

ENGINE

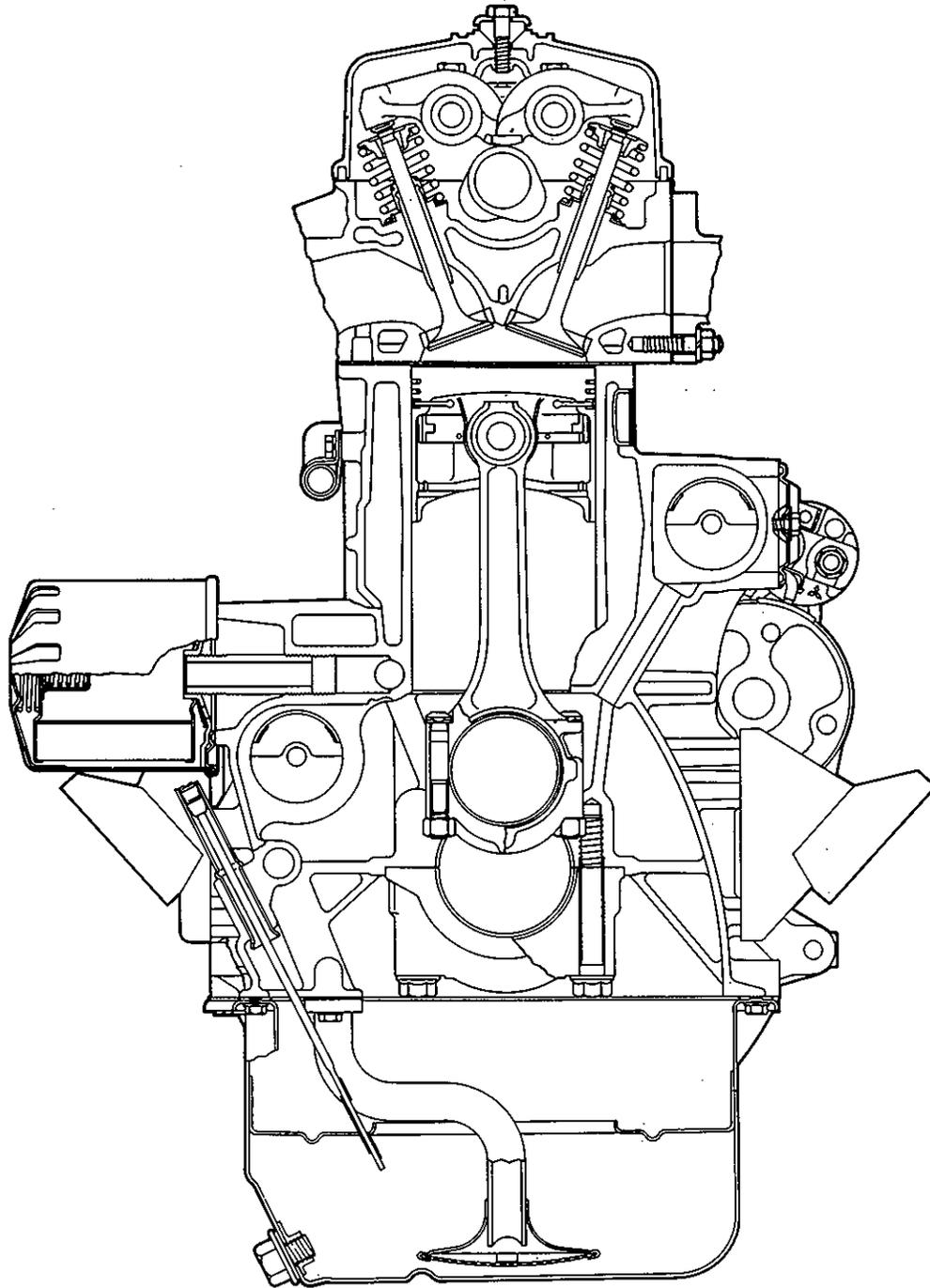
4G5 SERIES

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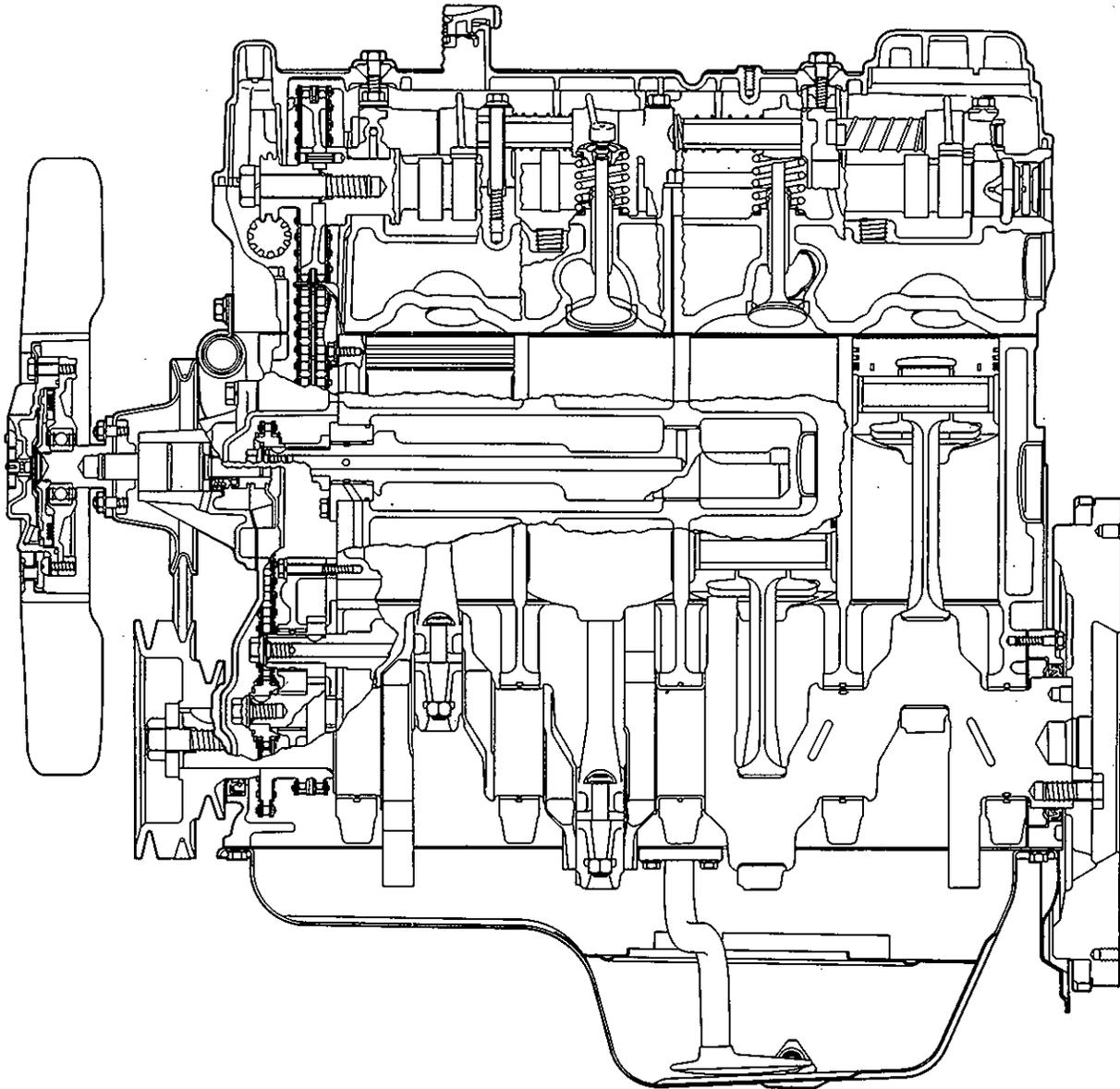
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GENERAL INFORMATION

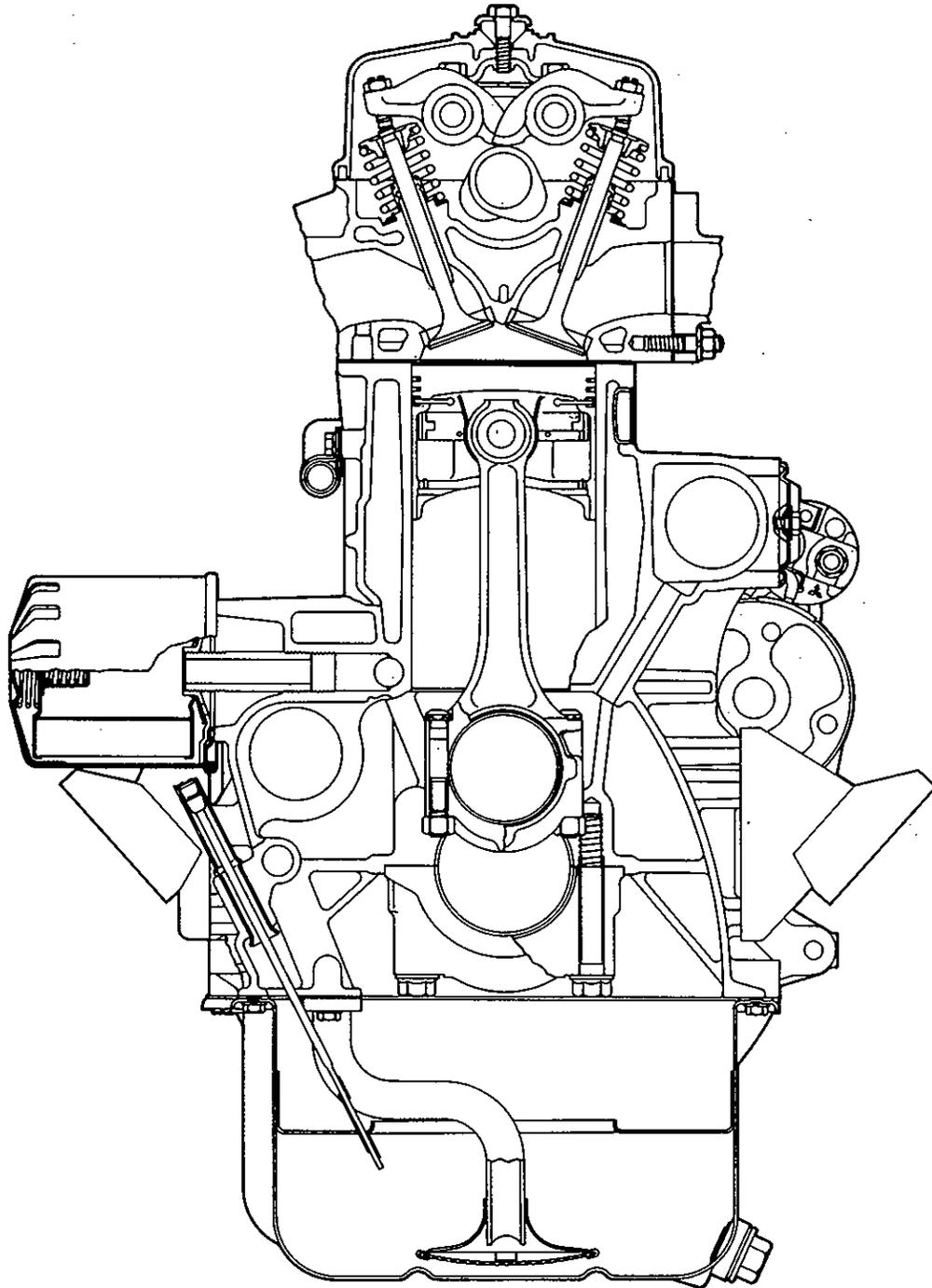
ENGINE SECTIONAL VIEW – ENGINE WITH SILENT SHAFT

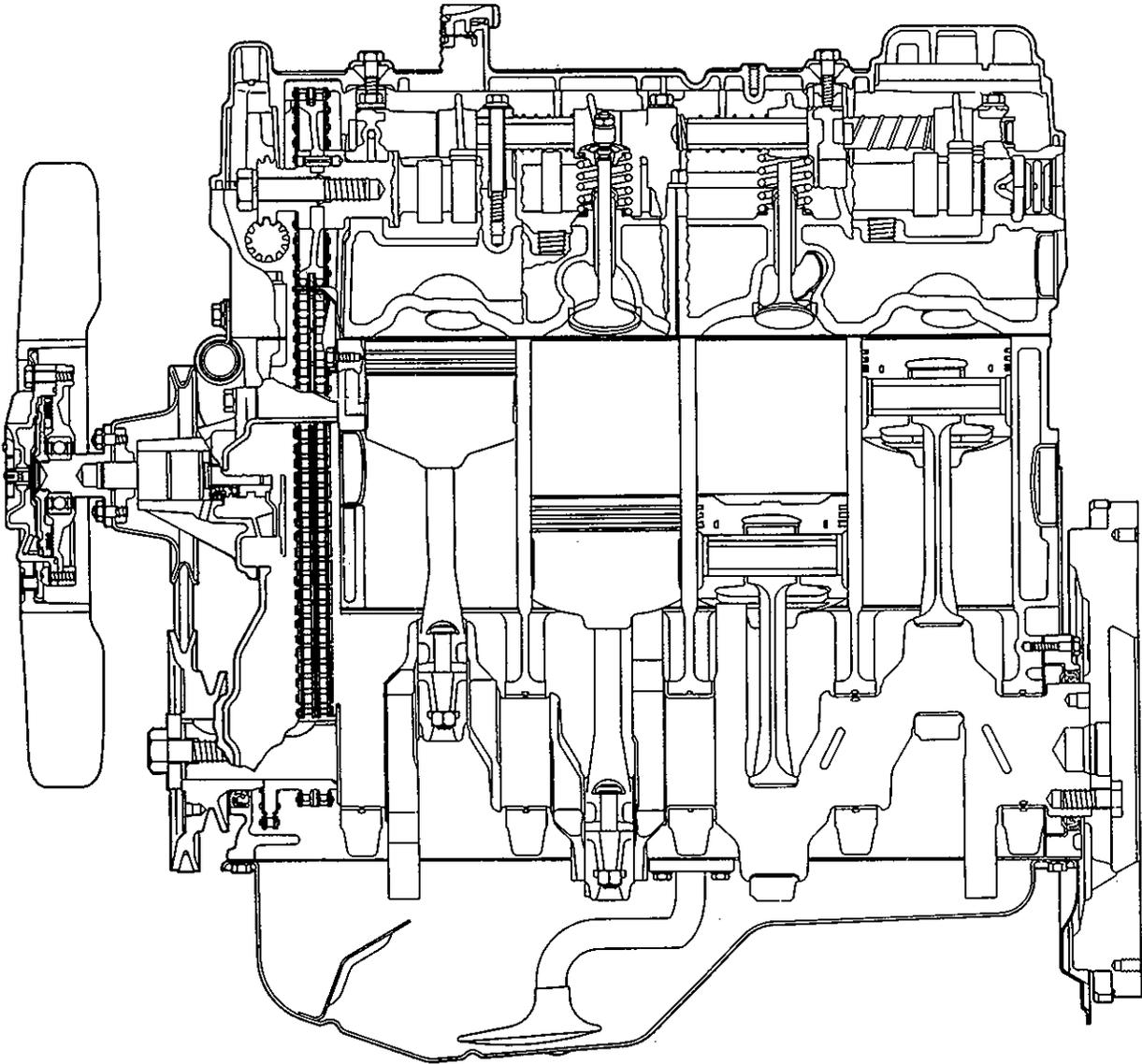


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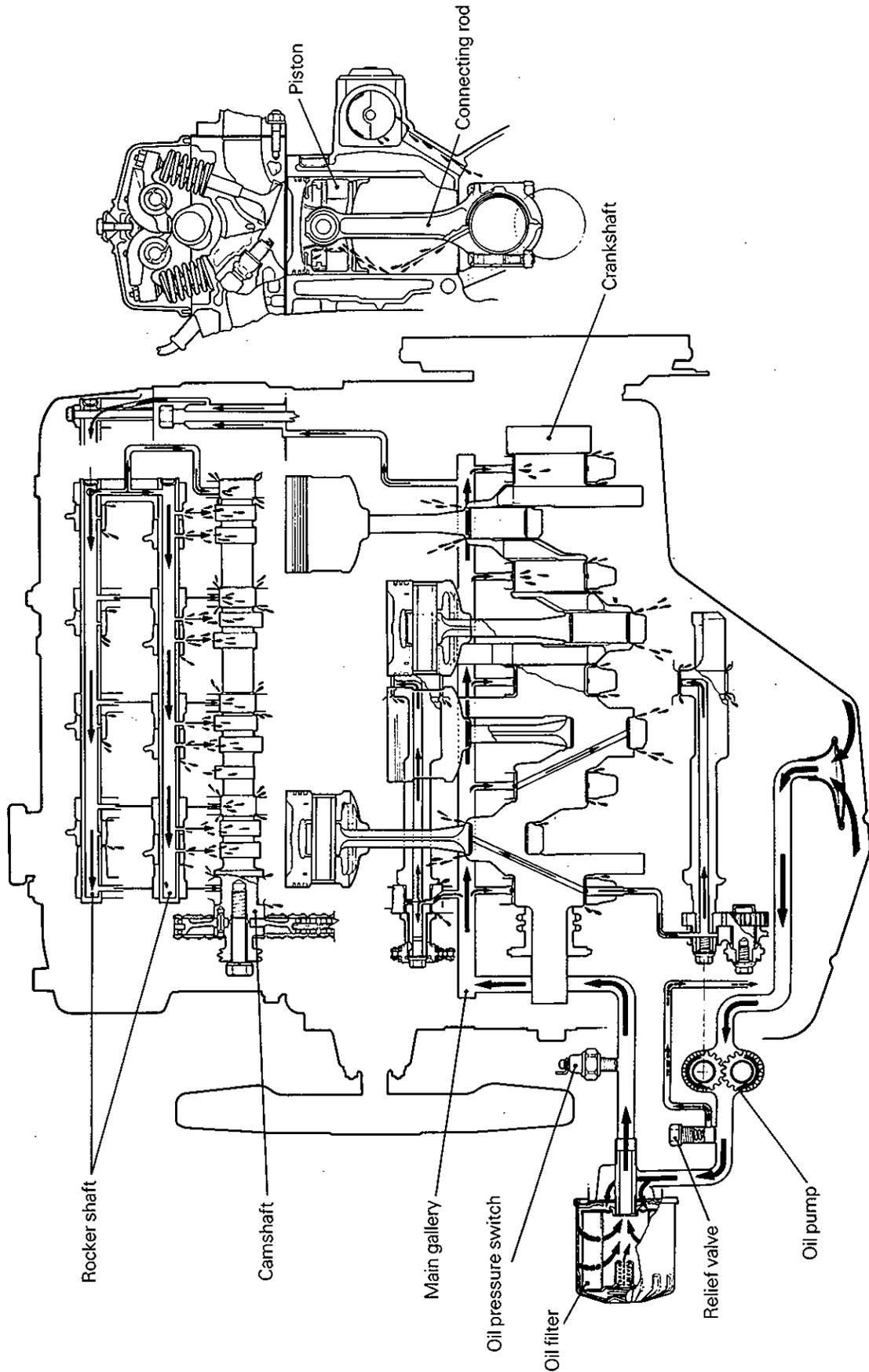


ENGINE SECTIONAL VIEW – ENGINE WITHOUT SILENT SHAFT

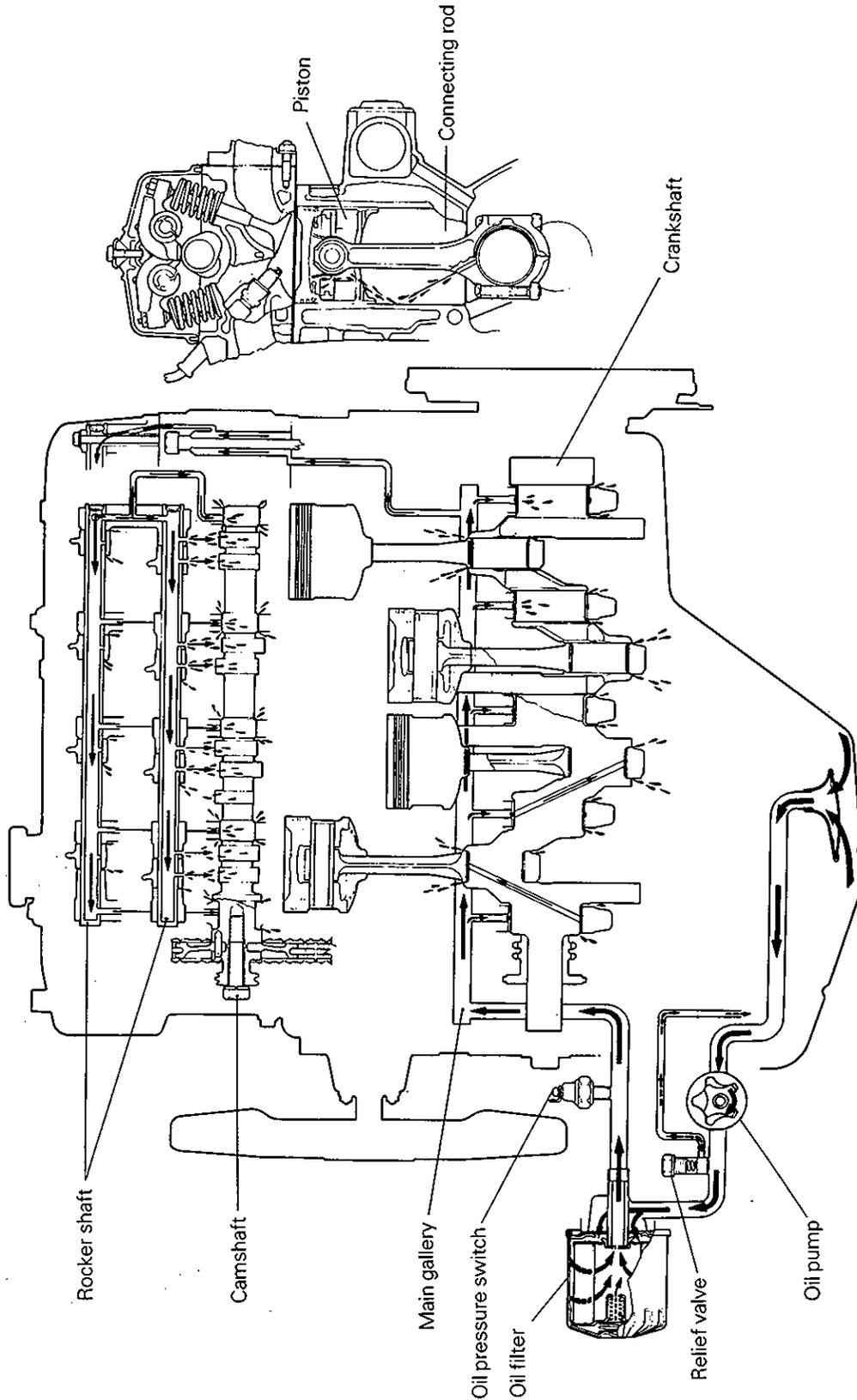




LUBRICATION SYSTEM - ENGINE WITH SILENT SHAFT



LUBRICATION SYSTEM – ENGINE WITHOUT SILENT SHAFT



1. SPECIFICATIONS**GENERAL SPECIFICATIONS**

Description	Specifications
Type	In-line OHV, SOHC
Number of cylinders	4
Combustion chamber	Compact type
Total displacement	2,555 cc (155.92 cu.in.)
Cylinder bore	91.1 mm (3.59 in.)
Piston stroke	98 mm (3.86 in.)
Compression ratio	8.2
Valve timing:	
Intake valve	
Opens	25° BTDC
Closes	59° ABDC
Exhaust valve	
Opens	64° BBDC
Closes	20° ATDC
Lubrication system	Pressure feed, full-flow filtration
Oil pump type	
Engine with silent shaft	Involute gear type
Engine without silent shaft	Trochoid type
Cooling system	Water-cooled forced circulation
Water pump type	Centrifugal impeller type

SERVICE SPECIFICATIONS

mm (in.)

	Standard	Limit
Cylinder head		
Flatness of gasket surface	0.05 (0.0020)	0.2 (0.008)
Grinding limit		*0.2 (0.008)
*If cylinder block gasket surface has already been ground, thickness of the removed stock should be included in the grinding limit of -0.2 mm (-0.008 in.).		
Flatness of manifold mounting surface	0.15 (0.0059)	0.3 (0.012)
Overall height	89.9 – 90.1 (3.539 – 3.547)	89.7 (3.531)
Oversize rework dimensions of valve guide hole (both intake and exhaust)		
0.05	13.05 – 13.07 (0.5138 – 0.5146)	
0.25	13.25 – 13.27 (0.5217 – 0.5224)	
0.50	13.50 – 13.52 (0.5315 – 0.5323)	
Oversize rework dimensions of intake valve seat ring hole		
0.30	47.30 – 47.33 (1.8622 – 1.8634)	
0.60	47.60 – 47.63 (1.8740 – 1.8752)	
Oversize rework dimensions of exhaust valve seat ring hole		
0.30	40.30 – 40.33 (1.5866 – 1.5878)	
0.60	40.60 – 40.63 (1.5984 – 1.5996)	
Camshaft – Identification mark: 6		
Cam height		
Intake	42.50 (1.6732)	42.00 (1.6535)
Exhaust	42.56 (1.6756)	42.06 (1.6559)
Camshaft – Identification mark: A		
Cam height		
Intake	42.43 (1.6705)	41.93 (1.6508)
Exhaust	42.43 (1.6705)	41.93 (1.6508)
NOTE: The camshaft identification mark is stamped on the rear end of the camshaft.		
Fuel pump driving cam diameter	37 (1.46)	36.5 (1.437)
Journal diameter	33.94 – 33.95 (1.3362 – 1.3366)	
Oil clearance	0.05 – 0.09 (0.0020 – 0.0035)	
Rocker arm		
I.D.	18.91 – 18.93 (0.7445 – 0.7453)	
Rocker arm-to-shaft clearance	0.01 – 0.04 (0.0004 – 0.0016)	0.1 (0.004)
Rocker shaft		
O.D.	18.89 – 18.90 (0.7437 – 0.7441)	
Overall length		
Intake	402.5 (15.846)	
Exhaust	406.5 (16.004)	

mm (in.)

