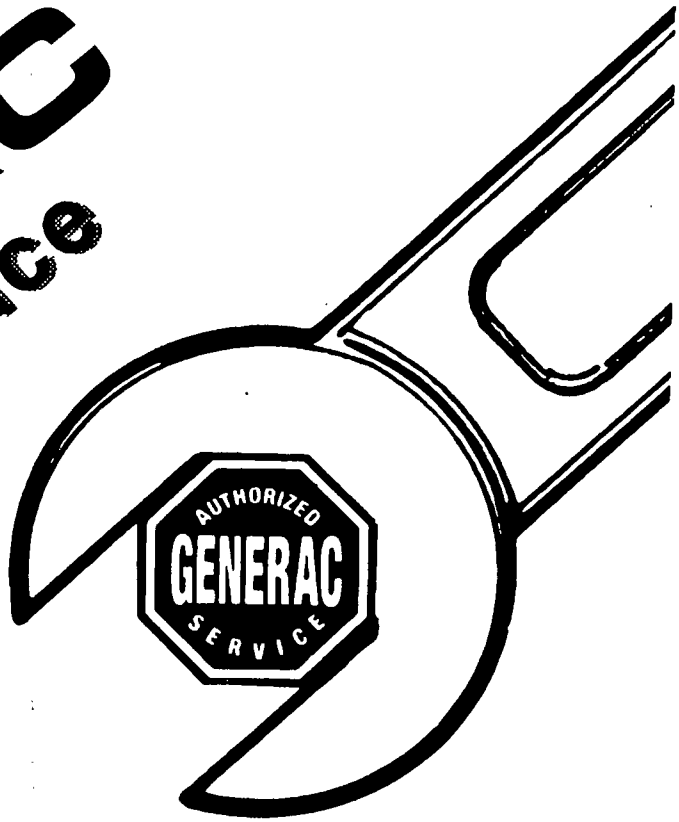
P/N 99341

GENERAC
One-Stop Service



3.0 DIESEL

REPAIR MANUAL

P.O. BOX 8 WAUKESHA WI. 53187

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**For your parts needs please order through your regular source and refer to parts catalog # PB30000D.*

Please refer to our Technical Publications Catalog #91021B for the complete line of* **GENERAC *reference materials.*

TROUBLESHOOTING GUIDE

SPECIFICATIONS:

Engine Type	Diesel, 4 cycle
Cylinder Arrangement and Number	In-line, 4 cylinders
Combustion Chamber Type	Pre-combustion chamber
Valve System	OHV, Gear-driven
Displacement	2,977 (181.60)
Bore X Stroke	95.0 x 105.0 (3.74 x 4.13)
Compression Ratio	21.0 :1
Compression Pressure kPa (kg/cm, psi)-rpm	2,943 (30.0, 427)-200
Valve Timing Intake (Open) BTDC	17°
Valve Timing Intake (Closed) ABDC	47°
Valve Timing Exhaust (Open) BBDC	51°
Valve Timing (Closed) ATDC	13°
Valve Clearance (Engine Cold) Intake (mm/in.)	0.30 (0.012)
Valve Clearance (Engine Cold) Exh. (mm/in.)	0.30 (0.012)

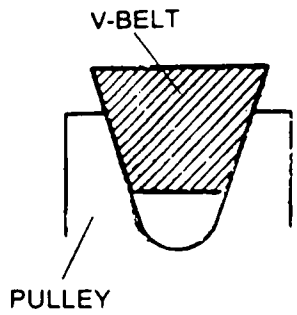
TROUBLESHOOTING GUIDE:

Problem	*Possible Cause*	*Action*
Difficult Starting	**Malfunction of engine-related components**	
	Burned valve	Replace
	Worn piston, piston rings or cylinder	Repair or replace
	Failed cylinder head gasket	Replace
	Malfunction of fuel or electrical system	
Poor Idling	**Malfunction of engine related components**	
	Improper valve clearance	Adjust
	Poor valve to valve seat contact	Repair or replace
	Failed cylinder head gasket	Replace
	Malfunction of fuel system	
Excessive oil Consumption	**Oil working up**	
	Worn piston ring groove or stuck piston ring	Replace
	Worn piston or cylinder	Repair or replace
	Oil working down	
	Worn valve seal	Replace
	Worn valve stem or guide	Replace
	Oil leakage	**See appopriate section**

TROUBLESHOOTING GUIDE

Problem	*Possible Cause*	*Action*
Insufficient power	**Insufficient compression**	
	Improper valve clearance	Adjust
	Compression leakage from valve seat	Repair
	Seized valve stem	Replace
	Weak or broken valve spring	Replace
	Failed cylinder head gasket	Replace
	Cracked or distorted cylinder head	Replace
	Sticking, damaged or worn piston rings	Replace
	Cracked or worn piston	Replace
	Malfunction of fuel system	
Abnormal combustion	**Malfunction of engine-related components**	
	Improper valve clearance	Adjust
	Sticking or burned valve	Replace
	Weak or broken valve spring	Replace
	Carbon accumulation in combustion chamber	Eliminate carbon
	Malfunction of fuel system	
Engine noise	**Crankshaft or bearing related parts**	
	Excessive main bearing oil clearance	Repair or replace
	Main bearing seized or heat damaged	Replace
	Excessive crankshaft end play	Repair or replace
	Excessive connecting rod oil clearance	Repair or replace
	Con-rod bearing seized or heat damaged	Replace
	Piston related parts	
	Worn cylinder	Repair or replace
	Worn piston or piston pin	Replace
	Seized piston	Replace
	Damaged piston ring	Replace
	Bent connecting rod	Repace
	Valves or timing related parts	
	Improper valve clearance	Adjust
	Broken valve spring	Replace
	Excessive valve guide clearance	Replace
	Malfunction of cooling system	
	Malfunction of fuel system	
	Others	
	Malfunction of water pump bearing	
	Improper drive belt tension	Adjust
	Malfunction of alternator bearing	
	Exhaust gas leakage	

Figure 1.

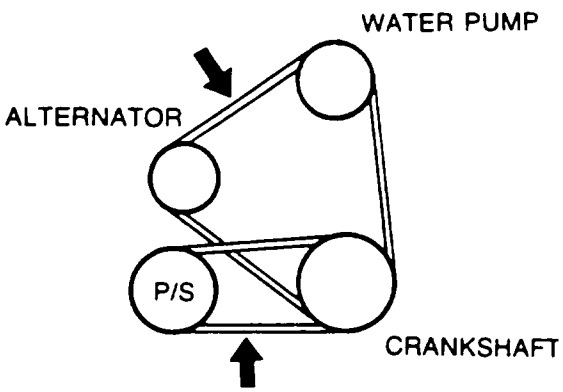


DRIVE BELT

Inspection

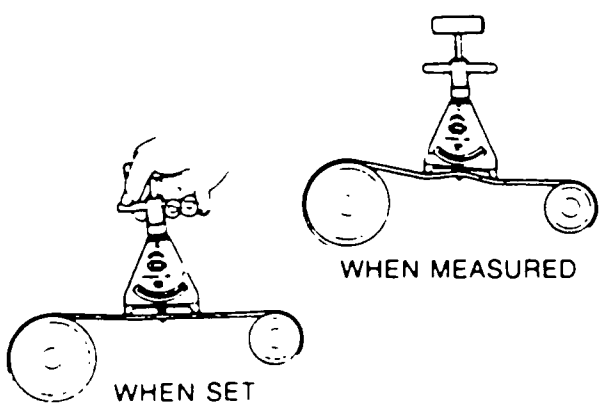
1. Remove the undercover for the inspection of the P/S belt.
2. Check the drive belts for wear, cracks, and fraying. Replace if necessary.
3. Verify that the drive belts are correctly mounted on the pulleys. (See Figure 1).
4. Check the drive belt deflection by applying moderate pressure **(98N, 10 kg, 22 lb)** midway between the pulleys as shown and adjust if necessary. (See Figure 2).

Figure 2.



Alternator belt deflection specs: (mm / in.)	
NEW	9.0-10.0 (0.35-0.39)
USED	10.0-11.0 (0.39-0.43)

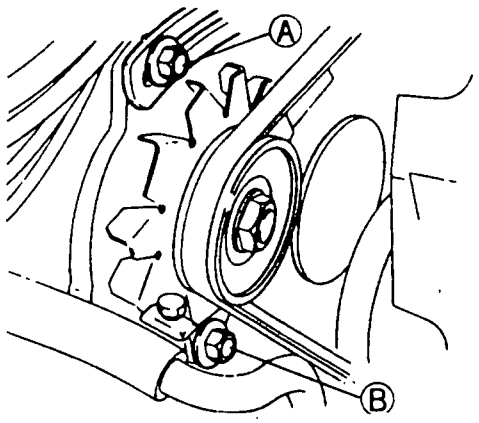
Figure 3.



5. Check the drive belt tension with a belt tension measuring devise. (See Figure 3).

Alternator belt tension specs: N (kg, lb)	
NEW	294-392, (30-40, 66-88)
USED	245-294 (25-30, 55-66)

Figure 4.



Adjustment

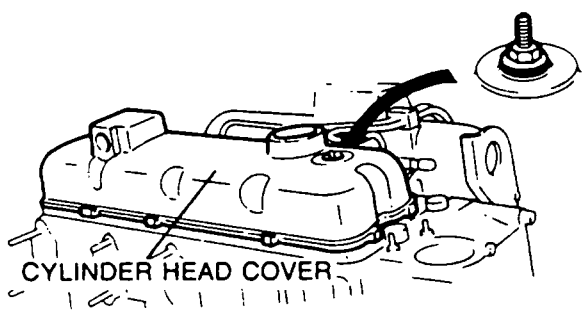
CAUTION:
*** If a new belt is used, adjust the belt deflection at the midpoint of new belt specification.**

1. Alternator belt
   *Loosen alternator bolts A and B and adjust the belt deflection. (See Figure 4).

Tightening torque:
A: 19-25 Nm (1.9-2.6 m-kg, 14-19 ft lb)
B: 37-52 Nm (3.8-5.3 m-kg, 27-38 ft lb)

ENGINE TUNE-UP

Figure 1.

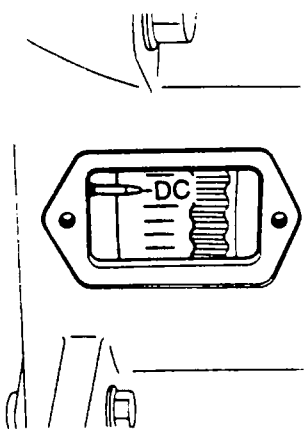


VALVE CLEARANCE

Inspection / Adjustment

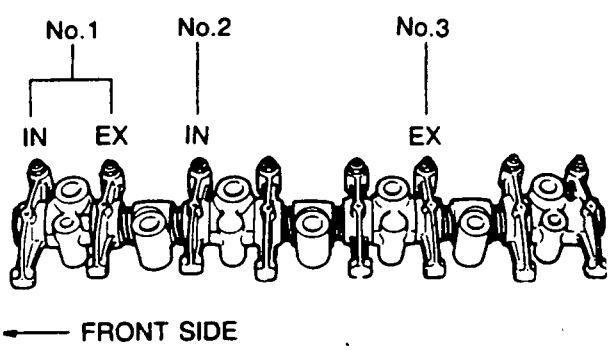
1. Remove the engine valve cover. (As shown in Figure 1).

Figure 2.



2. Remove the cover from the clutch housing. (See Figure 2).
3. Turn the crankshaft clockwise and set the No. 1 cylinder to compression TDC.

