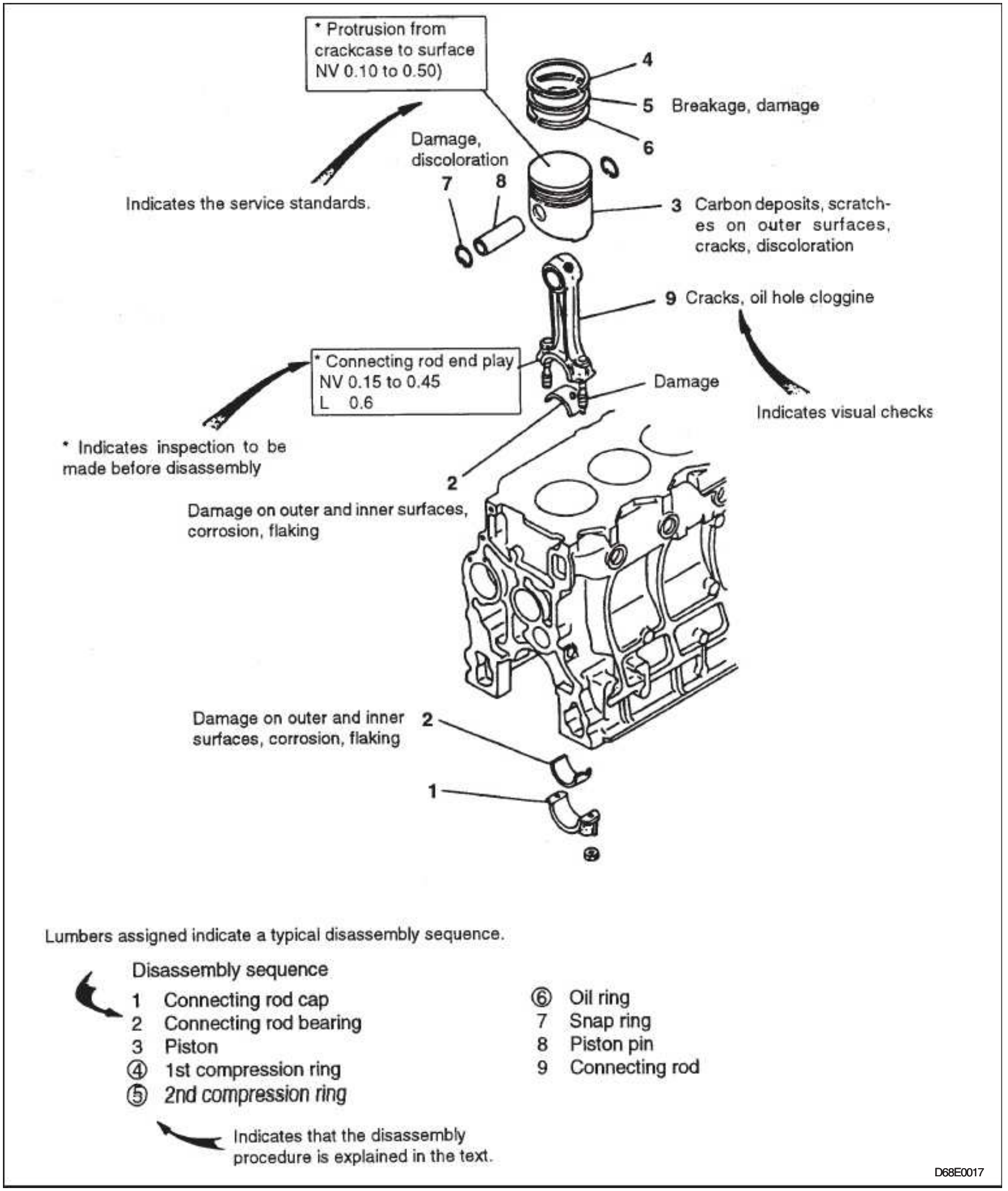
ENGINE MECHANICAL (D6A, D8A)

READING THE ILLUSTRATION

(Ex. 1: Disassembly and Inspection)



Lumbers assigned indicate a typical disassembly sequence.

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

Indicates that the disassembly procedure is explained in the text.

D68E0017

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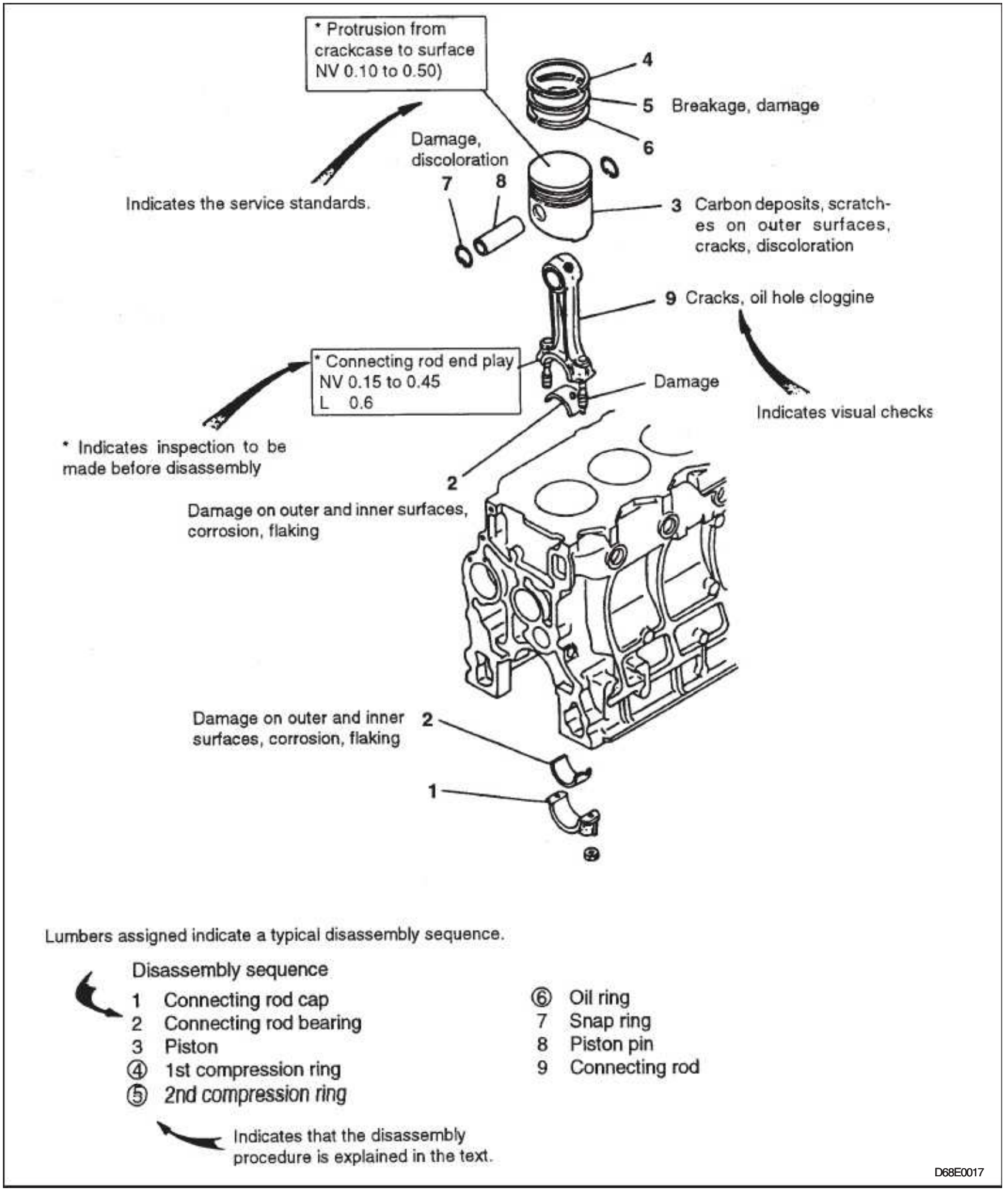

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D68E0017

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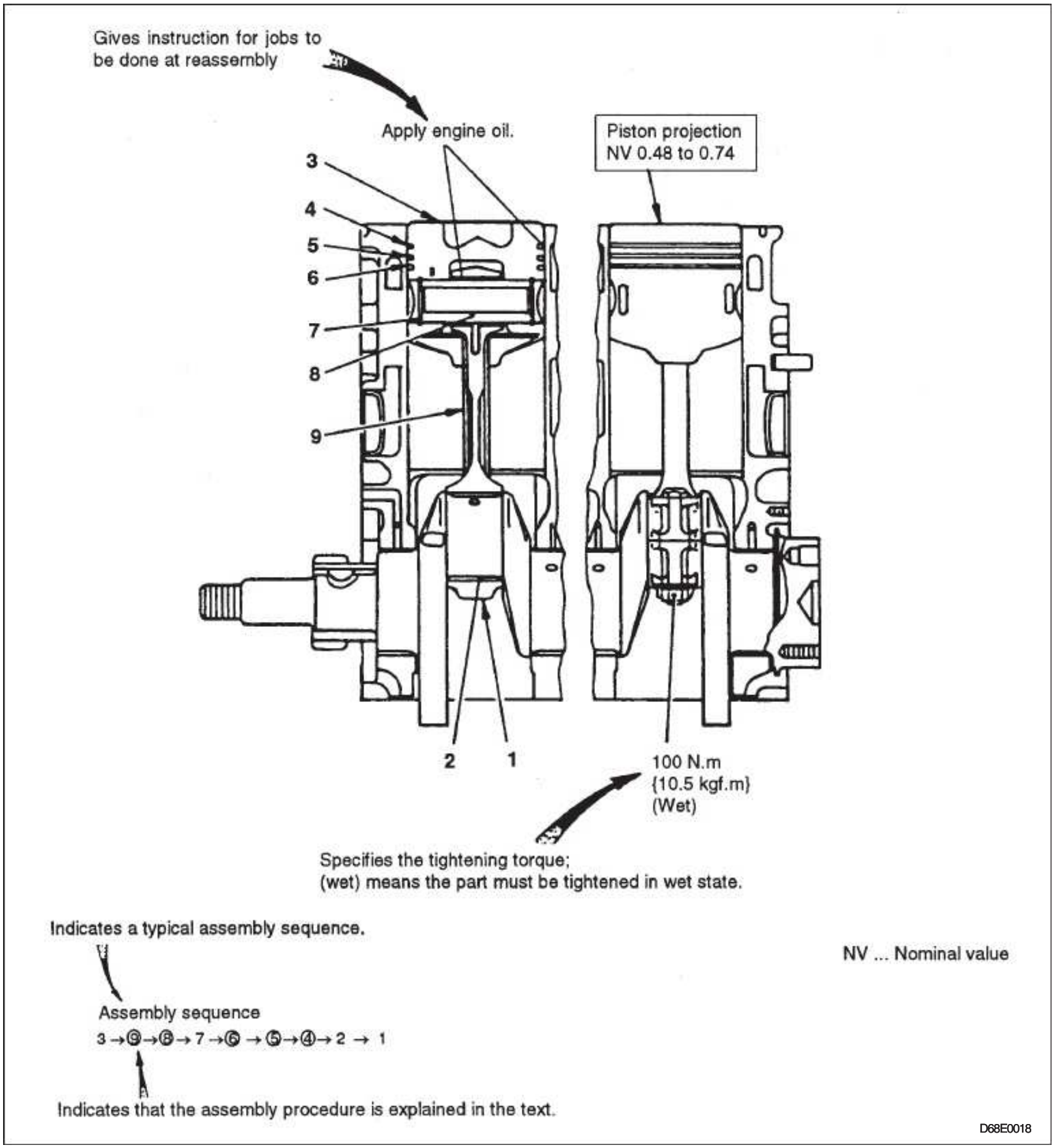
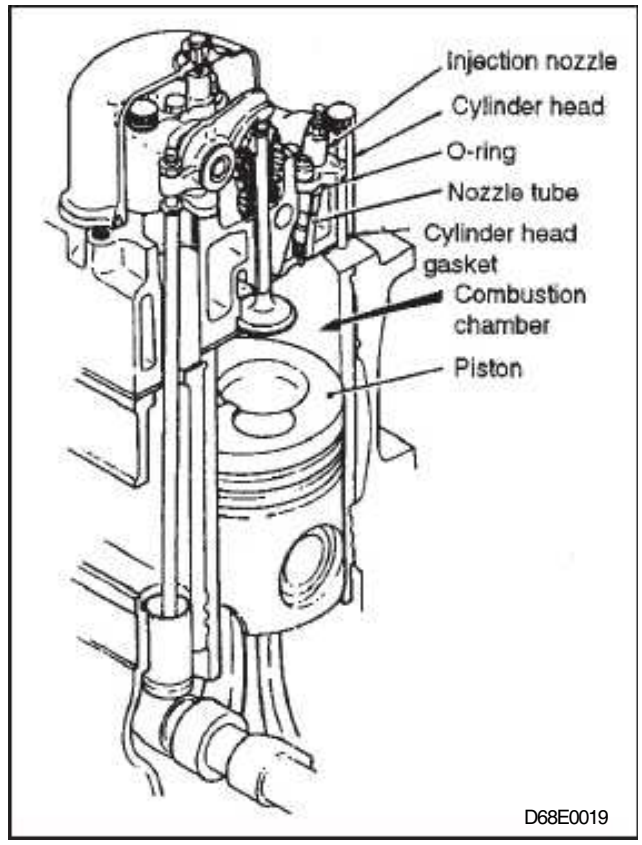
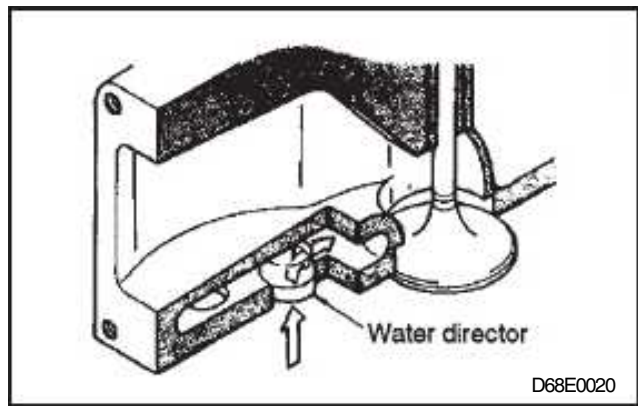


Illustrations (exploded views and assembly drawings) show a typical service procedures if it is identical among various types of available systems and units.

GENERAL [D6A]

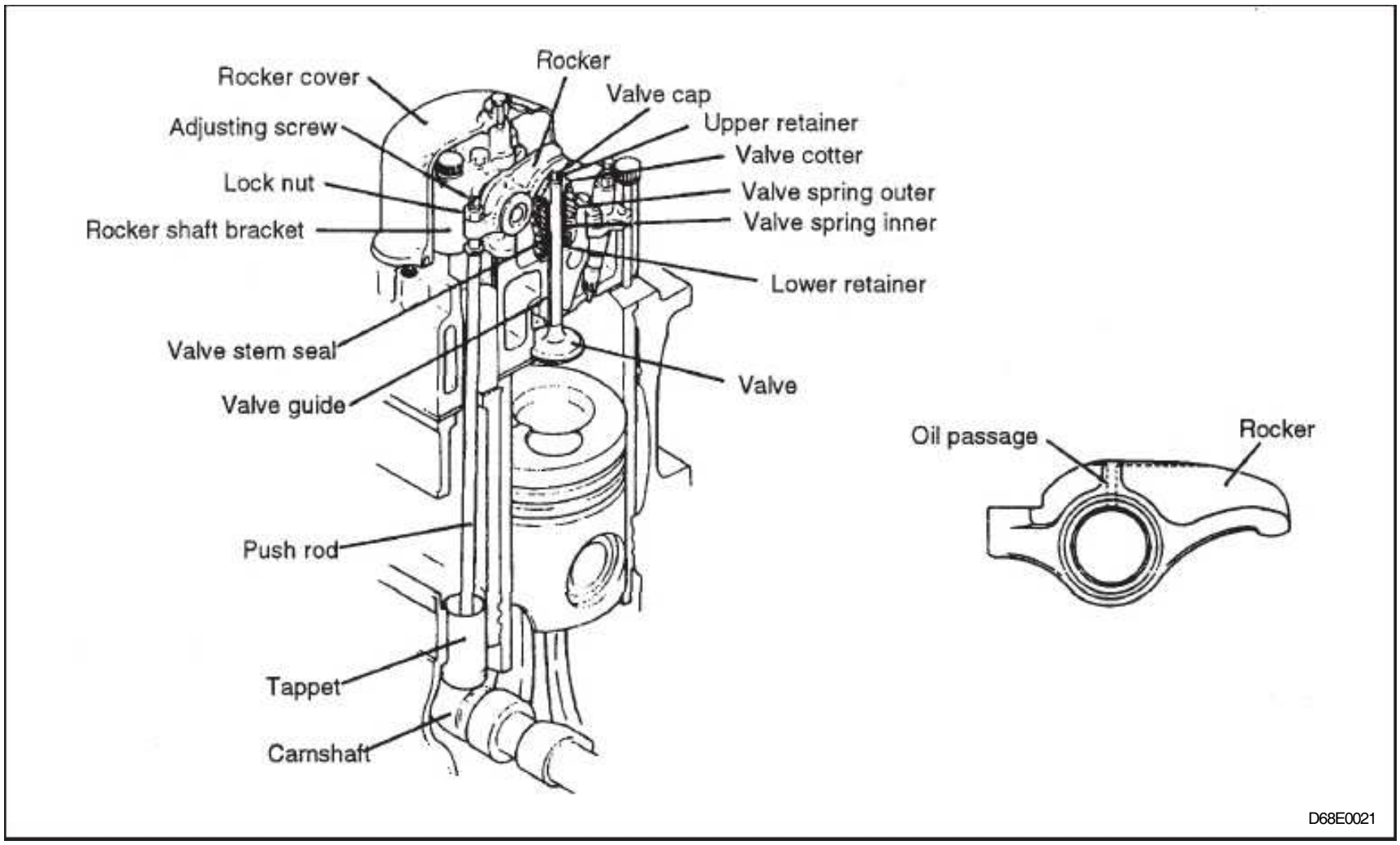
1. Combustion chamber
   The combustion chamber is made up of the cylinder head and piston top. The injection nozzle as well as the nozzle tube is mounted to the cylinder head. The nozzle tube holds the nozzle in position and protects the nozzle sheathed by it from coolant. Since the outside of the nozzle tube is exposed to the water jacket, the top end of the tube is sealed off with an O-ring and the bottom end staked to prevent entrance of water.
   Combustion is accomplished by compressing the fuel directly injected into the combustion chamber. For more effective cooling of the combustion chamber, water directors which direct coolant flow are pressed into the bottom of the cylinder head.
2. Valve mechanism





The valve mechanism is of overhead valve type and is constructed as shown below.

(a) The valve seat angle is 45°C



A valve stem seal is provided on the stem of valve to control the quantity of lubricant of the valve and valve guide sliding portions.

(b) The valve springs are unevenly-pitched springs.
Two inner and outer springs different in coiled direction are installed.

(c) The rocker and rocker shaft are supported on the rocker shaft bracket and are independently installe d for each cylinder. Some rockers are used for both inlet and exhaust valves.
The rocker shaft is a hollow round rod sealed off by thrust plates at both ends. The inside of the shaft constitutes and engine oil passage.

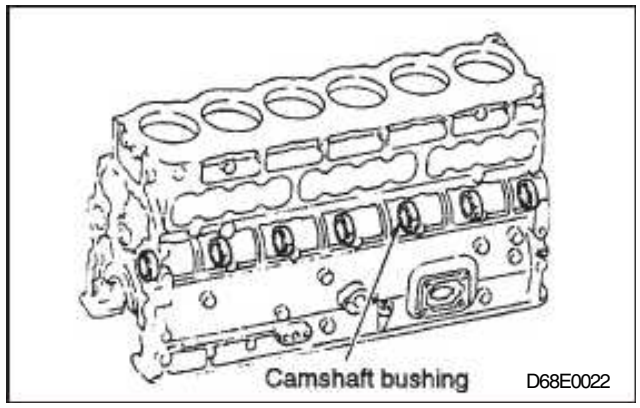
(d) A steel ball and concave piece are respectively welded to the bottom and top ends of the push rod.

(e) The tappet is of cylindrical shape and its mating surfaces with the camshaft are spherical. The tappet is removable through the side of the crankcase.

(f) The cam profile of the camshaft has a special curve. The surface is induction-hardened to improve the performance of the valve mechanism at high speed operation and improve wear resistance.

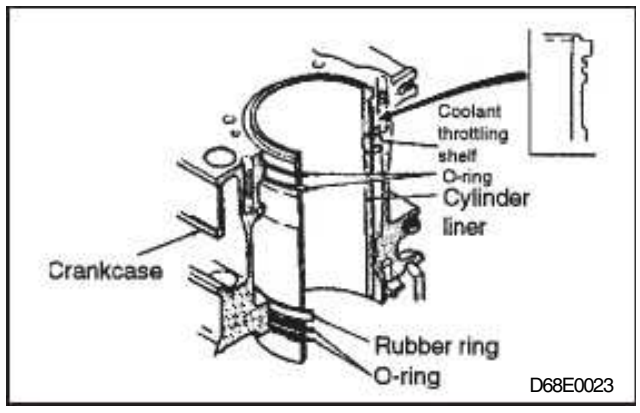
3. Crankcase and cylinder liner

(a) Seven camshaft bushings are installed to the camshaft bearing portion of the crankcase. To facilitate insertion and removal of the camshaft from the rear end of the case, the bearing I.D. is narrower toward the front.



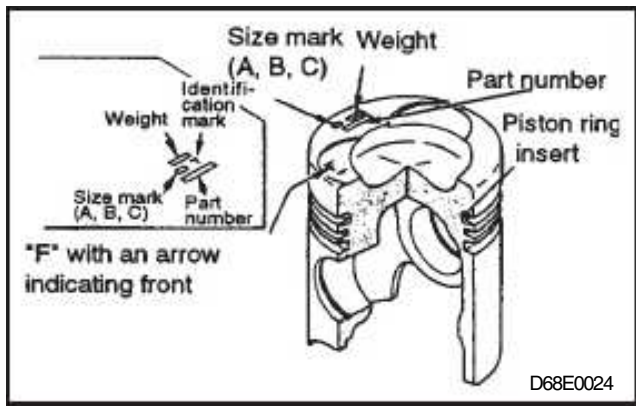
(b) The coolant fed in from the water pump at the left front end of the crankcase cools the oil cooler, then flows through the water jacket holes and around all the cylinders to cool them before reaching the cylinder head.

(c) The cylinder liner is of removable wet type and its top and bottom are press-fitted at the top of the crankcase and the water jacket in crankcase, respectively.
Rubber rings and O-ring are installed at the top and bottom of cylinder liner to prevent entry of coolant.
The water jacket has a coolant throttling shelf for higher cooling performance.

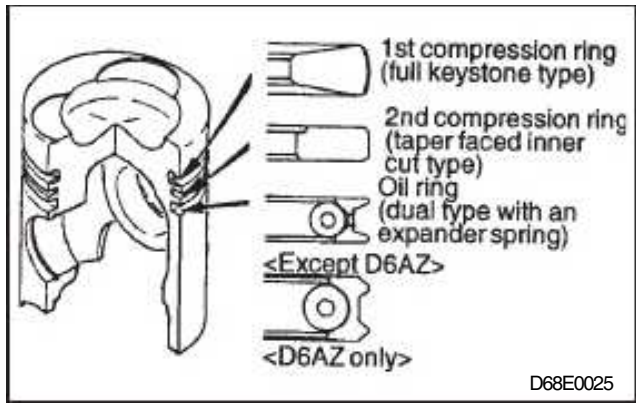


4. Piston and piston ring

(a) Piston
Stamped on the top surface of the piton are a size mark (or oversize dimension on oversize pistons) for selection fit with the cylinder liner, a piston weight mark, part number, and the "F" with and arrow for the front mark showing the piston installing direction.
Piston pin for connecting piston to connecting rod is of full-floating type and is prevented from moving out by means of a snap ring installed on each end of the pin ends.
On D6AU, a cavity is provided in the piston for cooling.

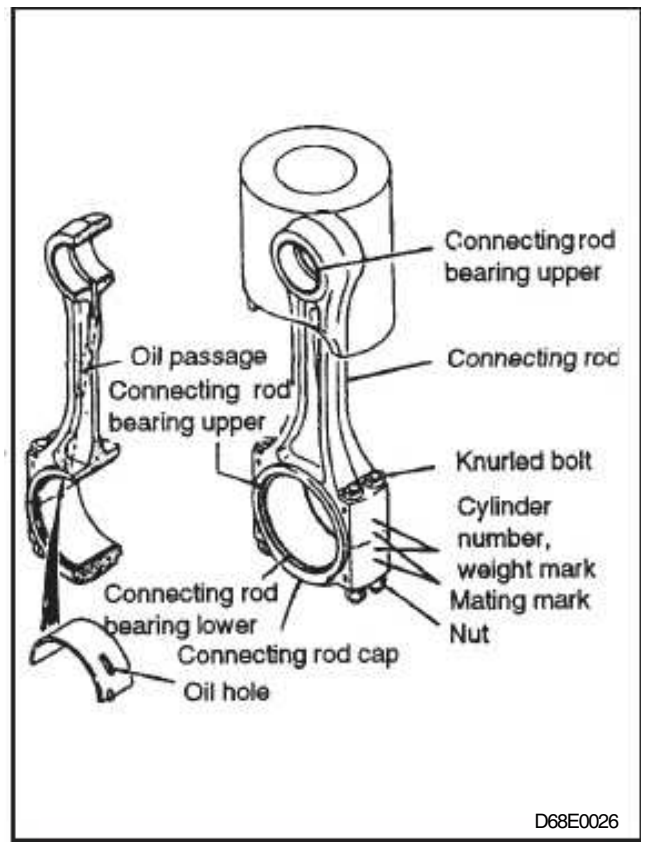


(b) Piston ring
There are three piston rings installed : two compression rings and one oil ring.
The piston rings are shaped as shown in the figure.



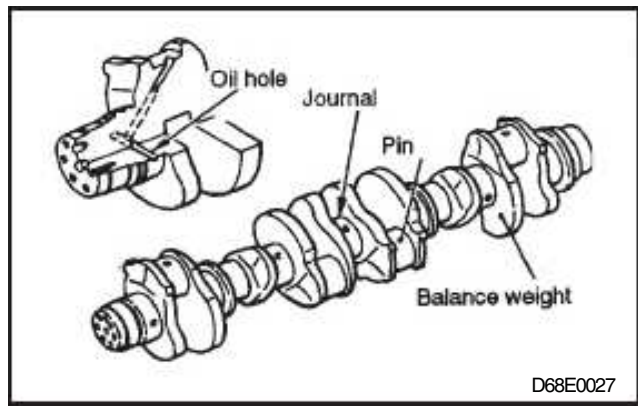
5. Connecting rod and connecting rod bearing

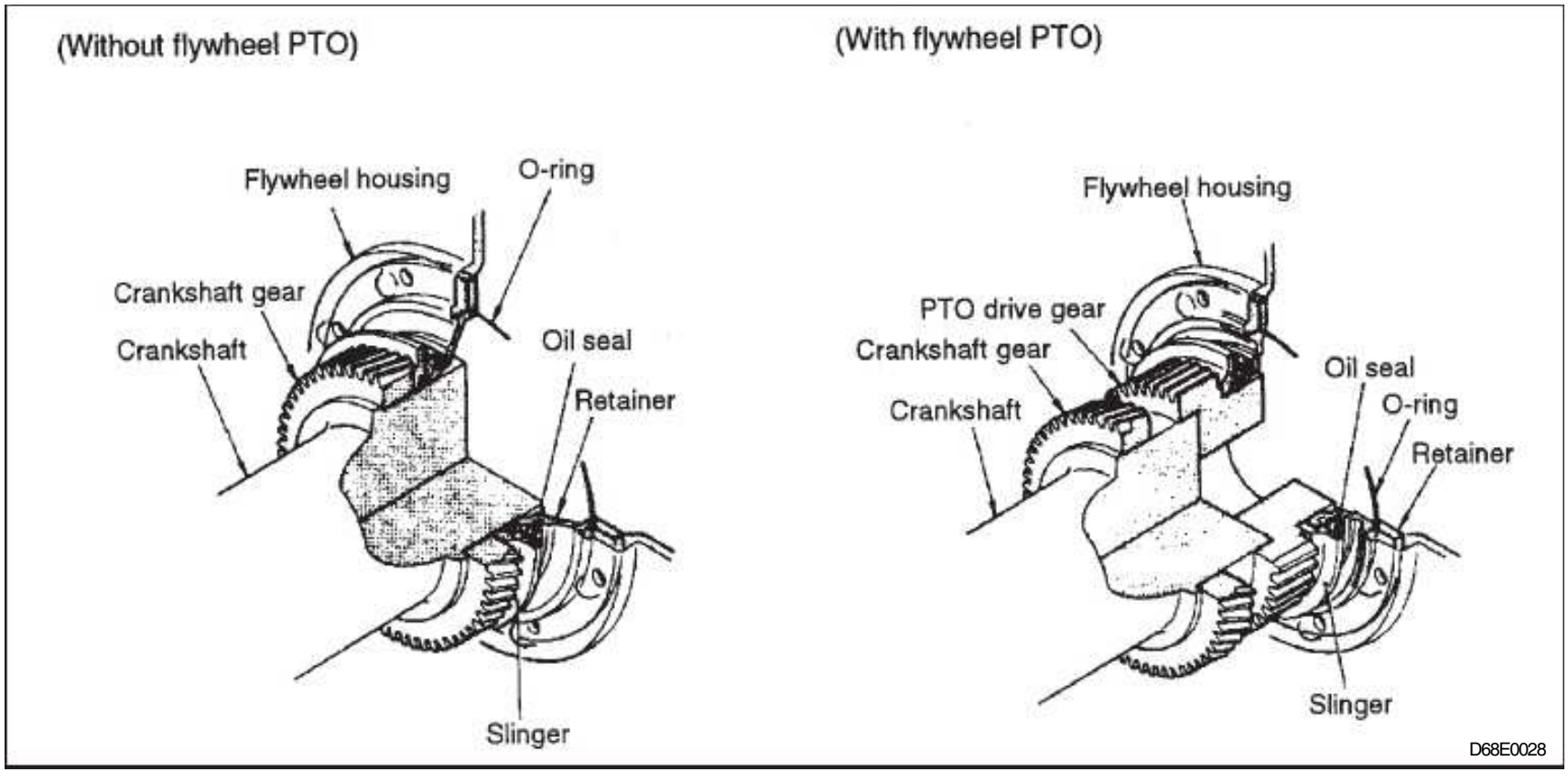
The connecting rod bearing of the big end is a split type plain bearing.
There are upper and lower connecting rod bearings, the upper having an oil hole.
Through the stem of connecting rod, and oil passage is provided obliquely to lubricate the small end bushing.
The connecting rod and connecting rod cap are coupled with four knurled bolts.
On D6AU, an oil hole is drilled in the top of the connecting rod for cooling the piston.



6. Crankshaft and main bearing

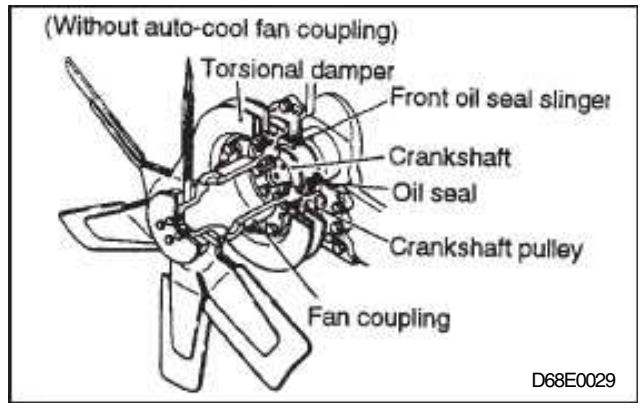
(a) Crankshaft
An oil hole in each journal is through to that in pin, feeding some of the main bearing lubricating to the pin for lubrication of the connecting rod bearing.



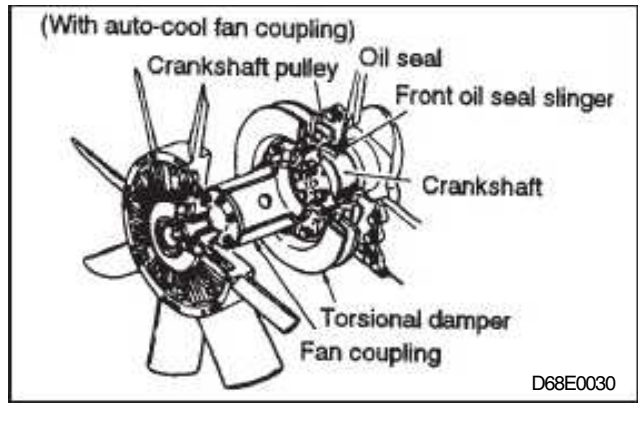


The crankshaft gear driving timing gear is fitted onto the rear end of the crankshaft.
Note that the crankshaft has an axial lip type oil seal fitted to each of its front and rear ends.

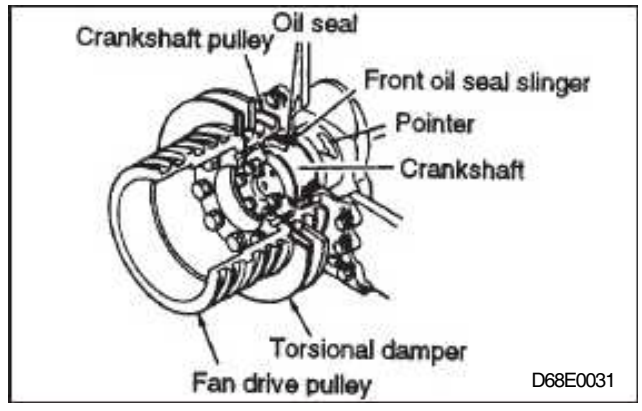
The front end of the crankshaft is of flange type to which the crankshaft pulley is bolted. A torsional damper absorbing torsional vibration of the crankshaft is mounted onto the pulley front together with a fan coupling.



For vehicle with auto-cool fan coupling, the coupling is mounted at the front of fan coupling that is equipped with a cooling fan.

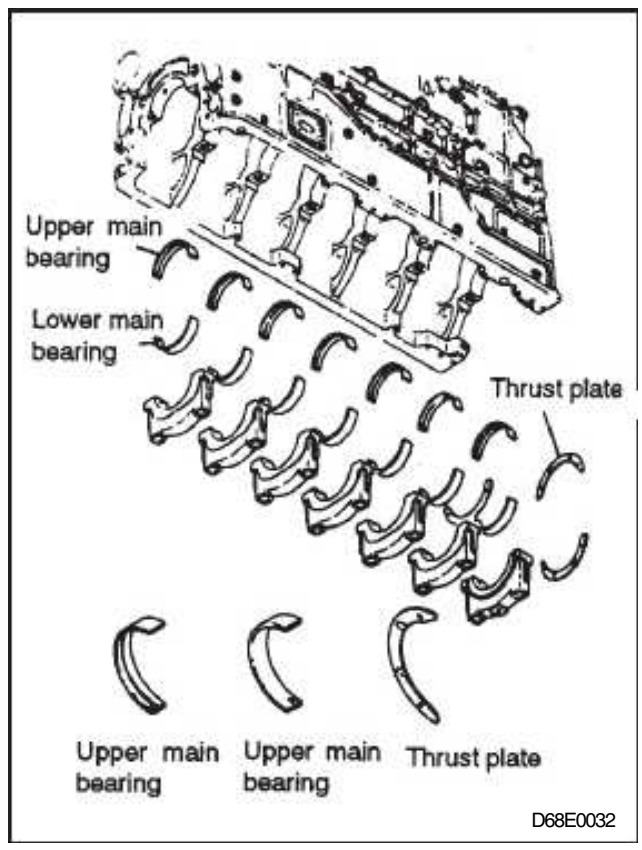


On engines for buses, the fan drive pulley is installed in place of the fan coupling so as to operate the fan drive.



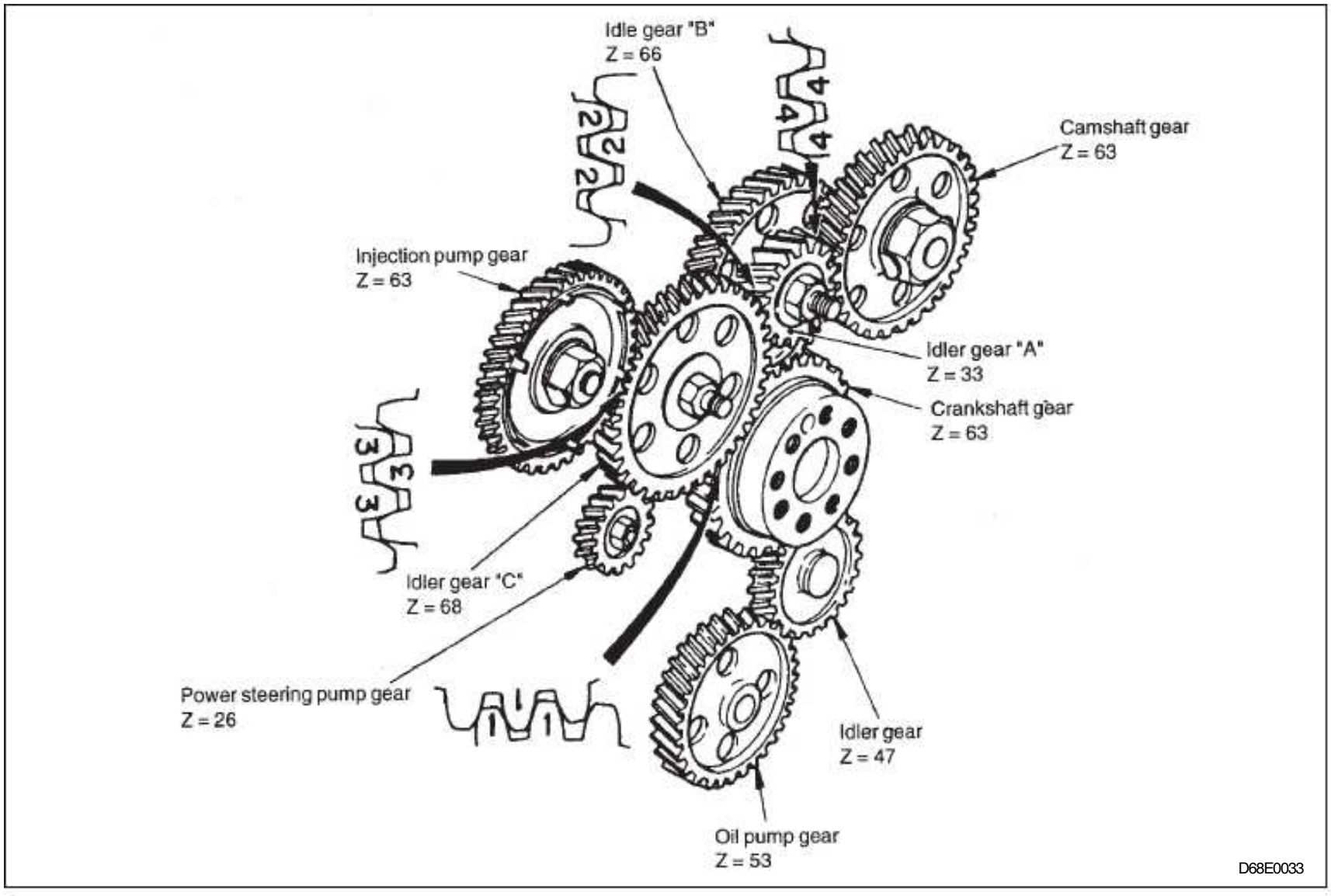
(b) Main bearing

The main bearing is a split type plain bearing made of special alloy plated kelmet metal with backing metal.
The upper main bearing has an internal oil groove and oil hole which coincides with the oil hole in the crankshaft.
Seven pairs of main bearings are provided. Split type thrust plates are mounted to the rear most bearing to bear the of the crankshaft.



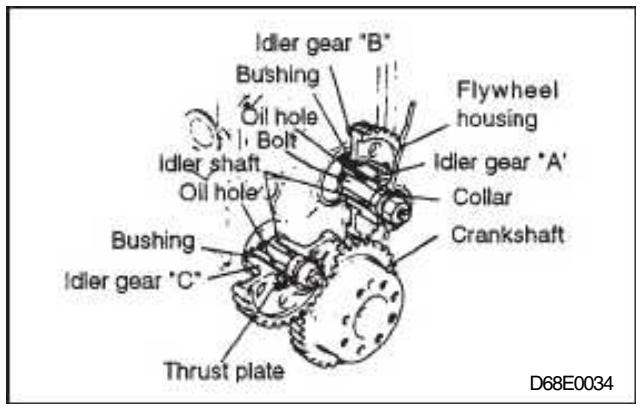
7. Timing gears

The timing gears are accommodated in the flywheel housing at the rear of the engine. The gear train is as shown below.
A timing mark is stamped on each timing gear.
Correct meshing can be achieved by aligning the timing marks at reassembly.

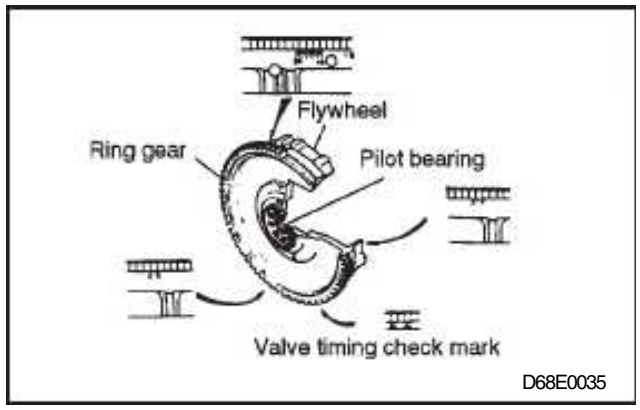


The crankshaft gear, pressfitted onto the crankshaft and held in position by a dowel pin, drives all gears. The idler gear i s, at on end, mounted to the crankcase with the idler shaft bolt, and supported, at the other end, on the flywheel housing.
A bushing is pressed into the idler gear which turns on the idler shaft. The bushing is lubricated by the engine oil flowing through the inside of the idler shaft from the crankcase oil hole.

8. Flywheel

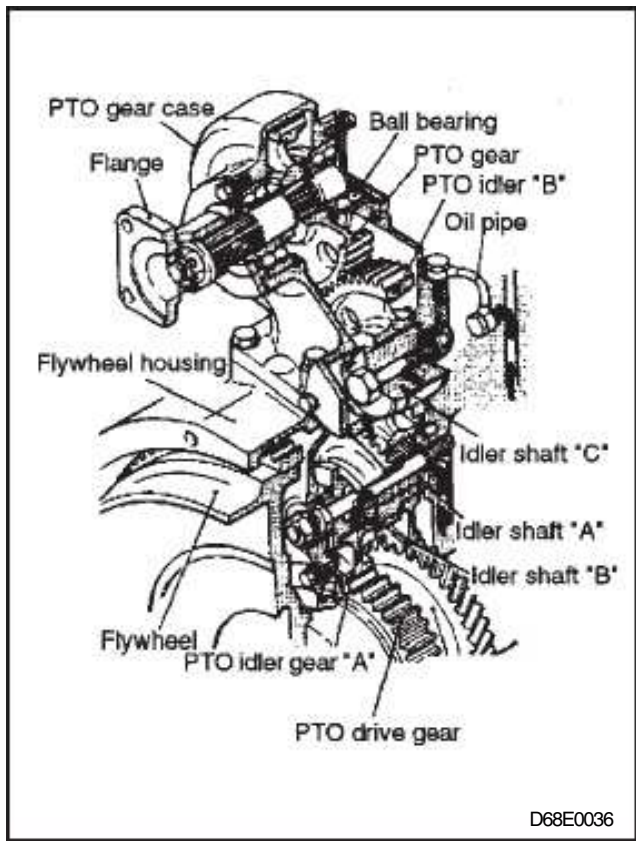


The pilot bearing of the transmission drive pinion is installed at the center of the flywheel. The ring gear which meshed with the starter pinion is shrinkage-fitted on the outside periphery of the flywheel.
One side of the teeth i s chamfered to make sure that the starter pinion fits easily.
The cylinder numbers and angle scale are stamped on the outside periphery of the flywheel as shown in the figure.



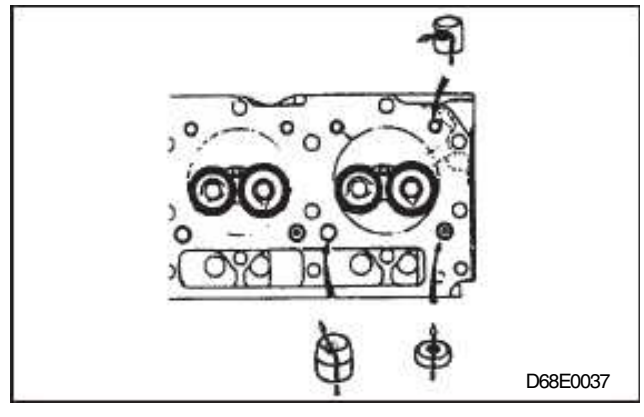
9. Flywheel PTO

The flywheel PTO is installed at the top of the flywheel housing located in the rear of engine. Power is transmitted from the drive gear mounted at the rear end of the crankshaft to PTO idler gear "A", then to PTO idler gear "B", and finally to PTO gear, and is taken off at the flange.
All gears and sliding surfaces are lubricated by the engine oil delivered from the crankcase through oil pipes and oil holes.

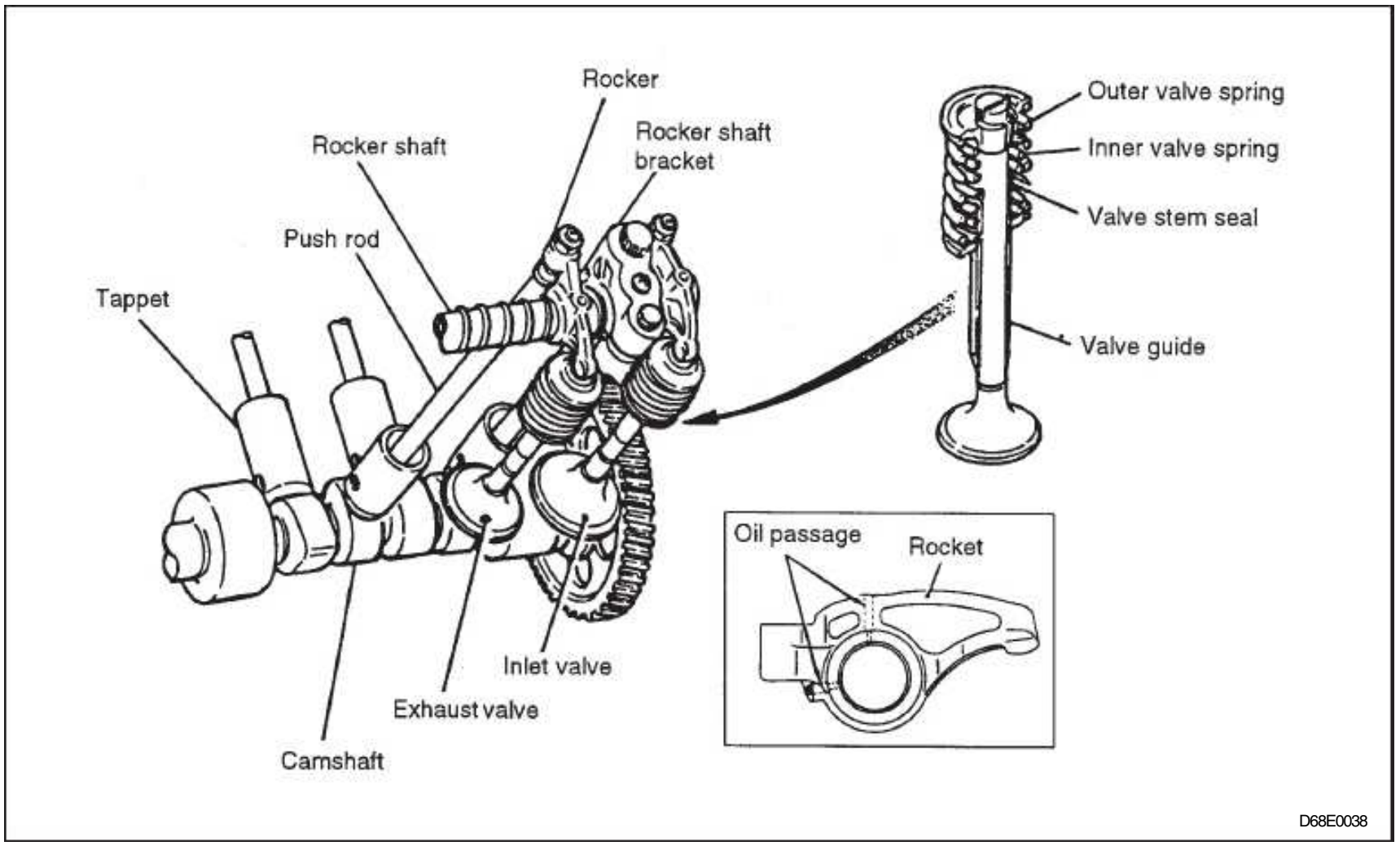


GENERAL [D8A]

1. Combustion chamber
   The combustion chamber is formed by the cylinder head and piston.
   The injection nozzle sheathed by the nozzle tube is mounted to the cylinder head. The nozzle tube holds the nozzle and protects it from cooling water. Since the nozzle tube is exposed to the water in water jacket, it is sealed by an O-ring at the top and by staking at the bottom.
   Combustion is accomplished by compression of the fuel directly injected into the combustion chamber.
   For more effective cooling of the combustion chamber, water directors which direct coolant flow are pressed into the bottom of the cylinder head.



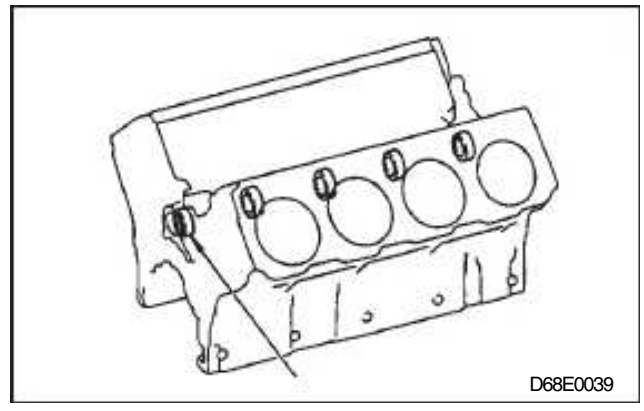
2. Valve mechanism
The valve mechanism is of an overhead valve (OHV) type and is constructed as shown below.



(a) The valve seat angle is 45° for both inlet and exhaust valves.
A valve stem seal is provided on the stem of the valve to prevent the oil from making its way down along the sliding surfaces of the valve and valve guide.
(b) Unevenly-pitched springs are used as valve springs to provide a sufficient allowance for surging of the valve mechanism.
Two inner and outer springs wound in opposite directions are provided.
(c) The rocker, rocker shaft are supported by the rocker shaft bracket.
The rocker shaft is a hollow round rod sealed off with expansion plugs at both ends. The inside of the shaft constitutes and engine oil passage.
(d) A steel ball is welded to the bottom end of the push rod and a spherical concave piece is welded to the top end.
(e) The tappet is of cylindrical, and the surface which makes contact with the camshaft is a largediameter spherical surface which helps prevent localized wear. The tappet can be removed and installed easily without removing the camshaft if the side cover is removed.
(f) The camshaft is located in the V of the crankcase and causes the valves in both right and left banks to move. The cam profile has a special curve which assures smooth acceleration.

3. Crankcase and cylinder liner

(a) Five camshaft bushings are inserted in the camshaft journal sections (bearing sections) of the crankcase. To facilitate removal and installation of the camshaft from the rear end of the case, the bushings are smaller in inside diameter toward the front.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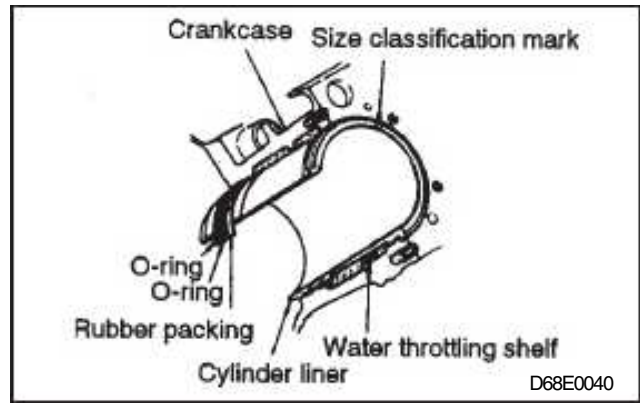
(b) Cylinder liner

<Except D8AB>
The cylinder liner is a wet type and is fitted in the crankcase at the top and bottom. A rubber packing and O-ring are provided at the bottom of the cylinder liner to seal off oil and coolant and minimize the clearance between the cylinder liner and crankcase, thereby preventing cavitation which may otherwise result from wall surface vibration.
The rubber packing is especially effective in preventing the coolant from entering through the fitted portion and pitting the crankcase.
The water jacket has a water throttling shelf to increase the flow velocity, thereby assuring better cooling effect and less temperature difference between one cylinder and another.
At the top of the cylinder liner, a size mark is stamped to permit an optimum combination of the liner and piston.



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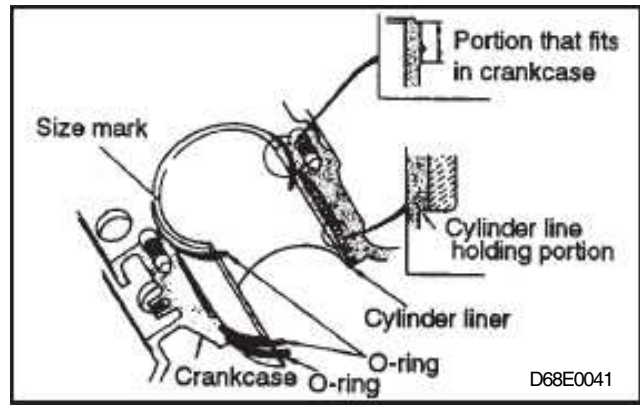
<D8AB>
The cylinder liner is held by the cylinder liner holding portion of the crankcase, and its upper portion fits in the crankcase. An O-ring is provided at the top of the cylinder liner and at the bottom of the crankcase to seal off the coolant.



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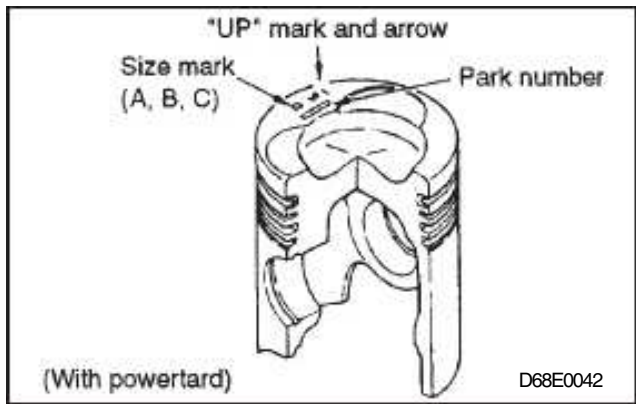
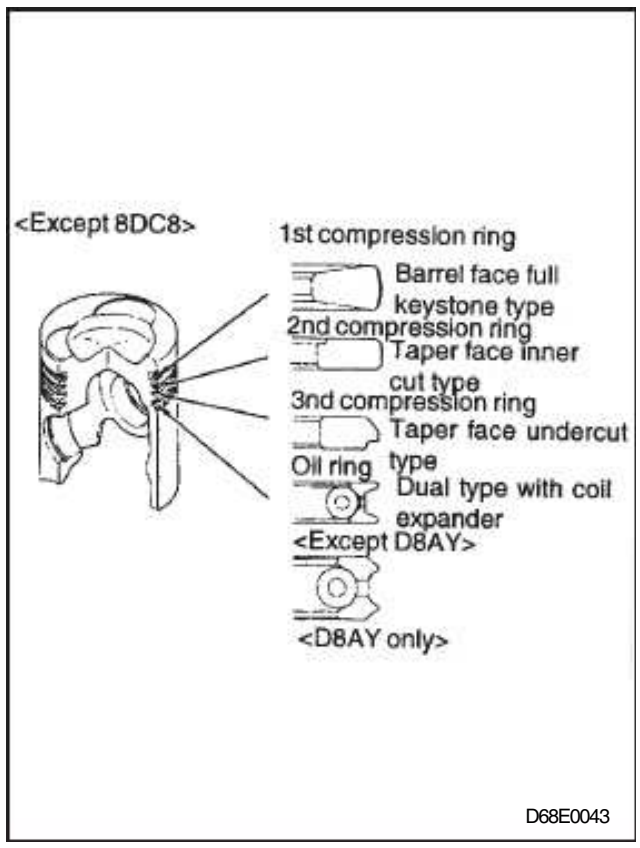
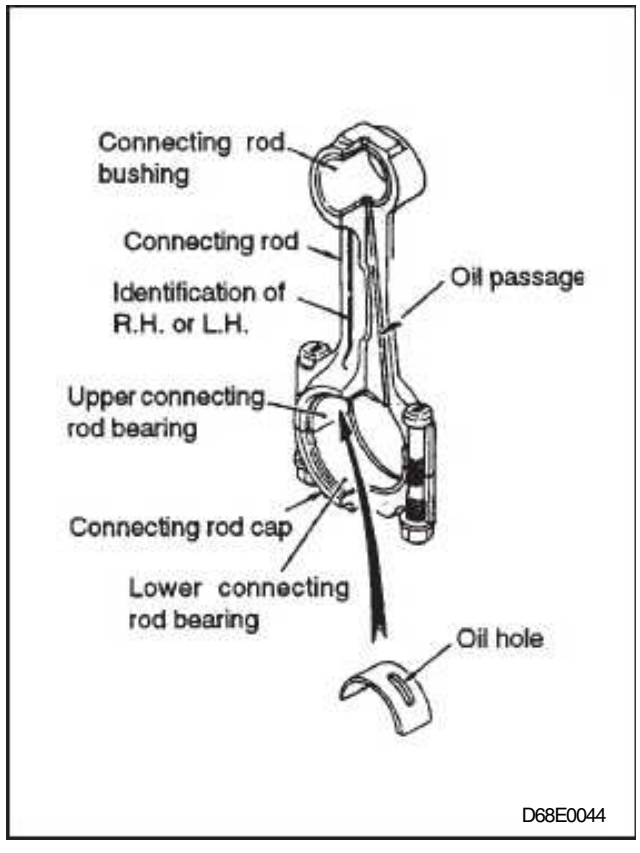
4. Piston and piston ring
   On the piston head, the size mark is stamped to insure the best fit between the piston and the cylinder liner.
   Besides the size mark, the UP and arrow marks indicating the piston installing direction are also stamped.
   The piston pin is fitted in the piston in full-floating style and held in position with snap rings at both ends.



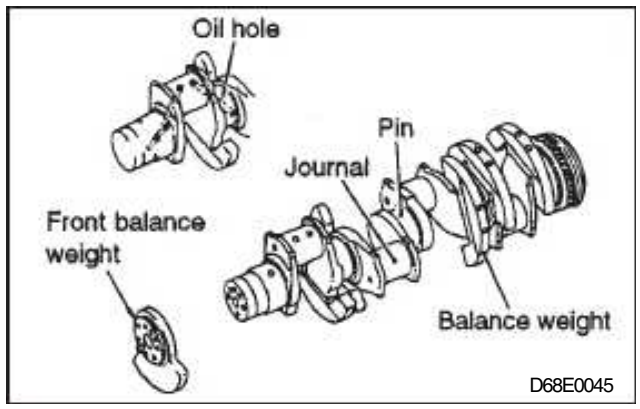


5. Connecting rod and connecting bearing
   Split-style plain bearings are used for the connecting rod big-end bearings.
   The connecting rod bearing may be either upper or lower, the upper one having an oil hole.
   The small end of the connecting rod is wedge-shaped and the oil passage in the connecting rod is inclined to prevent counter flow of oil by the inertia during high speed operation. Because of this inclined oil passage, the connecting rods for the right cylinders are different from those for the left cylinders.

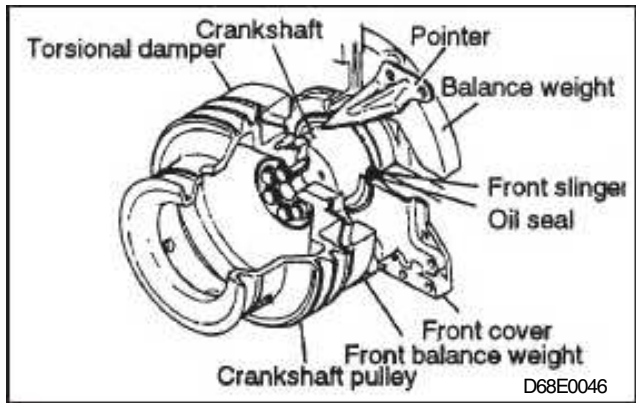


6. Crankshaft and main bearing

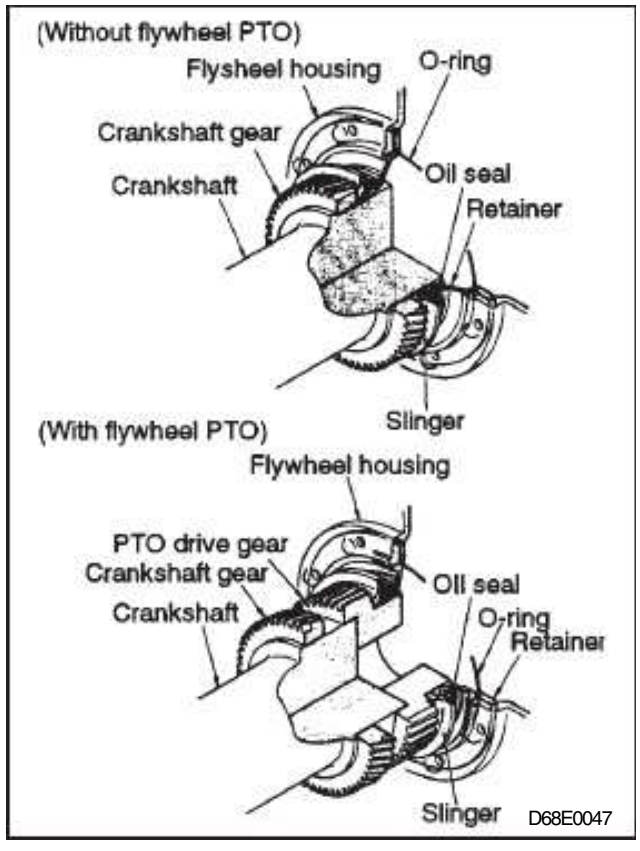
(a) Between each journal and pin, an oil hole is clear to each other feeding the lubricating oil to the pin for lubrication of the connecting rod bearing.
The crankshaft has six balance weights on the webs and a front balance weight at the front of the crankshaft to maintain an optimum balance during operation.



(b) The crankshaft pulley is mounted on the front of the crankshaft.
The front cover is provided with the front oil seal which prevents oil leak.
On engines with turbocharger, a torsional damper is installed on the crankshaft pulley to absorb torsion vibration of the crankshaft.



(c) The crankshaft gear which drives the timing gear is press-fitted on the rear of the crankshaft.
At rear of the crankshaft is provided oil seal to prevent oil leaks.

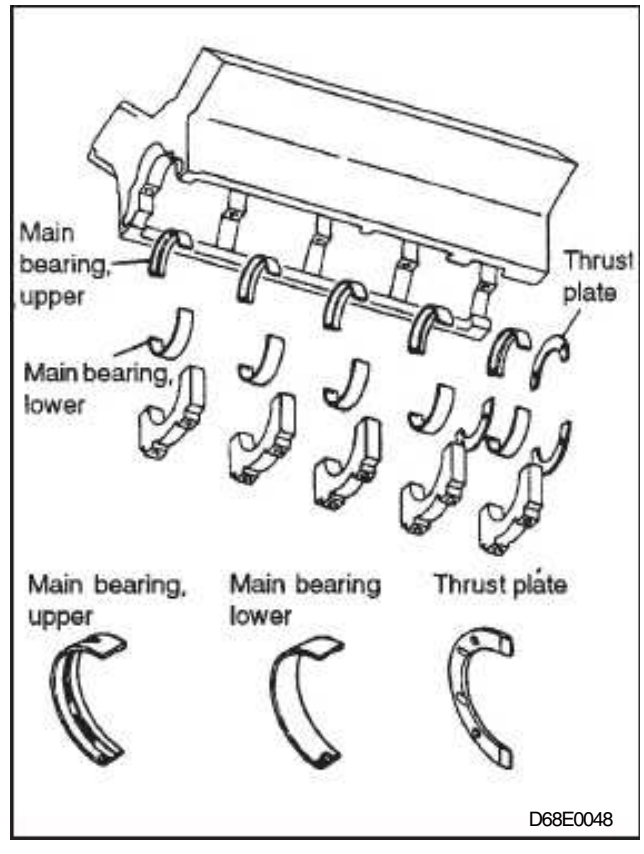


(d) Main bearing

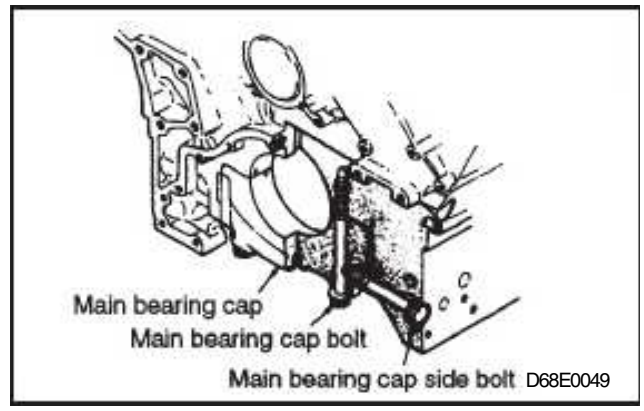
The main bearing is a split-type plain bearing which is a three-layer metal consisting of soft alloy overlay, kelmet metal and backing metal. The entire surface of the main bearing is flash plated with tin.

The inside surface of the upper main bearing is provided with an oil groove and oil hole which coincides with the oil hole of the crankcase.

The rearmost bearing cap is fitted with a split-type thrust plate to support the thrust of the crankshaft.



The main bearing cap is secured to the crankcase by its both sides with the bolts.



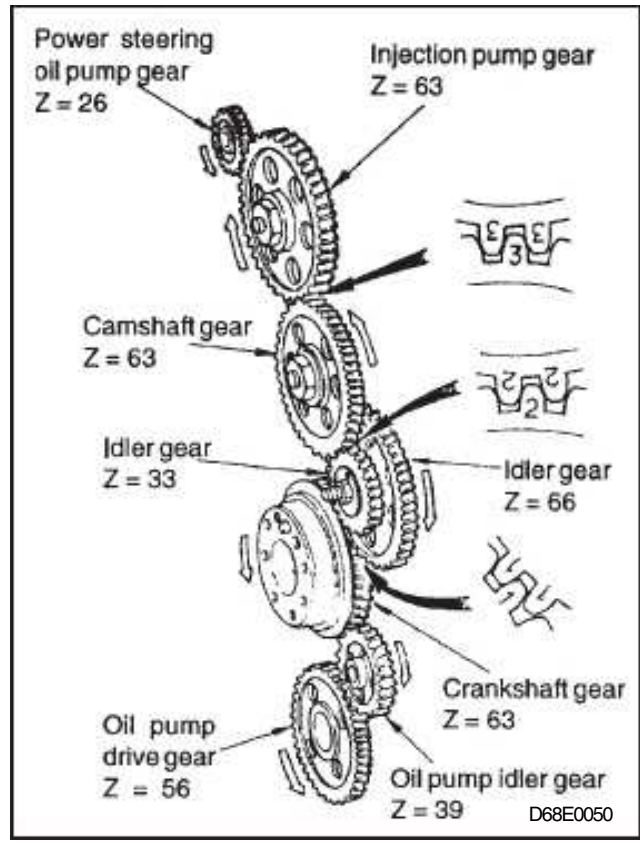
7. Timing gear

The timing gears are accomodated in the rear of the engine. the gear train mechanism is as shown below.

The crankshaft gear drives the idler gear which, in turn, drives camshaft, compressor, injection pump and power steering oil pump.

A timing mark is stamped on each timing gear.

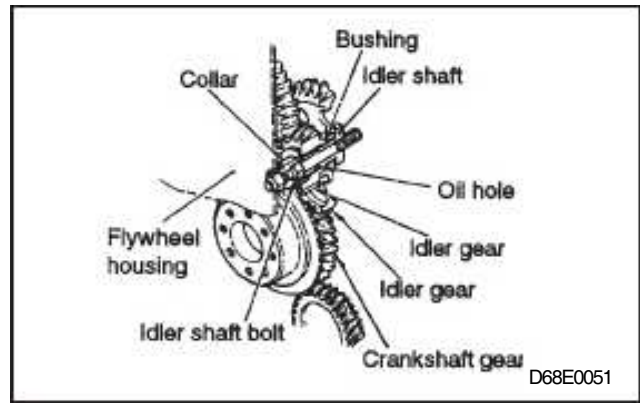
Correct meshing can be achieved by aligning the timing marks at reassembly.



The idler gear is, at one end, mounted to the crankcase with the idler shaft bolt, and supported, at the other end, on the flywheel housing.

A bushing is pressed into the idler gear which turns on the idler shaft.

The bushing is lubricated by the engine oil flowing through the inside of the idler shaft from the crankcase oil hole.

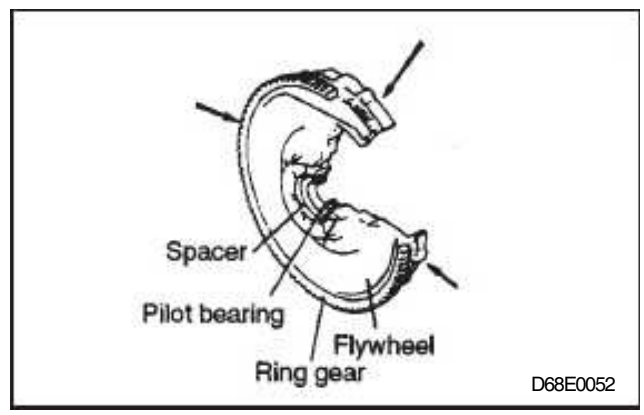


8. Flywheel

The pilot bearing of the transmission drive pinion is installed to the center of the flywheel. The ring gear which meshes with the starter pinion is shrinkagefitted on the flywheel.

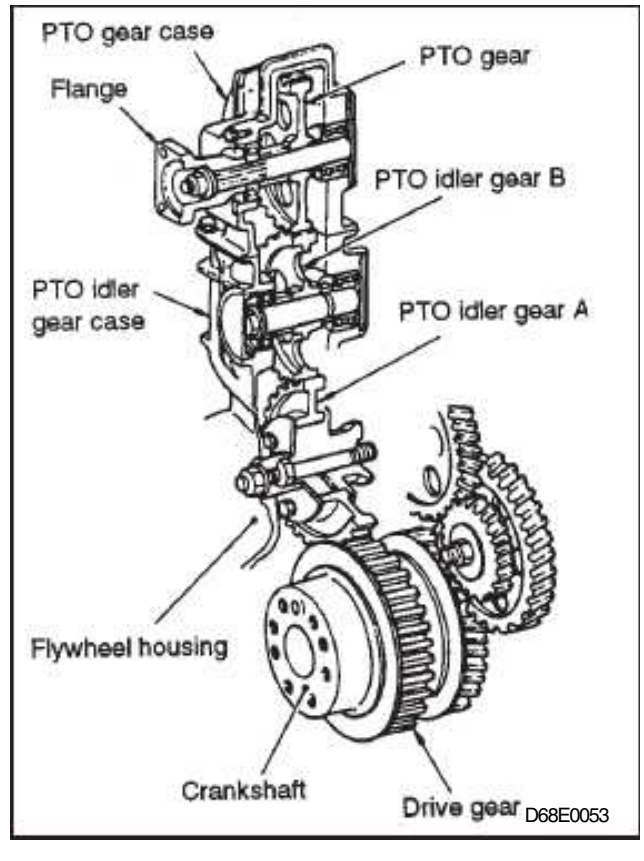
One side of the teeth is chamfered to make sure that the starter pinion fits easily.

The cylinder numbers and angle scale are stamped on the outside periphery of the flywheel as shown.



9. Flywheel PTO

The flywheel PTO is mounted on the upper part of the flywheel housing at the rear of the engine and serves to take out the engine power. It is usually mounted on vehicles such as concrete mixer trucks or crane carrier which often use the engine power during the vehicle running. Power is transmitted from drive gear at the rear end of crankshaft to PTO idler gear A, PTO idler gear B, PTO gear and to the flange.
Each gear is lubricated by oil from the oil main gallery to the PTO idler gear case by the oil pipe.



