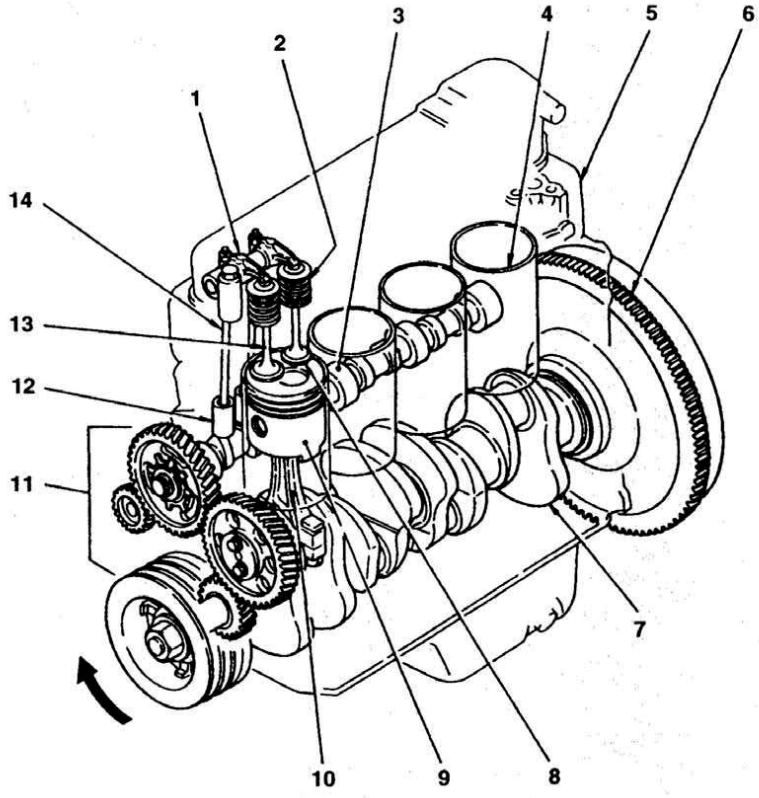
1. GENERAL



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

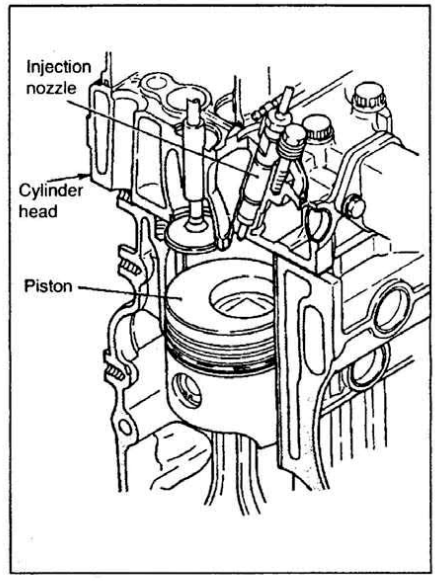
On engines, the pistons reciprocate in the cylinder sleeves inserted in the crankcase.

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.



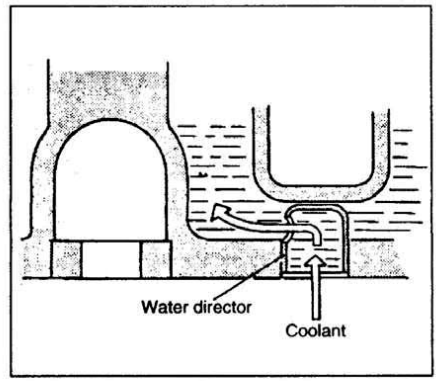
The combustion chamber is formed by the lobes-shaped main combustion chamber in the piston head and HYUNDAI'S own bell-shaped swirl chamber.

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.



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(2) Valve Mechanism

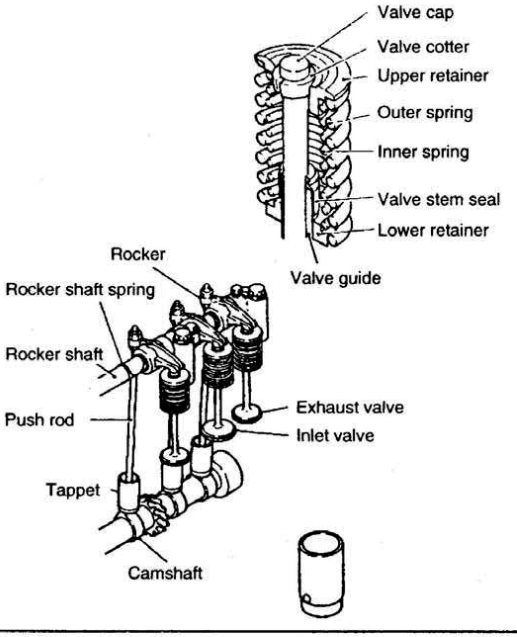
The valve mechanism is an overhead valve type.

(a) Both the inlet and exhaust valves are made of surface-treated heat-resistant steel.
The valve seat angle is 45° 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.



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(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.

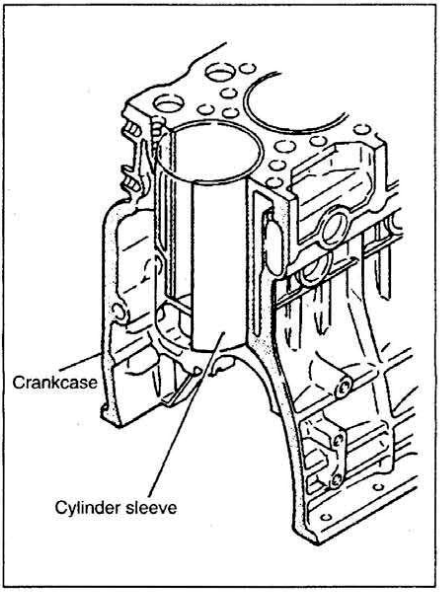
(g) The camshaft is provided with an oil pump drive gear, with its journals, cams, and gear induction-hardened.
The cam on D4A is a taper cam.

(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.



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(4) Piston and Piston Ring

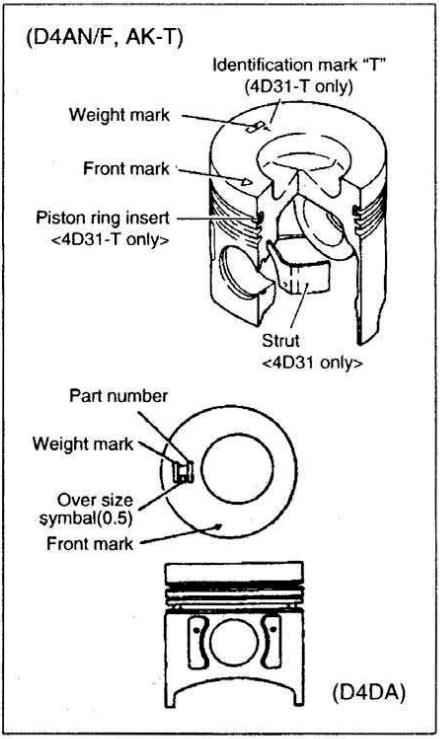
(a) Piston

The piston, made of aluminum alloy castng, 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 mak "◁" on D4A and D4D.

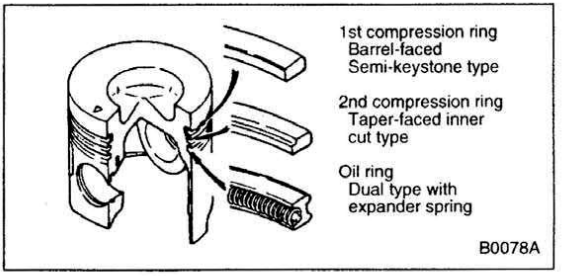
On D4AK-T, and ID mark "T" stamped on top and a Niresist piston ring insert is cast in the top ring groove for increased durability.



(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.

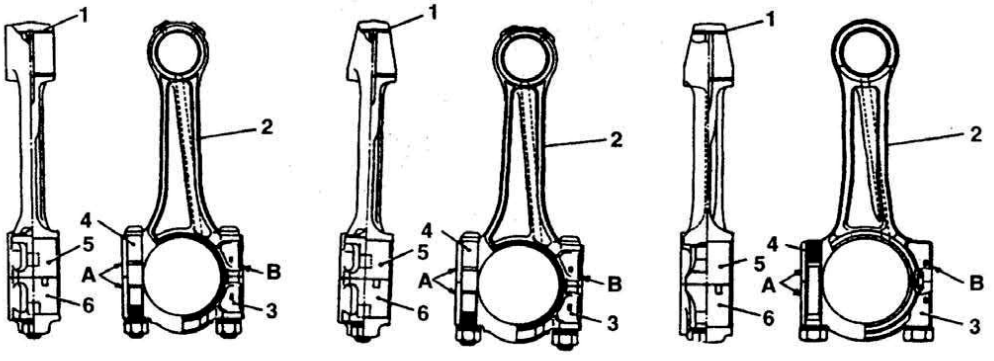


(5) Connecting Rod and Connecting Rod Bearing

The connecting rod is a die forging with an I cross section ensuring high rigidity. A lead bronze buhing 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.

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(D4AN/AF) (D4AK-T) (D4DA)

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

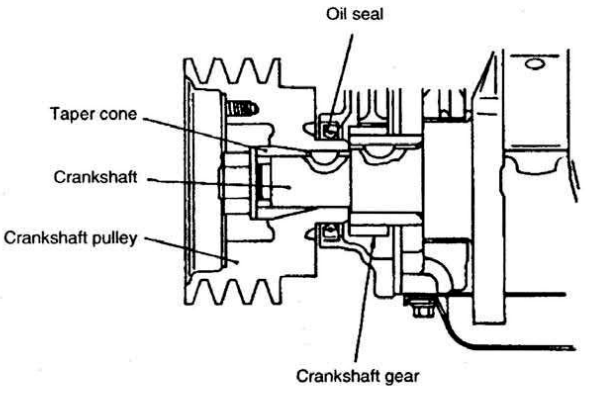
(6) Crankshaft and Main Bearing

(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.

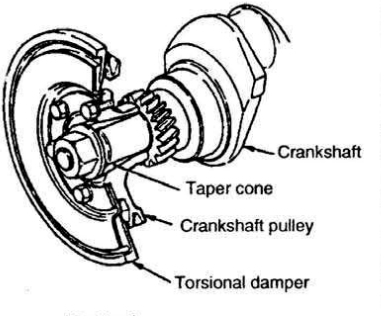
By means of oil passages drilled through the pins and journals, part of the main bearing lubricating oil is fed to pins for lubrication of the connecting rod bearing

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.



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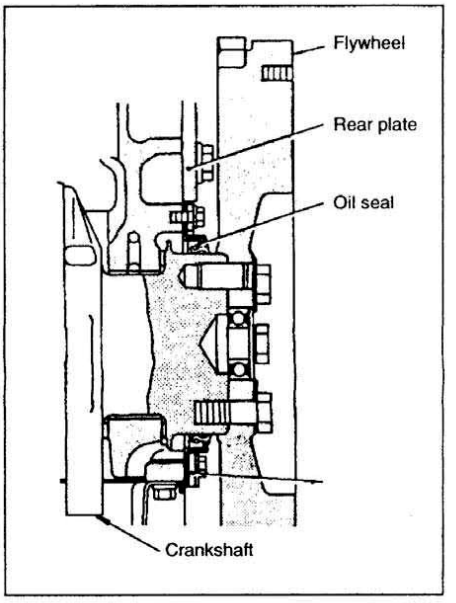
As an option a torsional damper may be installed that absorbs torsional vibration of the crankshaft.



(Option)

The flywheel is mounted in the rear of the crankshaft.

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

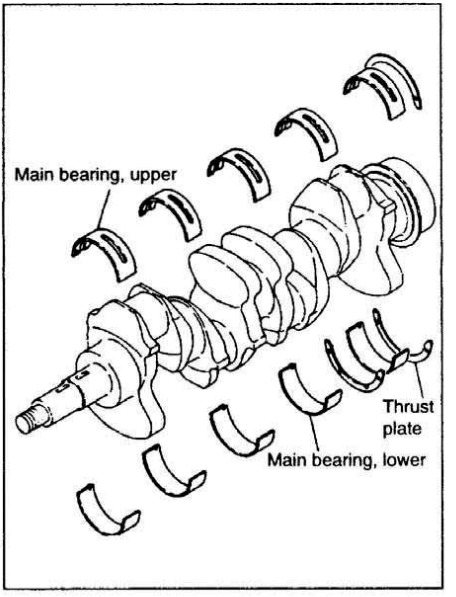


(5) Main bearing

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.



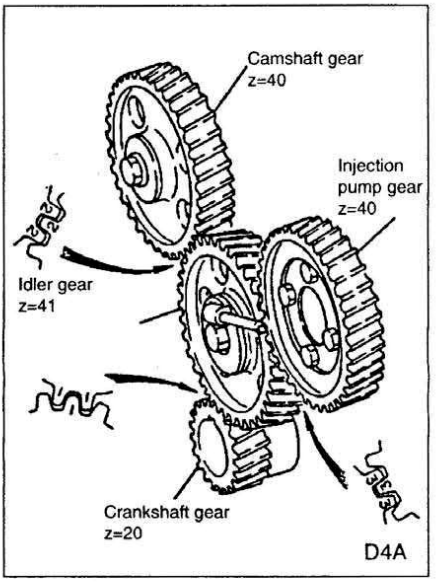
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(7) Timing Gear

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.

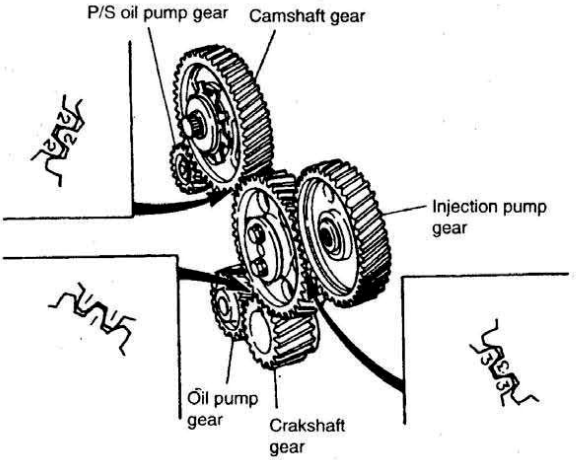
A timing mark is a stamped on each gear.
At resassembly, correct meshing can be achieved by aligning these marks.
On D4A, an oil pipe is installed in the idler shaft that is used for forced lubrication of the injection pump gear.

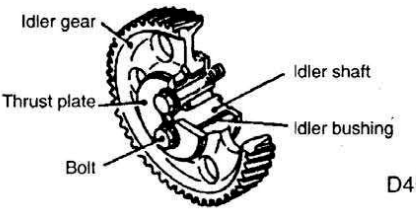


D4A

A bushing is press-fitted into the idlergear which turns on the idle shaft.
The oil hole dirlled through the idler shaft and gear provides anoil passage for lubrication of bushing and gears.

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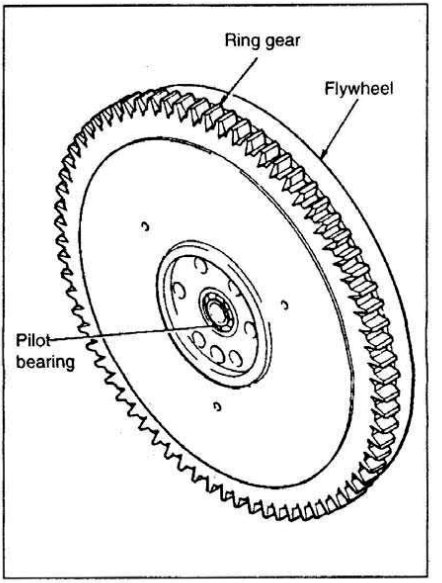
D4D

(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-heardened 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.



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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	←	←	←
Mixmum no-load engine speed rpm	Varies with specifications	←	←	←

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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/cm²)	1960 kPa (20 kgf/cm²)	Adjust. Difference between cylinder with -in 390 kPa (4 kgf/cm²)
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 sufrface runout (In installed state)	0.1 or less	0.2	Correct or replace

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Unit : mm

Description		Nominal value [Basic diameter]	Limit	Correction and remarks
Timing gear backlash	Between carnkshaft 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 bushing 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 clearance	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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Unit : mm

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

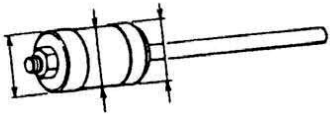
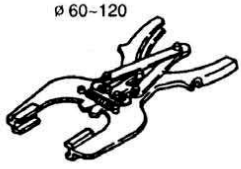
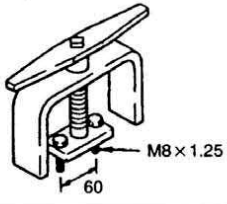
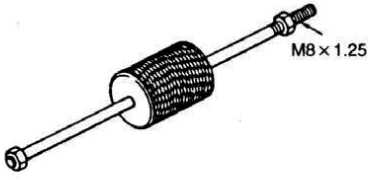
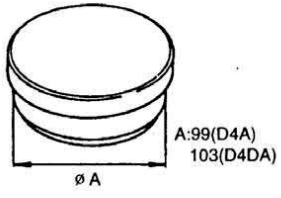
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3-2 Tightening Torque Table.

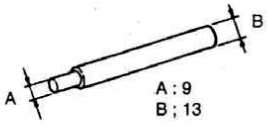
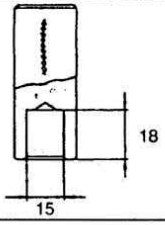
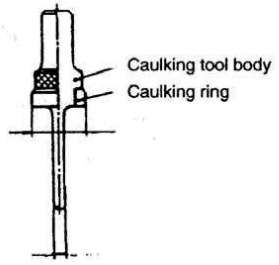
Pescription	O.D × pitch Thread size	Tightening torque k · gm	Remarks
Cylinder head bolt	M14 × 2.0	18<D4A>	Wet
		15kg · m+90° <D4DA>	
Flywheel bolt	M12 × 1.25	12.5<D4A>	Wet
	M14 × 1.5	4.0kg · m+40° <D4DA>	
Rear Plate bolt	M10 × 1.5	6	
		6.5<D4DA>	
Flywheel housing bolt	M10 × 1.5	5.6	
Idler shaft bolt	M10 × 1.5	4.5	Wet
Crankshaft pulley nut	M24 × 1.5	60	
Main bearing cap bolt	M14 × 2.0	18	
Conneeting 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	

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4. SPECIAL TOOLS

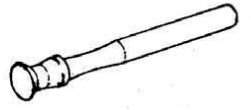
Tool name	Part number	Shape	Application
Camshaft bushing Installer and Extractor	09221-45000	 <table><tr><th></th><th>A, C</th><th>B</th></tr><tr><td>NO.1</td><td>ø 58.5</td><td>ø 54.5</td></tr><tr><td>NO.1</td><td rowspan="2">ø 58</td><td rowspan="2">ø 54.5</td></tr><tr><td>NO.1</td></tr><tr><td>NO.1</td><td>ø 57.5</td><td>ø 54</td></tr><tr><td>NO.1</td><td>ø 57</td><td>ø 53</td></tr></table>	Removal and installation of Camshaft bushing
Piston ring tools	MH060014		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

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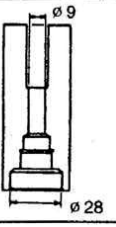
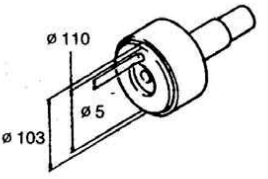
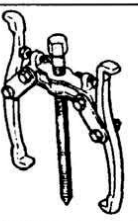
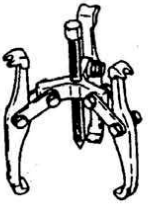
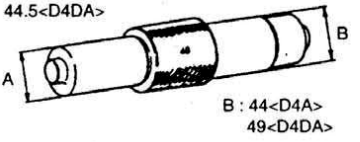
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<tr><td>Value guide remover</td><td>MH061066</td><td> 
</td><td>Removal of value guide</td></tr>
<tr><td>Value guide installer</td><td>061293</td><td> 
</td><td>Installation of valve guide</td></tr>
<tr><td>Caulking tool body</td><td>MH061067</td><td rowspan="2"> 

Caulking tool lody
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<tr><th>Part No</th><th>Demension</th></tr>
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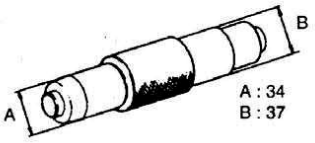
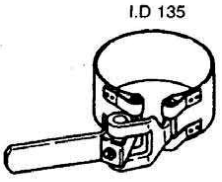
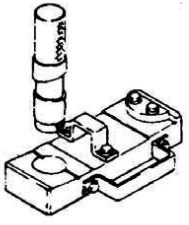
Inlet caulking ring
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Exhaust Caulking ring
<table>
<tr><th>Part No</th><th>Demension</th></tr>
<tr><td>MH061069</td><td>40.6</td></tr>
</table></td><td rowspan="2">Press-fitting of value seat</td></tr>
<tr><td>Caulking ring</td><td>MH061275
MH061069</td></tr>
<tr><td>Value lapper</td><td>30091-07500</td><td>  </td><td>Lapping of value seat</td></tr>
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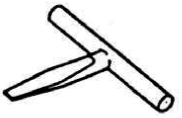
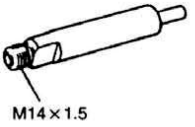
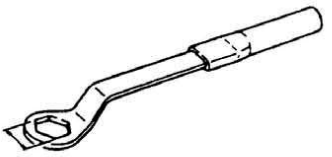
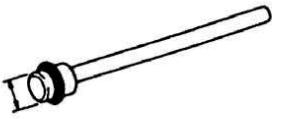
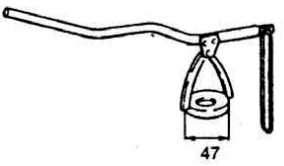
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Tool name	Part number	Shape	Application
Valve stem seal installer	09222-45200		Installation of valve stem seal
Rear oil seal shinger Installer	MH062677		Installation of Rear oil seal slinger
Gear puller	MH061061		Removal of pulley and gear
Gear puller	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

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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	<D4DA> 	Installation of cylinder head

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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

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5. SERVICE PROCEDURES

5-1 Engine Proper

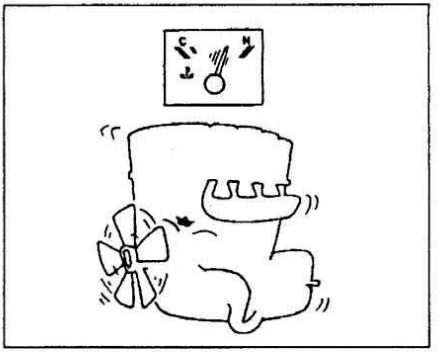
1. Measurement of Compression Pressure

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

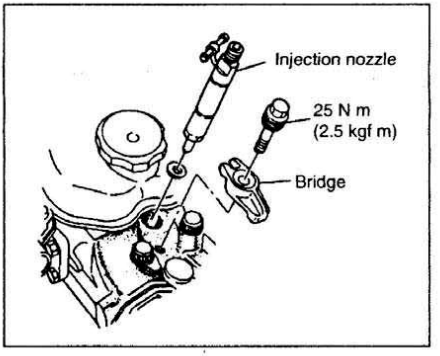
Measure the compression pressure at regular intervals and keep track of its changes. During the break-in period or after parts have been replaced with new ones, there is a slight increase in the piston rings and valve seats fit snugly in position. As rough edges and friction between parts are gradually 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℃ to 85℃.



