MITSUBISHI DIESEL ENGINES

SERVICE MANUAL
SL-SERIES

S3L,S3L2
S4L,S4L2

Sep. '97

INTRODUCTION

This service manual has instructions and procedures for the subject on the front cover.

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.

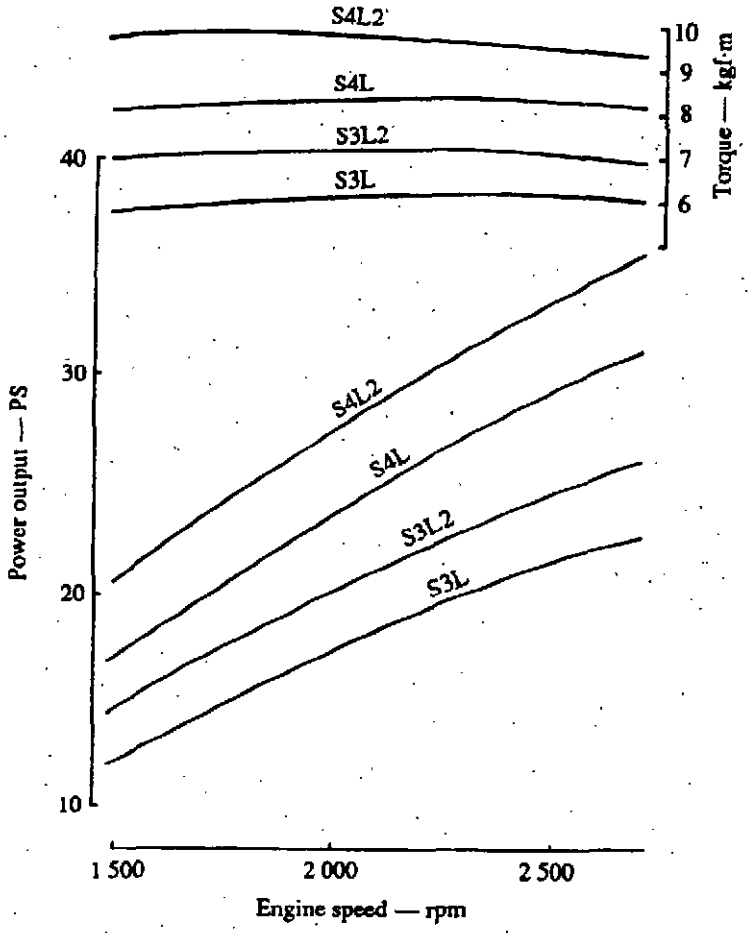
Correct servicing, test and repair procedures will give the engine a long service life. Before starting a test, repair or rebuild job, the serviceman must read the respective sections of this manual to know all the components he will work on.

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.

Pub. No. 99619–12120

PERFORMANCE CURVES (ONE-HOUR RATING, WITH FAN)



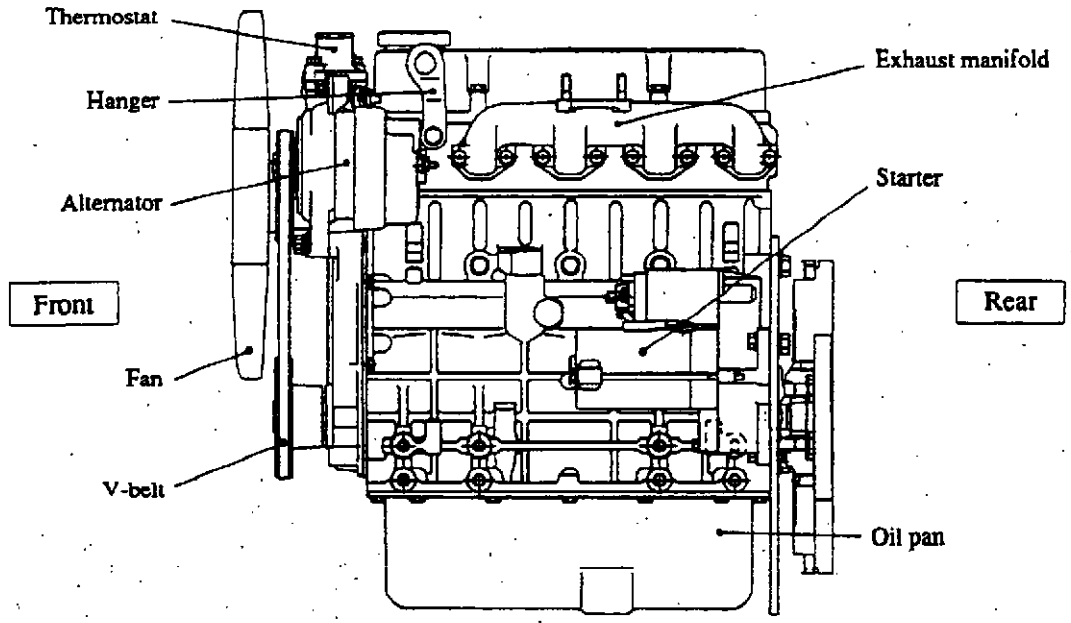
PRIME POWER OUTPUT CHART

Unit: PS

Rating	RPM \ Engine model	S3L	S3L2	S4L	S4L2
		With fan	With fan	With fan	With fan
One-hour (no overload)	1 500	12.0	14.5	17.0	20.5
	1 800	15.0	18.0	21.0	25.0
	2 000	17.0	20.0	23.5	27.5
	2 200	19.0	22.0	26.0	30.0
	2 500	21.5	24.5	29.0	33.5
Continuous	1 500	11.4	13.8	16.2	19.5
	1 800	14.3	17.1	20.0	23.8
	2 000	16.2	19.0	22.3	26.1
	2 200	18.1	20.9	24.7	28.5
	2 500	20.4	23.3	27.6	31.8

INDEX

S4L/S4L2



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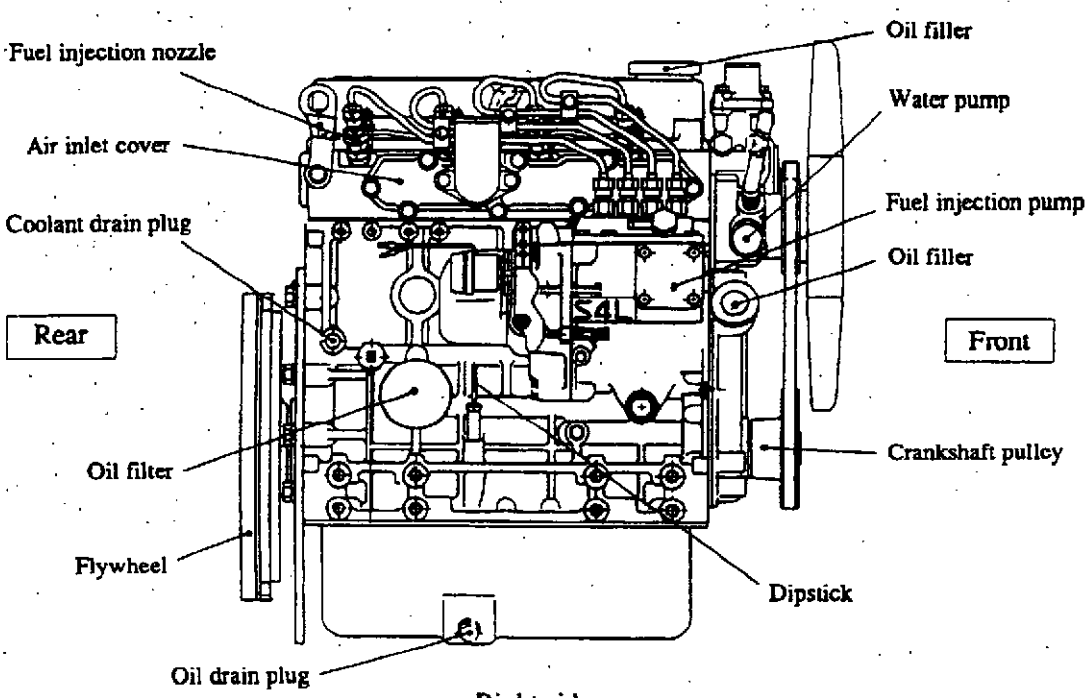

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GENERAL INFORMATION

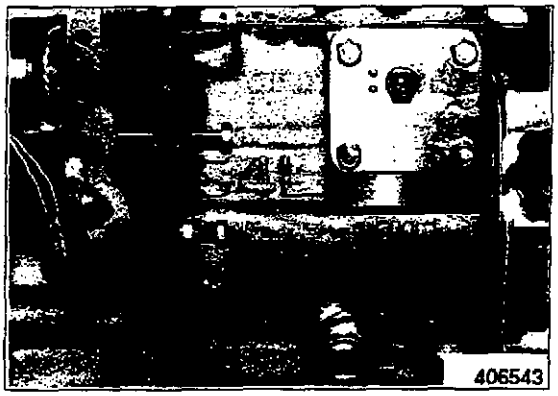
MODEL IDENTIFICATION AND SERIAL NUMBER LOCATION

1. Model identification location

(a) The model identification is embossed on the right side of the cylinder block, near the fuel injection pump mount.

(b) The model identifications and displacements of the engines in current production are as listed below:

	Displacement
S3L–61A	1.125 liters (68.7 cu in.)
S3L2–61A	1.318 liters (80.4 cu in.)
S4L–61A	1.500 liters (91.5 cu in.)
S4L2–61A	1.758 liters (107.3 cu in.)



Model identification location

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

Example: Coded designation

S 4 L (2) – 61 A

- A — Specification code
- 61 — Export code
- (2) — Stroke code (No code: 78.5 mm (3.09 in.), 2: 92 mm (3.62 in.)
- L — Series code [Bore: 78 mm (3.07 in.)]
- 4 — Number-of-cylinders code ["4" stands for four cylinders]
- S — Identification of "Sagamihara Machinery Works"

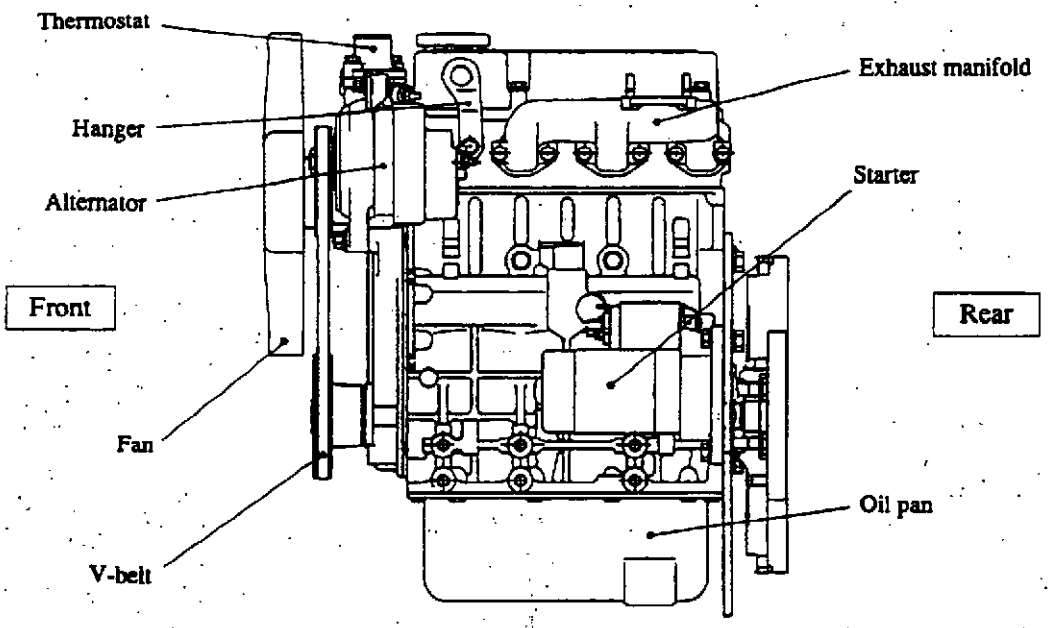
2. Serial Number Location

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

Serial number location

COMPONENT LOCATION

S3L/S3L2



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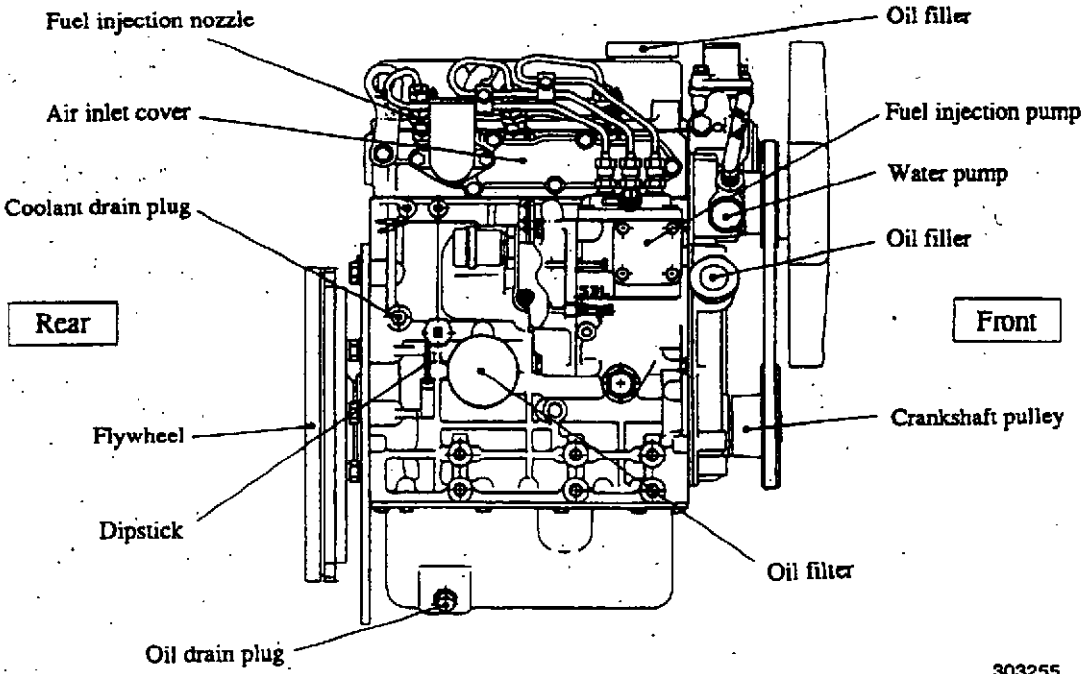

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SPECIFICATIONS

Model		S3L–61A	S3L2–61A	S4L–61A	S4L2–61A
Type		Water-cooled, 4-stroke cycle, in-line diesel engine			
Firing order (injection sequence)		1 - 3 - 2		1 - 3 - 4 - 2	
Compression ratio		22			
Combustion chamber, type		Swirl			
Weight, kg (lb)		125 (276)		150 (331)	
No. of cylinders		3		4	
Bore x Stroke, mm (in.)		78 x 78.5 (3.07 x 3.09)	78 x 92 (3.07 x 3.62)	78 x 78.5 (3.07 x 3.09)	78 x 92 (3.07 x 3.62)
Displacement, liter (cu in.)		1.125 (68.7)	1.318 (80.4)	1.500 (91.5)	1.758 (107.3)
Fuel system	Injection pump, type	Bosch M			
	Injection nozzle, type	Throttle			
	Governor, type	Centrifugal flyweight			
	Fuel	ASTM No. 2-D			
Lubrication system	Type	Force feed (by trochoid pump)			
	Engine oil	API Service Classification CC			
	Oil filter	Paper-element (full-flow)			
	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)	
Cooling system	Type	Forced cooling			
	Capacity (approximate), liter (U.S. gal)	1.8 (0.5)		2.5 (0.7)	
Starter, V – kW		12 – 1.6		12 – 2.0	
Alternator, V – A		12 – 50			

HOW TO USE THIS MANUAL

1. 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.

2. 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.

3. 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 from the flywheel end.

4. 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.

5. 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 torques unless otherwise specified.

OVERHAUL INSTRUCTIONS

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.

COMPRESSION PRESSURE MEASUREMENT

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.

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.

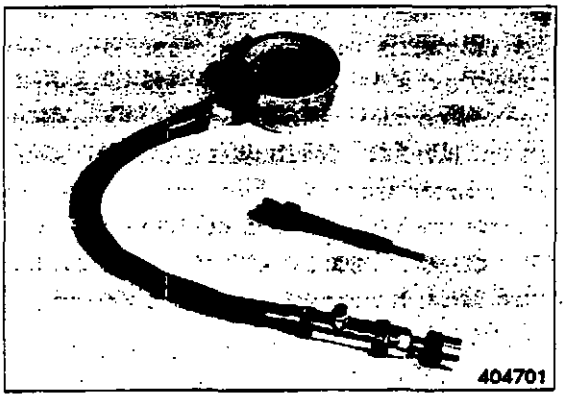
(4) If the gauge reading is below the limit, overhaul the engine.

⚠ CAUTION

a) Be sure to measure the compression pressure on all cylinders.

b) 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.

Item		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]	—



Compression gauge and adaptor

Measuring compression pressure

⚠ CAUTION

a) It is important to measure the compression pressure at regular intervals to obtain the data on the gradual change of the compression pressure.

b) 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.

TROUBLESHOOTING

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 trouble-shooting 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)

2. Engine troubleshooting

Problem 1: Hard starting

(1) Items to be checked for ahead

- 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.

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 for ahead

- Clogged air cleaner
- Poor quality fuel

(2) Inspection procedure

Is injection timing correct (not too advanced)? — No ⇨ Make adjusment 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.

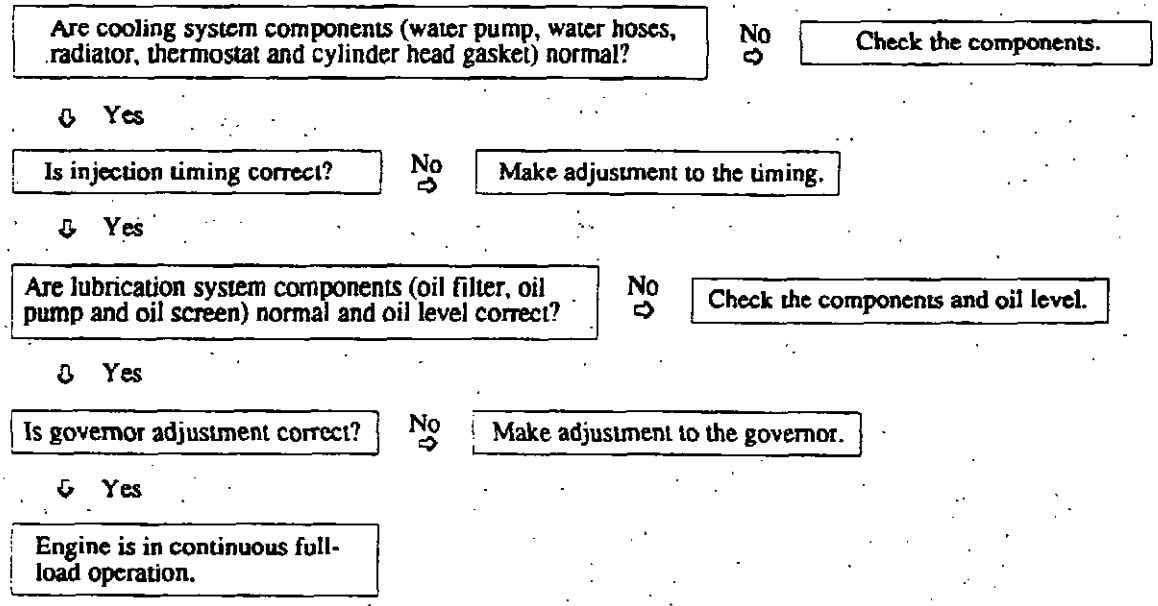
Problem 3: Overheating

(1) Items to be checked for ahead

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.

- Insufficient coolant and exterior coolant leaks
- Loose fan belt
- Radiator core openings plugged with dirt

(2) Inspection procedure



Problem 4: Black exhaust smoke

(1) Items to be checked for ahead

- 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.

Problem 5: Erratic idle speeds

(1) Items to be checked for ahead

- 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.

Problem 6: Low power or loss of power

(1) Items to be checked for ahead

- 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.

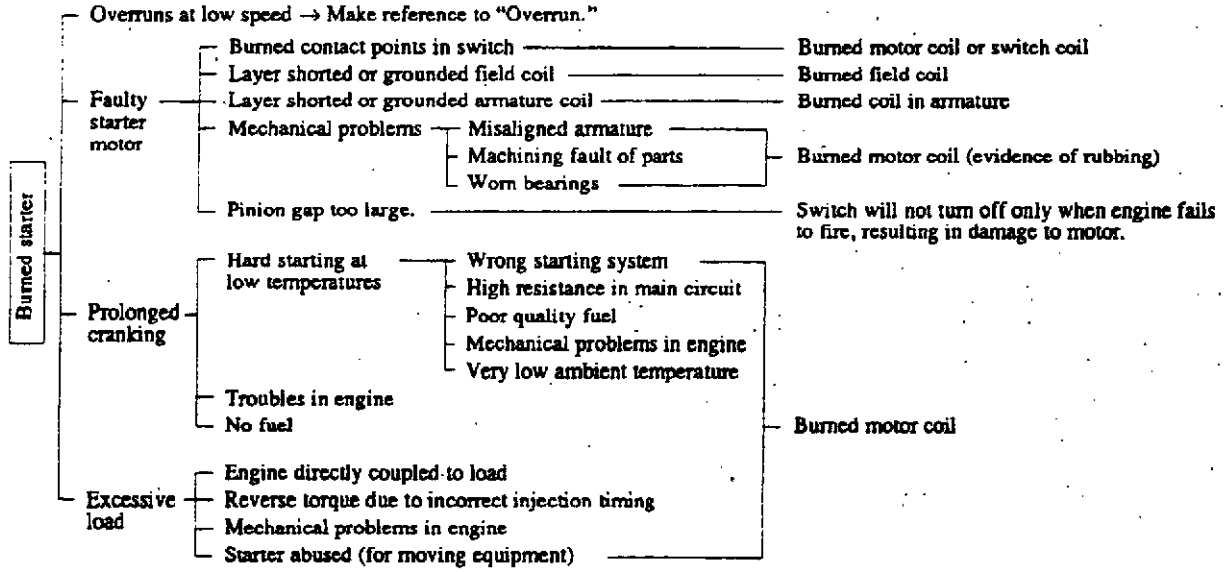
⇩ Yes

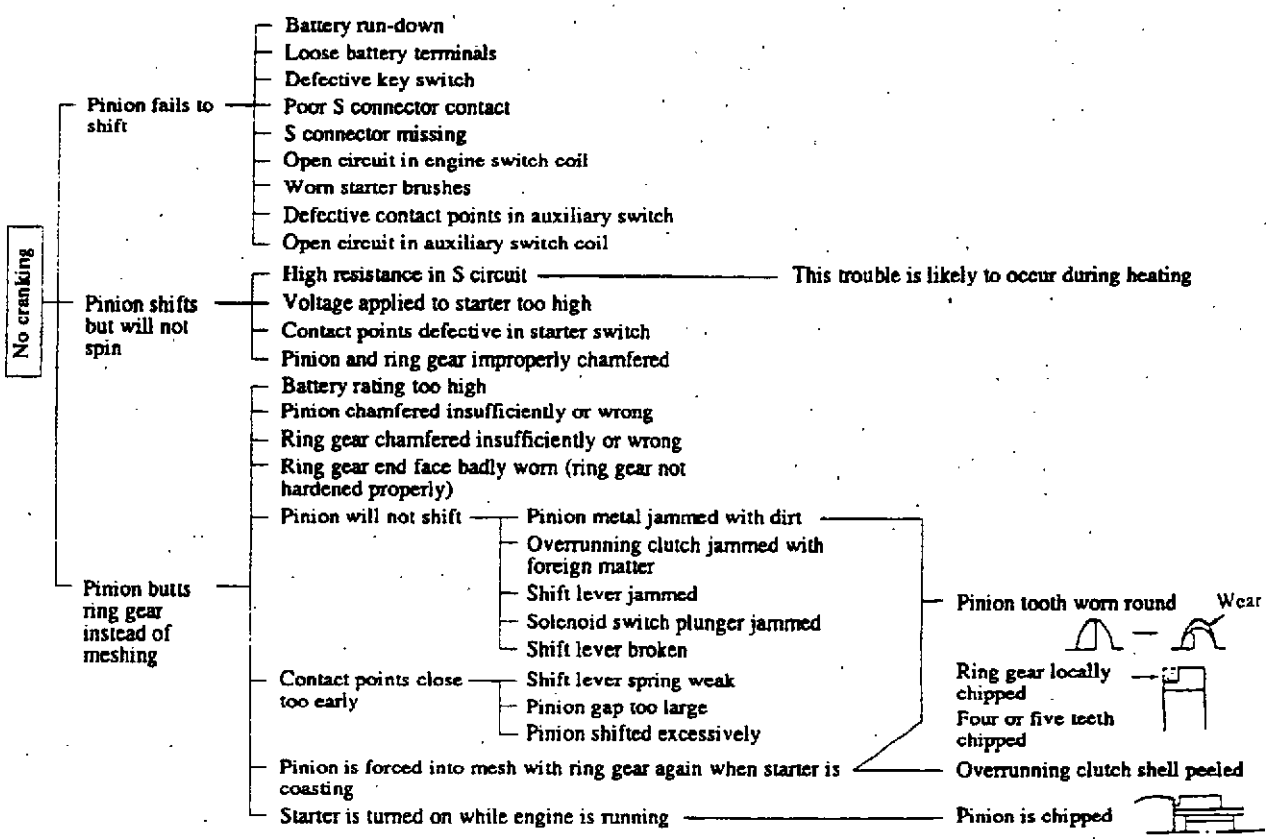
Is compression pressure correct? → No ⇨ Check valves, piston rings and cylinder head gaskets.

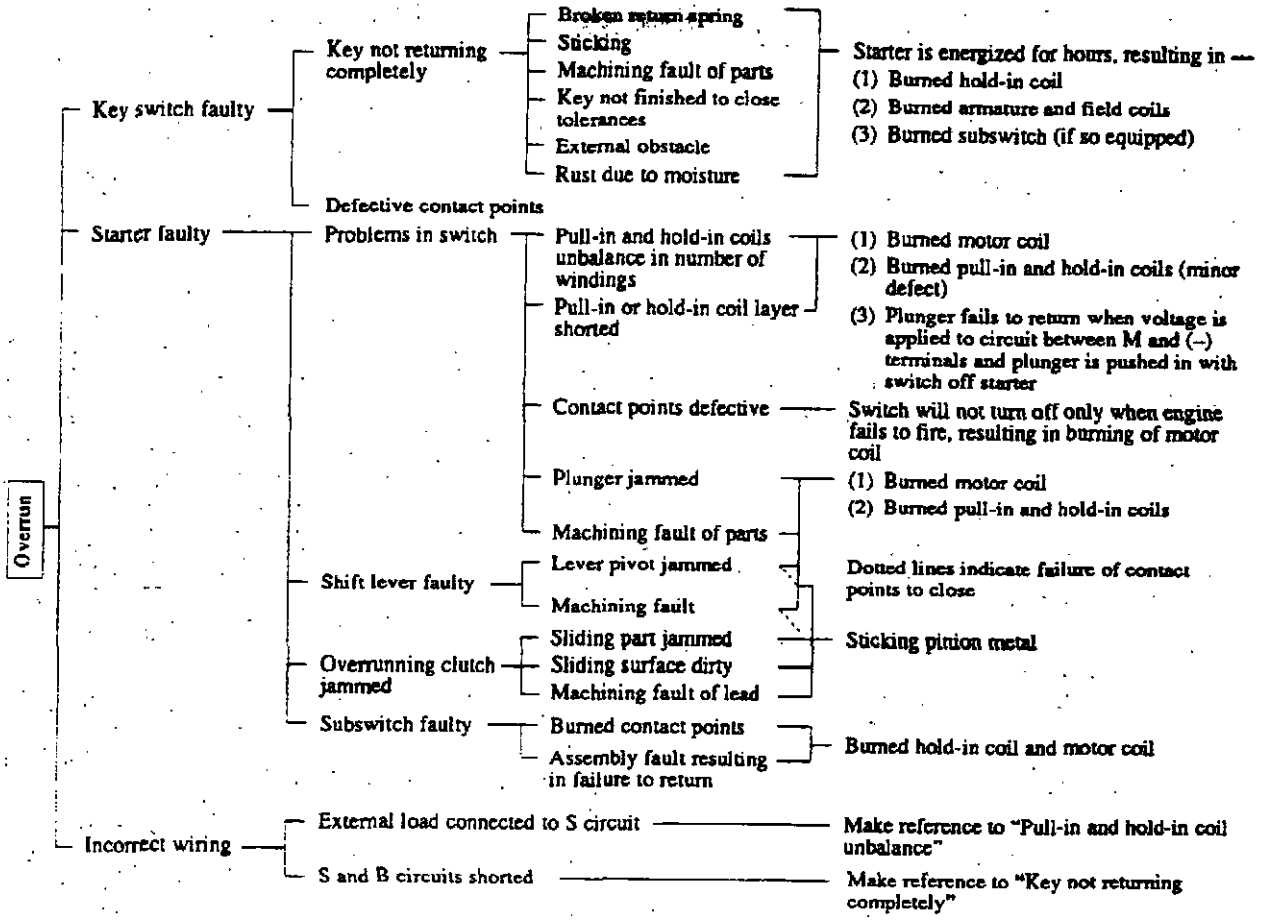
⇩ Yes

Fuel injection pump is faulty.

3. Starting system troubleshooting







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

BASIC PRECAUTIONS FOR DISASSEMBLY AND ASSEMBLY

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

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.

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

PREPARATION FOR DISASSEMBLY

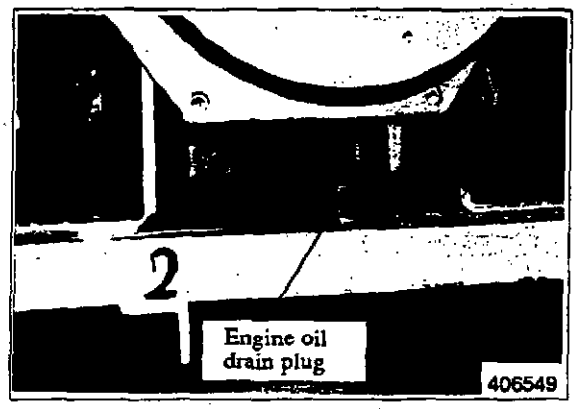
1. Engine oil draining

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.

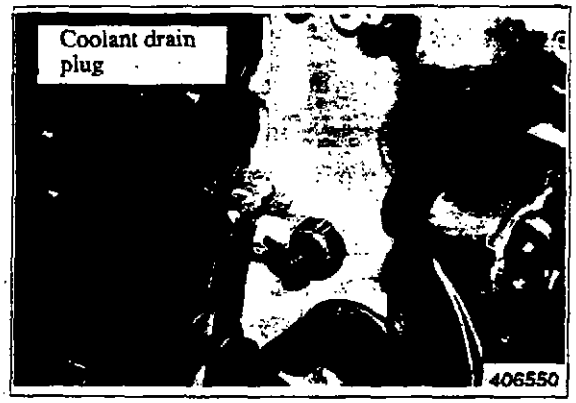


Draining engine oil

2. Coolant draining

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)



Draining coolant

ELECTRICAL SYSTEM

1. Starter

1.1. Testing before disassembly

(1) Clearance between pinion and housing (pinion clearance)

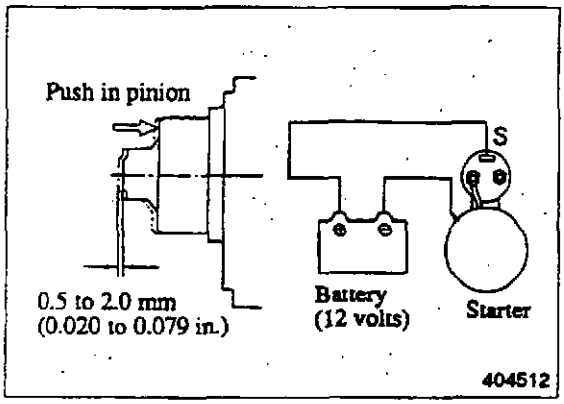
(a) Connect the starter to a 12 volt battery as shown in the illustration to cause the pinion to shift into cranking position and remain there.

⚠ CAUTION

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

(b) Push the pinion toward the commutator end by hand to measure its free movement (pinion clearance).

(c) 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.

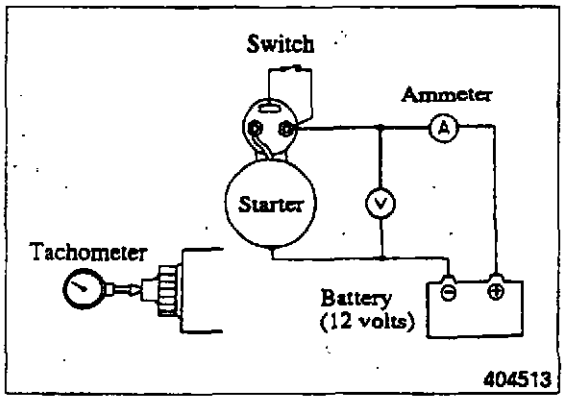


Connections for measuring pinion clearance

(2) No-load characteristics

(a) Connect the starter to a 12 volt battery with an ammeter capable of indicating several hundred amperes as shown in the illustration.

(b) 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.



Connections for testing no-load characteristics

⚠ CAUTION

a) The size of wires used for this test must be as large as possible. Tighten the terminals securely.

b) This starter has a reduction gear. Do not confuse gear noise with some abnormal noise else.

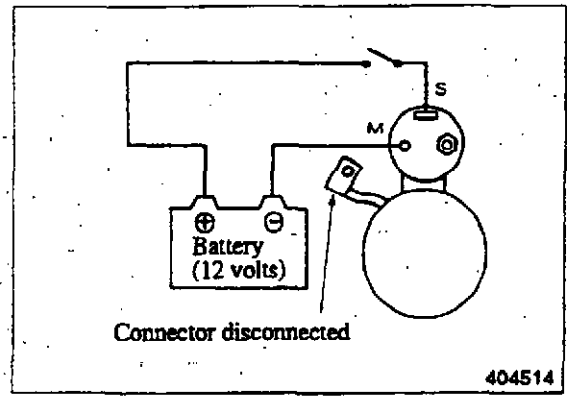
c) When measuring the starter speed at the end of the pinion, be ready for accidental shifting of the pinion.

Item		Standard	
Model		MZT56272	MZT50381
Nominal output, V – kW		12 – 2.0	12 – 1.6
No-load characteristics	Terminal voltage, V	11	11.5
	Current draw, A	130, maximum	100, maximum
	Speed, rpm	3 850, minimum	3 000, minimum

(3) Magnetic switch

(a) Disconnect the connector from the M terminal of the magnetic switch.

(b) 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.

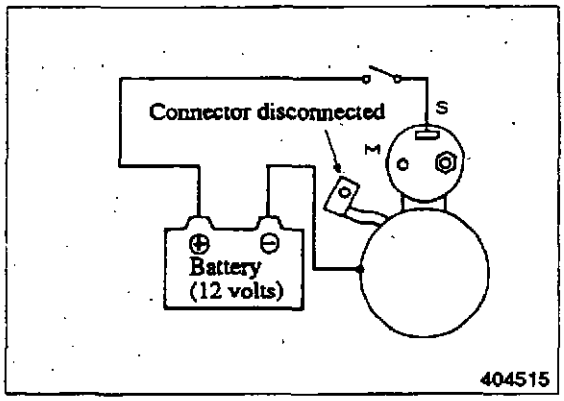


Connections for testing pull-in coil

⚠ CAUTION

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

(c) Connect the magnetic switch to a 12 volt battery with a switch as shown in the illustration to test the hold-in coil. Close the switch and pull the pinion away from the commutator end by hand. Release the pinion to see if it remains there. If the pinion returns, the magnetic switch is faulty.



Connections for testing hold-in coil

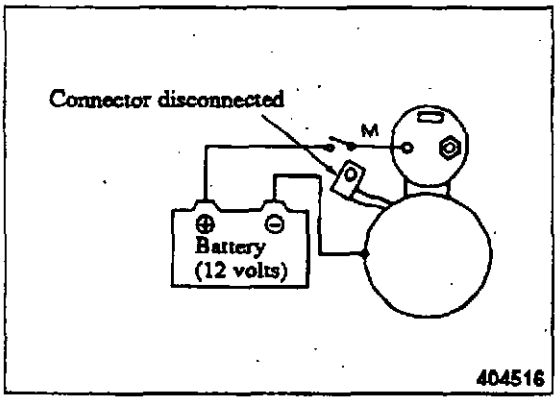
⚠ CAUTION

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

(d) 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.



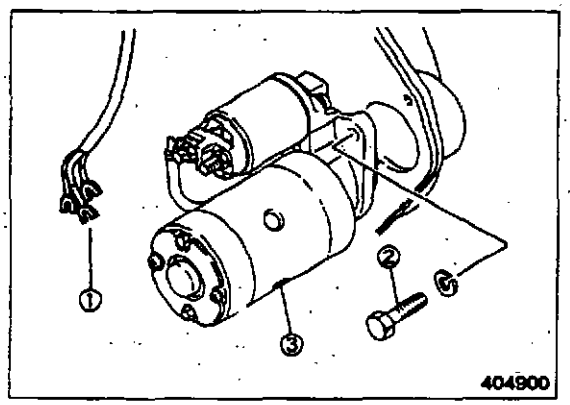
Connections for pinion return test

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.



Removing starter

2. Alternator

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

Alternator on engine

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).

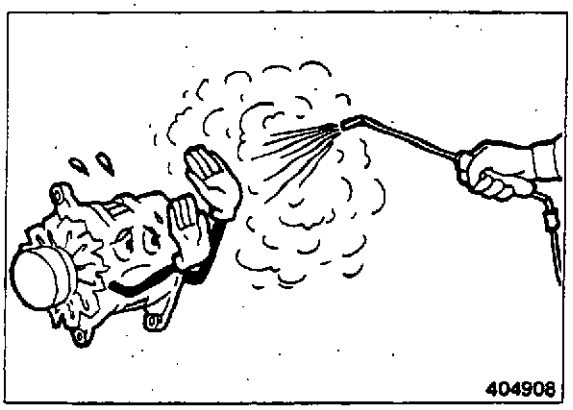
(3) Disconnect the battery cables before charging the battery.

(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.



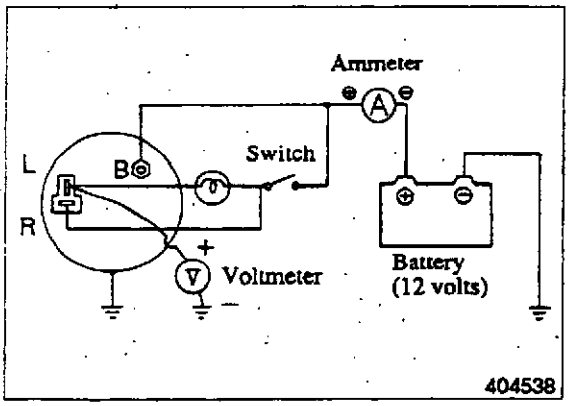
2.3. Testing voltage setting

(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 rpm and also at 2500 rpm with all electrical loads turned off. The voltage setting varies with alternator temperature. Generally, the higher the alternator temperature, the lower the voltage setting.



Connections for testing voltage setting

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

2.4. Testing output characteristics

(1) Disconnect the battery ground (negative) cable.

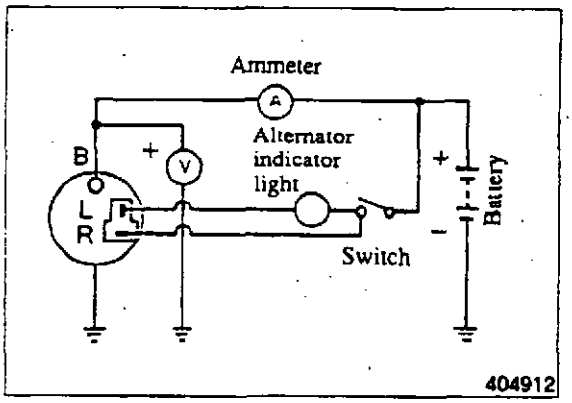
(2) Connect one ammeter lead to the B terminal of the alternator and the other lead to the positive terminal of the battery. Connect one voltmeter lead to the B terminal and the other lead to the ground.

(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.



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

Item	Model	Standards	
		Terminal voltage/ current	Speed
Output characteristics (at normal temperature)	A7T02071	13.5 V/33 A	2 500 rpm, maximum
		13.5 V/47 A	5 000 rpm, maximum

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.

Removing alternator

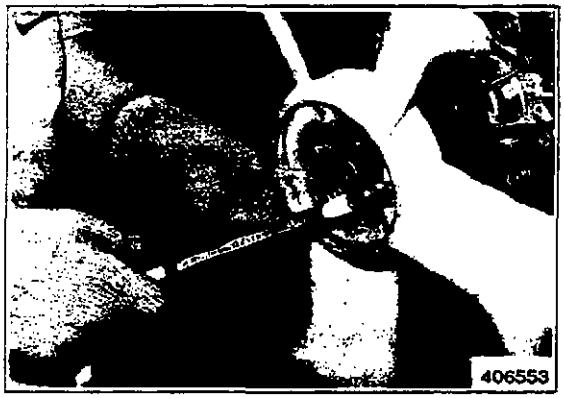
COOLING SYSTEM

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

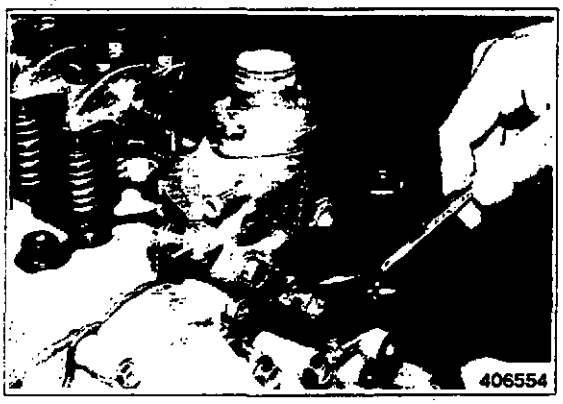
Keep the spacers with the fan for installation.