MAJOR SPECIFICATIONS. [D6A]

Unit: mm

ENGINE MODEL		D6AV	D6AC	D6AB (D6ABDD)
TYPE		4Cycle water cooled direct injection diesel engine	With turbo charger and inter cooler	
NO. OF CYLINDERS	6	6 in line	←	←
ARRANGMENT		1-5-3-6-2-4	←	←
FIRING ORDER		11149	←	←
PISTON DISPLACEMENT (CC)		130x140	←	←
BORE X STROKE (MMX MM)		17.5 : 1	15.5 : 1	16.5 : 1
COMPRESSION RATIO		200/2200	340/2200	310(270)/2200
MAX POWER (PS /RPM)		70/1400	140/1400	125(100)/1400
MAX TORGUE (KG.M/ RPM)		905	990	←
WEIGHT (KG)	DRY	952	1035	1037
	WET	NA	TCI	←
ASPIRATION		1362	1338.6	1482
ENG. SIZE	LENGTH	945	1041.9	←
	WIDTH	1005.7	1171.6	1157
	HEIGHT			
LUBICATION SYSTEM		Forced lubrication system.		
OIL FILTER		Full flow end by pass type.		
OIL COOLER		Plate type.		
OIL PAN CAPACITY (LITS)		20	20	←
LUB OIL (API)		Above CC gra de	←	←
MINIMUM NO -LOAD ENGINE SPEED (RPM)		650±25	600±25	←
MAXIMUM NO-LOAD ENGINE SPEED		2600±20	2520^{+0}_{-30}	2570±20
COOLING TYPE		Water cooling		
COOLING FAN (OUTSIDE DIA.)		Ø580	Ø670	←

MAJOR SPECIFICATIONS. [D8A]

Unit: mm

ENGINE MODEL		D8AB	D8AY	D8AX
TYPE		4Cycle water cooled direct injection diesel engine	←	←
NO. OF CYLINDERS	8	8 in V90°	←	←
ARRANGMENT		1-2-7-3-4-5-6-8	←	←
FIRING ORDER		17787	16031	←
PISTON DISPLACEMENT (CC)		142.2 x 140	135x140	←
BORE X STROKE (MMX MM)		17:1	←	15.5 : 1
COMPRESSION RATIO		355/2200	320/2200	400/2000
MAX POWER (PS /RPM)		125/1400	110/1400	170/1400
MAX TORGUE (KG.M/ RPM)		1165	1120	1285
WEIGHT (KG)	DRY	1220	1170	1340
	WET	NA	NA	TCI
ASPIRATION		1368	1366	1481
ENG. SIZE	LENGTH	1313	1313	1410
	WIDTH	1168	1168	1260
	HEIGHT			
LUBICATION SYSTEM		Forced lubrication system.		
OIL FILTER		Full flow and by pass type.		
OIL COOLER		Plate type.		
OIL PAN CAPACITY (LITS)		20.5	←	←
LUB OIL (API)		Above CD grade		
MINIMUM NO -LOAD ENGINE SPEED (RPM)		600±25	550 ± 25	600 ± 25
MAXIMUM NO-LOAD ENGINE SPEED		2530±20	2480 ± 20	2400 ± 20
COOLING TYPE		Water cooling		
COOLING FAN (OUTSIDE DIA.)		Ø700	Ø670	Ø700

SERVICE STANDARDS AND SPECIFICATIONS [D6A]

Service Standard Table

Unit: mm

Maintenance item		Nominal value (Basic diameter in [ ])	Limit	Remedy and remarks
Compression pressure (at 200 rpm)		2.75 MPa {28 kgf/cm²}	1.96 MPa {20 kgf/cm²}	Difference between cylinder within 0.39 MPa {4 kgf/cm²}
Clearance between rocker and rocker shaft		[28] 0.03 to 0.08	0.2	Replace bushing
Outer valve spring	Free length	89.38	85.0	Replace
	Load N {kgf} (installed length: 58.35)	450 {46.1}	380 {39}	
Inner valve spring	Free length	65.04	62.0	Replace
	Load N {kgf} (installed length: 50.35)	115 {12}	100 {10.2}	
	Squareness	-	2.5	
Clearance between tappet and crankcase		[35] 0.06 to 0.10	0.2	Replace tappet
Runout of push rod		-	0.6	Replace
Cylinder head bottom surface distortion		0.07 or less	0.08	Correct or replace
Height of cylinder head from top to bottom surface		130	129.8	
Sinkage of valve from cylinder head surface	Inlet	0.25 to 0.75	1.0	Replace insert. Measure with new valve. (- shows projection.)
	Exhaust	-0.05 to 0.45	0.7	
Valve stem O.D.	Inlet valve	11.95 to 11.96	11.85	Replace
	Exhaust valve	11.91 to 11.93		
Clearance between valve stem and valve guide	Inlet valve	[12] 0.05 to 0.09	0.2	Replace valve guide
	Exhaust valve	[12] 0.09 to 0.12		
Valve seat angle		45°	-	
Valve margin	Inlet valve	2.2	1.7	Replace
	Exhaust valve	2.5	2.0	Reface up to service limit.
Valve seat insert seat width	Inlet valve	2.69 to 2.97	3.5	Correct or replace
	Exhaust valve			
Eccentricity of flywheel housing		-	0.2	Correct installed condition
Flywheel	Runout	-	0.2	Correct installed condition
	Friction surface distortion	0.1 or less	0.2	Correct or replace
	Depth from clutch cover mounting surface to friction surface	47.8 to 48.2	49.5	Replace
Timing gear backlash	Between crankshaft gear and idler gear B	0.08 to 0.20	0.4	Replace
	Between idler gear A and camshaft gear	0.07 to 0.18	0.4	Replace
	Between idler gear A and idler gear C	0.07 to 0.18	0.4	Replace
	Between idler gear C and injection pump gear	0.08 to 0.20	0.4	Replace
	Between idler gear C and power steering pump gear	0.07 to 0.18	0.4	Replace

Unit: mm

Maintenance item			Nominal value (Basic diameter in [ ])	Limit	Remedy and remarks	
End play of idler gear			0.10 to 0.28	0.4	Replace thrust plate	
End play of PTO idler gear A			0.15 to 0.51	1.0		
End play of camshaft gear			0.05 to 0.22	0.4	Replace bushing	
Idler gear A to idler shaft A clearance			[40] 0.03 to 0.06	0.2	Replace bushing	
Idler gear C to idler shaft C clearance			[46] 0.03 to 0.06	0.2		
PTO idler gear A to idler shaft B clearance			[58] 0.03 to 0.07	0.2	Replace bushing, or after grinding journal for correction, replace with 0.25 undersize bushing	
Clearance between camshaft journal and crankcase	No. 1 journal		[65.00] 0.03 to 0.08	0.25		
	No. 2 journal		[65.25] 0.03 to 0.08			
	No. 3,4 journal		[65.50] 0.03 to 0.08			
	No. 5,6 journal		[65.75] 0.03 to 0.08			
	No. 7 journal		[66.00] 0.03 to 0.08			
Cam profile (Difference between lob height and base circle diameter)	Inlet		8.83	8.3	Replace	Lobe height: 56.167 Base circle diameter: 47.334
			8.82	8.3	Replace	Lobe height: 56.036 Basecirclediameter:47.216
Exhaust			0.05 or less	0.08	Correct or replace	
Camshaft bend Flatness of cylinder liner flange			-	More than 0.1	Replace	
supporting surface on crankcase Crankshaft top surface distortion			0.07 or less	0.2	Remove the minimum necessary metal for correction by grinding	
Projectionofpistonfromtopsurfaceof crankcase			0.87 to 1.33	-	Check all details concerned.	
Cylinder liner	Flange projection		0 to 0.08		Replace	
	I.D.		130.014 to 130.054	130.25		
	Cylindericity		0.02 or less	-	Replace or regrind to oversize	
Clearance between piston and cylinder liner	D6AU		[130] 0.178 to 0.204	-	Replace or correct to oversize	
	D6AZ		[130] 0.173 to 0.199	-		
	D6AB		[130] 0.188 to 0.214	-		
Piston ring groove to piston ring clearance	1st compression ring		0.02 to 0.08	0.25	Replace	
	2nd compression ring	D6AU	0.05 to 0.08	0.15		
		D6AZ, D6AB	0.07 to 0.10	0.15		
	Oil ring		0.03 to 0.06	0.15		
Piston ring end gap			0.4 to 0.6	1.5	Replace	
Clearancebetweenpistonpinandpistonpinhole			[50] 0.01 to 0.02	0.1	Replace piston or piston pin	
Clearance between piston pin and connecting rod small end			[50] 0.02 to 0.05	0.1	Replace bushing	
Connecting rod end play			0.2 to 0.5	1.0	Replace	
Connecting rod bend and torsion			-	0.05 or less	Correct or replace	

Unit: mm

Maintenance item			Nominal value (Basic diameter in [ ])	Limit	Remedy and remarks
Connecting rod bearing	Oil clearance		[84] 0.07 to 0.13	0.25	Replace bearing
	Span when free		-	Less than 90.5	
Crankshaft end play			0.09 to 0.23	0.4	Adjust with oversize thrust plate
Crankshaft bend			0.04 or less	0.1	Correct or replace
Crankshaft pin and journal	Roundness		0.01 or less	0.08	Grind to undersize
	Cylindricity		0.006 or less	-	
Main bearing	Oil clearance		[100] 0.08 to 0.15	0.25	Replace bearing
	Tension when free		-	Less than 106.5	Replace
Flywheel PTO gear overall backlash			0.32 to 0.46	-	Adjust with shims or replace
Backlash between PTO idler gear B and PTO gear			0.13 to 0.25	1.0	Replace bushing
PTO idler gear B end play			0.15 to 0.53	1.0	Replace thrust plate
PTO idler gear B and idler shaft C clearance			[58] 0.03 to 0.07	0.20	Replace
Valve clearance		Intake	0.4	-	Adjust
		Exhaust	0.6	-	

SERVICE STANDARDS AND SPECIFICATIONS [D8A]

Unit: mm

Maintenance item		Nominal value (Basic diameter in [ ])	Limit	Remedy and remarks
Compression pressure (at 200 rpm)		2.75 MPa {28 kgf/cm²}	1.96 MPa {20 kgf/cm²}	Difference between cylinder within 0.39 MPa {4 kgf/cm²}
Clearance between rocker and rocker shaft		[24] 0.01 to 0.08	0.2	Replace bushing, Variation in
Outer valve spring	Free length	89.38	85.0	Replace clearance engine not to exceed 0.08
	Load N {kgf} (installed length: 58.35)	450 {46.1}	380 {39}	
Inner valve spring	Free length	65.04	62.0	Replace
	Load N {kgf} (installed length: 50.35)	115 {12}	100 {10.2}	
	Squareness	-	2.5	
Clearance between tappet and crankcase		[35] 0.06 to 0.10	0.2	Replace tappet
Runout of push rod		-	0.5	Replace
Cylinder head bottom surface distortion		0.07 or less	0.2	Correct or replace
Height of cylinder head from top to bottom surface		114.9 to 115.1	114.6	
Sinkage of valve from cylinder head surface	Inlet	0.25 to 0.75	1.0	Replace insert. Measure with new valve. (- shows projection.)
	Exhaust	-0.05 to 0.45	0.7	
Valve stem O.D.	Inlet valve	11.95 to 11.96	11.85	Replace
	Exhaust valve	11.91 to 11.93		
Clearance between valve stem and valve guide	Inlet valve	[12] 0.05 to 0.09	0.2	Replace valve guide
	Exhaust valve	[12] 0.09 to 0.12		
Valve seat angle		45°	-	
Valve margin	Inlet valve	2.2	1.7	Replace Reface up to service limit.
	Exhaust valve	2.5	2.0	
Valve seat insert seat width	Inlet valve	2.69 to 2.97	3.5	Correct or replace
	Exhaust valve			
Eccentricity of flywheel housing		-	0.2	Correct installed condition
Flywheel	Runout	-	0.2	Correct installed condition
	Friction surface distortion	0.1 or less	0.2	Correct or replace
	Depth from clutch cover mounting surface to friction surface	47.8 to 48.2	49.5	Replace
Timing gear backlash	Between crankshaft gear and idler gear	0.08 to 0.20	0.4	Replace
	Between idler gear and camshaft gear	0.07 to 0.18	0.4	Replace
	Between camshaft gear and injection pump gear	0.08 to 0.20	0.4	Replace
	Between injection pump gear and power steering pump gear	0.07 to 0.18	0.4	Replace
	Between PTO drive gear and PTO idler gear A	0.17 to 0.29	0.4	Replace

Unit: mm

Maintenance item			Nominal value (Basic diameter in [ ])	Limit	Remedy and remarks	
End play of idler gear	Camshaft gear side		0.10 to 0.28	0.4	Replace thrust plate	
	PTO gear side		0.10 to 0.20	0.4		
End play of camshaft gear			0.11 to 0.20	0.4	Replace thrust plate	
Clearance between idler shaft and idler gear	Camshaft gear side		[40] 0.03 to 0.06	0.2	Replace bushing	
	PTO gear side		[76] 0.06 to 0.11	0.25		
Clearance between camshaft journal and crankcase	No. 1 journal		[65.25] 0.07 to 0.10	0.25	Replace bushing, or after grinding journal for correction, replace with 0.25 undersize bushing	
	No. 2 journal		[65.25] 0.07 to 0.10			
	No. 3 journal		[65.50] 0.07 to 0.10			
	No. 4 journal		[65.75] 0.07 to 0.10			
	No. 5 journal		[66.00] 0.07 to 0.10			
Cam profile (Difference between lob height and base circle diameter)	Inlet		8.86	8.36	Replace	Lobe height: 56.167 Base circle diameter: 47.282
	Exhaust		8.78	8.36	Replace	Lobe height: 56.036 Basecirclediameter:47.239
Camshaft bend			0.05 or less	0.08	Correct or replace	
Crankshaft top surface distortion			0.07 or less	0.2	Remove the minimum necessary metal for correction by grinding	
Projection of piston from top surface of crankcase			0.72 to 1.22	-	Check all details concerned.	
Cylinder liner	Flange projection	Except D8AB	0.08 to 0.17	-	Replace	
		D8AB only	0.25 to 0.4	-		
	I.D.	Except D8AB	130.014 to 130.054	135.25		
		D8AB only	142 to 142.04	142.25		
	Cylindericity		0.02 or less	-	Replace or regrind to oversize	
Clearance between piston and cylinder liner	D8AY		[135] 0.193 to 0.219	-	Replace or correct to oversize	
	D8AB		[142] 0.193 to 0.219	-		
Piston ring groove to piston ring clearance	1st compression ring		0.02 to 0.08	0.25	Replace	
	2nd, 3rd compression ring	D8AY	0.05 to 0.08	0.15		
		D8AB	0.07 to 0.10	0.15		
	Oil ring		0.03 to 0.06	0.15		
Piston ring end gap	1st compression ring	Except D8AB	0.4 to 0.6	1.5	Replace	
		D8AB only	0.55 to 0.7	-		
	2nd, 3rd compression ring	Except D8AB	0.04 to 0.6	-		
		D8AB only	0.45 to 0.6	-		
	Oil ring		0.4 to 0.6	-		
Clearance between piston pin and piston pin hole			[50] 0.01 to 0.02	0.1	Replace piston or piston pin	
Clearance between piston pin and connecting rod small end			[50] 0.01 to 0.05	0.1	Replace bushing	
Connecting rod end play			0.4 to 0.8	1.0	Replace	
Connecting rod bend and torsion			-	0.05 or less	Correct or replace	

Maintenance item		Nominal value (Basic diameter in [ ])	Limit	Remedy and remarks
Connecting rod bearing	Oil clearance	[90] 0.05 to 0.11	0.25	Replace
	Span when free	[90] 0.05 to 0.11	Less than 90.5	
Crankshaft end play		0.15 to 0.29	0.4	Adjust with oversize thrust plate
Crankshaft bend		0.03 or less	0.1	Correct or replace
Crankshaft pin and journal	Roundness	0.01 or less	0.08	Grind to undersize
	Cylindricity	0.006 or less	-	
Main bearing	Oil clearance	[100] 0.06 to 0.12	0.25	Replace bearing
	Span when free	-	Less than 106.5	Replace
Flywheel PTO gear overall backlash (at 100 on flange)		0.18 to 0.31	-	Adjust with shims or replace
Backlash between PTO idler gear B and PTO gear		0.08 to 0.2	-	Replace
Valve clearance (when cold)	Inlet	0.4	-	
	Exhaust	0.6		

Tightening Torque Table [D6A]

Location tightened	Screw size O.D. x pitch (mm)	Tightening torque N.m {kgf.m}	Remarks
Cylinder head bolt	M14 x 2	-	Wet. Refer to Item 6 , Page 20-51 for tightening procedure.
Rocker bracket bolt	M10 x 1.5	34 {35}	
Rocker cover bolt	M10 x 1.25	4.9 {0.5}	
Rocker adjusting screw lock nut	M10 x 1.25	59 {6}	
Check valve of oil jet	M12 x 1.75	34 {3.5}	
Connecting rod nut	M13 x 1.25	115 {12}	Wet
Main bearing cap bolt	M18 x 2.5	370 {38}	Wet
Crankshaft pulley bolt	M14 x 1.5	175 {18}	
Camshaft gear nut	M27 x 1.5	265 {27}	Wet
Idler shaft A bolt	M16 x 2	155 {16}	
Idler shaft C bolt	M16 x 2	155 {16}	
Idler shaft nut (for mounting collar)	M16 x 1.5	98 {10}	
Flywheel bolt	M16 x 1.5	315 {32}	Wet
Flywheel housing bolt	M12 x 1.75	67 {7}	
PTO idler shaft C bolt	M16 x 2	135 {14}	
PTO shaft nut (for mounting flange)	M18 x 1.5	125 {12.8}	

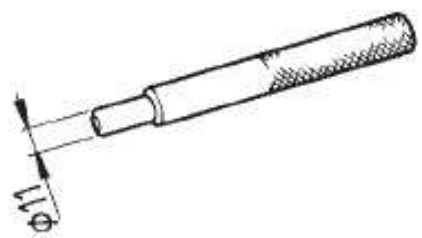
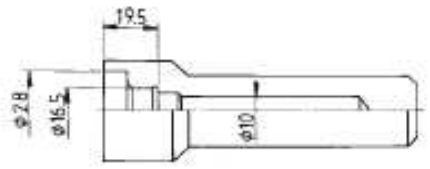
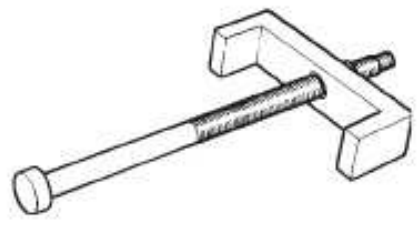
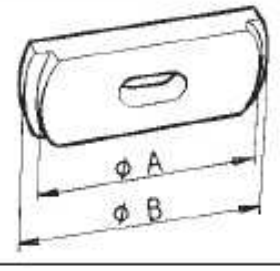
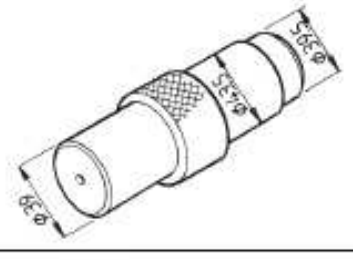
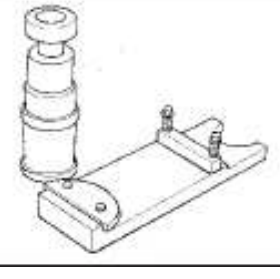
[D8A]

Unit: Nm(kgf m)

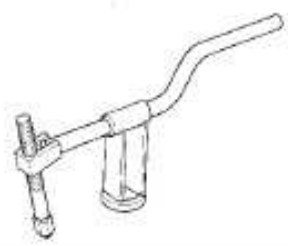
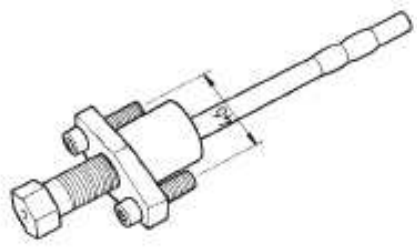
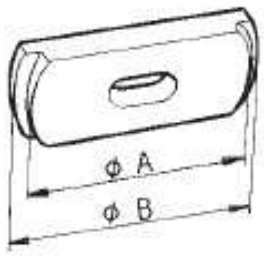
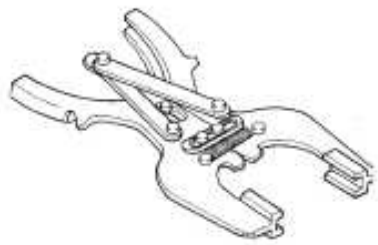
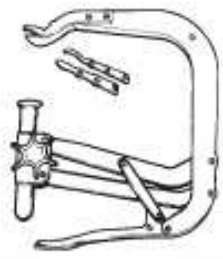
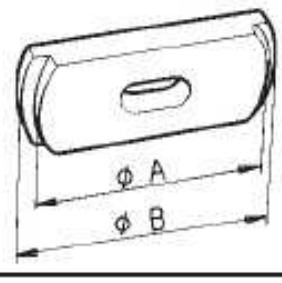
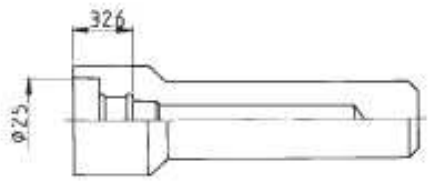
Locationtightened		Screw size O.D x pitch (mm)	Tightening torque	Remarks
Cylinder head bolt		M14 x 2.0	175 (18)	Wet
		M16 x 2.0	285 (29)	Wet
Rocker bracket bolt		M12 x 1.75	49 (5)	
Rocker cover screw		M8 x 1.25	3.9 (0.4)	
Rocker adjusting screw lock nut		M10 x 1.25	59 (6)	
Side cover bolt		M10 x 1.5	2.9 (0.3)	
Connecting rod nut		M16 x 1.5	225 (23)	Wet
Main bearing cap bolt		M18 x 2.5	370 (38)	Wet
Main bearing cap side bolt		M14 x 2.5	175 (18)	Wet
Balance weight mounting bolt		M16 x 1.5		Wet. Refer to Item (18)
Crankshaft pulley bolt		M14 x 1.5	175 (18)	
Front cover bolt		M10 x 2.0	31 (3.4)	
Torsional damper mounting bolt		M12 x 2.0	98 (10)	
Camshaft gear nut		M27 x 1.5	265 (27)	Wet
Flywheel bolt		M16 x 1.5	315 (32)	Wet
Check valve (oil jet position)		M12 x 1.75	34 (3.5)	Wet
Idler gear shaft bolt		M16 x 2.0	115 (12)	
PTO idler gear shaft bolt		M16 x 2.0	155 (16)	
PTO shaft nut (for mounting collar)		M18 x 1.5	125 (12.8)	
PTO idler shaft nut		M18 x 1.5	125 (12.8)	
Idler shaft nut (for mounting collar)	Camshaft gesr side	M16 x 1.5	98 (10)	
	PTO gear side	M16 x 1.5	155 (16)	
Flywheel housing bolt		M12 x 1.75	69 (7)	

SPECIAL TOOLS

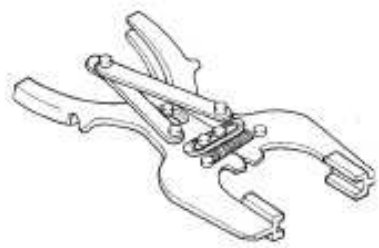
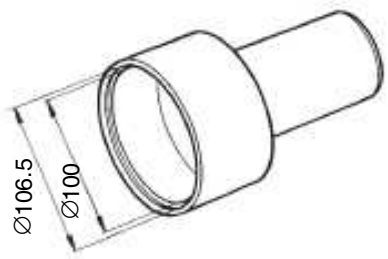
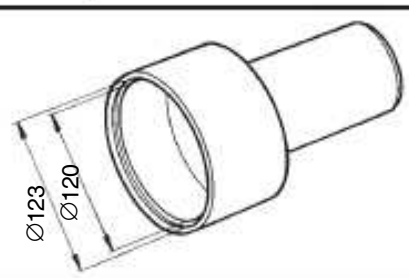
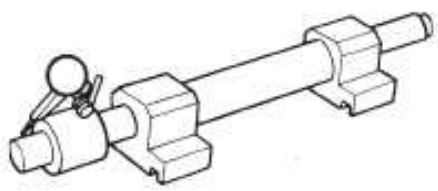
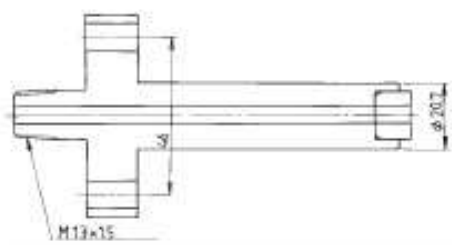
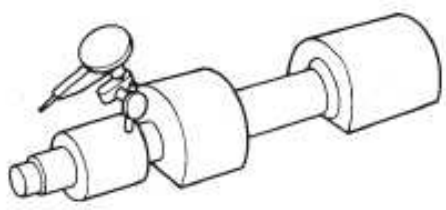
Unit : mm

Tool name (Number and Name)	Illustration	Use
Nozzle tube remover 09211-70200		Removal of nozzle tube
Valve guide remover 09211-71100		Removal of valve guide
Valve stem seal installer 09222-45100		Installation of valve stem seal
Cylinder liner puller 09222-62100		Removal of cylinder liner
Cylinder liner remover 09222-62200		Removal of cylinder liner (Use with 09222-62100)
Rocker bush puller 09222-71000		Removal and installation of rocker bushing
Con-rod bushing puller 09222-71100		Replacement of connecting rod bushing

Unit : mm

Tool name (Number and Name)	Illustration	Use
Valve spring compressor 09222-71200		Removal and installation of valve cotter
Nozzle tube installer 09222-71300		Installation of nozzle tube
Cylinder liner remover 09222-72000		Removal of cylinder liner (Use with 09222-62100)
Piston ring tool 09222-83200		Removal and installation of piston ring
Valve spring compressor 09222-83300		Removal and installation of valve cotter
Cylinder liner remove 09222-87100		Removal of cylinder liner (Use with 09222-62100)
Valve stem seal installer 09222-87200		Installation of valve stem seal

Unit : mm

Tool name (Number and Name)	Illustration	Use
Piston ring tool 09222-87300		Removal and installation of piston ring
Piston guide clamp 09222-88200		Installation of piston
Rear oil seal slinger 09231-62100		Installation of oil seal slinger
Pear oil seal slinger installer 09231-87100		Installation of oil seal slinger
Injection pump centering tool 09353-87101		Centering of bracket AD type injection pump
Air compression adapter 09353-87200		Measurement of compression pressure
Valve stem seal installer 09353-87300		Centering of bracket P type injection pump

Unit : mm

Tool name (Number and Name)	Illustration	Use
Puller set 09431-83100		Removal of gear and bearing

TROUBLESHOOTING

Deterning Time to Overhall

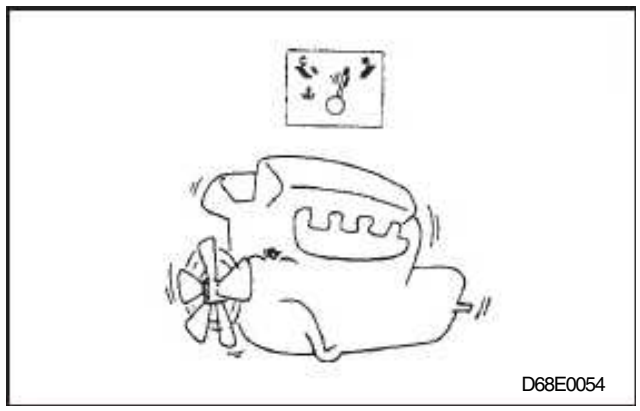
A time to overhall the engine should be determined on the basis of a reduced compression pressure and also in cansideration of an increased blow-by gas.

A reduced output, increased fuel consumption, reduced oil pressure, hard starting, etc. also can be data for determining a time to overhall the engine, but thege are often bue to the effects of other causes and do not always provide yardsticks for determining a time to overhall the engine.

NOTE:

1) Measure the compression pressure at regular inter vals and keep records of its changes.

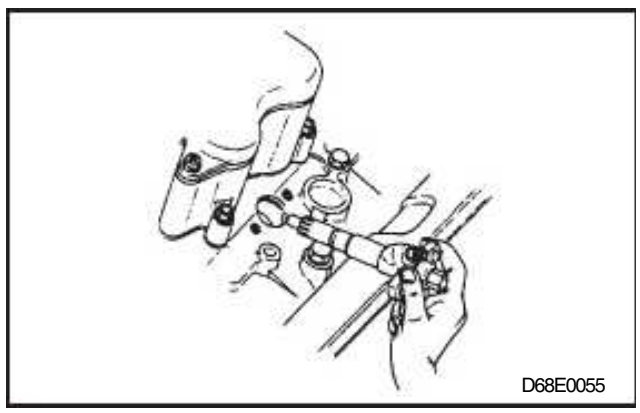
2) When the vehicle is new or when parts are replaced, the compression pressure slightly rises due to inad equate seating of the piston rings, valve seats, etc. but will soon fall as the parts are worn down.


D68E0054

Measurement of Compression Pressure

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

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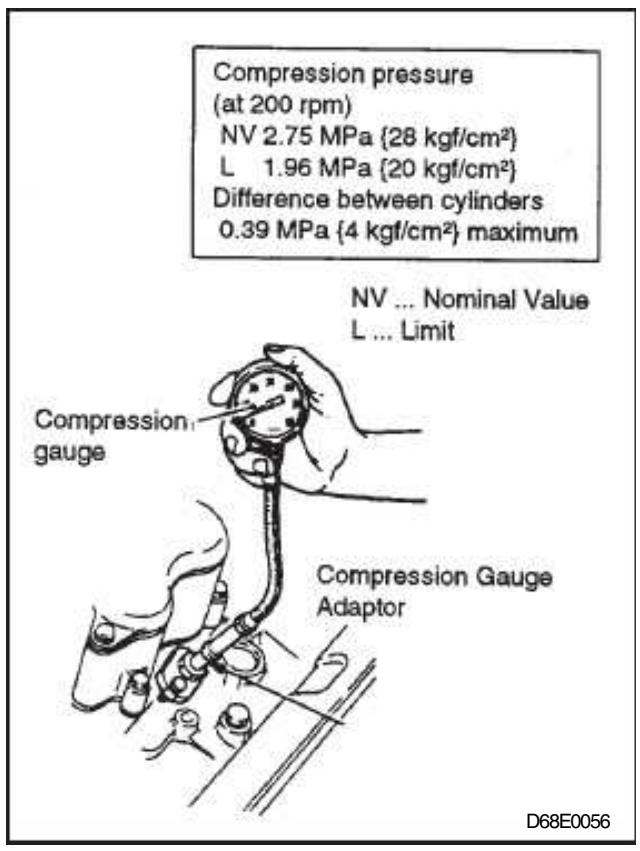


D68E0056

Measurement Procedure

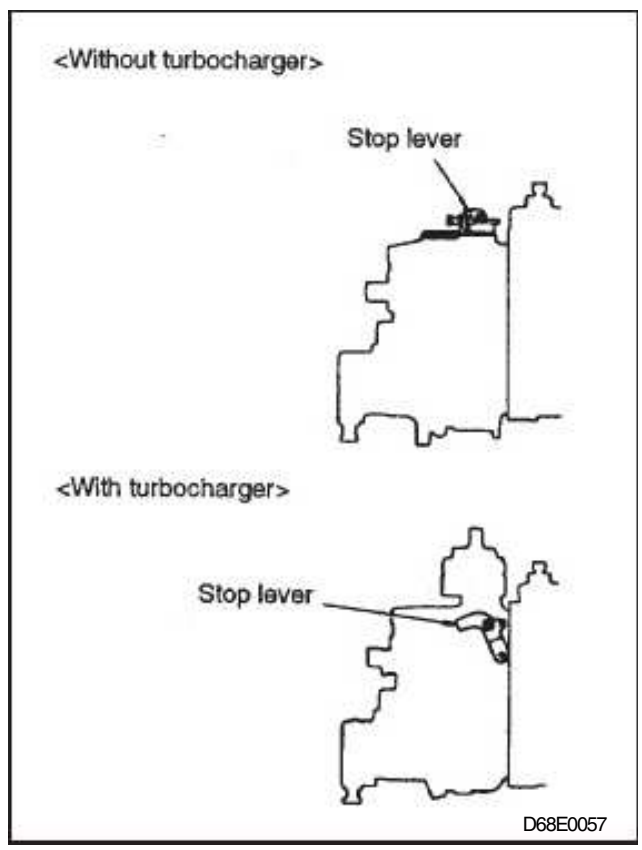
1. Retighten the cylinder head bolts to specified torque and let the engine warm up until the coolant temperature reaches 75 to 85°C.

   NOTE
   For the cylinder head bolt retightening sequence, refer to installation of cylinder head, page 20-

2. Remove all injection nozzles from the cylinder head.

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

3. Install compression Gauge Adaptor (special tool) on the injection nozzle mounting hole together with a gaxket and connect the compression gauge (measuring instrument.)
4. To prevent fuel from being injected out of the injection pump, keep the stop lever of the injection pump pulled in the stop direction all the way.
5. In this state, operate the starter to run the engine and measure the compression pressure when the engine speed reaches 200rpm. (D6A), (D8A)



Norminal value	Limit	Difference in pressure between cylinders
2.75 Mpa (28kgf/cm²)	1.96Mpa (20kgf/cm²)	0.39 Mpa (4kgf/cm²)

NOTE:
1) Make sure that the engine speed is also measured as compression pressure varies with the engine speed.
2) Make measurement for all cylinders, as wear and othe conditions vary from one cylinder to another.

Engine Oil Consumption.

The increase of oil consumption may be due to the operating condition, engine oil quality, oil leaks, etc.
So the time to overhall should be determined in consideration of the compression pressure as well.

Low Oil Pressure

1. Allow the engine to warm up until the oil temperature reaches 70to90°C
2. Measure oilpressures at idling and maximum speeds.
   If the readings are below the repair limit, overhall the lubrication system.

TROUBLESHOOTING

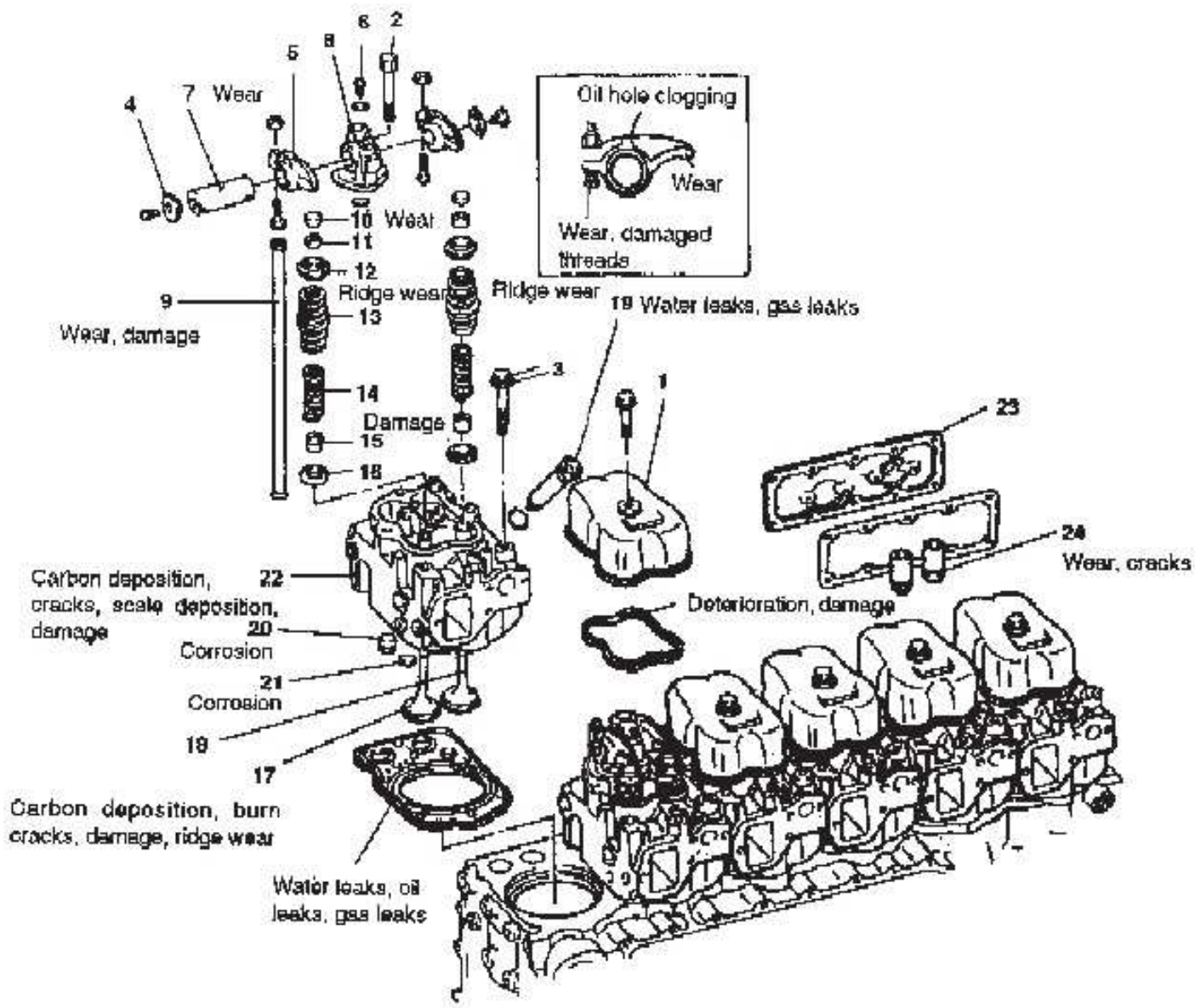
Symptom	Probable cause	Remedy
Engine will not start	Inadequate oil viscosity	Replace
	Incorrect fuel in use	
	Low compression pressure	Adjust
	o Incorrect valve clearance	
	o Defective head gasket	Replace
	o Worn valve and valve seat, carbon deposit	
	o Deteriorated valve spring	
	o Worn or damaged piston ring	
	o Worn or damaged piston ring groove	
	o Worn piston and cylinder liner	Change to oversize
	Defective preheater	Correct or replace
	o Defective starter switch	
	o Defective heater relay	
	Incorrect injection timing	Adjust
	Insufficient injection amount	Correct or replace
	o Defective injection pump	
	o Incorrect injection amount	
	Cooling system not functioning properly	Correct or replace
Rough idle	Inadequate oil viscosity	Replace
	Incorrect fuel in use	
	Defective cooling system	Correct or replace
	Low compression pressure (See "Engine will not start".)	
	Incorrect injection timing	Adjust
	Defective fuel system	Correct or replace
	o Defective injection pump	
	o Defective injection nozzle	
	o Air trapped in fuel system	
Abnormal exhaust gas color	Incorrect fuel in use	Replace
	Cooling system not functioning properly	Correct or replace
	Intake/exhaust system not functioning properly	Correct or replace
	o Clogged air cleaner	
	o Clogged muffler	
	o Oil leaks to intake/exhaust pipes	
	Low compression pressure (See "Engine will not start".)	
	Defective fuel system	Correct or replace
	o Defective injection pump	
	o Defective injection nozzle	
	o Incorrect injection timing	
	Excessive engine oil	Adjust
	Binding of major moving parts	Correct or replace

Symptom	Probable cause	Remedy
Low output	Inadequate oil viscosity	Replace
	Incorrect fuel in use	
	Defective cooling system	Correct or replace
	Intake/exhaust system not functioning properly	
	o Clogged air cleaner	Change to oversize
	o Clogged muffler	
	Low compression pressure (See "Engine will not start".)	
	Defective fuel system	
	o Defective injection pump	Correct or replace
	o Defective injection nozzle	
	o Incorrect injection timing	
	o Incorrect injection timing	
	o Air trapped in fuel system	
Large oil consumption	Oil leaks from lubrication system	Correct
	Oil leaks from engine and related parts	
	o Defective gasket and oil seal	Replace
	Oil entered to combustion chamber from piston side	
	o Worn cylinder liner and piston	Correct or replace
	o Worn, damaged or seized piston ring	Relplace as a set
	o Clogged piston and oil ring oil holes	Clean
	Oil entered to combustion chamber from valve side	
	o Worn valve stem and valve guide	Replace
	o Worn valve stem seal	
Abnormal engine noise	Noise produced from around the engine	
	o Loose piping or hosing connection	Correct
	o Injection pump, alternator or other auxiliary units defective or incorrectly mounted	Adjust
	o Loose or damaged V-belt	Replace
	o Crankshaft pulley incorrectly mounted	Adjust
	o Air cleaner, muffler not functioning properly	Correct or replace
	Noise produced from around rocker cover	
	o Incorrect valve clearance	Adjust
	o Defective valve spring	Replace
	o Defective rocker shaft and bracket	Correct
	o Improper lubrication of rocker shaft	Check
	Noise produced from around flywheel housing	
	o Incorrect timing gear backlash	Replace
	o Improper lubrication of timing gears and idler shaft	Check

Symptom	Probable cause	Remedy
Abnormal engine noise	Noise produced from cylinder head or crankcase	
	o Low compression pressure (See "Engine will not start")	
	o Incorrect injection timing	Adjust
	o Incorrect spray condition	Correct or replace
	o Worn connecting rod small end bushing and piston pin	Replace
	o Worn or damaged crankshaft pin and connecting rod big end bearing	
	o Worn or damaged crankshaft journal and main bearing	
	o Excessive crankshaft, to camshaft end play	Replace thrust plate
	o Worn tappet and camshaft	Replace worn part

Cylinder Head and Valve Mechanism

Disassembly [D6A]



Disassembly sequence

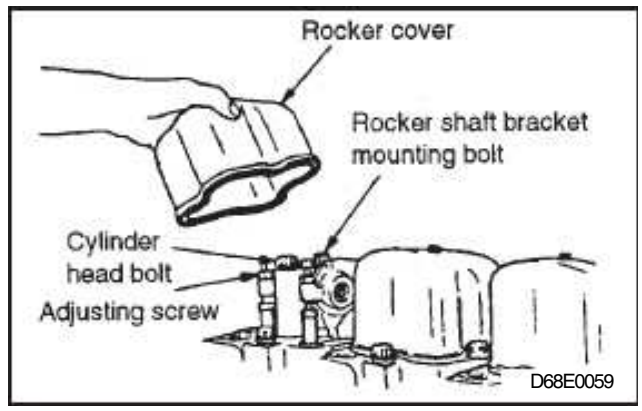
1. Rocker cover
2. Rocker shaft bracket mounting bolt
3. Cylinder head bolt
4. Thrust plate
5. Rocker
6. Set screw
7. Rocker shaft
8. Rocker shaft bracket
9. Push rod
10. Valve cap
11. Valve cotter
12. Upper retainer
13. Outer valve spring
14. Inner valve spring
*1 15. Valve stem seal
16. Lower retainer
17. Inlet valve
18. Exhaust valve
*2 19. Nozzle tube
*2 20. Water director
*2 21. Sealing cap
22. Cylinder head
23. Crankcase side cover
24. Tappet

For parts with ana encircled number, refer to Disassembly Procedure that follows.
Part marked with *1 should not be reused, but replaced. It must be replaced when the valve only is removed.
Parets marked with *2 should not be removed unless defects are evident.

D68E0058

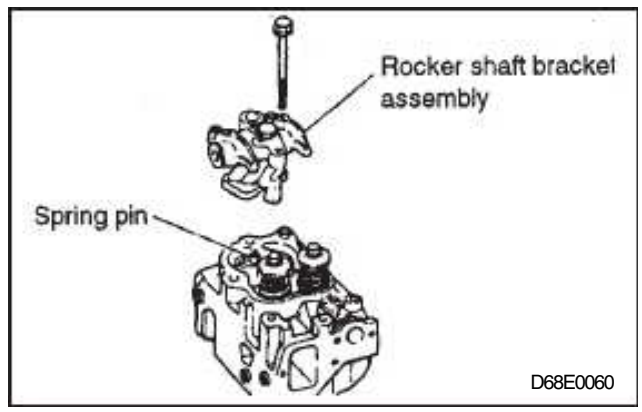
Disassembly Procedure

1. Where the push rod is forcing the rocker up, the rocker adjusting screws should be loosened before all bolts are removed.
2. Removal of the rocker shaft bracket assembly



The rocker shaft bracket assembly is positioned in the cylinder head with a spring pin. Remove it by raising it straight upward.

3. Removal of cylinder head assembly



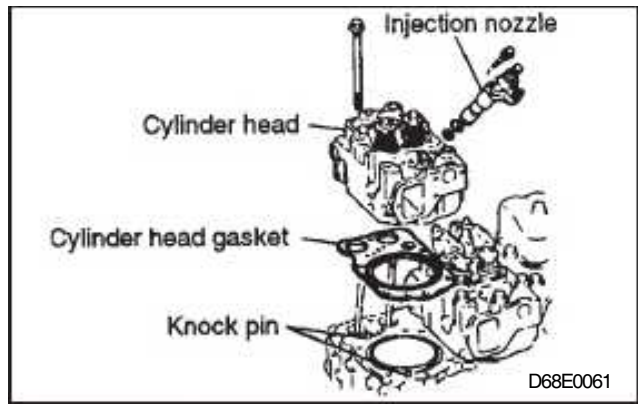
Since the cylinder head is located by dowel pins on the top surface of the crankcase, make sure that the cylinder head is lifted straight upward when removed.

NOTE:

1) To remove the cylinder head, make sure that the injection nozzle is removed beforehand. (Refer to Group 31 Fuel and Engine Control.)

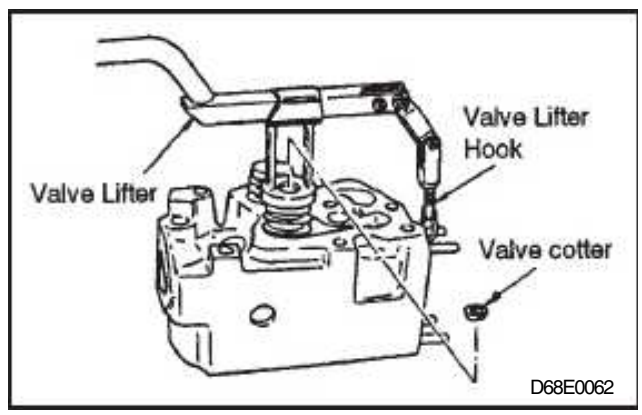
If the cylinder head with nozzle mounted is placed on the work table, damage to the nozzle end projecting from the bottom surface of the cylinder head will result.

2) When the cylinder head gasket is removed, make sure that the cylinder head and crankcase are not scratched.



4. Removal of valve cotter

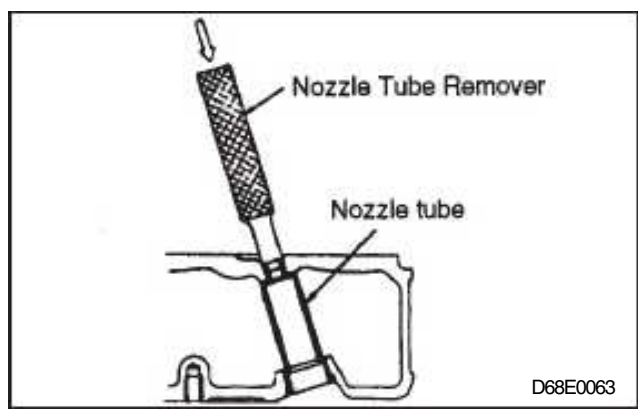
To remove the valve cotter, use Valve Lifter and Valve Lifter Stud (special tools) and compress evenly the valve spring.



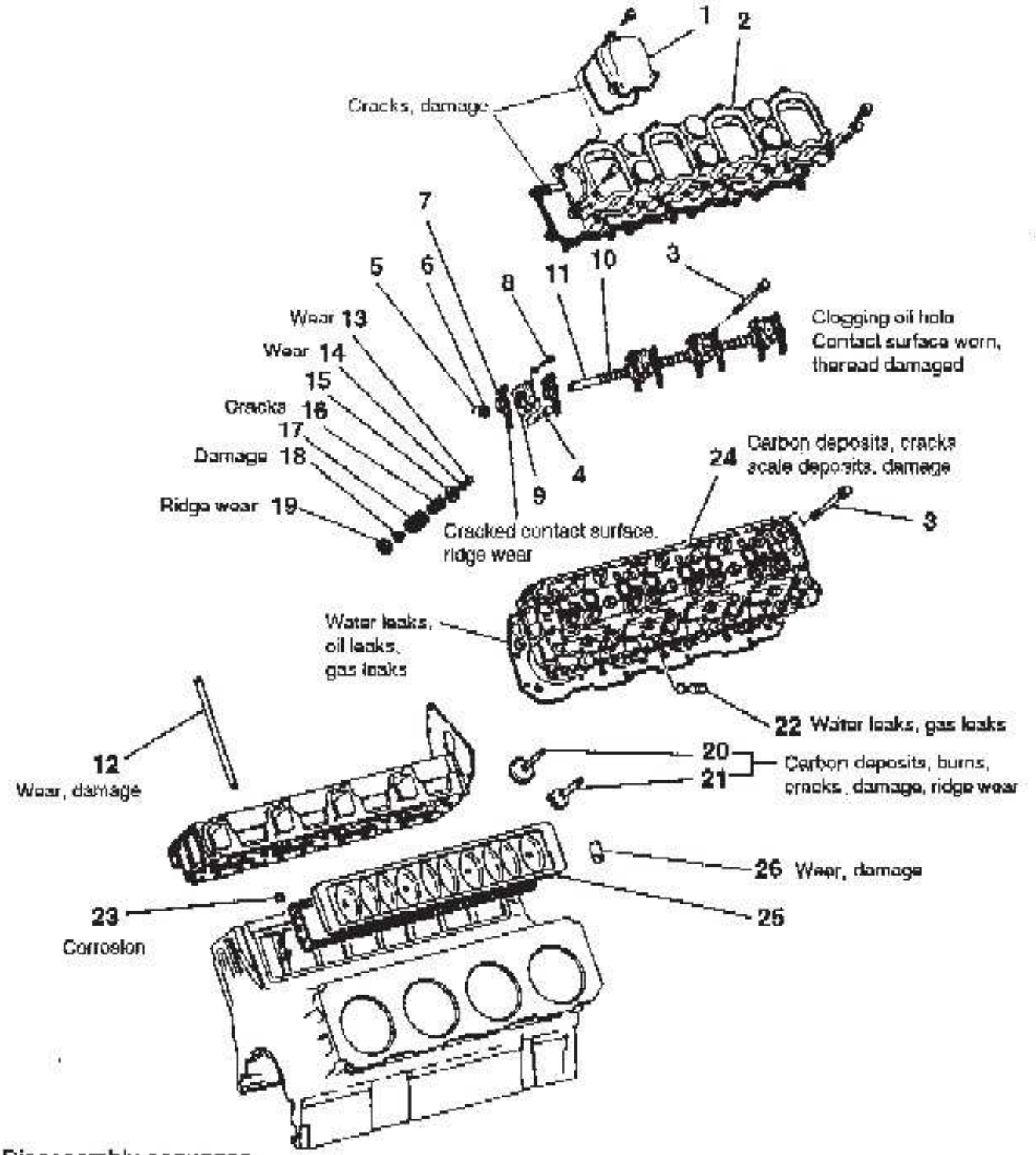
5. Removal of nozzle tube

NOTE:

Whenever the nozzle tube is moved, it must be replaced with a new one.



Disassembly [D8A]



Disassembly sequence

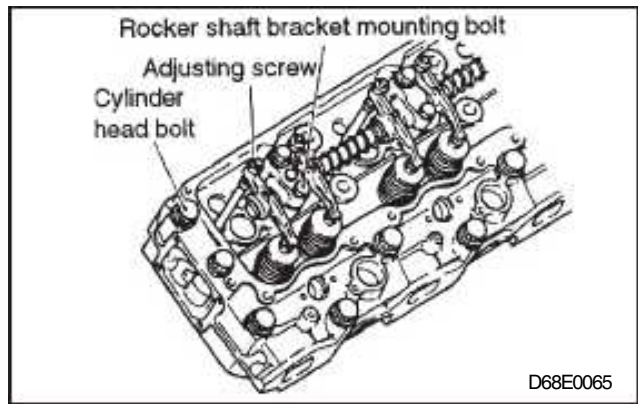
1. Rocker cover
2. Rocker case
3. Cylinder head bolt
4. Rocker bracket attaching bolt
5. Snap ring
6. Washer
7. Rocker
8. Set screw
9. Rocker shaft bracket
10. Rocker shaft spring
11. Rocker shaft
12. Push rod
13. Valve cap
14. Valve cotter
15. Upper retainer
16. Outer valve spring
17. Inner valve spring
18. Valve stem seal
19. Lower retainer
20. Inlet valve
21. Exhaust valve
22. Nozzle tube
23. Water diretor.
24. Cylinder head
25. Crankcase sidecover
26. Tappet

For parts with an encircled number, refer to Disassembly Procedure that follows.
Part marked with "1 should not be reused, but replaced
It must be replaced when the valve only is removed.
Parts marked with "2 should not be removed unless defects are evident.

D68E0064

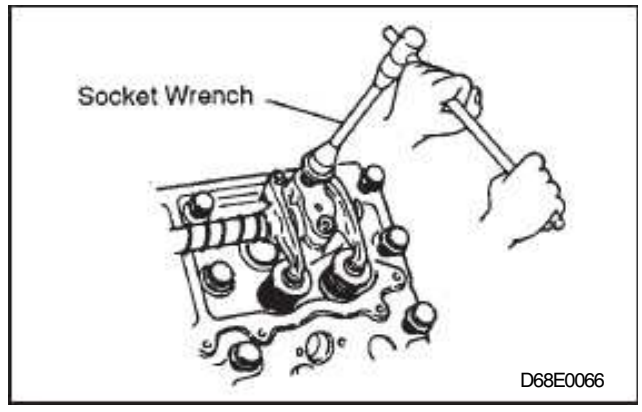
Disassembly Procedure

1. Where the push rod is forcing the rocker up, the rocker adjusting screws should be loosened before all bolts are removed.
2. Removal of cylinder head assembly



Loosen the cylinder head bolts in reverse order of tightening,

beginning with M14 bolt.
Use Socket Wrench (spedial tool) to remove the cylinder head bolts (M16 bolt) and the rocker bracket mounting bolts.

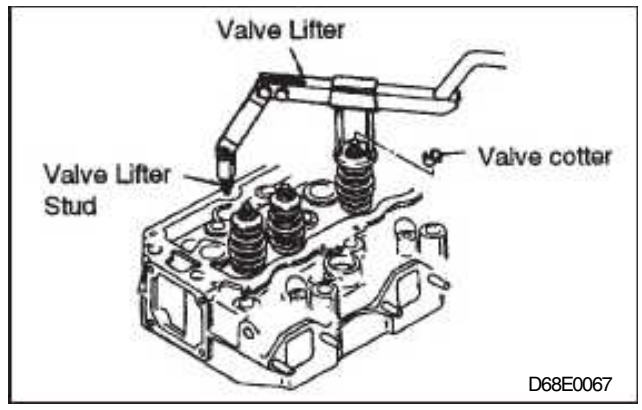


NOTE:
1) To remove the cylinder head, make sure that the injection nozzle is removed beforehand. (Refer to Group 31 Fuel and Engine Control.)
If the cylinder head with nozzle mounted is placed on the work table, damage to the nozzle end projecting from the bottom surface of the cylinder head will result.

2) When the cylinder head gasket is removed, make sure that the cylinder head and crankcase are not scratched.

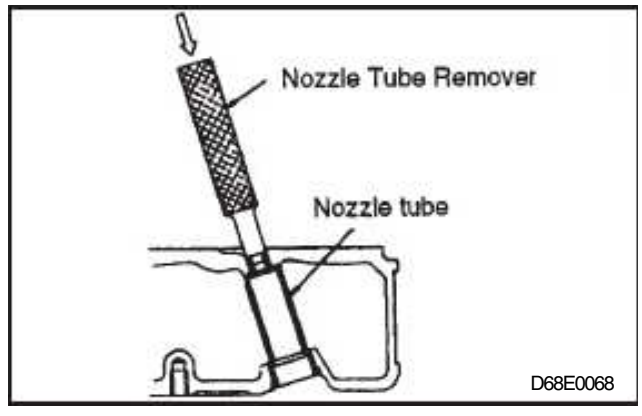
3. Removal of valve cotter

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



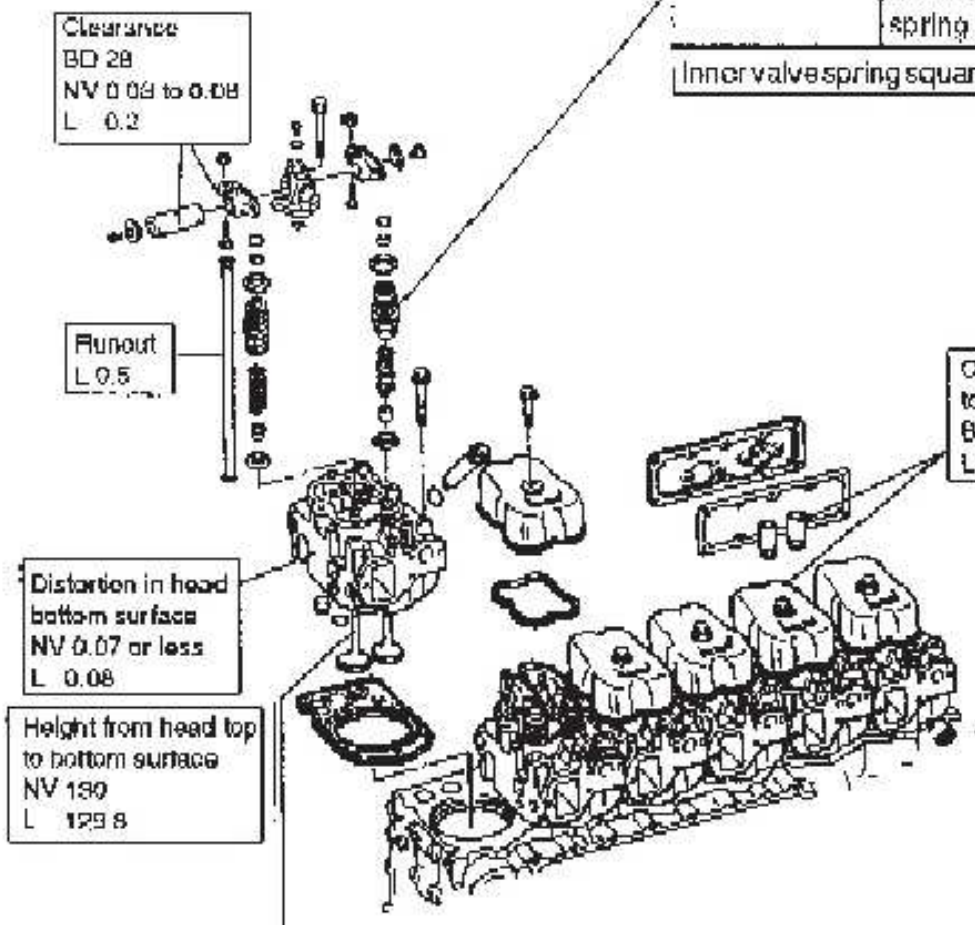
4. Removal of nozzle tube

NOTE:
Whenever the nozzle tube is moved, it must be replaced with a new one.



Inspection [D6A]

Item		NV	L
Free length	Outer valve spring	89.38	85
	Inner valve spring	65.04	62
Installed load/ length	Outer valve spring	450 N {46.1 kgf} /58.35	380 N {39 kgf} /58.35
	Inner valve spring	115 N {12 kgf} /50.35	100 N {46.1 kgf} /50.35
Inner valve spring squareness		2.5	2.5



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

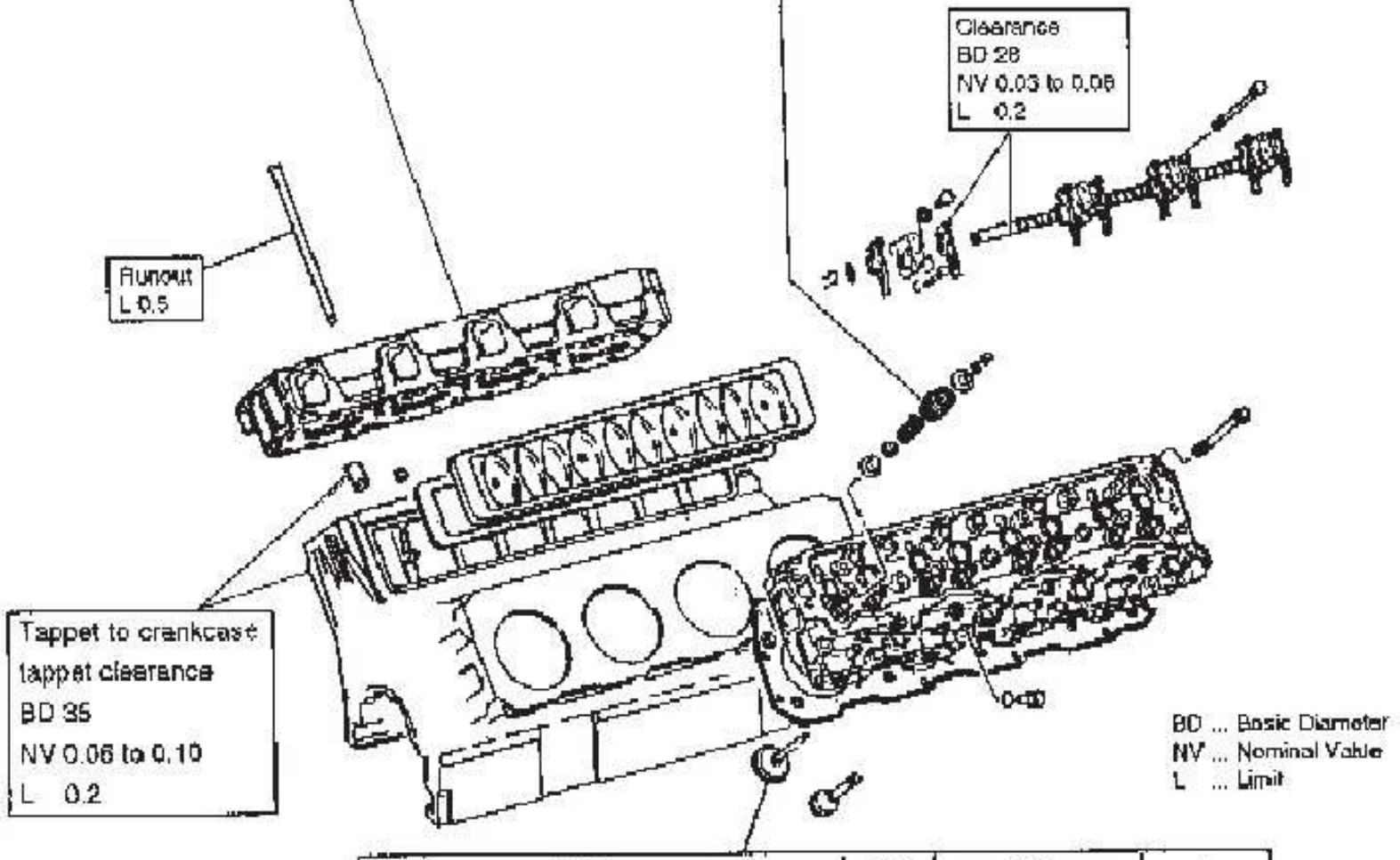
Item		BD	NV	L
Valve stem O.D.	Inlet valve	-	11.95 to 11.96	11.85
	Exhaust valve	-	11.91 to 11.93	
Valve guide to valve stem width	Inlet valve	12	0.05 to 0.09	0.2
	Exhaust valve	12	0.09 to 0.12	
Valve seat insert seat width	Inlet valve	-	2.68 to 2.97	3.5
	Exhaust valve			
Valve sinkage from cylinder head bottom surface	Inlet valve	-	0.25 to 0.75	1.0
	Exhaust valve	-	-0.05 to 0.45	0.7
Valve margin	Inlet valve	-	2.2	1.7
	Exhaust valve	-	2.5	2.0
Valve seat angle		-	45	-

D68E0069

Inspection [D8A]

Item		NV	L
Valve seat insert seat width	Inlet valve / Exhaust valve	2.69 to 2.97	3.5
Distortion in head bottom surface		0.07 or less	0.2
Height from head top to bottom surface		114.9 to 115.1	114.6

Item		NV	L
Free length	Outer valve spring	89.38	85
	Inner valve spring	65.04	62
Installed load/ length	Outer valve spring	450 N {46.1 kgf}/ 58.35	360 N {39 kgf}/ 58.35
	Inner valve spring	115 N {12 kgf}/ 50.35	100 N {46.1 kgf}/ 50.35
Inner valve spring squareness		2.5	2.5



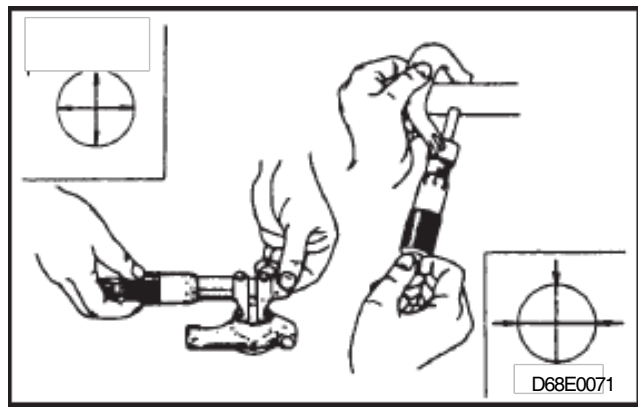
Item		BD	NV	L
Valve stem O.D.	Inlet valve	-	11.95 to 11.96	11.85
	Exhaust valve	-	11.91 to 11.93	
Valve guide to valve stem width	Inlet valve	12	0.05 to 0.09	0.2
	Exhaust valve	12	0.09 to 0.12	
Valve seat insert seat width	Inlet valve	-	2.69 to 2.97	3.5
	Exhaust valve			
Valve sinkage from cylinder head bottom surface	Inlet valve	-	0.25 to 0.75	1.0
	Exhaust valve	-	-0.05 to 0.45	0.7
Valve margin	Inlet valve	-	2.2	1.7
	Exhaust valve	-	2.5	2.0
Valve seat angle		-	45	-

D68E0070

Inspection Procedure

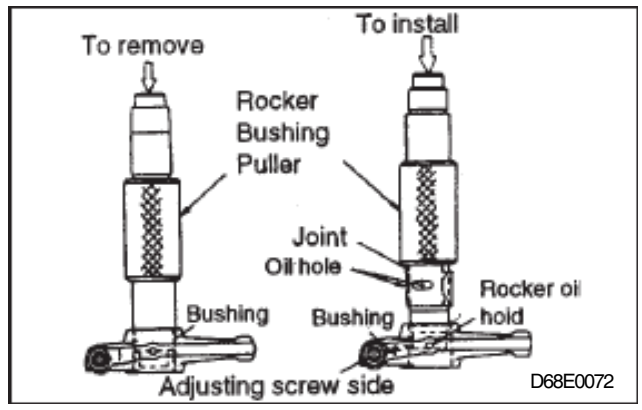
1. Rocker to rocker shaft (rocker shaft bracket on models with powertard) clearance

   If the limit exceeded, replace the bushing in the rocker.



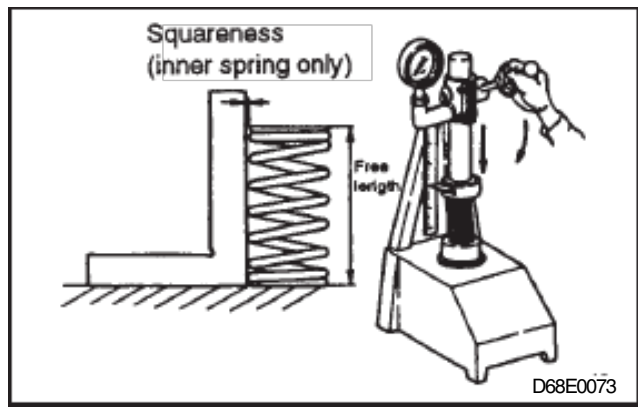
2. Replacement of rocker bushing

   Face the bushing joint toward the adjusting screw.
   Align the bushing and rocker oil holes.



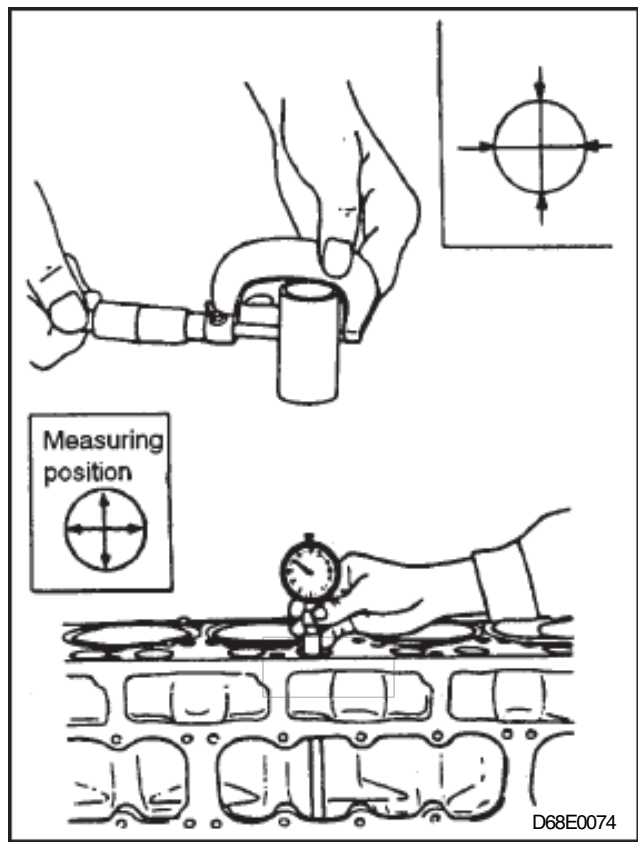
3. Inspection of valve spring

   Measure the free length and installed load of the spring and replace if the measurement exceeds the limit. For the inner spring, check also for squareness.



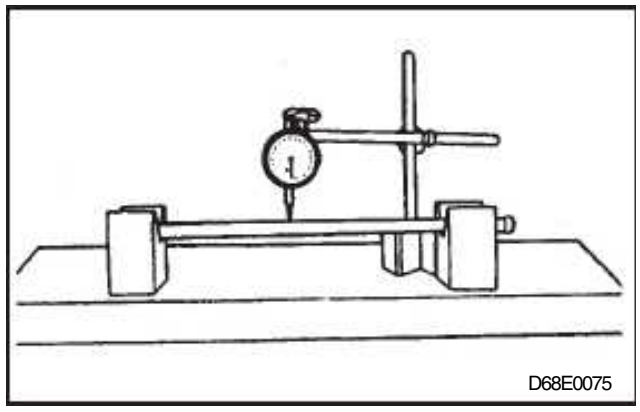
4. Tappet to crankcase clearance

   If the measurement exceeds the limit, replace the tappet.



5. Runout of push rod

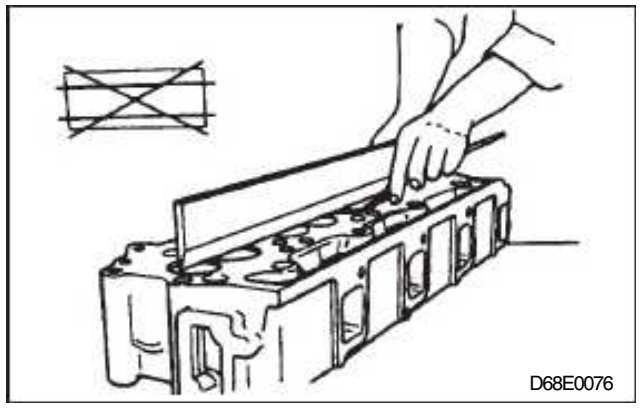
   Check for runout and replace if the reading on the dial indicator exceeds the limit.



6. Cylinder head bottom surface distortion

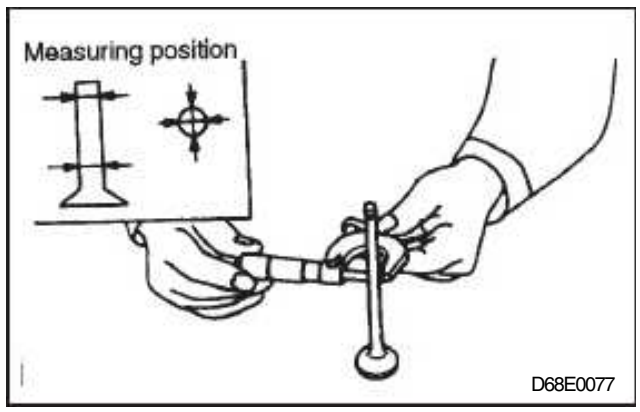
   If the measurement exceeds the limit, correct by using a surface grinder.

   NOTE:
   Grind the cylinder head only to the extent that the height from the top to bottom surfaces is within the limit.



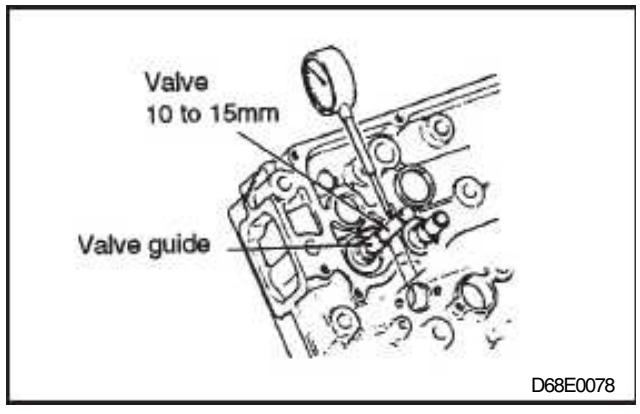
7. Valve stem O.D.

   Replace the valve if the measurement is below the limit.



8. Valve guide to valve stem clearance

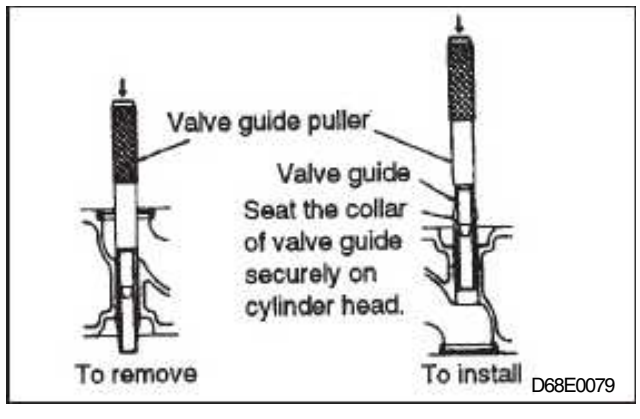
   Insert the valve in the valve guide and measure the valve play at the illustrated position above the top end of the valve guide.



9. Replacement of valve guide

   Using Valve Guide Puller (special tool), replace the valve guide.

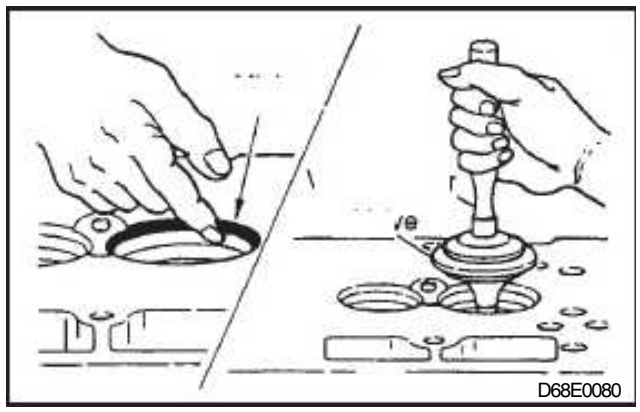
   NOTE:
   When the valve guide is installed, make sure that the valve guide flange is securely seated on the cylinder head.



10. Valve contact with valve seat insert

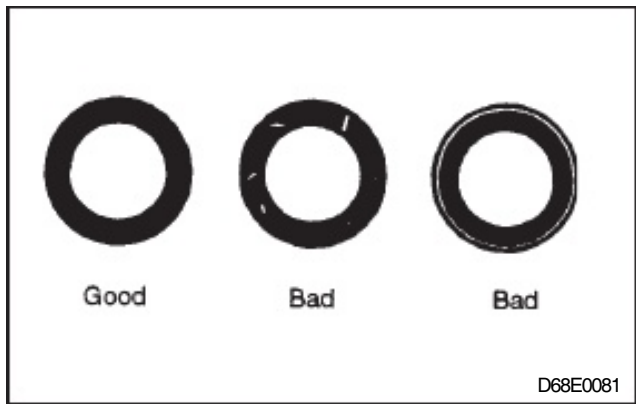
(a) Apply an even coat of minium to the valve seat insert surface in contact with the valve.
(b) Using Valve lapper (special tool), let the valve hit against the valve seat insert once.

NOTE:
1) When letting the valve hit against the valve seat insert, do not turn the valve.
2) Contact pattern should be checked when the valve guide is inspected or replaced.


D68E0080

If any unusual contact pattern is noted, correct as follows.

Minor fault: Lapping
Serious fault: Correct valve and valve seat.

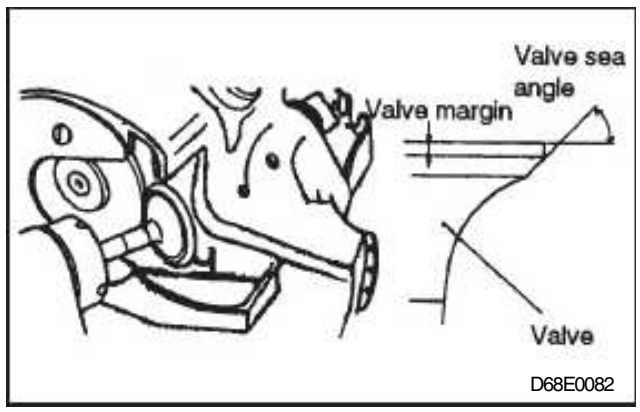


D68E0081

11. Correction of valve face

Grind the valve face with a valve refacer to obtain the specified valve seat angle.

NOTE:
1) Keep grinding margin to a minimum.
2) If the valve margin is below the limit after the grinding correction, replace the valve.
3) After the grinding correction, be sure to lap the valve and valve seat insert. [Refer to Item (14) that follows.]



D68E0082

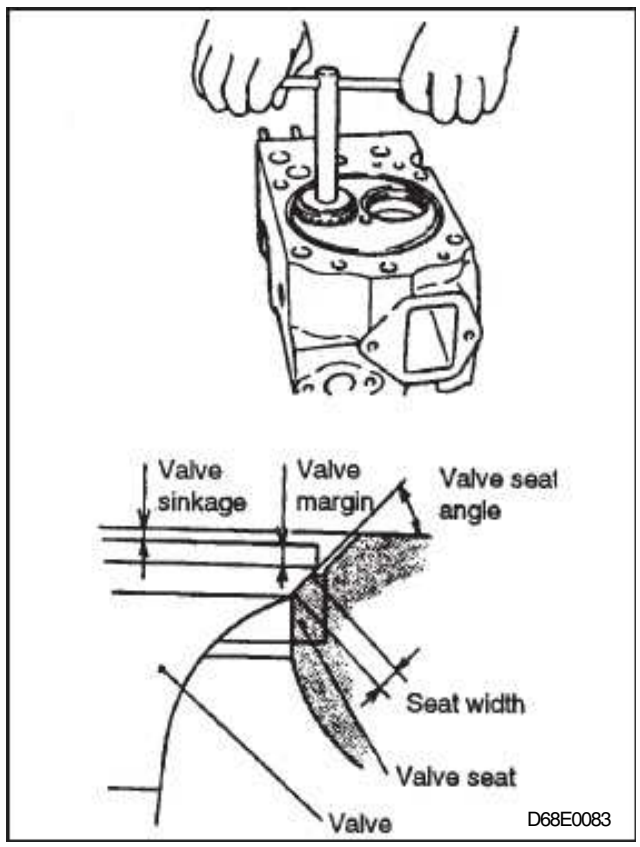
12. Correction of valve seat insert

(a) Using a valve seat cutter, cut the insert to obtain the specified valve seat angle and seat width.
Use 15° or 75° cutter first, then 45° one.

NOTE:
1) Keep the amount of cut to a minimum.
2) If the valve sinkage after cutting exceeds the limit, replace the valve seat insert.

(b) After correction, lightly grind by holding about #400 sandpaper between the cutter and valve seat insert.

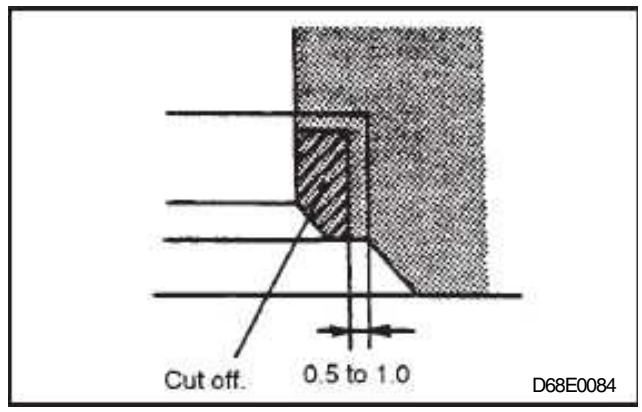
NOTE:
After the correction procedure, be sure to lap the valve and valve seat insert.



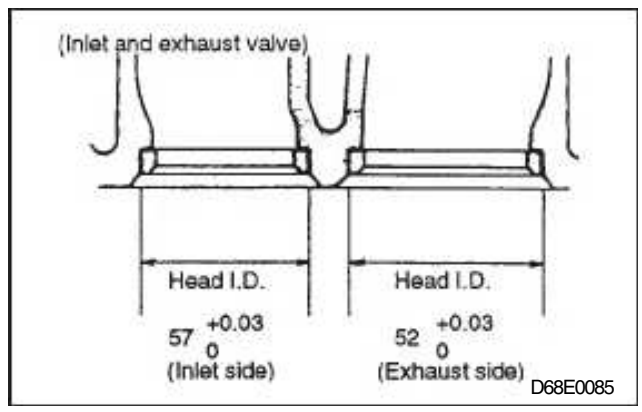
D68E0083

13. Replacement of valve seat insert
Since the valve seat insert is installed by expansion fit, replace it by the following procedures.

(a) Grind inside surface of the valve seat insert to reduce the thickness and then remove it at room temperature

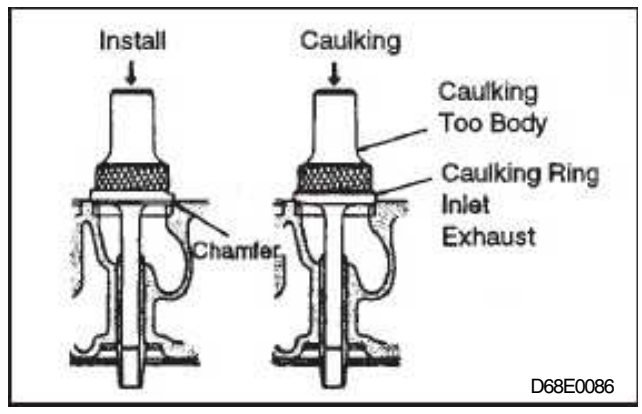


(b) Make sure that the cylinder head and valve seat insert are provided with sufficient interference.
(c) Immerse the valve seat insert in liquid nitrogen for cooling it, and fully heat the cylinder head.



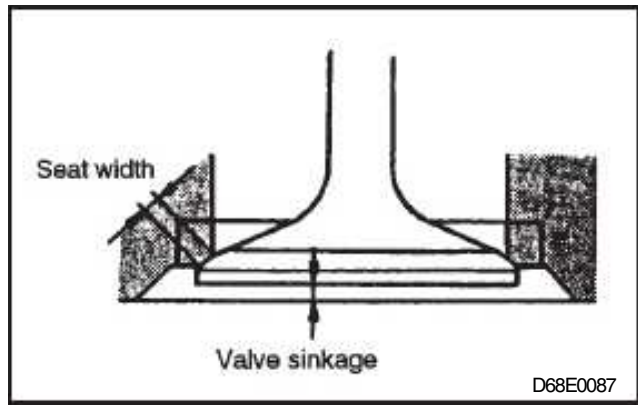
(d) Install the valve seat insert using the Caulking Tool Body, Caulking Ring and Caulking Tool (special tools) and caulk the periphery of the valve seat insert.

NOTE:
When the valve seat insert is installed, direct the chamfered side of the caulking ring toward the valve seat insert.



(e) Reface the valve seat insert so that the seat width and valve sinkage are up to specifications.

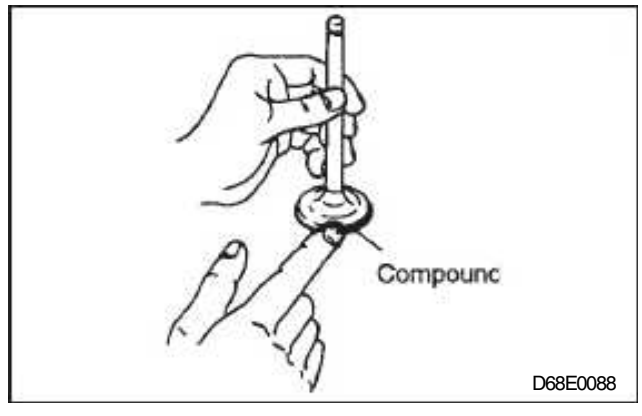
14. Lapping the valve and valve seat insert



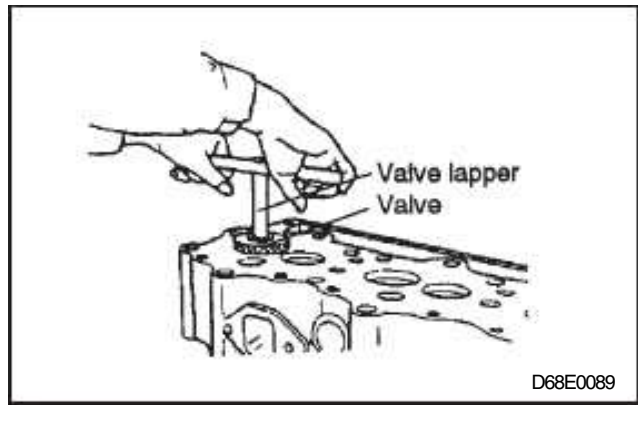
The valve and valve seat insert contact must be even throughout their contacting surfaces.
They must be lapped whenever either the valve or valve seat insert has been corrected or replaced.

(a) Apply a thin, even coat of lapping compound to the seating surface of the valve.

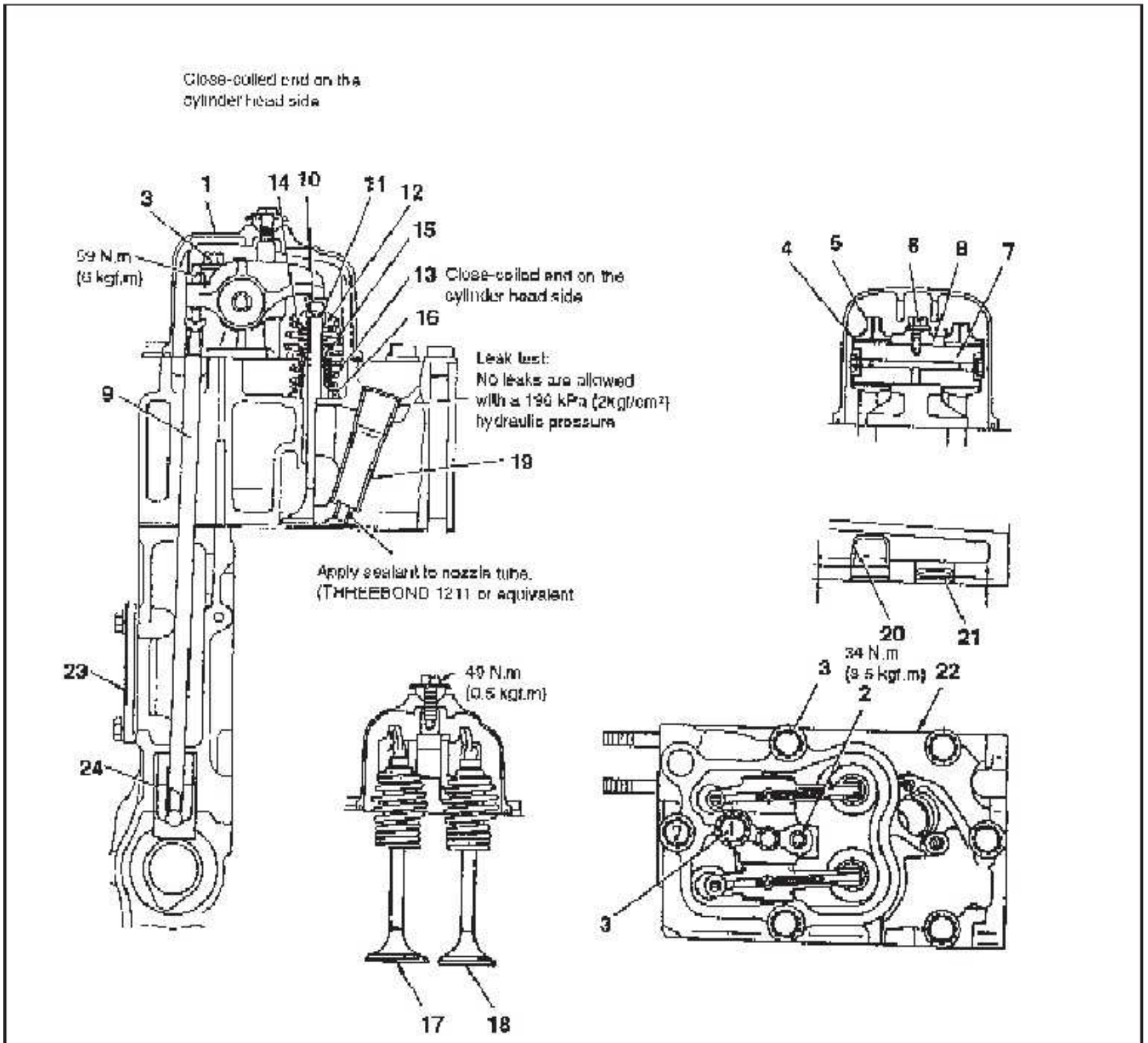
NOTE:
1) Make sure that no compound sticks to the valve stem.
2) Use intermediate-mesh compound (120 to 150 meshes) first, then fine-mesh compound (200 meshes or more) for finishing.
3) Addition of a small amount of engine oil to the com pound helps make it easier to apply it evenly.



(b) Using Valve Lapper (special tool), seat the valve and valve seat insert.
While turning the valve slightly at a time, strike it against the valve seat insert.
(c) Wash away the compound in gas oil, etc.
(d) Apply engine oil to the contacting surface to seat them with oil.
(e) Check to ensure that they are properly seated.



Reassembly [D6A]



Assembly sequence

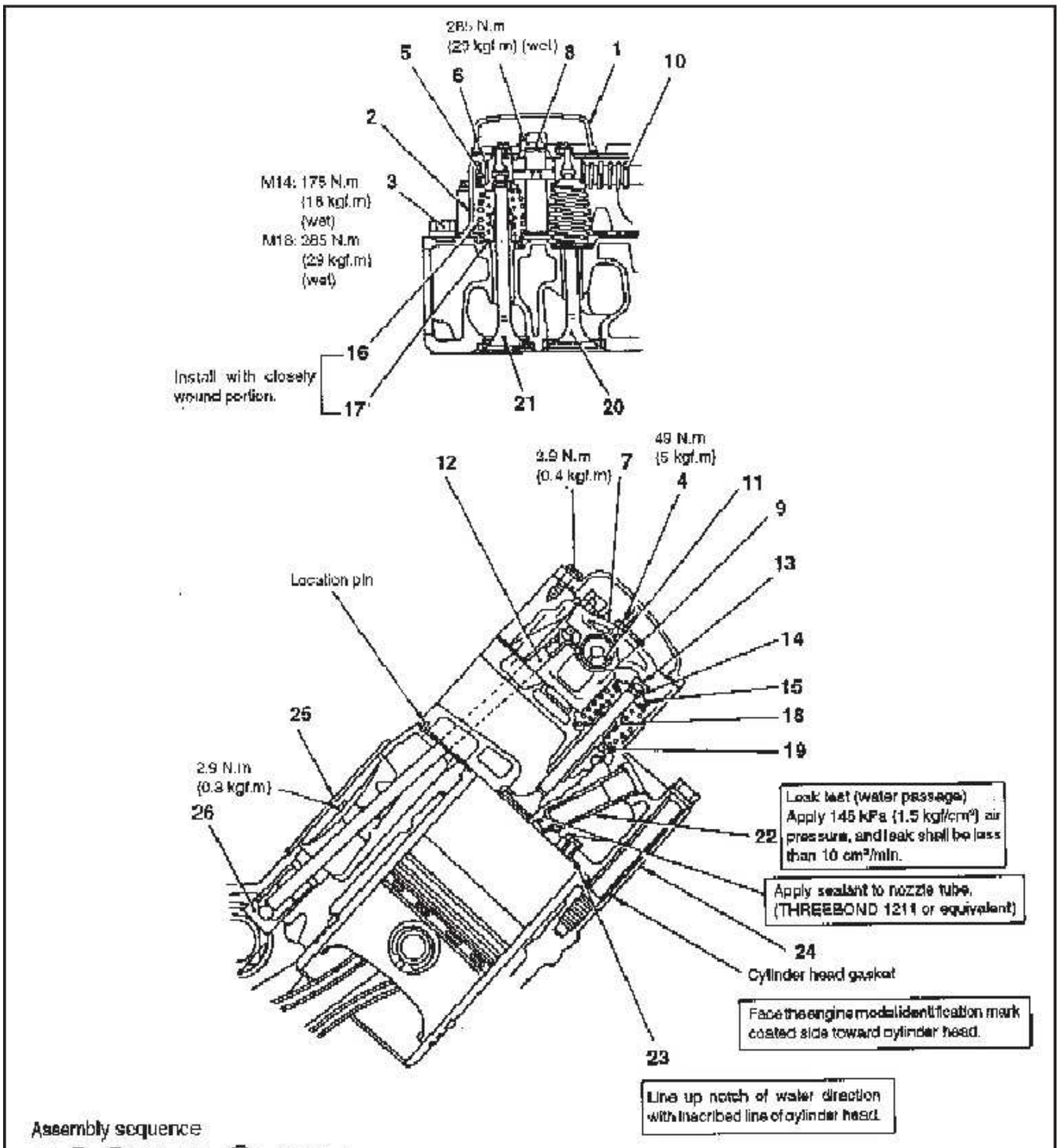
22 → 20 → 21 → 19 → 18 → 17 → 15 → 16 → 14 → 13 → 14 → 11 → 10 → 24 → 23

9 → 8 → 7 → 6 → 5 → 4 → 3 → 2 → 1

For parts with an encircled number, refer to Reassembly Procedure that follows.

D68E0090

Reassembly [D8A]



Assembly sequence

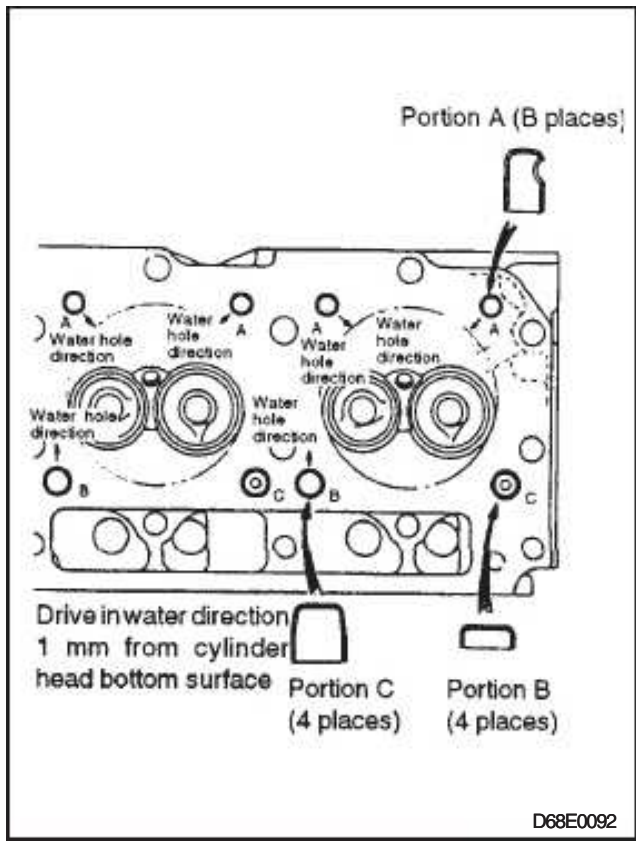
24 → (23) → (22) → 20 → 19 → (18) → 17 → 16 →
15 → (14) → 13 → 12 → 4 → (3) → 2 → 1
26 → 25
11 → 10 → (9) → 8 → (7) → 6 → 5

For parts with an encircled number, refer to Reassembly Procedure that follows.

D68E0091

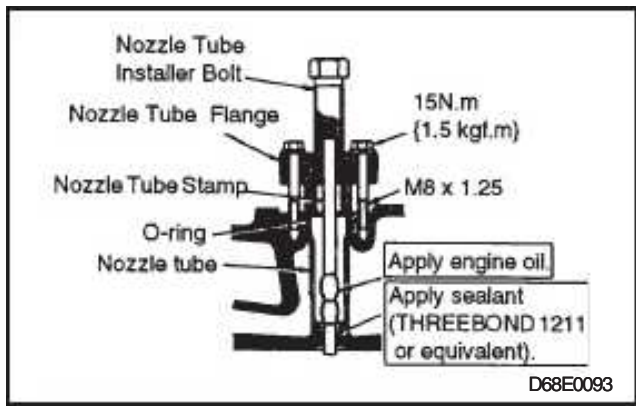
Reassembly Procedure

1. Installation of water director



2. Installation of nozzle tube

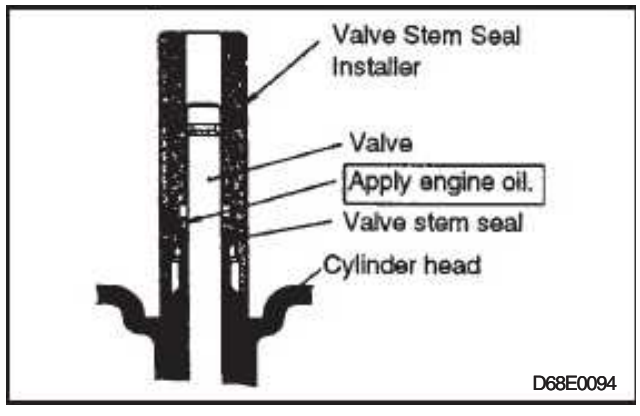
   (a) Apply sealant to the end of the nozzle tube and insert into the cylinder head.
   (b) Using Nozzle Tube Flange (special tool), press the nozzle tube against the cylinder.
   (c) Apply engine oil to Nozzle Tube Stamp (special tool) and insert into the nozzle tube.
   (d) Thread Nozzle Tube Installer Bolt (special tool) to push the stamp until it can be removed from the bottom of the cylinder head.
   (e) After installation, perform leak test to verify air-tightness.



