MITSUBISHI DIESEL ENGINE

SERVICE MANUAL

L2/L3 MODELS

MITSUBISHI HEAVY INDUSTRIES, LTD

08/2004

FOREWORD

This service manual is written to familiarize you with the maintenance of your L-series Diesel Engine. If the engine is carefully maintained, it will deliver a long productive life and efficient performance marked by power and economy.

Before attempting to inspect, disassemble, or repair the engine, read this manual carefully to learn more about the engine and how to care for it properly. All descriptions, illustrations, specifications and serial numbers in this manual are effective as of the date of printing of this manual.

The information contained in this manual applies to the engine model produced at the time of publication. It should be noted that specifications and design may change due to improvements made thereafter.

What this manual covers

This service manual covers standard specifications for the L-series Mitsubishi Diesel Engine, and describes

- Specification
- Maintenance standard
- Adjustment
- Disassembly, inspection and repair
- Reassembly

In addition to the Summary of Manual Contents, a short summary of contents is found on the first page of each group of the manual.

Operation and periodic maintenance are described in the *Operation & Maintenance Manual*, component parts and ordering of service parts are described in the *Parts Catalogue*. Structure and function of the engine are described in the various training manuals.

How to use this manual

1. Parts in illustrations are numbered to correspond with references to those numbers in the disassembly sequence.
2. Items or conditions to be inspected during disassembly are enclosed in a box in the disassembled views:
3. Clogged oil hole
4. Maintenance standards for inspection and repair are described in text where they are relevant. For a quick summary of maintenance standards, refer to group 9 of this manual.
5. Tightening torque under *wet* conditions is indicated as “(wet)” in text, drawings and tables. When so indicated as (wet), apply engine oil to the threaded portion of the fastener. Unless indicated as such, the tightening torque is to be assumed in the dry condition.
6. Measurements are based on the International System of Units (SI), and they are converted to the metric and English system units in this manual based on the following conversion rates.

- Pressure 1 Mpa = 10.197 kgf/cm^2
- Torque N·m = 0.10197 kgf·m
- Force N = 0.10197 kgf
- Horsepower 1 kW = 1.341 HP = 1.3596 PS

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

WARNING SIGNS

The following safety related signs are used in this manual to emphasize important and critical instructions:

⚠ DANGER — Indicates the most serious specific potential hazard which could result in serious personal injury or death.

⚠ WARNING — Indicates a specific potential hazard which could result in personal injury.

⚠ CAUTION — Indicates operating procedures, practices, etc. which could result in personal injury or damage causing destruction to the engine. Some of the CAUTION signs also indicate a specific potential hazard which could result in serious personal injury or death.

⚠ NOTE — Indicates procedures, conditions, etc. which are important to highlight.

TERMS USED IN THIS MANUAL

Before reading this manual, note that the following special terms are used in dimensional and other specifications.

Assembly standard

Indicates the dimension of a part, the dimension to be attained at the time of reassembly or the standard performance. The value is rounded to the nearest number needed for inspection and is different from the design value.

Repair limit

A part which has reached this limit must be repaired.

Service limit

A part which has reached this limit must be replaced.

SUMMARY OF MANUAL CONTENTS

Section		Contents
1.	General	Engine model and engine number, external views, features, engine specifications, maintenance, troubleshooting
2.	Engine main parts	General, rocker arms and rocker shaft, cylinder head, valves and valve springs, inlet manifold and exhaust manifold, gear case and oil pump, timing gear, camshaft (valve camshaft and injection pump camshaft), piston and connecting rod, crankshaft, cylinder block
3.	Lubrication system	General, oil filter and oil pressure switch
4.	Fuel system	General, fuel injection pump, injection nozzle
5.	Governor system	General, torque spring
6.	Cooling system	General, fan and fan belt, water pump, thermostat, water temperature gauge unit and thermoswitch
7.	Air cleaner	Air cleaner
8.	Electrical system	General, starter, alternator and dynamo, glow plug, key-off stop system, glow timer system
9.	Service specifications and standard	Periodic service chart, specifications and standards, tightening torque chart and sealant chart, special tools

Table 1 Sections in the service manual

TABLE OF CONTENTS

GENERAL

ENGINE MAIN PARTS

GENERAL

1 ENGINE MODEL AND ENGINE NUMBER

1.1 Model, classification and use

1.1.1 Engine model

Model	Application	Use
L2A	11,12 -	For Agricultural
L2C		
L2B	31, 32 -	For Industrial
L3A		
L3C	61, 62 -	For Export only
L3E		

Table 1 Engine model and usage

1.1.2 Engine model and application codes

L 3 C – 11 A

L – Name of series (L: Lightweight engine)

3 – Number of cylinders (2: two, 3: three)

C – Cylinder bore
- A: ø65, C: ø70,
- E: ø76

11 – Application
- 11: Agricultural, 31: Industrial,
- 61: For export only

A – Subdivision of specification

1.2 Engine model embossment and engine number stamp

1.2.1 Embossment of engine model and cylinder volume

The engine model and cylinder volume are embossed on the side of injection pump mounting portion of the cylinder block.

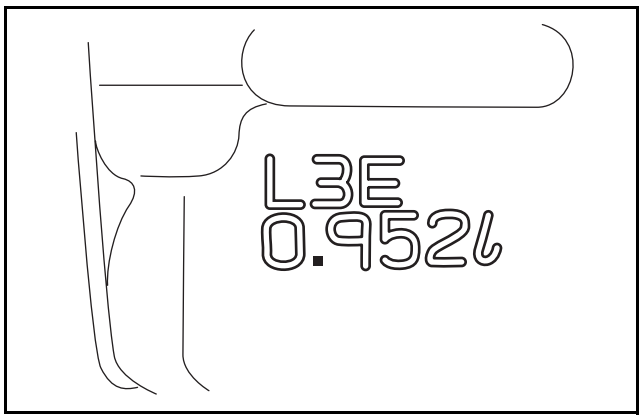


Figure 1 Engine model and cylinder volume

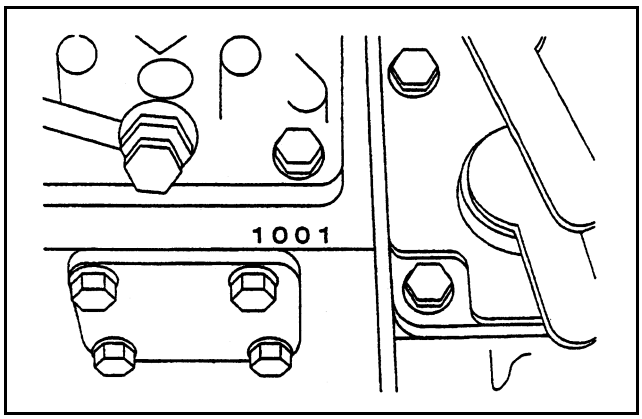


Figure 2 Engine number

1.2.2 Engine number stamp

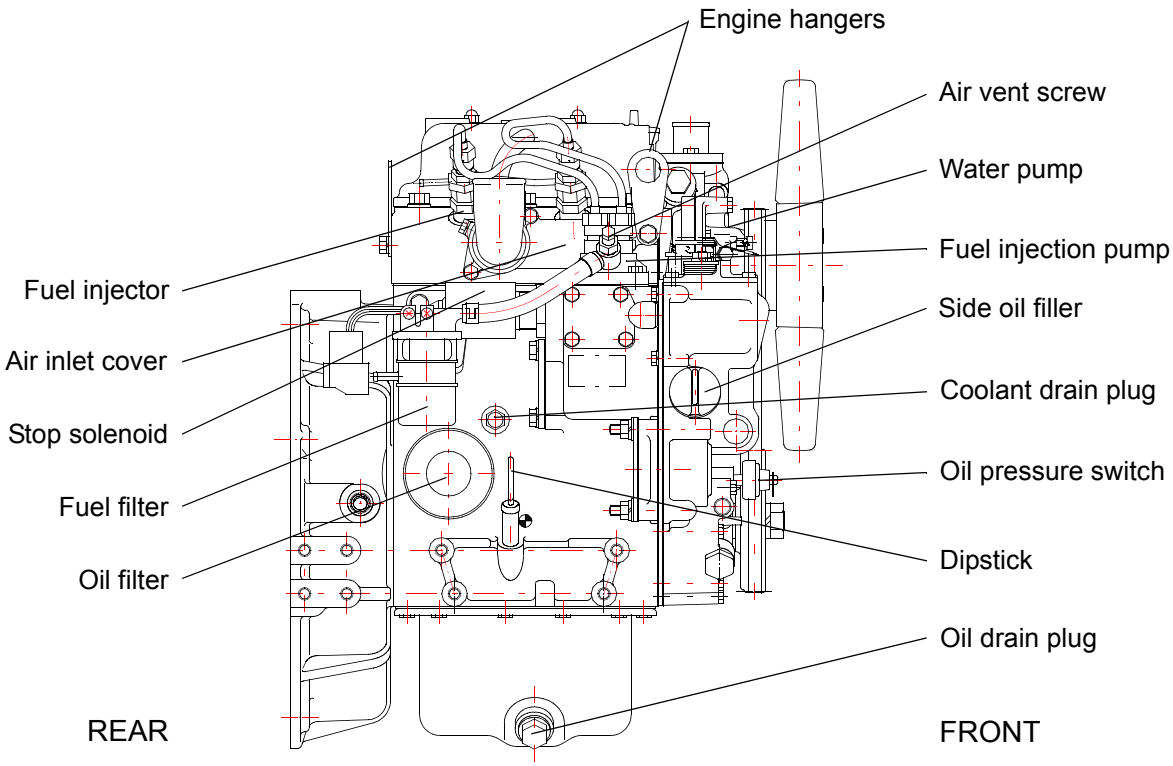
The engine number is stamped on the injection pump mounting portion of the cylinder block (on the upper side of the tie rod cover). It is a serial number beginning with 1001 shown as below.

Number	Engine model
1001 -	(ALL models)

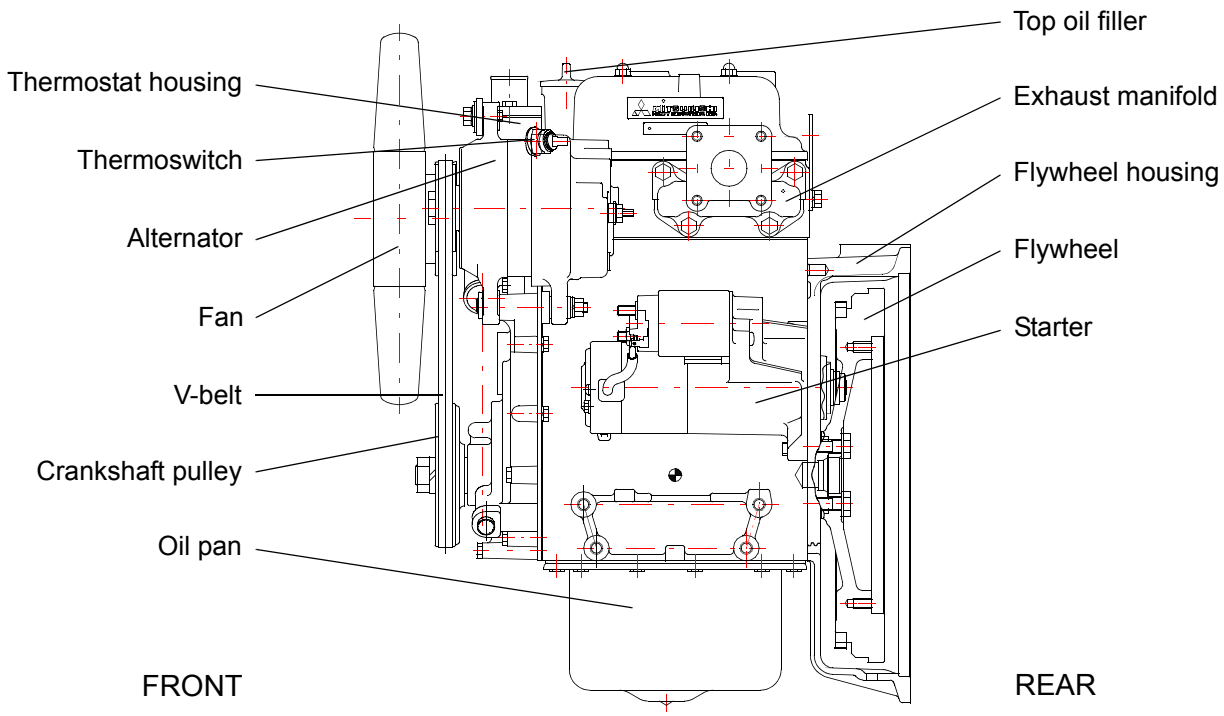
Table 2 Engine number stamp

2 EXTERNAL VIEW

2.1 Engine L2

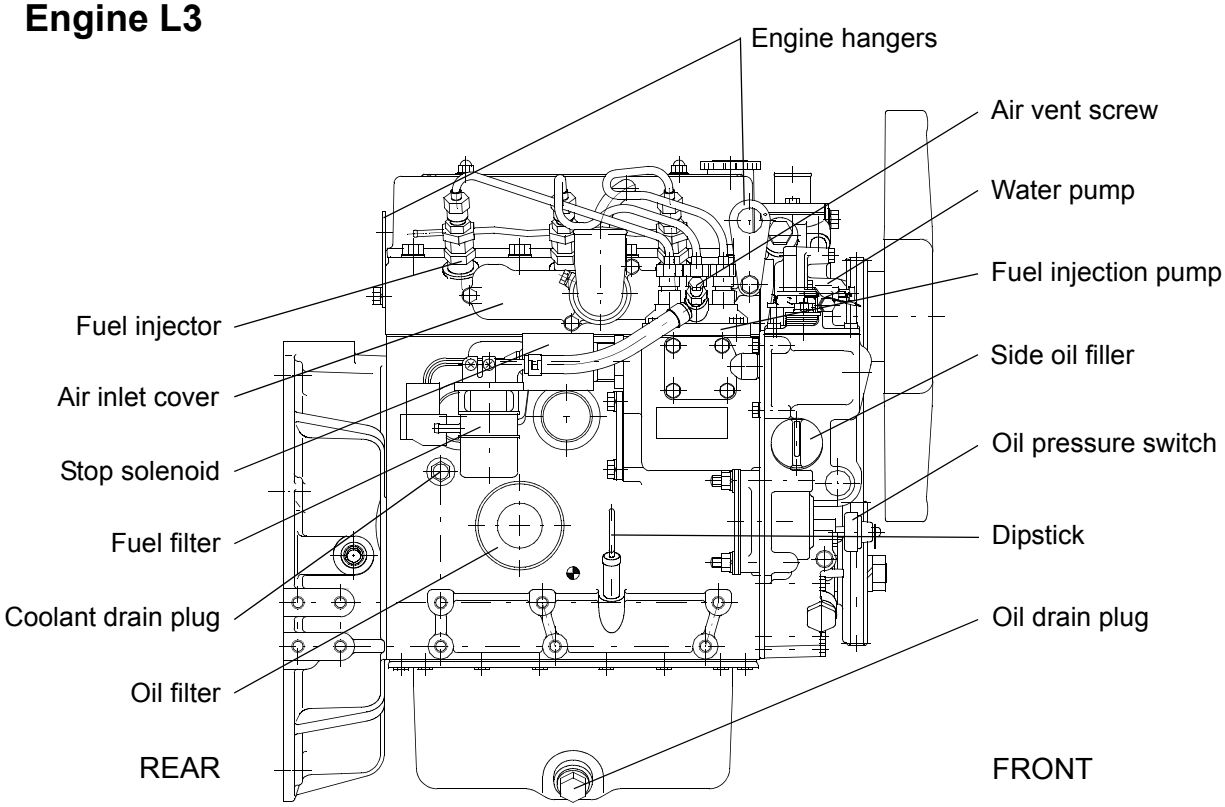


RIGHT SIDE VIEW

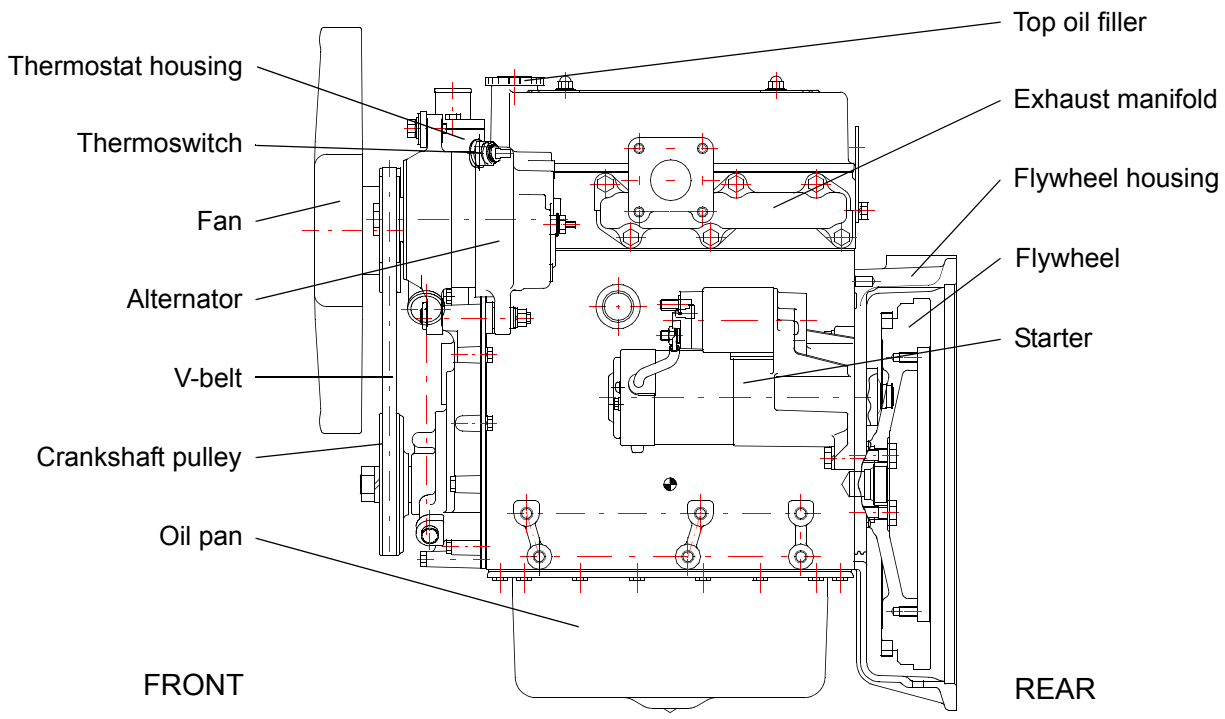


LEFT SIDE VIEW

2.2 Engine L3



RIGHT SIDE VIEW



LEFT SIDE VIEW

3 FEATURES

3.1 Aim of development

The L-series designs are compact, lightweight engines suitable for superseding gasoline engines to power lawn mowers, vehicles, etc. The high-speed (3600 min^{-1} continuous) engines are also available for generators, welders, and marine use. The L series are the smallest and the lightest water-cooled diesel engines in the world.

3.2 Features of the new series

3.2.1 Small and lightweight engine

The new L-series are 10 to 20% lighter in weight and 15 to 20% smaller in contour volume than the same class of competitor's engines.

3.2.2 Low noise and economical fuel consumption

Low noise and economical fuel consumption are attained by the well designed cylinder block construction (having curved side faces), the rearranged combustion chambers, and the compacted fuel injection system.

3.2.3 Easy starting

The engine can be started instantly only by keeping the starting switch key in the ON position for about 6 seconds to feed electric current to the glow plugs automatically (For engines with the automatic glow plug system). The new governor mechanism also contributes to easy engine start, by increasing the amount of fuel injection and delaying injection timing, without moving the throttle lever to the "full throttle" position.

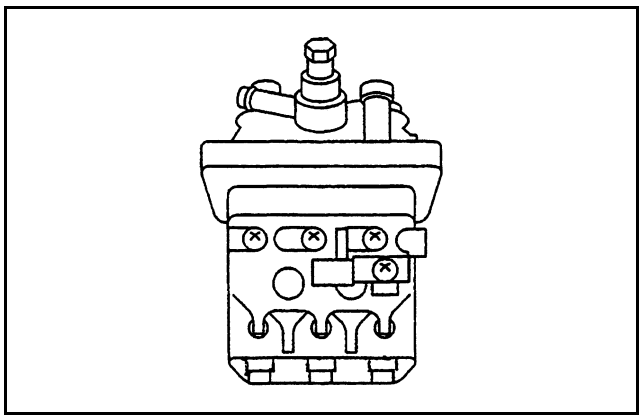


Figure 3 Injection pump

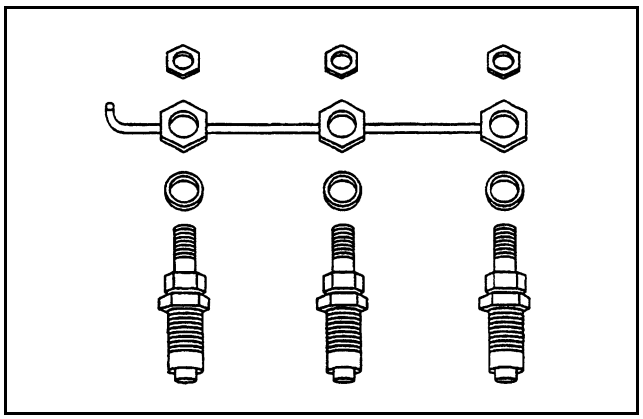


Figure 4 Nozzle holders and return pipe

3.2.4 Multipurpose engine

The L-series engine can be equipped with various kinds of optional devices.

Ex.
- Key-OFF stop system (Fuel cutoff valve)
- Torque spring
- Manual stop lever

4 SPECIFICATIONS[1]

System	Item	Model					
		L2A	L2C	L2E	L3A	L3C	L3E
ENGINE PROPER	Type	4-cycle, water-cooled, vertical, overhead valve, diesel engine					
	Combustion chamber	Swirl chamber type					
	No. of cylinders	2			3		
	Bore x Stroke (mm)	65x70	70x70	76x70	65x70	70x70	76x70
	Total displacement (*l*)	0.464	0.538	0.635	0.696	0.808	0.952
	Compression ratio	23					
	Firing order	1 - 2			1 - 3 - 2		
	Dry weight (kg)	61			75		
LUBRICATING SYSTEM	Lubricating method	Forced lubrication					
	Oil pump	Gear type					
	Oil filter	Paper element type					
	Oil capacity: FULL level/EMPTY level (*l*) (Exclusive of oil filter capacity 0.5 *l*)	2.4/1.4			3.0/1.5 or 3.6/1.8 or 4.8/3.0		
FUEL SYSTEM	Fuel injection pump	Bosch type NC					
	Nozzle	Throttle type					
	Fuel injection pressure	140 kgf/cm^2 (1,991 psi) [13,729 kPa]					
	Fuel to be used	Diesel fuel; see chapter 7					
	Governor	Centrifugal weight type					
INTAKE SYSTEM	Air cleaner	Paper-element type or Oil-bath type					
COOLING SYSTEM	Cooling method	Forced circulation of water					
	Water pump	Centrifugal type					
	Coolant capacity (*l*) (Engine proper only)	1.2			1.8		
ELECTRICAL SYSTEM	Starter (V - kW)	Solenoid shift type (12-1.2 or 12-1.6 or 12-1.7)					
	Alternator (V - A)	AC generator (12-40)					
	Glow plug	Sheathed type					
	Battery (capacity depends on application)	12V, 45 Ah or more			12V, 60 Ah or more		

Table 3 Specifications

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

5 MAINTENANCE

5.1 Engine oil and oil filter

5.1.1 Checking and correcting the engine oil level

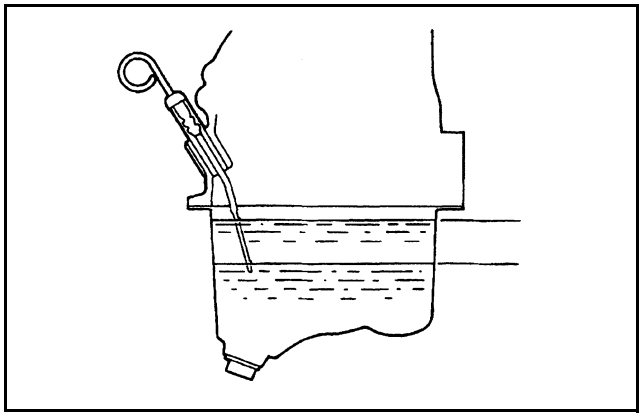


Figure 5 Checking oil level

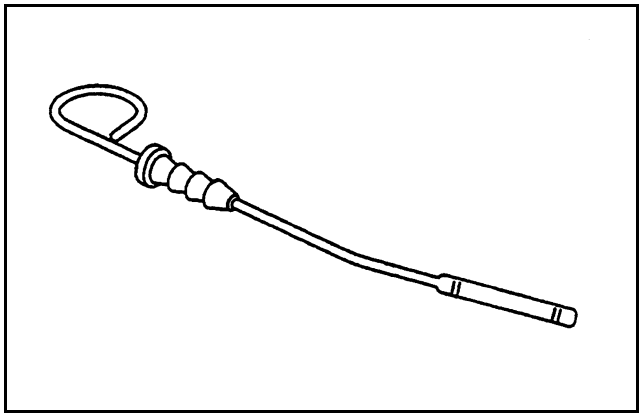


Figure 6 Oil level gage

Procedure
1. Place the engine horizontally.
2. Check the oil level with the oil level gage. If the oil level has fallen to the lower limit, add oil up to the upper limit.
3. Check the oil level before (everyday) operation of the engine.

⚠ CAUTION

a. Whenever oil is added, check the oil level again after waiting for about 1 minute.
b. When adding oil, use only the same engine oil as used in the engine.
c. When checking the oil level in an engine which has not been used for long time, check the oil level again after running the engine for a few minutes.

5.1.2 Oil change intervals

Change the oil and the oil filter after initial 50 service hour of a new engine and, thereafter, every 100 hours of operation or once a year (whatever comes first). Except generator application, 250 hours or once a year (whatever comes first) can be applied for industrial and marine application.

5.1.3 Engine oil to be used

Engine oil must conform to the API classification and viscosity number specified in the table below.

API classification	Atm. temperature	Viscosity
Class CF or CF-4	Above 20°C [68°F]	SAE30
	5° to 20°C [41 to 68°F]	SAE20
	Below 5°C [41°F]	SAE10W-30
	All seasons	SAE10W-30

Table 4 API classification

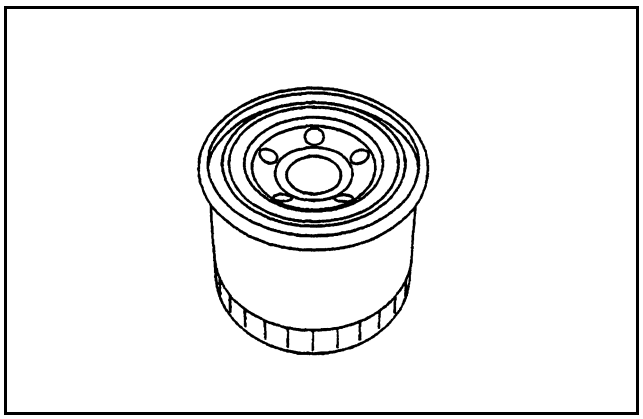


Figure 7 Oil filter

5.1.4 Replacing the oil filter

When replacing the oil filter, use only the genuine replacement filter.

5.1.5 Changing the oil

To change oil, first warm up the engine and remove the drain plug to let oil drain completely. Put back the drain plug and refill the oil pan with fresh engine oil through the oil filler.

Tightening torque N·m (kgf·m) [lbf·ft]	
Description	Standard
Oil pan drain plug tightening torque	49.0 to 58.8 (5.0 to 6.0) [36.17 to 43.40]

Table 5 Tightening torque

	L2	L3
Oil capacity (Upper limit/Lower limit) (excluding 0.5 l of oil filter capacity) 1 [U.S.gal]	2.4/1.4 [0.6341/ 0.3699]	Ordinary type 3.0/1.5 [0.7926/0.3963] Deep type 3.6/1.8 [0.9511/0.4756] or 4.8/3.0 [1.2682/ 0.7926]

Table 6 Oil capacity

5.1.6 Replacing the oil filter

Procedure
1. Remove the oil filter with a filter wrench or the like.

2. Thoroughly clean the filter mounting surface of the filter bracket. Install the new filter with the O-ring coated with engine oil and tighten securely by hand.

	Unit: N·m (kgf·m) [lbf·ft]
Tightening torque	10.8 to 12.7 (1.1 to 1.3) [7.96 to 9.40]

Table 7 Tightening torque

⚠ CAUTION

Be careful not to twist the O-ring.

3. Run the engine for several minutes and make sure that no oil leaks.
4. After stopping the engine, check the oil level. If necessary, add oil.

5.2 Retightening the cylinder head bolts

When retightening the cylinder head bolts, drain out coolant, loosen the bolts slightly, and then retighten the bolts to the specified torque in the numerical order illustrated at right.

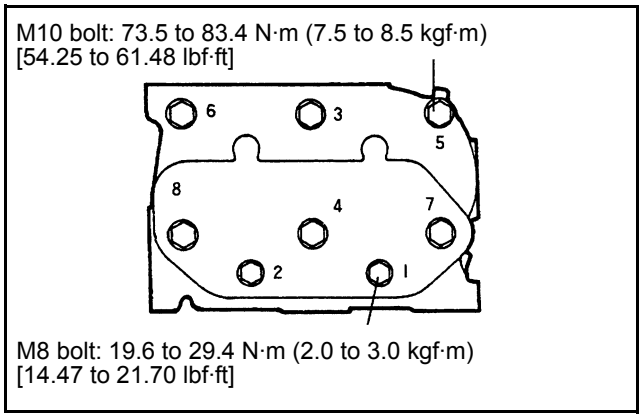


Figure 8 Cylinder head bolt tightening sequence (L2)

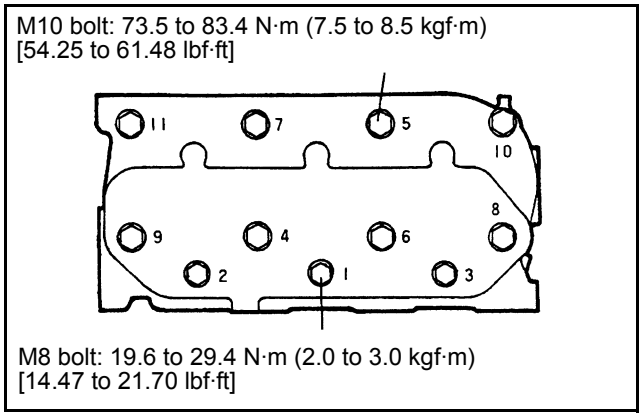


Figure 9 Cylinder head bolt tightening sequence (L3)

Tightening torque	Unit: N·m (kgf·m) [lbf·ft]
M10 bolt	73.5 to 83.4 (7.5 to 8.5) [54.25 to 61.48]
M8 bolt	19.6 to 29.4 (2.0 to 3.0) [14.47 to 21.70]

Table 8 Tightening torque

Rocker stay tightening torque	Unit: N·m (kgf·m) [lbf·ft]
M10 bolt	73.5 to 83.4 (7.5 to 8.5) [54.25 to 61.48]
M8 bolt	19.6 to 29.4 (2.0 to 3.0) [14.47 to 21.70]

Table 9 Rocker stay tightening torque

The rocker assembly (the rocker arms, shaft and stays) is to be kept removed when the cylinder head bolts are retightened.

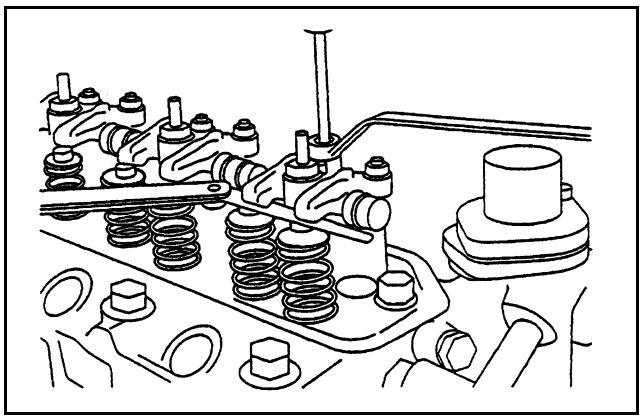


Figure 10 Adjusting valve clearance

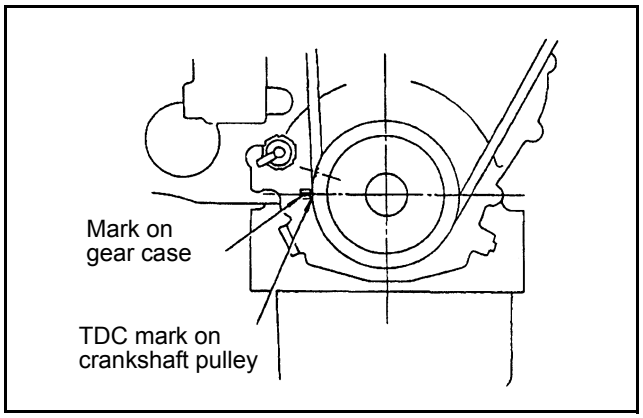


Figure 11 Timing mark

5.3 Adjusting the valve clearance

⚠ CAUTION

Be sure to retighten the cylinder head bolts before adjusting the valve clearance.

Procedure

1. Set the cylinder to be adjusted to the top dead center of compression stroke.

Tightening torque	Unit: N·m (kgf·m) [lbf·ft]
M10 bolt	73.5 to 83.4 (7.5 to 8.5) [54.25 to 61.48]
M8 bolt	19.6 to 29.4 (2.0 to 3.0) [14.47 to 21.70]

Table 10 Tightening torque

2. The top dead center of compression stroke can be obtained by aligning the TDC (Top Dead Center) mark (notch) on the crankshaft pulley with the mark on the gear case.
3. First align the TDC mark for the No. 1 cylinder. Confirm that the valves do not move up and down when the crankshaft is turned about 20° in normal direction of rotation and in reverse direction.
4. When setting the top dead center for the No. 2 cylinder and that for the No. 3 cylinder, perform as follows:
   a L2 (Two-cylinder engine)
   Turn the crankshaft 180° clockwise from TDC (Top Dead Center) of the No. 1 cylinder, to set the No. 2 cylinder TDC.
   b L3 (Three-cylinder engine)
   Turn the crankshaft 240° clockwise from TDC of the No. 2 cylinder, to set the No. 3 cylinder TDC. Further, turn the crankshaft 240° clockwise from No. 3 cylinder TDC and reconfirm the position of the No. 2 cylinder TDC.

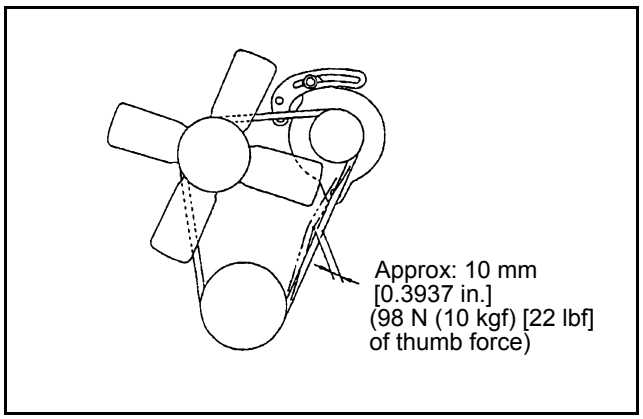


Figure 12 Adjusting fan belt tension

5.4 Adjusting the fan belt tension

To check if the belt tension is appropriate, press the belt at a midpoint between the alternator pulley and crankshaft pulley with your thumb, and check that the amount of belt deflection is about 10 mm [0.3937 in.] (about 98 N (10 kgf) [22 lbf]).

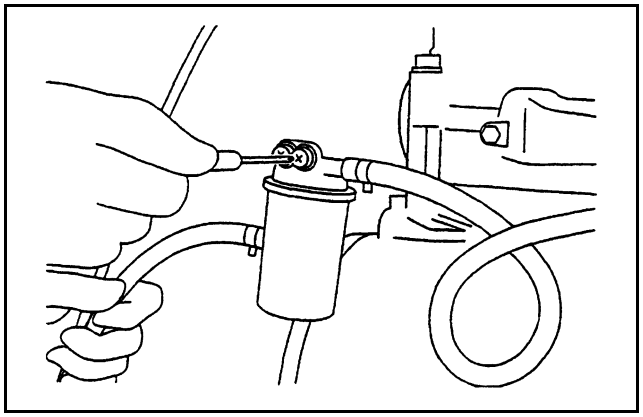


Figure 13 Fuel filter air bleeding

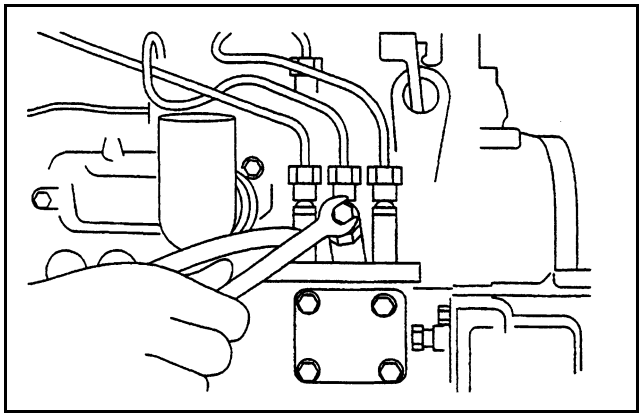


Figure 14 Fuel injection pump air bleeding

5.5 Bleeding air from the fuel system

Procedure

1. Loosen the air vent screw on the fuel filter.
2. For engine without feed pump, fuel flows down and enters the fuel filter, wait for fuel to overflow from the air vent screw. Then tighten the air vent screw.
3. For engine with the electromagnetic fuel pump, turn the starting switch key to the ON position to feed fuel to the fuel filter. Loosen the air vent screw on the filter and, after bleeding air, tighten the air vent screw.
4. Loosen the air vent screw on the fuel injection pump to let air bleed from the fuel pipe and fuel injection pump.
5. Air in the injection pipes and nozzles is driven out automatically by cranking the engine.

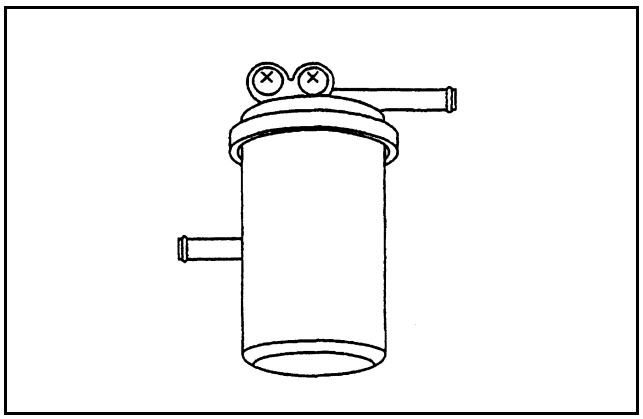


Figure 15 Cartridge type filter

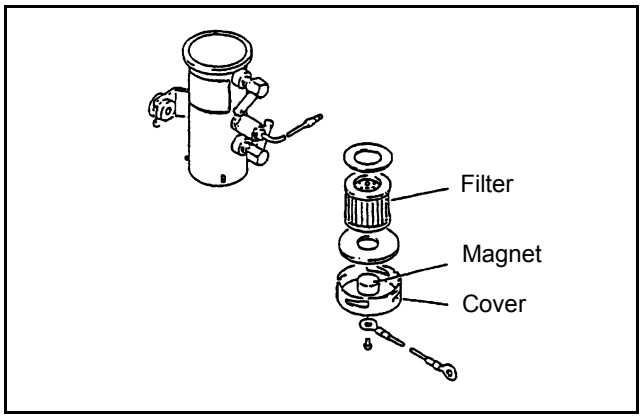


Figure 16 Plunger type (common) fuel pump

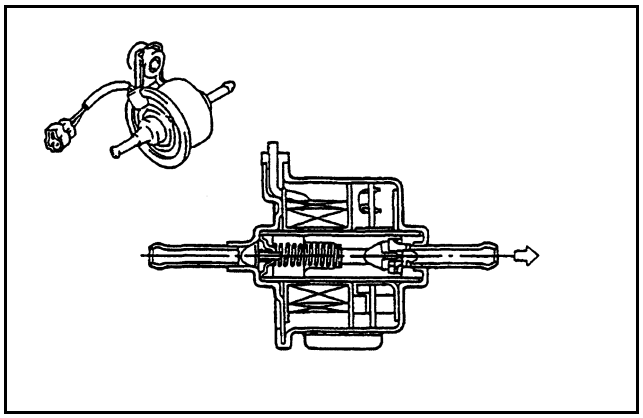


Figure 17 Plunger type (compact) fuel pump

5.6 Replacing the fuel filter

5.6.1 Cartridge type

Replace the cartridge type filter as an assembly if accumulation of dust or water is in its element. Regular replacement interval is every 500 service hours of engine operation. Check the filter every 100 service hours and, if necessary, replace early.

5.6.2 Separate type filter with cock

Close the filter cock, remove the ring nut, and take out the element from the inside of filter. Clean or replace the element.

5.6.3 Fuel pump

The following three types of fuel pumps are available. Which type of pump is to be used for an engine depends upon engine specification.

1. Plunger type electromagnetic pump
   The plunger-type pumps are classified as the common, large-sized pump having a filter element or as the compact lightweight, low-priced pump without filter element. Regardless of classification, check the plunger-type pump for normal function and make sure that it does not leak fuel. Only on the pump with filter element, remove the cover and clean or replace the filter element.

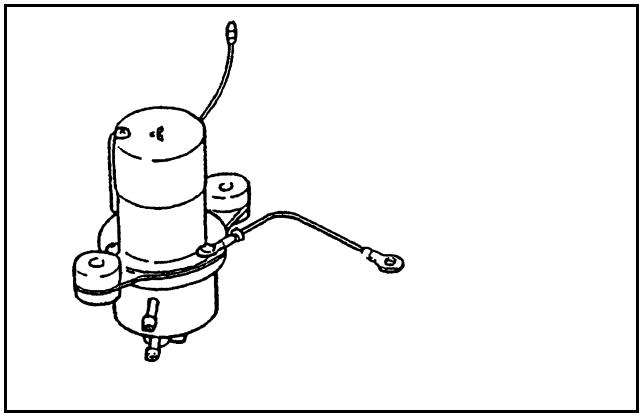


Figure 18 Diaphragm type fuel pump

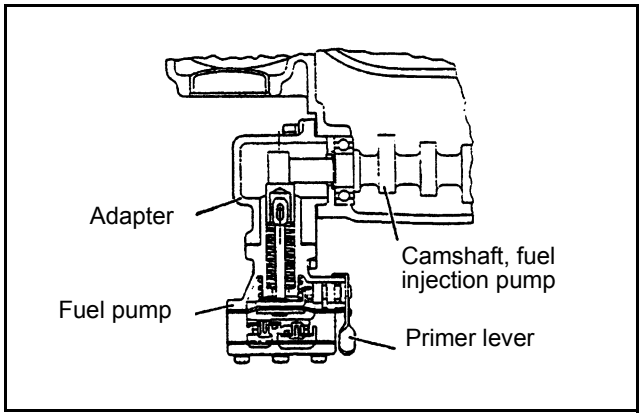


Figure 19 Mechanical type fuel pump

2. Diaphragm type electromagnetic pump
The diaphragm type electromagnetic pump should not be disassembled. Like the compact plunger-type pump mentioned above, check the pump for functions and fuel leak.

3. Mechanical type fuel pump
This type of fuel pump is installed with an adapter on the rear-end side of the fuel injection pump camshaft. As the camshaft rotates, the fuel pump cam pushes the tappet to actuate the diaphragm of the fuel pump. This type of fuel pump is provided with a priming lever to allow manual feed to fuel. Check the fuel pump for normal function and make sure that it does not leak fuel or make unusual noise.

Pump type	Delivery flow	Shut-off pressure
Plunger type (common)	0.9 l [0.24 U.S.gal]/ min or more	0.03 MPa (0.35 kgf/cm^2) [4.98 psi]
Plunger type (compact)	0.4 l [0.11 U.S.gal]/ min or more	0.03 MPa (0.35 kgf/cm^2) [4.98 psi]
Diaphragm type	0.37 l [0.10 U.S.gal]/ min or more	0.01 MPa (0.15 kgf/cm^2) [2.13 psi]
Mechanical type	0.255 l [0.06 U.S.gal]/ min or more	0.01 MPa (0.15 kgf/cm^2) [2.13 psi]

Table 11 Fuel pumps at 12V (electromagnetic pumps only) and at 20°C [68°F]

5.6.4 Draining water from the water sedimentator

For engine provided with a water sedimentator, remove the filter ring nut involved and take out the cup. Wipe off water and dust accumulated in the cup.

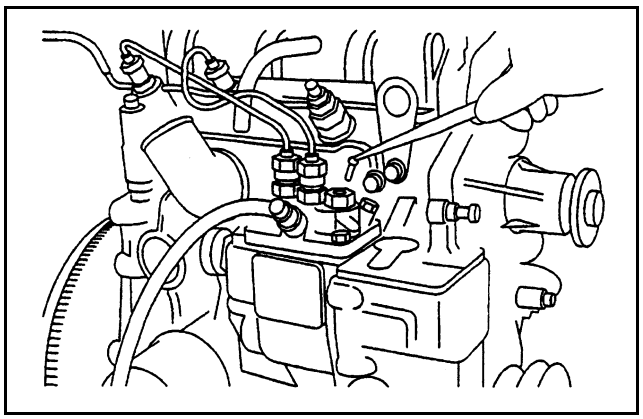


Figure 20 Removing delivery valve

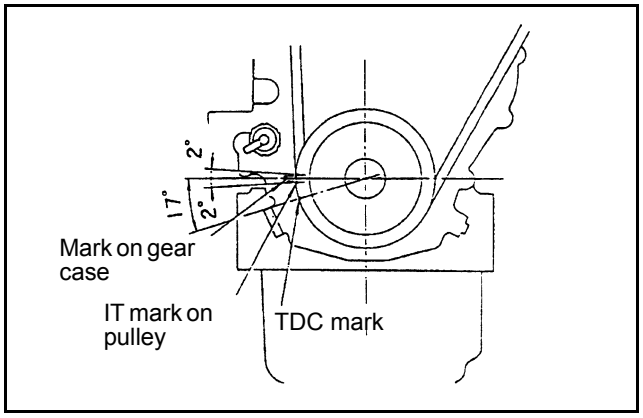


Figure 21 Injection timing mark

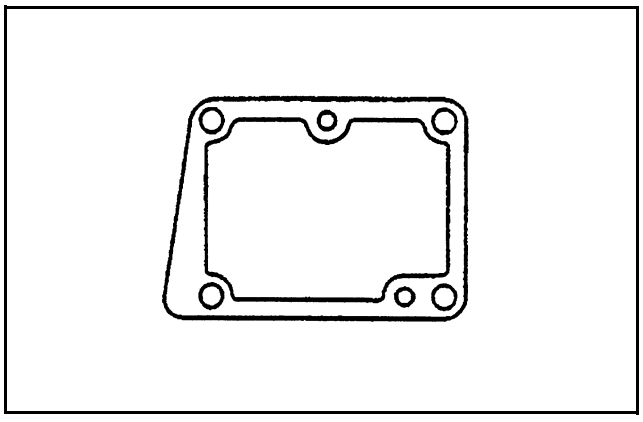


Figure 22 Adjusting shim thickness

5.7 Checking and adjusting injection timing

To check and adjust injection timing, use the following procedure:

1. Disconnect the No. 1 injection pipe.
2. Remove the No. 1 delivery valve from the injection pump. Put back the valve holder only.

