INTRODUCTION

This service manual has instructions and procedures for the Mitsubishi SL-series diesel engines.

The information, specifications and illustrations in this manual are on the basis of the information that was current at the time this issue was written.

Correct servicing, test and repair procedures will give the engine a long service life. Before starting a test, repair or rebuild job, the serviceman must read the respective sections of this manual to know all the component he will work on.

Continuing improvement of product design may have caused changes to your engine which are not included in this manual.

Whenever a question arises regarding your engine, or this manual, consult your Mitsubishi dealer for the latest available information.

Service Manual
Mitsubishi SL-Series diesel engines
Version 08/2004

HOW TO USE THIS MANUAL

Exploded views
In the exploded views, the component parts are separated but so arranged to show their relationship to the whole. Index numbering is used to identify the parts and to indicate a sequence in which the parts are to be removed for disassembly, or they are to be installed for assembly.

Symbols
The following symbols are used in this manual to emphasize important and critical instructions:

NOTE	Indicates a condition that is essential to highlight.
⚠ CAUTION	Indicates a condition that can cause engine damage
⚠ WARNING	Indicates a condition that can cause personal injury or death.

Definition of locational terms
The fan end is “front” and the flywheel end is “rear”. The words “left” and “right” are as these directions would appear as seen from the flywheel side. The cylinder sequencing begins on the front side (timing gearcase side) of the engine and works its way to the flywheel side.

Dimensional or specification terms

Nominal size	Is the named size which has no specified limits of accuracy.
Standard	Is the dimension of a part to be attained at the time of assembly, or the standard performance.
Limit	Is the maximum or minimum permissible limit beyond which a part must be repaired or replaced.

Tightening torques
Tighten bolts, nuts, etc. in a wet condition (apply oil to threads) when specified as [WET]. Tighten them in a dry condition unless so specified. Use the general tightening torques unless otherwise specified.

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GENERAL INFORMATION

1 MODEL IDENTIFICATION AND SERIAL NUMBER LOCATION

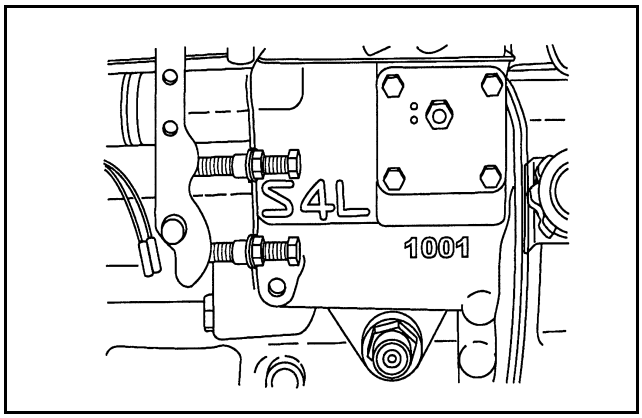


Figure 1 Model identification location

1.1 Model identification location

- The model identification is embossed on the right side of the cylinder block, near the fuel injection pump mount.
- The model identifications and displacements of the engines in current production are as listed below:

	Displacement
S3L	1.125 liters (68.7 cu in.)
S3L2	1.318 liters (80.4 cu in.)
S4L	1.500 liters (91.5 cu in.)
S4L2	1.758 liters (107.3 cu in.)

- A scheme of coding used for identifying the engines in current production is as follows:

S 4 L (2) – 61 A

S - Identification of “Sagamihara Machinery Works”

4 - Number-of-cylinders code [“4” stands for four cylinders]

L - Series code [Bore: 78 mm (3.07 in.)]

(2) - Stroke code
- (No code: 78.5 mm (3.09 in.)
- 2: 92 mm (3.62 in.)

61 - Export code

A - Specification code

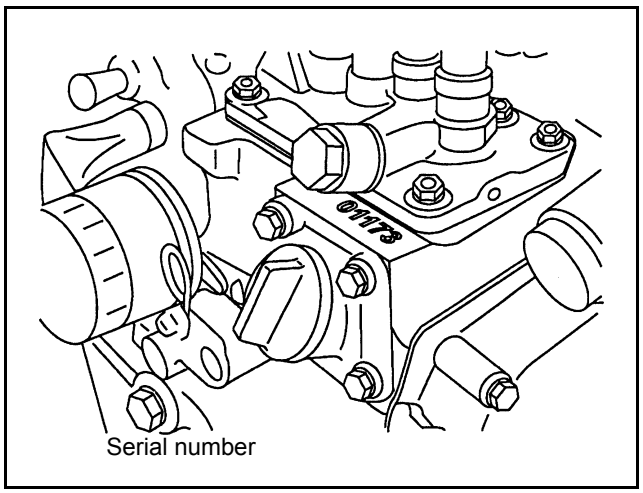


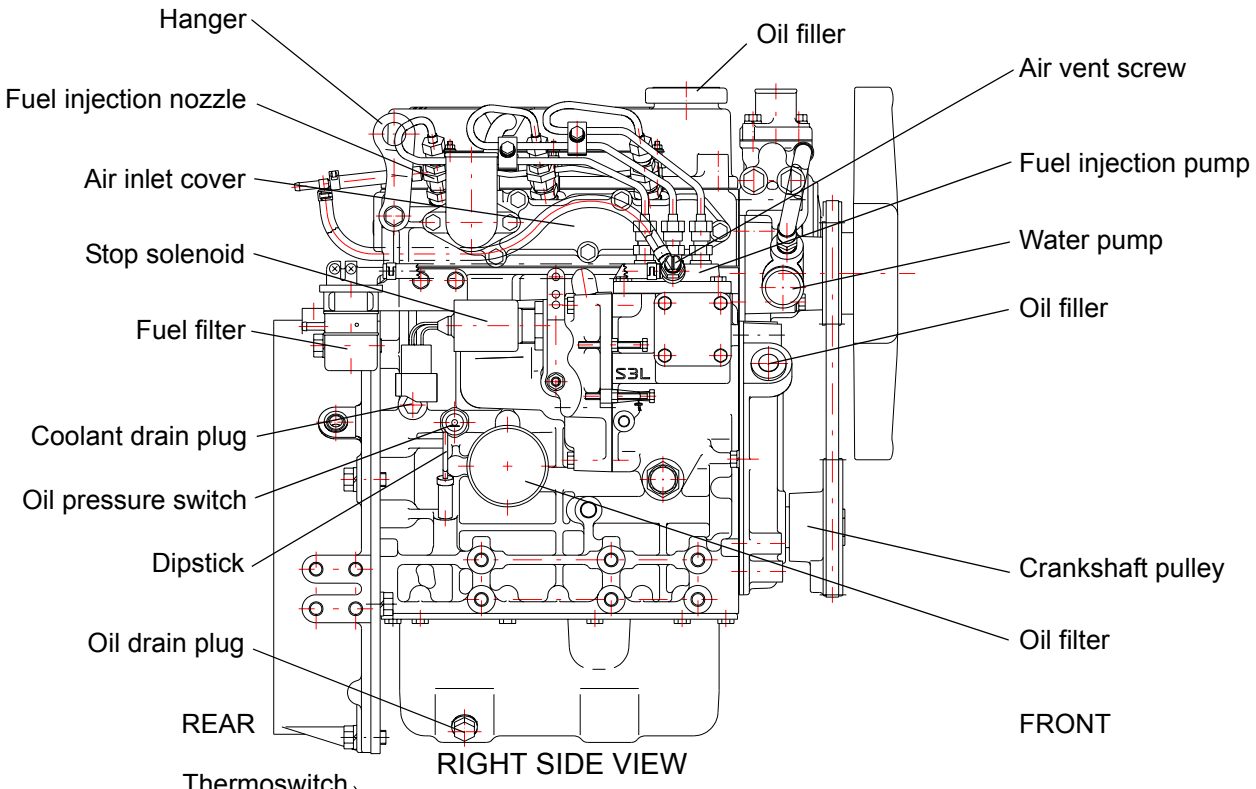
Figure 2 Serial number location

1.2 Serial Number Location

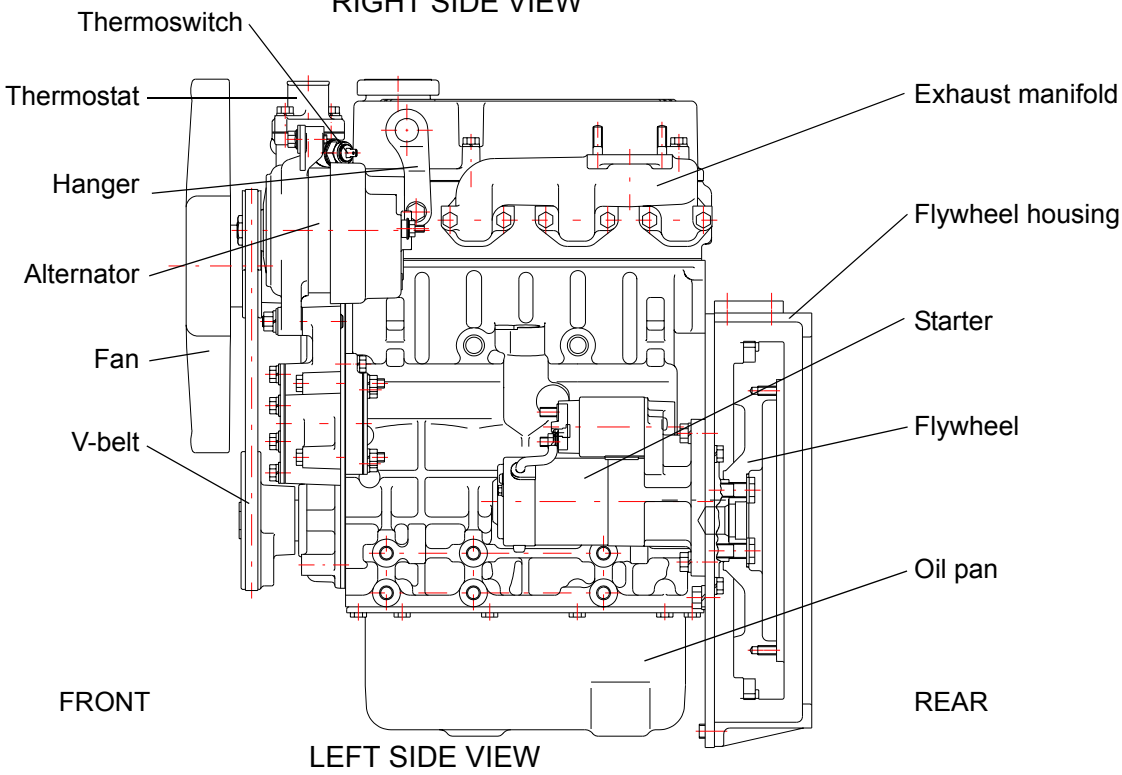
The serial number is punched on the cylinder block, near the fuel injection pump mount.

2 COMPONENT LOCATION

2.1 S3L/S3L2

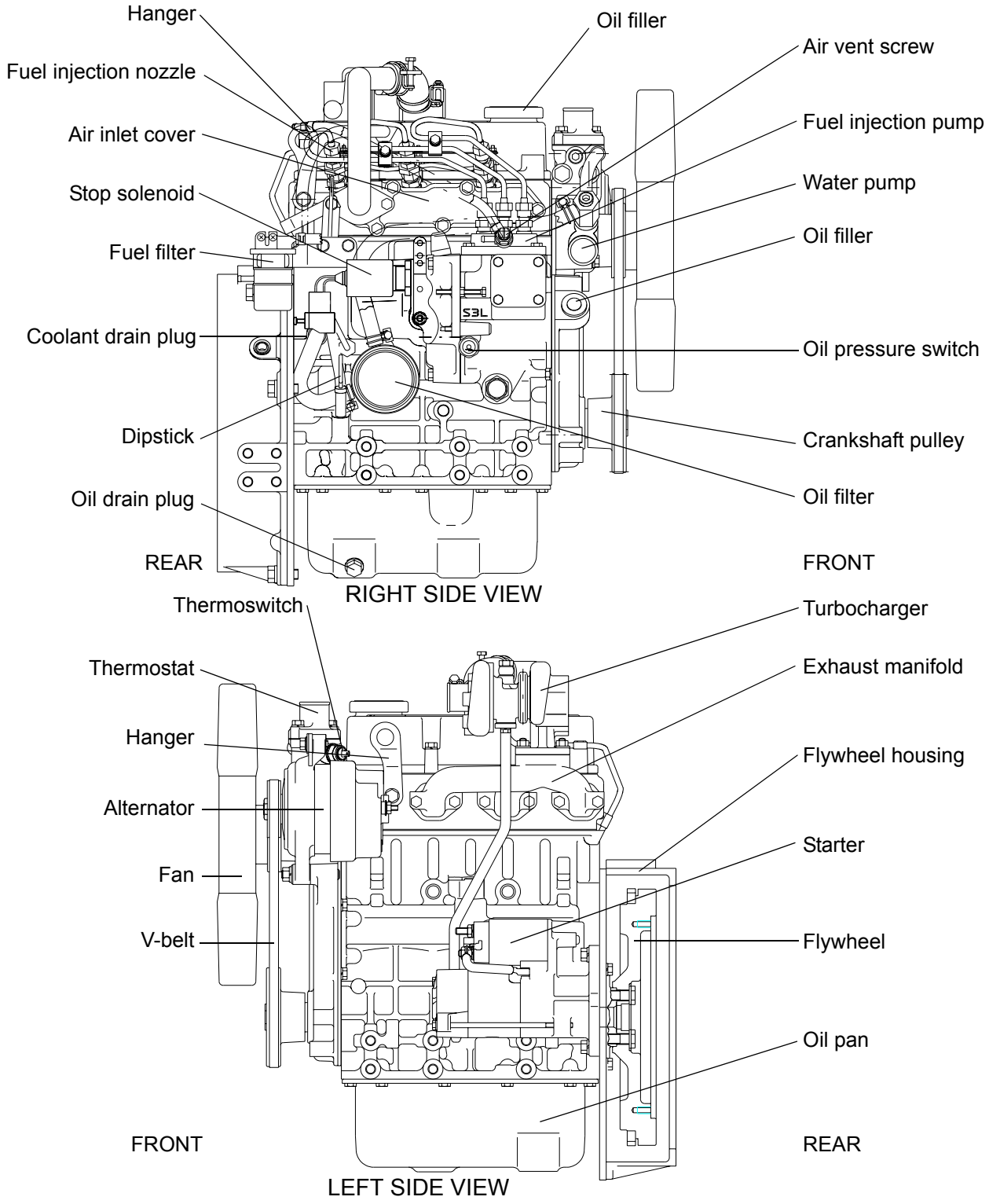


RIGHT SIDE VIEW

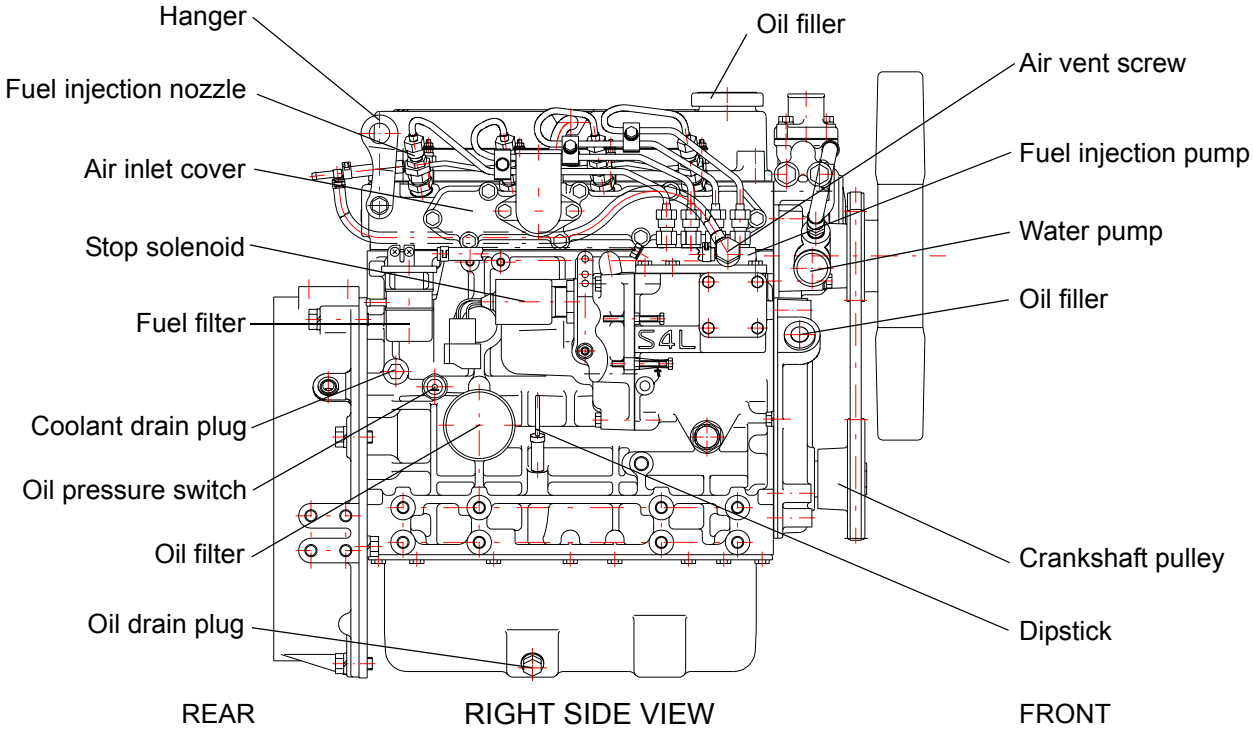


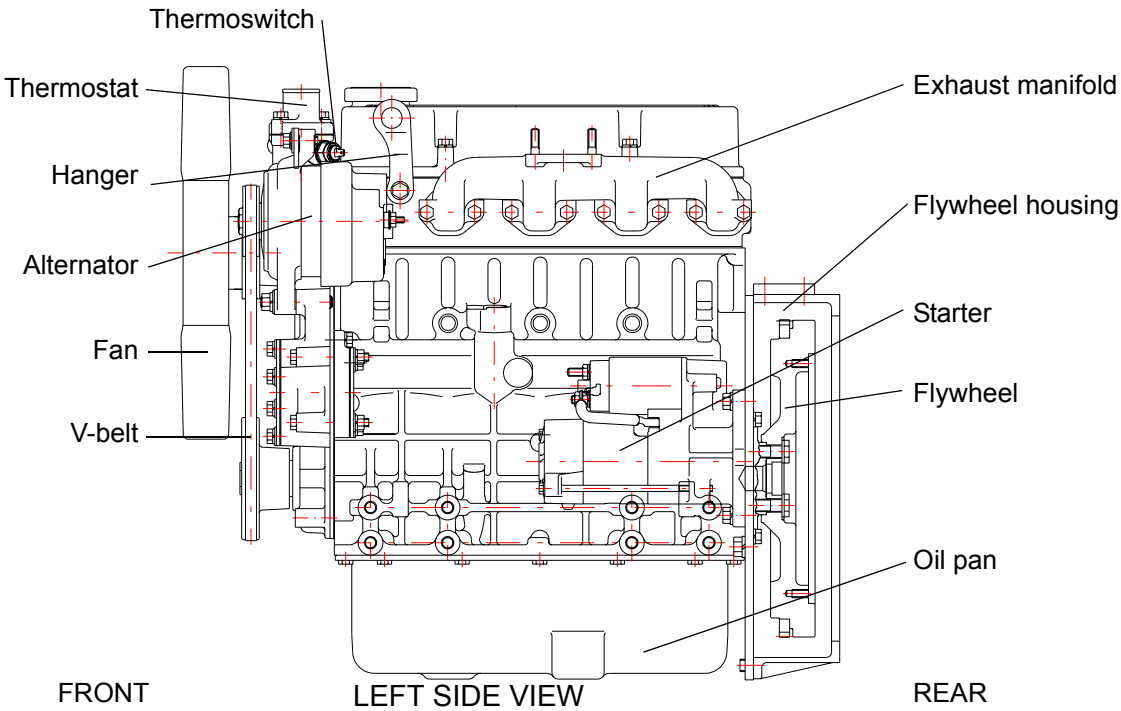
LEFT SIDE VIEW

2.2 Engine S3L-T/S3L2-T

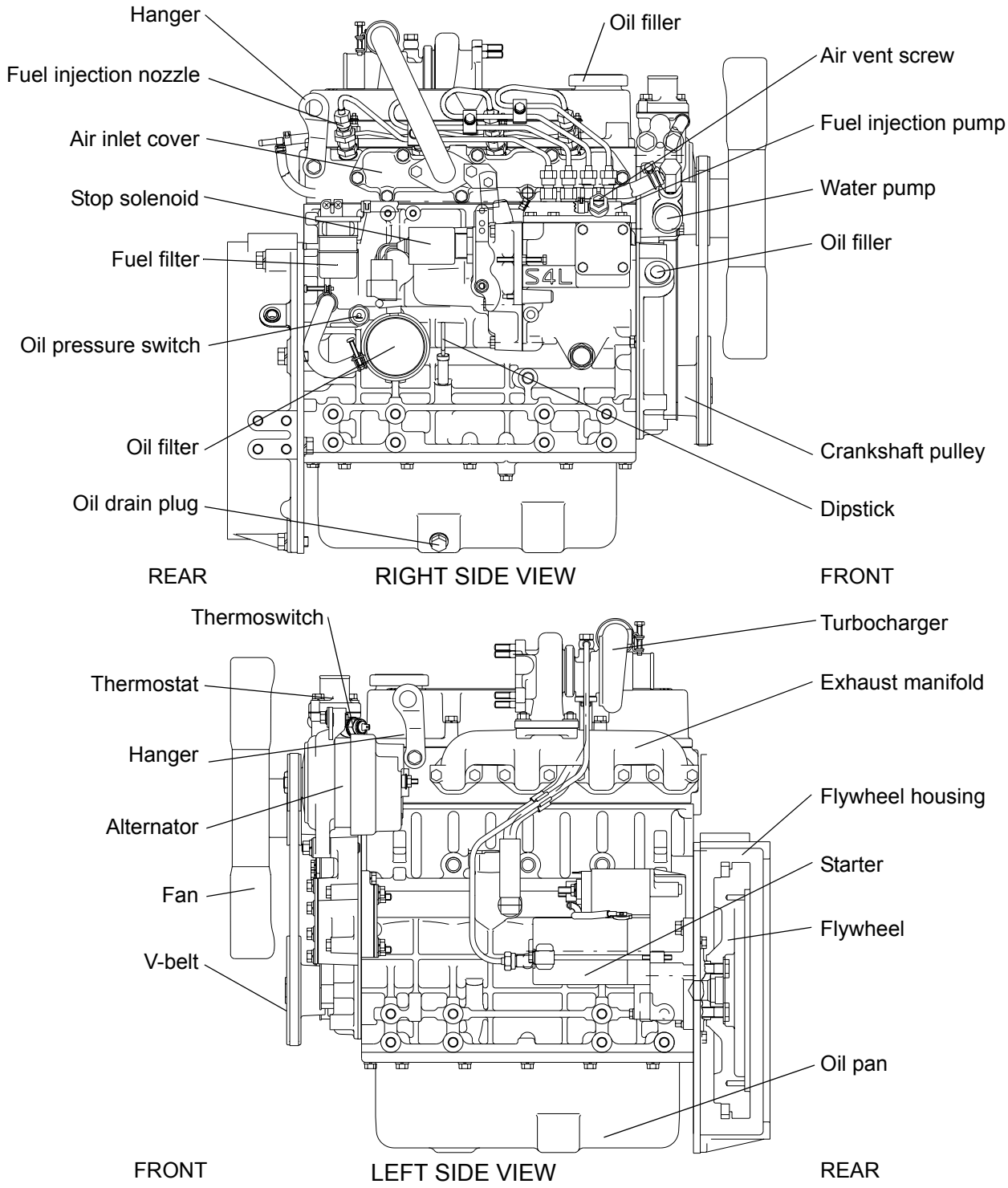


2.3 S4L/S4L2


Hanger
Fuel injection nozzle
Air inlet cover
Stop solenoid
Fuel filter
Coolant drain plug
Oil pressure switch
Oil filter
Oil drain plug
Oil filler
Air vent screw
Fuel injection pump
Water pump
Oil filler
Crankshaft pulley
Dipstick
S4L
REAR
RIGHT SIDE VIEW
FRONT


Thermoswitch
Thermostat
Hanger
Alternator
Fan
V-belt
Exhaust manifold
Flywheel housing
Starter
Flywheel
Oil pan
FRONT
LEFT SIDE VIEW
REAR

2.4 Engine S4L-T/S4L2-T



3 SPECIFICATIONS[1]

System	Item	Model							
		S3L	S3L-T	S3L2	S3L2-T	S4L	S4L-T	S4L2	S4L2-T
ENGINE PROPER	Type	4-cycle, water-cooled, vertical, overhead valve, diesel engine							
	Combustion chamber	Swirl chamber type							
	No. of cylinders	3				4			
	Bore x Stroke (mm)	78x78.5		78x92		78x78.5		78x92	
	Total displacement (*l*)	1.125		1.318		1.500		1.758	
	Compression ratio	22							
	Firing order	1-3-2				1-3-4-2			
	Dry weight (kg)	135	139	135	139	155	159	155	159
LUBRICATING SYSTEM	Lubricating method	Forced lubrication							
	Oil pump	Trochoid pump							
	Oil filter	Paper element type							
	Oil capacity: FULL level/EMPTY level (*l*) (Exclusive of oil filter capacity 0.5 *l*)	Shallow type oil pan: 3.7/2.3 Deep type oil pan: 5.7/3.1				Shallow type oil pan: 5.5/3.7 Deep type oil pan: 7.6/4.2			
FUEL SYSTEM	Fuel injection pump	Bosch M							
	Nozzle	Throttle type							
	Fuel injection pressure	140 kgf/cm^2							
	Fuel to be used	Diesel fuel; see chapter 7							
	Governor	Centrifugal weight type							
INTAKE SYSTEM	Air cleaner	Paper-element type							
	Turbocharger model	Without	TD025	Without	TD025	Without	TD025	Without	TD03
COOLING SYSTEM	Cooling method	Forced circulation of water							
	Water pump	Centrifugal type							
	Coolant capacity (*l*) (Engine proper only)	1.8				2.5			
ELECTRICAL SYSTEM	Starter (V - kW)	12 - 1.6 or 12 - 1.7 or 12 - 2.0							
	Alternator (V - A)	AC generator (12 - 50)							
	Glow plug	Sheathed type							
	Battery (capacity depends on application)	12V, 65 Ah or more				12V, 80 Ah or more			

Table 1 Specifications

1. All specifications are subject to change without any prior notice.

OVERHAUL INSTRUCTIONS

4 DETERMINING WHEN TO OVERHAUL THE ENGINE

Generally, when to overhaul the engine is to be determined by taking into account a drop in compression pressure as well as an increase in lube oil consumption and excessive blowby gases.

Lower power or loss of power, an increase in fuel consumption, a drop in lube oil pressure, hard starting and excessive abnormal noise are also troubles. These troubles, however, are not always the result of low compression pressure and give no valid reason for overhauling the engine.

The engine develops troubles of widely different varieties when the compression pressure drops in it. Following are the typical troubles caused by the compression pressure failure:

1. Low power or loss of power
2. Increase in fuel consumption
3. Increase in lube oil consumption
4. Excessive blowby through breather due to worn cylinders, pistons, etc.
5. Excessive blowby due to poor seating of worn inlet and exhaust valves
6. Hard starting or failure to start
7. Excessive engine noise

In most cases, these troubles occur concurrently. Some of them are directly caused by low compression pressure, but others are not. Among the troubles listed above, (2) and (6) are caused by a fuel injection pump improperly adjusted with respect to injection quantity or injection timing, worn injection pump plungers, faulty injection nozzles, or poor care of the battery, starter and alternator.

The trouble to be taken into account as the most valid reason for overhauling the engine is (4): in actually determining when to overhaul the engine, it is reasonable to take this trouble into account in conjunction with the other ones.

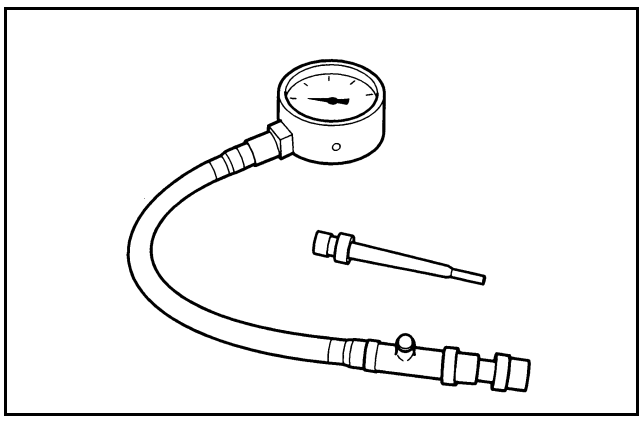


Figure 3 Compression gauge and adaptor

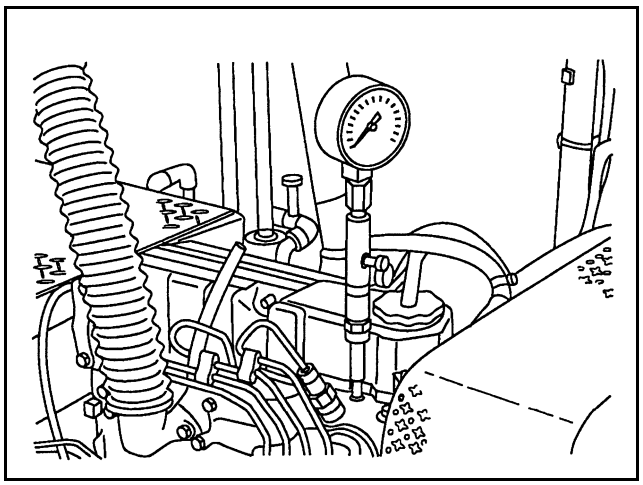


Figure 4 Measuring compression pressure

5 COMPRESSION PRESSURE MEASUREMENT

5.1 Inspection

Check to make sure:

1. The crankcase oil level is correct, and the air cleaner, starter and battery are all in normal condition.
2. The engine is at the normal operating temperature.

5.2 Measurement

1. Move the control lever to a position for shutting off fuel supply.
2. Remove all glow plugs from the engine. Install the compression gauge and adaptor (ST332270) combination to a cylinder on which the compression pressure is to be measured.
3. Turn the engine with the starter and read the gauge pressure at the instant the gauge pointer comes to stop.
4. If the gauge reading is below the limit, overhaul the engine.

⚠ CAUTION

- Be sure to measure the compression pressure on all cylinders.
- The compression pressure varies with change of engine rpm. This makes it necessary to check engine rpm at the time of measuring the compression pressure.

⚠ CAUTION

- It is important to measure the compression pressure at regular intervals to obtain the data on the gradual change of the compression pressure.
- The compression pressure would be slightly higher than the standard in a new or overhauled engine owing to breaking-in of the piston rings, valve seats, etc. It drops as the engine components wear down.

	Standard		Limit
Engine speed, rpm	290		--
Compression pressure, kgf/cm2 (psi) [kPa]	SL	30 (427) [2 942]	23 (327) [2 256]
	SL2	32 (455) [3 138]	25 (356) [2 452]
Maximum permissible difference between average compression pressure of all cylinders in one engine, kgf/cm2 (psi) [kPa]	3 (42.7) [294]		--

6 TROUBLESHOOTING

6.1 General

The diagnosis of troubles, especially those caused by a faulty fuel injection pump or injection nozzles, or low compression pressure, can be difficult. It requires a careful inspection to determine not which item is the cause, but how may causes are contributing to the trouble, someone of which is the primary cause. Several causes may be contributing to a single trouble.

On the following pages, there are troubleshooting charts on which engine troubles can be traced to their causes. Each chart has items to be verified ahead and suggested inspection procedure.

Diesel engines exhibit some marked characteristics during operation. Knowing these characteristics will help minimize time lost in tracing engine troubles to their source. Following are the characteristics of diesel engines you should know about for diagnosis:

- Combustion knock (diesel knock)
- Some black exhaust smoke (when the engine picks up load)
- Vibration (due to high compression pressure and high torque)
- Hunting (when the engine speed is quickly decreased)
- Some white exhaust smoke (when the engine is cold, or shortly after the engine has been started)

6.2 Engine troubleshooting

6.2.1 Problem 1: Hard starting

1. Items to be checked ahead of time
- Clogged air cleaner
- Wrong oil grade for weather conditions
- Poor quality fuel
- Low cranking speed

2. Inspection procedure

Is heating system normal?
No ▷ Glow plugs are energized shortly after starter switch is turned to ON.
No ▷ Check control timer unit.

▽Yes

Are fuel lines free of restriction? (Is fuel pump operating properly when starter switch in ON position?)
No ▷ Check fuel filter, fuel lines and fuel tank.

▽ Yes

Are fuel injection timing and valve clearance correct?
No ▷ Make adjustment to the timing and clearance.

▽ Yes

Is fuel injection nozzle discharge pattern normal? Is injection pressure correct?
No ▷ Make adjustment to the nozzles.

▽ Yes

Is compression pressure correct?
No ▷ Check valves, piston rings and cylinder head gasket.

▽ Yes

Fuel injection pump is faulty.

6.2.2 Problem 2: Fuel knock

More or less fuel knock occurs in diesel engines. This may be caused either by an excessively large delay period or by a too fast rate of fuel injection.

1. Items to be checked ahead of time
- Clogged air cleaner
- Poor quality fuel

2. Inspection procedure

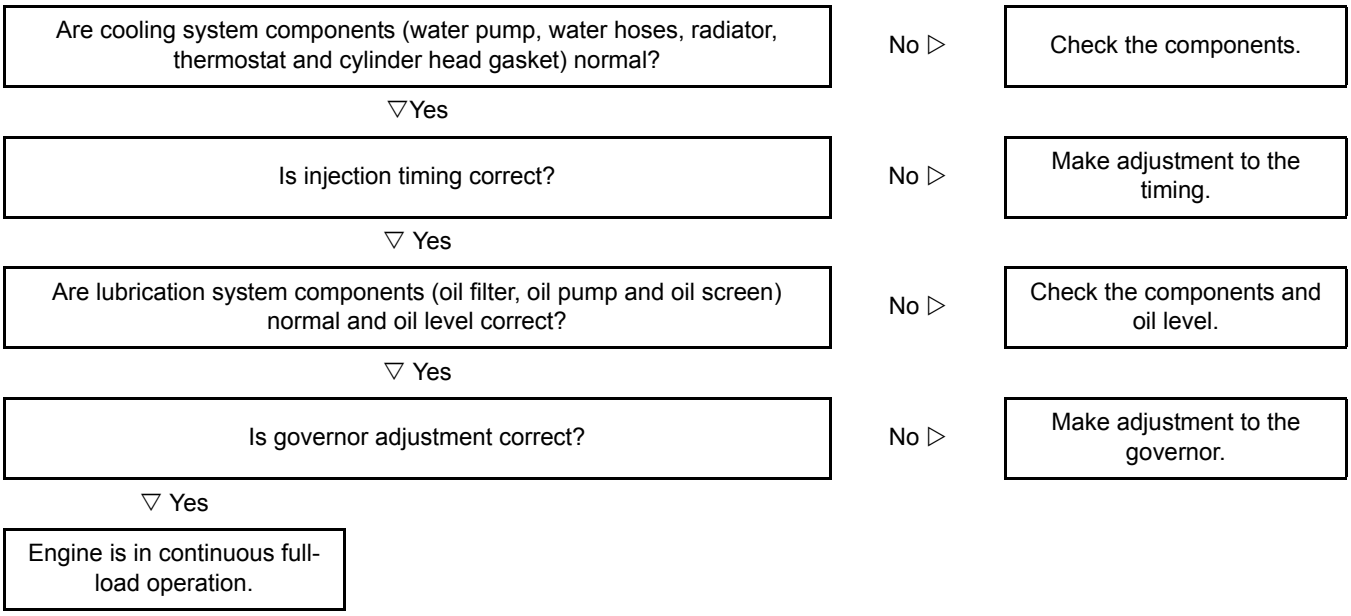
Is injection timing correct (not too advanced)?	No ▷	Make adjustment to the timing.
▽Yes		
Is solenoid switch normal?	No ▷	Check the switch.
▽ Yes		
Is injection pressure (injection nozzle valve opening pressure) correct (not too low)?	No ▷	Make adjustment to the pressure.
▽ Yes		
Is compression pressure correct?	No ▷	Check valves, piston rings, and cylinder head gasket.
▽ Yes		
Fuel injection pump is faulty.		

6.2.3 Problem 3: Overheating

Overheating might also be caused by abnormal operating conditions. If the engine is overheating but its cooling system is not contributing to this trouble, it is necessary to check the difference between the ambient temperature and coolant temperature when the engine is in normal operation (with the thermostat fully open). If the ambient temperature is higher than the normal coolant temperature by more than 60°C (108°C), investigate other items than those related to the engine cooling system.

1. Items to be checked ahead of time
- Insufficient coolant and exterior coolant leaks
- Loose fan belt
- Radiator core openings plugged with dirt

2. Inspection procedure



6.2.4 Problem 4: Black exhaust smoke

1. Items to be checked ahead of time
- Clogged air cleaner
- Poor quality fuel

2. Inspection procedure

Are valve clearance and injection timing correct?
No ▷ Make adjustment to the clearance and timing.

▽Yes

Is injection nozzle discharge pattern normal? Is injection pressure correct (not too high)?
No ▷ Make adjustment to the nozzles.

▽ Yes

Is compression pressure correct?
No ▷ Check valves, piston rings and cylinder head gasket.

▽ Yes

Fuel injection pump is faulty.

6.2.5 Problem 5: Erratic idle speeds

1. Items to be checked ahead of time
- Maladjusted engine control
- Wrong oil grade for weather conditions
- Poor quality fuel

2. Inspection procedure

Are valve clearance and injection timing correct?
No ▷ Make adjustment to the clearance and timing.

▽Yes

Is injection nozzle discharge pattern normal? Is injection pressure constant?
No ▷ Make adjustment to the nozzles.

▽ Yes

Is compression pressure correct (no difference in compression pressure between cylinders)?
No ▷ Check valves, piston rings and cylinder head gasket.

▽ Yes

Fuel injection pump is faulty.

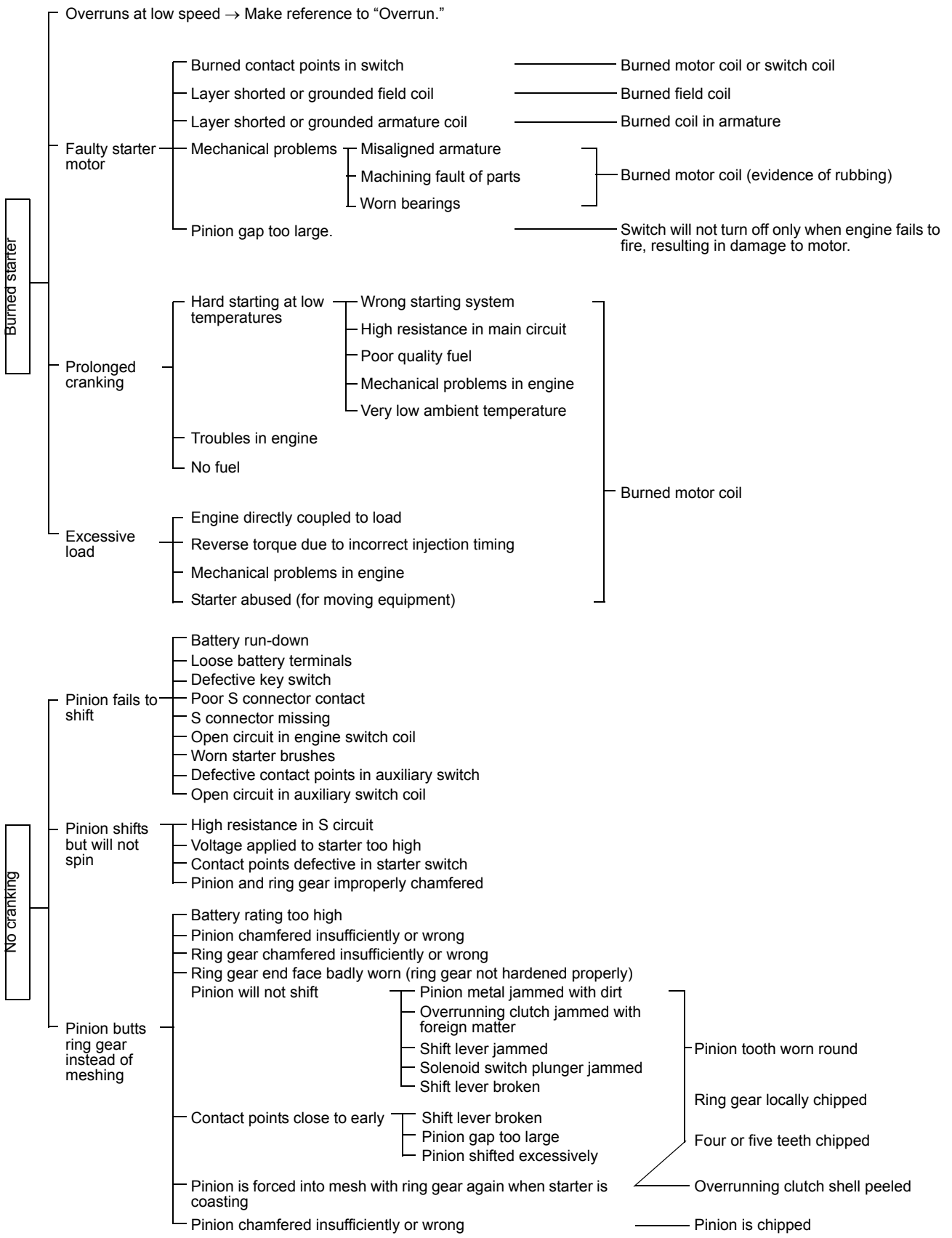
6.2.6 Problem 6: Low power or loss of power

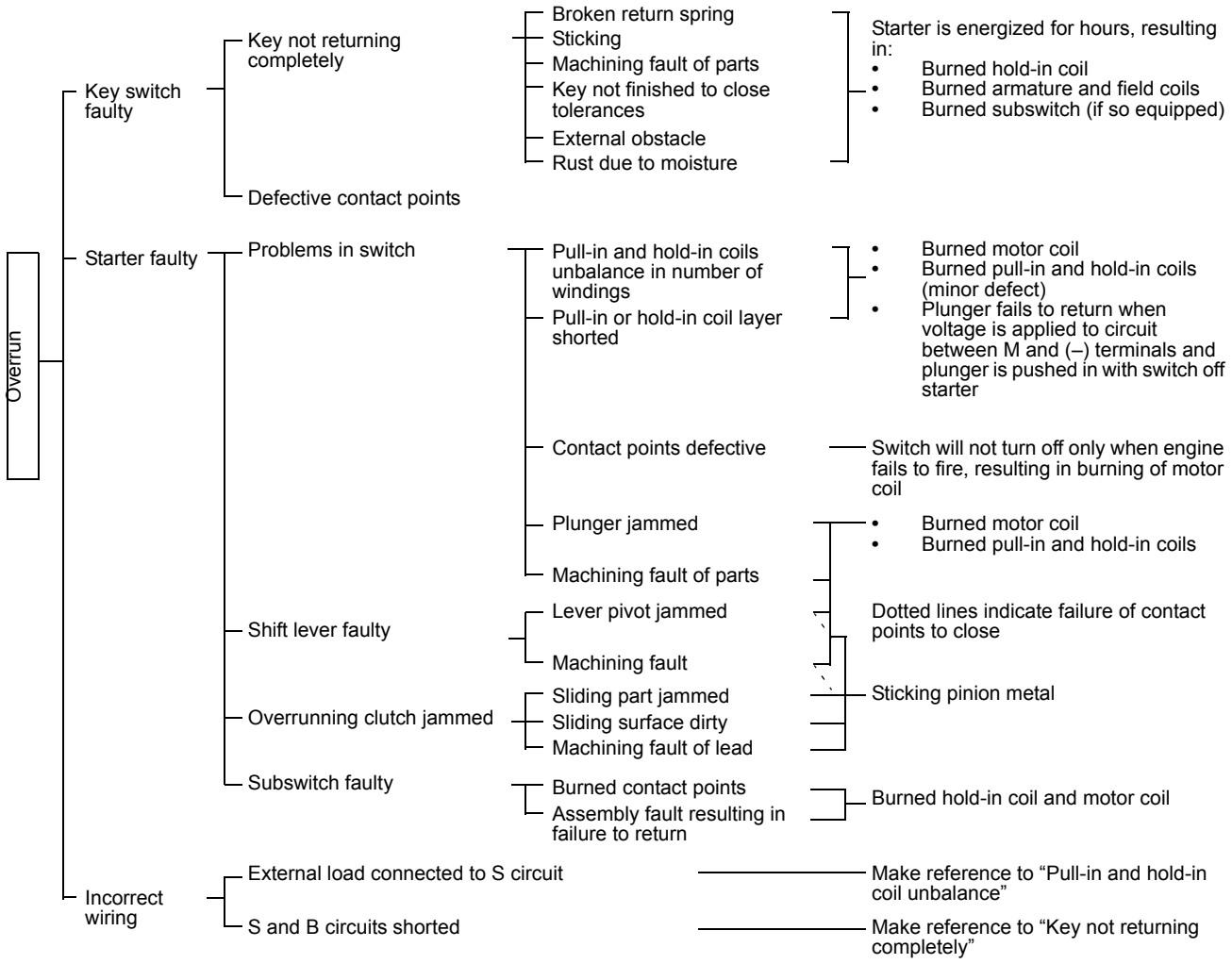
1. Items to be checked ahead of time
- Stuck running parts
- Wrong oil grade for weather conditions
- Poor quality fuel
- Clogged air cleaner
- Restricted exhaust line
- Faulty power take-off

2. Inspection procedure

Are valve clearance and injection timing correct?	No ▷	Make adjustment to the clearance and timing.
▽Yes		
Are fuel lines free from restriction? (Is fuel pump operating properly when starter switch is in ON position?)	No ▷	Check fuel tank, fuel filter and fuel lines.
▽ Yes		
Is governor adjustment correct?	No ▷	Make adjustment to the governor.
▽ Yes		
Is injection nozzle discharge pattern normal? Is injection pressure correct?	No ▷	Make adjustment to the nozzles.
▽ Yes		
Is compression pressure correct?	No ▷	Check valves, piston rings and cylinder head gaskets.
▽ Yes		
Fuel injection pump is faulty.		

6.3 Starting system troubleshooting





[Other possibility is sticking pinion metal in case of overrun trouble.]

7 BASIC PRECAUTIONS FOR DISASSEMBLY AND ASSEMBLY

This section outlines basic precautions recommended by Mitsubishi that should always be observed.

7.1 Disassembly

1. Always use tools that are in good condition and be sure you understand how to use them before performing any job.
2. Use an overhaul stand or a work bench, if necessary. Also, use bins to keep engine parts in order of removal.
3. Parts must be restored to their respective components from which they were removed at disassembly. This means that all parts must be set aside separately in groups, each marked for its component, so that the same combination or set can be reproduced at assembly.
4. Pay attention to marks on assemblies, components and parts for their positions or directions. Put on marks, if necessary, to aid assembly.
5. Carefully check each part or component for any sign of faulty condition during removal or cleaning. The part will tell you how it acted or what was abnormal about it more accurately during removal or cleaning.
6. When lifting or carrying a part too heavy or too awkward for one person to handle, get another person's help and, if necessary, use a jack or a hoist.

7.2 Assembly

1. Wash all parts, except for oil seals, O-rings, rubber sheets, etc., with cleaning solvent and dry them with pressure air.
2. Always use tools that are in good condition and be sure you understand how to use them before performing any job.
3. Use only good-quality lubricants. Be sure to apply a coat of oil, grease or sealant to parts as specified.
4. Be sure to use a torque wrench to tighten parts for which torques are specified.
5. Any time the engine is assembled, new gaskets and O-rings must be installed.

DISASSEMBLY

8 PREPARATION FOR DISASSEMBLY

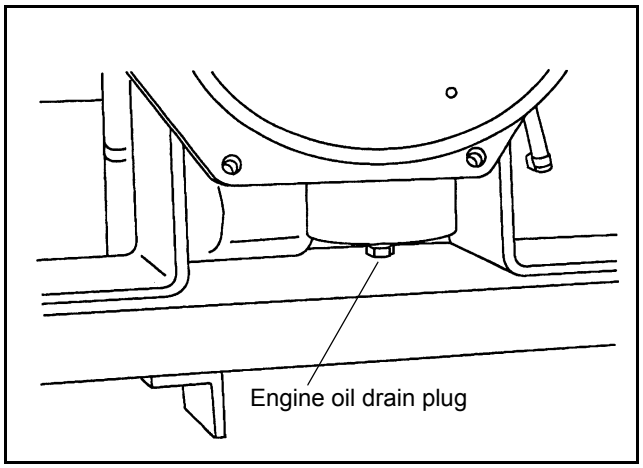


Figure 5 Draining engine oil

8.1 Engine oil draining[1]

Remove the drain plug from the bottom of the oil pan and allow the oil to drain.

Refill capacities (high level excl. 0.5 liter (0.13 U.S. gal) of oil in oil filter, liter (U.S. gal)	S3L/S3L2: 5.7 (1.5) (with deep oil pan) 3.7 (1.0) (with standard oil pan)
	S4L/S4L2: 7.7 (2.0) (with deep oil pan) 5.4 (1.4) (with standard oil pan)

⚠ WARNING

Hot oil and components can cause personal injury.
Do not allow hot oil or components to contact skin.

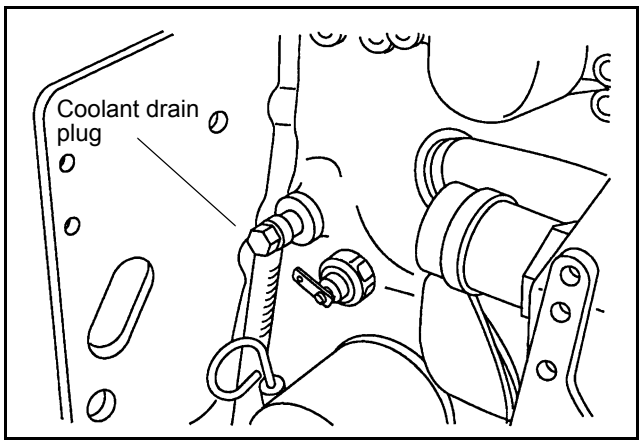


Figure 6 Draining coolant

8.2 Coolant draining [1]

Loose the drain plug on the right side of the cylinder block and allow the coolant to drain.

Refill capacities, liter (U.S. gal)	S3L/S3L2: 1.8 (0.5) S4L/S4L2: 2.5 (0.7)

1. Please refer to the applicable engine model specification sheet for actual data

9 ELECTRICAL SYSTEM

9.1 Starter

9.1.1 Testing before disassembly

1. Clearance between pinion and housing (pinion clearance)
   1) Connect the starter to a 12 volt battery as shown in the illustration to cause the pinion to shift into cranking position and remain there.

⚠ CAUTION

Due to the amount of current being passed through the solenoid series winding, this test must be made within 10 seconds.

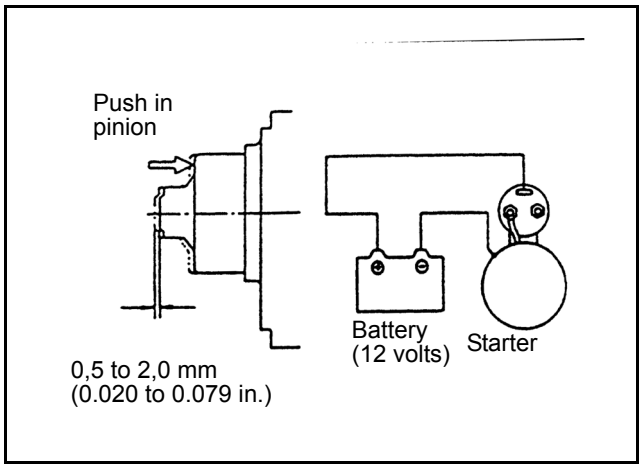


Figure 7 Connections for measuring pinion clearance

   2) Push the pinion toward the commutator end by hand to measure its free movement (pinion clearance).
   3) The pinion clearance must be 0.5 to 2.0 mm (0.020 to 0.079 in.). If the clearance is out of this range, make an adjustment to it by adding or removing the packings on the magnetic switch. Adding the packings will decrease the clearance.

2. No-load characteristics
   1) Connect the starter to a 12 volt battery with an ammeter capable of indicating several hundred amperes as shown in the illustration.
   2) Close the switch to make sure the pinion shifts into cranking position properly and the starter runs at speeds higher than is specified. If the current draw and/or operating speed is out of the standard, disassemble the starter for inspection and repairs.

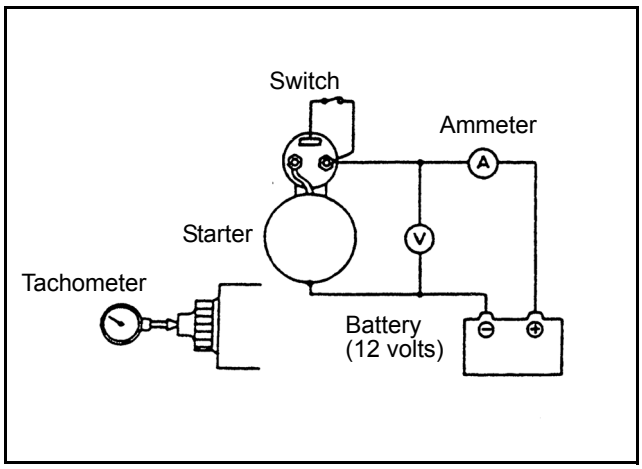


Figure 8 Connections for testing no-load characteristics

⚠ CAUTION

- The size of wires used for this test must be as large as possible. Tighten the terminals securely.
- This starter has a reduction gear. Do not confuse gear noise with some abnormal noise else.
- When measuring the starter speed at the end of the pinion, be ready for accidental shifting of the pinion.

Item		Standard	
Model		M8T70471	M1T68281
Nominal output, V – kW		12 – 2.0	12 – 1.7
No-load characteristics	Terminal voltage, V	11	11.5
	Current draw, A	130 maximum	100 maximum
	Speed, rpm	3 850 minimum	3 000 minimum

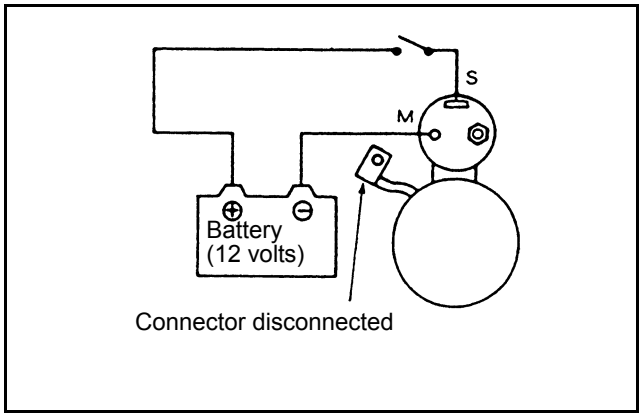


Figure 9 Connections for testing pull-in coil

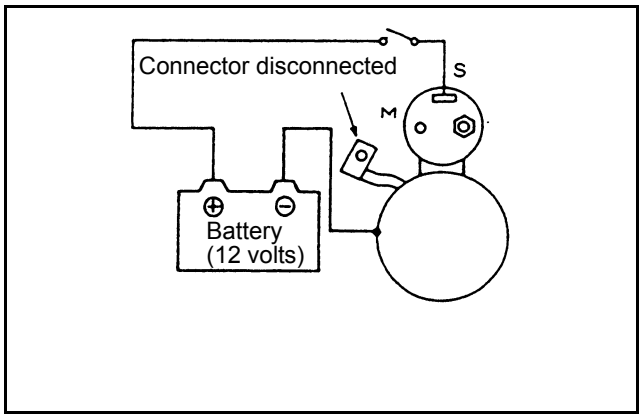


Figure 10 Connections for testing hold-in coil

3. Magnetic switch
   1) Disconnect the connector from the M terminal of the magnetic switch.
   2) Connect the magnetic switch to a 12 volt battery with a switch as shown in the illustration to test the pull-in coil. Close the switch to see if the pinion shifts. If the piston fails to shift, the magnetic switch is faulty.

⚠ CAUTION

Due to the amount of current being passed through the solenoid series winding, this test must be made within 10 seconds.

   3) Connect the magnetic switch to a 12 volt battery with a switch as shown in the illustration to test the pull-in coil. Close the switch to see if the pinion shifts. If the piston fails to shift, the magnetic switch is faulty.

⚠ CAUTION

Due to the amount of current being passed through the solenoid series winding, this test must be made within 10 seconds.

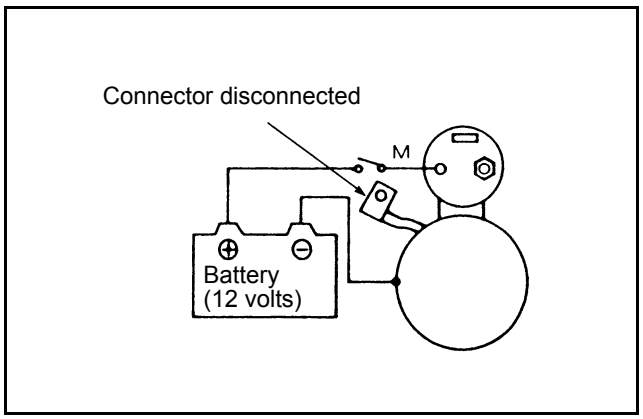


Figure 11 Connections for pinion return test

4) Connect the magnetic switch to a 12 volt battery with a switch as shown in the illustration to make a pinion return test. Close the switch and pull the pinion away from the commutator end by hand. Release the pinion to see if it returns immediately when released. If the pinion fails to so return, the magnetic switch is faulty.

⚠ CAUTION

Due to the amount of current being passed through the solenoid series winding, this test must be made within 10 seconds.

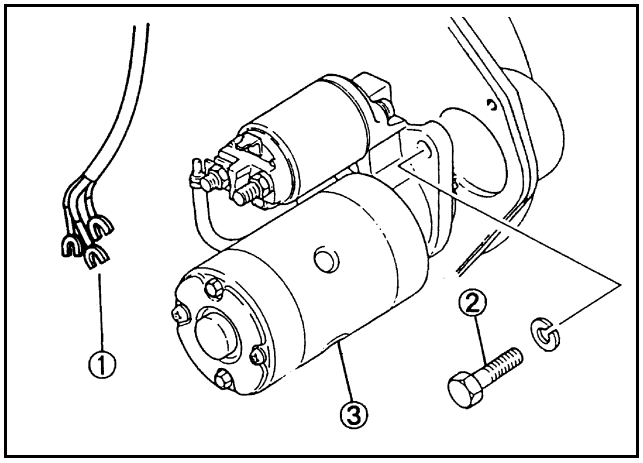


Figure 12 Removing starter

9.1.2 Removal

1. Disconnect the battery wires. Disconnect the negative (–) wire first.
2. Disconnect wire (1) from the starter.
3. Loosen bolts (2) (two) holding starter (3) in position and remove the starter.

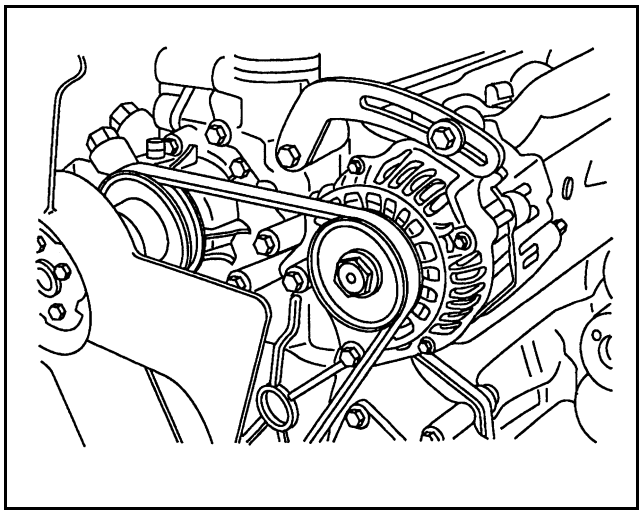


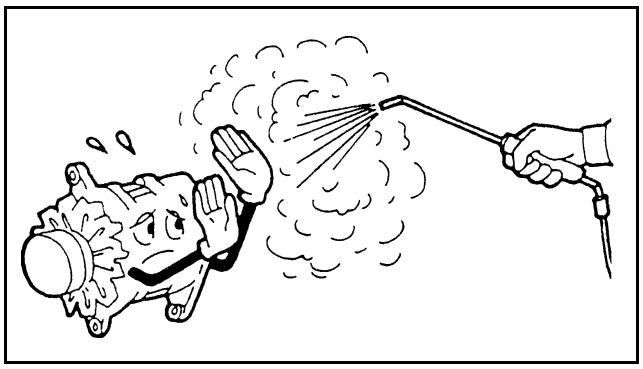
Figure 13 Alternator on engine

9.2 Alternator

9.2.1 Inspection before removal

The correct diagnosis of the charging system requires a careful inspection with the alternator on the engine to determine whether or not it is necessary to remove the alternator from the engine for further inspection. The following chart, in which two troubles are listed with four possible causes of each, will help locate the cause of the trouble:

Alternator charge too high	Voltage regulator setting too high
	Ground return circuit defective
	Wiring incorrect
	Series resistor or winding open-circuited
Alternator gives no charge	Alternator drive belt loose
	Voltage regulator setting too low
	Alternator output low
	Brushes worn



9.2.2 Precautions for removal

Following is a list of basic precautions that should always be observed for removal:

1. When installing the battery, care must be used to make sure the negative (–) terminal is grounded.
2. Do not use a megger (an instrument for high resistance of electrical materials).
3. Disconnect the battery cables before charging the battery.
4. Do not attempt to disconnect the lead from the B terminal of the alternator when the engine is running.
5. Battery voltage is being applied to the B terminal of the alternator. Do not ground it.
6. Do not short or ground the L terminal of the alternator with a built-in IC regulator.
7. Do not blow a spray from the steam cleaner nozzle at the alternator.

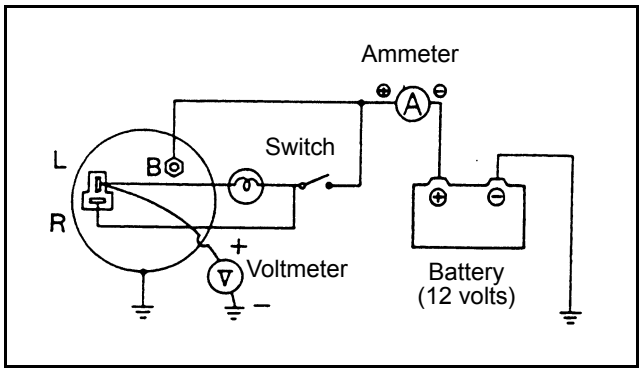


Figure 14 Connections for testing voltage setting

9.2.3 Testing voltage setting

1. Connect the alternator to a 12 volt battery with an ammeter, a voltmeter and a switch as shown in the illustration.
2. The voltmeter reading must be zero (0) when the starter switch is in OFF position. It must be lower than the battery voltage when the switch is in ON position (the engine will not start).
3. With one ammeter lead short-circuited, start the engine.
4. Read the voltmeter when the ammeter reading is below five amperes and the engine is running at 1800 min–1 and also at 2500 min–1 with all electrical loads turned off. The voltage setting varies with alternator temperature. Generally, the higher the alternator temperature, the lower the voltage setting.

Item	Standard
Voltage setting [at 20°C (68°F)]	14.7 ± 0.3 V

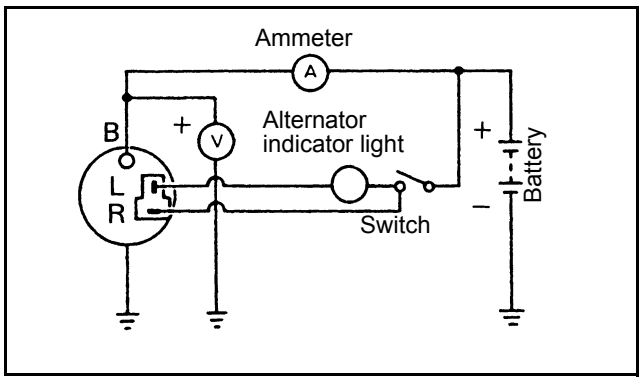


Figure 15 Connections for testing output characteristics (alternator with built-in regulator)

9.2.4 Testing output characteristics

1. Disconnect the battery ground (negative) cable.
2. Connect one ammeter lead to the B terminal of the alternator and the other lead to the positive terminal of the battery. Connect one voltmeter lead to the B terminal and the other lead to the ground.
3. Connect the battery ground cable.
4. Start the engine.
5. Turn on all electrical loads.
6. Increase the engine speed. Measure the maximum output current at the specified alternator speed when the voltmeter reading is 13.5 volts.