3. Installation of valve stem seal

   The valve stem seal should be installed by applying engine oil to the lip and striking down Valve Stem Seal Installer (special tool) until it touches the cylinder head.

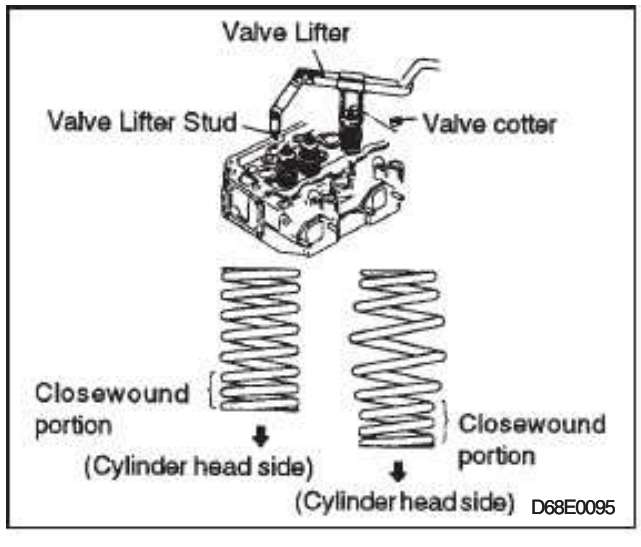
   NOTE:
   1) Before the valve is installed, apply a small amount of engine oil to the stem.
   2) After installation, check to ensure that the valve stem seal spring has not been deformed or damaged.



4. Installation of valve cotter

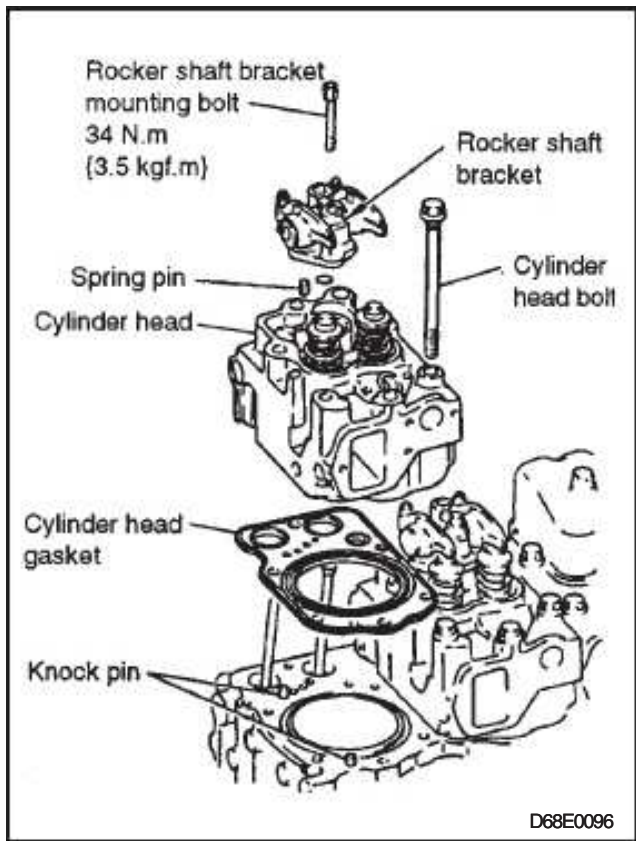
   Install the valve cotter, while compressing the valve spring, using Valve Lifter (special tool).

   NOTE:
   1) Both inner and outer valve springs are unevenly pitched springs. Install the springs with the closely wound portion toward the cylinder head.
   2) When compressing the valve spring, make sure that the upper retainer does not make contact with the valve stem seal.



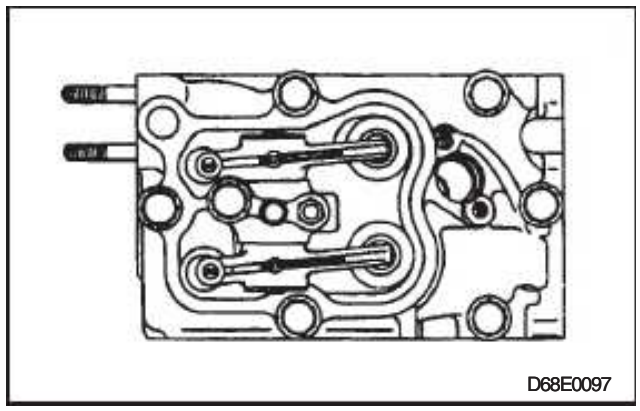
5. Installation of rocker shaft bracket and cylinder head

Install the rocker shaft bracket by positioning it with the spring pin in the cylinder head and install the cylinder head by positioning it with the knock pin in the crankcase.

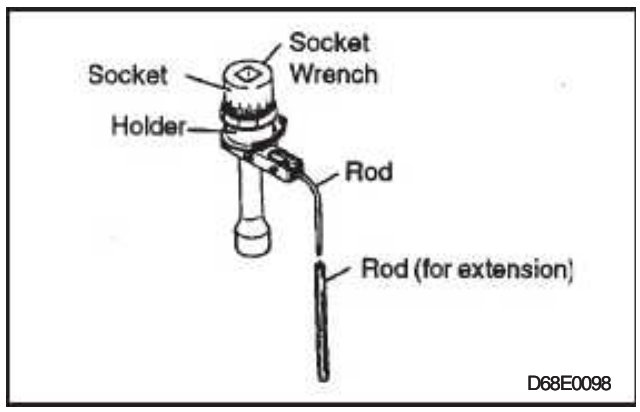


6. Cylinder head bolt tightening procedures

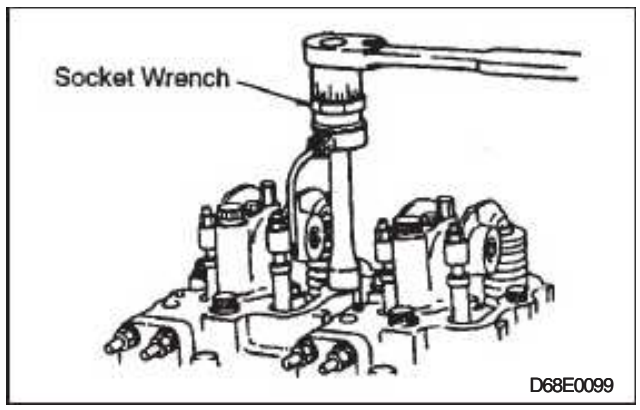
(a) Tighten the cylinder head bolts to 175 N.m {18 kgf.m} (wet) in the order shown.
After tightening, check to see that the torque of each cylinder head bolt is 175 N.m {18 kgf.m}. Then observe the following procedure to retighten each bolt in the specified tightening sequence.



(b) Before fitting the special tool, Socket Wrench, over the cylinder head bolt, turn the holder counter-clockwise to tension the socket spring in the socket wrench.

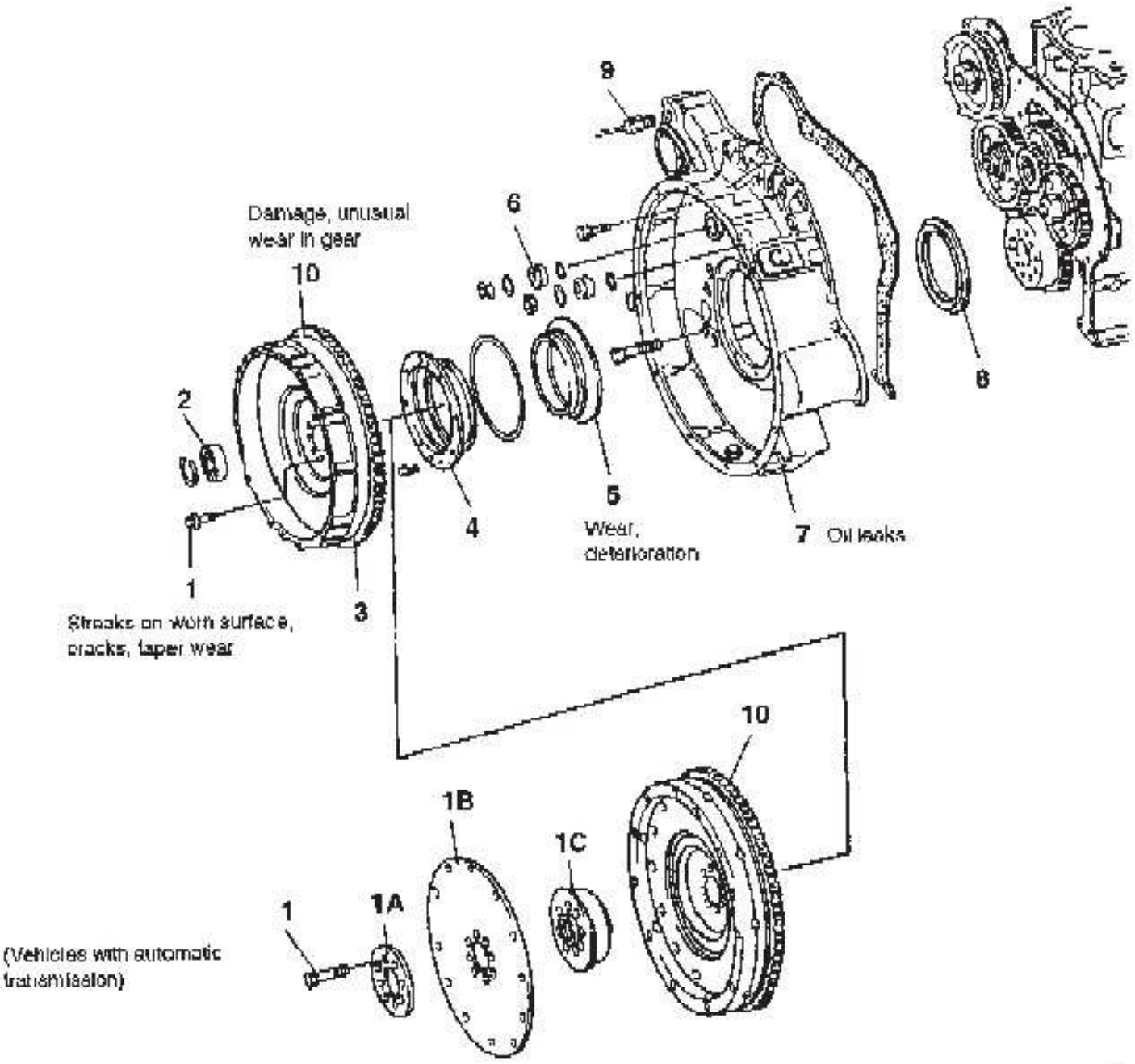


(c) In this state, fit the special tool over the cylinder head bolt and set it so that the rod is forced onto the rocker shaft bracket, injection pipe or other adjacent parts by spring.



Flywheel, Timing Gear and Camshaft

Disassembly [D6A]



Disassembly sequence

	1	Flywheel mounting bolt	Vehicles with automatic transmission
	1A	Washer plate	
	1B	Flex plate	
	1C	Adapter	
*1	2	Pilot bearing	
	③	Flywheel	
	④	Oil seal retainer	
	5	Oil seal	
	⑥	Collar	
	7	Flywheel housing	
*1	8	Rear oil seal slinger	
*2	9	Tachometer sensor	
*1	⑩	Ring gear	

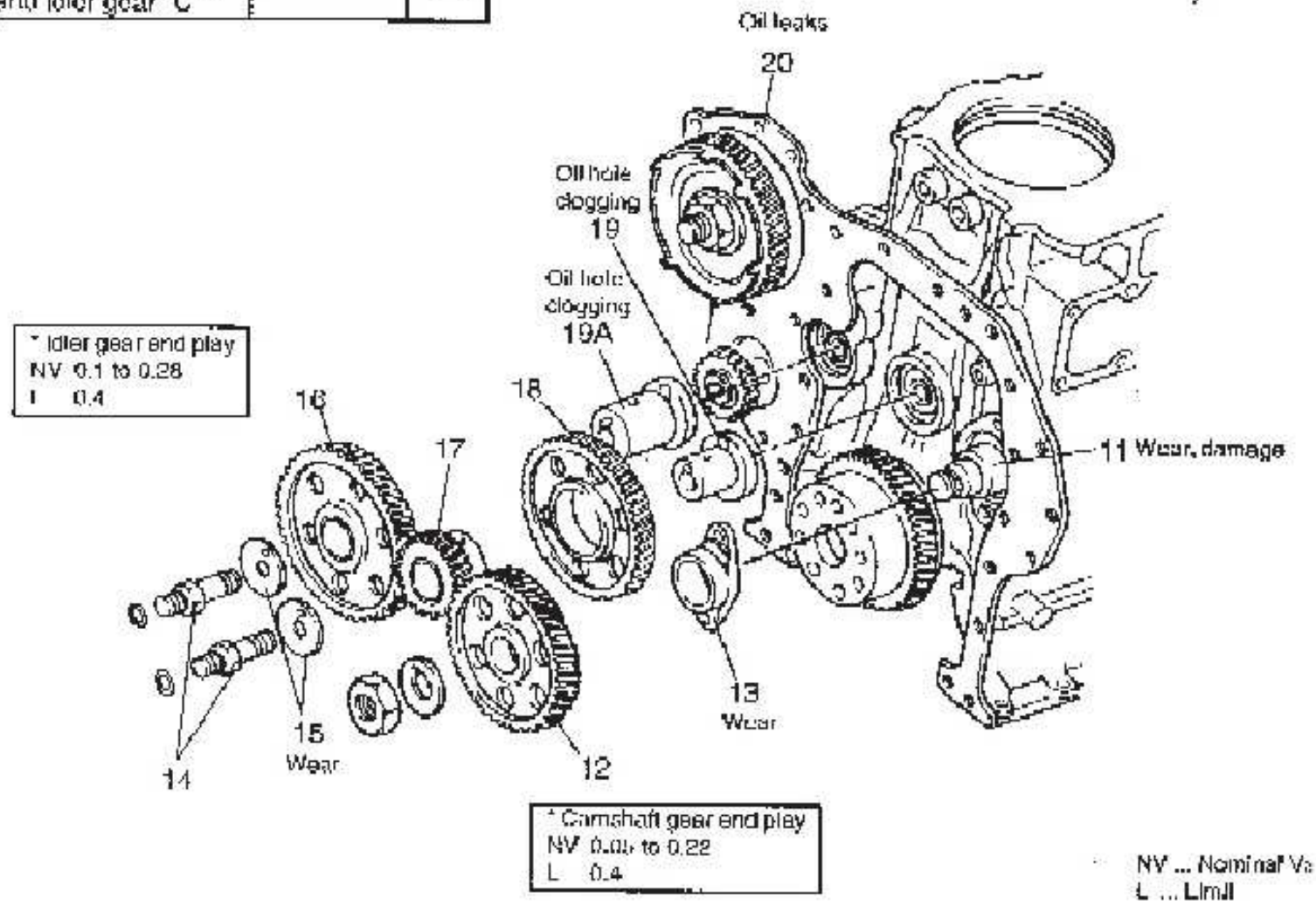
For parts with an encircled number, refer Disassembly Procedure that follows.
Parts marked with *1 should not be removed unless defects are evident.
For Inspection of part marked with *2, refer to Chassis part of Shop Manual.

D68E0100

Without flywheel PTO)

Timing gear backlash

Item	NV	L
Between crankshaft gear and idler gear "B"	0.08 to 0.20	0.4
Between idler gear "A" and crankshaft gear	0.07 to 0.18	0.4
Between idler gear "A" and idler gear "C"	0.07 to 0.18	0.4
Between injection pump gear and idler gear "C"	0.08 to 0.20	0.4
Between power steering gear and idler gear "C"	0.07 to 0.18	0.4



* Idler gear end play
NV 0.1 to 0.28
L 0.4

* Camshaft gear end play
NV 0.05 to 0.22
L 0.4

NV ... Nominal Va
L ... Limit

Disassembly sequence

(11)	Camshaft	17	Idler gear "A"
*(12)	Camshaft gear	18	Idler gear "B"
13	Thrust plate	19	Idler shaft "A"
14	Idler shaft bolt	19A	Idler shaft "B"
15	Thrust plate	20	Rear plate
16	Idler gear "C"		

For parts with an encircled number, refer to Disassembly Procedure that follows.
Service items marked with should be inspected before disassembly.
Part marked with * should not be removed unless defects are evident.

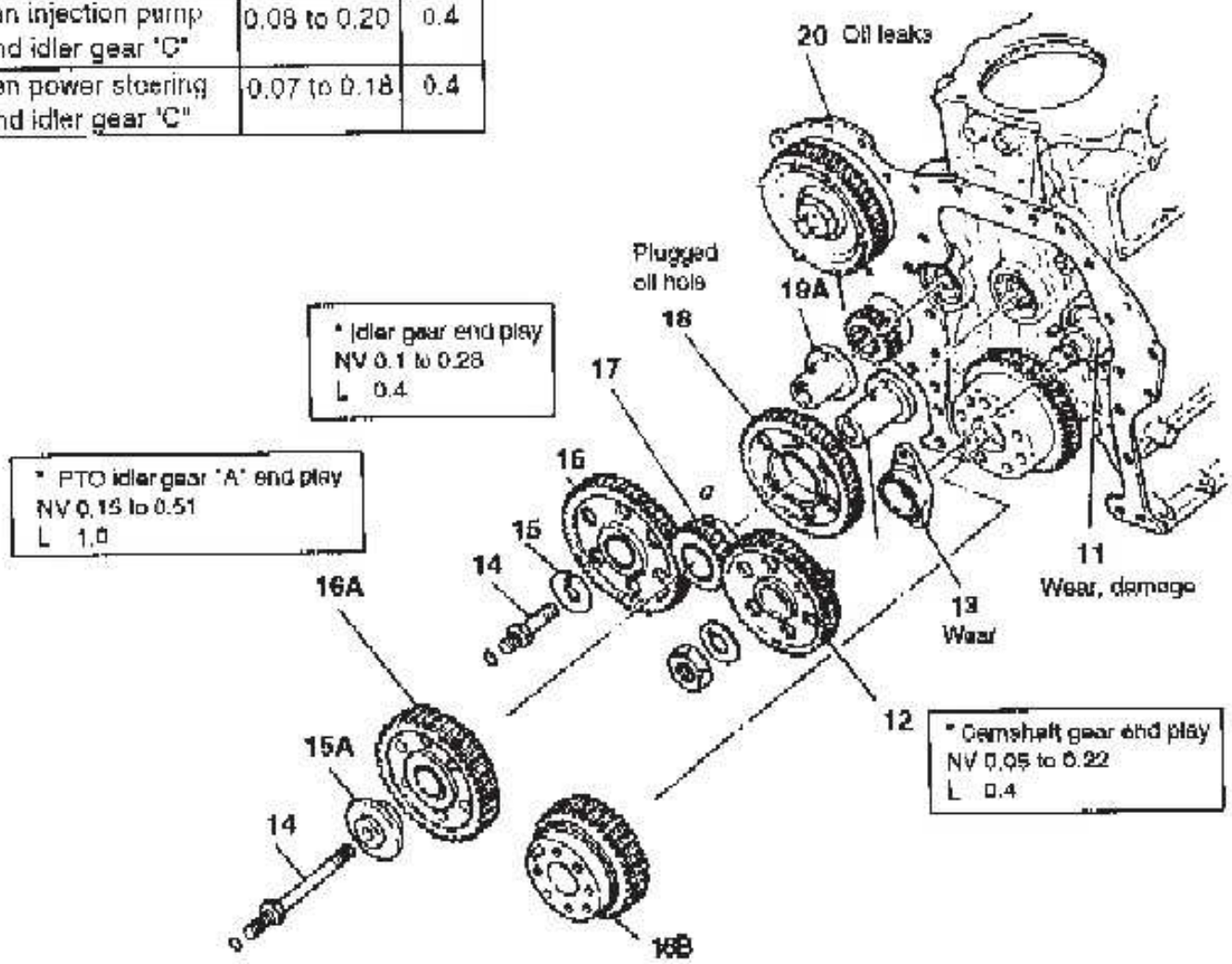
D68E0101

(With flywheel PTO)

Timing gear backlash

Item	NV	L
Between crankshaft gear and idlor gear "B"	0.08 to 0.20	0.4
Between idler gear "A" and crankshaft gear	0.07 to 0.18	0.4
Between idler gear "A" and idler gear "C"	0.07 to 0.18	0.4
Between injection pump gear and idler gear "C"	0.08 to 0.20	0.4
Between power steering gear and idler gear "C"	0.07 to 0.18	0.4

NV .. Nominal Value
L Limit



Disassembly sequence

11	Camshaft	16A	PTO idler gear "A"
*(12)	Camshaft gear	16B	Drive gear
13	Thrust plate	17	Idler gear "A"
14	Idler shaft bolt	18.	Idler gear "B"
15	Thrust plate	19.	Idler shaft "A"
15A	Idler shaft "B"	19A.	Idler shaft "B"
16.	Idler gear "C"	20.	Rear plate

For parts with an encircled number, refar to Disassembly Procedure that follows.
Service items marked with should be inspected before disassembly.
Part marked with * should not be removed unless defects are evident.

D68E0102

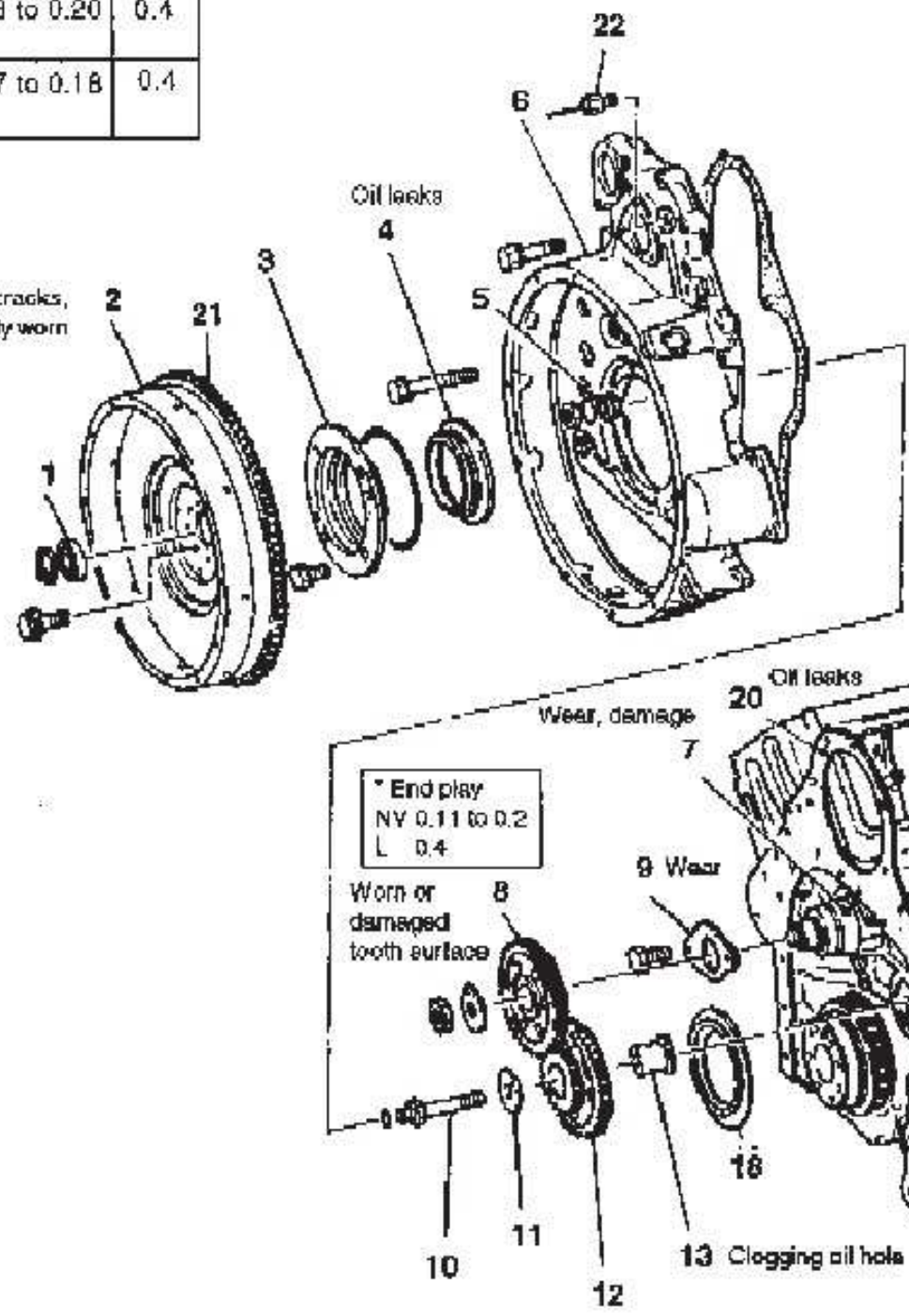
Flywheel, Timing Gear and Camshaft

Disassembly [D8A]

Timing gear backlash

Item	NV	L
Between crankshaft gear and idler gear	0.08 to 0.20	0.4
Between idler gear and crankshaft gear	0.07 to 0.18	0.4
Between camshaft gear and injection pump gear	0.08 to 0.20	0.4
Between injection pump gear and power steering pump gear	0.07 to 0.18	0.4

NV ... Nominal Value
L ... Limit



Disassembly sequence

*1	1	Pilot bearing
	(2)	Flywheel
	(3)	Oil seal retainer
	4	Oil seal
	5	Collar
	6	Flywheel housing
	(7)	Camshaft
	(8)	Camshaft gear
	9	Thrust plate
	10	Idler shaft bolt
	11	Thrust plate
	12	Idler gear
	13	Idler shaft
*1	18	Rear oil seal slinger
	20	Rear plate
*1	(21)	Ring gear
*2	22	Tachometer sensor

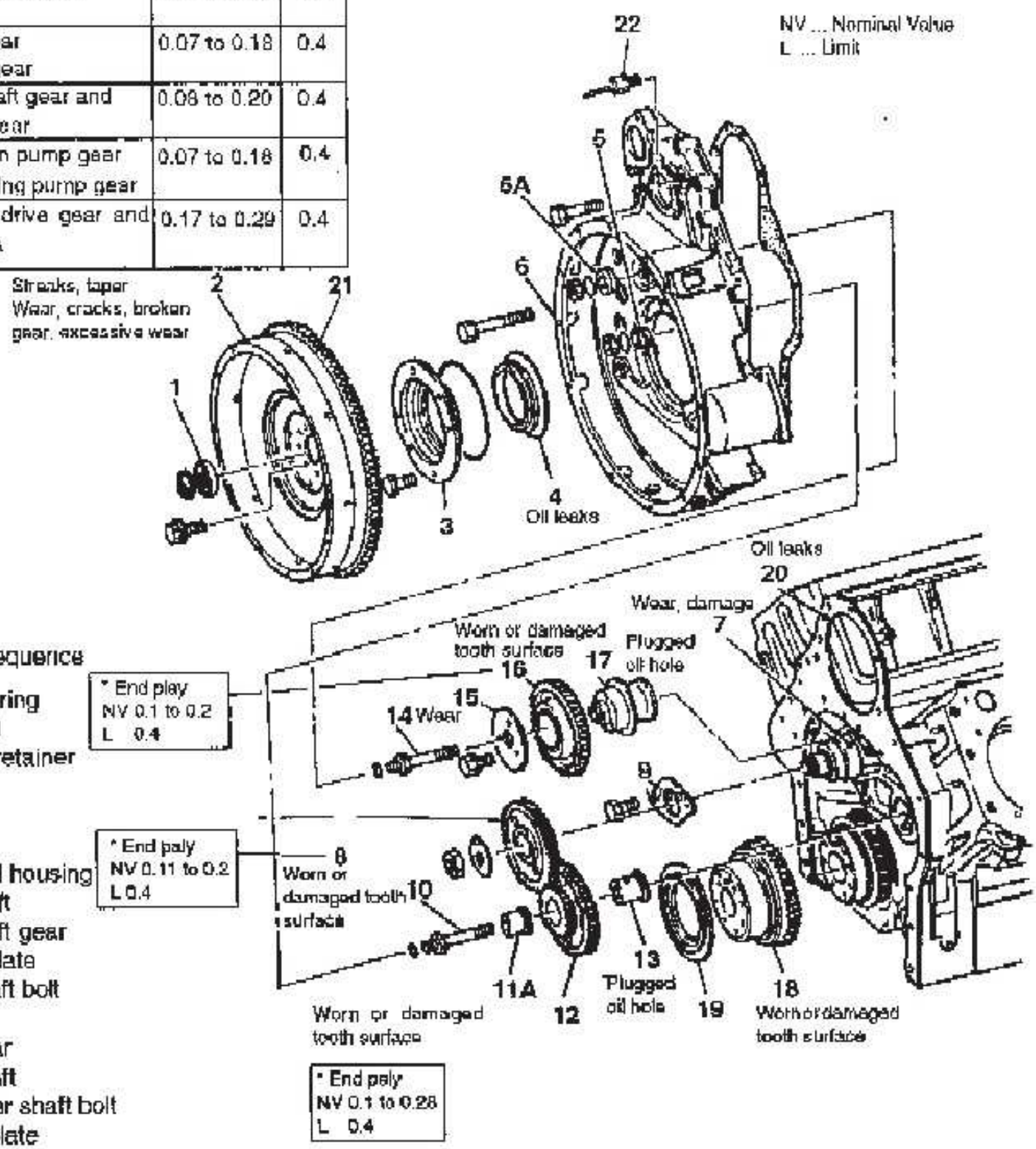
For parts with an encircled number, refer Disassembly Procedure that follows.
Service items marked with * should be checked before disassembly.
Parts marked with *1 should not be removed unless defects are evident.
For inspection of part marked with *2, refer to Chassis part of Shop Manual.

D68E0103

(With flywheel PTO)

Timing gear backlash

Item	NV	L
Between crankshaft gear and idler gear	0.08 to 0.20	0.4
Between idler gear and crankshaft gear	0.07 to 0.18	0.4
Between camshaft gear and injection pump gear	0.08 to 0.20	0.4
Between injection pump gear and power steering pump gear	0.07 to 0.18	0.4
Between PTO drive gear and PTO idler gear A	0.17 to 0.29	0.4



Disassembly sequence

*1	1	Pilot bearing
	②	Flywheel
	③	Oil seal retainer
	4	Oil seal
	⑤	Collar
	⑤A	Collar
	6	Flywheel housing
	⑦	Camshaft
	⑧	Camshaft gear
	9	Thrust plate
	10	Idler shaft bolt
	11A	Spacer
	12	Idler gear
	13	Idler shaft
	14	PTO idler shaft bolt
	15	Thrust plate
	16	PTO idler gear A
	17	PTO idler shaft
	18	Rear oil seal slinger
*1	19	PTO drive gear
	19A	Idler shaft "B"
	20	Rear plate
*1	㉑	Ring gear
*2	22	Tachometer sensor

For parts with an encircled number, refer to Disassembly Procedure that followe.

Service Items marked with should be inspected before disassembly.

Part marked with " should not be removed unless defects are evident.

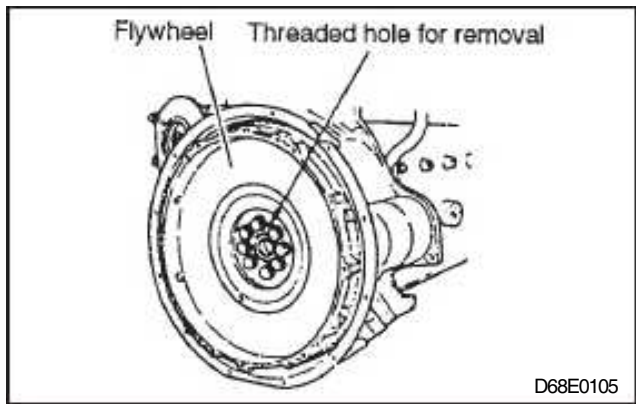
For inspecition of part marked with *2, refer to Group 90 Body Electrical

D68E0104

Disassembly Procedure

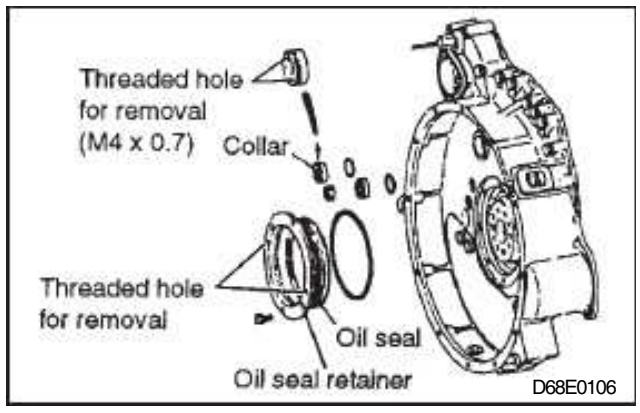
1. Removal of flywheel

   Thread the attaching bolts into the removing threaded holes to remove the flywheel.



2 Removal of the seal retainer and coller

- o To remove the oil seal retainer, turn down the attaching bolts into the removing threaded holes evenly. While making sure that the oil sea retainer does not have eccenticity, remove the retainer with the oil seal attached.
- o Remove the collar by screwing M4 x 0.7 bolts into the removing threaded holes.



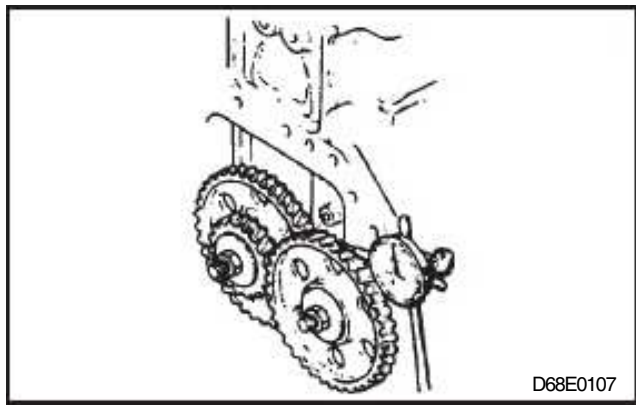
3. Measurement of gear backlash

   If the backlash exceeds the limit, check idler gear bushing and gears and replace parts as necessary.

   NOTE:

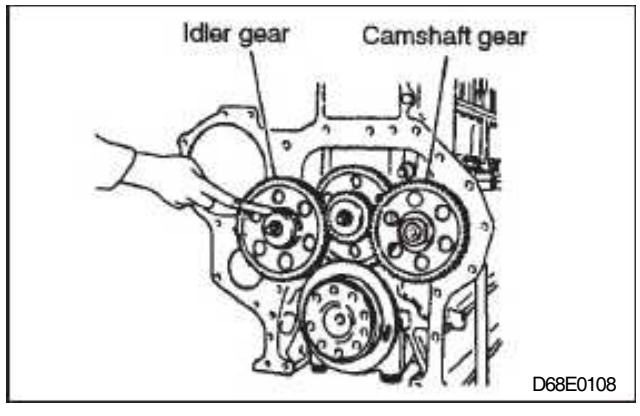
   1) Secure the air compressor to the rear plate before measurement of the backlash of the injection pump gear.

   2) For a pair of gears, the backlash should be measured at more than three points to determine whether it is acceptable.



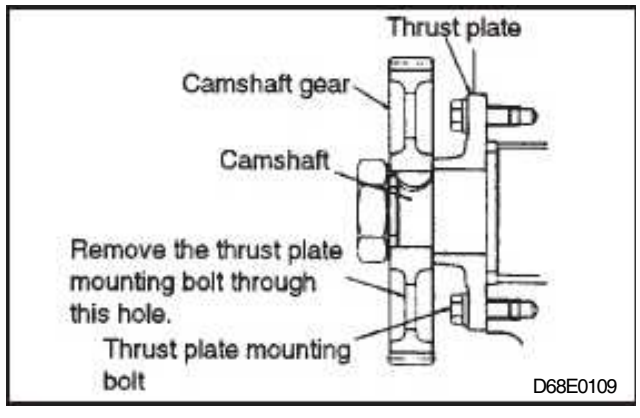
4. Measurement of end play in idler gear and camshaft gear

   If the end play exceeds the limit, replace the thrust plate.



5. Removal of camshaft

   Loosen the thrust plate mounting bolt through the camshaft gear hole and remove the camshaft.

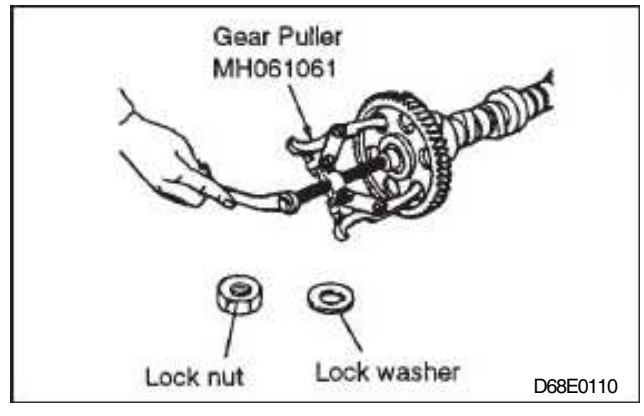


6. Removal of camshaft gear

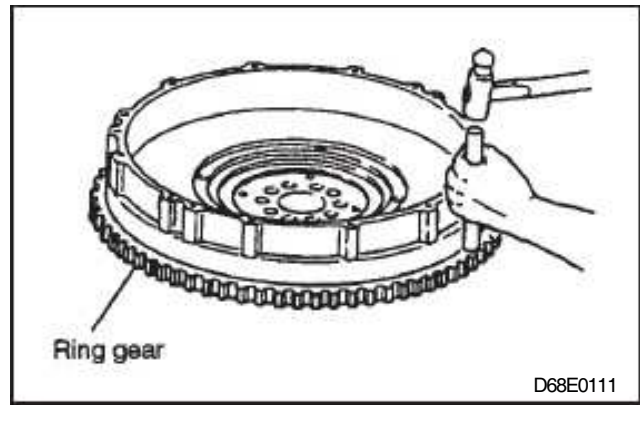
Remove the lock nut and lock washer from the camshaft gear and, using Gear Puller (special tool), remove the camshaft gear.

NOTE:
Do not strike the gears with hammer. Make sure that the gears are removed by use of a gear puller.

7. Removal of ring gear

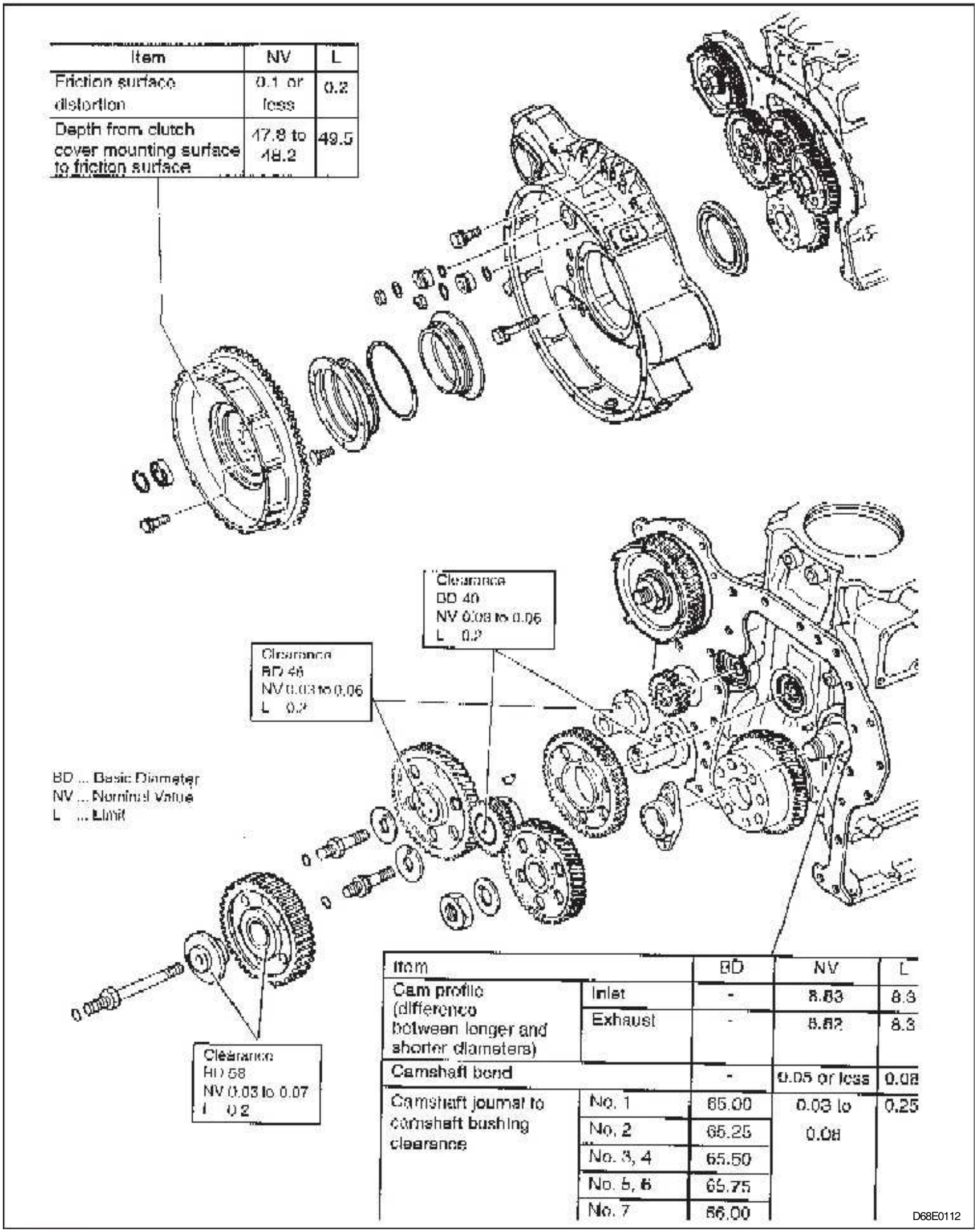


Using an acetylene torch, heat evenly the ring gear and apply a rod to the ring gear to tap it throughout its periphery.



Inspection [D6A]

Item	NV	L
Friction surface distortion	0.1 or less	0.2
Depth from clutch cover mounting surface to friction surface	47.8 to 48.2	49.5

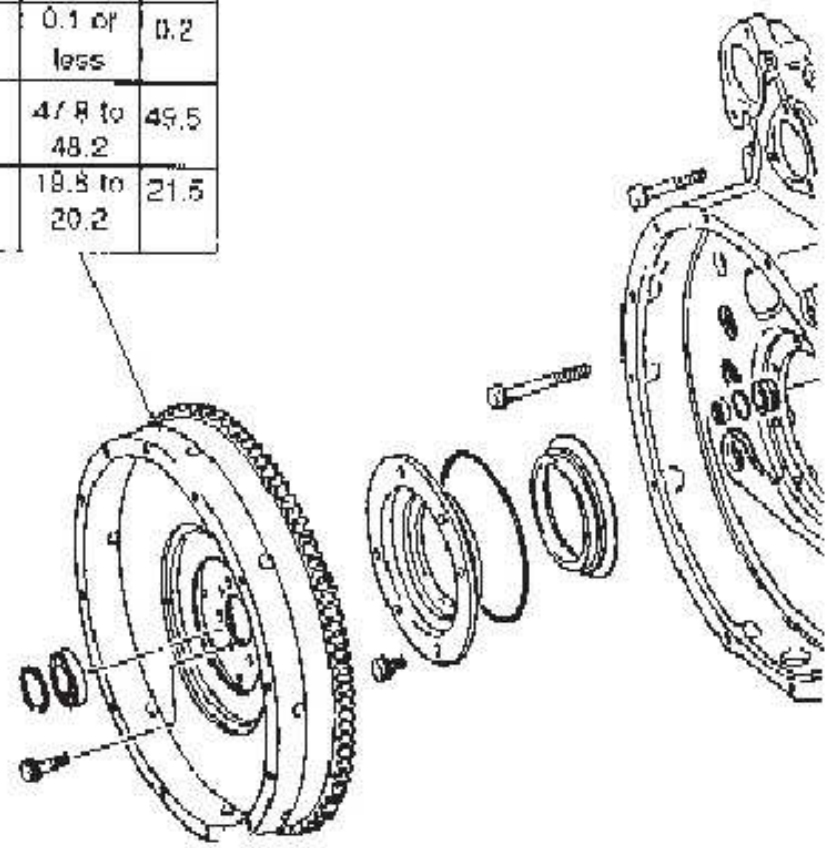


Item		BD	NV	L
Cam profile (difference between longer and shorter diameters)	Inlet	-	8.83	8.3
	Exhaust	-	8.82	8.3
Camshaft bend		-	0.05 or less	0.08
Camshaft journal to camshaft bushing clearance	No. 1	65.00	0.03 to 0.08	0.25
	No. 2	65.25		
	No. 3, 4	65.50		
	No. 5, 6	65.75		
	No. 7	66.00		

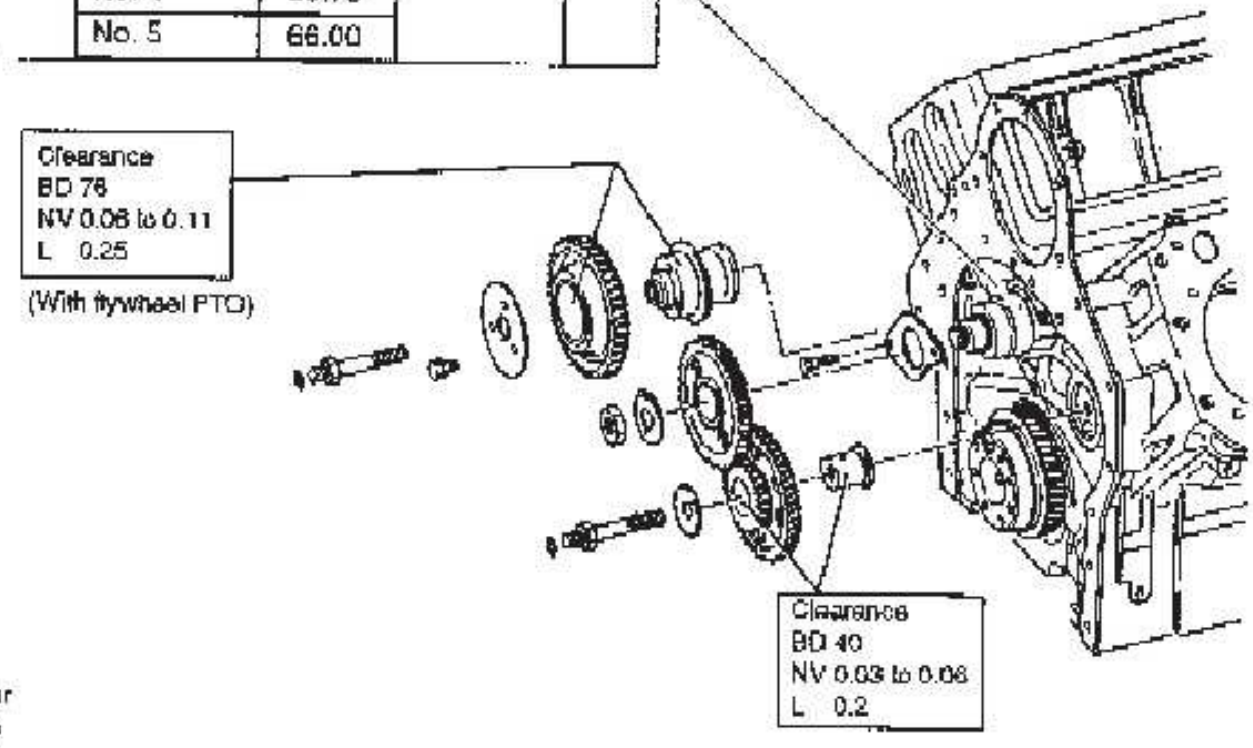
D68E0112

Inspection [D8A]

Item		NV	L
Friction surface distortion		0.1 or less	0.2
Depth from clutch cover mounting surface to friction surface	D8AY	47.8 to 48.2	49.5
	D8AB	19.8 to 20.2	21.5



Item		BD	NV	L
Cam profile (difference between longer and shorter diameters)	Inlet	-	8.86	8.36
	Exhaust	-	8.78	8.36
Camshaft alignment (or bend)		-	0.05 or less	0.08
Camshaft journal to camshaft bushing clearance	No. 1, 2	65.25	0.07 to 0.10	0.25
	No. 3	65.50		
	No. 4	65.75		
	No. 5	66.00		



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

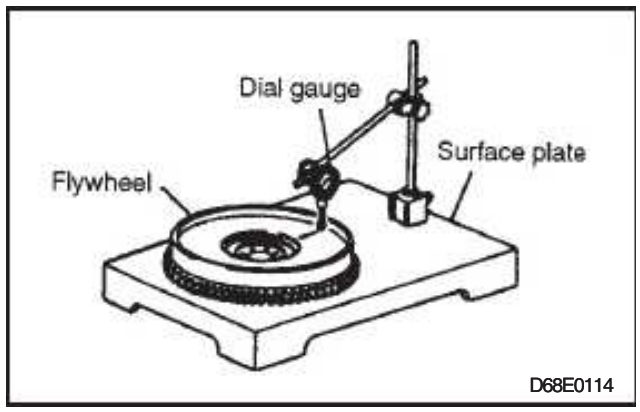
D68E0113

Inspection Procedure

1. Distortion of friction surface

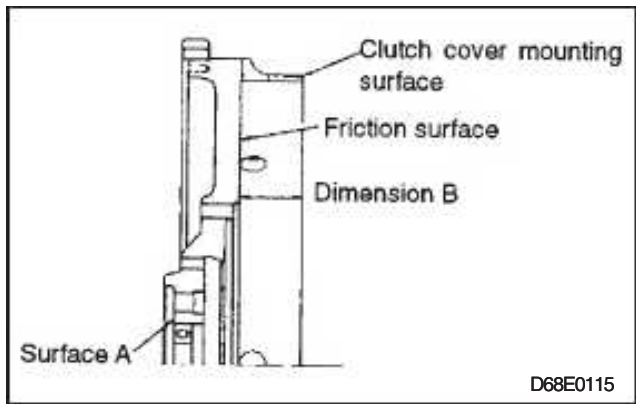
   Place the flywheel on a surface plate. Measure distortion by moving a dial gauge in the diametrical direction of the flywheel. If the distortion exceeds the repair limits, grind the friction surface.

   NOTE:
   If the ring gear shown an abnormal condition, replace the ring gear before measurement.



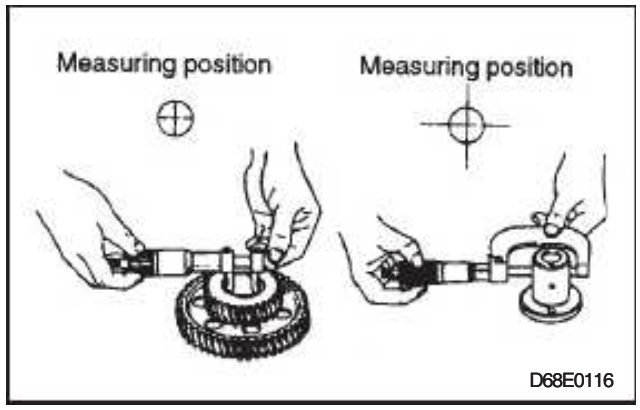
2. Correction of flywheel friction surface

   Correct the friction surface so that dimension B (height from clutch cover mounting surface to friction surface) is below the limit and the friction surface is parallel to surface A within 0.1. If dimension B exceeds the limit, replace the flywheel.



3. Idler gear to idler shaft clearance

   If the limit is exceeded, the bushing in the gear should be replaced.

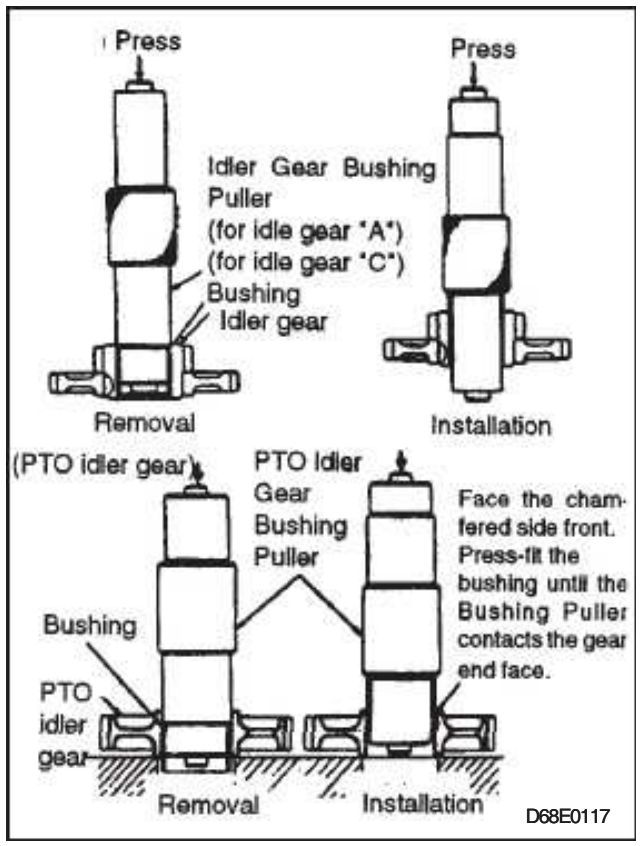


4. Replacement of idler gear bushing

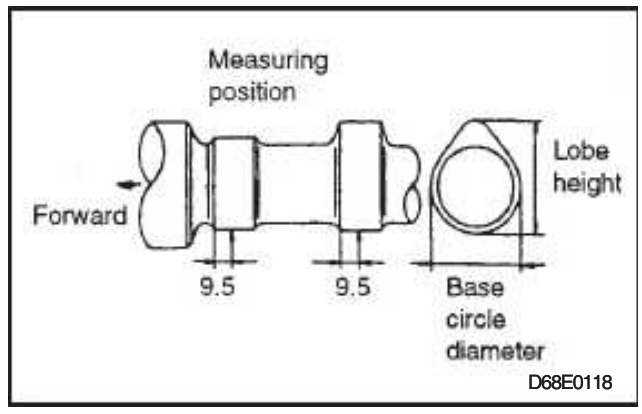
   Replace the bushing by the procedures shown in illustration, using idler Gear Bushing Puller (special tool).

   NOTE:
   1) Install the bushing with chamfered side of gear I.D. inward.
   2) After installation, check to ensure that the bushing to idler shaft clearance is within the nominal dimension. If it is below the nominal dimension, ream the bushing.

5. Cam profile



Measure the lobe height and base circle diameter and replace the camshaft if the difference between the two is below the limit.



NOTE:
The cam must be measured at locations shown as it is tapered.

6. Camshaft journal to crankcase camshaft bushing clearance

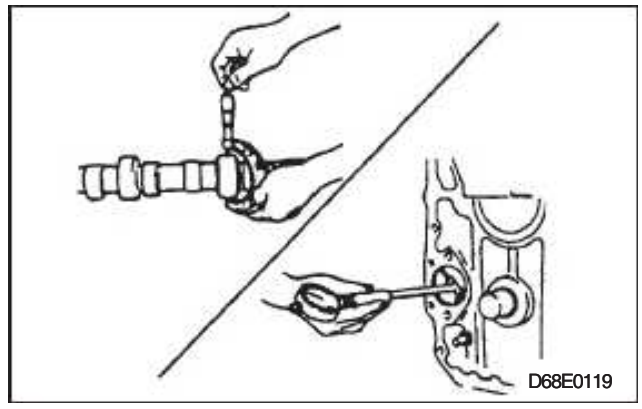
If the limits are exceeded, the bushing in the crankcase should be replaced.

7. Camshaft bushing replacement procedures

Removal

Remove the camshaft bushings in the order of No.6 →No.5 → No.4 →No.3 →No.2 →No.1 →No.7 and according to the following procedures.

(1) Removal of camshaft bushings No.6 to No.1

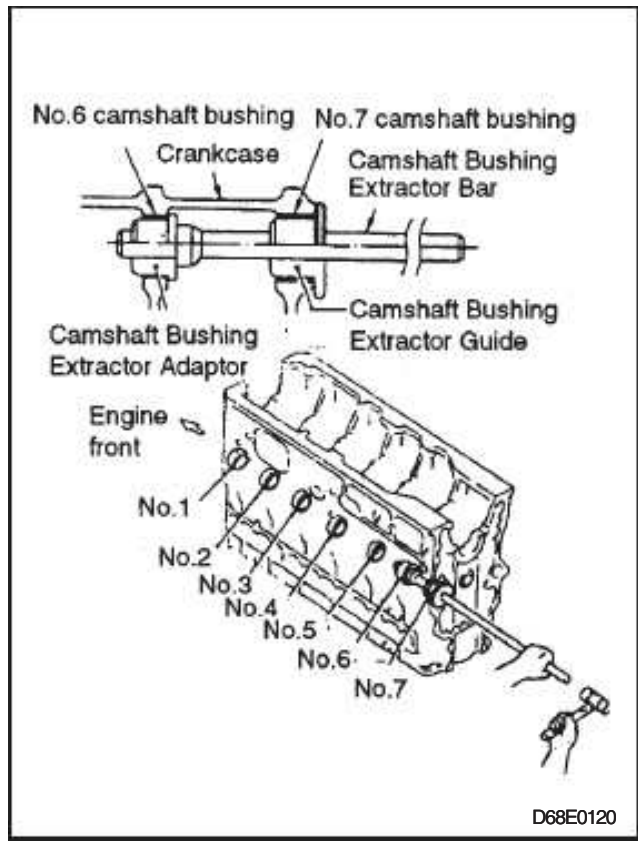


a) Fit the special tools, Camshaft Bushing Extractor Adaptor and Camshaft Busing Extractor Guide, to the special tool, Camshaft Bushing Extractor Bar and insert the assembly into the crankcase, fitting the Camshaft Bushing Extractor Guide to No. 7 camshaft bushing to hold the Camshaft Bushing Extractor Bar.

b) Applying the special tool, Camshaft Bushing Extractor Adaptor, to No.6 camshaft bushing, strike the Camshaft Bushing Extractor Bar with a hammer as illustrated drive out No.6 camshaft bushing.

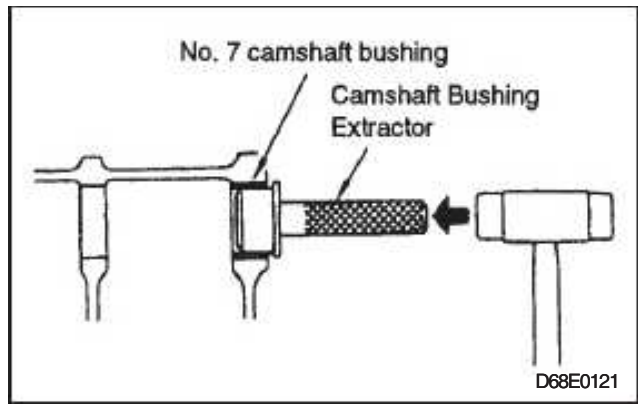
c) After removal of No. 6 camshaft bushing, remove No. 5 to no. 1 camshaft bushings in order, using respective special tool, Camshaft Bushing Extractor Adaptor.

(2) Removal No. 7 camshaft bushing



• Installation

Install the camshaft bushings No.2 , No. 3 and No. 4 simultaneously at first, then No. 5 and No. 6 simultaneously and then No. 1 and finally No. 7 by the following procedures.



(3) Installation of No. 2, No. 3, No. 4 camshaft bushing

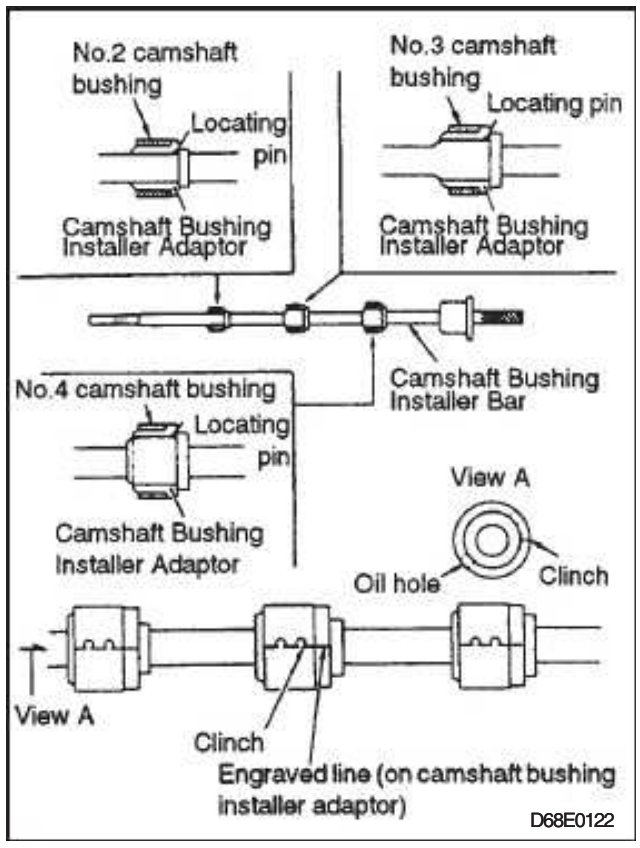
a) Fit the special tools, Camshaft Bushing Installer Adaptors, and camshaft bushings No.2 to No.4 to the illustrated portion of the special tool, Camshaft Bushing Installer Bar with the engraved line of the special tool, Camshaft Bushing Installer Adaptor, and the clinch of the bushing in alignment.

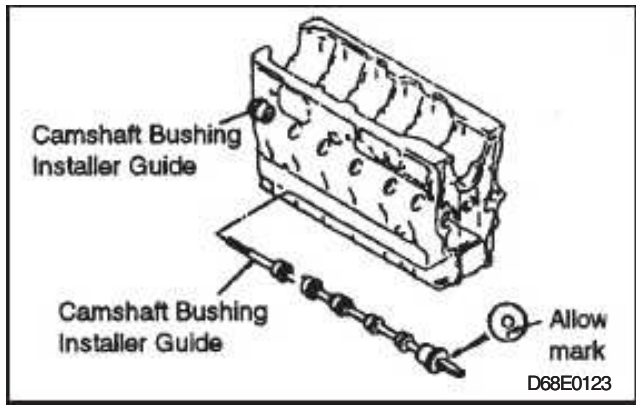
b) Fit the special tool, Camshaft Bushing Installer Guide, to where No. 1 camshaft bushing is to be installed so that the special tool, Camshaft Bushing Installer Bar may be supported. Then, insert the Camshaft Bushing Installer Bar into the crankcase, making sure that the bar is positioned with its arrow facing toward the crankcase top.

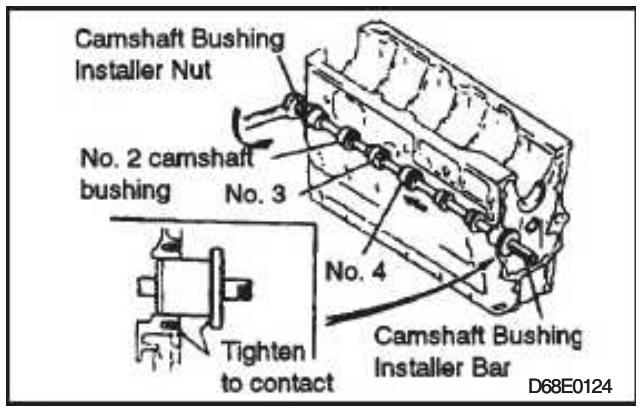
c) Making sure that the engraved lines on the special tools, Camshaft Bushing Installer Adaptors and the clinch are lined up, fit the special tool, Camshaft Bushing Installer Bar and tighten to install each bushing. Tighten until the flange of the Camshaft Bushing Installer Bar is seated on the crankcase.

d) After installation of the bushings, remove the Camshaft Bushing installer Nut and gently remove the Camshaft Bushing Installer Bar.

NOTE:
When removing the Camshaft Bushing Installer Bar, use care not to damage the bushing inside surface.

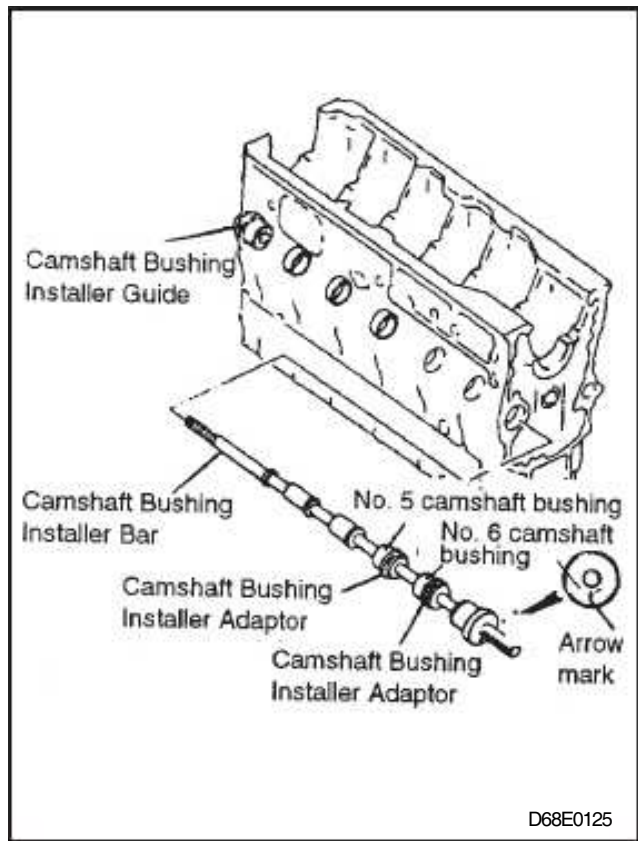






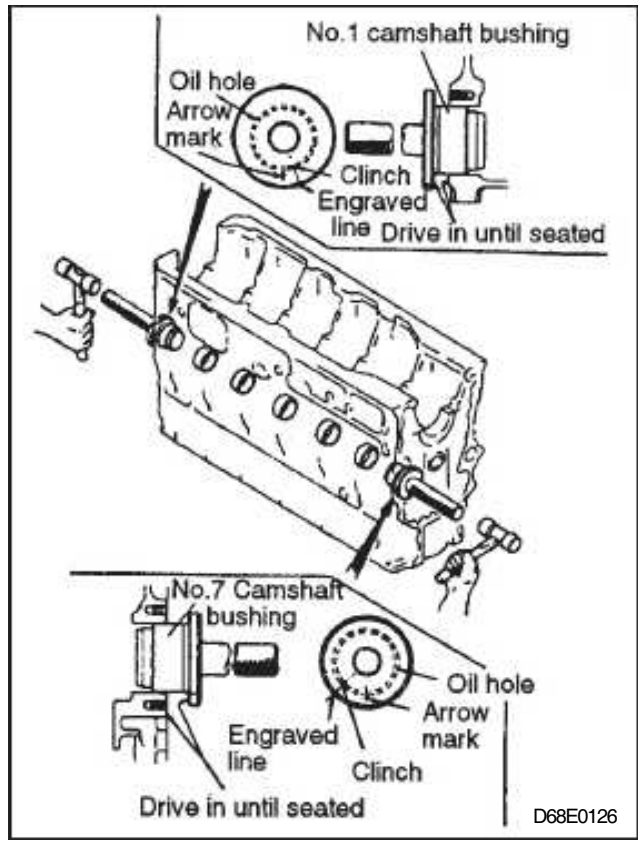
(4) Simultaneous installation of No.5 and No. 6 camshaft bushing.

Work as in 1) above, using the special tool, Camshaft Bushing Installer Adaptor for respective No. 5, and No. 6 bushing.



(5) Installation of No. 1 and no. 7 camshaft bushings

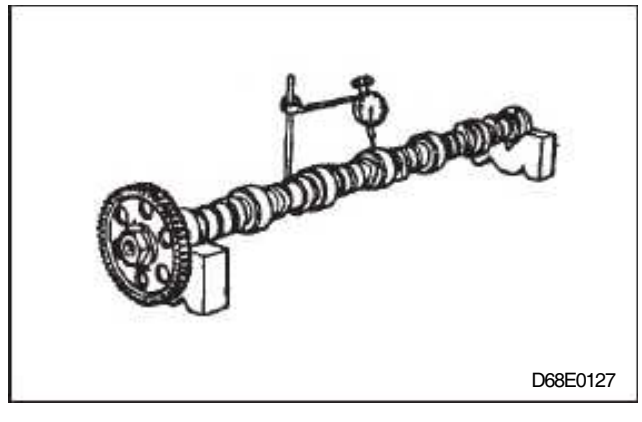
Install the bushings by striking the special tool, Camshaft Bushing Installer with its engraved line lined up with the clinch on the bushing and with the installer arrow mark facing toward the top of the crankcase. Drive in until the flange of the Camshaft Bushing Installer is seated on the crankcase.



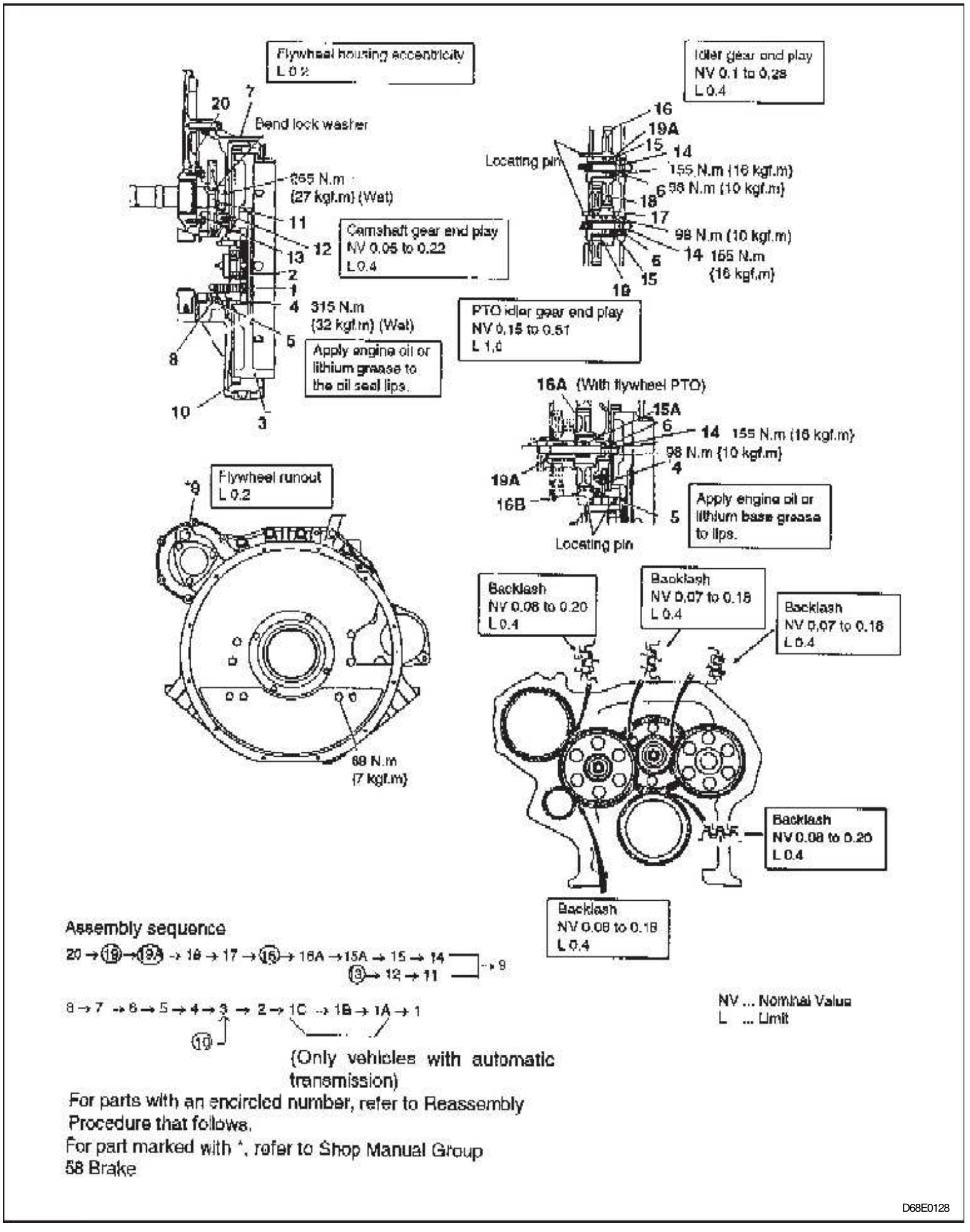
8. Bend of camshaft

Measure the bend of the camshaft. If the limit is exceeded, replace.

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



Reassembly [D6A]



Assembly sequence

20 → ⑲ → ⑲A → 16 → 17 → ⑮ → 16A → 15A → 15 → 14 → *9
⑬ → 12 → 11

8 → 7 → 6 → 5 → 4 → ⑩ → 3 → 2 → 1C → 1B → 1A → 1

(Only vehicles with automatic transmission)

NV ... Nominal Value
L ... Limit

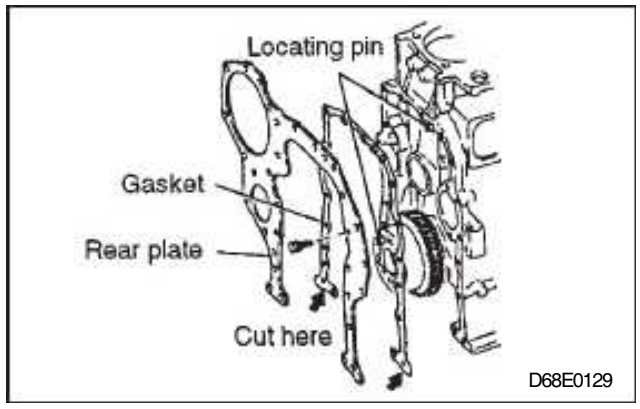
For parts with an encircled number, refer to Reassembly Procedure that follows.
For part marked with *, refer to Shop Manual Group 58 Brake

D68E0128

Reassembly Procedure

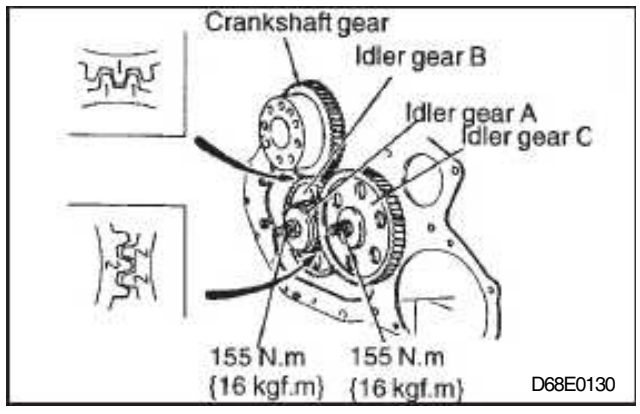
1. Installation of rear plate

   Install the rear plate and gasket so that they are aligned with the locating pins.
   The gasket is forced out from the bottom. Cut of the excess after the flywheel housing is installed.



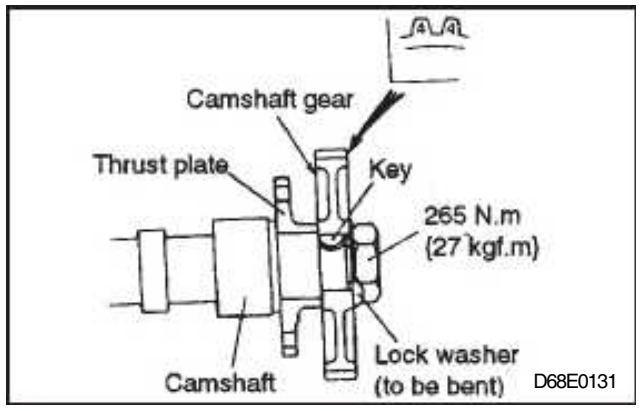
2. Installation of idler gears

   Install the idler shaft so that it is aligned with the locating pin in the crankcase.
   Then, install the idler gear B so that its alignment mark "1" is aligned with the alignment mark "1" on the crankshaft gear.
   Next, install idler gears A and C so that their alignment marks "2" are aligned.
   Tighten the idler shaft bolt to specification.



3. Installation of camshaft gear

   Install the camshaft gear so that the side having stamped numbers "4" faces front.



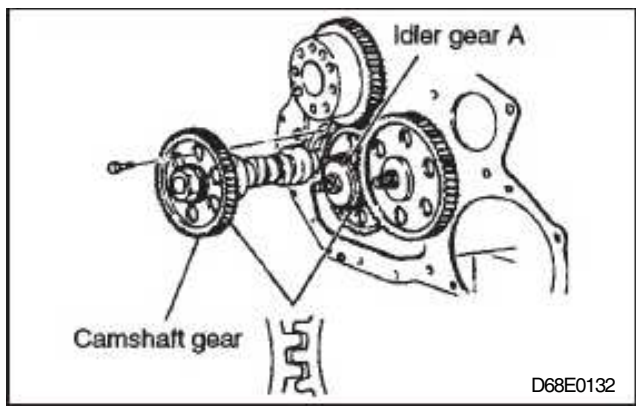
4. Installation of camshaft

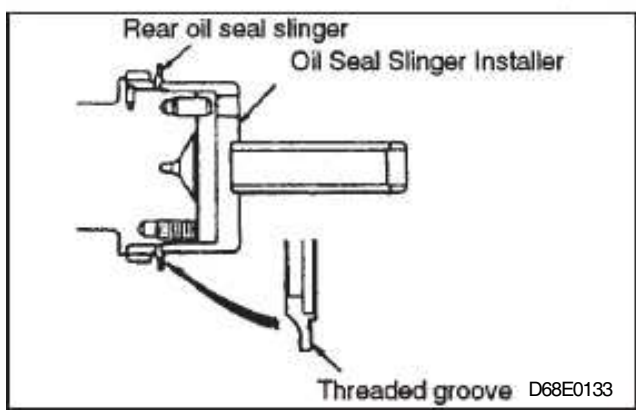
   Install the camshaft so that the alignment mark "4" on the camshaft gear is aligned with the alignment mark "4" on idler gear A.

   NOTE:
   When the camshaft is inserted, take care not to damage the camshaft bushing.

5. Check camshaft gear and idler gear for correct end play.
6. Check backlash in gears.
8. Installation of ring gear
7. Installation of rear oil seal slinger
   Install the oil seal slinger, using Oil Seal Slinger Installer (special tool).

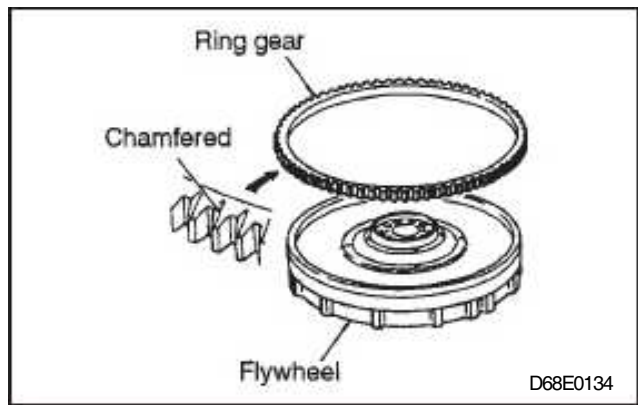
   NOTE:
   Pay attention to the oil seal slinger installing direction.
   Face the threaded groove side toward the flywheel.



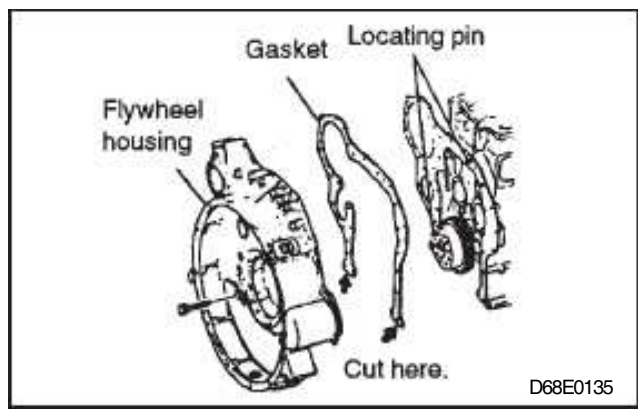


(a) Heat the ring gear for 3 minutes with piston heater (approx. 100°C).
(b) Fit the ring gear onto the flywheel with the nonchamfered side of the teeth end toward the flywheel.

9. Installation of flywheel housing

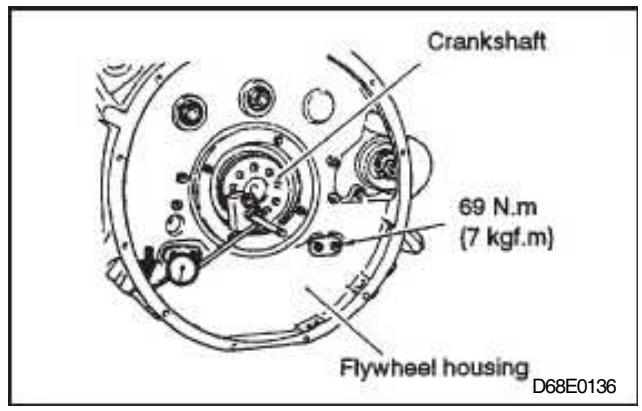


Install the flywheel housing and gasket so that they are aligned with the locating pins in the crankcase. Cut the bottom portions of the gasket after installation as they are excess.
Cut at the same time the excess portions of the gasket between the rear plate and crankcase.



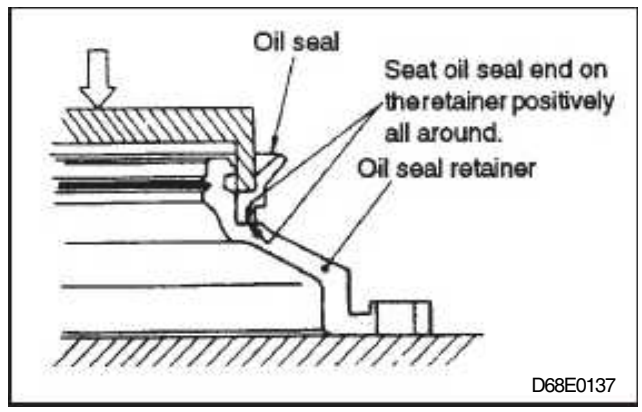
10. Flywheel housing eccentricity check

Install the flywheel housing to crankcase by tightening to the specified torque.
Measure the mounting condition (eccentricity) at the flywheel housing joint. If the pointer of a dial indicator deflects beyond the limit, loosen the bolts and lightly strike the housing to correct the mounting condition.



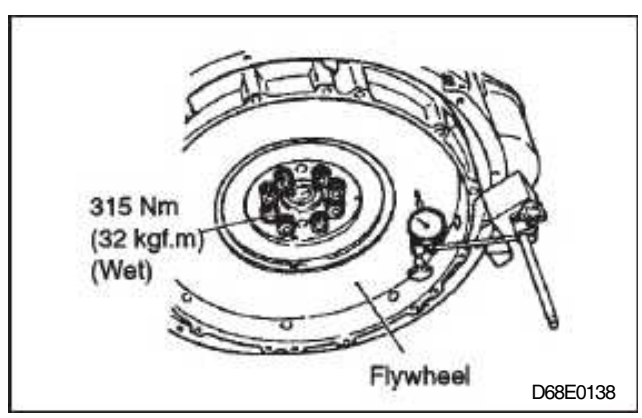
11. Installation of oil seal

When press-fitting an oil seal to the retainer, apply force uniformly to the entire periphery.