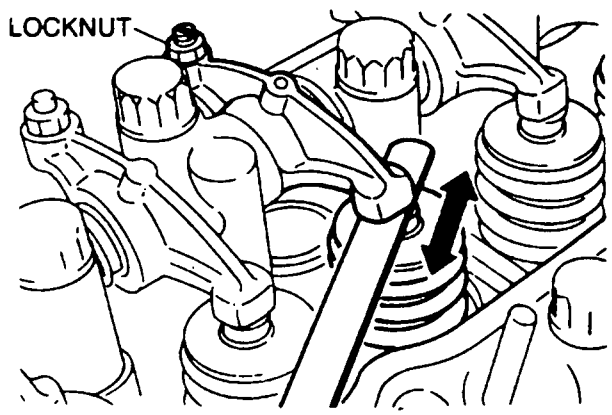
Figure 3.



4. Measure the valve clearances as shown in Figure 3.

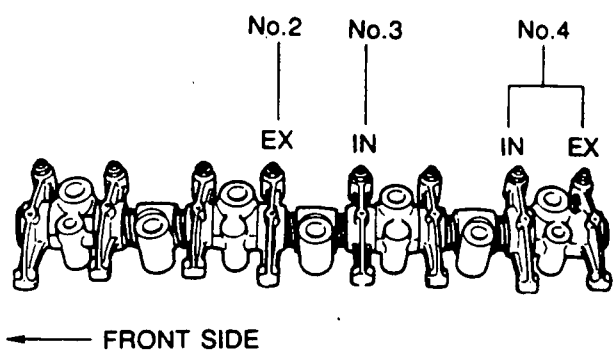
Valve clearance (Engine cold) mm (in)	
INTAKE	0.30 (0.012)
EXHAUST	0.30 (0.012)

Figure 4.



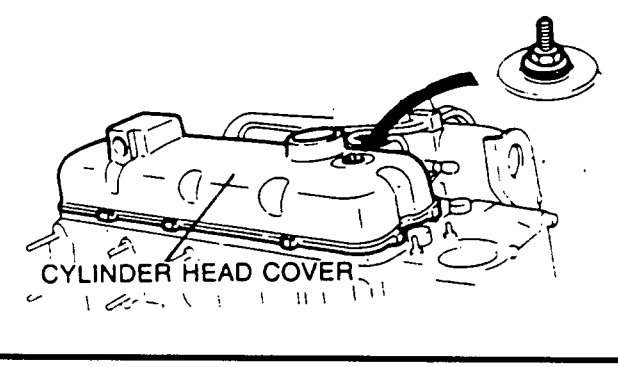
5. If necessary, loosen the locknut and adjust the valve clearance by turning the adjusting screw.
6. Tighten the locknut. (See Figure 4)
Tightening torque:
12-17 Nm, (120-170 cm-kg, 104-148 in-lb).

Figure 5.



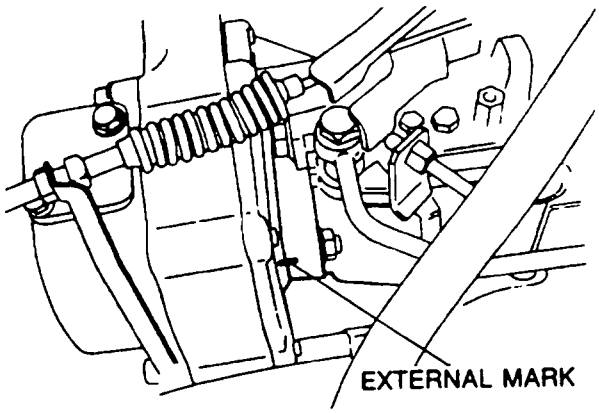
7. Turn the crankshaft clockwise one full turn and set the No. 4 cylinder to TDC.
8. measure the remaining valve clearances as shown in Figure 5.

Figure 6.



9. Install the valve cover as shown in Figure 6.
Tightening torque:
2.0-3.4 Nm (20-35 cm-35 cm-kg, 17-30 in-lb)

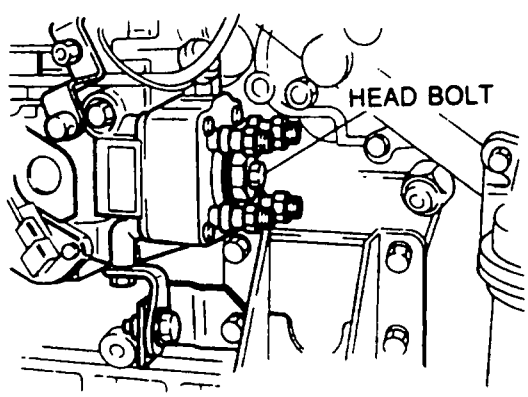
Figure 1.



INJECTION TIMING
Inspection

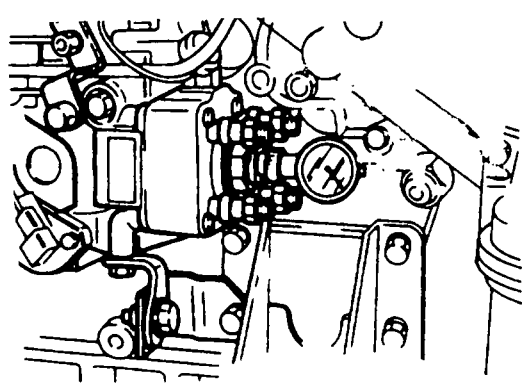
NOTE
*** Usually it is enough to confirm that the external marks are aligned. (See Figure 1).**
*** Set the injection timing after the installation of the injection pump.**

Figure 2.



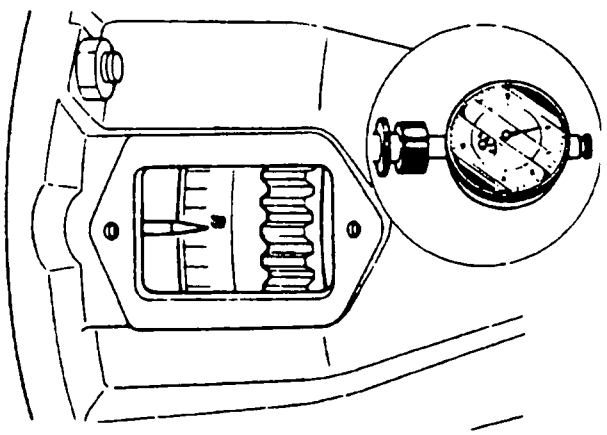
1. Disconnect the fuel injection pipes from the injection pump.
2. Remove the bolt and gasket from the distributer head of the injection pump. (See Figure 2).

Figure 3.



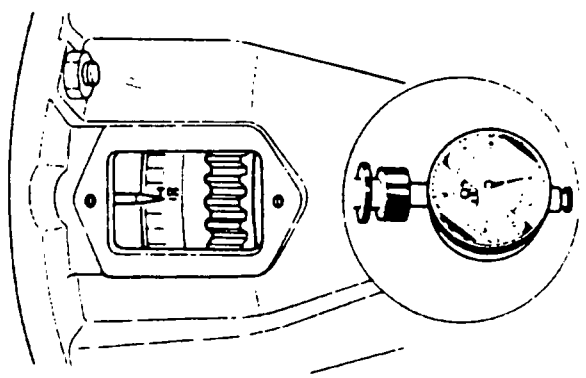
3. Screw the pressure gauge into the injection pump (See Figure 3).
4. Make sure that the tip of the feeler of the measuring device is in contact with the plunger end at this time.

Figure 4.



5. Turn the flywheel and set to approximately **30° BTDC.**
6. Find the position in which the needle of the dial gauge does not move when the flywheel is turned. (See Figure 4).
7. When the dial gauge needle does not deflect, set the needle to "0" on the scale.

Figure 5.



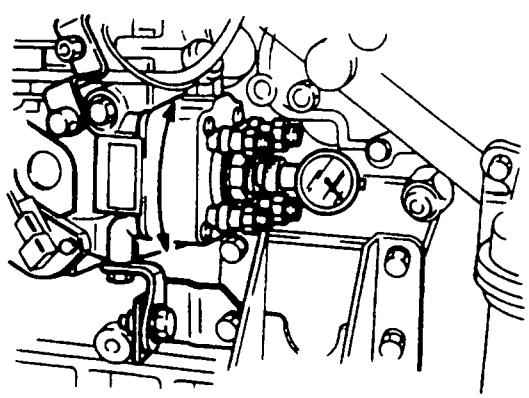
8. Turn the flywheel until **3° BTDC** is indicated.
9. The injection timing is normal when the dial gauge needle is advanced 1.00mm(0.0394 in) ahead of the valve set in step 7. (See Figure 5).

Static injection:

Cam lift 1.00mm (0.0394 in)

10. If the change is not as specified, adjust the injection timing.

Figure 6.

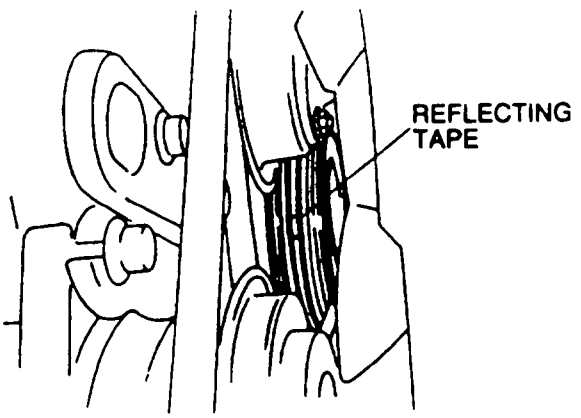


Adjustment

1. If the injection timing is faulty, turn the injection pump to a position in which the dial gauge indicates 1.00mm (0.0394 in). (See Figure 6).
* When the cam lift is larger than 1.00mm (0.0394 in), turn the injection pump all the way in the engine revoloution direction once, and then turn it in the reverse direction adjusting the cam lift to the 1.00mm (0.0394 in) point.
* If the cam lift is smaller than 1.00mm (0.0394 in), adjust the lift by turning the pump in the direction inverse to the engine revolving direction.
2. After adjustment, install the new head bolt and gasket.

ENGINE TUNE-UP

Figure 1.

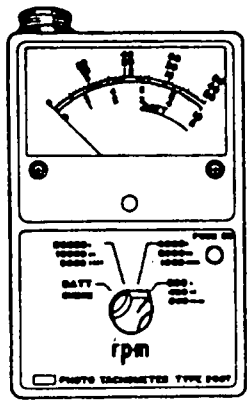


IDLE SPEED

Adjustment

1. Attach suitable reflector tape to the crankshaft pulley. (See Figure 1).
2. Run the engine at idle to normal operating temperature.
3. Turn OFF all electrical loads.

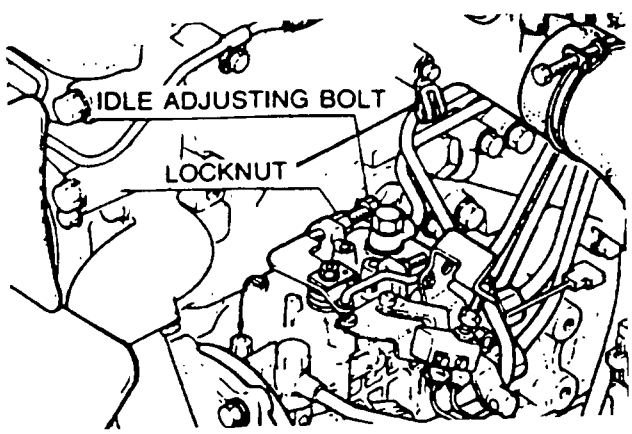
Figure 2.



