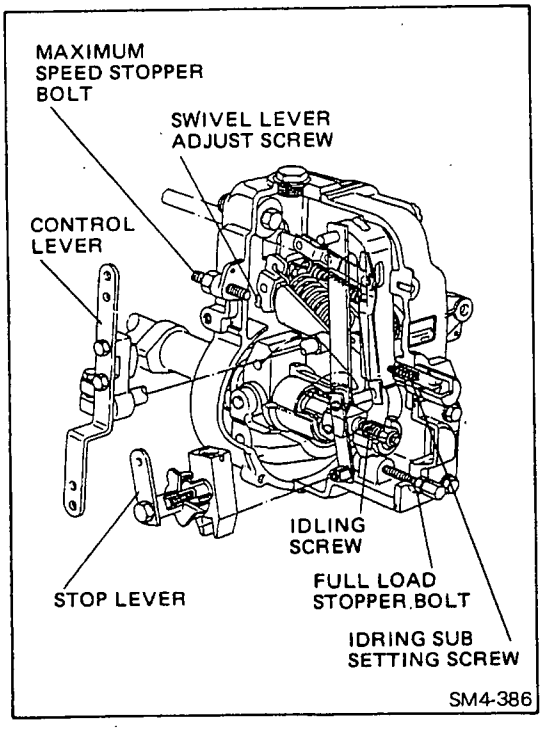
INSTALL THE GOVERNOR HOUSING TO PUMP BODY.

1. Connect the start spring.
2. Connect the shackle to control rack.

ADJUSTMENT OF THE GOVERNOR [MODEL; RSV]

1. 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.

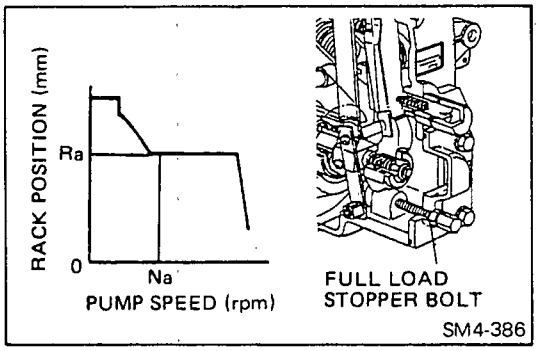


SM4-386

2. STEPS IN GOVERNOR ADJUSTMENT.

Perform governor testing and adjustment in the following sequence (For values of **N.** and **R** Refer to "CALIBRATION chart"):

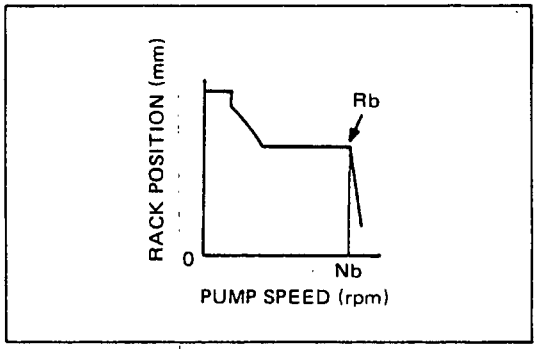
1. Adjustment of maximum speed control.
2. Adjustment of speed droop.
3. Adjustment of idling speed control.



1. Adjustment of maximum speed control

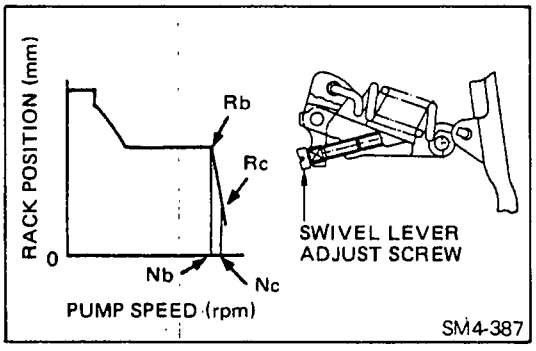
NOTE: The control lever should be full load position.

a) Adjust the full load stopper bolt.
At a pump speed of Na rpm, adjust the rack position to Ra mm with the full load stopper bolt.

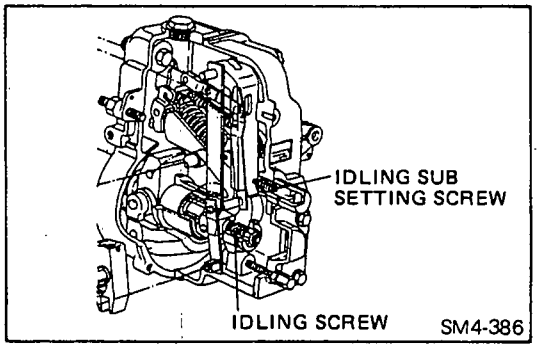


b) Adjust the maximum speed stopper bolt.
At a pump speed of Nb rpm, adjust the rack position to Rb mm with maximum speed stopper bolt.

NOTE: The control rack should start to be pulled.



2. Adjust of speed droop.
At a pump speed of Nc rpm, adjust rack position to Rc mm with swivel lever adjusting screw.

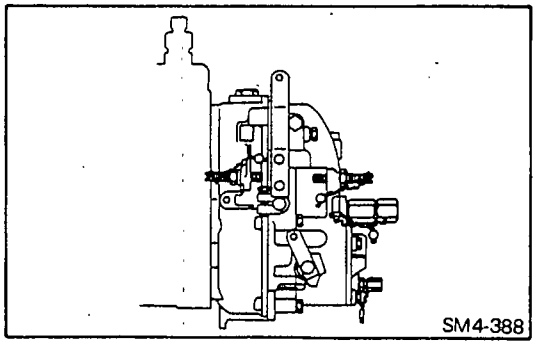


3. Adjusting of idling speed control

a) At a pump speed of Na rpm, adjust the rack position to Rd mm with idling screw.

NOTE: The control lever angle, refer to CALIBURATION chart.

b) At a pump speed of Ne rpm, adjust the rack position to Re mm with idling sub setting screw.



GOVERNOR EXTERNAL LEAD SEALS AND CRIMP CAPS.

NOTE: All adjusting devices on the fuel injection pump governor, are wired and lead sealed as a protection for the customer. This is to prevent unauthorized readjustment which may cause engine malfunction and/or engine failure. Periodically check to insure that these seals are not broken as this will void the warranty.

(K.P.)

GE-96E-01

CHAPTER GE

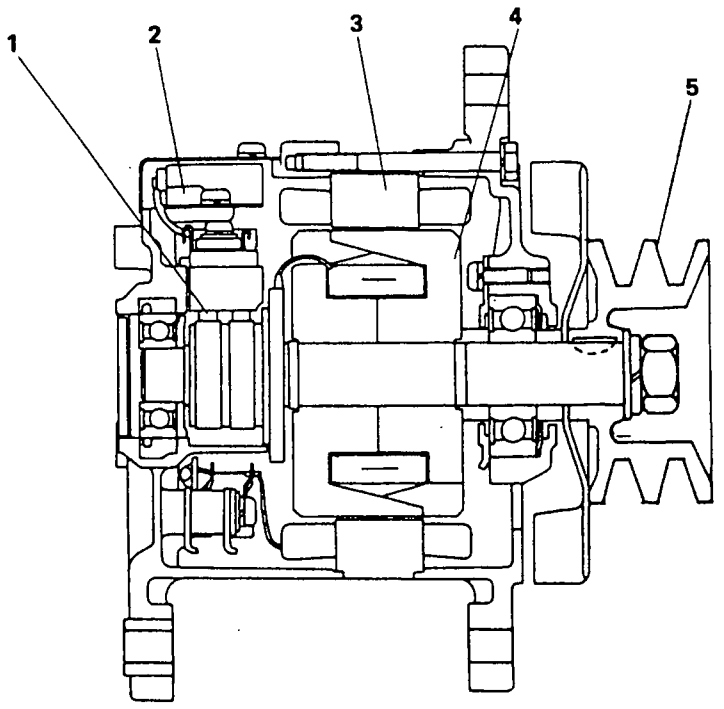
GENERATOR

(24V, 20A)

DATA AND SPECIFICATIONS

MODEL	27040–1470
GENERATOR	
Type	Alternator
Output	24V, 20A
Normal voltage	24V
Charging rotation and voltage	900 r.p.m., 27V
Direction of rotation	Right (From the pulley side)
Allowable max. speed	7,200 r.p.m.
Max. output	28V, 20A at 5,000 r.p.m.