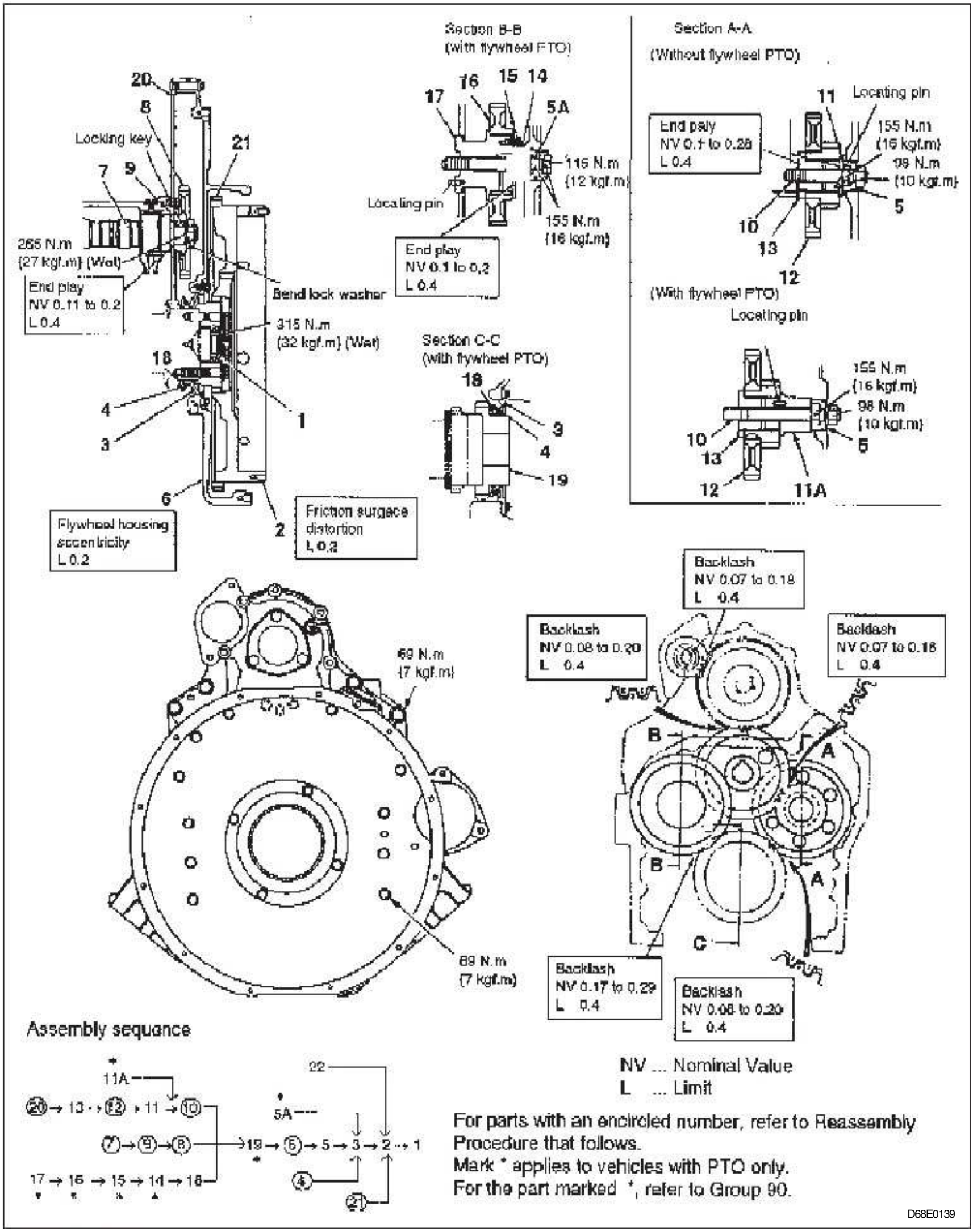


12. Flywheel runout check

Install the flywheel to the crankshaft by tightening to the specified torque.
Measure the flywheel mounting condition (runout). If the pointer of the dial indicator deflects beyond the limit, check the bolt tightness or mounting surface.



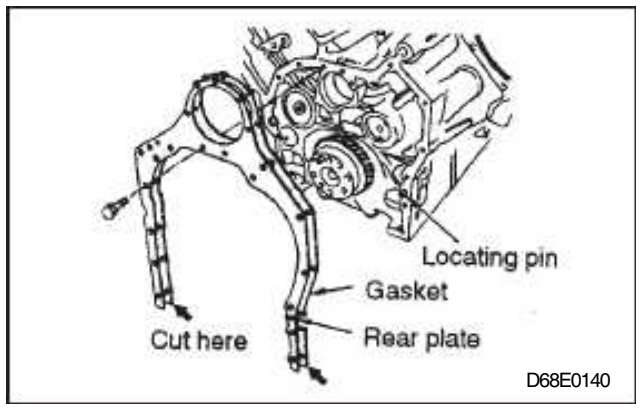
Reassembly (D8A)



Reassembly Procedure

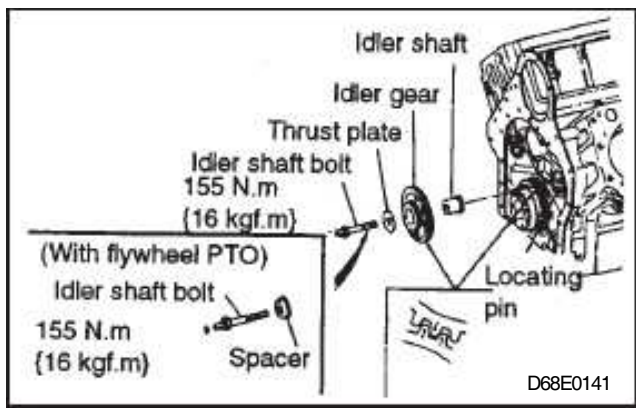
1. Installation of rear plate

   Install the rear plate and gasket making sure they are aligmed with the locating pin on the crankcase.
   The gasket is forced out from the bottom. Cut of the excess after the flywheel housing is installed.



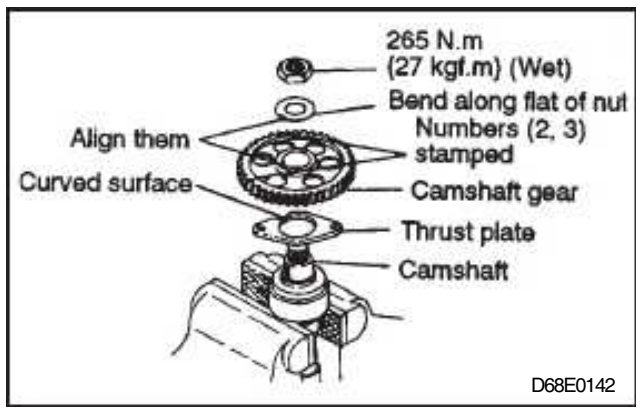
2. Installation of idler gears

   Install the idler shaft by aligning it with the locating pin on the crankcase.
   install the idler gear so that its alignment mark "1" is aligned with the alignment mark "1" on the crankshaft gear.
   Then, tighten the idler shaft bolt to specification.



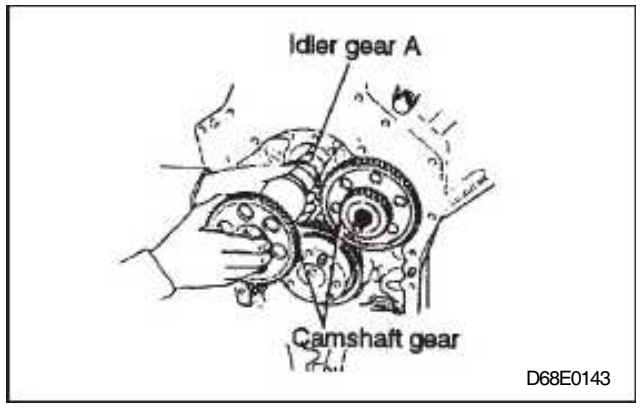
3. Installation of thrust plate and camshaft gear.

   Install the thrust plate so that its curved surface faces as shown.
   Install the camshft gear so that the side, on which numbers "2, 3" are stamped, face front
4. Installation of camshaft



   Install the camshaft so that the alignment mark "2" on the camshaft gear is aligned with the alignment mark "2" on idler gear.

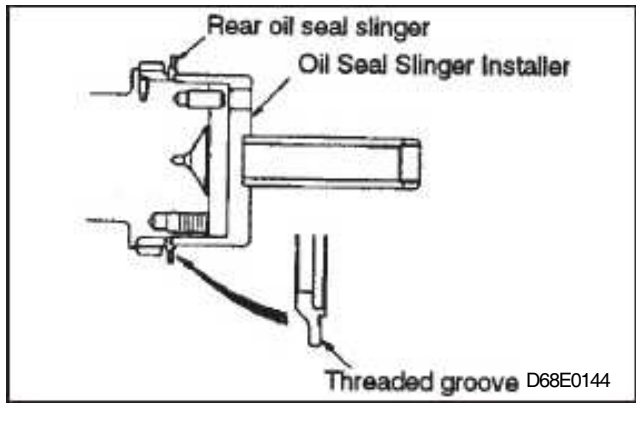
   NOTE:
   When the camshaft is inserted, take care not to damage the camshaft bushing.



5. Check the end play in the camshaft gear and idler gear.
6. Check backlash in gears.

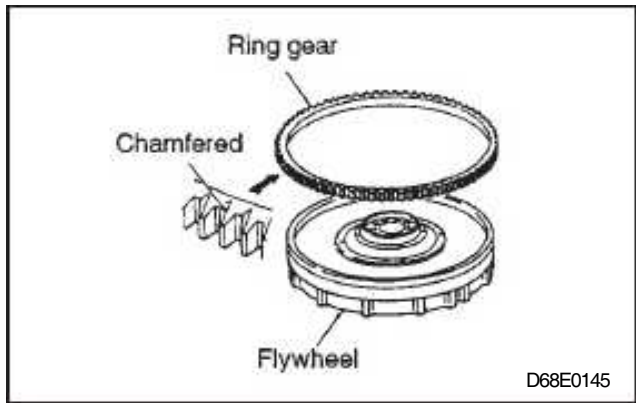
7. Installation of rear oil seal slinger
   Install the oil seal slinger, using Oil Seal Slinger Installer (special tool).

   NOTE:
   Pay attention to the oil seal slinger installing direction.
   Face the threaded groove side toward the flywheel.



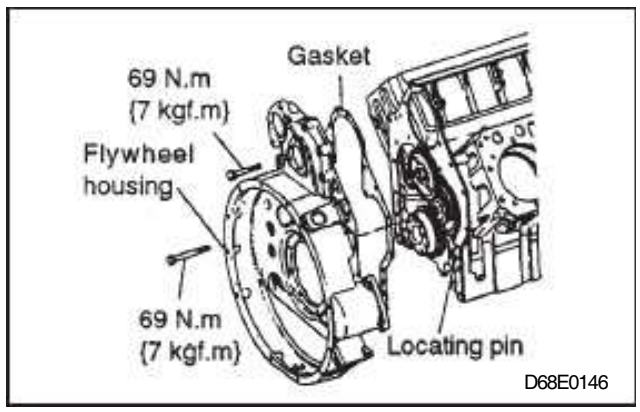
8. Installation of ring gear

(a) Heat the ring gear for 3 minutes with piston heater (approx. 100°C).
(b) Fit the ring gear onto the flywheel with the nonchamfered side of the teeth end toward the flywheel.



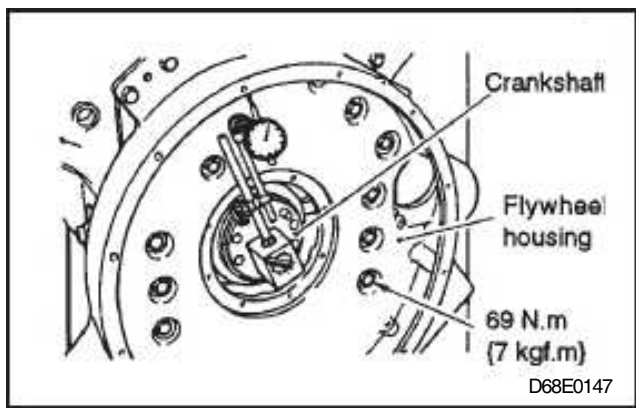
9. Installation of flywheel housing

Install the flywheel housing and gasket so that they are positioned by the locating pin on the crankcase. Cut the bottom portions of the gasket after installation as they are excess. Cut also the excess between the rear plate and crankcase.



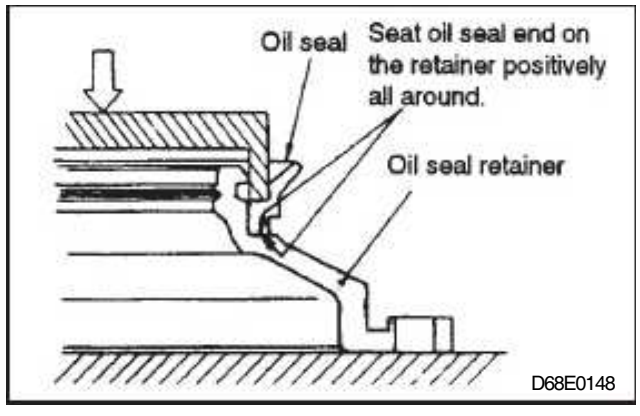
10. Flywheel housing eccentricity check

Install the flywheel housing to crankcase by tightening to the specified torque.
Measure the mounting condition (eccentricity) at the flywheel housing joint. If the pointer of a dial indicator deflects beyond the limit, loosen the bolts and lightly strike the housing to correct the mounting condition.



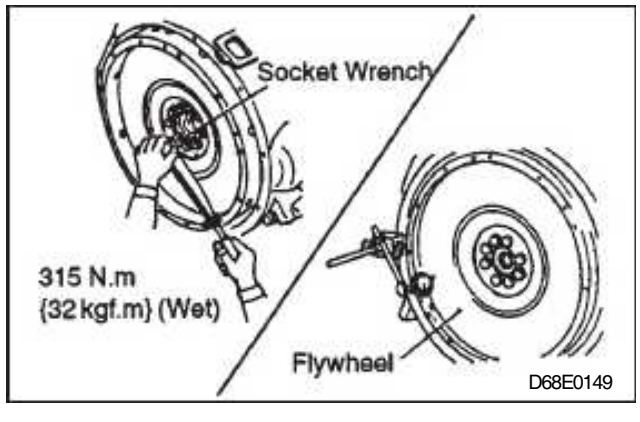
11. Installation of oil seal

When press-fitting an oil seal to the retainer, apply force uniformly to the entire periphery.



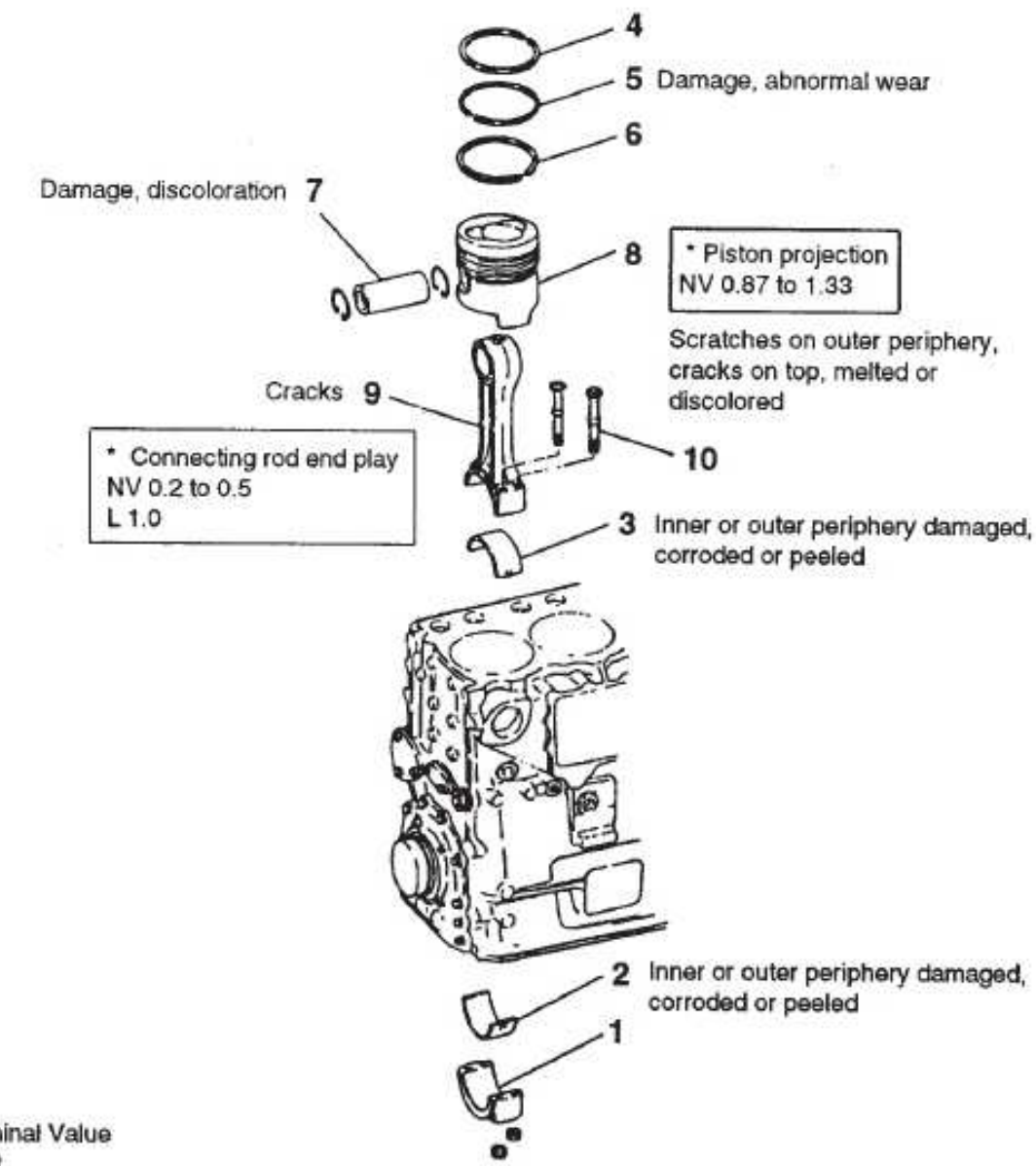
12. Flywheel runout check

Install the flywheel to the crankshaft by tightening to the specified torque.
Measure the flywheel mounting condition (runout). If the pointer of the dial indicator deflects beyond the limit, check the bolt tightness or mounting surface.



Crankcase and Main Moving Parts

Disassembly [D6A]



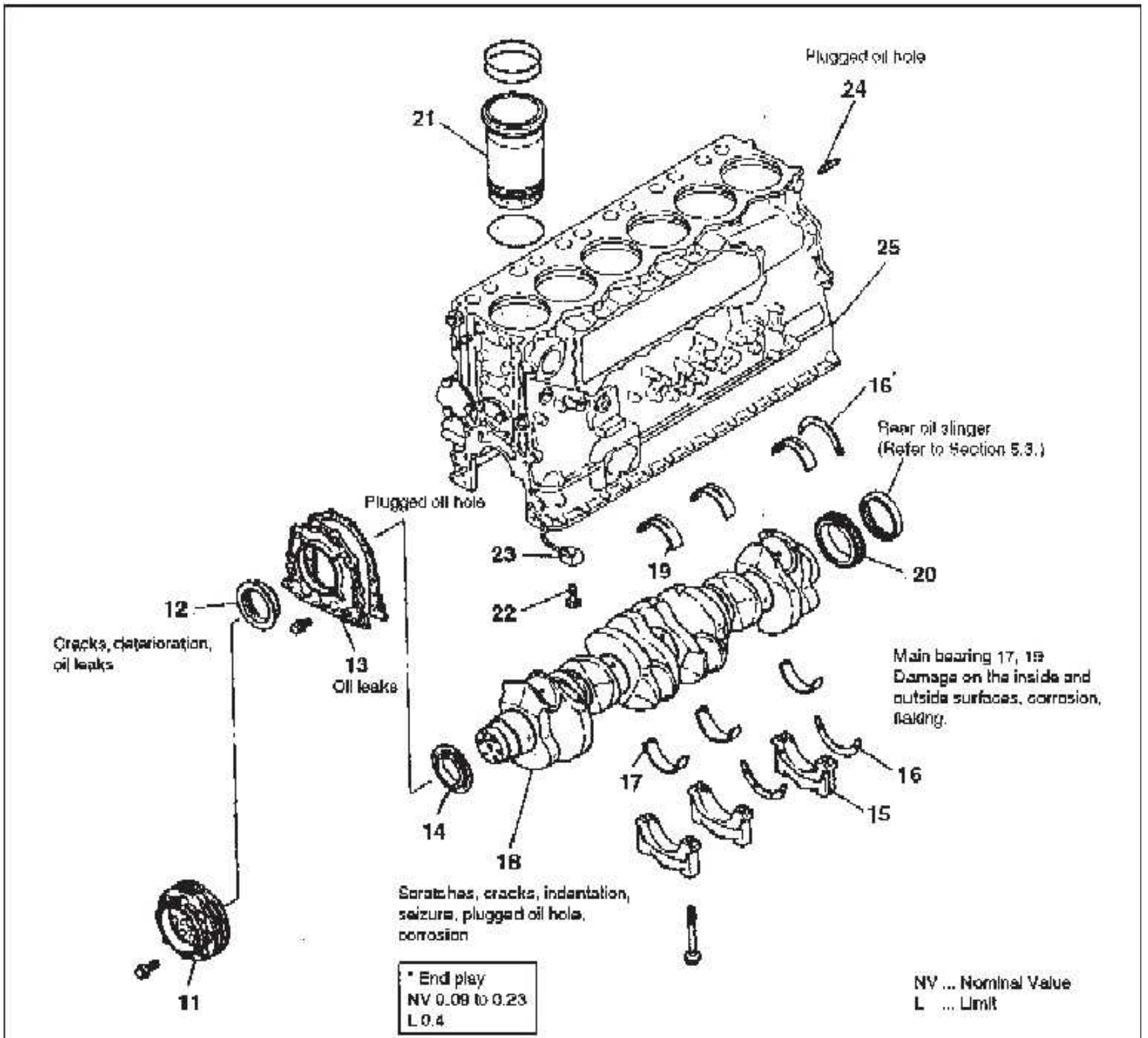
NV ... Nominal Value
L ... Limit

Disassembly sequence

1 Connecting rod cap
2 Lower connecting rod bearing
3 Upper connecting rod bearing
④ 1st compression ring
⑤ 2nd compression ring
⑥ Oil ring
7 Piston pin
⑧ Piston
⑨ Connecting rod
*10 Connecting rod bolt

For parts with an encircled number, refer to Disassembly Procedure that follows.
Part marked with * should not be removed unless defects are evident.
Service items marked with should be inspected before disassembly.

D68E0150



Disassembly sequence

	(11)	Crankshaft pulley		16	Thrust plate	*1	21	Cylinder liner
*1	12	Front oil seal		17	Lower main bearing	*2	22	Check valve
	13	Front cover		18	Crankshaft		23	Oil jet
*1	14	Front oil seal slinger		19	Upper main bearing		24	Oil spray plug
	15	Main bearing cap	*1	(20)	Crankshaft gear		25	Crankcase

For parts with an encircled number, refer to Disassembly Procedure that follows.
Service items marked with should be checked before disassembly.
Parts marked with *1 should not be removed unless defects are evident.
For inspection of the part marked with *2, refer to Group 21 Lubrication.

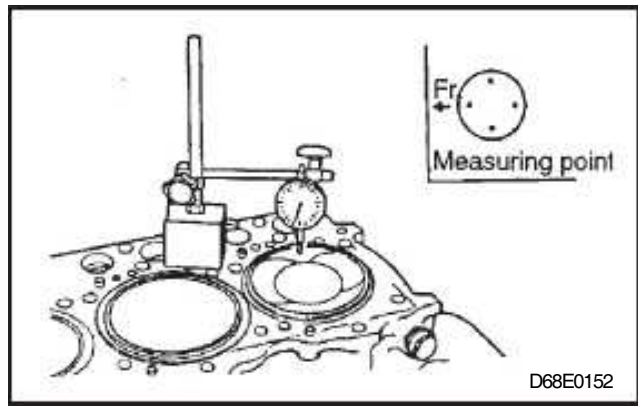
D68E0151

Disassembly Procedure

1. Piston projection

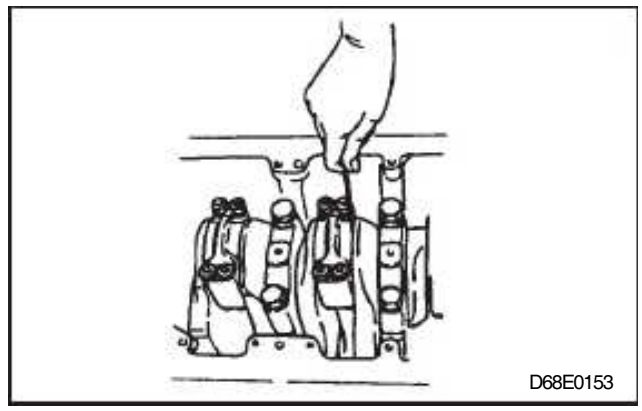
   The piston projection must be up to specification, as it affects engine performance and is also necessary for preventing interference with the valve.

   (a) Hold the dial indicator to the top surface of the crankcase and make zero adjustment.
   (b) Find the top dead center of piston with a dial indicator.
   (c) Measure four points on the top surface of piston to find the average value.
   (d) If the projection is out of specification, check the connecting rod, bushing, piston pin, connecting rod bearing, etc. and replace defective parts.



2. Connecting rod end play

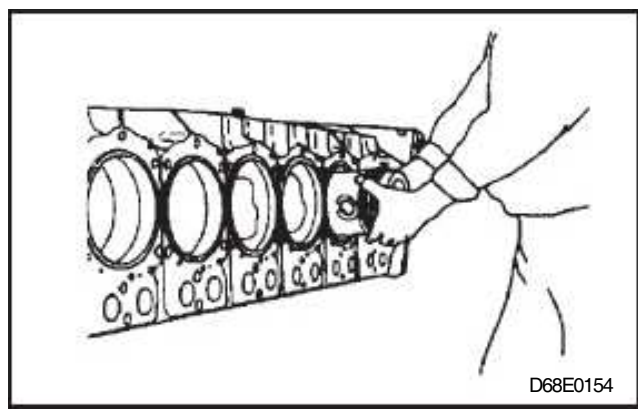
   Measure the end play of each connecting rod. If the limit is exceeded, replace the connecting rod assembly.



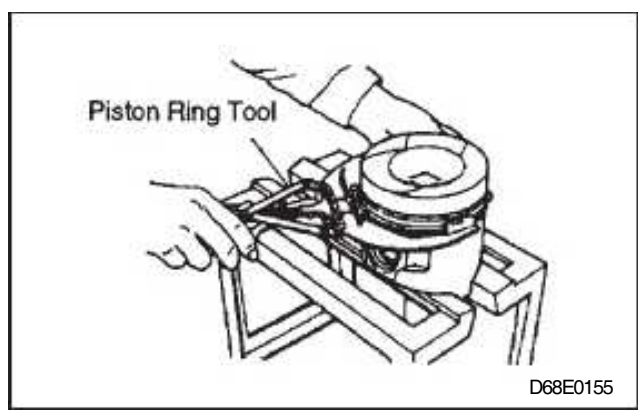
3. Removal of piston

   Remove the piston from the crankcase together with the connecting rod.

   NOTE:
   When removing the pistons, use care to prevent damage to the cylinder liner.

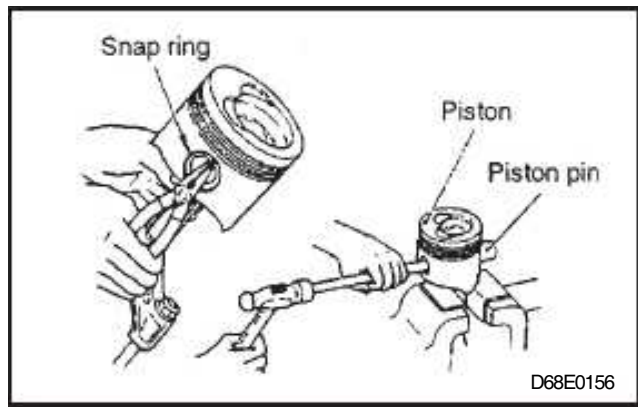


4. Removal of piston rings



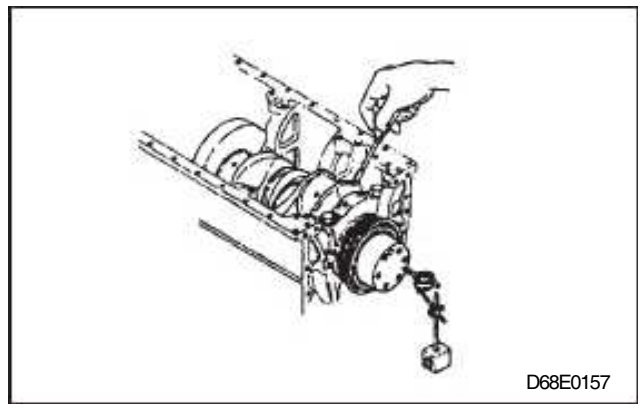
5. Separating piston from connecting rod

Remove the snap ring and, using a rod, tap piston pin off.
If, however, the piston pin is hard to remove, heat the piston with a piston heater or in hot water.



6. Crankshaft end play

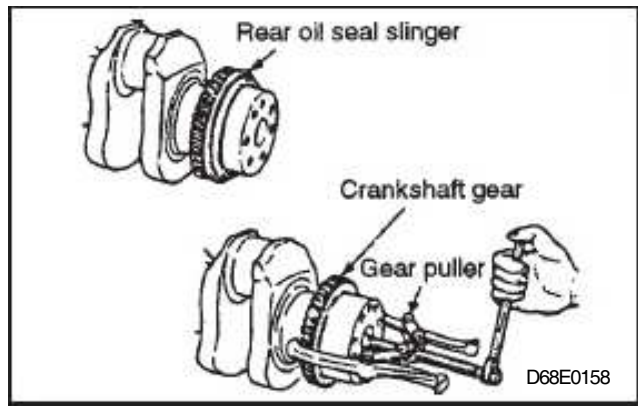
Before removing the main bearing caps, measure the end play in the crankshaft.
If the end play exceeds the limit, replace the thrust plate with an oversize one.



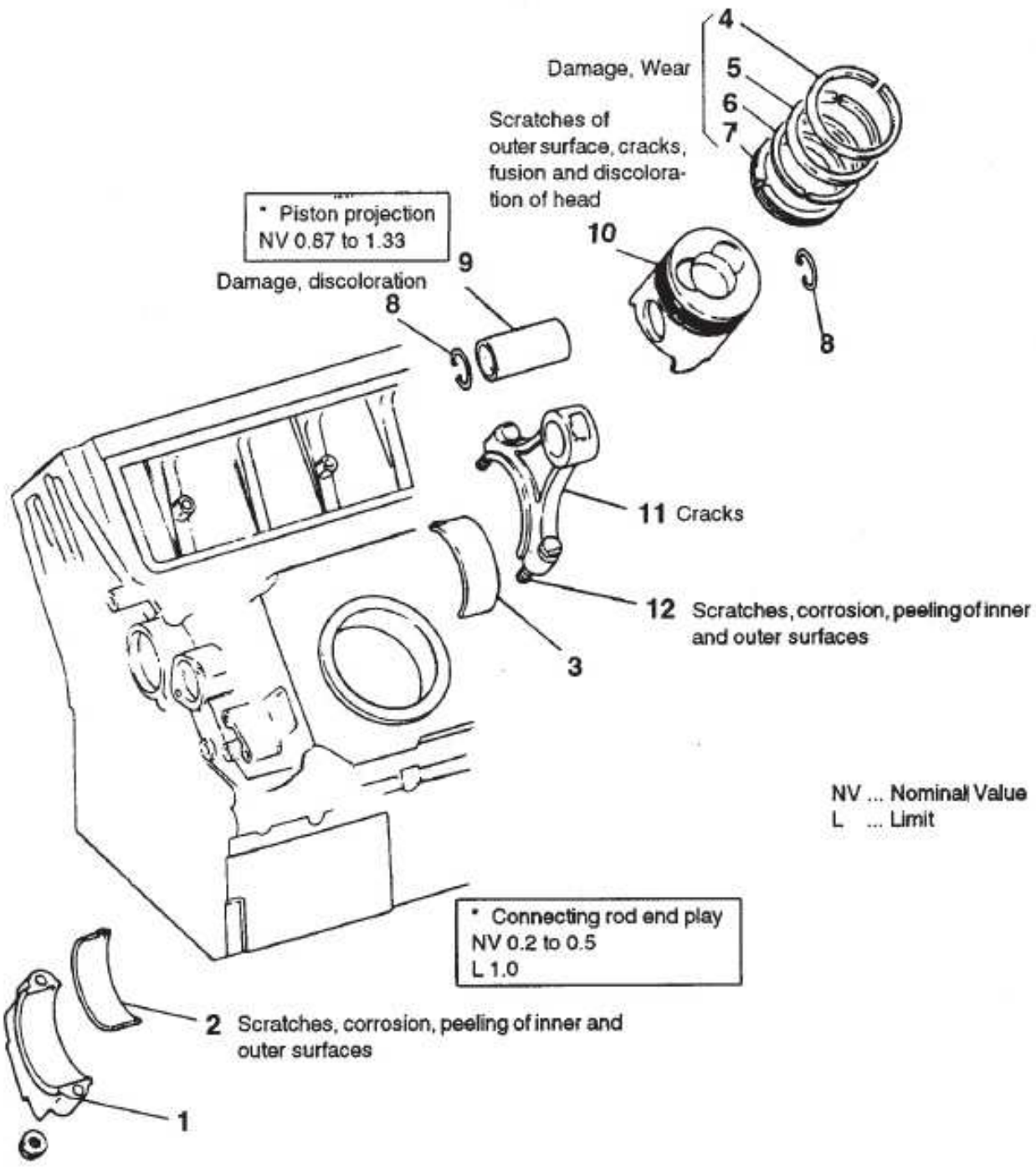
7. Removal of crankshaft gear

(a) Remove the rear oil seal slinger from the crankshaft by cutting it with a punch.
(b) Remove the crankshaft gear from the crankshaft, using Gear Puller (special tool).

NOTE:
Do not attempt removing the crankshaft gear by striking with a hammer or prying with a lever.



Disassembly [D8A]

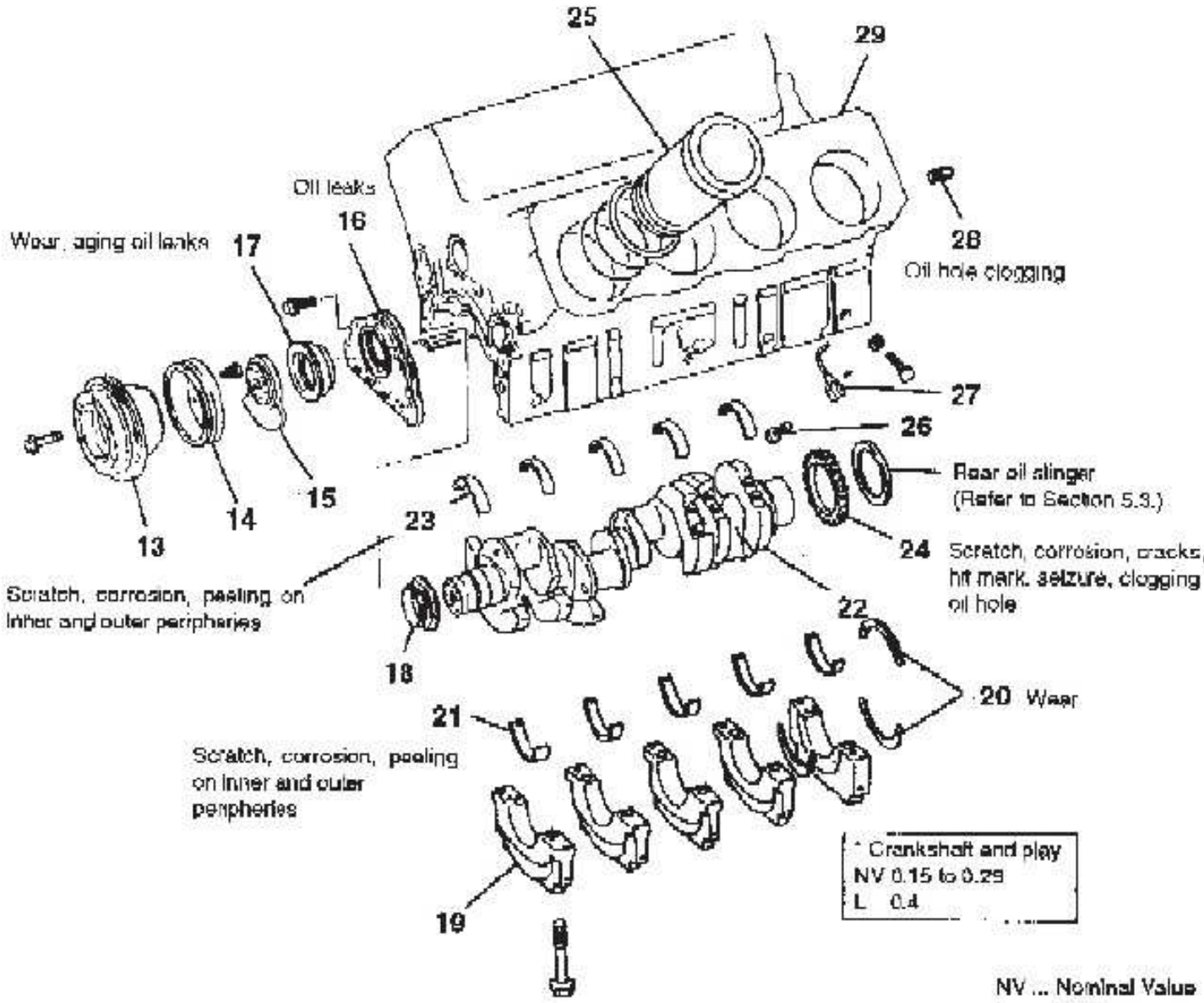


Disassembly sequence

① Connecting rod cap	⑦ Oil ring
2 Lower connecting rod bearing	8 Snap ring
3 Upper connecting rod bearing	9 Piston pin
④ 1st compression ring	*⑩ Piston
⑤ 2nd compression ring	⑪ Connecting rod
⑥ 3rd compressin ring	*12 Connecting rod bolt

For parts with an encircled number, refer to Disassembly Procedure that follows.
Service items marked with * should be inspected before disassembly.
Part marked with * should not be removed unless defects are evident.

D68E0159



Disassembly sequence

13 Crankshaft pulley
14 Torsional damper <DBAY, D8AB>
15 Front balance weight
16 Front cover
*1 17 Front oil seal
*1 18 Front oil seal slinger
(19) Main bearing cap
20 Thrust plate
21 Low main bearing
22 Crankshaft
23 Upper main bearing
*1 (24) Crankshaft gear
*1 25 Cylinder liner
*1 26 Check valve
27 Oil jet
28 Oil spray plug
29 Crankcase

For parts with an encircled number, refer to Disassembly Procedure that follows.
Service items marked with should be checked before disassembly.
Parts marked with *1 should not be removed unless defects are evident.
The parts marked *2 have a locking agent applied to their threaded portions. do not reuse the parts, as thry might be deformed when removed.

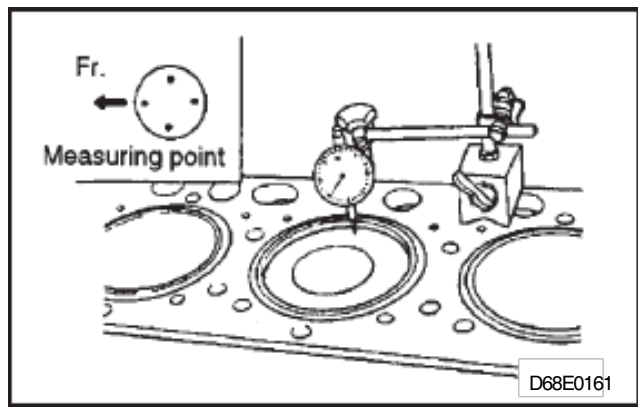
D68E0160

Disassembly Procedure

1. Piston projection

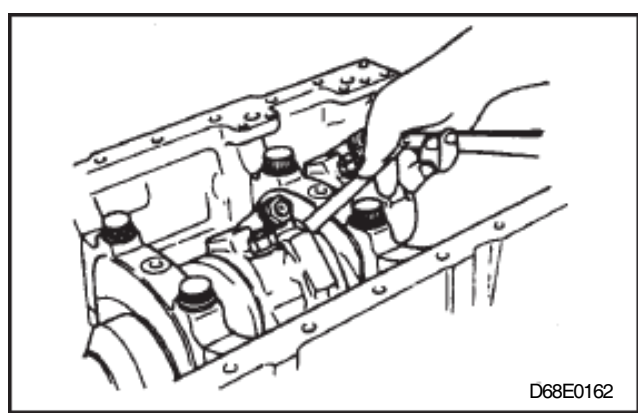
   The piston projection must be up to specification, as it affects engine performance and is also necessary for preventing interference with the valve.

   (a) Hold the dial indicator to the top surface of the crankcase and make zero adjustment.
   (b) Find the top dead center of piston with a dial indicator.
   (c) Measure four points on the top surface of piston to find the average value.
   (d) If the projection is out of specification, check the connecting rod, bushing, piston pin, connecting rod bearing, etc. and replace defective parts.

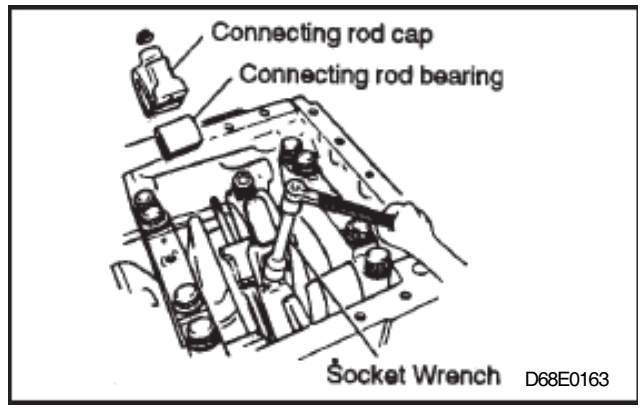


2. Connecting rod end play

   Measure the end play of each connecting rod. If the limit is exceeded, replace the connecting rod assembly.



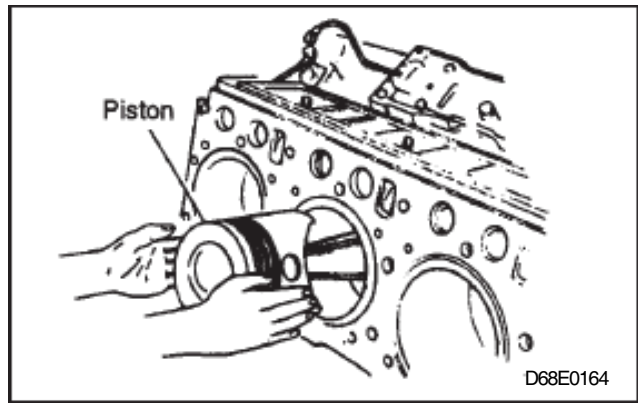
3. Removal of connecting rod cap.



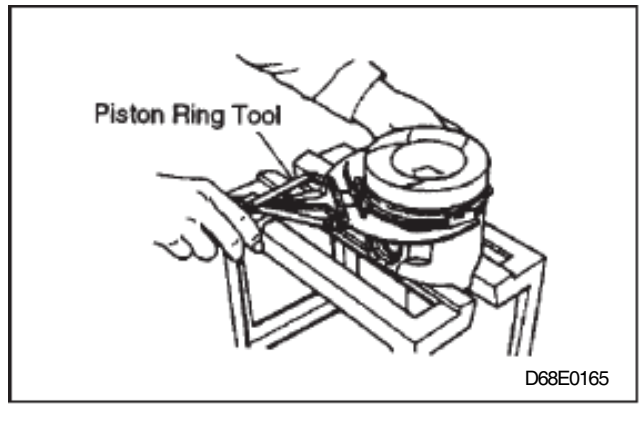
4. Removal of piston

   Remove the piston from the crankcase together with the connecting rod.

   NOTE:
   When removing the pistons, use care to prevent damage to the cylinder liner.

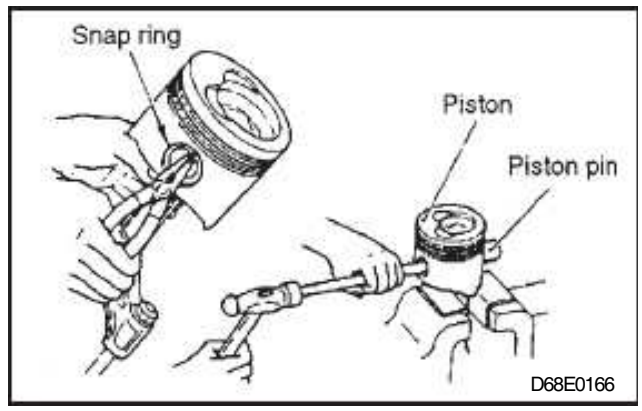


5. Removal of piston rings



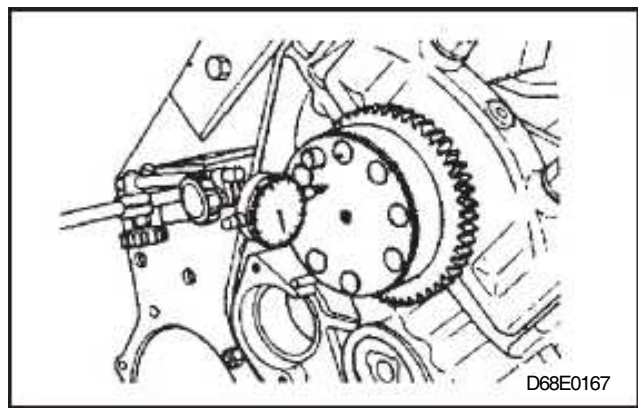
6. Separating piston from connecting rod

Remove the snap ring and, using a rod, tap piston pin off.
If, however, the piston pin is hard to remove, heat the piston with a piston heater or in hot water.



7. Crankshaft end play

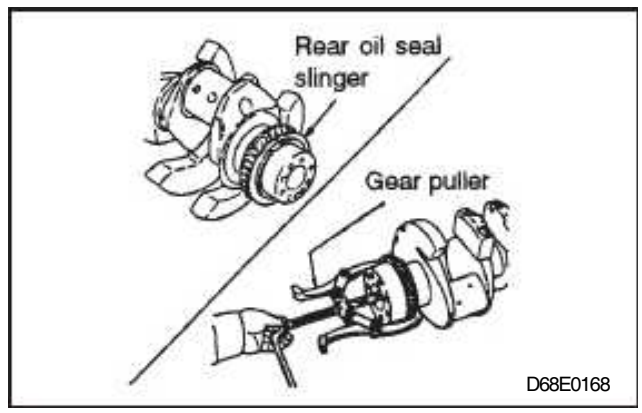
Before removing the main bearing caps, measure the end play in the crankshaft.
If the end play exceeds the limit, replace the thrust plate with an oversize one.



8. Removal of crankshaft gear

(a) Remove the rear oil seal slinger from the crankshaft by cutting it with a punch.
(b) Remove the crankshaft gear from the crankshaft, using Gear Puller (special tool).

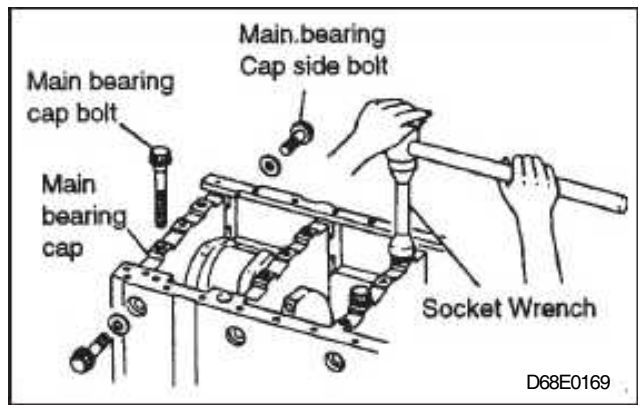
NOTE:
Do not attempt removing the crankshaft gear by striking with a hammer or prying with a lever.

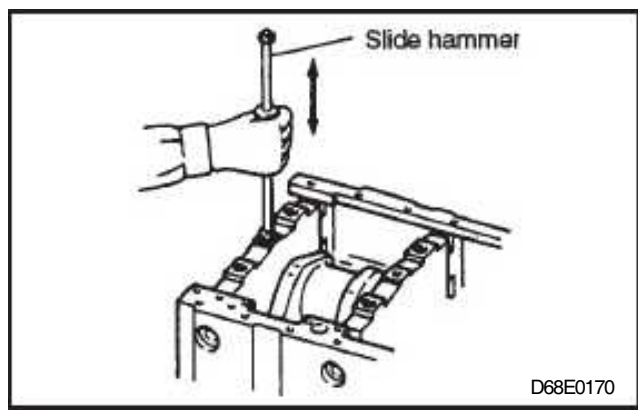


9. Removal of main bearing cap

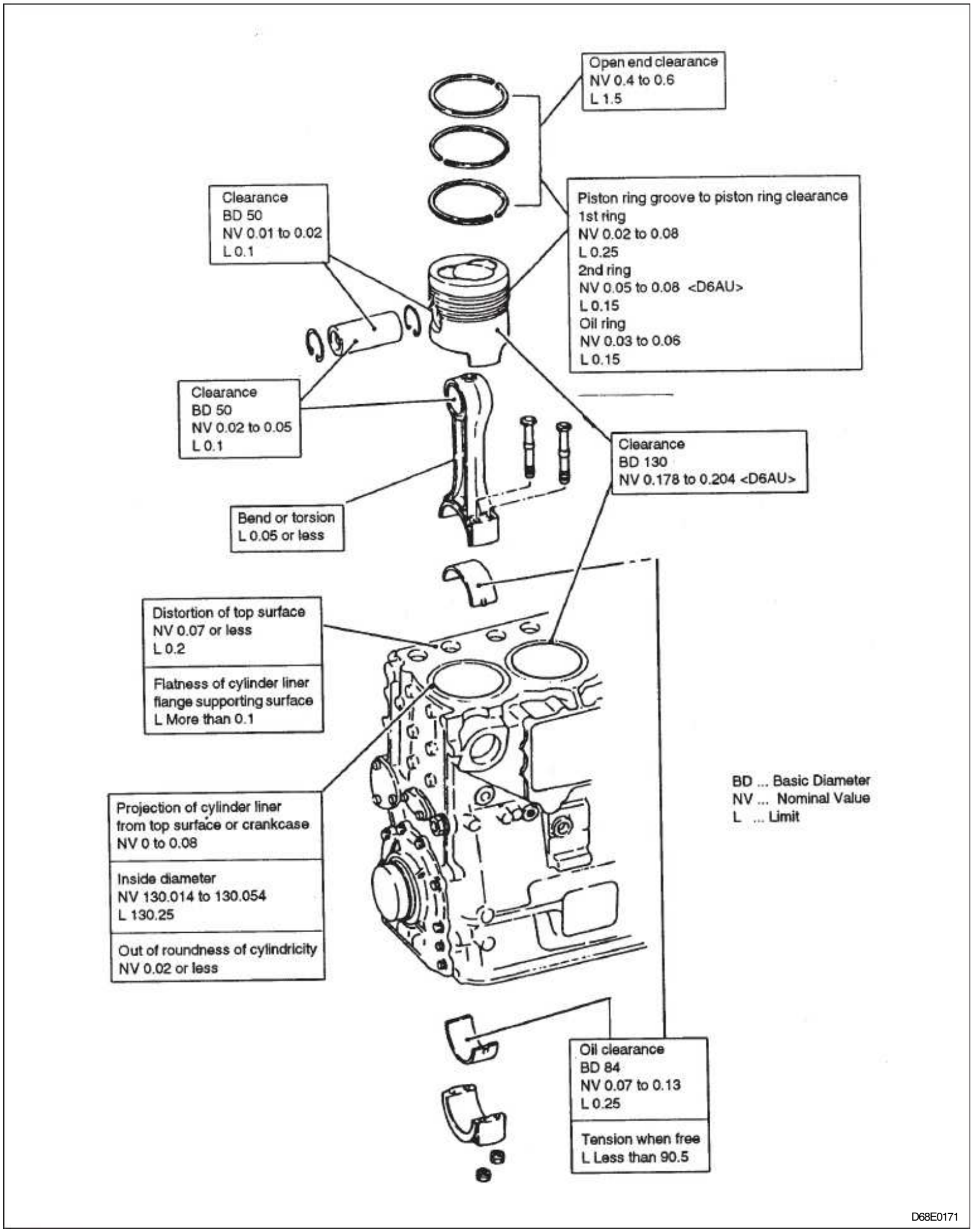
(a) Remove the main bearing cap side bolts, then the main bearing cap bolts.
Use Socket Wrench (special tool) for the bolt removal.
(b) Using a slide hammer or the like, remove the main bearing cap.

NOTE:
1) Do not remove the main bearing cap forcibly by prying.
2) The main bearing cap is positioned to the crankcase with dowel pins. Therefore, be sure to pull up the main bearing cap upright.

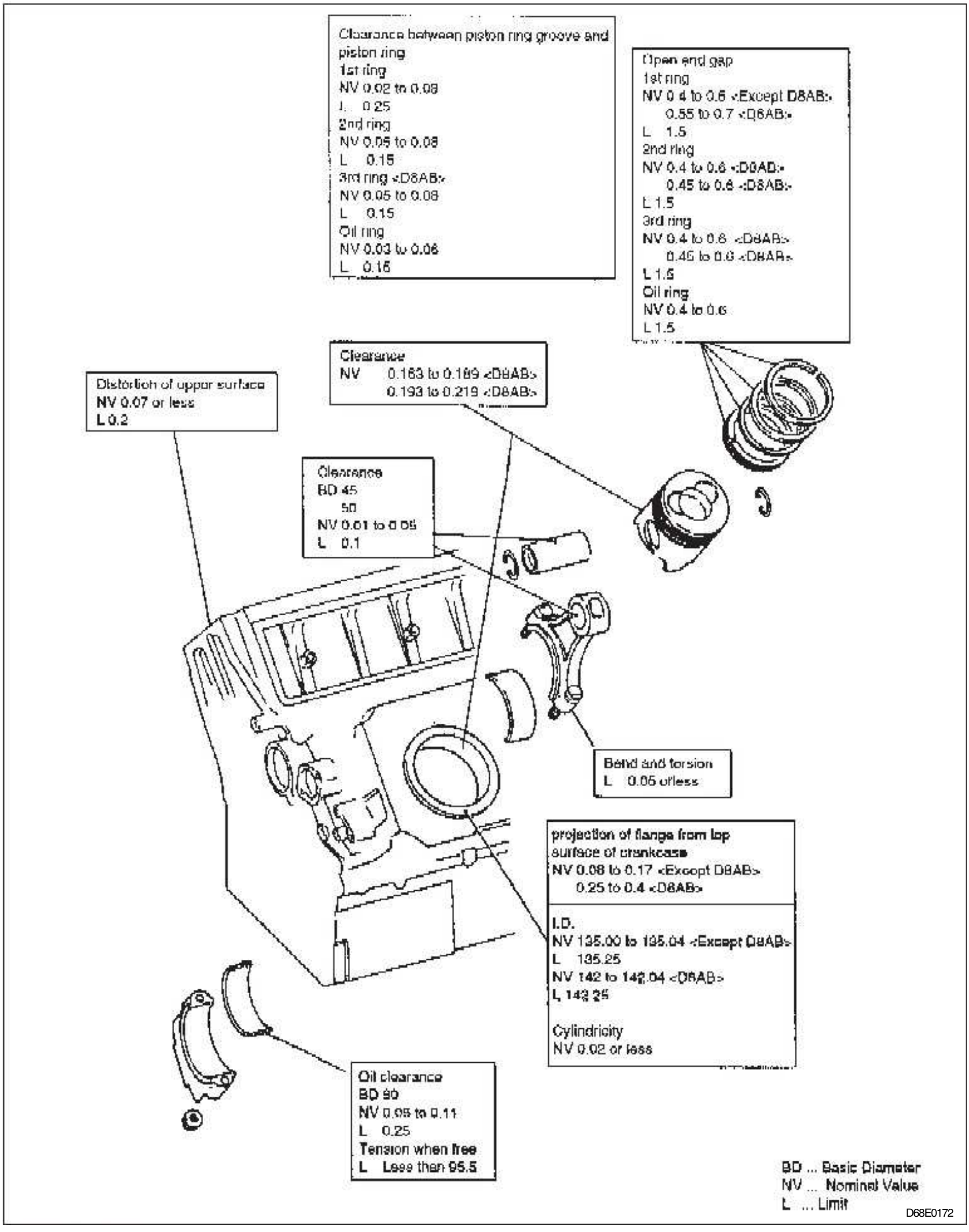




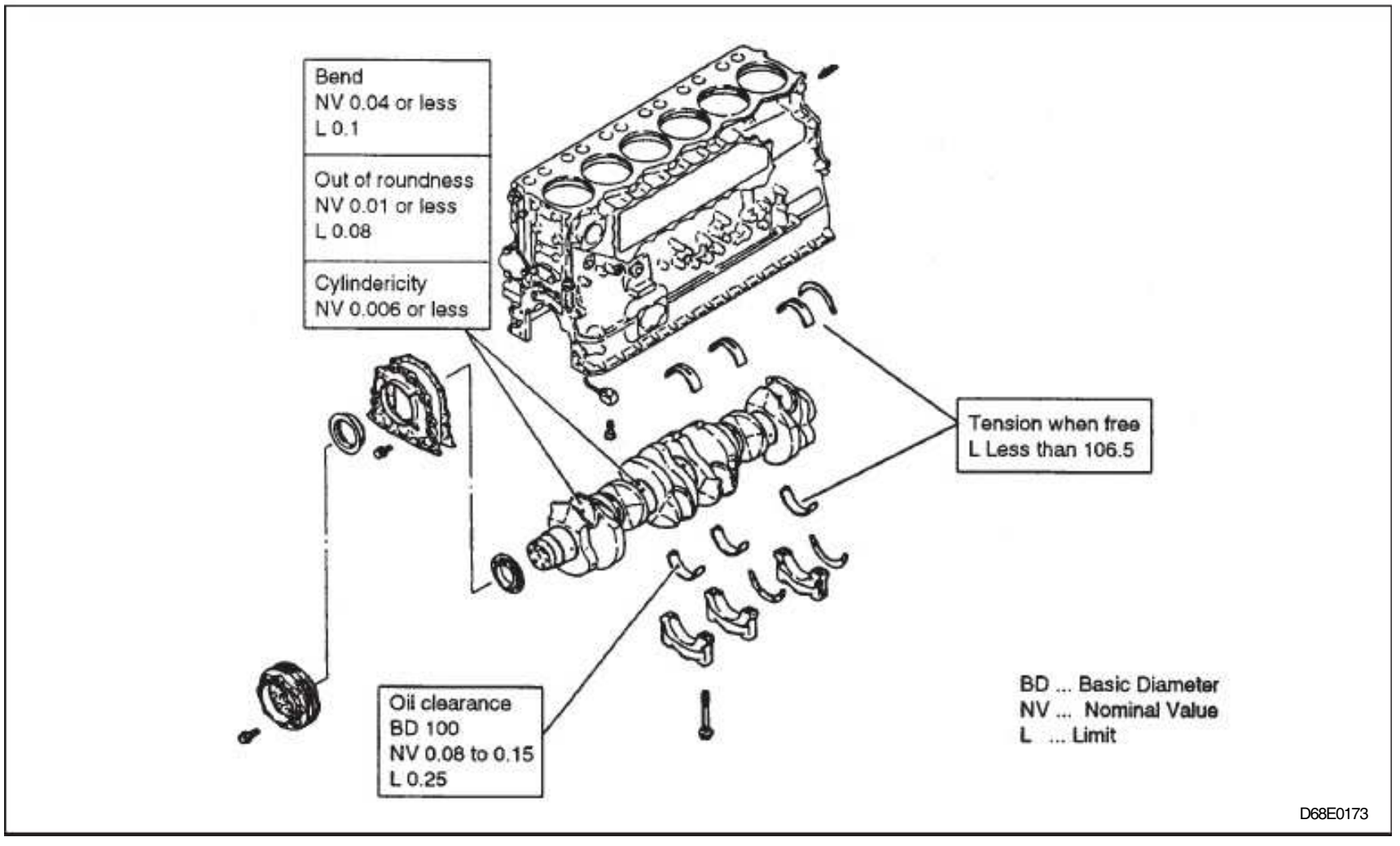
Inspection [D6A]



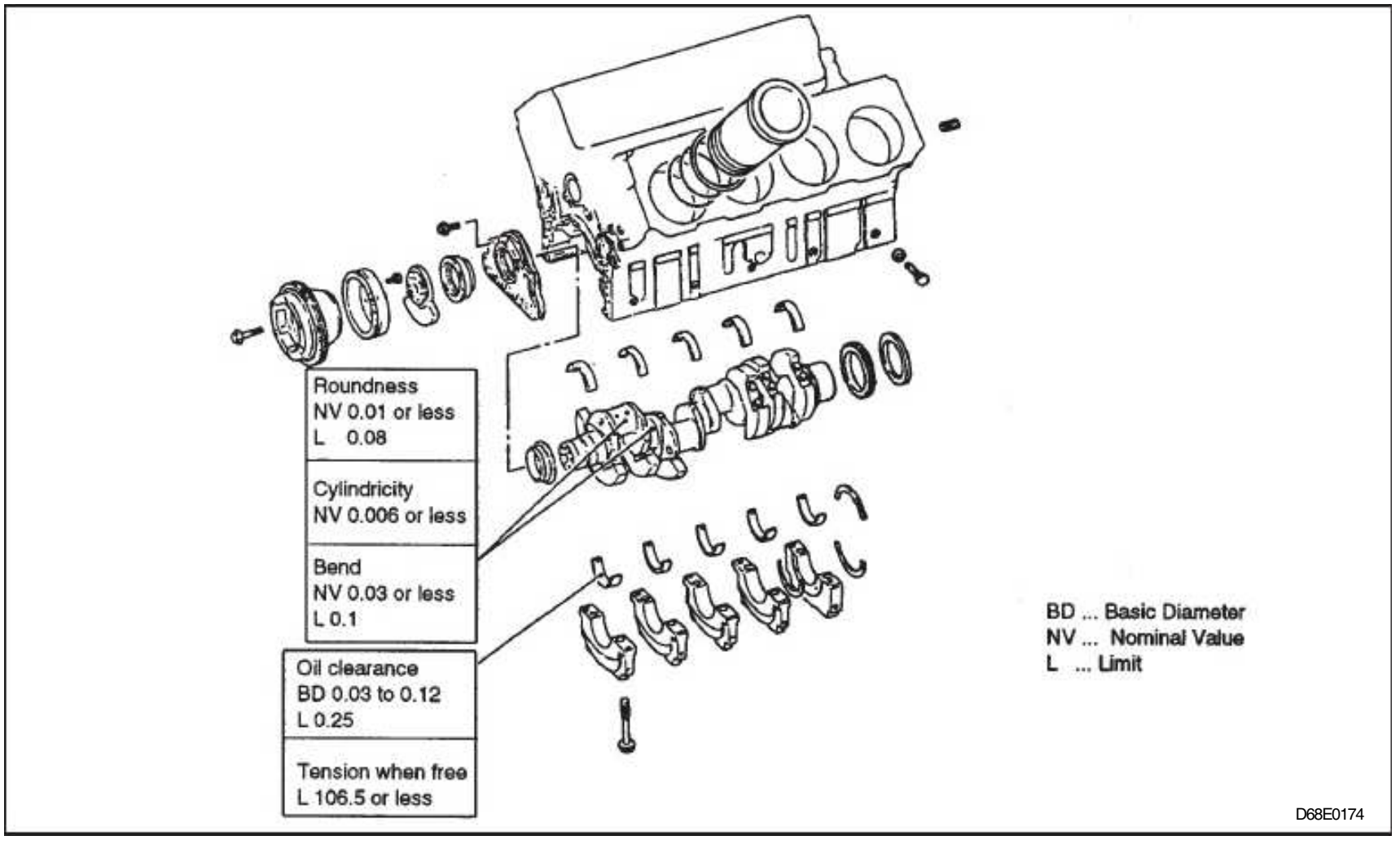
Inspection [D8A]



[D6A]


Bend
NV 0.04 or less
L 0.1
Out of roundness
NV 0.01 or less
L 0.08
Cylindericity
NV 0.006 or less
Tension when free
L Less than 106.5
Oil clearance
BD 100
NV 0.08 to 0.15
L 0.25
BD ... Basic Diameter
NV ... Nominal Value
L ... Limit
D68E0173

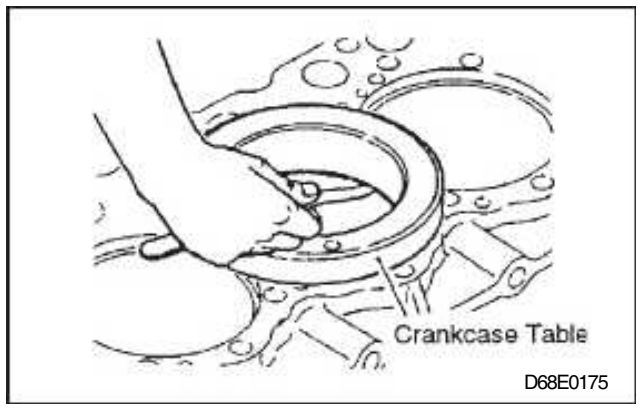
[D8A]


Roundness
NV 0.01 or less
L 0.08
Cylindricity
NV 0.006 or less
Bend
NV 0.03 or less
L 0.1
Oil clearance
BD 0.03 to 0.12
L 0.25
Tension when free
L 106.5 or less
BD ... Basic Diameter
NV ... Nominal Value
L ... Limit
D68E0174

Inspection Procedure

1. Flatness of cylinder liner flange supporting surface on crankcase

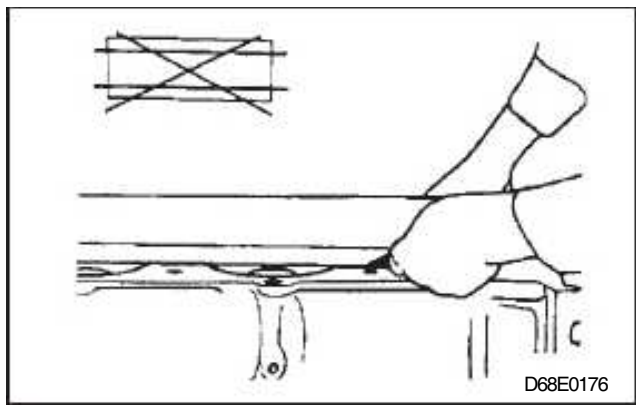
   Using Crankcase Table (special tool) and a thickness gauge, measure the flatness of the cylinder liner flange supporting surface on the crankcase.
   Replace the crankcase with new one if the limit is exceeded.



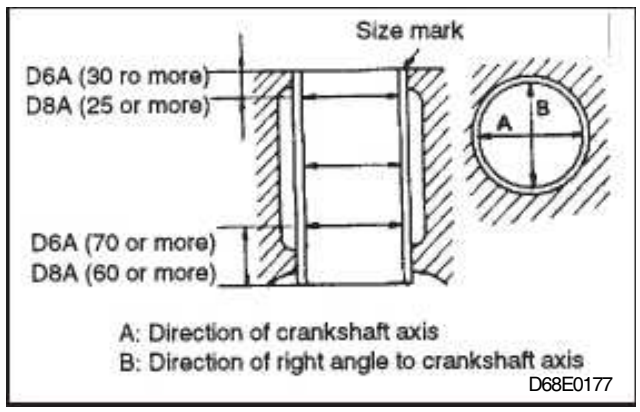
2. Crankcase top surface distortion

   Measure the crankcase top surface distortion. If it exceeds the limits, correct the distortion with a surface grinder.
   To make sure that the liner projection does not change, grind the liner seating surface, too.

   NOTE:
   1) When the crankcase is ground, make sure that the piston projection does not exceed the nominal value.
   2) Remove the cylinder liner before measurement.

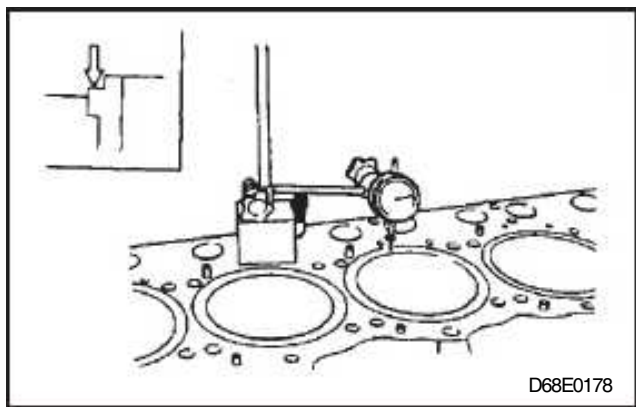


3. Cylinder liner I.D.
   Measure the cylinder liner I.D. at six positions as shown in the right figure. If the I.D. is more than the limits, replace the cylinder liner or bore it to oversize.
   [For replacement of the cylinder liner, refer to Item 5.]



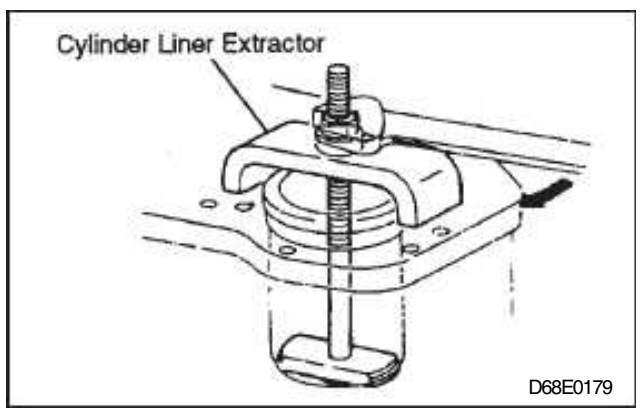
4. Cylinder liner flange projection

   Make sure that the cylinder liner collar projects from the top surface of the crankcase to the extent as specified. If the projection is less than the nominal values, replace either the cylinder liner or the crankcase. Remove the O-ring and rubber packing before measurement.
   [For replacement of the cylinder liner, refer to Item 5.]

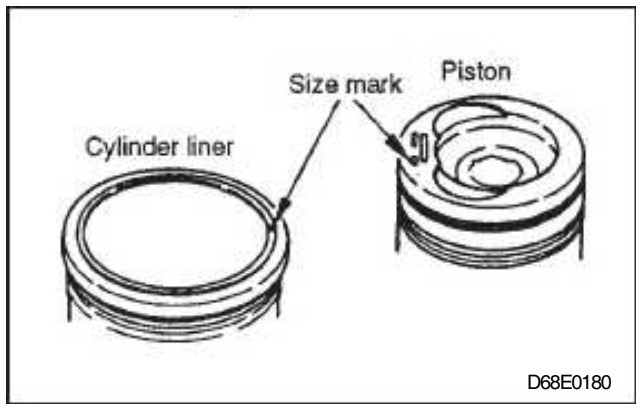


5. Replacement of cylinder liner

   (a) Removal

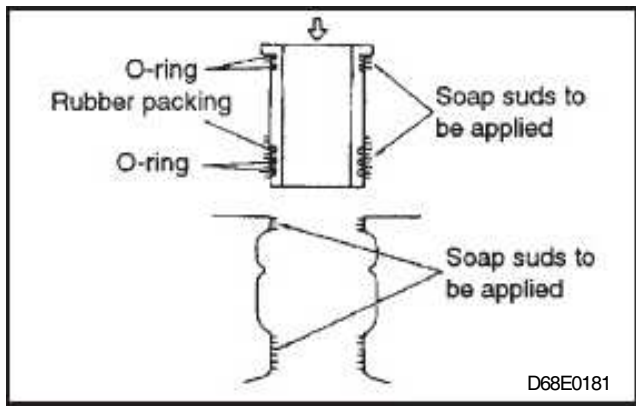


(b) Installation



1) When replacing the cylinder liner, use a cylinder liner with the same size mark as that of the piston to be selected.

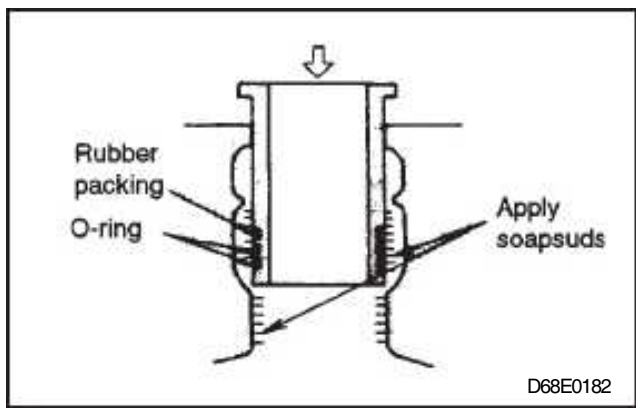
Size mark of piston	A	B	C
Size mark of cylinder liner	A	B	C



2) After a new rubber packing and O-ring have been installed to the cylinder liner, slowly insert the cylinder liner into the crankcase.

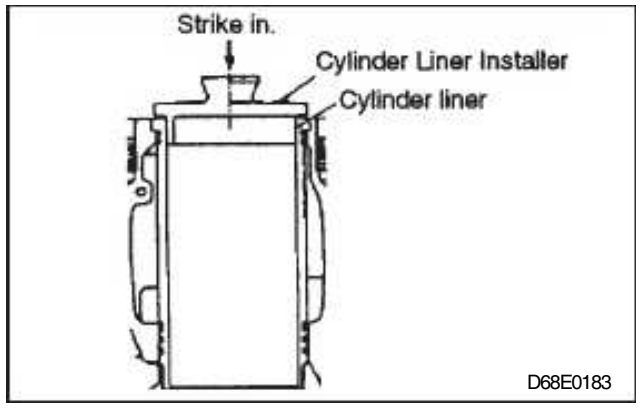
NOTE:
Apply soap suds to the crankcase and cylinder liner fitting portions and make sure that the rubber packing and O-ring are twisted when inserted.

3) Securely seat the cylinder liner on the crankcase by lightly striking the flange portion, using Cylinder Liner Installer (special tool).



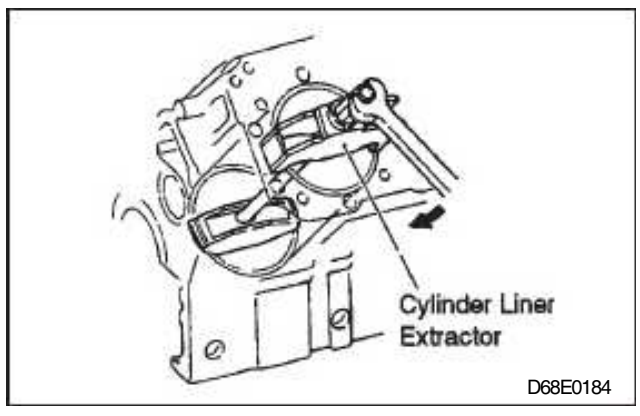
NOTE:
After installation, conduct the leak test to verify airtightness.
Apply thrust force to cylinder liner flange.

6. Selection of piston and cylinder liner

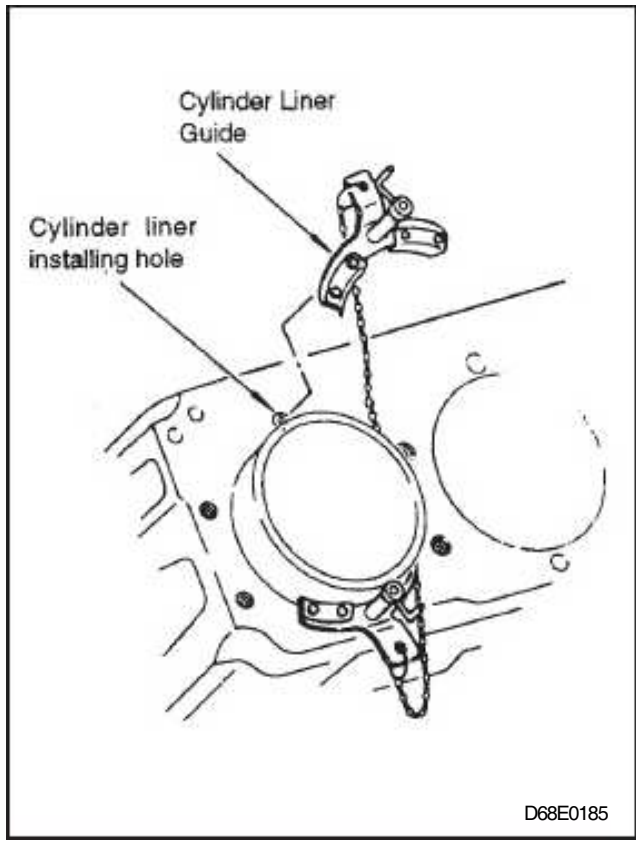


[D8AB]

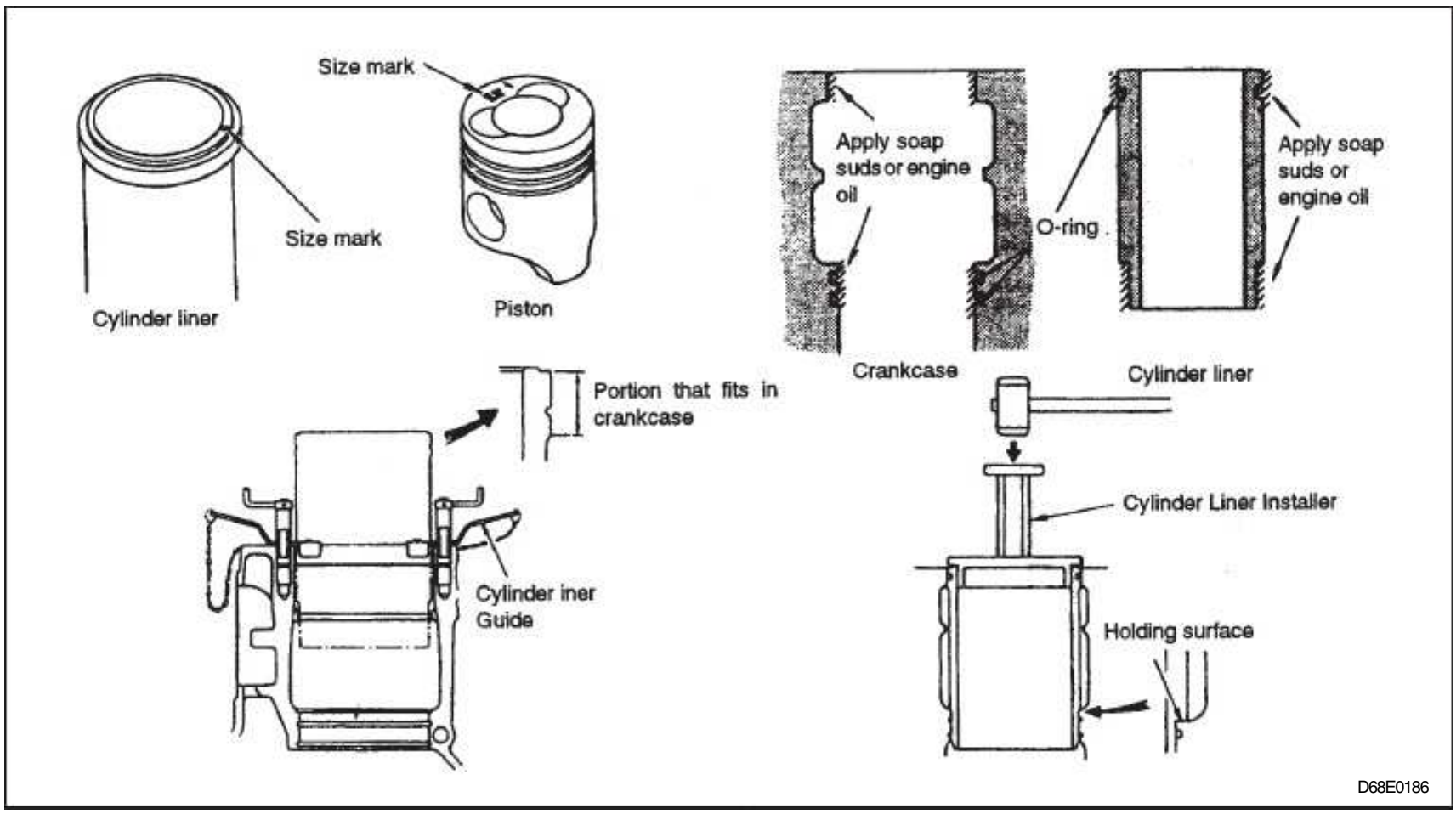
1. Removal
(a) Using a special tool (Cylinder Liner Extractor), remove that portion of the cylinder liner which fits in the crankcase.



(b) Using special tools (Cylinder Liner Guides), remove the cylinder line, while using care to prevent the cylinder liner from causing damage to the fitting hole portion (inside surface) of the crankcase.
Install the cylinder liner guides (two in a set) by taking advantage of the cylinder head installing holes of the crankcase.



2. Installation.



(a) To replace the cylinder liner, make sure that the size mark of a replacement cylinder liner is the same as that of the piston.

Size mark of piston	A	B	C
Size mark of cylinder liner	A	B	C

(b) If there are deposits on the cylinder liner fitting hole portion (inside surface) and holding surface of the crankcase or rust, clogging. etc. in the water jacket, clean them.

(c) Mount new O-rings on the cylinder liner and crankcase. In this case, apply a grease to the crankcase O-rings only to facilitate the mounting work. For this purpose, use the recommended HMC wheel bearing grease or equivalent.
NOTE:
1)Do not elongate the O-rings more than necessary. Use care to prevent damage.
2)Gas oil, kerosene, antirust, etc. cause the O-rings to swell. If any such fluid was deposited, wipe it away immediately.
(d) Mount special tools (Cylinder Liner Guides) on the crankcase. [Refer to Item b) in 1.]
(e) After the cylinder has been inserted in the upper fitting portion, remove the special tools (Cylinder Liner Guides).
Using a special tool (Cylinder Liner Installer), strike the installer until the cylinder liner is held tightly against the holding surface of the crankcase.

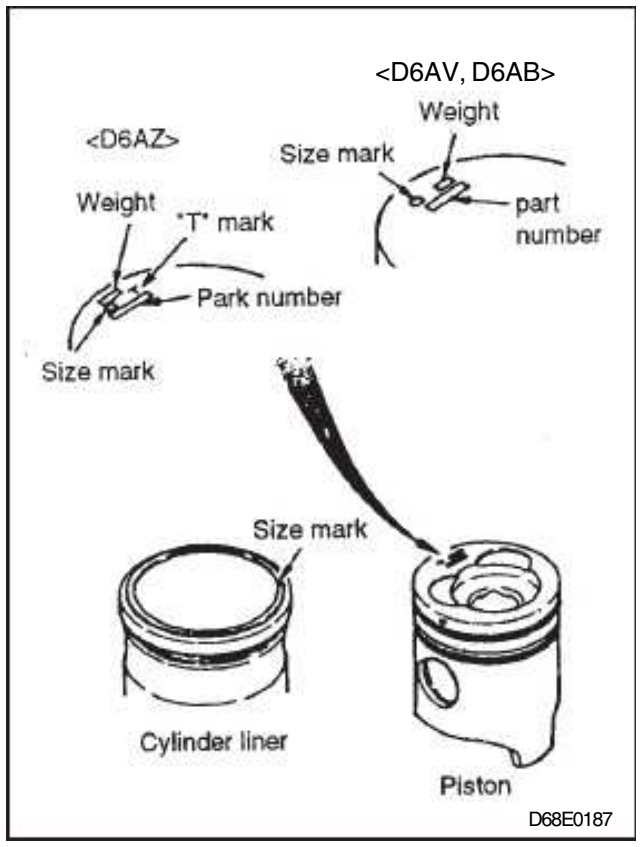
A piston may be standard or oversize, depending on which the cylinder liner is to be selected as follows.

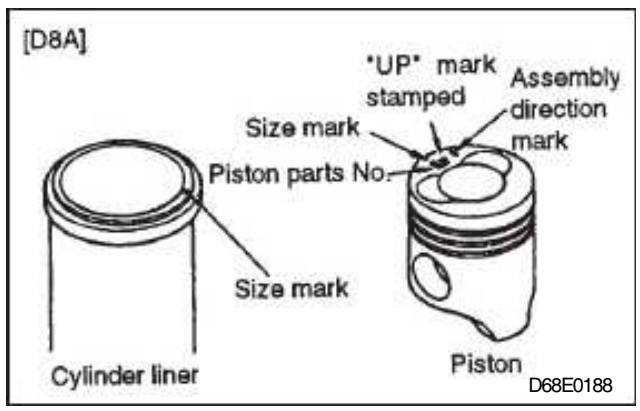
(a) Standard piston

1) Select the piston with the same size mark as that stamped on the cylinder liner.
2) Make sure that the weight of pistons for one engine (six pistons) is in the range of ±10g of the weight stamped.

NOTE:
Whenever the piston is replaced, replace the piston rings.

(b) Oversize piston

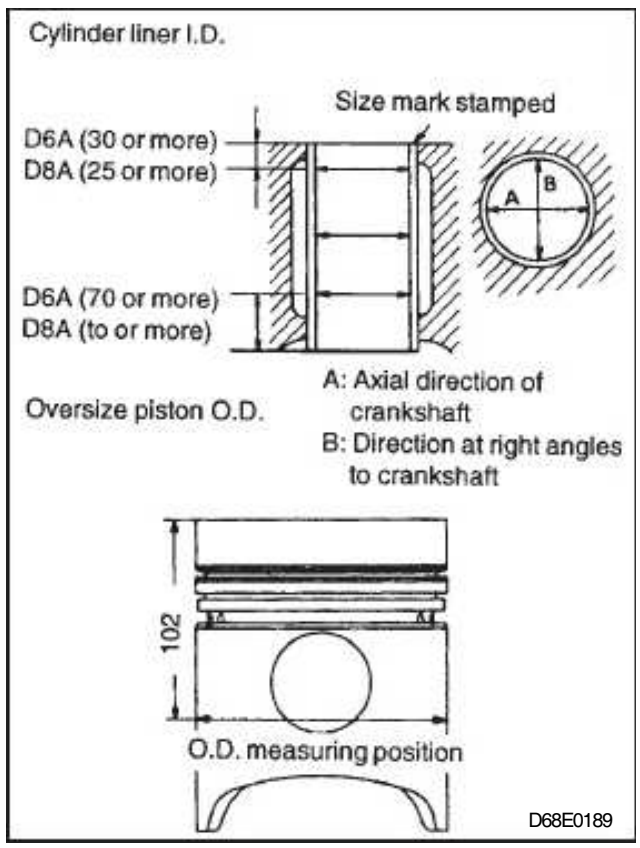




Bore the cylinder liner as follows according to the type of piston (+0.5, +0.75, +1.00 mm).