4. Confirm the free play of the accelerator cable.
Free play: 1-3mm (0.04-0.12 in).

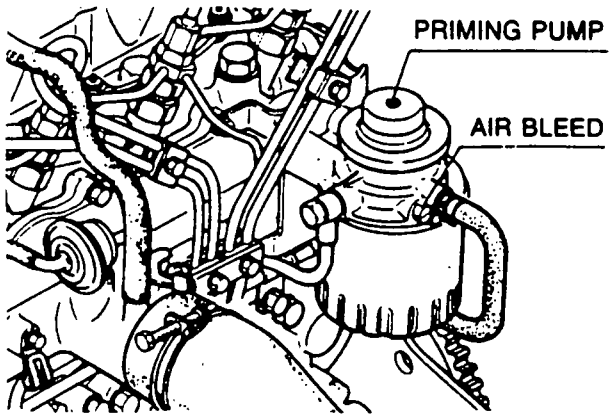
5. Aim the light of the photo electric tachometer onto the reflecting tape to measure the engine speed. (See Figure 2).
Idle speed: 600-650 rpm.

Figure 3.



6. If not as specified, loosen the locknut of the idle adjusting bolt and adjust by turning the bolt.
7. Tighten the locknut (See Figure 3).
Tightening torque:
5.9-8.8 Nm (60-90 cm-kg, 52-78 in-lb).

Figure 1.

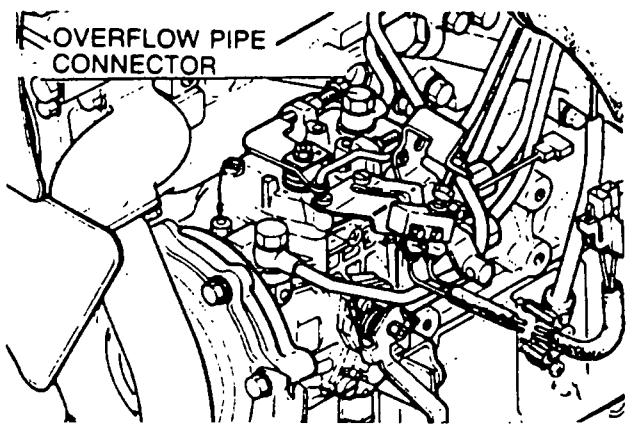


AIR BLEEDING

WARNING
*** Keep sparks, cigarattes, and open flames away from the fuel area.**

1. Remove the air bleeder plug. (See Figure 1).
2. Pump the priming pump until clear (no air bubbles) fuel flows from the bleeder plug hole.
3. Install the air bleeder plug.

figure 2.

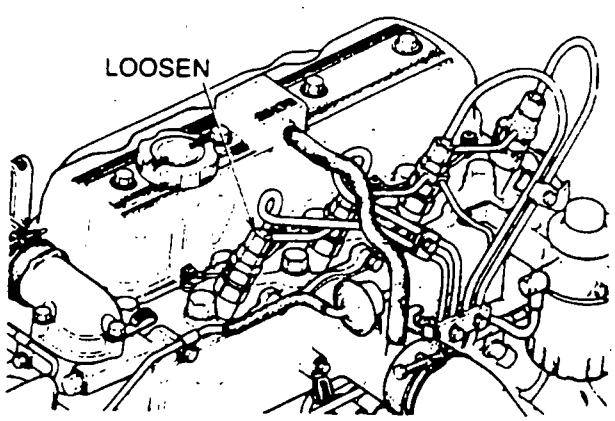


4. Loosen the overflow pipe connector of the injection pump.
5. Pump the priming pump until fuel flows from the pipe.
6. tighten the overflow pipe connector. (See Figure 2).

Tightening torque:
20-29 Nm (2.0-3.0 m-kg, 14-22 ft-lb).

7. Start the engine and run it at idle until it runs smooth.

Figure 3.



8. Stop the engine.
9. Loosen the all flare nuts of the injection pipes of injection nozzle side. (See Figure 3).
10. Confirm fuel injection from the injectionpipes while cranking.
11. Tighten the nuts.

Tightening torque:
20-25 Nm (2.0-2.5 m-kg, 14-18 ft-lb).

ENGINE TUNE-UP

Figure 1.

HA ENGINE

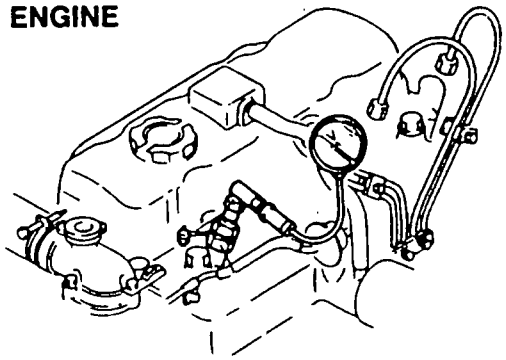
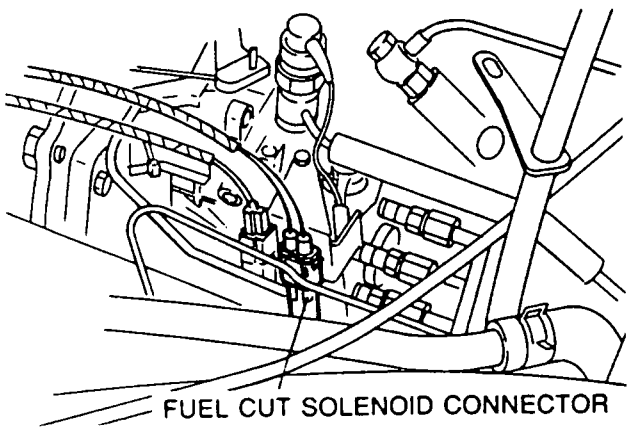


Figure 2.



COMPRESSION

If the engine exibits low power, poor fuel economy, or poor idle, check the following.

1. Compression.
2. Fuel system.

Inspection

1. Verify that the battery is fully charged. (Recharge as necessary).
2. Warm up the engine to normal operating temperature.
3. Turn the engine OFF.
4. Remove all fuel injection nozzles.
5. Connect a compression gauge to the No. 1 cylinder injection nozzle hole. (See Figure 1).

(Prevent fuel injection as follows)

WARNING

*** If this is not done, fuel will be pumped from the fuel injection pump while cranking.**

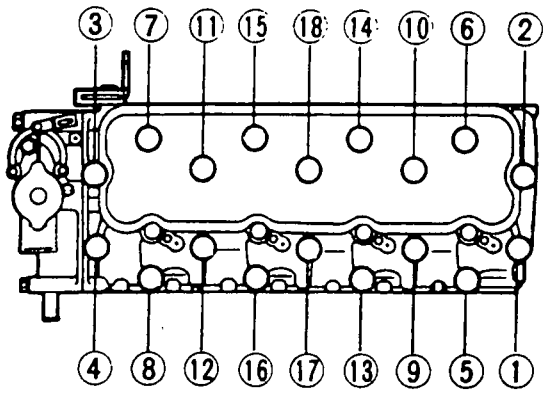
1. Disconnect the fuel cut solenoid connector. (See Figure 2).
2. Crank the engine and record the maximum gauge reading.
3. Check each cylinder using the same procedure.
4. If the compression in one or more cylinders is low, pour a small amount of oil into the cylinder and recheck the compression.

* If the compression increases, the piston, piston rings, or cylinder may be worn.
* If the compression stays low, the valve may be stuck or seating improperly.
* If the compression in adjacent cylinders stays low, the cylinder head gasket may be defective or the cylinder head distorted.

Compression: kPa (kg/cm^2 , psi)-rpm.
Standard: 2,943 (30.0, 427)-200
Minimum: 2649 (27.0, 384)-200
(variation between cylinders: 294 kPa (3.0 kg/cm^2, 43 psi) max.

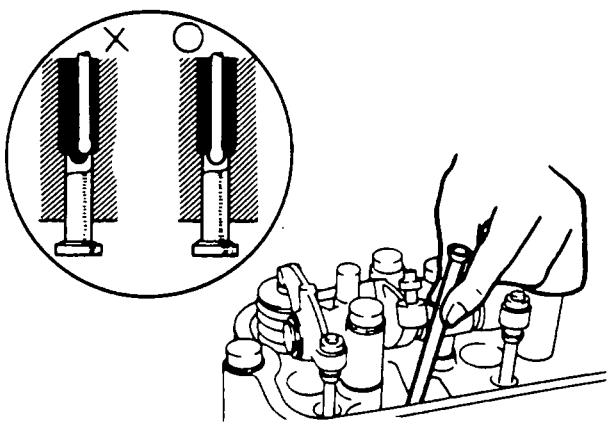
5. Connect the fuel cut solenoid connector.
6. Remove the compression gauge assembly.
7. Install all the fuel injector nozzles and pipes.
8. Bleed the air from the fuel line.

Figure 1.



Removal note
Cylinder head bolt
1. Loosen the cylinder head bolts in two or three steps in the order shown in Figure 1.
2 Remove cylinder head bolts.

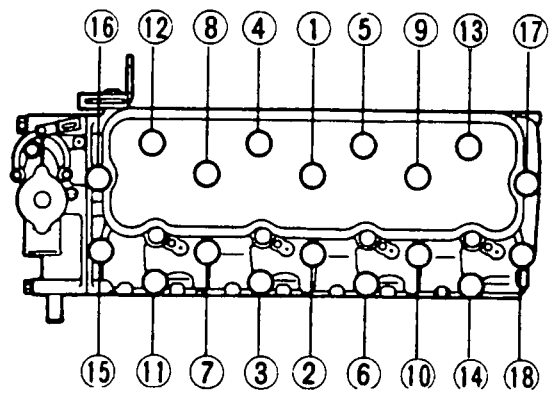
Figure 2.



Installation note
Push rod
1. Insert the push rods. (See Figure 2).

CAUTION:
*** Verify that the ends of the push rods are properly set into the tappets.**

Figure 3.



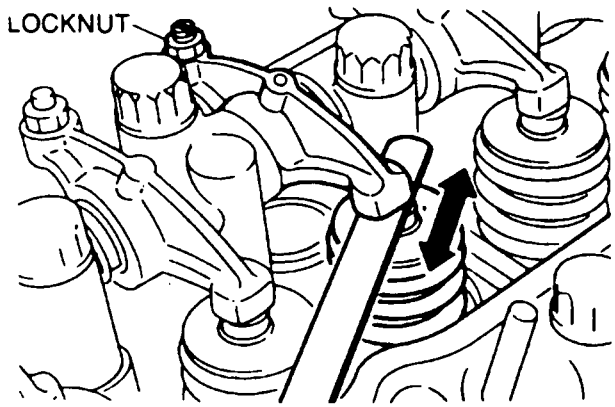
Cylinder head bolt

CAUTION:
*** Verify that the rocker arms and push rods are properly engaged while tightening.**

1. Apply clean engine oil to the bolt threads and seat faces.
2. Install the cylinder head bolts
3. Tighten the cylinder head bolts in two or three steps in the order shown in Figure 3.

Tightening torque:
116-123 Nm (11.8-12.5 m-kg, 85-90 ft-lb)

Figure 4.



Adjust the valve clearance (Refer to page 6).