Item	Model	Standards	
		Terminal voltage/ current	Speed
Output characteristics (at normal temperature)	A7T02071C	13.5 V/33 A	2 500 rpm maximum
		13.5 V/47 A	5 000 rpm maximum

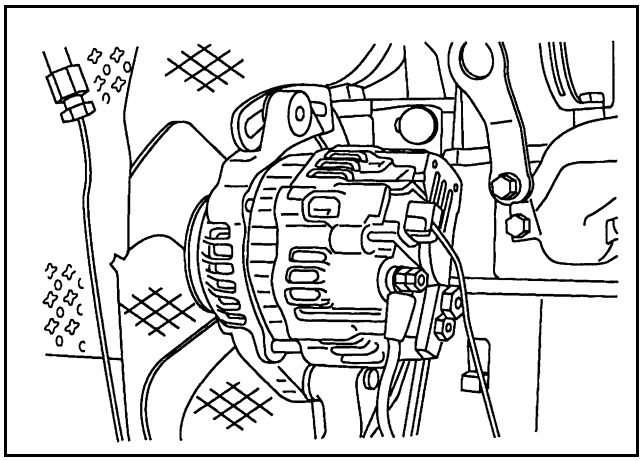


Figure 16 Removing alternator

9.2.5 Removal

1. Disconnect the battery cables.
2. Disconnect the lead from the B terminal of the alternator.
3. Disconnect the connector from the alternator.
4. Loosen the brace and support bolts. Move the alternator toward the engine and remove the drive belt.
5. Remove the alternator.

10 Cooling System

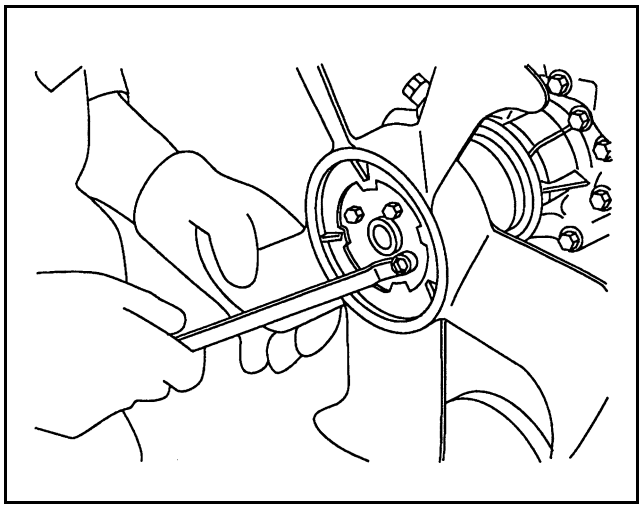


Figure 17 Removing cooling fan

10.1 Cooling fan removal

Hold the fan by one hand and remove the four bolts that hold the fan in position. Remove the fan and spacers.

NOTE

Keep the spacers with the fan for installation.

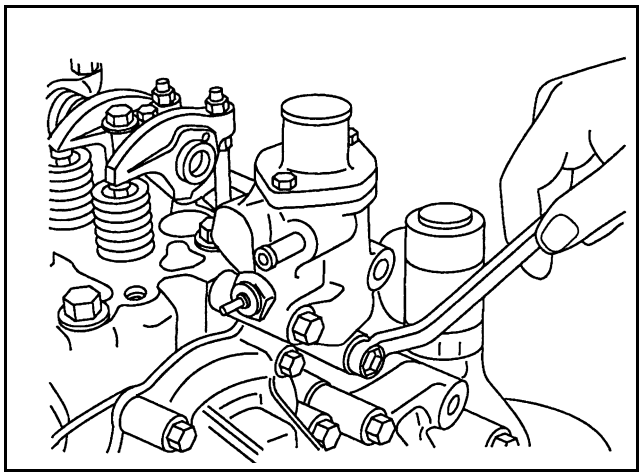


Figure 18 Removing thermostat assembly

10.2 Thermostat case removal

Remove the water pump assembly.

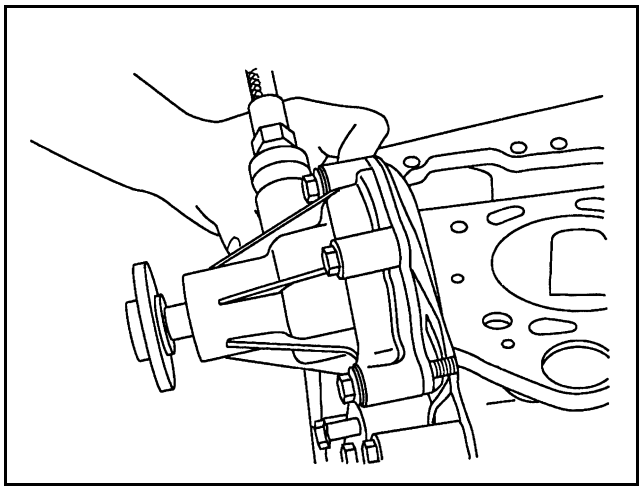


Figure 19 Removing water pump assembly

10.3 Water pump assembly removal

Remove the water pump assembly.

11 Fuel System

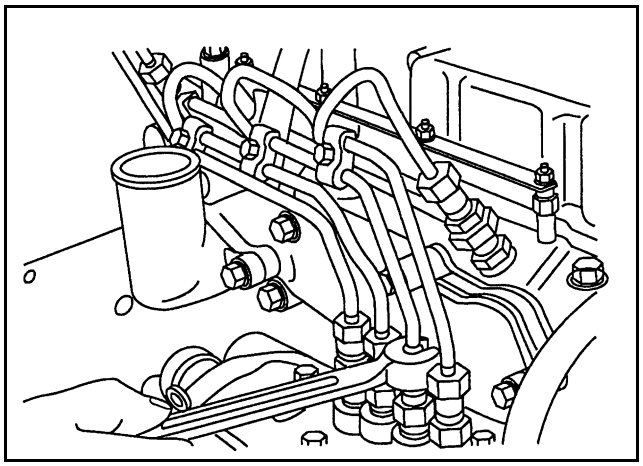


Figure 20 Removing fuel injection pipes

11.1 Fuel injection pipe removal

Disconnect the fuel injection pipes and fuel leak-off pipe from the fuel injection pump and nozzles.

NOTE

Put plugs or caps on the openings of the injection pump and nozzle connectors.

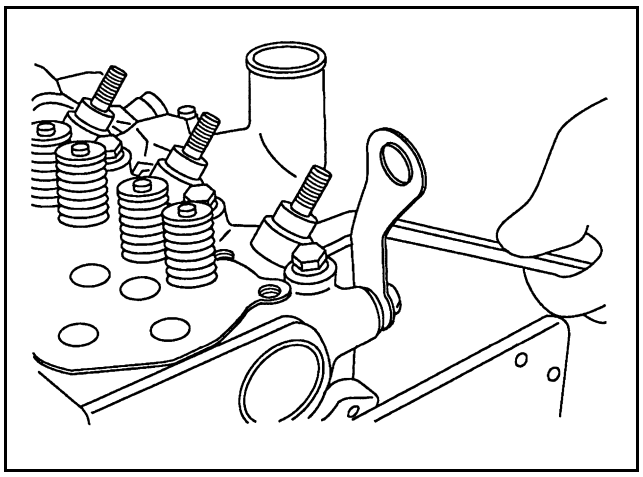


Figure 21 Removing fuel injection nozzles

11.2 Fuel injection nozzle removal

Loosen the fuel injection nozzles with a wrench. Remove the nozzles and gaskets from the cylinder head.

NOTE

Remove the gaskets from the cylinder head with a screwdriver or a similar tool. Discard defective gaskets.

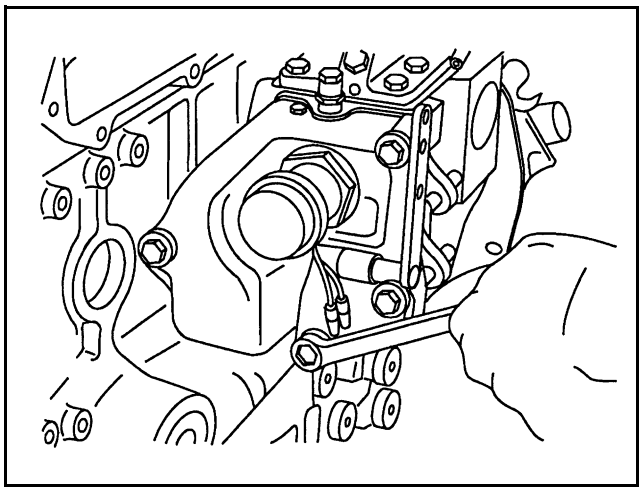


Figure 22 Removing governor assembly

11.3 Governor assembly removal

1. Remove the tie rod cover.
2. Remove the spring from the tie rod with a pliers to disconnect the tie rod from the fuel injection pump.
3. Remove the governor assembly.

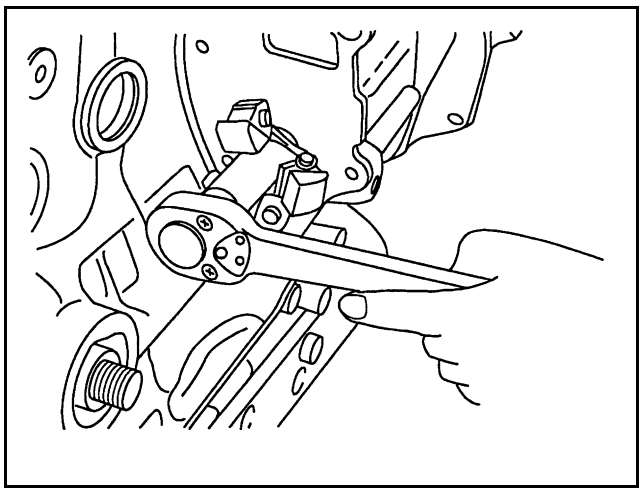


Figure 23 Removing governor weights

11.4 Governor weight removal

1. Remove the sliding sleeve.
2. Remove the sliding sleeve shaft and governor weights.

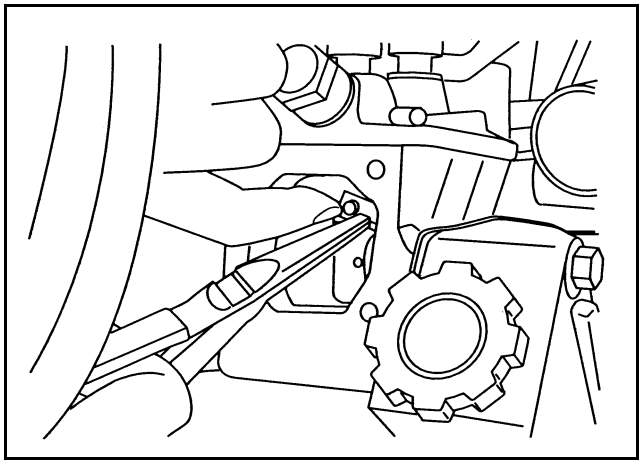


Figure 24 Removing tie rod

11.5 Fuel injection pump removal

1. Remove the tie rod cover.
2. Remove the spring from the tie rod with a pliers to disconnect the tie rod from the fuel injection pump.

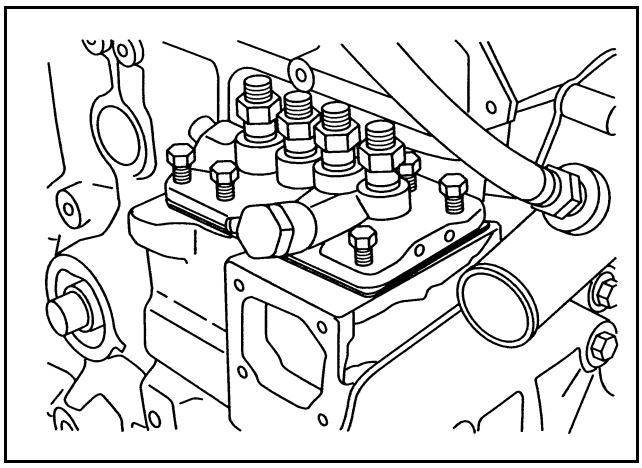


Figure 25 Removing fuel injection pump

3. Remove the fuel injection pump.

NOTE

Keep a record of the thickness of shims for installation.

12 Lubrication System

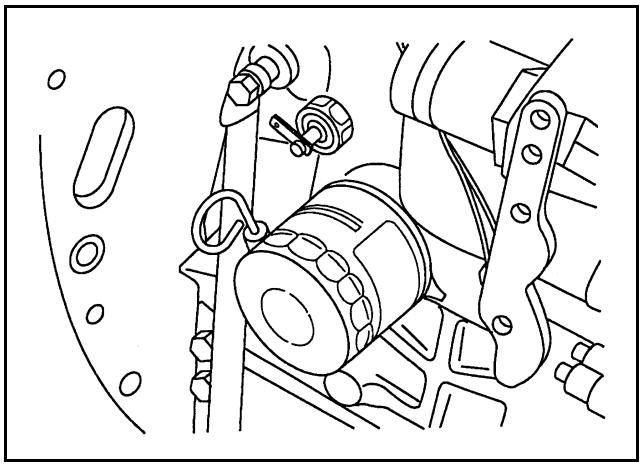


Figure 26 Removing oil filter

12.1 Oil filter removal

1. Put a container under the oil filter to catch the oil.
2. Remove the oil filter from the cylinder block with a filter wrench.

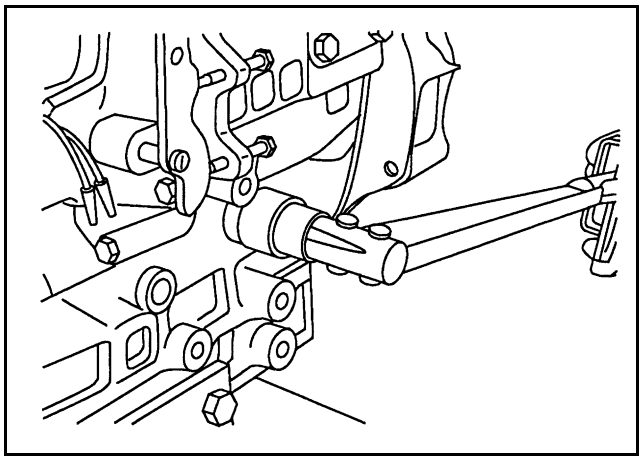


Figure 27 Removing pressure relief valve

12.2 Pressure relief valve removal

Remove the pressure relief valve from the cylinder block.

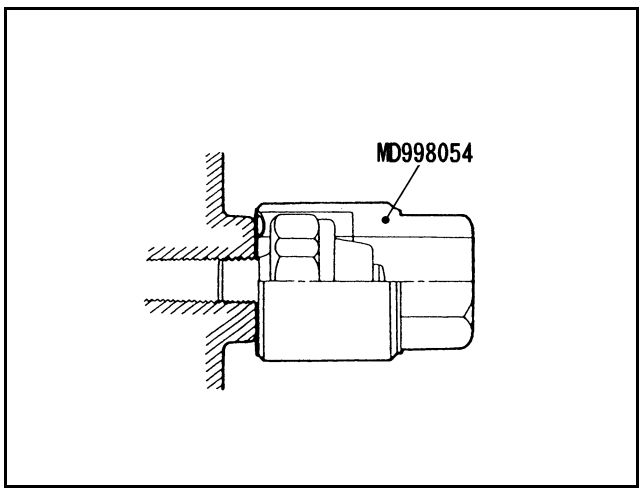


Figure 28 Removing oil pressure switch

12.3 Oil pressure switch removal

Remove the oil pressure switch with Oil Pressure Switch Socket Wrench (MD998054) (special tool).

13 AIR INLET SYSTEM AND EXHAUST SYSTEM

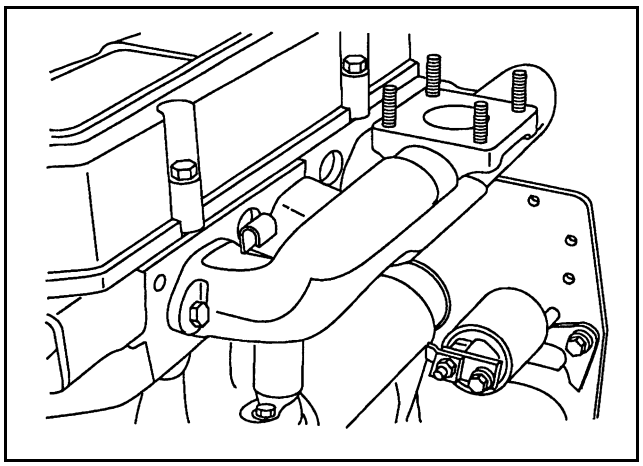


Figure 29 Removing exhaust manifold

13.1 Exhaust manifold removal

Remove the exhaust manifold from the cylinder head.

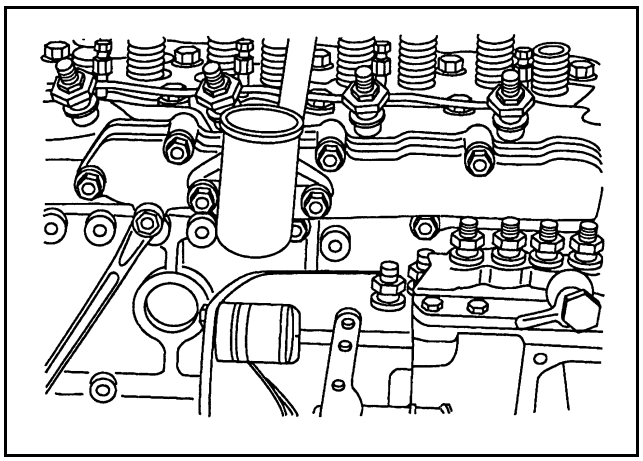
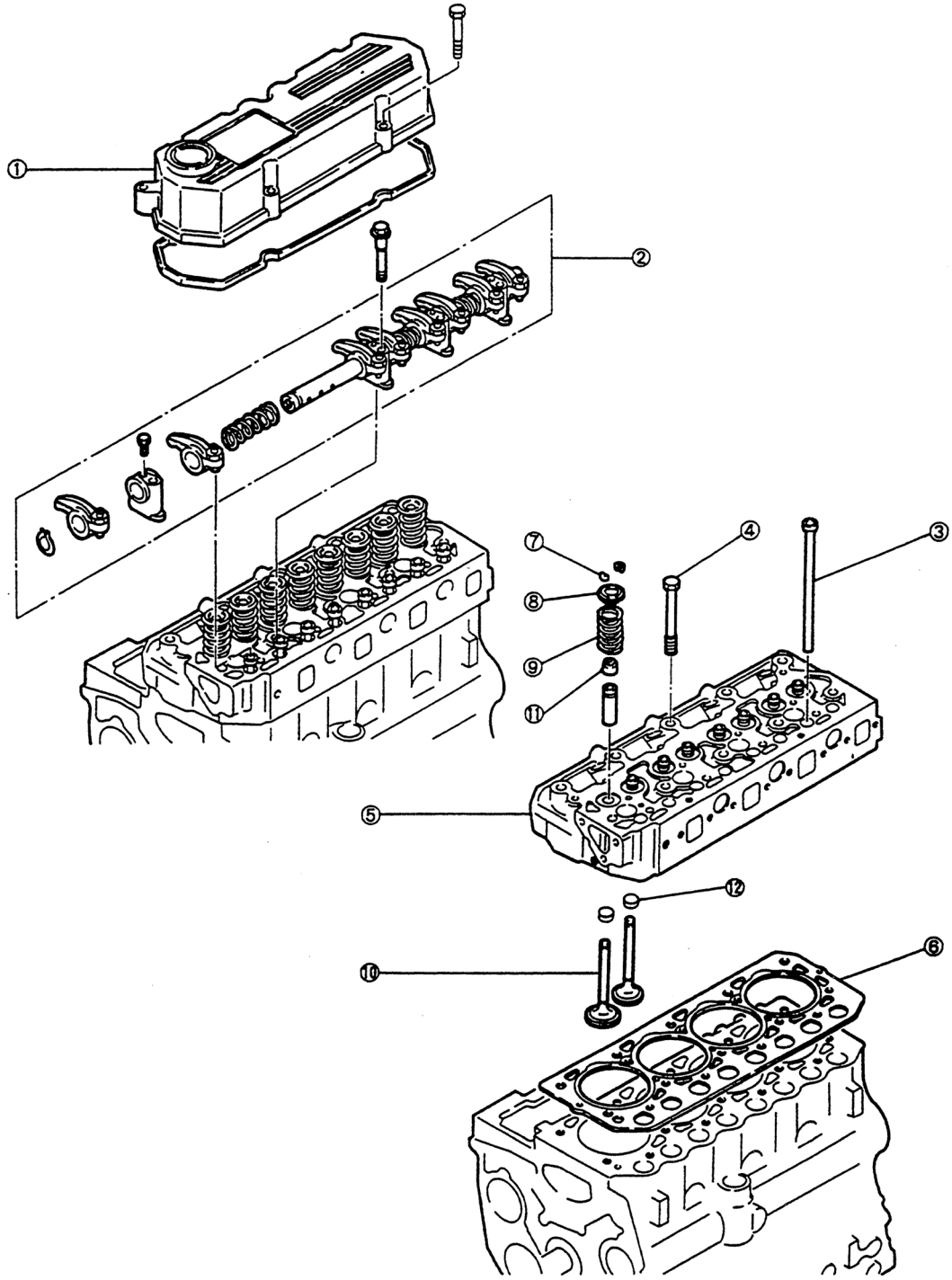


Figure 30 Removing air inlet cover

13.2 Air inlet cover removal

Remove the air inlet cover from the cylinder head.

14 CYLINDER HEAD AND VALVE MECHANISM



1. Rocker cover
2. Rocker shaft assembly
3. Valve push rod
4. Cylinder head bolt
5. Cylinder head
6. Cylinder head gasket
7. Valve lock
8. Valve retainer
9. Valve spring
10. Valve
11. Valve stem seal
12. Valve cap

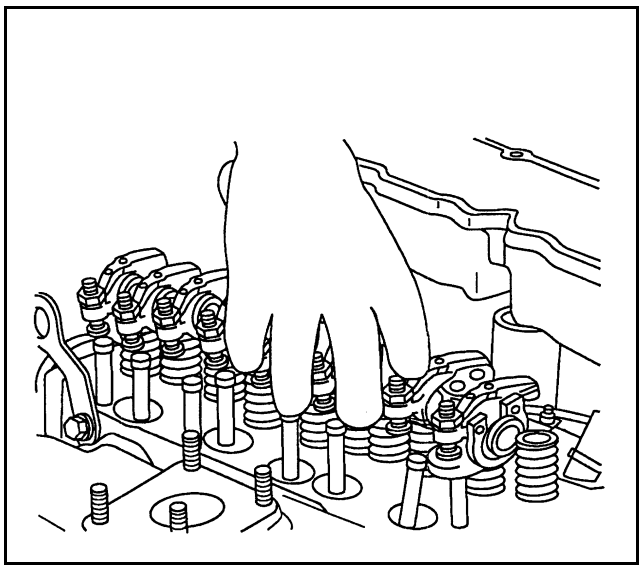


Figure 31 Removing rocker shaft assemblies

14.1 Rocker shaft assembly removal

1. Remove the bolts that hold the rocker stays in position and remove the rocker shaft assembly.
2. Remove the valve caps.

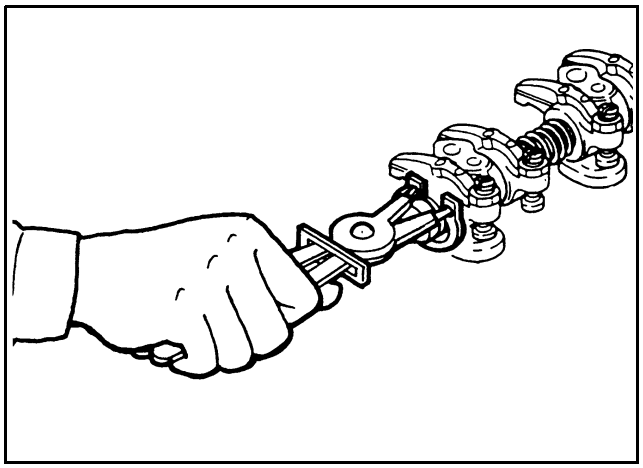


Figure 32 Disassembling rocker shaft assembly

14.2 Rocker shaft disassembly

Put identification on each rocker arm as to its location on the rocker shaft.

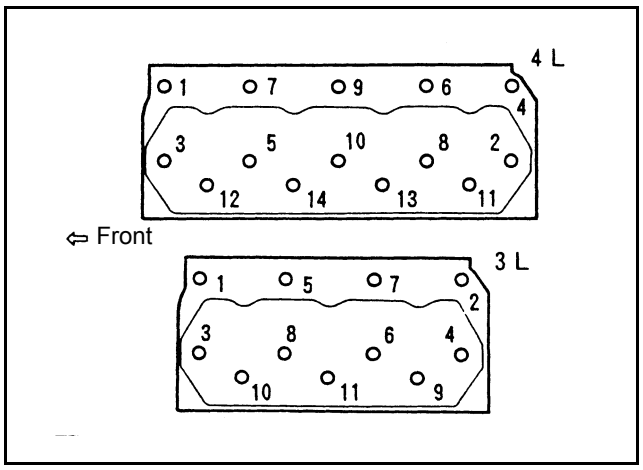


Figure 33 Cylinder head bolt loosening sequence

14.3 Cylinder head bolt removal

Loosen the cylinder head bolts in two or three steps in the sequence shown.

NOTE

If any parts on the cylinder head are faulty, check the cylinder head bolts for tightness with a torque wrench before loosening them.

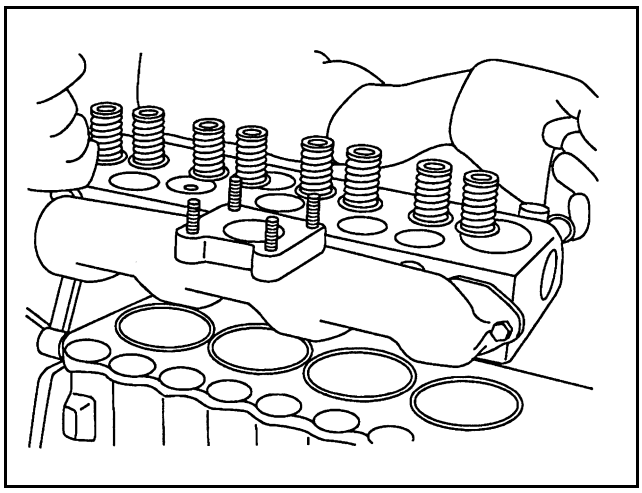


Figure 34 Removing cylinder head assembly

14.4 Cylinder head assembly removal

Lift the cylinder head straight up with a hoist.

NOTE

If the gasket is seized and the cylinder head cannot be separated from the cylinder block, tap around the thick side portion of the cylinder head with a plastic hammer.

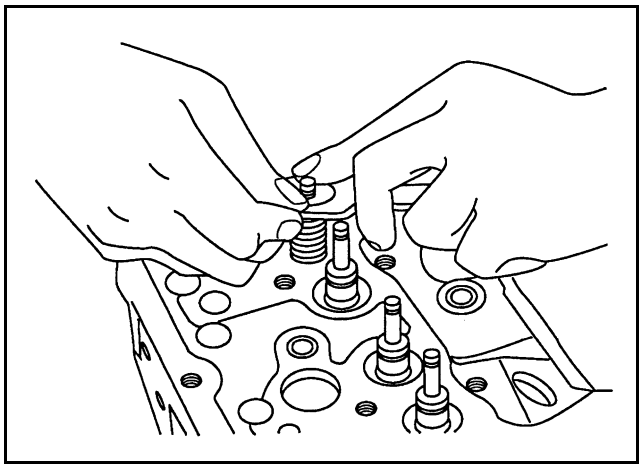


Figure 35 Removing valve springs

14.5 Valve and valve spring removal

1. Compress the valve spring with a valve lifter and remove the valve lock.
2. Remove the retainer, spring and valve.

NOTE

The valves, retainers, springs and valve locks must be set aside separately in groups, each tagged for cylinder number, for correct installation.

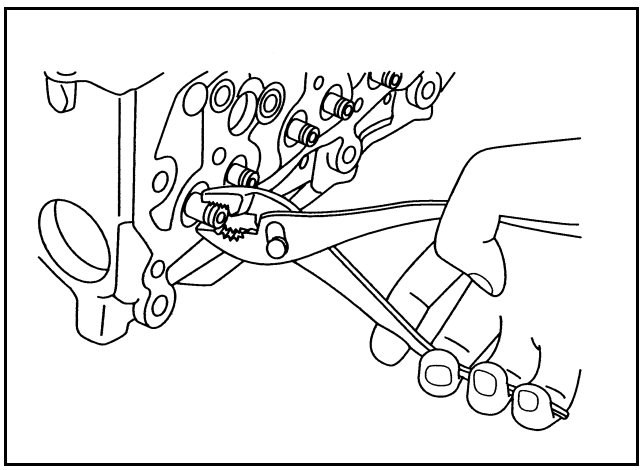


Figure 36 Removing valve stem seals

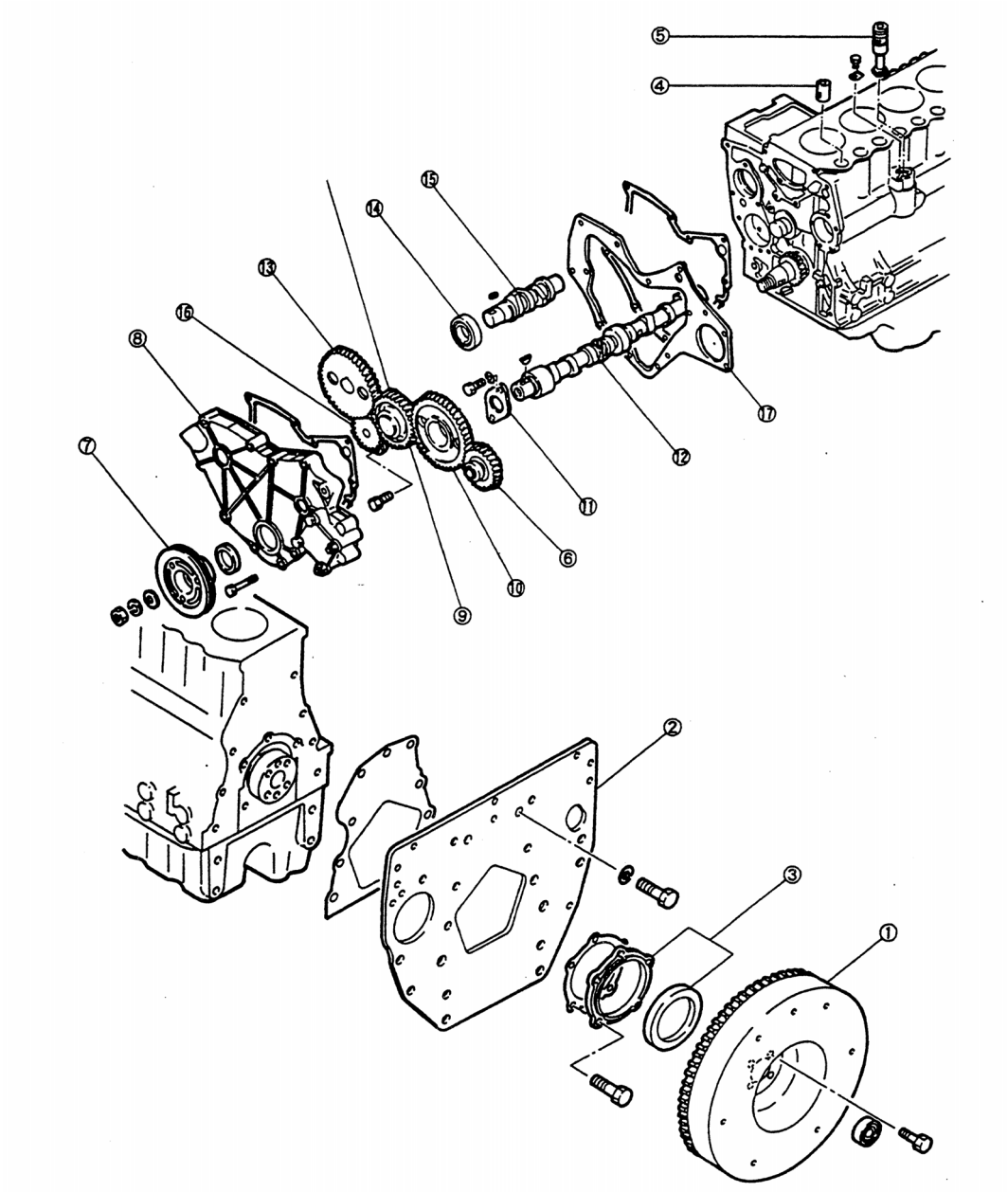
14.6 Valve stem seal removal

Remove the valve stem seals with a pliers.

NOTE

Do not reuse the valve stem seals, but replace them by new ones.

15 Timing Gears and Flywheel



1. Flywheel
2. Rear plate
3. Oil seal case; oil seal
4. Tappet
5. Speedometer driven gear
6. P.T.O. gear
7. Crankshaft pulley
8. Timing gear case
9. Idler gear

(Remove 10 thru 12 as an assembly.)

10. Camshaft gear
11. Thrust plate
12. Camshaft

(Remove 3 thru 5 as an assembly.)

13. Fuel injection pump camshaft gear
14. Bearing
15. Fuel injection pump camshaft
16. Oil pump
17. Front plate

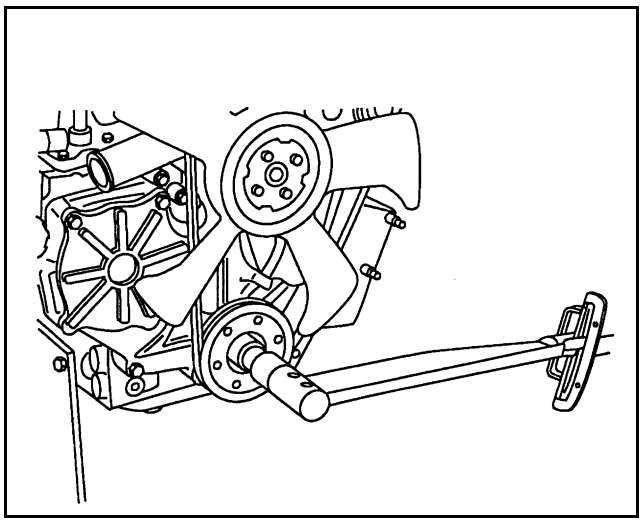


Figure 37 Holding flywheel

15.1 Flywheel removal

1. Have someone hold the crankshaft pulley with a wrench to prevent the flywheel from rotating.
2. Remove one of the bolts that hold the flywheel in position.

⚠ WARNING

Always signal each other to prevent possible personal injury.

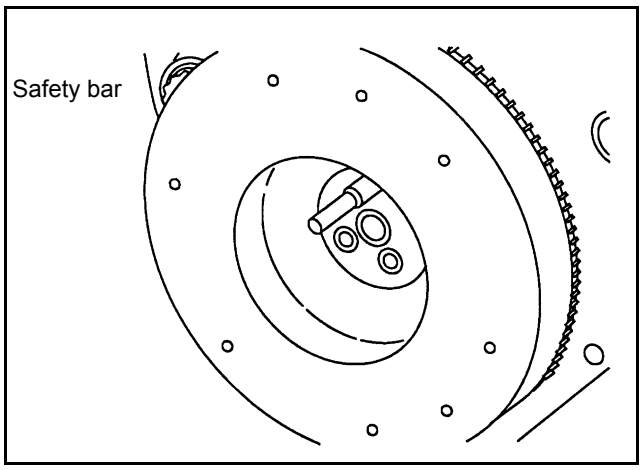


Figure 38 Removing flywheel

3. Install a safety bar (M12 x 1.25) into the threaded hole in the flywheel from which the bolt was removed in Step (2). Remove the remaining bolts.
4. Hold the flywheel by hands and withdraw it from the crankshaft. Joggling the flywheel back and forth will facilitate removal.

⚠ WARNING

When removing the flywheel, wear heavy gloves to avoid hand injury.

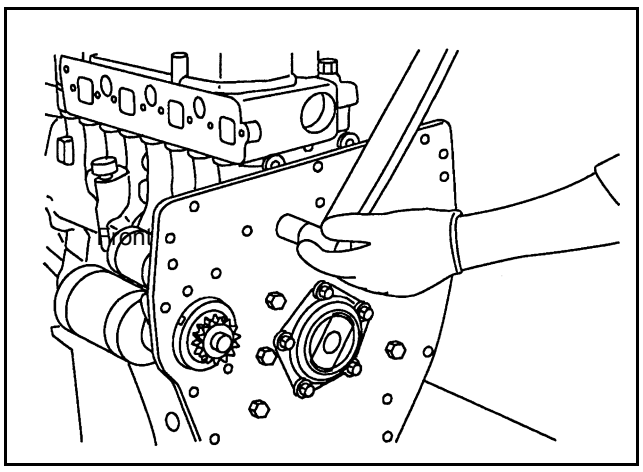


Figure 39 Removing rear plate

15.2 Rear plate removal

The rear plate is doweled in position. Pull the plate as straight as possible when removing it.

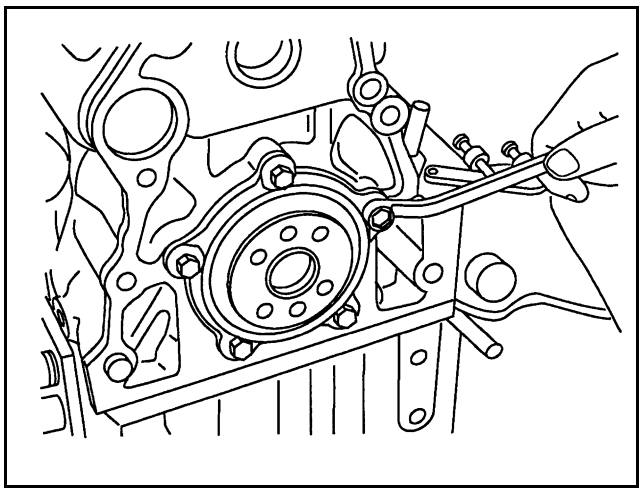


Figure 40 Removing oil seal case

15.3 Oil seal case removal

Remove the bolts that hold the oil seal case in position. Remove the case from the cylinder block with a screwdriver or the like.

⚠ CAUTION

Do not cause damage to the oil seal.

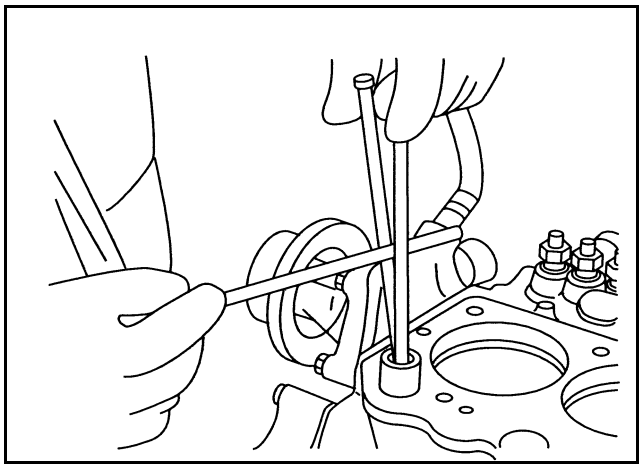


Figure 41 Removing tappets

15.4 Tappet removal

Remove the tappets from the cylinder block with a valve push rod.

NOTE

The valves, retainers, springs and valve locks must be set aside separately in groups, each tagged for cylinder number, for correct installation.

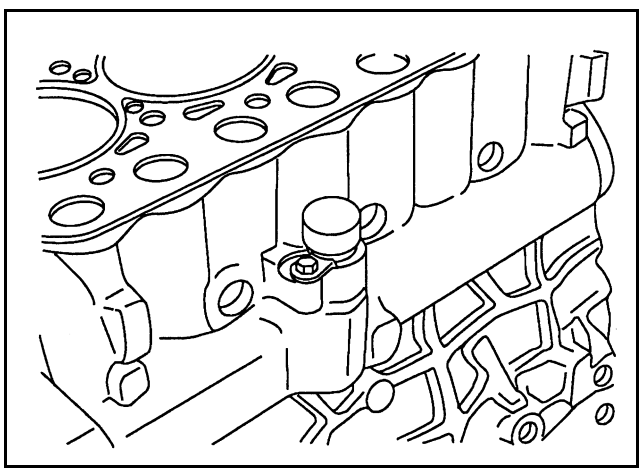


Figure 42 Removing speedometer driven gear

15.5 Speedometer driven gear removal

Remove the lock plate and speedometer driven gear in that order.

NOTE

Unless the speedometer driven gear is removed, the camshaft cannot be removed.

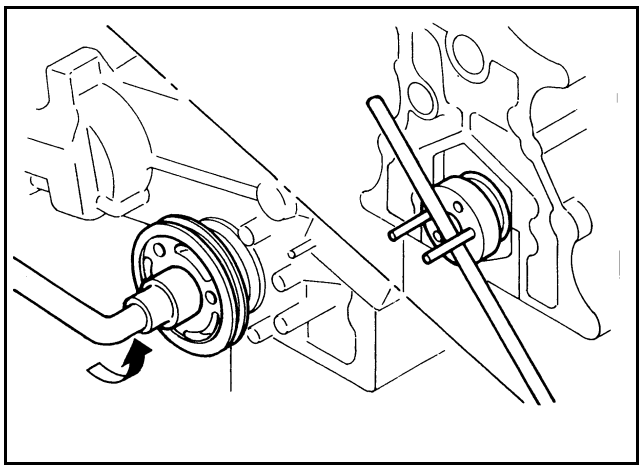


Figure 43 Removing crankshaft pulley

15.6 Crankshaft pulley removal

1. Install two safety bars (M12 x 1.25) into the threaded holes in the rear end of the crankshaft. Put a bar between the safety bars to hold the crankshaft to prevent it from rotating.
2. Remove the crankshaft pulley.

⚠ WARNING

When removing the crankshaft pulley, be prepared to stop the job in case the bar slips off the crankshaft to prevent injury.

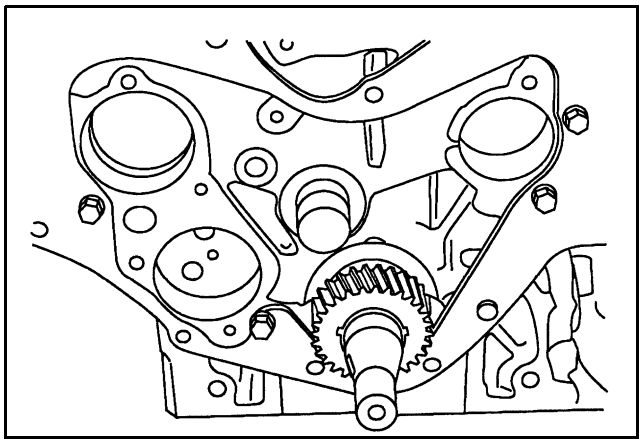


Figure 44 Front plate attaching bolts

15.7 Timing gear case removal

Remove the bolts that hold the timing gear case in position and remove the case.

⚠ CAUTION

The front plate is bolted inside the timing gear case. Do not attempt to remove this plate along with the timing gear case by tapping.

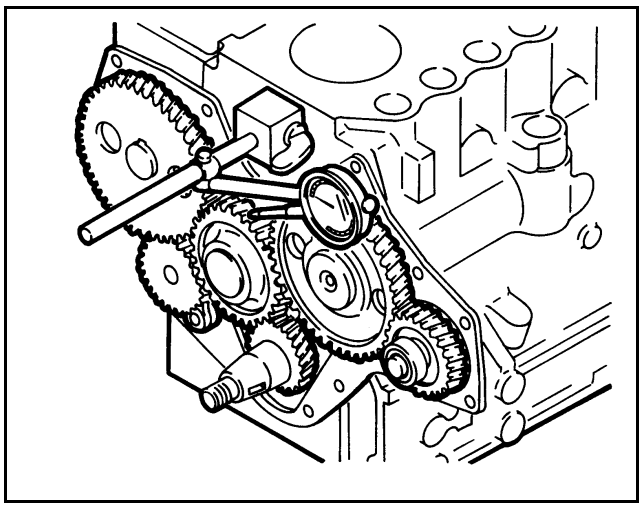


Figure 45 Measuring timing gear backlash

15.8 Timing gear backlash measurement

Measure the backlash of each gear and keep a record of it for correct installation. Replace the gears if the backlash exceeds the limit.

Unit: mm (in.)

Item		Standard	Limit
Timing gear backlash	Crankshaft gear and idler gear	0.04 to 0.12 (0.001 6 to 0.004 7)	0.30 (0.011 8)
	Idler gear and camshaft gear		
	Idler gear and fuel injection pump camshaft gear		
	Camshaft gear and P.T.O. gear	0.08 to 0.19 (0.003 1 to 0.007 5)	
	Fuel injection pump camshaft gear and oil pump gear	0.07 to 0.20 (0.002 8 to 0.007 9)	

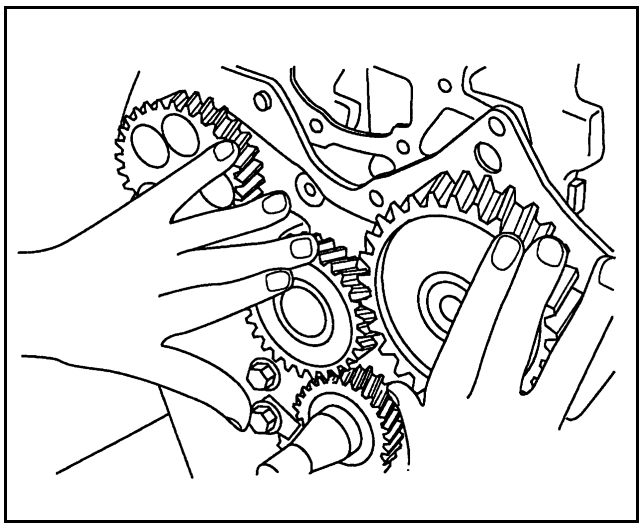


Figure 46 Removing idler gear

15.9 Idler gear removal

To remove the idler gear, rotate the gear in a direction of the helix of the teeth to pull it out of mesh.

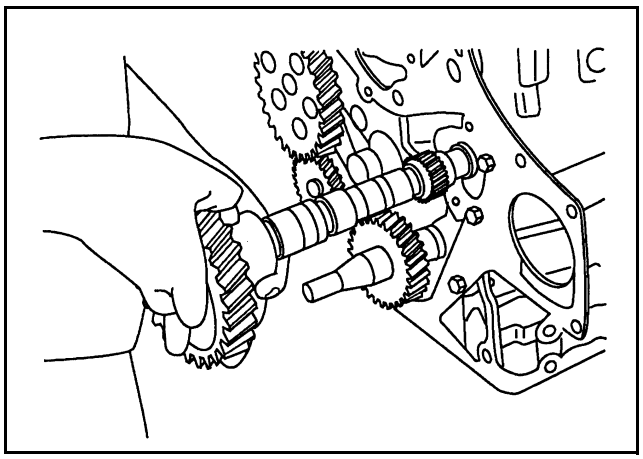


Figure 47 Removing camshaft

15.10 Camshaft removal

1. Remove the bolts that hold the thrust plate.
2. Pull the camshaft out of the cylinder block.

⚠ CAUTION

Do not cause damage to the lobes or bearing journals when removing the camshaft.

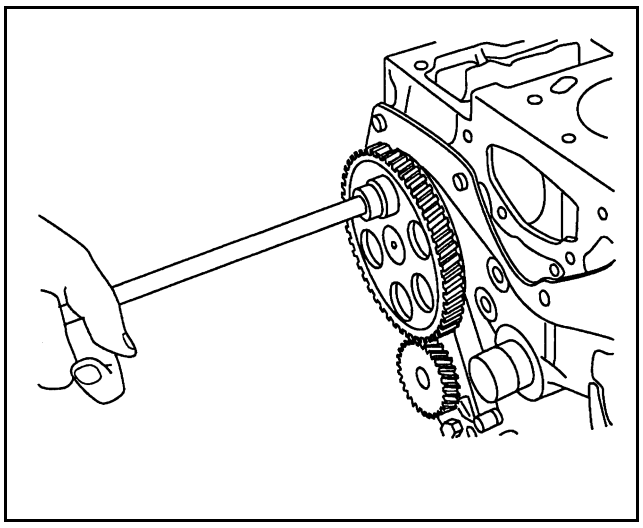


Figure 48 Removing camshaft stopper bolt

15.11 Fuel injection pump camshaft removal

1. Remove the stopper bolt.

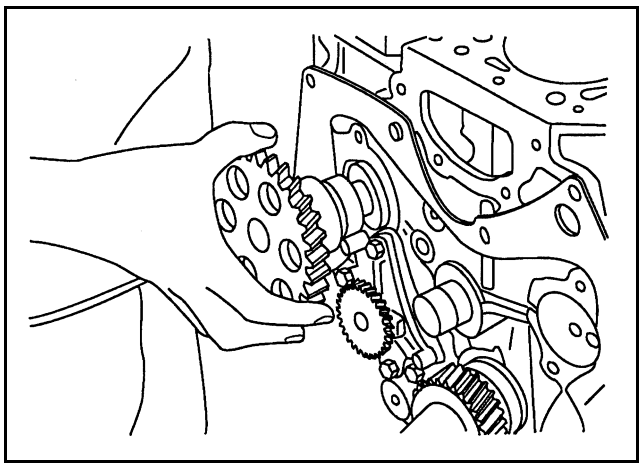


Figure 49 Removing fuel injection pump camshaft

2. Tap the rear end of the camshaft with a copper bar to push it out of the front side of the cylinder block.

15.12 Gear removal (when required)

To remove the gears from the camshaft and fuel injection pump camshaft, use an arbor press.

15.13 Oil pump removal

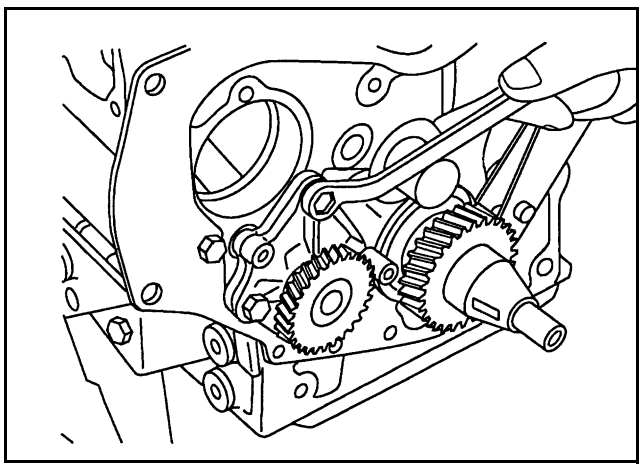


Figure 50 Removing oil pump

Remove the bolts that hold the oil pump to the cylinder block and remove the pump.

15.14 Front plate removal

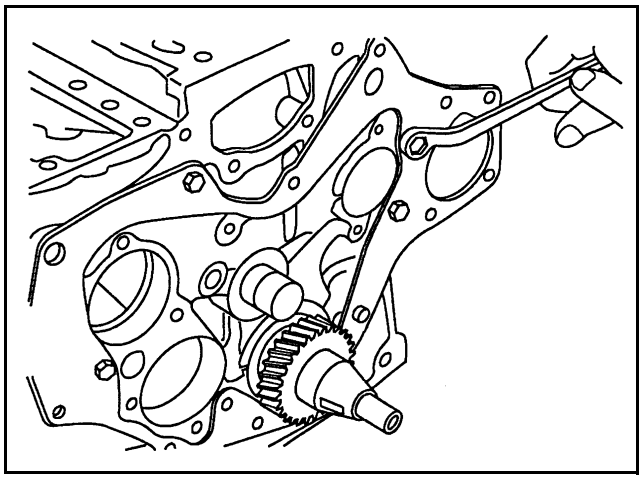
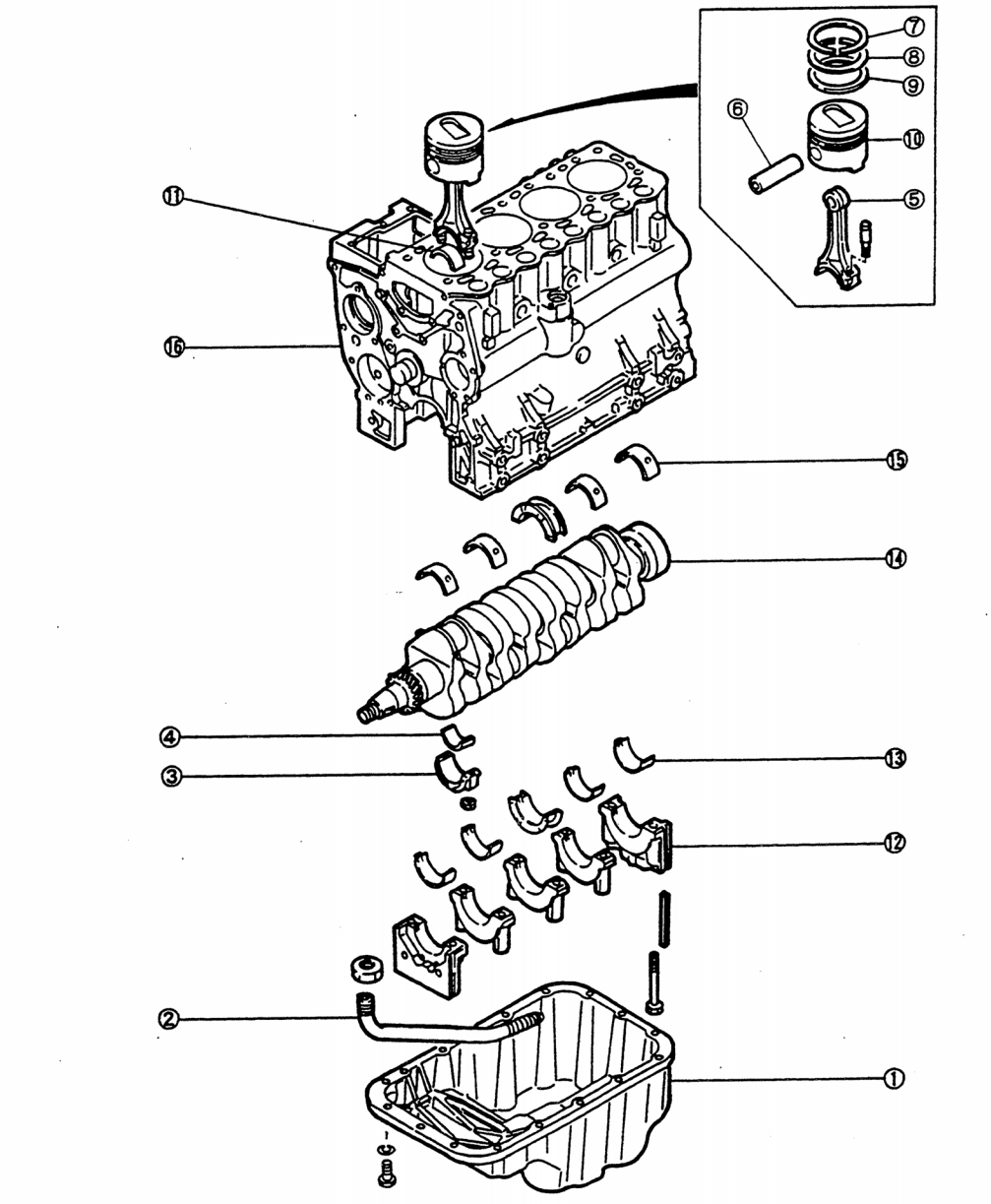


Figure 51 Removing front plate

Remove four bolts that hold the front plate in position. Tap the plate lightly with a plastic hammer to separate the gasket.

16 Cylinder Block, Crankshaft, Pistons and Oil Pan



1. Oil pan
2. Oil screen
3. Connecting rod cap
4. Connecting rod bearing (lower half)

(Remove 5 thru 10 as an assembly.)

5. Connecting rod
6. Piston pin
7. No. 1 ring
8. No. 2 ring
9. Oil ring
10. Piston
11. Connecting rod bearing (upper half)
12. Main bearing cap
13. Main bearing (lower half)
14. Crankshaft
15. Main bearing (upper half)
16. Cylinder block

NOTE: When the cylinder block is to be discarded, remove the components (pressure relief valve, etc.) from the block for reuse.

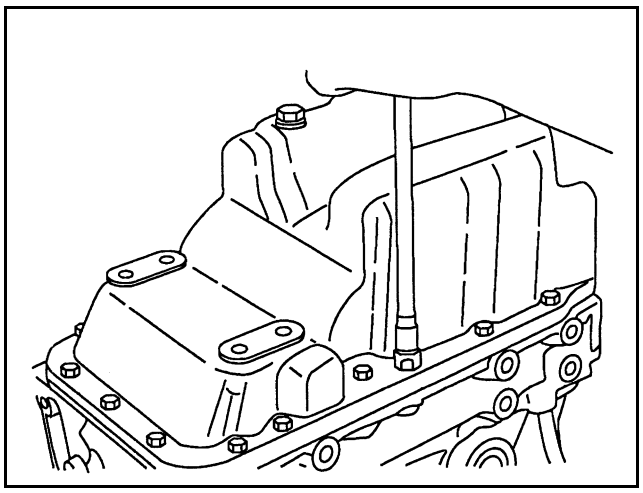


Figure 52 Removing oil pan

16.1 Oil pan removal

1. Turn the engine upside down.
2. Tap the bottom corners of the oil pan with a plastic hammer to remove the oil pan.

⚠ CAUTION

Do not attempt to pry off the oil pan by inserting a screwdriver or a chisel between the oil pan and cylinder block. Damage to the oil pan can be the result.

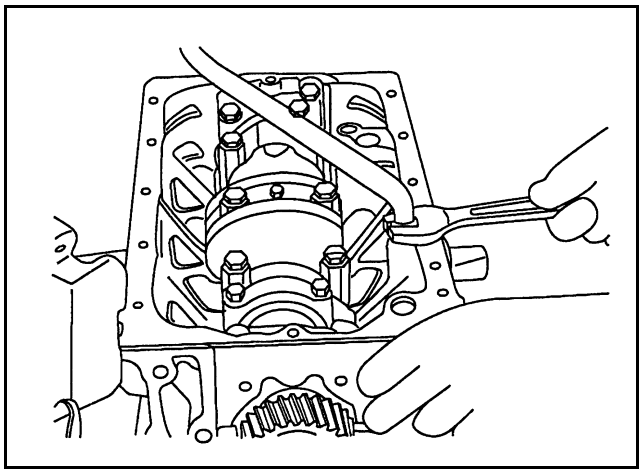


Figure 53 Removing oil screen

16.2 Oil screen removal

Loosen the nut that holds the oil screen in position and remove the screen.

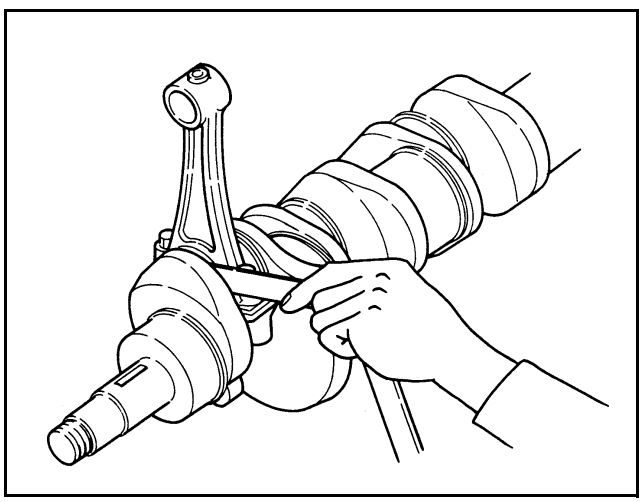


Figure 54 Measuring thrust clearance for connecting rod big end

16.3 Thrust clearance measurement for connecting rod big end

Install the connecting rod to its crankpin and tighten the cap nuts to the specified torque. Measure the thrust clearance with a feeler gauge. If the clearance exceeds the limit, replace the connecting rod.

Unit: mm (in.)

Item	Standard	Limit
Thrust clearance for connecting rod big end	0.10 to 0.35 (0.003 9 to 0.013 8)	0.50 (0.019 7)

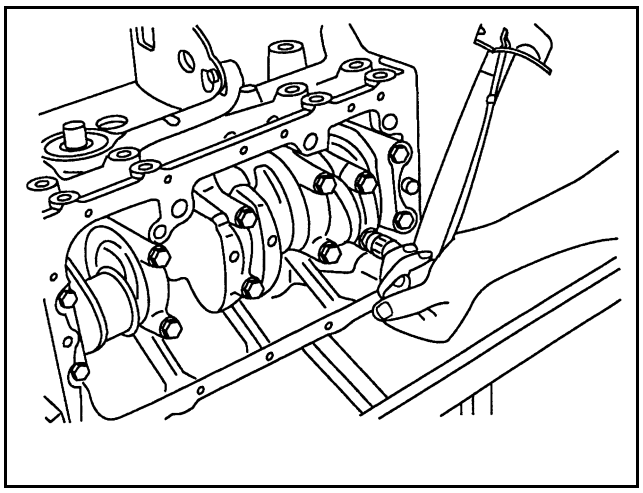


Figure 55 Removing connecting rod caps

16.4 Connecting rod cap removal

1. Lay the cylinder block on its side.
2. Put identification on each connecting rod and cap combination as to its location in the engine.
3. Remove the caps.

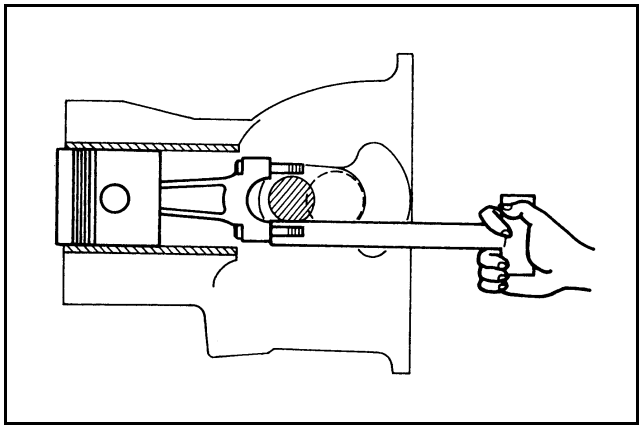


Figure 56 Removing piston

16.5 Piston removal

1. Turn the crankshaft until the piston is at top center.
2. Push the piston and connecting rod away from the crankshaft with the handle of a hammer or the like until the piston rings are above the cylinder. Remove the piston and connecting rod. Do Steps (1) and (2) for the removal of the other pistons.

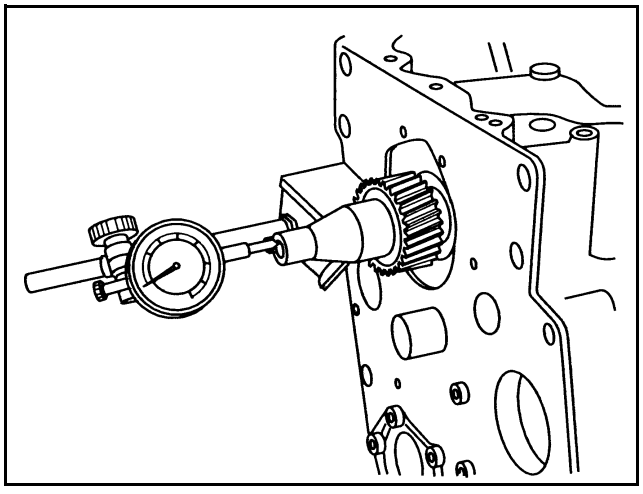


Figure 57 Measuring end play for crankshaft

16.6 End play measurement for crankshaft

Set a dial indicator so that it will touch the end of the crankshaft and measure the end play. If the end play exceeds the limit, replace No. 3 flanged bearing.

Unit: mm (in.)

Item	Standard	Limit
End play for crankshaft end play	0.050 to 0.175 (0.001 97 to 0.006 89)	0.500 (0.019 69)

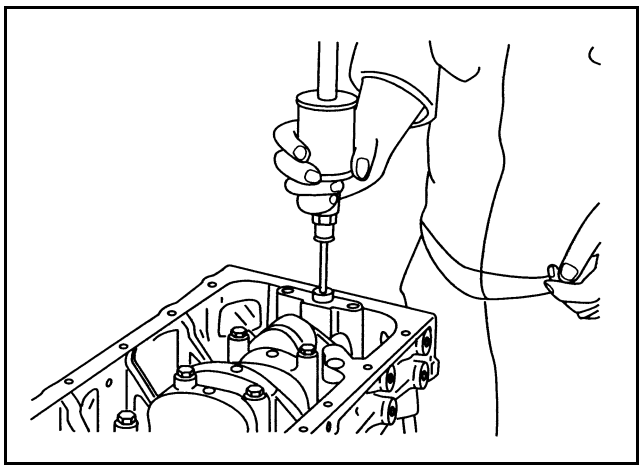


Figure 58 Removing main bearing caps

16.7 Main bearing cap removal

1. Lay the cylinder block with its bottom (oil pan) side up.
2. Remove the bolts that hold the main bearing caps in position. Remove the caps.
3. Remove the front and rear bearing caps with a sliding hammer.

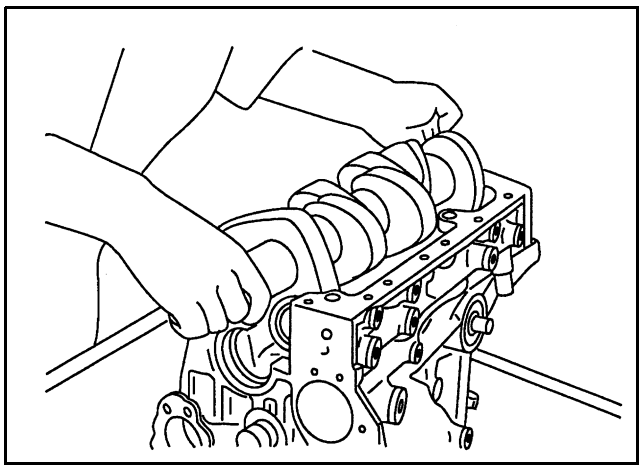


Figure 59 Removing crankshaft

16.8 Crankshaft removal

Remove the crankshaft.

