

# FOREWORD

This Shop Manual is published for the information and guidance of personnel responsible for maintenance of HYUNDAI D4A, D4D series diesel engine, and includes procedures for adjustment and maintenance services.

We earnestly look forward to seeing that this manual is made full use of in order to perform correct service with no wastage.

For more details, please consult your nearest authorized HYUNDAI dealer or distributor.

Kindly note that the specifications and maintenance service figures are subject to change without prior notice in line with improvement which will be effected from time to time in the future.

January.2005

## 1. How This Manual Is Compiled

- This manual is compiled by classifying various systems into certain groups.
- Each group contains specifications; troubleshooting; maintenance service standards; tightening torque; lubricant fluid and sealant; special tools; and service procedure.
- Page enumeration is independent by every group where first page is always 1.

<b>Group No.</b>	<b>Group denomination</b>	<b>Contents</b>
1	General	General specifications, engine No. and name plate, precautions for maintenance operations, table of standard tightening torques
2	Engine proper	Engine body
3	Lubrication	Lubrications system
4	Cooling	Cooling system
5	Engine electrical	Starter, alternator, preheating, engine start system
6	Intake and exhaust	Intake and exhaust system, air cleaner, turbocharger
7	Fuel system	Fuel system



## 2. Terms and Units

The terms and units in this manual are defined as follows.

- **Front and rear**

The terms "front" is the fan side and "rear" the flywheels side of the engine.

- **Left and right**

The terms "right" and "left" shall be used to indicate the side as viewed from the flywheel side of the engine.

- **Terms of service standards**

(1) Standard value

Standard value dimensions in designs indicating : the design dimensions of individual parts, the standard clearance between two parts when assembled, and the standard value for an assembly part, as the case may be.

(2) Limit

When the value of a part exceeds this, it is no longer serviceable in respect of performance and strength and must be replaced or repaired.

- **Tightening torque**

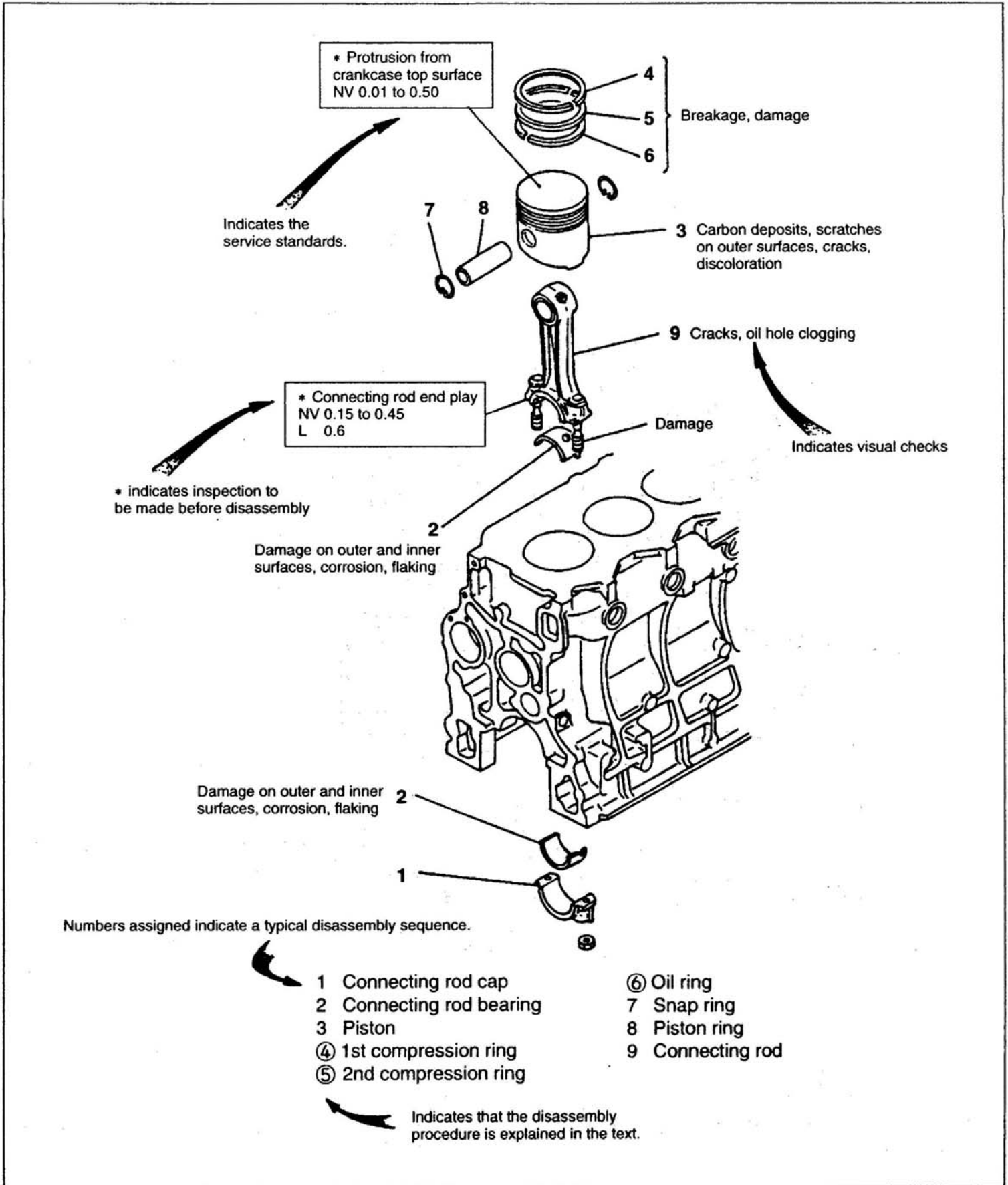
Appropriate tightening torque has particular importance in respect of performance. Accordingly, tightening torque is specified in locations that are to be tightened.

Where there is no specified figure for tightening torque, follow the table covering standard tightening torques.

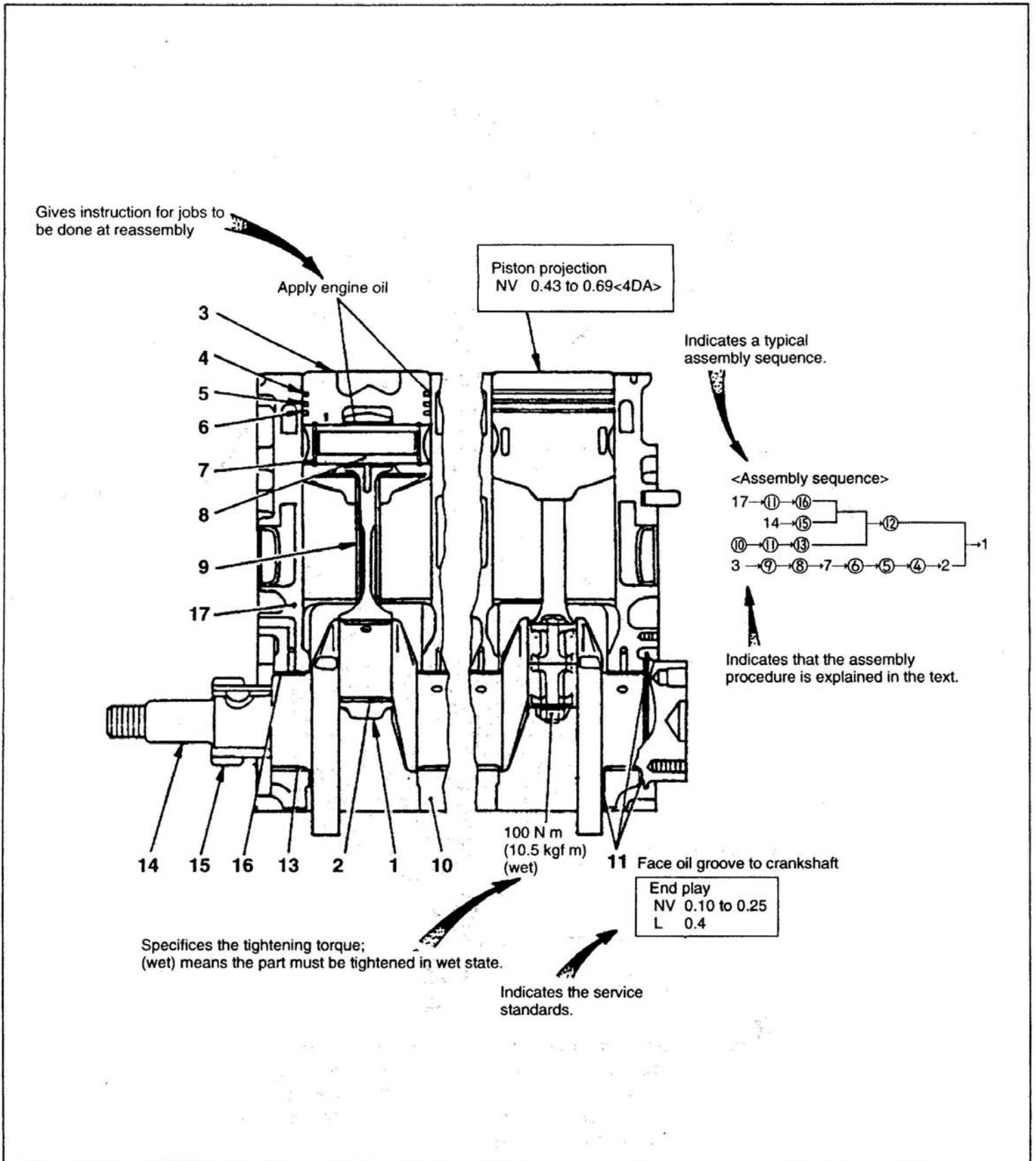
When the item is to be tightened in a "wet" state, wet is indicated. Where there is no indication, read it as dry, and tighten at specified torque.

### 3. READING THE ILLUSTRATION

(Ex. 1 : Disassembly and Inspection)



(Ex. 2 : Reassembly)



Illustrations(exploded views and assembly drawings) show a typical service procedures if it is identical among various types of available systems and units.

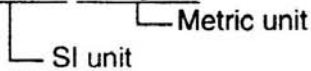
# 1. GENERAL SPECIFICATIONS

## ● Units

Tightening torques and other parameters are given in SI \* units with metric units added in brackets { }.

\* SI : Le Systeme International d'Unites

Example : 390 N.m {40 kgf.m}



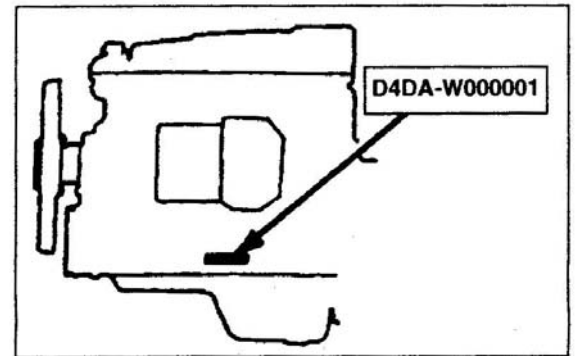
Unit		SI unit {metric unit}	Conversion factor
Force		N {kgf}	9.80665 N {1 kgf}
Moment of force		N · m {kgf · m}	9.80665 N · m {1 kgf · m}
Pressure	Positive pressure	kPa {kgf/cm <sup>2</sup> }	98.0665 kPa {1 kgf/cm <sup>2</sup> }
	Vacuum pressure	kPa {mmHg}	0.133322 kPa {1 mmHg}
		Pa {mmHg}	9.80665 Pa {1 mmHg}
Volume		dm <sup>3</sup> {L}	1 dm <sup>3</sup> {1 L}
Power		kW {PS}	0.7355 kW {1 PS}
Heat quantity		J {kcal}	4186.8 J {1 kcal}
Heat flow		W {kcal/h}	1.16279 W {1 kcal/h}
Angle		°	-
Temperature		°C	-
Electric current		A	-
Voltage		V	-
Resistance		Ω	-
Electric power		W	-

Unit	SI unit	Foot-pound unit	Conversion factor
Force	N(Newton)	lbf	1 N = 0.2248 lbf
Moment of force	N · m	lbf.ft	1 N · m = 0.7375 lbf.ft
Pressure	kPa(kilopascal)	lbf/in. <sup>2</sup>	1 kPa = 0.145 lbf/in. <sup>2</sup>
			1 kPa = 0.2953 in. Hg
Volume	L	gal.	1 L = 0.2642 gal. (U.S.) 1 L = 0.220 gal. (Imp.)
	cm <sup>3</sup>	oz	1 cm <sup>3</sup> = 0.033814 oz (U.S) 1 cm <sup>3</sup> = 0.035195 oz (Imp.)
	cm <sup>3</sup>	cu.in.	1 cm <sup>3</sup> = 0.061023 cu.in.
Power	kW(kilowatt)	HP	1 kW = 1.34 HP
Temperature	°C	°F	t°C = (1.8t°C+32)°F
Mass quantity of matter	kg	lb	1 kg = 2.2046 lb
	g	oz	1 g = 0.035274 oz
Dimension	m	ft.	1 m = 3.2808 ft.
	mm	in.	1 mm = 0.03937 in.
Stress	N/cm <sup>2</sup>	lbf/in. <sup>2</sup>	1 N/cm <sup>2</sup> = 1.45 lbf/in. <sup>2</sup>

The serial number for engine is assigned to the respective engine in manufacturing sequence : every engine has its own number. This number is required for incidental inspection of the engine. Please do not fail to mention this number to the dealers when ordering spare parts.

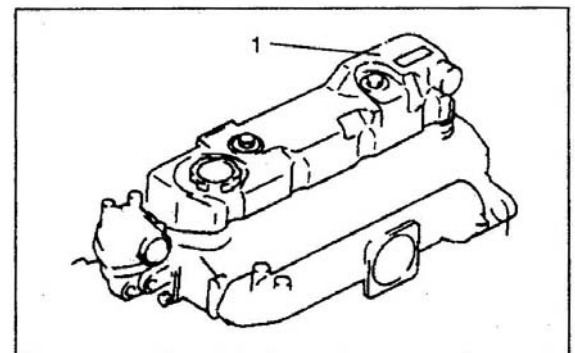
## 2. Engine Number

The engine number is punch-marked on the shown location.




## 3. Name Plate and Caution Plate

1 : Name plate or caution plate



1. ENGINE MODEL
2. TOTAL displacement
3. Rated output
4. Engine speed

<b>D4DA-C</b>			
 <b>HYUNDAI</b>			
TOTAL CYLINDER	VOLUME	3907(cc)	
ENGINE OUTPUT	100/2400 (ps/rpm)		
VALVE CLEARANCE	(GOLD)		
INLET	0.4 mm	EXHAUST	0.4 mm
FIRING ORDER	1 - 3 - 4 - 2		
FUEL INJECTION	TIMING	7° BTDC	

## 4. PRECAUTIONS FOR MAINTENANCE OPERATION

In order to determine the condition of the engine adequately, attend the engine beforehand to find and keep record of the accumulated mileage, operating condition, what the customer's demand is, and other information that may be necessary. Prepare the steps to be taken and perform efficient and wasteless maintenance procedure.

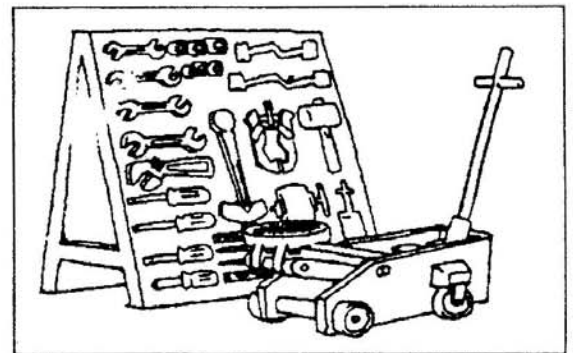
- Determine where the fault exists and check for the cause to see whether removal or disassembly of the part is necessary. Then follow the procedure specified by this manual.
- Perform maintenance work at a level area.



- Prepare general and special tools necessary for the maintenance work.

**NOTE:**

**Do not attempt to use tools other than special tools where use of special tools is specified in this manual. This will avoid injury or damage.**



- When removing or installing the engine, attach the lifting wire rope hooks to the engine's lifting eyes and hoist the engine slowly such that it does not touch other components.

**NOTE:**

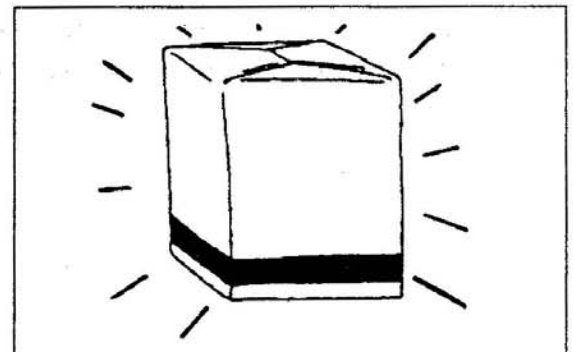
**Check that the wire rope and crane are sufficiently strong.**

- Be particularly careful not to work in shoes that have oily soles and are slippery. When working as a team of two or more, arrange signals in advance and keep confirming safety. Be careful not to accidentally bump switches or levers.
- Check for oil leakage before cleaning the area having the fault other-wise you might miss detecting the leakage.
- Prepare replacement part(s) beforehand.

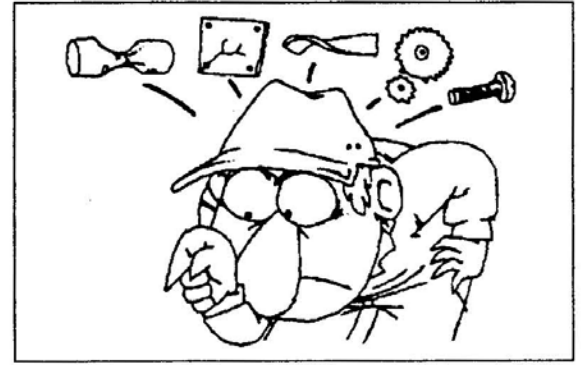


- Replace oil seals, packing, O-rings and other rubber parts ; gaskets and split pins with new parts whenever any of them has been removed.

Use only genuine HYUNDAI replacement parts.



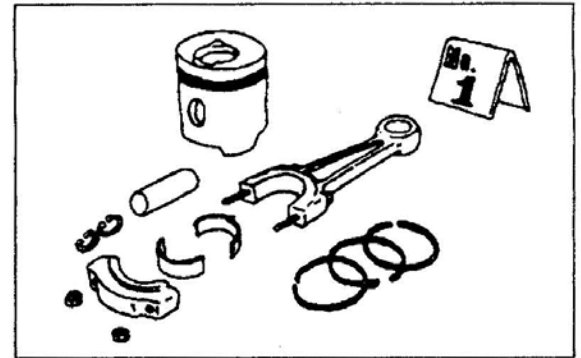
- On disassembly, visually inspect all parts for wear and tear, cracks, damage, deformation, degradation, rust, corrosion, smoothness in rotation, fatigue, clogging and any other possible defect.



- Put alignment marks on part combinations before disassembly and arrange the disassembled parts neatly. This will help avoid mismatching of the parts later. Put the alignment marks, punch marks, etc. Where performance and appearance will not be affected. Cover the area left open after removal of parts to keep it free from dust.

**NOTE:**

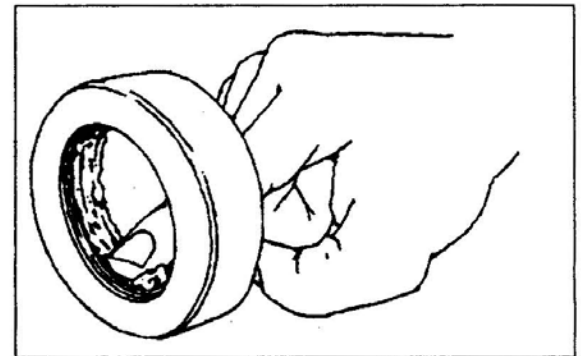
- 1) Take care to avoid mixing up numerous parts, similar parts, left and right, etc.
- 2) Keep new parts for replacement and original (removed) parts separate.



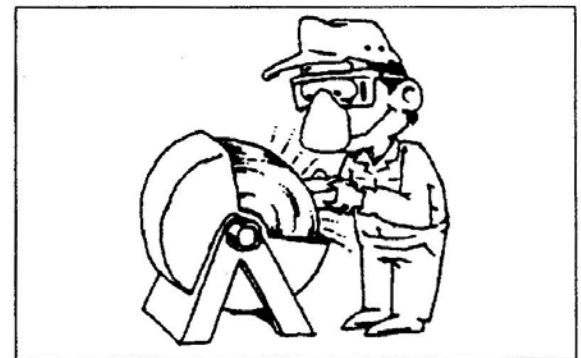
- Apply the specified oil or grease to U-packings, oil seals, dust seals and bearings during assembly.

**NOTE:**

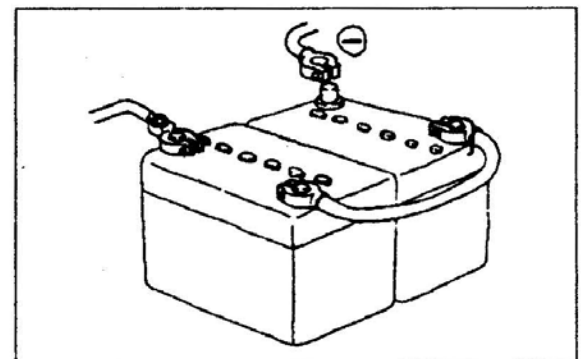
- Use only the specified oil, grease, ect. for lubricant.**  
**Remove the excess immediately after application with a piece of rag.**



- Wear goggles when using a grinder or welder. Pay full attention to safety by wearing gloves when necessary. Watch out for sharp edges, ect. that might injure your hands or fingers.

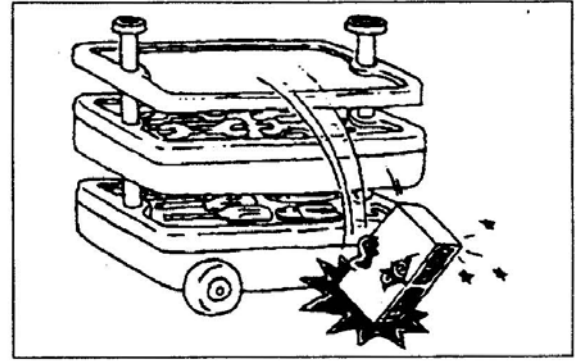


- Before carrying out maintenance work on the electric system, disconnect the negative terminals of the batteries.

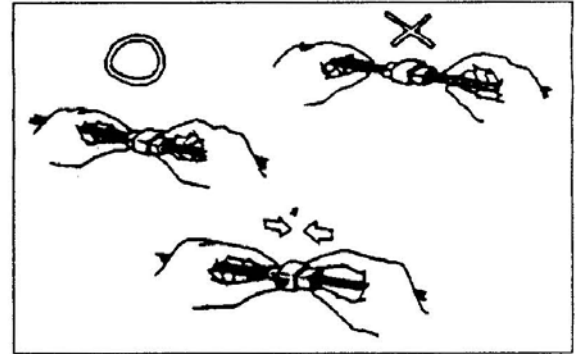




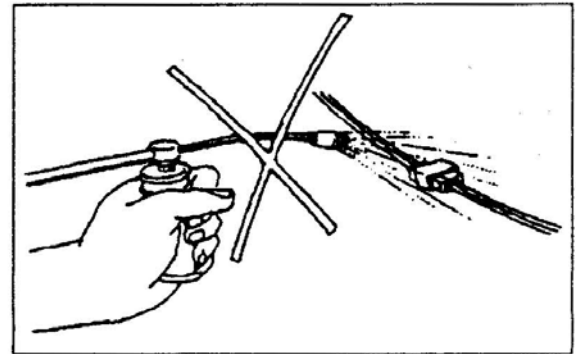
- Take care when handling sensors, relays, etc. which are vulnerable to shock and heat.



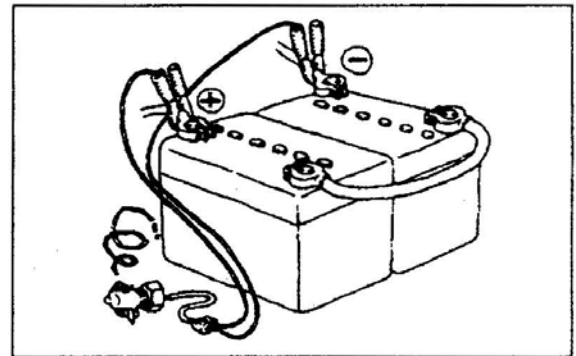
- Pull the connector, and not the harness lead, to separate connectors.  
To separate a lock-type connector, first push toward arrow mark. To re-connect a lock-type connector, press the separated parts until they click together.



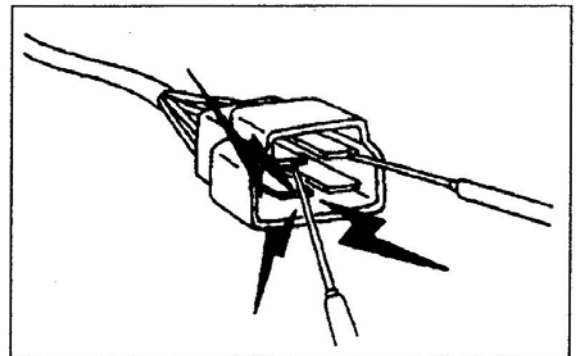
- When washing the Engine, cover the electric system parts and instruments with waterproof material beforehand (Cover with vinyl sheet or the like). Keep water away from harness wire connectors and sensors.  
If any of them should get wet, wipe them off immediately.



- To apply voltage for testing, check that the positive and negative cables are connected properly, then increase voltage gradually from 0 volt. Do not apply voltage higher than the specified value.  
In particular, pay close attention to the electronic control unit and sensors, since they are not always supplied with 24V.



- When using testers or the like for continuity tests, be careful not to allow test probes to touch the wrong terminals.





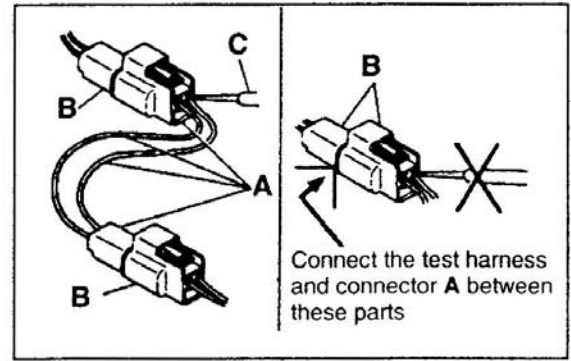
## ● Measurement Procedures Using Connectors

### Test with connectors engaged (continuity through circuit obtained)

<Waterproof connector>

Prepare a test harness and connectors **A**, then connect it between the two parts of harness **B** that is to be tested. Check the circuit by touching test probe **C** to the test connector.

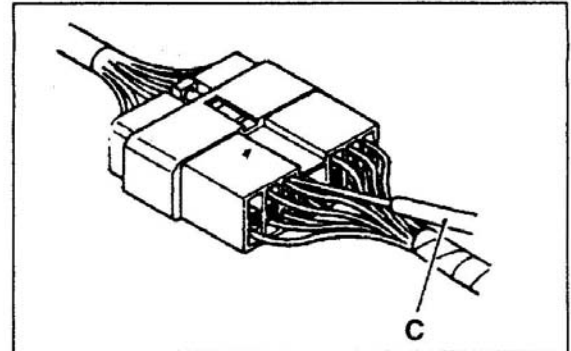
Never insert the test probe from the harness side of the waterproof connection, or waterproof performance might be diminished causing corrosion of the connector.



<Non-waterproof connector>

Insert test probe **C** from the harness side of the connector.

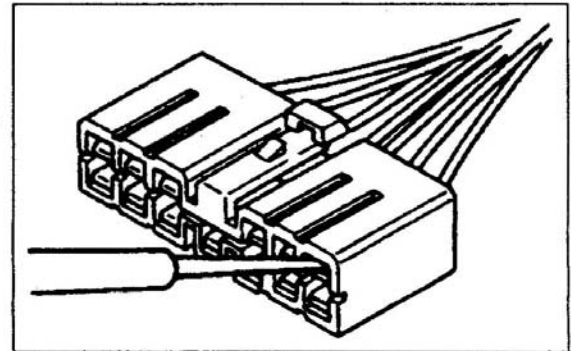
Where control units, etc. have connectors that are too small to accept the test probe, do not force the test probe into them.



### Test with connectors disengaged

Using female pins

Insert a test probe into a terminal. However, do not force the probe into the terminal, or it will cause a poor contact.

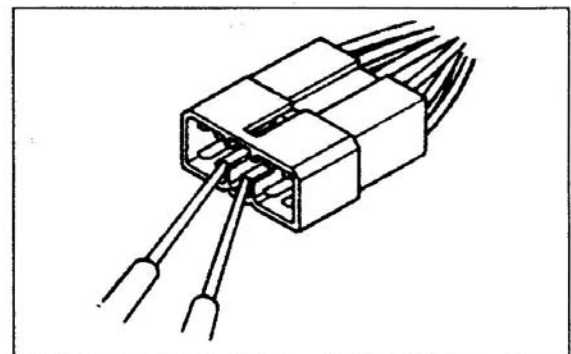


Using male pins

Touch the pins directly using test probes.

#### NOTE:

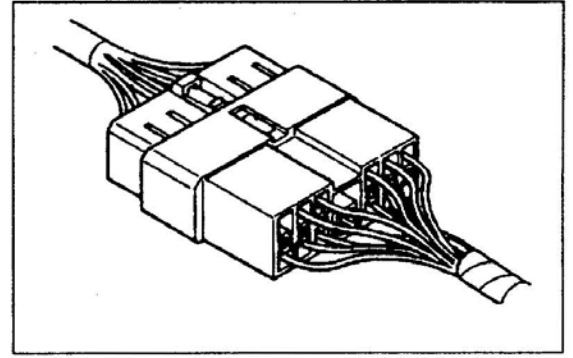
**Be sure that you do not short circuit the connector pins when you use the test probe because this could damage the internal circuit of the electronic control unit.**



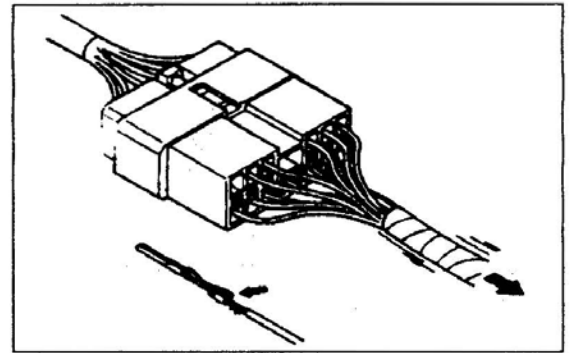
## ● Connector Inspection Procedures

### Visual inspection

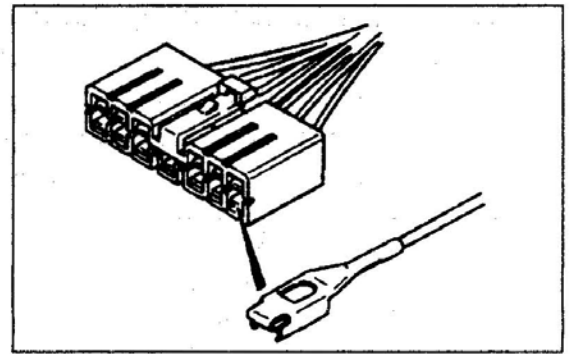
Check for loose connection and poor engagement.



Check if harnesses are broken by pulling gently around the terminals.



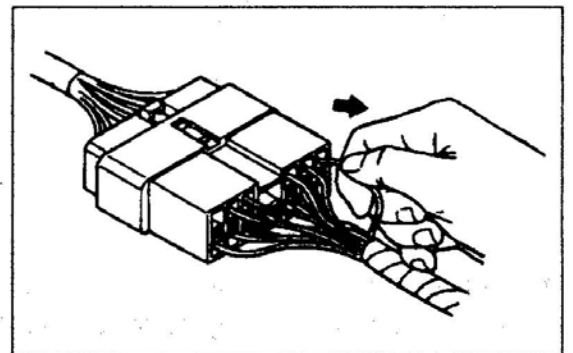
Check for a decrease in contact pressure between the male and female terminals.



Check for poor contact caused by connector pins having fallen out, rusted terminals or foreign particles.

### Connector pin fall out inspection

Damaged connector pin stoppers can cause poor engagement of the terminals (male and female pins) even if the connector body is secured, and might cause some pins to fall out. Check if the pins have fallen out from the connector by pulling each harness gently.



### ● Inspection Procedures for Blown Fuses

Remove fuse **B** and measure resistance between the loaded side of the fuse and ground.

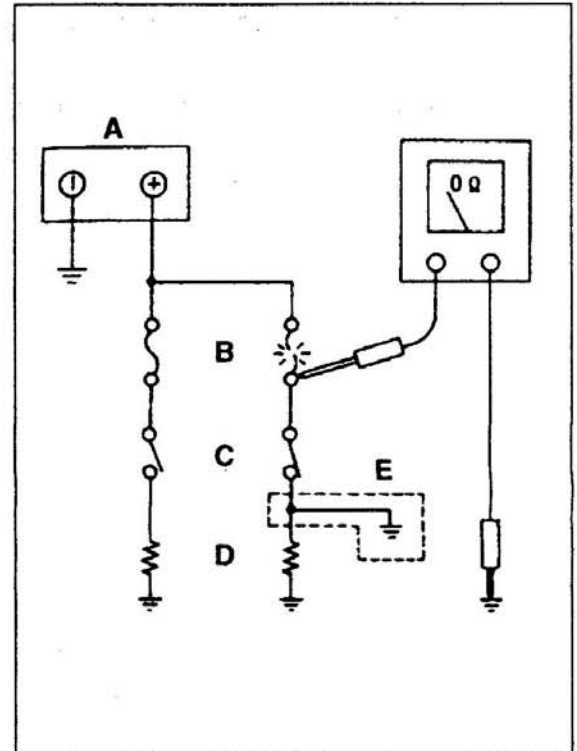
Turn on all circuit switches (connected to the fuse).

If the resistance value reading is approximately 0, a short has occurred between the switch and the loaded point. A value of other than zero may indicate that the fuse was blown by a temporary short but the short is no longer present.

The major causes of a short circuit are as follows :

- Harness stuck onto the vehicle body.
- Harness sheath damaged by friction or heat.
- Water in connectors or circuits.
- Mistakes (accidental short circuits)

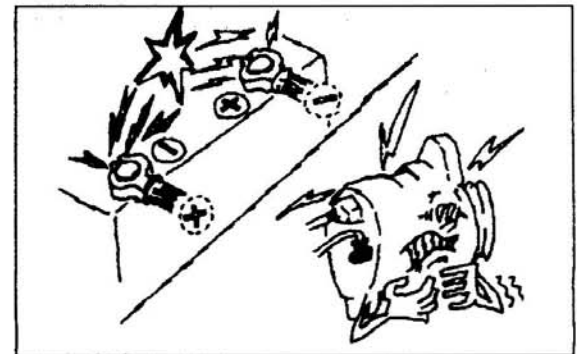
**A** : Battery                      **D** : Load  
**B** : Fuse                              **E** : Short circuit  
**C** : Loaded switch



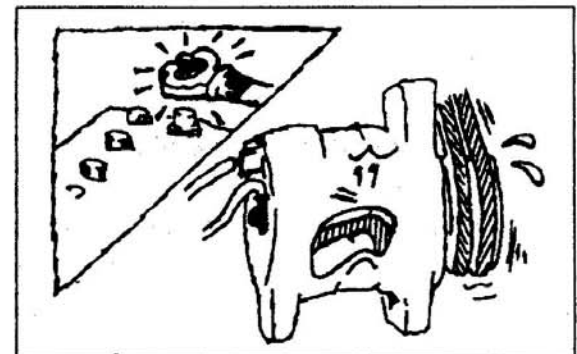
### ● Precautions for Handling Alternator

When servicing the alternator, pay attention to the following :

- Do not connect the alternator with battery polarities reversed.  
If the alternator is connected with reversed polarities, a large current flow from the battery to the alternator occurs, and the diode or regulator might be damaged.



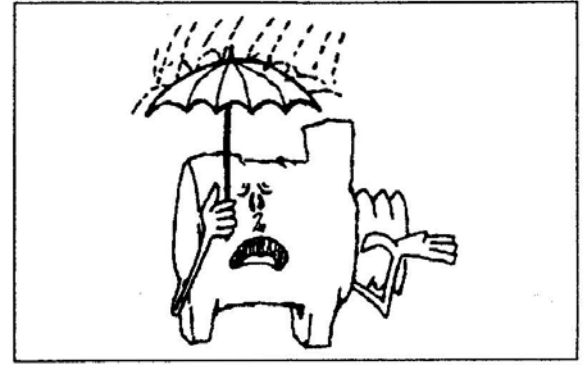
- While the engine is running, do not remove the battery terminals, if the battery terminals are removed at that time, a surge voltage is generated and the diode or regulator might be weakened.



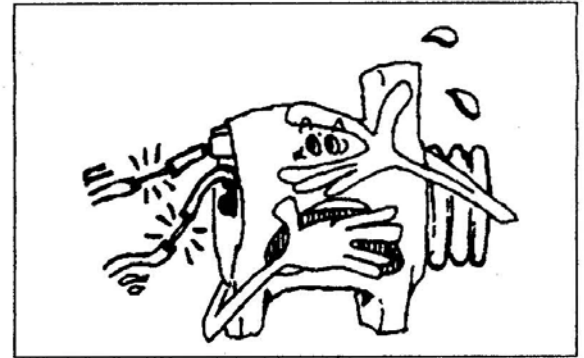
- Do not use a high-voltage tester such as a megger for inspection. If a high-voltage tester is used, the diode or regulator might be destroyed.



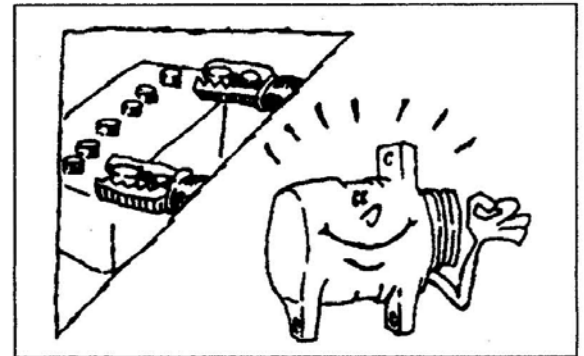
- Do not splash water over the alternator.  
If water is directly splashed over the alternator, individual components will be short-circuited and might be destroyed.



- Do not short-circuit terminal B and terminal L while running the alternator.  
If the terminals are short-circuited while the alternator is running, the diode trio might be destroyed.



- Disconnect the battery terminals before quick-charging the battery.  
Quick-charging without disconnecting the battery terminals might damage the diode or regulator.





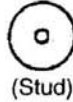
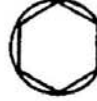

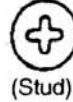



## 5. TABLE OF STANDARD TIGHTENING TORQUES

- Use specified bolts and nuts and tighten them at specified torques according to the following table, unless otherwise specified.
- Threads and contact seats shall be dry.
- Where there is a difference in strength classification between the nut and bolt(or stud bolt), the torque specified for the bolt shall apply.







### Hex-head Bolt and Stud Bolt

Unit: N · m {kgf · m}

Strength classification	4T		7T		8T	
Representation Diameter symbol	  (Stud)		  (Stud)		  (Stud)	
M5	2 to 3 {0.2 to 0.3}	-	4 to 6 {0.4 to 0.6}	-	5 to 7 {0.5 to 0.7}	-
M6	4 to 6 {0.4 to 0.6}	-	7 to 11 {0.7 to 1.1}	-	8 to 12 {0.8 to 1.2}	-
M8	9 to 14 {0.9 to 1.4}	-	17 to 26 {1.7 to 2.6}	-	20 to 29 {2.0 to 3.0}	-
M10	19 to 28 {1.9 to 2.8}	18 to 26 {1.8 to 2.7}	36 to 52 {3.5 to 5.5}	33 to 49 {3.3 to 5.0}	45 to 60 {4.5 to 6.0}	41 to 59 {4.3 to 6.0}
M12	35 to 50 {3.4 to 5.0}	31 to 46 {3.1 to 4.7}	70 to 95 {7.0 to 9.5}	65 to 85 {6.5 to 8.5}	85 to 110 {8.5 to 11}	75 to 100 {7.5 to 10}
M14	60 to 85 {6.0 to 8.5}	55 to 75 {5.5 to 7.5}	120 to 160 {12 to 16}	110 to 140 {11 to 14}	130 to 180 {13 to 18}	120 to 160 {12 to 17}
M16	90 to 130 {9.5 to 13}	90 to 120 {9.0 to 12}	180 to 240 {18 to 24}	160 to 220 {16 to 22}	200 to 270 {20 to 27}	190 to 260 {19 to 26}
M18	140 to 190 {14 to 19}	120 to 160 {12 to 16}	260 to 340 {26 to 35}	220 to 290 {22 to 30}	290 to 390 {30 to 40}	260 to 340 {26 to 35}
M20	190 to 260 {19 to 26}	170 to 230 {17 to 23}	350 to 470 {36 to 48}	320 to 420 {32 to 43}	410 to 550 {41 to 56}	370 to 490 {37 to 50}
M22	260 to 340 {26 to 35}	230 to 300 {23 to 31}	470 to 640 {48 to 65}	430 to 570 {43 to 58}	550 to 740 {56 to 75}	490 to 670 {50 to 68}
M24	340 to 450 {34 to 46}	290 to 390 {29 to 40}	630 to 840 {63 to 86}	540 to 730 {55 to 74}	730 to 980 {74 to 100}	630 to 840 {64 to 86}






### Hex-head Flange Bolt

Unit: N · m {kgf · m}

Strength classification	4T		7T		8T	
Representation Diameter symbol						
M6	4 to 6 {0.4 to 0.6}	-	8 to 12 {0.8 to 1.2}	-	9 to 14 {0.9 to 1.4}	-
M8	10 to 15 {1.0 to 1.5}	-	19 to 28 {1.9 to 2.8}	-	22 to 32 {2.2 to 3.3}	-
M10	21 to 30 {2.1 to 3.1}	20 to 28 {1.9 to 2.9}	39 to 58 {3.9 to 6.0}	37 to 53 {3.6 to 5.4}	50 to 65 {5.0 to 6.5}	45 to 65 {4.5 to 6.5}
M12	38 to 54 {3.8 to 5.5}	35 to 51 {3.4 to 5.2}	80 to 110 {8.0 to 11}	70 to 95 {7.0 to 9.5}	90 to 120 {9.0 to 12}	85 to 110 {8.5 to 11}


## Hex-head Nut

Unit: N · m {kgf · m}

Strength classification	4T		6T			
Representation						
Diameter symbol	Standard screw	Coarse screw	Standard screw	Coarse screw		
M5	2 to 3 {0.2 to 0.3}	—	4 to 6 {0.4 to 0.6}	—		
M6	4 to 6 {0.4 to 0.6}	—	7 to 11 {0.7 to 1.1}	—		
M8	9 to 14 {0.9 to 1.4}	—	17 to 26 {1.7 to 2.6}	—		
M10	19 to 28 {1.9 to 2.8}	18 to 26 {1.8 to 2.7}	36 to 52 {3.5 to 5.5}	33 to 49 {3.3 to 5.0}		
M12	35 to 50 {3.4 to 5.0}	31 to 46 {3.1 to 4.7}	70 to 95 {7.0 to 9.5}	65 to 85 {6.5 to 8.5}		
M14	60 to 85 {6.0 to 8.5}	55 to 75 {5.5 to 7.5}	120 to 160 {12 to 16}	110 to 140 {11 to 14}		
M16	90 to 130 {9.5 to 13}	90 to 120 {9.0 to 12}	180 to 240 {18 to 24}	160 to 220 {16 to 22}		
M18	140 to 190 {14 to 19}	120 to 160 {12 to 16}	260 to 340 {26 to 35}	220 to 290 {22 to 30}		
M20	190 to 260 {19 to 26}	170 to 230 {17 to 23}	350 to 470 {36 to 48}	320 to 420 {32 to 43}		
M22	260 to 340 {26 to 35}	230 to 300 {23 to 31}	470 to 640 {48 to 65}	430 to 570 {43 to 58}		
M24	340 to 450 {34 to 46}	290 to 390 {29 to 40}	630 to 840 {63 to 86}	540 to 730 {55 to 74}		

## Hex-head Flange Nut

Unit: N · m {kgf · m}

Strength classification	4T	
Representation		
Diameter symbol	Standard screw	Coarse screw
M6	4 to 6 {0.4 to 0.6}	—
M8	10 to 15 {1.0 to 1.5}	—
M10	21 to 30 {2.1 to 3.1}	20 to 28 {1.9 to 2.9}
M12	38 to 54 {3.8 to 5.5}	35 to 51 {3.4 to 5.2}

**Tightening torque for flare nut for general purpose**

Unit:N · m {kgf · m}

Pipe diameter	$\phi$ 4.76mm	$\phi$ 6.35mm	$\phi$ 8mm	$\phi$ 10mm	$\phi$ 12mm	$\phi$ 15mm
Tightening torque	17 {1.7}	25 {2.6}	39 {4.0}	59 {6.0}	88 {9.0}	98 {10.0}

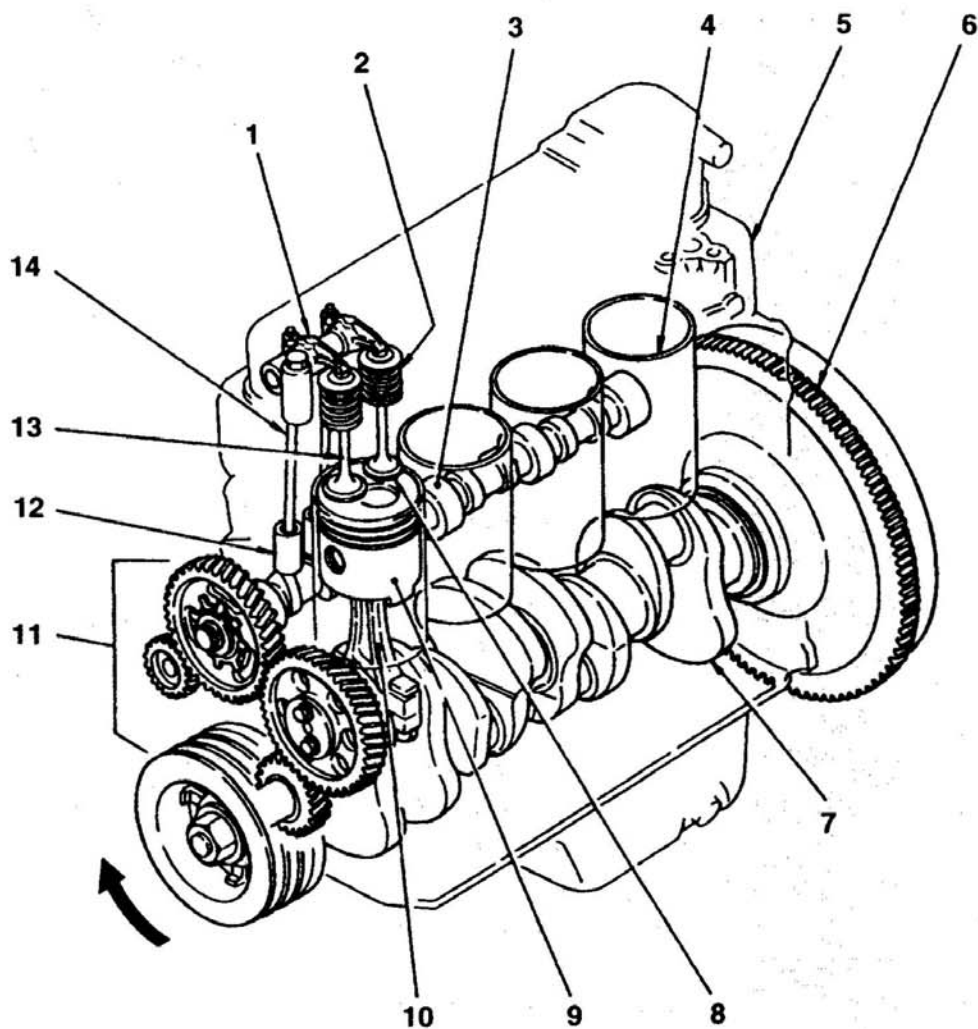
**Tightening torque for air piping nylon tube for general purpose  
{DIN type}**

Unit:N · m {kgf · m}

Standard diameter	6 × 1 mm	10 × 1.25 mm	12 × 1.5 mm	15 × 1.5 mm
Tightening torque	$20^{+6}_0 \left\{ \begin{matrix} +0.6 \\ 2.0 \\ 0 \end{matrix} \right\}$	$34^{+10}_0 \left\{ \begin{matrix} +1.0 \\ 3.0 \\ 0 \end{matrix} \right\}$	$49^{+10}_0 \left\{ \begin{matrix} +1.0 \\ 5.0 \\ 0 \end{matrix} \right\}$	$54^{+5}_0 \left\{ \begin{matrix} +0.5 \\ 5.5 \\ 0 \end{matrix} \right\}$



# 1. GENERAL



- |                         |                    |
|-------------------------|--------------------|
| 1. Rocker arm           | 8. Exhaust valve   |
| 2. Valve spring         | 9. Piston          |
| 3. Camshaft             | 10. Connecting rod |
| 4. Cylinder sleeve <D4> | 11. Timing gear    |
| 5. Cylinder head        | 12. Tappet         |
| 6. Flywheel             | 13. Inlet valve    |
| 7. Crankshaft           | 14. Push rod       |

On engines, the pistons reciprocate in the cylinder sleeves inserted in the crankcase.

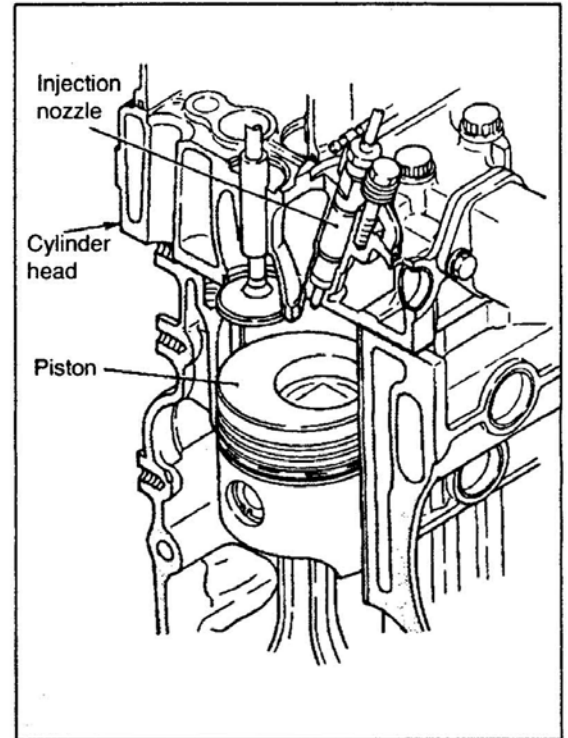


## 1-1 Engine Proper

### (1) Combustion Chamber

The combustion chamber consists of the cylinder head and toroidal pistons, hole type injection nozzles being installed in the cylinder head.

Combustion occurs when the fuel is directly injected into the combustion chamber with the power operating the piston directly.



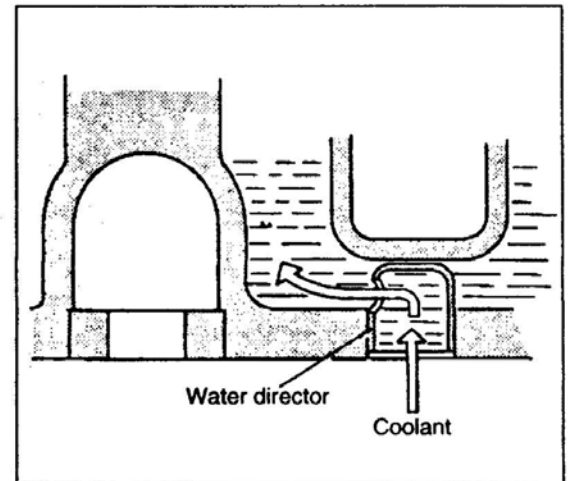
The combustion chamber is formed by the lobes-shaped main combustion chamber in the piston head and HYUNDAI'S own bell-shaped swirl chamber.

A chamber jet is press-fitted into the swirl chamber that is made of material with little thermal expansion and good thermal conductivity. Also installed in the chamber are the sheathed glow plug and throttle injection nozzle.

The upward movement of the piston during the compression stroke imparts a violent swirling motion to the air charged into the swirl chamber, to which fuel is injected for combustion.

As the combustion goes on, the gas moves from the swirl to main combustion chamber where it is mixed with the air present. And further combustion occurs.

For more effective cooling of the combustion chamber, water directors that direct coolant flow are pressed into the bottom of the cylinder head.



## (2) Valve Mechanism

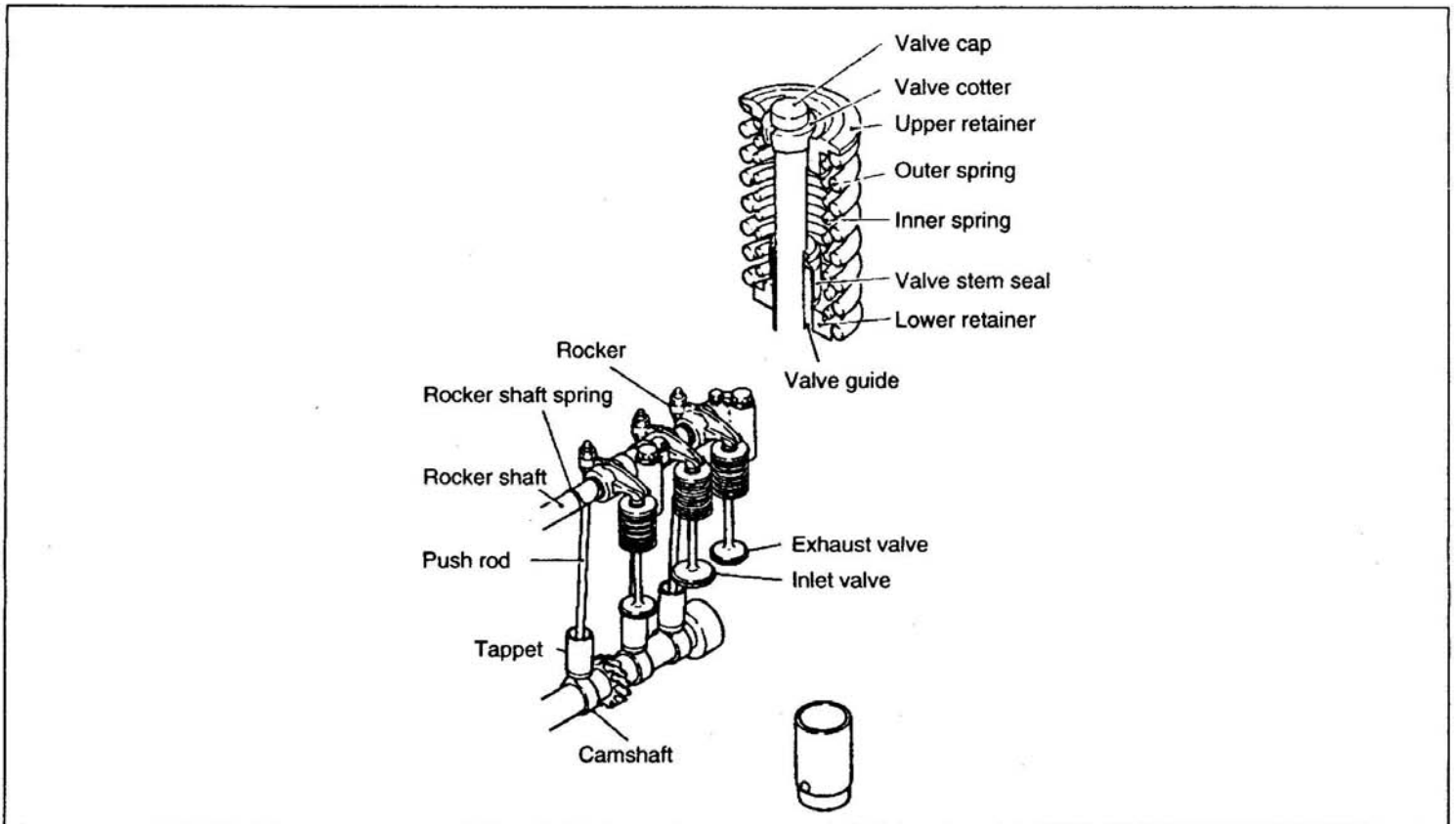
The valve mechanism is an overhead valve type.

- (a) Both the inlet and exhaust valves are made of surface-treated heat-resistant steel.  
The valve seat angle is  $45^\circ$  in both valves.

Valve stem seal is mounted to the valve stem, which controls the amount of lubricant on the sliding surfaces between the valve and valve guide.

A valve guide with carbon cutter is used for the exhaust side.

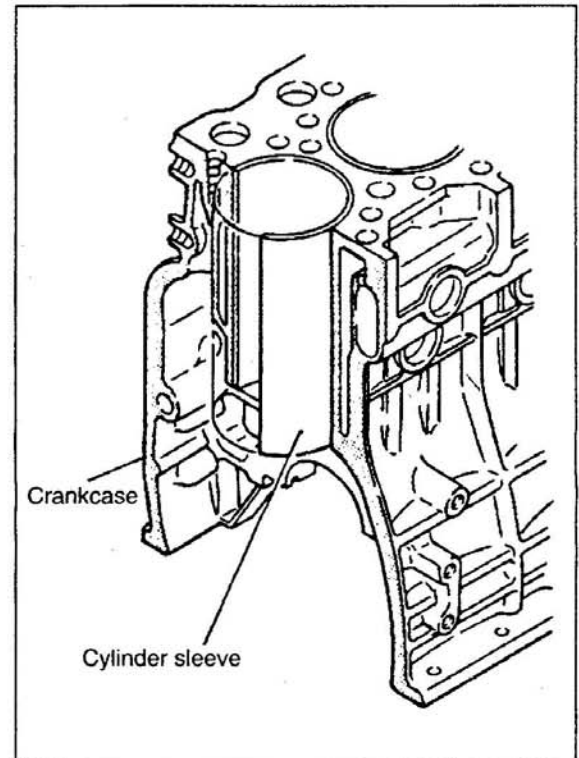
- (b) Two unevenly pitched valve springs are used, the inner and outer with coil directions opposite to each other.



- (c) The rocker has an induction-hardened surface in contact with the valve cap, A bushing is used in the hole, into which the rocker shaft is fitted. Because of them, wear resistance is improved.
- (d) The rocker shaft is a hollow round rod with sealing caps at both ends to seal it off. Its inside is an engine oil passage.
- (e) The push rod has a steel ball welded to its bottom end and a spherical or depressed piece welded to its top end. Both ends are carburized case-hardened.
- (f) The tappet on the D4A is of cylindrical shape, while that on D4D of mushroom shape. Its mating surface with the camshaft is a large-diameter sphere to prevent local wear.
- (g) The camshaft is provided with an oil pump drive gear, with its journals, cams, and gear induction-hardened. The cam on D4A is a taper cam.

### (3) Crankcase and Cylinder Sleeve

- (a) The crankcase is made of cast iron and built rigid with minimum stress concentration and deformation.
- (b) Three camshaft bushings are installed in the camshaft bearings of the crankcase. To facilitate insertion and removal of the camshaft from the front end of the crankcase, the bushing I.D. is made smaller toward the rear.
- (c) The special cast-iron cylinder sleeve, that is highly resistance to wear, is press-fitted into the crankcase.



### (4) Piston and Piston Ring

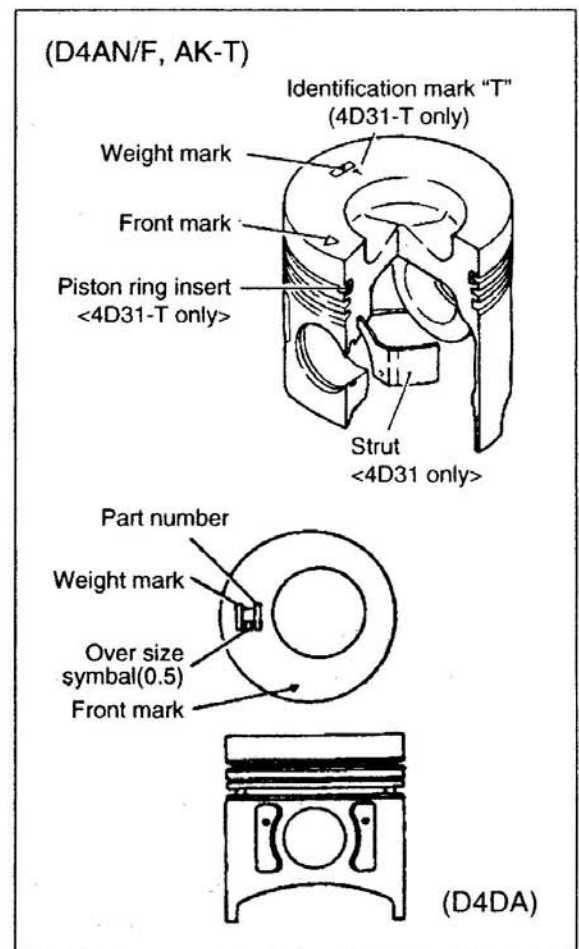
#### (a) Piston

The piston, made of aluminum alloy casting, has a strut inside (no strut installed on D4AK-T) that ensures an adequate clearance between the piston and cylinder sleeve.

The piston-pin arrangement is full-floating. The piston pin is offset toward the thrust side, which, together with the effect of the strut, minimizes piston slap.

Stamped on the top surface of the piston is the piston weight mark, plus the front mark "◁" on D4A and D4D.

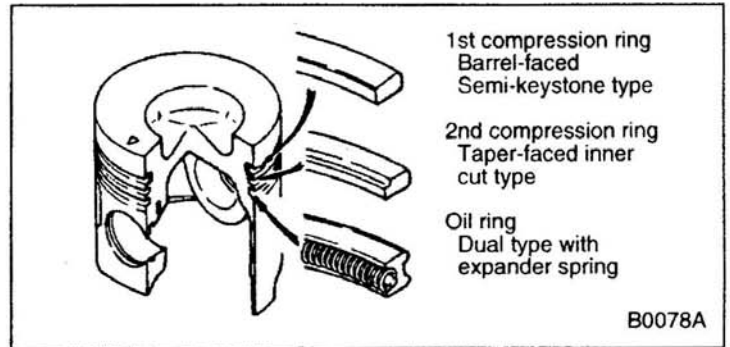
On D4AK-T, and ID mark "T" stamped on top and a Niresist piston ring insert is cast in the top ring groove for increased durability.



(b) Piston ring

There are three piston rings installed :  
Two compression rings and one oil ring.  
The sliding surface of each ring, is hard chrome plated.

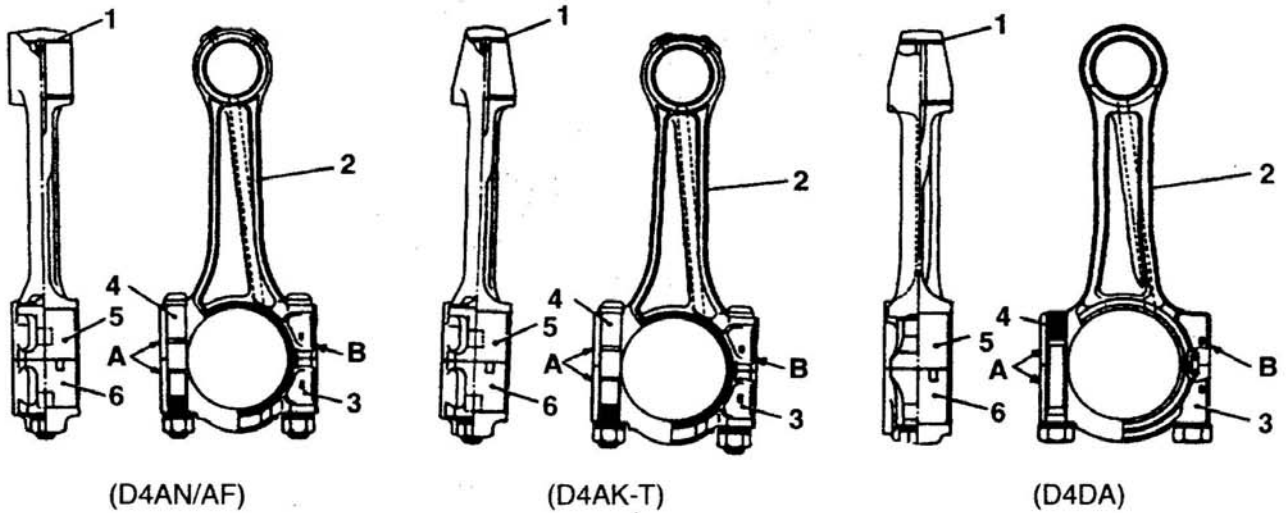
Piston rings are shaped as illustrated.



(5) **Connecting Rod and Connecting Rod Bearing**

The connecting rod is a die forging with an I cross section ensuring high rigidity. A lead bronze bushing is press-fitted into its small end while a split-style plain bearing is used in its big end.

On D4A, an oil passage is provided obliquely through the stem and an oil jet the connecting rod small end of D4AK, D4DA is wedge-shaped.



- 1. Connecting rod bushing
- 2. Connecting rod
- 3. connecting rod cap
- 4. connecting rod bolt

- 5. Upper connecting rod bearing
- 6. Lower connecting rod bearing
- A. Alignment mark
- B. Weight mark

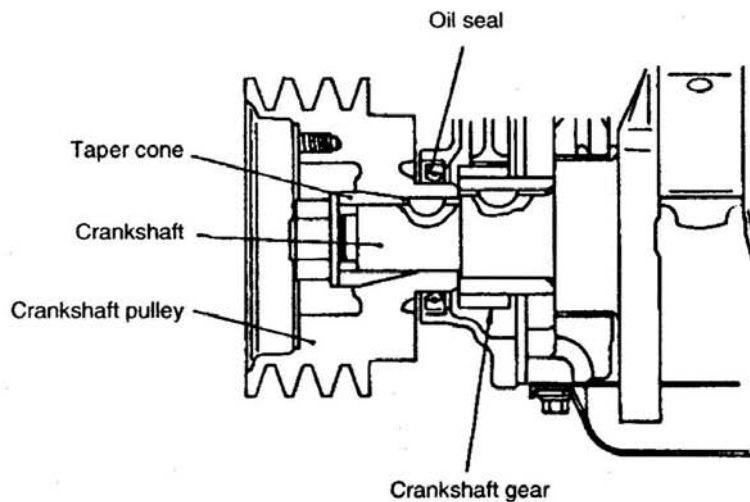
## (6) Crankshaft and Main Bearing

### (a) Crankshaft

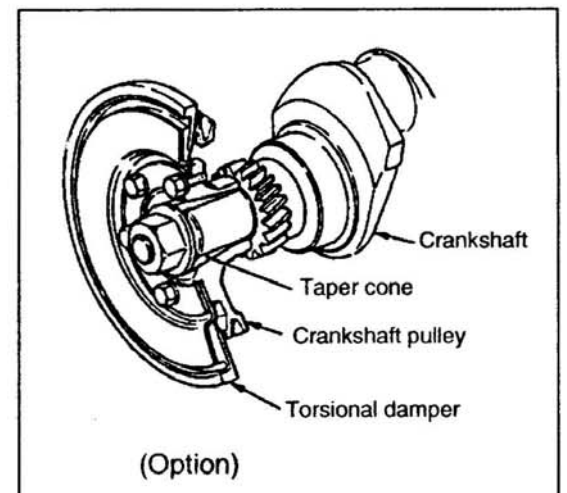
The crankshaft is a highly-rigid die forging integral with the balance weights. The pins, journals, and rear oil seal sliding surfaces are induction-hardened for improved wear resistance.

By means of oil passages drilled through the pins and journals, part of the main bearing lubricating oil is fed to pins for lubrication of the connecting rod bearing

At the front end of the crankshaft, there are a crankshaft pulley and crankshaft gear attached with a nut. The crankshaft pulley drives the alternator and water pump through the V-belt and the crankshaft gear drives the camshaft and injection pump.

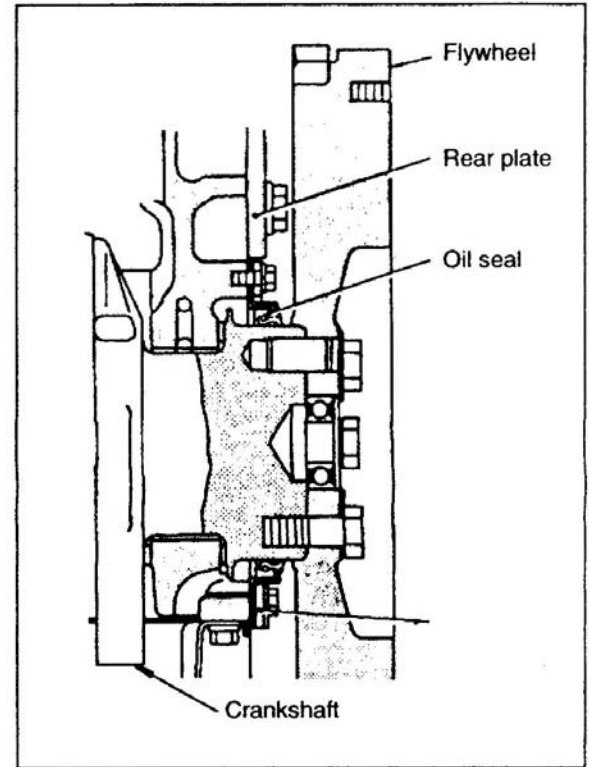


As an option a torsional damper may be installed that absorbs torsional vibration of the crankshaft.



The flywheel is mounted in the rear of the crankshaft.

An oil seal is installed at front and rear of the crankshaft.



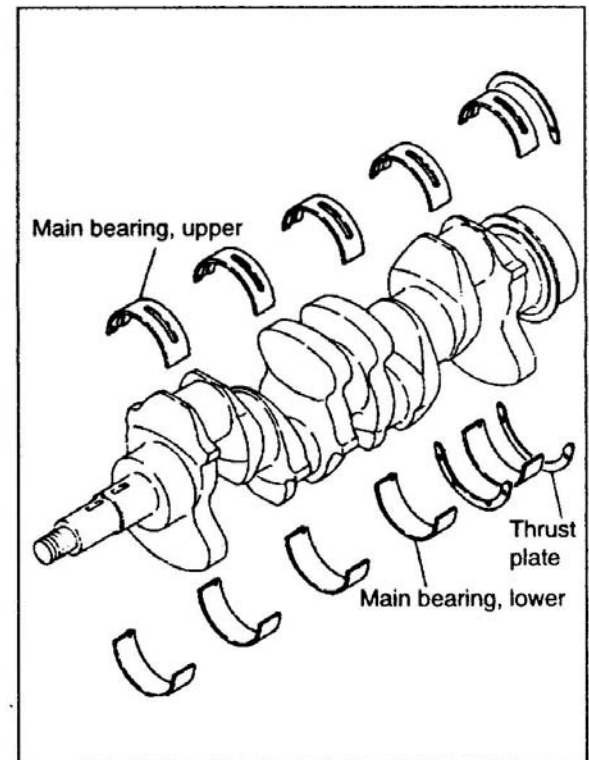
**(b) Main bearing**

The main bearing is a split-style plain bearing made of special alloy plated kelmet metal with a steel back.

The upper main bearing has an internal oil groove and oil hole which is aligned with the oil hole in the crankshaft.

Five pairs of main bearings are used.

Split-style thrust plates are mounted with the rear pair of main bearings.



## (7) Timing Gear

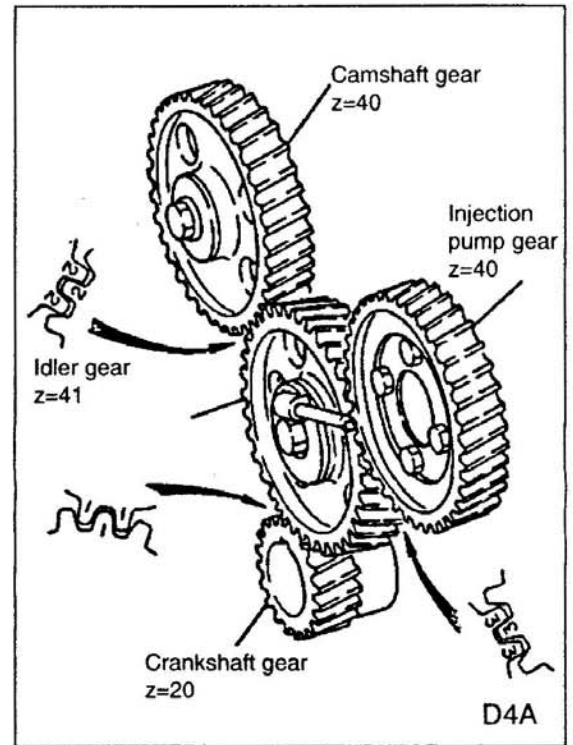
The timing gears are housed in the timing gear case at the front of the engine. Illustration shows the gear train.

Each gear is a helical gear machined by a shaving machine to high precision and surface-treated for enhanced durability.

A timing mark is stamped on each gear.

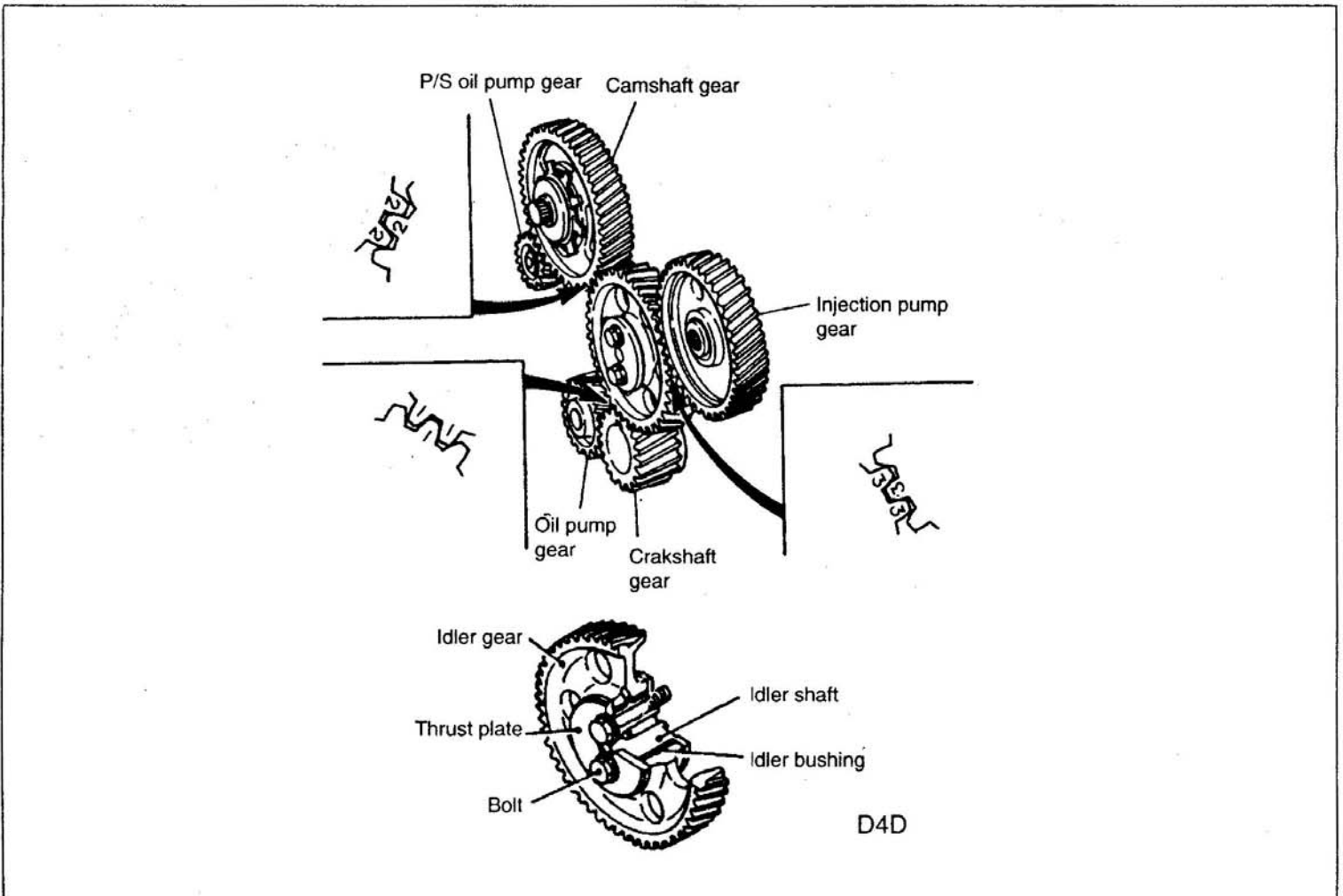
At resassembly, correct meshing can be achieved by aligning these marks.

On D4A, an oil pipe is installed in the idler shaft that is used for forced lubrication of the injection pump gear.



A bushing is press-fitted into the idler gear which turns on the idle shaft.

The oil hole drilled through the idler shaft and gear provides an oil passage for lubrication of bushing and gears.

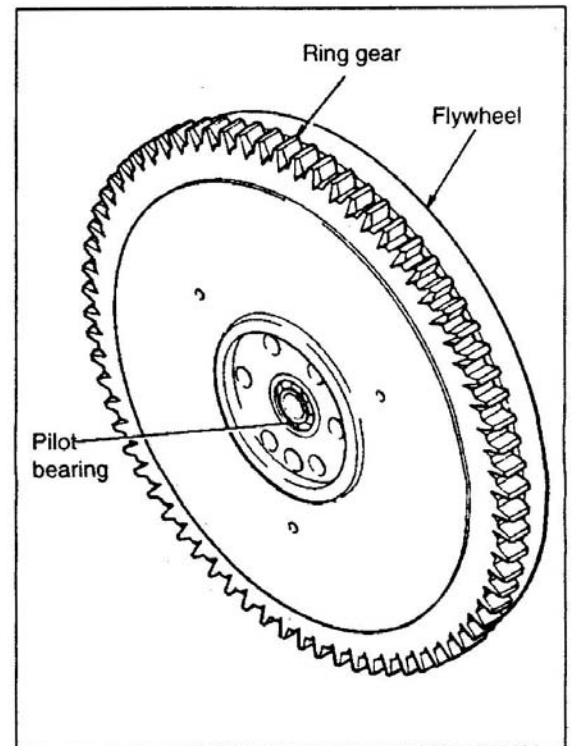


### (8) Flywheel

The flywheel is made of cast iron. The pilot bearing of the transmission drive pinion is installed at its center. On its periphery, the ring gear is shrink-fitted that meshes with the starter pinion.

The ring gear tooth crests are induction-hardened for greater durability.

At the same time, one side of the crests is chamfered to ensure that the starter pinion meshes easily when starter is operated.





## 2. SPECIFICATIONS

Item	Specifications			
Engine				
Model	D4AN	D4AK	D4AF	D4DA
Type	4 in-line, 4-cycle digsel engine	←	←	←
Combustion chamber type	Direct injection	Direct injection (with turbocharger)	Direct injection	Direct injection (with turbocharger)
Valve mechanism	Overhead valve	←	←	←
Cylinder bore × stroke mm	100 × 105	←	104 × 105	104 × 115
Total displacement cc	3298	←	3567	3907
Compression ratio	17.5	16	17.5	16.5
Firing order	1-3-4-2	←	←	←
Cylinder liner type	Dry	←	←	←
Piston type	Trunk slipper-skirt	←	←	←
No. of piston rings Performance	Compression ring : 2 oil ring : 1	←	←	←
Minimum no-load engine speed rpm	Varies with specifications	←	←	←
Miximum no-load engine speed rpm	Varies with specifications	←	←	←

### 3. SERVICE STANDARDS

3-1 Service standard table

Unit : mm

Description		Nominal value [Basic diameter]	Limit	Correction and remarks
Compression pressure (at 200 rpm)		2550 kPa (26 kgf/cm <sup>2</sup> )	1960 kPa (20 kgf/cm <sup>2</sup> )	Adjust. Difference between cylinder with -in 390 kPa (4 kgf/cm <sup>2</sup> )
Rocker to rocker shaft clearance		[19] 0.01~0.08(D4A)	0.2	Replace bushing
		[19] 0.01~0.11(D4DA)		
outer valve spring	Free length	60.84	57.8	Replace
	Installed load/installed length	240 N (24.5 kgf)/47.25	205 N (20.8 kgf)/47.25	
	Sequareness	-	2.5	
Inner valve spring	Free length	55.07	52.1	Replace
	Installed load/installed length	93 N (9.5 kgf)/40.3	79 N (8.1 kgf)/40.3	
	Sequareness	-	2	
Push rod runout		-	0.4	Replace
Tappet to crankcase tappet hole clearance		[28] 0.06~0.10	0.2	Replace
Cylinder head bottom surface distortion		0.05 or less	0.2	Correct or replace
Hight of cylinder head from top to bottom surface		94.9~95.1	94.6	Replace
Valve seat width	Inlet	2.6~3.0	3.6	Replace
	Exhaust	1.8~2.2	2.8	
Valve to valve guide clearance	Inlet	[9]0.04~0.06	0.15	Replace
	Exhaust	[9]0.07~0.10	0.2	
Valve stem O.D.	Inlet	8.96~8.97	8.85	Replace
	Exhaust	8.93~8.94	8.85	
Valve sinkage	Inlet	0.75~1.25	1.5	Replace valve seat insert
	Exhaust	0.75~1.25	1.5	
Valve margin		1.5	1.2	Correct or replace
Valve seat angle		45°	-	
Flywheel	Friction surface distortion	0.05 or less	0.2	Correct or replace
	Friction suurface runout (In installed state)	0.1 or less	0.2	Correct or replace

Description		Nominal value [Basic diameter]	Limit	Correction and remarks
Timing gear backlash	Between camshaft gear and idler gear	0.11~0.23(D4A)	0.3	Replace
		0.07~0.16(D4DA)	0.4	
	Between idler gear and camshaft gear	0.12~0.25(D4A)	0.3	
		0.07~0.17(D4DA)	0.4	
	Between idler gear and injection pump gear	0.18~0.31(D4A)	0.3	
		0.07~0.17(D4A)	0.4	
	Between oil pump gear and crankshaft gear	0.10~0.18(D4DA)	0.3	
Between P/s oil pump gear and crankshaft gear	0.08~0.16(D4DA)	0.3		
Camshaft end play		0.05~0.22	0.35	Replace thrust plate
Idler gear end play		0.05~0.25(D4A)	0.35	Replace thrust plate
		0.05~0.15(D4DA)	0.15	
Camshaft journal to bush- ing clearance	No.1, No.2, No.3, No.4	[54.5] 0.04 to 0.09	0.15	Replace bushing
	No.5	[53] 0.04 to 0.09	0.15	
Camshaft	Cam profile (Difference between cam height and base circle diameter)	6.86	6.36	Replace. Cam height 46.939 Base circle dia : 40.080
	Inlet	7.19±0.05(D4DA)	6.70	Long dia : 47.10 Short dia : 39.10
	Exhaust	7.32±0.05(D4DA)	6.82	Long dia : 46.98 Short dia : 39.66
	Bend	0.02 or less	0.05	Correct or replace
Idler gear to idler shaft clearance		[40] 0.03~0.07(D4A)	0.1	Replace bushing
		[45] 0.03~0.06(D4DA)	0.6	
Connecting rod end play		0.15~0.45	0.6	Replace
Crankshaft end play		0.10~0.26	0.4	Replace thrust plate
Piston projection from crankcase top surface		0.48~0.74(D4AN,AF)	-	Check parts for clearance
		0.47~0.65(D4AK,D4DA)	-	
Piston ring to Piston ring groove clear- ance	1st ring	0.04~0.10(D4A)	0.2	Replace piston ring
		0.05~0.10(D4DA)		
	2st ring	0.03~0.06(D4A)	0.15	
		0.05~0.08(D4DA)		
	Oil ring	0.03~0.06		

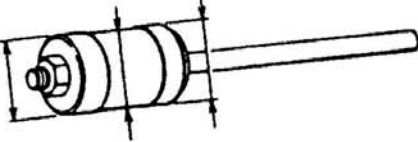

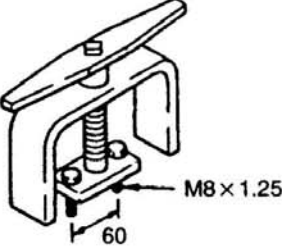
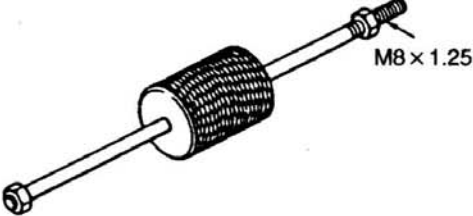
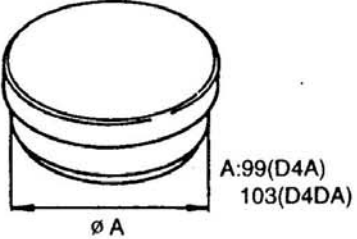
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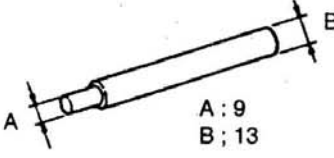
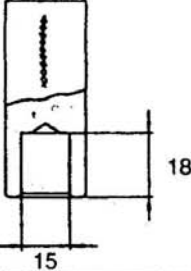
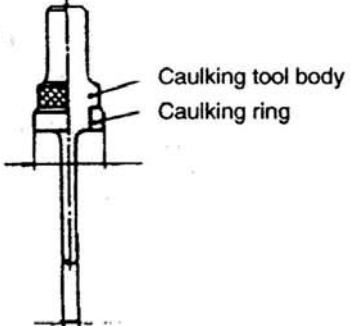
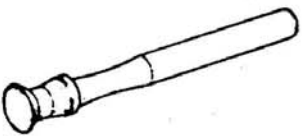
Description		Nominal value [Basic diameter]	Limit	Correction and remarks	
Piston ring gap		0.3~0.5	1.5	Replace	
Piston pin to piston pin hole clearance		[34]0.007~0.021(D4A)	0.05	Replace	
		[36]0.007~0.021(D4DA)			
Piston pin to connecting rod small-end bushing clearance		[34]0.02~0.05(D4A)	0.1	Replace bushing	
		[36]0.03~0.04(D4DA)			
Connecting rod bend and twist		-	0.05	Correct or replace	
Piston to cylinder sleeve clearance		[100]0.05~0.09(D4A)	-	Correct to oversize or replace	
		[104]0.07~0.1(D4DA)	-		
Crankcase top surface distortion		0.07 or less	0.2	Regrind small amount	
Cylinder sleeve	I.D.	104~104.03 (D4AF,D4DA)	104.25	Correct to oversize or replace	
		100~100.03 (D4AN,D4AK)	100.25		
	Roundness	0.01 or less	-		
	Cylindricity	0.03 or less	-		
Crankcase to sleeve inter- ference	STD	0.16~0.22	Less than 0.16	Replace with an oversize	
	O.S	0.18~0.20	Less than 0.18	Replace	
Crank-shaft	Roundness of pins and journals	0.01 or less	0.03	Correct or replace	
	Cylindricity of pins and journals	0.006 or less	0.03		
	Bend	0.02 or less	0.05		
Main bearing	Oil clearance	[78]0.04~0.10	0.15	Replace	
	Tension when free	Upper	-		Less than 82.5
		Lower	-		Less than 82.27
Connecting rod bearing	Oil clearance	[60]0.05~0.09(D4A)		Replace	
		[65]0.04~0.09(D4DA)			
	Tension when free	-	Less than 64.27(D4A) 69.5 or less(D4DA)		
Valve clearance		0.4	-	Adjust	

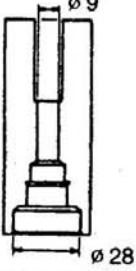
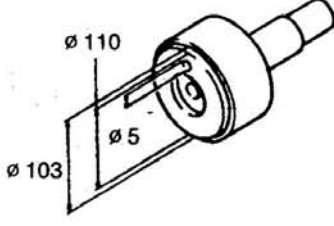
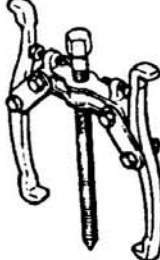
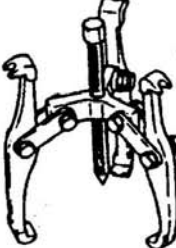

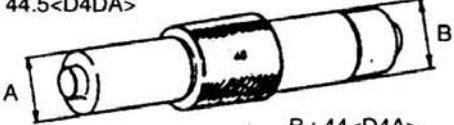
### 3-2 Tightening Torque Table.

Description	O.D × pitch	Tightening torque	Remarks
	Thread size	k · gm	
Cylinder head bolt	M14 × 2.0	18<D4A>	Wet
		15kg · m+90° <D4DA>	
Flywheel bolt	M12 × 1.25	12.5<D4A>	Wet
	M14 × 1.5	4.0kg · m+40° <D4DA>	
Rear Plate bolt	M10 × 1.5	6	
		6.5<D4DA>	
Flywheel housing bolt	M10 × 1.5	5.6	
Idler shaft bolt	M10 × 1.5	4.5	Wet
Crankshaft pulley nut	M24 × 1.5	60	
Main bearing cap bolt	M14 × 2.0	18	
Connecting rod bolt	M12 × 1.25	10.5<D4A>	Wet
	M12.5 × 1.25	6kg · m+40° ±5° <D4DA>	Wet
Front mounting bracket bolt	M12 × 1.25	9~12	
Rear lower support bolt	M10 × 1.25	4~5.5	
Rear upper support bolt	M14 × 1.5	18	
Oil pan drain plug	M18 × 1.5	7	
Water drain plug	M20 × 1.5	8.3	
Engine rotating sensor		3	
Thrust plate bolt		2.4	
Can shaft gear bolt		18	

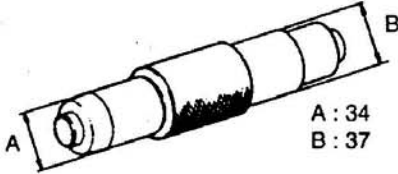
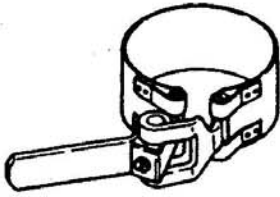
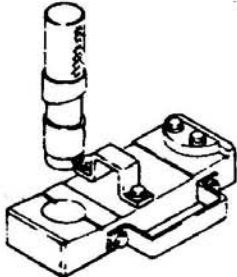
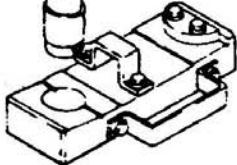

## 4. SPECIAL TOOLS


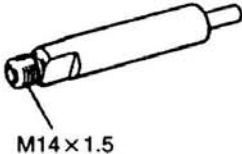
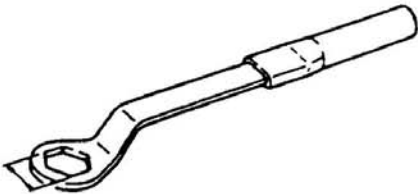

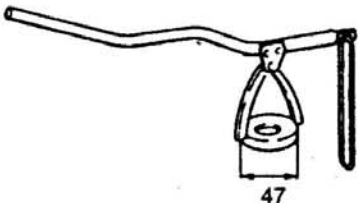

Tool name	Part number	Shape	Application															
Camshaft bushing Installer and Extractor	09221-45000	 <table border="1" data-bbox="619 613 1023 853"> <thead> <tr> <th></th> <th>A, C</th> <th>B</th> </tr> </thead> <tbody> <tr> <td>NO.1</td> <td>∅ 58.5</td> <td>∅ 54.5</td> </tr> <tr> <td>NO.1</td> <td>∅ 58</td> <td>∅ 54.5</td> </tr> <tr> <td>NO.1</td> <td>∅ 57.5</td> <td>∅ 54</td> </tr> <tr> <td>NO.1</td> <td>∅ 57</td> <td>∅ 53</td> </tr> </tbody> </table>		A, C	B	NO.1	∅ 58.5	∅ 54.5	NO.1	∅ 58	∅ 54.5	NO.1	∅ 57.5	∅ 54	NO.1	∅ 57	∅ 53	Removal and installation of Camshaft bushing
	A, C	B																
NO.1	∅ 58.5	∅ 54.5																
NO.1	∅ 58	∅ 54.5																
NO.1	∅ 57.5	∅ 54																
NO.1	∅ 57	∅ 53																
Piston ring tools	MH060014	<p>∅ 60-120</p> 	Removal and installation of piston ring															
Bearing Cap Extractor	MH061083		Removal of bearing Caps at front and rear															
Bearing Cap Extractor	MH061071		Removal of bearing caps															
Clinder sleeve installer	09211-45000		Installation of Cylinder sleeve															

Tool name	Part number	Shape	Application												
Value guide remover	MH061066	 <p>A : 9 B : 13</p>	Removal of value guide												
Value guide installer	061293	 <p>18 15</p>	Installation of valve guide												
Caulking tool body	MH061067	 <p>Caulking tool body Caulking ring</p>	Press-fitting of value seat												
Caulking ring	MH061275 MH061069	<p>Caulking tool lody</p> <table border="1" data-bbox="614 1299 1021 1377"> <thead> <tr> <th>Part No</th> <th>Demension</th> </tr> </thead> <tbody> <tr> <td>MH061067</td> <td>9</td> </tr> </tbody> </table> <p>Inlet caulking ring</p> <table border="1" data-bbox="614 1456 1021 1534"> <thead> <tr> <th>Part No</th> <th>Demension</th> </tr> </thead> <tbody> <tr> <td>MH061275</td> <td>47.6</td> </tr> </tbody> </table> <p>Exhaust Caulking ring</p> <table border="1" data-bbox="614 1612 1021 1691"> <thead> <tr> <th>Part No</th> <th>Demension</th> </tr> </thead> <tbody> <tr> <td>MH061069</td> <td>40.6</td> </tr> </tbody> </table>	Part No	Demension	MH061067	9	Part No	Demension	MH061275	47.6	Part No	Demension	MH061069	40.6	
Part No	Demension														
MH061067	9														
Part No	Demension														
MH061275	47.6														
Part No	Demension														
MH061069	40.6														
Value lapper	30091-07500		Lapping of value seat												

Tool name	Part number	Shape	Application
Valve stem seal installer	09222-45200		Installation of valve stem seal
Rear oil seal shinger Installer	MH062677		Installation of Rear oil seal slinger
Gear puller	MH061061		Removal of pulley and gear
Gear puller	MH061326		Removal of gear
Plug	09212-45000	 A : M10 × 1.25<D4A> M14 × 11.5<D4DA>	Blank plug used for removal of camshaft gear
Idler gear bushing puller	09221-45000	 A : 39.5<D4A> 44.5<D4DA> B : 44<D4A> 49<D4DA>	Installation and removal of Idler gear bushing



Tool name	Part number	Shape	Application
Connecting rod bushing puller	09235-45000		Removal and Installation of Connecting rod
Piston guide	MH061890		Installation of piston
Piston guide rever	MH061658		
Crank shaft front oil seal Installer	09214-45000		Installation of front oil seal
Connecting rod bushing puller kit	MH061891		Removal and Installation of connecting rod bushing
Socket wrench	MH061560	<p data-bbox="555 1749 671 1778">&lt;D4DA&gt;</p> 	Installation of cylinder head

Tool name	Part number	Shape	Application
Slotted screw driver			
compression gauge adaptor	MH062677		Measurement of compression pressure
Cranking handle	MH061061		Engine cranking
Tappet extractor	MH061326		Removal of tappet
Valve lifter	09212-45000		Removal and installation of valve cotter
Rocker bushing puller	09221-45000		Removal and installation of rocker bushing

## 5. SERVICE PROCEDURES

### 5-1 Engine Proper

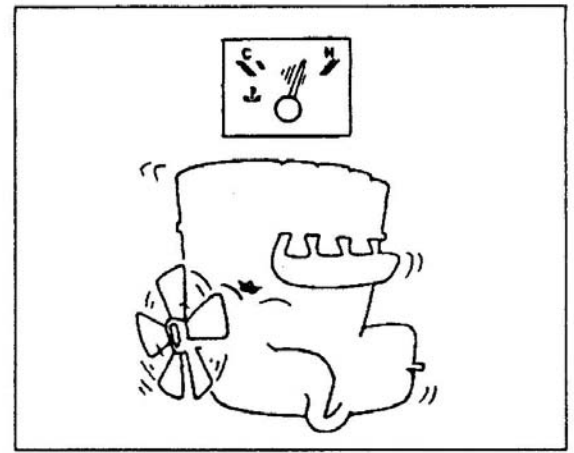
#### 1. Measurement of Compression Pressure

Compression Pressure must be measured prior to disassembly of the engine.

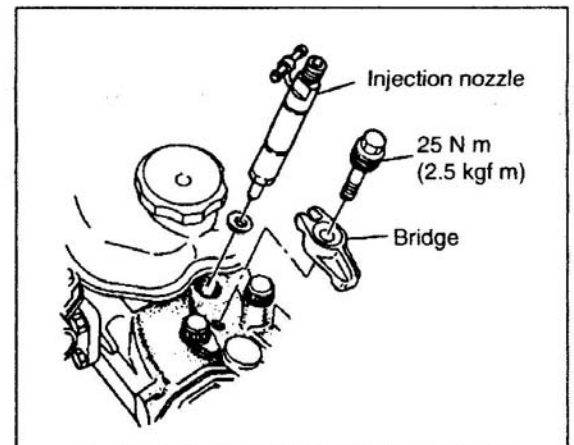
Measure the compression pressure at regular intervals and keep track of its changes. During the break-in period or after parts have been replaced with new ones, there is a slight increase in the piston rings and valve seats fit snugly in position. As rough edges and friction between parts are gradually reduced, the pressure comes down.

#### Measurement procedure

- (1) Retighten the cylinder head bolts to specified torque and let the engine warm up until the coolant temperature reaches 75°C to 85°C.



- (2) Remove all injection nozzles from the cylinder head.



**NOTE :** Cover the mounting holes and injection pipes to prevent entry of dust and dirt.

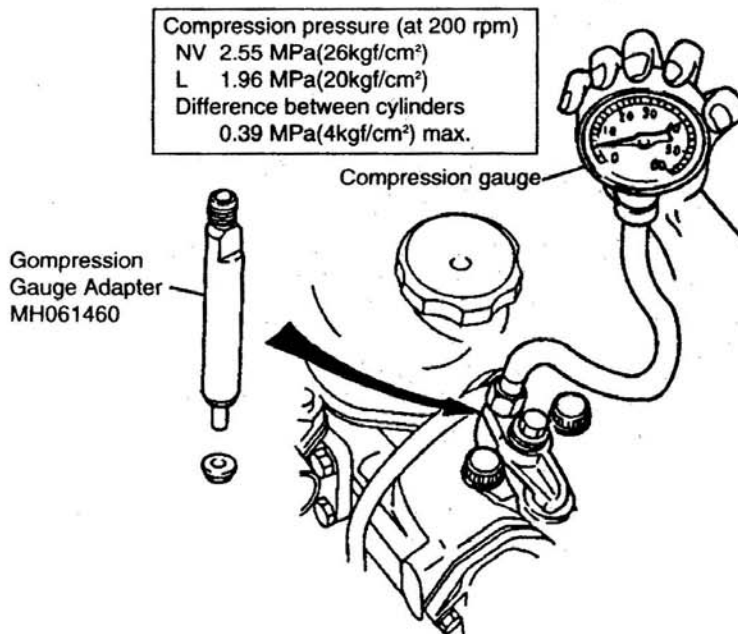
- (3) Install Compression Gauge Adaptor (special tool) on the injection nozzle hole together with a gasket and connect the compression gauge (measuring instrument).
- (4) Turn the engine with the starter and read the compression gauge pointer value with the specified engine speed.

**NOTE : 1. Keep on fuel injected.**

**2. Make sure that the engine speed is also measured as compression pressure varies with the engine speed.**

**3. Make measurement for all cylinders as wear and other conditions vary from one cylinder to another.**

- (5) If the measurement is below the limit, disassemble and check.



NV ... Nominal Value

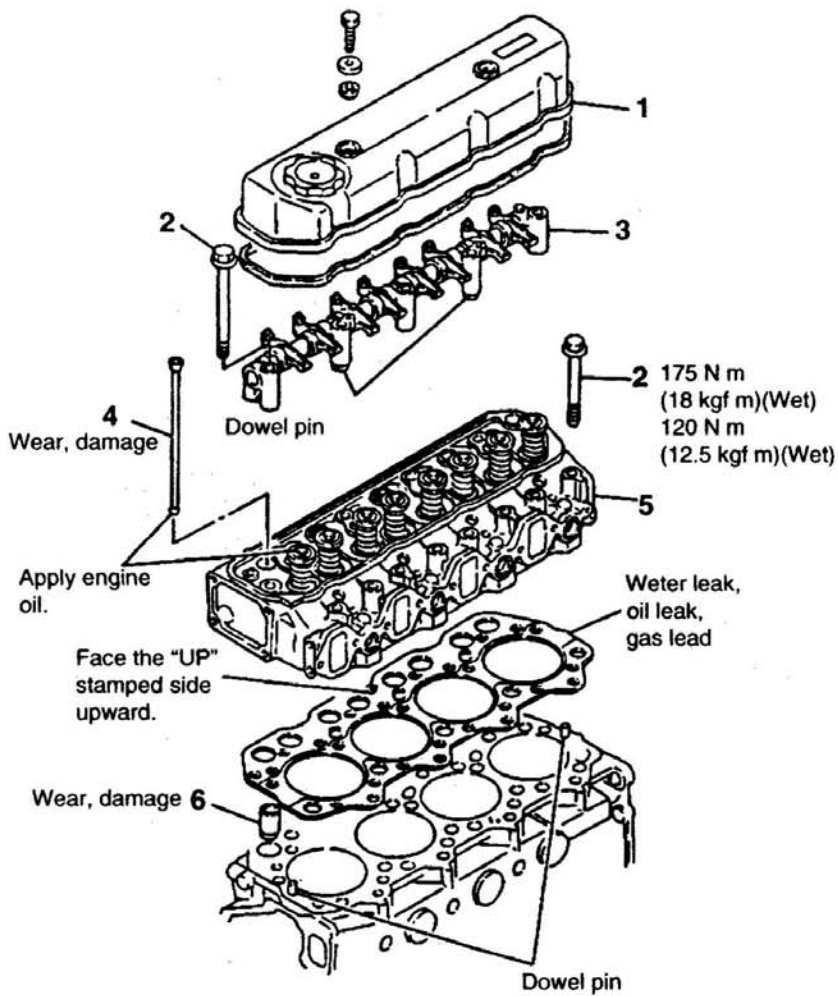
L ... Limit

## 2. Cylinder Head and Valve Mechanism

### (1) Removal and Installation

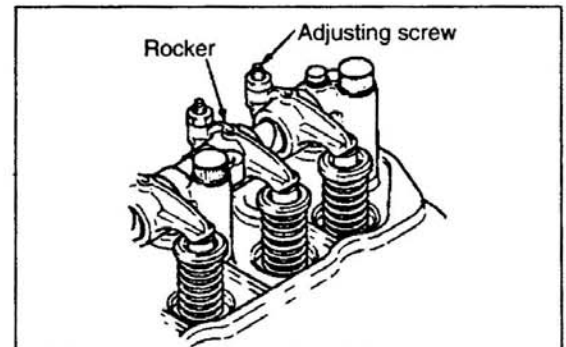
For disassembly of parts with an encircled number, see following items.

- 1 Rocker cover
- 2 Cylinder head bolt
- ③ Rocker and bracket assembly
- 4 Push rod
- 5 Cylinder head assembly
- ⑥ Tappet

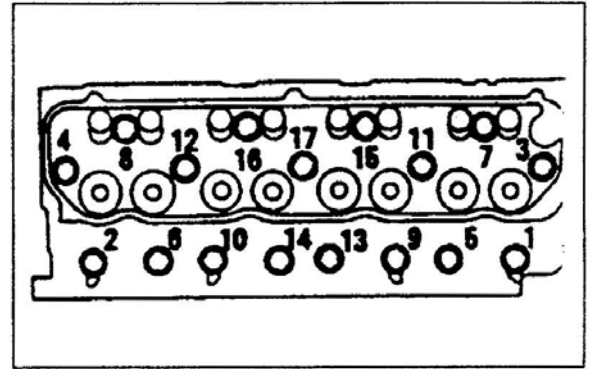


### Removal Procedure

- (a) Where the push rod is forcing up the rocker, the rocker adjusting screw must be loosened before all cylinder head bolts are removed.

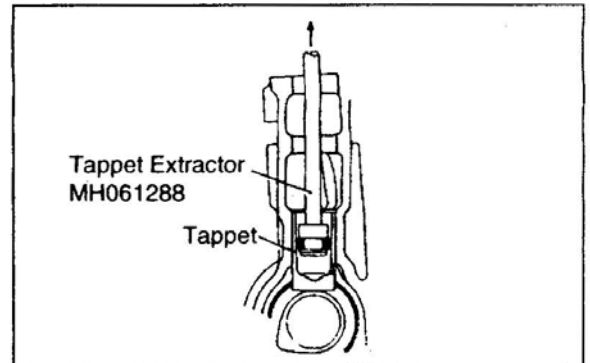


- (b) Loosen the cylinder head bolts in the reverse order of tightening.
- (c) Remove the rocker and bracket assembly and cylinder head assembly, raising them straight upward.
- (d) When removing the cylinder head gasket, use care to prevent scratches on the cylinder head and crankcase.



(e) Removal of the tappet

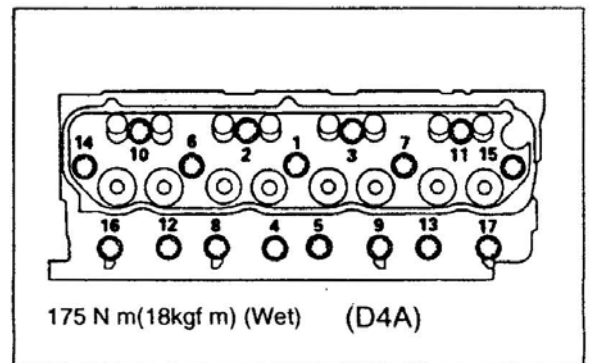
- Remove the tappet, using Tappet Extractor(special tool).
- For removal, press the special tool until its O-ring is pressed tightly against each other and remove the tappet together with the special tool.



**Installation Procedure**

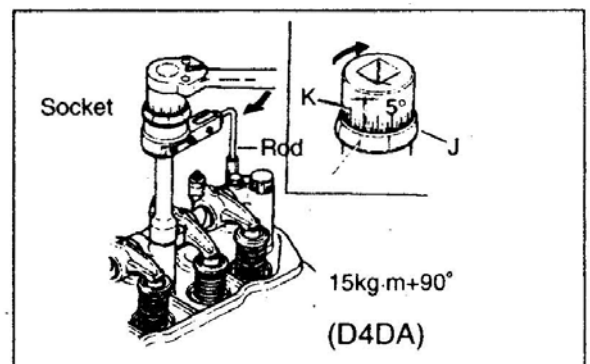
<D4A>

- (a) Install the cylinder head assembly and rocker and bracket assembly to align the dowel pins.
- (b) Tighten the cylinder head bolts in the sequence shown in illustration. Tighten step by step, and as a final step, tighten to specified torque.



<D4DA>

- (a) Set the socket such that the built-in spring force forces rod against the rocker shaft bracket, and injection pipe, or another nearby part.
- (b) On holder, select inscribed line J that is easiest to see.
- (c) Using the selected line as a reference, turn socket 90° clockwise.  
(One gradation on scale K represent 5°.)
- (d) After tightening the cylinder head bolts 11 using the plastic region tightening method, make a punch mark on the head of each one to indicate the times of use.



**NOTE:**

Since cylinder head bolts 4 utilize the plastic region tightening method, they must not be tightened further after this procedure.

## Cylinder head gasket

### [Removal]

#### NOTE:

Be careful not to scratch cylinder head assembly or the crankcase when removing cylinder head gasket.

### [Installation]

Install cylinder head gasket in the direction as illustrated.

- Cylinder head gasket installed must be the one which can accommodate the piston projection. To obtain such a gasket, measure the piston projection at each cylinder and take an average. Select a cylinder head gasket appropriate for the average value from the following table.
- If any of the piston projection Measurements is more than 0.05mm larger than the average value, then use the gasket one rank higher than that rank(A→B, B→C)

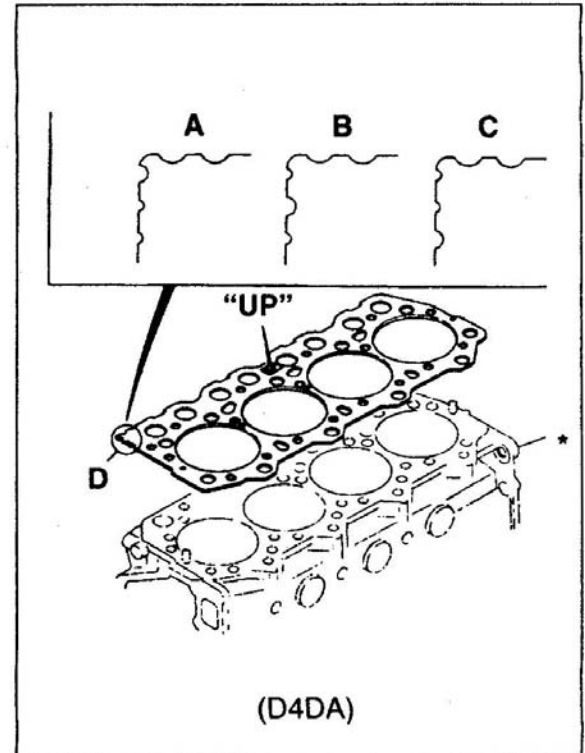
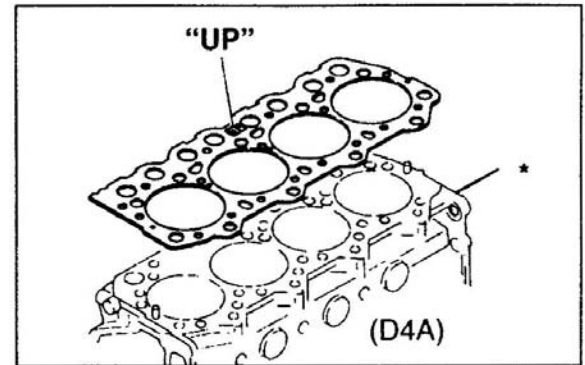
Average value of piston projection	Cylinder head gasket	
	Size Classification	Thickness when tightening
0.546 to 0.610	A	$1.35 \pm 0.03$
0.610 to 0.674	B	$1.40 \pm 0.03$
0.674 to 0.738	C	$1.45 \pm 0.03$

- The classification(size) and the application(engine model) of cylinder head gasket can be known from the shape of the notches D cut in the gasket edge.

#### NOTE:

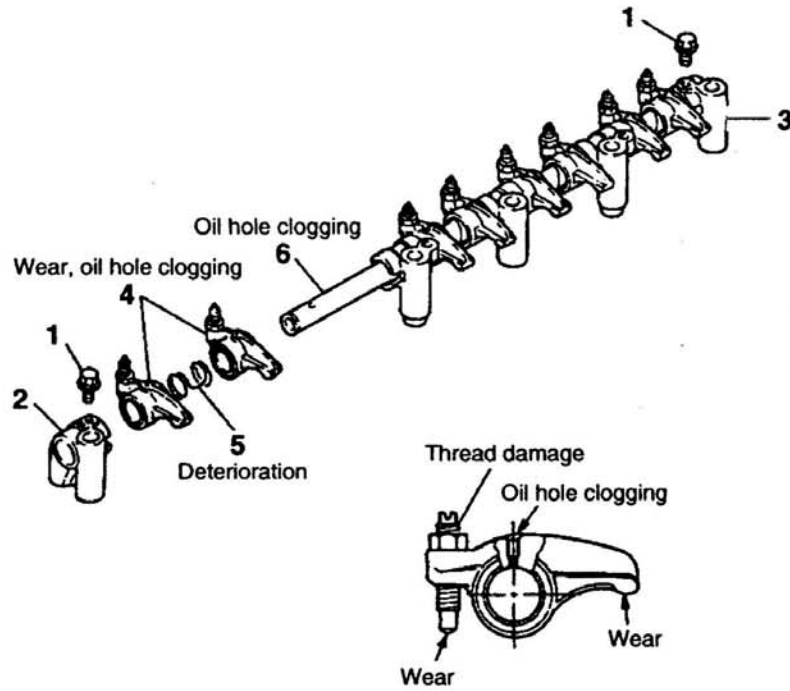
Changing a piston or a connecting rod can cause the piston projection to change.

Measure the piston projection whenever a piston or connecting rod is replaced.



**(2) Disassembly**

**(a) Rocker and bracket assembly**



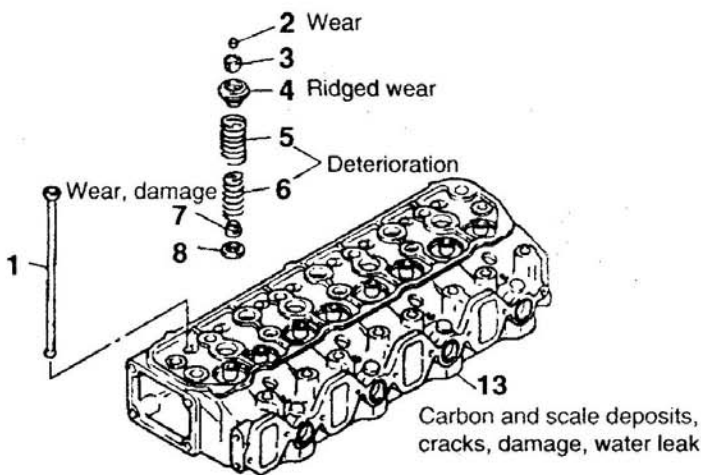
<Disassembly sequence>

- 1 Set bolt
- 2 Front rocker shaft bracket
- 3 Rear rocker shaft bracket

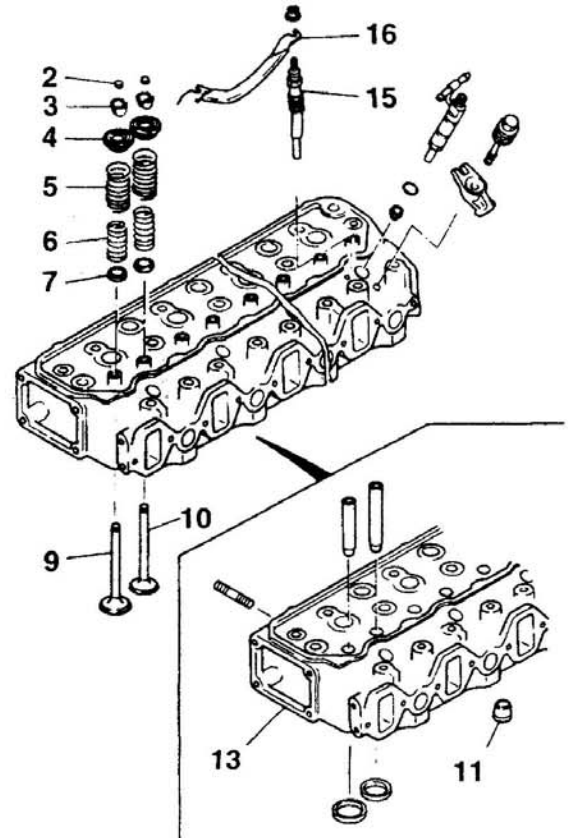
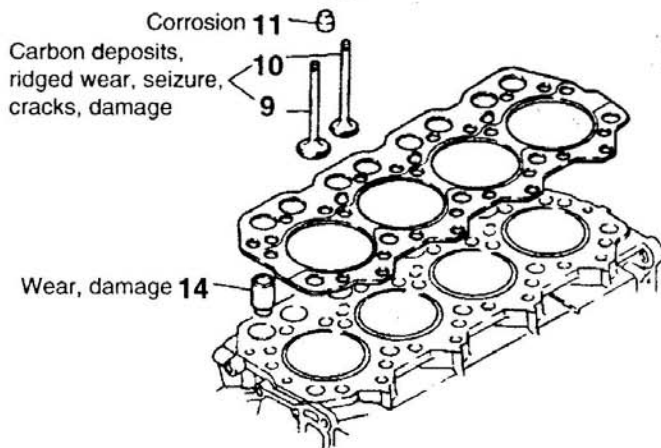
- 4 Rocker ASS'Y
- 5 Rocker shaft spring
- 6 Rocker shaft



**(b) Cylinder head assembly**



D4A



D4AF(Fork Lift)  
D4DA

<Disassembly seequence>

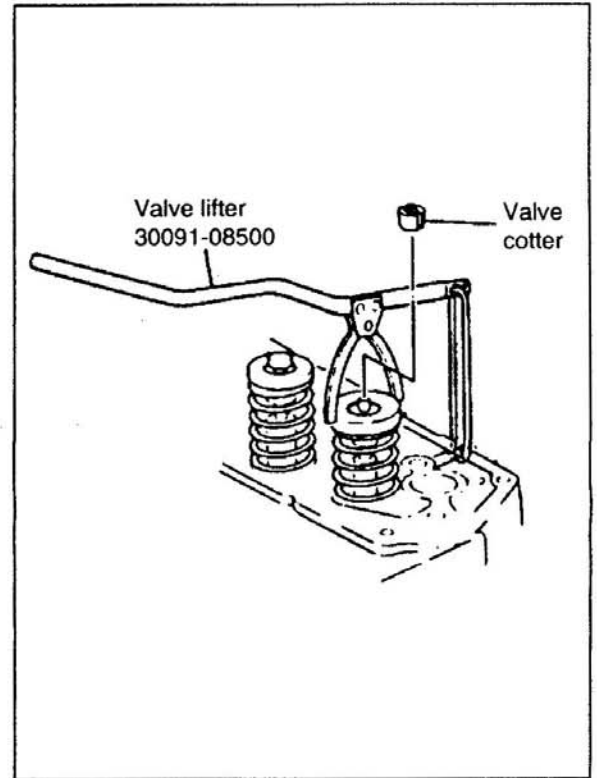
- |                      |                      |                     |
|----------------------|----------------------|---------------------|
| 1 Push rod           | 6 Inner valve spring | ⓪ Water director    |
| 2 Valve cap          | ⑦ Valve stem seal    | 13 Cylinder head    |
| ③ Valve cotter       | 8 Lower retainer     | 14 Tappet           |
| 4 Upper retainer     | 9 Inlet valve        | 15 Glow plug        |
| 5 Outer valve spring | 10 Exhaust valve     | 16 Connecting plate |

For disassembly of parts with an encircled number, see following items.  
Glow plug 15 take care not to damage.

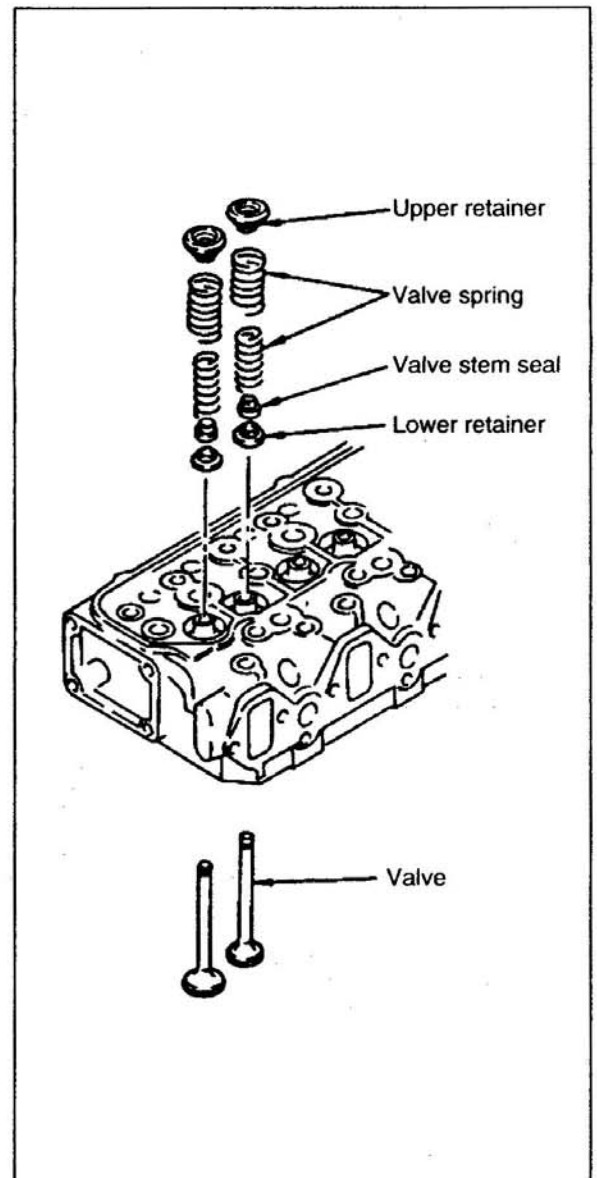
- 1) To remove the valve cotter, use Valve Lifter (special tool) and compress evenly the valve spring.

**NOTE:**

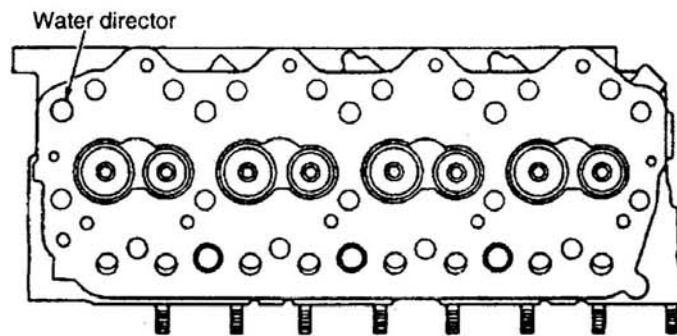
**Do not compress value springs more than is necessary. If the valve springs are compressed excessively, upper retainer can touch valve stem seal and be damaged.**



- 2) Whenever the valve stem seal or valve is removed, the valve stem seal must be replaced with a new one.

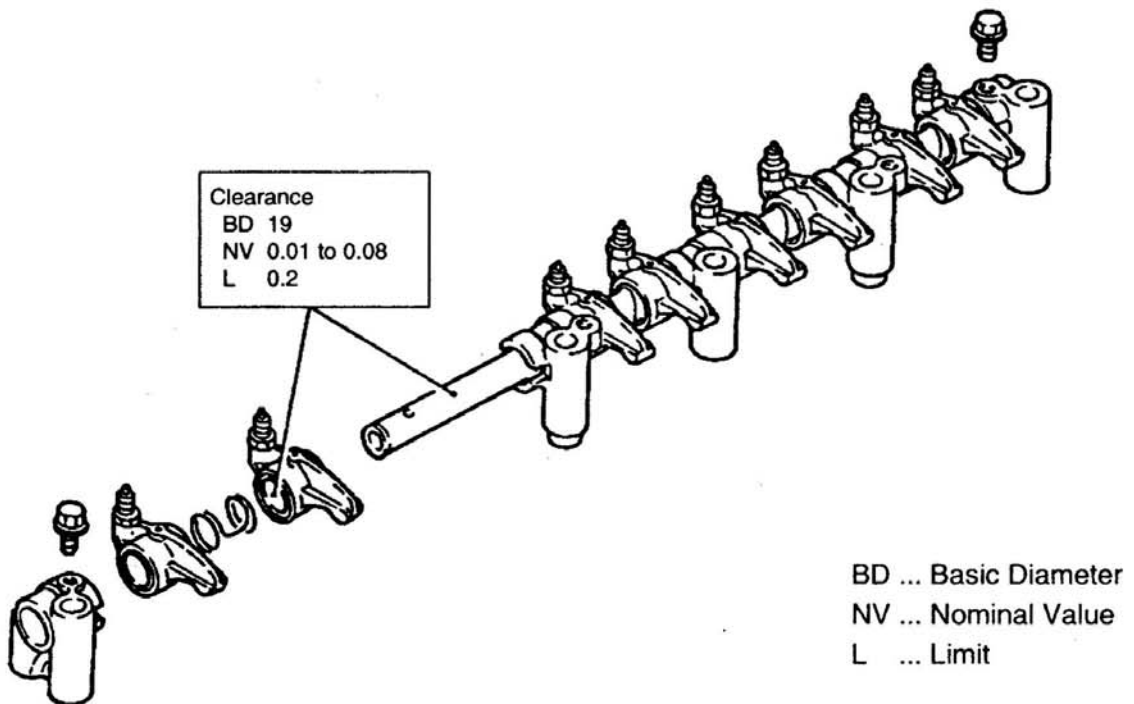


3) Remove the water director if corroded.