Removing cooling fan

2. Thermostat case removal

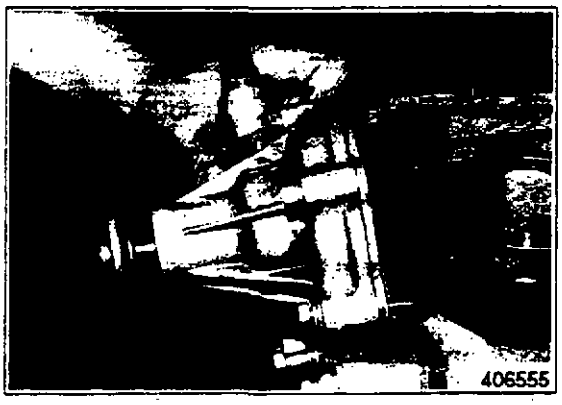
Remove the thermostat case assembly containing thermostat.



Removing thermostat assembly

3. Water pump assembly removal

Remove the water pump assembly.



Removing water pump assembly

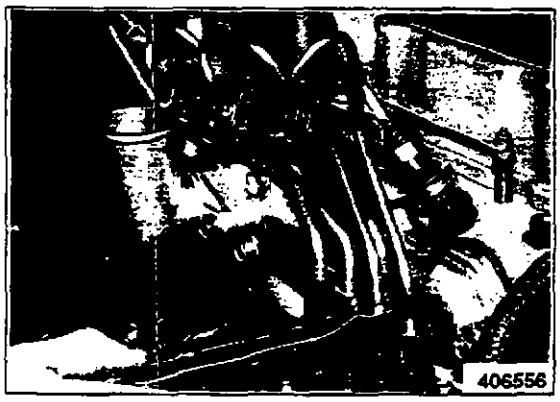
FUEL SYSTEM

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.



Removing fuel injection pipes

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 the like. Discard defective gaskets.

Removing fuel injection nozzles

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.

Removing governor assembly

4. Governor weight removal

(1) Remove the sliding sleeve.

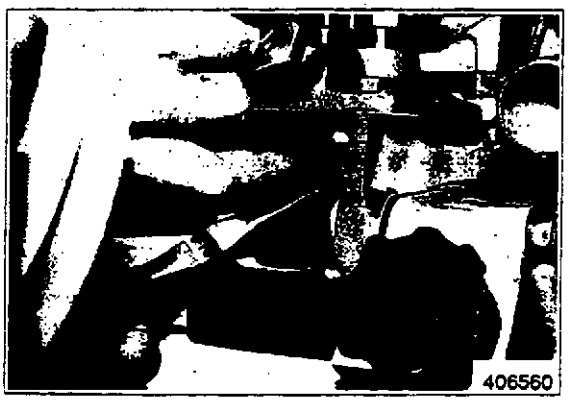
(2) Remove the sliding sleeve shaft and governor weights.

Removing governor weights

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.



Removing tie rod

(3) Remove the fuel injection pump.

NOTE

Keep a record of the thickness of shims for installation.

Removing fuel injection pump

LUBRICATION SYSTEM

1. Oil filter removal

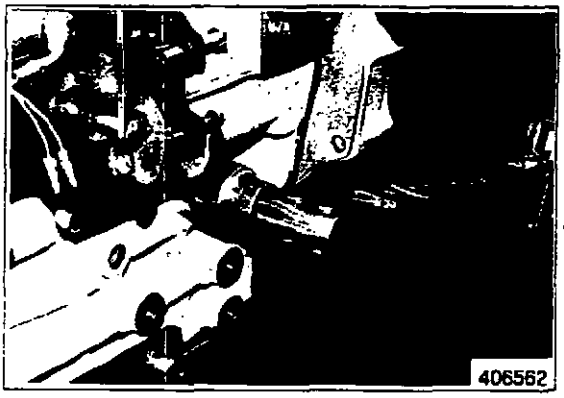
(1) Put a container under the oil filter to catch the oil.

(2) Remove the oil filter from the cylinder block with a filter wrench.

Removing oil filter

2. Pressure relief valve removal

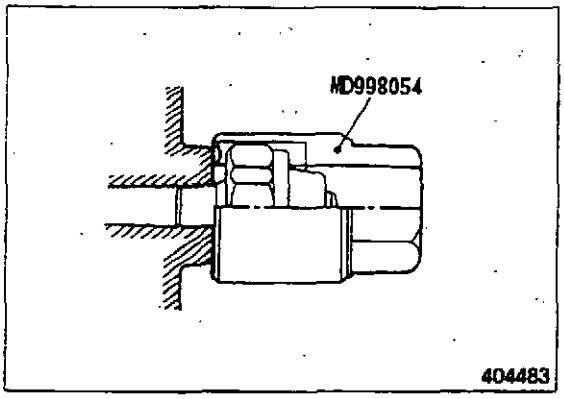
Remove the pressure relief valve from the cylinder block.



Removing pressure relief valve

3. Oil pressure switch removal

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



Removing oil pressure switch

AIR INLET SYSTEM AND EXHAUST SYSTEM

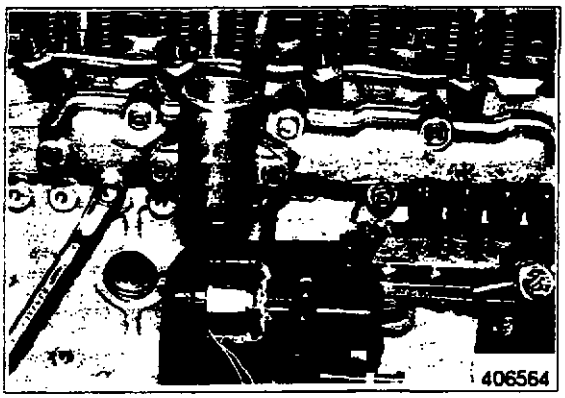
1. Exhaust manifold removal

Remove the exhaust manifold from the cylinder head.

Removing exhaust manifold

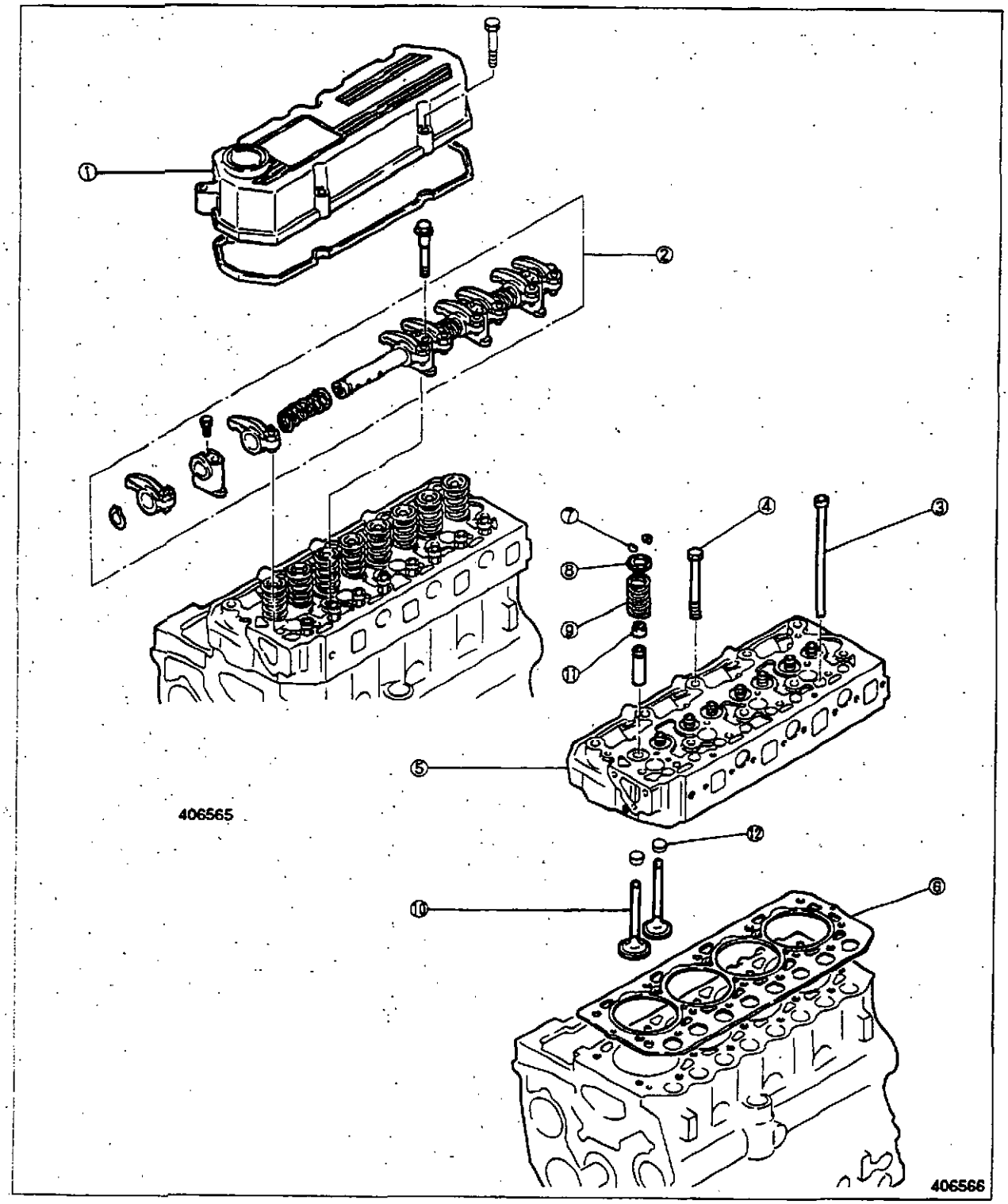
2. Air inlet cover removal

Remove the air inlet cover from the cylinder head.



Removing air inlet cover

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

1. Rocker shaft assembly removal

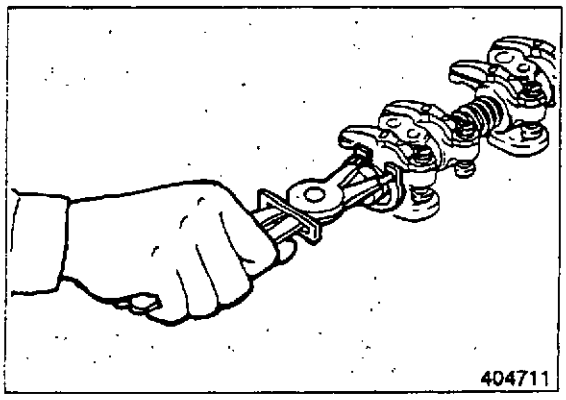
(1) Remove the bolts that hold the rocker stays in position and remove the rocker shaft assembly.

(2) Remove the valve caps.

Removing rocker shaft assemblies

2. Rocker shaft disassembly

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



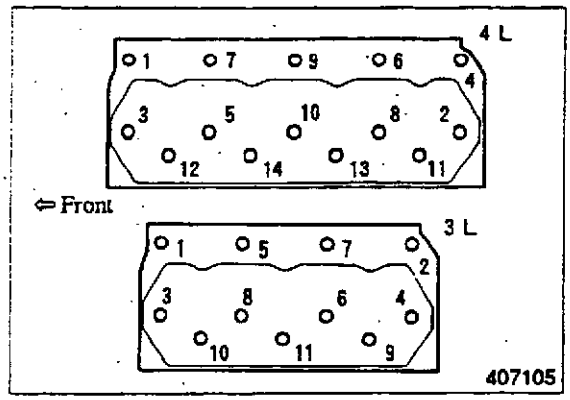
Disassembling rocker shaft assembly

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.



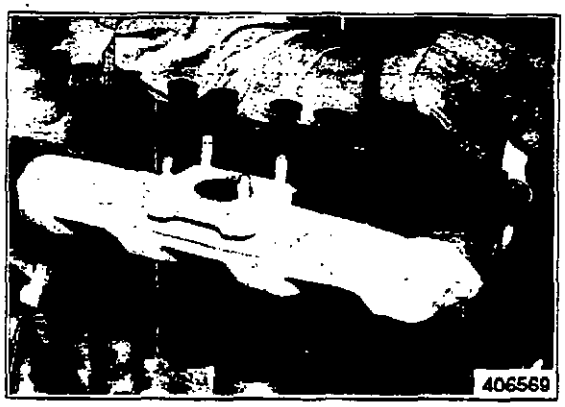
Cylinder head bolt loosening sequence

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.



Removing cylinder head assembly

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.

Removing valve springs

6. Valve stem seal removal

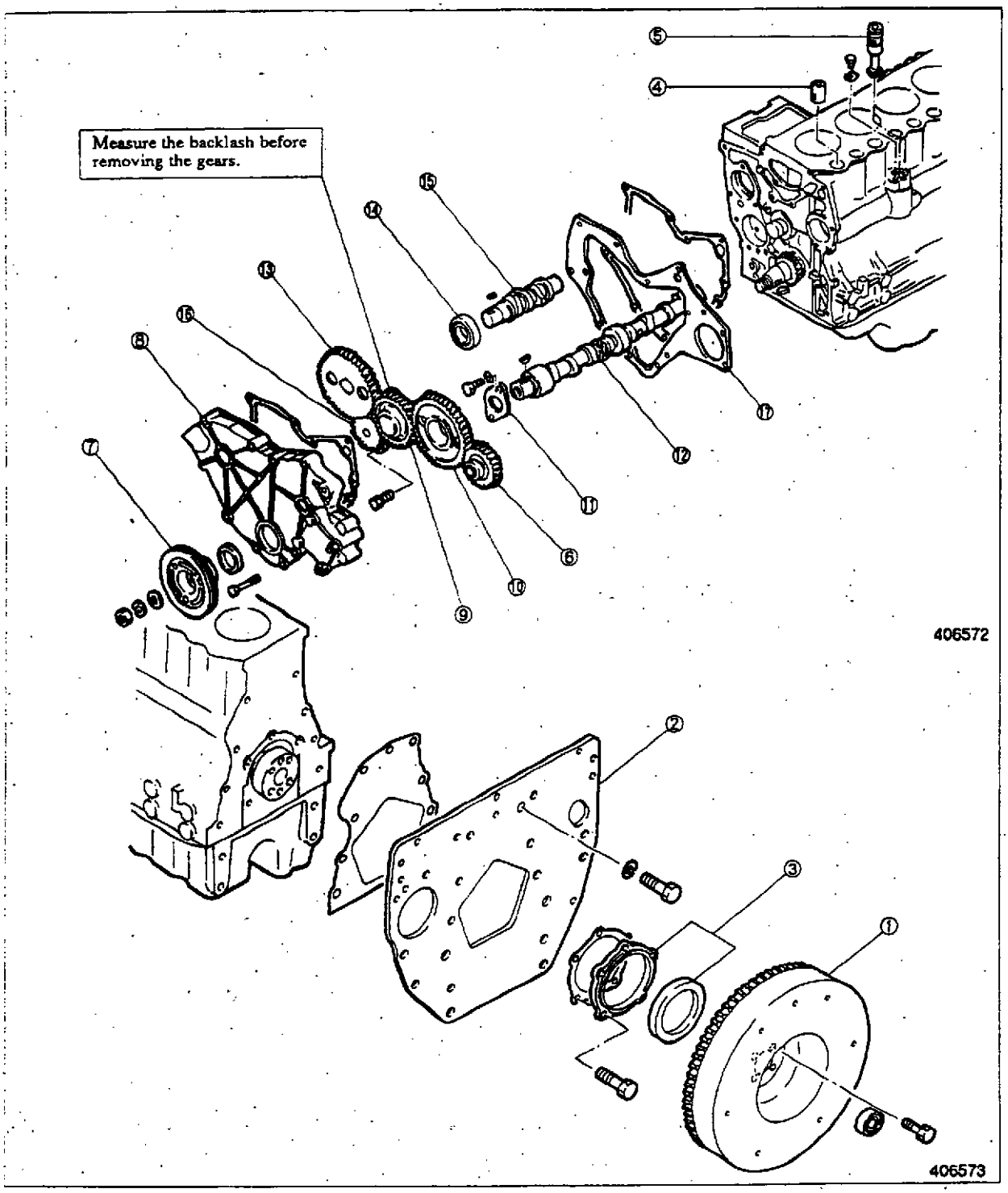
Remove the valve stem seals with a pliers.

NOTE

Do not reuse the valve stem seals.

Removing valve stem seals

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 ⑬ thru ⑮ as an assembly.)
⑬ Fuel injection pump camshaft gear
⑭ Bearing
⑮ Fuel injection pump camshaft
⑯ Oil pump
⑰ Front plate

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.

Holding 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.

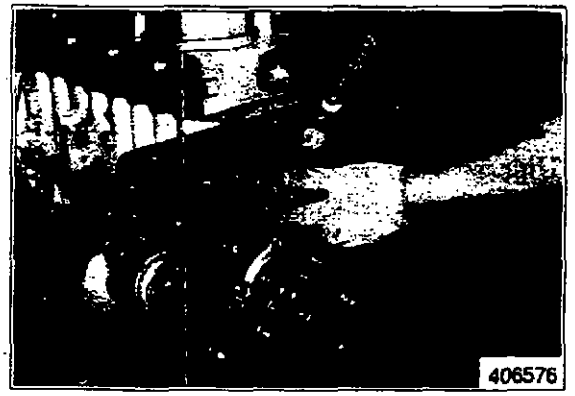
⚠ WARNING

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

Removing flywheel

2. Rear plate removal

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



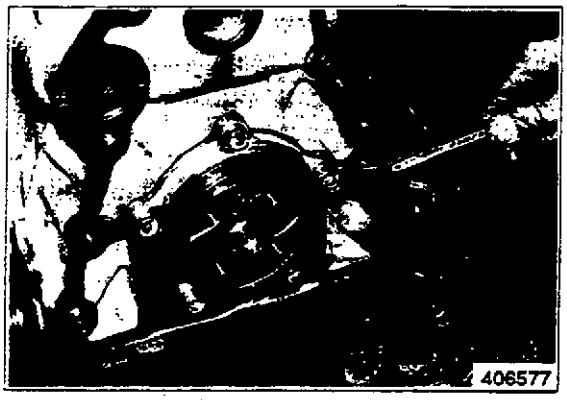
Removing rear plate

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.



Removing oil seal case

4. Tappet removal

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

NOTE

The tappers will fall into the oil pan if the camshaft is removed before the tappets are removed.

Removing tappets

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.

Removing speedometer driven gear

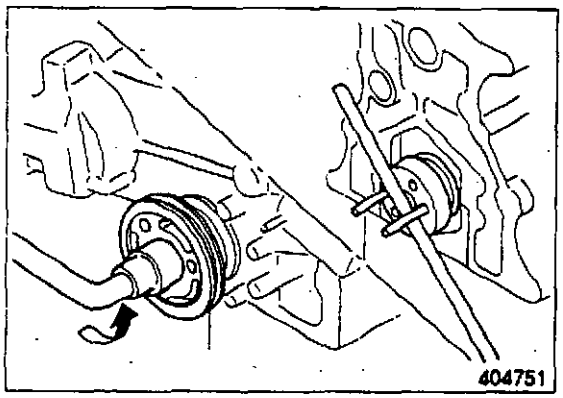
6. Crankshaft pulley removal

(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.



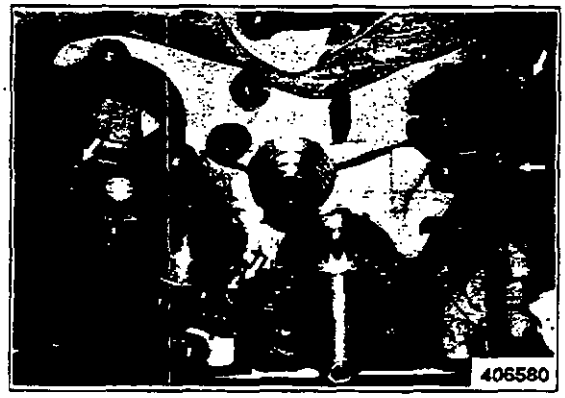
Removing crankshaft pulley

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.



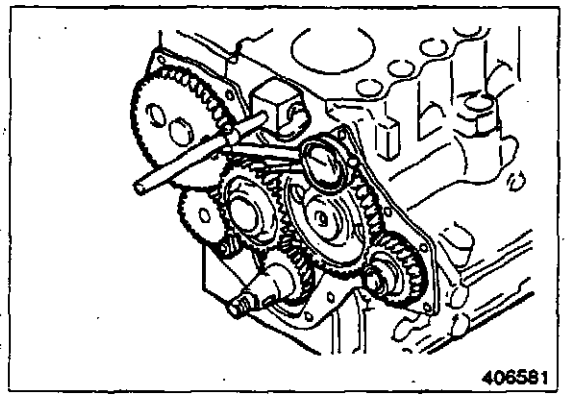
Front plate attaching bolts

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)	



Measuring timing gear backlash

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.

Removing idler gear

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.

Removing camshaft

11. Fuel injection pump camshaft removal

(1) Remove the stopper bolt.

Removing camshaft stopper bolt

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

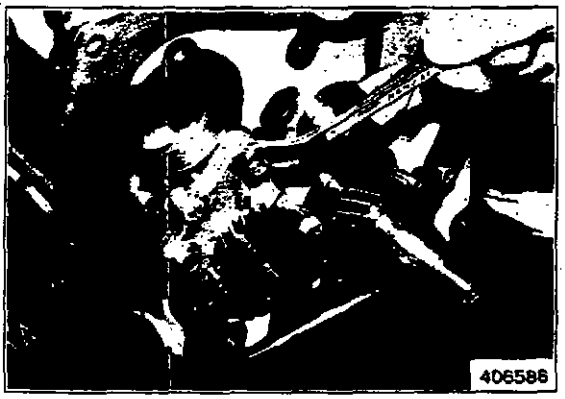
Removing fuel injection pump camshaft

12. Gear removal (when required)

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

13. Oil pump removal

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



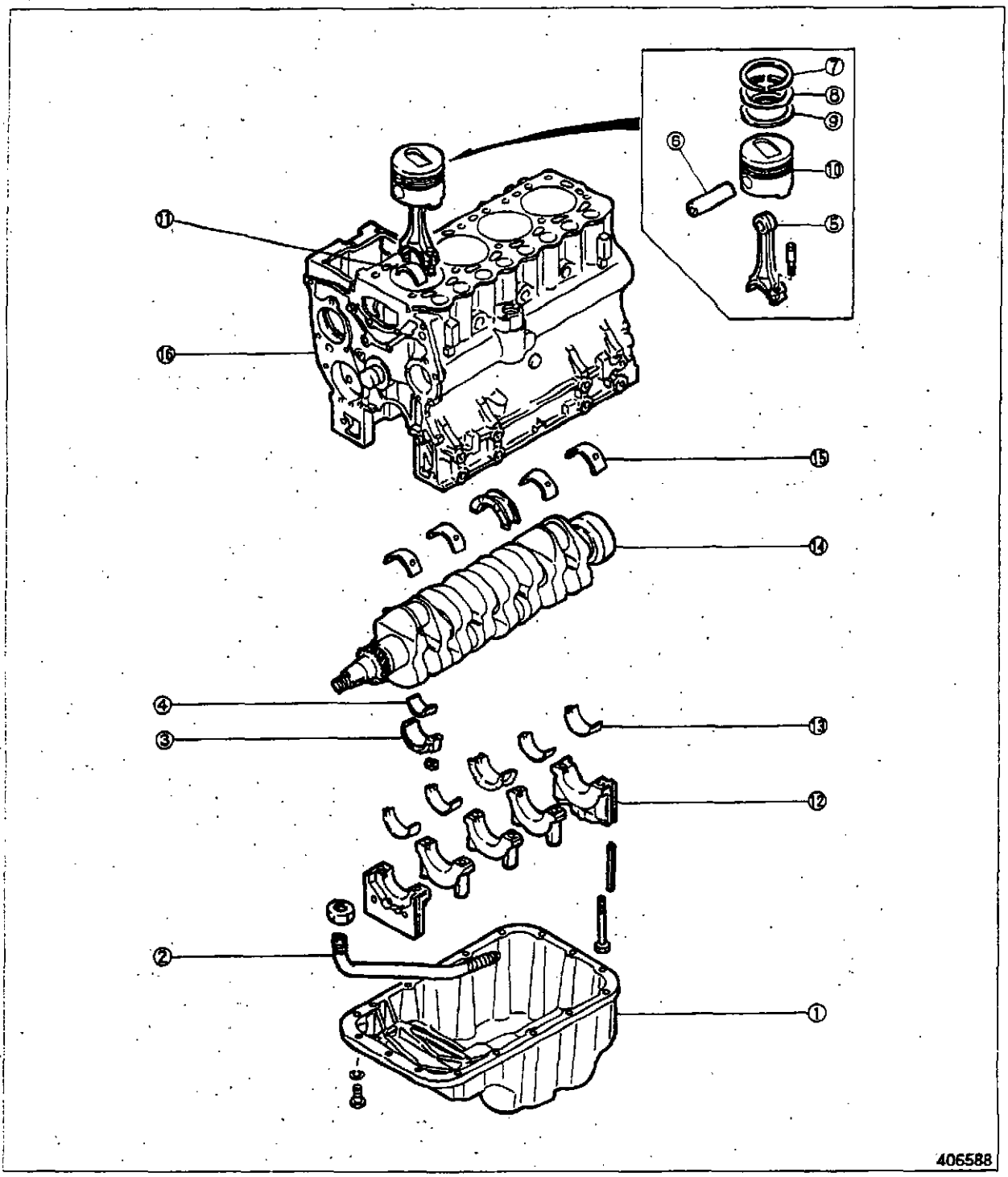
Removing oil pump

14. Front plate removal

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

Removing front plate

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.

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.

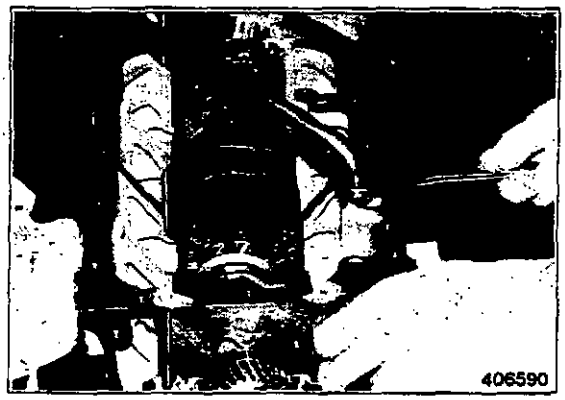
⚠ CAUTION

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.

Removing oil pan

2. Oil screen removal

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



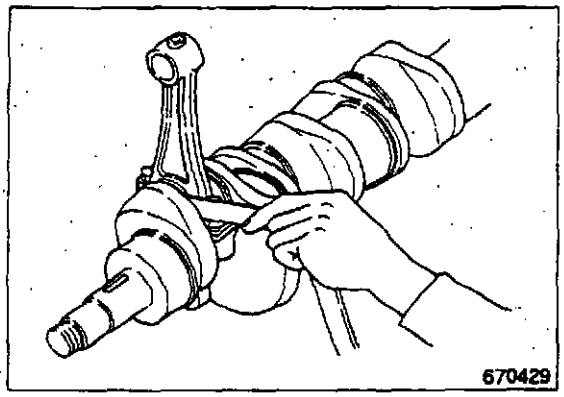
Removing oil screen

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)



Measuring thrust clearance for connecting rod big end

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.

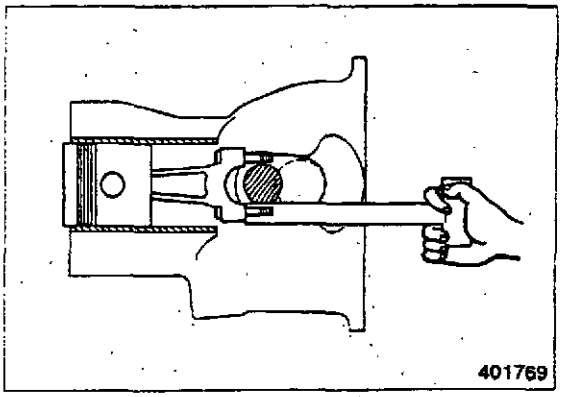
(3) Remove the caps.

Removing connecting rod caps

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.



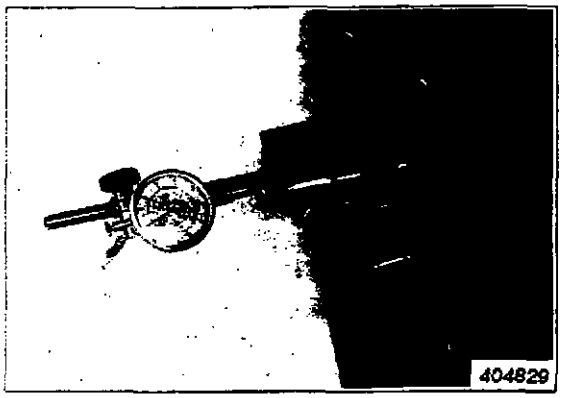
Removing piston

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)



Measuring end play for crankshaft

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.

Removing main bearing caps

8. Crankshaft removal

Remove the crankshaft.

⚠ CAUTION

Do not cause damage to the bearings.

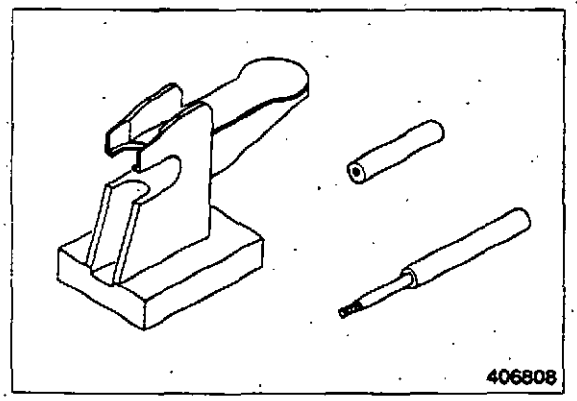
NOTE

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

Removing crankshaft

9. Piston separation from connecting rod

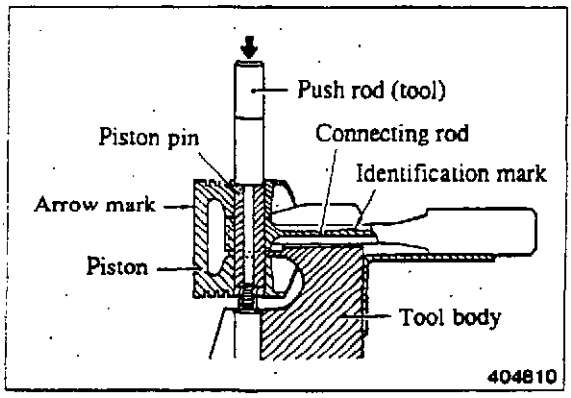
(1) Use Piston Pin Setting Tool (31A91-00100) (special tool) to separate the piston from the connecting rod.



Piston pin setting tool

(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.

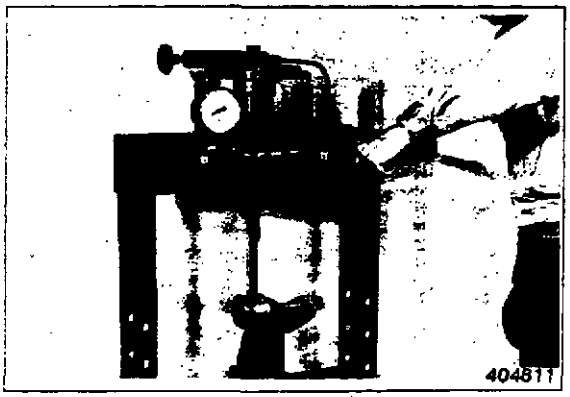
(3) Use this Piston Pin Setting Tool to install the connecting rod to the piston.



Removing piston pin (1)

⚠ CAUTION

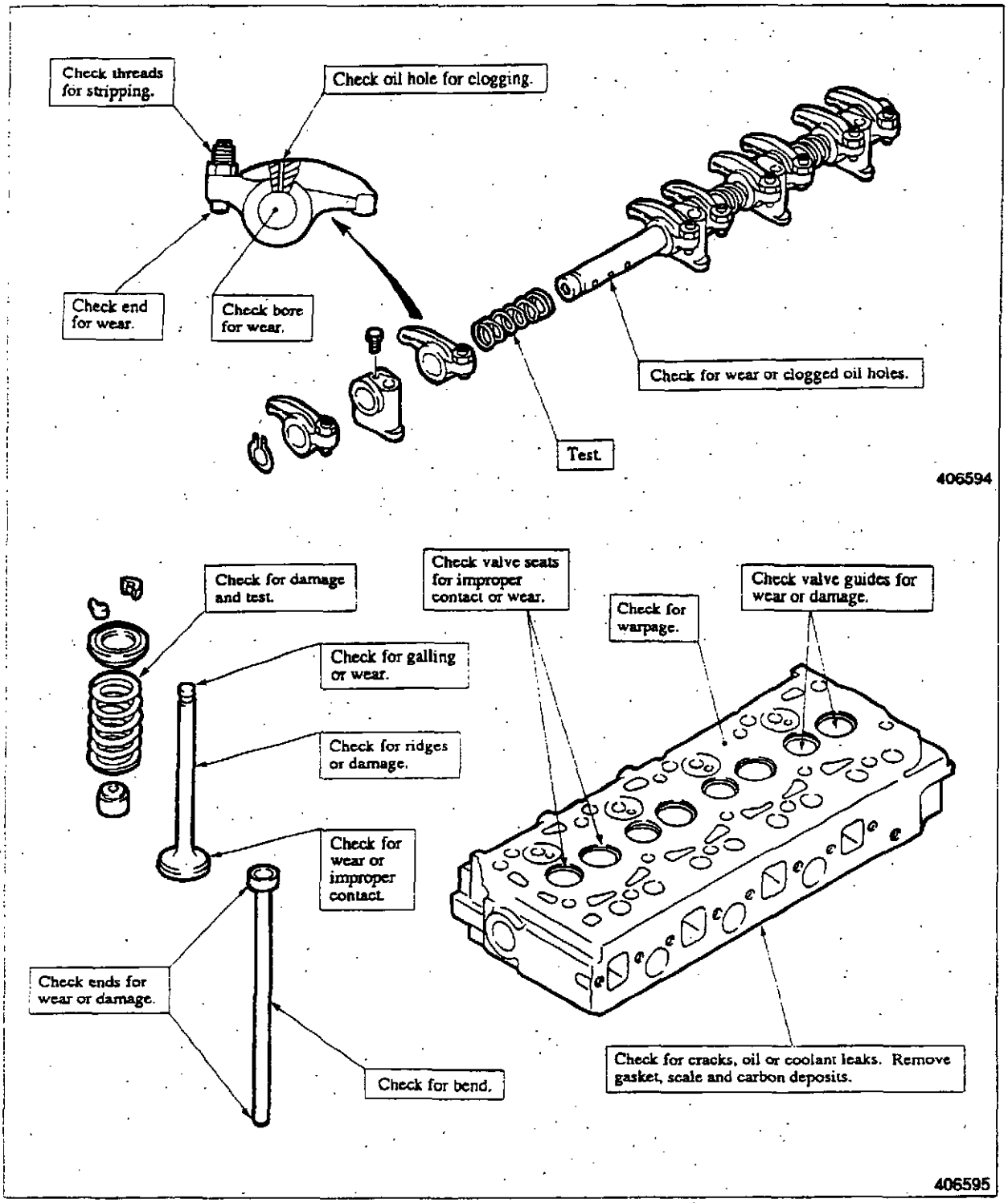
Do not attempt to remove the piston pin by tapping. Replace a piston pin which needs a greater force for removal.



Removing piston pin (2)

INSPECTION

CYLINDER HEAD AND VALVE MECHANISM



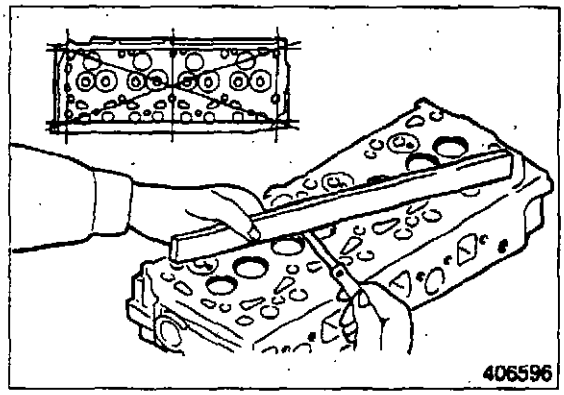
Inspection points

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)



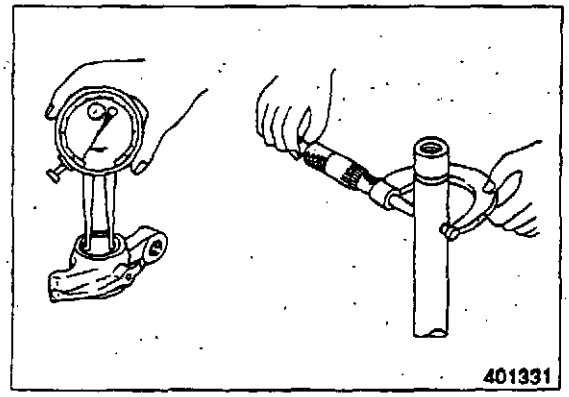
Checking cylinder head bottom face for warpage

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)



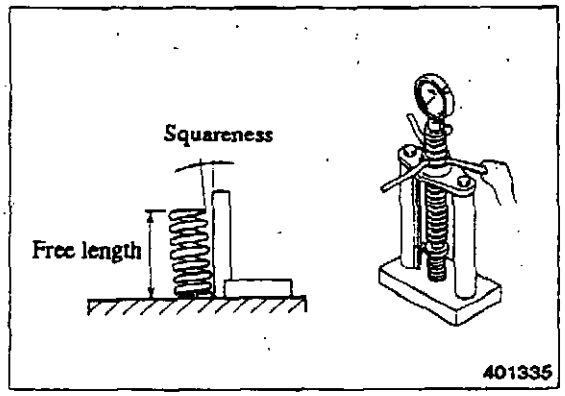
Measuring rocker arm and rocker shaft

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]	



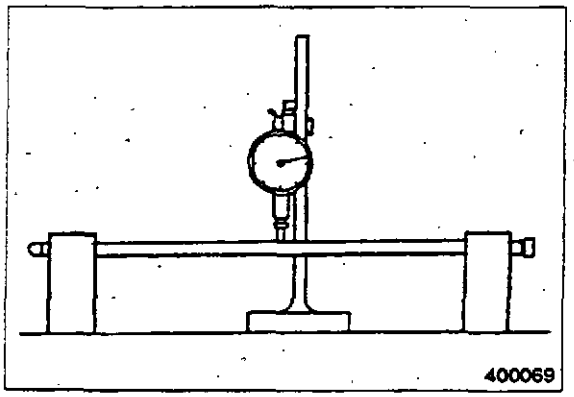
Testing valve spring

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



Checking bend of valve push rod

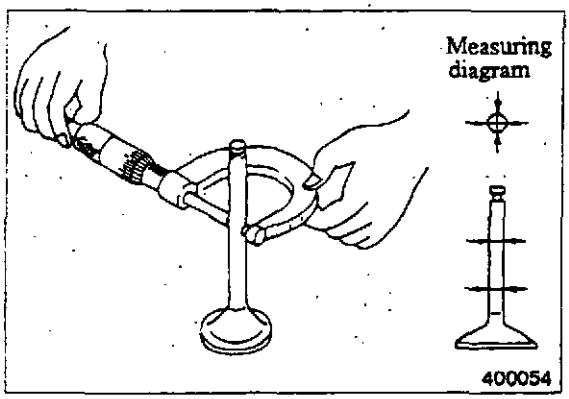
5. Valves, valve guides and valve seats

(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.)

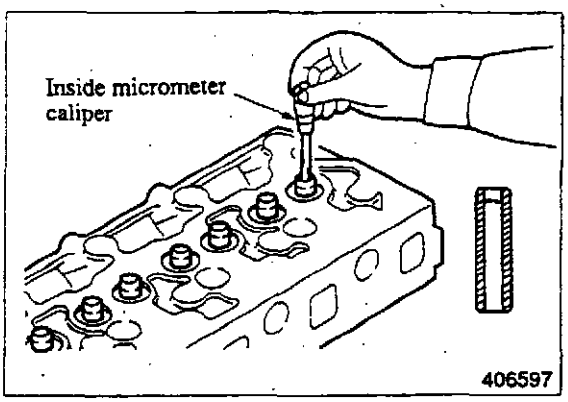
Item		Nominal size	Standard	Limit
Diameter of valve stem	Inlet valve	6.6 (0.260)	6.565 to 6.580 (0.258 46 to 0.259 05)	6.500 (0.255 91)
	Exhaust valve	6.6 (0.260)	6.530 to 6.550 (0.257 09 to 0.257 87)	



Measuring valve stem

(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.



Measuring valve guide

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.