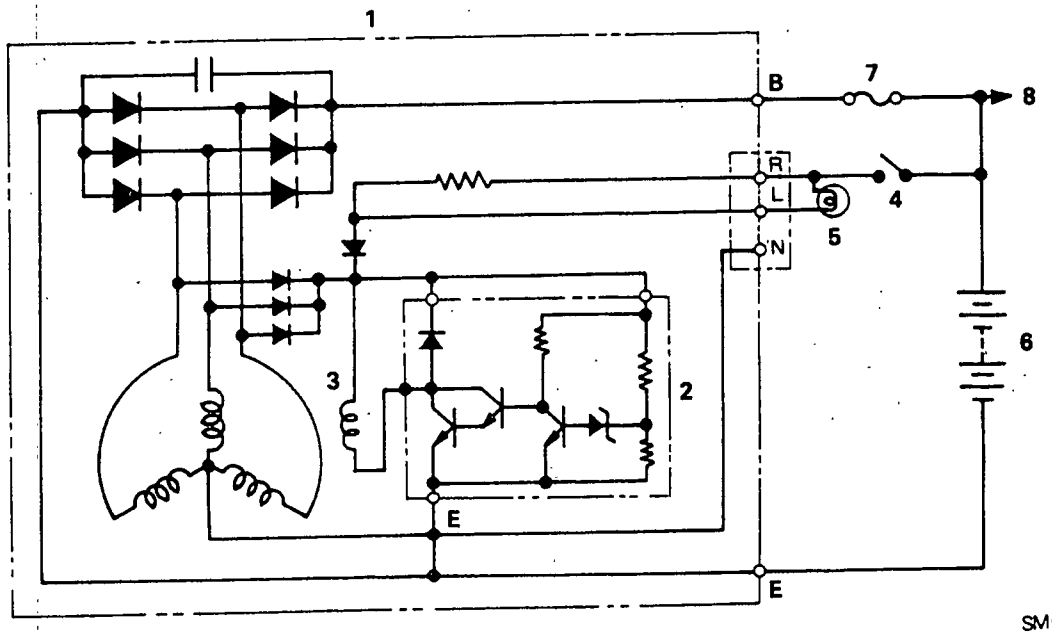
DESCRIPTION



SMGE-115

GENERATOR WITHOUT VACUUM PUMP

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



SMGE-116

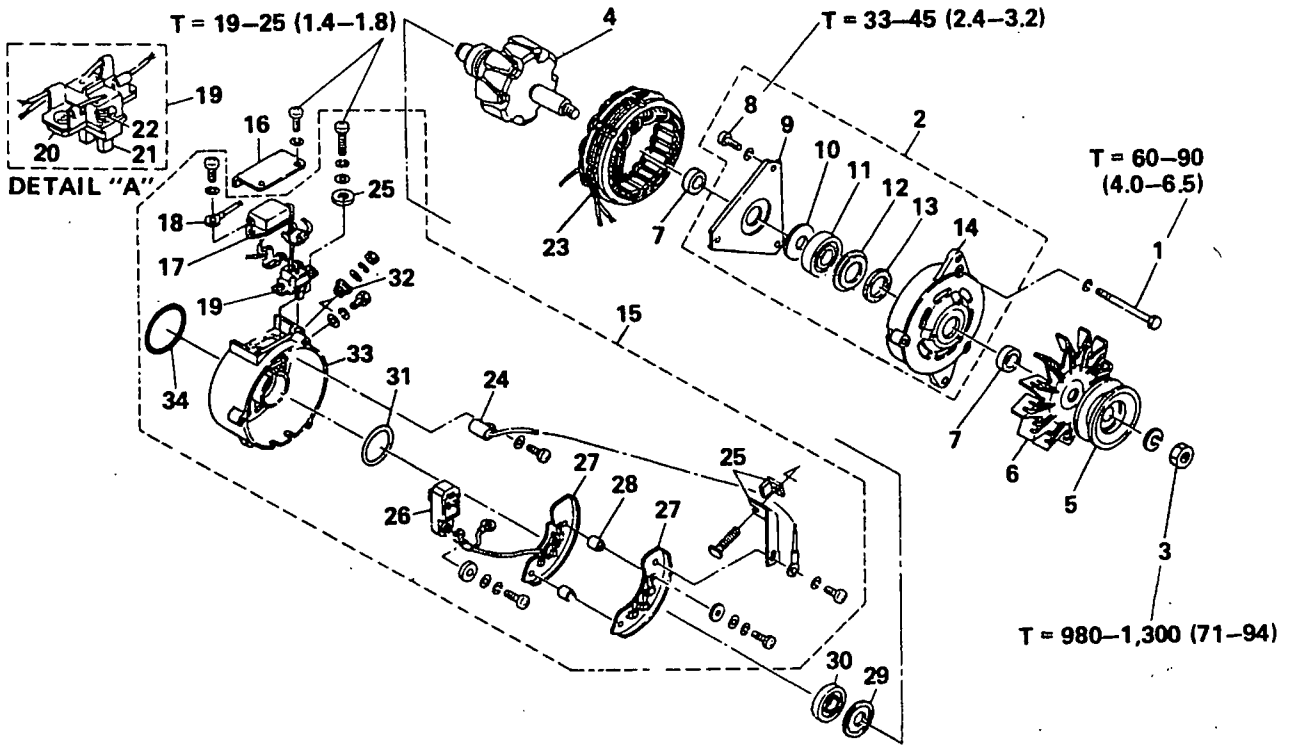
CHARGING SYSTEM CIRCUIT

1. Alternator
2. I.C. regulator
3. Field coil
4. Starter switch
5. Charging warning lamp
6. Battery
7. Fuse
8. Load

TROUBLESHOOTING

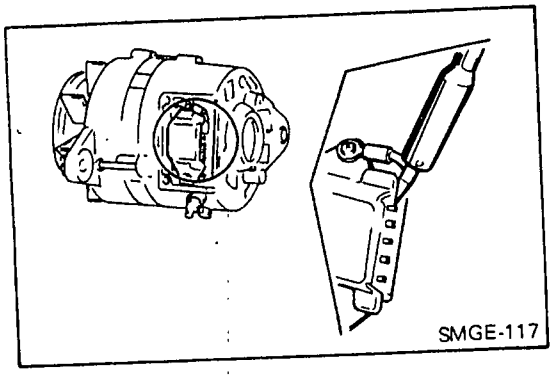
Symptom	Possible cause	Remedy/Prevention
Charging warning lamp does not light with starter switch ON and engine off	Fuse blown	Determine cause and replace fuse
	Lamp burned out	Replace lamp
	Wiring connection hose	Tighten loose connections
	Charge lamp relay faulty	Check relay
	IC regulator faulty	Replace IC regulator
Charge warning lamp does not go out with engine running (Battery requires frequent recharging)	Drive belt loose or worn	Adjust or replace drive belt
	Battery cables loose, corroded or worn	Repair or replace cables
	Fuse blown	Determine cause and replace fuse
	Fusible link blown	Replace fusible link
	Charge lamp relay, IC regulator or generator faulty	Check charging system
	Wiring faulty	Repair wiring

GENERATOR



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

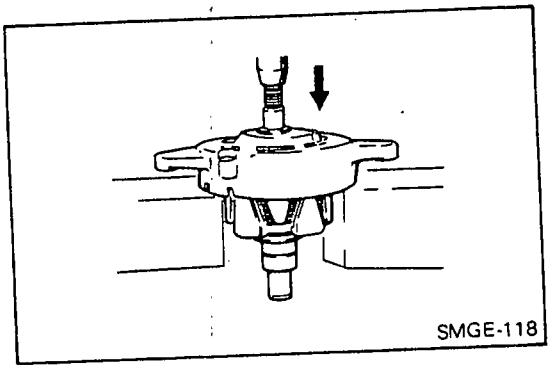
1. Through bolt
2. Front bracket assembly
3. Nut
4. Rotor
5. Pulley
6. Fun
7. Collar
8. Bolt
9. Bearing retainer
10. Retainer plate
11. Ball bearing
12. Felt cover
13. Felt
14. Front bracket
15. Rear bracket assembly
16. Cover
17. Regulator assembly
18. Terminal with lead wire
19. Brush holder assembly
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


SMGE-117

IMPORTANT POINT (S) – DISASSEMBLY

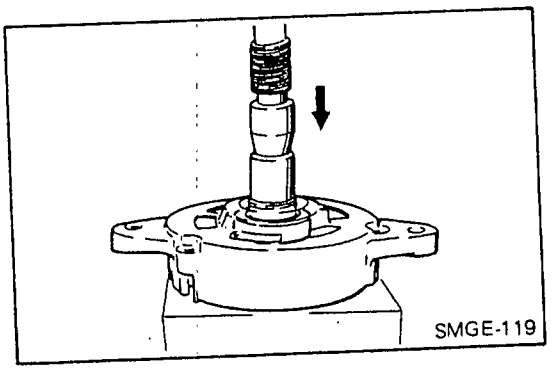
REMOVE THE REGULATOR AND THE BRUSH HOLDER.

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


SMGE-118

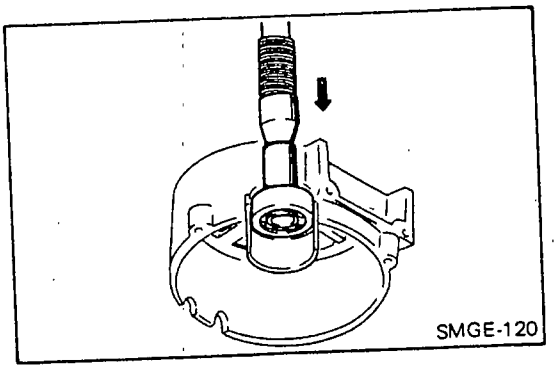
REMOVE THE ROTOR.

Using a press, remove the rotor.

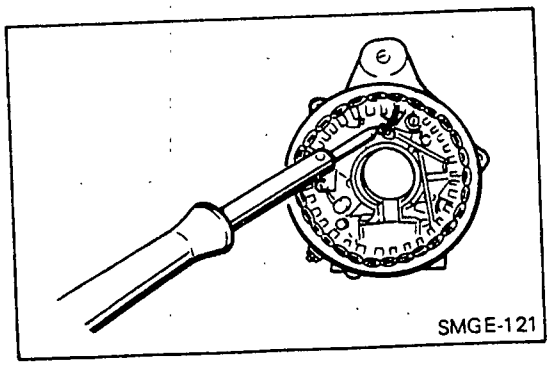

SMGE-119

REMOVE THE FRONT AND REAR BEARINGS.

1. Using a press, remove the front ball bearing.

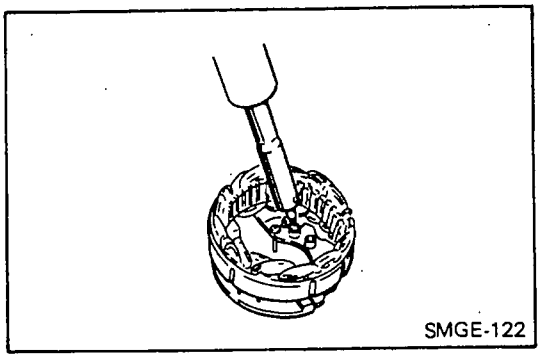

SMGE-120

2. Using a puller, remove the rear ball bearing.


SMGE-121

REMOVE THE STATOR ASSEMBLY.

1. Unsolder the regulator lead wire.

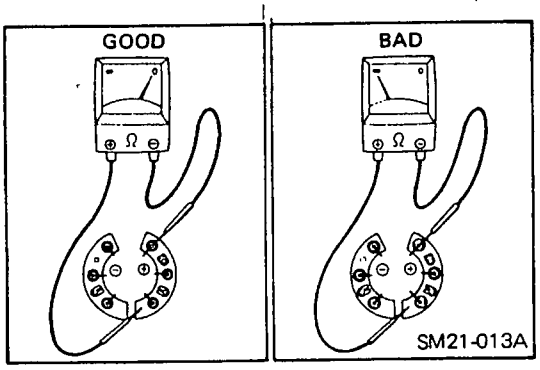

SMGE-122

2. Unsolder the each terminal of stator coil then remove the stator coil assembly.

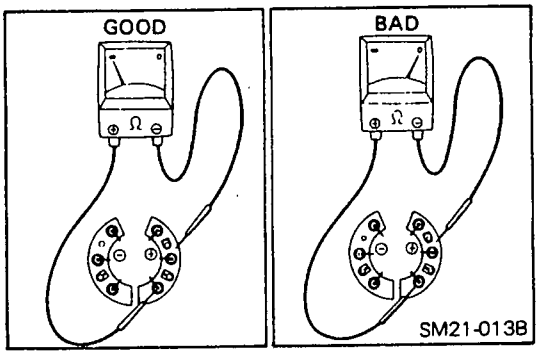
IMPORTANT POINT (S) – TESTING

RECTIFIER.

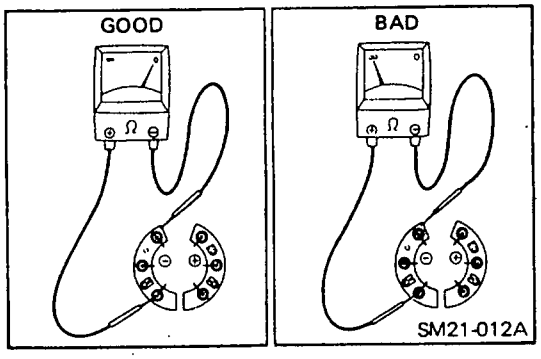
Test the each positive side rectifier condition.
Connect the circuit tester ⊕ lead to the rectifier holder and the ⊖ lead to the rectifier terminal.