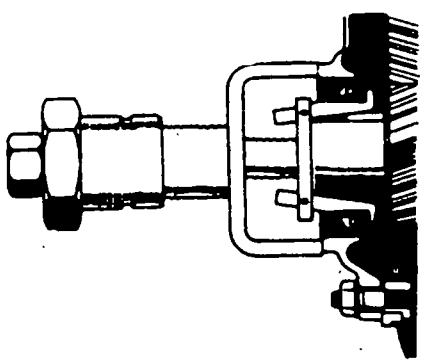
FRONT OIL SEAL
Replacement

CAUTION:
*** Position hose clamps in their original location on hoses, and squeeze lightly with a large pliers to ensure a good fit.**

1. Disconnect the negative battery cable.
2. Remove the undercover.
3. Drain the engine coolant.
4. Remove in order shown in the figure, referring to **Removal note.**
5. Install in the reverse order of removal, referring to **Installation note.**

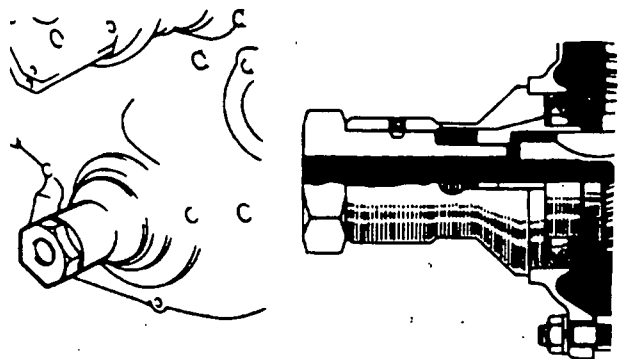
Steps After Installation
1. Fill the radiator with the specified amount and type of coolant.
2. Install the undercover.
3. Connect the negative battery cable.
4. Start the engine and check as follows.
* Engine oil and engine coolant leakage.
* Drive belt deflection.
5. Recheck the engine coolant levels.

Figure 1.



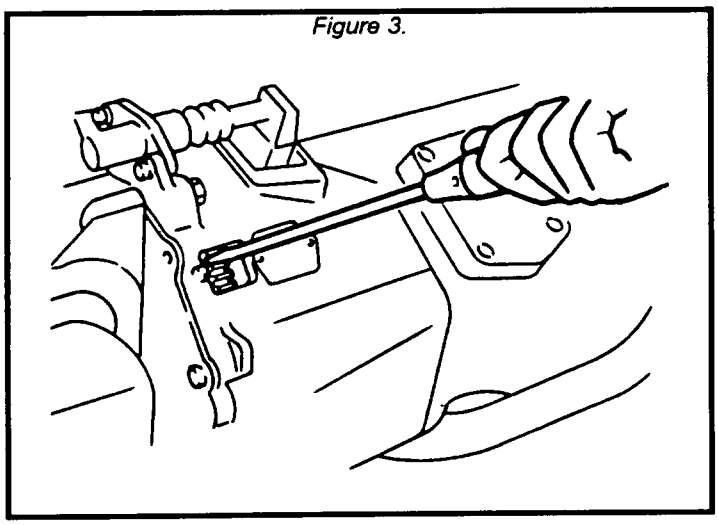
Oil seal
1. Assemble the seal puller as shown in Figure 1.
2. Set the seal puller against the oil seal and remove the seal by tightening the center bolt.

Figure 2.



Installation note
Oil seal
1. Apply a small amount of clean engine oil to the lip of the new oil seal.
2. Push the oil seal slightly in by hand.
CAUTION:
***The oil seal must be tapped in until it is 6.5mm (0.26 in) inside the edge of the timing cover.**
3. Tap the oil seal in evenly with a wood block and a hammer using caution not to pinch or deform the new seal.

Figure 3.



Crankshaft pulley

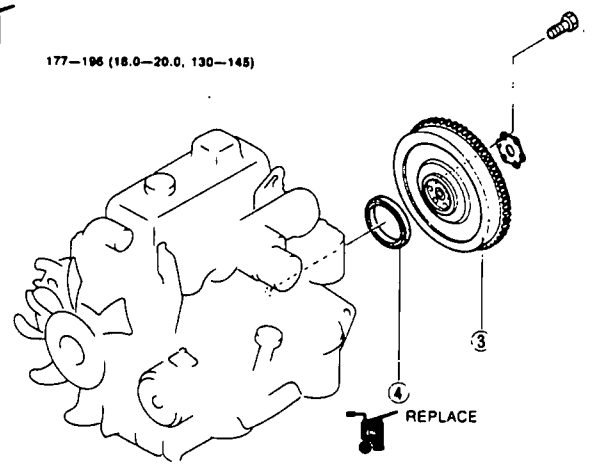
1. Apply clean engine oil to the bolt threads and seat faces. (See Figure 3)
2. Install the crankshaft pulley.
3. Install the bolt or nut and washer.

CAUTION:

*** Perform this operation with the aid of a helper.**

4. Hold the flywheel and tighten the pulley bolt or nut to **343-392 Nm, (35.0-40.0 m-kg, 253-289 ft-lb).**
5. Install the cover to the clutch housing or to the end plate.

Figure 1.



REAR OIL SEAL

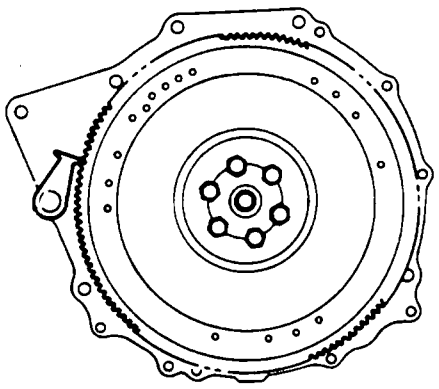
Replacement

1. Disconnect the negative battery cable.
2. Remove in the order shown in figure 1, referring to **Removal Note.**
3. Install in the reverse order of removal, referring to **Installation Note.**

Steps After Installation.

1. Connect the negative battery cable.
2. Start the engine and perform engine adjustments as necessary.

Figure 2.



Removal note

Flywheel

1. Hold the flywheel with a flywheel tool. (See Figure 2)
2. Remove the flywheel lock bolts.
3. Remove the flywheel.

Installation note

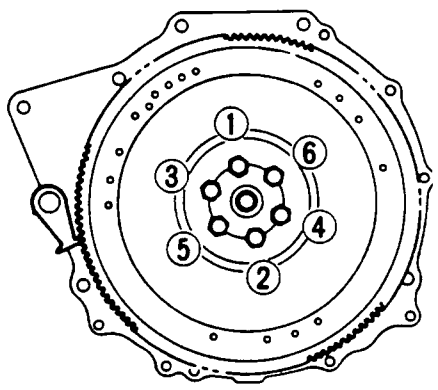
Oil seal

1. Apply a small amount of clean engine oil to the lip of the new oil seal.
2. Push the oil seal in slightly by hand.

CAUTION:

*** The oil seal must be tapped in until it is flush with the edge of the rear oil seal cap.**

Figure 3.



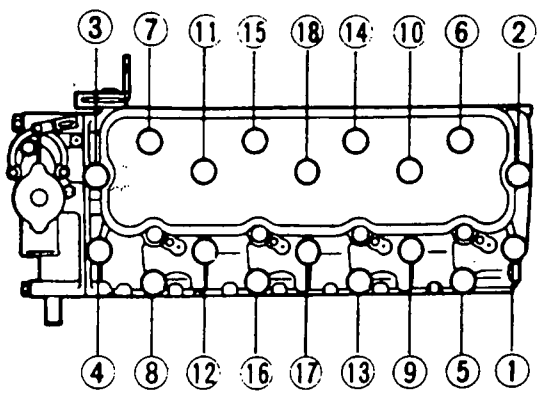
3. Tap the oil seal in evenly a wood block and a hammer, using caution not to pinch or deform the seal.

Flywheel

1. Apply clean engine oil to the bolt threads and seat faces.
2. Set the flywheel onto the crankshaft and loosely install the bolts.
3. Hold the flywheel with a flywheel tool.
4. Tighten the bolts in two or three steps as shown in figure 3. **Tighten to: 177-196 Nm, (18.0-20.0 m-kg, 130-145 fl-lb).**

DISASSEMBLY

Figure 1.

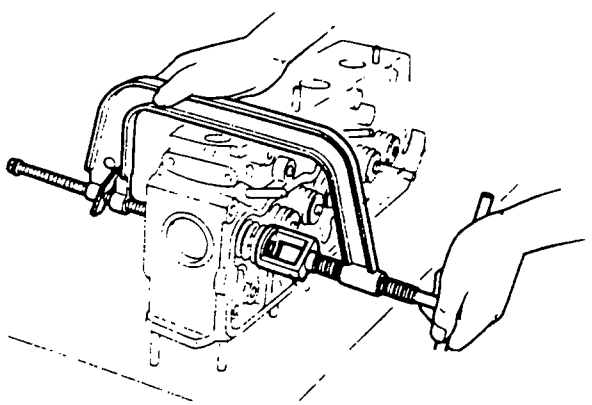


Disassembly note

Cylinder head bolt

1. Loosen the cylinder head bolts in two or three steps in the order shown in Figure 1.
2. Remove the cylinder head bolts.

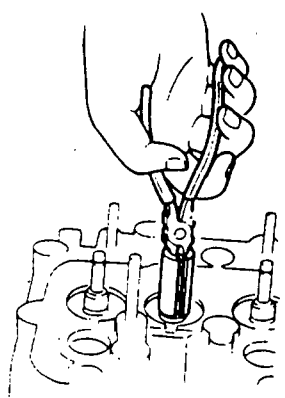
Figure 2.



Valve keeper

1. Set the valve spring compressor against the upper valve seat as shown in Figure 2.
2. Remove the valve keepers.

Figure 3.



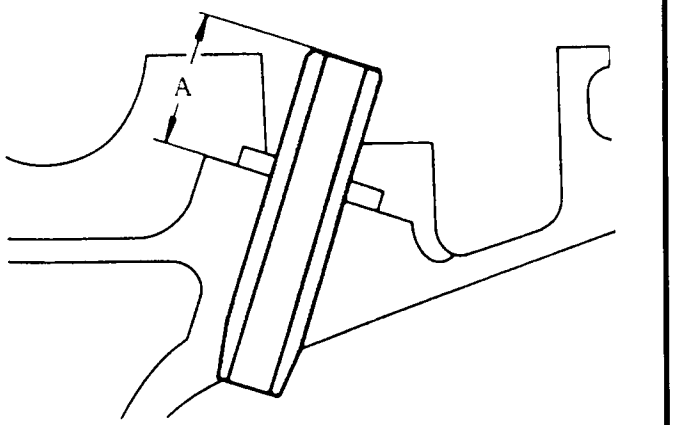
Valve seal

1. Remove the valve seal with the valve seal removal tool. (See Figure 3).

NOTES

DISASSEMBLY

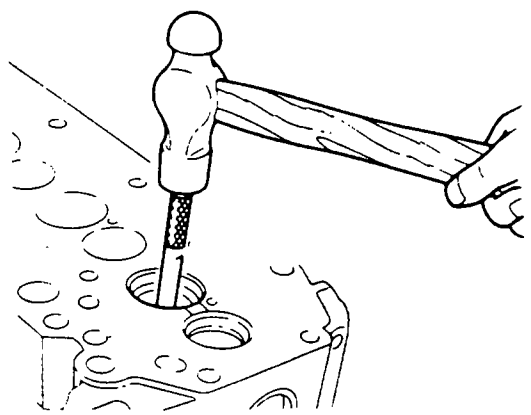
Figure 4.