⚠ CAUTION

Be sure to shut off the fuel feed before removing the delivery valve.

3. Remove the tie-rod cover and disconnect the tie-rod from the control rack.
4. Set the control rack to a midway position in the working range.
5. Open the fuel feed pipe and make sure that fuel flows from the delivery valve holder.
6. Turn the crankshaft in the direction of normal rotation (clockwise) and find an instant that fuel stops flowing from the delivery valve holder. This instant is the real injection timing.

⚠ CAUTION

The standard injection timing differs with engine specification and engine speed.
Check to see whether the real injection timing coincides with the standard injection timing (whether the IT mark on the crankshaft pulley aligns with the mark on the gear case).

7. If they do not coincide with each other, adjust thickness of the injection pump mounting shim. Increasing or decreasing shim thickness by 0.1 mm [0.0039 in.] causes the real injection timing to vary about 1°.

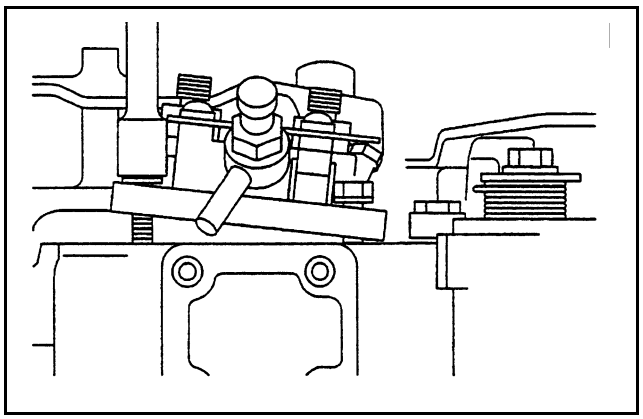


Figure 23 Removing injection pump

8. To remove the injection pump, first disconnect the injection pipes and fuel feed pipe from the injection pump. Then, remove the tie-rod cover and tie-rod. Dismount the pump assembly. Reassembly sequence of the pump is the reverse of disassembly.
9. In the dusty place or when the engine is dirty, removal of a delivery valve may cause dust to enter into the injection pump. Under such circumstances leave the delivery valve installed and check injection timing using the following procedure:
   a Remove the tie-rod cover and disconnect the tie-rod from the control rack.
   b Set the control rack to a midway position in the working range. Disconnect the injection pipe from the No. 1 nozzle. Turn the crankshaft gradually in the direction of normal rotation until swelling of fuel is found at the open end of the injection pipe. This instant is the real injection timing, which will come approx. 1° later than standard injection timing.

min-^{1}	Model L2	Model L3
Less than 2000	BTDC 15°	BTDC 15°
200 to less than 3600	BTDC 17°	BTDC 17°
3600 or more	BTDC 19°	BTDC 19°

Table 12 Standard injection timing

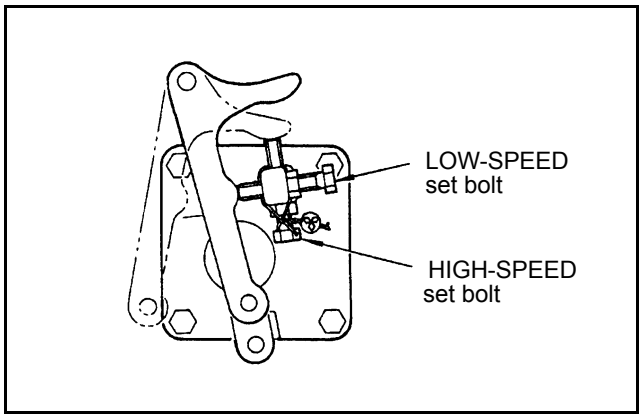


Figure 24 HIGH-SPEED and LOW-SPEED set bolts

5.8 Adjusting the engine speeds

To adjust engine speed, remove the cooling fan and install the safety cover over the fan to reduce the risk of injury.

1. The upper limit of engine speed can be adjusted with the HIGH-SPEED stopper bolt. This stopper bolt has been set properly and sealed in the factory before shipping of the engine. Never attempt to open the seal unless it is necessary.
2. The lower limit of engine speed can be adjusted with the LOW-SPEED stopper bolt.
3. Never remove the sealing cap unless it is necessary to adjust the torque spring set.

⚠ CAUTION

Warm up the engine (until coolant temperature rises up to 60°C [140°F] or above) before adjusting engine speeds.

4. During running of the engine for speed adjustment, check the engine for gas leak, water leak, oil leak and fuel leak.

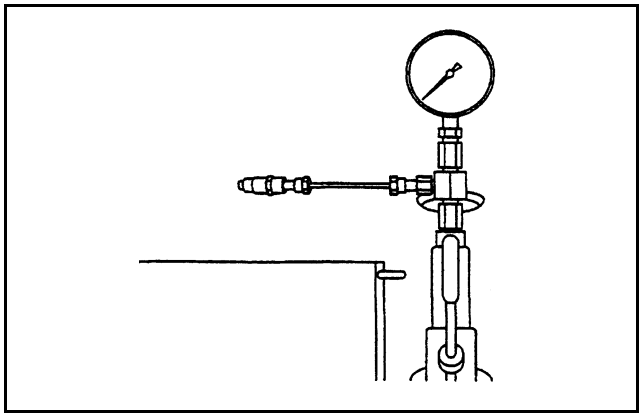


Figure 25 Testing injection start pressure

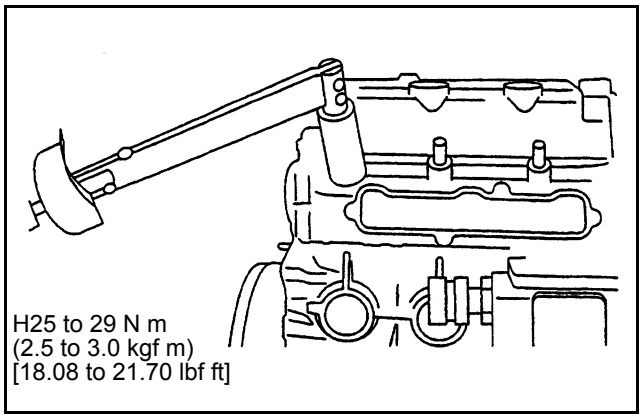


Figure 26 Installing nozzle assembly

5. After adjustment, perform engine acceleration and deceleration test to confirm that the engine is free from hunting and smoking.

5.9 Checking and adjustment of nozzles

To check and adjust the injection nozzles, use the following procedure:

5.9.1 Injection start pressure

1. Remove the nozzle assembly to be tested from the cylinder head and set the nozzle on the nozzle tester.
   Perform air bleeding by moving the tester handle up and down.
2. Operate the handle at a rate of one discharge a second or more and read the gage pressure of fuel injected from the nozzle.

Injection start pressure	$13.7^{+1.0}_{-0}$ MPa $(140^{+10}_{-0}$ kgf/cm^2) $[1992^{+142}_{-0}$ psi]

Table 13 Start pressure

3. If reading of gage pressure exceeds the specified range, disassemble the nozzle and adjust by using the adjusting shim.
   Increasing or decreasing shim thickness by 0.1 mm [0.0039 in.] will cause injection pressure to vary about 0.98 MPa (10 kgf/cm2) [142 psi].
4. When reassembling the nozzle, use the following values of tightening torque:

Nozzle	Tightening torque
Nozzle tightening (to cylinder head) torque	49.0 to 58.8 N·m (5.0 to 6.0 kgf·m) [36.17 to 43.40 lbf·ft]
Nozzle retaining nut tightening torque	34.3 to 39.2 N·m (3.5 to 4.0 kgf·m) [25.32 to 28.93 lbf·ft]
Nozzle union collar tightening torque	25 to29 N·m (2.5 to 3.0 kgf·m) [18.08 to 21.70 lbf·ft]

Table 14 Tightening torque

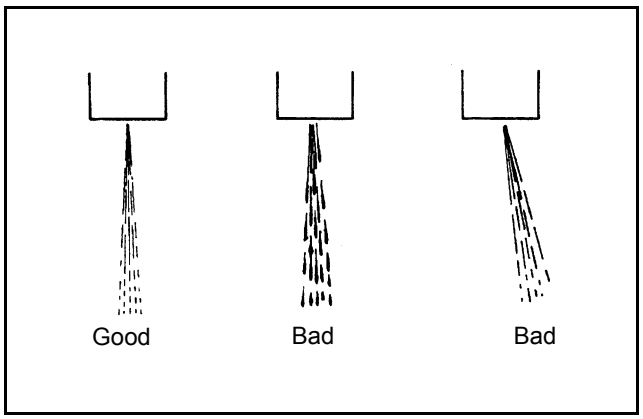


Figure 27 Chattering test

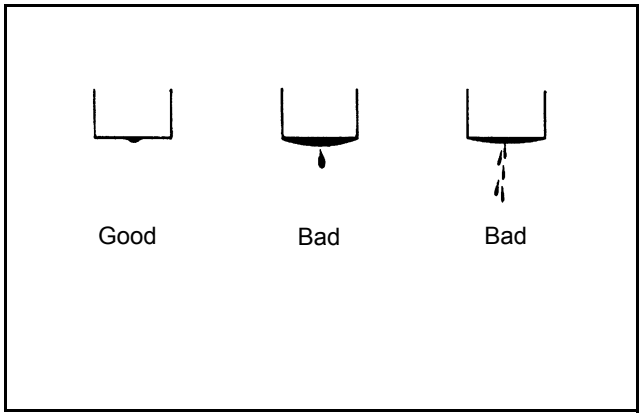


Figure 28 After-spilling

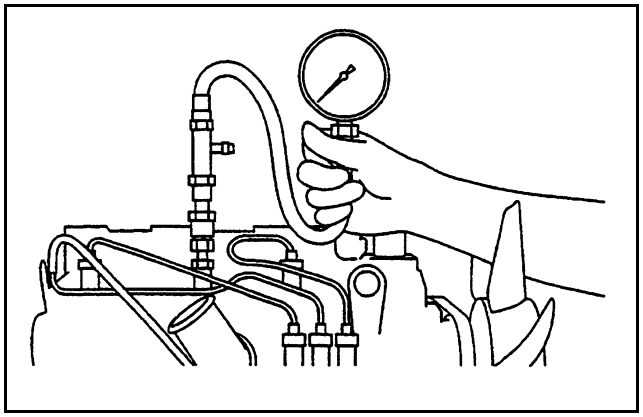


Figure 29 Testing compression pressure

5.9.2 Chattering test

Operate the tester handle at a speed of about one stroke per second.

1. Needle valve oscillation
   If the fuel spray shows good atomization, making intermittent sounds, and oscillations of the needle valve are transmitted to the handle, then the nozzle is considered as normal.

2. Shape of fuel spray
   The nozzle should inject fuel spray straight in the direction of its axis. A nozzle is defective if it does not inject steadily or it injects fuel in several separate stripes.
   A nozzle is defective if it spills fuel accumulated on the bottom of the nozzle after chattering test. However, a very small drop of fuel remaining on the tip of nozzle after chattering test may be regarded as normal.

5.9.3 Injection Test

1. Operate the tester handle at a speed of 4 to 6 strokes per second.
2. A nozzle should inject fuel spray uniformly in the shape of a cone.

5.9.4 Checking the compression pressure

Make sure of the following:
1. The engine oil level, air cleaner, starting motor, and battery are well-conditioned.

Engine speed	250 to 280 min^{-1}
Compression pressure	2.84 to 3.14 Mpa (29 to 32 kgf/cm^2) [413 to 455 psi]
Pressure difference between cylinders	0.29 MPa (3 kgf/cm^2) [43 psi] or less

Table 15 Conditions to perform test

2. Warm up the engine to the coolant temperature of 50°C [122°F] or more.

Measure the compression pressure using the following procedure:
1. The following are the conditions to perform test.
2. Pull the stop lever to the “non-injection” position.
3. Remove the glow plug from the cylinder to be tested. Set the compression gage adapter to that cylinder and install the gage.

Special tool name	Part No.
Compression gage adapter	ST332270

Table 16 Tools

4. Crank the engine with the starting motor until a stable reading of the compression gage is obtained.
5. After reading the gage, remove the compression gage and adapter. Put back the glow plug.
6. Check all cylinders using the same procedure described above.

6 TROUBLESHOOTING

6.1 Hints on using the trouble-diagnosis chart

1. As for diesel engines, trouble symptoms and causes are often so complicated that it will be difficult to locate the root cause by judging from a trouble symptom.
2. For example, trouble symptoms caused by the faulty injection pump, faulty injection nozzles and improper cylinder compression, make the same kind of phenomenon. When judging the cause of trouble from examination, be careful to make conclusion because it can be very complicated.
3. The trouble-diagnosis charts on the following pages are prepared in such a way of beginning with the most possible or easiest-to-inspect item and then proceeding stepwise to less possible or more complicated items.
4. Before troubleshooting, you should have a right understanding of the following features about the structure and fuel combustion in the diesel engines.
   a Normal engine operation is accompanied by combustion noise (diesel knocking sound).
   b A heavy-loaded engine exhausts some black smoke.
   c When operated, an engine may cause vibration because of high cylinder compression and large output torque.
   d When an engine is accelerated or decelerated quickly, some hunting may occur.

⚠ CAUTION

a. Do not attempt to readjust or disassemble the injection pump for the purpose of troubleshooting, without use of a pump tester, which is indispensable to measure injection quantity for each cylinder.
b. To check if state of combustion in a cylinder is normal or not, loosen the injection pipe to cut fuel feed to that cylinder, and check the slowdown speed of the engine. Compare the degree of slowdown with the other cylinders.

6.2 Hard starting

6.2.1 Matters to be checked before diagnosis

1. Clogging of the air cleaner
2. Coagulation of engine oil
3. Use of poor-quality fuel
4. Lowering of cranking speed

6.2.2 Diagnosis

Does preheating system operate properly?
No ▷ Does current flow in glow plug circuit as soon as key switch is turned to 'H' (ON)?
No ▷ Inspect key switch, wiring and glow indicator.

▽ Yes
Yes ▷ Inspect glow plug.

Is electric wiring normal?
Does fuel feed pump, if provided operate when key switch is turned ON?
No ▷ Inspect fuel pump and/or wiring.

▽ Yes

Does fuel flow in fuel line?
No ▷ Does fuel flow out when fuel injection pump air vent screw is loosened?
No ▷ Inspect fuel filter, fuel pipe and fuel tank.

▽ Yes

Is engine in good order?
(Injection timing and valve timing)
No ▷ Adjust engine properly.

▽ Yes

Do injection nozzles operate properly?
State of fuel spray and injection starting pressure.
No ▷ Inspect injection nozzles.

▽ Yes

Is cylinder compression pressure proper?
No ▷ Inspect valves, pistons, piston rings and cylinder head gasket.

▽ Yes

Inspect injection pump.

6.3 Knocking

Diesel engines are usually accompanied by fuel combustion noise (diesel knocking sounds) because of its inherent mechanism.
A trouble should be suspected only when the engine makes abnormally large sounds.

6.3.1 Matters to be checked before diagnosis

1. Clogging of the air cleaner
2. Use of poor-quality fuel (Low cetane number fuel such as used for burner)

6.3.2 Diagnosis

Is injection timing correct?	No ▷	Adjust injection timing.
▽ Yes		
Do injection nozzles operate properly? (Check for lowering of injection start pressure and improper shape of fuel spray.)	No ▷	Inspect injection nozzles.
▽ Yes		
Is cylinder compression proper?	No ▷	Inspect valves, pistons, piston rings and cylinder head gasket.
▽ Yes		
Does injection pump operate properly? (Check for uniformity of injection quantity.)		
▽ Yes		
Mechanical noise (Worn or damaged main moving parts)		

6.4 Overheating

6.4.1 Matters to be checked before diagnosis

1. Lack of coolant and leakage
2. Loosening of fan belt
3. Clogging of radiator fins
4. Wrong concentration of antifreeze solution
5. Clogging of muffler
6. Lack of engine oil and deterioration
7. Lack of cooling air
8. Defective thermostat

6.4.2 Diagnosis

Is engine operating condition too heavy? (Check for overload continuous running.)	No ▷	Find the cause over overload.
▽ Yes		
Is cooling system in good order? (Check cylinder head gasket for leaking, water pump, water hose and radiator fins for clogging and thermostat for malfunctioning.)	No ▷	Repair cooling system.
▽ Yes		
Is injection timing correct?	No ▷	Adjust injection timing.

⚠ CAUTION

Overheating is mostly caused by mis-matching load to the engine. If overheating arises only when the engine drives a load, measure the ambient temperature and coolant temperature under the working load condition (with full open thermostat) to see if the rise of the temperature is 60°C or lower than ambient temperature. If it exceeds, it is recommended to check other factors than engine main parts.

6.5 Black-smoky exhaust

6.5.1 Matters to be checked before diagnosis

1. Clogging of air cleaner element
2. Use of poor-quality fuel
3. Overload

6.5.2 Diagnosis

Is smoke set of injection pump correct?	No ▷	Adjust smoke set.
▽ Yes		
Is engine adjusted properly? (Check for excessive valve clearance and improper injection timing.)	No ▷	Adjust engine.
▽ Yes		
Do injection nozzles operate properly? (Check for improper shape of fuel spray and for excessively high injection starting pressure.)	No ▷	Inspect injection nozzles.
▽ Yes		
Is cylinder compression proper?	No ▷	Inspect valves, cylinder head gasket, pistons, and piston rings.
▽ Yes		
Inspect injection pump.		

6.6 Unsteady idling

6.6.1 Matters to be checked before diagnosis

1. Faulty engine control system
2. Too high viscosity of engine oil
3. Use of poor-quality fuel

6.6.2 Diagnosis

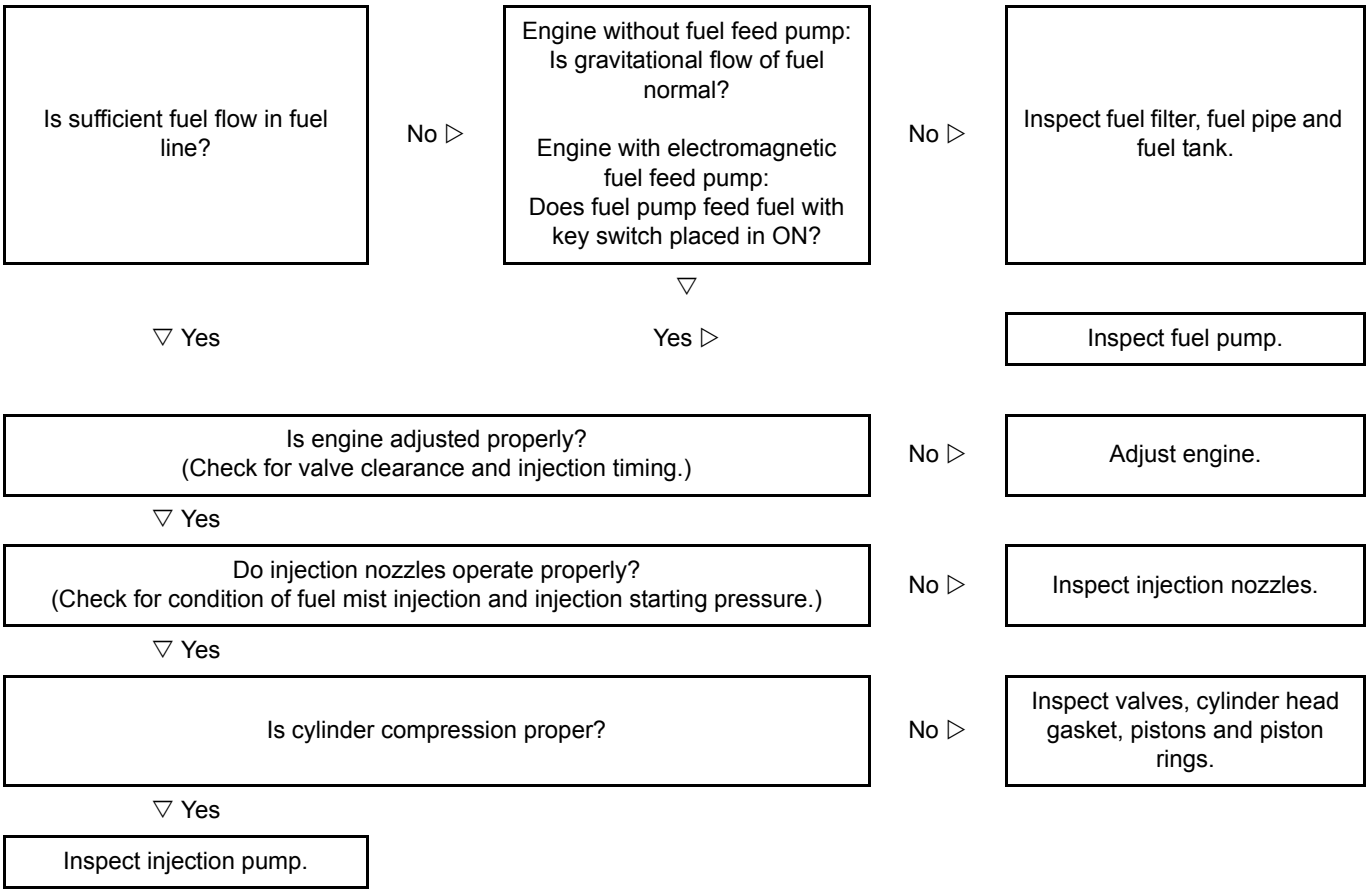
Is engine adjusted properly? (Check for idling speed, valve clearance, and injection timing.)	No ▷	Adjust engine.
▽ Yes		
Do injection nozzles operate properly? (Check for shape of fuel spray and injection starting pressure.)	No ▷	Inspect injection nozzles.
▽ Yes		
Is cylinder compression pressure proper? (Check equality between cylinders.)	No ▷	Inspect valves, pistons and piston rings.
▽ Yes		
Inspect injection pump and governor system.		

6.7 Low output

6.7.1 Matters to be checked before diagnosis

1. Seizing of engine moving parts
2. Too high engine oil viscosity
3. Use of poor-quality fuel
4. Clogging of air cleaner element
5. Clogging of muffler
6. Malfunctioning of drive system

6.7.2 Diagnosis



ENGINE MAIN PARTS

7 GENERAL

7.1 Specifications

Item		Model					
		L2			L3		
CYLINDER HEAD	Material	Special cast iron					
	Combustion chamber type	Swirl chamber					
	Material of chamber	Heat-resisting steel (press-fitted in cylinder head)					
	Type of intake and exhaust ports	Cross-flow type					
VALVE SEATS	Material	Heat-resisting steel (3600 min^{-1} specification engines)					
		Special cast iron (3000 min^{-1} or less engines)					
VALVES	Face angle	45°					
	Identification mark inlet	IN					
	Identification mark exhaust	EX					
VALVE SPRINGS	Type	Uniformly pitched, single					
	Identification mark	White paint atop (common to inlet and exhaust valves)					
CYLINDER HEAD GASKET	Material	Carbon sheet (Graphoil)					
CYLINDER HEAD BOLTS	Material	Special steel					
	Size x number bolts	M10 x 6			M10 x 8		
		M8 x 2			M8 x 3		
CAMSHAFT	Material valve cam	Carbon steel					
	Material pump cam						
	Arrangement – drive	Side – gear driven					
CYLINDER BLOCK	Cylinder bore mm [in.]	L2A	L2C	L2E	L3A	L3C	L3E
		65 [2.5591]	70 [2.7559]	76 [2.9921]	65 [2.5591]	70 [2.7559]	76 [2.9921]
	Cylinder liner type	Monoblock type					
	Water jacket type	A, C: Full jacket, E: “Siamese” type					
CRANKSHAFT	Material	Carbon Steel					
	Surface treatment	Hardening (Induction)					
	Main journal dia. x Crankpin dia. mm [in.]	43 x 40 [1.6929 x 1.5748]					
PISTON	Type	“Autothermic”					
	Joint to connecting rod	Semi-floating					
	Cooling	Oil jet					

Table 17 Specifications

Item		Model	
		L2	L3
PISTON RINGS	No. 1	Semi-keystone type	
	No. 2	Plain type	
	Oil ring	With coil expander	
OIL PUMP	Type	Gear type	
	Drive	Direct drive by crankshaft	
TIMING GEARS	Crankshaft gear	Number of teeth: 26	
	Idle gear	Number of teeth: 40	
	Injection pump camshaft gear	Number of teeth: 52	
	Valve camshaft gear	Number of teeth: 52	

Table 17 Specifications

7.2 Special Tools

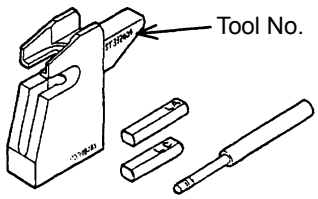
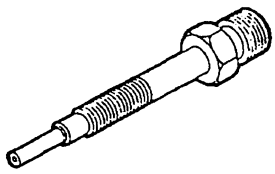
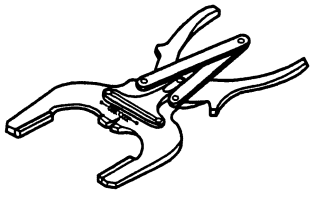
Tool name	Part No.	Shape	Use
Piston pin setting tool	For L2A, L3A: 30L91-00030 For L2C, L3C: 30L91-00020 For L2E, L3E: 30L91-10010		Removal and installation of piston pin
Compression gage adapter	ST332270		Measurement of cylinder compression
Piston ring pliers	31391-12900		Removing and installing piston ring

Table 18 Special tools

8 ROCKER ARMS AND ROCKER SHAFT

8.1 Disassembly

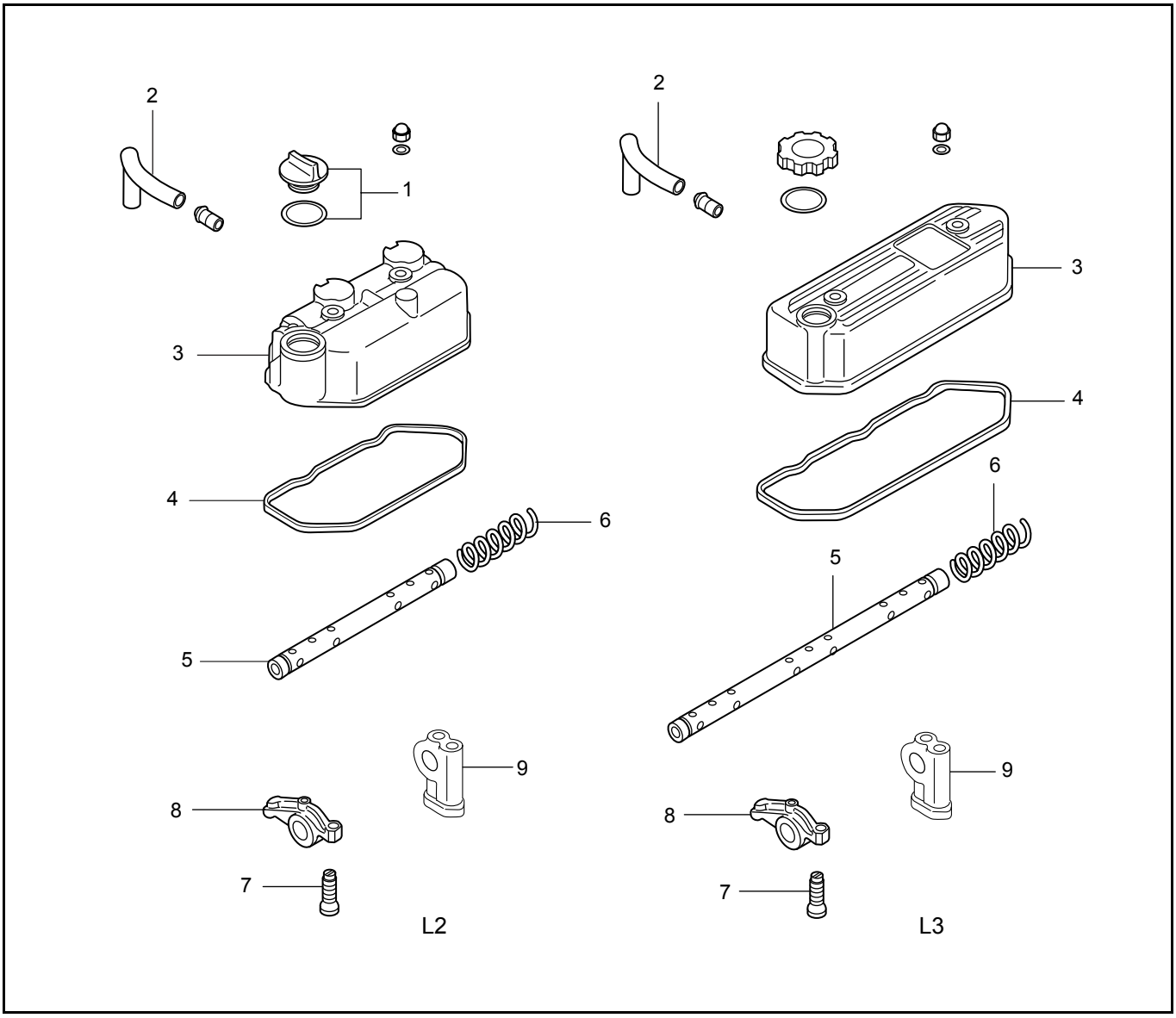


Figure 30 Rocker system components parts

Disassembly sequence
1. Oil filter cap
2. Breather hose
3. Rocker cover
4. Rocker cover gasket
5. Rocker shaft
6. Rocker spring
7. Adjust screw
8. Rocker arm

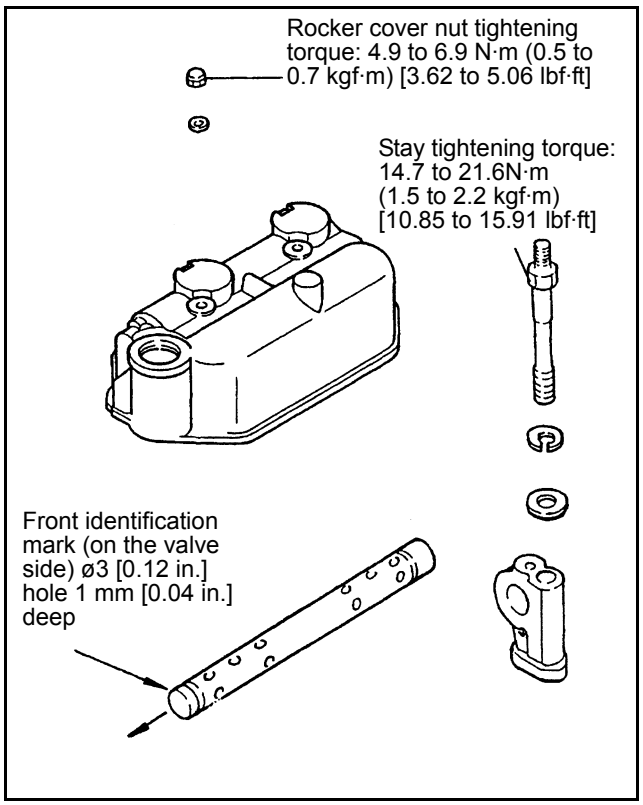


Figure 31 Installing rocker shaft and rocker cover

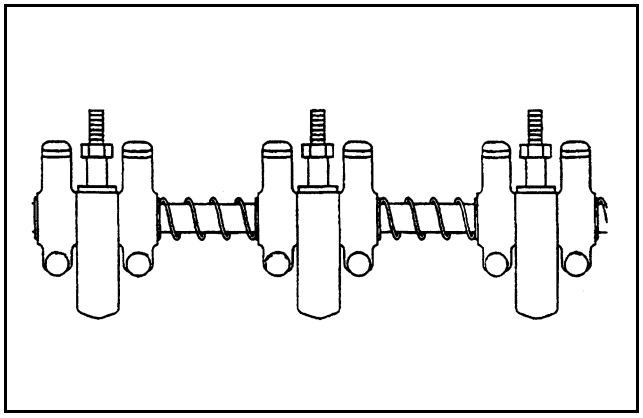


Figure 32 Inspecting rocker shaft and rocker arms

8.2 Removal and installation

⚠ CAUTION

a. Be careful not to confuse proper direction of installation of the rocker shaft.
b. After installing the rocker shaft, adjust valve clearance.

8.3 Inspection

Check the rocker shaft and rocker arms. If any defective parts are found, replace them.

9 CYLINDER HEAD

9.1 Disassembly

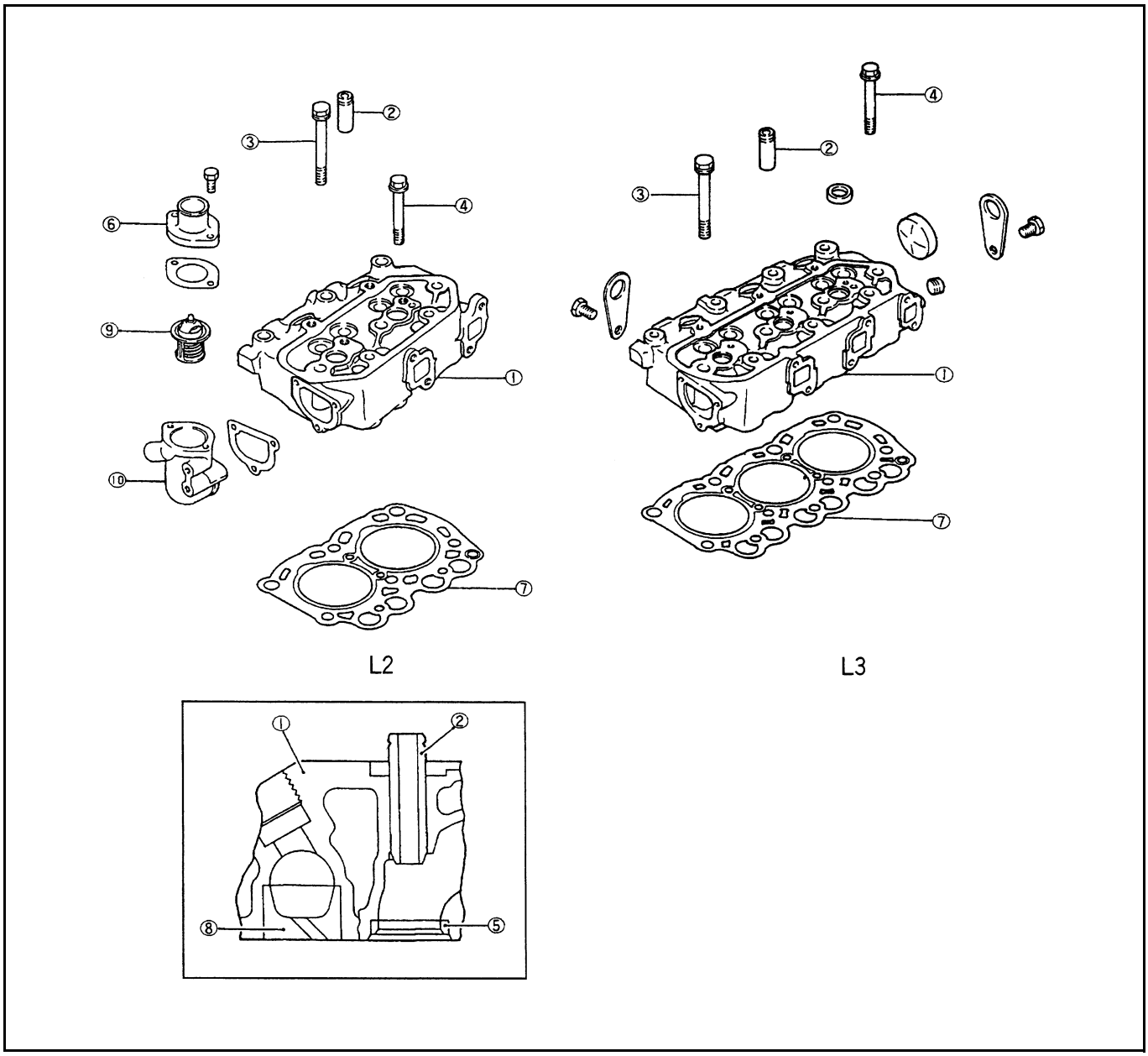


Figure 33 Cylinder head component parts

Disassembly sequence
1. Cylinder head
2. Valve guide
3. Cylinder head bolt (main bolt)
4. Cylinder head bolt (sub-bolt)
5. Seat ring (3600 min^{-1} specification engine)
6. Water outlet fitting
7. Cylinder head gasket
8. Mouth piece
9. Thermostat
10. Thermostat fitting

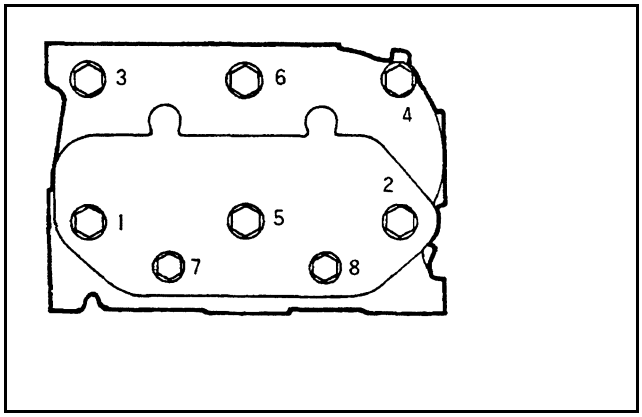


Figure 34 Sequence for loosening cylinder head bolts (L2)

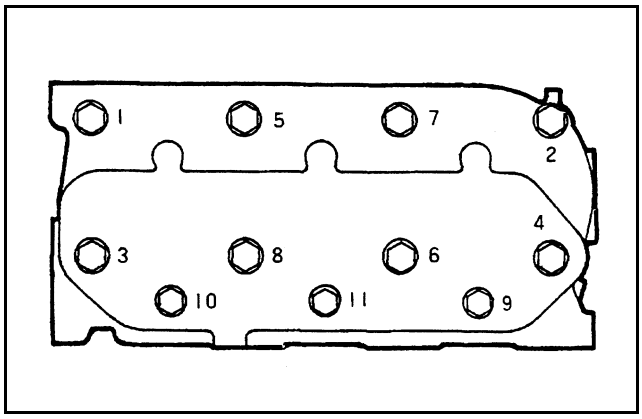


Figure 35 Sequence for loosening cylinder head bolts (L3)

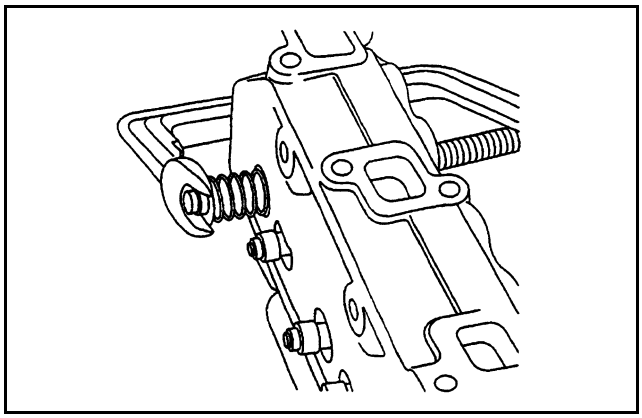


Figure 36 Removing valves

9.2 Removal

1. Remove the injection pipe assembly.

⚠ CAUTION

a. When disconnecting each injection pipe from the delivery valve holder of the injection pump, hold the holder with a wrench to prevent from loosening.
b. After removing the pipe assembly, place a cap to the nozzle holders and delivery valve holders to prevent from entering the dust.

2. Disconnect the glow plug lead wire.
3. Loosen the alternator bracket bolts and dismount the alternator.
4. Disconnect the air breather hose.
5. Remove the rocker cover.
6. Remove the rocker shaft assembly.
7. Loosen the cylinder head mounting bolts in the numerical order illustrated at right and remove the cylinder head assembly (including the inlet and exhaust manifolds).
8. Remove the cylinder head gasket.
9. Clean the cylinder head and the cylinder block surface from which the gasket has been removed.
10. Remove the nozzle holder assemblies and glow plugs from the cylinder head.

11. Remove the inlet manifold and exhaust manifold from the cylinder head.

⚠ CAUTION

a. When disconnecting each injection pipe from the delivery valve holder of the injection pump, hold the holder with a wrench to prevent from loosening.
b. After removing the pipe assembly, place a cap to the nozzle holders and delivery valve holders to prevent from entering the dust.

12. Remove the valve stem seals.

9.3 Inspection and Repair

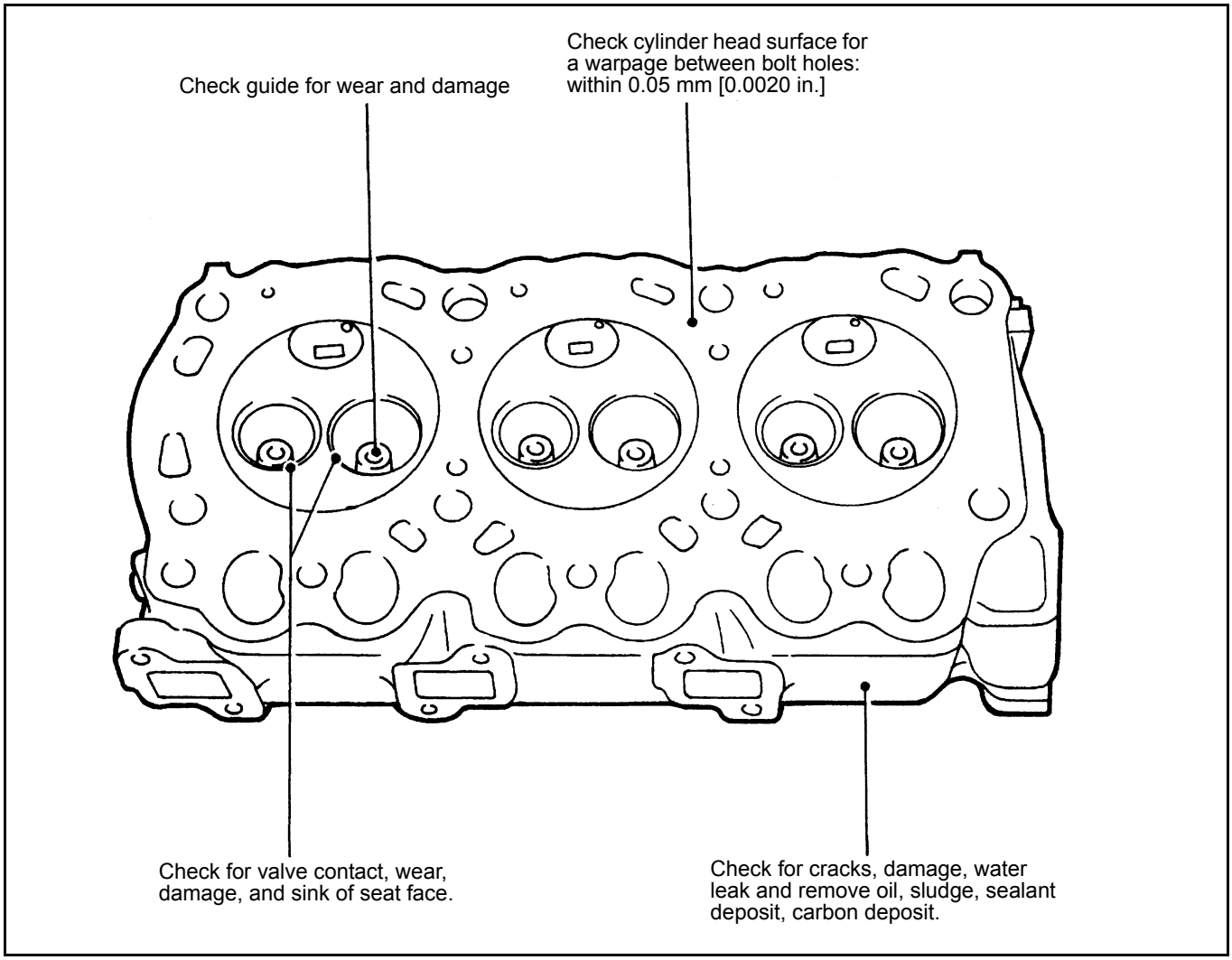


Figure 37 Inspection of cylinder head

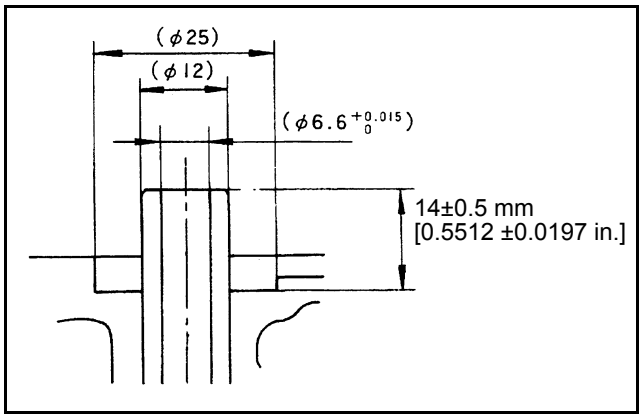


Figure 38 Press-fitting valve guide

9.4 Replacement of valve guide

If a valve guide is defective, replace it.

9.4.1 Removal

Press the guide at its upper end and push it out to the valve seat side.

9.4.2 Installation (press-fitting)

Press-fit the guide from the upper side of the cylinder head to a height of 14 ±0.5 mm [0.5512 ±0.0197 in.] from the valve spring seat face.