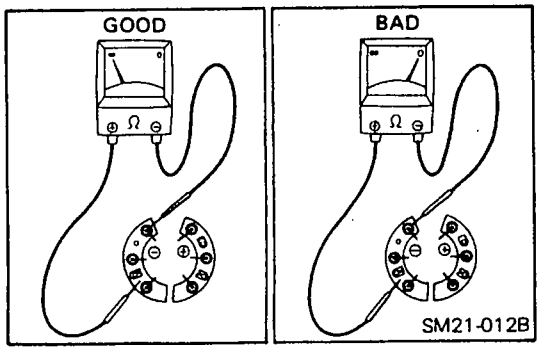
⊕ lead to the rectifier terminal and ⊖ lead to the rectifier holder.



Test the each negative rectifier condition.
Connect the circuit tester ⊕ lead to the rectifier terminal and the ⊖ lead to the rectifier holder.

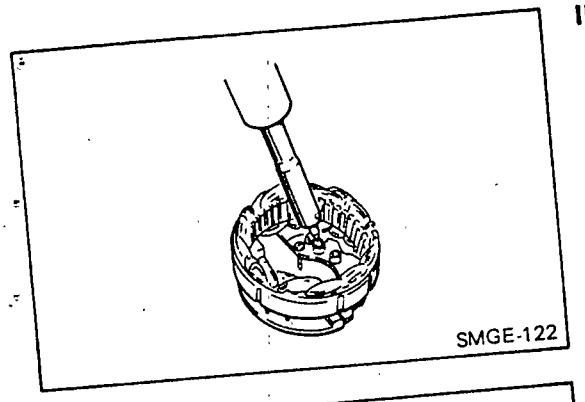


⊕ lead to the rectifier holder and ⊖ lead to the rectifier terminal.

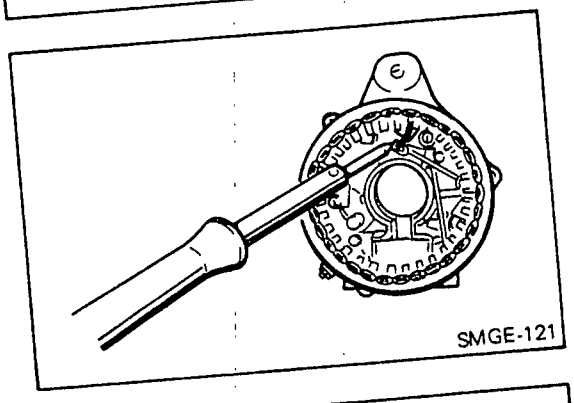


IMPORTANT POINT (S) – ASSEMBLY

INSTALL THE STARTOR COIL ASSEMBLY.

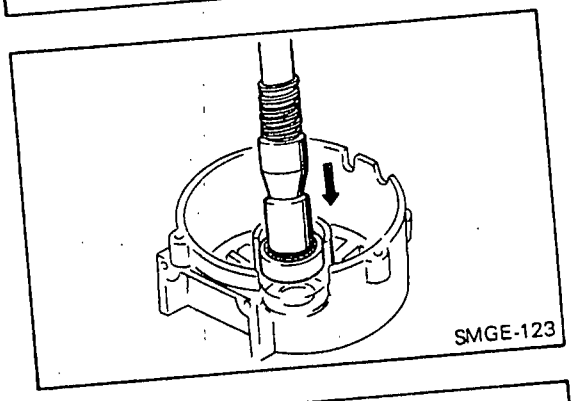

SMGE-122

1. Install the stator coil assembly, and then solder the each terminal of stator coil.

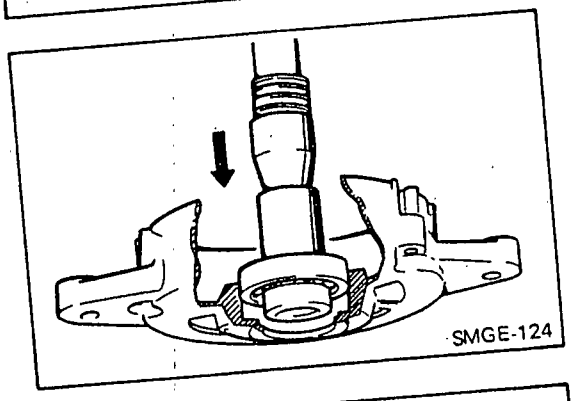

SMGE-121

2. Solder the regulator lead wire.

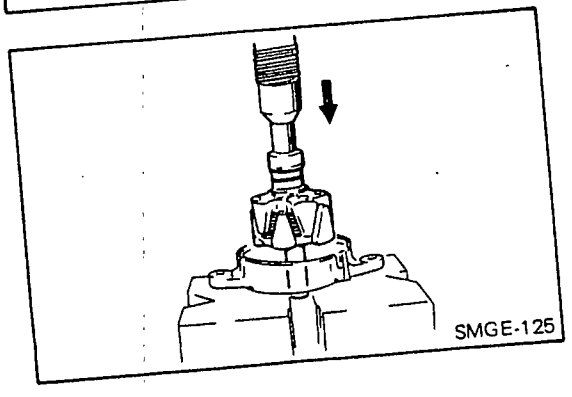
INSTALL THE FRONT AND REAR BALL BEARINGS.


SMGE-123

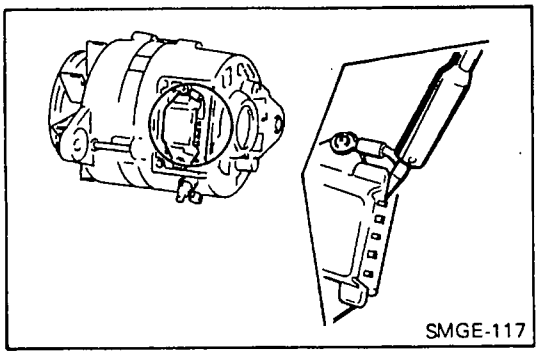
1. Using a press, install the rear ball bearing.


SMGE-124

2. Using a press, install the front ball bearing.

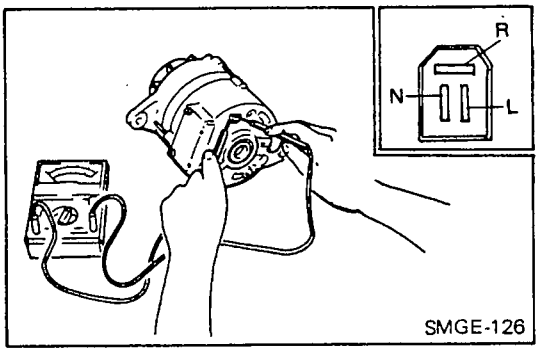

SMGE-125

3. Using a press, install the rotor assembly into the front bracket.


SMGE-117

INSTALL THE REGULATOR AND THE BRUSH HOLDER ASSEMBLY.

1. Install the brush holder assembly and regulator.
2. Solder the lead wire to the regulator.



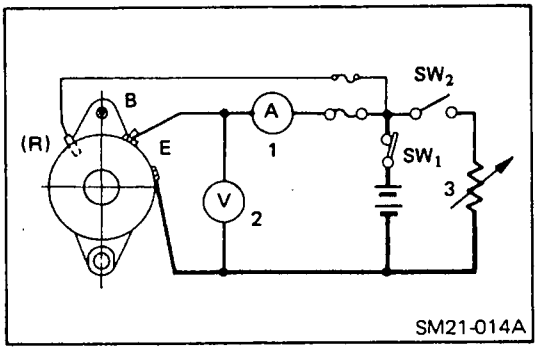
SMGE-126

AFTER ASSEMBLING THE GENERATOR, MEASURE THE RESISTANCE BETWEEN EACH TERMINAL.

Tester		Resistance	Tester		Resistance
+ Lead	– Lead	(Ω)	+ Lead	– Lead	(Ω)
B	R	∞	N	E	7–10
B	N	7–10	N	B	∞
R	L	400–500	E	R	∞
R	E	∞	E	L	∞
L	E	∞	E	N	∞

PERFORMANCE TEST

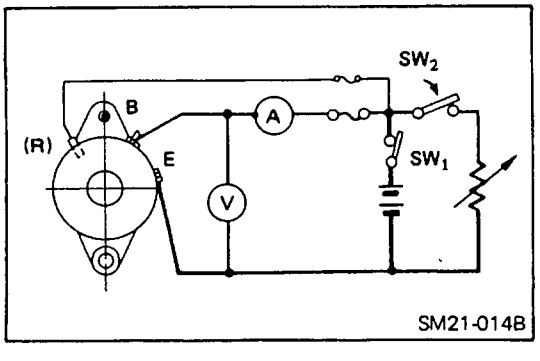
NOTE:
- **Note the battery polarity carefully so as not to make reverse connections.**
  If the connections are reversed, the diodes will short the circuit and allow large current to flow through and damage the diodes and IC regulator as well as burn up the wiring harness.
- **Use care not to make wrong connections of terminals.**
- **When charging the battery with a quick charge.**
  Disconnect the battery terminals.
- **Do not perform tests with high voltage insulation resistance tester.**
- **When in operation, never disconnect the battery.**



SM21-014A

GENERATOR PERFORMANCE TEST.

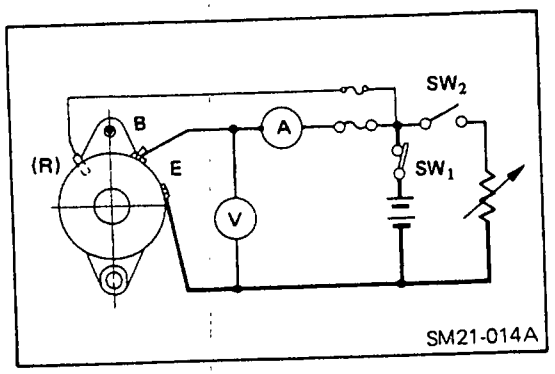
1. Turn on switch SW_1 and off SW_2 to increase the rotation of the alternator slowly.



SM21-014B

2. When voltage reaches 28V, turn on switch SW_2 regulate load resistance. Increase the rotation of the rotor keeping voltage at 28V.