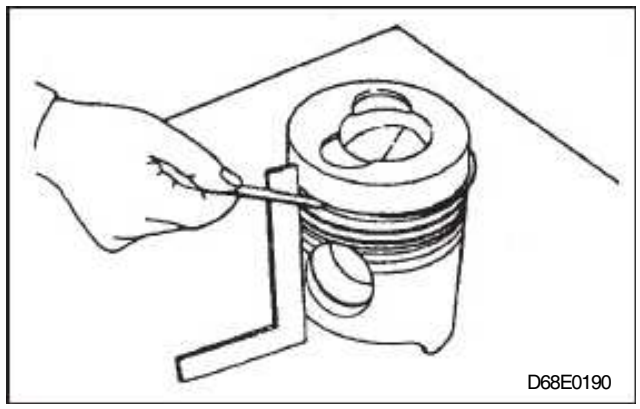
1) Determine the amount of metal to be bored from the cylinder liner by taking into account the portion which wears most with reference to the measurements of I.D.s of all cylinders.
2) Bore and hone-finish the cylinder liner to obtain the specified clearance between the oversize piston and cylinder liner.

NOTE:
1) Even when only one cylinder requires boring, bore all cylinders to the same oversize.
2) Replace the piston rings to those corresponding to the oversize.

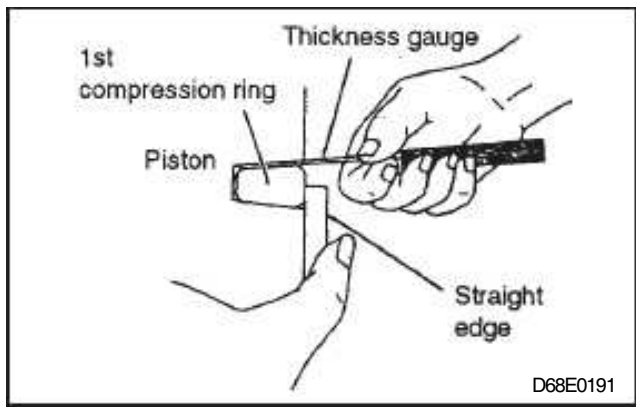


7. Piston to cylinder liner clearance.
If the clearance is out of specification, replace the piston or cylinder liner. [Refer to Item 6.]

8. Piston to piston ring clearance
If the clearance exceeds the limits, replace the piston rings or piston.
NOTE:
1) After removing carbon, measure the clearance over the entire circumference of the piston.
2) Replace the piston rings as a set.

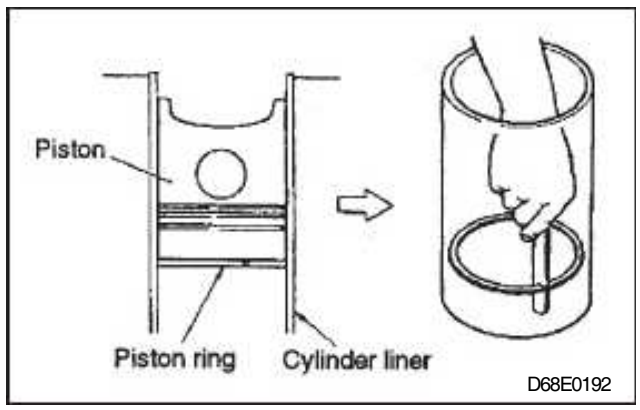


Measure the 1st compression ring by pressing the ring against the piston with a straight edge.



9. Piston ring gap
Measure the piston ring gap with the piston ring horizontally pushed into a standard cylinder liner or actual one in the crankcase with a piston.
Replace the piston ring if the gap exceeds the limit.

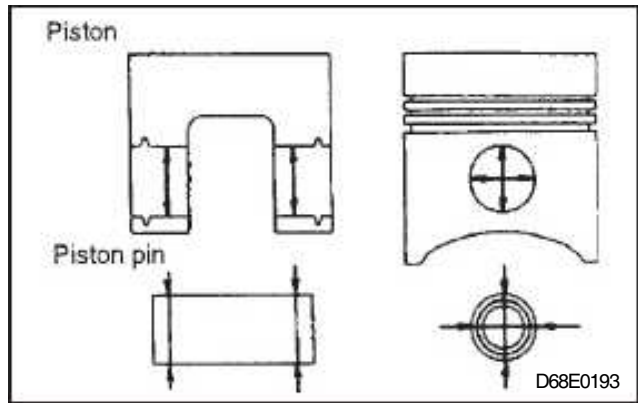
Standard cylinder liner I.D.: 130±0 [D6A]
135±0 [D8A except D8AB]
NOTE: 142±0 [D8AB]
Use the piston to push the piston rings horizontally into the standard gauge.



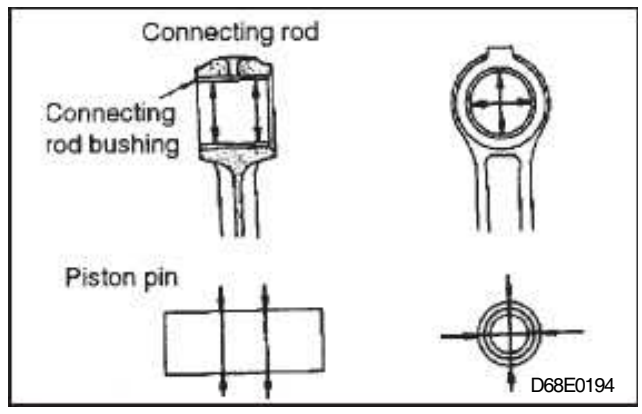
10. Piston to piston pin clearance

    If the clearance exceeds the limits, replace the piston pin or piston.

    NOTE:
    Whenever the piston is replaced, be sure to replace the piston rings.



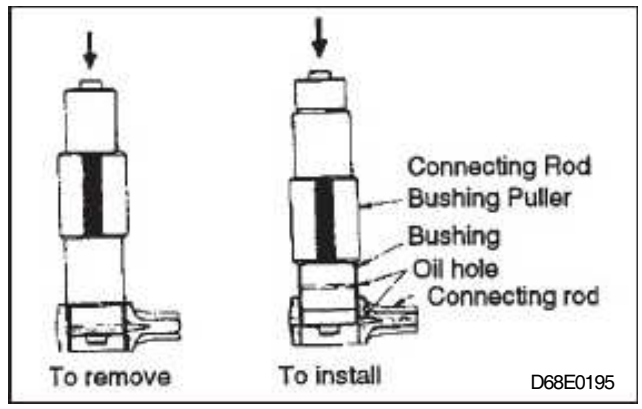
11. Piston pin to connecting rod small end clearance
    If the clearance exceeds the limits, replace bushing in the connecting rod.



12. Replacement of connecting rod bushing

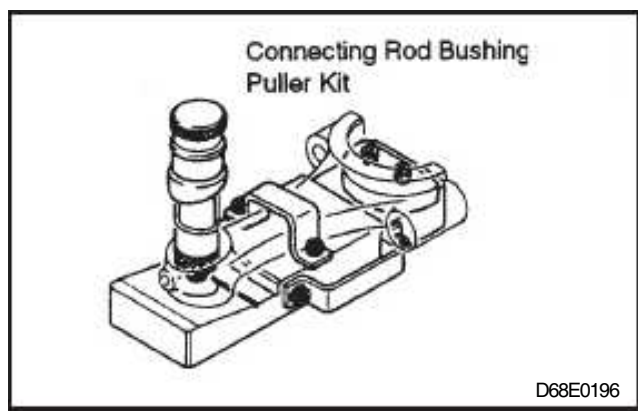
    Replace the bushing by procedures shown in illustration, using Connecting Rod Bushing Puller (special tool).

    (a) Align the oil hole of the bushing with the oil hole of the connecting rod.
    (b) Press the bushing in form the chamfered side of connecting rod end.
    (c) After the bushing has been pressed in, insert the piston pin and check to ensure that it turns lightly without play.



[D8A]

When replacing the bushing, use Connecting Rod Bushing Puller kit (special tool).



(a) Removal of bushing

1) Removal the connecting rod bearing from the connecting rod large end fix the connecting rod to the special tool (base).

2) Set Bandrel and Collar A (special tool) on the connecting rod small end as shown in the above figure. Slowly apply pressure with a press capable of applying a pressure of more than 49 kN [5 tf]

(b) Press-fit of bushing

1) Set the bushing to Mandrel, Collar B, Collar A and Nut (special tool).

2) Apply engine oil to the connecting rod small end and the bushing.

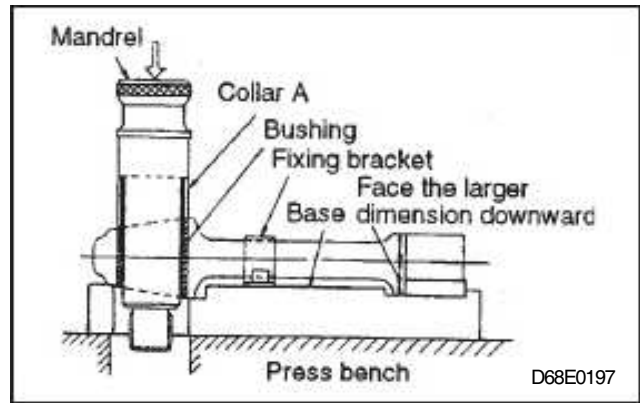
3) Press the special tool fitted with the bushing into the connecting rod small end by using a press machine [capacity: approx. 49 kN [5tf].

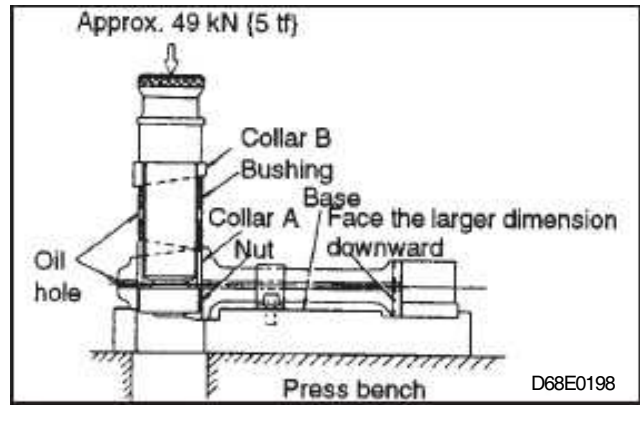
4) After press-fitting the bushing and removing the special tool, ream to finish the bushing so that the clearance between the bushing and piston pin will be up to the nominal value.

NOTE:

1) When press-fitting the bushing, align the bushing oil hole with the connecting rod oil hole.

2) When the piston pin is inserted, make sure that the pin turns lightly and smoothly without play.

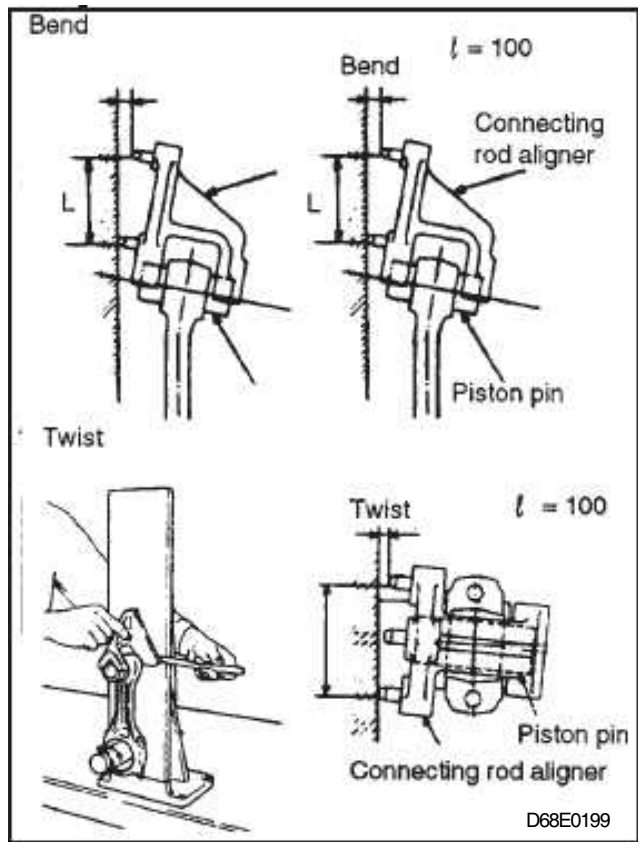




13. Connecting rod bend and twist

Measure the bend and torsion of the connecting rod with the measuring instrument (connecting rod aligner). If the readings exceed the limits, replace the connecting rod or correct it with a press machine.

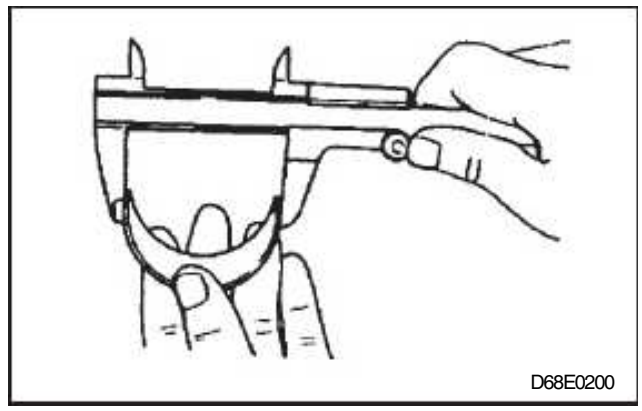
NOTE:
1) Install the bushing and connecting rod bearings to the connecting rod before measurement.
2) Tighten the connecting rod and connecting rod cap to the specified torque before measurement.



14. Tension of connecting rod bearing and main bearing when free

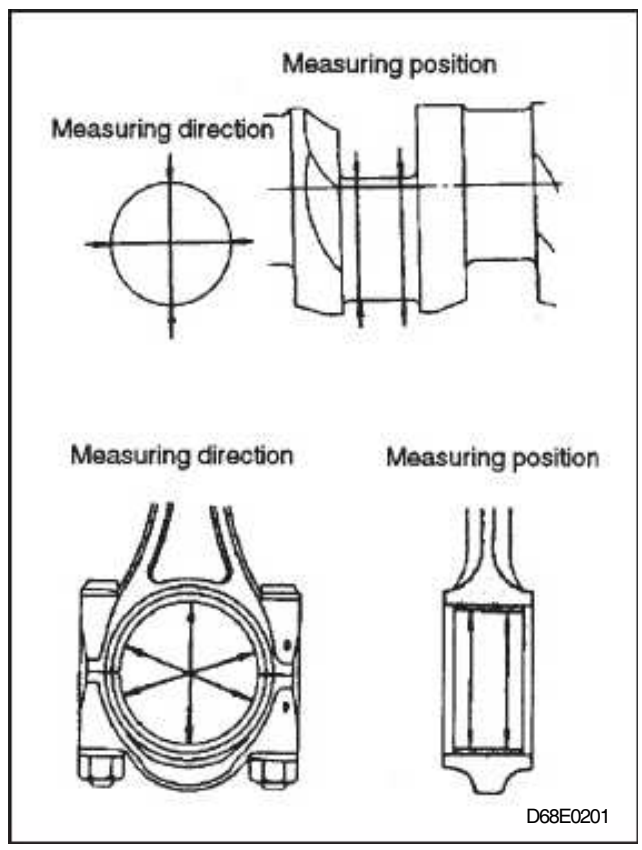
If the tension is lower than the limit, replace the upper and lower bearings as a set.

NOTE:
Do not use the bearing by artificially expanding it.



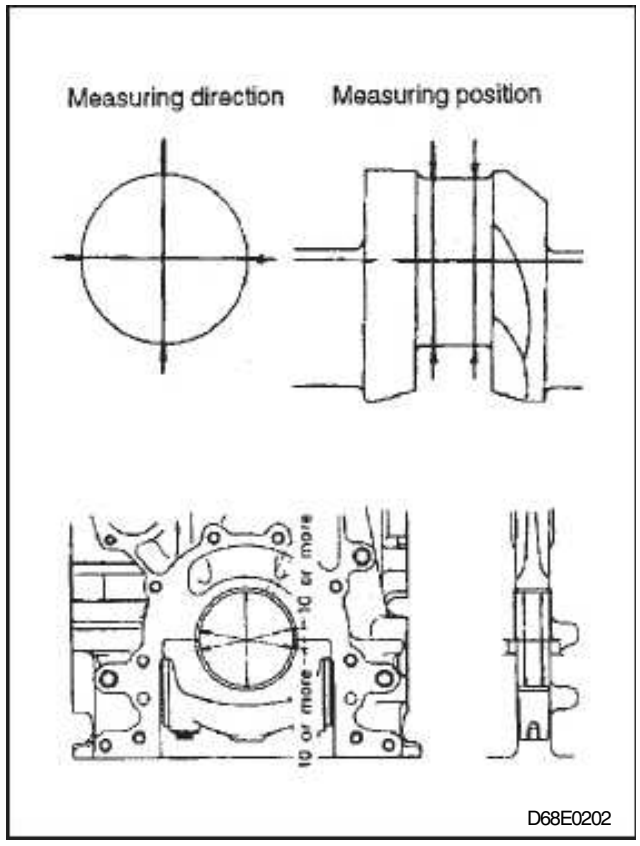
15. Connecting rod bearing to crankshaft pin clearance.

If the clearance exceeds the limits, replace the upper and lower bearings as a set.



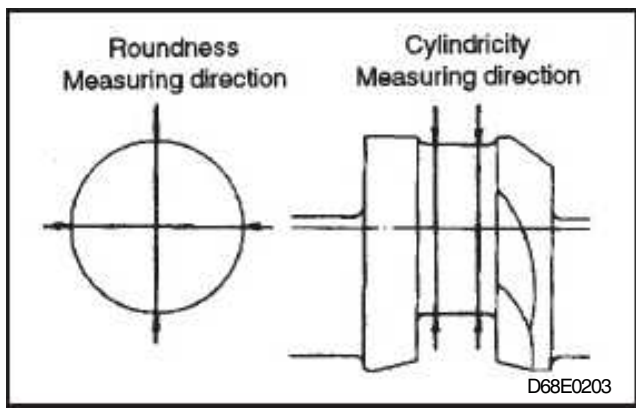
16. Main bearing to crankshaft journal clearance

    If the clearance exceeds the limits, replace the upper and lower bearings as a set.



17. Crankshaft roundness and cylindricity

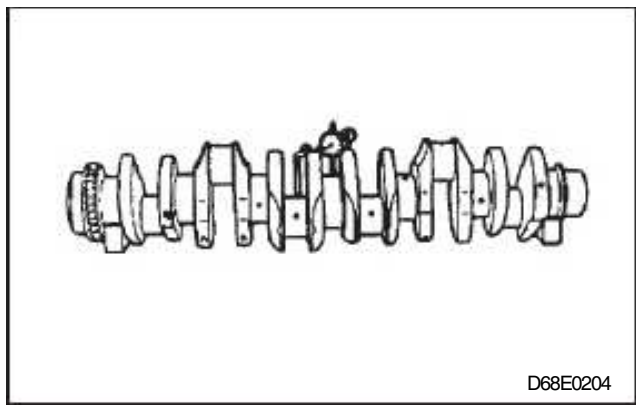
    Determine the out-of-roundness and cylindricity on the basis of the crankshaft journal and crankpin I.D. measurements. If they are more than the limits, grind to undersize. [Refer to Item 19.]



18. Crankshaft bend

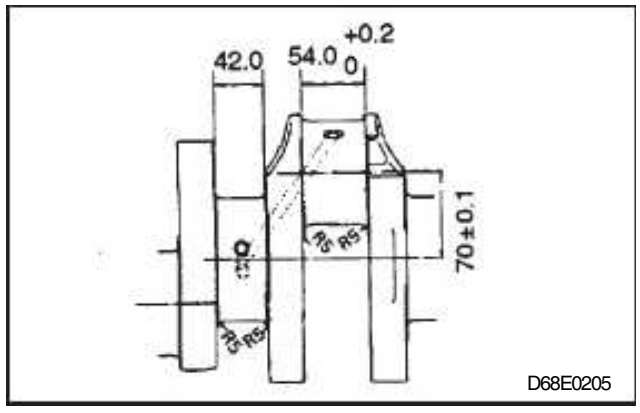
    Measure the bend of the crankshaft. If the reading exceeds the limits, grind to undersize or replace.

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

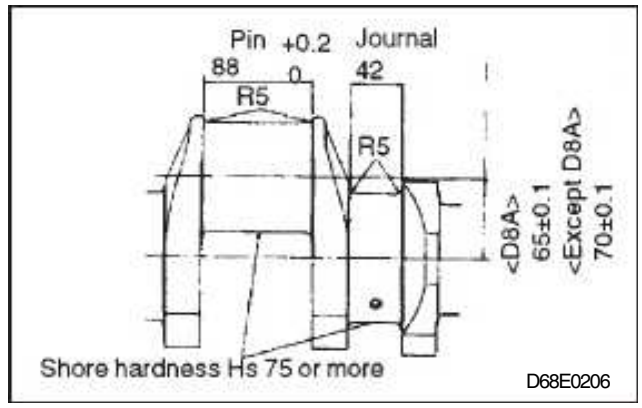


19. Correction of crankshaft to undersize

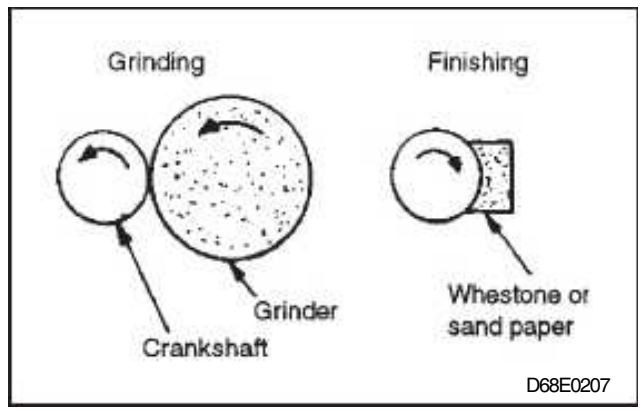
    Any damaged or burnt journal or pin should be ground by the following procedures. The bearing should be replaced with an undersizedone.



(a) When the crankshaft is ground, make sure that the center distance between the journal and pin may not be changed.
(b) Grind the crankshaft with care not to change the width of the journal and pin.
(c) Finish the corner fillet to the specified radius (R).
(d) Check for ground cracks of the crankshaft by the magnetic flaw detection method. Also make sure to check that the surface hardness (Hs 75 or more) is not deteriorated.

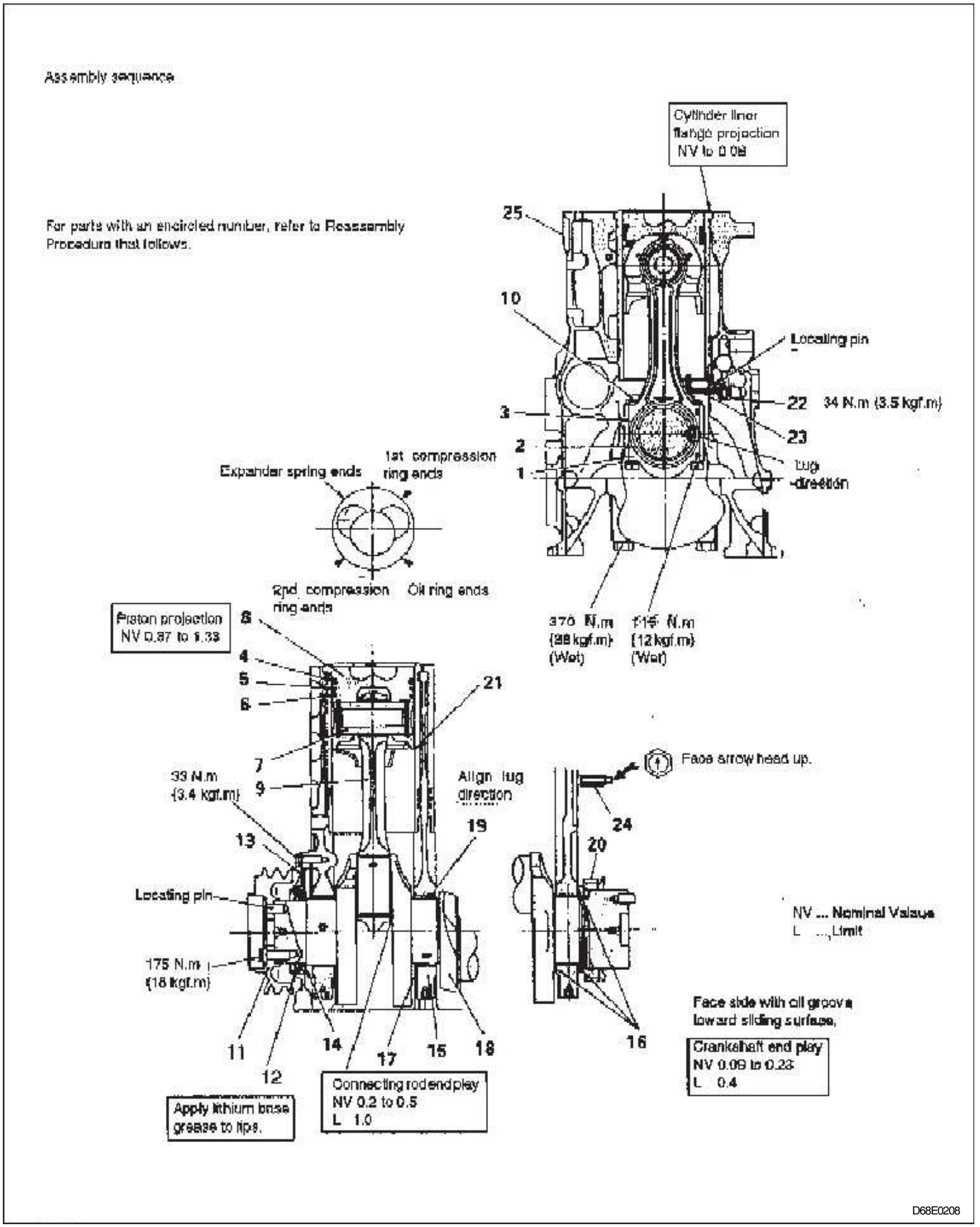


(e) To grind the crankshaft with a grinder, turn the grinder and crankshaft counterclockwise as viewed from the crankshaft front end.
(f) To finish the crankshaft with a wear stone or sandpaper, turn crankshaft clockwise.



Amount of undersize	Journal O.D. finish dimension	Pin O.D. finish dimension	Round-ness	Cylind-ricity
-0.25	99.65 to 99.67	83.66 to 83.69	0.01 or less	0.006 or less
-0.50	99.40 to 99.42	83.41 to 83.44		
-0.75	99.15 to 99.17	83.16 to 83.19		
-1.00	98.90 to 98.92	82.91 to 82.94		

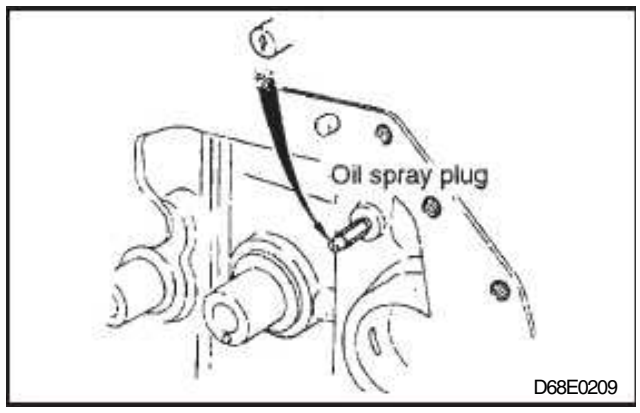
Reassembly [D6A]



Reassembly Procedure

1. Installation of oil spray plug

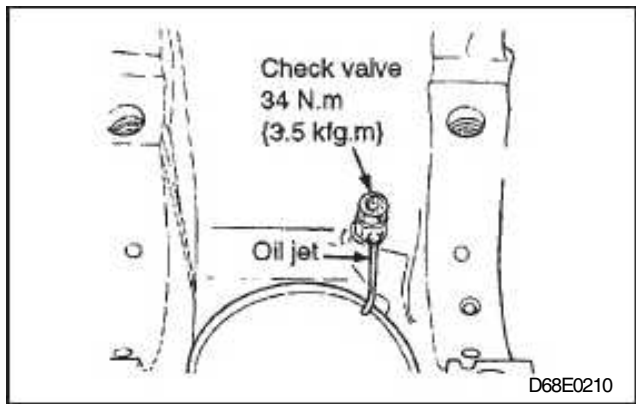
   Install the oil spray plug with the arrow stamped on the plug toward the top of the engine.



2. Installation of oil jet and check valve

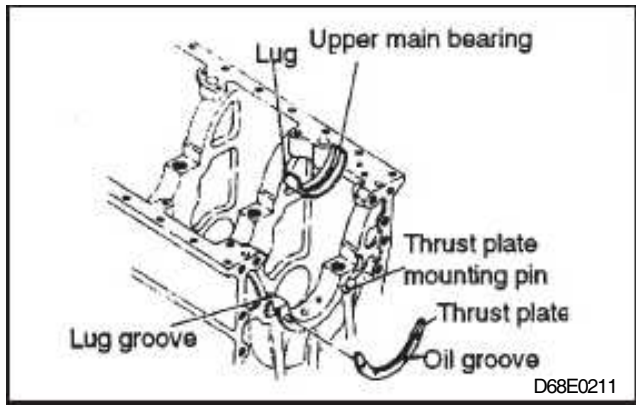
   Insert the locating pin of the oil jet into the hole on the crankcase and tighten the check valve to specified torque.

   NOTE:
   The check valve cannot be reused. Use, therefore, a new checkvalve.



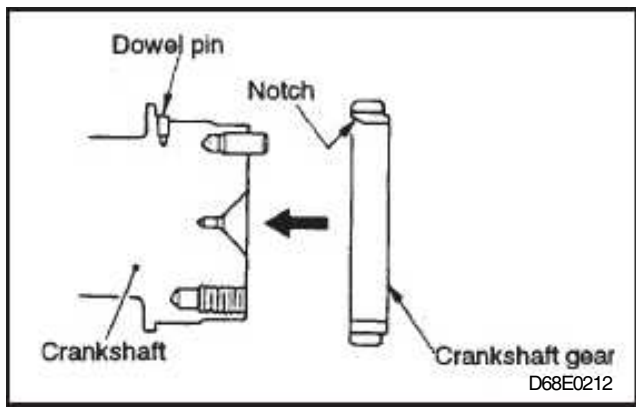
3. Installation of upper main bearing and thrust plate

   NOTE:
   1) Install the thrust plate with the oil grooveless side toward the crankcase.
   2) Line up the lug of the main bearing and the groove of the crankcase.
   The upper main bearing is one with oil holes.
   Take care not to confuse it with the lower one.
   3) Oversize (0.15, 0.30, 0.45 mm) thrust plates are available for adjusting the end play in crankshaft. If any one of these is used, ensure the correct size of the thrust plate to be installed to the main bearing cap.



4. Installation of crankshaft gear

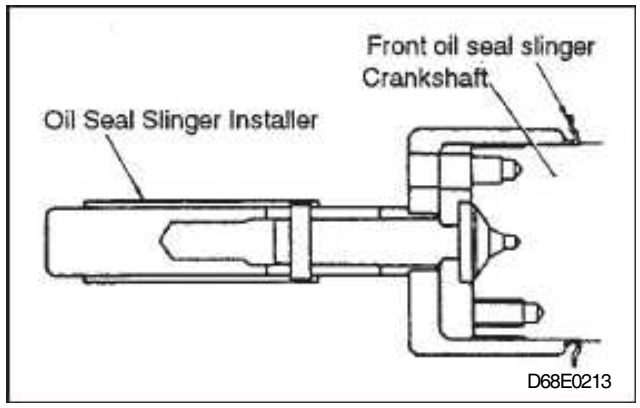
(a) Heat the gear to about 100℃, using a piston heater, etc.



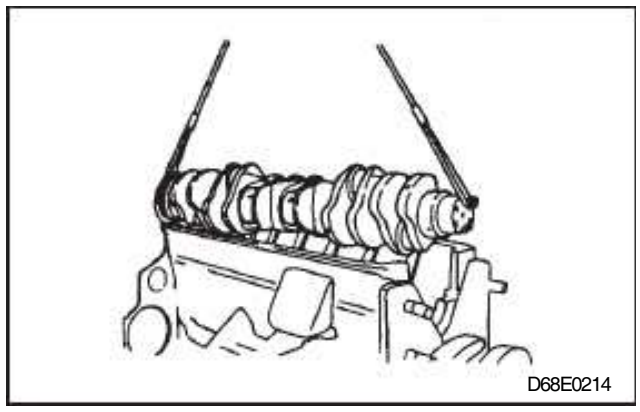
(b) Locate the gear so that the dowel pin of the crankshaft will fit in the notch of the gear and fit the gear by lighty striking the gear end with a soft hammer.
(c) Install the rear oil seal slinger.

5. Installation of front oil seal slinger

   Install the front oil seal slinger, using Oil Seal Slinger Installer (special tool).

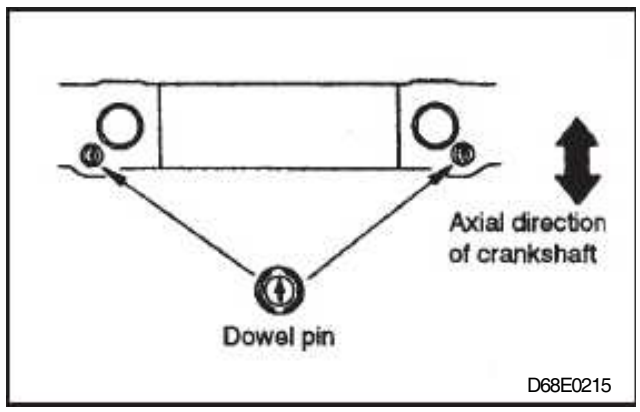


6. Installation of crankshaft
   Lift the crankshaft 18 with chain blocks, etc. While keeping it in horizontal position, slowly lower it into the crankcase.

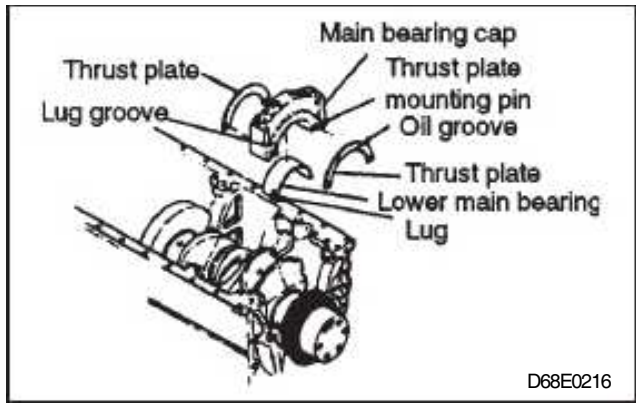


7. Installation of lower main bearings and main bearing caps
   Follow the procedure given below.

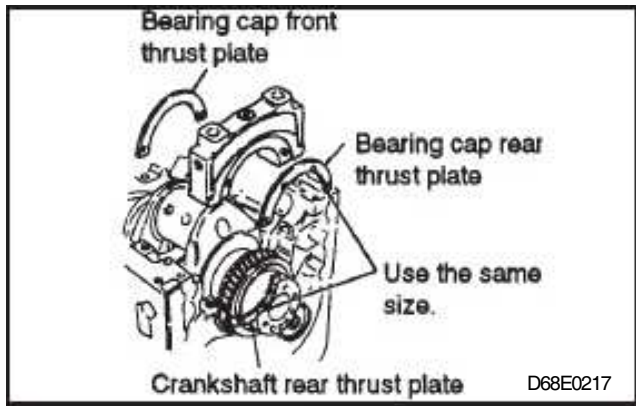
   (a) Drive the locating dowel pins into the rearmost main bearing cap the direction shown.



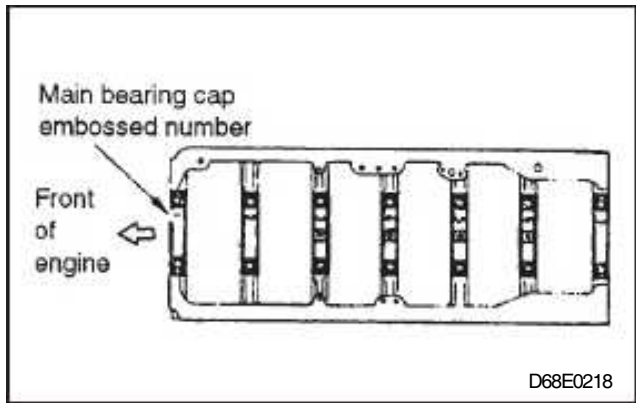
   (b) Mate the lower main bearing with each main bearing cap, marking sure that the lug bearing is fitted into the lug groove in cap.
   (c) Only to both sides of the rearmost main bearing cap, install the thrust plates facing their oil grooveless side toward the cap.



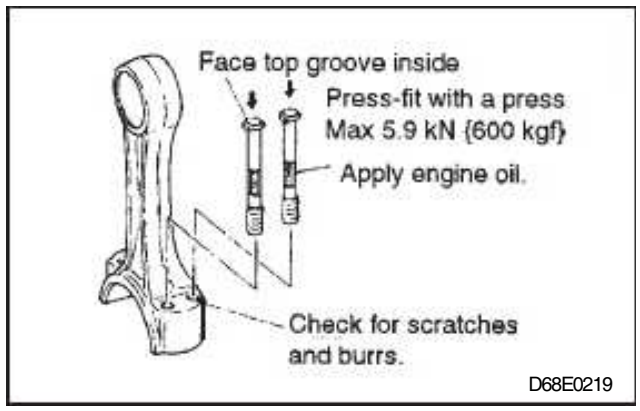
NOTE:
If an oversize thrust plate is used, use the bearing cap rear thrust plate of the same size as that of the thrust plate in the crankcase rear end. Note, however, that the bearing cap front and rear thrust plates may be of different sizes.



(d) Install the main bearing caps, caps making sure that the side with the lug groove placed on the right-hand side of the engine and they are installed in the order of embossed numbers from the front of engine.
(e) Tighten main bearing cap bolts to specified torque. Then, tighten main bearing cap side bolts to specified torque.
After the bolts are tightened, make sure that the crankshaft is free to rotate by hand.
(f) Check to see if the end play of the crankshaft is within nominal value.



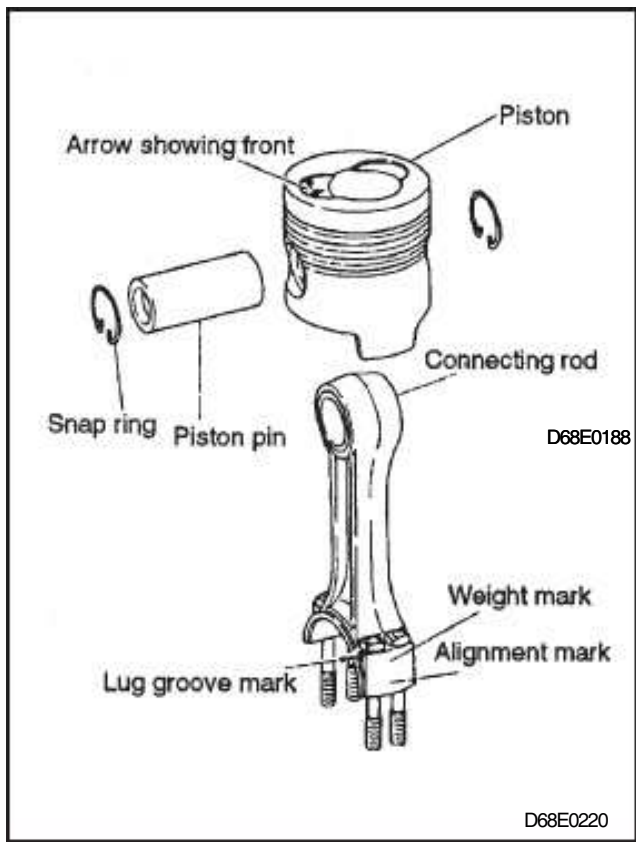
8. Installation of connection rod bolt
After checking the connecting rod for damage and bur in the bolt hole, apply engine oil to the connecting rod bolt and press-fit it into the connecting rod.



9. Reassembly of piston and connecting rod

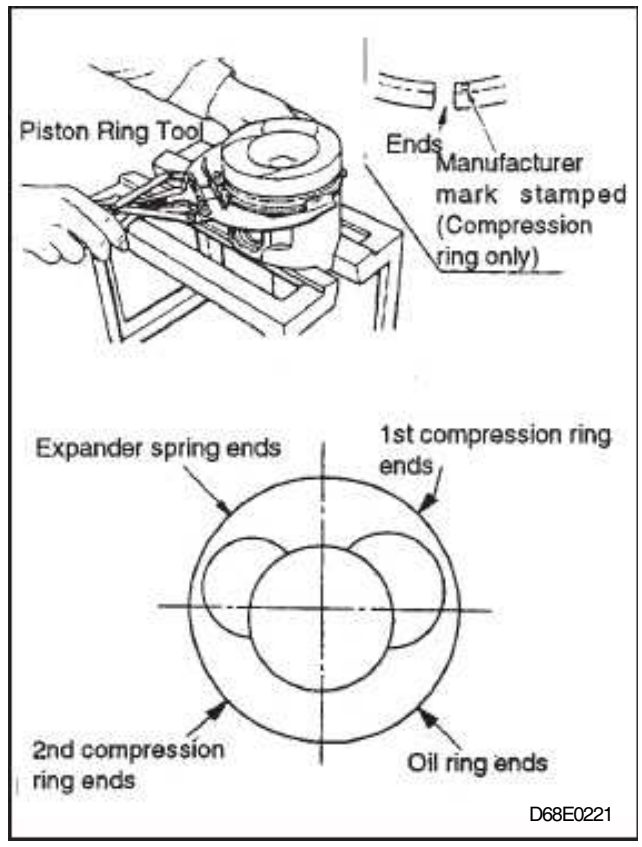
Connect the piston to the connection rod with the piston pin so that the Front mark on piston and lug groove mark in connecting rod are placed on the same side.
If the piston and piston pin are hard to insert, heat the piston with a piston heater or in hot water.

NOTE:
The parts for an engine must be of the same weight mark.
Weight marks
Heavy ——————————————————— Light
A B C D E F G H I J K



10. Installation of piston ring

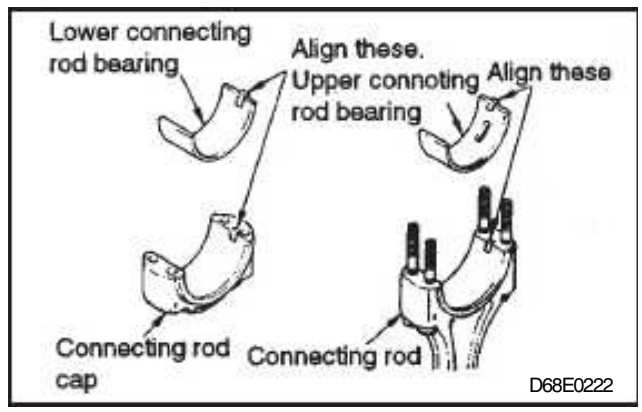
Using Piston Ring Tool (special tool), install the piston rings in the following sequence.
1) Oil ring
2) 2nd compression ring
3) 1st compression ring



11. Installation of upper and lower connecting rod bearings

Install the upper connecting rod bearing, making sure that the bearing lug is aligned with the lug groove in the connecting rod. Install the lower connecting rod bearing, making sure that the bearing lug is aligned with the lug groove in the connecting rod cap.

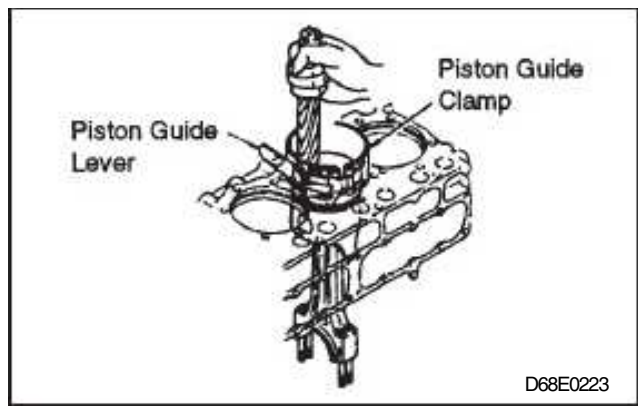
NOTE:
Note that the only the upper connecting rod bearing has an oil hole.



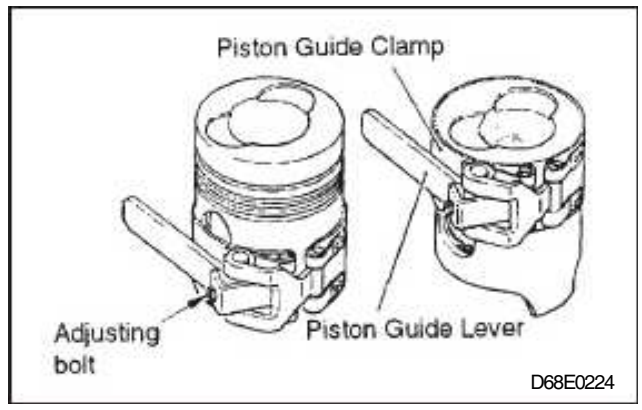
12. Installation of piston and connecting rod

Using Piston Guide Clamp and Piston Guide lever (specialtools), install the piston and connecting rod so that the front mark on piston head faces the front of engine.

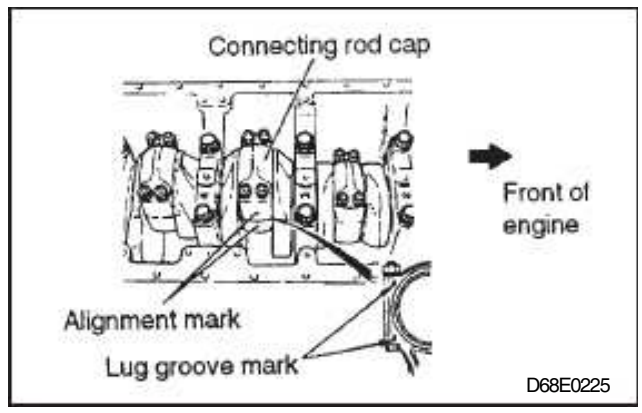
NOTE:
1) Make sure that the size symbol of the piston is the same as that of the cylinder liner.
2) Make sure that the piston ring open end directions do not change.
3) Put a vinyl hose or something else on the bolt of connecting rod for protection of the crankshaft pin against damage by the bolt.

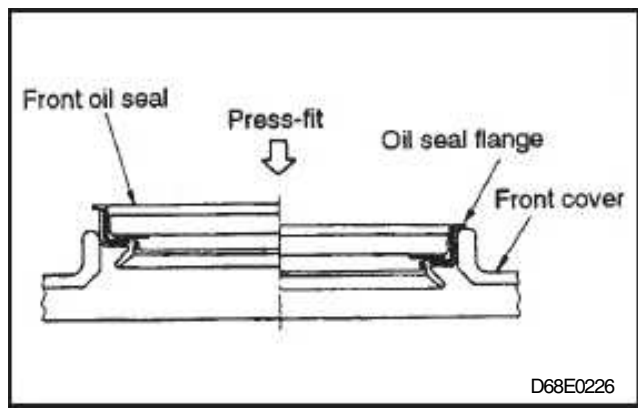


Using the Piston Guide Clamp and Piston Guide Lever (special tools).
Line up the Piston Guide with the piston skirt and set the lever into position. Then, turn the adjusting bolt so that the clamp I.D. equals piston O.D. After the adjustment, apply engine oil to piston outer surfaces, Piston Guide inner surfaces, and cylinder liner inner surfaces.
After these procedures have been completed, fit Piston Guide onto the piston so that it is flush with the pistonhead. Using a mallet or wood block, tap piston into position with care not to damage it.

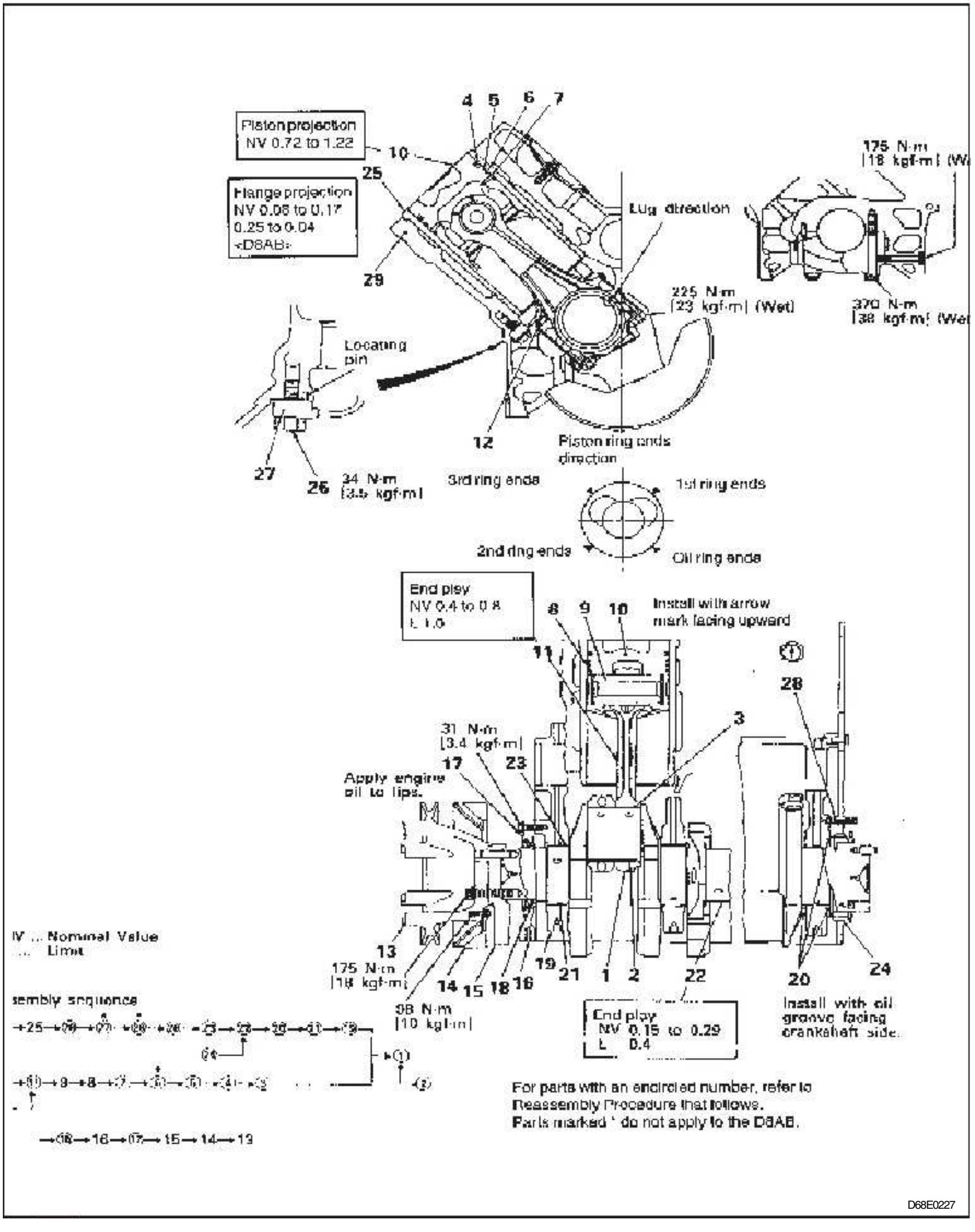


13. Installation of connecting rod caps
    Make sure that the alignment marks and lug groove marks on the connecting rod cap and connecting rod are aligned.
14. Measure the connecting rod end play and check to ensure that the measured value is me with the nominal value.
15. Measure the projection of the pistons and confirm that it does not exceed the nominal value. [Refer to Item 1, Section
16. Installation of front oil seal
    Evenly press the oil seal throughout its entire periphery to prevent it from tilting. Press-fit the oil seal into the front cover until the oil seal flange is held tight up against the front cover.





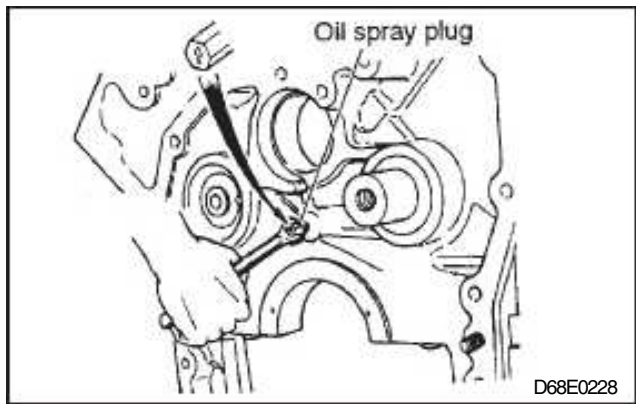
Reassembly [D8A]



Reassembly Procedure

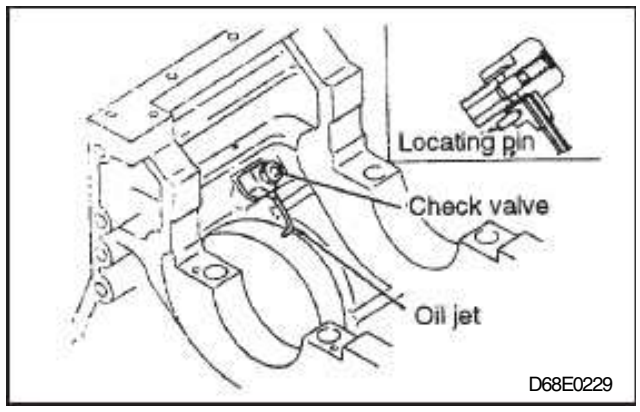
1. Installation of oil spray plug

   Install the oil spray plug with the arrow stamped on the plug toward the top of the engine.



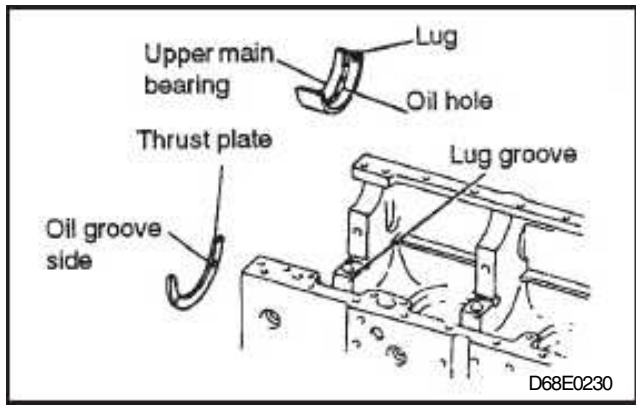
2. Installation of oil jet and check valve

   Put the locating pin of the oil jet in the hole of the crankcase and tighten the check valve to the specified torque.
   The check valve must not be reused. Use a new one



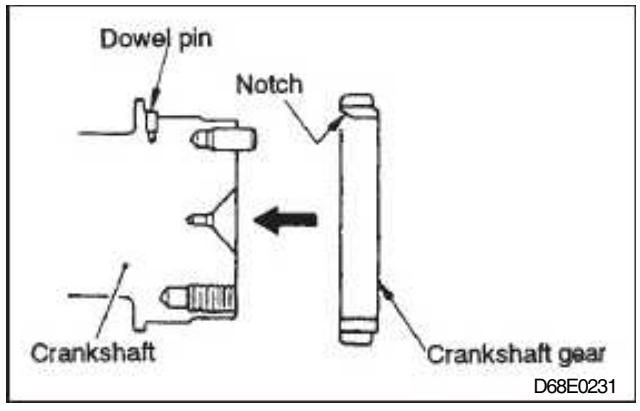
3. Installation of upper main bearing and thrust plate

   NOTE:
   1. **Install the thrust plate with the oil grooveless side toward the crankcase.**
   2. **Line up the lug of the main bearing and the groove of the crankcase.**
      The upper main bearing is one with oil holes.
      Take care not to confuse it with the lower one.
   3. **Oversize (0.15, 0.30, 0.45 mm) thrust plates are available for adjusting the end play in crankshaft [refer to Item 6]. If any one of these is used, ensure the correct size of the thrust plate to be installed to the main bearing cap [refer to Item 6.].**



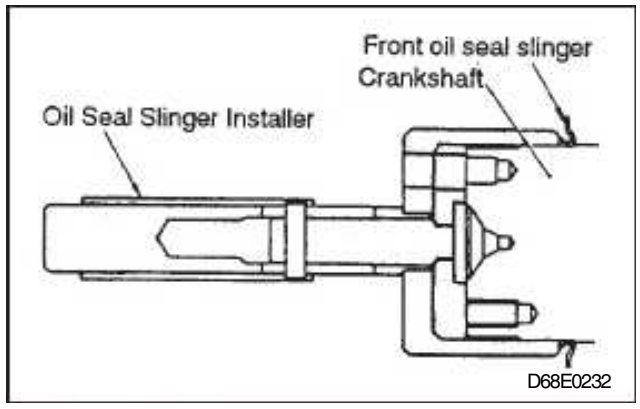
4. Installation of crankshaft gear

   (a) Heat the gear to about 100℃, using a piston heater, etc.
   (b) Locate the gear so that the dowel pin of the crankshaft will fit in the notch of the gear and fit the gear by lighty striking the gear end with a soft hammer.
   (c) Install the rear oil seal slinger.

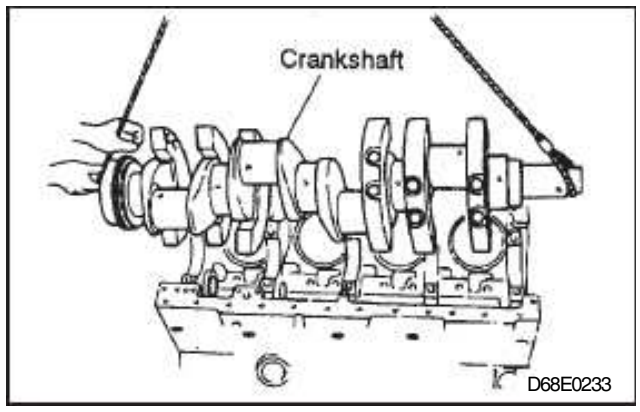


5. Installation of front oil seal slinger

   Install the front oil seal slinger, using Oil Seal Slinger Installer (special tool).

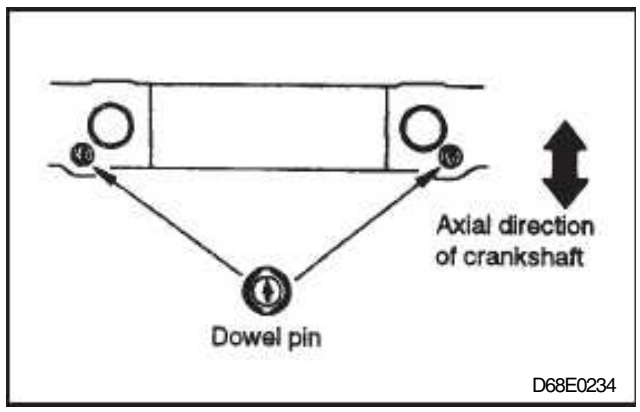


6. Installation of crankshaft
   Lift the crankshaft 18 with chain blocks, etc. While keeping it in horizontal position, slowly lower it into the crankcase.

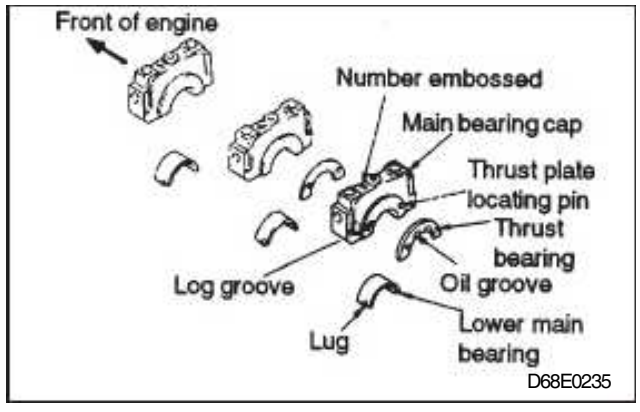


7. Installation of lower main bearings and main bearing caps
   Install the parts as follows.

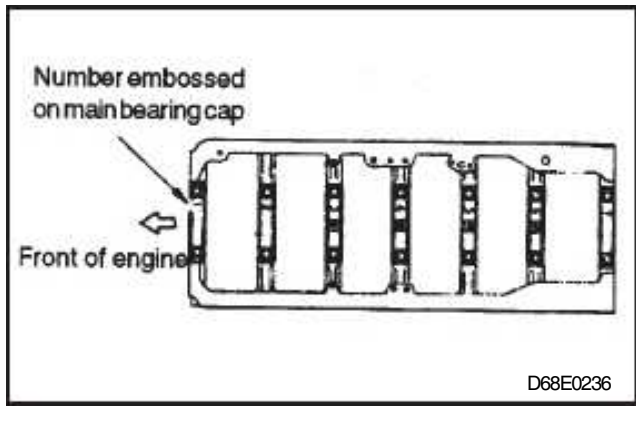
   (a) Drive dowel pins into the rearmost main bearing cap in the direction shown for corredt positioning.



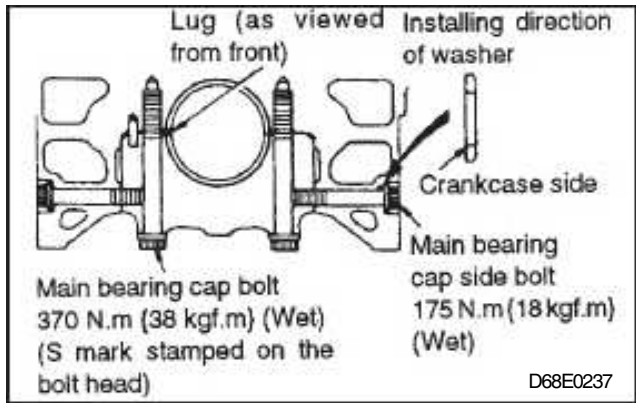
   (b) Fit the lower main bearing into each main bearing cap ensuring that the vearing lug is aligned with the lug groove in the cap.
   (c) Install thrust plates to the both sides of the rearmost main bearing cap only so that their oil grooveless sides face the cap.



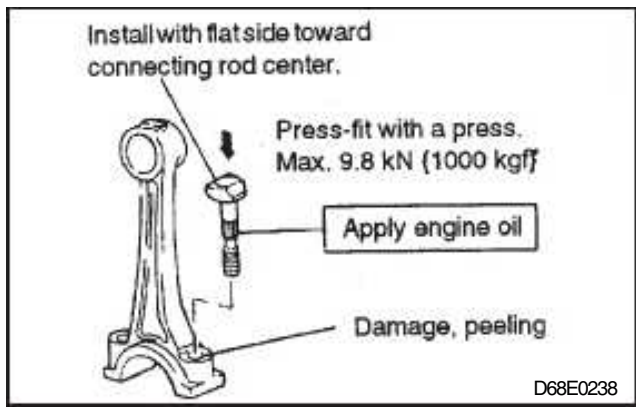
NOTE:
If an oversize thrust plate is used, use the bearing cap rear thrust plate of the same size as that of the thrust plate in the crankcase rear end [refer to Item 3.]. Note, however, that the bearing cap front and rear thrust plates may be of different sizes.



(d) Install the main bearing caps, caps making sure that the side with the lug groove placed on the right-hand side of the engine and they are installed in the order of embossed numbers from the front of engine.
(e) Tighten main bearing cap bolts to specified torque. Then, tighten main bearing cap side bolts to specified torque.
After the bolts are tightened, make sure that the crankshaft is free to rotate by hand.
(f) Check to see if the end play of the crankshaft is within nominal value.

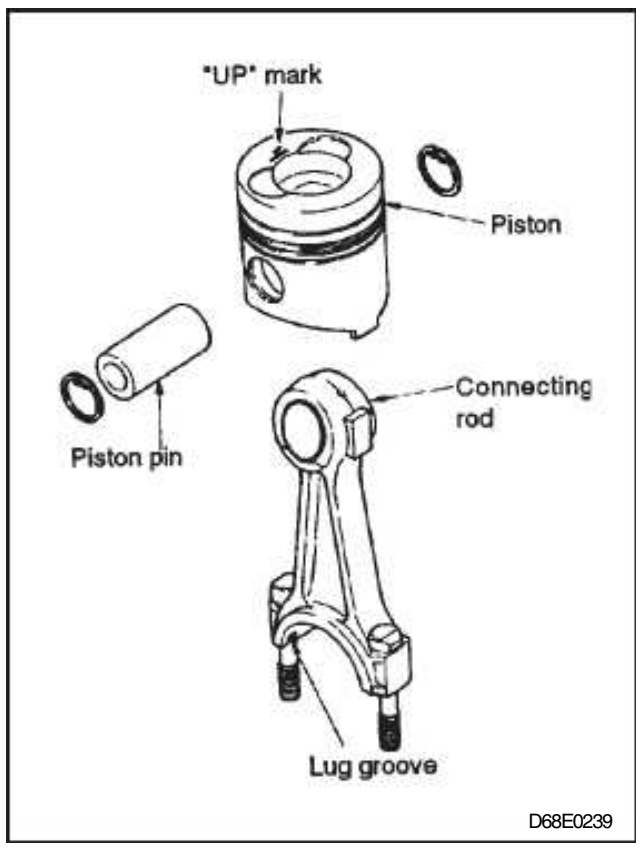


8. Installation of connection rod bolt
After checking the connecting rod for damage and bur in the bolt hole, apply engine oil to the connecting rod bolt and press-fit it into the connecting rod.



9. Reassembly of piston and connecting rod

Connect the piston to the connection rod with the piston pin so that the "UP" mark on the piston and lug groove in the connecting rod are positioned on the same side.
If the piston and piston pin are hard to insert, heat the piston with a piston heater or in hot water.

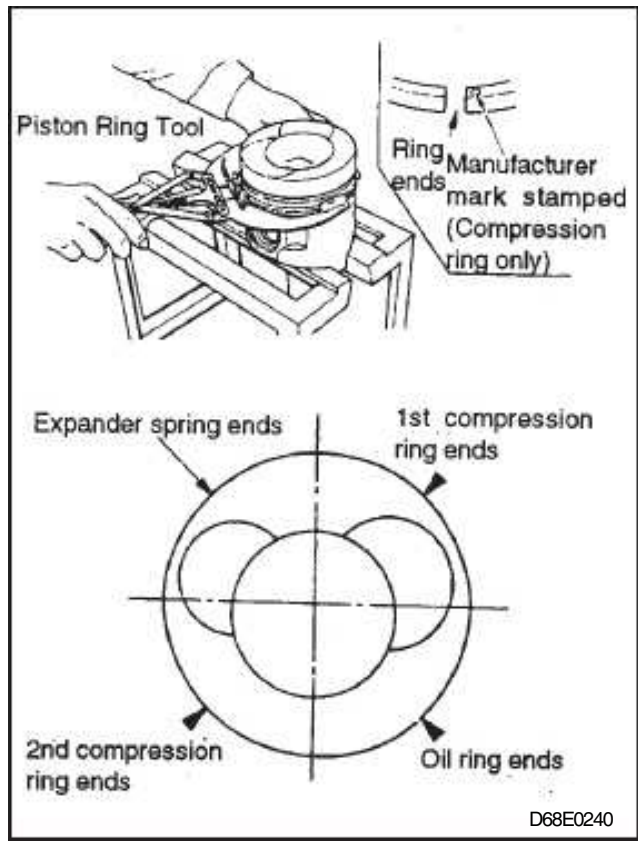


10. Installation of piston ring

Using Piston Ring Tool (special tool), install the piston rings in the following sequence.

1. Oil ring
2. 3rd compression ring
3. 2nd compression ring
4. 1st compression ring

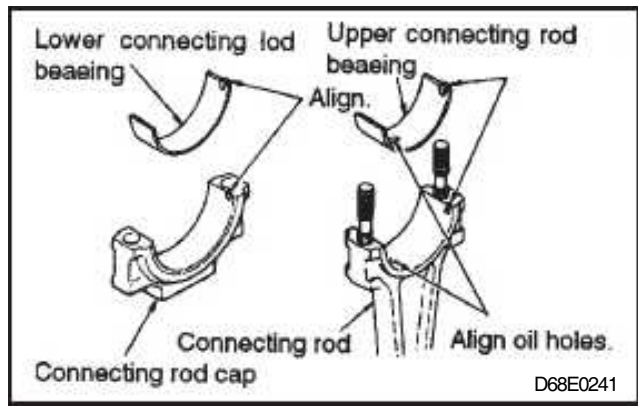
NOTE:
The manufacturer's mark is inscribed near the open end of piston ring. Install the piston ring with the manufactur er's marks upward.



11. Installation of upper and lower connecting rod bearings

Install the upper connecting rod bearing, so that its lug is aligned with the lug groove in the connecting rod and the oil hole in bearing is aligned with that in connecting rod.
Install the lower connecting rod bearing so that its lug is aligned with the lug groove in the connecting rod cap.

NOTE:
Note that the connecting rod bearing with an oil hole is the upper; the one having no oil hole is the lower.
Be alert also that different parts are used for the left and right banks.

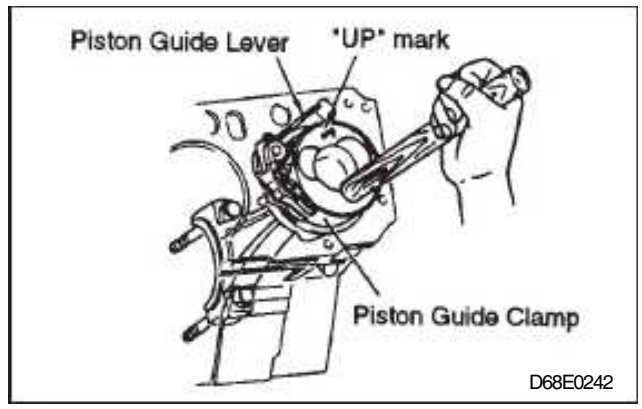


12. Installation of piston and connecting rod

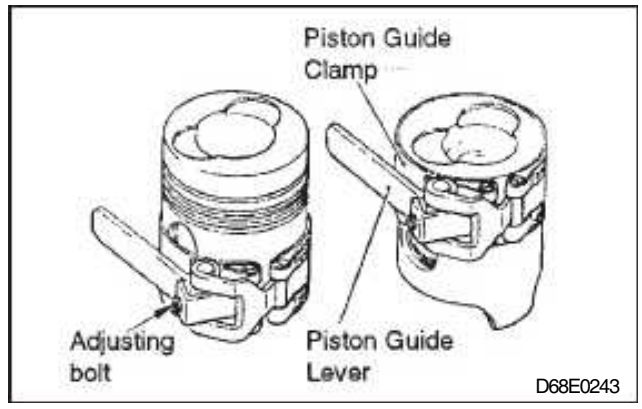
Using Piston Guide Clamp and Piston Guide lever (special tools), install the piston and connecting rod assembly so that the "UP" mark on the piston is on the bottom side of the V arrangement.

NOTE:
1. Different connecting rods are used on the right and ldft banks. Right and left identification symbols (LH, RH) are embossed on the connecting rods. Use care to prevent confusion at installatin.
2. Make sure that the size symbol of the piston is the same as that of the cy linder liner.
3. Make sure that the piston ring open end directions do not change.
4. Put a vinyl hose or something else on the bolt of connecting rod for protection of the crankshaft pin against damage by the bolt.

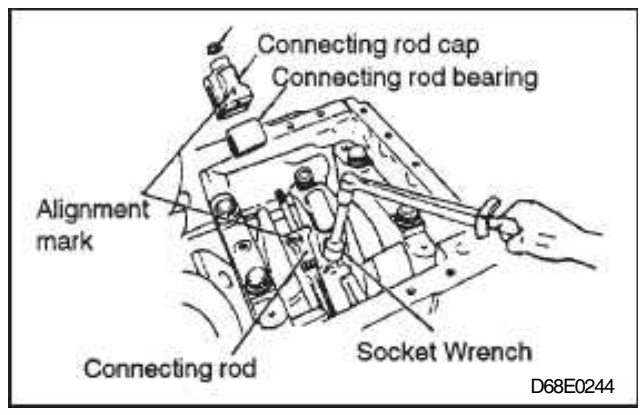
Using the Piston Guide Clamp and Piston Guide Lever (special tools).



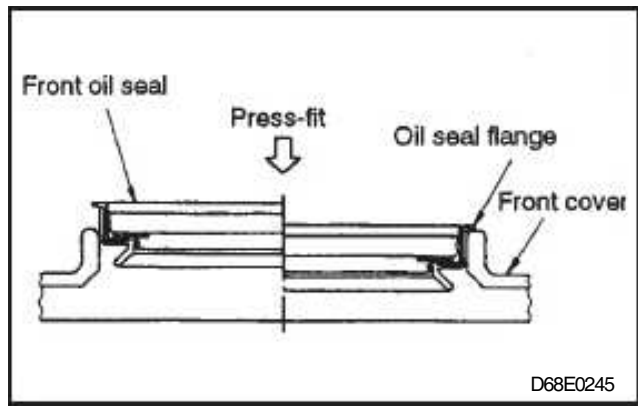
Line up the Piston Guide with the piston skirt and set the lever into position. Then, turn the adjusting bolt so that the clamp I.D. equals piston O.D. After the adjustment, apply engine oil to piston outer surfaces, Piston Guide inner surfaces, and cylinder liner inner surfaces.
After these procedures have been completed, fit Piston Guide onto the piston so that it is flush with the pistonhead. Using a mallet or wood block, tap piston into position with care not to damage it.



13. Installation of connecting rod caps
    Fit the connecting rod cap so that its alignment mark is aligned with that on the connecting rod.
    Then, using Socket Wrench (Special tool). torque to specification
    Measure the connecting rod end play and check to ensure that the measured value is me with the nominal value. [Refer to Item 2].
    Measure the projection of the pistons and confirm that it does not exceed the nominal value.

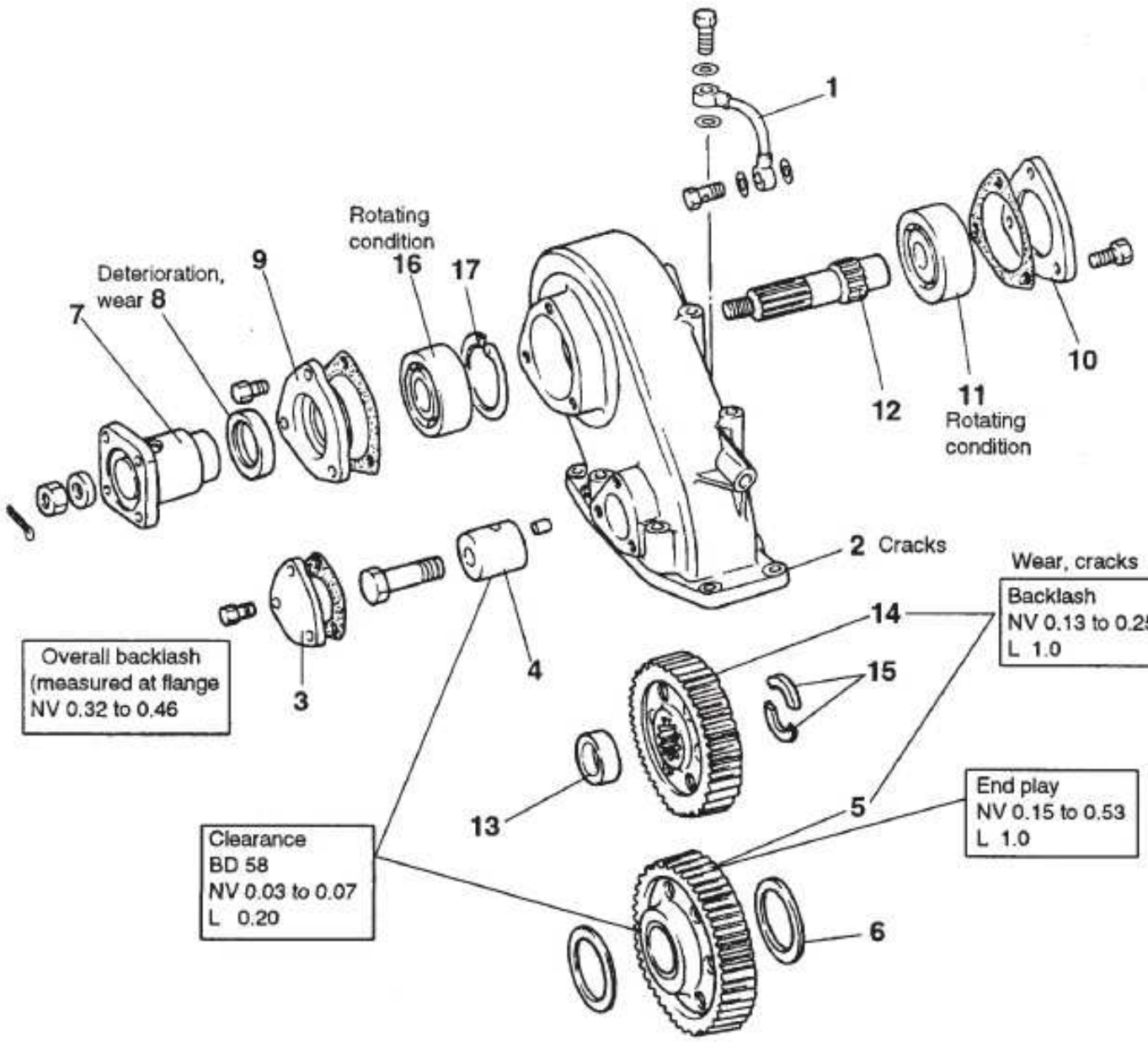


14. Installation of front oil seal
    Press the oil seal evenly throughout its entire periphery so that it will not tilt. Press-fit the oil seal into position until its flange tightly contacts the front cover.



Flywheel PTO

Disassembly and inspection [D6A]



Disassembly sequence

1. Oil pipe
2. Gear case
3. Cover "A"
④ Idler shaft "C"
⑤ PTO idler gear "B"
6. Thrust plate
⑦ Flange
*8. Oil seal
9. Cover "B"
10. Cover "C"
*11. Ball bearing
12. PTO shaft
13 Spacer
⑭ PTO gear
15 Cotter
*16 Ball bearing
17 Snap ring

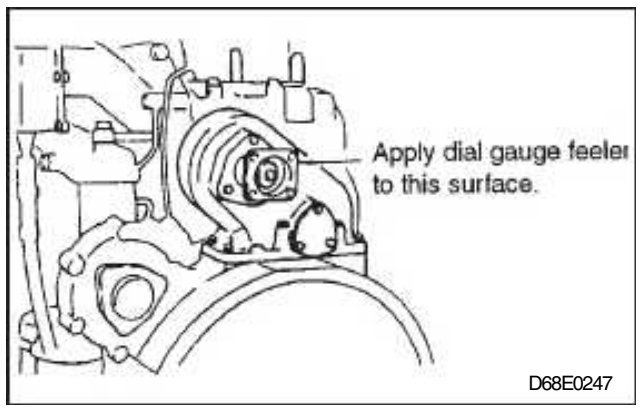
For parts with an encircled number, refer to Inspection Procedure that follows.
Service items marked with should be checked before disassembly.
Parts marked with * should not be removed unless defects are evident.

D68E0246

Disassembly and Inspection Procedures

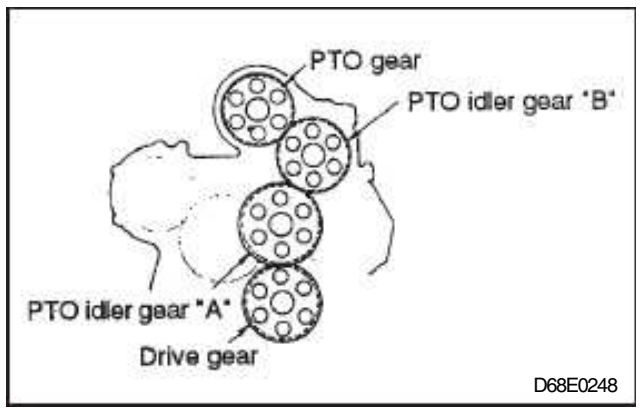
1. Overall backlash in each gear

   Since the backlash cannot be measured at the gears, measure it at the flange as shown, while holding the crankshaft in position. The backlash is the overall value of the individual gears.
   If the backlash is over the nominal dimension, check each gear for wear and replace if defective.



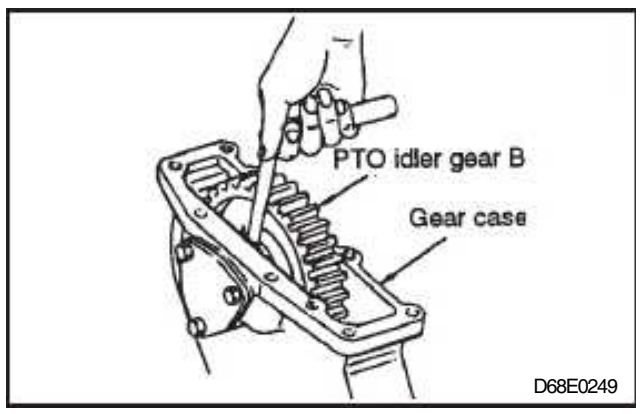
NOTE:

The overall backlash in each gear refers to the back lash present when the PTO gear, PTO idler gear B, PTO idler gear A, and drive gear are in mesh with each other.



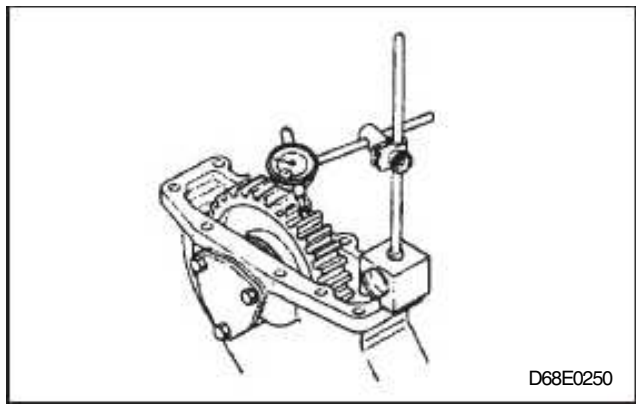
2. PTO idler gear B end play

   Remove the PTO head assembly and measure the end play of the PTO idler gear "B". If the end play is over the nominal dimension, replace the thrust plate.



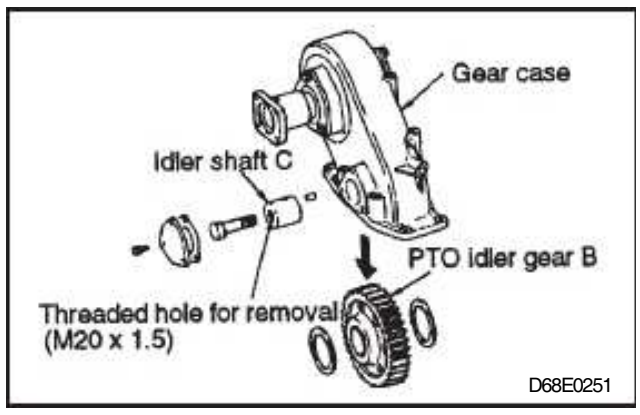
3. Backlash between PTO gear and PTO idler gear B

   If the backlash exceeds the limit, check gear bushings and gears and replace as necessary.



4. Removal of PTO idler gear B

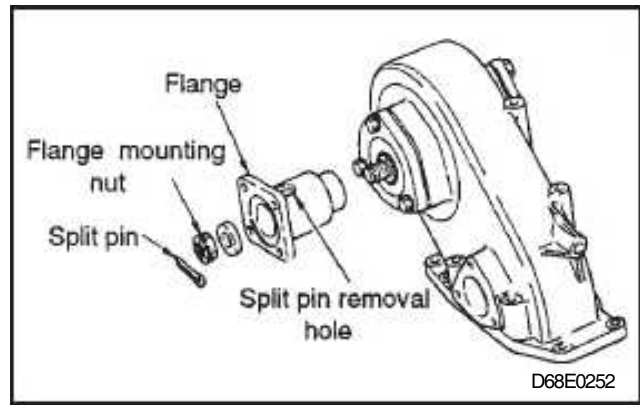
   Remove PTO idler gear B after idler shaft C has been removed. The idler shaft "C" should be removed by turning down a bolt of 20 mm thread diameter and 1.5 mm pitch.



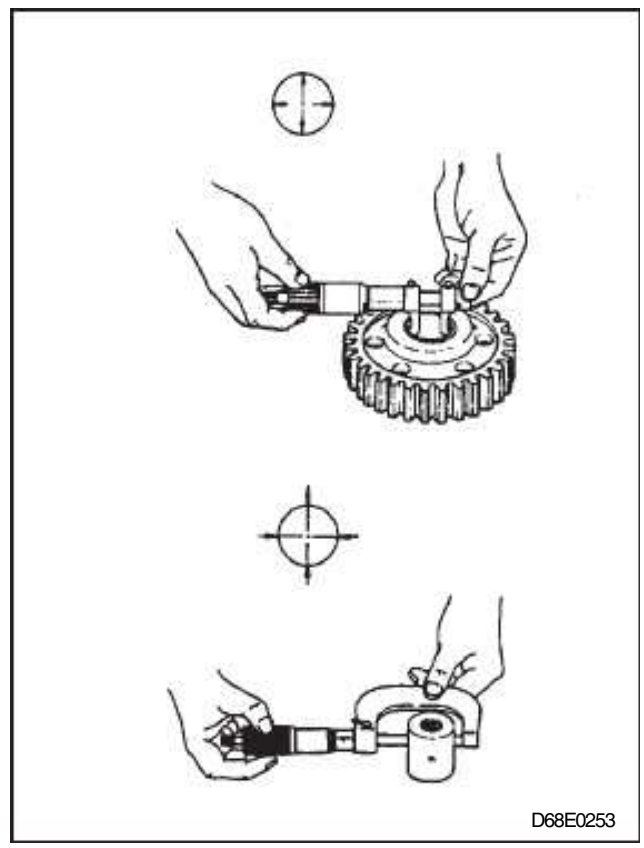
5. Removal of flange

   To remove the flange, first remove the split pin through the split pin removal hole in the flange to remove the flange mounting nut.