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



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

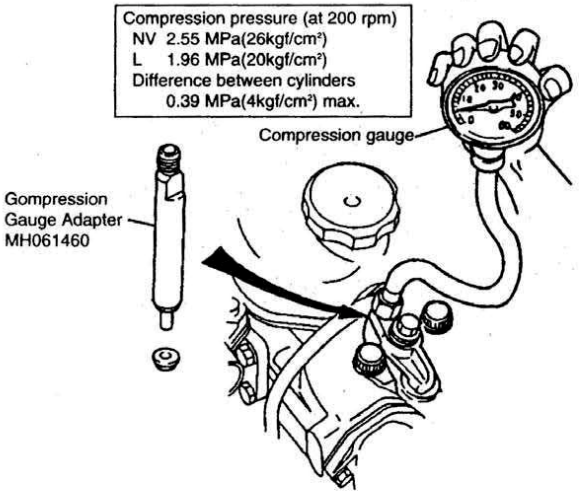
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(3) Install Compression Gauge Adaptor (special tool) on the injection nozzle hole together with a gasket and connect the compression gauge (measuring instrument).

(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 enigne 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

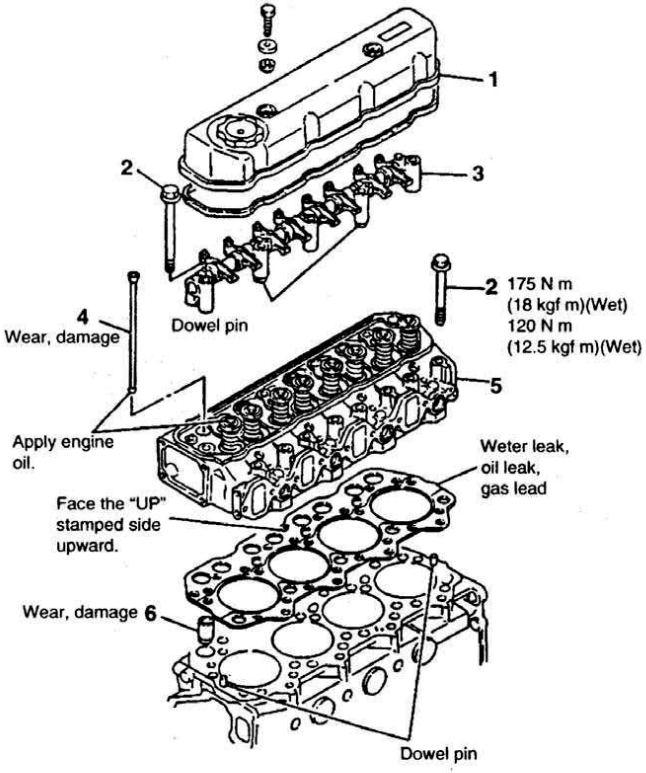
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2. Cylinder Head and Valve Mechanism

(1) Removal and Installation

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

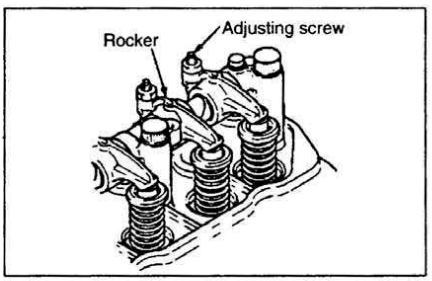
1 Rocker cover
2 Cylinder head bolt
③ Rocker and bracket assembly
4 Push rod
5 Cylinder head assembly
⑥ Tappet



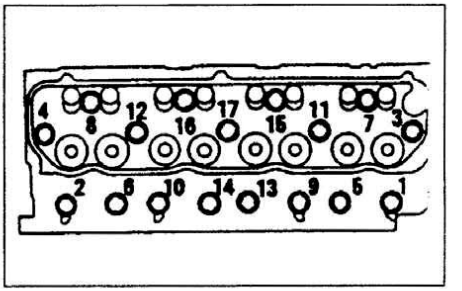
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Removal Procedure

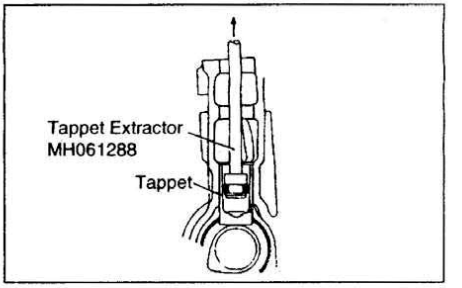
(a) Where the push rod is forcing up the rocker, the rocker adjusting screw must be loosened before all cylinder head bolts are removed.



(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.

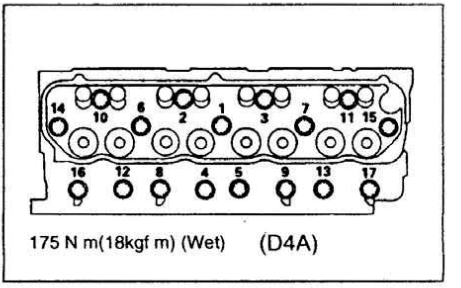


(e) Removal of the tappet
Remove the tappet, using Tappet Extractor(special tool). For removal, press the special tool until its O-ring is pressed tightly against each other and remove the tappet together with the special tool.

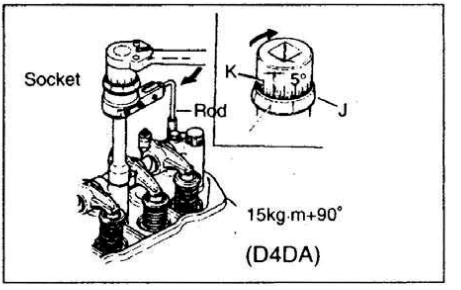


Installation Procedure

<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.



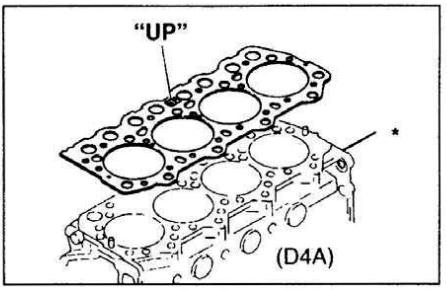
<D4DA>
(a) Set the socket such that the built-in spring force forces rod against the rocker shaft bracket, and injection pipe, or another nearby part.
(b) On holder, select inscribed line J that is easiest to see.
(c) Using the selected line as a reference, turn socket 90° clockwise.
(One gradation on 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.

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Cylinder head gasket



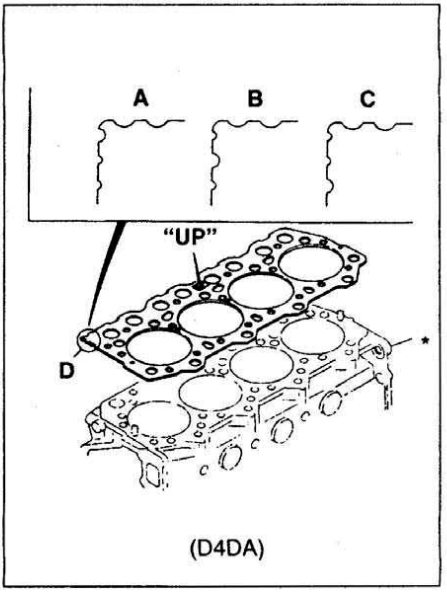
[Removal]

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 accomodate the poston 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 lager 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	
	Szie Classification	Thickness when tightening
0.546 to 0.610	A	1.35±0.03
0.610 to 0.674	B	1.40±0.03
0.674 to 0.738	C	1.45±0.03

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- 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.

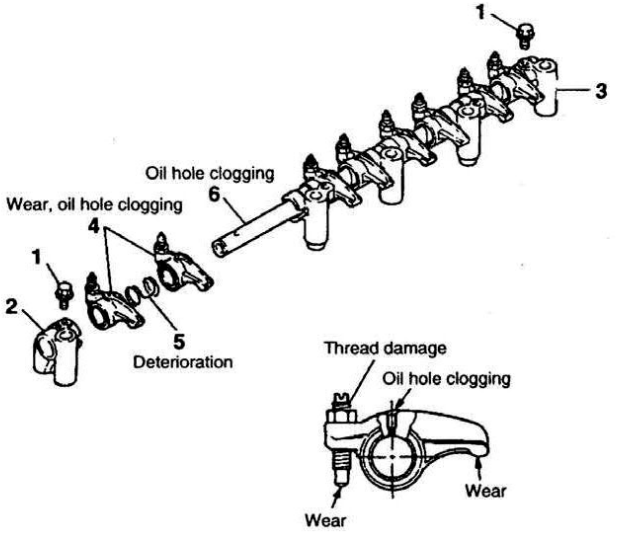
NOTE:

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

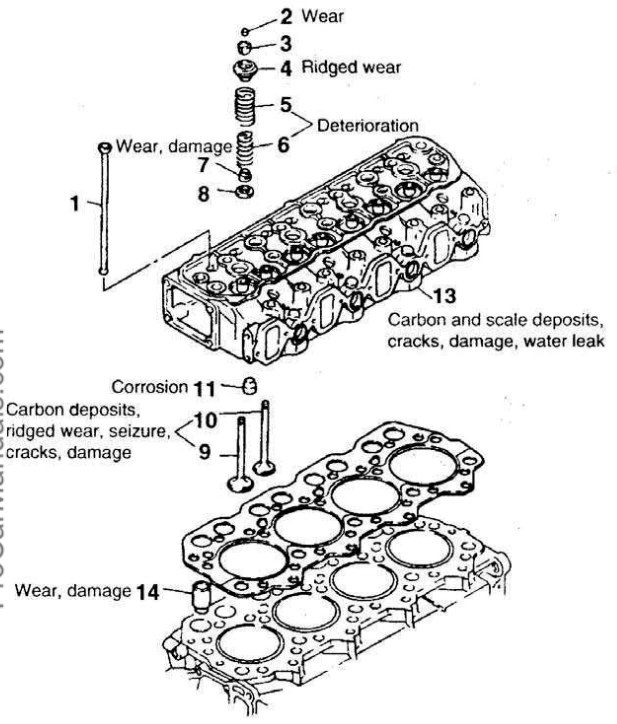


<Disassembly sequence>

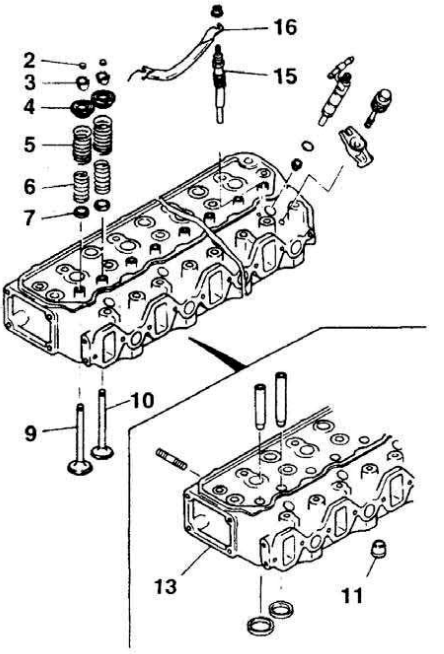
1 Set bolt
2 Front rocker shaft bracket
3 Rear rocker shaft bracket
4 Rocker ASS'Y
5 Rocker shaft spring
6 Rocker shaft

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(b) Cylinder head assembly



D4A



D4AF(Fork Lift)
D4DA

<Disassembly seequence>

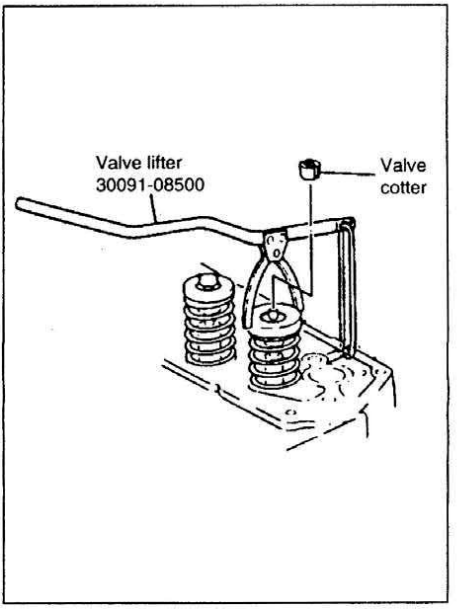
1	Push rod	6	Inner valve spring	⑪	Water director
2	Valve cap	⑦	Valve stem seal	13	Cylinder head
③	Valve cotter	8	Lower retainer	14	Tappet
4	Upper retainer	9	Inlet valve	15	Glow plug
5	Outer valve spring	10	Exhaust valve	16	Connecting plate

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

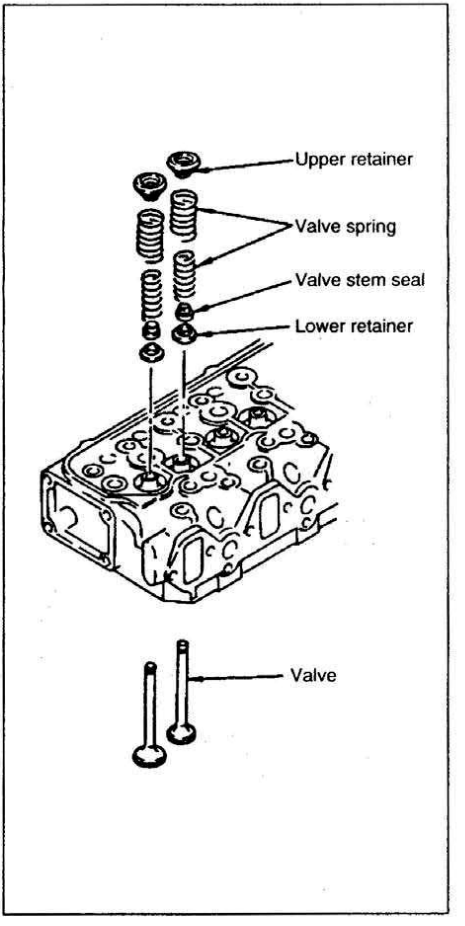
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1) To remove the valve cotter, use Valve Lifter(special tool) and compress evenly the valve spring.

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.

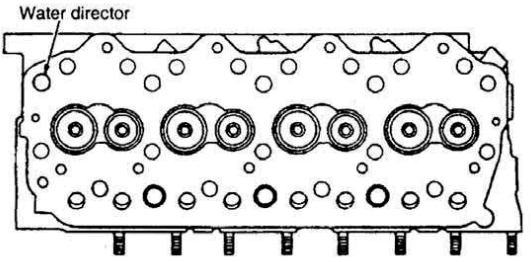


2) Whenever the valve stem seal or valve is removed, the valve stem seal must be replaced with a new one.



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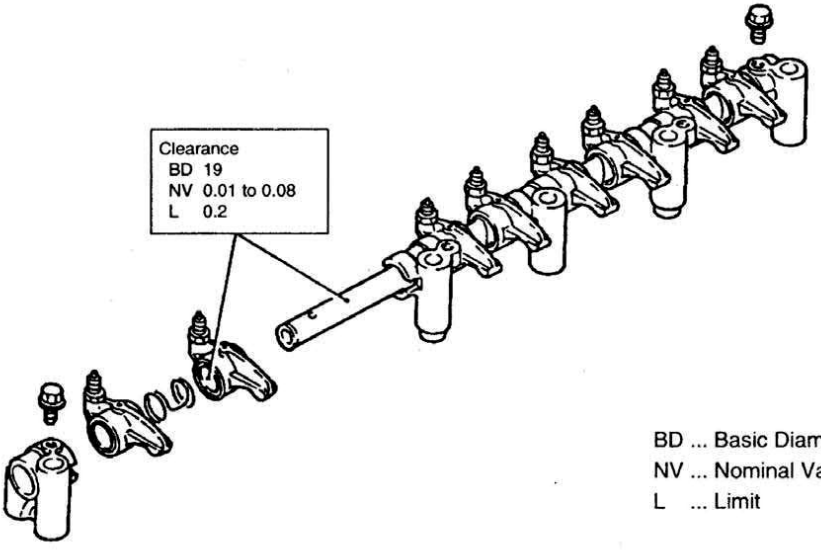
3) Remove the water director if corroded.



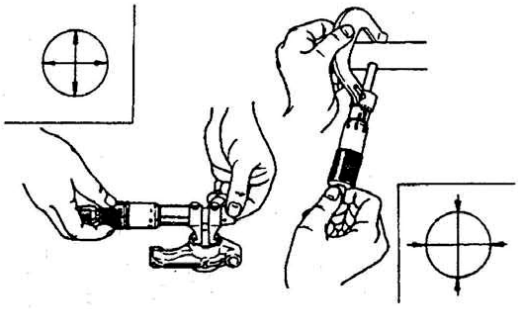
(3) Inspection

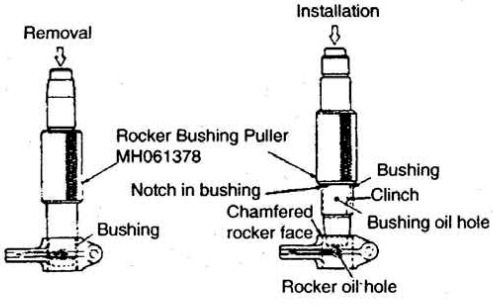
(a) Rocker and bracket assembly

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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.



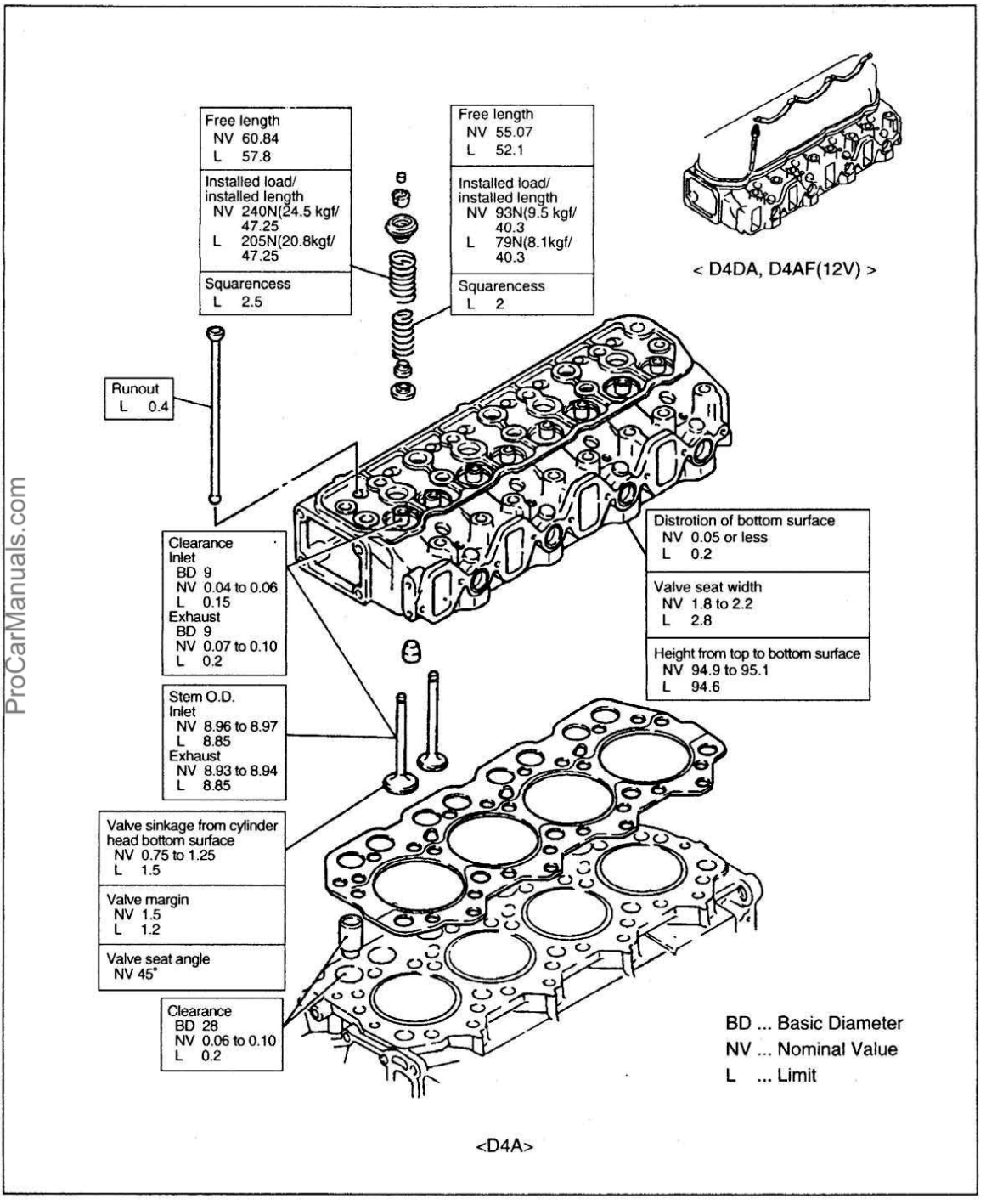


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NOTE:

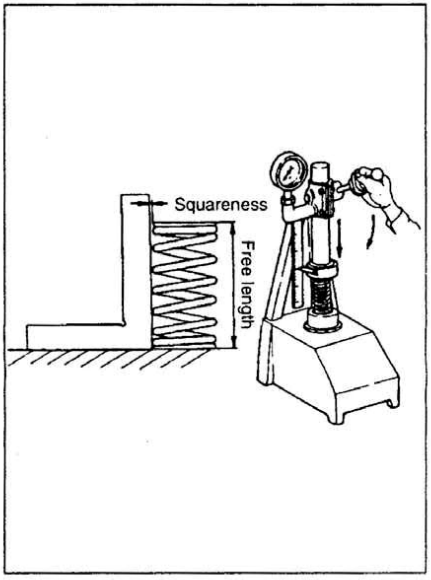
1. **Align the oil hole in the bushing with that in the rocker.**
2. **Ensure that the bushing clinch is on the adjusting screw end.**
3. **When press-fitting the bushing into rocker, start with the chamfered side on the rocker.**

(b) Cylinder head assembly

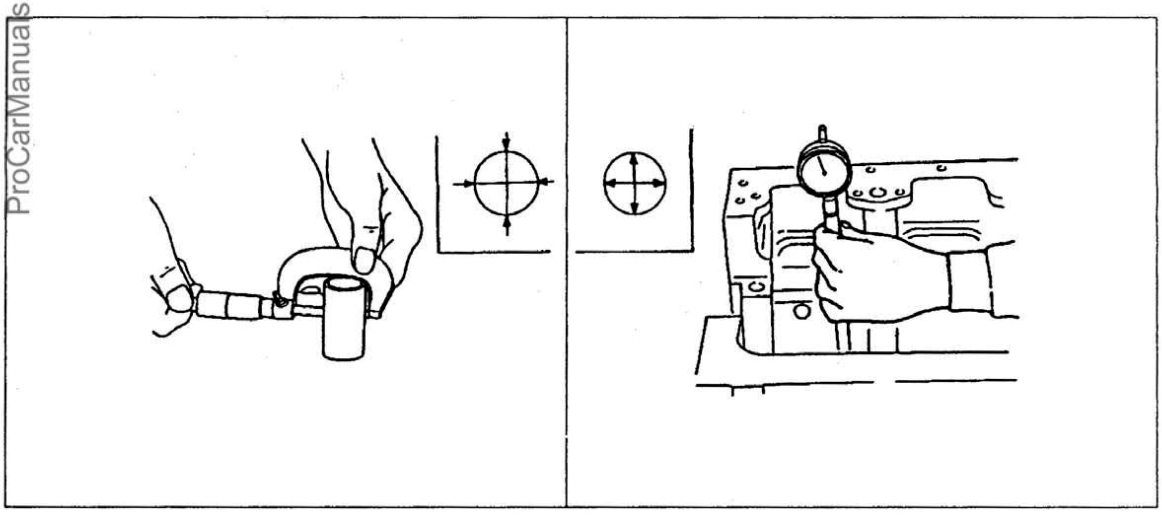


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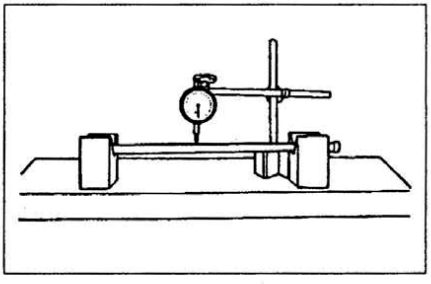
1) Inspection of valve spring
Check the valve spring for squareness, free length, and proper tension, and replace if the limit is exceeded.