Generator Speed: 5,000 rpm at 28V, 20A



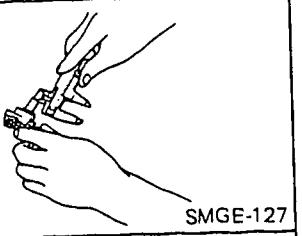
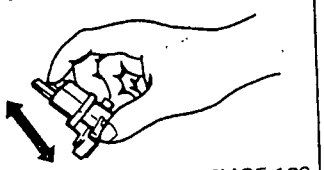
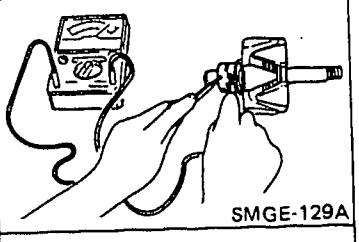
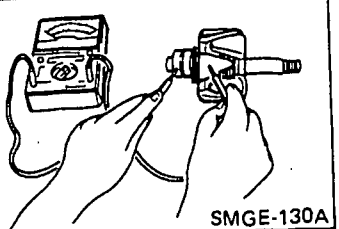
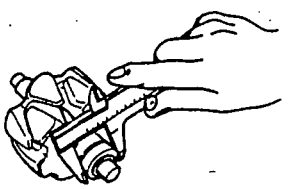
VOLTAGE REGULATION TEST.

Turn on switch SW_1 and off SW_2 to increase the rotation of rotor to 5,000 rpm.

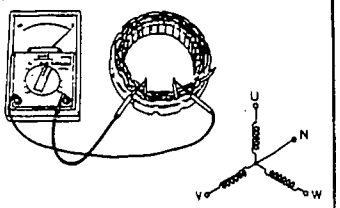
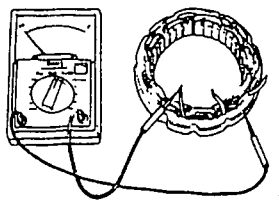
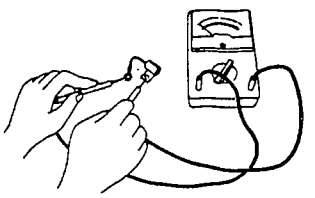
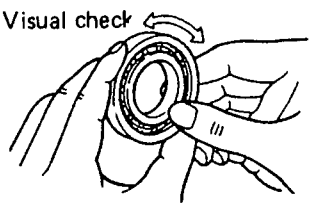
Standard Voltage: 28.5 ± 0.5 V

INSPECTION AND REPAIR

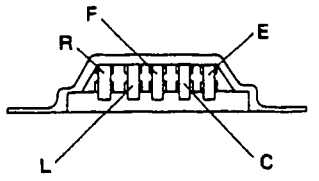
Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Brush length	16 (0.630)	7.0 (0.2755)	Replace	 SMGE-127
Function of the brush holder.	—	—	Replace, if necessary.	Visual check  SMGE-128
Conductance of the rotor coil.	About 12.5Ω	Less than 11Ω or infinity (∞)	Replace.	 SMGE-129A
Insulation between the slip ring and the core.	More than 1.0 MΩ	Less than 0.5 MΩ	Replace.	 SMGE-130A
Diameter of the slip ring.	34.5 (1.3583)	33.5 (1.3188)	Replace.	 SMGE-131A

Unit: mm (in)

Inspection Item	Standard		Limit	Remedy	Inspection Procedure
Conductance of the stator coil (U.V.W. terminal)	N–U N–V N–W	About 0.4Ω	–	Replace	 SM21-037
Insulation of the stator coil.	More than 1.0 MΩ		Less than 0.5 MΩ	Replace	 SM21-038
Condenser capacity.	0.5 μF		–	Replace	 SMGE-114
Wear or damage of the bearings.	–		–	Replace, if necessary.	Visual check  SM21-083
Wear or damage of the oil seal and O-ring.	–		–	Replace, if necessary.	Visual check –

Unit: mm (in)

Inspection Item		Standard	Limit	Remedy	Inspection Procedure
Resistance between each terminal of I.C. regulator.			–	Replace.	 SM21-035
+ Lead Tester	– Lead Tester				
R	L	About 10 Ω			
R	F	About 10 Ω			
R	C	∞			
R	E	About 1.5K Ω			
L	F	About 10 Ω			
L	C	About 90 Ω			
L	E	About 100 Ω			
F	C	About 10 Ω			
F	E	About 180 Ω			
C	E	About 40 Ω			
L	R	∞			
F	R	∞			
C	R	∞			
E	R	∞			
F	L	About 2K Ω			
C	L	∞			
E	L	About 1.5K Ω			
C	F	∞			
E	F	∞			
E	C	∞			

(K.P.)

ST-79E-01

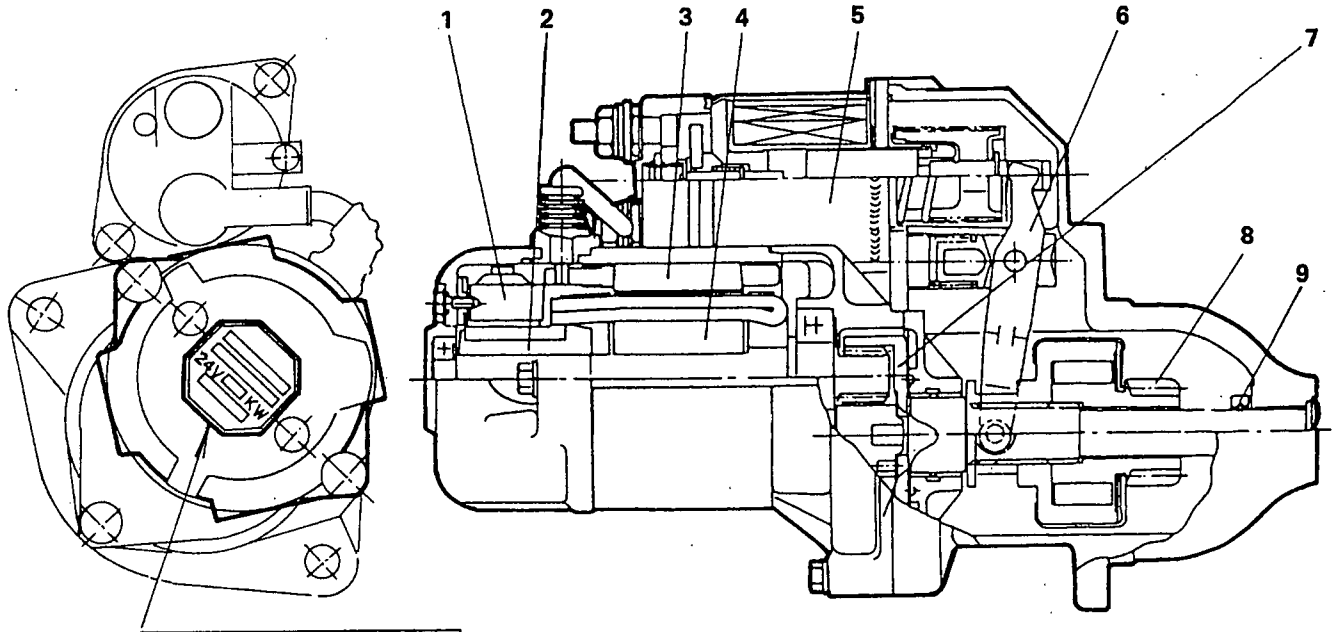
CHAPTER ST

STARTER
(24V, 7,0KW)

DATA AND SPECIFICATIONS

MODEL NO.	28100-1790
STARTER	
Type	Reduction gear type
Rated output	24V, 7.0kW
Number of teeth of pinion	11
Module	3.5
Rotating direction	Clockwise (Seen from pinion side)

DESCRIPTION



The starter parts number is engraved at the commutator end frame

SMST-124A

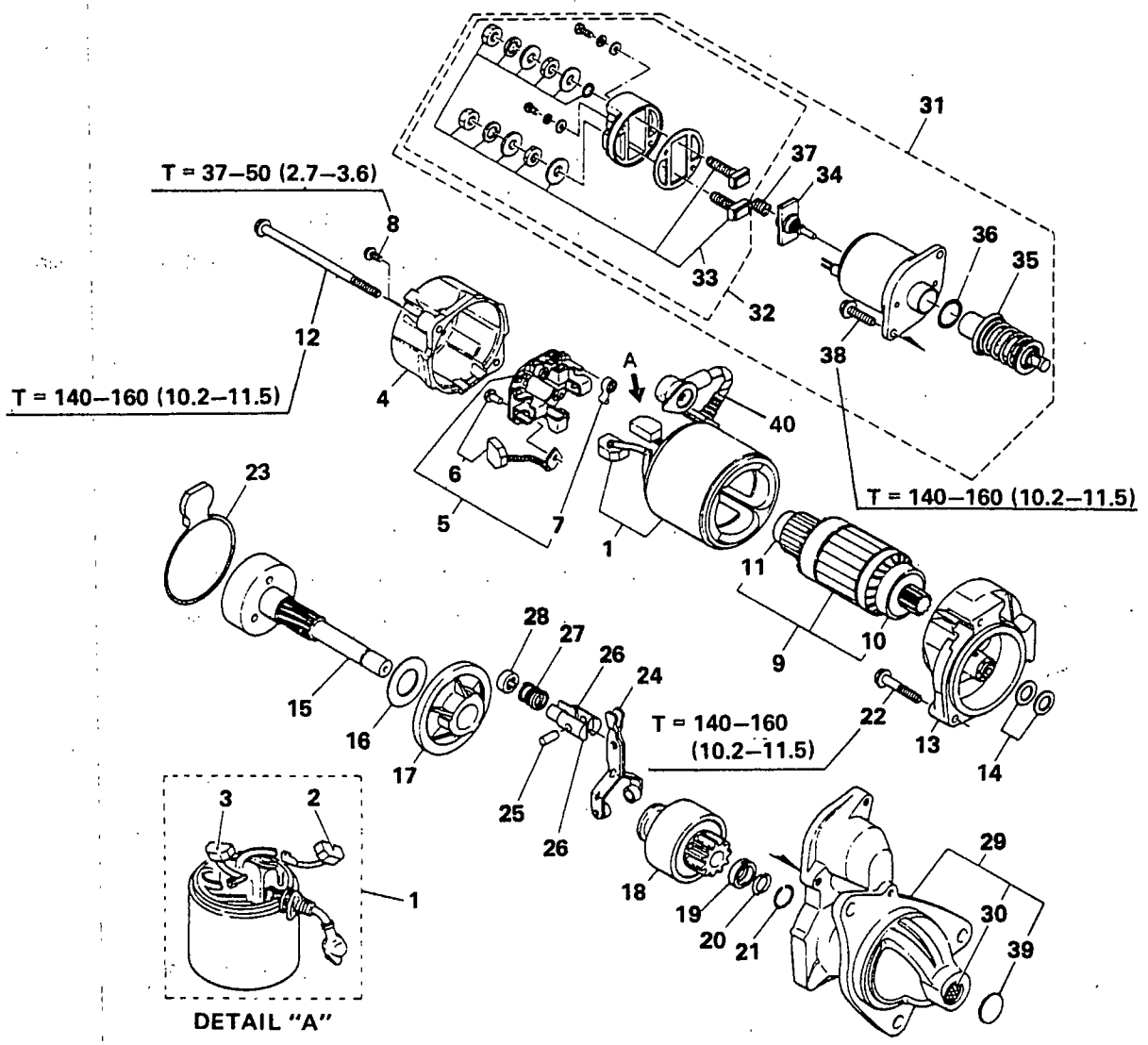
1. Brush
2. Commutator
3. Field coil
4. Armature
5. Magnetic switch
6. Pinion shift lever
7. Reduction gear
8. Clutch and pinion
9. Pinion stopper