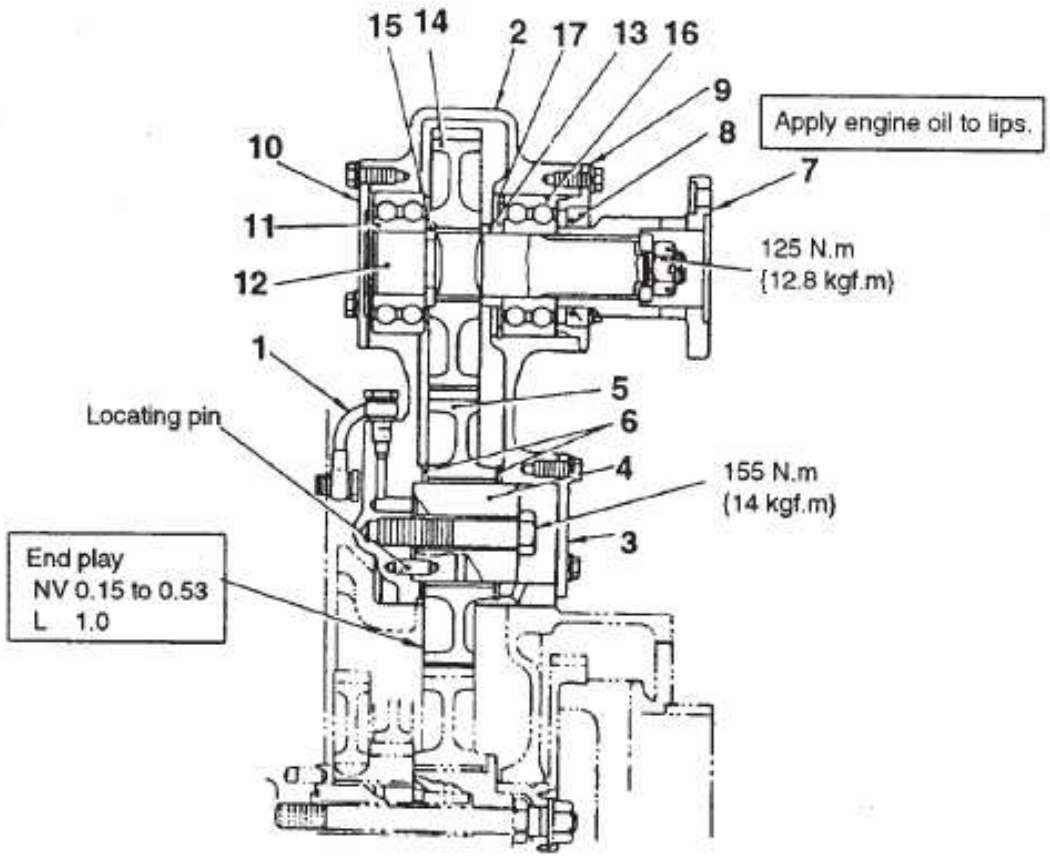
6. Idler shaft C to PTO idler gear B clearance

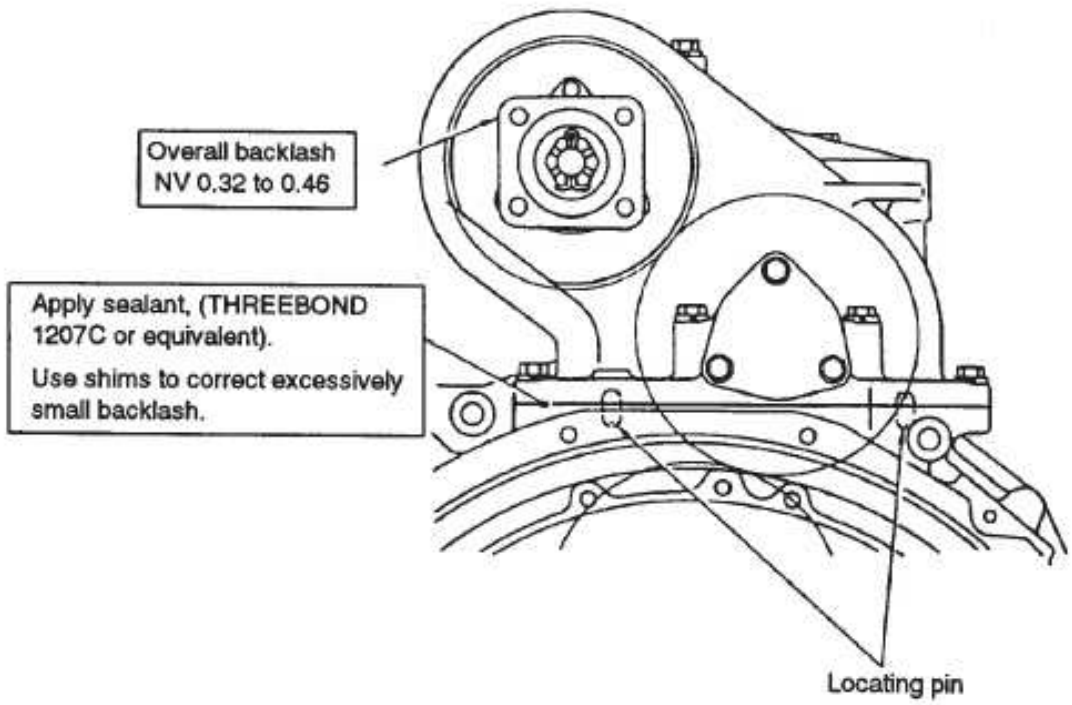


If the clearance exceeds the limit, replace the bushing in the idler gear.



Reassembly





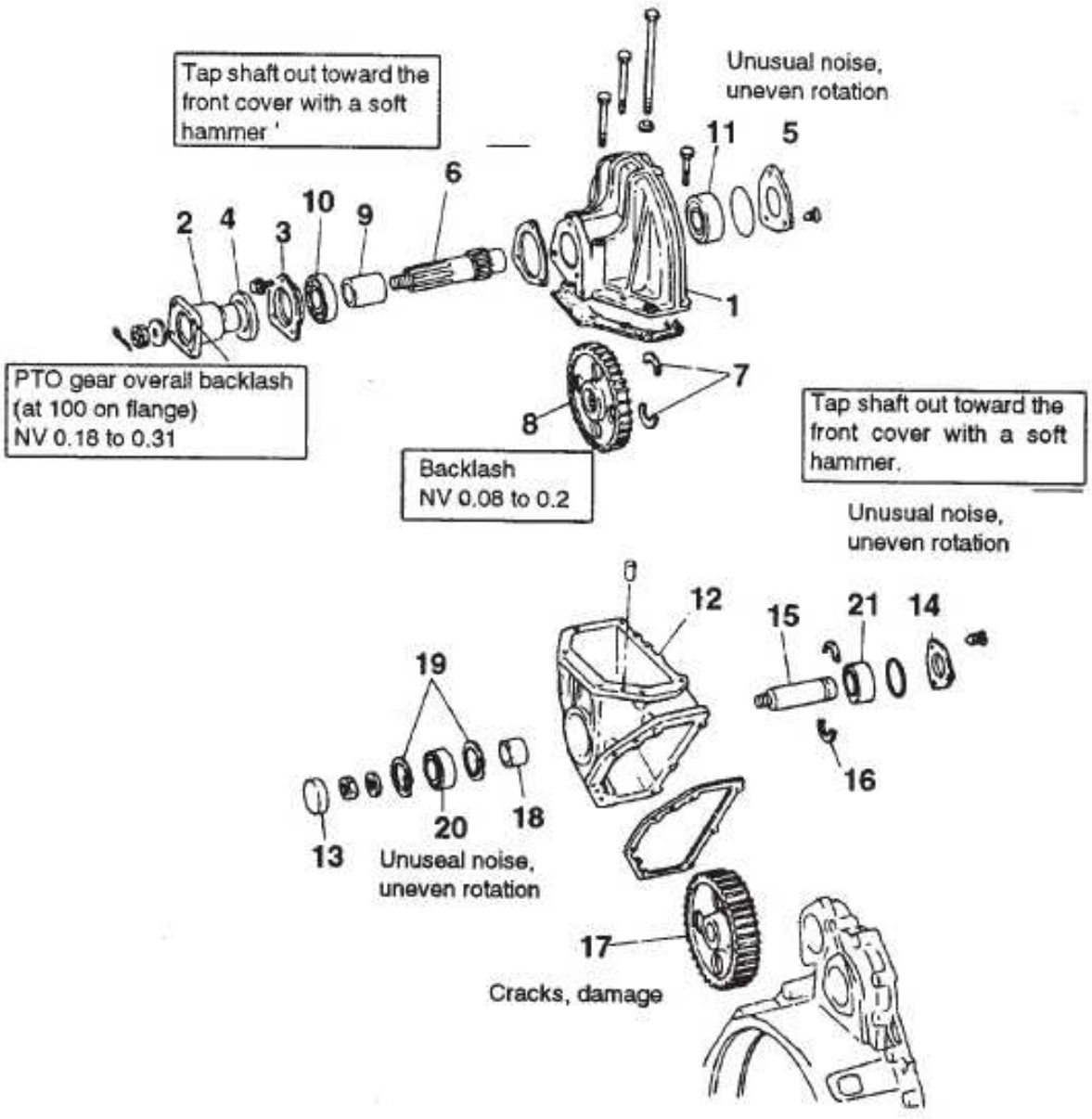
NV ... Nominal Value
L ... Limit

Assembly sequence
17→16→13→14→15→12→11→10→8→9→7→6→5→4→3→2→1

D68E0254

Flywheel PTO

Disassembly and inspection [D8A]



Disassembly sequence

1. PTO gear case
2. Flange
3. Rear cover
4. Oil seal
5. Front cover
6. PTO shaft
7. Cotter

*8. PTO gear
9. Spacer
10. Ball bearing
*11. Ball bearing
12. PTO idler gear case
13 Seal cap
14 Front cover

15 Idler shaft
*16 Cotter
17 PTO idler gear B
18 Spacer
19 Snap ring
20 Ball bearing
21 Ball bearing

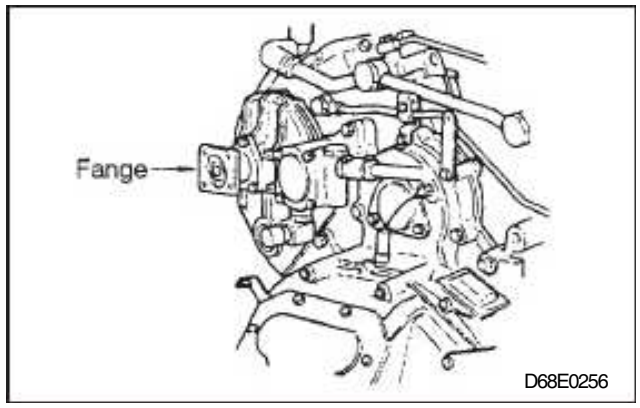
For parts with an encircled number, refer to Inspection Procedure that follows.
Service items marked with should be checked before disassembly.
Parts marked with * should not be removed unless defects are evident.

D68E0255

Disassembly and Inspection Procedures

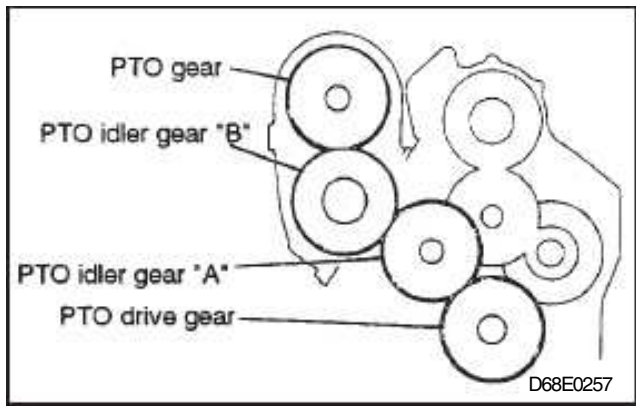
1. Overall backlash in each gear

   Since the backlash cannot be measured at the gears, measure it at the flange as shown, while holding the crankshaft in position. The backlash is the overall value of the individual gears.
   If the backlash is over the nominal dimension, check each gear for wear and replace if defective.



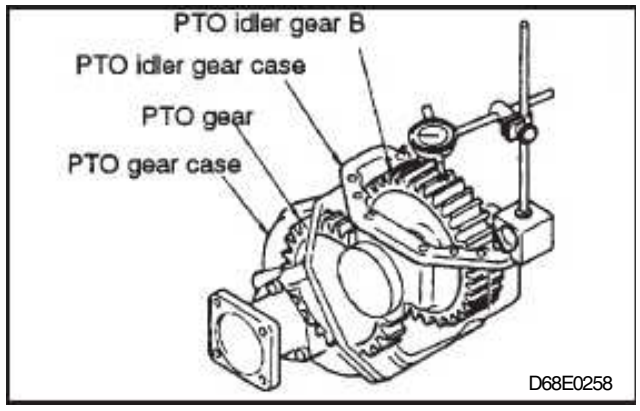
NOTE:

The overall backlash in each gear refers to the back lash present when the PTO gear, PTO idler gear B, PTO idler gear A, and drive gear are in mesh with each other. For inspection of PTO idler gear A and drive gear, refer to S e c - tion

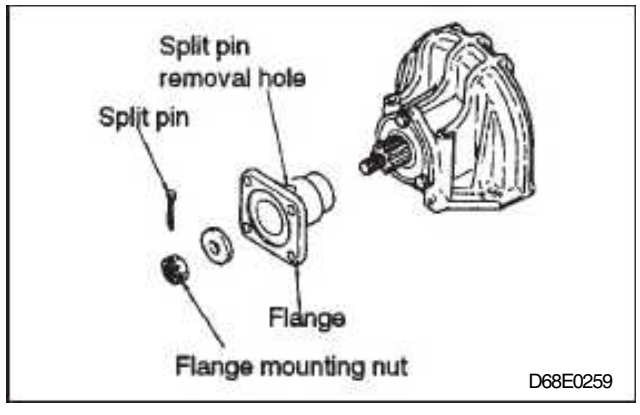


2. Backlash between PTO gear and PTO idler gear B.

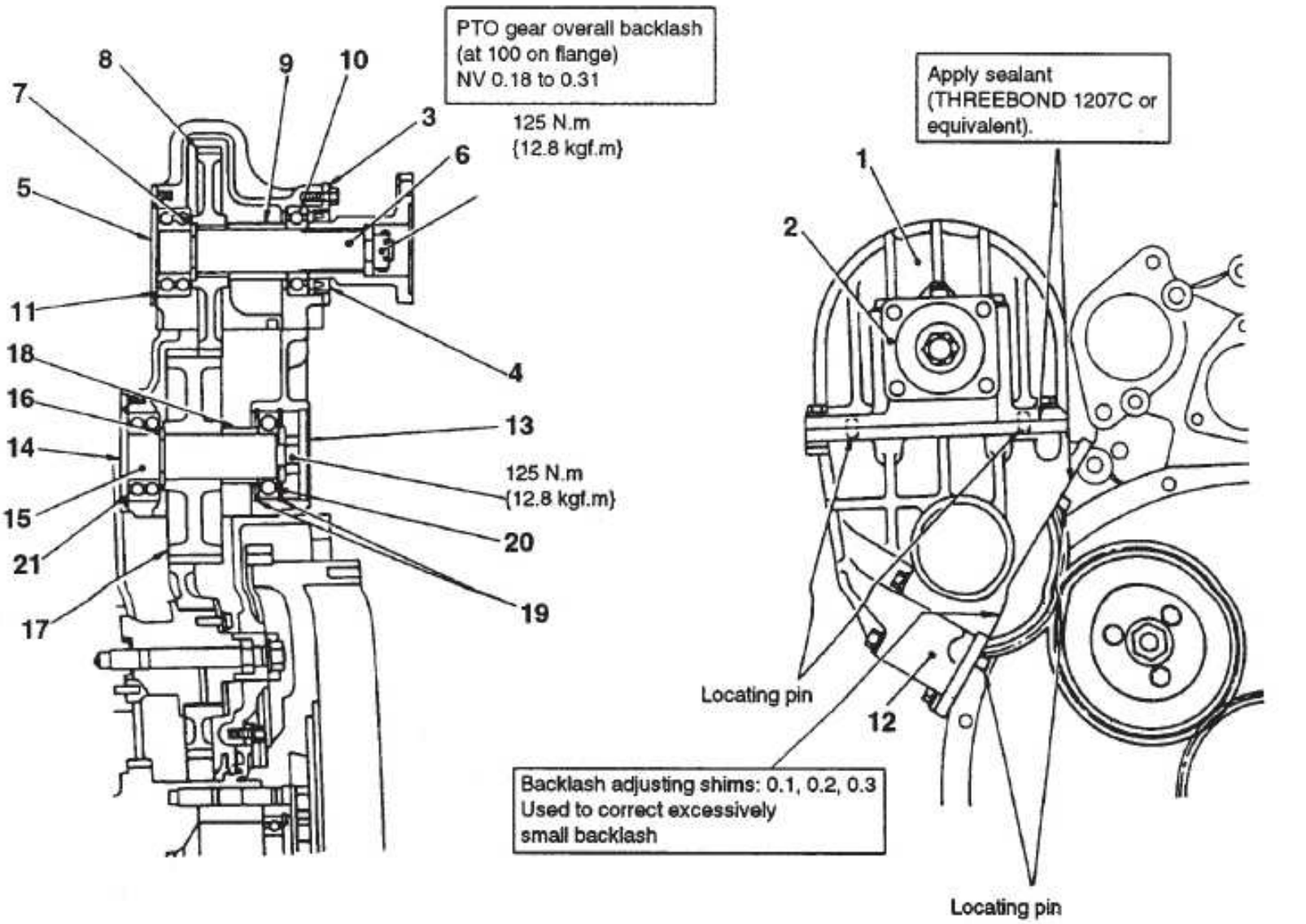
   Remove the PTO gear case and PTO idler gear case as an assembly and measure the backlash. If the backlash exceeds the limit, check the gears and replace as necesary.



3. Removal of flange
   To remove the flange, remove the split pin through the split pin removal hole in the flange and remove the flange mounting nut.



Reassembly [D8A]



NV ... Nominal Value
L ... Limit

Assembly sequence

15, 21 → 17 → 16 → 18 → 19 → 20 → 13 → 14 → 12

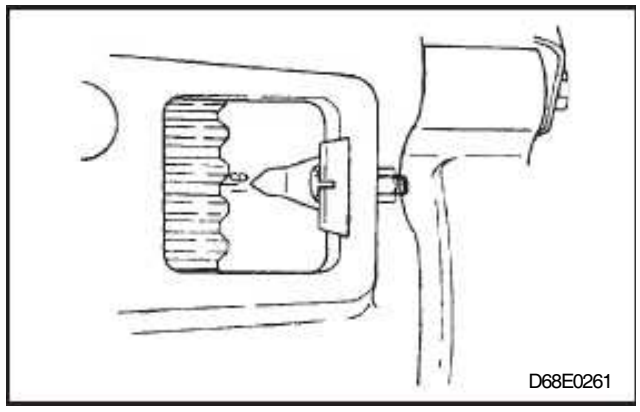
6, 11 → 8 → 7 → 9 → 10 → 3, 4 → 2 → 5 → 1

D68E0260

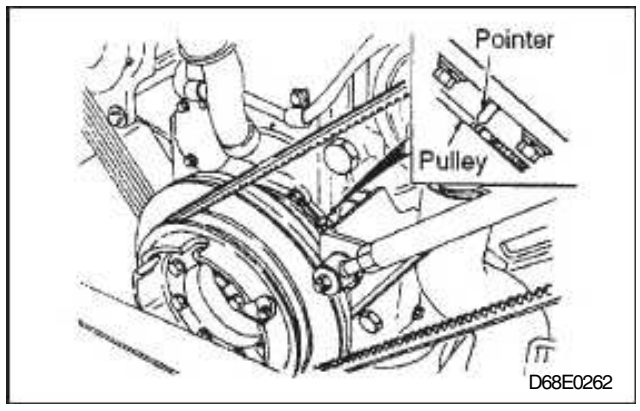
Inspection and Adjustment of Valve Clearance [D6A]

The valve clearance should be checked and adjusted when the engine is cold.

1. Crank the engine to align the pointer of the inspection window of the flywheel housing with the inscribed mark 1.6 of the flywheel. Check the push rods, and the piston whose push rod is not pushing up the rocker is at the top dead center of the compression stroke.


D68E0261

On bus engines, a pointer is provided in front of the engine. The piston in No.1 to no. 6 cylinder is at the top dead center on the compression stroke when the inscribed line marked 1, 6 on the crankshaft pulley aligns with this pointer.

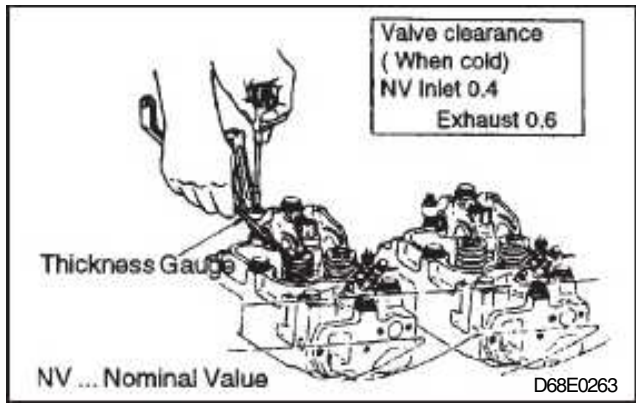


D68E0262

2. When the piston in No.1 cylinder is at the top dead center on the compression stroke, inspect and adjust valve clearance in respect to the valves marked O in the table below. Cranking the crankshaft one turn, proceed to inspect and adjust valve clearance in respect to the remaining valves marked X.
When the piston in No. 6 cylinder is at the top dead center on the compression stroke, inspect and adjust valve clearance in respect to the valves marked X. Cranking the crankshaft one turn, proceed to inspect and adjust valve clearance in respect to the remaining valves marked O.

Cylinder No.	1		2		3		4		5		6	
Valve arrangement	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.
No. 1 at TDC on compression stroke	O	O	O			O	O			O		
No. 6 at TDC on compression stroke				X	X			X	X		X	X

3. Measure the clearance between the rocker arm and valve cap with a specified thickness gauge to see if it meets specification.
Check the valve clearance by inserting Thickness Gauge (special tool) between the rocker arm and valve cap.
If the clearance is incorrect, loosen the lock nut and correct the clearance by turning the adjusting screw.
After adjustment of the clearance, turn down the lock nut to secure the adjusting screw.



D68E0263

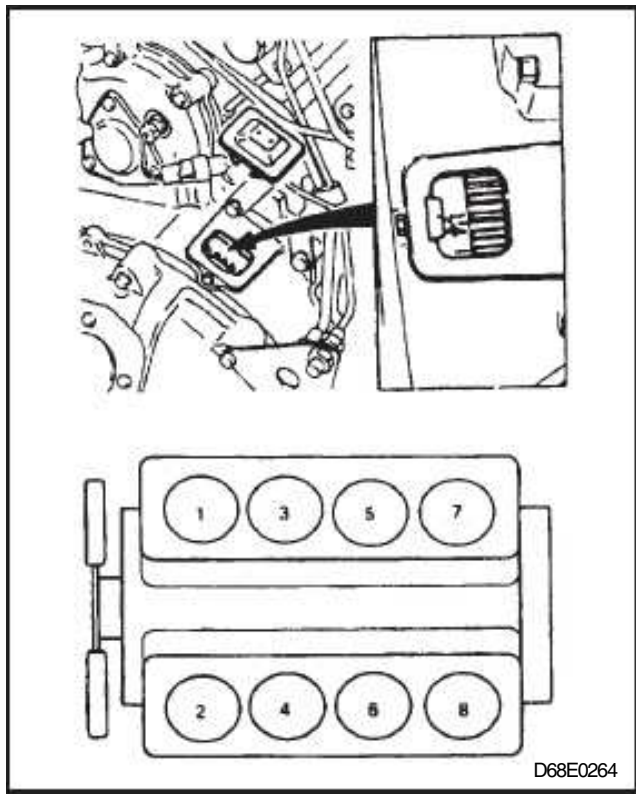
NOTE:
After the lock nut has been turned down, reconfirm the clearance.

Inspection and Adjustment of Valve Clearance [D8A]

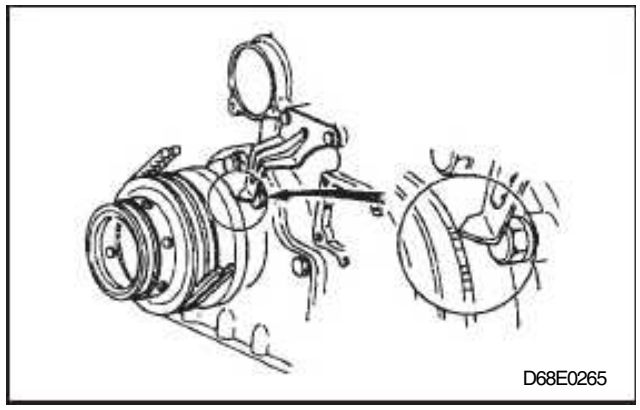
The valve clearance should be checked and adjusted when the engine is cold.

1. Crank the engine to align the pointer of the inspection window of the flywheel housing with the inscribed mark 1.4 of the flywheel. Check the push rods, and the piston whose push rod is not pushing up the rocker is at the top dead center of the compression stroke.

   On bus engines, a pointer is also provided on the front of engine. When the inscribed line maked 1, 4 on the crankshaft pulley aligns with this pointer, the piston in No. 1 or No. 4 cylinder is at the top dead center on the compression stroke.



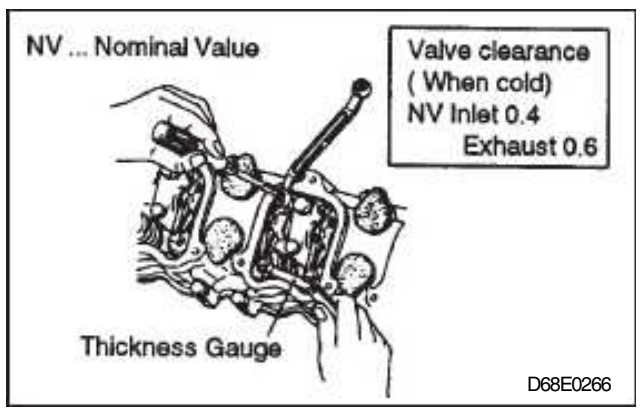
2. When the piston in No.1 cylinder is at the top dead center on the compression stroke, inspect and adjust valve clearance in respect to the valves marked O in the table below. Cranking the crankshaft one turn, proceed to inspect and adjust valve clearance in respect to the remaining valves marked X.
   When the piston in No. 6 cylinder is at the top dead center on the compression stroke, inspect and adjust valve clearance in respect to the valves marked X. Cranking the crankshaft one turn, proceed to inspect and adjust valve clearance in respect to the remaining valves marked O.



Cylinder No.	1		2		3		4		5		6		7		8	
Valve arrangement	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.	In.	Ex.	Ex.	In.	Ex.	In.
No. 1 at TDC on compression stroke	O	O	O			O			O			O		O		O
No. 6 at TDC on compression stroke				X	X		X	X		X	X		X		X	

3. Measure the clearance between the rocker arm and valve cap with a specified thickness gauge to see if it meets specification.
   Check the valve clearance by inserting Thickness Gauge (special tool) between the rocker arm and valve cap.
   If the clearance is incorrect, loosen the lock nut and correct the clearance by turning the adjusting screw.
   After adjustment of the clearance, turn down the lock nut to secure the adjusting screw.

   NOTE:
   After the lock nut has been turned down, reconfirm the clearance.

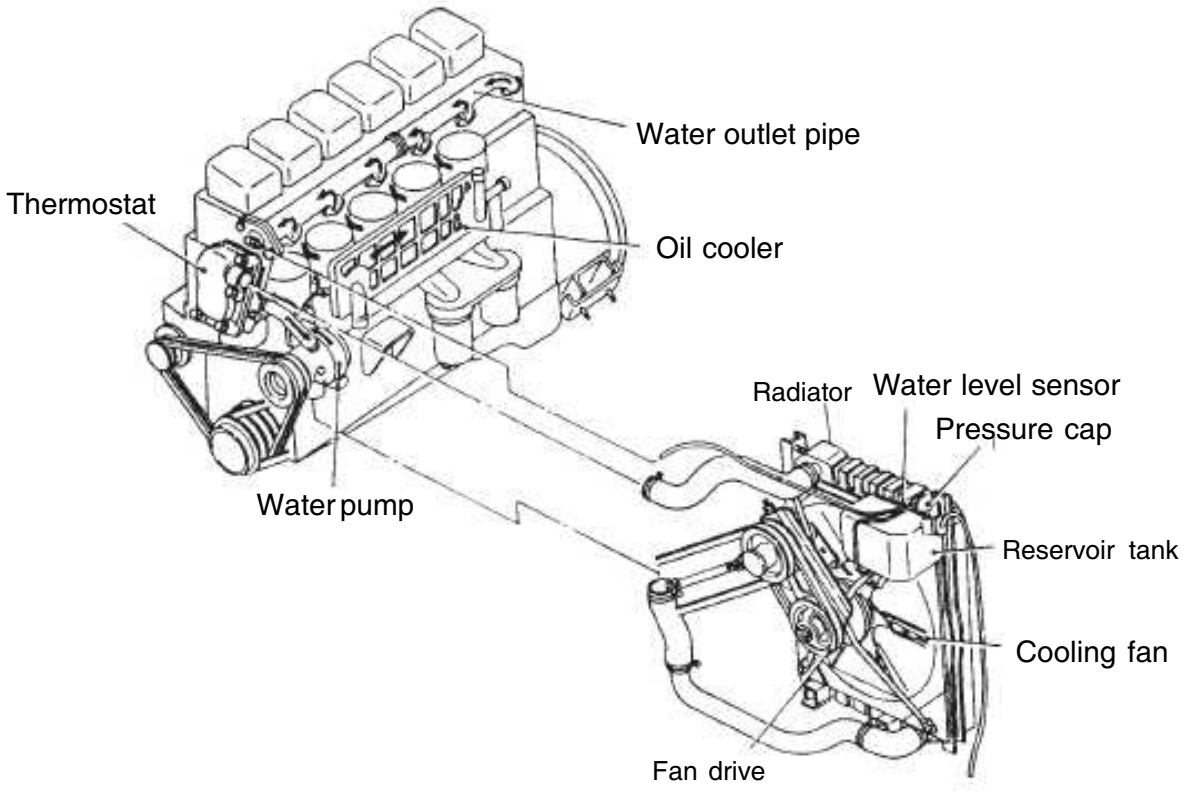


COOLING

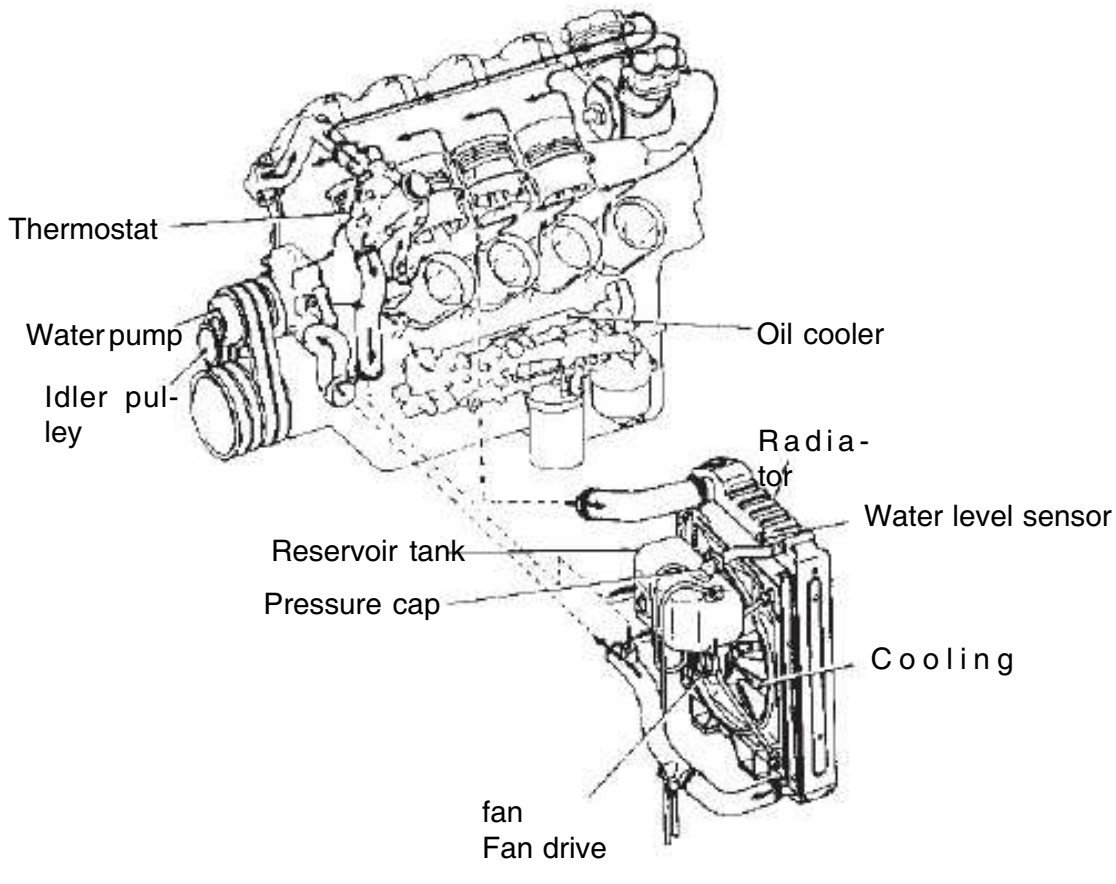
GENERAL

Cooling system

[D6]



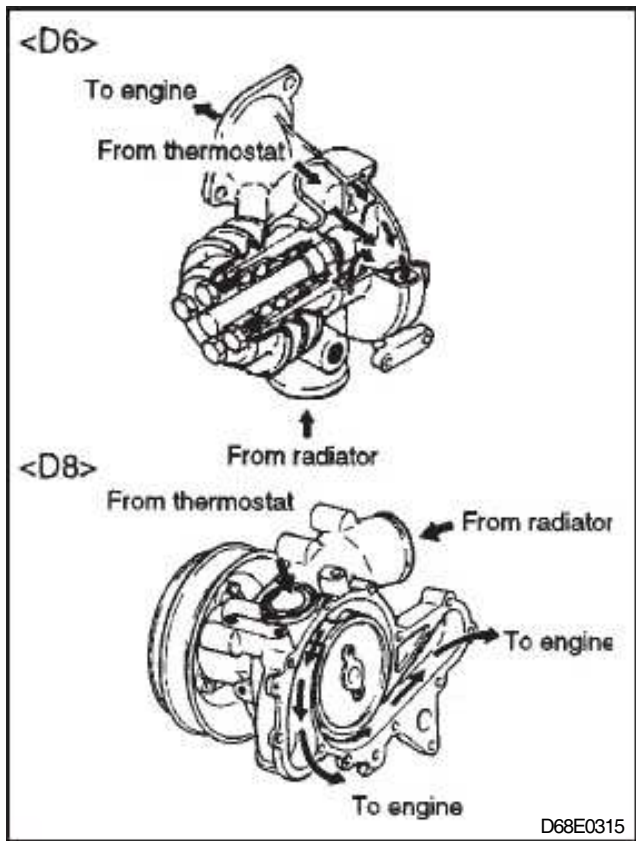
[D8]



The cooling system is a water-cooled, forced-circulation system, consisting of radiator, water pump, thermostat, reservoir tank, and other parts.
The coolant sent from the water pump circulates and cools the engine parts and is directed to the thermostat case.
The coolant is then sent to the radiator if its temperature is high and directly to the water pump if the temperature is low to cool the engine parts again.
The reservoir tank is provided to keep the radiator full of coolant at all times.
The reservoir tank, on the other hand, is installed at a level lower than the radiator coolant level; it uses a vacuum produced in the radiator when the coolant temperature rises or drops to replenish the coolant.
On buses, the radiator is located at the rear right of the vehicle. The cooling fan is driven by the fan drive system.

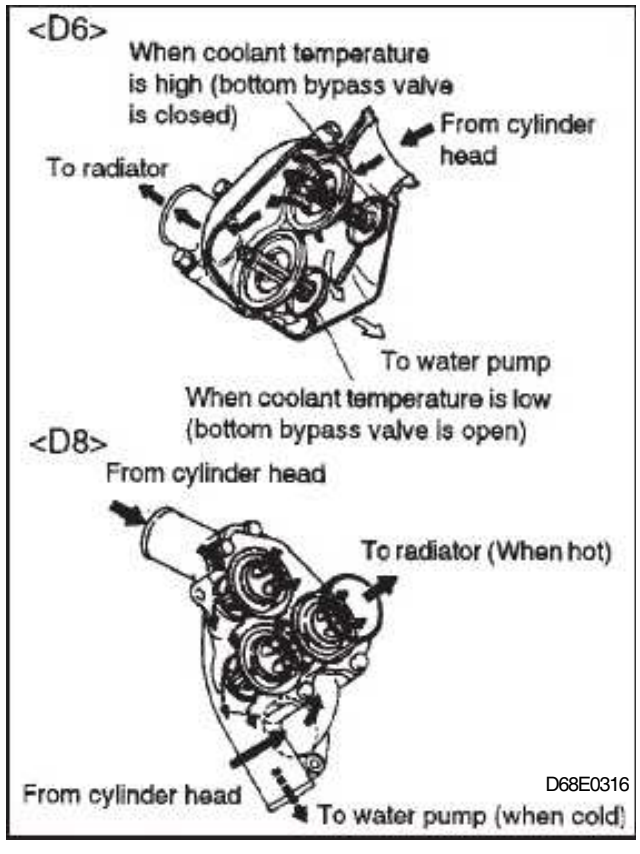
Water pump

The water pump, of the centrifugal type, is driven by V-belt from the crankshaft pulley.
Mounted at one end of the water pump shaft is an impeller with blades and the coolant is sealed up by unit seal.
The ball bearing supporting water pump shaft is lubricated by grease.

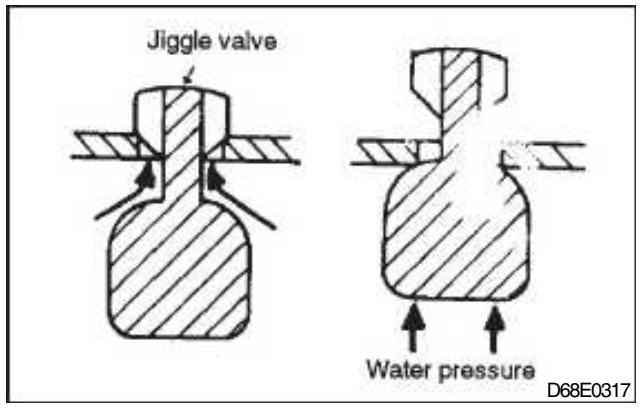


Thermostat

The thermostat is of bottom bypass type with a valve controlled by special wax enclosed in a pellet. When the wax is heated, it passes from a solid to a liquid state with its volume changing. This change in volume regulates the amount of coolant flowing into the radiator and water pump (bypass side), thereby controlling coolant temperature.

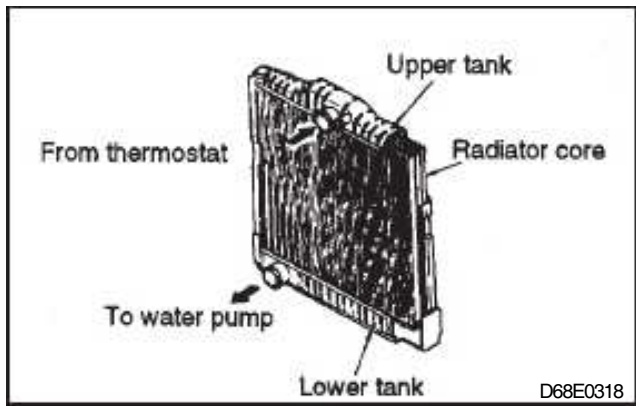


A jiggle valve is installed in the thermostat for D8A.
The jiggle valve is normally in the lower position. Air in the engine is led to radiator through the clearance between the jiggle valve and the breather hole, which permits easy supply of coolant.
When the engine is started and coolant flows, the jiggle valve is pushed up to close the breather hole.
Therefore, coolant cannot flow into the radiator until the temperature rises enough to open the thermostat valve. This contributes to a shorter engine worm up time.



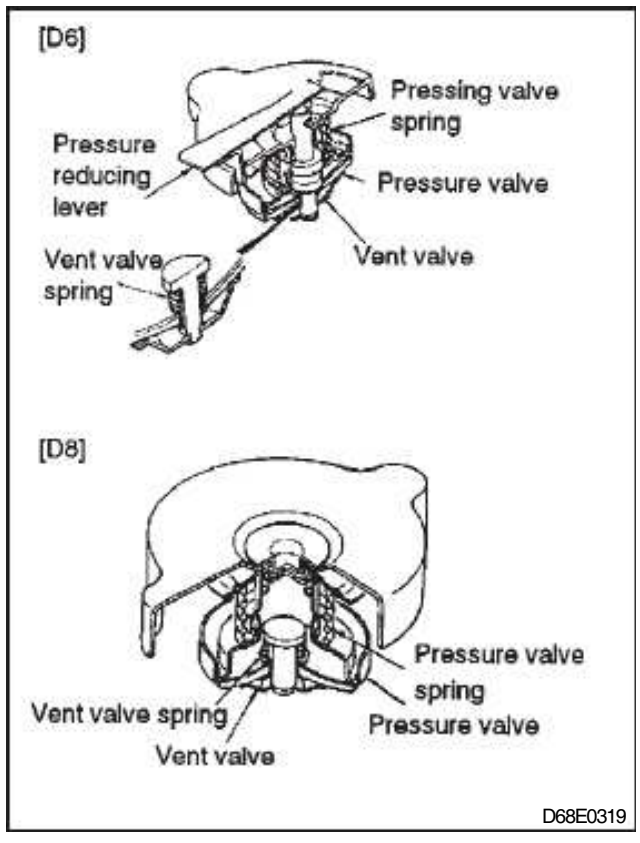
Radiator

The radiator, consisting of the upper tank, radiator core, lower tank, and other parts, functions to cool the coolant whose temperature has become high as a result of circulation through the engine parts.
The coolant is introduced into the upper tank, passes through the radiator core consisting of a number of tubes and fins, and is returned via the lower tank back to the water pump.
The coolant is cooled by the outside air as it passes through the radiatorcore.



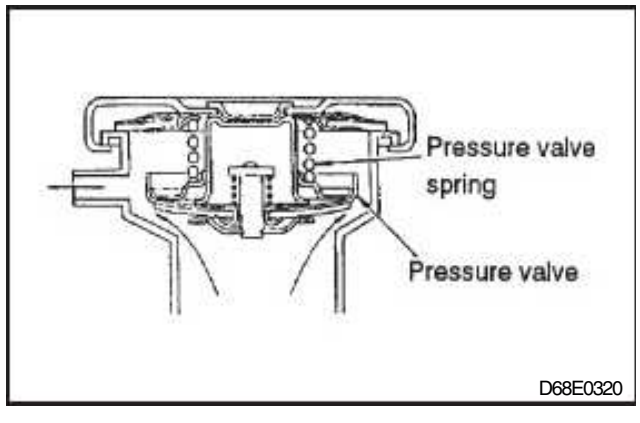
Pressure cap

The pressure cap, consisting of the pressure valve, vent valve, and other parts, maintains the pressure in the cooling system at an optimum level to prevent the radiator.



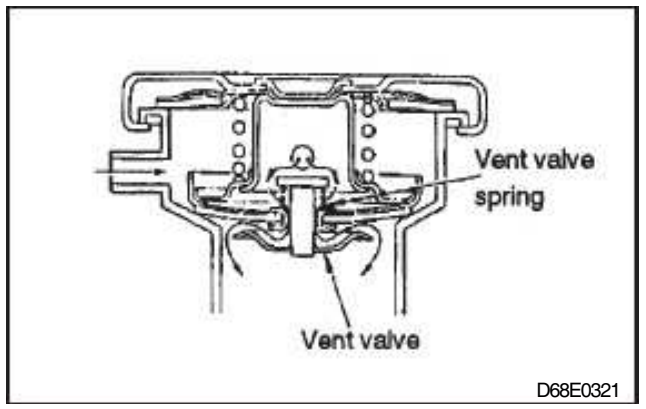
Pressure valve operation

When the pressure in the cooling system builds up to exceed a predetermined level, the pressure valve spring is compressed by the pressure and the valve opens to release the pressure.



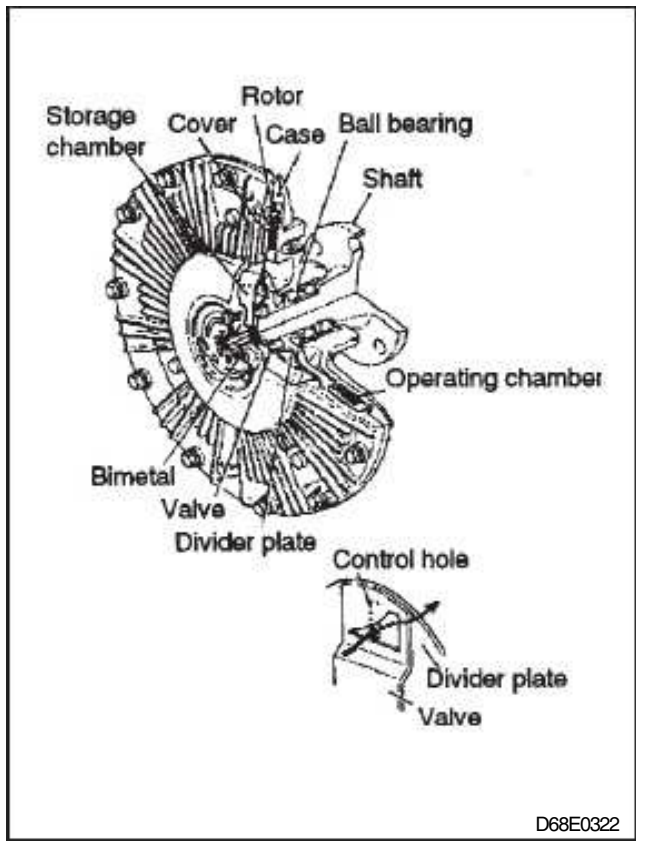
Vent valve operation

When the coolant temperature becomes low, a vacuum is created inside the radiator, which cause the vent val ve to compress the vent valve spring, allowing atmosphere in. This effectively prevents the radiator from being deformed.



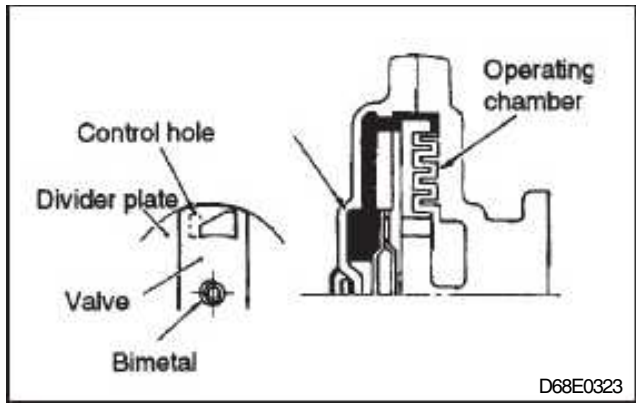
Autocool fan coupling.

Depending on the temperature of the air passing through the radiator, the autocool fan coupling automatically controls the rotating speed of the fan.
The continuous control type autocool fan adjusts the operating amount of silicone oil by movement of the control hole of the divider plate, thereby adjusting the transmitted torque. If the transmitted torque increases, the fan rotates at higher speed.



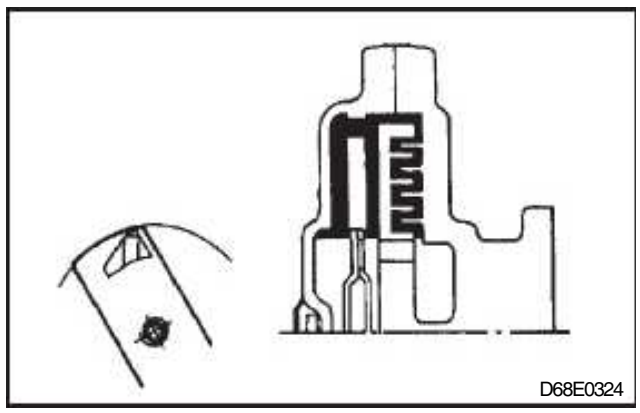
(a) When the temperature of the air passing through the radiator is low

The valve fully closes the control hole of the divider plate. As a result, the silicon oil forced back from the pump hole is stored in the storage chamber and is not sent into the operating chamber. In the meantime, the silicone oil in the operating chamber decreases, and consequent slippage between the case and cover and the rotor causes the fan to rotate at a lower speed.



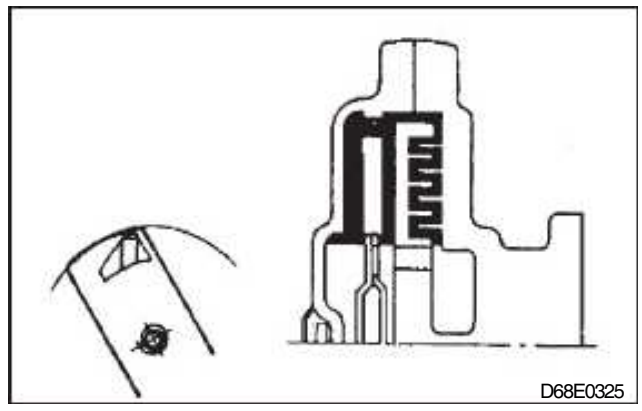
(b) When the temperature of the air passing through the radiator rises

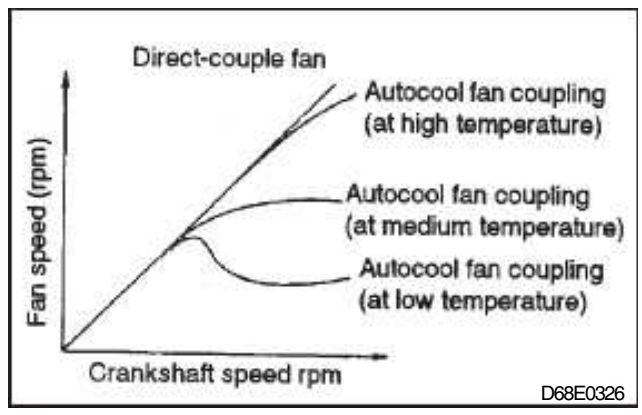
As the temperature rises, the valve slowly opens the control hole of the divider plate, allowing silicone oil to flow into the operating chamber. Therefore, the silicone oil contacting area between the case and cover and the rotor slowly increases. So more torque is transmitted to the fan, causing it to rotate at a higher speed.



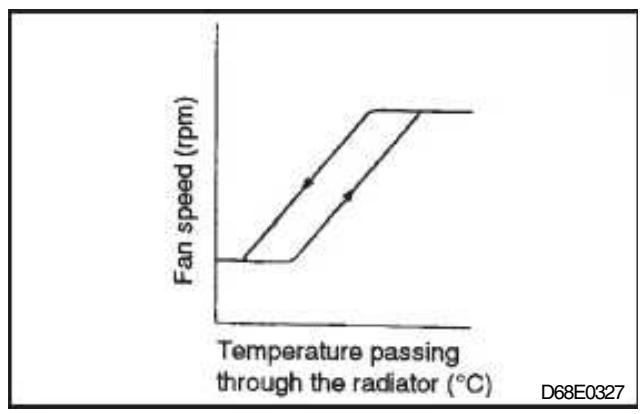
(c) When the temperature of the air passing through the radiator is high

The valve fully opens the control hole of the divider plate, and more silicone oil flows into the operating chamber.
As a result, a maximum torque is transmitted from the shaft to the fan, causing the fan to rotate at a given maximum speed.


D68E0325



D68E0326



D68E0327

SPECIFICATIONS

Item			Specification	
Cooling system			Water cooling forced circulation system	
Coolant quantity			D6	45L
			D8	57L
Water pump		Type	Centrifugal type	
Radiator		Type	Tube and corrugated fin type	
Thermostat		Type	Wax pellet type bottom bypass type	
		Valve opening temperature x Qty	D6	82°C x 2
			D8	82°C x 3
Cooling fan		Type	Suction type	
Autocool fan coupling		Type	Viscosity type	
		Hydraulic fluid	Silicone oil	
V-belt			D6	Low edge cog type B x 2
			D8	Low edge cog type C x 1
	Type x Q'ty	Between fan idler pulley and crankshaft pulley	Low edge cog C type x 1	
		Between fan idler pulley and fan pulley	Low edge cog C type x 1	
		Between crankshaft pulley, alternator and water pump pulley	D6	Low edge cog B type x 2
		Between water pump pulley and alternator	D8	Low edge cog C type x 2
		Between crankshaft pulley, water pump pulley and water pump idler pulley	D8	Low edge cog C type x 2

SERVICE STANDARDS

Service Standard Table

Maintenance item			Nominal value (Basic diameter in [ ])	Limit	Remedy and Remarks
Clearance between fan and fan shroud			3 or more	-	Adjust
Water pump pulley and water pump shaft interference	D6		[25] 0.05 to 0.08	-	Up to two reassemblings
	D8		[34] 0.05 to 0.08	-	
Impeller and water pump shaft interference	D6		[11.8] 0.03 to 0.06	-	Up to two reassemblings
	D8		[15.5] 0.03 to 0.05	-	
Thermostat	Valve opening start temperature		80 to 84°C	-	Replace
	Valve lift/ temperature		10 or more/95°C	-	
Radiator inspection pressure (air pressure)			98 kPa {1 kgf/cm²}	-	Correct or replace
Pressure valve opening pressure	D6		34 to 64 kPa {0.35 to 0.65 kgf/cm²}	-	Replace
	D8		39 to 59 kPa {0.4 to 0.6 kgf/cm²}	-	
V-belt deflection	Between fan idler pulley and fan pulley		7 to 12	-	Adjust
	Between fan idler pulley and crankshaft pulley		25 to 35	-	
	Between alternator and water pump pulley	D6	17 to 22	-	
		D8	6 to 8	-	
	Between water pump idler pulley and water pump pulley	D8	4 to 6	-	

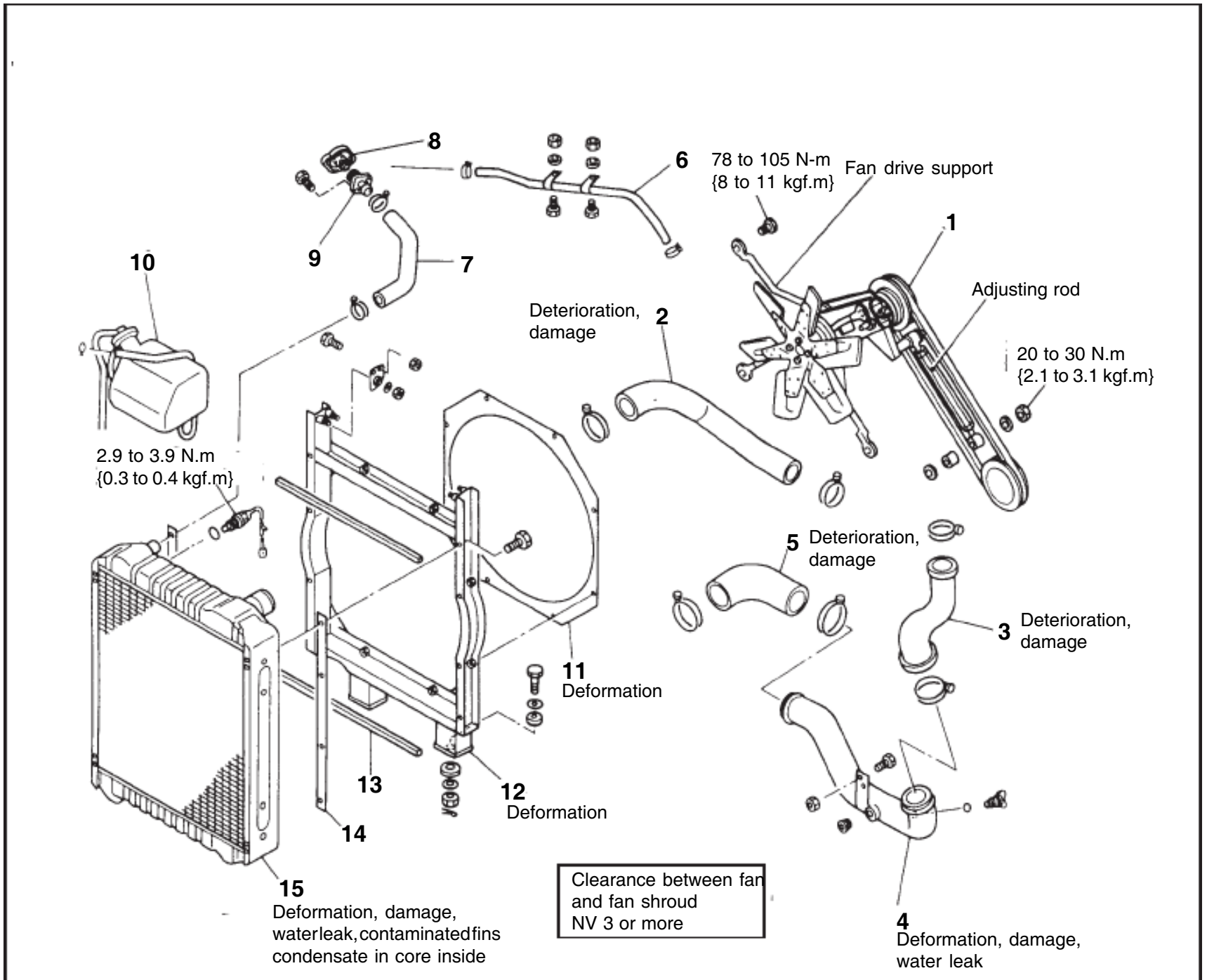
Tightening Torque Table

Locationtightened		Screw size O.D. x pitch (mm)	Tightening torque N·m {kgf.m}
Water level sensor		M18 x 1.5	2.9 to 3.9 {0.3 to 0.4}
Watertemperature gauge unit		M16 x 1.5	27 to 41 {2.8 to 4.2}
Water pump cover mounting bolt < D8 >			7.8 to 12 {0.8 to 1.2}
Water hose mounting hose clamps		M6 x 1.0	4.4 to 5.4 {0.45 to 0.55}
Fan drive system	Cooling fan mounting bolt	M10 x 1.25	38 to 59 {3.9 to 6}
	Fan drive support mounting bolt	M12 x 1.25	78 to 105 {8 to 11}
	Adjusting rod mounting nut	M10 x 1.25	20 to 30 {2.1 to 3.1}
	Idler adjust lock nut (upper)	M16 x 1.5	93 to 125 {9.5 to 13}
	Fan pulley shaft tightening nut	M20 x 1.5	145 {15}
	Idler pulley shaft tightening nut	M20 x 1.5	145 {15}
	Idler pulley mounting nut	M20 x 1.5	145 {15}

SERVICE PROCEDURE

Removal and Installation of Cooling System

<D6>
Removal and installation of parts around radiator



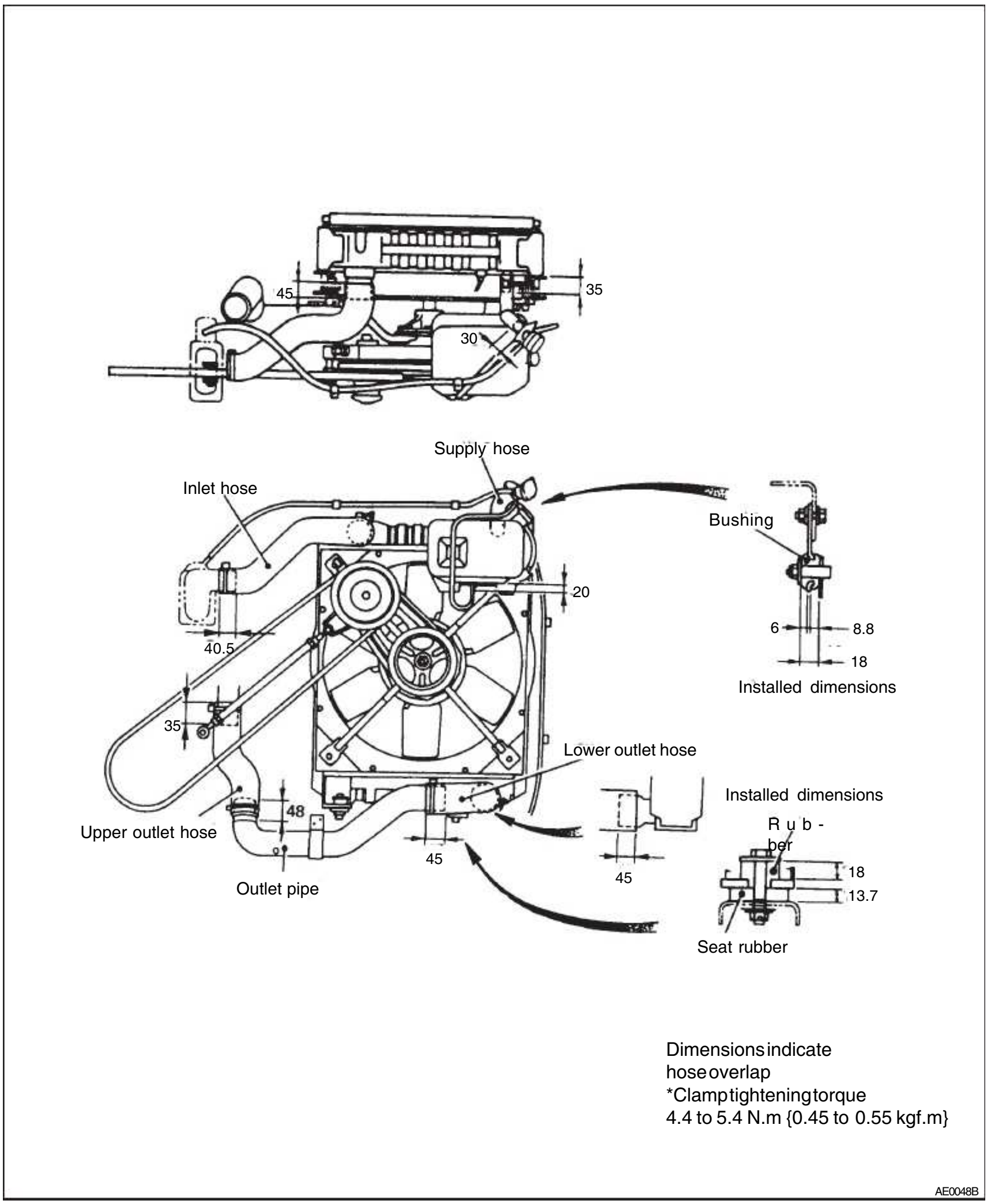
1. Fan drive system
2. Inlet hose
3. Upper outlet hose
4. Outlet pipe
5. Lower outlet hose
6. Air bleed pipe
7. Supply hose
8. Pressure cap
9. Supply pipe
10. Reservoir tank
11. Fan shroud
12. Radiator frame
13. Packing
14. Packing
15. Radiator
*16. Water level sensor

For parts with an encircled number, refer to Installation Procedure that follows.
For inspection of parts marked with *, refer to Group 60 Body Electrical of Shop Mannual separately provided.

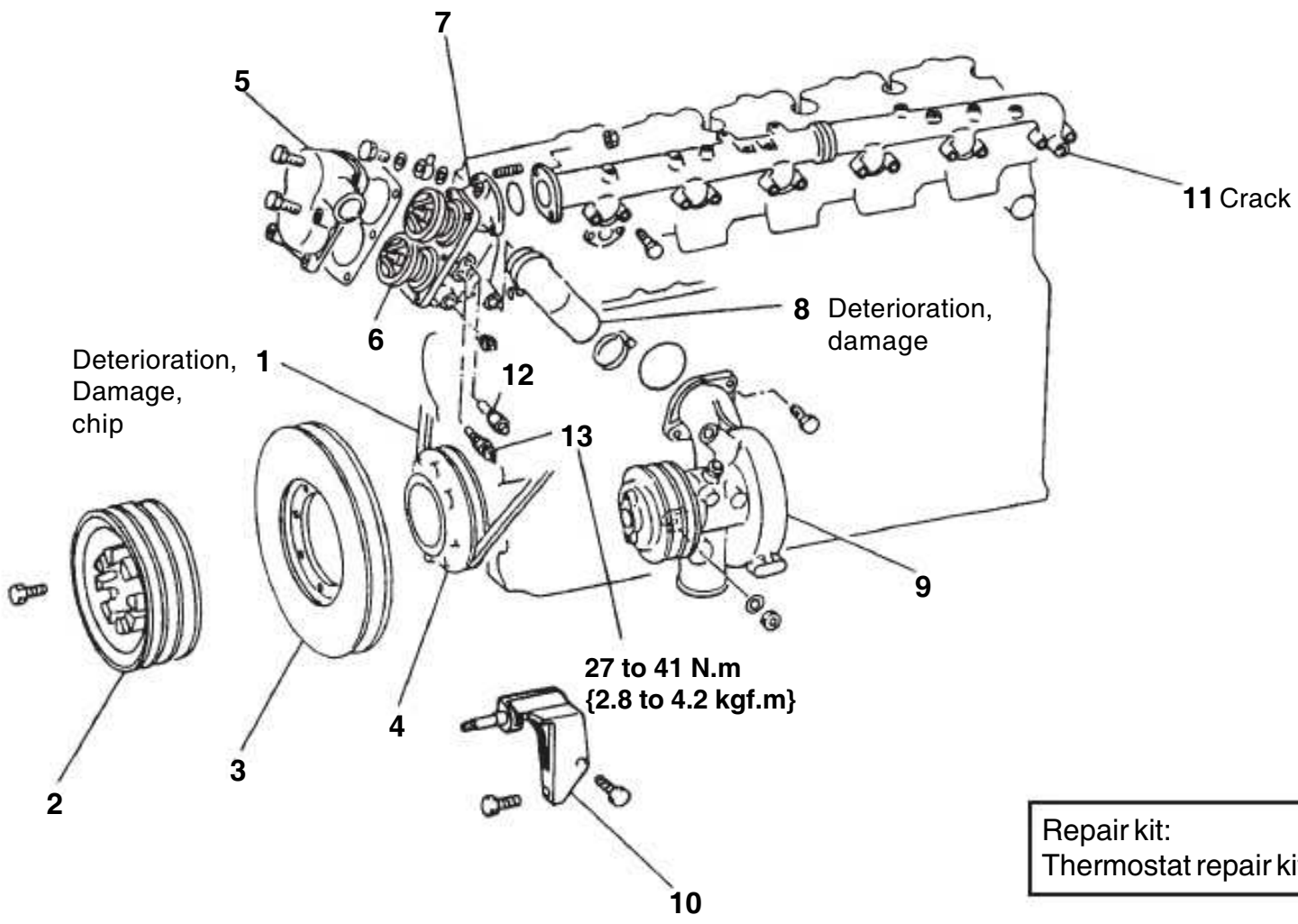
AE0020D

Installation Procedure

Installation of inlet hose, outlet hose, seat rubber, rubber, and bushing.



Removal and installation of parts around water pump



Repair kit:
Thermostat repair kit

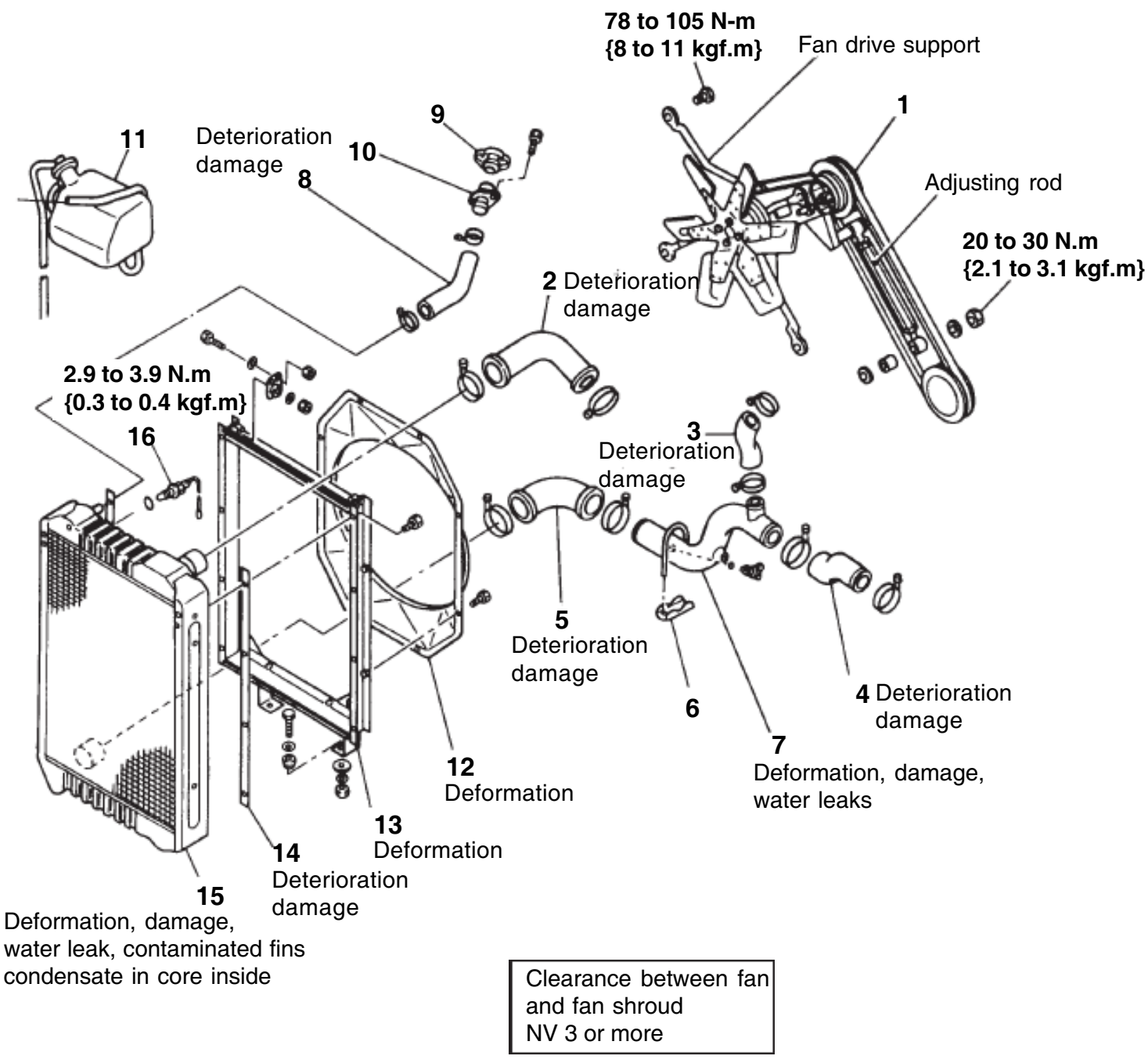
1. V-belt
2. Fan drive pulley
3. Torsional damper
4. Crankshaft pulley
5. Thermostat cover
6. Thermostat
7. Thermostat case
8. Bypass hose
9. Water pump
10. Adjusting rod bracket
11. Water outlet pipe
*12. Overheat sending unit
*13. Water temperature gauge unit

* To inspect the parts marked *, refer to Group 60 Body Electrical of Shop Manual separately provided.

AE0029A

<D8>

Removal and installation of parts around radiator



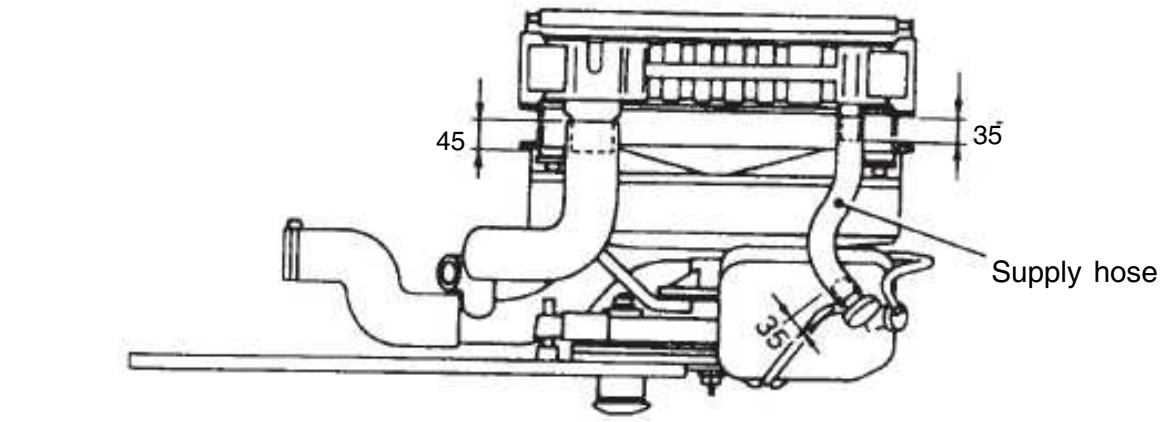
1. Fan drive system
2. Inlet hose
3. Bypass hose
4. Upper outlet hose
5. Lower outlet hose
6. Outlet support
7. Outlet pipe
8. Supply pipe
9. Pressure cap
10. Supply pipe
11. Reservoir tank
12. Fan shroud
13. Radiator frame
14. Packing
15. Radiator
*16. Water level sensor

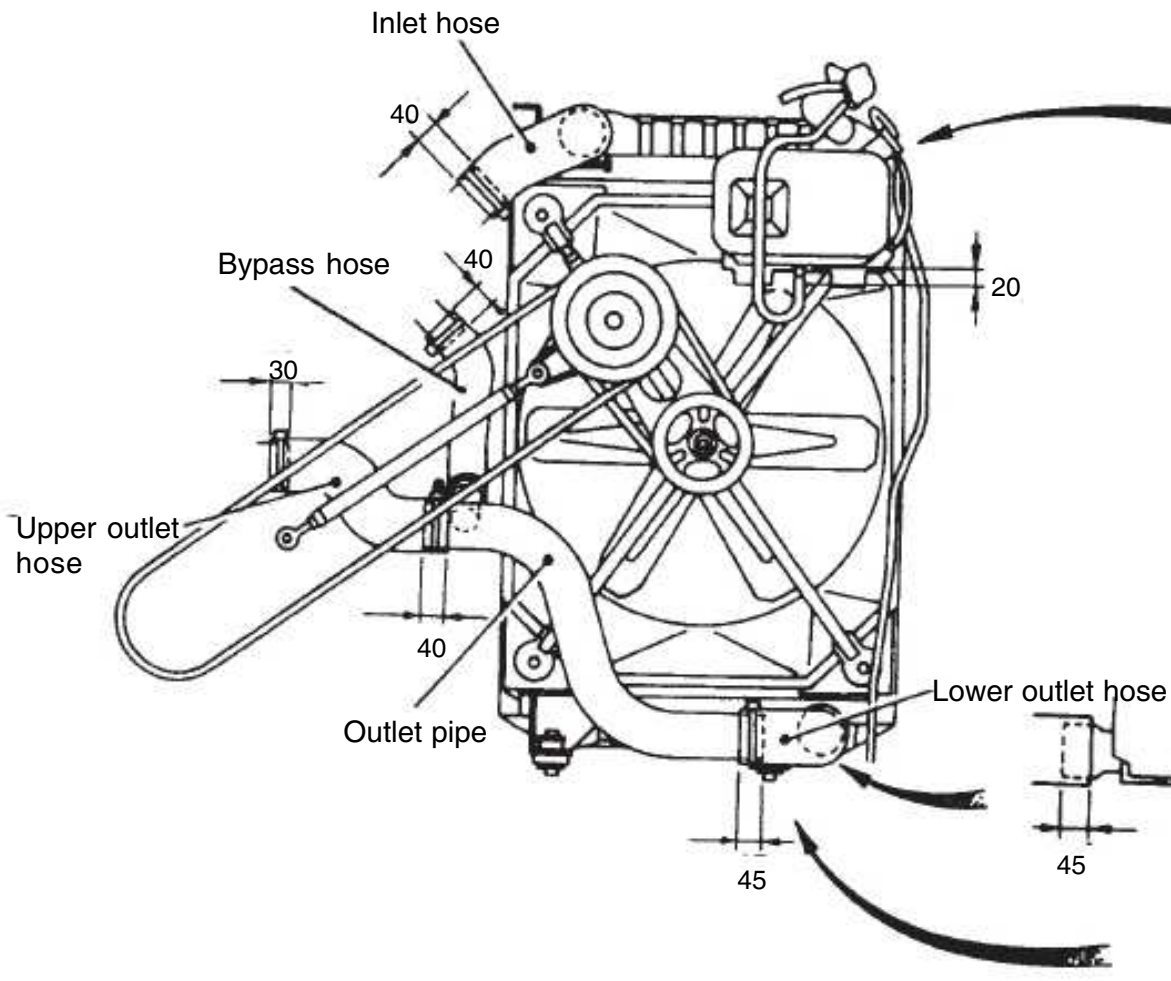
For parts with an encircled number, refer to Installation Procedure that follows.
For inspection of parts marked with *, refer to Group 60 Body Electrical of Shop Mannual separately provided.

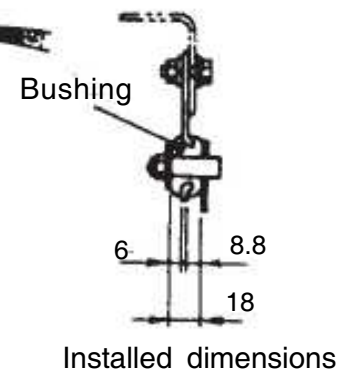
AE0021C

Installation Procedure

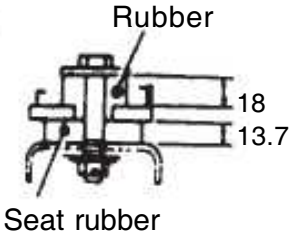
Installation of inlet hose, outlet hose, seat rubber, rubber, and bushing.







Installed dimensions

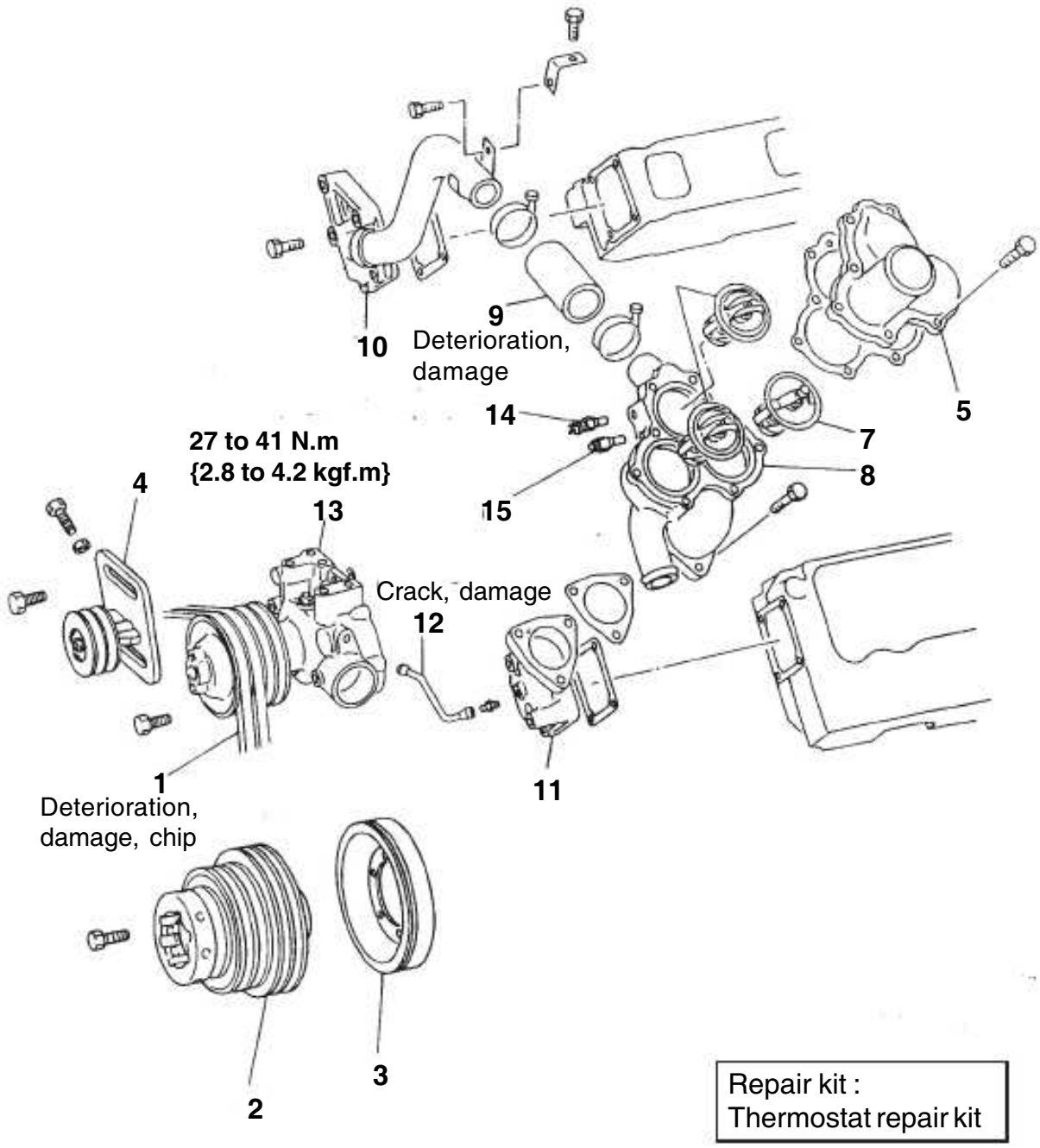


Dimensions indicate hose overlap

*Clamp tightening torque
4.4 to 5.4 N.m {0.45 to 0.55 kgf.m}

AE0049B

Removal and installation of parts around water pump



Repair kit :
Thermostat repair kit

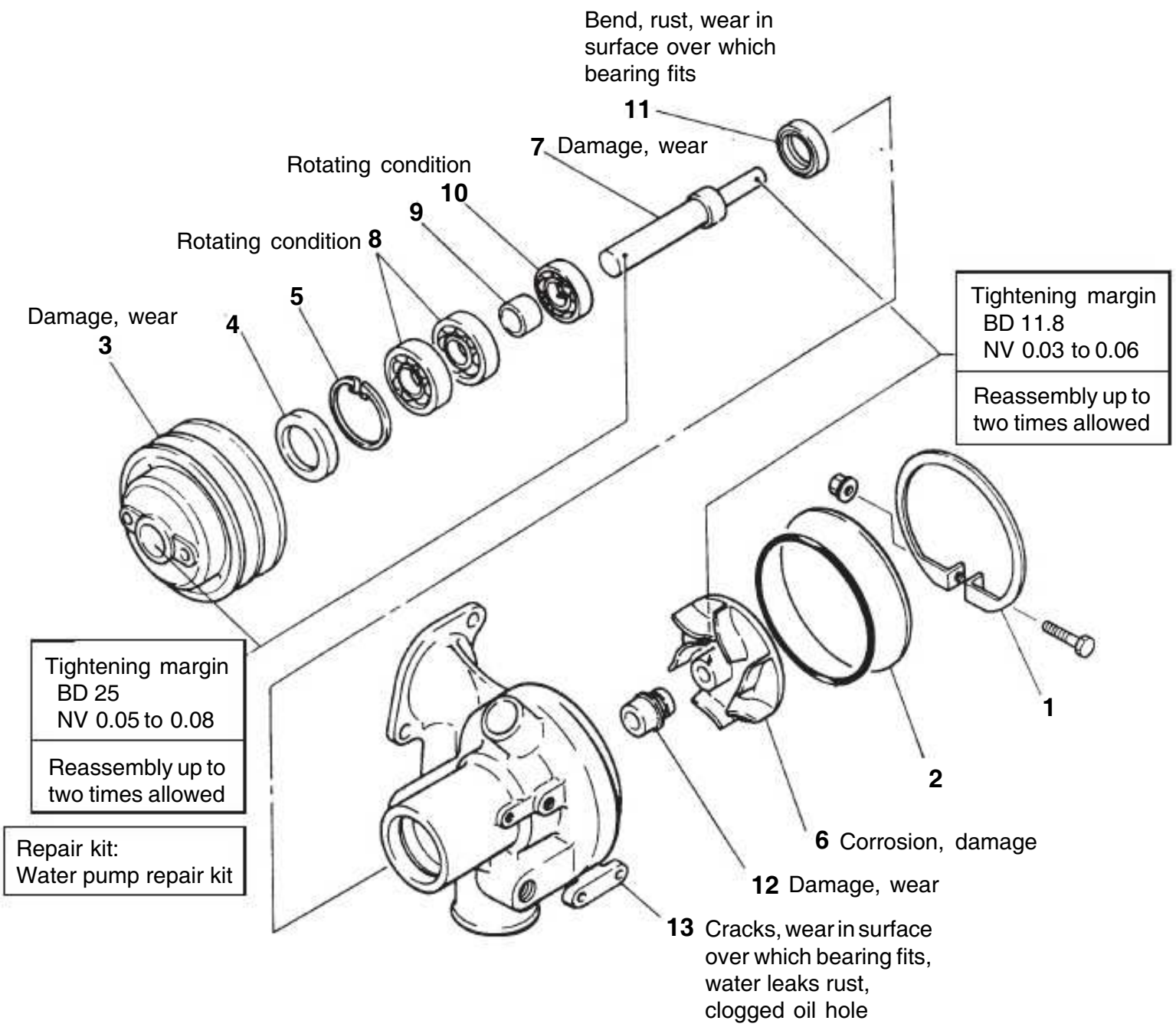
1. V-belt
2. Crankshaft pulley
3. Torsional damper
4. Idler pulley
5. Thermostat cover
6. Thermostat (with jiggle valve)
7. Thermostat
8. Thermostat case
9. Rubber hose
10. Water outlet pipe
11. Themostat elbow
12. Water pipe
13. Water pump
*14. Water temperature gauge unit
*15. Overheat sending unit

*To inspect the parts marked * refer to Group 60 Body Electrical of Shop Manual separately provided.