⚠ CAUTION

Do not cause damage to the bearings.

NOTE

Put identification on each main bearing as to its location in the engine.

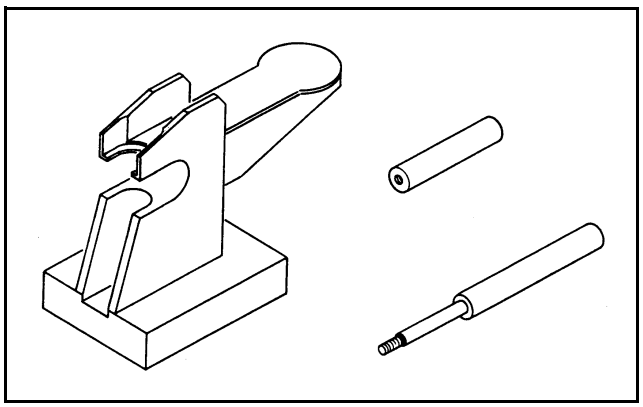


Figure 60 Piston pin setting tool

16.9 Piston separation from connecting rod

1. Use Piston Pin Setting Tool (31A91-00100) (special tool) to separate the piston from the connecting rod.

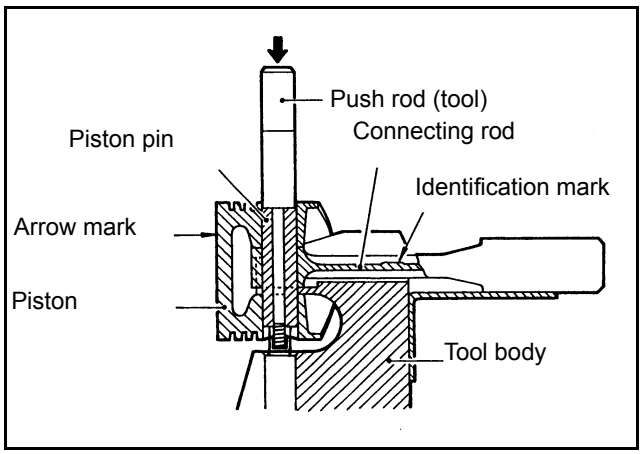


Figure 61 Removing piston pin (1)

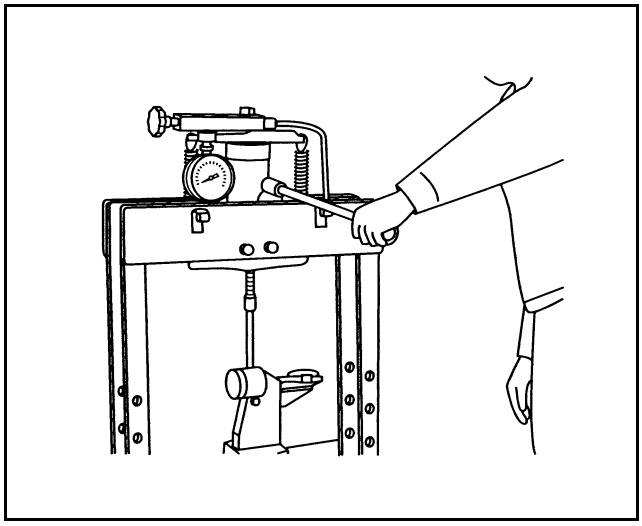


Figure 62 Removing piston pin (2)

2. Insert the push rod of the tool into the bore in the piston for the piston pin and, using an arbor press, remove the piston pin.
3. Use this Piston Pin Setting Tool to install the connecting rod to the piston.

⚠ CAUTION

Do not attempt to remove the piston pin by tapping. Replace a piston pin which needs a greater force for removal.

INSPECTION

17 CYLINDER HEAD AND VALVE MECHANISM

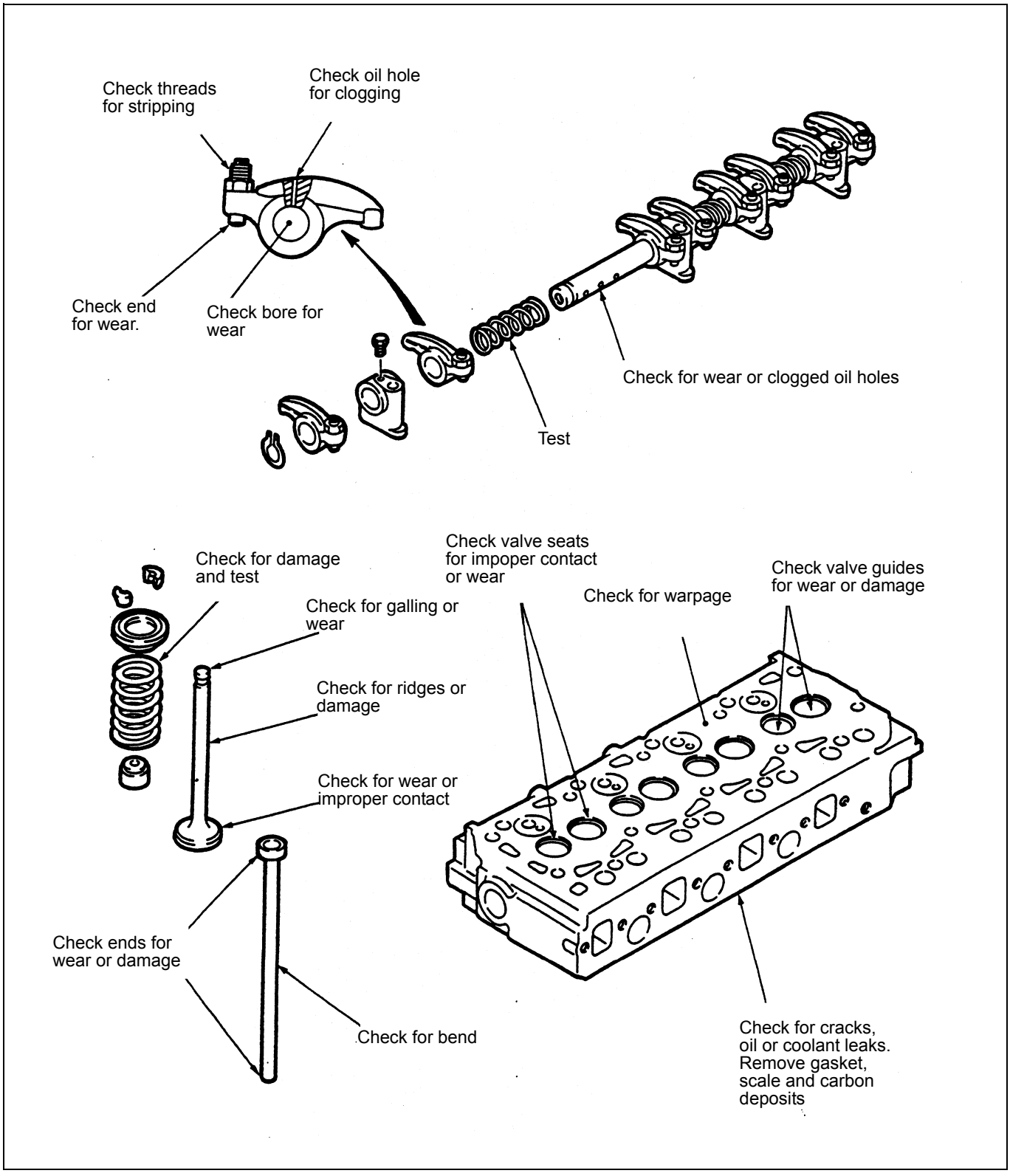


Figure 63 Inspection points

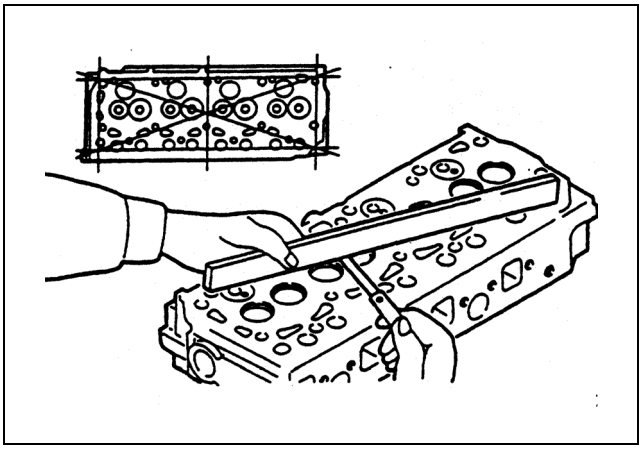


Figure 64 Checking cylinder head bottom face for warpage

17.1 Cylinder head

Using a heavy accurate straight edge and a feeler gauge, check the bottom face for warpage in three positions lengthwise, two crosswise and two widthwise as shown in the illustration. If warpage exceeds the limit, reface the bottom face with a surface grinder.

Unit: mm (in.)

Item	Standard	Limit
Warpage of cylinder head bottom face	0.05 (0.002 0) maximum	0.10 (0.003 9)

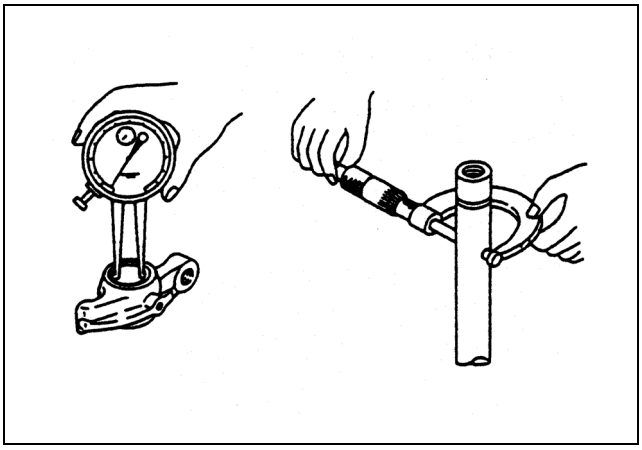


Figure 65 Measuring rocker arm and rocker shaft

17.2 Rocker arms and rocker shaft

Measure the bore in the rocker arm for the rocker shaft and the diameter of the rocker shaft to find the clearance between the arm and shaft. If the clearance has reached the limit, replace the rocker arm. If it exceeds the limit, replace both arm and shaft.

Unit: mm (in.)

Item	Nominal size	Standard	Limit
Bore in rocker arm for shaft	18.9 (0.744)	18.910 to 18.930 (0.744 49 to 0.745 27)	—
Diameter of shaft for arm	18.9 (0.744)	18.880 to 18.898 (0.743 31 to 0.744 01)	—
Clearance between rocker arm and shaft	—	0.012 to 0.050 (0.000 47 to 0.001 97)	0.200 (0.007 87)

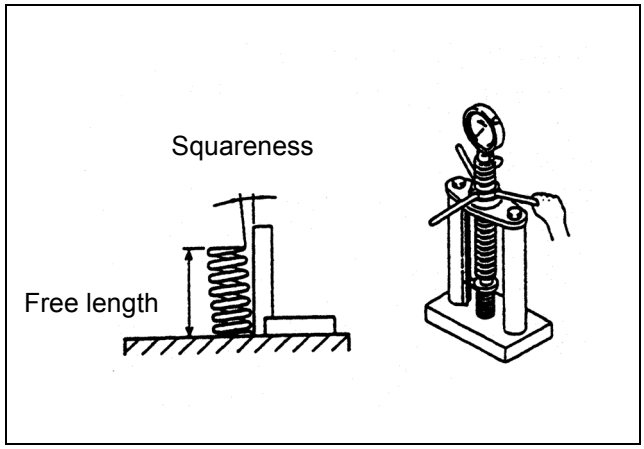


Figure 66 Testing valve spring

17.3 Valve springs

Check the squareness and free length. If the squareness and/or free length exceeds the limit, replace the spring.

Unit: mm (in.)

Item		Standard	Limit
Free length		47 (1.85)	46 (1.81)
Squareness		1.5° maximum	
Test force, kgf (lbf) [N]	Length under test force: 39.1 (1.54)	13.9 ± 0.7 (30.6 ± 1.5) [136 ± 7]	–15%
	Length under test force: 30.5 (1.20)	29 ± 2 (64 ± 4.4) [284 ± 20]	

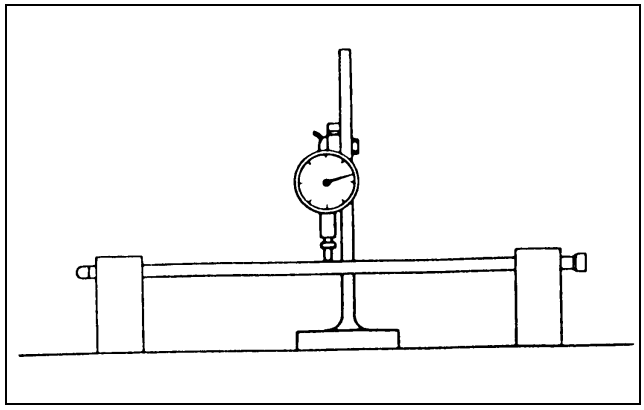


Figure 67 Checking bend of valve push rod

17.4 Valve push rods

Using V-blocks and a dial indicator, check for bend. If the bend exceeds the limit, replace the push rod.

Unit: mm (in.)

Item	Limit
Bend (dial indicator reading) of valve push rod	0.3 (0.012) maximum

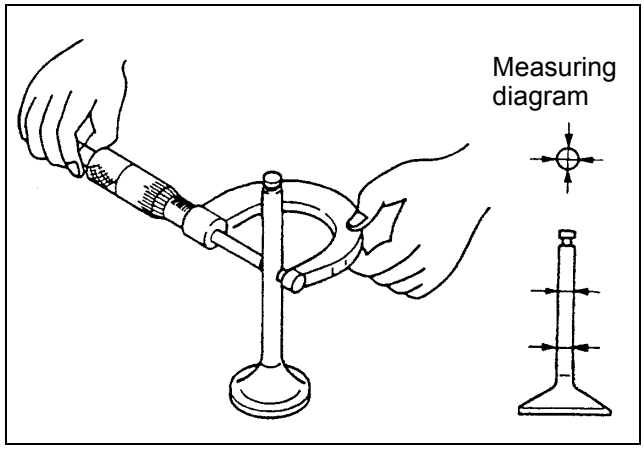


Figure 68 Measuring valve stem

17.5 Valves, valve guides and valve seats

1. Diameter of valve stem
   Measure the diameter of the valve stem as shown in the illustration. If the stem is worn beyond the limit, or if it is abnormally worn, replace the valve.

Unit: mm (in.)

Item		Nominal size	Standard	Limit
Diameter of valve stem	Inlet valve	6.6 (0.260)	6.565 to 6.580 (0.258 46 to 0.259 05)	6.500 (0.255 91)
	Exhaust valve	6.6 (0.260)	6.530 to 6.550 (0.257 09 to 0.257 87	

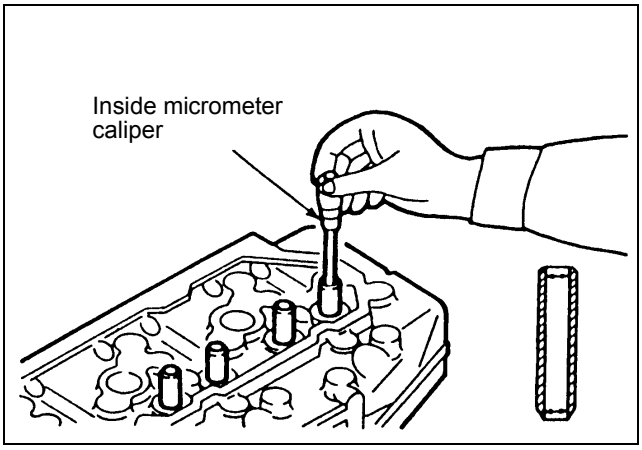


Figure 69 Measuring valve guide

2. Clearance between valve stem and valve guide

The valve guide wears more rapidly at its both ends than at any other parts. Measure the bore in the guide for the stem at its ends with an inside micrometer caliper to find the clearance between the stem and guide. If the clearance exceeds the limit, replace the guide or valve whichever is badly worn.

Unit: mm (in.)

Item		Nominal size	Standard	Limit
Clearance between valve stem and valve guide	Inlet valve	—	0.02 to 0.05 (0.000 8 to 0.002 0)	0.10 (0.003 9)
	Exhaust valve	—	0.05 to 0.085 (0.002 0 to 0.003 35)	0.15 (0.005 9)
Height to top of valve guide		10 (0.39)	9.5 to 10.5 (0.374 to 0.413)	—

NOTE

Before measuring the valve guides, clear the guides of lacquer and carbon.

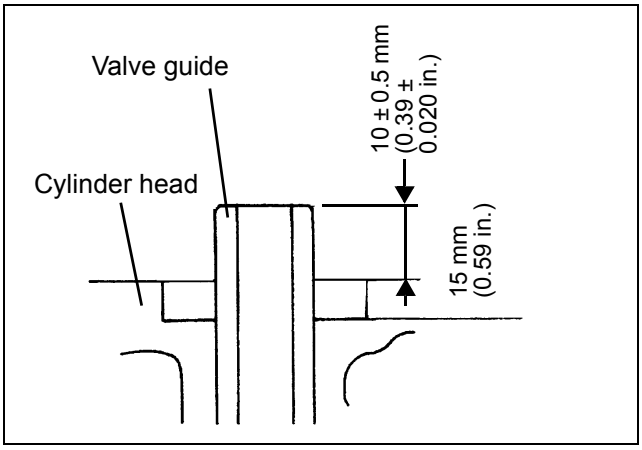


Figure 70 Height to top of valve guide

3. Valve guide replacement

1) Remove the guide from the cylinder head by pushing it with a tool and an arbor press from the bottom side of the head.
2) Install a new guide into the cylinder head by pushing it with an arbor press from the upper side of the head until the specified height to the top of the guide is obtained.
3) Insert a new valve into the guide and make sure the valve slides in the guide freely.
4) After the valve guide has been replaced, check the valve contact with its seat.

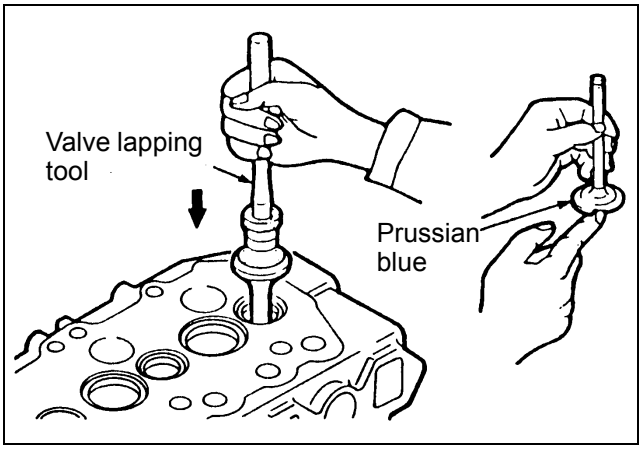


Figure 71 Checking valve contact with seat

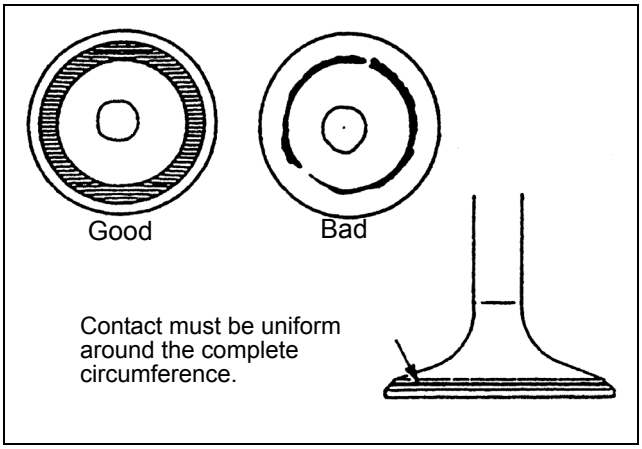


Figure 72 Valve and valve seat contact

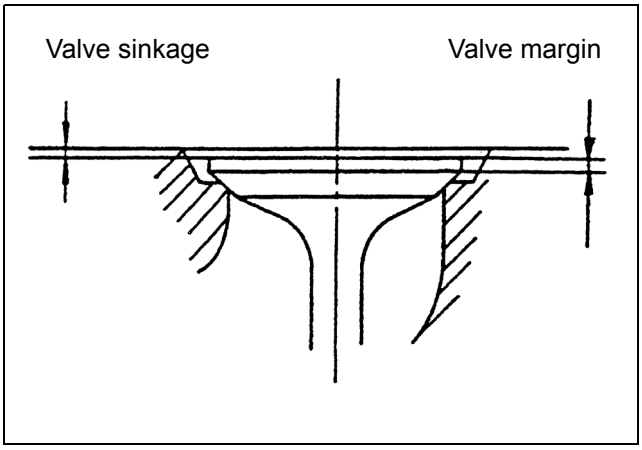


Figure 73 Valve margin and sinkage

4. Valves

1) Put a small amount of Prussian blue or red lead on the valve face. Hold the valve with a valve lapping tool (commercially available) and press it against the seat to check its contact.

2) The width of contact must be uniform all the way around both seat and valve. If the contact is bad, reface the valve and seat.

3) If the valve margin (valve lip thickness) exceeds the limit, replace the valve.

Unit: mm (in.)

Item	Standard	Limit
Valve margin (lip thickness)	1.0 (0.039)	0.5 (0.020)

4) If the valve sinkage (the dimension from the top of a closed valve to the face of cylinder head) exceeds the limit, recondition the valve seat or replace the cylinder head assembly.

Unit: mm (in.)

Item	Standard	Limit
Valve sinkage (dimension from top of closed valve to face of head)	0.5 ± 0.25 (0.020 ± 0.009 8)	1.5 (0.059)

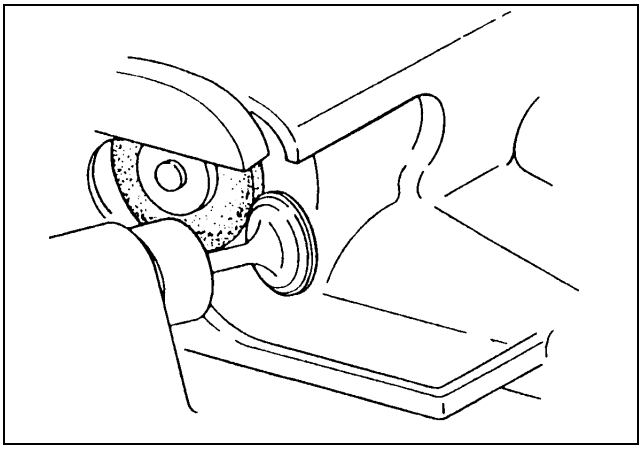


Figure 74 Refacing valve face

5. Valve refacing

   1) Set the valve refacer at an angle of 45° and grind the valve.
   2) The valve margin must be not less than the limit. If the margin seems to be less than the limit when the valve is refaced, replace the valve.

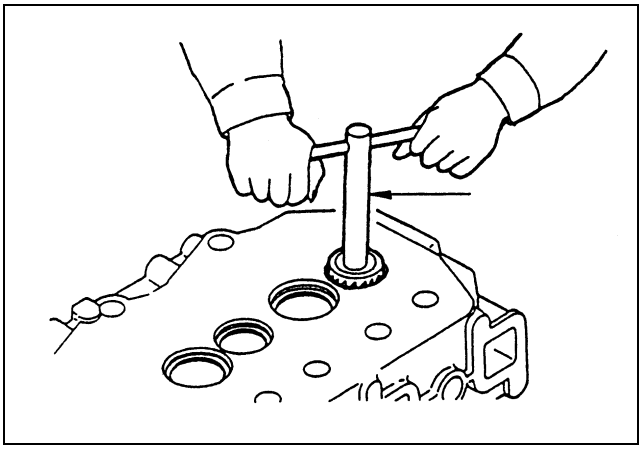


Figure 75 Refacing valve seat

6. Valve seat refacing

   1) Before refacing the valve seat, check the clearance between the valve and guide, and replace the guide if necessary.
   2) Cut the valve seat with a valve seat cutter (commercially available), or grind it with a valve seat grinder, and finish the width of valve seat and the angle of seat face to the correct values.

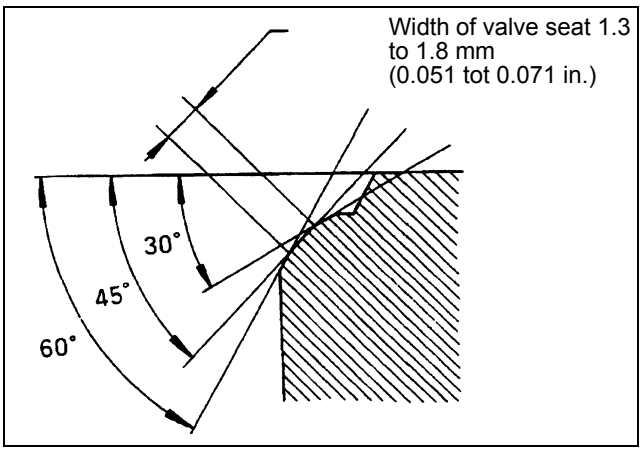


Figure 76 Valve seat width and valve face angle

Unit: mm (in.)

Item	Standard	Limit
Angle of seat face	45°	—
Width of valve seat	1.3 to 1.8 (0.051 to 0.071)	2.5 (0.098)

   3) After refacing the valve seat, put lapping compound on the valve face and lap the valve in the valve seat.

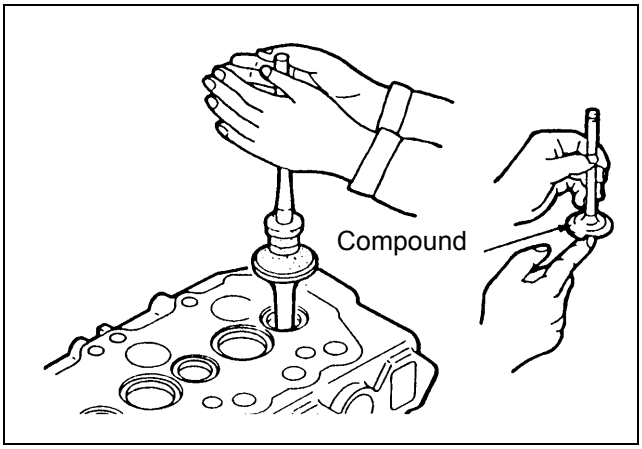


Figure 77 Lapping valve in seat

7. Valve lapping

   Be sure to lap the valves in the seats after refacing or replacing the valves or valve seats.

   1) Put a small amount of lapping compound on the valve face.

NOTE

- Do not put lapping compound on the valve stem.
- Use a lapping compound of 120 to 150 mesh for initial lapping and a compound of finer than 200 mesh for finish lapping.
- Mixing the compound with a small amount of engine oil will help put the compound on the valve face uniformly.

   2) Using a lapping tool, hold the valve against the seat and rotate it only a part of a turn, then raise the valve off its seat, rotating it to a new position. Press the valve against the seat for another part of a turn. Repeat this operation until the compound wears and loses its cutting property.
   3) Wash the valve and valve seat with dry cleaning solvent.
   4) Apply engine oil to the valve and lap it in the seat.
   5) Check the valve face for contact.

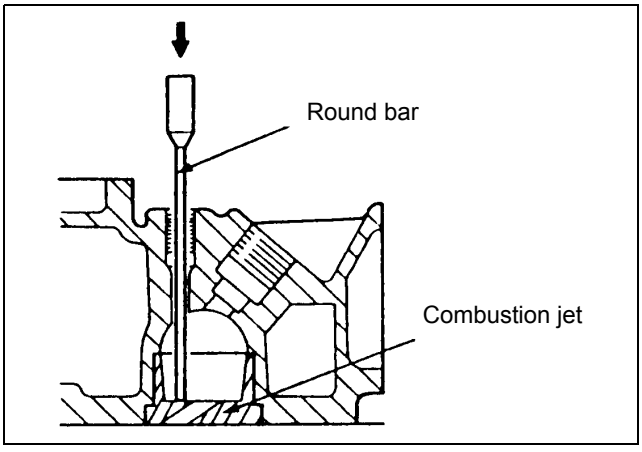


Figure 78 Removing combustion jet

17.6 Combustion jet replacement

Replace the combustion jets only when they are cracked or defective.

1. To remove the jet, insert a 6 mm (0.24 in.) diameter round bar through the bore in the cylinder head for the glow plug and tap around the jet.

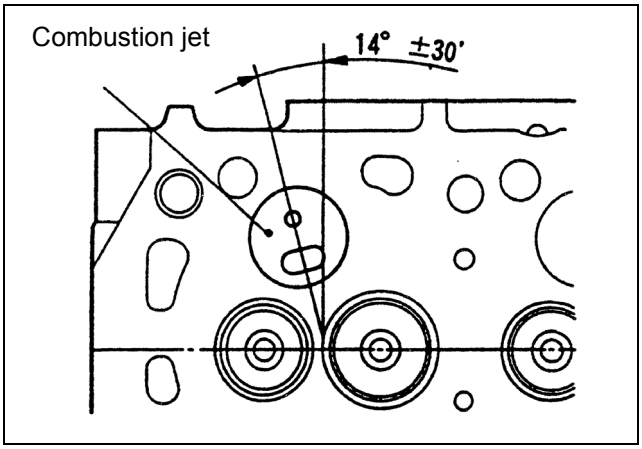


Figure 79 Installing combustion jet

2. To install a new jet, put the jet in position in the head with its tangential orifice in alignment with the center of the main chamber and tap it with a plastic hammer. The new jet must be flush with the cylinder head surface.

18 TIMING GEARS AND FLYWHEEL

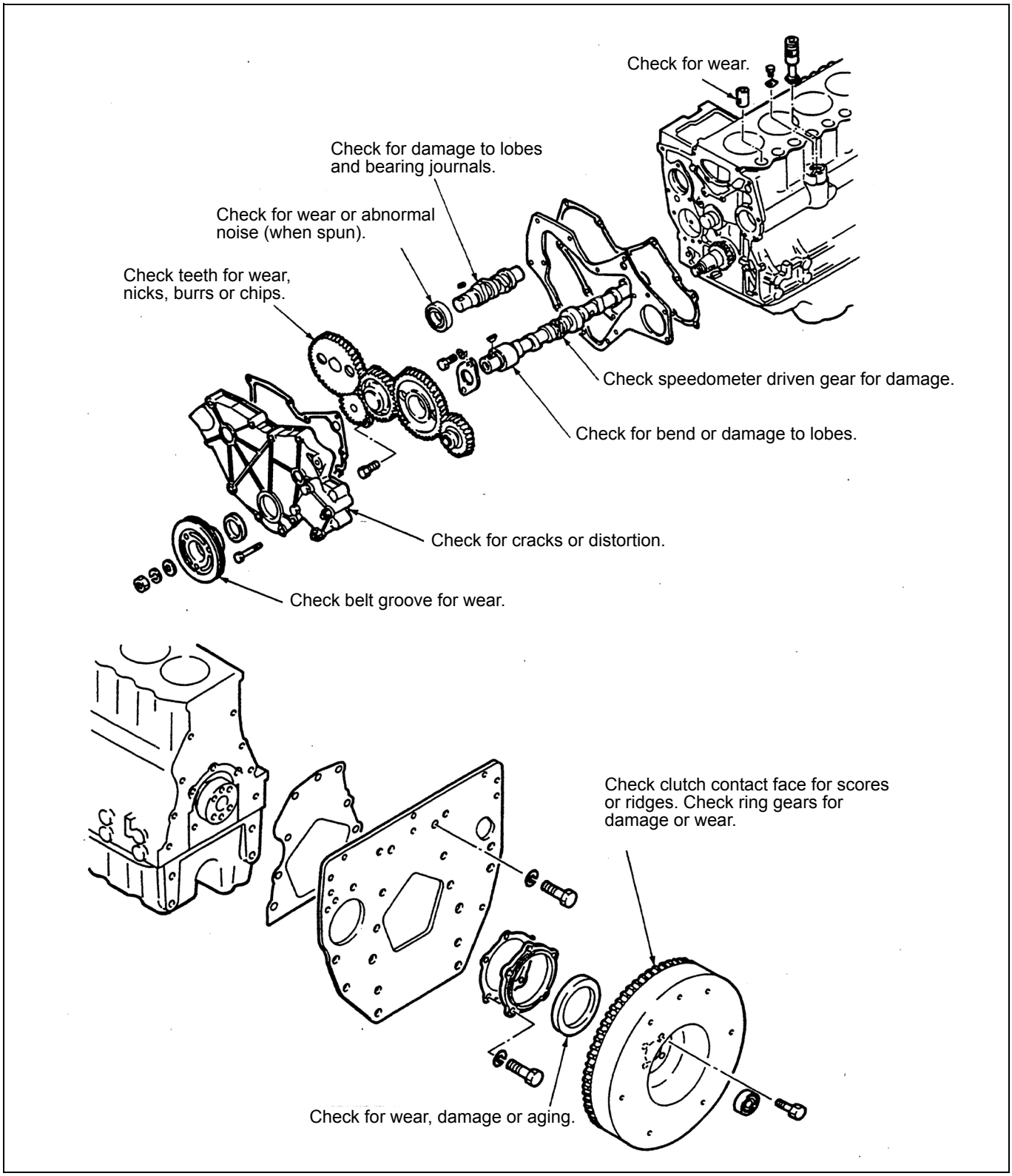


Figure 80 Inspection points

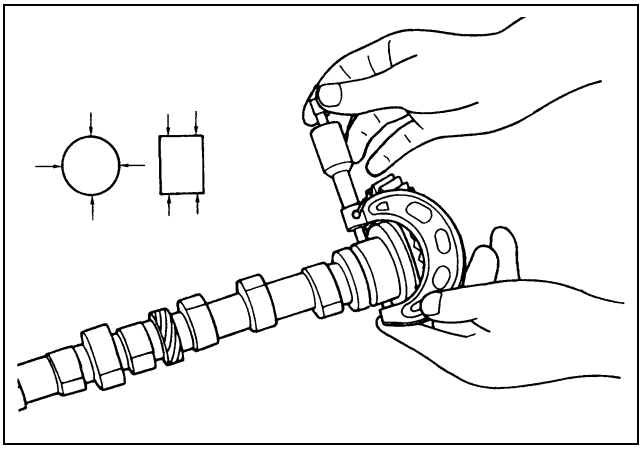


Figure 81 Measuring camshaft journal

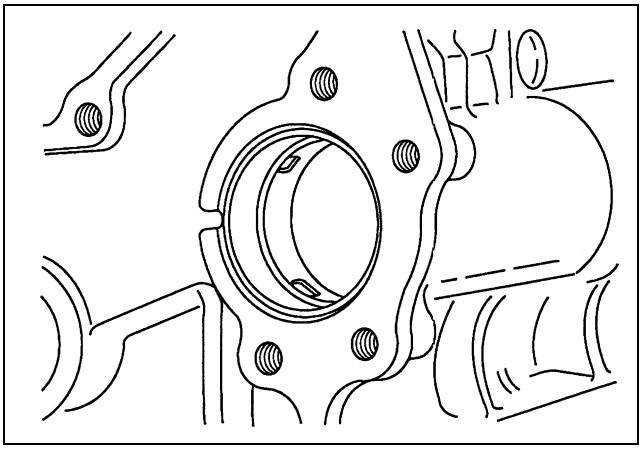


Figure 82 Measuring bore in camshaft bushing

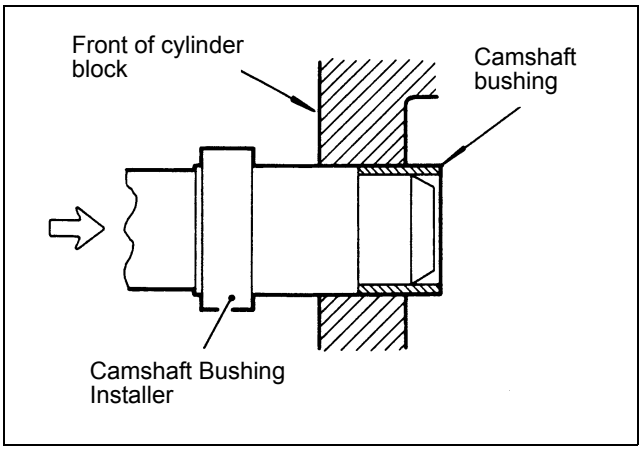


Figure 83 Removing camshaft bushing

18.1 Camshaft

1. Clearance between journal and bushing

Measure the diameter of the journal and the bore in the bushing for the shaft to find the clearance as shown in the illustration. If the clearance exceeds the limit, replace the bushing.

Unit: mm (in.)

Item	Standard
Clearance between camshaft journal and bushing	0.15 (0.005 9)

2. Bushing replacement

Use Camshaft Bushing Installer (ST332340) (special tool) for camshaft bushing replacement.

1) Removal
Remove the oil pan. Using a “remover” end of the Installer, push out the bushing into the cylinder block. Crush and take out the bushing from the block.

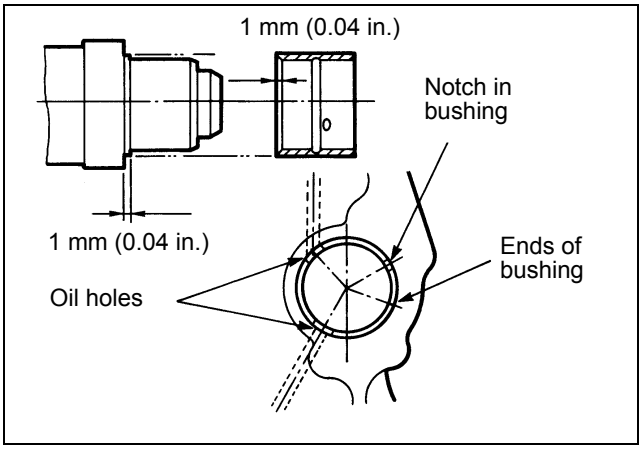


Figure 84 Installing camshaft bushing

2) Installation
Install a new bushing in position with its oil holes in alignment with those of the oil gallery.

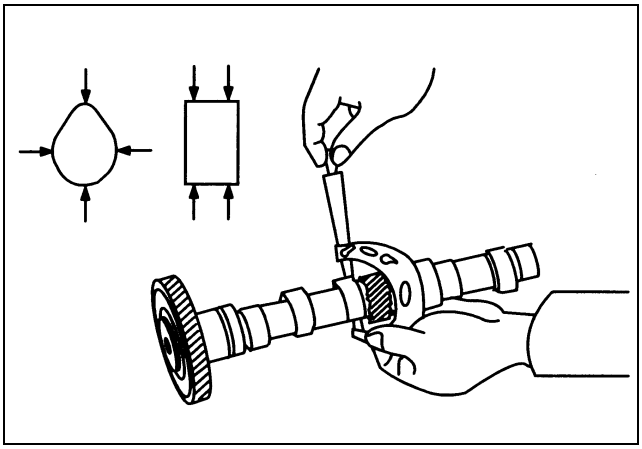


Figure 85 Measuring lobe height of camshaft

3. Lobe lift

Measure the lobe height and base circle as shown in the illustration. Subtract the base circle from the lobe height to find the lobe life. If the lobe lift exceeds the limit, replace the camshaft

.Unit: mm (in.)

Item	Standard	Limit
Lobe height of camshaft	35.72 (1.404 3)	34.72 (1.366 9)

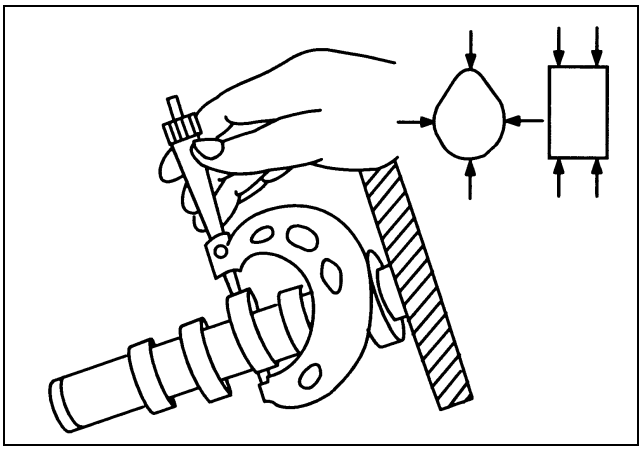


Figure 86 Measuring lobe height of fuel injection pump camshaft

18.2 Fuel injection pump camshaft

Measure the lobe height and base circle as shown in the illustration. Subtract the base circle from the lobe height to find the lobe life. If the lobe lift exceeds the limit, replace the camshaft.

.Unit: mm (in.)

Item	Standard	Limit
Lobe height of fuel injection pump camshaft	44 (1.73)	43 (1.69)

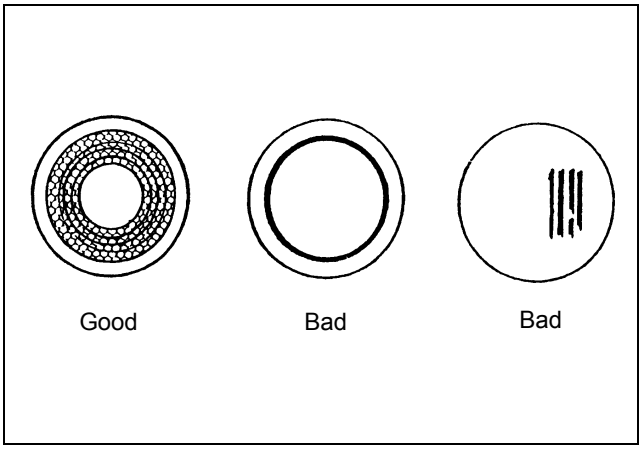


Figure 87 Cam contact face of tappet

18.3 Tappets

1. Cam contact face
   Check the cam contact face of each tappet for abnormal wear. Replace the tappet if the face is defective.

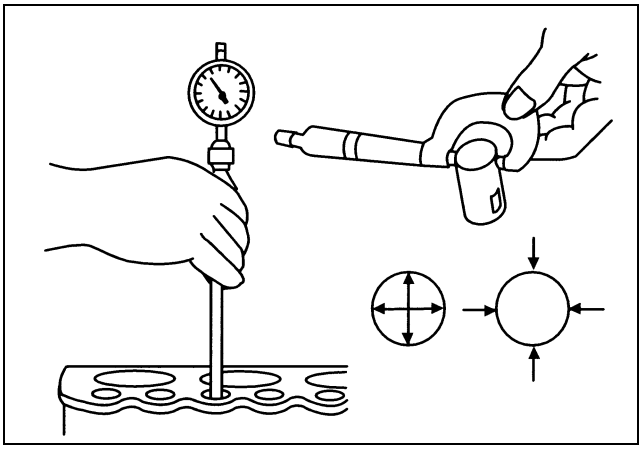


Figure 88 Measuring tappet and bore in cylinder block

2. Clearance between tappet and cylinder block
   Measure the diameter of the tappet and the bore in the cylinder block for the tappet to find the clearance. If the clearance exceeds the limit, replace the tappet.

Unit: mm (in.)

Item	Standard
Clearance between tappet and cylinder block	0.15 (0.005 9)

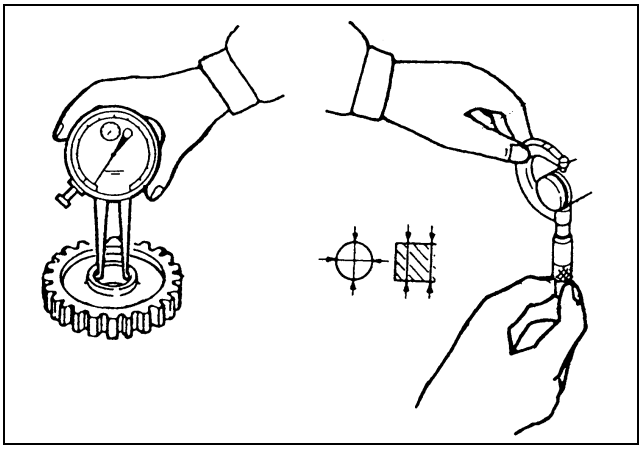


Figure 89 Measuring idler gear and shaft

18.4 Idler gear

1. Clearance between idler gear and shaft

   Measure the bore in the idler gear for the shaft and the diameter of the shaft to find the clearance. If the clearance exceeds the limit, replace the gear or shaft whichever is badly worn.

.Unit: mm (in.)

Item	Standard	Limit
Clearance between idler gear and shaft	0.03 to 0.07 (0.001 2 to 0.002 8)	0.20 (0.007 9)

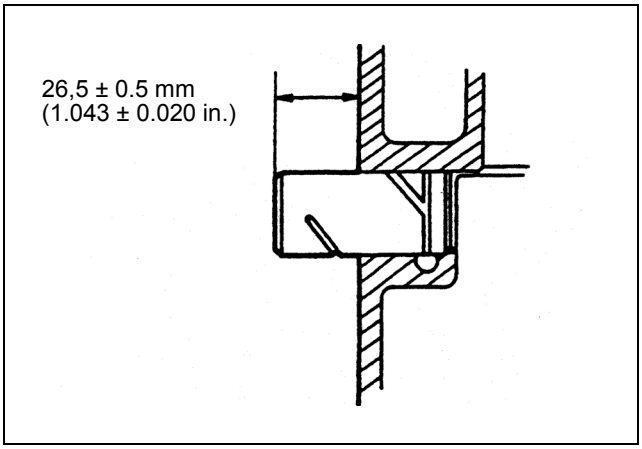


Figure 90 Idler shaft dimension

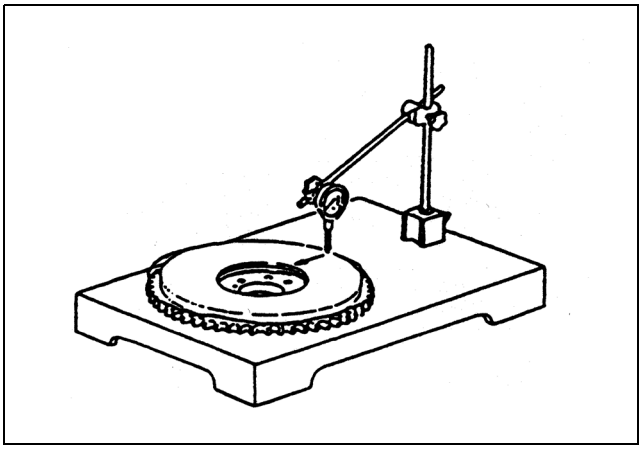


Figure 91 Measering flywheel flatness

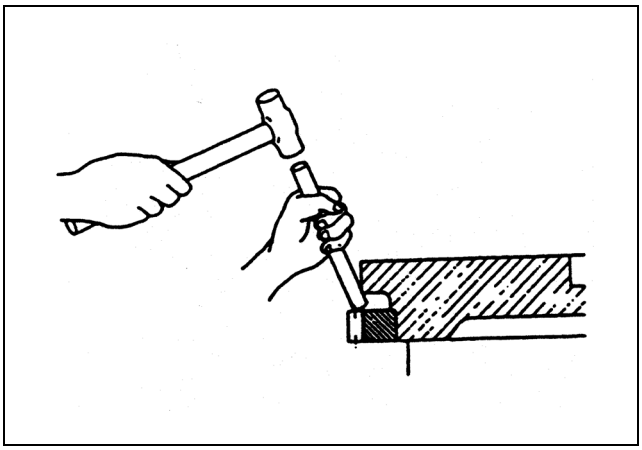


Figure 92 Removing ring gear

2. Idler shaft replacement

   Install a new idler shaft to the cylinder block so that its dimension from the face of the block is 26.5±0.5 mm (1.043±0.020 in.).

18.5 Flywheel and ring gear

1. Flatness (difference between lower and higher measurements) of flywheel

   Put the flywheel on the surface plate. Set a dial indicator at one side of the friction (clutch contact) face and move it over to the opposite side of the face as shown in the illustration to find the flatness. If the flatness exceeds the limit, grind the face.

Unit: mm (in.)

Item	Standard	Limit
Flatness of flywheel	0.15 (0.005 9) maximum	0.50 (0.019 7)

2. Ring gear replacement

   Check the ring gear and replace it if its teeth are abnormally worn or chipped.
   1) Removal
      Heat the ring gear evenly with an acetylene torch. Tap the ring gear all the way around with a bar and a hammer as shown in the illustration to remove it from the flywheel.
   2) Installation
      Heat a new ring gear up to a temperature of 150°C (302°F) with a piston heater and install it to the flywheel with its unchamfered side foremost.

19 CYLINDER BLOCK, CRANKSHAFT, PISTONS AND OIL PAN

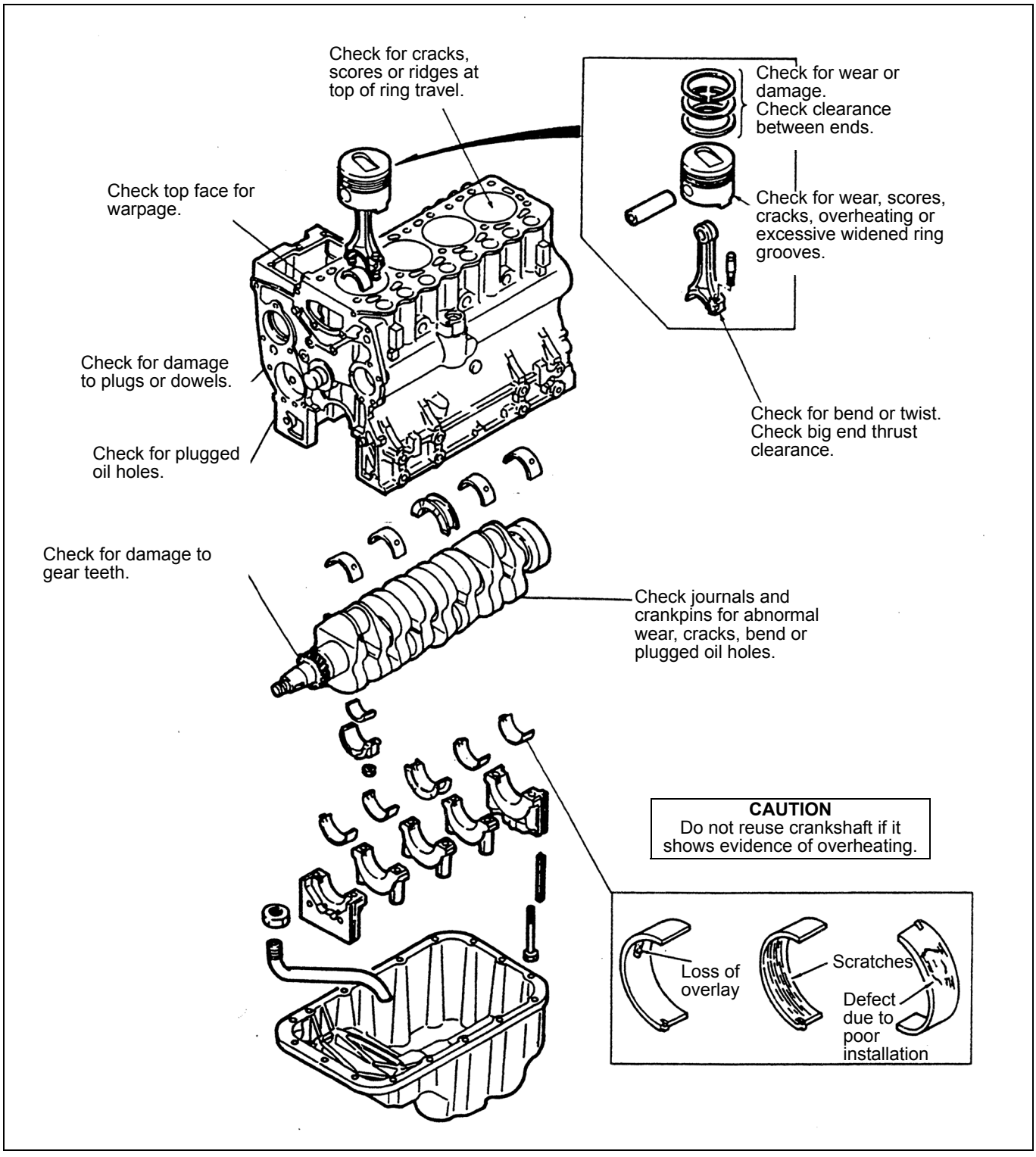


Figure 93 Points à inspecter

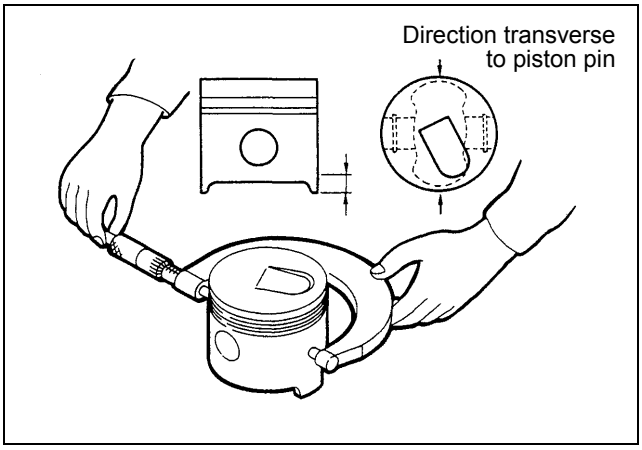


Figure 94 Measuring diameter of piston

19.1 Pistons, Piston Rings and Piston Pins

1. Diameter of piston

Measure the diameter of the piston at its skirt in a direction transverse to the piston pin with a micrometer as shown in the illustration. If the diameter exceeds the limit, replace the piston. Select a new piston so that the difference between average weight of all pistons in one engine does not exceed the standard.

Unit: mm (in.)

Item		Norminal size	Standard	Limit
Diameter of piston	Standard	78.00 (3.070 9)	77.93 to 77.95 (3.068 1 to 3.068)	77.80 (3.063 0)
	0.25 (0.009 8) oversize	78.25 (3.080 7)	78.18 to 78.20 (3.077 9 to 3.078 7)	78.05 (3.072 8)
	0.50 (0.019 7) oversize	78.50 (3.090 5)	78.43 to 87.45 (3.087 8 to 3.088 6)	78.30 (3.082 7)
Maximum permissible difference between average weight of all pistons in one engine, g (oz)			5 (0.18)	—

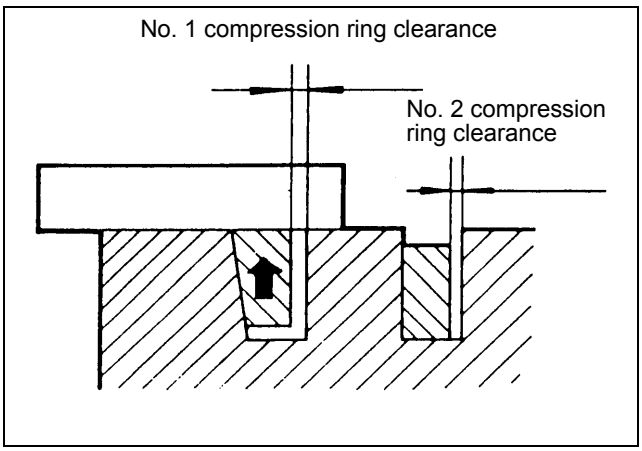


Figure 95 Measuring clearance between piston ring and groove

2. Clearance between piston ring and groove

1) Measure the clearance between the groove and piston with a straight edge and a feeler gauge as shown in the illustration. If the clearance exceeds the limit, replace the ring.

.Unit: mm (in.)

Item	Standard	Limit
No. 1 compression ring	0.06 to 0.10 (0.002 4 to 0.003 9)	0.30 (0.011 8)
No. 2 compression ring	0.06 to 0.10 (0.002 0 to 0.003 5)	0.20 (0.007 9)
Oil ring	0.06 to 0.10 (0.001 2 to 0.002 8)	0.20 (0.007 9)

2) If the clearance still exceeds the limit after new piston rings have been installed, replace the piston.

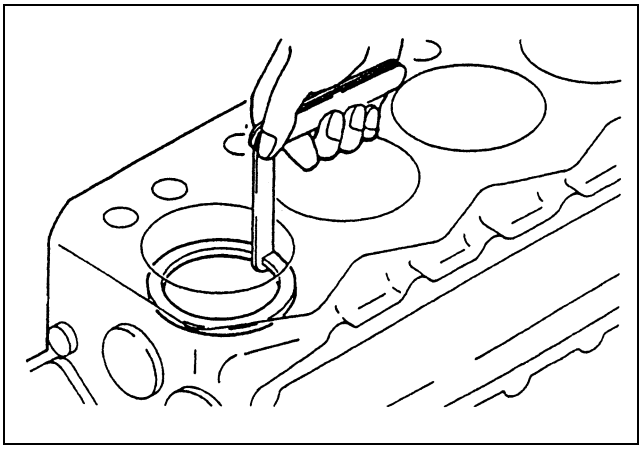


Figure 96 Measuring clearance between ends of piston ring

3. Clearance between ends of piston ring

Put the piston ring in a gauge or in the bore in a new cylinder block and measure the clearance between the ends of the ring with a feeler gauge as shown in the illustration. If the clearance exceeds the limit, replace all the rings.

Inside diameter of gauge

Standard: $78_0^{+0.03}$ mm ($3.07_0^{+0.0012}$ in.)

0.25 mm (0.0098 in.) oversize:

$78.25_0^{+0.03}$ mm ($3.08_0^{+0.0012}$ in.)

0.50 mm (0.0197 in.) oversize:

$78.50_0^{+0.03}$ mm ($3.09_0^{+0.0012}$ in.)

NOTE

Put the piston ring in the gauge or cylinder squarely with the piston.

.Unit: mm (in.)

Item		Standard	Limit
Clearance between ends of piston ring	No. 1 compression ring	0.15 to 0.30 (0.005 9 to 0.011 8)	1.50 (0.059 1)
	No. 2 compression ring	0.15 to 0.35 (0.005 9 to 0.013 8)	
	Oil ring	0.20 to 0.40 (0.007 9 to 0.015 7)	

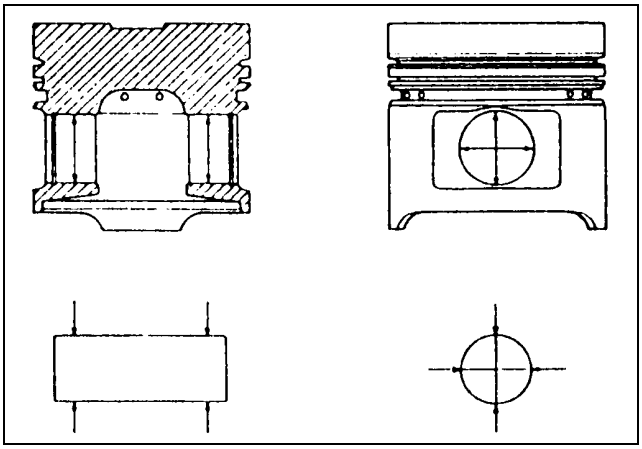


Figure 97 Measuring piston pin and bore in piston for pin

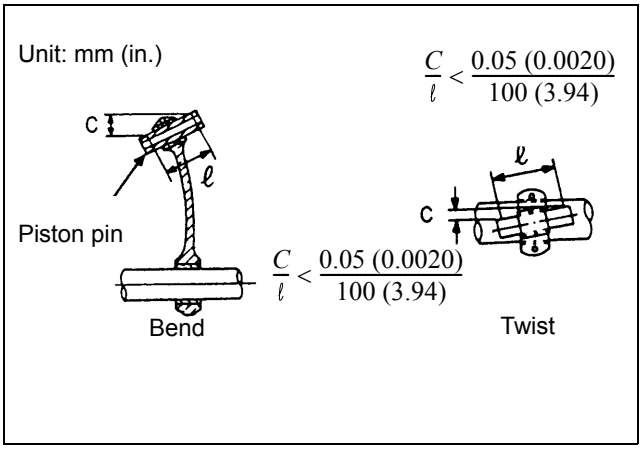


Figure 98 Checking connecting rod for bend or twist

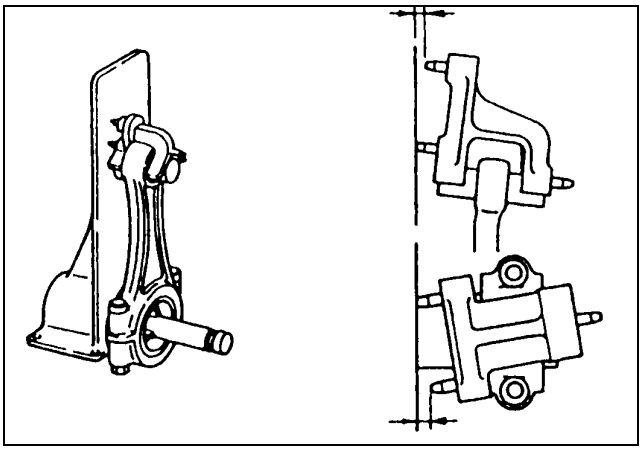


Figure 99 Check connecting rod on a connecting rod aligner

4. Clearance between piston pin and piston

Measure the diameter of the piston pin and the bore in the piston for the pin as shown in the illustration to find the clearance. If the clearance exceeds the limit, replace the piston or pin whichever is badly worn.

.Unit: mm (in.)

Item	Norminal size	Standard	Limit
Diameter of piston pin	23 (0.91)	22.994 to 23.000 (0.905 027 to 0.905 51)	
Clearance between piston pin and piston	—	0.006 to 0.018 (0.00024 to 0.00071)	0.050 (0.001 97)

19.2 Connecting rods

Check the connecting rod for bend or twist as follows:

1) Measure “C” and “ℓ.” If “C” exceeds 0.05 mm (0.0020 in.) per 100 mm (3.94 in.) of “ℓ,” straighten the connecting rod with a press.

.Unit: mm (in.)

Item	Standard	Limit
Bend or twist of connecting rod	0.05/100 (0.002 3/4.94) maximum	0.15/100 (0.005 9/3.94)

2) Generally, a connecting rod aligner is used to check the connecting rod for bend or twist.

NOTE

To check the rod for bend, install the cap to the connecting rod and tighten the cap nuts to the specified torque.

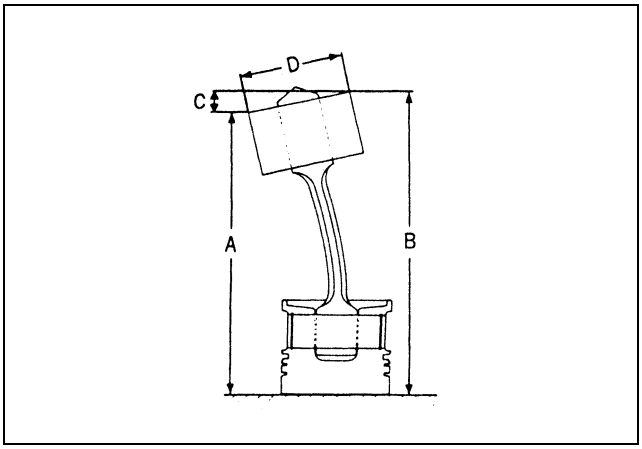


Figure 100 Checking connecting rod for bend with a dial indicator

3) To check the connecting rod fitted to the piston for bend, put the connecting rod and piston on the surface plate as shown in the illustration, insert a round bar having a diameter equal to that of the crankpin into the bore in the big end of the rod and measure “A” and “B” with a dial indicator. Subtract “A” from “B” to find the bend (“C”).

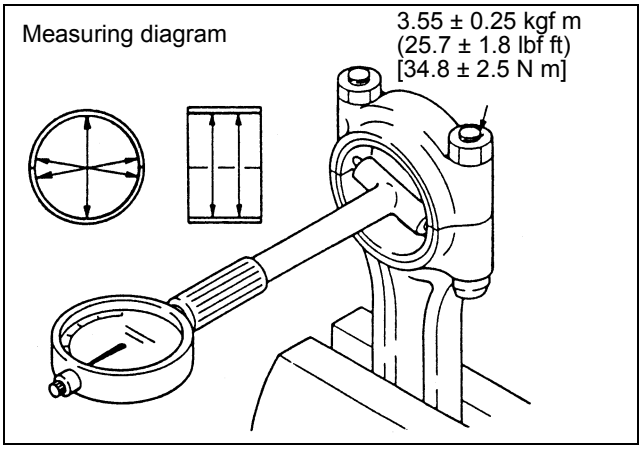


Figure 101 Measuring bore in connecting rod bearing

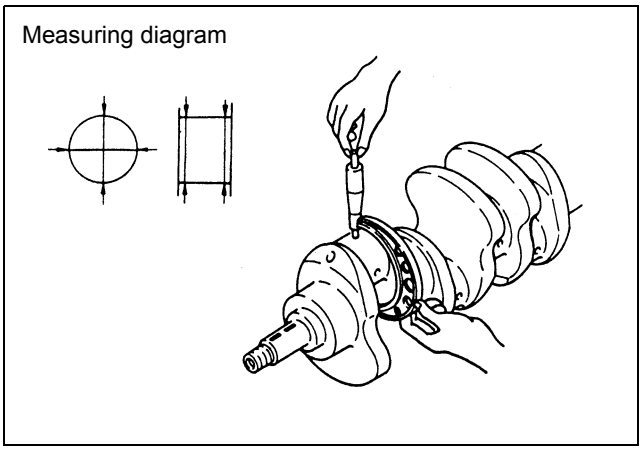


Figure 102 Measuring diameter of crankpin

19.3 Crankshaft

1. Clearance between crankpin and connecting rod bearing

   1) Install the bearing (upper and lower halves) and cap to the big end of the connecting rod and tighten the cap nuts to the specified torque. Measure the bore in the bearing for crankpin as shown in the illustration.