2) Tappet to crankcase clearance
If the measured valve in higher than the limit, replace the faulty parts.



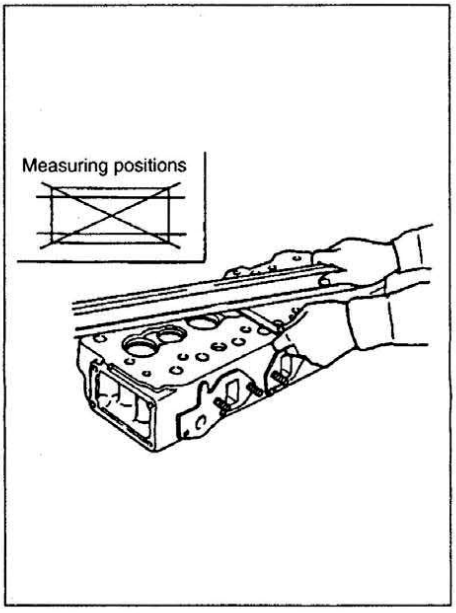
3) Measure the push rod run out.
If the limit is exceeded, replace.



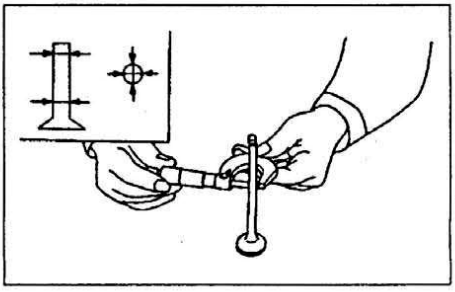
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4) Cylinder head bottom surface distortion
If the limit is exceeded, correct with a surface grinder.
If the cylinder head height from top to bottom surface is below the limit, replace.

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

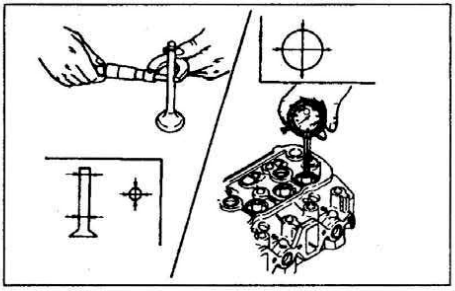


5) Inlet and exhaust valves
Measure the valve stem O.D. and, if the measurement is below the limit, replace.

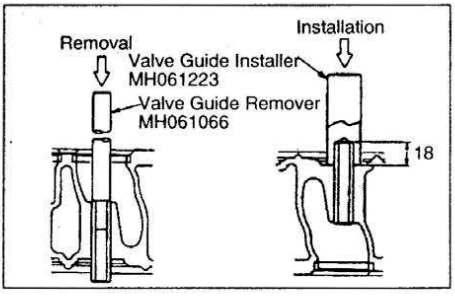


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6) Valves and value guides
Calculate the clearance with the valve guide I.D.
If the limit is exceeded, replace the valve guide.



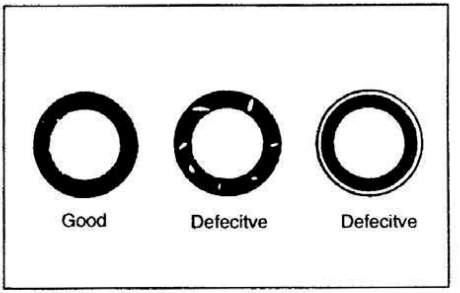
7) Replacement of valve guide
For removal of the valve guide, use the Valve Guide Remover(special tool).
To install, use Valve Guide Installer(special tool) and ensure that the special tool is positively seated on the cylinder head. The pressing force is specified for the valve guide, which must be reached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



8) Inspection of valve

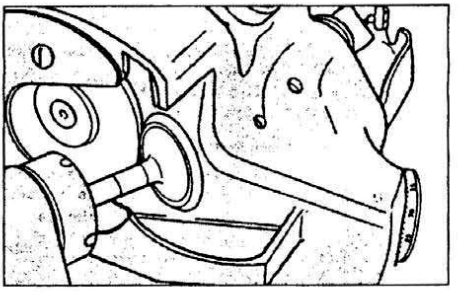
Check the contacting condition of the valve seat and valve, after inspection and replacement of the valve guide.

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.



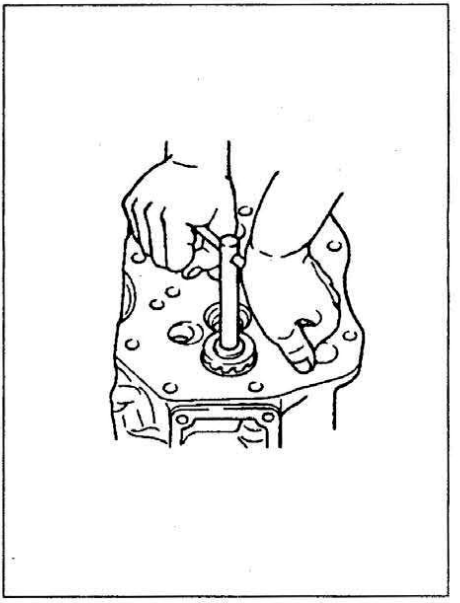
NOTE:

1. **The valve seat angle is 45° .**
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.

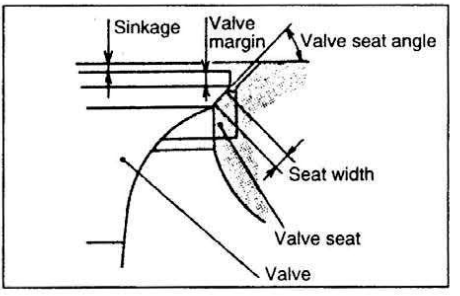


NOTE:

1. **The valve seat angle is 45° .**
2. **Correction must be made to ensure the valve seat width and valve sinkage are within the limit.**

c) Using a 15° or 75° cutter, correct the seat width to the nominal value.

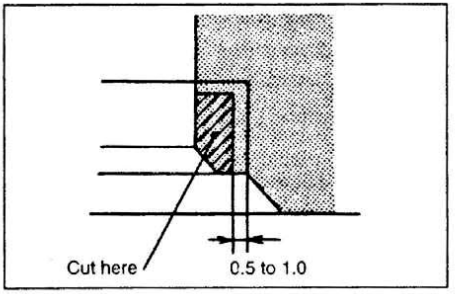
d) Seat the valve and valve seat. [See fig]



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11) Replacement of valve seat
The valve seat is cold fitted.
Replacement procedure is given below.

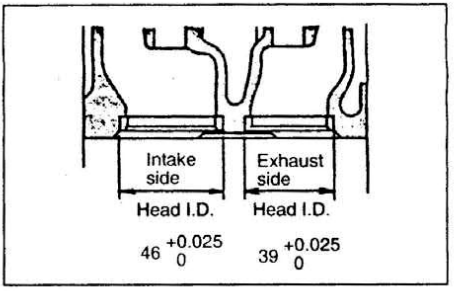
a) Grind the valve seat from inside to reduce the wall thickness.
Then, remove it at normal temperature.



(Installation)

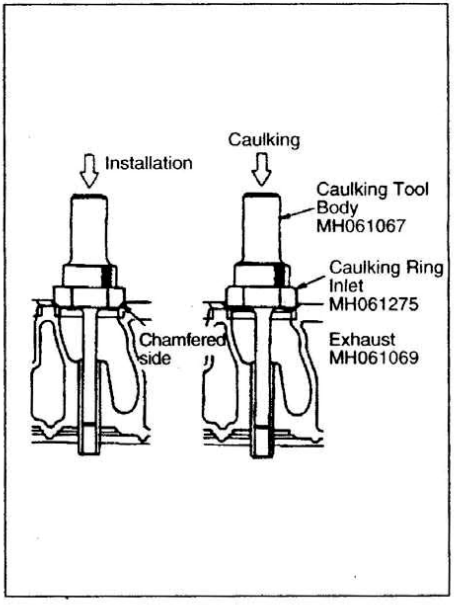
b) Check if there is sufficient interference between the cylinder head and valve seat.

c) Dip the valve seat into liquid nitrogen and let it cool down.
But heat the cylinder head sufficiently.

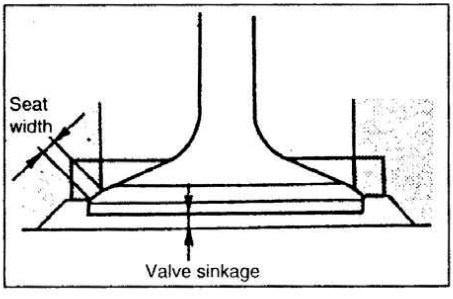


d) Using Caulking Tool Body and Caulking Ring(special tools), install the valve seat.

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.



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12) Seating of valve and valve seat

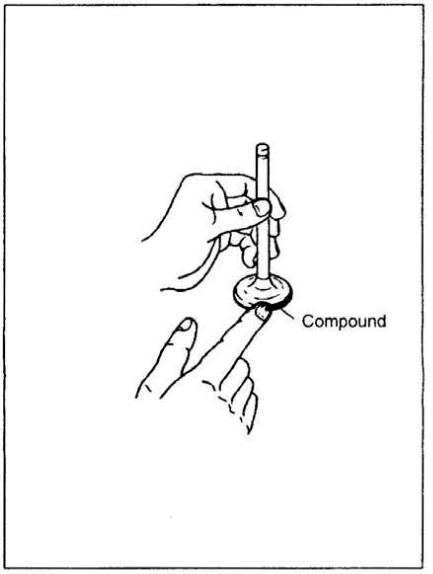
The valve and valve seat must be in even contact throughout the surfaces.

Whenever the valve or valve seat is corrected or replaced, they must bo 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.**

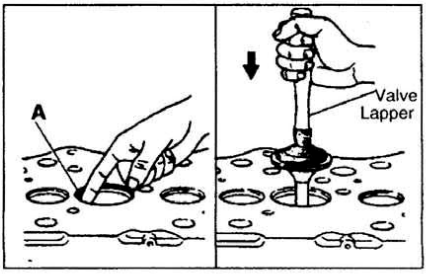


b) Using Valve lapper(special tool), seat the valve on valve seat. ('A' Surpace)
While turning the valve slightly at a time, strike it against the valve seat.

c) Wash off the compound with gas oil or similar object.

d) Seat the contact surfaces with engine oil.

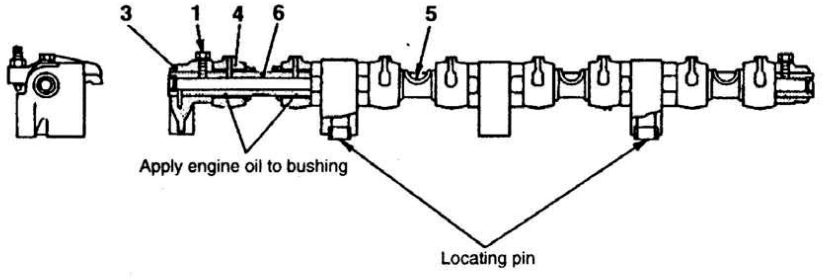
e) Seat the contact surfaces with engine oil.



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(4) Reassembly

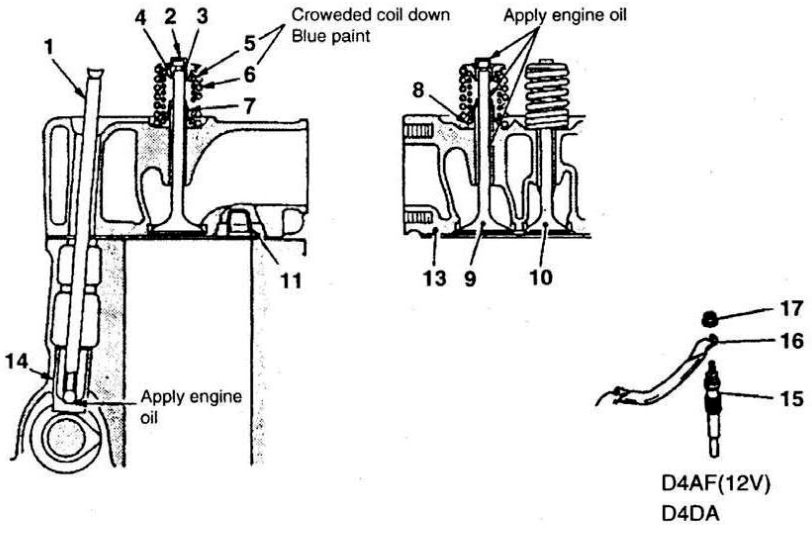
(a) Rocker and bracket assembly



<Assembly sequence>

6→3→4→5→1

(b) Cylinder head assembly

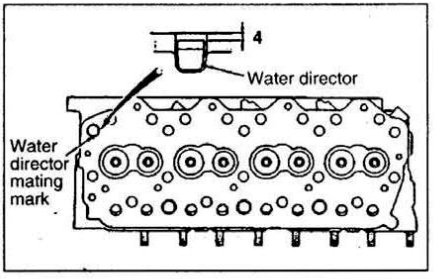


<Assembly sequence>

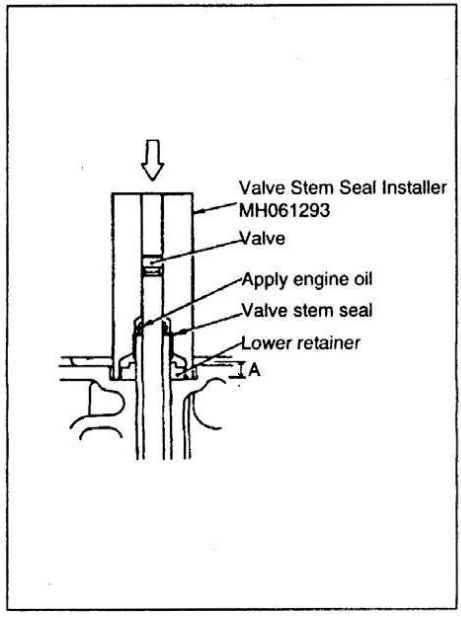
14→13→⑪→10→9→8→⑦→6→5→4→③→2→1→15→16→17

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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.

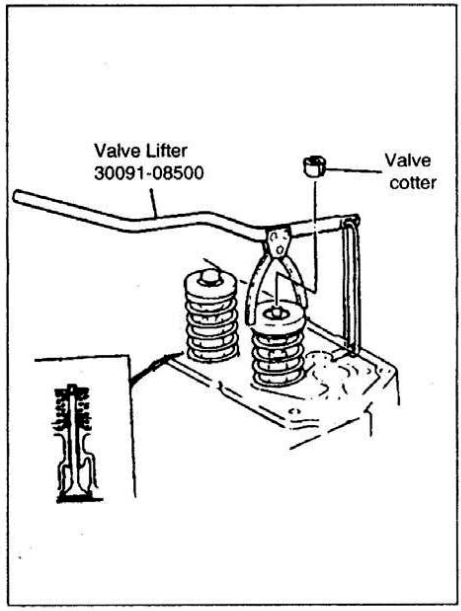


NOTE:

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.



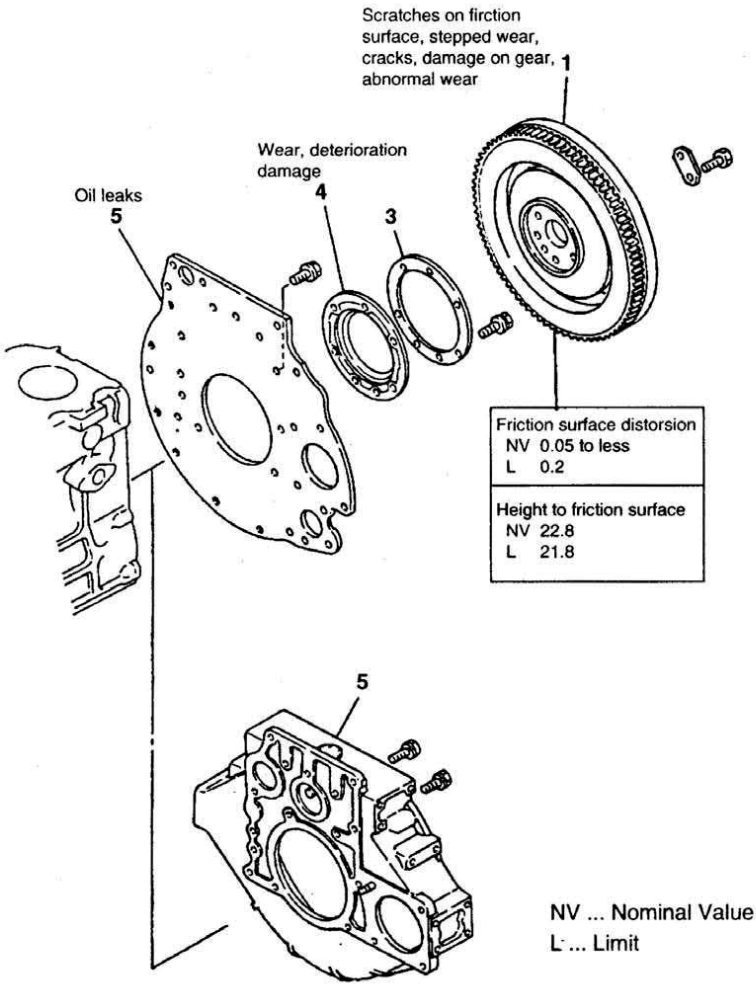
NOTE:

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.

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3. Flywheel and Rear plate

(1) Disassembly and Inspection



NV ... Nominal Value
L ... Limit

<Disassembly sequence>

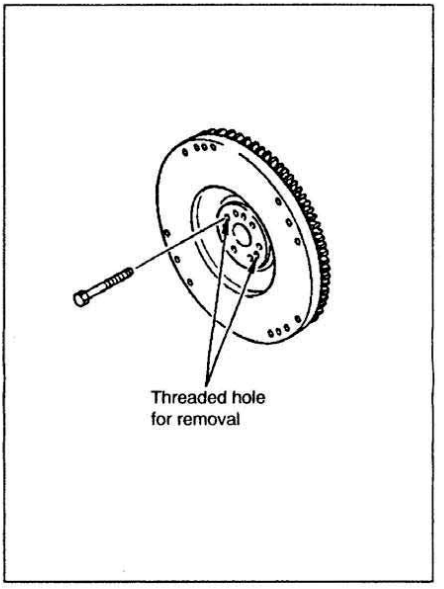
① Flywheel
3. Washer plate
4. Oil seal
5. Real plate or flywheel housing

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

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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.

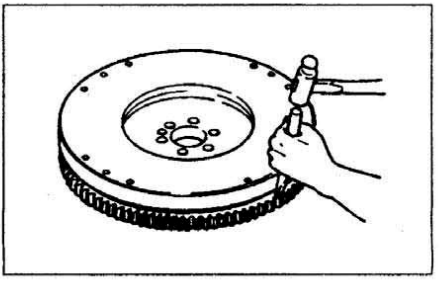


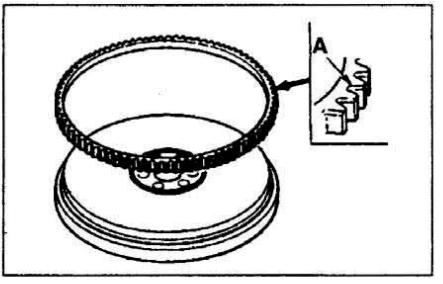
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Inspection Procedure

(a) Replacement of ring gear
1) Inspection
Inspectring 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℃) for three minutes.
Fit the ring gear onto the flywheel with the nonchamfered side of tooth crests toward the flywheel.

NOTE : Be carful not to get burned.



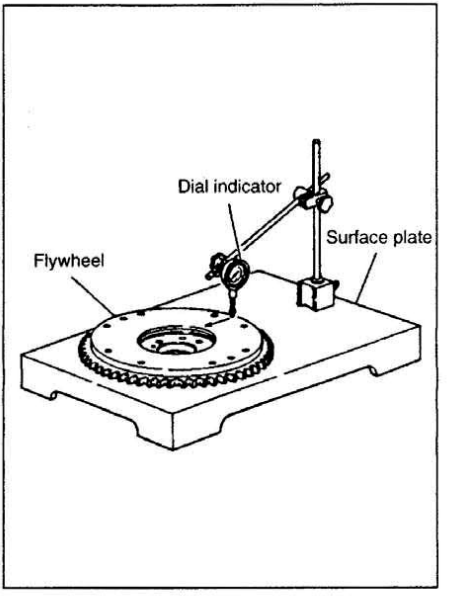


(b) Friction surface distortion

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.

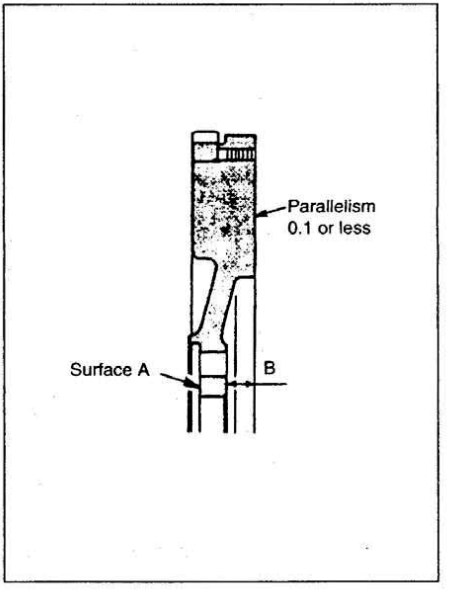


NOTE:

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.