AE0045A

Water Pump [D6]

Disassembly and inspection



BD ... Basic Diameter
NV ... Nominal Value

Disassembly sequence

1. Snap ring
2. Water pump cover
3. Water pump pulley
4. Flange
5. Snap ring
6. Impeller
7. Water pump shaft
8. Bearing
9. Spacer
10. Bearing
11. Oil seal
12. Unit seal
13. Water pump case

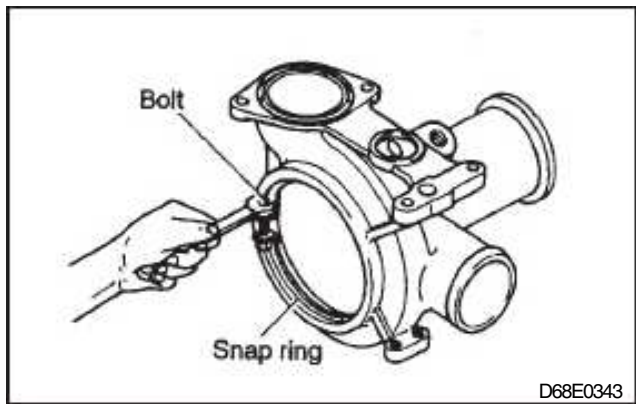
For parts with an encircled number, refer to Disassembly and Inspection Procedures that follow.

AE0100A

Disassembly and Inspection Procedure

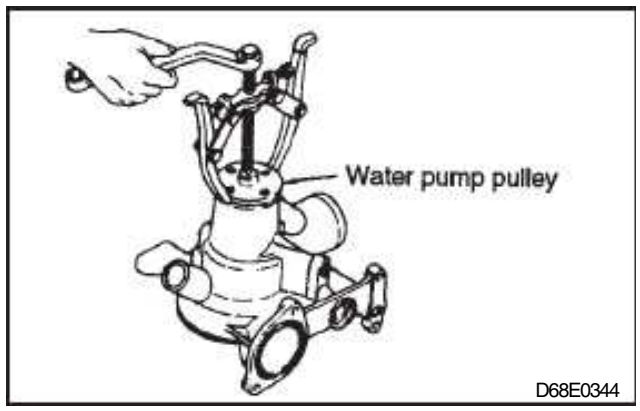
1. Removal of snap ring

   Mount a special tool (Snap Ring Mounting and Demounting Bolt and Nut) in the bolt hole of the snap ring and thread the bolt in to compress and remove the snap ring.



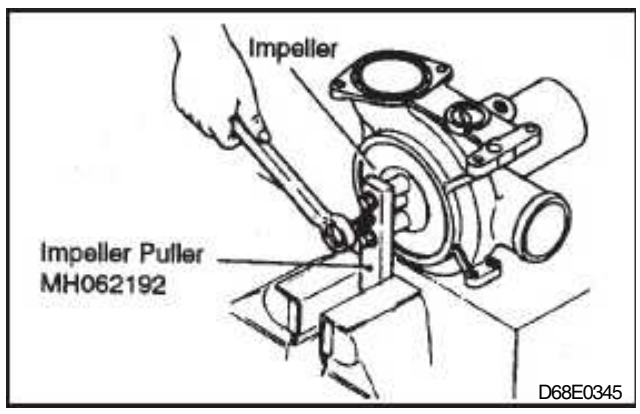
2. Removal of flange.

   Remove the water pump flange through use of a tool such as a gear puller.



3. Removal of impeller.

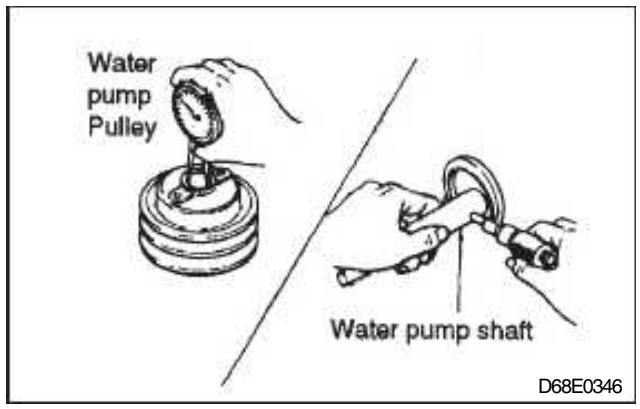
   Mount a special tool (Impeller Puller) in the screw hole (M8 x 1. 25) of the impeller and remove the impeller.



4. Flange and water pump shaft interference.

   If the interference is less than the nominal value, replace the flange or water pump shaft.

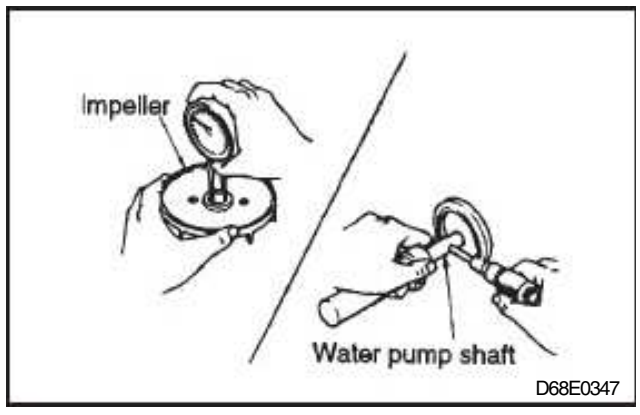
   NOTE:
   Avoid three or more reassemblings even if the nominal value is met.



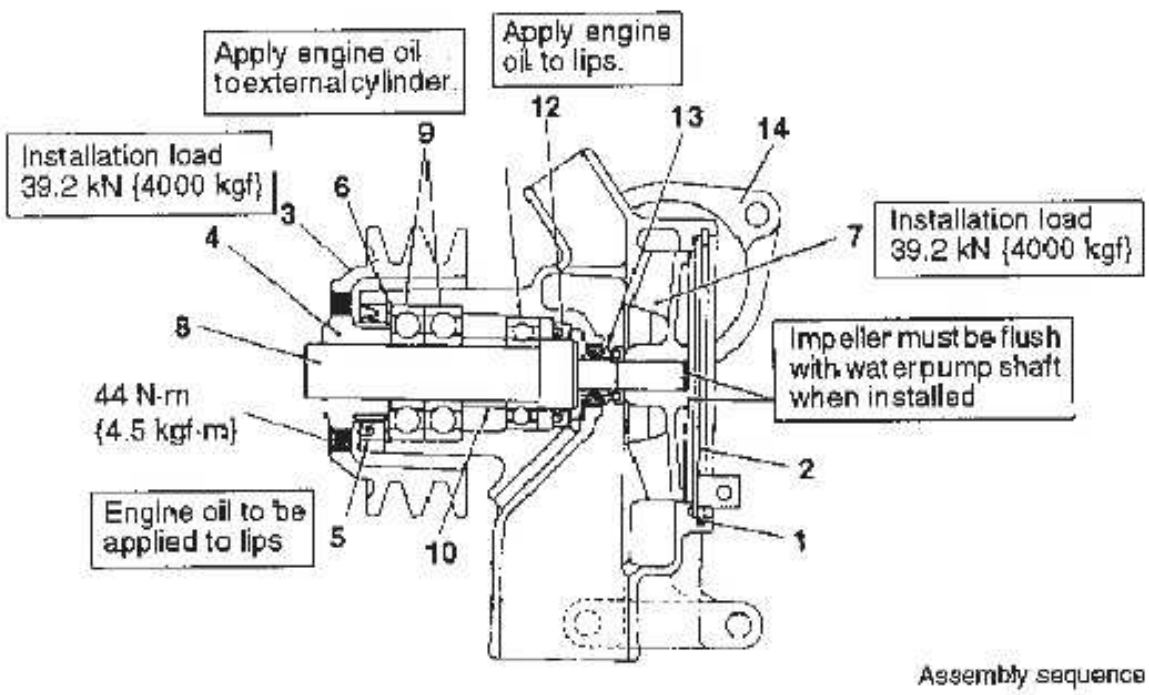
5. Impeller and water pump shaft interference.

   If the interference is less than the nominal value, replace the Impeller or water pump shaft.

   NOTE:
   Avoid three or more reassemblings even if the nominal value is met.



Reassembly



NOTE:

1. **After reassembly, rotate the water pump pulley by hand to check to ensure that the impeller does not interfere with the water pump cover and water pump case.**
2. **When the impeller and flange are installed, check to ensure that they are not installed by a load of 4.9 kN{500kgf}.**

Assembly sequence

12 → 11 → 10 → 9 → 14 → 7 → (13) → 6 → 5 → 4 → 3 → 2 → 1

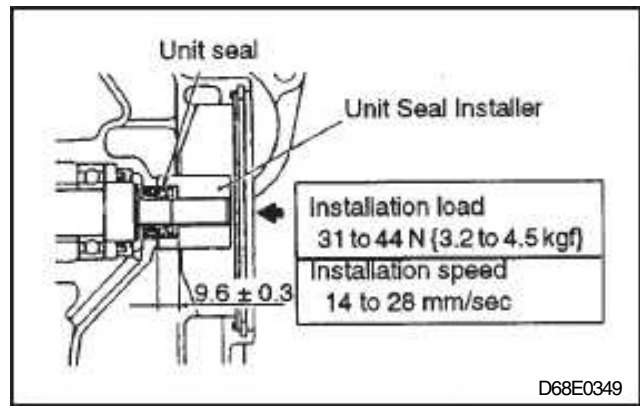
For the circled part, refer to the reassembly procedure that follows.

D68E0348

Reassembly Procedure

<Installation of unit seal>

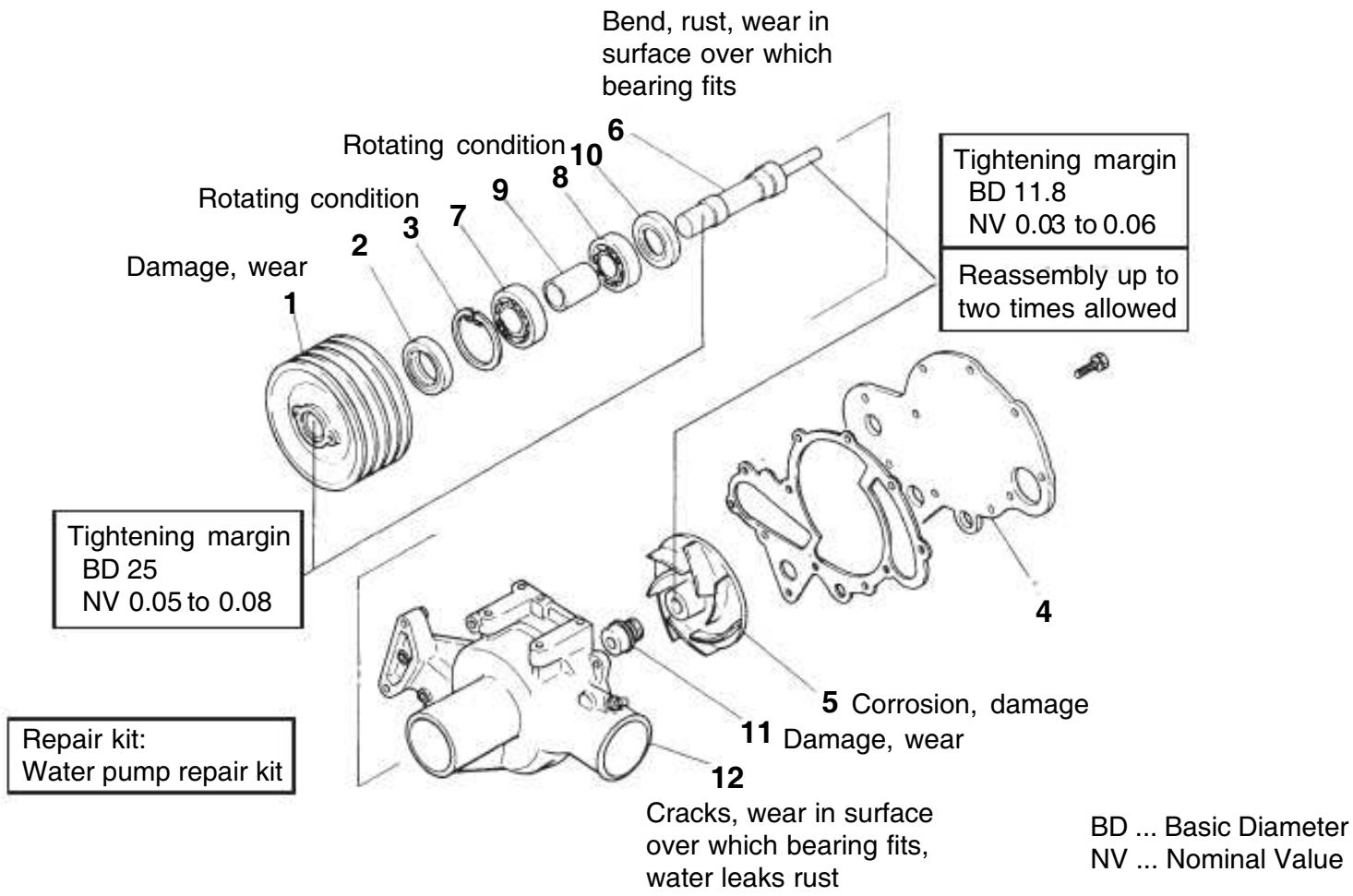
To install the unit seal, use the special tool, Unit Seal Installer as shown and press-fit unit seal until the installed dimensions shown are obtained.



D68E0349

Water Pump [D8]

Disassembly and inspection



Disassembly sequence

1. Water pump pulley
2. Oil Seal
3. Snap ring
4. Water pump cover
5. Impeller
6. Water pump shaft
7. Bearing
8. Bearing
9. Spacer
10. Oil seal
11. Unit seal
12. Water pump case

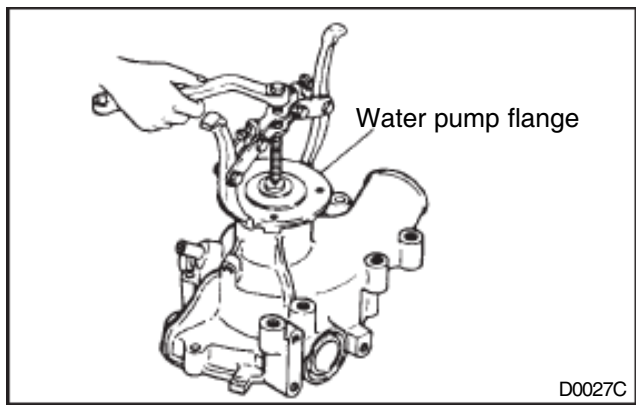
For parts with an encircled number, refer to Disassembly and Inspection Procedures that follow.

AE0103A

Disassembly and Inspection Procedure

1. Removal of water pump pulley

   Remove the water pump pulley through use of a tool such as a gear puller.

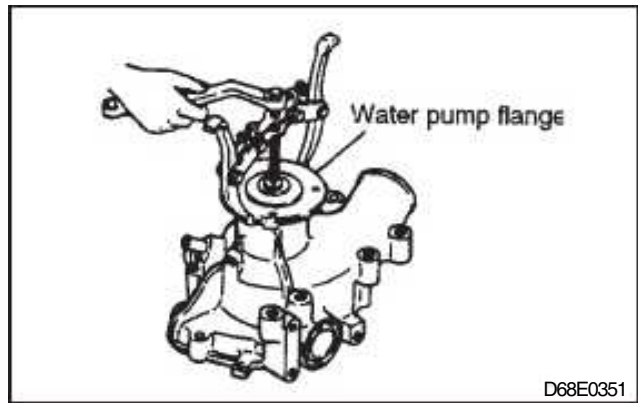


D0027C

Disassembly and Inspection Procedure

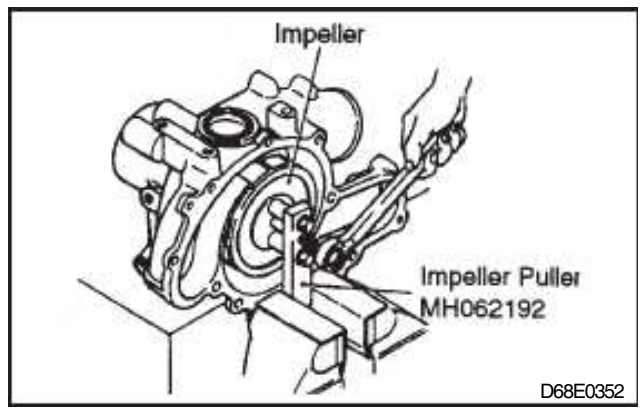
1. Removal of flange

   Remove the water pump flange through use of a tool such as a gear puller.



2. Removal of impeller.

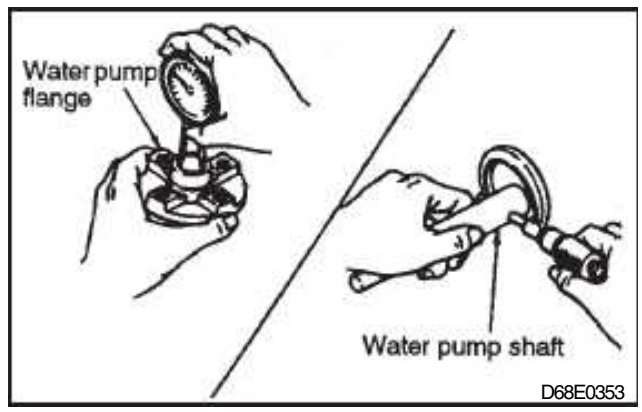
   Mount a special tool (Impeller puller) in the screw hole (M8 x 1. 25) of the impeller and remove the impeller.



3. Flange and water pump shaft interference.

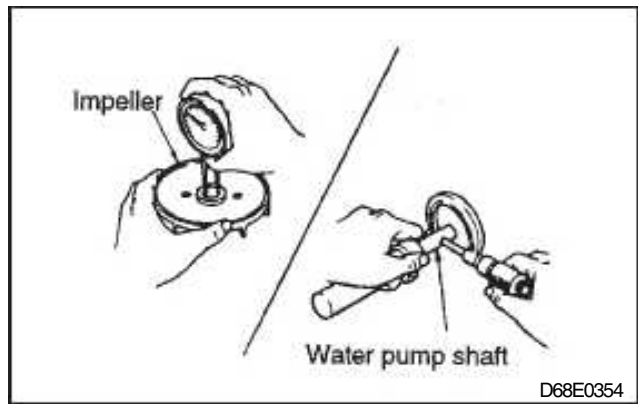
   If the interference is less than the nominal value, replace the flange or water pump shaft.

   NOTE:
   Avoid three or more reassemblings even if the nominal value is met.

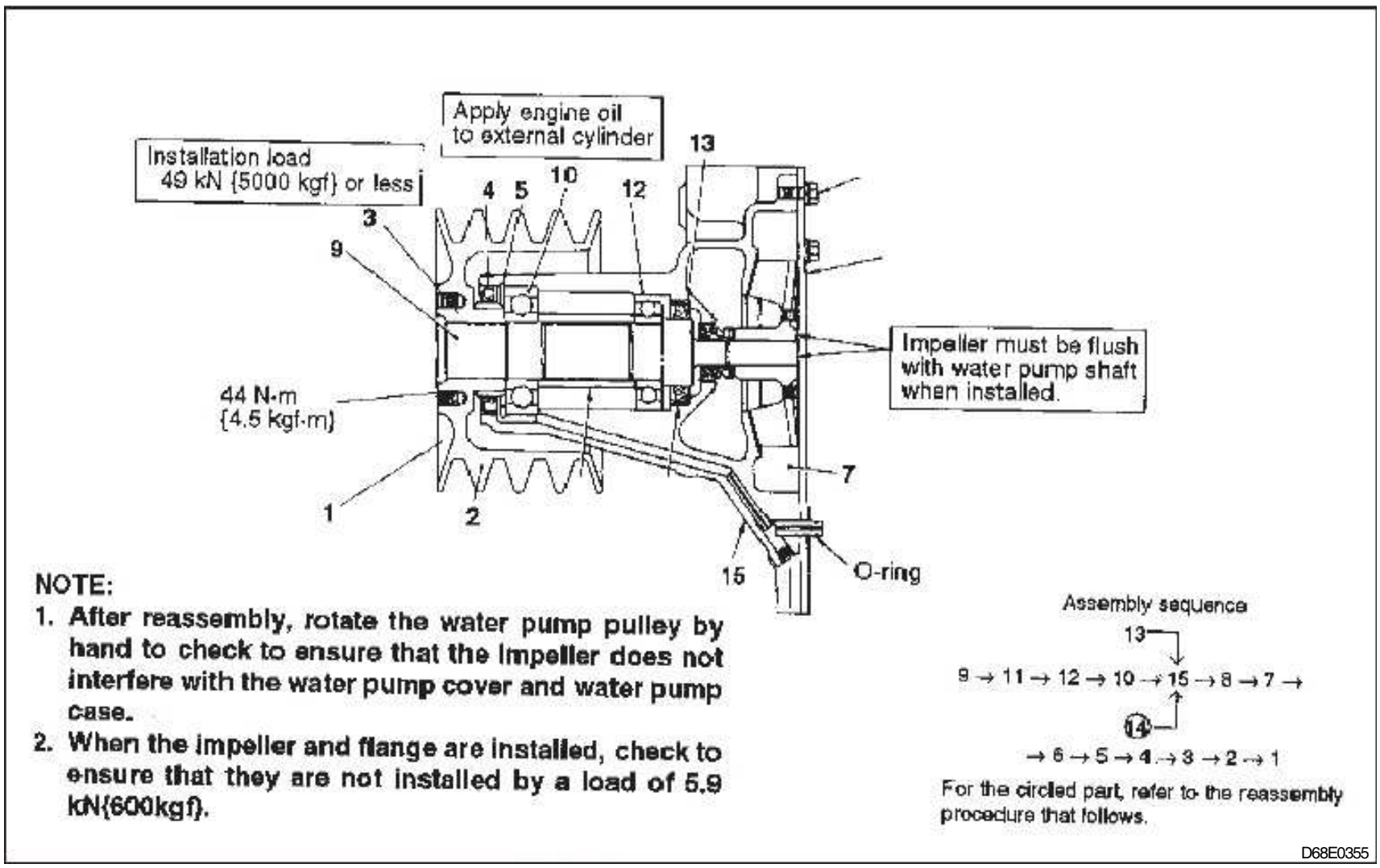


4. Impeller and water pump shaft interference.
   If the interference is less than the nominal value, replace the Impeller or water pump shaft.

   NOTE:
   Avoid three or more reassemblings even if the nominal value is met.



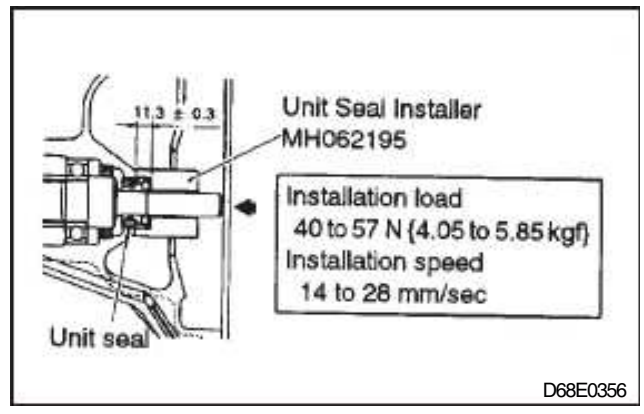
Reassembly



Reassembly Procedure

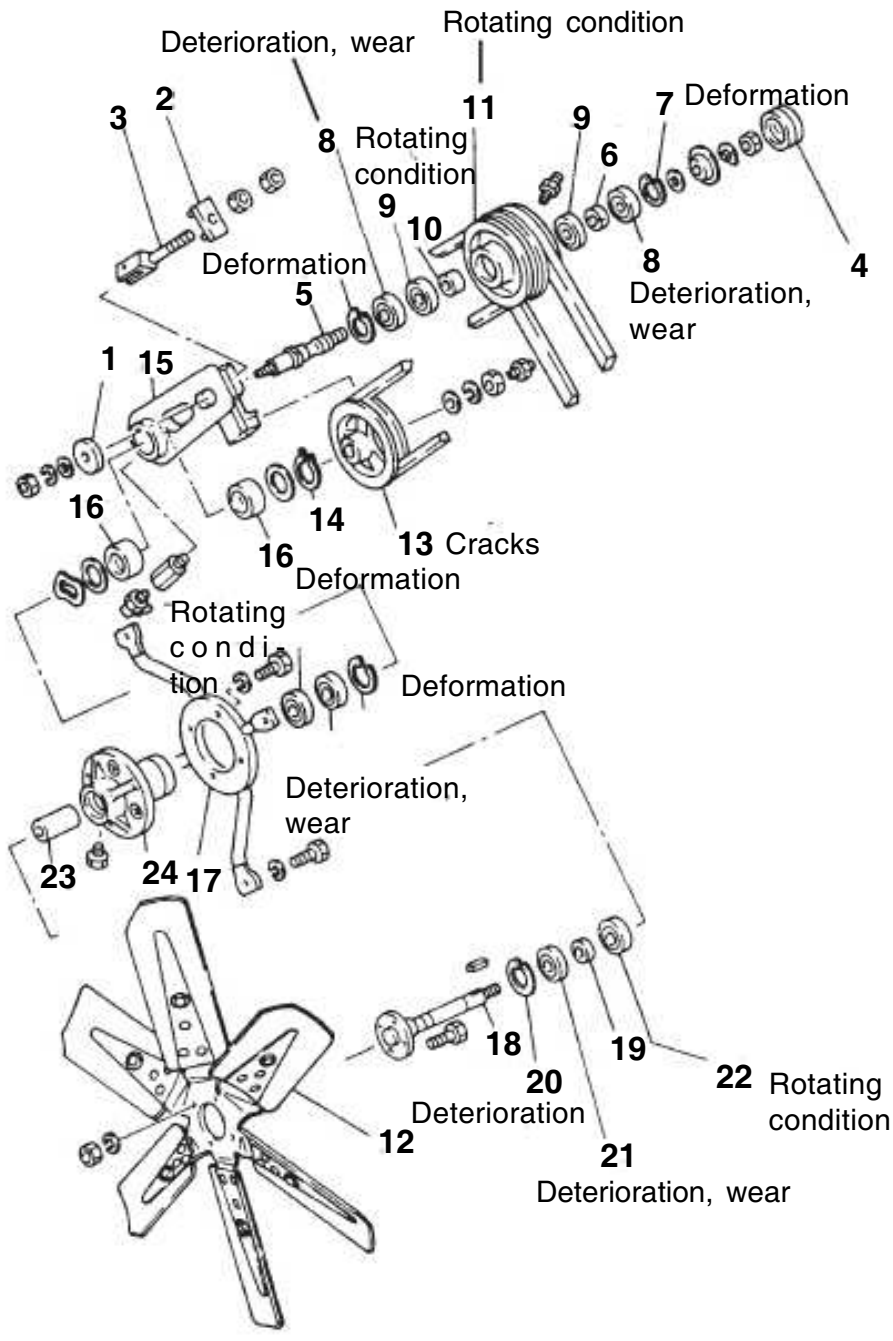
<Installation of unit seal>

To install the unit seal, use the special tool, Unit Seal Installer as shown and press-fit unit seal until the installed dimensions shown are obtained.



Fan drive system

Disassembly and inspection

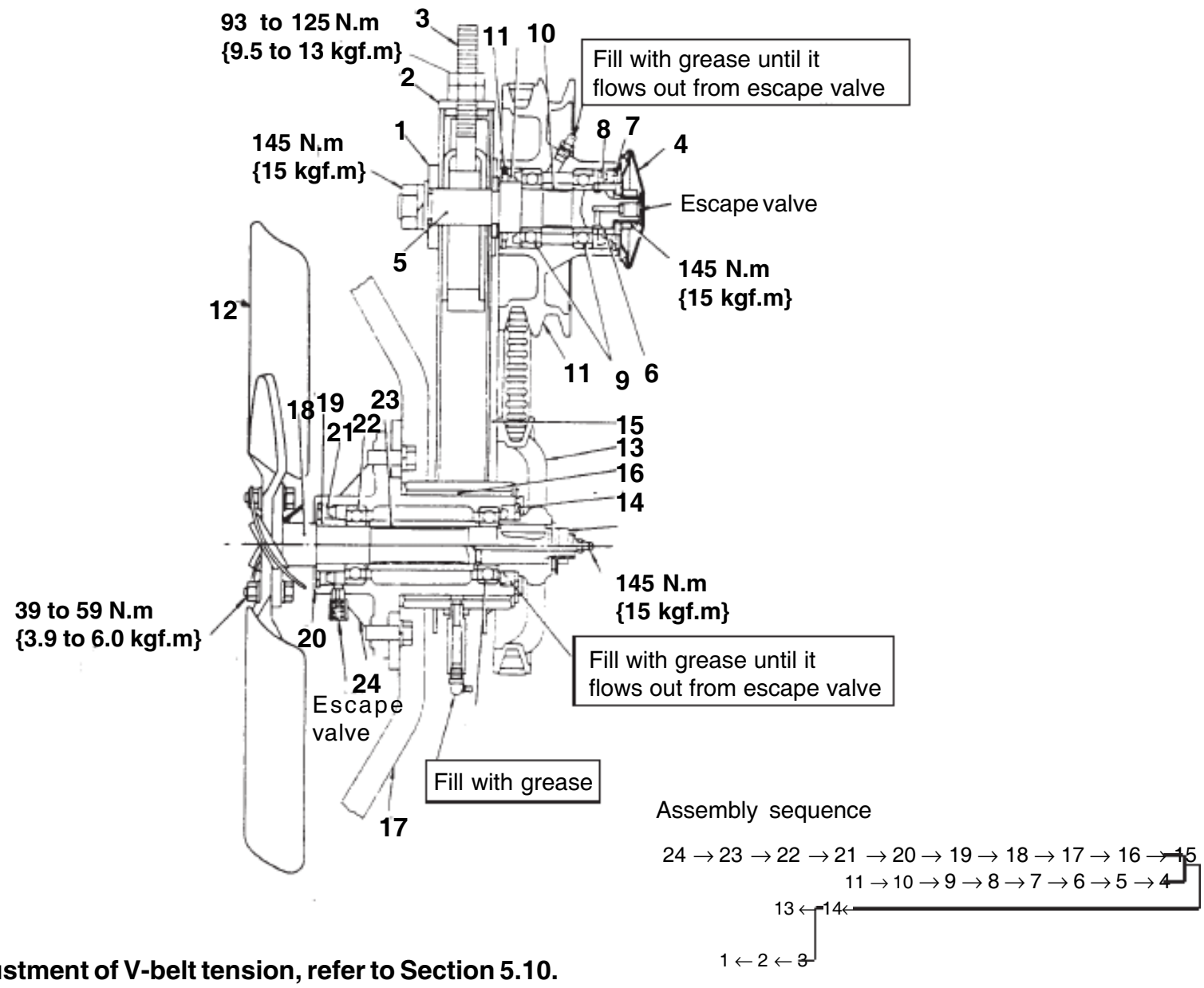


Diesassembly sequence

1. Spacer
2. Upper plate
3. Idler adjustor
4. Grease cover
5. Idler pulley shaft
6. Spacer
7. Snap ring
8. Oil seal
9. Ball bearing
10. Spacer
11. Idler pulley
12. Cooling fan
13. Fan pulley
14. Snap ring
15. Swing arm
16. Bushing
17. Fan drive support
18. Fan pulley shaft
19. Spacer
20. Snap ring
21. Oil seal
22. Ball beariang
23. Spacer
24. Bearing case

D0909A

Reassembly



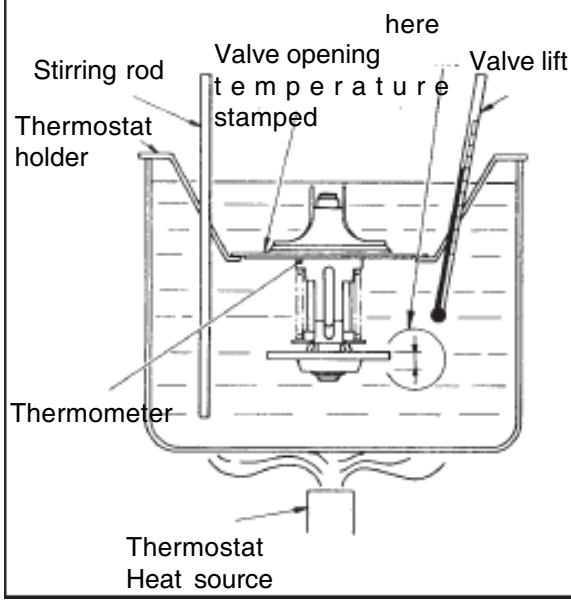
NOTE:
For adjustment of V-belt tension, refer to Section 5.10.

Inspection of Thermostat

Inspect the thermostat using the following procedure.
Stir up the water in the container with stirring rod to ensure that the water temperature is uniform at all times.

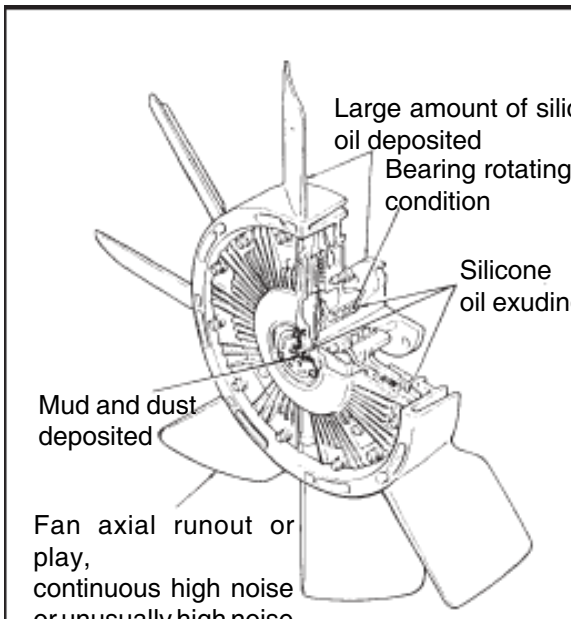
1. Slowly heat the thermostat to the valve opening temperature.
2. Keep this condition for about five minutes and check to ensure that the valve is open.
3. Further increase the temperature until the water temperature reaches 95°C.
   Keep this condition for five minutes and measure the lift of the pellet.
4. Lower the temperature to less than 65°C and check to see that the valve is held tightly against the valve seat.
   If any of the above items is not checked good, replace the thermostat.

Valve opening start temperature	Valve lift/ Temperature
80 to 84°C	10 or more/95°C

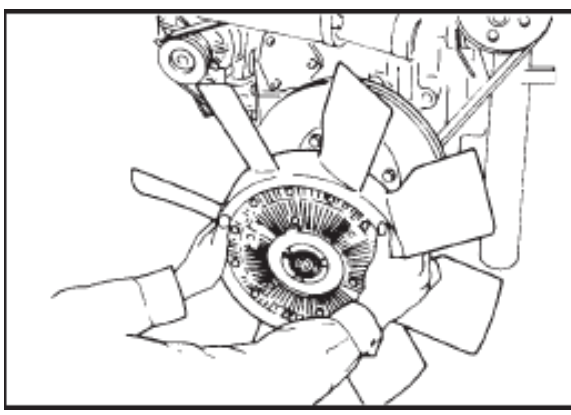


Inspection of Autocool Fan Coupling

1. Play in axial direction
   When engine is cold, pinch the fan fitting portion and move it in axial direction. If the fan blade tip has excessive runout or play is observed, replace the autocool fan coupling, because the ball bearing is defective.



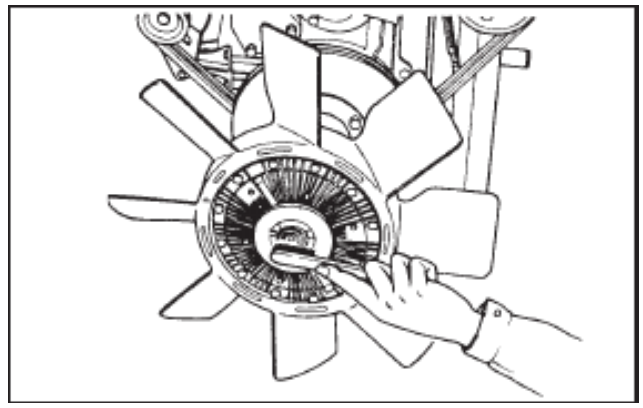
NOTE :
1. As it is unitized, autocool fan coupling does not require maintenance of silicone oil.
2. The auto cool fan coupling is non -maintainable and must be replaced as an assembly if defects are evident



2. Cleaning bimetal

If dirt or dust is adhering to the bimetal, remove it carefully with a wire brush or the like.

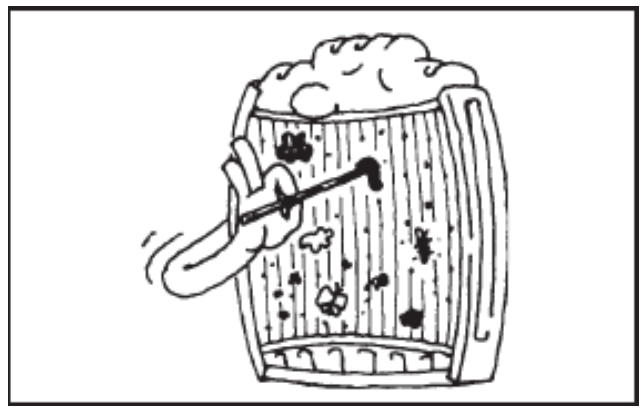
NOTE:
Use care not to apply excessive force to the bimetal.



Inspection of Radiator

1. Cleaning

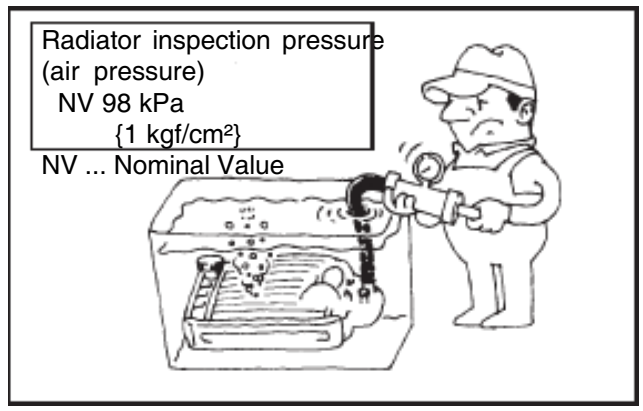
Remove mud, bugs, etc., if present on the radiator core front surface, with a copper wire. During the removal work, use care to prevent damage to the tubes.



2. Inspection

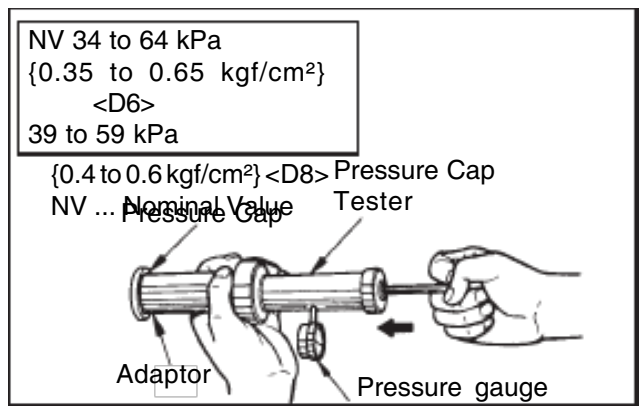
Attach hose to the inlet of the radiator and cap the outlet. Then, immerse the radiator in a waterfilled tank.
Using a radiator cap tester, send compressed air at the specified inspection pressure through the hose to check for leaks.
If leaks are evident, re-solder or replace the radiator.

NOTE:
Clean the radiator before inspection.



3. Inspection of pressure cap
Inspection the pressure valve and vent valve as follows.

(a) Inspection of pressure valve
Apply the specified pressure to the pressure cap with the Pressure Cap Tester to check to see if the pressure valve opens to discharge air. If the pressure valve fails to discharge air at the specified pressure, replace the pressure cap.



(b) Inspection vent valve

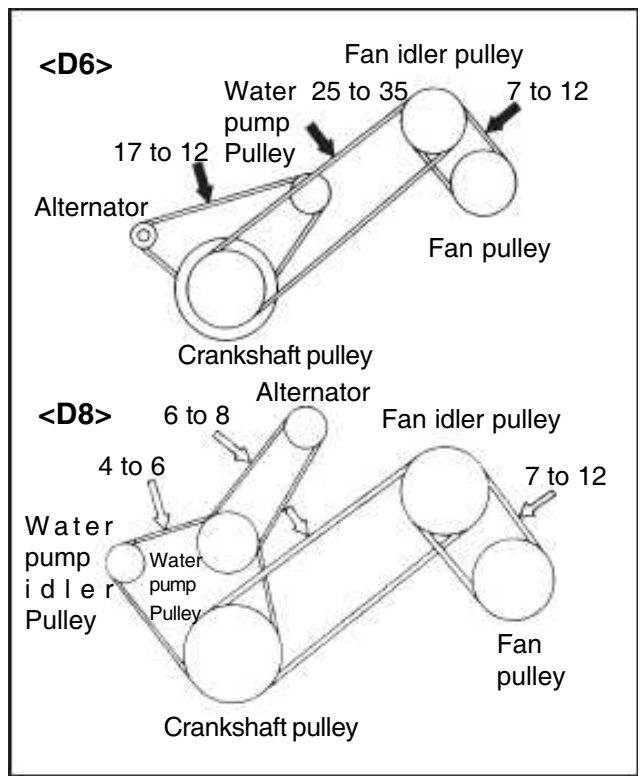
1) First, note the level of coolant in the reservoir tank. Then, run the engine at maximum speed and, as a certain amount of coolant overflows to the reservoir tank, stop the engine.
2) Leave everything as it is for some while. When the coolant temperature becomes almost equal to ambient temperature, check to see if the level of coolant in the reservoir tank is as it was before the engine was started.
3) If the coolant level is not lowered, it indicates that the vent valve is not operational and therefore the pressure cap must be replaced.

NOTE:
One footnote statement about the radiator on <D8> : if the pressure cap is removed before the coolant temperature comes down to ambient temperature, the vacuum in the radiator is gone, resulting in the coolant being unable to return to the reservoir tank.

Inspection and Adjustment of V-belt Tension

Press each belt strongly in the middle [approx. 98 N{10 kgf}] and see if the deflection is within specified limits.
If the belt deflection is not within the specified limits, adjust the belt tension by the procedure on the procedure on the next page.
Check the V-belt for damage.
Replace if damaged or badly worn.

NOTE
A loose belt could result in an overheated engine or cause inadequate charging of the battery by the alternator.
A too tight belt, on the other hand, could cause damage to the bearing or belt.

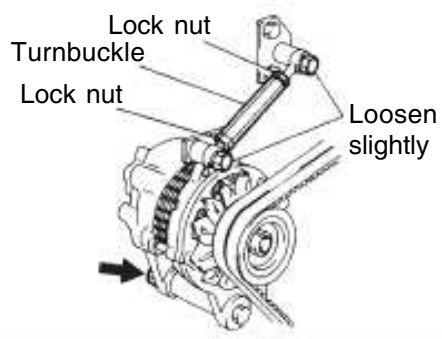


Adjustment by moving the alternator

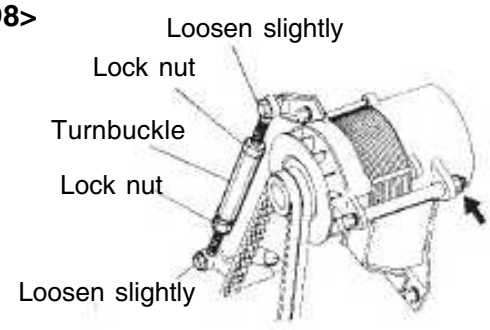
Loosen the alternator mounting nut (arrow marked) slightly. Loosen the lock nuts and adjust the belt tension by turning the turnbuckle. Extending the rod strengthen the belt tension. After adjustment, tighten the lock nuts to fix the turnbuckle. Then tighten the alternator mounting nut securely.

NOTE:
Turning the head of alternator mounting bolt for tightening can be a cause of looseness. Always turn the nut.

<D6>



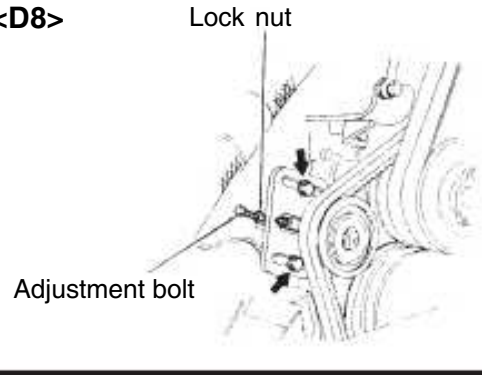
<D8>



Adjustment by moving the water pump idler pulley

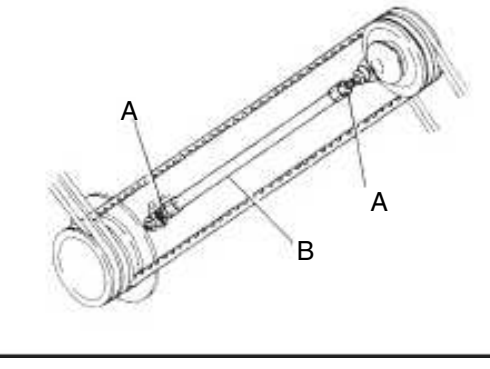
First loosen the idler pulley mounting bolts and the lock nut of adjusting bolt, and then turn the adjusting bolt to adjust the belt tension. The belt tension increases when the bolt is screwed in. After the adjustment, hold the adjusting bolt to prevent it from turning and firmly tighten the lock nut.

<D8>

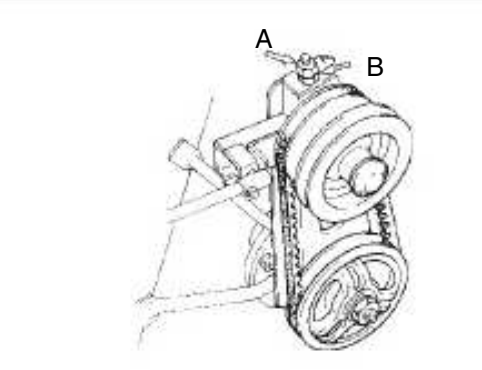


Adjustment of the fan belt

Slightly loosen the lock nut (A). Adjust the belt tension by turning the turnbuckle (B) as much as required.
Retighten the lock nut (A) securely after the adjustment.



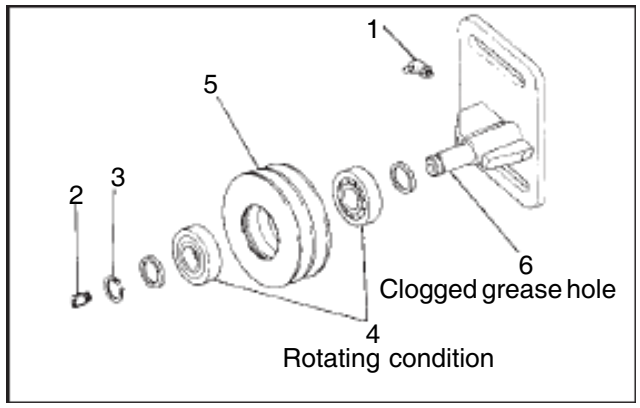
Slightly loosen the lock nut (A). Adjust the belt tension by turning the nut (B) as much as required.
Retighten the lock nut (A) securely after the adjustment.



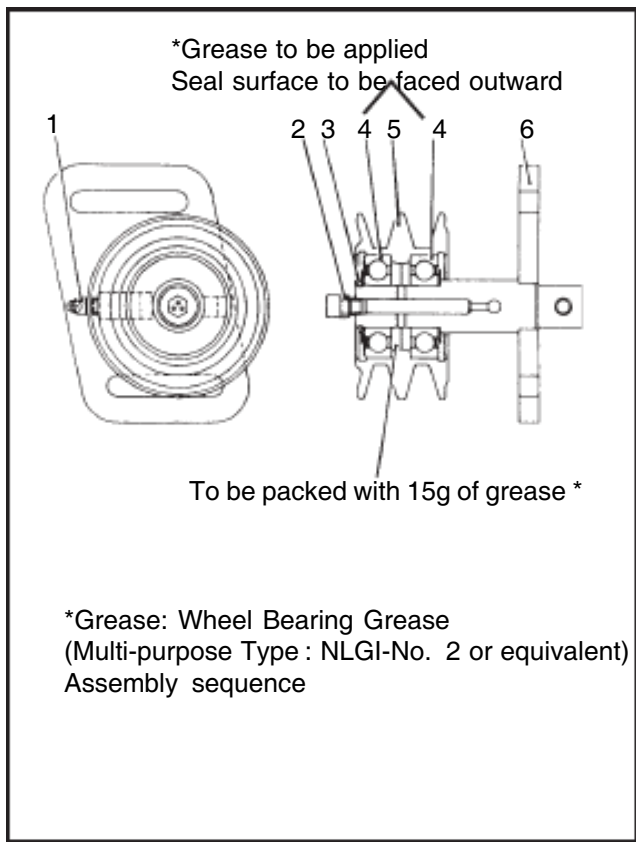
Idler Pulley <D8>

Disassembly and inspection

Disassembly Sequence
1. Grease nipple
2. Escape valve
3. Snap ring
4. Ball bearing
5. Idler pulley
6. Idler pulley bracket



Reassembly



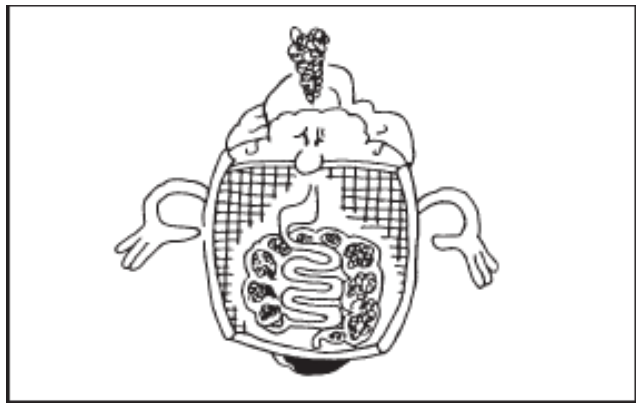
*Grease: Wheel Bearing Grease
(Multi-purpose Type : NLGI-No. 2 or equivalent)
Assembly sequence

Cleaning of Cooling System

If the radiator is used for a long time, rust, scale, mud, etc. are deposited inside, resulting in overheat. Clean the cooling system with city water by using the following procedures.
Place the room heater temperature control knob in the maximum temperature position so that the room heater system can be cleaned at the same time.
The city water to be used should have the following properties.

Required properties of city water

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



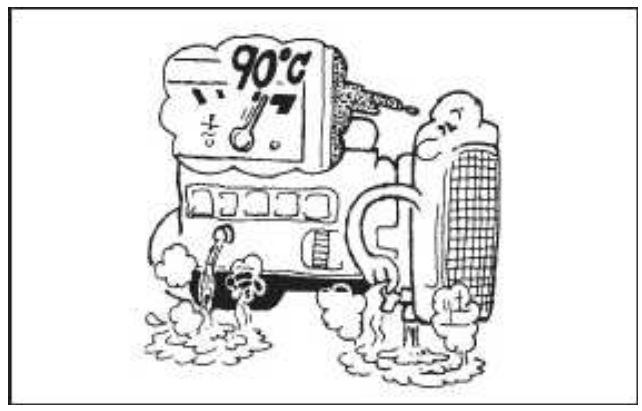
NOTE:

1. **Use a cleaning solution if the radiator is seriously obstructed or coolant is seriously contaminated.**
2. **When the cooling system is cleaned or washed with water, make sure that the coolant temperature is maintained at 90°C; the coolant temperature below the valve opening temperature closes the thermostat, resulting in poor coolant circulation.**
3. **If a large amount of rust has already gathered, water leak tends to occur after cleaning and therefore every part should be checked very closely.**
4. **If the coolant temperature is still very high, never attempt to remove the pressure cap.**

1. Washing with water

(a) Discharge coolant from the radiator and crankcase.
On D8, discharge coolant also from the oil cooler and reservoir tank.

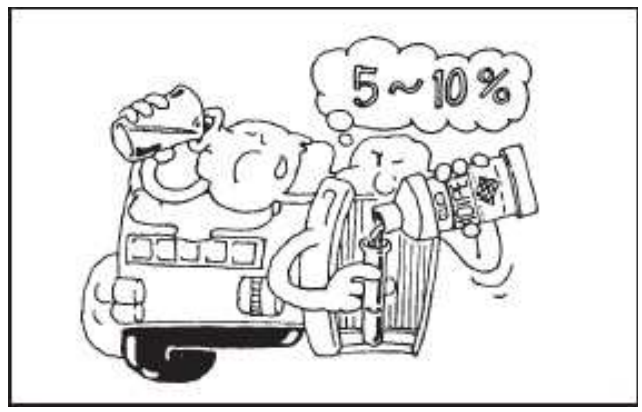
(b) After draining the system, fill it with tap water (preferably hot water) and, with the water temperature kept at around 90°C, run the engine at idle for about 10 minutes. Then, discharge water. Continue flushing until the drained water runs clear.



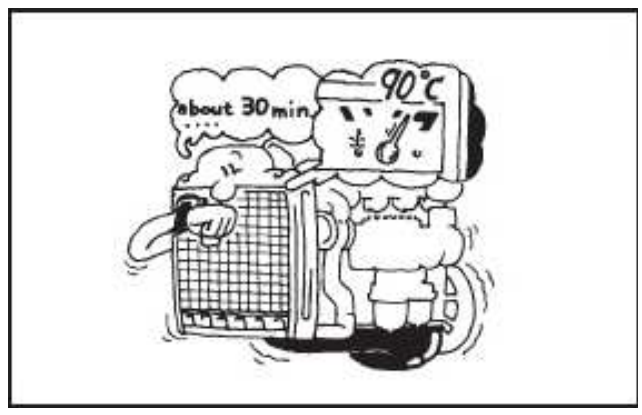
2. Washing with cleaning solution (when radiator clogging or coolant contamination are serious)

(a) Discharge coolant from the radiator and crankcase.
On D8, discharge coolant also from the oil cooler and reservoir tank.

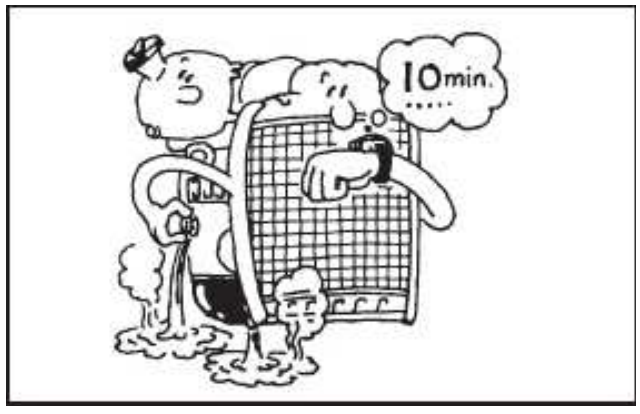
(b) Ready a mixture of Fuso Raditor Cleaner (Radipet-7 or equivalent: 5 to 10%) and cooling water.
Pour the specified amount of mixture into the radiator



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



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

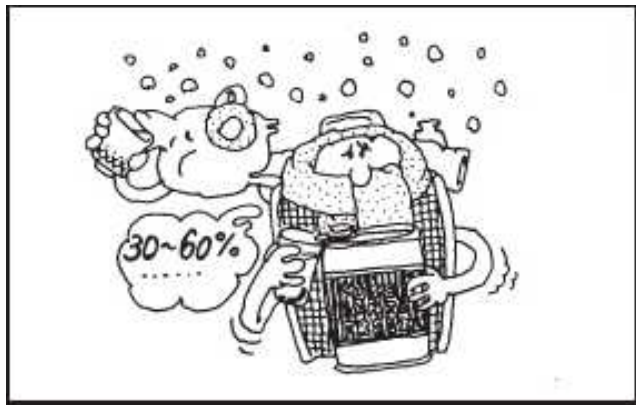


NOTE:
1. If the inside is seriously contaminated, flush the system with tap water before pouring radiator cleaner, which makes the flushing job more effective.
2. Running the engine at idle for more than one hour with the system charged with the cleaner could damage the cooling system. Stick to the cleaning time.
3. After flushing the system with the cleaner, pour cool ant as soon as possible.

3. Coolant

(a) To use long life coolant

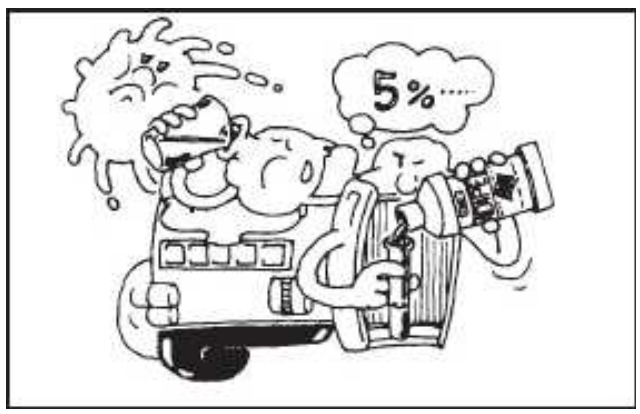
To prevent the coolant from being frozen and protect the cooling system from corrosion, add the "FUSO Diesel Long Life Coolant" at a ratio of 30 to 60% of the coolant quantity.
To ensure effective antifreeze and antirust performance, replace the coolant every two years.
For information on the procedure for use of the long life coolant, refer to the Owner's Handbook for the long life coolant.



NOTE:
When you use the FUSO Diesel Long Life Coolant, avoid mixing it with DIAQUEEN long life coolant, commercially available long life coolant, antifreeze, antirust, etc.

(b) To use antirust and antifreeze

1) After the cooling system has been cleaned, add the "FUSO Radiator Antifreeze" (Radipet-9B) at a ratio of 5% of the coolant capacity in summer to prevent corrosion



2) To prevent the coolant from being frozen in winter, add the "FUSO Antifreeze" at a ratio of 30 to 60% of the coolant capacity.
For use of an antifreeze and antirust, refer to the respective Owner's handbook.

NOTE:
When you use an antirust of antifreeze, avoid mixing it with another brand of long life coolant.

Bleeding Cooling System

Remove the pressure cap of the radiator and let the engine run at idle with the coolant at approx. 90°C to thoroughly remove the air. (In this case, the temperature control lever of the heater control panel should be kept at the extreme right to circulate the coolant through the heating system as well.)

NOTE:
After the system has been bled of air, be sure to check for level of coolant in the radiator and surge tank or reservoir tank and add it as necessary.

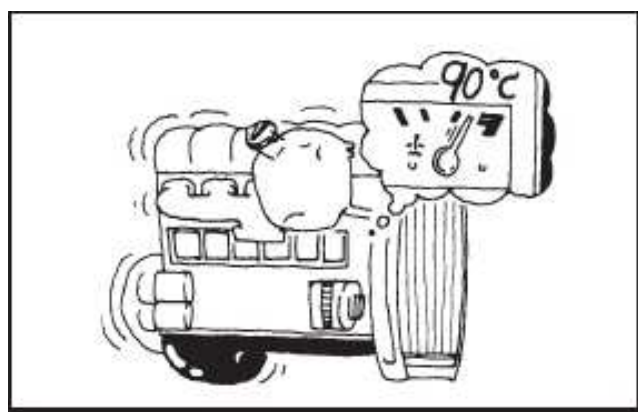
Gas Leak Test

Air or exhaust gas leaked into the coolant promotes corrosion and rust formation. Perform the following check and, if defects are found, take remedial action.

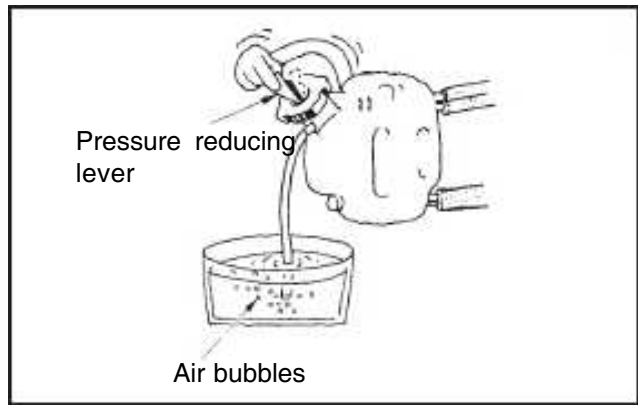
1. Inspection

<D6>

1) Run the engine to raise the coolant temperature up to around 90°C.



2) Place the end of the overflow pipe of the surge tank into a container containing water and turn the pressure reducing lever on the pressure cap to open the pressure valve. If air bubbles are formed continuously in the container, it indicates that the coolant contains air or exhaust gas.



<D8>

Remove the pressure cap from the radiator, and run the engine to raise the coolant temperature up to around 90°C.
If bubbles continue forming in the coolant under the condition, if indicates that air or exhaust gas has leaked into the coolant.

2. Causes

(a) If air is trapped in coolant, check cylinder head bolts, water pump mounting bolts, and hose and its connections for looseness. Check also hoses for damage.
(b) If the exhaust gas has leaked into coolant, check the cylinder head gasket or nozzle tube end stake for damage. Check also cylinder head for cracks.

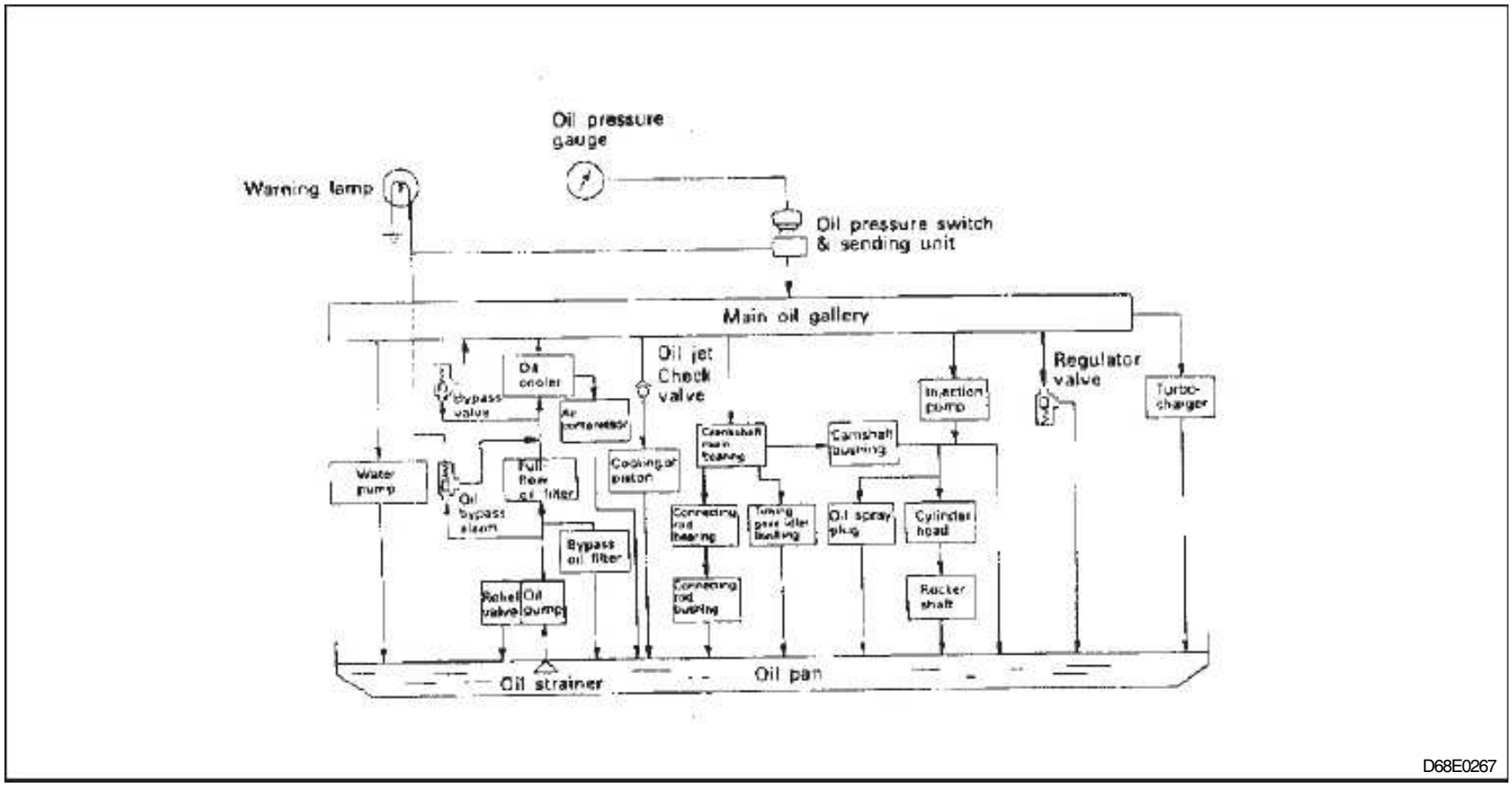
TROUBLESHOOTING

Symptom	Probable cause	Remedy
Overheat	Defective V-belt	
	· Incorrect tension	Adjust
	· Broken belt	Replace
	Clogged cooling system	Clean
	Defective thermostat	Replace
	Defective water pump	
	· Loose shaft to flange engagement	Replace
	· Loose shaft to impeller engagement	
	· Damaged impeller	
	· Improper clearance between impeller and case	
	Clogged radiator fins	Clean
	Defective autocool fan coupling	
	· Damaged bimetal	Replace
	· Defective autocool fan coupling proper	
	· Clogged bimetal	Clean
	Damaged cooling fan	Replace
	Low coolant level	Replenish
Overcool	Defective thermostat	Replace
Quick loss of coolant	Defective radiator hose	
	· Loose hose connection	Correct
	· Cracked or damaged hose	Replace
	Defective radiator	
	· Radiator proper not tight	Replace
	· Pressure cap not tight	
	Defective water pump	
	· Defective unit seal	Replace
	· Defective oil seal	
	· Pump mounted improperly (defective gasket)	
	Defective oil cooler	Replace
	Thermostat case mounted improperly (defective gasket)	Replace
	Thermostat cover mounted improperly (defective gasket)	
	Defective heater hose	
	· Loose hose connection	Correct
	· Cracked or damaged hose	Replace
	Defective cylinder head gasket	Replace

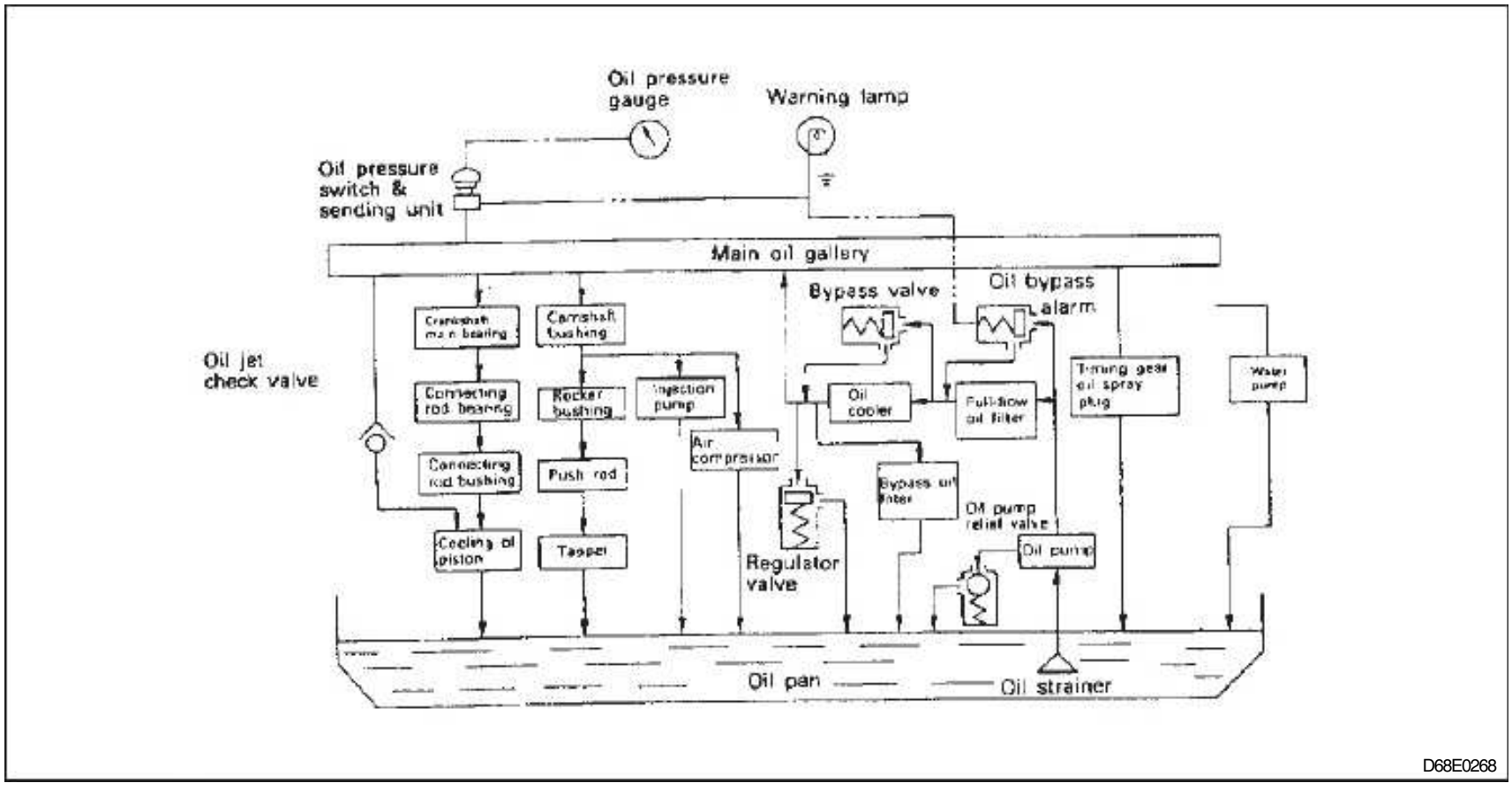
LUBRICATION

GENERAL

<D6A>

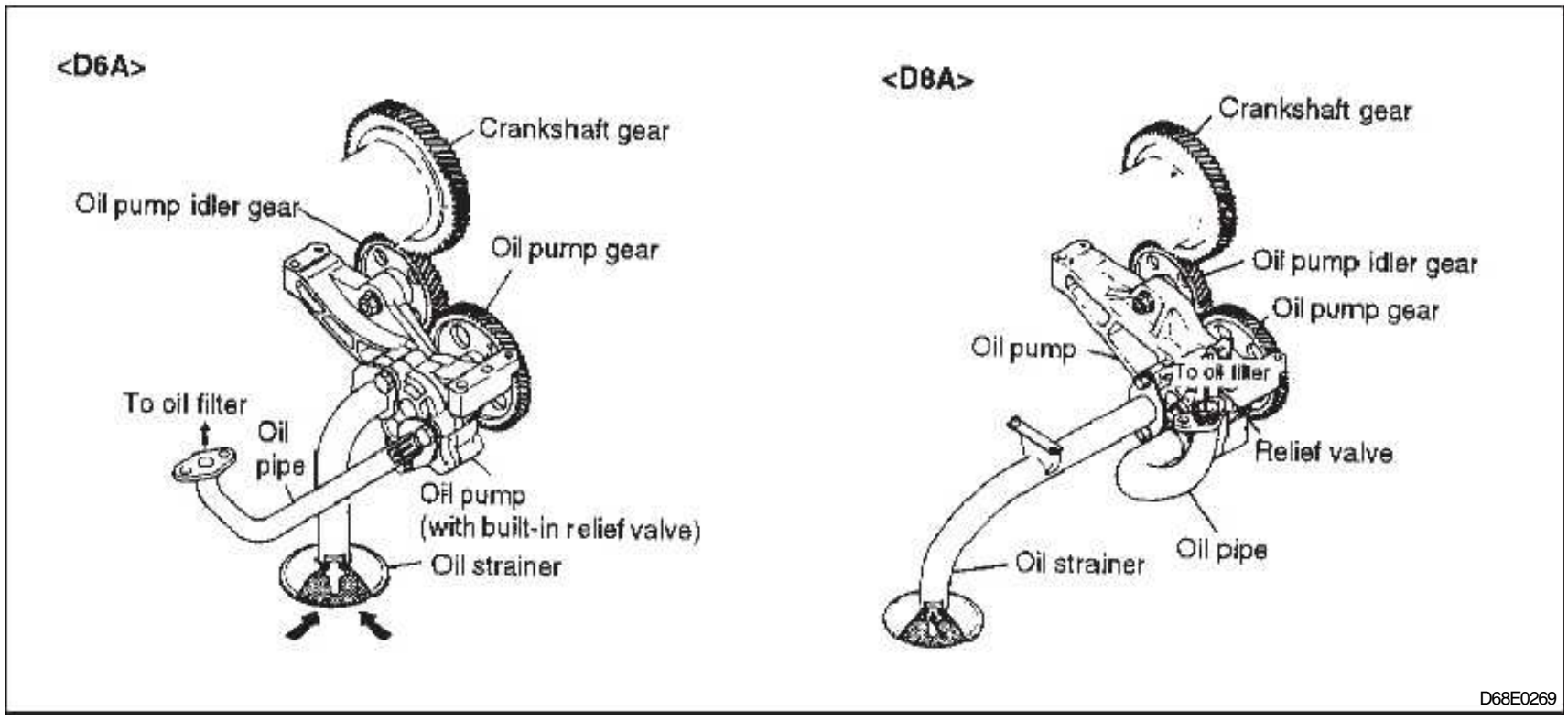


<D8A>



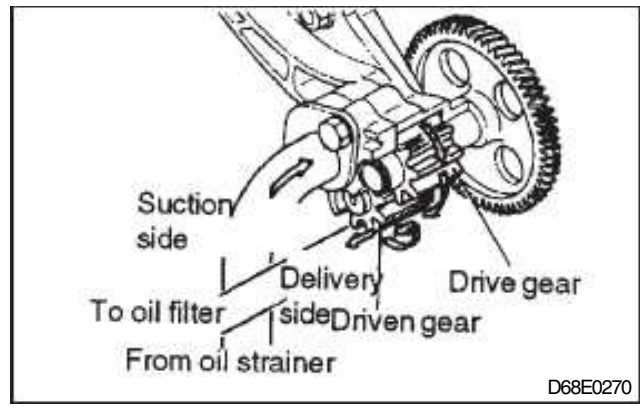
Engine lubrication is accomplished by forced lubrication system using gear pump. The engin e oil in the oil pan in drawn up through the oil strainer by the oil pump and force-fed to the filter and oil cooler to lubricate all parts.

Oil pump

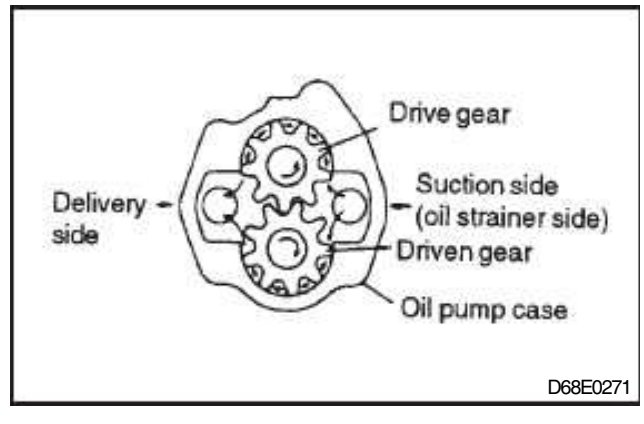


The oil pump, of a gear pump type, is mounted in the rear bottom portion of the crankcase, driven by the crankshaft gear. The oil strainer at the suction port prevents entry of foreign matter in the oil pan and air. The engine oil is routed to the crankcase by the oil pipe connected to the delivery port.

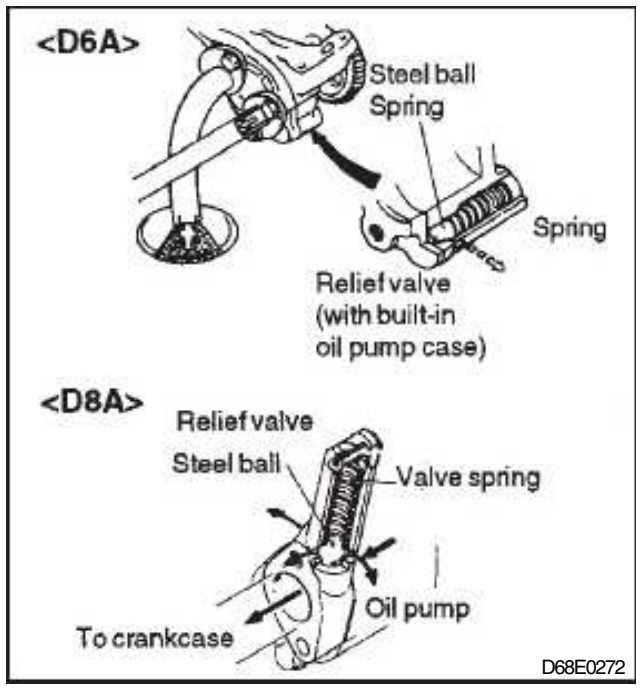
The crankshaft gear drives the oil pump idler gear and oil pump idler gear and oil pump gear to transmit rotation to the oil pump drive gear. In the oil pump, the oil pump drive gear is in mesh with the oil pump driven gear. When the oil pump drive gear is driven, the oil pump driven gear is turned in the opposite direction.



Inside the oil pump case, there are oil pump drive gear and driven gear which are in mesh with each other. When the drive gear is driven, the driven gear is caused to turn in an opposite direction.
As the gears rotate with the gear teeth sliding on the inner surfaces of pump case, the resultant negative pressure causes the engine oil to enter the oil pump and the oil trapped in the space formed by the teeth and gear case inner wall is forced out through the delivery port.



The oil pump is driven at a speed proportionate to the engine speed. Therefore, it is provided with a relief valve that prevents excessive pressure from being applied to the lubrication system when the engine is started in cold weather involving a surge in oil pump delivery pressure.

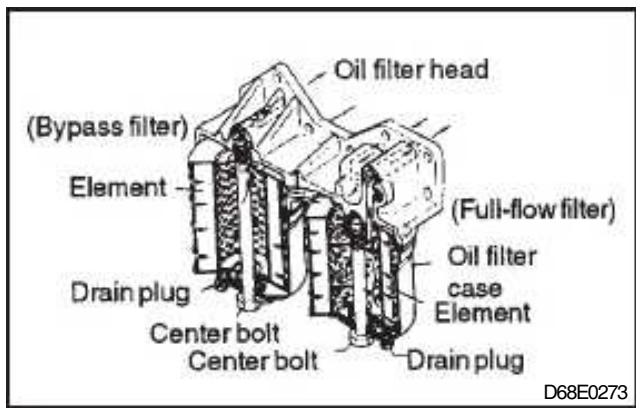


Oil filter

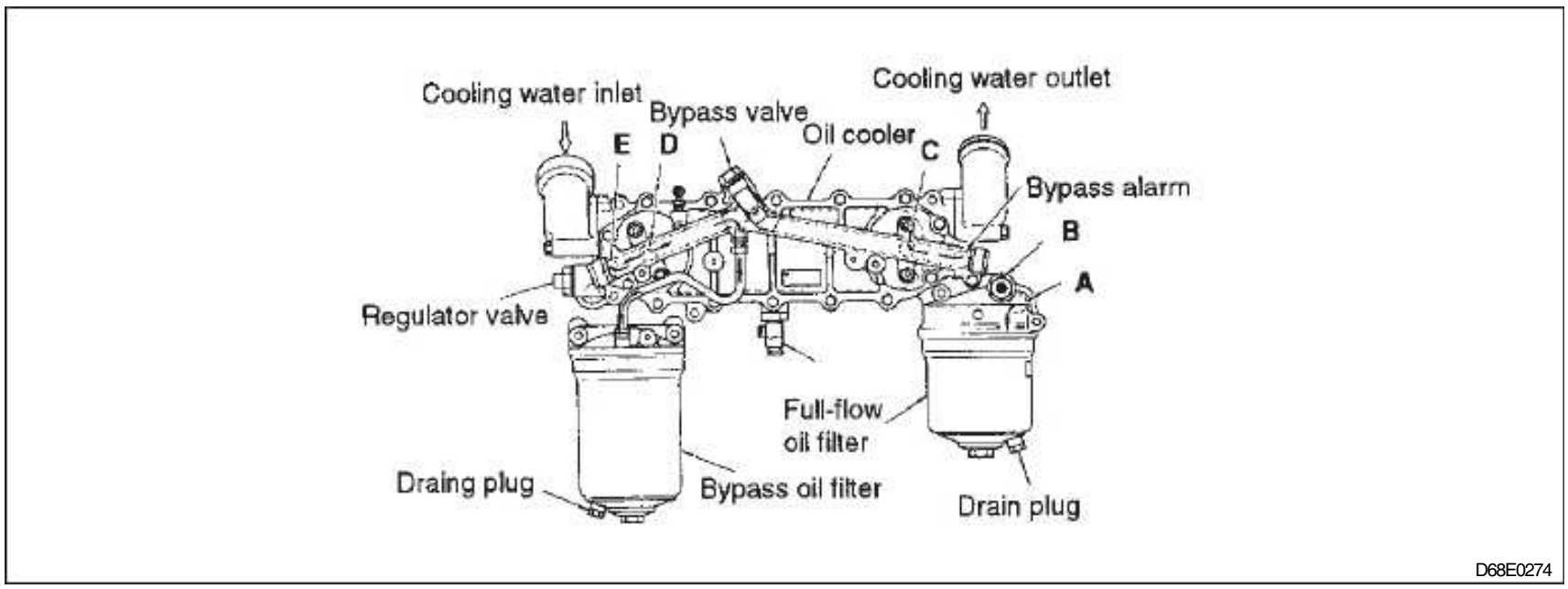
1. D6A

The oil filter is a double oil filter consisting of a full-flow filter made integral with bypass filter. Element is a filter paper element. Engine oil fed under pressure from the oil pump passes through the oil hole in the crankcase and flows from the oil filter head into the full-flow filter and bypass filter. The engine oil filtered through the full-flow filter is routed from the oil filter head through the crankcase oil hole to the oil cooler. The engine oil filtered through the bypass filter returns to the oil pan. An oil bypass alarm is installed at the oil filter head.

When the oil viscosity is high at low temperatures or when the



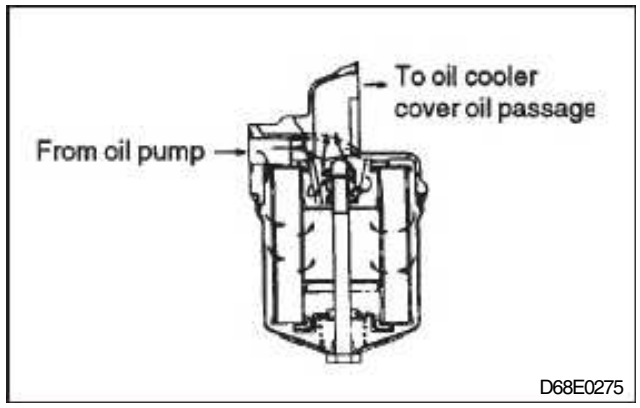
2. D8A



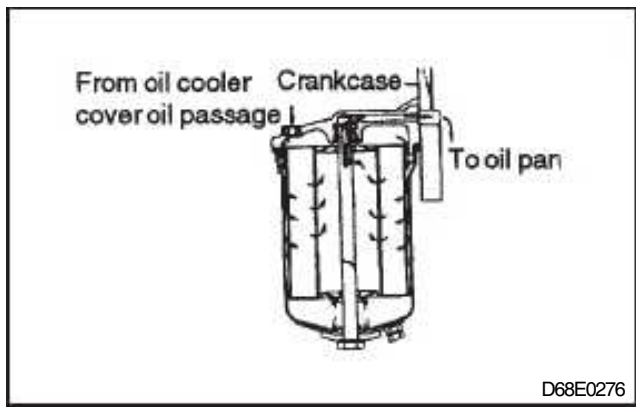
The oil cooler and full-flow oil filter are constructed as an integral unit and the bypass oil filter is connected by an oil pipe to oil cooler to keep oil in good condition

Oil hole A... From crankcase oil passage to inside oil cover oil passage
Oil hole B ... From full-flow oil filter to oil cooler cover oil passage
Oil hole C ... From oil cooler cover oil passage to oil cooler element
Oil hole D ... From oil cooler element to oil cooler cover oil passage
Oil hole E ... From oil cooler cover oil passage to crankcase main gallery

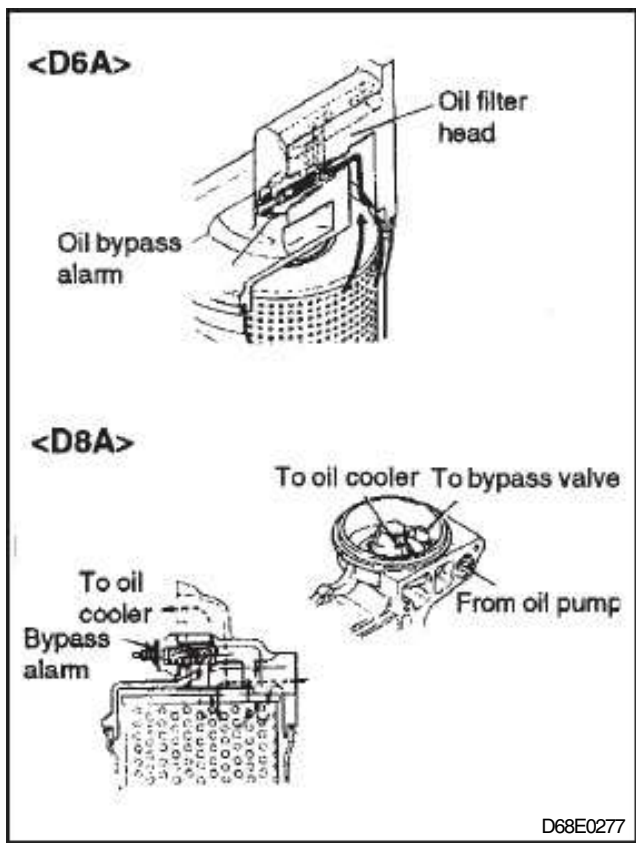
1) Full-flow oil filter
The oil filter element is filter paper element. Oil supplied by the oil pump is fed into the oil filter through the crankcase oil passage Then, oil filtered by element is fed into the oil passae of the oil cooler cover.