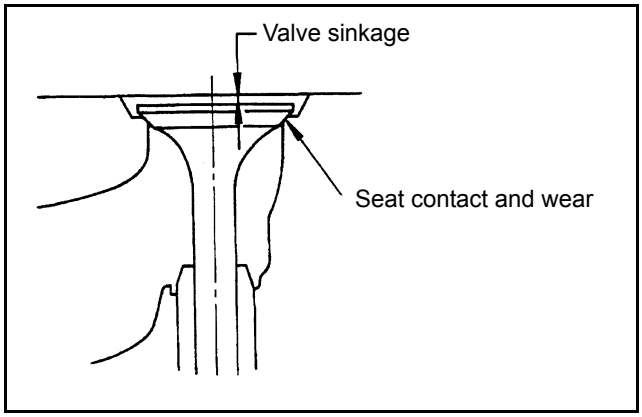


Figure 39 Checking valve sinkage

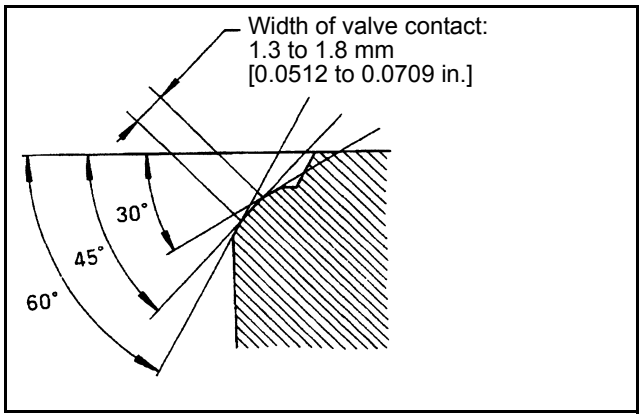


Figure 40 Refacing valve seat (Both inlet and exhaust valves)

9.5 Repair of valve seat

If a valve seat is found defective, reface or replace it.

Sinkage of valve	
Standard	Service limit
0.5 mm [0.0197 in.]	1.5 mm [0.0591 in.]

Table 19 Sinkage of valve

⚠ CAUTION

a. When checking valve sinkage, the valve guide must be in the normal condition.
b. Resurface the valve seat so that it contacts the mid-portion of the valve face.

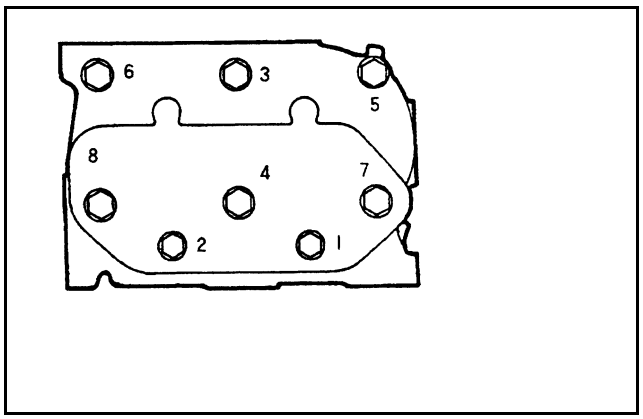


Figure 41 Sequence for tightening cylinder head bolts (L2)

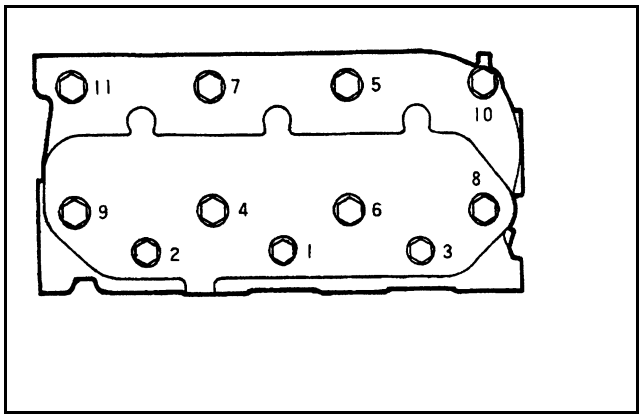


Figure 42 Sequence for tightening cylinder head bolts (L3)

9.6 Installation

Installation sequence of the cylinder head is reverse order of removal. Pay attention to the following:

1. Renew the cylinder head gasket. Any sealant is not necessary. The engine model is printed on the upper front of the gasket. Be careful not to confuse with a gasket for other engine model.
2. Tighten the cylinder head bolts in the numerical order shown in the figure at right. Tighten each bolt a little two or three times in total until all are tightened to the specified torque.
3. When connecting the injection pipe assembly, loosen the pipe clamp first.
   When tightening the nut at each end of pipe, hold the nozzle holder or delivery valve holder with a wrench to prevent from being turned together with the nut.
   Also, be careful not to allow dust to enter the fuel line.

10 VALVES AND VALVE SPRINGS

10.1 Disassembly

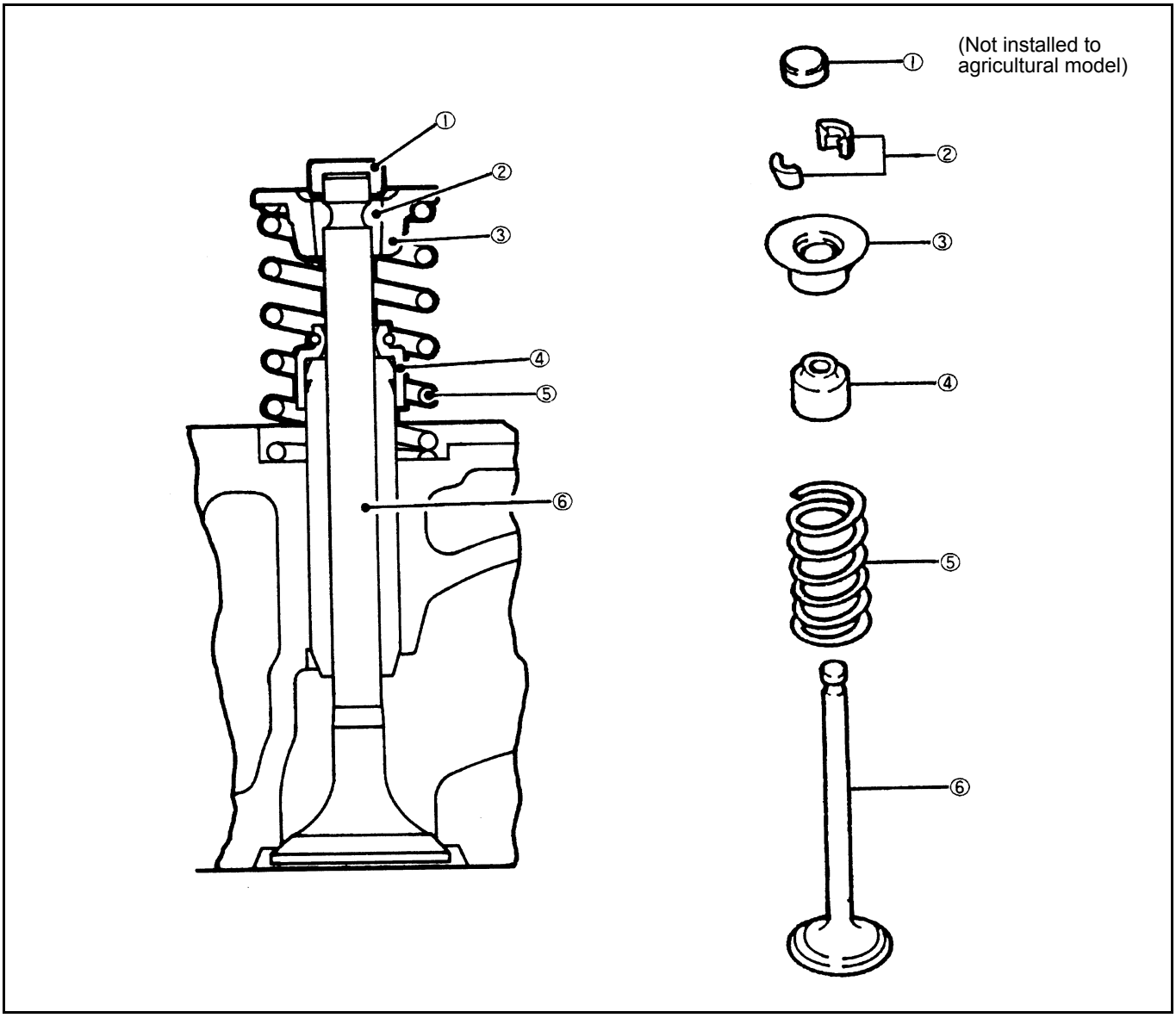


Figure 43 Valve system component parts

Disassembly sequence
1. Valve stem cap
2. Valve lock
3. Valve spring retainer
4. Valve stem seal
5. Valve spring
6. Valve

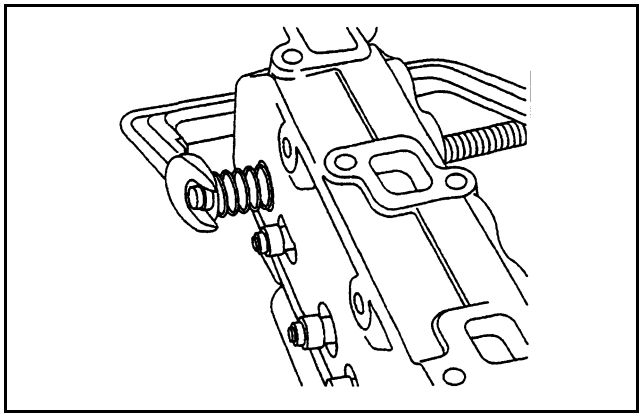


Figure 44 Removing valve and valve spring

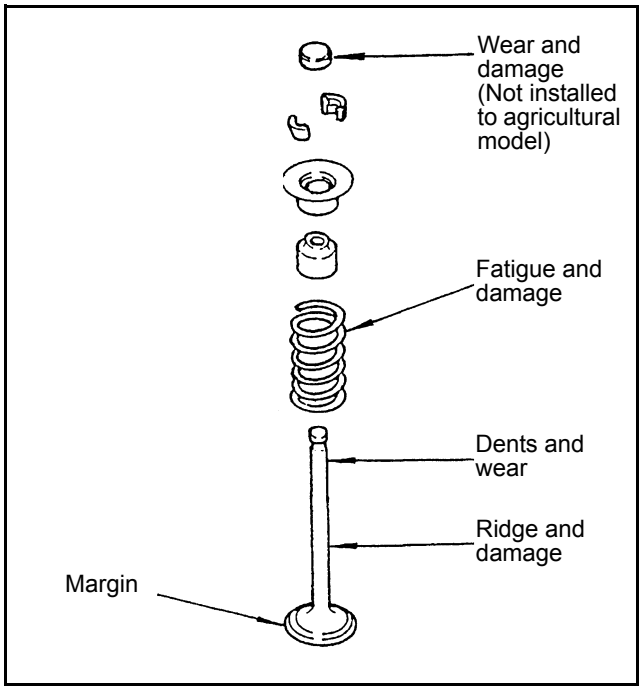


Figure 45 Inspection of valve and valve spring

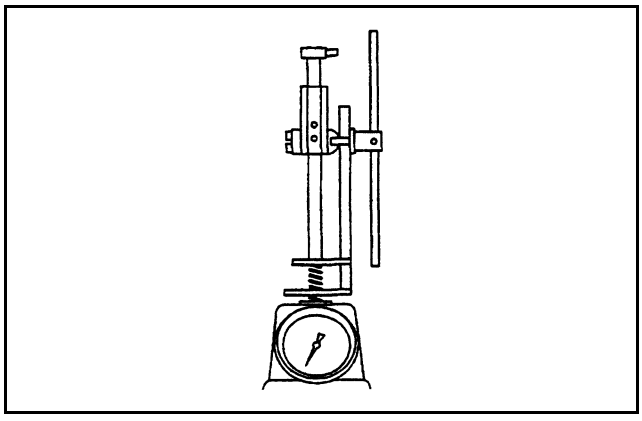


Figure 46 Valve spring tester

10.2 Removal

1. Dismount the cylinder head assembly.
2. Press the valve spring retainer (to compress the valve spring) and remove the valve lock.
3. Remove the valve and place it cylinder by cylinder.

10.3 Inspection and repair

Check the removed parts. If any parts are found defective, repair or replace them.

Valve fatigue and damage		
Inspection item	Standard	Service limit
Free length (61SG, 63SG) (Others) mm [in.]	40.5 [1.5945] 40.0 [1.5748]	-1 [-0.0394]
Set force/Set length (61SG, 63SG) (Others) N (kgf) [lbf]/ mm [in.]	58 (5.94) [13.1]/ 35.5 [1.3976] 146 (14.84) [32.7]/ 28 [1.1024] 68 (6.89) [15.2]/ 35.5 [1.3976] 180 (18.36) [40.5]/ 28 [1.1024]	-15%
Perpendicularity	2°	3°
Margin mm [in.]	1.0 [0.0394]	0.5 [0.0197]

Table 20 Valve inspection and repair

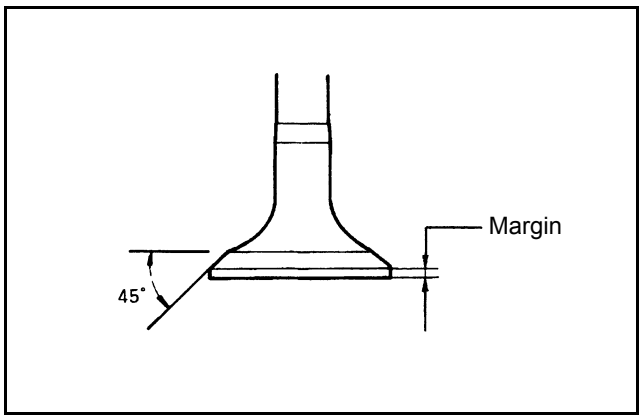


Figure 47 Inspecting valve

10.3.1 Repair of valve face

If the valve face is found worn, resurface with a valve refacer. If margin of the resurface valve is less than the service limit, replace the valve.

10.3.2 Repair of valve stem end

If the valve stem end is indented by wear, flatten with an oil stone.

10.4 Installation

1. Reassemble the valves and valve springs, referring to the illustrations shown below.
2. Mount the cylinder head assembly.
3. Adjust the valve clearances.

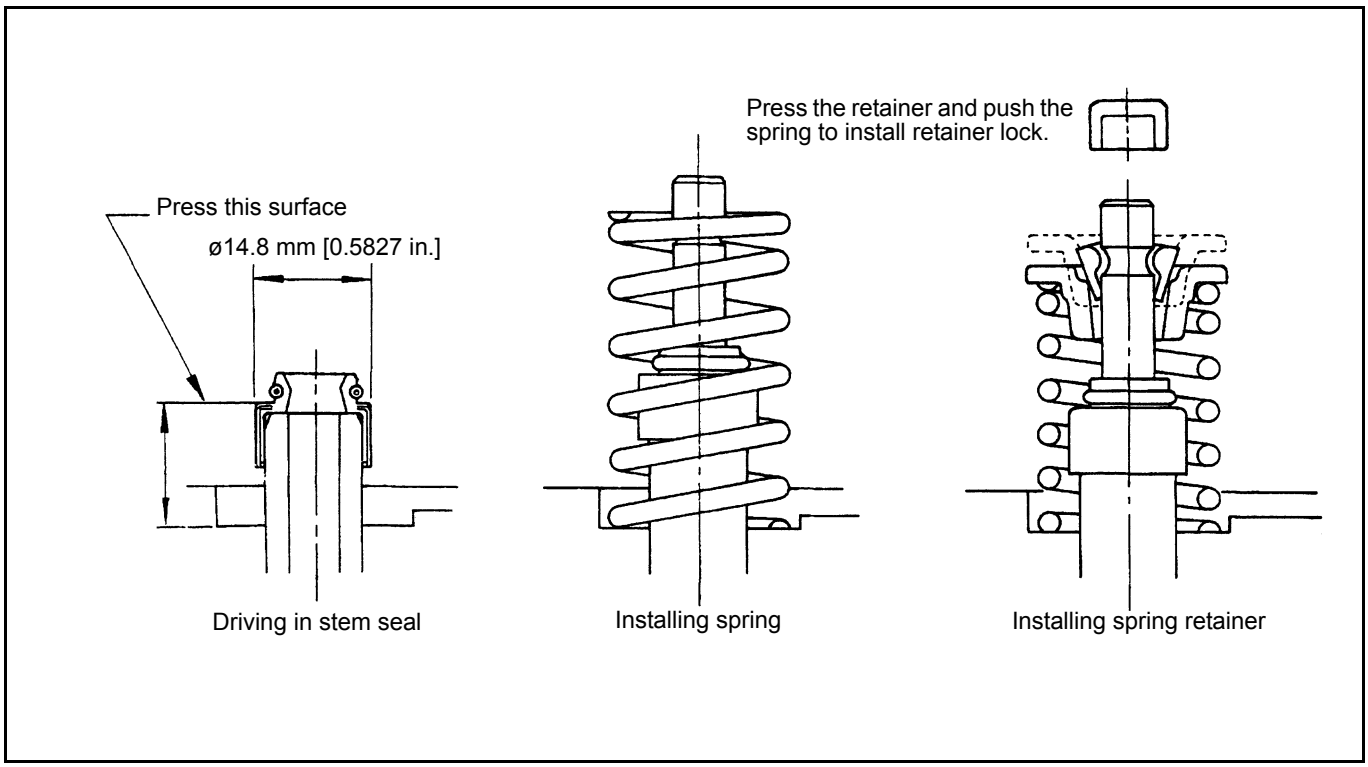


Figure 48 Installation of valve spring

⚠ CAUTION

Be careful not to damage the spring and stem seal by excessively pushing the spring when installing the valve spring.

11 INLET MANIFOLD AND EXHAUST MANIFOLD

11.1 Disassembly

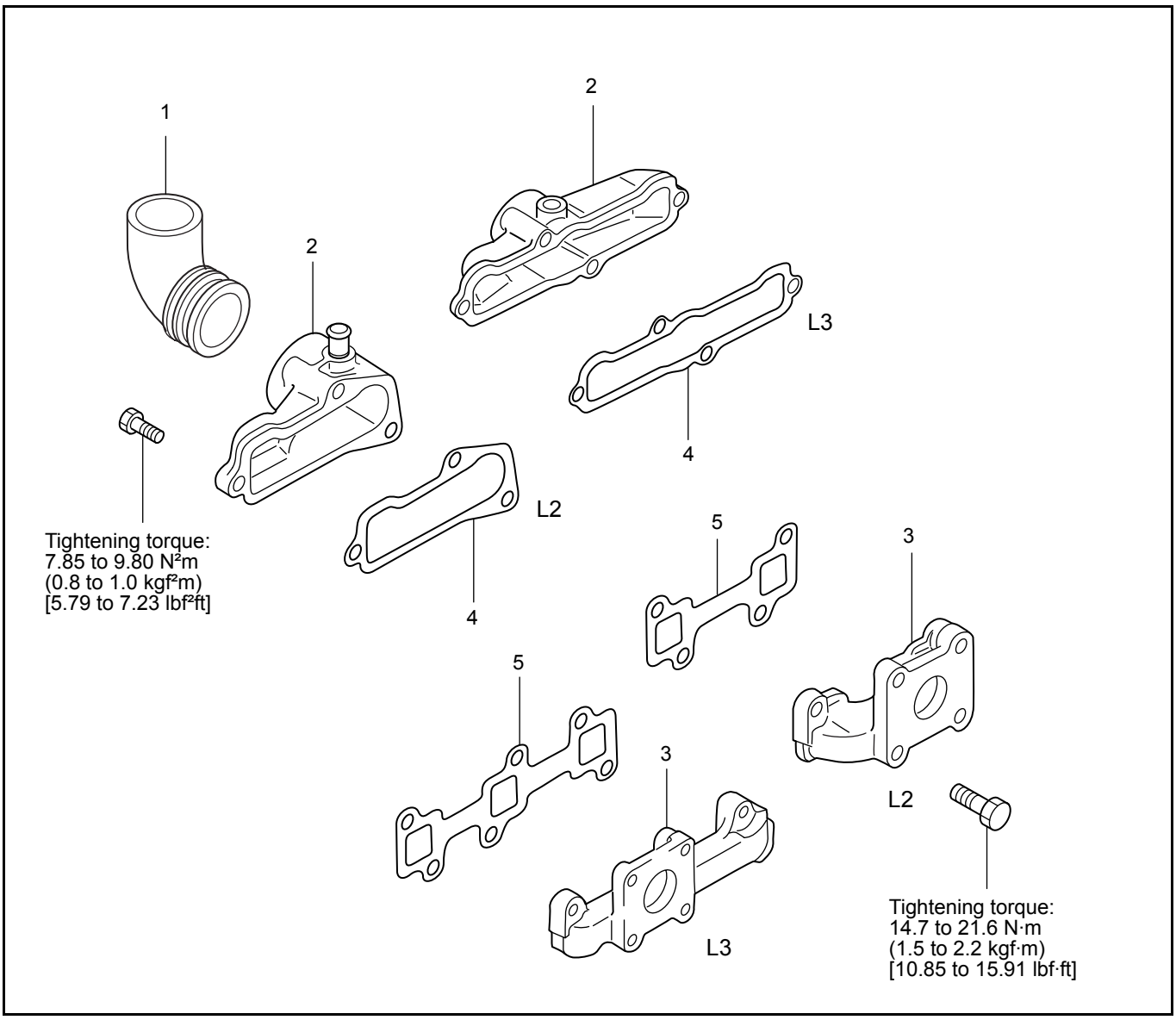


Figure 49 Manifold component parts

Disassembly sequence
1. Inlet pipe
2. Inlet manifold
3. Exhaust manifold
4. Inlet manifold gasket
5. Exhaust manifold gasket

11.2 Inspection

Check the following matters. If any defect is found, repair or replace the manifold.

1. Check the mounting surfaces to the cylinder head for flatness. The surfaces must be flat within 0.15 mm [0.0059 in.].
2. Check the manifolds for corrosion, damage and cracks.

⚠ CAUTION

a. Check the interior of the inlet manifold for dust and dirt.
b. If any dust is found, check the joints of the air cleaner and inlet pipe for sealed condition.

12 GEAR CASE AND OIL PUMP

12.1 Disassembly

Common to L2 and L3

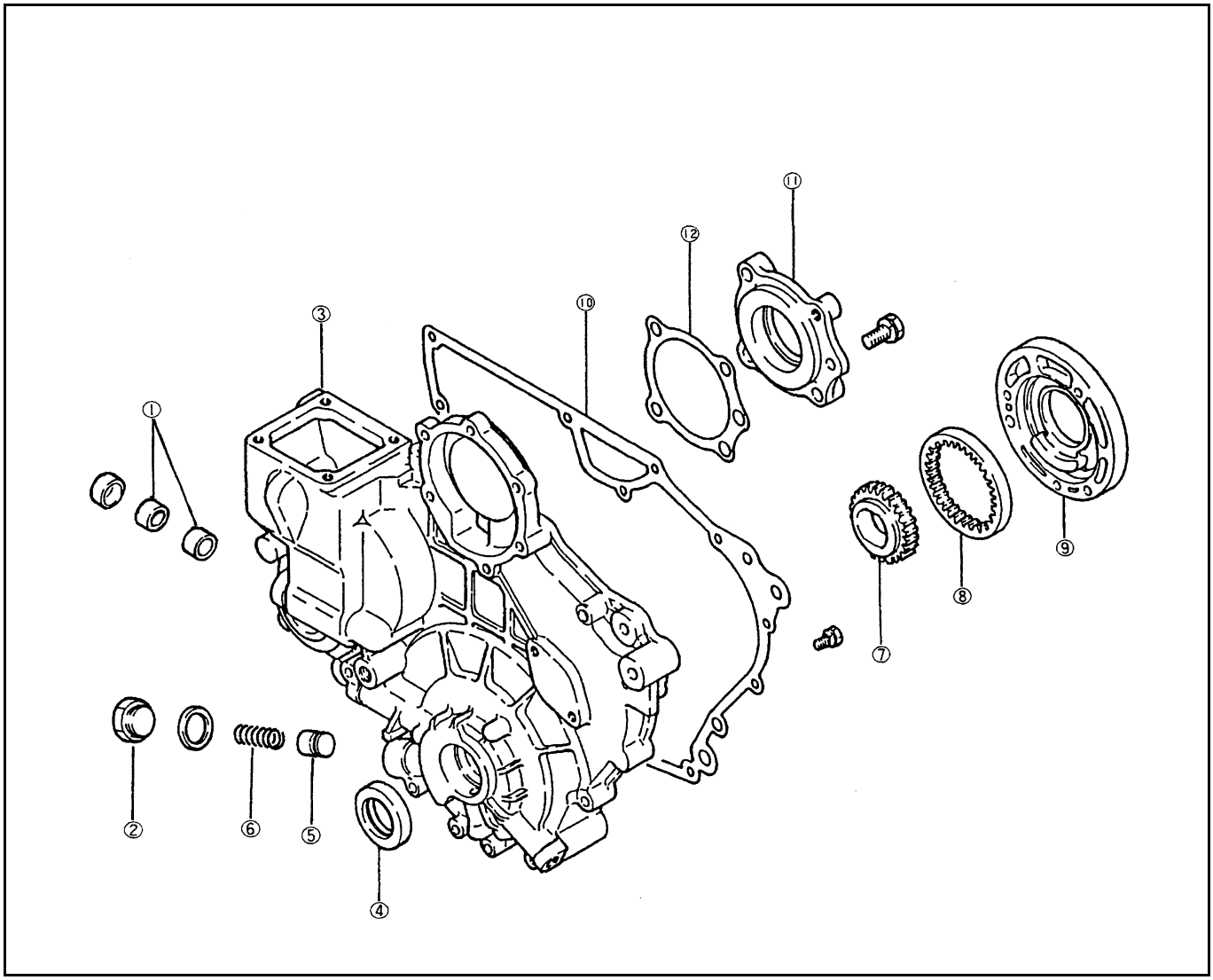


Figure 50 Gear case component parts

Disassembly sequence
1. Bushings
2. Plug
3. Gear case
4. Front oil seal
5. Relief plunger
6. Relief spring
7. Oil pump inner gear
8. Oil pump outer gear
9. Oil pump housing
10. Gear case gasket
11. High-pressure pump gear housing
12. Housing gasket

12.2 Removal

1. Remove the crankshaft pulley.
2. Remove the fan and fan belt.
3. Remove the tie-rod cover from the side face of the injection pump.
4. Remove the tie-rod and tie-rod spring. Be careful not to let the spring drop to inside of the case.
5. Remove the governor cover assembly.
6. Remove the water pump assembly.
7. Remove the alternator.
8. Remove the pump housing.
9. Remove the gear case assembly.

12.3 Inspection

Check the removed parts. If any parts are found defective, repair and replace them.

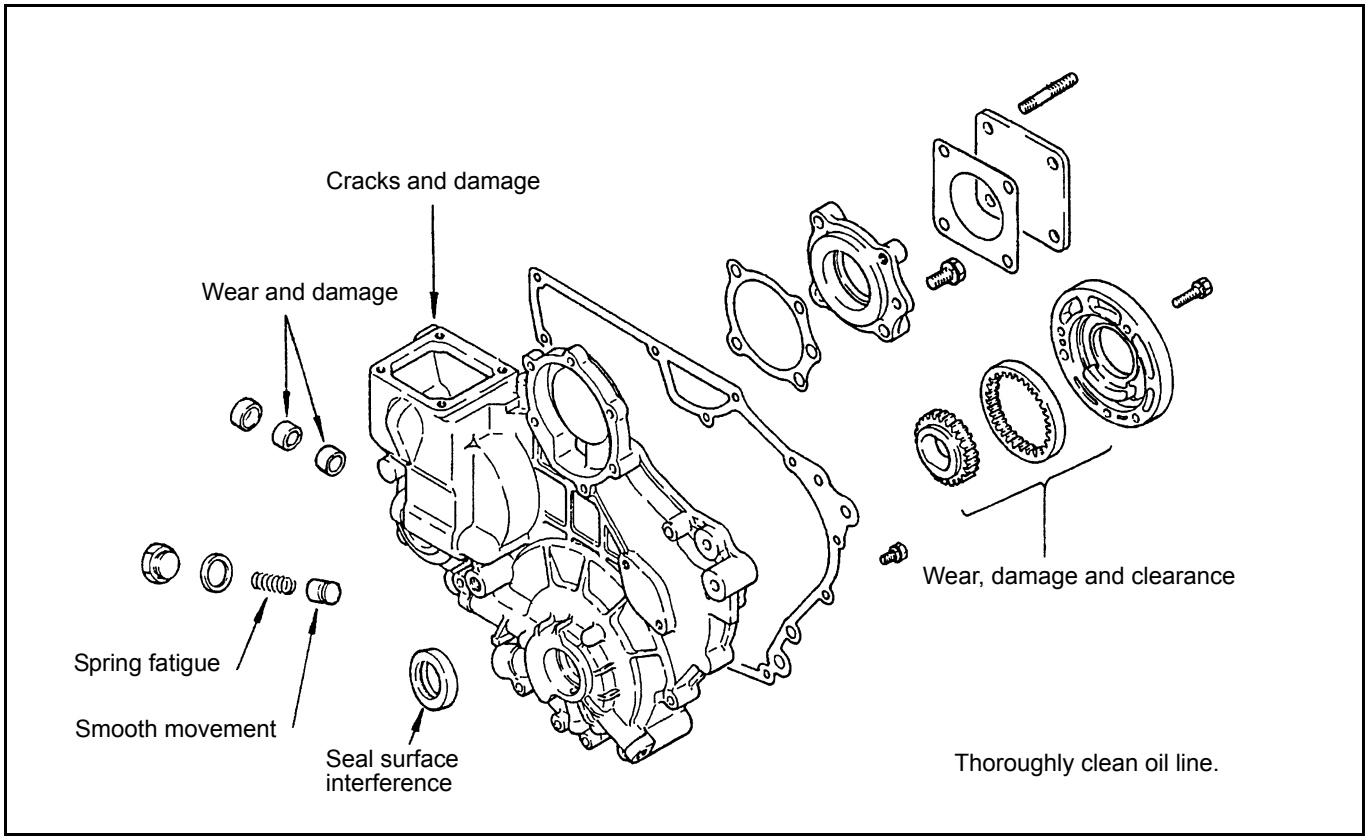


Figure 51 Inspection of gear case and oil pump

Description	Speed, min^{-1}	1000	4000
Discharge	Pressure MPa (kgf/cm2) [psi]	0.15 (1.5) [21]	0.20 (2.0) [28]
	Flow rate l [U.S.gal]/min	3 [0.79] or more	8 [4.76] or more

Table 21 Oil pump performance, oil used: SAE30, 100±5°C [212±9°F]

Description	Speed, min^{-1}	1000	4000
Relief valve	Opening pressure MPa (kgf/cm^2) [psi]	0.29 (3.0) [43]	—
	Closing pressure MPa (kgf/cm^2)[psi]	—	0.49 (5) [71] or below

Table 21 Oil pump performance, oil used: SAE30, 100±5°C [212±9°F]

12.4 Replacement of front oil seal

1. Remove the front oil seal.
2. Press-fit the new front oil seal.

⚠ CAUTION

Apply thin coat of engine oil to the periphery and lip of the oil seal

12.5 Replacement of governor shaft bushings

1. Remove the expansion plug and draw the bushings out.
2. Press-fit the new bushings into the positions shown at right.

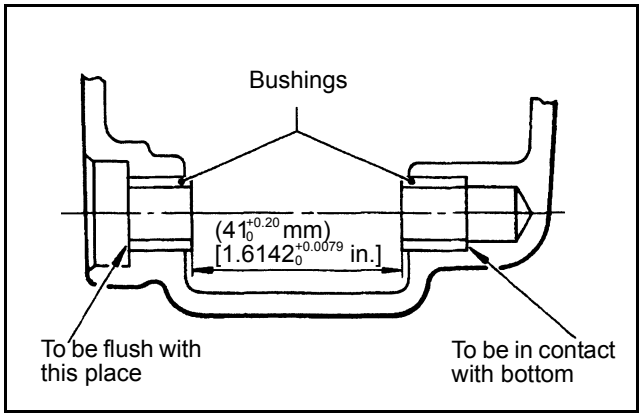


Figure 52 Press-fitting governor shaft bushing

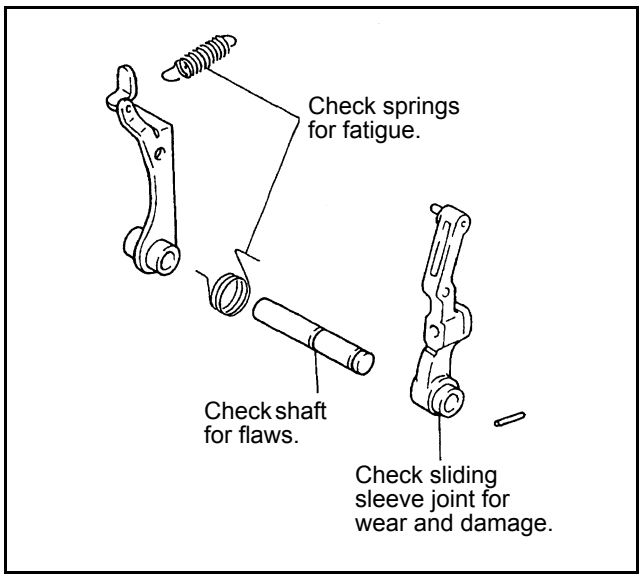


Figure 53 Check governor system

12.6 Inspection of governor system

Check the governor system in the gear case. If any parts are found defective, repair or replace them.

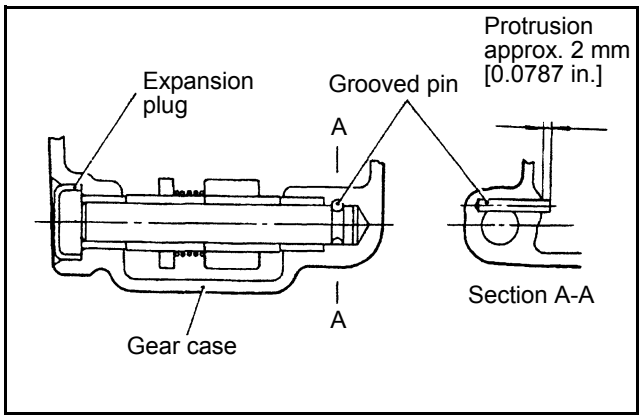


Figure 54 Reassembling governor shaft

12.7 Disassembly and reassembly of governor levers

12.7.1 Disassembling shaft

1. Remove the expansion plug, paying attention not to scratch the gear case.
2. Pull out the grooved pin.

12.7.2 Reassembling Shaft

1. Reassemble the shaft in the reverse sequence of disassembly.
2. After reassembling the shaft, press-fit the expansion plug into the shaft hole in the gear case.

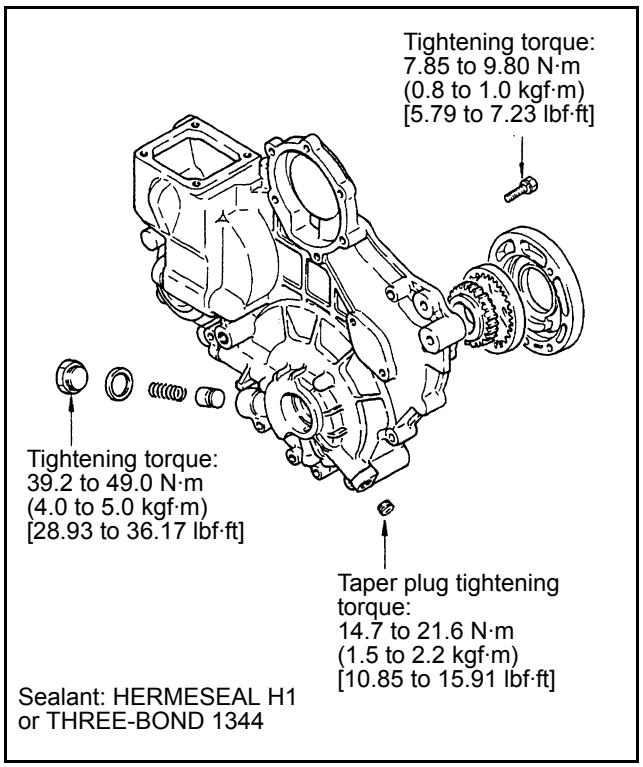


Figure 55 Gear case assembly

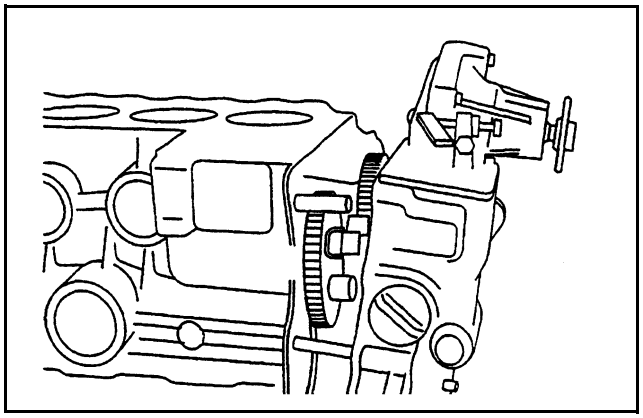


Figure 56 Installing gear case assembly

12.8 Installation of gear case assembly

13 TIMING GEARS

13.1 Disassembly

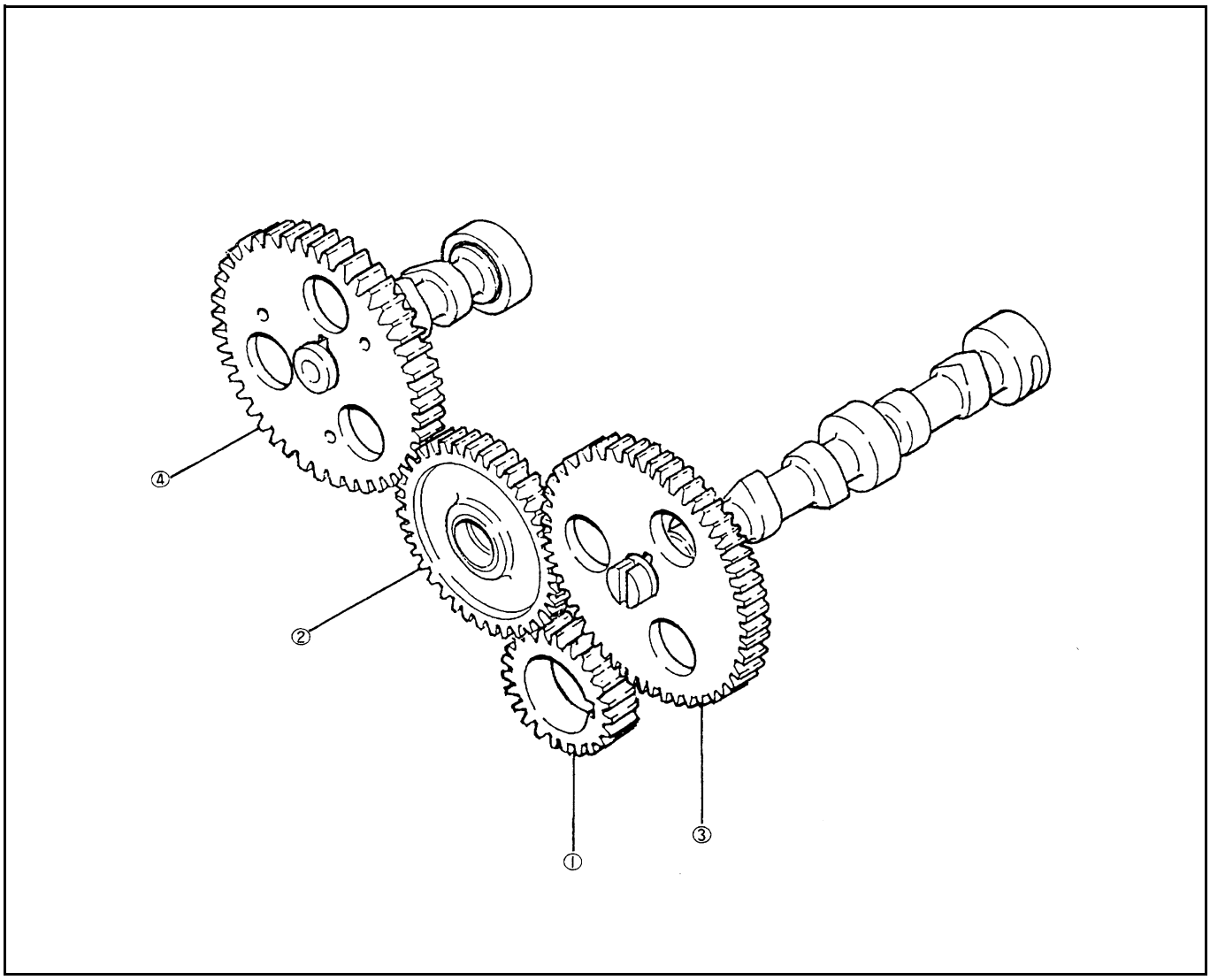


Figure 57 Timing gear component parts

Disassembly sequence
1. Crankshaft gear
2. Idle gear
3. Camshaft gear
4. Injection pump camshaft gear

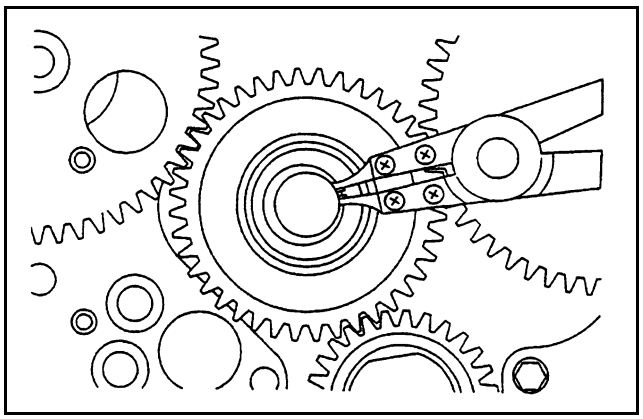


Figure 58 Removing idle gear

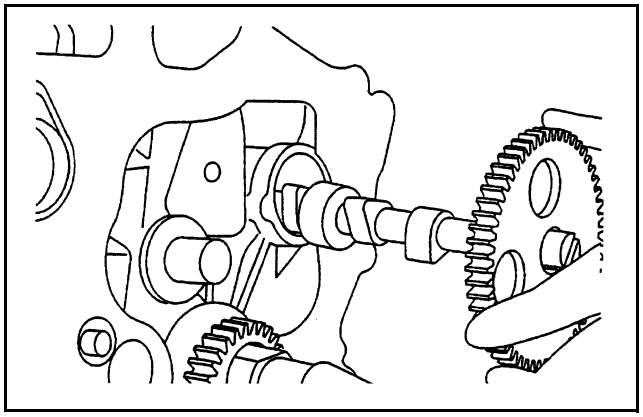


Figure 59 Removing camshaft gear

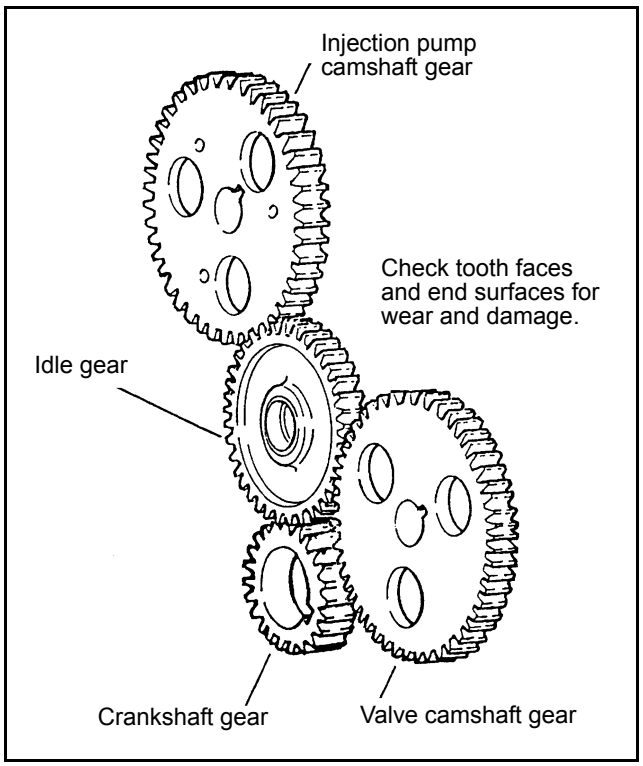


Figure 60 Inspecting timing gears

13.2 Removal

1. Remove the snap ring and remove the idle gear.
2. Since camshaft gear is press-fitted, remove camshaft gear (valve-cam and injection pump cam) only after disassembling the shaft independently.
3. Remove the crankshaft gear as same procedure as camshaft gear.

13.3 Inspection

Check the removed gears. If any gear is found defective, replace it.

Description	Standard Value	Service Limit
Clearance between bushing and shaft	0.03 to 0.07 [0.0012 to 0.0028]	0.2 [0.0079]

Table 22 Idle gear bushing, unit in mm [in.]

Description	Standard Value	Service Limit
Crankshaft-idle	0.01 to 0.14 [0.0004 to 0.0055]	0.3 [0.0118]
Idle-camshaft		
Idle-fuel pump gear		

Table 23 Backlash between gears after installation, unit in mm [in.]

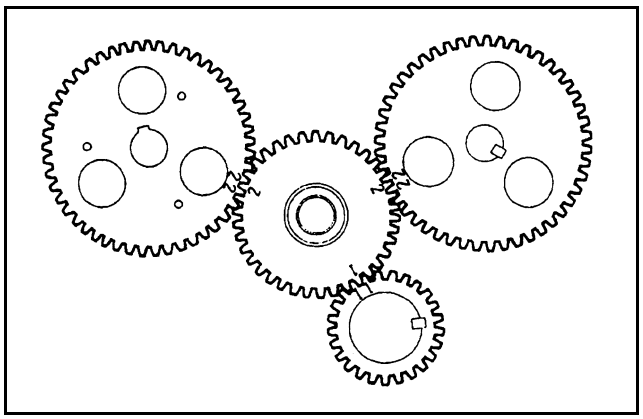


Figure 61 Timing gears in alignment

13.4 Installation of timing gears

1. Press-fit the crankshaft gear onto the shaft.
2. Press-fit the gears to the camshaft (valve camshaft and injection pump camshaft).
3. Install the gears in the following sequence.
   a Turn the crankshaft to set the No. 1 cylinder to top dead center on compression stroke.
   b Install the valve camshaft and injection pump camshaft.
   c Install the idle gear aligning with the timing marks of other gears.
   d Confirm the positions of timing gears again.