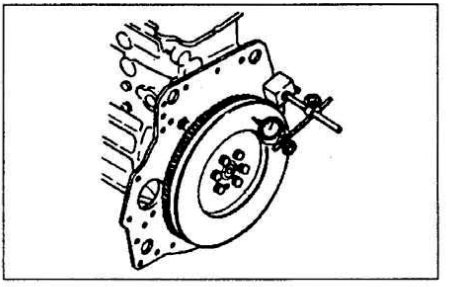


NOTE:

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

(d) Inspection of runout.

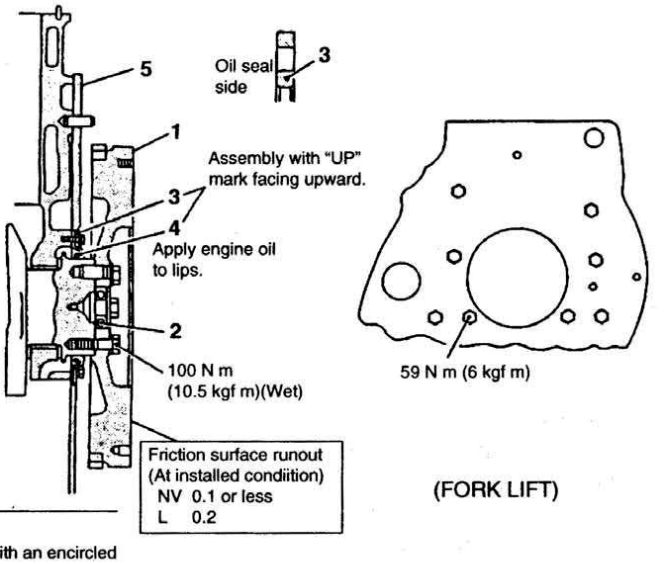
If runout exceeds the specified limit, check that bolts are tightened correctly and inspect the crankshaft mounting surface. Then, rectify or replace flywheel assembly as required.



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(2) Reassembly

<Rear plate type>



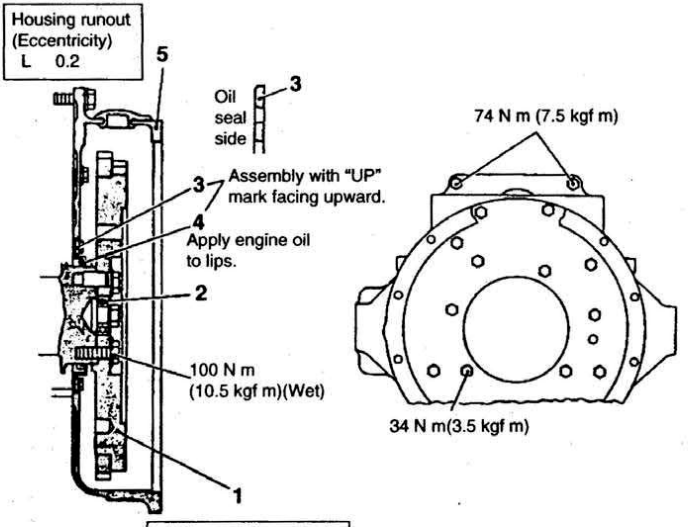
NV ... Nominal Value
L ... Limit

(FORK LIFT)

<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

(GENERATOR, MARINE)

<Assembly sequence>

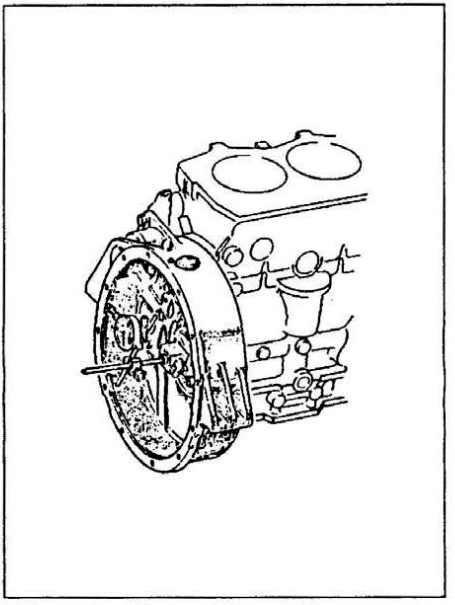
5→④→③→2→1
For reassembly of parts with an encircled number, see following items.

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(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.

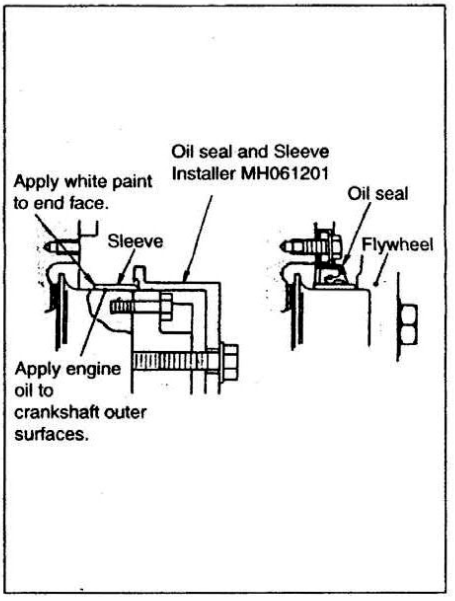


(b) Installation of oversize oil seal

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

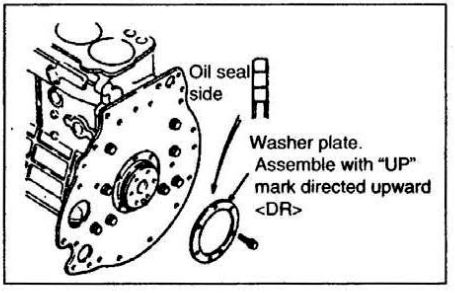
To install the sleeve, sue oil seal and Sleeve Installer(special tool). The pressed position of the sleeve is datermined where the flywheel is installed.

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.



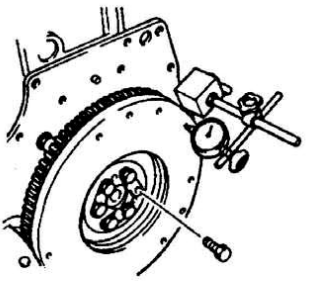
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(d) Installation of flywheel

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.

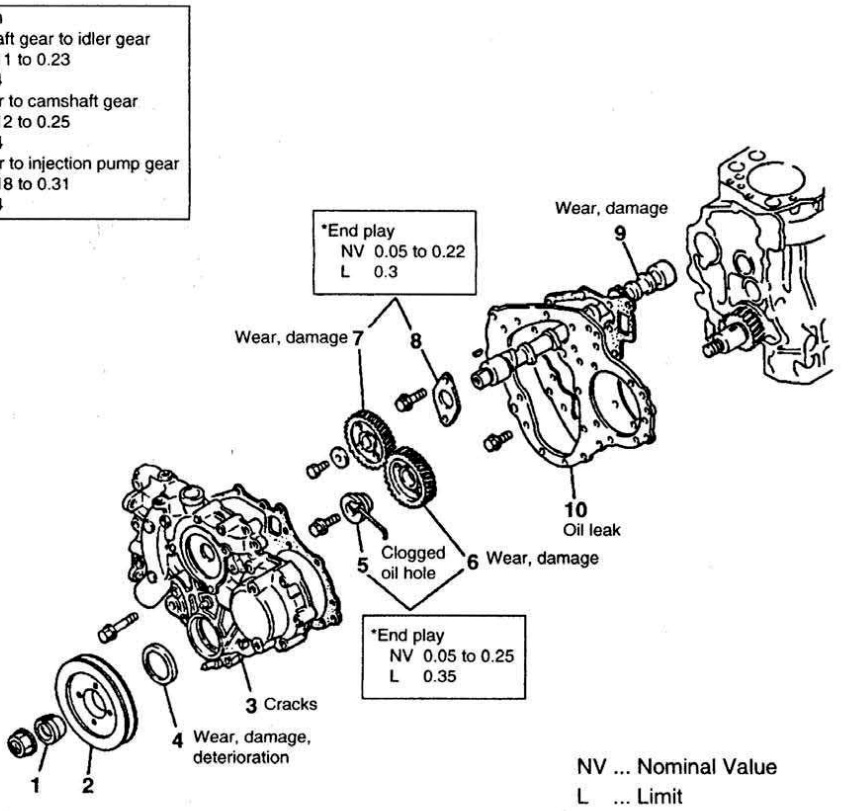


D4A:100 N m
(10.5 kgf m)(Wet)
D4DA:18kgf.m(Wet)

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4. Timing Gear and Camshaft

(1) Disassembly (D4A)



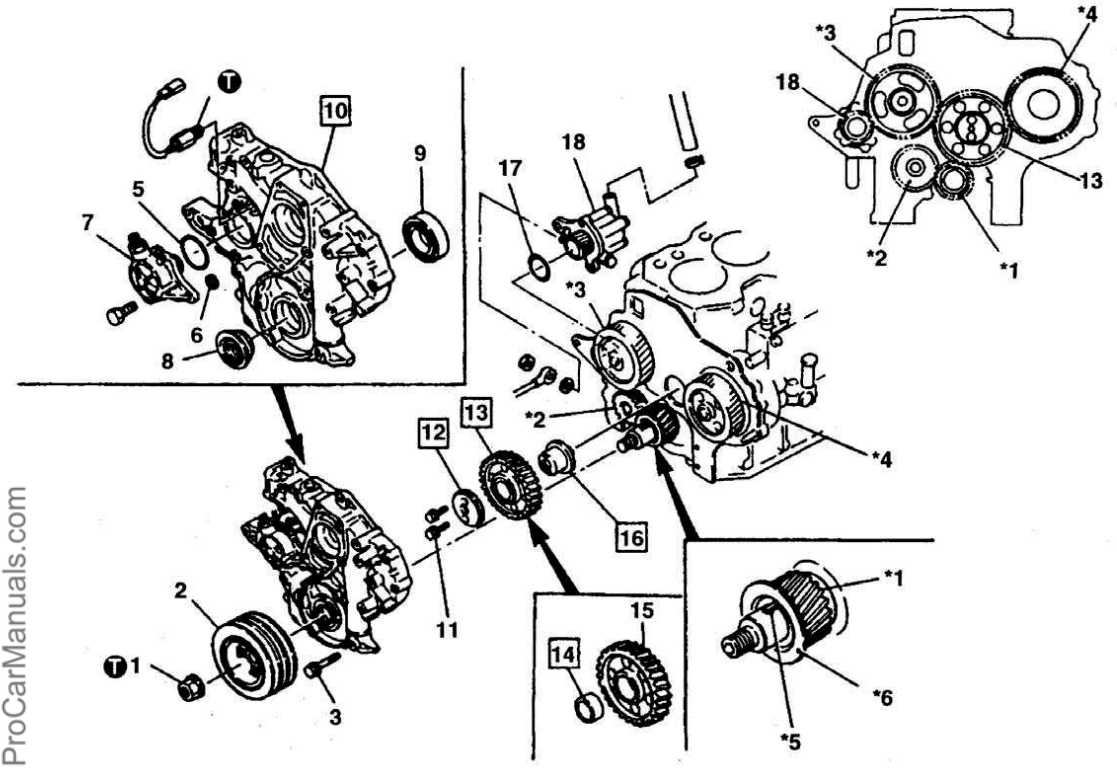
<Disassembly sequence>

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

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<D4DA>



<Disassembly sequence>

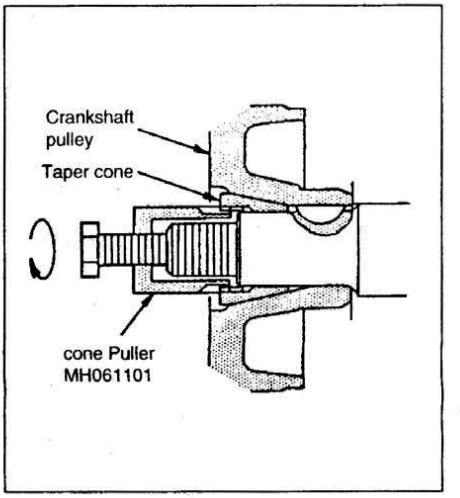
1 Nut
2 Crankshaft pully
3 Bolt
4 Engine revolutiion sensor
5 O-ring
6 O-ring
7 Vacuum pump assembly
8 Front oil seal
9 Bearing
10 Timiing gear case
11 Bolt
12 Thrust plate
13 Idler gear assembly
14 Idler gear bushing
15 Idler gear
16 Idler shaft
17 O-ring
18 Power steering oil pump

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

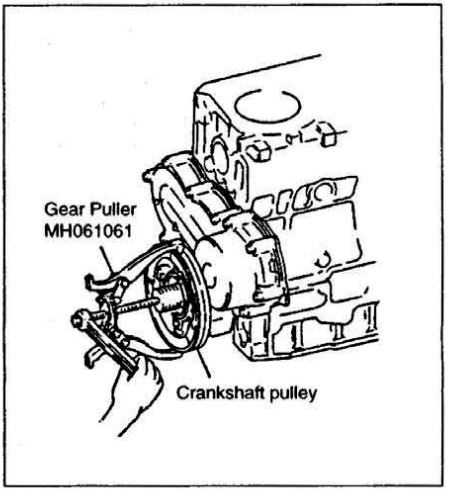
NOTE : Do not remove front oil seal 8 and bearing 9 unless they are faulty.

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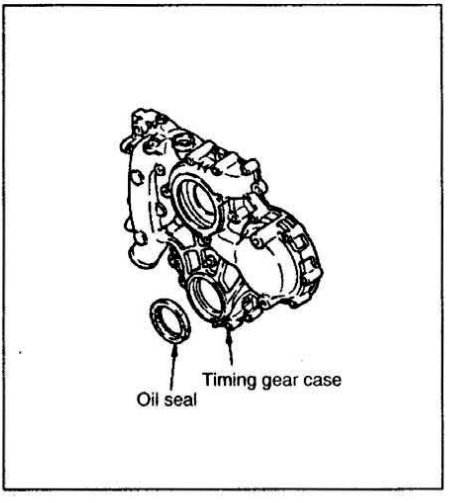
(a) Remove of taper cone
To remove, use Cone Puller (special tool).



(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.

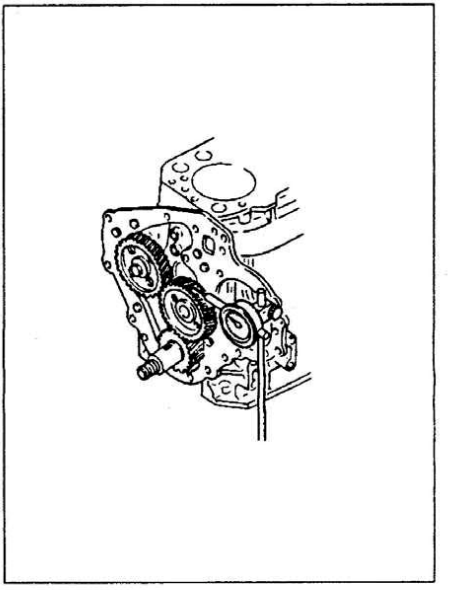


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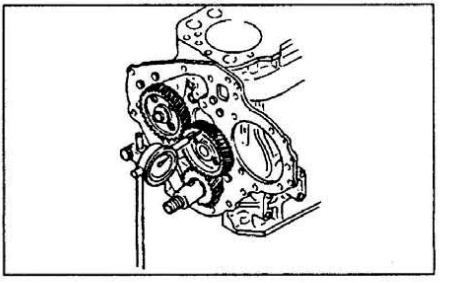
(d) Measurement of backlash
Measure the backlash between gears and replace if the limit is exceeded.

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.**



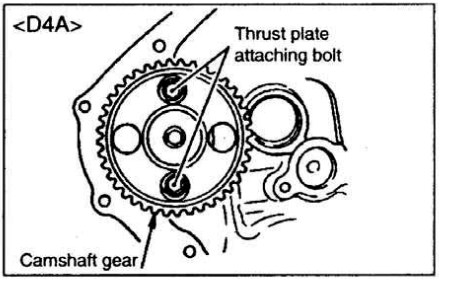
(e) Measurement of end play
Measure the end play of the idler gear and camshaft with a thickness gauge or dial indicator.
If the measurements exceed the limit, replace the parts.

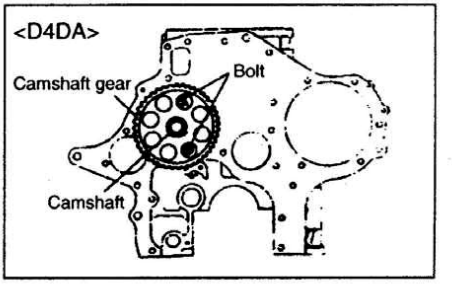


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(f) Removal of camshaft gear
1) Accessing through the holes in camshaft gear, loosen the thrust plate attaching bolts.
Then, remove the gear together with the camshaft.

NOTE:
Turn the crankcase upside down before removing the camshaft.

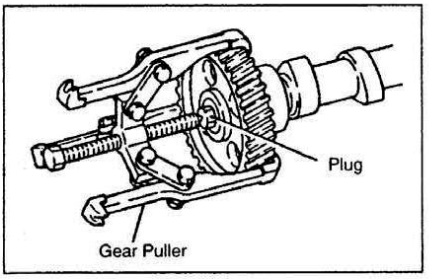




2) To remove, use Gear Puller(special tool).

NOTE:

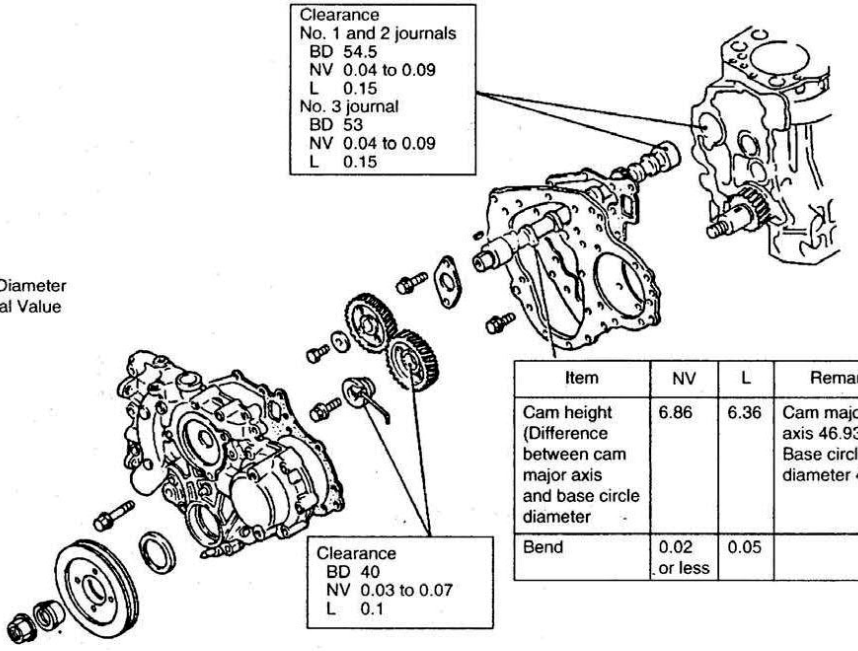
1. **Do not remove the gear unless defect is evident.**
2. **For removal, never attempt to tap the gear with a hammer.**



(2) Inspection

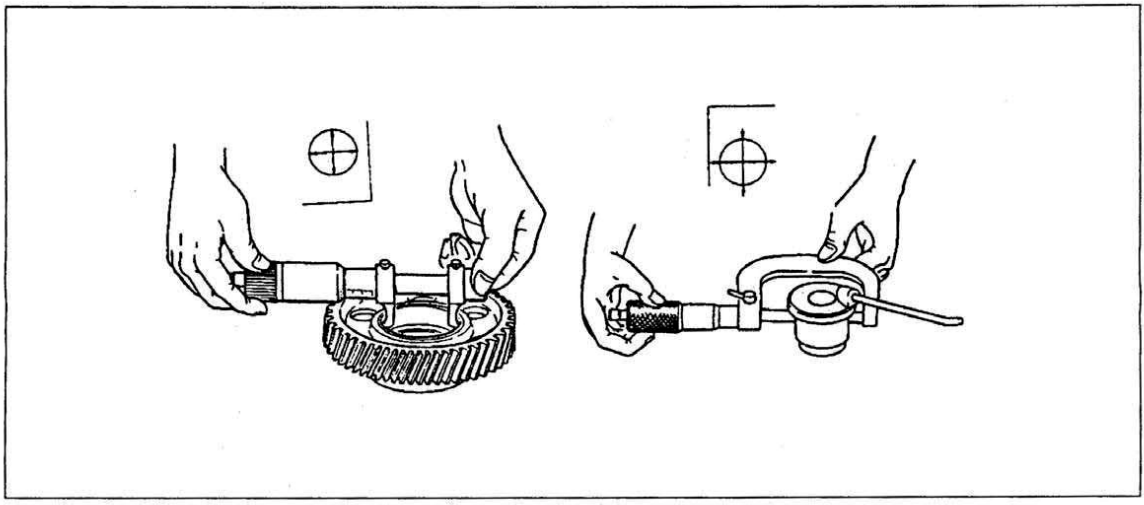
<D4A>

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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	

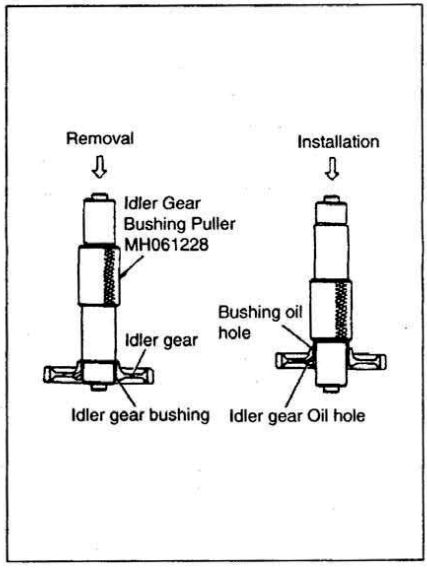
(a) With the idler gear I.D. and idler shaft O.D., calculate the clearance. If the limit is exceeded, replace the bushing in the idler gear.



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

NOTE:

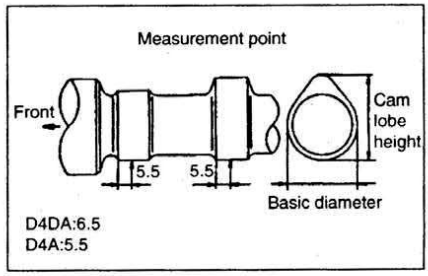
1. **When installing the bushing, align the oil hole in bushing with that in idler gear.**
2. **After installation, make sure that the bushing to idler shaft clearance is within nominal value.**
   If the clearance is below specification, ream the bushing.