Tightening torque	3.55 ± 0.25 kgf.m (25.7 ± 1.8 lbf.ft) [34.8 ± 2.5 N.m]

   2) Measure the diameter of the crankpin as shown in the illustration to find the clearance between the crankpin and connecting rod bearing.

.Unit: mm (in.)

Item	Norminal size	Standard	Limit
Diameter of crankpin (standard)	48 (1.89)	47.950 to 47.965 (1.887 79 to 1.888 38)	—
Clearance between crankpin and connecting rod bearing	—	0.025 to 0.072 (0.000 98 to 0.002 83)	0.150 (0.005 91)

   3) If the clearance exceeds the limit, install a new bearing and check the clearance again.
   4) If the clearance still exceeds the limit, grind the crankpin to 0.25 mm (0.0098 in.), 0.50 mm (0.0197 in.) or 0.75 mm (0.0295 in.) undersize and use undersize connecting rod bearing.

Unit: mm (in.)

Item	Undersize	Finish
Crankpin	0.25 (0.009 8)	$47.75^{-0.035}_{-0.050}$ ($1.8799^{-0.00138}_{-0.00197}$)
	0.50 (0.019 7)	$47.50^{-0.035}_{-0.050}$ ($1.8701^{-0.00138}_{-0.00197}$)
	0.75 (0.029 5)	$47.25^{-0.035}_{-0.050}$ ($1.8602^{-0.00138}_{-0.00197}$)

Table 2 Crankpin undersizes

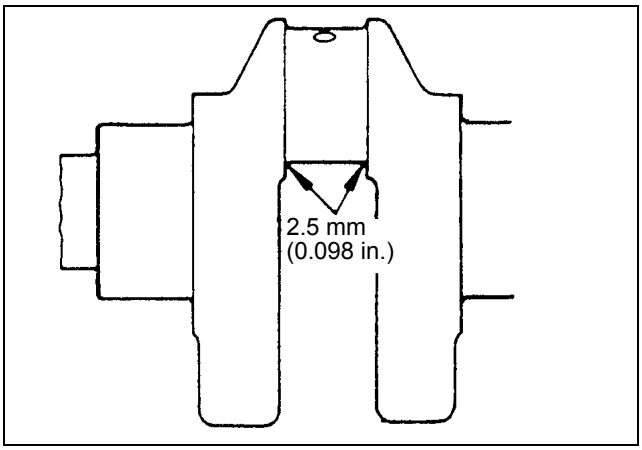


Figure 103 Crankpin fillet radius

⚠ CAUTION

- Grind all the crankpins of one crankshaft to the same undersize.
- Finish the crankpin fillets to a radius of 2.5 mm (0.098 in.).

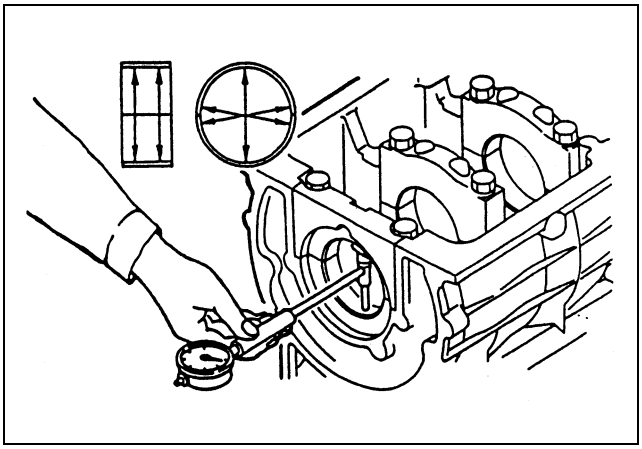


Figure 104 Measuring bore in main bearing

2. Clearance between journal and main bearing

   1) Install the main bearing (upper and lower halves) and cap to the cylinder block and tighten the cap bolts to the specified torque. Measure the bore in the bearing for the journal as shown in the illustration.

Tightening torque	5.25 ± 0.25 kgf·m (38 ± 1.8 lbf·ft) [51.5 ± 2.5 N·m]

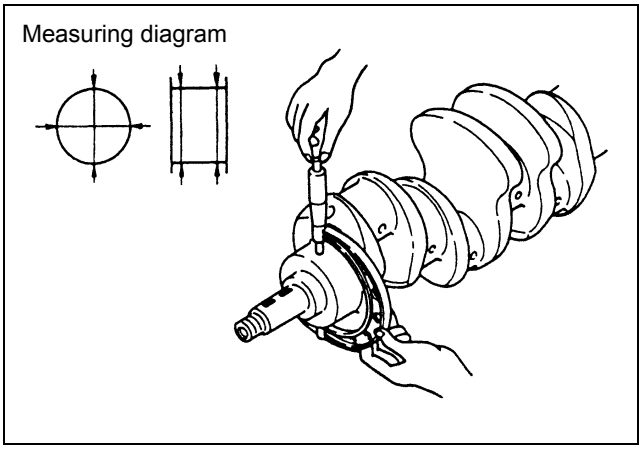


Figure 105 Measuring diameter of journal

2) Measure the diameter of the journal as shown in the illustration to find the clearance between the journal and main bearing.

.Unit: mm (in.)

Item	Norminal size	Standard	Limit
Diameter of journal (standard)	52 (2.05)	51.985 to 52.000 (2.046 65 to 2.047 24)	—
Clearance between journal and main bearing	—	0.030 to 0.077 (0.001 18 to 0.003 03)	0.100 (0.003 94)

3) If the clearance exceeds the limit, install a new bearing and check the clearance again.
4) If the clearance still exceeds the limit, grind the journal to 0.25 mm (0.009 8 in.), 0.50 mm (0.019 7 in.) or 0.75 mm (0.029 5 in.) undersize and use undersize main bearing.

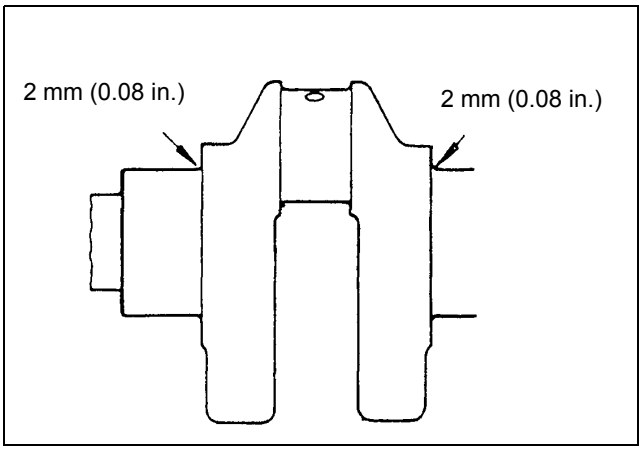


Figure 106 Journal fillet radius

Journal undersizes

Unit: mm (in.)

Item	Undersize	Finish
Journal	0.25 (0.009 8)	$51.75^{0}_{-0.015}$ ($2.0374^{0}_{-0.00059}$)
	0.50 (0.019 7)	$51.50^{0}_{-0.015}$ ($2.0276^{0}_{-0.00059}$)
	0.75 (0.029 5)	$51.25^{0}_{-0.015}$ ($2.0177^{0}_{-0.00059}$)

⚠ CAUTION

- Grind all the journals of one crankshaft to the same undersize.
- Finish the journal fillets to a radius of 2 mm (0.08 in.).

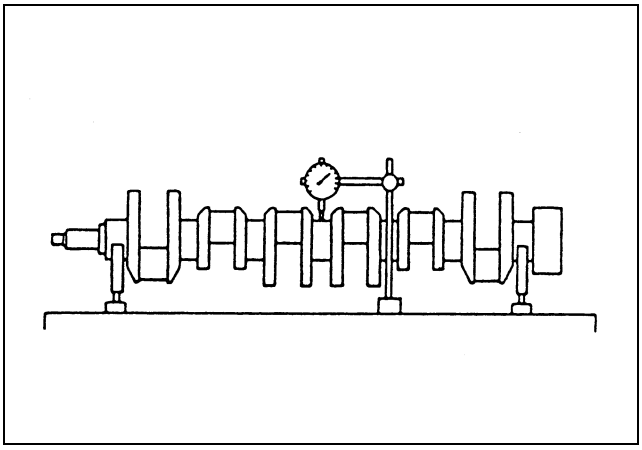


Figure 107 Checking crankshaft runout

3. Runout
   Support the crankshaft on its front and rear journals in V-blocks or in a lathe and check runout at the center journal with a dial indicator as shown in the illustration. Depending on the amount of runout, repair the crankshaft by grinding or by straightening with a press. If runout exceeds the limit, replace the crankshaft.

Unit: mm (in.)

Item	Standard	Limit
Crankshaft runout	0.025 (0.000 98)	0.05 (0.002 0)

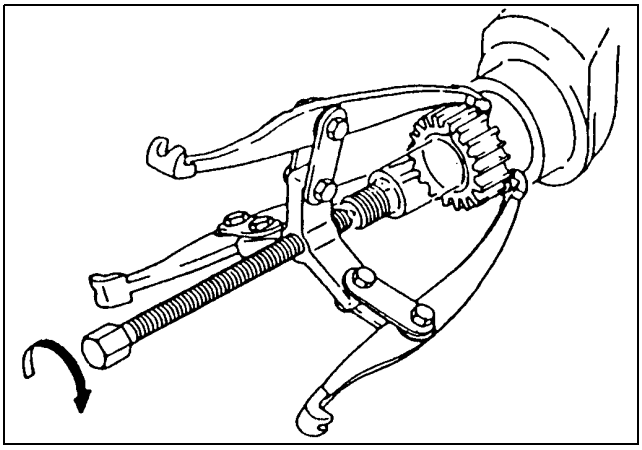


Figure 108 Removing crankshaft gear

4. Crankshaft gear removal
   Use a gear puller to remove the gear from the crankshaft

NOTE

Do not remove the gear unless the gear or crankshaft is defective.

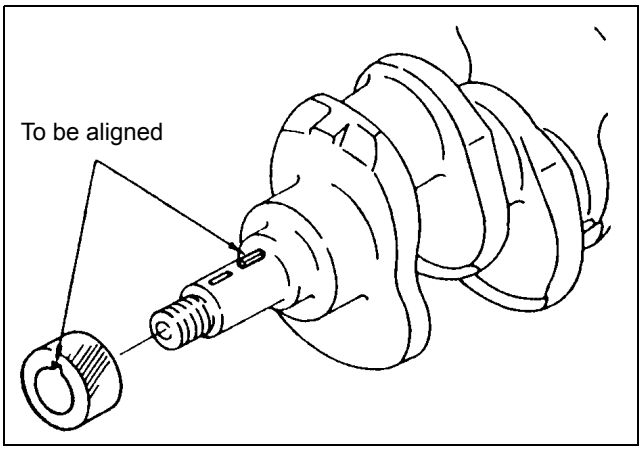


Figure 109 Installing crankshaft gear

5. Crankshaft gear installation
   1) Install the key in position on the crankshaft.
   2) Install the gear in position with its keyway in alignment with the key as shown in the illustration.

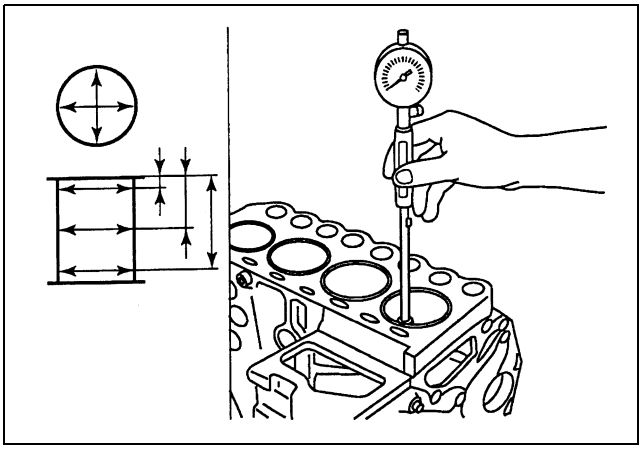


Figure 110 Measuring bore in cylinder block

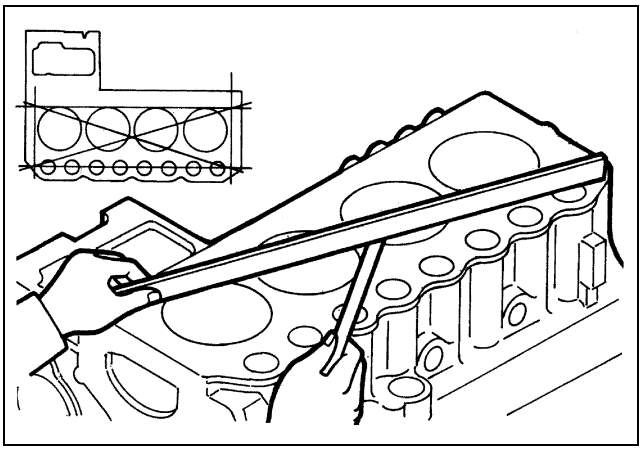


Figure 111 Checking cylinder block top face for warpage

19.4 Cylinder block

1. Bore
   Measure the bore at the top, middle and bottom points on axes A and B with a cylinder bore gauge as shown in the illustration. If any one of the cylinders exceeds the limit, hone out all the bores for oversize pistons.

Unit: mm (in.)

Pioston and piston ring		Bore	
Size	Size code	Standard	Limit
Standard	STD	$78^{+0.03}_{0}$ ($3.07^{+0.0012}_{0}$)	Standard: +0.2 (+0.008)
0.25 (0.009 8) oversize	25	$78.25^{+0.03}_{0}$ ($3.0807^{+0.0012}_{0}$)	
0.50 (0.019 7) oversize	50	$78.50^{+0.03}_{0}$ ($3.0905^{+0.0012}_{0}$)	
Taper and out-of-round		0.01 (0.000 4) maximum	—

2. Warpage of top face
   Using a heavy accurate straight edge and a feeler gauge, check the top face for warpage in two positions lengthwise, two crosswise and two widthwise as shown in the illustration. If warpage exceeds the limit, reface the top face with a surface grinder.

⚠ CAUTION

The maximum permissible amount of stock to be removed from the cylinder head and block by grinding is 0.2 mm (0.008 in.) in total.

.Unit: mm (in.)

Item	Standard	Limit
Warpage of cylinder block top face	0.05 (0.002 0) maximum	0.10 (0.003 9)

ASSEMBLY

20 Cylinder Block, Crankshaft, Pistons and Oil pan

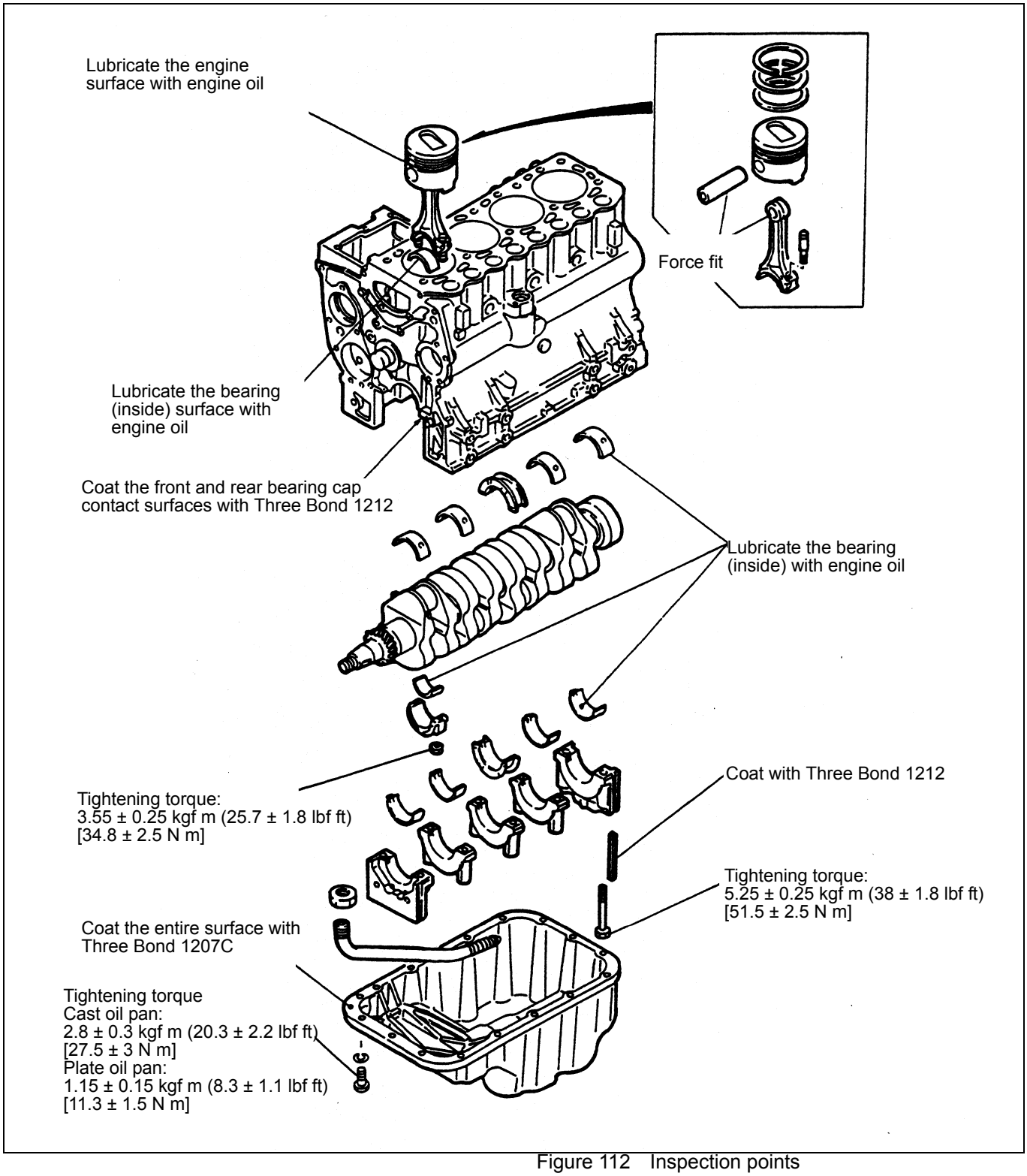


Figure 112 Inspection points

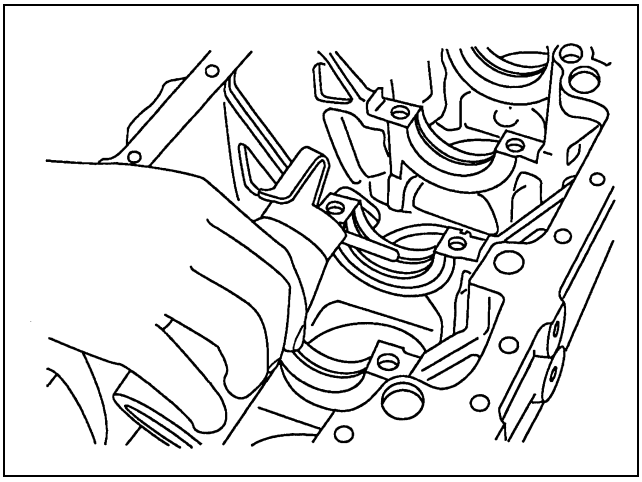


Figure 113 Installing main bearings

20.1 Main bearing installation

1. Install the upper halves of the main bearings in the cylinder block and the lower halves in the main bearing caps so their tabs fit into the notches in the cylinder block and the main bearing caps.
2. Install the flanged bearing in the No. 3 journal.
3. Lightly lubricate the inside surfaces of the bearings with engine oil.

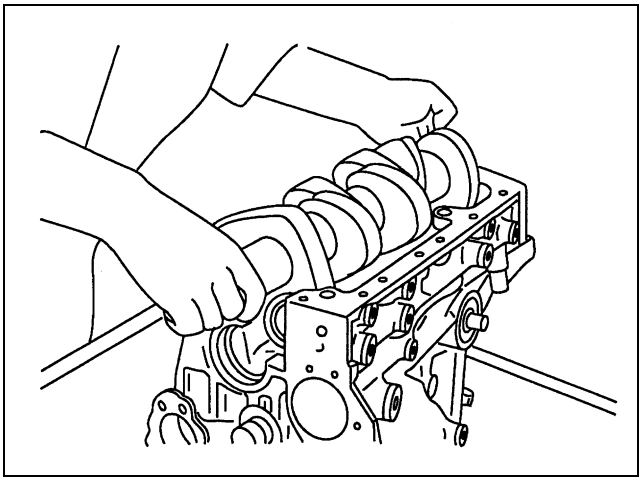


Figure 114 Installing crankshaft

20.2 Crankshaft installation

1. Clean the crankshaft with cleaning solvent and blow dry with compressed air.
2. Fasten a hoist to the crankshaft and hold it in horizontal position. Carefully put the crankshaft in position in the cylinder block.
3. Lightly lubricate the crankshaft journals with engine oil.

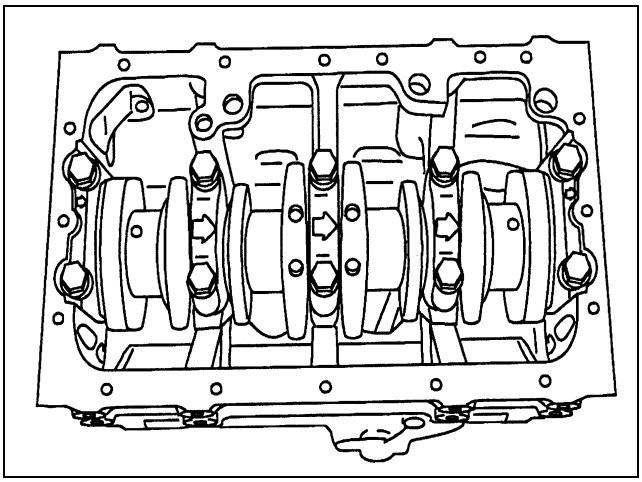


Figure 115 Main bearing caps installed

20.3 Main bearing cap installation

1. Coat the mating surfaces of the rear bearing cap and cylinder block with Three Bond 1212.
2. Install the main bearing caps in position. Make sure the number (arrow head) on the main bearing cap is toward the front of the engine.
3. Tighten the main bearing cap bolts finger tight only.

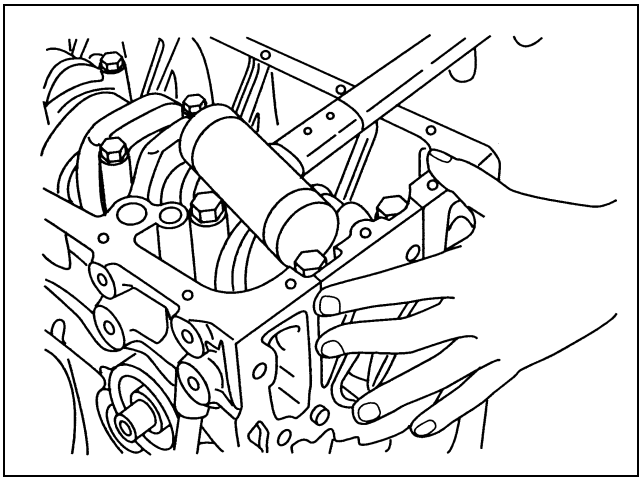


Figure 116 Installing front and rear bearing caps

⚠ CAUTION

Install the front and rear bearing caps in position so their end faces are even with the end faces of the cylinder block.

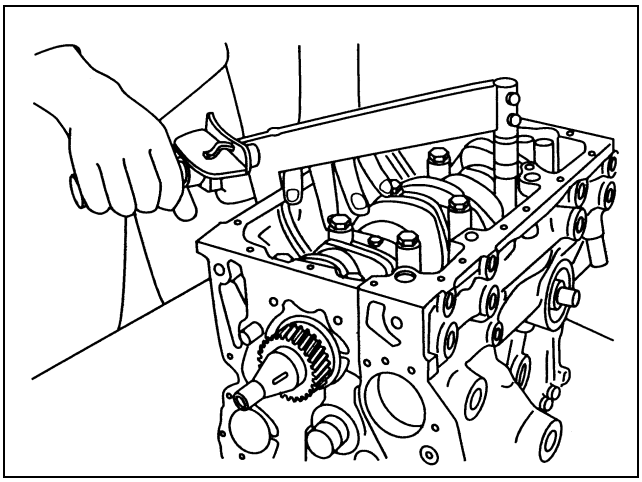


Figure 117 Tightening bolts holding main bearing caps

4. Tighten the bolts holding the main bearing caps in steps to the specified torque.

Tightening torque	5.25 ± 0.25 kgf·m (38 ± 2 lbf·ft) [51.5 ± 2.5 N·m]

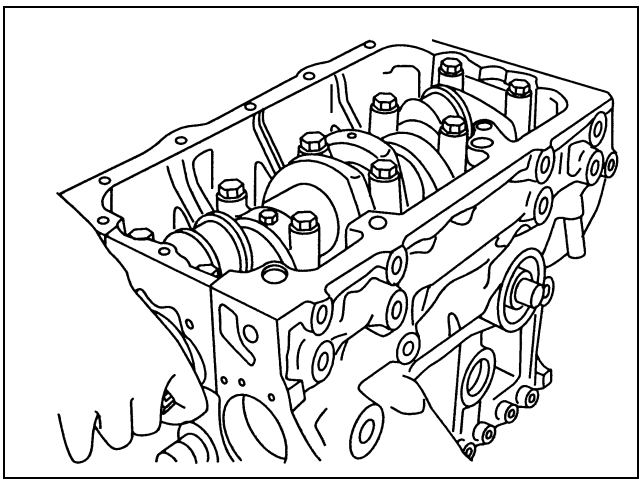


Figure 118 Checking crankshaft for rotation

5. Make sure the crankshaft rotates freely without binding or catching.
6. Measure the end play for the crankshaft. Make reference to “End play measurement for crankshaft” (page 42). If the end play is incorrect, loosen the bolts holding the main bearing caps once and tighten them again.

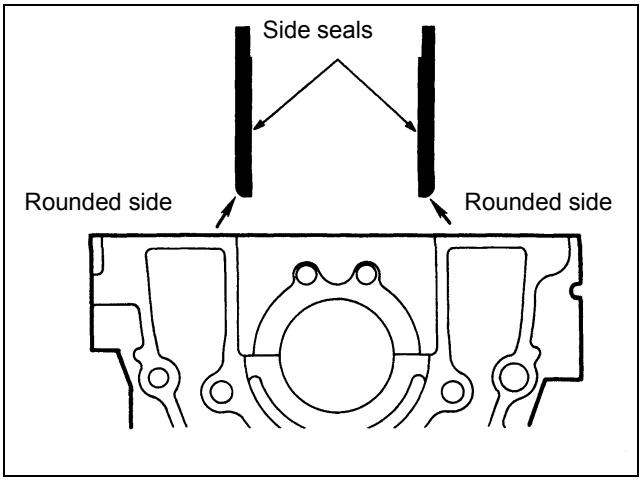


Figure 119 Side seals

20.4 Side seal installation

1. Coat the side seals with Three Bond 1212.
2. Insert the side seals between the cylinder block and the front and rear caps and push in them by hand as far as possible, with their rounded side toward the outside of the cylinder block.

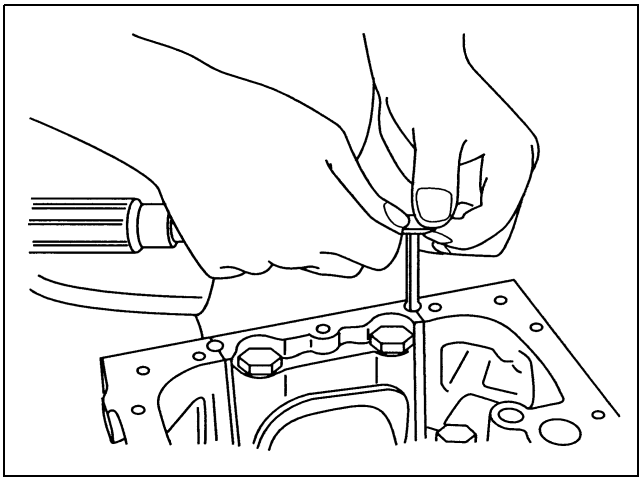


Figure 120 Installing side seals

3. Using a flat plate, push the seals into position, taking care not to bend them.

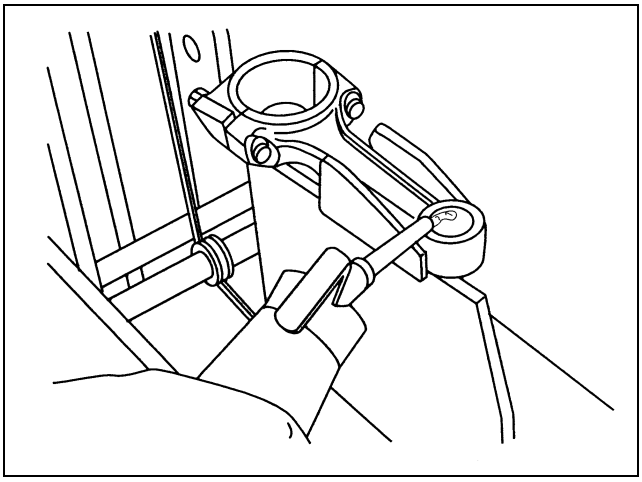


Figure 121 Connecting rod on Piston Setting Tool

20.5 Piston assembling to connecting rod

1. Set Piston Setting Tool (31A91-00100) (special tool) in a hydraulic press.
2. Put the connecting rod on the Tool and lubricate the bore in the rod for the piston pin with engine oil.

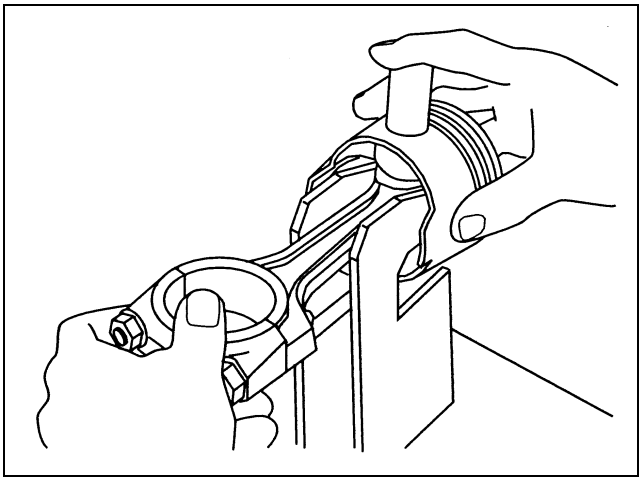


Figure 122 Installing piston pin

3. Put the piston in position on the connecting rod, making sure the model identification on the rod is on the same side as the arrow head on the top of the piston. Put the piston pin in position.

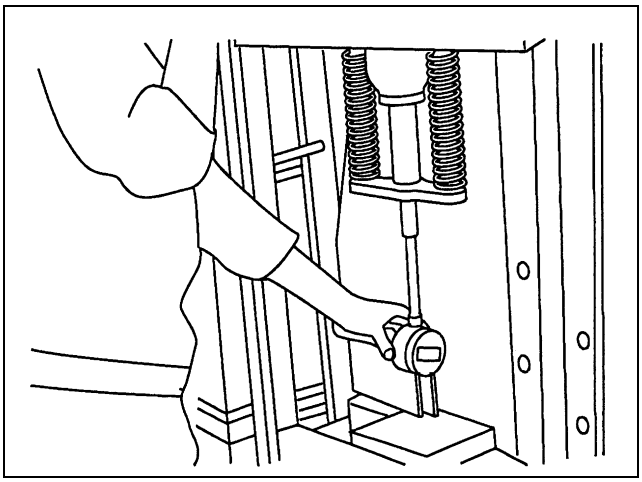


Figure 123 Pressing piston pin

4. Insert the push rod of the Tool into the bore in the piston for the piston pin and press the pin with the press.

⚠ CAUTION

Observe the indicator of the press when pressing the piston pin. If the force of the press is ready to exceed 50 kgf (110 lbf) [490 N], stop pressing the pin and check the bores in the piston and connecting rod for alignment.

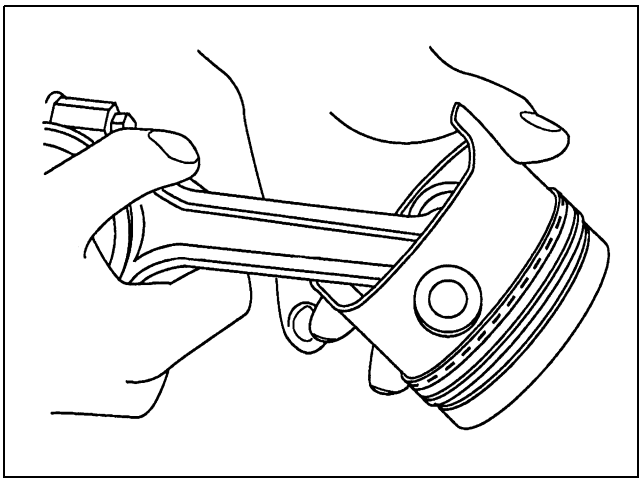


Figure 124 Checking piston and connecting rod

5. After assembling the piston and connecting rod, make sure the connecting rod moves freely.

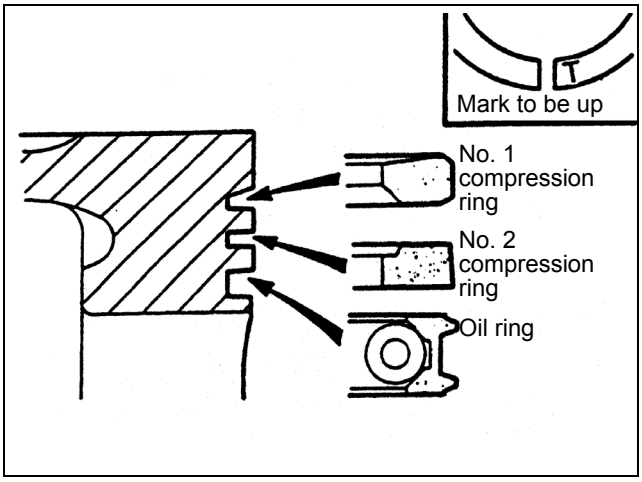


Figure 125 Piston rings

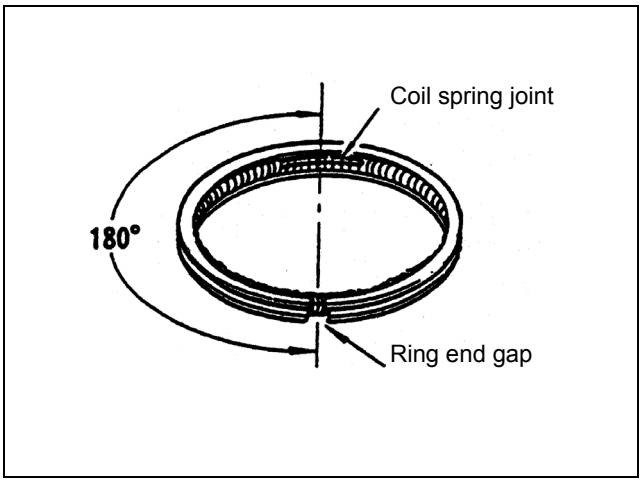


Figure 126 Oil ring

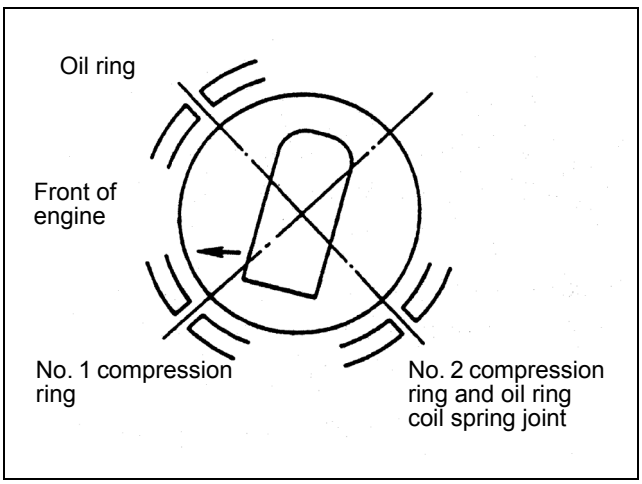


Figure 127 Relative location of piston ring end gaps

20.6 Piston ring installation

Using a piston ring pliers, install the piston rings to the piston.

NOTE

1. The piston rings must be installed with the side that has the mark “T” toward the top of the piston.
2. The oil ring must be installed with the ring end gap 180° apart from the coil spring joint.

20.7 Piston and connecting rod installation

1. Lubricate the piston and piston rings with engine oil.
2. Move the piston rings on the piston so that the end gaps are apart from a direction parallel to, or transverse to, the piston pin.
3. Install the connecting rod bearing (upper half) to the rod, making sure the tab in the back of the bearing is in the notch of the connecting rod.
4. Turn the crankshaft until the crankpin for the piston and connecting rod to be installed is at the top center.
5. Hold the piston and connecting rod with “FRONT” mark (arrow head) on the top of the piston toward the front (timing gear case side) of the engine.

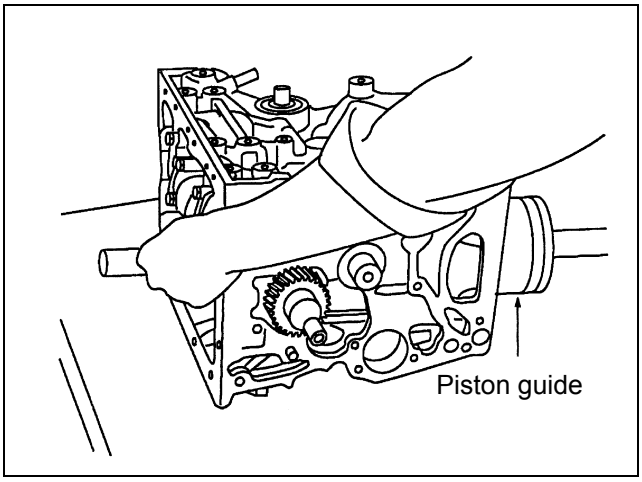


Figure 128 Installing piston and connecting rod

6. Using a piston guide (commercially available), put the piston and connecting rod into the cylinder from the top of the cylinder block.

⚠ CAUTION

Do not hit the piston with a hammer to install the piston and connecting rod. This will put force on the piston and connecting rod and cause damage to the piston rings and crankpin..

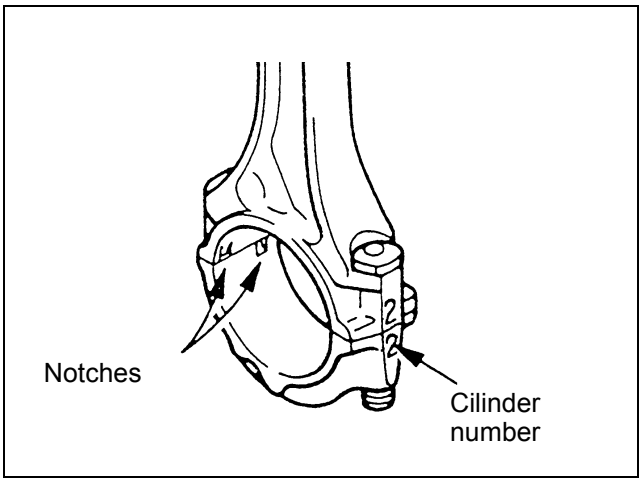


Figure 129 Installing connecting rod cap

20.8 Connecting rod cap installation

1. Push the piston into position until the big end of the connecting rod is put into position over the crankpin. Then turn the crankshaft 180° while pushing on the top of the piston.
2. Install the lower half of the connecting rod bearing in the connecting rod cap, making sure the tab in the back of the bearing is in the notch of the cap.
3. Install the bearing cap to the connecting rod.

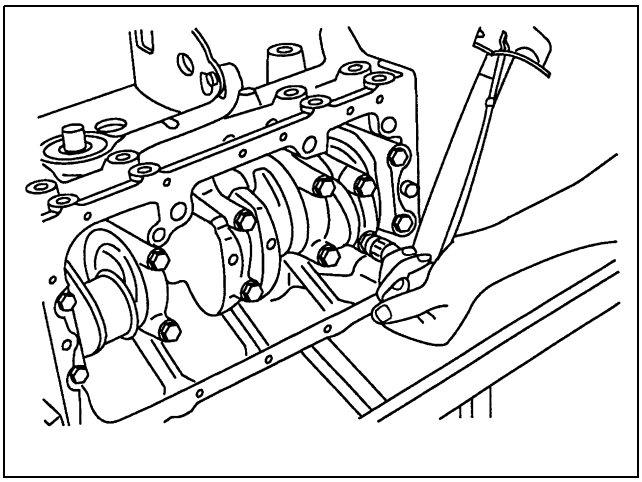


Figure 130 Tightening connecting rod cap nuts

NOTE

- Make sure the number on the cap is the same as the number on the connecting rod.
- In case of a new connecting rod having no cylinder number, install the cap to the rod with the notches on the same side.

4. Tighten the connecting rod cap nuts in steps to the specified torque.

Tightening torque	3.55 ± 0.25 kgf·m (25.7 ± 2 lbf·ft) [34.8 ± 2.5 N·m]

5. Check the thrust clearance for the connecting rod big end.

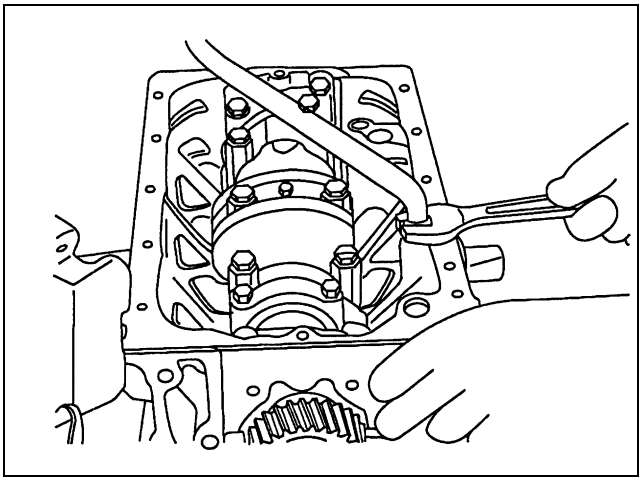


Figure 131 Installing oil screen

20.9 Oil screen installation

1. Lay the cylinder block with the bottom (oil pan side) up.
2. Install the oil screen in position.

NOTE

The oil screen must be installed in position so that it is below the oil level line and away from the oil pan.

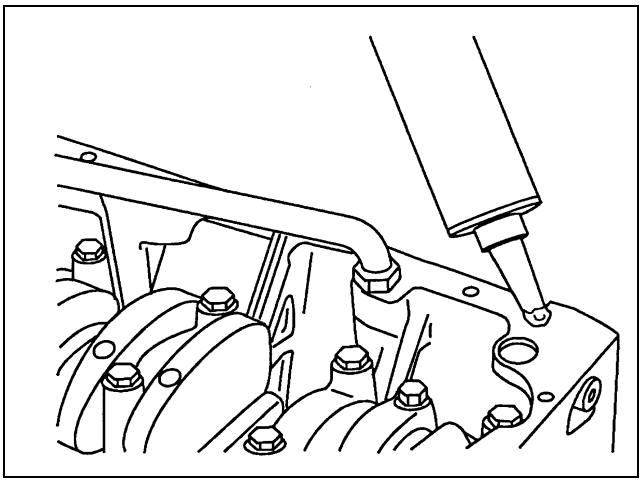


Figure 132 Coating mating surfaces with adhesive

20.10 Oil pan installation

1. Clean the mating surfaces of the oil pan and cylinder block and coat them with Three Bond 1207C.

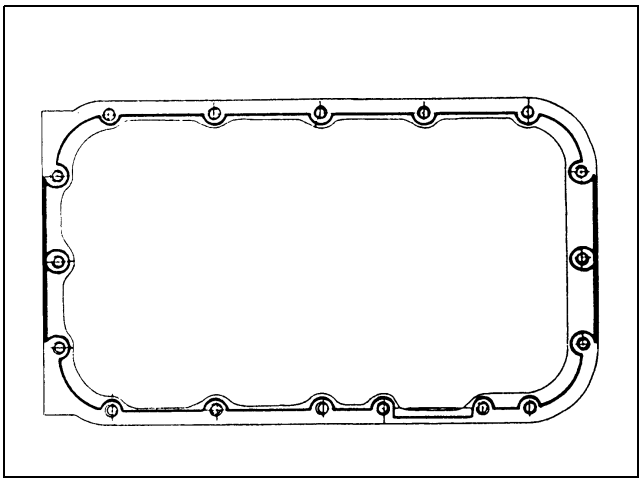


Figure 133 Oil pan for S4L and S4L2 engines

NOTE

Squeeze out a 4 mm (0.2 in.) thick bar of sealing compound (Three Bond) from the tube and put it on the flange of the oil pan as shown.

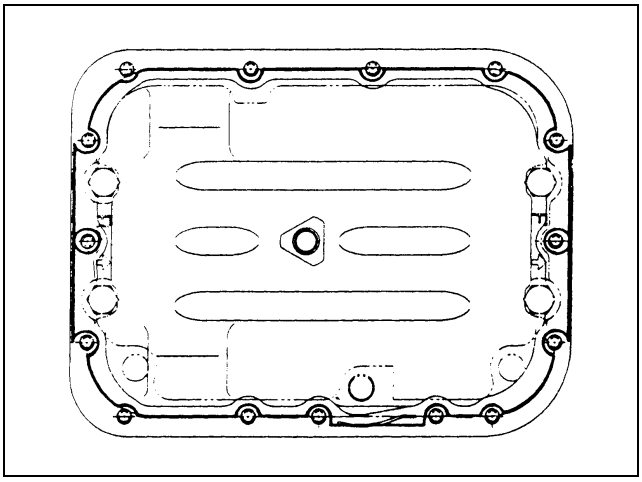


Figure 134 Oil pan for S3L and S3L2 engines

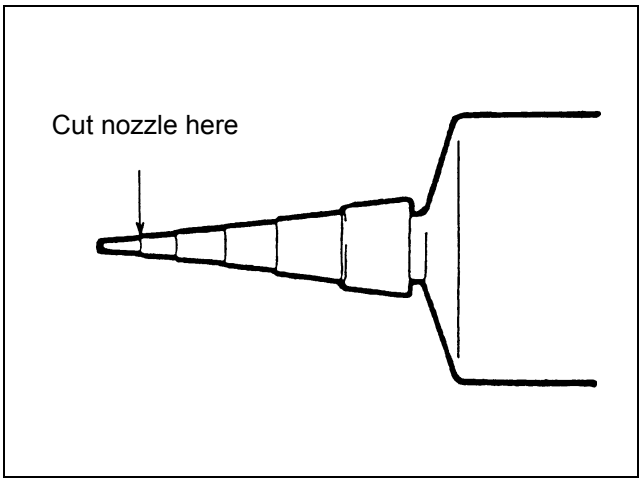


Figure 135 Cutting sealing compound tube nozzle

To squeeze out a 4 mm (0.2 in.) thick bar, cut the nozzle of the tube as shown.

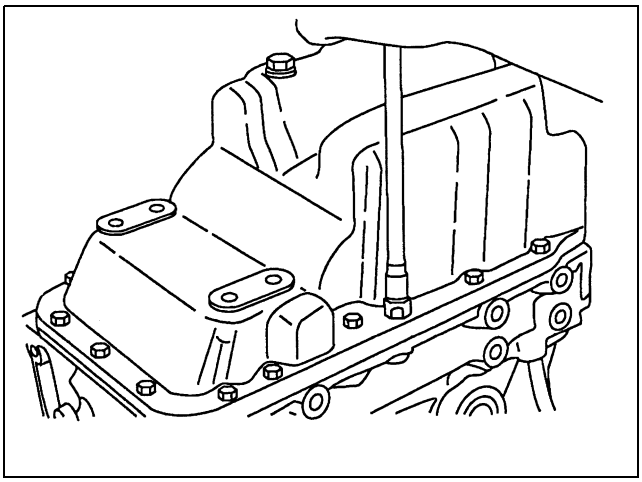


Figure 136 Tightening oil pan bolts

2. Tighten the bolts that hold the oil pan to the cylinder block in a crisscross pattern to the specified torque.

Tightening torque	Cast oil pan: 2.8 ± 0.3 kgf·m (20.3 ± 2.2 lbf·ft) [27.5 ± 3 N·m] Plate oil pan: 1.15 ± 0.15 kgf·m (8.3 ± 1.1 lbf·ft) [11.3 ± 1.5 N·m]

21 Timing Gears and Flywheel

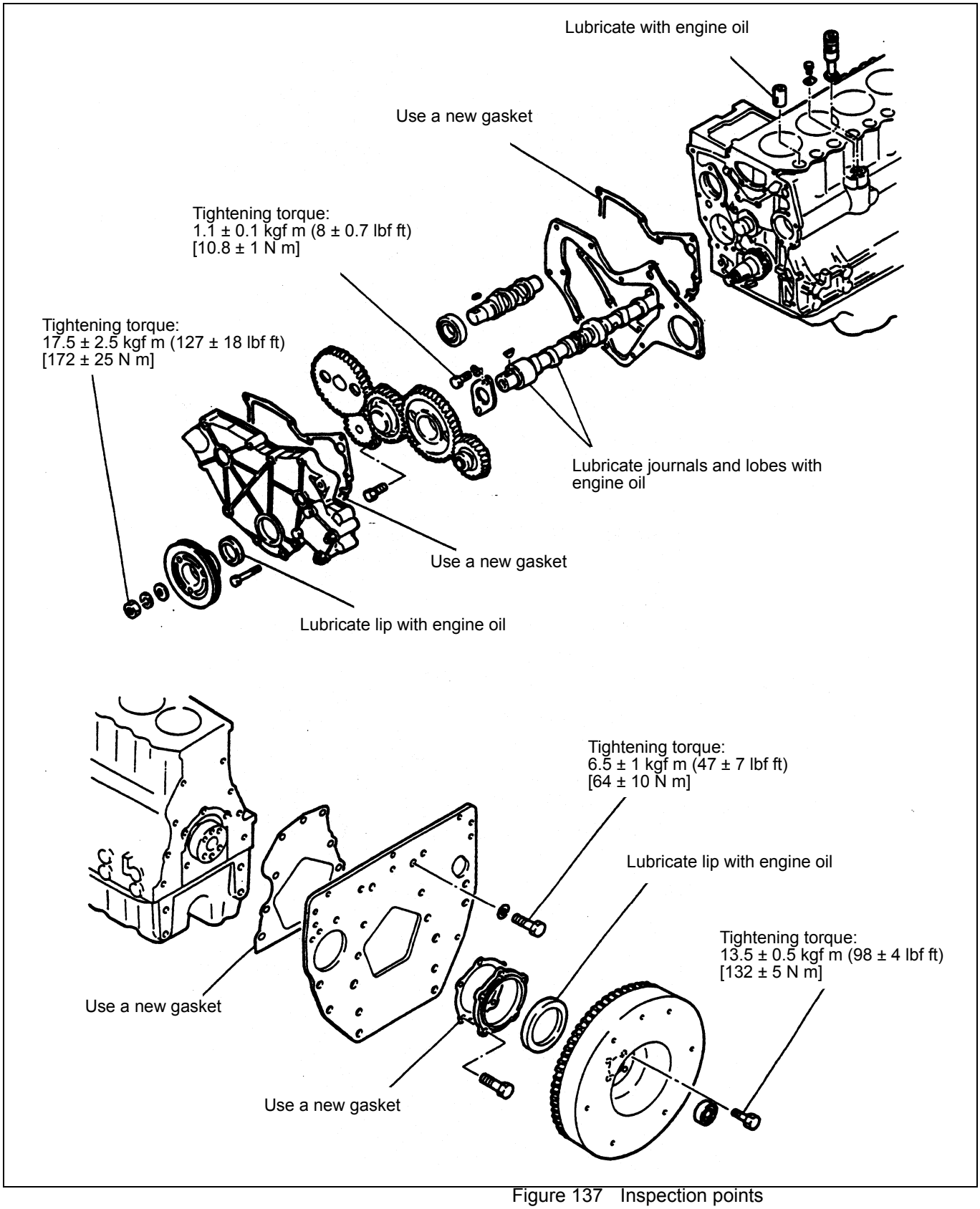


Figure 137 Inspection points

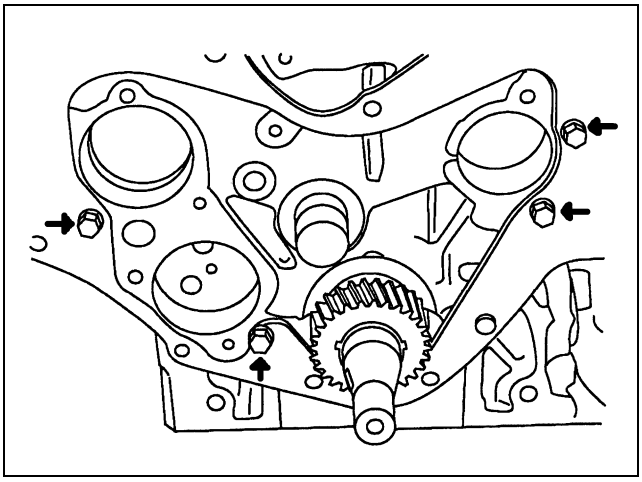


Figure 138 Installing front plate

21.1 Front plate installation

1. Scrape the gasket from the cylinder block and front plate.
2. Coat the gasket contact surface of cylinder block with adhesive and put a new gasket in position, making sure the holes in the gasket are all in alignment with the holes in the cylinder block.
3. Put the front plate in position. Install four bolts and tighten them.

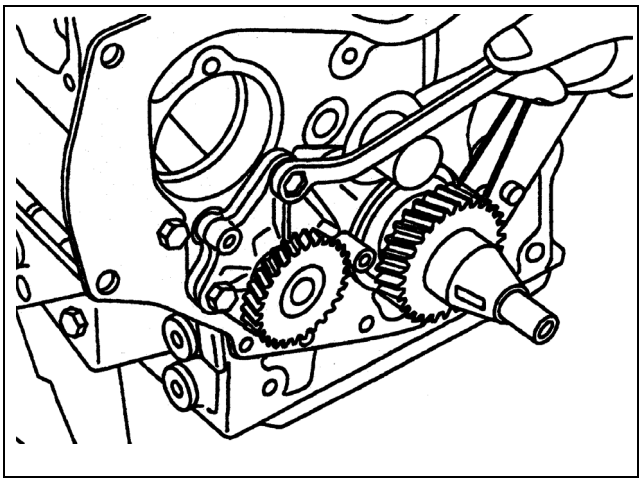


Figure 139 Installing oil pump

21.2 Oil pump installation

1. Make sure the packing has been put in position on the oil pump.
2. Put the oil pump in position on the cylinder block. Install three bolts and tighten them evenly.
3. Make sure the oil pump gear rotates freely.

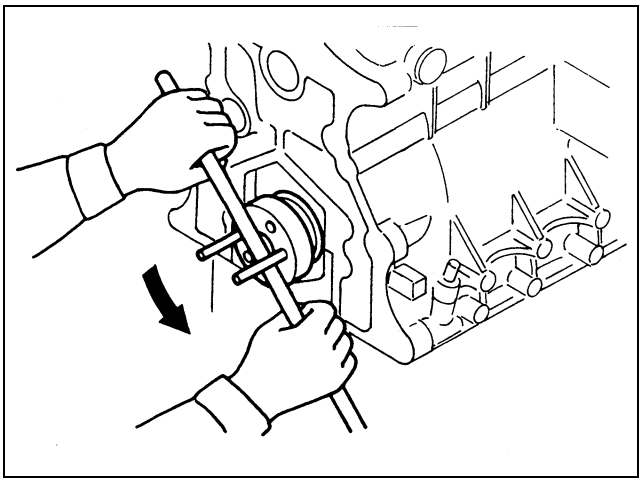


Figure 140 Turning engine

21.3 Engine turning

1. Install two bolts (M12 x 1.25) in the flywheel bolt holes in the crankshaft.
2. Put a bar between the bolts and turn the crankshaft to bring No. 1 piston to the top center as shown in the illustration.

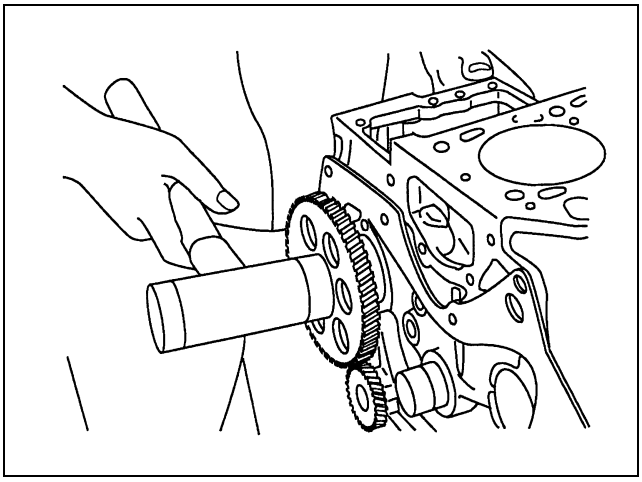


Figure 141 Installing fuel injection pump camshaft

21.4 Engine turning

1. Put the camshaft (with bearing and gear) in position in the cylinder block.
2. Hit the gear with a plastic hammer to fit the bearing in position.
3. Make sure the camshaft rotates freely.
4. Tighten the stopper bolt.

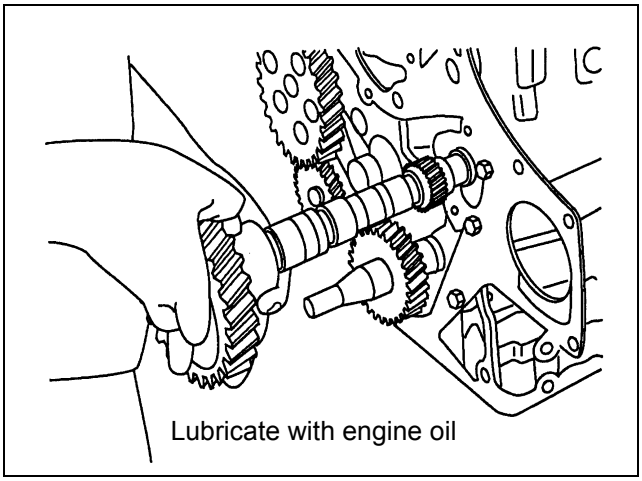


Figure 142 Installing camshaft

21.5 Camshaft installation

1. Lubricate the lobes and journals with engine oil.
2. Put the camshaft (with gear) in position in the cylinder block.

⚠ CAUTION

Do not cause damage to the lobes and journals when the camshaft is installed.

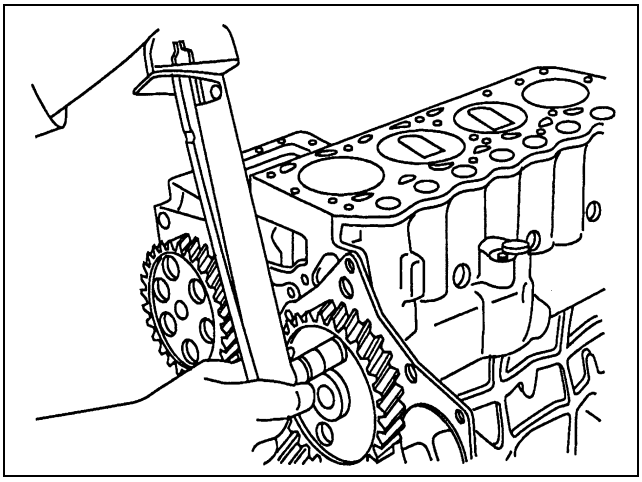


Figure 143 Installing thrust plate

3. Tighten the bolts that hold the thrust plate to the specified torque.

Tightening torque	1.1 ± 0.1 kgf·m (38 ± 2 lbf·ft) [51.5 ± 2.5 N·m]

4. Make sure the camshaft rotates freely. Check the end play for the camshaft.

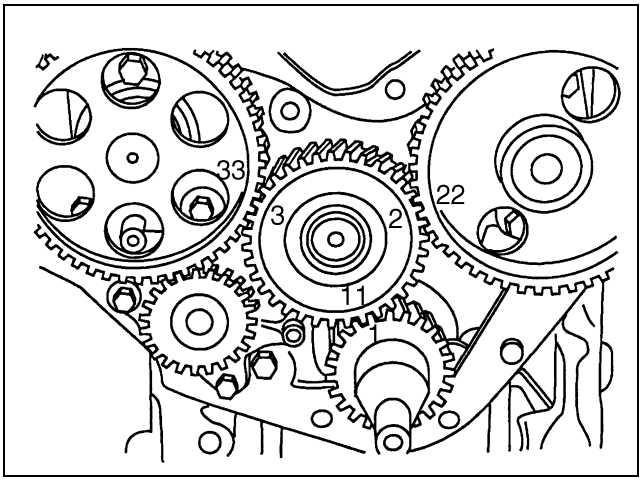


Figure 144 Marks on timing gears

21.6 Idler gear installation

1. Lubricate the idler gear with engine oil.
2. Install the idler gear in position with its “3,” “2” and “11” marks in alignment with the “33” mark on the fuel injection pump camshaft gear, the “22” mark on the camshaft gear and the “1” mark on the crankshaft gear respectively.
3. Check the backlash of the gears. Make reference to “Timing gear backlash measurement” (page 37).

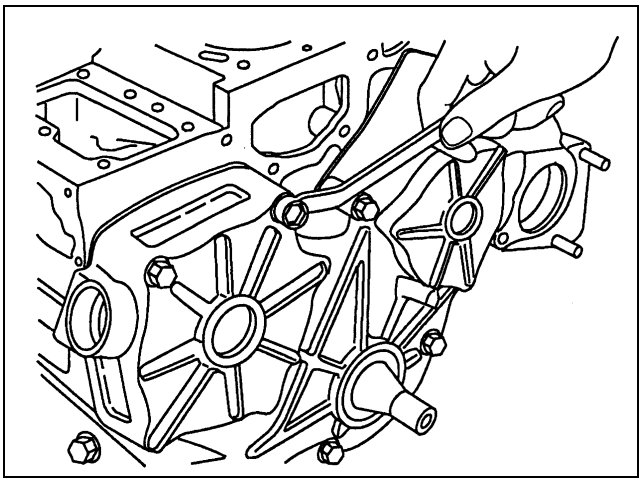


Figure 145 Installing timing gear case

21.7 Timing gear case installation

1. Coat the gasket with adhesive and put it in position on the front plate.
2. Lubricate the oil seal lip with engine oil.
3. Tighten the bolts that hold the timing gear case.

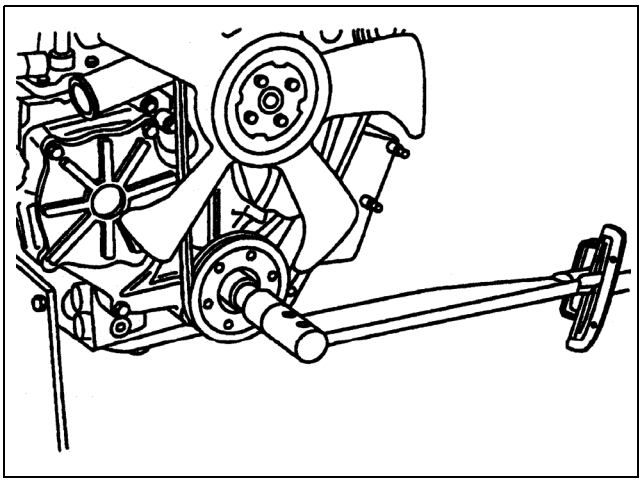


Figure 146 Tightening crankshaft pulley nut

21.8 Crankshaft pulley nut tightening

1. Install two bolts (M12 x 1.25) in the flywheel bolt holes in the crankshaft and hold the crankshaft.
2. Tighten the crankshaft pulley nut to the specified torque.

Tightening torque	17.5 ± 2.5 kgf·m (127 ± 18 lbf·ft) [172 ± 25 N·m]

⚠ WARNING

Check the strength of the bolts and bar used for holding the crankshaft.

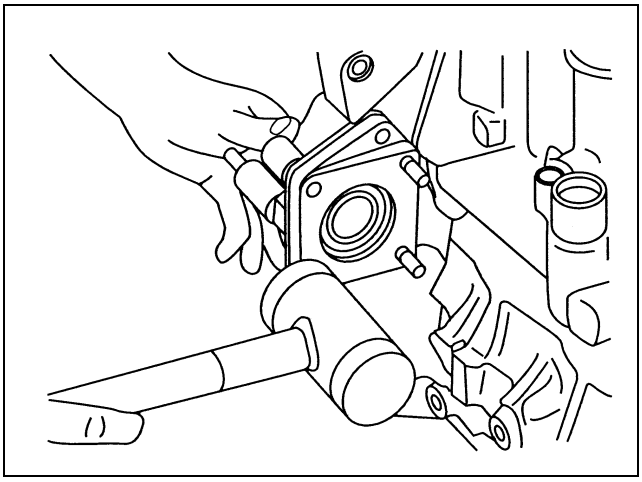


Figure 147 Installing P.T.O. gear

21.9 P.T.O. gear installation

Install the P.T.O. gear in position in the timing gear case with the side that has no oil hole toward the rear of the engine.