Valve guide
CAUTION
*** If the valve guide is removed, it must be replaced with a new one.**

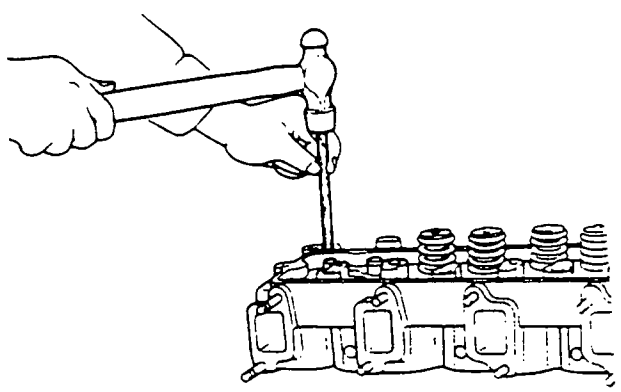
1. Measure height A of each valve guide. (See Figure 4).
Height A: 15.2-15.4mm (0.598-0.606 in)

Figure 5.



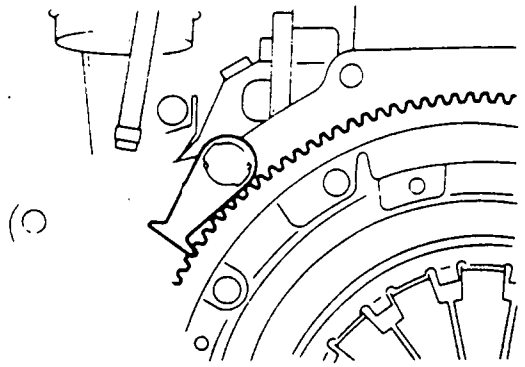
2. If height A is not within specification, replace the valve guide.
3. Remove the valve guide from the side opposite the combustion chamberwith the valve guide ramoval / installation tool. (See Figure 5).

Figure 6.



Combustion chamber insert
1. Inspect the combustion chamber insertfor damage and cracks.
2.If necessary, remove the insert with a suitable mandrel, tapping through the nozzle hole.

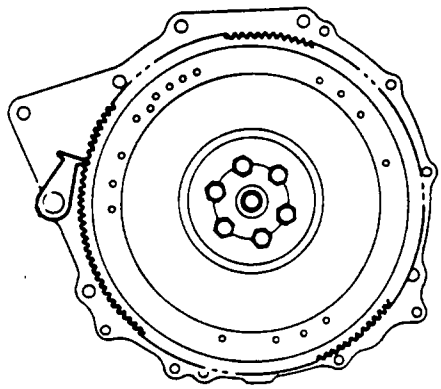
Figure 1.



Disassembly Note
Crankshaft pulley

1. Hold the flywheel the a flywheel holding tool.
2. Loosen the pulley lock bolt.
3. Remove the lock bolt, washer, and crankshaft pulley. (See Figure 1).

Figure 2.

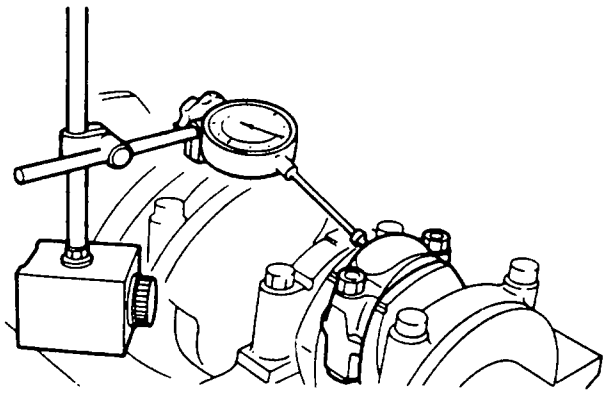


Flywheel

1. Hold the flywheel with a floywheel holding tool.
2. Loosen the flywheel lock bolts. (See Figure 2).
3. Remove the lock bolts, washers, and flywheel.

DISASSEMBLY

Figure 1.

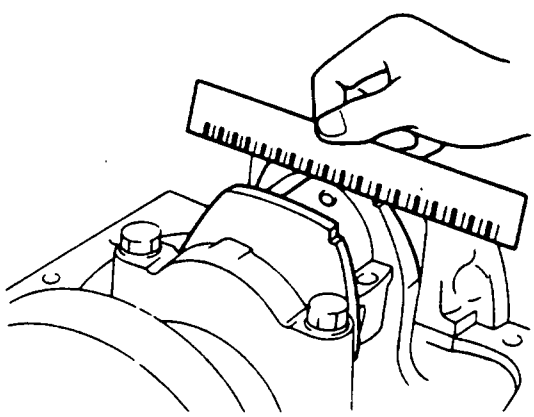


Disassemble Note

Connecting rod cap

1. Before removing the connecting rod caps, measure the connecting rod side clearance. (See Figure 1).

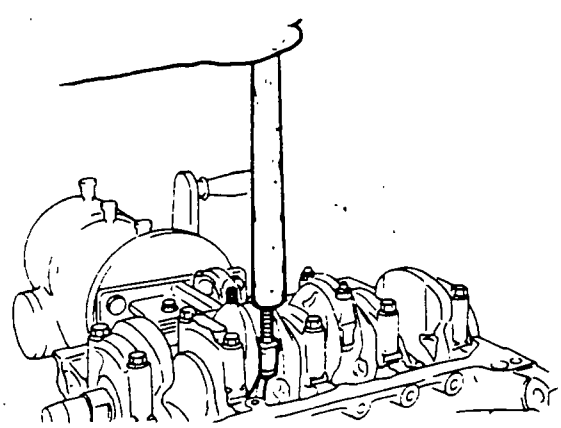
Figure 2.



Connecting rod

1. Before removing the connecting rods, measure the connecting rod oil clearance.
2. Remove the plastigauge from the crankpin journals. (See Figure 2).

Figure 3.



CAUTION:

*** Do not scratch the crankpin journal or the cylinder liner.**

*** Protect the connecting rod bolts with rubber sleeves to prevent damage to the crankpin journal.**

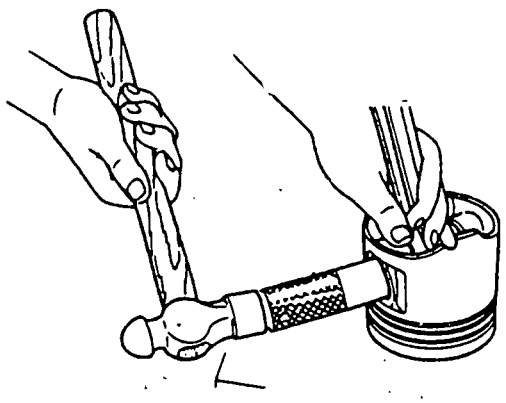
3. Use the handle of a hammer to remove the piston and connecting rod assembly through the top of the cylinder bore. (See Figure 3).

Figure 4.

Piston Ring

CAUTION:
*** Do not apply excessive tension, which may cause a ring to break.**
1. Remove the piston rings with a piston ring expander (See Figure 4).

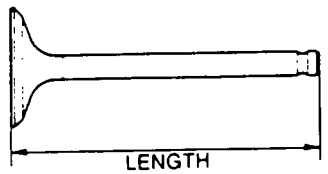
Figure 5.



Piston pin

CAUTION:
*** Mark the connecting rod direction for proper assambly.**
1. Remove the piston pin with a piston pin removal tool. (See Figure 5).

Figure 4.

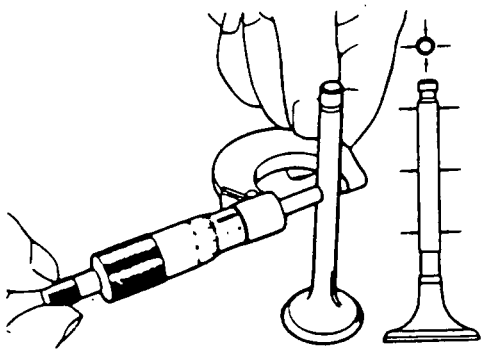


3. Measure the length of the valve at the points shown in Figure 4.

Length mm (in)

	Standard	Minimum
Intake	114.6 (4,512)	114.1 (4,492)
Exhaust	114.6 (4,512)	114.1 (4,492)

Figure 5.



4. Measure the stem diameter of each valve. (See Figure 5).

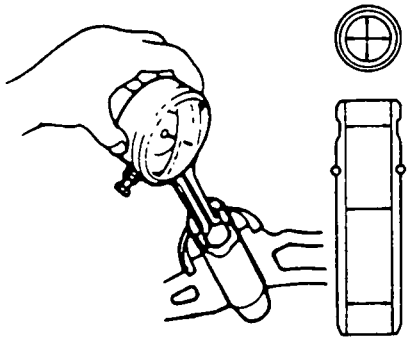
Diameter mm (in)

Intake	8.955-8.980 (0.0015-0.0031)
Exhaust	8.935-8.960 (0.3518-0.3528)

5. Measure the inner diamater of each valve guide at the points shown in Figure 6.

Inner diameter
Intake: 9.018-9.033mm (0.3550-0.3556 in)
Exhaust: 9.018-9.033mm (0.3550-0.3556 in)

Figure 6.

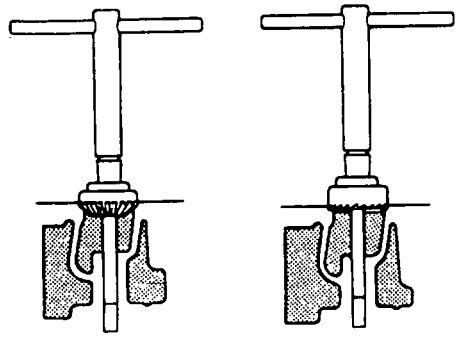


6. Subtract the outer diameter of the valve stem from the inner diameter of the corresponding valve guide to calculate the valve stem to guide clearance. (See Figure 7).

Clearance mm (in)

Standard:
Intake: 0.038-0.078 (0.0015-0.0031)
Exhaust: 0.058-0.098 (0.0023-0.0039)
Maximum:
Intake / Exhaust: 0.127 (0.0050)

Figure 7.



7. If the clearance exceeds specification, replace the valve and / or valve guide.

Figure 8.

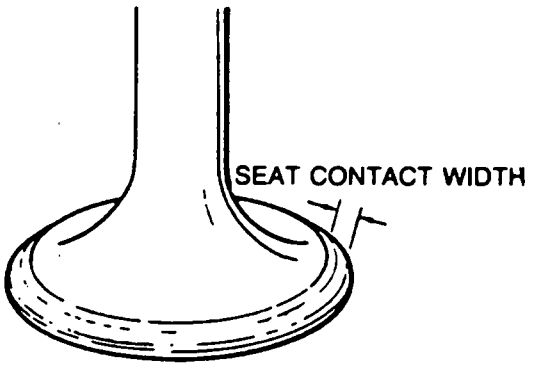


Figure 9.