(3) Valve guide replacement

(a) Remove the guide from the cylinder head by pushing it with a tool and an arbor press from the bottom side of the head.

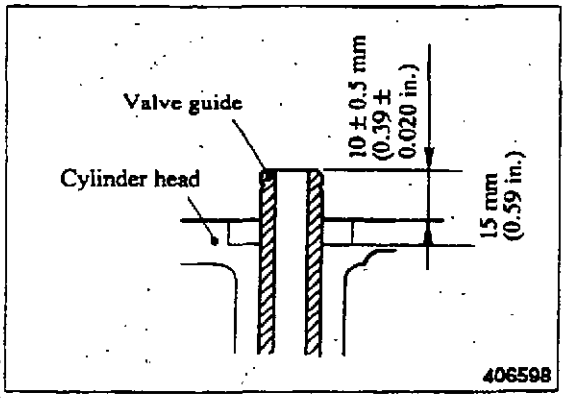
(b) Install a new guide into the cylinder head by pushing it with an arbor press from the upper side of the head until the specified height to the top of the guide is obtained.

(c) Insert a new valve into the guide and make sure the valve slides in the guide freely.

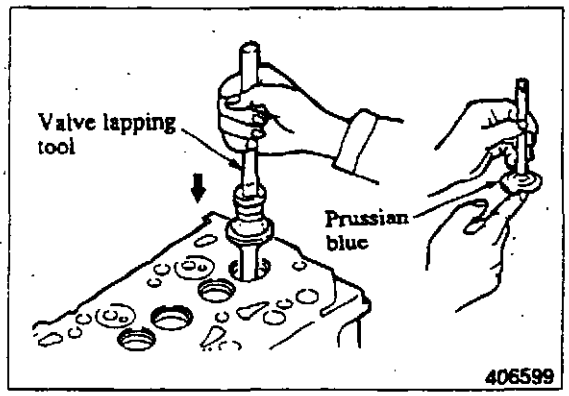
(d) After the valve guide has been replaced, check the valve contact with its seat.

(4) Valves

(a) Put a small amount of Prussian blue or read 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.

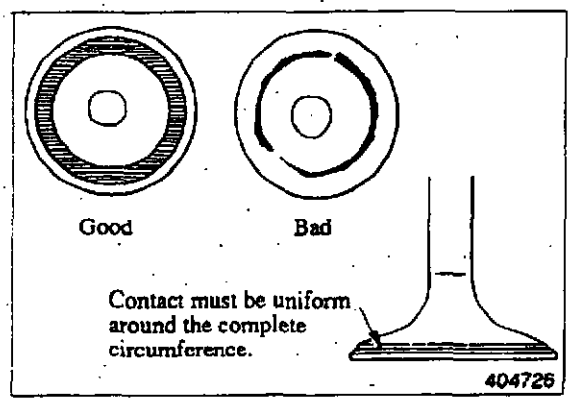


Height to top of valve guide



Checking valve contact with seat

(b) 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.



Valve and valve seat contact

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

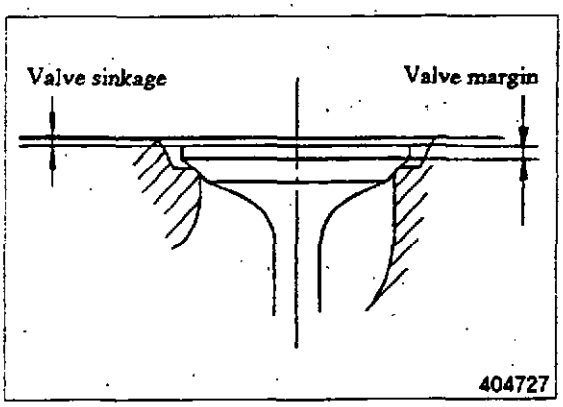
Unit: mm (in.)

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

(d) 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)

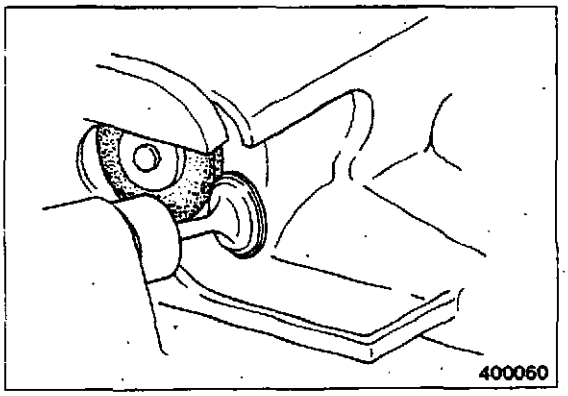


Valve margin and sinkage

(5) Valve refacing

(a) Set the valve refacer at an angle of 45° and grind the valve.

(b) 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.

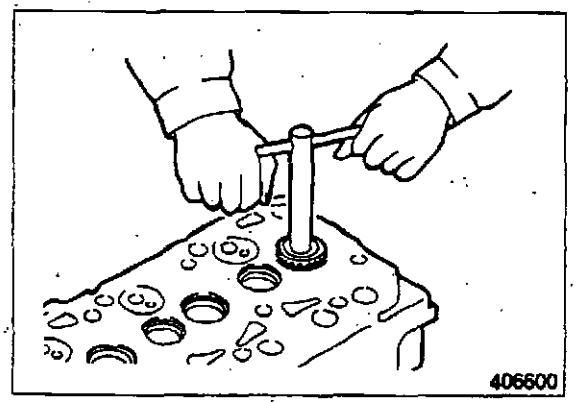


Refacing valve face

(6) Valve seat refacing

(a) Before refacing the valve seat, check the clearance between the valve and guide, and replace the guide if necessary.

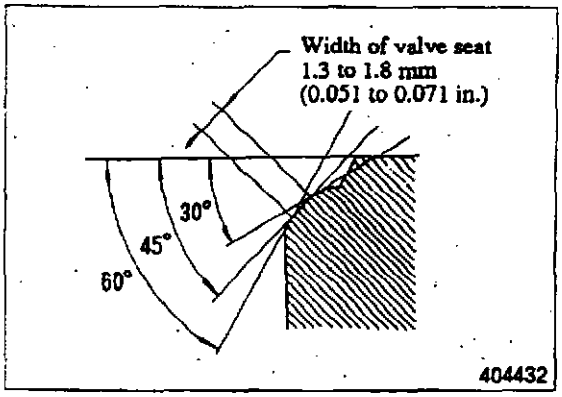
(b) Cut the valve seat with a valve seat cutter (commercially available), or grind it with a valve seat grinder, and finish the width of valve seat and the angle of seat face to the correct values.



Refacing valve seat

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)



Valve seat width and valve face angle

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

(7) Valve lapping

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

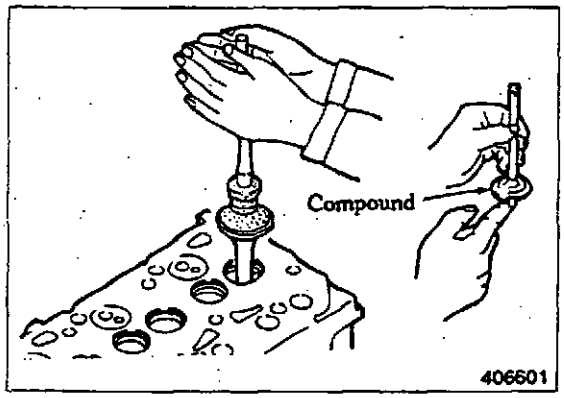
(a) Put a small amount of lapping compound on the valve face.

NOTE

a) Do not put lapping compound on the valve stem.

b) Use a lapping compound of 120 to 150 mesh for initial lapping and a compound of finer than 200 mesh for finish lapping.

c) Mixing the compound with a small amount of engine oil will help put the compound on the valve face uniformly.



Lapping valve in seat

(b) 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 seal,

rotating it to a new position. Press the valve against the seal for another part of a turn. Repeat this operation until the compound wears and loses its cutting property.

(c) Wash the valve and valve seat with dry cleaning solvent.

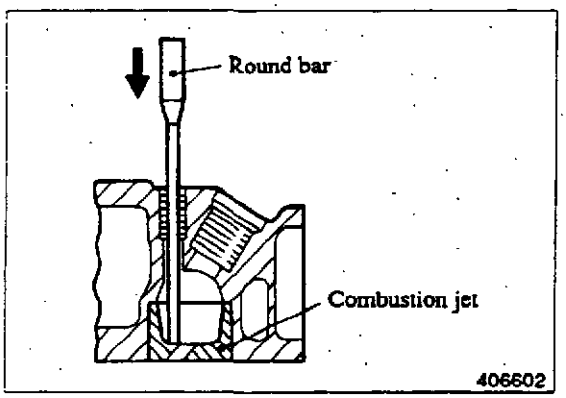
(d) Apply engine oil to the valve and lap it in the seat.

(e) Check the valve face for contact.

6. Combustion jet replacement

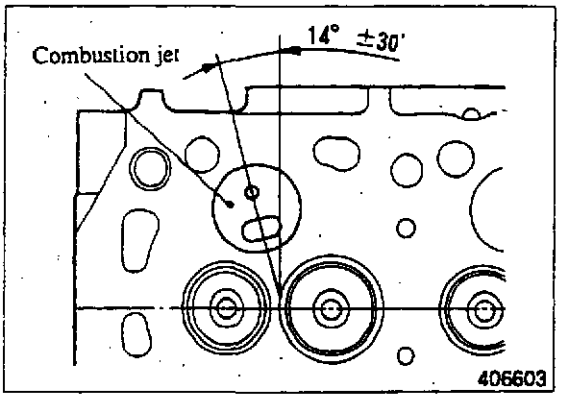
Replace the combustion jets only when they are cracked or defective.

(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.



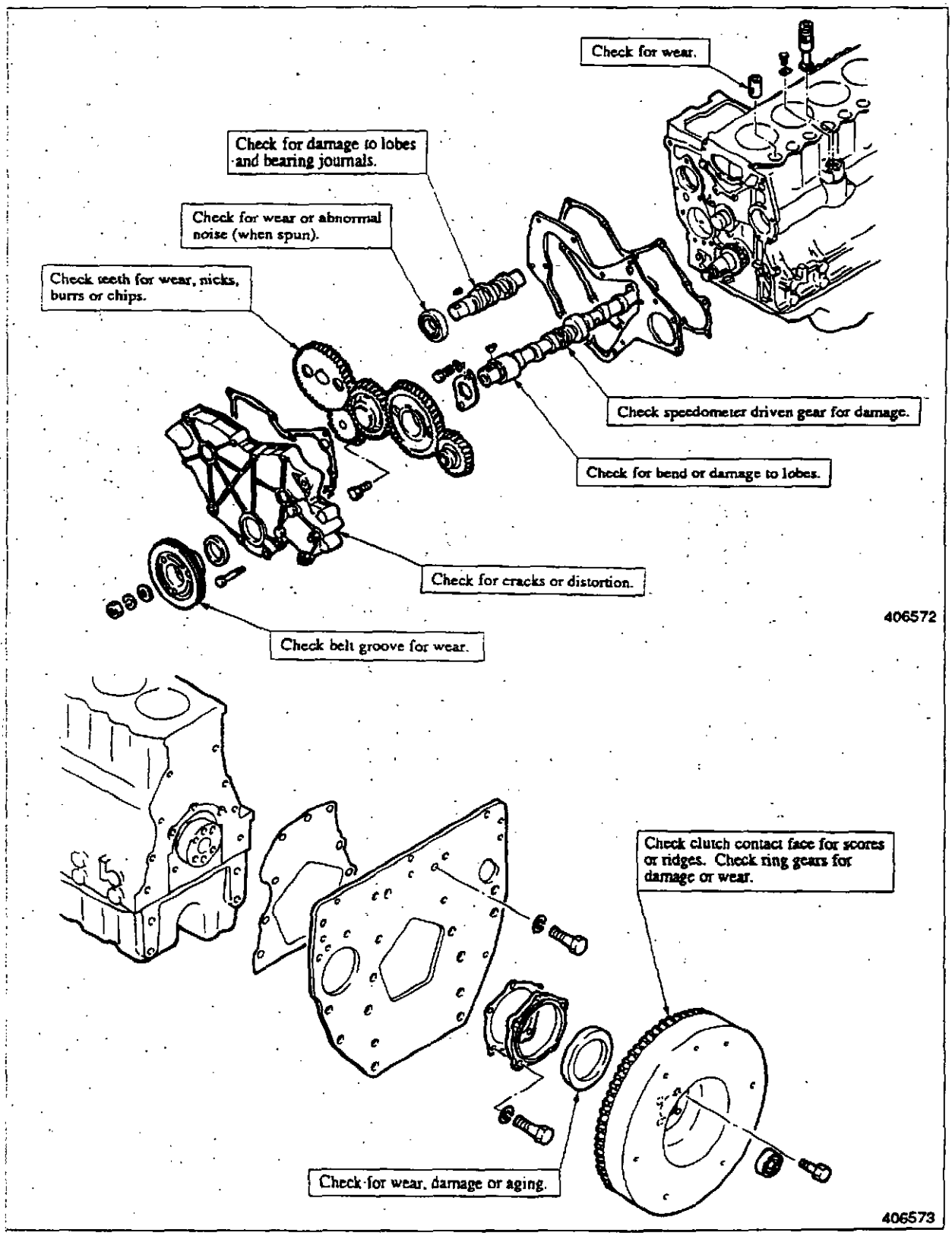
Removing combustion jet

(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.



Installing combustion jet

TIMING GEARS AND FLYWHEEL



Inspection points

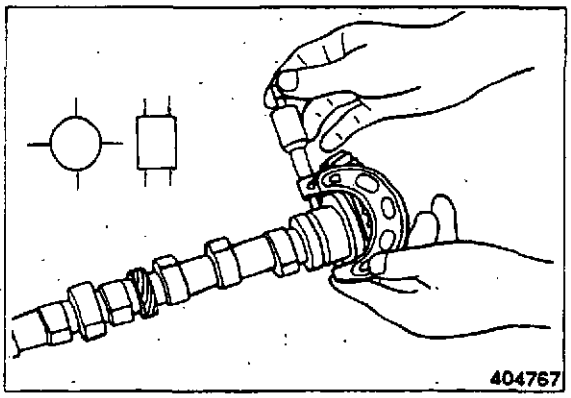
1. Camshaft

(1) Clearance between journal and bushing

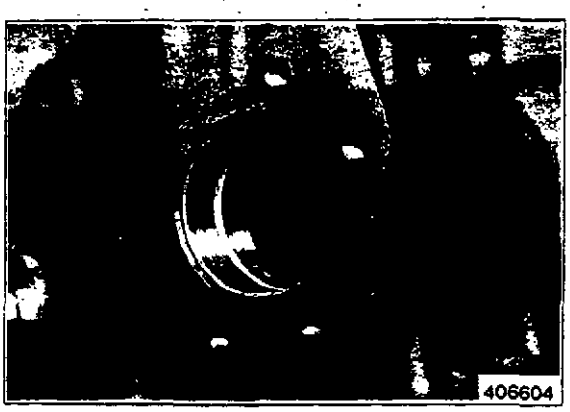
Measure the diameter of the journal and the bore in the bushing for the shaft to find the clearance as shown in the illustration. If the clearance exceeds the limit, replace the bushing.

Unit: mm (in.)

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



Measuring camshaft journal



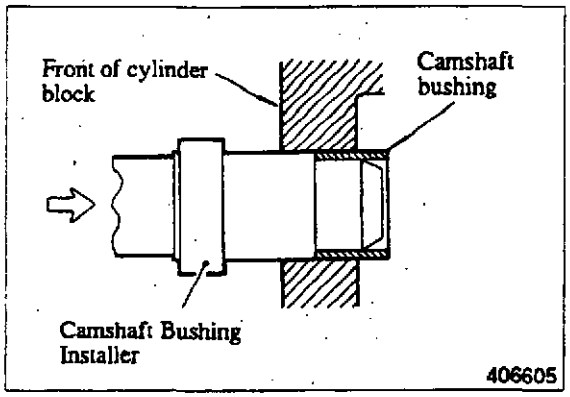
Measuring bore in camshaft bushing

(2) Bushing replacement

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

(a) Removal

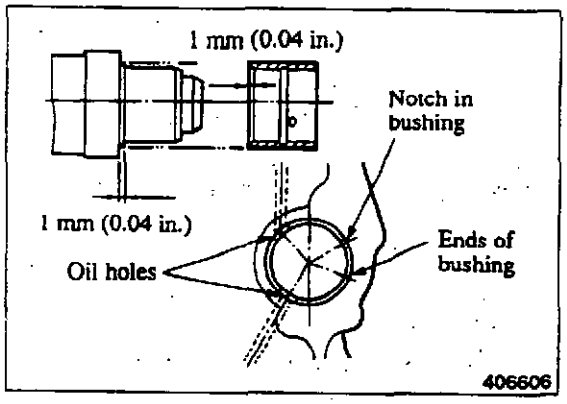
Remove the oil pan. Using a "remover" end of the Installer, push out the bushing into the cylinder block. Crush and take out the bushing from the block.



Removing camshaft bushing

(b) Installation

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



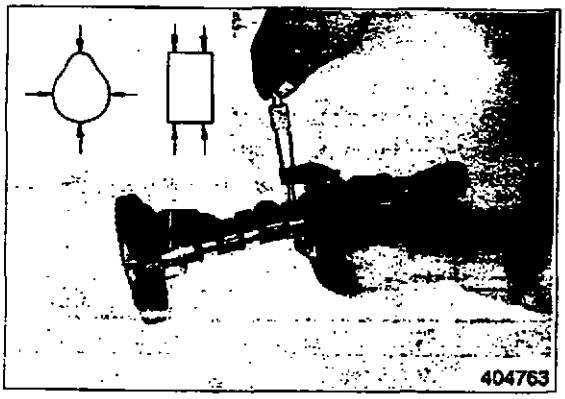
Installing camshaft bushing

(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 (1.406 3)	34.72 (1.366 9)



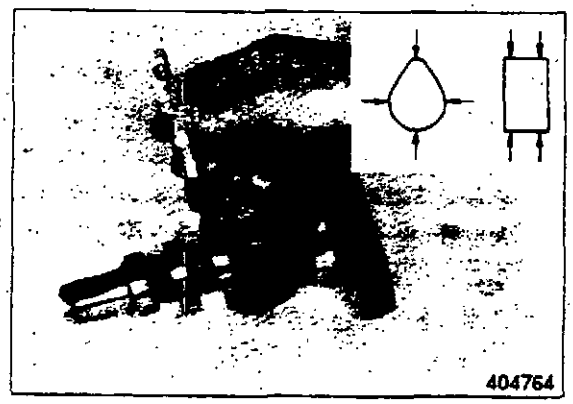
Measuring lobe height of camshaft

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)

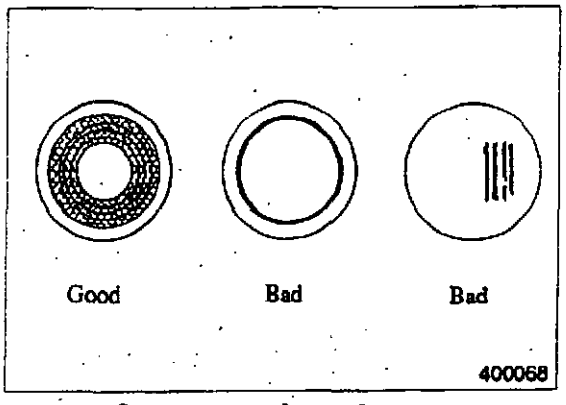


Measuring lobe height of fuel injection pump camshaft

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.



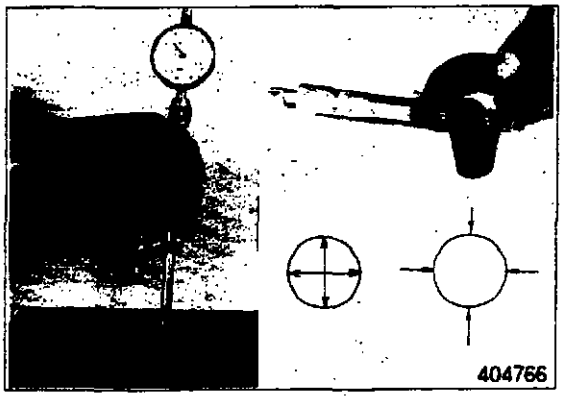
Cam contact face of tappet

(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)



Measuring tappet and bore in cylinder

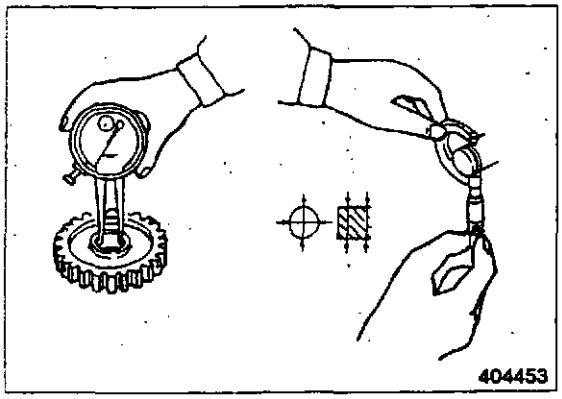
4. Idler gear

(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.)

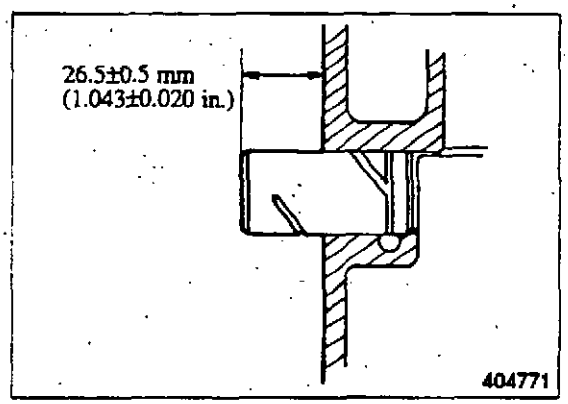
Item	Standard	Limit
Clearance between idler gear and shaft	0.03 to 0.07 (0.001 2 to 0.002 8)	0.20 (0.007 9)



Measuring idler gear and shaft

(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.).



Idler shaft dimension

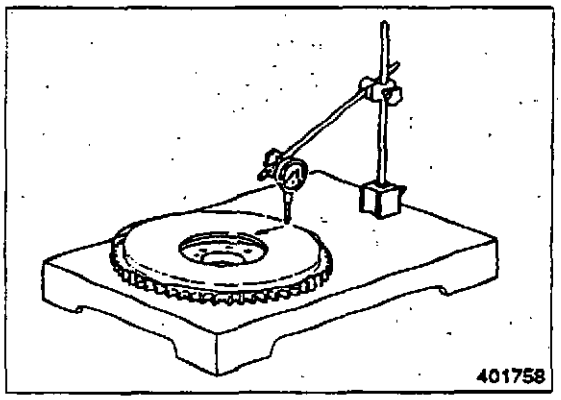
5. Flywheel and ring gear

(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)



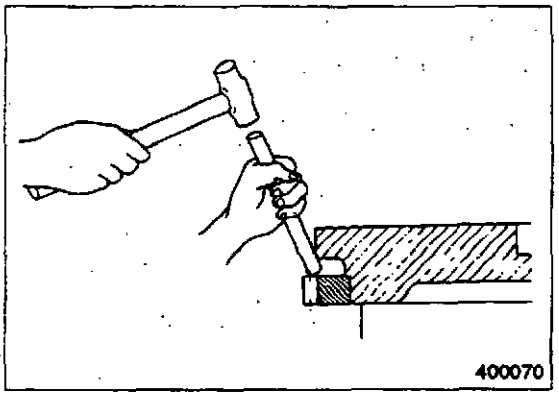
Measuring flywheel flatness

(2) Ring gear replacement

Check the ring gear and replace it if its teeth are abnormally worn or chipped.

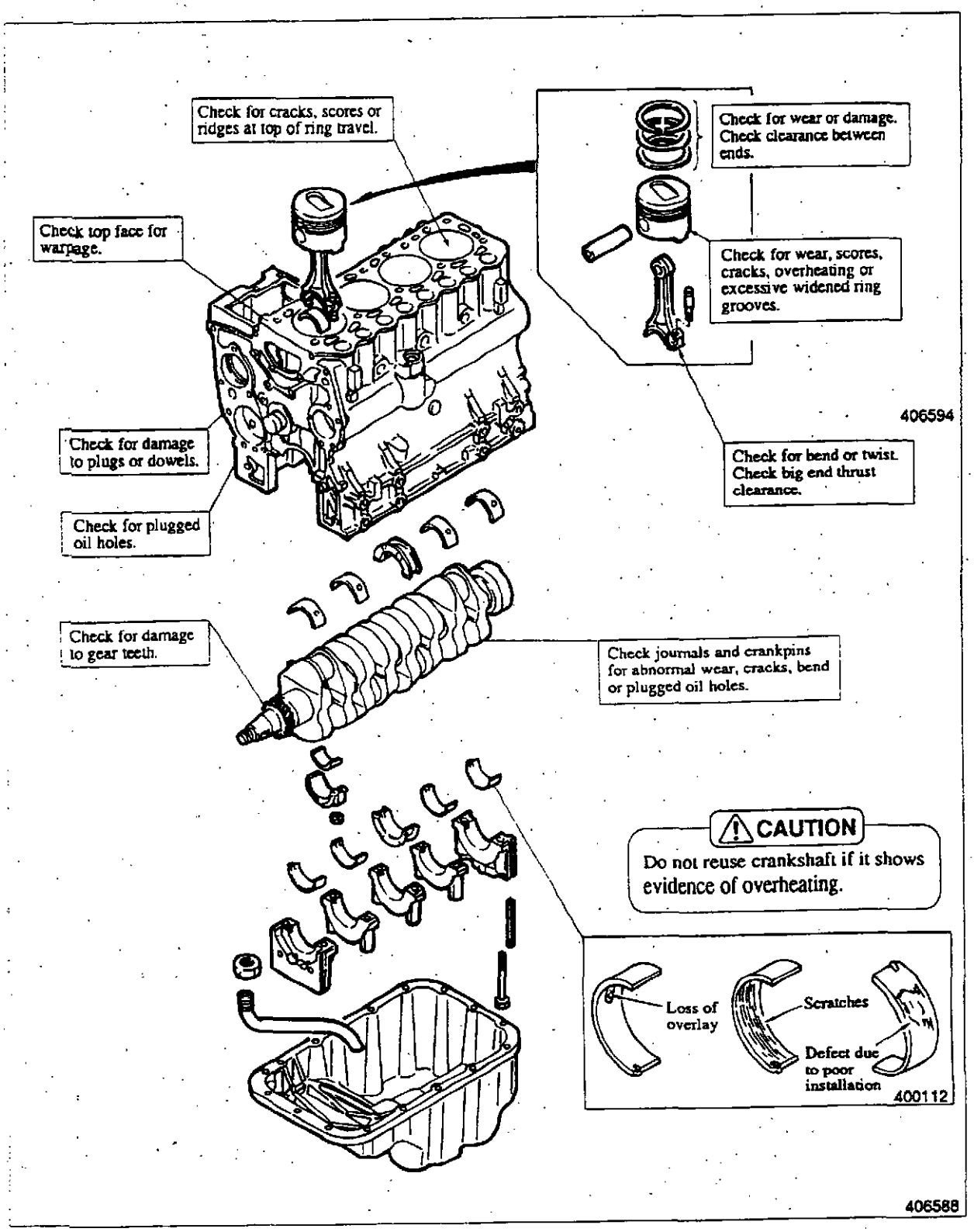
(a) Removal
Heat the ring gear evenly with an acetylene torch. Tap the ring gear all the way around with a bar and a hammer as shown in the illustration to remove it from the flywheel.

(b) 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.



Removing ring gear

CYLINDER BLOCK, CRANKSHAFT, PISTONS AND OIL PAN

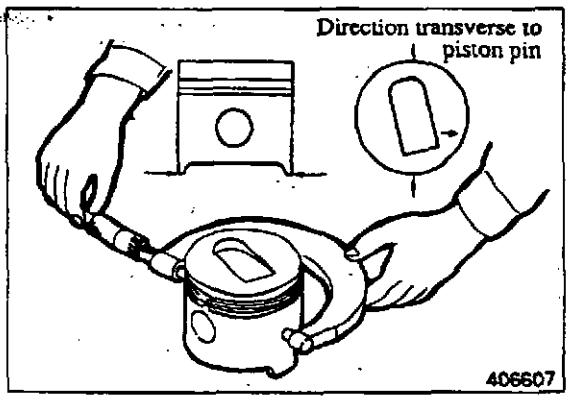


Inspection points

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.



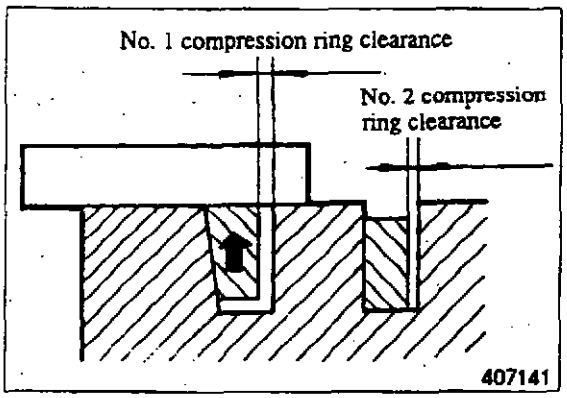
Measuring diameter of piston

Unit: mm (in.)

Item		Nominal size	Standard	Limit
Diameter of piston	Standard	78.00 (3.070 9)	77.93 to 77.95 (3.068 1 to 3.068 9)	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 78.45 (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)	—

(2) Clearance between piston ring and groove

(a) 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.



Measuring clearance between piston ring and groove

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	0.05 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)

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

(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

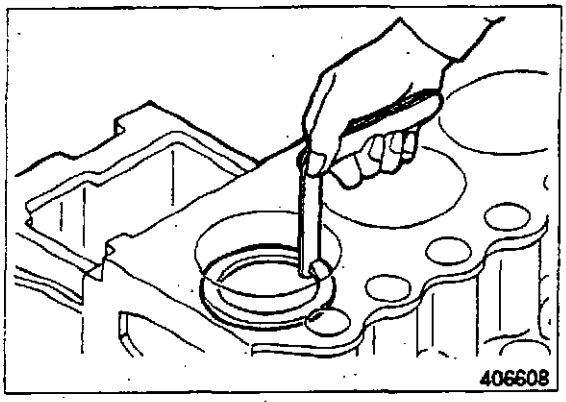
Standard: $78^{+0.03}_{0}$ mm ($3.07^{+0.001\,2}_{0}$ in.)

0.25 mm (0.0098 in.) oversize:

$78.25^{+0.03}_{0}$ mm ($3.08^{+0.001\,2}_{0}$ in.)

0.50 mm (0.0197 in.) oversize:

$78.50^{+0.03}_{0}$ mm ($3.09^{+0.001\,2}_{0}$ in.)



Measuring clearance between ends of piston ring

NOTE

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

Unit: mm (in.)

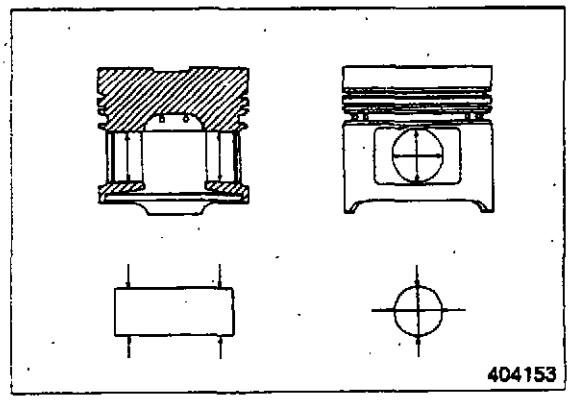
Item		Standard	Limit
Clearance between ends of piston ring	No. 1 compression ring	0.15 to 0.30 (0.005 9 to 0.011 8)	1.50 (0.059 1)
	No. 2 compression ring	0.15 to 0.35 (0.005 9 to 0.013 8)	
	Oil ring	0.20 to 0.40 (0.007 9 to 0.015 7)	

(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	Nominal size	Standard	Limit
Diameter of piston pin	23 (0.91)	22.994 to 23.000 (0.905 27 to 0.905 51)	
Clearance between piston pin and piston	—	0.006 to 0.018 (0.000 24 to 0.000 71)	0.050 (0.001 97)



Measuring piston pin and bore in piston for pin

2. Connecting rods

Check the connecting rod for bend or twist as follows:

(a) 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.)

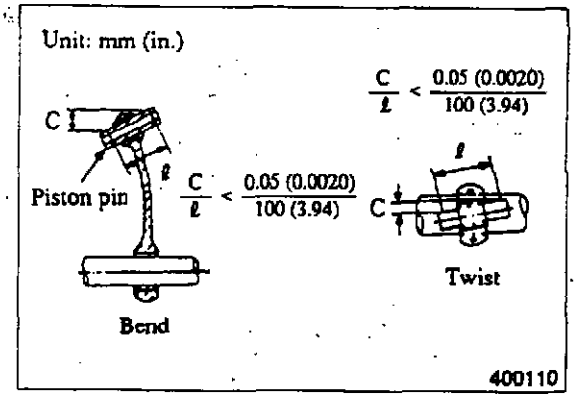
Item	Standard	Limit
Bend or twist of connecting rod	0.05/100 (0.002 0/3.94) maximum	0.15/100 (0.005 9/ 3.94)

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

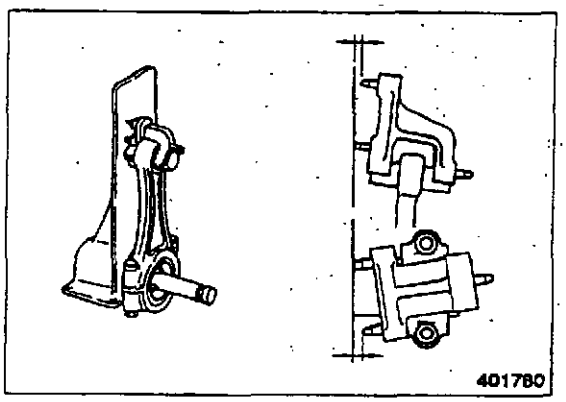
NOTE

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

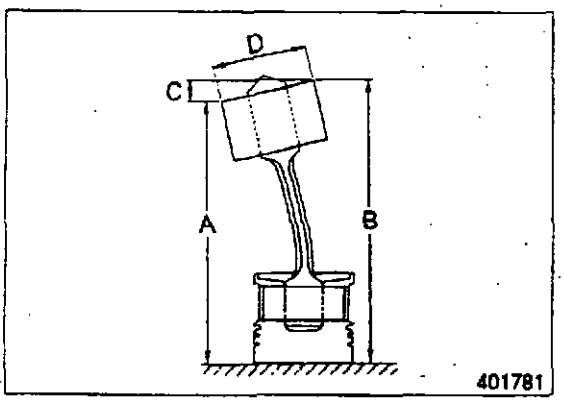
(c) To check the connecting rod fitted to the piston for bend, put the connecting rod and piston on the surface plate as shown in the illustration, insert a round bar having a diameter equal to that of the crankpin into the bore in the big end of the rod and measure "A" and "B" with a dial indicator.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



Checking connecting rod for bend or twist



Check connecting rod on a connecting rod aligner



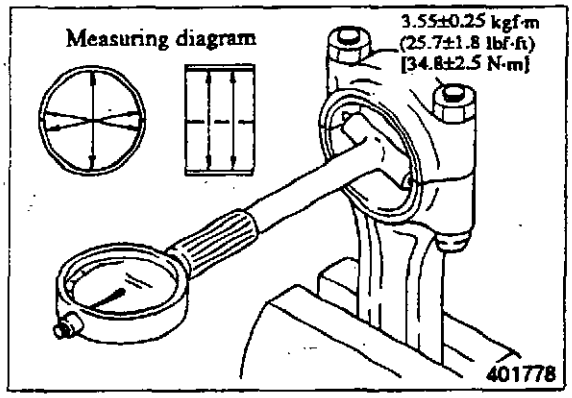
Checking connecting rod for bend with a dial indicator

3. Crankshaft

(1) Clearance between crankpin and connecting rod bearing

(a) 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]

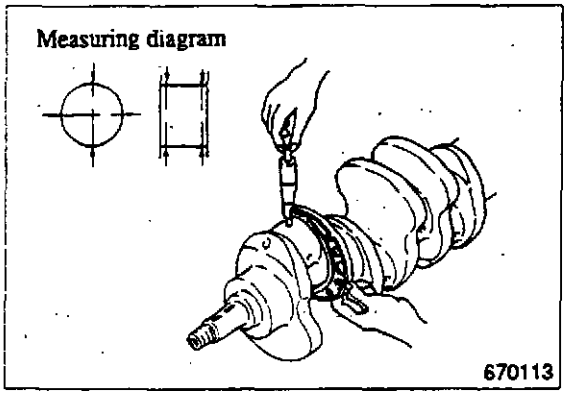


Measuring bore in connecting rod bearing

(b) 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	Nominal 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)



Measuring diameter of crankpin

(c) If the clearance exceeds the limit, install a new bearing and check the clearance again.

(d) 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.

Crankpin undersizes

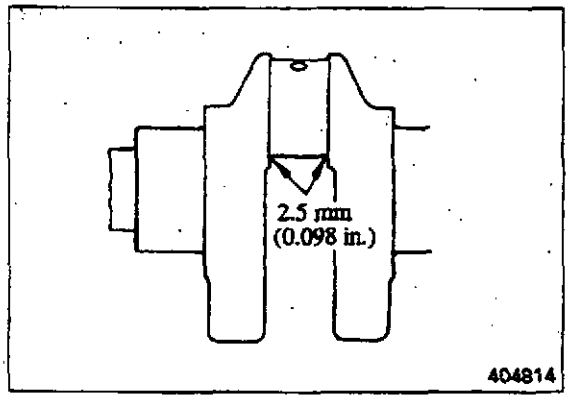
Unit: mm (in.)

Item	Undersize	Finish
Crankpin	0.25 (0.009 8)	$47.75^{-0.035}_{-0.050}$ ($1.879\,9^{-0.001\,38}_{-0.001\,97}$)
	0.50 (0.019 7)	$47.50^{-0.035}_{-0.050}$ ($1.870\,1^{-0.001\,38}_{-0.001\,97}$)
	0.75 (0.029 5)	$47.25^{-0.035}_{-0.050}$ ($1.860\,2^{-0.001\,38}_{-0.001\,97}$)

⚠ CAUTION

a) Grind all the crankpins of one crankshaft to the same undersize.

b) Finish the crankpin fillets to a radius of 2.5 mm (0.098 in.).

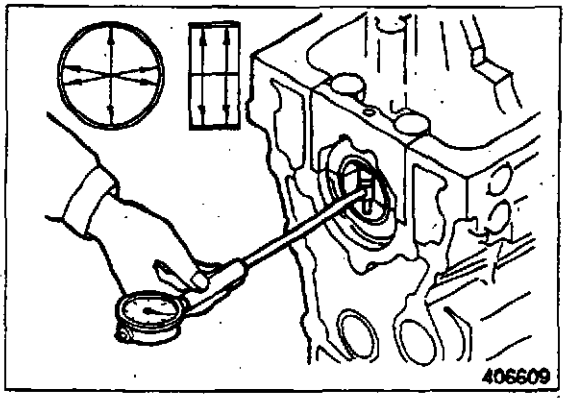


Crankpin fillet radius

(2) Clearance between journal and main bearing

(a) 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]

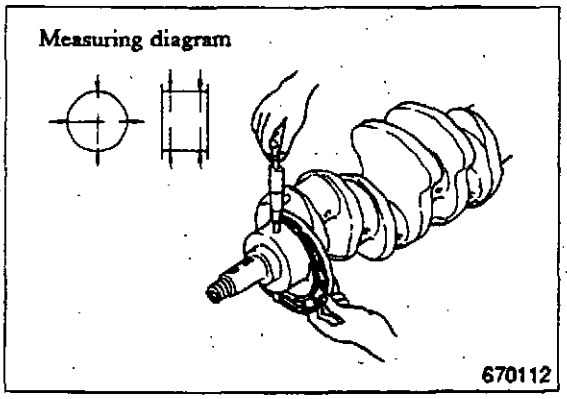


Measuring bore in main bearing

(b) 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	Nominal 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)



Measuring diameter of journal

(c) If the clearance exceeds the limit, install a new bearing and check the clearance again.

(d) 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.

Journal undersizes

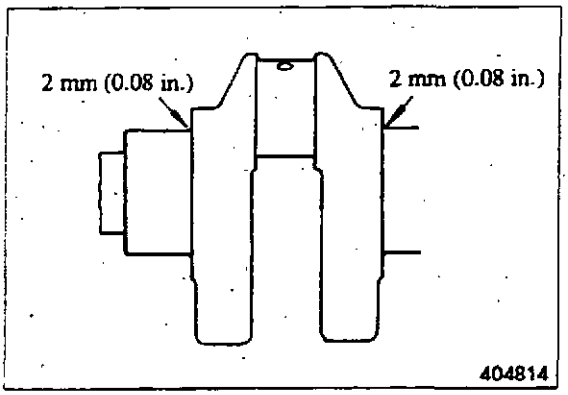
Unit: mm (in.)

Item	Undersize	Finish
Journal	0.25 (0.009 8)	$51.75^{0}_{-0.015}$ ($2.037\ 4^{0}_{-0.000\ 59}$)
	0.50 (0.019 7)	$51.50^{0}_{-0.015}$ ($2.027\ 6^{0}_{-0.000\ 59}$)
	0.75 (0.029 5)	$51.25^{0}_{-0.015}$ ($2.017\ 7^{0}_{-0.000\ 59}$)

⚠ CAUTION

a) Grind all the journals of one crankshaft to the same undersize.

b) Finish the journal fillets to a radius of 2 mm (0.08 in.).