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

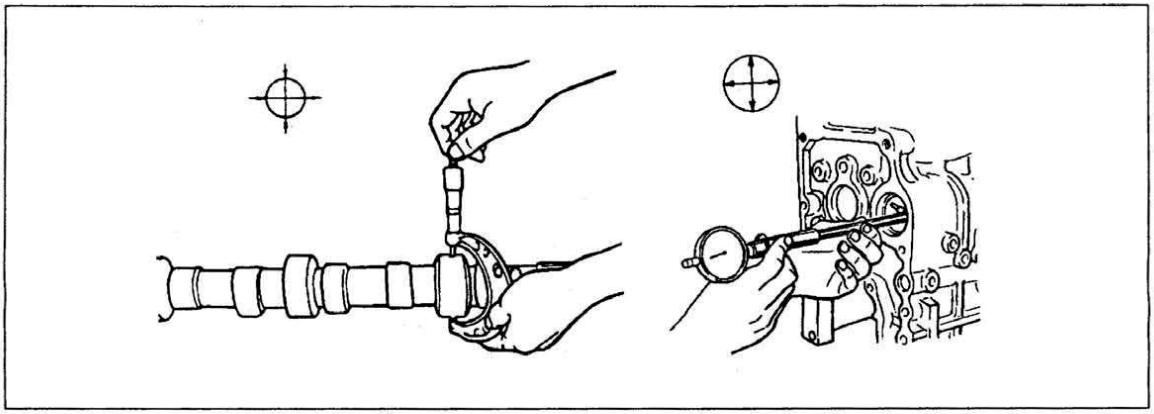
NOTE:

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



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

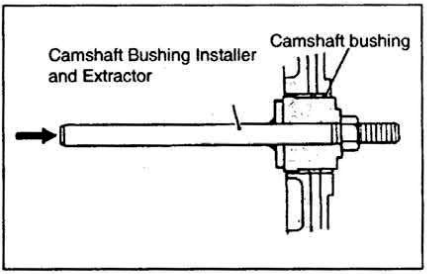


(e) Replacement of camshaft bushing

1) Removal

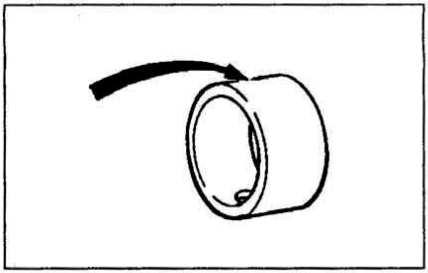
Remove the sealing cap through the camshaft hole in the rear-end face of the crankcase.

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

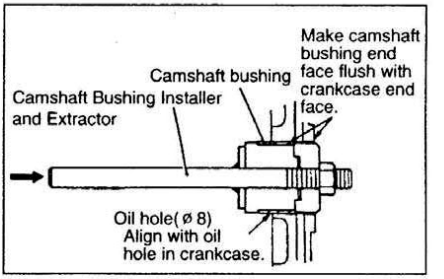
(D4A)

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

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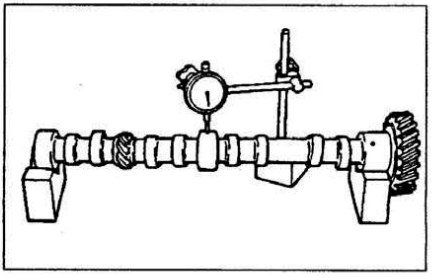
Then, using Camshaft Bushing Installer and Extractor(special tool), press-fit the bushings.

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

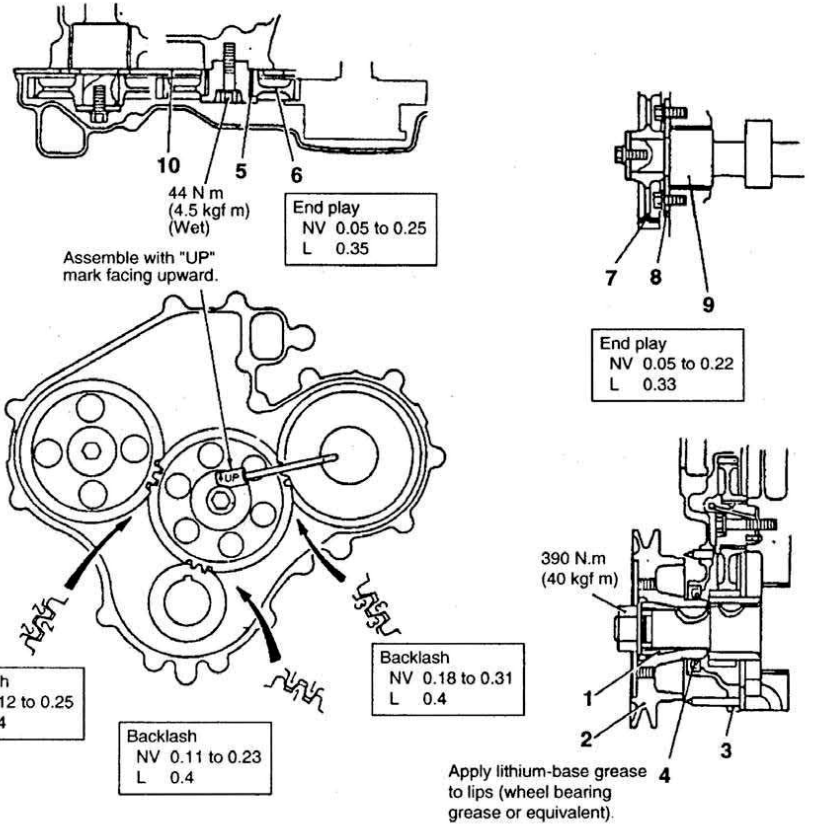
(f) Measure the bend of camshaft. If the limit is exceeded, correct with a press or replace.



NOTE:
Rotate the camshaft a turn and read the deflection of the dial indicator pointer.
One half of the reading is the bend.

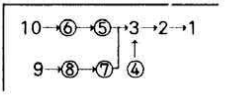
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(3) Reassembly



NV...Nominal Value
L...Limit

<Assembly sequence>



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(a) Installation of camshaft gear

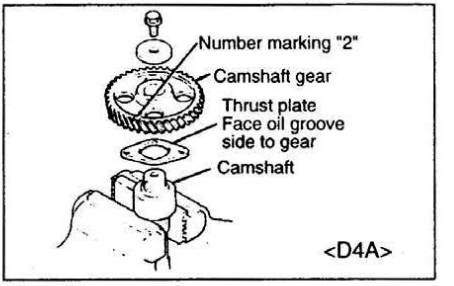
<D4A>

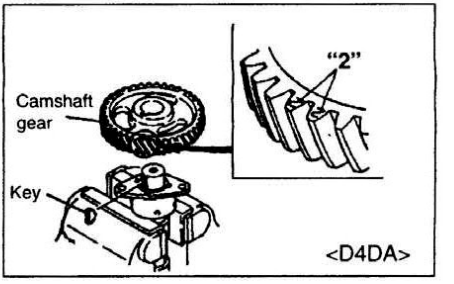
After mounting the thrust plate, install the camshaft gear with its number marking side facing outward.

<D4DA>

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

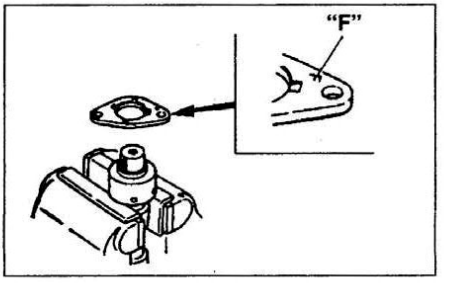
Do not forget to fit key



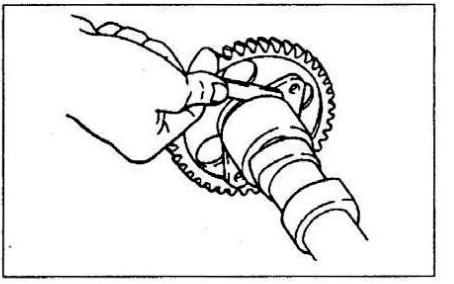


(b) Installation of thrust plate

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



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



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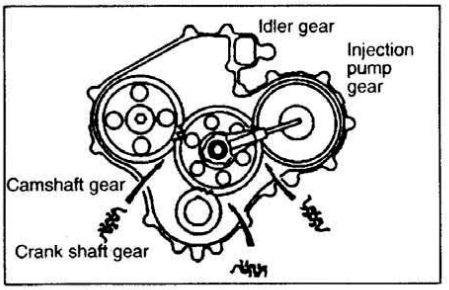
(d) Installation of idler gear

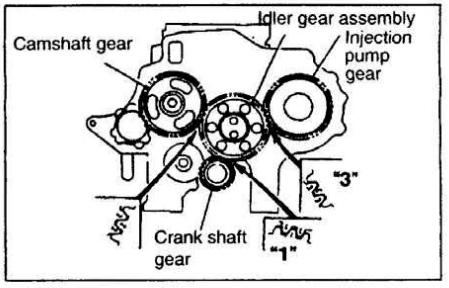
1) <D4A>

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

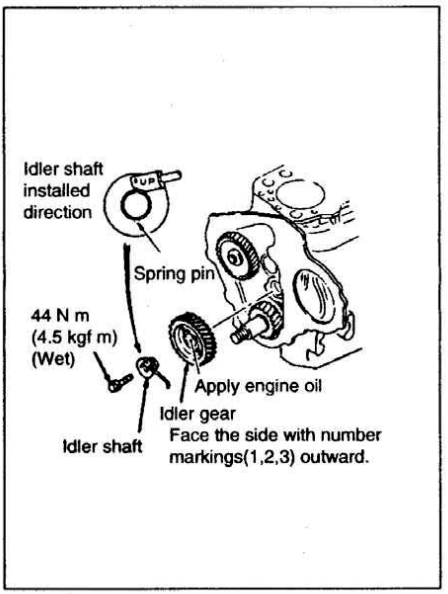
2) <D4DA>

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.



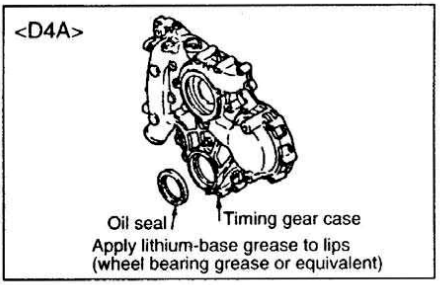


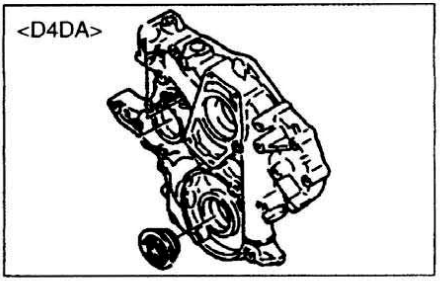
3) Make also sure that the idler shaft spring pin rests in the crankcase oil groove and the "UP" mark with an arrow on the shaft faces upward.



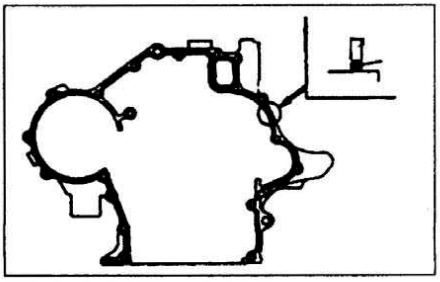
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(d) Check gears for backlash
(e) Apply lithium-base grease to the oil seal lips.





(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.



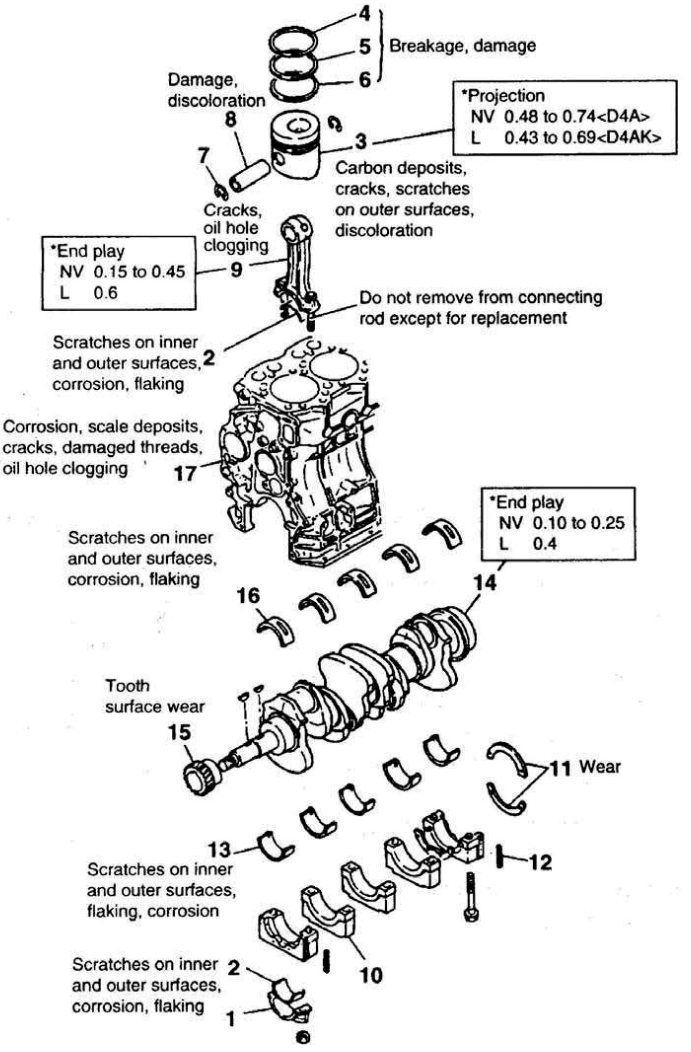
NOTE:

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.**

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Crankcase and Main Moving Parts

<D4A>



NV...Nominal Value
L...Limit

<Disassembly sequence>

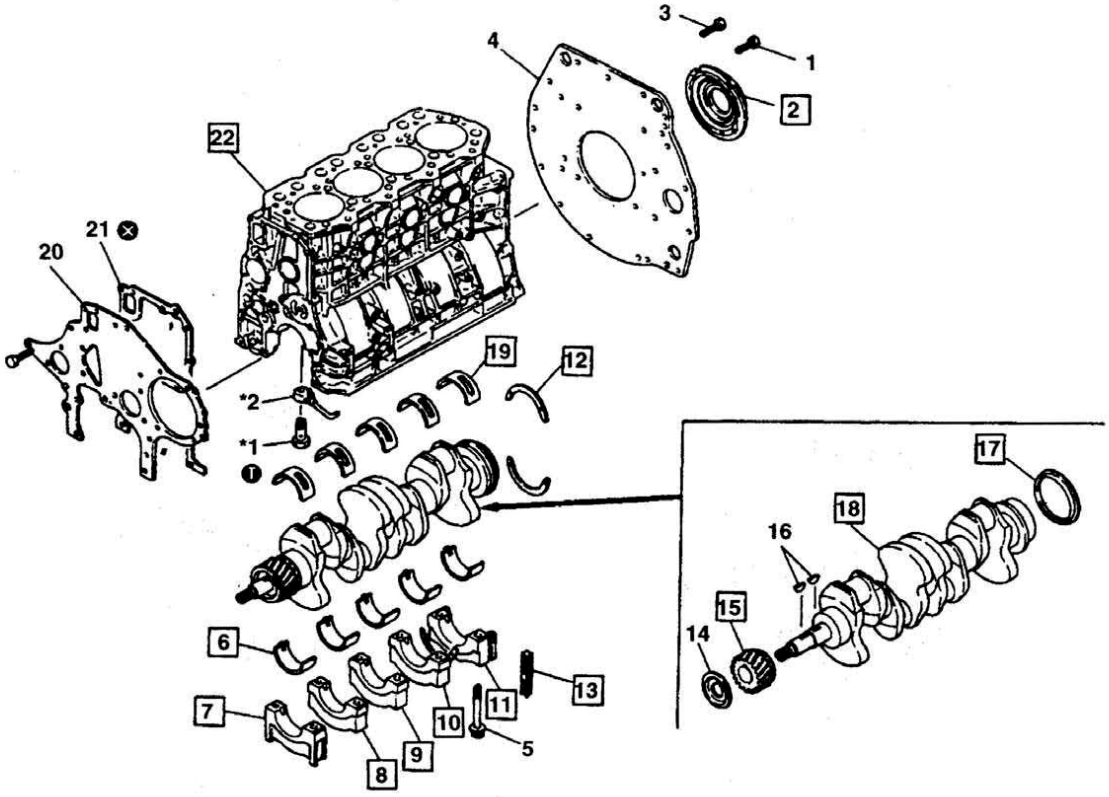
1 Connecting rod cap
2 Connecting rod bearing
③ Piston
④ 1st compression ring
⑤ 2nd compression ring,
⑥ Oil ring
7 Snap ring
⑧ Piston pin
⑨ Connecting rod
⑩ Main bearing cap
⑪ Thrust plate
12 Side seal
13 Lower main bearing
14 Crankshaft
⑮ Crankshaft gear
16 Upper main bearing
17 Crankcase

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

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CRANKSHAFT AND CRANKCASE

<D4DA>



<Disassembly sequence>

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

*1:Check vlave
*2:Oil jet

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

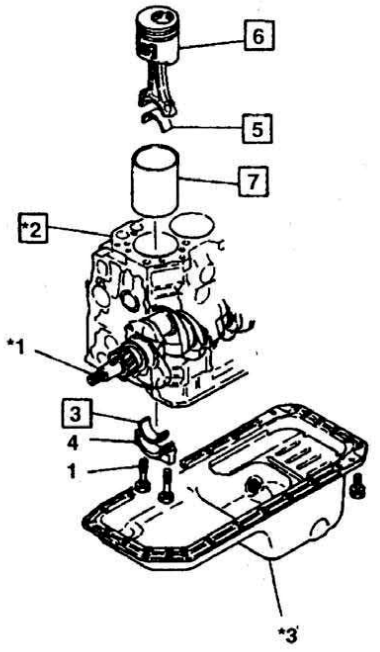
Assembly sequence

Follow the disassembly sequence in reverse.

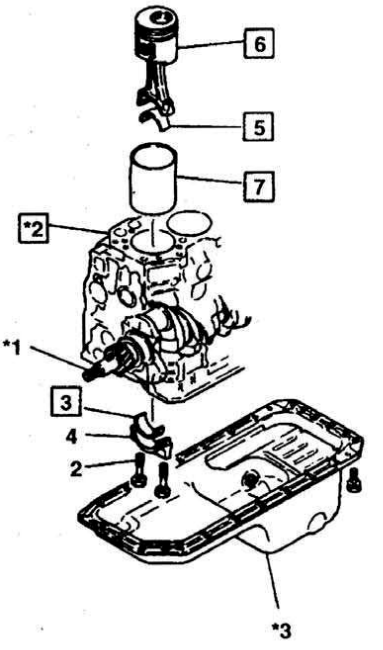
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PISTON, CONNECTING ROD AND CYLINDER SLEEVE

<D4A>



<D4DA>



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<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.

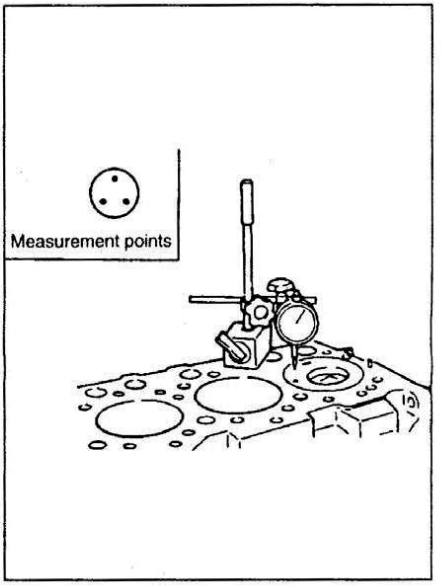
1. Disassembly

(a) Inspection of piston projection

Incorrect piston projection adversely affects the engine performance.

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

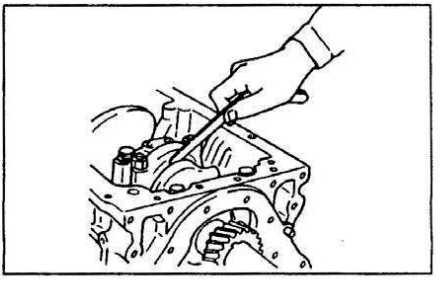
1) Hold the dial indicator on the crankcase top surface to make zero adjustment.
2) Locate the piston TDC with the dial indicator.
3) Measure projections at three points on the piston top surface to obtain the average value.



(b) Connecting rod end play

Measure the end play of each connecting rod.

If the limit is exceeded, replace the connecting rod.

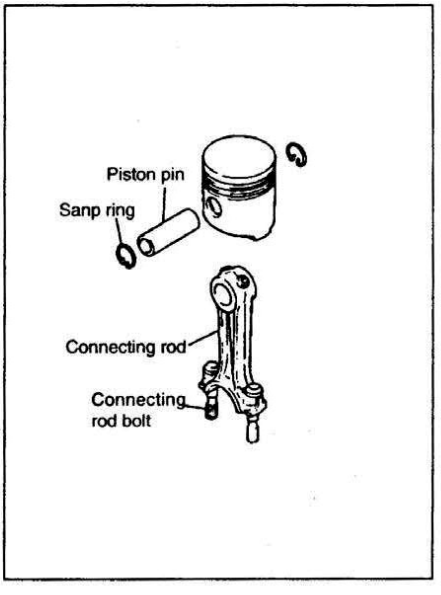


(c) Removal of piston

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

NOTE:

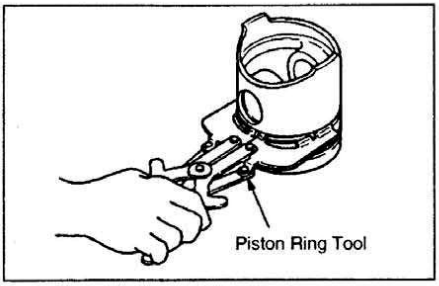
1. **If the piston pin is hard to remove, heat the piston with a piston heater or hot water.**
2. **Do not remove the connecting rod bolts from the connecting rod unless defective.**
   If the bolt is damaged, install a new connecting rod bolt by referring to reassembly connecting rod.



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(d) Removal of piston ring

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



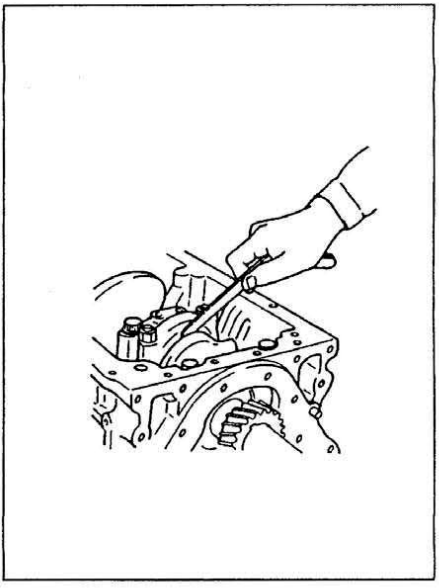
(e) Crankshaft end play

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.