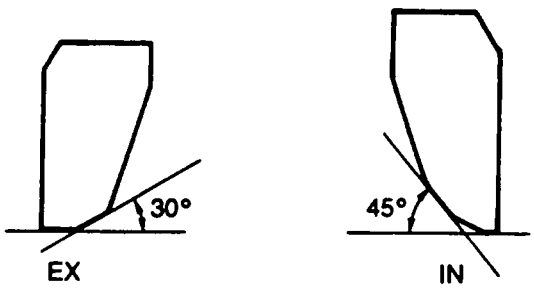
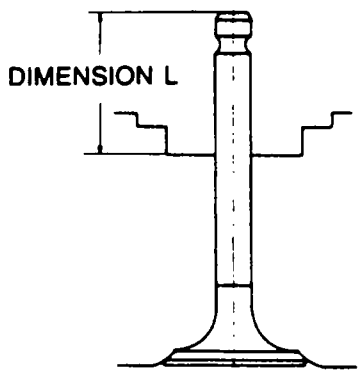


Figure 10.



Valve Seat

1. Inspect the contact surface of each valve seat and valve face for the following.
* Roughness
* Damage
2. If necessary, resurface the valve seat with a **45° (intake) or 30° (exhaust)** valve face.
3. Apply a thin coat of prussian blue to the valve face.
4. Inspect the seating by pressing the valve against the seat.
* If blue does not appear 360° around the valve face, replace the valve.
* If blue does not appear 360° around the valve seat, resurface the seat.
5. Measure the seat contact width. (See Figure 8).

Width	**mm (in)**
Intake:	2.0 (0.079)
Exhaust:	2.0 (0.079)

6. Verify that the valve seating position is at the center of the valve face (See Figure 9).
7. If the seating position is too high or too low, correct the valve seat with a valve seat cutter.
8. Seat the valve to the valve seat with lapping compound.

9. Inspect the sinking of the valve seat.
10. Measure the protruding length **(dimension L)** of the valve stem.

Dimension L	**mm (in)**
Intake:	48.05 (1,892)
Exhaust:	48.05 (1,892)

(1) If dimension L is as below, no correction is needed.
Intake: 48.05-48.55 (1.892-1.911)
Exhaust: 48.05-48.55 (1.892-1.911)

(2) If demension L is as below, adjust with washer on spring seat area of cylinder head area.
Intake: 48.55-49.55 (1.911-1.951)
Exhaust: 48.55-49.55 (1.911-1.951)

(3) If demension L is as below, replace cylinder head.
Intake: 49.55 (1.951)
Exhaust: 49.55 (1.951)

Figure 11

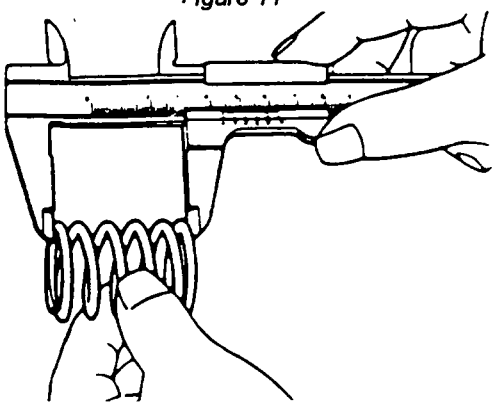


Figure 12.

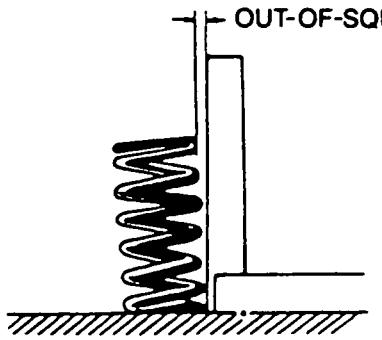


Figure 13.

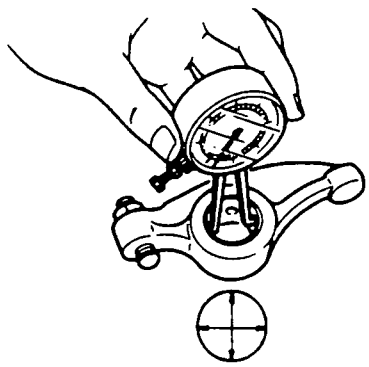
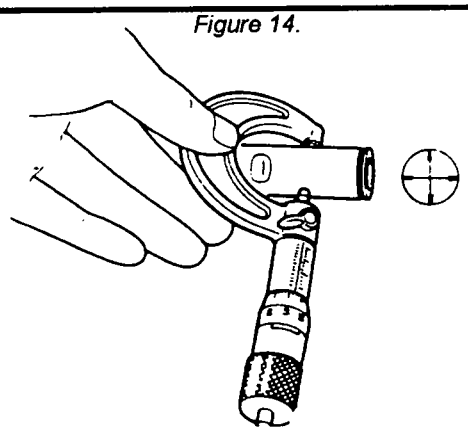


Figure 14.



Valve Spring

1. Inspect each valve spring for cracks and damage.
2. Measure the free length (Figure 11) and out-of-square as shown in (Figure 12). Replace the valve spring if necessary.

Free Length mm (in)

	Standard	Minimum
Intake (inner)	44.1 (1.736)	43.1 (1.697)
Intake (outer)	55.7 (2.193)	54.7 (2.154)
Exhaust (inner)	44.01 (1.736)	43.1 (1.697)
Exhaust(outer)	55.7 (2.193)	54.7 (2.154)

Out-of-square mm (in)

	Outer	Inner
Intake:	1.37 (0.0539)	1.25 (0.0492)
Exhaust:	1.37 (0.0539)	1.25 (0.0492)

ROCKER ARM ASSEMBLY

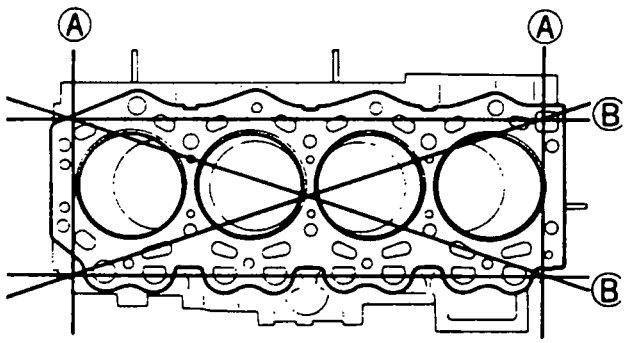
1. Check for wear or damage to the contact surfaces of the rocker arm shaft. Replace if necessary.
2. Measure the rocker arm inner diameter.(See Figure 13).

Inner diameter mm (in)
15.876-15.896 (0.6250-0.6258)

3. Measure the rocker arm shaft diameter (See Figure 14).**Diameter mm (in) 15.835-15.860 (0.6234-0.6244)**
4. Subtract the outer diameter of the rocker shaft from the inner diameter or the rocker arm to calculate the rocker arm to shaft clearance.

Clearance
Standard: 0.016-0.061 (0.0006-0.0024)
Maximum: 0.07 (0.003)
5. If the clearance exceeds the maximum, replace the rocker arm and/or shaft.

Figure 1.

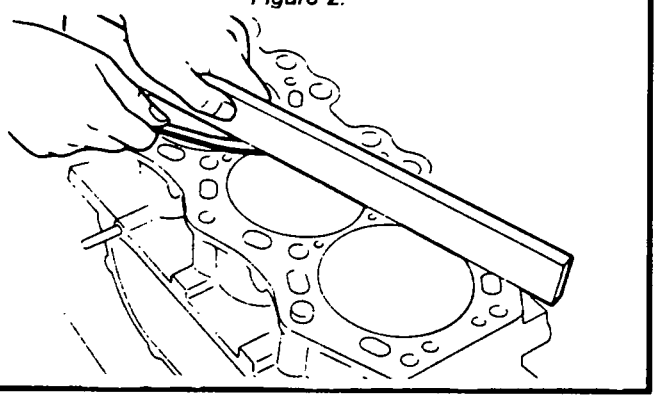


CYLINDER BLOCK

1. Inspect the cylinder block for the following, and repair or replace the block as necessary.
* Leakage damage
* Cracks
* Scoring of the cylinder liner.
2. Measure the distortion of the deck of the cylinder block in the six directions shown in Figure 1.

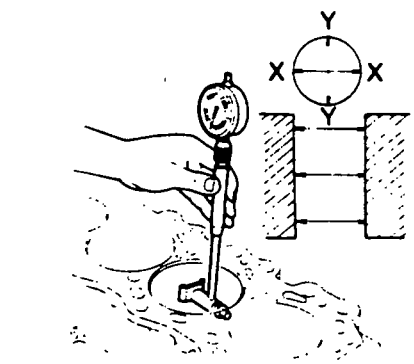
Distortion: A = 0.10mm (0.004 in) max.
B = 0.25mm (0.010 in) max.

Figure 2.



3. If the block distortion exceeds specification, replace the cylinder block. (See Figure 2).

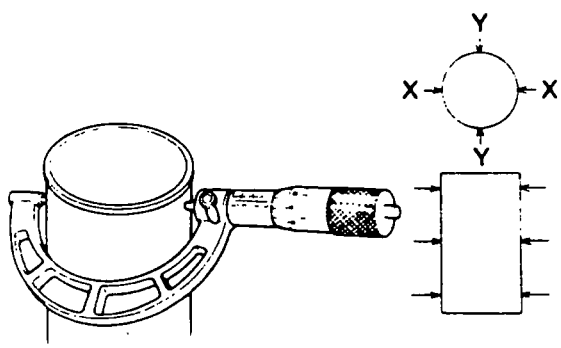
Figure 3.



4. Measure each cylinder bore in X and Y directions three levels (upper, middle, and lower) as shown in Figure 3.

Cylinder liner bore diameter:
98.500-98.526mm (3.8779-3.8790 in)

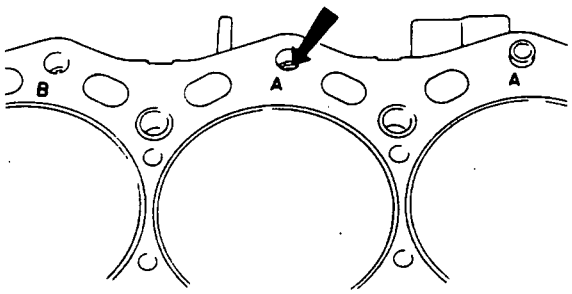
Figure 4.



5. Measure each cylinder liner outer diameter in X and Y directions at three levels (upper, middle, and lower) as shown in Figure 4.

Cylinder liner outer diameter:
98.530-98.580 (3.8791-3.8811 in)

Figure 5.

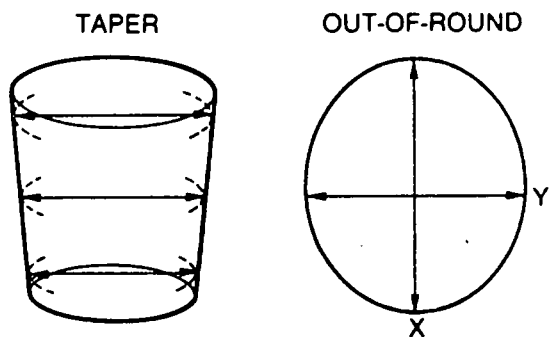


6. Subtract the cylinder liner outer diameter from the cylinder bore diameter to calculate the cylinder block to cylinder liner clearance.

Clearance:
-0.004--0.080mm (-0.0002--0.0031 in)
7. If the clearance exceeds specification, replace the cylinder liner.
8. If the difference between measurements of the cylinder liner exceeds the maximum taper, replace the cylinder liner. (See Figure 5)

Taper: 0.03mm (0.0012 in) max.