TROUBLESHOOTING

Symptom	Possible cause	Remedy/Prevention
Engine does not crank, or cranks slowly.	**Key switch**	
	• Poor contact	Polish or replace contacts
	Battery	
	• Discharged battery	Charge
	• Short circuited between electrodes	Replace battery
	• Poor contact at battery terminal	Polish or retighten
	Engine oil	
	• Improper viscosity oil	Change oil
	Magnetic switch	
	• Poor contact caused by burnt contact plate	Polish or replace contact plate
	• Contact plate worn out	Repair
	• Hold-in coil disconnected (Overrunning clutch moves back and forth)	Replaced field coil
	• Pull-in coil disconnected or short circuited	Replace
	Starter relay	
	• Defective or poor contact	Repair or replace
	Starter	
	• Brush worn out	Replace
	• Commutator burnt out	Correct on lathe
	• Commutator worn out	Correct by undercutting
	• Field winding shorted or grounded	Rewind or replace
	• Armature winding shorted or grounded	Replace armature
	• Insufficient brush spring tension	Replace brush spring
	• Poor contact between magnetic switch and field windings	Repair
	• Armature contacts pole core because of worn bearing bush or bent armature shaft	Replace bearing brush or armature
	• Overrunning clutch mulfunction	Replace
Engine does not crank while starter is running in good condition	**Overrunning clutch**	
	• Overrunning clutch mulfunction	Replace
	• Pinion teeth worn out	Replace
	• Poor sliding of spline teeth	Remove foreign materials, dirt, or replace

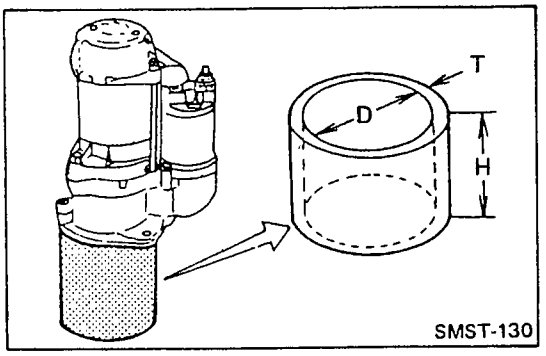
Symptom	Possible cause	Remedy/Prevention
Starter does not stop running.	**Key switch**	
	• Contacts keep closing.	Replace
	• Key switch sticks.	Replace
	• Overrunning clutch sticks to armature	Repair or replace overrunning clutch or armature
	Starter relay	
	• Contacts keep closing.	Repair or replace

STARTER



T = Tightening torque: kg·cm (lb.ft)

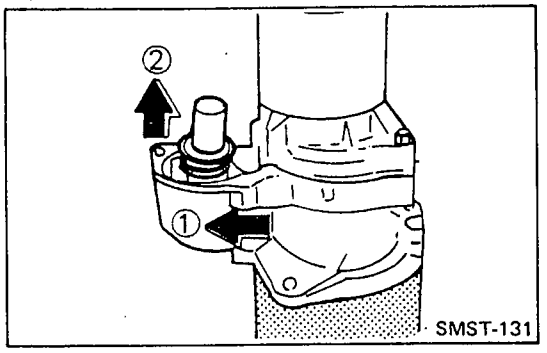
1. Yoke assembly
2. Brush
3. Brush
4. Commutator end frame
5. Brush holder assembly
6. Brush
7. Brush spring
8. Set bolt
9. Armature assembly
10. Ball bearing
11. Ball bearing
12. Set bolt
13. Gear housing
14. Shim
15. Drive shaft assembly
16. Shim
17. Bearing housing
18. Clutch and pinion assembly
19. Pinion stopper
20. Hook
21. Clip
22. Set bolt
23. Gasket
24. Drive pinion lever
25. Lever pinion
26. Lever holder
27. Holder spring
28. Insert
29. Drive housing assembly
30. Bushing
31. Magnetic switch assembly
32. Contactor with terminal cover assembly
33. Terminal assembly
34. Contactor assembly
35. Moving core assembly
36. O-ring
37. Contactor spring
38. Bolt
39. Plug
40. M terminal



IMPORTANT POINT(S) – DISASSEMBLY

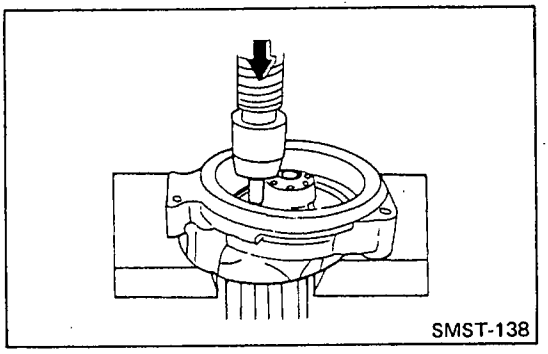
When disassembling the starter, prepare a work stand as shown in the figure.

D: Diameter = 130 mm (5.118 in)
T: Thickness = 10 mm (0.394 in)
H: Hight = 120 mm (4.724 in)



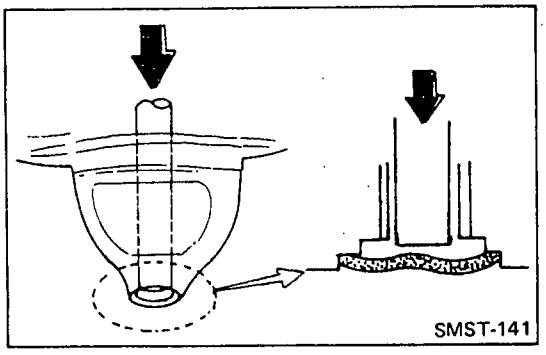
REMOVE THE MOVING CORE.

Remove the moving core in the direction of the marked arrow in the order ① and ②.



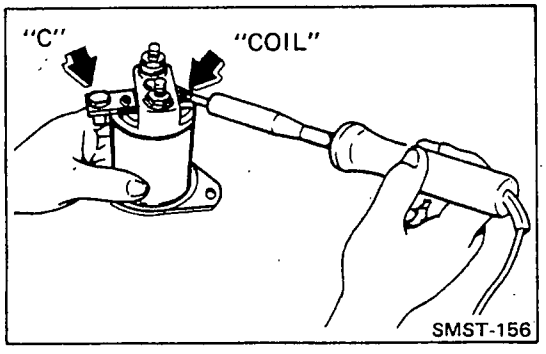
REMOVE THE ARMATURE ASSEMBLY.

Using a press, remove the armature assembly.



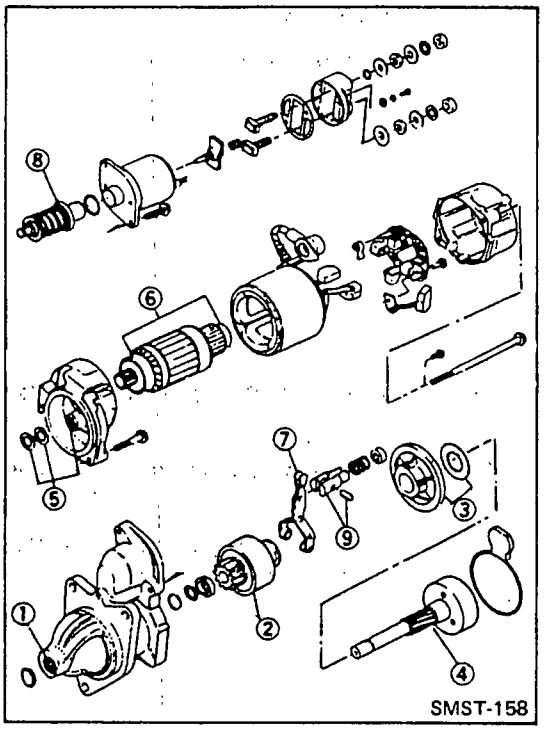
REMOVE THE PLUG

Remove the drive housing plug using a press.



REMOVE THE MAGNETIC SWITCH.

Unsolder the "COIL" terminal and "C" terminal.

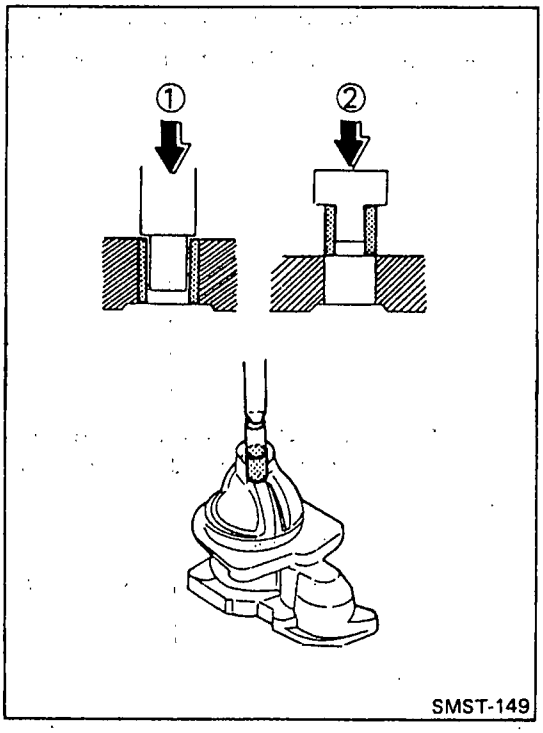


IMPORTANT POINT(S) – ASSEMBLY

LUBRICATION

Before reassembling, apply the recommended grease as follows and replace the O-ring with new one.

① Bushing
② Clutch and pinion assembly
③ Bushing and shim
④ Drive shaft
⑤ Gear housing and shim
⑥ Bearing
⑦ Drive pinion lever
⑧ Moving core
⑨ Lever holder and pin

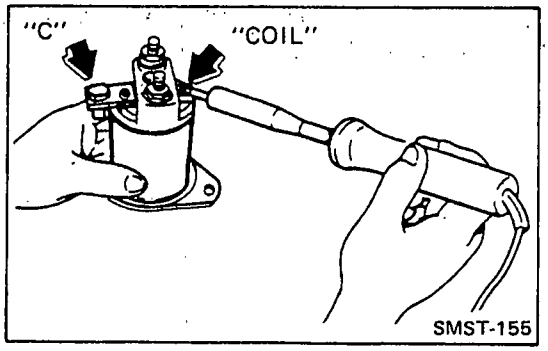


REPLACEMENT OF BUSHING

① Remove the bushing using a press.