14 CAMSHAFTS (VALVE AND INJECTION PUMP)

14.1 Disassembly

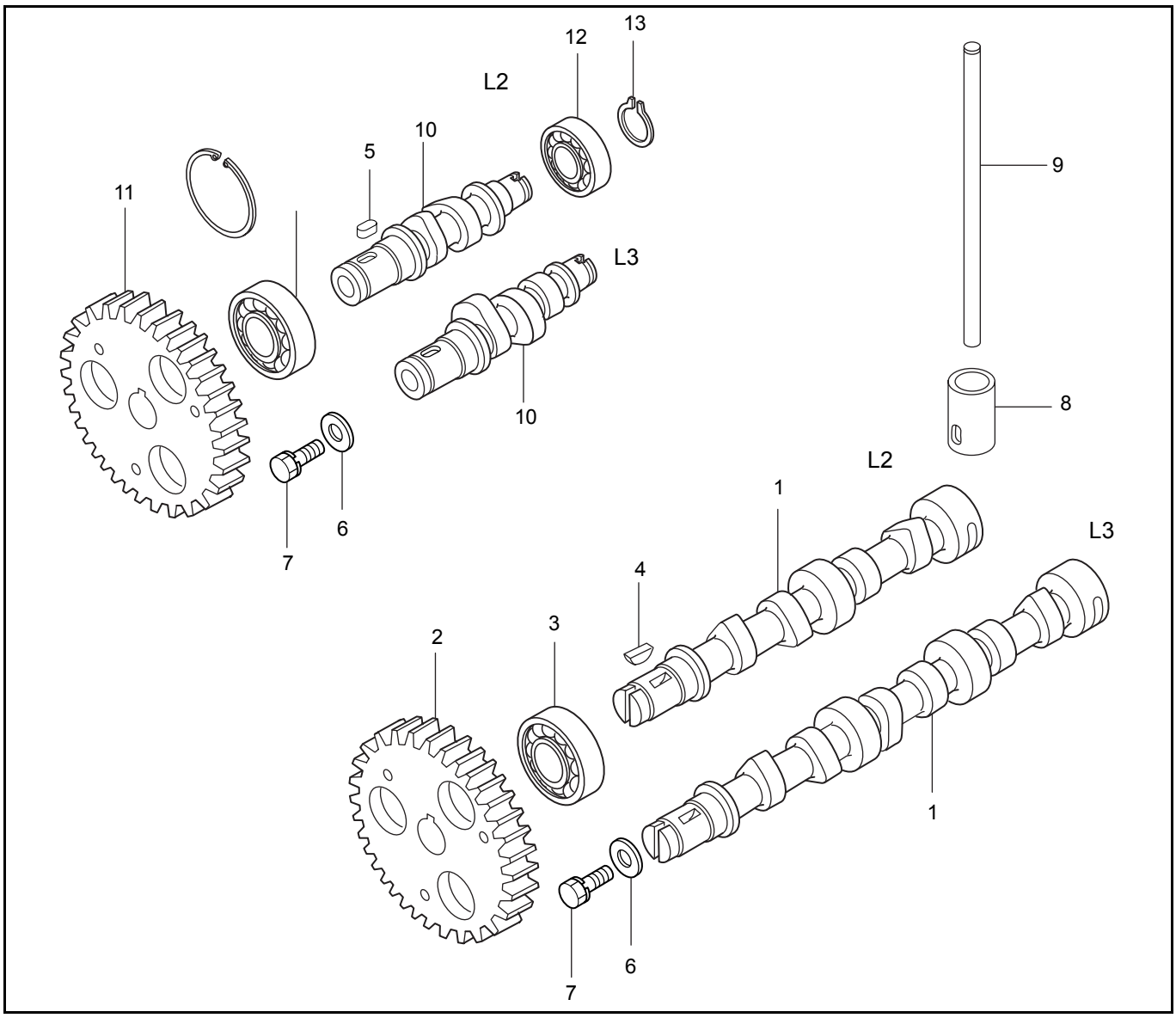


Figure 62 Camshaft component parts

Disassembly sequence
1. Camshaft (Valve)
2. Camshaft gear
3. Ball bearing (Front)
4. Woodruff key
5. Sunk key
6. Camshaft stopper washer
7. Bolt
8. Tappet
9. Pushrod
10. Camshaft (Injection pump)
11. Camshaft gear
12. Ball bearing (Rear)
13. Snap ring

14.2 Removal of Valve Camshaft

14.2.1 Remove only the valve camshaft

When it is necessary to remove only the valve camshaft, use the following procedure:

1. Dismount the cylinder head assembly.
2. Pull out the pushrods.
3. Pull out the tappets.
4. Remove the gear case assembly.
5. Remove the camshaft stopper bolt.
6. Draw out the camshaft assembly.

14.2.2 Removal of the injection pump camshaft

1. Disconnect the injection pipes.
2. Remove the injection pump assembly.
3. Remove the gear case assembly.
4. Remove the shaft rear cover.
5. Remove the stopper bolt.
6. Pull out the shaft to the front side.

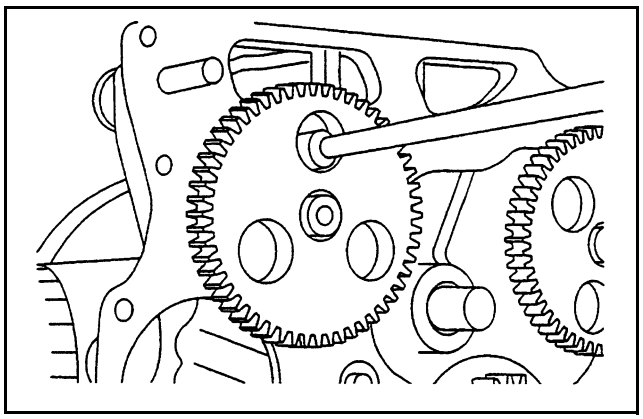


Figure 63 Removing injection pump camshaft

14.3 Inspection

Check the removed parts. If any parts are found defective, repair or replace them.

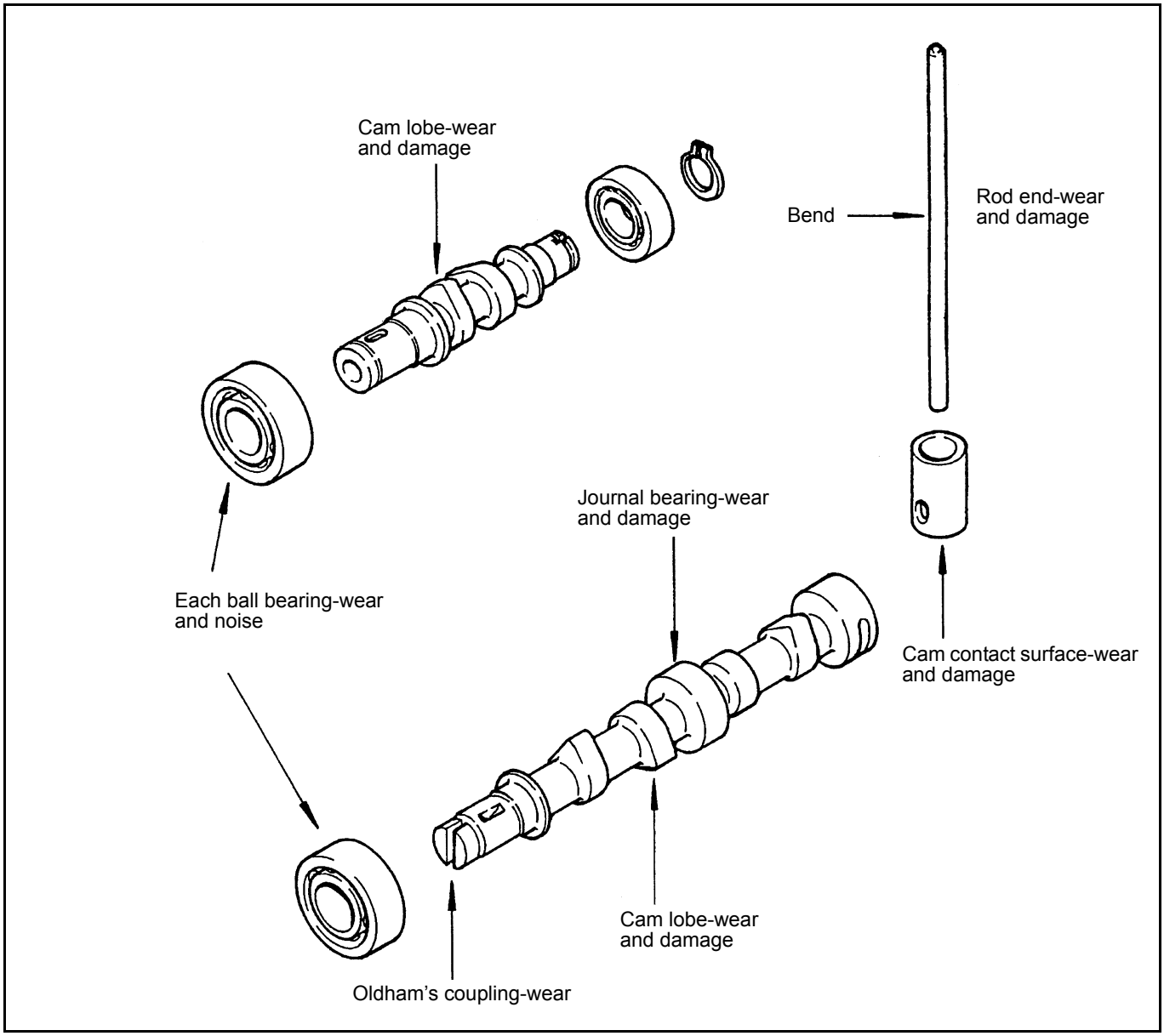


Figure 64 Inspection of camshafts

	Standard value	Service limit
Major diameter of injection pump cam	30 [1.1811]	-0.7 [-0.0276]
Major diameter of valve cam	27.37 [1.0776]	-1.0 [-0.0394]

Table 24 Inspection of camshafts, unit in mm [in.]

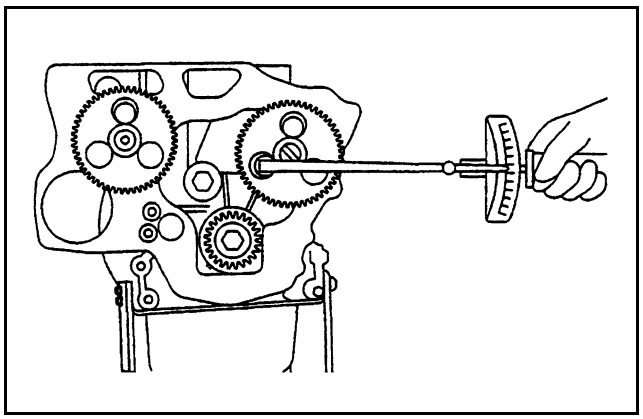


Figure 65 Installing valve camshaft

14.4 Installation

When installing the camshafts, pay attention to the following:

1. Apply oil to the bearings and cam lobes.
2. Reassembly sequence of the camshaft is the reverse of disassembly.
3. Align the timing marks on the gears to the marks on the idler gear.
4. After installation, check and adjust fuel injection timing and valve clearances.

15 PISTON AND CONNECTION ROD

15.1 Disassembly

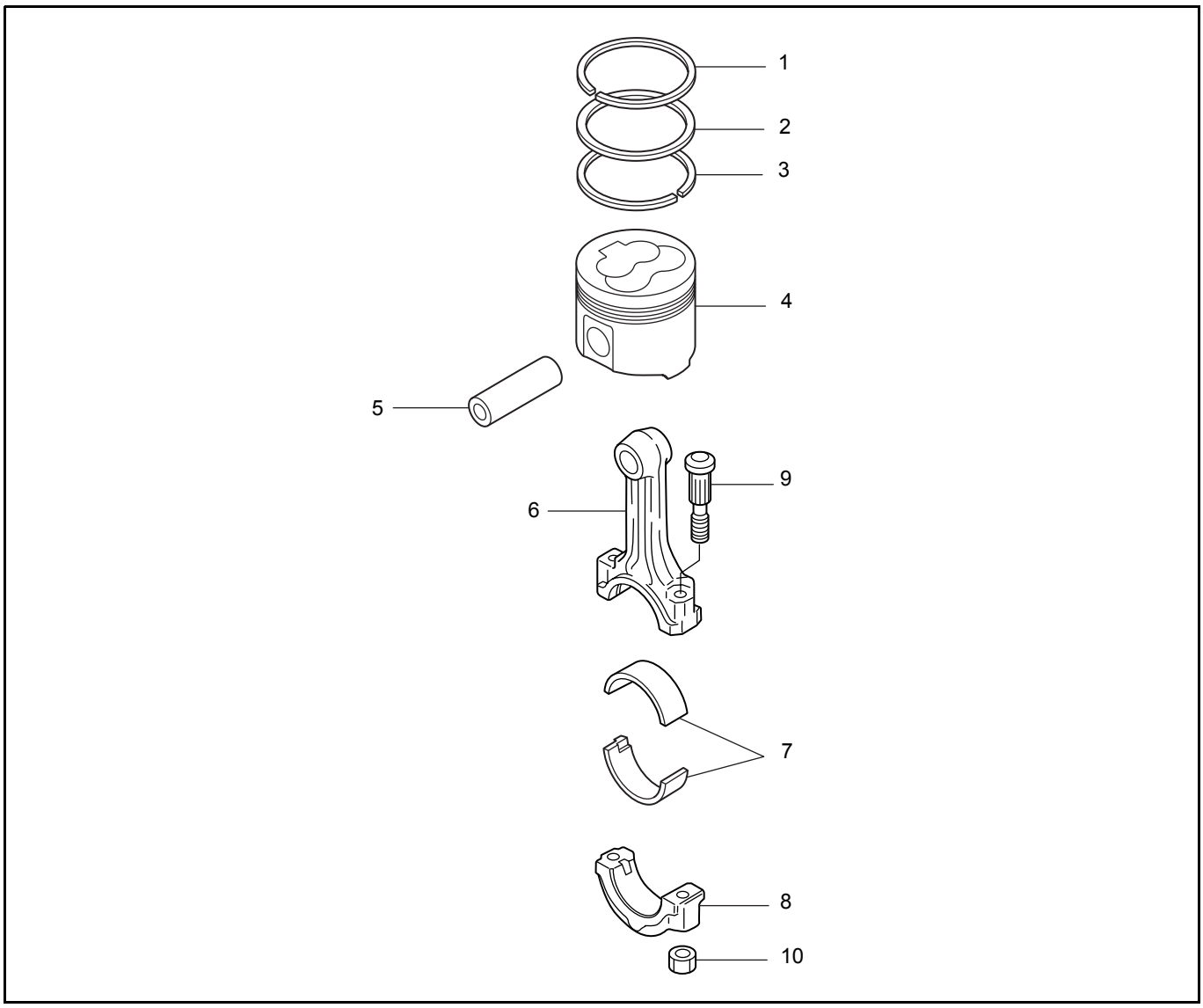


Figure 66 Piston and connecting rod component parts

Disassembly sequence
1. Piston ring No. 1
2. Piston ring No. 2
3. Oil ring
4. Piston
5. Piston pin
6. Connecting rod
7. Connecting rod bearing
8. Connecting rod cap
9. Connecting rod bolt
10. Connecting rod nut

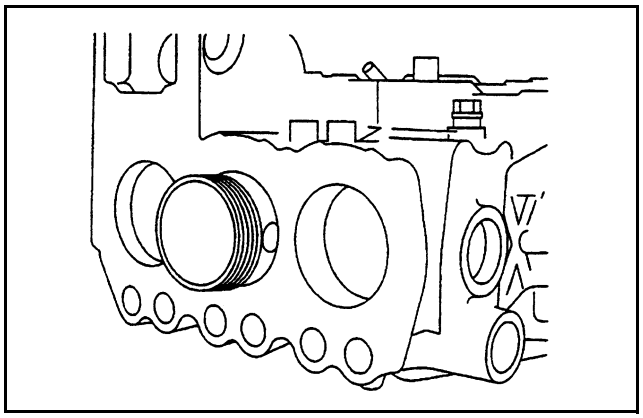


Figure 67 Removing connecting rod and piston

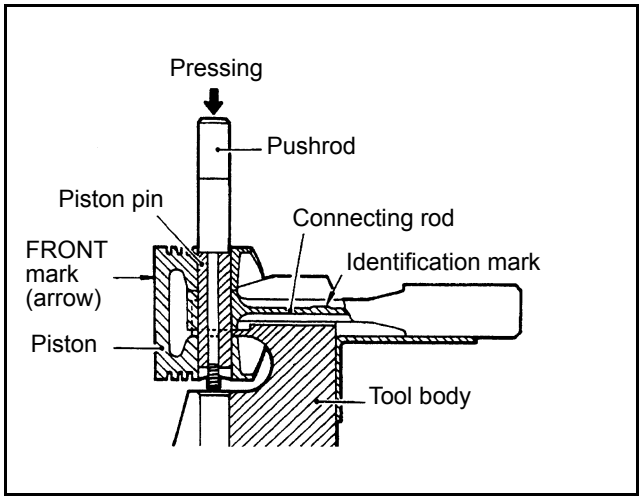


Figure 68 Removing piston pin

15.2 Removal

1. Remove the cylinder head assembly.
2. Remove the oil pan.
3. Remove the oil screen.
4. Mark the cylinder number on the side face of big end of each connecting rod to prevent confusion at reassembly.
5. Remove the connecting rod cap from each connecting rod piston assembly, and pull the assembly upward.
   Be careful not to allow the connecting rod to scratch the crankshaft pin and cylinder.
   Place the removed parts (connecting rod, rod cap, piston, etc.) classifying by each cylinder.
6. Remove the rings from each piston by the piston ring pliers.

Special tool	Part No.
Piston ring pliers	31391-12900

Table 25 Piston ring pliers

7. Using the piston pin setting tool, push out the piston pin from each piston.

Special tool	Part No.
Piston pin setting tool	for L2A, L3A, 30L91–00030
	for L2C, L3C, 30L91–00020
	for L2E. L3E, 30L91–10010

Table 26 Piston pin setting tool

15.3 Inspection

Inspect the removed parts. If any parts are found defective, replace or repair them.

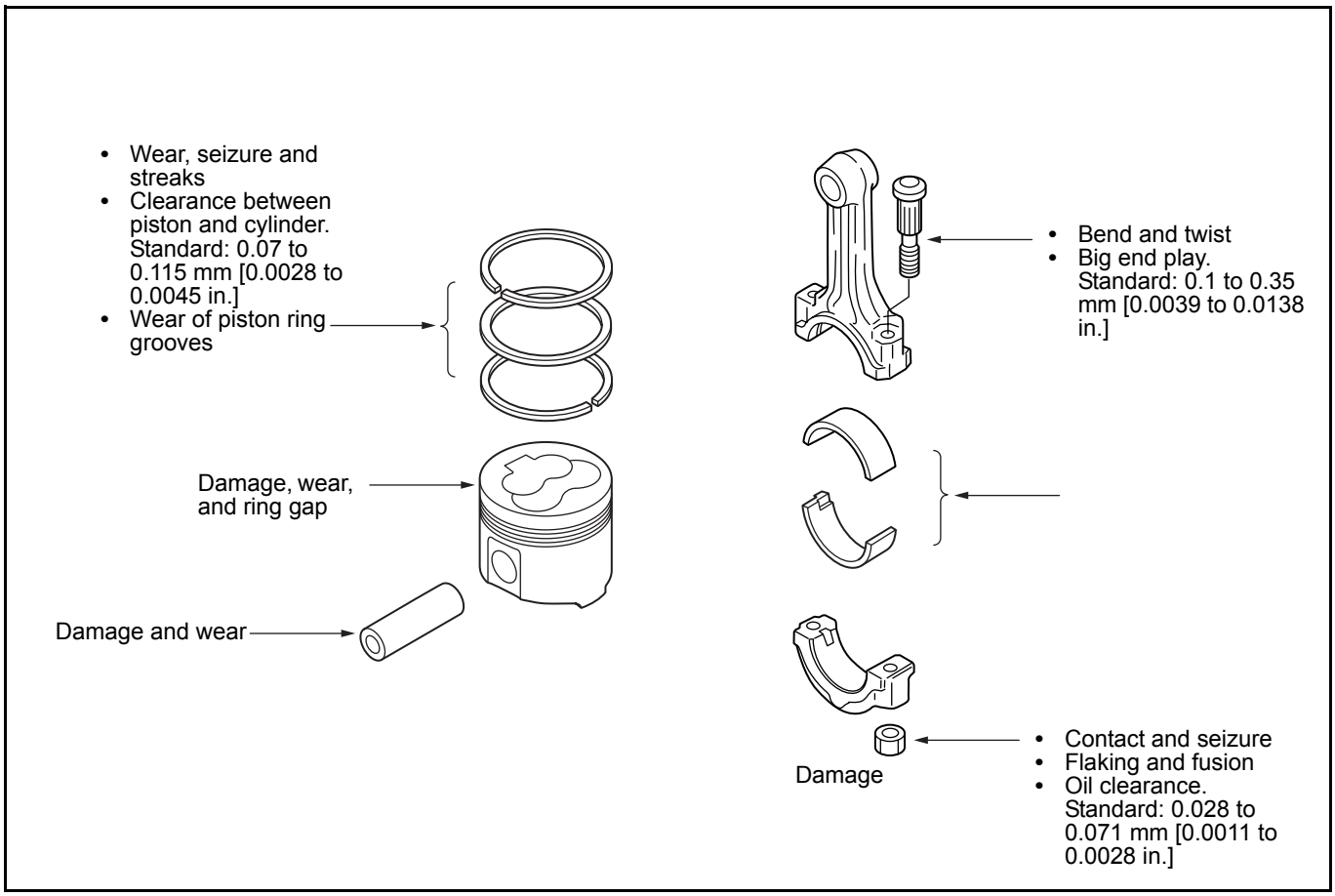


Figure 69 Inspection of piston and connecting rod

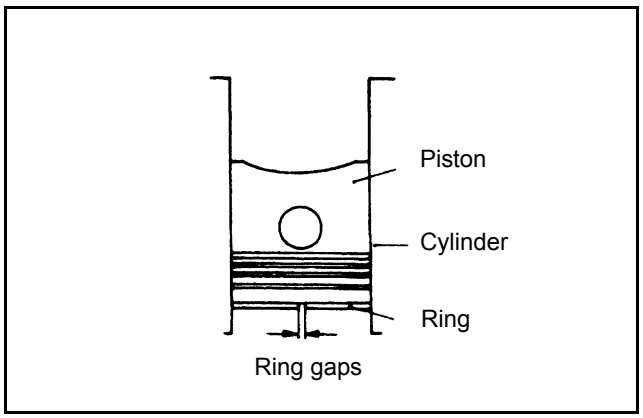


Figure 70 Measuring ring gap

15.3.1 Inspection of piston ring gaps

Place each piston ring into the cylinder bore and push the ring with piston to have square position to the cylinder wall. Measure the ring gap with feeler gages. If the measurement exceeds service limits, replace that piston ring.

Ring	Standard	Service Limit
No. 1 No. 2	0.15 to 0.30 [0.0059 to 0.0118]	1.5 [0.059]
Oil	0.15 to 0.35 [0.0059 to 0.0138]	

Table 27 Inspection of camshafts, unit in mm [in.]

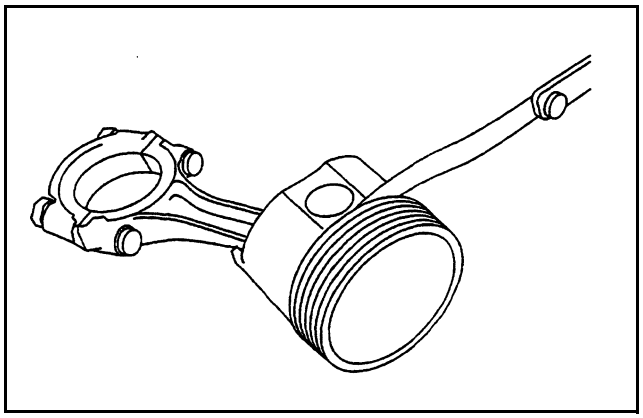


Figure 71 Measuring ring side clearance

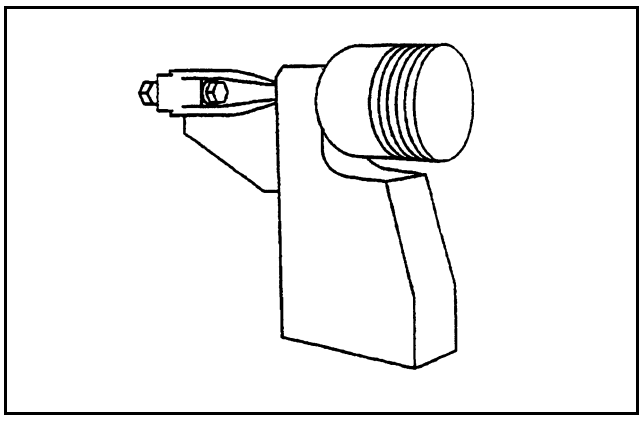


Figure 72 Installation of piston and connecting rod

⚠ CAUTION

a. When only the replacement of rings are to be made, without reboring (honing) of the cylinder, measure the ring at less worn portion of the cylinder bore.
b. When replacing rings, make sure to install the new rings having the same size as the piston.
c. Piston rings available for servicing are sized by three classes: STD, 0.25 OS, and 0.50 OS.

15.3.2 Inspection of ring groove in piston

Measure the side clearance between each piston ring and ring groove of the piston. If the service limit is exceeded, replace the ring with new one. If the clearance still exceeds the service limit, replace the piston with new one.

Ring	Standard	Service Limit
No. 1	—	0.3 [0.0118]
No. 2	0.05 to 0.09 [0.0020 to 0.0035]	0.2 [0.0079]
Oil	0.03 to 0.07 [0.0012 to 0.0028]	0.2 [0.0079]

Table 28 Inspection of ring groove in piston, unit in mm [in.]

⚠ NOTE

No. 1 ring is the semi-key stone type ring.

15.4 Installation

When reassembling the piston and connecting rod and installing the piston-and-rod assemblies in the cylinder block, pay attention to the following:

1. Reassembling the piston and connecting rod Using the piston pin setting tool, press the piston pin into the set position.

Special tool	Part No.
Piston pin setting tool	ST332400

Table 29 Piston pin setting tool

Description	Standard
Pin press-fitting force (at a normal temperature)	1000 ±500 kg [2205 ±1102 lb]

Table 30 Pin press-fitting force

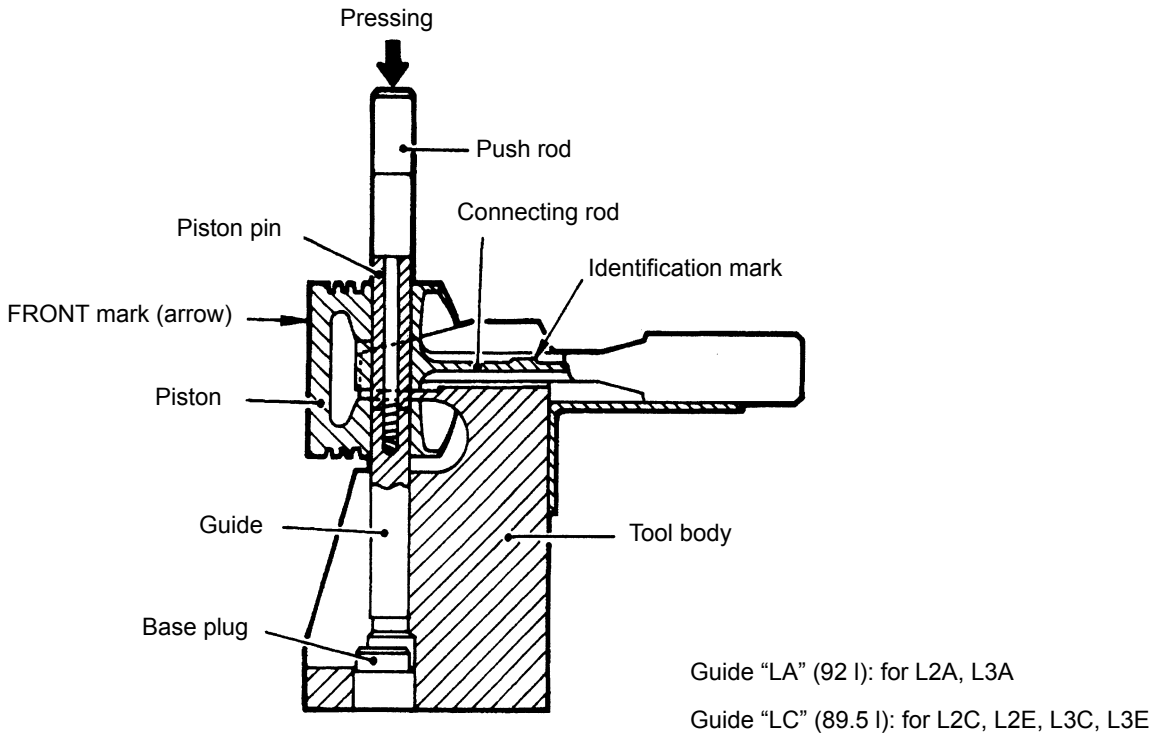


Figure 73 Reassembling piston pin

2. Installation of piston rings

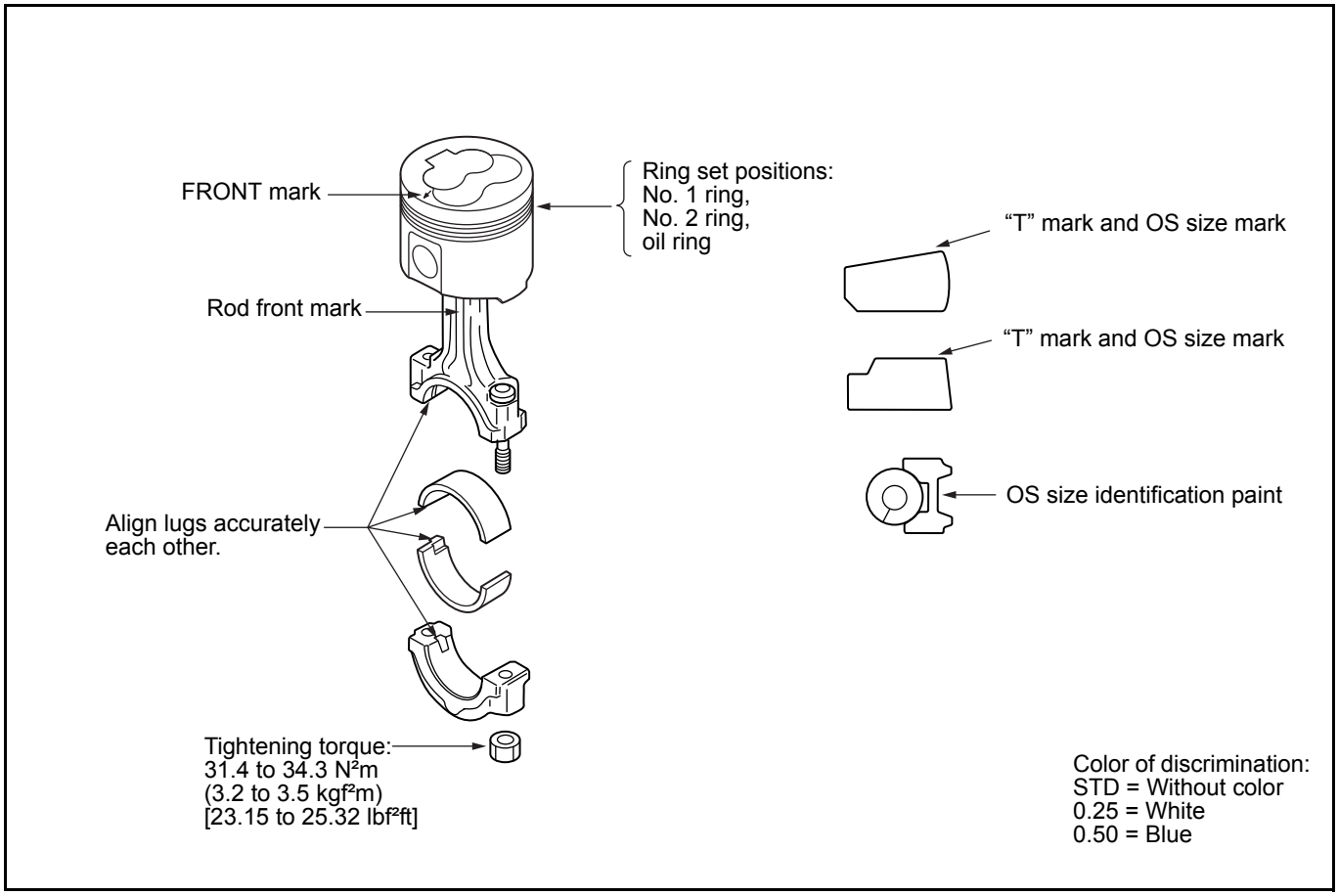


Figure 74 Reassembly of piston rings and connecting rod cap

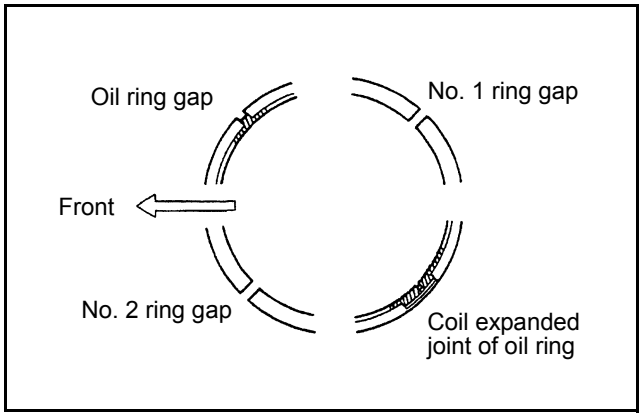


Figure 75 Proper arrangement of ring gaps

3. Set the piston ring gaps to the proper positions as shown at right. Apply oil to the rings and cylinder wall.
4. Using a piston-ring compressor to compress the rings into the grooves, push the piston-and-connecting rod assembly down into the cylinder. Be careful not to break the rings by knocking the head of piston excessively. Note that the front marks on the piston and connecting rod are in direction of the engine front.

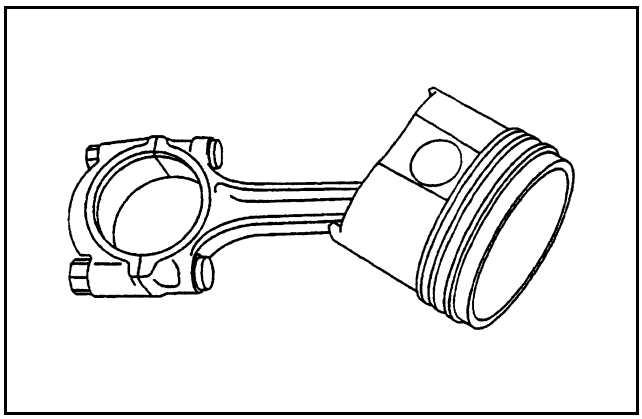


Figure 76 Fitting cap to connecting rod

5. Apply engine oil to the bearing surface of the connecting rod caps. Fit each cap to the connecting rod using match marks placed before removal as a guide. In the case of a new rod which does not have such a match mark, position the lugs (provided for preventing the bearing from rotating) on the same side.

16 CRANKSHAFT

16.1 Disassembly

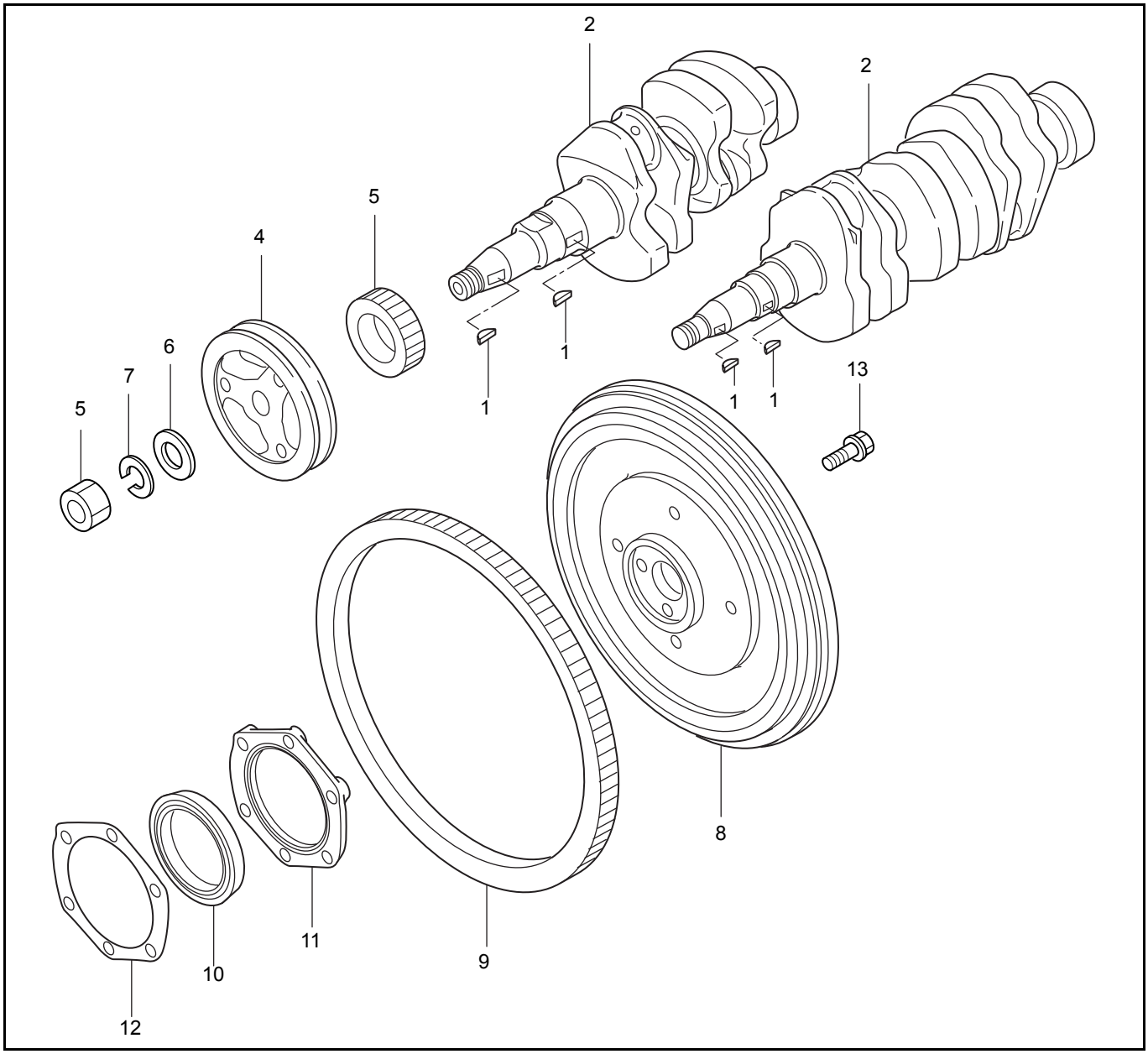


Figure 77 Crankshaft component parts

Disassembly sequence
1. Key
2. Crankshaft
3. Crankshaft gear
4. Crankshaft pulley
5. Nut
6. Washer
7. Spring washer
8. Flywheel
9. Ring gear
10. Rear oil seal
11. Rear oil seal case
12. Gasket
13. Flywheel bolt

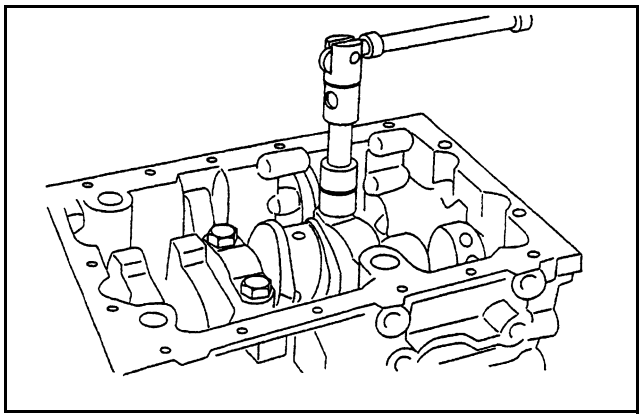


Figure 78 Removing main bearing cap

16.2 Removal

1. Loosen the flywheel bolts and remove the flywheel.
2. Unscrew the crankshaft pulley nut and remove the crank pulley.
3. Remove the rear oil seal case assembly.
4.
5. Remove the main bearing caps. Keep each set of removed bearings together with its bearing cap.
6. Remove the crankshaft.

16.3 Inspection

Inspect the removed parts. If any parts are found defective, repair or replace them.

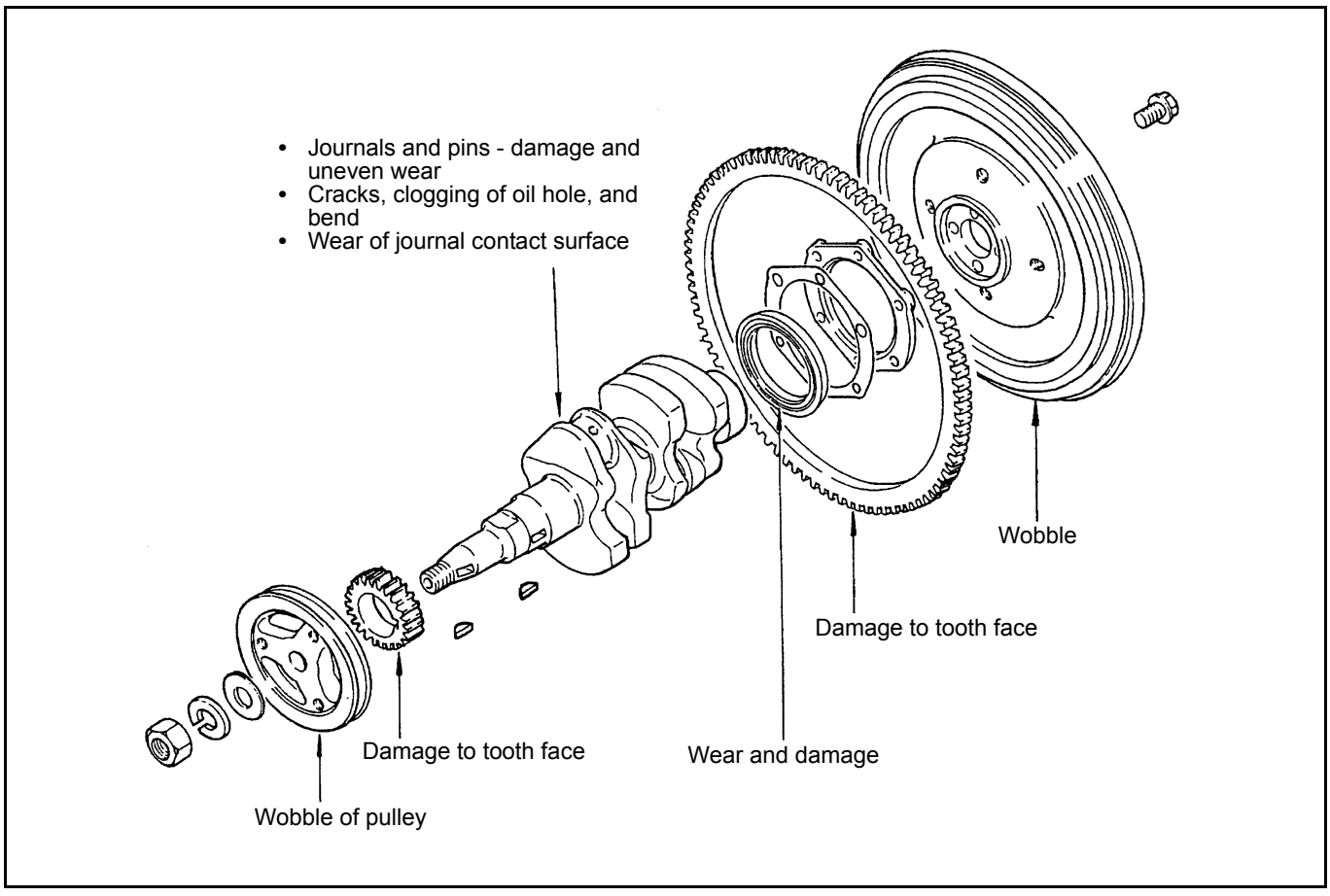


Figure 79 Inspection of crankshaft and flywheel

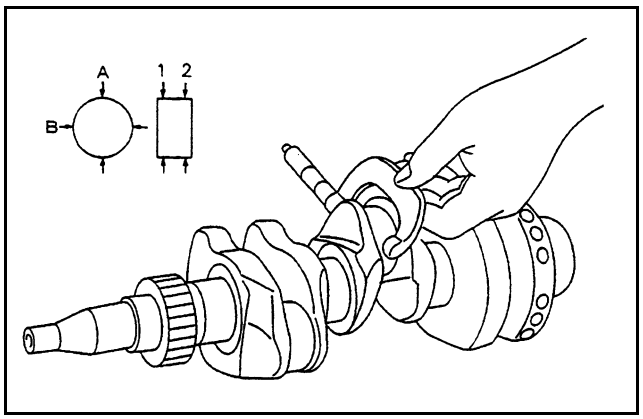


Figure 80 Measuring ring gap

16.3.1 Checking the crankshaft for wear

To check the crankpins and main journals for cylindricity and roundness, measure the diameter of each crankpin and main journal at two places 1 and 2 in directions “A” and “B” for a total of 4 measurements in the figure at right. If necessary, regrind the crankpins and main journals to the next under size. If any crankpin or main journal has been worn out beyond the service limit, replace the crankshaft.

Ring	Standard	Service Limit
Main journal diameter	43 [1.6929]	-0.70 [-0.0276]
Crankpin diameter	40 [1.5748]	-0.70 [-0.0276]

Table 31 Diameter of crankpin and main journal (mm [in.])

Ring	Standard	Service Limit
0.25 US	42.715 to 42.730 [1.6817 to 1.6823]	39.715 to 39.730 [1.5636 to 1.5642]
0.50 US	42.465 to 42.480 [1.6718 to 1.6724]	39.465 to 39.480 [1.5537 to 1.5543]

Table 32 Undersize diameters (mm [in.])

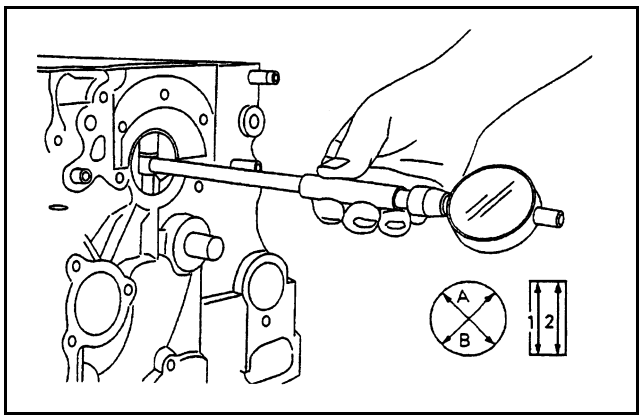


Figure 81 Measuring main bearing I. D.