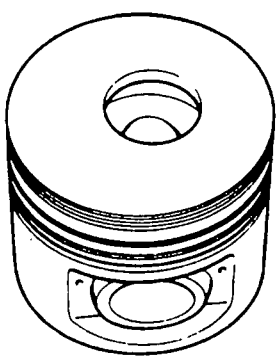
Figure 6.



9. If the difference between measurements X and Y of the cylinder liner exceeds the maximum taper, replace the cylinder liner. (See Figure 6).

Out-of Round: 0.03mm (0.0012 in) max.

Figure 1.

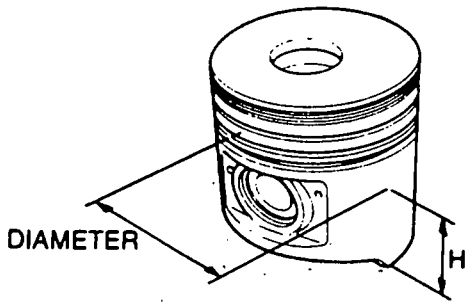


PISTON, PISTON RING, AND PISTON PIN
Piston

CAUTION:
*** If the piston is replaced, the piston rings must also be replaced.**

1. Inspect the outer circumferences of all the pistons for seizure or scoring. Replace pistons as necessary.

Figure 2

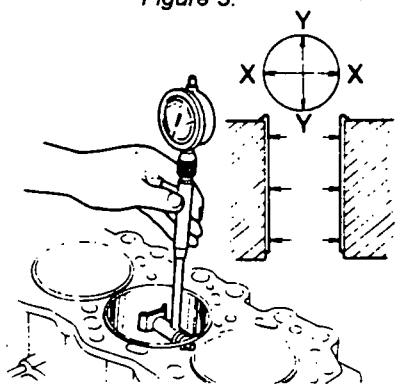


2. Measure each piston at a right angle **(90°)** to the piston pin at **point H** Shown in Figure 2 as measured from the bottom of the piston.

Diameter: mm (in) H=22.0 (0.866)
94.967-94.933 (3.7389-3.7399)

3. Measure each cylinder liner inner diameter in X and Y directions at three levels (upper, middle and lower) as shown in Figure 3.

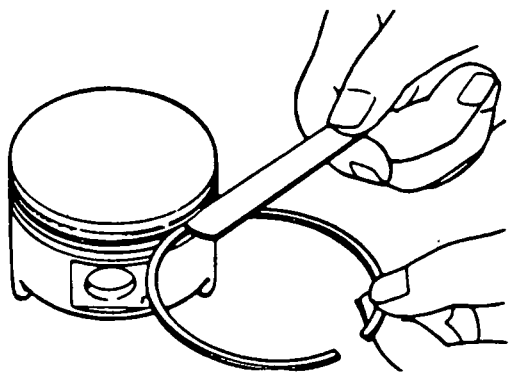
Figure 3.



Cylinder liner inner diameter: mm (in)
95.025-95.050 (3.7411-3.7421)
4. Subtract the piston diameter from the cylinder inner liner to calculate the piston to cylinder liner clearance.

Clearance: mm (in)
0.032-0.083 (0.0013-0.0033)
5. If the clearance exceeds specification, replace the piston and or the cylinder liner.

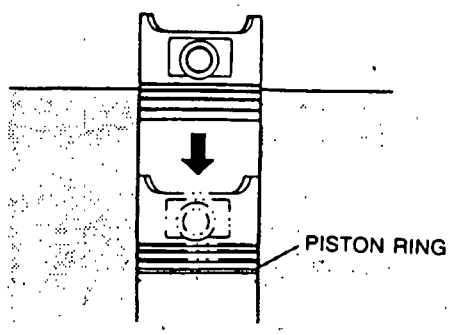
Figure 4.



Piston and Piston Rings
1. Measure the piston ring to ring land clearance around the entinre circumference using a new piston ring. (See Figure 4)

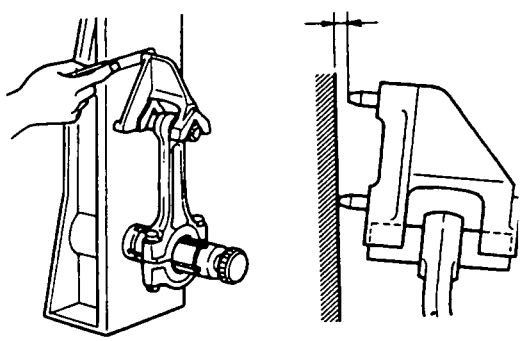
Clearance: mm (in)
Top: 0.05-0.18 (0.0020-0.0071)
Second: 0.04-0.08 (0.0016-0.0031)
Oil: 0.03-0.07 (0.0012-0.0028)
Maximum: 0.30 (0.012)

Figure 5.



2. If the clearance exceeds the maximum, replace the piston.
3. Inspect the piston rings for damage, abnormal wear.
4. Insert the piston ring into the cylinder liner by hand and use the piston to push it to the bottom of the ring travel. (See Figure 5)

Figure 1.



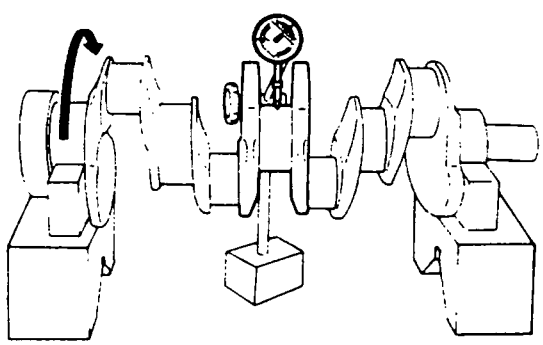
2. Calculate the clearance between the connecting rod bushing and piston pin.

Clearance: mm (in)
Standard: 0.012-0.039 (0.0005-0.0015)
Maximum: 0.05 (0.0020)

3. Measure each connecting rod for bending. Repair or replace the connecting rod as necessary. (See Figure 1).

Bending: mm (in)
0.05 (0.0020) max. / 100 (3.94)

Figure 2.

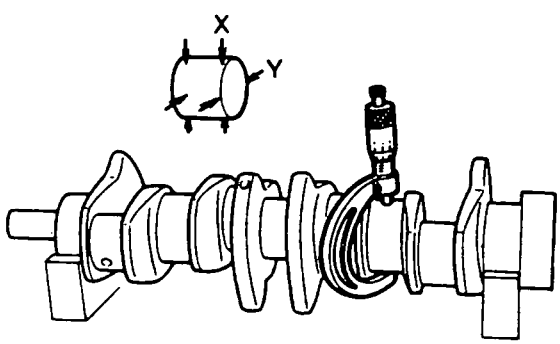


CRANKSHAFT

1. Check the journals and pins for damage, scoring, and hole clogging.
2. Set the crankshaft on V-blocks.
3. Measure the crankshaft runout at the center journal. Replace the crankshaft as necessary. (See Figure 2).

Runout: 0.05mm (0.0020 in) max.

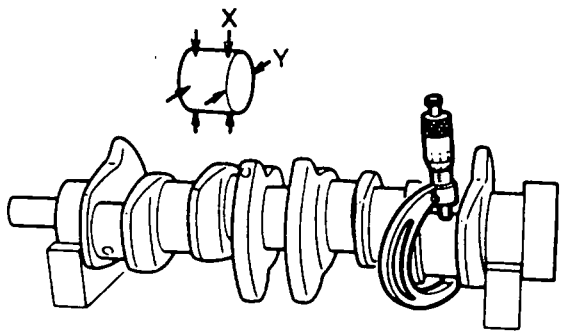
Figure 3.



4. Measure each journal diameter in X and Y directions at two points. (See Figure 3)

Main journal diameter mm (in)
75.805-75.825 (2.9844-2.9852)
Out of round: 0.003mm (0.00012 in) max.
Crankpin journal diameter: 61.112-61.125mm (2.4060-2.4065)
Out of round: 0.003mm (0.00012 in) max.

Figure 4.

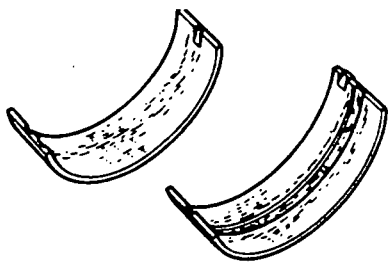


5. If the diameter is less than minimum, grind the journals to match an undersize bearing. (See Figure 4)

Undersize bearing: 0.254mm (0.0100 in), 0.508mm (0.0200 in), 0.762mm 0.300 in)

Bearing size	Journal diameter
0.254 (0.0100) undersize	75.551-75.571 (2.9744-2.9752)
0.508 (0.0200) undersize	75.297-75.317 (2.9644-2.9652)
0.762 (0.0300) undersize	75.043-75.063 (2.9544-2.9552)

Figure 5.



Crankpin journal diameter undersize: mm (in)

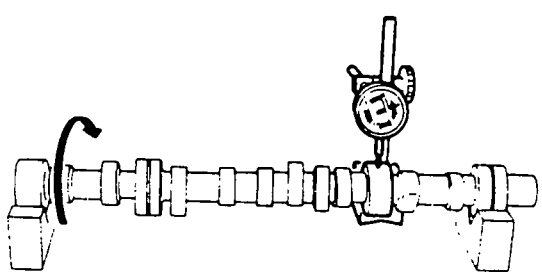
Bearing size	Journal diameter
0.254 (0.0100) undersize	60.858-80.871 (2.3960-2.3965)
0.508 (0.0200) undersize	60.604-60.617 (2.3860-2.3865)
0.762 (0.0300) undersize	60.350-60.363 (2.3760-2.3765)

BEARING

Main Bearing and Connecting Rod Bearing

1. Check the main bearings and the connecting rod bearings for peeling, scoring, and other damage. (See Figure 5)
2. Replace as necessary.

Figure 6.

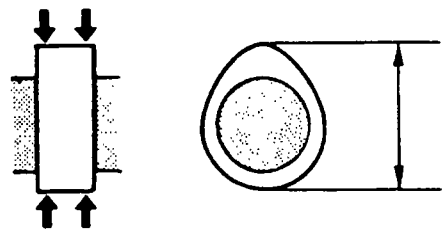


CAMSHAFT

1. Set the front and rear journals on V-blocks. (See Figure 6)
2. Measure the camshaft runout. Replace the camshaft as necessary.

Runout: 0.08mm (0.0031 in) max.

Figure 7.

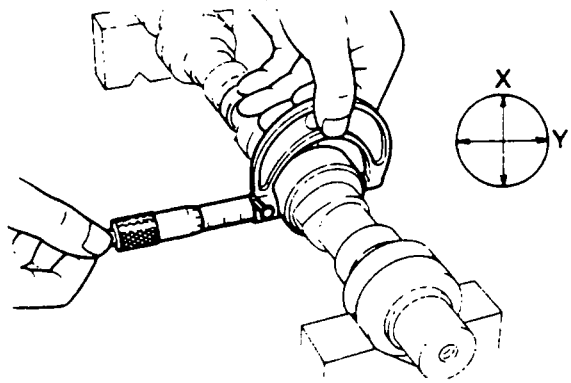


3. Inspect the camshaft for wear or damage. Replace the camshaft if necessary.
4. Measure the cam lobe heights at the two points as shown in Figure 7.

Height

	Standard	Minumum
Intake	42.580 (1.6764)	42.080 (1.6567)
Exhaust	42.580-(1.6764)	42.080 (1.6567)

Figure 8.