	Standard	Limit
Valve		
Overall length		
Intake	108.0 (4.250)	
Exhaust	105.9 (4.168)	
Stem diameter		
Intake	7.96 – 7.98 (0.3134 – 0.3142)	
Exhaust	7.93 – 7.95 (0.3122 – 0.3130)	
Face angle	45° – 45°30'	
Thickness of valve head (margin)		
Intake	1.2 (0.047)	0.7 (0.028)
Exhaust	2.0 (0.079)	1.5 (0.059)
Stem-to-guide clearance		
Intake	0.03 – 0.06 (0.0012 – 0.0024)	
Exhaust	0.05 – 0.09 (0.0020 – 0.0035)	
Valve spring		
Free height	49.8 (1.961)	48.8 (1.921)
Load/installed height N (kg, lbs.)/mm (in.)	329 (32.9, 73)/40.4 (1.591)	
Out-of-squareness	Max. 2°	4°
Valve guide		
Overall length		
Intake	47 (1.85)	
Exhaust	52 (2.05)	
I.D.	8.00 – 8.02 (0.3150 – 0.3157)	
O.D.	13.06 – 13.07 (0.5142 – 0.5146)	
Service size	0.05 (0.002), 0.25 (0.010), 0.50 (0.020) oversize	
Press-in temperature	Room temperature	
Valve seat		
Seat angle	45°	
Valve contact width		
Intake	0.9 – 1.3 (0.035 – 0.051)	
Exhaust	1.2 – 1.6 (0.047 – 0.063)	
Sinkage		0.2 (0.0079)
Service size	0.3 (0.012), 0.6 (0.024) oversize	
Jet valve		
Overall height	92.53 (3.6429)	
Stem diameter	4.3 (0.169)	
Face angle	45°	
Jet valve spring		
Free height	29.60 (1.1654)	
Load/installed height N (kg, lbs.)/mm (in.)	35 (3.5, 7.7)/21.5 (0.846)	

	Standard	Limit
Silent shaft		
Journal diameter		
Front (left)	22.96 – 22.980 (0.9039 – 0.9047)	
Rear	43.01 – 43.025 (1.6933 – 1.6939)	
Oil clearance		
Front (left)	0.02 – 0.06 (0.0008 – 0.0024)	
Rear	0.06 – 0.10 (0.0024 – 0.0039)	
Piston		
O.D.	91.07 – 91.10 (3.5854 – 3.5866)	
Piston-to-cylinder clearance	0.02 – 0.04 (0.0008 – 0.0016)	
Ring groove width		
No. 1 ring		
Engines for Europe and Australia	1.51 – 1.53 (0.0594 – 0.0602)	
Engines for General Export	2.02 – 2.04 (0.0795 – 0.0803)	
No. 2 ring		
Engines for Europe and Australia	1.51 – 1.53 (0.0594 – 0.0602)	
Engines for General Export	2.01 – 2.03 (0.0791 – 0.0799)	
Oil ring	4.01 – 4.03 (0.1579 – 0.1587)	
Service size	0.25 (0.010), 0.50 (0.020), 0.75 (0.030), 1.00 (0.039) oversize	
Piston ring		
End gap		
No. 1 ring	0.25 – 0.45 (0.0098 – 0.0177)	0.8 (0.031)
No. 2 ring	0.25 – 0.45 (0.0098 – 0.0177)	0.8 (0.031)
Oil ring	0.30 – 0.80 (0.0118 – 0.0315)	1.0 (0.039)
Ring-to-ring groove clearance		
No. 1 ring	0.05 – 0.10 (0.0020 – 0.0039)	
No. 2 ring	0.02 – 0.06 (0.0008 – 0.0024)	
Service size	0.25 (0.010), 0.50 (0.020), 0.75 (0.030), 1.00 (0.039) oversize	
Piston pin		
O.D.	22.00 – 22.01 (0.8661 – 0.8665)	
Press-in load N (kg, psi)	7,500 – 17,500 (750 – 1,750, 1,653 – 3,858)	
Press-in temperature	Room temperature	
Connecting rod		
Big end center-to-small end center length	165.9 – 166.0 (6.531 – 6.535)	
Bend	0.05 (0.0020)	
Twist	0.1 (0.004)	
Big end side clearance	0.10 – 0.25 (0.0039 – 0.0098)	

mm (in.)

	Standard	Limit
Crankshaft		
End play	0.05 – 0.18 (0.0020 – 0.0071)	0.4 (0.016)
Journal O.D.	60 (2.36)	
Pin O.D.	53 (2.09)	
Out-of-roundness and taper of journal and pin	within 0.01 (0.0004)	
Concentricity of journal	within 0.02 (0.0008)	
Oil clearance of journal	0.02 – 0.05 (0.0008 – 0.0020)	0.1 (0.004)
Oil clearance of pin	0.02 – 0.06 (0.0008 – 0.0024)	0.1 (0.004)
Journal		
0.25 U.S.	59.74 – 59.75 (2.3520 – 2.3524)	
0.50 U.S.	59.49 – 59.50 (2.3421 – 2.3425)	
0.75 U.S.	59.24 – 59.25 (2.3323 – 2.3327)	
Pin		
0.25 U.S.	52.74 – 52.75 (2.0764 – 2.0768)	
0.50 U.S.	52.49 – 52.50 (2.0665 – 2.0669)	
0.75 U.S.	52.24 – 52.25 (2.0567 – 2.0571)	
Cylinder block		
I.D.	91.10 – 91.13 (3.5866 – 3.5878)	
Flatness of gasket surface	0.05 (0.020)	0.1 (0.004)
Grinding limit		*0.2 (0.008)
*If cylinder head gasket surface has already been ground, thickness of the removed stock should be included in the grinding limit of –0.2 mm (–0.008 in.).		
Overall height	315.95 – 316.05 (12.4390 – 12.4429)	
Flywheel		
Runout		0.13 (0.0051)
Valve clearance		
Intake	0.07 (0.0028)	
Exhaust	0.17 (0.0067)	
Oil pump (Involute gear type)		
Tip clearance	0.11 – 0.15 (0.0043 – 0.0059)	0.20 (0.008)
Side clearance		
Drive gear	0.05 – 0.11 (0.0020 – 0.0043)	0.15 (0.006)
Driven gear	0.04 – 0.10 (0.0016 – 0.0039)	0.15 (0.006)
Oil pump (Trochoid type)		
Tip clearance	0.04 – 0.15 (0.0016 – 0.0059)	0.20 (0.008)
Side clearance	0.05 – 0.11 (0.0020 – 0.0043)	0.15 (0.006)
Body clearance	0.10 – 0.17 (0.0039 – 0.0067)	0.20 (0.008)
Drive belt		
Deflection	9 – 12 (0.350 – 0.472)	

TORQUE SPECIFICATIONS

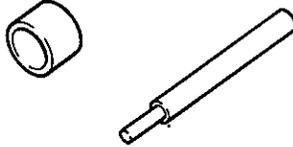
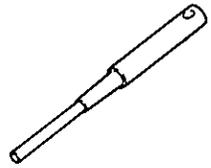
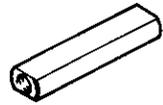
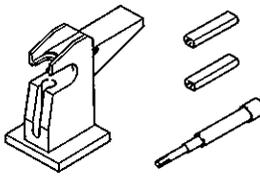
	Nm	Torque kgm	ft.lbs.
Water pump and exhaust manifold			
Cooling fan bolt	9	0.9	7
Water pump pulley bolt	9	0.9	7
Exhaust manifold cover bolt	14	1.4	10
Heat protector bolt	9	0.9	7
Exhaust manifold bolt	18	1.8	13
Water inlet pipe bolt	11	1.1	8
Water pump bolt	14	1.4	10
Intake manifold, rocker cover and oil pan			
Coolant temperature sensor	30	3.0	22
Coolant temperature gauge unit	11	1.1	8
Water outlet fitting bolt	19	1.9	13
Intake manifold bolt and nut	18	1.8	13
Rocker cover bolt	6	0.6	4
Drain plug	40	4.0	29
Oil pan bolt	7	0.7	5
Oil screen bolt	19	1.9	13
Rocker cover assembly and camshaft			
Camshaft sprocket bolt	55	5.5	40
Camshaft bearing cap bolt	20	2.0	14
Camshaft bearing cap bolt, rear	24	2.4	17
Rocker arms and rocker shafts			
Rocker arm lock nut			
Intake and exhaust	15	1.5	11
Jet valve	9	0.9	7
Cylinder head and valves			
Cylinder head bolt	95	9.5	69
Cylinder head flange bolt	19	1.9	13
Jet valve assembly	20	2.0	14
(with engine oil applied to threads and seat surface)			

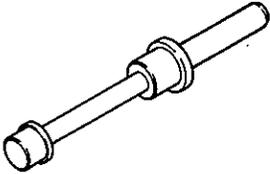
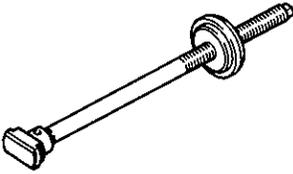
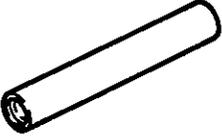
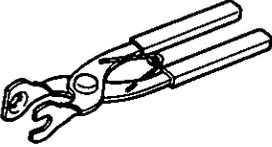
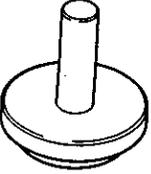
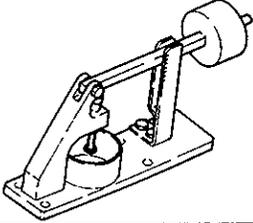
	Nm	Torque kgm	Nm
Timing chain			
Crankshaft bolt	120	12	87
Timing chain case bolt	14	1.4	10
Chain guide access hole cover bolt	11	1.1	8
Chain guide "B" bolt			
Upper	12	1.2	9
Lower	19	1.9	13
Chain guide "A" and "C" bolt	11	1.1	8
Oil pump sprocket bolt			
Engine with silent shaft	65	6.5	47
Engine without silent shaft	35	3.5	25
Silent shaft sprocket bolt	65	6.5	47
Loose side and tension side chain guide bolt	16	1.6	11
Sprocket holder bolt	16	1.6	11
Oil pump and silent shaft			
Oil relief valve plug	38	3.8	27
Oil pump bolt	11	1.1	8
Right silent shaft bolt	65	6.5	47
Thrust plate bolt	11	1.1	8
Piston and connecting rod			
Connecting rod bearing cap nut	47	4.7	34
Crankshaft, flywheel and drive plate			
Flywheel and drive plate bolt	135	13.5	98
Oil seal case bolt	11	1.1	8
Bearing cap bolt	80	8.0	58
Cylinder block			
Engine support bracket bolt	55	5.5	40
Oil pressure switch	19	1.9	13
Silent shaft chamber cover bolt	6	0.6	4

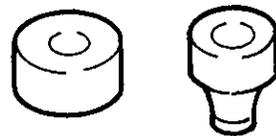
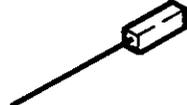
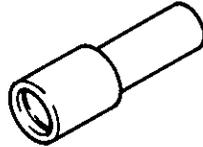
SEALANT

	Specified sealant	Quantity
Engine coolant temperature sensor	3M Nut Locking Part No. 4171 or equivalent	As required
Engine coolant temperature gauge unit	3M ATD Part No. 8660 or equivalent	As required
Semi-circular packing	3M ATD Part No. 8860 or equivalent	As required
Cylinder head gasket surface and oil pan gasket surface at butt joint between rear oil seal and cylinder block	3M ATD Part No. 8860 or equivalent	As required
Oil pan gasket surface at butt joint	3M ATD Part No. 8860 or equivalent	As required
Oil pan gasket surface at butt joint between rear oil seal and cylinder block		
Oil pressure switch threads	3M ATD Part No. 8660 or equivalent	As required

2. SPECIAL TOOLS

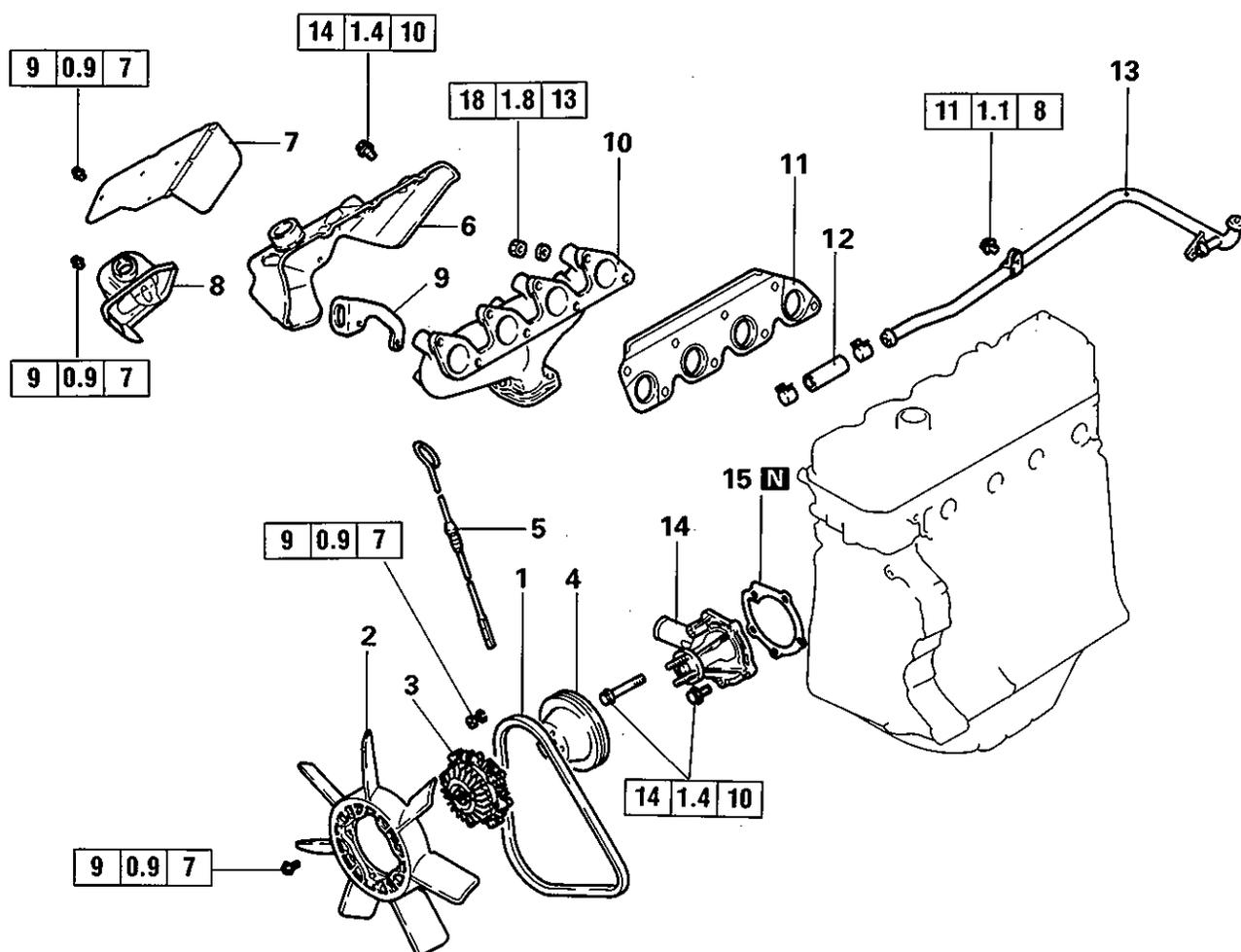
Tool	Number	Name	Use
	MD998002	Valve guide installer	Removal and installation of valve guide
	MD998148	Valve seat cutter pilot	Correction of valve seat
	MD998159 (intake) MD998158 (exhaust)	Valve seat cutter 45°	Correction of valve seat
	MD998165	Valve seat cutter 65°	Correction of valve seat
	MD998175 (intake) MD998173 (exhaust)	Valve seat cutter 30°	Correction of valve seat
	MD998183	Guide	Installation of piston pin [Used in combination with MD998184]
	MD998184	Piston pin setting tool	Removal and installation of piston pin

Tool	Number	Name	Use
	MD998250	Silent shaft bearing installer	Installation of silent shaft rear bearing
	MD998251	Silent shaft bearing pulley	Removal of silent shaft rear bearing
	MD998308	Jet valve stem seal installer	Installation of jet valve stem seal oil seal
	MD998309	Jet valve spring pliers	Compression of jet valve spring
	MD998310	Jet valve socket wrench	Removal and installation of jet valve
	MD998376	Crankshaft rear oil seal installer	Installation of crankshaft rear oil seal
	MD998440	Leak-down tester	Leak-down test of lash adjuster

Tool	Number	Name	Use
	MD998441	Lash adjuster retainer	Bleeding of air inside the adjuster
	MD998442	Air bleed wire	Air bleeding of auto-lash adjuster
	MD998443	Lash adjuster holder	Holding of the lash adjuster to prevent it from falling when rocker shaft assembly is removed or installed
	MD998729	Valve stem seal installer	Installation of valve stem seal

NOTES

3. WATER PUMP AND EXHAUST MANIFOLD



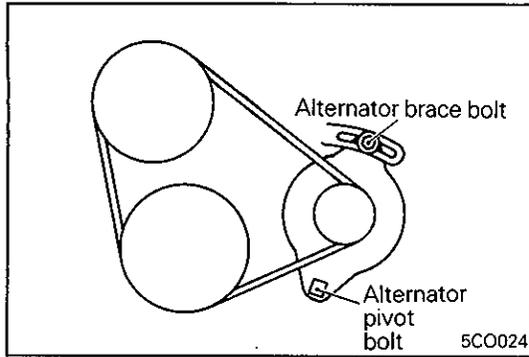
Removal steps

- ▶A▶
1. Drive belt (V type belt)
 2. Cooling fan
 3. Fan clutch
 4. Pulley
 5. Oil level gauge
 6. Exhaust manifold cover*
 7. Heat protector**
 8. Heat cowl**
 9. Engine hanger
 10. Exhaust manifold
 11. Exhaust manifold gasket
 12. Water hose
 13. Water pipe
 14. Water pump
 15. Water pump gasket

NOTE

*: Engines for Europe and Australia

**: Engines for General Export

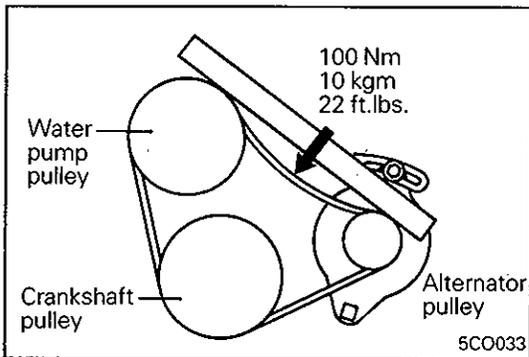


SERVICE POINT OF INSTALLATION

◆A◆ ADJUSTMENT OF DRIVE BELT TENSION

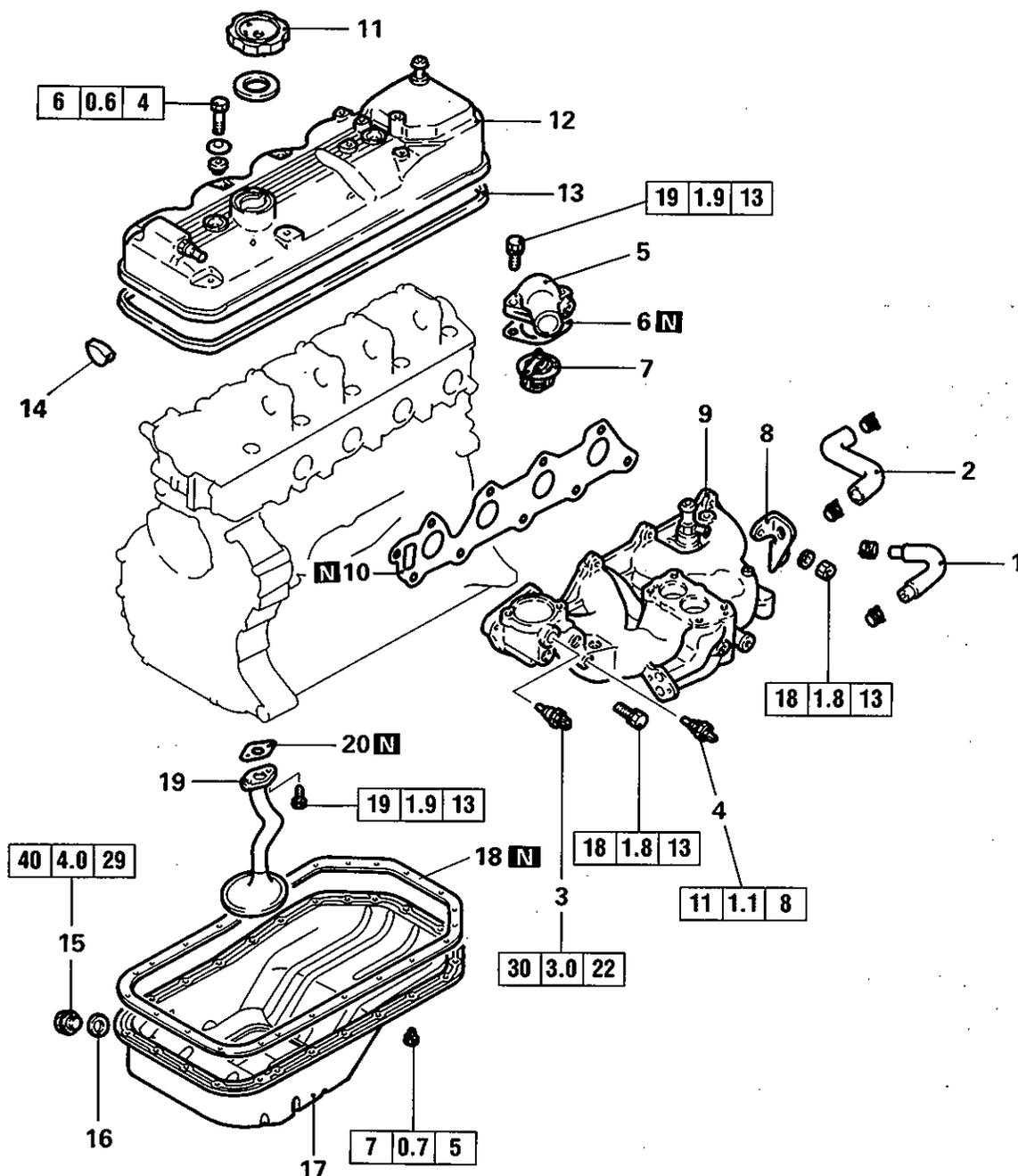
- (1) Loosen the nut for alternator pivot bolt.
- (2) Loosen alternator brace bolt.
- (3) Move the alternator to give greater tension to the belt so that the specified deflection is obtained.

Standard value: 9 – 12 mm (0.35 – 0.47 in.)



- (4) Tighten alternator brace bolt.
- (5) Tighten nut for alternator pivot bolt.