16.3.2 Inspection of crankshaft oil clearance

Oil clearance is calculated by subtracting the diameter of main journal and crankpin from the inside diameter of main bearing and rod bearing. To check the main bearings and rod bearings for tapering wear and out-of-round wear, inside diameter of each main bearing and rod bearing should be measured, after its bearing-cap is fastened to the specified torque, at two places along the bearing, in two directions “A” and “B” each place, as shown in the figure at right. If necessary, replace the worn bearing with new one. If oil clearance still exceeds the service limit, regrind the crankshaft to the next under size and replace the bearing with one of the corresponding under size.

⚠ CAUTION

A crankshaft, which has been seized, cannot be reground to any under size.

Description	Standard
Main bearing cap bolt	49.0 to 53.9 (5.0 to 5.5) [36.17 to 39.78]
Rod bearing cap nut	31.4 to 34.3 (3.2 to 3.5) [23.15 to 25.32]

Table 33 Tightening torque N·m (kgf·m) [lbf·ft]

Description	Standard
Main bearing	0.10 [0.0039]
Rod bearing	0.15 [0.0059]

Table 34 Oil clearance (mm [in.])

16.4 Replacement of crankshaft rear oil seal

When reassembling the piston and connecting rod and installing the piston-and-rod assemblies in the cylinder block, pay attention to the following:

1. Pry the oil seal out with a screwdriver.
2. Drive in a new oil seal to the oil seal case.

16.5 Installation

When installing the crankshaft, pay attention to the notes given in the figure below.

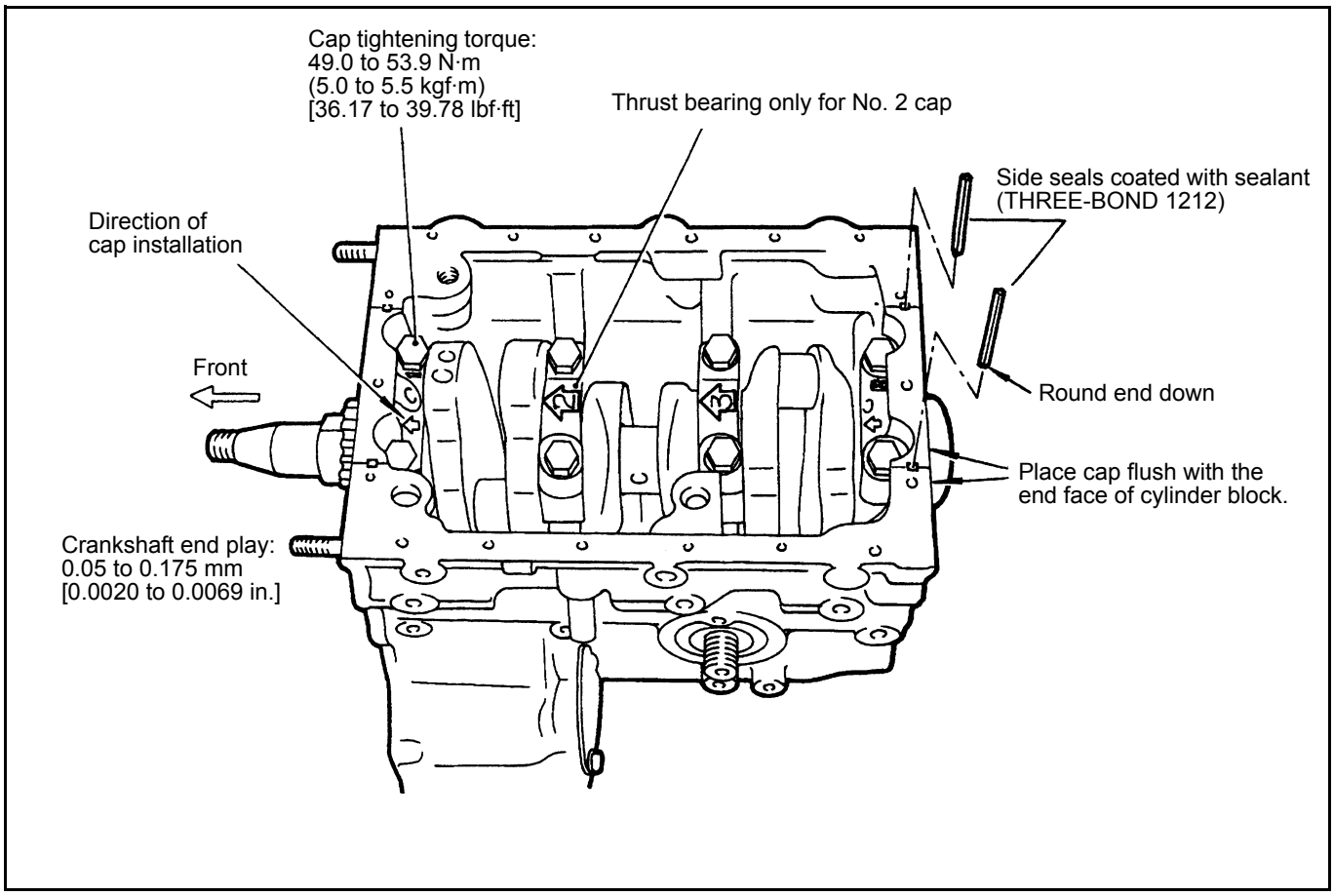


Figure 82 Installation of crankshaft

17 CYLINDER BLOCK

17.1 Disassembly

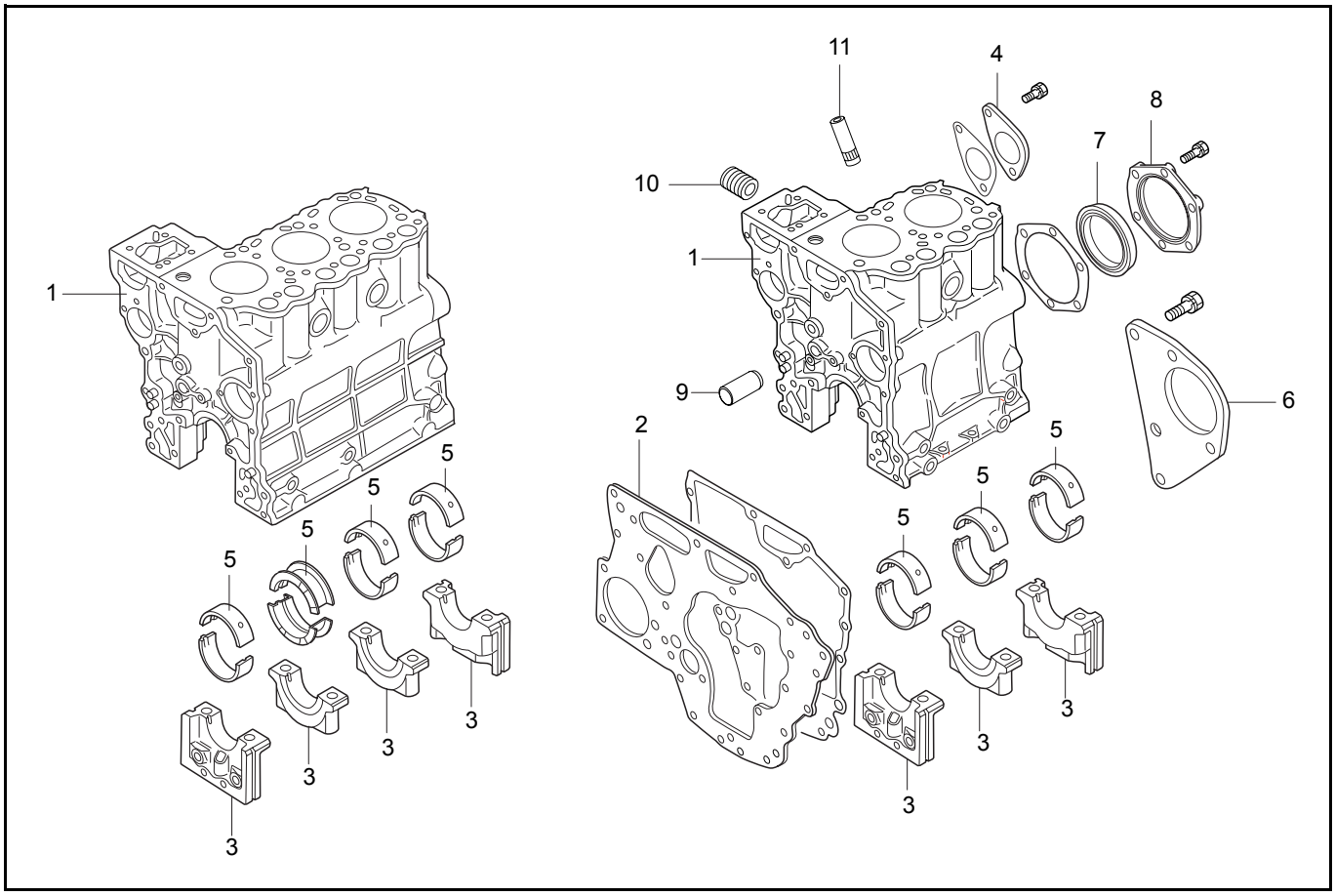


Figure 83 Cylinder block component parts

Disassembly sequence
1. Cylinder block
2. Front plate
3. Bearing cap
4. Cover
5. Main bearing
6. Starter bracket
7. Rear oil seal
8. Oil seal case
9. Idler gear shaft
10. Oil filter shaft
11. Oil level gage guide

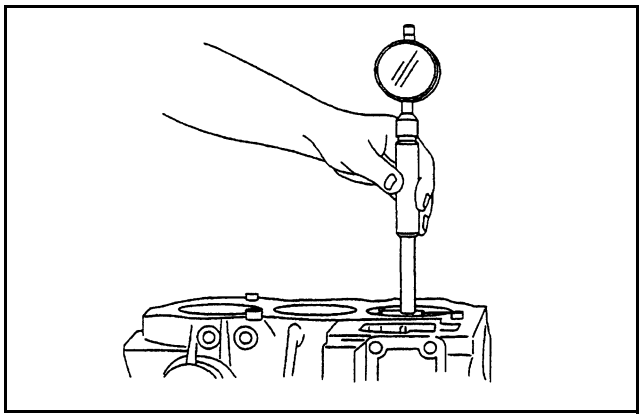


Figure 84 Measuring cylinder bore

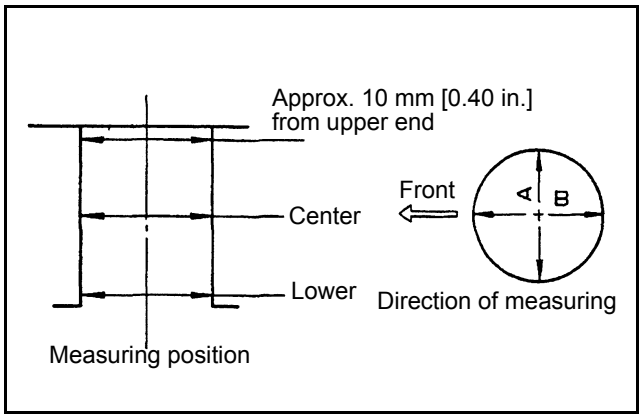


Figure 85 Cylinder bore measuring positions

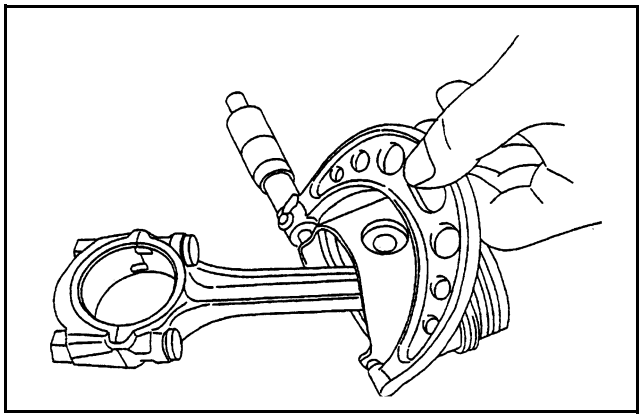


Figure 86 Measuring piston diameter

17.2 Inspection

Inspect the cylinder block. If it is found defective, repair or replace the block.

Model	Standard	Service limit
L2A, L3A	$65_{0}^{+0.03}$ [$2.5591_{0}^{+0.0012}$]	+0.7 [+0.0276]
L2C, L3C	$70_{0}^{+0.03}$ [$2.7559_{0}^{+0.0012}$]	+0.7 [+0.0276]
L2E, L3E	$76_{0}^{+0.03}$ [$2.9921_{0}^{+0.0012}$]	+0.7 [+0.0276]

Table 35 Cylinder bore (mm [in.])

17.3 Reboring of cylinder

When reboring a cylinder, use the following procedure :

1. Selecting a piston
   Piston service size
   0.25 OS or 0.50 OS
2. Measuring the piston diameter
3. Reboring finish dimension =
   [Piston OD] + [Clearance] –
   [Honing allowance (0.02 mm [0.00079 in.])]

Description	Standard
Clearance (between piston and cylinder)	0.071 to 0.084 [0.00280 to 0.00331] (A to D)

Table 36 Oil clearance (mm [in.])

⚠ CAUTION

When it is necessary for a cylinder to be rebored to the next over size, other cylinders must also be rebored to the same over size.

LUBRICATION SYSTEM

18 GENERAL

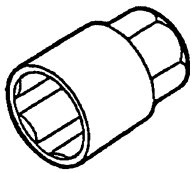
18.1 Specification[1]

Description		Specification	
Lubricating system and filtering system		Pressure-feed lubricating, full-flow filtering	
Oil capacity (Upper limit/lower limit): excluding 0.5 l for oil filter l [U.S.gal]		L2: 2.4/1.4 [0.6341/0.3699]	L3: 3.0/1.5, 3.6/1.8 or 4.8/3.0 [0.7926/0.3963, 0.9511/0.4756 or 1.2682/0.7926]
Oil pump	Type	Gear type (Inner and outer gears in mesh) enclosed in gear case	
	Driving method	Direct drive by crankshaft	
Relief valve opening pressure		0.3±0.03 MPa (3.0±0.3 kgf/cm2) [42.68±4.27 psi]	
Lamp lighting and valve opening pressure (Differential pressure)		0.05±0.01 MPa (0.5±0.1 kgf/cm2) [7.11±1.42 psi]	
Oil filter	Type	Paper-element cartridge type	
	Relief valve opening pressure	0.1±0.02 MPa (1.0±0.2 kgf/cm2) [14.23±2.85 psi]	

Table 37 Specification lubrication system

For the oil pump, which is enclosed in the gear case, see Group 2 Engine Main Parts

18.2 Special tools

Tool name	Part No	Shape	Use
Socket wrench	MD998054		Removal and installation of oil pressure switch

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

19 OIL FILTER AND OIL PRESSURE SWITCH

19.1 Disassembly

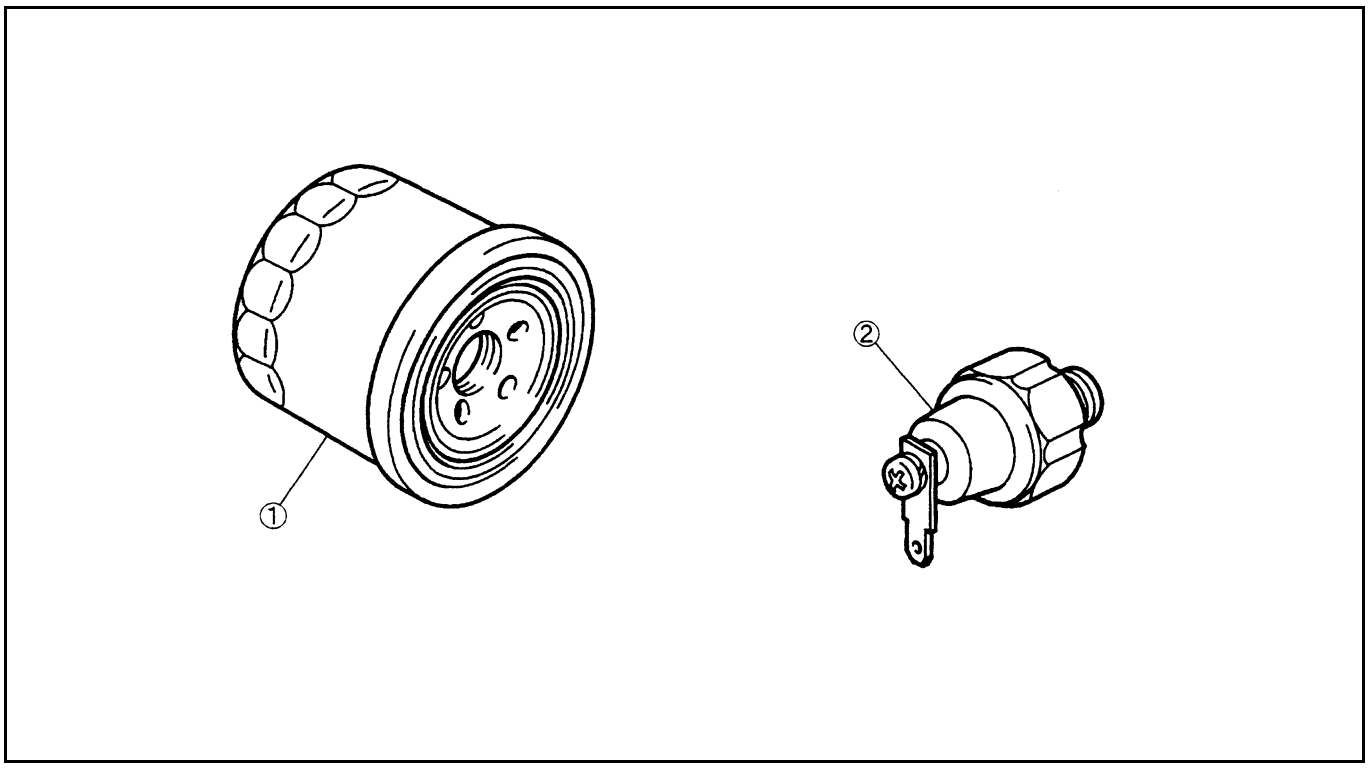


Figure 87 Oil filter and pressure switch

Disassembly sequence
1. Oil filter
2. Oil pressure switch

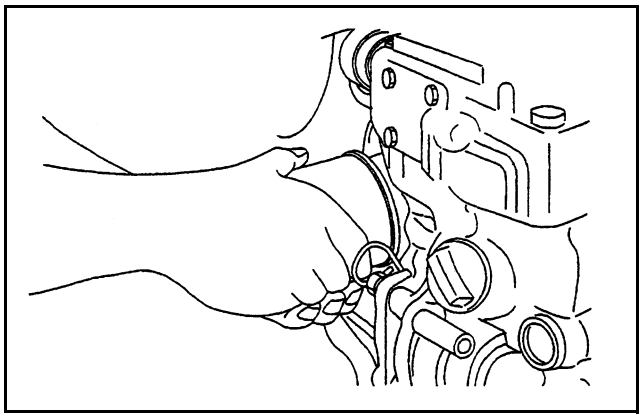


Figure 88 Installing oil filter

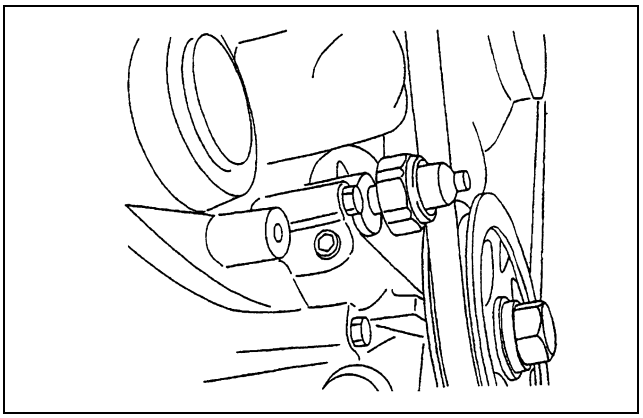


Figure 89 Installing pressure switch

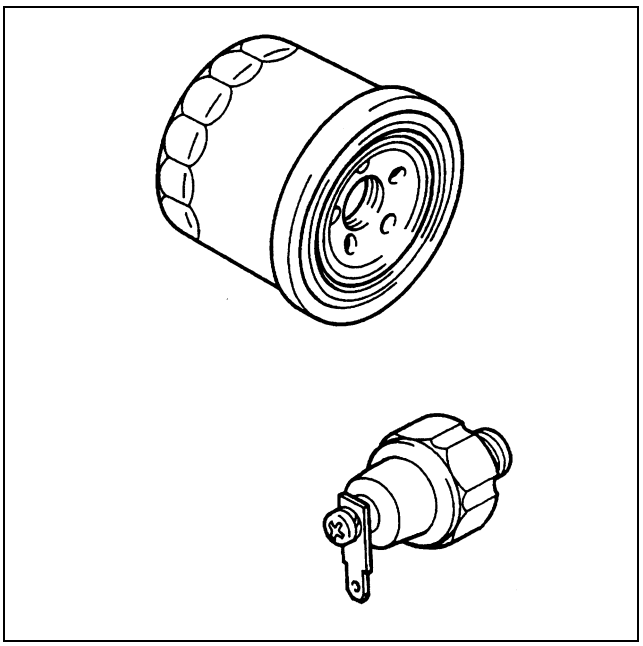


Figure 90 Inspecting oil filter and oil pressure switch

19.2 Removal and installation

1. Remove the filter by the filter wrench.
2. Remove the oil pressure switch by the special tool named socket wrench.

Special tool name	Part No.
Socket wrench	MD998054

Table 38 Special tool

3. Apply engine oil to the O-rings. Pay attention not to twist the O-rings.
4. Apply sealant (HERMESEAL H1 or THREE-BOND 1314) to the threads of the oil pressure switch before installation.
5. Install the oil filter by hands.

⚠ CAUTION

After installation, check for oil leak while the engine is running.

19.3 Inspection

Inspect the following.

19.3.1 Oil leak

Pressure switch ON pressure:	0.05±0.01 MPa ($0.5±0.1$ kgf/cm^2) [7.11±1.42 psi]

Table 39 Pressure

⚠ CAUTION

Check the oil filter for contamination. If necessary, clean the engine interior with flushing oil.

FUEL SYSTEM

20 GENERAL

20.1 Specifications[1]

Description			Specification	
			L2	L3
INJECTION PUMP	Type		In-line type (Bosch NC)	
	Direction of rotation		Clockwise (as viewed from driving side)	
	Injection order		1–2	1–3–2
	Fuel injection timing[a] if the rated speed "n" is:	n ≤ 2000 rpm	15° bTDC	
		2000 ≤ n ≤ 3000 rpm	17° bTDC	
		n = 3600 rpm	19° bTDC	
	Plunger diameter		ø 6 mm [0.2362 in.]	
	Number of plungers		2	3
	MS retard		4° (for crank)	
	Delivery valve		Silt or Bosch	
INJECTION NOZZLE	Type		Thread type	
	Nozzle, type		Throttle type	
	Nozzle, number of jets		1	
	Injection pressure		13.7 MPa (140 kg/cm^2) [1991.5 psi]	
FUEL PUMP (optional)	Type		Electromagnetic diaphragm type	
	Delivery		0.37 l [0.0977 U.S.gal]/min (12V, at 20°C [68°F])	
	Type		Electromagnetic plunger type	
	Delivery, common type Delivery, compact type		0.9 l/min [0.2378 U.S.gal/min] (12V, at 20°C [68°F]) 0.4 l/min [0.1057 U.S.gal/min] (12V, at 20°C [68°F])	
	Type		Mechanical drive type	
	Delivery		0.225 l [0.0594 U.S.gal]/min	

Table 40 Specifications

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

Description			Specification	
			L2	L3
FUEL CUTT OFF VALVE	Type		Solenoid pull hold type	
	Rated current, pull Rated current, hold		55A 1.0A	
	Working voltage		12V, DC	
	Stroke		13.5 mm [0.5315 in.]	
	Type		Solenoid, push out type	
	Coil resistance		1.6Ω±10% (at 20°C [68°F])	
	Stroke		10 mm [0.3937 in.]	
FUEL FILTER			Paper-element type	

Table 40 Specifications

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

20.2 Disassembly

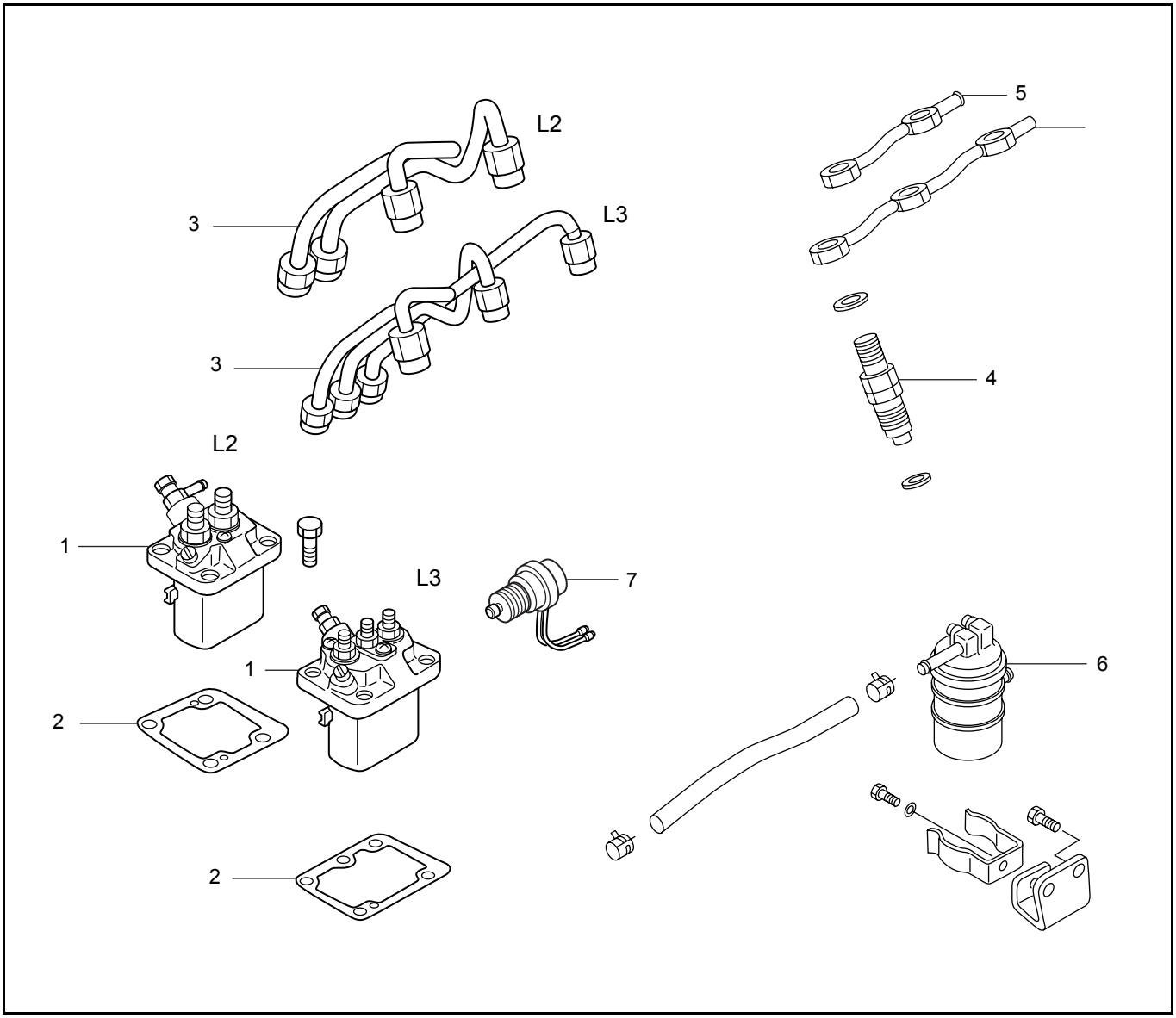


Figure 91 Fuel system component parts

Disassembly sequence
1. Injection pump
2. Adjusting shim
3. Injection pipe
4. Injection nozzle
5. Return pipe
6. Fuel filter
7. Fuel cutoff solenoid

21 FUEL INJECTION PUMP

21.1 Disassembly

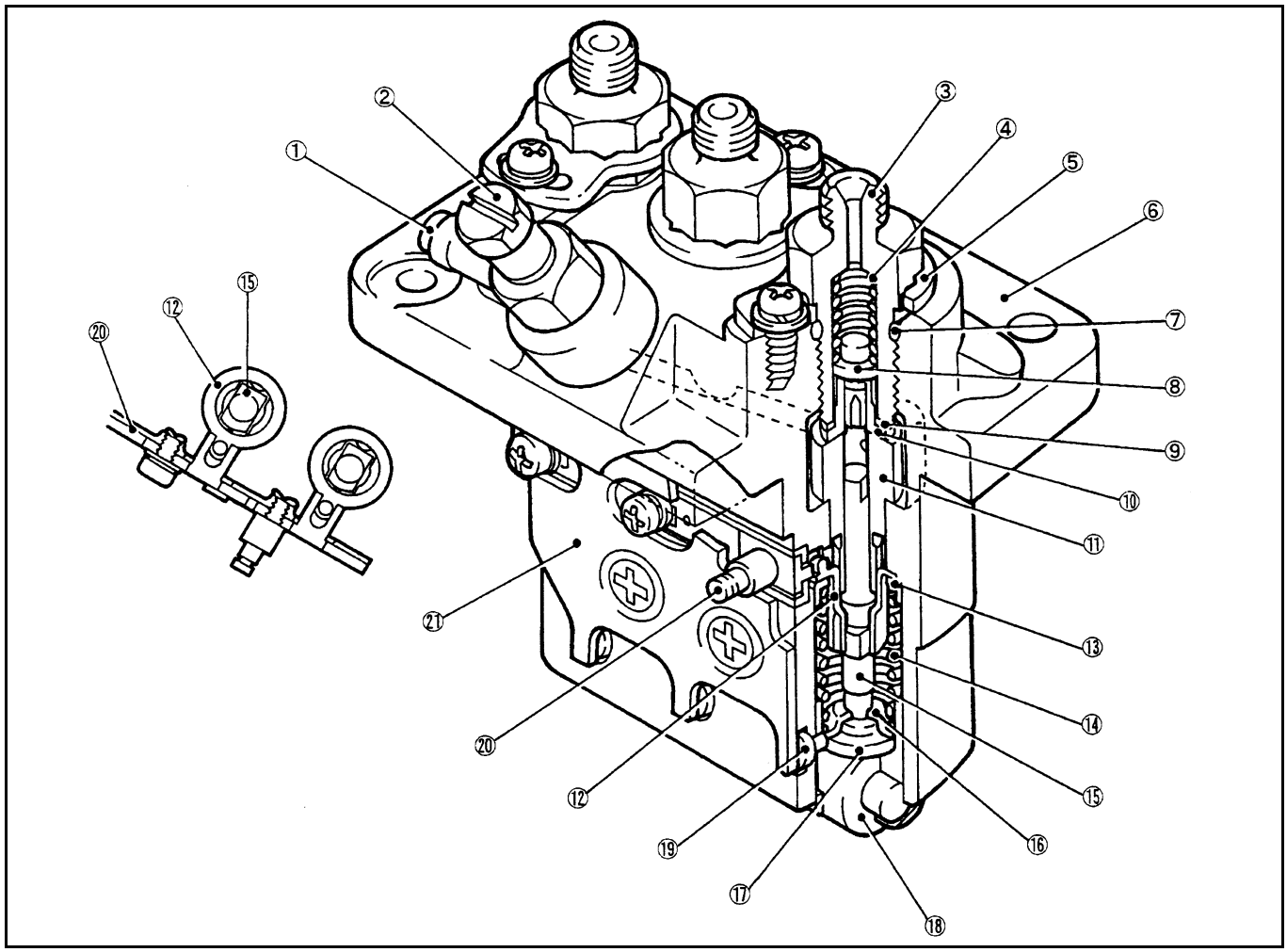


Figure 92 Injection pump component parts

Disassembly sequence
1. Union collar
2. Air vent screw
3. Delivery valve holder
4. Valve spring
5. Holder stopper
6. Housing
7. O-ring
8. Delivery valve
9. Gasket
10. Seat valve
11. Plunger barrel
12. Sleeve
13. Upper seat
14. Plunger spring
15. Plunger
16. Lower seat
17. Adjusting shim
18. Tappet roller
19. Pin
20. Control rack
21. Stop wire bracket

21.2 Inspecting the injection pump while operating the engine

Never attempt to disassemble the pump unless it is necessary.If the pump is assumed defective, it is recommended to replace the pump assembly.

Item	Inspection procedure	Criteria
Idling speed	Measure engine speed	900 rpm
Exhaust smoke color	1. Quickly accelerate engine without load. 2. Apply load to	No remarkably blacksmoke exhaust permitted.
Fuel cut-off solenoid	Turn ignition switch to OFF from ON.	A solenoid acting sound.

Table 41 Inspection injection pump

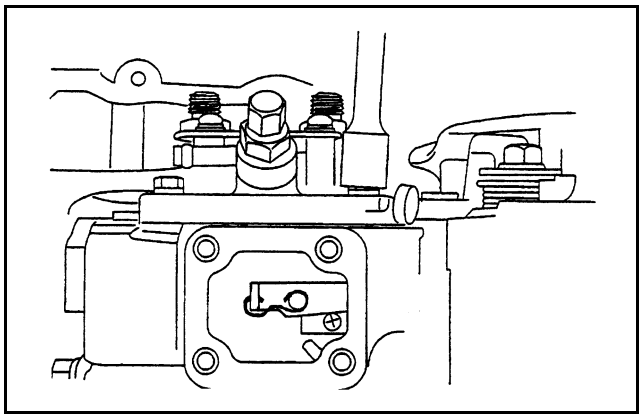


Figure 93 Removing injection pump

21.3 Removal

1. Disconnect the fuel injection pipes.
2. Remove the tie-rod clip cover.
3. Remove the tie-rod clip and tie-rod.
4. Remove the injection pump assembly.

21.4 Disassembly

1. Remove the stopper plate.
2. Unscrew the delivery holder. Remove the delivery valve and valve spring.
3. Remove the tappet roller and stopper pin.
4. Remove the tappet, plunger spring, etc.

⚠ CAUTION

a. When replacing the plunger barrel, delivery valve, etc., do not loosen the adjusting screw and plate of each cylinder.
b. When those parts have been replaced, it is necessary to measure fuel injection quantity by using the pump tester and cam box.
c. All removed parts from the pump should be classified by cylinders and immersed in clean fuel.

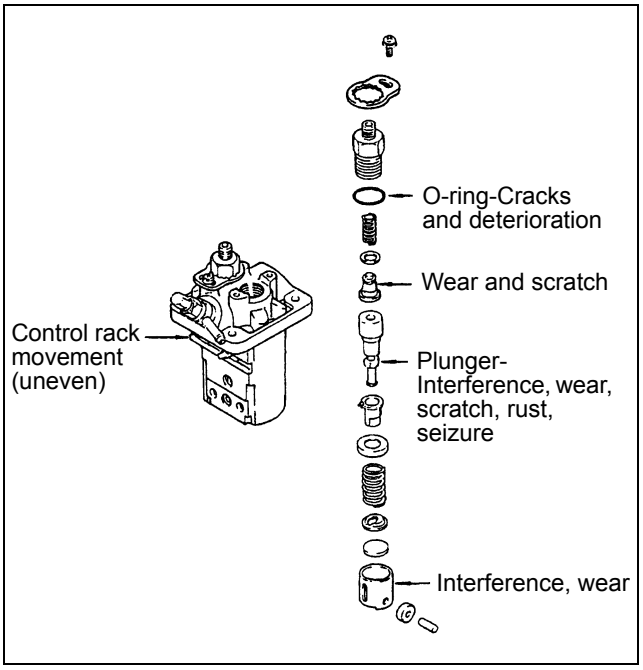


Figure 94 Inspection of injection pump

21.5 Inspection

Inspect all removed parts, if any part is found defective, replace it.

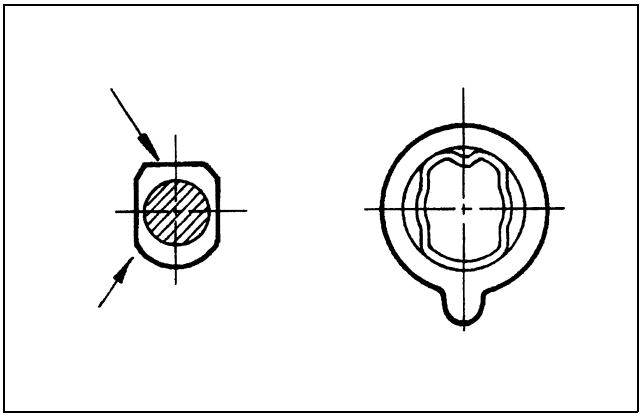


Figure 95 Direction of reassembly of plunger

21.6 Reassembly of plunger

1. Insert the plunger barrel into the housing.
2. Install the delivery valve and valve spring. Temporarily tighten the holder.
3. Insert the control rack.
4. Insert the control pinion. Align the matchmark of the rack to that of the pinion.
5. Install the spring upper seat.
6. Insert the plunger spring.
7. Fit the lower seat to the plunger. Insert the plunger into the barrel side.
8. Press the tappet roller assembly and install the stopper pin.
9. Tighten the delivery holder.

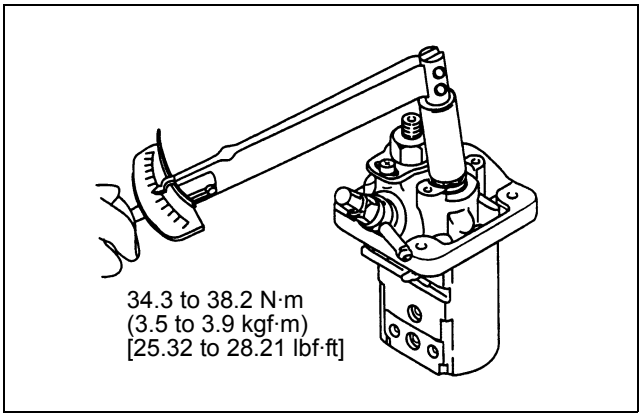


Figure 96 Installation of delivery valve holder

21.7 Reassembly of delivery valve

Reassemble the injection pump in the reverse sequence of removal.

⚠ CAUTION

a. When installing the plunger barrel, engage the dowel pin on the housing side with the groove in the barrel.
b. Position the part-number stamp of the plunger to the opposite side of the rack (engage the feed hole with the plunger lead).
c. After installation, check for proper injection timing.

22 INJECTION NOZZLE

22.1 Disassembly

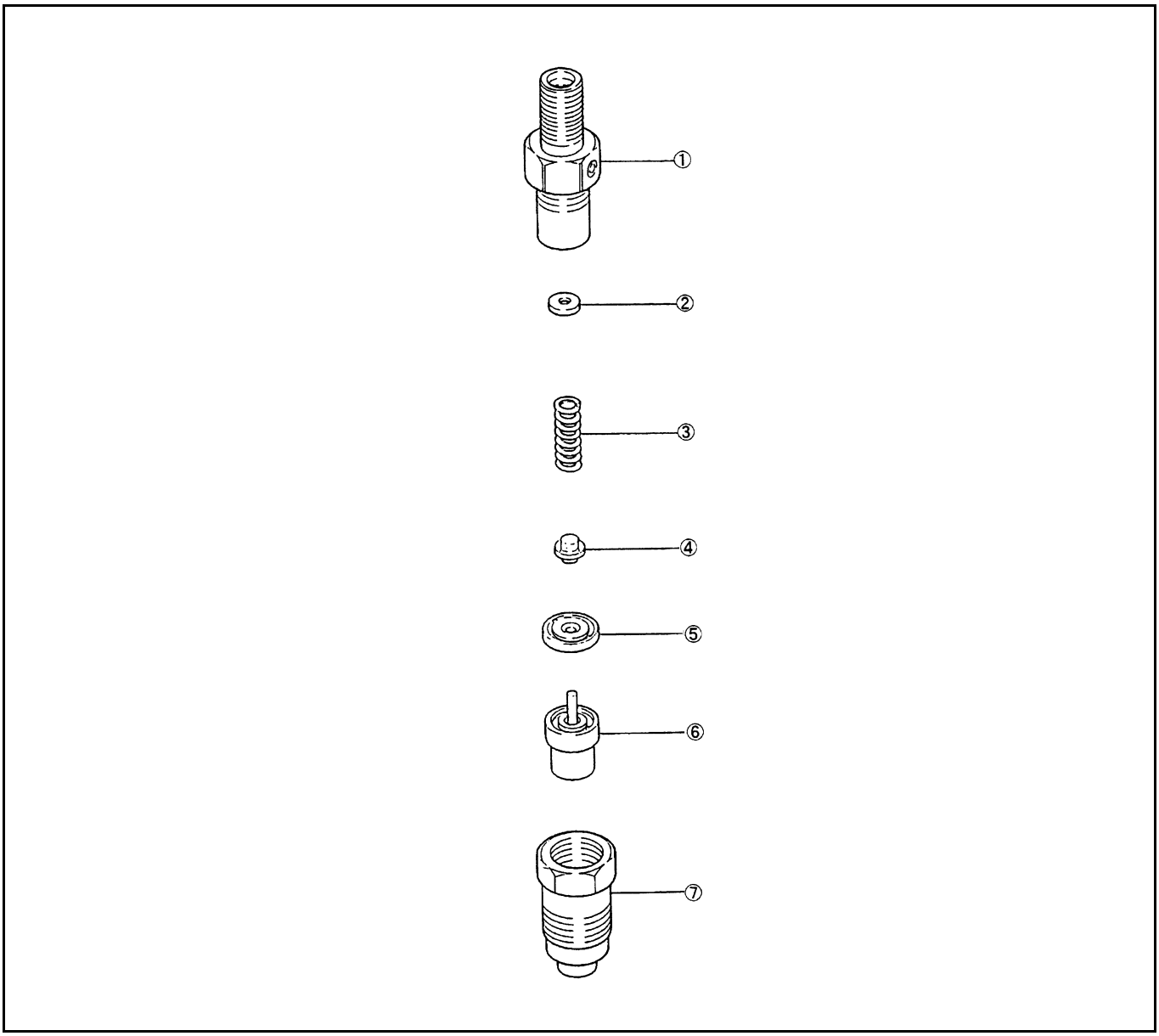


Figure 97 Nozzle holder assembly component parts

Disassembly sequence
1. Body sub-assembly
2. Shim washer
3. Pressure spring
4. Pin
5. Distance piece
6. Nozzle assembly
7. Retaining nut

22.2 Removal

1. Disconnect the injection pipe and fuel return pipe.

2. Remove the injection nozzle assembly from the cylinder head.

⚠ CAUTION

a. Attach an identification-number tag to the removed injection nozzle.
b. Plug the openings, to prevent entering of dust, water and other foreign particles into the pipes and combustion chamber.
c. Do not mix the parts of any nozzle assy with others, but keep the parts of each nozzle assembly as a unique combination.

22.3 Disassembly

If the removed nozzle assembly is assumed defective, disassemble the assembly and repair or replace the defective parts.

1. Grip the nozzle holder body in a vise. Loosen the retaining nut. Never vise the retaining nut to prevent deformation.
2. Remove the shim washer, pressure spring, distance piece and nozzle assembly.

⚠ CAUTION

Scrape off carbon deposit with a wooden piece. Keep the removed parts immersed in washing oil (kerosene). Pay special attention not to scratch the needle valve in the nozzle assembly.

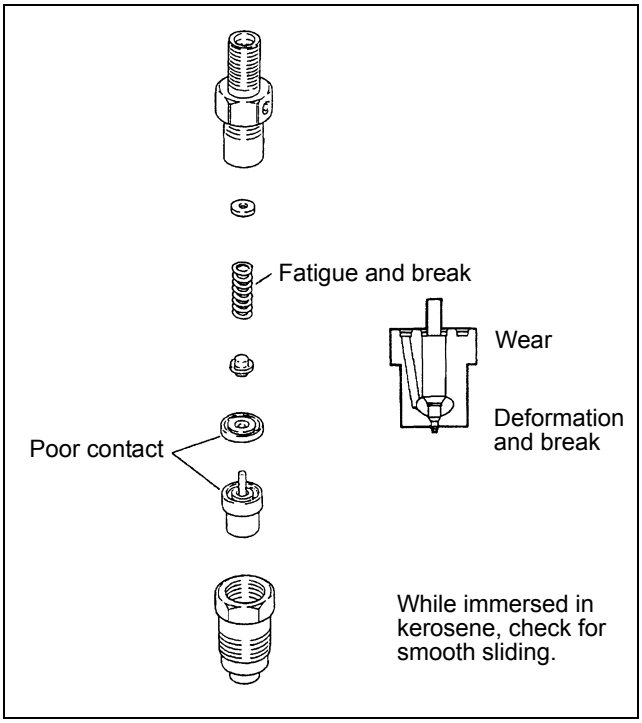


Figure 98 Inspecting nozzle

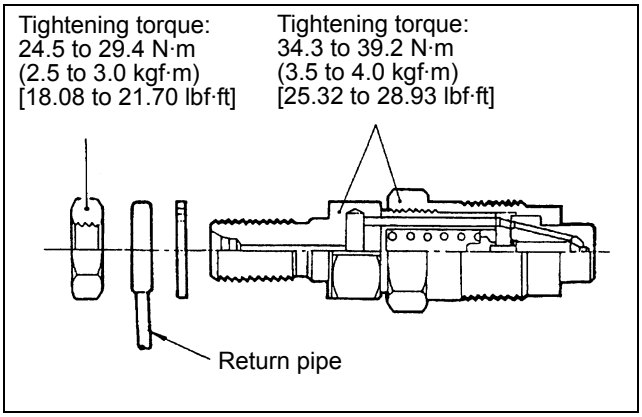


Figure 99 Assembling the nozzle

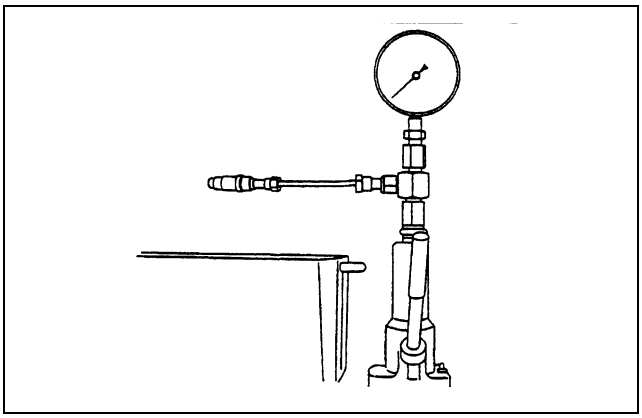


Figure 100 Testing nozzle

22.4 Inspection

Never attempt to disassemble the pump unless it is necessary.If the pump is assumed defective, it is recommended to replace the pump assembly.