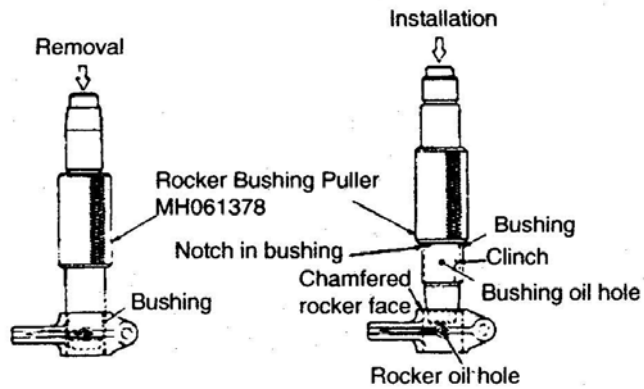
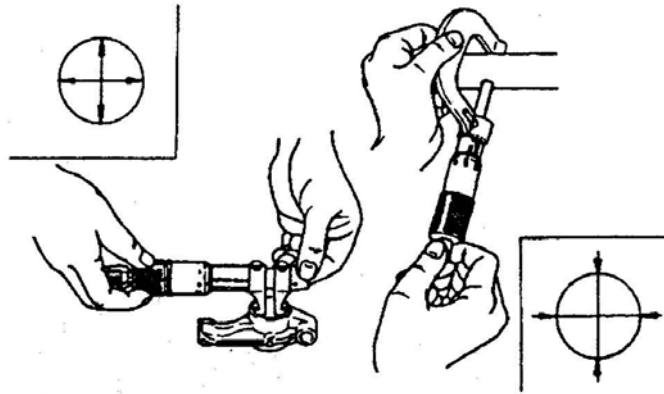


### (3) Inspection

(a) Rocker and bracket assembly



- 1) Using the rocker I.D. and rocker shaft O.D., calculate the clearance. If the limit is exceeded, replace the bushing in the rocker.



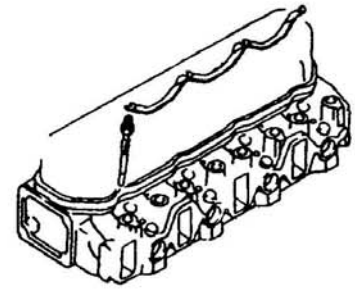
**NOTE:**

1. Align the oil hole in the bushing with that in the rocker.
2. Ensure that the bushing clinch is on the adjusting screw end.
3. When press-fitting the bushing into rocker, start with the chamfered side on the rocker.

(b) Cylinder head assembly

Free length	NV 60.84
L	57.8
Installed load/ installed length	NV 240N(24.5 kgf/ 47.25
L	205N(20.8kgf/ 47.25
Squareness	L 2.5

Free length	NV 55.07
L	52.1
Installed load/ installed length	NV 93N(9.5 kgf/ 40.3
L	79N(8.1kgf/ 40.3
Squareness	L 2



< D4DA, D4AF(12V) >

Runout	L 0.4
--------	-------

Clearance	
Inlet	BD 9
NV	0.04 to 0.06
L	0.15
Exhaust	BD 9
NV	0.07 to 0.10
L	0.2

Stem O.D.	
Inlet	NV 8.96 to 8.97
L	8.85
Exhaust	NV 8.93 to 8.94
L	8.85

Valve sinkage from cylinder head bottom surface	
NV	0.75 to 1.25
L	1.5

Valve margin	
NV	1.5
L	1.2

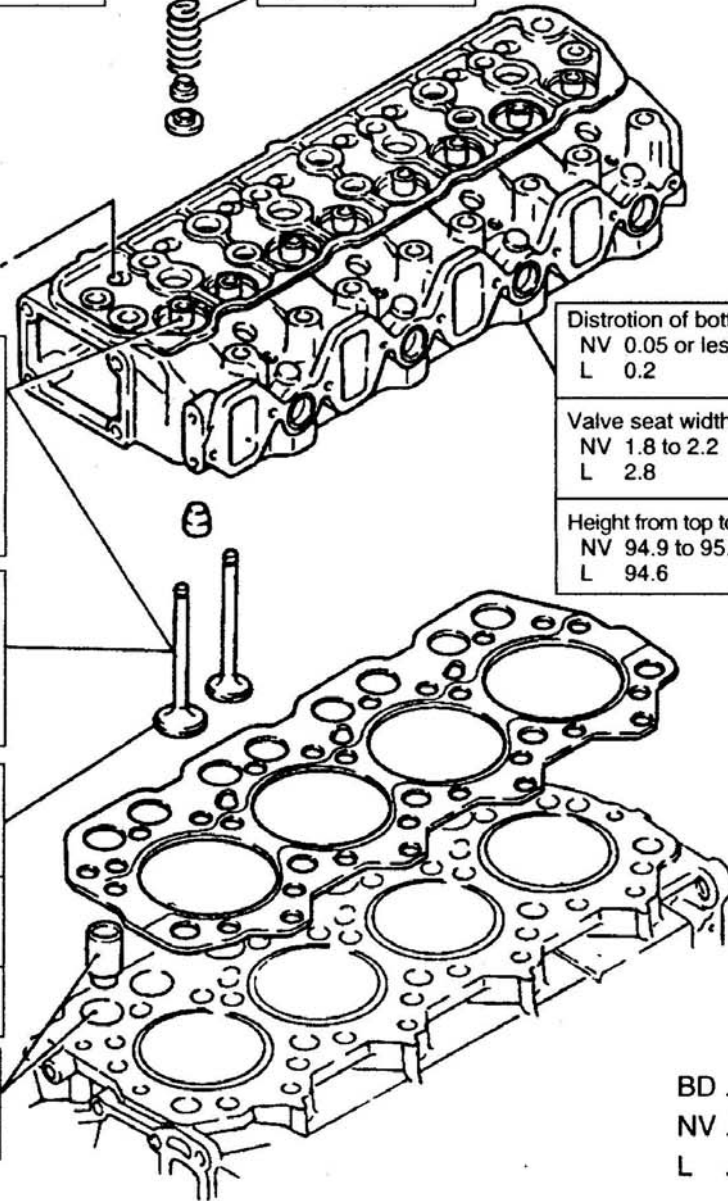
Valve seat angle	
NV	45°

Clearance	
BD 28	NV 0.06 to 0.10
L	0.2

Distortion of bottom surface	
NV	0.05 or less
L	0.2

Valve seat width	
NV	1.8 to 2.2
L	2.8

Height from top to bottom surface	
NV	94.9 to 95.1
L	94.6

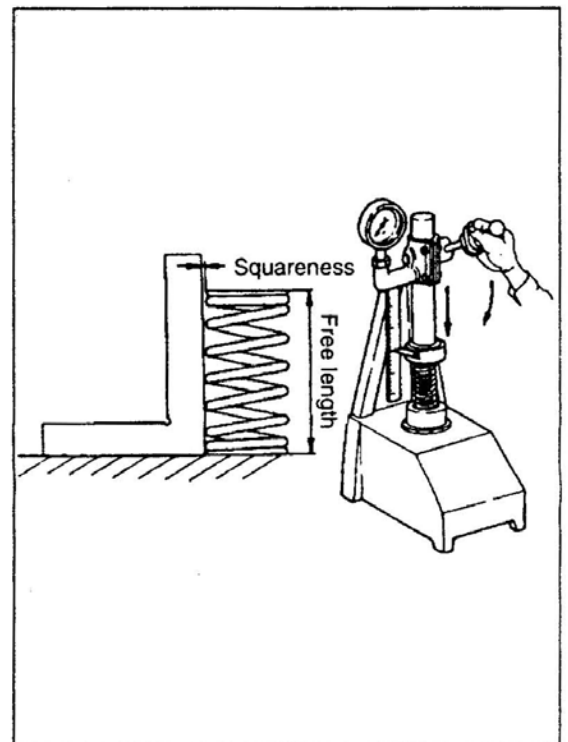


BD ... Basic Diameter  
 NV ... Nominal Value  
 L ... Limit

<D4A>

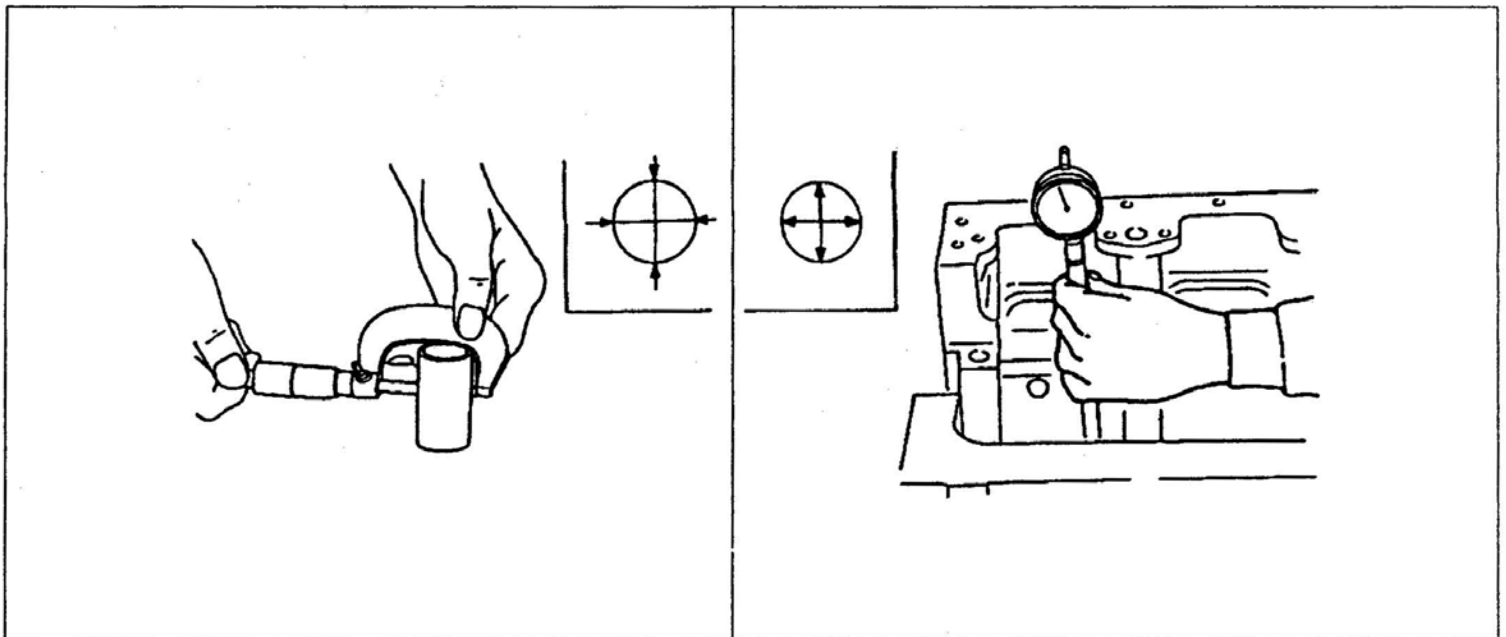
1) Inspection of valve spring

Check the valve spring for squareness, free length, and proper tension, and replace if the limit is exceeded.



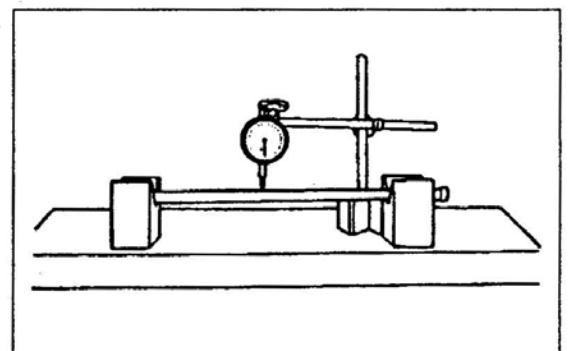
2) Tappet to crankcase clearance

If the measured valve is higher than the limit, replace the faulty parts.



3) Measure the push rod run out.

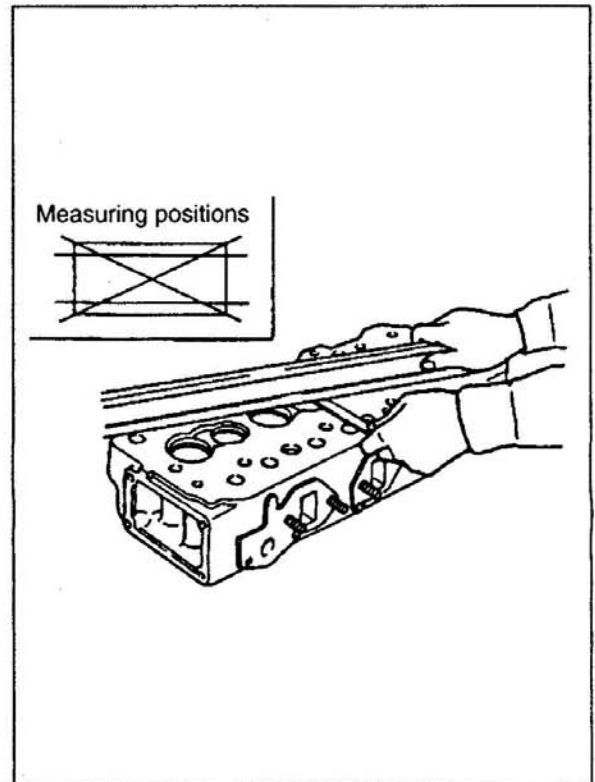
If the limit is exceeded, replace.



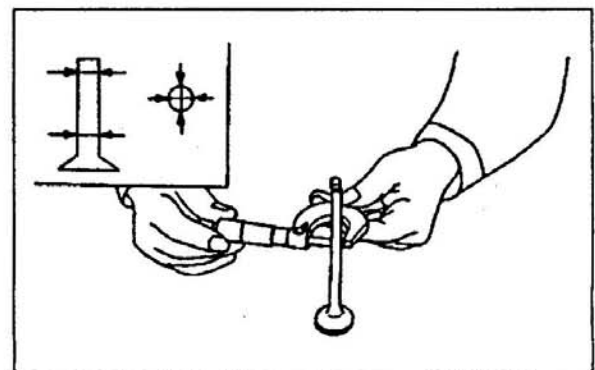
- 4) Cylinder head bottom surface distortion  
 If the limit is exceeded, correct with a surface grinder.  
 If the cylinder head height from top to bottom surface is below the limit, replace.

**NOTE:**

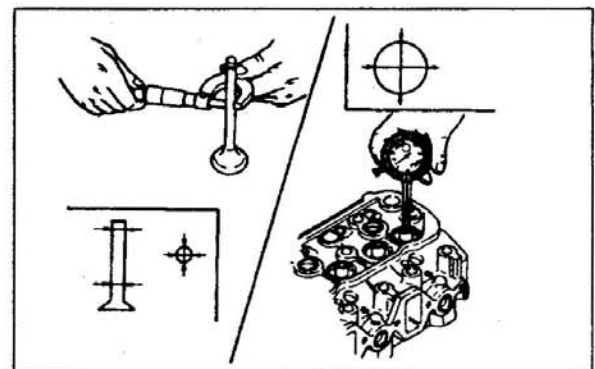
Ensure that grinding does not cause the cylinder head's top surface-to-bottom surface distance to fall below the specified limit.



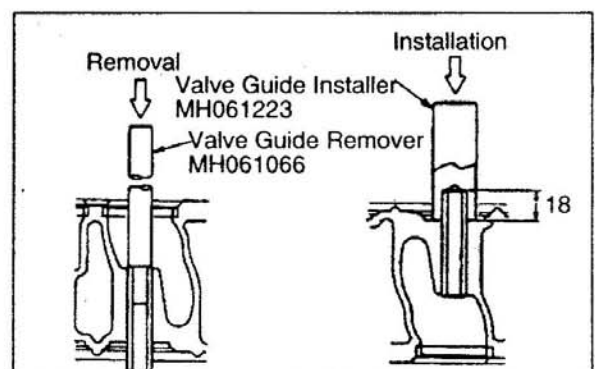
- 5) Inlet and exhaust valves  
 Measure the valve stem O.D. and, if the measurement is below the limit, replace.



- 6) Valves and valve guides  
 Calculate the clearance with the valve guide I.D.  
 If the limit is exceeded, replace the valve guide.



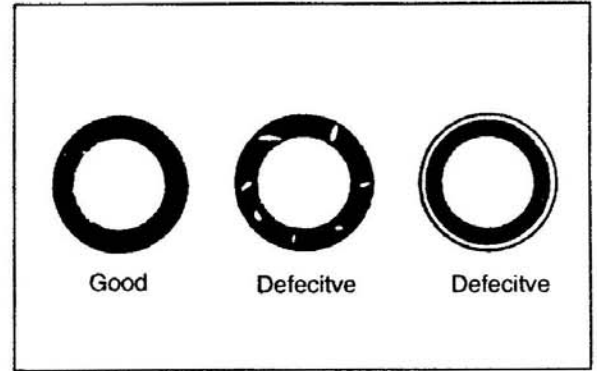
- 7) Replacement of valve guide  
 For removal of the valve guide, use the Valve Guide Remover (special tool).  
 To install, use Valve Guide Installer (special tool) and ensure that the special tool is positively seated on the cylinder head. The pressing force is specified for the valve guide, which must be reached by using the special tool.



8) Inspection of valve

Check the contacting condition of the valve seat and valve, after inspection and replacement of the valve guide.

When the valve is pressed against the valve seat coated with red lead, make sure that the valve is not turned.

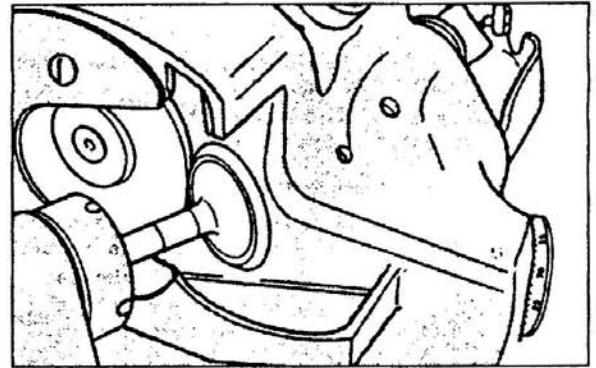


9) Correction of valve face

Grind the valve face with a valve refacer, the grinding dimension being limited to a minimum.

**NOTE:**

1. The valve seat angle is  $45^\circ$  .
2. Correct to ensure that the valve margin is up to the limit.

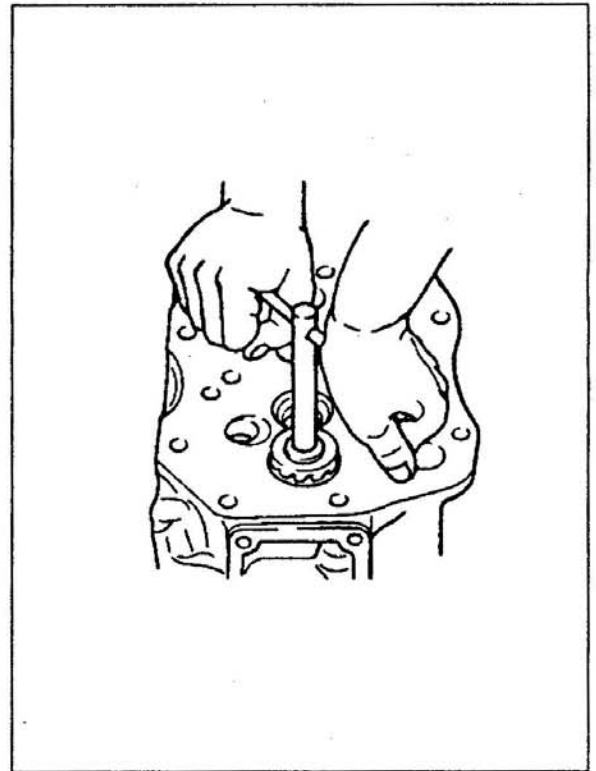


10) Correction of valve seat

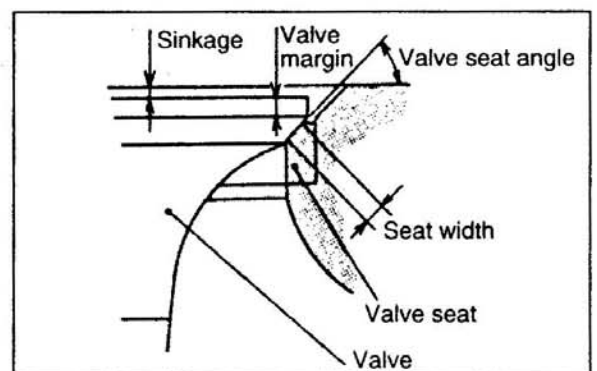
- a) Grind with a valve seat cutter or valve seat grinder.
- b) After grinding, hold a #400 or similar sand paper between the cutter and valve seat and regrind lightly.

**NOTE:**

1. The valve seat angle is  $45^\circ$  .
2. Correction must be made to ensure the valve seat width and valve sinkage are within the limit.



- c) Using a  $15^\circ$  or  $75^\circ$  cutter, correct the seat width to the nominal value.
- d) Seat the valve and valve seat. [See fig]

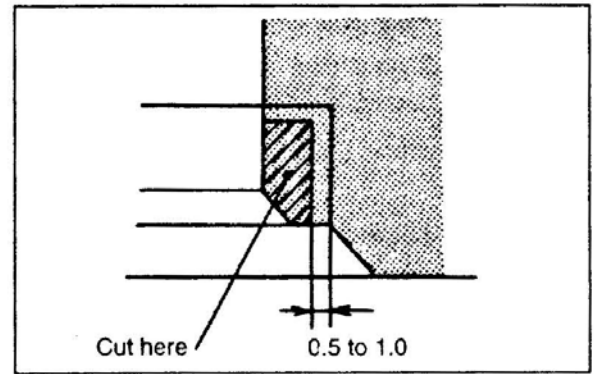




### 11) Replacement of valve seat

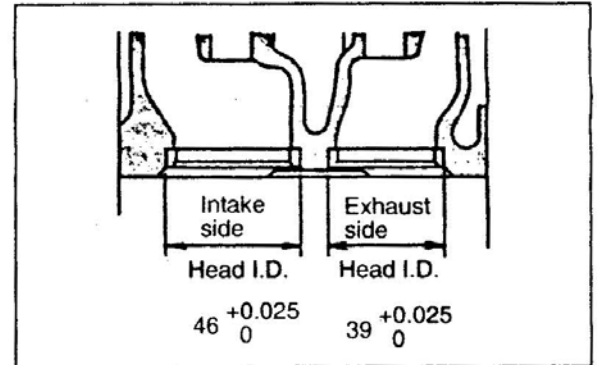
The valve seat is cold fitted.  
Replacement procedure is given below.

- a) Grind the valve seat from inside to reduce the wall thickness.  
Then, remove it at normal temperature.



(Installation)

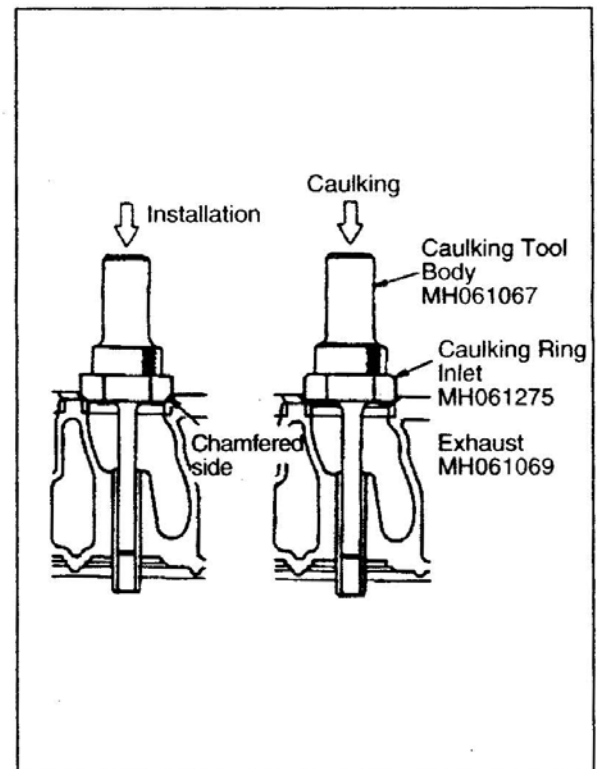
- b) Check if there is sufficient interference between the cylinder head and valve seat.
- c) Dip the valve seat into liquid nitrogen and let it cool down.  
But heat the cylinder head sufficiently.



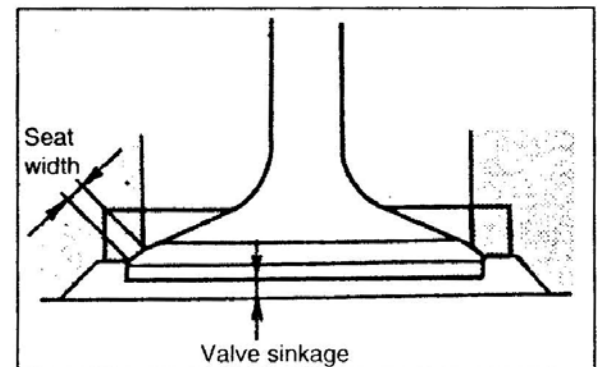
- d) Using Caulking Tool Body and Caulking Ring(special tools), install the valve seat.

#### NOTE:

**After pressing in position the valve seat with the chamfered side of the caulking ring, face the ring in the opposite direction to caulk the cylinder head.**



- e) Reface the valve seat to obtain the nominal values for the seat width and valve sinkage.



## 12) Seating of valve and valve seat

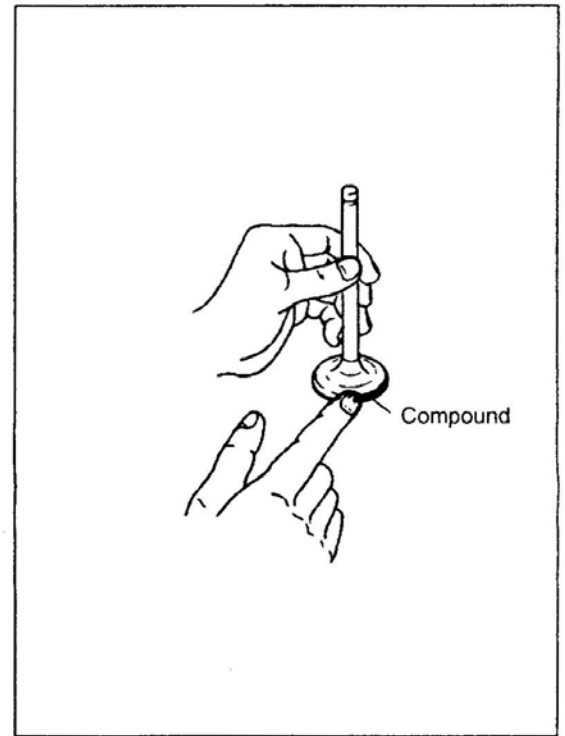
The valve and valve seat must be in even contact throughout the surfaces.

Whenever the valve or valve seat is corrected or replaced, they must be seated.

- a) Apply a thin coat of compound evenly to the seating surface of the valve.

### NOTE:

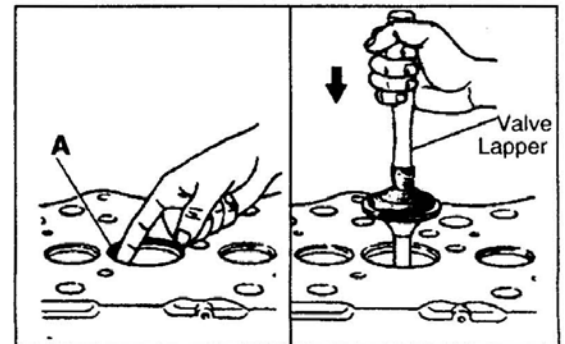
1. Make sure that there is no compound on the stem of the valve.
2. Use intermediate mesh compound(120 to 150 meshes) first and then use fine mesh compound(200 meshes or more) for the finish.
3. Mix the compound with a small amount of engine oil and the compound can be applied evenly.



- b) Using Valve lapper(special tool), seat the valve on valve seat. ('A' Surface )

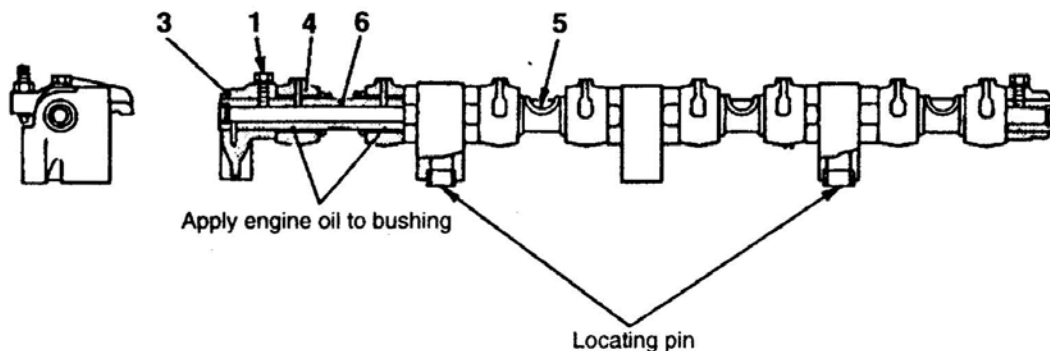
While turning the valve slightly at a time, strike it against the valve seat.

- c) Wash off the compound with gas oil or similar object.
- d) Seat the contact surfaces with engine oil.
- e) Seat the contact surfaces with engine oil.



## (4) Reassembly

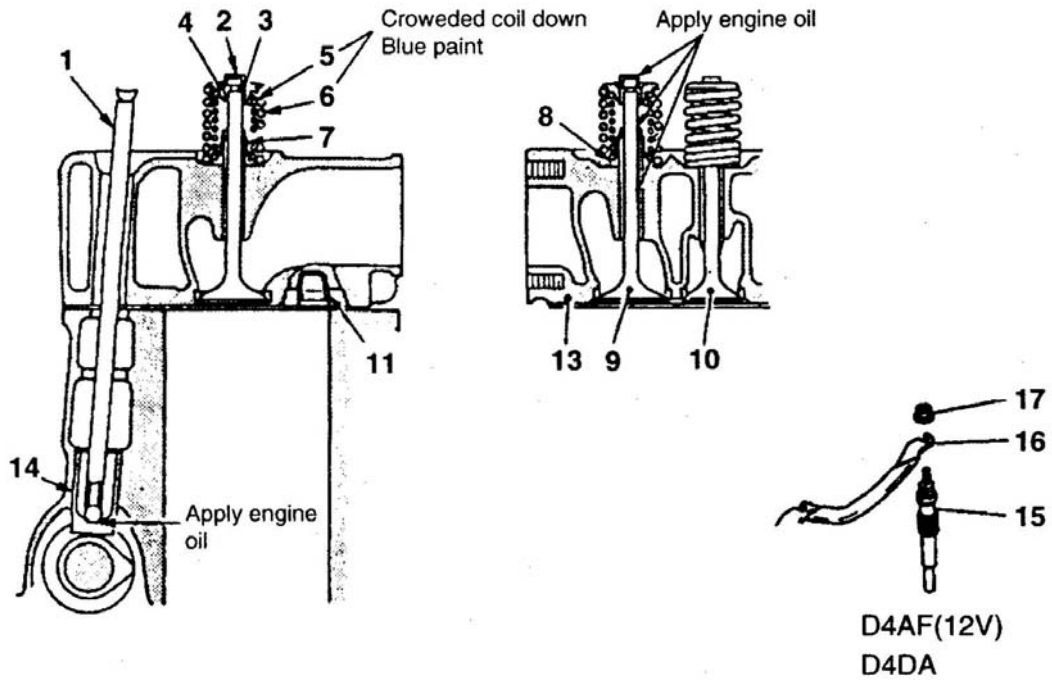
### (a) Rocker and bracket assembly



<Assembly sequence>

6→3→4→5→1

(b) Cylinder head assembly

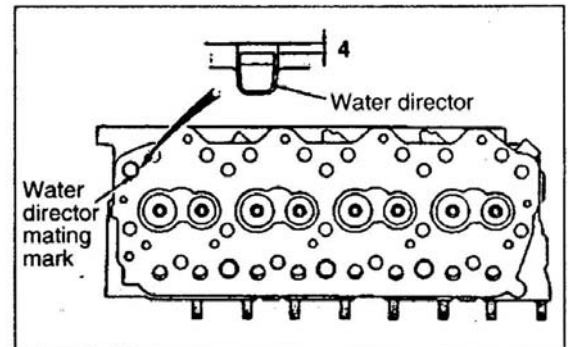


<Assembly sequence>

14 → 13 → ⑪ → 10 → 9 → 8 → ⑦ → 6 → 5 → 4 → ③ → 2 → 1 → 15 → 16 → 17

1) Installation of water director

Install the water director with its cut facing toward the specified direction.



2) Installation of valve stem seal

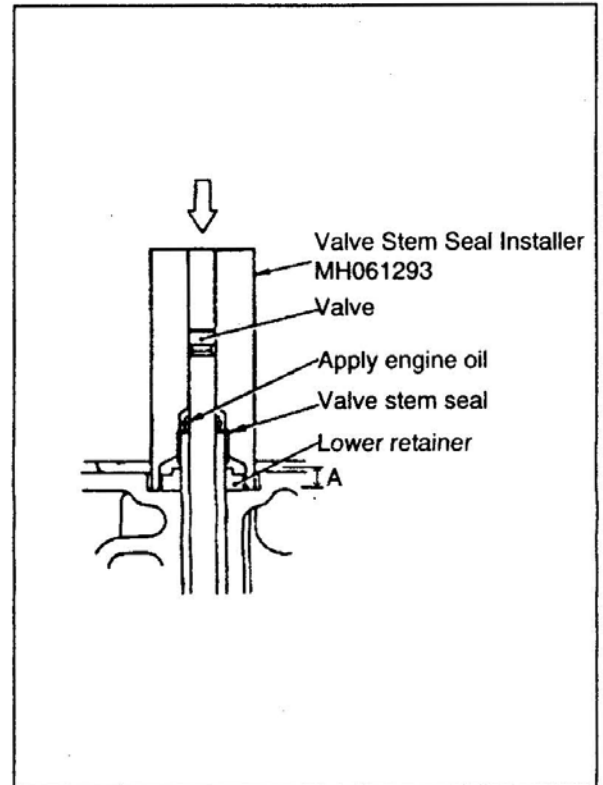
Apply engine oil to the lips of the valve stem seal and strike valve stem seal Installer(special tool) until it touches the cylinder head.

**NOTE:**

a) Valve guides must be pressed in to the specified depth A.

Be sure to use the Valve Guide installer for this operation. A:10mm

b) Exhaust valve guides are longer than inlet valve guides. Be sure to install the correct type of guide in each location.



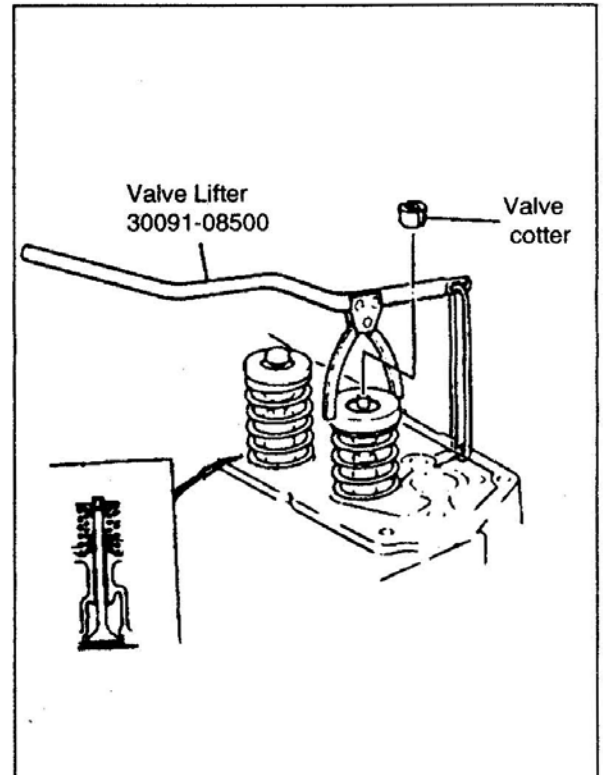
3) Installation of valve cotter

Using Valve Lifter(special tool), install the valve cotter while compressing the valve spring.

**NOTE:**

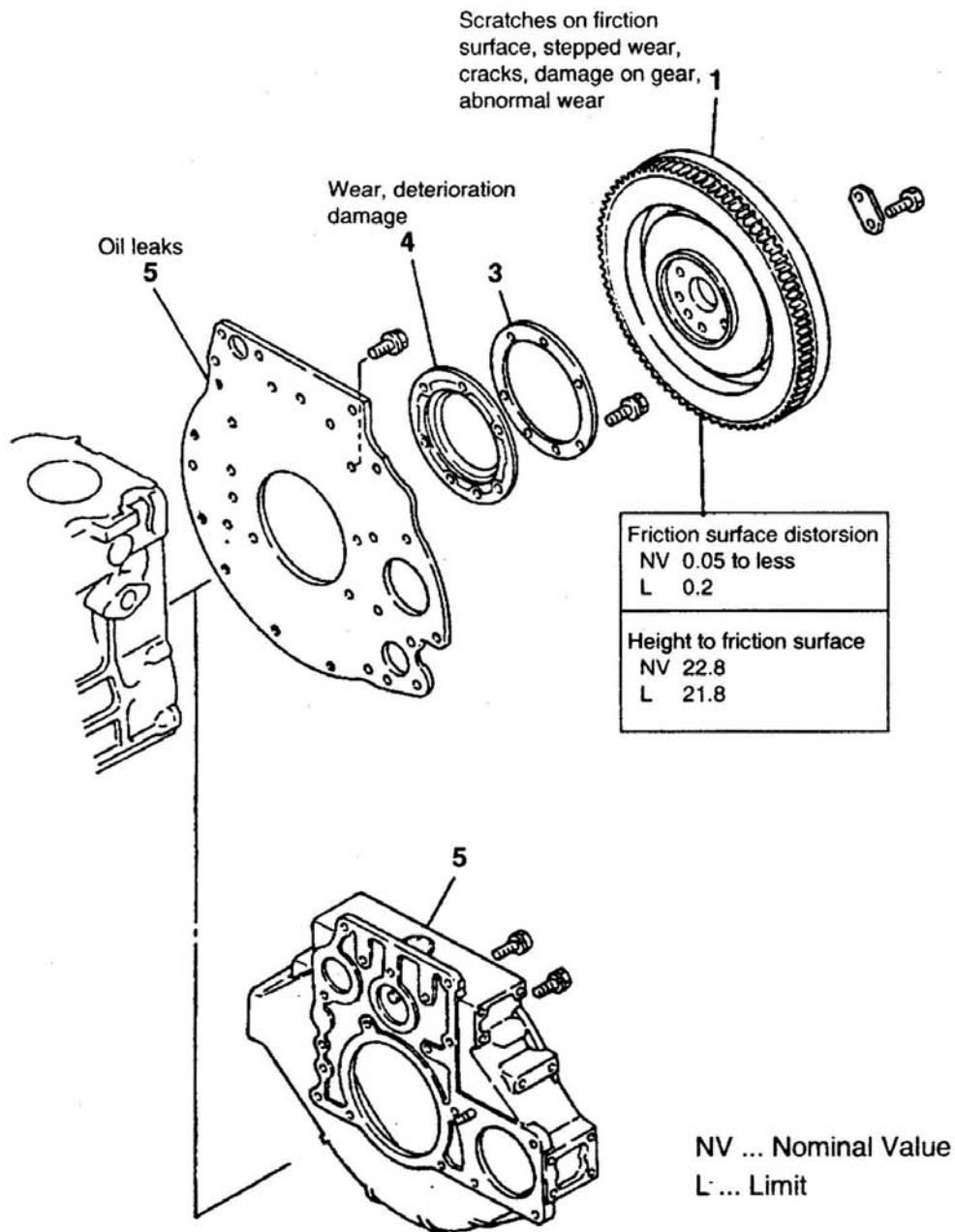
Do not compress valve springs more than is necessary.

If the valve springs are compressed excessively, upper retainer can touch valve stem seal and be damaged.



### 3. Flywheel and Rear plate

#### (1) Disassembly and Inspection



<Disassembly sequence>

①. Flywheel

3. Washer plate

4. Oil seal

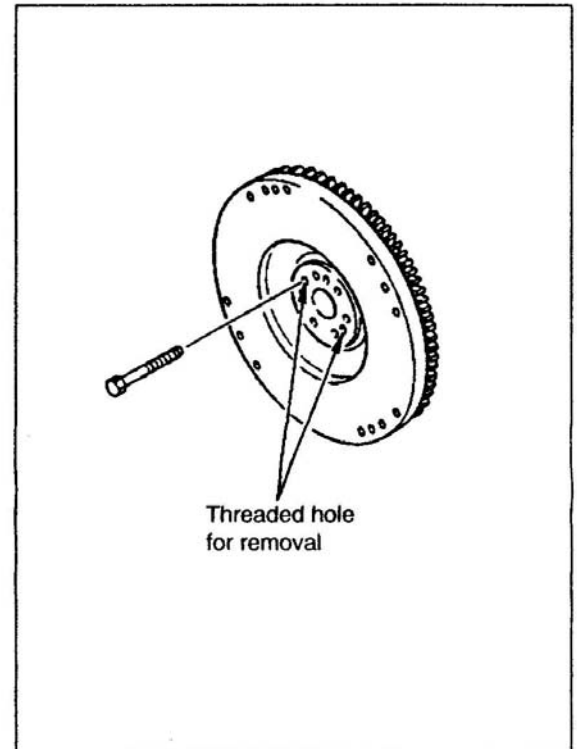
5. Rear plate or flywheel housing

For disassembly of parts with an encircled number, see following items.

## Removal Procedure

### (a) Removing flywheel

Remove the flywheel by insertion flywheel mounting bolts evenly into the flywheel removing holes.  
Remove the ring gear integral with the flywheel.



## Inspection Procedure

### (a) Replacement of ring gear

#### 1) Inspection

Inspecting gear for damage and abnormal wear.  
If any defect is evident, the ring gear must be replaced.

#### 2) Removal

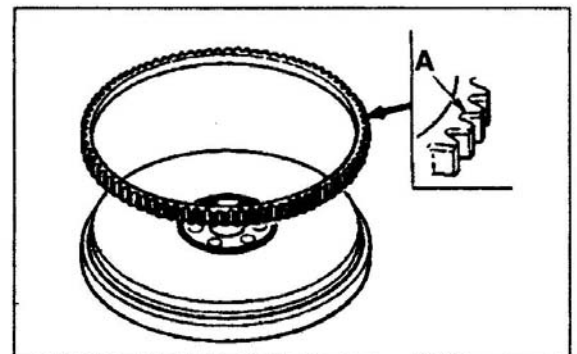
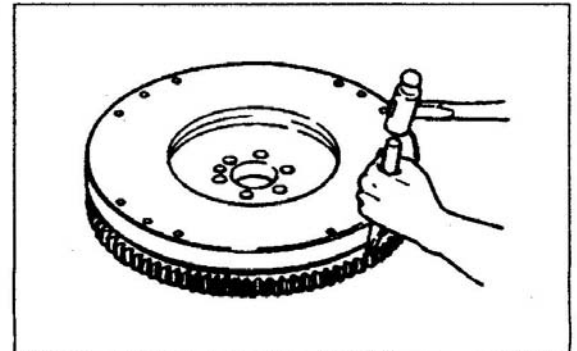
Using an acetyline torch or similar device, evenly heat the ring gear.

By applying a protective rod, hammer the entire periphery of the ring gear, forcing it off.

#### 3) Installation

Heat the ring gear with piston heater (approx. 100 °C) for three minutes.

Fit the ring gear onto the flywheel with the nonchamfered side of tooth crests toward the flywheel.



**NOTE : Be careful not to get burned.**

(b) Friction surface distortion

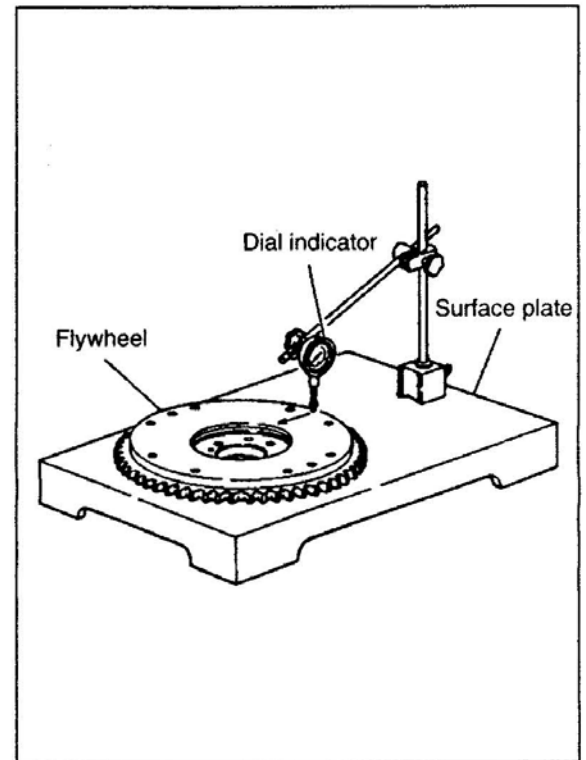
Place the flywheel on a surface plate and move a dial indicator over the flywheel friction surface to measure the distortion.

For more accurate measurement, use a portable jack.

If the distortion is beyond the limit, regrind the friction surface.

**NOTE:**

**If the ring gear develops any unusual condition, replace it with a new one before taking a measurement.**

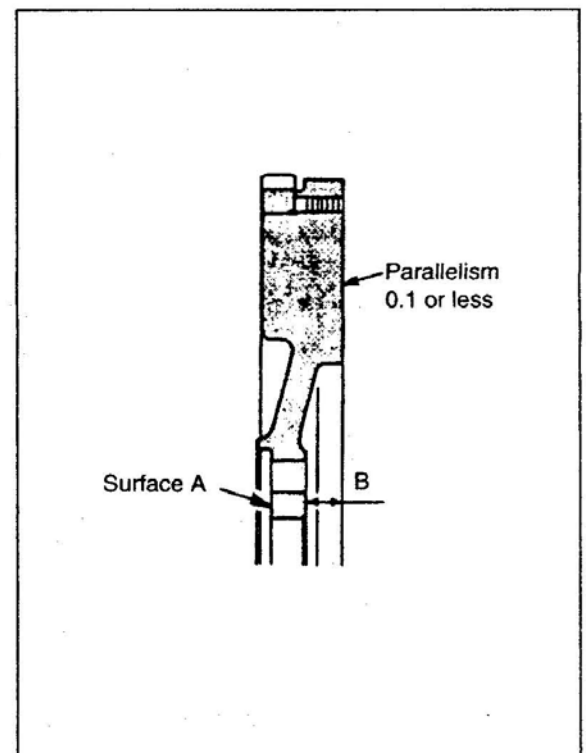


(c) Correction of friction surface

Correct the friction surface with a surface grinder. Make sure that the friction surface is parallel to surface A within 0.1mm.

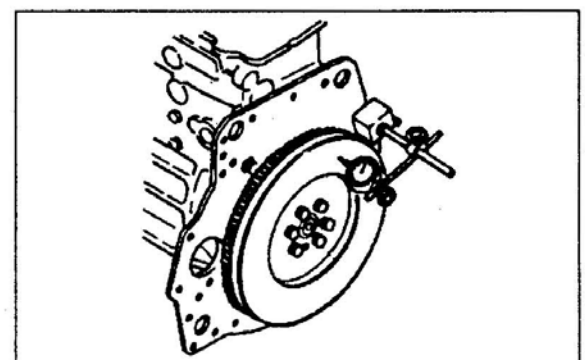
**NOTE:**

**After correction, make sure that the height of the friction surface (dimension B) is within the limit.**



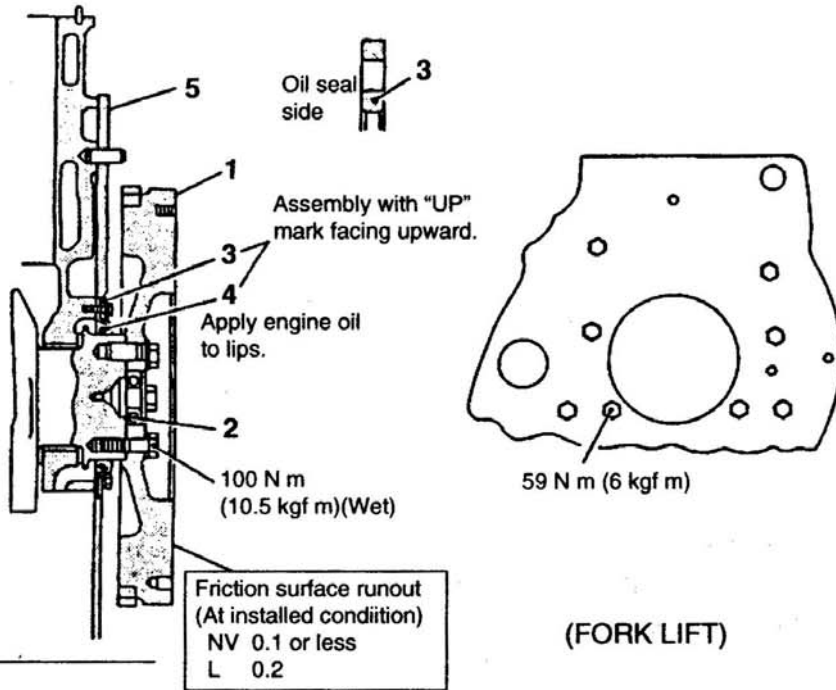
(d) Inspection of runout.

If runout exceeds the specified limit, check that bolts are tightened correctly and inspect the crankshaft mounting surface. Then, rectify or replace flywheel assembly as required.



(2) Reassembly

<Rear plate type>



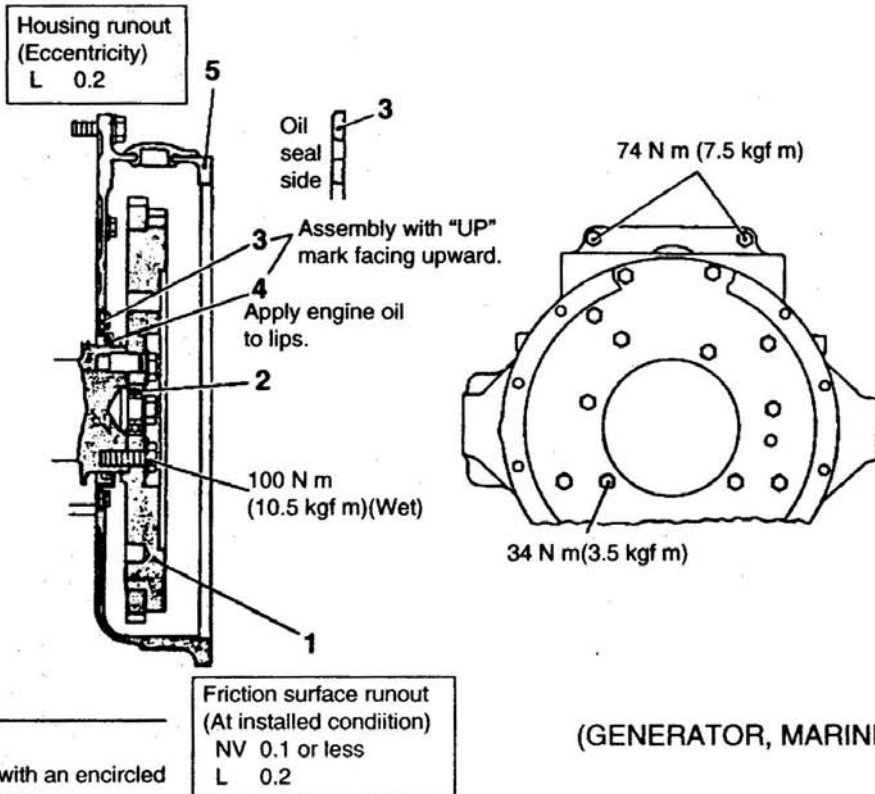
NV ... Nominal Value  
L ... Limit

<Assembly sequence>

5-④-③-2-1

For reassembly of parts with an encircled number, see following items.

<Flywheel housing type>



NV ... Nominal Value  
L ... Limit

<Assembly sequence>

5-④-③-2-1

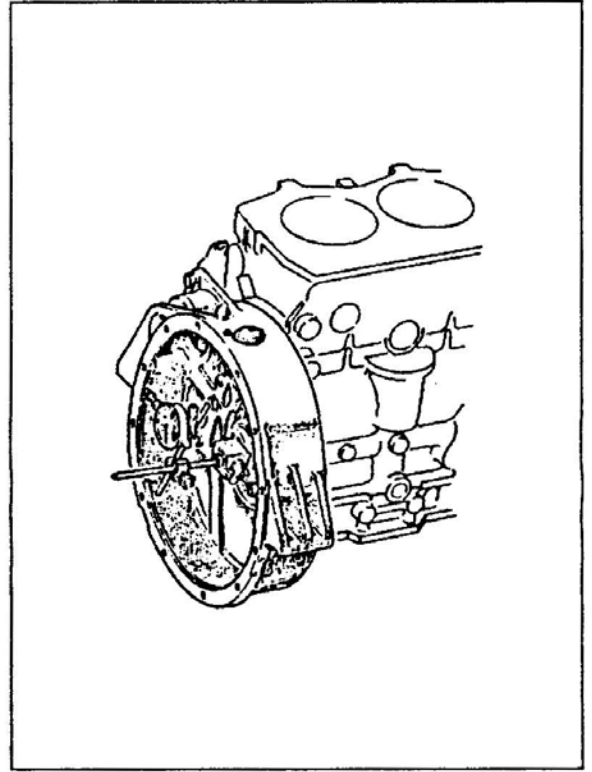
For reassembly of parts with an encircled number, see following items.



(a) Installing flywheel housing

Measure the installed state(eccentricity) at the spigot joint of the flywheel housing.

If the dial gauge indicates runout exceeding the specified limit, loosen the bolts and tap the housing lightly to correct position.

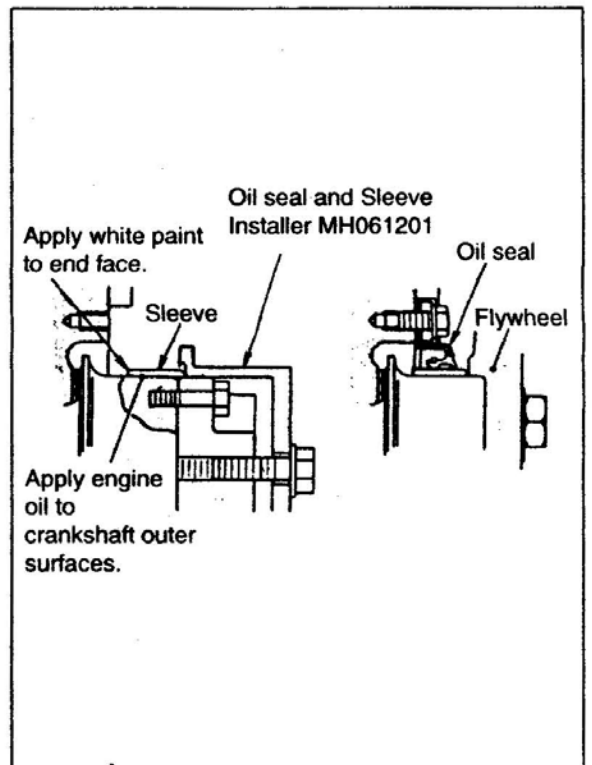


(b) Installation of oversize oil seal

If an excessive amount of oil leaks from the oil seal, use the auxiliary oil seal and sleeve.

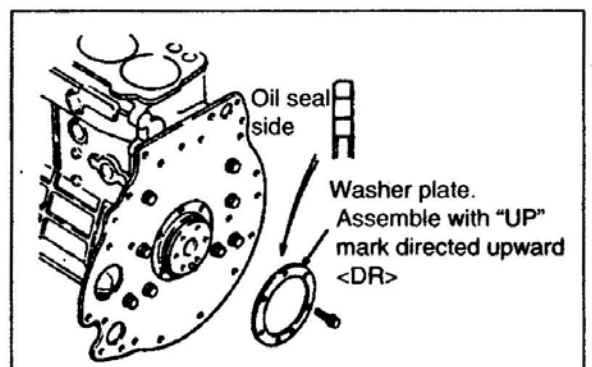
To install the sleeve, use oil seal and Sleeve Installer(special tool). The pressed position of the sleeve is determined where the flywheel is installed.

**NOTE: Face the white painted side of sleeve, toward the crankcase.**



(c) Installation of washer plate

Install the washer plate with its shear droop end facing toward oil seal side.

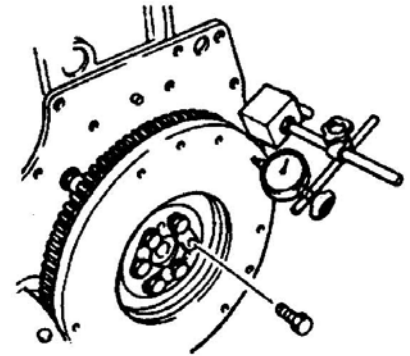


(d) Installation of flywheel

Mount the flywheel onto the crankshaft and tighten bolts to specification.

Measure runout(installed position) of the flywheel.

If the dial indicator deflects over the limits, check bolts for looseness or mounting surface.

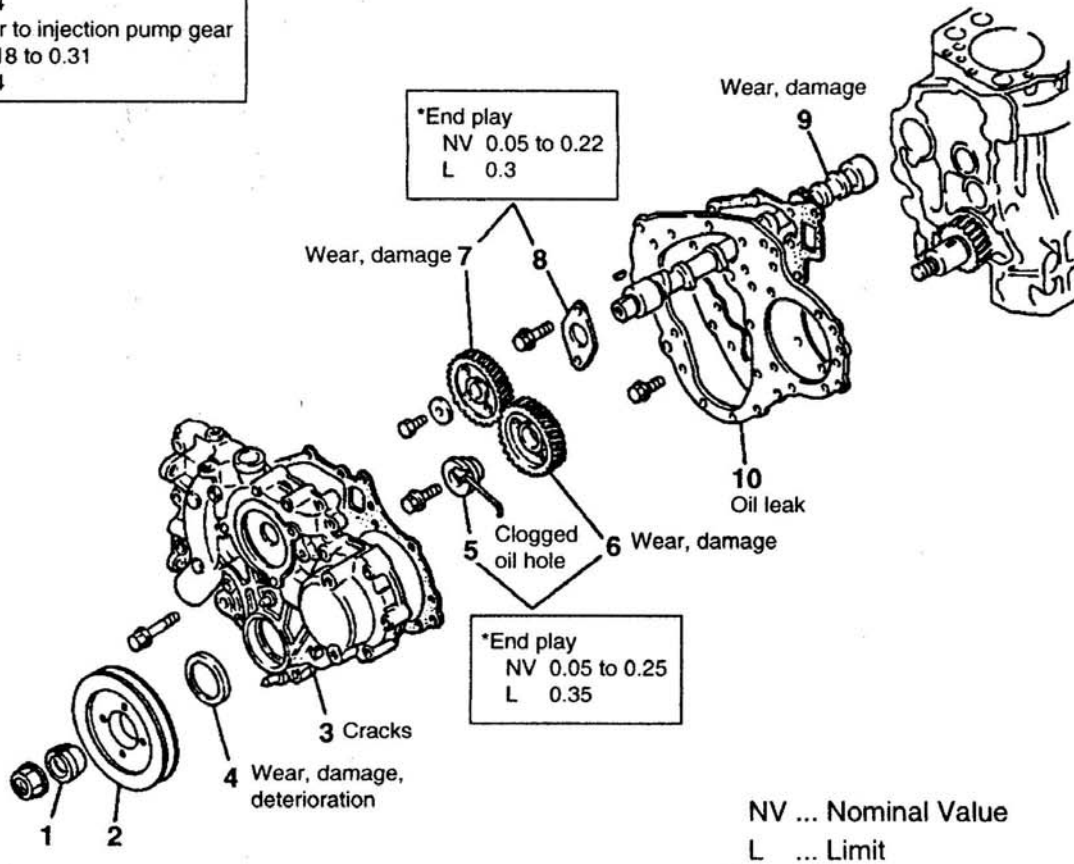


D4A:100 N m  
(10.5 kgf m)(Wet)  
D4DA:18kgf.m(Wet)

## 4. Timing Gear and Camshaft

### (1) Disassembly (D4A)

\*Backlash  
 Crankshaft gear to idler gear  
 NV 0.11 to 0.23  
 L 0.4  
 Idler gear to camshaft gear  
 NV 0.12 to 0.25  
 L 0.4  
 Idler gear to injection pump gear  
 NV 0.18 to 0.31  
 L 0.4



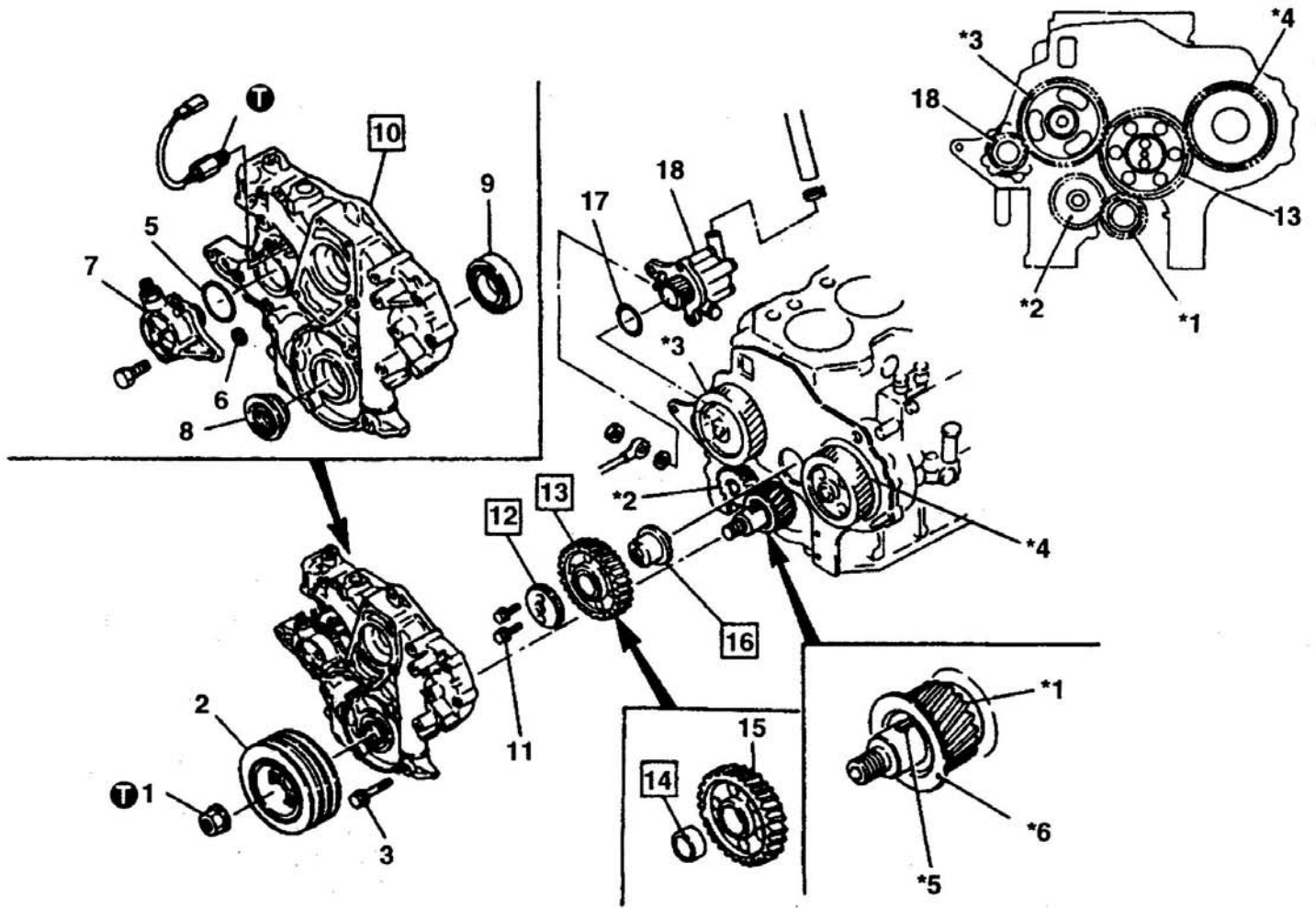
#### <Disassembly sequence>

- |                     |                 |
|---------------------|-----------------|
| ① Taper cone        | 6 Idler gear    |
| ② Crankshaft pulley | ⑦ Camshaft gear |
| 3 Timing gear case  | ⑧ Thrust plate  |
| ④ Oil seal          | ⑨ Camshaft      |
| 5 Idler shaft       | 10 Front plate  |

For disassembly of parts with an encircled number, see following items.

The part marked with \* must be inspected before disassembly

<D4DA>



<Disassembly sequence>

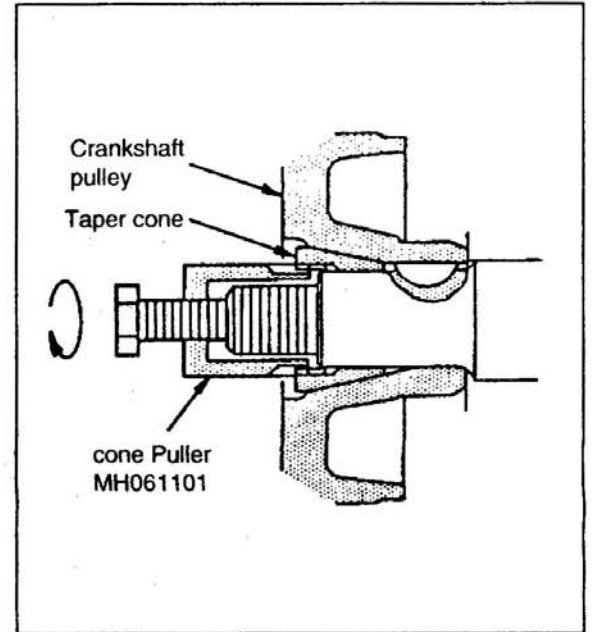
- 1 Nut
- 2 Crankshaft pulley
- 3 Bolt
- 4 Engine revolution sensor
- 5 O-ring
- 6 O-ring
- 7 Vacuum pump assembly
- 8 Front oil seal
- 9 Bearing

- 10 Timing gear case
- 11 Bolt
- 12 Thrust plate
- 13 Idler gear assembly
- 14 Idler gear bushing
- 15 Idler gear
- 16 Idler shaft
- 17 O-ring
- 18 Power steering oil pump

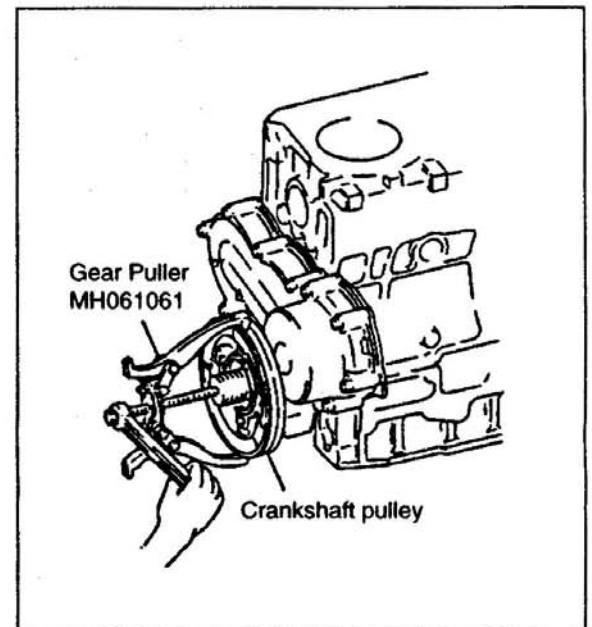
- \*1: Crankshaft gear
- \*2: Oil pump gear
- \*3: Camshaft gear
- \*4: Injection pump gear
- \*5: Key
- \*6: Front oil seal slinger

**NOTE : Do not remove front oil seal 8 and bearing 9 unless they are faulty.**

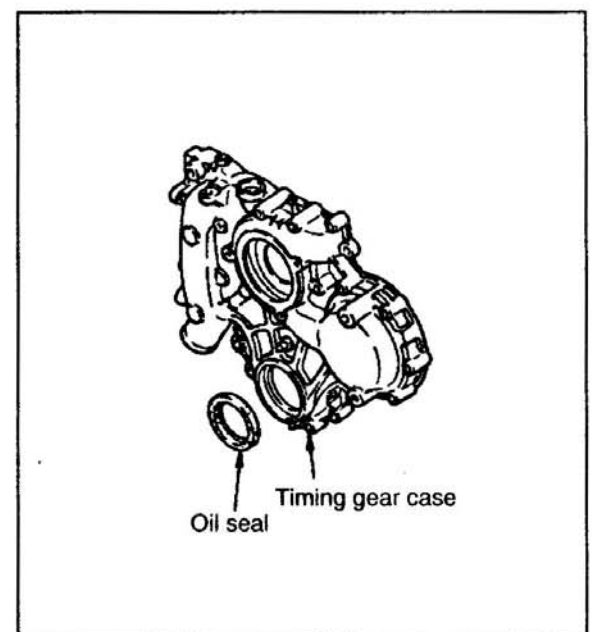
- (a) Remove of taper cone  
To remove, use Cone Puller  
(special tool).



- (b) If the crankshaft pulley flange and crankshaft pulley are hard to remove, use Gear Puller(special tool).



- (c) Do not remove oil seal and seal plate unless abnormal condition is evident.

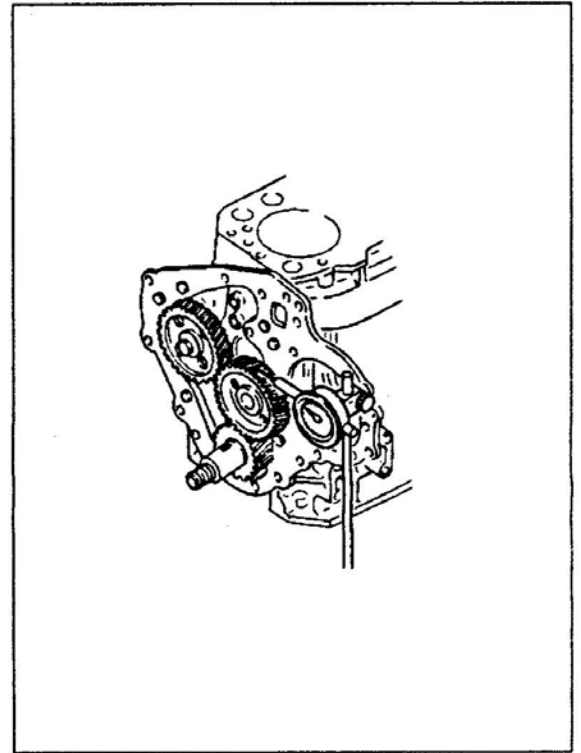


(d) Measurement of backlash

Measure the backlash between gears and replace if the limit is exceeded.

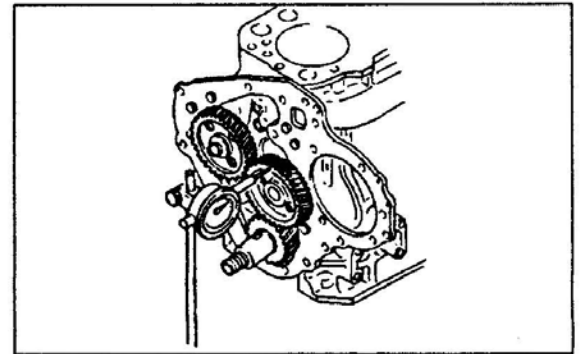
**NOTE:**

1. For a pair of gears, the backlash must be measured at three points or more to determine the condition.
2. When measuring the backlash in injection pump gears, keep the pump fixed onto the front plate.



(e) Measurement of end play

Measure the end play of the idler gear and camshaft with a thickness gauge or dial indicator. If the measurements exceed the limit, replace the parts.

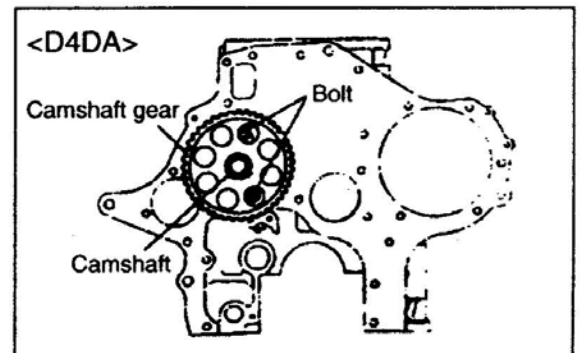
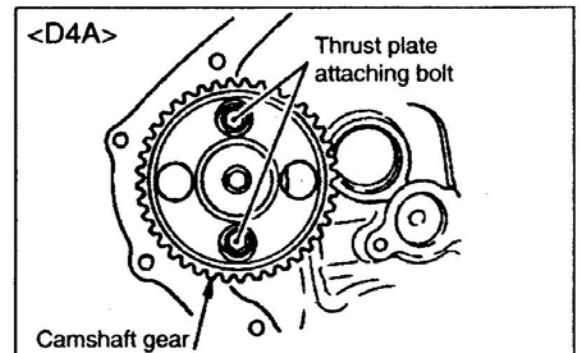


(f) Removal of camshaft gear

- 1) Accessing through the holes in camshaft gear, loosen the thrust plate attaching bolts. Then, remove the gear together with the camshaft.

**NOTE:**

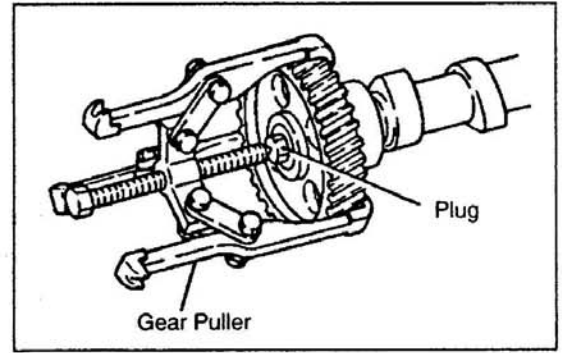
Turn the crankcase upside down before removing the camshaft.



2) To remove, use Gear Puller(special tool).

**NOTE:**

1. Do not remove the gear unless defect is evident.
2. For removal, never attempt to tap the gear with a hammer.

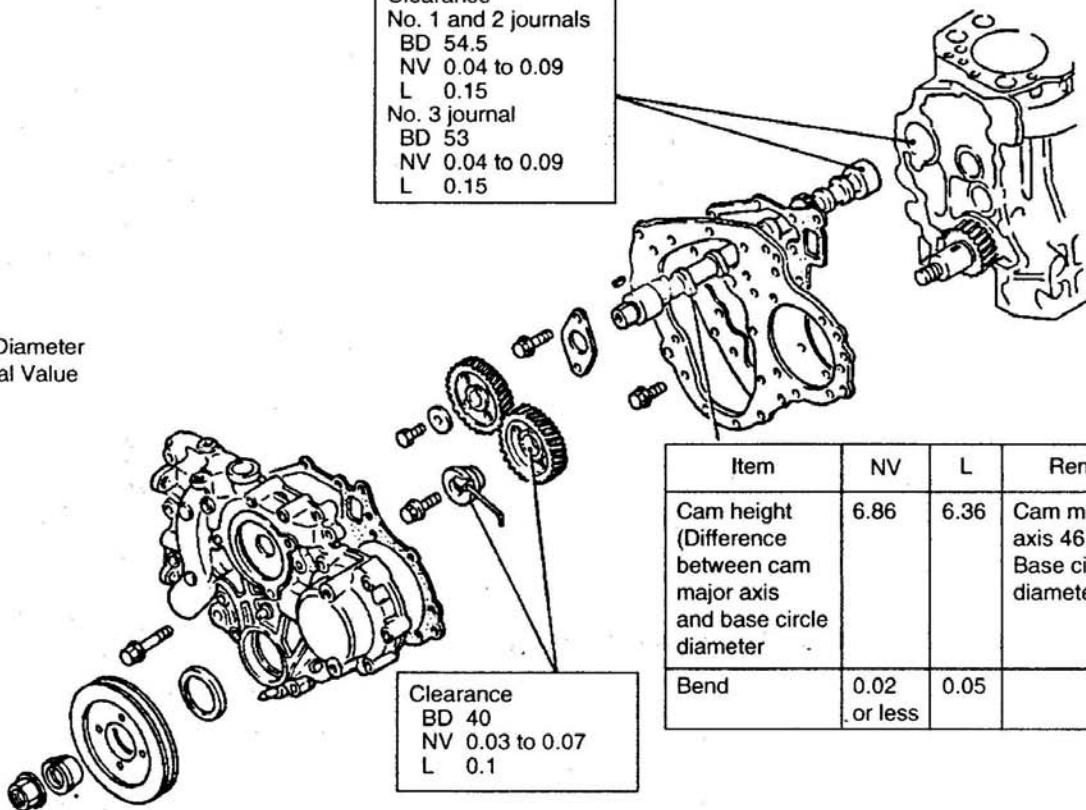


**(2) Inspection**

<D4A>

Clearance  
 No. 1 and 2 journals  
 BD 54.5  
 NV 0.04 to 0.09  
 L 0.15  
 No. 3 journal  
 BD 53  
 NV 0.04 to 0.09  
 L 0.15

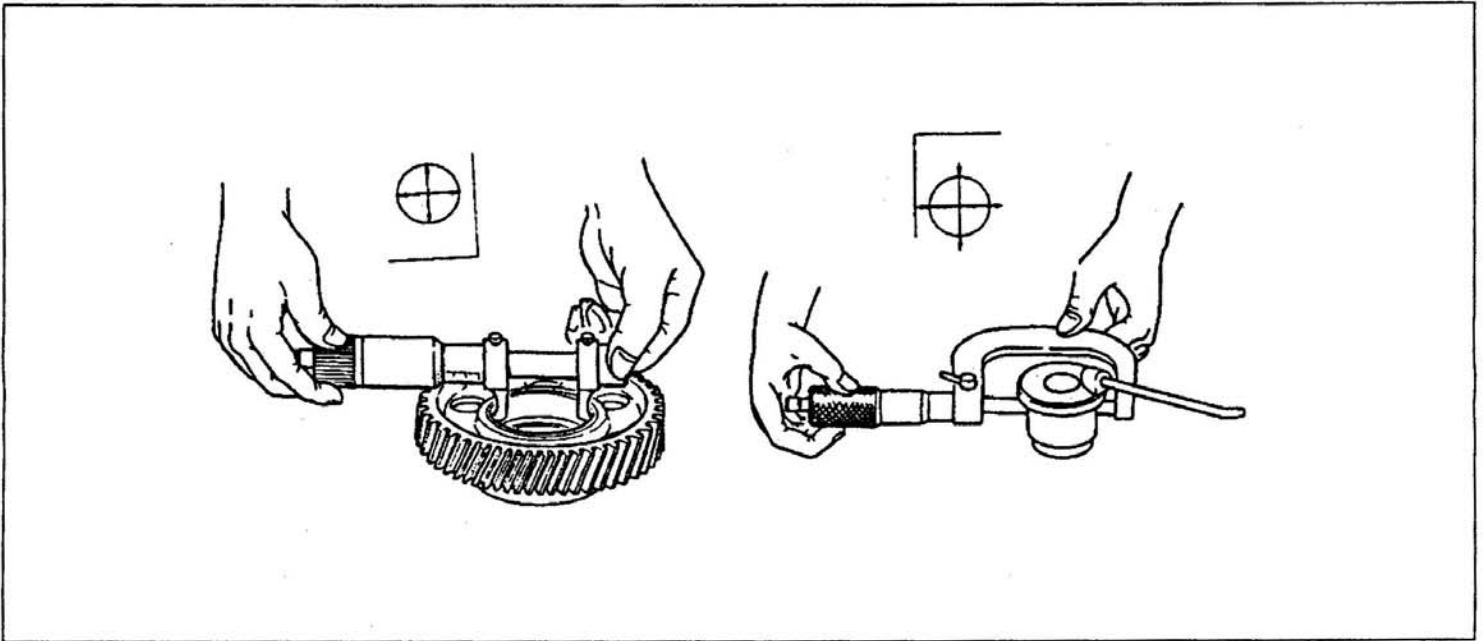
BD...Basic Diameter  
 NV...Nominal Value  
 L...Limit



Clearance  
 BD 40  
 NV 0.03 to 0.07  
 L 0.1

Item	NV	L	Remarks
Cam height (Difference between cam major axis and base circle diameter)	6.86	6.36	Cam major axis 46.939 Base circle diameter 40.080
Bend	0.02 or less	0.05	

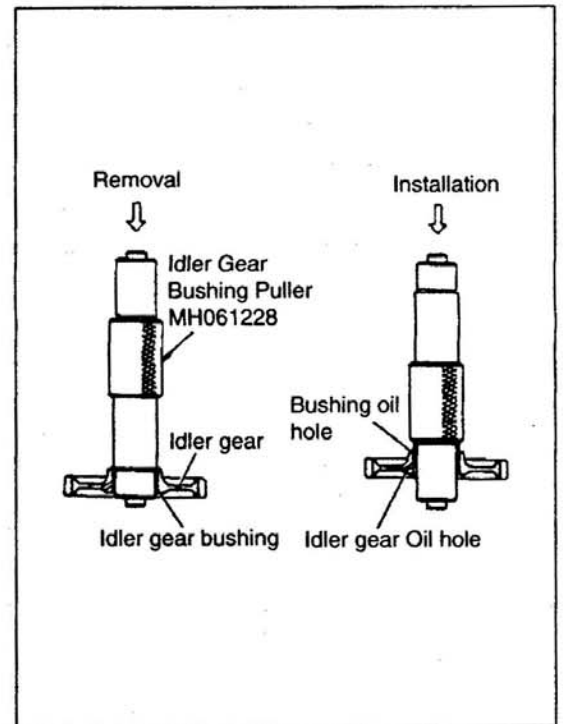
- (a) With the idler gear I.D. and idler shaft O.D., calculate the clearance. If the limit is exceeded, replace the bushing in the idler gear.



- (b) Replacement of idler gear bushing  
Using Idler Gear Bushing Puller(special tool), replace the idler gear bushing. See illustration for procedure.

**NOTE:**

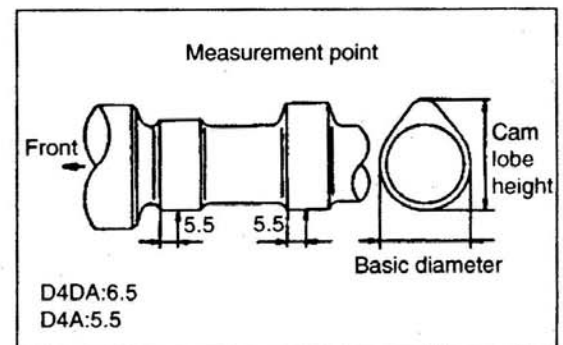
1. When installing the bushing, align the oil hole in bushing with that in idler gear.
2. After installation, make sure that the bushing to idler shaft clearance is within nominal value. If the clearance is below specification, ream the bushing.



- (c) Measure the lobe height and basic diameter of each cam. If the difference between them is below the limit, replace.

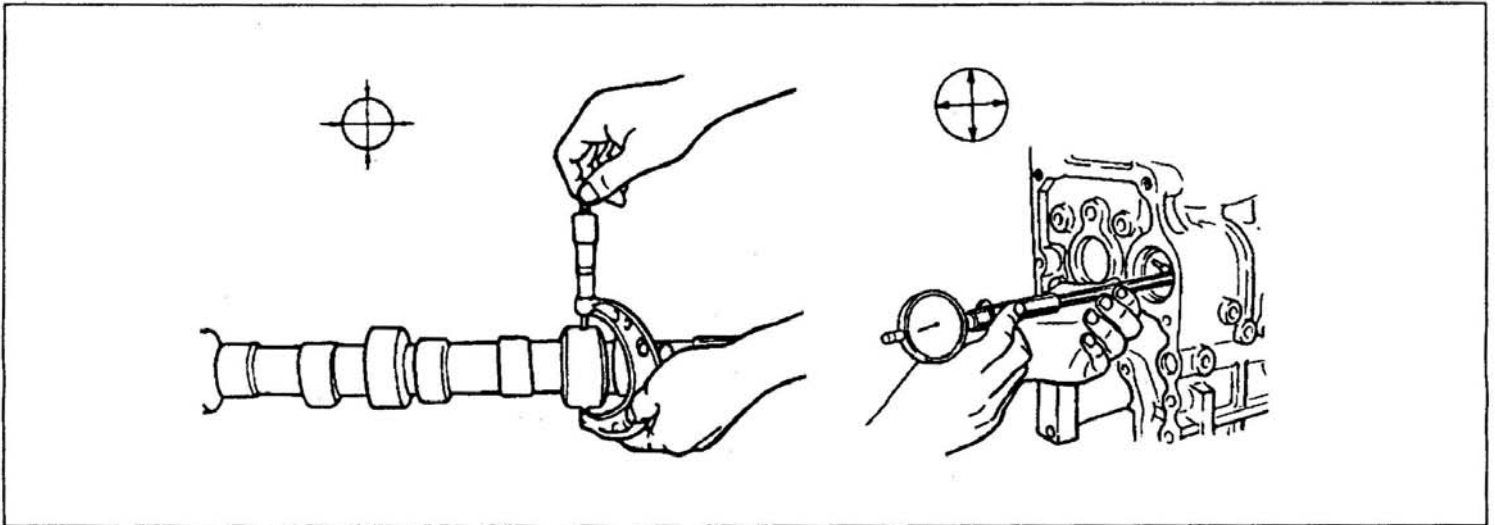
**NOTE:**

Since the taper cam is used on D4A, ensure that the measurement is taken at the location indicated in illustration.





(d) Measure the camshaft journal O.D. and crankcase I.D. If the limit is exceeded, replace the bushing in the crankcase.



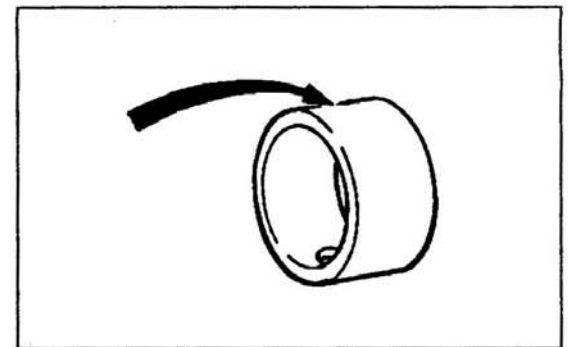
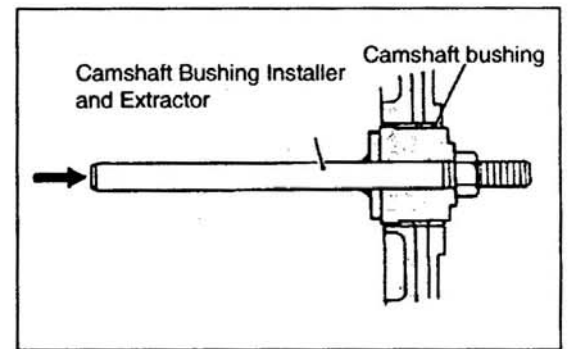
(e) Replacement of camshaft bushing

1) Removal

Remove the sealing cap through the camshaft hole in the rear-end face of the crankcase. Then, using Camshaft Bushing Installer and Extractor (special tool), remove the camshaft bushing.

2) Installation

Identify bushings with a unique number stamped on the external surface, indication the installation position.



(D4DA)

Bushing No. (from front of engine)	Identification mark	Outer diameter A (mm)
No. 1	1	φ 58.50
No. 2	A	φ 58.25
No. 3	2	φ 58.06
No. 4	C	φ 57.75
No. 5	4	φ 57.06

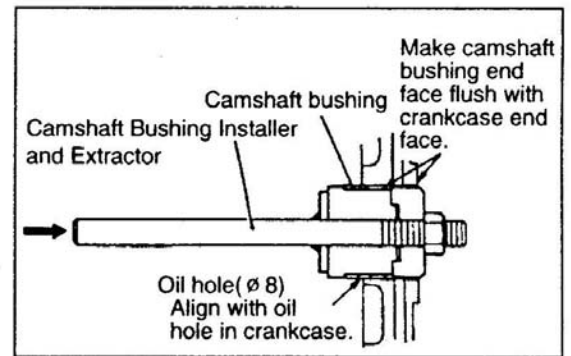
(D4A)

Bushing No. (Ascending from front of engine)	Stamped number
No. 1	1
No. 2	2
No. 3	4

Then, using Camshaft Bushing Installer and Extractor(special tool), press-fit the bushings.

If the marking is illegible, determine by measuring the I.D. and width.

Bushing No. (Ascending from front of engine)	No. 1	No. 2	No. 3
I.D.	54.5	54.5	53
Width	41	21	21
Mark	1	2	3

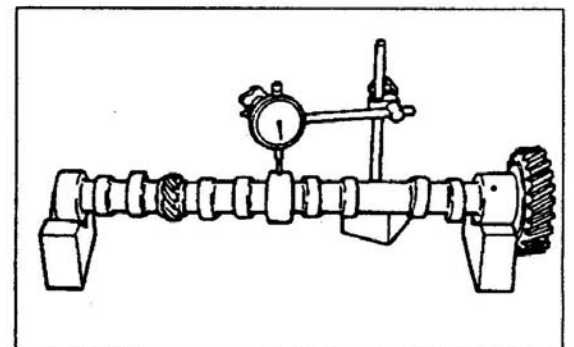


(f) Measure the bend of camshaft. If the limit is exceeded, correct with a press or replace.

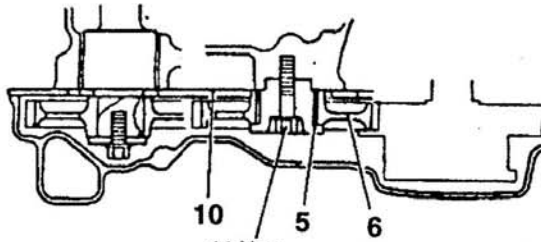
**NOTE:**

Rotate the camshaft a turn and read the deflection of the dial indicator pointer.

One half of the reading is the bend.



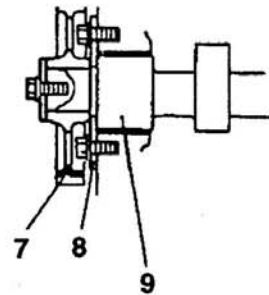
### (3) Reassembly



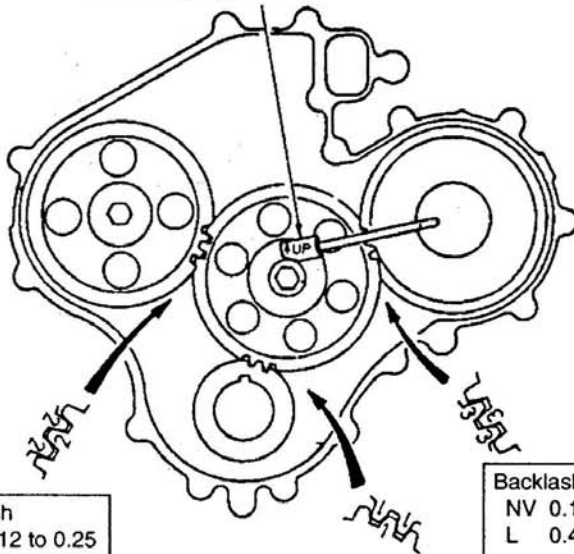
44 N m  
(4.5 kgf m)  
(Wet)

End play  
NV 0.05 to 0.25  
L 0.35

Assemble with "UP"  
mark facing upward.



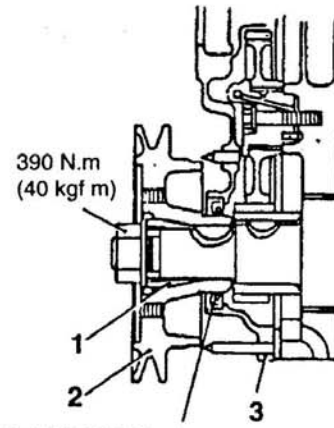
End play  
NV 0.05 to 0.22  
L 0.33



Backlash  
NV 0.12 to 0.25  
L 0.4

Backlash  
NV 0.11 to 0.23  
L 0.4

Backlash  
NV 0.18 to 0.31  
L 0.4

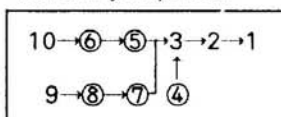


390 N.m  
(40 kgf m)

Apply lithium-base grease  
to lips (wheel bearing  
grease or equivalent).

NV...Nominal Value  
L...Limit

<Assembly sequence>



(a) Installation of camshaft gear

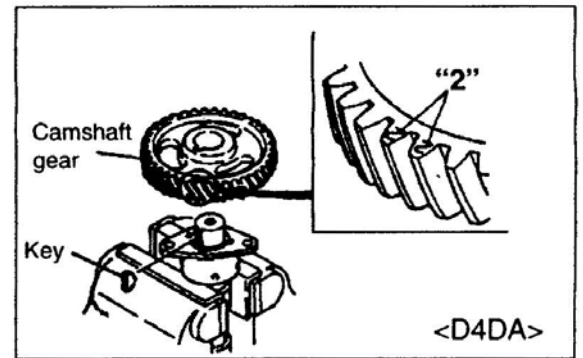
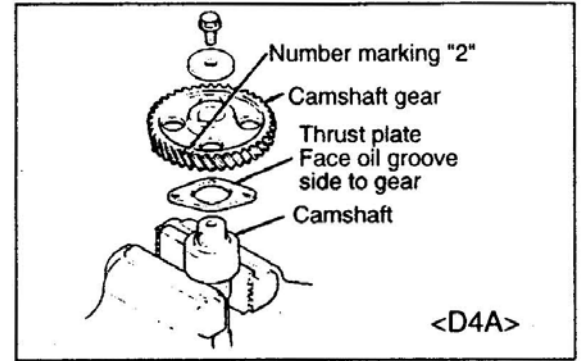
<D4A>

After mounting the thrust plate, install the camshaft gear with its number marking side facing outward.

<D4DA>

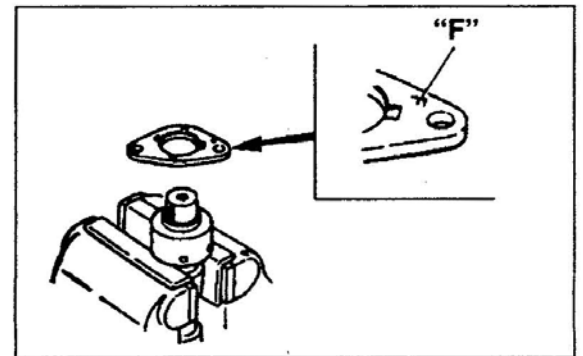
Fit camshaft gear onto camshaft with "2" alignment marks positioned as shown.

Do not forget to fit key

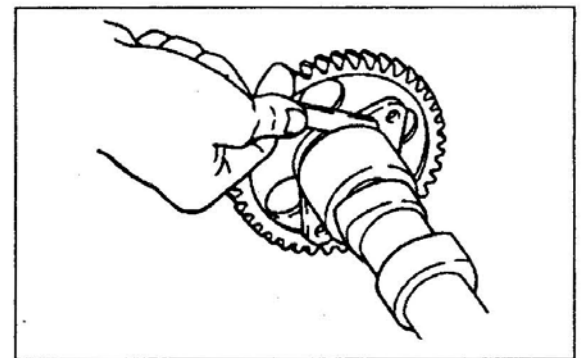


(b) Installation of thrust plate

Fit thrust plate with "F" mark positioned as shown.



(c) Check the camshaft end play. Then, install the camshaft into the crankcase.



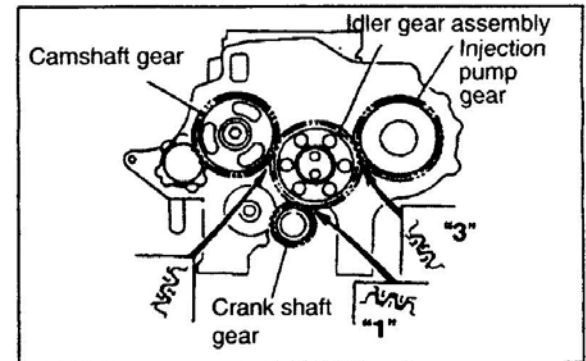
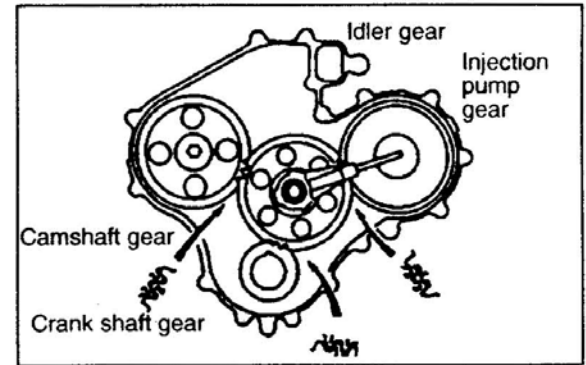
(d) Installation of idler gear

1) <D4A>

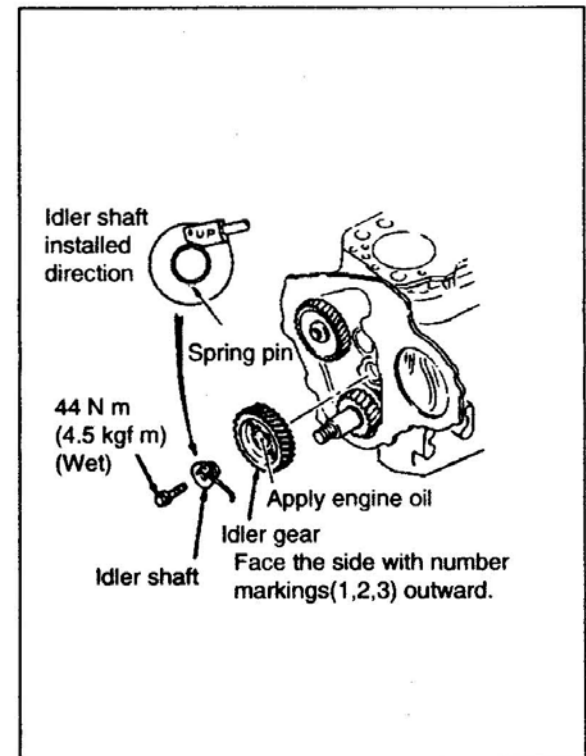
Install the idler gear, its side with a number marking facing outward and its alignment mark lining up with others.

2) <D4DA>

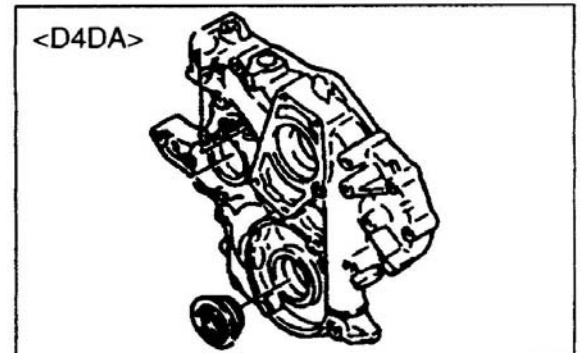
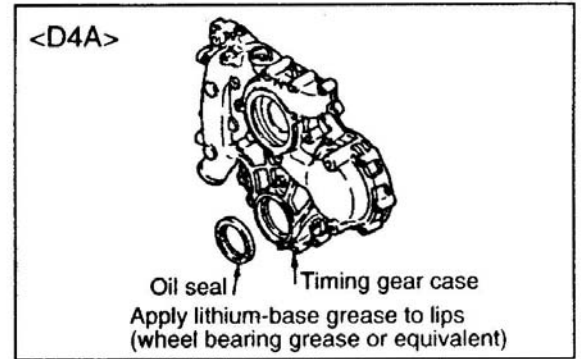
Fit idler gear assembly such that the alignment marks("1", "2", and "3") on the idler gear are aligned with those on the gears with which it mates.



3) Make also sure that the idler shaft spring pin rests in the crankcase oil groove and the "UP" mark with an arrow on the shaft faces upward.



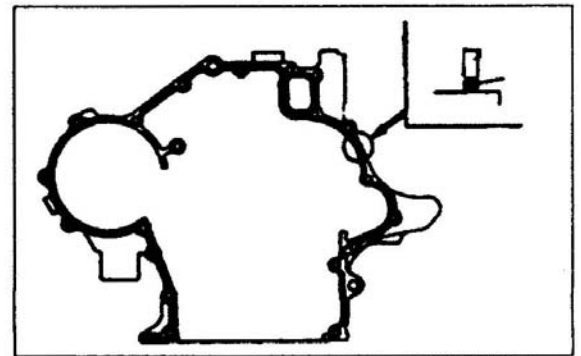
- (d) Check gears for backlash
- (e) Apply lithium-base grease to the oil seal lips.



- (f) Installation of timing gear case  
Apply an even, unbroken bead of sealant A to the mounting surface of timing gear case. Fit the timing gear case onto the front plate within three minutes of applying the sealant.

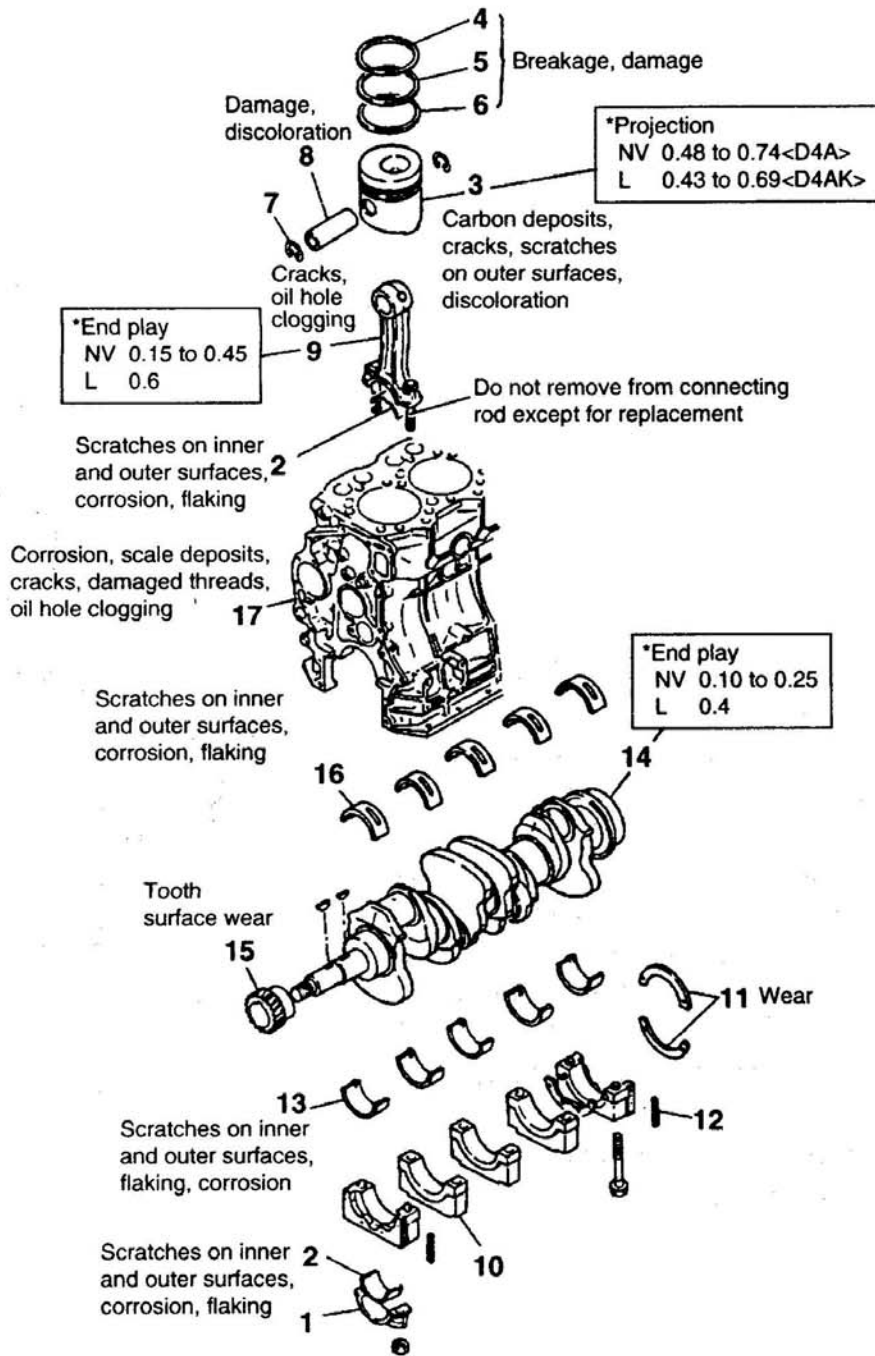
**NOTE:**

1. When fitting the timing gear case, hold it firmly in position to prevent spreading the sealant.
2. Before applying the sealant, make sure the application surface is free of oil and other contamination.
3. Apply a new bead of sealant whenever bolts have been loosened.
4. After fitting the timing gear case, wait at least an hour before starting the engine.



# Crankcase and Main Moving Parts

<D4A>



<Disassembly sequence>

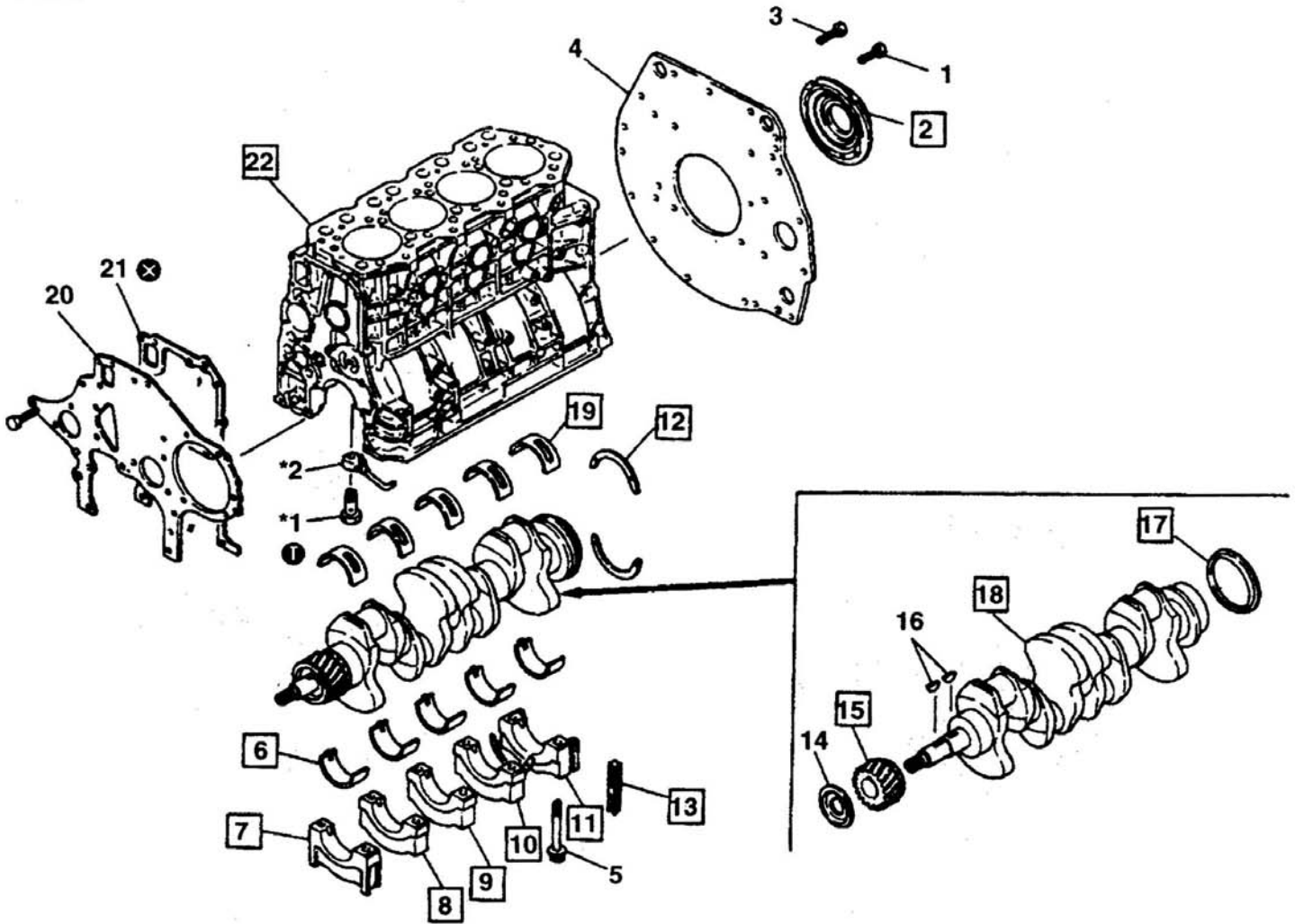
NV...Nominal Value  
L...Limit

- |                          |                    |                       |
|--------------------------|--------------------|-----------------------|
| 1 Connecting rod cap     | ⑥ Oil ring         | 12 Side seal          |
| 2 Connecting rod bearing | 7 Snap ring        | 13 Lower main bearing |
| ③ Piston                 | ⑧ Piston pin       | 14 Crankshaft         |
| ④ 1st compression ring   | ⑨ Connecting rod   | ⑮ Crankshaft gear     |
| ⑤ 2nd compression ring,  | ⑩ Main bearing cap | 16 Upper main bearing |
|                          | ⑪ Thrust plate     | 17 Crankcase          |

For disassembly of parts with an encircled number, see following items.  
The parts marked with \* must be inspected before disassembly.

# CRANKSHAFT AND CRANKCASE

<D4DA>



<Disassembly sequence>

- |                                  |                           |                       |
|----------------------------------|---------------------------|-----------------------|
| 1 Bolt                           | 10 No.4 main bearing cap  | 19 Upper main bearing |
| 2 Rear oil seal                  | 11 Real main bearing cap  | 20 Front plate        |
| 3 Bolt                           | 12 Thrust plate           | 21 Gasket             |
| 4 Rear plate or flywheel housing | 13 Side seal              | 22 Crankcase          |
| 5 Bolt                           | 14 Front oil seal slinger |                       |
| 6 Lower main bearing             | 15 Crankshaft gear        |                       |
| 7 No.1 main bearing cap          | 16 Key                    |                       |
| 8 No.2 main bearing cap          | 17 Real oil seal slinger  |                       |
| 9 No.3 main bearing cap          | 18 Crankshaft             |                       |

\*1: Check valve  
\*2: Oil jet

**NOTE:**

Do not remove the crankshaft gear 15 unless it is faulty.

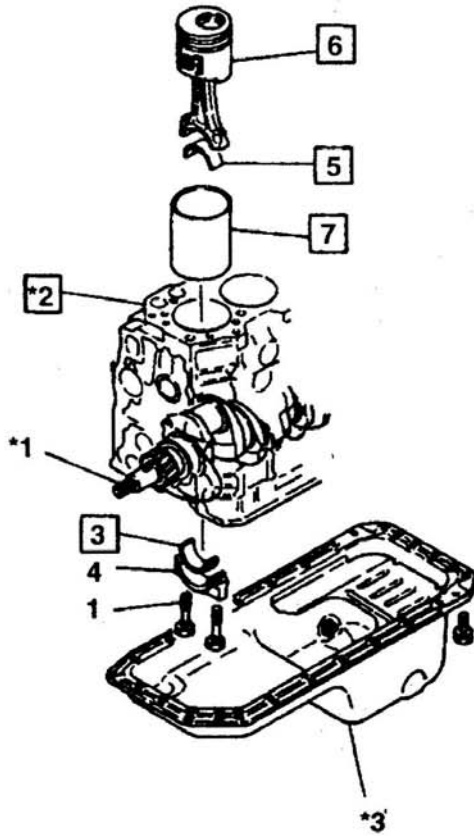
**Assembly sequence**

Follow the disassembly sequence in reverse.

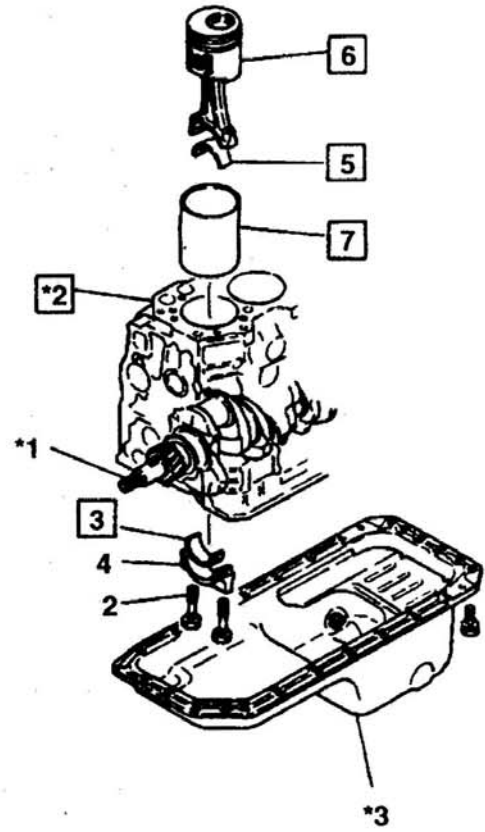


# PISTON, CONNECTING ROD AND CYLINDER SLEEVE

<D4A>



<D4DA>



<Disassembly sequence>

- 1 Nut<D4A>
- 2 Bolt<D4DA>
- 3 Lower connecting rod bearing
- 4 Connecting rod cap
- 5 Upper connecting rod bearing

- 6 Piston and connecting rod assembly
- 7 Cylinder sleeve  
<D4AK, D4DA>

- \*1:Crankshaft  
\*2:Crankcase  
\*3:Oil pan

## Installation sequence

Follow the disassembly sequence in reverse.

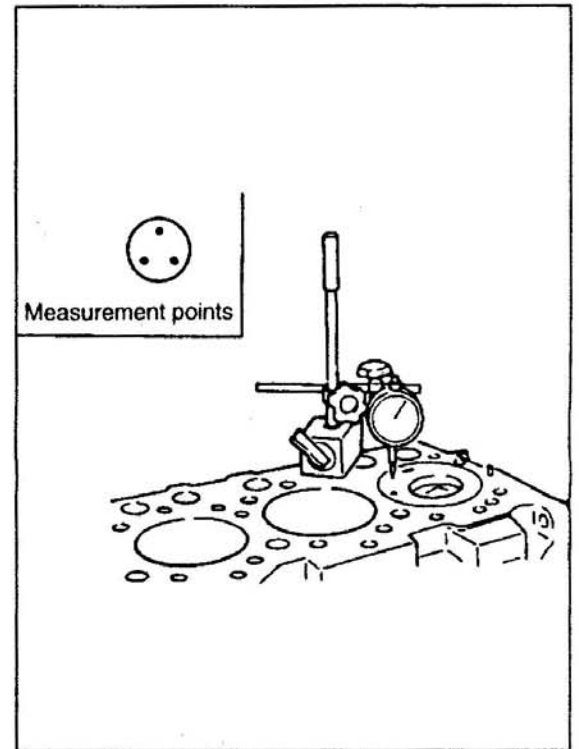
## 1. Disassembly

### (a) Inspection of piston projection

Incorrect piston projection adversely affects the engine performance.

If measurements are out of specification, check parts for clearance.

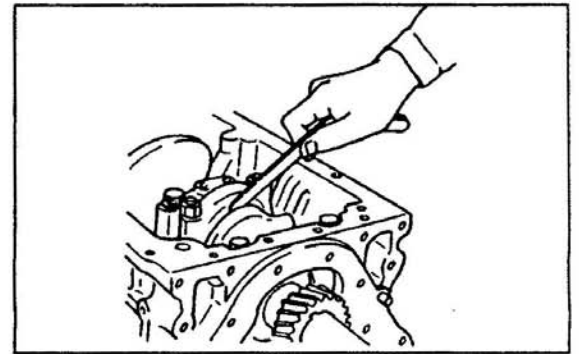
- 1) Hold the dial indicator on the crankcase top surface to make zero adjustment.
- 2) Locate the piston TDC with the dial indicator.
- 3) Measure projections at three points on the piston top surface to obtain the average value.



### (b) Connecting rod end play

Measure the end play of each connecting rod.

If the limit is exceeded, replace the connecting rod.

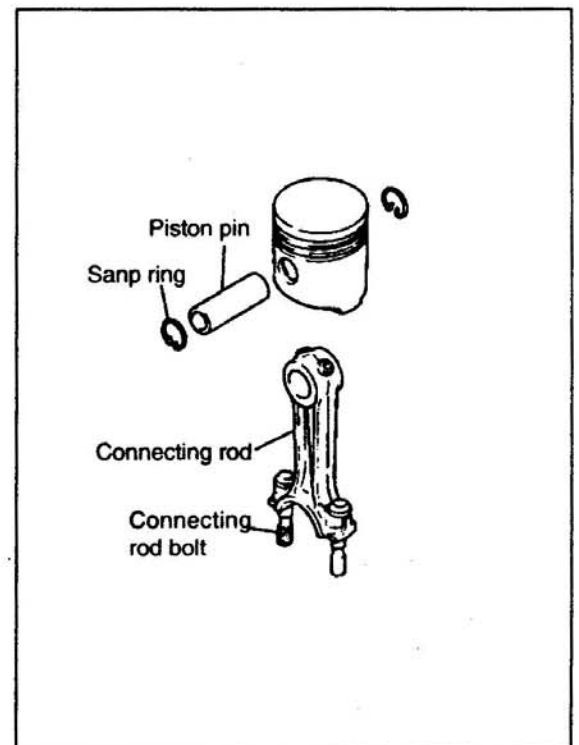


### (c) Removal of piston

Withdraw the piston from the crankcase, pushing it up together with the connection rod.

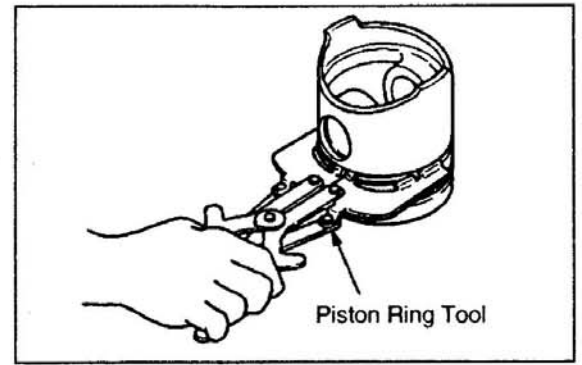
#### NOTE:

1. If the piston pin is hard to remove, heat the piston with a piston heater or hot water.
2. Do not remove the connecting rod bolts from the connecting rod unless defective.  
If the bolt is damaged, install a new connecting rod bolt by referring to reassembly connecting rod.



(d) Removal of piston ring

To remove the piston rings, use piston Ring Tool (special tool).



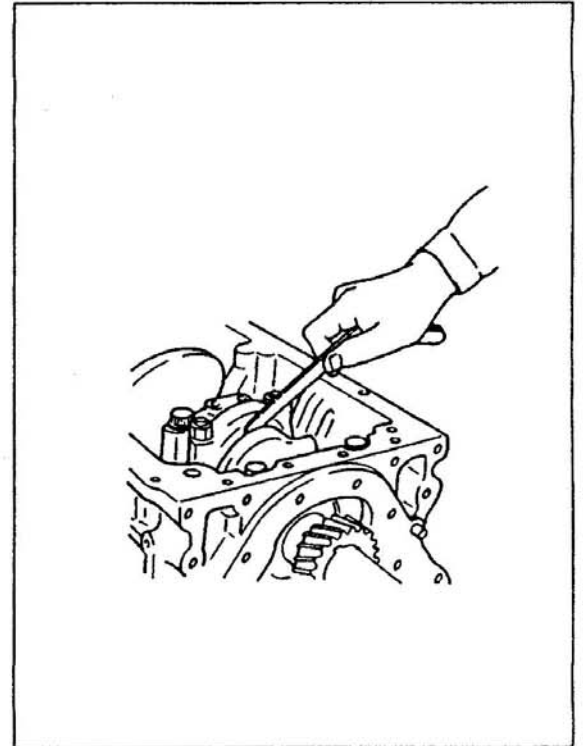
(e) Crankshaft end play

If the end play exceeds the limit, replace the thrust plate with an oversize.

Three oversize thrust plates are available: +0.15, +0.30, and +0.45mm

**NOTE:**

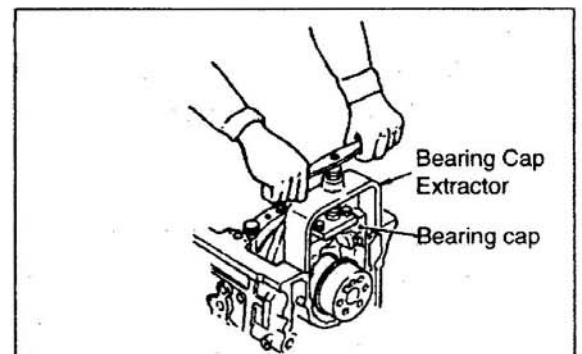
The thrust plates on both ends of the bearing cap need not be of the same size; however, use the one of the same size for those at the rear end of the crankcase and in rear of the bearing cap.



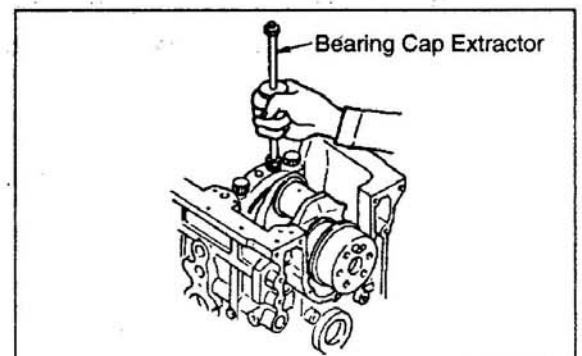
(f) Removal of main bearing cap

To remove the main bearing cap, use Bearing Cap Extractor (special tool).