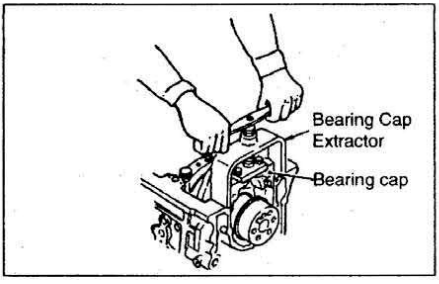


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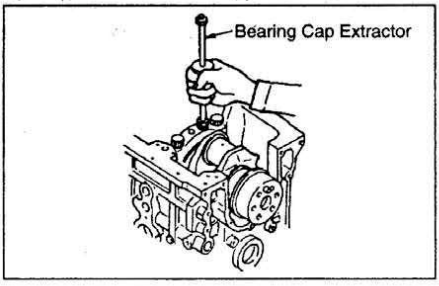
(f) Removal of main bearing cap

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

1) At front and rear ends

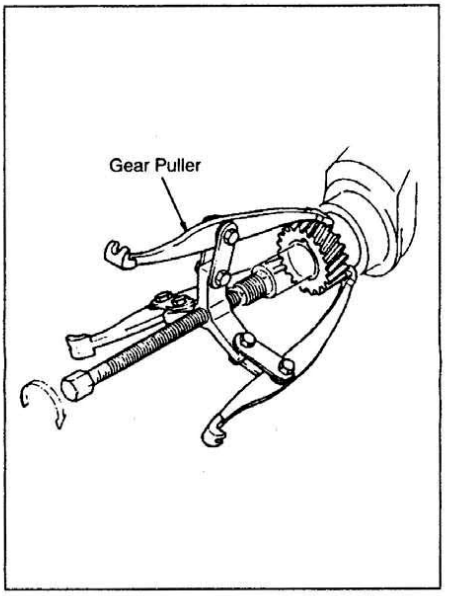


2) Intermediate position



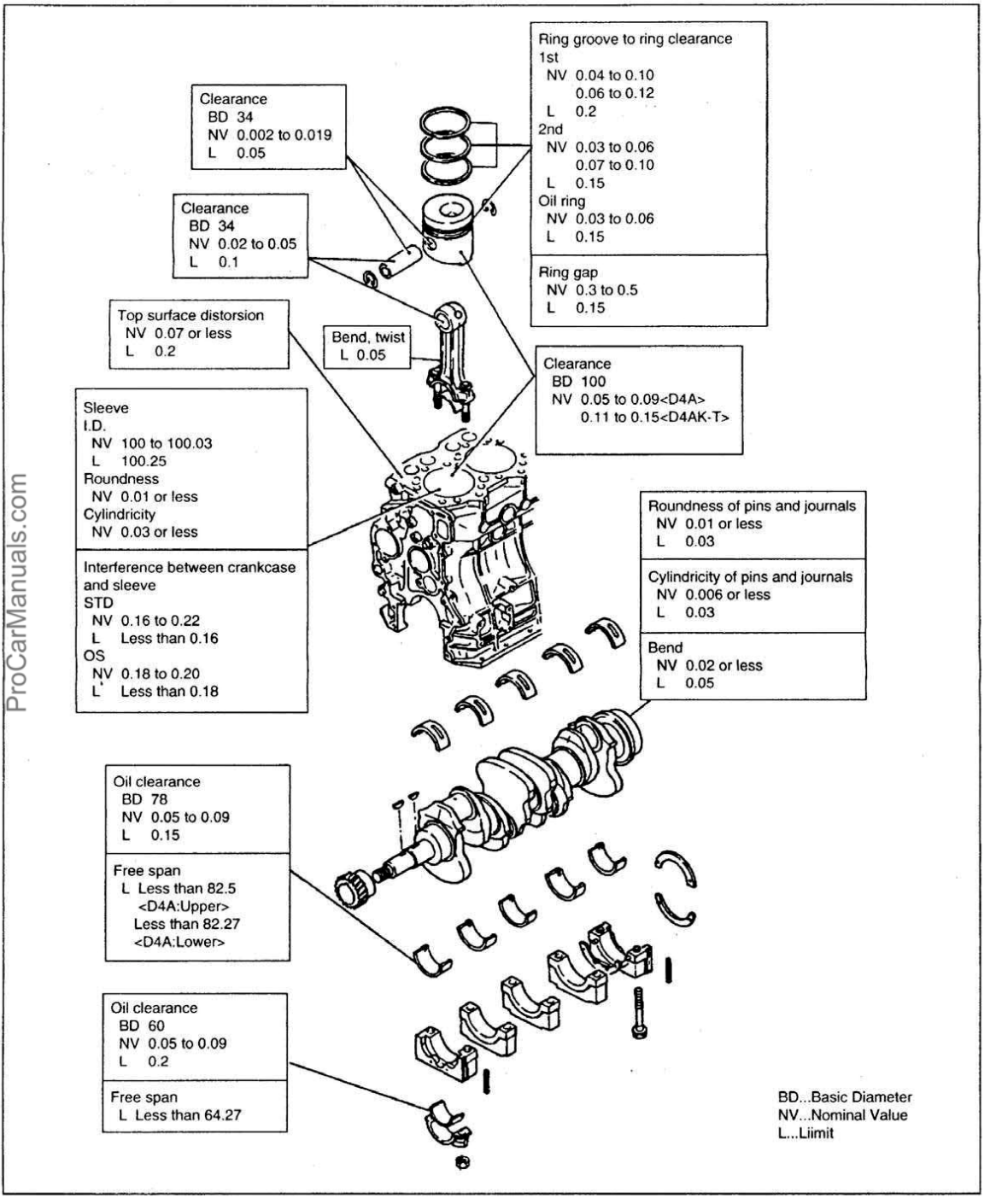
(g) Removal of crankshaft gear
To remove the crankshaft gear, use Gear Puller (special tool).

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



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2. Inspection



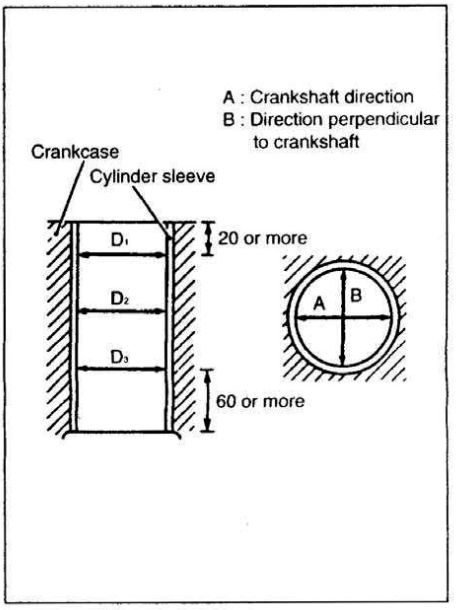
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(a) Measurement of cylinder sleeve I.D.

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.



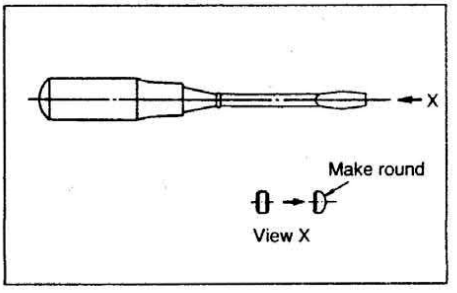
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(b) Replacement of cylinder sleeve

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.

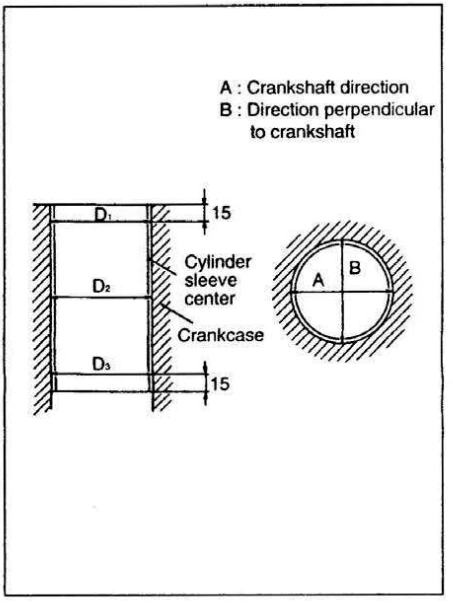
2) Installation

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.

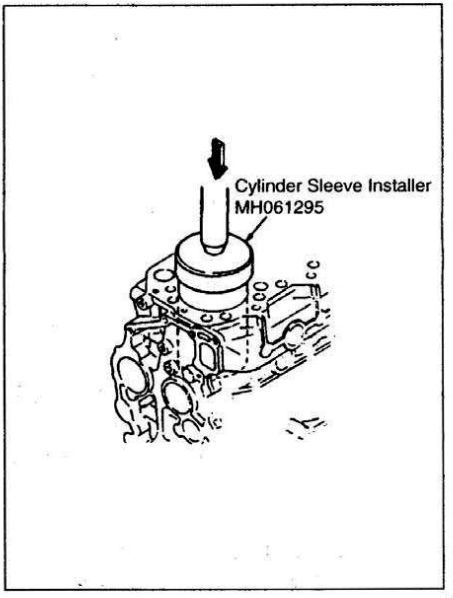
If the interference exceeds the limit, bore the crankcase sleeve hole to oversize.



- 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.



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- 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.

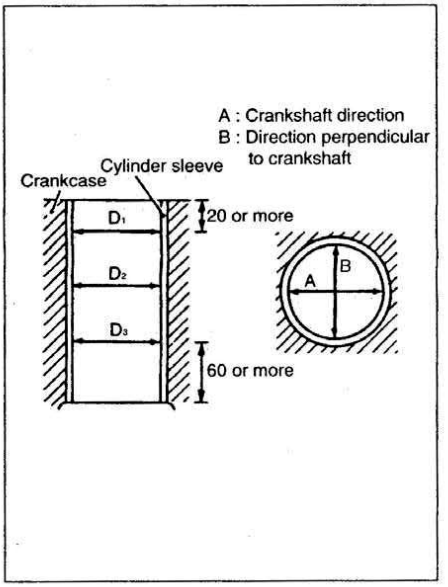
NOTE:

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.**

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(c) Selection of oversize
Available oversizes(4 types): +0.25, +0.5, +o.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 bo used.
3) Bore and hone the cylinder sleeve to obtain the nominal value for the cylinder sleeve to piston clearance.



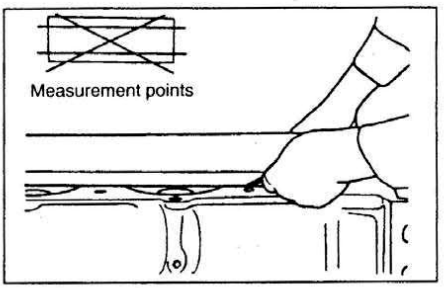
NOTE:

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.

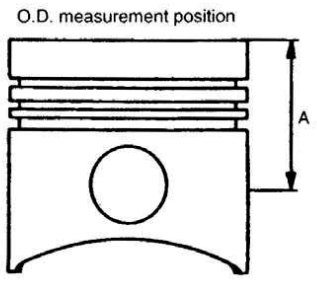
NOTE:

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.



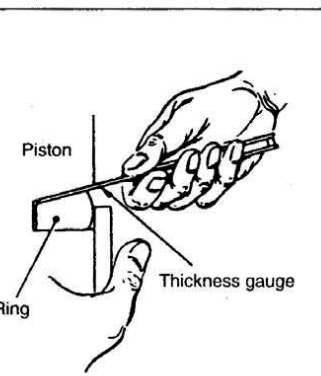
MODEL	A
D4A	60.65
D4DA	62.15

(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.





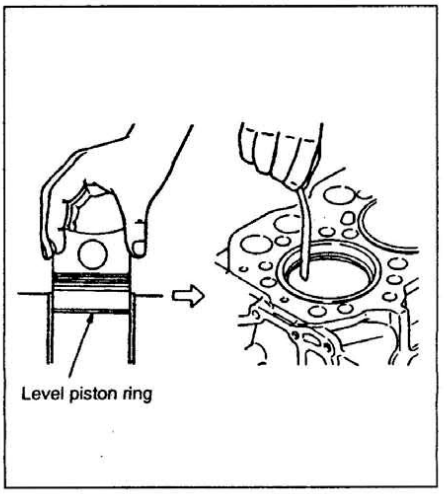
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(g) Piston ring gap

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

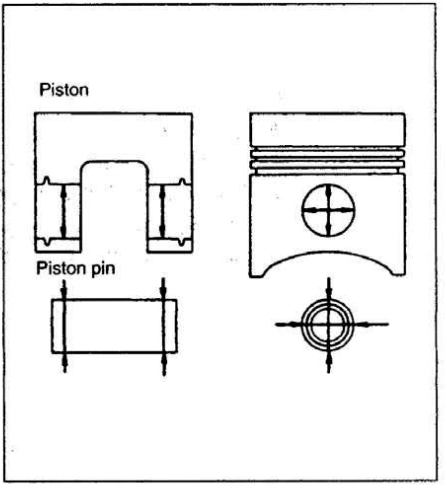
If the limit is exceeded, replace.

Standard I.D.: D4AN/AK:100±0mm
D4AF/D4DA:104±0mm



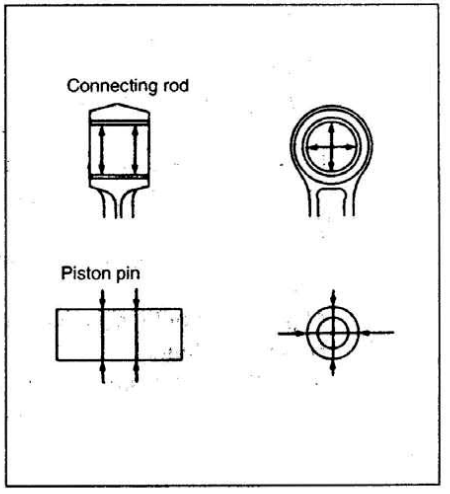
(h) Piston to piston pin clearance

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.

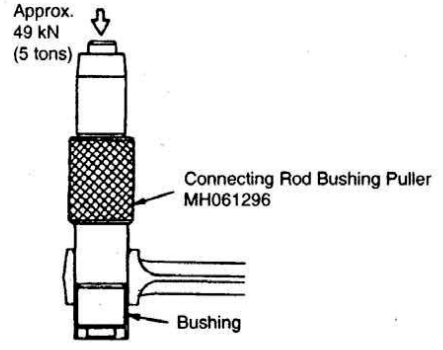


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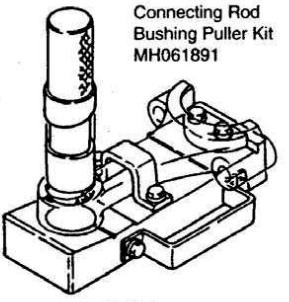
(j) Replacement of connecting rod bushing.

1) Removal of bushing

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



<D4A>

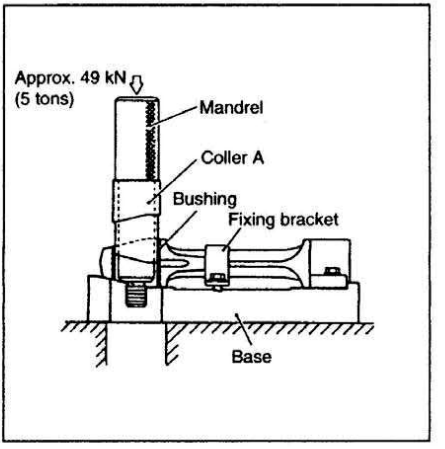


<D4DA>

<D4DA>

a) With the connecting rod bearing removed from the connecting rod big end, secure the connecting rod to Base(special tool).

b) 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>

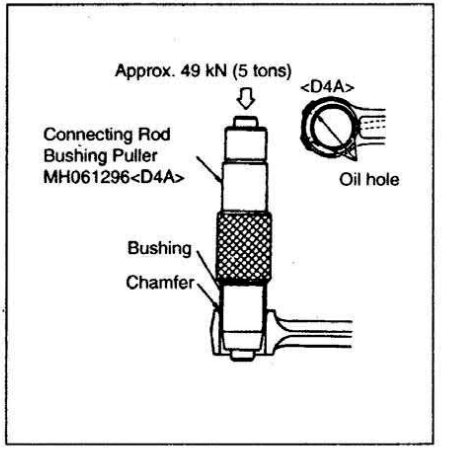
a) Insert the bushing into Connecting Rod Bushing Puller(special tool).

b) Apply engine oil to the bushing and connecting rod.

c) Press-fit the bushing into the connecting rod.

NOTE:

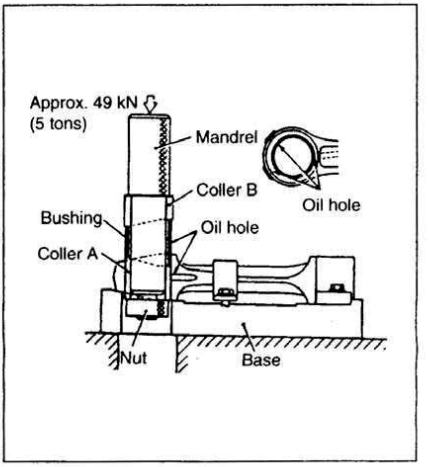
1. **Press the bushing into the chamfered end of the connecting rod.**
2. **Align the oil hole in the bushing with that in the connecting hole.**
3. **After the piston pin has been inserted, make surface that there is no excessive play and it turns smoothly.**



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<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.

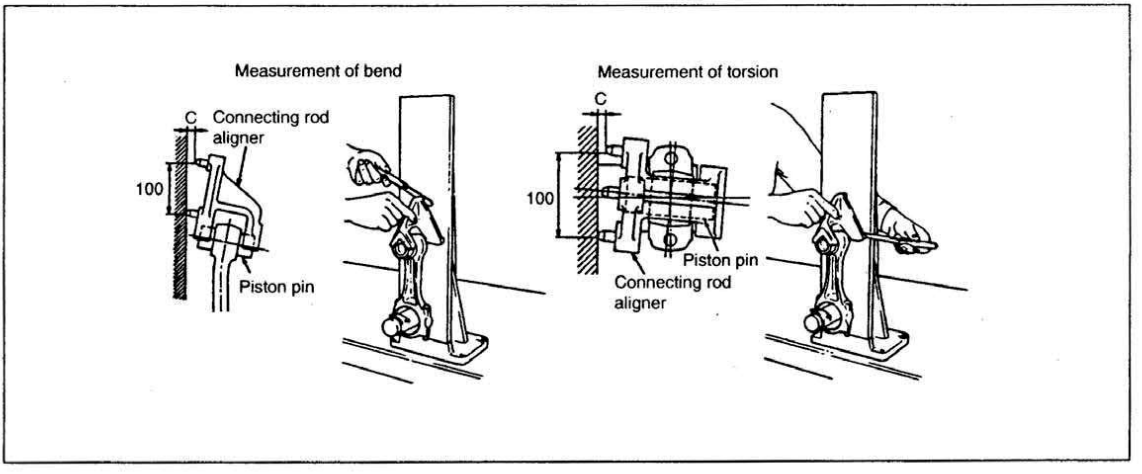
NOTE:

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:

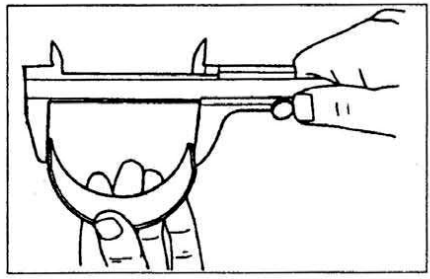
1. **Measure with the bushing and connecting rod bearing installed in the connecting rod.**
2. **The connecting rod and connecting rod cap bolts must also be tightened to specification in measuring.**



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(l) Connecting rod bearing tension

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

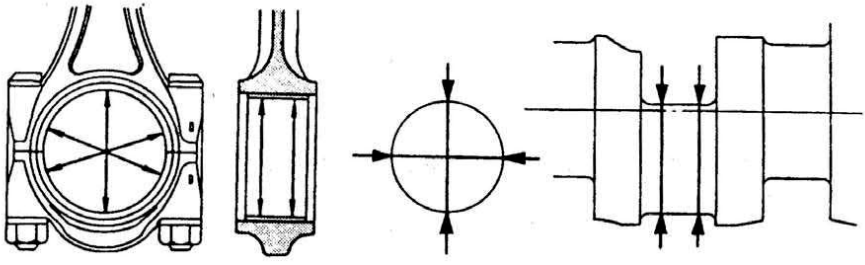


NOTE :

Never attempt to expand the bearings for reuse.

(m) Connecting rod bearing to crankshaft clearance

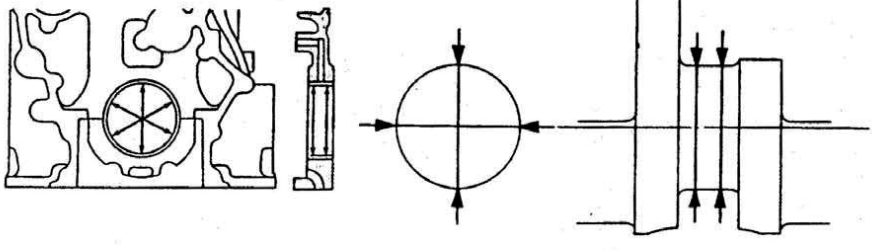
If the limit is exceeded, replace the upper and lower and lower connecting rod bearings as a set.



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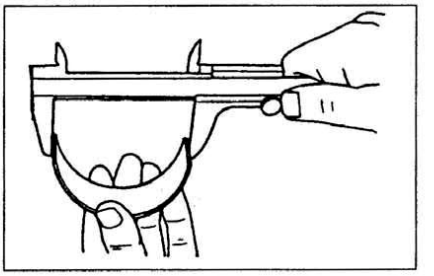
(n) Main bearing to crankshaft clearance

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



(o) Main bearing tension

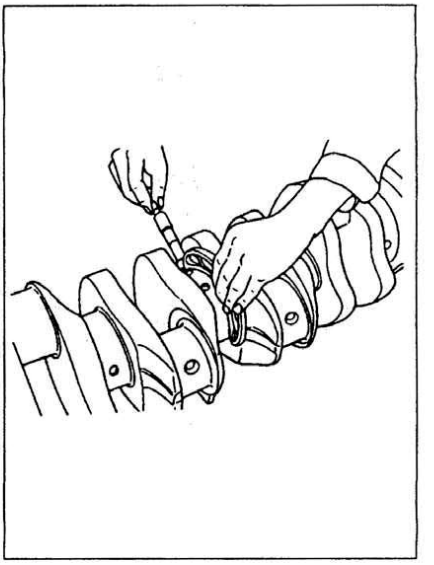
Measure the tension of the main bearings when free.
If the measurements are below the limit, replace the upper and lower main bearings as a set.



NOTE:
Never attempt to expand the bearings for reuse.

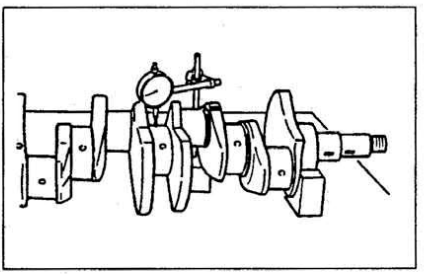
(p) Roundness and cylindricity of crankshaft

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.