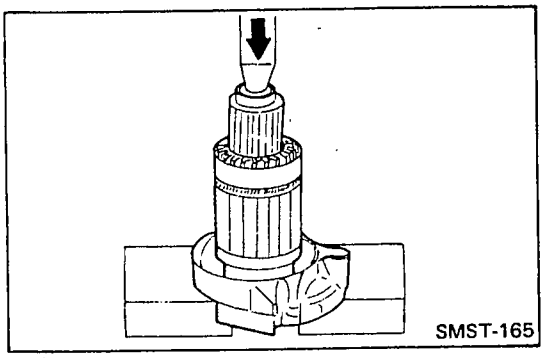
② Replace the bushing with a new one using a press.

NOTE: In the case of the bearing housing bushing, also replace the bearing housing bushing.



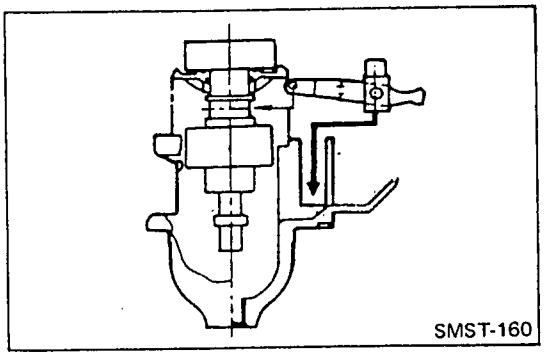
INSTALL THE MAGNETIC SWITCH.

Solder the "COIL" terminal and "C" terminal.


SMST-165

INSTALL THE ARMATURE ASSEMBLY.

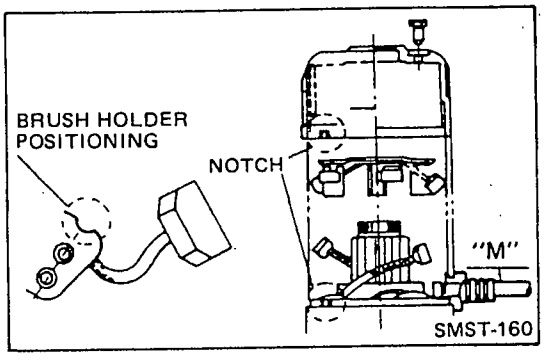
Using a press, install the armature assembly.


SMST-160

TO REASSEMBLE, FOLLOW THE DISASSEMBLY PROCEDURE IN REVERSE ORDER.

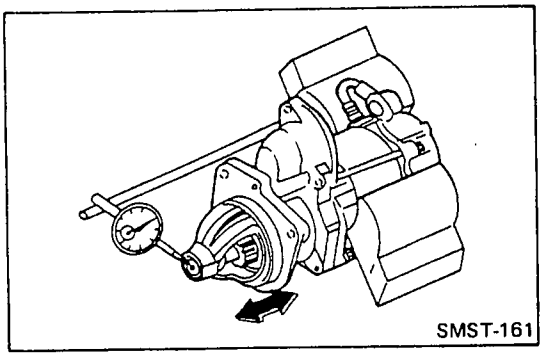
NOTE: When assembling the starter, pay attention to the following points.

1. When installing the drive pinion lever on the shaft, pay attention to the direction in which the lever is installed.



SMST-160

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

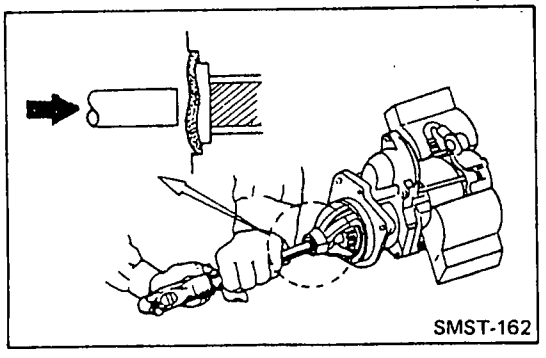

SMST-161

MEASURE THE THRUST GAP.

After assembling the starter (without the magnetic switch), use a dial gauge to measure the thrust gap as you move the drive shaft in and out by hand.

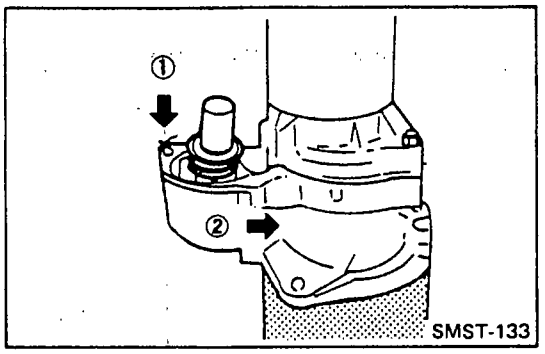
Standard: 0.1 – 0.5 mm (0.004 – 0.0196 in)

If the thrust gap exceeds the standard, adjust by decreasing or increasing the shim.


SMST-162

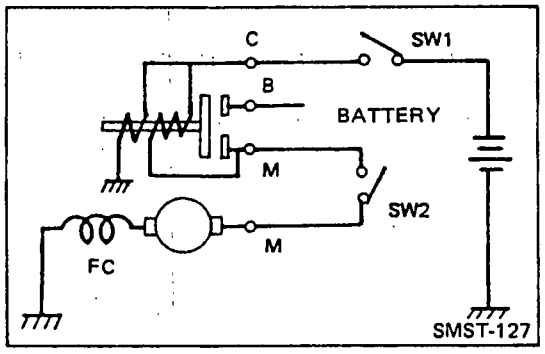
AFTER MEASURE THE NO-LOAD TEST OF THE STARTER, INSTALL THE DRIVE HOUSING PLUG.

NOTE: Use a new plug.



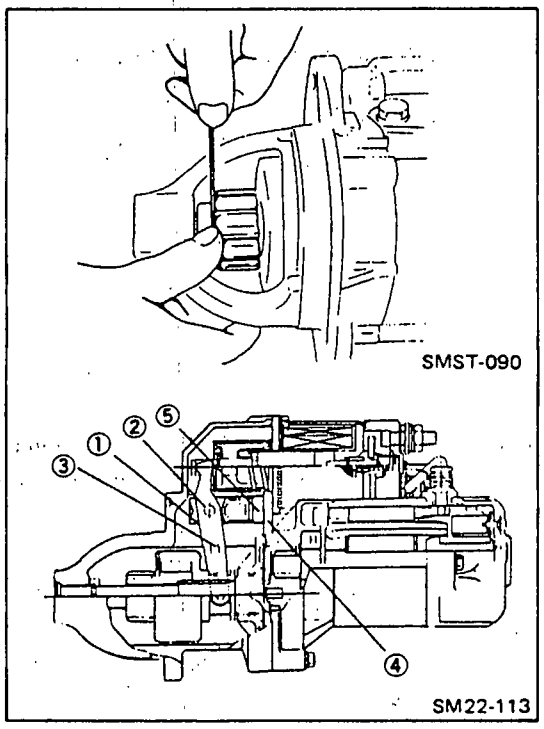
INSTALL THE MOVING CORE.

Install the moving core in the direction of the marked arrow in the order ① and ②.



AFTER ASSEMBLING THE STARTER, MEASURE THE TIMING GAP.

- Arrange the circuit.
- Close switches SW1 and SW2.
- Open SW2 alone when the pinion pops out.
- In the above condition, push the pinion back to measure the gap.



Standard: 0.5 – 3.0 mm (0.020 – 0.118 in)

If the gap exceeds the standard, check the following parts and, if necessary, replace them.

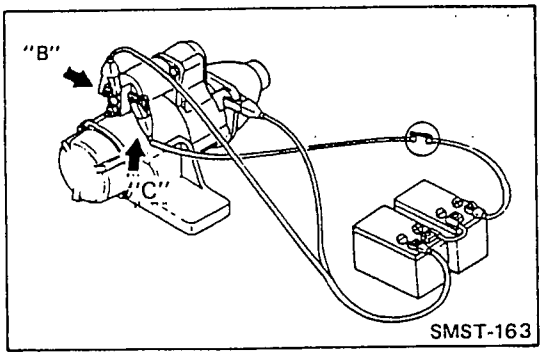
① Lever holder
② Lever pin
③ Drive pinion lever
④ Gasket
⑤ Insert

TEST

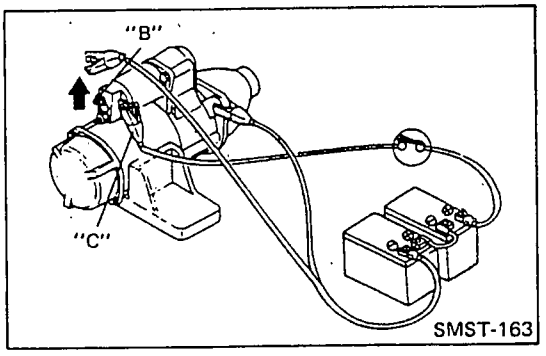
MAGNETIC SWITCH TEST.

The following test should be performed with the starter assembled without the "M" terminal lead with specified voltage applied.

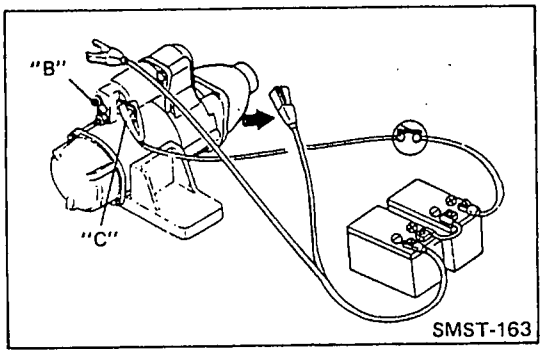
NOTE: **Each test should be performed a short time (3 to 5 sec.) to prevent the magnetic switch winding from burning.**



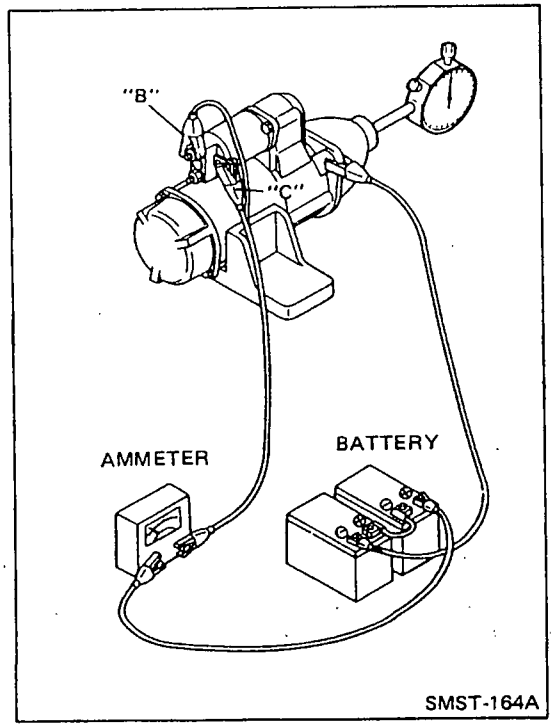
1. Pull-in test
Connect the test leads as shown. When the switch is closed, the pinion should jump out.