1) At front and rear ends



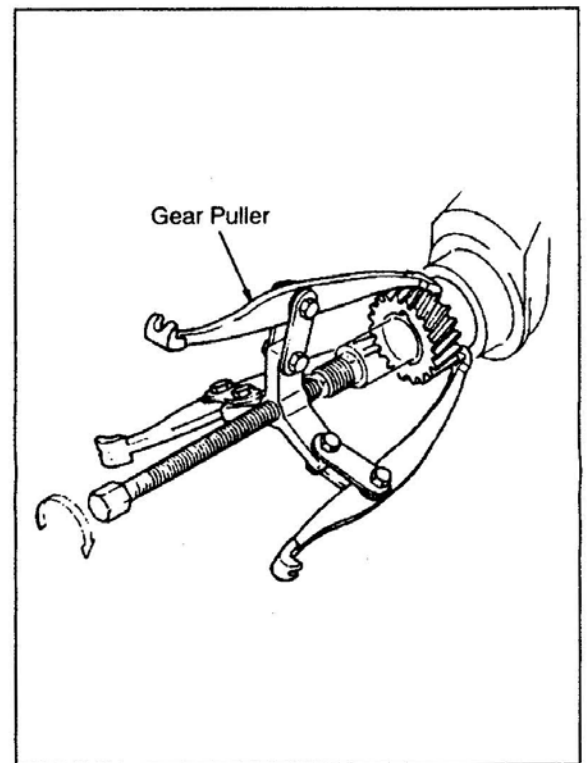
2) Intermediate position



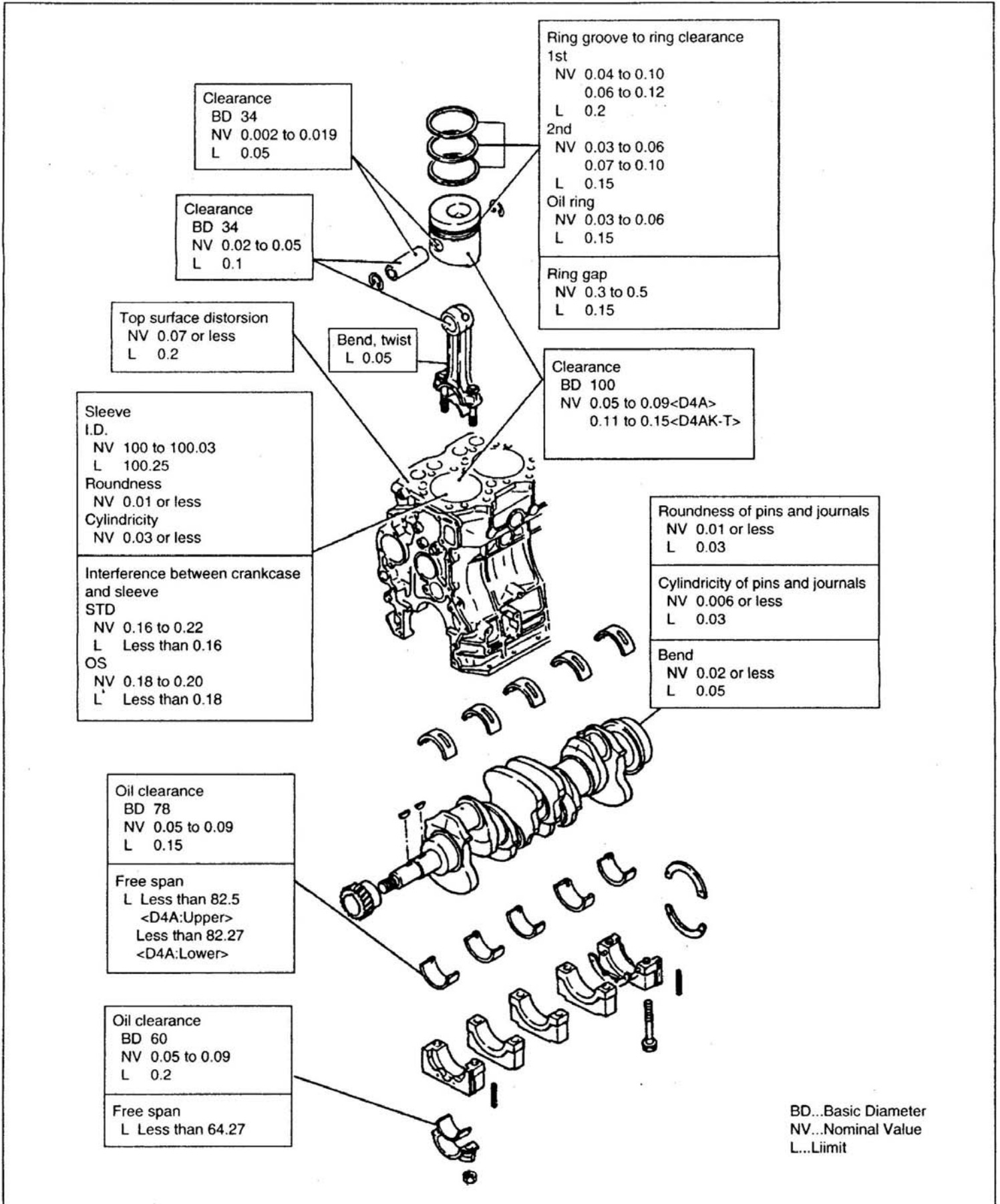
- (g) Removal of crankshaft gear  
To remove the crankshaft gear, use Gear Puller  
(special tool).

**NOTE:**

**It is not necessary to remove the crankshaft gear unless defect is evident.**



## 2. Inspection

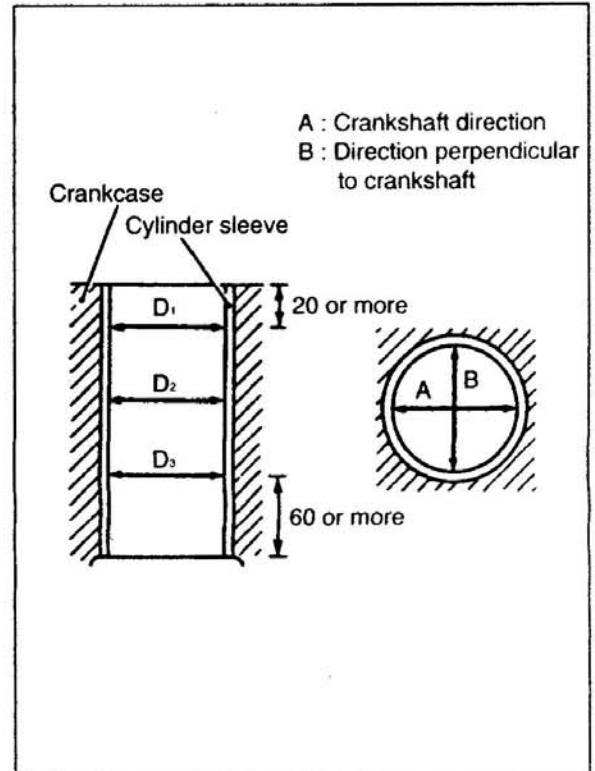


(a) Measurement of cylinder sleeve I.D.

Measure the cylinder sleeve I.D. at the six points shown in illustration.

If the I.D. exceeds the limit, replace or bore to oversize.

If the cylinder sleeve is to be used without being bored, correct the ring ridge wear at its top by grinding with a ridge reamer.



(b) Replacement of cylinder sleeve

1) Removal

a) With a boring machine fixed in the crankcase, center the machine.

Make sure that the machine is centered at the bottom of the cylinder sleeve which develops uneven wear least.

b) Bore until the wall thickness is reduced down to approximately 0.5mm.

c) Insert a screwdriver (machined as illustrated) between the crankcase and cylinder sleeve.

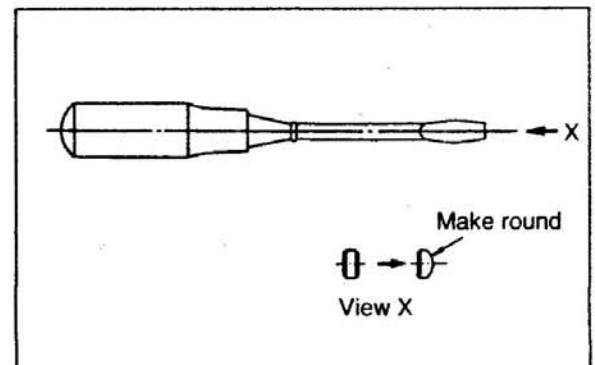
Tap the screwdriver to break and remove the sleeve.

Make sure that the rounded part of the screwdriver faces to the case.

2) Installation

After the cylinder sleeve has been removed, check the crankcase sleeve hole for damage and proper interference.

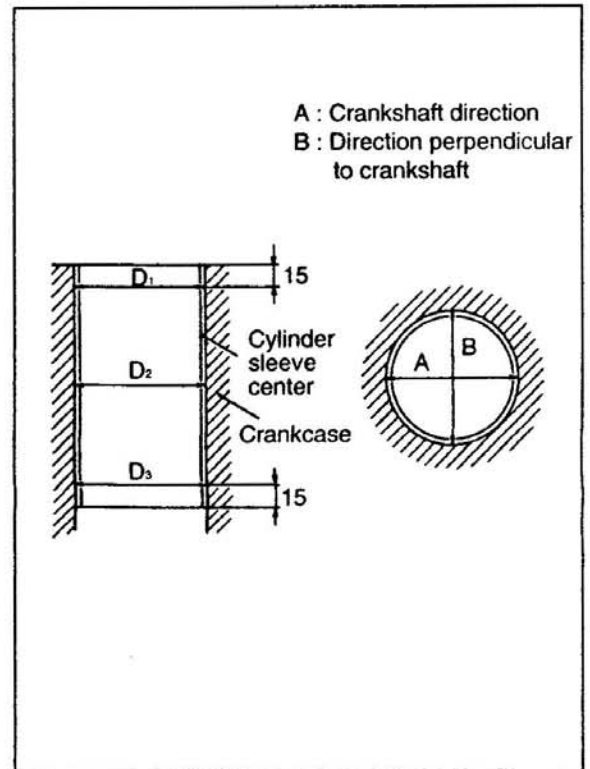
If defects are evident, bore the crankcase sleeve hole.



For measurement of interference, measure the cylinder sleeve O.D. and crankcase sleeve hole I.D. at the positions indicated in illustration.

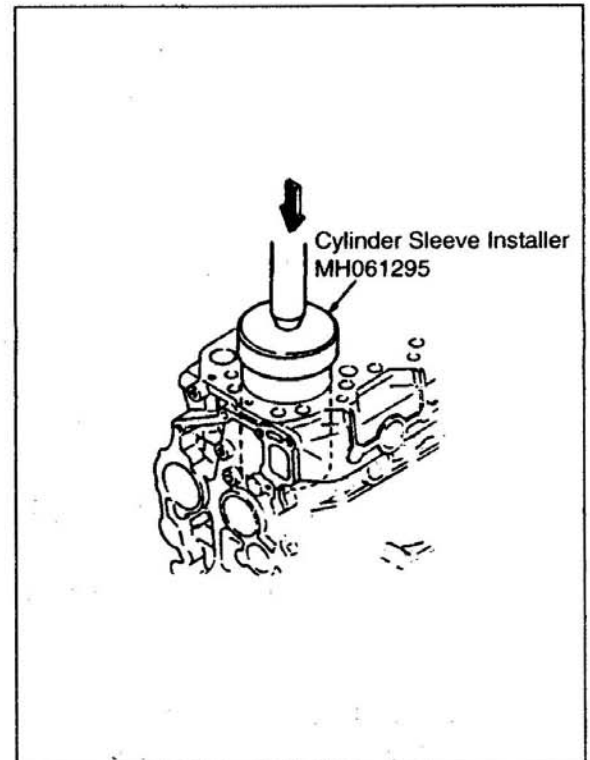
Calculate the average value of the measurements in the vertical (D1, D2, D3) and diametrical(A, B) directions.

If the interference exceeds the limit, bore the crankcase sleeve hole to oversize.



● When crankcase sleeve hole interference is sufficient:

- a) Using Cylinder Sleeve Installer(special tool) and a hydraulic press(sleeve installation load: 4.7 to 9t), install the STD cylinder sleeve into the crankcase. During installation, ensure that the chamfered side of the sleeve faces down and the sleeve top surface is flush with the crankcase top surface.
- b) After installing the cylinder sleeve, obtain the nominal dimension for I.D. and finish to 3.2-S by honing operation.



● When crankcase sleeve hole interference is insufficient:

a) Ready an oversize cylinder sleeve with a 0.5mm larger O.D.

Hone the crankcase sleeve hole to 8S to obtain the nominal value for the interference between the cylinder sleeve O.D. and crankcase sleeve hole.

b) Using Cylinder Sleeve Installer(special tool), install the cylinder sleeve into the crankcase.

After installation, obtain the nominal value for the cylinder sleeve I.D. and hone the surface to 3.2-S.

**NOTE:**

1. When boring the crankcase sleeve hole, remove sleeves from all cylinders and bore to roundness.
2. Before installing the sleeve, apply spindle oil(MECHANIC #32 or equivalent) to the crankcase sleeve hole.

(c) Selection of oversize

Available oversizes(4 types): +0.25, +0.5, +0.75, +1.00mm

- 1) An oversize must be determined in consideration of the part developing the most serious wear from all cylinder I.D. measurements.
- 2) Using a micrometer, measure the O.D. of individual oversize pistons to be used.
- 3) Bore and hone the cylinder sleeve to obtain the nominal value for the cylinder sleeve to piston clearance.

**NOTE:**

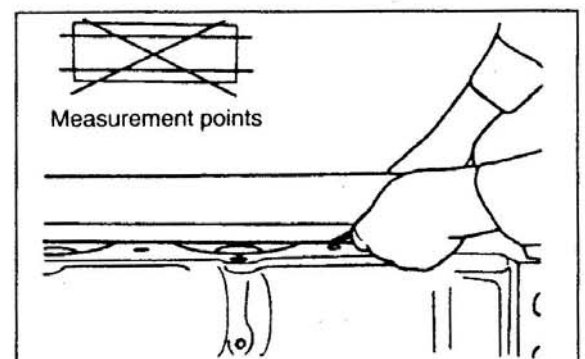
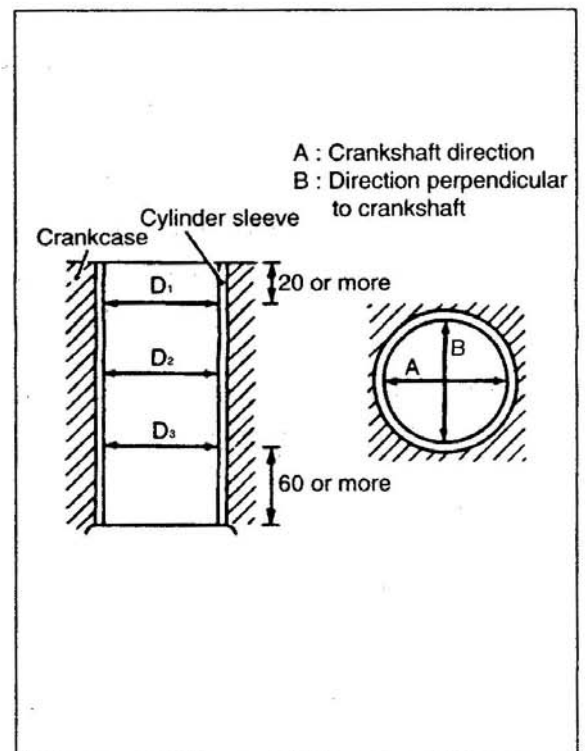
1. Even if only one cylinder requires boring, make sure that all cylinders are bored to the same oversize.
2. Replace the piston and the piston rings with the corresponding oversizes.

(d) Crankcase top surface distortion

If the limit is exceeded, correct with a surface grinder.

**NOTE:**

Crankcase must be ground only to the extent that the piston projection does not exceed the nominal value.



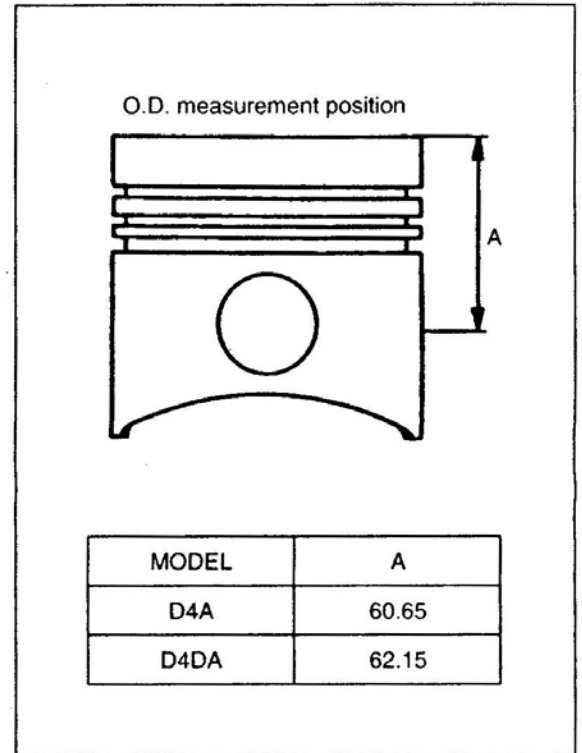


(e) Piston O.D.

Measure the piston skirt O.D. and calculate the clearance with the smallest cylinder sleeve I.D. measurement. If the limit is exceeded, replace the cylinder sleeve or piston.

**NOTE:**

**If a piston is replaced, replace also the piston ring.**



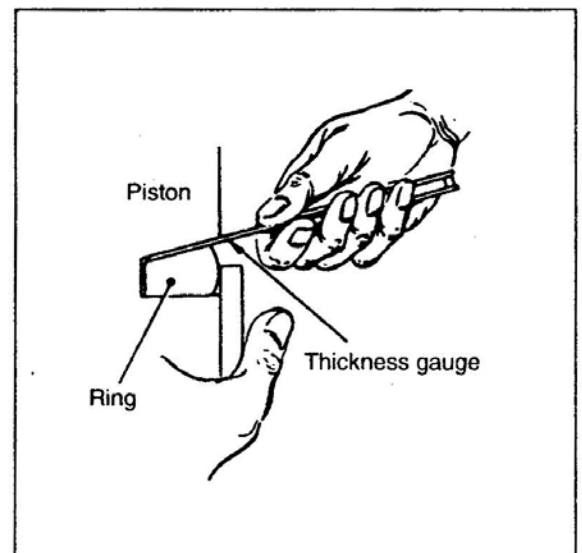
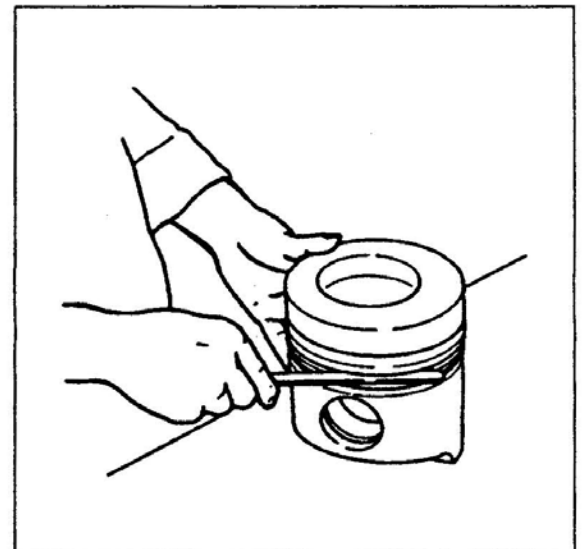
(f) Piston to piston ring clearance

If the limit is exceeded, replace the piston ring or piston.

**NOTE:**

- 1. Remove carbon and measure the clearance throughout the entire periphery of the piston.**
- 2. Replace piston rings as a set.**

For the 1st compression ring, press the ring against the piston with a straightedge.

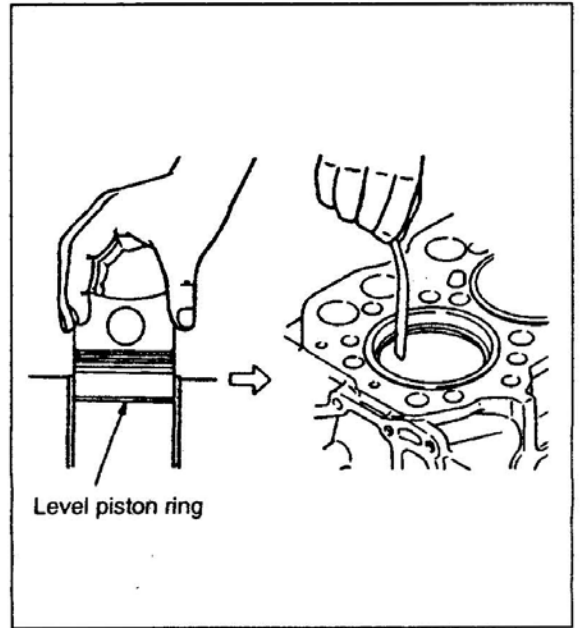


(g) Piston ring gap

Put the piston ring in the standard gauge or crankcase cylinder sleeve by pushing it with piston and measure the ring gap.

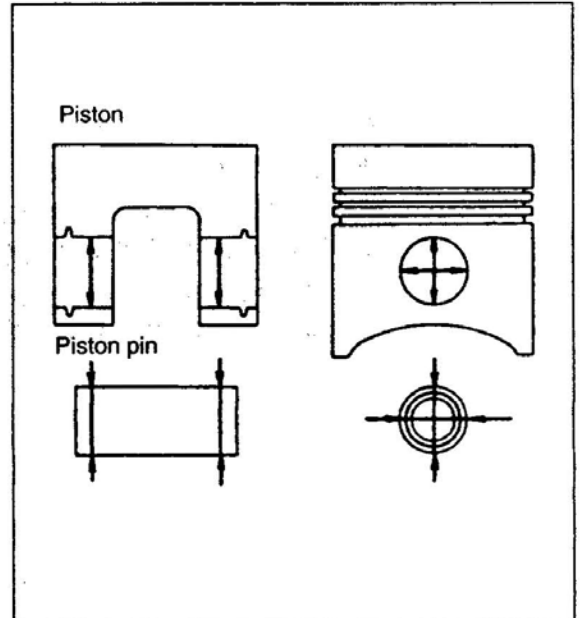
If the limit is exceeded, replace.

Standard I.D.: D4AN/AK:  $100 \pm 0$ mm  
D4AF/D4DA:  $104 \pm 0$ mm



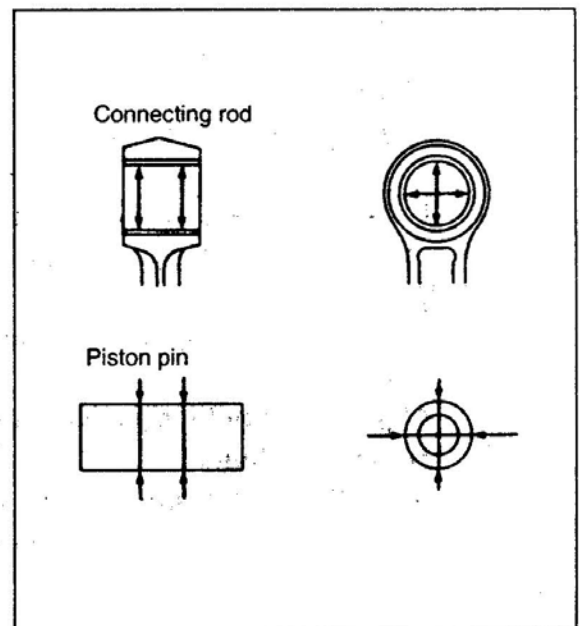
(h) Piston to piston pin clearance

If the limit is exceeded, replace the piston pin or piston.



(i) Piston pin to connecting rod clearance

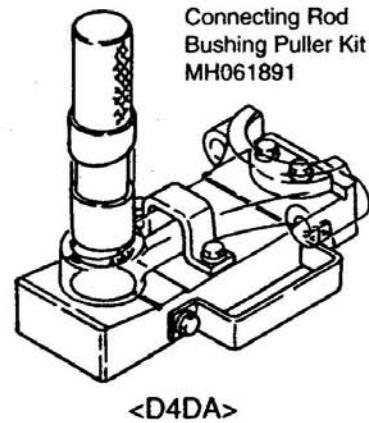
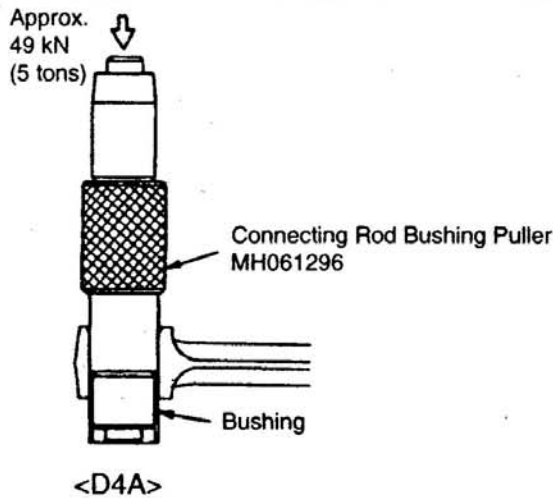
If the limit is exceeded, replace the connecting rod bushing.



(j) Replacement of connecting rod bushing.

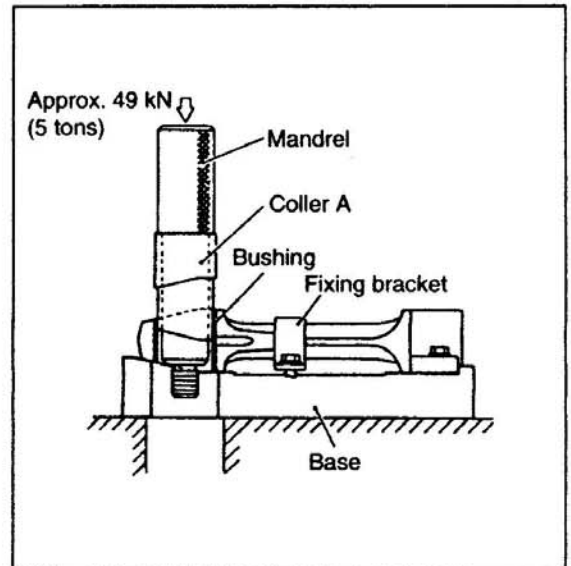
1) Removal of bushing

Using Connecting Rod Bushing Puller or Connecting Rod Bushing Puller Kit(special tool), remove the bushing.



<D4DA>

- With the connecting rod bearing removed from the connecting rod big end, secure the connecting rod to Base(special tool).
- Set Mandrel and Collar A(special tools) onto the connecting rod small end as illustrated at right and gradually apply force with a press.



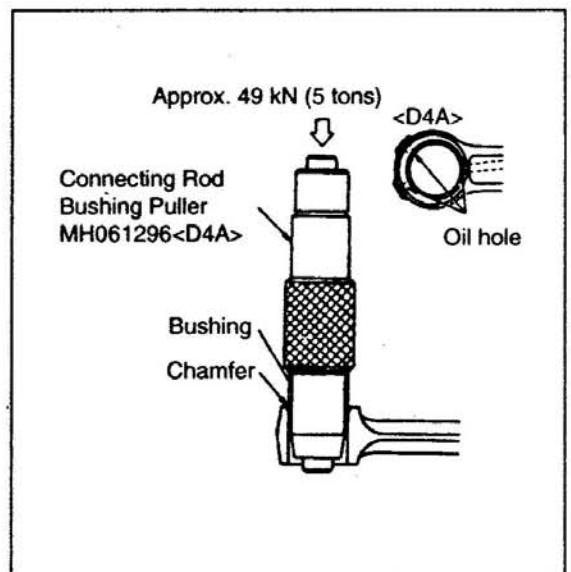
2) Installation of busing

<D4A>

- Insert the bushing into Connecting Rod Bushing Puller(special tool).
- Apply engine oil to the bushing and connecting rod.
- Press-fit the bushing into the connecting rod.

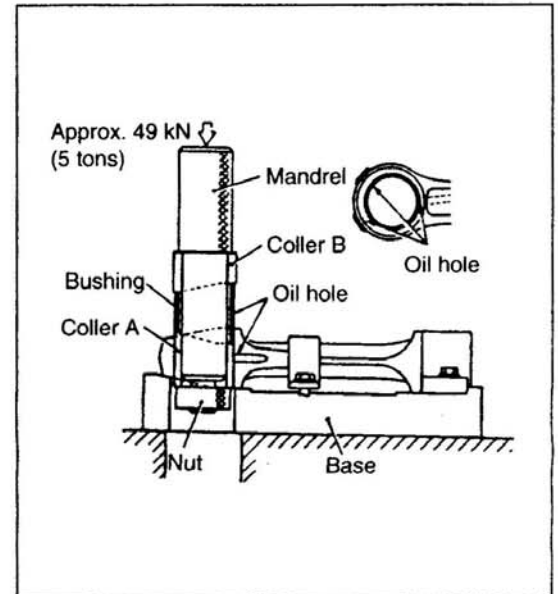
**NOTE:**

- Press the bushing into the chamfered end of the connecting rod.**
- Align the oil hole in the bushing with that in the connecting hole.**
- After the piston pin has been inserted, make surface that there is no excessive play and it turns smoothly.**



<D4DA>

- a) Set the bushing to Mandrel, Collar B, Collar A, and Nut(special tools).
- b) Apply engine oil to the connecting rod small end and bushing.
- c) Press the special tools, to which the bushing is set, into the connecting rod small end with a press.



- d) After the bushing is pressed into position and special tools are removed, ream the bushing to obtain the specified bushing to piston pin clearance.

**NOTE:**

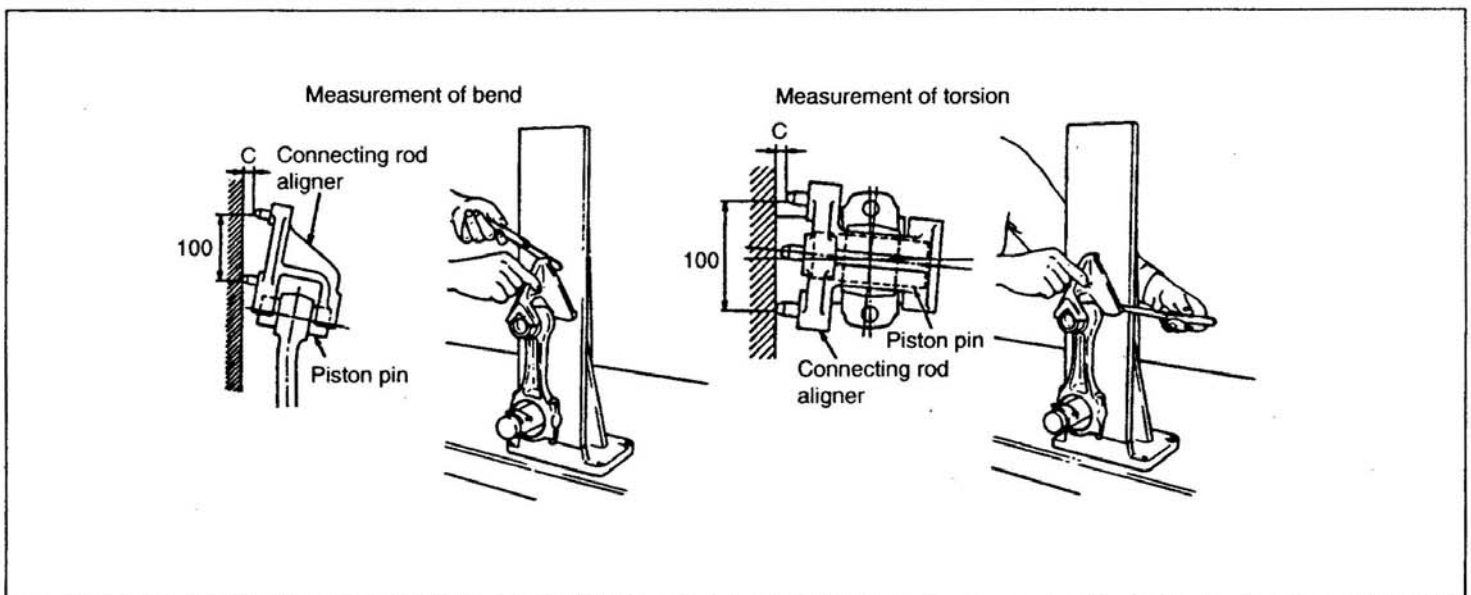
1. When installing the bushing, make sure that the oil hole in bushing is aligned with that in the connecting rod.
2. When the piston pin has been installed, ensure that it turns smoothly with no excessive play.

(k) Bend and twist of connecting rod.

Measure with Connecting Rod Aligner(special tool). If the limit is exceeded, replace or correct with a press.

**NOTE:**

1. Measure with the bushing and connecting rod bearing installed in the connecting rod.
2. The connecting rod and connecting rod cap bolts must also be tightened to specification in measuring.

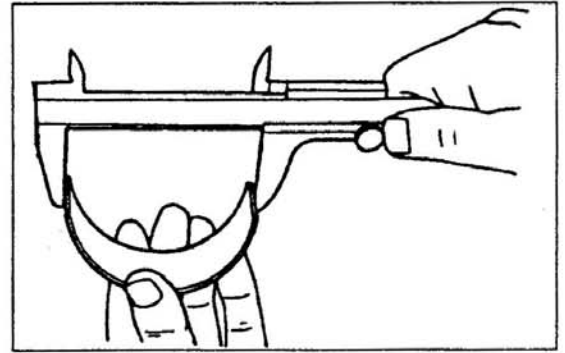


(l) Connecting rod bearing tension

Measure the tension of the connecting rod bearing when free and, if the measurement falls short of the limit, replace the upper and lower bearings as a set.

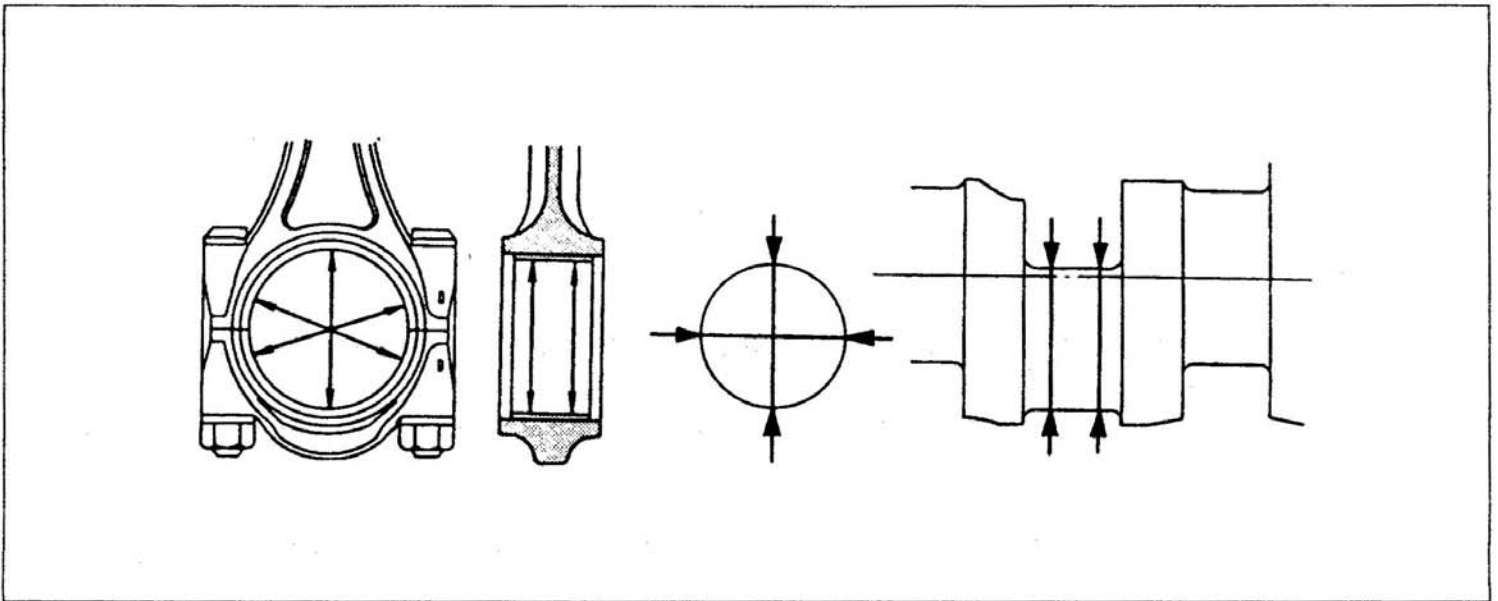
**NOTE :**

**Never attempt to expand the bearings for reuse.**



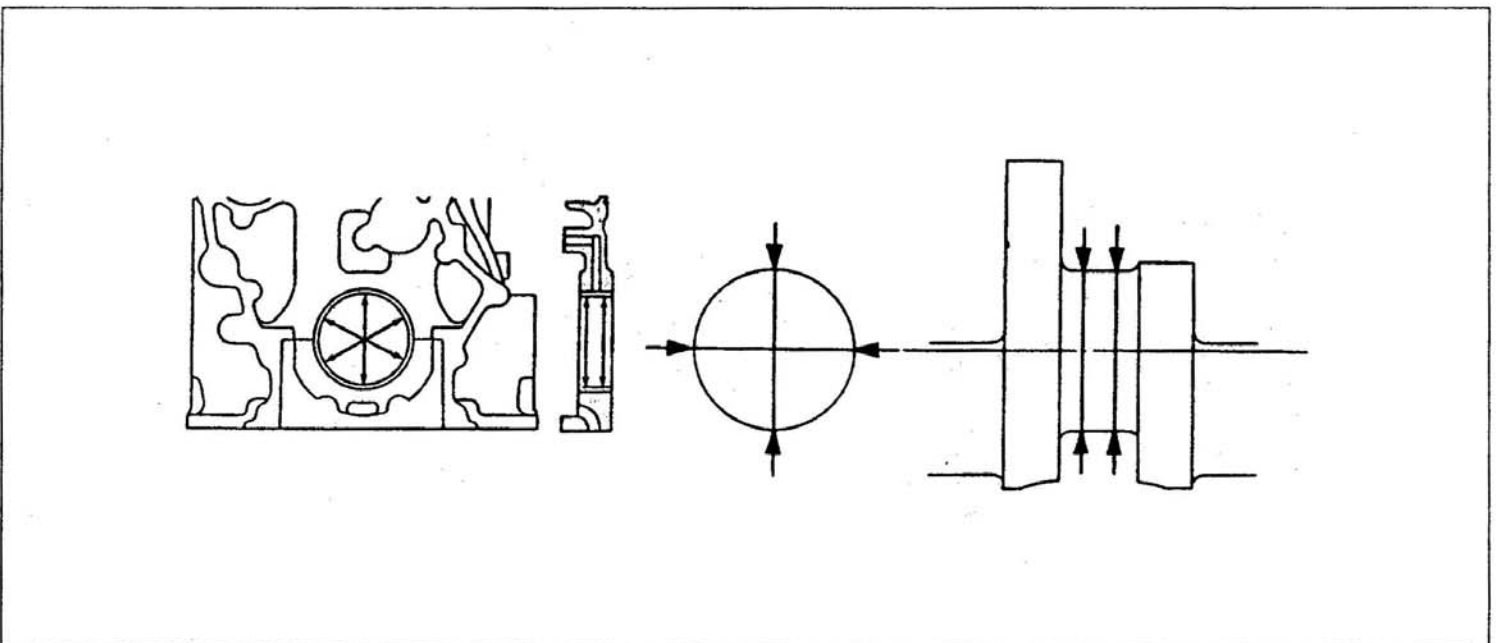
(m) Connecting rod bearing to crankshaft clearance

If the limit is exceeded, replace the upper and lower and lower connecting rod bearings as a set.



(n) Main bearing to crankshaft clearance

If the limit is exceeded, replace the upper and lower main bearings as a set.

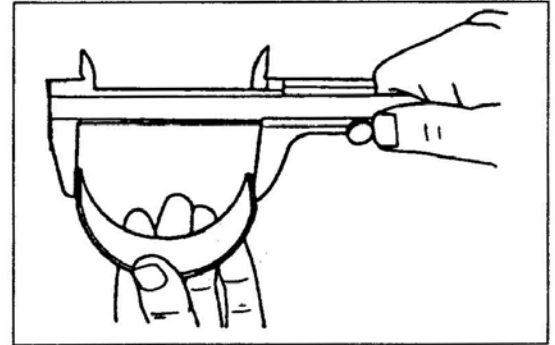


(o) Main bearing tension

Measure the tension of the main bearings when free.  
If the measurements are below the limit, replace the upper and lower main bearings as a set.

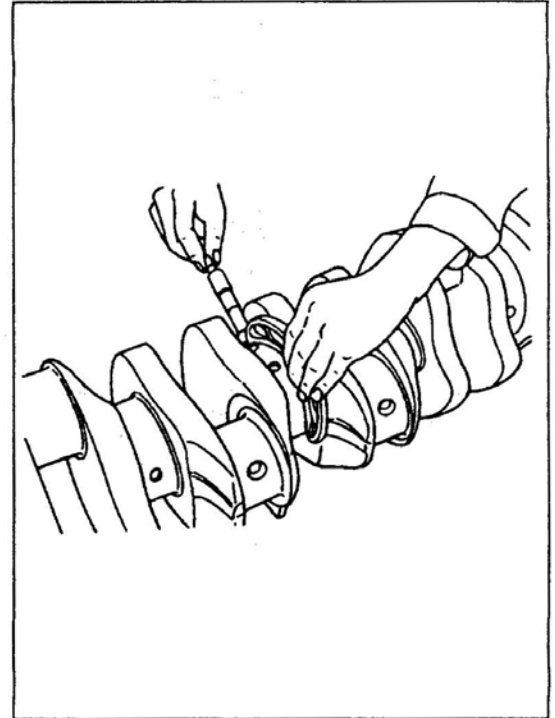
**NOTE:**

**Never attempt to expand the bearings for reuse.**



(p) Roundness and cylindricity of crankshaft

Determine roundness and cylindricity of the crankshaft based on measurements of journal and pin O.S.s.  
If the limit is exceeded, grind to undersize.

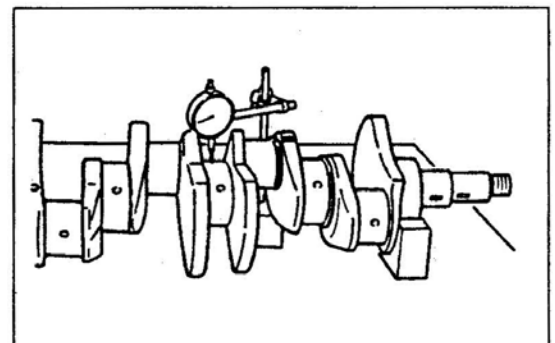


(q) Crankshaft bend

If the limit is exceeded, correct with a press or grind to undersize.  
If the bend is excessive, replace.

**NOTE:**

**Read the crankshaft center journal runout with a dial indicator. One half of the reading is the bend.**

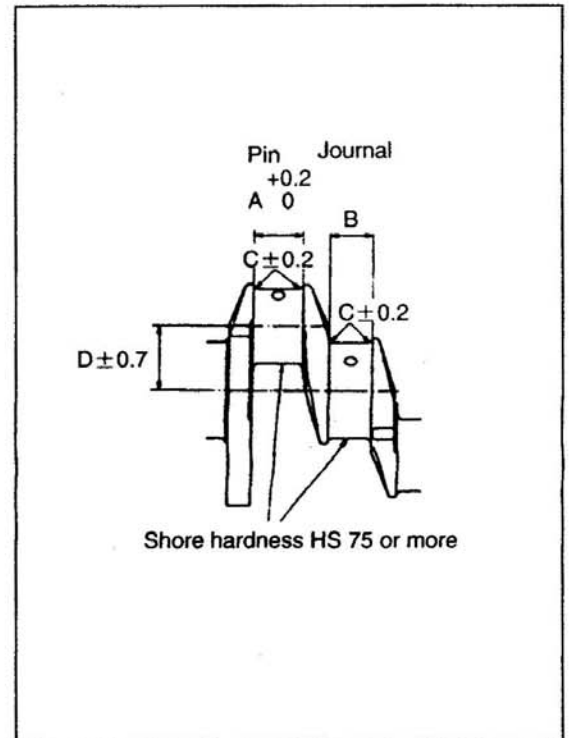


(r) Correction of crankshaft to undersize

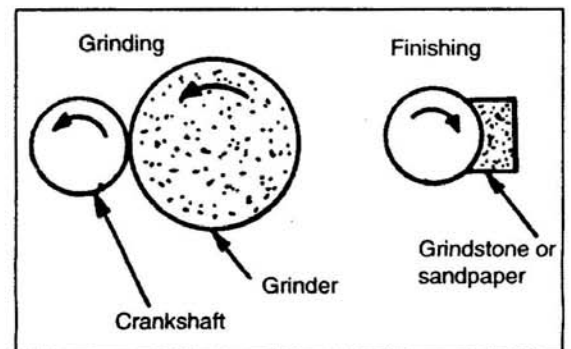
Item	Nominal value mm
A	41
B	35
C	R4
D	52.5

If a journal or pin is damaged or seized, grind the crankshaft by using the following procedures.

Replace the bearing with an undersize.



- 1) During grinding, use care not to change the center distance of journal and pin.
- 2) Use care also not to change the width of journal and pin.
- 3) Finish the fillet smooth to the specified radius.
- 4) Check for grinding cracks by the magnetic particle inspection method. Make also sure that the surface hardness (shore hardness Hs 75 or more) has not decreased.
- 5) When grinding the crankshaft with a grinder, the grinder and crankshaft must be turned counterclockwise as viewed from the crankshaft front end.
- 6) To finish the crankshaft with a grindstone or sandpaper, turn the crankshaft clockwise.

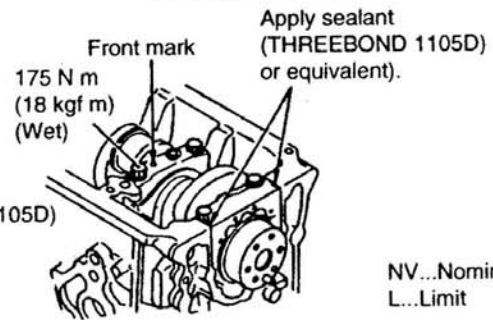
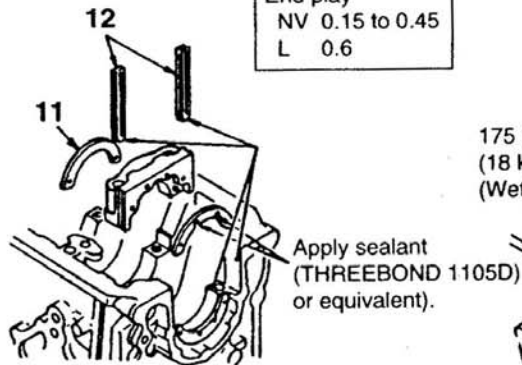
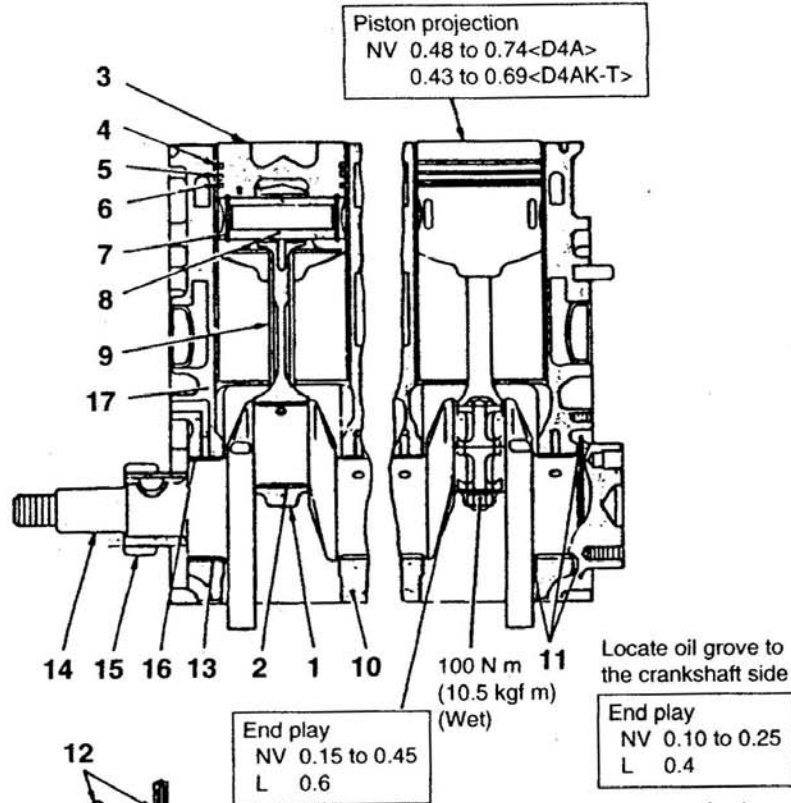
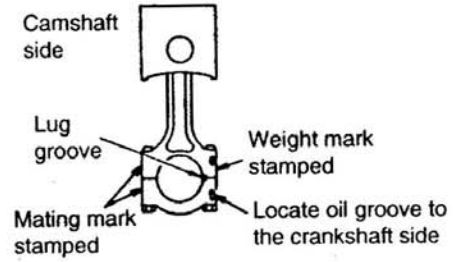
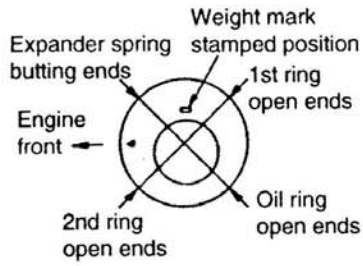


Crankshaft Undersize Dimensions

Unit : mm

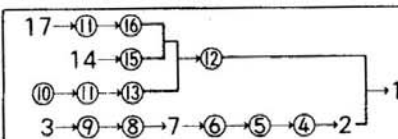
Under size	Journal O.D finish dimension	Pin O.D finish demension		Out-of-roundness	Cylindicity
		D4A	D4DA		
0.25	77.68~77.70	59.695~59.715	64.69~64.71	0.01 or less	0.006 or less
0.50	77.43~77.45	59.445~59.465	64.44~64.46		
0.75	77.13~77.20	59.145~59.215	64.19~61.21		
1.00	76.93~76.95	58.945~58.965	63.94~63.96		

### 3. Reassembly



NV...Nominal Value  
 L...Limit

#### <Assembly sequence>

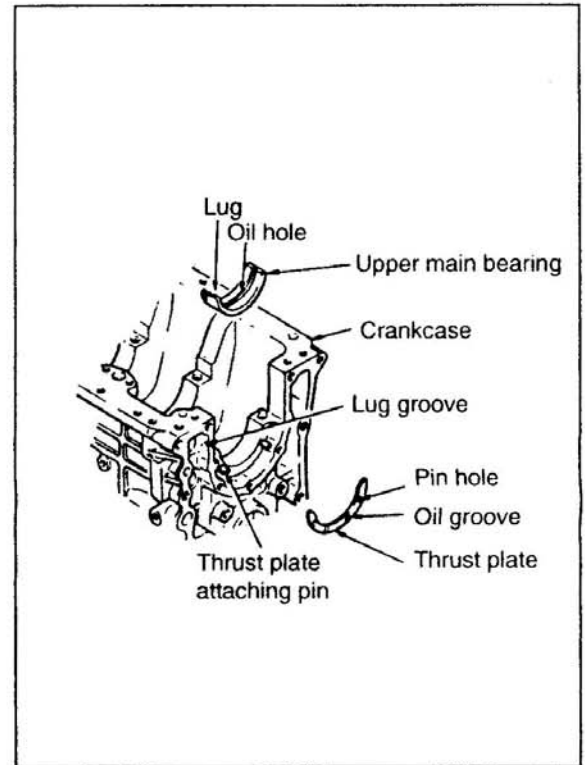




- (a) Install the thrust plate and upper main bearing to the crankcase.

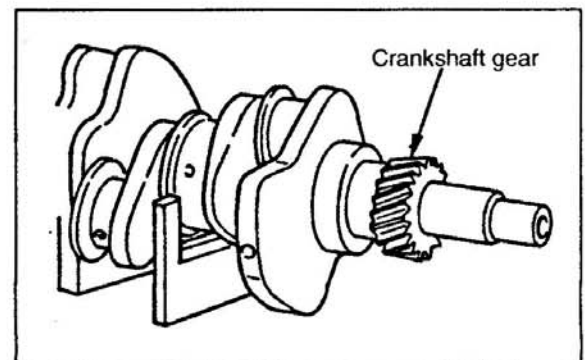
**NOTE:**

1. Install the thrust plate with its side having no oil groove toward the crankcase.
2. Line up the lug of main bearing with the lug groove in crankcase.  
Note that the upper main bearing has an oil hole, which must not be confused with the lower.
3. Apply engine oil to all sliding surfaces.



- (b) Installation of crankshaft gear

When the crankshaft gear was removed, it must be heated with a piston heater or similar device before being reinstalled onto the crankshaft.



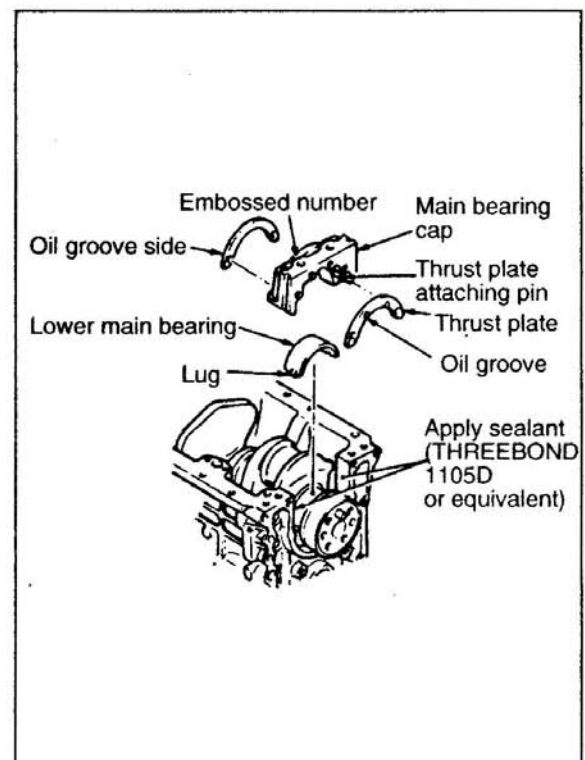
- (c) Installation of main bearing cap

<D4A>

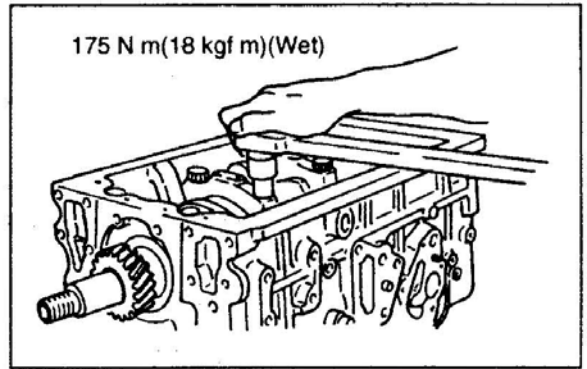
- 1) Fit the lower main bearing into the main bearing cap. At the time, make sure that the main bearing lug is aligned with the main bearing cap lug groove.
- 2) Install also the thrust plate onto the main bearing cap in the rear-end position.
- 3) Make sure that the main bearing cap lug groove are on the same side. Ensure also that the embossed numbers on main bearing caps are in ascending order from the front of engine.

**NOTE:**

1. Face the side of thrust plate having no oil groove toward the main bearing cap.
2. Use thrust plates of the same size for the crankcase and main bearing cap rear end.
3. Apply sealant to the crankcase front and rear surfaces onto which bearing caps are mounted.



- 4) Tighten the main bearing cap bolt to specification.  
Then, make sure that the crankshaft turns smoothly by hand.
- 5) Measure the crankshaft end play to determine if it is within the nominal value.

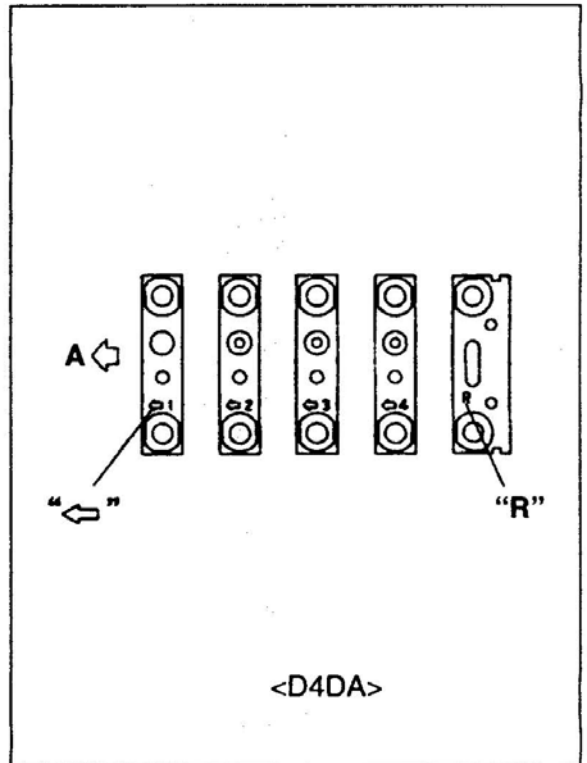


<D4DA>

- 1) Fit main bearing caps their front marks("←") pointing toward the front of engine.
- 2) Fit rear main bearing cap with its embossed mark("R") positioned as shown in the drawing.
- 3) Bolts 5 can be reused only three times.  
Before fitting the bolts, make a punch mark on the head of each one to indicate how many times it has been reused.

**NOTE:**

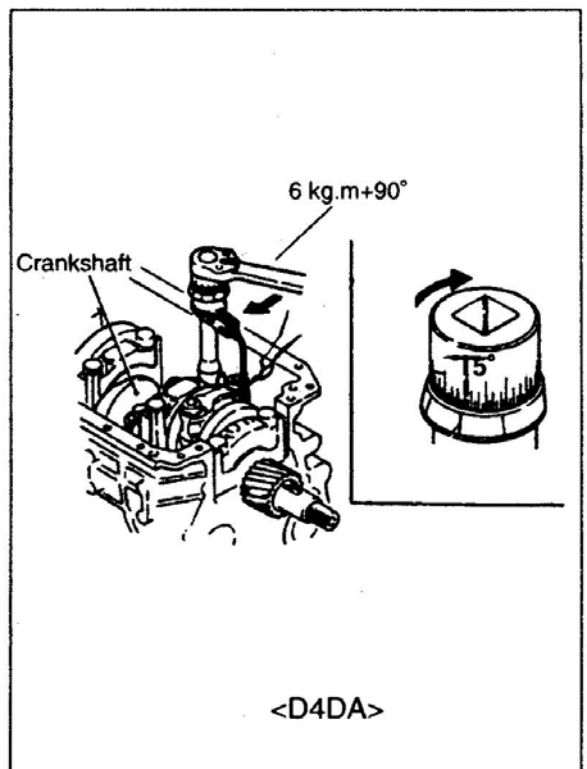
**If any bolt already has three punch marks, it cannot be used again; replace it with a new one.**



- 4) Set the socket wrench such that the built-in spring force forces rod against crankshaft.
- 5) On holder, select inscribed line F that is easiest to see.
- 6) Using the selected line as a reference, turn socket 90° clockwise.  
(One gradation on scale represents 5°.)

**NOTE:**

**since bolts 1 utilize the plastic region tightening method, they must not be tightened further after this procedure.**

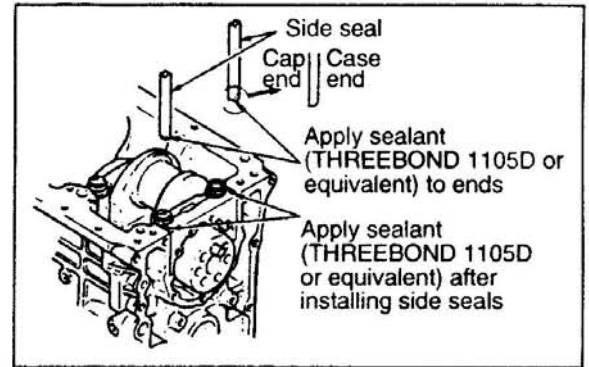


(d) Installation of side seal

Install the side seal with sealant applied to its end.  
Then, apply sealant to the bearing cap.

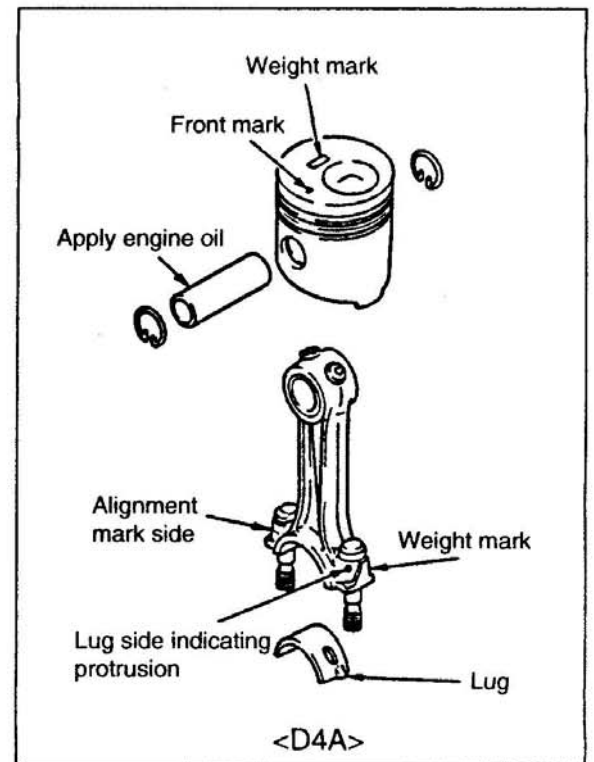
**NOTE:**

**When installing the side seal, ensure the correct installation direction.**



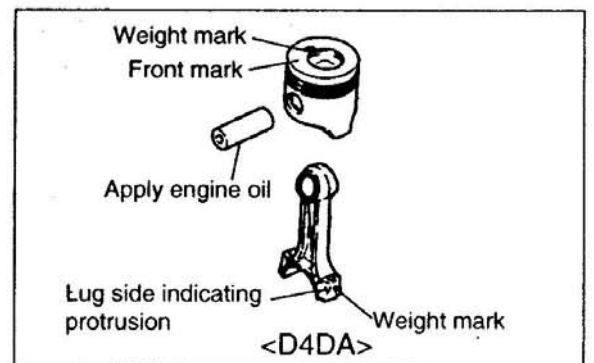
(e) Reassembly of piston and connecting rod.

- 1) Assemble the piston and the connecting rod, ensuring correct direction as illustrated.
- 2) Insert the piston pin to couple the piston and connecting rod. Mount the snap ring to hold the piston pin in position. The piston pin is a clearance fit in the piston. If the piston pin is hard to fit, heat the piston with a piston heater or hot water.



**NOTE:**

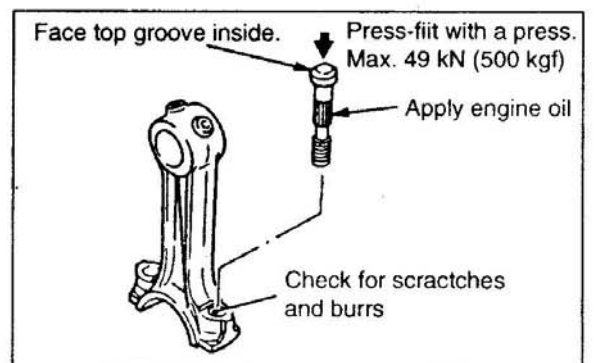
1. **Pistons must all have the same mass mark.**
2. **Connecting rods must all have the same mass mark.**
3. **After inserting piston pin check that it turns smoothly and with out play.**



- 3) The connecting rod bolts do not normally need removal; however, where replacement is necessary for damaged bolt, install new bolts by using the following procedures.

Make sure that the connecting rod bolt hole is free from damage and burrs. Then, with engine oil applied to the connecting rod bolt, press it into position with a press.

(pressing load: Max. 4.9 kN or 500 kgf)

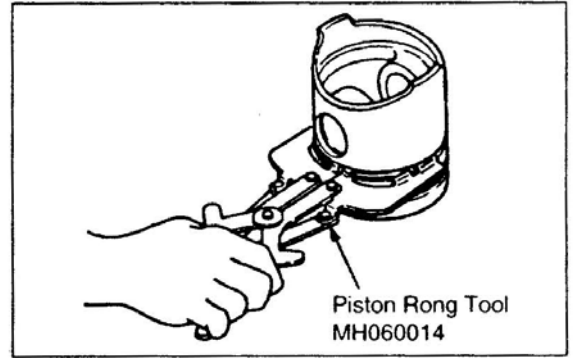


(f) Installation of piston rings

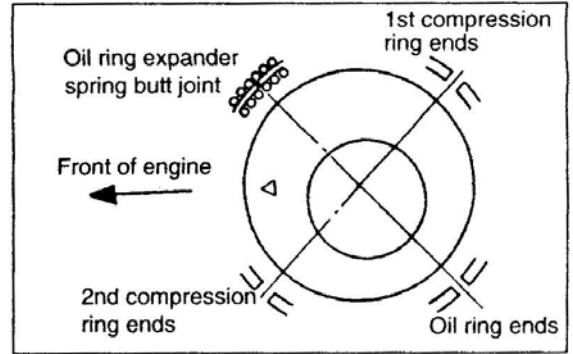
To install piston rings, use piston Ring Tool(special tool).

**NOTE:**

**A manufacturer's mark is stamped near the piston ring ends. Install with the mark up.**



Direct the open ends of piston ring as shown.

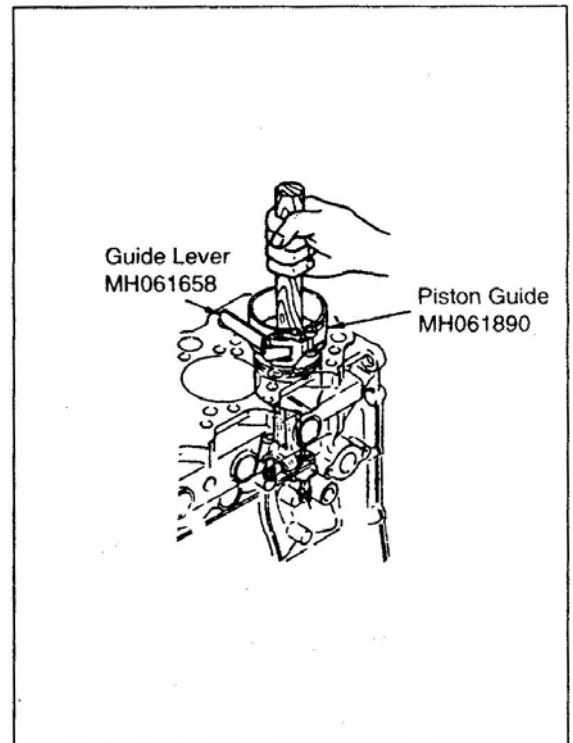


(g) Installation of piston and connecting rod assembly

Fit the upper and connecting rod bearing into the connecting rod and install the piston into the crankcase with piston Guide(special tool).

**NOTE:**

1. Face the position mark on the lug end toward front of engine.
2. Make sure that the piston ring ends position does not change during installation.
3. Cover the connecting rod bolt with a vinyl hose so as not to damage to crankshaft pins.



## Use of Piston Guide

With the piston guide lined up with the piston skirt, set the lever in position and adjust with the adjusting bolt to match the clamp I.D. with piston O.D.

On completion of adjustment, remove the piston Guide from piston and apply engine oil to piston external surfaces, piston Guide internal surfaces, and cylinder liner internal surfaces.

After these procedures have been completed, install piston Guide to the piston with their top surfaces flush with each other and tap piston top with a mallet or other soft object into piston so as not to damage to the piston.

- (h) Fit the lower connecting rod bearing to the connecting rod cap and tighten the connecting rod to specification.

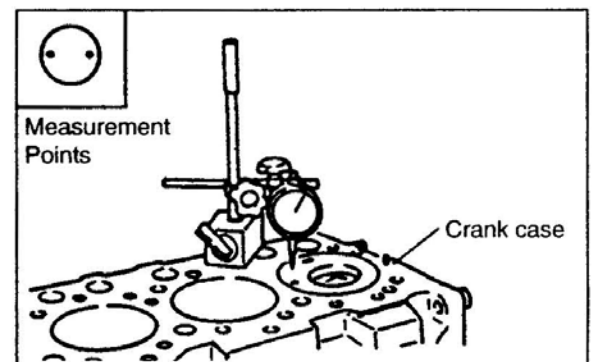
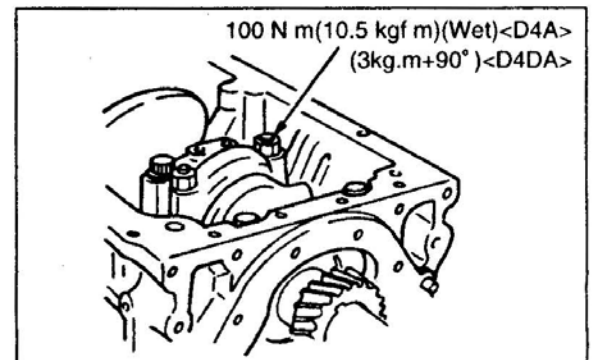
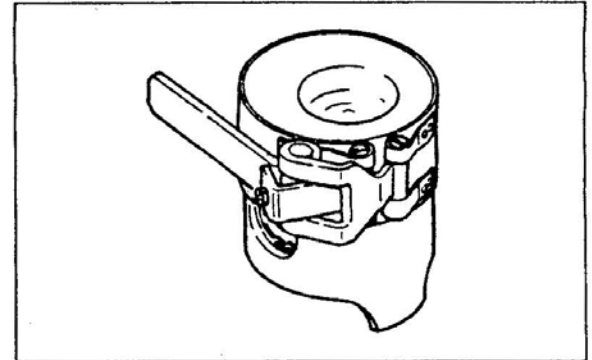
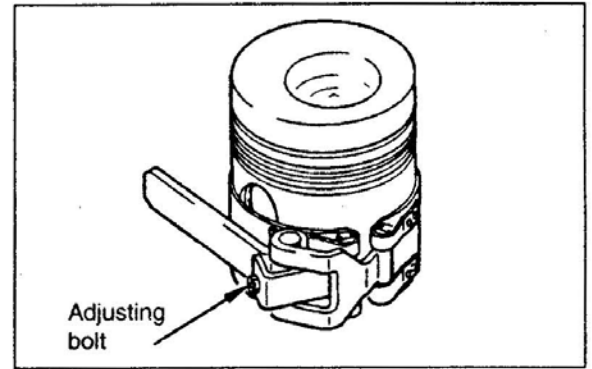
### NOTE:

**The lug sides of the connecting rod and connecting rod cap must be in the same direction.**

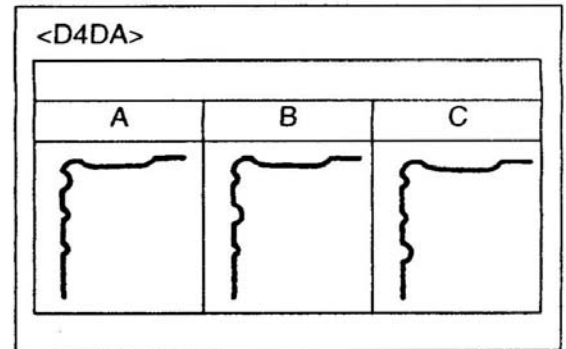
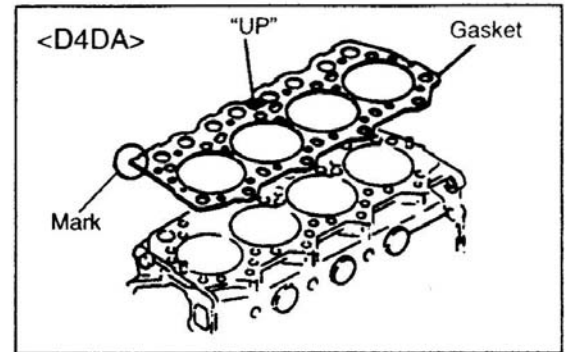
- (i) Check the connecting rod end play.  
(j) Check piston for projection.

Incorrect piston projection adversely affects the engine performance. If measurements are out of specification, check parts for clearance.

- 1) Hold the dial indicator on the crankcase top surface to make zero adjustment.
- 2) Locate the piston TDC with the dial indicator.
- 3) Measure projections at three points on the piston top surface to obtain the average value.



Average value of piston projection	Size classification	Thickness when tightening
0.466~0.526	A	$1.35 \pm 0.03$
0.526~0.588	B	$1.40 \pm 0.03$
0.588~0.648	C	$1.45 \pm 0.03$



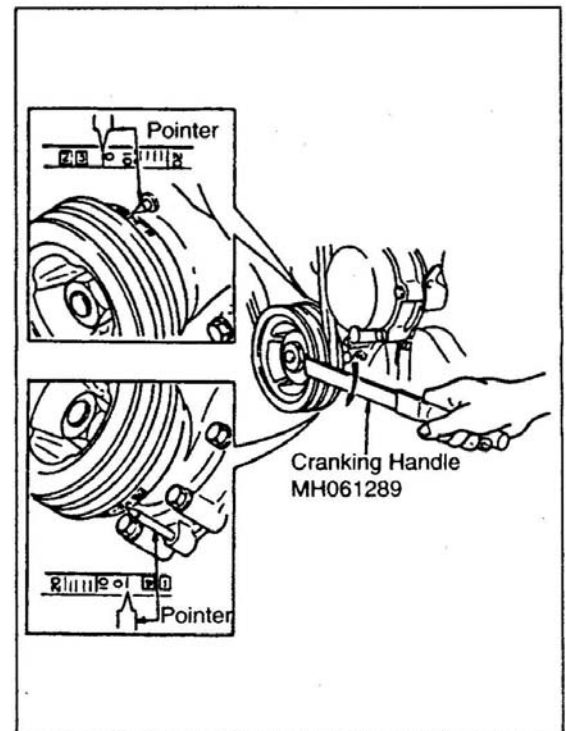
#### 4. Inspection and Adjustment of Valve Clearance

Inspect and adjust the valve clearance when the engine is cold by using the following procedures.

- (a) Crank the engine with Cranking Handle(special tool) to line up the inscribed line "0" position on the "1.4" stamped side of the crankshaft pulley with the pointer.

Another pointer is provided on the crankshaft pulley top.<D4A>

If this pointer is used, use the inscribed line "0" position on the "2.3" marking side of the crankshaft pulley.



- (b) When the piston in No.1 cylinder is at TDC on the compression stroke(the push rods of No.1 cylinder not pushing up the intake and exhaust valves), check and adjust clearances of valves marked with “○” in the following Table. Then, with the crankshaft rotated a turn, check and adjust clearances of the remaining valves marked with “x”.

If the No.4 or No.6 cylinder piston is at TDC on the compression stroke(push rods in the NO.4 or NO.6 cylinder not pushing up the intake and exhaust valves), similarly check and adjust the clearances of valves marked with “x” first; then, turn the crankshaft a turn, check and adjust valves marked with “o”.

Cylinder No.	1		2		3		4	
	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.
No. 1 at Tdc on compression stroke	○	○	○			○		
No.4 at TDC on compression stroke				x	x		x	x

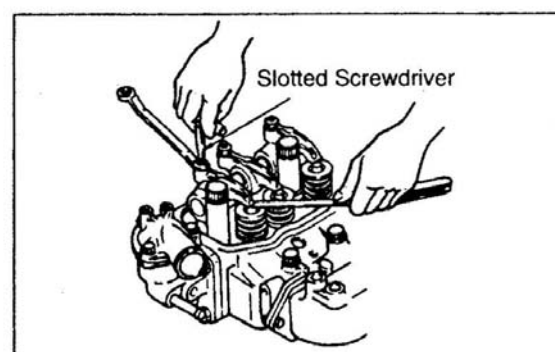
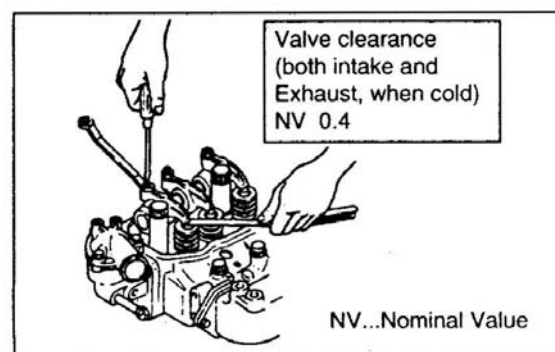
- (c) Insert the specified thickness gauge between the rocker and valve cap to check for clearance.

If the valve clearance is out of the nominal value, loosen the lock nut and turn the adjusting screw to the extent that the thickness gauge moves slightly tight.

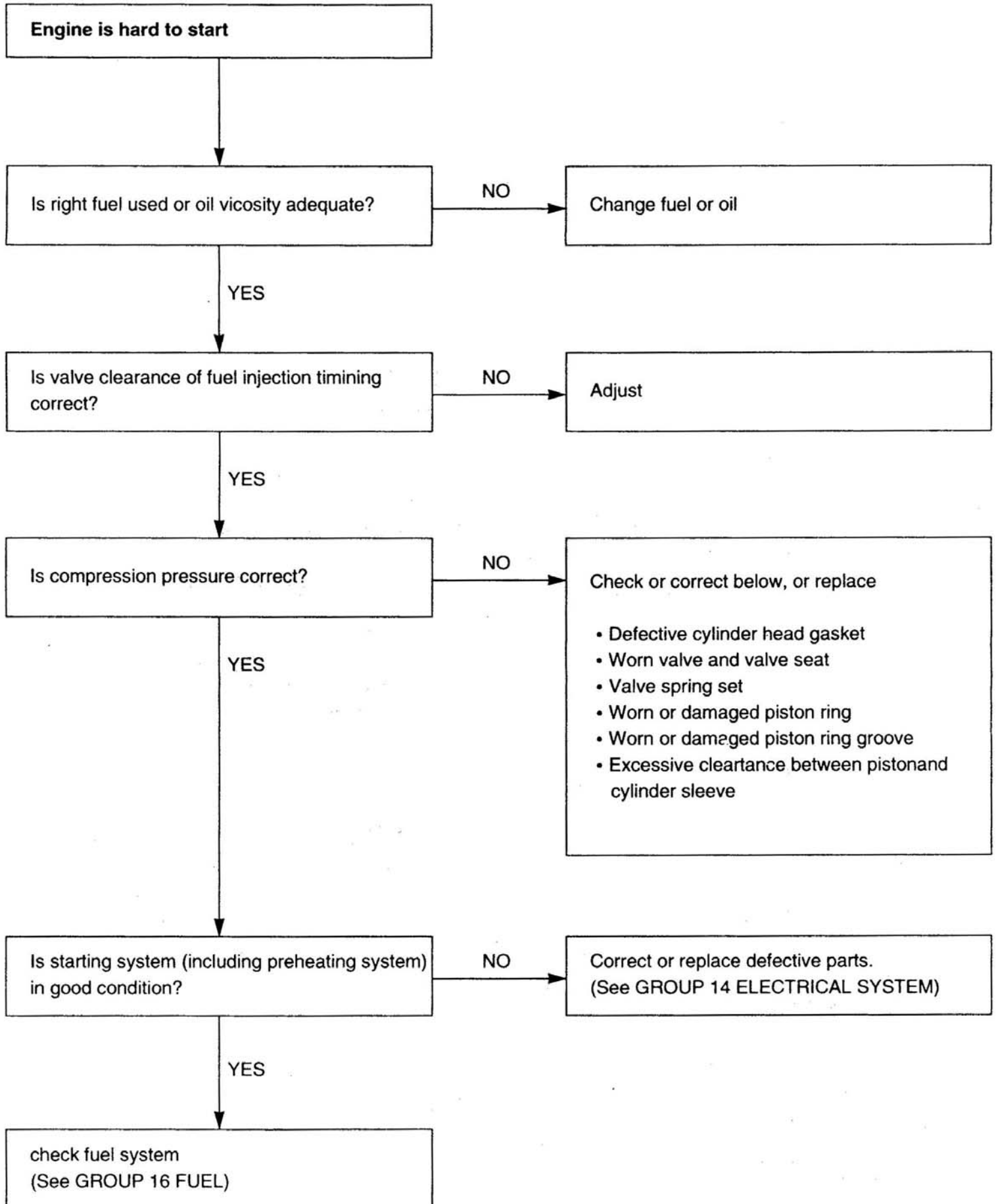
After adjustment, hold the adjusting screw in position with a screwdriver, and tighten to secure the lock nut.

Recheck the valve clearance with the thickness gauge.

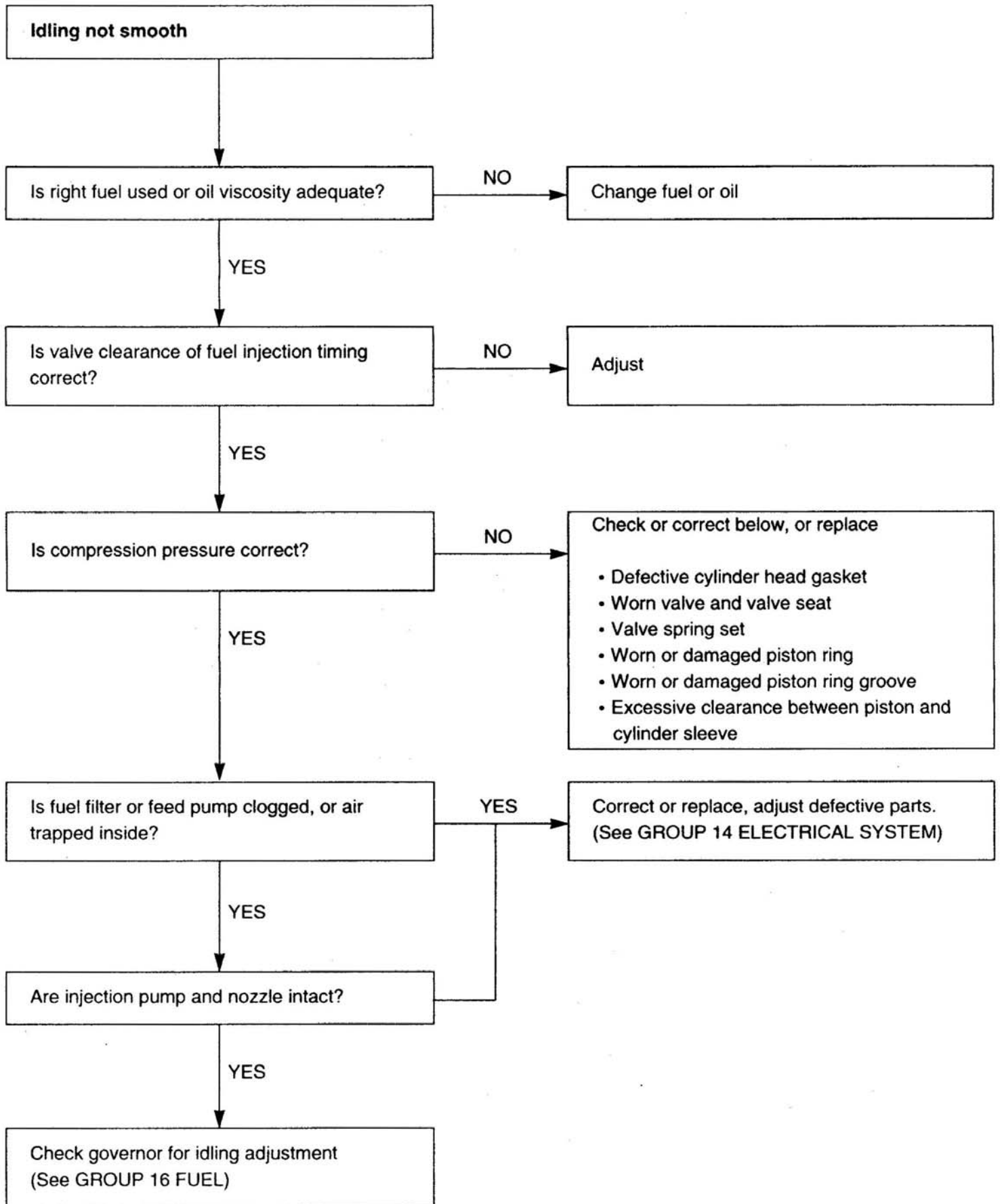
For on-vehicle adjustment of the valve clearance, use slotted Screwdriver(special tool) to turn the adjusting screw, which makes the job easier.

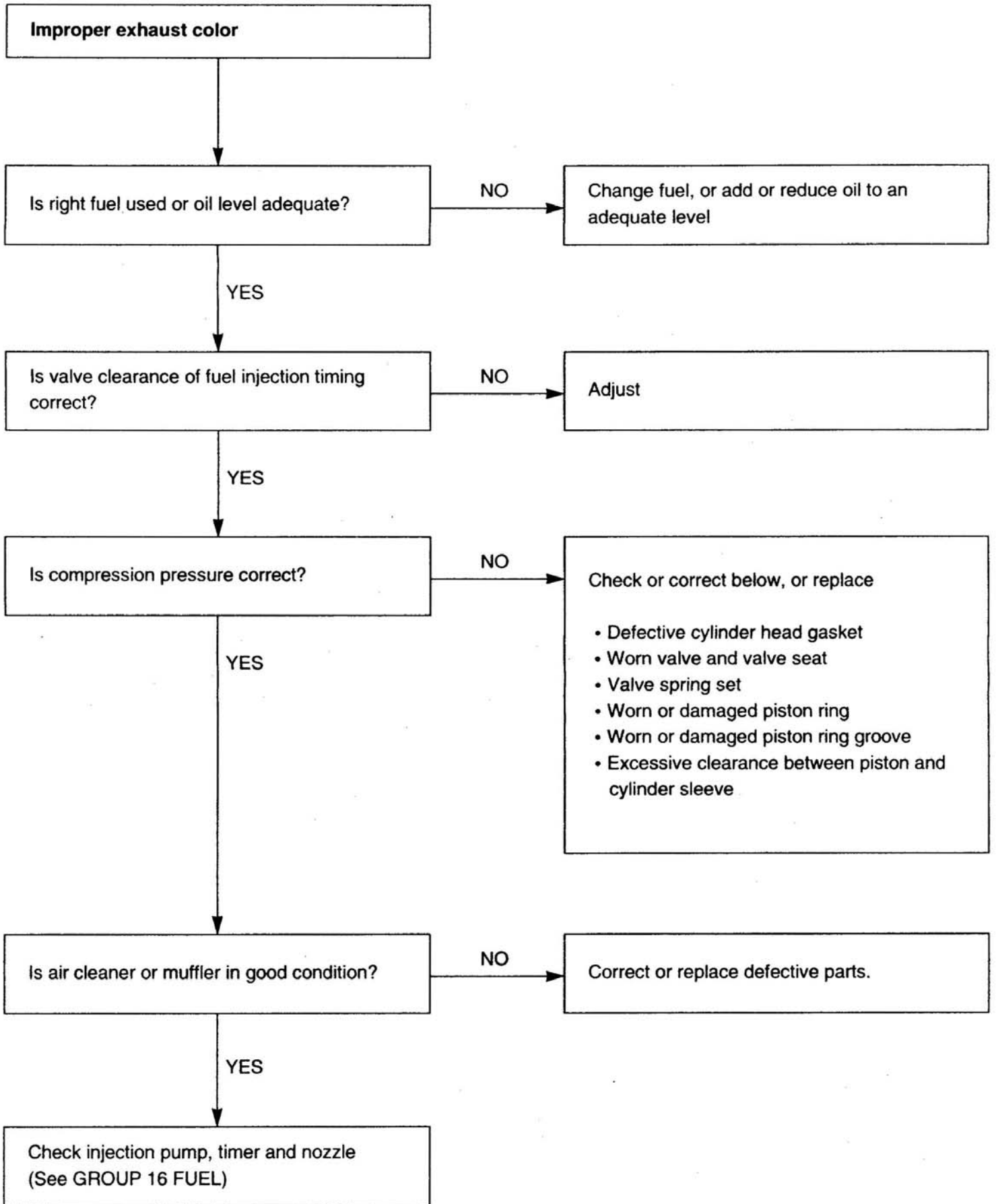


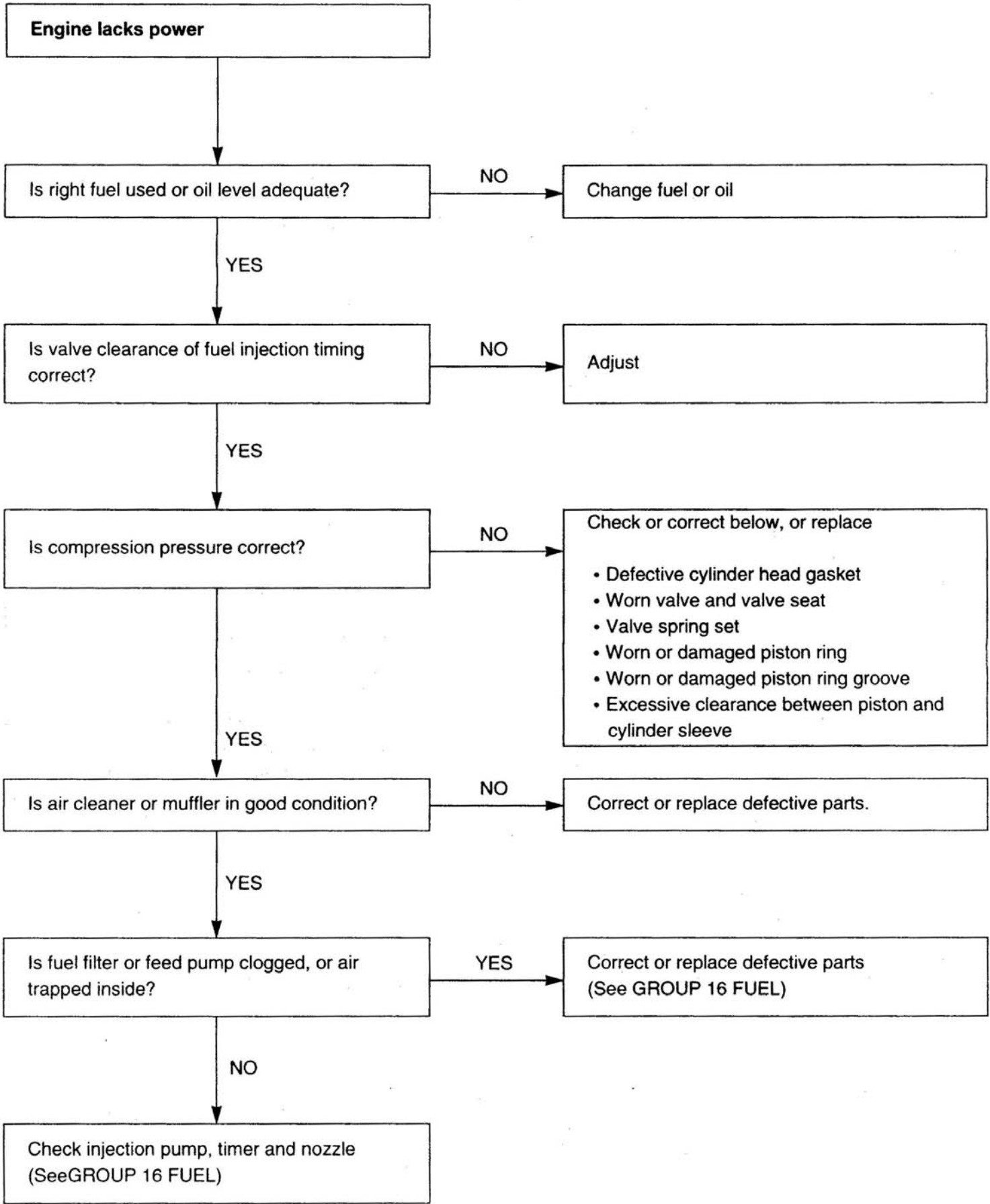
## 6. TROUBLESHOOTING











**Engine lacks power**

Is right fuel used or oil level adequate?

NO

Change fuel or oil

YES

Is valve clearance of fuel injection timing correct?

NO

Adjust

YES

Is compression pressure correct?

NO

Check or correct below, or replace

- Defective cylinder head gasket
- Worn valve and valve seat
- Valve spring set
- Worn or damaged piston ring
- Worn or damaged piston ring groove
- Excessive clearance between piston and cylinder sleeve

YES

Is air cleaner or muffler in good condition?

NO

Correct or replace defective parts.

YES

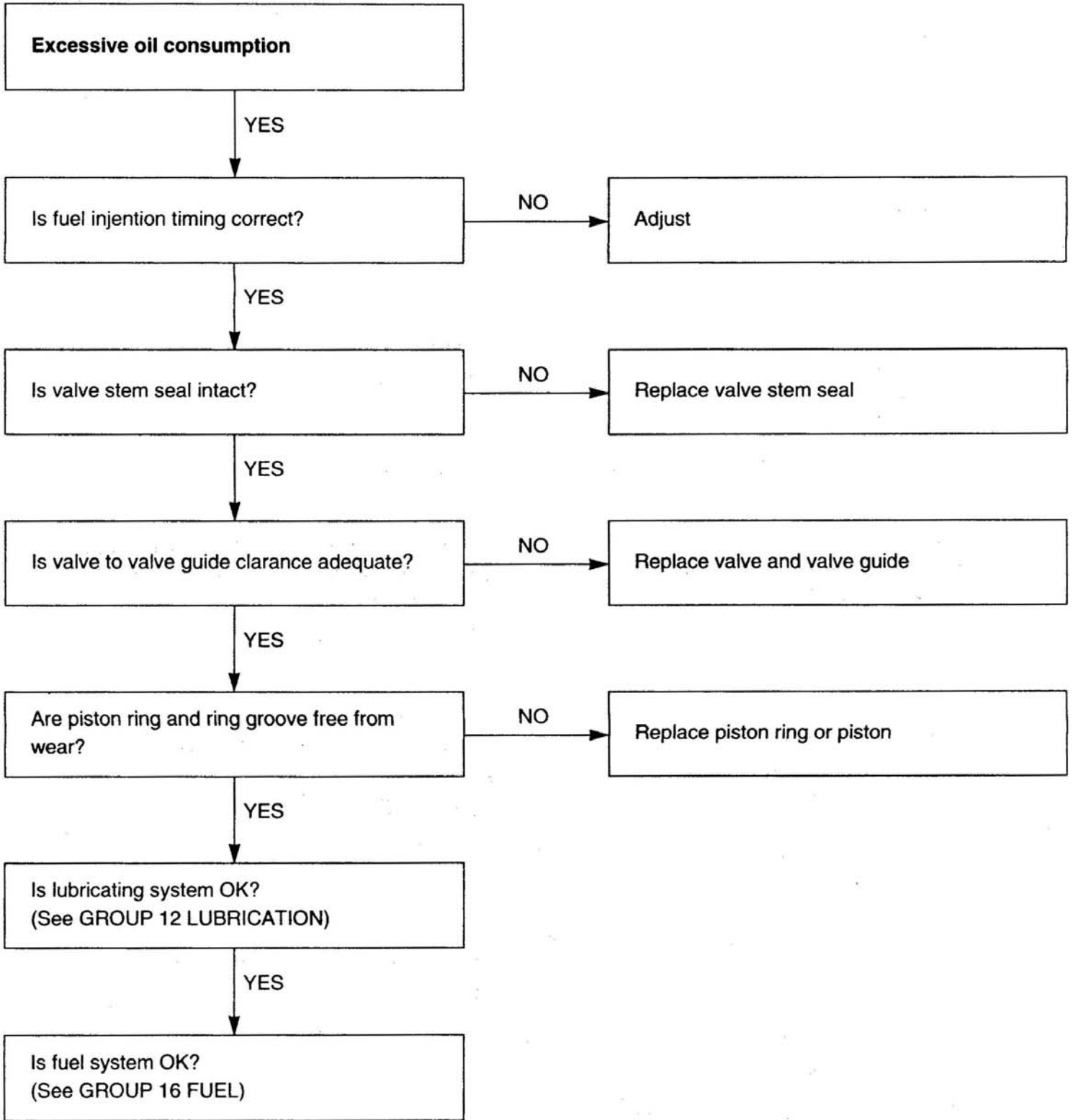
Is fuel filter or feed pump clogged, or air trapped inside?

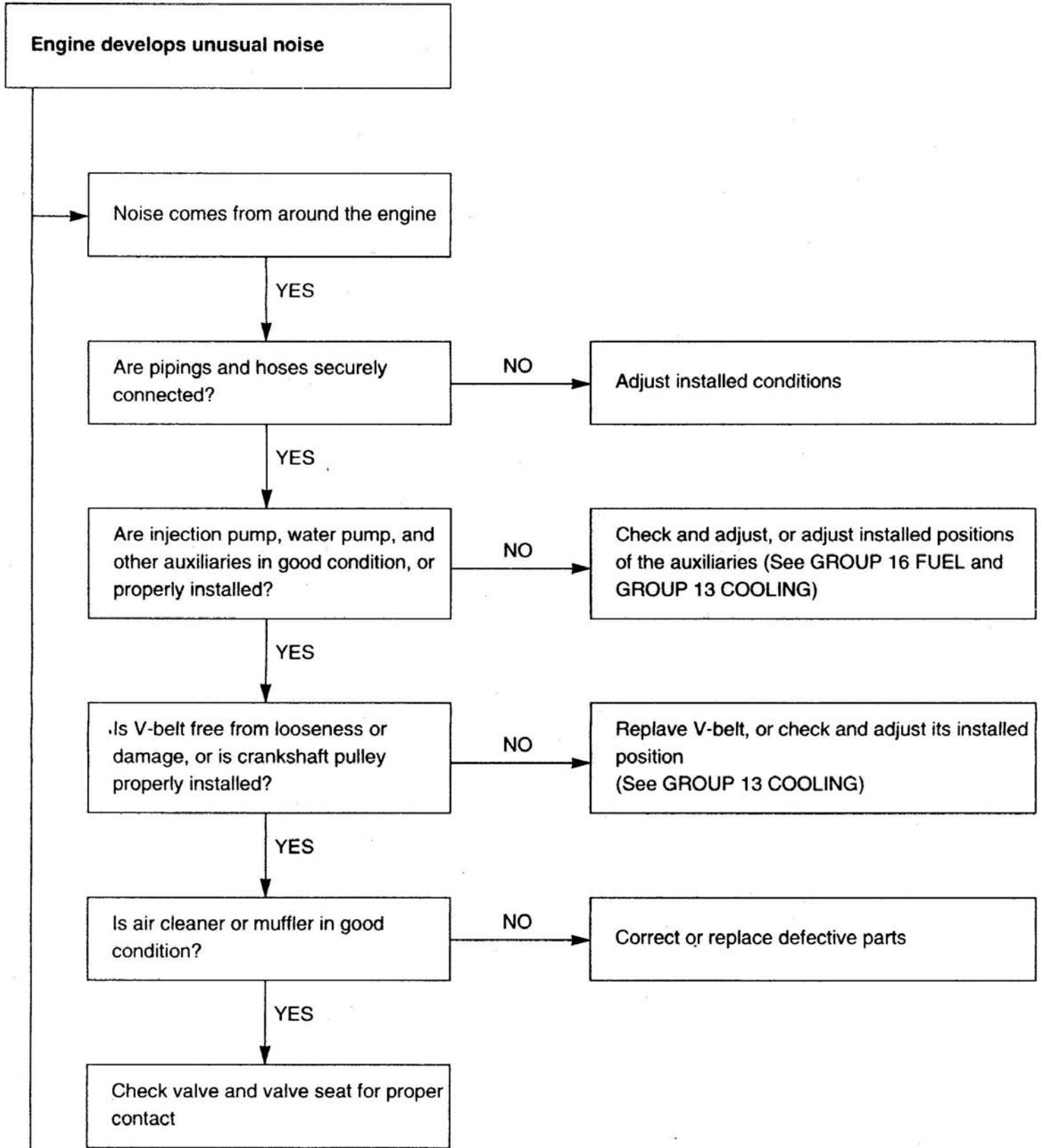
YES

Correct or replace defective parts  
(See GROUP 16 FUEL)

NO

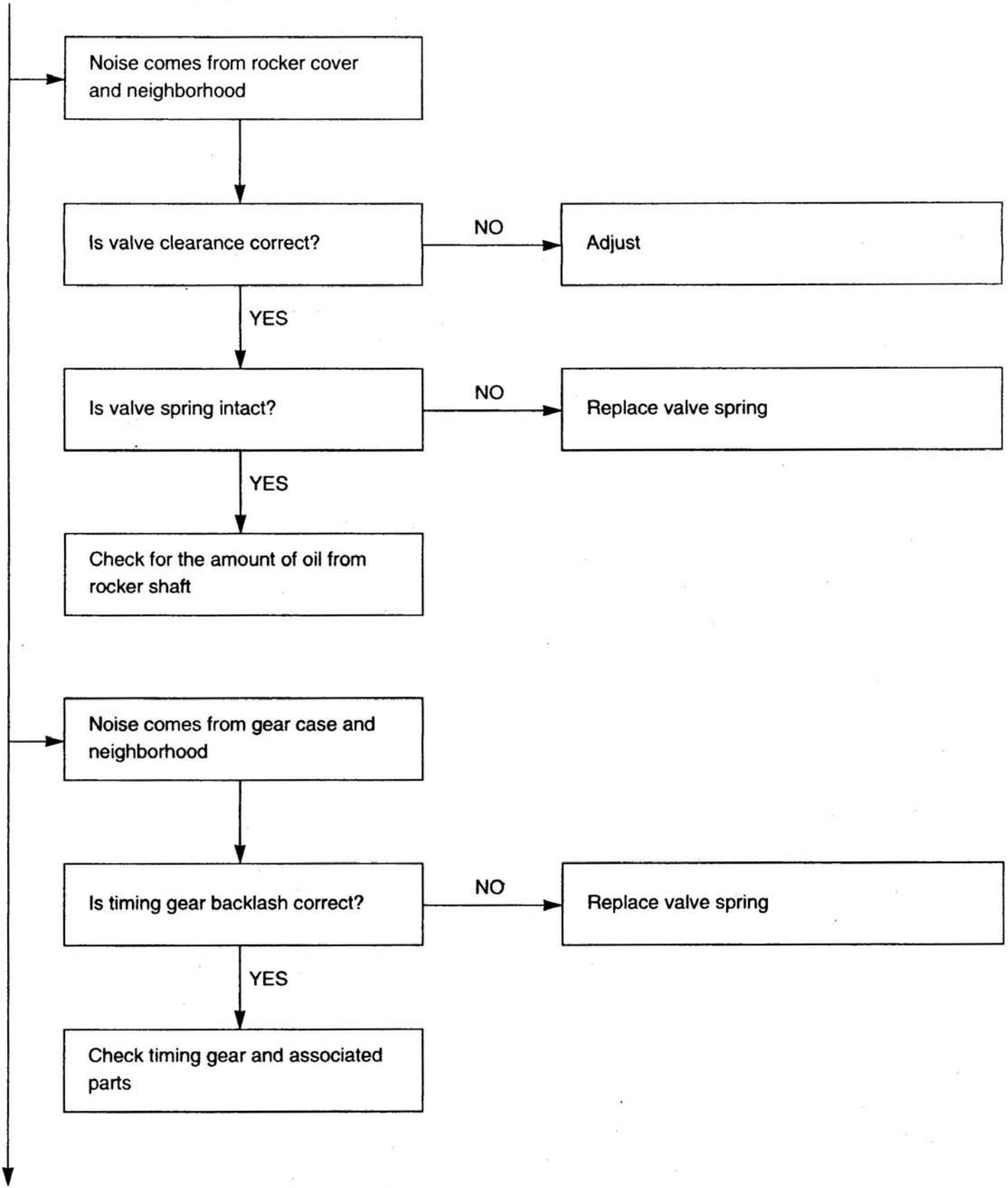
Check injection pump, timer and nozzle  
(See GROUP 16 FUEL)





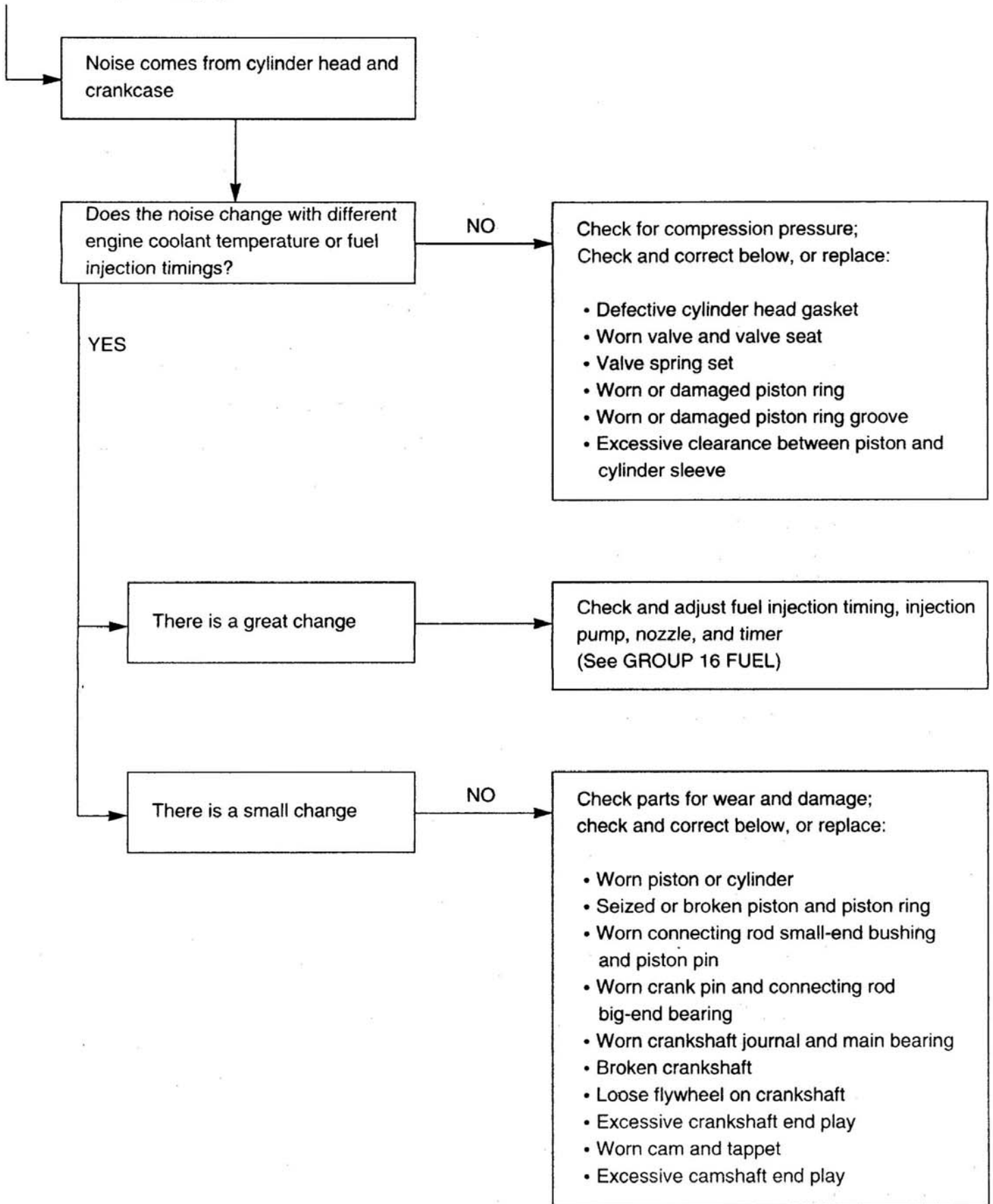
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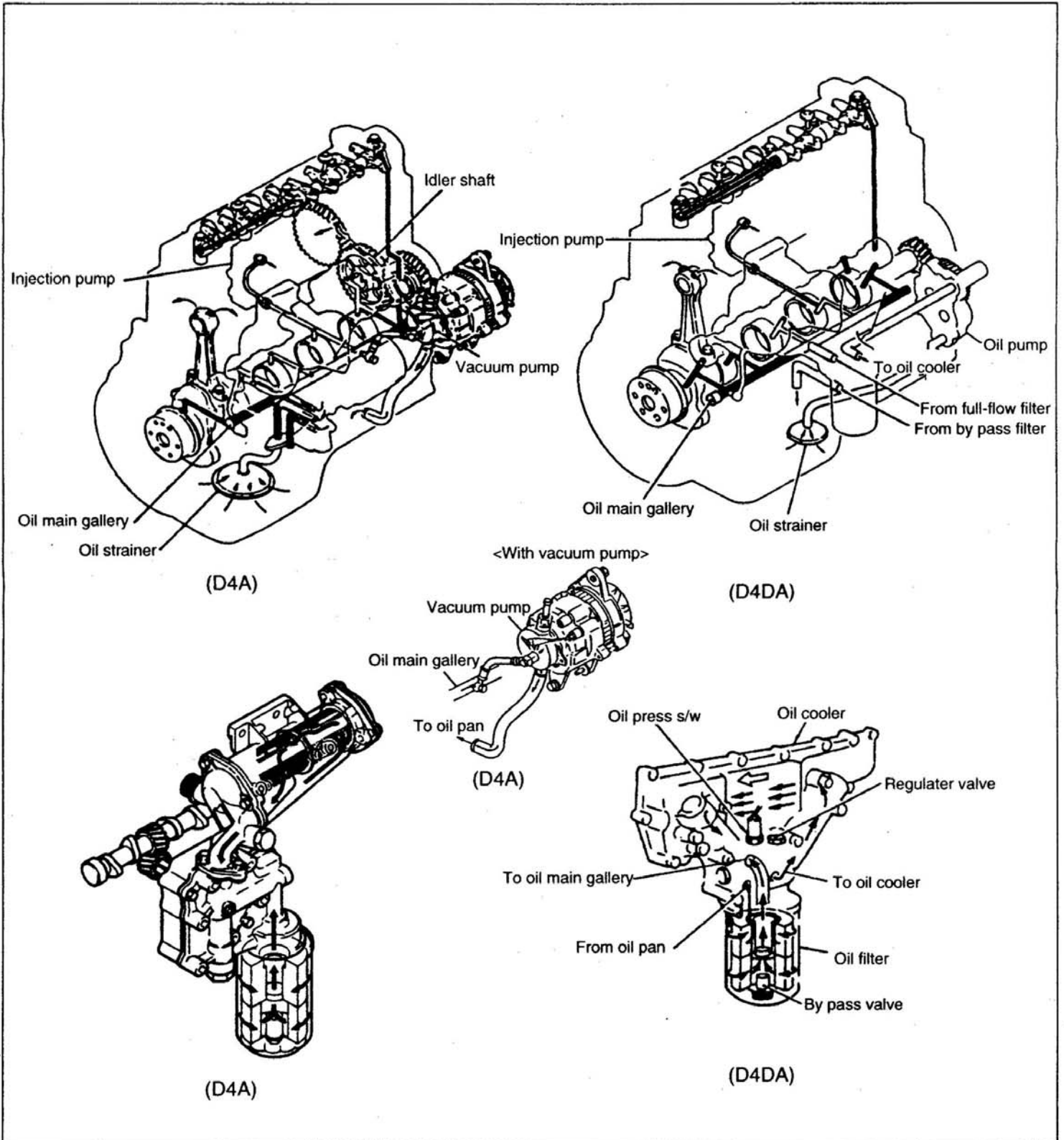
Continued from previous page



# 1.GENERAL

The engine is lubricated by a gear-type oil pump that forces engine oil through the oil cooler and oil filter into the engine for lubrication of various engine parts.

The illustration below shows the flow of engine oil.



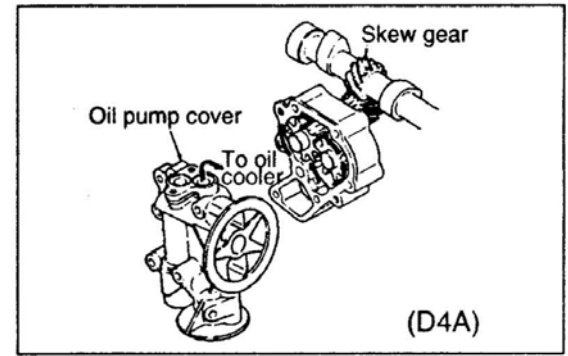


## (1) Oil pump

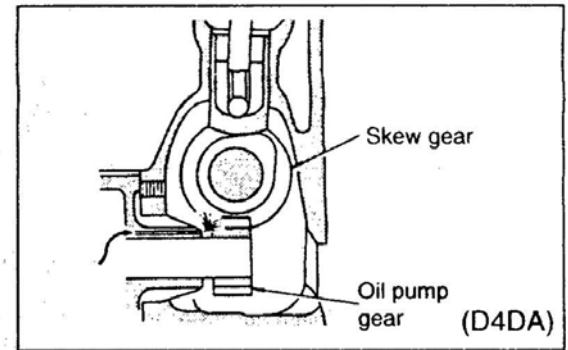
### <D4A>

The oil pump, of a gear type, is driven by the skew gear mounted on the camshaft.

The oil pump cover serves also as the oil filter head, requiring no oil pipe.



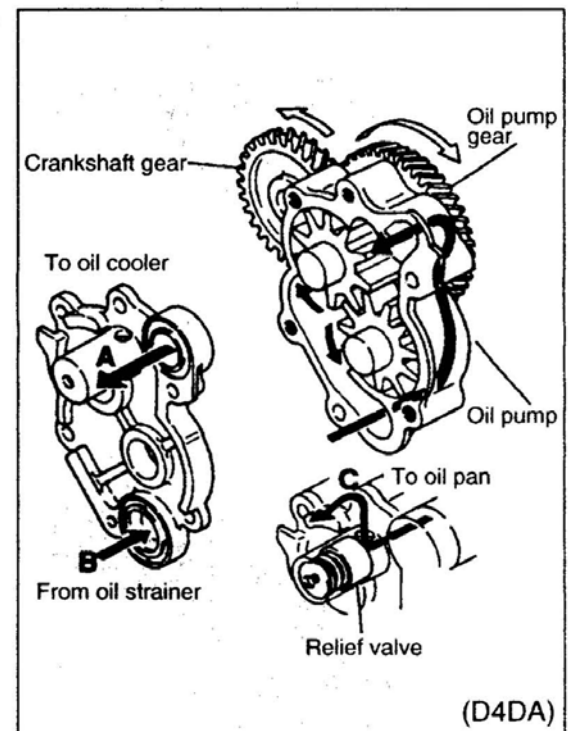
The camshaft skew gear and oil pump gear are lubricated by oil sprayed from the oil hole drilled in the oil pump case. The engine oil fed under pressure by the oil pump is delivered to the oil cooler.



### <D4DA>

Oil pump is a geartype. It is driven by rotation of the crankshaft via crankshaft gear and oil pump gear.

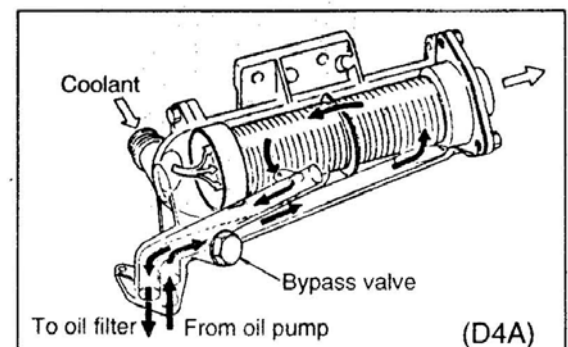
Relief valve is fitted to the oil pump. When the oil pump discharge pressure exceeds a specified level, the relief valve returns some of the engine oil to the oil pan, thus protecting the lubrication system from excessive oil pressure.

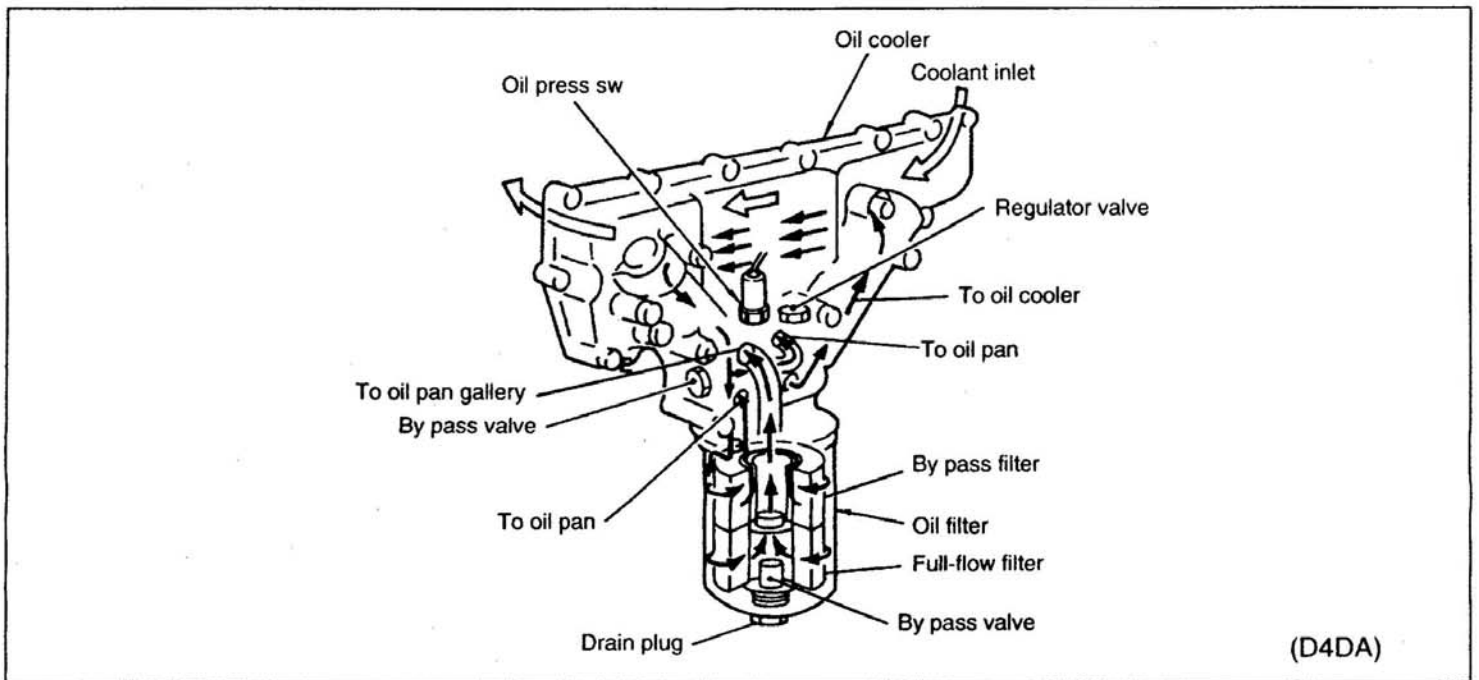


## (2) Oil Cooler

The oil cooler is an equipment for heat exchange between the coolant and oil fed under pressure from the crankcase water jacket and oil pump, respectively.

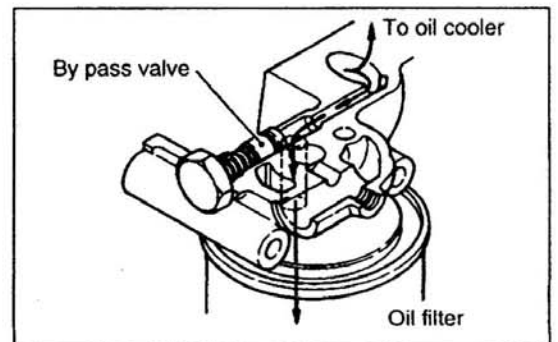
The oil cooler has bypass valve that opens when the element passes less oil as it becomes clogged.





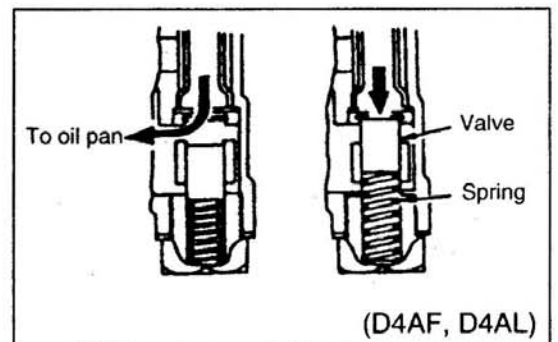
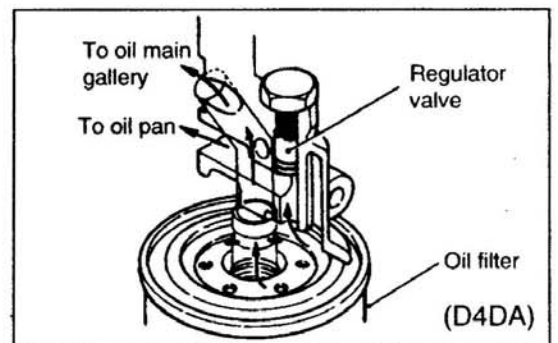
**(a) Operation of bypass valve**

When the oil's viscosity is high at low temperatures or when oil cooler element is clogged and resists the oil's flow, bypass valve opens, thus allowing oil to flow to oil filter without passing through the cooler.



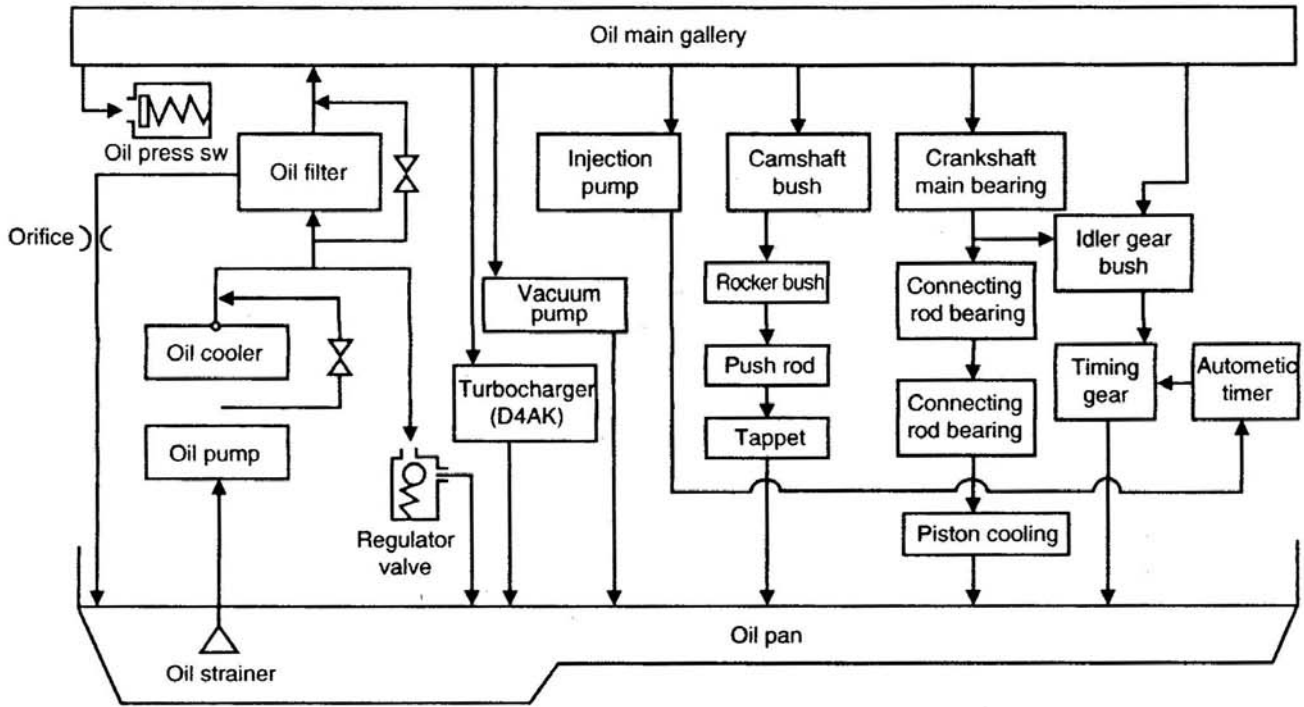
**(b) Operation of regulator valve**

When the pressure of oil going to the main oil gallery exceeds a specified level, regulator valve opens, allowing some of the oil to return to the oil pan. The oil pressure is thus constantly regulated.