4. INTAKE MANIFOLD, ROCKER COVER AND OIL PAN REMOVAL AND INSTALLATION

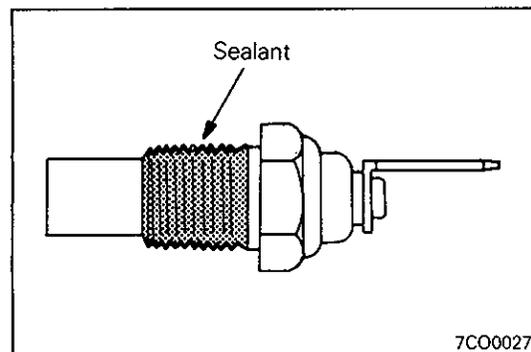
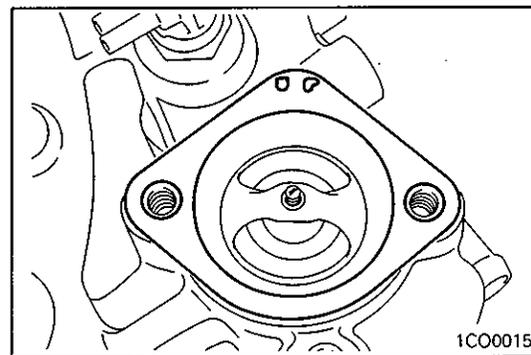
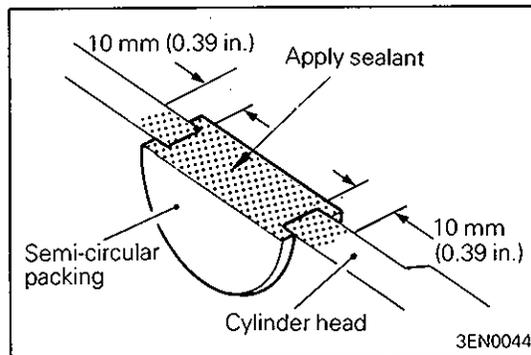
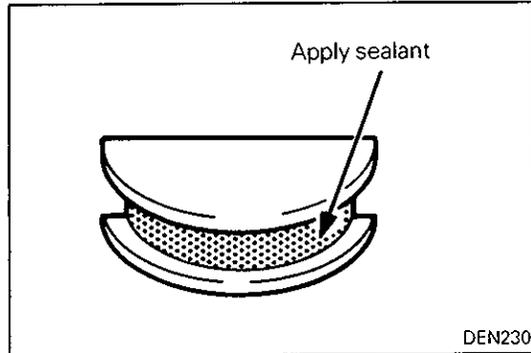
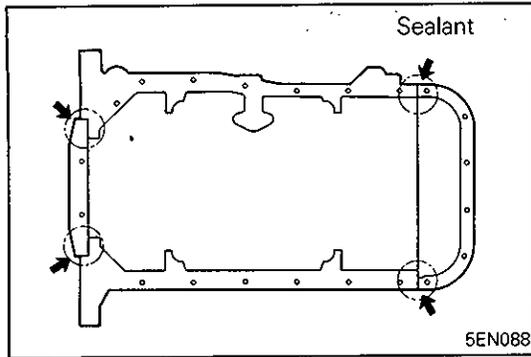


Removal steps

- | | |
|---------------------------------------|-------------------------------|
| 1. Water hose | 12. Rocker cover |
| 2. Water bypass hose | 13. Rocker cover gasket |
| ▶E▶ 3. Coolant temperature sensor* | ▶B▶ 14. Semi-circular packing |
| ▶D▶ 4. Coolant temperature gauge unit | 15. Drain plug |
| ▶C▶ 5. Water outlet fitting | 16. Drain plug gasket |
| 6. Water outlet fitting gasket | ▶A▶ 17. Oil pan |
| 7. Thermostat | ▶A▶ 18. Oil pan gasket |
| 8. Engine hanger | 19. Oil screen |
| 9. Intake manifold | 20. Oil screen gasket |
| 10. Intake manifold gasket | |
| 11. Oil filler cap | |

NOTE

*: Engines with electronic control carburetor



SERVICE POINTS OF INSTALLATION

▶A◀ INSTALLATION OF GASKET / OIL PAN

- (1) Clean both gasket surfaces of cylinder block and oil pan.
- (2) If chain case gaskets protrude from cylinder block bottom surface, remove such portions using a knife.
- (3) Apply sealant to cylinder block bottom where it joins with chain case and rear oil seal case.

Specified sealant:

3M ATD Part No. 8660 or equivalent

- (4) Install oil pan with gasket. Tighten bolts in diagonal order beginning at end. Use care not to overtighten as it could force gasket out, resulting in oil leaks.

▶B◀ APPLICATION OF SEALANT ON SEMI-CIRCULAR PACKING

Specified sealant:

3M ATD Part No. 8660 or equivalent

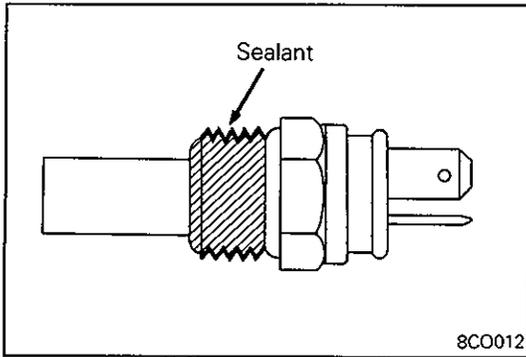
▶C◀ INSTALLATION OF WATER OUTLET FITTING GASKET FOR RUBBER COATED METAL GASKET ONLY

- (1) Install the water outlet fitting gasket with its "UP" mark facing up (toward the water outlet fitting side).

▶D◀ APPLICATION OF SEALANT TO COOLANT TEMPERATURE GAUGE UNIT

Specified sealant:

3M ATD Part No. 8660 or equivalent



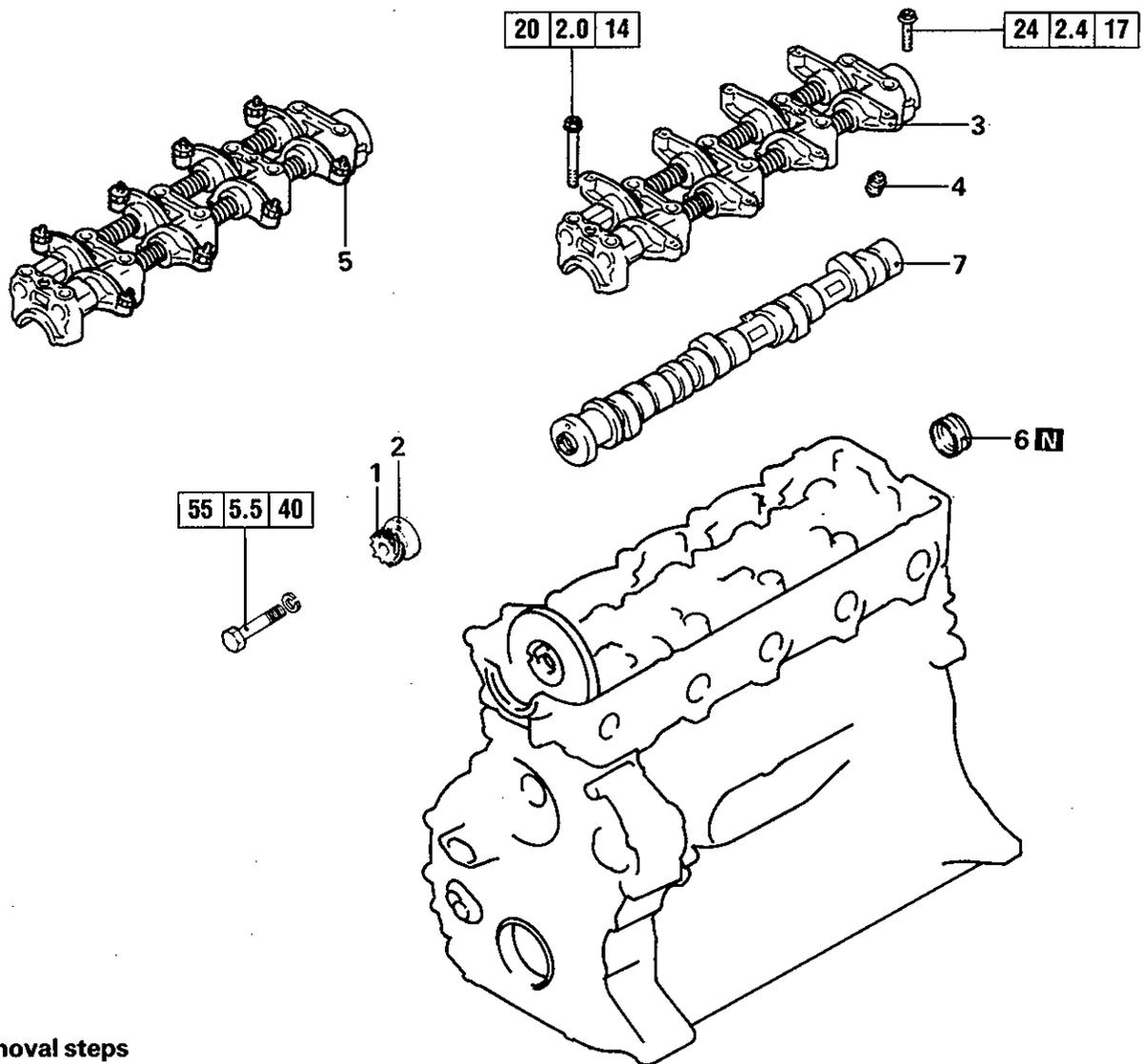
⇨E⇨ APPLICATION OF SEALANT TO COOLANT TEMPERATURE SENSOR

Specified sealant:
3M Nut Locking Part No. 4171 or equivalent

NOTES

5. ROCKER ARMS AND CAMSHAFT

REMOVAL AND INSTALLATION

**Removal steps**

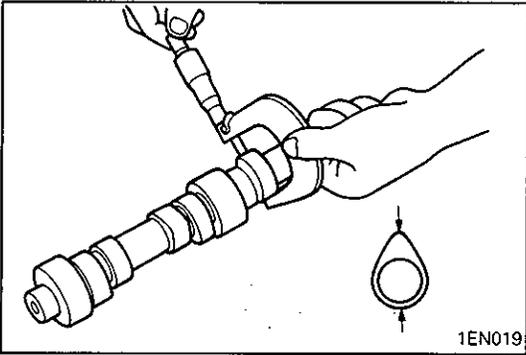
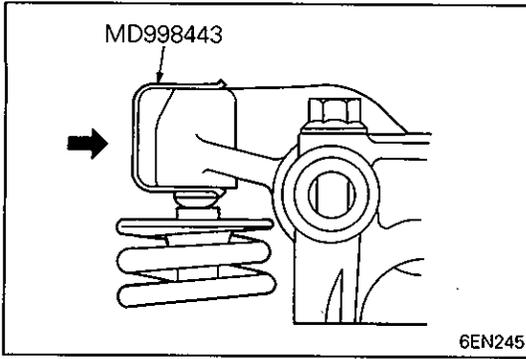
1. Distributor gear
2. Special washer
3. Rocker arms and shafts*
- ▶A▶ 4. Lash adjuster
5. Rocker arms and shafts**
6. Circular packing
7. Camshaft

Installation steps

7. Camshaft
- ▶A▶ 6. Circular packing
5. Rocker arms and shafts**
- ▶B▶ 4. Lash adjuster*
3. Rocker arms and shafts**
- ▶C▶ Jet valve clearance adjustment***
- ▶D▶ Valve clearance adjustment**
2. Special washer
1. Distributor gear

NOTE

- *: Engines with lash adjuster
 **: Engines without lash adjuster
 ***: Engines with jet valve



SERVICE POINTS OF REMOVAL

◊A◊ REMOVAL OF LASH ADJUSTERS

- (1) Before removing rocker arms shafts assembly, install the special tool as illustrated to prevent adjuster from dropping.

**INSPECTION
CAMSHAFT**

- (1) Check camshaft journal and cam lobes for excessive wear or damage. Replace if defects are evident.
- (2) Measure the cam height and, if the limit is exceeded, replace.

Unit: mm (in.)

Identification mark	Standard value	Limit
6: Intake	42.50 (1.6732)	42.00 (1.6535)
Exhaust	42.56 (1.6756)	42.06 (1.6559)
A: Intake	42.43 (1.6705)	41.93 (1.6508)
Exhaust	42.43 (1.6705)	41.93 (1.6508)

NOTE:

The camshaft identification mark is stamped on the opposite end of the camshaft sprocket.

LEAK DOWN TEST OF LASH ADJUSTER

Caution

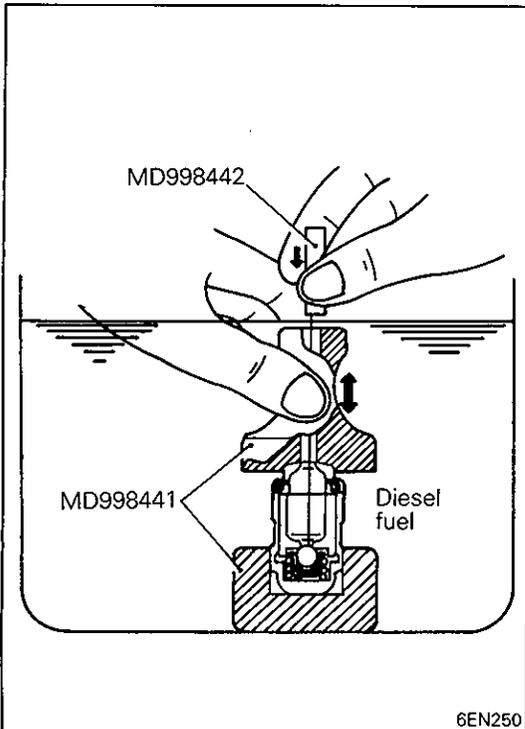
- The lash adjuster is a precision part. Keep it free from dust and other foreign matters.
- Do not disassemble lash adjuster.
- When cleaning lash adjuster, use clean diesel fuel.

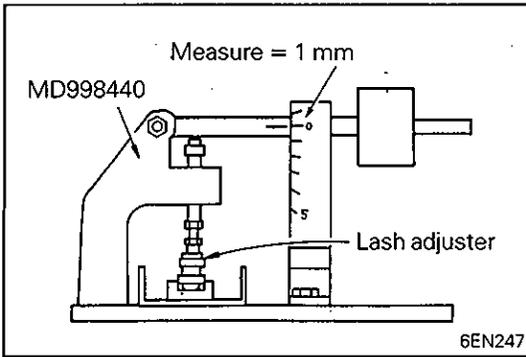
- (1) Combine auto-lash adjuster with the special tools (Retainers A and B MD998441) as illustrated and immerse the assembly in diesel fuel.
- (2) While lightly pushing down inner steel ball using the special tool (Air Bleed Wire MD998442), move plunger up and down four or five times to bleed air.
- (3) Remove the special tool (Air Bleed Wire) and hold down Retainer A firmly. Lash adjuster is okay if it is locked (not compressed.).

If it is compressed, repeat step (2). If lash adjuster is still compressed, replace it.

Caution

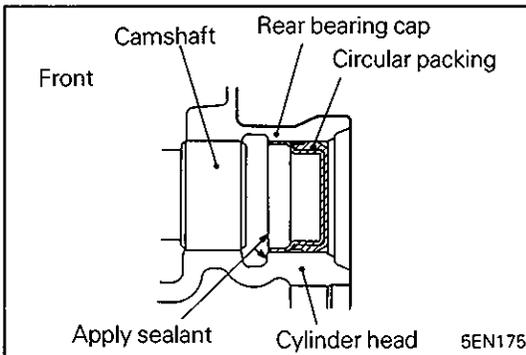
- Upon completion of air bleeding, hold lash adjuster upright to prevent inside diesel fuel from spilling.





- (4) After air bleeding, set lash adjuster on the special tool (Leak Down Tester MD998440).
- (5) After plunger has gone down somewhat (0.2 to 0.5 mm), measure time taken for it to go down 1 mm. Replace if measured time is out of specification.

Standard value: 4 to 20 seconds / 1 mm (0.04 in.)
[Diesel fuel at 15 to 20°C (59 to 68°F)]



SERVICE POINTS OF INSTALLATION

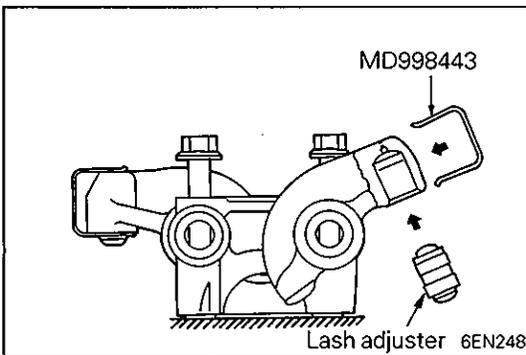
◆A◆ INSTALLATION OF CIRCULAR PACKING

- (1) Apply specified sealant to outer surface of circular packing.

Specified sealant:

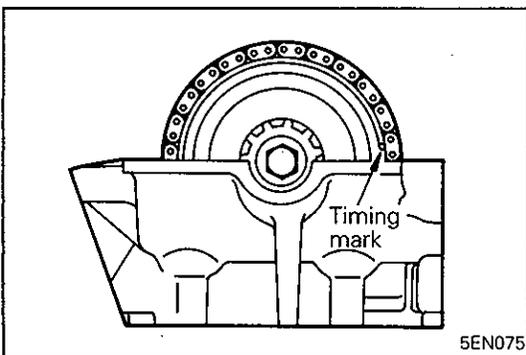
3M ATD Part No. 8660 or equivalent

- (2) Set circular packing on cylinder head as illustrated and install cam cap.



◆B◆ INSTALLATION OF LASH ADJUSTER

- (1) Insert lash adjuster from below as illustrated, using care not to spill diesel fuel from inside of adjuster. Then, install the special tool to prevent adjuster from dropping.



◆C◆ ADJUSTMENT OF JET VALVE CLEARANCE (ENGINE WITH JET VALVE ONLY)

- (1) Set the No. 1 piston at top dead center on the compression stroke.

Turn the crankshaft clockwise until the notch on pulley is lined up with the "T" mark on timing chain cover. In this state, check that the mating mark on the camshaft sprocket is at the position shown in the illustration.

Caution

- Do not turn the crankshaft counterclockwise.

NOTE

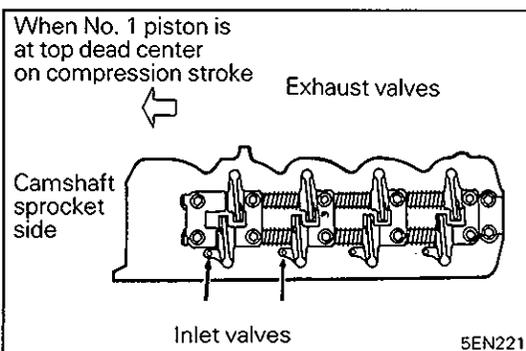
If the mating mark is at the opposite side, No. 4 piston is at top dead center on the compression stroke.

- (2) Measure the jet valve clearance at points indicated by arrows.

Standard value (on cold engine):

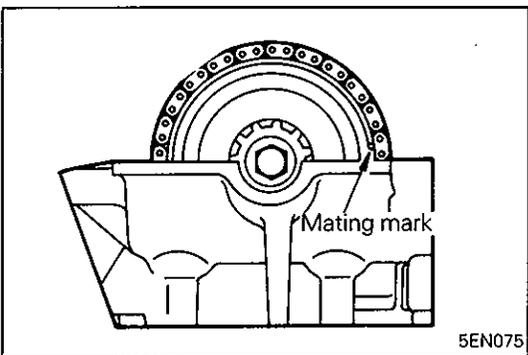
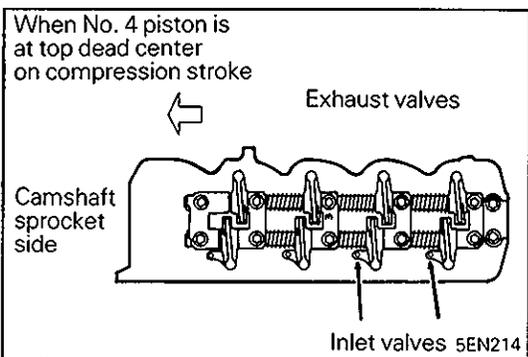
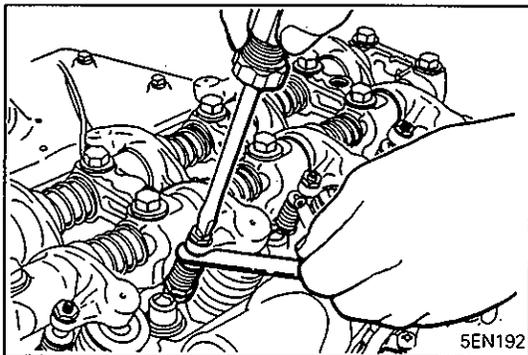
0.17 mm (0.007 in)

- (3) If the jet valve clearance is not as specified, loosen the lock nut and adjust the clearance using a feeler gauge while turning the adjusting screw.



Caution

- The jet valve spring has a small tension and the adjustment is somewhat delicate. Be careful not to push in the jet valve by turning adjusting screw too much.



- (4) While holding the adjusting screw with a screwdriver to prevent it from turning, tighten the lock nut to specified torque.
- (5) Turn the crankshaft through 360° to line up the notch on the crankshaft pulley with the "T" mark on timing chain cover.
- (6) Check the other valves and if they are out of specification, readjust according to steps (3) and (4).

◆D◆ ADJUSTMENT OF VALVE CLEARANCE (FOR ENGINE WITHOUT LASH ADJUSTER)

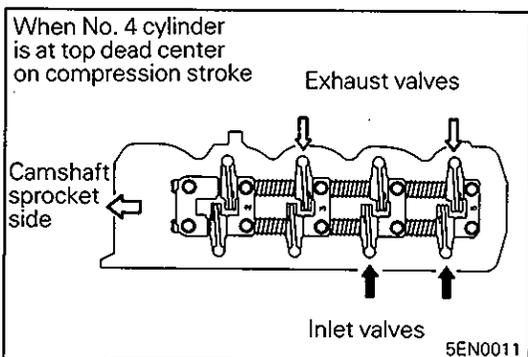
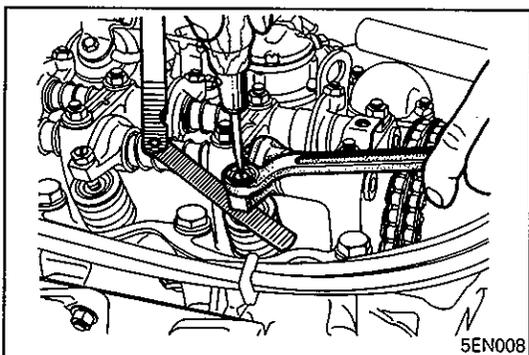
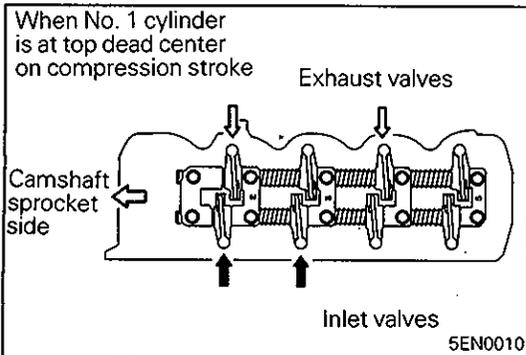
- (1) Set the No. 1 piston at top dead center on the compression stroke.
Turn the crankshaft clockwise until the notch on pulley is lined up with the "T" mark on timing chain cover.
In this state, check that the mating mark on the camshaft sprocket is at the position shown in the illustration.

Caution

- Do not turn the crankshaft counterclockwise.

NOTE

If the mating mark is at the opposite side, No. 4 piston is at top dead center on the compression stroke.



(2) Measure the valve clearance at points indicated by arrows.

Standard value (on cold engine):

0.08 mm (0.0031 in.)	.....	Intake
0.18 mm (0.0071 in.)	.....	Exhaust

(3) If the valve clearance is not as specified, loosen the lock nut and adjust the clearance using a feeler gauge while turning the adjusting screw.

(4) While holding the adjusting screw with a screwdriver to prevent it from turning, tighten the lock nut to specified torque.

(5) Turn the crankshaft through 360° to line up the notch on the crankshaft pulley with the "T" mark on timing chain cover.

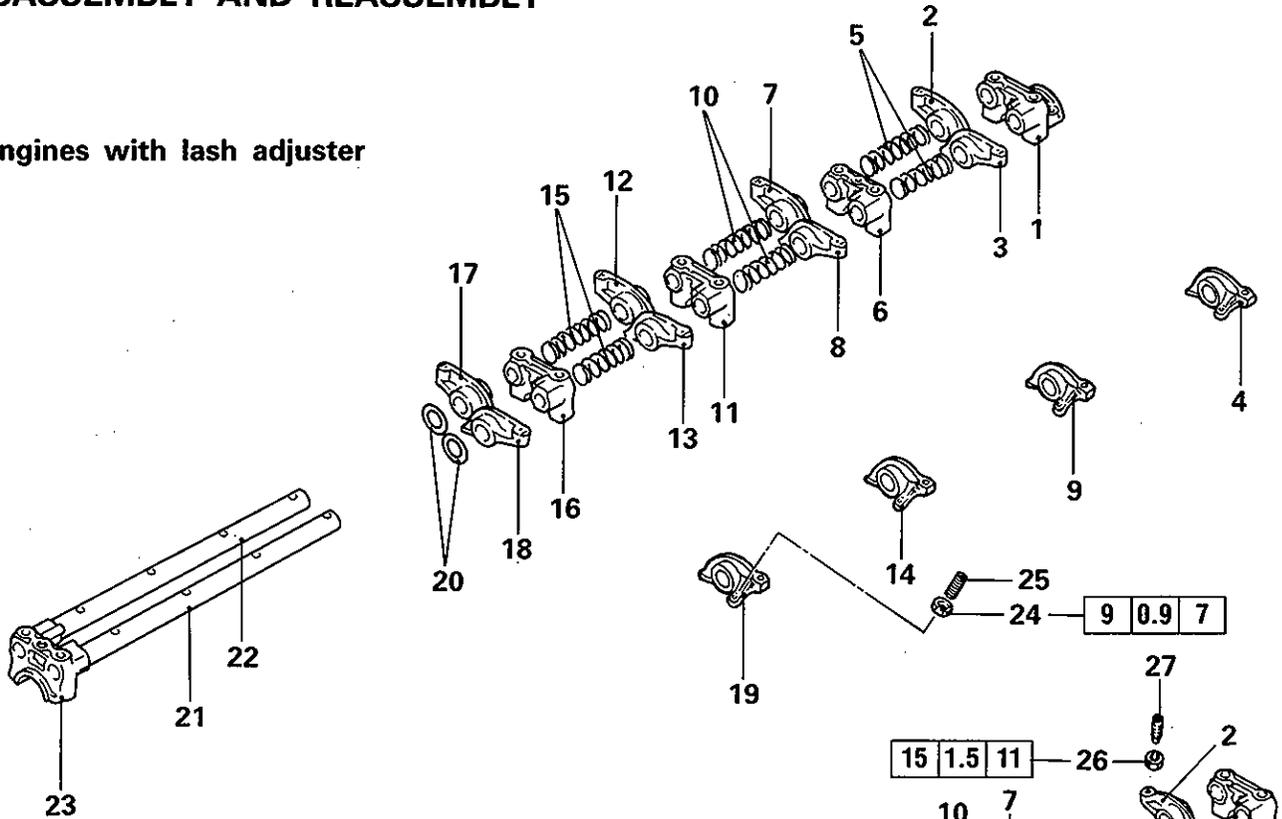
(6) Check the other valves and if they are out of specification, readjust according to steps (3) and (4).