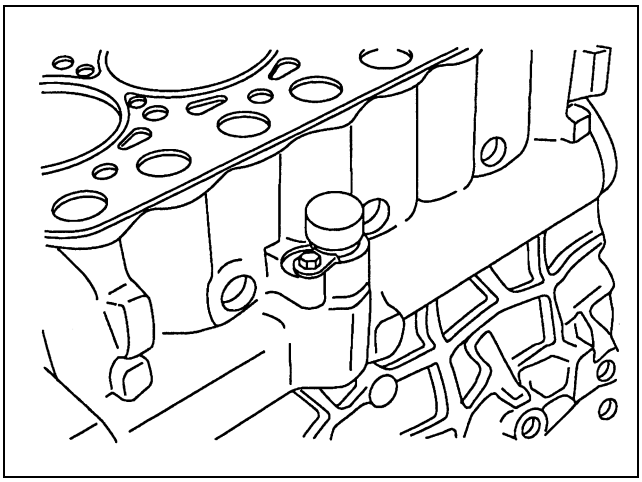


Figure 148 Installing speedometer driven gear

21.10 Speedometer driven gear installation

1. Install the O-ring in the groove in the driven gear sleeve.
2. Install the speedometer driven gear in position in the cylinder block while rotating it or the camshaft.

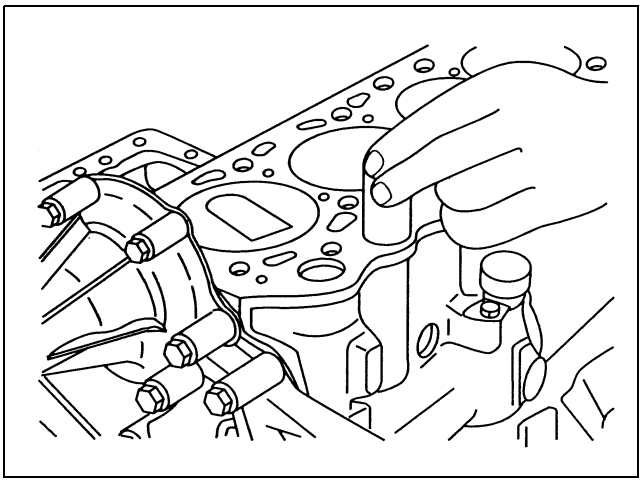


Figure 149 Installing tappets

21.11 Tappet installation

Lubricate the tappets with engine oil and put them in position in the cylinder block.

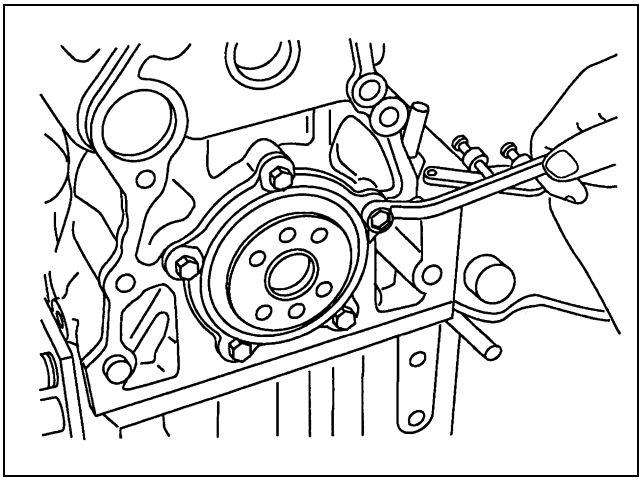


Figure 150 Installing oil seal case

21.12 Oil seal case installation

1. Put a new gasket in position on the oil seal case.
2. Lubricate the oil seal lip with engine oil and install the oil seal in position in the cylinder block.

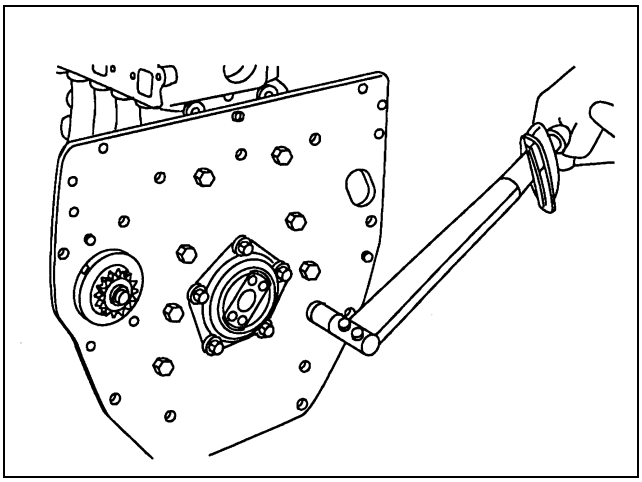


Figure 151 Installing rear plate

21.13 Rear plate installation

1. Put a new gasket in position on the rear plate.
2. Put the rear plate in position on the cylinder block with its dowel holes in alignment with the dowels. Tighten the bolts that hold the rear plate to the specified torque.

Tightening torque	6.5 ± 1 kgf·m (47 ± 7 lbf·ft) [64 ± 10 N·m]

NOTE

Install the starter to the rear plate before installing the plate to the cylinder block for convenience of rear plate installation.

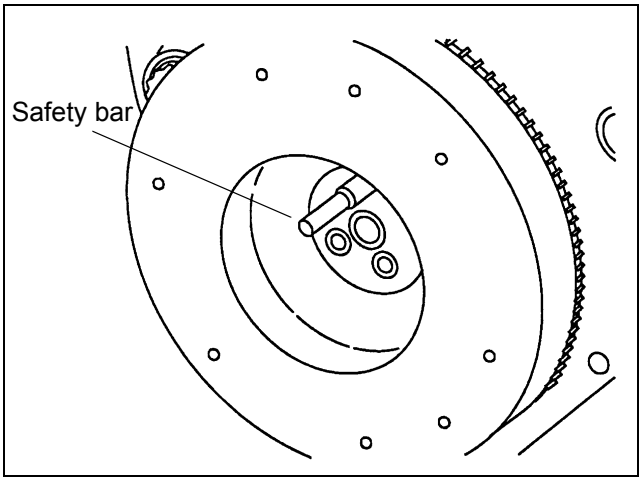


Figure 152 Safety bar

21.14 Flywheel installation

1. Install a safety bar (M12 x 1.25) in the rear end of the crankshaft.
2. Put the flywheel in position in alignment with the safety bar.
3. Install three of four bolts in the flywheel and tighten them finger tight only.
4. Remove the safety bar. Install the last bolt in the flywheel and tighten it finger tight only.

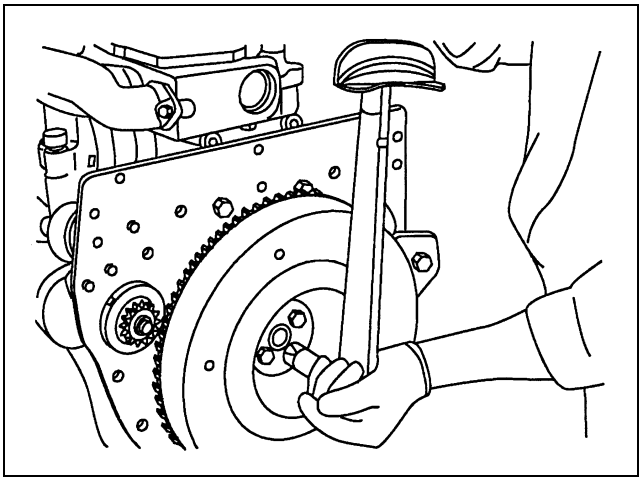


Figure 153 Tightening flywheel bolts

5. Have someone hold the crankshaft pulley with a wrench to prevent the flywheel from rotating.
6. Tighten the four bolts that hold the flywheel to the specified torque.

Tightening torque	13.5 ± 0.5 kgf·m (98 ± 4 lbf·ft) [132 ± 5 N·m]

⚠ WARNING

Always signal each other to prevent possible personal injury.

22 CYLINDER HEAD AND VALVE MECHANISM

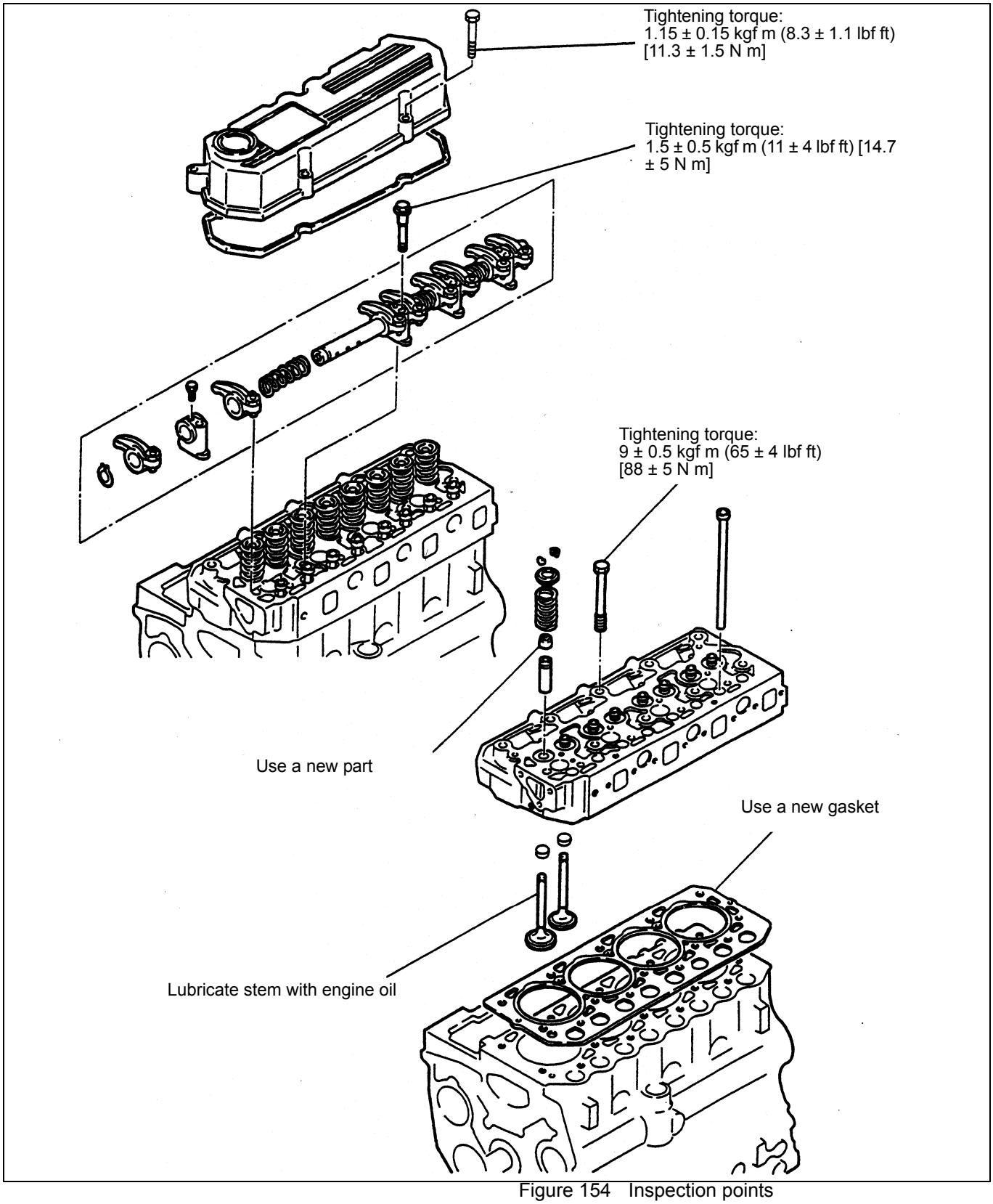


Figure 154 Inspection points

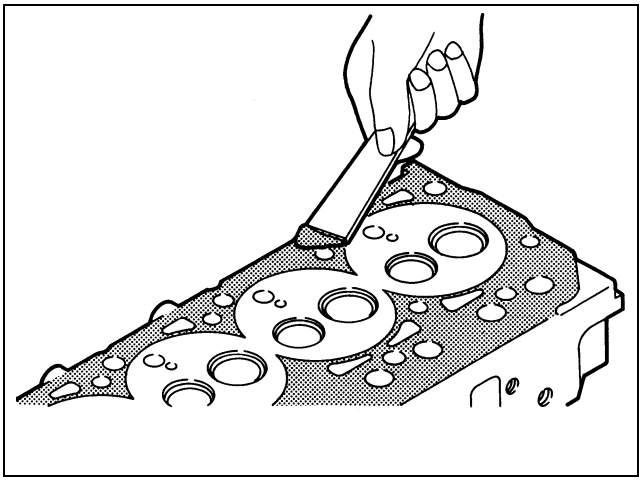


Figure 155 Removing cylinder head gasket

22.1 Cylinder head bottom face cleaning

Scrape the gasket from the bottom face of the cylinder head.

NOTE

After scraping the gasket, rub off gasket remnants from the face with an oilstone smeared with engine oil and thoroughly clean the face.

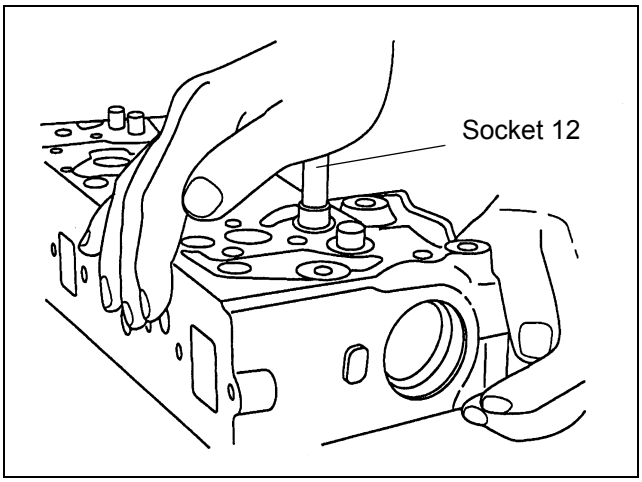


Figure 156 Installing valve stem seal

22.2 Valve stem seal installation

Using Socket 12, install the valve stem seal in position in the valve guide. After installation, make sure the seal is in its correct position.

NOTE

Improper stem seal installation can cause a failure to seal against downward flow of oil along the stem.

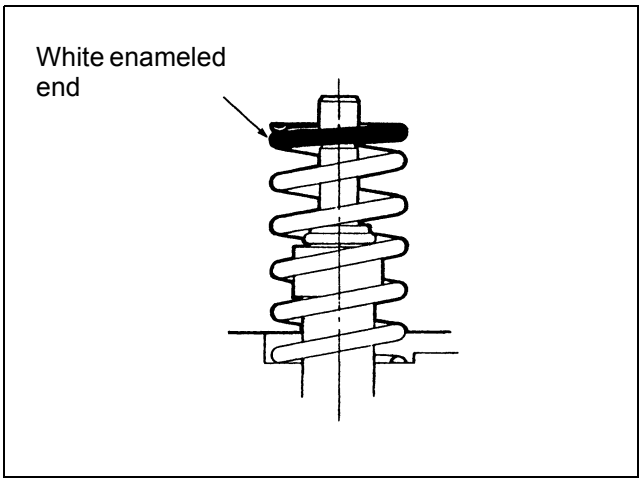


Figure 157 Installing valve spring

22.3 Valve spring installation

Install the valve spring with the white enameled end up.

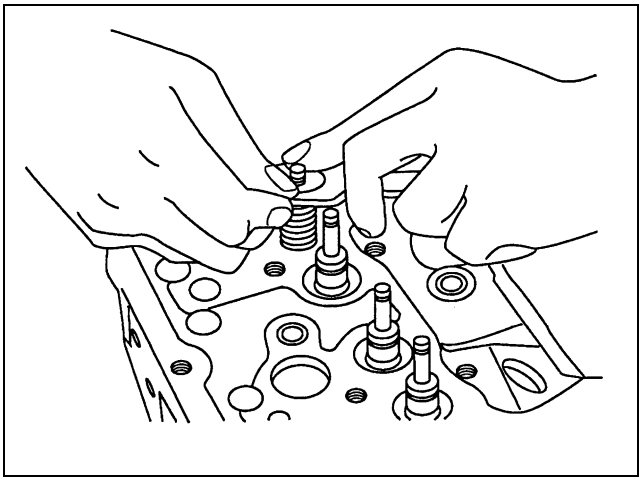


Figure 158 Installing valve block

22.4 Installing valve block

Put compression on the valve spring with a valve lifter and install the block in position on the valve top.

⚠ CAUTION

Do not put excessive compression on the valve spring. This can cause the retainer to hit and damage the stem seal.

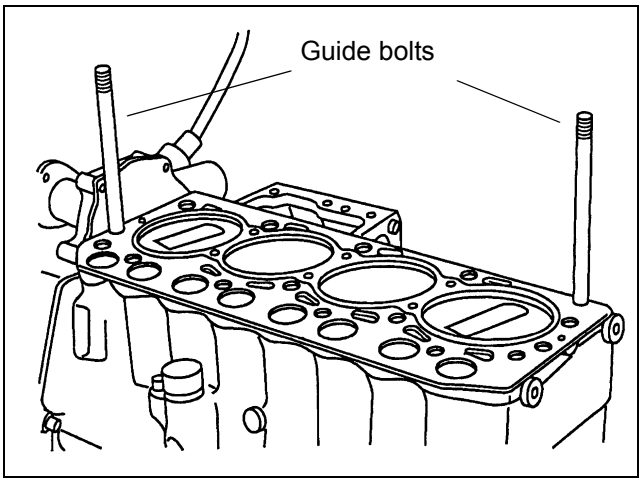


Figure 159 Putting cylinder head gasket

22.5 Cylinder head gasket installation

1. Thoroughly clean the top faces of the cylinder block and pistons.
2. Install two guide bolts (M10 x 1.25) in the bolt holes in the cylinder block.
3. Put a new cylinder head gasket in position on the cylinder block, making sure the guide bolts are all in alignment with their respective holes in the gasket.

⚠ CAUTION

Do not use any gasket adhesive or other substances on the top face of the cylinder block.

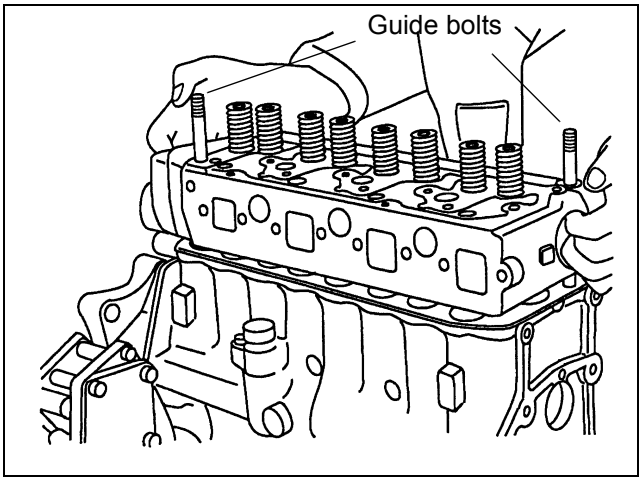


Figure 160 Installing cylinder head

22.6 Cylinder head installation

Put the cylinder head in position on the cylinder block, making sure the guide bolts are all in alignment with their respective bolt holes in the head.

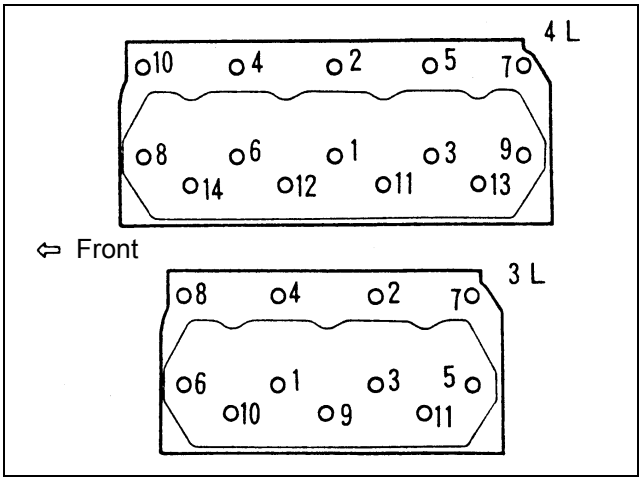


Figure 161 Tightening sequence

22.7 Cylinder head bolt tightening

1. Remove the guide bolts and install the bolts that hold the cylinder head to the cylinder block.
2. Tighten the bolts in number sequence in two or three steps to the specified torque.

Tightening torque	9 ± 0.5 kgf·m (65 ± 4 lbf·ft) [88 ± 5 N·m]

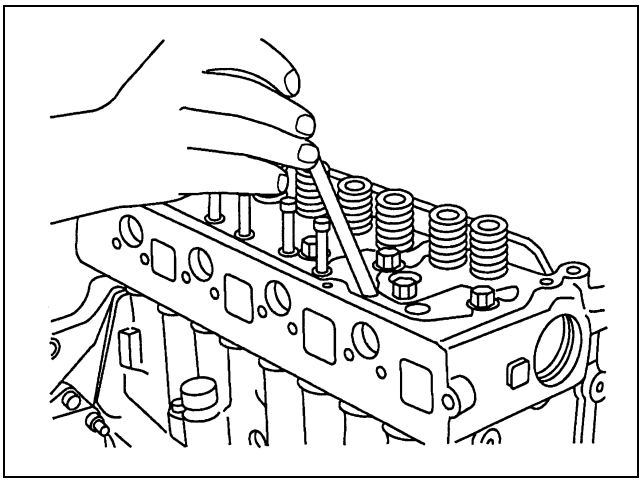


Figure 162 Installing valve push rods

22.8 Valve push rod installation

1. Put the valve push rod into position through the bore in the cylinder head.
2. Make sure the ball end of the push rod has been put into position over the top of the tappet.

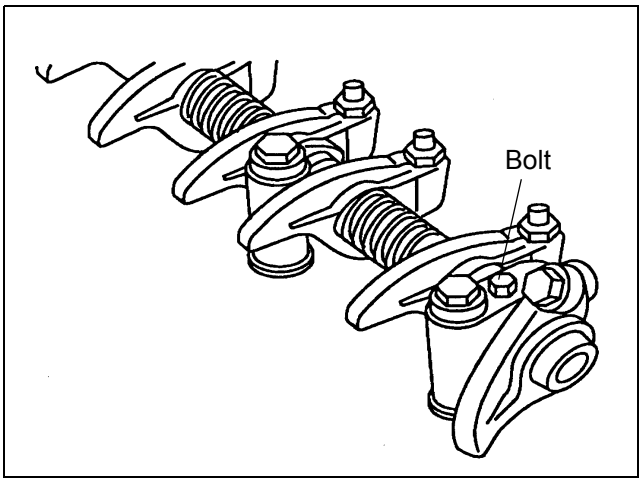


Figure 163 Assembling rocker arms

22.9 Rocker shaft assembling

1. Install the rocker arms, brackets and springs on the rocker shaft. Secure the brackets to the shaft by tightening the bolts.
2. Make sure the rocker arms move freely.

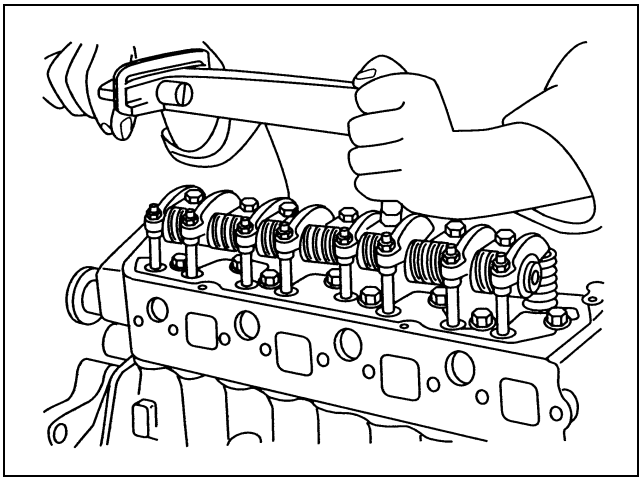


Figure 164 Installing rocker shaft assembly

22.10 Rocker shaft assembly installation

1. Install the valve caps in position on the top of the valves.
2. Put the rocker shaft assembly in position on the cylinder head. Tighten the bolts that hold the rocker shaft assembly to the specified torque.

Tightening torque	1.5 ± 0.5 kgf·m (11 ± 4 lbf·ft) [14.7 ± 5 N·m]

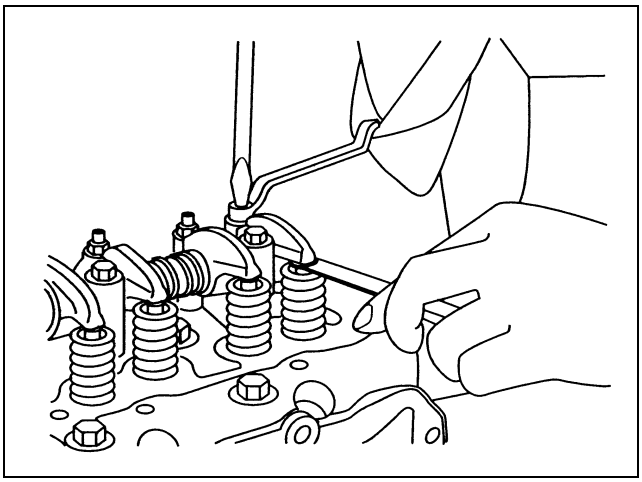


Figure 165 Adjusting valve clearance

22.11 Valve clearance adjustment

Make reference to “VALVE CLEARANCE” (page 159).

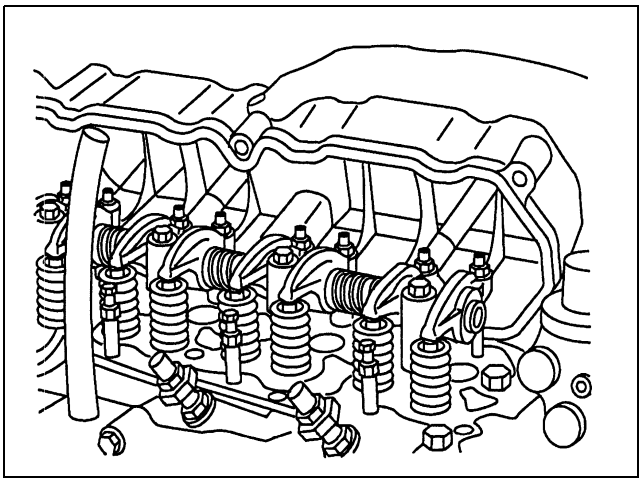


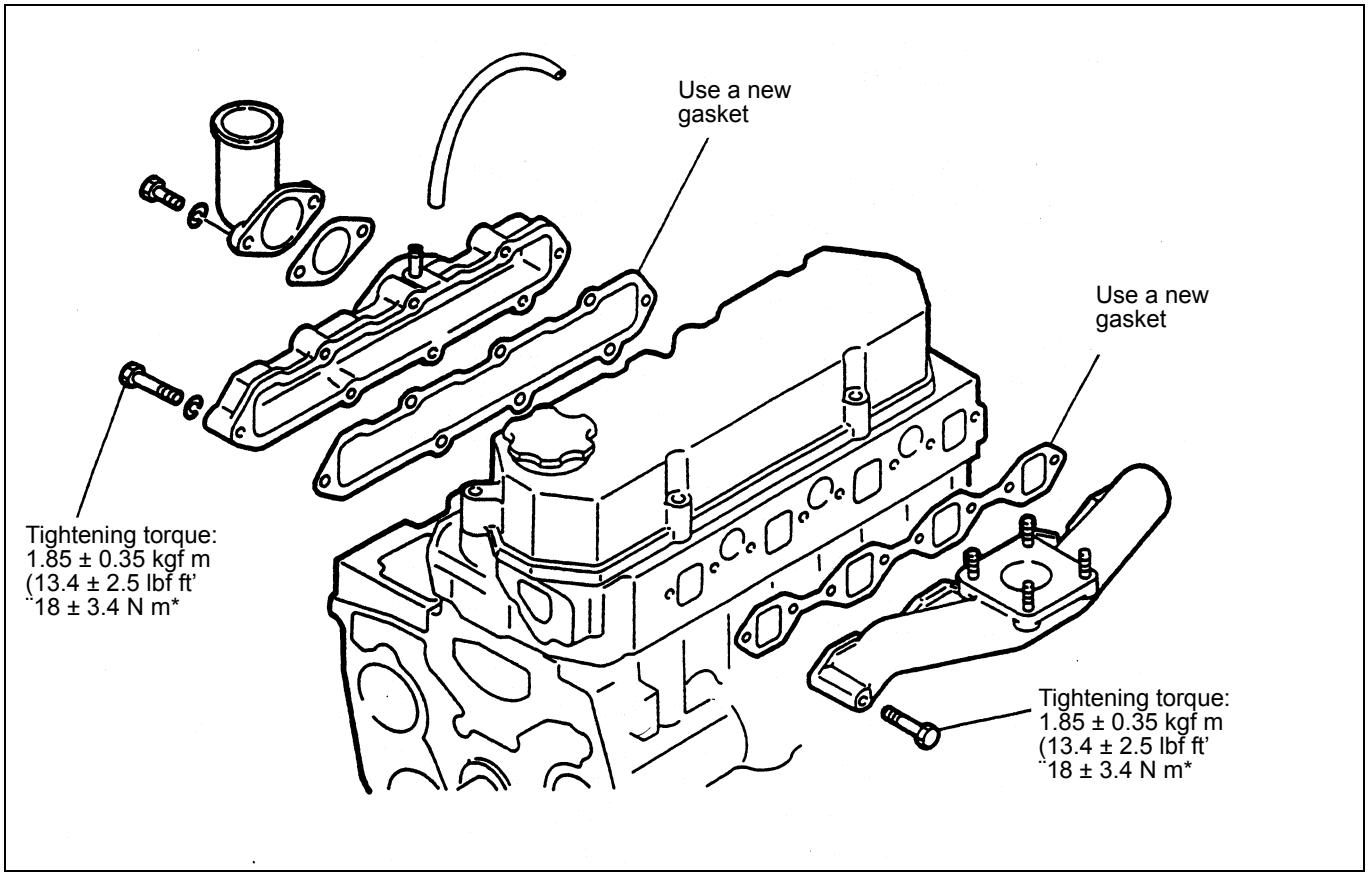
Figure 166 Installing rocker cover

22.12 Rocker cover installation

1. Make sure the gasket is put on the rocker cover.
2. Tighten the bolts that hold the rocker cover to the specified torque.

Tightening torque	1.15 ± 0.15 kgf·m (8.3 ± 1.1 lbf·ft) [11.3 ± 1.5 N·m]

23 Air Inlet System and Exhaust System



23.1 Air inlet cover installation

Tighten the bolts that hold the air inlet cover to the specified torque.

Tightening torque	1.85 ± 0.35 kgf·m (13.4 ± 2.5 lbf·ft) [18 ± 3.4 N·m]

23.2 Exhaust manifold installation

Tighten the bolts that hold the exhaust manifold to the specified torque.

Tightening torque	1.85 ± 0.35 kgf·m (13.4 ± 2.5 lbf·ft) [18 ± 3.4 N·m]

24 Fuel System

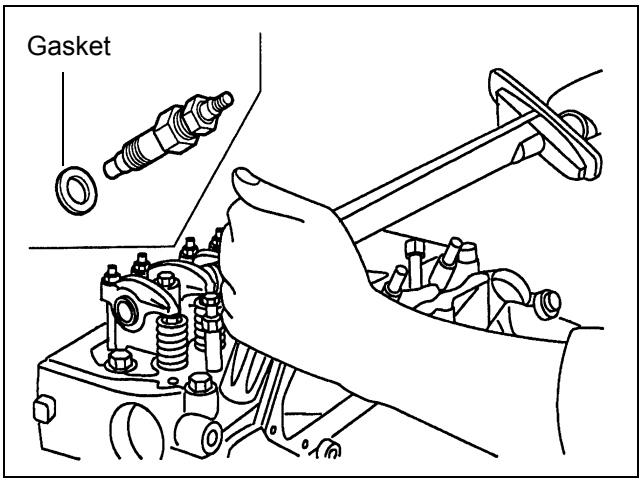


Figure 167 Installing fuel injection nozzle

24.1 Fuel injection nozzle installation

1. Put the gasket on the nozzle.
2. Put the nozzle assembly in position in the cylinder head and tighten it to the specified torque.

Tightening torque	5.5 ± 0.5 kgf·m (40 ± 4 lbf·ft) [54 ± 5 N·m]

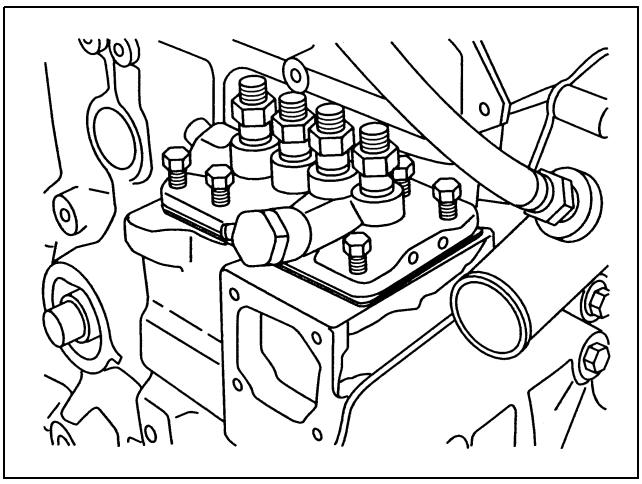


Figure 168 Installing fuel injection pump

24.2 Fuel injection pump installation

Put the pump in position on the cylinder block and tighten the bolts that hold the pump to the specified torque.

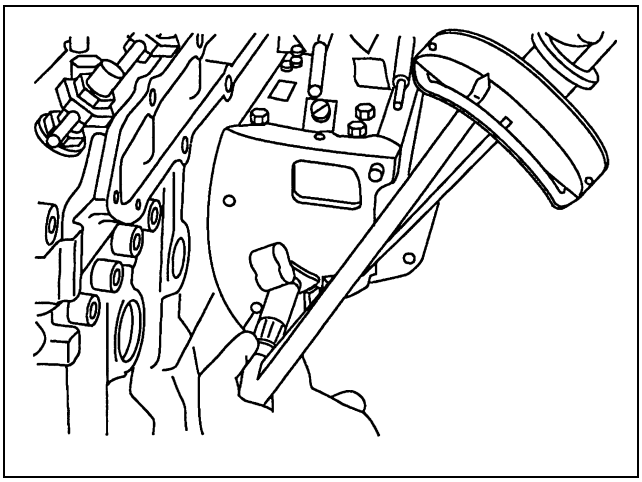


Figure 169 Installing flyweight assembly

24.3 Flyweight assembly installation

Put the flyweight assembly in position on the rear end of the fuel injection pump camshaft and tighten the sliding sleeve shaft to the specified torque.

Tightening torque	3.6 ± 0.6 kgf·m (26 ± 4.3 lbf·ft) [35 ± 6 N·m]

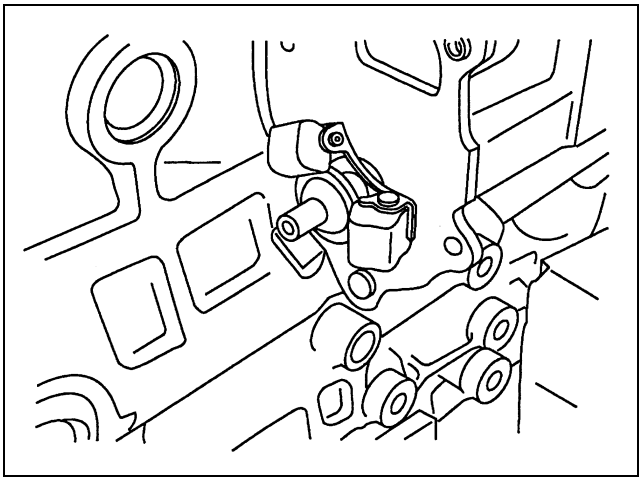


Figure 170 Installing sliding sleeve

24.4 Sliding sleeve installation

Install the sliding sleeve on the sliding sleeve shaft and make sure the sleeve moves freely.

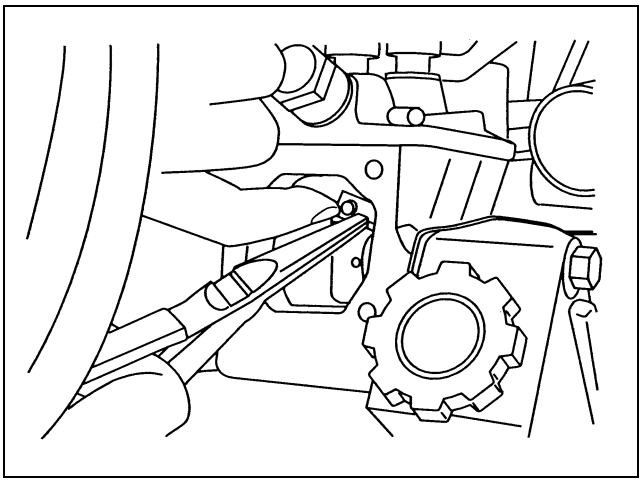


Figure 171 Installing governor assembly

24.5 Governor assembly installation

1. Install the governor assembly in position while putting the tie rod and spring into position in the injection pump.
2. Install the tie rod to the pin of the control rack and secure it with the tie rod spring.
3. Install the tie rod cover in position.

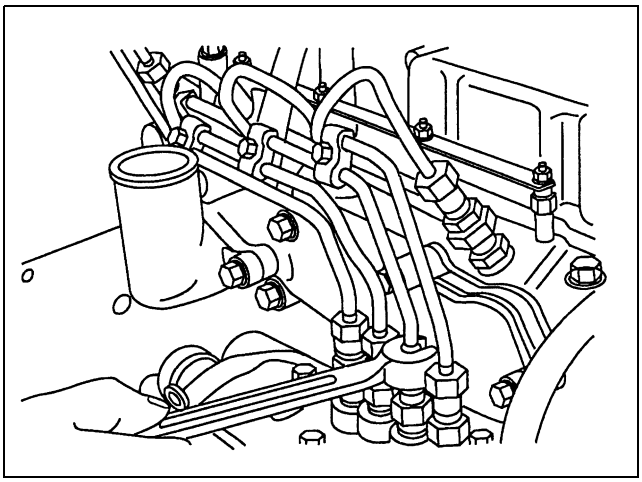


Figure 172 Installing fuel injection lines

24.6 Fuel injection line installation

1. Put the fuel leak-off line in position and connect it to the fuel injection nozzles.
2. Put the fuel injection lines in position and connect them to the fuel injection pump. Install the clamps.

25 Lubrication system

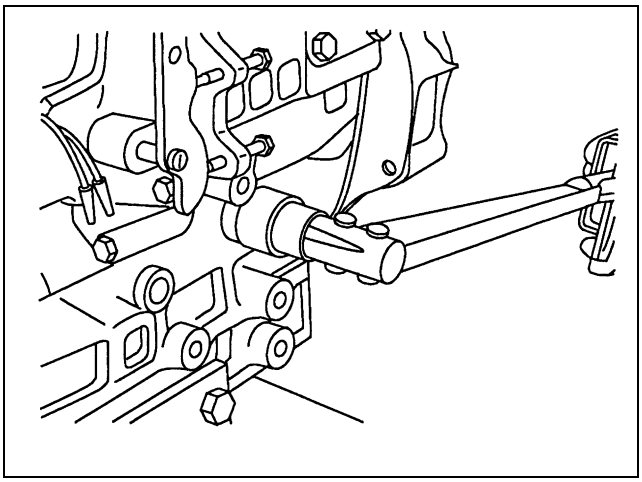


Figure 173 Installing pressure relief valve

25.1 Pressure relief valve installation

Put the relief valve in position on the cylinder block and tighten it to the specified torque.

Tightening torque	5 ± 0.5 kgf²m (36 ± 4 lbf²ft) [49 ± 5 N²m]

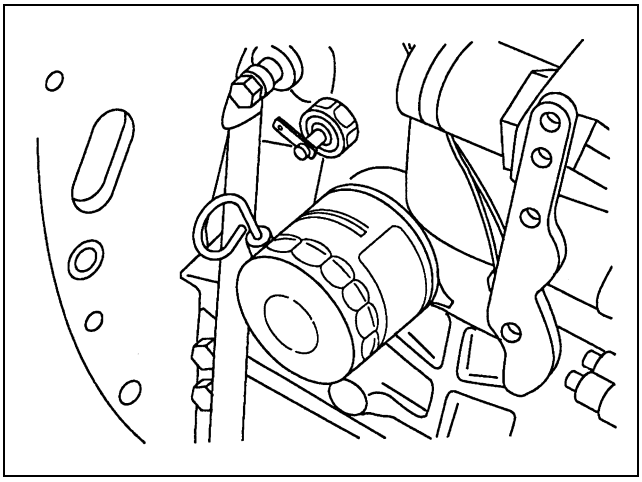


Figure 174 Installing oil filter

25.2 Oil filter installation

1. Lightly lubricate the gasket with engine oil.
2. Install the new filter element by hand. When the gasket contacts the base, tighten one turn more.

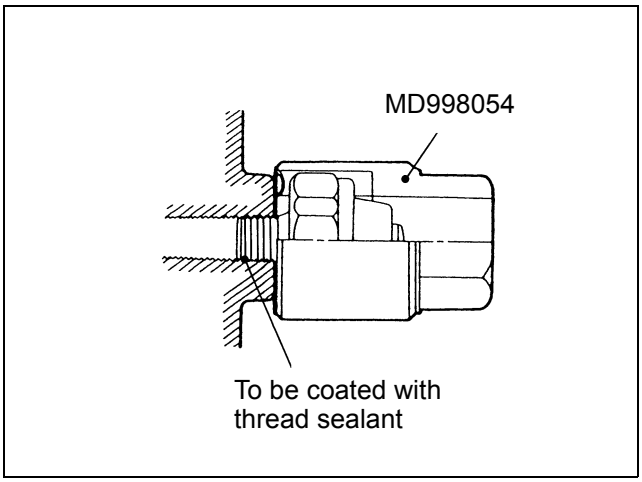


Figure 175 Installing oil pressure switch

25.3 Oil pressure switch installation

Coat the threads of the switch with thread sealant (Three Bond 1102). Use Oil Pressure Switch Socket Wrench (MD998054) (special tool) to install the oil pressure switch.

⚠ CAUTION

1. Put the sealant on the threads only.
2. Do not over-tighten the oil pressure switch when it is installed.

26 Cooling system

26.1 Water pump installation

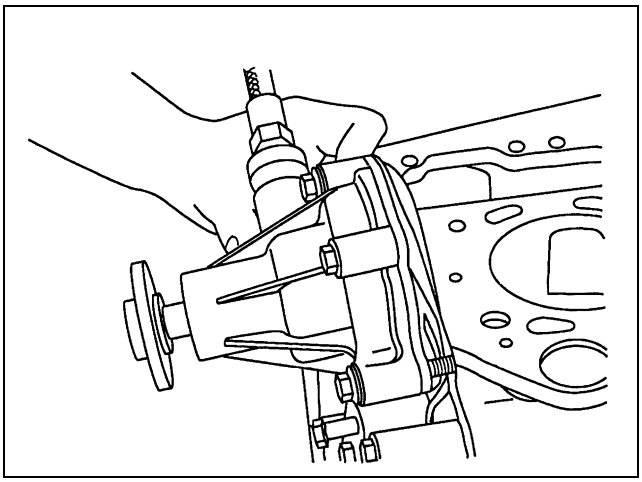


Figure 176 Installing water pump

Put a new gasket in position on the water pump flange.
Install the water pump in position on the cylinder block.

26.2 Thermostat installation

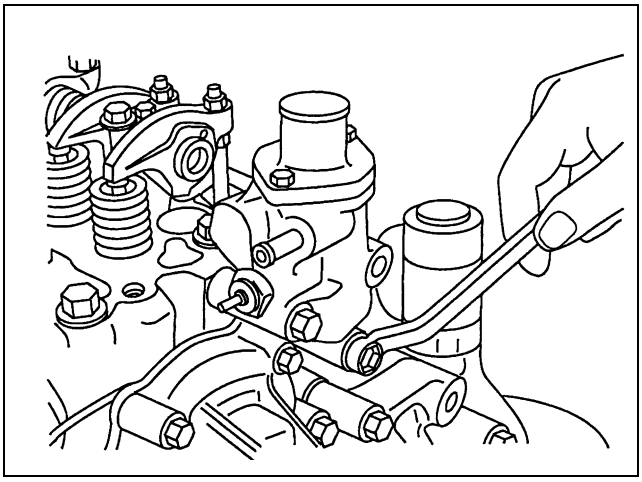


Figure 177 Installing thermostat

1. Put the thermostat in the thermostat case.
2. Put a new gasket in position on the thermostat case. Install the thermostat assembly in position on the cylinder head.

26.3 Cooling fan installation

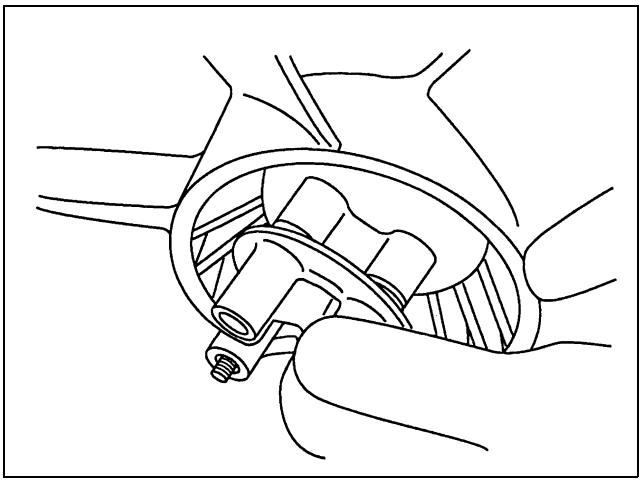


Figure 178 Installing cooling fan

1. Install the spacers in position in the fan as shown.
2. Install the pulley in position on the water pump. Install the fan and spacer combination in position on the pulley.

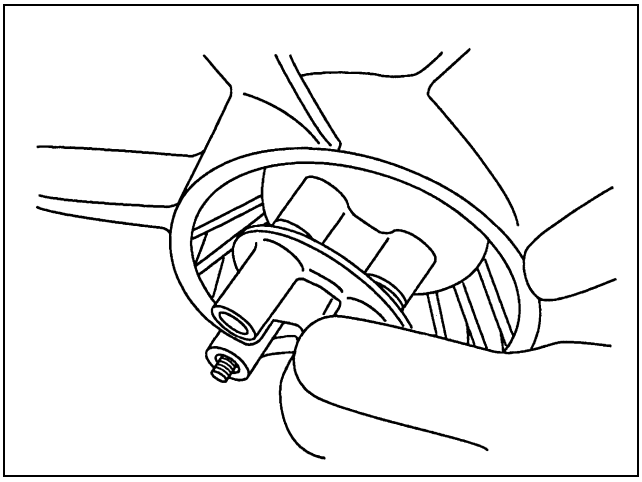


Figure 179 Installing thermoswitch and thermounit combination

26.4 Thermoswitch and thermounit combination installation

Coat the threads of the combination with Three Bond 1104. Put the combination in position and tighten it to the specified torque.

27 Electrical System

27.1 Glow plug installation

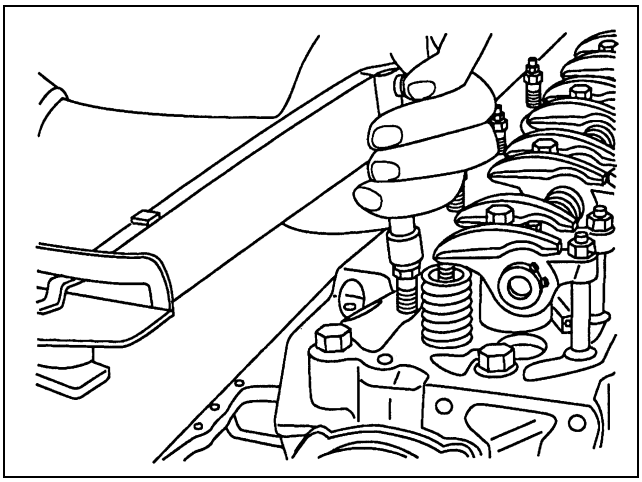


Figure 180 Installing glow plugs

Install the glow plug in position in the precombustion chamber and tighten it to the specified torque

Tightening torque	1,75 ± 0,25 kgf·m (12.7 ± 1.8 lbf·ft) [17,2 ± 2,5 N·m]

27.2 Alternator installation

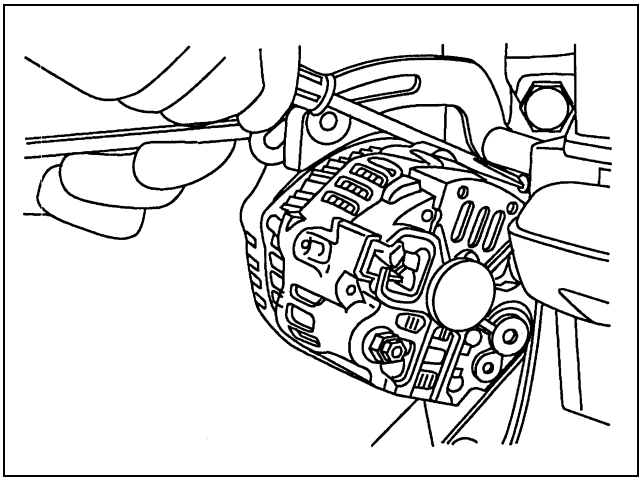


Figure 181 Installing alternator

1. Put the alternator in position. Install the adjusting plate bolt in position to hold the alternator in position.
2. Put the belt in position on the pulley. Move the alternator away from the engine to make an adjustment to the belt.
3. Tighten the bolts.
4. Make sure the deflection (tension) of the belt is correct.

Unit: mm (in.)

Deflection under 10 kgf (22 lbf) [98 N] force	10 to 12 (0.4 to 0.5)

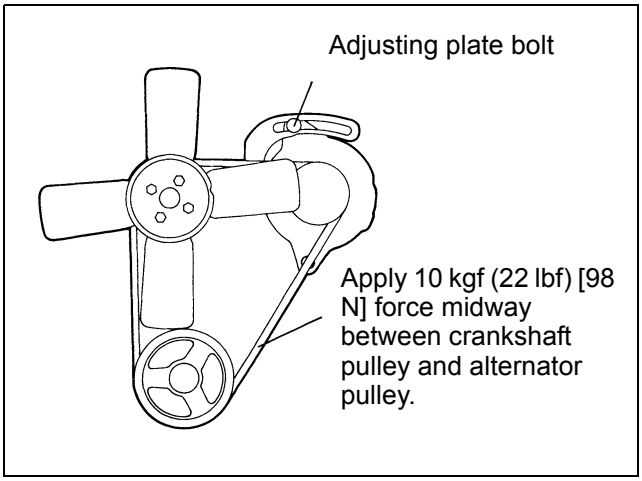


Figure 182 Adjusting alternator and fan belt

ELECTRICAL SYSTEM

28 GENERAL

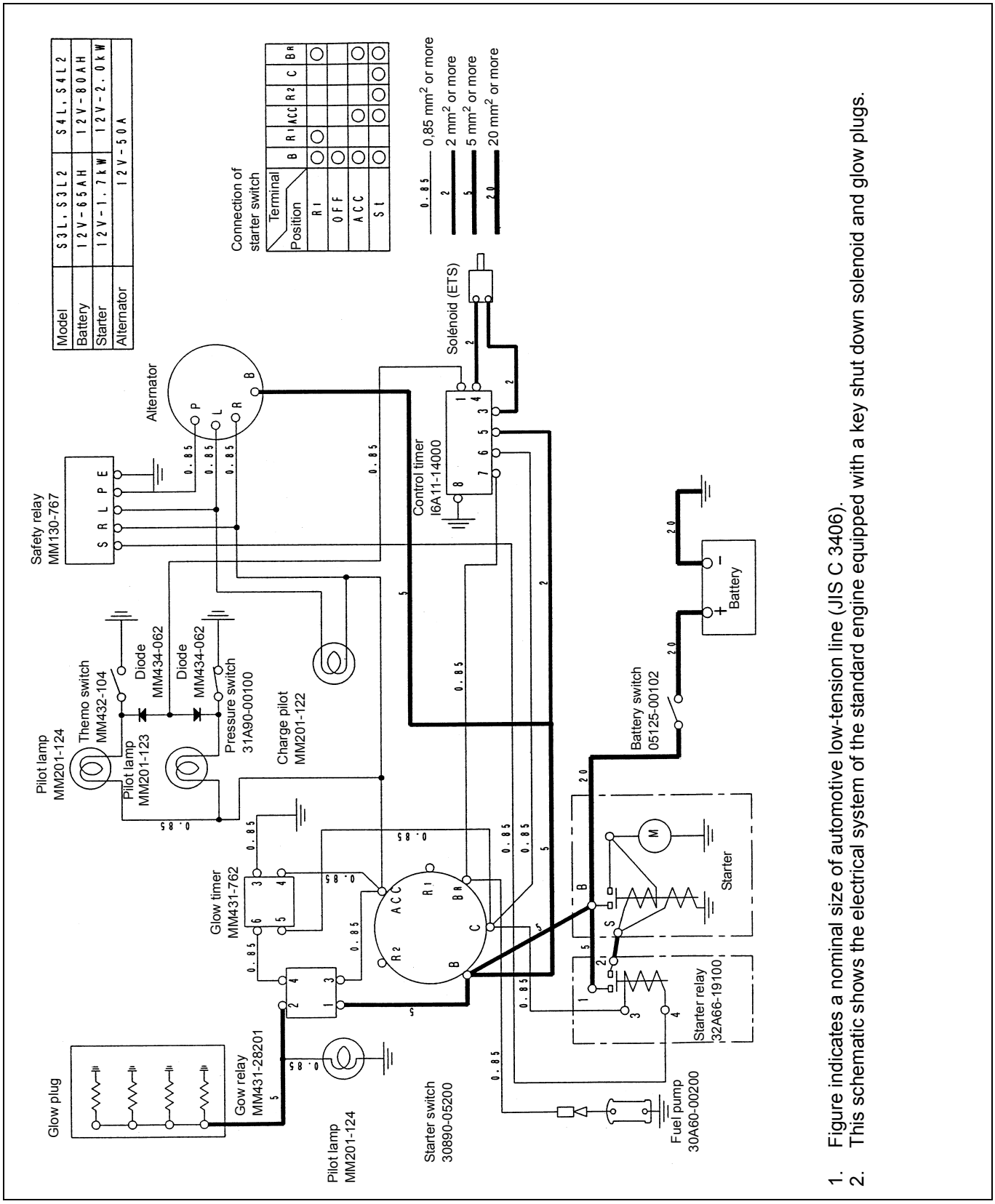
28.1 Specifications (standard)[1]

Engine model		S3L/S3L2	S4L/S4L2
Starter	Model	M1T68281	M8T70471
	Type	DC solenoid shifted (with reduction gear)	
	Nominal output, V–kW	12 - 1.7	12 - 2.0
Alternator	Model	A7T02071C	
	Regulator, type	IC	
	Nominal output, V–A	12 – 50	
Glow plug	Model	008816-4C	
	Type	Sheathed	
	Rated voltage, V	10.5	
	Current draw, A	9.7 ± 1.0 (30 seconds at rated voltage)	
Glow plug relay	Model	G71SP	
	Rated voltage, V	DC 12	
	Continuous rating	1 minute	
	Resistance in coil, Ω	13	
Control timer unit	Model	YM-1C	
	Input voltage range, V	DC 9 to 15	
	Load	Solenoid (resistance in coil: 1.7 Ω minimum)	
ETS type stop solenoid	Model	YMS-1	
	Type	Solenoid	
	Resistance in coil, Ω	1.8 ± 10% at 20°C (68°F)	
	Stroke, mm (in.)	13 ± 0.5 (0.53 ± 0.02)	
	Operating voltage, V	DC 10 to 15	
Glow timer	Model	QGS	
	Rated voltage, V	DC 12	
	Operating voltage, V	7 to 15	
	Operating temperature range °C (°F)	-30 to +70 (-22 to 158)	
	Storage temperature range °C (°F)	-40 to +80 (-40 to 176)	
	Pre-glow time, second	6.2 ± 0.7	

1. All specifications are subject to change without any prior notice.

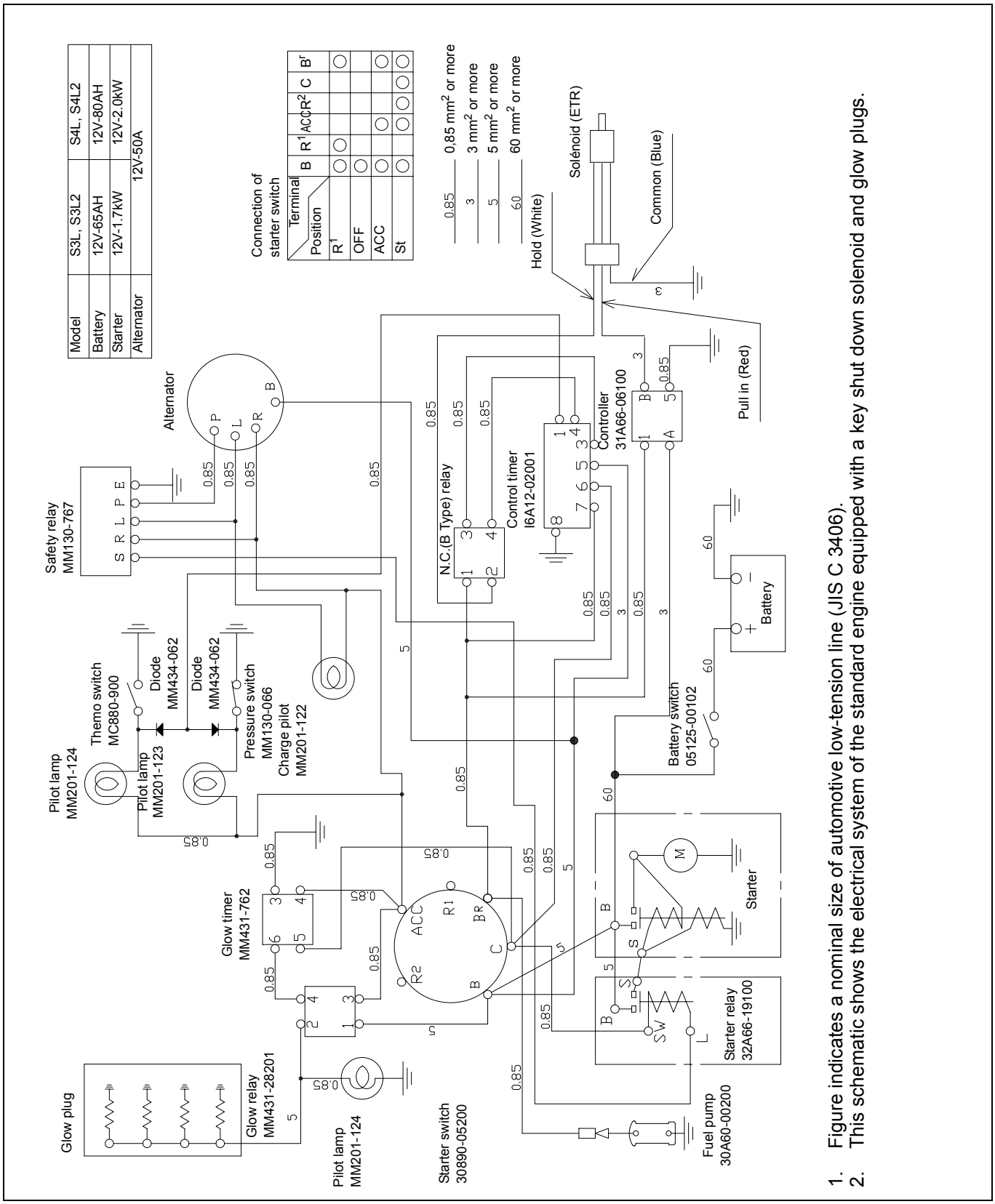
< ETS type stop solenoid >

28.2 Wiring diagrams



1. Figure indicates a nominal size of automotive low-tension line (JIS C 3406).
2. This schematic shows the electrical system of the standard engine equipped with a key shut down solenoid and glow plugs.

< ETR type stop solenoid >



1. Figure indicates a nominal size of automotive low-tension line (JIS C 3406).
2. This schematic shows the electrical system of the standard engine equipped with a key shut down solenoid and glow plugs.

29 STARTER

29.1 Disassembly

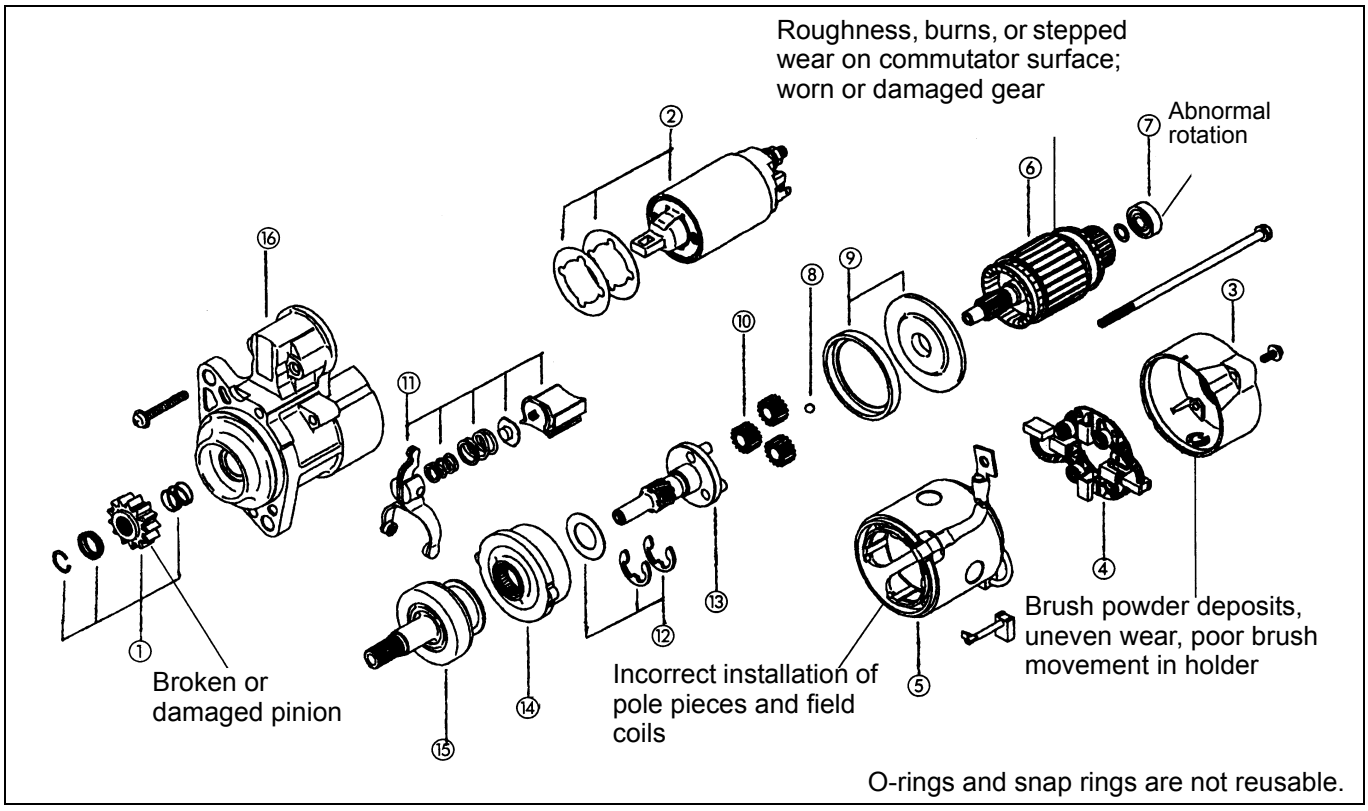
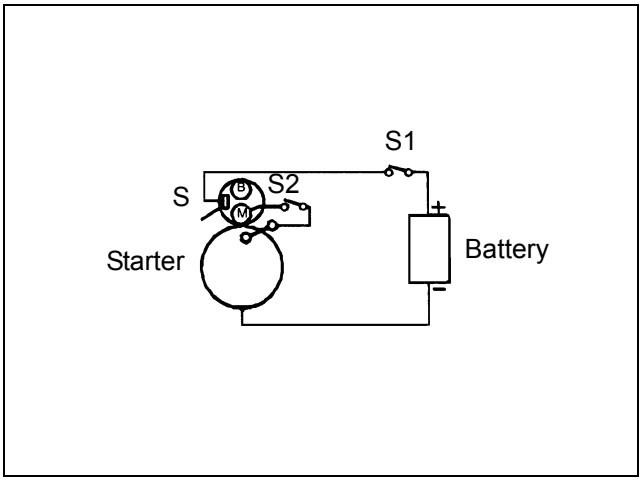


Figure 183 Starter component parts

Disassembly sequence
1. Pinion set
2. Solenoid switch
3. Rear bracket
4. Brush holder
5. Yoke
6. Armature
7. Ball bearing
8. Ball
9. Seal set
10. Reduction gears
11. Lever set
12. Washer set
13. Gear shaft
14. Internal gear
15. Overrunning clutch
16. Front bracket

⚠ CAUTION

The pinion must be removed before removal or replacement of the following parts:
1. Front bracket
2. Reduction gears
3. Overrunning clutch



29.1.1 Removing Pinion

The pinion can be removed when it is held in the pushed-out position during energization of the solenoid switch.