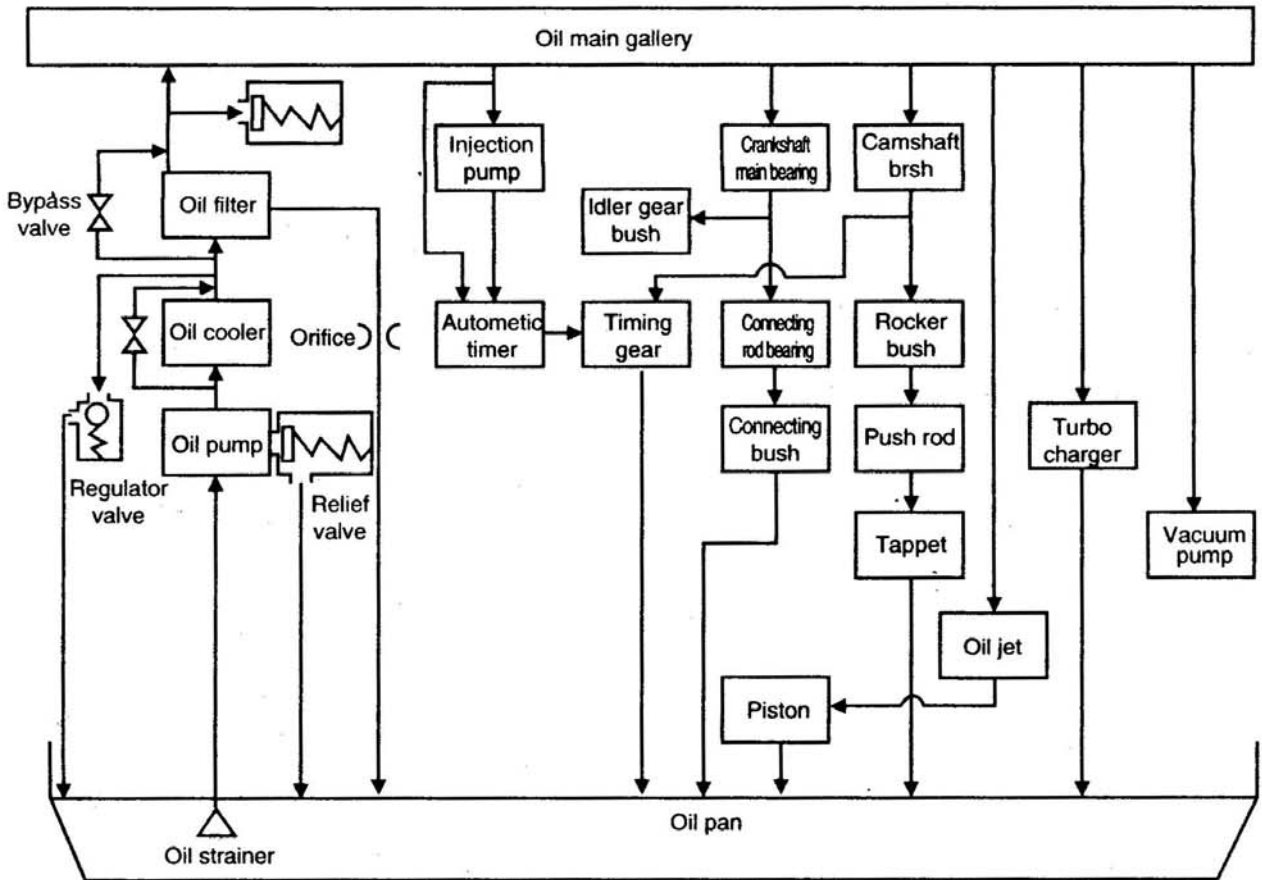


# Lubrication system (Oil flow)

(D4A)

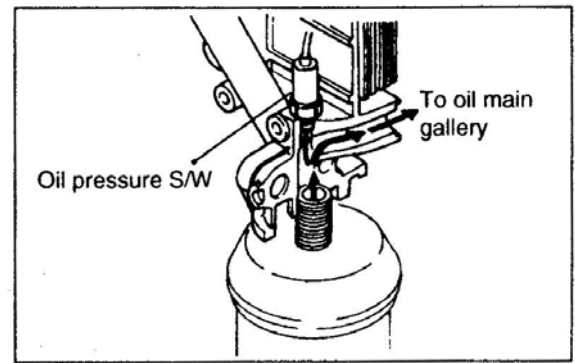


(D4DA)



(C) Operation of oil pressure switch

If the pressure of oil fed to main oil gallery drops below the specified level, electric contacts close inside pressure switch. As a result, a warning lamp illuminates in the meter cluster to alert the driver.



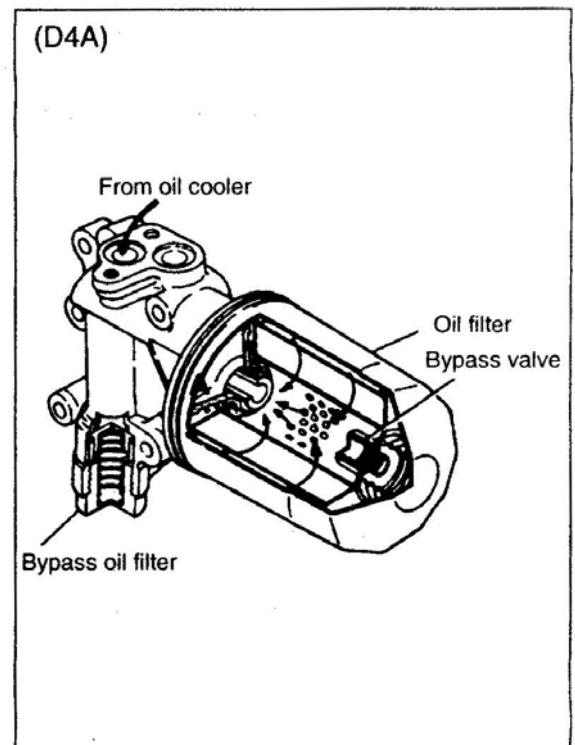
(3) Oil filter

<D4A>

The oil filter is a type incorporating both the full-flow and bypass filters. The element is a spin-on type that allows easy replacement.

The engine oil filtered through the full-flow filter is delivered to the crankcase oil main gallery and the oil circulating through the bypass filter returns through the crankcase to the oil pan.

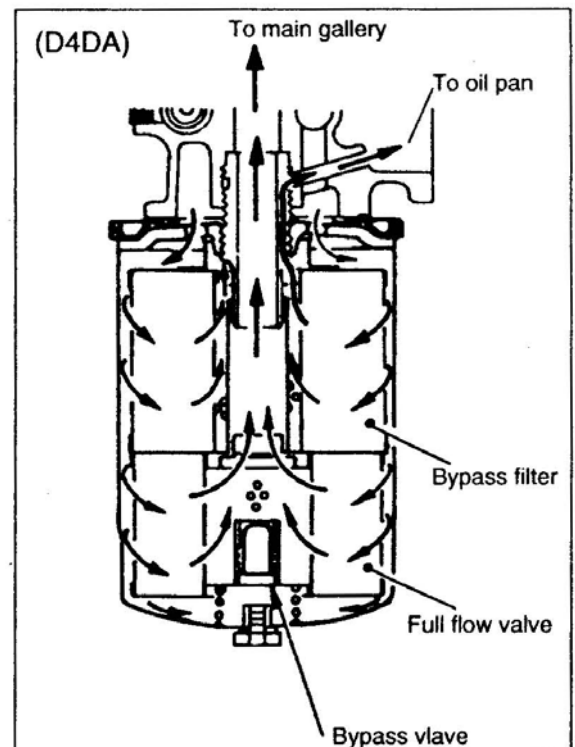
The oil pump cover has a relief valve that reroutes the engine oil to the oil pan when the oil pressure exceeds a predetermined level, thus preventing the lubricating system from being overloaded.



<D4DA>

The oil filter is a spin-on filter-paper type incorporating a full-flow filter and a bypass filter.

A bypass valve is fitted at the bottom of the filter assembly. If the elements become clogged, the bypass valve opens and allows oil to flow to main gallery without passing through the elements. This operation prevents seizure of the engine.



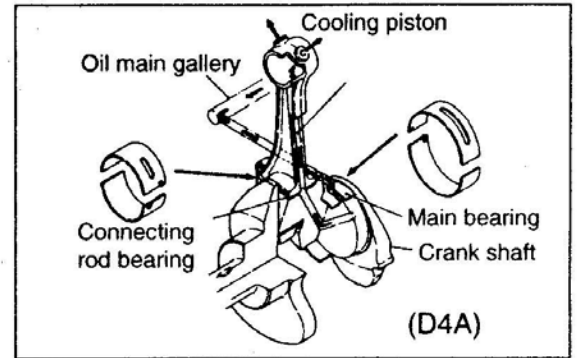
#### (4) Lubrication of parts

The engine oil routed from the oil filter to crankcase oil main gallery lubricates all engine parts as detailed below before returning to the oil pan.

##### (a) Main bearing and connecting rod bearing.

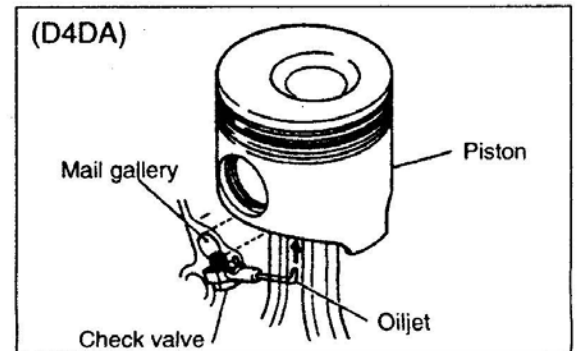
<D4A>

There is an oil passage provided from the oil main gallery to each main bearing. The oil flows through the oil hole to lubricate the main bearing and passes through the oil passage drilled into the crankshaft to lubricate the connecting rod bearing.



<D4DA>

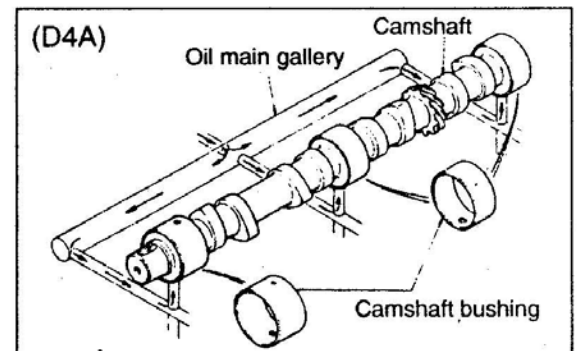
An oil jet is fitted in the lower part of main oil gallery for each piston. These oil jets cool pistons by injecting oil into them. Each oil jet is fitted with a check valve that opens and closes at specified oil pressure levels. At low oil pressures, these check valves close to maintain the required volume of oil in the lubrication system and prevent reductions in oil pressure.



##### (b) Camshaft

Camshaft bushings are lubricated by the oil flowing through the oil passages leading from the oil main gallery to each bushing.

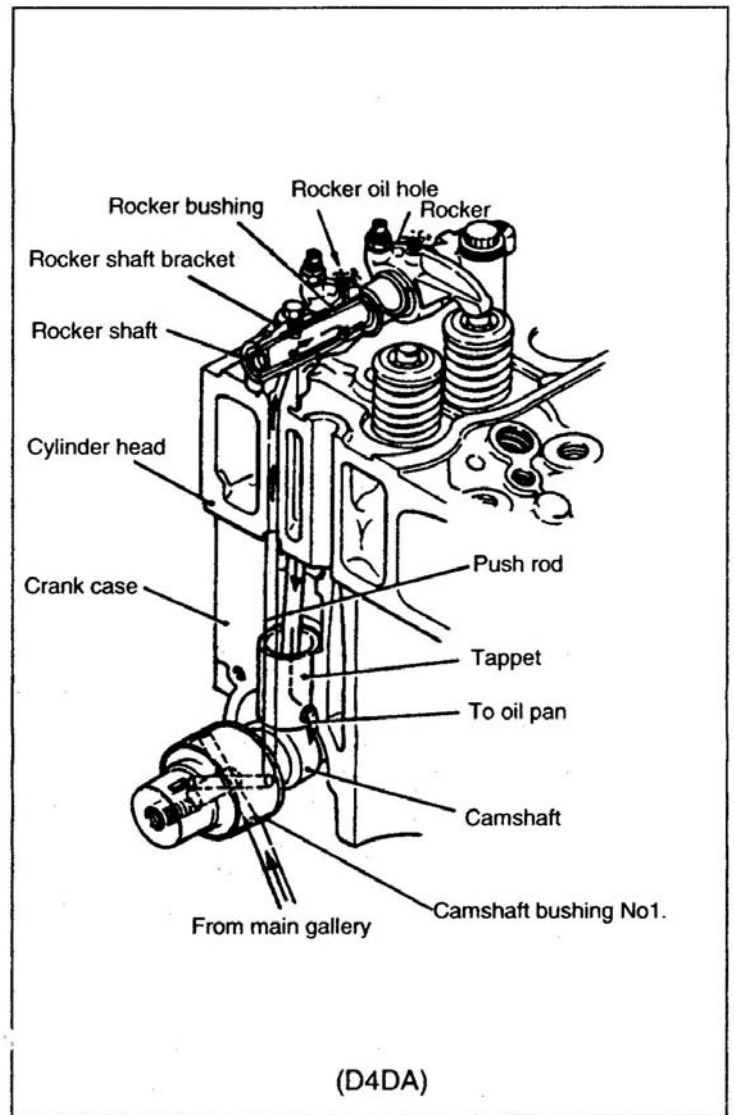
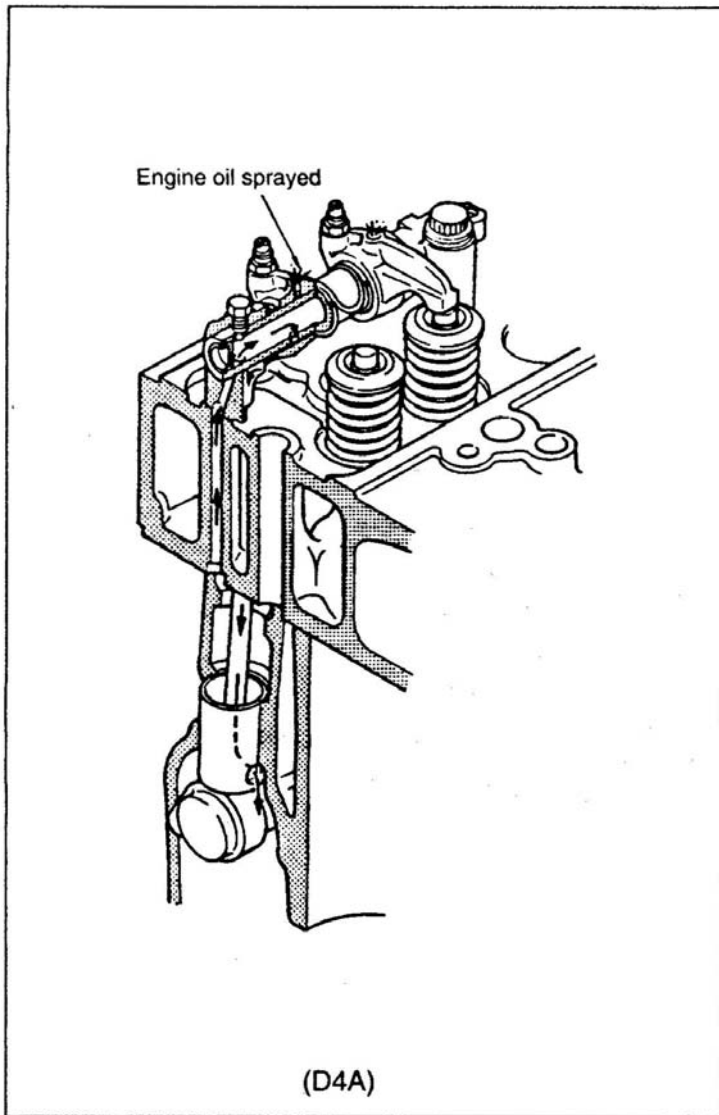
There is an oil hole provided in the journal at the front end of engine that serves as an oil passage to lubricate the camshaft gear and valve mechanism.



(c) Valve mechanism

The engine oil that has lubricated No. 1 camshaft bushing passes through the oil hole and pipe provided at the top portion of crankcase to the cylinder head.

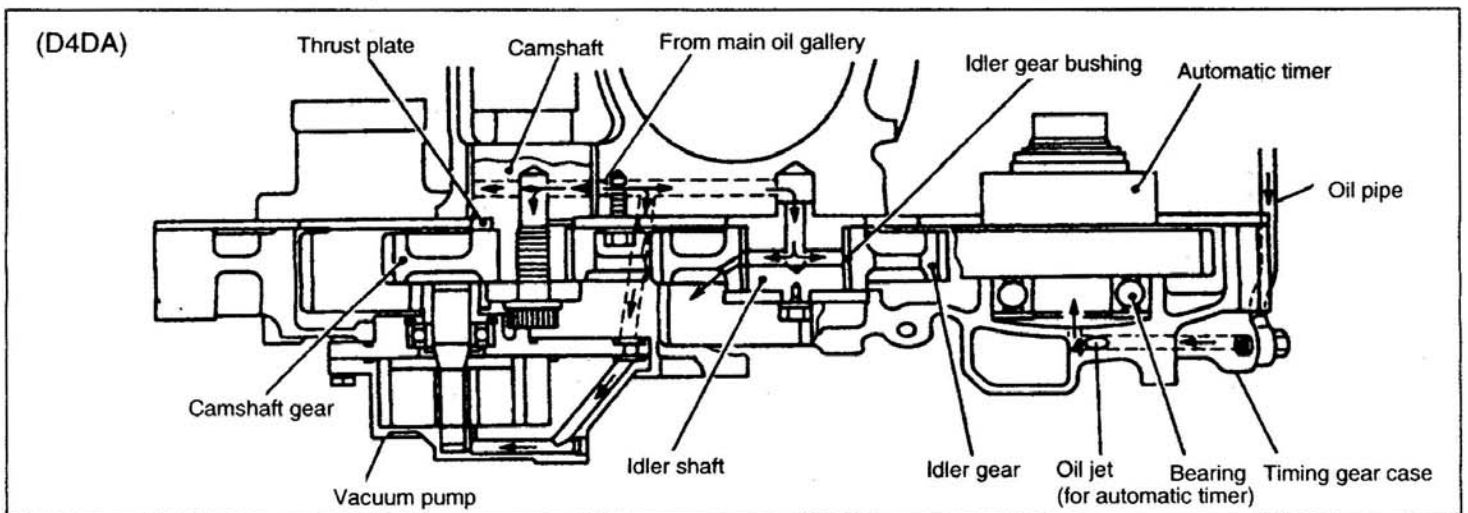
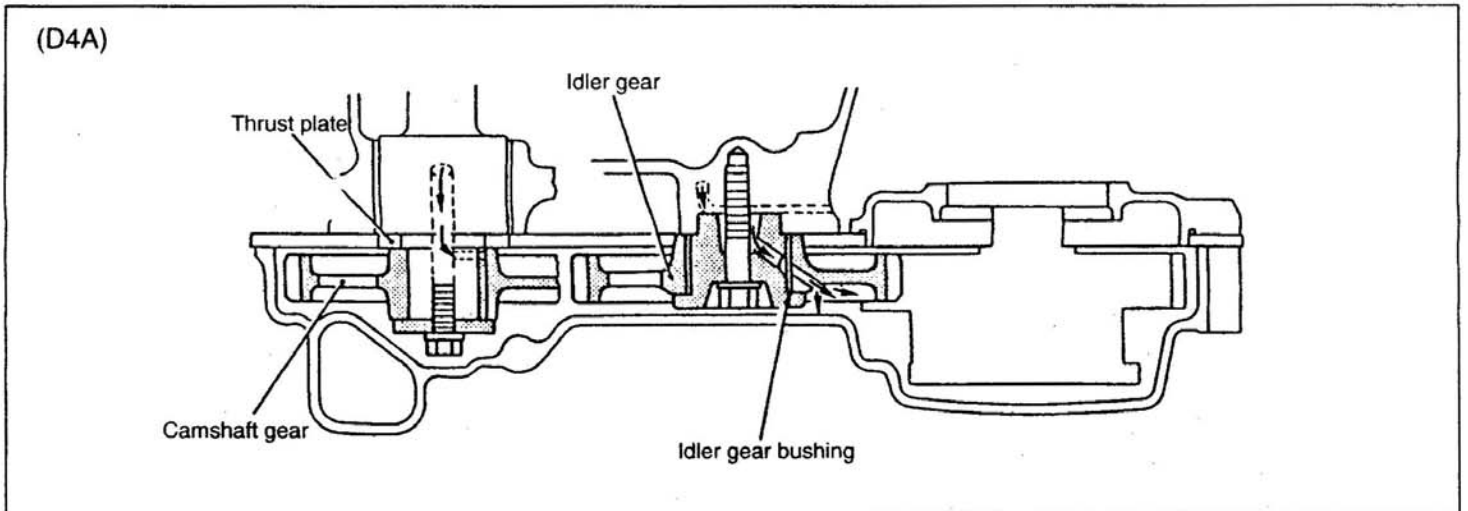
The engine oil then goes through the front-end rocker shaft bracket into the rocker shaft, lubricating each rocker bushing. At the same time, it sprays from the oil hole at top of rocker to lubricate the surfaces over which the valve cap slides and valve stem. The oil then passes through in the cylinder head and crankcase to lubricate the tappets and camshaft cams before returning to the oil pan.



## (5) Timing gear

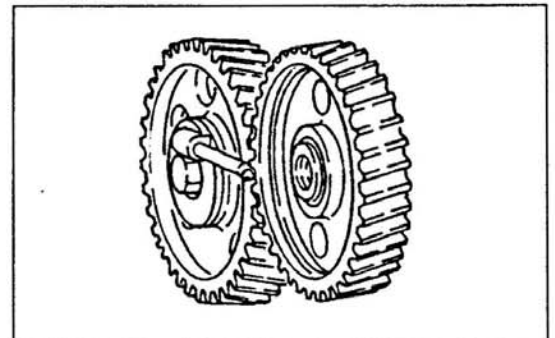
The timing gear idler gear bushing is lubricated by the engine oil routed from the oil main gallery, part of which spraying from the idler gear oil hole to lubricate each gear.

The camshaft gear and thrust plate are lubricated by the engine oil routed from NO.1 camshaft bushing through the camshaft oil hole.



Engine oil from main oil gallery passes through camshaft and idler to lubricate the gears and vacuum pump. An oil jet is provided in timing gear case to provide constant, forced lubrication of the automatic timer.

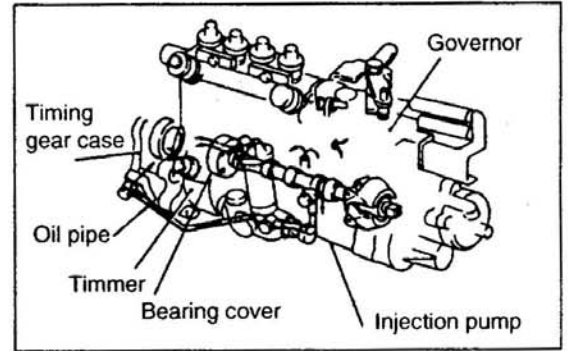
On D4A the idler shaft is provided with an oil pipe for the forced-lubrication of the auto timer.





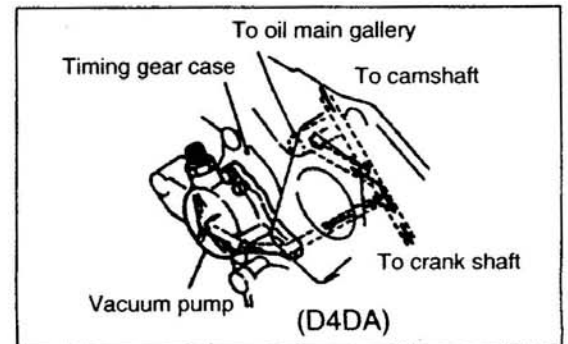
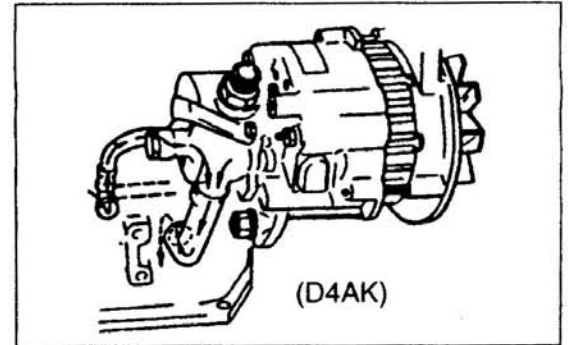
**(6) Injection pump**

Engine oil that has lubricated injection pump and governor returns to the oil pan through the oil passage of bearing cover.



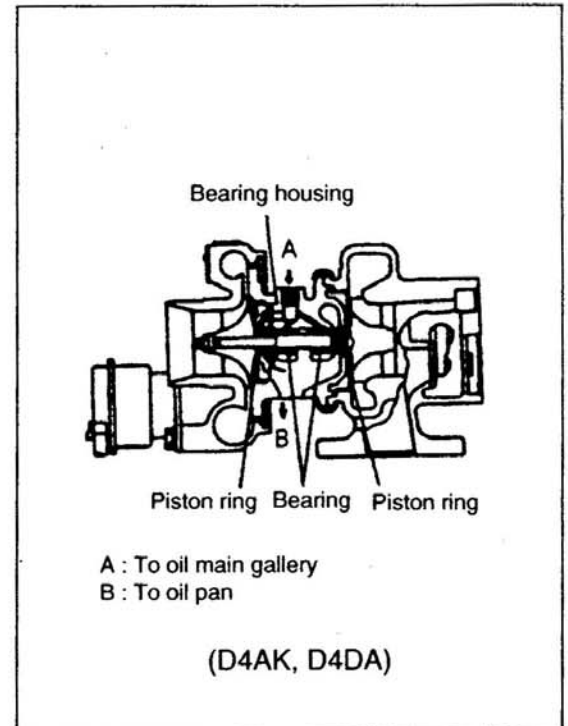
**(7) Vacuum pump**

Engine oil is delivered from main oil gallery to vacuum pump through the oil passage of timing gear case to lubricate the vanes. Then, the oil is discharged to timing gear case through the air outlet port together with air to be returned to the oil pan.



**(8) Turbocharger**

Via an oil pipe, engine oil is delivered from the main oil gallery to bearing housing to lubricate bearing. At each end of the turbine wheel shaft, piston ring acts as an oil seal.





## 2. SPECIFICATIONS

Item \ Model	D4AN	D4AK	D4DA
Engine oil			
Quality	API classification class CC or better	API classification class CC or better	←
Capacity	Oil pan Approx. 8.2 lit.	←	7.5 l (oil filter 1 l )
Lubrication method	Pressure feed by oil pump	←	←
Oil pump			
Type	Gear pump	←	←
Relief valve	Piston valve		
Oil filter			
Full-flow filter element	Spin-on type filter paper (with built- in bypass valve)	←	←
Bypass filter element	Spin-on, type filter paper	←	←
Regulator valve		-	Piston valve type
Oil cooler			
Type	Shell-and-tube	←	Shell-and-plate
Bypass valve	Piston valve	←	←

### 3. SERVICE STANDARDS

#### 1. Service Standard Table

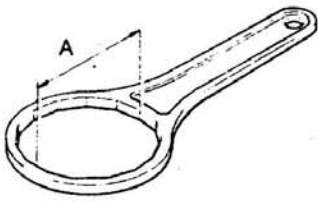
Unit : mm

Description		Nominal value [Basic diameter]	Limit	Correction and remarks
Oil pressure (Oil temperature at 70 to 90℃)	At idle	1.5 kg/cm <sup>2</sup> or more	49kPa(0.5 kg/cm <sup>2</sup> )	Adjust
	At maximum speed	3~5kg/cm <sup>2</sup>	195kPa(2 kg/cm <sup>2</sup> )	Adjust
Oil pump	Oil pump case to gear tooth end clearance	0.10 ~ 0.19	0.2	Replace
	Difference between oil pump case depth and gear height (Sinkage)	0.01 ~ 0.07	0.18	Replace
	Driven gear to driven shaft clearance	0.04 ~ 0.07[20]	0.15	Replace
	Drive gear end play	0.03 or more		Replace
	Relief valve opening pressure	D4A	3.7~4.3kg/cm <sup>2</sup>	
D4DA		10~12kg/cm <sup>2</sup>		
Oil cooler	Bypass valve Opening pressure	D4A	1.8~2.2kg/cm <sup>2</sup>	Replace
		D4DA	3.7~4.3kg/cm <sup>2</sup>	
	Bypass valve spring installed load (Installed length : 51)	D4A	2.6~2.7kg/cm <sup>2</sup>	Replace
	Regulator valve opening pressure	D4DA	5.7~6.3kg/cm <sup>2</sup>	Replace

## 2. Tightening Torque Table

Description			Thread size O.D. × pitch mm	Tightening torque (kgf m)	Remarks
Oil pump	Relief valve	D4A	M27 × 1.5	7	
	Cover to case mounting bolt	D4A	M8 × 1.5	2	
Oil Filter	Combination filter element		M26 × 1.5	1.8 ~ 2.2	
	Bypass filter			12 to 20(1.2 to 2)	
Oil cooler	Mounting bolt		M10 × 1.5	4.5	
	Front and rear cover bolt	D4A	M8 × 1.5	1.3 ~ 2.1	
	Bypass valve	D4A	M20 × 1.5	1.5 ~ 2	
		D4DA	M16 × 1.5	2	
Strainer mounting bolt			M10 × 1.5	4.1	

## 4. SPECIAL TOOLS

Tool name	Part number	Shape (Unit : mm)	Use						
Filter wrench	MH06158	 <table border="1" data-bbox="566 1780 1061 1982"> <thead> <tr> <th>Part No.</th> <th>Dimension A</th> <th>Application</th> </tr> </thead> <tbody> <tr> <td>MH06158</td> <td>101.2</td> <td>Full-flow filter element</td> </tr> </tbody> </table>	Part No.	Dimension A	Application	MH06158	101.2	Full-flow filter element	Removal and installation of oil filter element
Part No.	Dimension A	Application							
MH06158	101.2	Full-flow filter element							

## 5. SERVICE PROCEDURES

### 5-1 Engine oil replacement

#### 1) Draining

Warm up the engine and remove oil filler cap. Then, remove oil pan drain plug and allow the engine oil to drain out.

<D4DA>

Remove the oil filter drain plug to allow the engine oil inside the oil filter to drain out.

#### 2) Filling

Tighten oil pan drain plug to the specified torque. Then, pour the specified amount of new engine oil into the engine.

Tightening torque: 34 to 39 N · m {3.5~4.0 kgf · m}

#### 3) Engine oil.

Engine	D4AN/AF	D4AK	D4DA
API Quality	CC or above	CD or above	←
Oil Quality	8.2 l	←	7.5 l

#### Oil pressure measurement

With the oil pressure switch removed and pressure gauge installed, warm up the engine until the oil temperature reaches 70℃ to 90℃.

Measure the oil pressure at idle and maximum speeds.

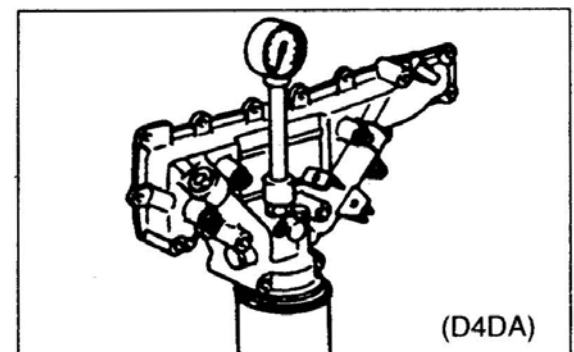
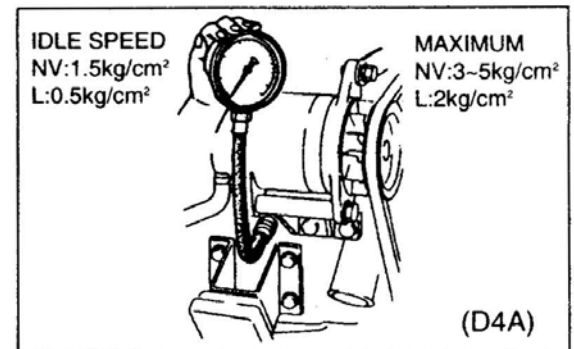
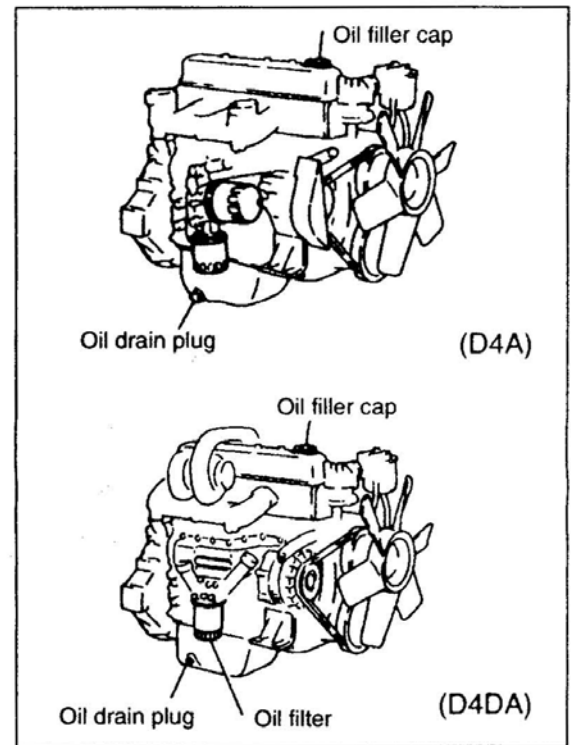
If the measurement is below the limit, overhaul the lubricating system.

<D4DA>

Removal engine oil pressure switch from oil cooler.

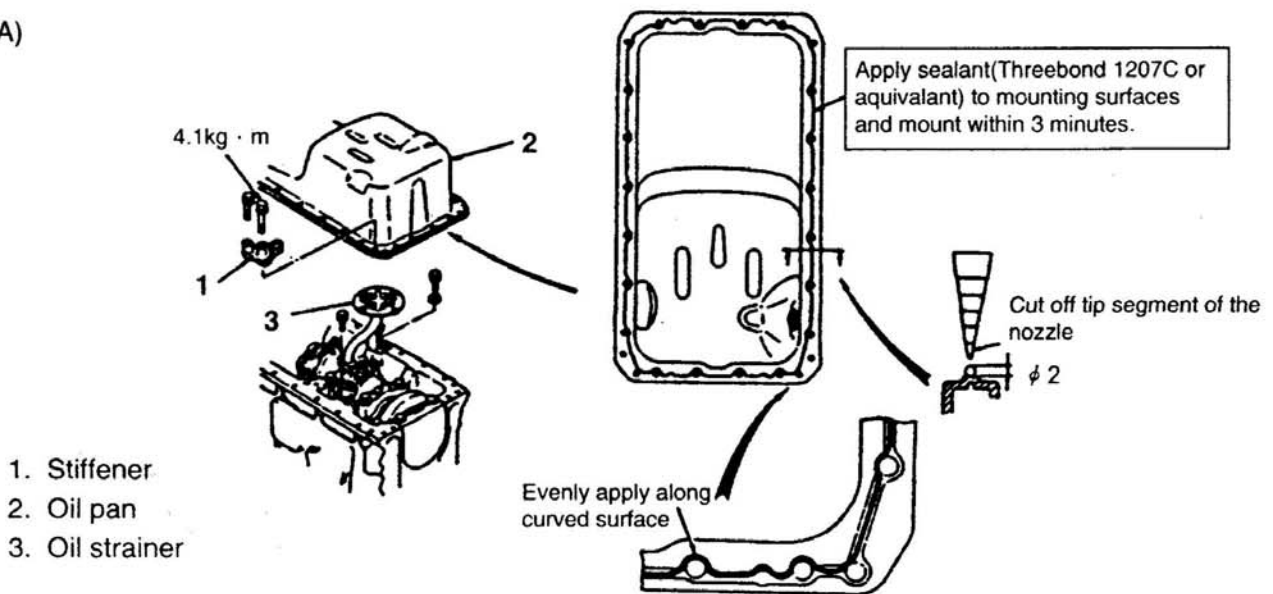
Mount an oil pressure gauge in the place

	Standard value	Limit	Remedy
At no-load minimum speed	1.5kg/cm <sup>2</sup>	0.5kg/cm <sup>2</sup>	Inspect
At no-load maximum speed	3~5kg/cm <sup>2</sup>	2kg/cm <sup>2</sup>	

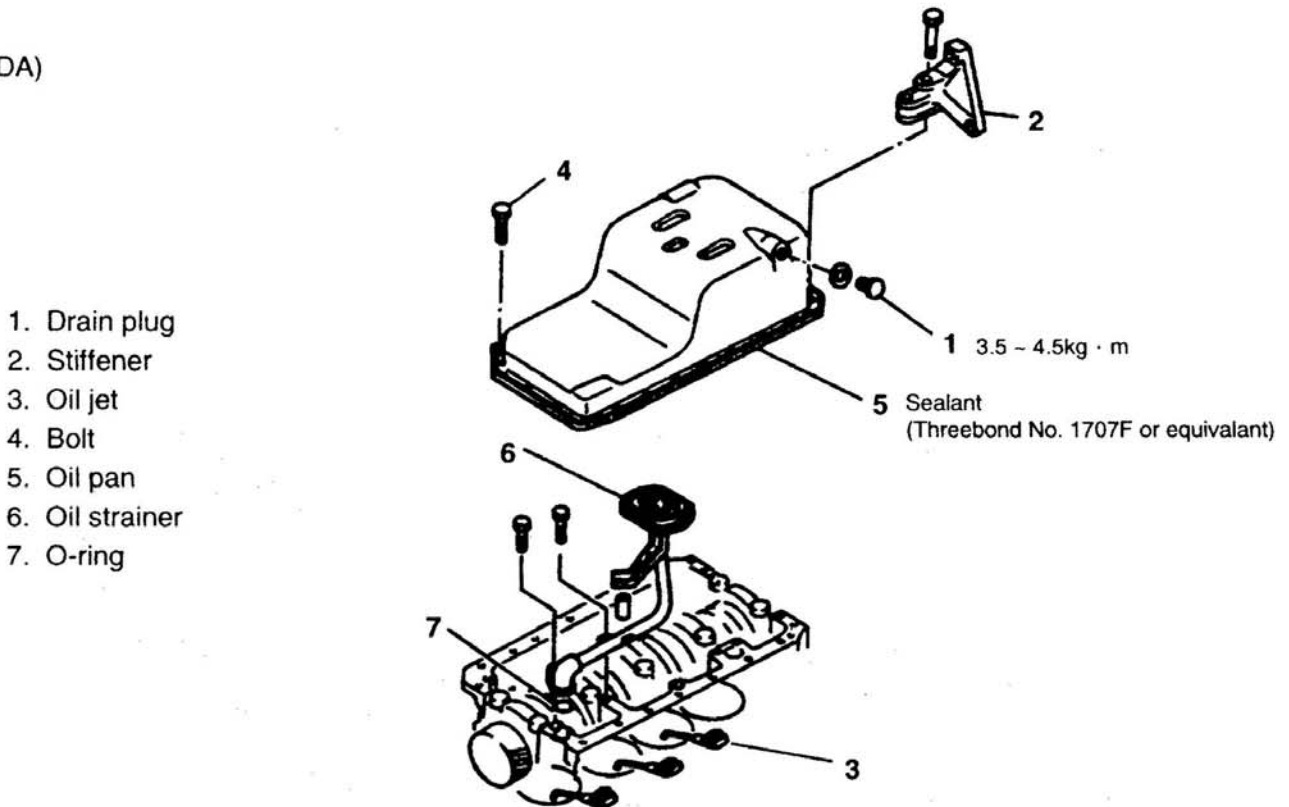


## 5-2 OIL STRAINER, OIL PAN

(D4A)

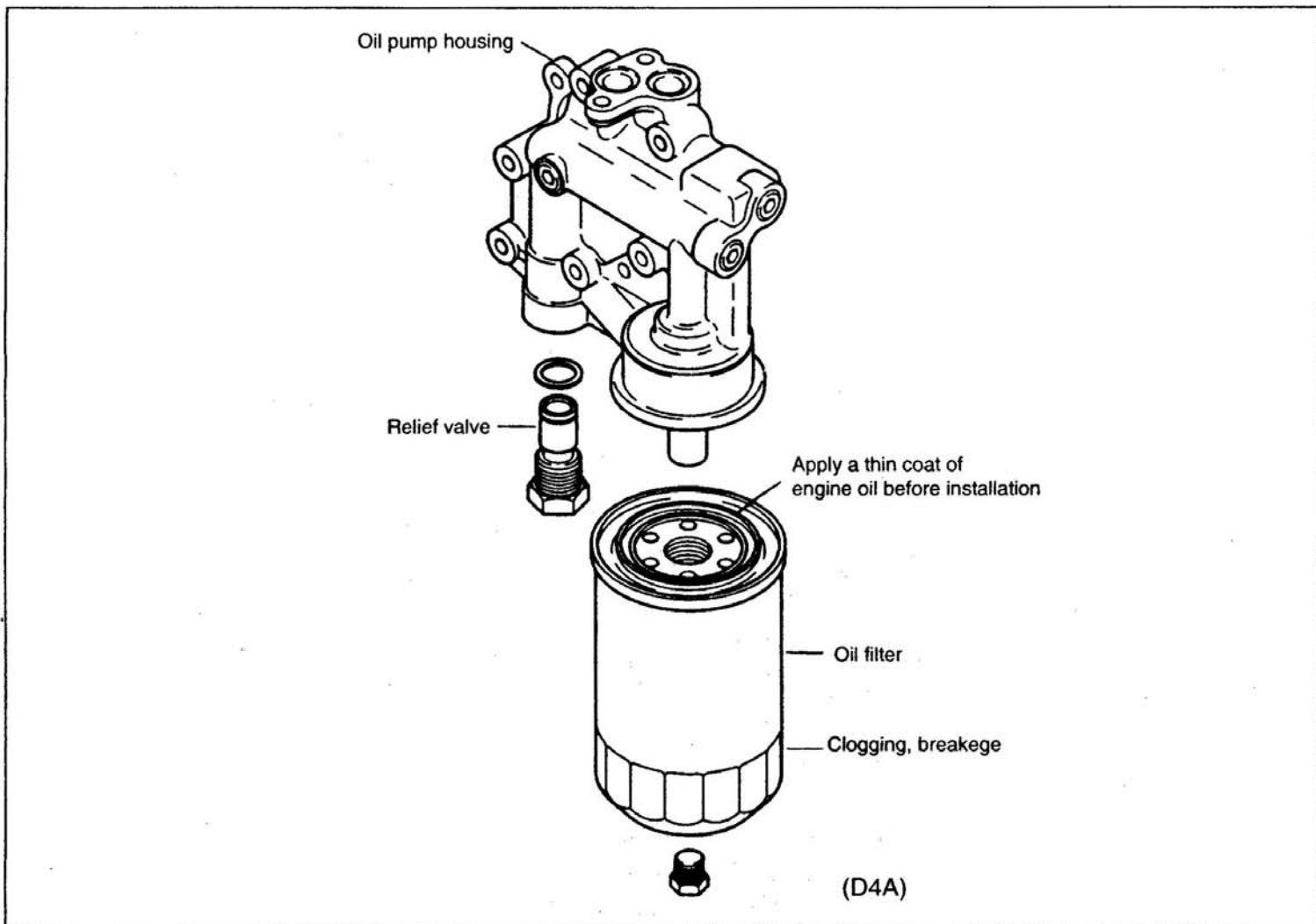


(D4DA)



- NOTE:**
1. When applying sealant to the oil pan surfaces, make sure that the surfaces are free from oil and grease.
  2. Sealant must be applied evenly.
  3. After installing the oil pan, ensure that there is no shift.
  4. Never attempt to start the engine within one hour after the oil pan is installed.
  5. If the oil pan attaching bolt has been loosened, be sure to apply new sealant.

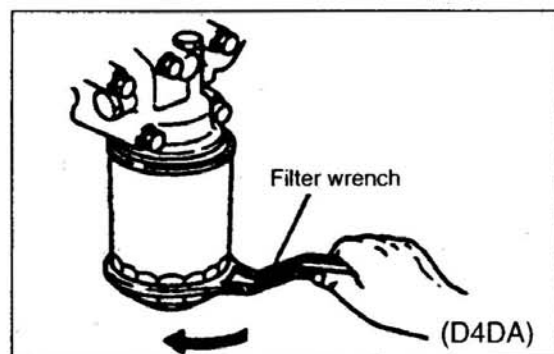
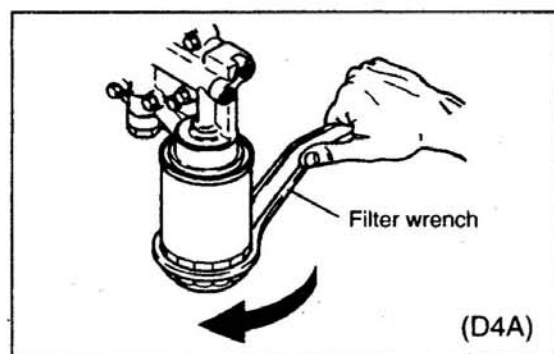
## 5-3 OIL FILTER



Removal use of filter wrench(Special tool) oil filter

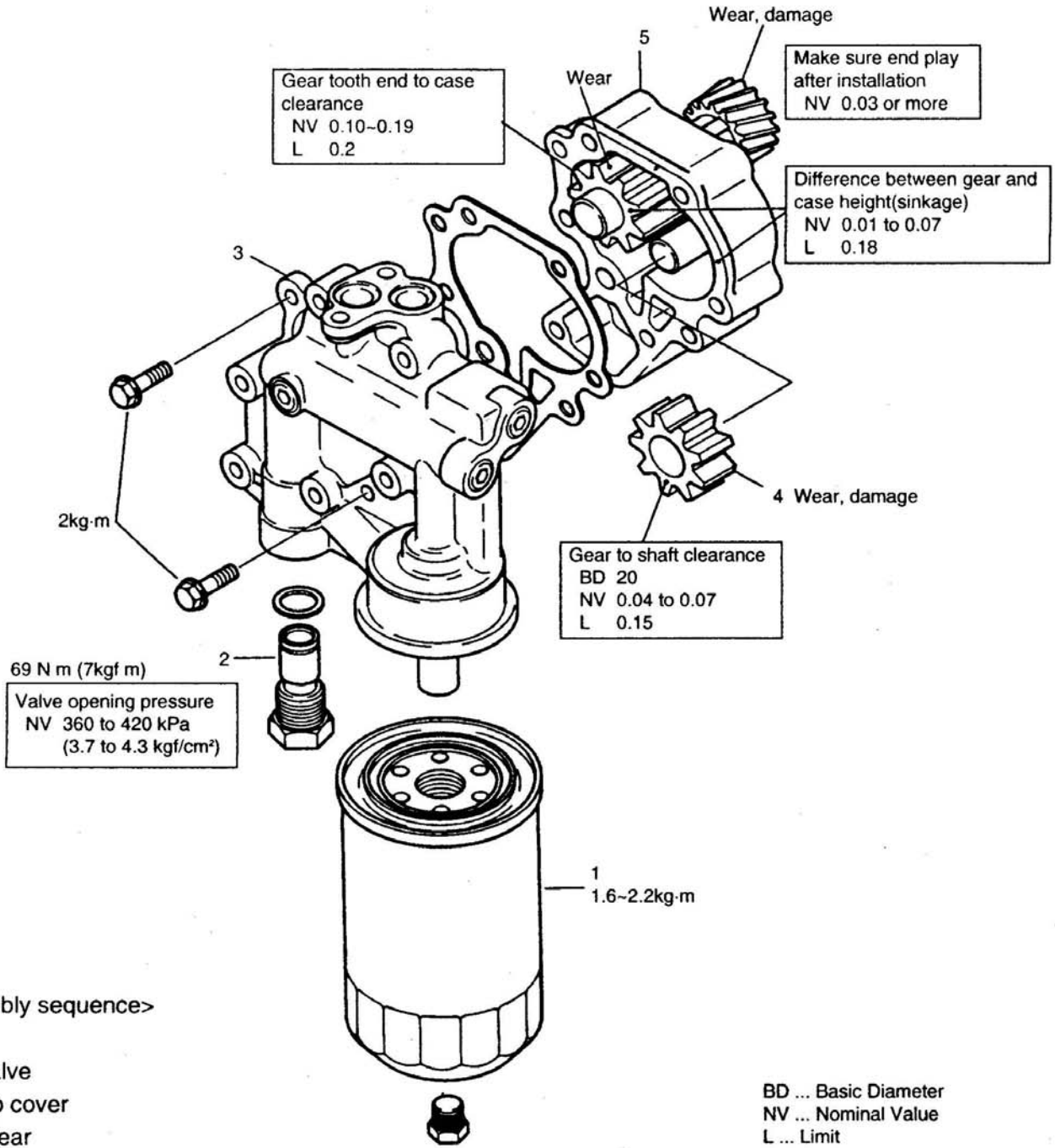
### NOTE:

1. For removal and installation of the spin-on type element, use Filter Wrench (special tool). Note, however, that the bypass oil filter element must be tightened by hand.
2. After the element has been installed, start the engine and check connections for oil leaks.



## 5-4 OIL PUMP

<D4A>

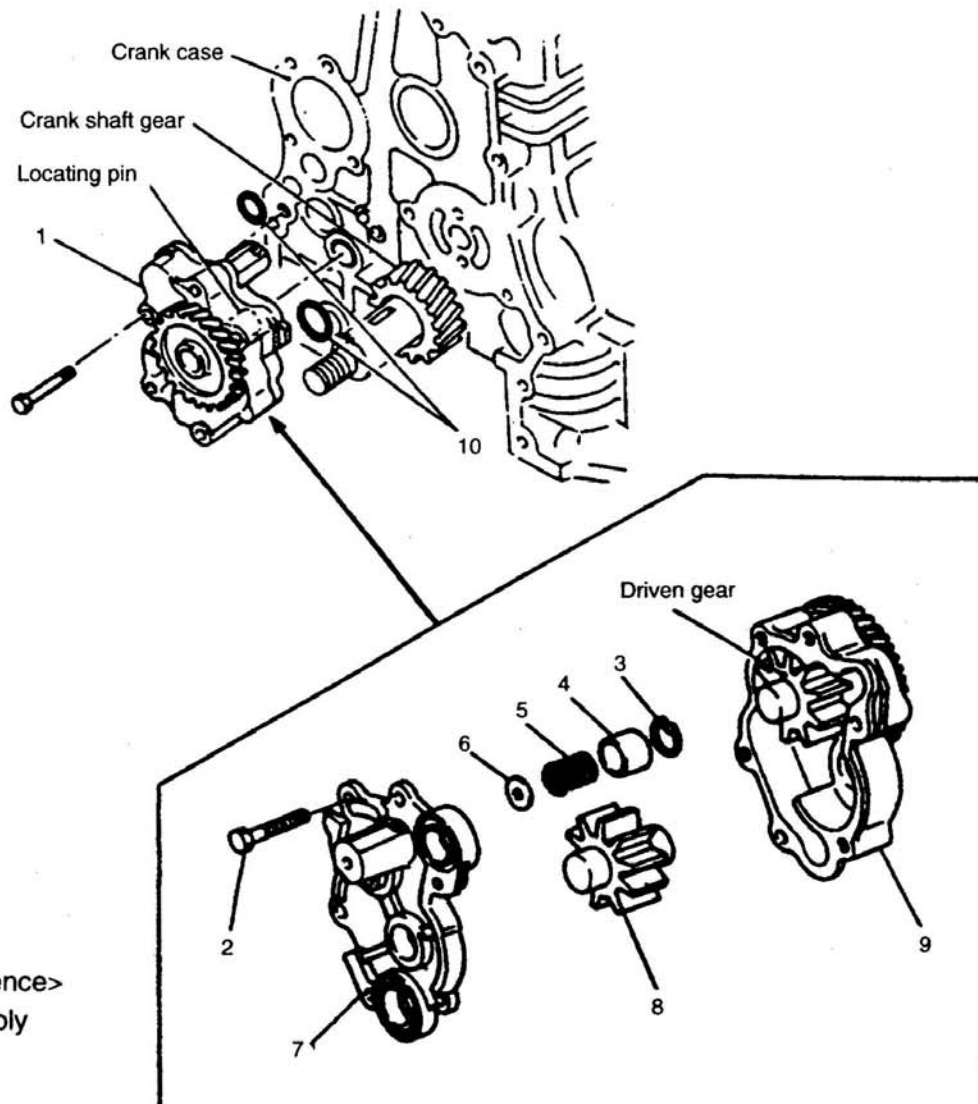


### NOTE:

1. The gear is a shrink fit in the shaft of the oil pump case assembly and do not attempt to disassemble more than the illustration.
2. Before reassembly, be sure to apply engine oil to parts.

For reassembly, reverse the order of disassembly.

<D4DA>



<Disassembly sequence>

1. Oil pump assembly
2. Bolt
3. Snap ring
4. Relief valve
5. Spring
6. Seat
7. Oil pump cover
8. Driven gear assembly
9. Oil pump case assembly
10. O-ring

Assembly sequence

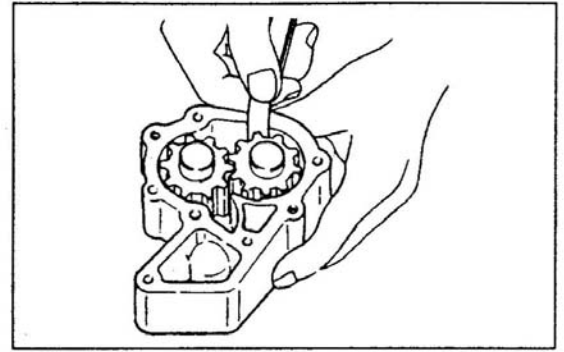
Reverse the order of disassembly



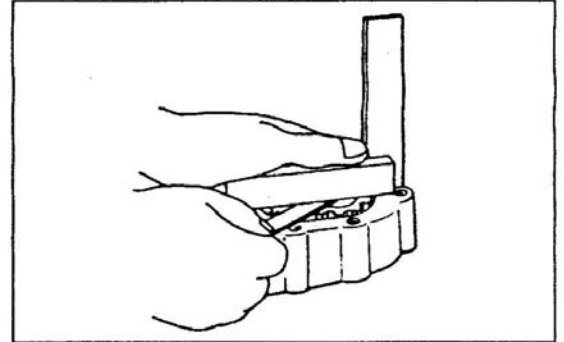
## Service procedure

<D4A>

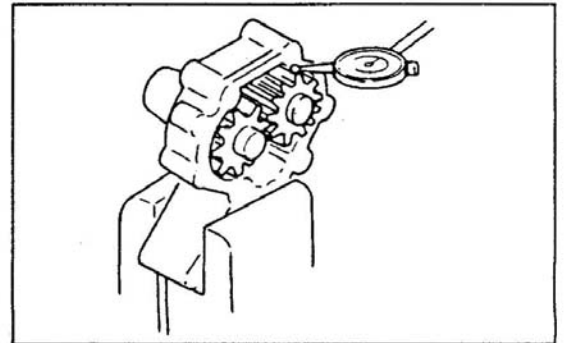
- (a) Measure the drive and driven gear tooth end to oil pump case clearance. If the measurement exceeds the limit, replace the parts.



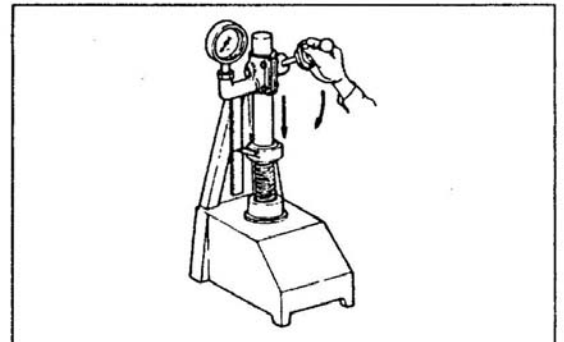
- (b) Measure the difference between the drive and driven gears tooth end height and the oil pump case depth. If the limit is exceeded, replace the parts.



- (c) Measure the play in the diametral direction of the driven gear to check for driven gear to shaft clearance. If the clearance exceeds the limit, replace the parts.

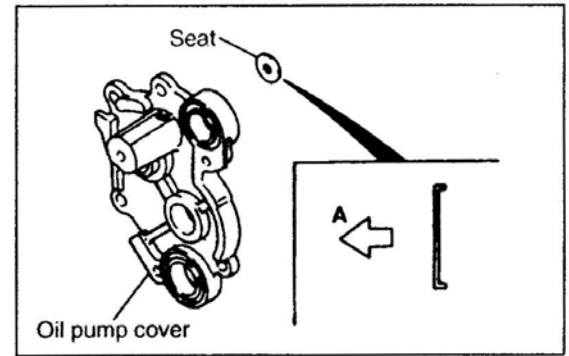


- (d) Measure the load at installed length of the relief valve spring. If the load is far beyond the nominal value, replace parts.

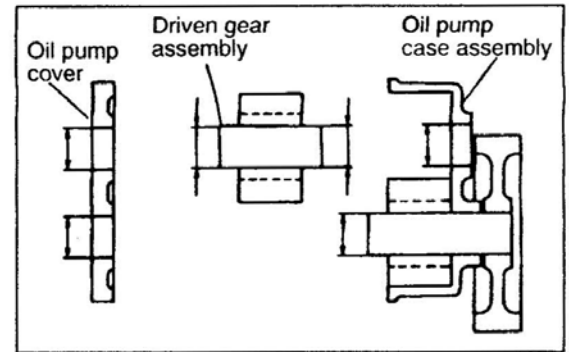


<D4DA>

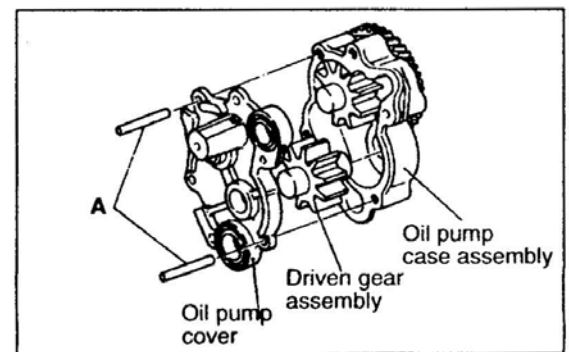
- (a) Installation of seat  
A: Oil pump assembly side.



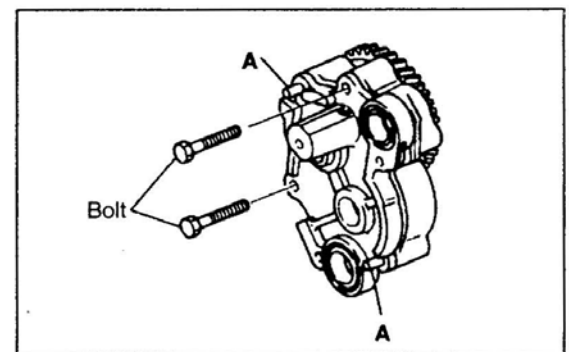
- (b) Measure the clearance between each gear shaft and the oil pump case or cover. If the measured value exceeds the limit, replace the faulty parts



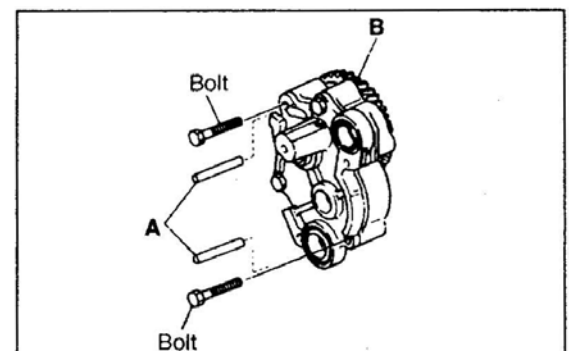
- (c) Position oil pump cover on oil pump case assembly using two  $\phi 9\text{mm}$  pins A.



- (d) Fit bolts and tighten to the specified torque.



- (e) Remove pins A, then fit other bolts and tighten to the specified torque.

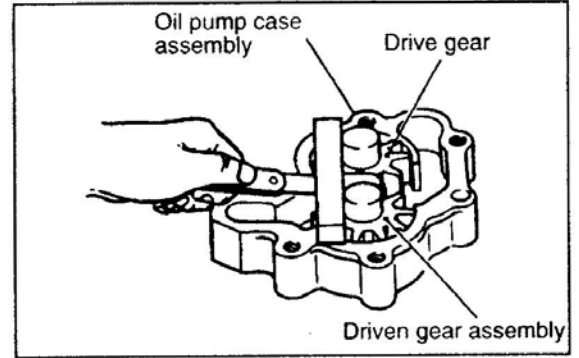


**NOTE:**

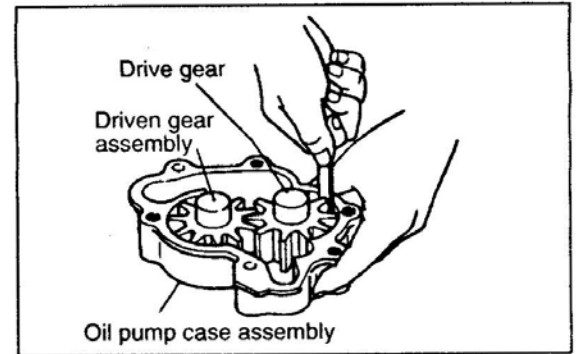
After assembly, turn the oil pump gear B by hand and check that it rotates smoothly.

If the gear does not rotate smoothly, disassemble and reassemble the components.

- (f) Differences between gear heights and case depth  
Replace any component whose measurement is out of specification.



- (g) Clearance between gear teeth and oil pump case  
Replace any component whose measurement is out of specification.

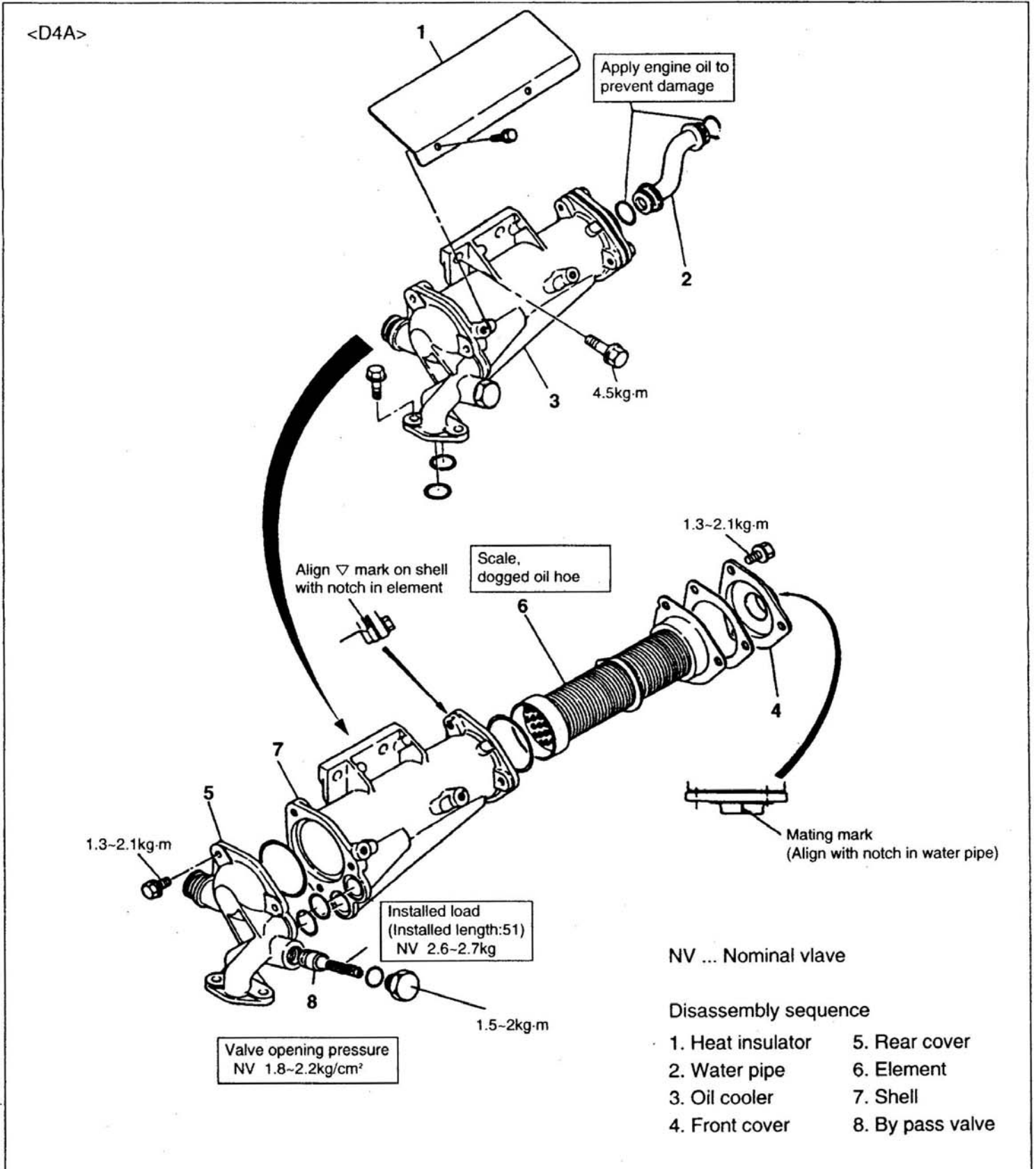


## 5-5. OIL COOLER

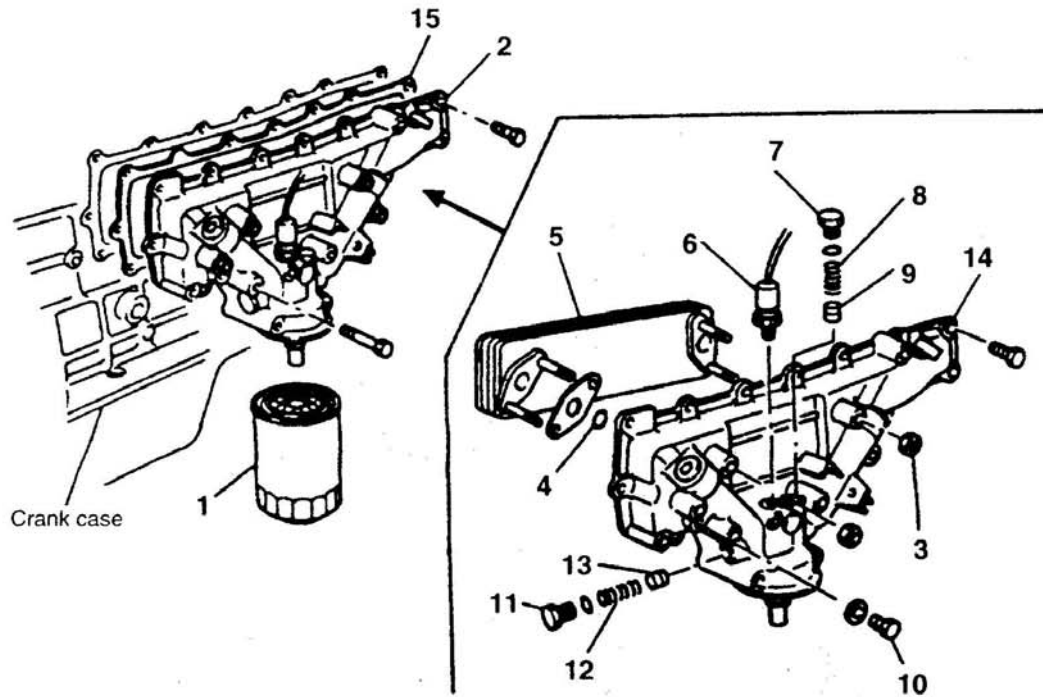
### Disassembly and Reassembly

Removal oil cooler after removing exhaust manifold.

When installing the oil cooler, align it with the oil pump mounting surface.



<D4DA>



Disassembly sequence

- |                       |                        |                     |
|-----------------------|------------------------|---------------------|
| 1. Oil filter         | 6. Oil pressure switch | 11. Plug            |
| 2. Oil cooler         | 7. Plug                | 12. Spring          |
| 3. Nut                | 8. Spring              | 13. By pass valve   |
| 4. O-ring             | 9. Regulator valve     | 14. Oil cooler body |
| 5. Oil cooler element | 10. Drain plug         | 15. Gasket          |

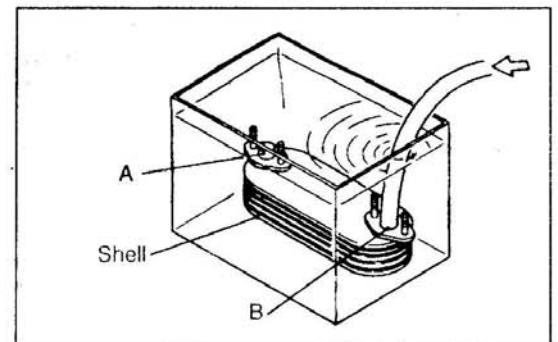
(a) Cleaning

- Check whether carbon deposits or sludge have accumulated in the oil passages of oil cooler element and the oil cooler's bypass arrangement. Remove any deposits with cleaning sealant.
- Clean out any water scale or fur that has accumulated in oil cooler element or oil cooler body.

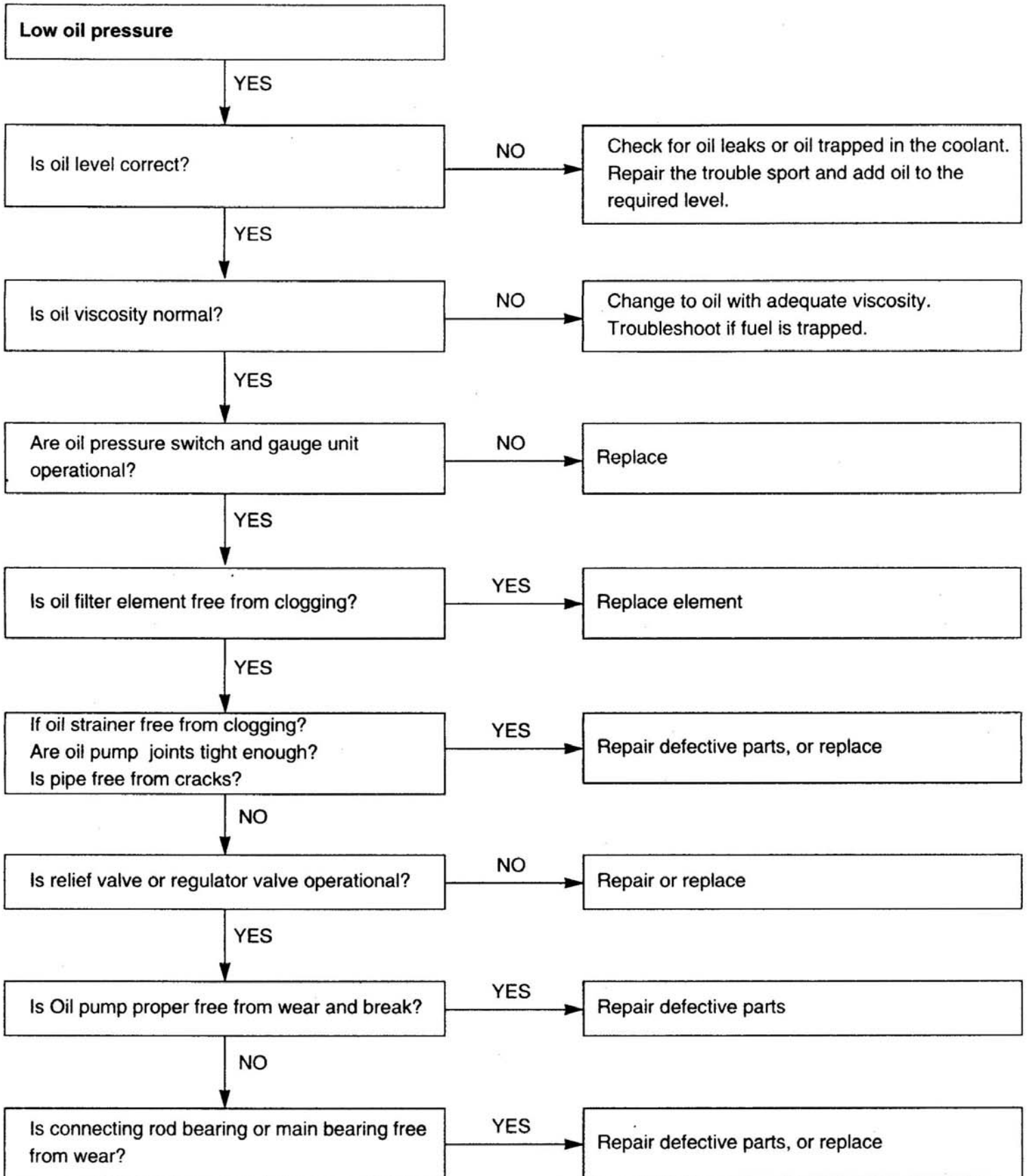
(b) Inspection of oil cooler element (D4DA)

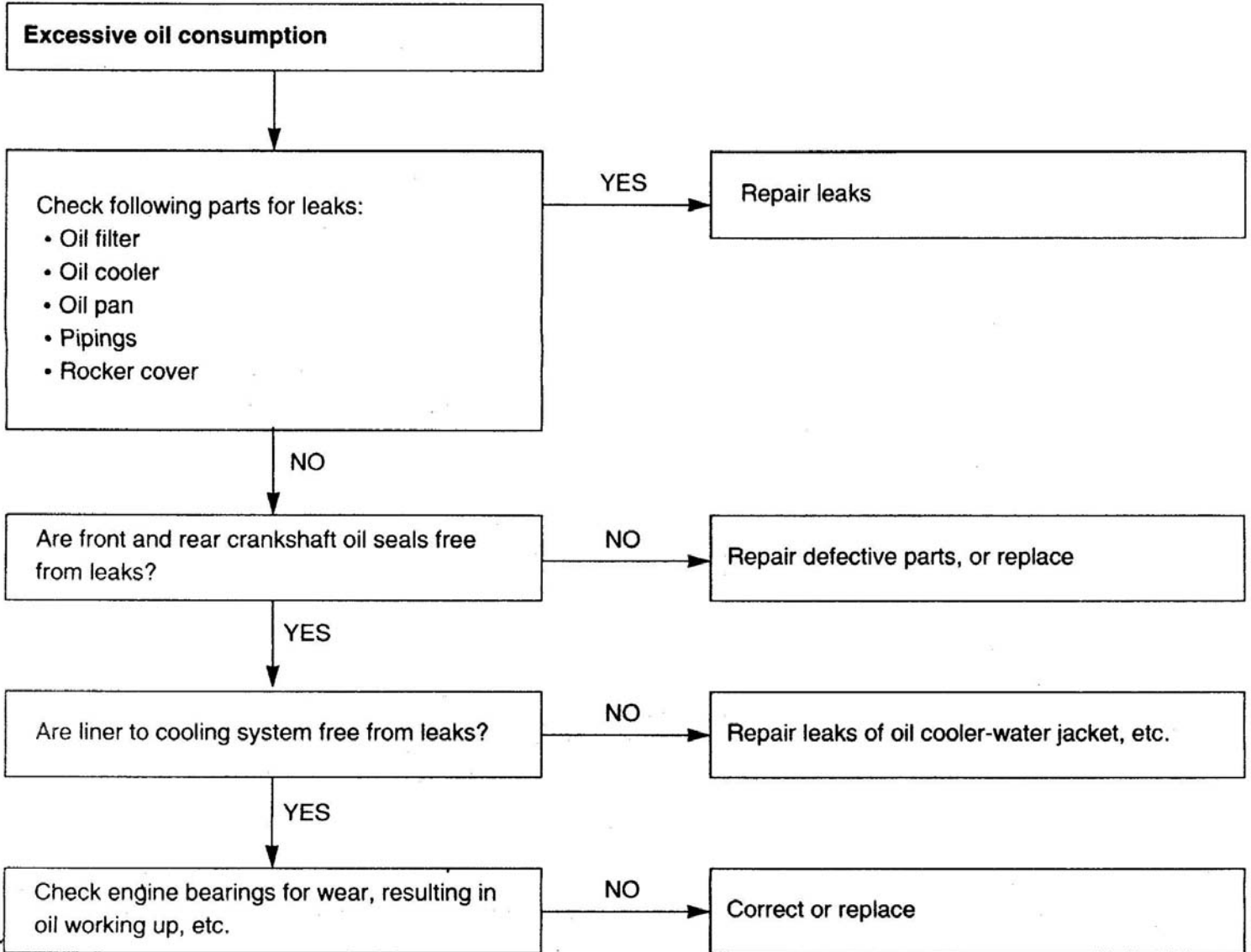
[inspection]

- Seal outlet A of oil cooler element and connect a hose to engine oil inlet B. Then, immerse the oil cooler element in a tank of water.
- Apply air pressure of 980 kPa{10 kgf/cm<sup>2</sup>} for seconds via the hose and check whether air leaks out of oil cooler element.
- If any air leaks, replace the oil cooler element.



## 6.TROUBLESHOOTING

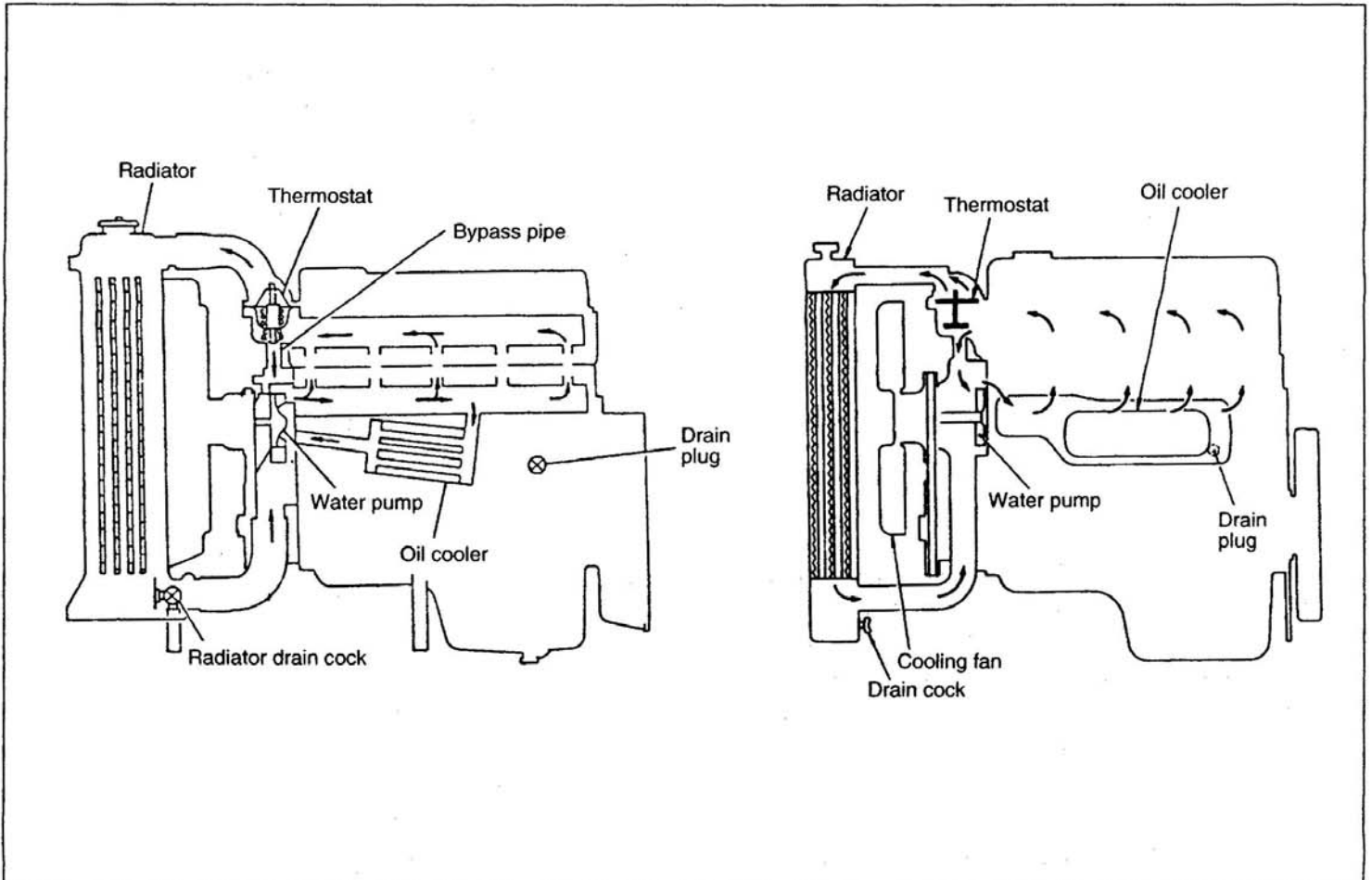




# 1.GENERAL

The engine is cooled by forced circulation of coolant by the water pump.

The illustration below shows the coolant flow.



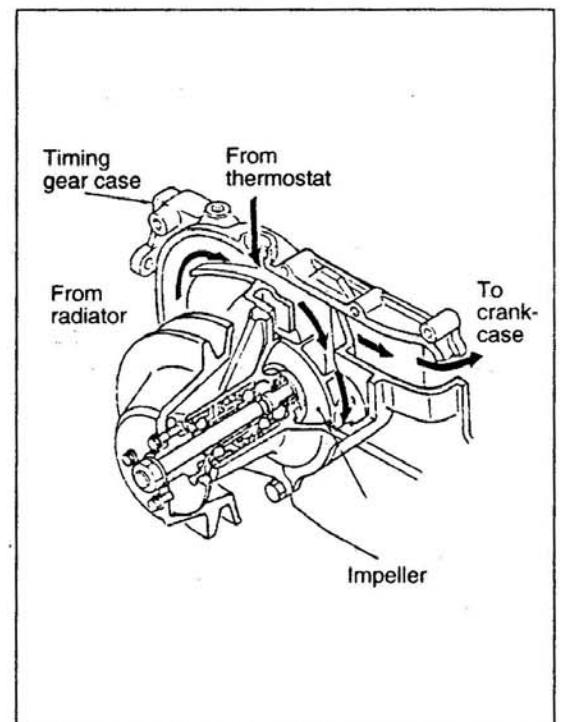
## (1) Water pump

Of a centrifugal type, the water pump is driven by the V-belt from the crankshaft pulley.

A unit seal is installed between the impeller and water pump that prevents leakage of coolant. There is a drain hole provided at the bottom of the water pump case, which ensures that coolant, should it leak from the unit seal, does not enter bearings.

The water pump is mounted on the timing gear case provided with a suction pipe and swirl chamber.

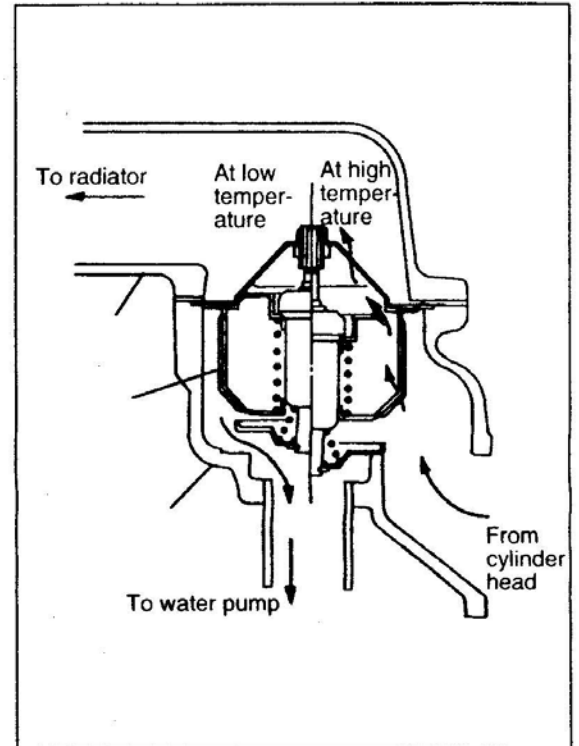
Pressed into the one end of water pump shaft is the impeller with combination-type blades which feeds coolant under pressure into the engine.





(2) Thermostat

The thermostat is bottom bypass type that stops supply of coolant to the bypass side when the path to the radiator becomes full open.

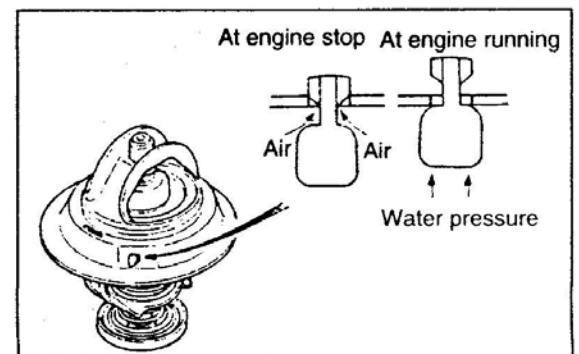


The thermostat pellet, of wax pellet type, contains a special wax which changes from a solid to liquid state and vice versa, depending on heat, and consequent change in its volume causes the valve to open or close, thereby changing the quantity of coolant which flows into the radiator and water pump (bypass side) to control the coolant temperature.

A jiggle valve is provided in the air purge hole of the thermostat to quickly increase the coolant temperature.

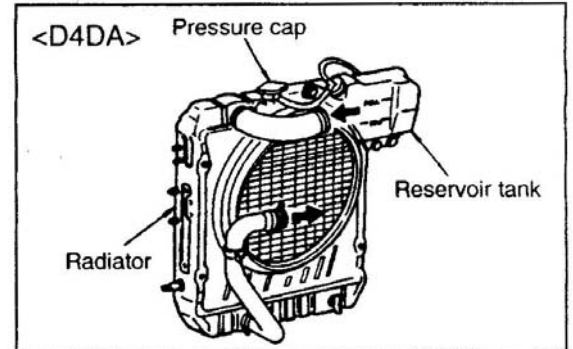
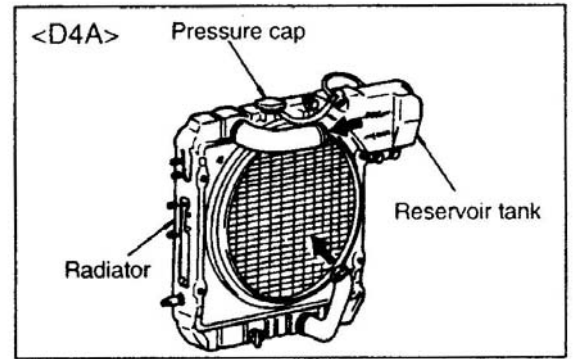
The jiggle valve is in down position by its own weight when the engine is stationary. When pouring in coolant, the air in the system is forced into the radiator through the clearance between the air purge hole and jiggle valve.

When the engine is started, coolant circulates and the jiggle valve is forced upward by the hydraulic pressure. As a result, the valve closes the air purge hole, preventing outflow of coolant the air purge hole.



(3) Radiator

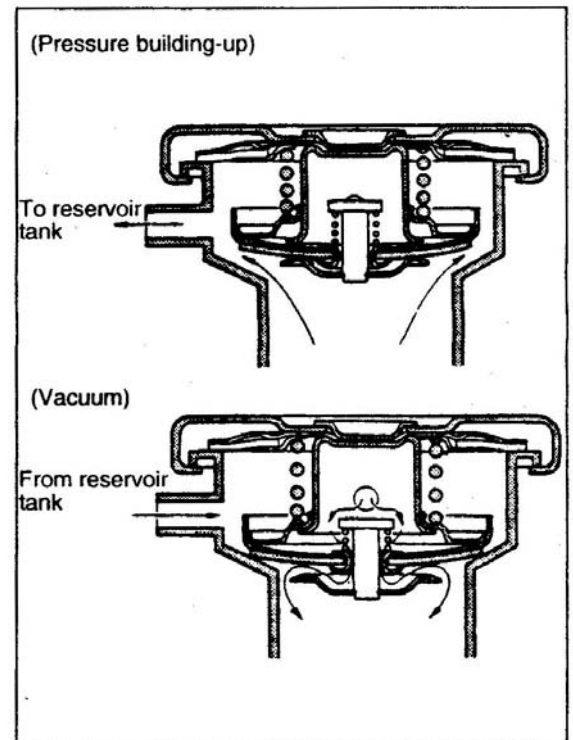
The radiator, with a tube-and-corrugated-fin type core, not only cools the engine coolant but also separates vapor from liquid water and regulates pressure in the cooling system.



The radiator is of a simple closed type equipped with a pressure cap. The reservoir tank is open to atmosphere. The coolant overflowing from the radiator is therefore stored in the reservoir tank, maintaining the radiator full with coolant at all times.

The pressure cap regulates the pressure in the cooling system. When the pressure builds up exceeding the predetermined level, the pressure valve compresses the pressure spring relieving the excessive pressure to the atmosphere.

As the coolant temperature falls forming a vacuum in the radiator, the vent valve opens to admit air into the radiator, thus preventing the radiator from being deformed by the vacuum.



## 2. SPECIFICATIONS

Item \ Model	D4AN/AF	D4AK	D4DA
Cooling method	Water-cooling, forced circulation	←	←
Coolant capacity	8.3 lit. (engine proper)	←	←
Water pump Type Drive	Centrifugal type V-belt	← ←	Velt-driven involute type ←
V-belt Type x q'ty	(Cooling Fan) Low edge cogged B type x 1  (Water pump) Low edge cogged B type x 1	Low edge cogged B type x 2	←
Thermostat Type/válve opening temperature	Wax-pellet, bottom bypass(with jiggle valve)/ 82 °C	←	←
Fan Type	Polypropylene, pusher	←	←
Cap Type	Pressure type	←	←

### 3. SERVICE STANDARDS

#### 1. Service Standard Table



Unit : mm

Description		Nominal value [Basic diameter]	Limit	Correction and remarks
Water pump	Interference between pump shaft and and flange	[17] 0.08~0.10	Reassembly up to twice	Replace
	Interference between pump shaft and impeller	[13] 0.03~0.06		
	Pump case to impeller installed dimension	20.8~21.7		Replace
Thermo-stat	Valve opening temperature	80~84℃		Replace
	Valve lift / temperature	10 or more/95℃		Replace
V-belt deflection (between alternator and water pump)		10~15		Replace
Radiator	Opening pressure of radiator cap		0.75~1.05kg/cm <sup>2</sup>	Replace
		Vacuum	0.05kg/cm <sup>2</sup> less	
	Radiator cap inspection pressure		1.4kg/cm <sup>2</sup>	

## 2. Tightening Torque Table

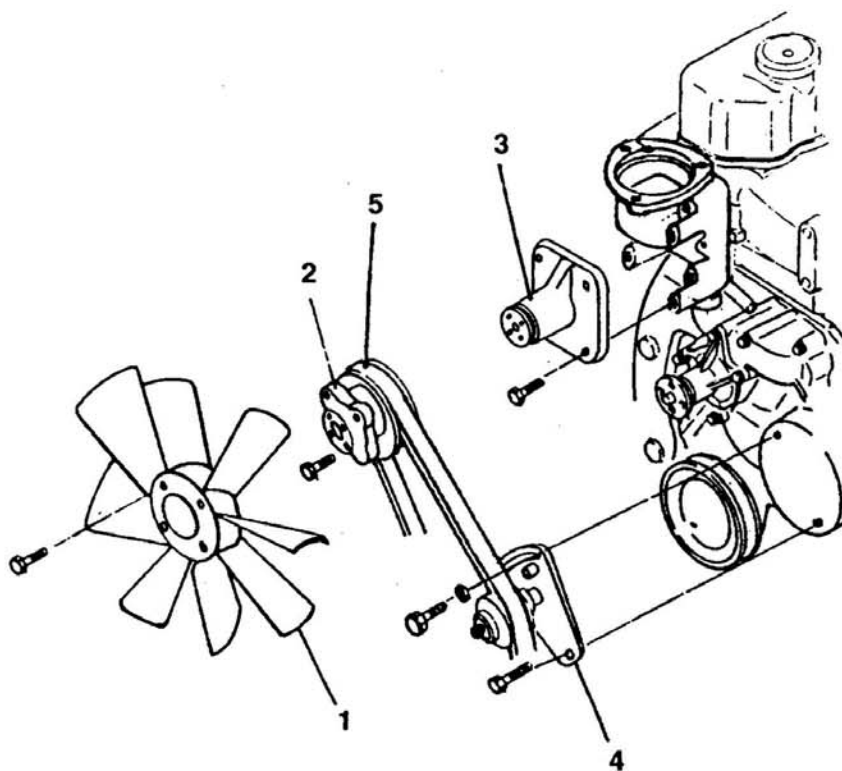
Description	Thread size O.D. × pitch mm	Tightening torque (kgf m)	Remarks
Cooling fan attaching bolt	M8 × 1.25	20(2)	
Fan coupling attaching bolt	M8 × 1.25	20(2)	
Alternator attaching nut	M12 × 1.25	91(9.3)	
Alternator adjusting bolt	M12 × 1.25	82(8.4)	
Water pump flange attaching nut	M14 × 1.5	88(9)	
	M22 × 1.5	155(16)	

## 4. SPECIAL TOOLS

Tool name	Part number	Shape (Unit : mm)	Use
Puller	MH061298		Removal of water pump flange
Water pump impeller puller	MH061417		Removal of water pump impeller

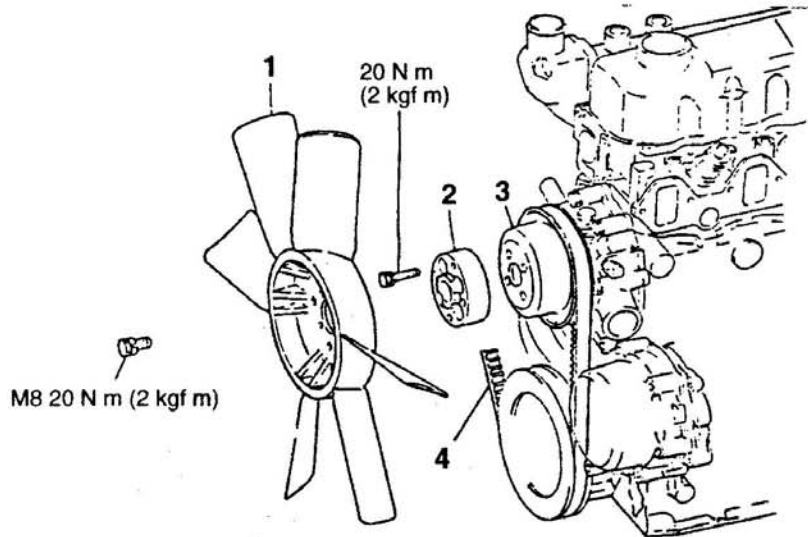
## 5. SERVICE PROCEDURES

### Removal and Installation



- 1 Cooling fan
- 2 Fan pulley
- 3 Fan drive ass'y
- 4 Tension pulley
- 5 V-belt

## 5-1 Cooling fan



- 1 Cooling fan
- 2 Spacer
- 3 Water pump pulley
- 4 V-belt

## 5-2 Inspection and Adjustment of V-Belt tension.

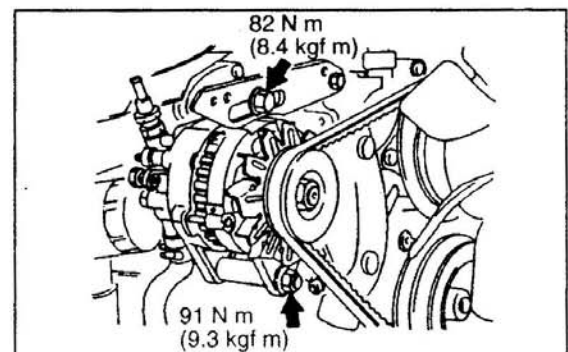
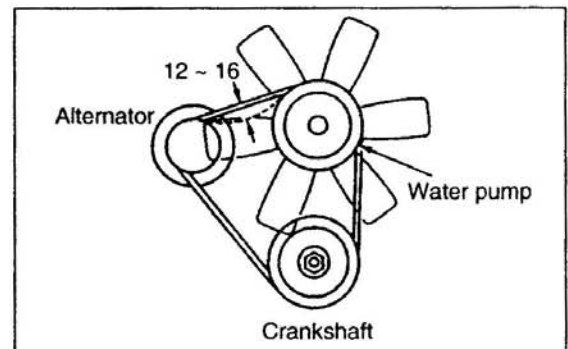
- 1) Adjust the belt tension to obtain the specified belt deflection when the center of each belt is pressed with a force of approximately 98 N (10kgf).

### NOTE:

1. A slack belt can be a cause of over heating and undercharge.
2. An excessively tight belt may result in damaged bearings and belts.

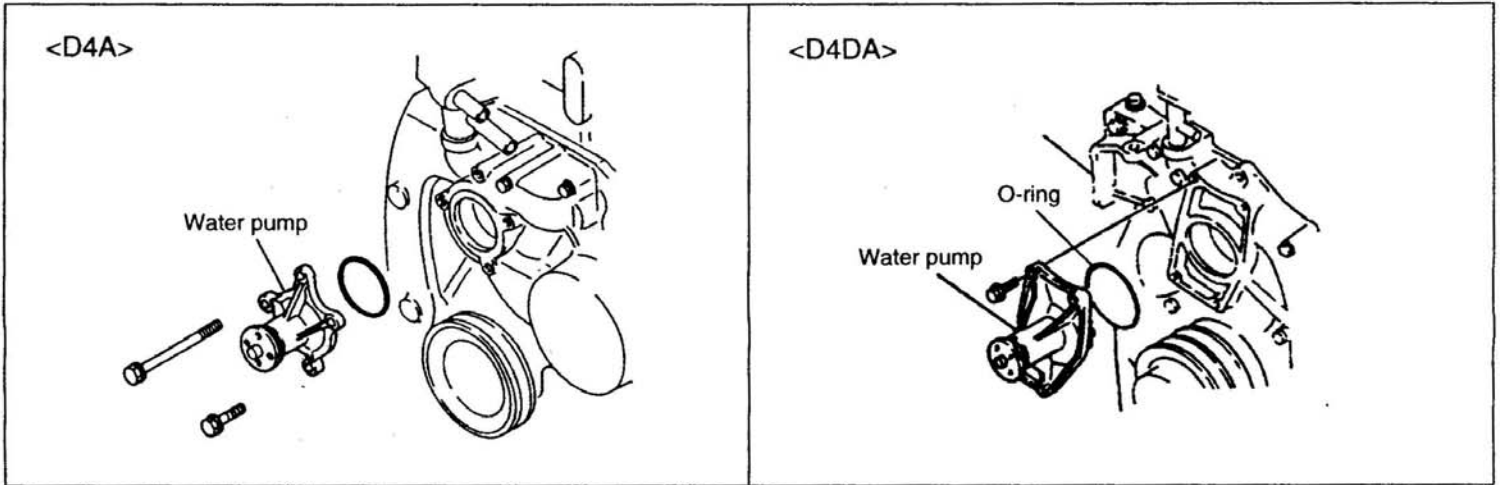
- 2) Adjustment of Fan Belt

To adjust the fan belt tension, slightly back off the alternator attaching nut and adjusting bolt and move the alternator.

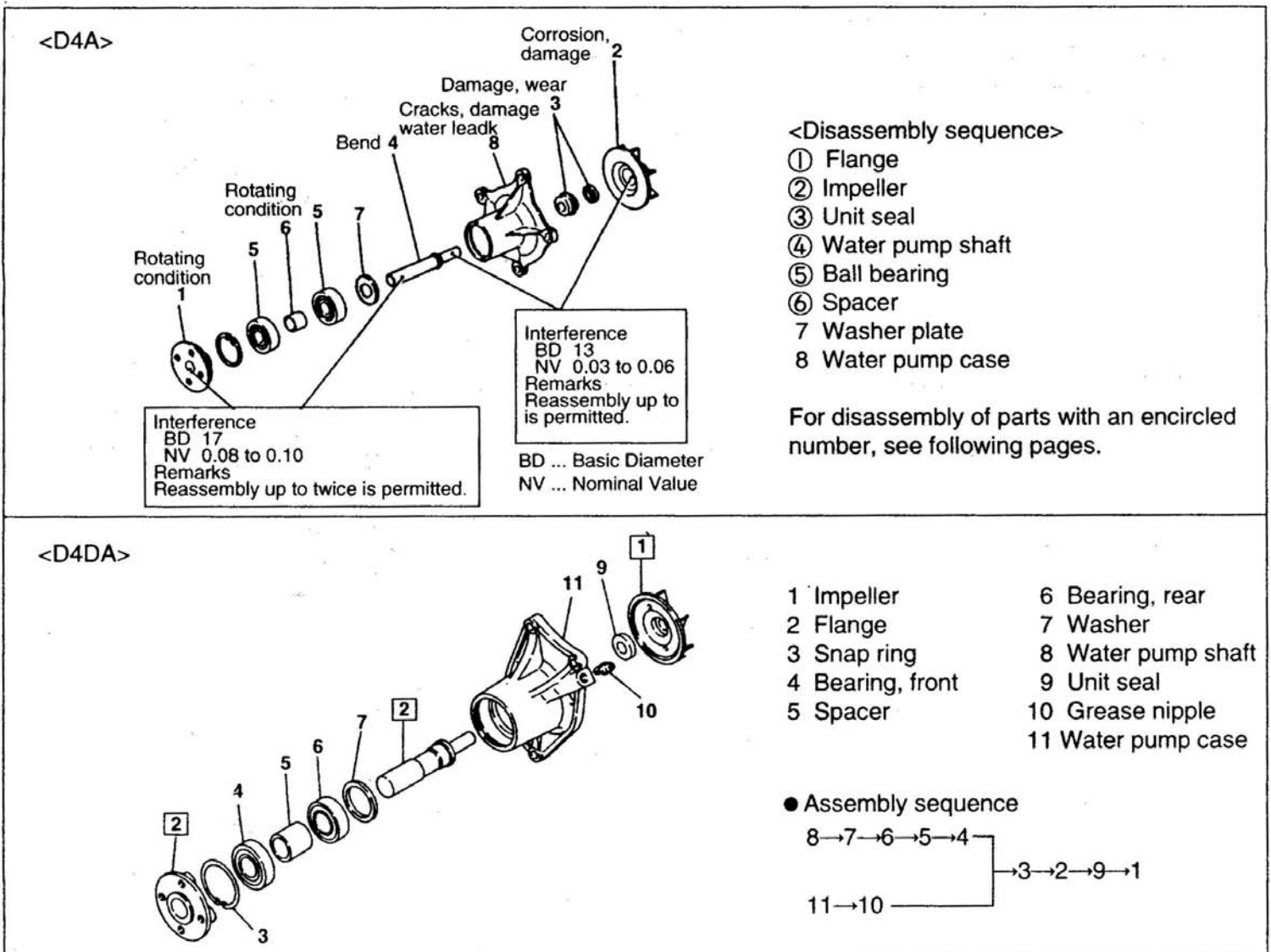


## 5-3 Water pump

### 5-3-1 Removal and Installation

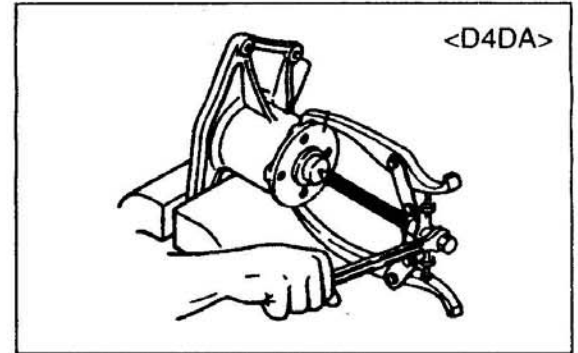
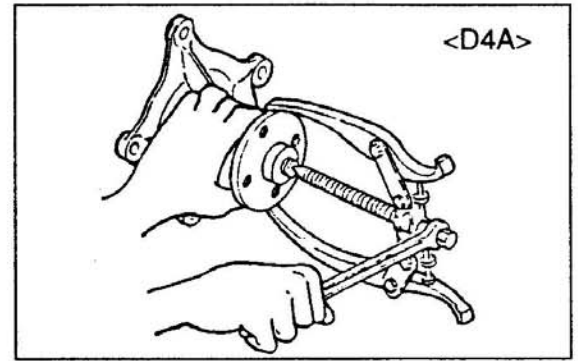


### 5-3-2 Disassembly and Inspection

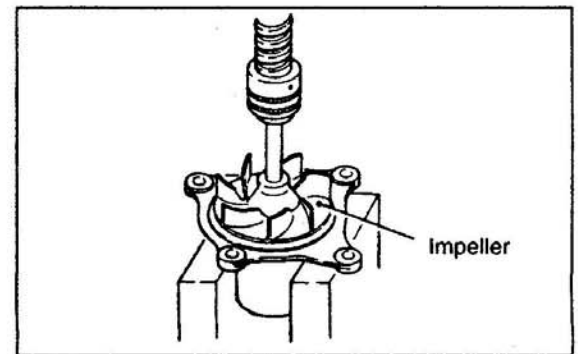




(a) Using gear puller, remove the flange.



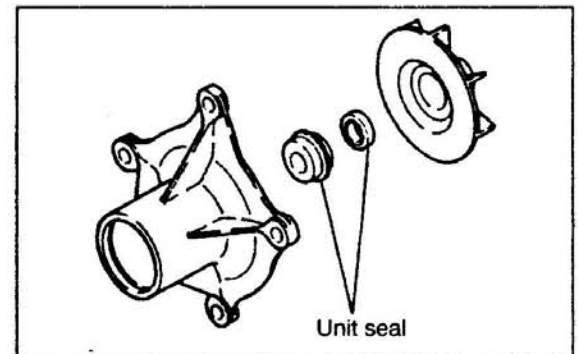
(b) After removing the snap ring, withdraw the water pump shaft together with the ball bearing by using a press and remove the impeller. Heating the water pump case to approximately 80°C helps make the job easier.



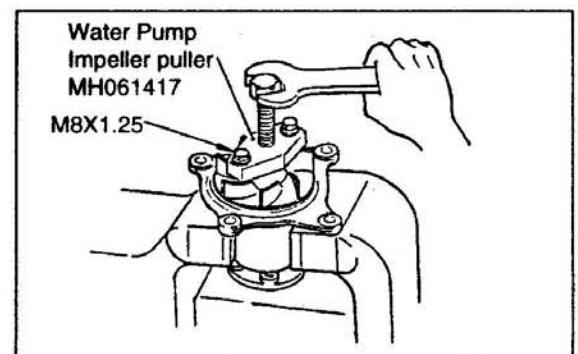
(c) Check the unit seals installed in the impeller and water pump case for damage and wear. If defects are evident, or when water leaks during operation, replace the unit seals with new ones.

**NOTE:**

**Whenever the unit seal is removed, it must be replaced with a new one.**



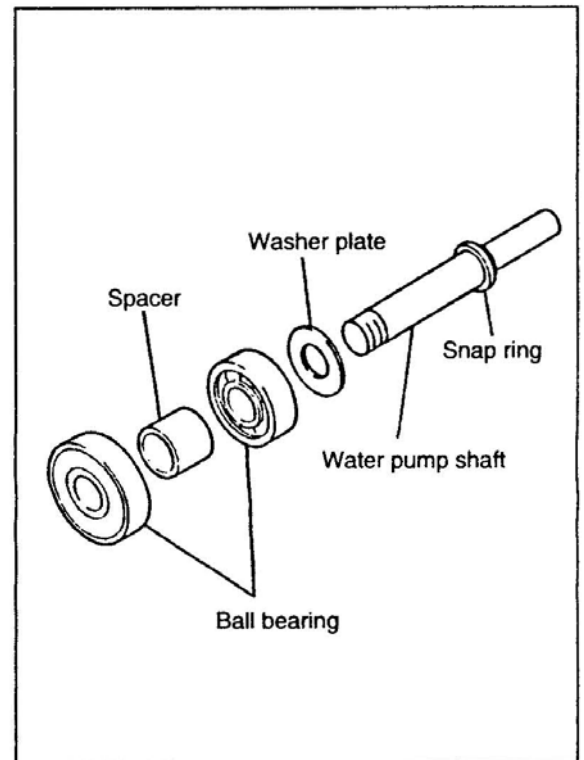
When the unit seals alone are to be replaced, tap two holes in the impeller to M8 and, using Water Pump Impeller Puller (special tool), remove the impeller.



(d) Using a gear puller or press, remove the ball bearings.

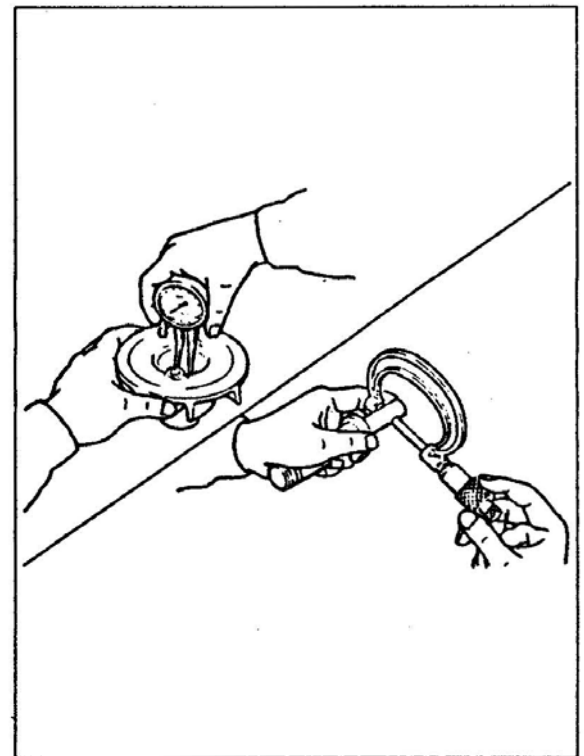
**NOTE:**

**Do not remove the snap ring from the water pump shaft.**

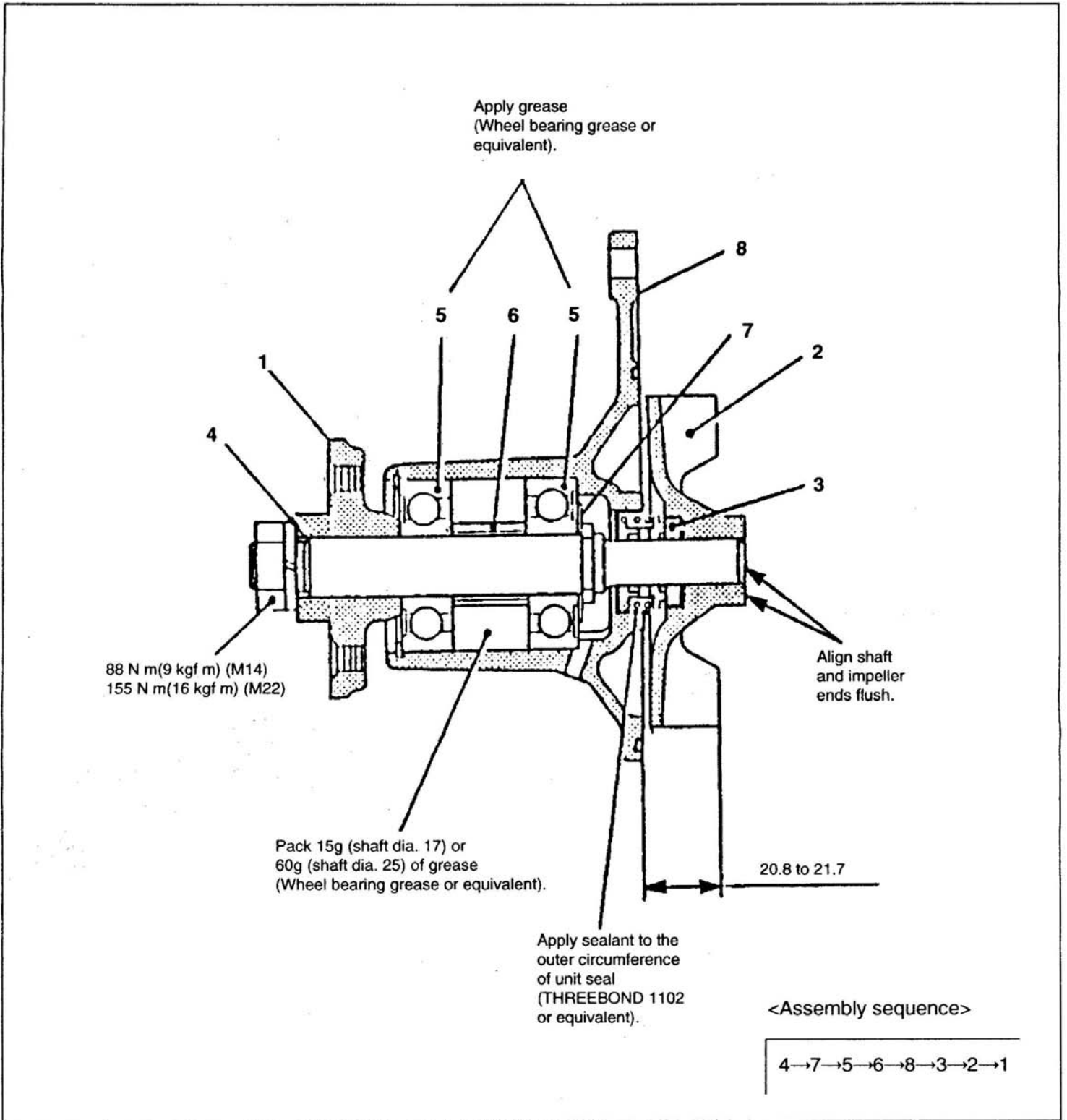


(e) When the impeller and flange are removed from the water pump shaft, it may result in insufficient interference.

If they are reassembled three times or more, or if the interference is below the specification even reassembly is two times or less, they must be replaced with new ones.



### 5-3-3 Reassembly

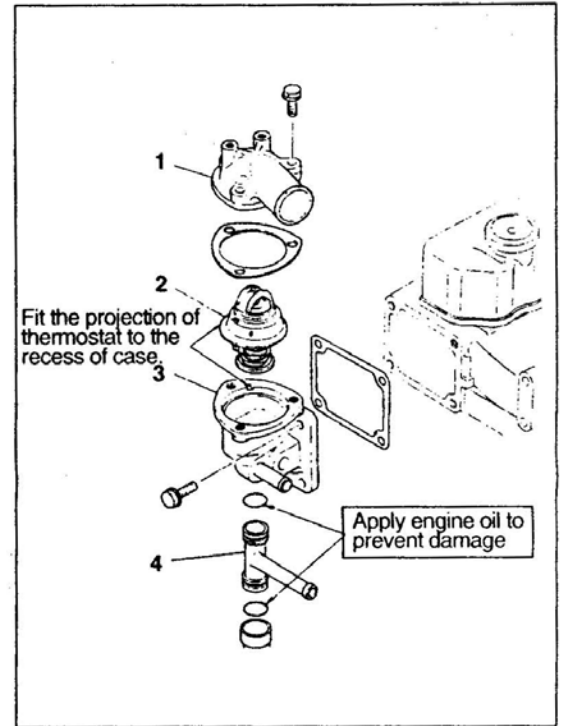


- NOTE:**
1. After reassembly, install the water pump onto the timing gear case and make sure that the impeller is not in contact with the timing gear case.
  2. Reassembly of the flange and impeller into the water pump shaft is allowed up to two times.

## 5-4 Thermostat

### 5-4-1 Removal and Installation

- 1 Thermostat cover
- 2 Thermostat
- 3 Thermostat case
- 4 Bypass pipe



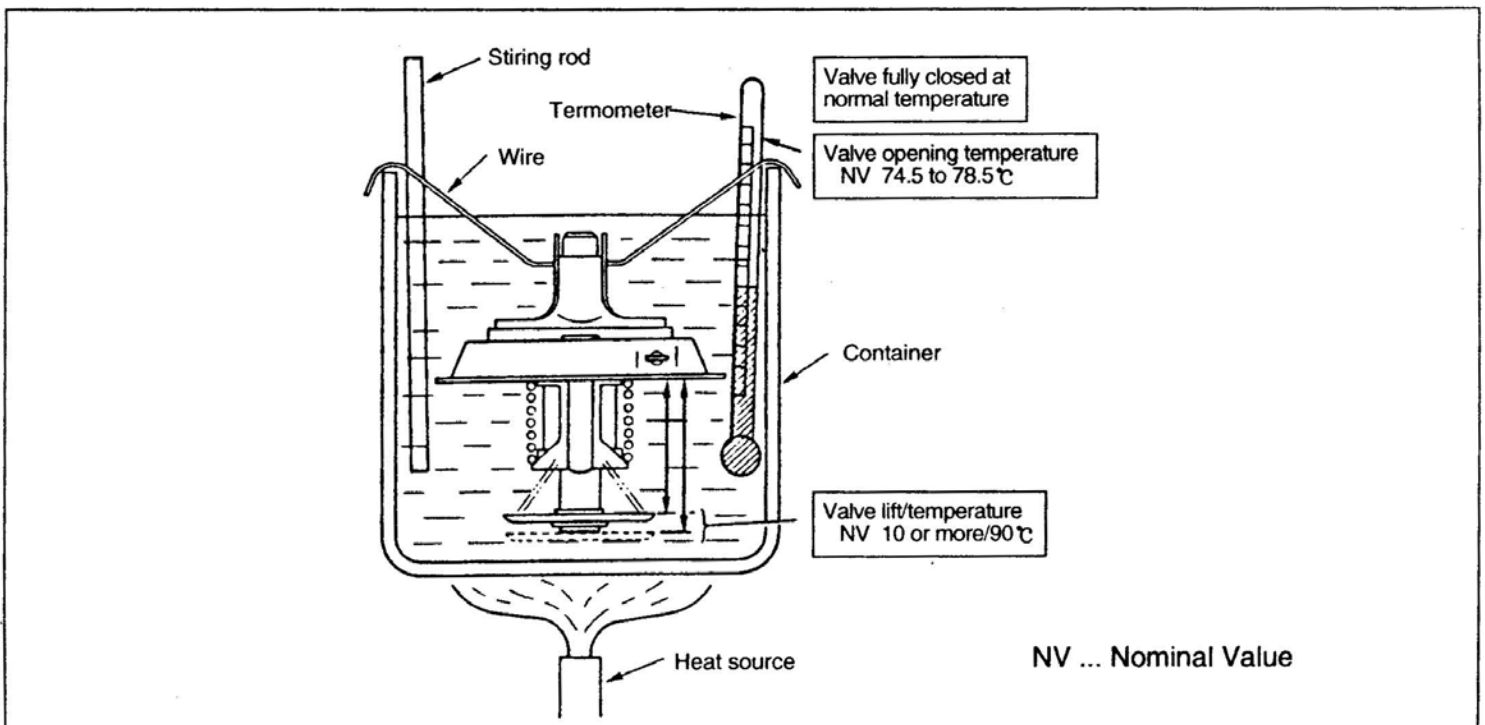
### 5-4-2 Inspection

Agitate water in the container with the stirrer to obtain uniform temperature.

For the inspection, use the following procedures.

- (1) Slowly heat water to the thermostat valve opening temperature. Keep this condition for about five minutes and make sure that the valve is open.
- (2) Raise the water temperature up to 95 °C.  
Keep the condition for five minutes and measure the lift of pellet.
- (3) Lower temperature down to 65 °C or below and ensure that the valve is fully closed.

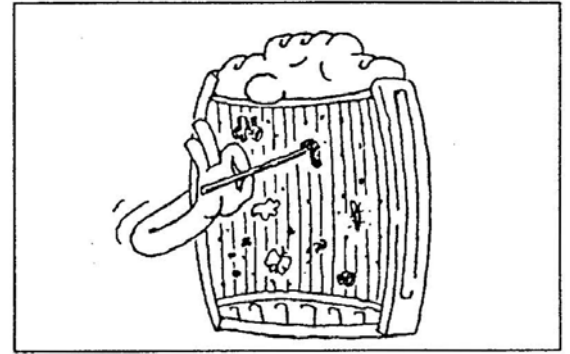
If the thermostat is found defective in any of the above items, replace it with a new one.



## 5-5 Radiator

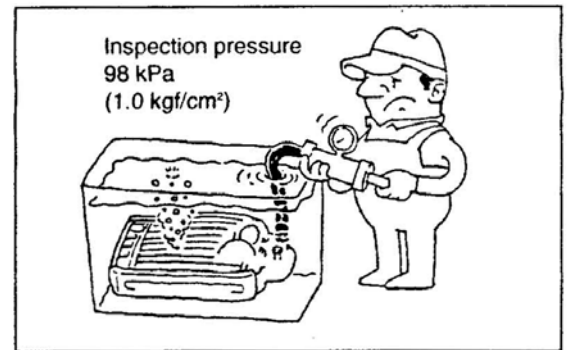
### 5-5-1 Inspection

- (1) Using a copper wire or similar device, remove dirt, mud, and bugs from the front of radiator core with care to prevent damage to tubings.



- (2) Connect a hose to one of the radiator ports, cap the other port, and immerse the radiator into water. Using a radiator cap tester, force the compressed air under the specified inspection pressure from the hose end to check for leaks.

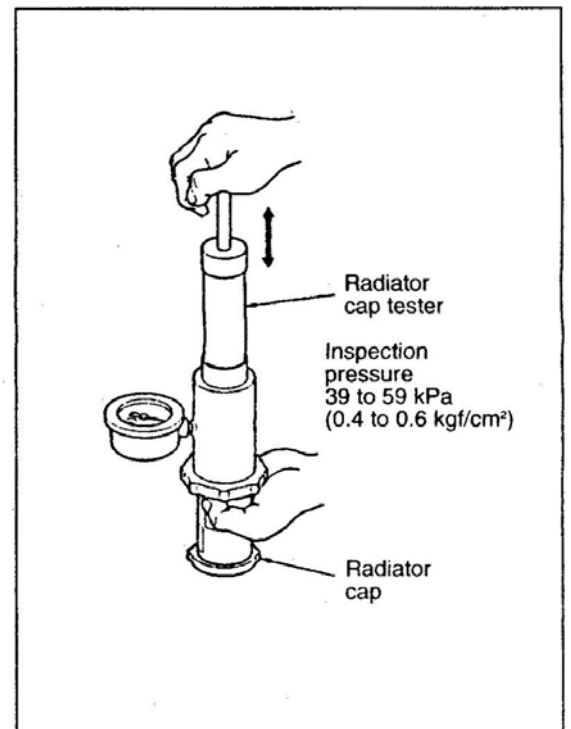
If there is a leak, resolder the point of leakage or replace the radiator.



- (3) Inspection of Radiator Cap

Check the spring tension and sealing condition of the pressure valve and vent valve. If defective, replace.

Check the pressure valve opening pressure, using a radiator cap tester.



## 5-6 Cleaning of Cooling System

If the radiator is used for a long time, rust, scale, mud, etc. are deposited inside, resulting in overheat. Clean the cooling system with city water by using the following procedures.

The city water to be used should have the following properties.