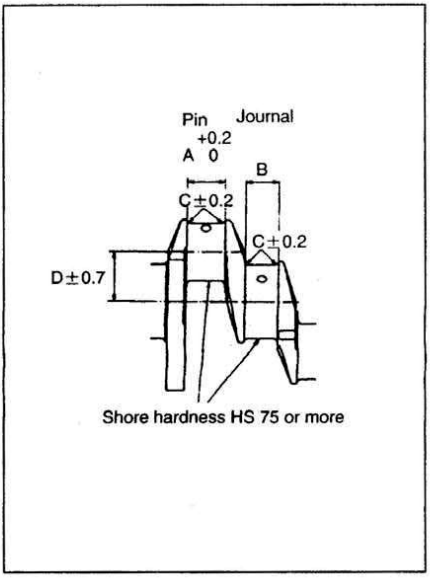
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(r) Correction of crankshaft to undersize

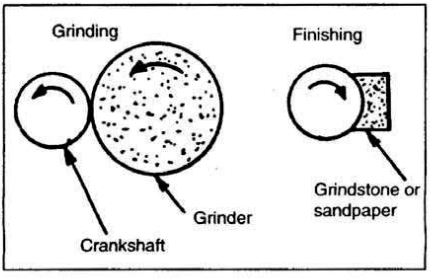
Item	Nominal value mm
A	41
B	35
C	R4
D	52.5

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.



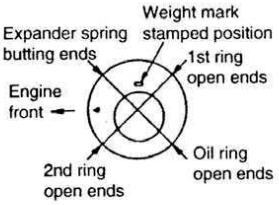
Crankshaft Undersize Dimensions

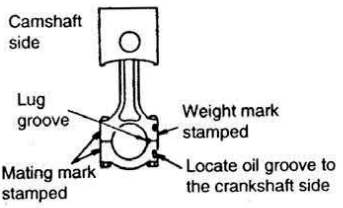
Unit : mm

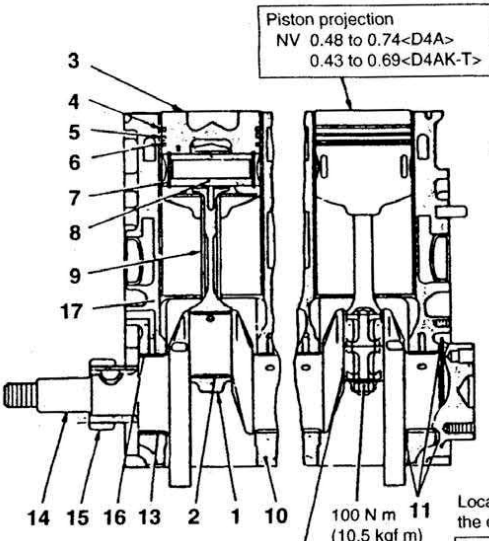
Under size	Journal O.D finish dimension	Pin O.D finish demension		Out-of-roundness	Cylindicity
		D4A	D4DA		
0.25	77.68~77.70	59.695~59.715	64.69~64.71	0.01 or less	0.006 or less
0.50	77.43~77.45	59.445~59.465	64.44~64.46		
0.75	77.13~77.20	59.145~59.215	64.19~61.21		
1.00	76.93~76.95	58.945~58.965	63.94~63.96		

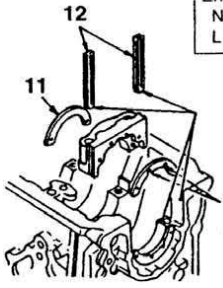
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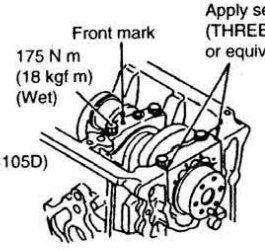
3. Reassembly





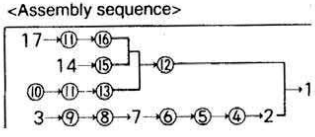






NV...Nominal Value
L...Limit

<Assembly sequence>

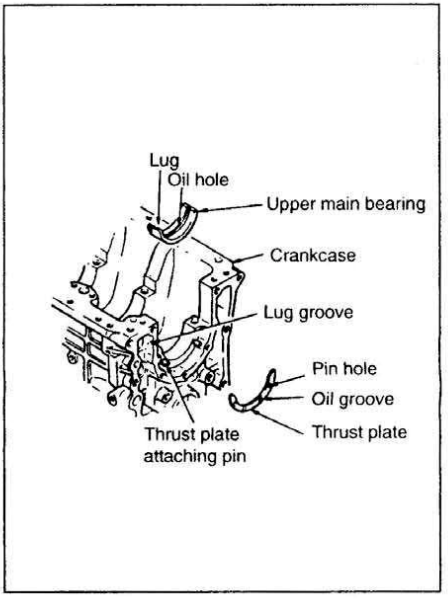


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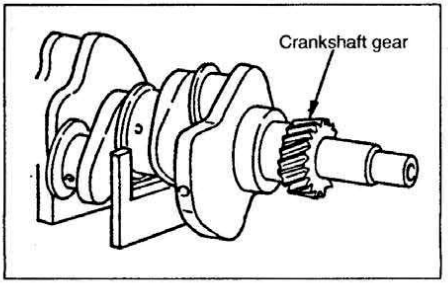
(a) Install the thrust plate and upper main bearing to the crankcase.

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.

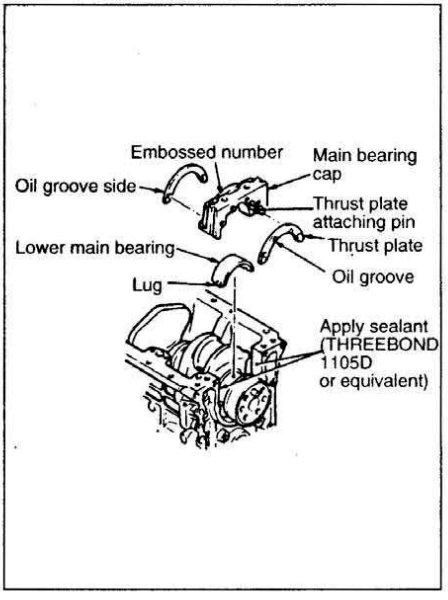


(c) Installation of main bearing cap
<D4A>

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.

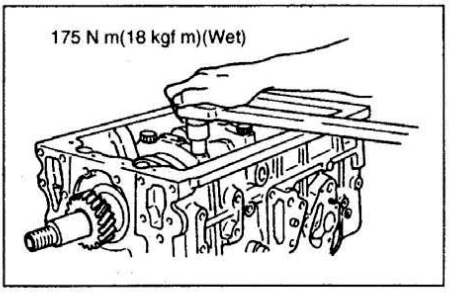
NOTE:

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.**



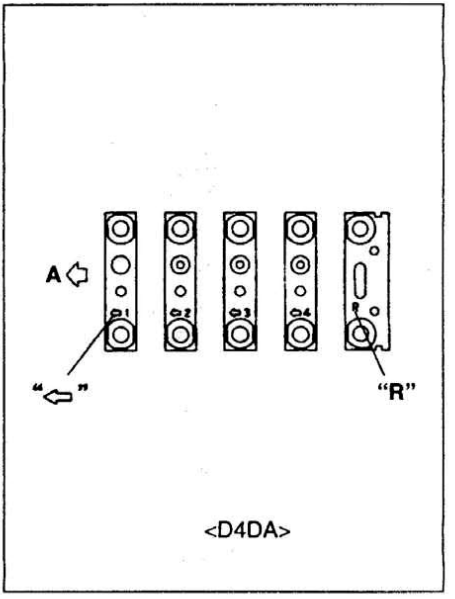
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4) Tighten the main bearing cap bolt to specification. Then, make sure that the crankshaft turns smoothly by hand.
5) Measure the crankshaft end play to determine if it is within the nominal value.



<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.

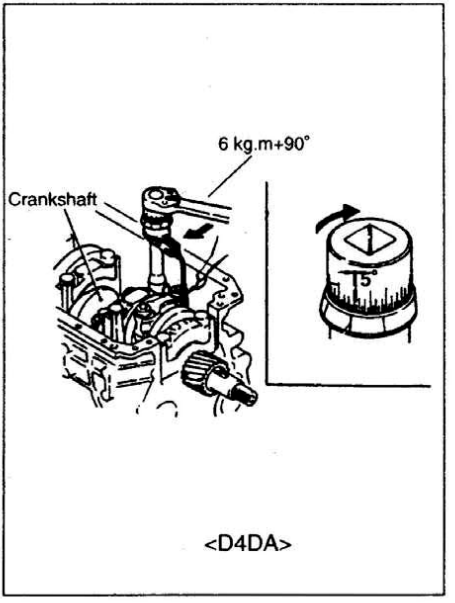
NOTE:
If any bolt already has three punch marks, it cannot be used again; replace it with a new one.



<D4DA>

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° .)

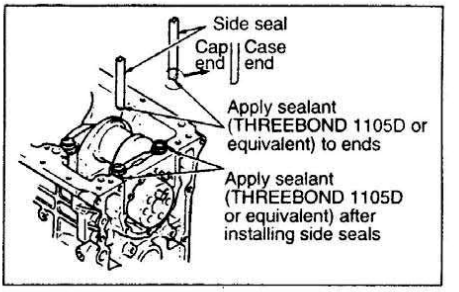
NOTE:
since bolts 1 utilize the plastic region tightening method, they must not be tightened further after this procedure.



<D4DA>

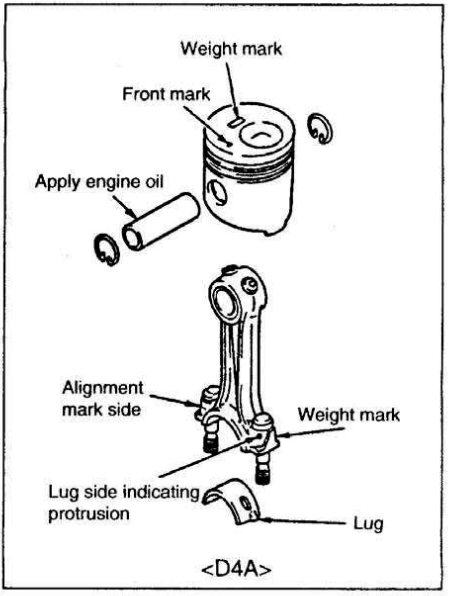
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(d) Installation of side seal
Install the side seal with sealant applied to its end. Then, apply sealant to the bearing cap.



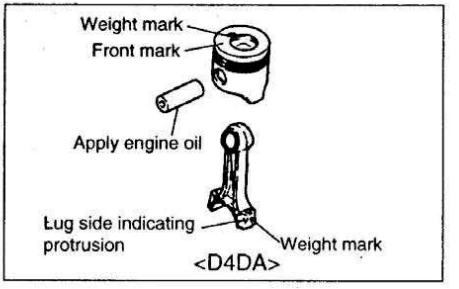
NOTE:
When installing the side seal, ensure the correct installation direction.

(e) Reaseembly 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.

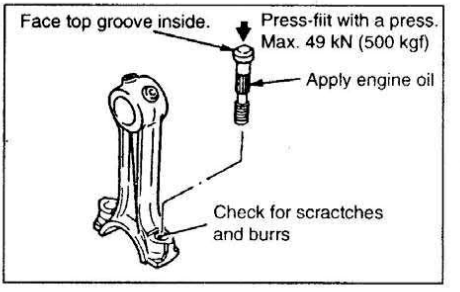


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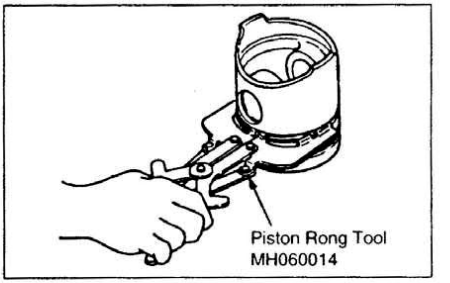
NOTE:
1. **Pistons must all have the same mass mark.**
2. **Connecting rods must all have the same mass mark.**
3. **After inserting piston pin check that it turns smoothly and with out play.**



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)

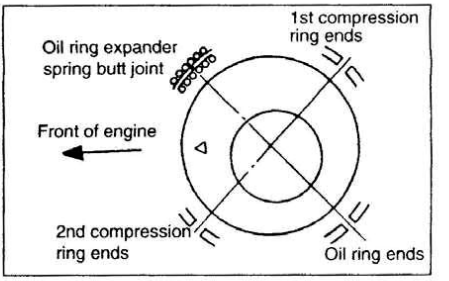


(f) Installation of piston rings
To install piston rings, use piston Ring Tool(special tool).

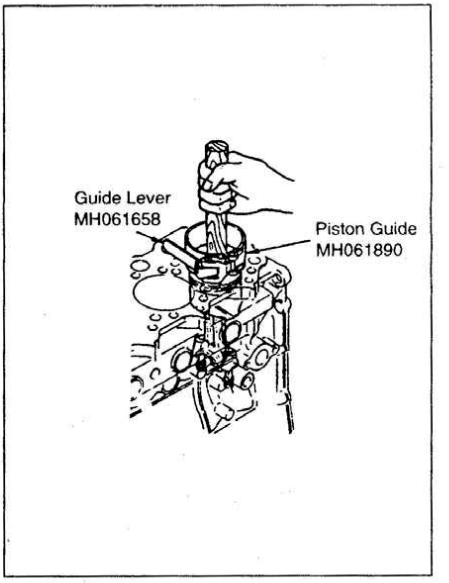


NOTE:
A manufacturer's mark is stamped near the piston ring ends. Install with the mark up.

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).

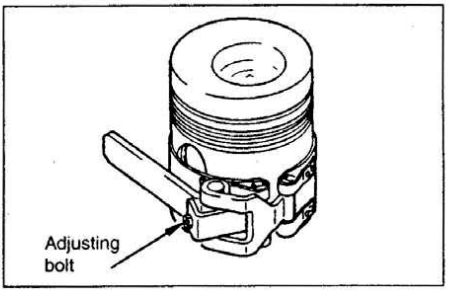


NOTE:
1. **Face the position mark on the lug end toward front of engine.**
2. **Make sure that the piston ring ends position does not change during installation.**
3. **Cover the connecting rod bolt with a vinyl hose so as not to damage to crankshaft pins.**

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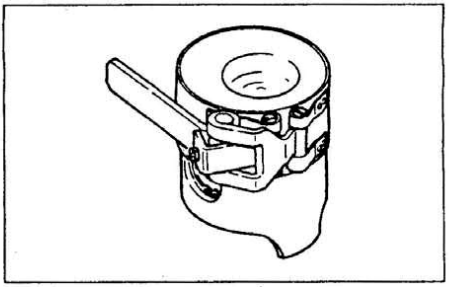
Use of Piston Guide

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.

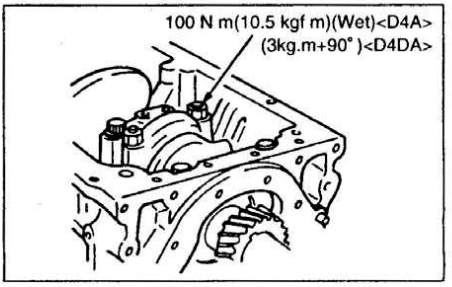


On completion of adjustment, remove the piston Guide from piston and apply engine oil to piston external surfaces, piston Guide internal surfaces, and cylinder liner internal surfaces.

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.



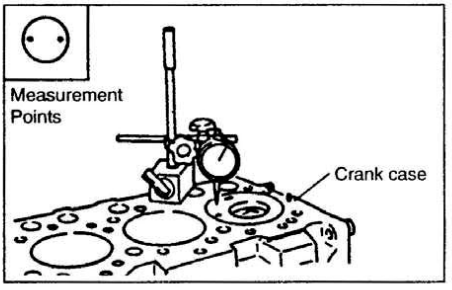
NOTE:
The lug sides of the connecting rod and connecting rod cap must be in the same direfction.

(i) Check the connecting rod end play.

(j) Check piston for projection.

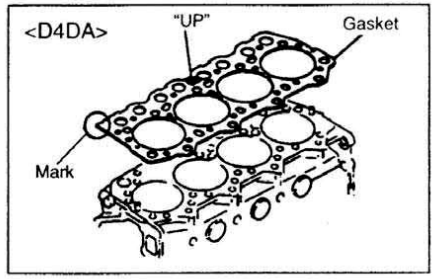
Incorrect piston projection adversely affects the engine performance. If measurements are out of specification, check parts for clearance.

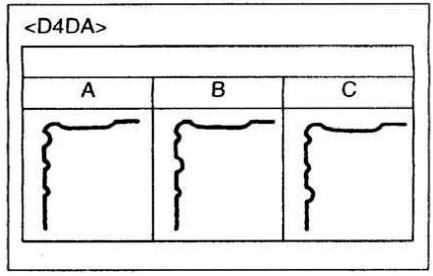
1) Hold the dial indicator on the crankcase top surface to make zero adjustment.
2) Locate the piston TDC with the dial indicator.
3) Measure projections at three points on the piston top surface to obtain the average value.



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

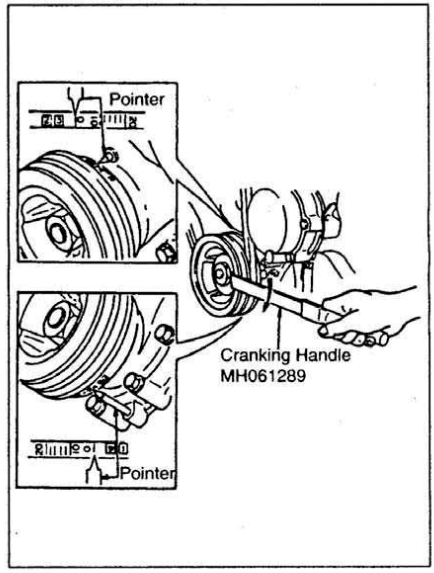




4. Inspection and Adjustment of Valve Clearance

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.



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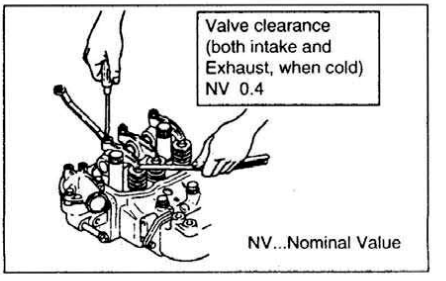
(b) When the piston in No.1 cylinder is at TDC on the compression stroke(the push rods of No.1 cylinder not pushing up the intake and exhaust valves), check and adjust clearances of valves marked with "○" in the following Table. Then, with the crankshaft rotated a turn, check and adjust clearances of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

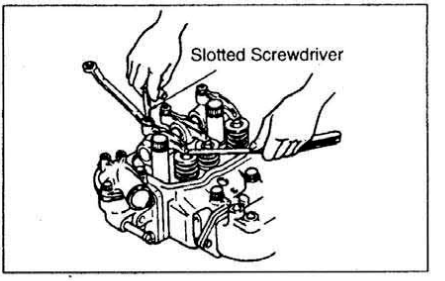
If the No.4 or No.6 cylinder piston is at TDC on the compression stroke(push rods in the NO.4 or NO.6 cylinder not pushing up the intake and exhaust valves), similarly check and adjust the clearances of valves marked with "x" first; then, turn the crankshaft a turn, check and adjust valves marked with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

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

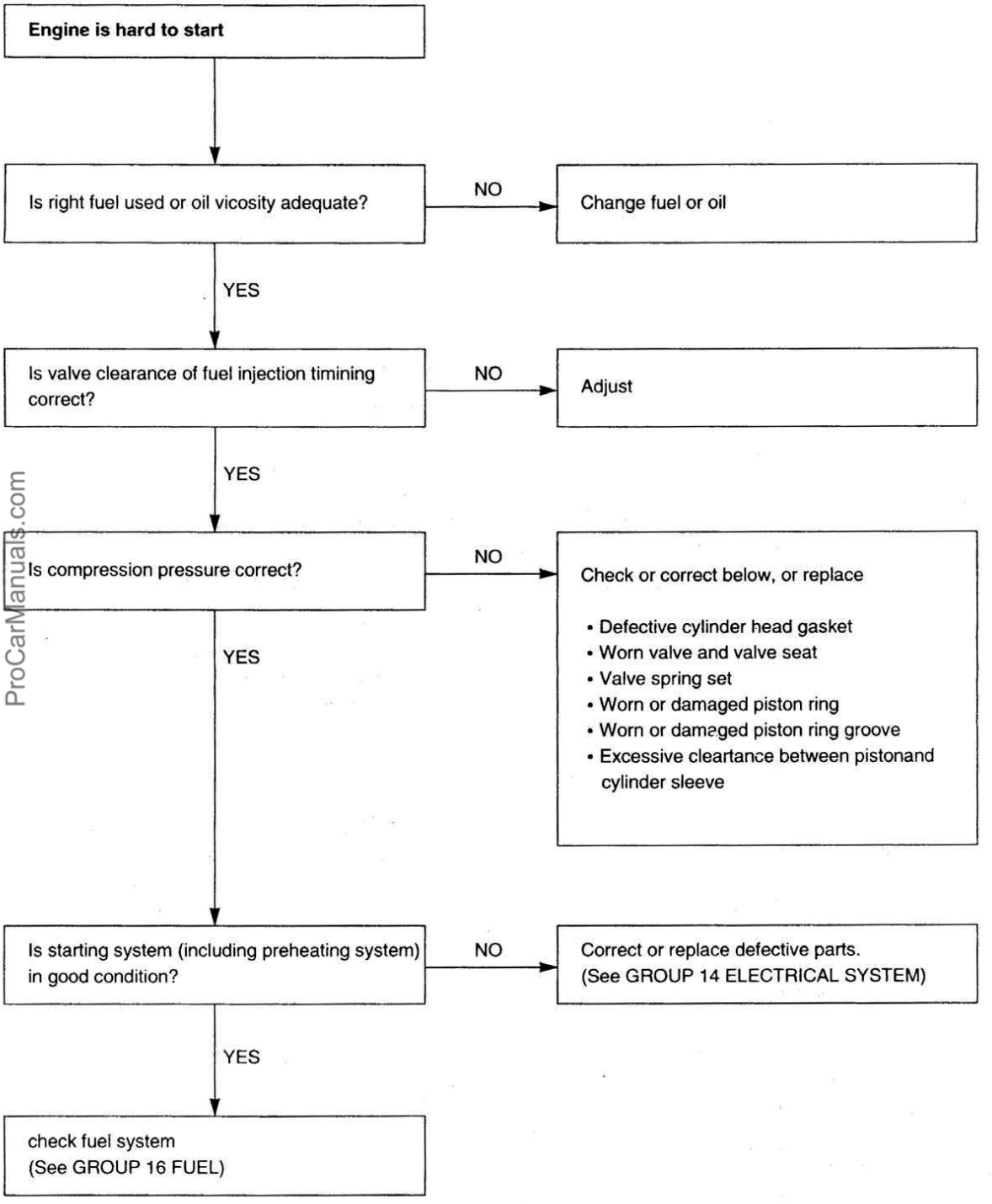
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(c) Insert the specified thickness gauge between the rocker and valve cap to check for clearance.
If the valve clearance is out of the nominal value, loosen the lock nut and turn the adjusting screw to the extent that the thickness gauge moves slightly 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.