Disconnect the M-terminal connector and make a circuit that connects the starter motor and the battery as shown in the drawing. Close switches S1 and S2 to make the pinion come out and rotate. Then, open switch S2. The pinion will stop rotating but will stay in the pushed-out position. Apply a pipe-shaped implement to the pinion stopper and lightly tap it with a hammer to remove the pinion.

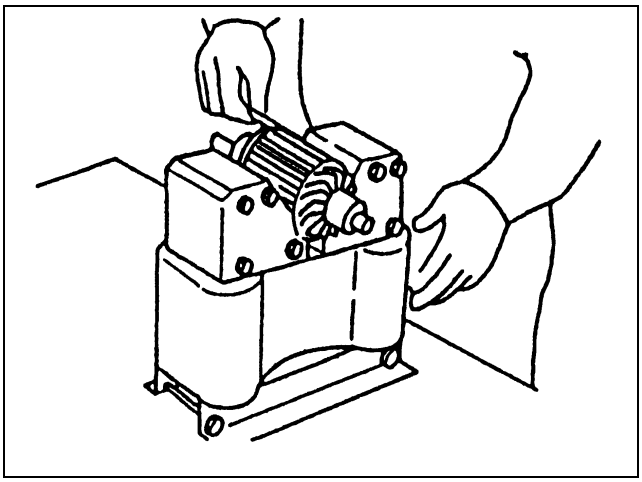
If the pinion returns to the retracted position before disengagement of the stopper while the tool is being tapped, repeat the procedure from the beginning.

29.1.2 Ball

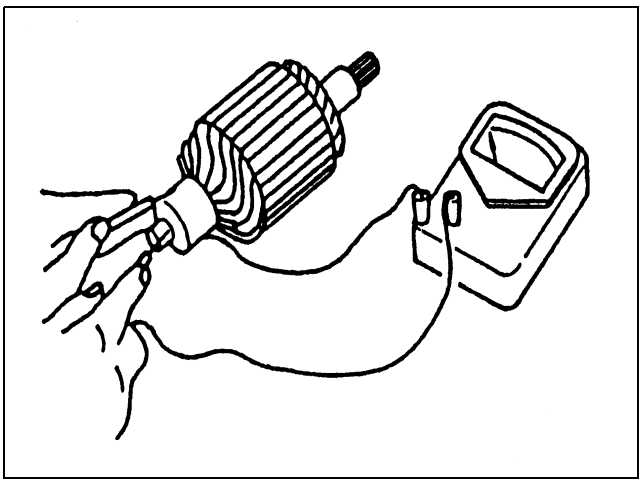
The ball at the end of the armature acts as a bearing for movement of the armature in the thrust direction. When the armature is removed, the ball may stick to the grease on it. Be careful not to lose the ball.

29.2 Inspection

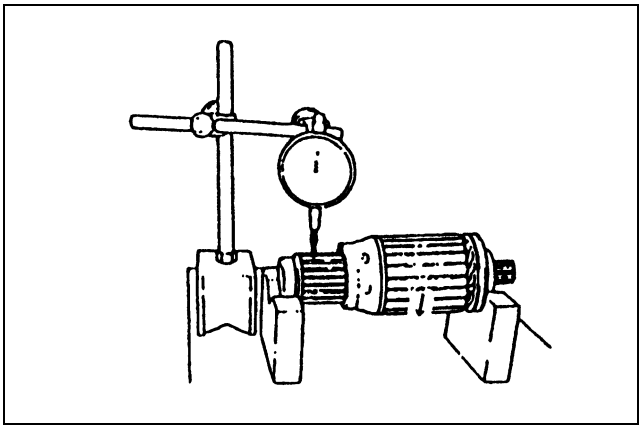
29.2.1 Armature

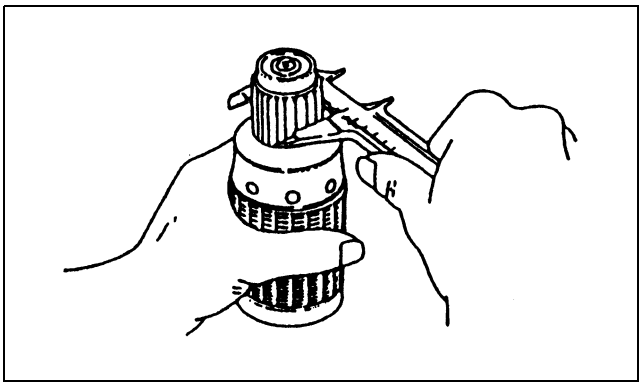


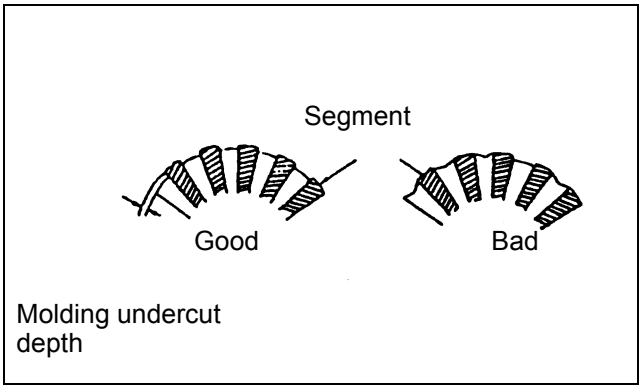
1. Coil Short Circuit Test
   Place the armature on a growler tester. Hold an iron rod parallel with the armature and slowly rotate the armature by hand. If the iron rod vibrates or is pulled toward the armature, the armature has a short-circuited coil and must be replaced.

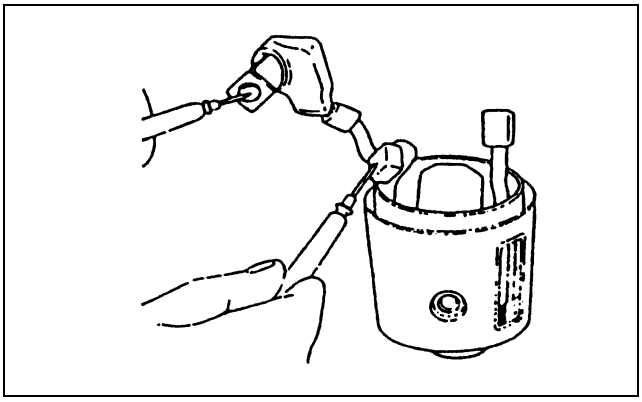


2. Coil Ground Test
   Check whether continuity exists between the commutator and shaft (or core). If continuity exists, the coil is grounded and the armature must be replaced.









3. Commutator Inspection
   1) Measure the commutator's runout using a dial gauge. If the measurement exceeds the specified limit, rectify the problem, making sure that the outside diameter stays within specification. If the surface is rough or has stepped wear, rectify the problem with emery paper (#300 – 500).

Unit: mm (in.)

	Limit
Commutator runout	0.1 (0.004)

   2) Measure the commutator's outside diameter. If the measurement is out of specification, replace the armature.

Unit: mm (in.)

	Standard value	Limit
Commutator outside diameter	32.0 (1.26)	31.4 (1.24)

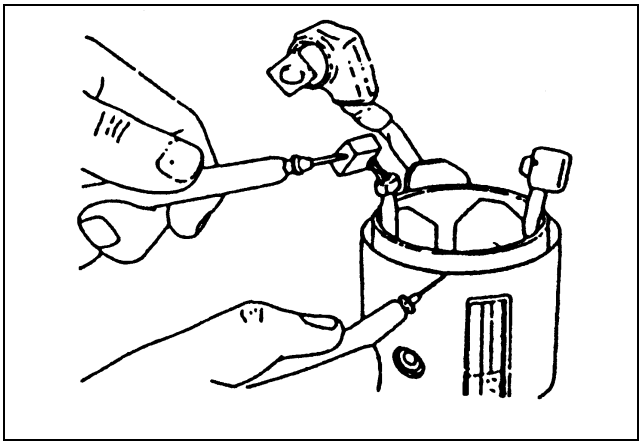
   3) Measure the molding undercut depth between segments. If the depth is smaller than the limit, cut the molding to a depth of 0.4-0.6 mm (0.016-0.024 in).

Unit: mm (in.)

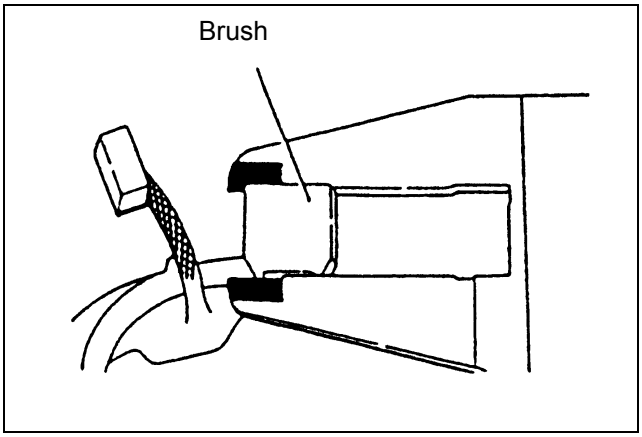
	Limit
Commutator runout	0.1 (0.004)

29.2.2 Field Coil

1. Coil Open Circuit Test
   Check whether continuity exists between the terminal lead and each brush. If continuity does not exists, the field coil has an open circuit and the yoke assembly must be replaced



2. Coil Gound Test
Check whether continuity exists between the yoke and each brush. If continuity exists, the coil is grounded and must be checked for defective insulation. If repair is impossible, replace the yoke assembly.

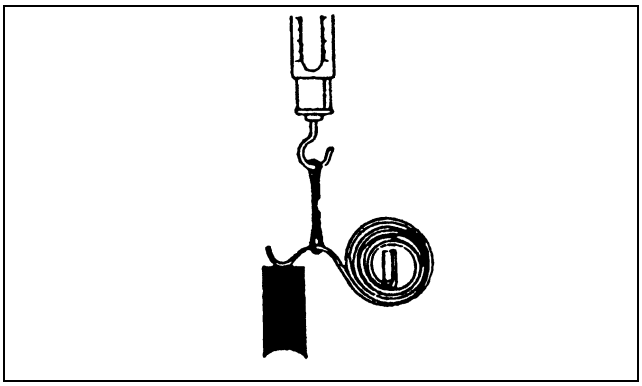


29.2.3 Brushes and Brush Holders

1. Brush Wear
Measure the length of the brush. If the measurement is smaller than the limit, replace the brush. If the brush is worn unevenly or has a rough contact surface, rectify the problem with fine emery paper (#300–500).

Unit: mm (in.)

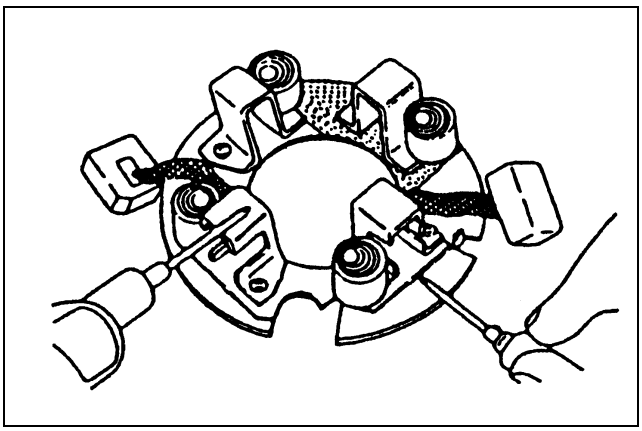
	Standard value	Limit
Brush length	18 (0.71)	11 (0.43)



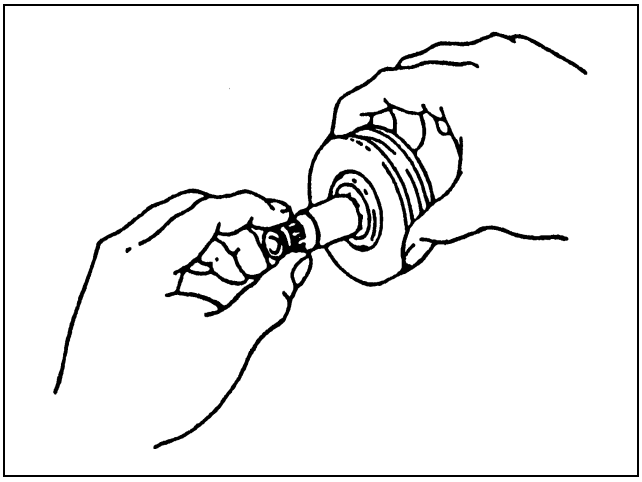
2. Brush Spring Force
With a new brush installed, pull the brush spring with a spring balance and read the load at the point where the spring leaves the brush. Replace the spring if its force is lower than the limit.

N {kgf} (lbf)

	Standard value	Limit
Brush spring force	26.7 – 36.1 {2.7 – 3.7} (6.0 – 8.3)	14.7 {1.5} (3.3)



3. Brush Holder Insulation Test
Check whether continuity exists between the (+) brush holder and the (–) brush holder plate. If continuity exists, replace the brush holder assembly.



29.2.4 Overrunning Clutch

Make sure the pinion shaft rotates smoothly when turned clockwise (in the drive direction) and locks when turned counterclockwise. If the pinion shaft's operation is defective, replace the overrunning clutch.

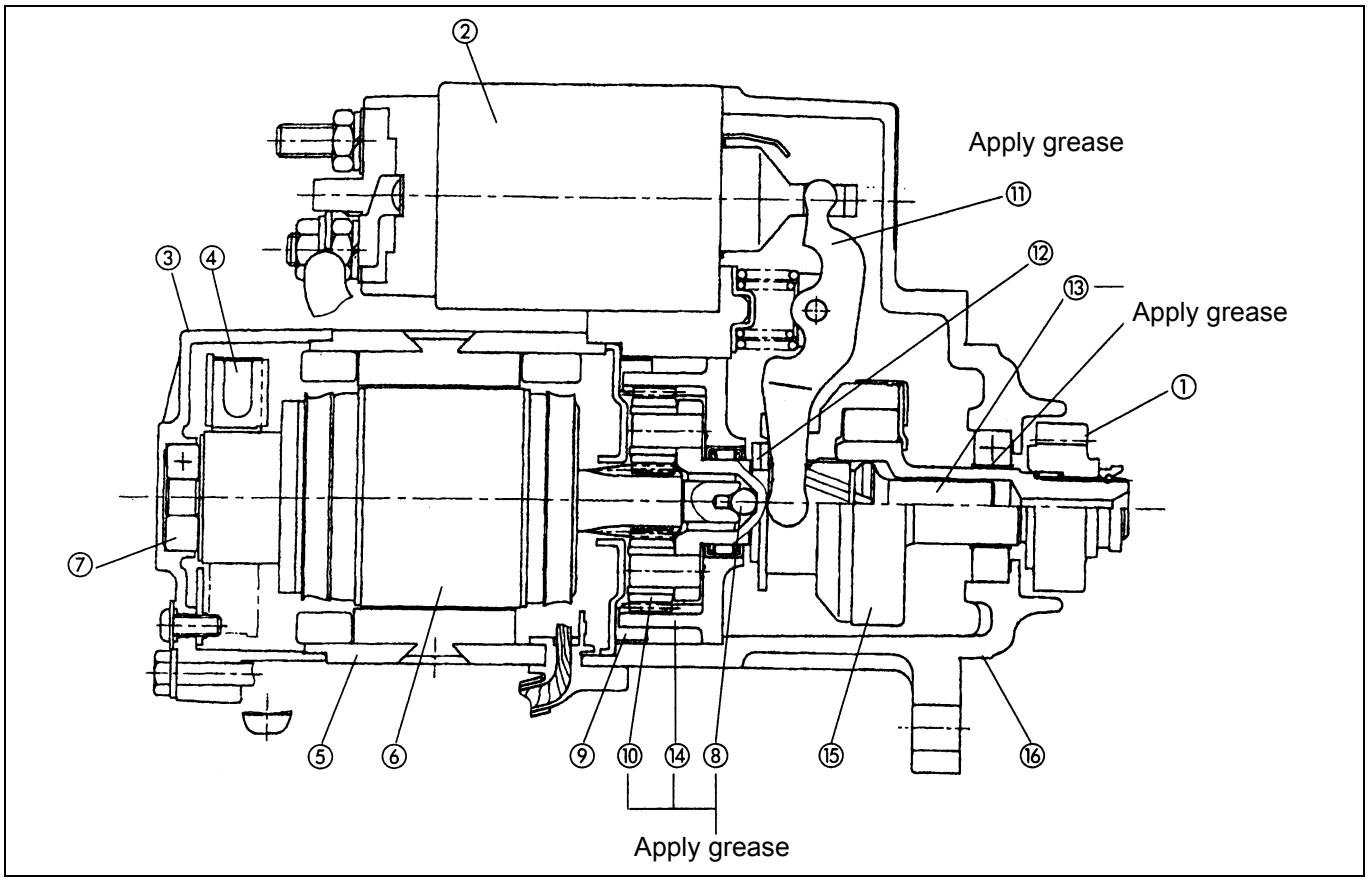
29.2.5 Gear Shaft Thrust Gap

Adjustment of the gear shaft's thrust gap is not necessary.

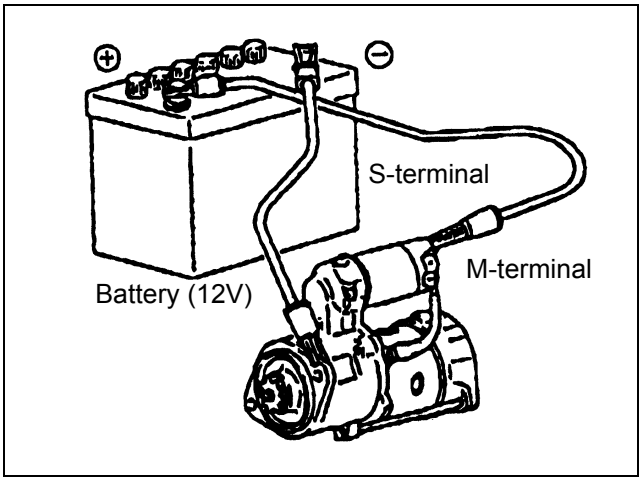
29.2.6 Armature Thrust Gap

Adjustment of armature's thrust gap is not necessary.

29.3 Assembly

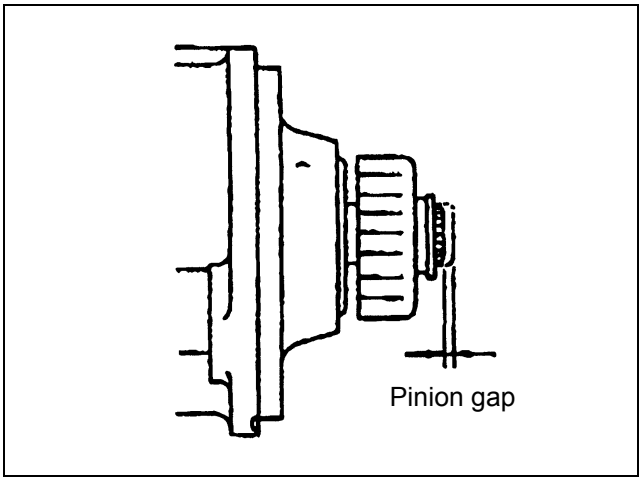


Assembly sequence
16 → 12 → 13 → 14 → 15 → 1 → 10 → 11 → 9 → 8 → 5 → 6 → 7 → 4 → 3 → 2



29.4 Inspection and Testing after Assembly

After assembling the starter, perform the following inspections and tests:



29.4.1 Inspection and Adjustment of Pinion Gap

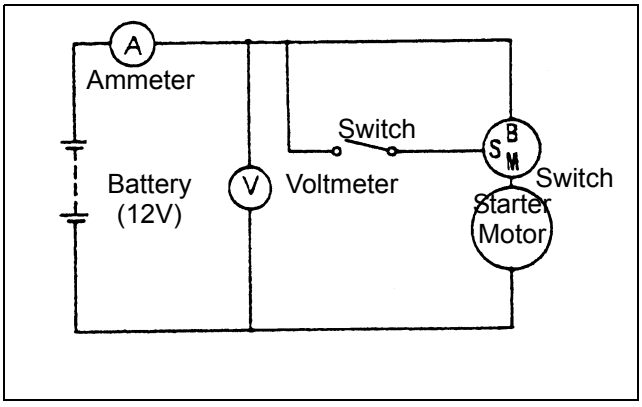
1. Connect the assembled starter to the battery as shown in the drawing. The pinion will come out and rotate slowly. Then, remove the M-terminal connector to stop the motor.
2. Lightly push the pinion shaft toward the armature and measure the amount of axial movement, which corresponds to the pinion gap.
3. If the pinion gap is not within the 0.5 – 2.0 mm (0.02 – 0.08 in.) range, adjust it by increasing or decreasing the number of seals in the solenoid switch. (Increasing the number of seals reduce the pinion gap). It may be necessary to replace the lever to obtain the correct pinion gap.

Unit: mm (in.)

	Standard value
Pinion gap	0.5 – 2.0 (0.02 – 0.08)

NOTE

To prevent the solenoid switch coil from overheating, do not energize the solenoid switch for longer than 10 seconds.



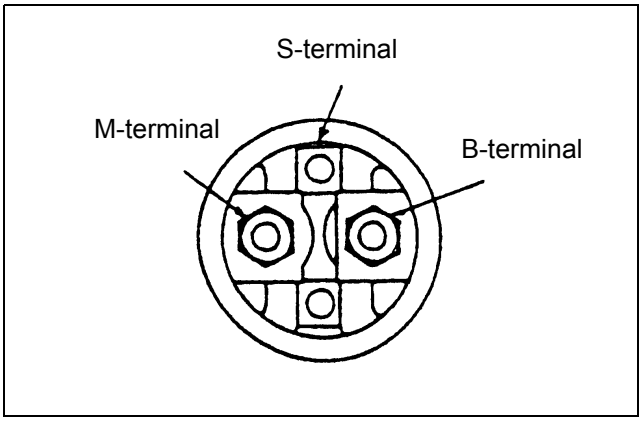
29.4.2 No-Load Test

When the pinion gap has been correctly adjusted, connect an ammeter and a voltmeter between the starter motor and battery as shown in the drawing, then check the starter's no-load characteristics.

⚠ CAUTION

Use the thickest wires possible, and tighten each terminal firmly.

	Voltage (V)	Current (A)	Speed (min^{-1})
No-Load characteristics	11	130 maximum	3,600 minimum



29.4.3 Solenoid Switch

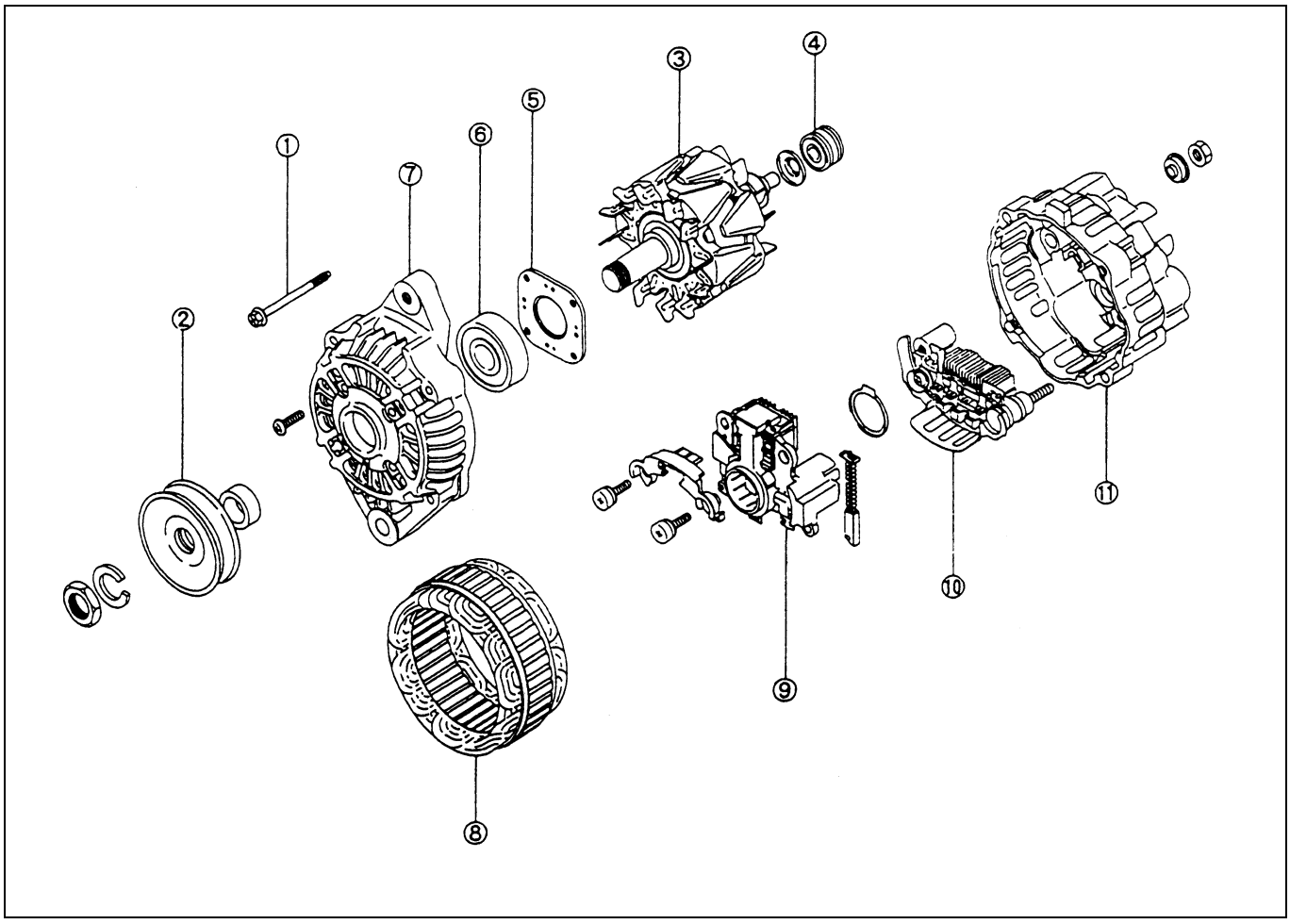
Perform the following continuity tests. If the solenoid switch fails either tests, replace it.

1) Test for Coil Open Circuit
   Continuity should exists between the S- and M-terminals and between the S-terminal and ground (case).

2) Test for Fused Contacts
   Continuity should not exist between the B- and M-terminals.

30 ALTERNATOR

30.1 Disassembly



Disassembly sequence
1. Through bolt
2. Pulley
3. Rotor
4. Rear bearing
5. Bearing retainer
6. Front bearing
7. Front bracket
8. Stator core
9. Brush holder
10. Rectifier
11. Rear bracket

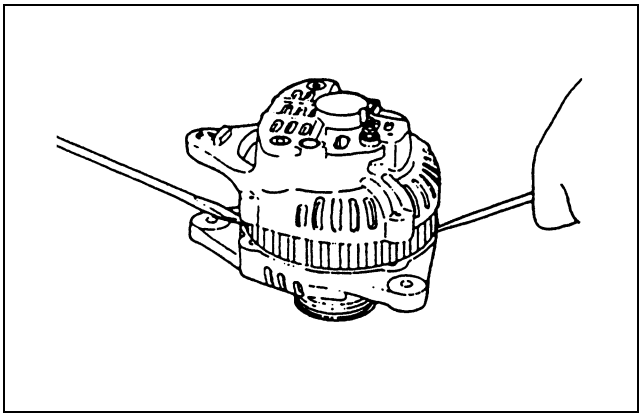


Figure 184 Disassembling alternator

30.1.1 Stator core separation from front bracket

1. Pry the stator core off the front bracket with a screwdriver as shown in the illustration.

⚠ CAUTION

Be careful not to insert the screwdriver too deep. Damage to the stator core can be the result.

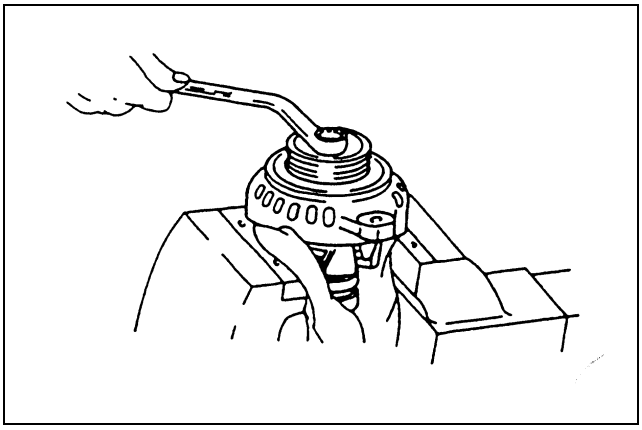


Figure 185 Removing pulley

30.1.2 Pulley removal

1. Hold the rotor assembly in a vise by using thick cloth as shown in the illustration. Remove the nut that holds the pulley in position, and remove the pulley and spacer.
2. Remove the rotor assembly from the front bracket.

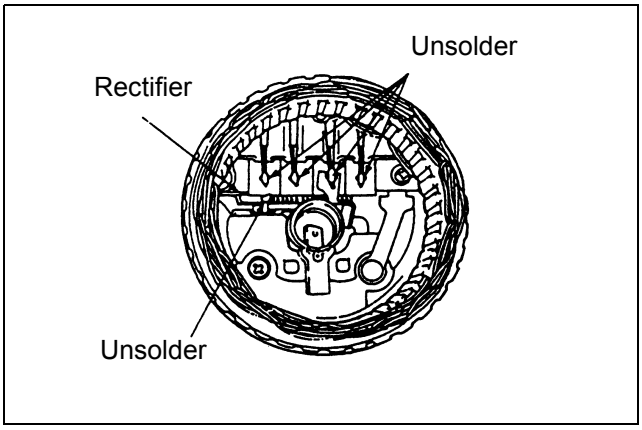


Figure 186 Removing stator core

30.1.3 Stator core and rectifier removal

1. Unsolder the leads from the rectifier and remove the stator core from the rectifier.

⚠ CAUTION

Unsolder the leads as quickly as possible to prevent damage to the diodes in the rectifier.

2. Remove the screws that hold the rectifier in position and remove the rectifier.

30.2 Inspection

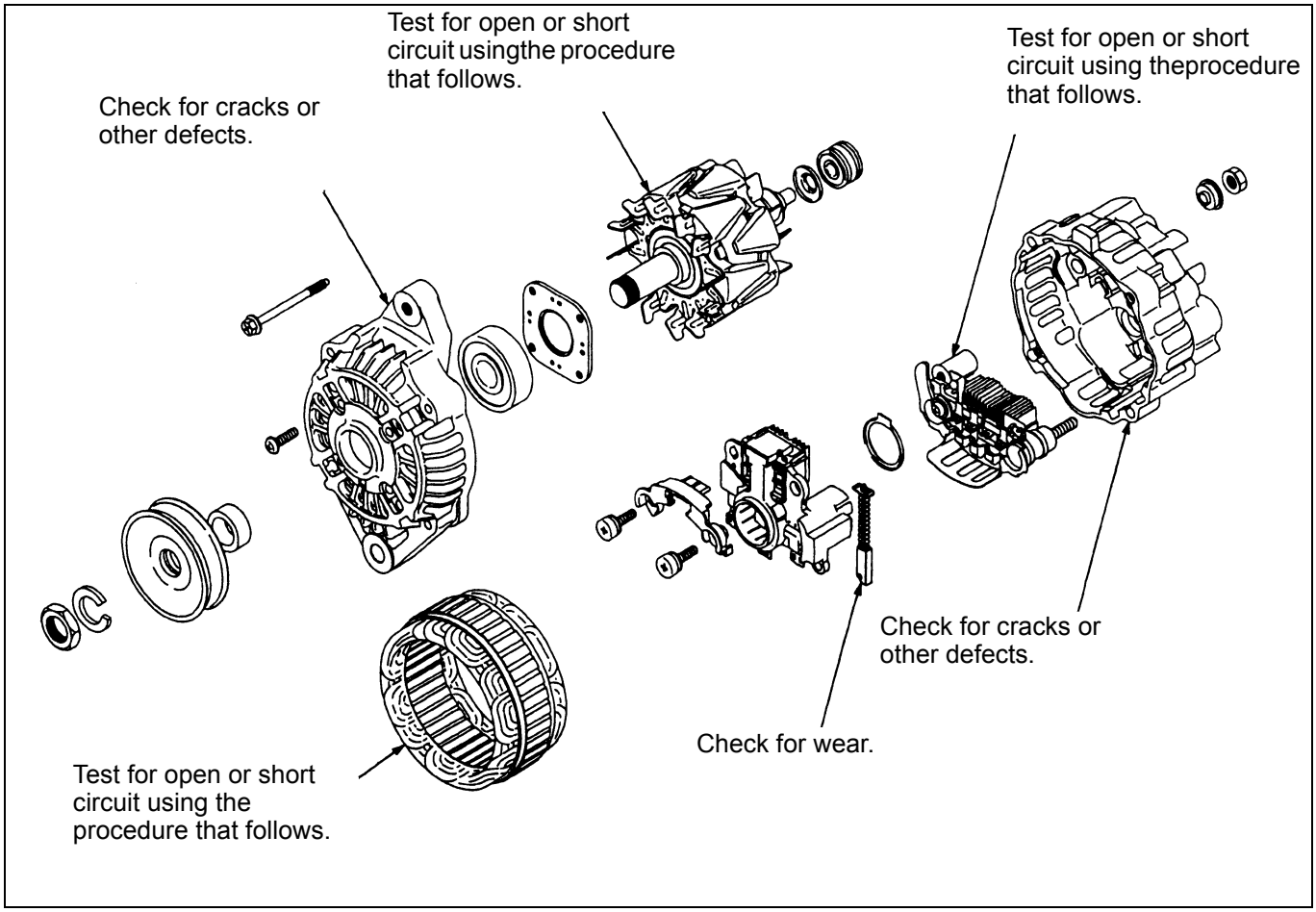


Figure 187 Inspection points

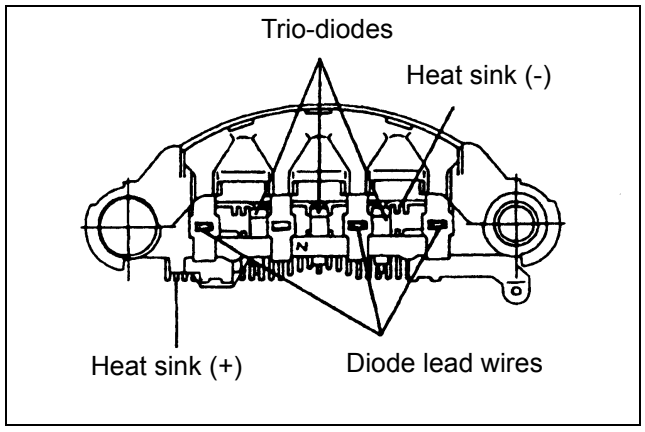


Figure 188 Testing diode

30.2.1 Diodes

1. Test the resistance between the diode and heat sink. First touch the positive (+) prod of an ohmmeter to the diode, then the negative (–) prod. If the resistance is infinite in both cases, the diode is open. If it is nearly zero in both cases, the diode is shorted. Do the same step for the remainder of the diodes. If any diode is open or shorted, replace the rectifier.

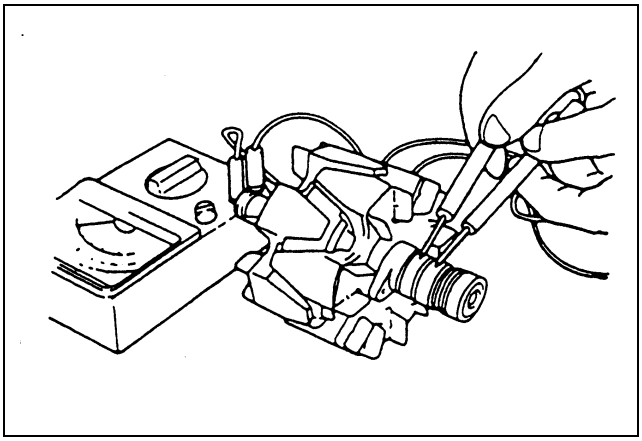


Figure 189 Testing field coil for open circuit

30.2.2 Field coil

1. Test for continuity between the slip rings as shown in the illustration. No continuity shows there is an open circuit in the field coil. Replace the field coil.

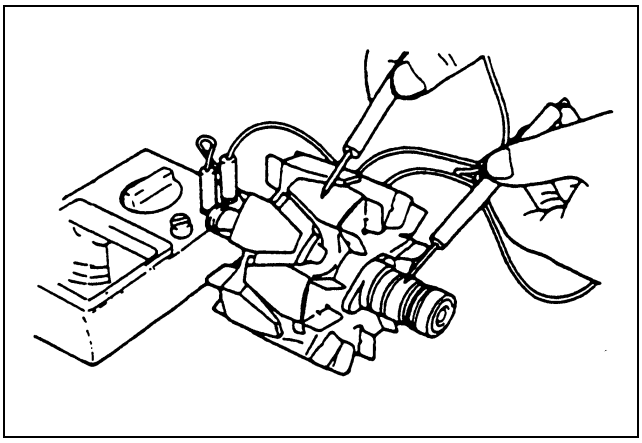


Figure 190 Testing field coil for grounded circuit

2. Test for no continuity between the slip ring and shaft (or core) as shown in the illustration. Any continuity shows there is a grounded circuit in the field coil. Replace the field coil.

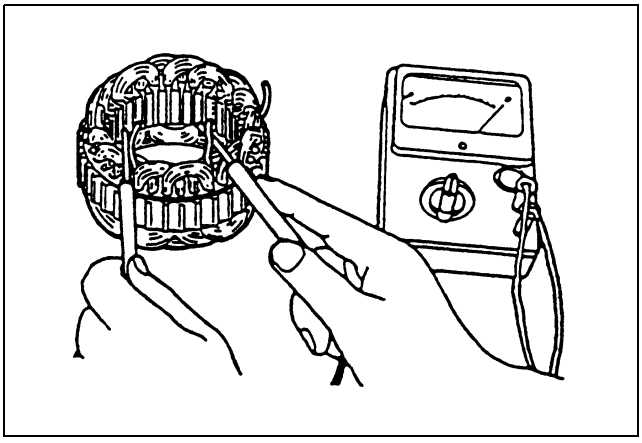


Figure 191 Testing stator core for open circuit

30.2.3 Stator core

1. Test for continuity between the leads as shown in the illustration. No continuity shows there is an open circuit in the stator core. Replace the stator core.

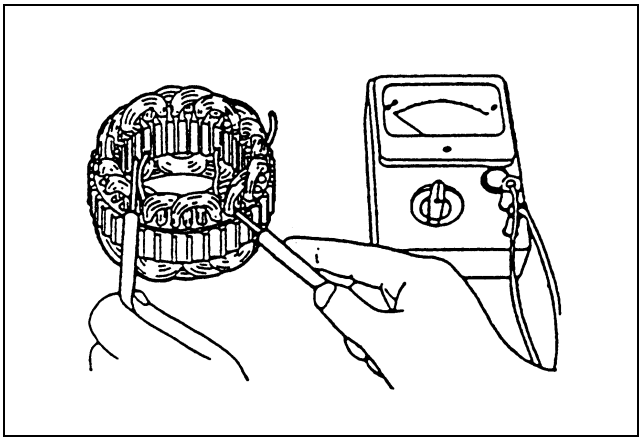


Figure 192 Testing stator core for grounded circuit

2. Test for no continuity between each lead and stator core as shown in the illustration. Any continuity shows there is a grounded circuit in the stator core. Replace the stator core.

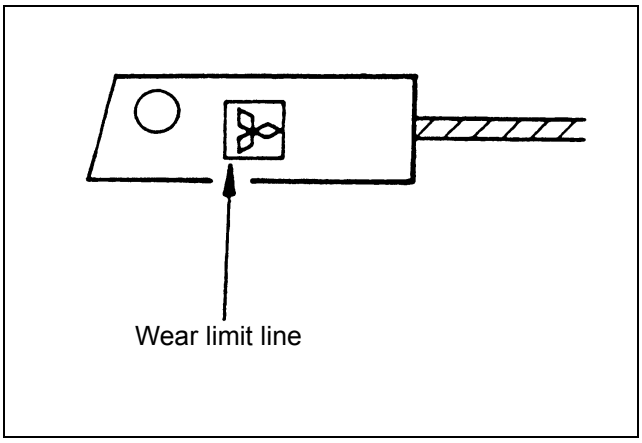


Figure 193 Checking brush for wear

30.2.4 Brushes

1. Make replacement of brushes that have been worn down to, or beyond, the wear limit line.

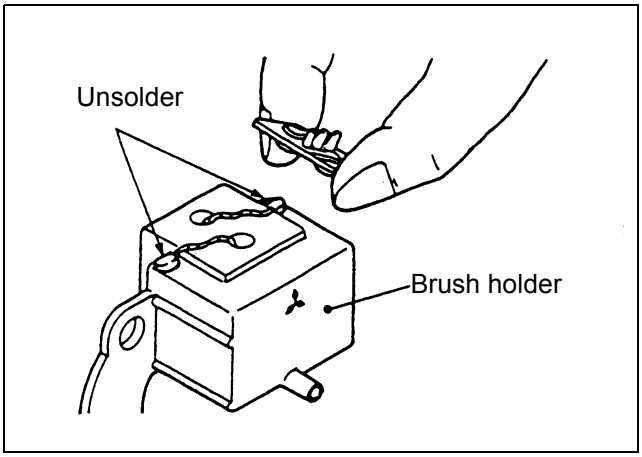


Figure 194 Removing brushes for replacement

2. To remove the brushes from the brush holder for replacement, unsolder the leads from the brushes. This will permit removal of the brushes and springs.

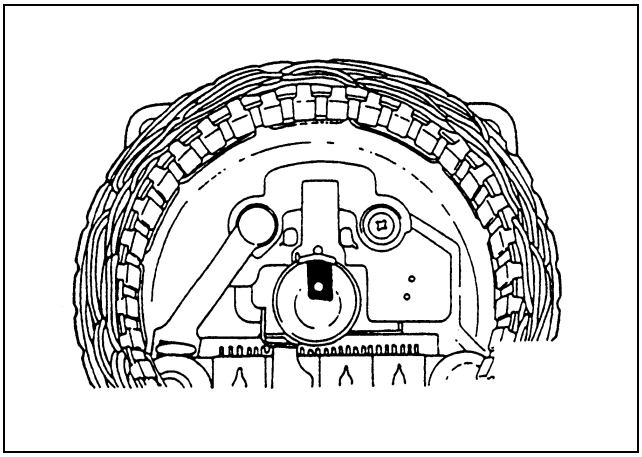


Figure 195 Installing new brushes

3. To install the new brushes, put them in position in the brush holder and solder the leads to the brushes.

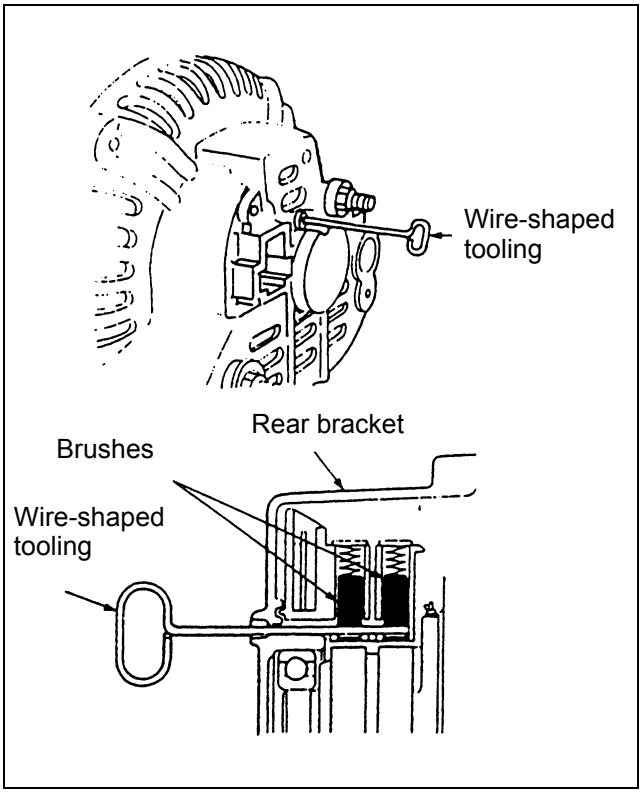


Figure 196 Assembling alternator

30.3 Assembly

Follow the reverse of disassembly and use the procedure that follows.

1. The rear bearing has a groove for the snap ring. Install the snap ring in this groove, making sure its tab is in the deep portion of the groove.
2. When installing the new rear bearing, put it in position with the side that has a groove toward the slip rings of the rotor.
3. To install the rear bearing in the rear bracket, heat the rear bracket.
4. Before installing the rotor in the rear bracket, insert a wire-shaped tooling into the hole in the rear bracket to lift the brushes off the slip rings. Remove the tooling after the rotor has been installed in position.

31 KEY SHUTOFF SYSTEM (ETS solenoid type)

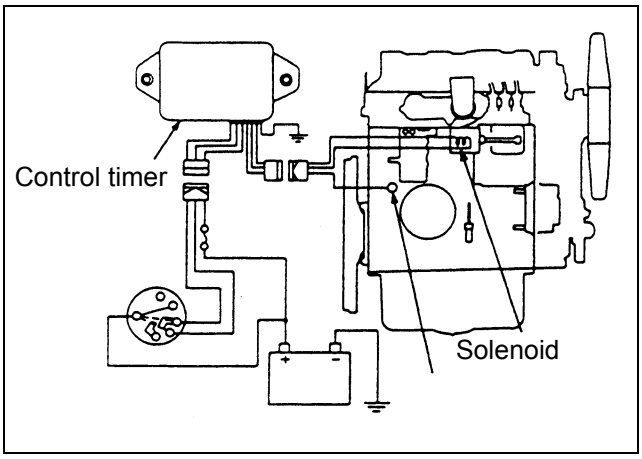


Figure 197 Key shutoff system

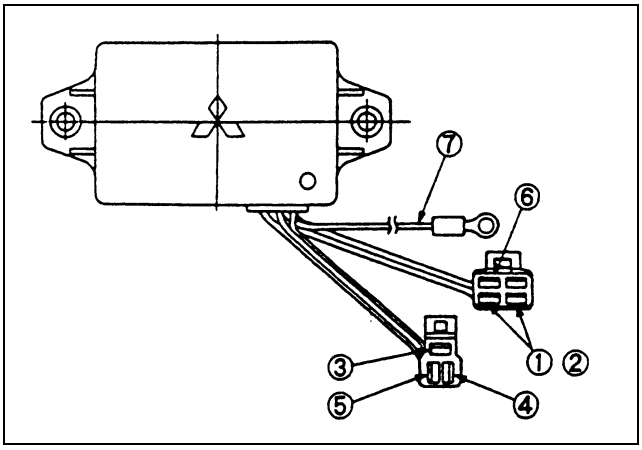


Figure 198 Control timer connection

31.1 General

This system, consisting of a switch, a control timer and a solenoid, permits the operator to shut off the engine by turning the starter switch key to OFF position. Another function of this system is to shut off the engine automatically when the oil pressure is too low, or when coolant temperature is too high.

31.2 Cord color (standard)

No.	Cord color	Connected to
1	Blue	Solenoid
2	Blue	Solenoid
3	Red	Battery (starter switch B terminal)
4	Green	Starter switch ON terminal
5	Red/white	Starter (starter switch and starter)
6	Yellow	Oil pressure switch
7	Black	Ground

31.3 Shutoff solenoid installation

1. Remove the tie rod cover.
2. Coat the threads of the stop solenoid with thread sealant (Three Bond 1212).

NOTE

Coat the length of the threads to be turned in the governor case.

3. Temporarily install the shutoff solenoid and nut in the governor case.
4. Move the injection pump control rack all the way to the non-injection (shutoff) position.

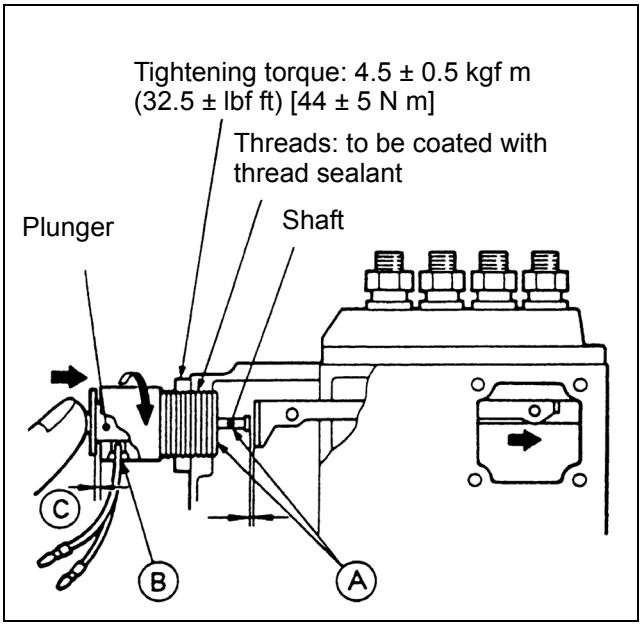


Figure 199 Installing shutoff solenoid

5. Turn the shutoff solenoid in the governor case while pushing the plunger toward the control rack until the shaft is in touch with the tie rod. At this time, clearance C must be 0 mm. (Under this condition, the plunger will be rotated by the shutoff solenoid being turned in.)
6. Back off the shutoff solenoid 30° to 45° turn (the clearance between the control rack and plunger will be 0.15 to 0.20 mm (0.0059 to 0.0079 in.)) and tighten the nut to the specified torque.
7. Start the engine and make sure the engine stops when the plunger is pushed all the way.

NOTE

- Do not allow thread sealant to contact (A)
- Do not allow cleaning solvent to enter the solenoid through (B)

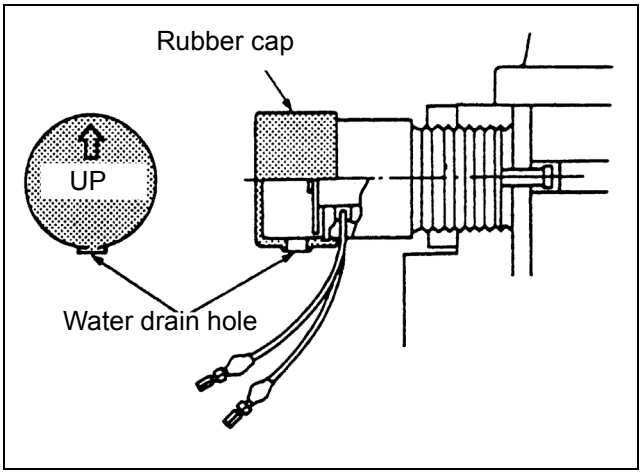


Figure 200 Installing rubber cap

8. Install the rubber cap in position with teh arrow head toward up (with the side that has a water drain hole down) as shown in the illustration.

⚠ CAUTION

Do not allow cleaning solvent to contact any solenoid parts.

31.4 Inspection after assembly

1. For the schematic of the key shutoff system, see page 113 or 114.
2. Start the engine and make sure the engine stops when the starter switch key is turned to OFF position.
3. Start the engine and make sure the engine stops when the oil pressure switch terminal is shorted to the switch body.

NOTE

It will take about 10 seconds to restart an engine which was shut down by the key shutoff device.

32 KEY SHUTOFF SYSTEM (ETR solenoid type)

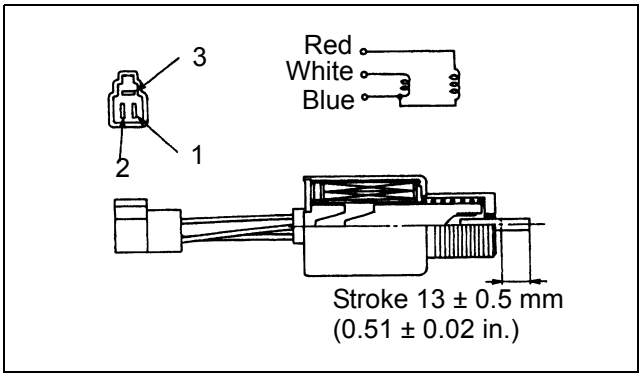
32.1 General

The energize-to-run (ETR) solenoid-controlled engine shutdown system operates as follows:

When the starter switch is turned to the “ON” position, the pull-in coil of the solenoid is energized for three seconds, pulling the push rod inward.

During operation with the starter switch at the “ON” position, the hold-in coil of the solenoid remains energized, keeping the push rod in the retracted position.

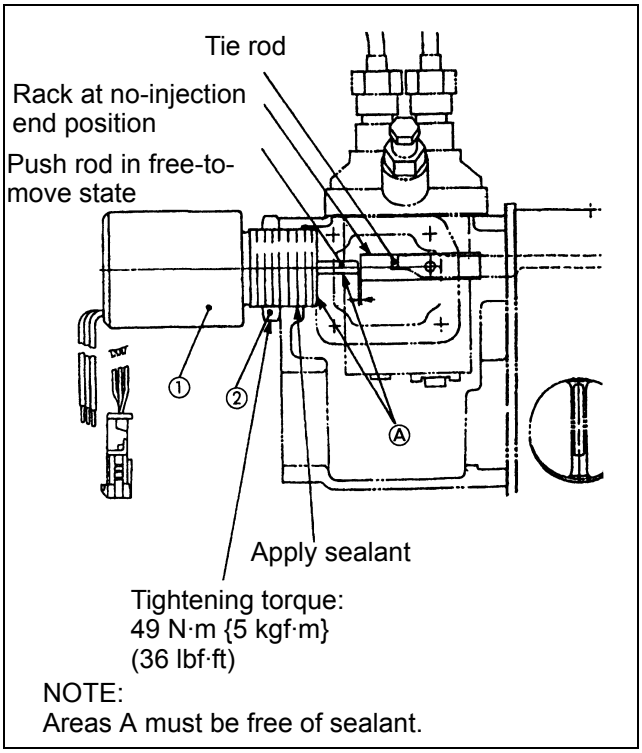
Like the conventional energize-to-stop (ETS) solenoid engine shutdown system, this system is a safety device designed to bring the injection pump into the no-injection state whenever the wiring is open or the starter switch is turned to the “OFF” position.



32.2 Cord color (standard)

The wires of the solenoid are identified by color as follows:

No.	Color	Remarks/Connection
1	Red	PULL (pull-in coil)/starter
2	White	HOLD (hold-in coil)/starter switch
3	Blue	COM (earth)/ground



32.3 Shutoff solenoid installation

1. Remove the tie rod cover on the injection pump to enable movement of the rack to be observed.
2. Put the nut 2 on the solenoid 1 and turn the nut down to the inner end of the threads on the solenoid.
   Apply sealant to the threads on the solenoid.

NOTE

Sealant should be applied over those threads which are concealed when the solenoid is installed on the cylinder block.

Sealant	Threebond 1212 or 1211

3. Screw the solenoid 1 into the cylinder block.
4. While moving the rack in both directions, screw in the solenoid 1 until the rack is against the solenoid's push rod and cannot move any more.
5. Unscrew the solenoid 1 approximately 90 – 180° from the position achieved in (d), and temporarily lock the solenoid with the nut 2.
6. Move the rack in both directions. There should be a play of approximately 0.3 – 0.7 mm (0.01 – 0.03 in.).
7. Tighten the nut 2 to the specified torque.

Nut tightening torque	Threebond 1212 or 1211

8. Reinstall the tie rod cover on the injection pump.
9. Start the engine. Turn the starter switch to the OFF position. The push rod then should extend, pushing back the rack and stopping the engine.

NOTE

It will take about 10 seconds to restart an engine which was shut down by the key shutoff device.

33 AUTOMATIC GLOW SYSTEM

33.1 General

Turning the starter switch to ON position activates the glow plugs to heat the engine and causes the glow plug indicator to come on.

Heating time	6.2 ± 0.7 seconds

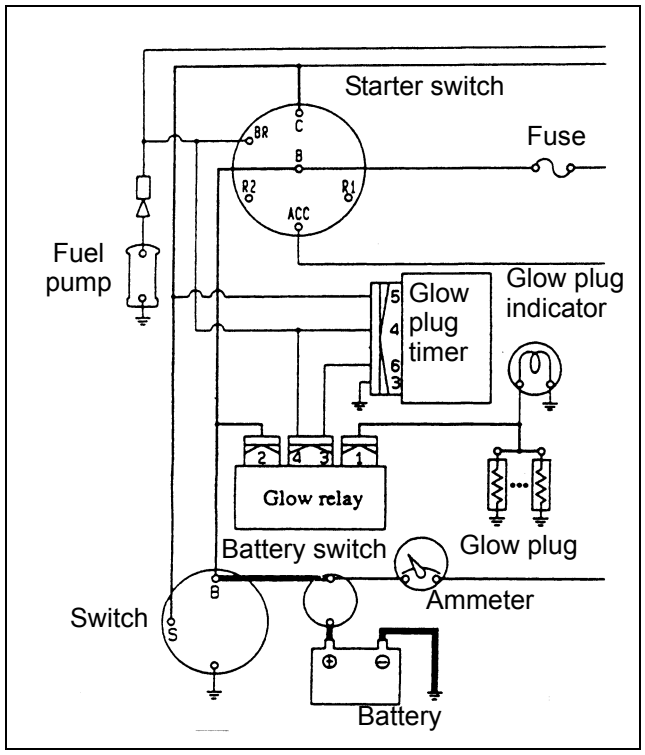


Figure 201 Automatic glow plug system

33.2 Glow timer specification (standard)[1]

Part number	MM431-762
Type	Quick heating
Rated voltage	DC 12 V
Operating voltage range	7 to 15 V
Operating temperature range	–30°C to +70°C (–22°F to +158°F)
Storage temperature range	–40°C to +80°C (–40°F to +176°F)
Glow plug activating time	6.2 ± 0.7 seconds

1. All specifications are subject to change without any prior notice.

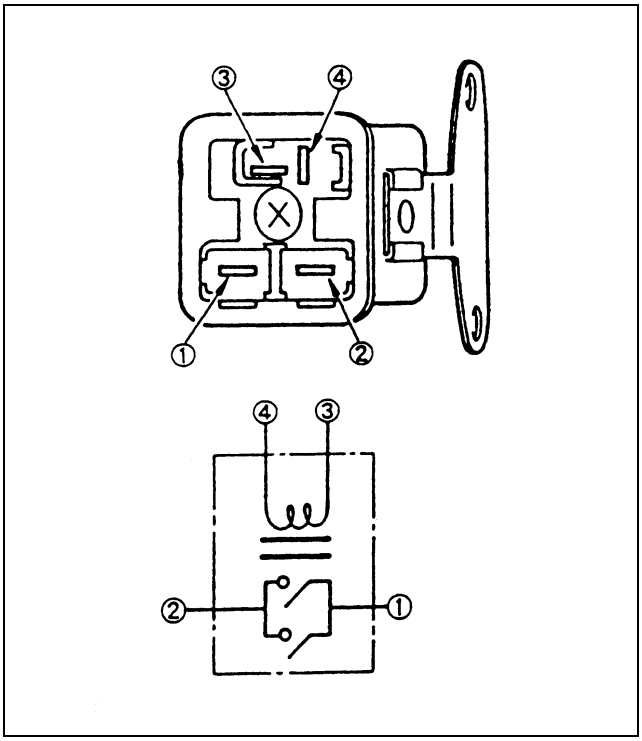


Figure 202 Glow plug relay

33.3 Glow plug relay specifications (standard)[2]

Part number	MM431-28201
Rated voltage	DC 12 V
Continuous rating	1 minute
Coil resistance	13 Ω
Operating temperature range	–40°C to +100°C (–40°F to +212°F)

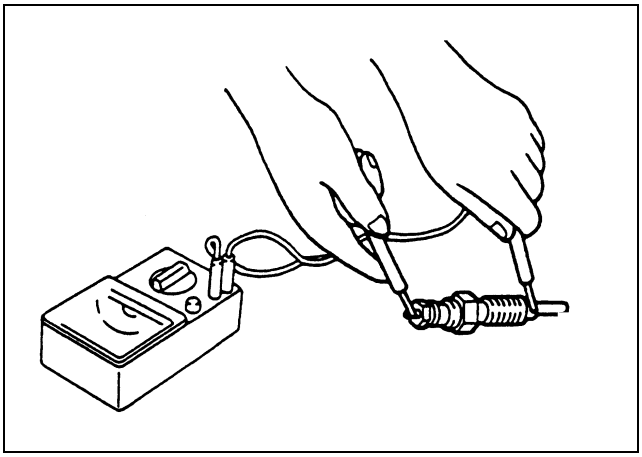


Figure 203 Testing glow plug

33.4 Glow plug inspection

Test for continuity between the terminal and body as shown in the illustration. If no continuity, replace with new one.

Item	Standard
Resistance	0.55 Ω

2. All specifications are subject to change without any prior notice.

COOLING SYSTEM

34 GENERAL

34.1 Schematic

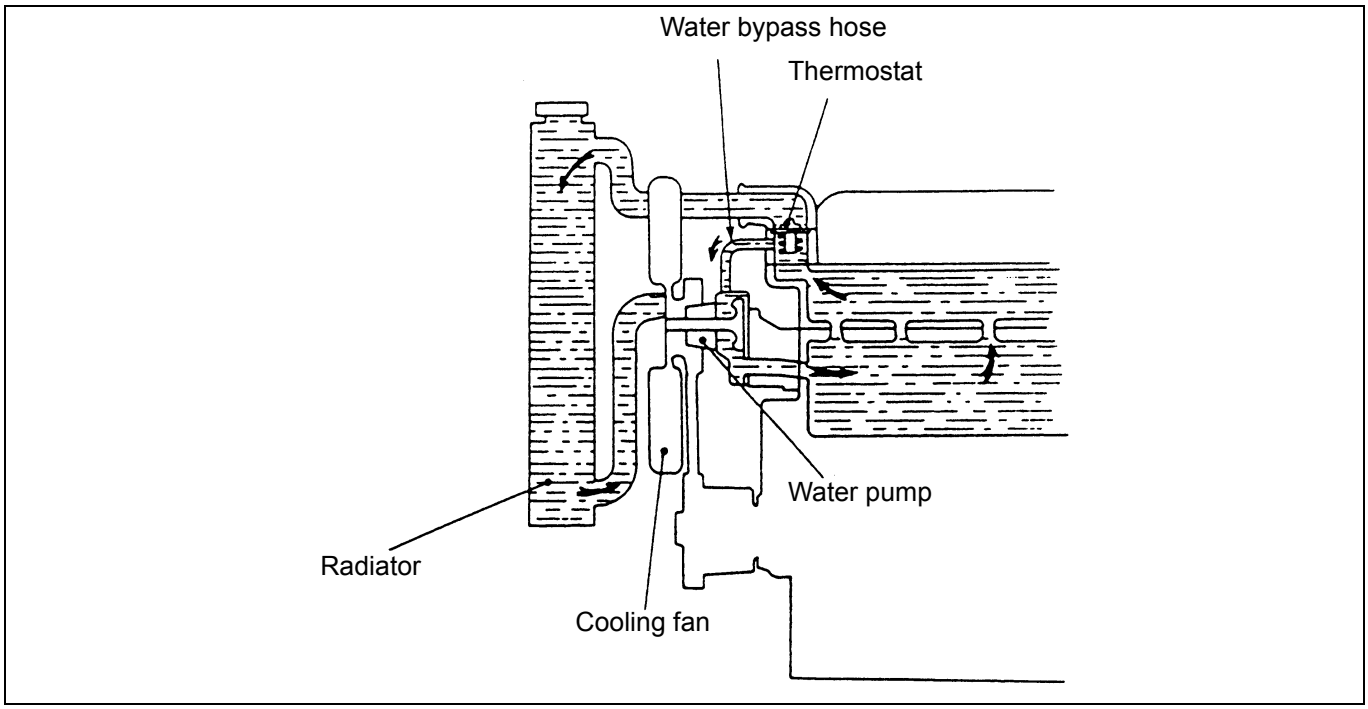


Figure 204 Schematic

34.2 Specifications (standard)[1]

Engine model		S3L/S3L2	S4L/S4L2
Fan belt (for farm or industrial engine)		LL or HM type (width = 10.7 mm (0.42 in.), V angle = 38°, outer circumference = 980 mm (38.6 in.)	
Cooling fan	**Suction type**	No. of blades = 5, diameter = 320 mm (12.6 in.)	No. of blades = 5, diameter = 360 mm (14.2 in.)
Water pump		Centrifugal type	
Thermostat	Temperature at which valve starts opening	82 ± 1.5°C (180 ± 2.7°F)	
	Temperature at which valve lift is 8 mm (0.3 in.)	95°C (203°F)	
Thermo switch	Type	Bimetal	
	Temperature at which switch is turned ON	111 ± 3.5°C (232 ± 6.3°F)	
	Temperature difference for ON-OFF control	8 ± 3.5°C (46.4 ± 6.3°F)	
Resistance in thermounit		50°C (122°F): 80 ± 10 Ω 80°C (176°F): 29.5 ± 2.5 Ω 120°C (248°F): 10 ± 0.3 Ω	

1. All specifications are subject to change without any prior notice.

35 INSPECTION

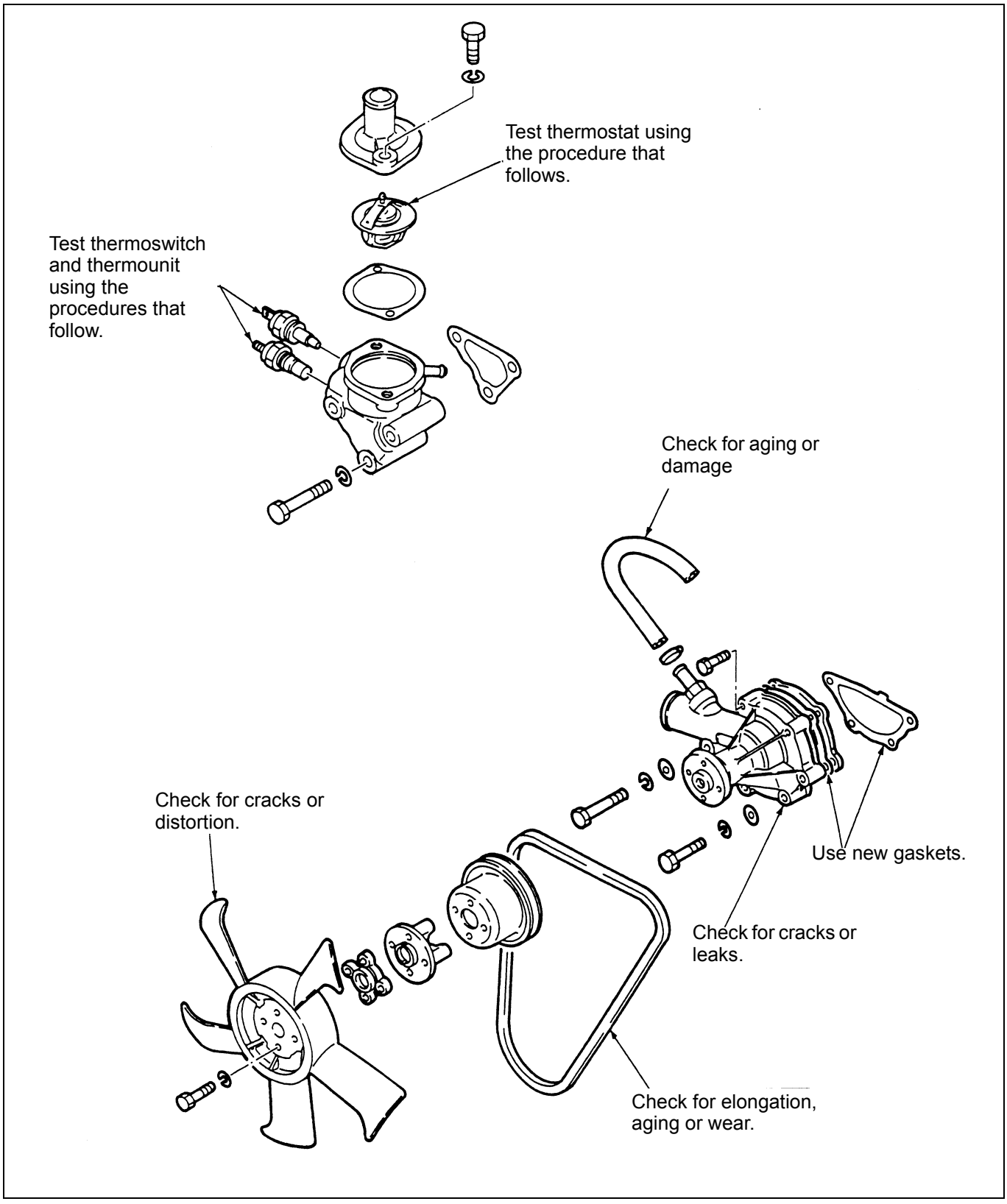


Figure 205 Inspection points

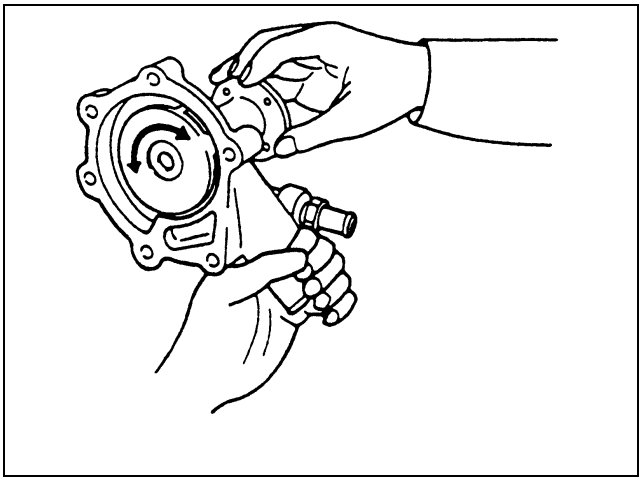


Figure 206 Checking water pump

35.1 Water pump

Check the impeller and shaft for rotation. If they do not rotate freely or have noise, replace the water pump assembly.