### Required Properties of City Water

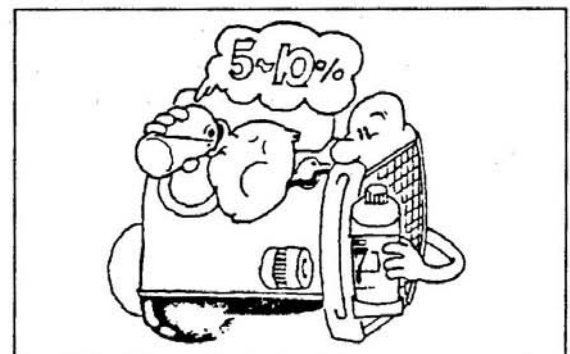
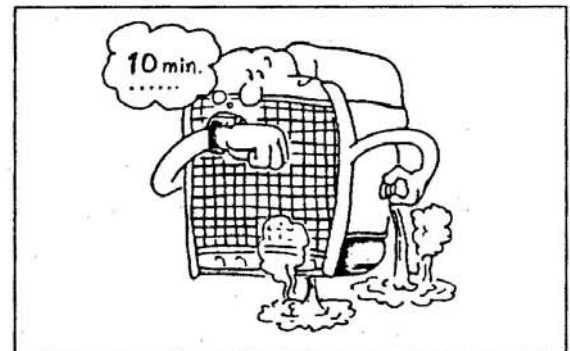
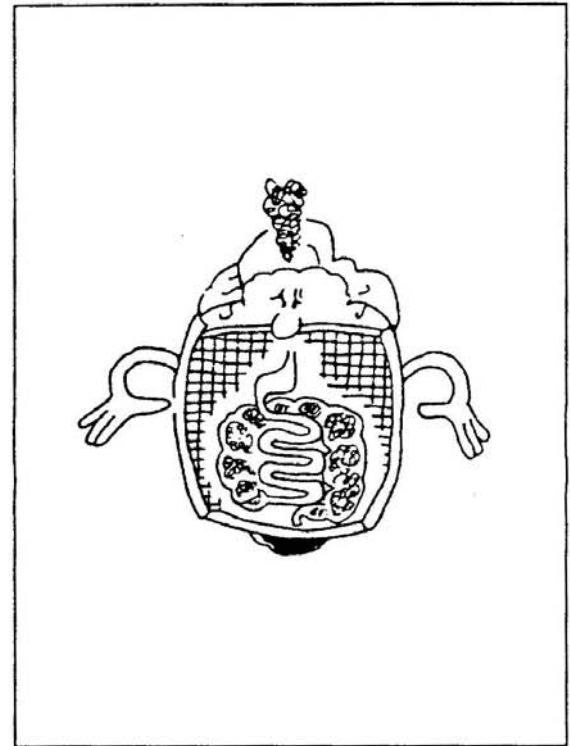
Total hardness	300 ppm or less
Sulfate $SO_4^{2-}$	100 ppm or less
Chloride $Cl^-$	100 ppm or less
Total dissolved solids	500 ppm or less
PH	6 to 8

### NOTE:

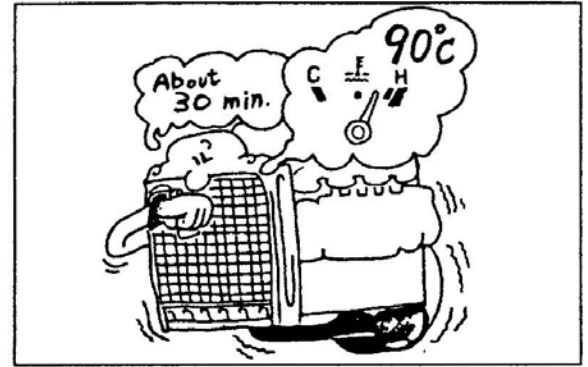
1. Use a cleaning solution if the radiator is seriously obstructed or coolant is seriously contaminated.
2. When the cooling system is cleaned or washed with water, make sure that the coolant temperature is maintained at  $90^\circ C$ ; the coolant temperature below the valve opening temperature closes the thermostat resulting in poor coolant circulation.

- (1) Washing with Water (Every six months at coolant change or before and after the use of antifreeze)
  - (a) Discharge coolant from the radiator, and crankcase.
  - (b) After draining the system, fill it with tap water (preferably hot water) and, with the water temperature kept at around  $90^\circ C$ , run the engine at idle for about 10 minutes. Then, discharge water.  
Continue flushing until the drained water runs clear.

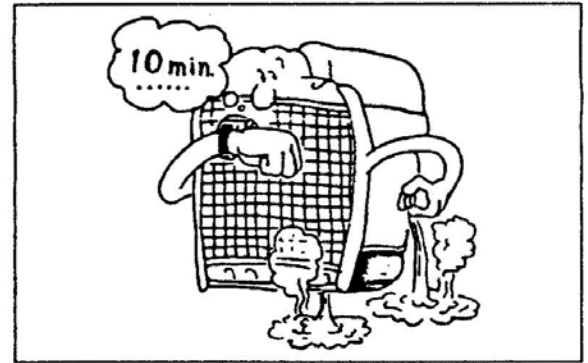
- (2) Washing with Cleaning Solution (Radipet-7 of equivalent) (When radiator clogging or coolant contamination are serious)
  - (a) Discharge coolant from the radiator and crankcase.
  - (b) Ready a mixture of Fuso Radiator Cleaner (Radipet-7 or equivalent: 5 to 10%) and cooling water.  
pour the specified amount of mixture into the radiator.



- (c) Run the engine to raise the solution temperature to around 90°C. Let the engine run at idle another 30 minutes, then remove the solution.

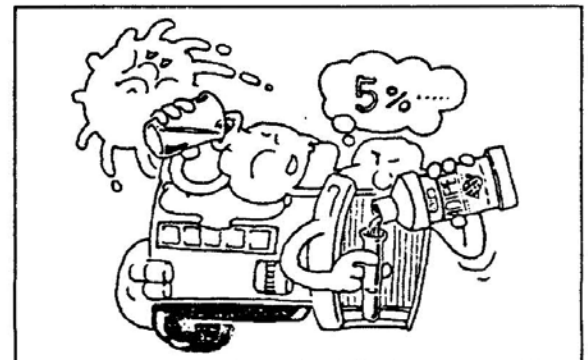


- (d) After discharging the solution, fill the system with tap water (preferably hot water) and, with the water temperature kept at around 90°C, run the engine at idle for about 10 minutes. Then, drain water. Continue flushing until the drained water runs clear.



### (3) Antirust and Antifreeze

- (a) After cleaning, add the Fuso Radiator Antirust (Radipet-9B) or equivalent at a ratio of 5% to the coolant quantity to prevent corrosion in summer.



- (b) In winter, add the Fuso Antifreeze or equivalent at a ratio of 30 to 60% to prevent freezing.

#### NOTE:

1. Make sure that the antirust is added in summer and the antifreeze in winter at the specified ratios.
2. The antifreeze or antirust added coolant used for a season (about six months) must not be reused.
3. Use the antifreeze at a proper mixing ratio of 30 to 60% suitable for the atmospheric temperature. If the mixing ratio is less than 30%, the antirust effect will fall. If the ratio exceeds 60%, the antifreeze effect will fall, and engine overheating will result.

## 5-7 Gas Leak Test

Air or exhaust gas leaked into the coolant promotes corrosion and rust formation.

Perform the following check and, if defects are found, take remedial action.

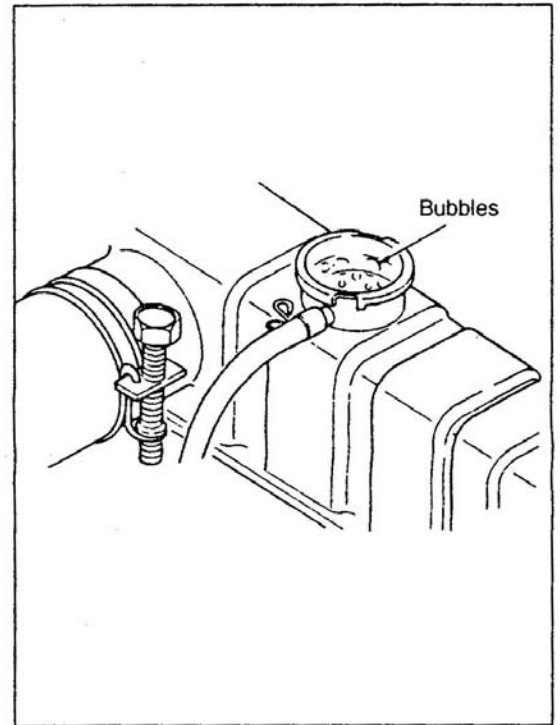
### (1) Inspection

Remove the pressure cap from the radiator, and run the engine to raise the coolant temperature up to around 90 °C.

### (2) Causes

(a) If air is trapped in coolant, check cylinder head bolts, water pump mounting bolts, and hose and its connections for looseness. Check also hoses for damage.

(b) If the exhaust gas has leaked into coolant, check the cylinder head gasket or nozzle tube end stake for damage. Check also cylinder head for cracks.



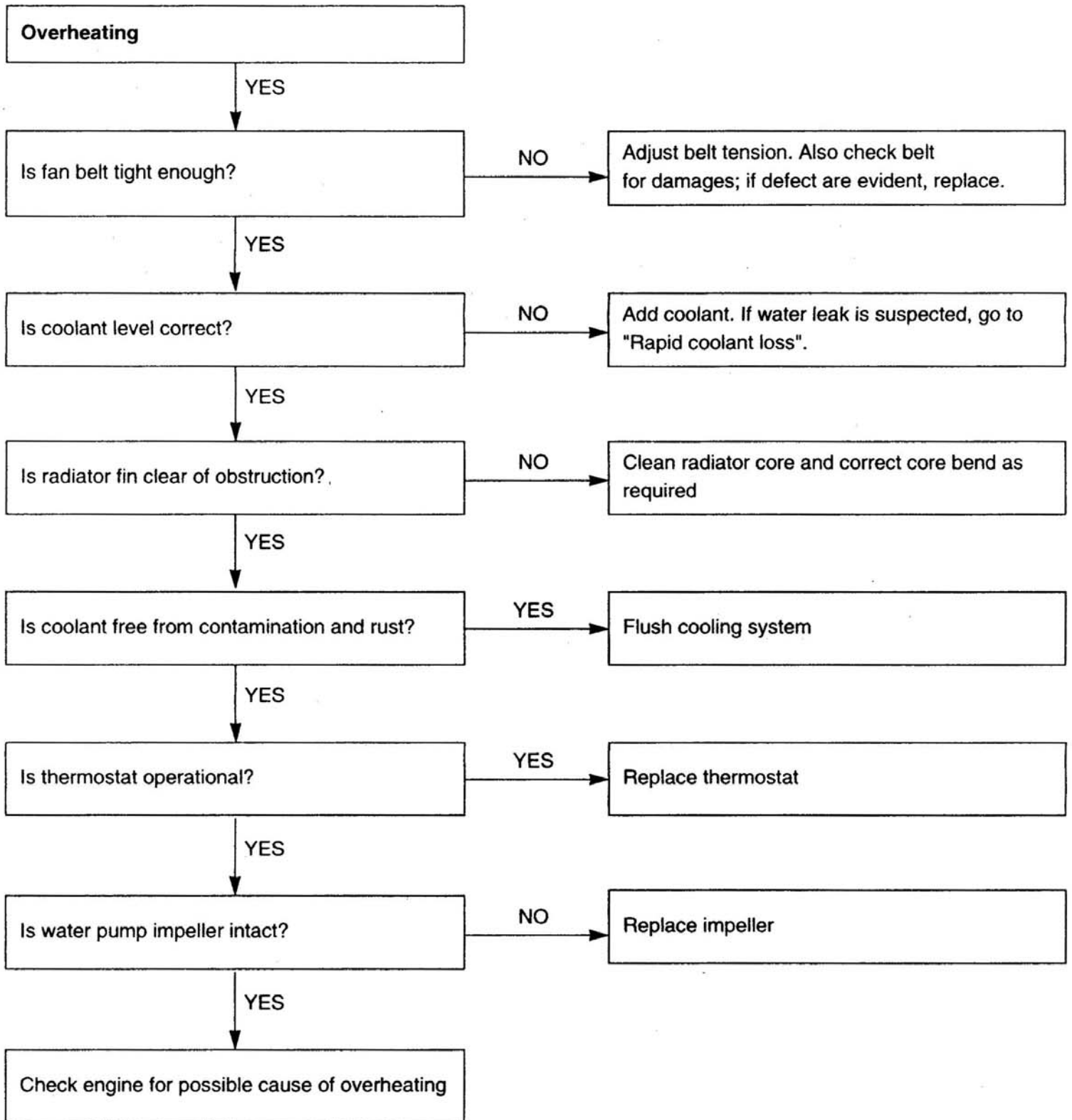
## 5-8 Bleeding the Cooling System

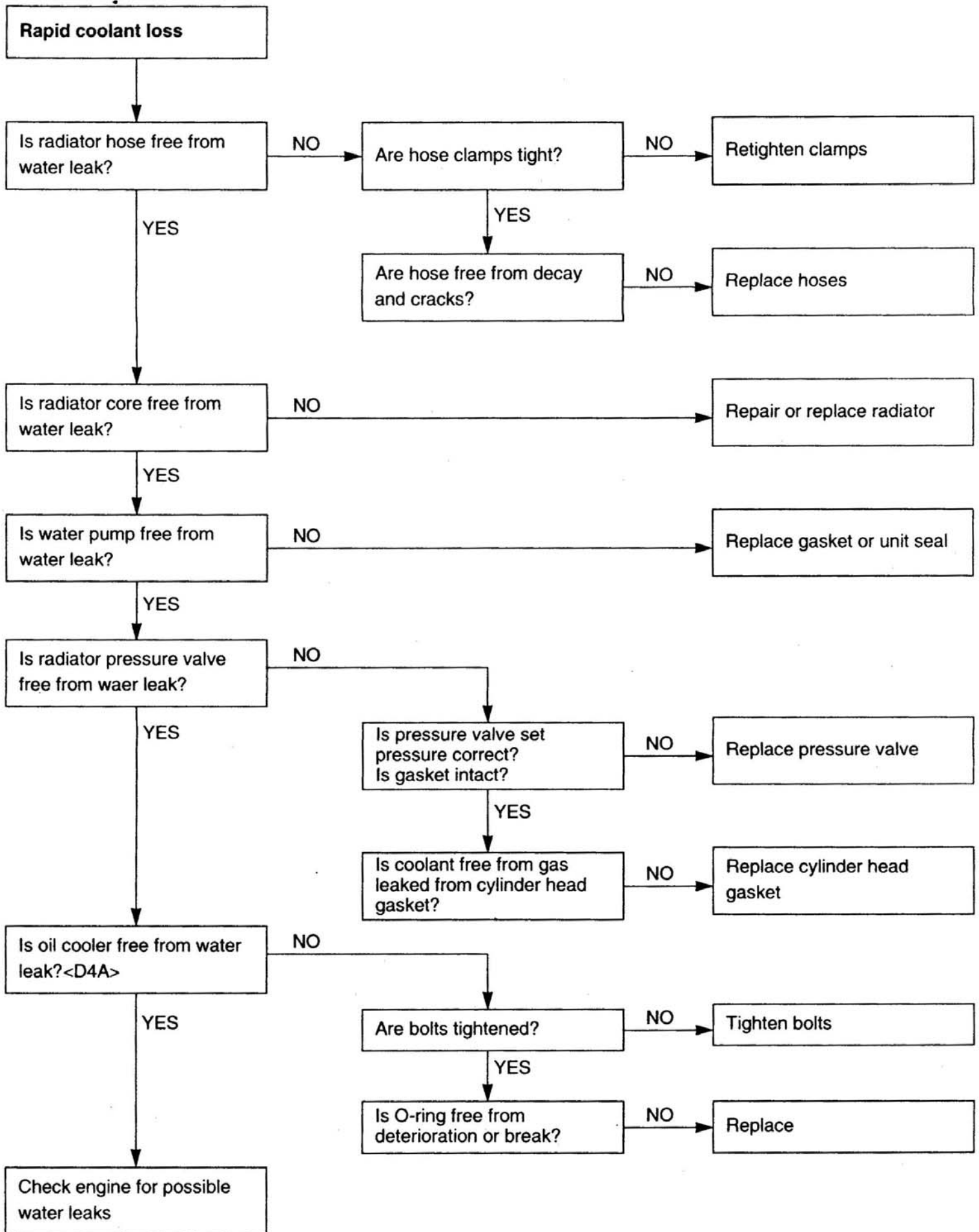
(1) With the pressure cap removed from the radiator, let the engine run at idle with coolant temperature of about 90 °C to bleed the system completely.

(2) After the system has been bled of air, add coolant to radiator as required.



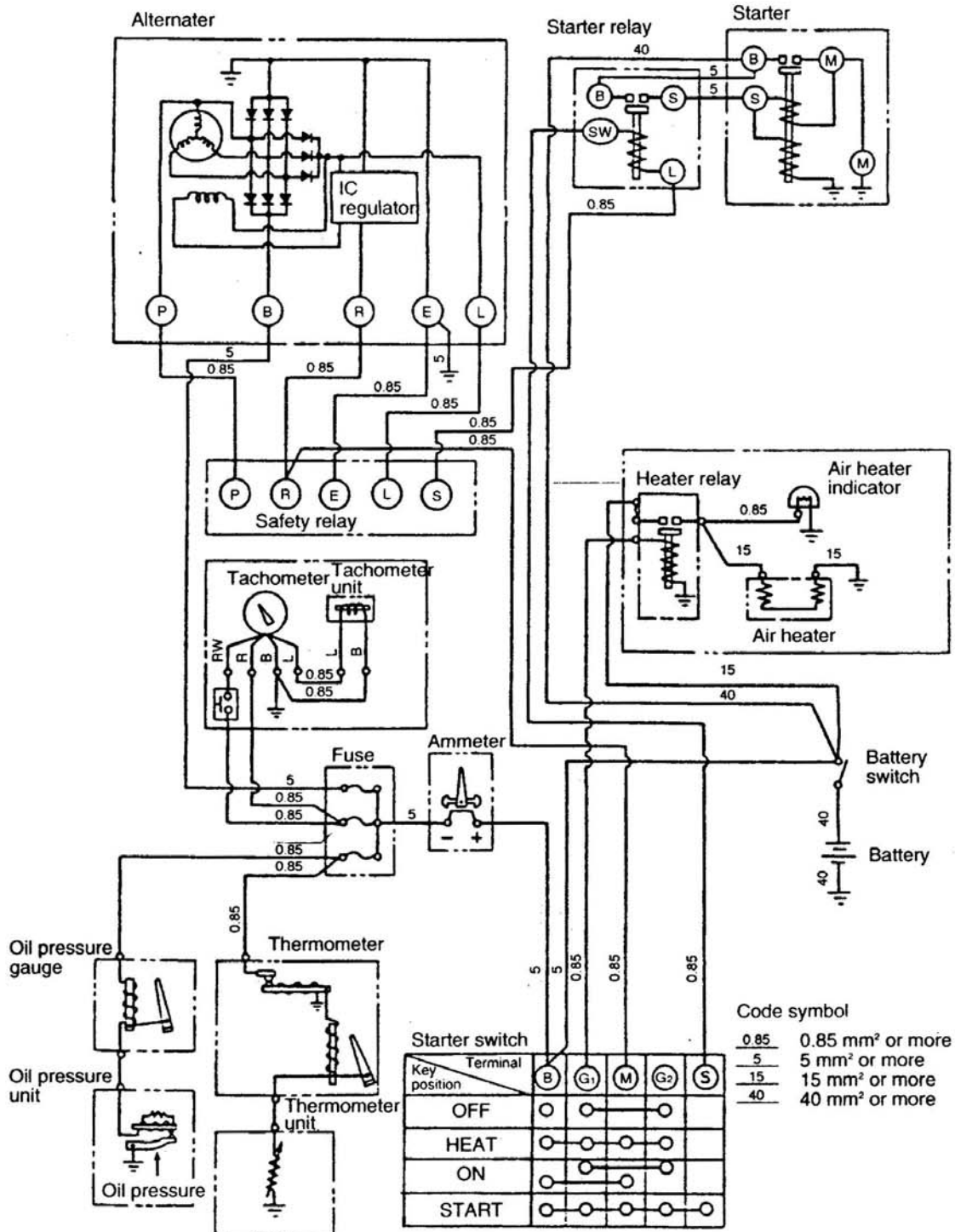
## 6. TROUBLESHOOTING





# 1.GENERAL

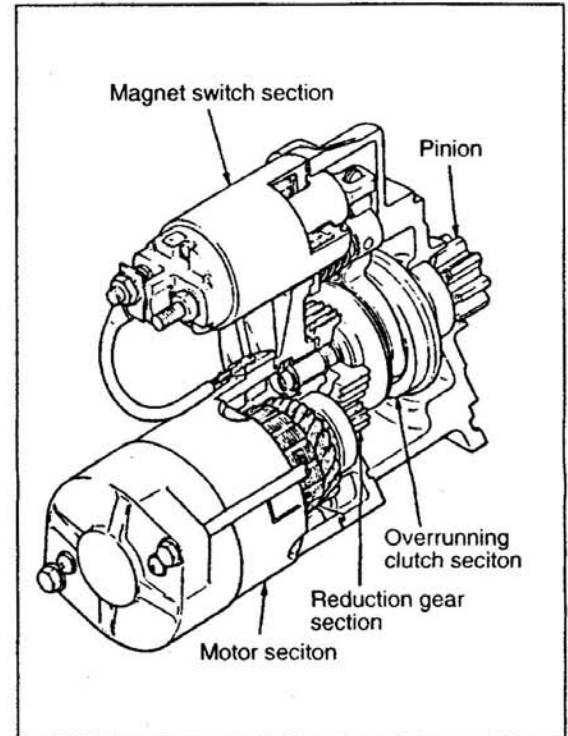
<24V type>



## 1-1 Starter

The strater is an overhang type in which the pinion sliding surface are not exposed to the outside.

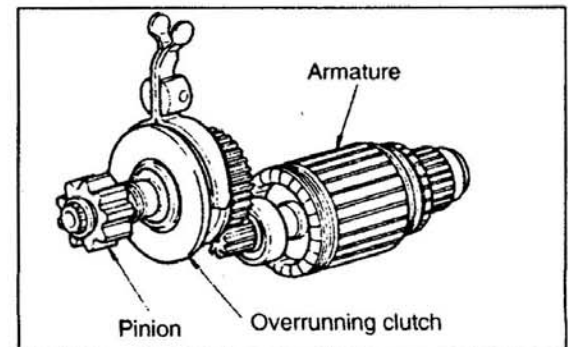
Major components include: the motor that develops a high torque required to get the engine started; overrunning cluth that transmits torque and prevents the starter from overrunning; magnetic swith that brings the pinion into mesh with the ring gear, while turning on/off the load current to the motor; and, the reduction gear which boosts the armature torque.



### (1) Reduction Gear

The end of the armature is a gear which is in mesh with the reduction gear.

The armature torque is multiplied by about 3.6 with its speed reduced as they are transmitted to the pinion.

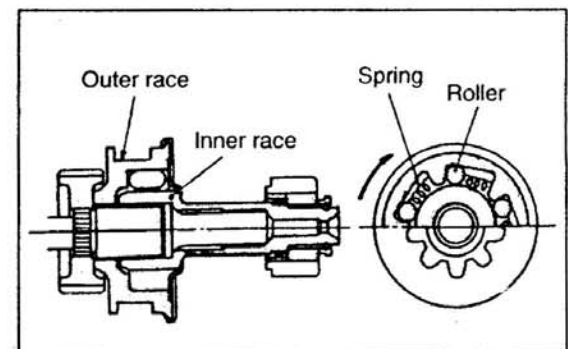


### (2) Overrunning Clutch

A roller-type overrunning clutch is used.

Rollers are housed in the wedgeshaped grooves formed by the outer and inner races (sleeve) and pressed by springs.

When the starter is started, the roller is pressed towards the narrower side of the groove, functioning as a key to transmit rotation of the outer race to the pinion. No torque is transmitted, however, from the pinion (as it is turned by the engine), as the roller compresses the spring moving toward the wider side of groove and releasing the key action.



(3) Operation

While the starter switch is ON, current flows from the terminal "SW" of the starter relay to the terminal "L" and closes the contact P<sub>2</sub>.

When the contact P<sub>2</sub> closes, current from the battery flows from the terminal "S" to the magnetic switch to the pull-in coil (P) and holding coil (H). Furthermore, the current that has decreased flows from the terminal "M" to the motor section.

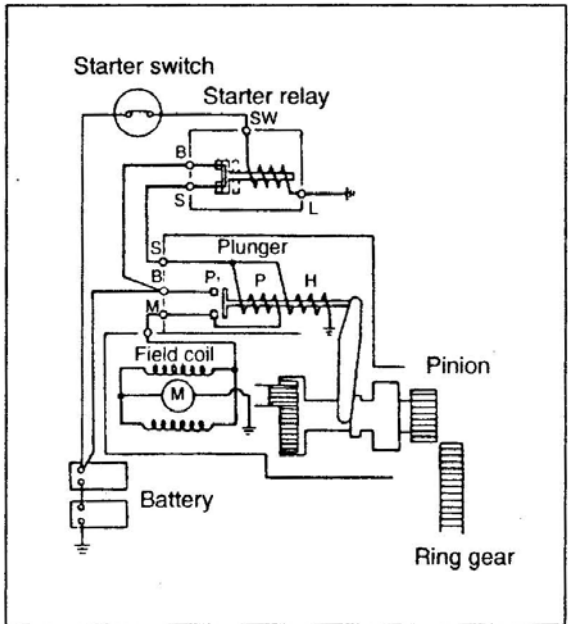
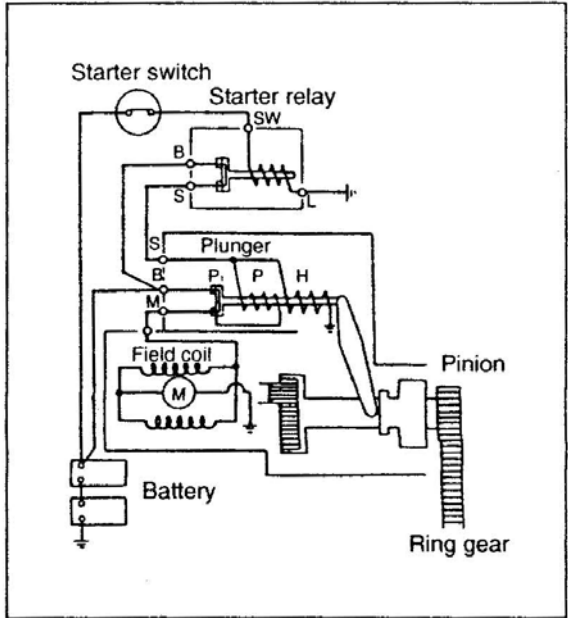
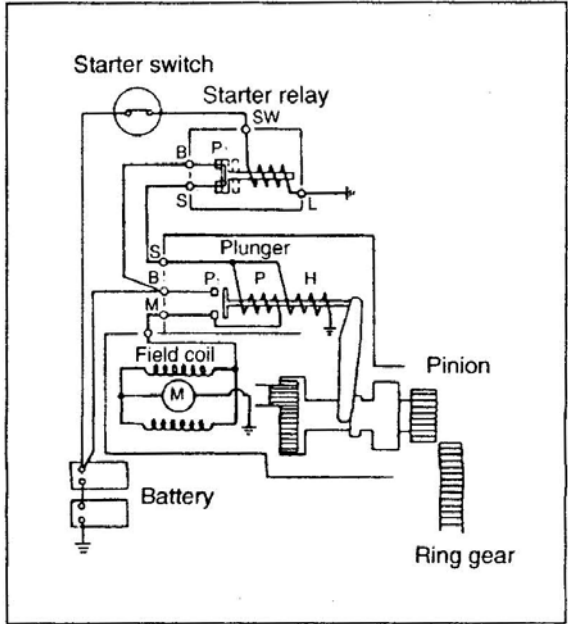
The plunger, attracted by the magnetic flux of the pull-in coil and holding coil, closes the contact P<sub>1</sub> and simultaneously pushes out the pinion turning slowly on weak current.

When the pinion comes into complete mesh with the ring gear, the contact P<sub>1</sub> closes and the large current of the battery directly flows to the motor section to turn the pinion powerfully.

In this condition, no current flows to the pull-in coil. The plunger is retained by the holding coil alone.

When the starter switch is placed to OFF, current to the holding coil (H) is interrupted. The plunger is returned to its original position by the return spring and the contact P<sub>1</sub> opens so that current to the motor section is interrupted.

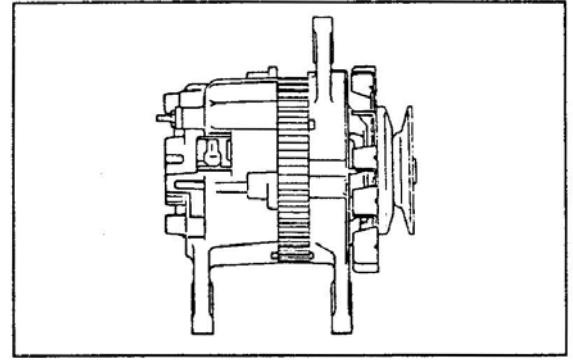
The moment the starter switch is opened, the battery current flows from the terminal "B" to the pull-in coil (P) and holding coil (H). Since the coils are wound in opposite direction to each other, the magnetic fluxes cancel each other so that the return spring can move the plunger back to its original position.



## 1-2 Alternator

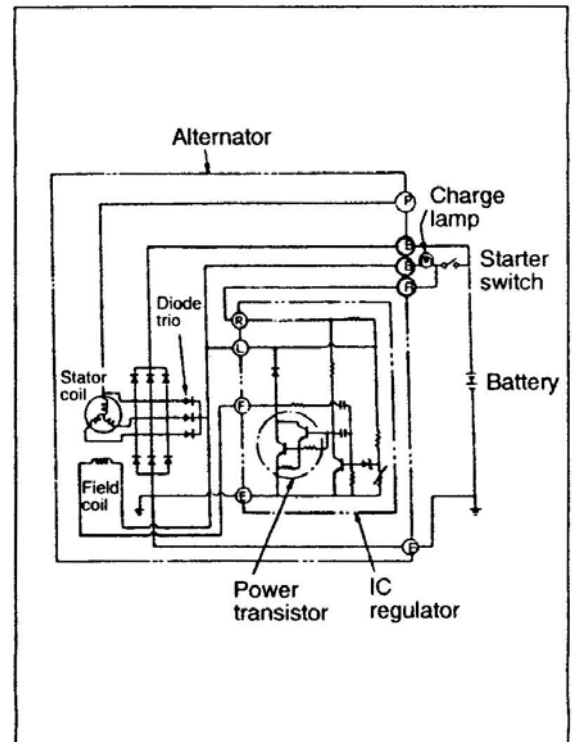
The alternator with a built-in IC Regulator (abbreviated to the built-in alternator) is used.

The alternator consists of the IC regulator and brush holder accommodated in the rear bracket.



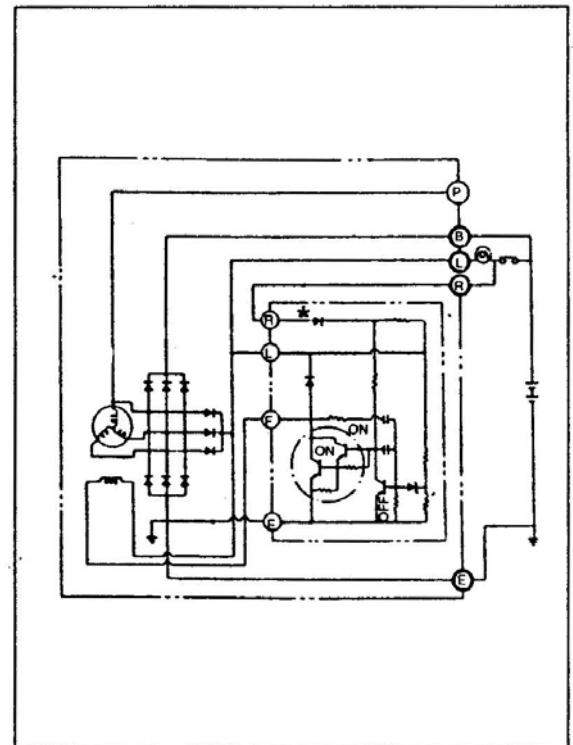
### a) Features of the Built-in Alternator

- (1) For better voltage buildup especially at idle speeds, the alternator is provided with the R terminal independent from the L terminal (charge lamp circuit) as the initial excitation circuit.
- (2) The three diodes (diode trio) built into the alternator apply the field current directly to the field coil, eliminating voltage drop caused by the starter switch and wiring.
- (3) The P terminal is for detecting the safety frequency.



### b) Operation

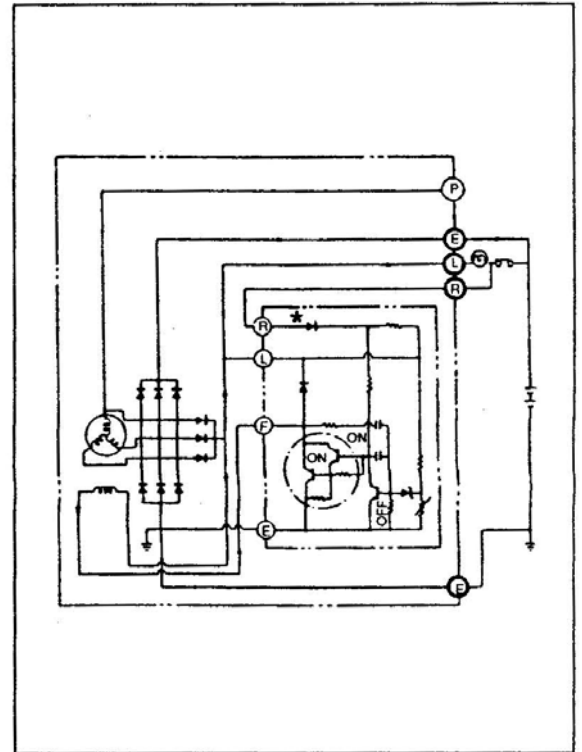
When the starter switch is turned ON, base current flows from the battery to power transistor to turn it ON, allowing the current to flow through the field coil to turn on the charge lamp.



As the engine starts with the alternator generating power, the base current is supplied by the alternator itself.

The field current also flows from the diode trio to energize the rotor.

At the time the charge lamp goes off, since the output voltage from the B terminal becomes the same as that from the L terminal.

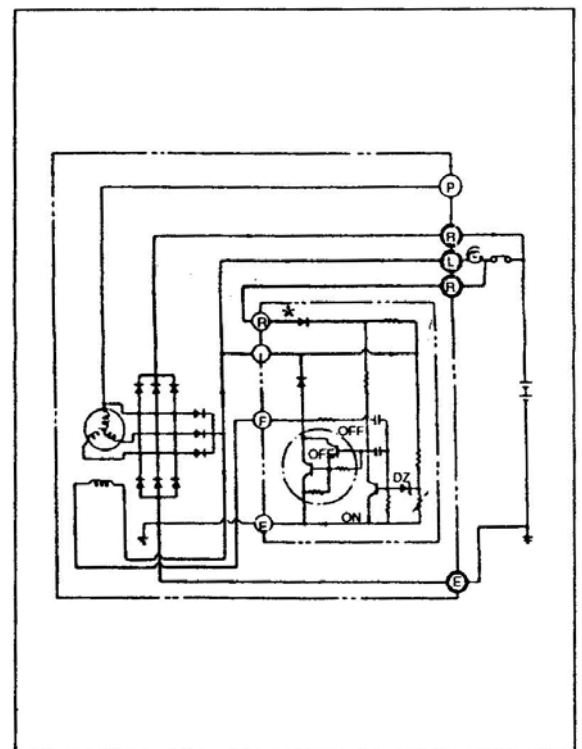


As the voltage developed by the alternator builds up, the zener diode Dz conducts providing base current for the transistor Tr1 to turn it ON.

As a result, the base current of the power transistor is shorted to Tr1, which turns OFF the power transistor. This means that there is no field current flow, dropping the voltage generated by the alternator.

When the zener diode Dz is shut off with a voltage drop, the base current flows to the power transistor to turn it ON. As a result, the field current again starts flowing, increasing the generated voltage.

These IC regulator operations repeat to regulate the alternator voltage.

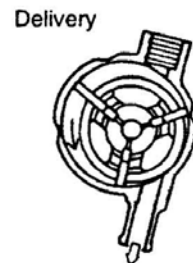
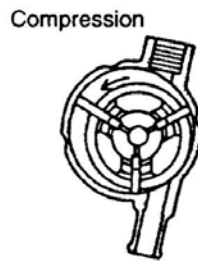
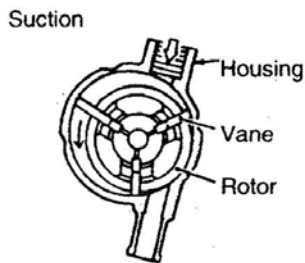
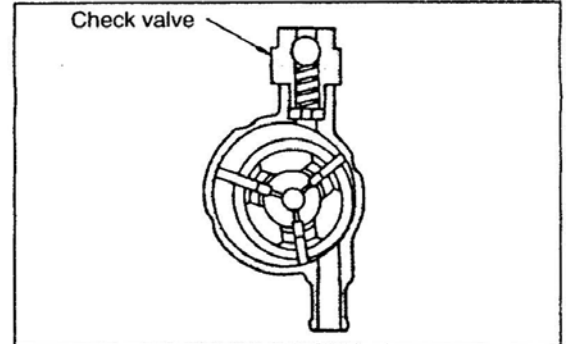
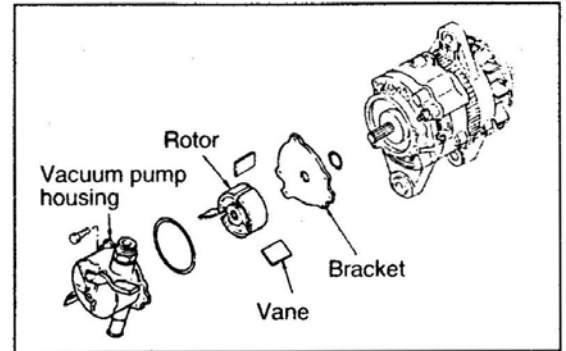


### 1-3 Vacuum Pump

The vacuum pump is of a rotary type with movable vanes. The rotor with three movable vanes turns in the housing of a cylindrical shape. The housing is mounted on the rear bracket of the alternator with the rotor spline-coupled into the alternator shaft.

The rotor and housing are eccentric. The air drawn in through the suction port is gradually compressed and discharged from the deliver port. Oil is also drawn in through the oil filler port to provide sealing, lubricating, and cooling functions for the housing, and discharged from the deliver port with the compressed air to the oil pan.

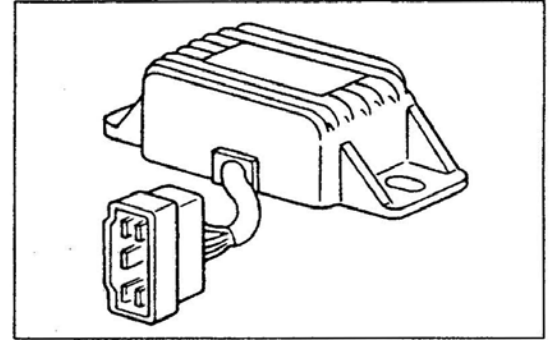
The check valve prevents the engine oil and compressed air from flowing back to the vacuum tank when the engine is stationary.



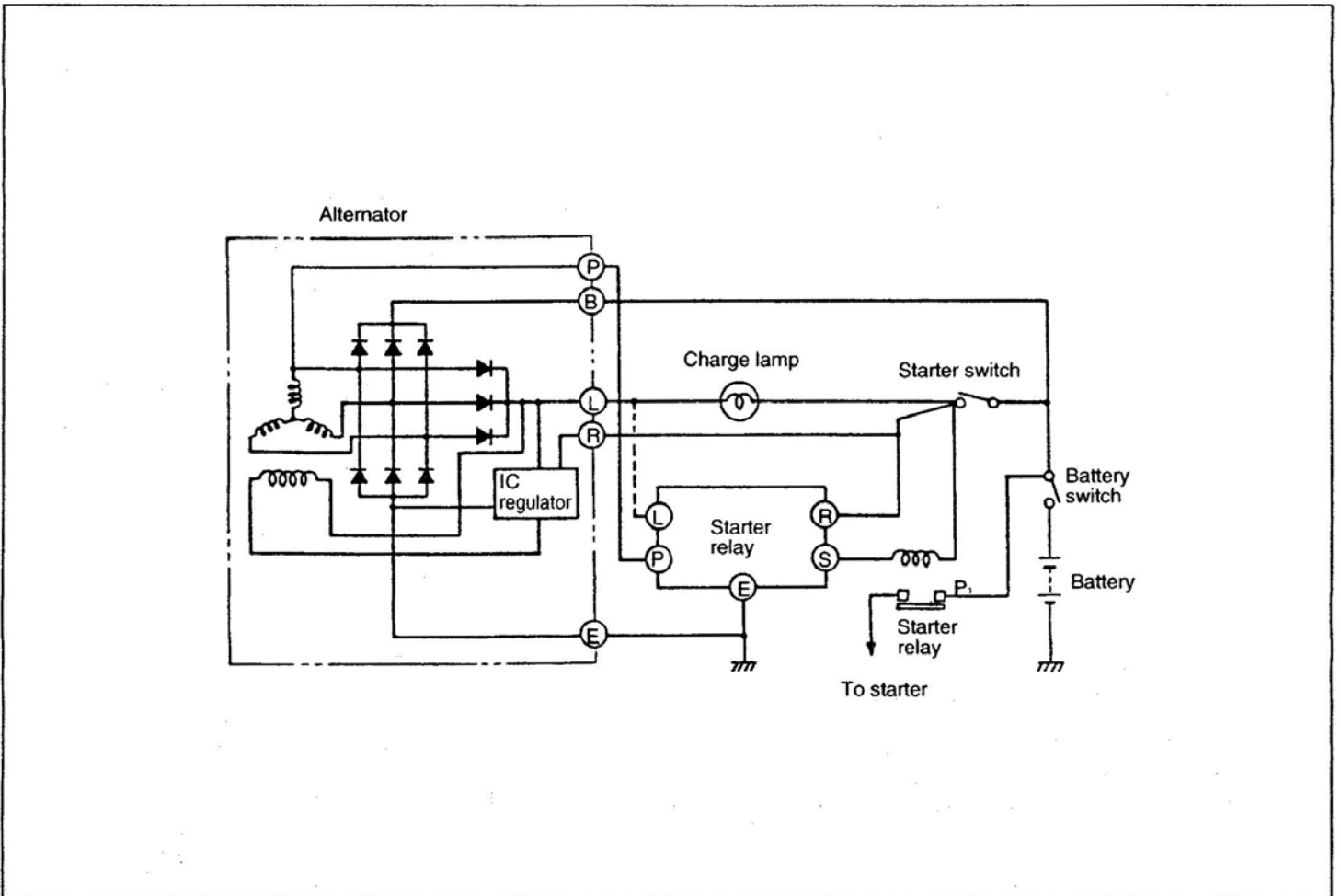


## 1-4 Safety Relay

The alternator rpm is detected and when it exceeds the reference level, the safety relay prevents the starter from operating even if its switch is accidentally turned on during engine revolution.



### Operation



- (1) When the starter switch is set to ON, current flow from the starter relay to terminal "s" and to terminal "E" of the safety relay, closing contact P<sub>1</sub>. The charge lamp also illuminates if provided.
- (2) As the starter runs and the engine starts running, pluses of frequency 1/10th of the alternator speed appear at terminal "P" of the alternator.  
The charge lamp goes out.
- (3) When the pulse frequency at terminal "P" exceeds the specified value, continuity between terminals "S" and "E" is lost. Then, the starter does not operate even if the starter switch is set to ON while the engine is running.

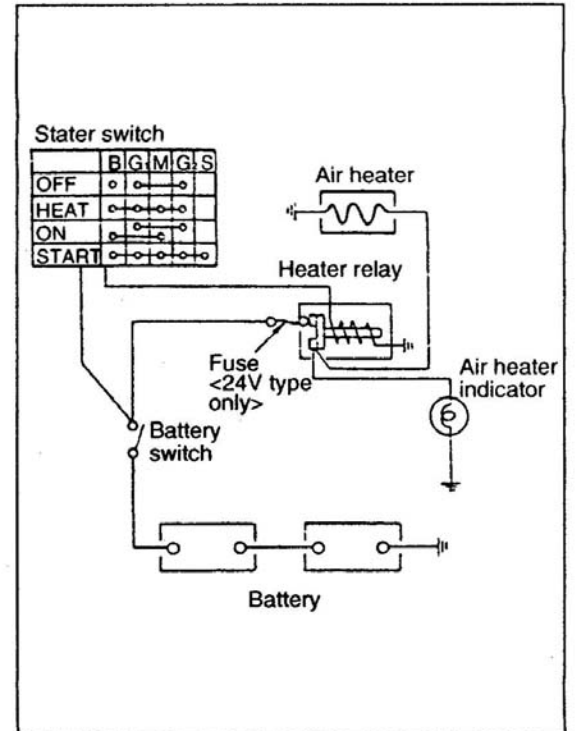
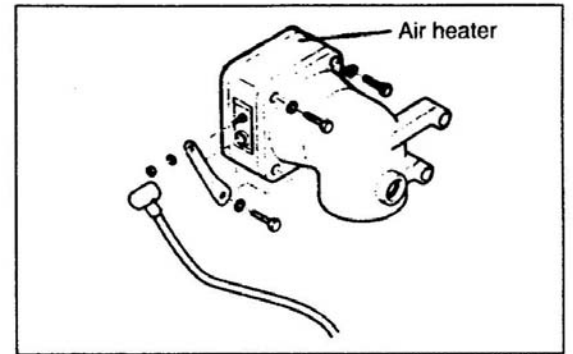
## 1-5 Preheater

### (1) Intake Air Heater<D4A>

The intake air heater which is electric type heats intake air in the inlet manifold to facilitate engine startup in cold weather.

Set the starter switch to HEAT to energize the intake air heater mounted on the inlet manifold. The heater becomes red heated and in about 20 to 30 seconds, its temperature reaches 800 °C or higher. Then, the it heater indicator comes on to indicates heat state to the driver.

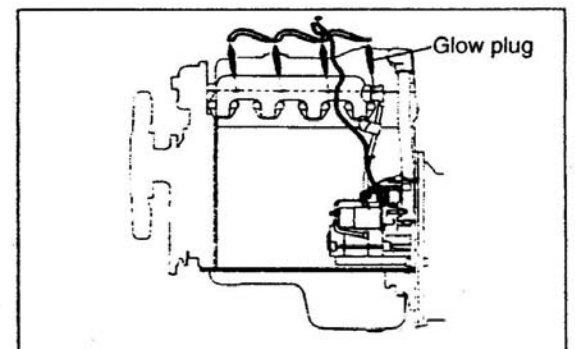
The heater relay has a fuse to prevent overcurrent from flowing to the intake air heater circuit.

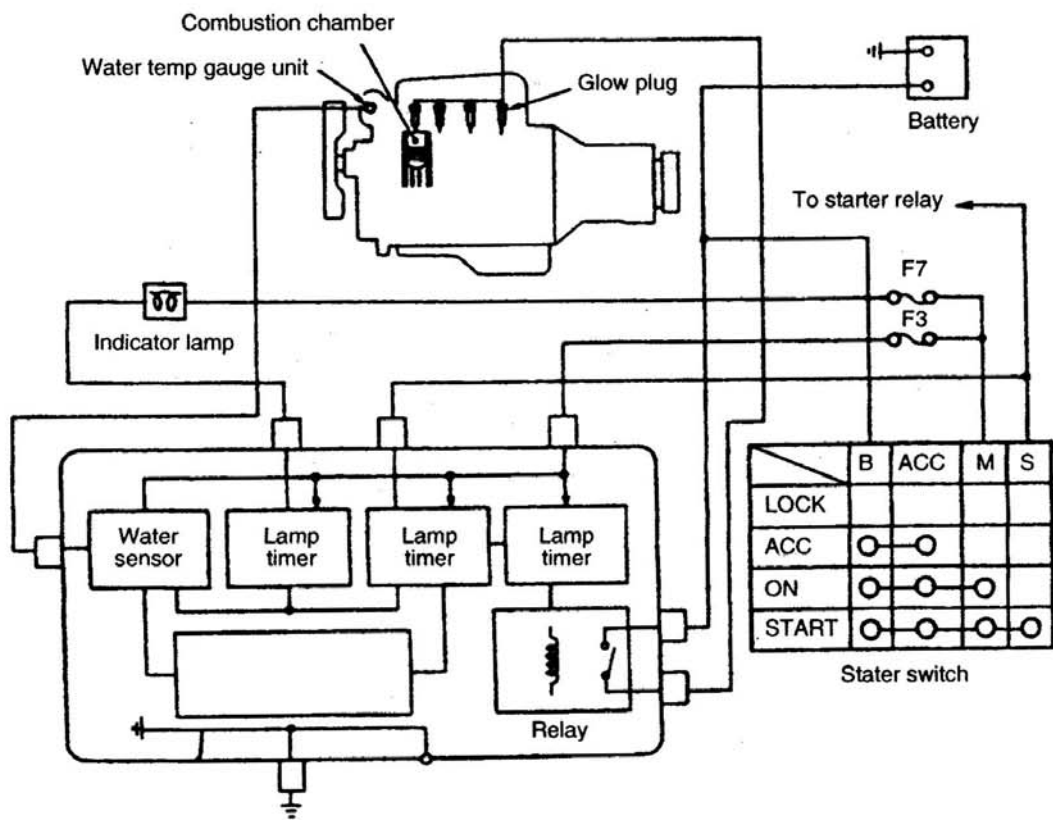


### (2) Glow plug sys (D4DA, D4AF Fork Lift)

The glow plug heats the switch chamber to easily start the engine in cold weather.

The glow plug, of a sheathed type, is connected in parallel.



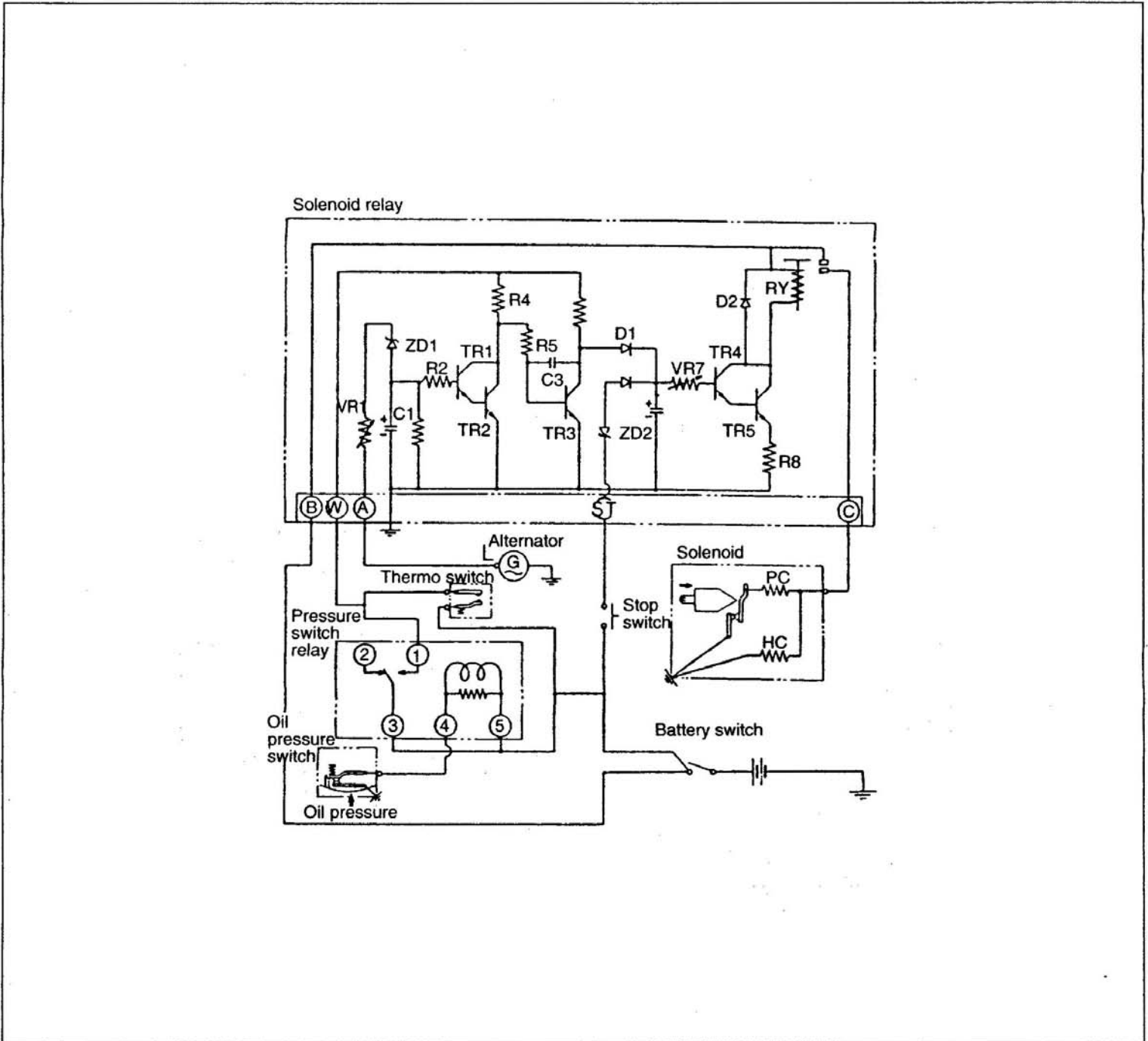


	B	ACC	M	S
LOCK				
ACC	○—○			
ON	○—○	○—○	○—○	
START	○—○	○—○	○—○	○—○

## 1-6 Automatic Stop Device

If the coolant temperature rises or the oil pressure falls while the engine is running, this device operates the stop lever of the injection pump governor to cut fuel supply and automatically stops the engine.

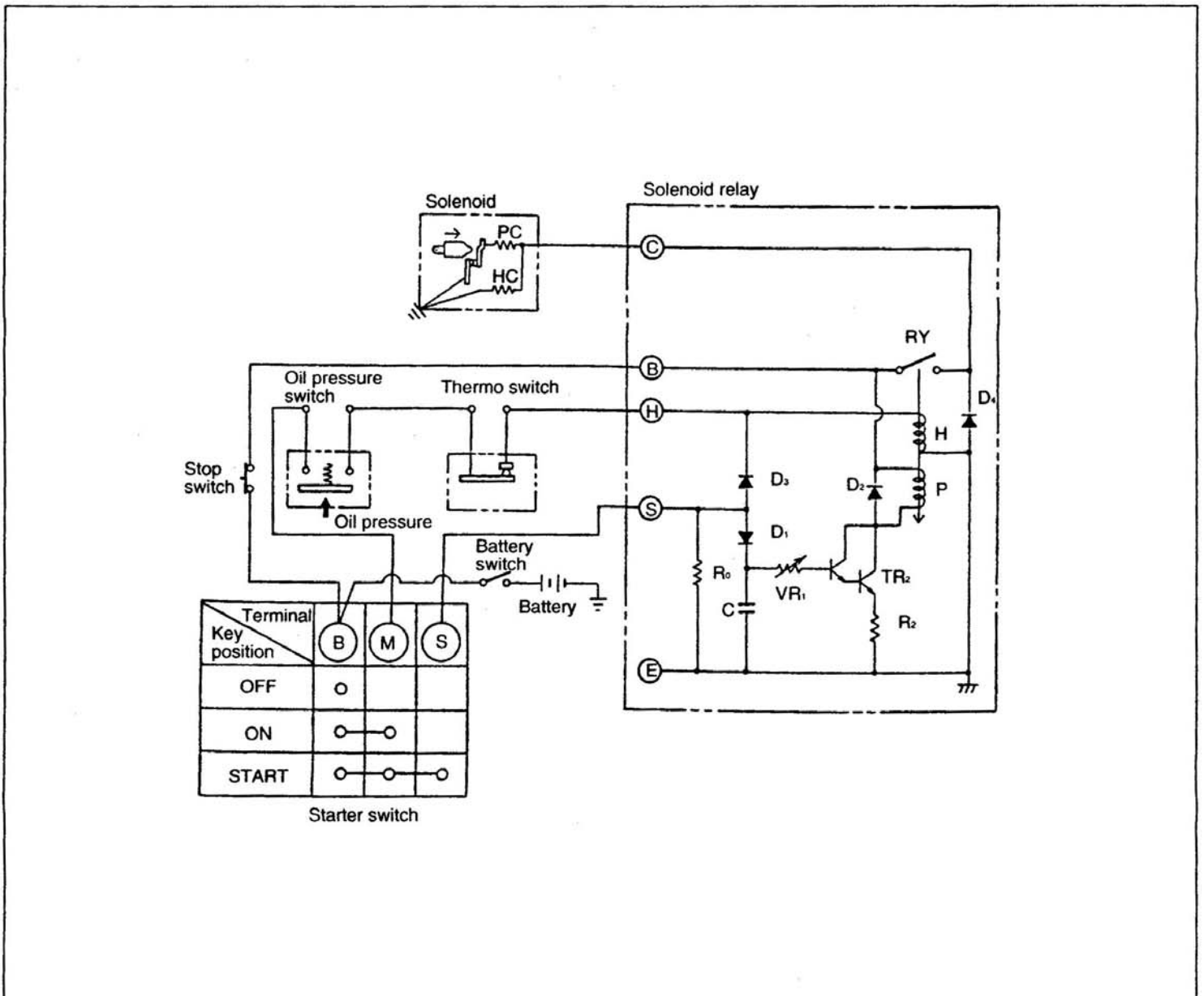
### (1) Run Off Type



#### (a) Start circuit

- 1) current flows from the solenoid relay (B) to the RY coil and applies the voltage to the collectors of TR<sub>4</sub> and TR<sub>5</sub> but RY does not operate, as there is no input to the base.
- 2) Current also flows from the oil pressure switch to the solenoid relay (W) to R<sub>4</sub> to R<sub>5</sub> and applies the voltage to the base of TR<sub>3</sub>, when the voltage is applied to the base of TR<sub>3</sub> current flow from R<sub>6</sub> to C and E of TR<sub>3</sub> to the ground, and RY does not operate, as there is no input to TR<sub>4</sub> and TR<sub>5</sub> of the stop circuit.

(2) Run On Type <24V Type>



(a) Start circuit

1) When the battery switch is turned ON:

Solenoid relay (B) → RY pull-in coil P → TR<sub>1</sub> collector  
 → TR<sub>2</sub> collector

RY contacts do not operate with no input to the base of TR<sub>1</sub> and TR<sub>2</sub>.

2) When the starter switch is placed in the START position:

Starter switch S → Solenoid relay (S) → Resistor R<sub>0</sub> → Ground

→ Diode D<sub>3</sub> → RY holding coil H → Ground  
 → Diode D<sub>1</sub> → Capacitor C

When the capacitor C is charged, voltage is applied from VR<sub>1</sub> to the base of TR<sub>1</sub> actuating TR<sub>1</sub>.

As voltage is applied to TR<sub>1</sub> collector, TR<sub>1</sub> emitter, and to TR<sub>2</sub> base, a current flows from TR<sub>2</sub> collector to TR<sub>2</sub> emitter, resistor TR<sub>2</sub>, and ground, causing the RY pull-in coil P to close the RY contacts.

3) When the RY contacts turn ON:

Current flows from solenoid relay (B) to RY, solenoid relay (C), and the solenoid, activating the solenoid and starting the engine.

4) As the engine starts and starter switch is placed in the ON position, voltage to the solenoid relay (S) is cut off; however, TR<sub>1</sub> and TR<sub>2</sub> stay ON for approximately another 30 seconds by the discharge current of the capacitor C. During capacitor C's discharging, the oil pressure builds up as the engine speed increases, causing the oil pressure switch to turn ON. This causes the current to flow from the starter switch (M) to oil pressure switch, thermo switch, solenoid relay (H), RY holding coil H, and to ground, keeping the RY contacts in ON state.

(b) Automatic stop circuit

When the thermo switch and oil pressure switch detect an abnormal condition, each switch turns OFF and the RY contacts open, deactivating the solenoid and stopping the engine.

(C) Pushbutton stop

To stop the engine during operation, operate the stop switch, and the stop operation is performed just as when the automatic stop is performed.

## 2. SPECIFICATIONS

Description	Specification		
Model	D4A / D4AF(Fork Lift)	D4DA	
		Fork Lift	Generator
Voltage-Polarity	(-) earth	←	
Starter type	Overhang electro-magnatic push-in type reduction starter	←	
Starter output	24V-5Kw / 12V-3.2Kw	12V-3.2Kw	
Alternator type	Alternator with built-in Ic regulator (Idle-speed efficient type)	←	
Alternator output	24V-25A/12V-90A	12V-90A	24V-40A
Vacuum pump type	Rotary pump with 3 vanes, directly coupled with alternator	-	
Preheater system	Air heater / Glow plug system	←	
Glow plug temperature(30sec)	-	1050 ± 80 °C	
Glow plug voltage(30sec)	-	3A	
Air heater capacity	2.0Kw	-	
Relay fuse capacity	95A	-	

### 3. SERVICE STANDARDS

#### 3-1 Service Standard Table

Unit : mm

Description		Nominal value [Basic diameter]	Limit	Correction and remarks	
Starter	Commutator O.D.	32	31	Replace	
	Commutator runout on periphery		0.05 or more	Correct or replace	
	Mica depth of grooves between segment		0.2 or less	Correct	
	Brush length	18	11	Replace	
	Brush spring tension	25 to 34 N (2.55~3.45 kg)	20N(2kg)	Replace	
	Pinion shaft thrust gap	0.1 ~ 0.5		Adjust with washer	
	Pinion gap	0.5 ~ 2.0		Adjust with packing	
	No-load	Voltage	23V		
	Character- istics	Current	24V type 80A or less		Check
		Speed	3,400 rpm or more		
Magnet switch operating voltage		24V type 16V or less			
Alter- nator	25A type	Slip ring O.D.	32.8~33.2	32.4	Replace
		Brush spring tension	3 to 4.2N (0.31~0.43kg)	2.1 N (0.21 kgf)	Replace
		Brush length	18.5	7	Replace
		Field coil resistance(20)	Approx. 10 $\Omega$		Replace
	Load character- istics (When cold)	Terminal Voltage	27V		Check
		Current	22A or more		
		Rotating speed	2,500 rpm		



Description			Nominal value [Basic diameter]	Limit	Correction and remarks
Alter- nator	25A type	lc regulator regulated voltage rang(5,000 rpm, 5A or less)	28 to 29V		Check
Vacuum Pump	60cc type	Maximum at- tainable vaccum	Vacuum	91 kPa(680 mmHg) or more	Check. Oil supply pressure(at 3,000 rpm): 295 to 345 kPa (3 to 3.5 kgf/cm <sup>2</sup> )
			Rotating spped	3,000 rpm	
	Deliver char- acteristic after 20 seconds with a 10 lit tank load	At low speed	Vacuum	67 kPa (500 mmHg) or more	
			Rotating speed	1,500 rpm	
		At high speec	Vacuum	77 kPa (580 mmHg) or more	
			Rotating speed	3,500 rpm	
*Quick- heating air heater	Heat indicator lamp on time	Coolant temperature -5℃	6 seconds	Check	
		Coolant temperature -15℃	10 seconds		
		Coolant temperature -20℃	20 seconds		
	Preheating time	Coolant temperature -5℃	14 seconds		
		Coolant temperature -15℃	18 seconds		
		Coolant temperature -20℃	28 seconds		
	Afterheating time	Coolant temperature -5℃ to 10℃	10 seconds		
		Coolant temperature -5℃ or less	30 seconds		

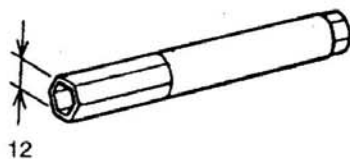
Unit : mm

Description		Nominal value [Basic diameter]	Limit	Correction and remarks
Glow plug	Time required for indicator to become red hot	15 to 35 seconds		Check
	Resistance under normal temperature	24V type	3.08 to 3.75 $\Omega$	Replace
		12V type	1.14 to 1.39 $\Omega$	

### 3.2 TIGHTENING TORQUE TABLE

Description	Thread size O.D. $\times$ pitch mm	Tightening torque (kgf m)	Remarks
Alternator pulley nut	M17 $\times$ 1.5	83 to 105(8.5 to 11)	
Alternator bolt	M12 $\times$ 1.25	91(9.3)	
Alternator adjusting bolt	M12 $\times$ 1.25	82(8.4)	
Glow plug	M12 $\times$ 1.25	20(2)	

### 4. SPECIAL TOOLS

Tool name	Part number	Shape (Unit : mm)	Use
Socket	31391-12400 (D4DA)		Removal and installation of glow plug

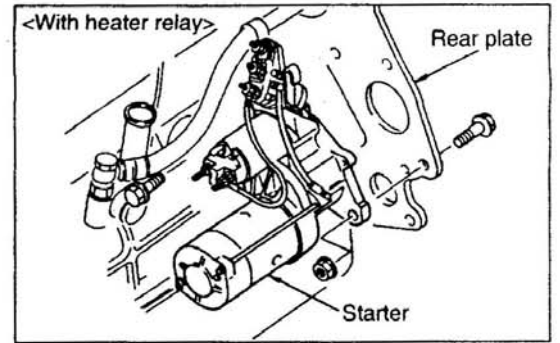
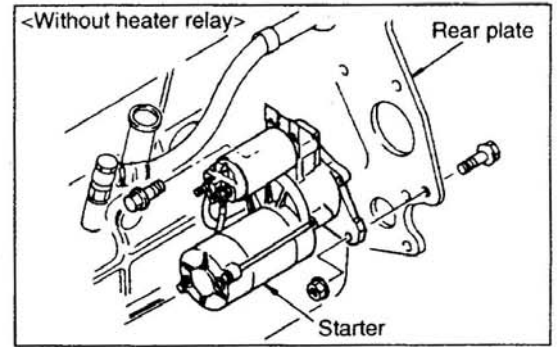
## 5. SERVICE PROCEDURES

Whenever removing electrical parts from the engine, be sure to place the starter switch in OFF position and disconnect the negative battery cable from the frame.

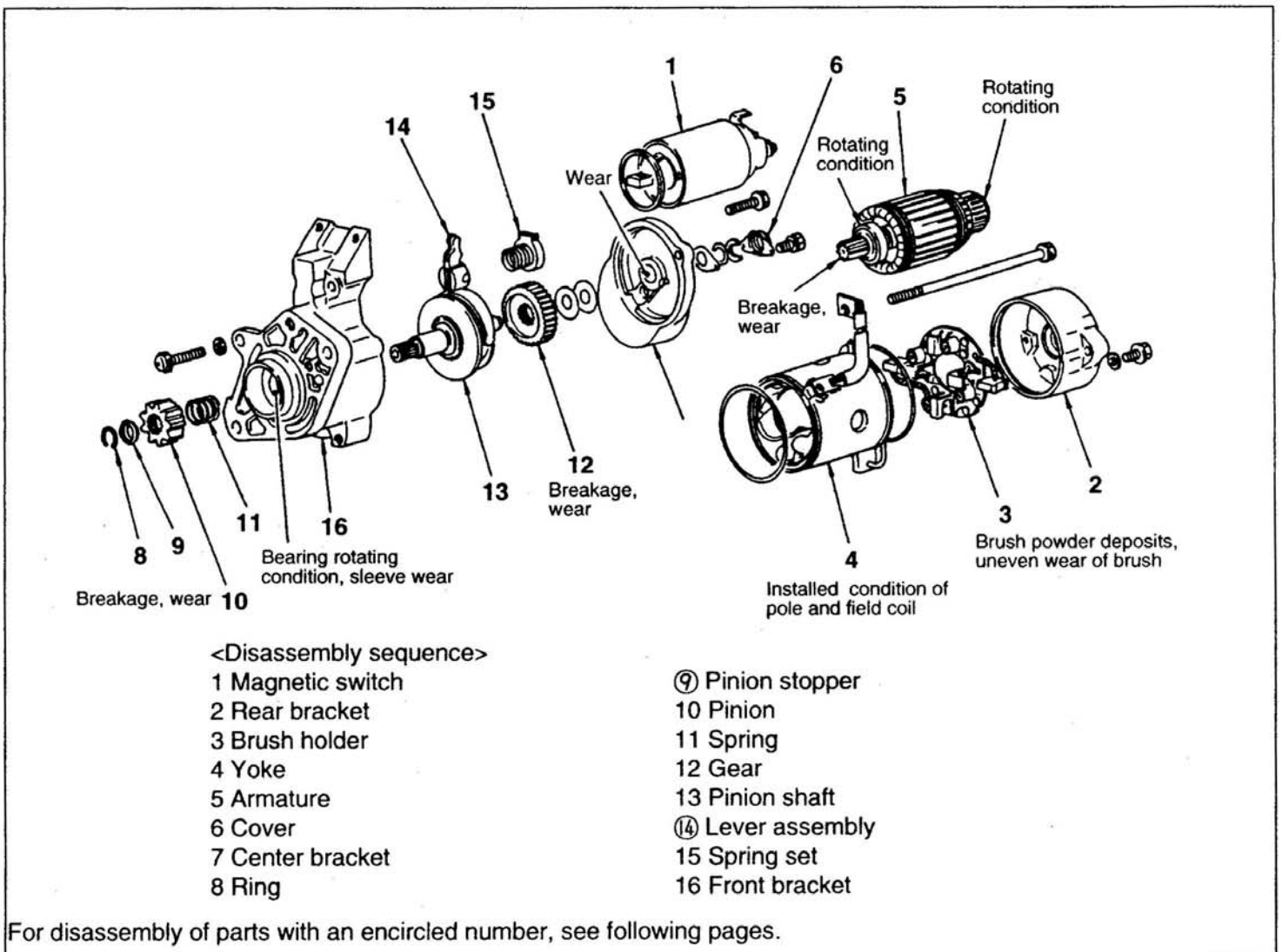
### 5.1 STARTER

#### 5.1.1 Removal and Installation

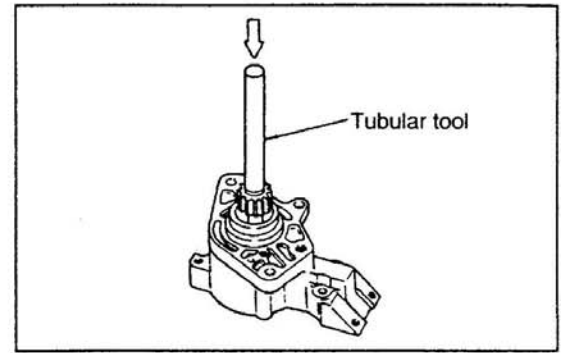
Remove the starter from the rear plate and FLY wheel housing.



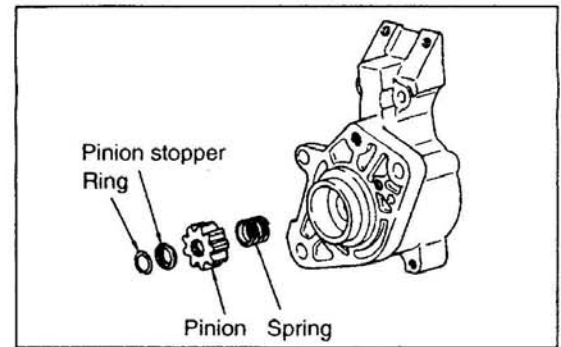
#### 5.1.2 Disassembly



- (1) Do not remove the bearings on both ends of the armature unless defective.



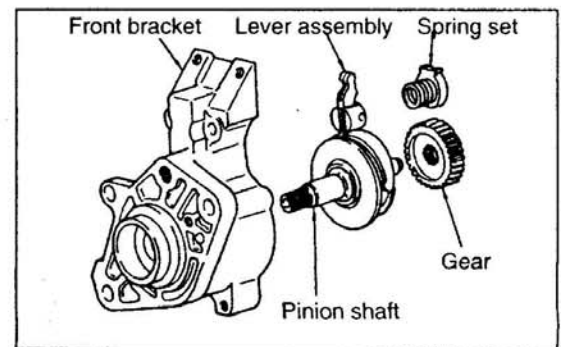
- (2) Apply a tubular tool to the pinion stopper and tap it with a hammer until the pinion stopper comes off position to the clutch side.



**NOTE:**

If the pinion stopper cannot be removed, deburr the groove in the pinion shaft.

- (3) Note the installed direction of the level to avoid wrong reassembly.



**5.1.3 Inspection and Correction**

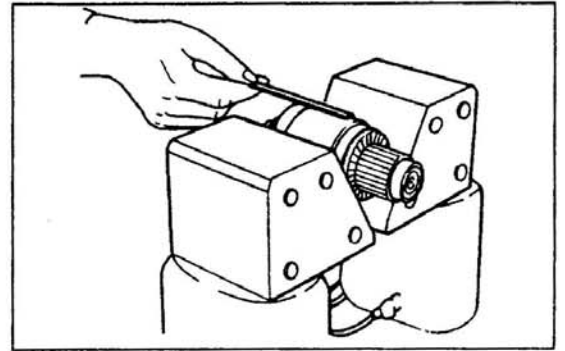
Short circuit test	Commutator O.D.
Coil earth test	NV 32
	L 31
Commutator runout	Depth of groove between bars
L 0.05 or more	L 0.2 or less

NV ... Nominal Value  
 L ... Limit

(1) Armature

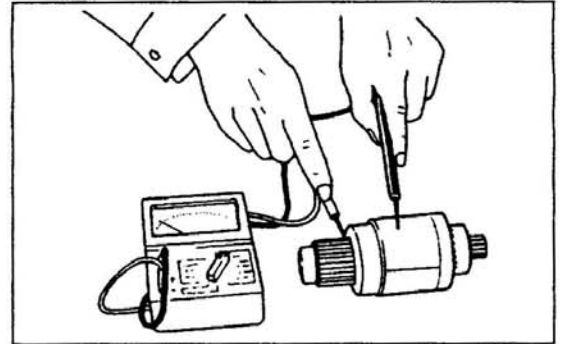
(a) Coil Short Circuit Test

Place the armature on a growler tester. Hold a piece of iron in parallel with the armature and slowly turn armature by hand. If the iron piece is attracted or vibrates, it means there is a short circuit. Replace the armature.



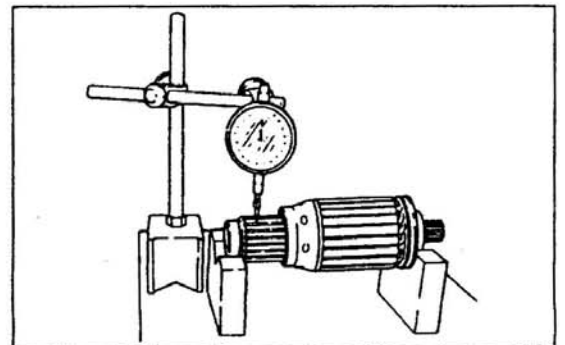
(b) Coil earth test

Check for continuity across the commutator and shaft (or core). If there is a continuity, indicating that the coil is earthed, replace the armature.

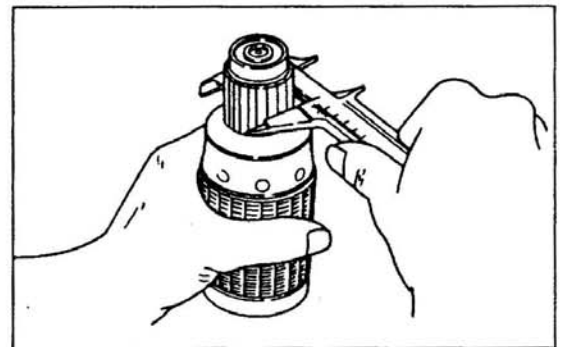


(c) Commutator check

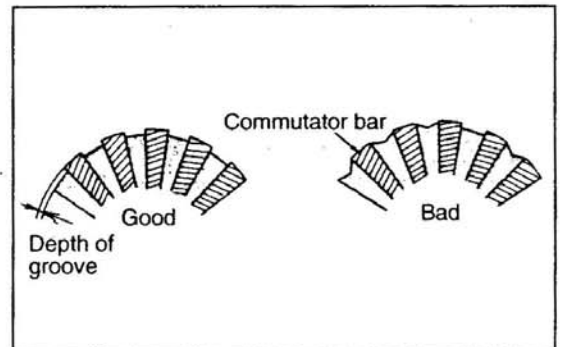
Measure the runout of commutator with a dial gauge. If the runout exceeds the limit, correct, ensuring that the O.D limit is not exceeded. If the commutator surface is rough developing ridge wear, correct with sandpaper (NO. 300 to 500).



(d) Measure the commutator O.D If the measurement exceeds the limit, replace the armature.



(e) Measure the depth of groove between bars. If it does not reach the limit, correct.

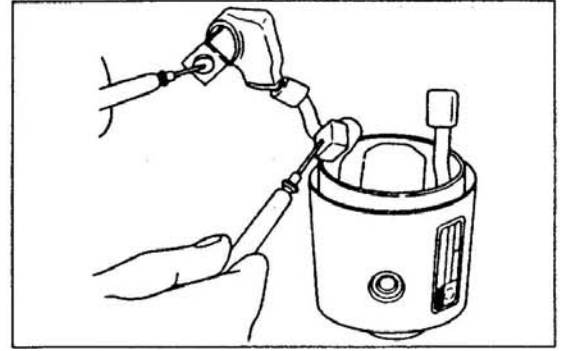


(2) Field coil

(a) Coil open circuit test

Check to ensure that there is continuity between the terminal lead and brush (+).

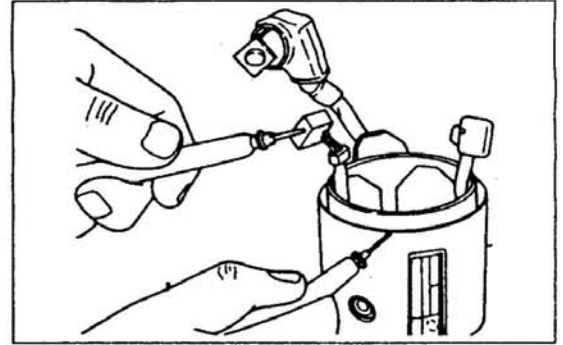
If there is continuity indicating an open circuit, replace the yoke assembly.



(b) Coil earth test

Check to ensure that there is no continuity between the yoke and brush(+).

If there is continuity indicating that the coil is earthed, check for poor insulation. If repair is impossible, replace the yoke assembly.



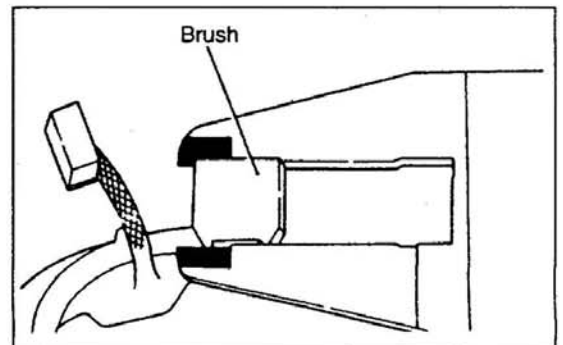
(3) Brush and brush Holder

(a) Brush Wear

Measure the brush length and, if the measurement is less than the limit, replace the brush.

If the brush is unevenly worn or develops rough surfaces, correct with sandpaper (NO. 300 to 500).

**NOTE:Correct the brush contact surface to a curve of the commutator.**

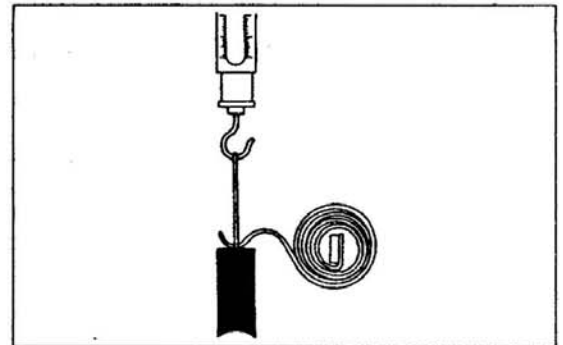


(b) Brush spring pressure

Measure the installed load of the brush spring.

Using a new brush, read the load at the moment the spring leaves the brush.

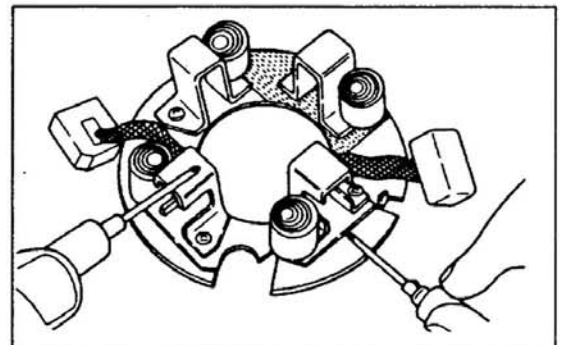
If the spring pressure is below the limit, replace the spring.



(c) Brush holder Insulation test

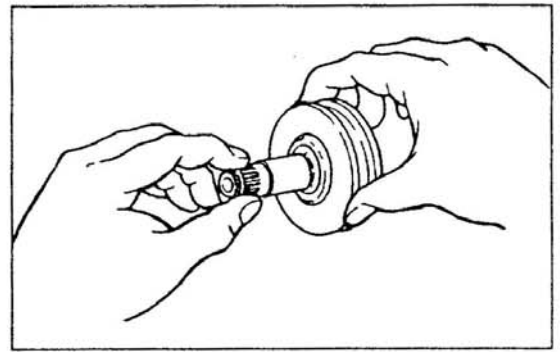
Check to ensure that there is no continuity between the (+) brush holder and (-) holder plate.

If there is continuity, replace the brush holder.



(4) Overrunning clutch

Check to ensure that the pinion shaft turns smoothly when turned in the drive direction (clockwise) and locks when turned in the opposite direction (counter clockwise). If the pinion shaft does not properly rotate, replace the overrunning clutch.



(5) Magnetic Switch

Perform the following continuity tests and, if any faulty condition is evident, replace the magnetic switch.

(a) Coil open circuit test

Check to ensure that there is a continuity across SM terminals, and S terminal and ground.

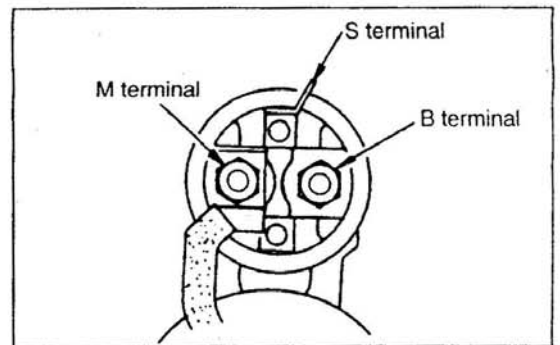
(b) Fused Contact Check

Check to ensure that there is no continuity across and M terminals.

(c) Loose Contact test

Check to ensure that voltage drop across contacts small.

If a large voltage drop involves, it means that contacts are defective.



(6) Replacement of Front Bearing

If the front bearing is defective, replace it by the following procedure.

Bearing replacement procedure

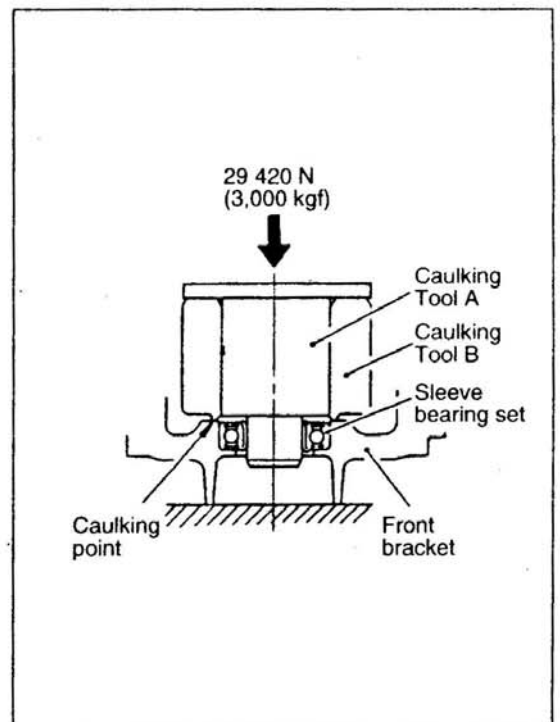
After replacing the bearing, use Caulking Tools A and B (special tools) to caulk the bearing two times. (Since one caulking operation can provide caulking at four points, two caulking operations will provide caulking at eight points.)

A caulking load of 29 420 N (3000 kgf) (static load) is applied.

After caulking, make sure that the bearing turns lightly.

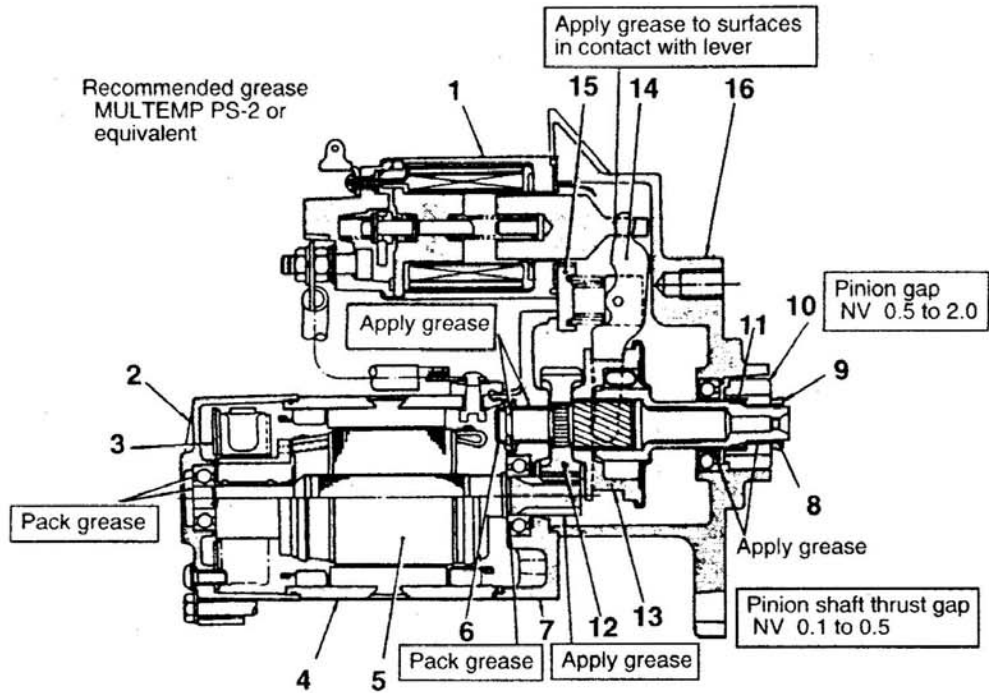
**NOTE:**

**Bearing replacement by the abovementioned procedure shall be made only once.**





## 5.1.4 Reassembly



NV ... Nominal Value

<Assembly sequence>

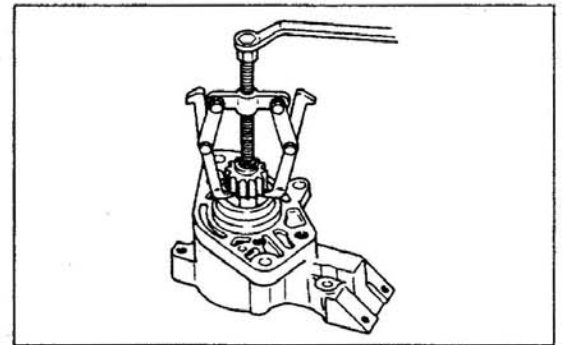
16 → 15 → 14 → ⑬ → 12 → 11 → ⑩ → 9 → 8 → 7 → ⑥ → ⑤ → ④ → ③ → ② → ①

For Reassembly of parts with an encircled number, see following pages.

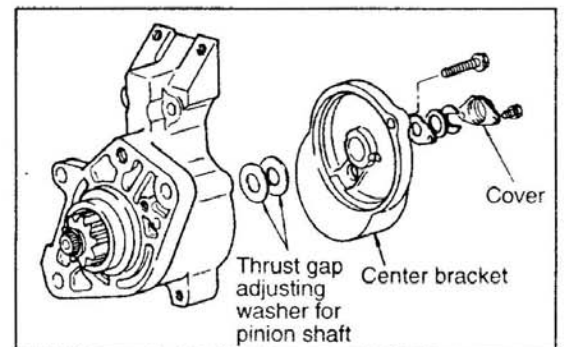
**NOTE:**

**Ensure Correct installation direction for the lever assembly.**

- (1) To install the pinion, pass the pinion shaft through front bracket. Then, with the spring, pinion, and pinion stopper mounted and the ring fixed to the pinion shaft groove, pull the pinion or pinion stopper toward ring to fix in position.



- (2) Adjustment of pinion Shaft Thrust Gap  
Measure the thrust gap with the following procedure and, if the measurement is of specification, adjust by using adjusting washers.





(a) With pinion Removed

Mount the gear onto the pinion shaft and pass the shaft through the center bracket.

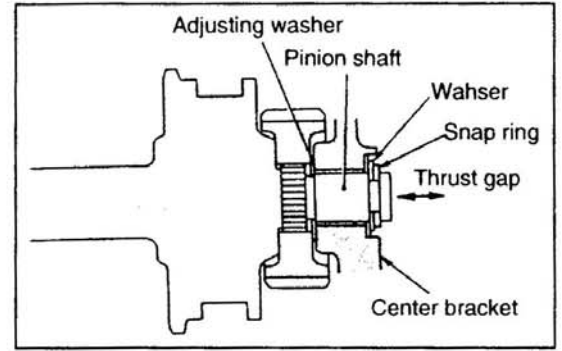
Then, secure the pinion shaft with a washer and snap ring.

Now, move the pinion shaft in the axial direction to measure the thrust gap.

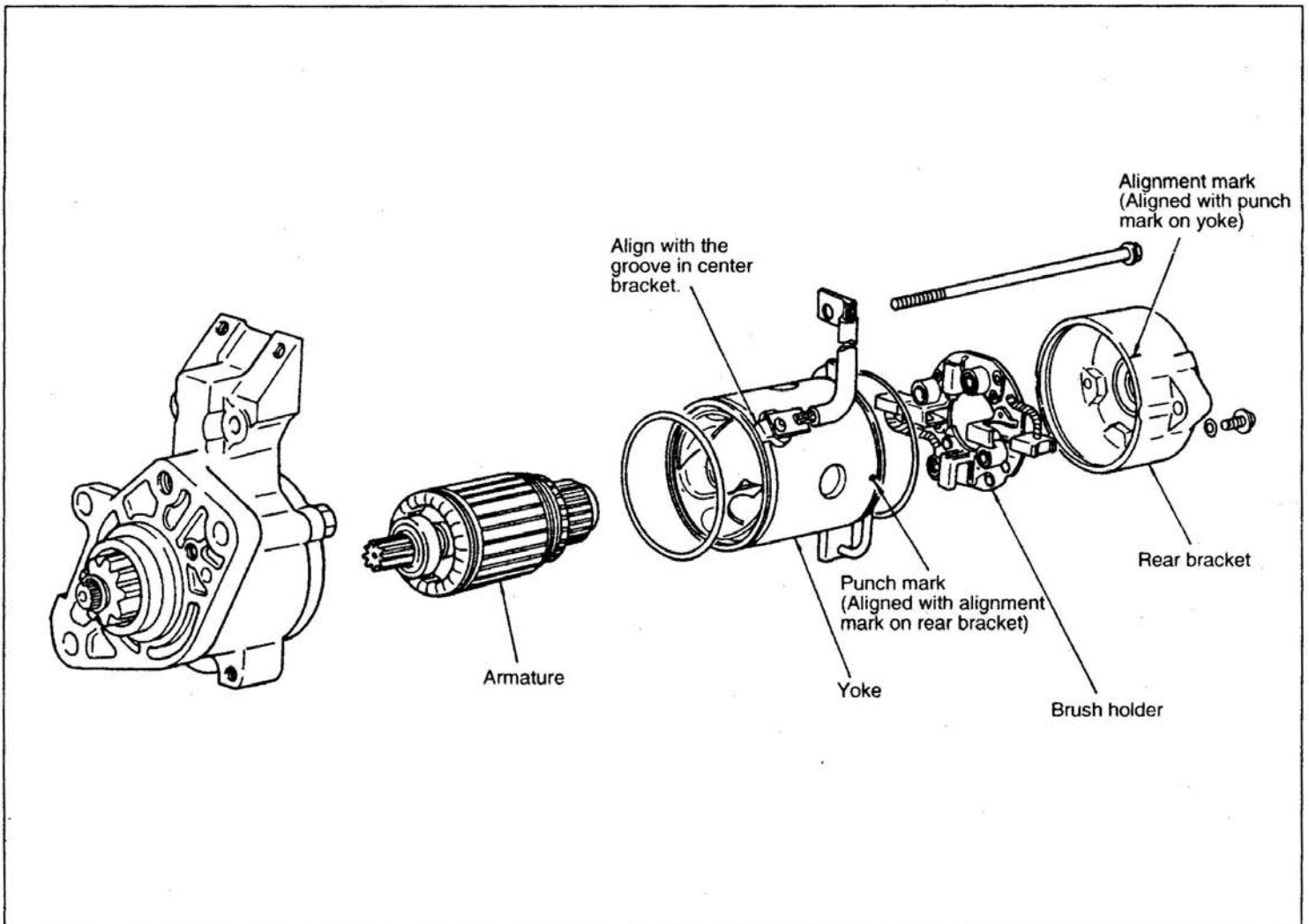
(b) With Pinion Mounted

Temporarily secure the pinion shaft and gear between the front and center bracket with attach bolts. Then, adjust the thrust gap by moving pinion shaft in the axial direction.

At the time, lead the spring set removed: the spring set, when installed can cause the center bracket to rise resulting incorrect measurement of the thrust gap.



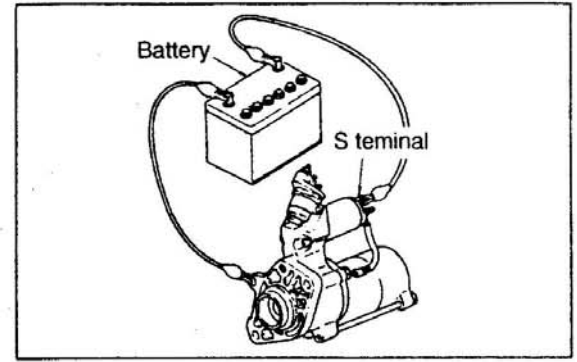
(3) Assemble by lining up alignment marks.



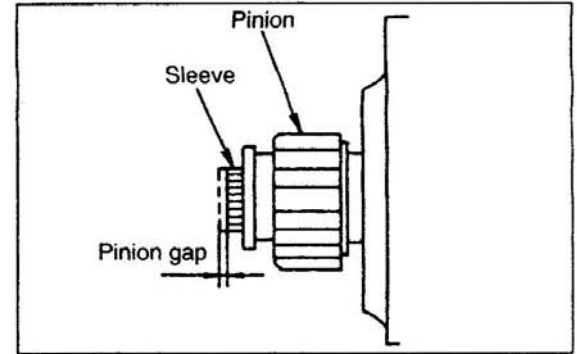
### 5.1.5 Adjustment and Test after reassembly

#### (1) Adjustment of pinion Gap

When the reassembled starter is wired as shown, the pinion comes out rotating. When the M terminal is disconnected, the pinion stops rotating, being held in the out position.



Then, push the sleeve lightly back and measure the backward travel (movement), which is the pinion gap. Adjust by varying the number of packings in the magnetic switch to obtain the nominal value for the gap. To reduce the pinion gap, use a greater number of packings.



#### (2) Test

Set up a circuit as shown check for no characteristics.

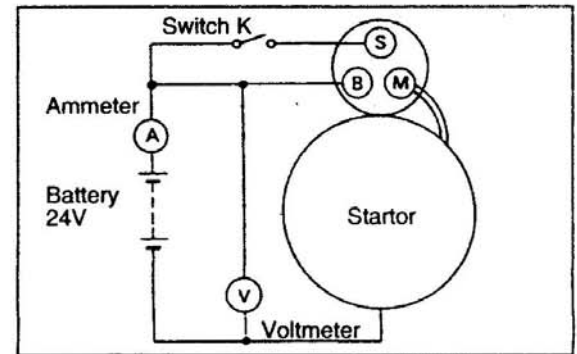
<24 V type unit>

No-load characteristics	Voltage	23 V
	Current	80 A or less
	Rotating speed	3 400 rpm or more

<12 V type unit>

No-load characteristics	Voltage	11 V
	Current	130 A or less
	Rotating speed	4 000 rpm or more

Magnetic switch operating voltage	16 V or less
-----------------------------------	--------------



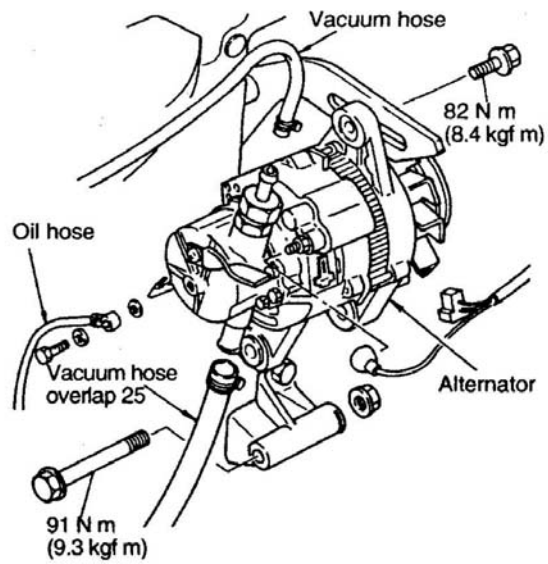
#### NOTE:

1. Use wires as thick as possible tighten all terminals securely.
2. The reduction gear built into the starter produces high rotating sound at load.
3. If the starter is operated for a long period, the battery will run down resulting in reduced rotating speed. Do not operate the starter for more than 10 to 15 seconds at one time.

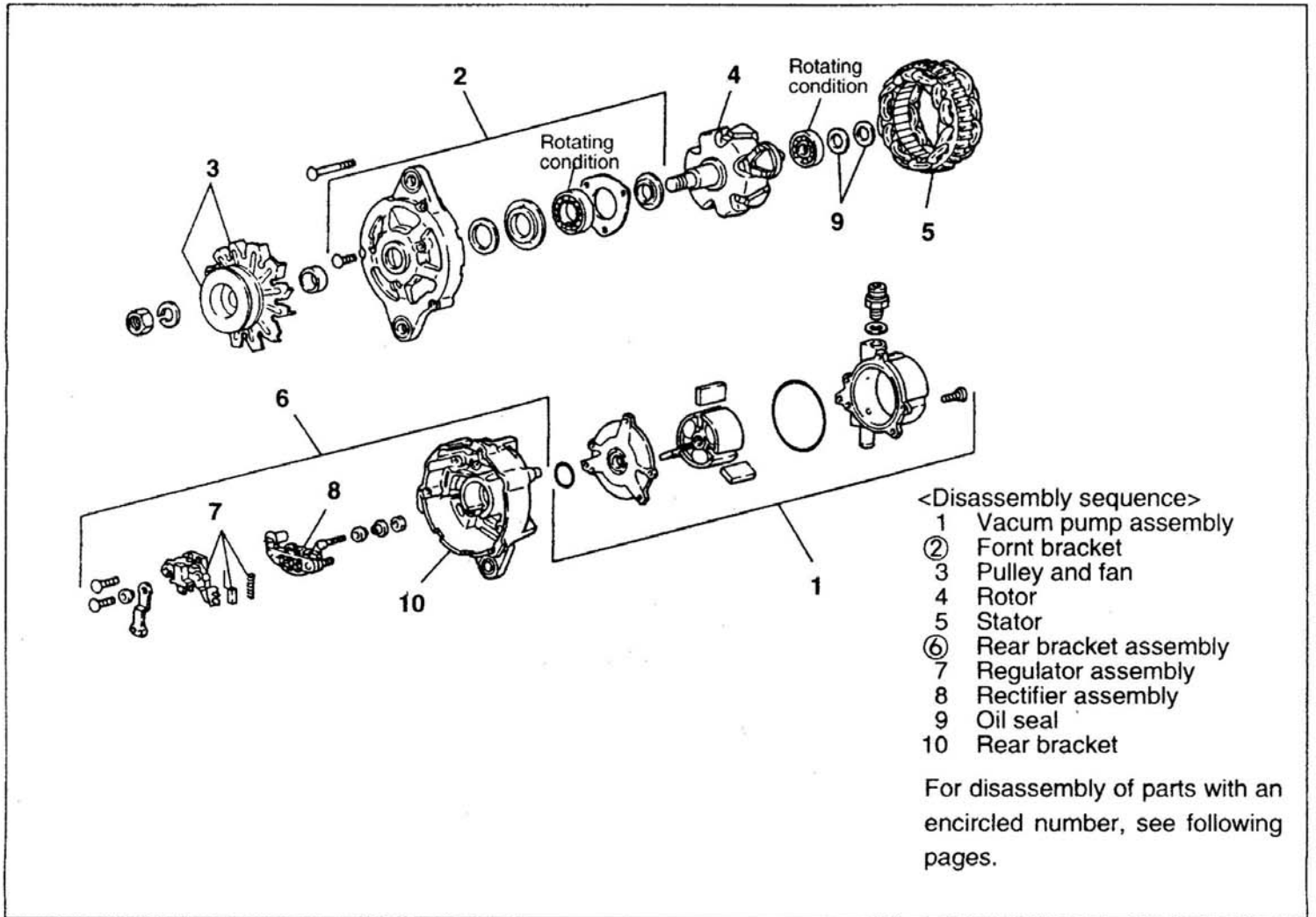
## 5.2 ALTERNATOR

### 5.2.1 Removal and Installation

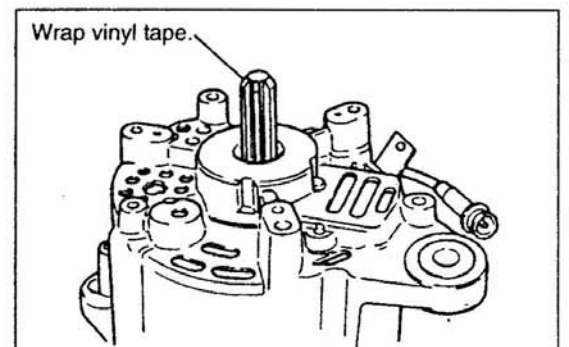
Remove the alternator, oil hose, vacuum hose, and other parts.



## 5.2.2 Disassembly



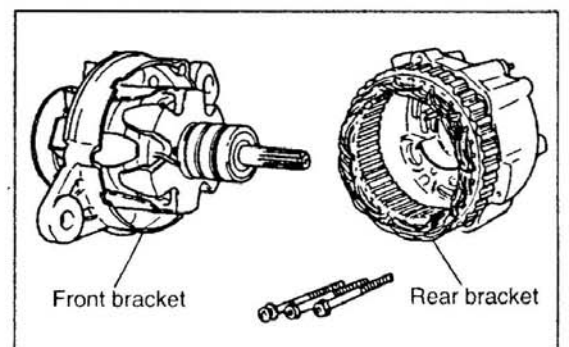
(1) Remove the vacuum pump.



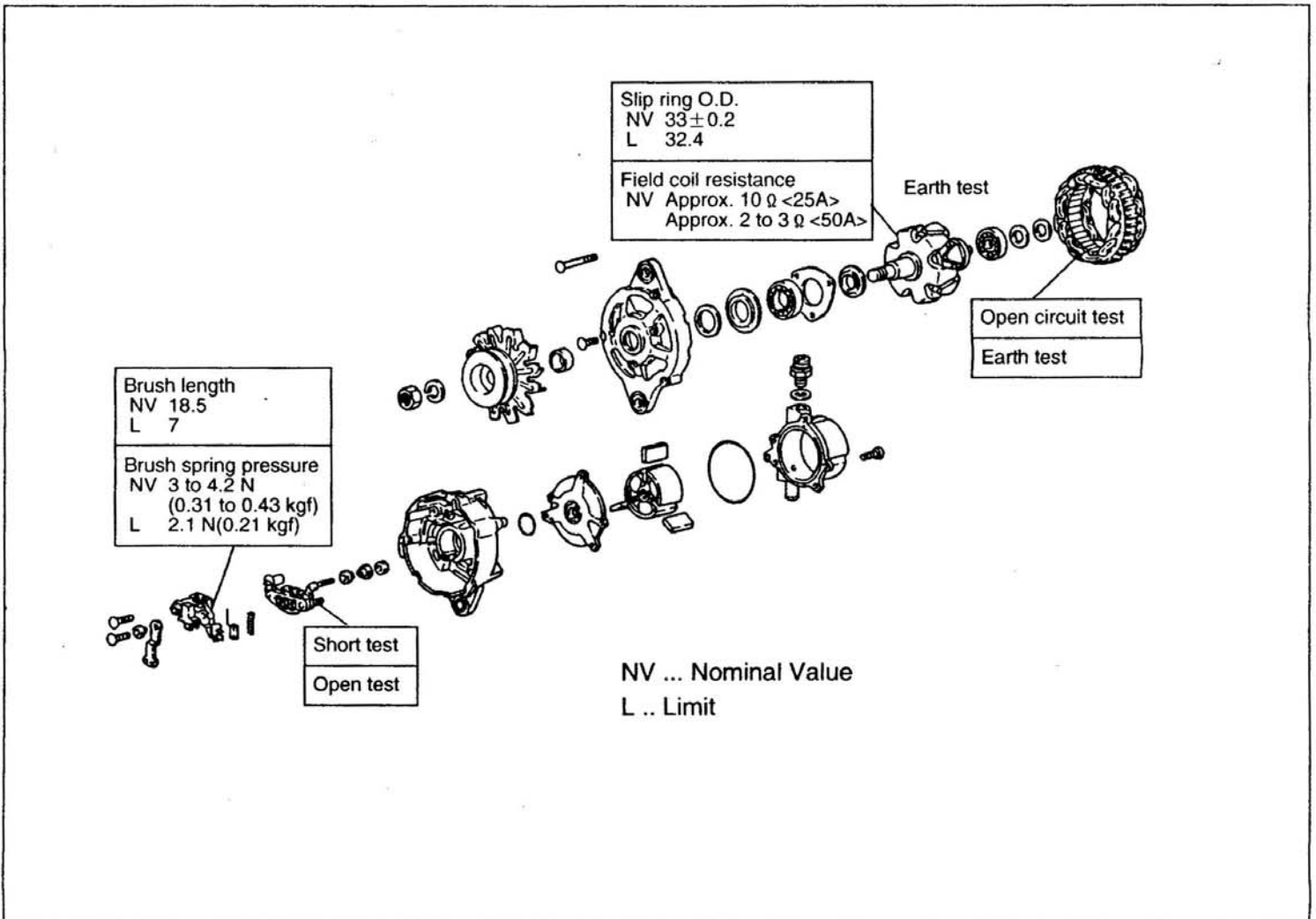
(2) When disconnecting the front from rear bracket wrap vinyl tape around the shaft splines to prevent damage to oil seal lips.

**NOTE:**

Use care not to lose the spring installed in the outer periphery of the bearing on the rear end.

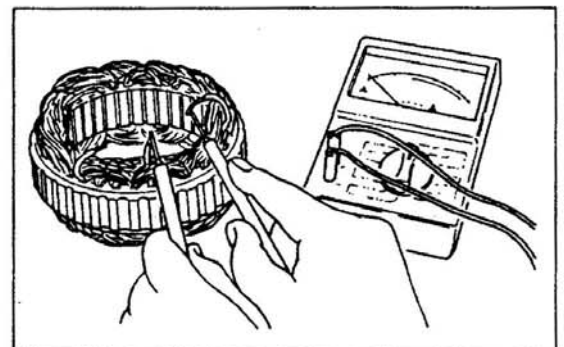


### 5.2.3 Inspection and Correction



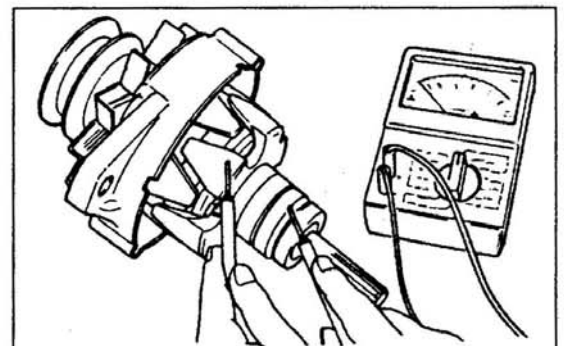
#### (1) Stator

Check that there is continuity across the stator leads.  
If there is no continuity indicating a broken wire, replace the stator. Check that there is no continuity across the stator leads and core. If there is, replace the stator as it is earthed.

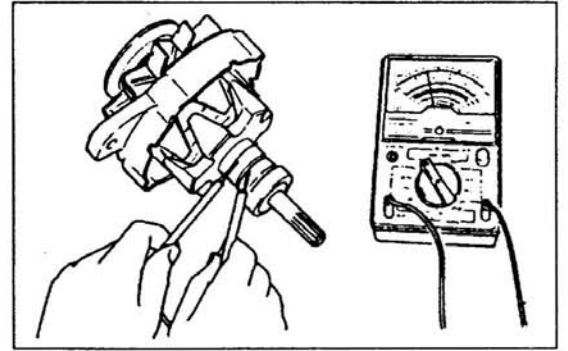


#### (2) Rotor

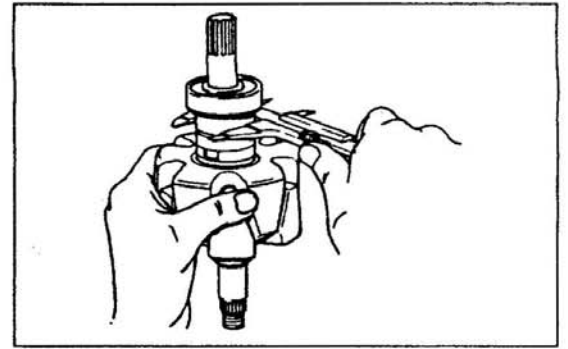
(a) Check that there is no continuity between the slip ring and core. If there is, replace the rotor.



(b) Measure the resistance across slip rings. Replace the rotor if the resistance is not within the specification.

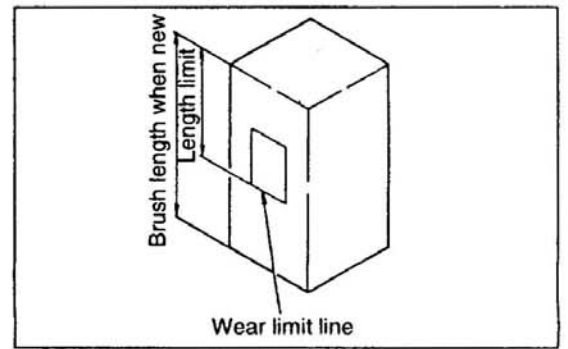


(c) If the slip ring has rough surface or is unevenly worn, correct with sandpaper or lathe. Correction must be made within the limit of slip ring O.D.

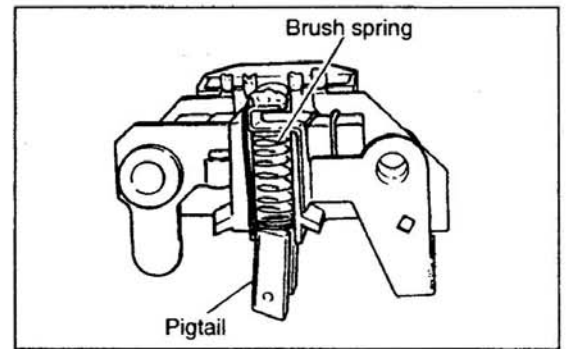


### (3) Brush

(a) Replace the brush if it is worn beyond the limit.



(b) When a brush has been replaced with a new one, push it in to measure the brush spring pressure. If the spring pressure is lower than the limit, replace the brush spring.



(c) Replacement of Brush and Brush Spring.

The brush and brush spring can be removed by unsoldering the pigtail.

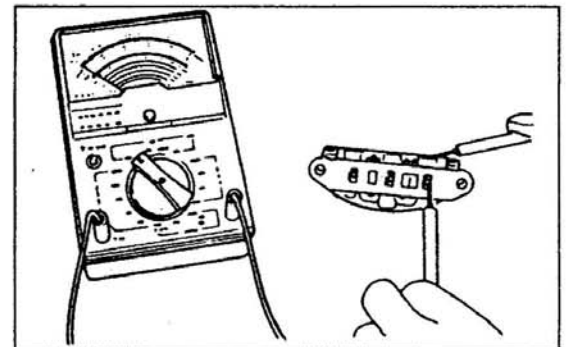
### (4) Diode

(a) For each diode, check the resistance across of leads and heat sink.

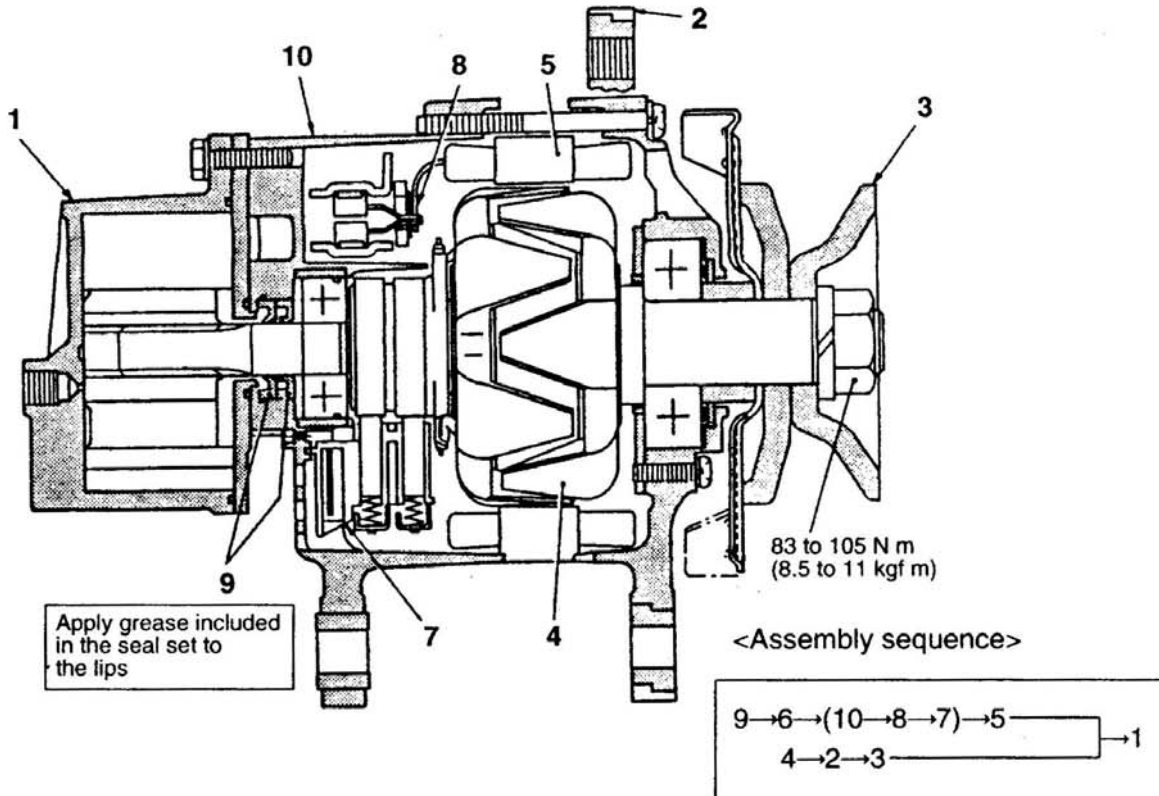
(b) Make the check in two modes, by connecting positive (+) lead of multimeter to the diode and negative (-) lead to the diode.

(c) The diode is open if the resistance is infinite in both cases.

(d) It is shorted if the resistance is almost 0 in both cases. Replace the rectifier if the diode is open or shorted. For the diode trio, check resistance across leads.



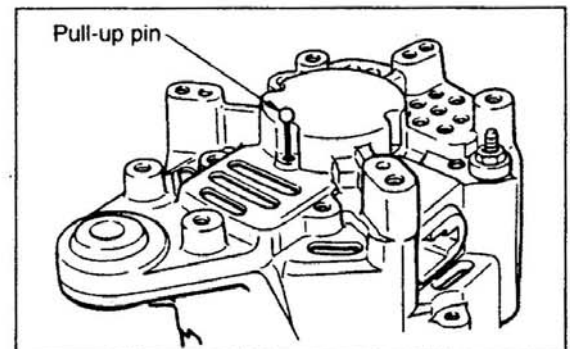
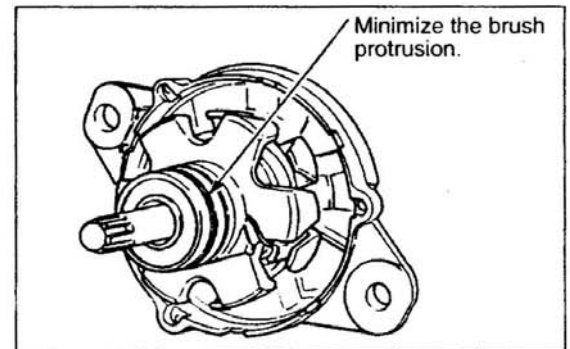
## 5.2.4 reassembly



When installing the lock spring into the eccentric groove in the outer periphery the rear bearing, ensure that the maximum protrusion rests in the deepest parts.

### NOTE:

1. When installing a new bearing, make sure that the groove on its outer periphery is positioned on the spring end.
2. Push the brush into the brush holder and secure with the brush pull-up pin. After reassembly, be sure to remove the pin.

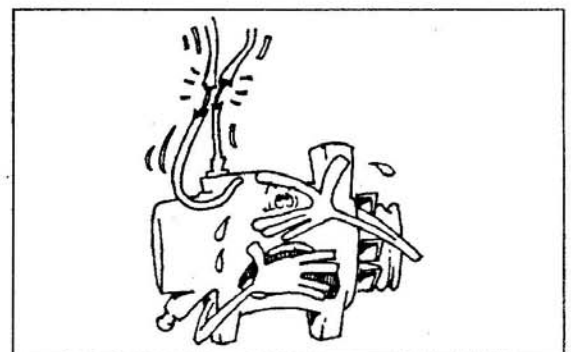
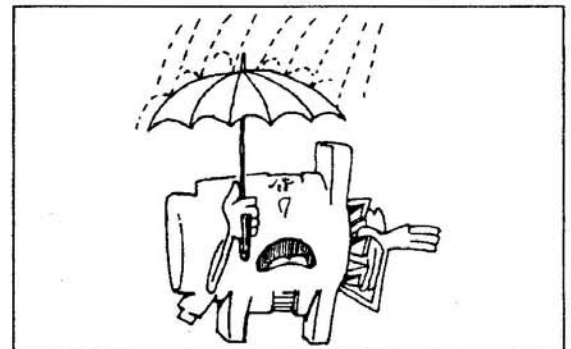
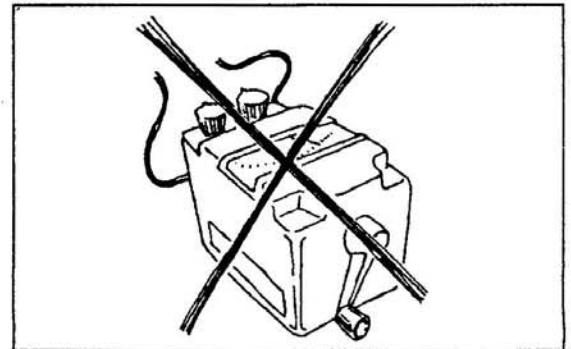
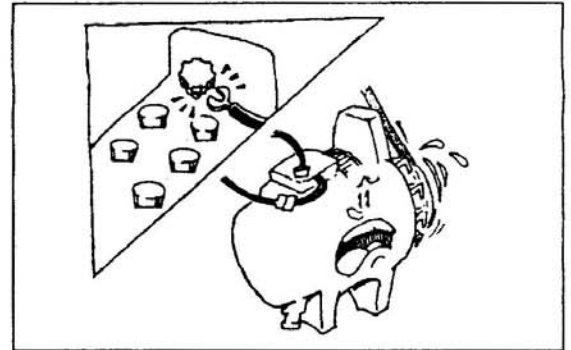
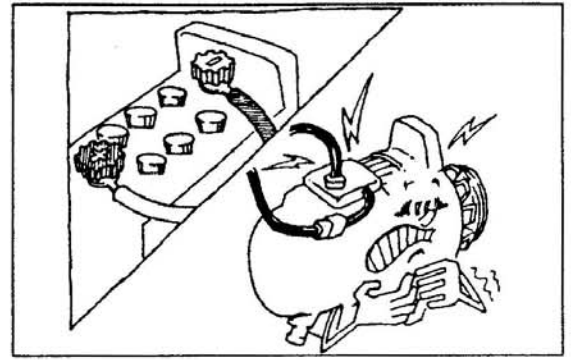


## 5.2.5 Tests

### Handling Precautions

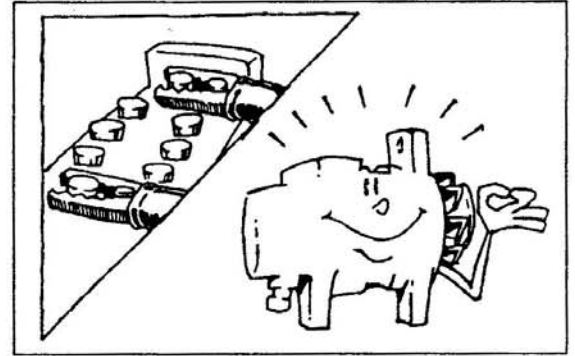
When servicing the alternator, observe the following precautions.

- (1) If the polarity of the battery is reversed when connections are made, a large current flows from the battery to alternator, damaging the diode and IC regulator.
- (2) Do not disconnect the battery terminal connections while the engine is running, or a surge voltage develops deteriorating the diode and regulator.
- (3) Do not use a megger or other high-voltage multimeter, or damaged diode and regulator will result.
- (4) When a steam cleaner is used, take adequate measures to prevent direct exposure of the alternator to the steam.
- (5) operating the alternator with its B and L terminals shorted results in the damaged diode trio.





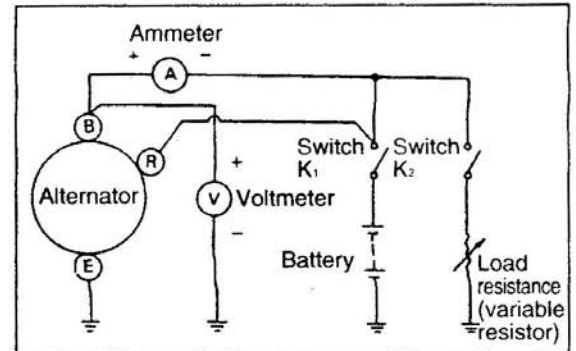
- (6) When quick-charging the battery with a quick charger, be sure to disconnect terminal connections in advance. otherwise, a damaged diode and regulator will result.



### Performance Test (on test bench)

With the load resistance set at maximum (meaning that there is almost no load current flowing), close switches  $K_1$ , and  $K_2$ .

While gradually increasing the alternator speed to reduce the load resistance, measure the current value with the specified terminal voltage and speed. If the measurement is below the specification, check alternator parts.



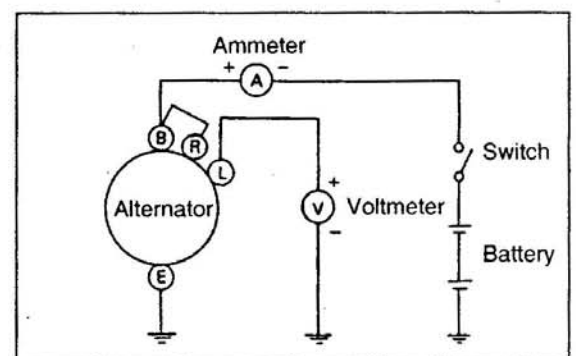
<Load characteristics>

Alternator	25 A type unit	
Terminal voltage	27V	27V
Current	14 A or more	22 A or more
Rotating speed	1,500 rpm	2,500 rpm

### IC Regulator Regulated Voltage Test (On test bench)

Use a fully-charged battery.