NOTES

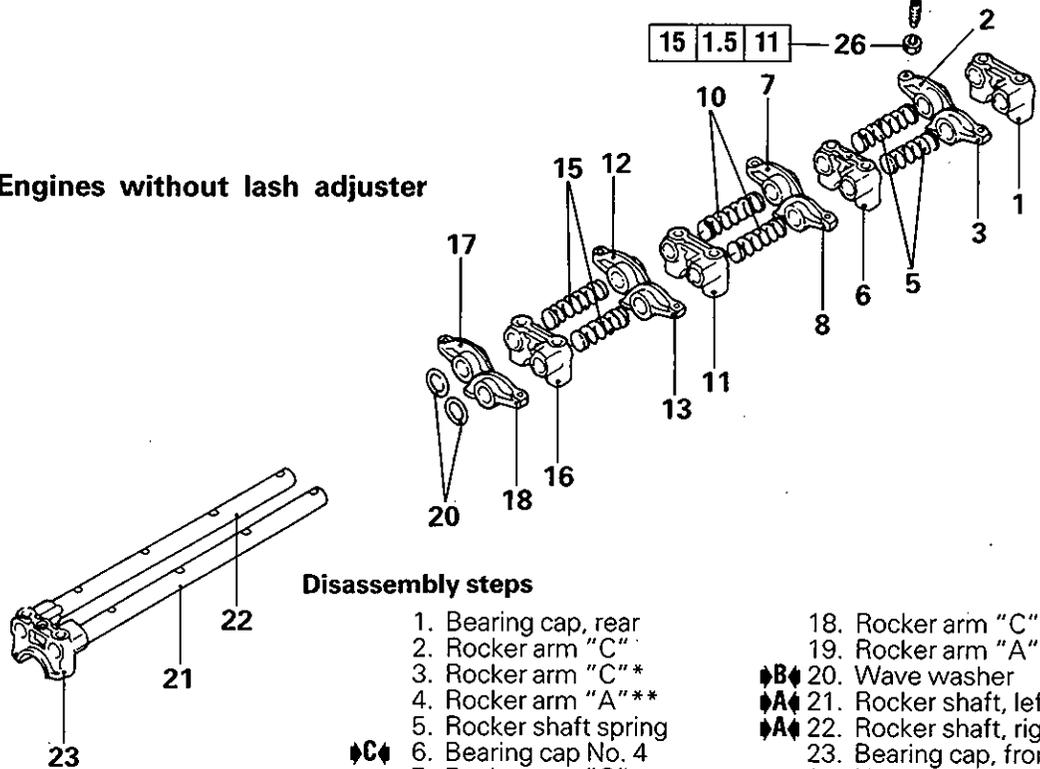
6. ROCKER ARMS AND ROCKER SHAFTS

DISASSEMBLY AND REASSEMBLY

Engines with lash adjuster



Engines without lash adjuster

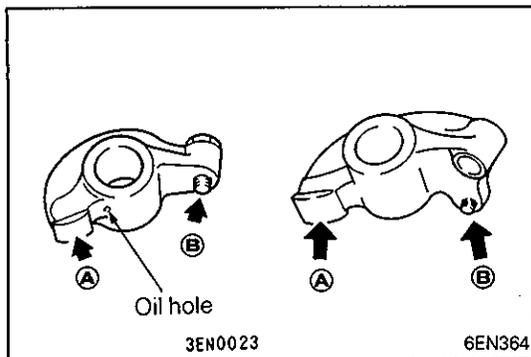


Disassembly steps

- | | |
|-----------------------------|-----------------------------|
| 1. Bearing cap, rear | 18. Rocker arm "C"* |
| 2. Rocker arm "C"* | 19. Rocker arm "A"*** |
| 3. Rocker arm "C"* | ▶B▶ 20. Wave washer |
| 4. Rocker arm "A"*** | ▶A▶ 21. Rocker shaft, left |
| 5. Rocker shaft spring | ▶A▶ 22. Rocker shaft, right |
| ▶C▶ 6. Bearing cap No. 4 | 23. Bearing cap, front |
| 7. Rocker arm "C" | 24. Nut |
| 8. Rocker arm "C"* | 25. Adjusting screw |
| 9. Rocker arm "A"*** | 26. Nut*** |
| ▶C▶ 10. Rocker shaft spring | 27. Adjusting screw*** |
| ▶C▶ 11. Bearing cap No. 3 | |
| 12. Rocker arm "C" | |
| 13. Rocker arm "C"* | |
| 14. Rocker arm "A"*** | |
| ▶C▶ 15. Rocker shaft spring | |
| ▶C▶ 16. Bearing cap No. 2 | |
| ▶C▶ 17. Rocker arm "C" | |

NOTE

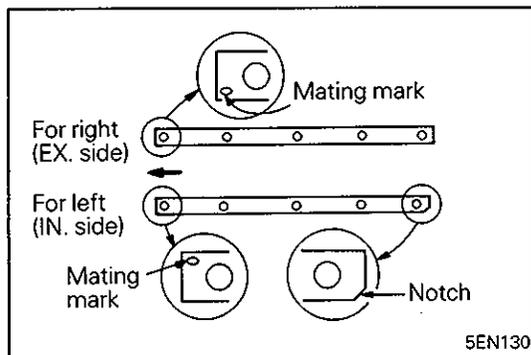
*: Engines without jet valve
 **: Engines with jet valve
 ***: Engines without lash adjuster

**INSPECTION****ROCKER ARMS**

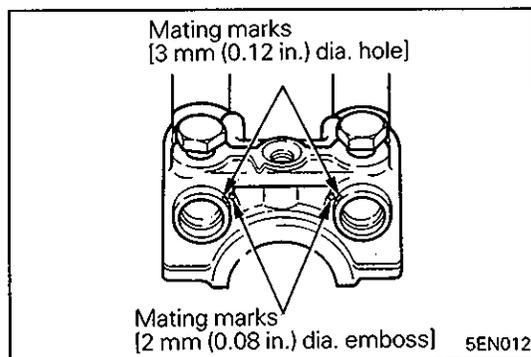
- (1) Check the surface (A) that contacts the cam lobe and replace if there is any dent, damage or seizure.
- (2) Check the adjusting screw end (B) and replace if it is worn flat.
- (3) Check the bore and replace if there is any damage or seizure.
- (4) Check the oil hole and clean if clogged.

SERVICE POINTS OF REASSEMBLY**◆A◆ INSTALLATION OF ROCKER SHAFT, RIGHT / ROCKER SHAFT, LEFT**

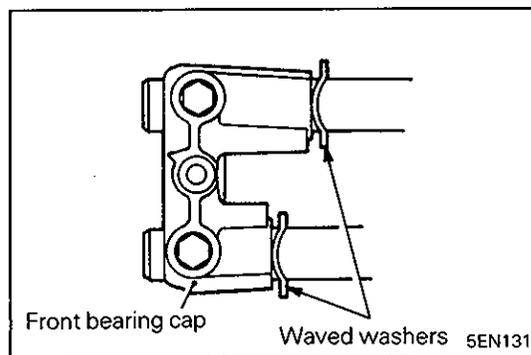
- (1) Right rocker arm shaft (exhaust valve side) is different from left one (inlet valve side). Left rocker arm shaft has a notch on its rear end.
At front end of each rocker arm shaft, a mating mark is provided for ready alignment of bolt holes in shaft and front bearing cap when they are assembled.



- (2) Insert both right and left rocker arm shafts in camshaft front bearing cap. Align mating mark on front end of each rocker arm shaft with that on bearing cap and insert bolts through cap and shafts to prevent shafts from being dislocated.

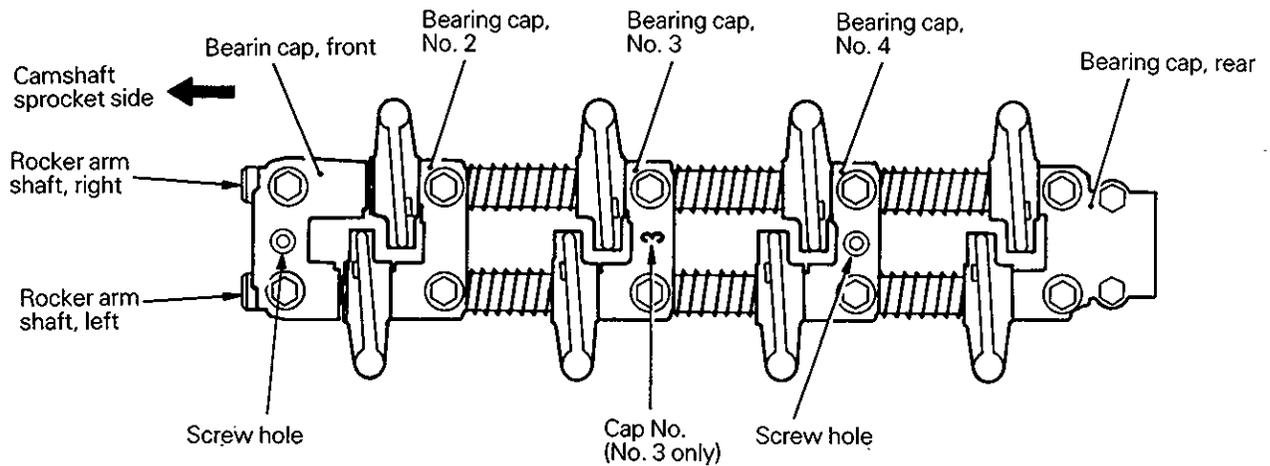
**◆B◆ INSTALLATION OF WAVE WASHER**

- (1) Install the wave washer in correct direction as shown.



INSTALLATION OF BEARING CAPS NO. 2, NO.3 AND NO. 4

- (1) Bearing caps No. 2, No. 3 and No. 4 are similarly shaped. Identify them referring to following illustration and install them at correct positions.

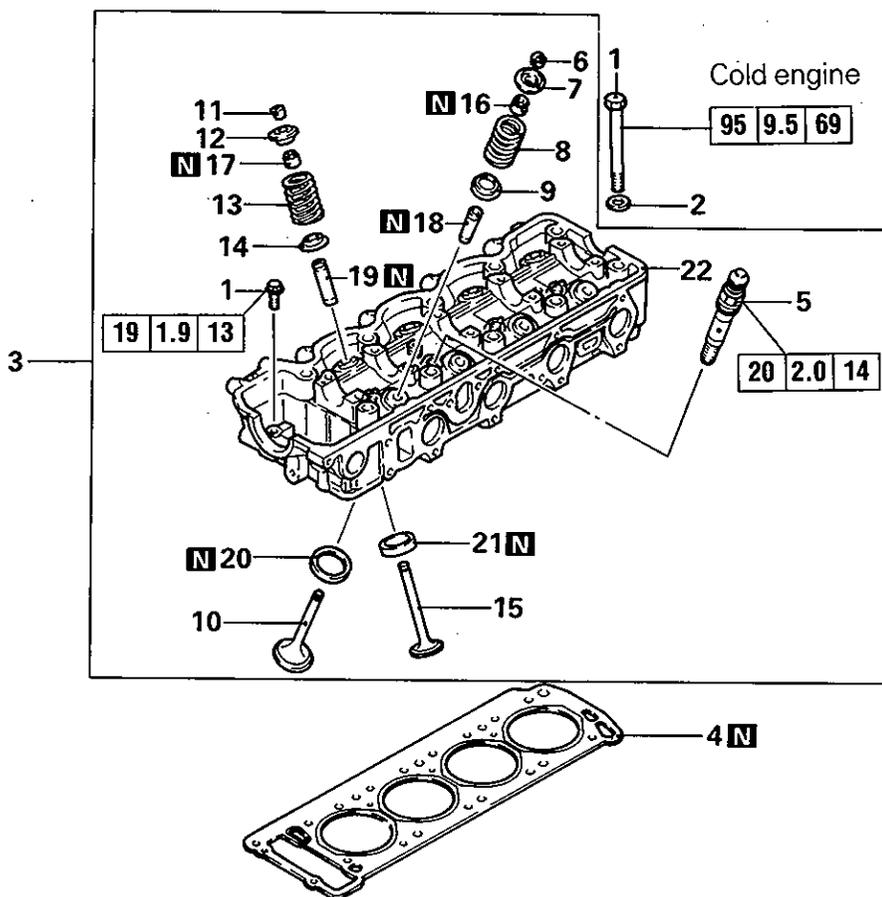


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NOTES

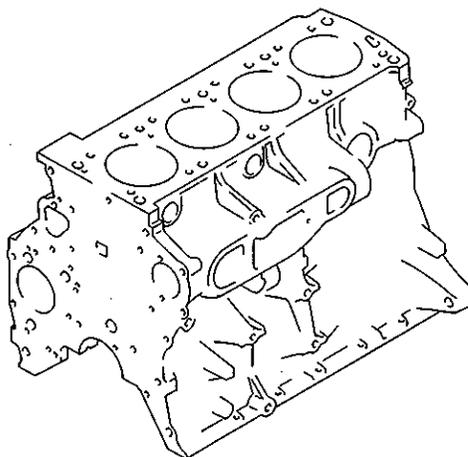
7. CYLINDER HEAD AND VALVES

REMOVAL AND INSTALLATION

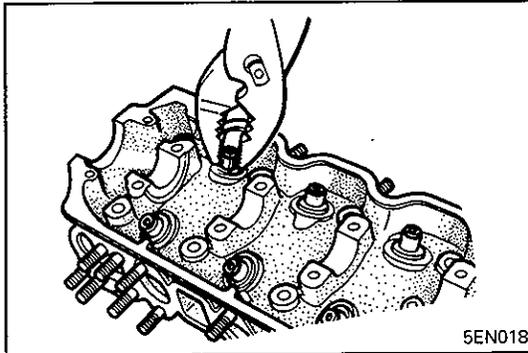
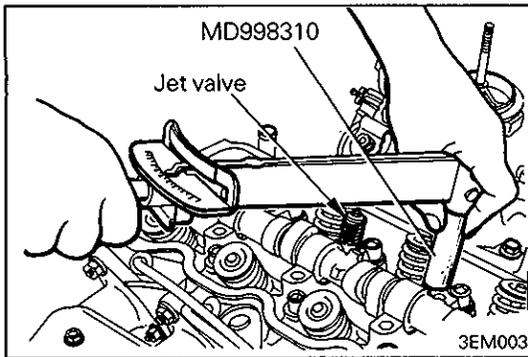


Removal steps

- ▶E◀ 1. Cylinder head bolt
- 2. Washer
- 3. Cylinder head assembly
- ▶D◀ 4. Gasket
- ◀A◀ ▶C◀ 5. Jet valve assembly*
- 6. Retainer lock
- 7. Valve spring retainer
- ▶B◀ 8. Valve spring
- 9. Valve spring seat
- 10. Intake valve
- 11. Retainer lock
- 12. Valve spring retainer
- ▶B◀ 13. Valve spring
- 14. Valve spring seat
- 15. Exhaust valve
- ◀B◀ ▶A◀ 16. Valve stem seal
- ◀B◀ ▶A◀ 17. Valve stem seal
- 18. Intake valve guide
- 19. Exhaust valve guide
- 20. Intake valve seat
- 21. Exhaust valve seat
- 22. Cylinder head



NOTE
*: Engines with jet valves



SERVICE POINTS OF REMOVAL

PRECAUTION FOR REMOVED PARTS

- (1) Keep removed parts in order according to the cylinder number and intake / exhaust.

◁A▷ REMOVAL OF JET VALVE ASSEMBLY

- (1) Use the special tool to remove jet valves.
- (2) For identification, put the corresponding cylinder number to the removed jet valves.

Caution

- When loosening a jet valve, hold the special tool securely so that it is not tilted with respect to the jet valve center line. Also avoid abruptly applying force.

◁B▷ REMOVAL OF VALVE STEM SEAL

To remove valve stem seal, use pliers.

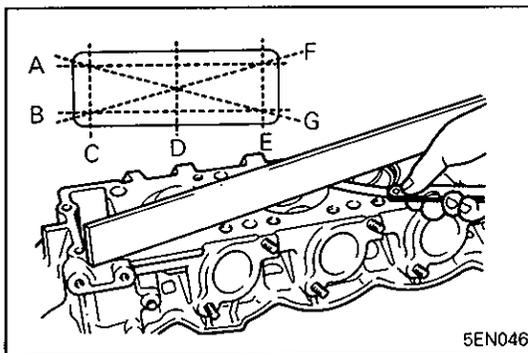
NOTE

Do not reuse valve stem seal.

INSPECTION

CYLINDER HEAD

- (1) Check the cylinder head, before cleaning, for water leaks, gas leaks, damage, and cracks.
- (2) Remove oil, scale, sealing compound, and carbon deposits completely. After cleaning oil passages, apply compressed air to ensure that the passages are not clogged.



- (3) Check the cylinder head gasket surface for flatness by using a straightedge in the directions of A through G shown in illustration.

Standard value: 0.05 mm (0.0020 in.)

Limit: 0.2 mm (0.008 in.)

- (4) If the service limit is exceeded, correct to meet specification.

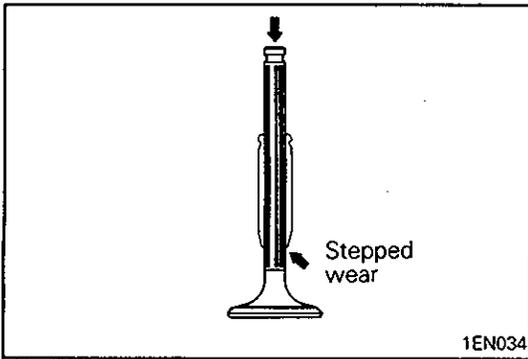
Grinding limit: 0.2 mm (0.008 in.)

Caution

- The total thickness of the stock allowed to be removed from cylinder head and mating cylinder block is 0.2 mm (0.008 in.).

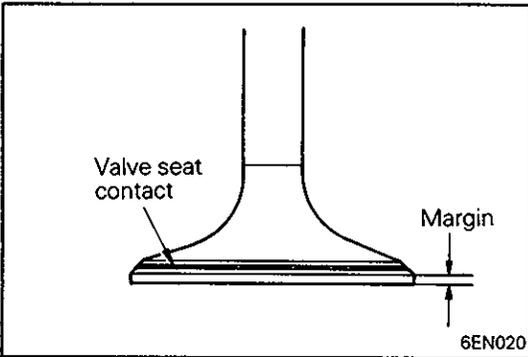
Cylinder head height (when new):

89.9 – 90.1 mm (3.539 – 3.547 in.)



VALVE

- (1) If the valve stem is worn (ridge wear) or otherwise damaged, replace. Also replace the valve if the stem end (that contacts to the rocker arm adjust screw) has a dent.



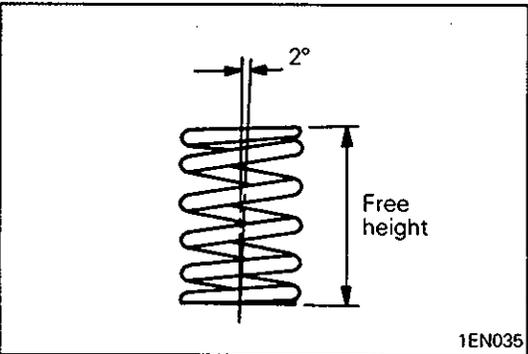
- (2) Check the valve face for correct contact. If incorrect, reface using valve refacer. Valve seat contact should be maintained uniform at the center of valve face.
- (3) If the margin exceeds the service limit, replace the valve.

Standard value:

1.2 mm (0.047 in.)	Intake
2.0 mm (0.079 in.)	Exhaust

Limit:

0.7 mm (0.028 in.)	Intake
1.5 mm (0.059 in.)	Exhaust



VALVE SPRING

- (1) Measure the free height of spring and, if the limit is exceeded, replace.

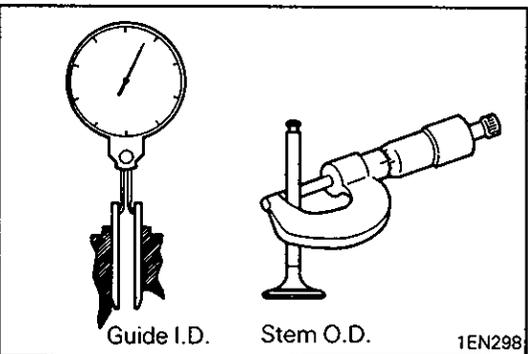
Standard value: 49.8 mm (1.961 in.)

Limit: 48.8 mm (1.922 in.)

- (2) Measure the squareness of the spring and, if the limit is exceeded, replace.

Standard value: 2°

Limit: 4°



VALVE GUIDE

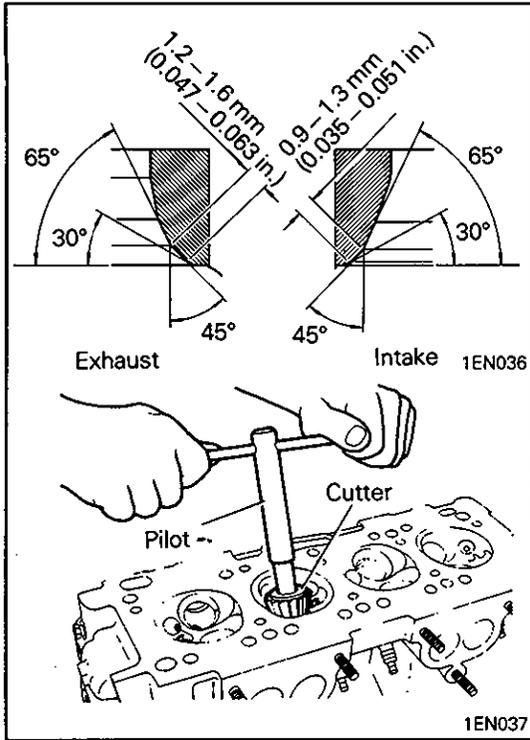
- (1) Measure the clearance between the valve guide and valve stem end. If the limit is exceeded, replace the valve guide or valve, or both.

Standard value:

0.03 – 0.06 mm (0.0012 – 0.0024 in.)	Intake
0.05 – 0.09 mm (0.0020 – 0.0035 in.)	Exhaust

Limit:

0.10 mm (0.0039 in.)	Intake
0.15 mm (0.0059 in.)	Exhaust

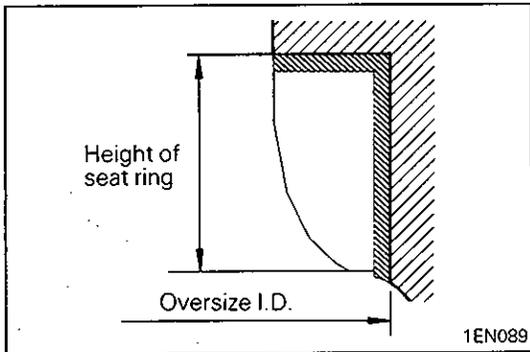
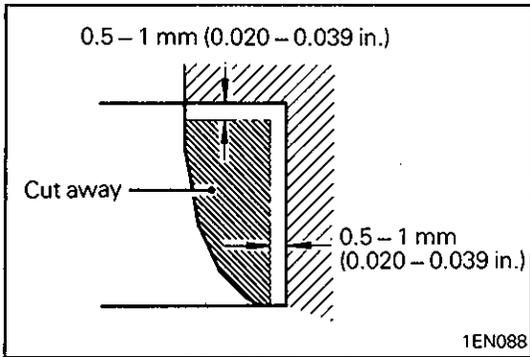


VALVE SEAT RECONDITIONING PROCEDURE

- (1) Before correcting the valve seat, check for clearance between the valve guide and valve and, if necessary, replace the valve guide.
- (2) Using the special tool or seat grinder, correct to obtain the specified seat width and angle.

Cutter angle	Tool number	
	Intake	Exhaust
45°	MD998159	MD998158
65°	MD998165	MD998165
30°	MD998175	MD998173

- (3) After correction, valve and valve seat should be lapped with a lapping compound.



VALVE SEAT REPLACEMENT PROCEDURE

- (1) Cut the valve seat to be replaced from the inside to thin the wall thickness. Then, remove the valve seat.

- (2) Rebore the valve seat hole in cylinder head to the oversize valve seat diameter.

Intake valve seat hole diameter

0.30 O.S.: 47.300 – 47.325 mm
(1.8622 – 1.8632 in.)

0.60 O.S.: 47.600 – 47.625 mm
(1.8740 – 1.8750 in.)

Exhaust valve seat hole diameter

0.30 O.S.: 40.300 – 40.325 mm
(1.5866 – 1.5876 in.)

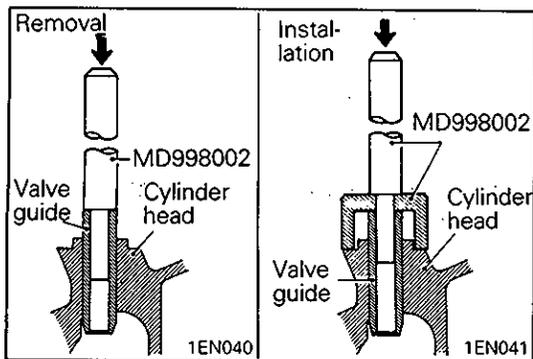
0.60 O.S.: 40.600 – 40.625 mm
(1.5984 – 1.5994 in.)

- (3) Before fitting the valve seat, either heat the cylinder head up to approximately 250°C (482°F) or cool the valve seat in liquid nitrogen, to prevent the cylinder head bore from galling.

- (4) Using valve seat cutter, correct the valve seat to the specified width and angle.

See "VALVE SEAT RECONDITIONING PROCEDURE."