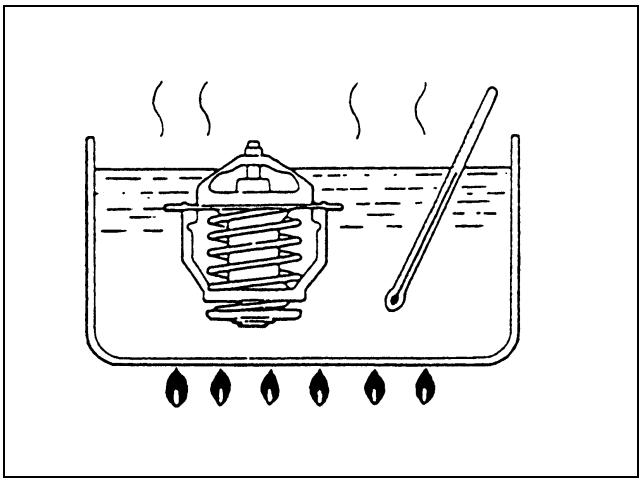


Figure 207 Testing thermostat

35.2 Thermostat (standard)

Hang the thermostat in the pan of water as shown in the illustration. The thermostat must be below the surface of the water and its must be away from the sides of the pan. Heat the water uniformly in the pan and measure a temperature at which the valve starts opening and a temperature at which the valve lift (distance) is 8 mm (0.3 in.). Replace the thermostat if defective.

Temperature at which valve starts opening	85 ± 1.5°C (180 ± 2.7°F)
Temperature at which valve lift is 8 mm (0.3 in.)	95°C (203°F)

⚠ WARNING

Water in the pan is hot. Any contact can cause severe burns.

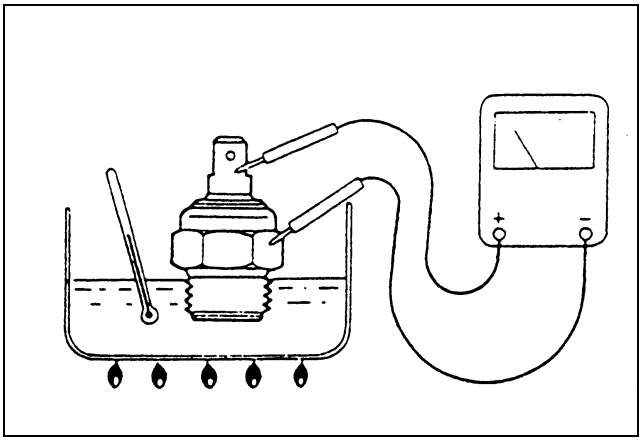


Figure 208 Testing thermoswitch

35.3 Thermoswitch (standard)

Hang the thermoswitch in the pan of oil with its temperature sensing end below the surface of oil and measure the resistance while heating the oil as shown in the illustration. If the resistance is incorrect, replace the thermoswitch.

Resistance at 120°C (248°F)	30 mΩ
Temperature at which switch is turned ON	111 ± 3.5°C (232 ± 6.3°F)

⚠ WARNING

Oil in the pan is hot. Any contact can cause severe burns.

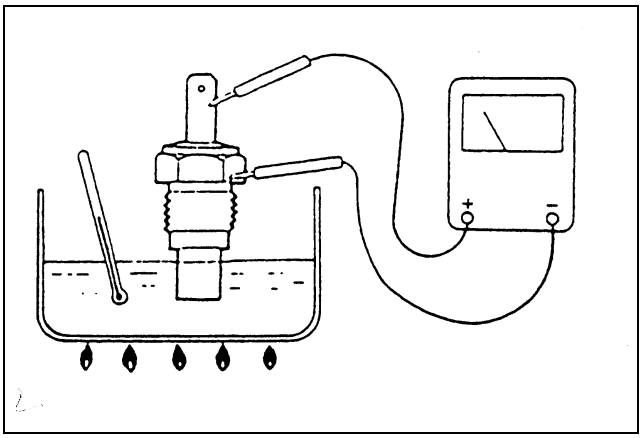


Figure 209 Testing thermounit

35.4 Thermounit (standard)

Hang the thermounit in the pan of antifreeze with its temperature sensing end below the surface of antifreeze and measure the resistance while heating the antifreeze as shown in the illustration. If the resistance is incorrect, replace the thermounit.

Standard	50°C (122°F): 80 ± 10 Ω 80°C (176°F): 29.5 ± 2.5 Ω 120°C (248°F): 10 ± 0.3 Ω

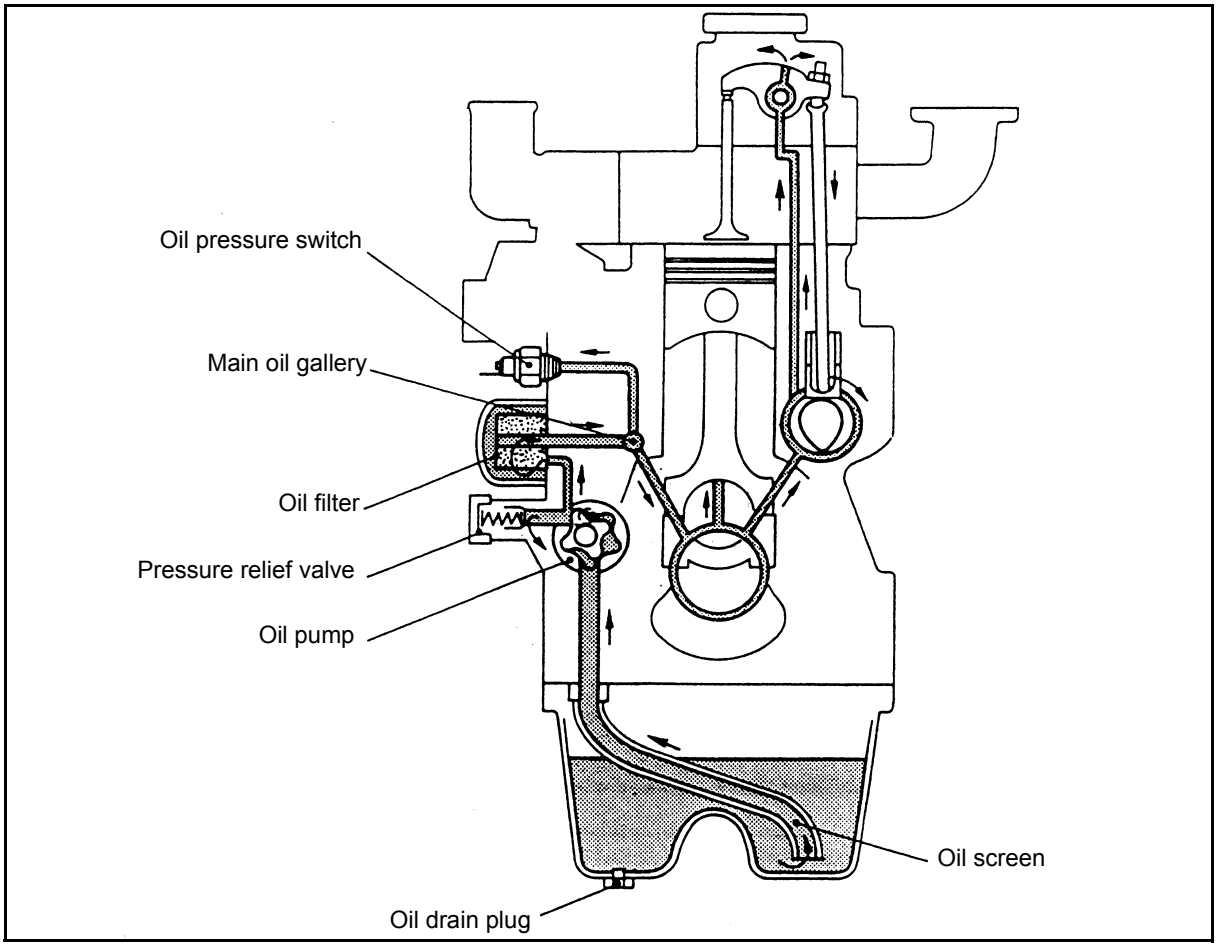
⚠ WARNING

Antifreeze in the pan is hot. Any contact can cause severe burns.

LUBRICATION SYSTEM

36 GENERAL

36.1 Schematic



36.2 Specifications[1]

Engine model		S3L/S3L2	S4L/S4L2
Type		Force feed	
Oil		API Service Classification CC or better	
Capacity (high level excl. 0.5 liter (0.13 U.S. gal) of oil in oil filter), liter (U.S. gal)		5.7 (1.5) (with deep oil pan) 3.7 (1.0 (with standard oil pan)	7.7 (2.0) (with deep oil pan) 5.4 (1.4) (with standard oil pan)
Oil pump	Type	Trochoid	
	Driven by	Camshaft gear	
Relief valve opening pressure		3.5 ± 0.5 kgf/cm^2 (50 ± 7 psi) [343 ± 49 kPa]	
Pressure difference at which oil pressure switch is closed (indicator light comes on)		0.5 ± 0.1 kgf/cm^2 (7 ± 1.4 psi) [49 ± 10 kPa]	
Oil filter		Paper-element cartridge (full flow) type	

1. All specifications are subject to change without any prior notice

37 INSPECTION

37.1 Oil pump

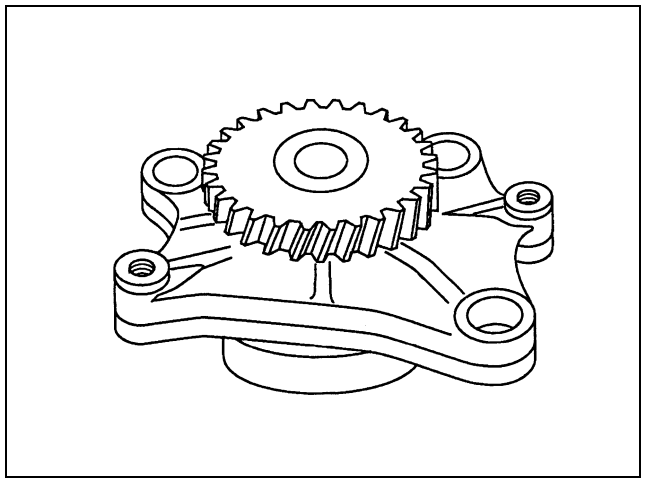


Figure 210 Checking oil pump

Visually check the pump for rough rotation or other defects. Replace the pump assembly if defective.

37.2 Oil pressure switch

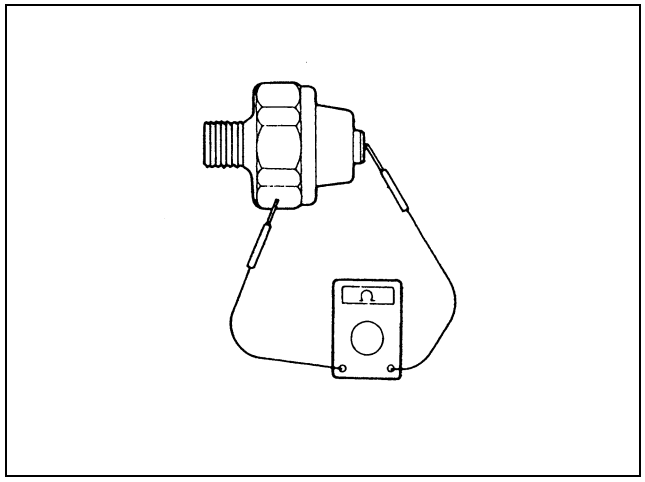


Figure 211 Testing oil pressure switch (1)

1. Test for continuity between the terminal and body with an ohmmeter as shown in the illustration. No continuity is the cause for replacing the switch.

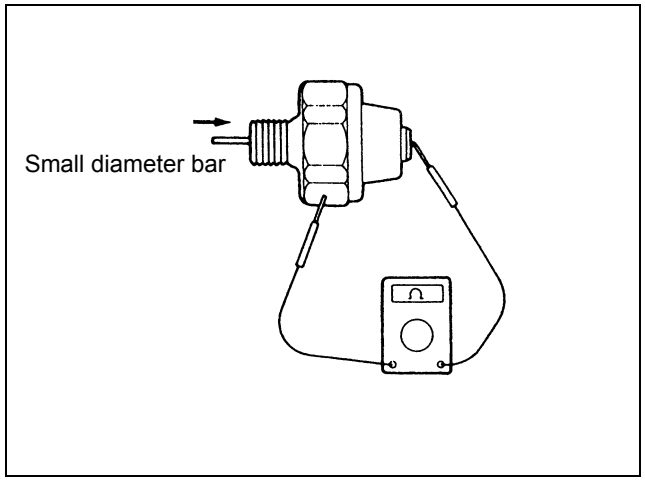


Figure 212 Testing oil pressure switch (2)

2. Insert a small diameter bar into the oil hole in the switch and lightly push it in to test for no continuity as shown in the illustration. Any continuity is the cause for replacing the switch.
3. Apply a pressure air of 0.5 kgf/cm^2 (7 psi) [49 kPa] to the switch through the oil hole to test for no continuity. Any continuity is the cause for replacing the switch. Also, check for air leaks. Any air leak is an indication of a ruptured diaphragm. In such a case, replace the switch.

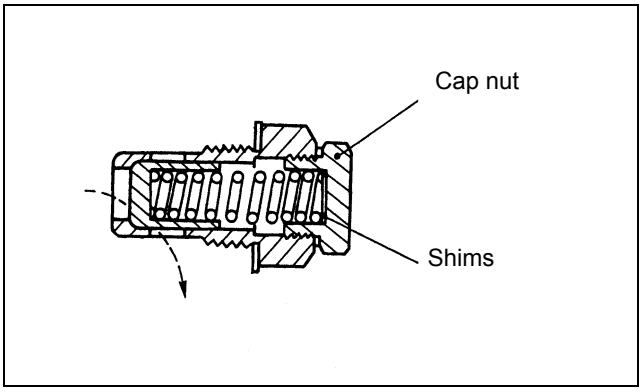


Figure 213 Checking pressure relief valve

37.3 Pressure relief valve

1. Check the valve seat for contact. Check the spring for damage.
2. Measure the oil pressure at which the relief valve opens (the oil pressure with the engine running at the rated rpm). If the pressure is not correct, remove the cap nut and increase or decrease the amount of shims. The engine oil pressure tap is located on the right side of the engine.

Relief valve opening pressure	3.5 ± 0.5 kgf/cm^2 (50 ± 7 psi) [343 ± 49 kPa]

FUEL SYSTEM

38 GENERAL

38.1 Schematic

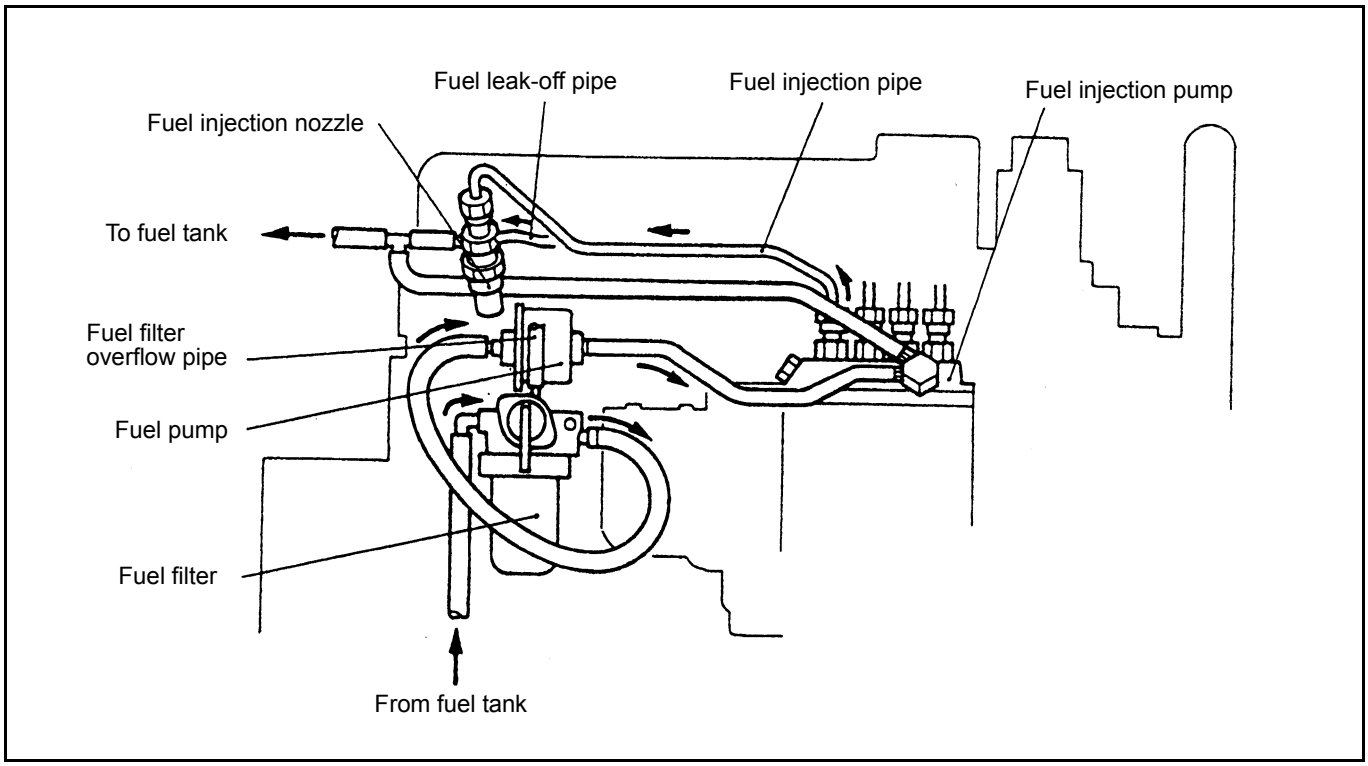


Figure 214 Schematic overview

38.2 Specifications (standard)[1]

Description		Specification	
		S3L/S3L2	S4L/S4L2
FUEL INJECTION PUMP	Type	Bosch M	
	Model	ND-PFR3M	ND-PFR4M
	Plunger diameter	5.5 mm (0.217 in.)	
	MS retard (crank angle), deg	8°	
	Delivery valve, type	Silto or Bosch	
	Air vent screw	Yes	
FUEL INJECTION NOZZLE	Type	Throttle	
	Model	DN15PD6	
	Injection pressure (valve opening pressure)	140_{0}^{+5} kgf/cm2 (1991_{0}^{+71} psi) [$13\ 729_{0}^{+490}$ kPa]	
FUEL FILTER (remote)	Type	Paper element	
FUEL FEED PUMP (remote)	Type	Electric (diaphragm)	
	Capacity (at terminal voltage of DC 12 V and 20°C (68°F))	300 cc (18.3 cu in.)/min minimum or 400 cc (24.4 cu in.)/min minimum	

Table 3 Specifications

1. All specifications are subject to change without any prior notice.

39 FUEL INJECTION NOZZLE

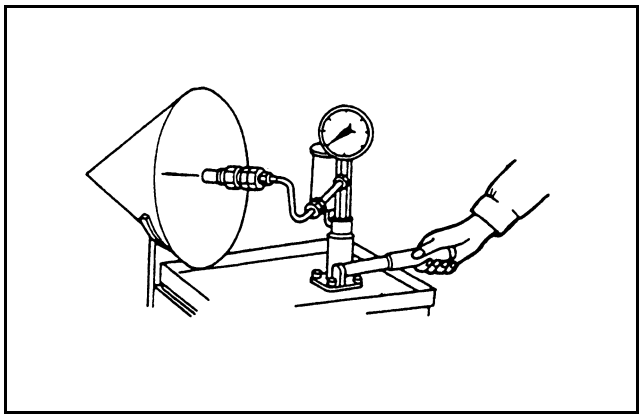


Figure 215 Fuel injection nozzle ready for test

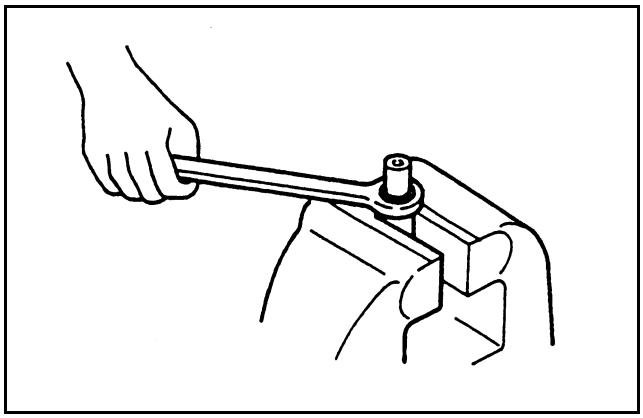


Figure 216 Removing tip from injection nozzle

39.1 Inspection

39.1.1 Injection pressure (valve opening pressure) test

1. Install the injection nozzle on the tester. Slowly operate the tester handle to bleed (remove) air from the tester.
2. Operate the tester handle at a speed of one stroke per second to make a slow increase in pressure until the valve in the injection nozzle starts to open. Read the maximum gauge pressure at the instant fluid flows from the tip.
3. If the injection pressure is incorrect, disassemble the nozzle and change the thickness of the washer.

Injection pressure (valve opening pressure) Standard	140_{0}^{+5} kgf/cm^2 (1991_{0}^{+71} psi) [13729_{0}^{+490} kPa]

NOTE

An increase or decrease of washer thickness by 0.1 mm (0.004 in.) will vary the injection pressure by 10 kgf/cm^2 (142 psi) [981 kPa]. 10 kinds of washer are available in thicknesses from 1.25 mm (0.049 2 in.) to 1.70 mm (0.066 9 in.) in increments of 0.05 mm (0.002 0 in.).

⚠ WARNING

When the injection nozzles are tested, be sure to wear eye protection. Fuel comes from the orifices in the nozzle tip with high pressure. The fuel can pierce (go through) the skin and cause serious injury to the operator. Keep the tip of the nozzle pointed away from the operator and into the fuel collector.

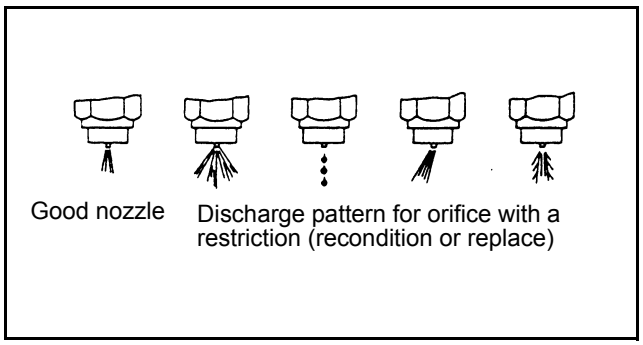


Figure 217 Orifice restriction test

39.1.2 Orifice restriction test

1. Look at the orifice discharge pattern (shape of discharge) when fluid begins to flow through the injection nozzle. The discharge must be straight. Any change is an indication of a bad nozzle.
2. Operate the tester handle at a speed of one stroke per second to make sure the discharge is straight.

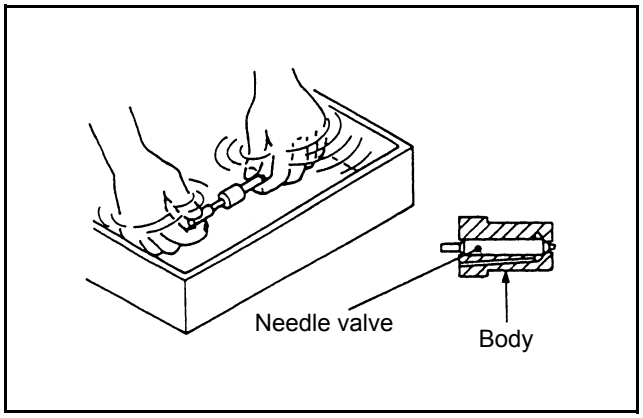


Figure 218 Washing nozzle tip

39.1.3 Nozzle tip washing and replacement

1. Loosen the retaining nut and remove the tip from the injection nozzle. Wash the needle valve and body in clean diesel fuel. After washing, put the needle valve in the body in clean diesel fuel.

⚠ CAUTION

Do not hit the tip when removing it from the injection nozzle.

NOTE

Keep the need valves with their respective bodies. Do not use needle valves or bodies with other bodies or needle valves.

2. After cleaning the tip, install it in the nozzle and tighten the retaining nut to the specified torque.

Tightening torque	3.75 ± 0.25 kgf·m (27 ± 1.8 lbf·ft) [36.8 ± 2.5 N·m]

3. If the injection nozzle is still bad after the tip has been washed, replace the tip.

NOTE

a. Do not touch the sliding surface of the needle valve.
b. When installing the new nozzle tip, remove synthetic resin film from the tip and slide the needle valve in the body in clean diesel fuel to wash off inhibitor completely.

39.2 Disassembly and assembly

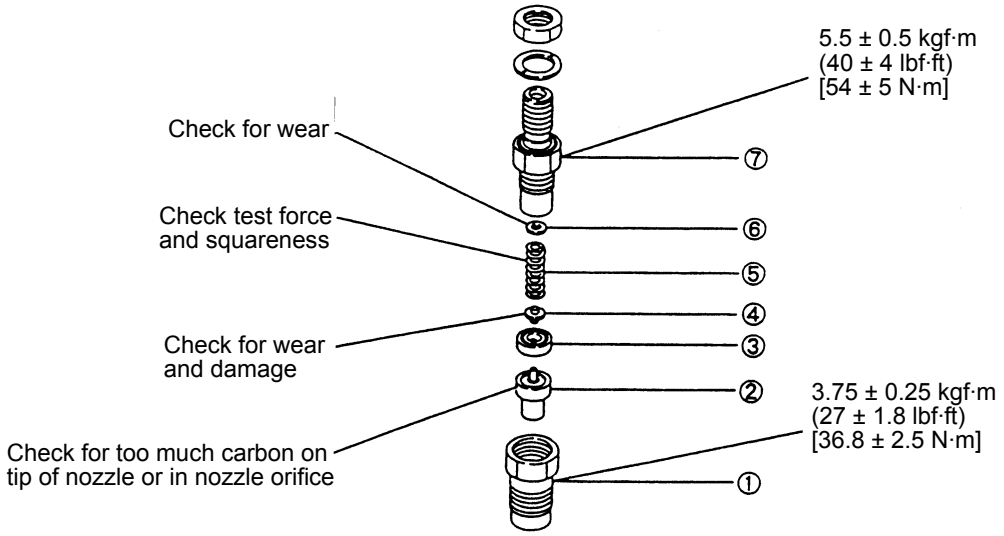


Figure 219 Disassembly sequence and inspection points

Disassembly sequence
1. Retaining nut
2. Nozzle tip assembly
3. Piece
4. Pin
5. Spring
6. Washer
7. Body

40 FUEL INJECTION PUMP

40.1 Test on engine

Check the injection pump for items listed in the chart below and replace it if defective. Do not attempt to make repairs by disassembling.

Test item	Test method	Criteria
Low idle speed	Use a tachometer.	Standard engine: 980_{0}^{+30} min^{-1}
Exhaust smoke	1. Check by quickly increasing engine speed under no-load condition. 2. Check by starting load.	No too much black or gray smoke
Orifice discharge patter	Remove injection nozzle and reinstall it with orifice toward outside of engine. Look at discharge pattern by cranking the engine with starter.	Good discharge pattern

Table 4 Injection pump chart

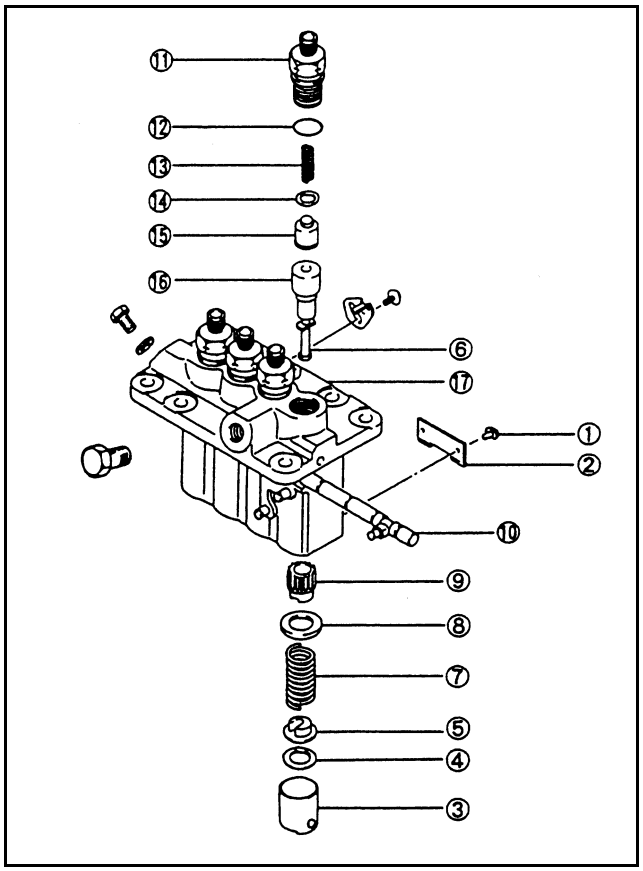


Figure 220 Disassembly sequence

40.2 Disassembly

1. Tappet guide pin
2. Lock plate
3. Tappet
4. Tappet adjusting shim
5. Lower spring seat
6. Plunger
7. Plunger spring
8. Upper spring seat
9. Control sleeve
10. Control rack
11. Delivery valve holder
12. O-ring
13. Delivery valve spring
14. Delivery valve gasket
15. Delivery valve
16. Plunger barrel
17. Pump housing

Disassembly procedure

40.2.1 Tappet removal

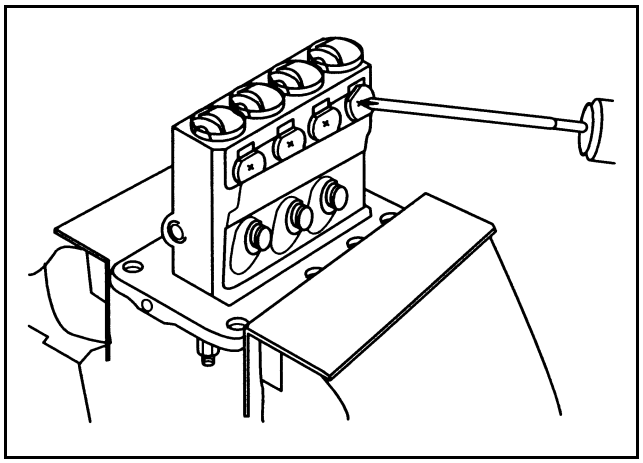


Figure 221 Removing tappet guide pins

1. Hold the injection pump in a vise with the side that has tappets up.
2. Straighten the lock plate away from the tappet guide pin with a screwdriver.
3. Rotate the tappet guide pin 180° to unlock it from the housing.

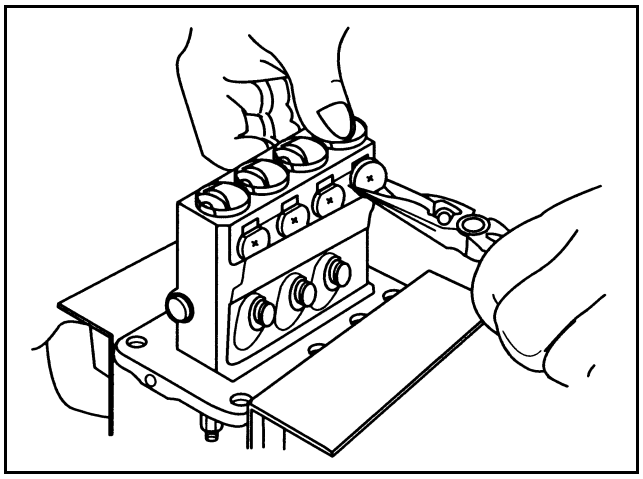


Figure 222 Removing tappets

4. Remove the tappet guide pin with a needle-nose pliers while pushing down on the tappet. Remove the tappet.
5. Do Steps (2) through (4) again for remainder of the tappets.

⚠ CAUTION

The tappet can be thrown from the housing when the tappet guide pin is removed. Hold the tappet to prevent it from falling.

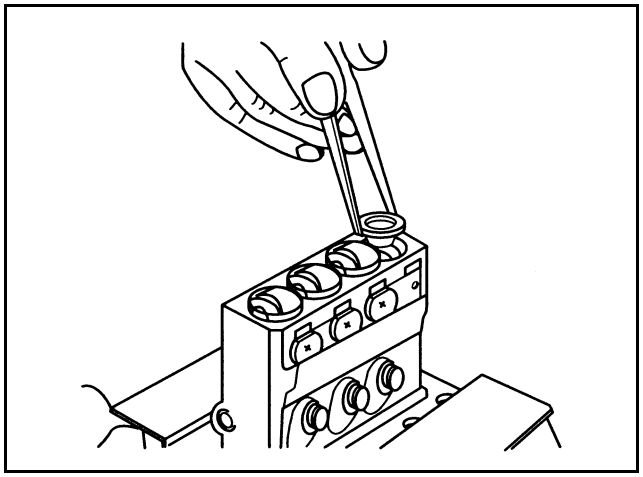


Figure 223 Removing plungers

40.2.2 Plunger removal

1. Remove the tappet adjusting shim.
2. Remove the lower spring seat and plunger with a tweezers.
3. Remove the plunger spring.
4. Remove the upper spring seat and control sleeve.
5. Do Steps (1) through (4) again for remainder of the plungers.
6. Remove the control rack.

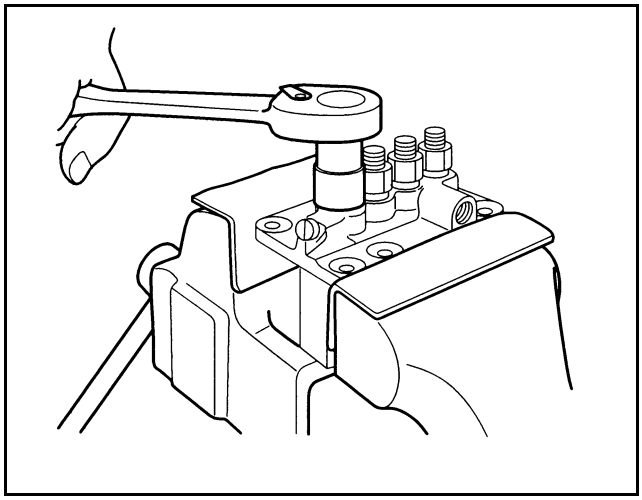


Figure 224 Removing delivery valve holders

40.2.3 Delivery valve removal

1. Turn the injection pump upside down and hold it in a vise.
2. Remove the delivery valve holder.
3. Remove the delivery valve spring.
4. Remove the delivery valve gasket.

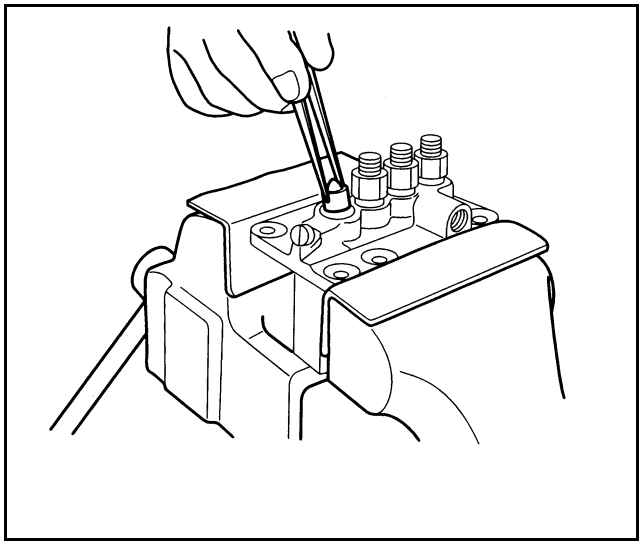


Figure 225 Removing delivery valves

5. Remove the delivery valve with a tweezers.
6. Do Steps (2) through (5) again for remainder of delivery valves.

⚠ CAUTION

The delivery valves are finely finished parts. Keep them as clean as possible.

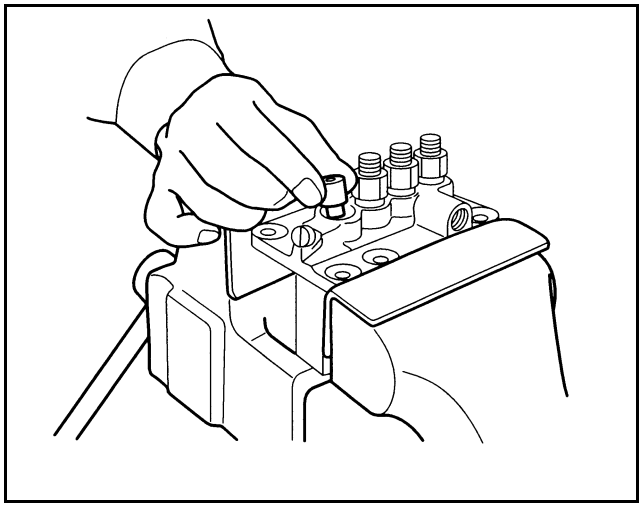


Figure 226 Removing barrels

40.2.4 Barrel removal

1. Remove the barrels from the housing.

⚠ CAUTION

a. The plungers and barrels are finely finished parts. Keep them as clean as possible.
b. Keep the plungers with their respective barrels for installation. Do not use plungers or barrels with other barrels or plungers.

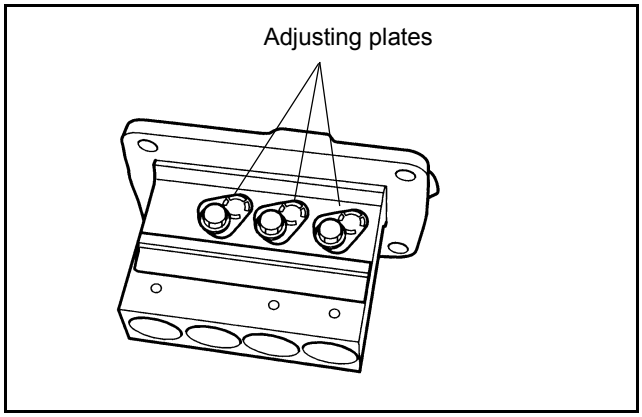


Figure 227 Adjusting plates

NOTE

a. When replacing the plungers and barrels or delivery valves, do not loosen the adjusting plates between the pumping elements.
b. After these parts have been replaced, the injection quantity must be measured. Pump Tester Cam Box is needed for measurement of injection quantity.
c. Keep the disassembled injection pump parts in clean diesel fuel.

40.3 Inspection

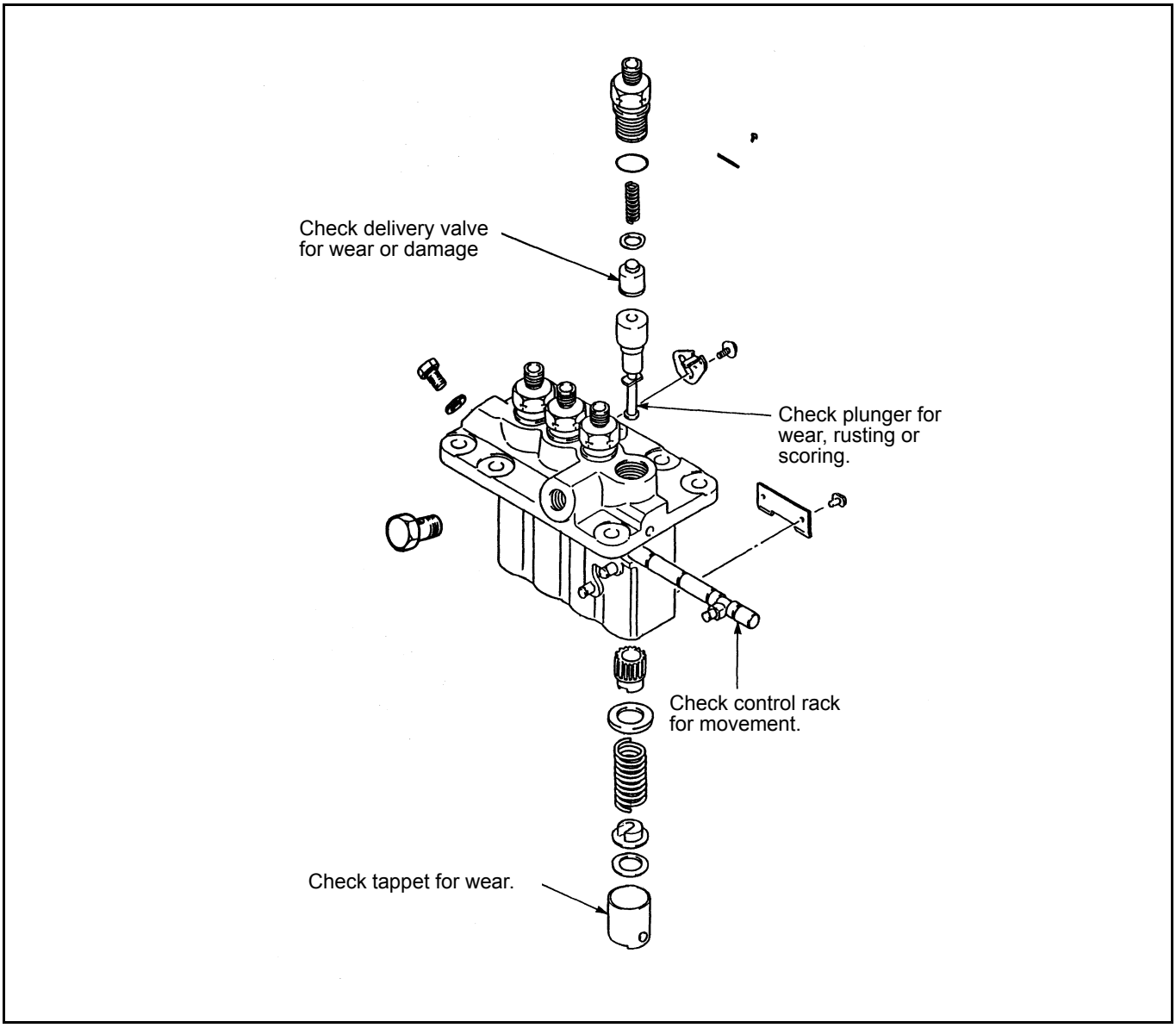


Figure 228 Inspection points

40.4 Assembly

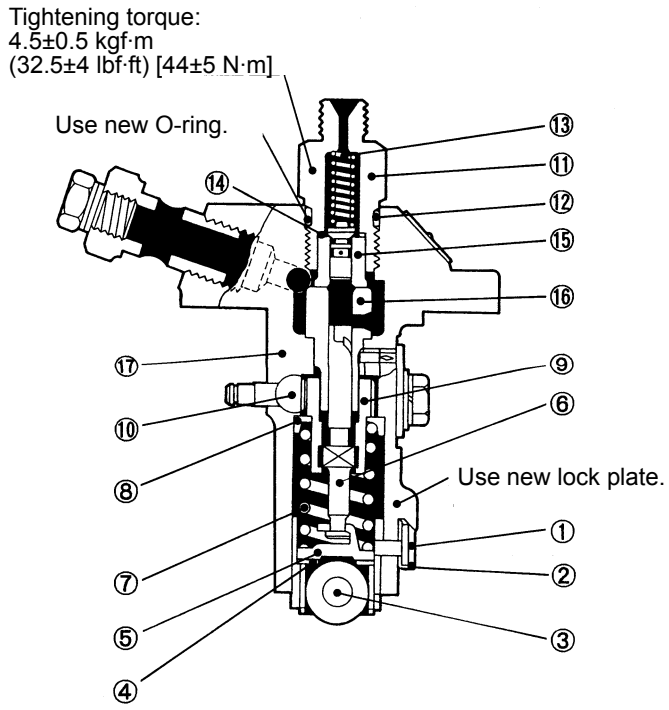


Figure 229 Assembly sequence

Follow the reverse of disassembly and use the procedure that follows.

Assembly procedure

40.4.1 Barrel installation

Put each barrel in position in the housing with its slot in alignment with the dowel of the housing and put it straight down into the bore.

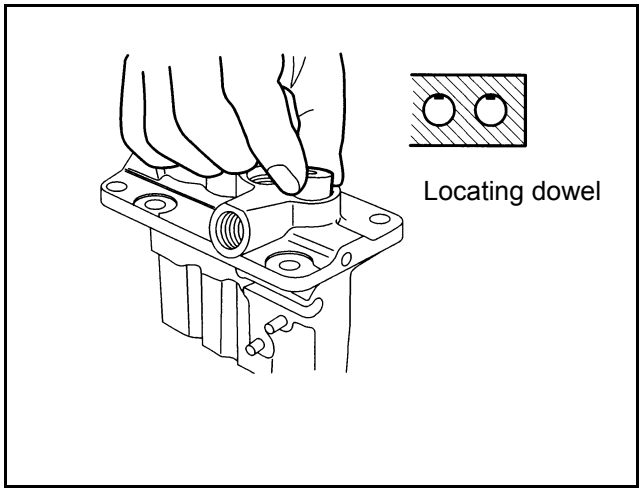


Figure 230 Installing barrels

NOTE

If the slot in the barrel is not aligned with the dowel of the housing, the O-ring will not seat correctly (still visible) after the delivery valve holder has been installed.

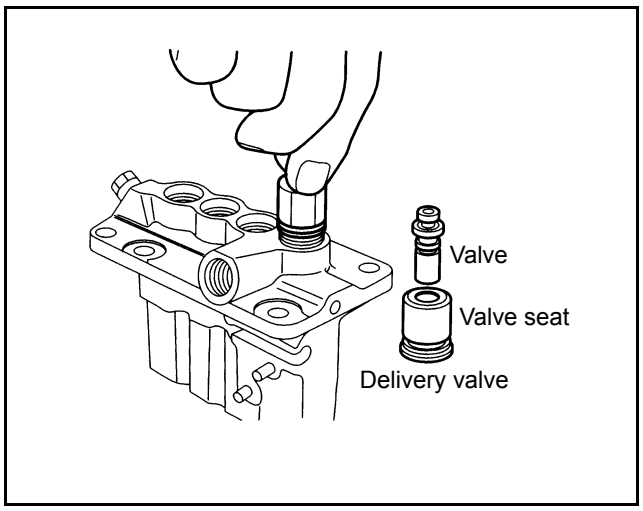


Figure 231 Installing delivery valves

40.4.2 Delivery valve installation

Install the delivery valve, gasket, spring and O-ring on the barrel and tighten the delivery valve holder finger tight. Do this step for remainder of the delivery valves.

⚠ CAUTION

a. Any time the injection pump is disassembled, a new O-ring must be installed.
b. Make sure the threads of the delivery valve holder do not cause damage to the O-rings.

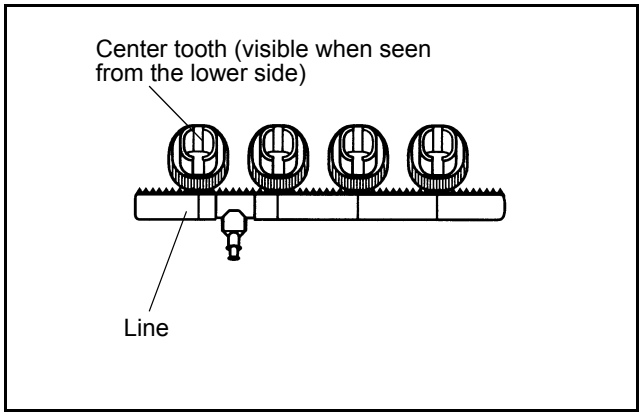


Figure 232 Installing control sleeves

40.4.3 Control sleeve installation

1. Install each control sleeve with the center tooth in alignment with the line mark of the control rack.

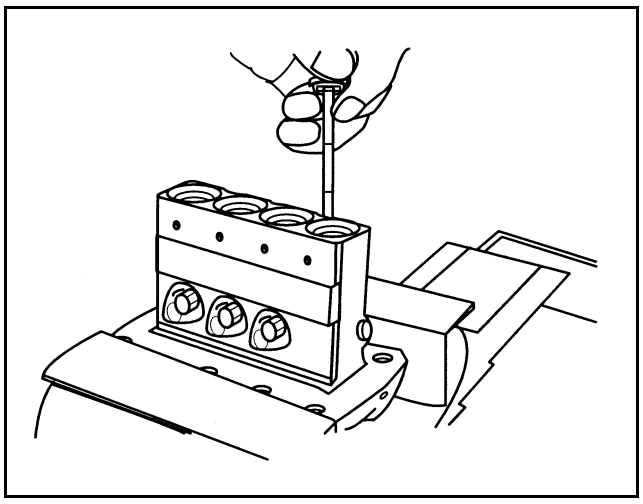


Figure 233 Installing plungers

2. Put the plungers in position in the barrels.

⚠ CAUTION

Make sure the notch in the plunger is toward the adjusting plate.

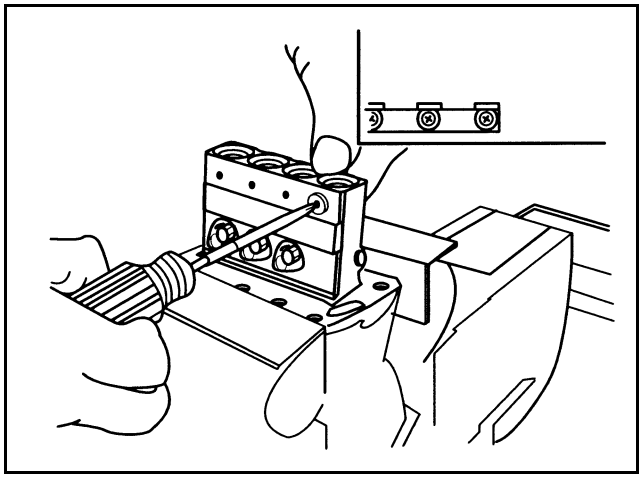


Figure 234 Installing tappets

40.4.4 Tappet installation

Move the control rack back and forth while pushing down on each tappet to align the slot in the tappet with the hole in the housing for the tappet guide pin. Install the lock plates and tappet guide pins in position.

⚠ CAUTION

Any time the injection pump is disassembled, new lock plates must be used.

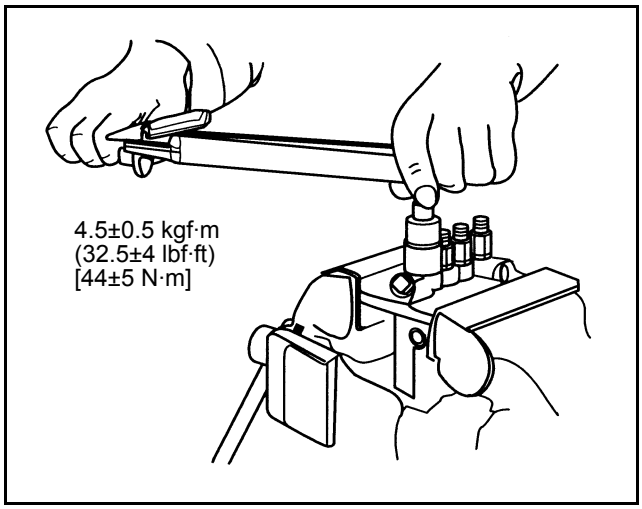


Figure 235 Tightening delivery valve holders

40.4.5 Delivery valve holder installation

Put the delivery valve holders in position and tighten them to the specified torque.

⚠ CAUTION

Do not over tighten the delivery valve holders. This can put end force on the barrels, resulting in a failure of the plungers to move freely. If the holders are not tightened to the specified torque, engine oil would leak in the injection pump.

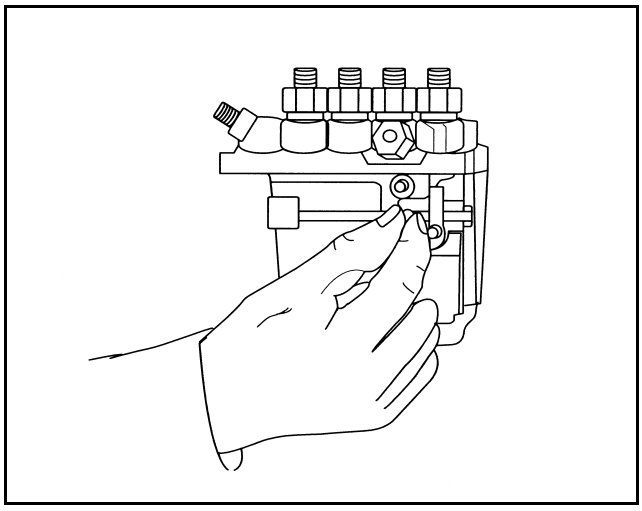


Figure 236 Checking control rack movement

40.4.6 Inspection after assembly

1. After the injection pump has been assembled, check to see if the control rack moves freely without any binding or catching.
2. If the control rack fails to move freely, the possible causes are:
   a Pumping element(s) sticking
   b Foreign particles lodged between control rack and sleeves
   c Over-tightening of delivery valve holder(s)
   Disassemble and check the injection pump to locate the cause of the trouble.
3. After the injection pump has been finally assembled, check the injection timing.

41 GOVERNOR

41.1 Disassembly and inspection

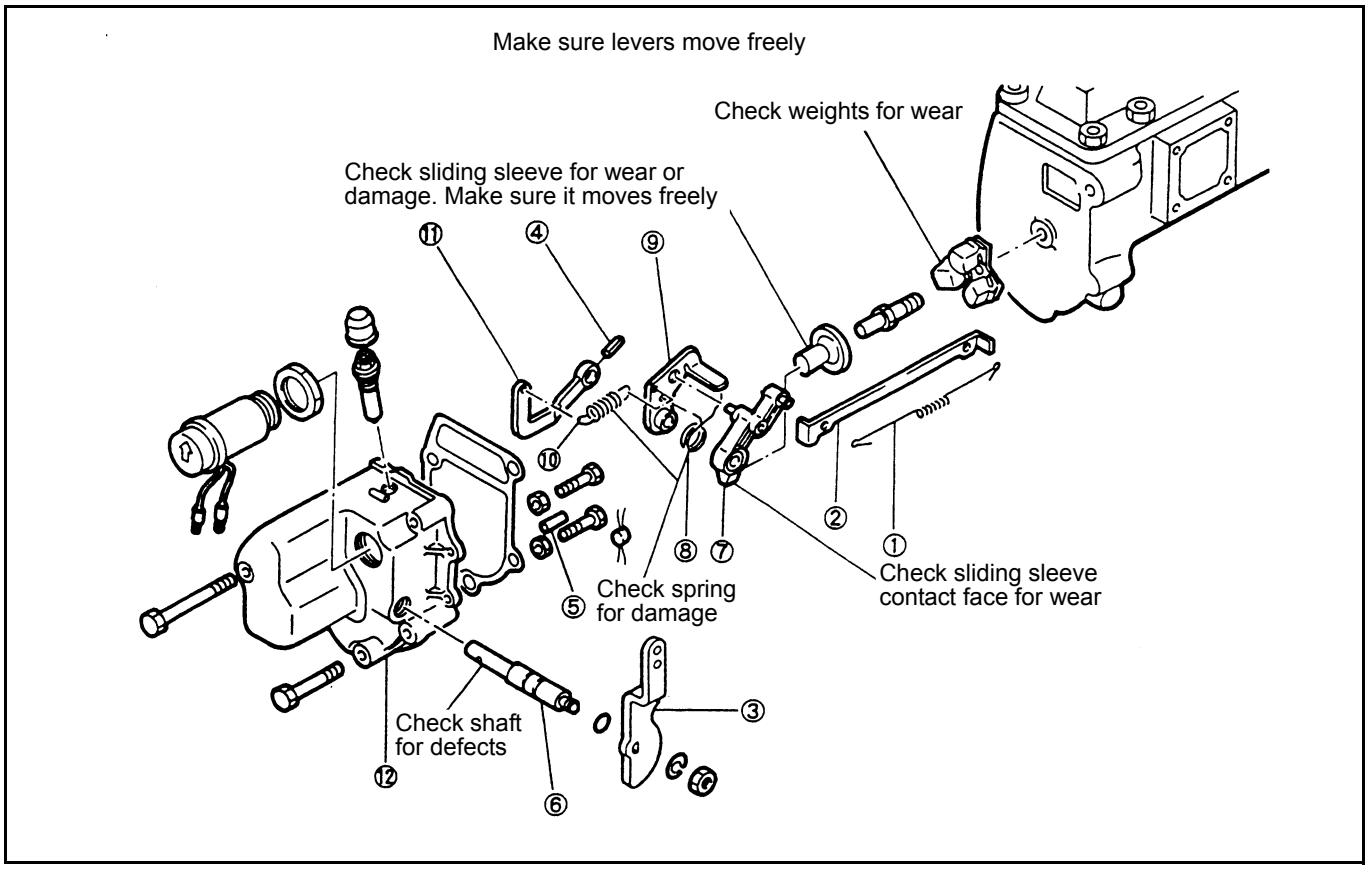


Figure 237 Disassembly sequence and inspection points

Disassembly sequence
1. Tie rod spring
2. Tie rod
3. Speed control lever
4. Spring pin
5. Grooved pin
6. Governor shaft (remove 7 thru 11 as an assembly)
7. Governor lever
8. Start spring
9. Tension lever
10. Governor spring
11. Governor spring lever
12. Governor case

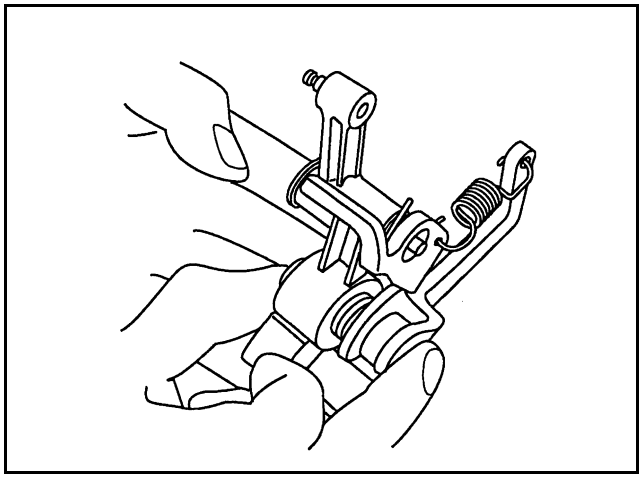


Figure 238 Installing governor levers

41.2 Assembly

1. Install the levers in position.

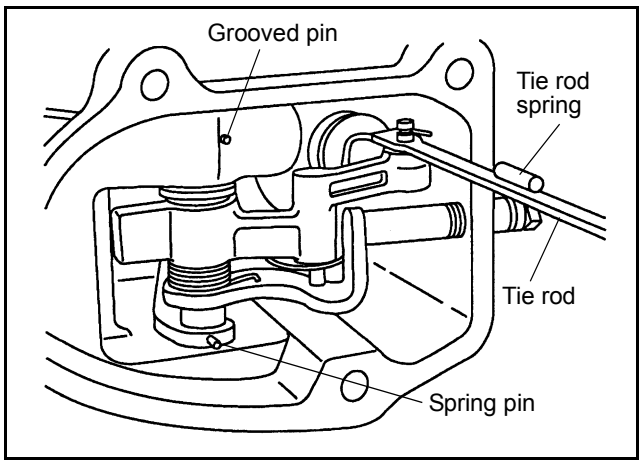


Figure 239 Assembling governor

2. Put O-ring on the governor shaft.
3. Put the governor shaft in position in the governor case and put the levers on the governor shaft.
4. Install the grooved pin and spring pin in position with a hammer.
5. Install the tie rod and tie rod spring in position.

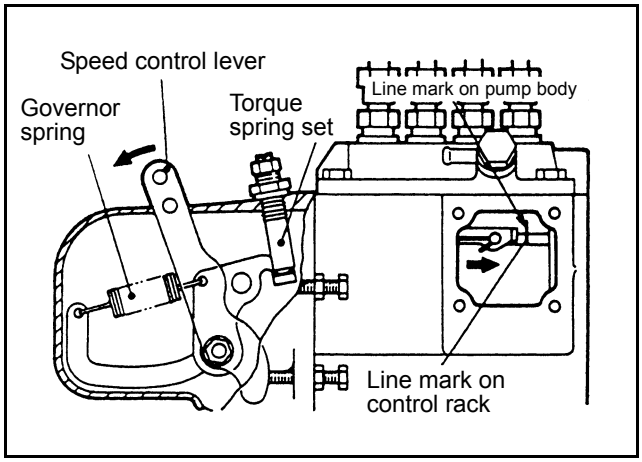


Figure 240 Installing torque spring set

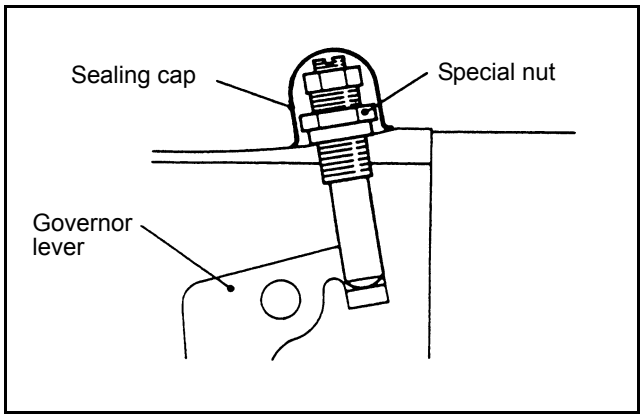


Figure 241 Sealing cap for torque spring set

41.3 Torque spring set installation

The torque spring set is to be installed and adjusted after an adjustment is made to the low idle speed and high idle speed, with the engine at a standstill.