22.5 Assembly

1. Insert the nozzle assembly into the retaining nut so that the nozzle is correctly seated in the nut.
2. Place the distance piece, retaining pin, pressure spring and shim washer on the nozzle tip.
3. Tighten the nozzle holder body fully by hand
4. Grip the nozzle holder in a vise. Tighten the retaining nut to the specified torque.

⚠ CAUTION

If required, always replace the nozzle as a complete assy.

22.6 Adjustment

Adjust injection starting pressure by increasing or decreasing the thickness of inserting shim washer. Varying shim thickness by 0.1 mm [0.0039 in.] causes injection start pressure to change 0.98 MPa (10 kgf/ cm_2) [142.3 psi].

Available shims:
10 kinds of shims available from 1.25 mm to 1.7 mm [0.0492 to 0.0669 in.] in thickness, in increment of 0.05 mm [0.0020 in.].

Standard	Allowable limit
Idling speed	Measure engine speed
13.7 MPa (140 kgf/cm^2) [1992 psi]	12.7 MPa (130 kgf/cm^2) [1849 psi] or less

Table 42 Injection start pressure

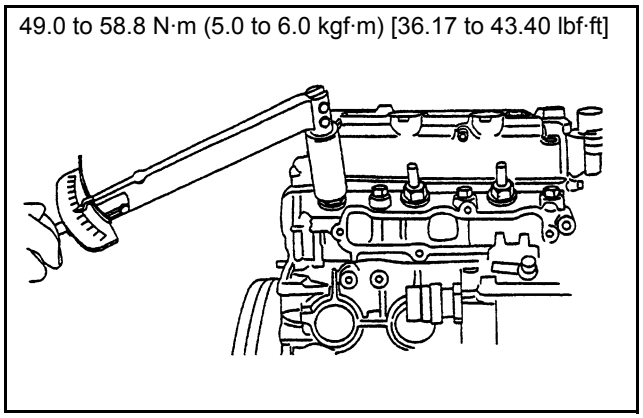


Figure 101 Installing nozzle holder

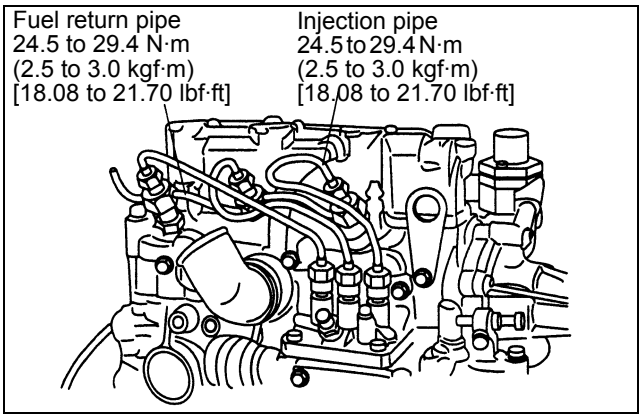


Figure 102 Installing injection pipe

22.7 Installation

1. Clean the nozzle holder fitting surface of the cylinder head. Install the nozzle holder with a gasket.

2. Connect the fuel return pipe and injection pipe.

GOVERNOR SYSTEM

23 GENERAL

23.1 Specification

Governor type	Centrifugal flyweight type

Table 43 Specification

23.2 Disassembly

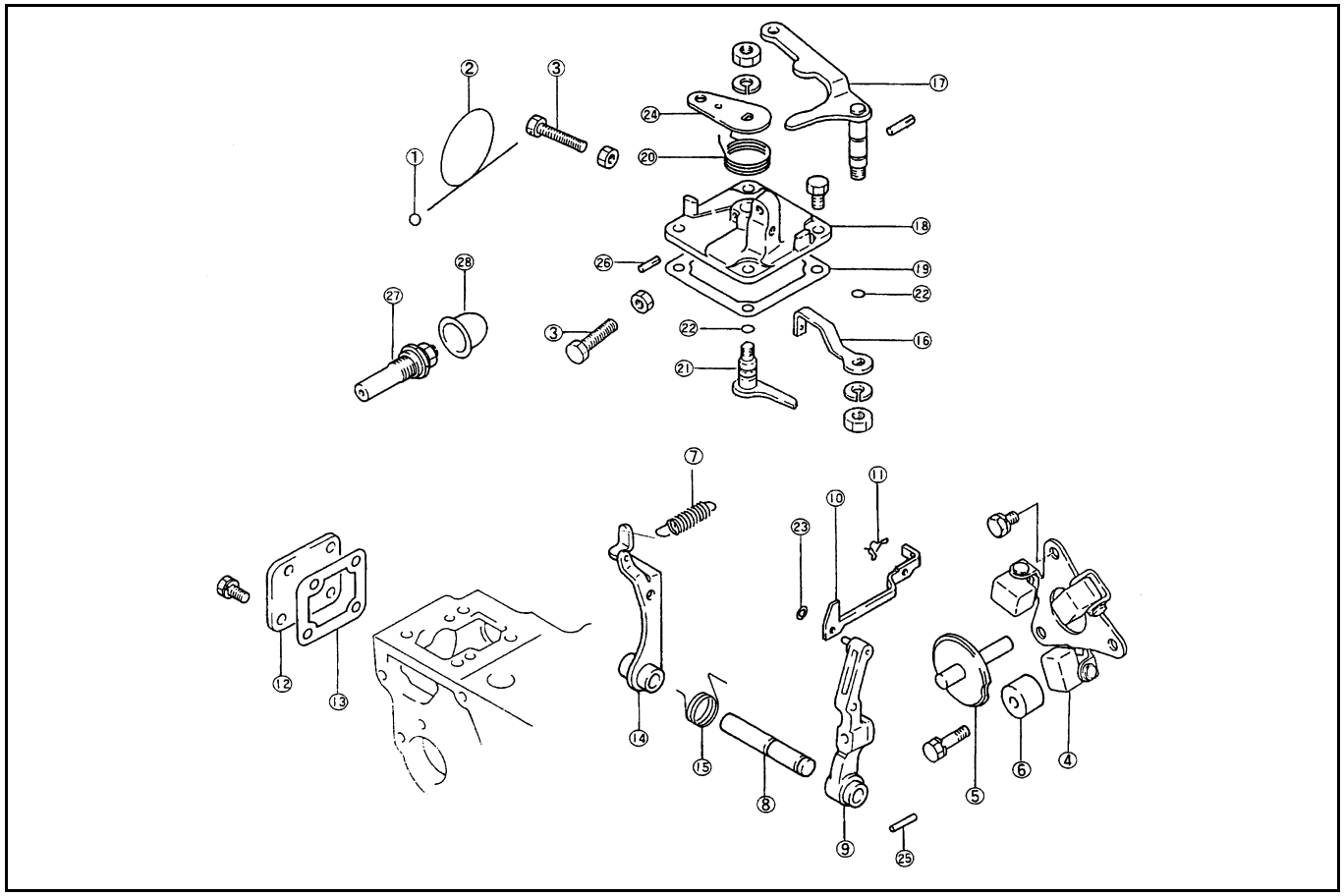


Figure 103 Governor system component parts

Disassembly sequence
1. Sealing metal
2. Sealing wire
3. Low and high-speed bolt
4. Governor weight assembly
5. Sliding shaft
6. Stopper
7. Governor spring
8. Governor shaft
9. Governor level
10. Tie-rod
11. Tie-rod clip
12. Tie-rod cover
13. Tie-rod cover gasket
14. Tension lever
15. Start spring
16. Governor spring lever
17. Speed control lever assembly
18. Cover assembly
19. Governor cover gasket
20. Return spring
21. Stop lever assembly
22. O-ring
23. Snap ring
24. Stop lever
25. Grooved pin (3 x 20)
26. Grooved pin (3 x 16)
27. Torque spring set
28. Sealing cap

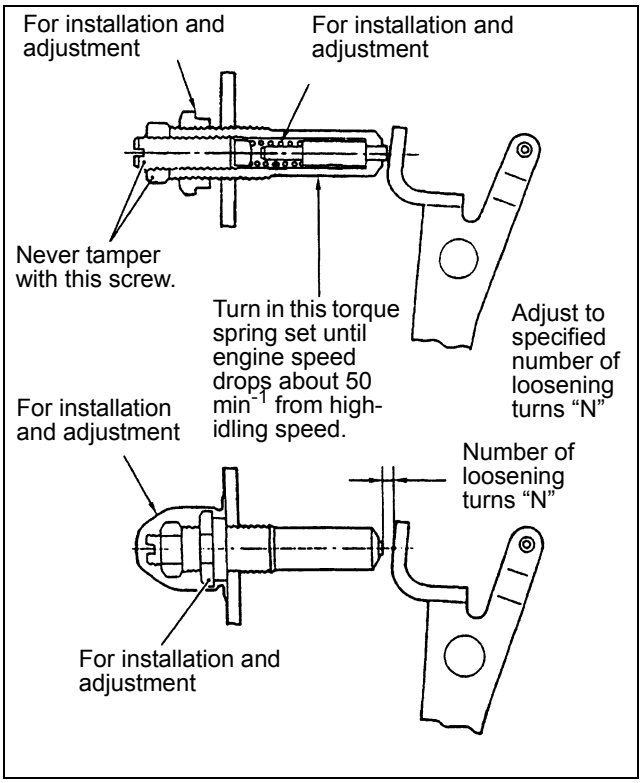


Figure 104 Torque spring set

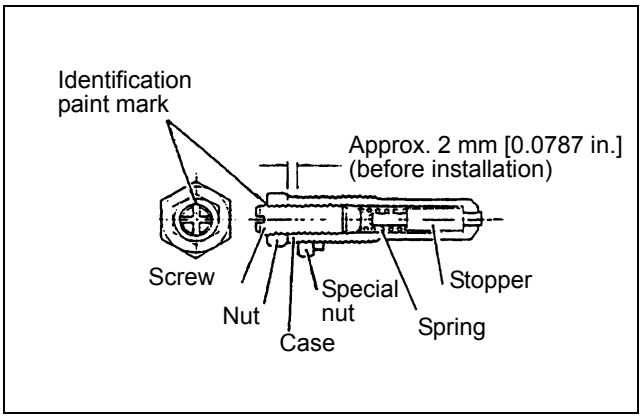


Figure 105 Assembling torque spring set

24 TORQUE SPRING

24.1 Installation of torque spring set

Install and adjust the torque spring set using the following procedure:

1. Set the speed control lever to the high-idling speed position by adjusting the high-speed set bolt.
2. Turn in the torque spring set until engine speed drops about 50 rpm from high-idling speed.
3. From this position, turn back the torque spring set by the specified number of turns (N). Lock the torque spring set at the position with the special nut.
4. Install the torque spring set sealing cap and make sure to tighten the cap to prevent loosening.

⚠ CAUTION

There are two types of torque spring set: The single spring type and the double-spring type. Since each torque spring set has been adjusted precisely in the manufacturer’s factory, do not tamper with the adjust screw unless it is necessary.

24.2 Assembling the torque spring set

When the torque spring set has been disassembled or its component parts have been replaced, reassemble and adjust the torque spring set using the procedure mentioned below:

Model	Number of loosening turns
L2A-61DA, L2A-62A, L2A-62DA, L2A-61DM	2.1
L3A-61DA, L3C-63WM	2.2
L2C-61RR, L2E-61IR, L3A-62DA, L3C-61ES	2.3
L2A-61A, L2A-61RR, L2A-61SS, L2A-62SS, L2A-62SDG, L2C-62A, L2C-62DA, L2E-62WM, L2E-W262WM, L3A-61A, L3A-62A, L3A-61BG, L3A-61RG, L3C-61A, L3C-62A, L3C-61DA, L3C-61RT	2.4

Model	Number of loosening turns
L2C-61A, L2C-61CV, L2C2-61CV, L2E-61R, L2E-61SC, L2E-61SDG, L2E-61GS, L2E-W264SGHM, L2E-61DPH, L2E-61DPHA, L2E-W261DPH, L2E-W261DPHA, L2E-W262SDH, L2E-W262WMG, L2E-62APH2, L3A-61TG, L3A-61ES, L3C-61TG, L3C-62DA, L3C2-62TG, L3E-61R, L3E-61TG, L3E-W261TG, L3E-61RG, L3E-W264SGHM, L3E-61DPH, L3E-61DPHA, L3E-W261DPH, L3E-W261SPHA, L3E-62APH, L3E-62APH2	2.5
L2C-61DM, L2E-61TM, L2E-62A, L2E-62DA, L2E-61ES, L2E-61RR, L2E-62PL, L2E-61DG, L2E-W261DG, L3E-61EG, L3E-61EG, L3E-61A, L3E-61SS, L3E-61SA, L3E-61DS, L3E-61HMG, L3E-61SHS, L3E-61LS, L3E-61KG, L3E2-62TG, L3E2-W262TG	2.6
L2E-61WM, L2E-61DA, L3C-63WMA, L3C-W263WMA, L3E-61TM, L3E-62A, L3E-62DA, L3E-61LT, L3E-62WM, L3E-Y162WM, L3E-62SS, L3E-61SC, L3E-61SC, L3E-61DG, L3E-W261DG, L3E-61DM, L3E-W262SD, L3E-W261CG, L3E-W261ML	2.7
L2E-61EG, L2E-61HMG, L2E-61A, L2E-61SS, L2E-62SS, L2E-62SDG, L2E-61SA, L2E-61DM, L2E-62ES, L2E-61SHG, L3E-61ES, L3E-62ES, L3E-61KL, L3E-61SPH, L3E-63SPH, L3E-63SGHM, L3E-W262KL	2.8
L2E-61WH, L2E-61SG, L2E-62AG2, L3A-61WM, L3E-61SDH, L3E-61SGH, L3E-63SGH, L3E-63SGHM, L3E-62AGH	2.9
L2E-61SDH, L2E-61SGH, L2E-63SGH, L2E-61SPH, L2E-63SPH, L2E-63SGHM, L2E-62AGH, L3E-61DA, L3E-W263ESA, L3E-W264ESA, L3E2-61ES, L3E2-62ES, L3E2-63ES, L3E2-63ESA, L3E2-64ESA, L3E2-65ESB	3.0
L3E-W261DW	3.2
L3E-61SD, L3E-61SG, L3E-63SG, L3E-62AG2	3.3

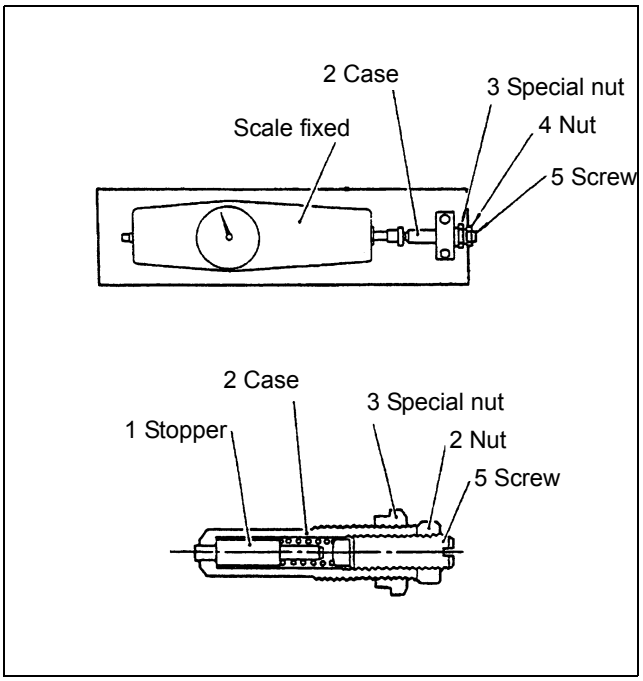


Figure 106 Setting of torque spring

24.3 Single spring type

When installing the single-spring type torque spring set, use the following procedure:

1. Turn the adjust screw 5 lightly (with a screwdriver) until a resistance is felt. Lightly lock the screw at that position with locknut 4.
2. Set the scale to the zero-point. Turn the spring case 2 until the value of load “A” shown in tablle below can be attained. Lock the spring case at that position with special nut 3. Special nut tightening torque: 14.7 to 24.5 N.m (1.5 to 2.5 kg.m) [10.8 to 18.1 lbf.ft]
3. Temporarily loosen adjust screw 5 until the value of load “A” is reduced by about 200 grams [7.06 oz], and then retighten the screw until the value of “B” is attained. Lock the screw at that position with locknut 4. Adjust screw tightening torque: 7.8 to 11.8 N.m (0.8 to 1.2 kgf.m) [5.8 to 8.7 lbf.ft].
4. To inspect if the torque spring set is properly adjusted spring load, arrange a spring set as shown in the figure at right. Gradually push the scale against the torque spring set until the stopper 1 is moved (or the pointer of dial gage deflects). Check that the load applied to the torque spring at that moment coincides with the value of load “C” shown in the table.

Model	A	B	C	Identification color
L3A-61TG, L3A-61ES, L3C-61DA, L3C-61ES, L3E-61DA, L3E-31NSA, L3E2-61ES, L3E2-62ES, L3E2-63ES, L2E-61GS, L3E2-63ESA, L2A-61DA, L2E–61ES, L2E–61DA	570	570	550	Green
L2E–62PL	1520	1520	1500	Red
L3E-61TG, L3A-61A, L3C-61A, L3C-61TG, L3E-61A, L3E-61SC, L3E-61SA, L3E-61DS, L3E-61SHS, L3E-61LS, L3E-61KL, L2A-61A, L2C-61A, L2C-61CV, L2E-61A, L2E-61SC, L2E-61SA, L2E-61WH, L2E–61HMG, L2E–61IR	970	970	950	Yellow
L3C2–62TG, L3E2–62TG, L3A–61RG, L3E–61RG	1270	1270	1250	Purple

Table 44 Applying loads

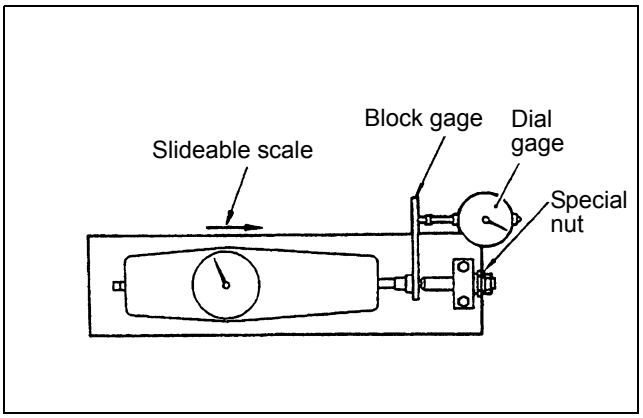


Figure 107 Inspecting torque spring

⚠ NOTE

The applying loads (A, B, C) differ depending on engine model.

24.4 Inspection

Remove the gear case and inspect the governor. When removing the gear case, be sure to remove the tie-rod cover by the side of the fuel pump and disconnect the tie-rod from the rack. If any parts are found defective, replace them.

⚠ CAUTION

When the governor is assumed to be malfunctioning, check the bearing on the gear case side, too.

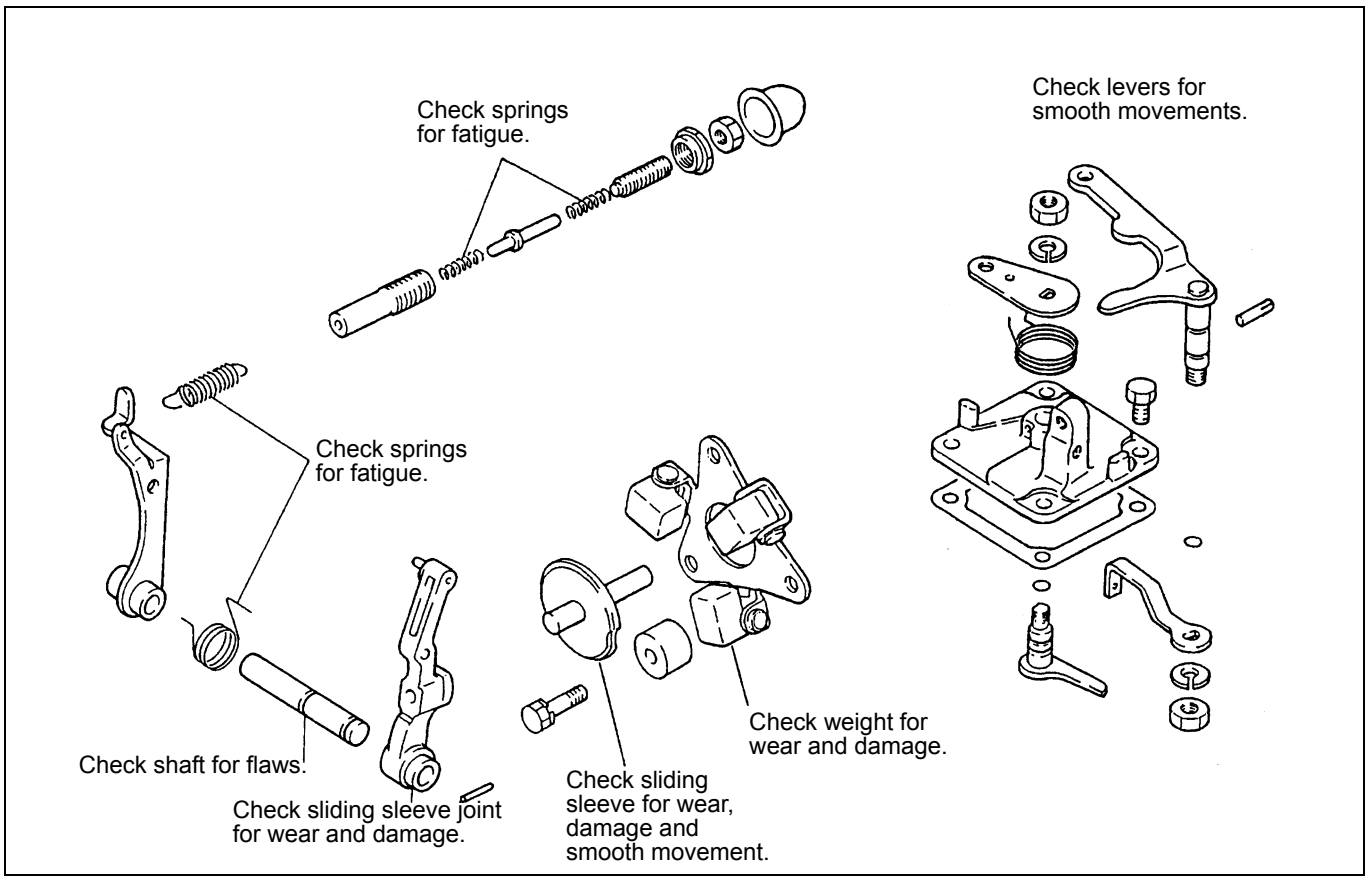


Figure 108 Inspection governor system parts

24.5 Removal and installation

Refer to Gear case and oil pump.

24.5.1 Removing the levers

1. To remove the levers, pull out the grooved pins which have been driven into the governor lever, stop lever, and speed control lever.
2. Loosen bolts fastening the levers and shafts.

24.5.2 Installation

Install the levers and shafts, one after another, checking for proper function of each lever.

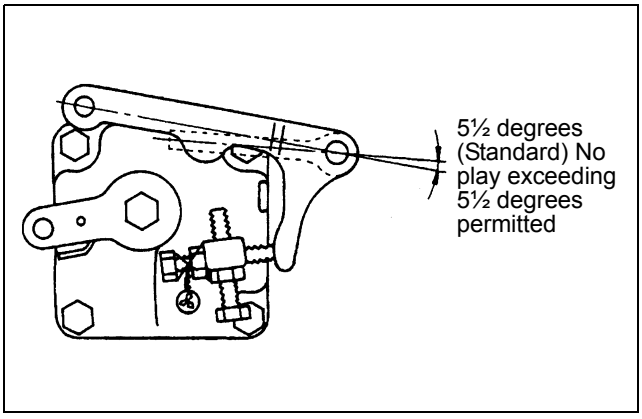


Figure 109 Installing speed control lever

⚠ CAUTION

a. After press-fitting each grooved pin, check if the shaft rotates smoothly.
b. Apply oil to the O-rings before installing them.
c. No deflection exceeding 20 mm [0.7874 in.] is permitted for the governor spring installation.
d. Install the governor spring lever and speed control lever so that play of angle between levers (standard: 5½ degrees) is minimized.

COOLING SYSTEM

25 GENERAL

25.1 Specifications[1]

Description		Specification
FAN BELT	Standard type for industrial application	LL HM type, length 905 mm [35.6299 in.]
COOLING FAN	L2: Standard type for industrial application	4-blade or 5-blade, unequal pitch, pusher or suction type, ø 290 [11.4173 in.]
	L3: Standard type for industrial application	5-blade or 6-blade, unequal pitch, pusher or suction type, ø320 mm [12.5984 in.]
WATER PUMP	Type	Centrifugal impeller
THERMOSTAT	Type	Wax pellet type
	Valve opening temperature	76.5±1.5°C [169.7±2.7°F]
	Full-opening temperature	90°C [194°F] (Valve lift 6 mm [0.2362 in.])
THERMOSWITCH	Standard type	Bi-metal type
	Switch-ON temperature	111±3.5°C [231.8±6.3°F]
TEMPERATURE GAGE UNIT	Gage specification	70°C [158°F]/104±13.5 W 115°C [239°F]/23.8±2.5 W
	Voltage used	12 volt DC

Table 45 Specifications

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

25.2 Disassembly

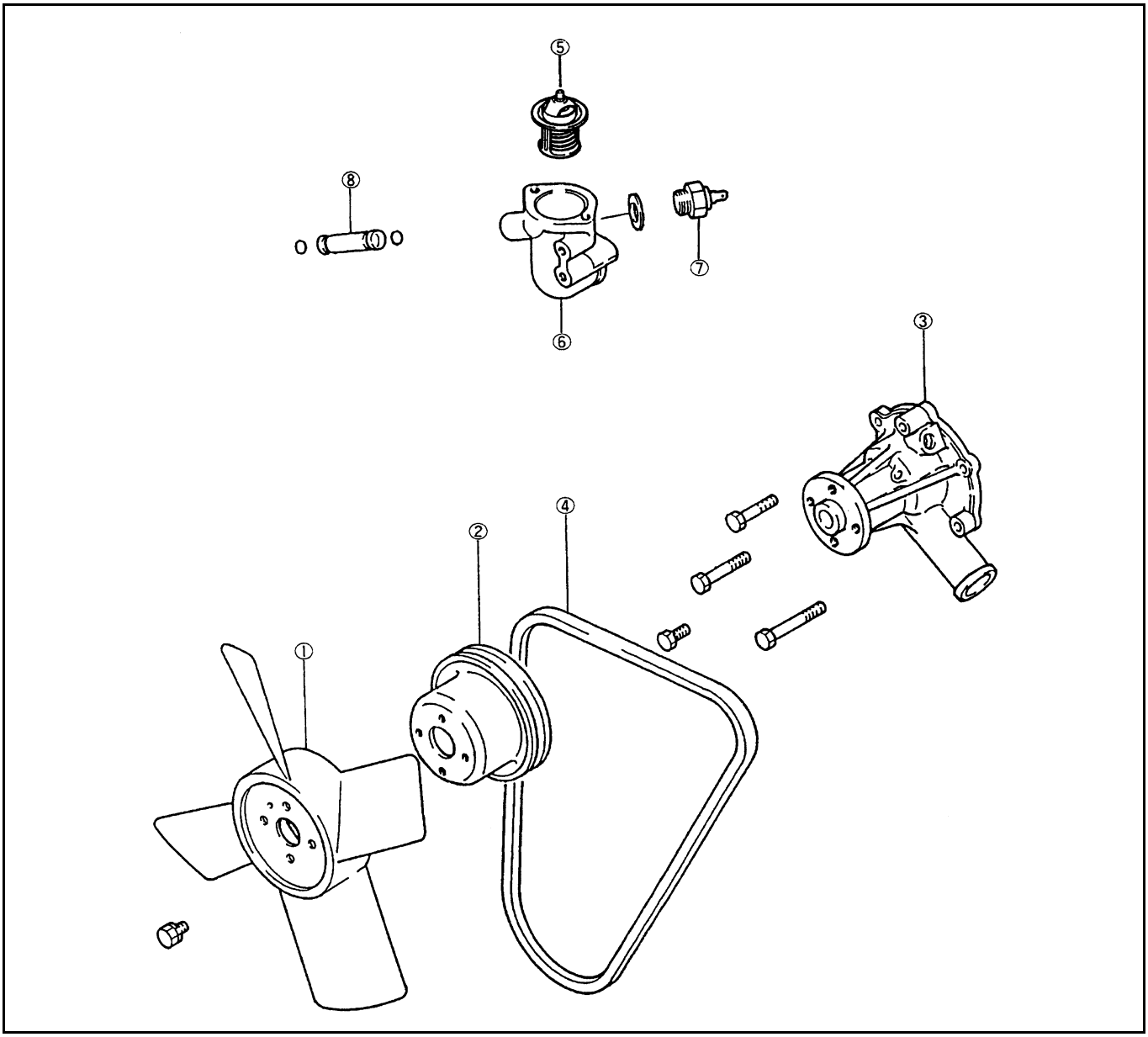


Figure 110 Cooling system component parts

Disassembly sequence
1. Cooling fan
2. Water pump pulley
3. Water pump assembly
4. V-belt
5. Thermostat
6. Thermostat fitting
7. Thermoswitch
8. Bypass pipe

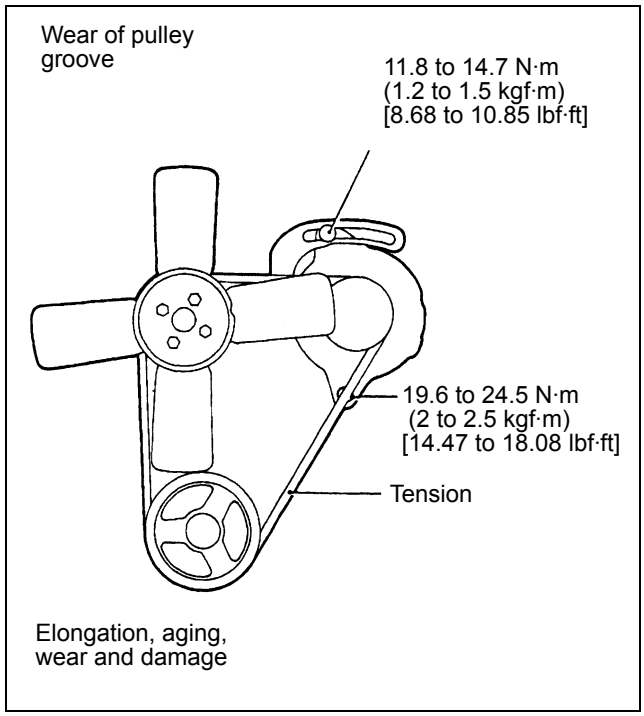


Figure 111 Inspecting fan belt

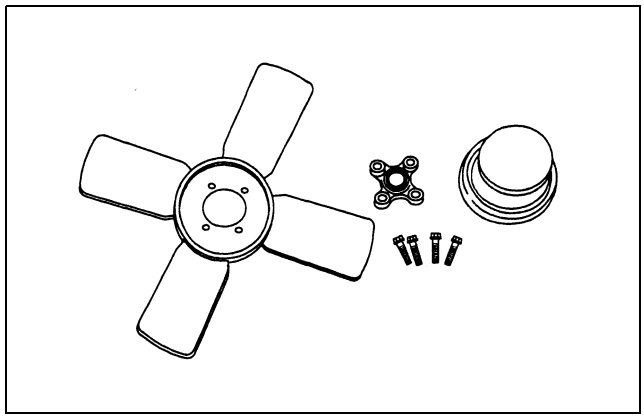


Figure 112 Inspecting fan

26 FAN AND FAN BELT

26.1 Fan belt inspection

For fan belt tension, see Maintenance (page xx).

26.2 Fan inspection

Check the fan for cracks, damage and deformation. If any, replace the fan.

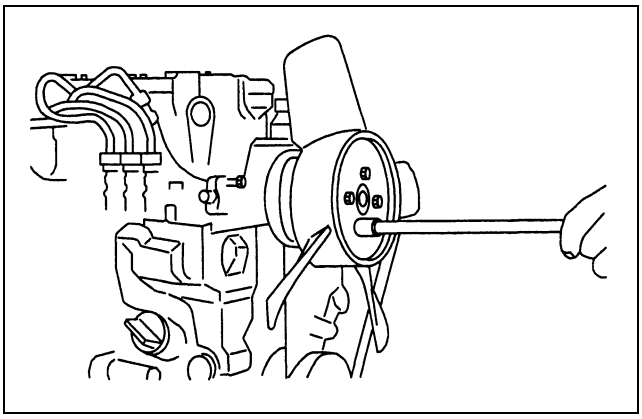


Figure 113 Removing water pump

27 WATER PUMP

27.1 Removal and installation

1. Remove the fan and fan belt.
2. Remove the water pump.
3. When installing the water pump, take reverse sequence of the removal.

27.2 Inspection

Check the water pump for water leak, improper rotation and cracks. If any, replace the water pump assembly

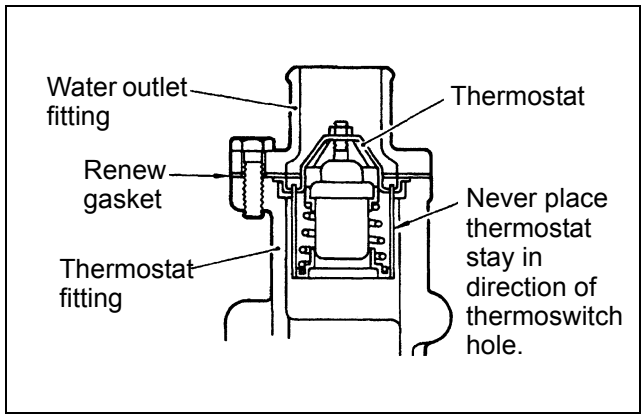


Figure 114 Installing thermostat

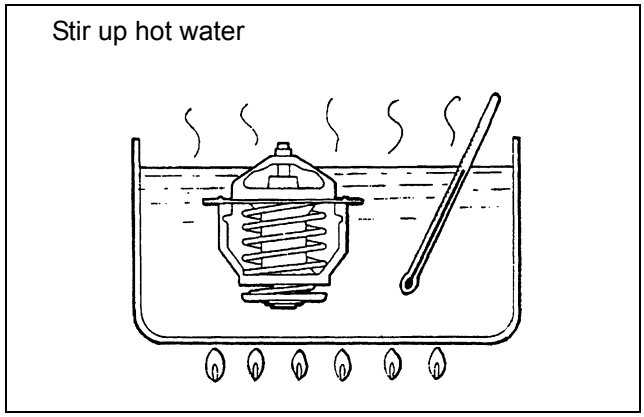


Figure 115 Inspecting thermostat

28 THERMOSTAT

28.1 Removal and installation

Pay attention to the following:

1. Set the thermostat in place.
2. Renew the gasket.

28.2 Inspection

If the thermostat does not operate properly, replace it.

Item	Specification	
	76.5°C [169.7°F]	**71°C [159.8°F]**
Valve cranking temperature	76.5±1.5°C [169.7±2.7°F]	71°C [159.8°F]
Full-open temperature (lift 6 mm)	90±1.5°C [194±2.7°F]	85°C 185°F]

Table 46 Inspection thermostat

29 WATER TEMPERATURE GAGE UNIT AND THERMOSWITCH

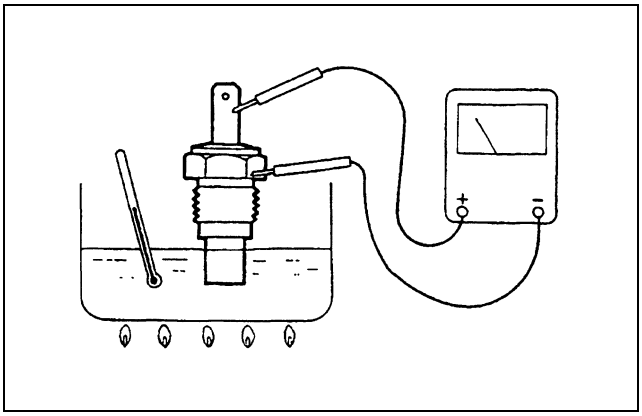


Figure 116 Inspecting temperature gage unit

29.1 Inspection of water temperature gage unit

If the gage does not function properly, replace it.

Gage unit part no.	Specification
MD001380	70°C [158°F]/104±13.5 Ω, 115°C [239°F]/23.8±2.5 Ω
MM435133	80°C [176°F]/118±6 Ω, 115°C [239°F]/42±2.5 Ω
0452510100	80°C [176°F]/29.5±2.5 Ω, 106°C [222.8°F]/14.3±0.5 Ω
05204-05300	67°C [152.6°F]/44.6 Ω, 110°C [230°F]/12.8 Ω

Table 47 Inspecting temperature gage unit

⚠ CAUTION

Take special care when handling hot oil in order not to cause burns or fire.

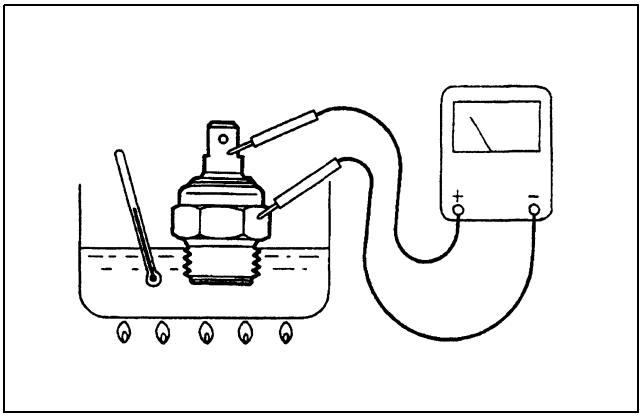


Figure 117 Inspecting thermoswitch

29.2 Inspection of thermoswitch

Switch-ON temperature	111±3.5°C [231.8±6.3°F]

Table 48 Inspecting thermoswitch

⚠ CAUTION

Take special care when handling hot oil in order not to cause burns or fire.

AIR CLEANER

30 AIR CLEANER

30.1 Disassembly

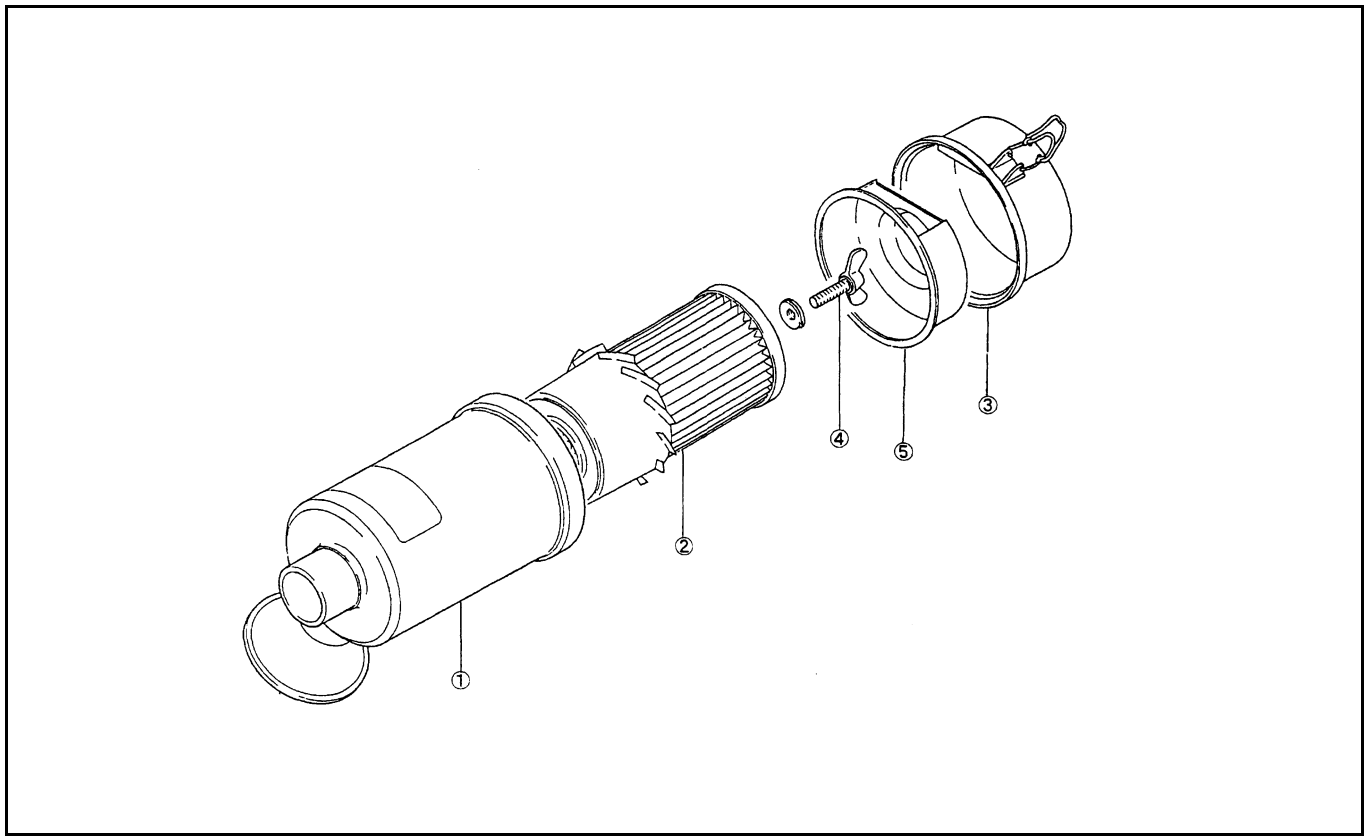


Figure 118 Air cleaner component parts

Disassembly sequence
1. Body assembly
2. Element assembly
3. Dust pan assembly
4. Bolt
5. Partition plate

30.2 Inspection

1. Check the air cleaner body and look for deformation, corrosion, and damage. If any defect is found, repair or replace.
2. If the body and cover (element) are not airtight, dust would enter into the engine, causing the cylinders and pistons to wear early. Check interior of the body for evidences of dust entering. If any, repair the air-leak part.
3. Check the element and packing for damage and air leak. If any defect is found, replace.
4. Check the element for contamination, clogging and damage. If necessary, clean or replace the element.
5. Check the intake hose for damage and cracks. If necessary, replace the hose.
6. When installing the air cleaner, properly place it so that the air inlet opening faces sideward or downward. Also, install the dust pan following the arrow marked “TOP”.

ELECTRICAL SYSTEM

31 GENERAL

31.1 Specifications[1]

Description		Specification			
		L2		L3	
STARTER	Model	M000T60481		M001T68381	
	Type	Solenoid shift type			
	Nominal output	12V-1.2 kW		12V-1.7 kW	
	No-load characteristic	11V/90A or less 2500 rpm or more		11V/110A or less 2400 rpm or more	
	Load characteristic	7.5V/300A 10.5 N·m (1.07 kgf·m) [7.7 lbf·ft] or more 850 rpm or more		7.7V/400A 16.0 N·m (1.63 kgf·m) [11.8 lbf·ft] or more 740 rpm or more	
ALTERNATOR	Model	L2		L3	
		A	B	A	B
		A000T25371	A007TA01718 (NEW TYPE)	A000T25371	A007TA01718 (NEW TYPE)
	Type	Alternator with built-in IC regulator			
	Nominal output	12V-40A		12V-40A	
	Output performance, hot	21A/2500 rpm 37A/5000 rpm		21A/2500 rpm 37A/5000 rpm	
GLOW PLUG	Model	Y–145T			
	Type	Sheath type, quick-heating			
	Rated voltage	10.5V DC			
	Current	9.7A±1.0A (when rated voltage is applied for 30 seconds)			
	Resistance at normal temperatures	0.2 Ω			
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)			

Table 49 Specifications

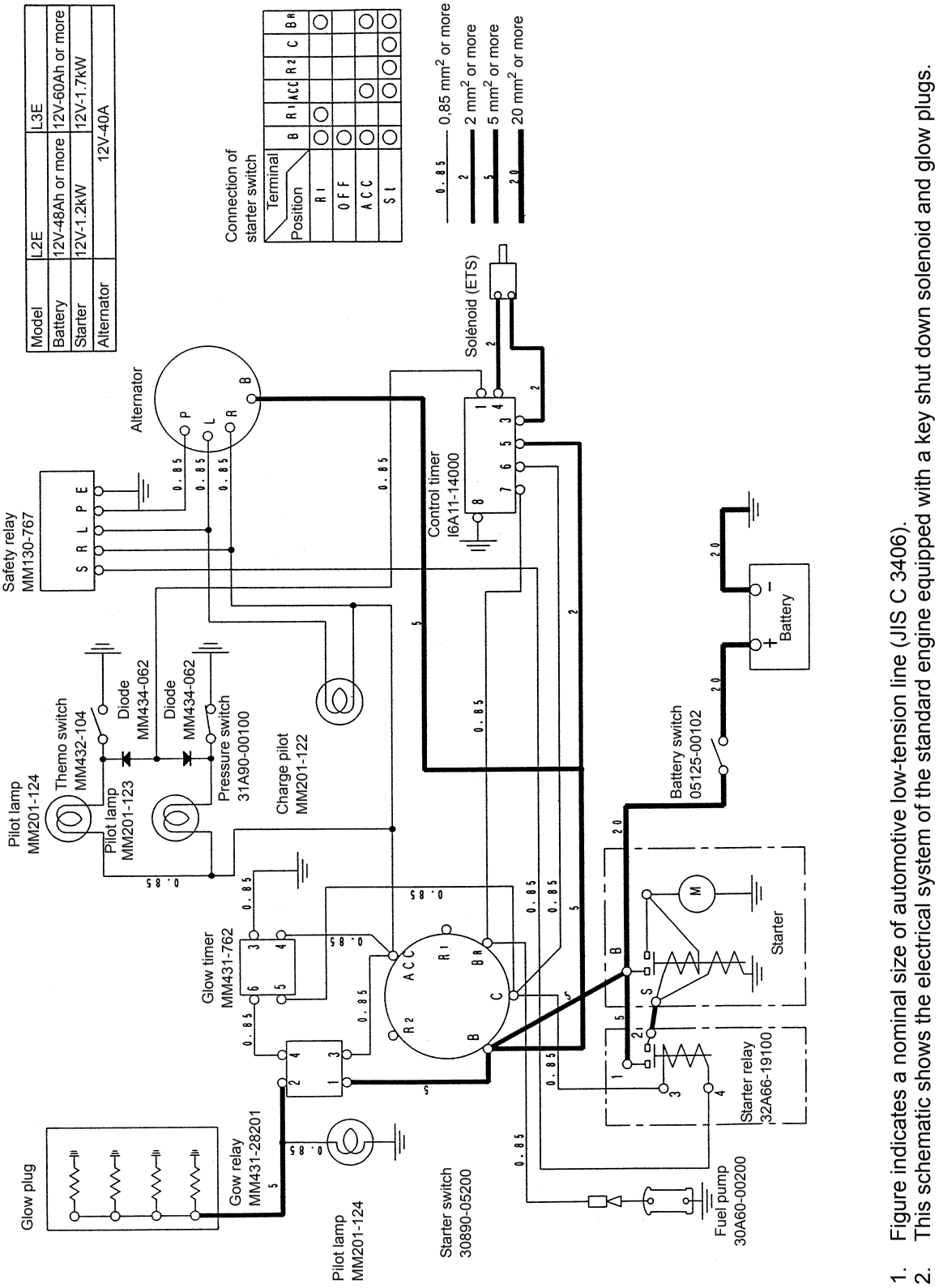
1. All specifications are subject to change without any prior notice.