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**VALVE GUIDE REPLACEMENT PROCEDURE**

- (1) Using the special tool and a press, remove the valve guide toward cylinder head gasket surface.
- (2) Rebore valve guide hole to the new oversize valve guide outside diameter.

Valve guide hole diameter

0.05 O.S.: 13.050 – 13.068 mm
(0.5138 – 0.5145 in.)

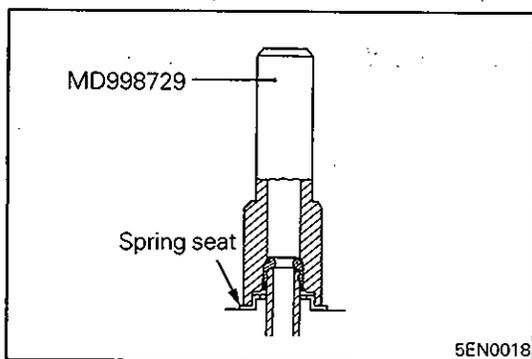
0.25 O.S.: 13.250 – 13.268 mm
(0.5217 – 0.5224 in.)

0.50 O.S.: 13.500 – 13.518 mm
(0.5315 – 0.5322 in.)

NOTE

Do not install a valve guide of the same size again.

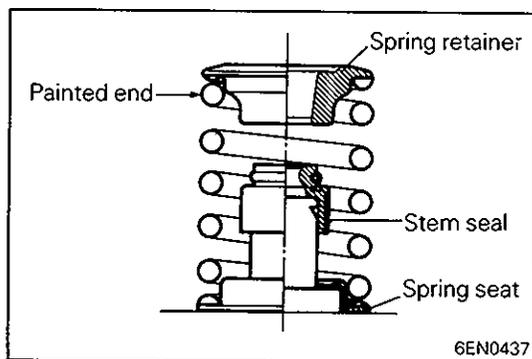
- (3) Using the special tool, press-fit the valve guide, working from the cylinder head top surface.
- (4) After installing valve guides, insert new valves in them to check for sliding condition.
- (5) When valve guides have been replaced check for valve contact and correct valve seats as necessary.

**SERVICE POINTS OF INSTALLATION****◆A◆ INSTALLATION OF VALVE STEM SEAL**

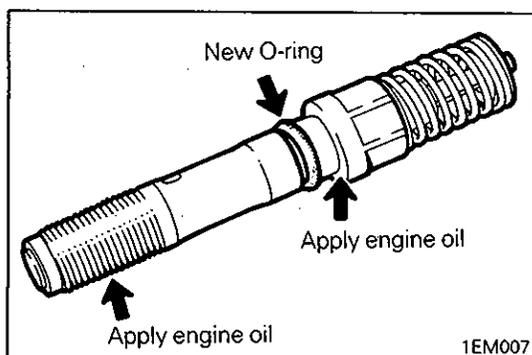
- (1) Install the valve spring seat.
- (2) Using the special tool, install a new stem seal to the valve guide.

Caution

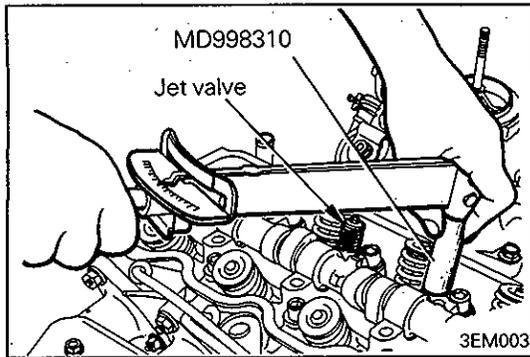
- Do not reuse the valve stem seal.

**◆B◆ INSTALLATION OF VALVE SPRING**

- (1) Direct the valve spring end with identification color to the spring retainer.

**◆C◆ INSTALLATION OF JET VALVE ASSEMBLY**

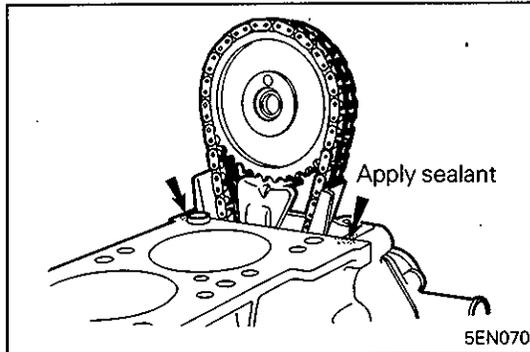
- (1) Install a new O-ring to the jet valve body.
- (2) Apply engine oil to threads and seat surface of jet body.



- (3) Install the jet valve assembly in the cylinder head finger tight.
- (4) Using the special tool and torque wrench, tighten the jet valve assembly to the specified torque.

Caution

- Hold the special tool securely not to tilt with respect to center of jet valve.

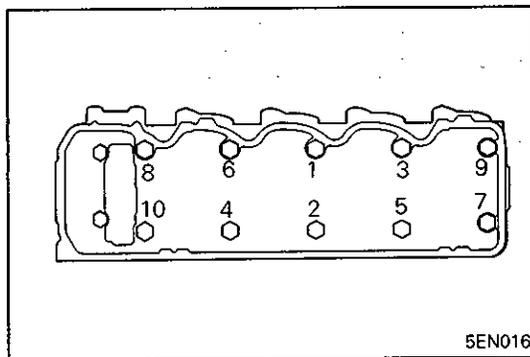
**◆D◆ INSTALLATION OF CYLINDER HEAD GASKET**

- (1) Clean both gasket surfaces of cylinder block and cylinder head.
- (2) If chain case gaskets protrude from cylinder block top surface, remove such portions using a knife.
- (3) Apply sealant to top surface (indicated by arrow in the illustration) of each butt joint between cylinder block and chain case.

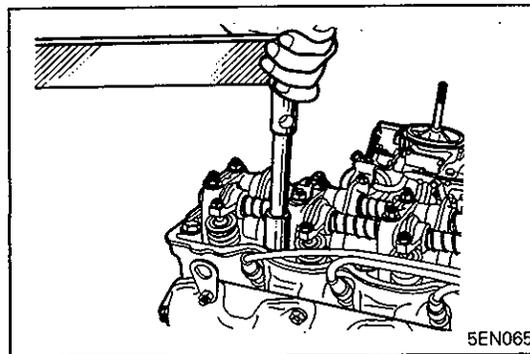
Specified sealant: 3M Part No. 8660 or equivalent

Caution

- Do not apply sealant to cylinder head gasket.

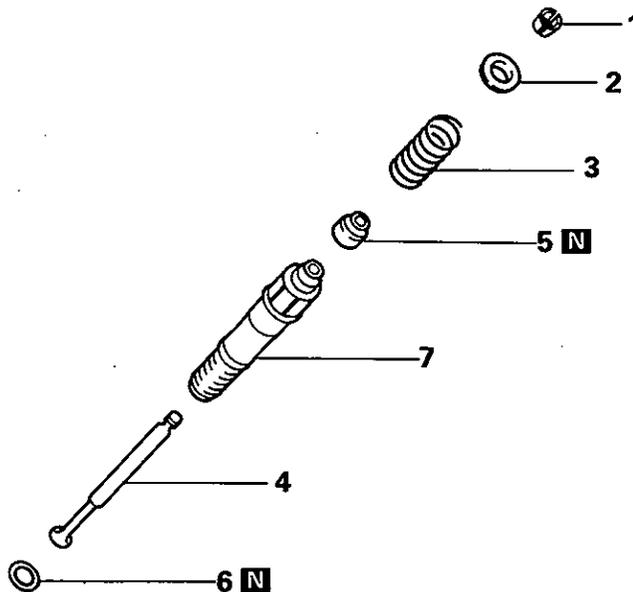
**◆E◆ INSTALLATION OF CYLINDER HEAD BOLT**

- (1) Tighten the cylinder head bolts in the sequence shown. Each bolt should be tightened in two to three steps, torquing progressively. Tighten to specified torque in the final sequence.



8. JET VALVE ASSEMBLY (ENGINE WITH JET VALVES)

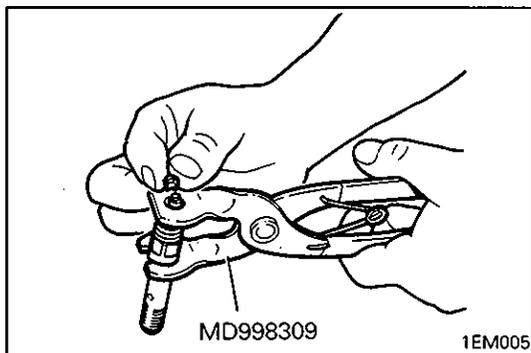
DISASSEMBLY AND REASSEMBLY



Disassembly steps

- ◀A▶ ▶B▶ 1. Retainer lock
 2. Valve spring retainer
 3. Valve spring
 ▶A▶ 4. Jet valve
 5. Stem seal
 6. O-ring
 7. Jet body

1EM177



SERVICE POINTS OF DISASSEMBLY

◀A▶ REMOVAL OF RETAINER LOCK

- (1) Using the special tool, compress the valve spring and remove the retainer lock.

NOTE

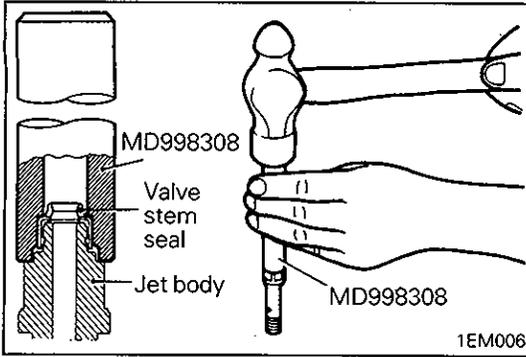
Keep disassembled parts neatly arranged for each cylinder.

INSPECTION

- Insert a jet valve into jet body and check for sliding conditions. If it does not slide smoothly, or too loose in the body, replace.

NOTE

Replace jet valve and jet body as an assembly.



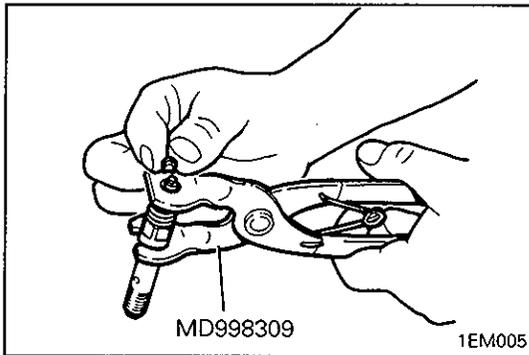
SERVICE POINTS OF REASSEMBLY

◆A◆ INSTALLATION OF STEM SEAL

- (1) Using the special tool and a hammer, drive the valve stem seal into the jet body.

Caution

- Valve stem seal cannot be reused.
- Incorrect installation of valve stem seal could cause an ingress of oil into cylinder. Make sure to use the special tool to install the seal.



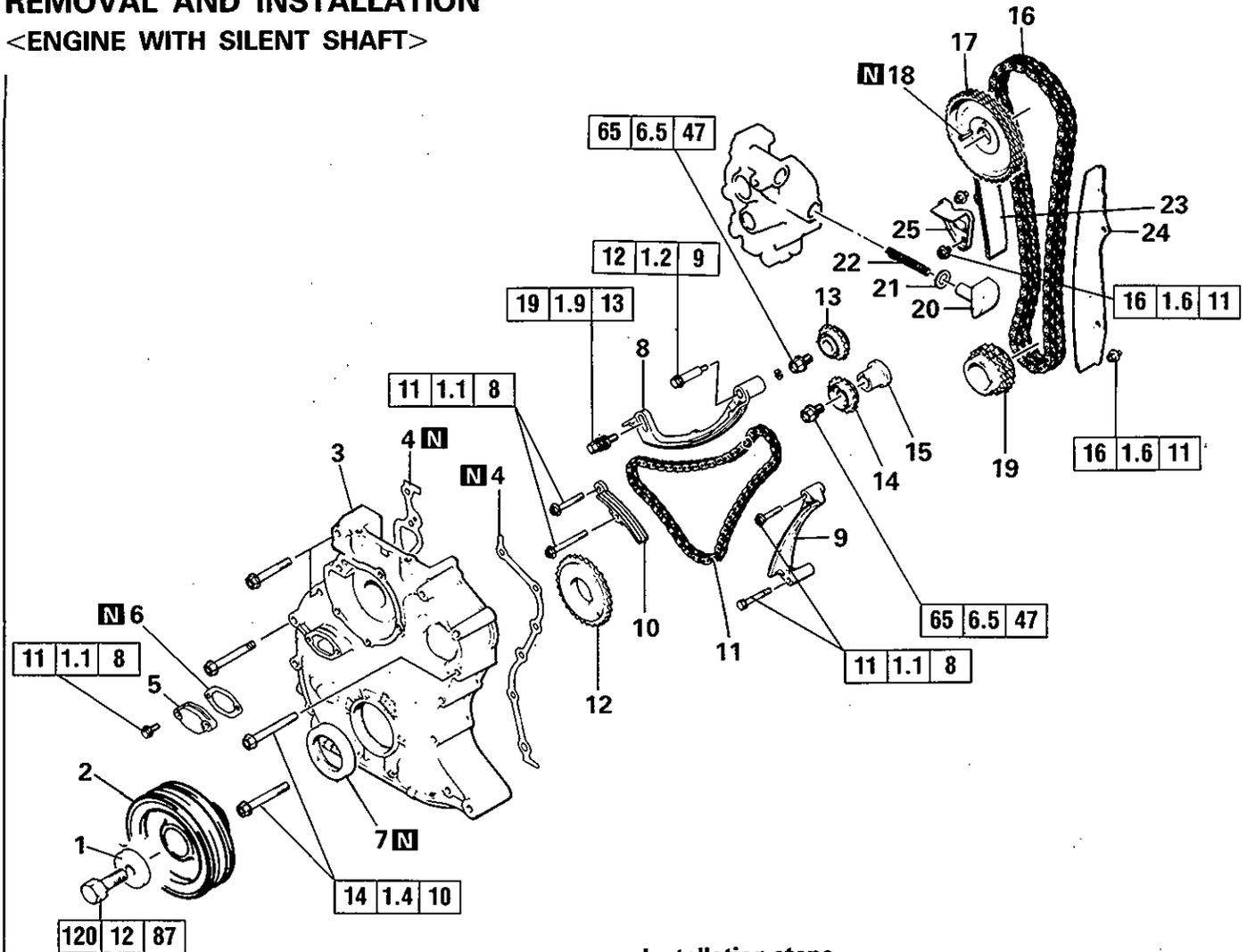
◆B◆ INSTALLATION OF RETAINER LOCK

- (1) While compressing the valve spring with the special tool, install the retainer lock. Use care not to damage the valve stem with the retainer bottom edge when compressing the spring.

9. TIMING CHAIN

REMOVAL AND INSTALLATION

<ENGINE WITH SILENT SHAFT>



Removal steps

1. Special washer
2. Crankshaft pulley
3. Timing chain case
4. Chain case gasket
5. Chain guide access hole cover
6. Chain guide access hole gasket
7. Oil seal
8. Chain guide "B"
9. Chain guide "A"
10. Chain guide "C"
11. Chain "B"
12. Crankshaft sprocket "B"
13. Oil pump sprocket
14. Silent shaft sprocket
15. Spacer
16. Timing chain
17. Camshaft sprocket
18. Spring pin
19. Crankshaft sprocket
20. Tension sleeve
21. Rubber seat
22. Tensioner spring
23. Loose side chain guide
24. Tension side chain guide
25. Sprocket holder

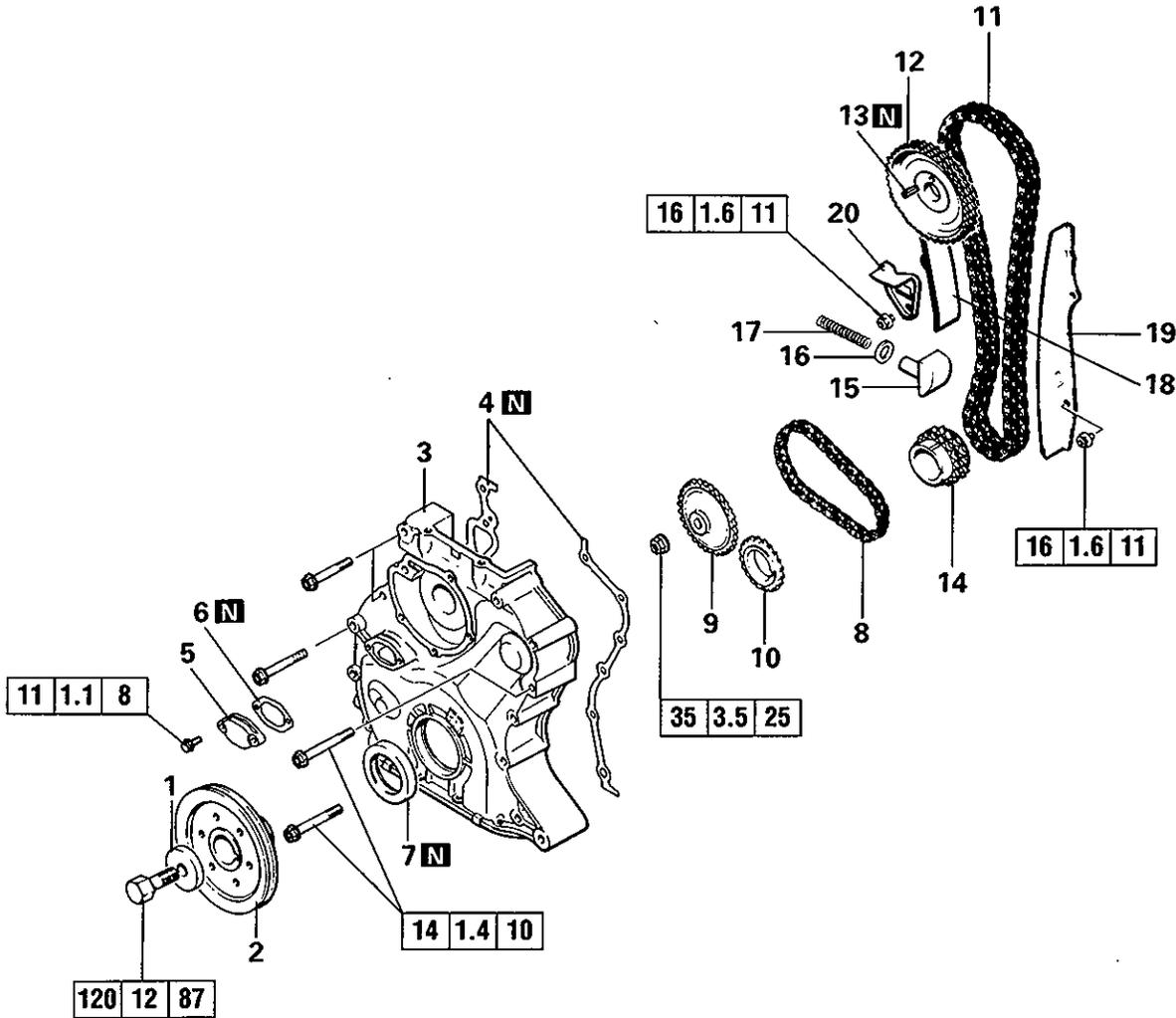
Installation steps

25. Sprocket holder
24. Tension side chain guide
23. Loose side chain guide
- ▶A▶ 22. Tensioner spring
- ▶A▶ 21. Rubber seat
- ▶A▶ 20. Tension sleeve
- ▶B▶ 19. Crankshaft sprocket
- ▶B▶ 16. Timing chain
17. Camshaft sprocket
18. Spring pin
15. Spacer
- ▶C▶ 14. Silent shaft sprocket
- ▶C▶ 13. Oil pump sprocket
- ▶C▶ 12. Crankshaft sprocket "B"
- ▶C▶ 11. Chain "B"
10. Chain guide "C"
9. Chain guide "A"
8. Chain guide "B"
- ▶D▶ Adjustment of drive chain "B" tension
- ▶F▶ 7. Oil seal
6. Chain guide access hole gasket
5. Chain guide access hole cover
4. Chain case gasket
3. Timing chain case
2. Crankshaft pulley
1. Special washer

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REMOVAL AND INSTALLATION

<ENGINE WITHOUT SILENT SHAFT>



Removal steps

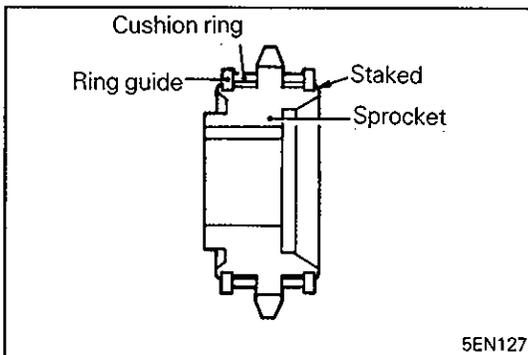
1. Special washer
2. Crankshaft pulley
3. Timing chain case
4. Chain case gasket
5. Chain guide access hole cover
6. Chain guide access hole gasket
7. Oil seal
8. Oil pump drive chain
9. Oil pump sprocket
10. Crankshaft sprocket "O"
- ◁A◇ 11. Timing chain
- ◁A◇ 12. Camshaft sprocket
- ◁A◇ 13. Spring pin
- ◁A◇ 14. Crankshaft sprocket
15. Tensioner sleeve
16. Rubber seat
17. Tensioner spring
18. Loose side chain guide
19. Tension side chain guide
20. Sprocket holder

Installation steps

20. Sprocket holder
19. Tension side chain guide
18. Loose side chain guide
- ▶A▶ 17. Tensioner spring
- ▶A▶ 16. Rubber seat
- ▶A▶ 15. Tensioner sleeve
14. Crankshaft sprocket
- ▶B▶ 11. Timing chain
12. Camshaft sprocket
13. Spring pin
- ▶E▶ 10. Crankshaft sprocket "O"
- ▶E▶ 9. Oil pump sprocket
- ▶E▶ 8. Oil pump drive chain
- ▶F▶ 7. Oil seal
6. Chain guide access hole gasket
5. Chain guide access hole cover
4. Chain case gasket
3. Timing chain case
2. Crankshaft pulley
1. Special washer

SERVICE POINTS OF REMOVAL**◀A▶ REMOVAL OF TIMING CHAIN / CAMSHAFT SPROCKET / CRANKSHAFT SPROCKET**

- (1) Remove crankshaft sprocket, camshaft sprocket and timing chain together.

**INSPECTION****SPROCKETS**

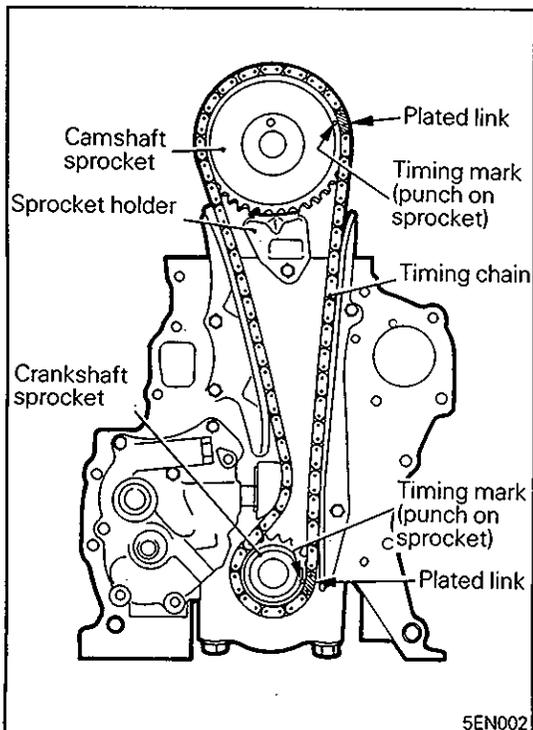
- (1) Check teeth of sprocket for wear or damage.
- (2) Check silent shaft sprocket for damaged cushion ring and ring guide. Check to ensure that cushion ring smoothly rotates.

CHAINS

- (1) Check chain for roller play, wear, damage or disconnected links.

CHAIN TENSIONER AND GUIDES

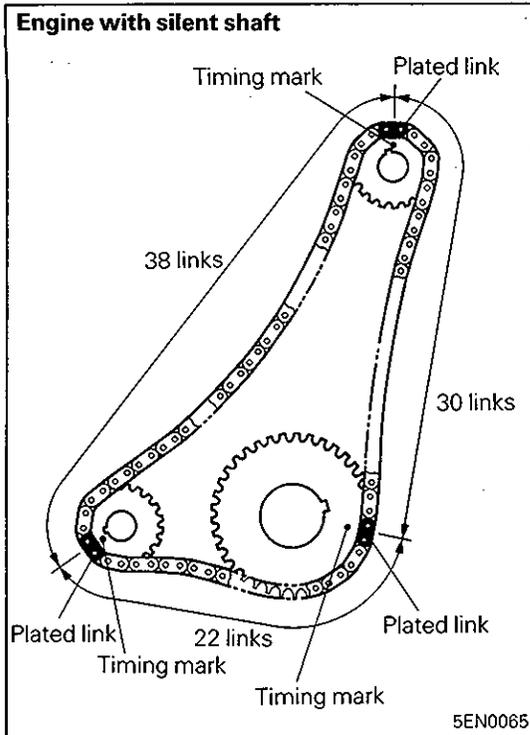
- (1) Check chain tensioner and guide rubber shoe for wear or damage.

**SERVICE POINTS OF INSTALLATION****▶A▶ INSTALLATION OF TENSIONER SPRING / RUBBER SEAT / TENSIONER SLEEVE**

- (1) Install tensioner spring, sleeve and rubber seat to oil pump.