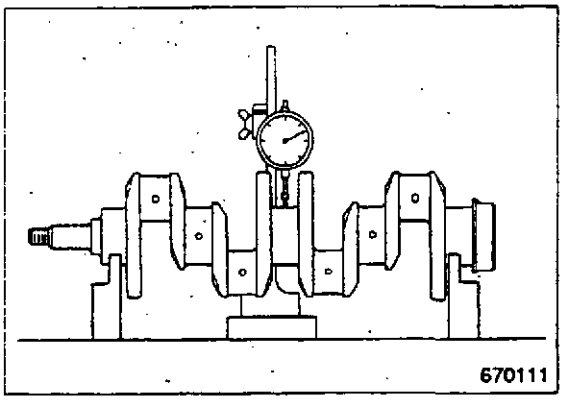
Journal fillet radius

(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)



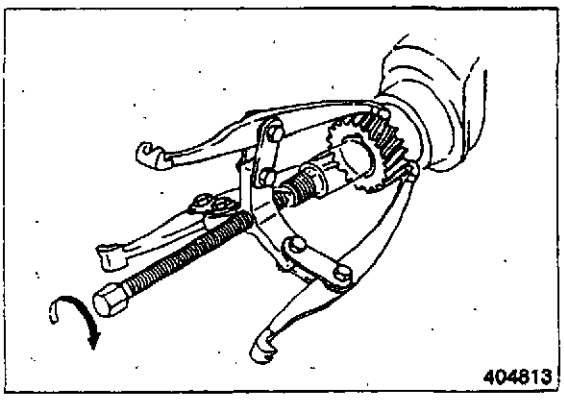
Checking crankshaft runout

(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.

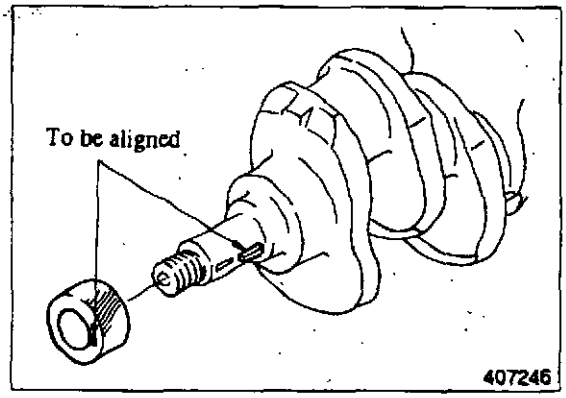


Removing crankshaft gear

(5) Crankshaft gear installation

(a) Install the key in position on the crankshaft.

(b) Install the gear in position with its keyway in alignment with the key as shown in the illustration.

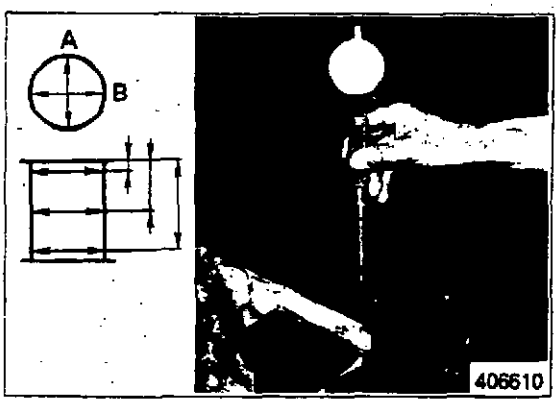


Installing crankshaft gear

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.



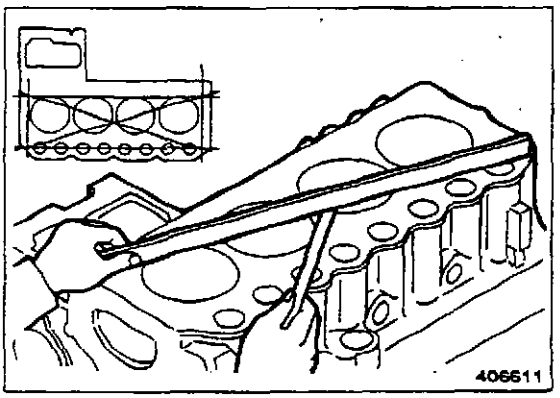
Measuring bore in cylinder block

Unit: mm (in.)

Piston and piston ring		Bore	
Size	Size code	Standard	Limit
Standard	STD	$78^{+0.03}_{0}$ ($3.07^{+0.001\,2}_{0}$)	Standard: +0.2 (+0.008)
0.25 (0.009 8) oversize	25	$78.25^{+0.03}_{0}$ ($3.080\,7^{+0.001\,2}_{0}$)	
0.50 (0.019 7) oversize	50	$78.50^{+0.03}_{0}$ ($3.090\,5^{+0.001\,2}_{0}$)	
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.



Checking cylinder block top face for warpage

⚠ CAUTION

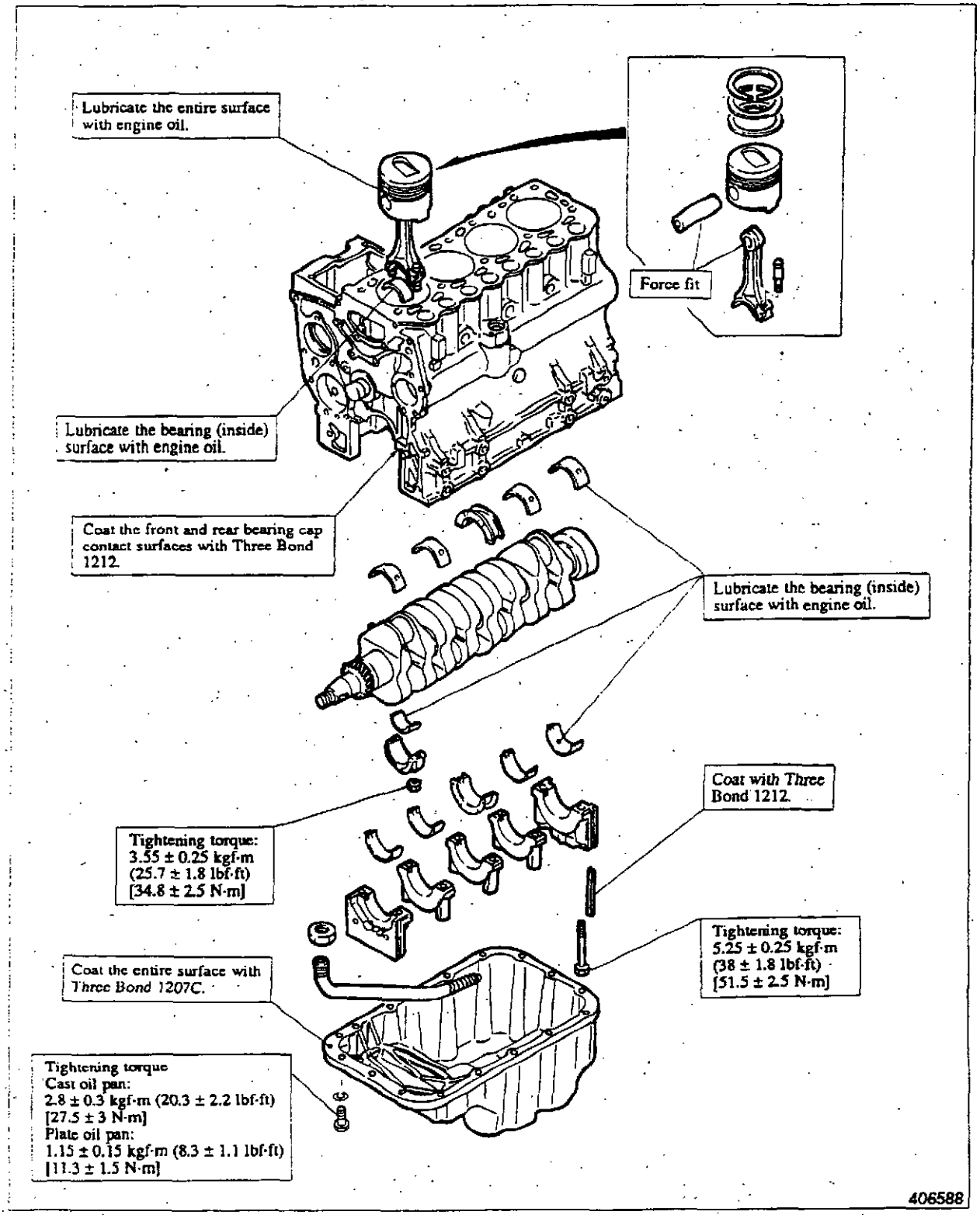
The maximum permissible amount of stock to be removed from the cylinder head and block by grinding is 0.2 mm (0.008 in.) in total.

Unit: mm (in.)

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

ASSEMBLY

CYLINDER BLOCK, CRANKSHAFT, PISTONS AND OIL PAN



Inspection points

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.

Installing main bearings

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.

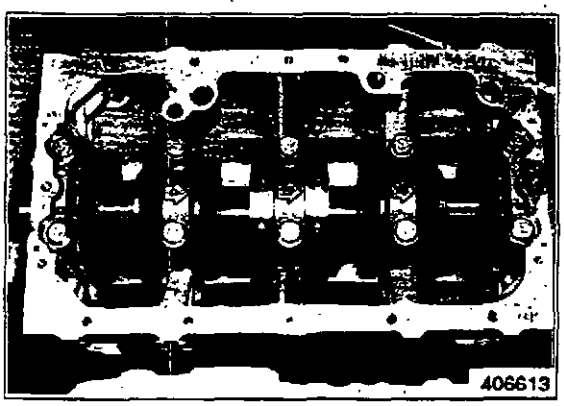
Installing crankshaft

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.



Main bearing caps installed

⚠ CAUTION

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

Installing front and rear 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]

Tightening bolts holding main bearing caps

(5) Make sure the crankshaft rotates freely without binding or catching.

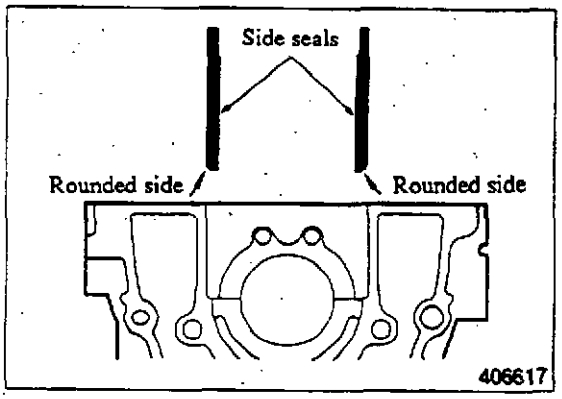
(6) Measure the end play for the crankshaft. Make reference to "End play measurement for crankshaft" (page 42). If the end play is incorrect, loosen the bolts holding the main bearing caps once and tighten them again.

Checking crankshaft for rotation

4. Side seal installation

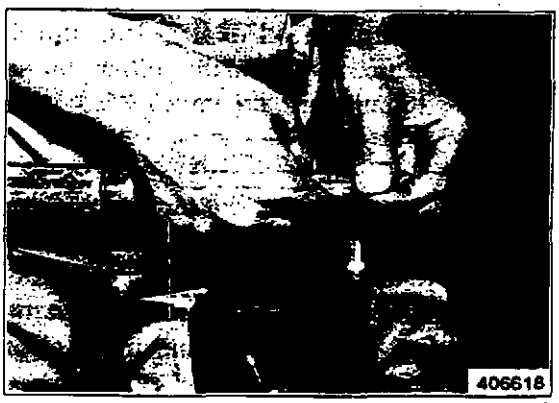
(1) Coat the side seals with Three Bond 1212.

(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.



Side seals

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



Installing side seals

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.

Connecting rod on Piston Setting Tool

(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.

Installing piston pin

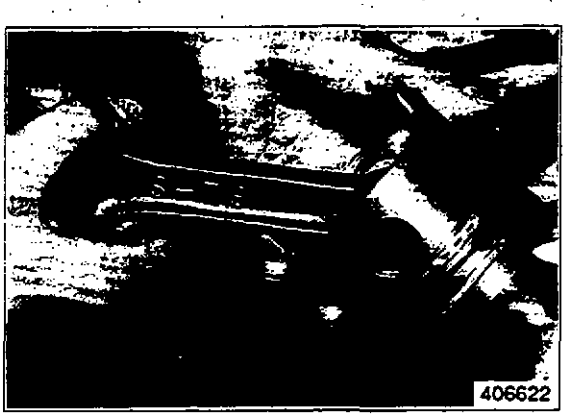
(4) Insert the push rod of the Tool into the bore in the piston for the piston pin and press the pin with the press.

⚠ 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.

Pressing piston pin

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



Checking piston and connecting rod

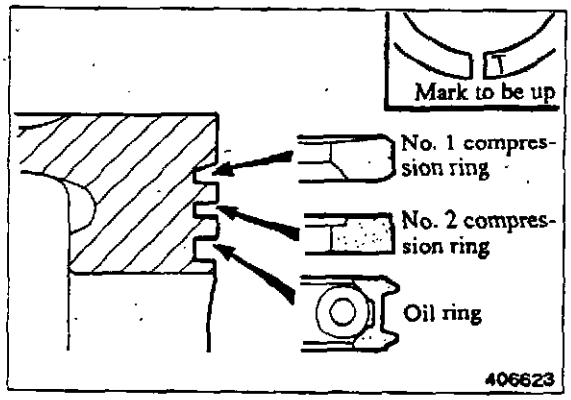
6. Piston ring installation

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

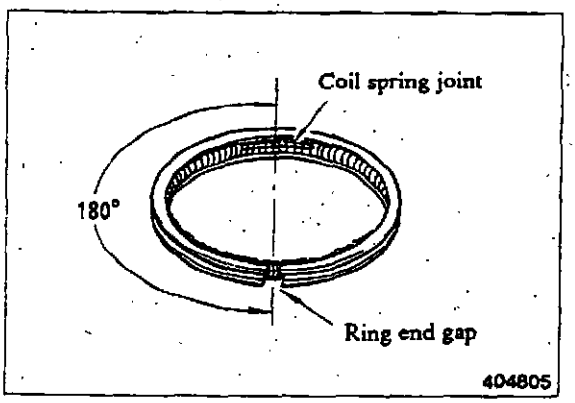
NOTE

a) The piston rings must be installed with the side that has the mark "T" toward the top of the piston.

b) The oil ring must be installed with the ring end gap 180° apart from the coil spring joint.



Piston rings



Oil ring

7. Piston and connecting rod installation

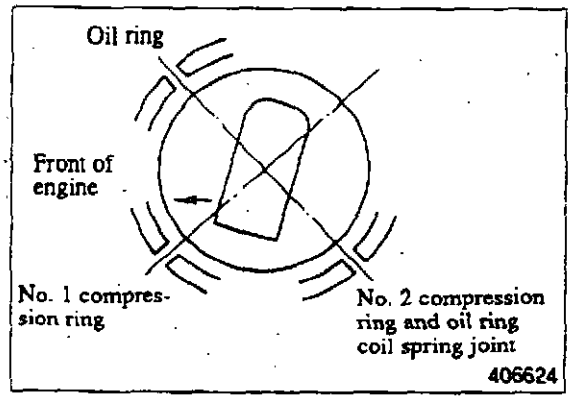
(1) Lubricate the piston and piston rings with engine oil.

(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.



Relative location of piston ring end gaps

(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.

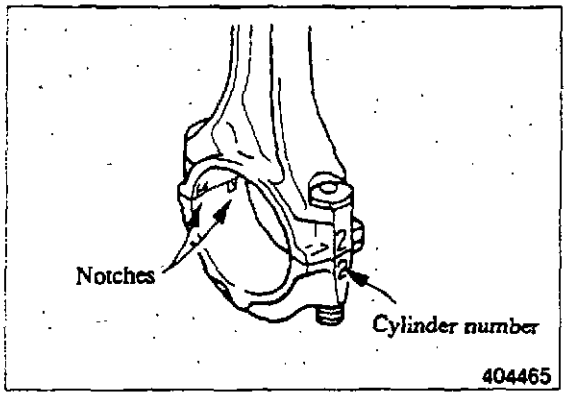
Installing piston and connecting rod

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.



Installing connecting rod cap

NOTE

a) Make sure the number on the cap is the same as the number on the connecting rod.

b) In case of a new connecting rod having no cylinder number, install the cap to the rod with the notches on the same side.

Tightening connecting rod cap nuts

(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.

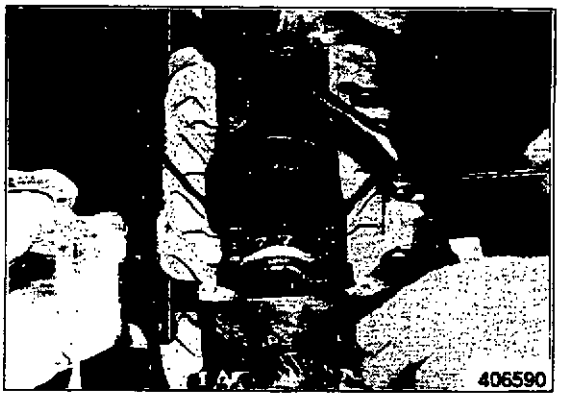
9. Oil screen installation

(1) Lay the cylinder block with the bottom (oil pan side) up.

(2) Install the oil screen in position.

NOTE

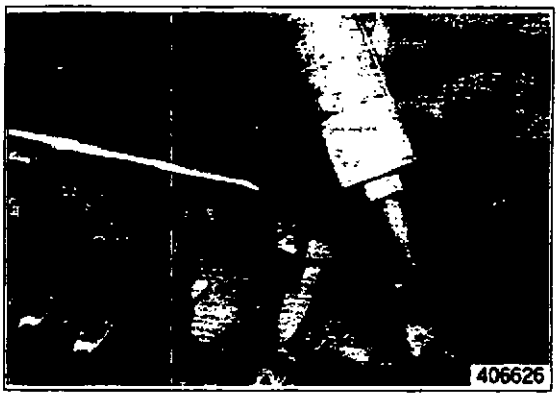
The oil screen must be installed in position so that it is below the oil level line and away from the oil pan.



Installing oil screen

10. Oil pan installation

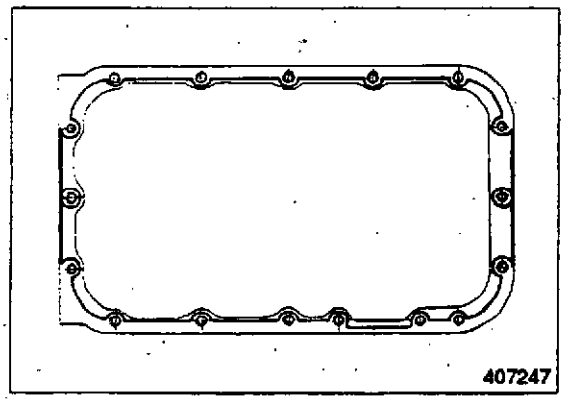
(1) Clean the mating surfaces of the oil pan and cylinder block and coat them with Three Bond 1207C.



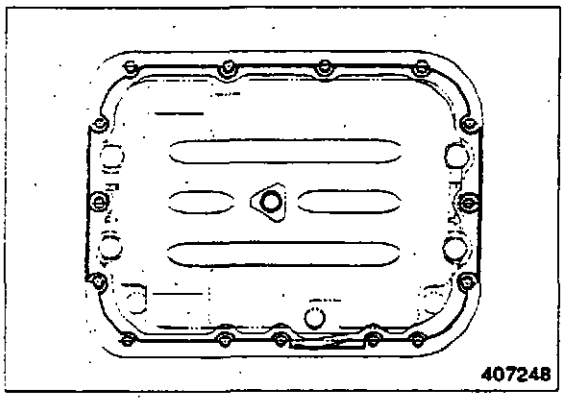
Coating mating surfaces with adhesive

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.

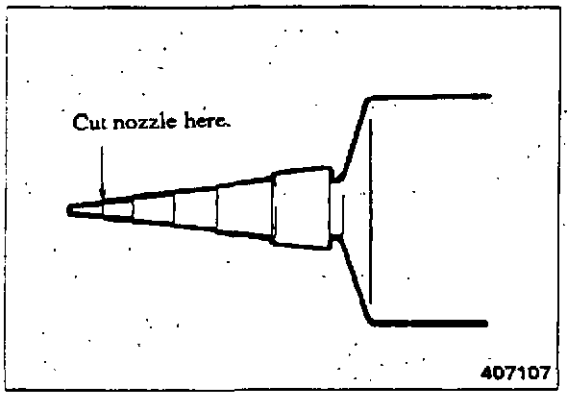


Oil pan for S4L and S4L2 engines



Oil pan for S3L and S3L2 engines

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



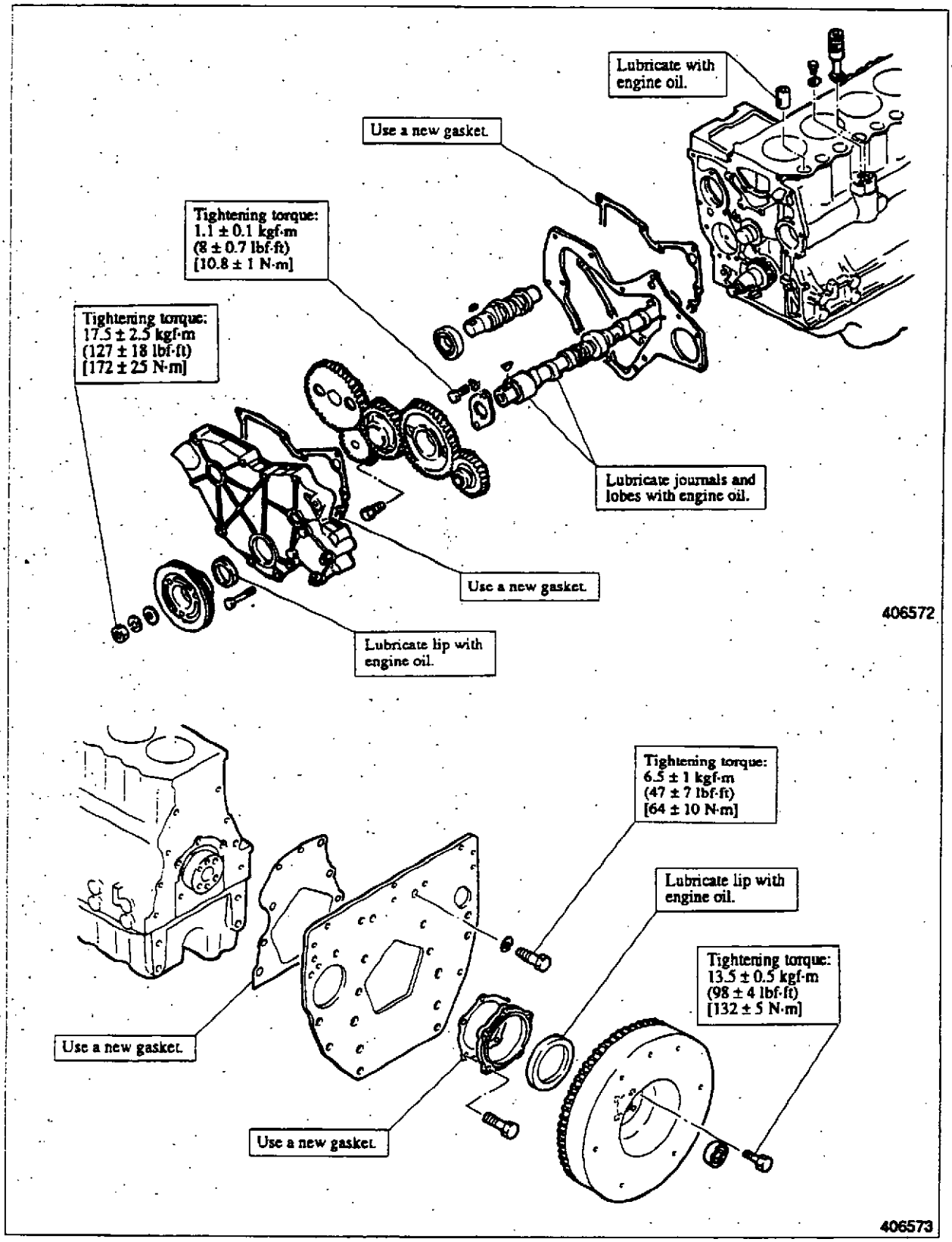
Cutting sealing compound tube nozzle

(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]

Tightening oil pan bolts

TIMING GEARS AND FLYWHEEL



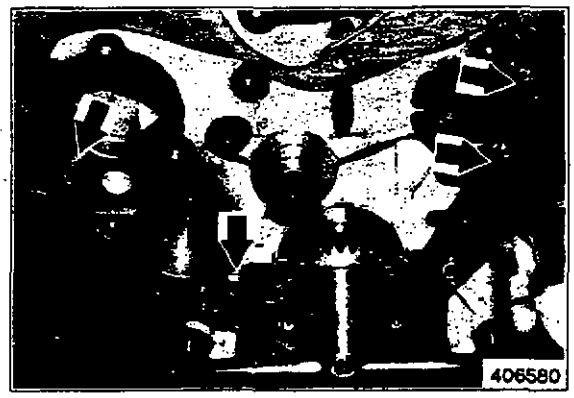
Inspection points

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.



Installing front plate

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.

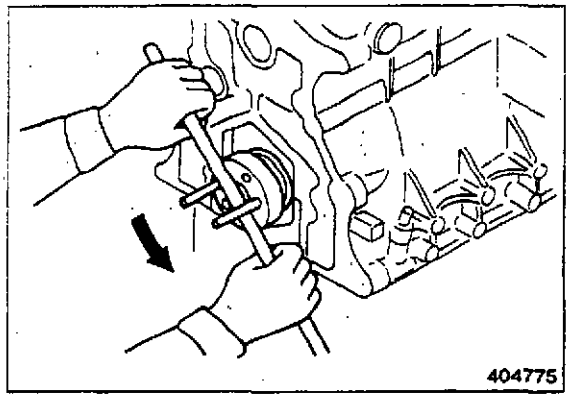
(3) Make sure the oil pump gear rotates freely.

Installing oil pump

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.



Turning engine

4. Fuel injection pump camshaft installation

(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.

Installing fuel injection pump camshaft

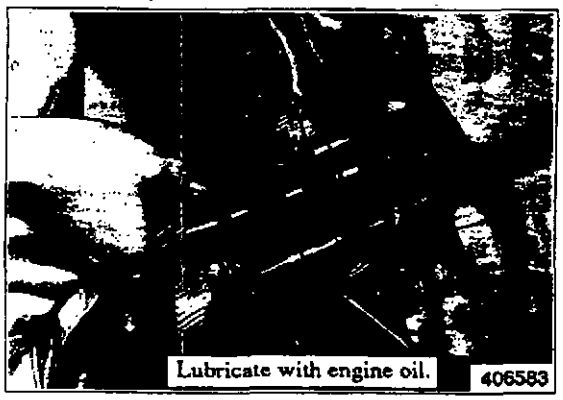
5. Camshaft installation

(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.



Installing camshaft

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

Tightening torque	1.1 ± 0.1 kgf·m (8 ± 0.7 lbf·ft) [10.8 ± 1 N·m]

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

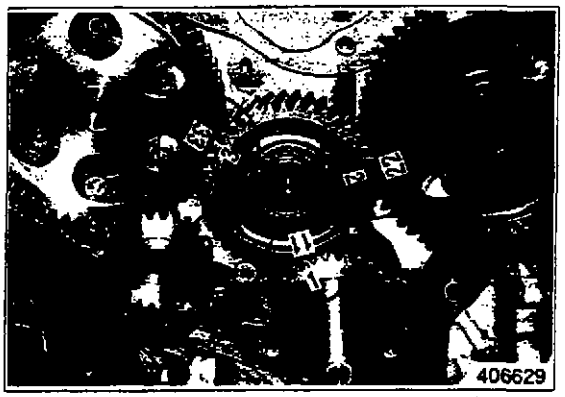
Installing thrust plate

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).



Marks on timing gears

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.

Installing timing gear case

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.

Tightening crankshaft pulley nut

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.

Installing P.T.O. gear

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.

Installing speedometer driven gear

11. Tappet installation

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

Installing tappets

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.

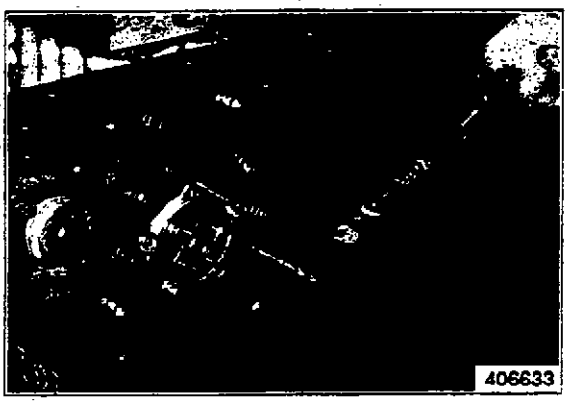
Installing oil seal case

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]



Installing rear plate

NOTE

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

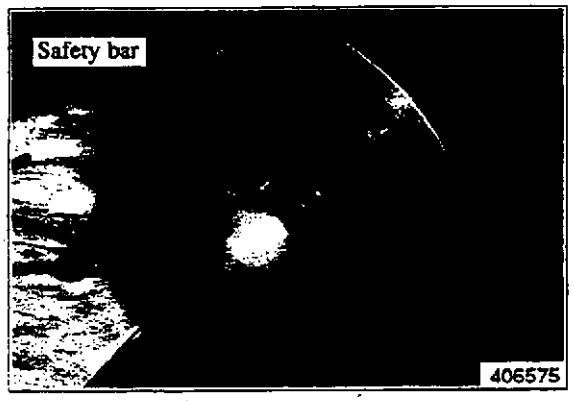
14. Flywheel installation

(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.



Safety bar

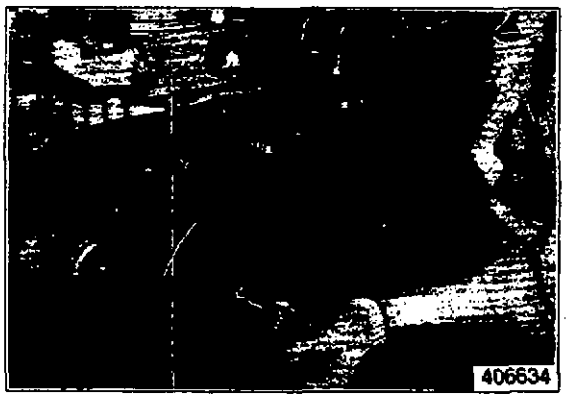
(5) Have someone hold the crankshaft pulley with a wrench to prevent the flywheel from rotating.

(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]

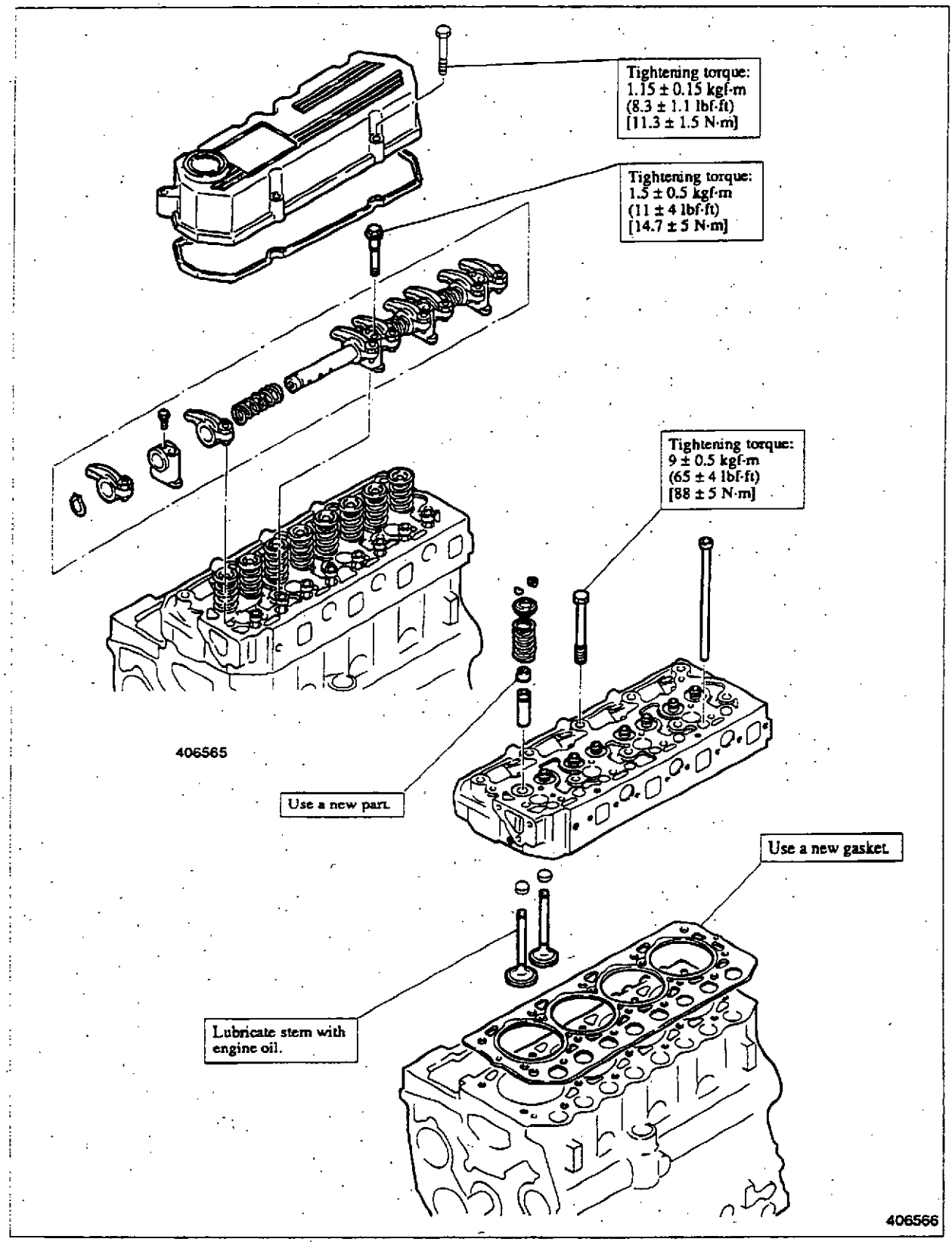
⚠ WARNING

Always signal each other to prevent possible personal injury.



Tightening flywheel bolts

CYLINDER HEAD AND VALVE MECHANISM



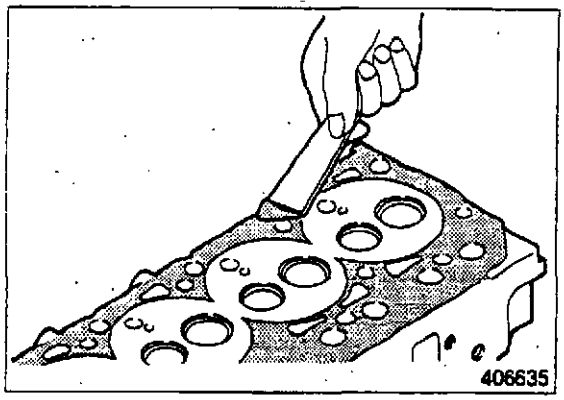
Inspection points

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.



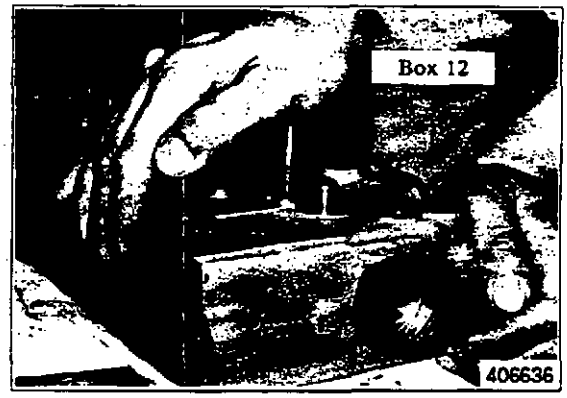
Removing cylinder head gasket

2. Valve stem seal installation

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

NOTE

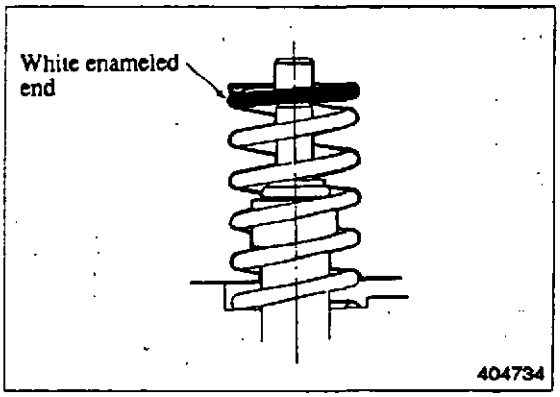
Improper stem seal installation can cause a failure to seal against downward flow of oil along the stem.



Installing valve stem seal

3. Valve spring installation

Install the valve spring with the white enameled end up.



Installing valve spring

4. Valve block installation

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.

Installing valve block

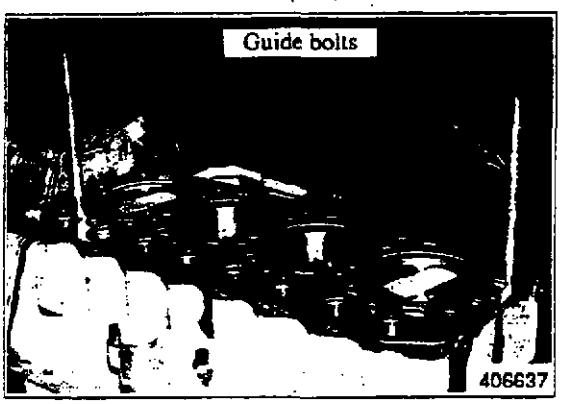
5. Cylinder head gasket installation

(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.

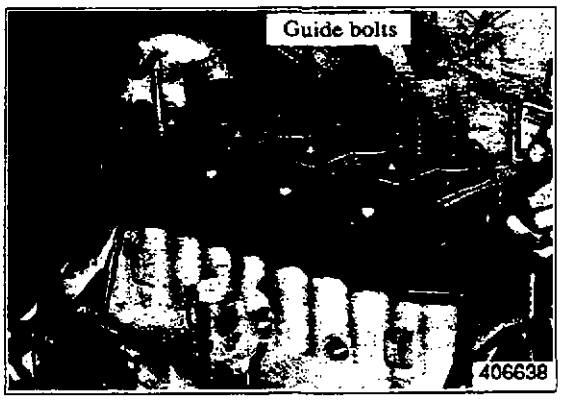
> **⚠ CAUTION**
> Do not use any gasket adhesive or other substances on the top face of the cylinder block.



Putting cylinder head gasket

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.



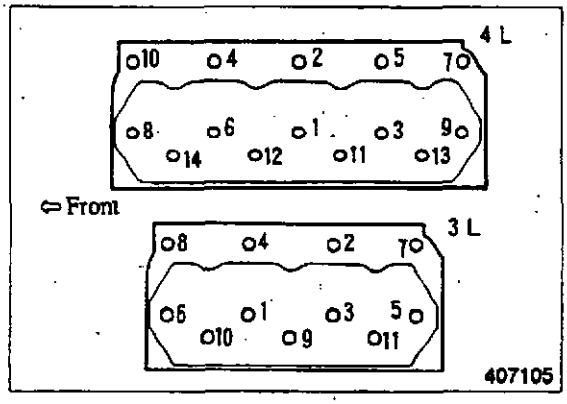
Installing cylinder head

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]



Tightening sequence

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.

Installing valve push rods

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.

Assembling rocker arms

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]

Installing rocker shaft assembly

11. Valve clearance adjustment

Make reference to "VALVE CLEARANCE" (page 159).

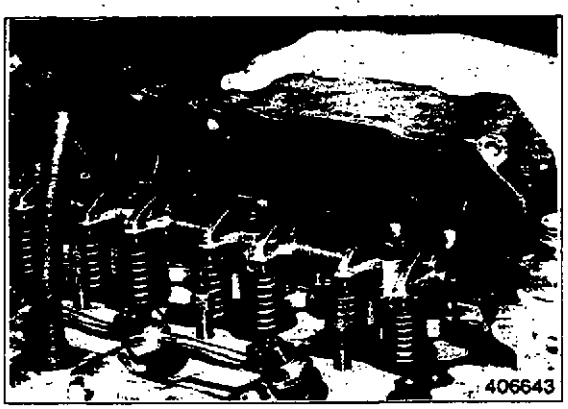
Adjusting valve clearance

12. Rocker cover installation

(1) Make sure the gasket is put on the rocker cover.