Description		Specification	
		L2	L3
ETS TYPE STOP SOLENOID	Model	YMS-1	
	Type	Solenoid	
	Resistance in coil, Ω	1.6 ± 10% at 20°C (68°F)	
	Stroke, mm (in.)	10 ± 0.5 (0.39 ± 0.02)	
	Operating voltage, V	DC 10 to 15	
GLOW TIMER	Model	QGS	
	Rated voltage, V	DC 12	
	Operating voltage, V	7 to 15	
	Operating temperature range °C (°F)	-30 to +70 (-22 to 158)	
	Storage temperature range °C (°F)	-40 to +80 (-40 to 176)	
	Pre-glow time, second	6.2 ± 0.7	

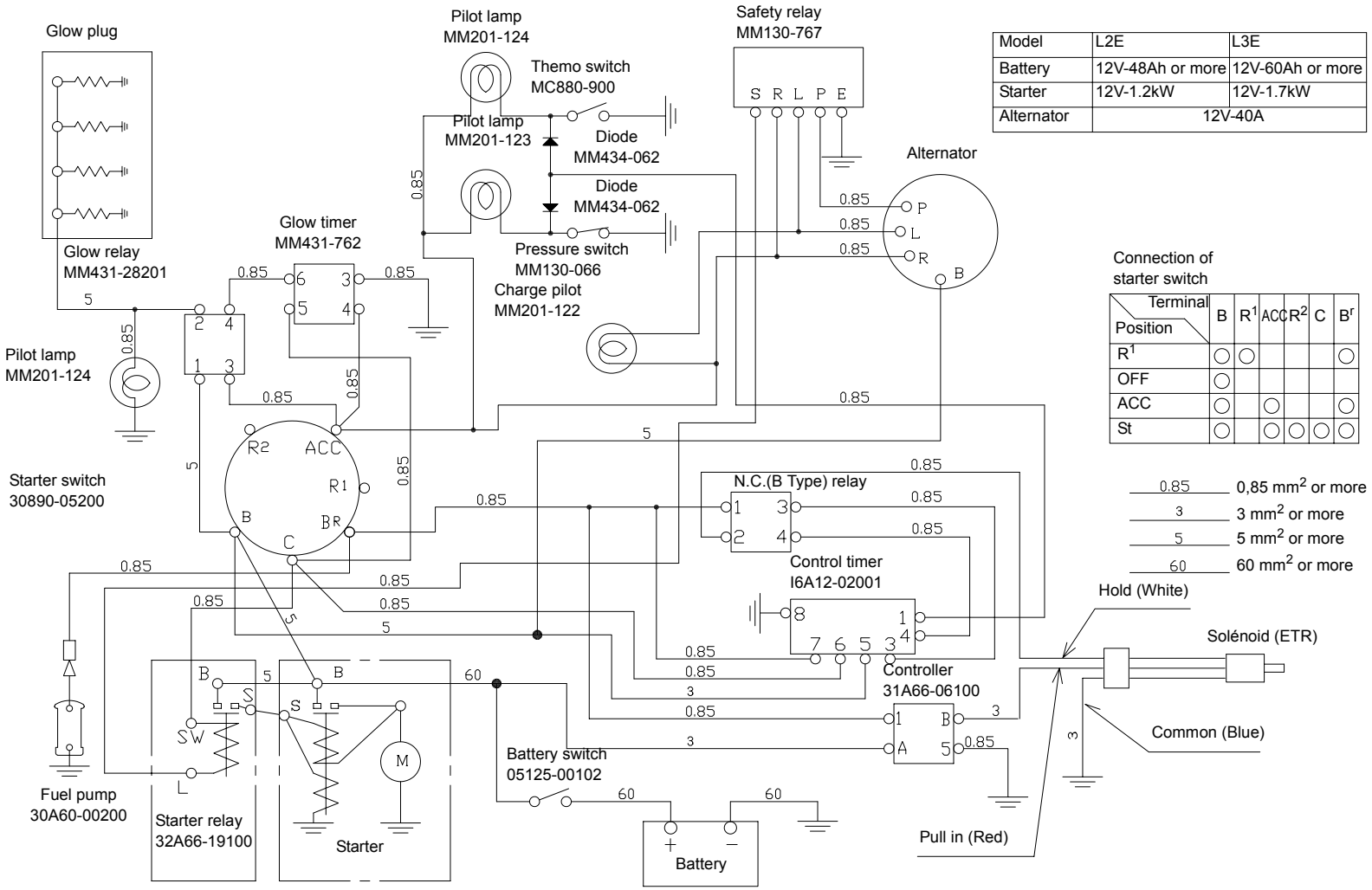
Table 49 Specifications

< ETS type stop solenoid >

31.2 Wiring diagrams



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



Model	L2E	L3E
Battery	12V-48Ah or more	12V-60Ah or more
Starter	12V-1.2kW	12V-1.7kW
Alternator	12V-40A	

Connection of starter switch

Terminal / Position	B	R^1	ACC	R^2	C	B^r
R^1	○	○				○
OFF	○					
ACC	○		○			○
St	○		○	○	○	○

0.85	0,85 mm^2 or more
3	3 mm^2 or more
5	5 mm^2 or more
60	60 mm^2 or more

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.

32 STARTER

32.1 Structure

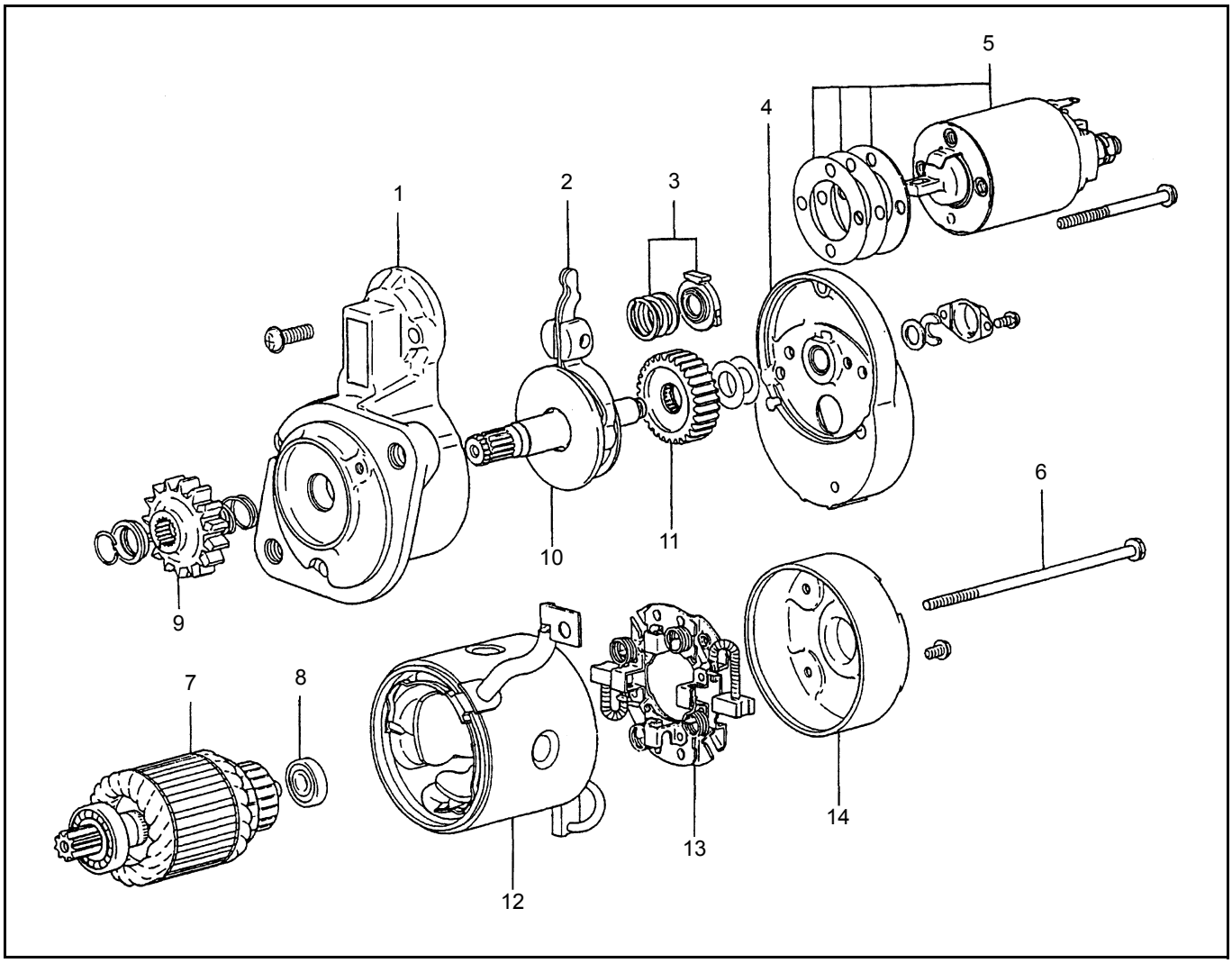


Figure 119 Starter component parts

Disassembly sequence
1. Front bracket assembly
2. Lever assembly
3. Spring set
4. Center bracket assembly
5. Switch assembly
6. Through bolt
7. Armature
8. Rear bearing
9. Pinion
10. Pinion shaft assembly
11. Gear
12. Yoke assembly
13. Brush holder assembly
14. Rear bracket

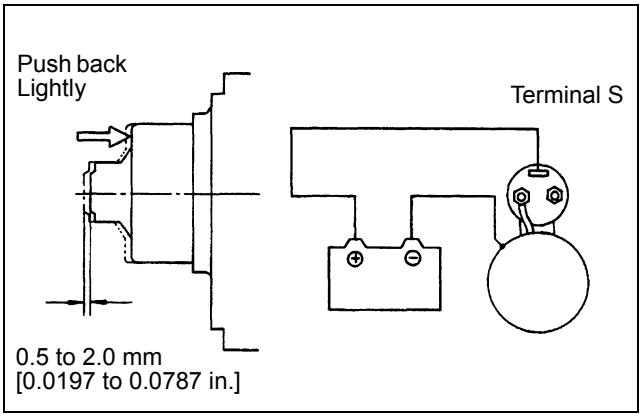


Figure 120 Inspecting pinion gap

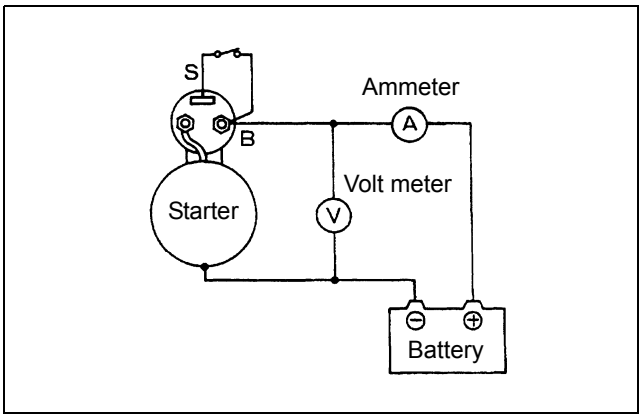


Figure 121 No-load test

32.2 Inspection (assembly)

If any abnormality is assumed by the following tests, adjust the starter or disassemble and repair it.

32.2.1 Pinion gap inspection

1. Connect + terminal of battery (12 V)to starter terminal “S” and – terminal to starter body, and the pinion will protrude and stop.

⚠ CAUTION

Never apply battery voltage for over 10 seconds continuously.

2. Lightly push the pinion back and measure the return stroke (called pinion gap).
3. If the pinion gap is not within the standard range (0.5 to 2.0 mm [0.0197 to 0.0787 in.]), adjust it by increasing or decreasing the number of packings on the magnetic switch. The gap is decreased as the number of packings increases.

32.2.2 No-load test

1. Connect the ammeter, voltmeter and battery to the starter as illustrated.
2. When the switch is closed, the pinion must protrude and the starter must run smoothly (at 3000 rpm or more). If the current or starter speed is out of specification, disassemble the starter and repair it.

⚠ CAUTION

a. Use wires as thick as possible for wiring and tighten every terminal securely.
b. This is a solenoid shift type starter which makes a rotating sound larger than that of a direct-drive type starter.
c. When detecting starter rotation at the pinion tip, pay attention to protrusion of the pinion.

32.2.3 Magnetic switch

Perform the following tests. If any defect is found, replace the magnetic switch assembly.

1. Disconnect wire from terminal “M”.

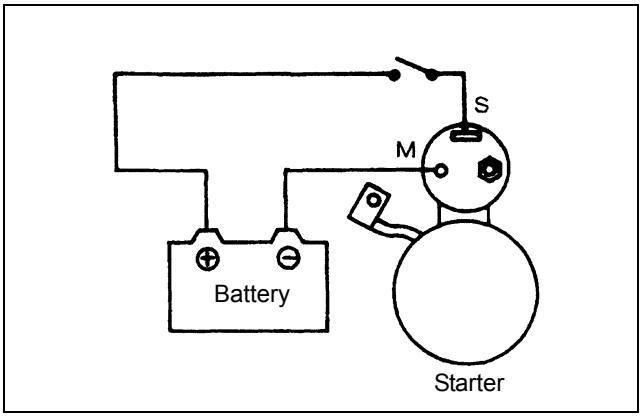


Figure 122 Attraction test

2. Attraction test. Connect a battery to the magnetic switch terminal S and M. The pinion must protrude.

⚠ CAUTION

Do not apply battery current for more than 10 seconds.

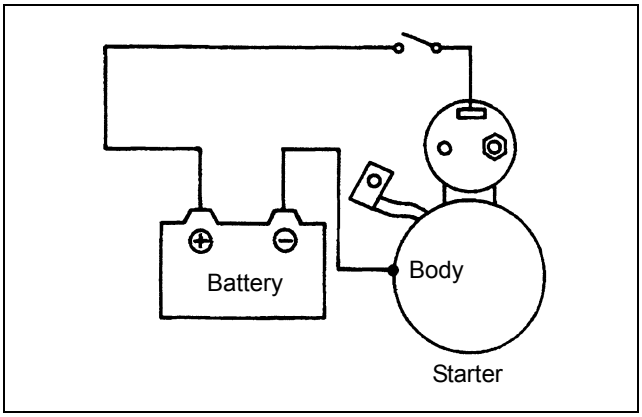


Figure 123 Holding test

3. Holding test. With a battery connected to the magnetic switch terminal “S” and to the starter body, manually pull out the pinion fully. The pinion must remain at that position when released from holding by hand.

⚠ CAUTION

Do not apply battery current for more than 10 seconds.

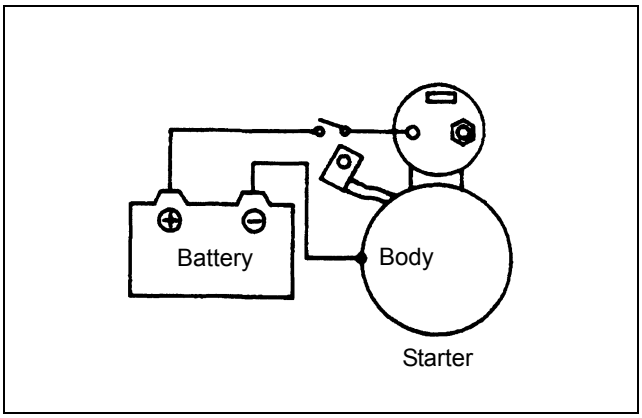


Figure 124 Return test

4. Return test. With a battery connected to the magnetic switch terminal “M” and to the starter body, manually pull out the pinion fully. The pinion must return to its original position when released from holding by hand.

⚠ CAUTION

Do not apply battery current for more than 10 seconds.

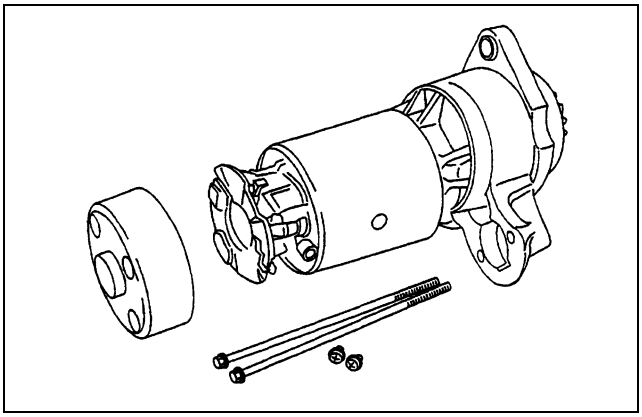


Figure 125 Removing brush holder assembly

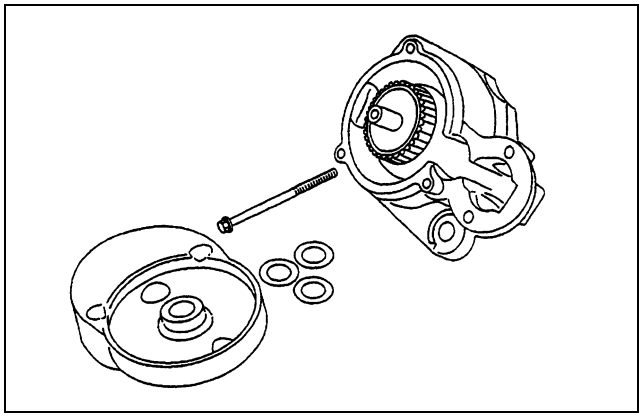


Figure 126 Removing reduction gear

32.3 Disassembly

1. Disconnect wire from the magnetic switch terminal “M”.
2. Loosen two screws fastening the magnetic switch. Remove the magnetic switch assembly.
3. Remove two through bolts and two screws fastening the brush holder. Remove the rear bracket.
4. With two brushes brought in floating state, remove the yoke-and-brush holder assembly. Then, pull the armature out.
5. Remove the cover, pry the snap ring out and remove the washer.
6. Unscrew the bolts and remove the center bracket. At the same time, washers for opinion shaft end play adjustment will be removed.
7. Pull out the reduction gear lever and lever spring from the front bracket.
8. On the pinion side, pry the snap ring out, and pull out the pinion and pinion shaft.
9. At each end of the armature, remove the ball bearing with a bearing puller.
   It is impossible to replace the ball bearing press-fitted in the front bracket. If that bearing has worn, replace the whole front bracket assembly.

32.4 Inspection

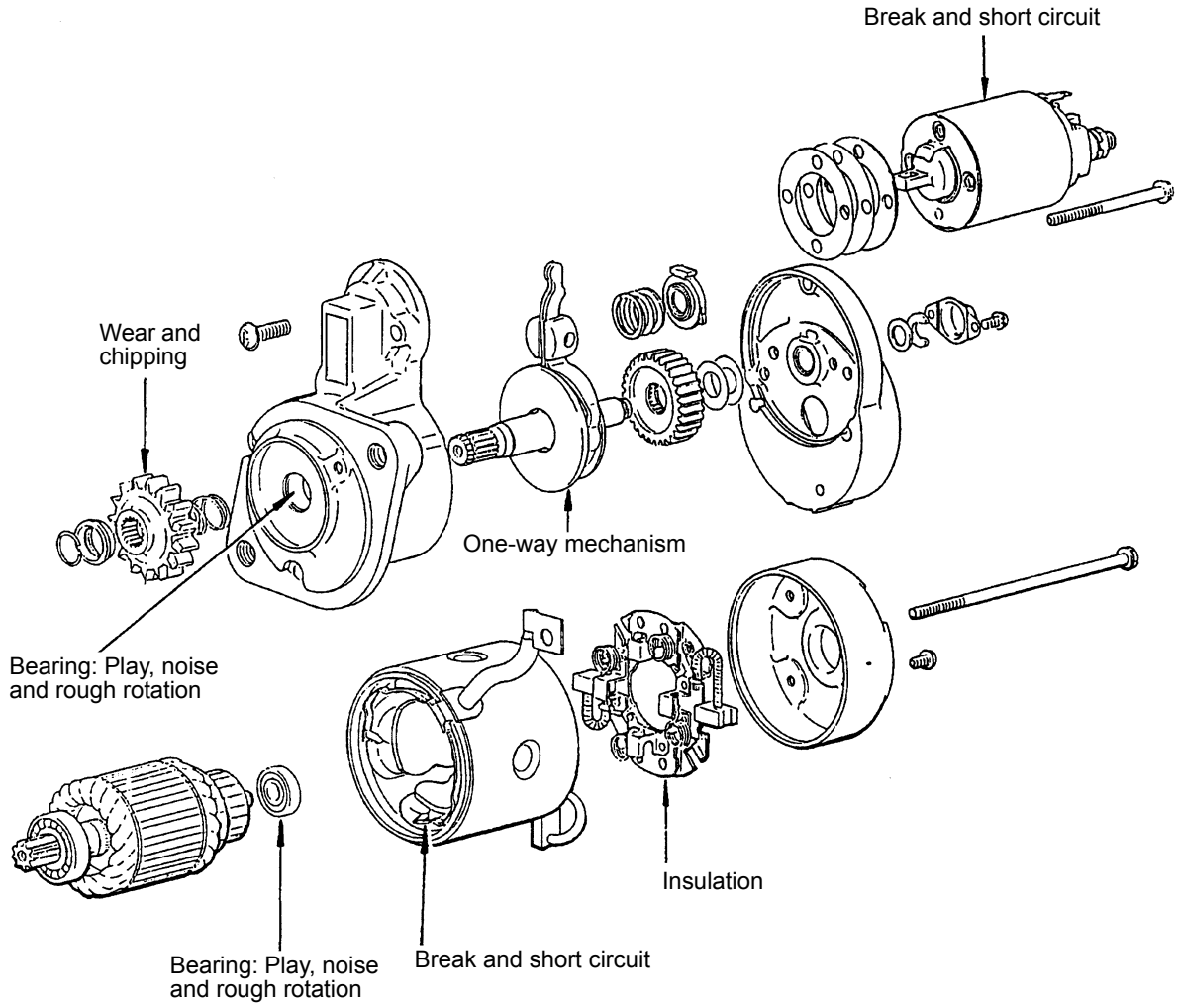


Figure 127 Inspecting starter

Inspect the following:

Description	Standard	Service Limit
Depth of under cut	0.5 mm [0.0197 in.]	0.2 mm [0.0079 in.]
Commutator O. D.	38.7 mm [1.5236 in.]	–1.0 mm [0.0394 in.]
Height of brush	17 mm [0.6693 in.]	6 mm [0.2362 in.]
Spring pressure	29.4 N (3 kgf) [6.61 lbf]	

Table 50 Inspection

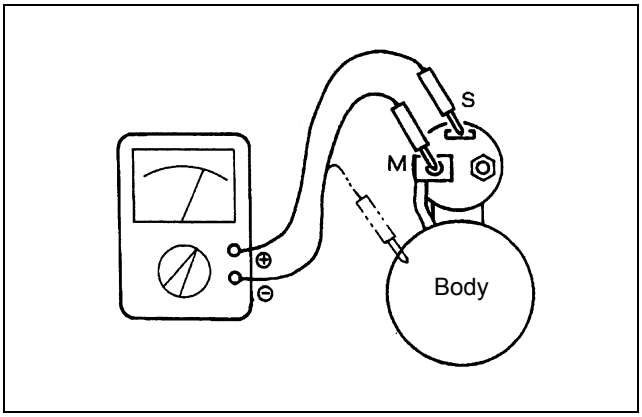


Figure 128 Checking magnetic switch

32.4.1 Inspecting the magnetic switch

Check the magnetic switch for continuity between terminal S and M, and between terminal S and body. If zero-ohm is indicated (as an evidence of short circuit), replace the magnetic switch.

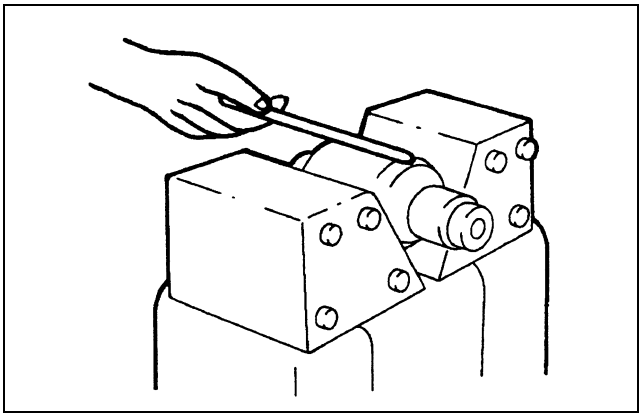


Figure 129 Checking armature coil

32.4.2 Inspecting the armature

1. Check the armature with a growler tester. If short-circuited, replace the armature. Also, check for insulation between the commutator and its shaft. Replace the armature if there is continuity.
2. Measure the outside dimension of the commutator and the depth of undercut. Repair or replace if exceed the service limit. Also, check the commutator outside surface for dirtiness and roughness. If it is rough, polish the commutator with fine-grain sandpaper.

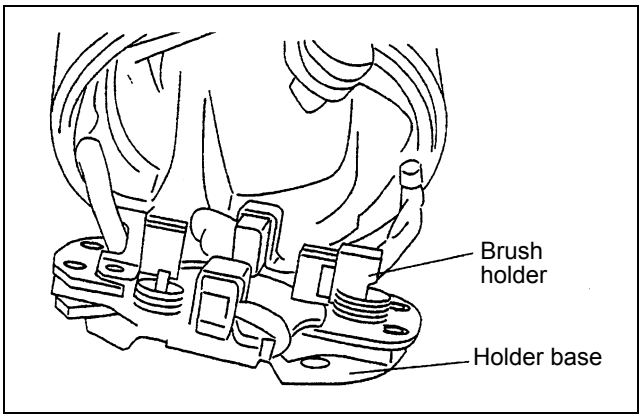


Figure 130 Checking brush holders

32.4.3 Brush holder inspection

1. Check the brushes. If worn out nearly to the service limit, replace the brushes.
2. Check the brush spring tension. If any defect is found, replace springs.
3. Check for insulation between the positive brush holder and holder base. If there is continuity, replace the holder assembly. Also, check the brush holder if itís firmly coaking the brushes.

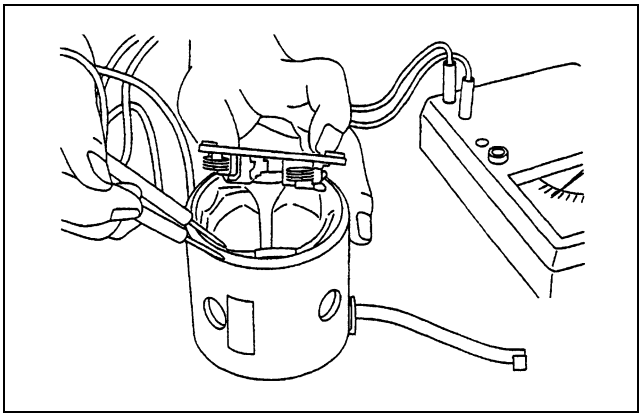


Figure 131 Checking field coil

32.4.4 Field coil inspection

1. Check for insulation between one end (brush) of coil and yoke.
2. Check for the continuity between both ends (brushes) of coil.

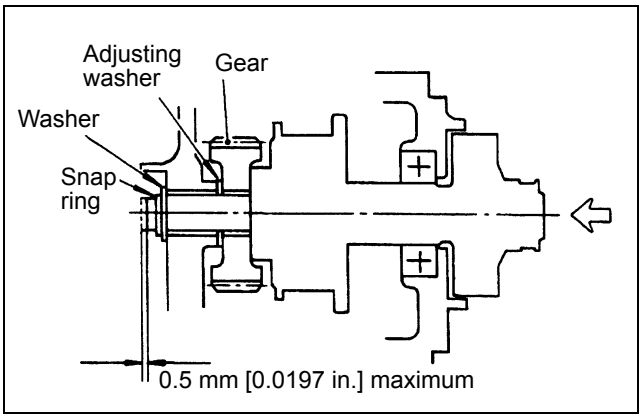


Figure 132 Adjusting pinion shaft end play

32.5 Assembly and adjustment

Reassemble the starter in the reverse sequence of disassembly and pay attention to the following:

32.5.1 Pinion shaft end play adjustment

Set the end play (thrust gap) to 0.5 mm [0.0197 in.] or less by inserting an adjusting washer between the center bracket and reduction gear.

1. Reassemble the pinion shaft, reduction gear washer and snap ring to the center bracket.
2. Measure the end play by moving the pinion shaft in the axial direction. If the end play exceeds 0.5 mm [0.0197 in.], increase the number of adjusting washers.

32.5.2 Greasing

Whenever the starter has been overhauled, apply grease to the following parts:

1. Armature shaft gear and reduction gear
2. All bearings
3. Bearing shaft washers and snap rings
4. Bearing sleeves
5. Pinion
6. Moving portion of lever

⚠ CAUTION

Never apply grease to the starter fitting surface, terminals, brushes and commutator.

33 ALTERNATOR AND DYNAMO

33.1 Structure

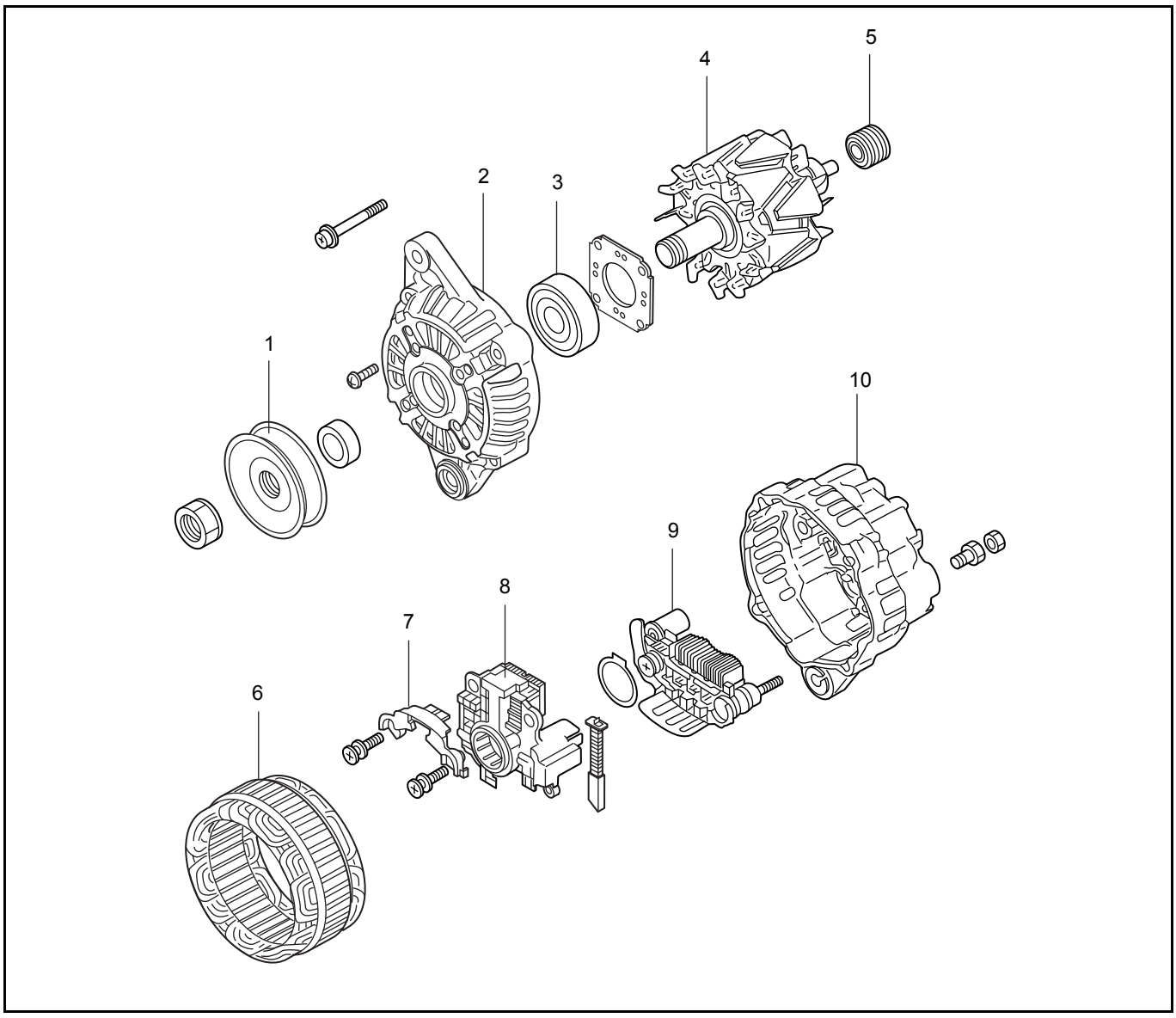


Figure 133 Alternator component parts

Disassembly sequence
1. Pulley
2. Front bracket assembly
3. Front bearing
4. Rotor assembly
5. Rear bearing
6. Stator
7. Terminal set
8. Regulator assembly
9. Rectifier assembly
10. Rear bracket assembly

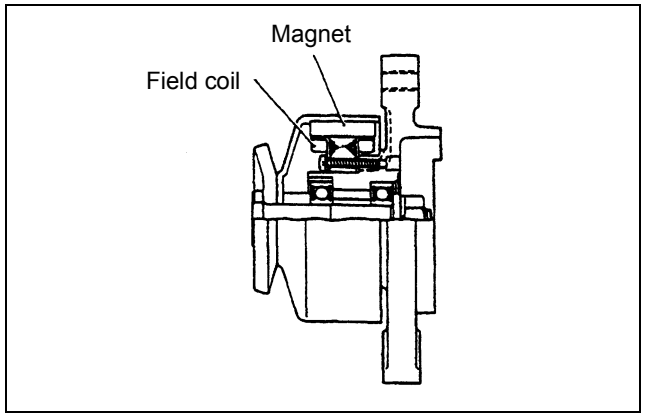


Figure 134 Dynamo

33.2 Dynamo

The dynamo is used for specific engines. This maintenance-free dynamo is the permanent magnet type, light-weight, compact, single-phase AC generator. Alternating current generated by the dynamo is rectified through the separated regulator-and-rectifier unit.

33.3 Inspection of the alternator (installed on the engine)

⚠ CAUTION

Improper handling will damage to the charging circuit and other troubles.

1. Never connect the battery in reverse.
2. Do not use a megger and other high-voltage testers.
3. When recharging the battery, disconnect the battery cable from the alternator.
4. Never disconnect the lead wire from the alternator terminal B during running of the engine.
5. Never ground the alternator terminal B, since this terminal is always charged.
6. Never short-circuit or ground terminal L.
7. When using a steam cleaner, be careful not to direct steam to the alternator.

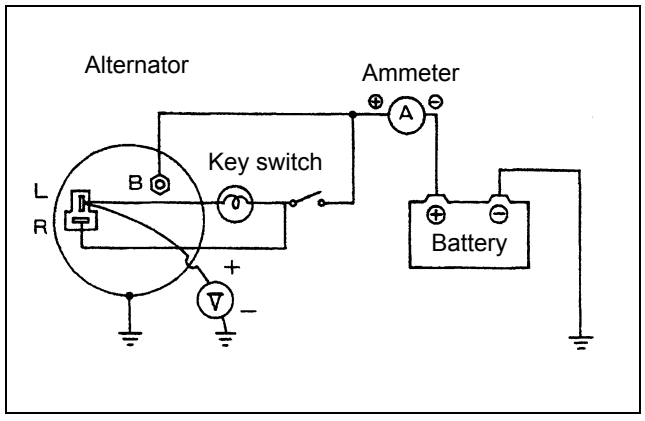


Figure 135 Checking for regulated voltage

33.3.1 Inspection for regulated voltage

1. Connect an ammeter between positive terminal of battery and terminal B of alternator.
2. Connect a voltmeter to the alternator terminal “L” and ground.
3. Note that the voltmeter indicates zero volt when the key switch is in the OFF position. The voltmeter will indicate a voltage considerably lower than battery voltage when the key switch is in the ON position (while the engine stops).
4. Short-circuit the ammeter terminals to start the engine.
5. Read the voltmeter indication (regulated voltage) under the following test conditions: Ammeter indication is below 5 A; engine speed is at 1800 rpm and 2500 rpm; and lamps are switched off. Regulated voltage shows a tendency to decrease as the alternator temperature increases.

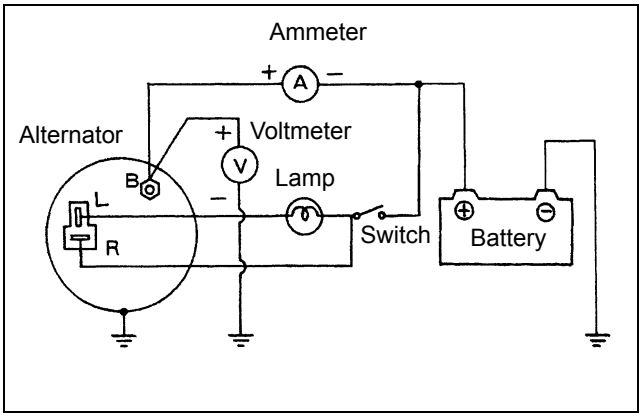


Figure 136 Checking for output

33.4 Output inspection

1. Disconnect the grounding cable from the battery.
2. Connect an ammeter between the battery and alternator terminal “B”. Ground the terminal “B” through a voltmeter.
3. Connect the battery cable to ground.
4. Start the engine.
5. Apply all load including the lamps.
6. Increase engine speed until normal alternator speed is attained. Read the maximum indication of the ammeter at 13.5V of voltmeter indication. Output current must correspond to the specification in the table.

Description		12V-35A	12V-40A
Alternator output at 13.5V	Cold	7A/1300 rpm	—
		30A/2500 rpm	
	Hot	3A/1300 rpm	—
		23A/2500 rpm	21A/2500 rpm
		36A/5000 rpm	37A/5000 rpm

Table 51 Output current

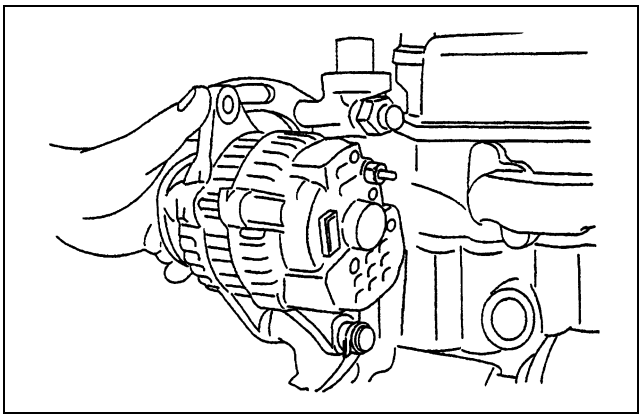


Figure 137 Removing alternator

33.5 Removal

1. Disconnect the battery cable.
2. Disconnect lead wire from terminal “B” on the back of alternator.
3. Disconnect the alternator connector.
4. Loosen the alternator brace bolt and support bolt. Push the alternator toward the engine and remove the fan belt.
5. Dismount the alternator.

33.6 Disassembly of alternator

1. Remove three through bolts.
2. Heat the rear bracket around the rear bearing portion up to 50 to 60°C [122 to140°F] (with a solder iron) and separate the bracket from the stator coil.

⚠ CAUTION

a. Insert a screwdriver blade into the clearance between the stator core and front bracket and pry up.
b. Be careful not to insert the blade too deep.

3. Grip the rotor in a vise, remove the pulley nut, and pull out the pulley, fan and spacer.
4. Pull out the rotor assembly from the front bracket.

5. Unsolder the stator coil lead wires. Remove the stator assembly.

> **⚠ CAUTION**
>
> a. Soldering must be done in short time.
> b. Never heat the lead wires too long to prevent damage to diodes.

6. Disconnect the capacitor from terminal ìBî.
7. Loosen the rectifier mounting screws and remove the rectifier.

33.7 Inspection

Inspect the disassembled parts. If any part is found defective, replace.

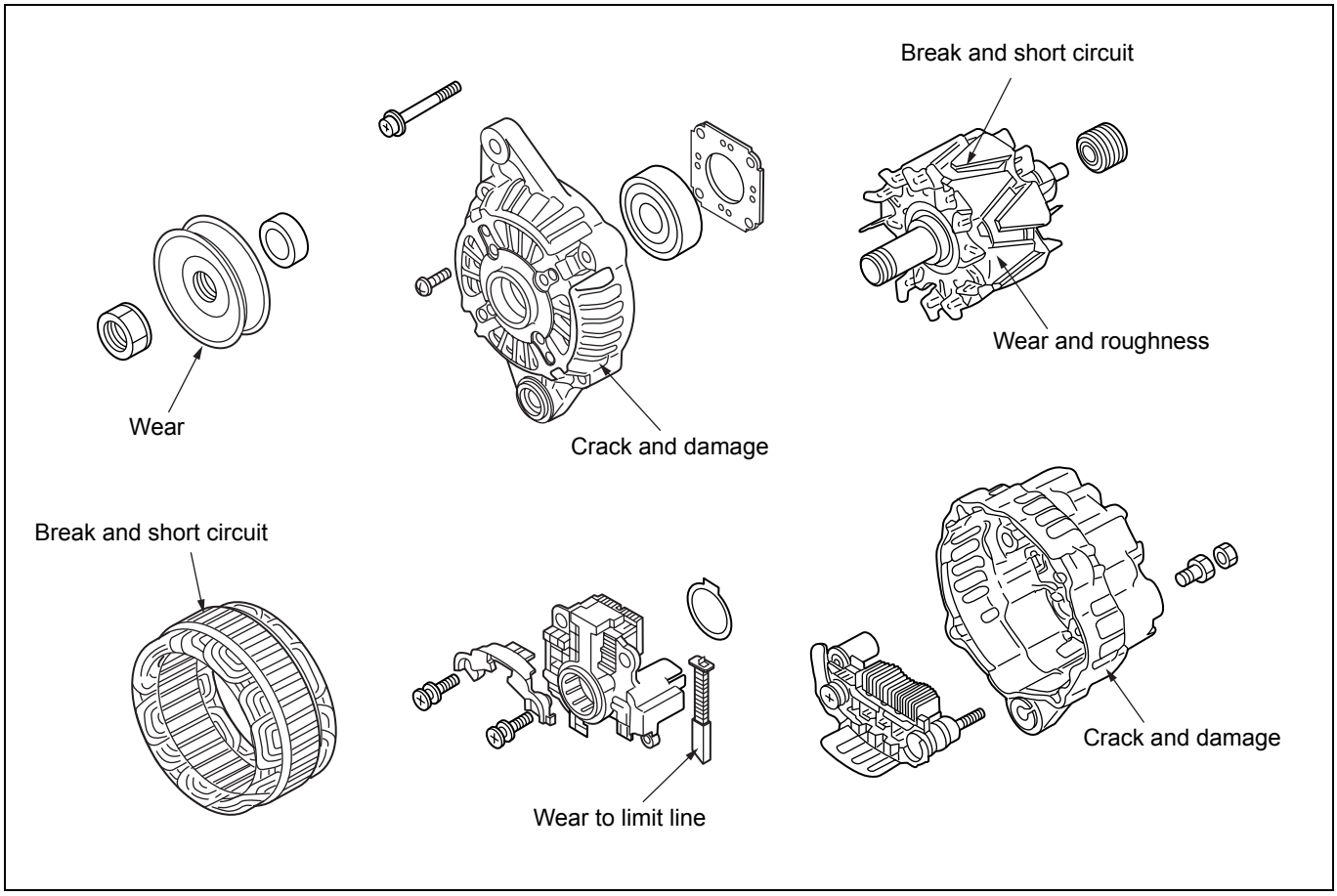


Figure 138 Inspection of alternator

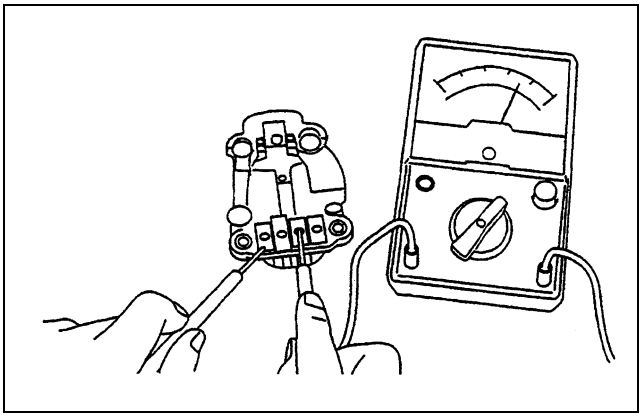


Figure 139 Checking diodes

33.7.1 Inspecting the diodes

Check each built-in diode in the rectifier for continuity as follows:

1. Connect a circuit tester (ohm meter) across the lead wire and case of the diode to be tested. The diode is considered as normal if its resistance is large in either direction and small in the reverse direction.
2. If there is equal resistance in both directions, the diode is suspected to be defective.
   Replace the rectifier assembly.
3. Check every diode for continuity.

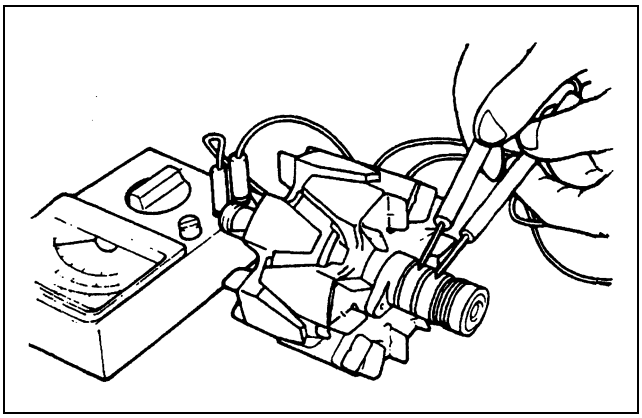


Figure 140 Checking field coil for continuity

33.7.2 Inspecting the field coil

1. Check continuity between slip rings. If there is no continuity, the field coil is suspected to be broken. Replace the field coil.
2. Check for continuity between a slip ring and shaft (or core). If any continuity is found, the field coil is suspected of grounding. Replace the field coil.