Turn on the switch and gradually increase the alternator speed up to 5000 rpm. Check that the current value at this speed is 5 A or less. The regulator is in good condition if the regulated voltage under this condition is within specification. If not, replace the regulator assembly as the regulated voltage is not readjustable.

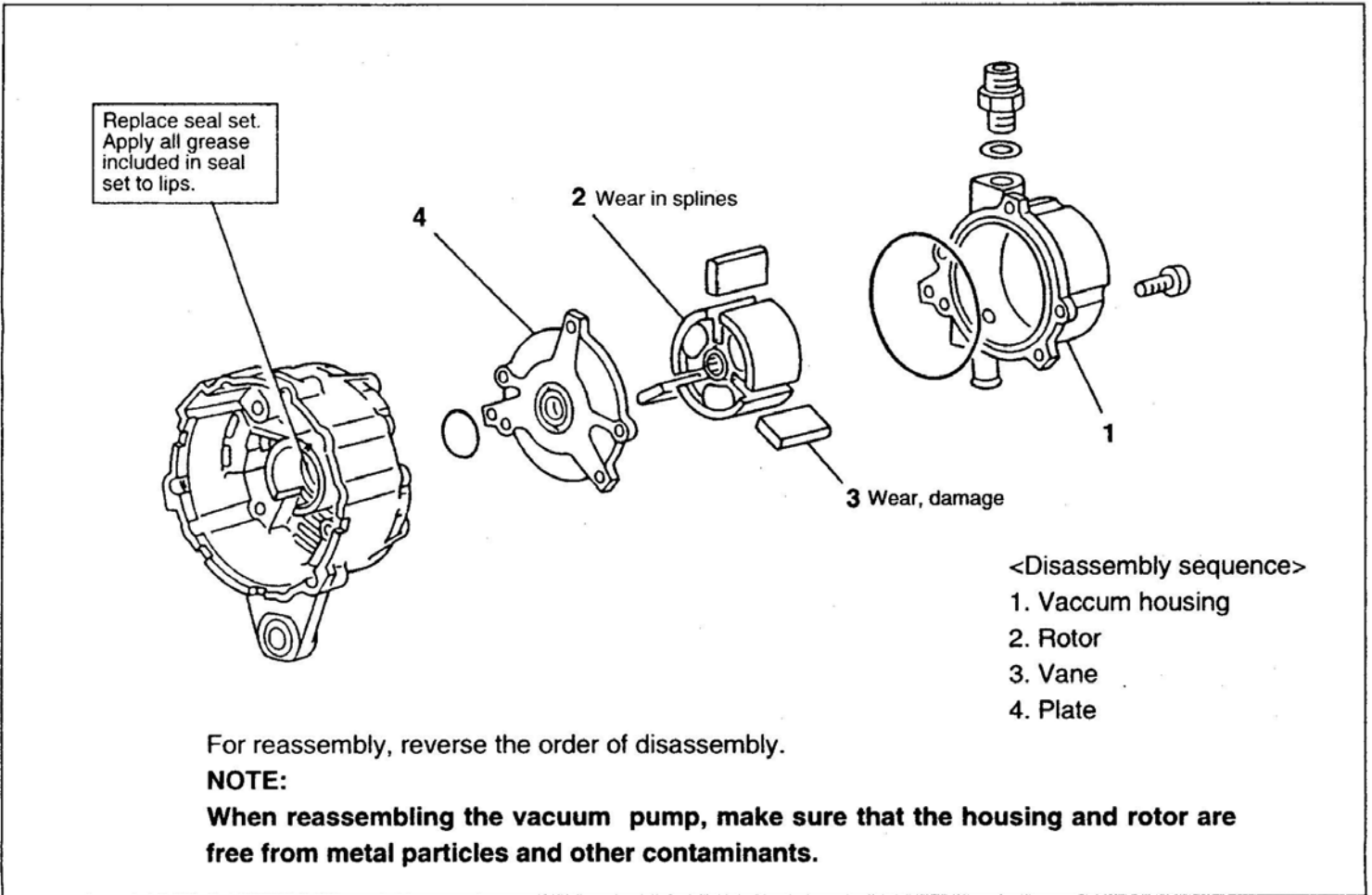


IC regulator regulated voltage

28 to 29 V (24 V type: 25 A alternator)	Measured across terminals L and E at 5,000 rpm, load 5 A or less
13.9 to 14.7 V (12 V type: 50 A alternator)	

## 5.3 VACUUM PUMP

### 5.3.1 disassembly, Inspection and Reassembly

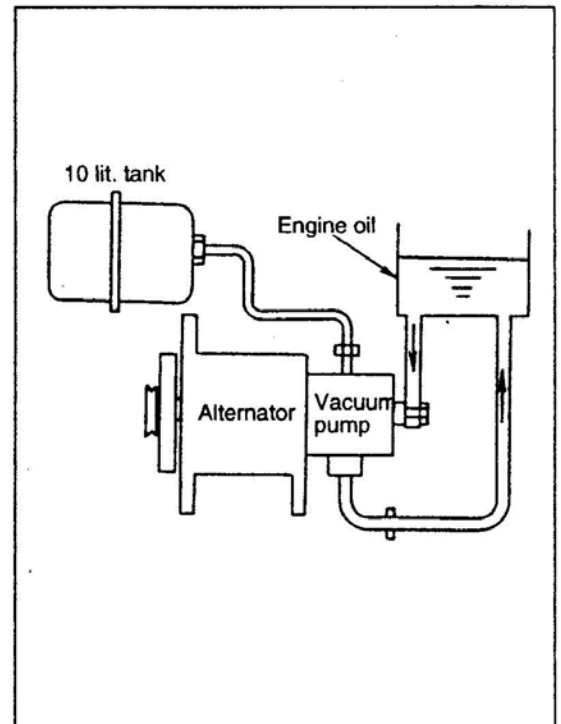


### 5.3.2 Test

If the performance is below standards, check hose joints for tightness and the amount of oil supplied.

Then, recheck. If poor performance is still persistent, check vanes for chips; housing, rotor, and rear bracket mating surfaces for scratches; and, oil seals and check valves. Replace parts if defective.

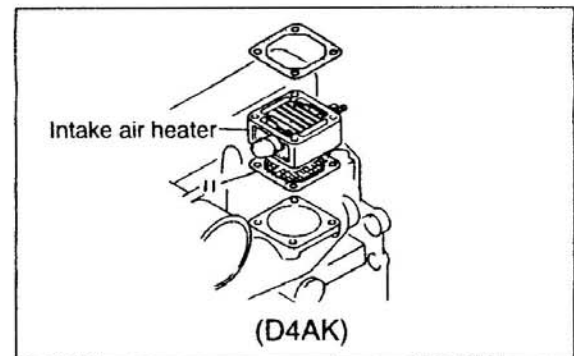
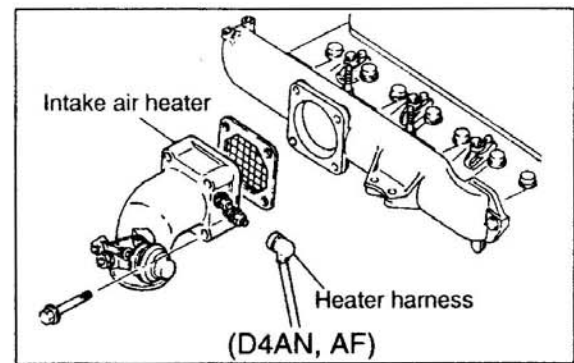
Maximum attainable vacuum		Vacuum	91 kPa(680 mmHg) or more
		Rotating speed	3,000 rpm
Deliver characteristics after 20 sec.(with 10 lit. tank)	At low speed	Vacuum	67 kPa(500 mmHg) or more
		Rotating speed	1,500 rpm
	At high speed	Vacuum	77 kPa(680 mmHg) or more
		Rotating speed	3,000 rpm



## 5.4 PREHEATING UNIT

### 5.4.1 Quick-heating Air Heater System

#### (1) Removal and Installation

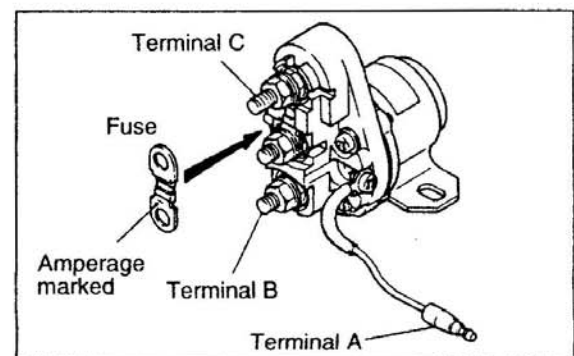


#### (2) Inspection of heater relay

Check to see if there is continuity between terminals B and C when an excitation current 2.3 A (24V) is applied across terminal A and body ground.

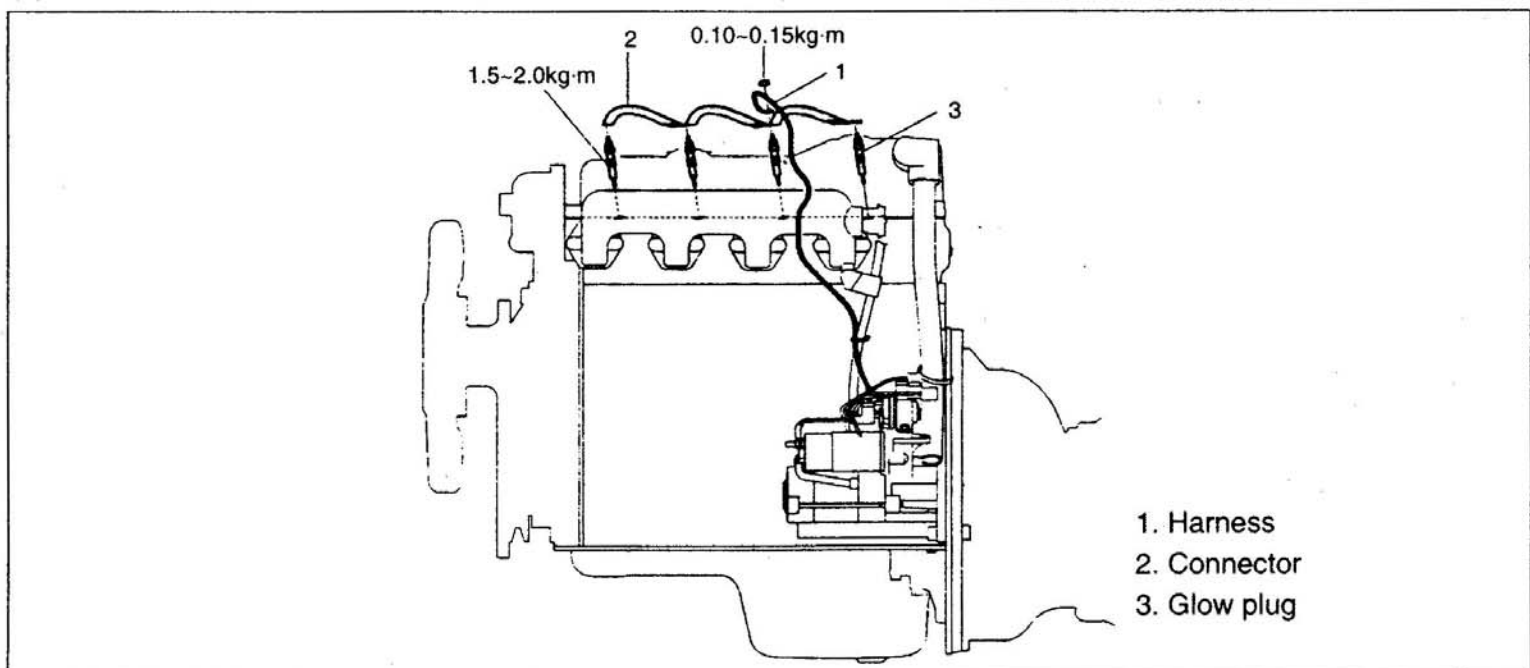
Check heater relay fuse and, if the fuse is blown, isolate the cause of trouble and replace the fuse.

Note the ampere stamped on the fuse at replacement.



### 5.4.2 Glow Plug (D4DA, D4AF)

#### (1) Removal and Installation.



(2) Inspection of glow plug

(a) With the starter switch in "G" position, measure time required for the indicator to become red hot.

Nominal value: 15 to 35 seconds

(b) If the measurement is out specification, or if the indicator does not become red hot, make the following checks.

If the specified time is not obtained, measure the resistance of glow plug at normal temperature.

Normal value:

24 V type

3.08 to 3.75  $\Omega$

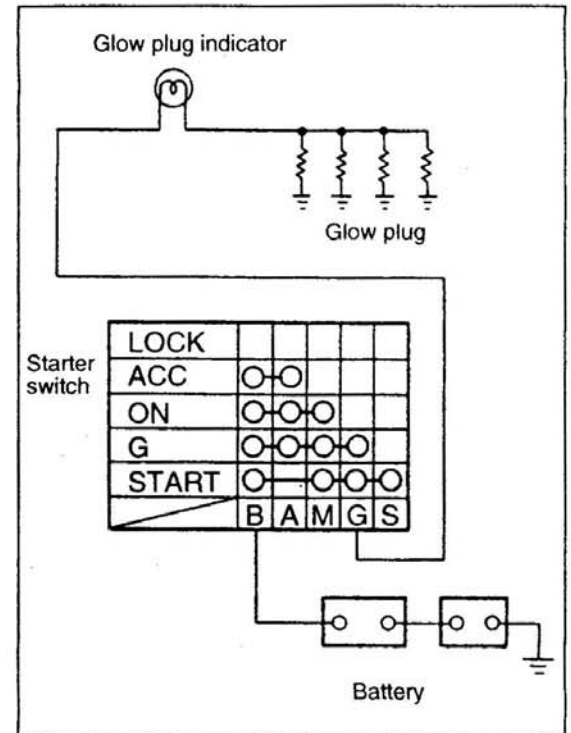
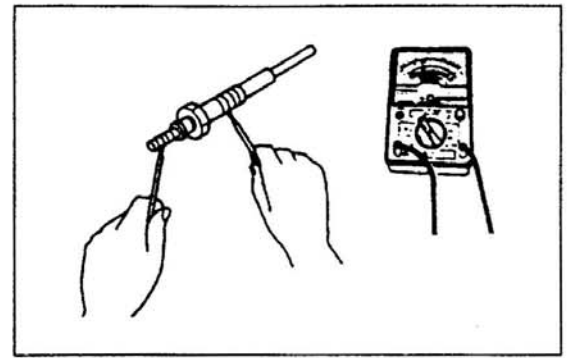
(20.5 V - 6 A  $\pm$  10%)

12 V type

1.14 to 1.39  $\Omega$

(10.5 V - 8.3 A  $\pm$  10%)

If the indicator does not become red hot, check wrings and indicator for broken wires.

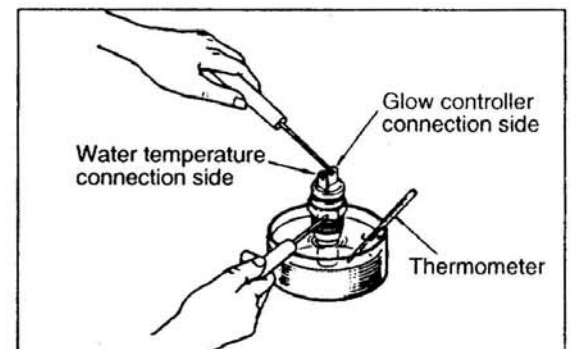


(3) Inspection of water temperature gauge unit.

Place the water temperature gauge unit in a container which contains water in it and measure the resistance when the specified water temperature is reached.

If the measurement is out of specifications, replace the water temperature gauge unit.

Water temperature	Nominal value
50 °C	230 $\Omega$
70 °C	104 $\pm$ 13.5 $\Omega$
90 °C	52 $\Omega$



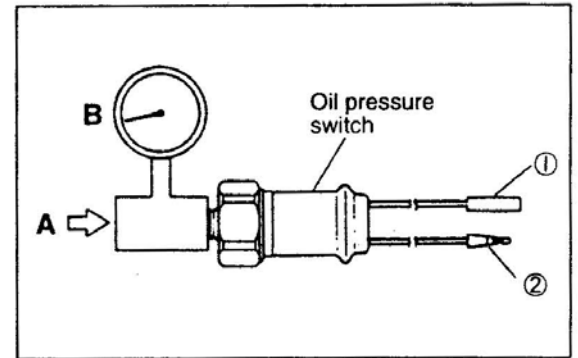
(4) Inspection of engine oil pressure switch

perform the following checks. If defective, replace engine oil pressure switch.

- Under the condition where no air pressure A is applied to engine oil pressure switch, check to ensure that there is continuity between terminals ① and ②.
- Slowly apply air pressure A to engine oil pressure switch, beginning at 0 kpa(0 kgf/cm<sup>2</sup>).

When there is no more continuity between terminals ① and ②, measure the air pressure and check to ensure that the air pressure has the standard value.

**B** : Air pressure gauge

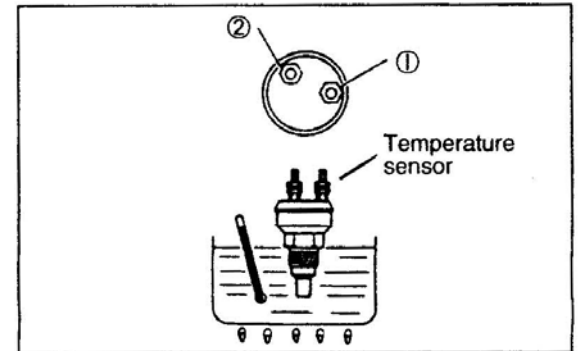


(5) Inspection of coolant temperature Sensor

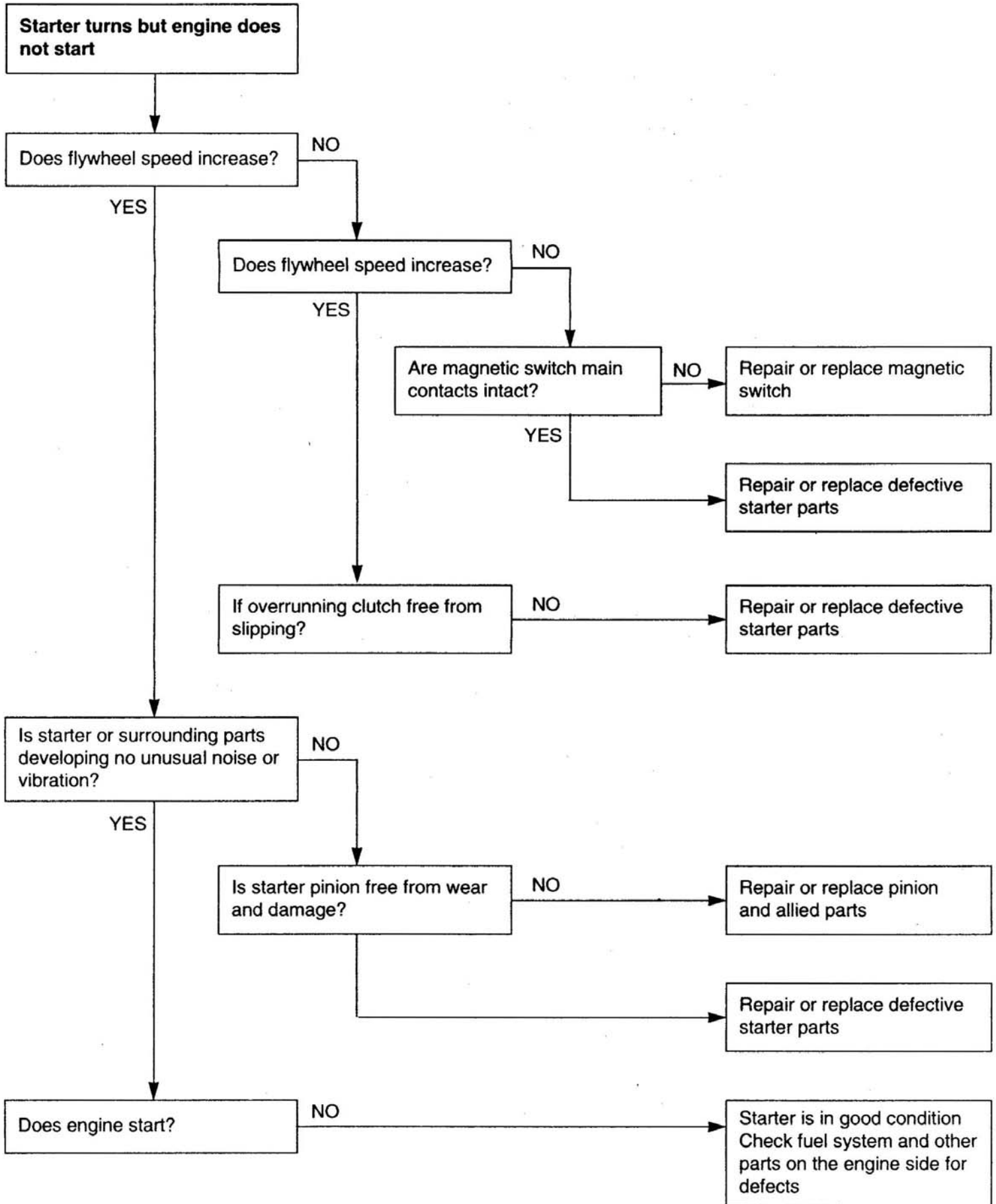
- Put coolant temperature sensor in a container filled with engine oil.
- Before raising the oil temperature, check to ensure that there is no continuity between terminals ① and ②.
- Slowly raise the oil temperature and stir the engine oil well.
- Measure the temperature at the time when there is continuity between terminals ① and ②.
- If the reading is out of the standard value, replace defective parts.

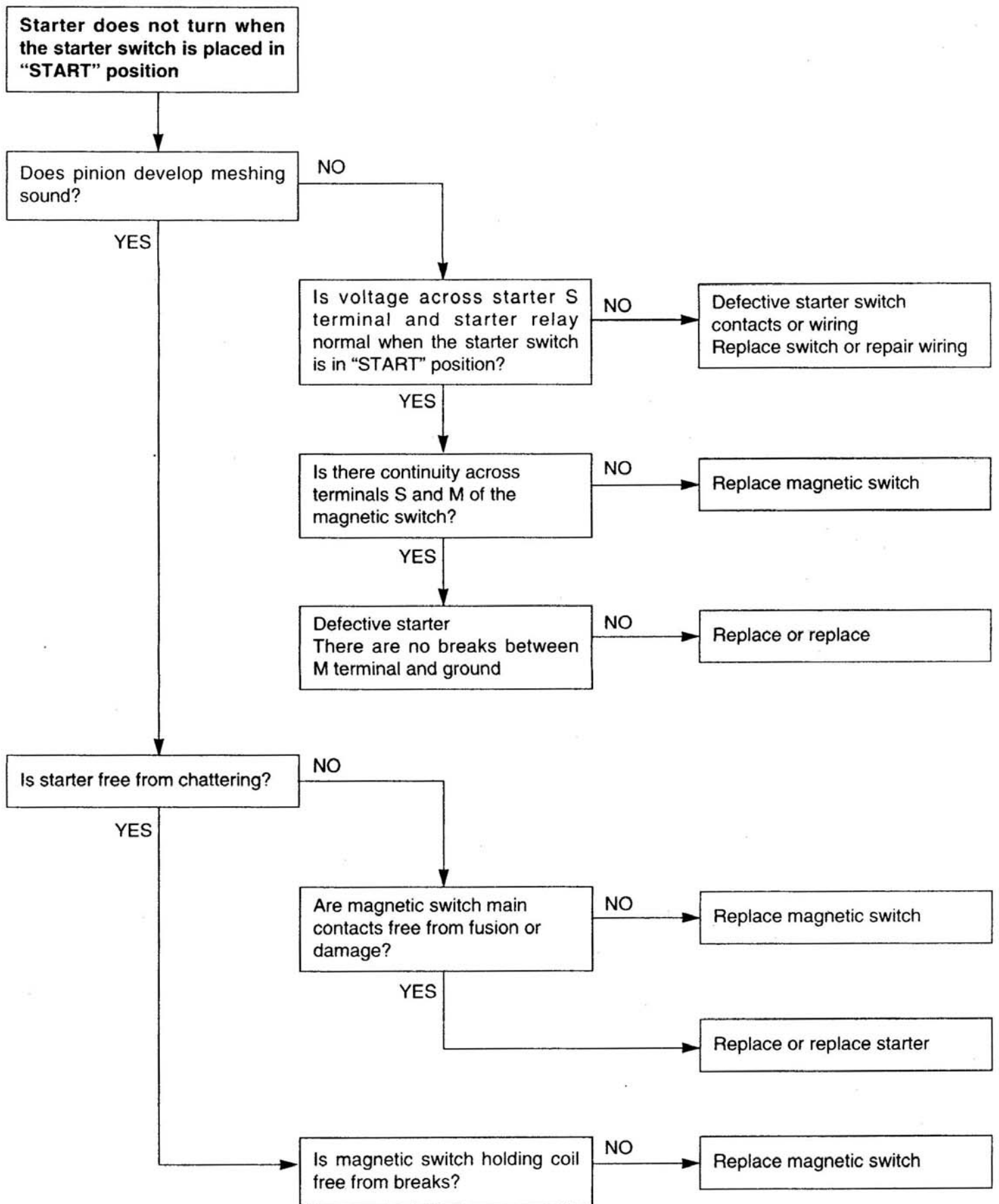
**NOTE:**

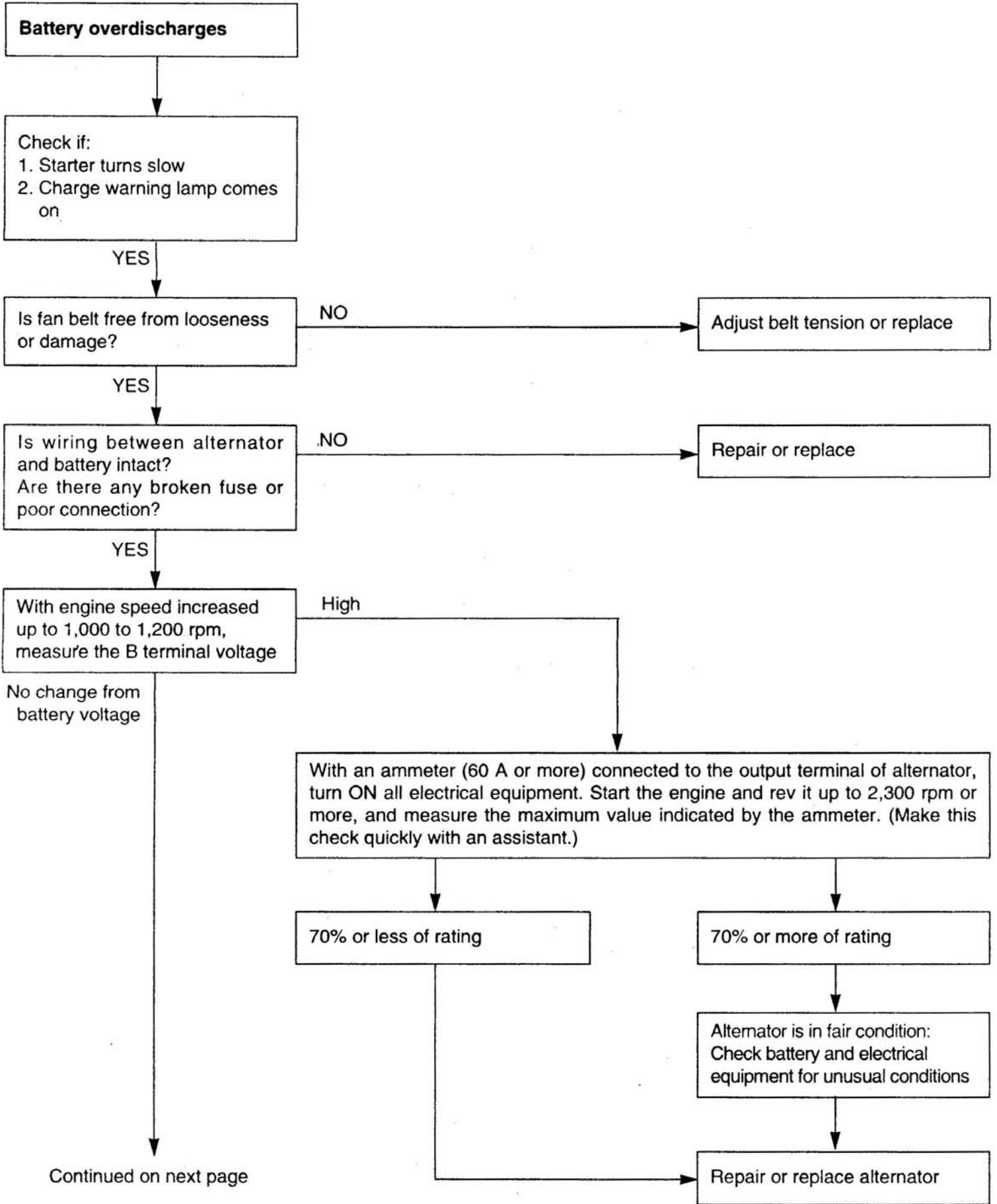
When the oil temperature is near the operating temperature, slowly heat the oil. (When the operating temperature -5℃ is reached, leave it alone for five minutes, and then raise the oil temperature at a rate of 1℃ in two or three minutes.)



## 6. TROUBLESHOOTING

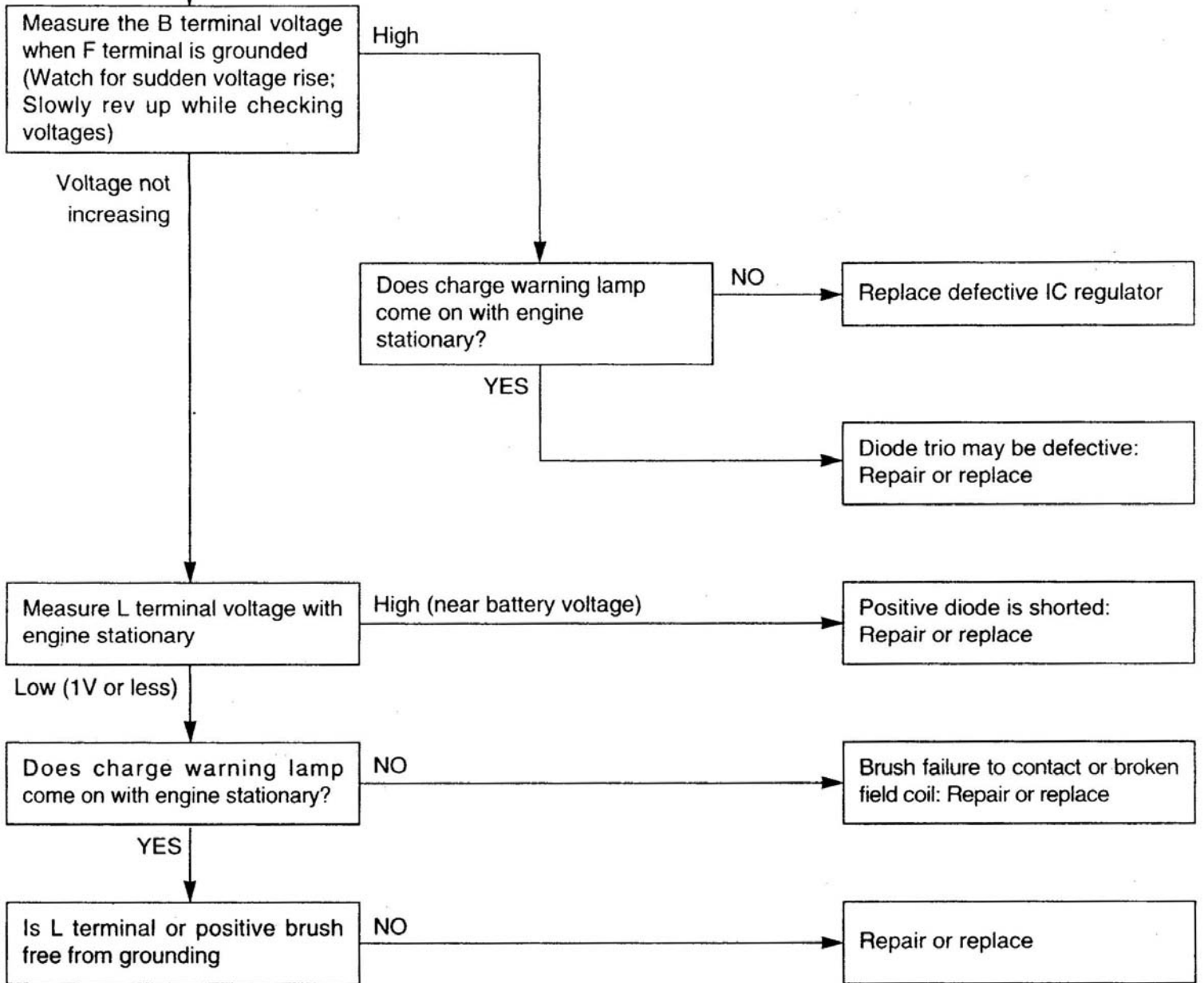


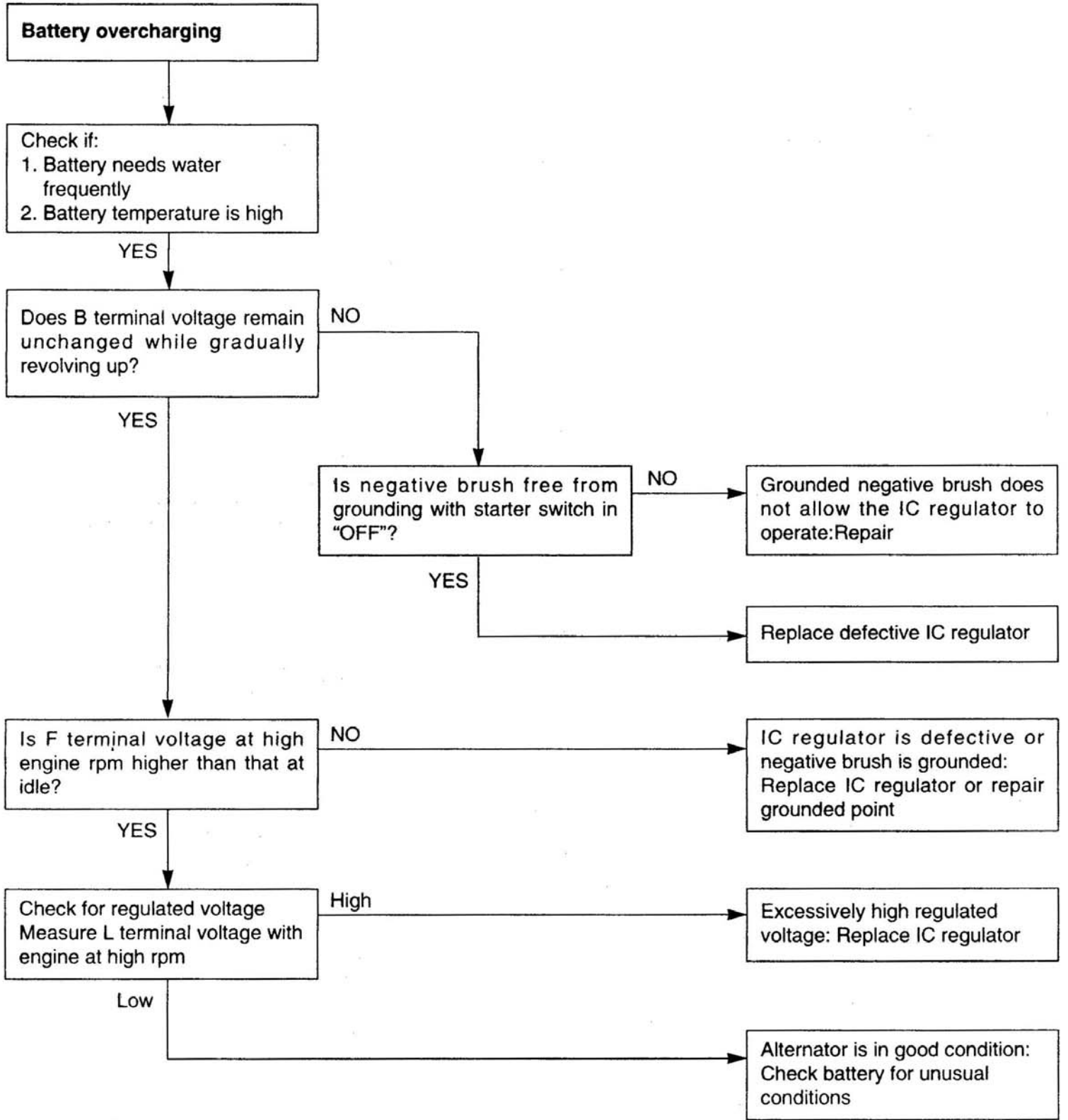






Continued from previous page





**Battery overcharging**

- Check if:
1. Battery needs water frequently
  2. Battery temperature is high

YES

Does B terminal voltage remain unchanged while gradually revolving up?

NO

Is negative brush free from grounding with starter switch in "OFF"?

NO

Grounded negative brush does not allow the IC regulator to operate: Repair

YES

Replace defective IC regulator

YES

Is F terminal voltage at high engine rpm higher than that at idle?

NO

IC regulator is defective or negative brush is grounded: Replace IC regulator or repair grounded point

YES

Check for regulated voltage  
Measure L terminal voltage with engine at high rpm

High

Excessively high regulated voltage: Replace IC regulator

Low

Alternator is in good condition: Check battery for unusual conditions

# 1.GENERAL

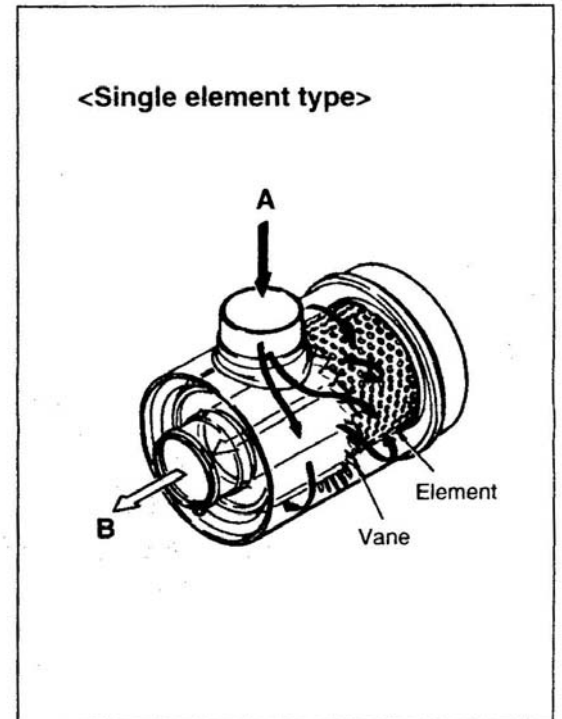
## (1) Air cleaner

The element, which comes in two types; the single element types, is the filter paper type. Coated with plastics and given heat treatment, the element offers outstanding resistance to water and oils.

The air that has been drawn in is made to rotate by vane, and large particles of dust are centrifugally separated. Furthermore, small particles of dust are filtered out by the filter paper element, and the air thus made clean is drawn into the engine.

A : Outside Air

B : To engine



## (2) Dust Indicator

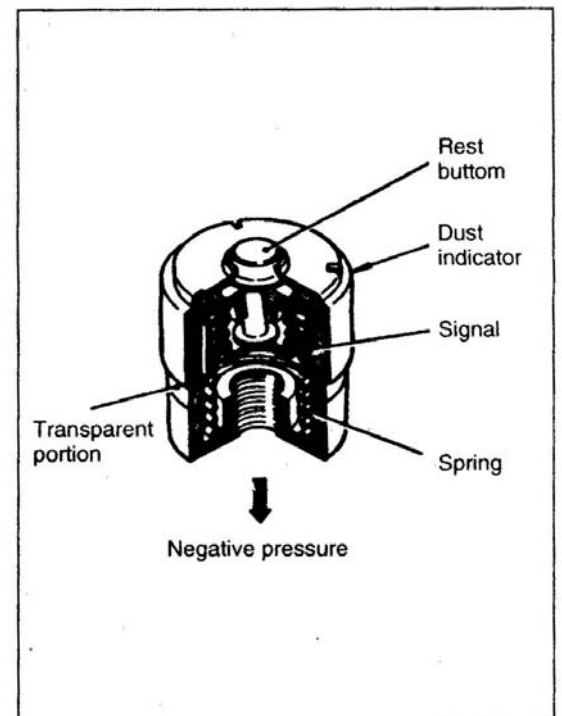
Mechanical type dust indicator is located near the intake air outlet of the air cleaner.

Operated by the negative pressure which is produced when the air is drawn into the engine, the dust indicator indicates that it is high time to clean or replace the element.

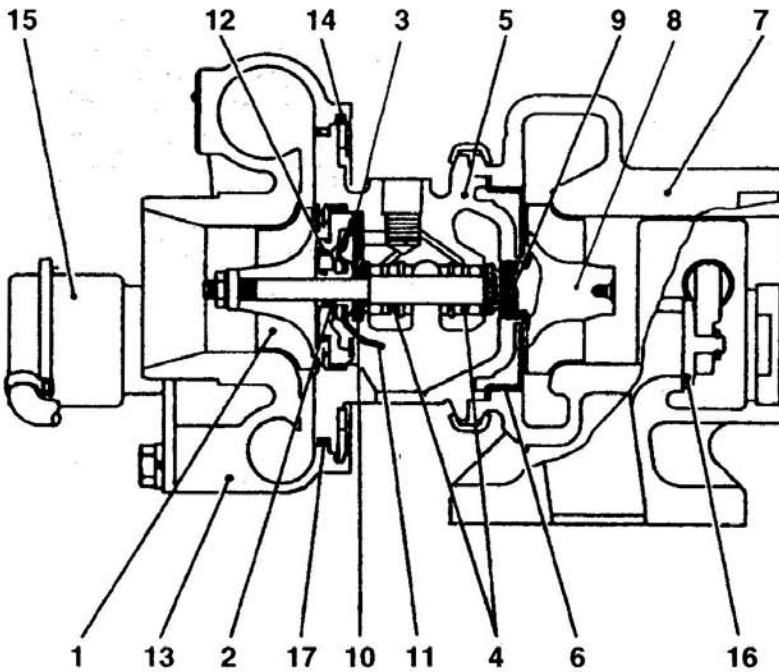
In other words, when the element is clogged with dust, the suction resistance increases.

When negative pressure A reaches 6.23 kpa{635 mmH<sub>2</sub>O}, signal(red) is pulled down against the spring pressure of spring . So the signal (red) appears in transparent portion of the body to indicate that it is high time to clean or replace the element.

After cleaning or replacing the element, press the reset button and the signal will return to its original position.



(3) turbo charger



- 1 Compressor wheel
- 2 Thrust sleeve
- 3 Thrust bearing
- 4 Bearing
- 5 Bearing housing
- 6 Turbine back plate
- 7 Turbine housing
- 8 Shaft & turbine wheel
- 9 Piston ring
- 10 Thrust ring
- 11 Oil deflector
- 12 Insert
- 13 Compressor cover
- 14 Snapping
- 15 Actuator
- 16 Waste gate valve
- 17 O-ring

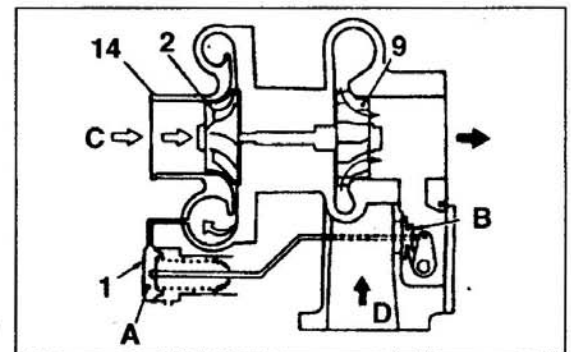
1 to 6, 8 to 12: Cartridge assemblies

(a) waste gate mechanism

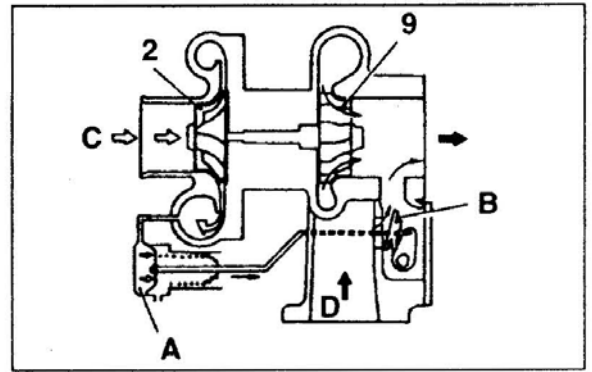
- 1) The waste gate mechanism has actuator assembly 1 to extra exhaust gas escape.

By so doing, the boost pressure is properly controlled to prevent the turbine wheel from overrunning and prevent an excessive pressure produced in the intake manifold.

- 2) The boost pressure is led from compressor housing 14 through a rubber hose to chamber A of actuator assembly 1. When the boost pressure that acts on chamber A is below the setting, the actuator assembly does not operate. and the waste gate valve remains closed, and exhaust gas D is blown against turbine wheel 9.

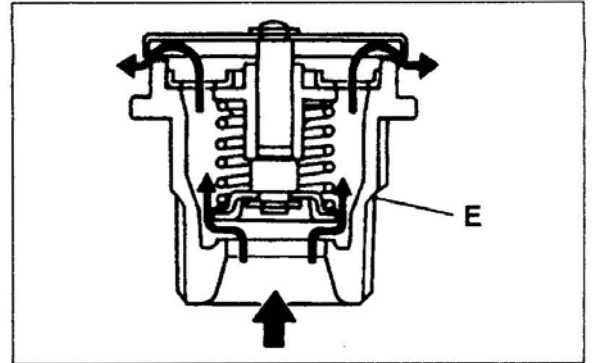


3) When the boost pressure that acts on chamber A exceeds the setting, the waste gate valve is opened. As a result, the amount of exhaust gas blown against turbine wheel 9 decreases, and the rotating speed of compressor wheel 2 also decreases, and the boost pressure falls.



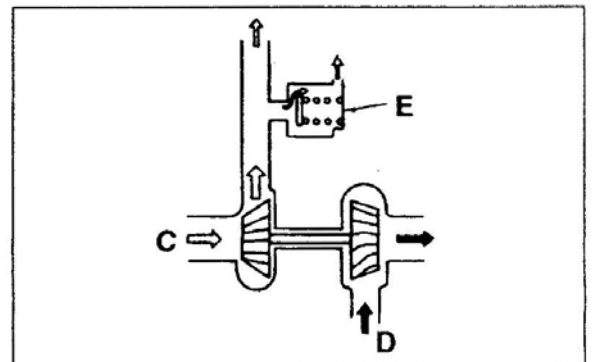
(b) Operation of overboost valve

1) Overboost valve E operates when the boost pressure becomes abnormally high due to the failure of the waste gate mechanism.



2) When the boost pressure of overboost valve E exceeds the setting, the valve releases the boost pressure into the atmosphere to make sure that a boost pressure more than necessary is not applied to the engine.

The valve whistles when it is in operation.



## 2. SPECIFICATIONS

Model	D4A	D4AK	D4DA
Element type	Paper filter type	←	←
Turbocharger type	-	TD04	TD05

## 3. SERVICE STANDARDS

### 3-1. Service standard table


Unit : mm

Description		Nominal value [Basic diameter]	Limit	Correction and remarks	
Turbo- charger	I.D. of bearing inserting portion of bearing housing	[15.6]	15.686	Replace	
	Turbine wheel shaft journal diameter	[9]	8.994	Replace	
	Turbine wheel shaft bend		0.015	Replace	
	Bearing	O.D.		15.574	Replace
		I.D.		9.04	
		Length	TD05	9.34	
	Piston ring open end clearance		0.05~0.15		Replace insert
	Clearance between turbine wheel and turbine housing		0.42~1.1		Check
	End play of turbine Wheel shaft	TD05	0.057~0.103		Check
	Clearance between turbine wheel and turbine back plate		0.37~0.85		Check
Boost pressure (20℃, 760mmHg)		200mmHg, 3800rpm		Check	

### 3-2. Tightening Torque Table

Maintenance item		Nominal value Basic diameter	Limit	Correction
Turbocharger (TD05)	Attaching Nut	M10 × 1.25	4.2	Apply MOLYKOTE (NLGI #2) to thred
	Compressor wheel attaching lock nut		0.8~0.9	
	Coupling		0.4~0.5	
Inlet manifold attaching bolt		M8 × 1.25	2.2	
Exhaust manifold attaching nut		M10 × 1.25	4.2	
Oil pipe lubrication eye bolt		M10 × 1.25	1.7	
Front pipe bolt		M10 × 1.25	4~5.0	

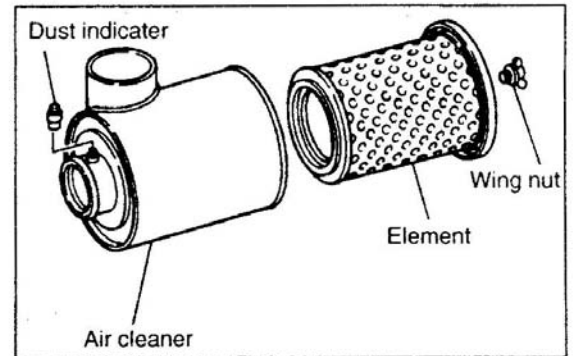
### 4. SPECIAL TOOLS

Tool name	Part number	Shape (Unit : mm)	Use
Boost pressure gauge	MH061366		

## 5. SERVICE PROCEDURES

### 5-1. Air cleaner

Disassembly and Assembly



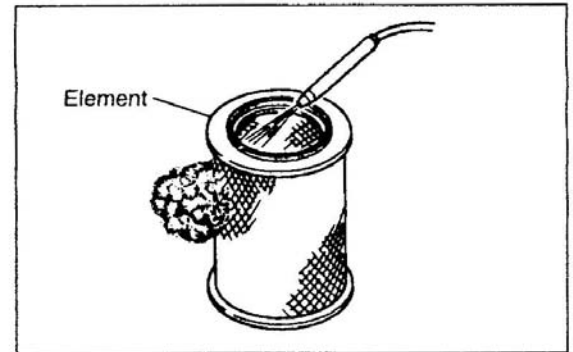
### 5-2. Element

#### a) Cleaning

- Blow compressed air 685 kPa {7 kgf/cm<sup>2</sup>} or less from inside element
- Blow the compressed air, working along the creases of filter paper of element up and down throughout the element.

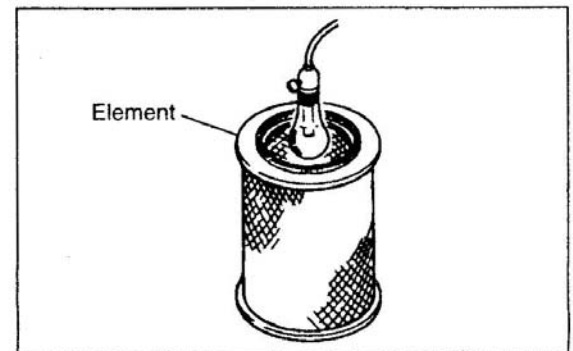
#### Note :

- Do not strike element to loosen dust.
- Do not blow the air from outside element.



#### b) Inspection

- Put a light inside element.
- If the filter paper is broken or partially thin, or if the packing on the top of element is broken, replace the element.
- If the dust deposited on element is wet with oil smoke or soot, replace the element irrespective of the replacement intervals.

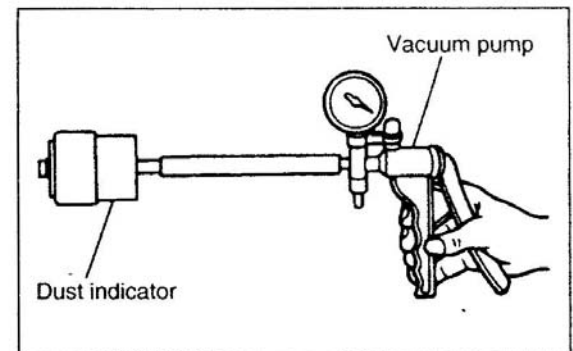


### 5-3. Inspection of dust indicator

Perform the following checks. If there is anything wrong, replace dust indicator.

#### <Mechanical type>

- Mount a hand vacuum pump on dust indicator and apply the standard operating negative pressure to check whether the red signal appears.

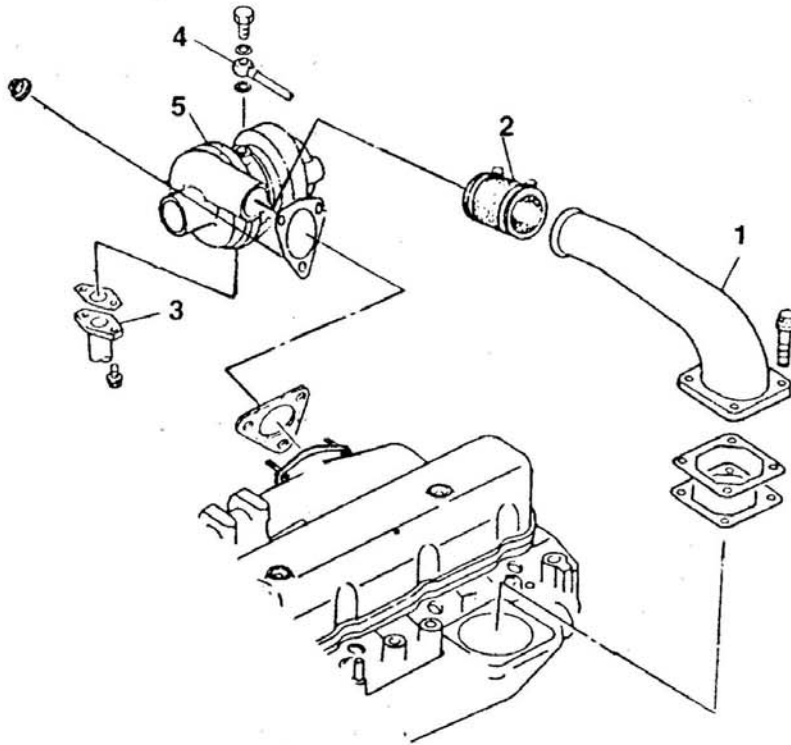




## 5-4. Turbocharger

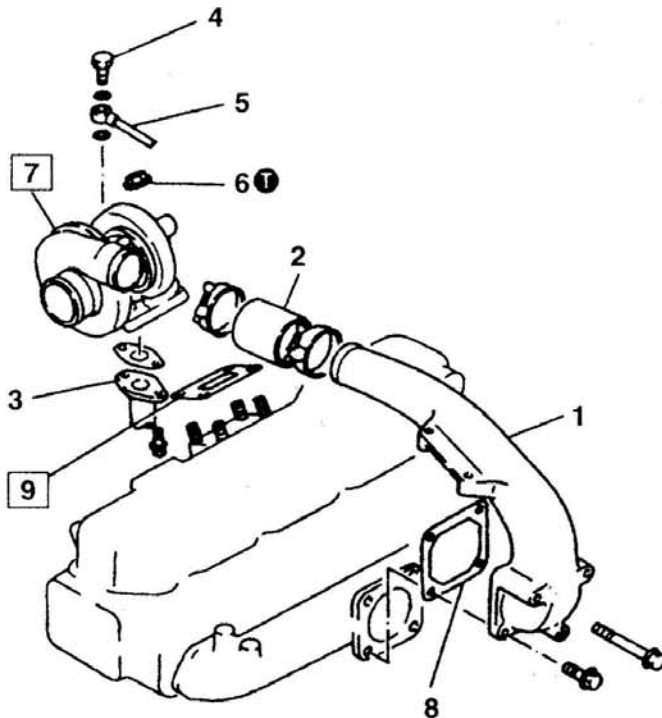
### Disassembly and assembly

(D4AK)



- 1 Air inlet pipe
- 2 Rubber hose
- 3 Oil return pipe
- 4 Oil inlet pipe
- 5 Turbocharger

(D4DA)



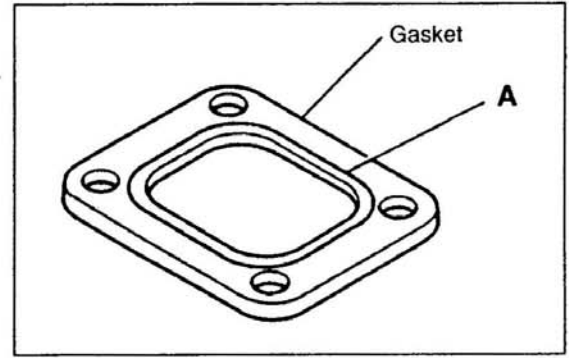
- 1 Air inlet pipe
- 2 Rubber hose
- 3 Oil return pipe
- 4 Eyebolt
- 5 Oil pipe
- 6 Nut
- 7 Turbocharger assembly
- 8 Gasket
- 9 Gasket
- 10 Overboost valve

● **Installation sequence**

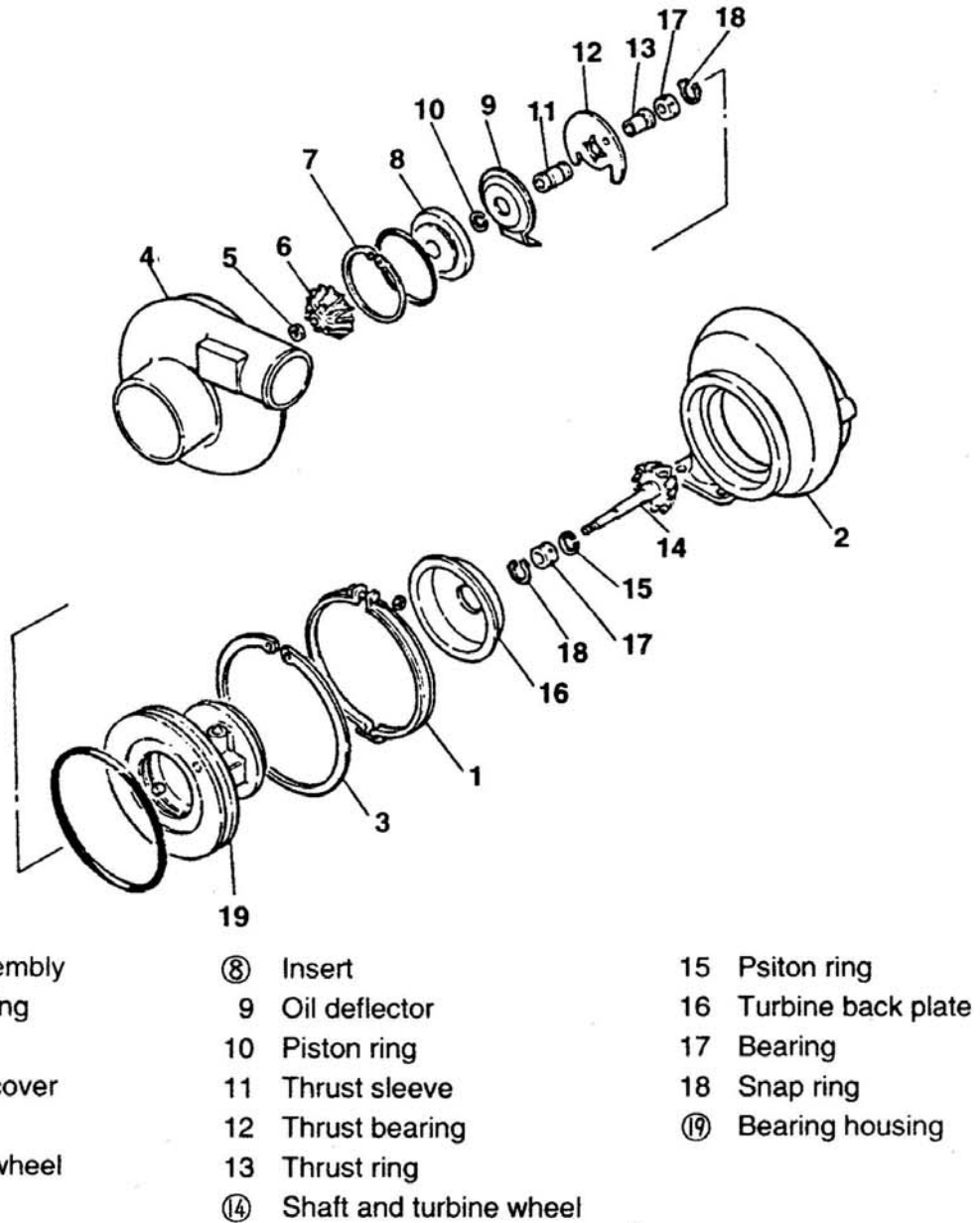
Follow the installation sequence in reverse.

### Installation of gasket

Install gasket with grommet fold-back portion A toward the exhaust manifold.



### 5-4-1. Disassembly



For disassembly of parts with an encircled number, see following items.

- (1) Be sure to make alignment marks on the compressor cover, bearing housing, and turbine housing, as their positional relationship is extremely critical at reassembly.
- (2) Remove the coupling assembly to remove turbine housing.

**NOTE:**

The compressor wheel and turbine wheel blades are easy to bend. Use care not to drop them or hit them against other objects.

- (3) Remove the snap ring.

**NOTE:**

Retain the snap ring by hand to prevent it from springing out when slipping off the snap ring pliers.

- (4) Using a plastic hammer, tap the compressor cover on its periphery and remove.

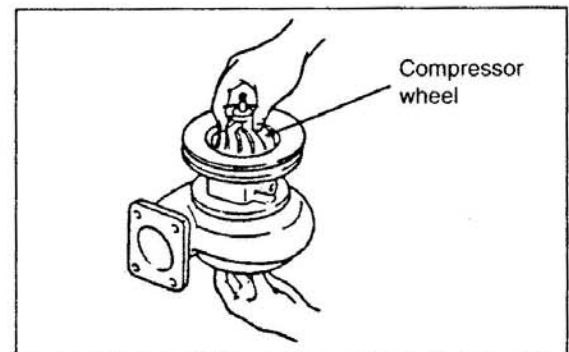
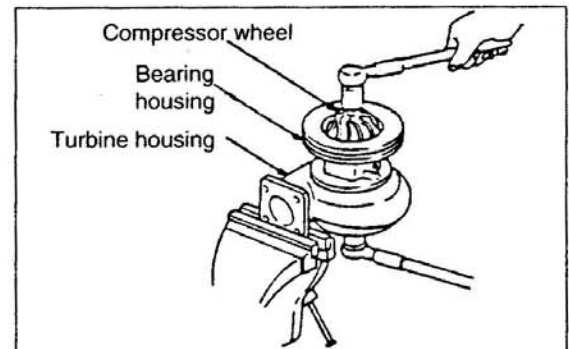
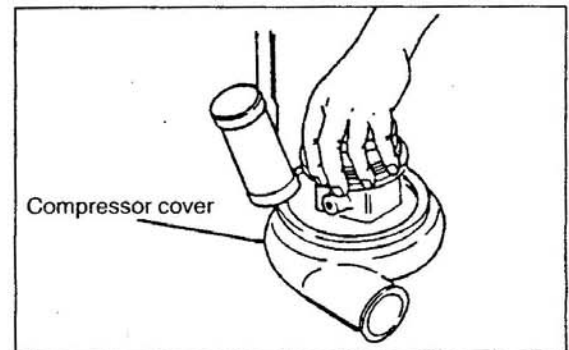
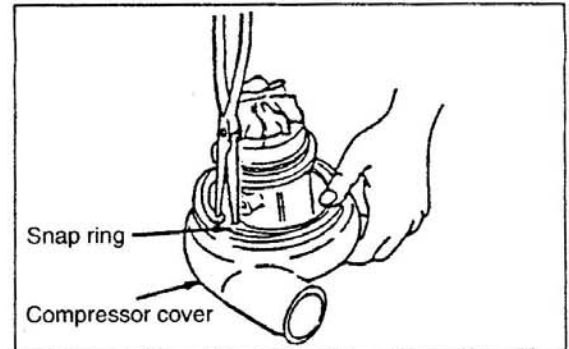
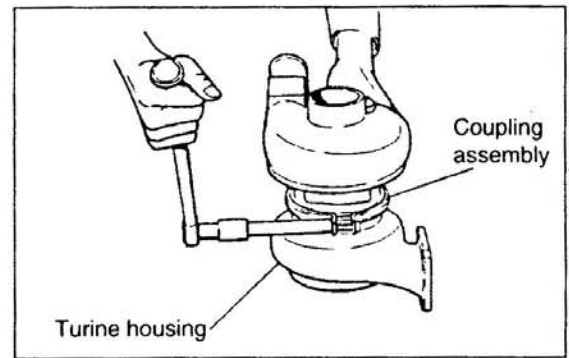
**NOTE:**

Be careful not to hit the compressor wheel against compressor cover as its blades are easy to bend.

- (5) Removal of Compressor Wheel

- (a) Fit the bearing housing into the turbine housing which is clamped in a vise. Hold the bolt on shaft and turbine wheel and remove the lock nut that attaches the compressor wheel.

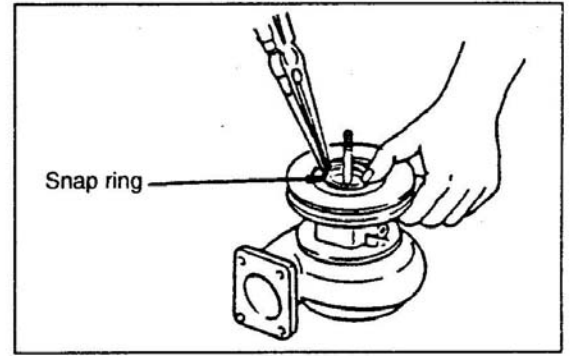
- (b) With the turbine wheel held by one hand, lightly turn the compressor wheel to remove it.



(6) Remove the snap ring.

**NOTE:**

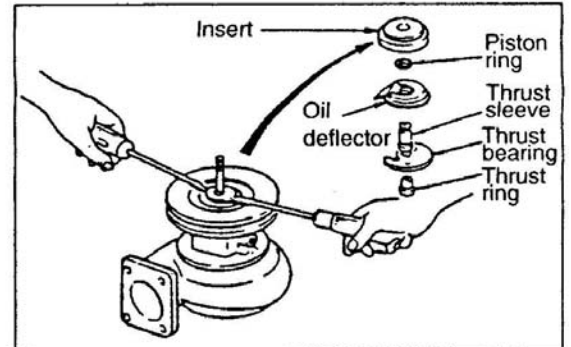
**Retain the snap ring by hand to prevent it from springing out when slipping off the snap ring pliers.**



(7) Removal of Insert, Oil Deflector, and Other parts

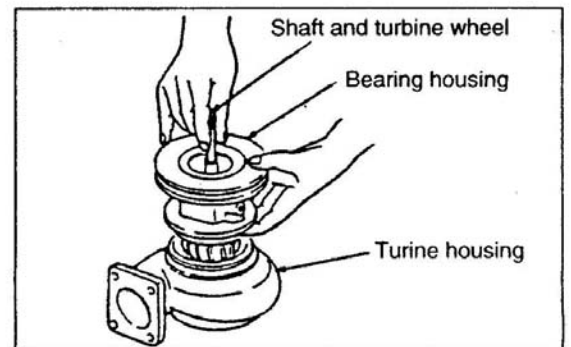
Using two screwdrivers, carefully remove the insert from the bearing housing.

Then, remove parts shown in illustration.

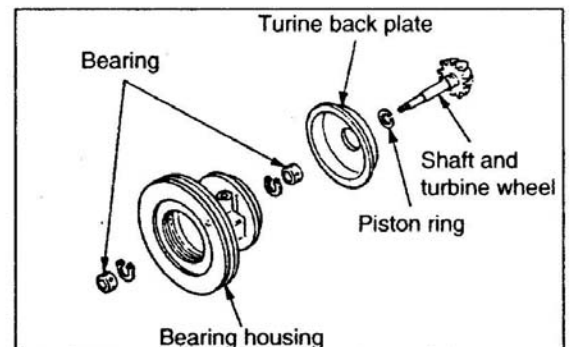


(8) Removal of Shaft and Turbine Wheel, and Bearing

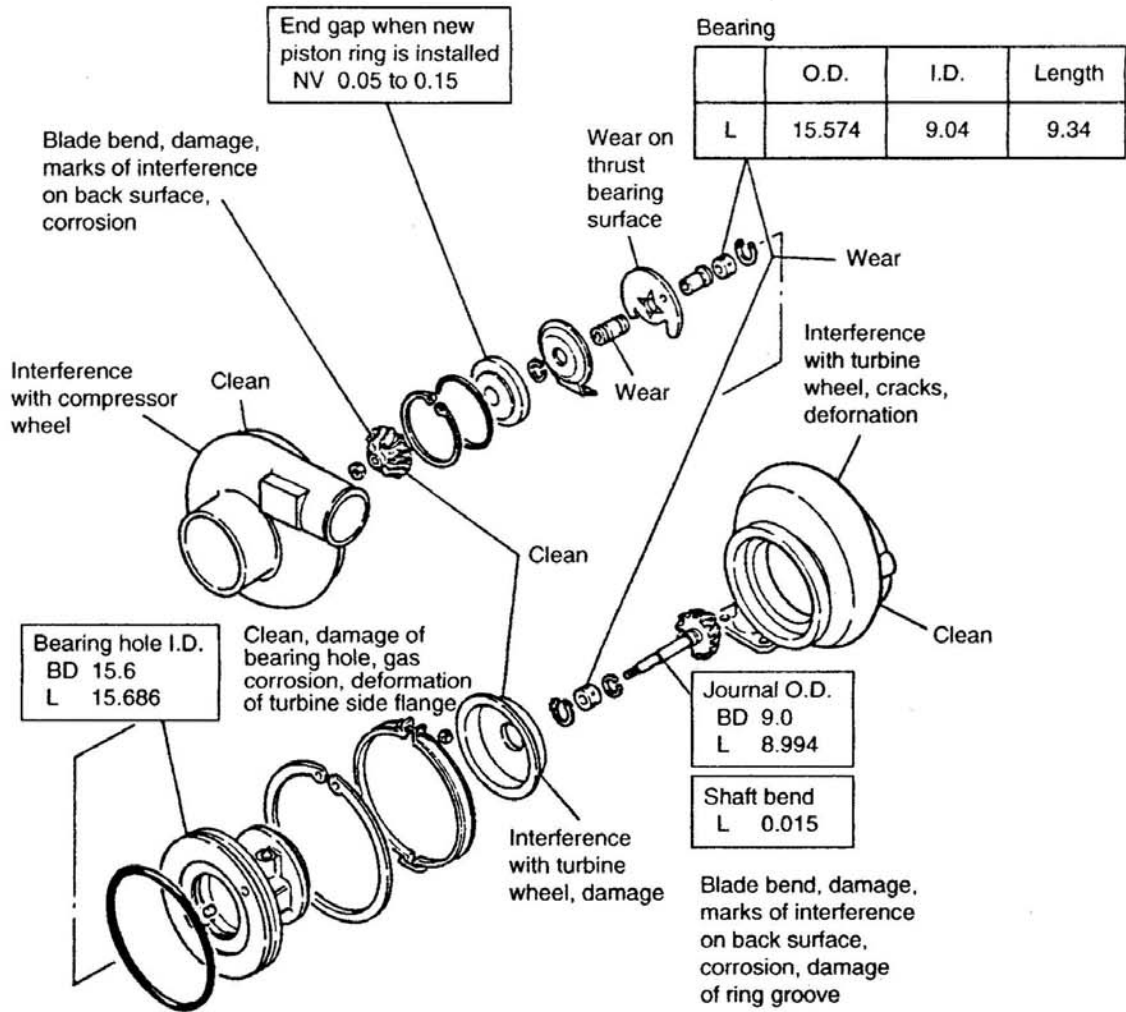
(a) Hold the shaft of turbine wheel and shaft by one hand and the bearing housing by the other hand, and carefully withdraw from the turbine housing.



(b) Remove the parts shown in illustration from the bearing housing.



## 5-4-2. Cleaning and Inspection



BD ... Basic Diameter

NV ... Nominal Value

L ... Limit

(1) Cleaning

Turbocharger manufacturers use a blasting equipment for cleaning parts at their workshop. As an alternative, effective method for overhaul at the dealer's workshop, use the following procedures.

**NOTE:**

**When a commercially-available neutral detergent is used for cleaning, make sure that it does not contain corrosive component.**

(a) Before cleaning, visually check the condition of parts. Check for burns, wear, and other defects which could not be identified after washing.

(b) Immerse disassembled parts in a nonflammable solvent to clean oily contamination.

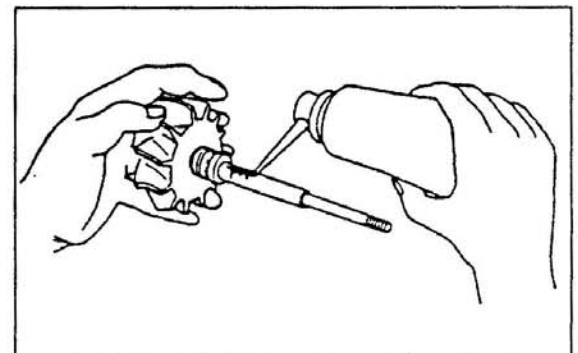
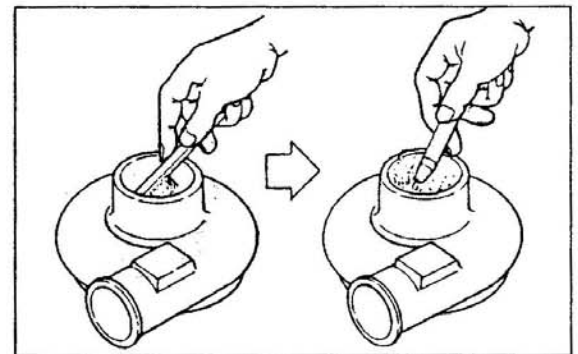
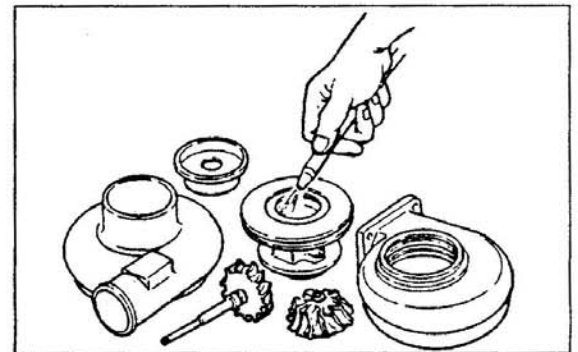
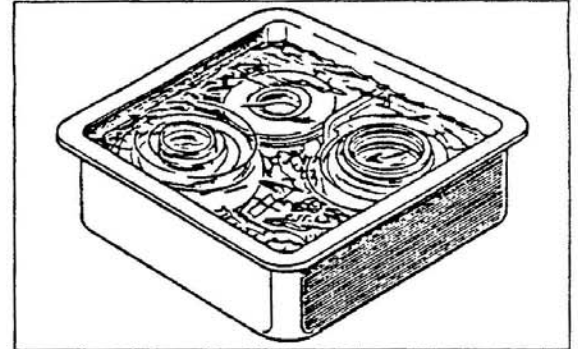
(c) Blow compressed air against the entire internal and external surfaces.

(d) Using a plastic scraper or bristle brush, remove deposits from the surfaces. then, dip parts in the nonflammable solvent and blow compressed air to them again.

**NOTE:**

**Use care to prevent damage to parts.**

(e) Apply clean engine oil to all sliding surfaces.

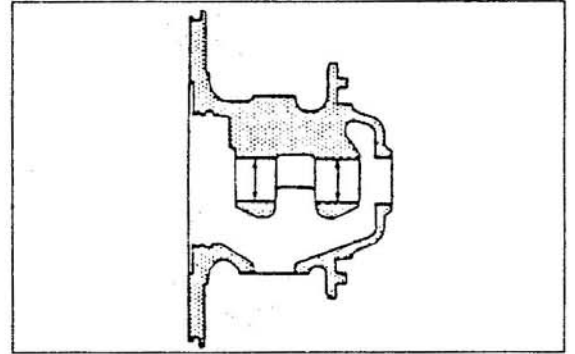


(2) Inspection

(a) Bearing housing

Measure the I.D. of bearing hole.

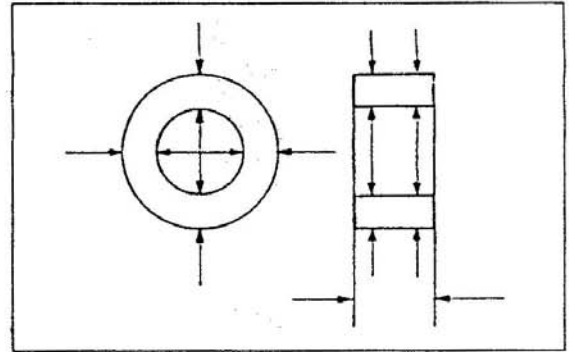
If the measurement exceeds the limit, replace the bearing housing.



(b) Bearing

Measure O.D., I.D., and length of the bearing.

If the measurement exceeds the limit, replace the bearing.

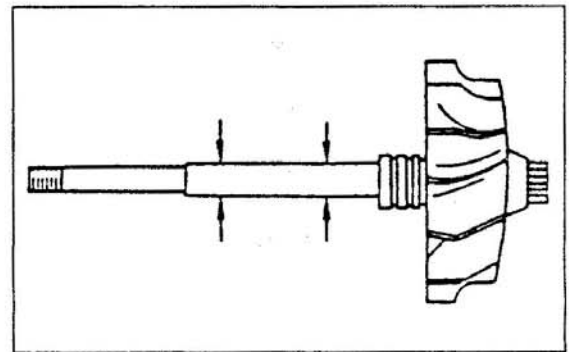


(c) shaft and turbine wheel

1) Measure O.D. of the shaft and turbine wheel journal.

If the measurement exceeds the limit, replace the shaft and turbine wheel.

Replace the piston ring with a new one.

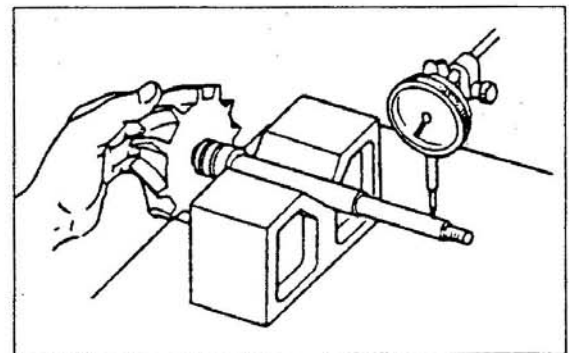


2) Measurement of shaft bend

Set a dial indicator just beside the threads on the shaft to measure bend.

If the deflection of dial indicator exceeds the limit, replace the turbine wheel and shaft.

If the shaft journal gets rough, hold the shaft between centers of a lathe, and polish the surface with a sand paper #400 and engine oil at a spindle speed of 300 to 600 rpm.



**NOTE:**

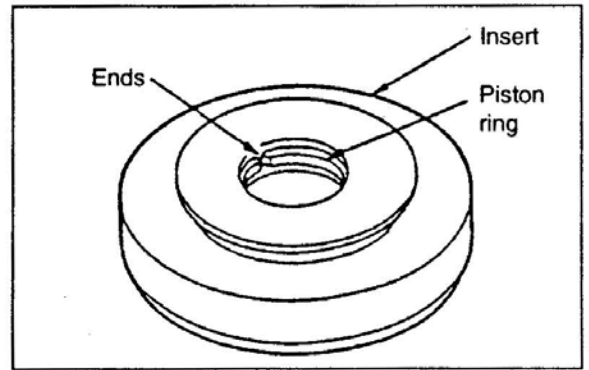
**Do not attempt to correct, but replace, a bent shaft.**

(d) Insert

Measure the piston ring gap.

Fit a new piston ring into the bore of the insert and measure the ring gap.

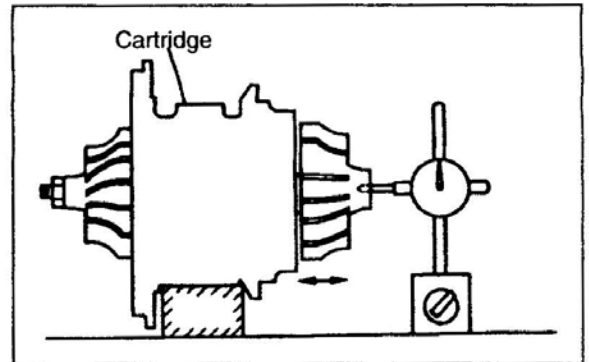
If the ring gap is out of the specification, replace the insert.



(e) Cartridge assembly

1) Axial play in shaft and turbine wheel assembly

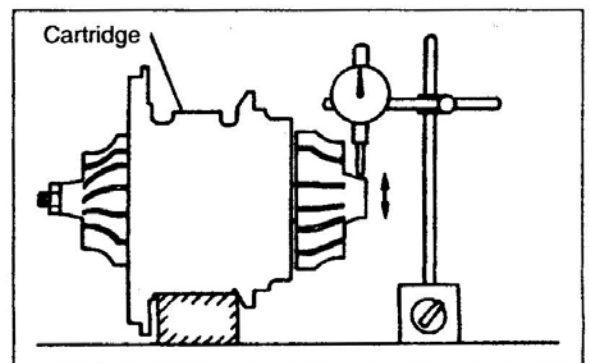
If the measurement exceeds the specified limit, replace cartridge assembly.



2) Play at right angle to shaft direction in shaft and turbine wheel assembly

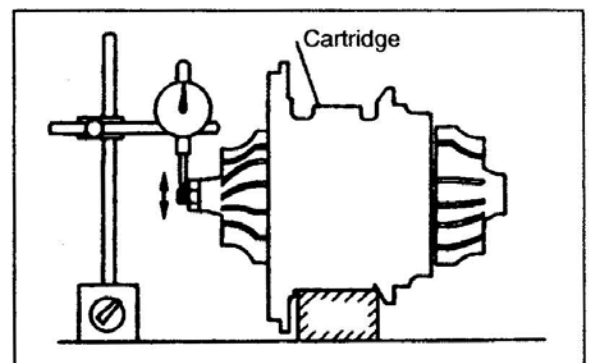
● Play on turbine wheel side

If the measurement exceeds the specified limit, replace cartridge assembly.



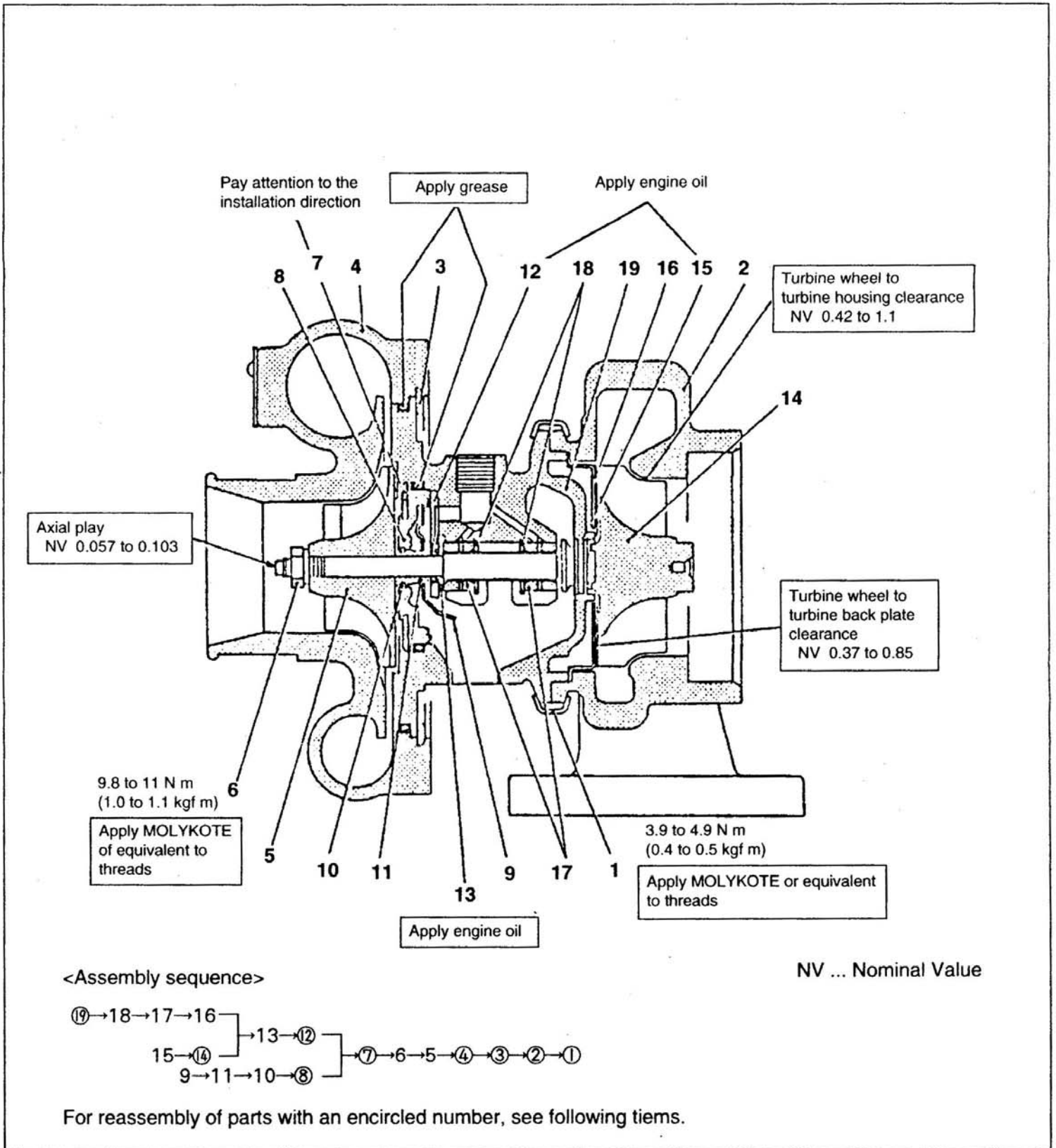
● Play on compressor wheel side

If the measurement exceeds the specified limit, replace cartridge assembly.





### 5-4-3. Reassembly



**NOTE:**  
 With the overhauled turbocharger mounted on the engine, crank the engine with starter to allow the engine oil to circulate through the turbocharger.

(1) Installation of Shaft and Turbine Wheel, and Bearing

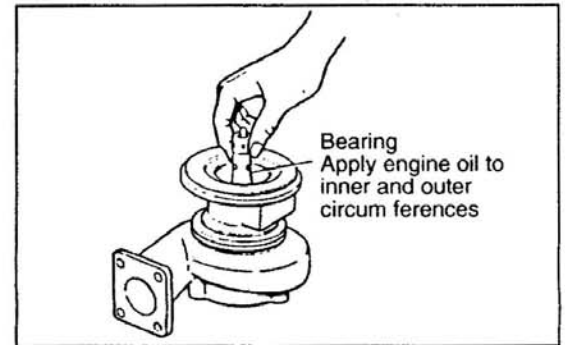
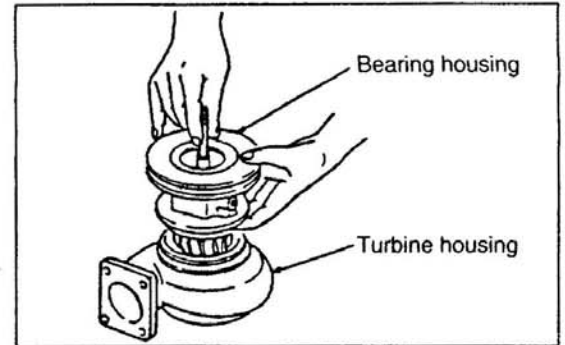
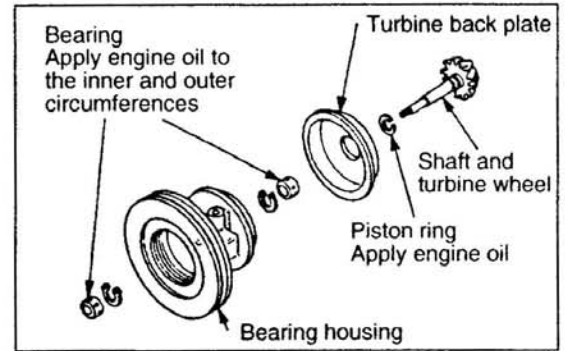
**NOTE:**

1. **Apply engine oil to the piston ring and do not expand the ends when mounting it onto the turbine rotor.**
2. **Do not apply excessive force to the turbine rotor during installation.**

After assembly, temporarily install the bearing housing to the turbine housing and temporarily secure with the coupling assembly.

**NOTE:**

**Face the bearing end face with six oil holes to the compressor wheel.**



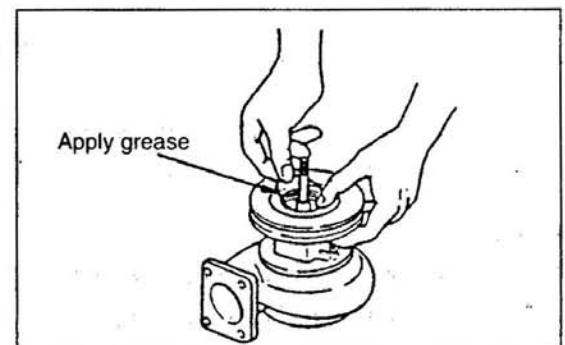
(2) Installation of Thrust Bearing

Before installation, apply engine oil to the surfaces of thrust ring and thrust bearing.



(3) Installation of O-ring

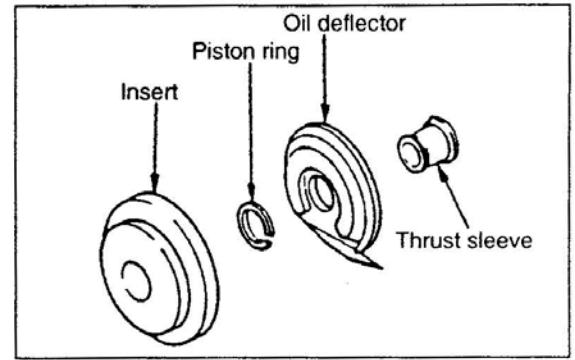
Install O-ring with grease applied to it.



#### (4) Assembly of Insert Subassembly

##### NOTE:

1. When mounting piston ring to the thrust sleeve, ensure that the ring is not expanded and ring ends are not twisted.
2. Apply MOLYKOTE or equivalent to the piston ring that has been mounted to the thrust sleeve. Install the thrust sleeve to the insert with care to prevent damage to the piston ring.



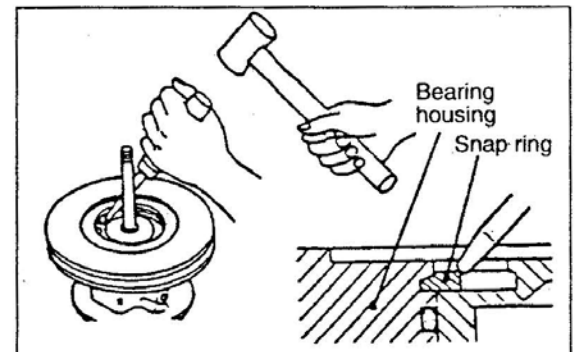
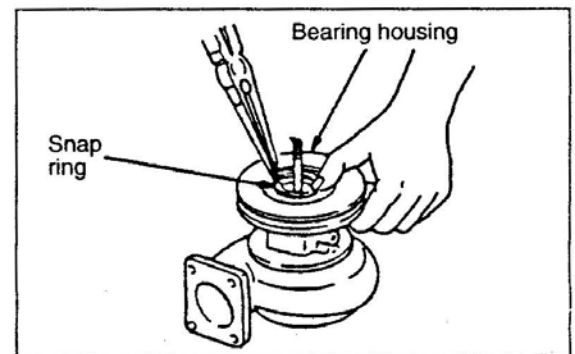
Install the subassembly into the bearing housing.

#### (5) Installation of Snap Ring

Install the snap ring to the bearing housing with its taper up.

##### NOTE:

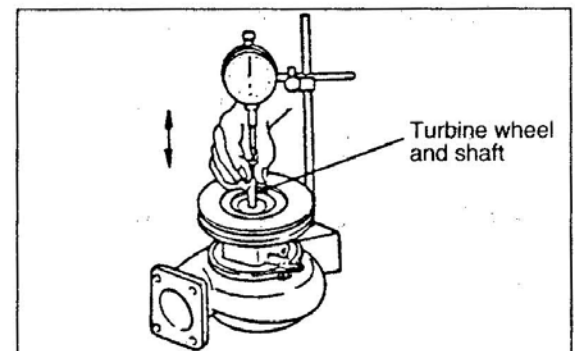
1. Ensure the correct installation direction.
2. To fit the snap ring into position, tap its ends with a screwdriver and hammer into the groove in bearing housing.
3. Special care must be exercised, when tapping the snap ring into position, to prevent damage to the bearing housing by the screwdriver.



#### (6) Measurement of Turbine Wheel to Turbine Housing Clearance

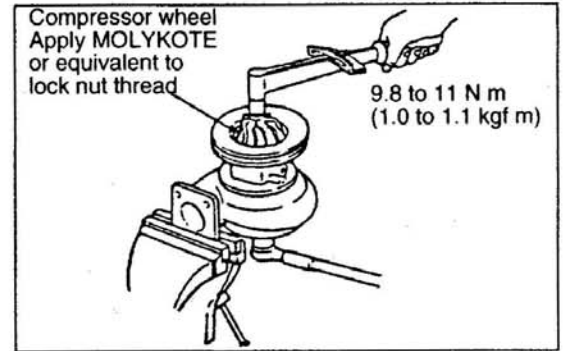
Set the dial gauge to the turbine wheel and shaft end. Move the turbine wheel and shaft and in the axial direction to measure the clearance.

If the measurement is not within specification, disassemble and locate the cause of trouble.



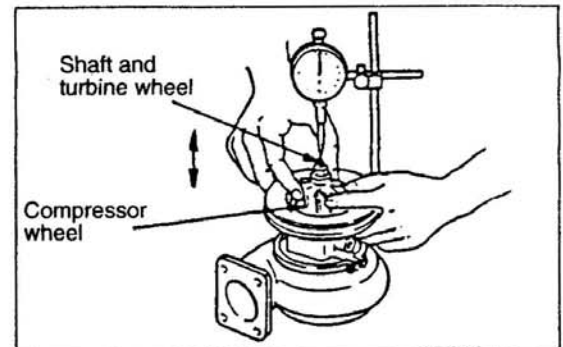
(7) Installation of Compressor Wheel

With the compressor wheel installed in position, apply MOLYKOTE to lock nut threads and tighten to specification.



(8) Measurement of play in Shaft and Turbine Wheel in Axial Direction

Set the dial indicator at the end of shaft and turbine wheel. Move the compressor wheel in the axial direction to measure the play. If the play is not within specification, disassemble and locate the cause of trouble.



(9) Measurement of Turbine Back Plate to Turbine Wheel Back Surface

With the turbine housing removed from the bearing housing and compressor cover installed, make the following measurement.

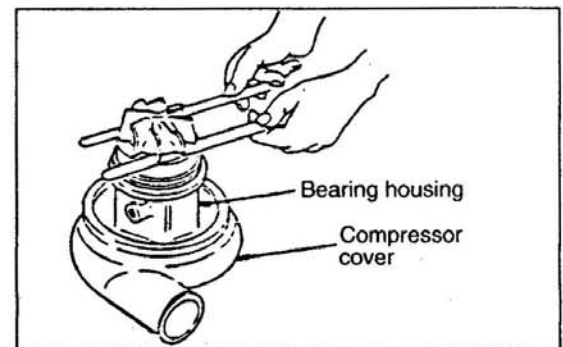
Using thickness gauges, measure the clearance between the turbine back plate and turbine wheel back surface.

If the clearance is not within specification, disassemble and locate the cause of trouble.

**NOTE:**

**Use two thickness gauges.**

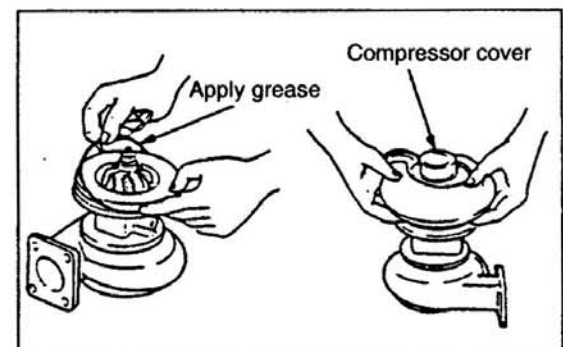
**Make the measurement at the end of the blade.**



(10) Installation of Compressor Cover

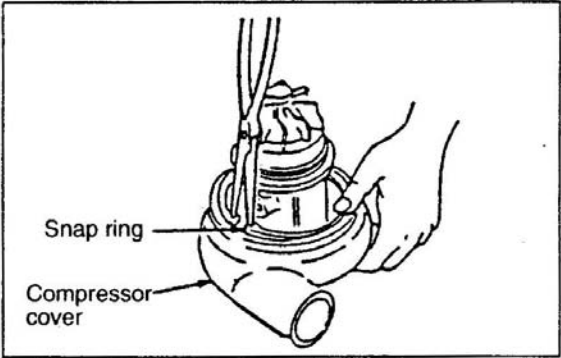
Install the compressor cover, ensuring the correct installation direction.

Apply grease to O-ring when mounting



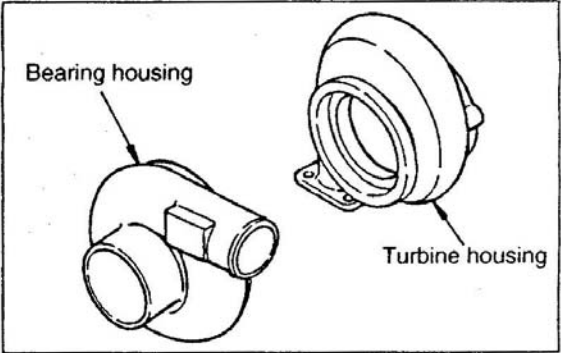
**(11) Installation of Snap Ring**

Install the snap ring to the compressor with its taper up.  
Use the snap ring pliers for installation.



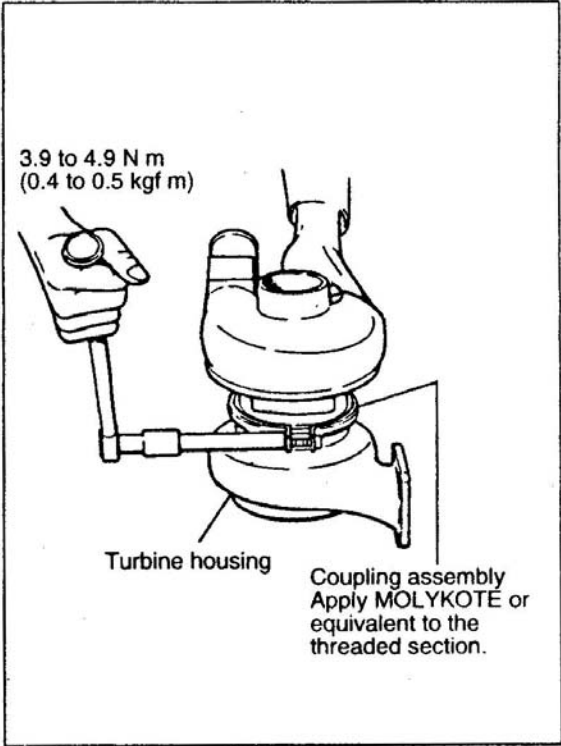
**(12) Installation of turbine Housing**

Install the turbine housing to the bearing housing, ensuring correct installation direction.



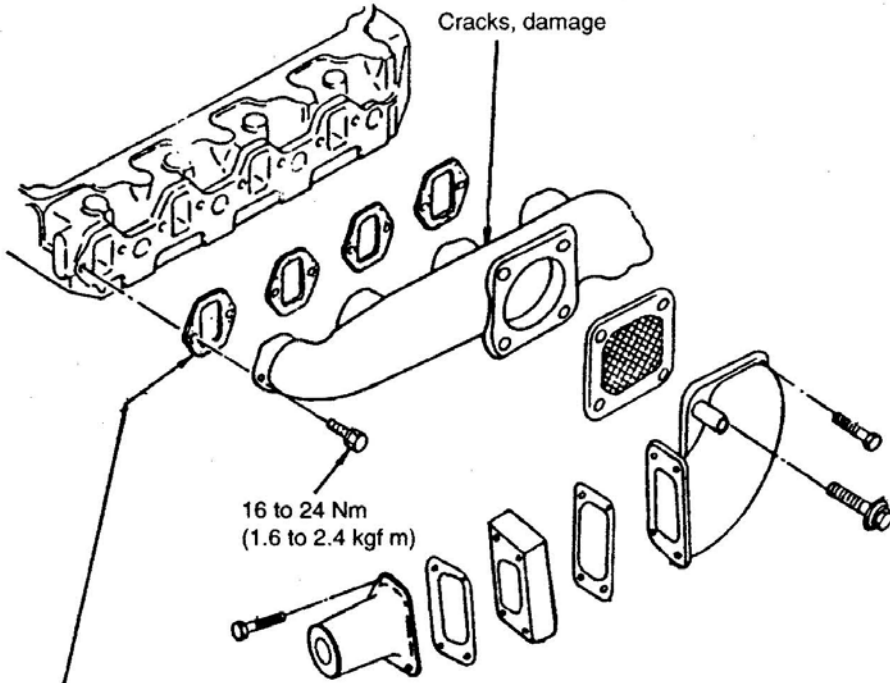
**(13) Installation of Coupling Assembly**

Apply MOLYKOTE or equivalent to threads in coupling assembly and tighten to specification



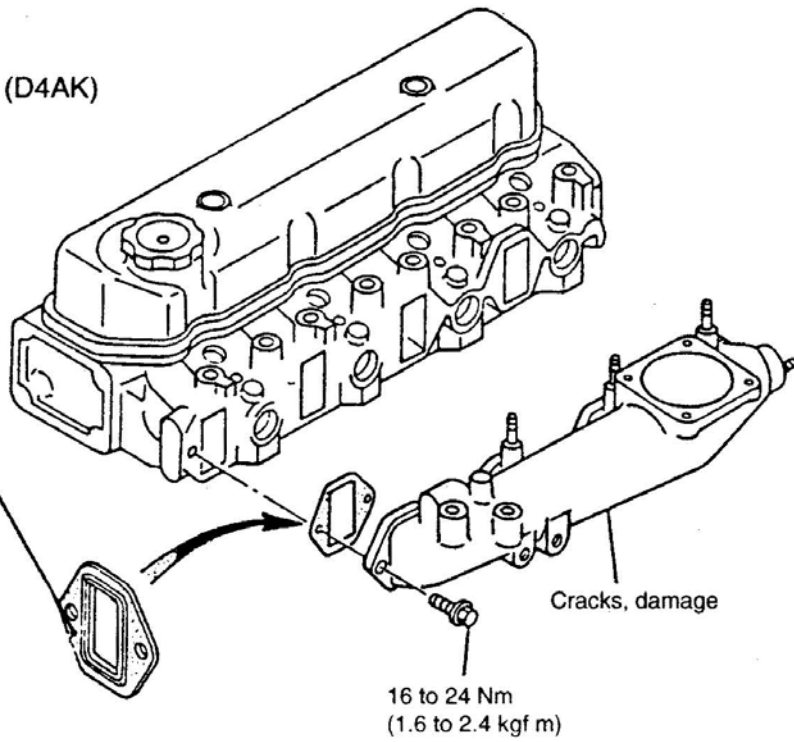
## 5-5. Inlet Manifold

(D4AN, D4DA, D4AF)

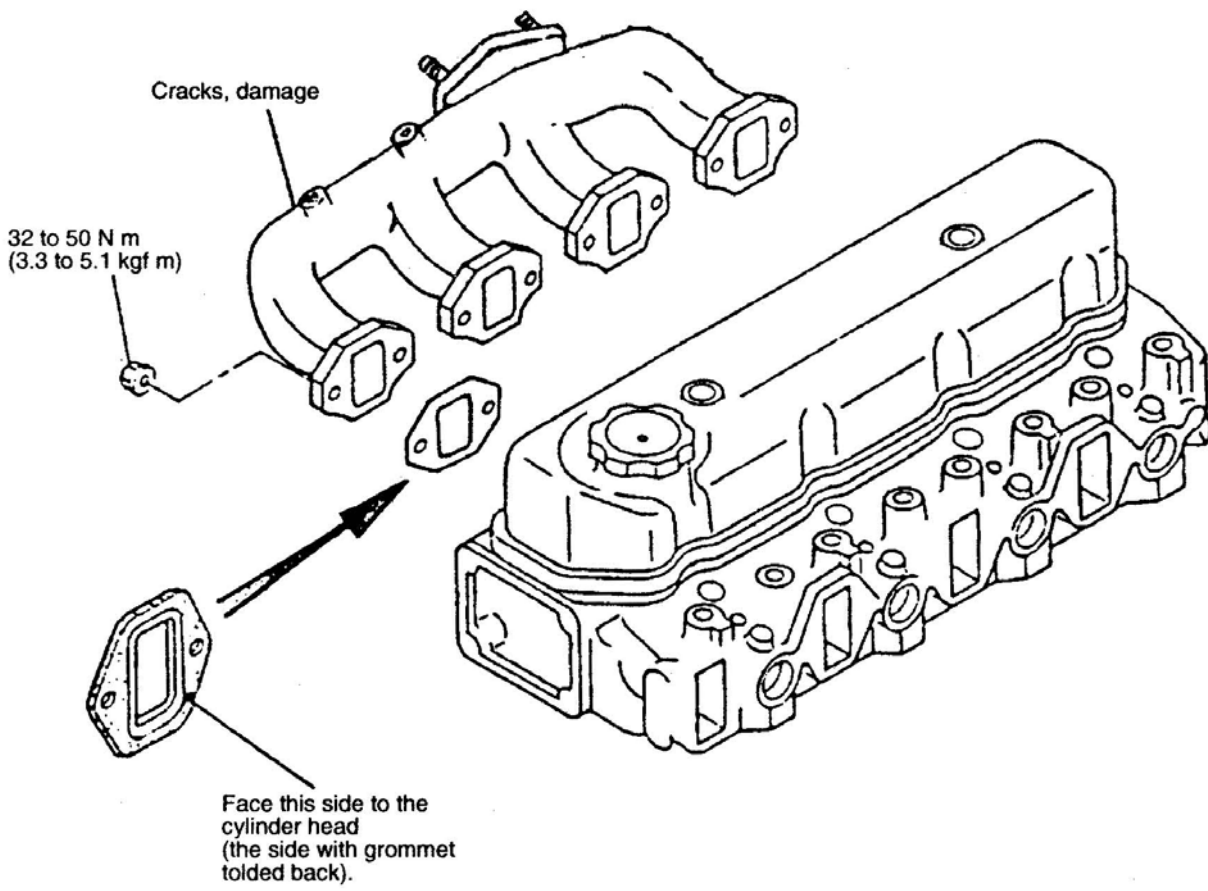


Face this side to the  
cylinder head  
(the side with grommet  
folded back).

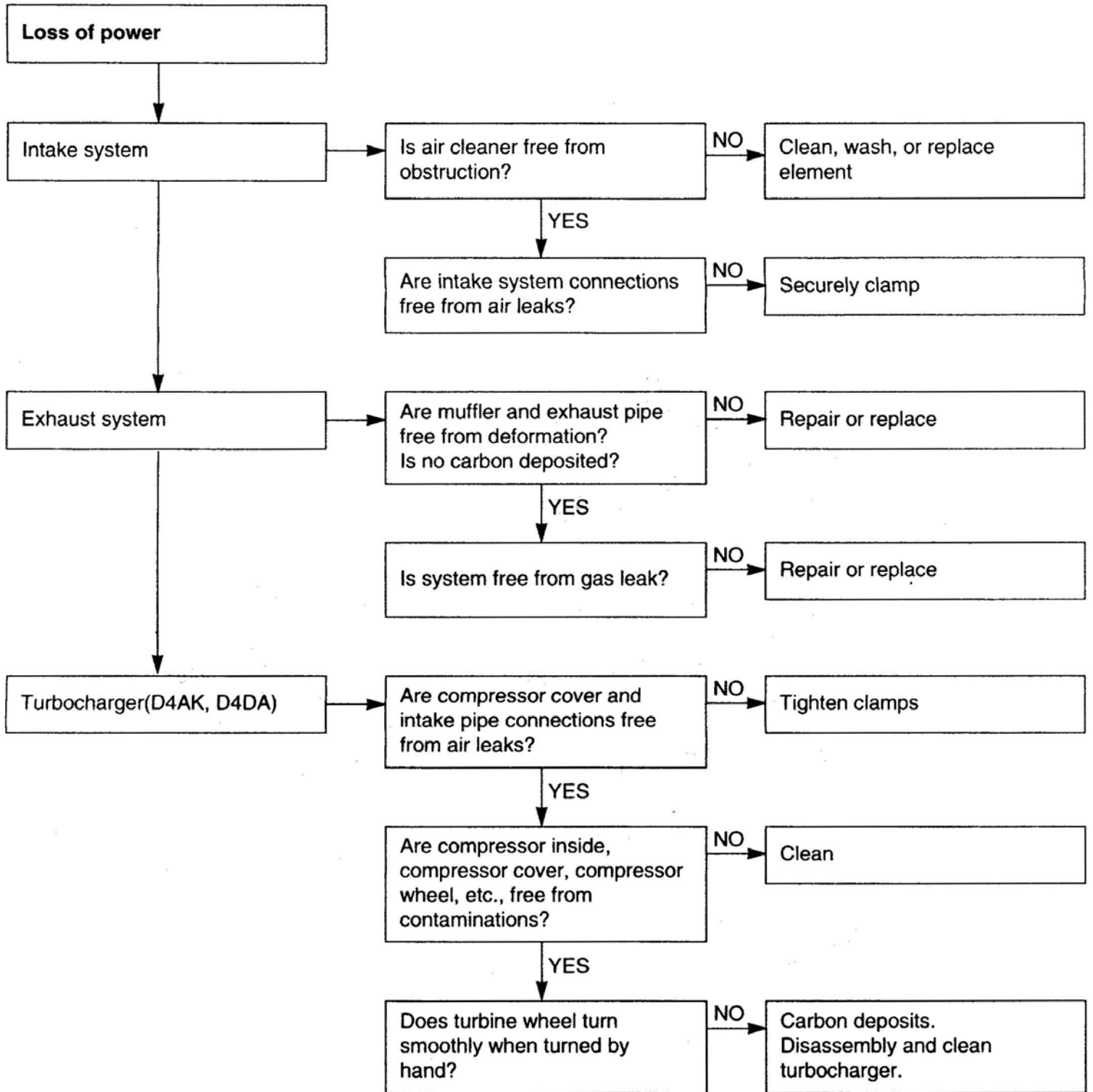
(D4AK)



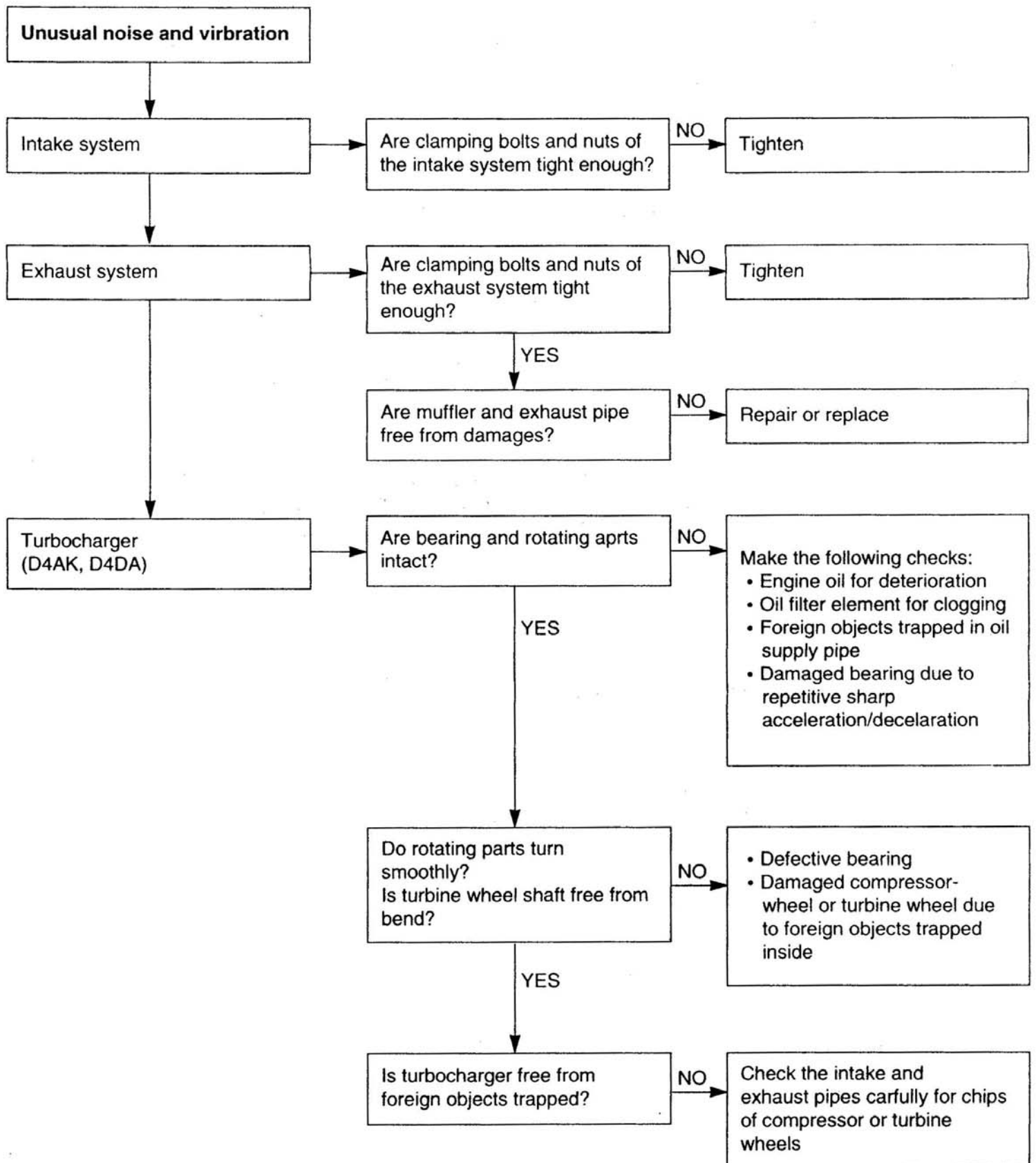
## 5-6. Exhaust Manifold

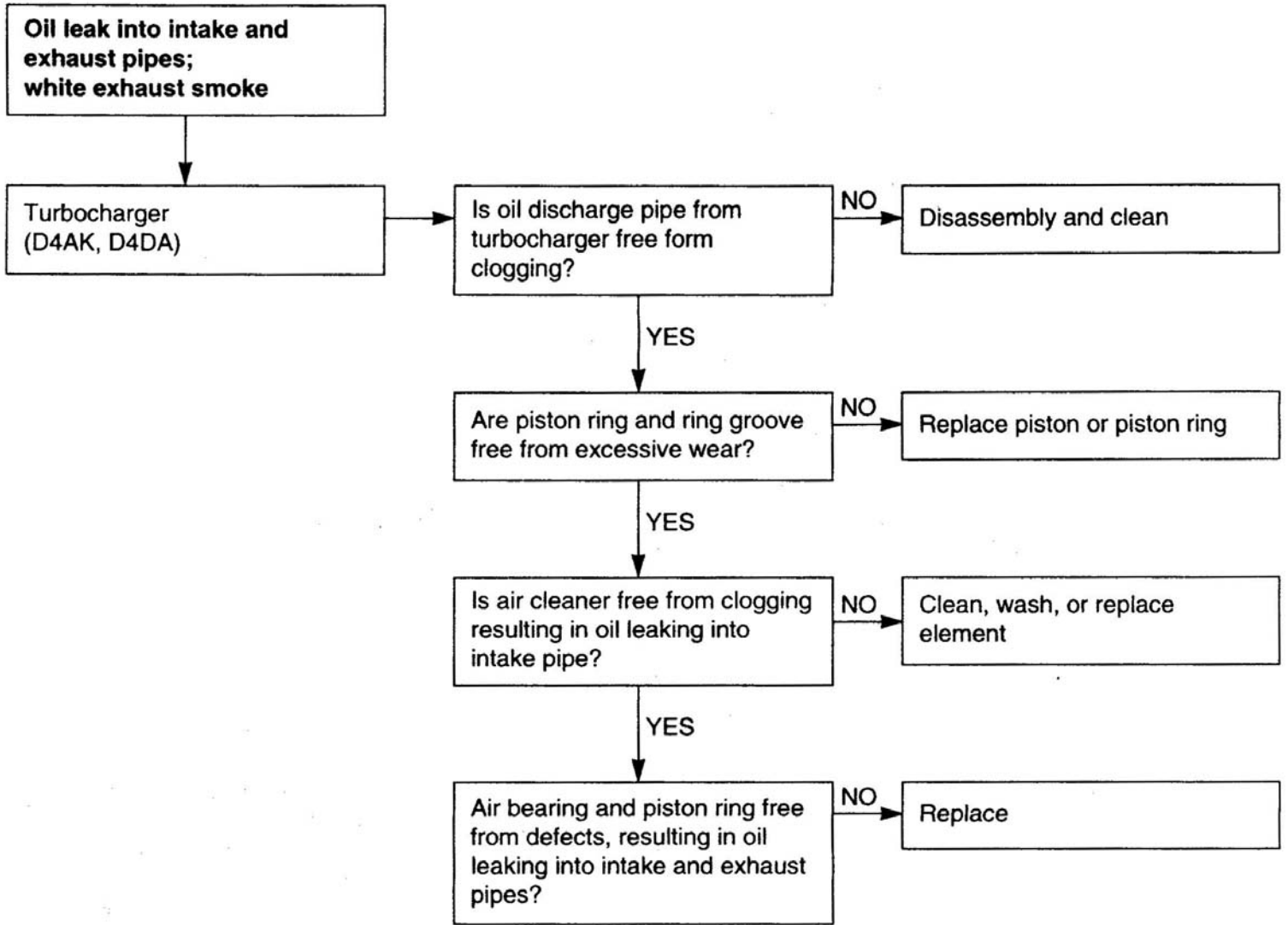


## 6. Thoubleshooting





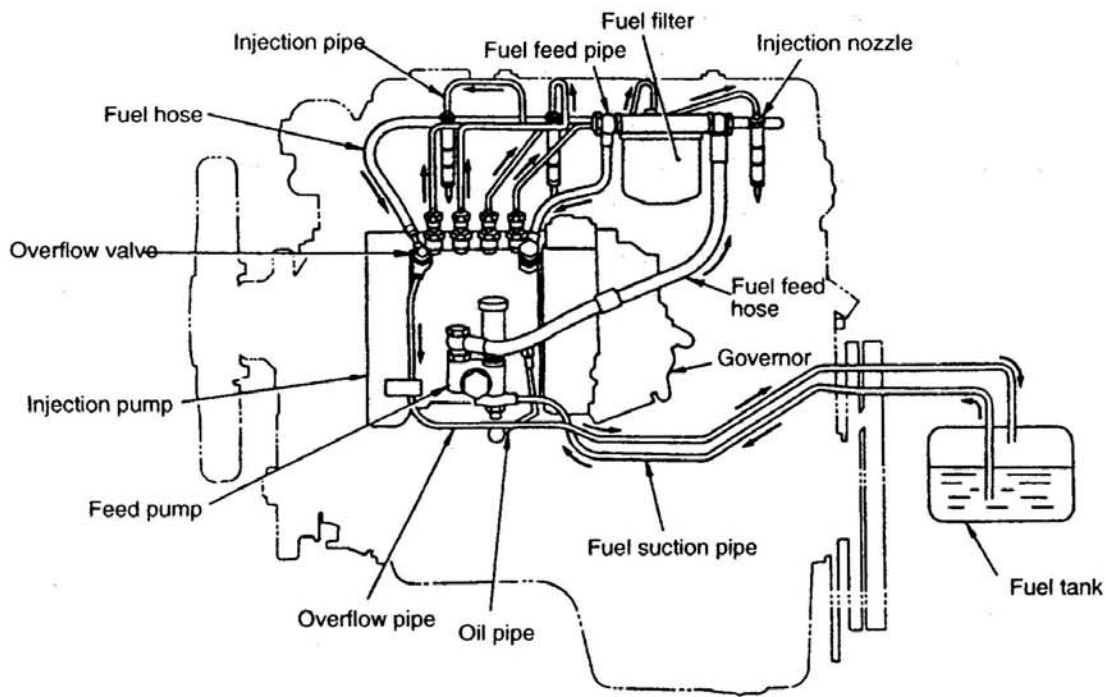




# 1. GENERAL

The fuel system consists of the injection pump assembly(injection pump proper, governor, feed pump), auto timer, fuel filter, injection nozzle, injection pipe, and other parts.

Fuel is fed from the fuel tank through suction pipe to the feed pump of the injection pump assembly, and then to the fuel filter, injection pump, and injection nozzle. The excess fuel is returned from the injection pump to fuel tank(direct injection type engine) or from the injection nozzle to the fuel tank(swirl chamber type engine).



(1) A-type Injection Pump

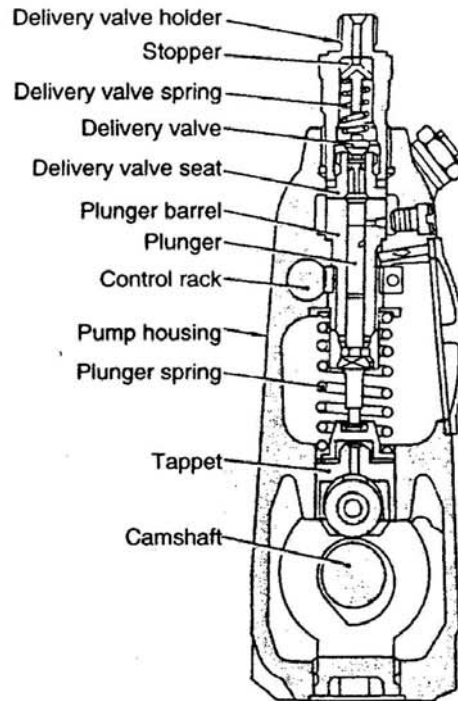
The injection pump is a device which forces fuel to the injection nozzle and has a mechanism for increasing or decreasing the pressure feed quantity according to the engine load and speed.

The injection pump is constructed as shown in illustration at right.

It has one plunger and delivery valve for each cylinder.

The plunger, pushed up by the camshaft and pushed back by the plunger spring, moves up and down through the plunger barrel on a predetermined stroke to feed fuel under pressure.

Both ends of the camshaft is supported by the taper roller bearings and is driven by the timing gear at 1/2 engine speed.