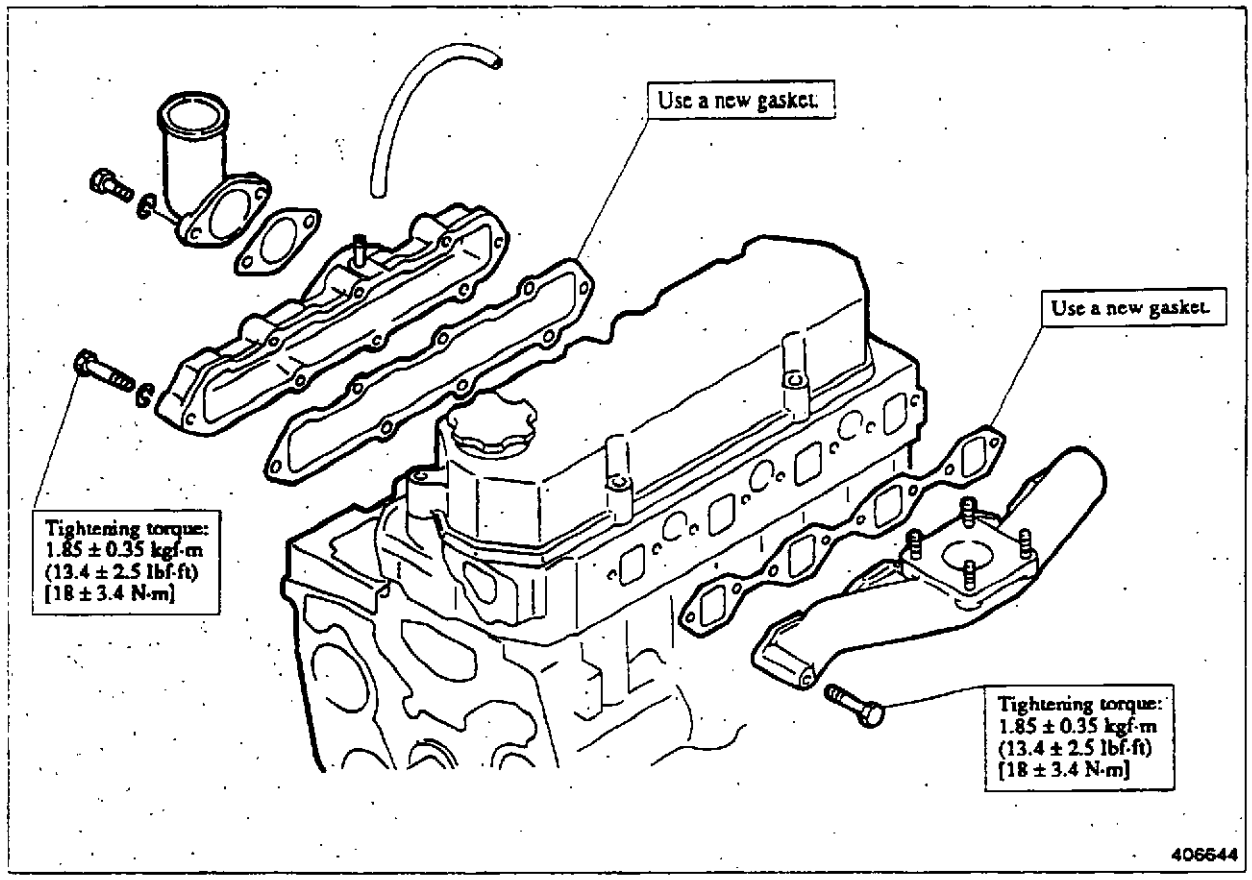
(2) Tighten the bolts that hold the rocker cover to the specified torque.

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



Installing rocker cover

AIR INLET SYSTEM AND EXHAUST SYSTEM



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]

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]

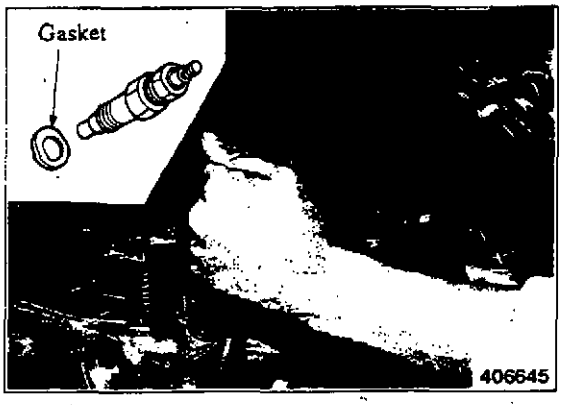
FUEL SYSTEM

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]



Installing fuel injection nozzle

2. Fuel injection pump installation

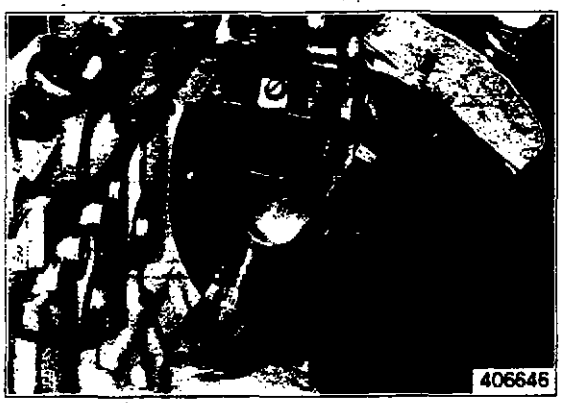
Put the pump in position on the cylinder block and tighten the bolts that hold the pump to the specified torque.

Installing fuel injection pump

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]



Installing flyweight assembly

4. Sliding sleeve installation

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

Installing sliding sleeve

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.

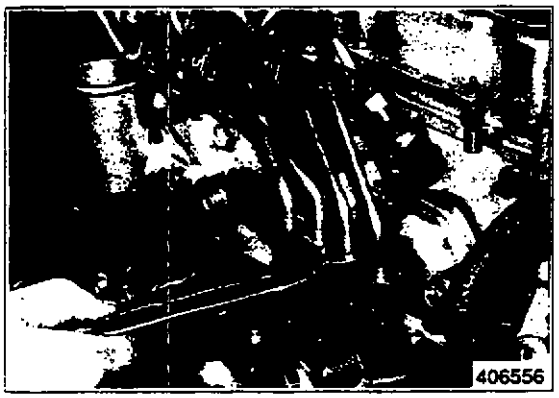
(3) Install the tie rod cover in position.

Installing governor assembly

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.



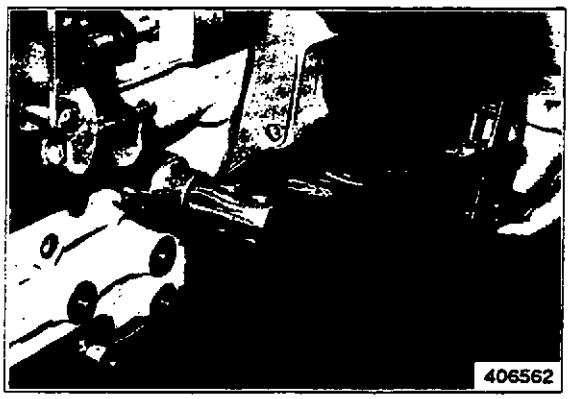
Installing fuel injection lines

LUBRICATION SYSTEM

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 kgf·m (36 ± 4 lbf·ft) [49 ± 5 N·m]



Installing pressure relief valve

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.

Installing oil filter

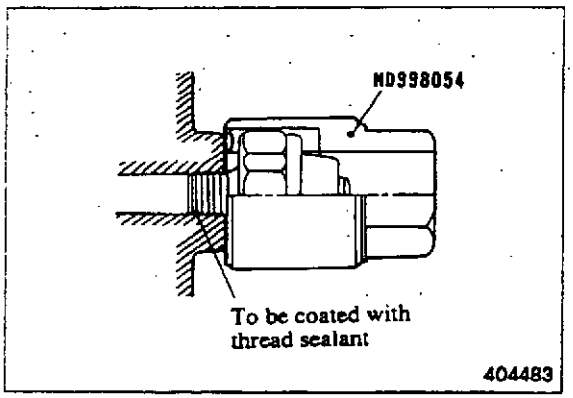
3. Oil pressure switch installation

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

a) Put the sealant on the threads only.

b) Do not over-tighten the oil pressure switch when it is installed.

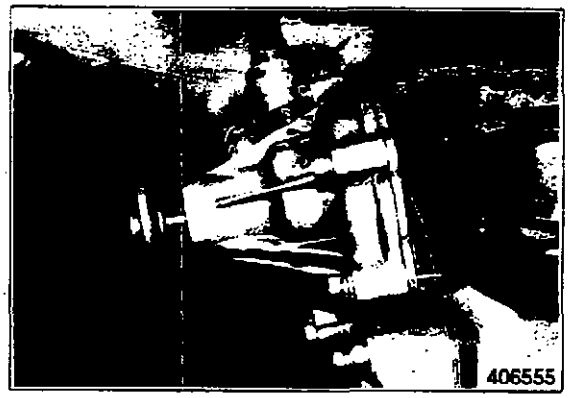


Installing oil pressure switch

COOLING SYSTEM

1. Water pump installation

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



Installing water pump

2. Thermostat installation

(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.

Installing thermostat

3. Cooling fan installation

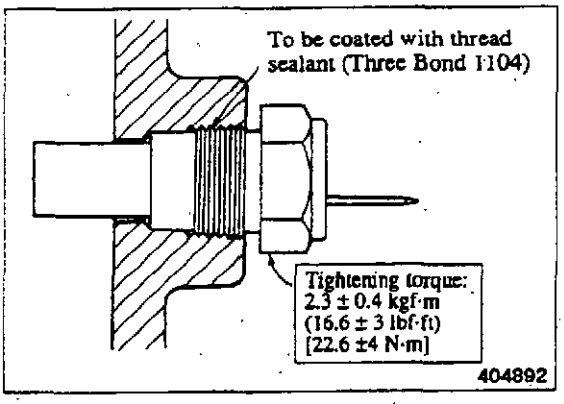
(1) Install the spacers in position in the fan as shown.

(2) Install the pulley in position on the water pump. Install the fan and spacer combination in position on the pulley.

Installing cooling fan

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.



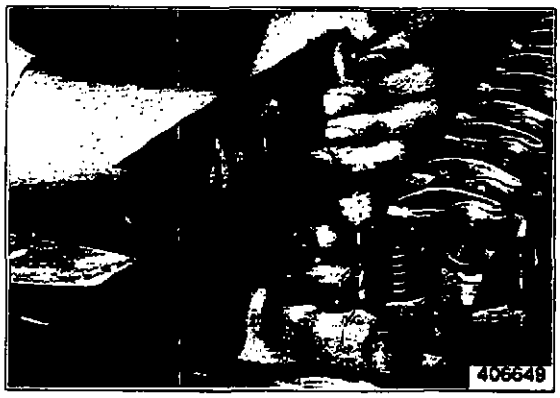
Installing thermoswitch and thermounit combination

ELECTRICAL SYSTEM

1. Glow plug installation

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]



Installing glow plugs

2. Alternator installation

(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.

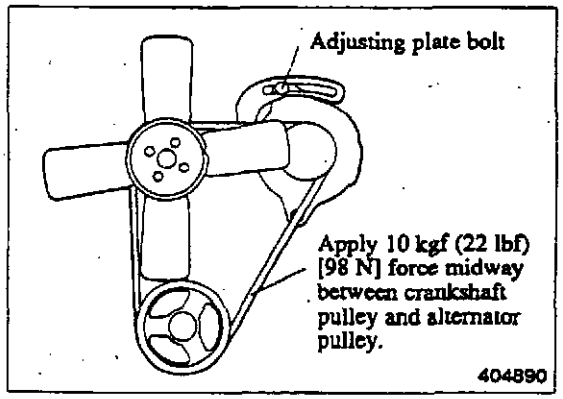
(3) Tighten the bolts.

(4) Make sure the deflection (tension) of the belt is correct.

Unit: mm (in.)

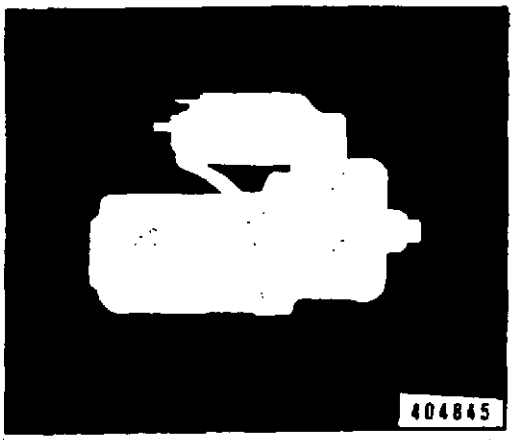
Deflection under 10 kgf (22 lbf) [98 N] force	10 to 12 (0.4 to 0.5)

Installing alternator



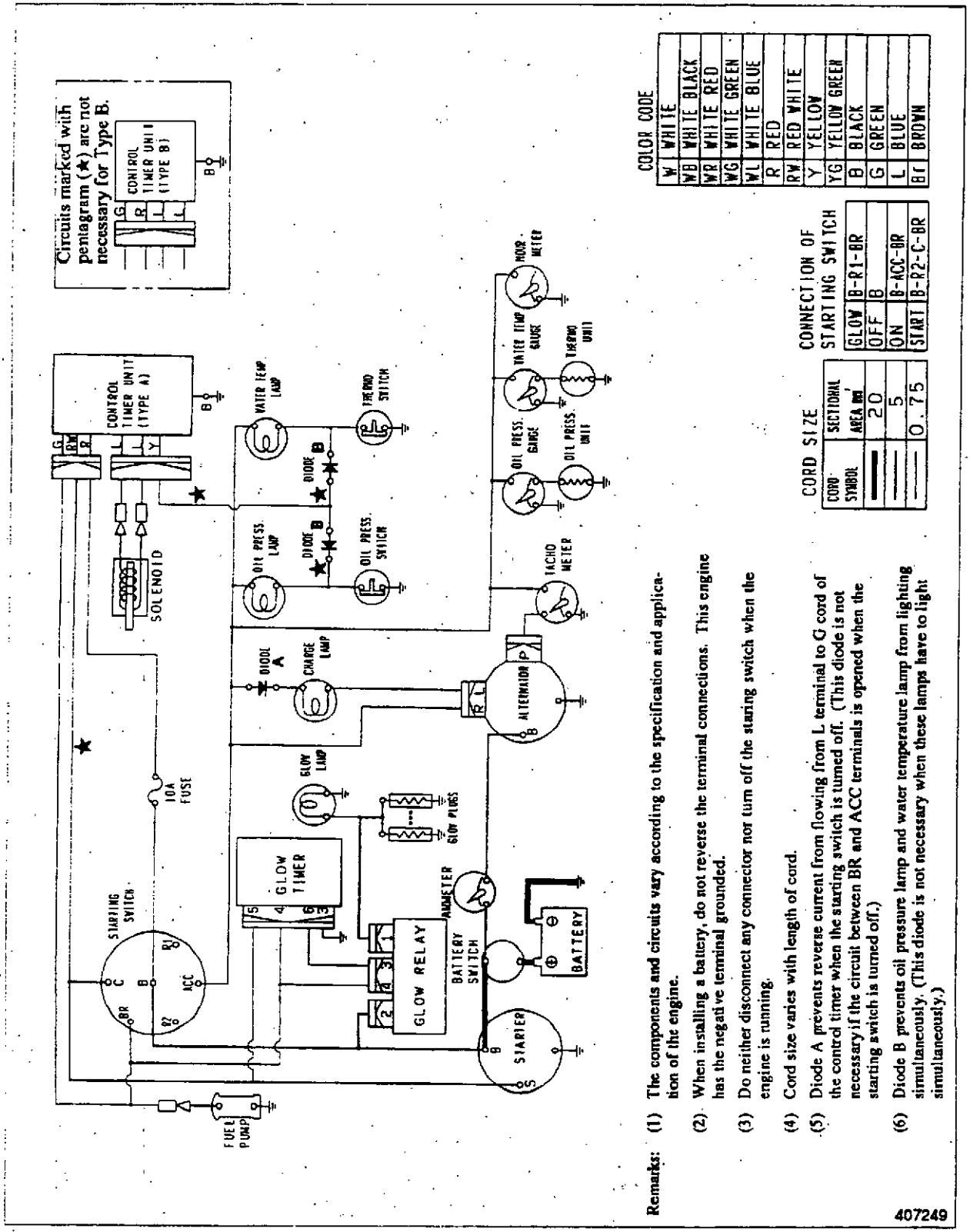
Adjusting alternator and fan belt

ELECTRICAL SYSTEM



GENERAL

1. Schematic



Remarks:
(1) The components and circuits vary according to the specification and application of the engine.
(2) When installing a battery, do not reverse the terminal connections. This engine has the negative terminal grounded.
(3) Do neither disconnect any connector nor turn off the staring switch when the engine is running.
(4) Cord size varies with length of cord.
(5) Diode A prevents reverse current from flowing from L terminal to G cord of the control timer when the starting switch is turned off. (This diode is not necessary if the circuit between BR and ACC terminals is opened when the starting switch is turned off.)
(6) Diode B prevents oil pressure lamp and water temperature lamp from lighting simultaneously. (This diode is not necessary when these lamps have to light simultaneously.)

407249

Schematic

(1) Figure indicates a nominal size of automotive low-tension line (JIS C 3406).

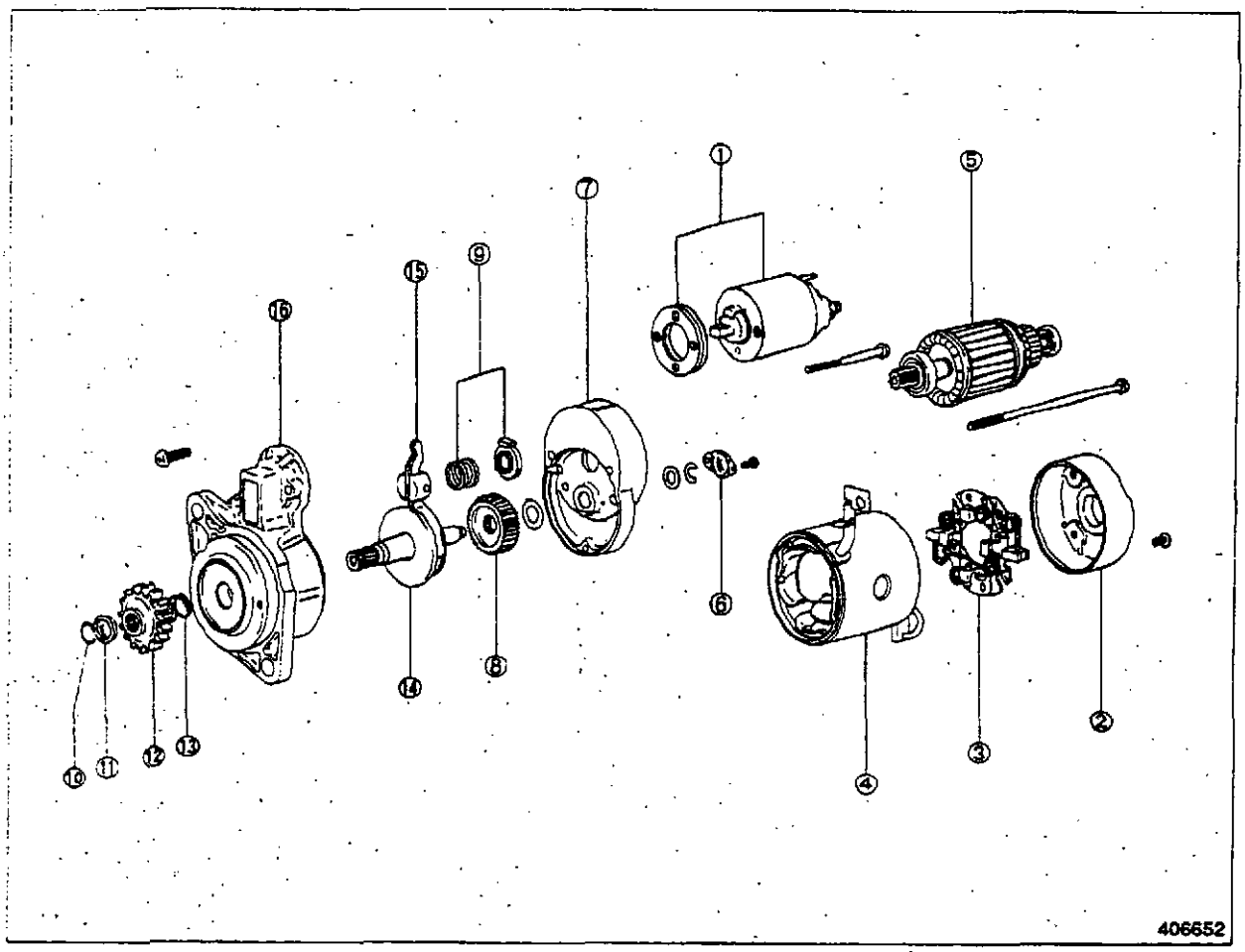
(2) This schematic shows the electrical system of the standard engine equipped with a key shut down solenoid and glow plugs.

2. Specifications (standard)

Engine model		S3L/S3L2	S4L/S4L2
Starter	Model	M2T50381	M2T56272
	Type	DC solenoid shifted (with reduction gear)	
	Nominal output, V–kW	12 –1.6	12 – 2.0
Alternator	Model	A7T02071	
	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)	
Key shut down solenoid	Model	YMS-1	
	Type	Solenoid	
	Resistance in coil, Ω	1.8 ± 10% at 20°C (68°F)	
	Stroke, mm (in.)	13.5 ± 0.5 (0.53±0.02)	
	Operating voltage, V	DC 10 to 15	
Glow controller	Model	QGS	
	Rated voltage, V	DC 12	
	Operating voltage range, 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	

STARTER

1. Disassembly



Disassembly sequence

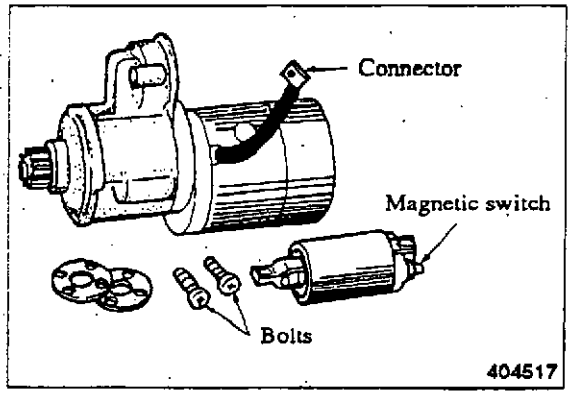
① Magnetic switch
② Rear bracket
③ Brush holder assembly
④ Yoke
⑤ Armature
⑥ Cover
⑦ Center bracket
⑧ Gear
⑨ Spring set
⑩ Stopper ring
⑪ Stopper
⑫ Pinion
⑬ Spring
⑭ Pinion shaft
⑮ Front bracket

Disassembly procedure

(1) Magnetic switch

(a) Loosen the nut that holds the connector to the M terminal of the magnetic switch and disconnect the connector from the magnetic switch.

(b) Remove the bolts (two) that hold the magnetic switch in position and remove the magnetic switch.



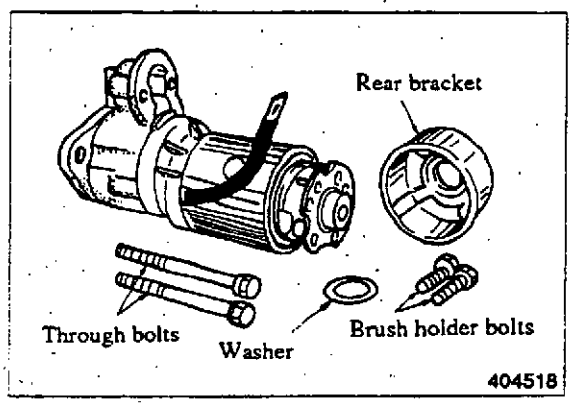
Removing magnetic switch

(2) Rear bracket removal

Remove the through bolts (two) and the bolts (two) that hold the brush holder in position. Remove the rear bracket.

NOTE

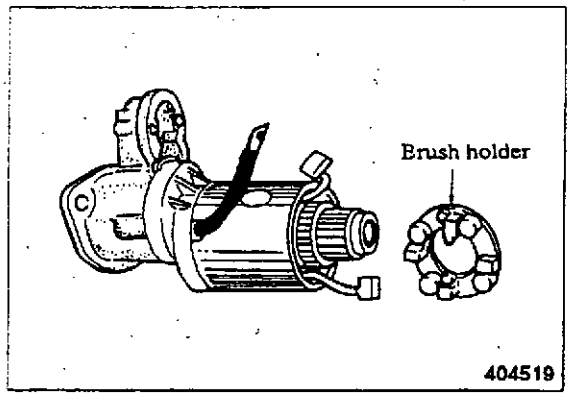
Keep the rear bracket with washer for installation.



Removing rear bracket

(3) Brush holder removal

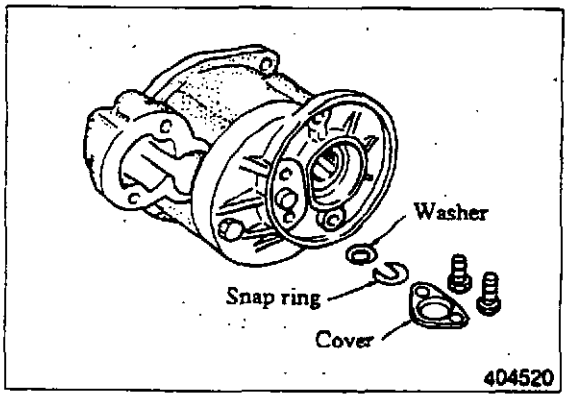
With the brushes (two) kept apart from the commutator, remove the yoke and brush holder assembly. Remove the armature.



Removing brush holder

(4) Cover removal

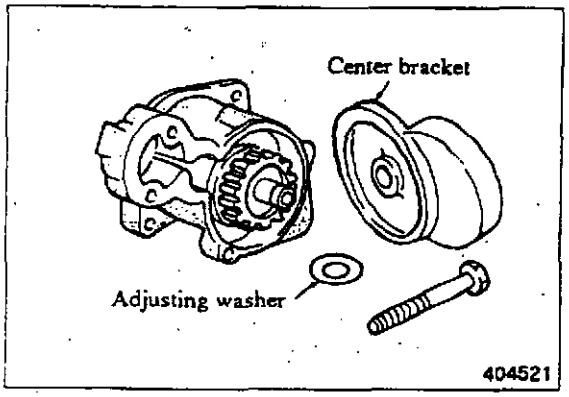
Remove the cover and remove the snap ring and washer.



Removing cover

(5) Center bracket removal

Remove the bolt and remove the center bracket. Remove the washer for adjusting the end play for the pinion shaft.



Removing center bracket

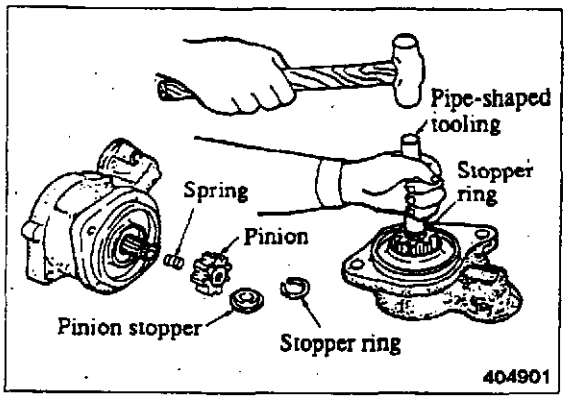
(6) Pinion removal

(a) Put a pipe-shaped tooling on the pinion stopper and hit the stopper with a hammer to expose the stopper ring.

(b) Remove the stopper ring with a pliers and remove the pinion.

NOTE

Any time the pinion is removed, a new stopper ring must be installed.



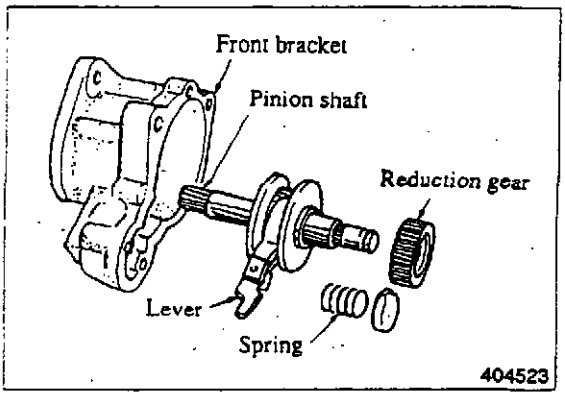
Removing pinion

(7) Pinion shaft removal

Remove the spring, lever, reduction gear and pinion shaft from the front bracket.

NOTE

Do not mix the sequence of spring, lever and reduction gear when the pinion shaft is removed.

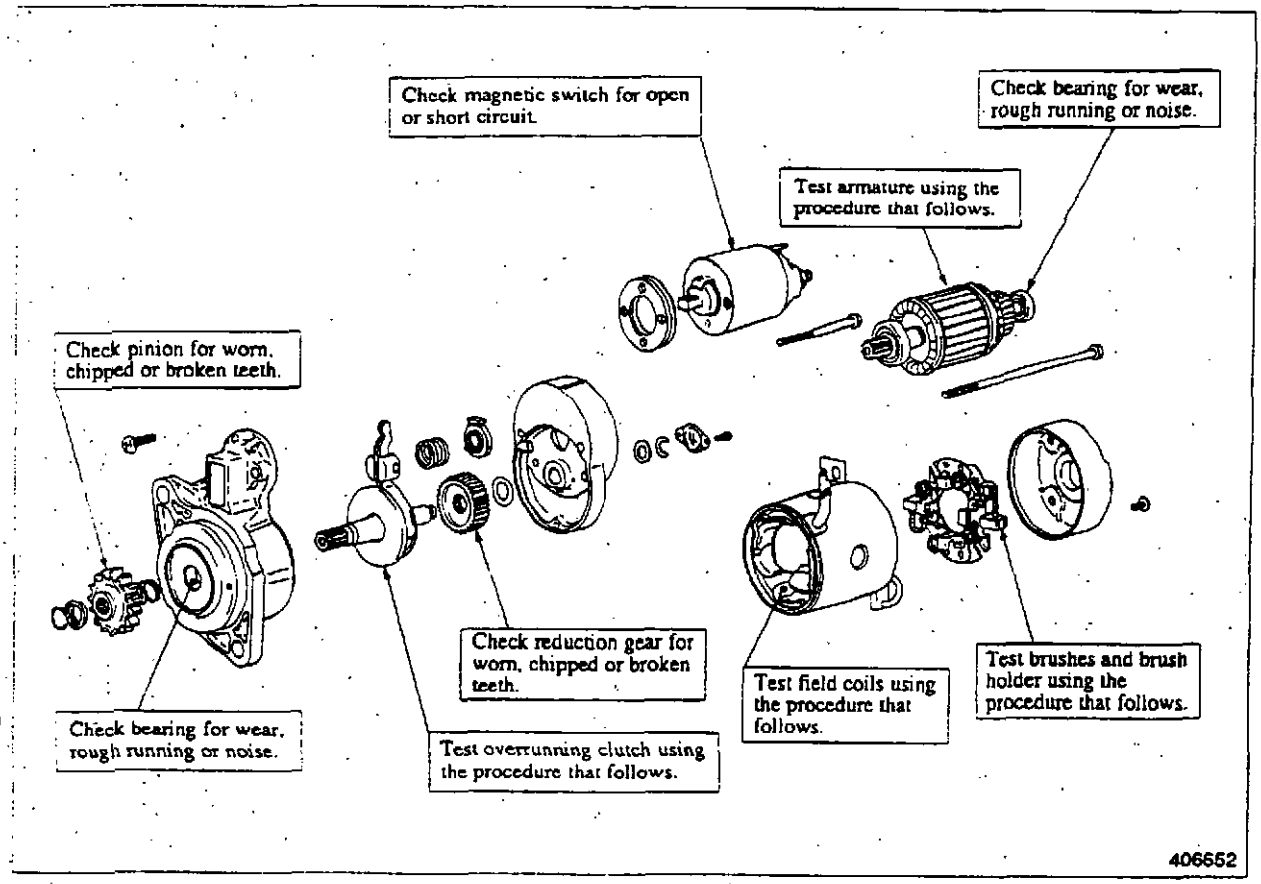


Removing pinion shaft

(8) Bearing removal

To remove the ball bearings from the ends of the armature, use a bearing puller. The bearing fitted in the front bracket is not replaceable. Replace the front bracket assembly if this bearing is defective.

2. Inspection



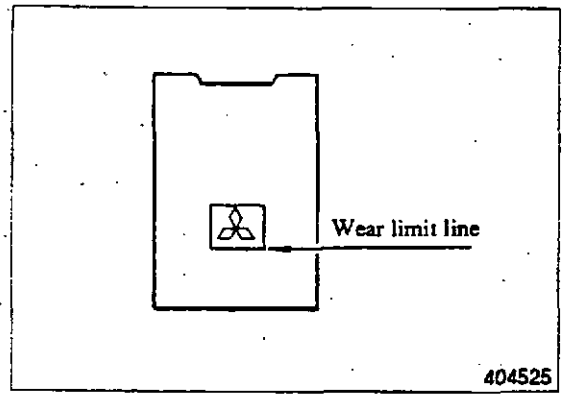
Inspection points

Inspection procedure

(1) Brushes

(a) Wear

Replace the brushes if they are worn down to the wear limit line which is the bottom of the border for Mitsubishi mark. Replace the brush holder assembly if the brushes are worn beyond the wear limit line.

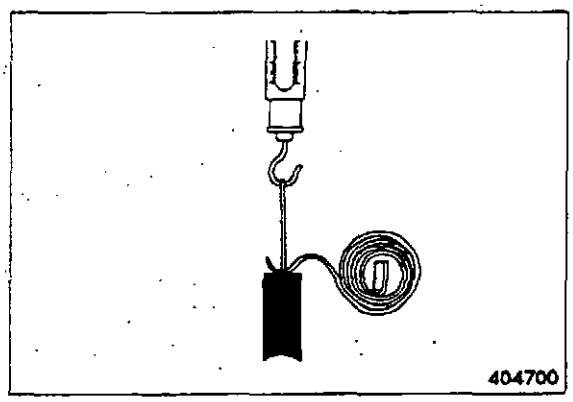


Checking brush

(b) Brush spring tension
Test the spring tension using a new brush as shown in the illustration. Read the load when the spring just moves off the brush. If the tension is below the limit, replace the spring.

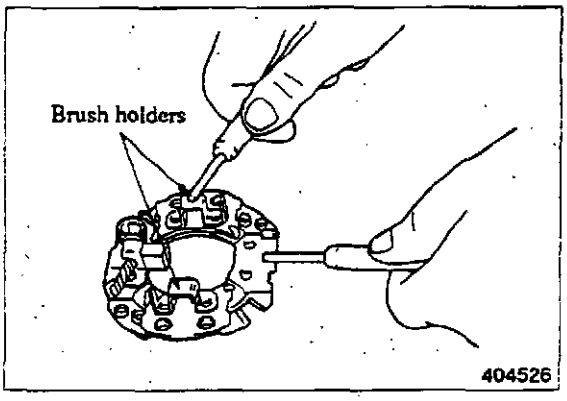
Unit: kgf (lbf) [N]

Item	Standard	Limit
Brush spring tension	3.0 (6.6) [29.4]	1.8 (4.0) [17.7]



Testing brush spring tension

(c) Brush holders
Test for no continuity between the positive brush holder and brush holder base as shown in the illustration. If there is any continuity between them, replace the brush holder. Also, check the brush holder for loose staking.



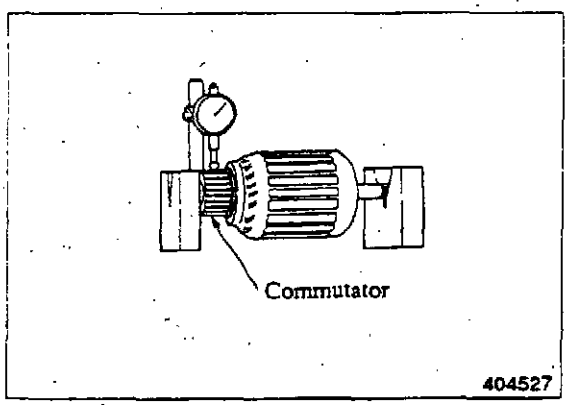
Testing brush holder for grounded circuit

(2) Armature

(a) Commutator runout
Support the armature in V-blocks and measure the commutator runout with a dial indicator. If runout exceeds the limit, turn the commutator in a lathe. The cut should be made within the limit of the commutator diameter.

Unit: mm (in.)

Item	Standard	Limit
Runout of commutator	0.03 (0.001 2)	0.10 (0.003 9)

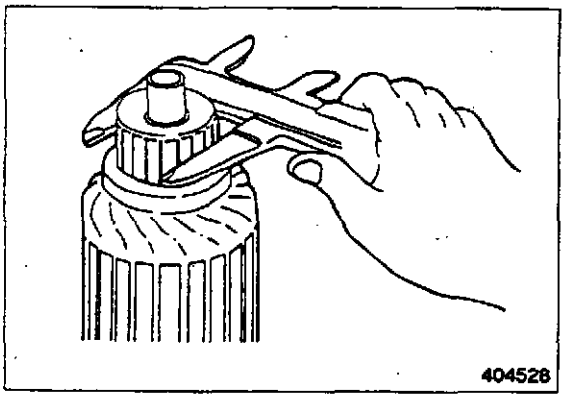


Checking commutator runout

(b) Diameter of commutator
Measure the diameter of the commutator. If it exceeds the limit, replace the armature.

Unit: mm (in.)

Item	Standard	Limit
Diameter of commutator	32 (1.26)	31 (1.22)

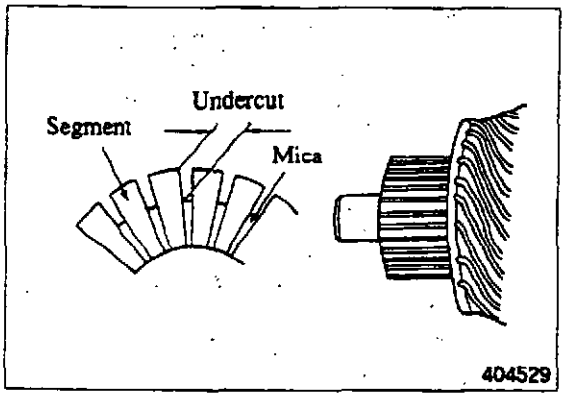


Measuring commutator diameter

(c) Mica undercut
Measure the undercut of mica insulation between the adjacent segments. If undercut exceeds the limit, recondition the mica, or replace the armature.

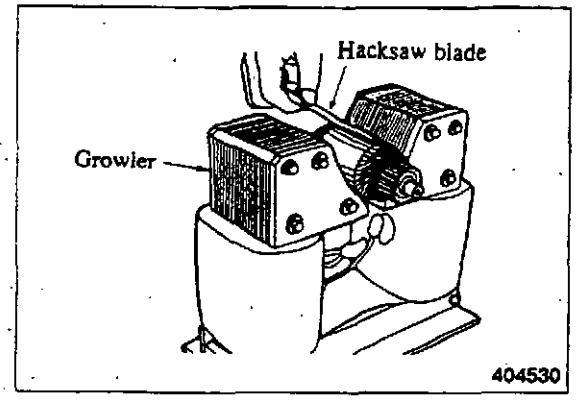
Unit: mm (in.)

Item	Standard	Limit
Undercut of mica	0.5 (0.020)	0.2 (0.008)



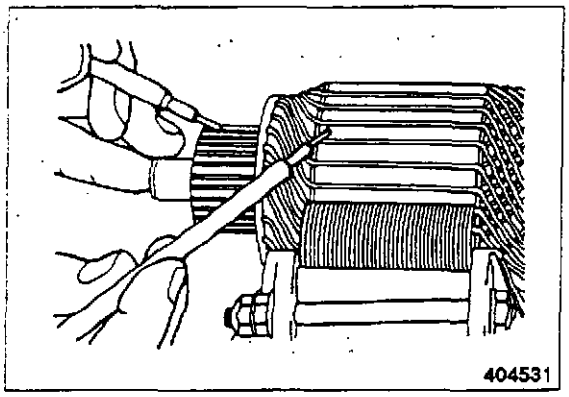
Undercut of mica

(d) Testing for short circuit
Place the armature on a growler and slowly rotate it with a hacksaw blade held above the armature core. The hacksaw blade vibrates against the core when it is above a slot containing a shorted winding. A shorted armature should be replace.



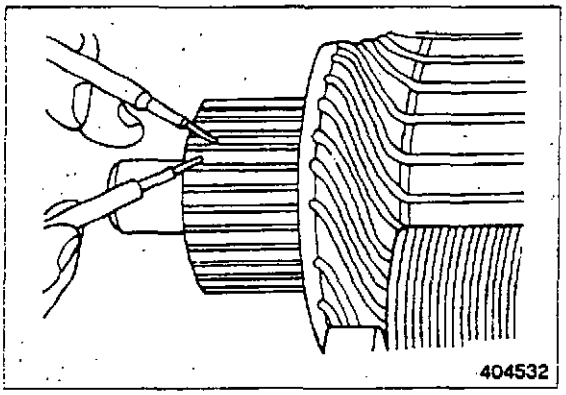
Testing armature for short circuit

(e) *Testing for grounded circuit*
Test the armature for grounded circuit as shown in the illustration. If there is any continuity between commutator segment and coil, the armature is grounded and should be replaced.



Testing armature for grounded circuit

(f) Testing for open circuit
Test the armature for open circuit as shown in the illustration. If there is no continuity between the segments, the armature is open circuited and should be replace.



Testing armature for open circuit

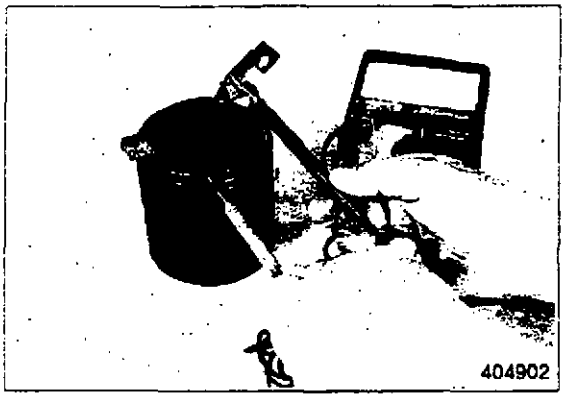
(3) Field coils

Replace the yoke assembly if —

(a) There is any continuity between the brush and yoke.