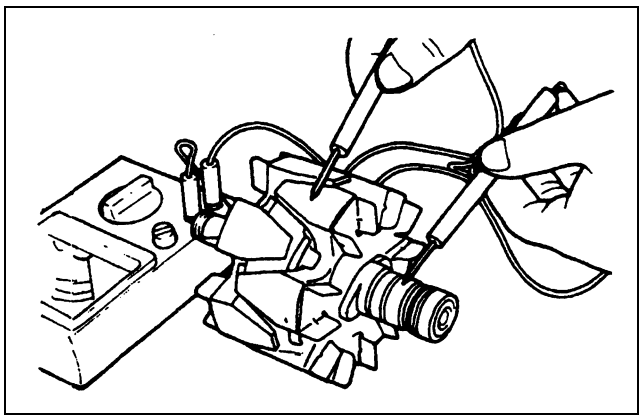


Figure 141 Checking field coil for insulation

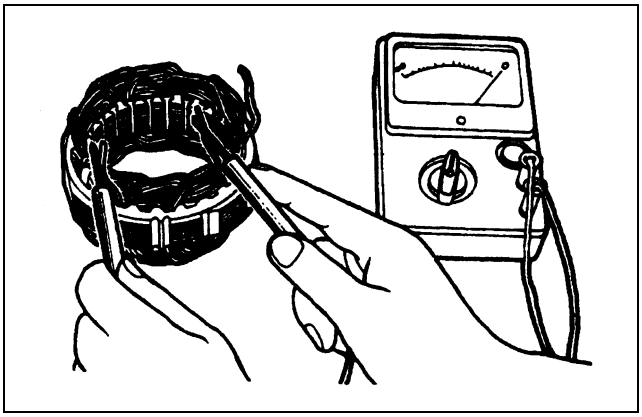


Figure 142 Checking stator coil for continuity

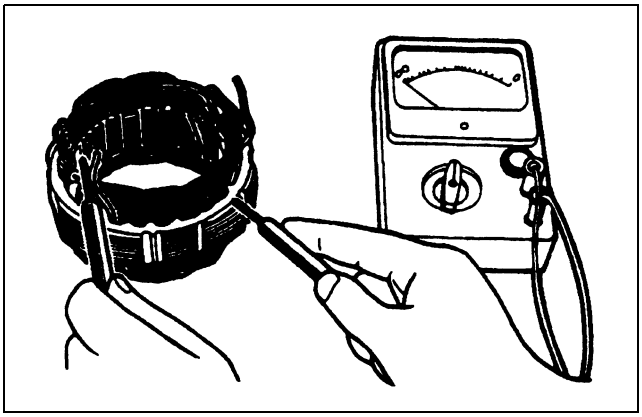


Figure 143 Checking stator coil for insulation

33.7.3 Inspecting the stator coil

1. Check for continuity between lead wires of the stator coil. If there is no continuity, the stator coil is suspected to be broken. Replace the stator coil.
2. Check for continuity between each lead wire and stator core. If any continuity is found, the stator coil is suspected of grounding. Replace the stator coil.

33.8 Assembly of alternator

Reassemble the alternator in the reverse sequence of disassembly and pay attention to the following:

1. The rear bearing has an eccentric groove. Install the snap ring so that its protrusion fits to the deepest part of the groove.
2. When installing a new rear bearing, press-fit the bearing with its groove facing to the slip ring side.
3. When press-fitting the rear bearing into the rear bracket, heat the bracket.

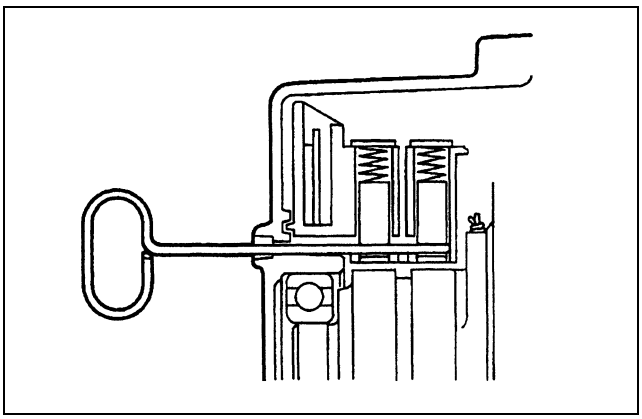


Figure 144 Lifting brushes

⚠ CAUTION

Before installing the rotor to the rear bracket, insert a wire through the small hole in the rear bracket to lift the brushes. Remove the wire after the rotor is installed.

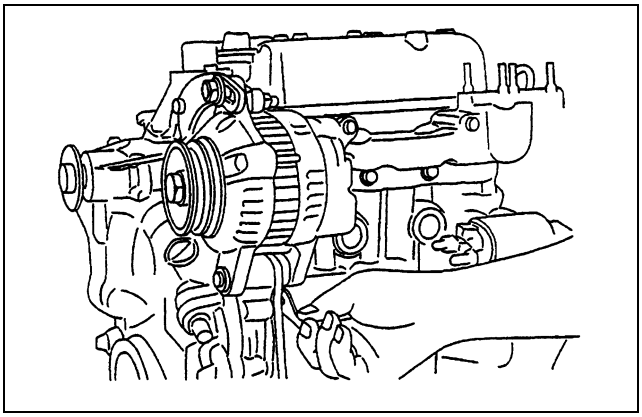


Figure 145 Inserting spacer

33.9 Installation

Install the alternator in the reverse sequence of removal.

33.9.1 Insertion of spacer

When installing the support bolts, insert the spacer in place using the following procedure:

1. Push in the support bolts to the normal position. (Without nuts.)
2. Push the alternator backward. Measure the clearance between the alternator rear bracket and gear case bracket to determine the number of spacers to be inserted into the clearance (0.2 mm [0.0079 in.] maximum).
3. Reinstall the alternator with the necessary spacer inserted in place. Tighten the support bolt nuts securely.
4. Perform the belt tension adjustment.

33.10 Alternator and regulator

33.10.1 Specifications

For specifications, refer to 8-2.

33.10.2 Inspection

1. Inspecting the unit in service
   Measure battery voltage between terminals with a circuit tester. It is considered as normal if no-load measurement is kept steady at about 15.0V with 5000 min^{-1} or more of alternator speed.

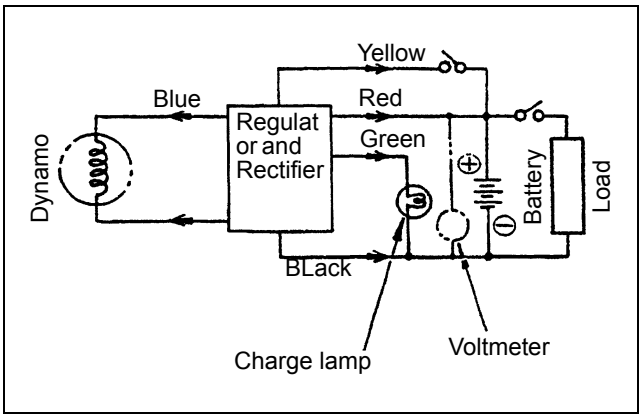


Figure 146 Measuring voltage across battery terminals

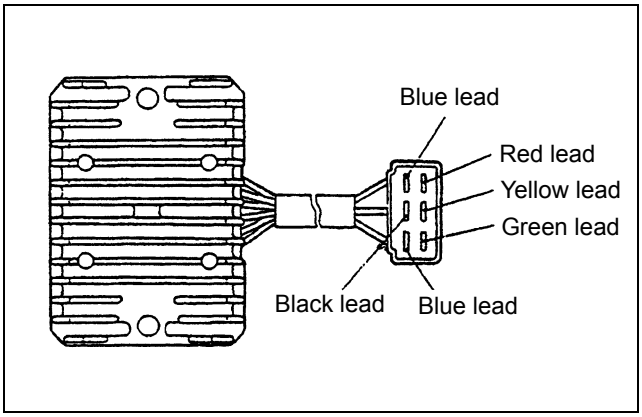


Figure 147 Lead outlet coupler

2. Inspecting the regulator alone
To judge if the regulator itself is acceptable or not, check the regulator for normal continuity by connecting the circuit tester to the lead wires as follows:

Item		Normal measure -ment	If abnormal – possible cause of regulator trouble
Tester (+)	Tester (–)		
Red	Blue 1	Continuity	Broken diode
Red	Blue 2		
Blue 1	Black		
Blue 2	Black		
Blue 1	Red	Non-continuity	Shorted diode
Blue 2	Red		
Black	Blue 1		Shorted diode or thyristor
Black	Blue 2		

Table 52 Inspection of the regulator

⚠ NOTE

For testing, use an ohmmeter as the circuit tester.

33.10.3 Installation

Heat tremendously affects the regulator and the rectifier. Therefore it is necessary to install them in a well-ventilated area. reassemble the regulator in the proper direction by positioning the head of the outlet leads downward.

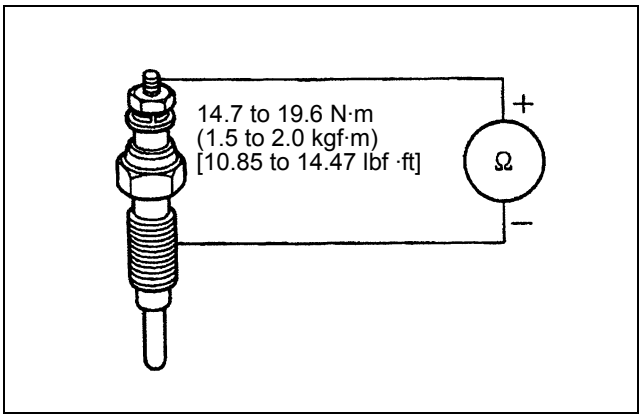


Figure 148 Checking glow plug

34 GLOW PLUG

34.1 Removal

Be careful not to damage the tip of glow plug when removing. Glow plug tightening torque : 14.7 to 19.6 N·m (1.5 to 2.0 kgf·m) [10.85 to 14.47 lbf·ft]

34.2 Inspection

Check for continuity between the glow plug terminal and body. If there is no continuity at all or large resistance, replace the plug.

34.3 Installation

Tighten the glow plug to the specified torque.

35 KEY-OFF STOP SYSTEM

35.1 General

The function of this system is to actuate the fuel cutoff solenoid when the starter key is placed in the OFF position. It also has the emergency engine stop function by actuating the control timer in case of abnormal low oil pressure or abnormal coolant temperature.

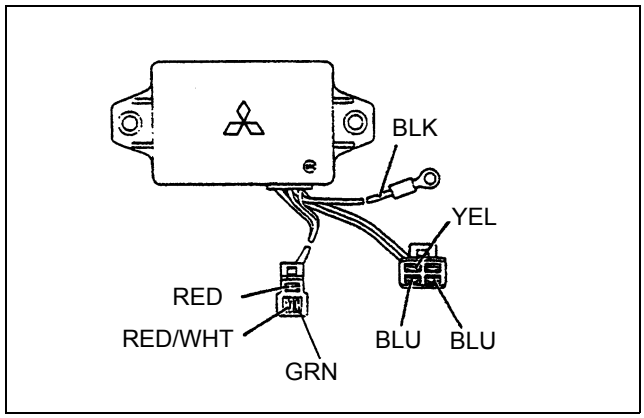


Figure 149 Timer unit

35.2 Control timer unit

Description	Specification
Input voltage	9V to 15V DC
Load	Solenoid (Coil resistance 1.7 Ω or more)

Table 53 Control timer unit

No.	Cord Color	Connect with
1	Blue	Solenoid
2	Blue	Solenoid
3	Red	Battery (Key switch “B”)
4	Green	Key switch “ON”
5	Red/White	Starter (Key switch “ST”)
6	Yellow	Oil pressure switch
7	Black	(Ground)

Table 54 Control timer unit

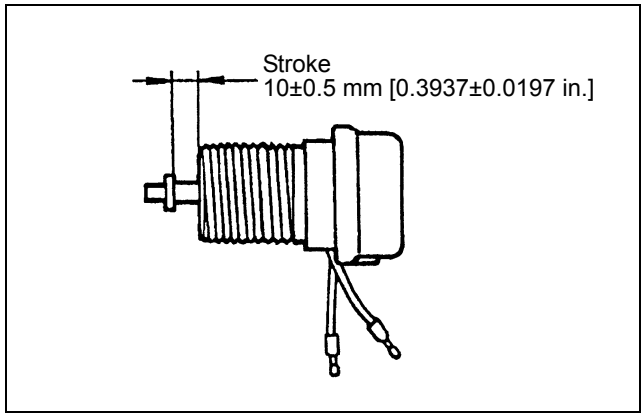


Figure 150 Fuel cutoff solenoid (ETS type)

35.3 Fuel cutoff solenoid (ETS type)

35.3.1 Specification

Description	Specification
Type	ETS type (Energize To Stop)
Voltage	10V to 15V DC
Coil resistance	1.6 Ω±10% (at 20°C [68°F])
Stroke	10±0.5 mm [0.3937±0.0197 in.]

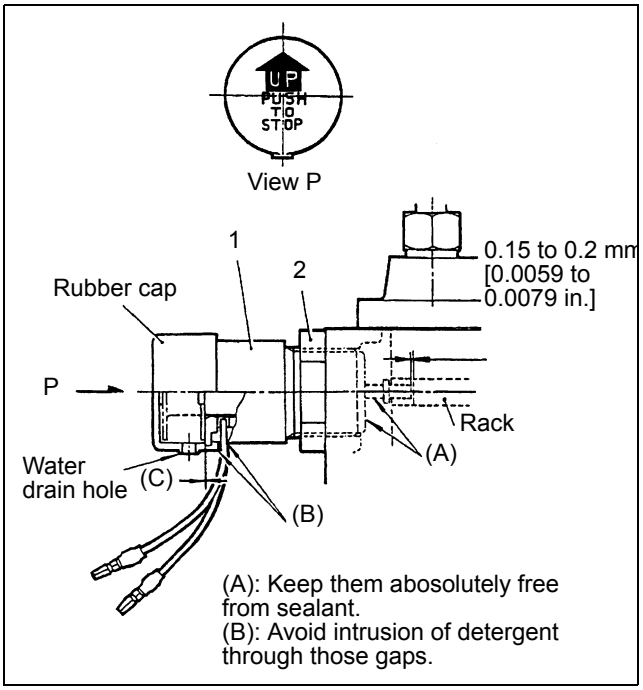


Figure 151 Solenoid installation

35.3.2 Solenoid installation procedure

1. Temporarily fit the solenoid 1 and nut 2 to the crankcase. (Coat the effective thread of solenoid with THREE-BOND 1212 or 1211.)
2. Turn in the solenoid so that clearance “C” becomes zero at the injection pump rack position zero (stop position).
3. Turn back the solenoid 30° to 40° (the clearance between the rack and shaft will be 0.15 to 0.20 mm [0.0059 to 0.0079 in.]) and tighten the locknut.
4. Start the engine. Confirm that the engine is stopped without fail when the solenoid shaft is fully pushed.
5. Install the rubber cap with the arrow mark pointing up (water drain hole faces down).

⚠ CAUTION

Be careful not to allow detergent intrude into the solenoid terminal and solenoid interior (cords and shaft).

35.3.3 Cares after engine assembly

1. Make the “Key-OFF stop” system wiring properly, according to the foregoing wiring diagrams. (Refer to GENERAL.)
2. Start the engine and confirm that the solenoid comes into action to stop the engine when the key switch is placed in the OFF position.
3. Confirm that the engine comes to stop when the oil pressure switch terminal is short-circuited to the switch body.

NOTE

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

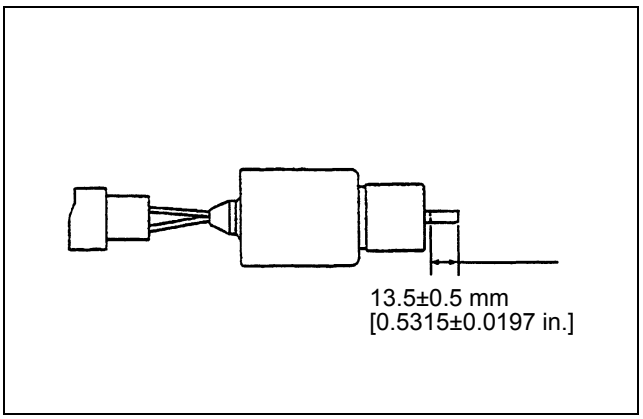


Figure 152 Fuel cutoff solenoid (ETR type)

35.4 Fuel cutoff solenoid (ETR type)

35.4.1 Specification

Description	Specification
Type	ETR type (Energize To Run)
Rated voltage	12V DC
Rated temperature	20°C [68°F]
Coil resistance, pull	0.25 Ω±10%
Coil resistance, hold	13.5 Ω±10%

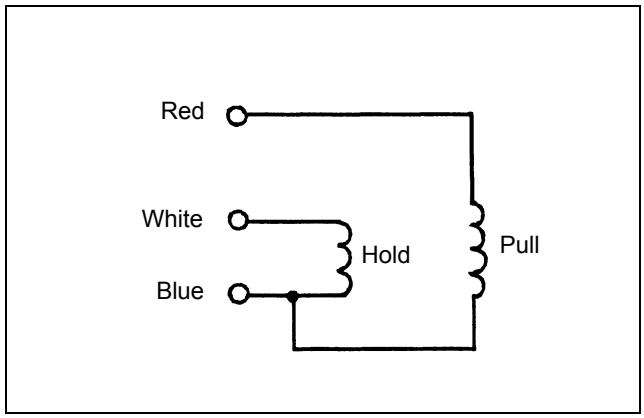


Figure 153 Fuel cutoff solenoid (ETR type) diagram

Description	Specification
Stroke	13.5±0.5 mm [0.5315±0.0197 in.]
Rated current, pull	55A
Rated current, hold	1A

35.4.2 Solenoid installation

In this solenoid, under the switch key is turned to the OFF position, the solenoid shaft is pulled in when the solenoid is functioned and the shaft is returned (protruded). Install the solenoid while it is not functioned (its shaft is protruded), using the same procedure as mentioned before for the push type, so that the specified clearance between the solenoid shaft and injection-pump rack can be obtained.

NOTE

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

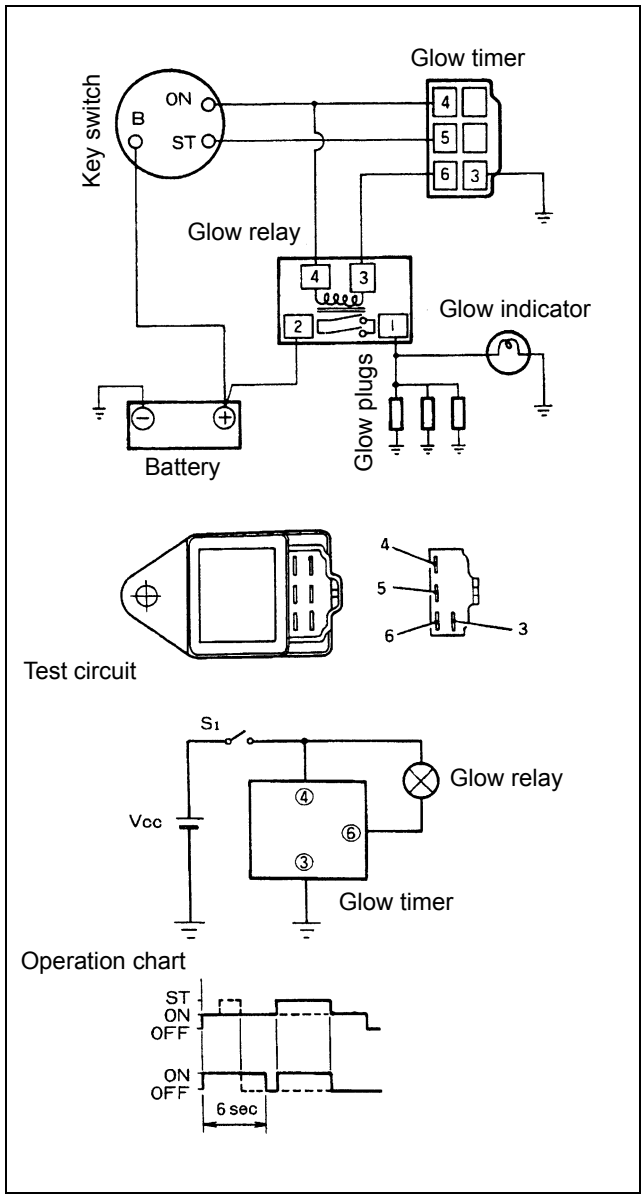


Figure 154 Glow timer system

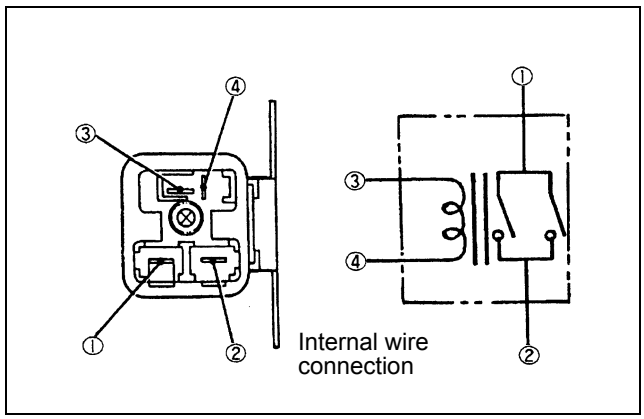


Figure 155 Glow relay

36 GLOW TIMER SYSTEM

36.1 General

The glow plugs are used to help easy start of a cold engine by preheating the combustion chamber.
In the standard-specification engines, it is necessary to keep the starter key at the “glow” position for 20 to 30 seconds by hand in order to heat the glow plugs.
The glow timer system eliminates the necessity of keeping the key switch at the “glow” position and shortens the glow plug heating time (6 seconds). This system remarkably simplifies the glow plug operation.

36.2 Glow timer

Description	Specification
Model	p/n MM431762
Rated voltage	12V DC
Working temperature	20°C [68°F]
Initial performance (at normal temperature, normal humidity, VCC: 12V)	$6\ ^{+1.4}_{-0}$ sec. (*1)

⚠ NOTE

*1 Using the test circuit shown, measure the time spent until the glow relay trips to ON after the switch S1 is closed.

36.3 Glow relay

Description	Specification
Model	p/n MM43128201
Rated voltage	12V DC
Continous rating	1 min
Coil resistance	13 Ω
Inductance	24 mH (at 1 kHz)

SERVICE DATA

37 PERIODIC INSPECTION CHART

37.1 Periodic service chart

⊗ ····Inspect, adjust or replenish, o ····Clean, ● ····Replace, Δ ····Drain

Unit and point	Service interval	Before daily operation	After first 50 service hours	Every 50 service hours	Every 100 service hours	Every 250 service hours	Every 500 service hours	Every 1000 service hours	Before storage	Remark
Engine	Loose damaged or leakage parts	⊗								
	Exhaust, noise and vibration	⊗								
	Retightening bolts and nuts		⊗					⊗		
	Valve clearance		⊗				⊗			
	Engine idling		⊗				⊗			
	Cylinder compression pressure							⊗		
Lubricating system	Engine lube oil	⊗	●			●				
	Oil filter (cartridge type)		●			●				
	Oil filter (disassembly type)		●			●				
Fuel system	Fuel	⊗							Δ	
	Fuel tank			Δ					o	
	Fuel filter (element)				o		●			
	Water sedimeter			Δ						
	Fuel feed pump (filter element)	⊗					●			
	Fuel injection nozzle						⊗			
Intake system	Air cleaner (Paper-element type)				o		●			
	Air cleaner (Oil-bath type)	⊗			o●					Clean filter and replace oil
Cooling system	Coolant	⊗	●					●	Δ	When no antifreeze is used, drain after daily operation
	Fan belt	⊗								
Electrical system	Instruments (Incl. pilot lamps)	⊗								
	Battery			⊗						Check elctrolyte level and specific gravity
	Starter, alternator and regulator						⊗	⊗*		*: Adjust for voltage and current.
	Glow plug						⊗			
	Stop solenoid	⊗								Inspect proper function.

Table 55 Specifications

38 SPECIFICATIONS[1] AND MAINTENANCE STANDARDS

38.1 Engine Main Parts

Unit: mm (in.)

Description	Specification or Standard	Repair Limit	Service Limit
Cylinder compression pressure	2.7 MPa (28 kgf/cm^2) [398 psi] (at 280 RPM)	2.5 MPa (25 kgf/cm^2) [356 psi]	2.2 MPa (22 kgf/cm^2) [313 psi]
Difference between cylinders (maximum)	0.25 MPa (2.5 kgf/cm^2) [35.6 psi]		
Fuel injection order	L2: 1-2, L3: 1-3-2		
Cylinder head			
Bottom surface distortion (Flatness)	Within 0.05 [0.0020]	0.1 [0.0039]	
Valve guide Inside diameter (IN and EX)	6.6 [0.2598]		
Valve seat angle (IN and EX)	45°		
Valve seat width (IN and EX)	1.3 to 1.8 [0.0512 to 0.0709]	2.5 [0.0984]	
Valve seat sinkage			–1 [-0.0394]
Valve clearance (IN and EX)	0.25 [0.0098] (Cold)		
Valve			
Valve head diameter (IN)	26.7 [1.0512]		
(EX)	24.7 [0.9724]		
Overall length	94 [3.7008]		
Stem Outside diameter	6.6 [0.2598]		
Stem to Guide clearance (IN)			0.10 [0.0039]
(EX)			0.15 [0.0059]
Valve face angle	45°		
Valve head thickness (Margin width)	1.0 [0.0394]		0.5 [0.0197]
Valve head sinkage (from cylinder head bottom face)	0.5 [0.0197]		
Valve spring			
Free length, p/n MM432-668 (white color on the 2 upper side coils)	40.5 [1.5945]	39.3 [1.5472]	
Free length, p/n 30L04-04500 (yellow color on the 2 upper side coils)	40.0 [1.5748]		
Set force/Set length, p/n MM432-668 (white color on the 2 upper side coils)	58 N (5.94 kgf) [13.1 lbf]/35.5 mm [1.3976 in.] 146 N (14.84 kgf) [32.7 lbf]/28 mm [1.1024 in.]		–15%
Set force/Set length, p/n 30L04-04500 (yellow color on the 2 upper side coils)	68 N (6.89 kgf) [15.2 lbf]/35.5 mm [1.3976 in.] 180 N (18.36 kgf) [40.5 lbf]/28 mm [1.1024 in.]		–15%
Perpendicularity	2°		3°
Rocker arm			
Rocker arm Inside diameter	12 [0.4724]		
Rocker arm to Shaft clearance			–0.2 [–0.0079]
Crankcase			
Camshaft hole diameter			
Front	42 [1.6535] Ball bearing hole		
No. 2	34 [1.3386]		
No.3	33 (L3) [1.2992]		
Rear	33 [1.2992]		

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

Unit: mm (in.)

Description	Specification or Standard	Repair Limit	Service Limit
Cylinder bore			
L2A, L3A	65 [2.5591]]	+0.2 [0.0079]	+0.70 [0.0276]
L2C, L3C	70 [2.7559]	+0.2 [0.0079]	+0.70 [0.0276]
L2E, L3E	76 [2.9921]	+0.2 [0.0079]	+0.70 [0.0276]
Oversize finish tolerance	0 to 0.03 [0 to 0.0012] for each oversize		
Cylindricity	0.01 [0.0004] or less		
Gasket fitting surface distortion	0.05 [0.0020] or less	0.1 [0.0039]	
Piston			
Type	Solid type		
Material	Aluminum alloy		
Outside diameter (Skirt end)			
L2A, L3A	65 [2.5591]		
L2C, L3C	70 [2.7559]		
L2E, L3E	76 [2.9921]		
Clearance to cylinder			0.2 [0.0079]
Oversize	0.25 [0.0098], 0.50 [0.0197]		
Protrusion from crankcase top surface	0.9 [0.0354]		
Piston pin			
Type	Semi-floating type		
Outside diameter	Outside diameter		
Piston pin to piston clearance			0.08 [0.0031]
Piston pin to connecting rod clearance	Press-fit load: 1000±500 kg [2204.6±1102.3 lb]		(Within standard range)
Piston ring			
Number of rings			
Compression	2{ No.1: Chrome plated, semi-keystone type No.2: Tapered		
Oil	1 (Chrome plated ring with coil expander)		
Ring width			
Compression (No.2)	2 [0.0787]		
Oil	3 [0.1181]		
Ring side clearance			
Compression No.1	—		
Compression No.2	0.05 to 0.09 [0.0020 to 0.0035]		0.2 [0.0079]
Oil ring	0.03 to 0.07 [0.0012 to 0.0028]		0.2 [0.0079]
Ring gap			
Compression No.1, No.2	0.15 to 0.30 [0.0059 to 0.0118]		1.5 [0.0591]
Oil ring	0.15 to 0.35 [0.0059 to 0.0138]		
Connecting rod			
Type	Forged I-beam		
Deflection and twist	Within 0.05 [0.0020]		0.15 [0.00591] max.
Big end thrust clearance	0.1 to 0.35 [0.0039 to 0.0138]		0.5 [0.0197]

Unit: mm (in.)

Description	Specification and Standard	Repair Limit	Service Limit
Connecting rod bearing			
Type	Aluminum metal with back metal		
Oil clearance			0.15 [0.0059]
Under size	0.25 [0.0098], 0.50 [0.0197]		
Crankshaft			
Type	Fully counterbalanced		
Deflection	Within 0.03 [0.0012]		0.05 [0.0020]
End play	0.05 to 0.175 [0.0020 to 0.0069]		0.08 [0.0031]
Journal outside diameter	43 [1.6929]	–0.15 [–0.0059]	–0.70 [–0.0276]
Pin outside diameter	40 [1.5748]	–0.15 [–0.0059]	–0.70 [–0.0276]
Undersize finishing			
Journal U.S.			
0.25 [0.0098]	42.715 to 42.730 [1.6817 to 1.6823]		
0.50 [0.0197]	42.465 to 42.480 [1.6718 to 1.6724]		
Pin U.S.			
0.25 [0.0098]	39.715 to 39.730 [1.5636 to 1.5642]		
0.50 [0.0197]	39.465 to 39.480 [1.5537 to 1.5543]		
Main bearing			
Type	Aluminum metal with back metal (No.2: Flanged metal)		
Oil clearance			0.10 [0.0039]
Undersize	0.25 [0.0098], 0.50 [0.0197]		
Camshaft			
Driving method	Gear drive		
Front journal	Ball bearing		
Journal to cylinder block hole clearance			0.15 [0.0059]
Major diameter of cam (IN and EX)	27.37 [1.0776]		–1.0 [–0.0394]
Oil clearance			0.15 [0.0059]
Piston pin			
Type	Semi-floating type		
Outside diameter	Outside diameter		
Piston pin to piston clearance			0.08 [0.0031]
Piston pin to connecting rod clearance	Press-fit load: 1000±500 kg [2204.6±1102.3 lb]		(Within standard range)
Injection pump camshaft			
Driving method	Gear drive		
Bearing	Ball bearing (Front and rear)		
Major diameter of cam	30 [1.1811]		–0.7 [–0.0276]
Tappet			
Outside diameter	19 [0.7480]		
Clearance between tappet and crankcase			0.15 [0.0059]
Pushrod			
Deflection	Within 0.3 [0.0118]		

38.2 Lubrication System

Unit: mm (in.)

Description	Specification and Standard	Repair Limit	Service Limit
Oil specification			
API service classification	Class CD or higher		
Viscosity			
above 20°C [68°F]	SAE30 or 10W – 30		
5 to 20°C [41 to 68°F]	SAE20 or 10W – 30		
below 5°C [41°F]	SAE10W – 30		
Oil capacity			
L2 (standard): Upper limit/Lower limit	2.4/1.4 l [0.6341/0.3699 U.S.gal] (excl. 0.5 l [0.1321 U.S.gal] in oil filter)		
L3 (standard): Upper limit/Lower limit	3.0/1.5 l [0.7926/0.3963 U.S.gal] (excl. 0.5 l [0.1321 U.S.gal] in oil filter)		
L3 (large): Upper limit/Lower limit	0.05 to 0.175 [0.0020 to 0.0069] (excl. 0.5 l [0.1321 U.S.gal] in oil filter)		
: Upper limit/Lower limit	4.8/3.0 l [1.2682/0.7926 U.S.gal] (excl. 0.5 l [0.1321 U.S.gal] in oil filter)		
Oil pump			
Type	Gear type		
Check valve opening pressure	0.3±0.03 MPa (3.0±0.3 kgf/cm^2) [42.68±4.27 psi] (1000 RPM)		
Outer rotor to Housing clearance	0.100 to 0.196 [0.0039 to 0.0077]	0.3 [0.0118]	
Outer rotor thrust clearance	0.04 to 0.10 [0.0016 to 0.0039]	0.25 [0.0098]	
Oil pressure switch			
Contact closing pressure (Standard type)	0.05±0.01 MPa (0.5±0.1 kgf/cm^2) [7.11±1.42 psi]		

38.3 Fuel System

Unit: mm (in.)

Description	Specification and Standard	Repair Limit	Service Limit
Fuel specification	Diesel-fuel JIS No.2 (JIS No.3 in cold weather)		
Fuel filter			
Type	Paper-element type		
Fuel feed pump			
Type	Electromagnetic diaphragm type		
Delivery	0.37 l [0.0977 U.S.gal]/min (12V, at 20°C [68°F])		
Fuel feed pump			
Type	Electromagnetic diaphragm type		
Delivery:	Electromagnetic diaphragm type		
Common type	0.37 l [0.0977 U.S.gal]/min (12V, at 20°C [68°F])		
Compact type	0.37 l [0.0977 U.S.gal]/min (12V, at 20°C [68°F])		
Fuel feed pump			
Type	Mechanical drive type		
Delivery	0.225 l [0.0594 U.S.gal]/min		
Fuel injection pump	For exclusive L2 or L3 use Model		
Type	ND-PFR2NC or ND-PFR3NC		
Nozzle			
Type	Throttle type		
Injection start pressure	$13.7^{+1.0}_{-0}$ MPa (140^{+10}_{-0} kgf/cm^2) [1992 psi]	Within Standard range	

38.4 Governor System

Unit: mm (in.)

Description	Specification and Standard	Repair Limit	Service Limit
Governor Type	Centrifugal weight type		

38.5 Cooling System

Unit: mm (in.)

Description	Specification and Standard	Repair Limit	Service Limit
Cooling fan Type L2: Standard L3: Standard	uneven pitch, pusher or suction 4-blade or 5-blade, (ø 290 [11.4173]) 5-blade or 6-blade, (ø 320 [12.5984])		
Fan belt Type Length (Standard)	HM type 890 [35.0393]		
Water pump Type	Centrifugal impeller type		
Thermostat (76.5°C specification) Type Valve cranking temperature Full-opening temperature at 6 mm [0.2362 in.] valve lift	Wax type 76.5 ± 1.5°C [169.7±2.7°F] 90°C [194°F]		
Thermostat (71°C specification) Type Valve cranking temperature Full-opening temperature at 6 mm [0.2362 in.] valve lift	Wax type 71°C [159.8°F] 85°C [185°F]		
Thermo switch Type Model (Part No.) Contact closing temperature	Bimetal type FW065102G220 (MM432104) 111±3.5°C [231.8±6.3°F]		
Temperature gage unit Type Model (Part No.) Standard (°C [°F]/Ω)	Thermistor type A20 – WEu (MD001380) 70 [158]/104±13.5, 115 [239]/23.8±2.5		
Temperature gage unit Type Model (Part No.) Standard (°C [°F]/Ω)	Thermistor type YM–016–02–Wo = Tu (MM435133) (35 [95.0]/670), (50[122.0]/350), 80 [176.0]/118±6, (100 [212.0]/63.5), (105 [221.0]/54.5), 115 [239.0]/42±2.5, (120 [248.0]/36.2, (140 [284.0]/22)		
Thermometer unit Type Model (Part No.) Standard (°C [°F]/Ω)	Thermistor type 51400–K002–0 (0452510100) 50 [122.0]/80±10, 60 [140.0]/56.3±5, 80 [176.0]/29.5±2.5, 100 [212.0]/16.5±2.5, 106 [222.8]/14.3±0.5		

38.6 Electrical System

Unit: mm (in.)

Description	Specification and Standard	Repair Limit	Service Limit
Starter for L2			
Type	Solenoid shift type		
Model	M000T60481 (30L66-10600)		
Voltage–output	12V–1.2 kW		
Direction of rotation	Clockwise as viewed from pinion side		
No-load characteristics			
Terminal voltage	11V		
Current	90A or less		
Speed	2500 RPM or more		
Load characteristics			
Terminal voltage	7.5V		11.5 [0.4528]
Current (torque)	300A (10.5 N·m (1.07 kgf·m) [7.7 lbf·ft] or more)		0.7 [0.0276]
Speed	850 RPM or more		
Pinion gap	0.5 to 2.0 [0.0197 to 0.0787]		
Thrust gap	0.5 [0.0197] or less		
Starter for L3			
Type	Solenoid shift type		
Model	M001T68381 (30L66-10500)		
Voltage–output	12V–1.7 kW		
Direction of rotation	Clockwise as viewed from pinion side		
No-load characteristics			
Terminal voltage	11V		
Current	110A or less		
Speed	2400 RPM or more		
Load characteristics			
Terminal voltage	7.7V		11.5 [0.4528]
Current (torque)	400A (16.0 N·m (1.63 kgf·m) [11.8 lbf·ft] or more)		0.7 [0.0276]
Speed	740 RPM or more		
Pinion gap	0.5 to 2.0 [0.0197 to 0.0787]		
Thrust gap	0.5 [0.0197] or less		
Alternator			
Type	AC type with built-in IC regulator		
Model	A007TA01718 (30A68-00801)		
Voltage-output	12V–40 A		
Direction of rotation	Clockwise as viewed from pulley side		
Output characteristic (Hot)			
Terminal voltage	13.5V		
Current/Speed	21A/ 2500 RPM 37A/5000 RPM		
Regulated voltage	14.7±0.3V		
Glow plug (Quick-heat type)			
Type	Sheath type		
Model: Y-145T	(With hex nut)		
Voltage–current	10.5V–9.7A		
Resistance	0.2 Ω		
Glow plug indicator (Quick-heat type) for L2			
Type	Red-hot type		
Model	DH-139V-19		
Rated current	19A		
Voltage across terminals (at 19A)	1.5V±0.2V		

Unit: mm (in.)

Description	Specification and Standard	Repair Limit	Service Limit
Glow plug indicator (Quick-heat type) for L3			
Type	Red-hot type		
Model	DH-139V-29		
Rated current	29A		
Voltage across terminals (at 29A)	1.7V±0.2V		
Fuel cutoff solenoid			
Type	Electromagnetic ETS push type		
Coil resistance	1.6 Ω±10% (at 20°C [68°F])		
Working voltage	10 to 15V DC		
Stroke	10±0.5 [0.3937±0.0197]		
Temperature range	–30 to 120°C [–22 to 248°F]		
Fuel cutoff solenoid			
Type	Electromagnetic ETR pull type		
Rated voltage	12V DC		
Rated temperature	20°C [68°F]		
Coil resistance	Pull 0.25 Ω±10% Hold 13.5 Ω±10%		
Rated pull current	55A		
Rated hold current	1A		
Control timer			
Input voltage	9V to 15V DC		
Load	Solenoid (Coil resistance 1.7 Ω or more)		
Working temperature	–30 to 80°C [–22 to176°F]		
Glow timer			
Model	S81NJ		
Rated voltage	12V DC		
Working temperature	–40 to 85°C [–40 to 185°F]		
Initial characteristic (Normal temperature, normal humidity, Vcc = 12V)	$6^{+1.4}_{-0}$ sec.		
Environmental characteristic (–30°C to 70°C [–22°F to 158°F], Vcc = 7 to 15V)	$6^{+2.0}_{-0.6}$ sec.		
Glow relay			
Model	G71S P		
Rated voltage	12 V DC		
Continous rating	1 minute		
Coil resistance	13 Ω		
Inductance	24 mH (at 1 KHz)		
Working temperature	-40 to 100°C [-40 to 212°F] (70 to 100°C [158 to 212°F] for 20 sec. or less continued use)		

39 TIGHTENING TORQUE CHART AND SEALANT CHART

39.1 Tightening Torque for Main Bolts

Parts to be tightened	Size (Width across flat of hex. head)	Tightening torque N·m (kgf·n) [lbf·ft]
Cylinder head bolt, main	M10 (14)	73.5 to 83.4 (7.5 to 8.5) [54.25 to 61.48]
Cylinder head bolt, sub	M8 (12)	19.6 to 29.4 (2.0 to 3.0) [14.47 to 21.70]
Connecting rod cap nut	M8 (14)	31.4 to 34.3 (3.2 to 3.5) [23.15 to 25.32]
Flywheel bolt	M10 (17)	83.4 to 93.2 (8.5 to 9.5) [61.48 to 68.71]
Crankshaft pulley nut	M16 (24)	98.1 to117.7 (10.0 to12.0) [72.33 to 86.80]
Main bearing cap bolt	M10 (17)	49.0 to 53.9 (5.0 to 5.5) [36.17 to 39.78]
Rocker stay bolt	M8 (12)	14.7 to 21.6 (1.5 to 2.2) [10.85 to 15.91]
Rocker cover nut	M6 (10)	4.9 to 6.9 (0.5 to 0.7) [3.62 to 5.06]
Nozzle holder (fitting to engine)	M20 (21)	49.0 to 58.8 (5.0 to 6.0) [36.17 to 43.40]
Nozzle union collar fixing nut	M12 (17)	19.6 to 29.4 (2.0 to 3.0) [14.47 to 21.70]
Nozzle retaining nut	M16 (21)	34.3 to 39.2 (3.5 to 4.0) [25.32 to 28.93]
Fuel injection pipe nut	M12 (17)	24.5 to 29.4 (2.5 to 3.0) [18.08 to 21.70]
Delivery valve holder	M16 (17)	34.3 to 38.2 (3.5 to 3.9) [25.32 to 28.21]
Injection pump hollow screw	M10 (14)	9.8 to 14.7 (1.0 to 1.5) [7.23 to 10.85]
Injection pump air vent screw	M6 (10)	4.9 to 6.9 (0.5 to 0.7) [3.62 to 5.06]
Solenoid locknut	M30 (36)	39.2 to 49.0 (4.0 to 5.0) [28.93 to 36.17]
Water temperature gage joint	M16 (23)	19.6 to 29.4 (2.0 to 3.0) [14.47 to 21.70]
Thermoswitch	M16 (19)	18.6 to 26.4 (1.9 to 2.7) [13.74 to 19.53]
Thermo gage unit	M16 (17)	18.6 to 26.4 (1.9 to 2.7) [13.74 to 19.53]
Oil filter	M20	10.8 to 12.7 (1.1 to1.3) [7.96 to 9.40]
Oil relief plug	M18 (22)	39.2 to 49.0 (4.0 to 5.0) [28.93 to 36.17]
Oil drain plug	M18 (19)	49.0 to 58.8 (5.0 to 6.0) [36.17 to 43.40]
Glow plug	M10 (12)	14.7 to 19.6 (1.5 to 2.0) [10.85 to 14.47]
Glow plug lead wire fitting nut	M4 (7)	0.98 to 1.47 (0.1 to 0.15) [0.723 to 1.085]

39.2 Tightening Torque for Common Bolts and Nuts

Unit: kgf·m (lbf·ft) [N·m]

Thread diameter	Identification on head
	7T
M6	7.85 to 9.80 (0.8 to 1.0) [5.79 to 7.23]
M8	14.7 to 21.6 (1.5 to 2.2) [10.85 to 15.91]
M10	29.4 to 41.2 (3.0 to 4.2) [21.70 to 30.38]

39.3 Tightening Torque for Common Plugs

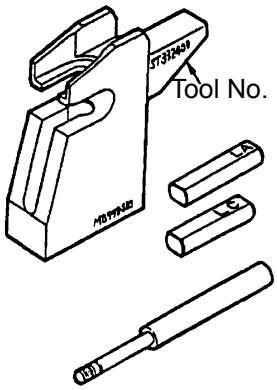
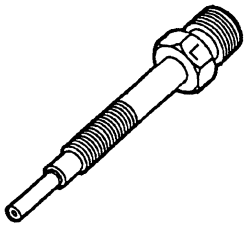
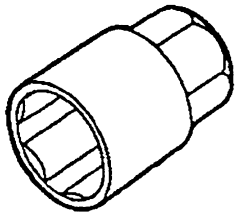
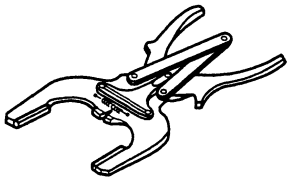
Unit: N·m(kgf·m)[lbf·ft]

Size	For aluminium materials	For ferrous materials
NPTF 1/16	—	7.85 to 11.8 (0.8 to 1.2) [5.79 to 8.68]
PT1/8	7.85 to 11.8 (0.8 to 1.2) [5.79 to 8.68]	14.7 to 21.6 (1.5 to 2.2) [10.85 to 15.91]
PT1/4, NPTF1/4	19.6 to 29.4 (2.0 to 3.0) [14.47 to 21.70]	34.3 to 44.1 (3.5 to 4.5) [25.32 to 32.55]

39.4 Sealant Chart

Parts requiring sealant application		Surface	Sealant	Where sealant-coated parts to be mounted
Threaded parts	Fuel cutoff solenoid	Effective screw threads	THREE-BOND 1212 or 1211	Crankcase
	Water drain joint		HERMESEAL H1 or THREE-BOND 1344	Crankcase
	Oil pressure switch			Crankcase
	Tapper plug (NPTF 1/16)			Crankcase
Press-fit part	Sealing cap	Periphery of press-fit part	HERMESEAL 52B	Cylinder head and crankcase
	Expansion plug			Crankcase
	Oil level gage guide			
Others	Side seal	Periphery	THREE-BOND 1212 or 1211	Crankcase
	Bearing cap	Contact surface with block	THREE-BOND 1212	

40 SPECIAL TOOLS

Tool No.	Toon Name	Style	Usage
ST332400	Piston pin setting tool (Exclusive use for L series)		Removal and installationof piston pin Guide LA (92 l) : for L2A, L3A Guide LC (89.5 l) : for L2C, E, L3C, E
ST332270	Compression gage adapter (Exclusive use for L series)		Measurement of cylinder compression (With “L’” mark)
MD998054	Oil pressure switch socket wrench (26)		Removal and installation of oil pressure switch
31391–12900	Piston ring pliers		Removal and installation of piston ring

In addition to the above, commercially available general tools such as bearing pullers, valve seat cutters, valve guide installers, oil filter wrenches, etc. are required.

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