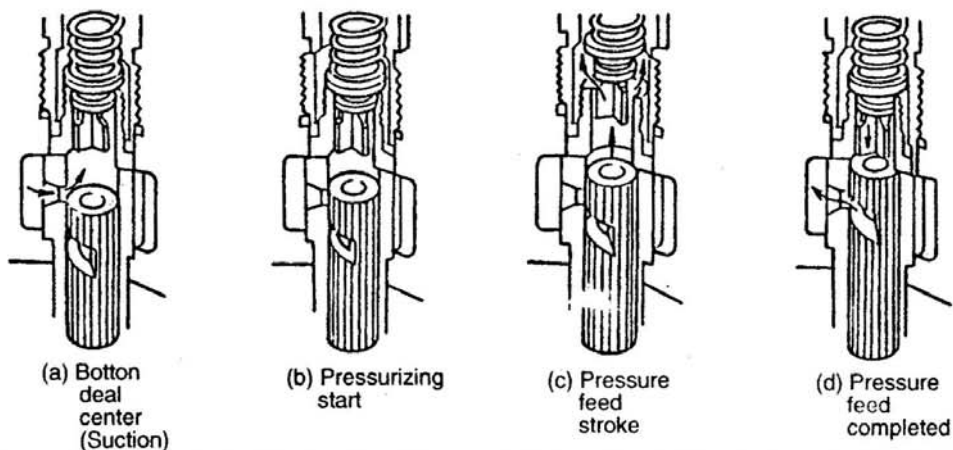
(a) Pressure feed of fuel

The plunger has an obliquely cut groove (lead) on its side as shown.

At the top of the plunger there is a hole which leads to the groove.

The plunger barrel has suction and discharge ports.

The fuel delivered to the injection pump is forced by the rotation of the camshaft or reciprocating motion of the plunger as shown below.



When the plunger is at the lowest position or bottom dead center(a), fuel flows through the suction and discharge ports into the plunger.

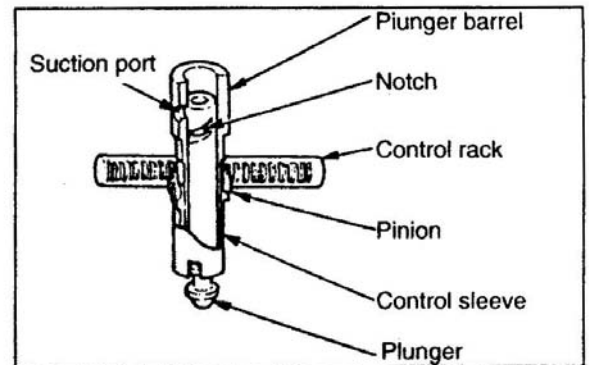
Rotation of the camshaft moves the plunger up. When the top surface of the plunger is lined up with the suction and discharge ports, application of pressure to fuel begins(b).

As the plunger moves up further(c), and the lead of the plunger meets with the suction and discharge ports, the high pressure fuel flows through the hole in the plunger and runs back from the lead to the suction and discharge port, and the pressure feed of fuel is completed(d).

The plunger stroke during which the fuel is fed under pressure is called the effective stroke.

**(b) Injection amount control system**

According to the engine load, the amount of injection is increased or reduced by turning the plunger a certain angle to change the position where the lead meets with the suction and discharge ports on the up stroke and increasing or reducing the effective stroke.



The control rack is coupled to the floating lever in the governor. If the control rack is moved to right or left by operation of the governor, the control sleeve in mesh with the rack is turned. Since the bottom of the control sleeve is in mesh with the bar of the plunger, the plunger turns with the control sleeve, so the effective stroke changes and the injection amount increases or decreases. The more the control rack is pulled toward the governor, the less the effective stroke and the less the injection amount.

Each plunger is in mesh with this single control rack and simultaneously turns the same amount.

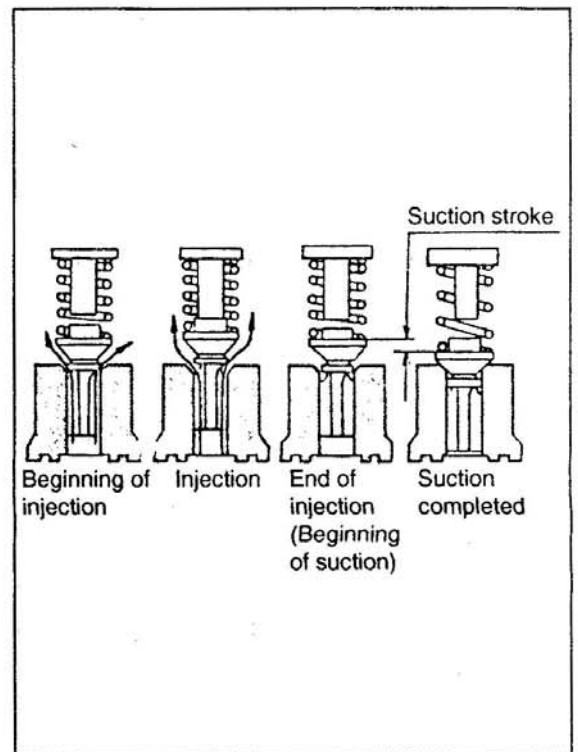
(c) Delivery valve

The delivery valve, provided on the top of the pump housing, performs the function of discharging the pressure in the injection pump.

The fuel compressed to a high pressure by the plunger pushes the delivery valve up and spouts out. If the pressure feed stroke of the plunger ends, the delivery valve is brought back to its original position by the pressure of the delivery valve spring to block the fuel path, thereby preventing counter flow of the fuel.

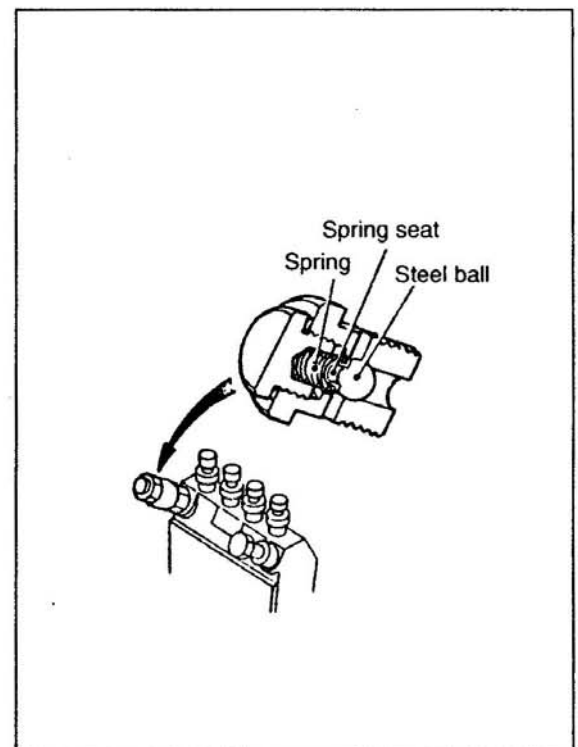
The delivery valve is brought down further until the seat surface is held tight. During that stroke the fuel is drawn back from above to instantly lower the residual pressure between the delivery valve and nozzle. The draw-back effect improves the end break of an injection from the nozzle and prevents after-injection dripping.

A delivery valve stopper is provided on the top of the delivery valve spring. The stopper limits the lift of the delivery valve and prevents valve surging during high speed rotation. In addition, it reduces the dead volume between the delivery valve and nozzle, thereby stabilizing the injection amount.



(d) Overflow valve

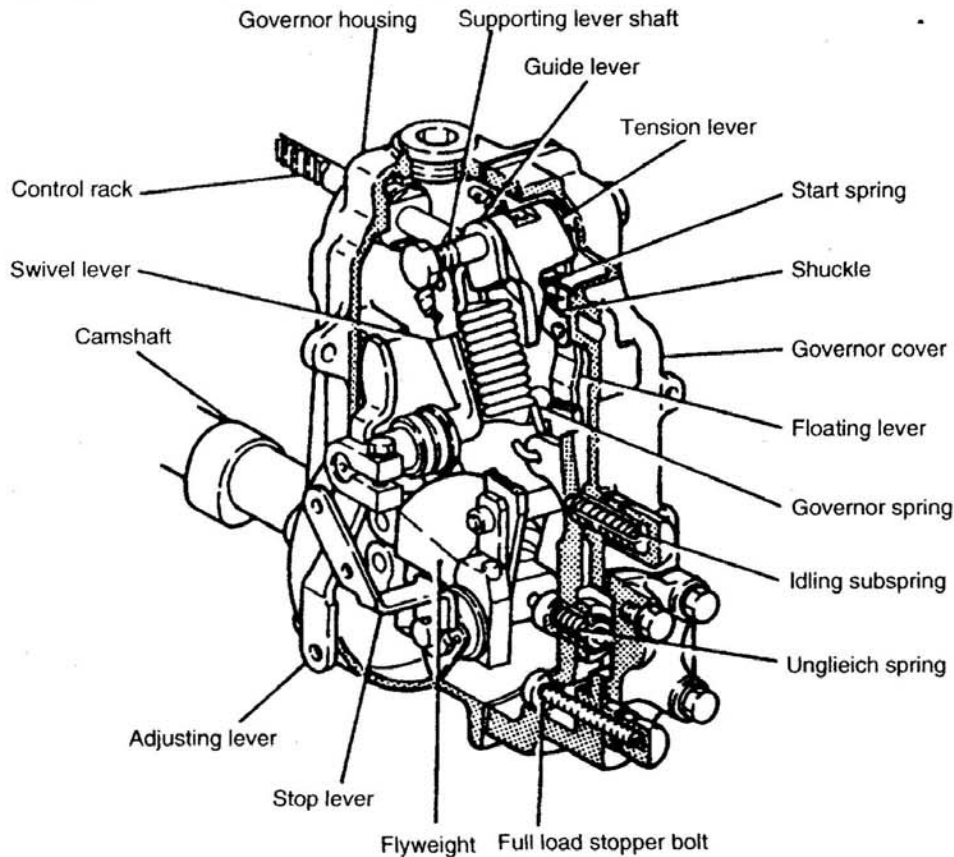
When the fuel pressure in the injection pump exceeds a set level, the steel ball in the overflow valve goes up to let the fuel flow out of the injection pump and return to the fuel tank, thereby stabilizing the fuel temperature and temperature distribution in the injection pump and maintaining the injection rate into each cylinder constant.



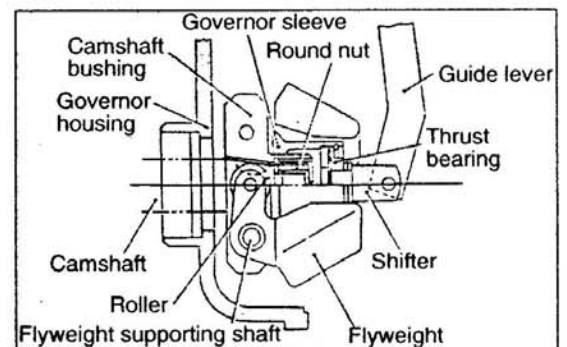
## (2) Governor

### (a) RSV type governor

The RSV type governor is a centrifugal type all-speed governor coupled to the camshaft of the injection pump. The governor not only controls the maximum and minimum speeds but also automatically controls the engine speed at any intermediate speed position.



The governor, as shown, consists of flyweights mounted to the injection pump camshaft. When the flyweights turning on the flyweight supporting shaft open outward, the roller mounted to the end of flyweight arm pushes the end of the sleeve in the axial direction. The governor sleeve, being made integral with the shifter through a bearing, moves only in the axial direction.



The shifter, mounted to the guide lever hung on the supporting lever shaft of the governor cover, prevents rotation.

The floating lever is mounted to the middle of the guide lever by the shaft with the bottom end as the fulcrum, whereas the top of the lever is coupled through the shackle to the control rack.

The start spring, attached to the top end of the floating lever, always pulls the control rack in the direction that fuel is increased.

The turning shaft of the swivel lever is fitted into the bushing of the governor cover and its center is eccentric with respect to the mounting position of the governor spring installed to the tension lever. The governor spring is installed to the end of the swivel lever. When the governor spring receives tension, the bottom end of the tension lever touches the adjustable full-load stopper bolt.



When the angle of the adjusting lever is changed, the angle of the swivel lever is also changed and the tension of the governor spring changed. This is because the turning center of the swivel lever and the mounting position of the governor spring installed to the tension lever are eccentric to each other as mentioned above.

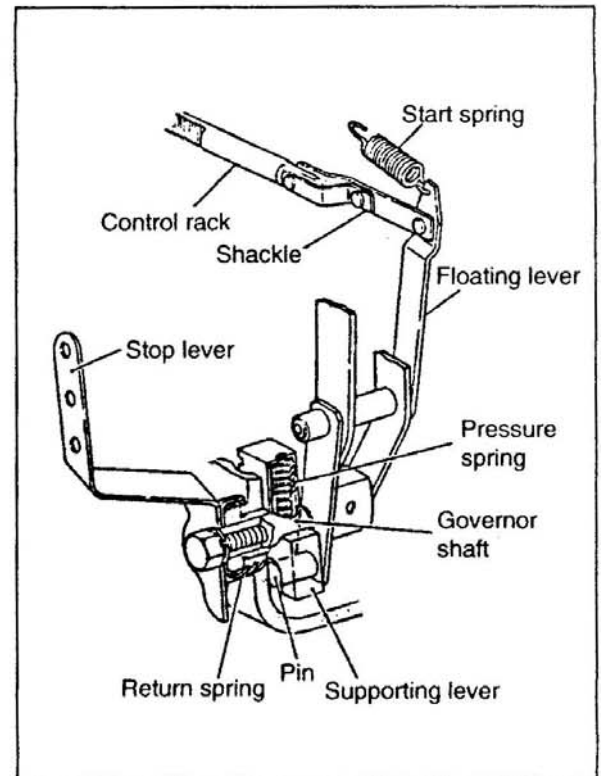
An adjusting screw is also mounted to the swivel lever. Adjustment of the screw changes the tension of the governor spring, thereby making it possible to adjust the speed regulation.

An Ungleich spring is provided in the bottom portion of the tension lever. Adjust the tension of the spring by adding or removing shims.

An idling sub spring adjustable from outside is provided in the middle of the governor cover.

During idling, the spring always keeps in contact with the tension lever to maintain a constant idling speed.

The stop lever, mounted through the supporting lever to the bottom end of the floating lever, returns the control rack to the stop position with a slight pressure irrespective of the adjusting lever position.



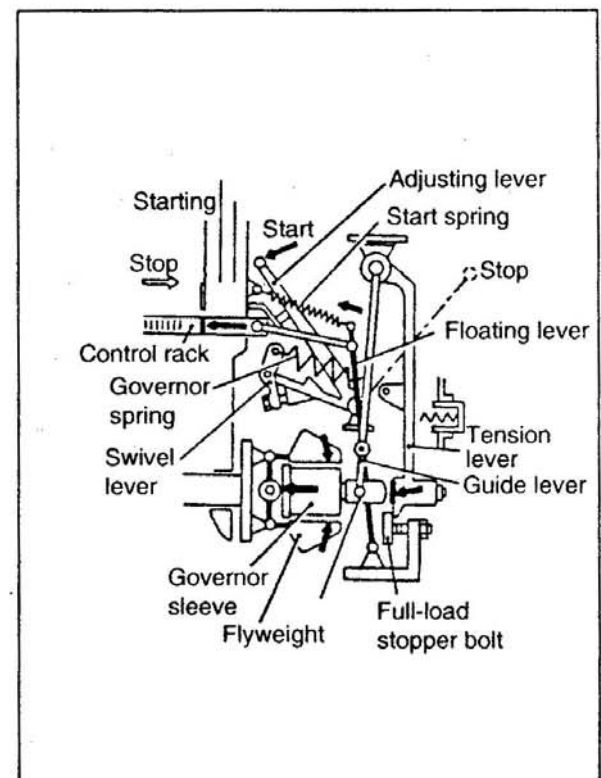
### 1) Start of engine

When the adjusting lever is moved to the start position (until it touches the maximum speed stopper), the swivel lever which moves with the adjusting lever pulls the governor spring and moves the tension lever until it touches the full-load stopper bolt.

At that time, the flyweights are stationary, and the start spring with weak tension pulls the floating lever in the direction that fuel is increased.

At the same time, the shifter and governor sleeve push the flyweight roller to the left.

As the result, the tension lever and shifter are spaced that much apart, and the corresponding amount of fuel is supercharged to facilitate starting.





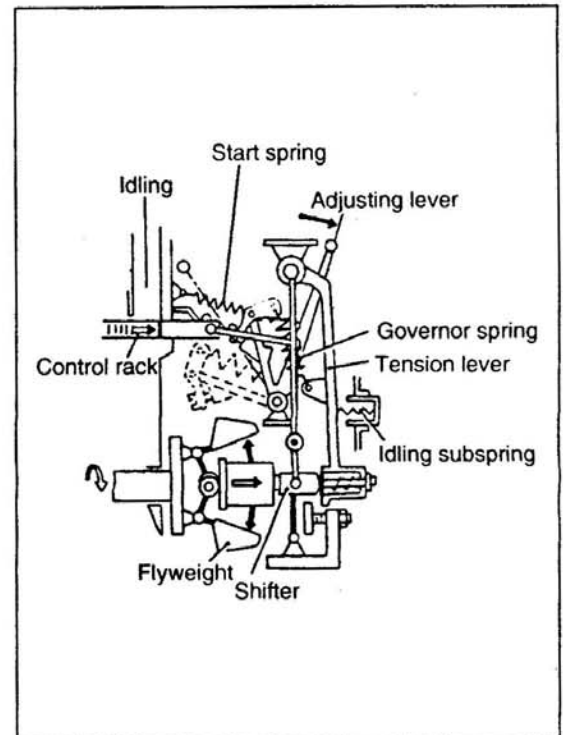
## 2) Idling control

Once the engine is started and the adjusting lever returned to the idling position, the tension of the governor spring is drastically reduced.

Now the flyweights can move outward even at a low speed, so the tension lever is pushed back until it touches the idling sub spring and places the control rack at the idling position. In this state, the centrifugal force of the flyweight and the weak-state governor spring and idling sub spring achieve balance and maintain smooth idling.

When the speed falls, the centrifugal force decreases, the flyweights move inward, and the idling sub spring pushes the tension lever to the left and moves the control rack in the direction that fuel is increased.

If the speed falls radically, the start spring with weak tension acts and moves the control rack in the direction that fuel is increased to maintain the idling speed.

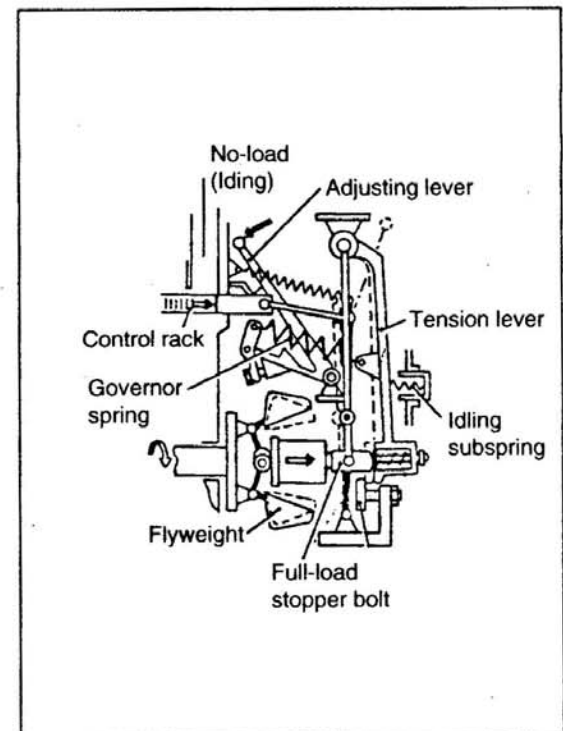


## 3) Maximum speed control

When the adjusting lever is moved to the full-load position, the tension of the governor spring is increased and pulls the tension lever until it touches the full-load stopper bolt.

When the engine exceeds the specified speed, the centrifugal force of flyweights becomes larger than the force of the governor spring pulling the tension lever. So the tension lever is moved to the right and moves the control rack in the direction that fuel is reduced, thereby preventing the engine from exceeding the specified speed.

If the speed further increases, the centrifugal force of flyweight increases and pushes the tension lever to the right and also compresses the idling sub spring to pull the control rack back to the no-load maximum speed position, thereby preventing over-speed operation of the engine.



The RSV type governor controls the entire speed range from idling to maximum speed.

If load increases or decreases at a certain speed determined by the position of the adjusting lever, the governor automatically functions and maintains the engine speed constant at all times.

#### 4) Ungleich operation

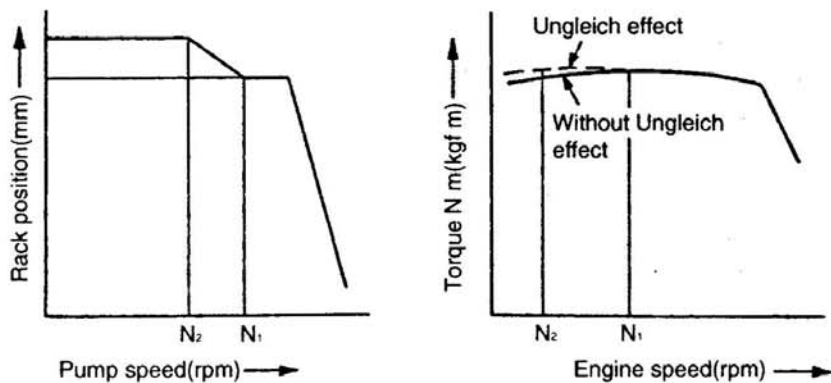
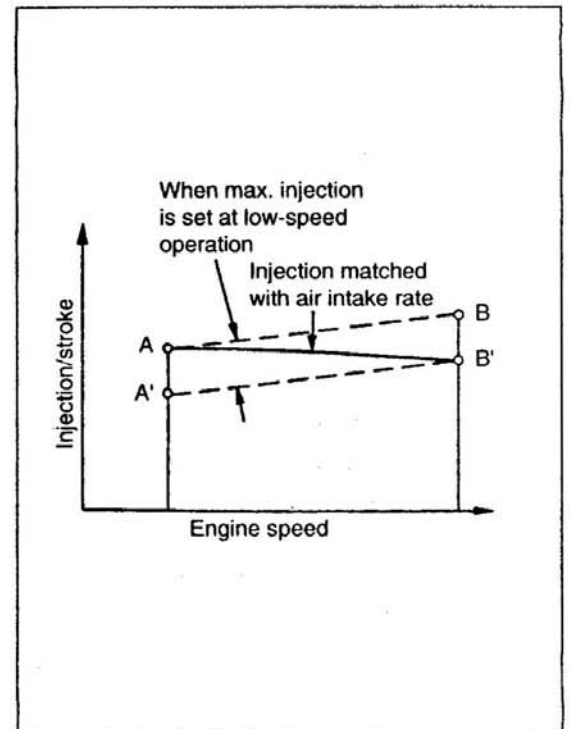
The Ungleich device controls fuel injection in such a way as to match the engine performance (the required injection varies with engine speed.)

The air intake rate of the engine falls as the engine speed increases. The injection pump, on the other hand, increases the per-stroke injection as the speed increases, even with the control rack at the same position.

Therefore, if full load is set at point A to derive enough output at low speeds, the injection will reach B as the speed increases, and the engine will produce black smoke.

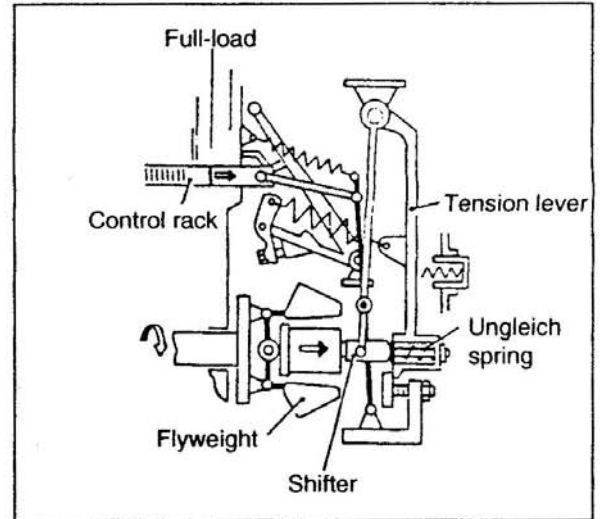
If full load is set at point B' to prevent black smoke, the low speed injection will come down to A', allowing combustion of more fuel.

So the Ungleich device accomplishes the function of setting full load at point A to derive the largest possible torque in the low speed range, and changing it to adjust the injection to point B' in the high speed range.



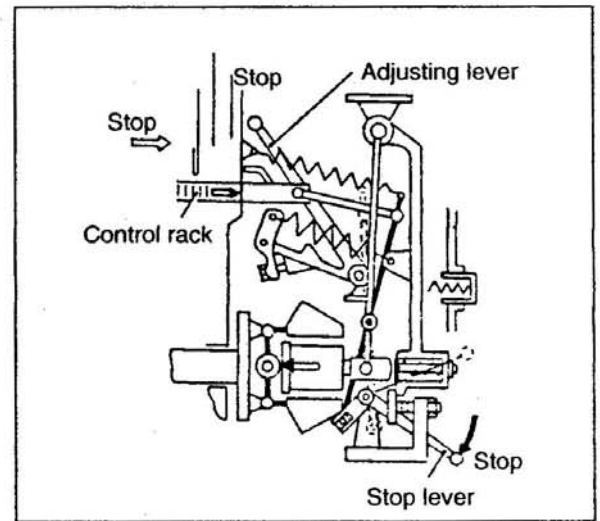
When the engine speed is low and the centrifugal force of flyweight smaller than the set tension of the Ungleich spring, the shifter is moved as much as the Ungleich stroke to the left, so the control rack moves in the direction that fuel is increased to increase the torque of the engine at low speeds.

As the engine speed increases, the centrifugal force of flyweight increases. If it becomes larger than the set tension of the Ungleich spring, the Ungleich spring is slowly compressed before the start of high speed control, and the control rack moves in the direction that fuel is reduced. The Ungleich stroke is completed at the position where the shifter directly touches the tension lever.



#### 5) Stopping of engine

When the stop lever is moved to the stop position, the control rack is moved to the stop position to stop the engine regardless of the position of the adjusting lever.

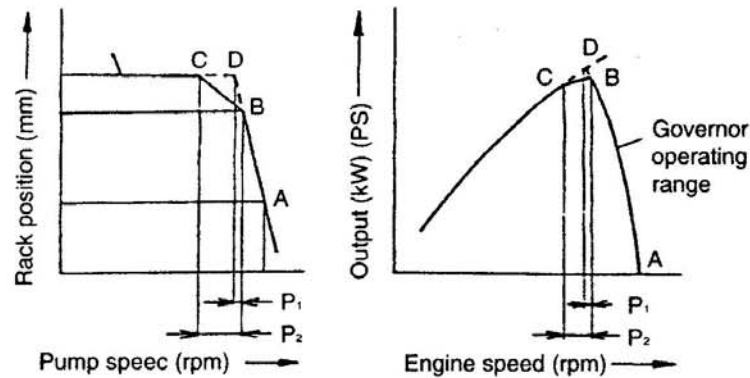


#### 6) Operation of torque spring

Construction machinery engines are often subjected to a large load during operation, and reduced speeds often lead to stalls. To prevent this, a torque spring is provided.

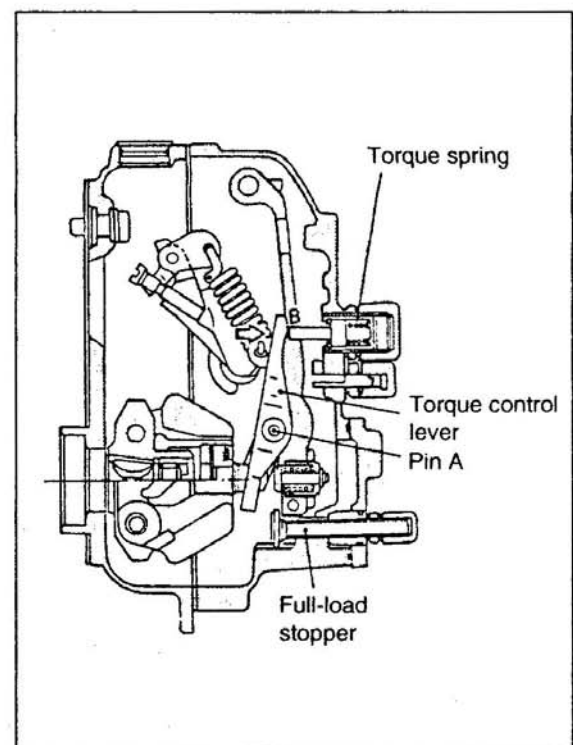
When the adjusting lever is fixed in the lever set position, a sudden increase of load, if no torque spring is provided, will move the control rack along the B-D curve as the speed falls. The rotational displacement at the time may be expressed as P1.

If a torque spring is provided, the control rack moves along B-C, and the rotational displacement at the time may be expressed as  $P_2$ . Therefore, large changes occur in  $P_2$  and engine speed, and because of increased fuel injection, the engine torque increases, and large combustion noise warns the operator of the increased load, enabling him to take proper action to prevent stopping the engine.



In an abrupt increase of load occurs when the engine is running at continuous rating, the engine speed falls. So the flyweights are moved inward and the tension lever pulled to left by the governor spring, causing the control rack to move in the direction that fuel is increased.

At the time, the tension lever pin pushes the bottom of the torque control lever, and the lever moves with the pin A as the fulcrum, whereas the portion B is pushed to right. As the result, the torque spring performs the function of reducing movement of the tension lever.

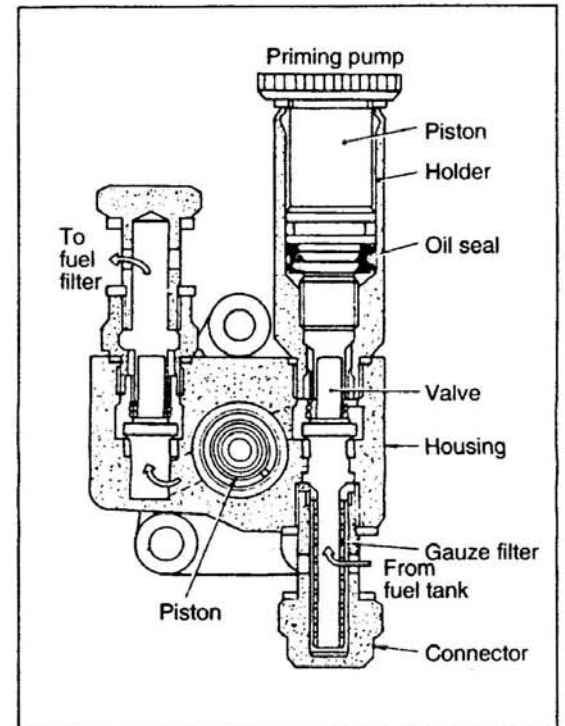


### (3) Feed Pump

The feed pump is driven by the camshaft of the injection pump.

The priming pump makes it possible to manually lift fuel when the injection pump is stationary, so it can be used in bleeding the fuel system.

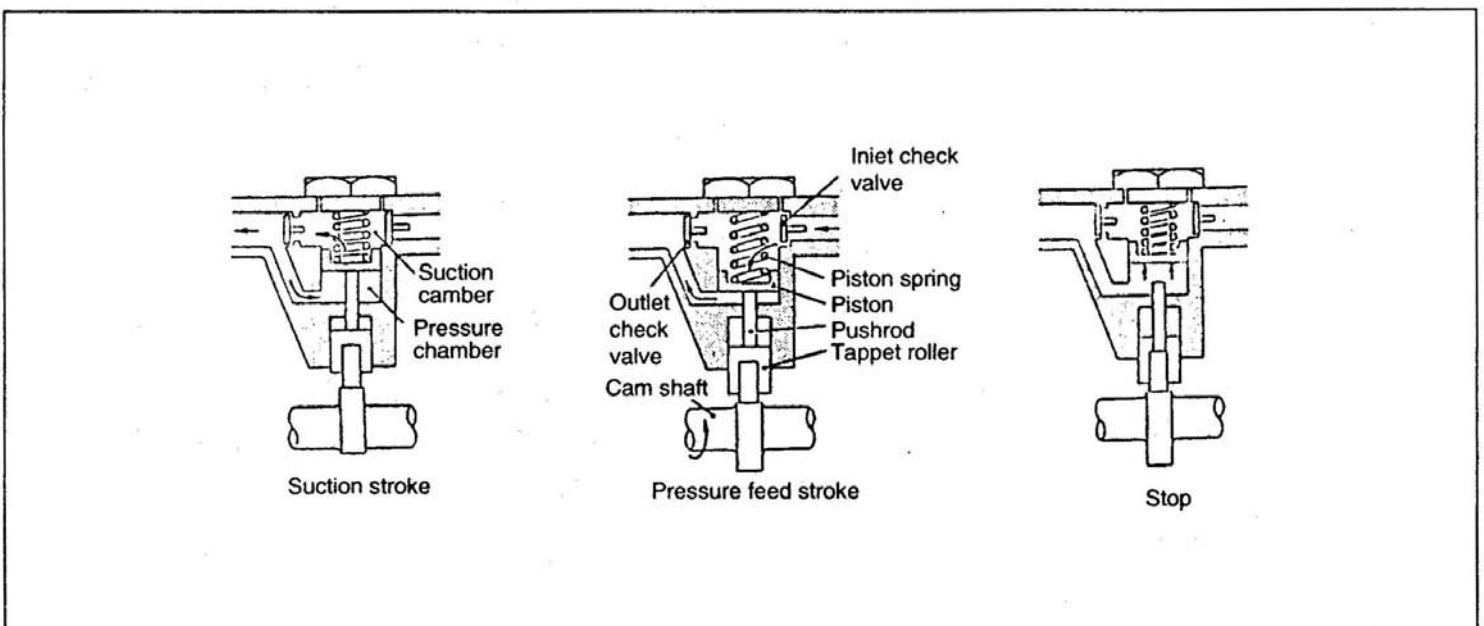
The gauze filter removes large particles of dust and dirt contained in the fuel lifted from the fuel tank to prevent clogging in the feed pump. Make sure the gauze filter is cleaned in gas oil at regular intervals.



The fuel is fed under pressure as described below. When the camshaft of the injection pump forces the push rod up, the fuel in the suction chamber is compressed and opens the outlet check valve. Most of the fuel forced out is drawn into the pressure chamber above the piston. When the cam, moved away by rotation of the camshaft, ceases to push up, the piston is pushed back by the pressure of the piston spring and forces out the fuel from the pressure chamber and forces it into the fuel filter.

At the time, the outlet check valve simultaneously closes, and the inlet check valve opens, so the fuel is drawn into the suction chamber.

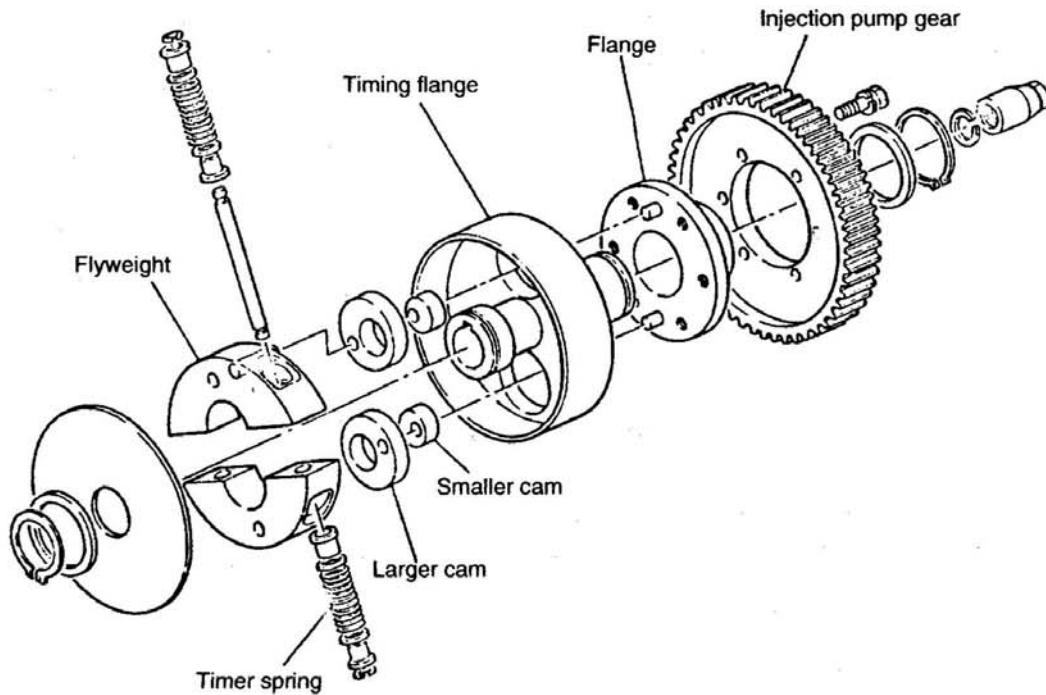
If the pressure in the pressure chamber exceeds specification, the piston cannot be brought back by the pressure of the piston spring and stops the pump function. So the pressure in the fuel filter is adjusted not to rise more than necessary.



#### (4) Automatic timer

##### (a) SCDM type timer(D4A)

The SCDM type auto timer, of a mechanical type, varies the fuel injection timing automatically according to engine speed. Attached to the injection pump camshaft with round nuts, the auto timer is driven by the injection pump gear from the idler gear.



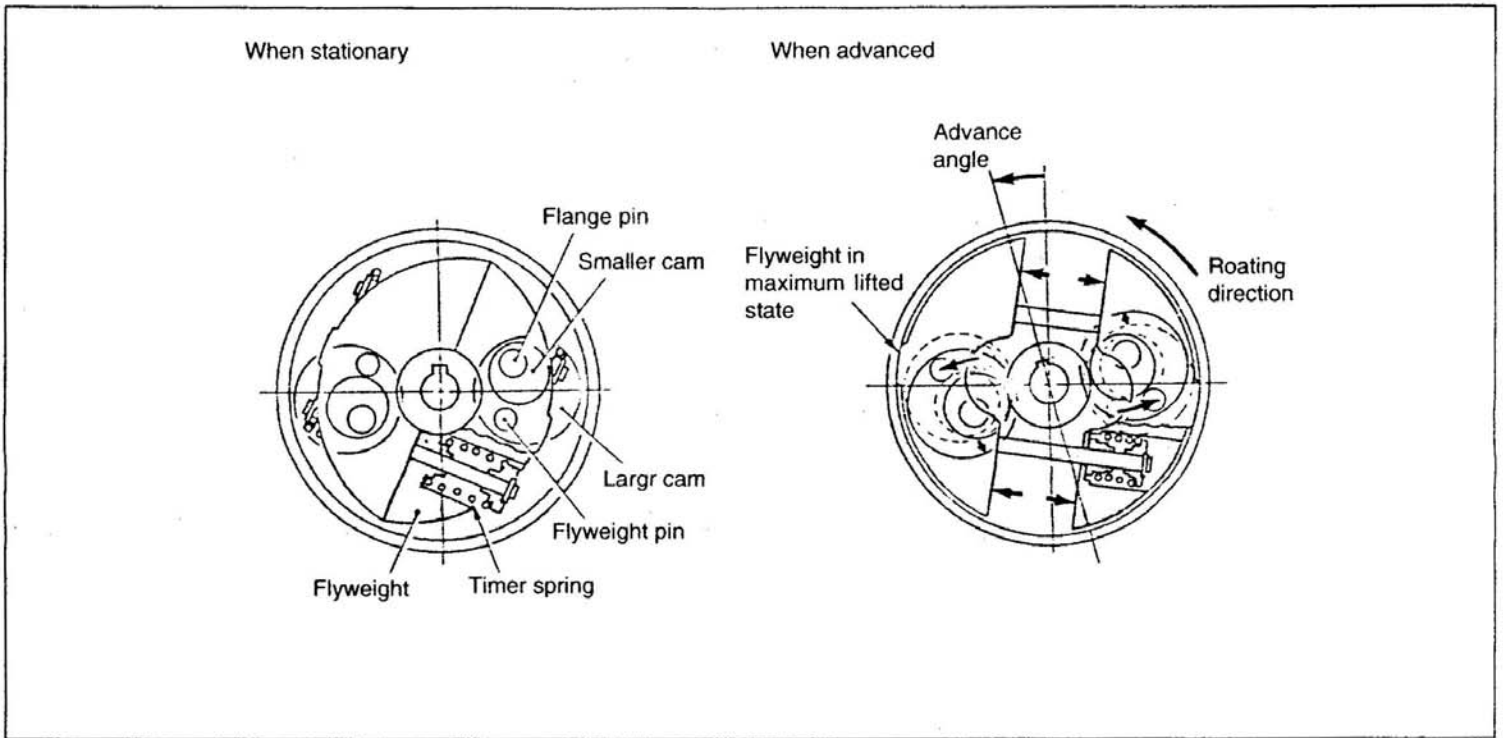
There are two pins opposing to each other press-fitted into the flange, to which the injection pump gear is attached. An eccentric smaller cam is installed on the pin, and mounted on the periphery of the smaller cam is a larger cam. The larger cams fit into the two holes in the timing flange, which causes the timing flange to turn as the flange rotates, thus driving the injection pump.

The two flyweights are installed with a given tension by the timer springs. The pins press-fitted into the flyweights are inserted into the holes in the larger cams.

With the engine running at low speed, the flyweights are unable to lift because of the timer spring set tension.

When the centrifugal force of flyweights becomes greater as the engine speed goes up, it overcomes the timer spring set tension allowing the flyweights to lift. This causes the larger and smaller cams to move in the turning direction.

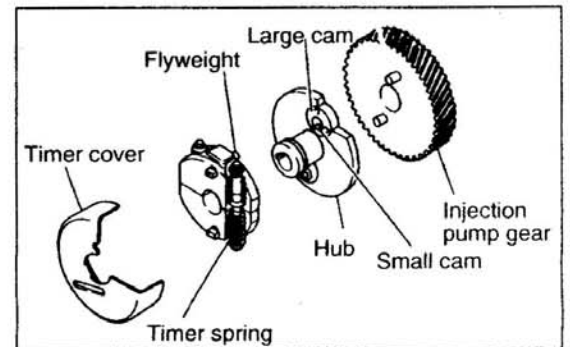
Since the larger cams are fitted into the holes in timing flange, the motion of the cams is imparted to the timing flange, thus providing an advance.



(b) SBO type Automatic timer (D4DA)

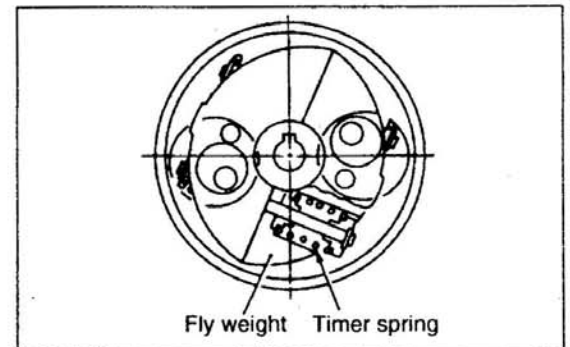
The automatic timer utilizes a mechanical arrangement to adjust the injection timing in accordance with the engine speed.

The automatic timer is mounted on the injection pump camshaft using a round nut. It is driven by the idler gear which is in engagement with the injection pump gear.



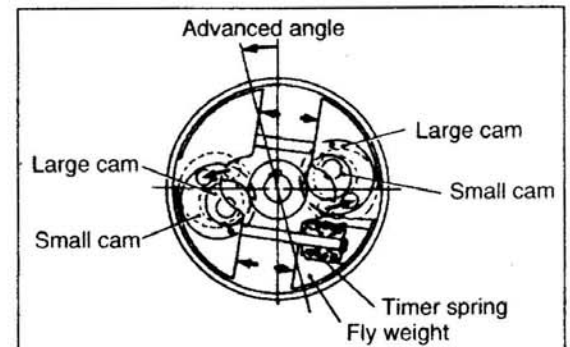
1) At standstill

Flyweight is forced to close by the tension of timer spring.



2) At operation

As the engine speed rises, the centrifugal force acting on flyweight increases, and when it overcomes the tension of the timer spring, the flyweight start to open. Therefore, the small cam and the large cam move in the direction of rotation. Since the large cam is fitted in the hole of hub, the movement of the large cam is transmitted to the hub, thus the injection timing being advanced.



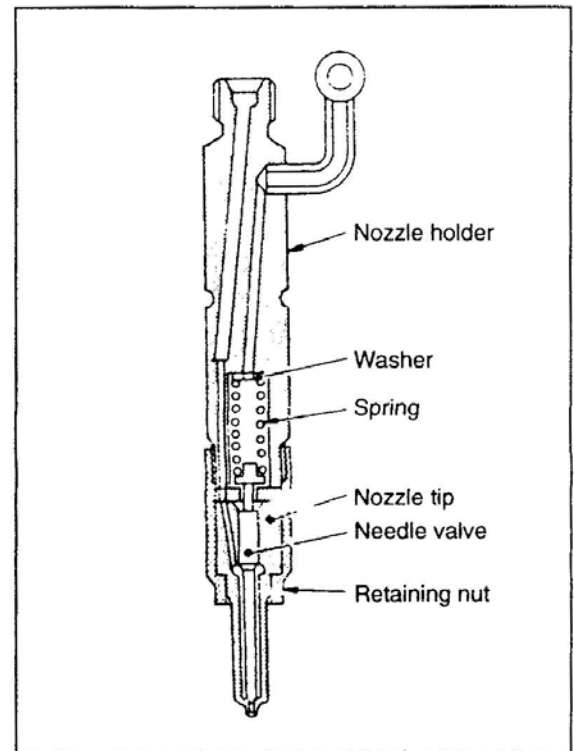


## (5) Injection Nozzle

The injection nozzles are of the hole type and the throttle type.

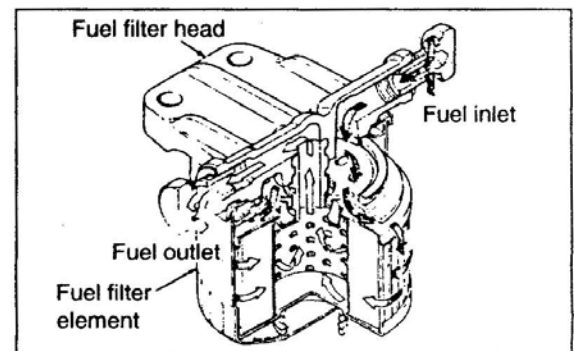
The fuel delivered from the injection pump enters the nozzle holder. When reaching the specified pressure valve, the fuel overcomes the spring force to push up the needle valve of the nozzle tip, spraying from the injection orifice at the end of the nozzle into cylinder(hole type).

The injection pressure can be adjusted by increasing or decreasing the number of washers in the spring.



## (6) Fuel filter

The fuel filter is of the spin-on type designed for ease of element replacement. The element is made integral with the outer casing, the center of the casing is being threaded.



## (7) Water Separator<Option>

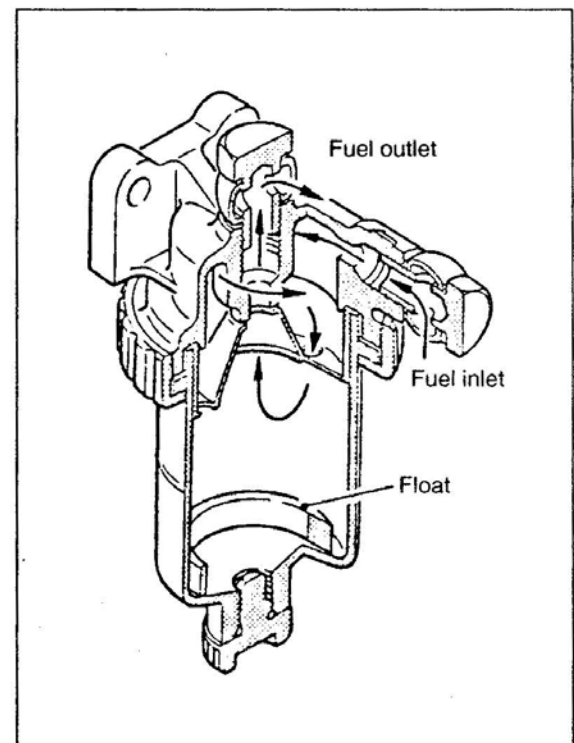
The sedimenter type water separator separates gas oil and water centrifugally by taking advantage of their difference in specific gravity.

The fuel that has flowed in from the inlet connector is squeezed by the fuel path of the head to increase the flow velocity and spins.

The separated water is sedimented in the case, whereas the water-separated fuel is drawn through the fuel path in the center of the head into the feed pump.

The water separator sediments not only water but also mud components.

A red float goes up and down with the water level in the semitransparent case, marking it possible to visually check the water quantity.





## 2. SPECIFICATIONS

Model		Specification		
		<D4AK>	<D4AN/AF>	<D4DA>
Injection pump proper	Type	BOSHC A	←	←
	Model	NP-PES4A90	ND-PES4A90	
Turning direction (As viewed from driven side)		Clockwise	←	
Plunger	Diameter	9mm	←	←
	Lead	R.H. single or two-step	R.H. single-step	←
Governor	Type	RSV, all speed mechanical minimum-maximum, mechanical	RSV, all speed mechanical	←
Feed pump	Model	NP-FP/KS22AC	ND-FP/KS22AC	
Auto-timer	Type	SCDM, mechanical (2,600 rpm or more)	←	SBO
Injection Nozzle	Type	Hole		←
	Model	NP-DLLA	ND-DLLA	
	No. of orifices	5	←	←
	Orifice diameter	0.28 or 0.30 mm	0.28 mm	
	Orifice angle	160	←	
	Injection pressure	17.7 MPa (180 kgf/cm <sup>2</sup> ) or 21.6 MPa (220 kgf/cm <sup>2</sup> )	17.7 MPa (180 kgf/cm <sup>2</sup> )	
Fuel filter	Type	Spin-on, filter paper		
Water separator <Option>	Type	Sediment trap		

### 3. SERVICE STANDARDS

#### 3-1 Service standard Table

Unit : mm

Description		Nominal value [Basic diameter]	Limit	Correction and remarks	
Injection pump Proper	Overflow valve opening pressure		255 kPa(2.6 kgf/cm <sup>2</sup> )		
	Control rack sliding resistance (When not rotating)		1.5N (0.15 kgf) or less		
	Camshaft end play		0.02 to 0.06	0.1	Adjust or replace
	Backlash between control rack and pinion		0.15	0.3	Replace
	Tappet roller overall clearance			0.2	Replace
	Tappet to pump housing clearance		[24] 0.03 to 0.07	0.2	Replace
	Wear on lower spring seat surface in contact with plunger			0.2	Replace
	Plunger driving face to control sleeve clearance		0.02 to 0.08	0.12	Replace
	Control rack full stroke		21 or more		Adjust
	Prestroke		3.5 ± 0.05		Adjust
	Injection start interval		90° ± 30°		Adjust
	Tappet clearance		0.3 or more		Adjust
RSV governor	Governor housing end face to shifter distance	Nippondenso products(D4DA)	15 to 15.2	Adjust	
		DOOWON products(D4A)	19		
Feed pump	Airtightness(When 195 kPa or 2 kgf/cm <sup>2</sup> ) air pressure is applied)		0 cc/min	Adjust	
	Priming pump lift capacity (No. of strokes required before lifting when operated at 60 strokes/min		25 strokes or less	Adjust	
	Delivery pressure	At 600 rpm	D4AN	175 to 215 Kpa (1,8 to 2.2 kgf/cm <sup>2</sup> )	Replace
			D4AK-T	335 to 410 Kpa (3.4 to 4.2 kgf/cm <sup>2</sup> )	
	Delivery amount	For 1 min. at 1,000 rpm through a ø 1.54 nozzle	D4AN	900 cc or more	Replace
		For 1 min. at 1,000 rpm	D4AK-T	1,620 cc or more	

Unit : mm

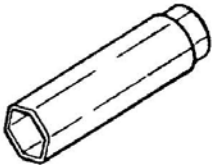
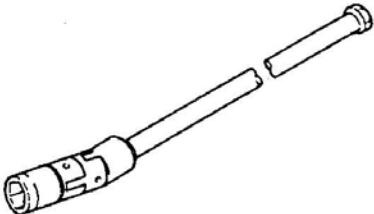
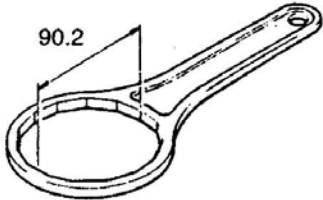
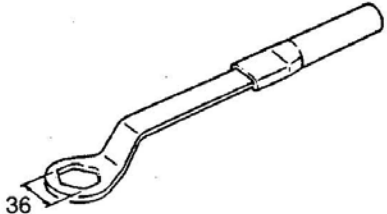
Description				Nominal value [Basic diameter]	Limit	Correction and remarks
Feed pump	Lift capacity	When operated at 150 rpm	D4AN	45 sec. or less		Replace
		When operated at 100 rpm	D4AK-T	40 sec. or less		
SCDM auto timer	Flange to shim clearance			0.02 to 0.1		Adjust
	Flyweight to cover clearance			0.05 to 0.2		Adjust
Injection nozzle injection pressure	Orifice diameter 0.3			21.6 to 22.6 MPa (220 to 230 kgf/cm <sup>2</sup> )		Adjust

### 3-1 Tightening Torque Table

Unit : mm

Description			Thread size O.D. × pitch mm	Tightening torque N m(kgf m)
Injection pump	Delivery valve holder	D4A		39 ~ 49 (4 ~ 4.5)
	Screw plug			54 ~ 74 (5.5 ~ 7.5)
	Lock plate	D4AN		7.8 ~ 11 (0.8 ~ 1.1)
		D4AK-T		4.4 ~ 5.9 (0.45~0.6)
RSV governor round nut				49 ~ 59 (5 ~ 6)
Auto timer	Round nut	D4A		83 ~ 98 (8.5 ~ 10)
	Injection pump gear attaching bolt	D4AK-T		7.8 ~ 12 (0.8 ~ 1.2)
Injection nozzle	Nozzle bridge bolt	D4A	M10 × 1.5	25 (2.5)
	Retaining nut	D4AN		25 ~ 34 (2.5 ~ 3.5)
		D4AK-N	M15 × 0.5	29 ~ 39 (3 ~ 4)
Fuel filter	Fuel feed hose connector bolt		M14 × 1.5	34(3.5)
	Filter element			7.8 ~ 12 (0.8 ~ 1.2)
	Air vent plug		M8 × 1.25	7.8 ~ 12 (0.8 ~ 1.2)
Water separator connector bolt			M4 × 1.5	34 (3.5)
Secondary fuel filter	Connector bolt		M4 × 1.5	34 (3.5)
	Center bolt		M4 × 1.5	27 ~ 41 (2.8 ~ 4.2)

## 4. SPECIAL TOOLS

Tool name	Part number	Shape (Unit : mm)	Use
Socket wrench	31391-14100	 <p data-bbox="711 595 935 622">Width across flats 12</p>	<ul data-bbox="1139 300 1533 533" style="list-style-type: none"> <li>● For timing gear case bolt used for removal and installation of injection pump(on-vehicle service)</li> <li>● Removal and installation of timer round nut</li> </ul>
Universal extension	MH061099	 <p data-bbox="711 1016 935 1043">Width across flats 14</p>	Adjustment of fuel injection start timing
Filter wrench	MH061509	 <p data-bbox="707 1285 756 1312">90.2</p>	Removal of fuel filter element
Cranking handle	MH061289	 <p data-bbox="619 1899 652 1926">36</p>	For engine cranking

## 5. SERVICE PROCEDURES

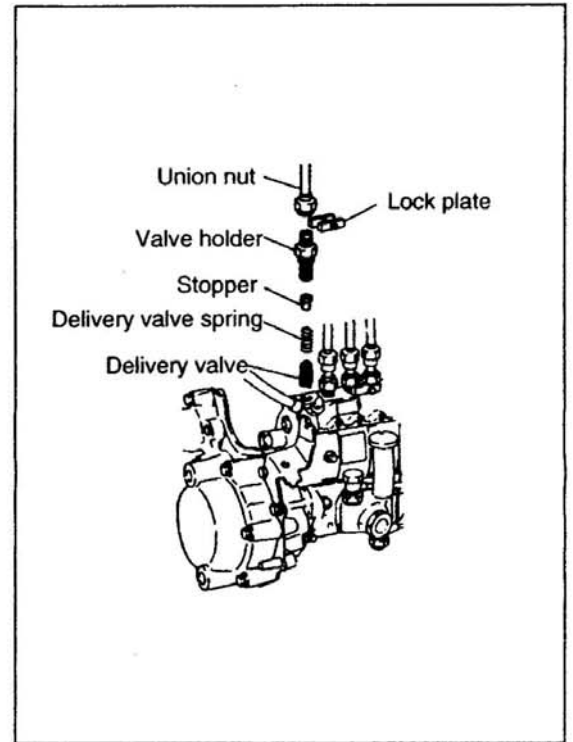
### Inspection and Adjustment of Injection Timing

#### 5-1. Inspection

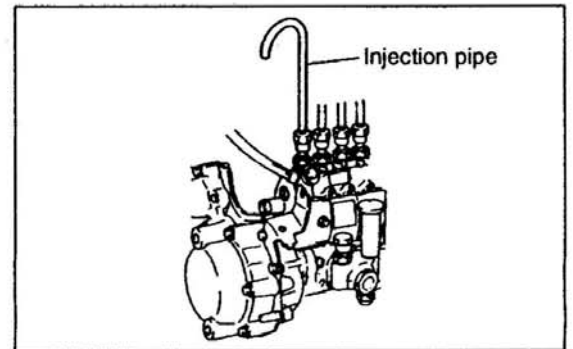
- (1) From the injection pump's No.1 cylinder, remove union nut of injection pipe, lock plate, delivery valve holder, stopper, delivery valve spring, and delivery valve.
- (2) Fit delivery valve holder 3.

**NOTE:**

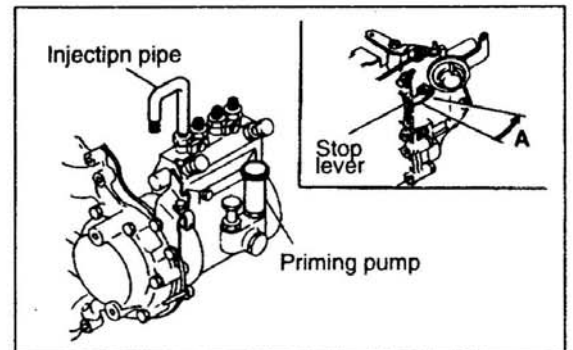
Place all parts in gas oil after removal to keep them free of dust.



- (3) Fit an injection pipe onto cylinder No.1 point the pipe's other end downward such that fuel flowing out can be seen clearly.
- (4) Rotate the crankshaft pulley clockwise(as seen from the front of engine) by at least 180° and bring cylinder No. 1 to approximately 30° BTDC on its compression stroke.



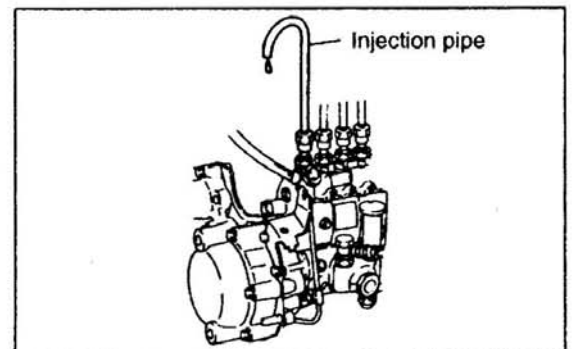
- (5) Feed fuel into the injection pump using priming pump. With fuel flowing out of injection pipe, crank the engine slowly clockwise(as seen from the front of engine).



**NOTE:**

Make sure the stop lever on top of the governor is in its engine starting position A.

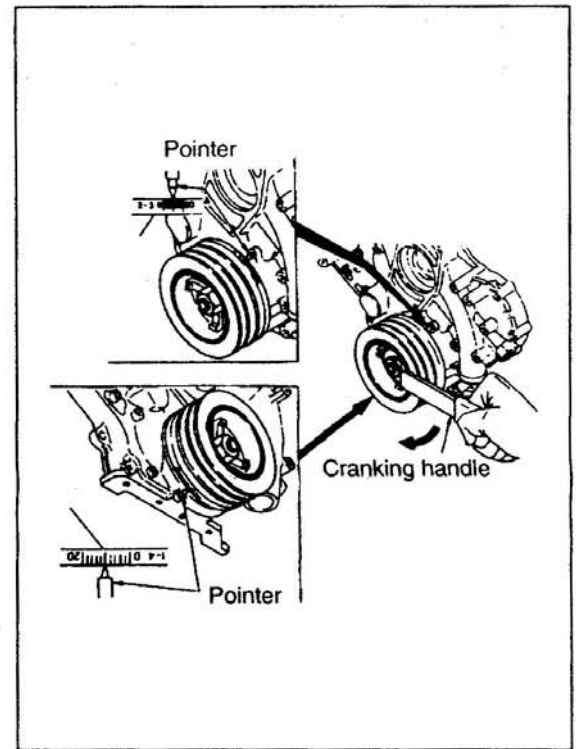
- (6) When the flow of fuel from injection pipe diminishes, crank the engine more slowly. When the flow of fuel stops completely, stop cranking the engine.



- (7) Check that pointer on the timing gear case is pointing to inscribed line on the crankshaft pulley which corresponds to the specified fuel injection timing.

If the injection timing should be measured in a dusty location, perform as follows:

- Rotate the crankshaft clockwise (as seen from the front of engine) and bring the No.1 cylinder to 30° BTDC on its compression stroke.
- Disconnect injection pipe with a little amount of fuel remained at the top of delivery valve holder.
- Slowly rotate the crankshaft clockwise. When the injection timing is reached, the fuel at the top of delivery valve holder starts to move.



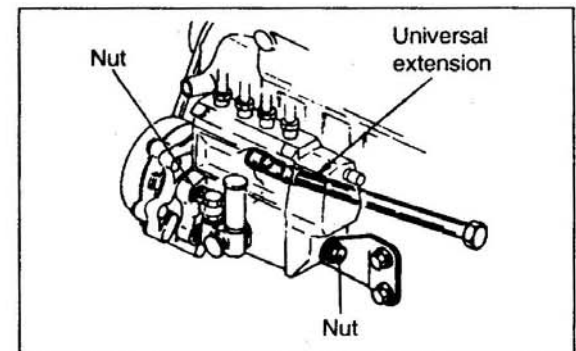
- (8) If the fuel injection timing is out of specification, make adjustments in accordance with the following procedure.

## 5-2. Adjustment

- (1) Loosen injection pump mounting nuts

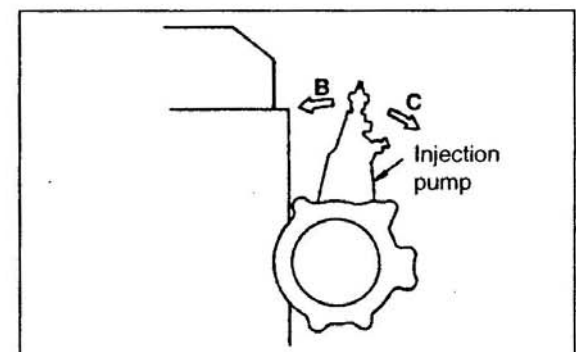
Nut(4-off; on flange)

Nut(1-off)



- (2) If the fuel injection timing is overly retarded, incline injection pump toward crankcase B.

- (3) If the fuel injection timing is overly advanced, incline injection pump away from crankcase C.

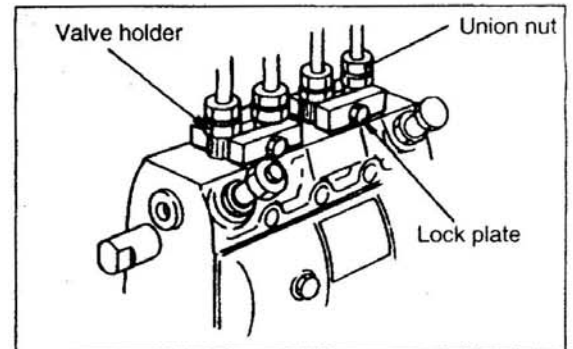
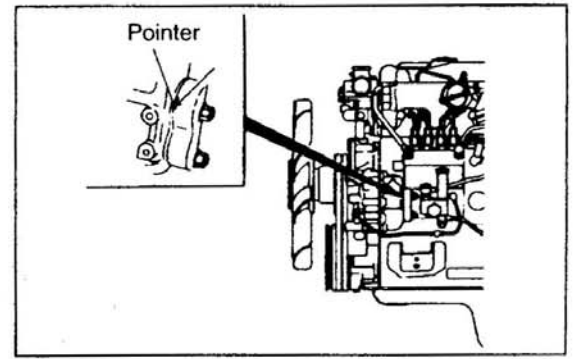


(4) Turning the injection pump by one of gradations inscribed on the timer case flange causes a 6° change in the injection timing.

(5) Tighten nuts then check the fuel injection timing again.

(6) After checking that the fuel injection timing is up to specification, fit delivery valve, delivery valve spring, and stopper, and then delivery valve holder, lock plate and union nut.

(7) Tighten each part to its specified torque.



Before making inspections and adjustments, warm up the engine until the coolant reaches 80 to 90°C.

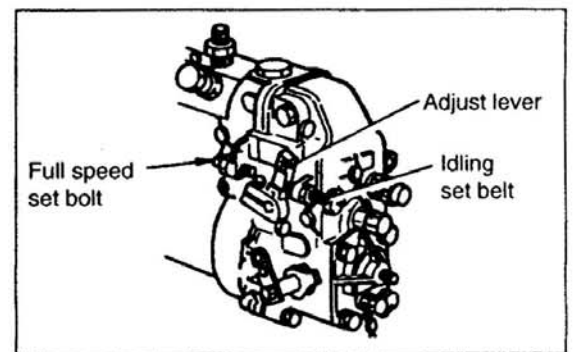
#### (1) No-load minimum speed

[Inspection]

Confirm that adjust lever is touching idling set bolt. Then check that the minimum speed is up to specification.

[Adjustment]

If the minimum speed is out of specification, adjust it using idling set bolt.



#### (2) No-load maximum speed

[Inspection]

Confirm that adjusting lever is touching full-speed set bolt. Then, check that the maximum speed is up to specification.

[Adjustment]

If the maximum speed is out of specification, adjust it using full-speed set bolt

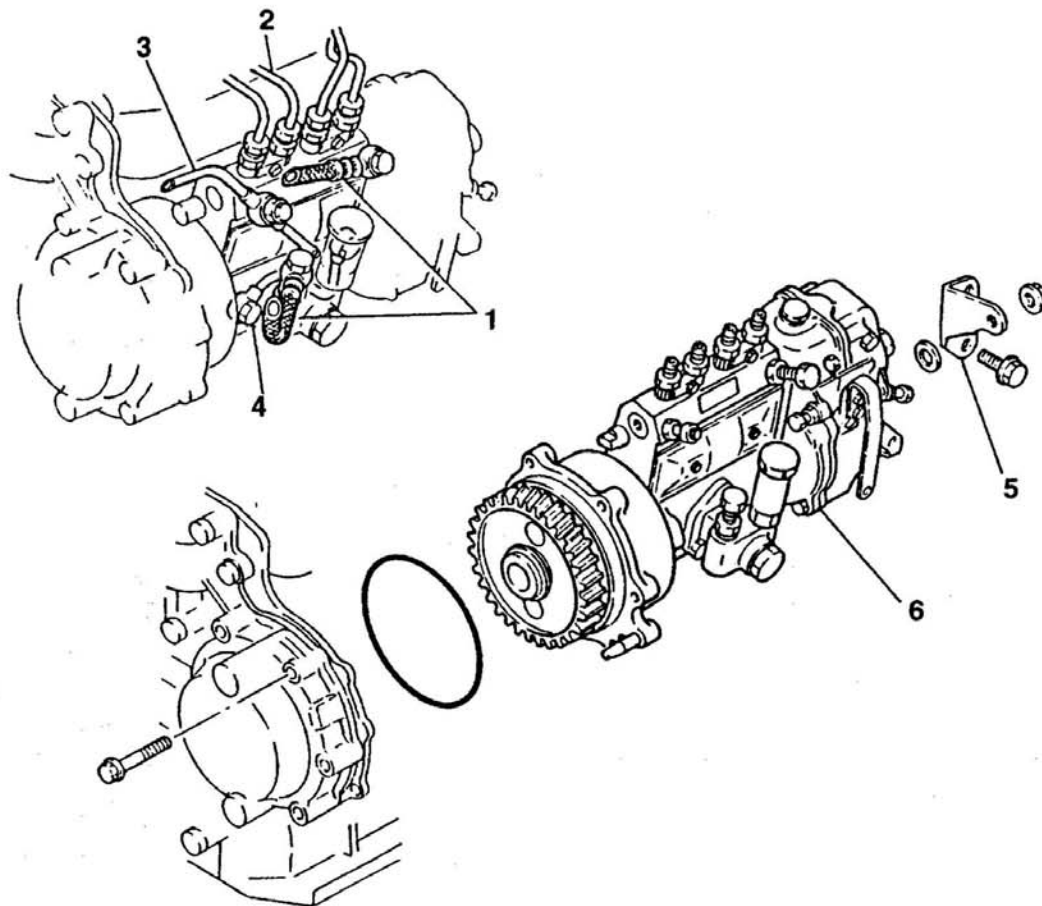
#### NOTE:

Check that the engine does not stall and that no hunting occurs when adjusting lever is moved quickly from the full-speed position to the idling position.

If any abnormality is apparent, make adjustments within the specified range.

## 5-3. A Type Injection Pump

### 5-3-1. Removal



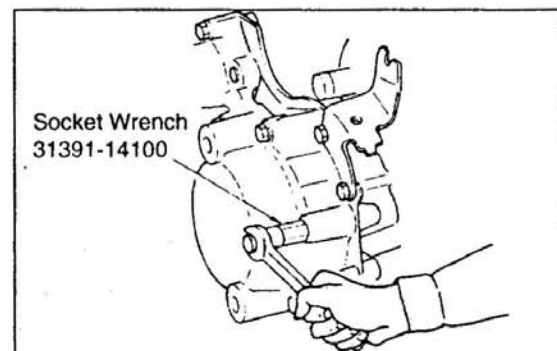
- 1 Fuel hose
- 2 Injection pipe
- 3 Leak off pipe
- 4 Oil pipe

- 5 Injection pump stay
- 6 Injection pump

Hold the injection pump by hand, and remove five timer case attaching bolts.

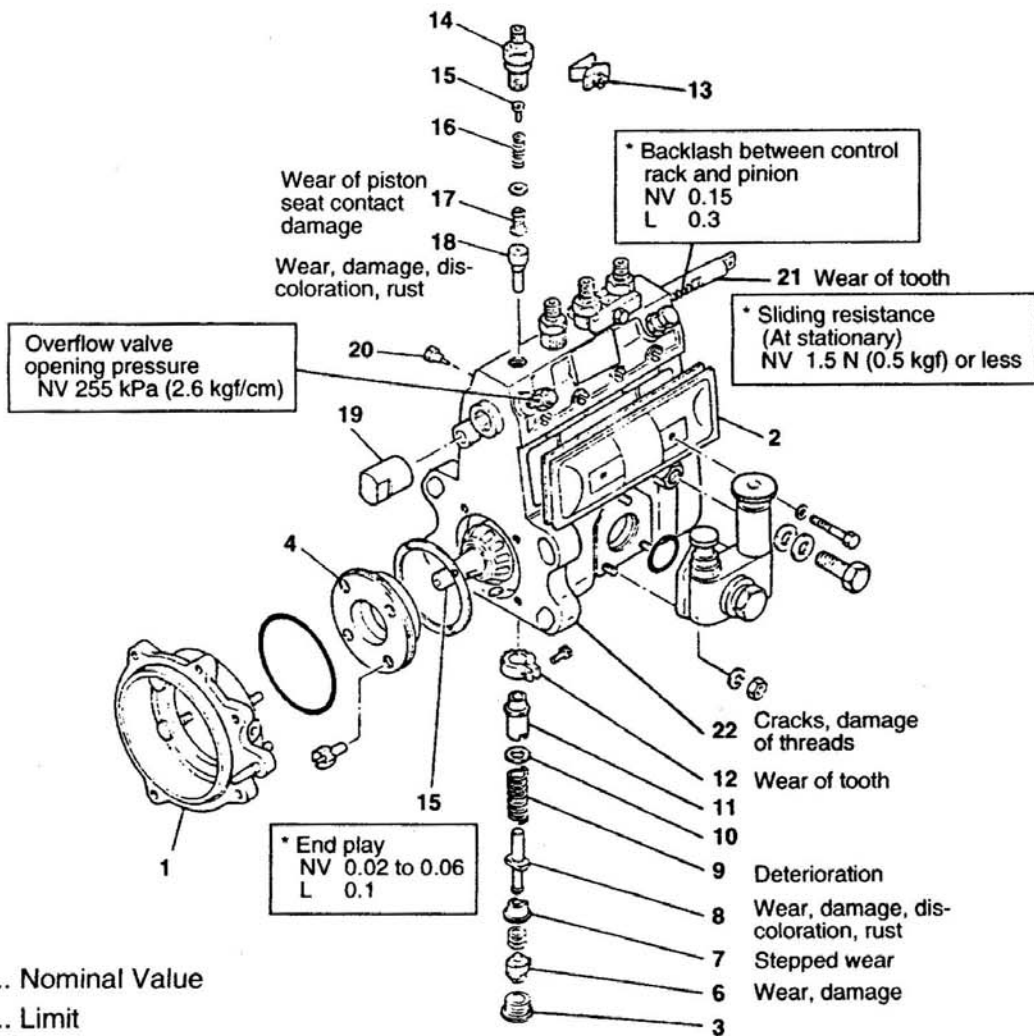
Then, remove the injection pump, pulling it rearward.

Use of Socket Wrench (special tool) will make the removal of timer case attaching bolts easier.





## 5-3-2. Disassembly



NV ... Nominal Value  
L ... Limit

- |                     |                          |                       |
|---------------------|--------------------------|-----------------------|
| 1 Timer case        | 9 Plunger spring         | ⑰ Delivery valve      |
| 2 Cover plate       | 10 Upper spring seat     | ⑱ Plunger barrel      |
| 3 Screw plug        | 11 Control sleeve        | 19 Control rack cover |
| 4 Bearing cover     | 12 Control pinion        | 20 Rack guide screw   |
| ⑤ Camshaft          | 13 Lock plate            | 21 Control rack       |
| ⑥ Tappet            | ⑭ Delivery valve holder  | 22 Pump housing       |
| ⑦ Lower spring seat | 15 Stopper               |                       |
| ⑧ Plunger           | 16 Delivery valve spring |                       |

For disassembly of parts with an encircled number, see following items.

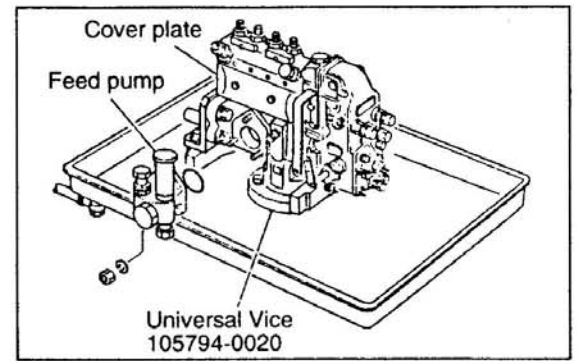
Inspection items marked with \* must be checked before disassembly.

### NOTE:

1. Keep disassembled parts neatly arranged for each cylinder.
2. Keep plunger, plunger barrel, and delivery valve in gas oil.

(1) With the auto timer and timer case removed, install the injection pump to the Universal Vise(special tool) and remove following parts.

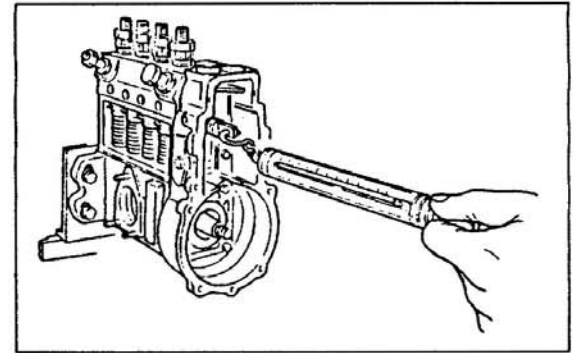
- Feed pump
- Governor
- Cover plate



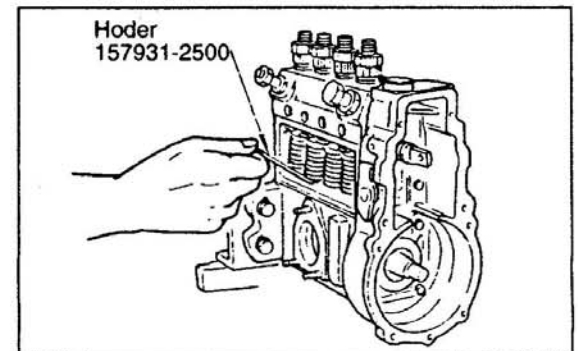
(2) Measure the sliding resistance of the control rack. Turn the camshaft to check that the value is as specified when measured at any position.

If the measurement exceeds specification, possible causes are:

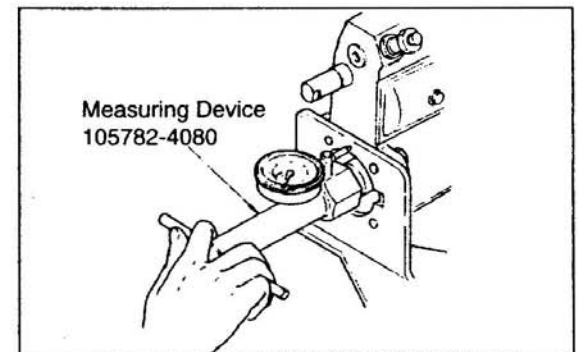
- Damage on control rack, defective teeth
- Defective pinion teeth, pinion in contact with housing
- Excessively tightened delivery valve holder



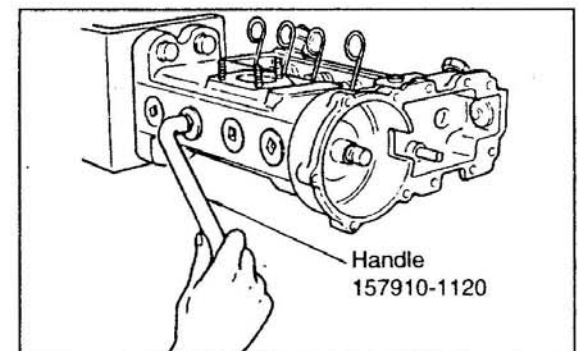
(3) Turn the camshaft to place the tappet at TDC. Insert Holder(special tool) into the tappet, one by one, to keep them off the camshaft.



(4) Install Measuring device(special tool) to the camshaft and measure the end play.



(5) Remove the screw plug from the bottom of injection pump with Handle(special tool).



- (6) Install Seal Guide(special toll) to the camshaft end(threads and keyway).

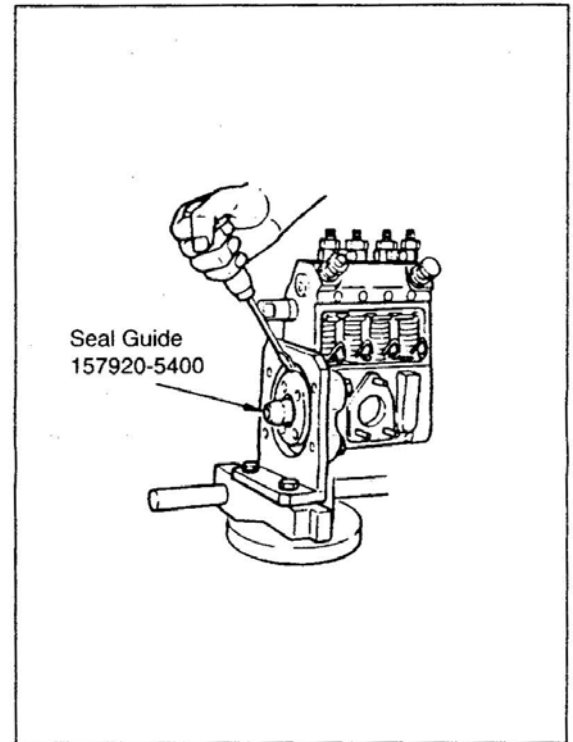
Remove the bearing cover by inserting a screwdriver into notches at tap and bottom of bearing cover.

If the bearing cover is hard to remove, tap the camshaft with a soft hammer from the governor end.

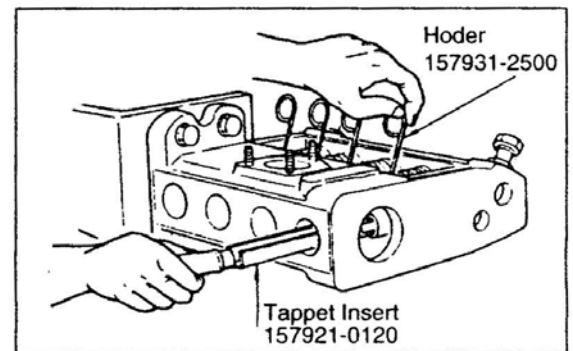
Remove camshaft at the same time.

**NOTE:**

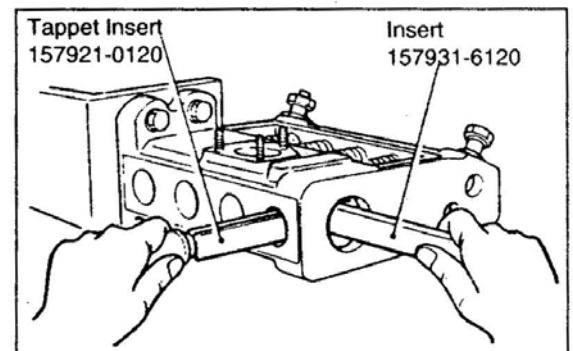
**Whenever the bearing cover is disassembled, its oil seals must be replaced with new ones.**



- (7) Using Tappet Insert(special tool), push the tappets from under the injection pump. Remove Holders(special tool).



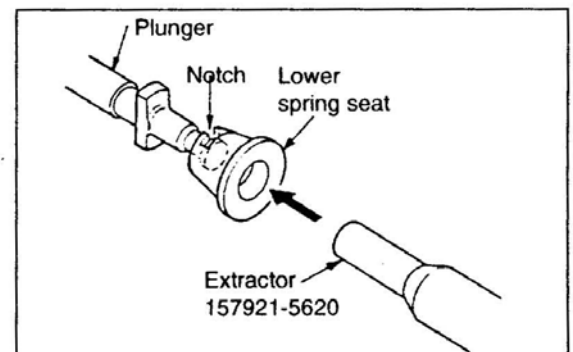
- (8) With the tappet held in position with Tappet Insert(special tool) insert Inserter(special tool) into camshaft hole to remove tappet.



- (9) Insert Extractor(special tool) from the bottom of the pump and fix its end to the lower spring seat. Then, withdraw the special tool, which removes the lower spring seat with plunger.

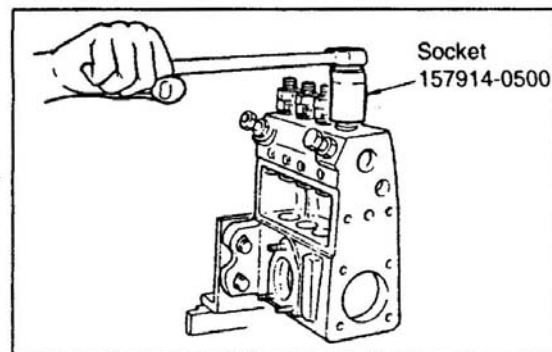
**NOTE:**

**When removing, ensure that the notch in the lower spring seat(for inserting the plunger) faces up to prevent the plunger from dropping.**



(10) Measure the backlash between the control rack and pinion. If the limit is exceeded, replace.

(11) Remove the lock plate and use Socket(special tool) to remove the delivery valve holder. Then remove the stopper and delivery valve spring.



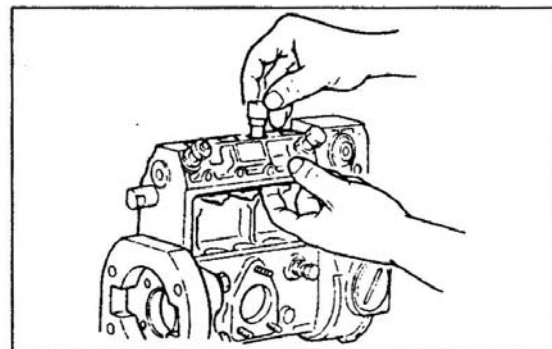
(12) Using Delivery Valve Extractor(special tool), remove the delivery valve.



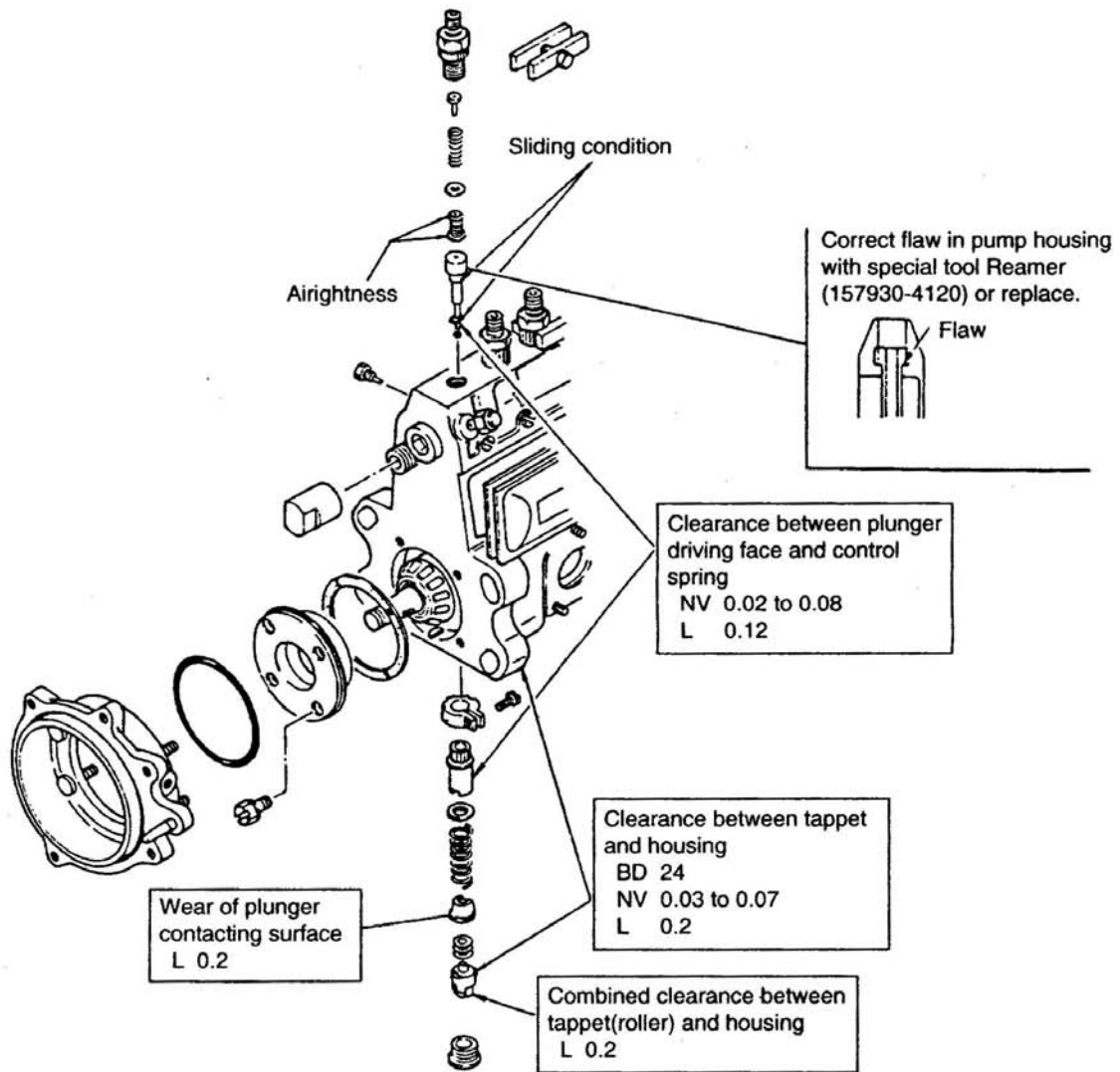
(13) Remove the plunger barrel.

**NOTE:**

**Keep the plunger and plunger barrel in original combination and leave them immersed in gas oil.**



### 5-3-3. Inspection and Correction



NV ... Nominal Value

L ... Limit

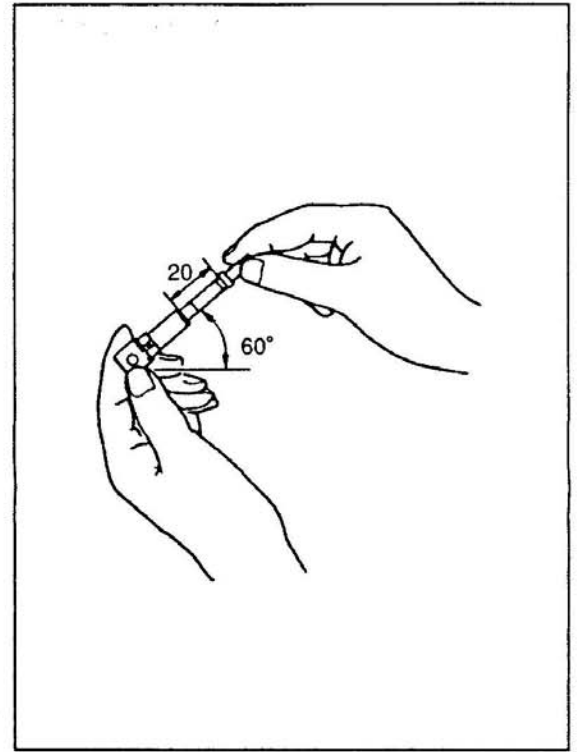
(1) Plunger and Plunger Barrel

After cleaning in gas oil, check to see if the plunger falls smoothly in the plunger barrel by its own weight.

For inspection, use the following procedure:

- Tilt the plunger barrel about  $60^\circ$ .
- Pull the plunger out by about 20mm, and let it go.
- Make the check several times by turning the plunger.

If the plunger does not fall by gravity, replace.



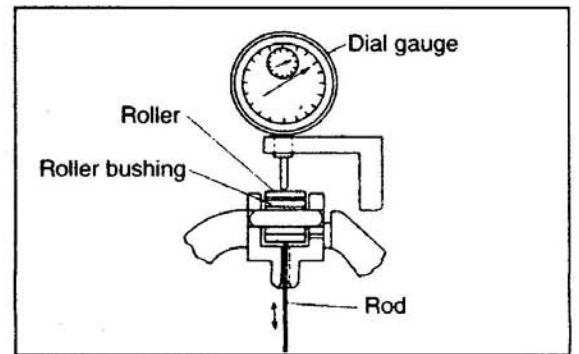
(2) Delivery Valve(with Ungleich Cut)

After cleaning the valve and valve seat of the delivery valve in gas oil, check for wear.

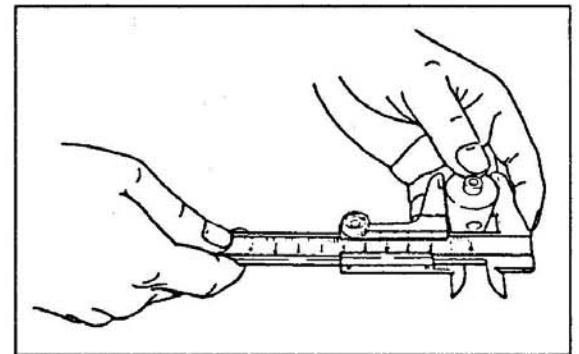
(3) Tappet

Set a dial indicator to the tappet roller and move roller up and down with a rod to check for overall clearance.

If the overall clearance exceeds the limit, replace as a tappet assembly.

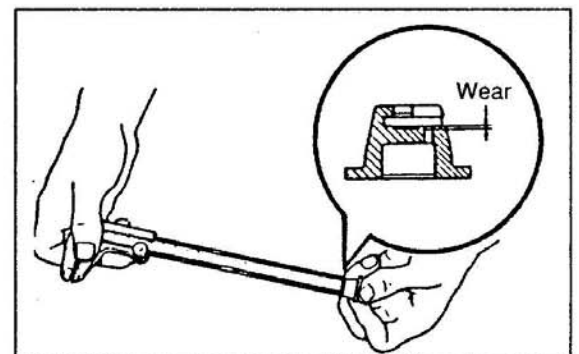


Measure the clearance between the tappet and pump housing and, if the limit is exceeded, replace parts.



(4) Lower Spring Seat

Check the lower spring seat surface in contact with the plunger for wear and, if the limit is exceeded, replace.



(5) Replacement of Taper Roller Bearing

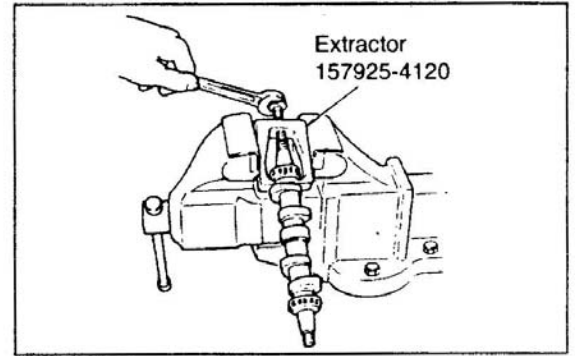
Inner Race

To remove the inner race, use Extractor(special tool) and remove the roller and inner race from the camshaft.

At installation, press-fit the ring, shim, and bearing, in that order.

**NOTE:**

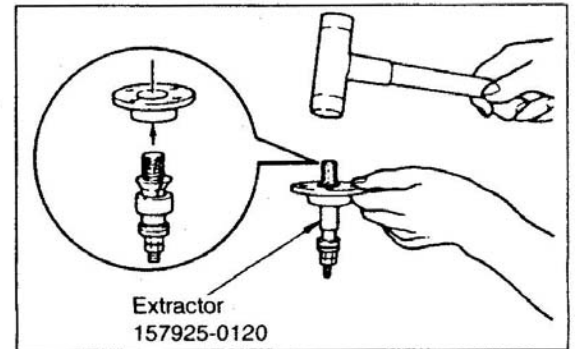
**Install shims of almost the same thickness on both ends of camshaft.**



Outer race

To remove the outer race, use Extractor(special tool).

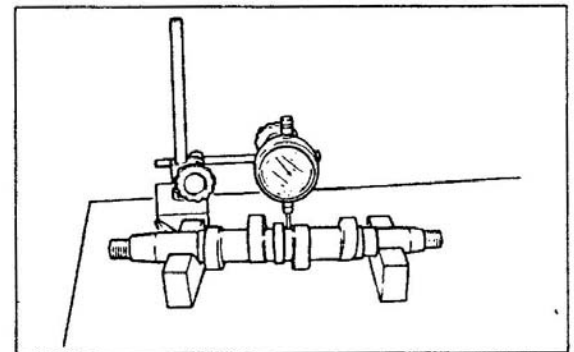
For installation, use a press.



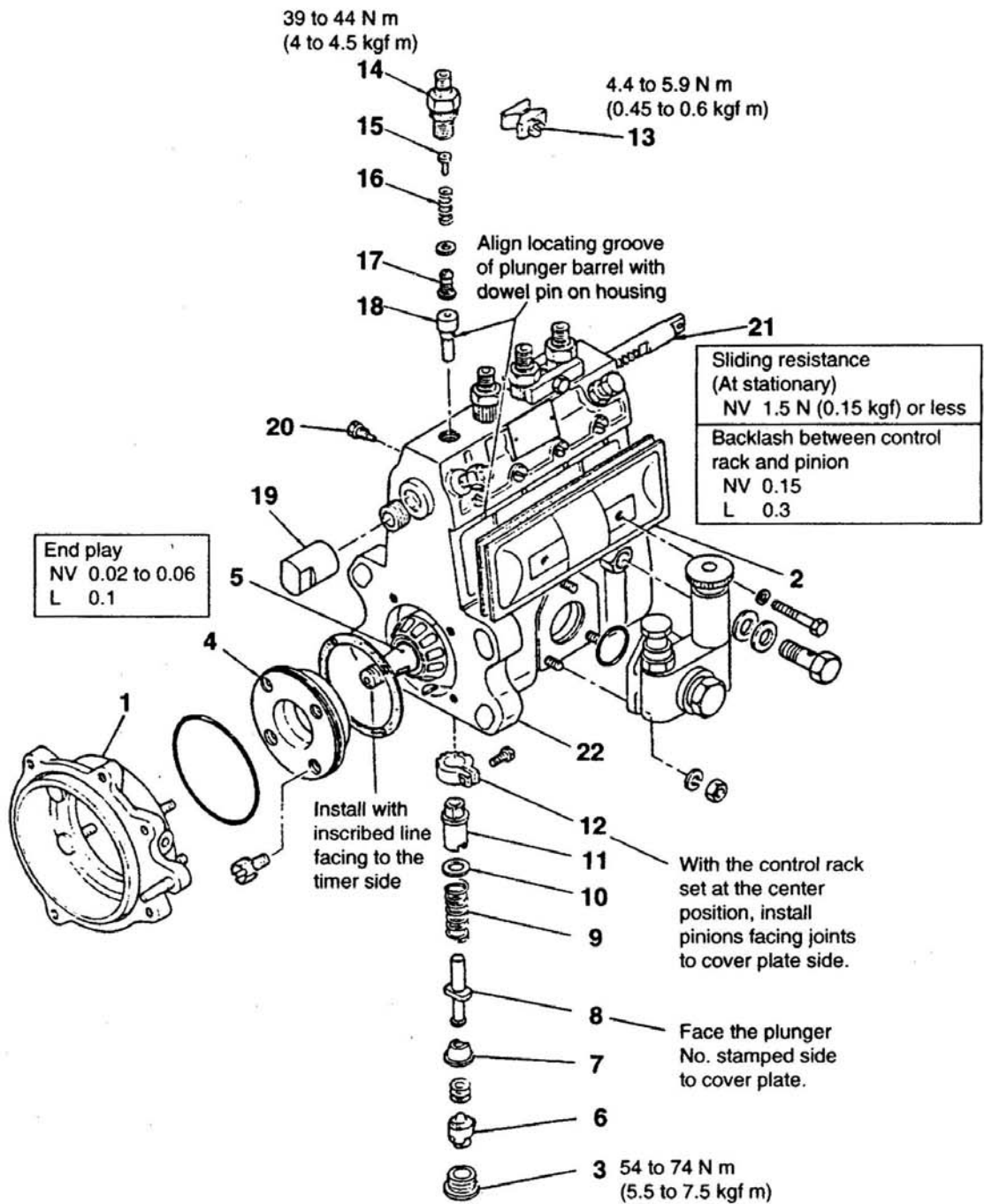
(6) Camshaft Bend(Runout)

Support the camshaft with a V-block at its ends(or the center holes at both ends), and check for bend at the center with a dial indicator.

If the limit is exceeded, correct with a press or replace.



## 5-3-4. Reassembly



### <Assembly sequence>

```

22 → ②1 → ②0 → ①8 → ①7 → ①6 → ①5 →
①4 → ①3 → ①0 → ①9 → ①6 → ①5 →
①1 → ①2 → ①8 → ①7 →
→ ①4 → ①3 → ①9 → ①1 → ①
    
```

For reassembly of parts with an encircled number, see following items.

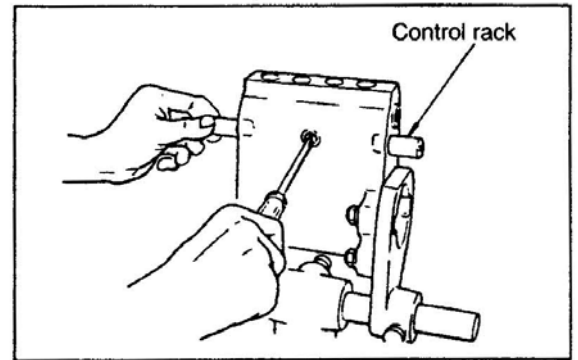
NV ... Nominal Value  
L ... Limit



- (1) Mount the control rack and rack guide screw.

**NOTE:**

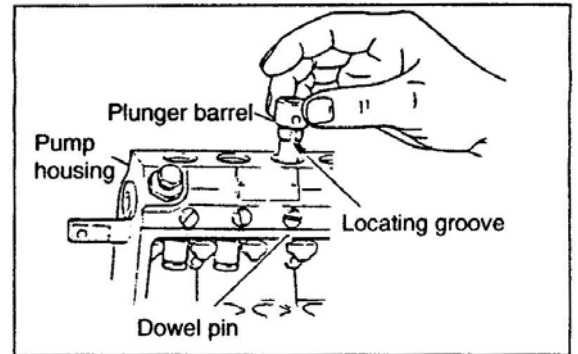
Check to see if the rack moves smoothly. Check also if the rack does not turn.



- (2) At installation of the plunger barrel into the housing, align the notch in the plunger barrel with the housing knock pin.

**NOTE:**

Do not tap the plunger barrel, but push into position with a finger.

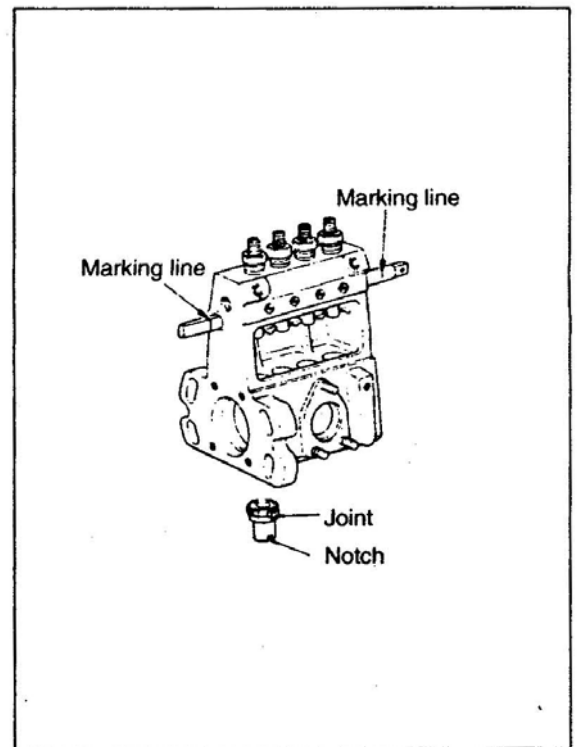


- (3) Place the injection pump horizontally, and set the control rack so that its marking lines are positioned at the same distance away from the housing end faces.

Mate the control pinion with control sleeve and put the pinion in mesh with the control rack teeth.

**NOTE:**

1. Make sure that the joint of control pinion and notch in control sleeve face toward you.
2. Move the control rack each time the pinion is in mesh to ensure that the control pinion joint evens out at right and left. (this is done to ensure an entire rack stroke of 21mm)

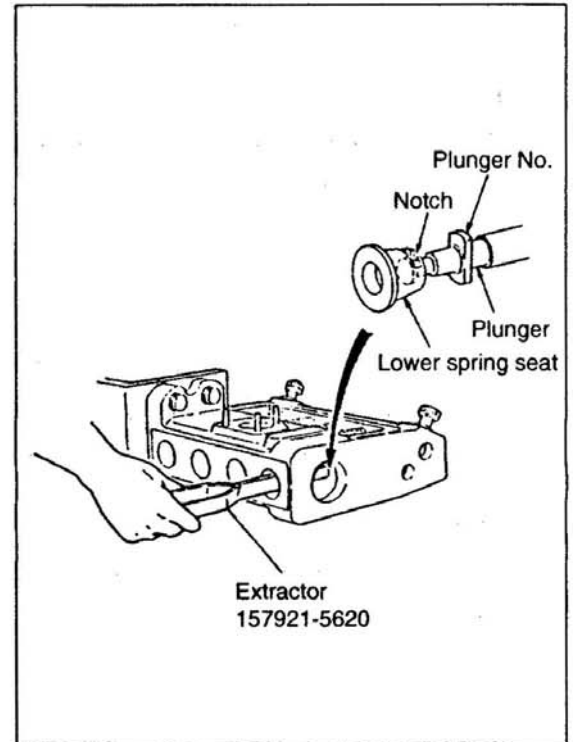


- (4) Fit Extractor(special tool) into the lower spring seat, and install the plunger into the lower spring seat.

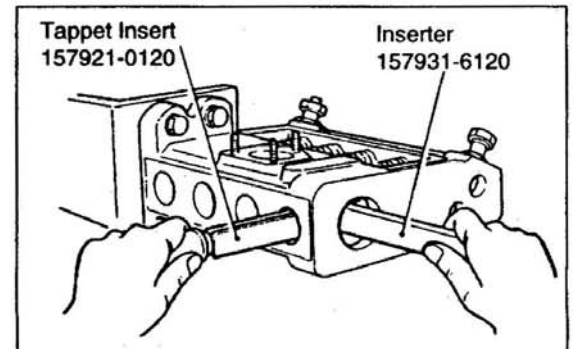
Insert the plunger into the plunger barrel with care not to allow the plunger end to hit the pump housing and plunger spring.

**NOTE:**

1. After the plunger has been installed, turn the lower spring seat to face its notch downward.  
This prevents the lower spring seat from coming off position.
2. Make sure that plunger flange side with a part number marking faces upward.



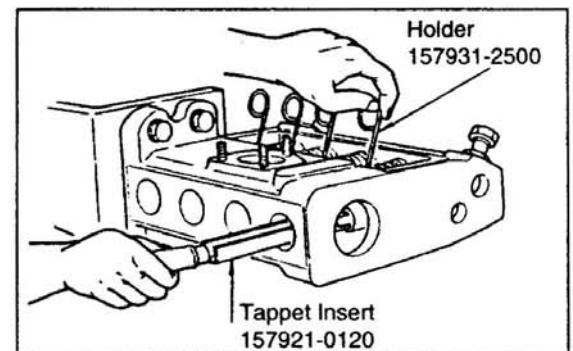
- (5) Clamp the tappet with Inserter(special tool) and with the tappet guide aligned with the housing groove, install it into the pump housing.



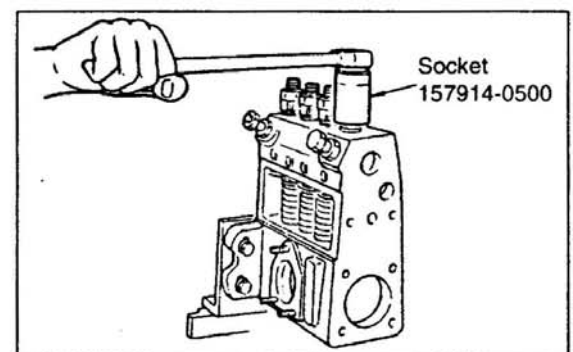
- (6) Using Tappet Insert(special tool), push the tappet to TDC, insert Holder(special tool) and remove Tappet Insert (special tool).

At this time, make sure that the part number marking on the plunger flange is positioned on the cover plate side.

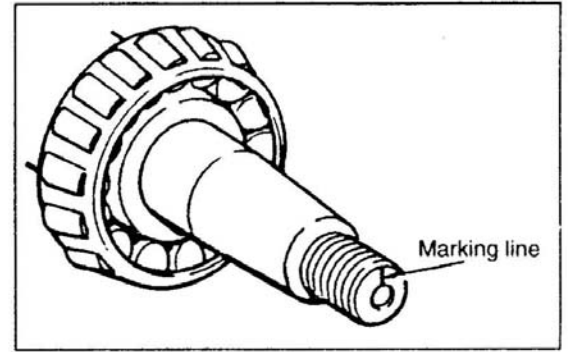
For each cylinder, check the control rack for sliding condition each time Holder(special tool) is installed.



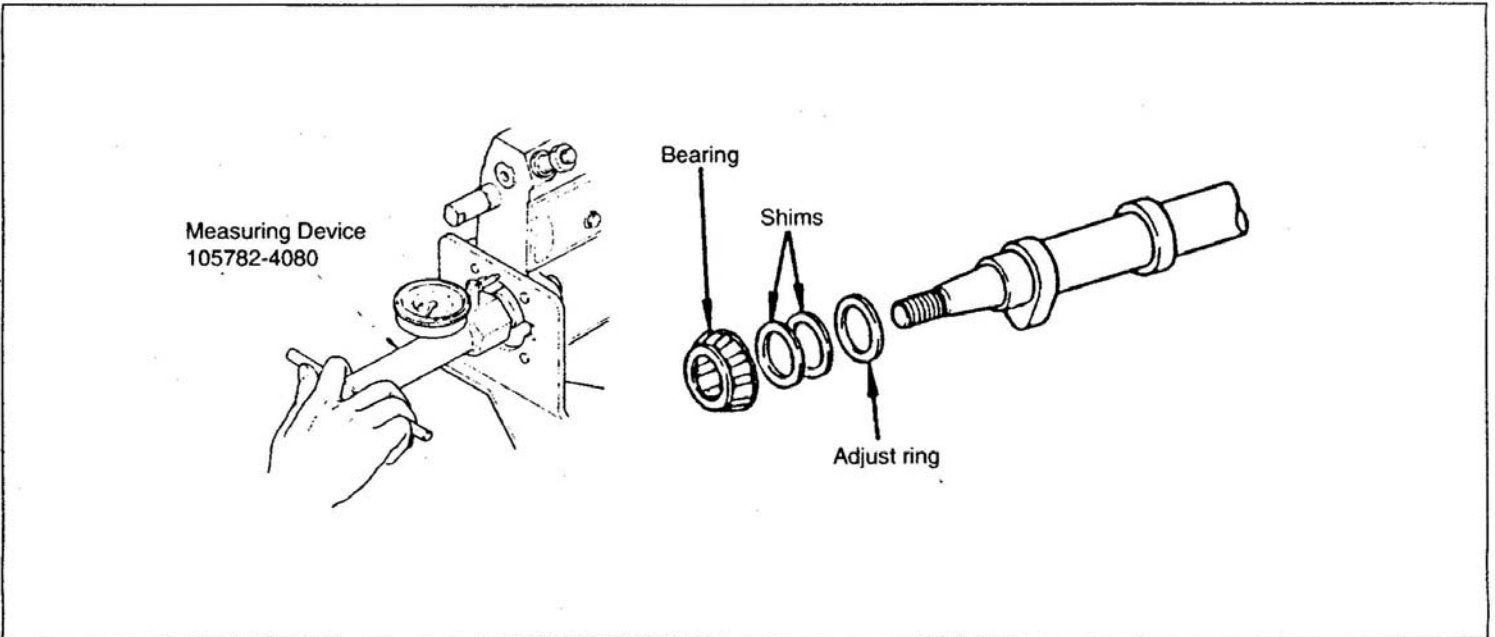
- (7) Using Socket(special tool), install the delivery valve holder.



- (8) Install the camshaft with the marking line at the end of its thread facing toward the drive end.



- (9) Temporarily mount the bearing cover to measure the camshaft end play with Measuring Device(special tool). If the limit is exceeded, adjust with shims or replace bearing.



**NOTE:**

**Use shims of almost equal thickness for the governor and timer end.**

Shim Thickness

Timer end	0.10, 0.12, 0.14, 0.16, 0.18, 0.30, 0.50, 1.00 mm
Governor end	0.10, 0.12, 0.14, 0.16, 0.18, 0.30, 0.50, 0.70, 1.00, 1.40 mm

After installing the bearing cover in position, measure again end play to ensure that it is up to specification.

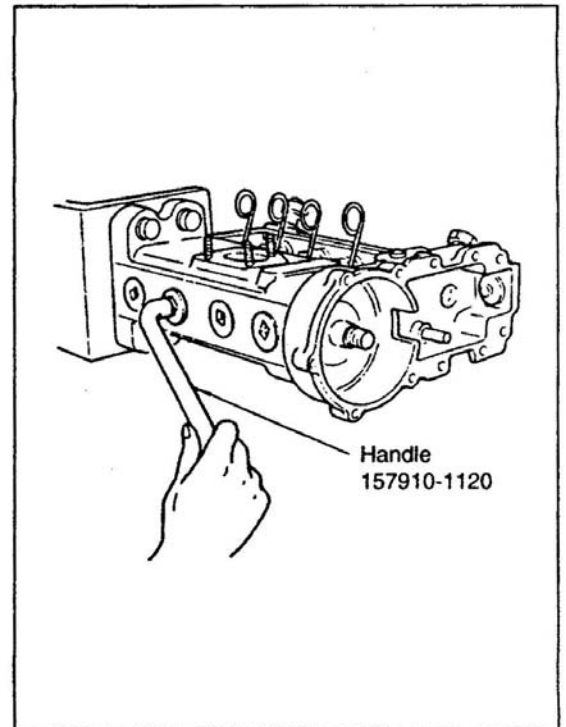
(10) With Tappet Insert(special tool) removed, measure the sliding resistance of the control rack.

(11) Apply sealant to screw plug and install it with Handle(special tool).

(12) Install the governor.

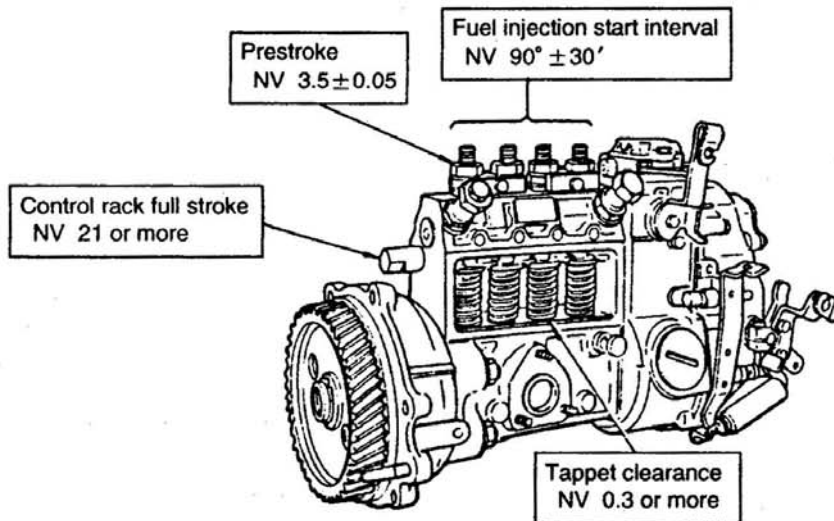
(13) Install the following parts after adjusting the injection pump:

- Control rack cover
- Cover plate
- Timer case
- Feed pump
- Auto timer



## 5-3-5. Adjustment after Reassembly

For fuel injection rate adjusting standard, see Service Information separately published.



NV ... Nominal Value

### NOTE:

Feed oil to the injection pump cam chamber.

### (1) Control Rack "O" position setting

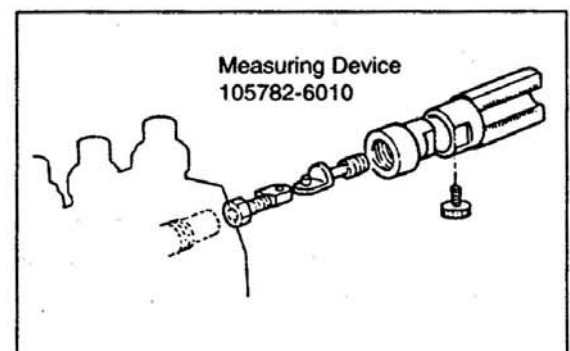
Install Measuring Device(special tool) on the injection pump.

Temporarily set the adjusting lever to maintain the injection pump speed at 500 to 600 rpm. Further increase the speed to pull the control rack; at the same time, push the control rack fully.

With this position of control rack regarded as "O", set "O" on the Measuring Device scale to the position.

### NOTE:

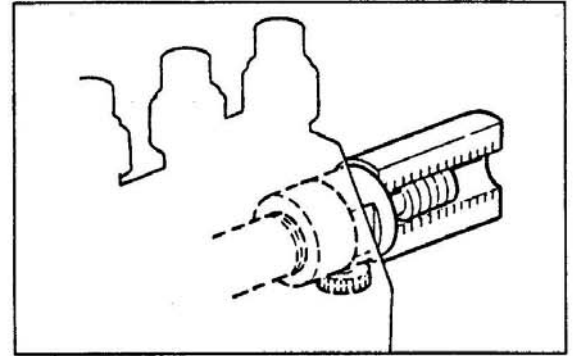
If zero position is set by the adjusting lever operation without running the injection pump, the governor linkage could be damaged. Do not use the adjusting lever to set the zero position.



(2) Control Rack Stroke Check

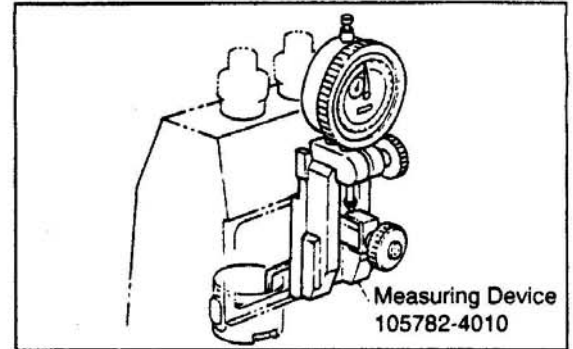
Move the control rack to check its stroke is more than the specified value.

Ensure also that the start spring and idling spring move the control rack smoothly in the direction to increase the amount of fuel injected.

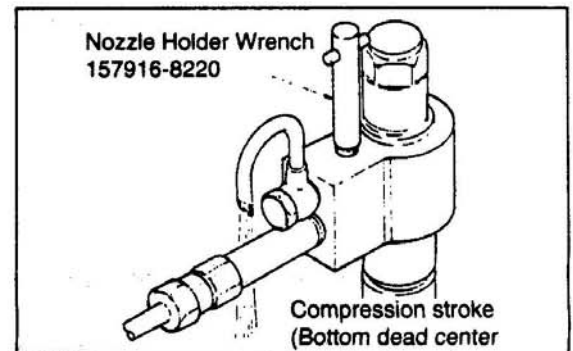


(3) Prestroke Check

(a) With the control rack withdrawn and fixed in the full injection position, install Measuring Device(special tool).



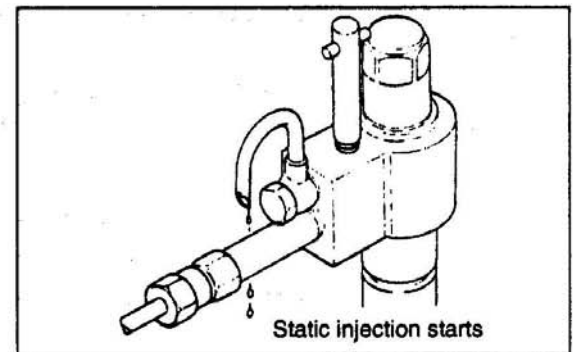
(b) With No.1 cylinder plunger at BDC, send fuel to injection pump under high pressure pump of the pump tester and install Nozzle Holder Wrench(special tool) to test nozzle to let the fuel flow out from overflow pipe.



**NOTE:**

The fuel pressure must be over the delivery valve opening pressure.

(c) Slowly turn the tester coupling until the fuel stops flowing out of the test nozzle overflow pipe(static injection starts).

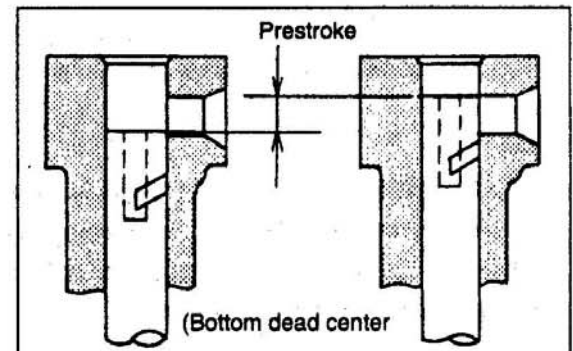


**NOTE:**

Measurement must be made with the camshaft turned in the normal rotating direction(clockwise as viewed from the drive end).

(d) Read the prestroke of plunger on the indicator, from BDC until fuel stops flowing.

If the prestroke is out of the nominal value, adjust as follows.



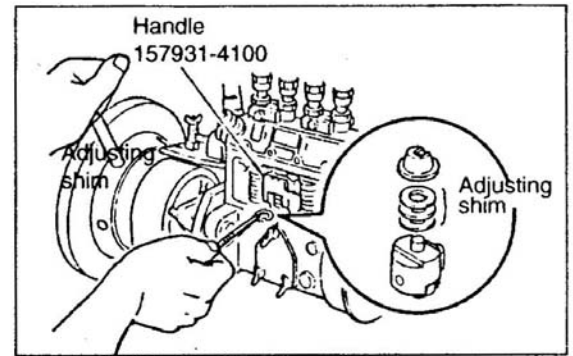
(4) Adjustment of Prestroke

With the tappet at TDC, insert Holder(special tool) between the lower spring seat and tappet.

Turn camshaft, and you have a clearance between the lower spring seat and tappet. Increase or decrease shim thickness to fill the clearance, to adjust the prestroke.

A greater shim thickness makes prestroke smaller.

A smaller shim thickness makes prestroke greater.

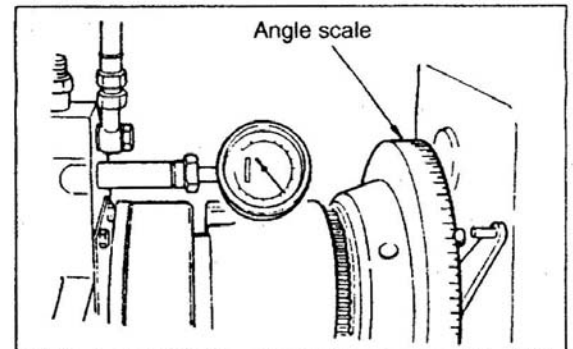


(5) measurement of Injection Start Interval

With the static injection start of NO.1 cylinder used as a basis, read the injection start interval of each cylinder according to the injection sequence using an angle scale of the tester. If the interval is out of specification, adjust as in prestroke adjustment.

Injection Sequence

1→3→4→2

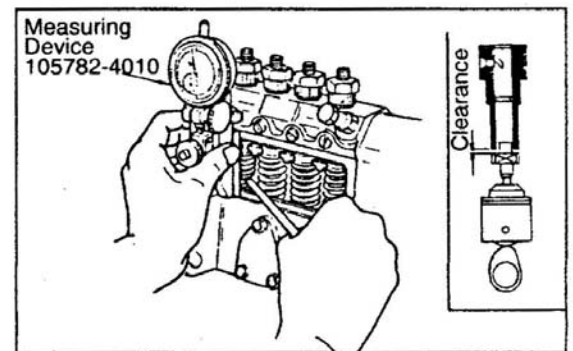


(6) Tappet Clearance measurement

Install Measuring Device(special tool) and turn the camshaft to bring the tappet to TDC.

Push up the tappet and measure the lift for the plunger flange top to come into contact with the plunger barrel.

If the tappet clearance is out of specification, adjust within the allowable range of injection start interval. If the range does not permit correction, read just with No1. 1 cylinder prestroke at the maximum nominal value.

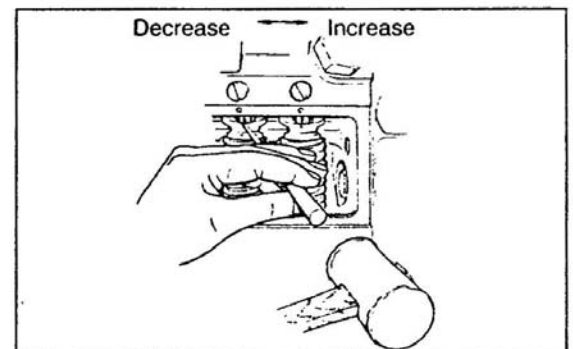


(7) Fuel Injection Rate Adjustment

Measure the fuel injection rate and uneven ratio at the specified rack position and speed.

If the injection rate is out of specification, adjust as follows.

- Loosen pinion clamp screw.
- With the control rack held in position, turn the control sleeve with the adjusting rod.
- Tighten pinion clamp screw.