(b) There is no continuity between the brushes.

(c) The pole piece or coil is loosen.



Testing field coils

(4) Bearings

Replace the bearings if they are noisy or fail to run freely.

(5) Overrunning clutch

Replace the overrunning clutch assembly if —

(a) The pinion is not locked when spun counterclockwise, or if it does not rotate freely when spun in the reverse direction (clockwise).

(b) The pinion is worn or chipped.

⚠ CAUTION

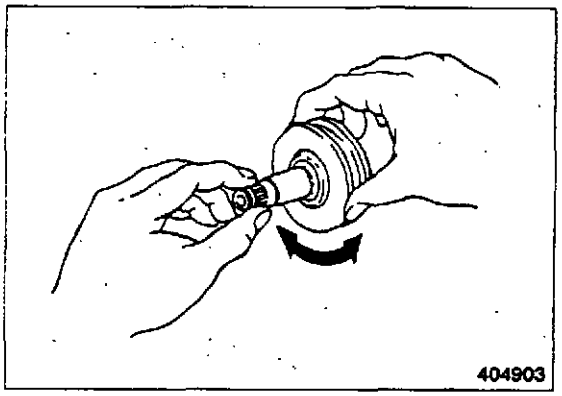
Do not wash the overrunning clutch with cleaning solvent.

(6) Front bracket

Replace the front bracket assembly if the ball bearing is noisy or fails to rotate freely.

(7) Reduction gears

Replace the reduction gears if they are worn or damaged.



Testing overrunning clutch

3. Assembly

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

Assembly procedure

(1) Lubrication

Lubricate the following starter components with grease after the starter has been assembled:

(a) Armature shaft gear and reduction gear

(b) Bearings

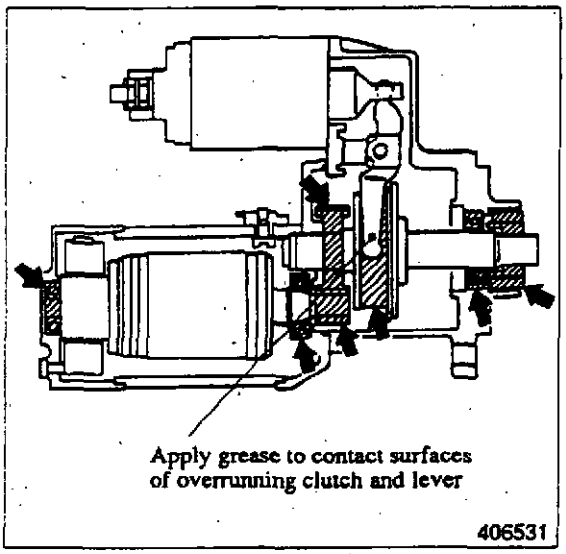
(c) Washer and stopper ring of pinion shaft

(d) Pinion

(e) Sliding surfaces of lever

⚠ CAUTION

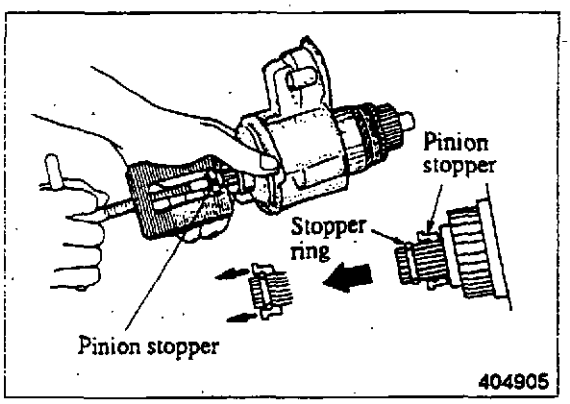
Do not put grease on the starter mounting face, brushes, commutator and other electrical parts.



Lubrication points on starter

(2) Stopper ring installation

Put the stopper ring on the pinion shaft. Using a puller, pull the pinion stopper to fit the ring in the groove.



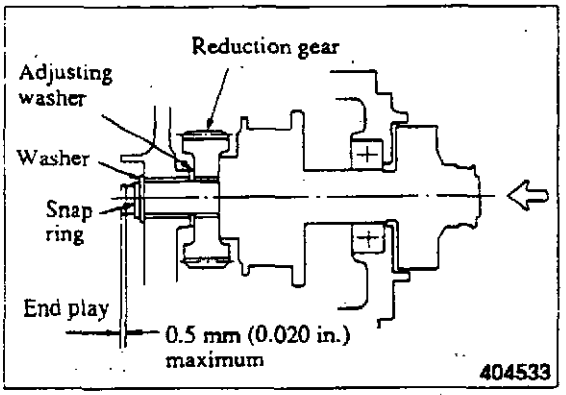
Installing stopper ring

(3) Pinion shaft end play adjustment

The maximum permissible limit of the end play (thrust gap) for the pinion shaft is 0.5 mm (0.020 in.).

(a) Put the pinion shaft, reduction gear washer and snap ring in position in the center bracket.

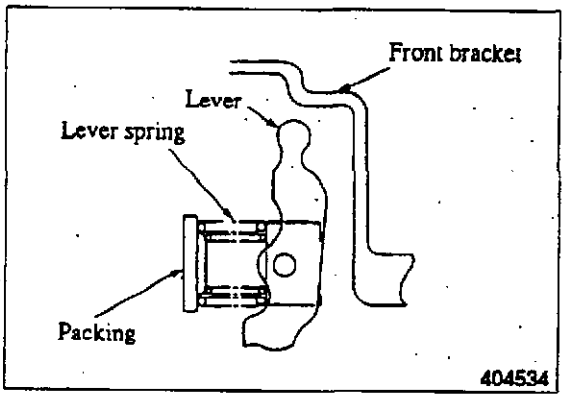
(b) Move the pinion shaft in the axial direction to measure the end play. If the end play exceeds 0.5 mm (0.020 in.), make adjustment to it by adding adjusting washer.



Adjusting pinion shaft end play

(4) Lever installation

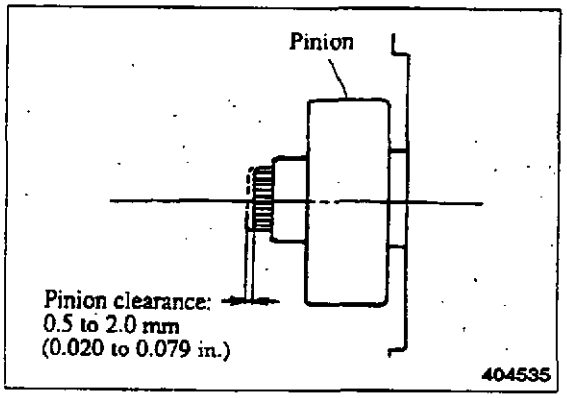
Install the lever in correct position.



Installing lever

(5) Pinion clearance adjustment

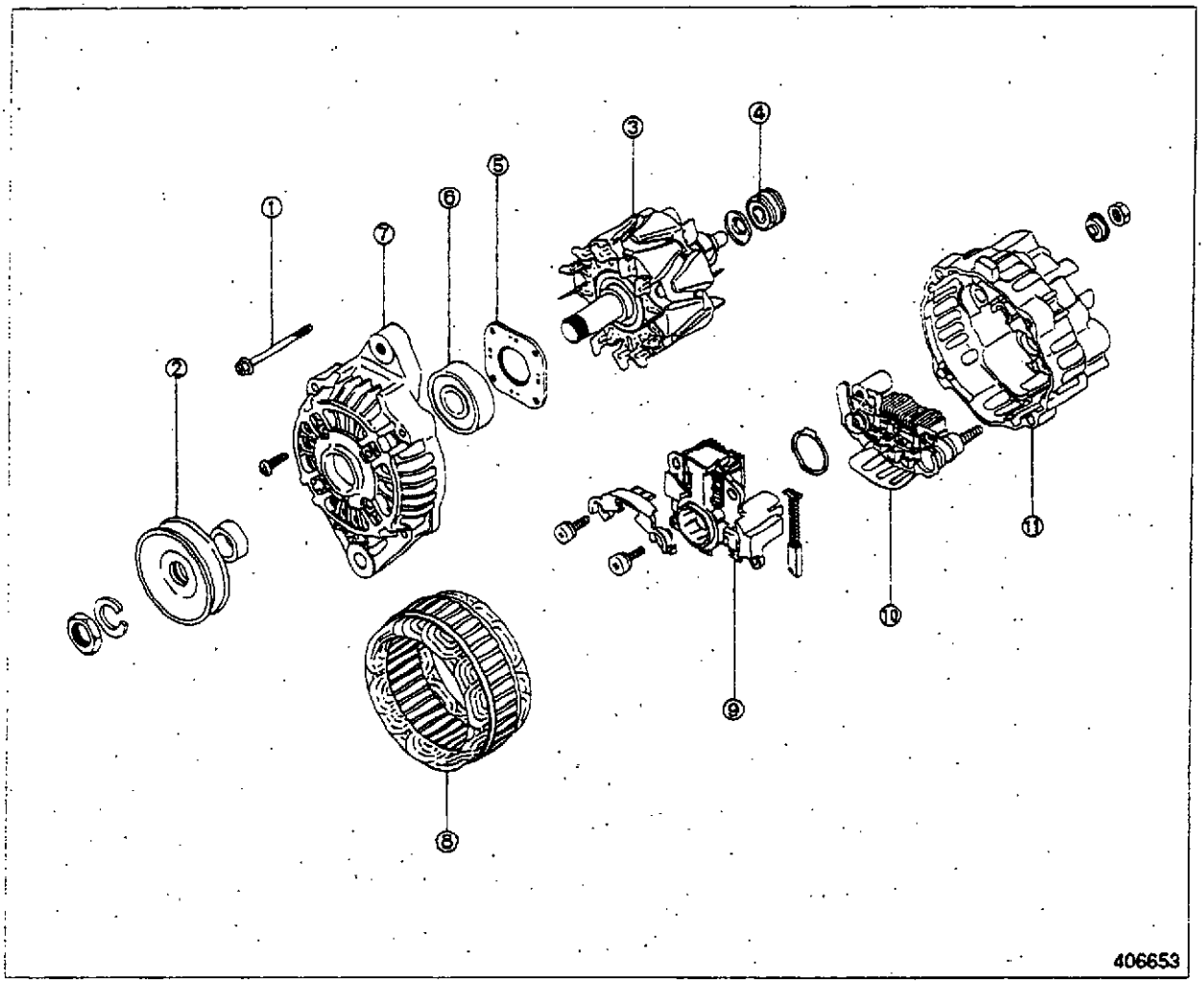
The pinion clearance must be 0.5 to 2.0 mm (0.020 to 0.079 in.). With the pinion held in cranking position, lightly push it toward commutator end to measure free movement (clearance). If the clearance is not correct, make adjustment to it. Increase the amount of packings if the clearance is too large; decrease it if the clearance is too small.



Adjusting pinion clearance

ALTERNATOR

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

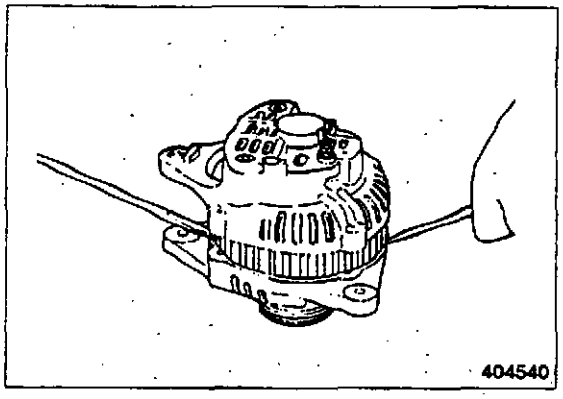
Disassembly procedure

(1) Stator core separation from front bracket

(a) 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.

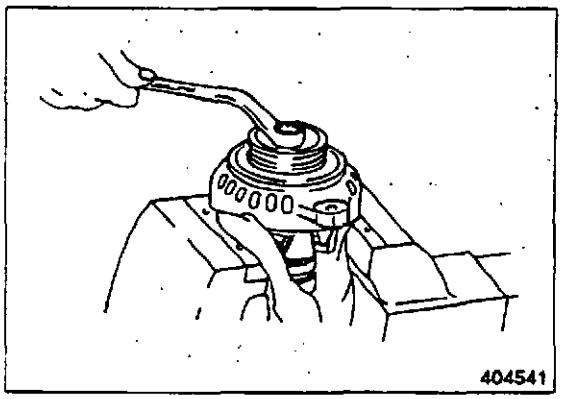


Disassembling alternator

(2) Pulley removal

(a) 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.

(b) Remove the rotor assembly from the front bracket.



Removing pulley

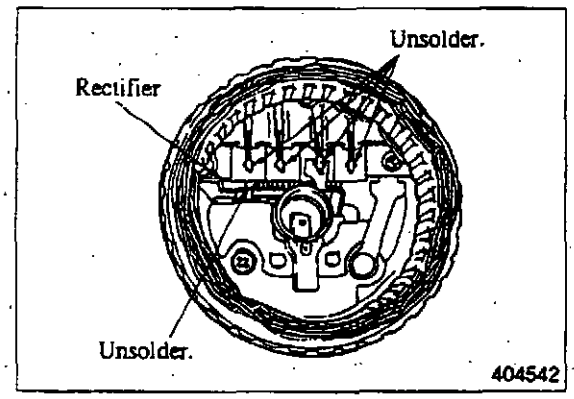
(3) Stator core and rectifier removal

(a) Unsolder the leads from the rectifier and remove the stator core from the rectifier.

⚠ CAUTION

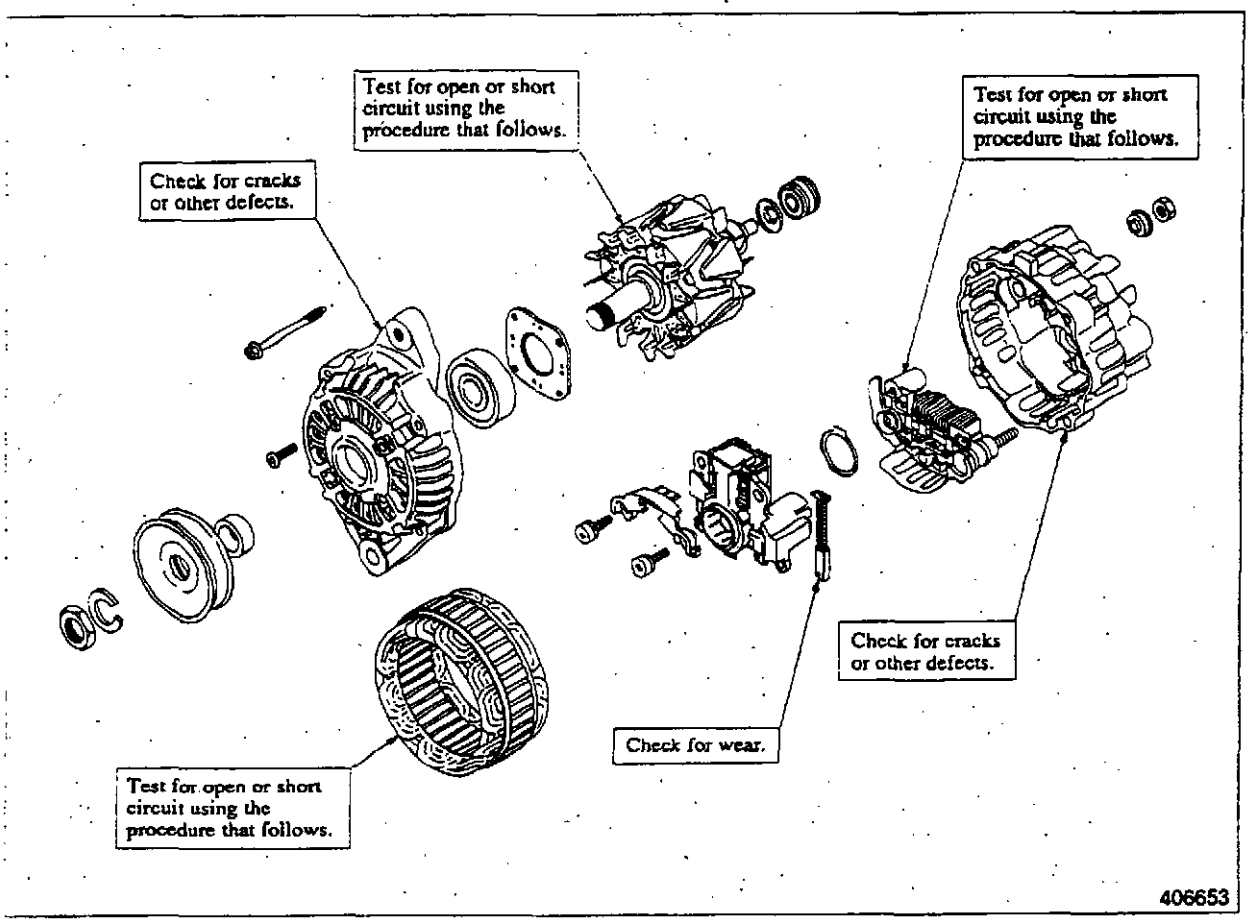
Unsolder the leads as quickly as possible to prevent damage to the diodes in the rectifier.

(b) Remove the screws that hold the rectifier in position and remove the rectifier.



Removing stator core

2. Inspection



Inspection points

Inspection procedure

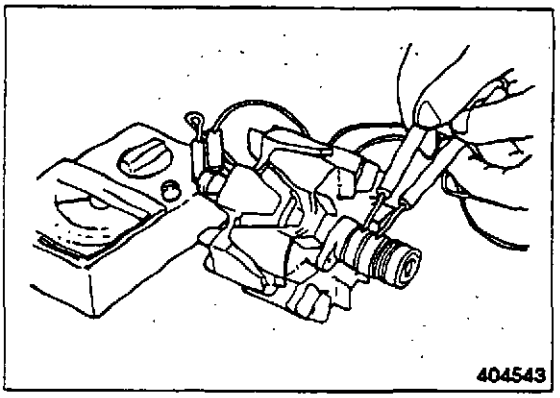
(1) Diodes

(a) 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.

Testing diode

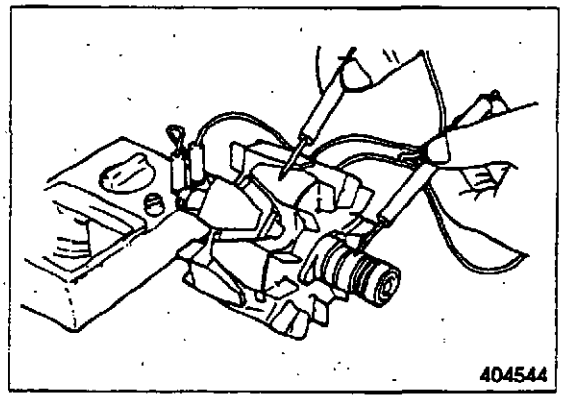
(2) Field coil

(a) 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.



Testing field coil for open circuit

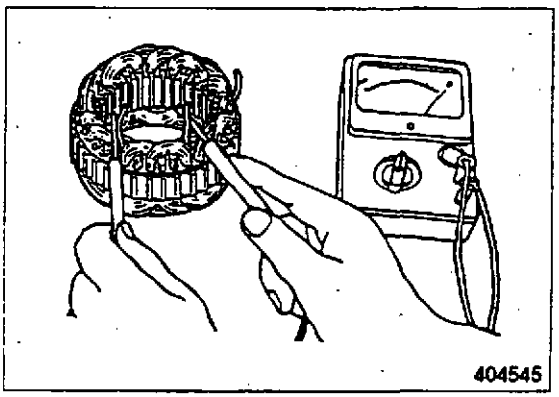
(b) Test for no continuity between the slip ring and shaft (or core) as shown in the illustration. Any continuity shows there is a grounded circuit in the field coil. Replace the field coil.



Testing field coil for grounded circuit

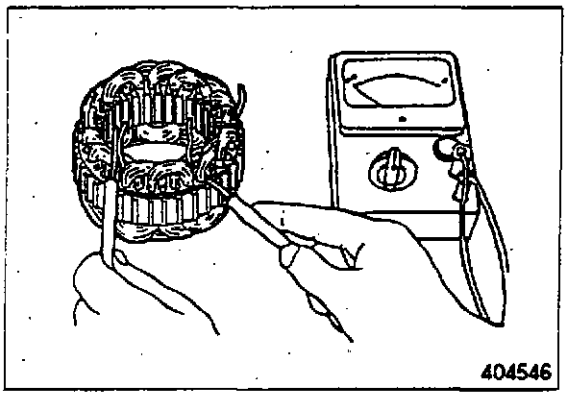
(3) Stator core

(a) 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.



Testing stator core for open circuit

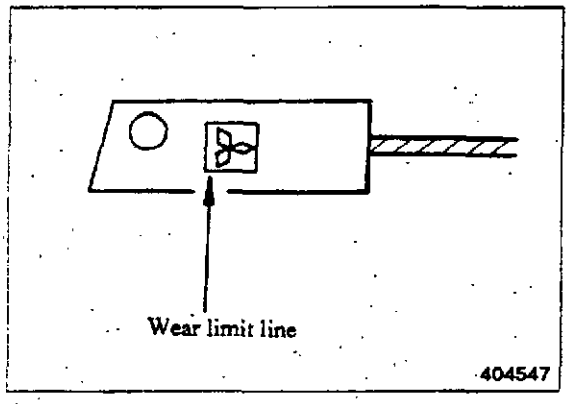
(b) Test for no continuity between each lead and stator core as shown in the illustration. Any continuity shows there is a grounded circuit in the stator core. Replace the stator core.



Testing stator core for grounded circuit

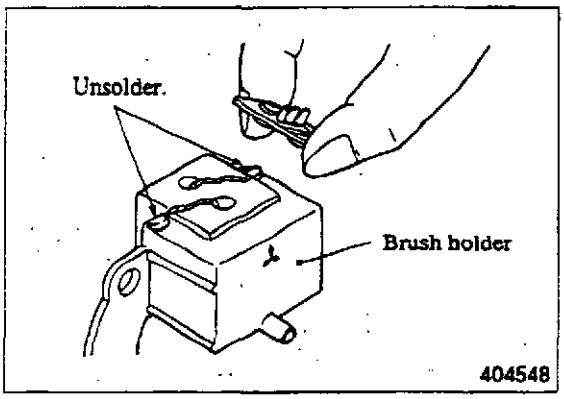
(4) Brushes

(a) Make replacement of brushes that have been worn down to, or beyond, the wear *limit line*.



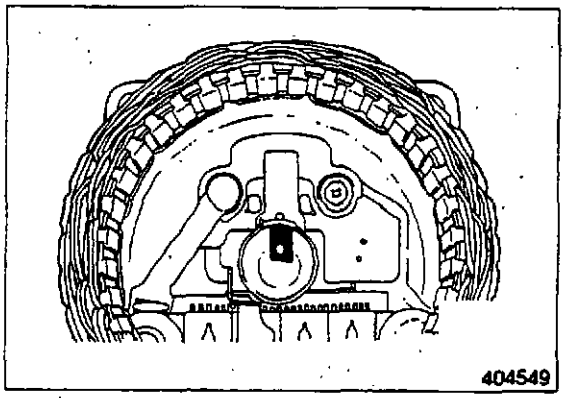
Checking brush for wear

(b) 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.



Removing brushes for replacement

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



Installing new brushes

3. Assembly

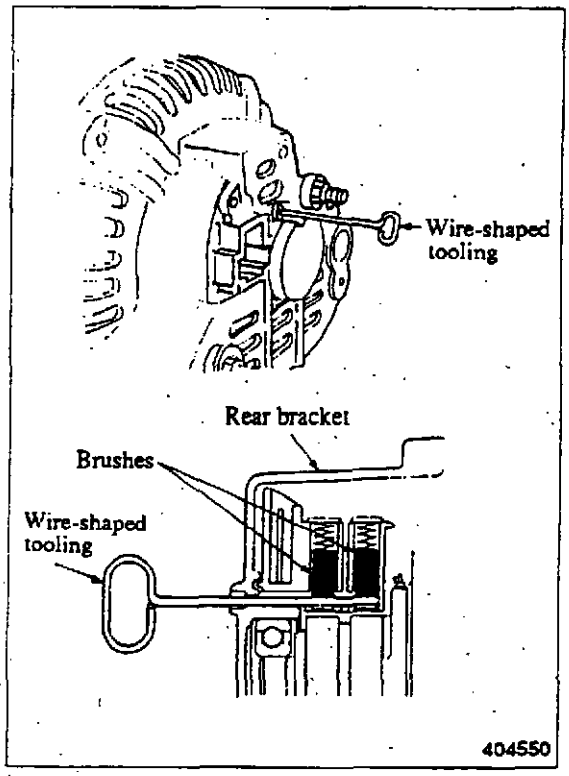
Follow the reverse of disassembly and use the procedure that follows.

(a) 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.

(b) When installing the new rear bearing, put it in position with the side that has a groove toward the slip rings of the rotor.

(c) To install the rear bearing in the rear bracket, heat the rear bracket.

(d) 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.

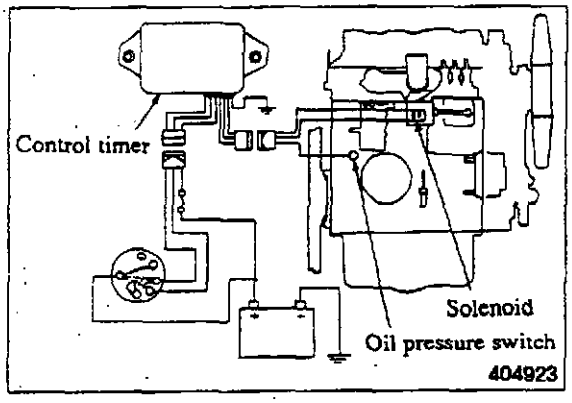


Assembling alternator

KEY SHUTOFF SYSTEM

1. General

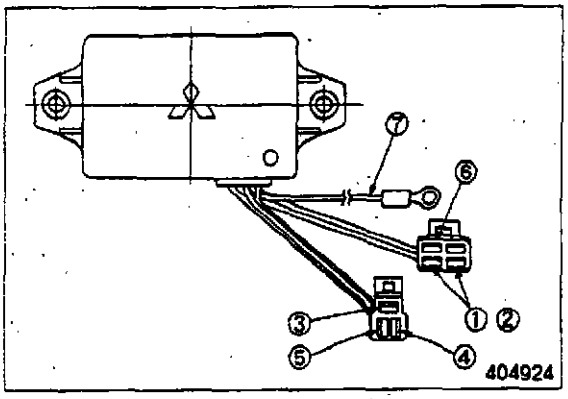
This system, consisting of a switch, a control timer and a solenoid, permits the operator to shut off the engine by turning the starter switch key to OFF position. Another function of this system is to shut off the engine automatically when the oil pressure is too low, or when coolant temperature is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



Key shutoff system

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



Control timer connection

3. *Shutoff solenoid installation*

(a) Remove the tie rod cover.

(b) 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.

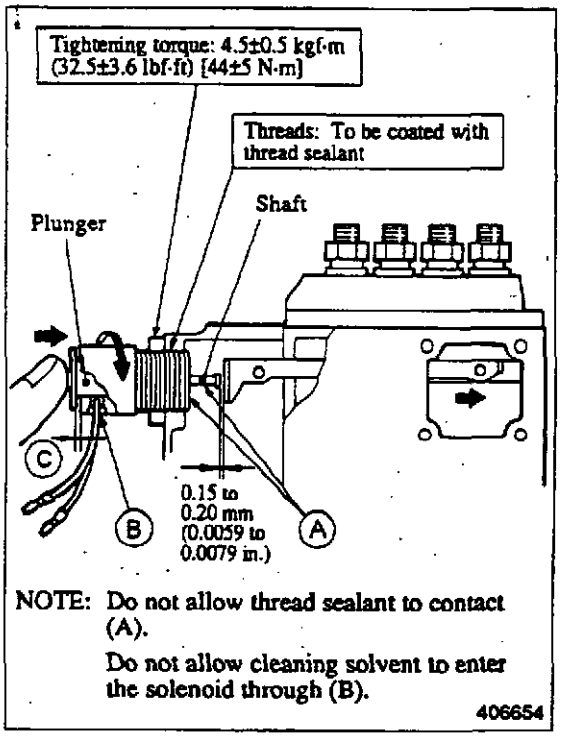
(c) Temporarily install the shutoff solenoid and nut in the governor case.

(d) Move the injection pump control rack all the way to the non-injection (shutoff) position.

(e) 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.)

(f) 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.

(g) Start the engine and make sure the engine stops when the plunger is pushed all the way.

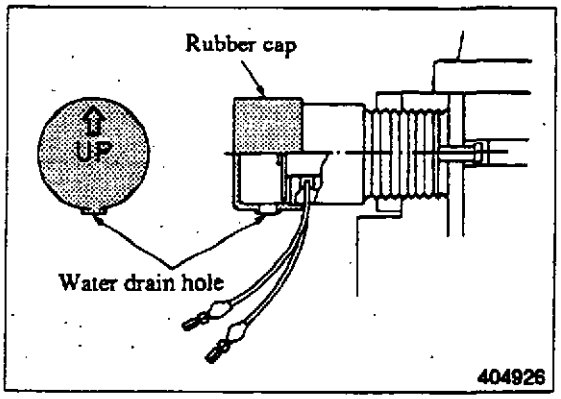


Installing shutoff solenoid

(h) Install the rubber cap in position with the 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.



Installing rubber cap

4. Inspection after assembly

(a) For the schematic of the key shutoff system, see page 98.

(b) Start the engine and make sure the engine stops when the starter switch key is turned to OFF position.

(c) Start the engine and make sure the engine stops when the oil pressure switch terminal is shorted to the switch body.

NOTE

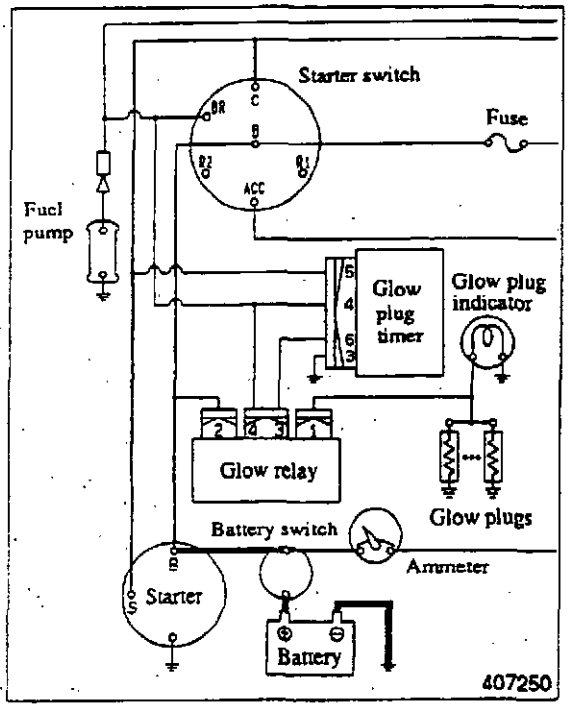
It will take about 5 minutes to restart an engine which was shut down by the key shutoff device.

AUTOMATIC GLOW PLUG SYSTEM

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



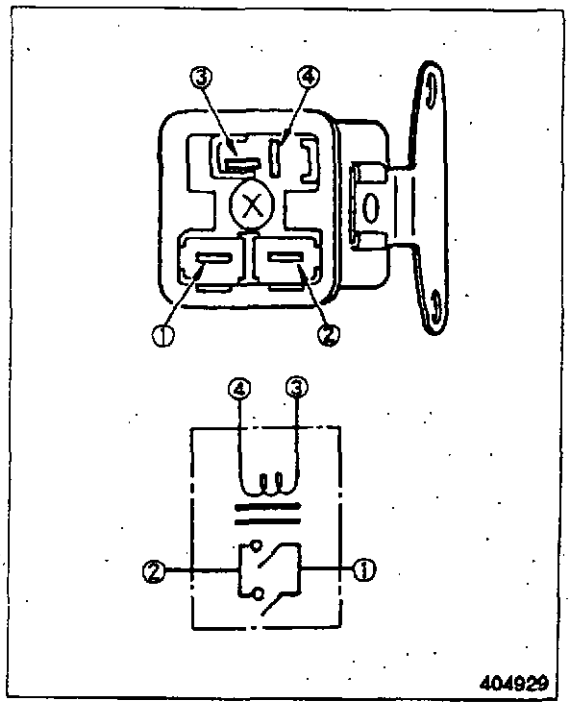
Automatic glow plug system

2. Glow plug timer specifications (standard)

Model	QGS
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

3. Glow plug relay specifications (standard)

Model	G71SP
Rated voltage	DC 12 V
Continuous rating	1 minute
Coil resistance	13Ω
Inductance	24 mH (at 1 kHz)
Operating temperature range	–40°C to +100°C (–40°F to +212°F)

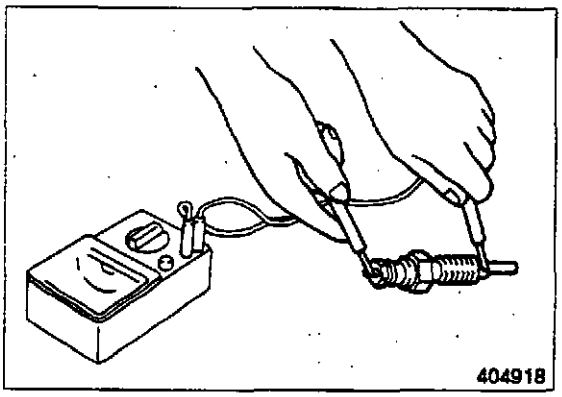


Glow plug relay

3. Glow plug inspection

Test for continuity between the terminal and body as shown in the illustration. No continu-

Item	Standard
Resistance	0.55Ω

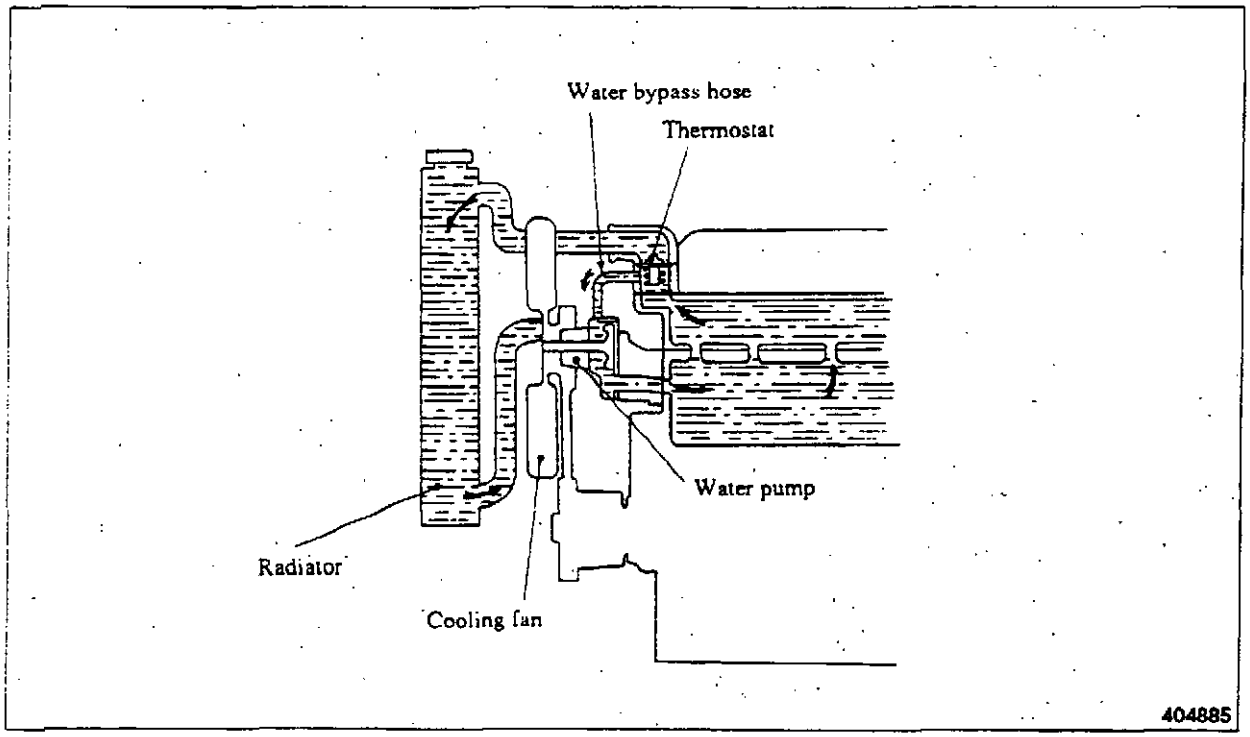


Testing glow plug

COOLING SYSTEM

GENERAL

1. Schematic

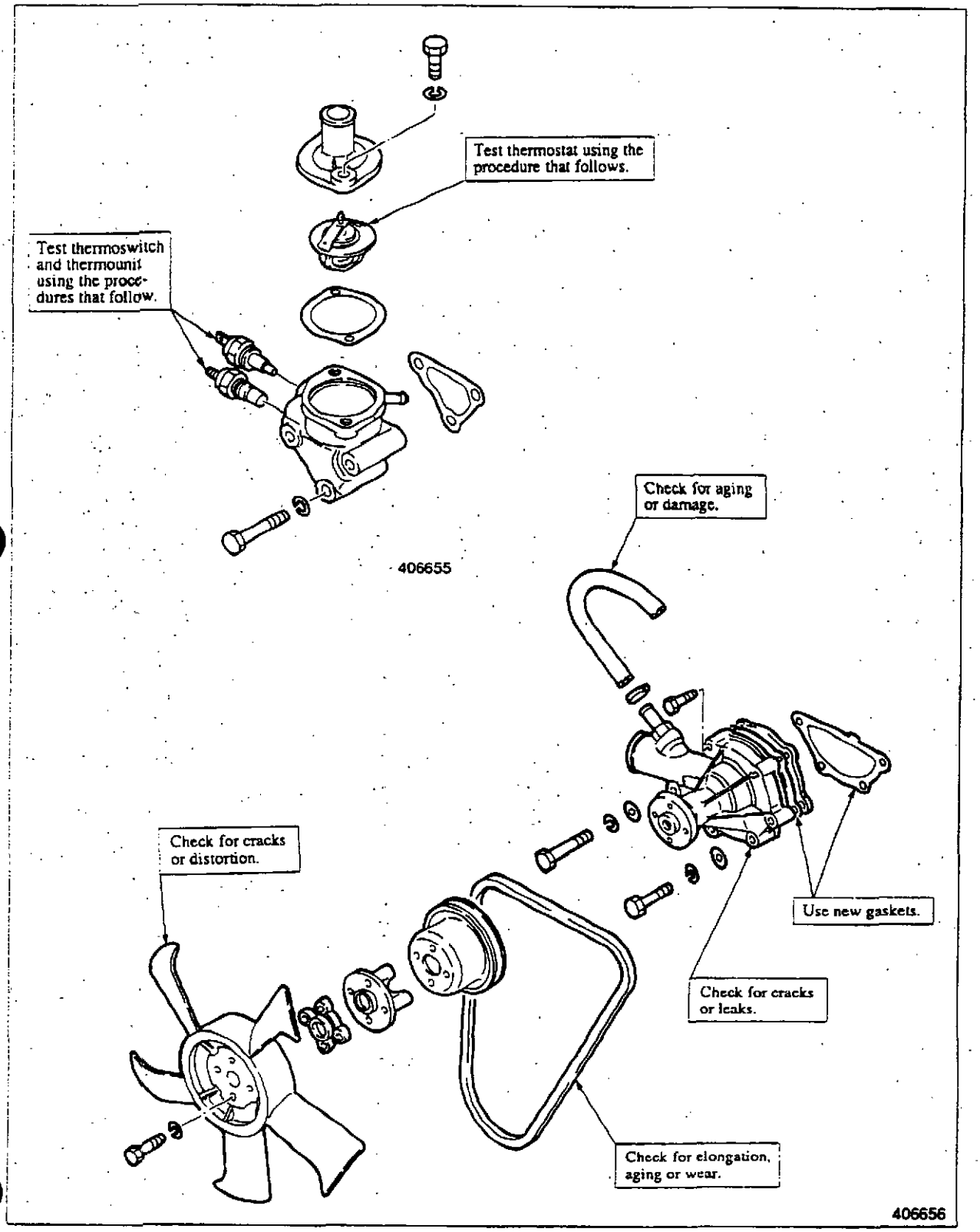


Schematic

2. Specifications (standard)

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)	
Thermoswitch	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	

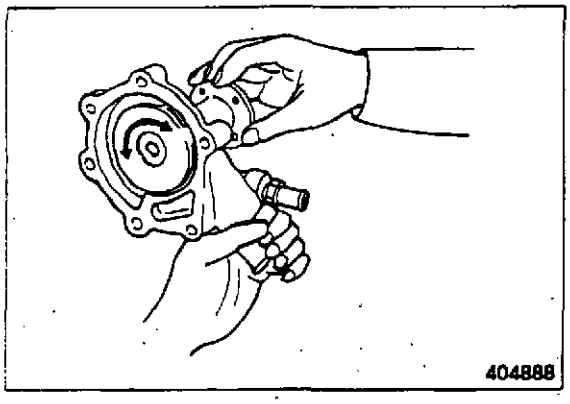
INSPECTION



Inspection points

1. Water pump

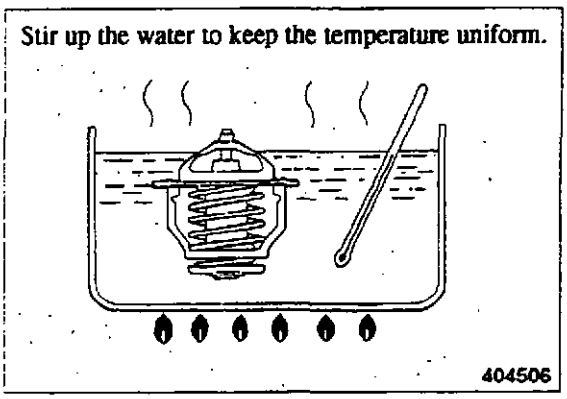
Check the impeller and shaft for rotation. If they do not rotate freely or have noise, replace the water pump assembly.