2. Holding test
With the same procedure as the pull-in test, disconnect the "B" terminal.
The pinion should remain in the "jumped out" position.



3. Return-test
With the same procedure as in the hold-in test, disconnect the "EARTH" jumper wire.
The pinion should return immediately.



PERFORMANCE TEST

The following test should be carried out after reassembling the starter. If suitable equipment is not available, at least the no-load test should be carried out.

No-load test

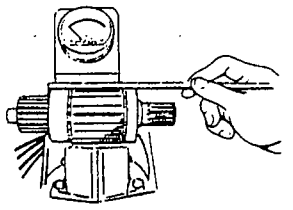
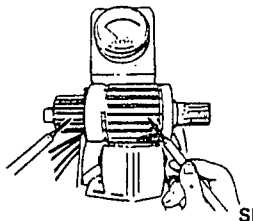
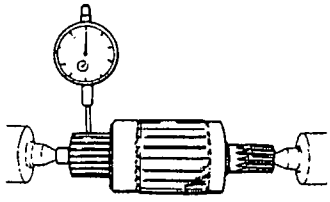
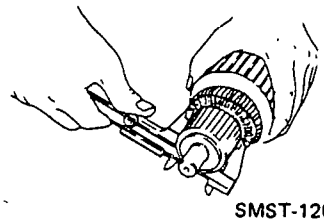
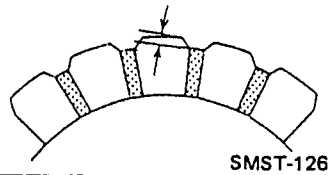
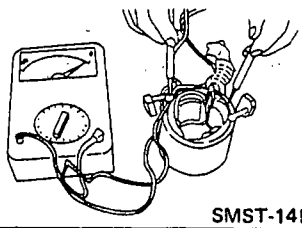
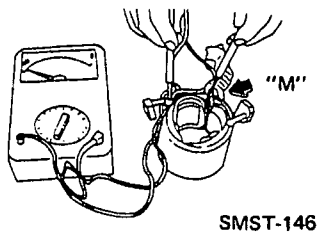
- With the starter securely clamped in a vice.
- Using a battery and suitable ammeter.
- Connect the positive lead to the ammeter, "B" and "C" terminal.
- Connect the "M" terminal.
- Connect the negative lead to the starter body.

The starter should show smooth and steady rotation immediately after jumping out of the pinion and should draw less than the specified current.

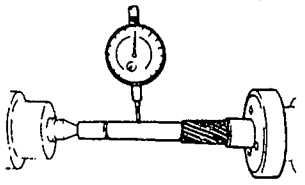
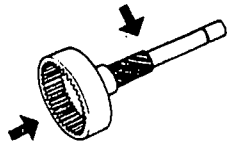
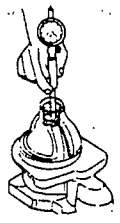
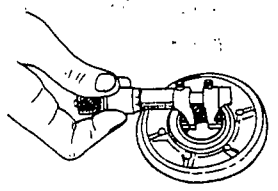
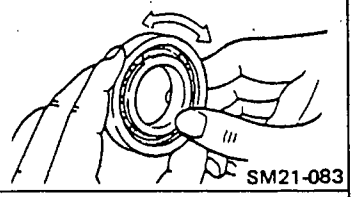
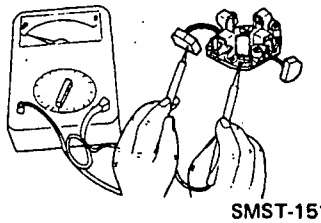
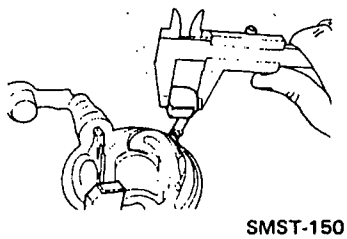
Revolution	**More than 4,000 rpm**
Current	**Less than 120A**

INSPECTION AND REPAIR

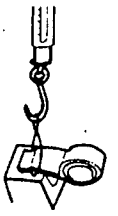
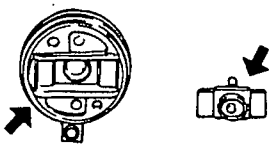
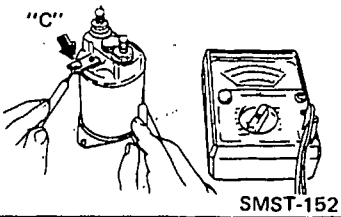
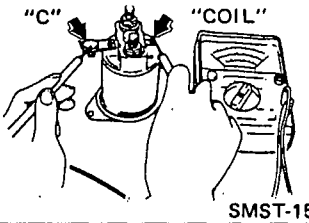
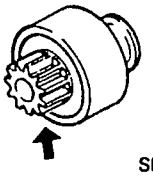
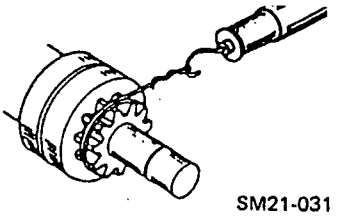
Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Armature Short Circuit Test	–	If the iron place is not vibrated, the armature is good	Repalce	 SMST-091
Armature Insulation	More than 1 MΩ	Less than 0.5 MΩ	Replace	 SMST-092
Swing of the Commutator	0.05 (0.0020)	–	Replace	 SMST-093
Outside Diameter of the Commutator	44.0 (1.7323)	42.0 (1.6535)	Replace	 SMST-126
Depth of Under Cut of the Mica	0.5–0.8 (0.0197–0.0315)	0.2 (0.0078)	Replace	COMMUTATOR UNDERCUT  SMST-126
Conductance between the Brush and the Yoke Body	–	Should be conducted	Replace	 SMST-145
Insulation between the Brush and the "M" Terminal	More than 1 MΩ	Less than 0.5 MΩ	Replace	 SMST-146

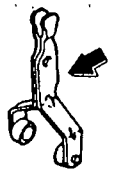
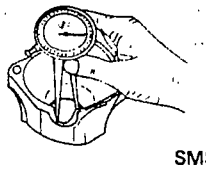
Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Bend of he Drive Shaft	0.05 (0.0020)	0.1 (0.0039)	Replace	 SMST-096
Wear or Damage of the Internal Gear and the Spline	–	–	Replace, if necessary	VISUAL CHECK  SMST-897
Drive Housing Bushing Inside Diameter	20.0 (0.7874)	20.2 (0.7952)	Replace	 SMST-147
Bearing Housing Inside Diameter.	35.0 (1.3780)	35.2 (1.3858)	Replace	 SMST-148
Wear or Damage of the Bearing	–	–	Replace, if necessary	VISUAL CHECK  SM21-083
Insulation between the Brush Holder and Bracket	More than 1 MΩ	Less than 0.5 MΩ	Replace	 SMST-151
Brush Length	20.0 (0.7874)	15.0 (0.5905)	Replace	 SMST-150

Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Tension of the Brush Springs	1.8 kg (3.97 lb)	1.2 kg (2.64 lb)	Replace	 SMST-117
Wear or Damage of the Moving Core, Spring, Seal Rubber and Seat	–	–	Repalce, if necessary	VISUAL CHECK
Damage of the Contactor Point	–	–	Replace, if necessary	VISUAL CHECK  SMST-104
Conductance between the C Terminal and the Body (Holding Coil)	0.2 – 0.6 Ω	Should be conducted	Repalce	 SMST-152
Conductance between the C Terminal and the Coil Terminal (Pulling Coil)	0.1 – 0.3 Ω	Should be conducted	Replace	 SMST-153
Damage of the Pinion Teeth	–	–	Replace, if necessary	VISUAL CHECK  SMST-158
Rotating Toruqe of Pinion	6 – 8 kg·cm (0.44 – 0.57 lb.ft)	–	Replace, if it turns both side or does not turn at all.	 SM21-031

Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Wear or Damage of the Pinion Shift Lever	—	—	Replace, if necessary	VISUAL CHECK  SMST-108
Damage of the O-rings	—	—	Replace, if necessary	VISUAL CHECK
Commutater End Frame Inside Diameter.	35.0 (1.3780)	35.1 (1.3818)	Replace	 SMST-159

CHAPTER C

INJECTION PUMP CALIBRATION

C-112E-01

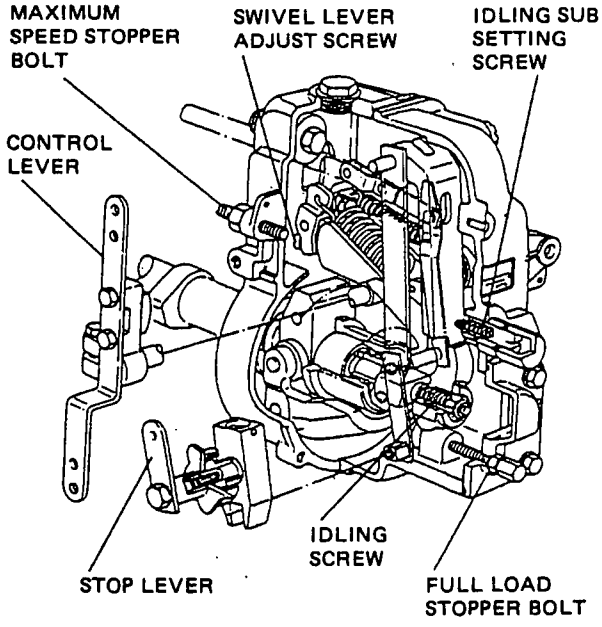
INJECTION PUMP NUMBER: 22020-3580A. USE FOR GENERATOR SET (50 Hz, 1,500 rpm)

INJECTION PUMP SPECIFICATION	Engine model		EK130T
	Injection pump part number		22020-3580A
	Injection pump type		NP-PE6P120/321LS3000
	Governor type		NP-EP/RSV200-1180
	Timer type		Not equipped
	Feed pump type		NP-FP/K-P
TEST CONDITION	Test nozzle type		105780-8140
	Test nozzle opening pressure		175 kg/cm^2 (2,489 psi)
	Injection pipe	Outer diameter	8.0 mm (0.315 in)
		Inner diameter	3.0 mm (0.118 in)
		Length	600 mm (23.6 in)
	Calibration oil	Type	SAE J967C
		Oil temperature	40 – 45°C (104 – 113°F)
	Fuel feed pressure		1.6 kg/cm^2 (22.8 psi)
OVERFLOW VALVE	Opening pressure		1.5 – 1.8 kg/cm^2 (21.33 – 25.59 psi)
INJECTION TIMING	Rotation		Clockwise viewed from drive side
	Injection order		1–4–2–6–3–5
	Injection interval		60° ± 30′
	Pre-stroke		3.2–3.3 mm (0.126–0.129 in)