**NOTE:**

1. Use special care to make the adjustment. Improper or failure of adjustment greatly influences engine performance engine.
2. The fuel injection rate varies with nozzle and pipe used. Observe measuring requirements strictly.
3. Uneven ratio

$$\text{Uneven ratio(+)} = \frac{\text{Max. fuel injection rate in each cylinder} - \text{Average fuel injection rate in each cylinder}}{\text{Average fuel injection rate in each cylinder}} \times 100$$

$$\text{Uneven ratio(-)} = \frac{\text{Min. fuel injection rate in each cylinder} - \text{Average fuel injection rate in each cylinder}}{\text{Average fuel injection rate in each cylinder}} \times 100$$

(8) Adaptation to Engine

After the governor has been adjusted, measure the fuel injection rate adaptable to the engine.

(9) Inspection of Fuel and Oil Leaks

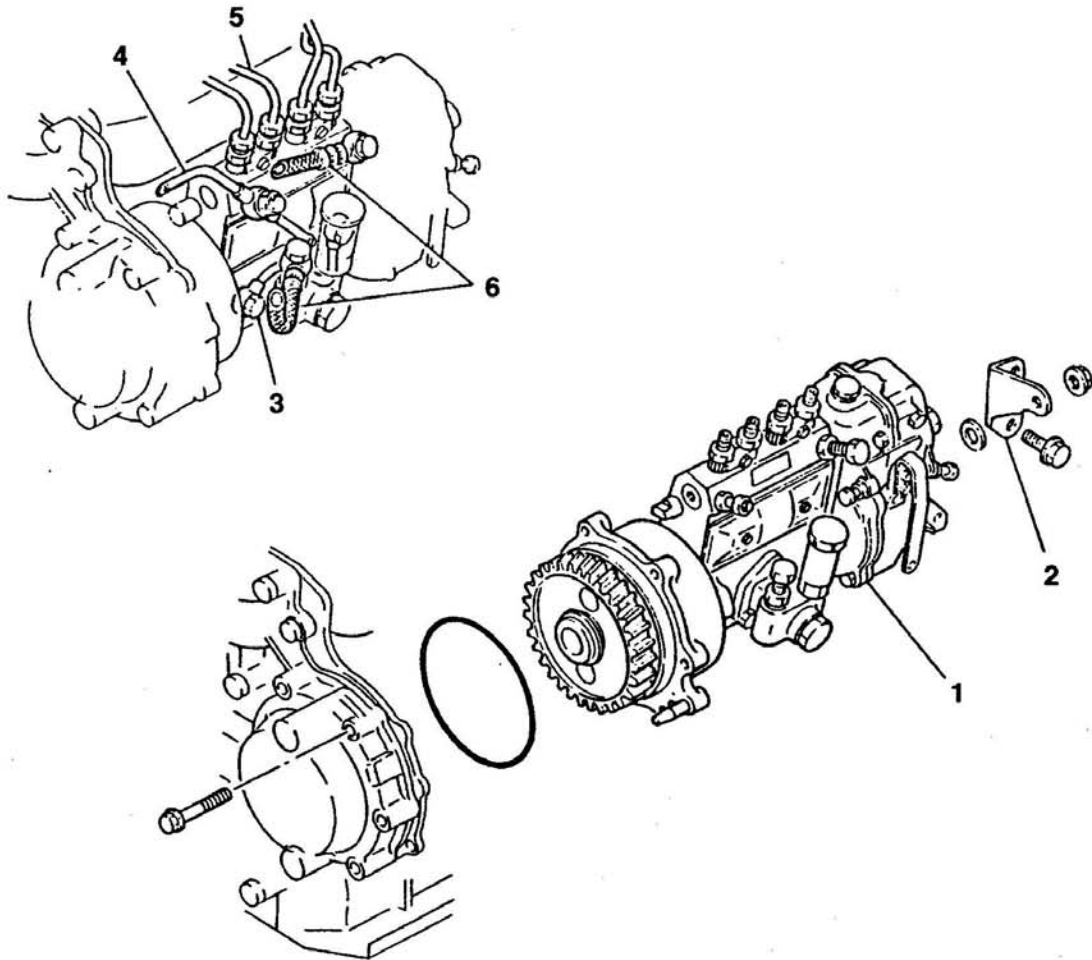
Fuel leaks from delivery valve attaching portion and other parts oil leaks from oil seals and other parts.

(10) Inspection of Parts

Check parts for unusual noise and bearings for excessive heat.



## 5-3-6. Installation



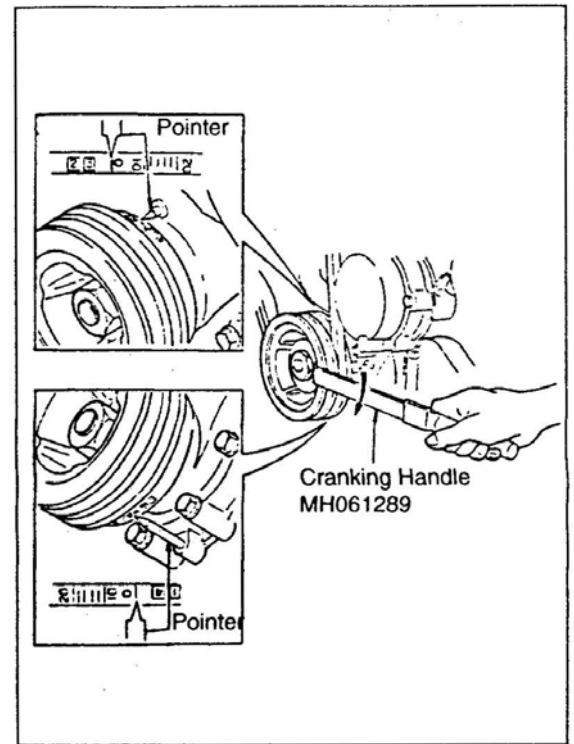
- 1 Injection pump
- 2 Injection pump stay
- 3 Oil pipe

- 4 Leak off pipe
- 5 Injection pipe
- 6 Fuel hose

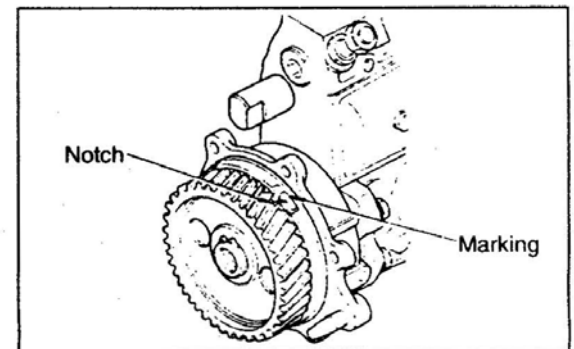
- (1) Set the piston of the engine No.1 cylinder at the top dead center on compression stroke. For this purpose, use Cranking Handle(special tool) to crank the engine until the engraved line "0" position on the side bearing "1.4" mark of the crankshaft pulley is lined up with the pointer.

In the case of D4A, another pointer is on top of the crankshaft pulley and if this pointer is used, align the engraved line "0" position on the side bearing "2.3" mark of the crankshaft pulley with the pointer.

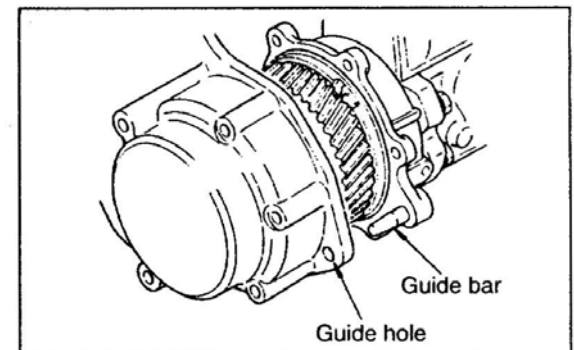
At this time, if the intake and exhaust valves of the No.1 cylinder are not pushed up by the push rod, the No.1 cylinder is at the top dead center on compression stroke. If the intake and exhaust valves are pushed up by the push rod, turn the crankshaft through 360 degrees.



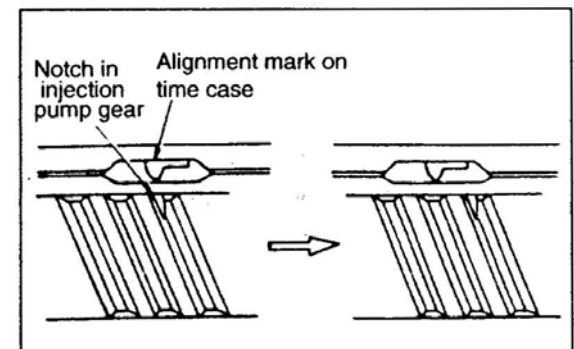
- (2) Line up the marking on the timer case with the notch in the injection pump gear.



- (3) Insert the guide bar on the timer case into the guide hole in front plate. Using this as a guide, push until the injection pump gear is about to be in mesh with the idler gear.



- (4) Make sure that the alignment mark of the injection pump gear is aligned with that of the timer case. Then, push in the injection pump. At the time, the alignment mark on the gear moves to the end of that on the timer case.



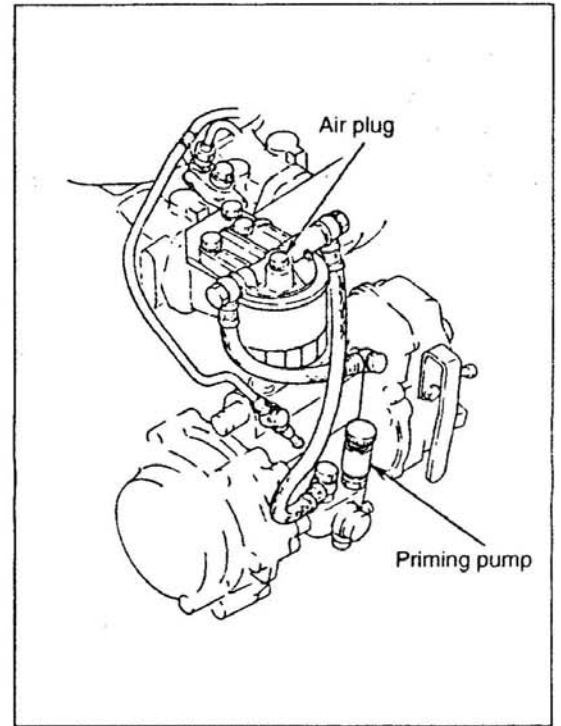
### 5-3-7. Bleeding the Fuel System

Here is the procedure for bleeding the fuel system.

- (1) Turn the injection pump priming pump counterclockwise until it comes loose.
- (2) Loosen the air plug of the fuel filter.
- (3) Move the priming pump up and down by hand to feed fuel until air bubble does not come out from the air plug.
- (4) When no air bubble comes out in fuel, keep the priming pump down and turn it clockwise until it fits into position. Then, tighten the air plug.

**NOTE:**

1. The air plug must be tightened after the priming pump is secured into position.
2. Sop up fuel spilt around.

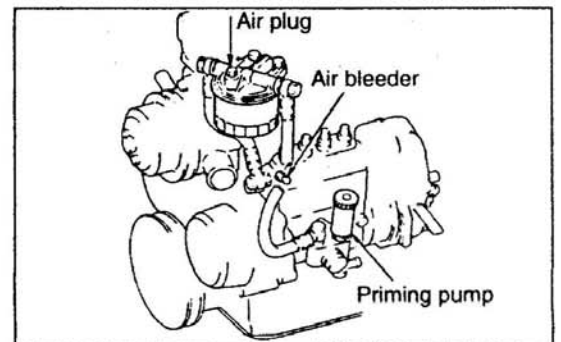


- (5) Actuate the starter to discharge air from the injection pump.

**NOTE:**

**Do not operate the starter for more than 15 seconds.**

The injection pump is provided with an air bleeder which can be loosened for bleeding as with the fuel filter.



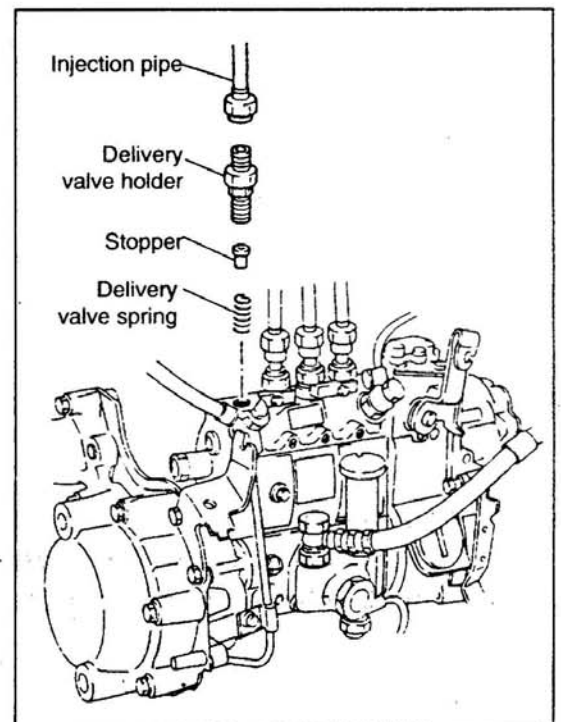
### 5-3-8. Inspection and Adjustment after Installation (Fuel Injection Timing)

- (1) Remove the injection pipe, delivery valve, delivery valve spring, and stopper from No.1 cylinder of the injection pump. Keep the delivery valve holder attached.

**NOTE:**

**Keep disassembled parts in gas oil to prevent contamination by dust and dirt.**

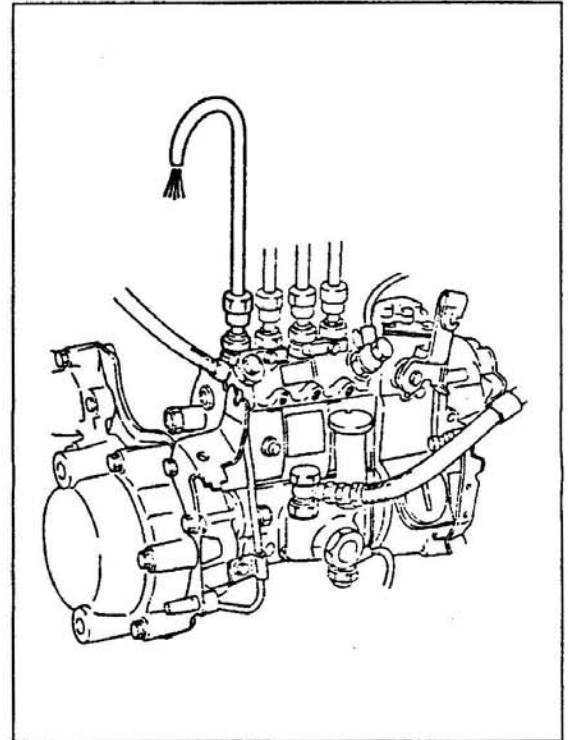
- (2) Install a spare injection pipe to No.1 cylinder. Face the other end of the pipe downward for easier observation of fuel flow out condition.
- (3) Crank the engine to bring the piston in No.1 cylinder 30° before top dead center.



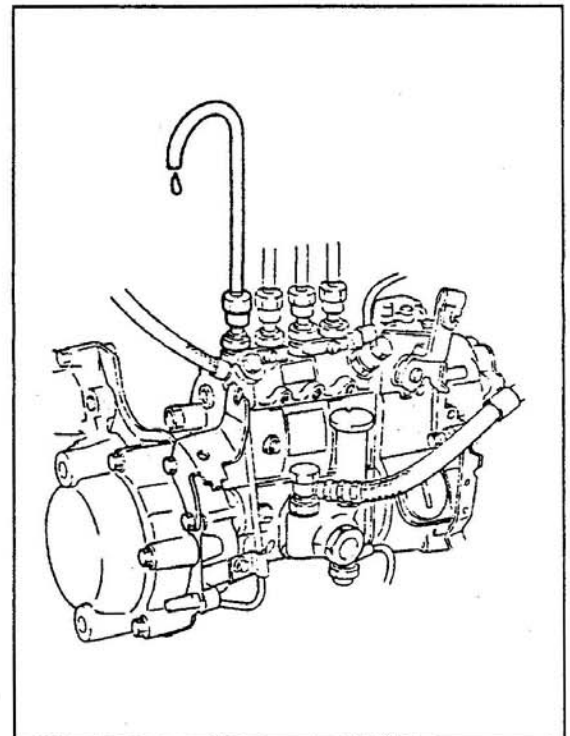
- (4) While operating the priming pump to let fuel run out from the injection pipe, slowly crank the engine in the direction of normal rotation.

**NOTE:**

**Make sure that the stop lever on the governor is not pulled toward the STOP position.**



- (5) Crank the engine even more slowly as the fuel is about to stop flowing out from the injection pipe. Stop cranking as soon as no more fuel comes out from the pipe.



- (6) Check that the inscribed line on the flywheel and the pointer indicate the position about 2 degrees before the fuel injection timing.

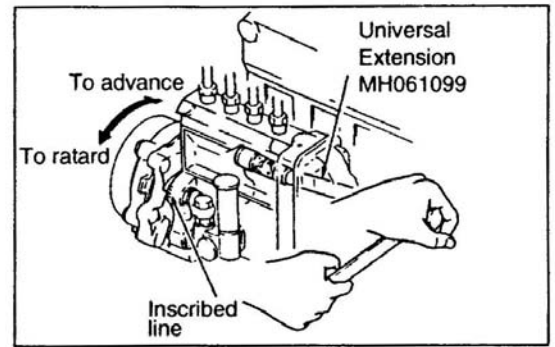
**NOTE:**

1. The injection timing is advanced by about 2 degrees from specified timing as the delivery spring's valve opening pressure does not work.
2. The injection timing is indicated at the caution plate on the rocker cover.

(7) Loosen the injection pump attaching nut with Universal Extension(special tool).

(8) To advance the fuel injection timing, move the injection pump toward the crankcase side.

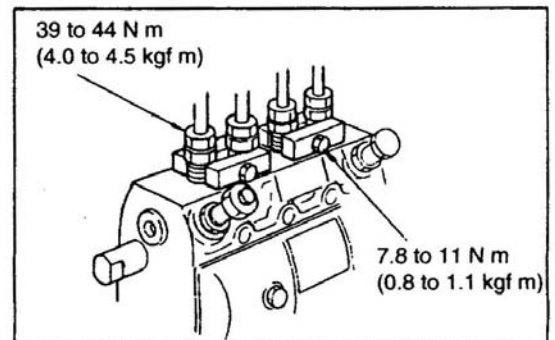
To retard the timing, move the injection pump away from the crankcase.



(9) Move the injection pump to the desired direction. A shift of one graduation of the adjustment marker varies the injection timing by 3 degrees.

(10) With the injection pump attaching nut tightened, measure the injection start timing again.

(11) After the adjustment has been made, install the delivery valve, delivery valve spring, and stopper and tighten the delivery valve holder to specification. Then, install the injection pipe.



(12) For inspection at dusty locations, proceed as follows.

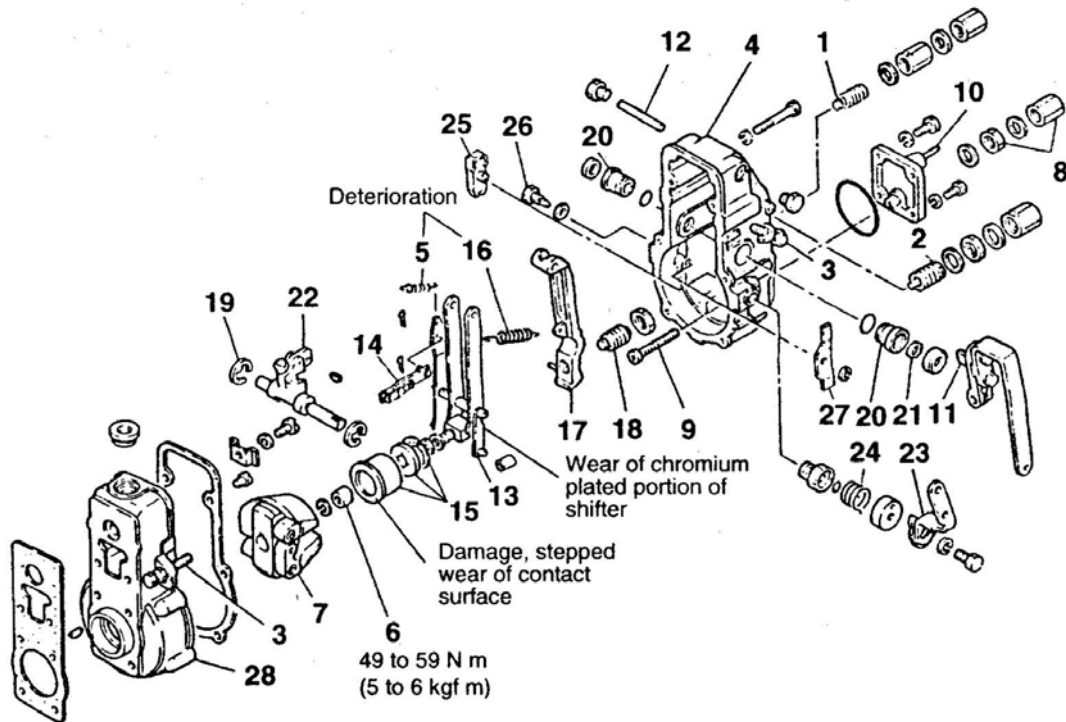
- Remove only the injection pipe and keep a small amount of fuel remaining at the top of delivery valve holder.
- Crank the engine to bring the piston in No. 1 cylinder to a position about BTDC 30° on the compression stroke. Further crank the engine slowly, and the fuel on top of the delivery valve will begin to move.
- This is the fuel injection start timing.

**NOTE:**

If the fuel injection timing is radically different from the specification and the deviation is beyond the adjustable range of the injection pump, the engine timing gear and injection pump gear are not probably in proper mesh. In this case, remove the injection pump and reinstall it.

## 5-4. RSV Type Governor

### 5-4-1. Disassembly, Inspection and Reassembly



#### <Disassembly sequence>

- |      |                                   |      |                         |
|------|-----------------------------------|------|-------------------------|
| 1    | Idling subspring adapter          | (15) | Governor sleeve         |
| 2    | Torque spring adapter             | (16) | Governor spring         |
| 3    | Stopper                           | 17   | Tension lever           |
| (4)  | Governor cover assembly (8 to 27) | 18   | Ungleich spring adapter |
| 5    | Start spring                      | 19   | Snap ring               |
| (6)  | Round nut                         | 20   | Lever bushing           |
| (7)  | Flyweight                         | 21   | Oil seal                |
| 8    | Cap nut, Lock nut                 | (22) | Swivel lever            |
| 9    | Full load stopper                 | 23   | Stop lever              |
| 10   | Cover                             | 24   | Return spring           |
| 11   | Adjusting lever                   | 25   | Supporting lever        |
| 12   | Supporting lever shaft            | 26   | Support pin             |
| (13) | Guide lever assembly              | 27   | Torque control lever    |
| 14   | Shackle                           | 28   | Governor housing        |

For disassembly and reassembly of parts with an encircled number, see following items.

#### NOTE:

1. Do not disassemble the shackle and governor sleeve from the guide lever, unless replacement is necessary.
2. Do not remove the governor housing unless removal is necessitated for correction of oil leaks, parts replacement, etc.

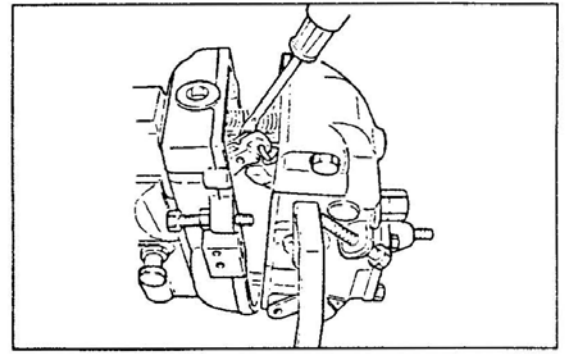
Before removing the housing, use Tappet Insert(special tool) to separate the camshaft from the tappet.

For reassembly, reverse the order of disassembly.

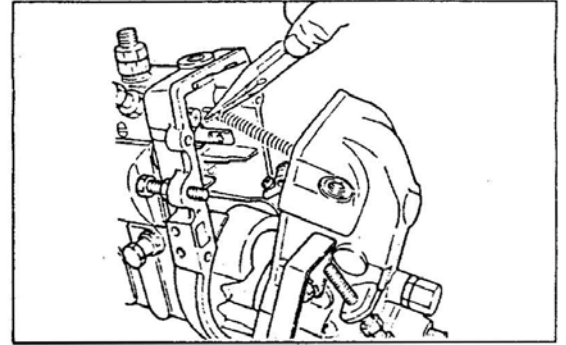
## 1. Disassembly Procedure

- (1) Remove the governor cover assembly from the governor housing.

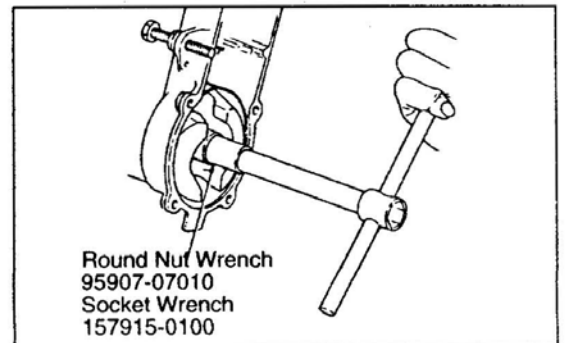
Open the governor cover slightly to the front and slide downward the shackle latch connected to the control rack to disconnect it from the control rack.



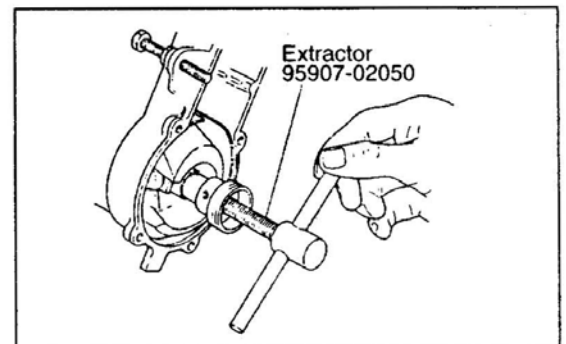
- (2) Remove the start spring using long-nose pliers.



- (3) Remove the round nut using Socket Wrench or Round Nut Wrench (special tools).



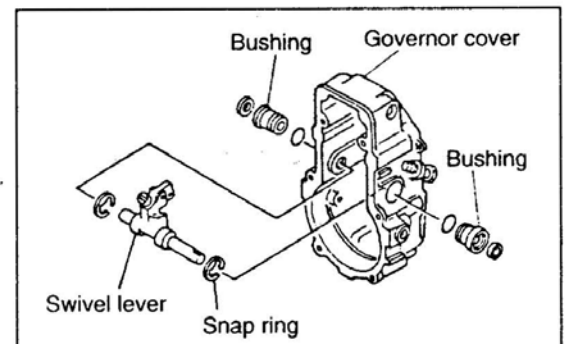
- (4) Screw in Extractor(special tool) to the flyweight and extract it.



- (5) Removal of Swivel Lever

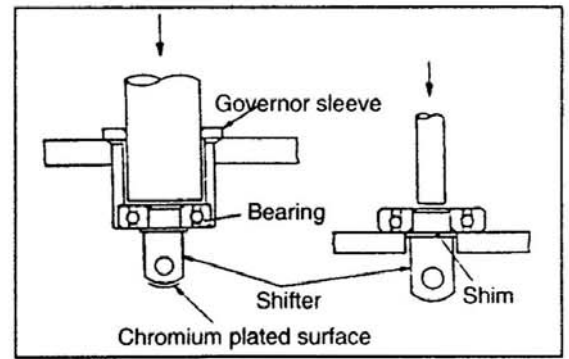
Remove the snap ring from the lever bushing and tap lightly the swivel lever shaft from the adjusting lever mounting side to remove the bushing from both ends. Then, remove the swivel lever.

**NOTE: Do not remove the swivel lever from the governor cover unless such removal is necessary for parts replacement or for correcting unsmooth motion.**



(6) Replacement of the Governor Sleeve or Guide Lever

(a) Using a press, remove the bearing in the governor sleeve and remove the guide lever assembly shifter from the bearing.



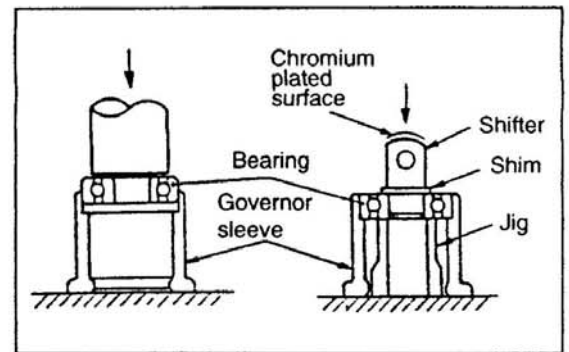
(b) Press-fit the bearing to the governor sleeve.

Press-fit the guide lever assembly shifter to the bearing.

(c) Make sure that the sleeve turns smoothly.

**NOTE:**

1. Do not replace the shim as its thickness has been established.
2. During removal and installation take care not to damage the chromium plated surface of the shifter.



**2. Reassembly procedure**

(1) If shims have to be replaced, assemble the associated parts correctly and select the thickness of shims that gives correct housing end to shifter dimension.

Shim Thickness

(5 types)

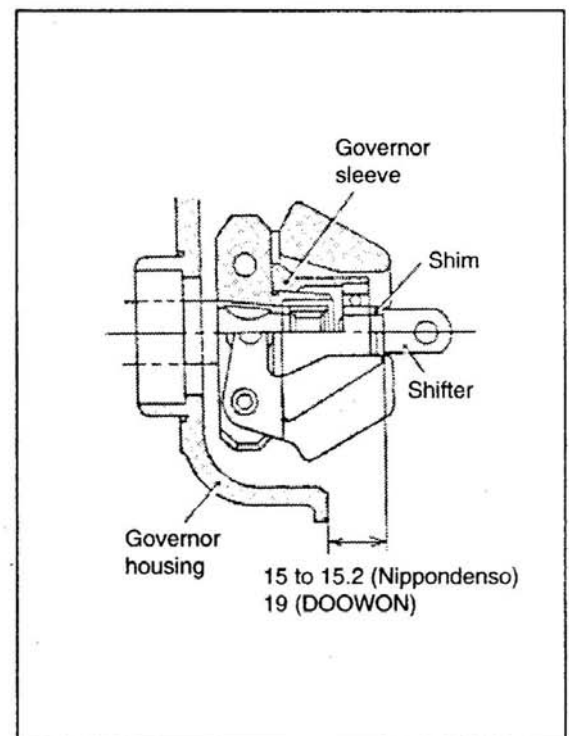
0.1, 0.2, 0.3, 0.4, 1.0 mm

(6 types)

0.2, 0.3, 0.4, 0.5, 1.0, 1.5 mm

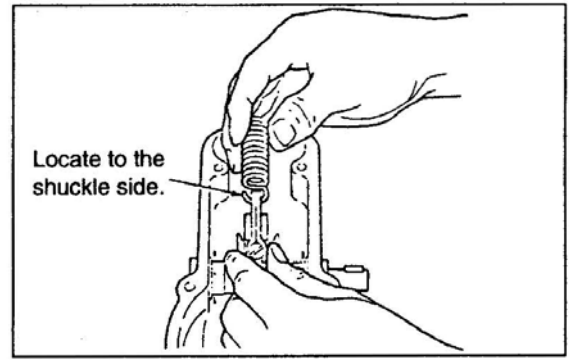
**NOTE:**

Measure the assembled dimension without lifting the flyweight.



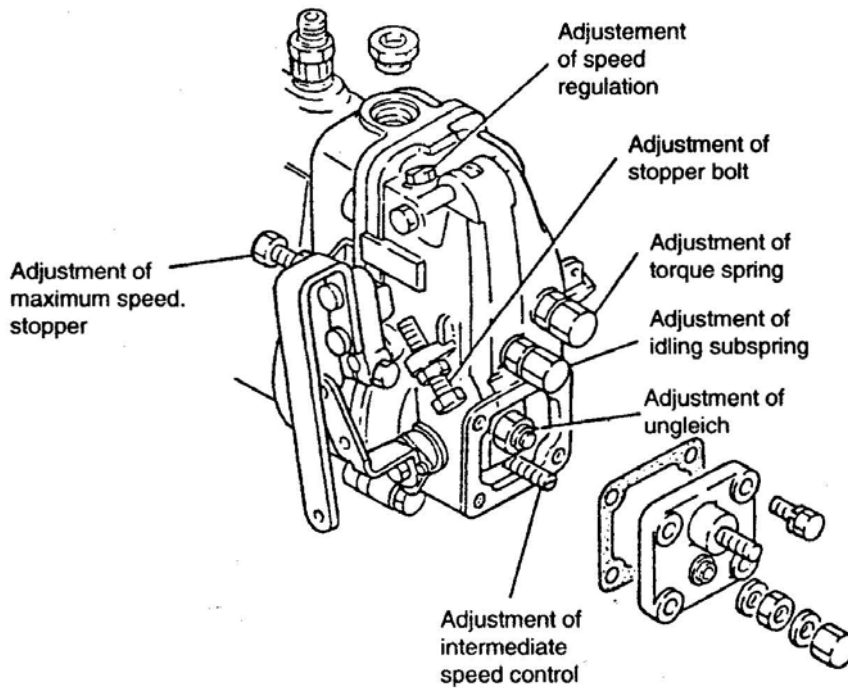


- (2) When mounting the governor spring to the swivel lever, position the spring so that its end faces the shackle.



#### 5-4-2. Adjustment after Reassembly

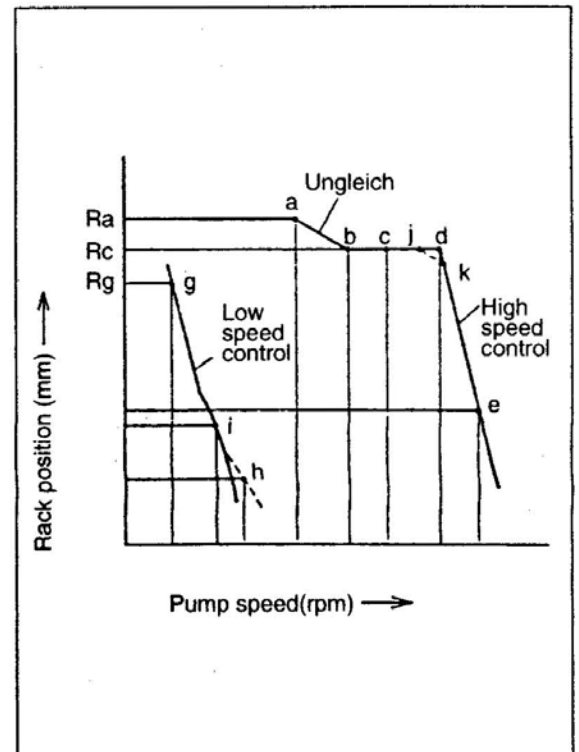
For governor performance curve, see Service Information separately published.



#### NOTE:

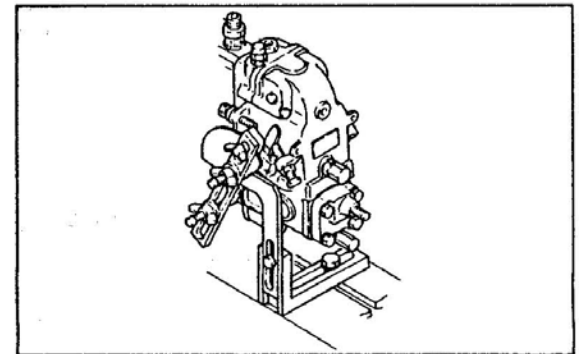
1. Supply engine oil to the injection pump cam chamber.
2. Loosen the adjusting lever stopper bolt.
3. Remove the idling subspring.
4. Do not allow the Ungleich spring and torque spring to work.

Adjust the relationship between the pump speed and the rack position to the specified governor performance curve as follows.



(1) "0" Position Setting of Control Rack

(2) Mount the angle scale plate for the adjusting lever fixing device.



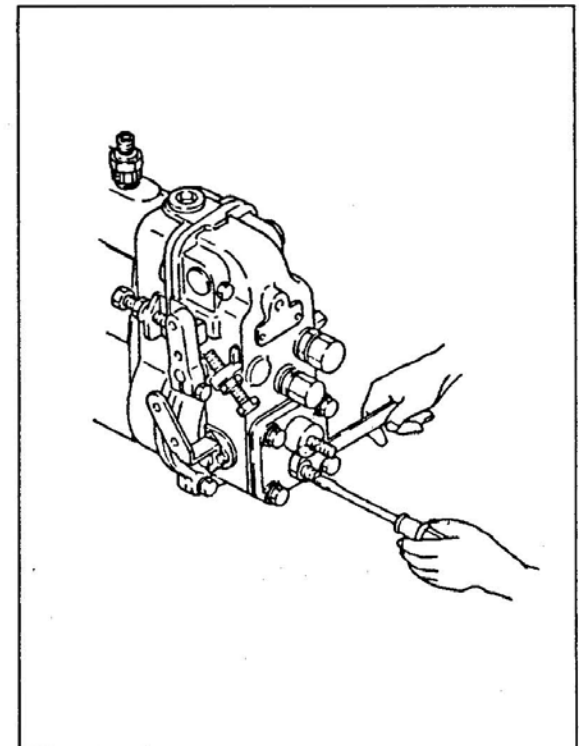
(3) Adjustment of Intermediate Speed Control

This adjustment sets the control rack position point C(maximum injection) when the injection pump is at full load.

With the injection pump at  $N_c$  rpm, set the adjusting lever to its tilted position where the governor spring in the governor is tensioned fairly strongly and hold the lever at that position temporarily.

Then, adjust the full load stopper to bring the control rack to the  $R_c$  position.

Turning the full load stopper clockwise as viewed from the rear of the governor moves the rack in the direction that fuel is increased and turning in counterclockwise moves the rack in the direction that fuel is decreased.



#### (4) Adjustment of Ungleich

Set the adjusting lever at the maximum speed stopper position.

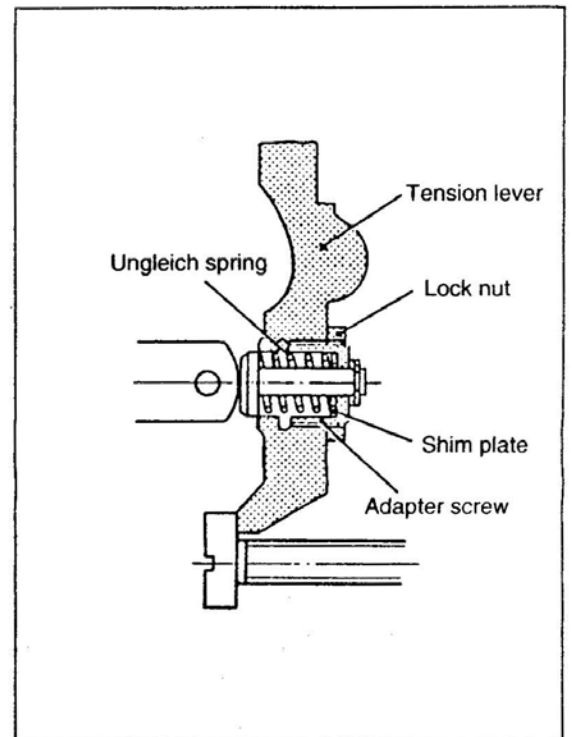
Adjust the adapter screw so that the rack position changes from Ra to Rc when the speed is changed from Na to Nb. The change in the rack position from Ra to Rc is called the Ungleich stroke.

Tightening the adapter screw increases the Ungleich stroke and loosening the screw decreases the Ungleich stroke.

Change the thickness of shim plate(Nippondenso products) the Ungleich spring assembly(DOOWON products) so that the rack is positioned at Ra when the speed is Na.

Shim Thickness(4 types)

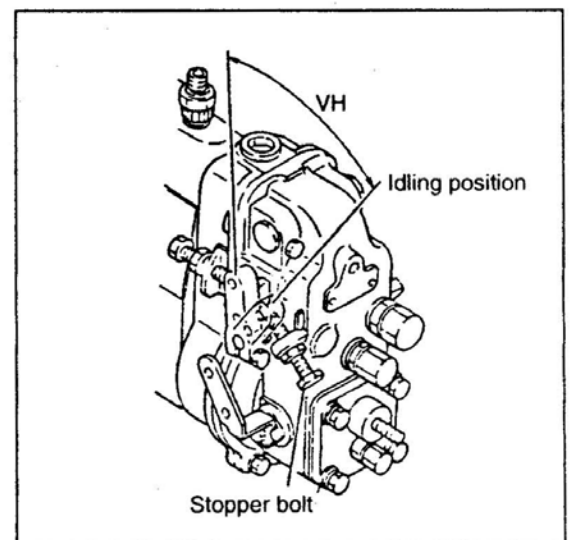
0.10, 0.20, 0.25, 0.50 mm



#### (5) Adjustment of Low Speed Control

##### (a) Adjustment of stopper bolt

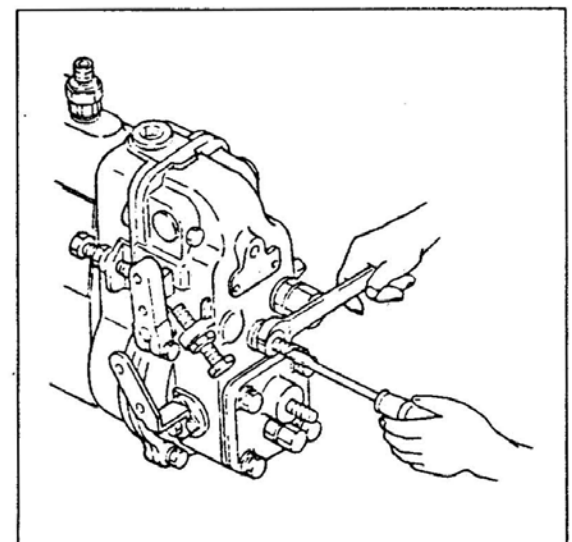
While rotating the pump at Ni, tilt the adjusting lever and adjust the stopper bolt to bring the control rack to the Ri position.



##### (b) Adjustment of idling subspring

Adjust the idling subspring so that the rack is positioned at Rh when the pump is running at a speed of Nh.

Then, decrease the pump speed and check that the rack is positioned at Rg and the pump speed of Ng.

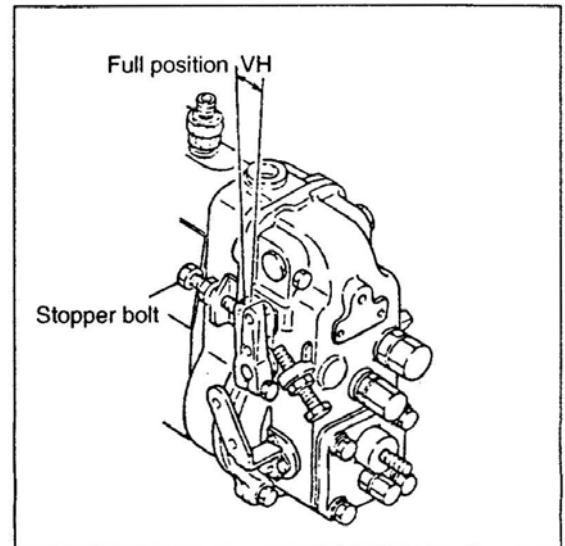


(6) Adjustment fo High Speed Control

(a) Adjustment of maximum speed stopper

Tilt the adjusting lever and set the maximum control speed of the governor.

Tilt the adjusting lever and adjust the maximum speed stopper so that the control rack is moved from the Rc position when the pump speed increased slowly from Nc reaches Nd.



(b) Adjustment of speed variation rate

Increase the pump speed from Nd and check to see that when the speed reaches Ne, the rack position is pulled back to Re.

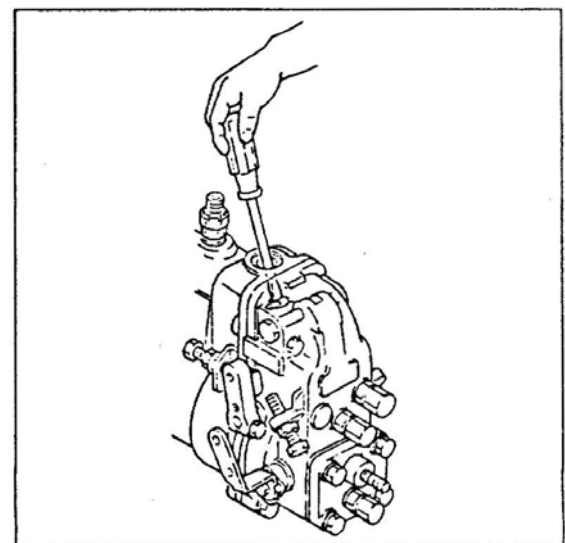
If it is out of specification, adjust the amount the adjusting screw of the swivel lever is turned down.

Tightening the screw will improve the speed variation rate.

Loosening it will worsen the speed variation rate.

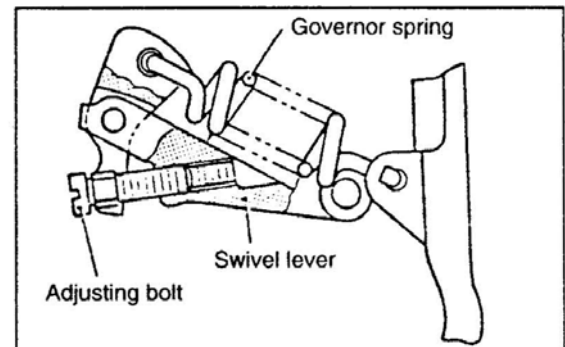
Speed variation rate

$$\frac{N_e - N_d}{N_d} \times 100(\%)$$



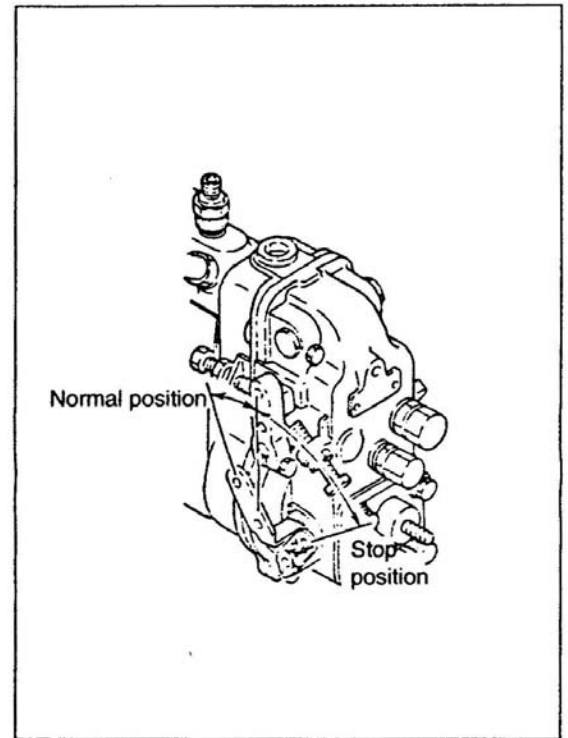
**NOTE:**

1. If the variation rate is poor, the engine will exceed the specified maximum speed at no load and will enter a hazardous condition.
2. The maximum extent to which the adjusting screw can be loosened is 20 notches(5 rotations) from the fully tightened position. Loosening it any further can be dangerous.
3. If the adjusting screw is adjusted, the tension of the governor spring will change and the high speed control start point will change. Make sure that the maximum speed stopper under Item(a) is readjusted.



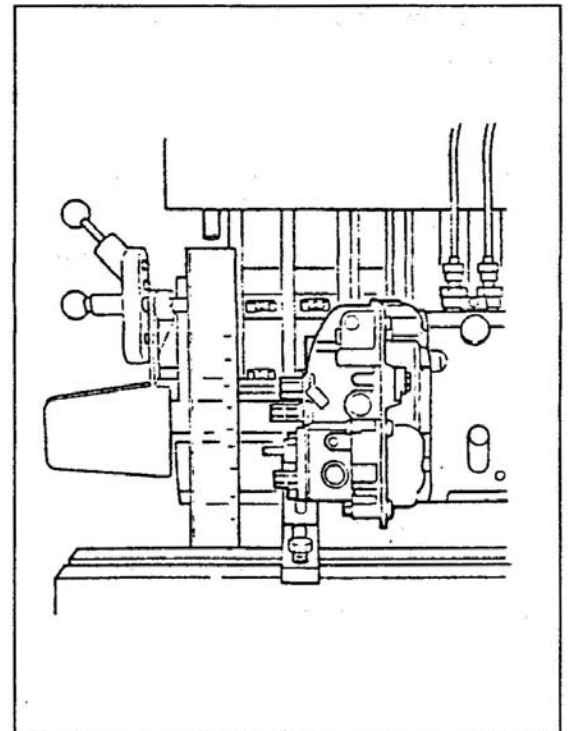
(7) Stop Lever Operation Check

With the injection pump at full load, move the stop lever fully to the stop side and check that this moves the rack to the 0mm position.



(8) Adjustment for Adaptation to engine

Upon completion of the governor adjustment, measure the total injection amount with the lever set at the same angle as in the high speed control in accordance with the adjustment standard and adjust as necessary.

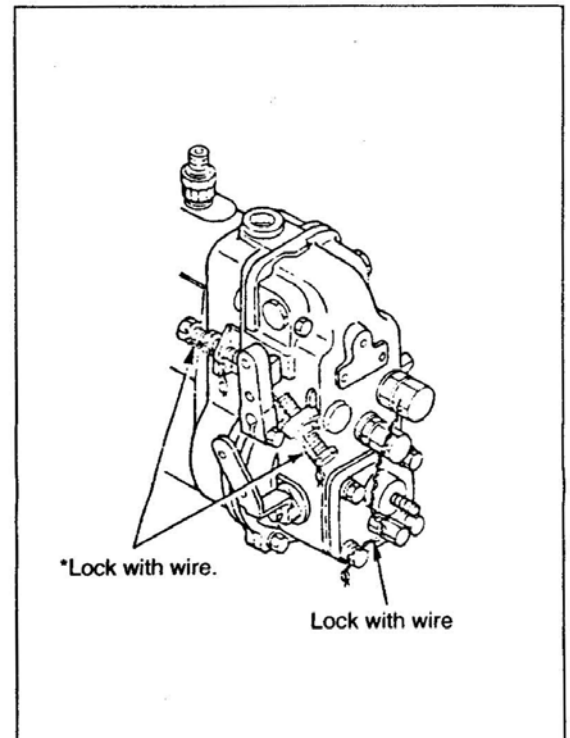


(9) Sealing

After all adjustments have been made, seal the governor as follows.

**NOTE:**

**Sealing of the sections marked with \* must be done after adjustment of no-load minimum and maximum speeds.**



**5-4-3. Inspection and Adjustment of No-load Minimum and Maximum Speeds**

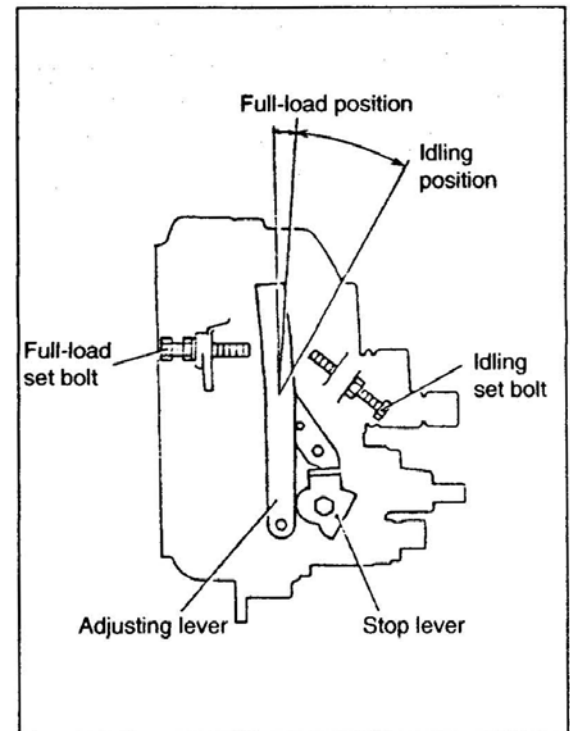
Start engine and warm up sufficiently. After the temperature of coolant exceeds 60°C, perform the following inspection and checks.

(1) Minimum Speed

- (a) Make sure that the adjusting lever is in contact with the idling set bolt.
- (b) In this state, measure the minimum speed to ensure that it is within the specification.
- (c) If the measurement is out of the specification, use the set bolt for adjustment.

(2) Maximum Speed

- (a) Operate the adjusting lever to the position where it touches the full load set bolt.
- (b) In this state, measure the maximum speed to ensure that it is within the specification.
- (c) If the measurement is out of the specification, adjust with full load set bolt.

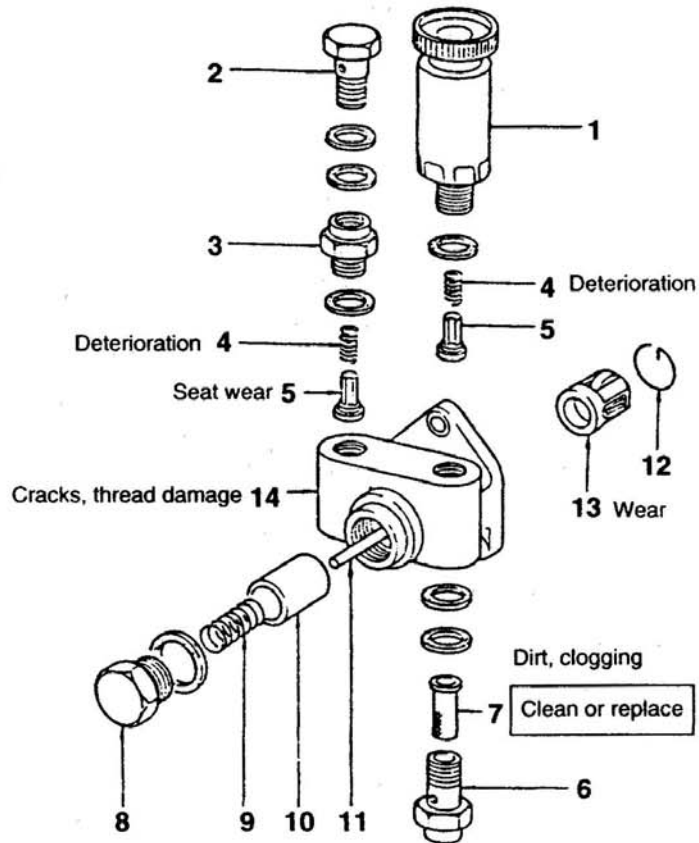


**NOTE:**

**Ensure that the engine does not stall or hunting does not occur even when the adjusting lever is abruptly returned from the full load to idling position. If any unusual condition is present, adjust within the specification range.**

## 5-5. Feed Pump

### 5-5-1. Disassembly, Inspection and Reassembly



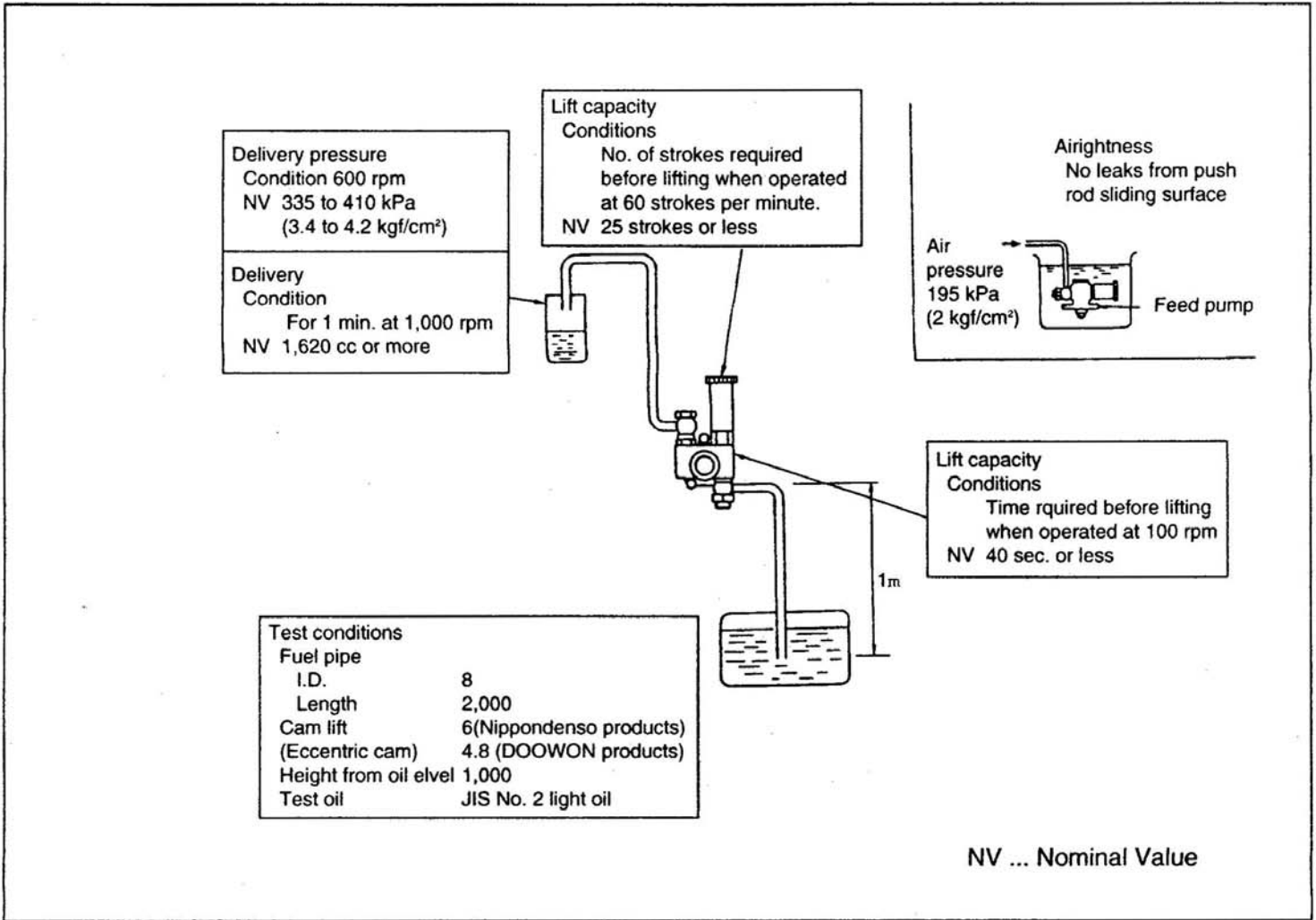
#### <Disassembly sequence>

- |                 |              |
|-----------------|--------------|
| 1 Priming pump  | 8 Plug       |
| 2 Eye bolt      | 9 Spring     |
| 3 Valve support | 10 Piston    |
| 4 Spring        | 11 Push rod  |
| 5 Check valve   | 12 Snap ring |
| 6 Eye bolt      | 13 Tappet    |
| 7 Gauze filter  | 14 Housing   |

For reassembly, reverse the order of disassembly.

**NOTE: Know the trouble spots thoroughly by making tests before disassembly.**

## 5-5-2. Test and Adjustment

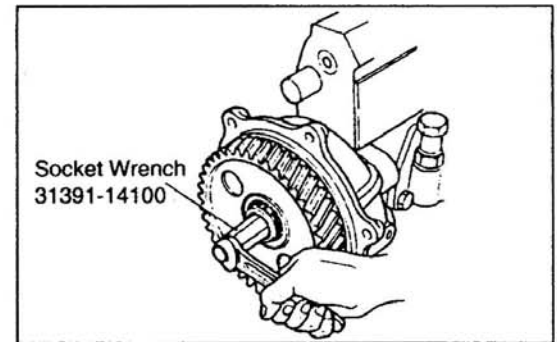


## 5-6. Automatic Timer

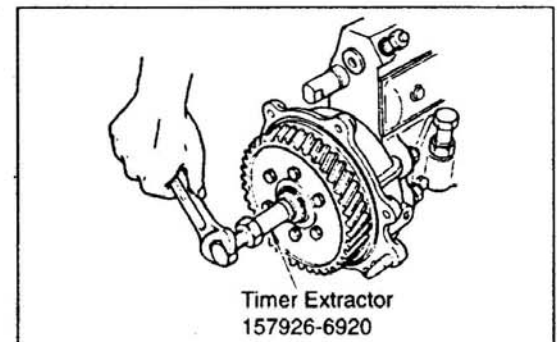
### 5-6-1. SCDM Type Automatic Timer

#### (1) Removal

- (a) Using Socket Wrench(special tool), loosen the roundnut.

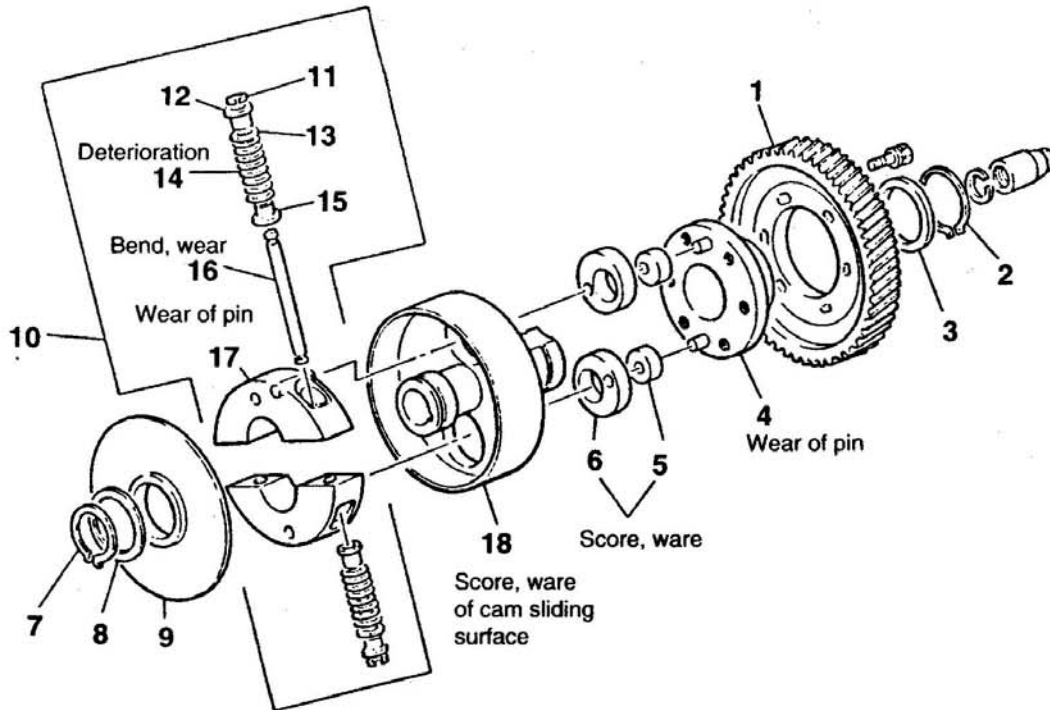


- (b) Using Timer Extractor(special tool), remove the auto timer from the injection pump.





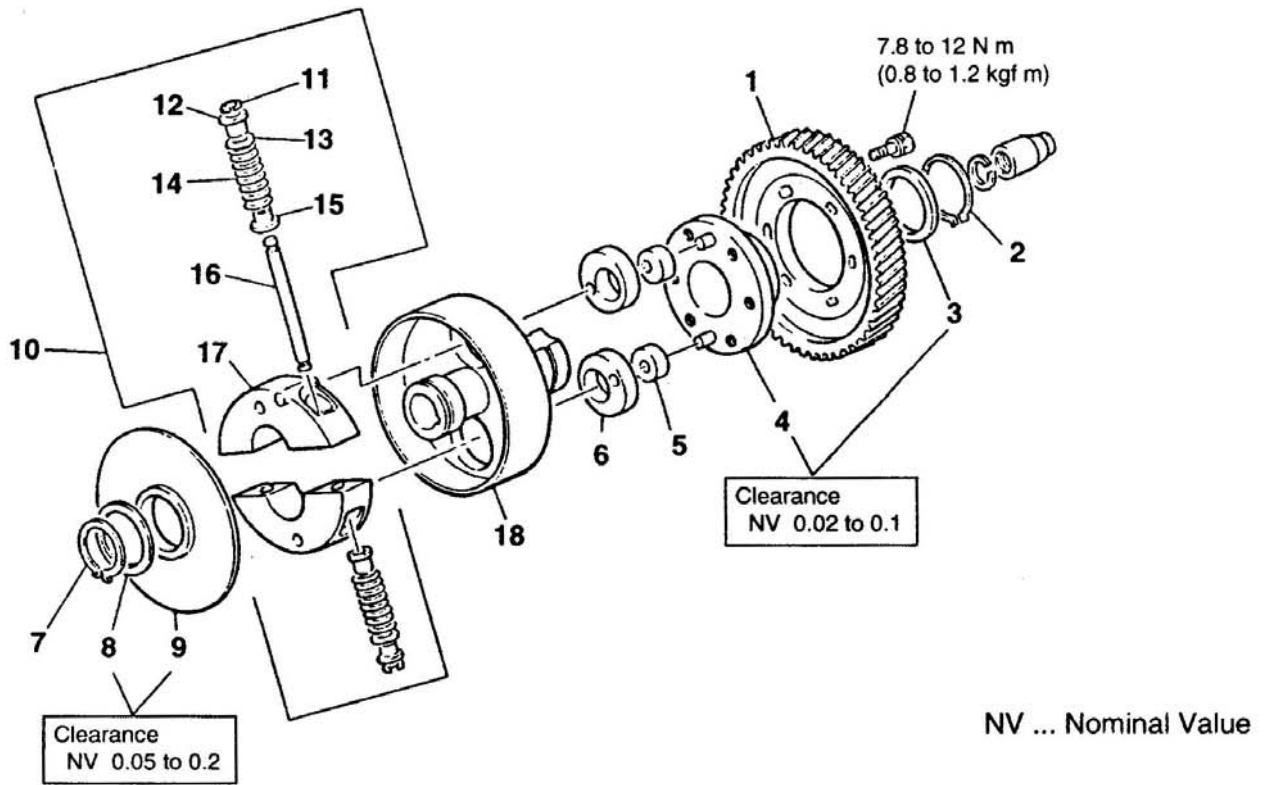
## 5-6-2. Disassembly and Inspection



### <Disassembly sequence>

- |                       |                       |                      |
|-----------------------|-----------------------|----------------------|
| 1 Injection pump gear | 7 Snap ring           | 13 Shim              |
| 2 Snap ring           | 8 Shim                | 14 Spring            |
| 3 Shim                | 9 Cover               | 15 Inner spring seat |
| 4 Flange              | 10 Flyweight assembly | 16 Pilot pin         |
| 5 Smaller cam         | 11 Snap ring          | 17 Flyweight         |
| 6 Larger cam          | 12 Outer spring seat  | 18 Timing flange     |

### 5-6-3. Reassembly

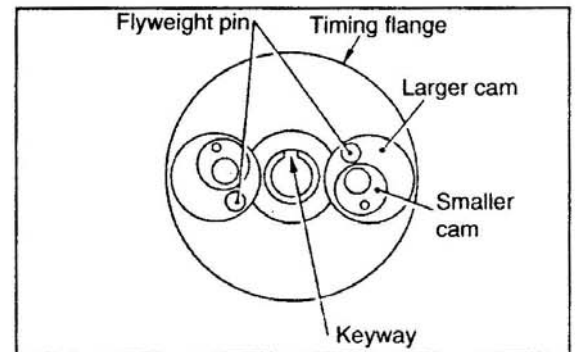


#### <Assembly sequence>

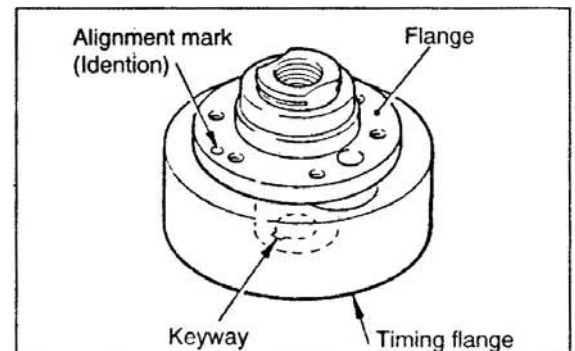
18 → 17 → 16 → 15 → 14 → 13 → 12 → 11 → ⑩ → ⑥ → ⑤ →  
 → ④ → 3 → 2 → 1 → ⑨ → 8 → 7

For reassembly of parts with an encircled number, see following items.

- (a) After the flyweight assembly has been installed to the timing flange, position the flyweight pins as shown, with reference to the keyway in the timing flange, and install the larger and smaller cams.



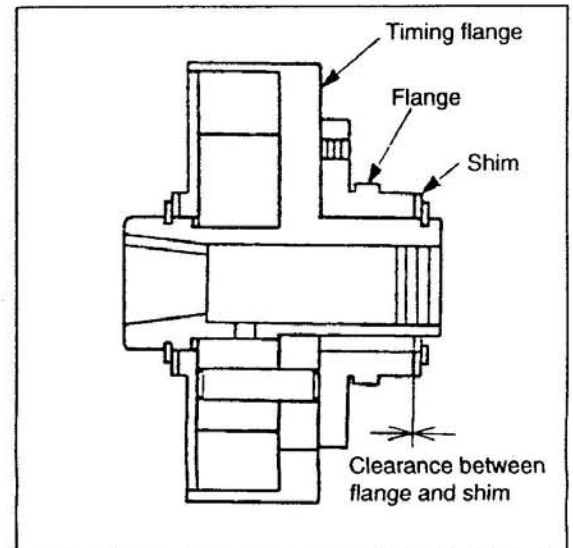
- (b) Install the flange, aligning it with the hole in the smaller cam and ensuring that its alignment mark (indentation) is positioned on the same side as the timing flange keyway.



- (c) Put the timing flange and flange closely tied together and ensure that the clearance between the flange and shim is up to specification. If the clearance is out of specification, replace shim.

**Shim Thickness**

0.10, 0.12, 0.14, 0.16, 0.18, 0.9,  
1.1, 1.3, 1.5, and 1.7mm



- (d) Vary shim to obtain the specified clearance between the cover and shim

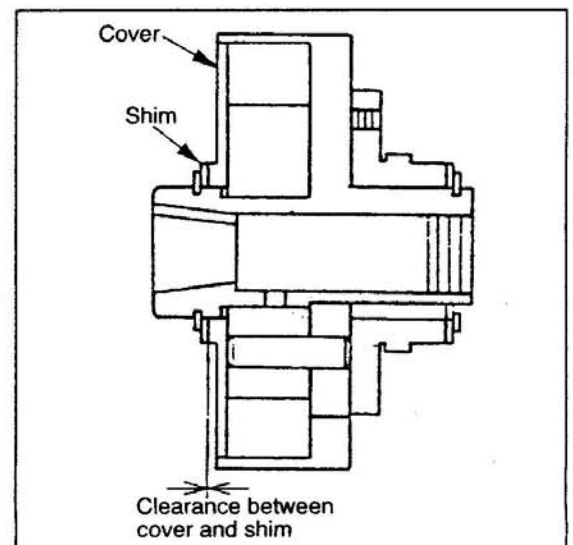
**Shim Thickness**

0.10, 0.12, 0.14, 0.16, 0.18, 0.9, 1.1, 1.3, 1.5, 1.7mm

**NOTE:**

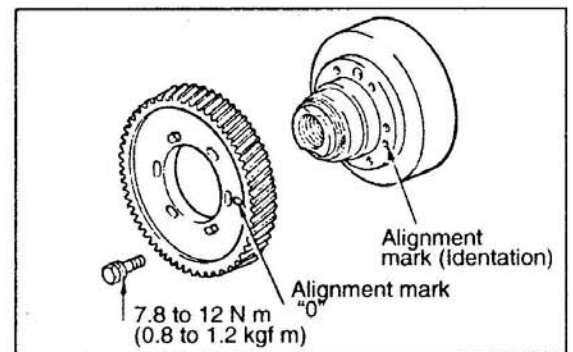
**When measuring the clearance, closely contact the cover and flyweight.**

**After adjustment, install snap ring.**



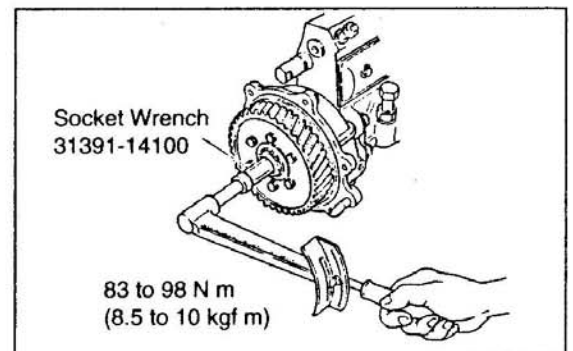
- (e) After the timer characteristic adjustments have been completed(see next items), install the gear with its alignment mark "0" lined up with the timing flange keyway or alignment mark on the flange.

Then tighten six bolts diagonally to the specified torque.



**1. Installation**

Mount the auto timer onto the camshaft, aligning it with the camshaft key. Using Socket Wrench(special tool), tighten the round nut to specification.



## 2. Test and Adjustment

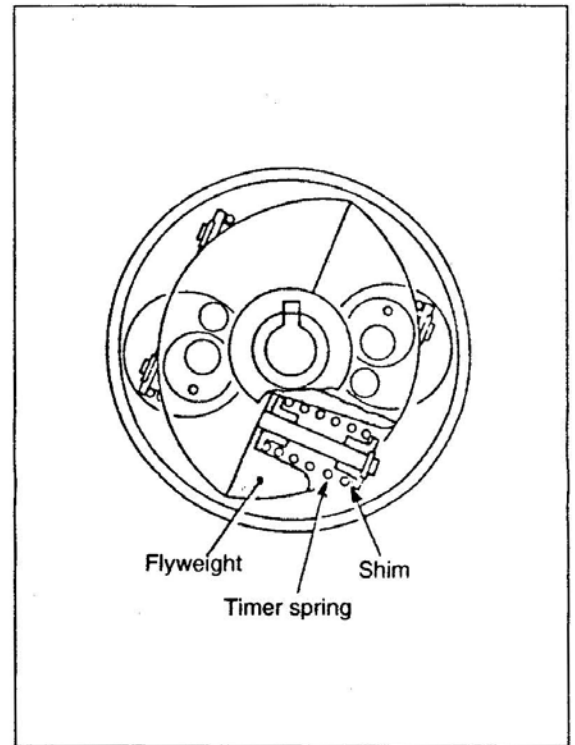
Whenever the auto timer has been disassembled, its advance angle must be measured and adjusted with the manufacturer's measuring device.

To adjust the advance characteristic of the auto timer, add or reduce the adjusting shims or replace the spring.

To reduce the advance angle, increase the shim thickness.

Shim Thickness

0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0mm

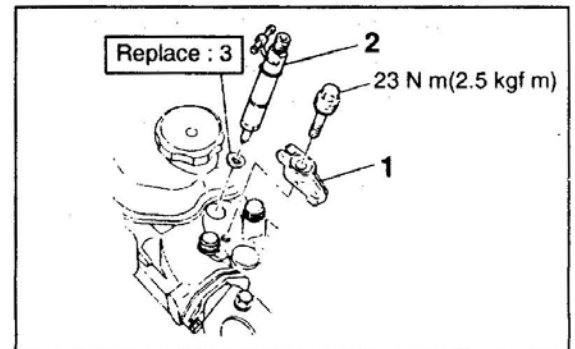


## 5-7. Injection Nozzle

### 5-7-1. Removal and Installation

- 1 Bridge
- 2 Injection nozzle
- 3 Nozzle tip gasket

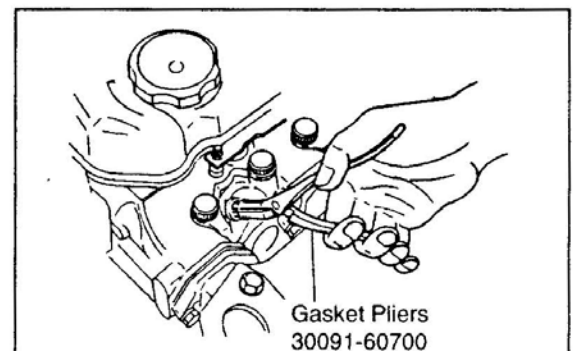
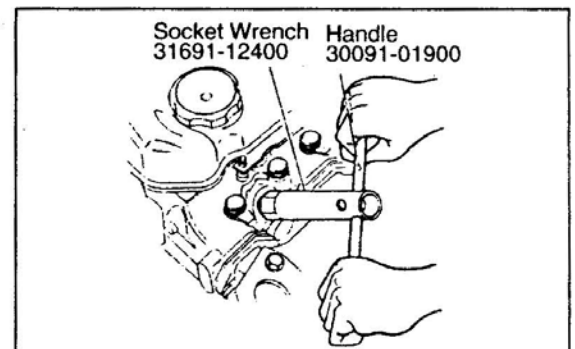
(a) To remove and reinstall the injection nozzle, use Socket Wrench and Handle(special tools).



(b) If the nozzle tip gasket is hard to remove because of seizure, use Gasket Pliers(special tool).

#### NOTE:

Cover pipes, injection nozzle, and injection pump to prevent entry of dust and dirt. If the injection nozzle is removed, provide adequate means to prevent entry of dust into the cylinder.



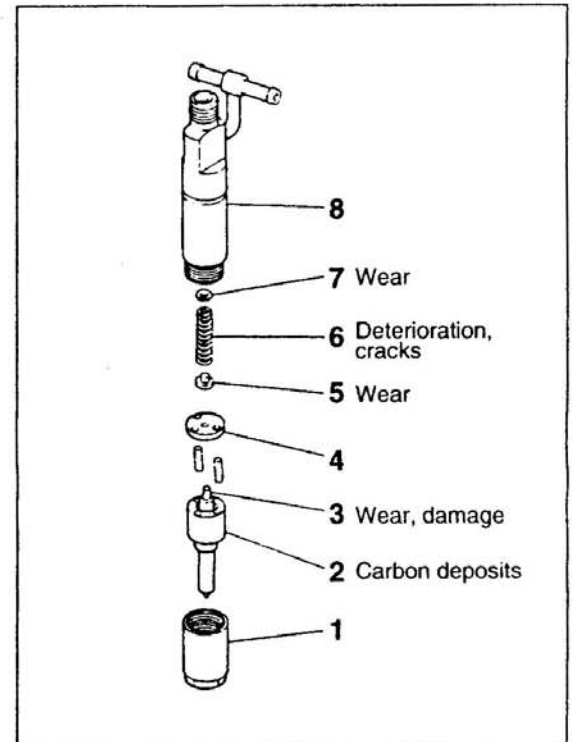
## 5-7-2. Disassembly

<Disassembly sequence>

- 1 Retaining nut
- 2 Nozzle
- 3 Needle valve
- 4 Packing
- 5 Pressure pin
- 6 Spring
- 7 Washer
- 8 Nozzle holder

### NOTE:

**Make sure that the combination of the nozzle and needle valve is not changed.**



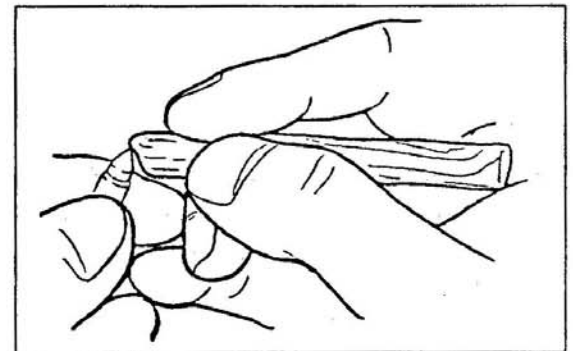
## 5-7-3. Cleaning and Inspection

### (1) Cleaning

After cleaning the nozzle with gas oil, remove carbon deposits with Nozzle Cleaning Tool (special tool). Proceed as follow.



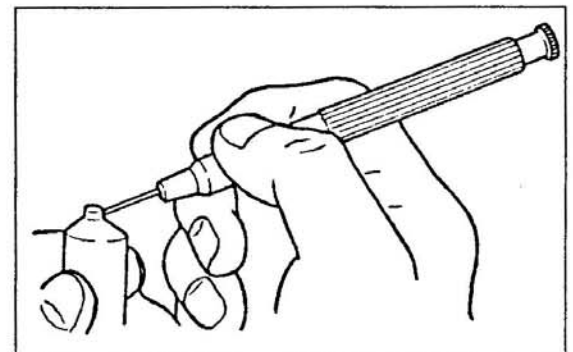
(a) Remove the needle valve from the nozzle and clean the needle valve with the needle valve cleaning wood piece.



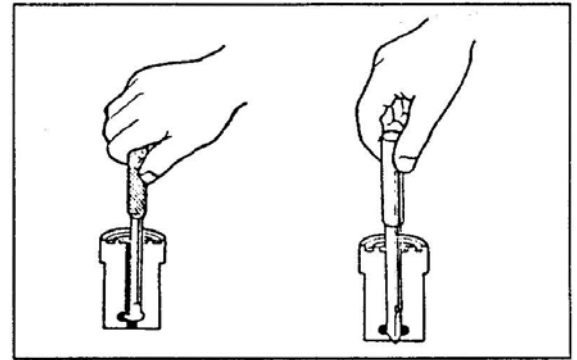
(b) Insert, while turning, a cleaning needle into the injection orifice of the nozzle to remove carbon.  
Use first a cleaning needle having smaller diameter than that of injection hole and then finish with following:

0.28mm [Valve opening pressure 17.7 MPa (180 kgf/cm<sup>2</sup>)]

0.30mm [Valve opening pressure 21.6 MPa (220 kgf/cm<sup>2</sup>)]



(c) Remove carbon from the oil pool and valve seat of the nozzle body.

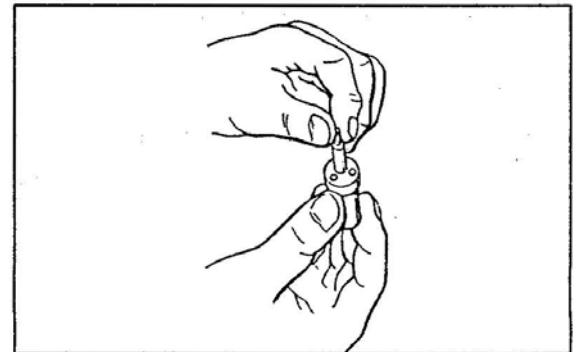


(d) To remove burnt and hardened carbon, use Fuso Carbon Remover.

(2) Inspection

Clean and immerse the nozzle in gas oil, slide the needle valve, and ensure that it moves smoothly.

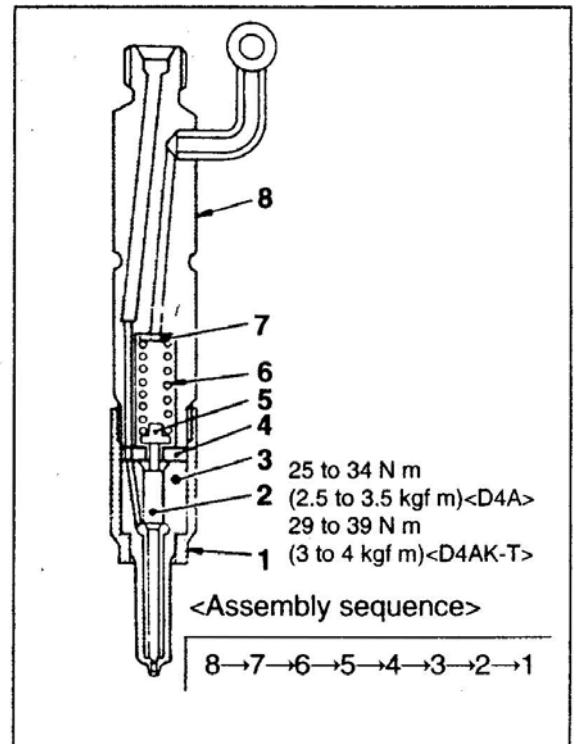
Next, pull up the needle valve vertically about 1/3 of its entire stroke and check if it falls under its own weight. If it does not fall, replace the nozzle.



5-7-4. Reassembly

NOTE:

1. Never touch the sliding surfaces of the needle valve by hand.
2. When replacing the nozzle tip with a new one, remove the seal peel(synthetic resin film) and move the needle valve in nozzle in a clean gas oil to completely remove the anti-rust oil..



## 5-7-5. Test and Adjustment

### (1) Injection Pressure

- (a) Install a nozzle tester to the nozzle.
- (b) Operate the nozzle tester to inject several times. This allows the tester to be bled of air.
- (c) Operate the nozzle tester at the specified speed. Then, vary shims to obtain the specified injection pressure.

### Shim Thickness

<D4A>

0.95 to 1.25mm in 0.05 increments

1.275 to 1.775mm in 0.025 increments

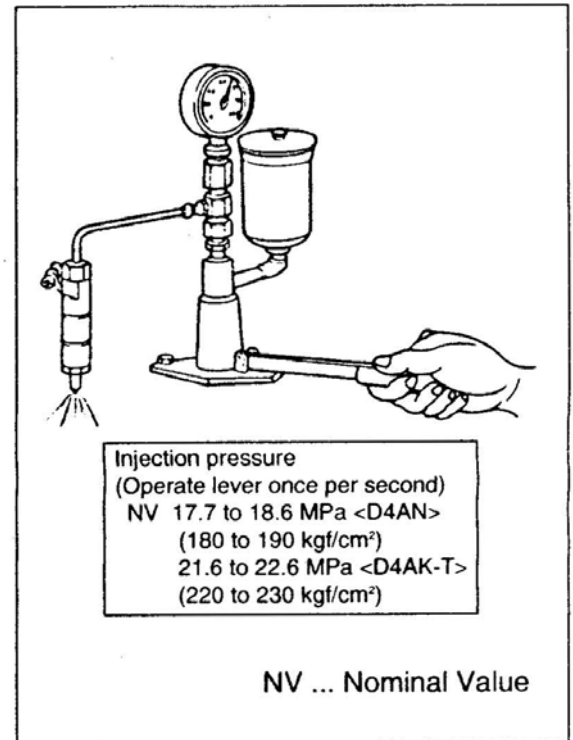
1.80 to 2.15mm in 0.05 increments

A 0.05mm variation in shim thickness varies the injection pressure by 0.49 MPa(5kgf/cm<sup>2</sup>).

- (d) With a correct shim selected, recheck the injection pressure.

### NOTE:

**Never let yourself exposed directly to the atomized fuel injected from the nozzle.**



### (2) Spray Condition

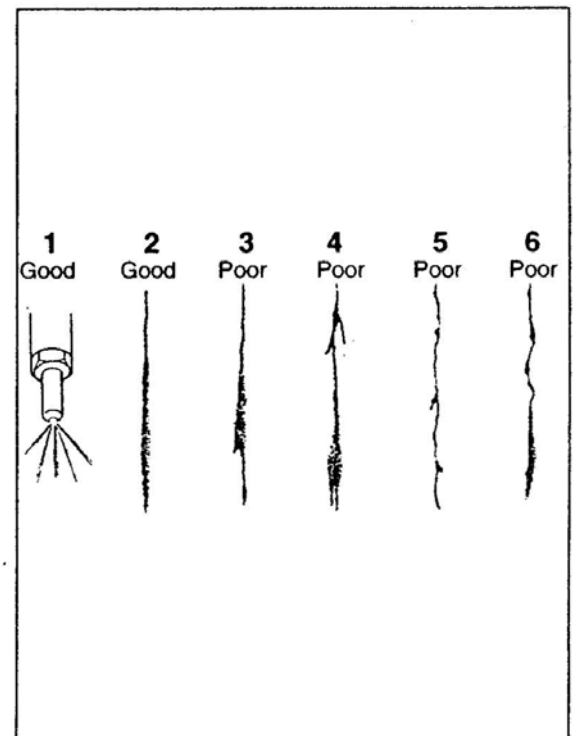
When adjusting the pressure with a nozzle tester, check also for clogged injection orifices, spray condition, and fuel leaks from the orifices. Replace the nozzle if defective.

#### Good

- 1 Evenly sprayed from five injection orifices
- 2 Even and symmetrical

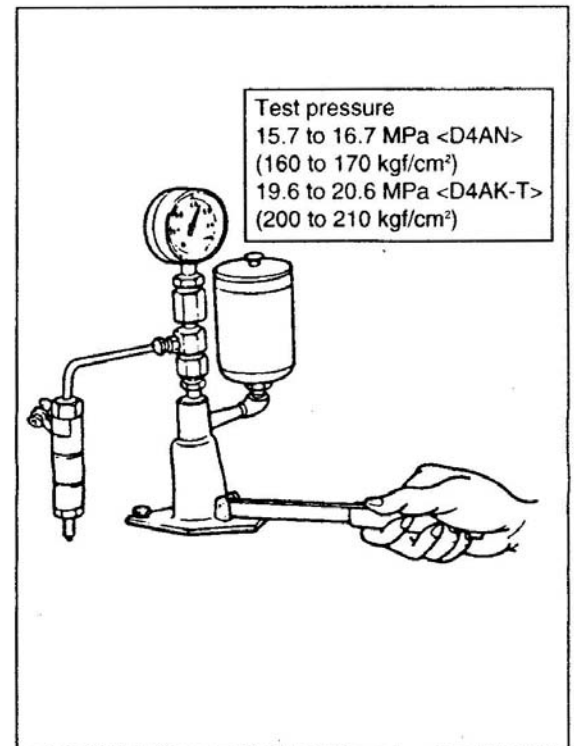
#### Poor

- 3 Asymmetrical
- 4 Branched
- 5 Thin
- 6 Irregular



### (3) Fuel Tightness Test

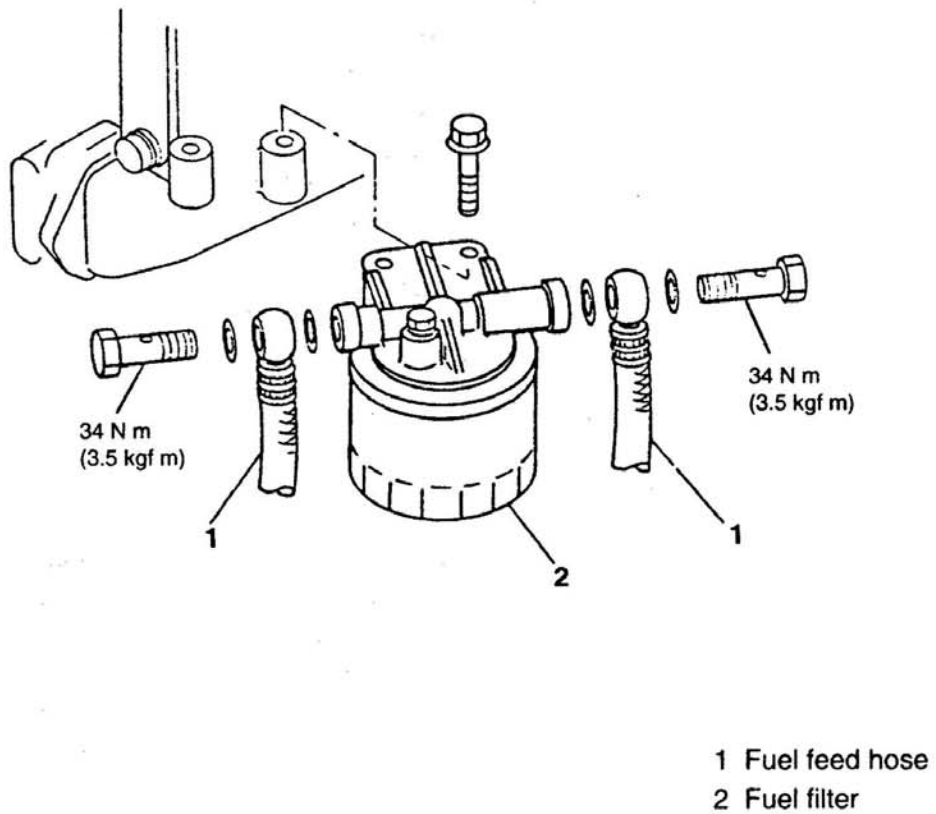
Mount a nozzle, that has been adjusted to start injection at the specified pressure, to the nozzle tester and slowly increase the pressure to the test pressure. Keeping this condition, check for fuel leaks from the bottom of the nozzle. The nozzle is in good condition if there is no leak.





## 5-8. Fuel Filter

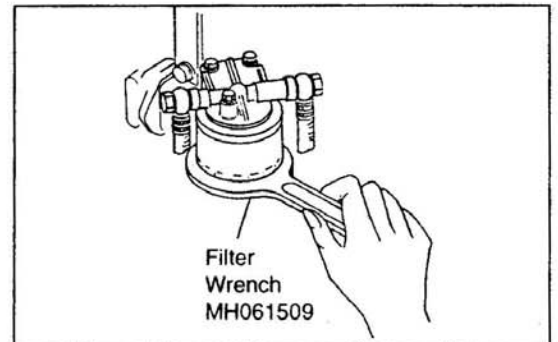
### 5-8-1. Removal and Installation



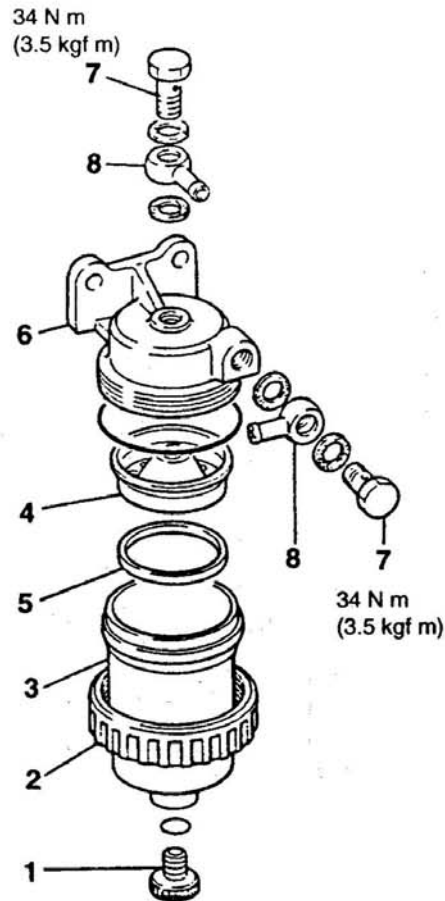
To remove the element, use Filter Wrench(special tool).

#### NOTE:

1. For installation, tighten the element by hands.
2. After installation, run the engine and check for fuel leaks.



## 5-9. Water Separator

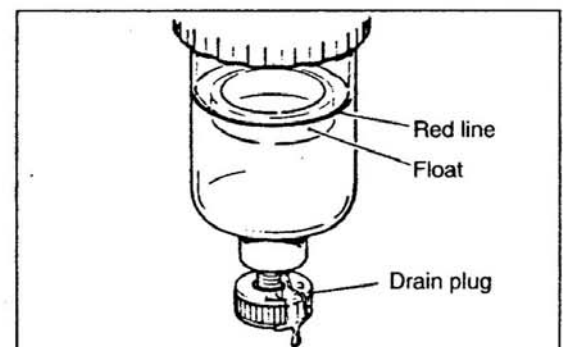


- 1 Drain plug
- 2 Ring nut
- 3 Case
- 4 Baffle plate
- 5 Float
- 6 Head
- 7 Connector bolt
- 8 Joint

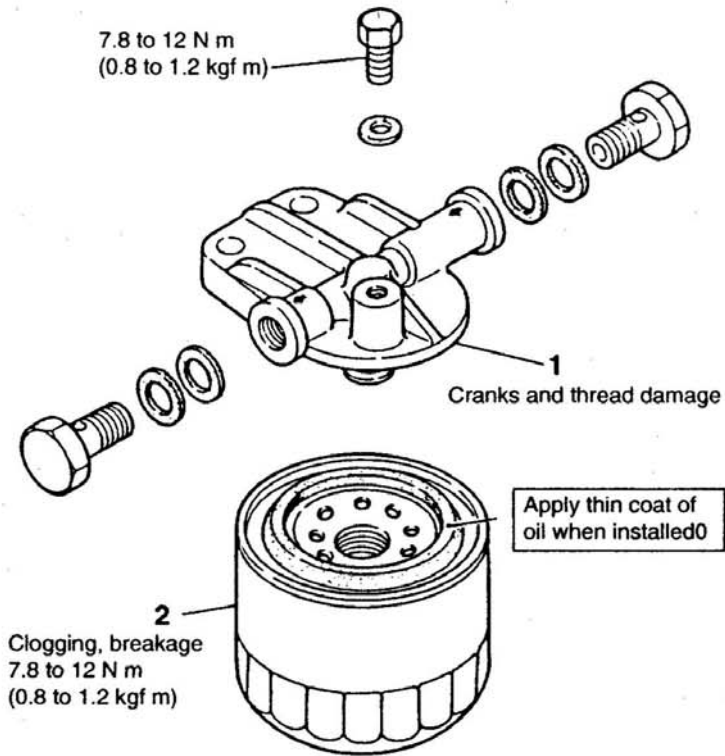
If the red float in the translucent case rises to the level of the red line marked on the outer circumference of the case, loosen the drain plug to discharge water.

It is not necessary to completely remove the drain plug as water is discharged gradually through the groove of the loosened plug.

**NOTE :** After draining, tighten firmly the drain plug before bleeding the fuel system.



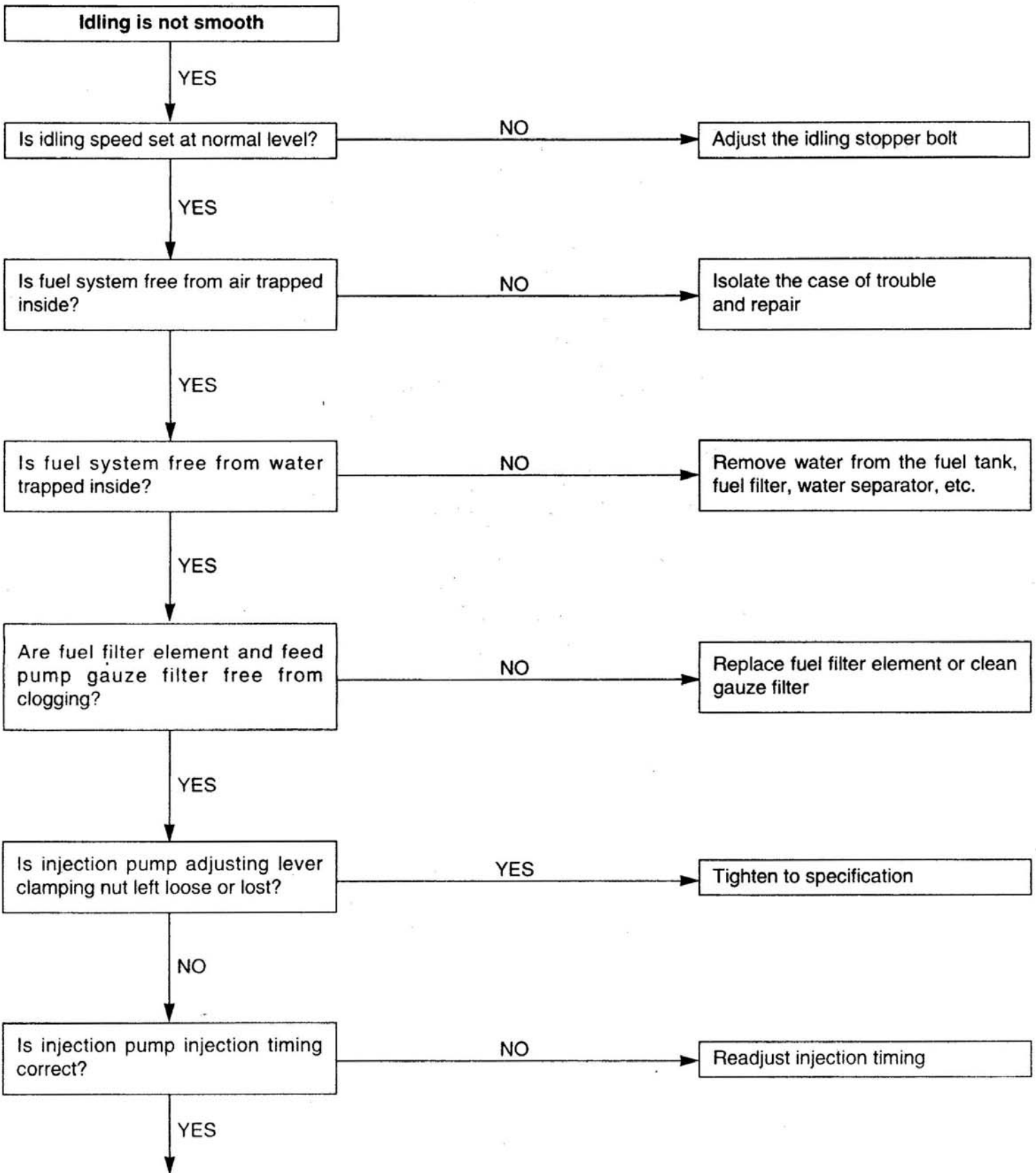
## Disassembly, Inspection and Reassembly



- 1 Fuel filter head
- 2 Element

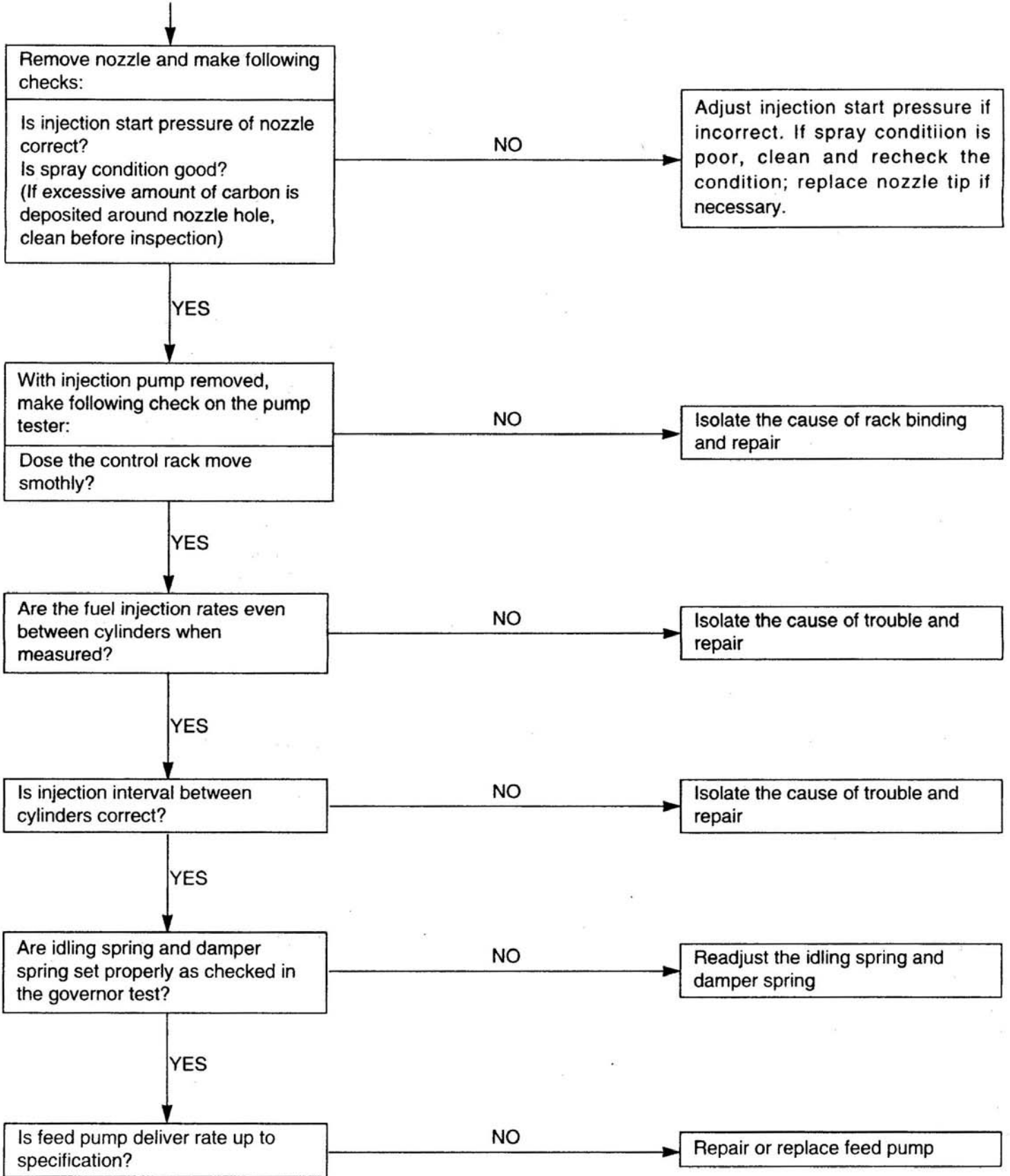
## 6. TROUBLESHOOTING

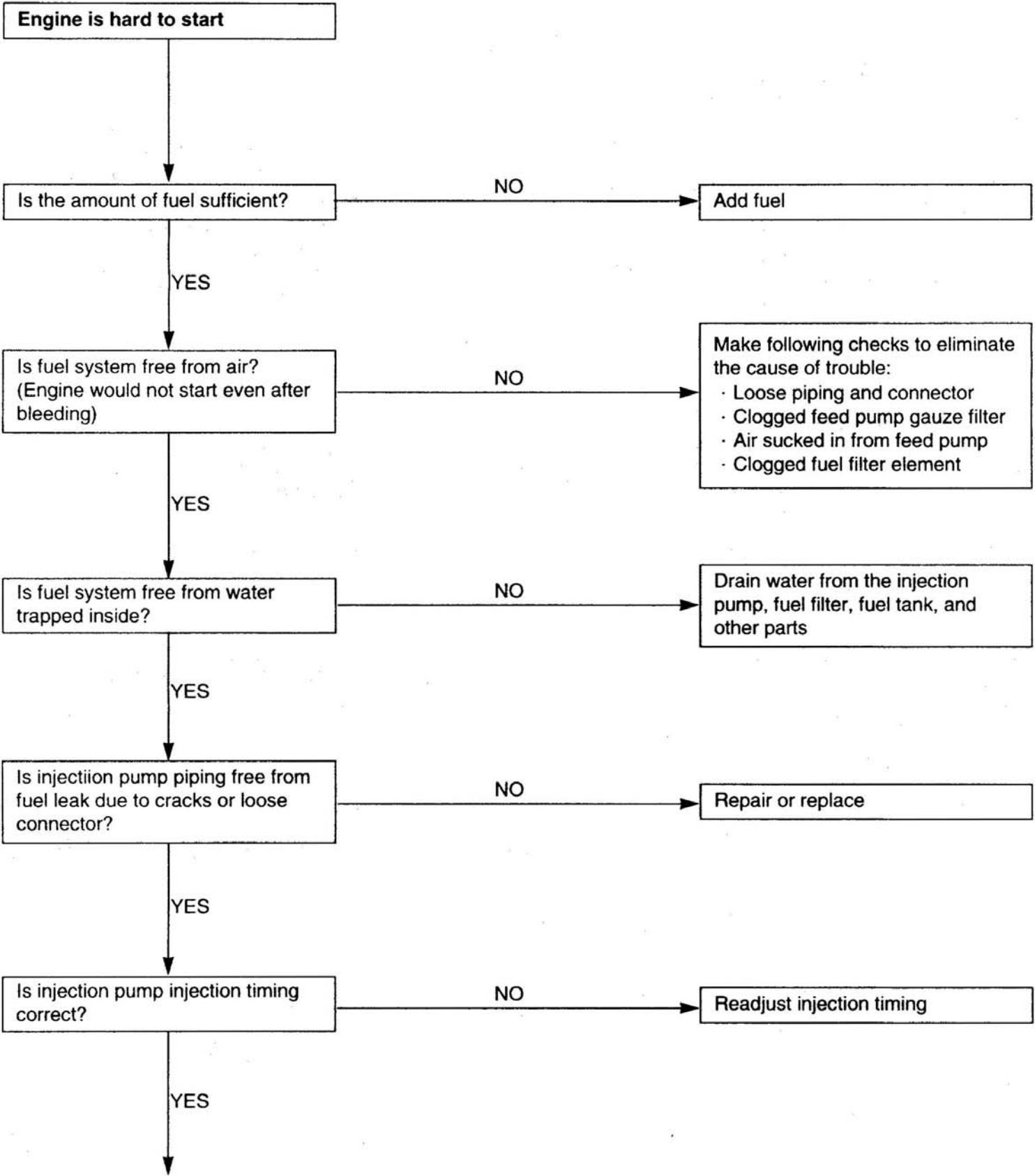
### (1) Fuel Injection Pump



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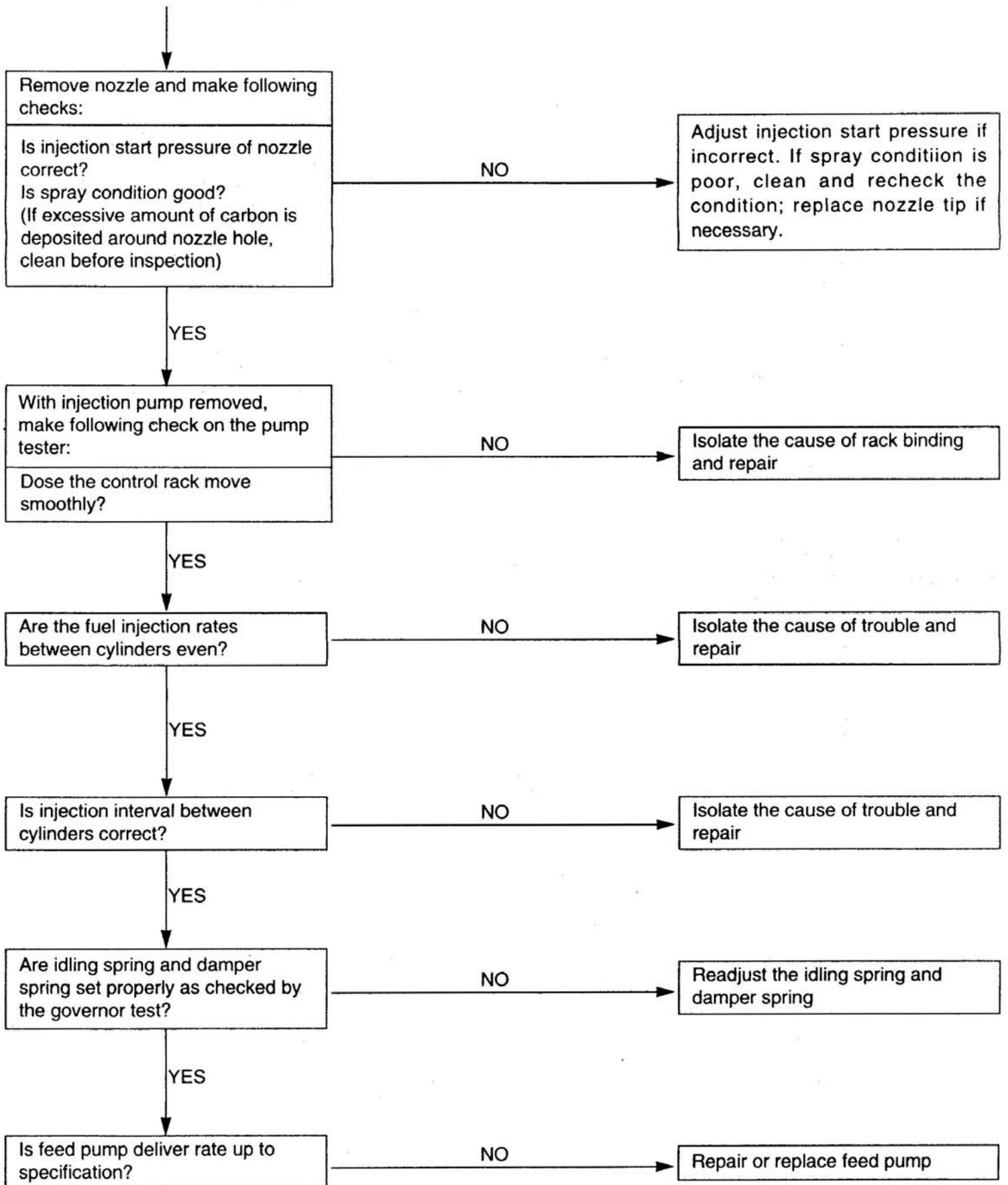
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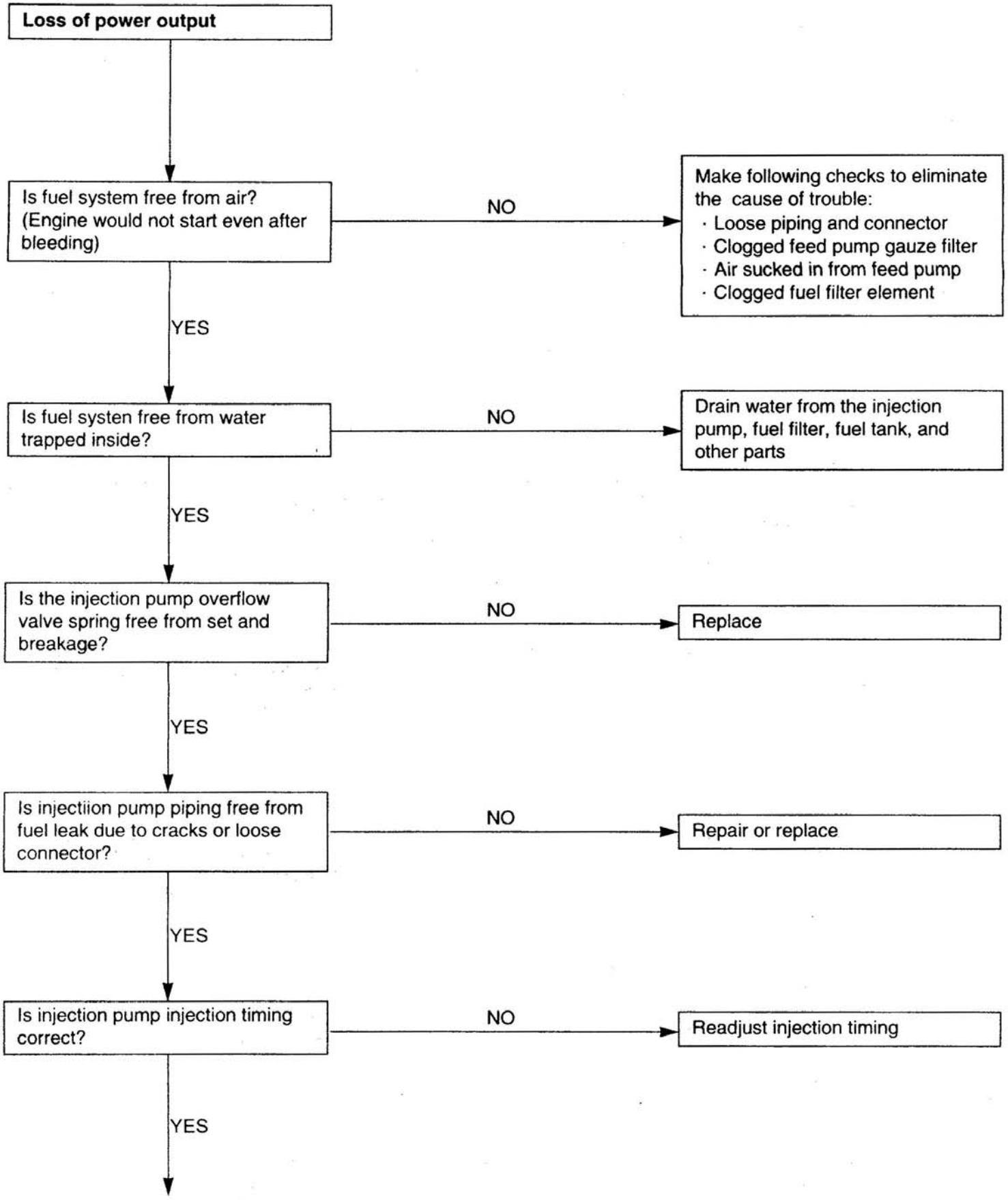




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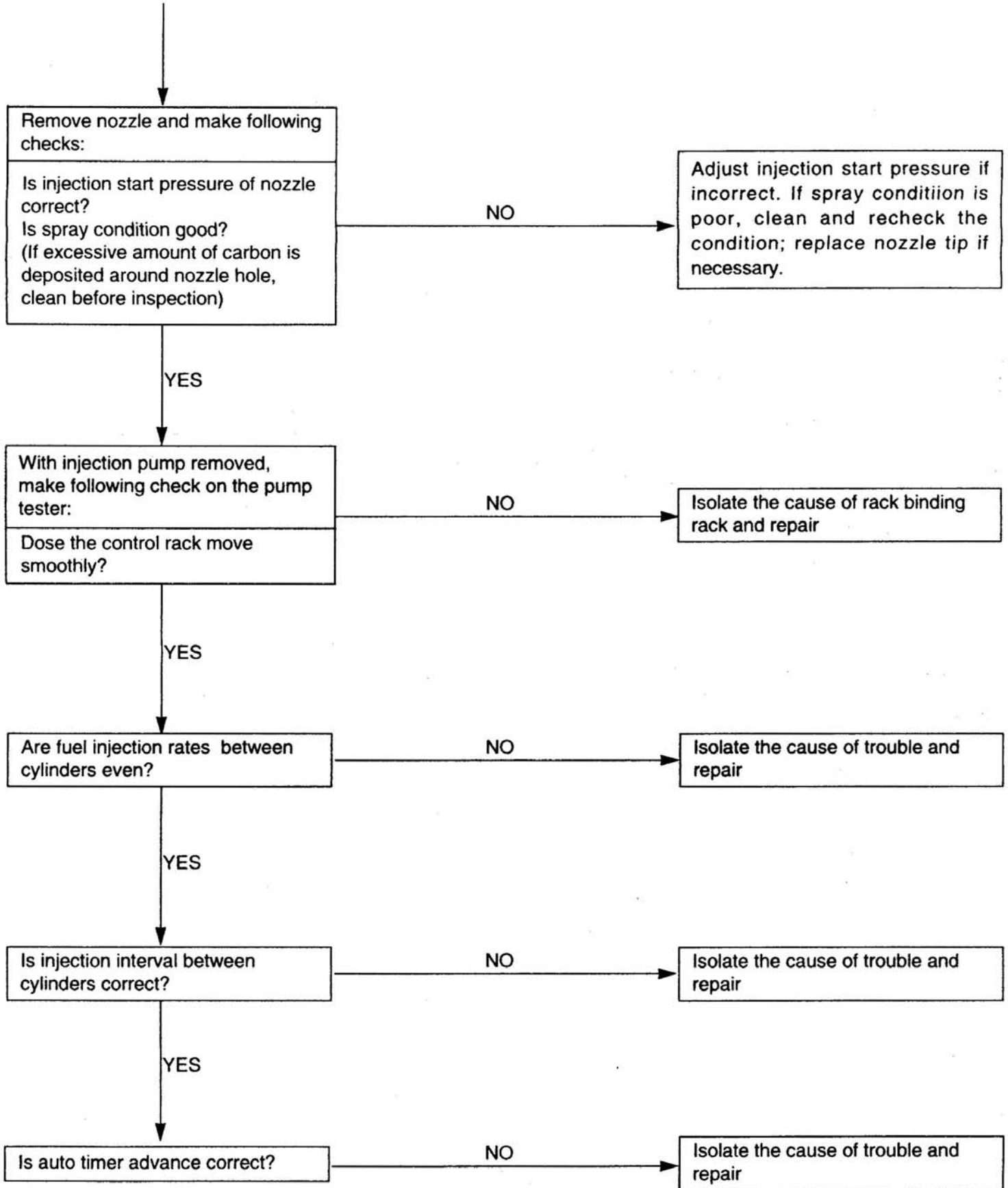


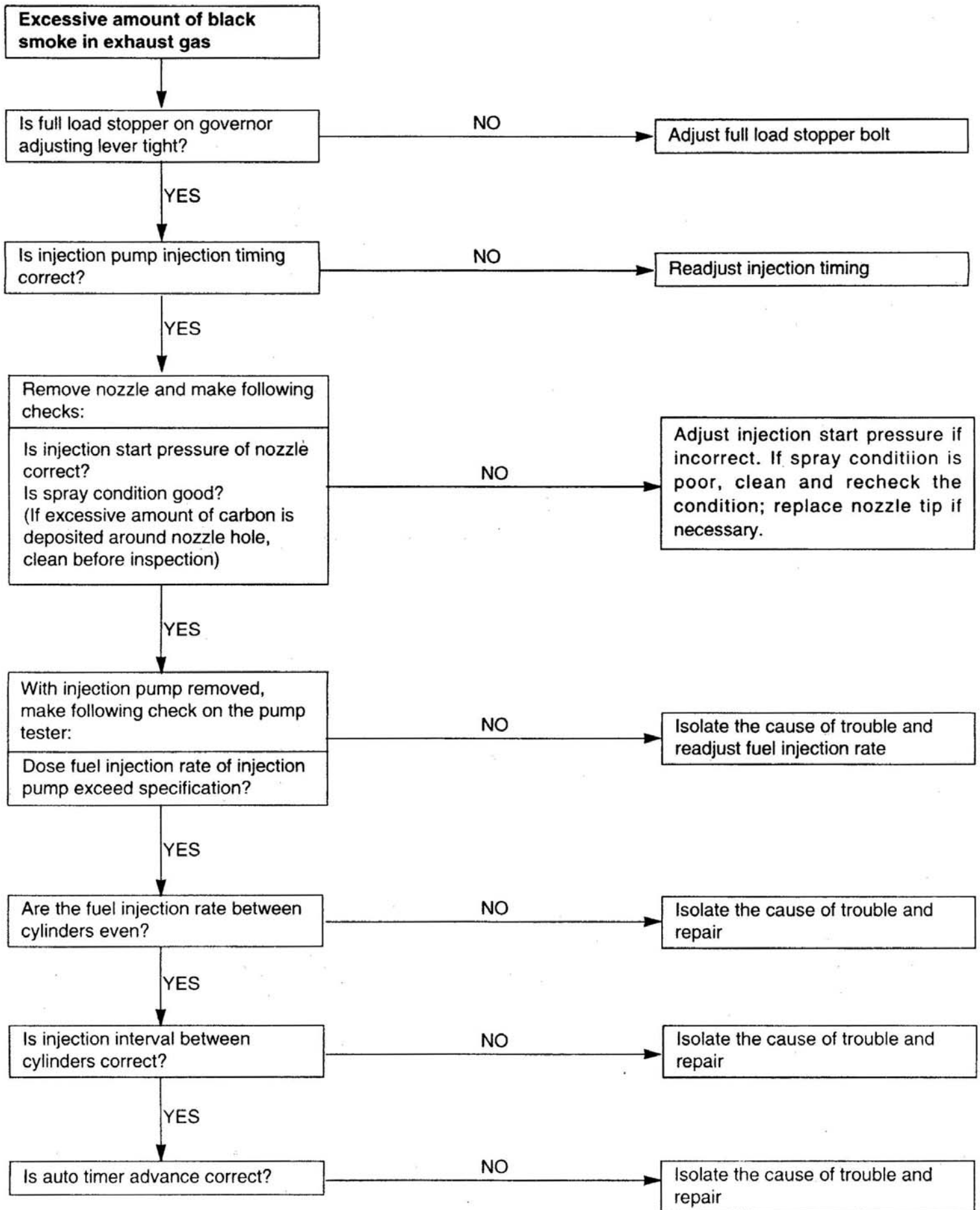


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**There is knocking noise from around the injection pump**

Is injection pump coupling tight?

NO

Align timing marks and retighten bolt

YES

Is injection pump piping free from cracks and loose connector?

NO

Repair or replace

YES

Is the injection pump free from unusual noise when the engine runs at low speed?

NO

Worn parts around tappet: disassemble injection pump and replace defective parts