1. Remove the tie rod cover.
2. Move the speed control lever to the high idle position and hold it there.
3. Pull the tie rod in the direction of arrow head to the point where a slight resistance is encountered.

NOTE

In this position, the tie rod does not pull on the governor spring.

4. Turn in the torque spring set while lightly pulling the tie rod until the line mark on the control rack is aligned with the line mark on the pump body.
5. With these line marks aligned, lock the torque spring set in position by tightening the special nut.
6. Install the sealing cap over the torque spring set and stake the cap in position.

42 FUEL PUMP

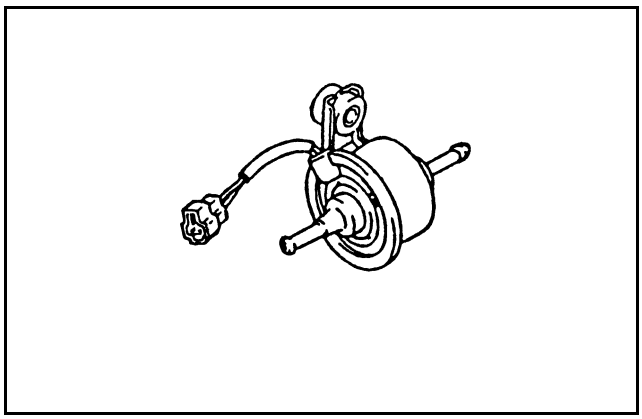


Figure 242 Fuel pump (plunger type)

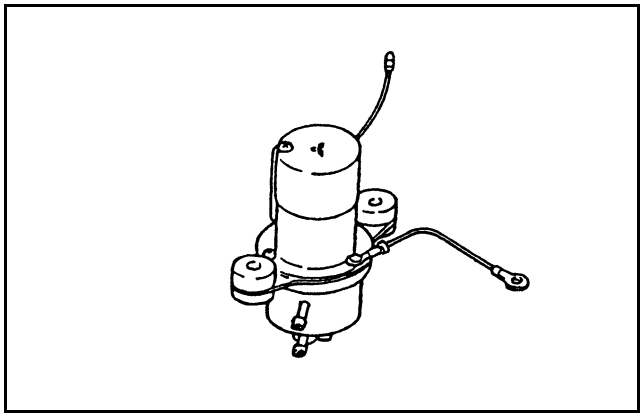


Figure 243 Fuel pump (diaphragm type)

42.1 Inspection

Look outside the pump for defects and test its performance. Do not attempt to disassemble the pump.

43 FUEL FILTER

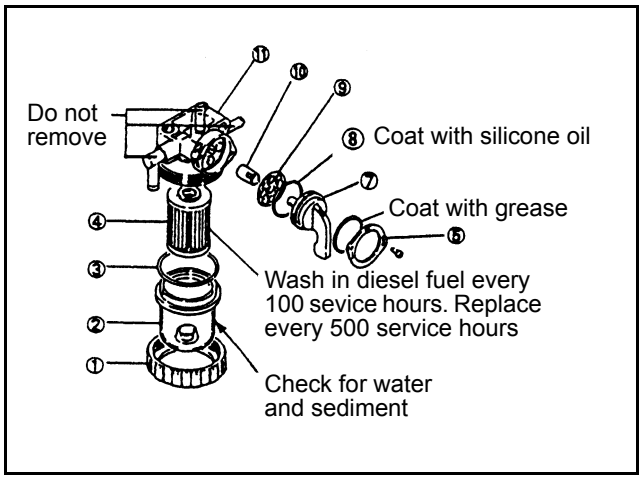


Figure 244 Fuel filter

1. Normally, the fuel filter is not to be disassembled. Only element removal for cleaning or replacement is recommended.
2. When installing the valve lever after washing, coat the O-ring for the lever with silicone oil and the washer with grease.

Parts fuel filter:
1. Ring nut
2. Cup
3. O-ring
4. Element
5. Lever plate
6. Washer
7. Valve lever
8. O-ring
9. Packing
10. Valve seat
11. Filter body

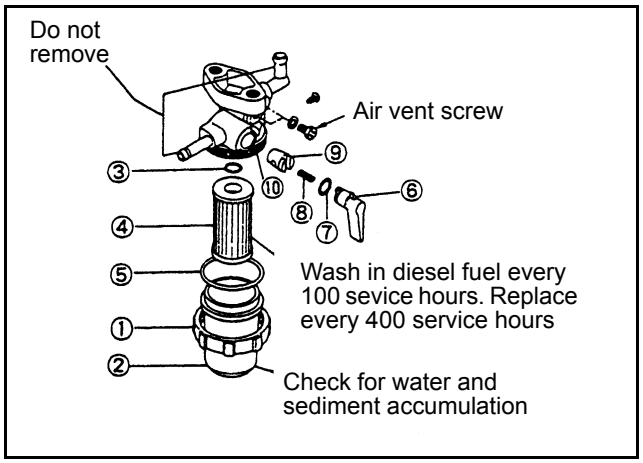


Figure 245 Fuel filter

Parts fuel filter:
1. Ring nut
2. Cup
3. O-ring
4. Element
5. O-ring
6. Valve lever
7. O-ring
8. Spring
9. Valve
10. Filter body

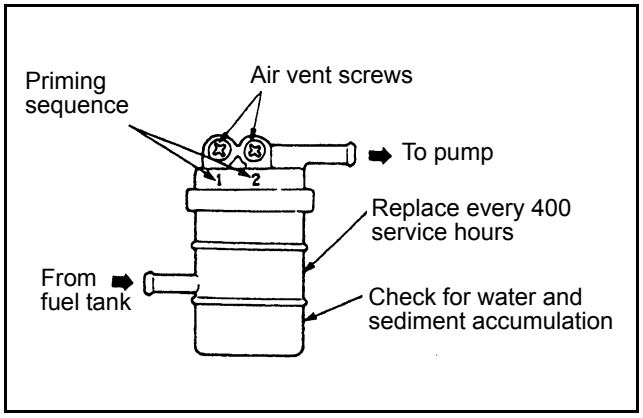


Figure 246 Fuel filter (cartridge type)

Do not attempt to disassemble the cartridge type fuel filter. Check the filter for contamination or damage and replace it as an assembly if necessary

AIR INLET SYSTEM AND EXHAUST SYSTEM

44 GENERAL

44.1 Schematic

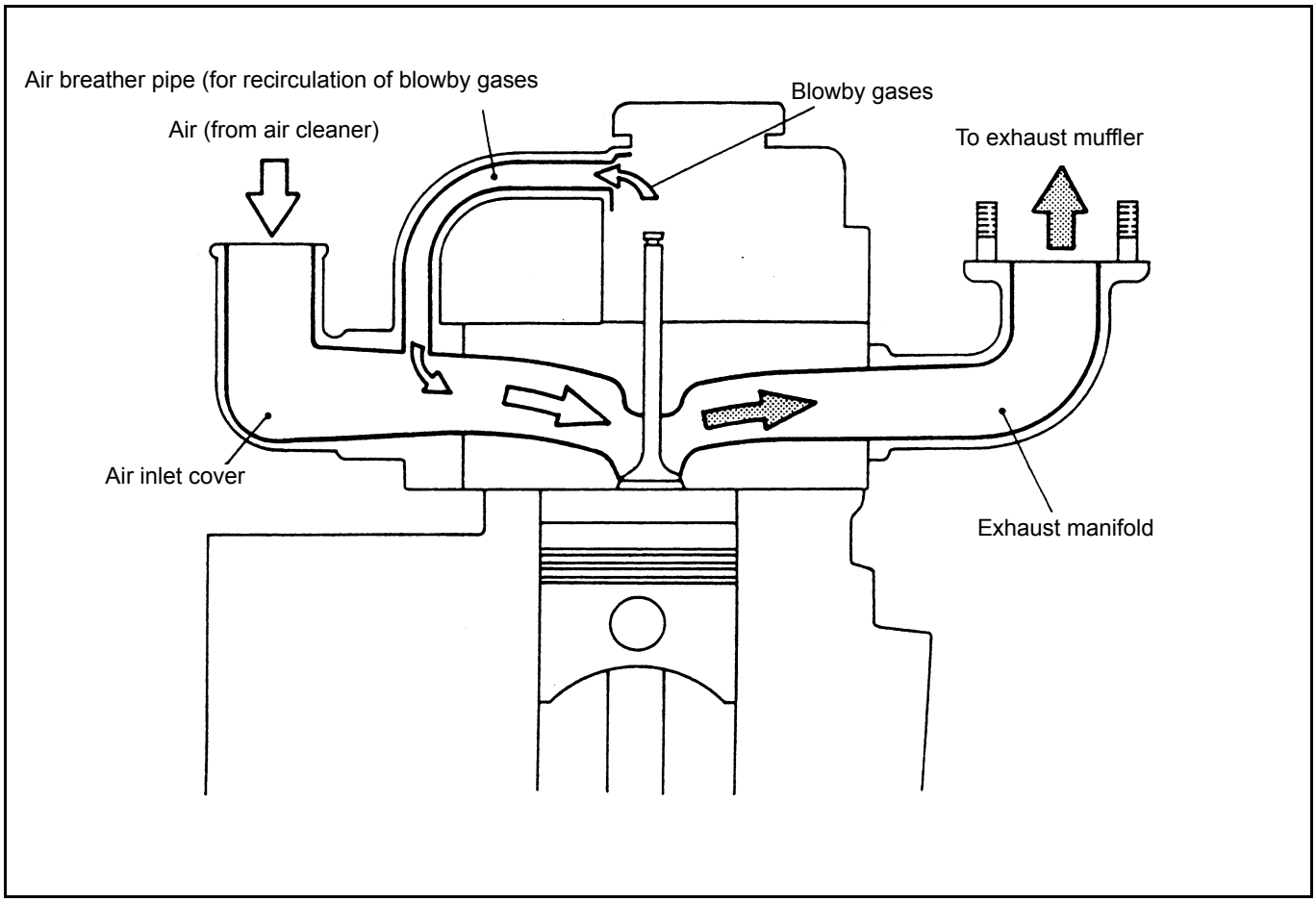


Figure 247 Schematic overview

45 INSPECTION

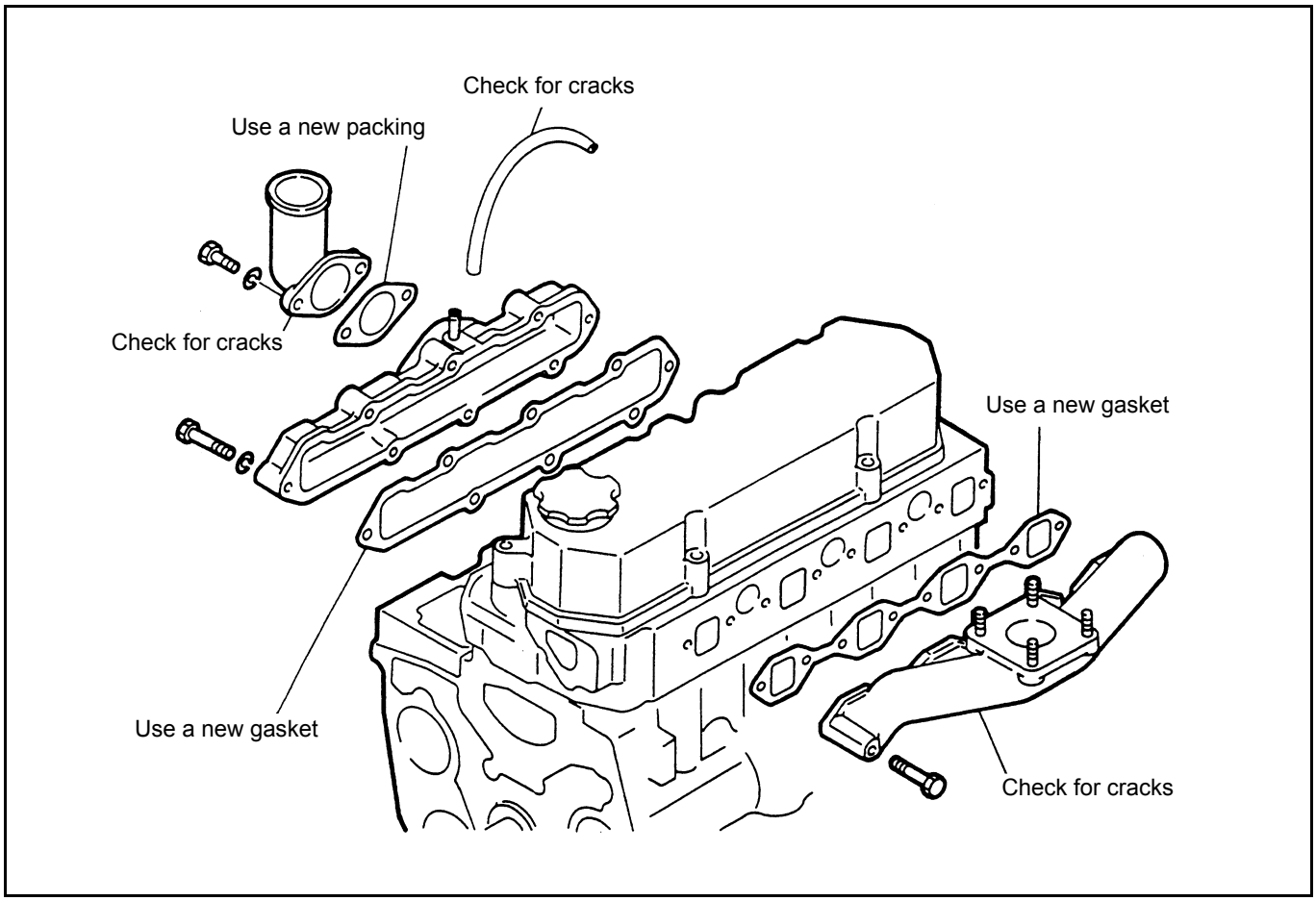


Figure 248 Inspection points

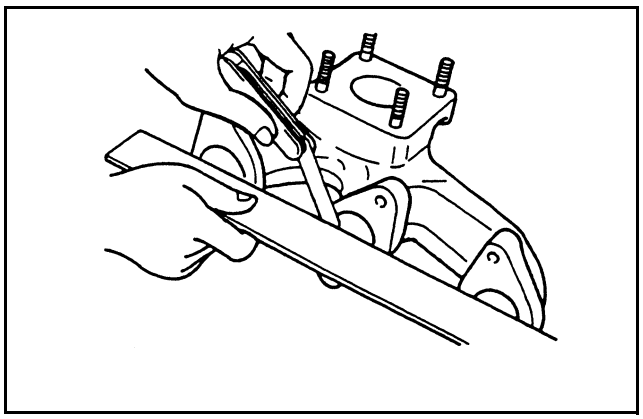


Figure 249 Checking manifold for warpage

45.1 Inspection procedure

Using a straight edge and a feeler gauge, check the flange faces of the manifold for warpage. If warpage exceeds the limit, recondition or replace the manifold.

Item	Standard
Warpage of manifold	0.15 (0.005 9)

Table 5 Inspection, unit mm (in.)

MAINTENANCE

46 LUBRICATION AND MAINTENANCE CHART

Recommended service should be performed at the specified intervals. Under extremely severe, dusty or wet operating conditions, more frequent lubrication than is specified in this chart may be necessary.

Perform service on items at multiples of the original requirement. For example, at Every 500 Service Hours, also service those items listed under Every 100 (250) Service Hours, Every 50 Service Hours and Every 10 Service Hours.

Interval	Item	Remarks (specifications)	Page
Every 10 Service Hours [Pre-Start Inspection]	Walk-around inspection	See operation manual	
	Check engine oil level		172
	Check fuel level	See operation manual	
	Check coolant level	See operation manual	
Every 50 Service Hours	Drain water and sediment from the fuel tank and water separator	See operation manual	
	Check the battery electrolyte level and specific gravity	See operation manual	
First 50 Service Hours of New or Reconditioned Engine	Change engine oil	See SPECIFICATIONS (page 16)	173
	Change oil filter		173
	Retighten nuts and bolts		191
Every 100 Service Hours	Clean fuel filter element	After cleaning, prime	181
	Clean radiator fins	See operation manual	
Every 250 Service Hours or once a year (whatever comes first)	Change engine oil	See SPECIFICATIONS (page 16)	173
	Change oil filter		173
Every 500 Service Hours	Check and adjust valve clearance	0.25 mm (0.0098 in.) for both inlet and exhaust valves	175
	Change fuel filter element	After changing, prime	180
	Check and adjust injection pressure	140 kgf/cm^2 (1 991 psi) [13 729 kPa]	183
	Check and adjust fan belt	Deflection: 13 mm (0.5 in.)	184
	Check glow plugs		133
Every 1000 Service Hours	Retighten nuts and bolts		191
	Check starter		115
	Check alternator		122
	Check turbocharger	See turbocharger manual	

Table 6 Lubrication and maintenance charts

Interval	Item	Remarks (specifications)	Page
Every 2 Years	Change coolant	See operation manual	
When Required	Prime fuel system		181
	Clean air cleaner element		180
	Change air cleaner element	See operation manual	

Table 6 Lubrication and maintenance charts

47 ENGINE OIL AND OIL FILTER

47.1 Engine oil specifications[1]

Use oils that meet the Engine Service Classification CF or CF-4.

Starting temperature, °C (°F)	-30 (-22)	-25 (-13)	-20 (-4)	-15 (5)	-10 (14)	-5 (23)	0 (32)	10 (50)	20 (68)	30 (86)	40 (104)
Oil viscosities						SAE 30			SAE 40		
					SAE 15W-40						
				SAE 10W-30							
			SAE 5W-20								

Table 7 Recommended oil viscosities

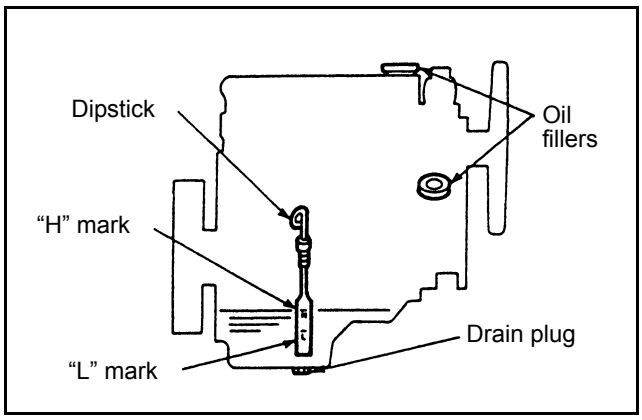


Figure 250 Checking oil level

47.2 Oil level check

1. Check the crankcase oil level with a dipstick with the engine put horizontal.
2. If the oil level is at or below "L" (low level) mark on the dipstick, add oil to "H" (high level) mark on the dipstick.

NOTE

a. After adding oil, leave the engine standing for one minute and check the oil level.
b. Avoid mixing different brands of oils. In some cases, they are not compatible with each other and deteriorate when mixed. Use the same brand at successive intervals.
c. If the engine has been left standing for a long period of time, check the oil for level and contamination before starting the engine. Start and run the engine for a few minutes. Then stop the engine and check the oil level again.

1.

47.3 Oil and oil filter change

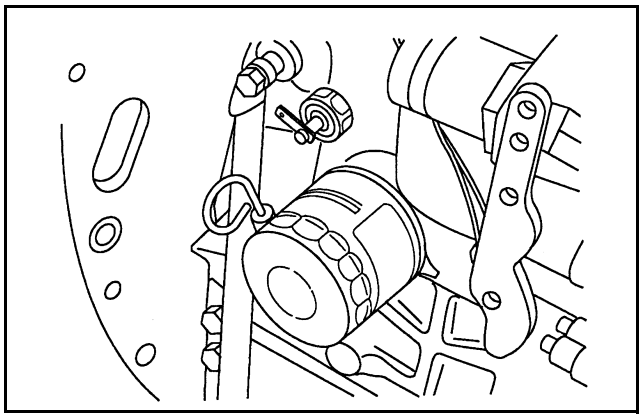


Figure 251 Removing used oil filter

1. Change the oil and the oil filter after the initial 50 service hours of a new or reconditioned engine and, thereafter, every 250 service hours or once a year (whatever comes first).
2. Warm up the engine. Remove the drain plug and allow the oil to drain in a container.
3. Remove the used filter with a filter wrench. Make sure that the formely used O-ring is removed from the filter base and clean the base with a cloth.

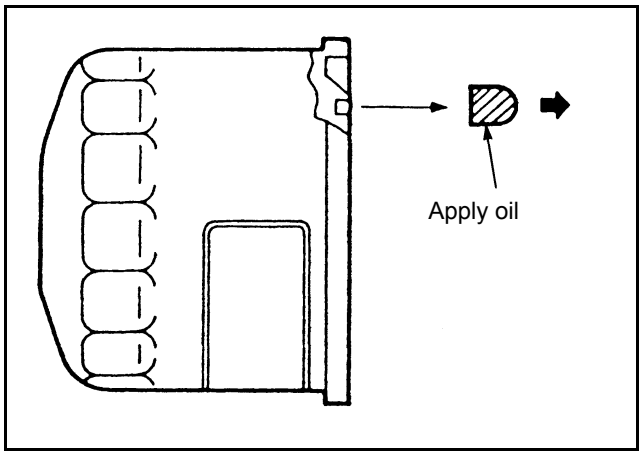


Figure 252 Removing used oil filter

4. Check the new oil filter and make sure that the O-ring is fitted in the groove. Apply a thin coat of lube oil to the O-ring of the new oil filter.
5. Install the new filter by hand untill the O-ring touched the base. Tighten 3/4 to 1 turn more.

⚠ CAUTION

Do not cause damage to the O-ring when installing the filter.

6. Install the drain plug and tighten it to the specified torque.

Tightening torque	4 ± 0.5 kgf·m (29 ± 4 lbf·ft) [39 ± 5 N·m]

7. Re-fill the engine to the "H" mark on the dipstick with the new oil. Approximately an additional 0.5 liter (0.5 qt) of oil is required for the oil filter and oil lines.
8. Start the engine, leave it idling for a few minutes and check for leaks. Re-tighten the filter in case of leakage.
9. Stop the engine. Check the oil level and add oil if necessary.

47.4 Oil filter change

1. Change the oil filter every 250 service hours.
2. Remove the used filter with a filter wrench. Discard the filter.
3. Remove all of the old filter gasket from the filter base and apply a thin coat of engine oil to the gasket on the new filter. Install the filter by hand until its gasket contacts the base. Tighten 3/4 turn more.

⚠ CAUTION

Do not cause damage to the O-ring when installing the filter.

4. Add 0.5 liter (0.5 qt) of oil.
5. Start the engine and check for leaks around the filter.
6. Stop the engine. Check the oil level and add oil if necessary.

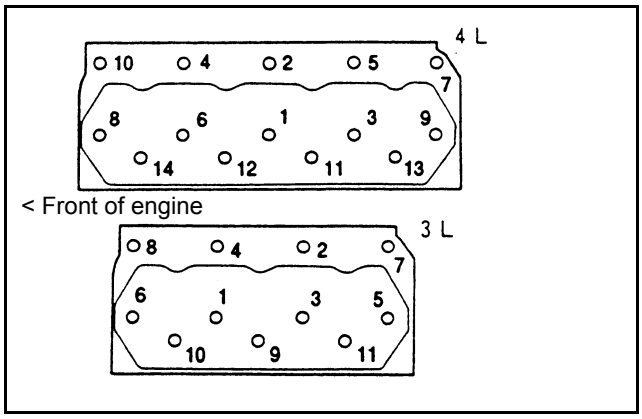


Figure 253 Cylinder head bolt tightening sequence

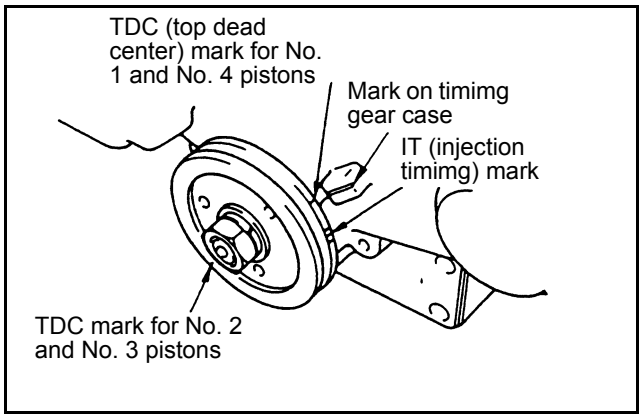


Figure 254 Timing mark

48 VALVE CLEARANCE

NOTE

Make an adjustment to the valve clearance when the engine is cold.

1. Slightly loosen the cylinder head bolts and retighten them to the specified torque in number sequence.

Tightening torque	9 ± 0.5 kgf^{2}m (65 ± 4 lbf^{2}ft) [88 ± 5 N^{2}m]

2. Find top dead center compression position for No. 1 piston by using the procedure that follows:
   a Turn the crankshaft until TDC mark on the crankshaft pulley is aligned with the mark on the timing gear case.
   b With No. 1 piston at top dead center on the compression stroke, the rocker arms will not be moved when the crankshaft is turned approximately 20° in both directions.
   c If the rocker arms move, No. 1 piston is at top dead center on the intake or exhaust stroke. In such a case, turn the crankshaft 360° in the direction of engine rotation again. No. 1 piston is now at top dead center on the compression stroke.
3. Loosen the lock nut for the adjusting screw. With a feeler gauge inserted between the rocker arm and valve cap, adjust the valve clearance by turning the adjusting screw.

Item	Standard
Valve clearance (both inlet and exhaust valves)	0.25 (0.0098)

Table 8 Valve clearance, unit mm (in.)

4. Hold the adjusting screw and tighten the lock nut.

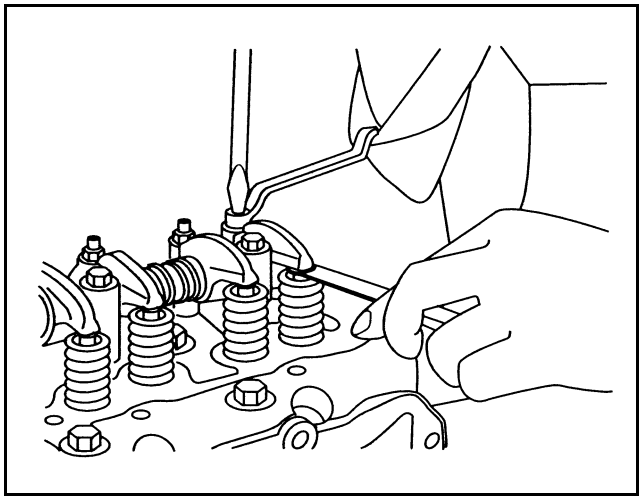


Figure 255 Adjusting valve clearance

5. After the valve clearance on the valves for No. 1 cylinder has been adjusted, turn the crankshaft 180° in the direction of engine rotation and adjust the valve clearance on the valves for the remainder of the cylinders in firing order (injection sequence)

Firing order (injection sequence)		Crankshaft rotation angle
S3L(2)	1 – 3 – 2	240°
S4L(2)	1 – 3 – 4 – 2	180°

Table 9 Firing order

⚠ CAUTION

After the valve clearance on the valves for all cylinders has been adjusted, turn the crankshaft two or three times and make sure the valve clearance is correct.

49 FUEL INJECTION TIMING

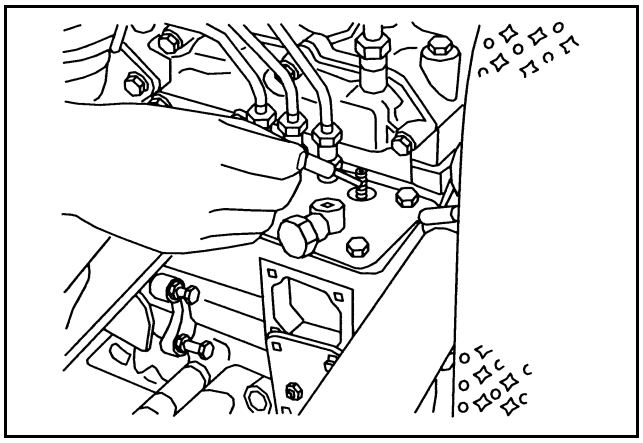


Figure 256 Removing delivery valve and spring

49.1 Preparation

1. Close the fuel filter valve.
2. Disconnect the No. 1 fuel injection pipe from the cylinder head and injection pump.
3. Remove No. 1 delivery valve holder from the injection pump. Remove the delivery valve and spring from the holder. Restore the delivery valve holder only to the injection pump.
4. Connect the fuel injection pipe to the injection pump.
5. Hold the speed control lever in the low speed position.

49.2 Inspection

49.2.1 Fuel flow method

1. Open the fuel filter valve. Turn the starter switch key to ON position.

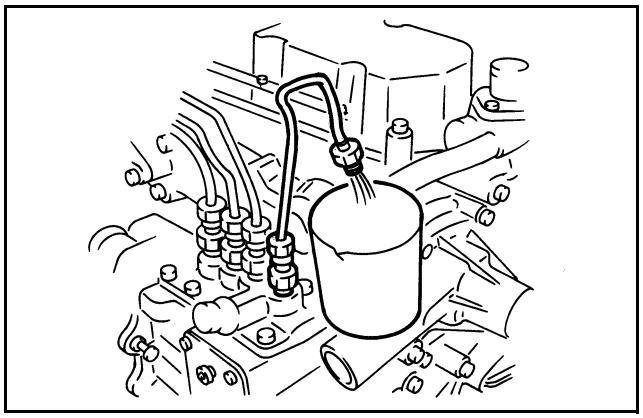


Figure 257 Fuel coming from injection pipe

NOTE

Fuel will come from the injection pipe with high pressure when the starter switch key is turned to ON position if the engine is equipped with an electric fuel pump. Direct fuel flow into the container.

2. Slowly turn the crankshaft clockwise, looking at the free end of the injection pipe. The instant fuel stops coming out is the fuel injection timing.

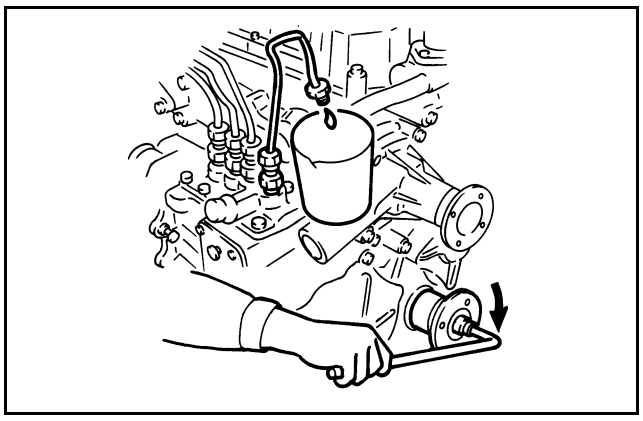


Figure 258 Fuel stops coming from injection pipe

NOTE

Turn the crankshaft in reverse direction just a little and do Step (2) again to verify the injection timing.

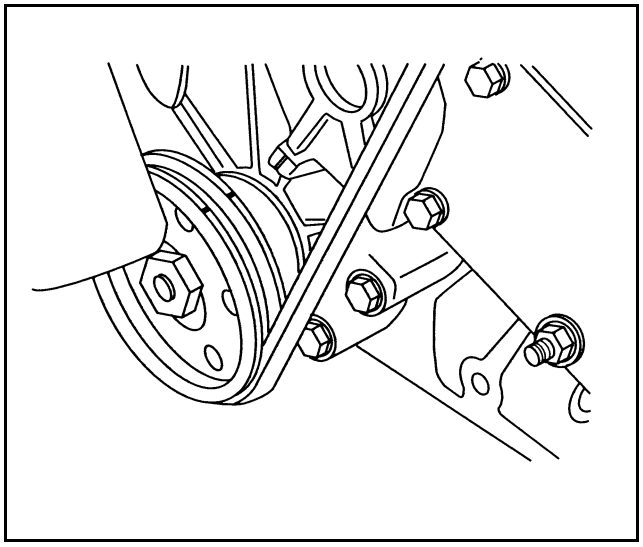


Figure 259 Timing mark

3. The fuel injection timing is correct if IT mark on the crankshaft pulley is aligned with the mark on the timing gear case when fuel stops from the injection pipe.

Fuel injection timing (BTDC)	17° (standard)[a]

a. Please refer to the applicable engine model specification sheet for actual data

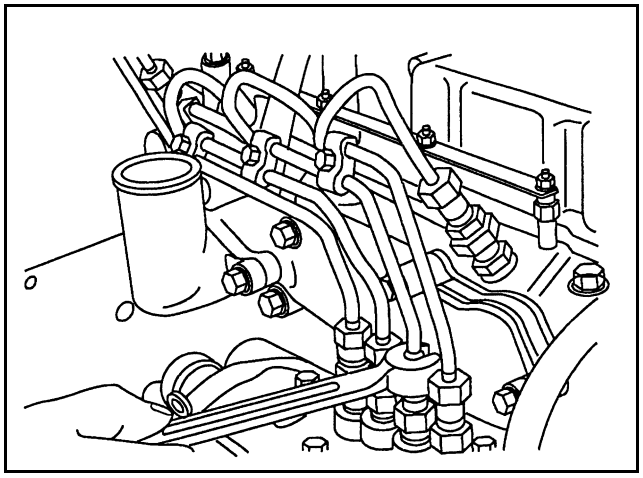


Figure 260 Disconnecting No. 1 fuel injection pipe

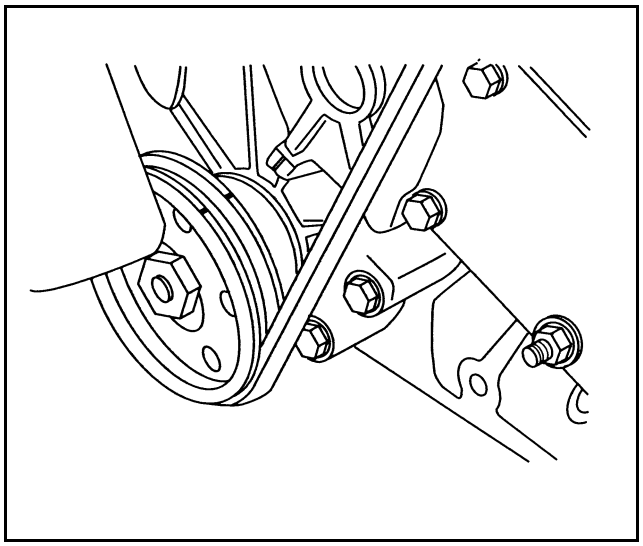


Figure 261 Timing mark

49.2.2 Alternate method

In the fuel flow method, the delivery valve has to be removed. As a result, there is a good chance for dirt particles to get inside the fuel injection pump. In this alternate method, however, it is not necessary to remove the delivery valve.

1. Disconnect No. 1 fuel injection pipe at the fuel injection nozzle (cylinder head).
2. Prime the fuel system.
3. Slowly turn the crankshaft clockwise until fuel just swells at the free end of the injection pipe and, at that instant, check the position of the IT mark with respect to the mark on the gear case. This timing is approximately 1° retarded. Take this 1° retardation into account when making a shim adjustment.

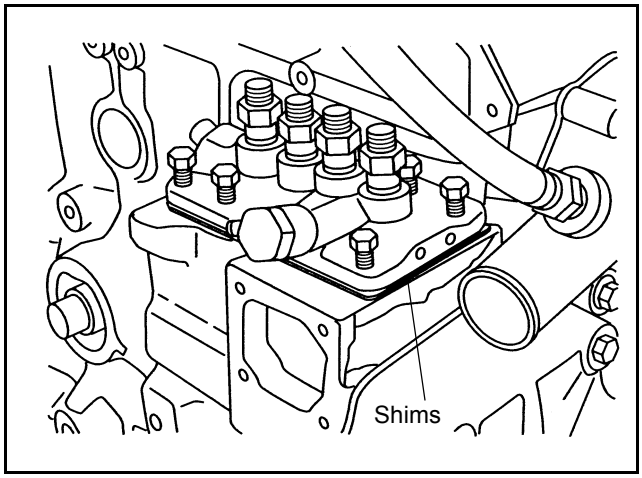


Figure 262 Adjusting fuel injection timing

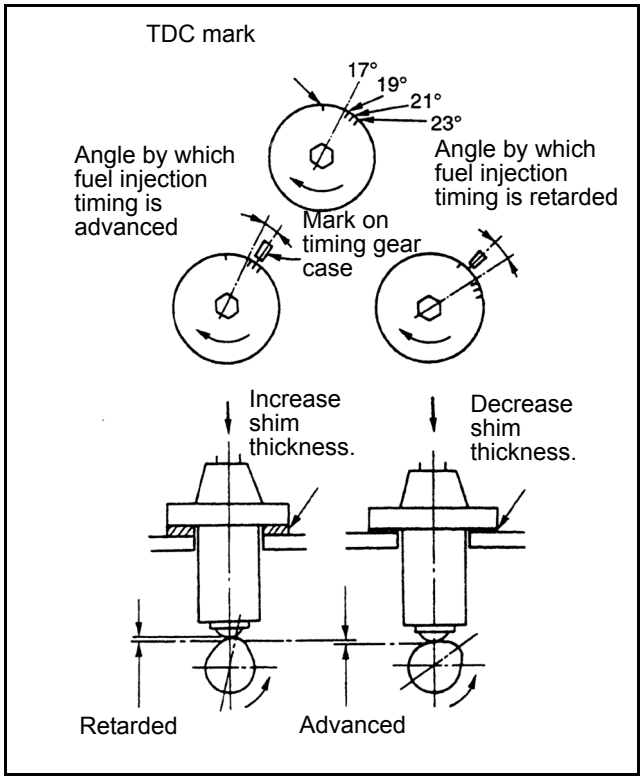


Figure 263 Adjusting fuel injection timing

49.3 Adjustment

1. If the fuel injection timing is incorrect, change the thickness of shims under the fuel injection pump. An increase or decrease of the shims by 0.1 mm (0.004 in.) will vary the timing by 1°.
2. Increase the thickness of the shims to retard the timing or decrease it to advance the timing.

Valve clearance (both inlet and exhaust valves)	0.25 (0.0098)

Four kinds of shims are available in thicknesses 0.2 mm (0.007 9 in.), 0.3 mm (0.011 8 in.), 0.4 mm (0.015 7 in.) and 0.8 mm (0.031 5 in.). These shims have no identification; measure the thickness of each shim with a calipers before using it.

⚠ CAUTION

Apply sealant to both faces of each shim to prevent oil leaks.

3. After the timing has been adjusted, make sure it is correct.
4. Close the fuel filter valve and restore the delivery valve and injection pipe to the original state.

50 FUEL FILTER

50.1 Fuel filter with [AIR] valve

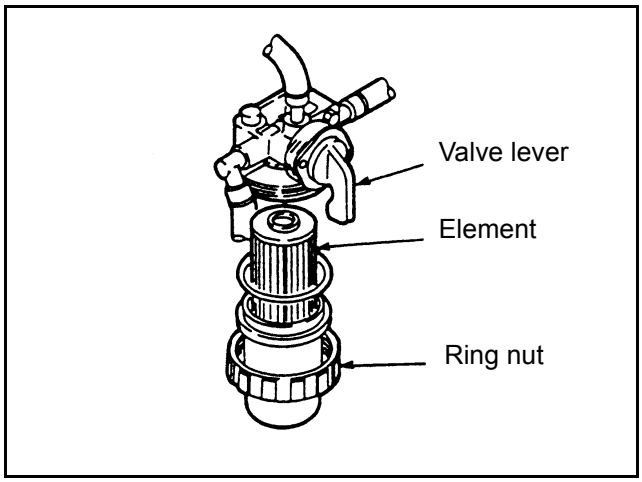


Figure 264 Fuel filter with [AIR] valve

Close the fuel filter valve. Loosen the ring nut and take out the element for cleaning or replacement.

50.2 Cartridge (air vent screw) type fuel filter

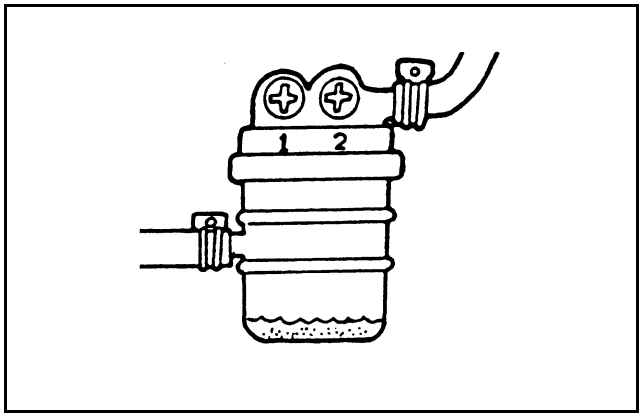


Figure 265 Cartridge type fuel filter

Replace the filter as an assembly if water and sediment have been accumulated in it.

51 FUEL SYSTEM PRIMING

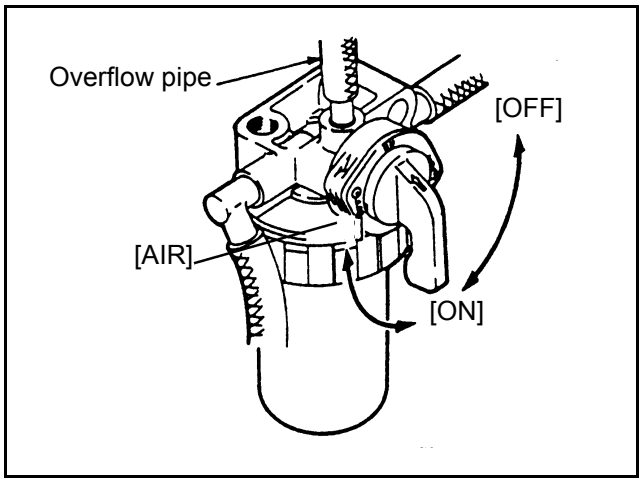


Figure 266 Priming fuel filter with [AIR] valve

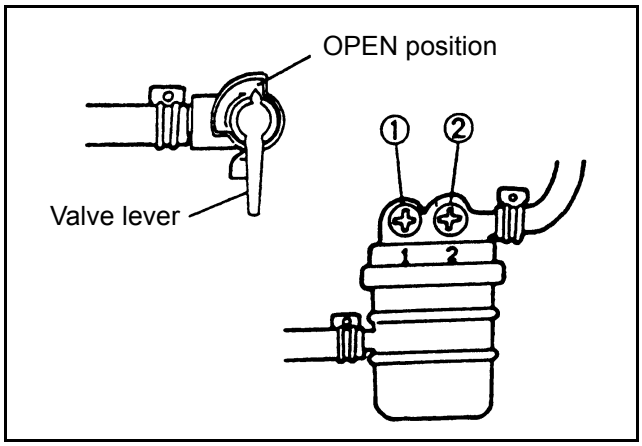


Figure 267 Priming cartridge (air vent screw) type fuel filter

51.1 Engine with fuel filter with [AIR] valve

1. Move the fuel filter valve lever to AIR position.
2. Move the lever to ON position when the fuel flows free of bubbles from the overflow pipe.
3. To prime the fuel pipe and fuel injection pump, loosen the air vent screw of the injection pump.
4. The injection pipes and nozzles can be primed by cranking the engine.

NOTE

The fuel system of the engine with an electric fuel pump can be primed by turning the starter switch key to ON position.

51.2 Engine with cartridge (air vent screw) type fuel filter

1. Loosen air vent screw (1). Tighten screw (1) when the fuel flows free of bubbles from this vent.
2. Loosen air vent screw (2). Tighten screw (2) when the fuel flows free of bubbles from this vent.
3. The injection pipes and nozzles can be primed by cranking engine engine.

NOTE

Turn the valve lever to OPEN position (if equipped) before loosening any air vent screw.

The fuel system of the engine with an electric fuel pump can be primed by turning the starter switch key to ON position.

52 IDLE RPM SETTING

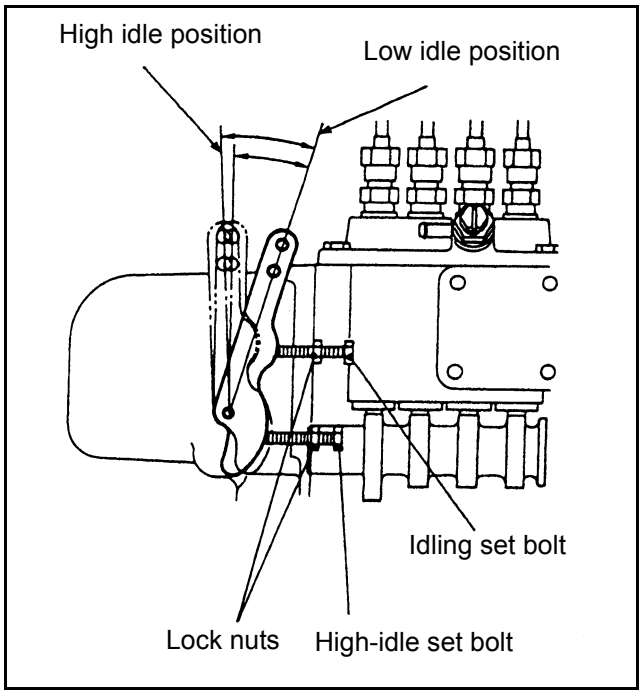


Figure 268 Idle speed setting

NOTE

Make sure that the valve clearance and injection timing are correct and that the fuel injection nozzles have no defect.

1. Start and run the engine at low idle until the coolant temperature is above 60°C (140°F).
2. To set the low idle speed, loosen the lock nut for the idling set bolt and turn the set bolt to make the engine run at the specified rpm. Tighten the lock nut.
3. To set the high idle speed , loosen the lock nut for the high-idle set bolt and turn the set bolt to make the engine run at the specified rpm. Tighten the lock nut.

53 FUEL INJECTION NOZZLES

53.1 Injection pressure (valve opening pressure) test

See FUEL INJECTION NOZZLE (page 148).

53.2 Orifice restriction test

Make reference to FUEL INJECTION NOZZLE (page 149).

53.3 Nozzle tip washing and replacement

Make reference to FUEL INJECTION NOZZLE (page 149).

53.4 Installation

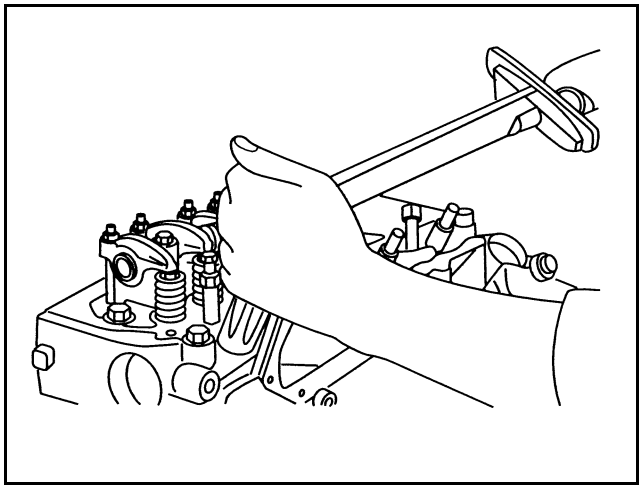


Figure 269 Installing fuel injection nozzles

1. Put the gasket on the injection nozzle.
2. Put the nozzle in position in the cylinder head and tighten it to the specified torque.

Tightening torque	5.5 ± 0.5 kgf·m (40 ± 4 lbf·ft) [54 ± 5 N·m

54 FAN BELT

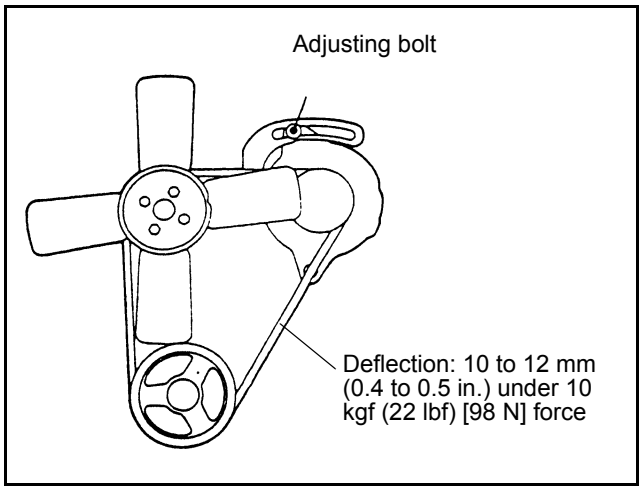


Figure 270 Installing fuel injection nozzles

1. Measure the deflection of the belt. Apply 10 kgf (22 lbf) [98 N] force midway between the alternator pulley and the crankshaft pulley.
2. Adjust the belt if the deflection is not correct. Loosen the adjusting bolt and move the alternator to obtain the required belt deflection.

Unit: mm(in.)

Item	Standard
Deflection	10 to 12 (0.4 to 0.5)

SERVICE DATA

55 SPECIFICATIONS[1]

55.1 Basic engine components

Unit: mm (in.)

Item		Standard		Limit	Correction-Remarks
Compression pressure		30 kgf/cm² (427 psi) [2 942 kPa]		27 kgf/cm² (384 psi) [2 648 kPa]	Repair or replace.
Maximum permissible difference between average compression pressure of all cylinders in one engine		3 kgf/cm² (42.7 psi) [294 kPa]		—	Repair or replace.
Fuel injection timing (BTDC)[a]		17°			
Clearance between rocker arm and shaft (oil clearance)		0.012 to 0.050 (0.000 47 to 0.001 97)		0.200 (0.007 87)	Replace rocker arm.
Valve clearance		0.25 (0.009 8)			Adjust.
Clearance between valve stem and valve guide	Inlet valve	0.02 to 0.05 (0.000 8 to 0.002 0)		0.10 (0.003 9)	Replace valve and valve guide.
	Exhaust valve	0.05 to 0.085 (0.002 0 to 0.003 35)		0.15 (0.005 9)	
Valve margin (valve lip thickness)		1.0 (0.039)		0.5 (0.020)	Replace valve.
Valve sinkage		0.5 ± 0.25 (0.020 ± 0.009 8)		1.5 (0.059)	Recondition valve seat or replace cylinder head.
Valve seat	Angle	45°		—	Recondition.
	Width	1.3 to 1.8 (0.051 to 0.071)		2.5 (0.098)	
Valve spring	Free length	47 (1.85)		46 (1.81)	Replace.
	Length under test force	39.1 (1.54)	30.5 (1.20)	—	
	Test force, kgf (lbf) [N]	13.9 ± 0.7 (30.6 ± 1.5) [136 ± 7]	29 ± 2 (64 ± 4.4) [284 ± 20]	-15%	
Warpage of cylinder head bottom face		0.05 (0.0020) maximum		0.10 (0.003 9)	Repair.
Bend (dial indicator reading) of valve push rod		—		0.3 (0.012)	Replace.

1. All specifications are subject to change without any prior notice.

Item		Standard	Limit	Correction-Remarks
Timing gear backlash	Crankshaft gear and idler gear	0.04 to 0.12 (0.001 6 to 0.004 7)	0.30 (0.011 8)	Replace.
	Idler gear and camshaft gear			
	Idler gear and fuel injection pump camshaft gear			
	Camshaft gear and P.T.O. gear	0.08 to 0.19 (0.003 1 to 0.007 5)		
	Fuel injection pump cam-shaft gear and oil pump gear	0.07 to 0.20 (0.0028 to 0.0079)		
Lobe height of camshaft		35.72 (1.406 3)	34.72 (1.366 9)	Replace.
Lobe height of fuel injection pump camshaft		44 (1.73)	43 (1.69)	Replace.
Flatness of flywheel		0.15 (0.005 9) maximum	0.50 (0.019 7)	Replace.
Clearance between tappet and cylinder block		—	0.15 (0.005 9)	Replace tappet.
Clearance between camshaft journal and bushing		—	0.15 (0.005 9)	Replace bushing.
Clearance between idler gear and shaft		0.03 to 0.07 (0.001 2 to 0.002 8)	0.20 (0.007 9)	Replace idler gear or shaft.
Warpage of cylinder block top face		0.05 (0.002 0) maximum	0.10 (0.003 9)	Repair.
Bore in cylinder block		$78.0\ ^{+0.03}_{0}$ ($3.07\ ^{+0.0012}_{0}$)	78.2 (3.079)	Hone out bore for oversize piston or replace cylinder block.
Taper and out-of-round of cylinder		0.01 (0.000 4) maximum	—	
Diameter of piston	Standard	77.93 to 77.95 (3.068 1 to 3.068 9)	77.80 (3.063 0)	
	0.25 (0.0098) oversize	78.18 to 78.20 (3.077 9 to 3.078 7)	78.05 (3.072 8)	
	0.50 (0.0197) oversize	78.43 to 78.45 (3.087 8 to 3.088 6)	78.30 (3.082 7)	
Clearance between piston pin and piston		0.006 to 0.018 (0.000 24 to 0.000 71)	0.050 (0.001 97)	
Clearance between piston ring and groove	No. 1 compression ring	0.06 to 0.10 (0.002 4 to 0.003 9)	0.30 (0.011 8)	Replace piston ring.
	No. 2 compression ring	0.05 to 0.09 (0.002 0 to 0.003 5)	0.20 (0.007 9)	
	Oil ring	0.03 to 0.07 (0.001 2 to 0.002 8)	0.20 (0.007 9)	
Clearance between ends of piston ring	No. 1 compression ring	0.15 to 0.30 (0.005 9 to 0.011 8)	1.50 (0.059)	Replace piston ring
	No. 2 compression ring	0.15 to 0.35 (0.005 9 to 0.013 8)		
	Oil ring	0.20 to 0.40 (0.007 9 to 0.015 7)		
Clearance between piston and cylinder		0.035 to 0.086 (0.001 38 to 0.003 39)	0.300 (0.011 81)	Hone out bore for oversize piston or replace cylinder block.

Item		Standard	Limit	Correction-Remarks
Clearance between crankpin and connecting rod bearing		0.025 to 0.072 (0.000 98 to 0.002 83)	0.150 (0.005 91)	Replace connecting rod bearing.
Thrust clearance for connecting rod big end		0.10 to 0.35 (0.003 9 to 0.013 8)	0.50 (0.019 7)	Replace connecting rod.
Crankshaft	Diameter of journal	51.985 to 52.000 (2.046 65 to 2.047 24)	—	
	Diameter of crankpin	47.950 to 47.965 (1.887 79 to 1.888 38)	—	
	Runout	0.025 (0.000 98)	0.05 (0.002 0)	Repair or replace.
	Clearance between journal and main bearing	0.030 to 0.077 (0.001 18 to 0.003 03)	0.100 (0.003 94)	Replace main bearing.
	Clearance between crankpin and connecting rod bearing	0.025 to 0.072 (0.000 98 to 0.002 83)	0.150 (0.005 91)	Replace connecting rod bearing.
	End play	0.050 to 0.175 (0.001 97 to 0.006 89)	0.500 (0.019 69)	Replace No. 3 flanged bearing

a. Please refer to the applicable engine model specification sheet for actual data

55.2 Lubrication system

Unit: mm (in.)

Item	Standard	Limit	Correction-Remarks
Pressure relief valve setting	3.5 ± 0.5 kgf/cm^2 (50 ± 7 psi) [343 ± 49 kPa]	—	Replace.
Pressure difference at which oil pressure switch is closed (indicator light comes on)	0.5 ± 0.1 kgf/cm^2 (7 ± 1.4 psi) [49 ± 10 kPa]	—	Replace.

55.3 Fuel system

Unit: mm (in.)

Item	Standard	Limit	Correction-Remarks
Injection pressure (valve opening pressure)	140_{0}^{+5} kgf/cm^2 ($1\ 991_{0}^{+71}$ psi) [$13\ 729_{0}^{+490}$ kPa]	—	Adjust with washer.

55.4 Air inlet system and exhaust system

Unit: mm (in.)

Item	Standard	Limit	Correction-Remarks
Paper-element type air cleaner element	Clean every 100 service hours	Change every 500 service hours.	
Warpage of mounting faces of manifolds	—	0.15 (0.005 9)	Repair or replace.

55.5 Cooling system (standard)

Unit: mm (in.)

Item		Standard	Limit	Correction-Remarks
Thermostat	Temperature at which valve starts opening	82 ± 1.5°C (180 ± 2.7°F)	—	Replace.
	Temperature at which valve lift is more than 8 mm (0.3 in.)	95°C (203°F)	—	
Thermo-switch	Temperature at which switch is turned ON	111 ± 3.5°C (232 ± 6.3°F)	—	Replace.
	Resistance at oil temperature of 120°C (284°F)	30 mΩ maximum	—	
Resistance in thermounit	At 50°C (122°F)	80 ± 10 Ω	—	Replace.
	At 80°C (176°F)	29.5 ± 2.5 Ω	—	
	At 120°C (248°F)	10 ± 0.3 Ω	—	
Deflection of fan belt under 10 kgf (22 lbf) [98 N] force applied midway between alternator pulley and crankshaft pulley		10 to 12 (0.4 to 0.5)	—	Replace.

55.6 Electrical system

Unit: mm (in.)

Item			Standard		Limit	Correction-Remarks
Starter	Pinion clearance		0.5 to 2.0 (0.020 to 0.079)		—	Adjust with packing.
	No-load charac-teristics		S3L/S3L2	S4L/S4L2		Test.
		Terminal voltage	11.5 V	11 V	—	
		Current draw	100 A maximum	130 A maximum	—	
		rpm	3 000 minimum	3 600 minimum	—	
	Brush length		—		Wear limit line	Replace.
	Brush spring tension		3.0 kgf (6.6 lbf) [29.4 N]		1.8 kgf (4.0 lbf) [17.7 N]	Replace.
	Runout of commutator		0.03 (0.001 2)		0.10 (0.003 9)	Repair or replace.
	Diameter of commutator		32 (1.26)		31 (1.22)	Replace.
	Undercut of mica		0.5 (0.020)		0.2 (0.008)	Repair.

Item				Standard	Limit	Correction-Remarks
Alternator	Regulated voltage at 20°C (68°F)			14.7 ± 0.3 V	—	
	Output characteristics (at operating temperature)	At 2500 rpm	Terminal voltage	13.5 V	—	Test.
			Current	33 A min.	—	
		At 500 rpm	Terminal voltage	13.5 V	—	
			Current	47 A min.	—	
	Brush length			—	Wear limit line	Replace.
Resistance in glow plug				0.55 Ω	—	Replace.

56 TIGHTENING TORQUES

56.1 Major bolts and nuts

Unit: mm (in.)

Bolt or nut	Thread, mm				Torque, kgf·m (lbf·ft) [N·m]
	Dia-meter	Pitch	Width	Clamp length	
Cylinder head bolt	M10	1.25	14	87	9 ± 0.5 (65 ± 4) [88 ± 5]
Rocker cover bolt	M8	1.25	12	40	1.15 ± 0.15 (8.3 ± 1.1) [11.3 ± 1.5]
Rocker shaft bracket bolt	M8	1.25	12	58	1.5 ± 0.5 (11 ± 4) [14.7 ± 5]
Thermoswitch	M16	1.5	17	31.5	2.3 ± 0.4 (16.6 ± 3) [22.6 ± 4]
Crankshaft pulley nut	M18	1.5	27	—	17.5 ± 2.5 (127 ± 18) [172 ± 25]
Main bearing cap bolt	M10	1.25	17	81	5.25 ± 0.25 (38 ± 2) [51.5 ± 2.5]
Connecting rod cap nut	M9	1.0	14	—	3.55 ± 0.25 (25.7 ± 2) [34.8 ± 2.5]
Rear plate bolt (for tractor engine)	M12	1.25	17	28	9.5 ± 1 (69 ± 7) [93 ± 10]
Rear plate bolt (standard)	M12	1.25	17	28	6.5 ± 1 (47 ± 7) [64 ± 10]
Rear plate bolt (stamping)	M8	1.25	12	16	1.15 ± 0.15 (8.3 ± 1.1) [11.3 ± 1.5]
Flywheel bolt	M12	1.25	19	29	13.5 ± 0.5 (98 ± 4) [132 ± 5]
Oil pan bolt (for tractor engine)	M8	1.25	12	25	2.8 ± 0.3 (20.3 ± 2.2) [27.5 ± 3]
Oil pan drain plug	M14	1.5	22	10	4 ± 0.5 (29 ± 4) [39 ± 5]
Pressure relief valve	M22	1.5	22	33	5 ± 0.5 (36 ± 4) [49 ± 5]
Oil filter	M20	1.5	—	—	1.2 ± 0.1 (8.7 ± 0.7) [12 ± 1]
Oil pressure switch	PT1/8	—	26	11	1 ± 0.2 (7.2 ± 1.4) [10 ± 2]
Fuel injection pipe nut	M12	1.5	—	—	3 ± 0.5 (22 ± 4) [29 ± 5]
Fuel leak-off pipe nut	M12	1.5	18	—	2.75 ± 0.25 (20 ± 2) [27 ± 2.5]
Delivery valve holder	—	—	19	—	4.5 ± 0.5 (32.5 ± 4) [44 ± 5]
Fuel injection nozzle holder	M20	1.5	21	—	5.5 ± 0.5 (40 ± 4) [54 ± 5]
Retaining nut for delivery valve holder body	M16	0.75	19	—	3.75 ± 0.25 (27 ± 2) [37 ± 2.5]
Sliding sleeve shaft	M10	1.25	14	29.5	3.6 ± 0.6 (26 ± 4) [35 ± 6]
Special nut for torque spring set	M12	1.0	17	—	2 ± 0.5 (14 ± 4) [20 ± 5]
Glow plug	M10	1.25	12	60	1.75 ± 0.25 (12.7 ± 2) [17.2 ± 2.5]
Glow plug connection plate	M4	0.7	8	—	0.125 ± 0.025 (0.9 ± 0.2) [1.2 ± 0.2]
Stop solenoid nut	M30	1.5	36	—	4.5 ± 0.5 (32.5 ± 4) [44 ± 5]
Starter B terminal	M8	1.25	12	—	1.1 ± 0.1 (8 ± 0.7) [10.8 ± 1]

56.2 Torques for bolts and nuts with standard threads

Unit: kgf·m (lbf·ft) [N·m]

Thread diameter	Identification on head		
	4	7	
M6	0.4 ± 0.1 (3 ± 0.7) [3.9 ± 1]	0.9 ± 0.1 (6.5 ± 0.7) [8.8 ± 1]	
M8	1.1 ± 0.1 (8 ± 0.7) [10.8 ± 1]	1.85 ± 0.35 (13.4 ± 2.5) [18 ± 3]	
M10	2.15 ± 0.35 (15.6 ± 2.5) [21 ± 3]	3.6 ± 0.6 (26 ± 4.3) [35.3 ± 6]	
M12	3.6 ± 0.6 (26 ± 4.3) [35.3 ± 6]	6.5 ± 1 (47 ± 7) [63.7 ± 10]	
M14	6 ± 1 (43 ± 7) [59 ± 10]	9.5 ± 1.5 (69 ± 11) [93.2 ± 15]	

56.3 Torques for plugs with taperlock threads

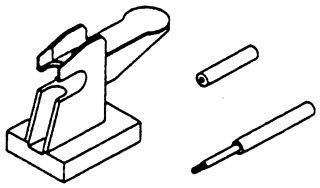
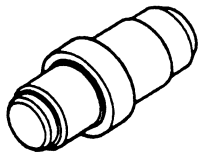
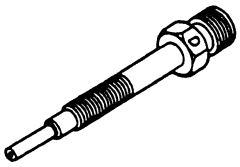
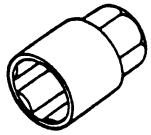
Unit: kgf·m (lbf·ft) [N·m]

Size	For aluminium materials	For ferrous materials
NPTF 1/16	0.65 ± 0.15 (4.7 ± 1) [6.4 ± 1]	1 ± 0.2 (7.2 ± 1) [10 ± 2]
PT 1/8	1 ± 0.2 (7.2 ± 1) [10 ± 2]	1.85 ± 0.35 (13.4 ± 2.5) [18 ± 3]
PT 1/4, NPTF 1/4	2.5 ± 0.5 (18 ± 4) [25 ± 5]	4 ± 0.5 (29 ± 4) [39 ± 5]
PT 3/8	—	6.5 ± 1 (47 ± 7) [64 ± 10]

57 SEALANTS

Component		Sealant	Mating part	Remarks
Thread parts	Stop solenoid	Three Bond 1212	Governor case	Apply to effective thread part.
	Water drain joint	Three Bond 1102	Cylinder block	
	Oil pressure switch			
	Torque spring set	Three Bond 1212	Governor case	
Force-fit parts	Sealing cap	Three Bond 1102	Cylinder block	Apply to holes in cylinder head and cylinder block.
			Cylinder head	
			Cylinder head and cylinder block	
	Expansion plug		Cylinder block	
	Dipstick guide			
Other parts	Side seal	Three Bond 1212	Cylinder block and main bearing caps	Apply to external surface.
	Main bearing caps (front and rear)		Cylinder block	Apply to surfaces that come into contact with cylinder block.
	Oil pan	Three Bond 1207C		Apply to sealing surface.

58 SPECIAL TOOLS

Tool No.	Toon Name	Style	Usage
31A91-00100	Piston Pin Setting Tool		Piston pin removal and installation
ST332340	Camshaft Bushin Installer		Camshat front bushing removal and installation
ST332270	Compression Gauge Adaptor		Compression pressure measurement
MD998054	Oil Pressure Switch Socket Wrench		Oil pressure switch removal and installation

NOTE

In addition to these special tools, commercially available tools such as bearing puller, valve seat cutting tool, valve guide installing tool, valve spring compressing tool, oil filter wrench, etc. are necessary.

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