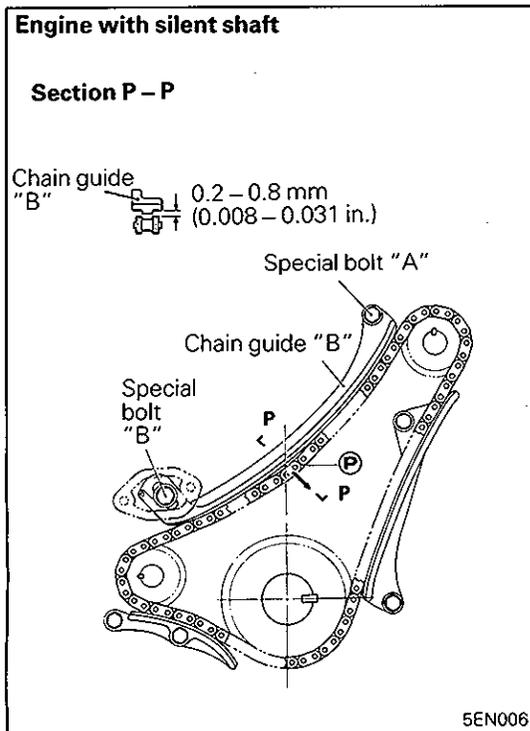
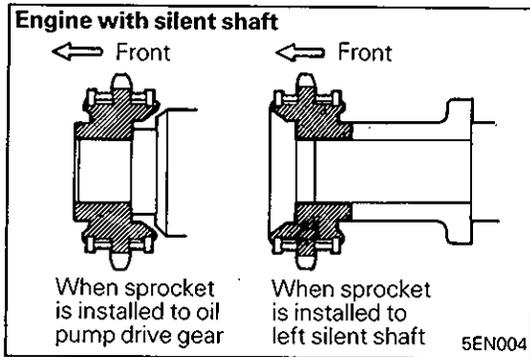
▶B▶ INSTALLATION OF TIMING CHAIN

- (1) Turn crankshaft until piston of No. 1 cylinder is at top dead center.
- (2) Line up plated links of timing chain and timing marks on sprockets as chain and sprockets are assembled.
- (3) While sliding crankshaft sprocket onto crankshaft, install chain and sprocket. Place camshaft sprocket on sprocket holder.



◆C◆ INSTALLATION OF CHAIN "B" AND SPROCKETS

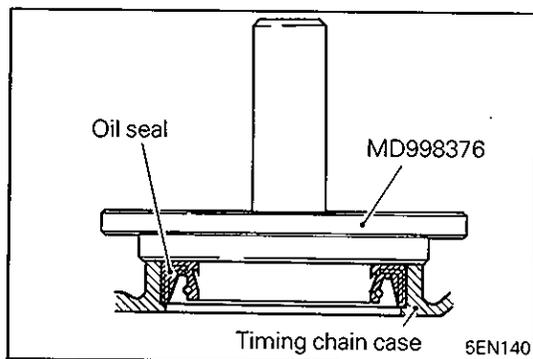
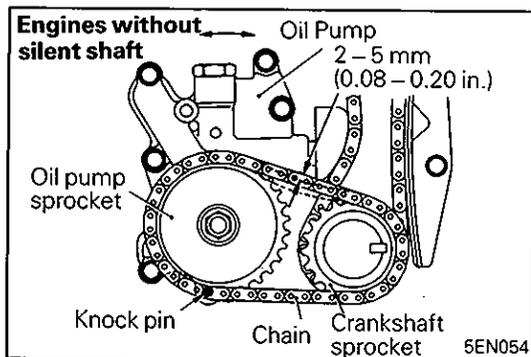
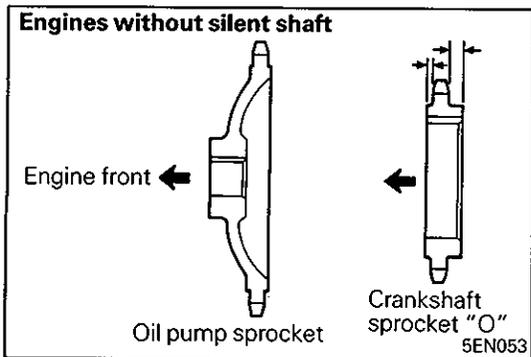
- (1) Assemble the sprockets with timing chain "B" while aligning the sprockets' timing marks with the corresponding plated links of the chain. The sprockets of both silent shafts are same in shape and size but different in mounting direction. Be sure to set them in correct directions.
- (2) Install the sprockets with chain on both silent shafts and the crankshaft.
- (3) Make sure that all timing marks on the sprockets and the plated links of the chain are in alignment.



◆D◆ ADJUSTMENT OF CHAIN "B" TENSION

- (1) Pull the chain at position **Ⓟ** in the direction of arrow with fingers.
- (2) Adjust the position of the chain guide so that the clearance between the chain and the guide conforms with the standard value.

Standard value: 0.2 – 0.8 mm (0.008 – 0.031 in.)



◆E◆ INSTALLATION OF CRANKSHAFT SPROCKET "O" / OIL PUMP SPROCKET / OIL PUMP DRIVE CHAIN (ENGINES WITHOUT SILENT SHAFT)

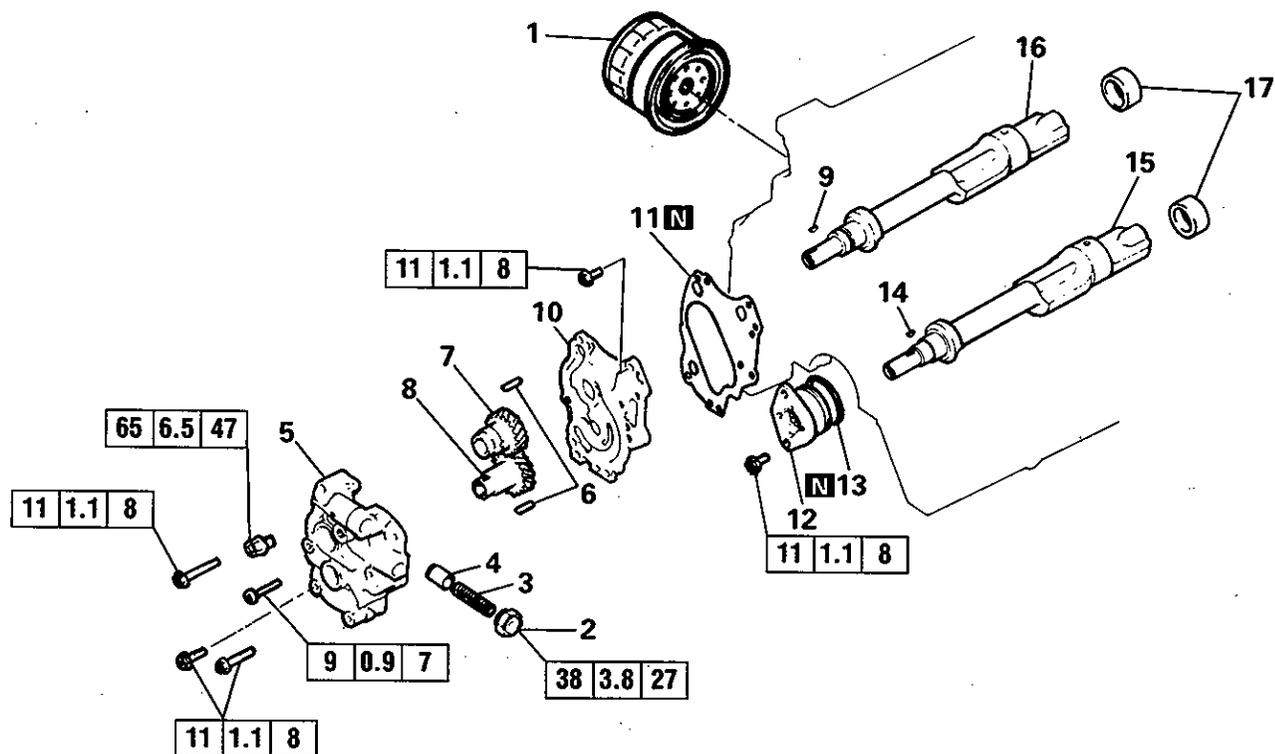
- (1) Install the crankshaft sprocket "O" and oil pump sprocket, on the oil pump drive chain, and install them as a unit on the crankshaft and oil pump shaft. Apply engine oil to the chain and sprockets.
- (2) Loosen the oil pump attaching bolts little by little.
- (3) With reference to knock pin in lower portion of oil pump, move pump in either direction until the chain deflection is as specified. Measure the chain deflection midway between crankshaft center and oil pump shaft center.
- (4) After oil pump drive chain deflection is adjusted on the specified value, tighten the oil pump attaching bolt to general screw tightening torque while holding the oil pump in position. After tightening, check the chain deflection again.

◆F◆ INSTALLATION OF OIL SEAL

NOTES

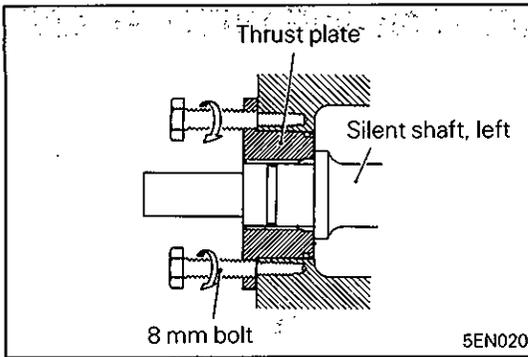
10. OIL FILTER, OIL PUMP AND SILENT SHAFT (ENGINE WITH SILENT SHAFT)

REMOVAL AND INSTALLATION

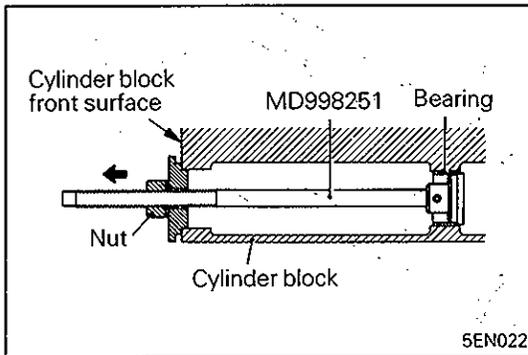


Removal steps

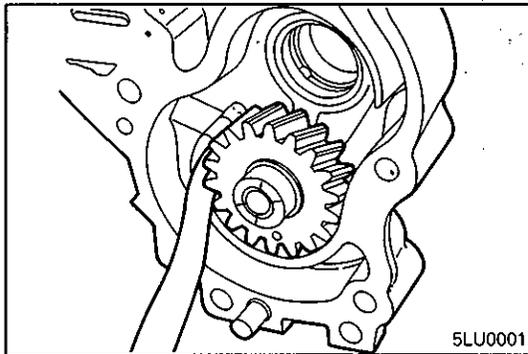
1. Oil filter
2. Plug
3. Relief spring
4. Relief plunger
- ↔E↔ 5. Oil pump body
- ↔D↔ 6. Pin
- ↔D↔ 7. Driven gear
- ↔D↔ 8. Drive gear
9. Woodruff key
10. Oil pump cover
11. Oil pump gasket
- ↔A↔ ↔C↔ 12. Thrust plate (with front bearing)
- ↔B↔ 13. O-ring
14. Woodruff key
15. Left silent shaft
16. Right silent shaft
- ↔B↔ ↔A↔ 17. Silent shaft rear bearing

**SERVICE POINTS OF REMOVAL****◁A▷ REMOVAL OF THRUST PLATE**

- (1) Install 8 mm dia. bolts into threaded holes of flange and turn down bolts at the same time and thrust plate will come off.

**◁B▷ REMOVAL OF SILENT SHAFT REAR BEARING**

- (1) Using the special tool, remove silent shaft bearing.

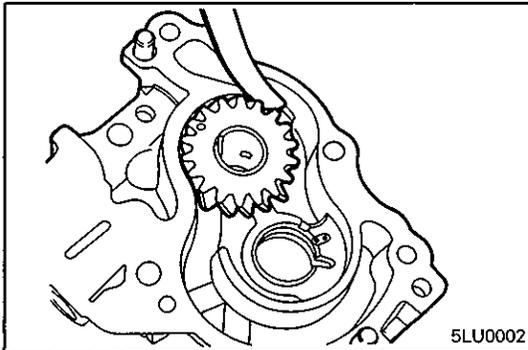
**INSPECTION****OIL PUMP**

- (1) Install drive gear and driven gear to oil pump body and measure tip clearance:

Standard value:

0.11 – 0.15 mm (0.0043 – 0.0059 in.)

Limit: 0.2 mm (0.008 in.)

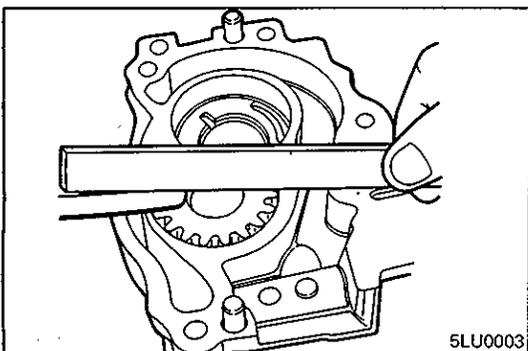


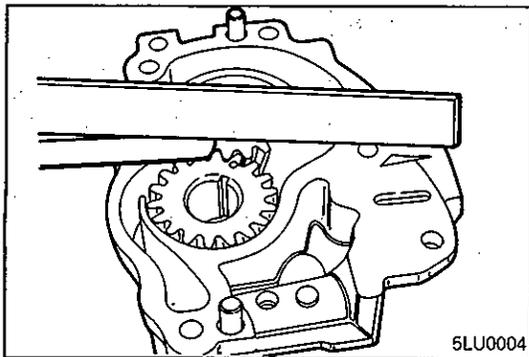
- (2) Check the drive gear side clearance.

Standard value:

0.05 – 0.11 mm (0.0020 – 0.0043 in.)

Limit: 0.15 mm (0.006 in.)





- (3) Check the driven gear side clearance.

Standard value:

0.04 – 0.10 mm (0.0016 – 0.0039 in.)

Limit: 0.15 mm (0.006 in.)

- (4) Check gear contacting surface of cover for ridge wear. If clearance is excessively large or if case or cover has ridge wear, replace case and cover assembly and/or gears.

SILENT SHAFT

- (1) Check oil holes for clogging.
- (2) Check journal for seizure, damage, and contact with bearing. If defects are evident, replace the silent shaft, bearing, or thrust plate.
- (3) Check the silent shaft oil clearance. If wear is excessive, replace the silent shaft bearing, silent shaft, or thrust plate.

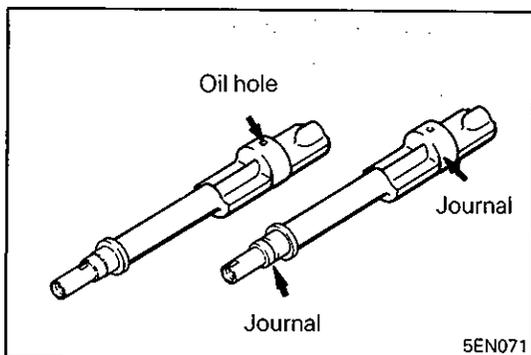
Standard value:

Front (left only)

0.02 – 0.06 mm (0.0008 – 0.0024 in.)

Rear

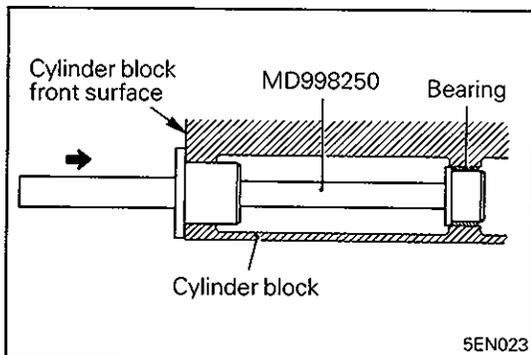
0.10 – 0.13 mm (0.0039 – 0.0051 in.)



SERVICE POINTS OF INSTALLATION

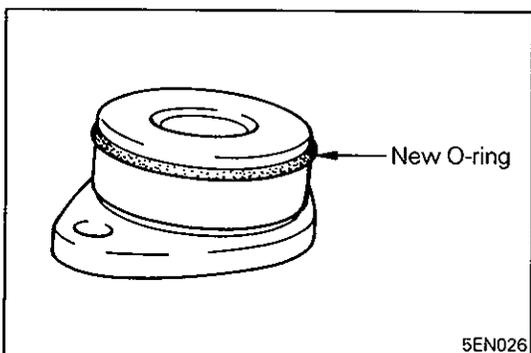
◆A◆ INSTALLATION OF SILENT SHAFT REAR BEARING

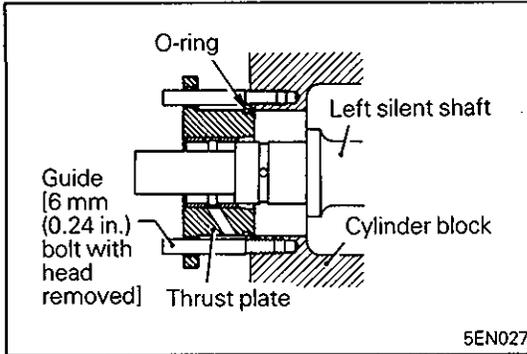
- (1) Apply engine oil to the rear bearing outer circumference and bearing hole in cylinder block.
- (2) Using the special tool and a hammer, drive the rear bearing into cylinder block.



◆B◆ INSTALLATION OF O-RING

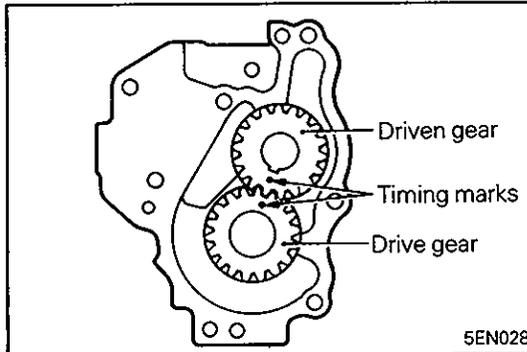
- (1) Install new O-ring in groove of thrust plate. Apply engine oil around O-ring.





◆C◆ INSTALLATION OF THRUST PLATE

- (1) Insert two guides in threaded holes for mounting thrust plate. Guides should be fabricated by cutting off hexagon heads of bolts 6 mm (0.24 in.) in diameter and 50 mm (1.97 in.) long.
- (2) Insert thrust plate into cylinder block along guides. Without use of guide, threaded holes will be hard to align. If thrust plate is turned to align holes, O-ring might be twisted or damaged. So make sure that thrust plate is correctly installed through use of guide.

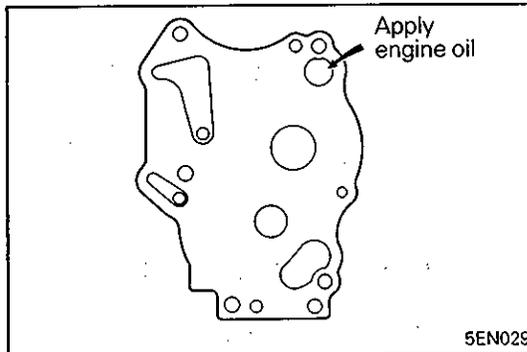


◆D◆ INSTALLATION OF OIL PUMP DRIVEN GEAR / OIL PUMP DRIVE GEAR

- (1) Install oil pump gears to oil pump body and align timing marks. When installing gears, apply engine oil to bearing surface and gear teeth.

Caution

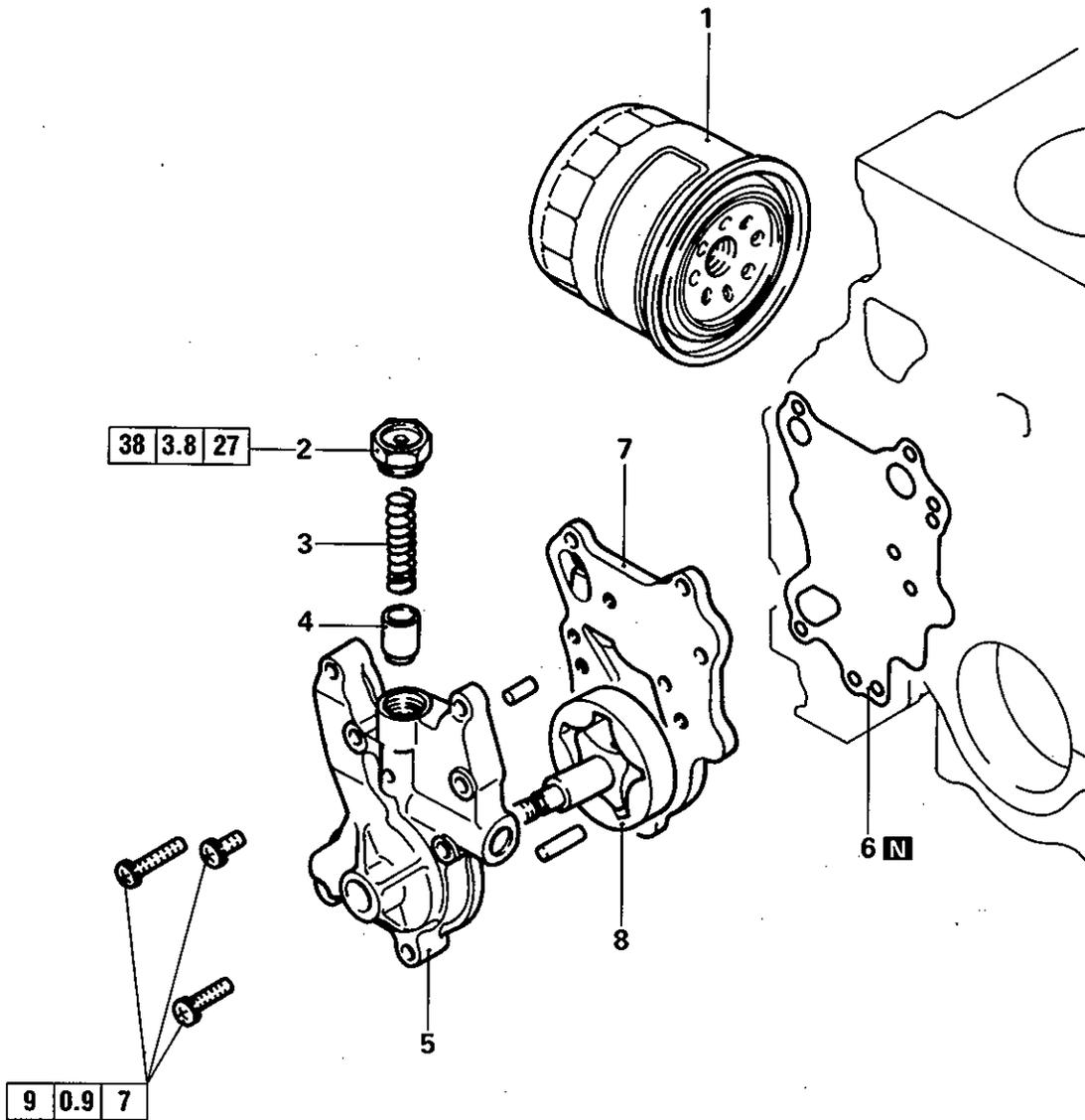
- If timing marks are out of alignment, phase of silent shafts will change and vibration will result.



◆E◆ INSTALLATION OF OIL PUMP BODY

- (1) Apply 10 cc (0.6 cu.in.) of clean engine oil in delivery port and then install oil pump to cylinder block.

11. OIL FILTER AND OIL PUMP (ENGINE WITHOUT SILENT SHAFT) REMOVAL AND INSTALLATION

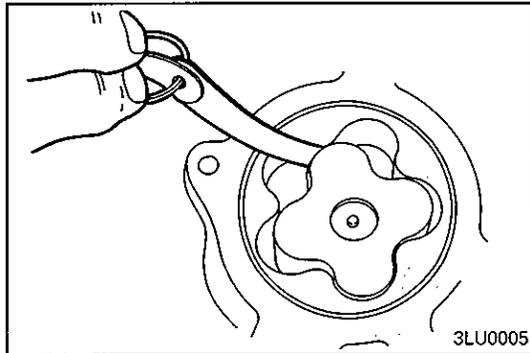


Removal steps

1. Oil filter
2. Plug
3. Relief spring
4. Relief plunger
- ◆B◆ 5. Oil pump body
6. Oil pump gasket
7. Oil pump cover
- ◇A◇ ◆A◆ 8. Pump rotor

SERVICE POINTS OF REMOVAL**◇A◇ REMOVAL OF OIL PUMP ROTOR**

- (1) Before removing outer rotor to disassemble oil pump, put mating mark on rear side in order to ensure reinstallation in same direction when they are to be reused.

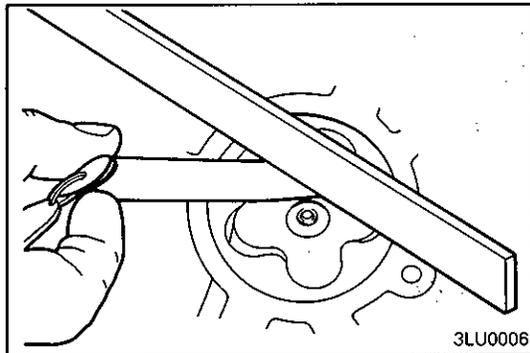
**INSPECTION****OIL PUMP**

- (1) Check outer rotor and inner rotor tip clearances.

Standard value:

0.04 – 0.15 mm (0.0016 – 0.0059 in.)