Checking water pump

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.



Testing thermostat

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)

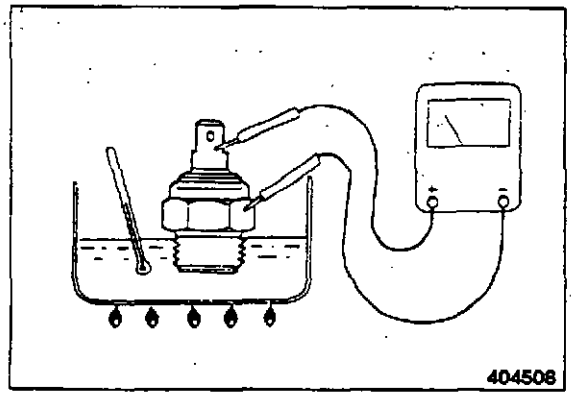
⚠ WARNING

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

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)



Testing thermoswitch

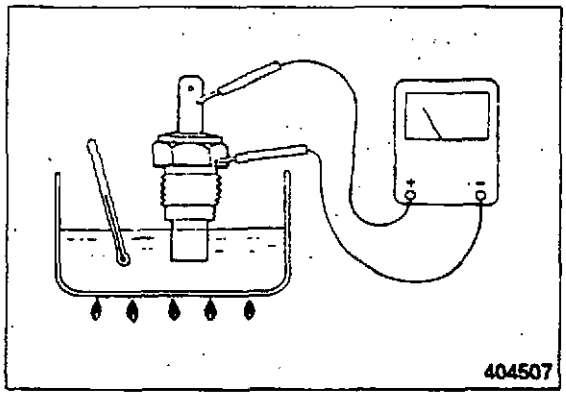
⚠ WARNING

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

3. 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



Testing thermounit

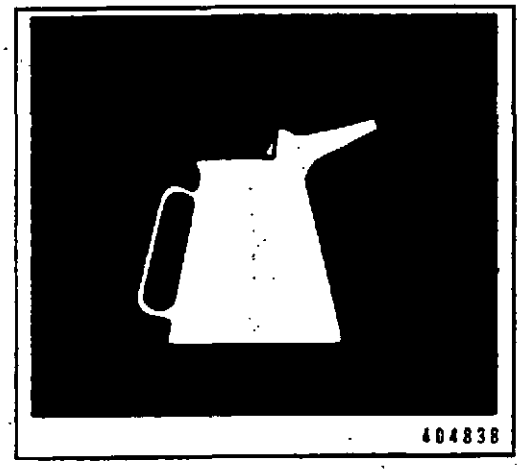
⚠ WARNING

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

LUBRICATION SYSTEM

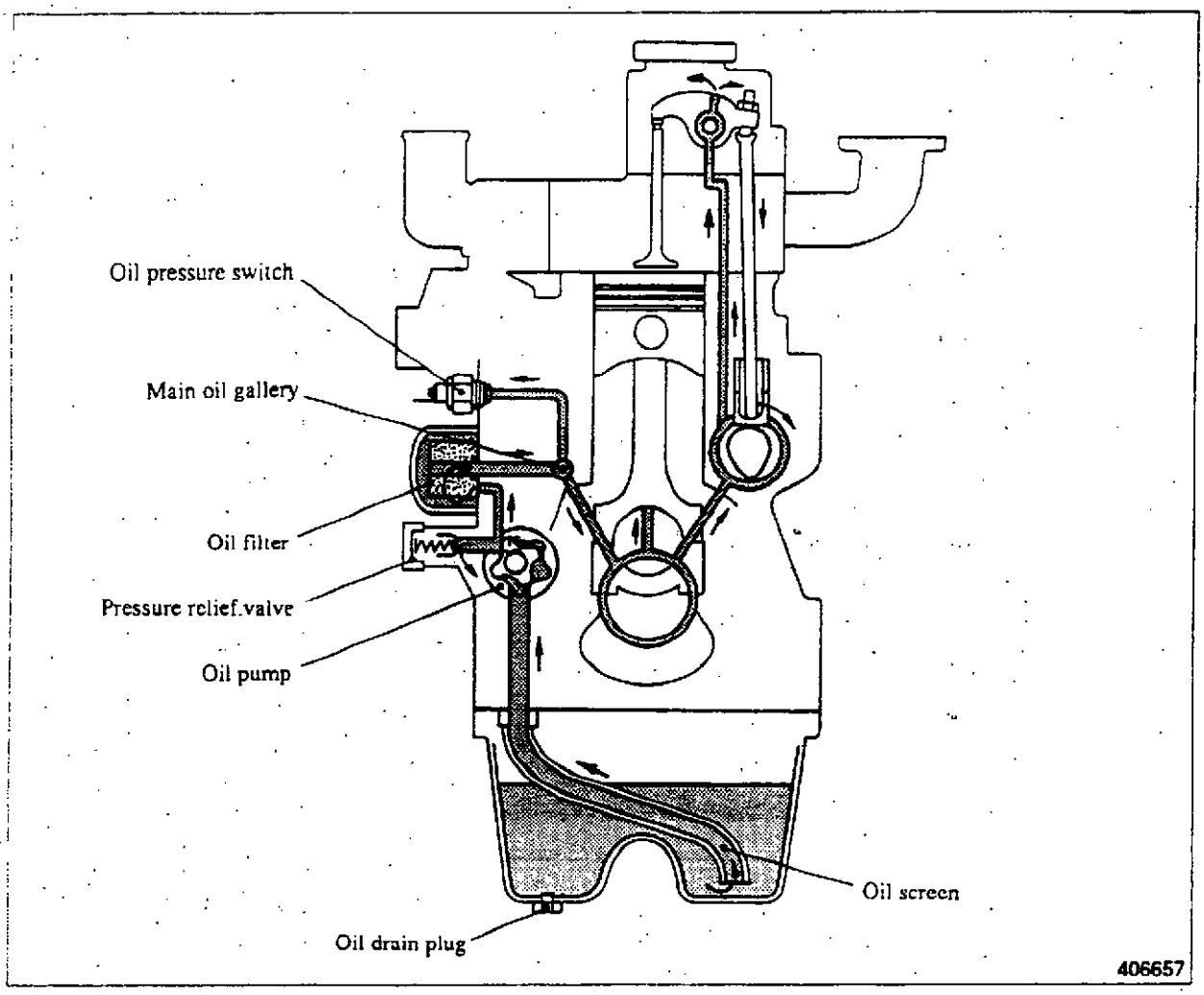
GENERAL

INSPECTION



GENERAL

1. Schematic



Schematic

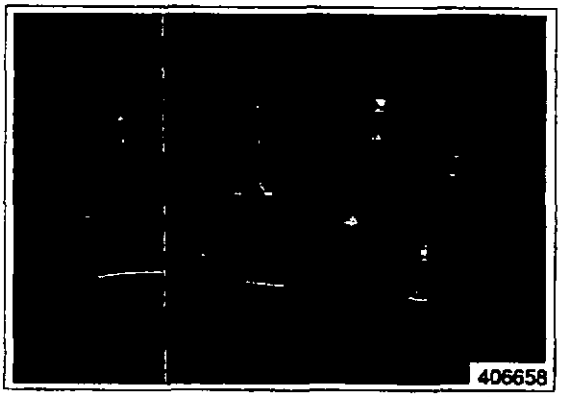
2. Specifications

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/cm² (50 ± 7 psi) [343 ± 49 kPa]	
Pressure difference at which oil pressure switch is closed (indicator light comes on)		0.5 ± 0.1 kgf/cm² (7 ± 1.4 psi) [49 ± 10 kPa]	
Oil filter		Paper-element cartridge (full flow) type	

INSPECTION

1. Oil pump

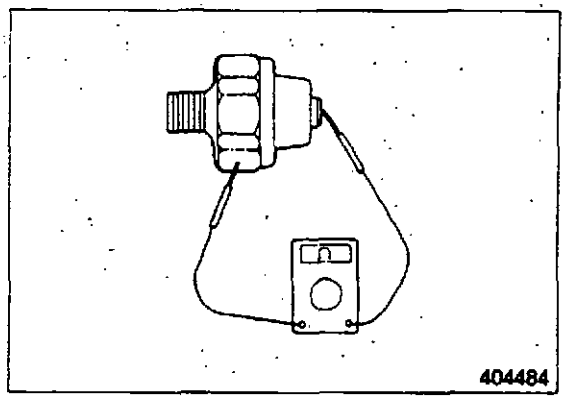
Visually check the pump for rough rotation or other defects. Replace the pump assembly if defective.



Checking oil pump

2. Oil pressure switch

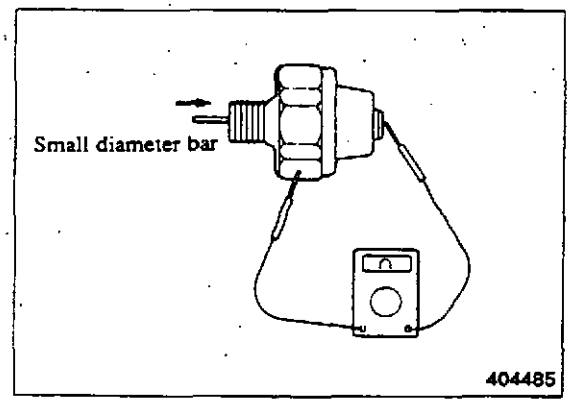
(1) Test for continuity between the terminal and body with an ohmmeter as shown in the illustration. No continuity is the cause for replacing the switch.



Testing oil pressure switch (1)

(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.



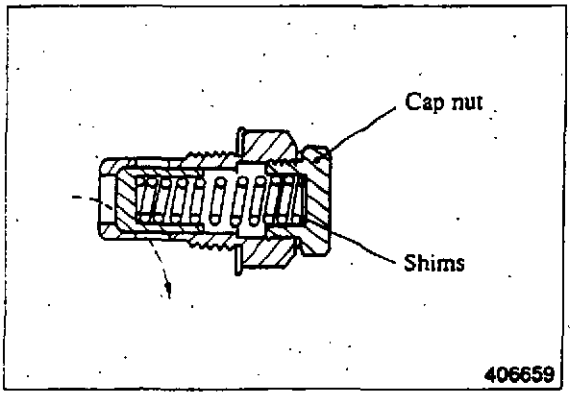
Testing oil pressure switch (2)

3. Pressure relief valve

(1) Check the valve seat for contact. Check the spring for damage.

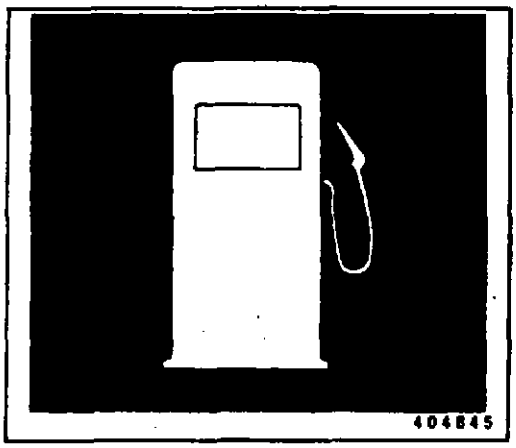
(2) Measure the oil pressure at which the relief valve opens (the oil pressure with the engine running at the rated rpm). If the pressure is not correct, remove the cap nut and increase or decrease the amount of shims. The engine oil pressure tap is located on the right side of the engine.

Relief valve opening pressure	3.5 ± 0.5 kgf/cm² (50 ± 7 psi) [343 ± 49 kPa]



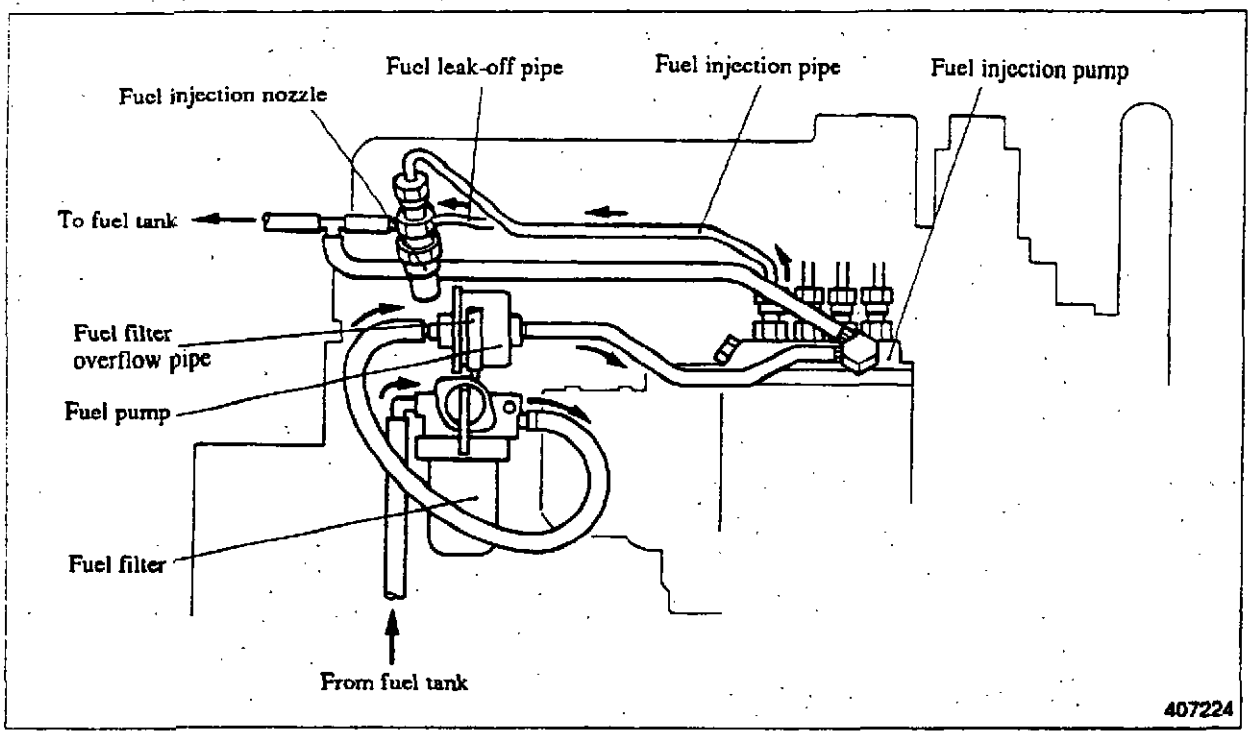
Checking pressure relief valve

FUEL SYSTEM



GENERAL

1. Schematic



2. Specifications (standard)

Engine model		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^{+5}_{0} kgf/cm^2 (1991^{+71}_{0} psi) [$13\,729^{+490}_{0}$ kPa]	
Fuel filter (remote)	Type	Paper element	
Fuel 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	

FUEL INJECTION NOZZLE

1. Inspection

(1) Injection pressure (valve opening pressure) test

(a) Install the injection nozzle on the tester. Slowly operate the tester handle to bleed (remove) air from the tester.

(b) 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.

(c) If the injection pressure is incorrect, disassemble the nozzle and change the thickness of the washer.

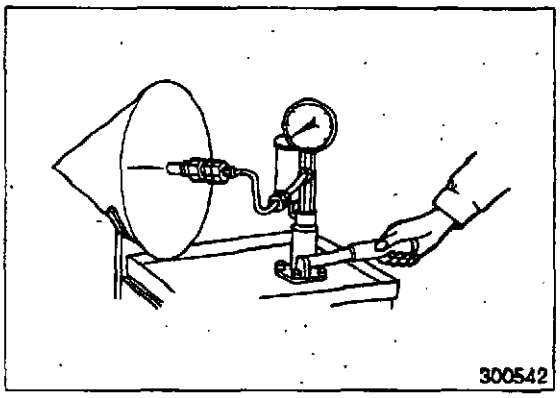
Injection pressure (valve opening pressure) Standard	140^{+5}_{0} kgf/cm^2 ($1\,991^{+71}_{0}$ psi) [$13\,729^{+490}_{0}$ kPa]

NOTE

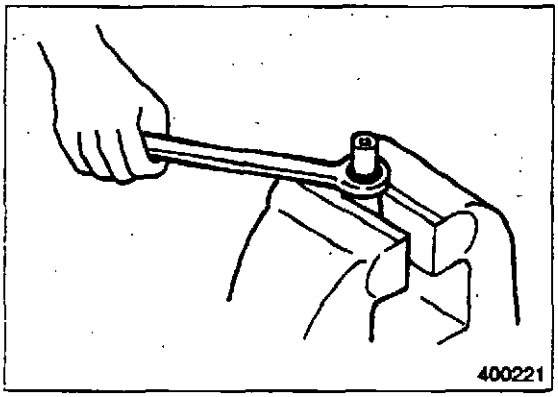
An increase or decrease of washer thickness by 0.1 mm (0.004 in.) will vary the injection pressure by 10 kgf/cm^2 (142 psi) [981 kPa]. 10 kinds of washer are available in thicknesses from 1.25 mm (0.049 2 in.) to 1.70 mm (0.066 9 in.) in increments of 0.05 mm (0.002 0 in.).

⚠ 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.



Fuel injection nozzle ready for test

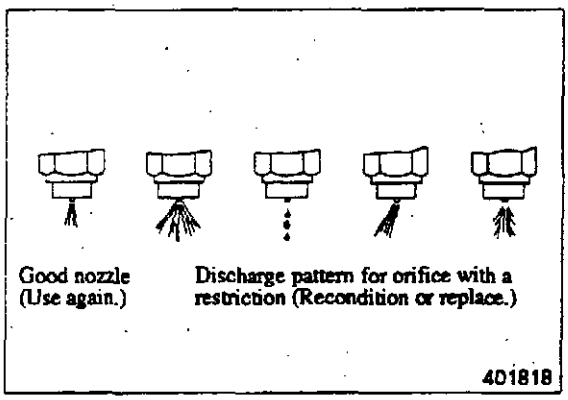


Removing tip from injection nozzle

(2) Orifice restriction test

(a) 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.

(b) Operate the tester handle at a speed of one stroke per second to make sure the discharge is straight.



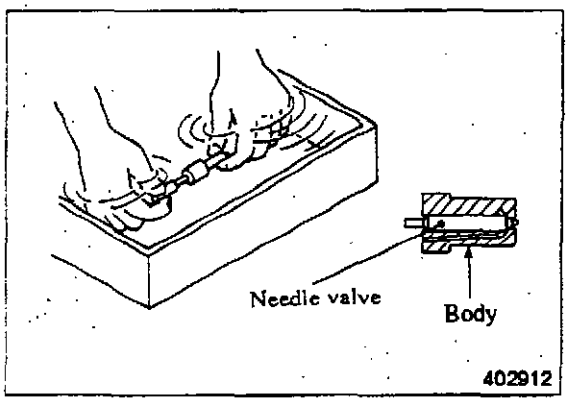
Orifice restriction test

(3) Nozzle tip washing and replacement

(a) 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.



Washing nozzle tip

NOTE

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

(b) 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]

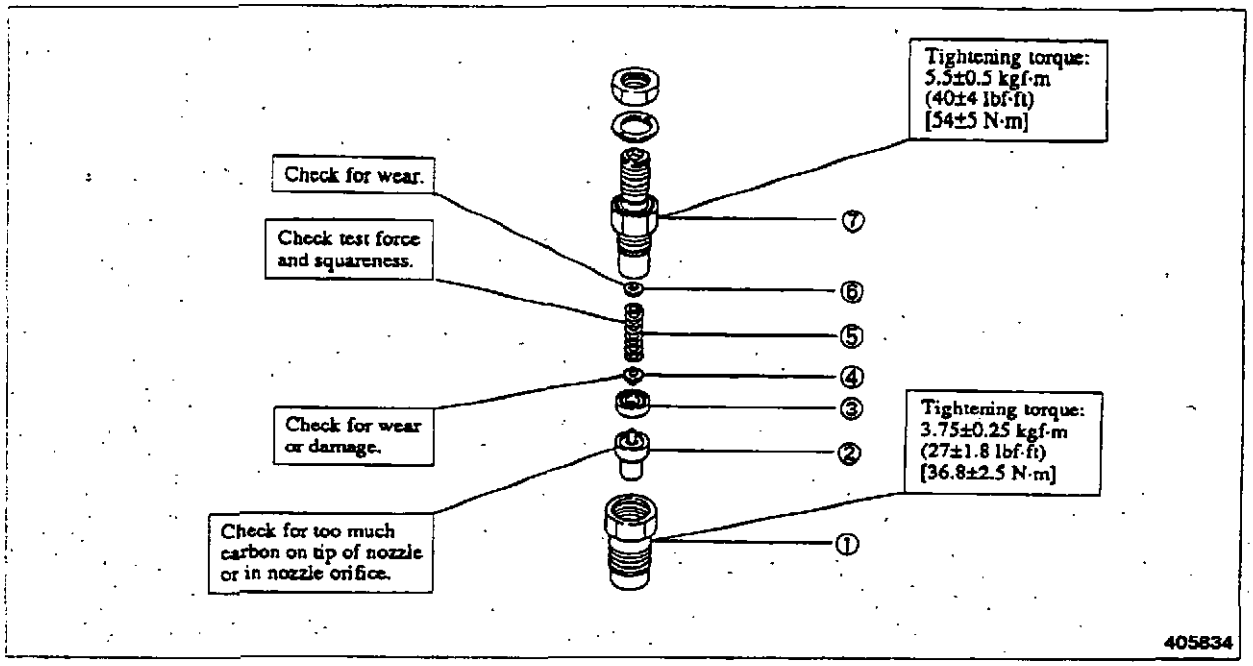
(c) If the injection nozzle is still bad after the tip has been washed, replace the tip.

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.

2. Disassembly and assembly



Disassembly sequence and inspection points

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

FUEL INJECTION PUMP

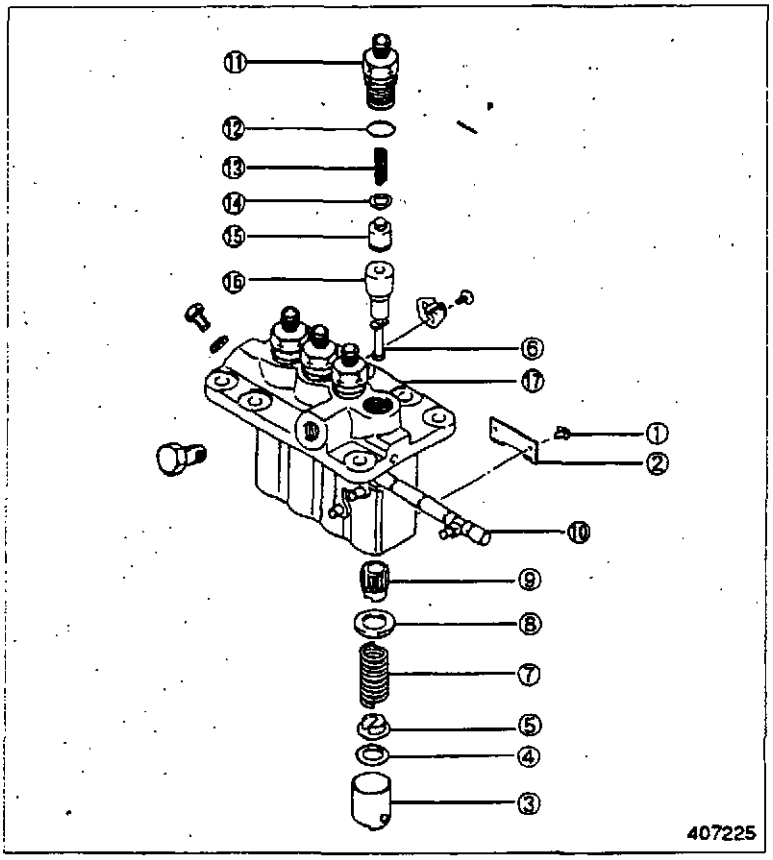
1. Test on engine

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 farm engine: 980^{+30}_{0} rpm
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

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 sequence

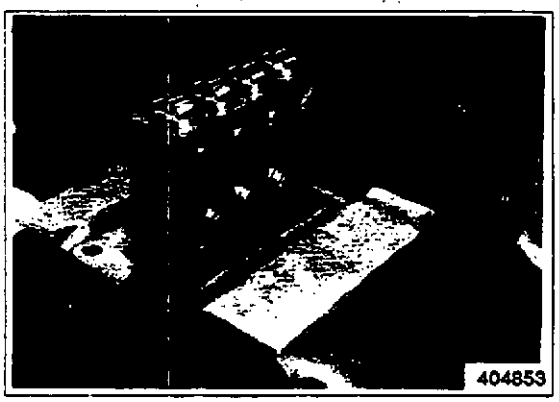
Disassembly procedure

(1) Tappet removal

(a) Hold the injection pump in a vise with the side that has tappets up.

(b) Straighten the lock plate away from the tappet guide pin with a screwdriver.

(c) Rotate the tappet guide pin 180° to unlock it from the housing.



Removing tappet guide pins

(d) Remove the tappet guide pin with a needle-nose pliers while pushing down on the tappet. Remove the tappet.

(e) Do Steps (b) through (d) again for remainder of the tappets.

Removing 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.

(2) Plunger removal

(a) Remove the tappet adjusting shim.

(b) Remove the lower spring seat and plunger with a tweezers.

(c) Remove the plunger spring.

(d) Remove the upper spring seat and control sleeve.

(e) Do Steps (a) through (d) again for remainder of the plungers.

(f) Remove the control rack.

Removing plungers

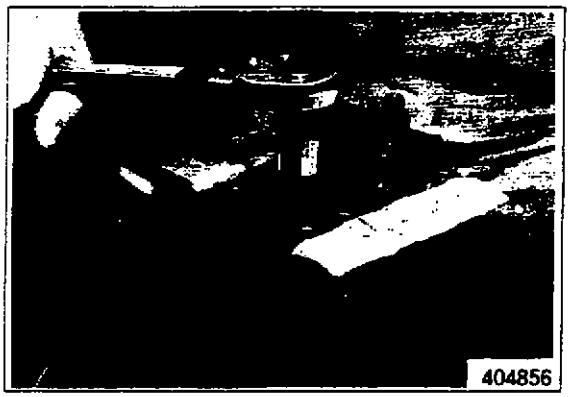
(3) Delivery valve removal

(a) Turn the injection pump upside down and hold it in a vise.

(b) Remove the delivery valve holder.

(c) Remove the delivery valve spring.

(d) Remove the delivery valve gasket.



Removing delivery valve holders

(e) Remove the delivery valve with a tweezers.

(f) Do Steps (b) through (e) again for remainder of delivery valves.

⚠ CAUTION

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

Removing delivery valves

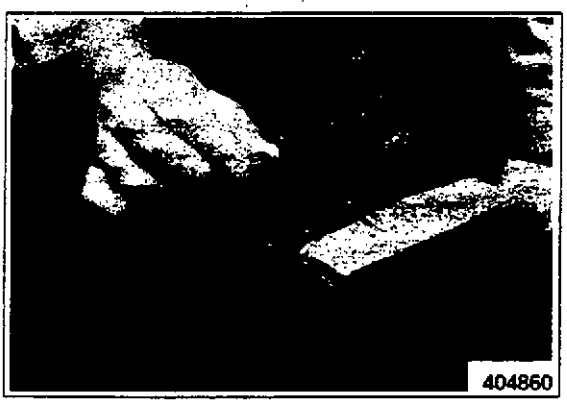
(4) Barrel removal

(a) 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.



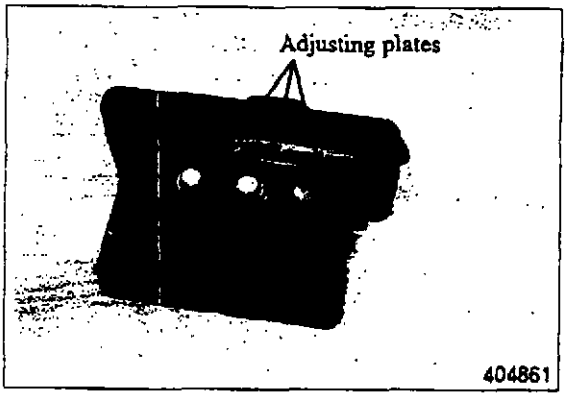
Removing barrels

NOTE

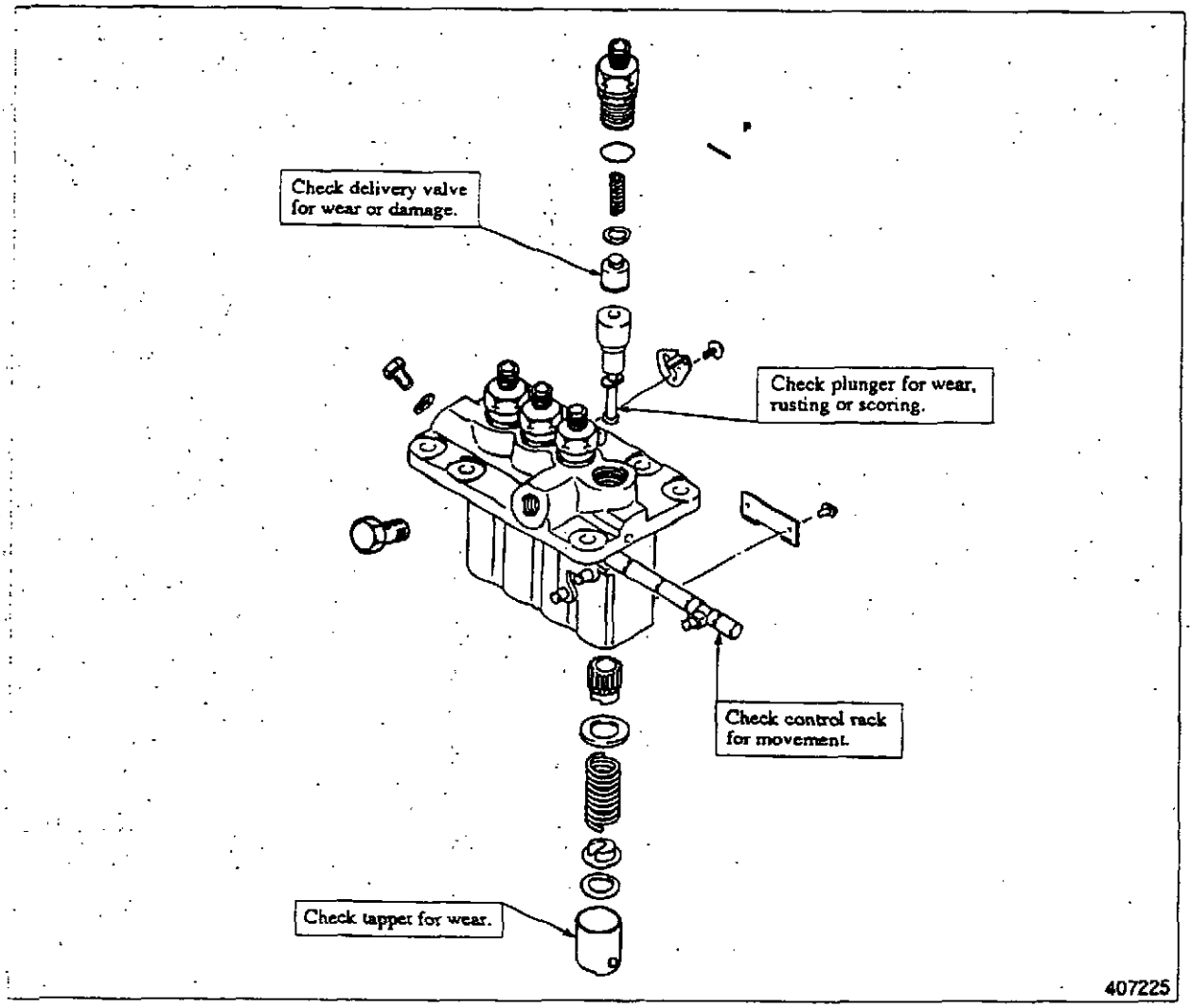
a) When replacing the plungers and barrels or delivery valves, do not loosen the adjusting plates between the pumping elements.

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.

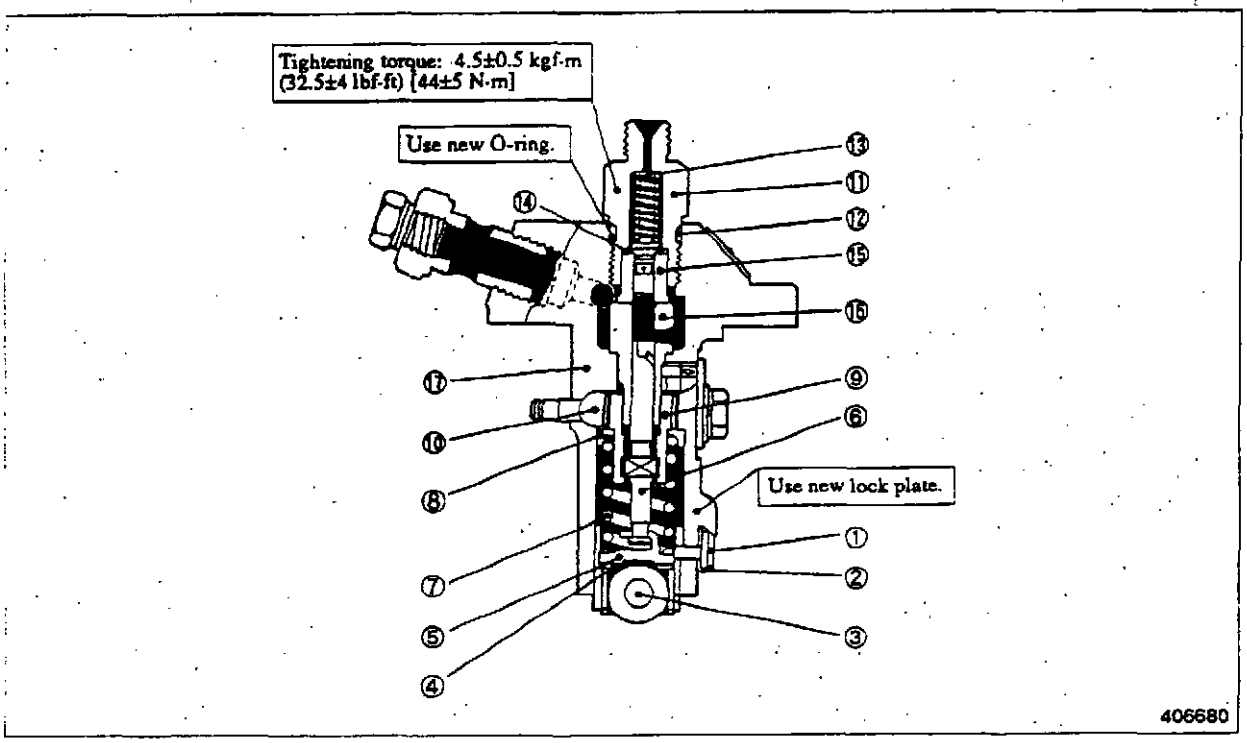


3. Inspection



Inspection points

4. Assembly



Assembly sequence

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

Assembly procedure

(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.

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.

Installing barrels

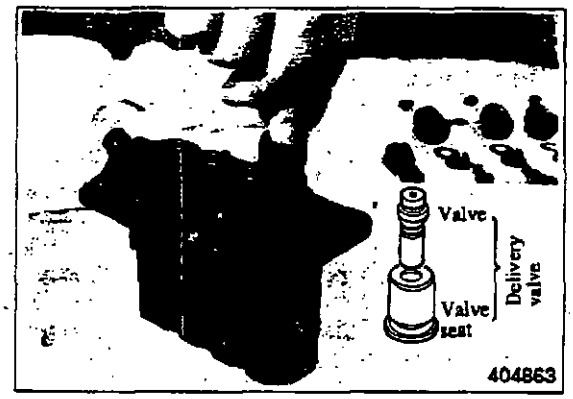
(2) Delivery valve installation

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.

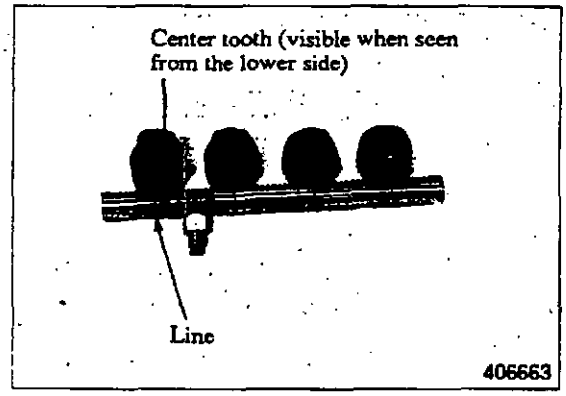
b) Make sure the threads of the delivery valve holder do not cause damage to the O-rings.



Installing delivery valves

(3) Control sleeve installation

(a) Install each control sleeve with the center tooth in alignment with the line mark of the control rack.

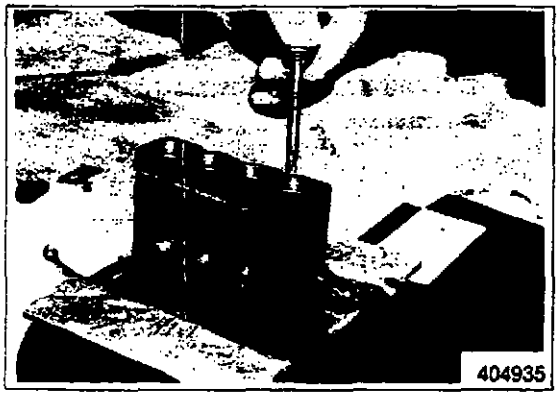


Installing control sleeves

(b) Put the plungers in position in the barrels.

⚠ CAUTION

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



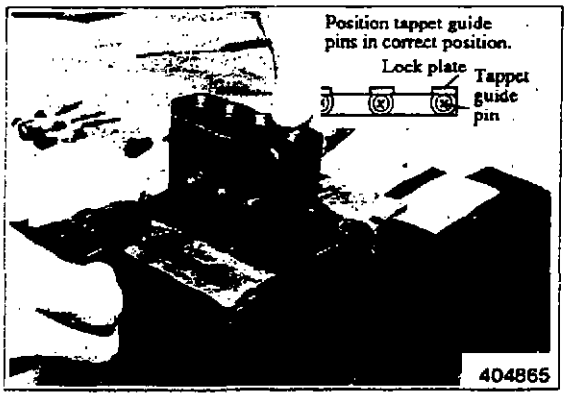
Installing plungers

(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.



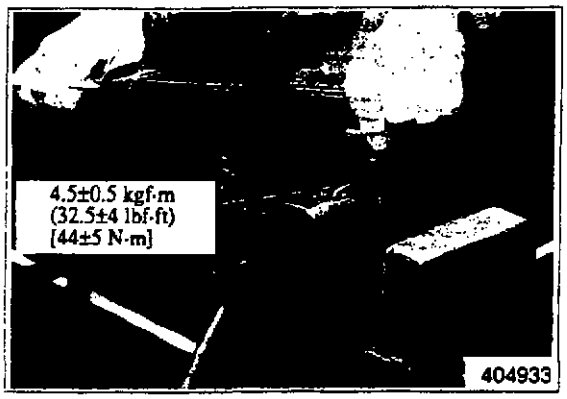
Installing tappets

(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.



Tightening delivery valve holders

(6) Inspection after assembly

(a) After the injection pump has been assembled, check to see if the control rack moves freely without any binding or catching.

(b) If the control rack fails to move freely, the possible causes are:

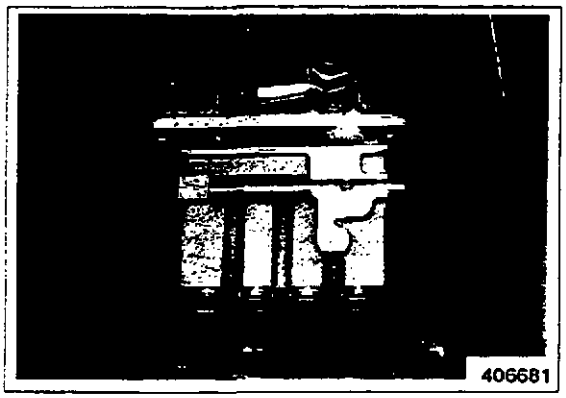
1) Pumping element(s) sticking

2) Foreign particles lodged between control rack and sleeves

3) Over-tightening of delivery valve holder(s)

Disassemble and check the injection pump to locate the cause of the trouble.