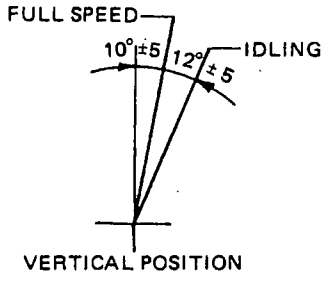
INJECTION VOLUME	Rack position mm (in)	Pump speed (rpm)	Measuring strokes	Injection volume cc (cu.in)	Max. variation limit (%)
A	9.1 (0.358)	750	500	79.75–83.25 (4.867–5.080)	± 4
B	8.7 (0.343)	750	500	72.40–75.40 (4.419–4.601)	± 4
C	5.0 (0.197)	360	500	3.75–6.75 (0.229–0.411)	±15

GOVERNOR ADJUSTMENT

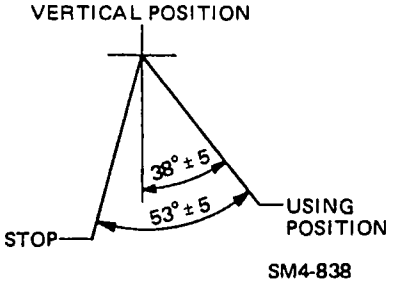
ADJUSTING POSITION



CONTROL LEVER ANGLE



STOP LEVER ANGLE

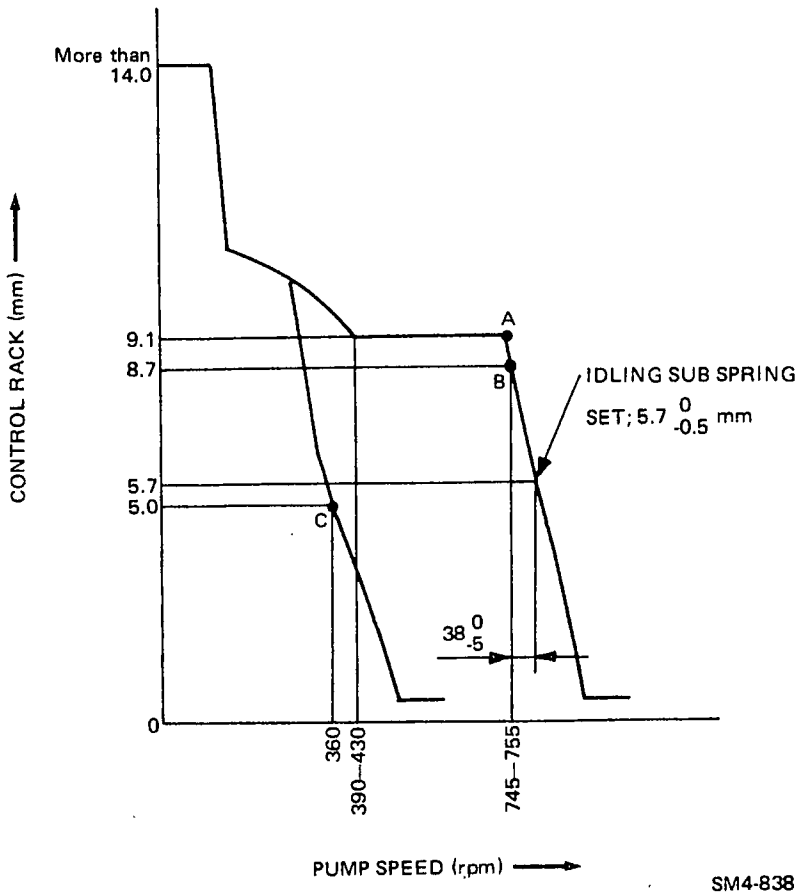


SM4-838

GOVERNOR CHARACTERISTIC DIAPHRAGM

NOTE: Recommended setting of swivel adjusting screw — 7 clicks from bottom end.

GOVERNING RANGE: 360—750 rpm



SM4-838

C-112E-01 (K.P.)

C-113E-01

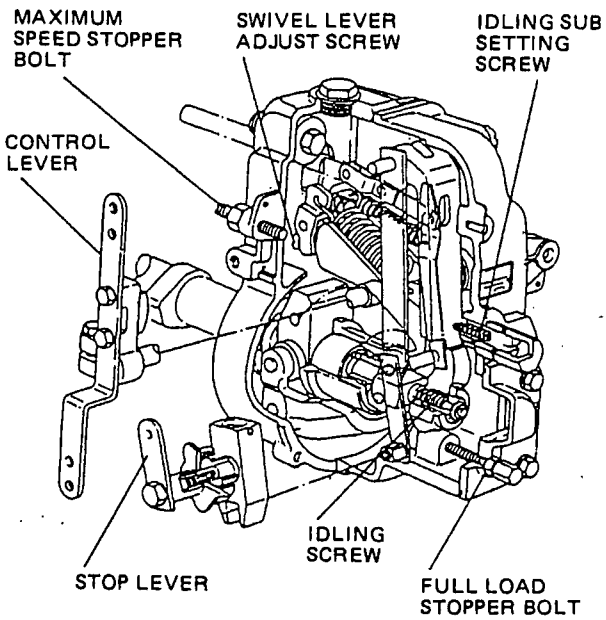
INJECTION PUMP NUMBER: 22020-2794A
USE FOR GENERATOR SET (50 Hz, 1,500 rpm and 60 Hz, 1,800 rpm)

INJECTION PUMP SPECIFICATION	Engine model				EK130T	
	Injection pump part number				22020-2794A	
	Injection pump type				NP-PE6P120	
	Governor type				NP-EP/RSV200-1180	
	Timer type				Not equipped	
	Feed pump type				NP/K-P	
TEST CONDITION	Test nozzle type				105780-8140	
	Test nozzle opening pressure				175 kg/cm^2 (2,489 psi)	
	Injection pipe	Outer diameter			8.0 mm (0.31 in)	
		Inner diameter			3.0 mm (0.12 in)	
		Length			600 mm (23.6 in)	
	Calibration oil	Type			SAE J967C	
		Oil temperature			40–45°C (104–113°F)	
	Fuel feed pressure				1.6 kg/cm^2 (22.8 psi)	
OVERFLOW VALVE	Overflow valve opening pressure				1.5–1.8 kg/cm^2 (21.33–25.59 psi)	
INJECTION TIMING	Rotation				Clockwise viewed from drive side	
	Injection order				1–4–2–6–3–5	
	Injection interval				60° ± 30′	
	Pre-stroke				3.2–3.3 mm (0.126–0.129 in)	

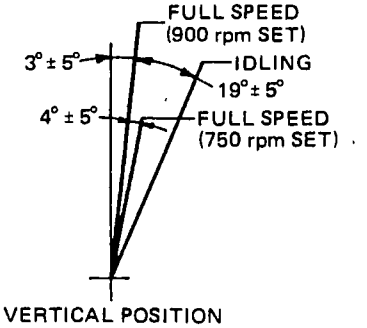
INJECTION VOLUME		Rack position mm (in)	Pump speed (rpm)	Measuring strokes	Injection volume cc (cu.in)	Max. variation limit (%)
	A	9.0 (0.35)	900	500	79.50–82.50 (4.852–5.034)	± 4
	B	9.3 (0.37)	750	500	85.75–87.75 (5.233–5.354)	± 4
	C	About 4.9 (0.19)	360	500	5.90–8.90 (0.360–0.543)	±15

GOVERNOR ADJUSTMENT

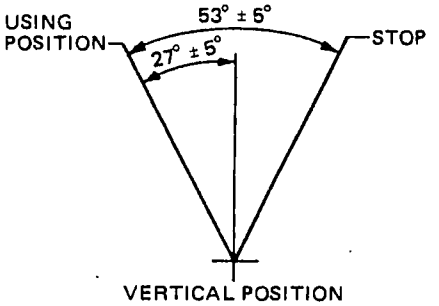
ADJUSTING POSITION



CONTROL LEVER ANGLE



STOP LEVER ANGLE

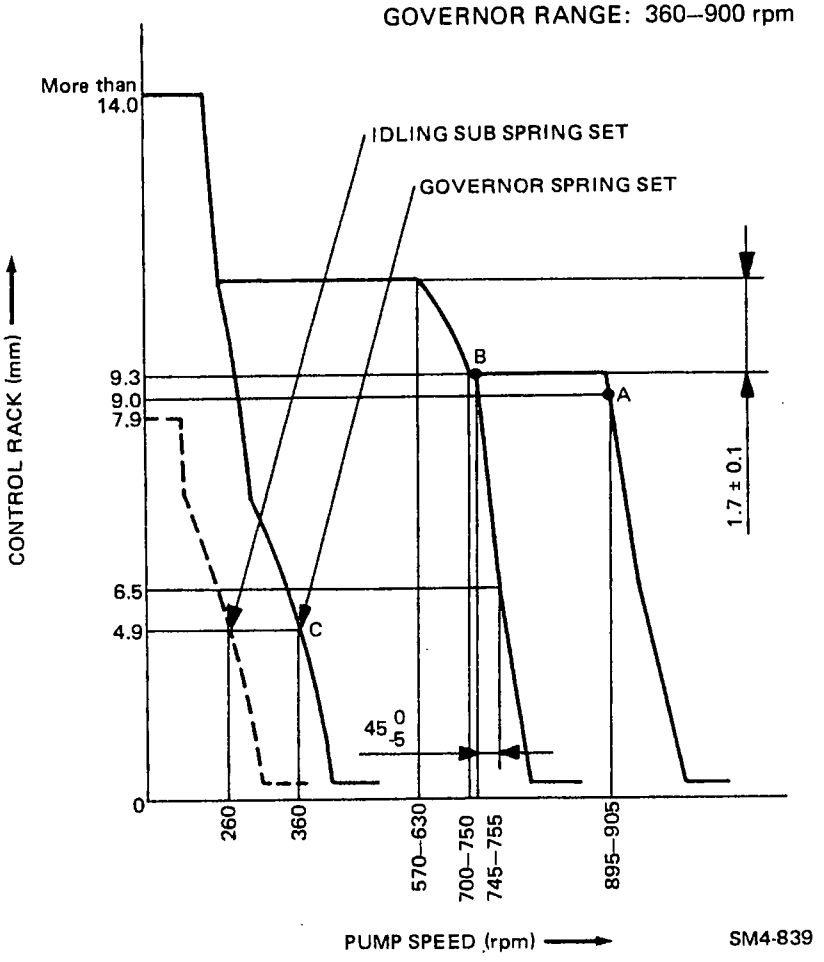


SM4-839

GOVERNOR CHARACTERISTIC DIAPHRAGM

NOTE: ○ Recommended setting of swivel adjusting screw – 7 clicks from bottom end.
○ Control rack position is less than 4.4 mm (0.173 in) when stop lever is stop position at pump speed 0 rpm.

GOVERNOR RANGE: 360–900 rpm



C-113E-01 (K.P.)