2) By pass oil filter
The oil filter element is a dual element type consisting of a corrugated filter paper and card paper filter. This unit serves to keep oil in good condition through circulation of a part of the oil from the oil filter to the oil cooler, bypass oil filter and then to oil pan. The location of bypass oil filter differs with engine models.

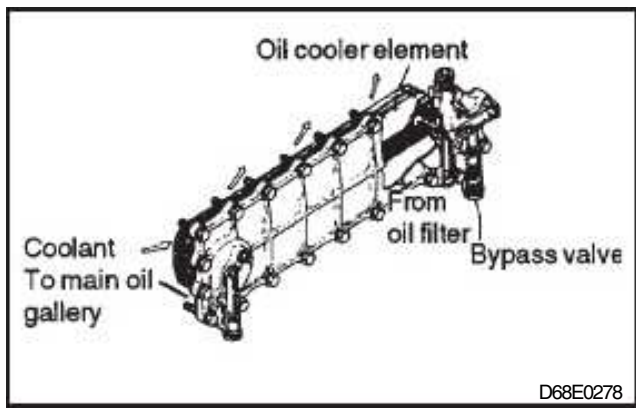


3) Oil bypass alarm
When the oil filter element is plugged resulting in the difference in pressures between before and after the element exceeding a predetermined level, the valve overcomes the spring tension to move. As a result, unfiltered oil flows directly to the oil cooler. The oil bypass alarm has built-in electric contacts which close when the valve opens, causing the warning lamp of the meter cluster in the cab to light to warn the driver.

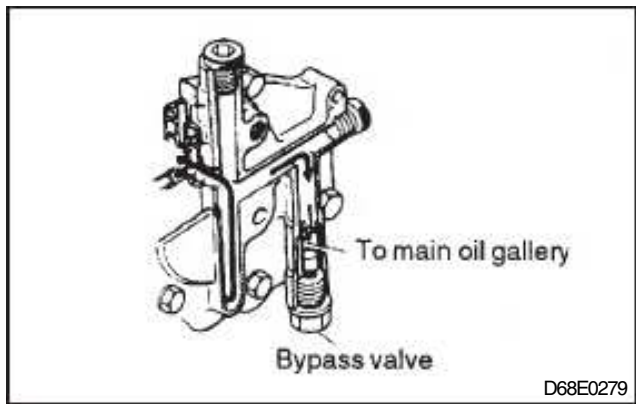


Oil cooler

1. D6A
The shell-and-plate type (multi-plate type) oil cooler is mounted in the coolant path on the left side of the crankcase.
Engine oil forced through the oil filter flows inside the oil cooler element; whereas the coolant forced from the water pump flows around the element. The engine oil in the element is then cooled or heated before it flows to the main oil gallery.

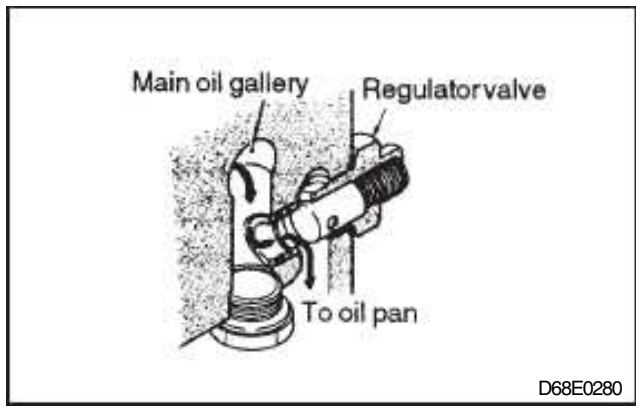


When the oil viscosity is high at low temperature or when the element has high resistance to flow because of clogging, the bypass valve installed at the oil cooler opens to allow engine oil to flow to the main gallery by passing the oil cooler.

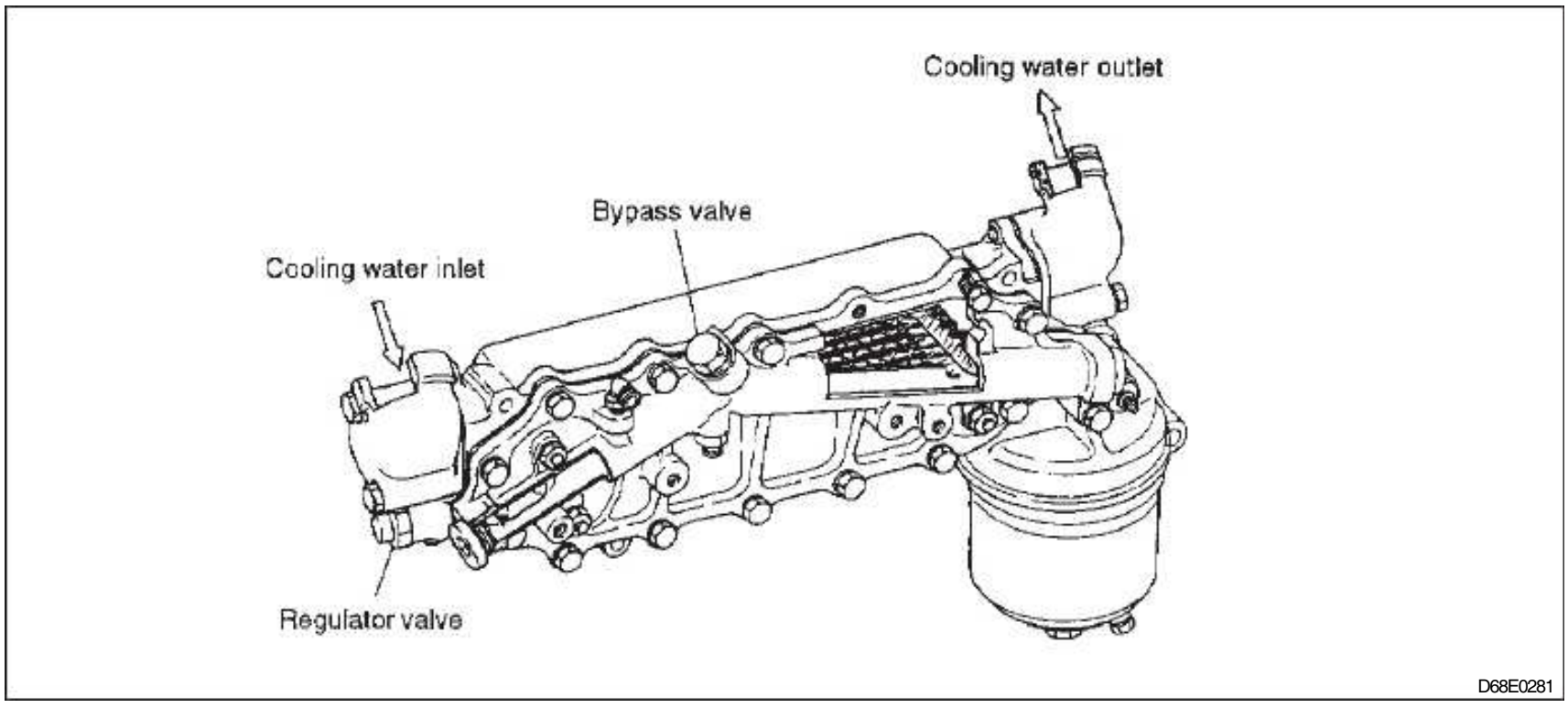


Regulator valve

The regulator valve is mounted in the main oil gallery in the crankcase. When oil pressure in the main gallery exceeds specification, the valve allows the engine oil to escape to the oil pan, thereby protecting the lubrication system against overload.

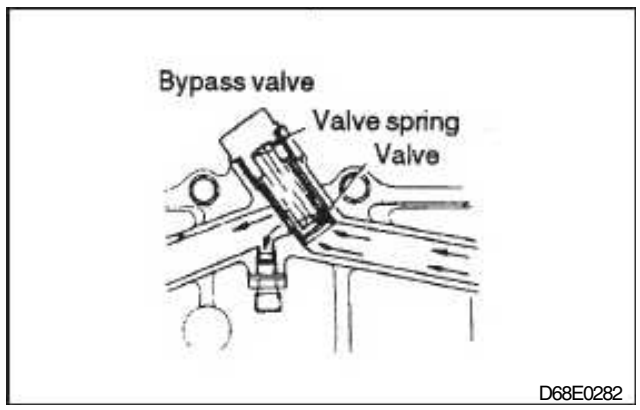


2. D8A



The oil cooler is of the shell and plate type (multi-plate type) and introduces coolant from the crankcase water jacket by means of a water pipe, Oil supplied from the oil filter flows inside the oil cooler element to allow heat exchange with the coolant around the element.

A bypass valve and regulator valve are provided in the oil passage of the oil cooler cover. When the oil viscosity is high because of a low oil temperature or when the flow resistance is high because of a clogged element, the bypass valve opens, allowing the oil to flow into the crankcase main gallery without heat exchange. For the regulator valve, refer to that for D6A in (Note that D8A has the regulator valve installed on the oil cooler.)

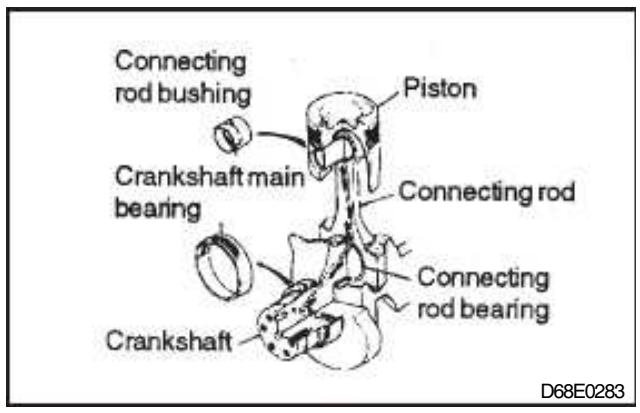


Lubrication of all parts

	D6AV	D6AC	D8AY	D8AB	D8AX
Oil hole	X	O	O	X	O
Oil zet	X	O	X	O	X

1. D6A
   The engine oil routed to the main oil gallery lubricates all parts as described in the following.

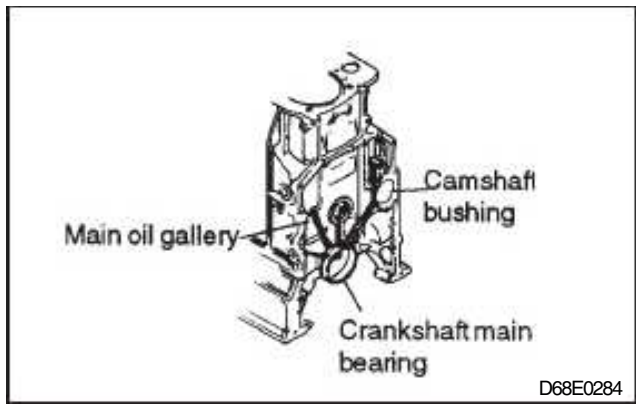
1) Main bearing, connecting rod bearing and connecting rod bushing.
   The oil hole extends from the main oil gallery to the crankshaft main bearing to lubricate the main bearing.
   Part of the engine oil that has lubricated the main bearing passes through the oil hole in the crankshaft to lubricate the connecting rod bearing, and then through the oil hole in the connecting rod to lubricate connecting rod bushing.
   On D6AB there is a hole provided in top of connecting rod, from which oil spurts out to the piston.



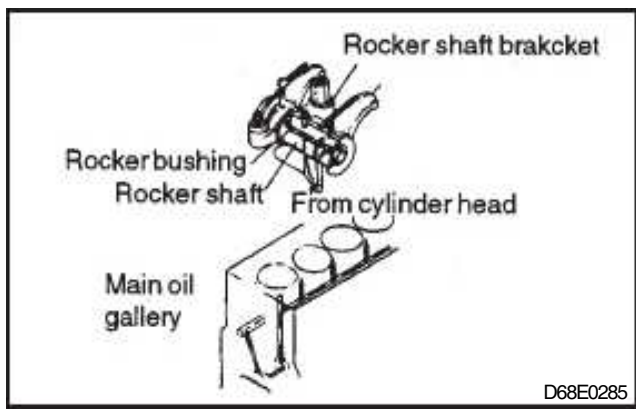
2) Camshaft

   Lubrication of the camshaft bushings is accomplished by the oil flowing through the oil holes from the outside periphery of the crankshaft main bearing to the individual camshaft bushing.

3) Valve mechanism

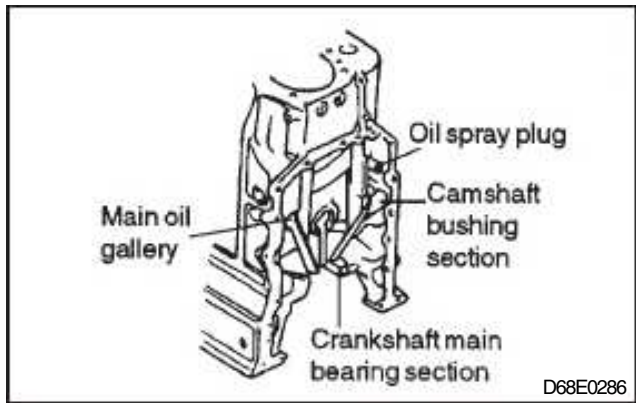


   The engine oil that has lubricated the No.7 camshaft bushing flows through the oil hole provided at the top of the crankcase to each cylinder head.
   Engine oil fed to the cylinder head flows through the oil holes in the rocker shaft bracket and rocker shaft to lubricate each rocker bushing. The engine oil is also sprayed out of the rocker oil holes for lubrication of the sliding surfaces of valve cap and valve stem as well as the sliding surfaces of push rod and adjusting screw. The oil then flows through the push rod holes in the cylinder head and crankcase to lubricate the tappet and cam of the camshaft and returns to the oil pan.



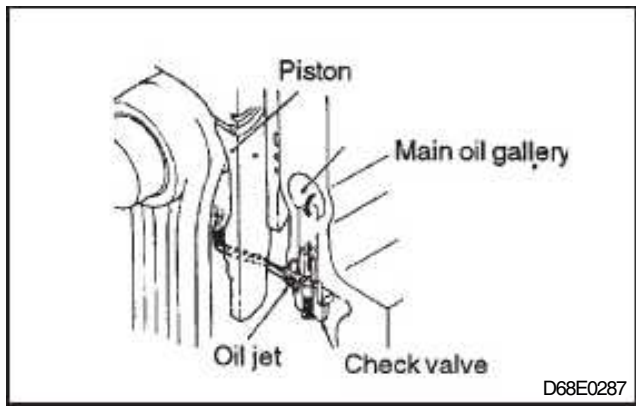
4) Timing gear

The timing gear idler shaft bushings are lubricated, as shown in the figure, by engine oil flowing through the oil holes routed from the main oil gallery and the crankshaft main bearing in the rear end. Each gear is lubricated by the engine oil sprayed from the oil spray plug.

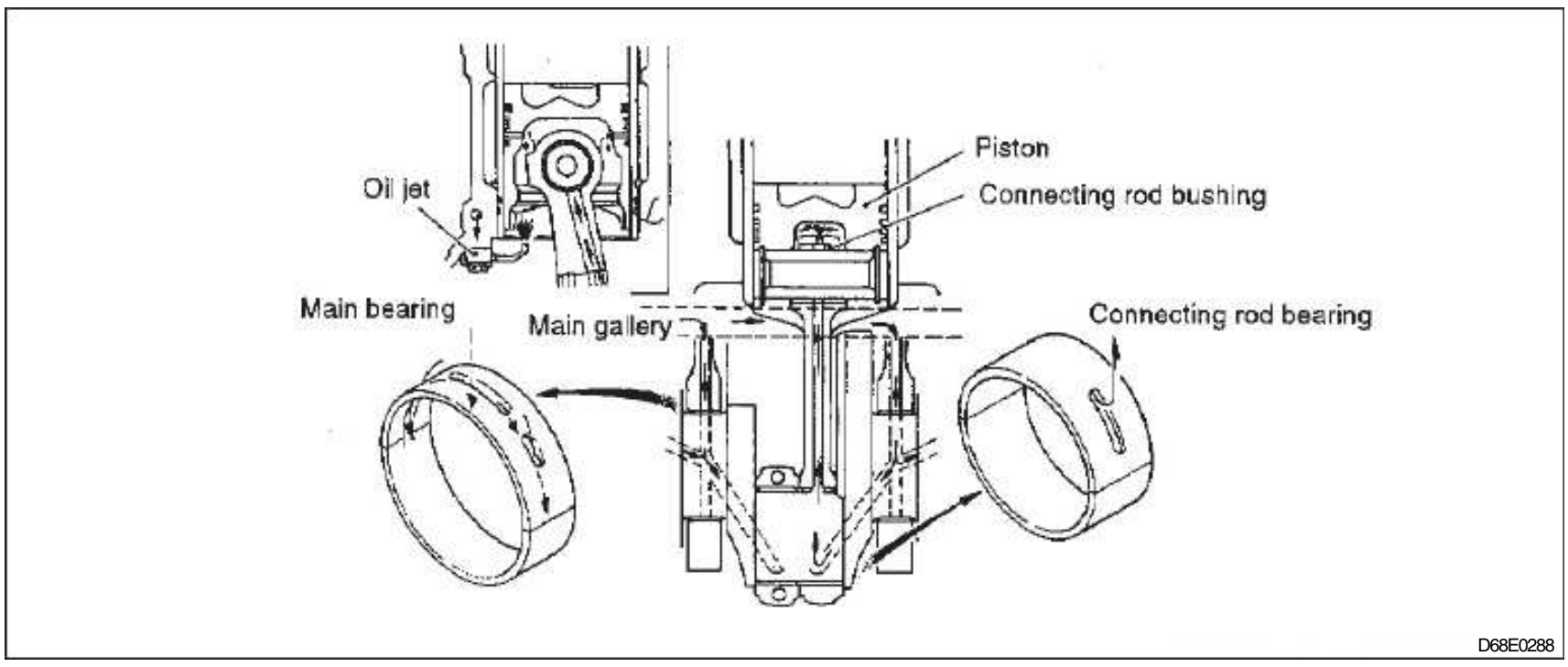


5) Cooling the piston (oil jet)

The oil jet provided under the main oil gallery for each cylinder sprays engine oil against the reverse surface of the piston to cool the piston.
The oil jet is equipped with a check valve which opens and closes at specified oil pressure, preventing the decreased amount of oil at low oil pressure and loss in oil pressure.



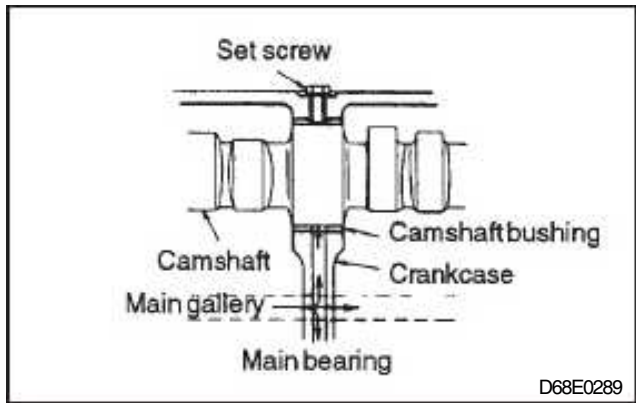
2. D8A



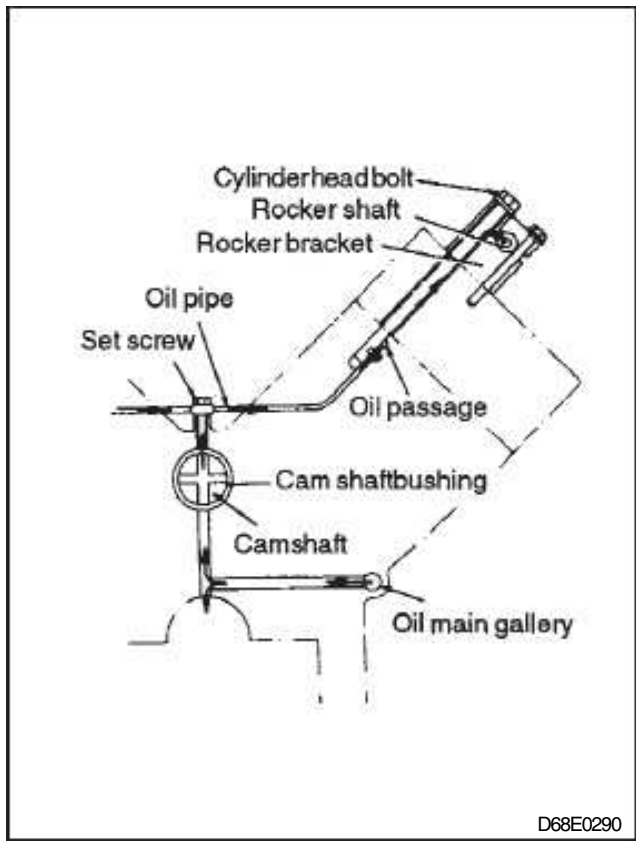
Oil supplied to the crankcase main gallery returns to the oil pan after lubricating each part.

1) Main bearing, connecting rod bearing and piston Oil fed from the oil main gallery through the oil passage cranklcase lubricates the main bearing. Then, it lubricates connecting rod bearing and, finally, it lubricates the connecting rod bushing through the oil passage in the connecting rod and splashes out from the top of connecting rod to cool the piston. The oil jet provided under the main oil gallery for each cylinder sprays engine oil against the reverse surface of the piston to cool the piston. the oil jet is equipped with a check valve which opens and closes at specified oil pressure, preventing the decreased amoustn of oil at low oil pressure and loss in oil pressure.

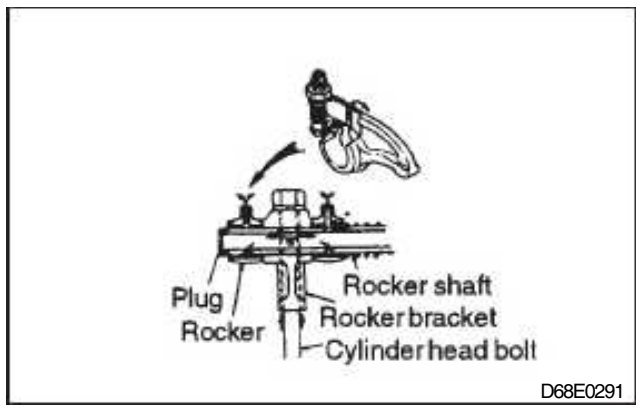
2) Camshaft
Oil fed through the crankcase passage from me the oil main gallery lubricates camshaft bushing.



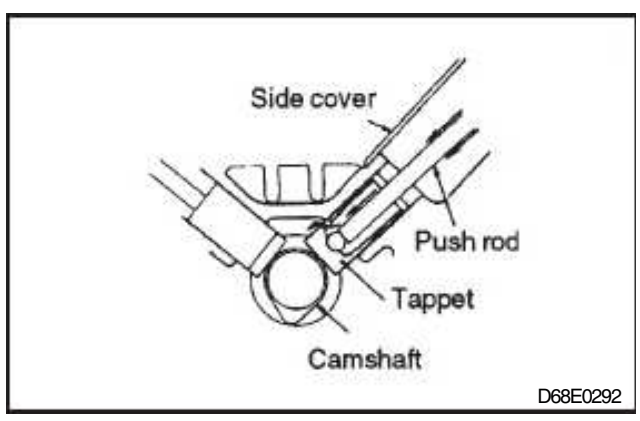
3) Valve mechanism
Oil, which has lubricated the camshaft bushing No.1, flows through an oil pipe into the oil passage at the top of the crankcase. The oil passage is connected to the hole for the cylinder head bolt and oil flows into the rocker shaft through the cylinder head bolt from the rocker bracket.



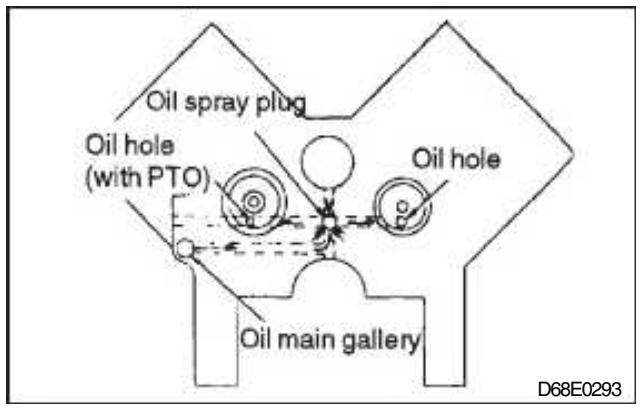
Oil fed into the rocker shaft lubricates the rocker bushing through the oil hole and then flows into an oil groove in the rocker bushing. Furthermore, oil spurts out from the top of the rocker to lubricate the surfaces in contact with the valve cap and the valve stem. Oil coming out of the oil hole in the side of the rocker lubricates the adjusting screws and the surfaces in contact with the push rod.



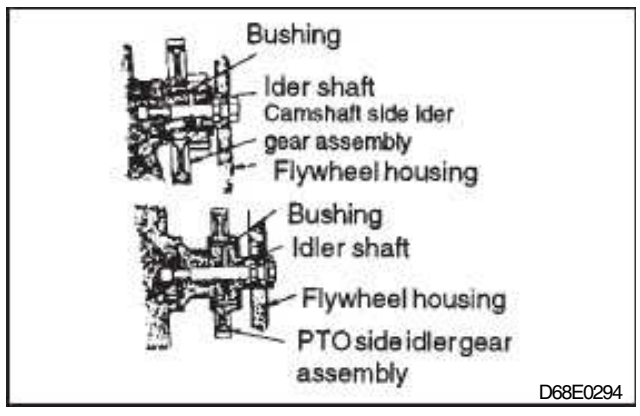
Oil flows into the tappet along the push rod. Oil coming out of the oil hole of tappet lubricates the sliding portion of tappet and the contact area of camshaft and returns to the oil pan.



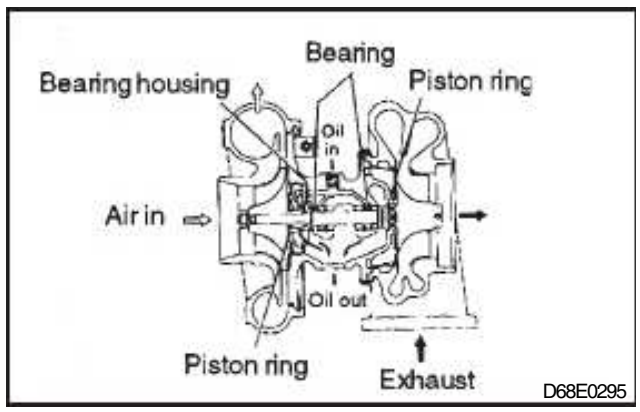
4) Timing gear
Oil flows from the oil main gallery through the crankcase oil passage to the oil spray plug area and then to the oil hole. Oil that has splashed from the oil hole lubricates the meshing surfaces of each gear.



Oil, which has reached the oil hole through the crankcase oil passage, lubricates the bushing through the gap between the bolt and idler shaft.

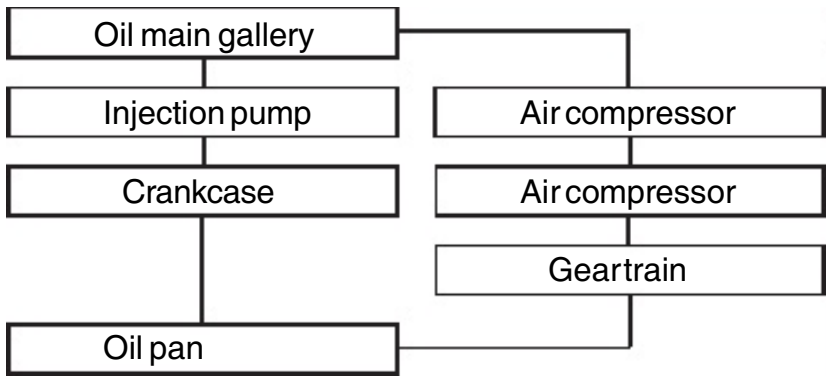


5). Lubrication of turbocharger.
Part of engine oil is directed through the oil pipe from the crankcase into the turbocharger. the engine oil passes through the oil hole in the turbocharger bearing housing to lubricate the bearings. It is then returned through the oil outlet at the bottom of the bearing housing back to the crankcase and to the oil pan. A piston ring is installed on the outside of each bearing, serving as an oil seal.



6). Injection pump and air compressor
The injection pump and air compressor are lubricated as follows:

<D6A>



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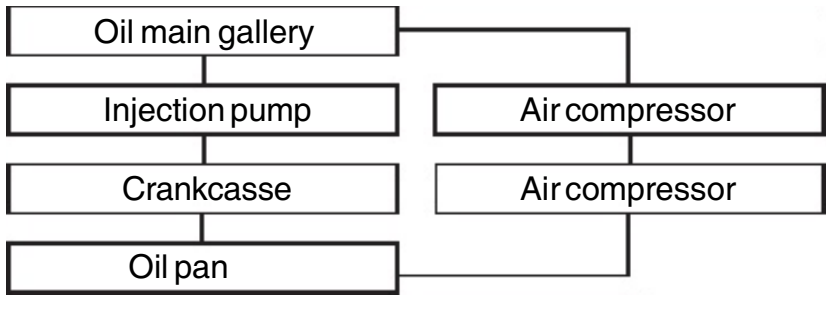
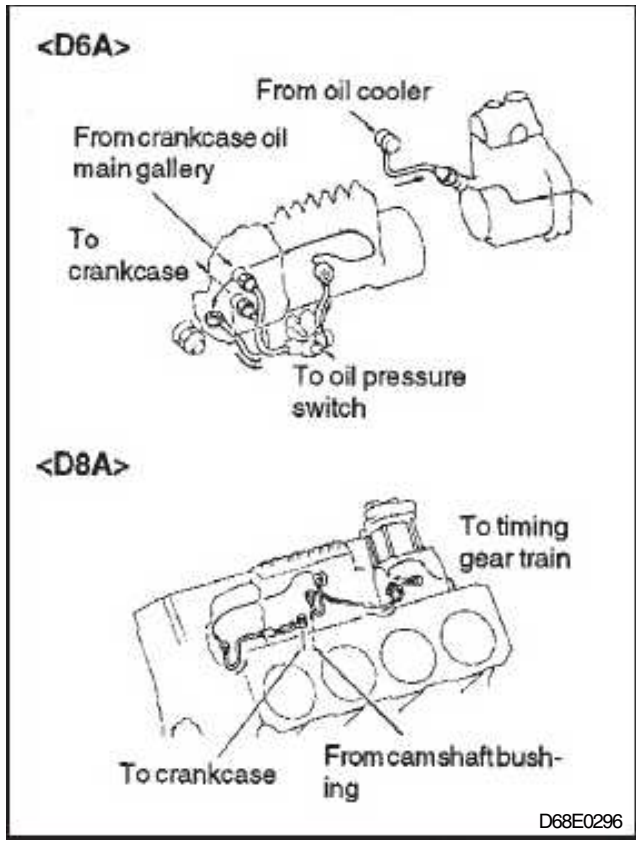




SERVICE STANDARD AND SPECIFICATIONS

Service Standard Table

Unit : mm

Maintenance item				Nominal value (Basic diameter in [ ])	Limit	Remedy and remarks
Oil press sure (oil temperature at 70 to 90°C)	At idle			145 kPa {1.5 kgf/cm²} or more	49 kPa {0.5 kgf/cm²}	Adjust
	At driving speed			295 to 490 kPa {3 to 5 kgf/cm²}	195 kPa {2 kgf.cm²}	Adjust
Oil pump	Backlash between crankshaft gear and oil pump idler gear			0.08 to 0.19	0.4	Replace
	Backlash between idler gear and oil pump gear			0.08 to 0.19	0.4	Replace
	Difference between pump case depthand gear height			0.05 to 0.11	0.15	Replace
	Gear tooth tip to pump case clearance			0.11 to 0.18	0.2	Replace
	Drive gear shaft to cover clearance			[20] 0.04 to 0.07	0.15	Replace
	Driven gear shaft to driven gear clearance			[20] 0.04 to 0.07	0.15	Replace
	Idler gear shaft to idler gear clearance		D6A	[22] 0.03 to 0.05	0.15	Replace bushing
			D8A	[20] 0.03 to 0.05		
Relief valve	Valve opening pressure		D6A	1180 kPa {12 kgf/cm²}	-	Replace
			D8A	1570 to 1860 kPa {16 to 19 kgf/cm²}		
	Spring load	Installed length (46.3)	D6A	150 to 165 N {15.3 to 16.9 kgf}	-	Replace
		Installed length (56.6)	D8A	175 to 215 kPa{1.8 to 2.2 kgf/cm²}	-	Replace
	Oil cooler bypass valve opening pressure		D6A	390 to 490 kPa {4 to 5 kgf/cm²}		
			D8A	360 to 420 kPa²}	-	Replace
Regulator Valve	Valve opening pressure			{3.7 to 4.3 kgf/cm²}	-	Replace
	Spring load (Installed length: 48.3)			76 to 80 N {7.8 to 8.2 kgf}	-	Replace

Tightening Torque Table

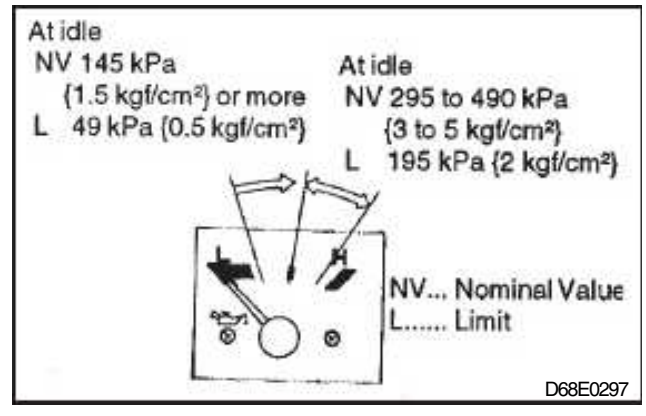
Location tightened	Screw size O.D. x pitch (mm)	Tightening torque N.m {kgf.m}	Remarks
Oil pan drain plug	M18 x 1.5	69 {7}	
Oil pump idler shaft nut	M12 x 1.25	59 to 78 {6 to 8}	Apply LOCTITE 262
Oil pump cover mounting bolt <D8A only>	M20 x 1.5	9.8 {1}	Wet
Oil filter oil bypass alarm	M20 x 1.5	44 to 54 {4.5 to 5.5}	
Oil filter center bolt	M16 x 1.5	59 to 69 {6 to 7}	
Oil cooler bypass valve	M27 x 1.5	15 to 20 {1.5 to 2.0}	
Regulator valve	M27 x 1.5	98 to 115 {10 to 12}	

SPECIFICATIONS

Item			Specification	
			D6A	D8A
Engine oil	Quality		(Without turbocharger) API classification class CC or better (With turbocharger) API classification class CD or better	
	Capacity	Oil pan	Approx. 24 L (single front axle) Approx. 27 L (tandem front axle) Approx. 20 L (Bus)	Approx. 20.5 L
		Oil filter	Approx. 4 to 4.5 L	
Lubrication method			Forced lubrication oil pump	
Oil pump		Type	Forced lubrication by gear pump (with built-in relief valve)	Forced lubrication by gear pump
Relief valve			Ball valve	
Oil filter	Type		Element replacement type	
	Full-flow filter element	Type	Filter paper type	
	Bypass filter element	Type	Filter paper type	
Oil cooler		Type	Shell and plate type (multi-plate type)	
Oil bypass valve		Type	Piston valve type	
Regulator valve		Type	Piston valve type	
Oil jet check valve		Type	Piston valve type	

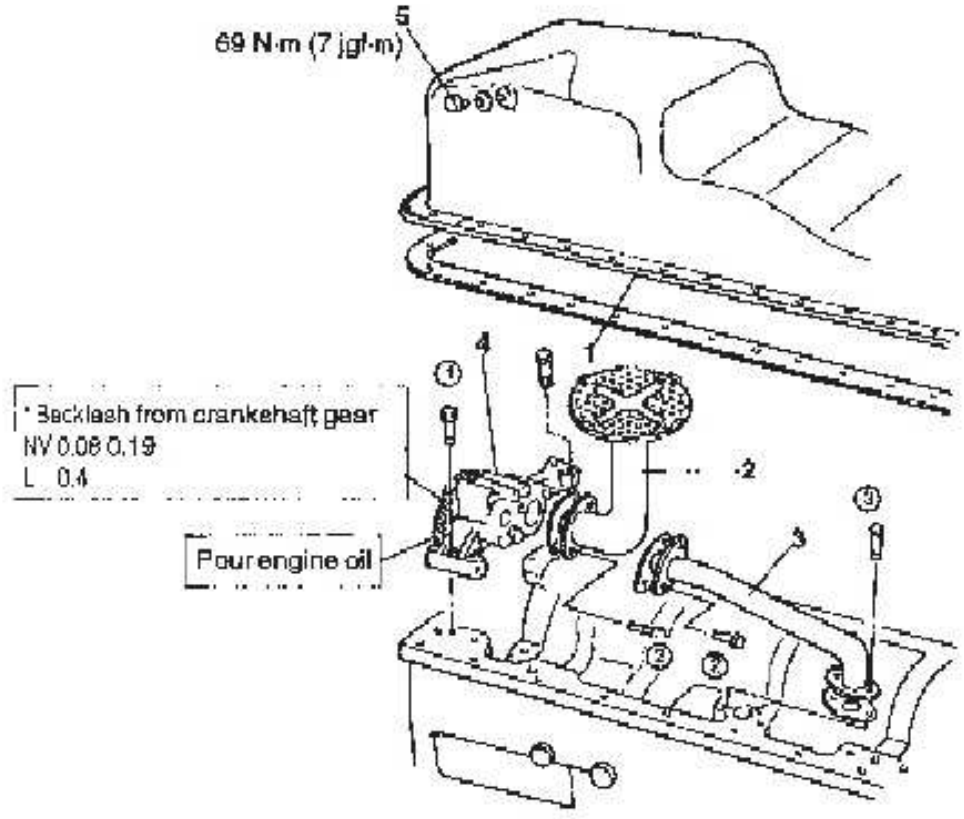
SERVICE PROCEDURE

(1) Warm up the engine until the oil temperature reaches 70 to 90°C
(2) Measure the oil pressure at idle and maximum speeds. If the measurement is below the limit, overhaul the lubricating system.



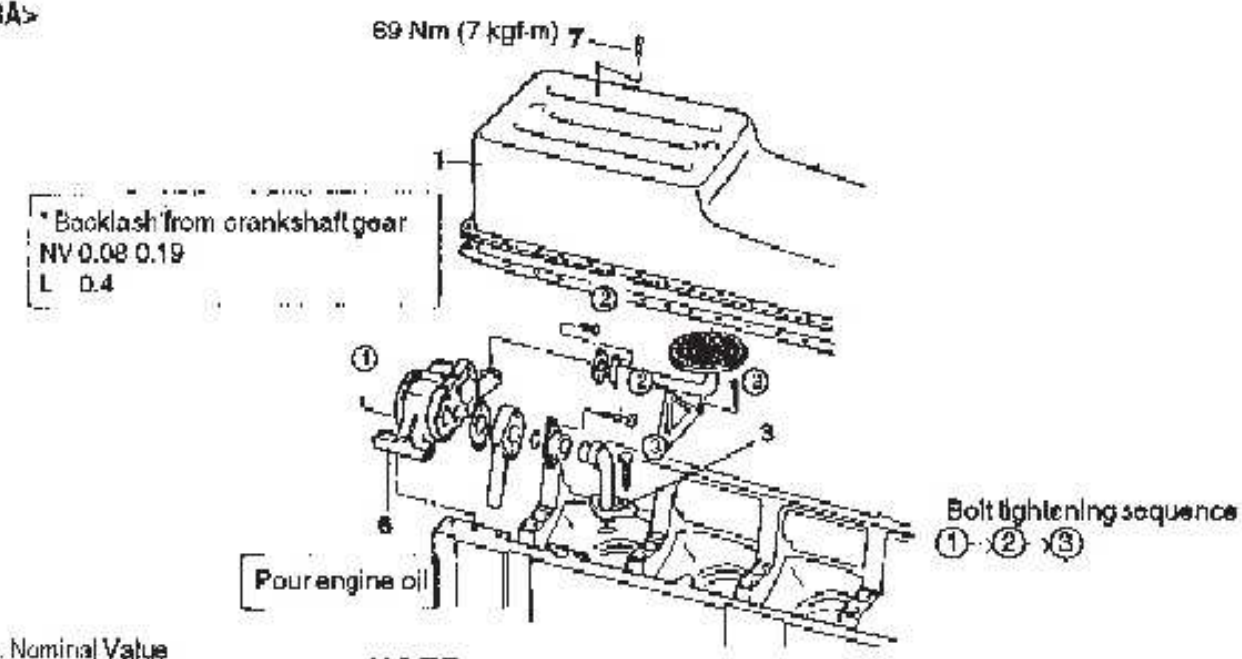
Oil Pump and Oil Strainer
Removal and installation

<D6A>



1.Oil pan
*2. Oil strainer
*3.Oil pipe
4.Oil pump
5.Drain plug

<D8A>



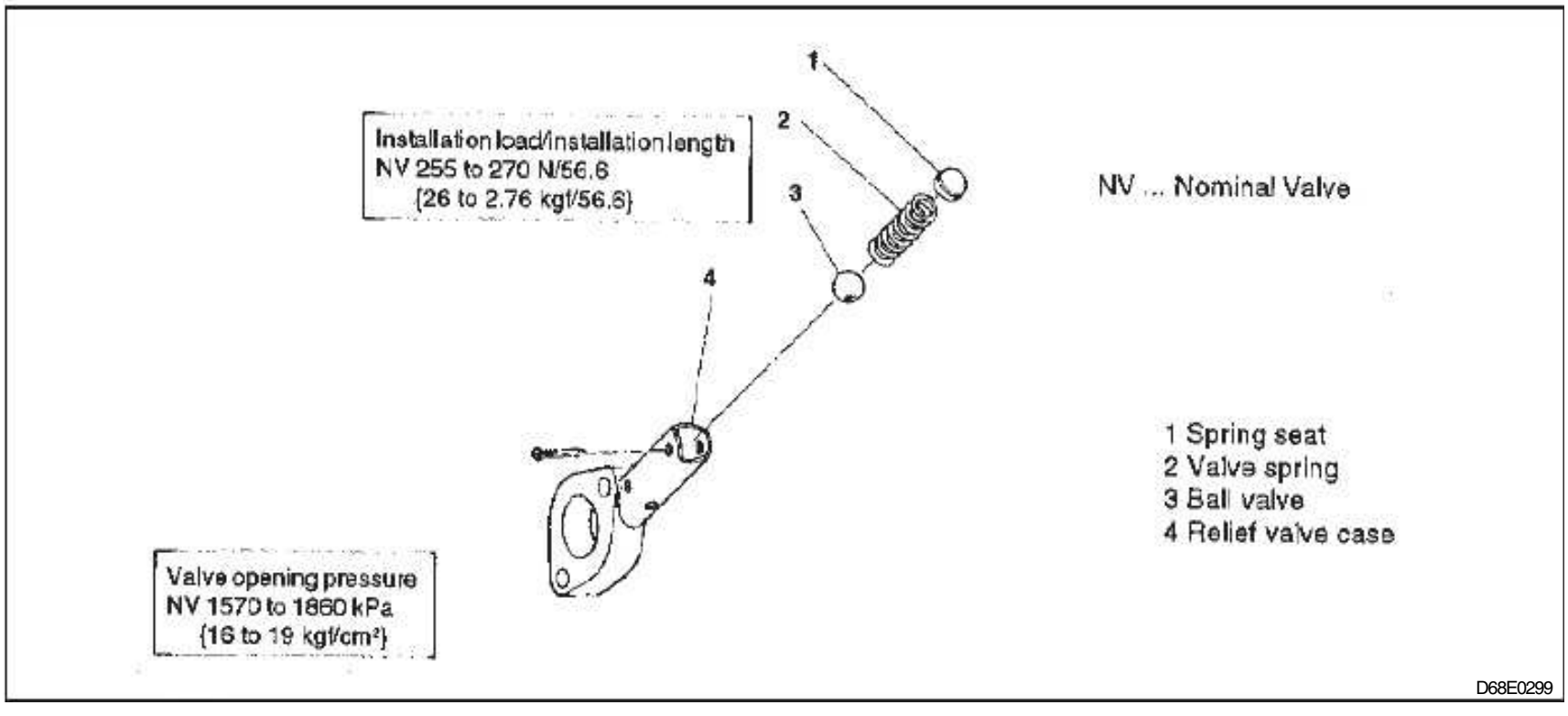
1 Oil pan
*2 Oil strainer
*3 Oil pipe
4 Flange
5 Relief valve
6 Oil pump
7 Drain plug

NV ... Nominal Value
L ... Limit

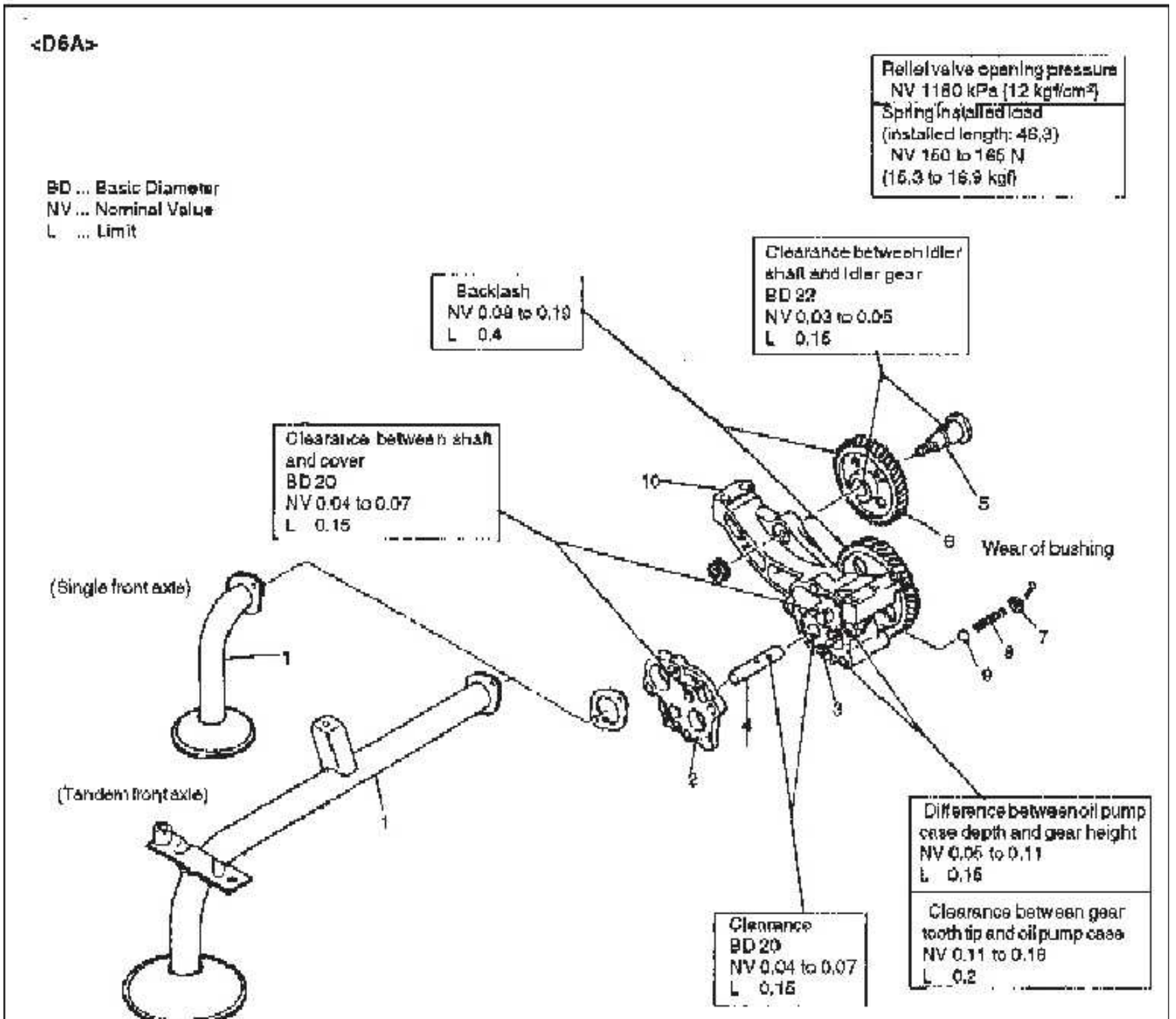
NOTE:
Service items marked with should be checked before and after the removal.
Parts marked with should not be removed unless defects are evident. (Remove it with the oil pump as an assembly.)
After installation, turn the oil pump gear by hand to make sure that it rotates smoothly.

D68E0298

1. Inspection of relief valve <D8A>



Disassembly and inspection

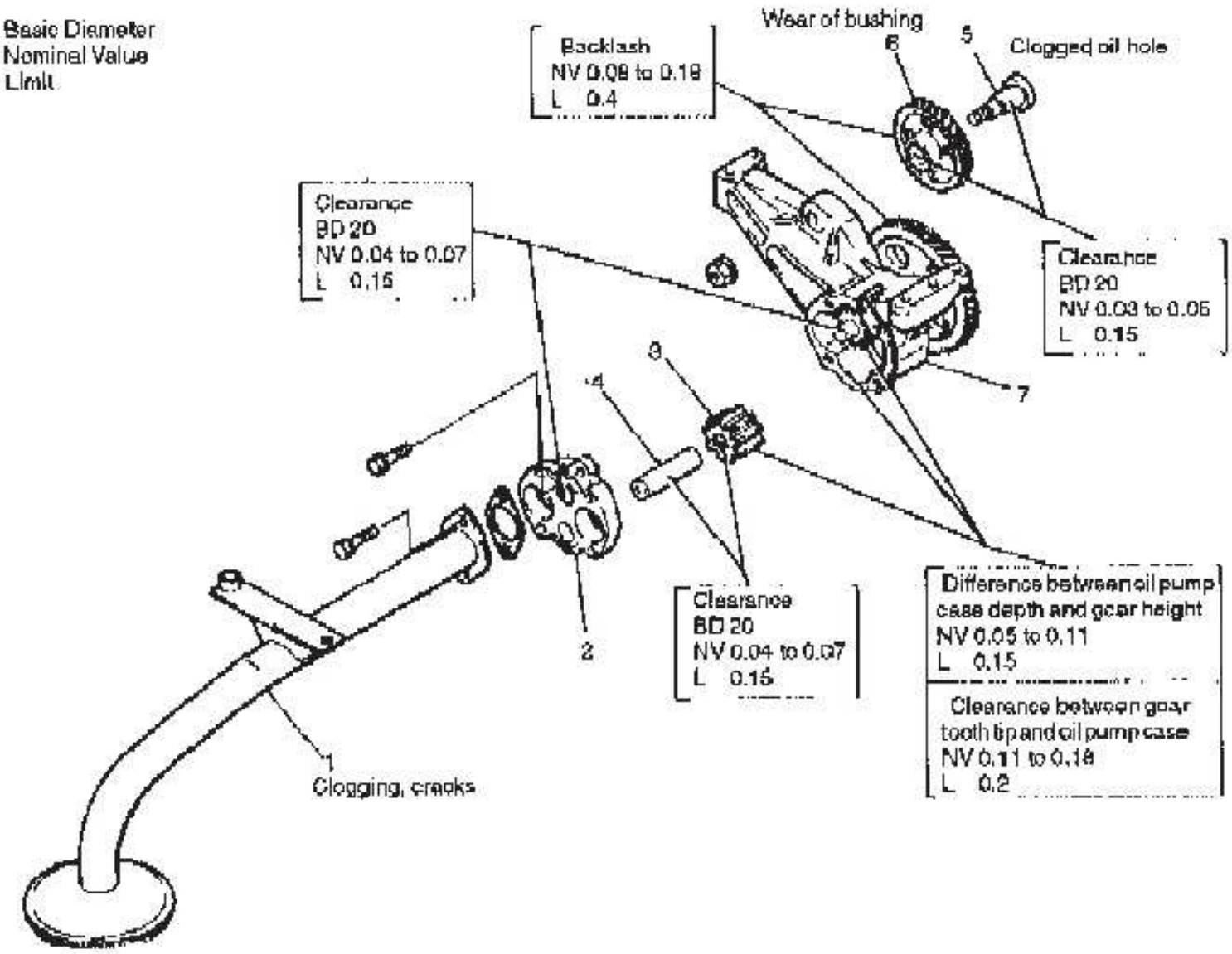


1. Oil strainer
2. Oil pump cover
3. Driven gear
*4. Driven gear shaft
5. Idler gear shaft
6. Idler gear
7. Seat
8. Spring
9. Ball
10. Case and gear assembly

NOTE:
For parts with an encircled number, refer to Disassembly and Inspection Procedures that follow.
Parts marked with * should not be removed unless defects are evident.
Service items marked with should be checked before disassembly.

D68E0300

<D8A>



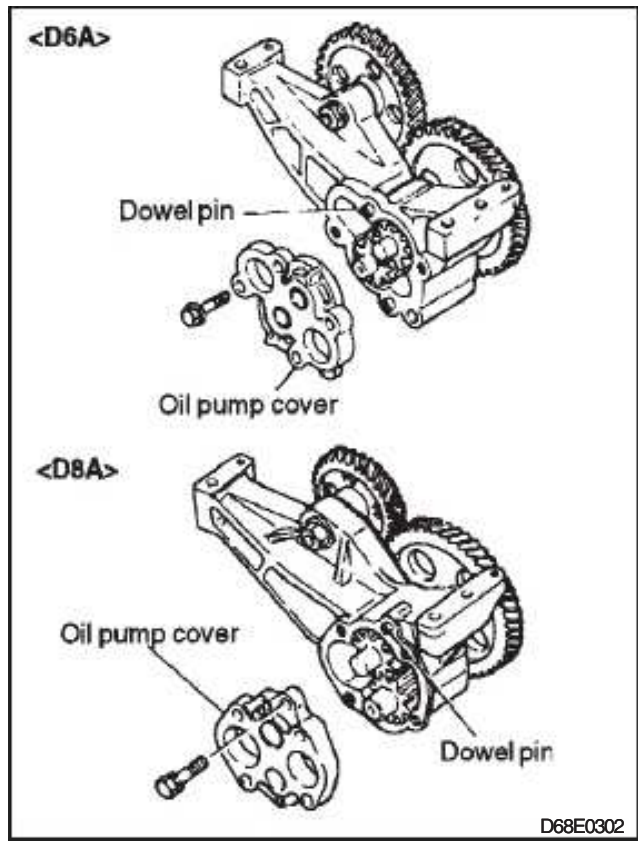
1. Oil strainer
2. Oil pump cover
3. Driven gear
*4. Driven gear shaft
5. Idler shaft
6. Idler gear
7. Case and gear assembly

NOTE:
For parts with an encircled number, refer to Disassembly and Inspection Procedures that follow.
Parts marked with * should not be removed unless defects are evident.
Service items marked with should be checked before disassembly.

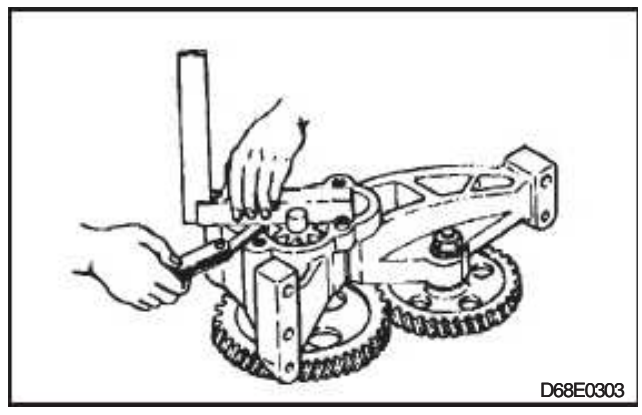
D68E0301

Disassembly and Inspection Procedures

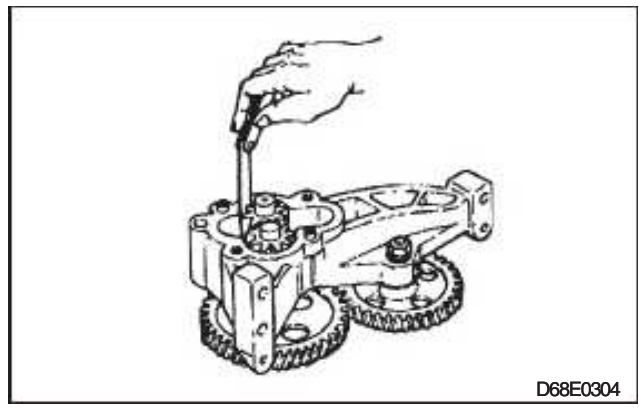
1. Removal of oil pump cover
   The oil pump cover is positioned with the dowel pin of the oil pump case.
   To remove the oil pump cover, tap on it with a plastic hammer or the like.



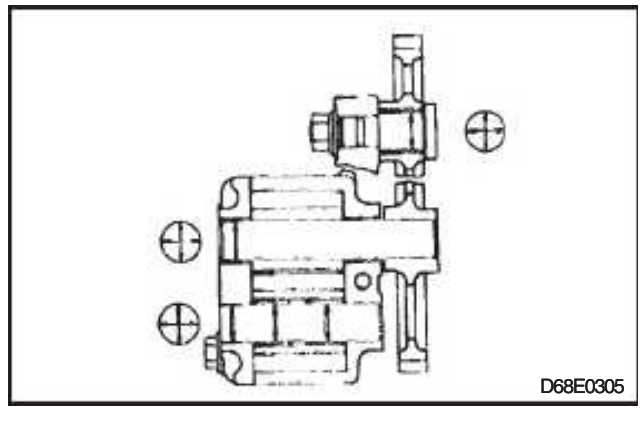
2. Difference between oil pump case depth and gear height
   If the measurement exceeds the limit, replace the gear. Note, however, that the drive gear must be replaced with a case and gear assembly.



3. Gear tooth end to oil pump case clearance
   If the measurement exceeds the limit, replace the gear. Note, however, that the drive gear must be replaced with a case and gear assembly.

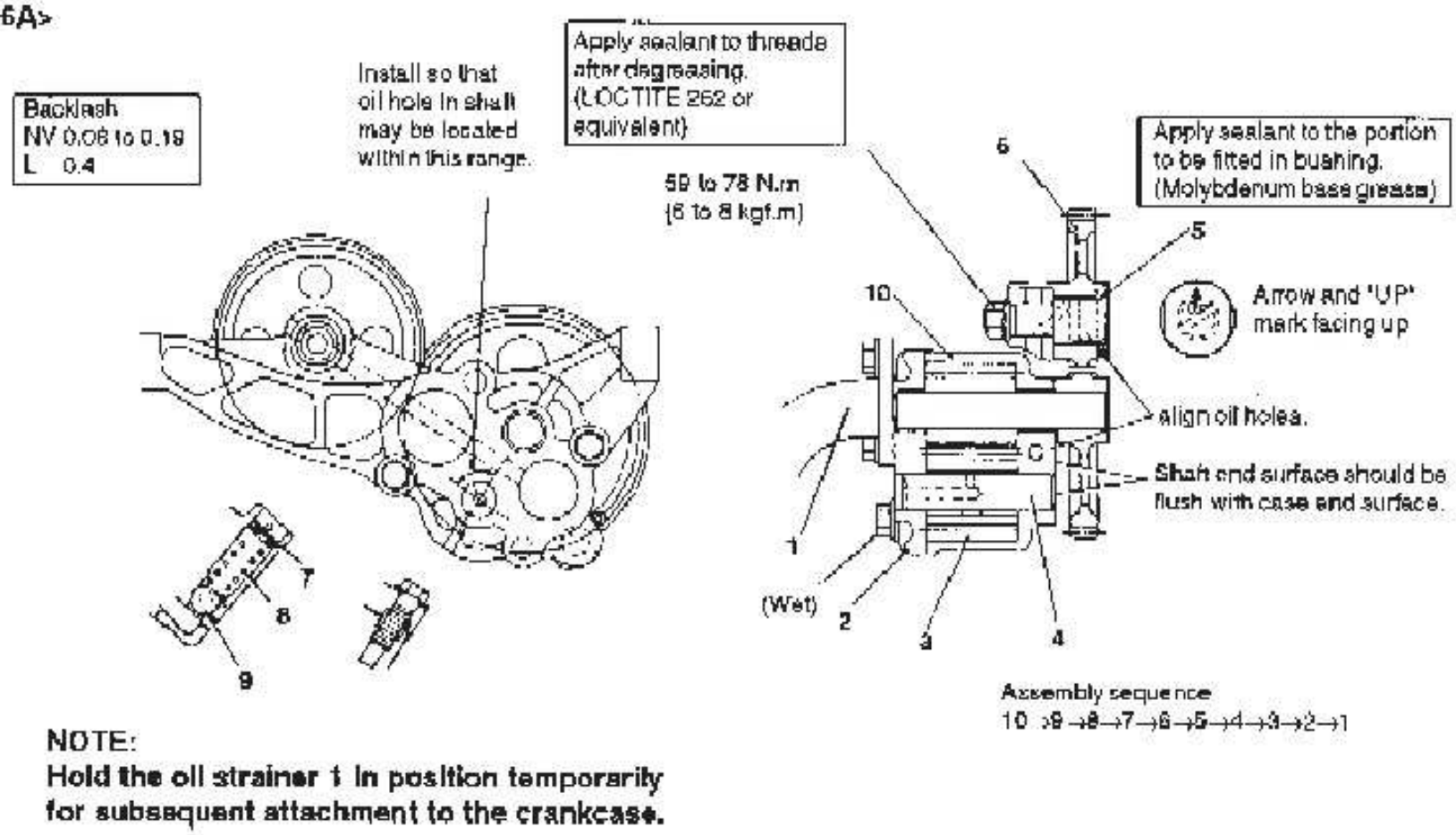


4. Gear shaft to case, cover, and driven gear clearance
   If the measurement exceeds the limit, replace the part to which bushing is installed.



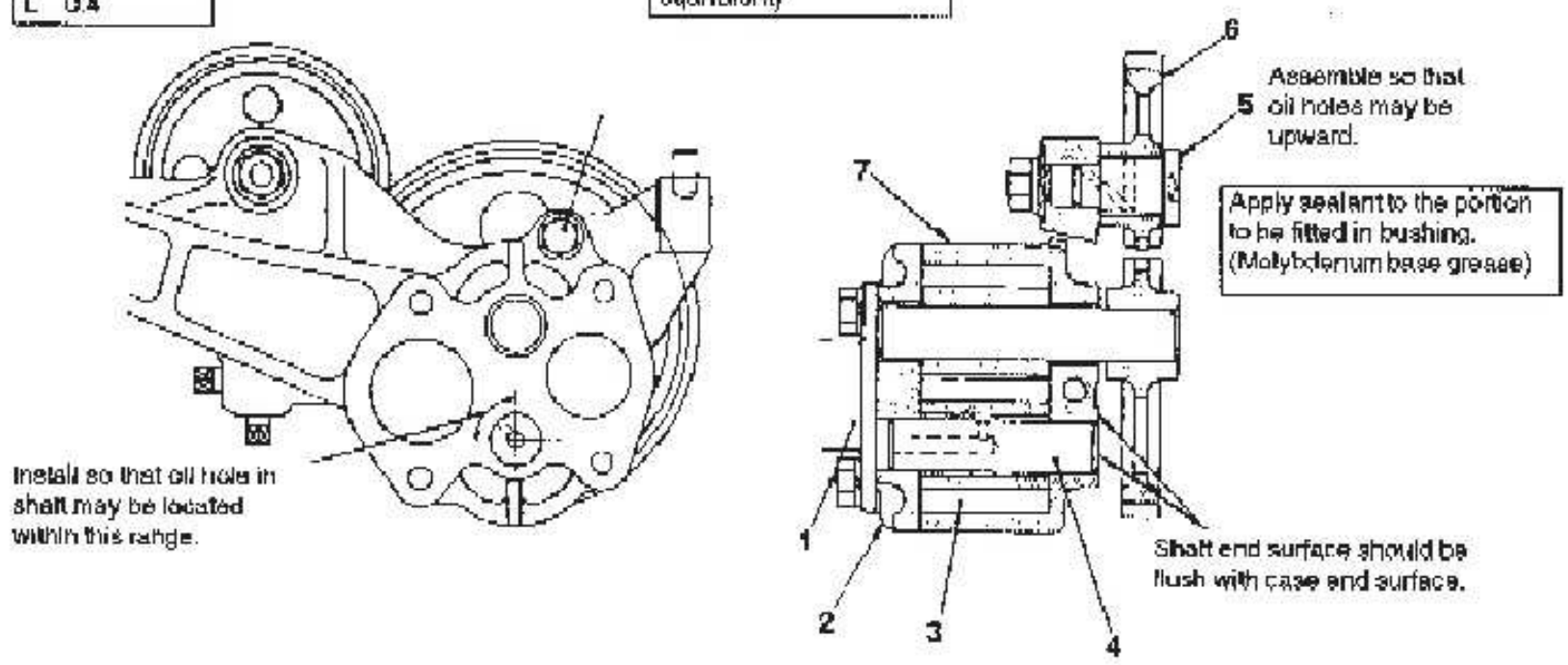
Reassembly

<D6A>



NOTE:
Hold the oil strainer 1 in position temporarily for subsequent attachment to the crankcase.

<D9A>



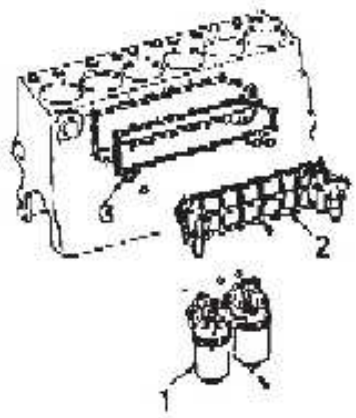
NOTE:
Hold the oil strainer 1 in position temporarily for subsequent attachment to the crankcase.

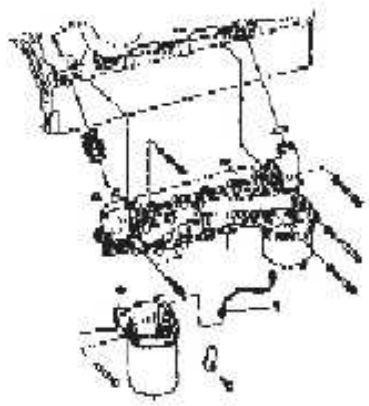
D68E0306

OIL FILTER AND OIL COOLER

Removal and installation

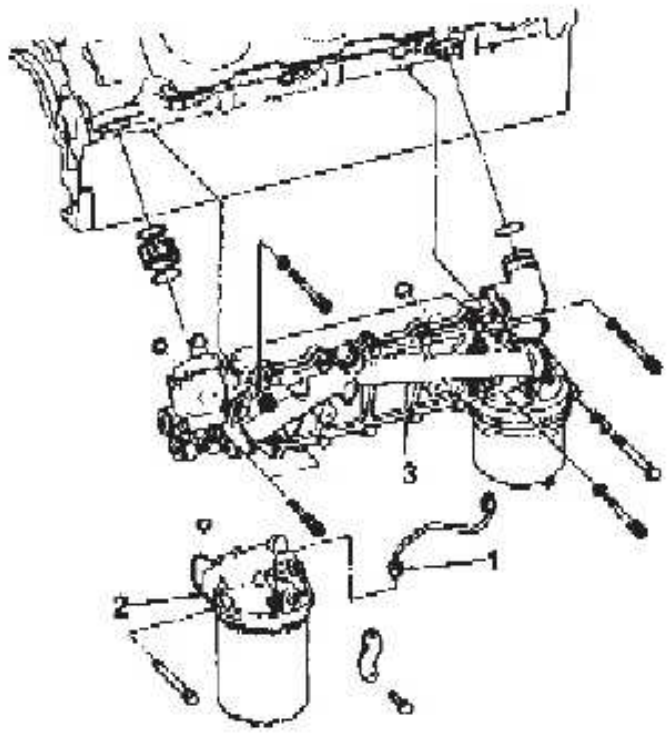
<D6A>





1. Oil filter
2. Oil cooler
3. Gasket

<D8A>



1. Oil pipe
2. Bypass oil filter
3. Oil cooler and Oil filter

NOTE

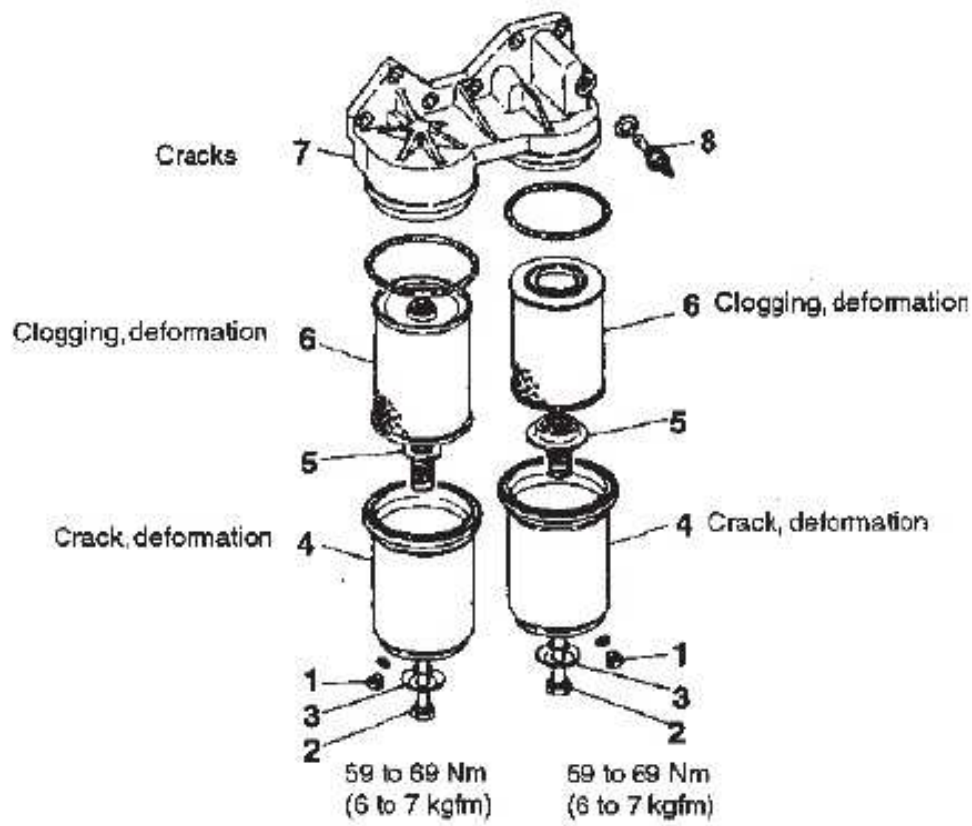
1. **Apply engine oil to the O-ring upon reinstallation, provided that any grease or engine oil should never be applied to the O-rings at the water inlet and outlet of the oil cooler fo D8A engine.**
2. **After installation, run the engine and check for possible oil and water leak.**

D68E0307

Oil filter

1. Disassembly and reassembly
   NOTE
   1) Replace the oil filter element (bypass filter, fullflow filter) at the time of engine oil replacement.
   2) For inspection of the oil bypass alarm, refer to Group 90.

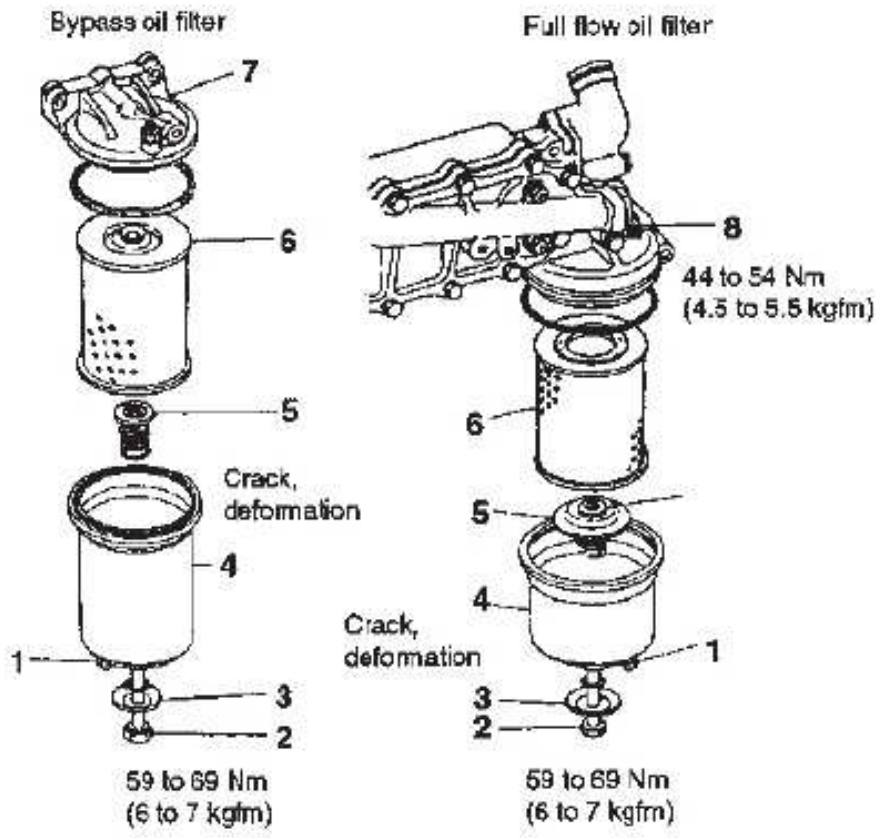
<D6A>



1. Drain plug
2. Center bolt
3. Washer
4. Oil filter case
5. Springretainer
6. Oil filter element
7. Oil filter head
8. Oil bypass alarm

D68E0308

<D8A>



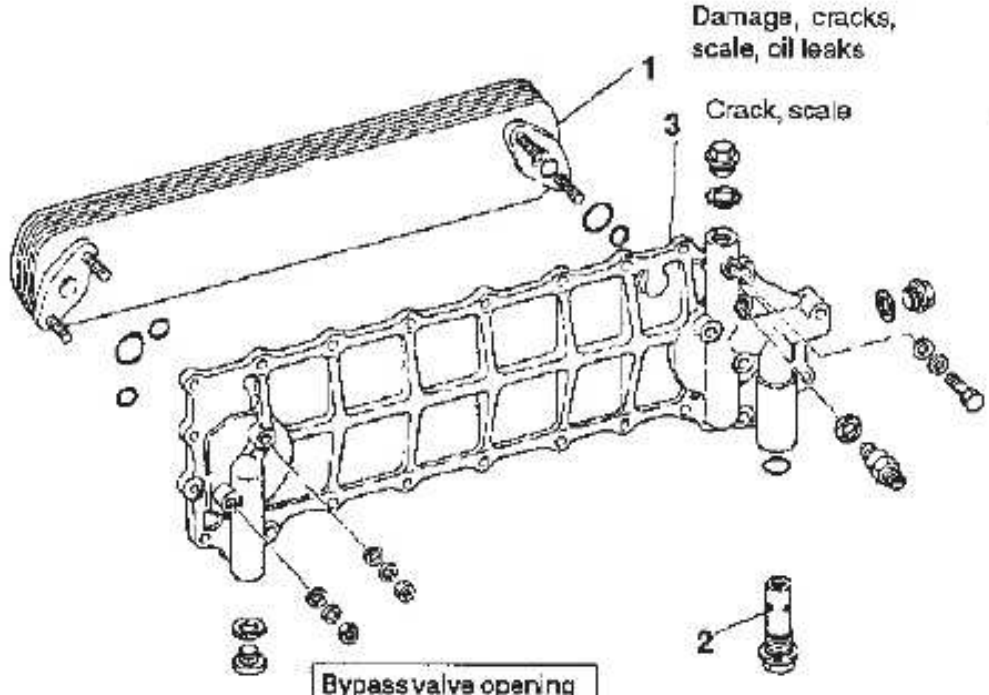
1. Drain plug
2. Center bolt
3. Washer
4. Oil filter case
5. Springretainer
6. Oil filter element
7. Oil filter head
8. Oil bypass alarm

D68E0309

Oil cooler

1.Disassembly and reassembly

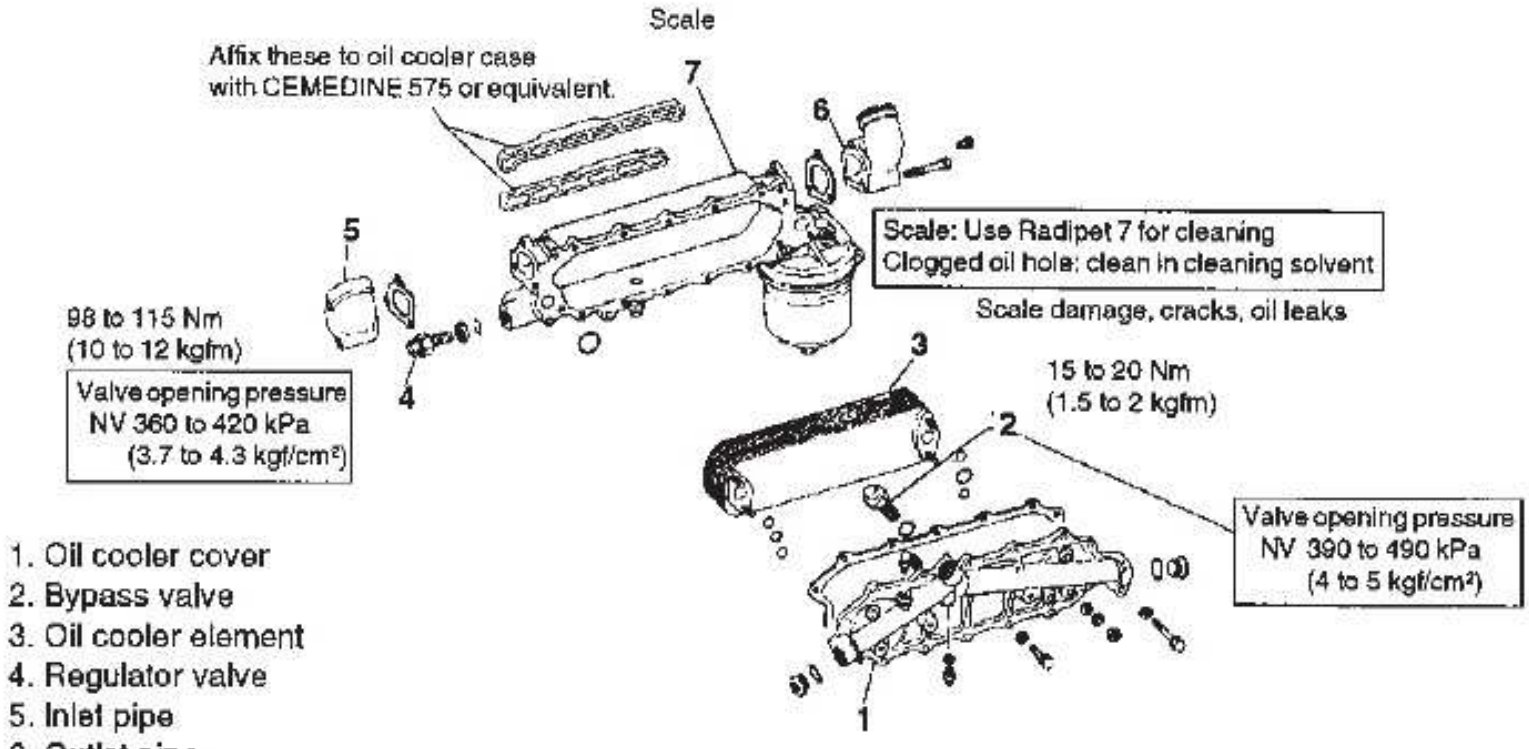
<D6A>



1. Oil cooler cover
2. Bypass valve
3. Oil cooler element

D68E0310

<D8A>



1. Oil cooler cover
2. Bypass valve
3. Oil cooler element
4. Regulator valve
5. Inlet pipe
6. Outlet pipe
7. Oil cooler case

D68E0311

2.Cleaning

Check for carbon or sludge deposited in the oil passage of the oil cooler element and bypass valve. if contamination is evident, wash in a cleaning oil.

If much scale is evident on the element and cover, wash with tap water (preferably hot water)

3. Pressure resistance test

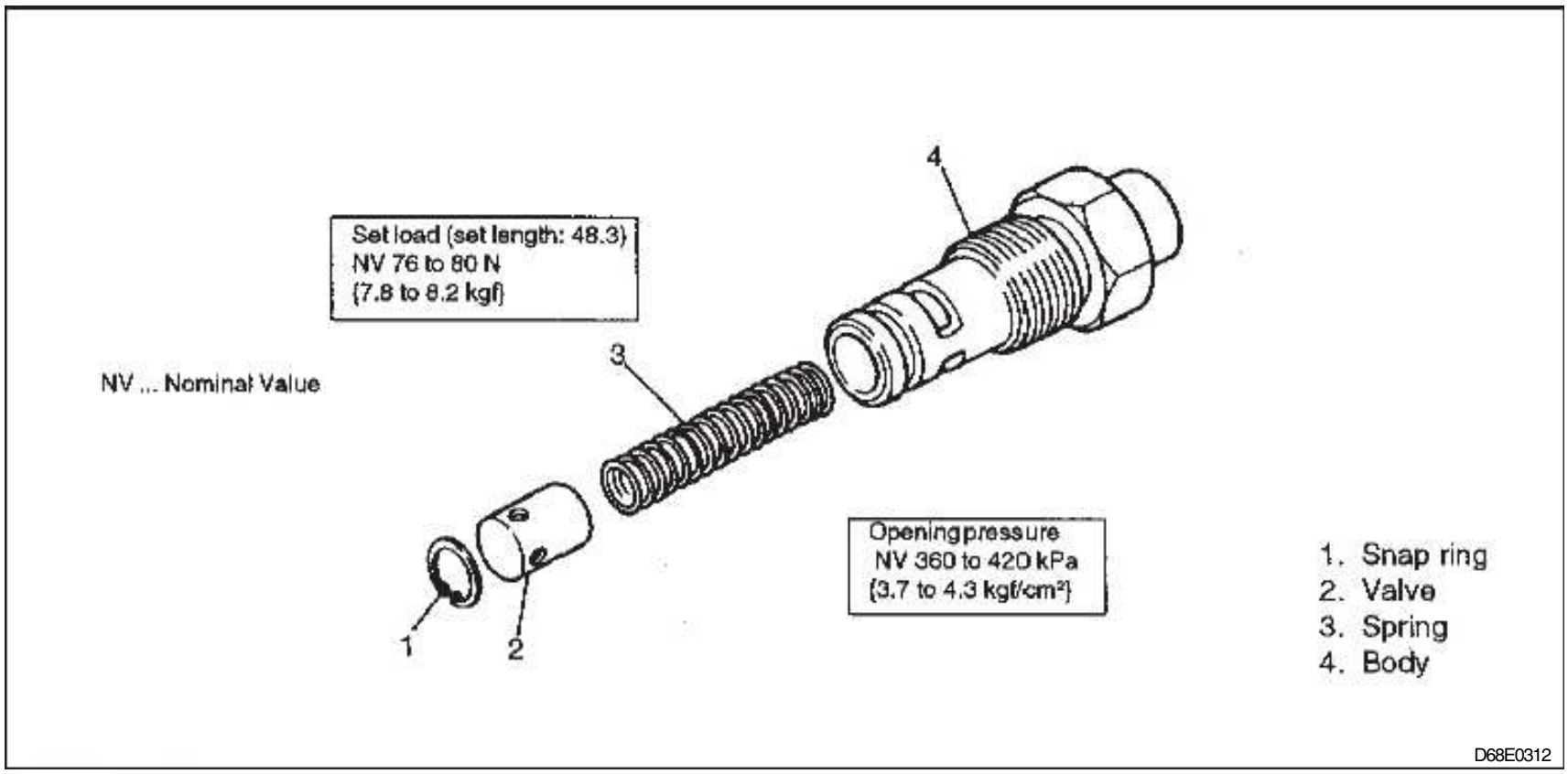
Conduct the pressure resistance test to check for oil leak caused by damaged or cracked element

NOTE

Never attempt to apply pressure exceeding the specified test pressure.

Check for possible leak by applying a 1470 kPa {15kgf/cm²} air pressure to the element. Replace the element if air or oil leak or any other faulty condition is evident as a result of the test.

Regulator Valve



Regulator valve installed position

D6A Crankcase, left side

D8A Oil cooler case