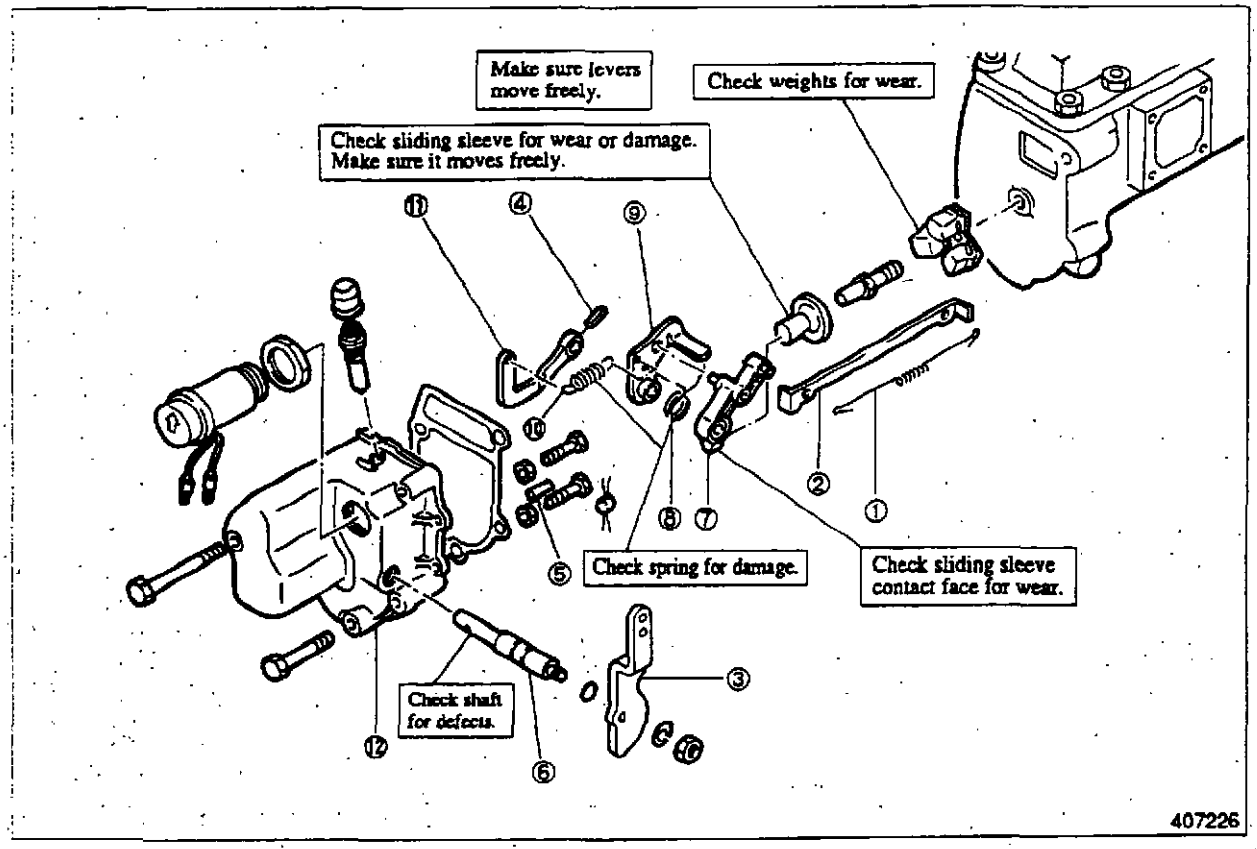
(c) After the injection pump has been finally assembled, check the injection timing.



Checking control rack movement

GOVERNOR

1. Disassembly and inspection

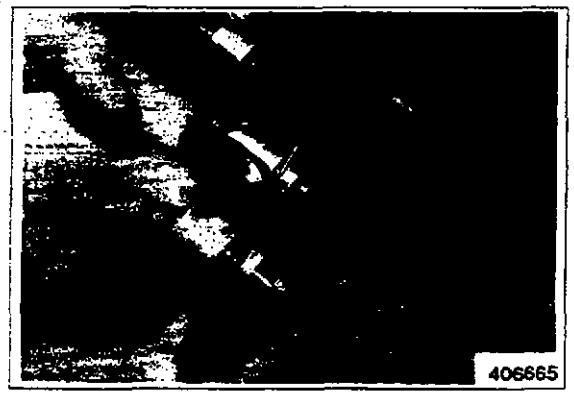


Disassembly sequence and inspection points

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

2. Assembly

(1) Install the levers in position.



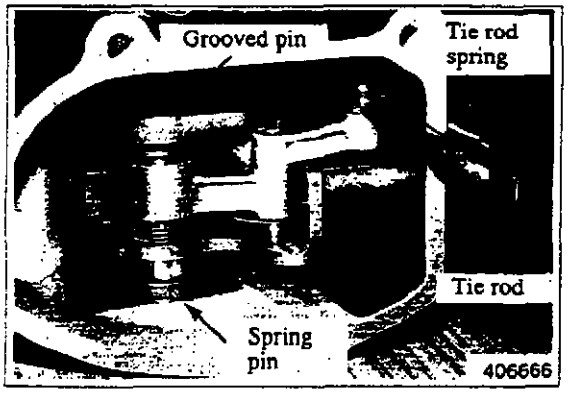
Installing governor levers

(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.



Assembling governor

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.

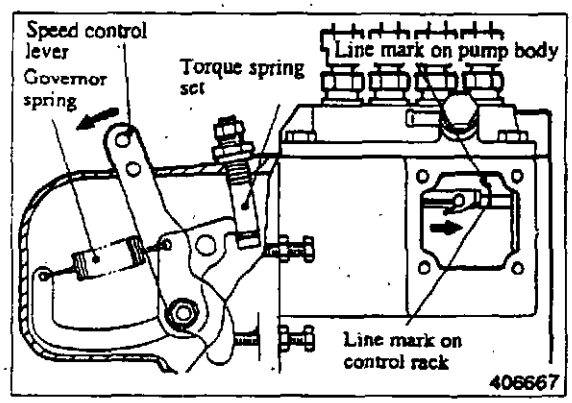
NOTE

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

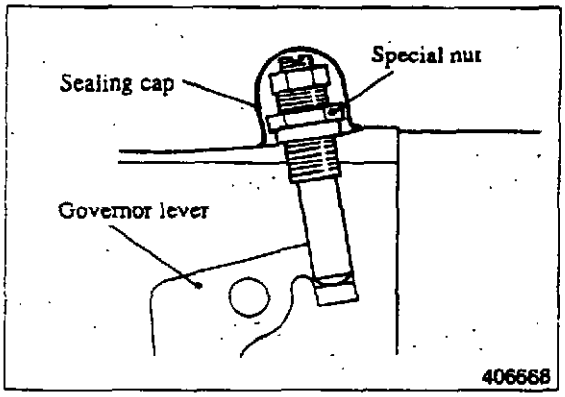
(4) Turn in the torque spring set while lightly pulling the tie rod until the line mark on the control rack is aligned with the line mark on the pump body.

(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.



Installing torque spring set

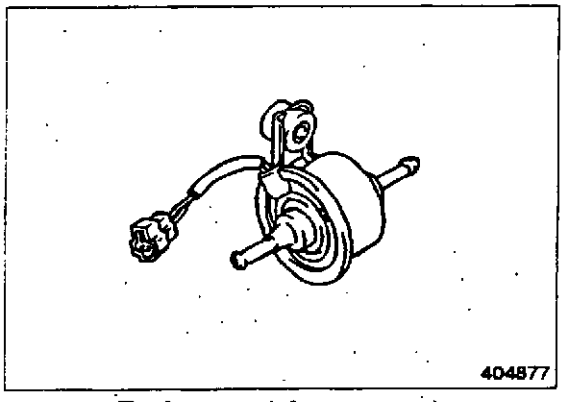


Sealing cap for torque spring set

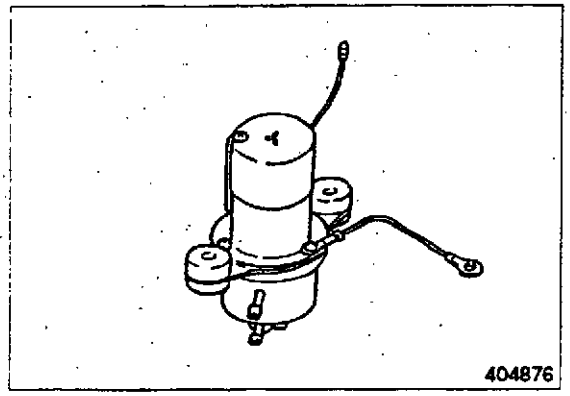
FUEL PUMP

Inspection

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



Fuel pump (plunger type)

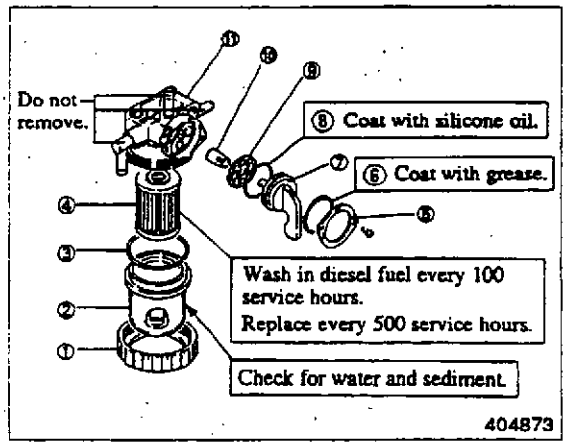


Fuel pump (diaphragm type)

FUEL FILTER

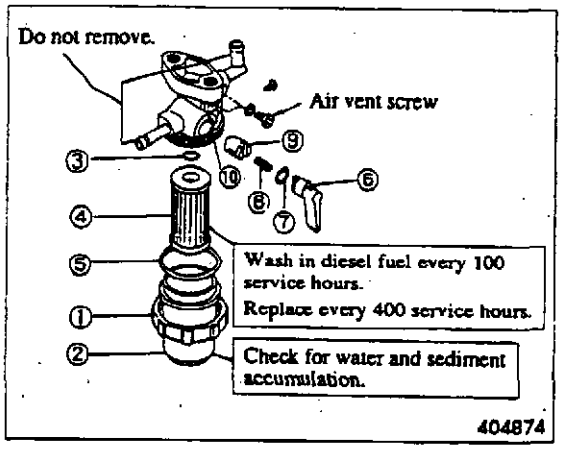
(1) Normally, the fuel filter is not to be disassembled. Only element removal for cleaning or replacement is recommended.

(2) When installing the valve lever after washing, coat the O-ring for the lever with silicone oil and the washer with grease.



Fuel filter

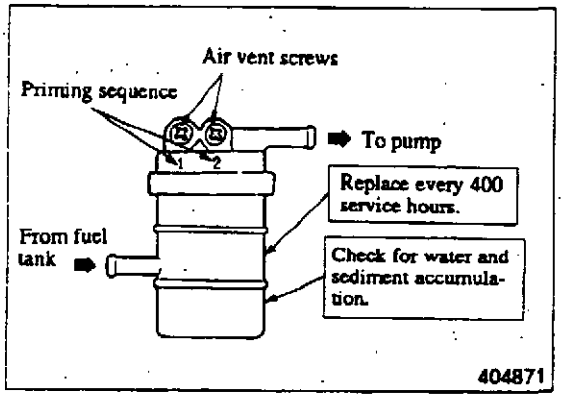
① Ring nut
② Cup
③ O-ring
④ Element
⑤ Lever plate
⑥ Washer
⑦ Valve lever
⑧ O-ring
⑨ Packing
⑩ Valve seat
⑪ Filter body



Fuel filter

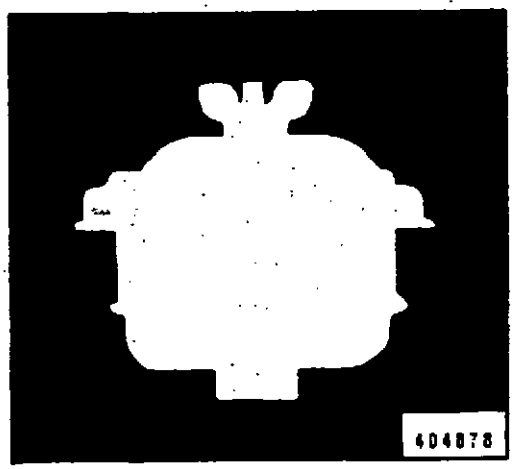
① Ring nut
② Cup
③ O-ring
④ Element
⑤ O-ring
⑥ Valve lever
⑦ O-ring
⑧ Spring
⑨ Valve
⑩ Filter body

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.



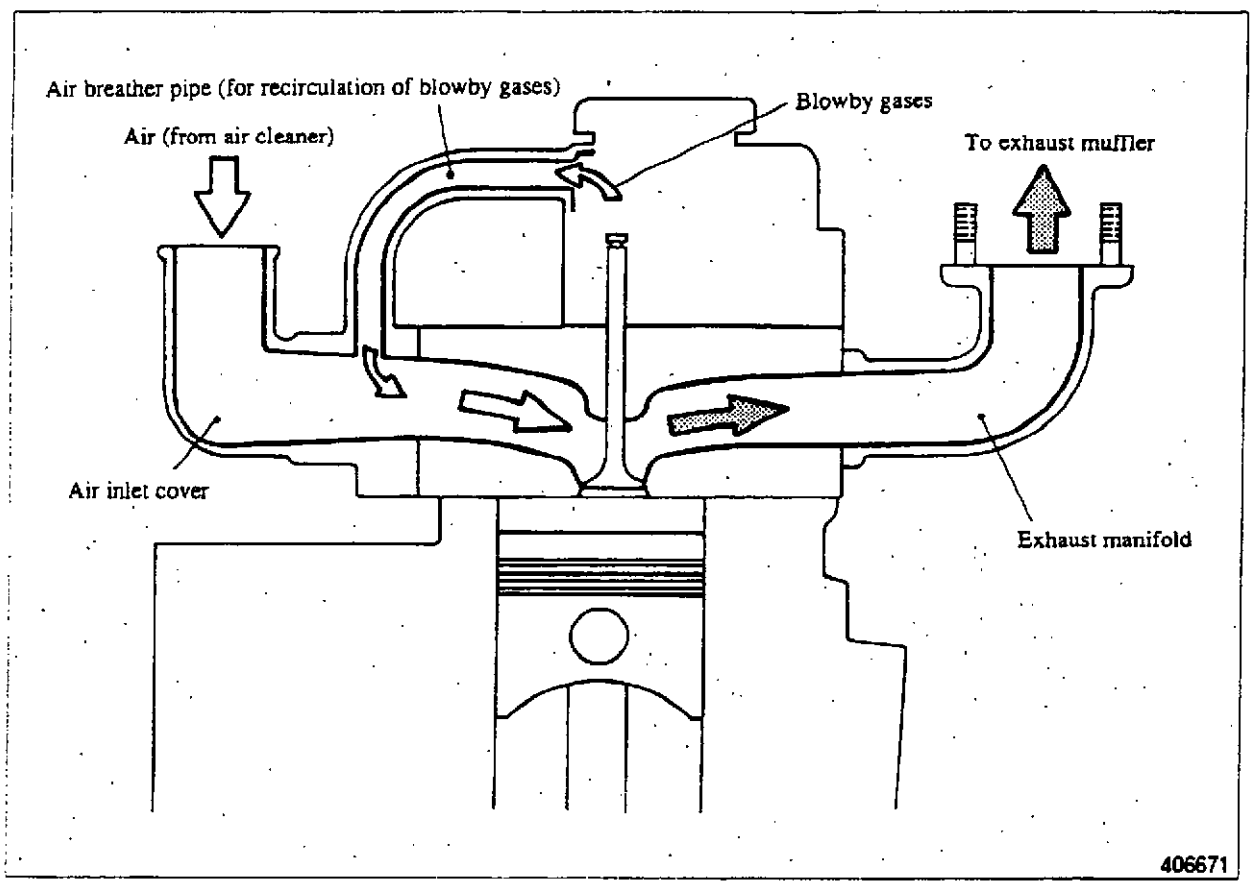
Fuel filter (cartridge type)

AIR INLET SYSTEM AND EXHAUST SYSTEM

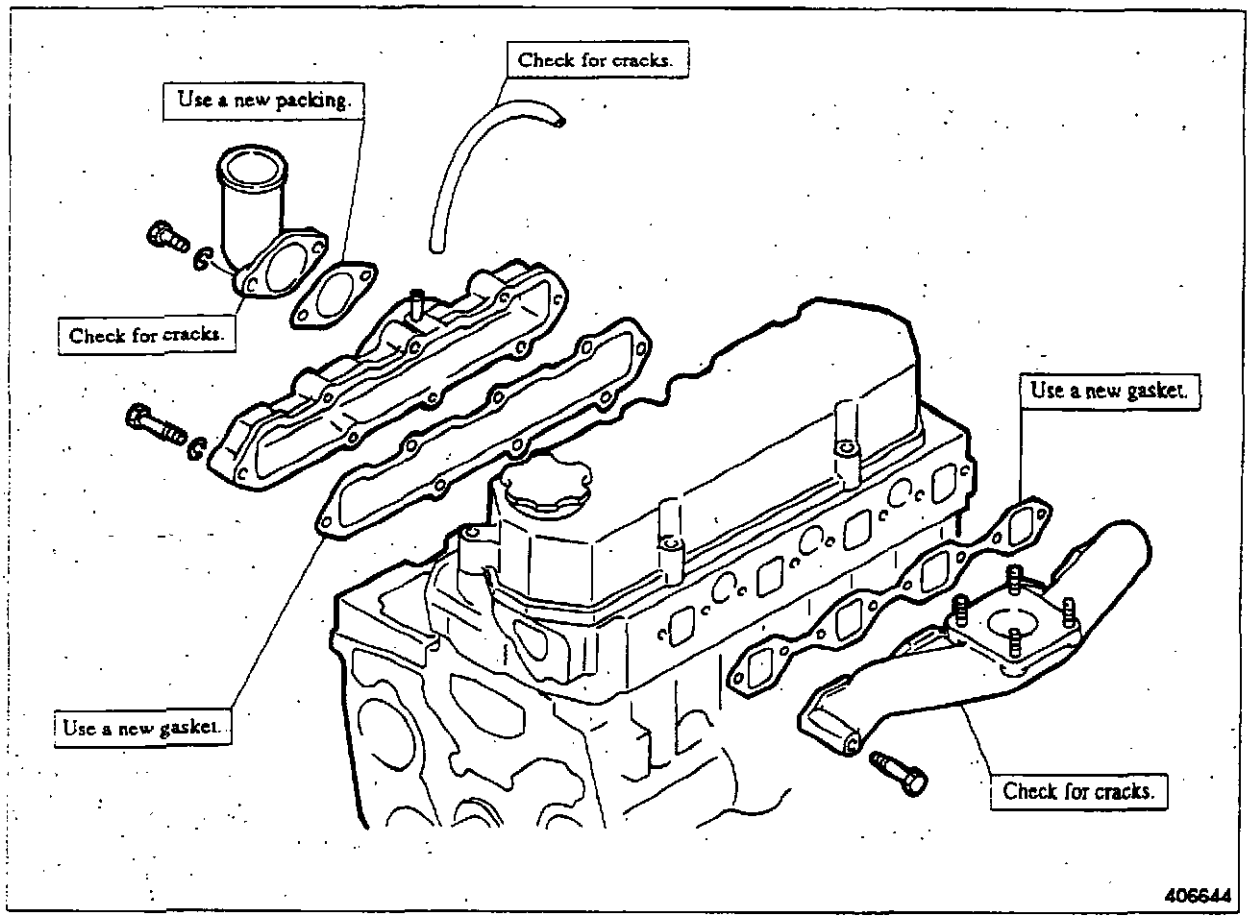


GENERAL

Schematic



INSPECTION



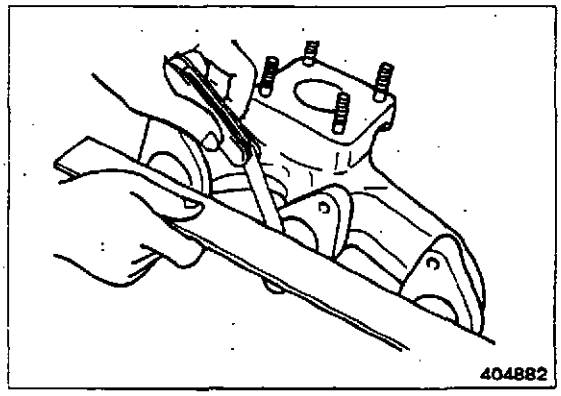
Inspection points

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.

Unit: mm (in.)

Item	Standard
Warpage of manifold	0.15 (0.005 9)



Checking manifold for warpage

MAINTENANCE

LUBRICATION AND MAINTENANCE CHART

(1) 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.

(2) 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 Service Hours, Every 50 Service Hours and Every 10 Service Hours.

Service intervals	Item	Remarks (service data)
Every 10 service hours	Walk-around inspection Check engine oil level. Check the amount of fuel. Check coolant level.	
Every 50 service hours	Check battery electrolyte level and specific gravity. Drain water and sediment from fuel tank.	
First 50 service hours of a new or reconditioned engine	Change engine oil. Change oil filter. Retighten bolts and nuts.	Capacity: See SPECIFICATIONS.
Every 100 service hours	Change engine oil. Change oil filter. Wash fuel filter. Clean radiator fins	Capacity: See SPECIFICATIONS. After fuel filter has been washed, prime fuel system (page 165)
Every 500 service hours	Check and adjust valve clearance. Change fuel filter element. Check and adjust fuel injection nozzles. Check fan belt. Check glow plugs.	0.25 mm (0.009 8 in.) for inlet and exhaust valves Injection pressure: 140 kgf/cm² (1 991 psi) [13 729 kPa] Tension (deflection): 10 to 15 mm (0.4 to 0.6 in.)
Every 1 000 service hours	Retighten bolts and nuts. Check starter. Check alternator.	
Every 2 years	Change coolant.	Capacity: See SPECIFICATIONS.
When required	Prime fuel system. Clean air cleaner element.	

ENGINE OIL AND OIL FILTER

1. Engine oil specifications

Use oils that meet the Engine Service Classification CC.

2. Oil level check

(1) Check the crankcase oil level with a dipstick with the engine kept level.

(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.

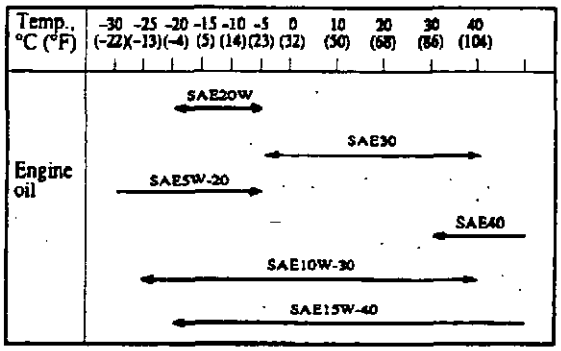
NOTE

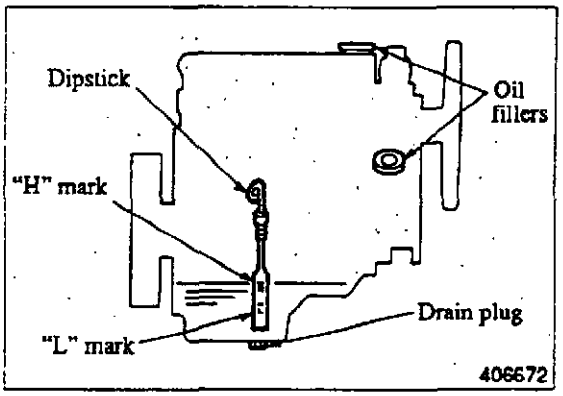
a) After adding oil, leave the engine standing for one minute and check the oil level.

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.

Recommended engine oil viscosities





Checking oil level

3. Oil change

(1) Change the oil after the first 50 service hours of operation of a new or reconditioned engine and every 100 service hours thereafter.

(2) Warm up the engine. Remove the drain plug and allow the oil to drain in a container. Install the drain plug, tightening it to the specified torque, and refill the engine with the new oil.

(3) Refill to the "H" mark on the dipstick. Approximately 0.5 liter (0.5 qt) of oil is required for the oil filter and oil lines.

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

4. Oil filter change

(1) Change the oil filter every 100 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

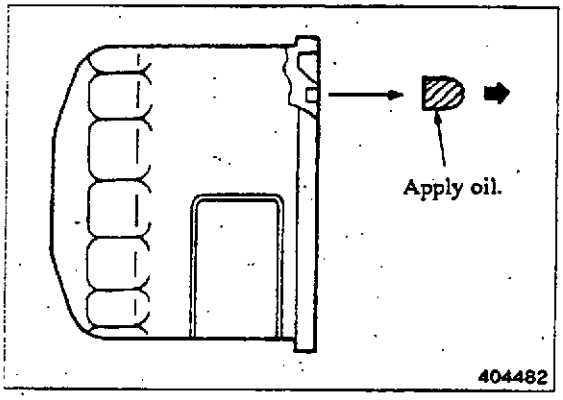
Do not cause damage to the O-ring when installing the filter.

(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.

Removing used oil filter



Installing new oil filter

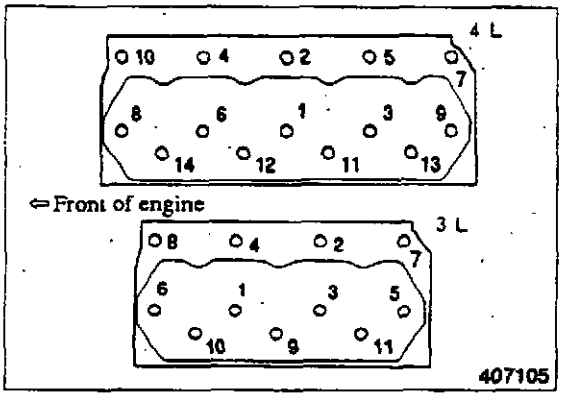
VALVE CLEARANCE

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·m (65 ± 4 lbf·ft) [88 ± 5 N·m]



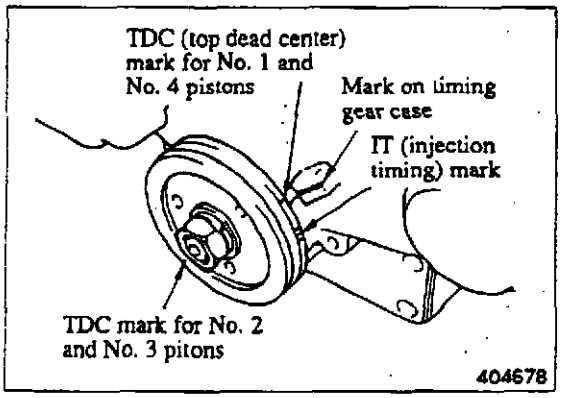
Cylinder head bolt tightening sequence

(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.



Timing mark

(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.

Unit: mm (in.)

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

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

(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	1 – 3 – 2	240°
S4L	1 – 3 – 4 – 2	180°

⚠ 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.

Adjusting valve clearance

FUEL INJECTION TIMING

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.

Removing delivery valve and spring

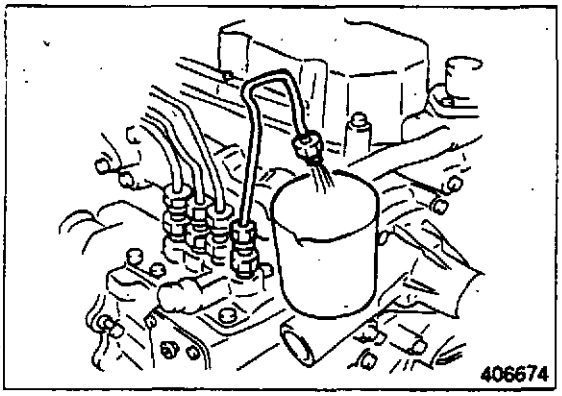
2. Inspection

2.2 Fuel flow method

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

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.

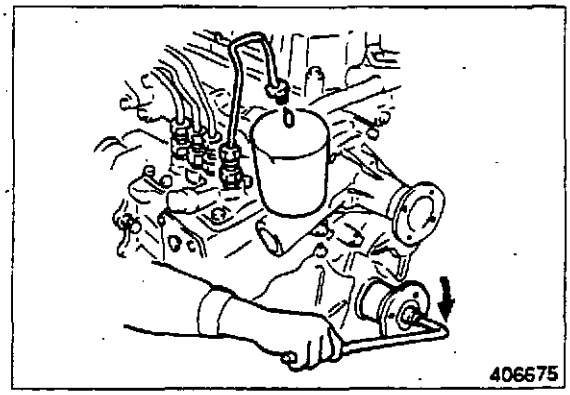


Fuel coming from injection pipe

(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.

NOTE

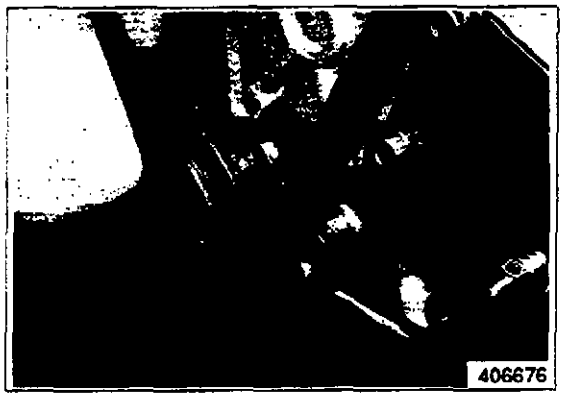
Turn the crankshaft in reverse direction just a little and do Step (2) again to verify the injection timing.



Fuel stops coming from injection pipe

(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)



Timing mark

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.

Disconnecting No. 1 fuel injection pipe

Timing mark

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.

Adjustment range	Standard ±1.5°

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.

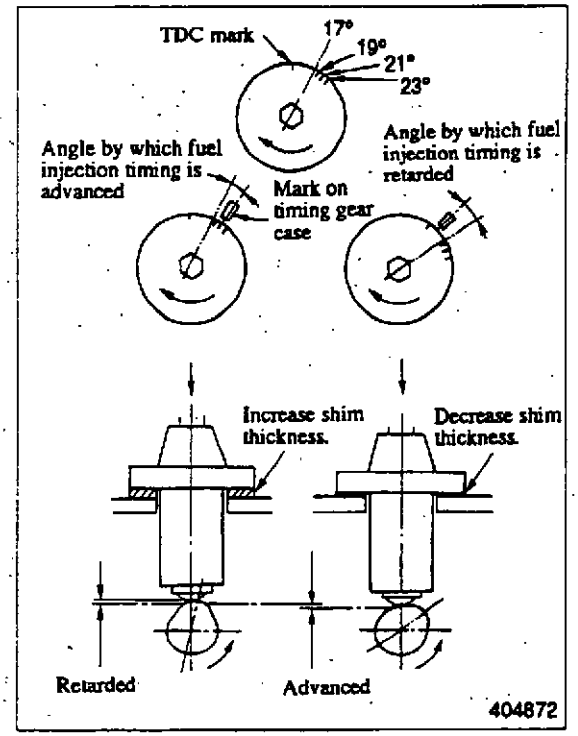
⚠ CAUTION

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.

Adjusting fuel injection timing

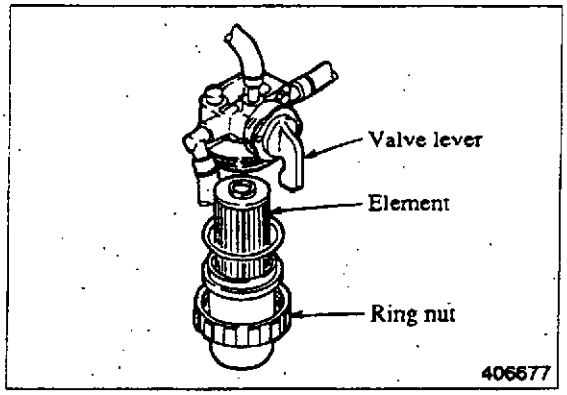


Adjusting fuel injection timing

FUEL FILTER

Fuel filter with [AIR] valve

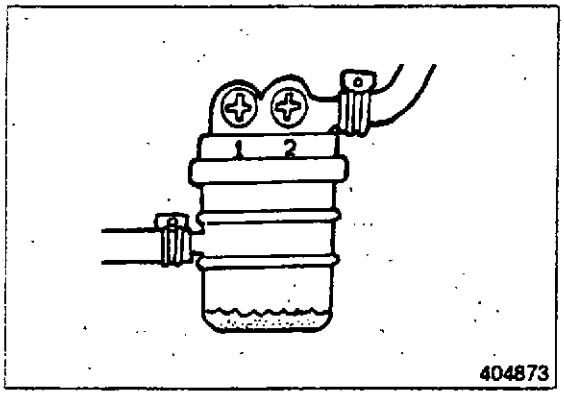
Close the fuel filter valve. Loosen the ring nut and take out the element for cleaning or replacement.



Fuel filter with [AIR] valve

Cartridge (air vent screw) type fuel filter

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



Cartridge type fuel filter

FUEL SYSTEM PRIMING

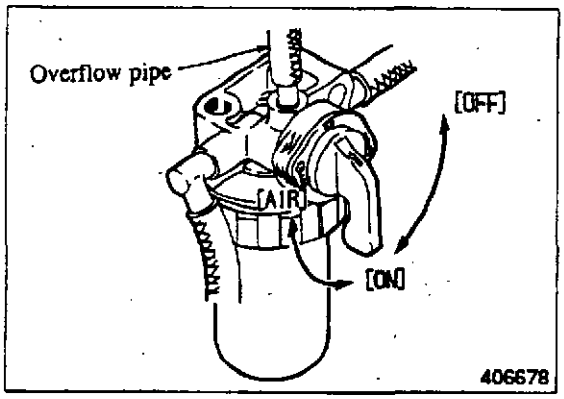
Engine with fuel filter with [AIR] valve

(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.



Priming fuel filter with [AIR] valve

NOTE

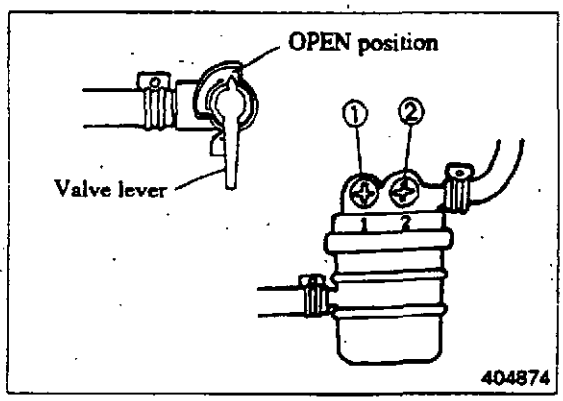
The fuel system of the engine with an electric fuel pump can be primed by turning the starter switch key to ON position.

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.



Priming cartridge (air vent screw) type fuel filter

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.

IDLE RPM SETTING

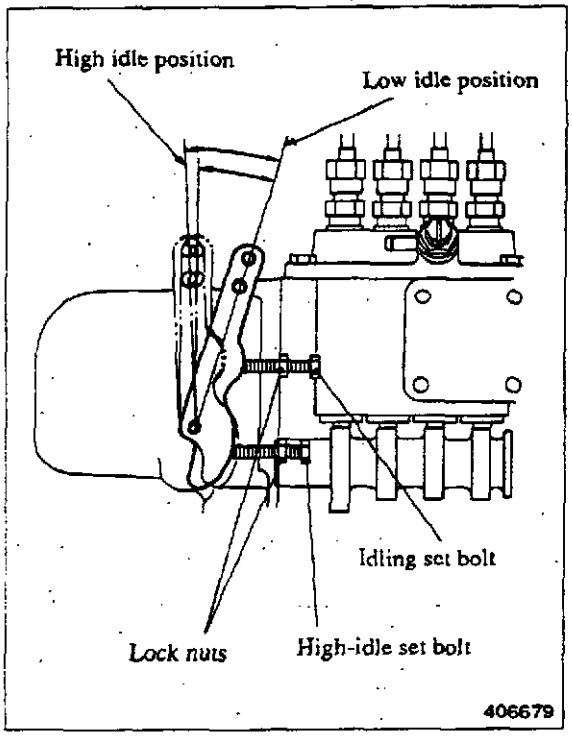
NOTE

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 rpm, 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 rpm, 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.



Idle rpm setting

FUEL INJECTION NOZZLES

1. Injection pressure (valve opening pressure) test

Make reference to FUEL INJECTION NOZZLE (page 135).

2. Orifice restriction test

Make reference to FUEL INJECTION NOZZLE (page 136).

3. Nozzle tip washing and replacement

Make reference to FUEL INJECTION NOZZLE (page 136).

4. Installation

(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]

Installing fuel injection nozzles

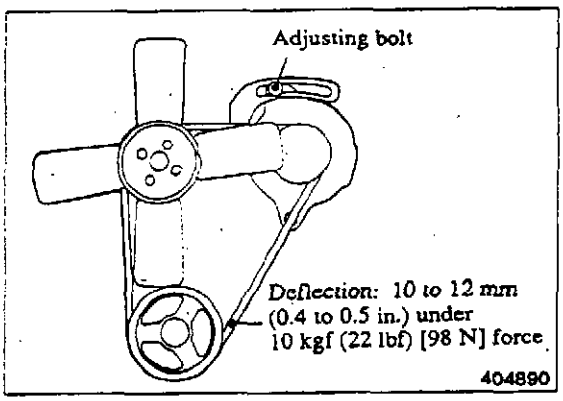
FAN BELT

(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)

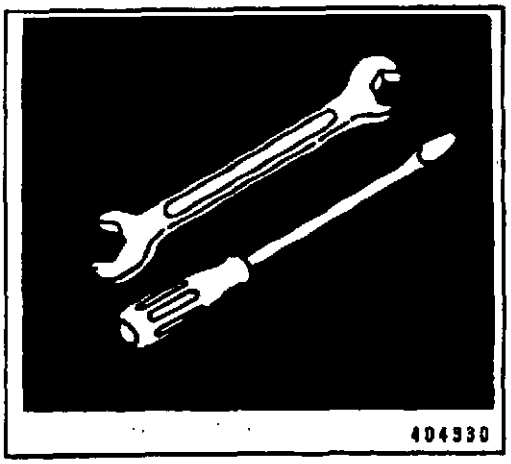


Adjusting fan belt

SERVICE DATA

SPECIFICATIONS

TIGHTENING TORQUES



SPECIFICATIONS

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)		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.
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 camshaft gear and oil pump gear	0.07 to 0.20 (0.002 8 to 0.007 9)			
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)	Recondition.

Unit: mm (in.)

Item		Standard	Limit	Correction-Remarks
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 (3.0827)	
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.
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.

2. Lubrication system

Unit: mm (in.)

Item	Standard	Limit	Correction-Remarks
Pressure relief valve setting	3.5 ± 0.5 kgf/cm² (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/cm² (7 ± 1.4 psi) [49 ± 10 kPa]	—	Replace.

3. Fuel system

Unit: mm (in.)

Item	Standard	Limit	Correction-Remarks
Injection pressure (valve opening pressure)	140^{+5}_{0} kgf/cm² ($1\,991^{+71}_{0}$ psi) [$13\,729^{+490}_{0}$ kPa]	—	Adjust with washer.

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.

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)	—	
Thermoswitch	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.

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 characteristics			S3L/S3L2	S4L/S4L2		Test.
		Terminal voltage		11.5 V	11 V	—	
		Current draw		100 A maximum	130 A maximum	—	
		Rpm		3 000 minimum	3 850 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.
Alternator	Regulated voltage at 20°C (68°F)			14.7 ± 0.3 V		—	
	Output characteristics (at operating temperature)	Below 2500 rpm	Terminal voltage	13.5 V		—	Test.
			Current	33 A		—	
		Below 5000 rpm	Terminal voltage	13.5 V		—	
			Current	47 A		—	
	Brush length			—		Wear limit line	Replace.
Resistance in glow plug				0.55 Ω		—	Replace.

TIGHTENING TORQUES

1. Major bolts and nuts

Bolt or nut	Thread, mm				Torque, kgf·m (lbf·ft) [N·m]
	Diameter	Pitch	Width across flats	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]

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]	

3. Torques for plugs with taperlock threads

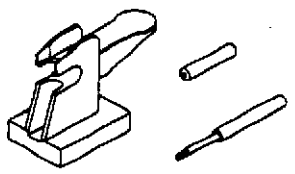
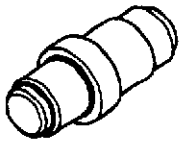
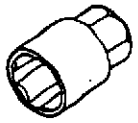
Unit: kgf·m (lbf·ft) [N·m]

Size	For aluminum materials	For ferrous materials
NPTF1/16	0.65 ± 0.15 (4.7 ± 1) [6.4 ± 1]	1 ± 0.2 (7.2 ± 1) [10 ± 2]
PT1/8	1 ± 0.2 (7.2 ± 1) [10 ± 2]	1.85 ± 0.35 (13.4 ± 2.5) [18 ± 3]
PT1/8, NPTF1/4	2.5 ± 0.5 (18 ± 4) [25 ± 5]	4 ± 0.5 (29 ± 4) [39 ± 5]
PT3/8	—	6.5 ± 1 (47 ± 7) [64 ± 10]

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.

SPECIAL TOOLS

Tool No.	Tool Name	Style	Usage
31A91-00100	Piston Pin Setting Tool	 406808	Piston pin removal and installation
ST332340	Camshaft Bushing Installer	 404704	Camshaft front bushing removal and installation
ST332270	Compression Gauge Adaptor	 404931	Compression pressure measurement
MD998054	Oil Pressure Switch Socket Wrench (26)	 404840	Oil pressure switch removal and installation

Note: In addition 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.

MITSUBISHI DIESEL ENGINES

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MITUSBISHI HEAVY INDUSTRIES, LTD.
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