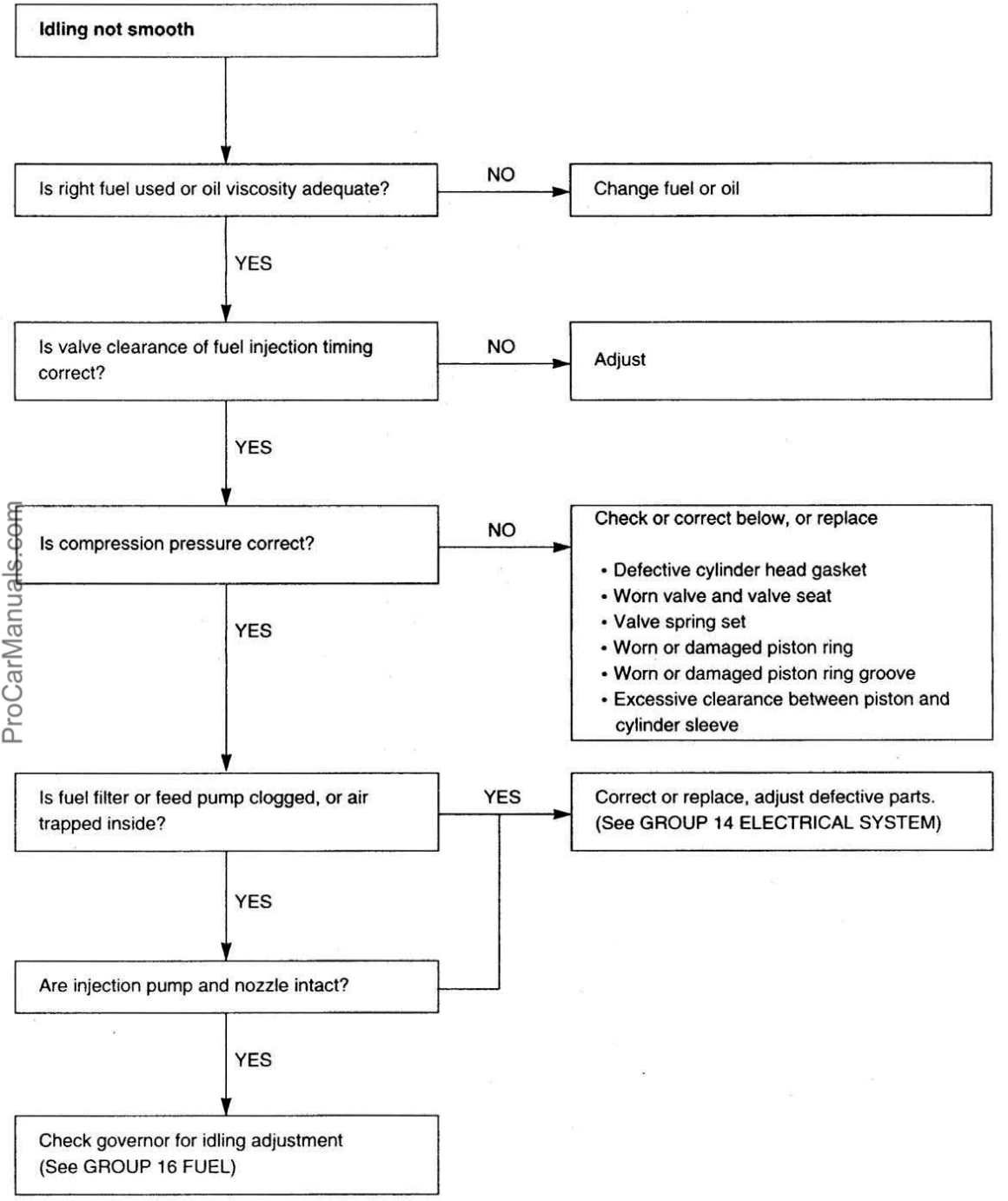




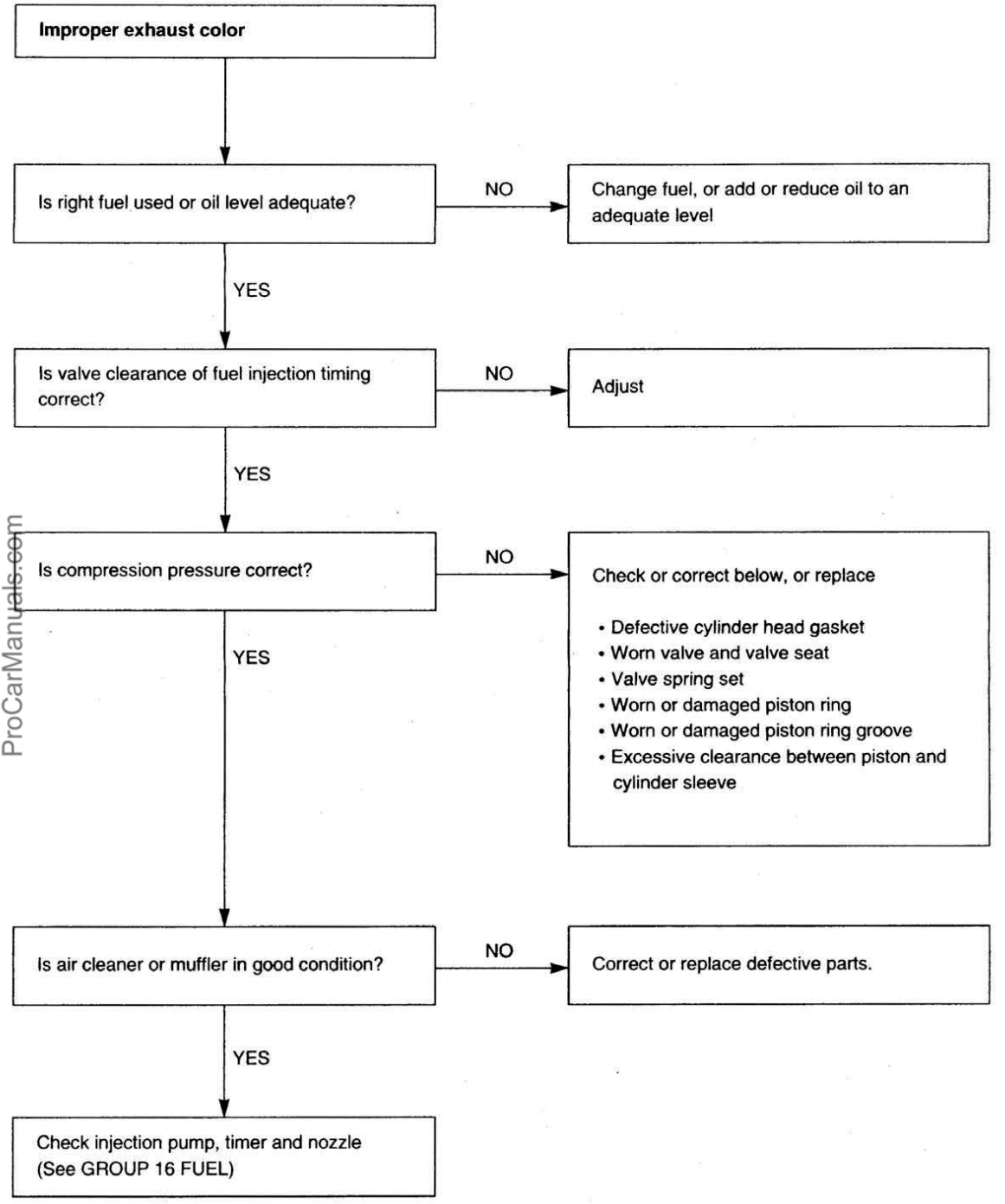
6. TROUBLESHOOTING



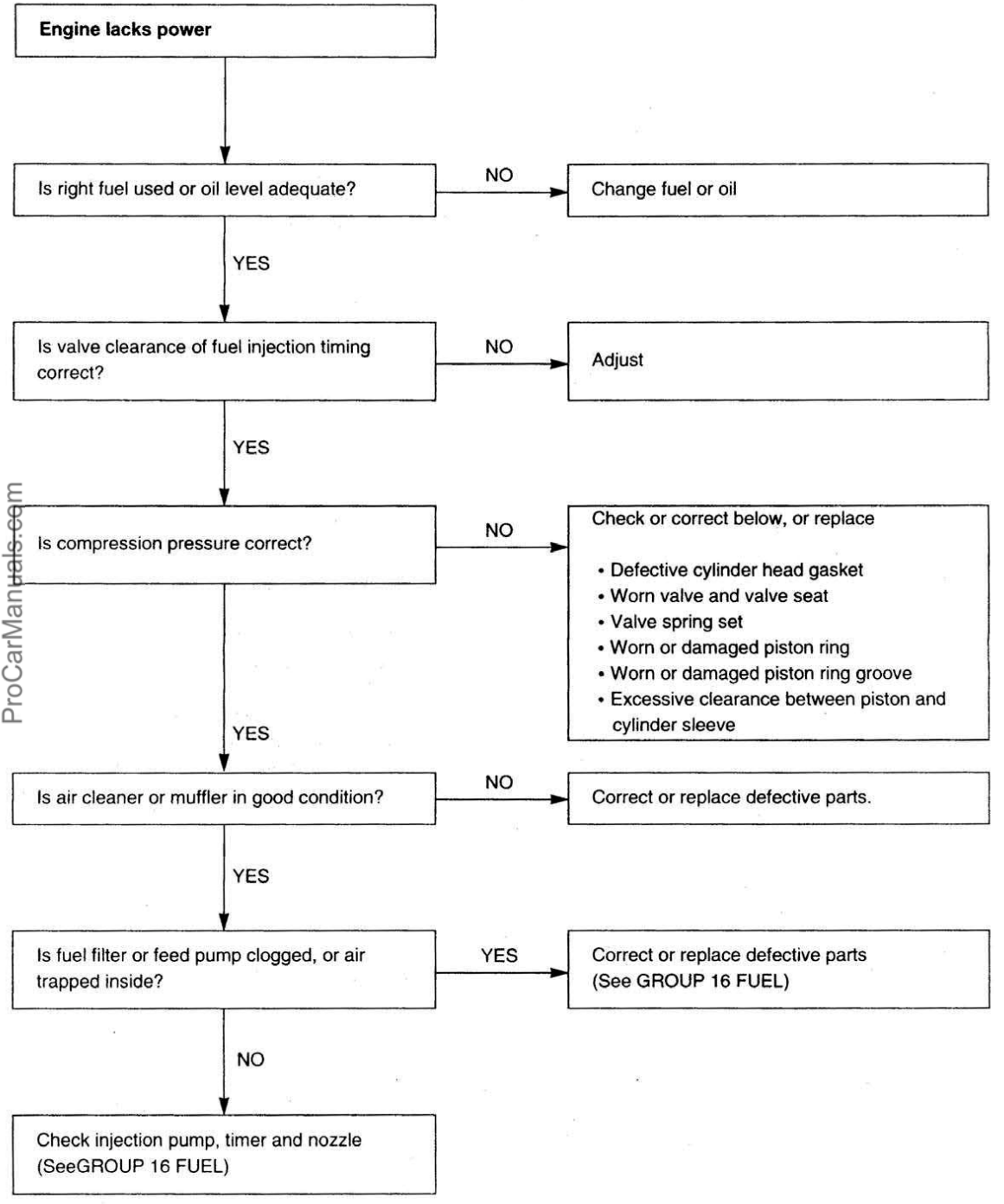
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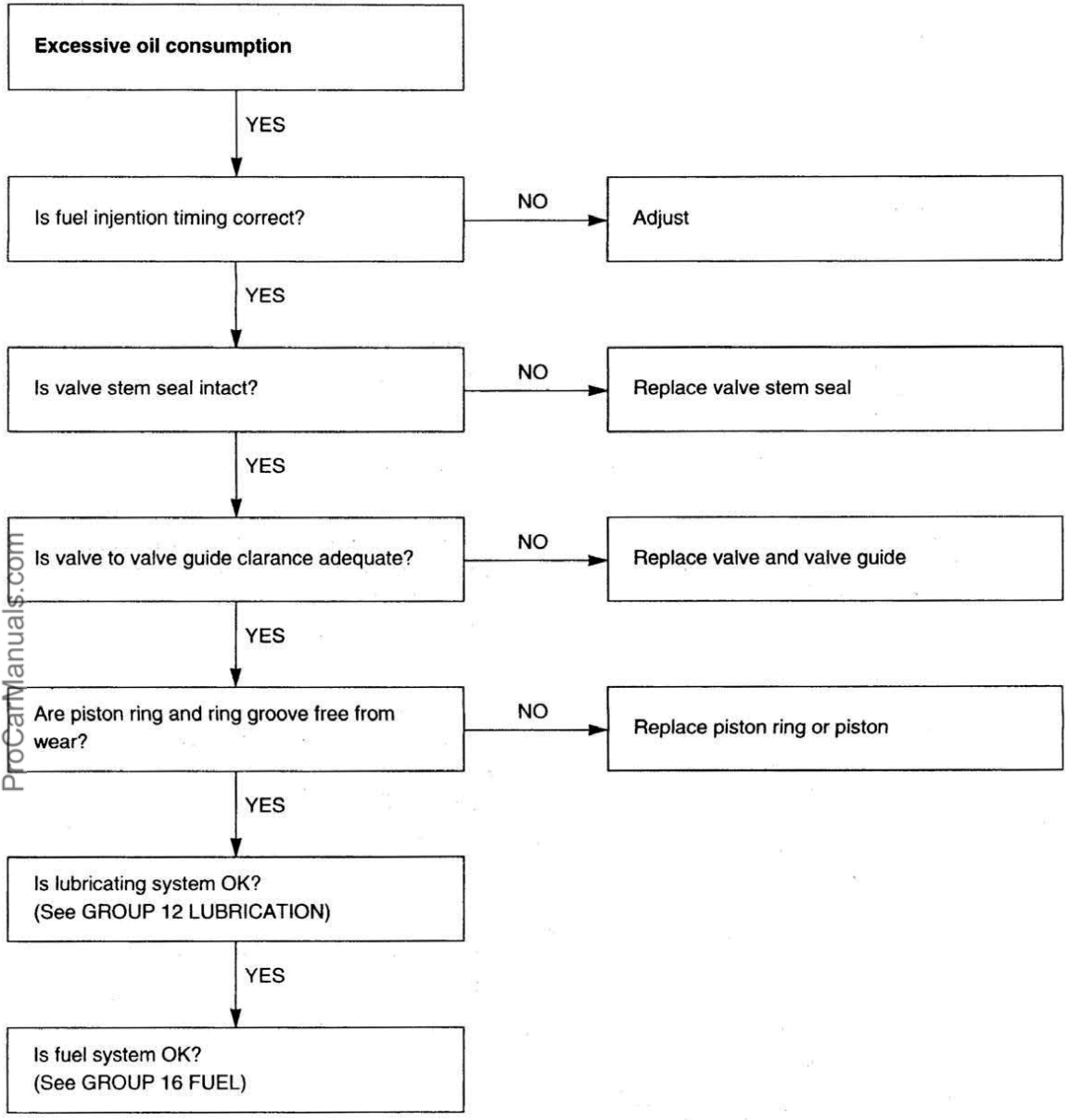
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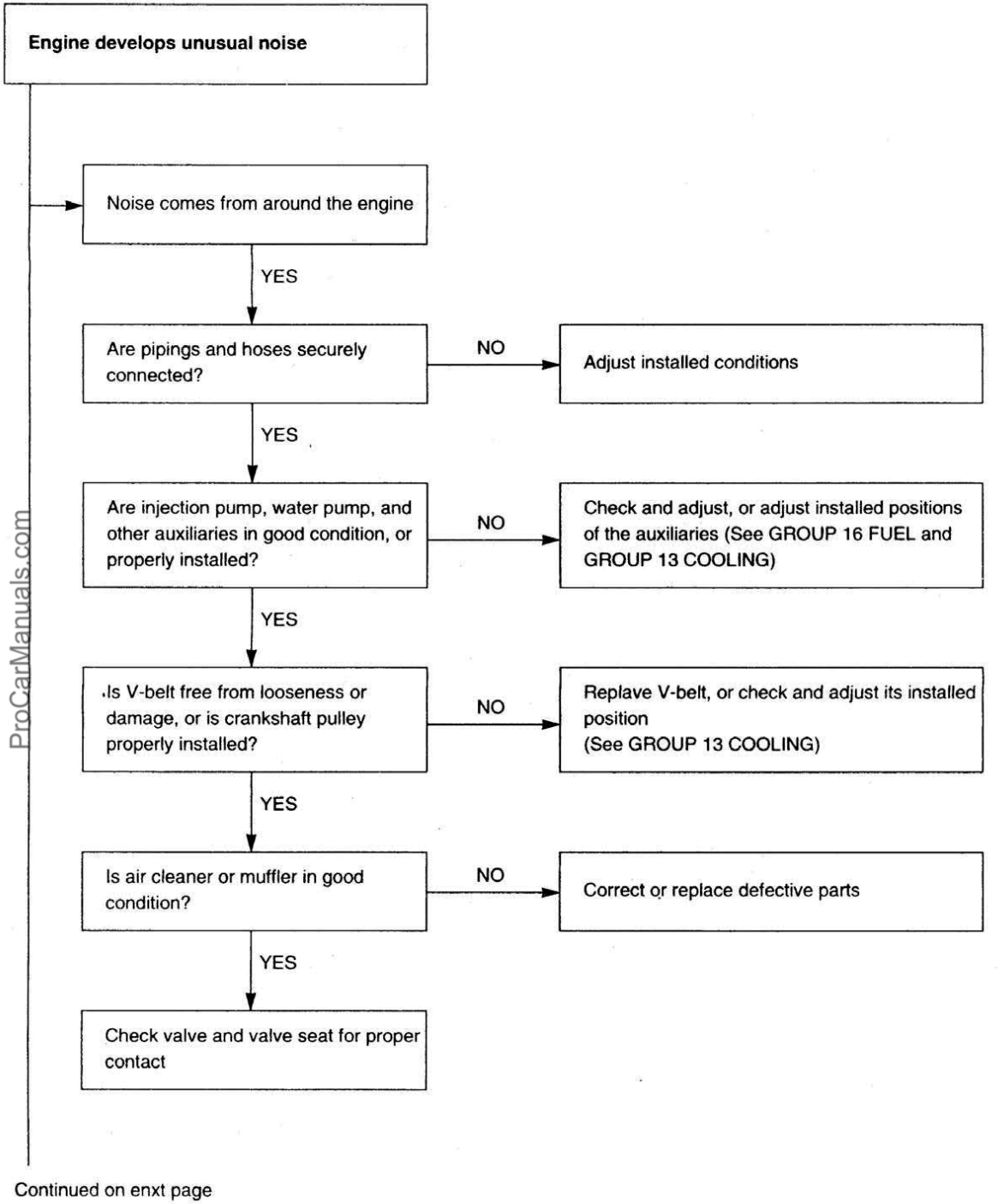
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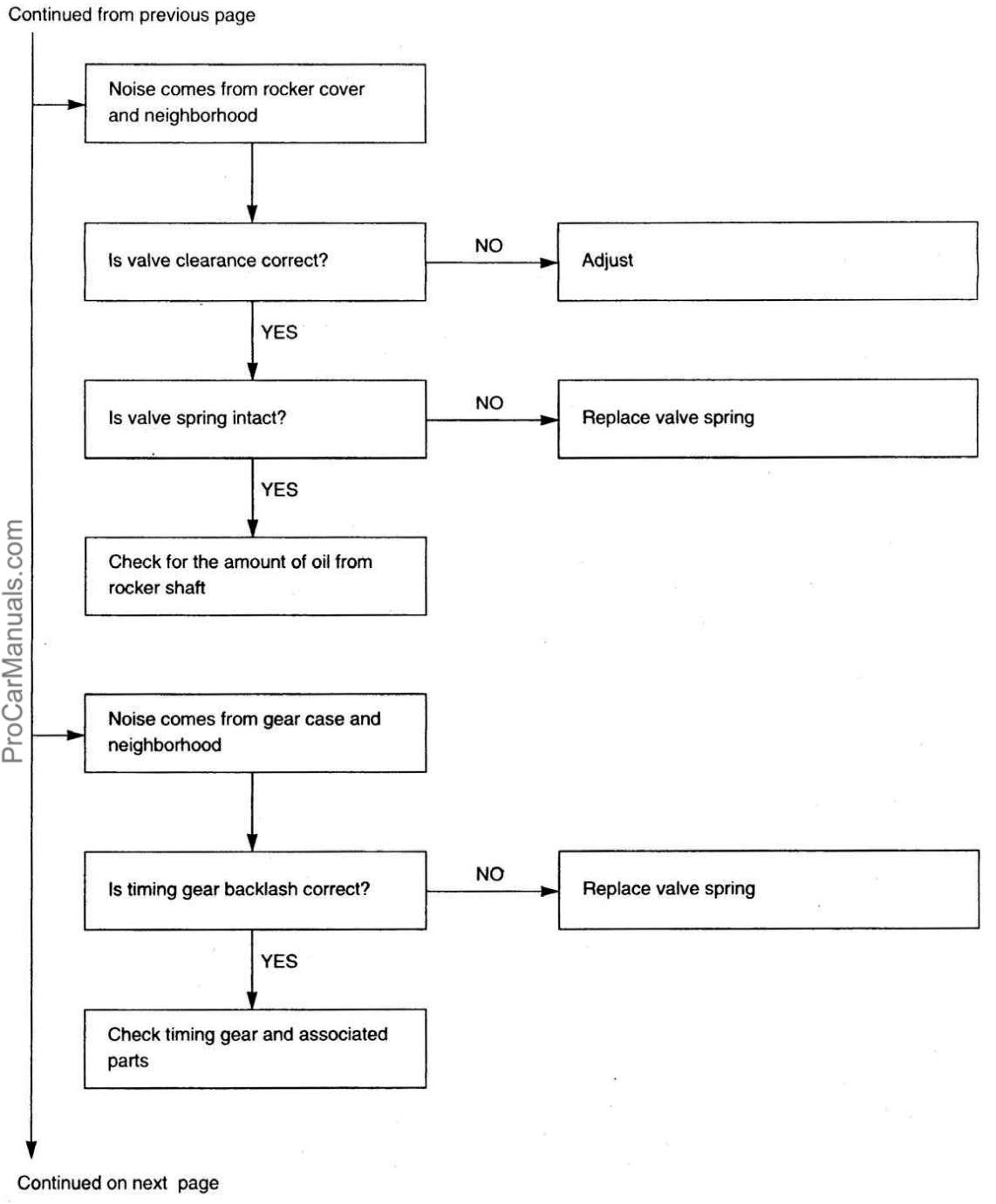
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Noise comes from cylinder head and crankcase

Does the noise change with different engine coolant temperature or fuel injection timings?

NO

Check for compression pressure;
Check and 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

There is a great change

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

There is a small change

NO

Check parts for wear and damage;
check and correct below, or replace:

- Worn piston or cylinder
- Seized or broken piston and piston ring
- Worn connecting rod small-end bushing and piston pin
- Worn crank pin and connecting rod big-end bearing
- Worn crankshaft journal and main bearing
- Broken crankshaft
- Loose flywheel on crankshaft
- Excessive crankshaft end play
- Worn cam and tappet
- Excessive camshaft end play

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