Limit: 0.2 mm (0.008 in.)

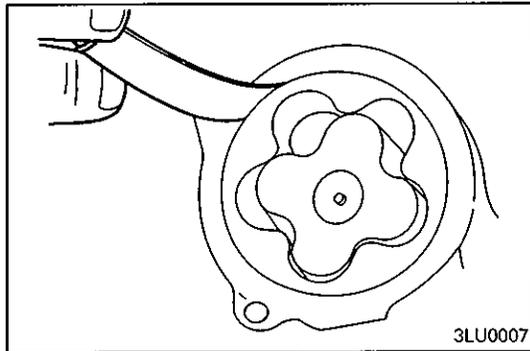


- (2) Check the side clearance.

Standard value:

0.05 – 0.11 mm (0.0020 – 0.0043 in.)

Limit: 0.15 mm (0.006 in.)



- (3) Check the oil pump body to rotor clearance. (Body clearance)

Standard value:

0.10 – 0.17 mm (0.0039 – 0.0067 in.)

Limit: 0.2 mm (0.008 in.)

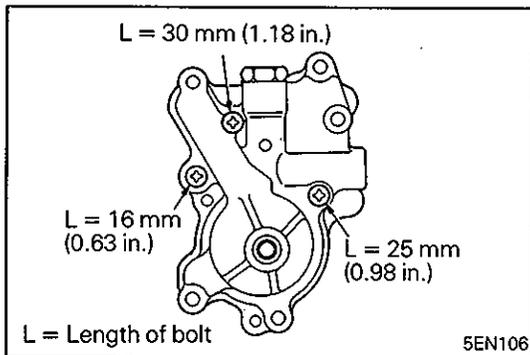
- (4) Check that outer rotor and inner rotor turn smoothly when installed in body.
- (5) Check that cover is free from ridge wear on its rotor contact surface.

RELIEF PLUNGER

- (1) Insert the relief plunger in the oil pump body and check that the plunger slides smoothly.

SERVICE POINTS OF INSTALLATION**◆A◆ INSTALLATION OF OIL PUMP ROTOR**

- (1) Apply engine oil amply to entire surface of inner rotor and outer rotor and install them to oil pump body. When reusing rotors, install them in original direction according to mating marks put before disassembly.

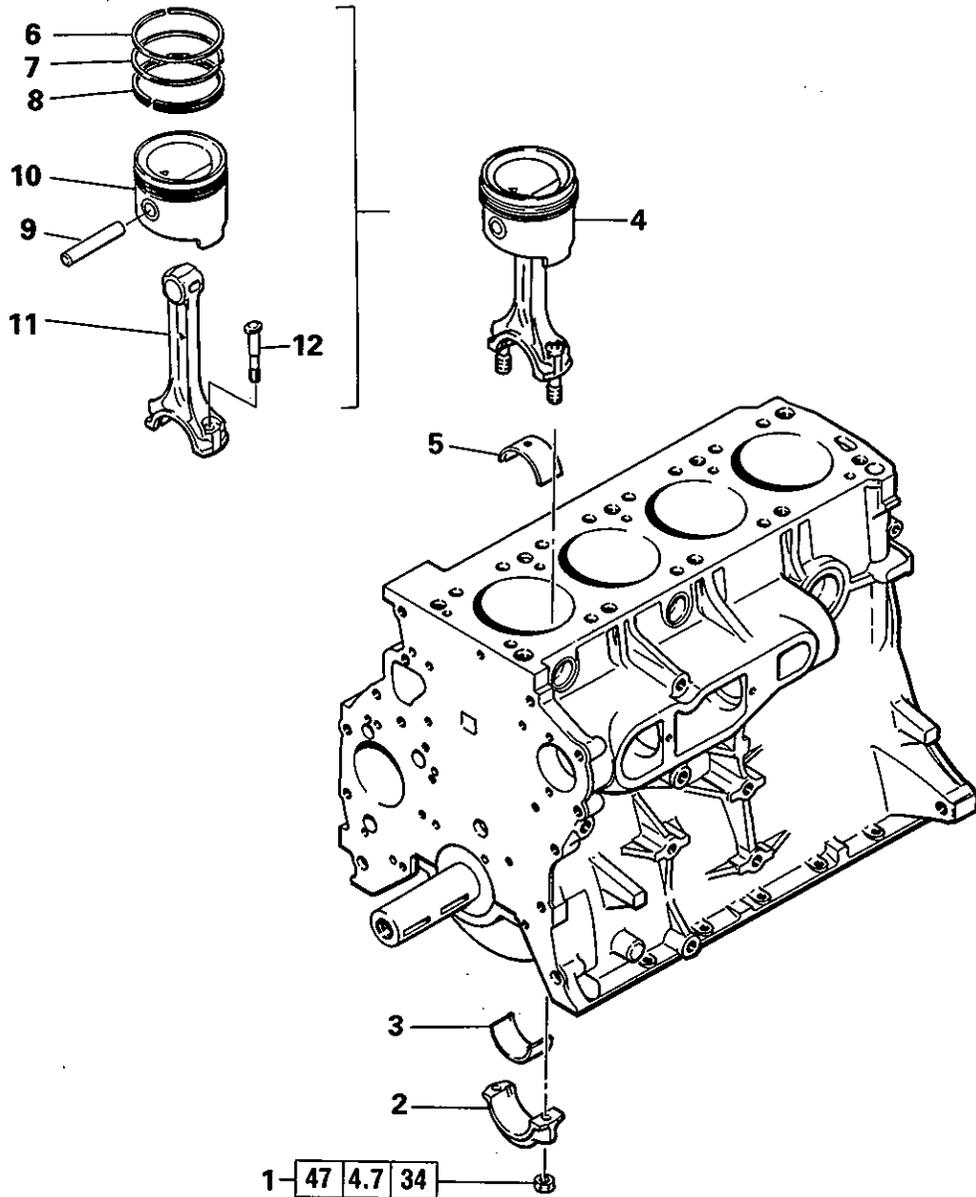
**◆B◆ INSTALLATION OF OIL PUMP COVER**

- (1) Install cover and tighten three screws to specified torque. Then check that rotors turn lightly and smoothly.

NOTES

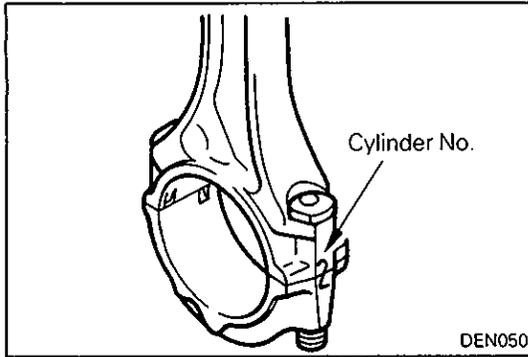
12. PISTON AND CONNECTING ROD

REMOVAL AND INSTALLATION

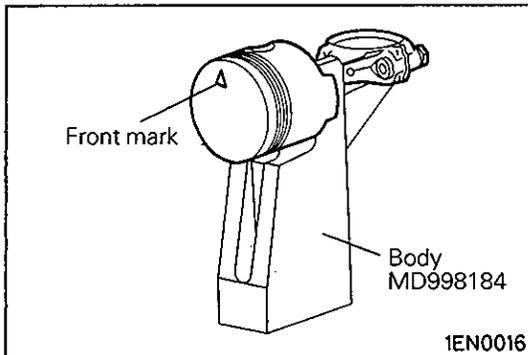


Removal steps

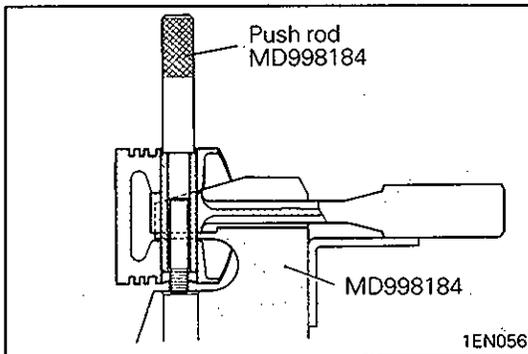
- 1. Nut
- ◀A▶▶E▶ 2. Bearing cap
- 3. Bearing
- ▶D▶ 4. Piston and connecting rod assembly
- 5. Bearing
- ▶C▶ 6. Piston ring No. 1
- ▶C▶ 7. Piston ring No. 2
- ▶B▶ 8. Oil ring
- ◀B▶▶A▶ 9. Piston pin
- 10. Piston
- 11. Connecting rod
- 12. Connecting rod bolt

**SERVICE POINTS OF REMOVAL****◁A▷ REMOVAL OF CONNECTING ROD CAP**

- (1) Mark the cylinder number on the side of the connecting rod big end for correct reassembly.

**◁B▷ REMOVAL OF PISTON PIN**

- (1) Place piston and connecting rod assembly into the special tool body with front mark (arrow mark) toward up.



- (2) Insert push rod in piston pin and remove piston pin with press.

NOTE

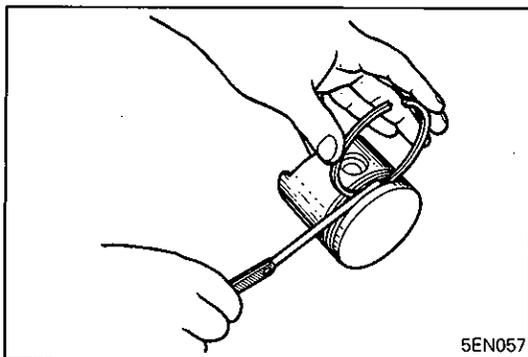
Keep disassembled piston, pin and connecting rod of a cylinder separate from those of another cylinder.

INSPECTION**PISTON**

- (1) Replace the piston if scratches or seizure is evident on its surfaces (especially the thrust surface). Replace the piston if it is cracked.

PISTON PIN

- (1) Insert the piston pin into the piston pin hole with a thumb. You should feel a slight resistance. Replace the piston pin if it can be easily inserted or there is an excessive play.
- (2) The piston and piston pin must be replaced as an assembly.

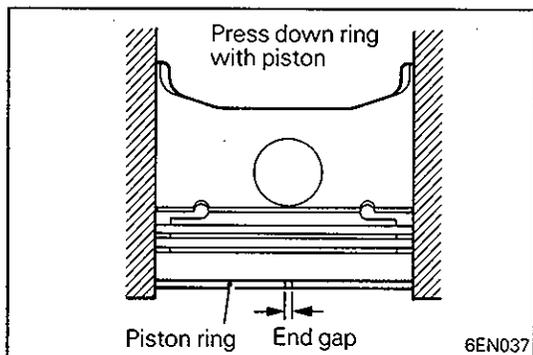


PISTON RING

- (1) Check the piston ring for damage, abnormal wear, and breakage. Replace if defects are evident. If a piston is replaced with a new one, the piston rings must also be replaced.
- (2) Check for side clearance.
If the limit is exceeded, replace the ring or piston, or both.

Standard value:

0.05 – 0.10 mm (0.0020 – 0.0039 in.)	.....	No. 1
0.02 – 0.06 mm (0.0008 – 0.0024 in.)	.....	No. 2



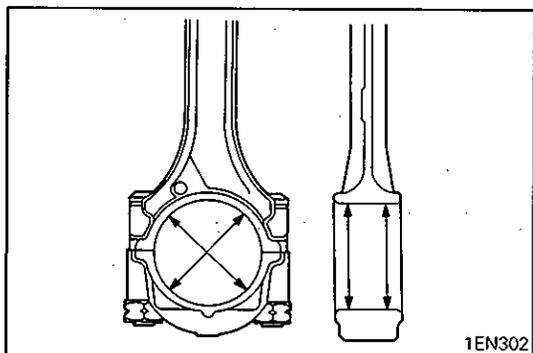
- (3) Insert the piston ring into cylinder bore. Force it down with a piston, its crown being in contact with the ring, to correctly position it at right angles to the cylinder wall. Then, measure the end gap with a feeler gauge. If the end gap is excessive, replace piston ring.

Standard value:

0.25 – 0.45 mm (0.0098 – 0.0177 in.)	.....	No. 1
0.25 – 0.45 mm (0.0098 – 0.0177 in.)	.....	No. 2
0.30 – 0.80 mm (0.0118 – 0.0315 in.)	.....	Oil

Limit:

0.8 mm (0.031 in.)	.....	No. 1, No. 2
1.0 mm (0.039 in.)	.....	Oil

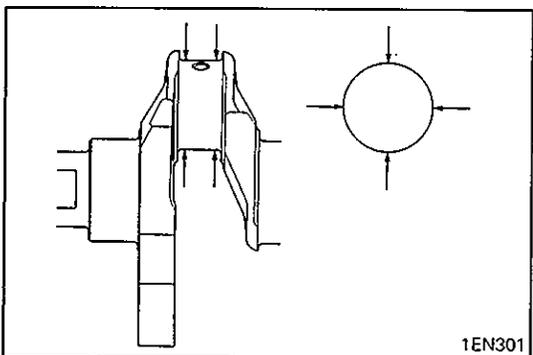


CONNECTING ROD BEARING

- (1) Visually check the bearing surface for uneven contact, streaks, scratches, and seizure. Replace if defects are evident. If streaks and seizure are excessive, check also the crankshaft. If damage is present on the crankshaft, replace crankshaft or regrind to undersize for reuse.

Caution

- Do not attempt an undersize machining on crankshaft with special surface treatment. This type of crankshaft can be identified by its dull gray appearance.

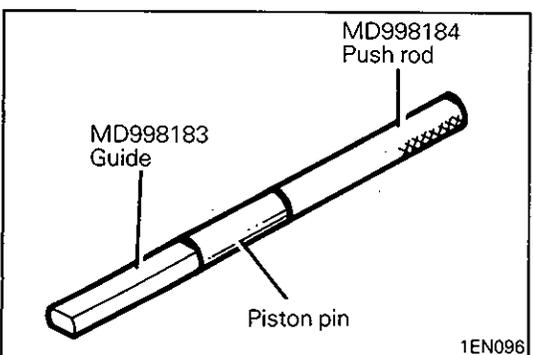


- (2) Measure the connecting rod bearing I.D. and crankshaft pin O.D. If the oil clearance exceeds the limit, replace bearing, and crankshaft if necessary.
Or, regrind the crankshaft to an undersize and replace bearing with an undersize one.

Standard value:

0.02 – 0.06 mm (0.0008 – 0.0024 in.)

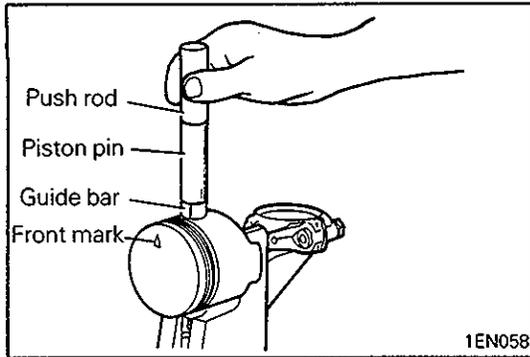
Limit: 0.10 mm (0.004 in.)



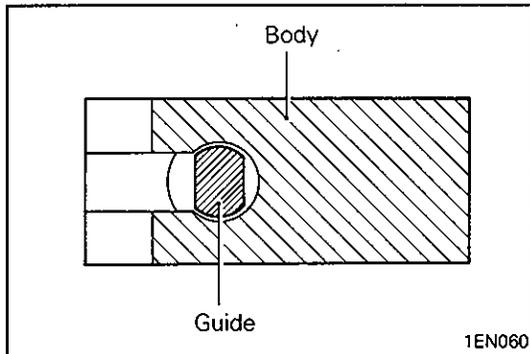
SERVICE POINTS OF INSTALLATION

▶▶ INSTALLATION OF PISTON PIN

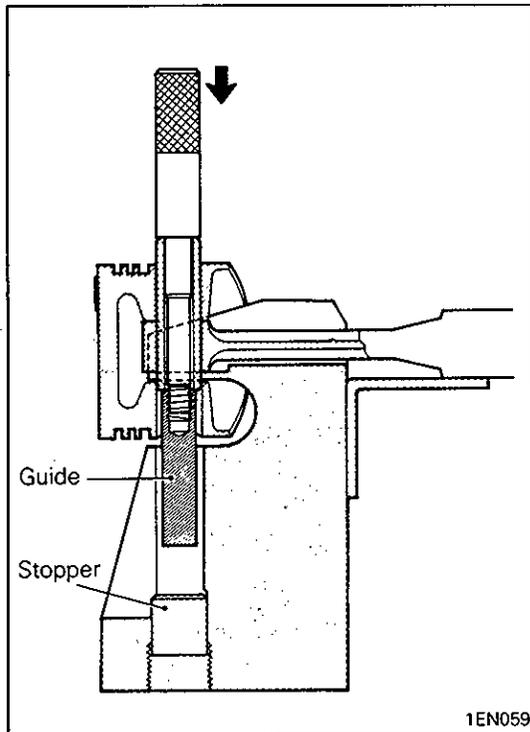
- (1) Attach the push rod and the guide bar included in the special tool set to the piston pin.
- (2) Apply engine oil to the outer circumference of piston pin.



- (3) Place the piston and connecting rod on the special tool body with their front marks (arrow mark for piston and embossed mark "54" for connecting rod) facing upward.
- (4) Insert the piston pin, guide bar and push rod assembled in step (1) into the piston and connecting rod.



- (5) Position the guide so its two surfaces running in parallel to each other are oriented as shown.

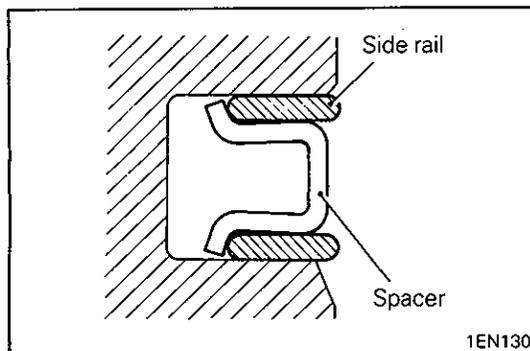


- (6) Install the piston pin into connecting rod with a press until the guide reaches to the stopper.
- (7) If the press-fitting load is out of specification, replace the piston pin and piston set or connecting rod, or both.

Piston pin press-fitting load:

7,500 – 17,500 N

(750 – 1,750 kg, 1,653 – 3,858 lbs.)

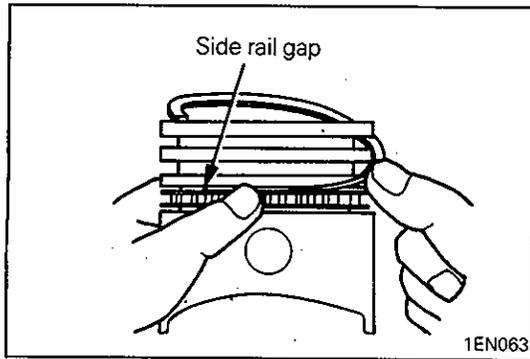


▶B▶ INSTALLATION OF OIL RING

- (1) Fit the oil ring spacer into the piston ring groove.

NOTE

The side rails and spacer may be installed in either direction.



(2) Install the upper side rail.

To install the side rail, first fit one end of the rail into the piston groove, then press the remaining portion into position by finger. See illustration.

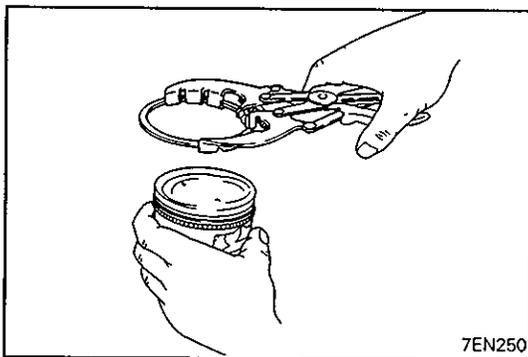
Use of ring expander to expand the side rail end gap can break the side rail, unlike other piston rings.

NOTE

Do not use piston ring expander when installing side rail.

(3) Install the lower side rail in the same procedure as described in step (2).

(4) Make sure that the side rails move smoothly in either direction.



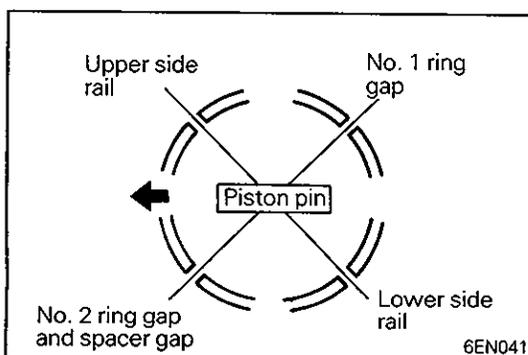
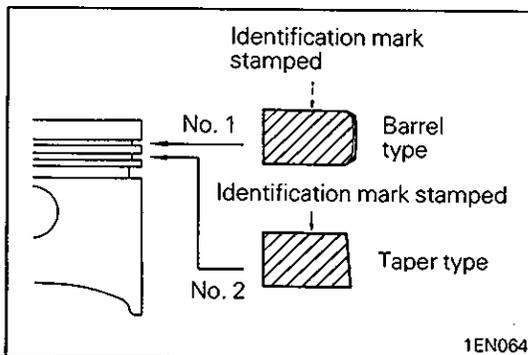
◆C◆ INSTALLATION OF PISTON RING NO. 2 / PISTON RING NO. 1

(1) Using piston ring expander, fit No. 2 and then No. 1 piston ring into position.

NOTE

(1) Note the difference in shape between No. 1 and No. 2 piston ring.

(2) Install piston rings No. 1 and No. 2 with their side having marks facing up (on the piston crown side).

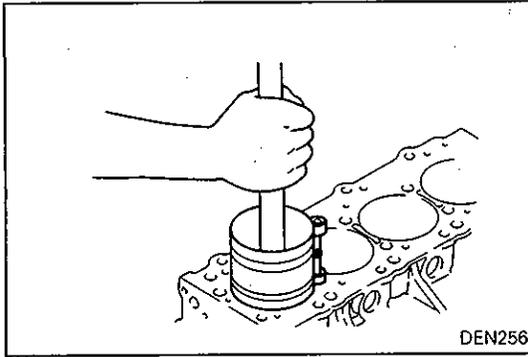


◆D◆ INSTALLATION OF PISTON AND CONNECTING ROD ASSEMBLY

(1) Liberally coat engine oil on the circumference of the piston, piston ring, and oil ring.

(2) Arrange the piston ring and oil ring gaps (side rail and spacer) as shown in the figure.

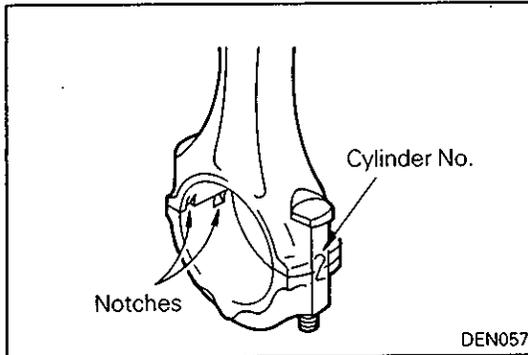
(3) Rotate crankshaft so that crank pin is on center of cylinder bore.



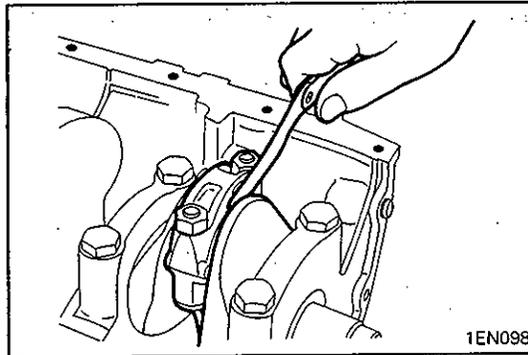
- (4) Use suitable thread protectors on connecting rod bolts before inserting piston and connecting rod assembly into cylinder block.
Care must be taken not to nick crank pin.
- (5) Using a suitable piston ring compressor, install piston and connecting rod assembly into cylinder block.

Caution

- Face the front mark (arrow) on the piston top toward the engine front (timing chain).

**▶E◀ INSTALLATION OF CONNECTING ROD CAP**

- (1) Verifying the mark made during disassembly, install the bearing cap to the connecting rod. If the connecting rod is new with no index mark, make sure that the bearing locking notches come on the same side as shown.

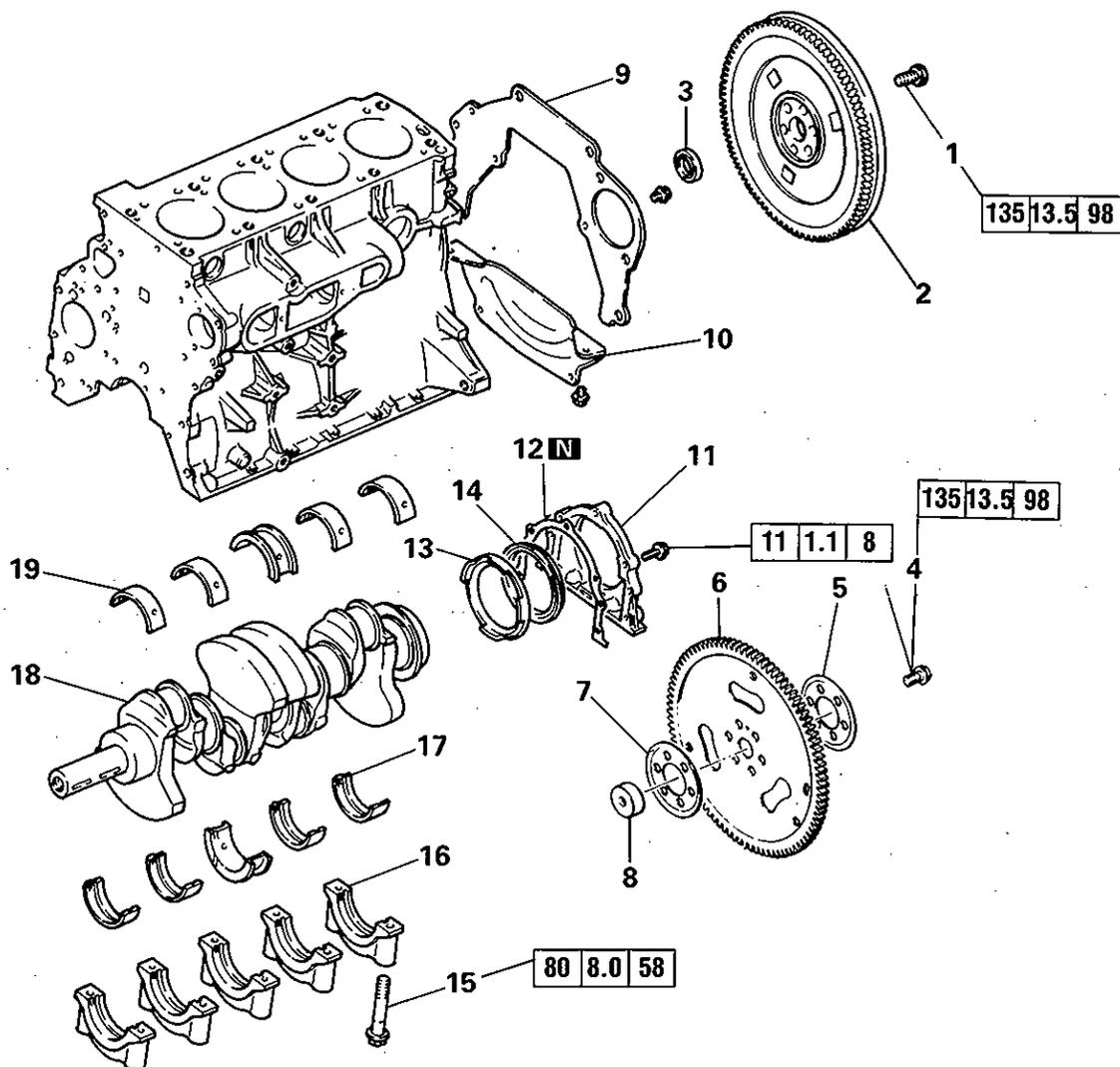


- (2) Make sure that connecting rod big end side clearance meets the specification.

Standard value: 0.10 – 0.25 mm (0.0039 – 0.0098 in.)
Limit: 0.4 mm (0.016 in.)

13. CRANKSHAFT, FLYWHEEL AND DRIVE PLATE

REMOVAL AND INSTALLATION

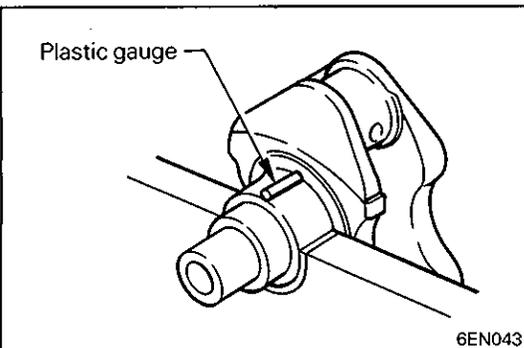
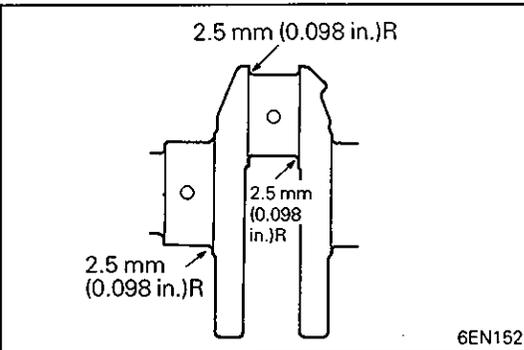
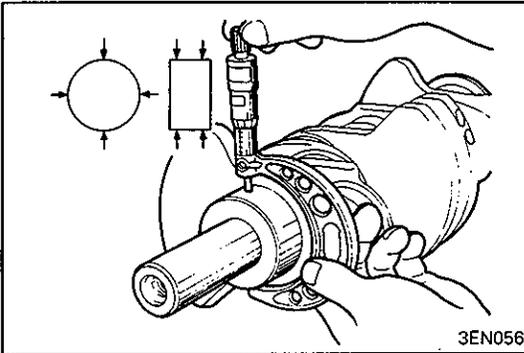
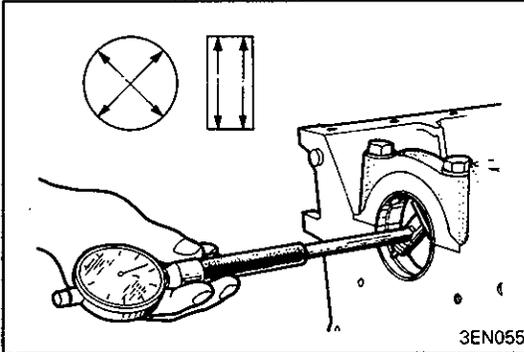


Removal steps

1. Flywheel bolt
2. Flywheel
3. Ball bearing
4. Drive plate bolt
5. Adapter
6. Drive plate
7. Adapter
8. Crankshaft bushing
9. Rear plate
10. Bell housing cover
11. Oil seal case
12. Gasket
- ▶E▶ 13. Separator
- ▶D▶ 14. Rear oil seal
15. Bearing cap bolt
- ▶C▶ 16. Bearing cap
- ▶B▶ 17. Crankshaft bearing (lower)
18. Crankshaft
- ▶A▶ 19. Crankshaft bearing (upper)

INSPECTION**CRANKSHAFT**

- (1) Check the crankshaft journals and pins for streaks and seizure. Replace if necessary.



- (2) Measure the outside diameter of journal and inside diameter of crankshaft bearing. If the difference between them (oil clearance) exceeds the limit, replace the crankshaft bearing and, if necessary, crankshaft. When the crankshaft is to be reused by machining to undersize, the crankshaft bearings should be changed to undersized ones.

Standard value:

0.02 – 0.05 mm (0.0008 – 0.0020 in.)

Limit: 0.1 mm (0.0039 in.)

Caution

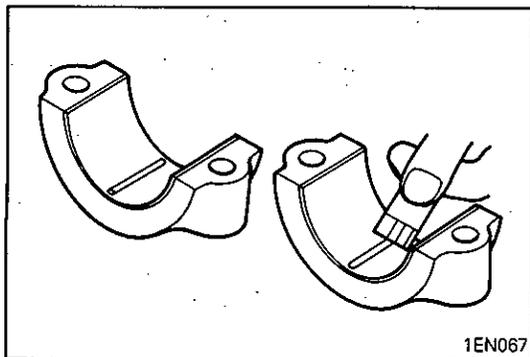
- Do not attempt an undersize machining on the crankshaft with special surface treatment which is used in engines with a turbocharger. This type of crankshaft can be identified by its dull gray appearance.

- (3) When the crankshaft is machined to undersize, finish the fillets of journals and pins to the specified radius.

CRANKSHAFT OIL CLEARANCE (PLASTIC GAUGE METHOD)

The crankshaft oil clearance can be measured easily by using a plastic gauge, as follows:

- (1) Remove oil and grease and any other foreign matters from crankshaft journal and bearing inner surface.
- (2) Install the crankshaft.
- (3) Cut the plastic gauge to the same length as the width of bearing and place it on journal in parallel with its axis.

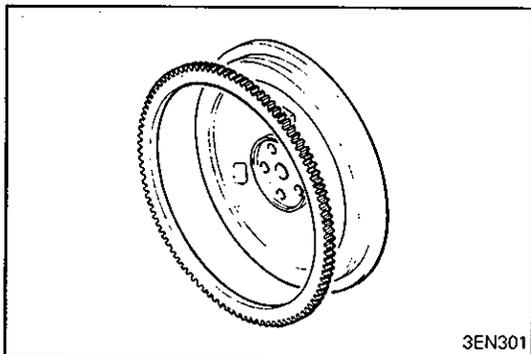


1EN067

- (4) Gently place the crankshaft bearing cap over it and tighten the bolts to the specified torque.
- (5) Remove the bolts and gently remove the crankshaft bearing cap.
- (6) Measure the width of the smashed plastic gauge at its widest section by using a scale printed on the plastic gauge bag.

CRANKSHAFT REAR OIL SEAL

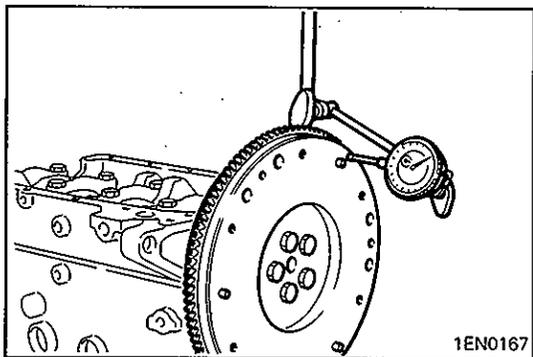
- (1) Check oil seal lip for wear and damage.
- (2) Check rubber for deterioration or hardening.
- (3) Check oil seal case for cracks and damage.



3EN301

RING GEAR

- (1) Check teeth of ring gear for wear and damage. If necessary, replace the ring gear.
- (2) If the ring gear teeth are worn or damaged, also check the starter motor pinion.
- (3) To remove the ring gear, strike the ring gear at several points on its outer circumference. The ring gear cannot be removed if it is heated.
To install the ring gear, heat the ring gear to 260 – 280°C (500 – 536°F) for shrink fit.



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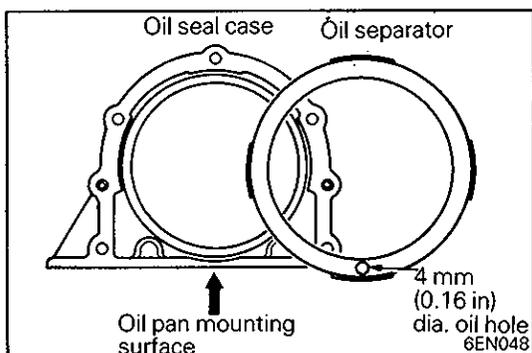
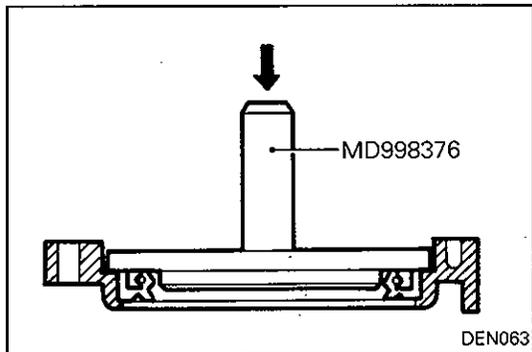
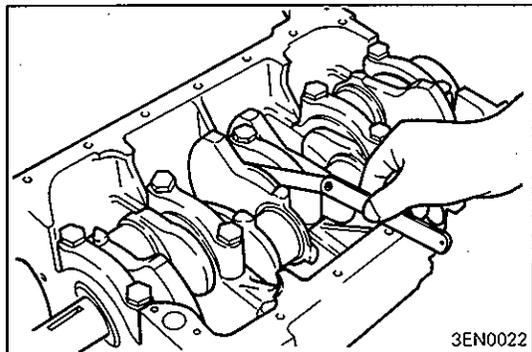
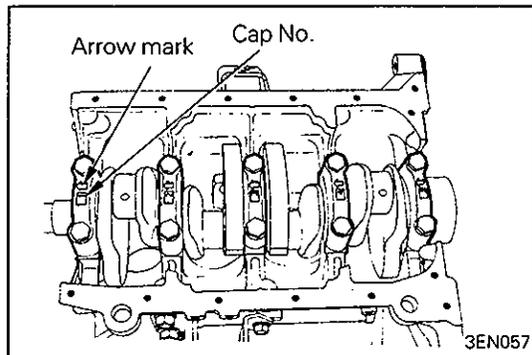
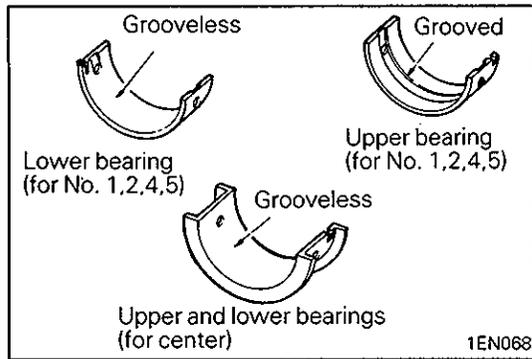
FLYWHEEL

- (1) Check the clutch disc friction surface for ridge wear, streaks, and seizure. If necessary, replace flywheel.
- (2) If the runout of flywheel exceeds the limit, replace.

Limit: 0.13 mm (0.0051 in.)

DRIVE PLATE

- (1) Check the drive plate for deformation, damage and cracks. If necessary, replace.



SERVICE POINTS OF INSTALLATION

◆A◆ INSTALLATION OF CRANKSHAFT BEARING (UPPER)

- (1) Install the upper crankshaft bearing to the cylinder block. There is an oil groove in the upper crankshaft bearing. There is no difference between upper and lower bearings for the center (with flange).

◆B◆ INSTALLATION OF CRANKSHAFT BEARING (LOWER)

- (1) Install the lower crankshaft bearing (with no oil groove; there is no difference for center) to each bearing cap and apply engine oil to bearing surfaces.

◆C◆ INSTALLATION OF BEARING CAP

- (1) Check the cap numbers for correct position and arrow marks for correct direction.

- (2) After installing the bearing caps, make sure that the crankshaft turns smoothly and the end play is correct. If the end play exceeds the limit, replace crankshaft bearings.

Standard value:

0.05 – 0.18 mm (0.0020 – 0.0071 in.)

Limit: 0.25 mm (0.0098 in.)

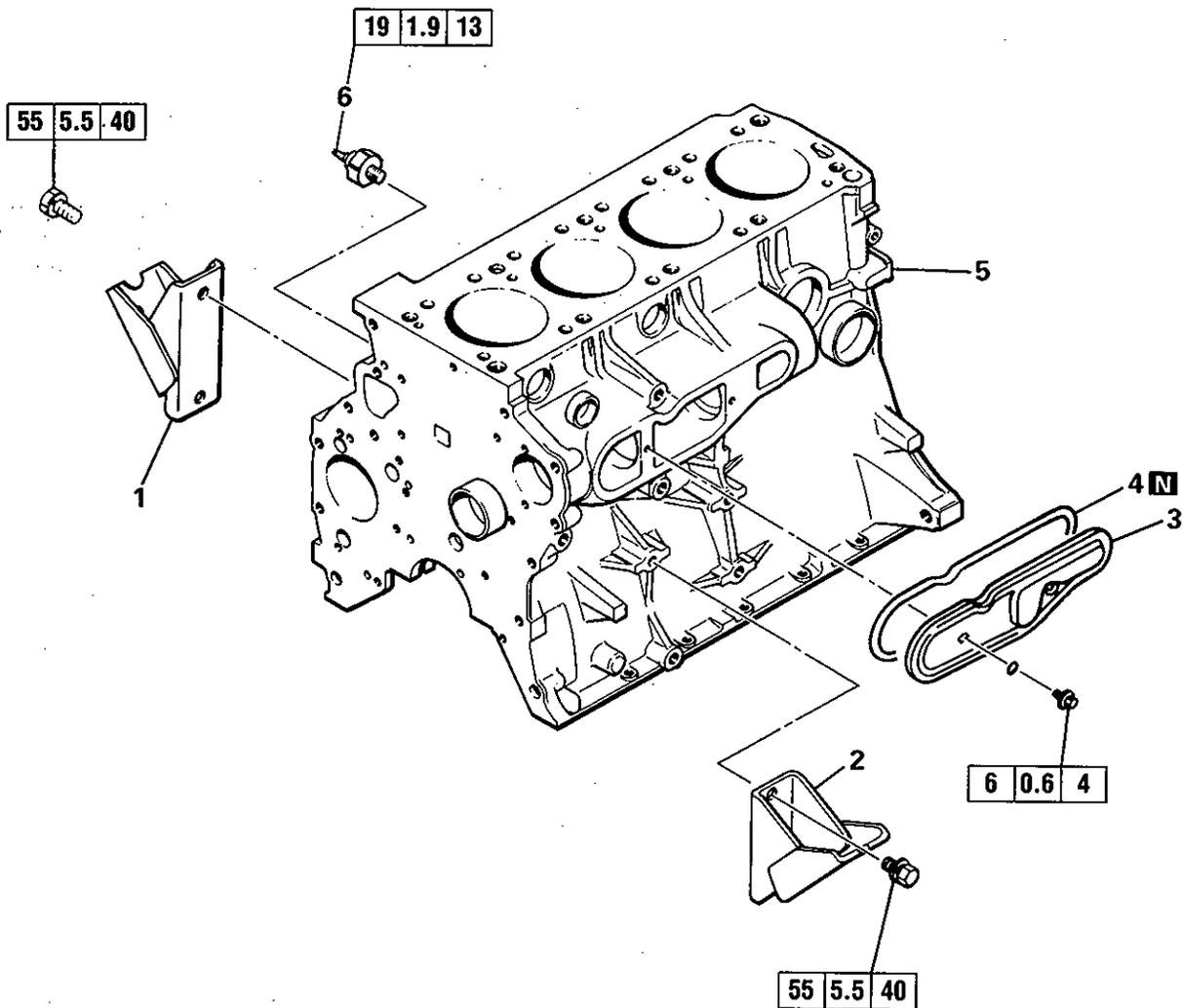
◆D◆ INSTALLATION OF OIL SEAL

- (1) Using the special tool, press-fit the oil seal into the crankshaft rear oil seal case. Use a new oil seal.

◆E◆ OIL SEPARATOR

- (1) Press oil separator into oil seal case. Make sure that the oil hole in separator faces downward (indicated by an arrow).

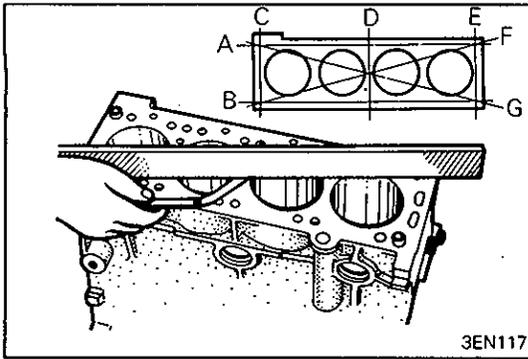
14. CYLINDER BLOCK REMOVAL AND INSTALLATION



Disassembly steps

1. Right engine support bracket
2. Left engine support bracket
3. Silent shaft chamber cover
4. Chamber cover gasket
5. Cylinder block
- ▶▶▶ 6. Oil pressure switch

5EN210



**INSPECTION
CYLINDER BLOCK**

- (1) Using a straightedge and feeler gauge, check the block top surface for warpage. Make sure that the surface is free from gasket chips and other foreign matter.

Standard value: 0.05 mm (0.0020 in.)

Limit: 0.1 mm (0.0039 in.)

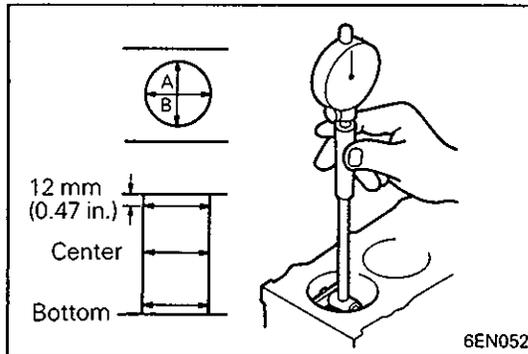
- (2) If the distortion is excessive, correct within the allowable limit or replace.

Grinding limit: 0.2 mm (0.008 in.)

If cylinder block gasket surface has already been ground, thickness of the removed stock should be included in the grinding limit of 0.2 mm (0.008 in.).

Cylinder block height (when new):

316 mm (12.44 in.)



- (3) Check cylinder walls for scratches and seizure. If defects are evident, correct (bored to oversize) or replace.

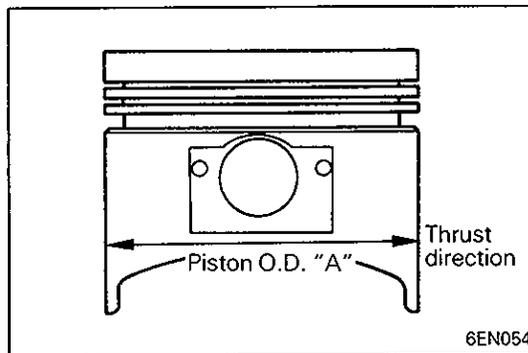
- (4) Using cylinder gauge, measure the cylinder bore and cylindricity. If worn badly, correct cylinder to an oversize and replace piston and piston rings. Measure at the points shown in illustration.

Standard value:

Cylinder I.D.

91.10 – 91.13 mm (3.5866 – 3.5878 in.)

Cylindricity: 0.01 mm (0.0004 in.)



BORING CYLINDER

- (1) Oversize pistons to be used should be determined on the basis of the largest bore cylinder.

Piston size identification

Size	Identification mark
0.25 mm (0.01 in.) O.S.	0.25
0.50 mm (0.02 in.) O.S.	0.50
0.75 mm (0.03 in.) O.S.	0.75
1.00 mm (0.04 in.) O.S.	1.00

NOTE

Size mark is stamped on piston top.

- (2) Measure outside diameter of piston to be used. Measure it at position "A" in thrust direction as shown.
- (3) Based on measured piston O.D. calculate boring finish dimension.

Boring finish dimension = Piston O.D. + (clearance between piston O.D. and cylinder) – 0.02 mm (0.0008 in.) (honing margin)

- (4) Bore all cylinders to calculated boring finish dimension.

Caution

- To prevent distortion that may result from temperature rise during honing bore cylinders, working from No. 2 to No. 4 to No. 1 to No. 3.

- (5)hone to final finish dimension (piston O.D. + clearance between piston O.D. and cylinder).

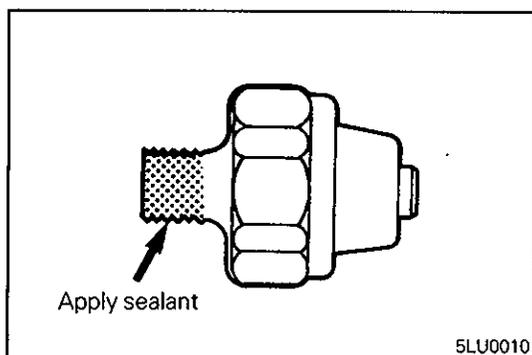
- (6) Check clearance between piston and cylinder.

Clearance between piston and cylinder:

0.01 – 0.03 mm (0.0004 – 0.0012 in.)

NOTE

When boring cylinders, finish all of four cylinders to same oversize. Do not bore only one cylinder to an oversize.



SERVICE POINT OF INSTALLATION

◆A◆ APPLICATION OF SEALANT TO OIL PRESSURE SWITCH

- (1) Coat the threads of switch with sealant and install the switch using the special tool.

Specified sealant:

3M ATD Part No. 8660 or equivalent

Caution

- Keep the end of threaded portion clear of sealant.
- Avoid an overtightening.

NOTES

Service Bulletins

Click on the applicable bookmark to select the Service Bulletin.



SERVICE BULLETIN

QUALITY INFORMATION ANALYSIS
OVERSEAS SERVICE DEPT. MITSUBISHI MOTORS CORPORATION

SERVICE BULLETIN		No.: MSB-98E11-501e	
		Date: 1999-05-15	<Model> (EC.EXP)PAJERO (V10,V20,V30,V40)
Subject: CORRECTION TO PISTON CLEARANCE		<M/Y> 98-10	
Group: ENGINE	Draft No.: 98EN570911		
CORRECTION	OVERSEAS SERVICE DEPT	 T.NITTA - VICE GENERAL MANAGER QUALITY INFORMATION ANALYSIS	

1. Description:

Correction has been made to the piston clearance described in the following Workshop Manual.

2. Applicable Manuals:

Manual	Pub. No.	Language	Page(s)
ENGINE 4G5 WORKSHOP MANUAL	PWEE9055	(English)	11A-14-3
	PWES9056	(Spanish)	
	PWEF9057	(French)	
	PWEG9058	(German)	
	PWED9059	(Dutch)	
	PWEW9060	(Swedish)	

3. Interchangeability:

No interchangeability.

- (4) Bore all cylinders to calculated boring finish dimension.
 - Caution**
 - To prevent distortion that may result from temperature rise during honing bore cylinders, working from No. 2 to No. 4 to No. 1 to No. 3.
- (5) Hone to final finish dimension (piston O.D. + clearance between piston O.D. and cylinder).
- (6) Check clearance between piston and cylinder.

Clearance between piston and cylinder:

0.01 - 0.03 mm (~~0.0004 - 0.0012 in.~~)

<Incorrect>

NOTE

When boring cylinders, finish all four cylinders to same oversize. Do not bore only one cylinder to an oversize.

<Correct>

0.02- 0.04 mm (0.008 - 0.0016 in.)

SERVICE POINT OF INSTALLATION

⇒A⇐ **APPLICATION OF SEALANT TO OIL PRESSURE SWITCH**

- (1) Coat the threads of switch with sealant and install the switch using the special tool.

Specified sealant:

3M ATD Part No. 8660 or equivalent

Caution

- Keep the end of threaded portion clear of sealant.
- Avoid an overtightening.