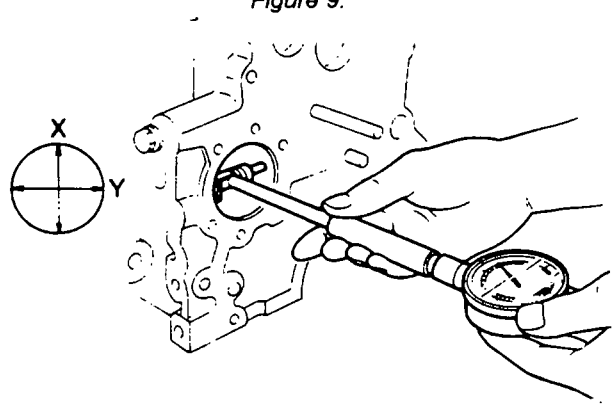


5. Measure the journal diameters in X and Y directions as shown in Figure 8.

Diameter: mm (in)

No. 1	51.910-51.940 (2.0437-2.0449)
No. 2	51.660-51.690 (2.0339-2.0350)
No. 3	51.410-51.440 (2.0240-2.0252)
No. 4	51.160-51.190 (2.0142-2.0154)

Figure 9.



6. Measure the camshaft bore diameters in X and Y directions as shown in Figure 9.

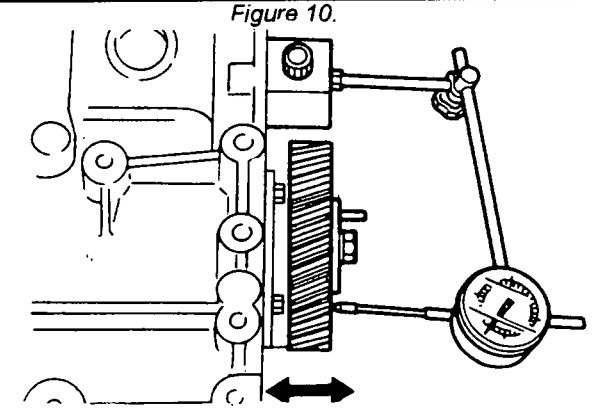
Diameter: mm (in)

No. 1	52.000-52.030 (2.0472-2.0484)
No. 2	51.750-51.780 (2.0374-2.0386)
No. 3	51.500-51.190 (2.0142-2.0154)
No. 4	51.160-51.190 (2.0142-2.0154)

7. Subtract the camshaft journal diameter from the camshaft bore diameter to calculate the camshaft journal to bore clearance.

Clearance: mm (in)
Standard: 0.06-0.12mm (0.0024-0.0047 in)
Maximum: 0.145mm (0.0057 in)

Figure 10.



8. If the clearance exceeds the maximum, replace the camshaft and or cylinder block.
9. Measure the camshaft end play. If the end play exceeds the maximum, replace the camshaft and / or cylinder head. (See Figure 10)

End play:
Standard: 0.02-0.18mm (0.0008-0.0071 in)
Maximum: 0.30mm (0.012 in)

Figure 1.

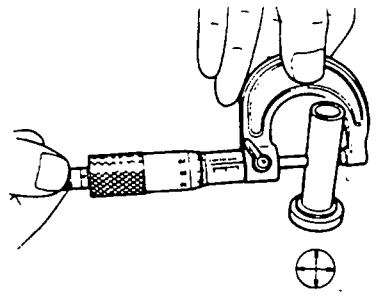


Figure 2.

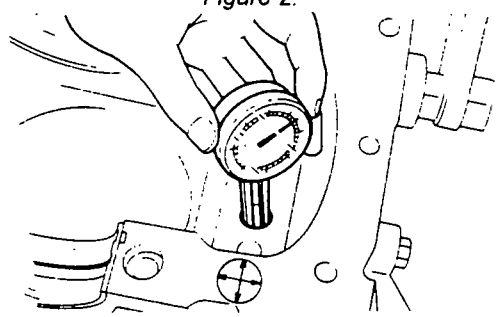


Figure 3.

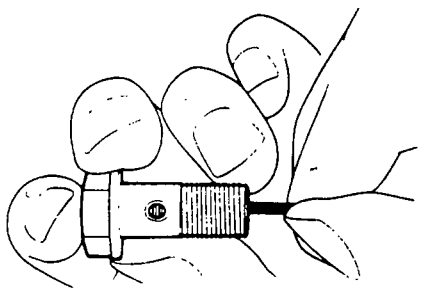


Figure 4.

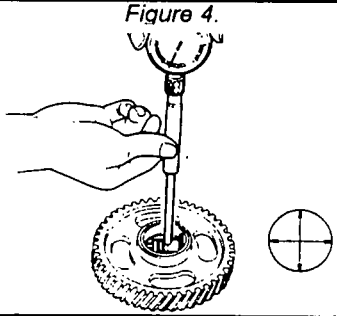
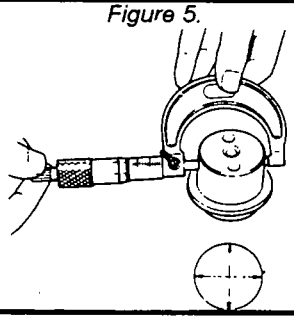


Figure 5.



TAPPET

1. Inspect the tappets for wear or damage. Replace the tappet if necessary.
2. Measure the tappet outer diameter. (See Figure 1).

Diameter: mm (in)
14-218-14.233 (0.5598-0.5604)

3. Measure the tappet bore of the cylinder block.

Diameter: mm (in)
14-288-14.319 (0.5625-0.5637)

4. Subtract the tappet outer diameter from the tappet bore diameter to calculate the tappet to tappet bore clearance. (See Figure 2)

Clearance: mm (in)
Standard: 0.055-0.101mm (0.0022-0.0040)
Maximum: 0.15mm (0.006 in)

5. If the clearance exceeds the maximum, replace the tappet, and/or cylinder block.

OIL JET

1. Push the check ball and verify that it moves smoothly. (See Figure 3)
2. Blow through the oil jet and verify that air flows.

IDLER GEAR

1. Measure the idler gear inner diameter. (See Figure 4)

Diameter: mm (in)
44.009-44.034mm (1.7326-1.7336 in)

2. Measure the idler gear spindle outer diameter. (See Figure 5)

Diameter: 43.950-43.975mm (1.7303-1.7313 in)

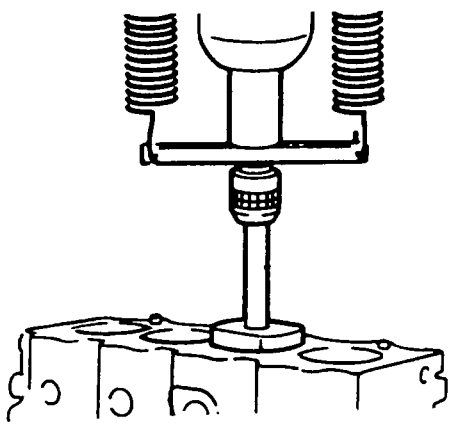
3. Subtract the spindle outer diameter from the idler gear inner diameter to calculate the spindle to idler gear clearance.

Clearance: mm (in)
Standard: 0.034-0.084mm (0.0013-0.0033 in)
Maximum: 0.15mm (0.006 in)

4. If the clearance exceeds the maximum, replace the idler gear and/or spindle.

ASSEMBLY

Figure 1.



Cylinder Liner

1. Apply engine oil to the cylinder liner.

CAUTION

*** Do not use a hammer.**

*** Align the marks on the cylinder liner and the cylinder block when installing.**

2. Install the cylinder liner into the cylinder block with the proper tools. (See Figure 1)

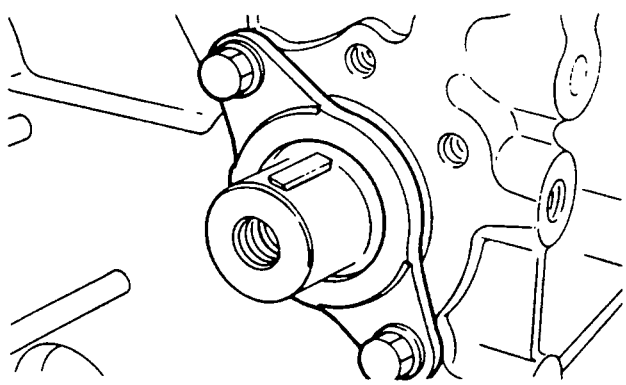
Pressure force:

9,810-29,430N (1,000-3,000 kg, 2,200-6,600lb)

Tappet

1. Apply clean engine oil to the tappet.
2. Install the tappet in the cylinder block.

Figure 2.



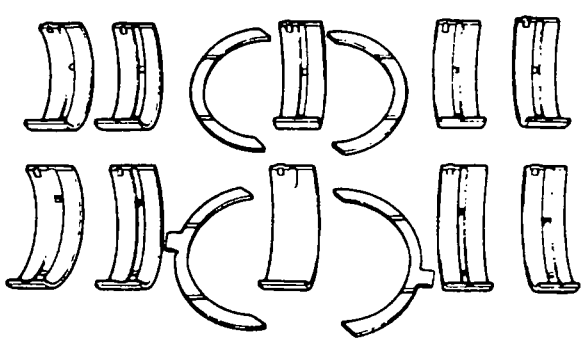
Camshaft

1. Apply engine oil to the camshaft journals and cam faces.
2. Install the camshaft in the cylinder block.
3. Apply engine oil to the thrust plate.
4. Install the thrust plate with the flat side facing the cylinder block. (See Figure 2)

Tightening torque:

16-24 Nm, (1.6-2.4 m-kg, 12-17 ft-lb)

Figure 3.



Crankshaft

1. Before installing the crankshaft, inspect the main bearing oil clearance as follows

* Remove all foreign material and oil from the journals and bearings. (See Figure 3)

Caution

*** Install the non-grooved main bearing into the No. 3 (center) main bearing cap.**

*** Install the thrust bearings with the oil groovefacing the crankshaft.**

2. install the upper main bearings and thrust bearings.
3. Set the crankshaft into the cylinder block.

Caution

Do not rotate the crankshaft when measuring oil clearances.

Figure 4.

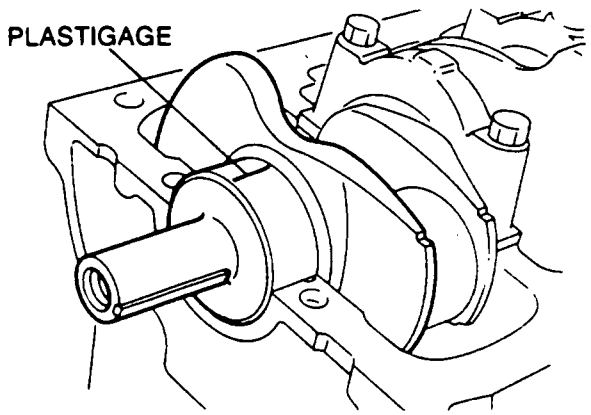


Figure 5.

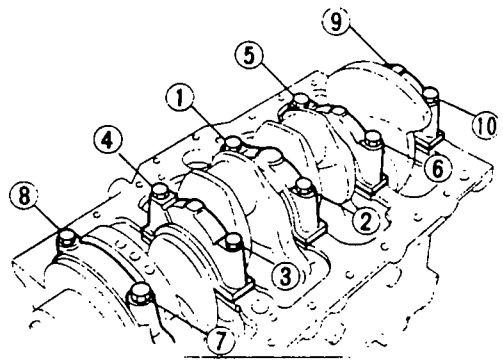


Figure 6.

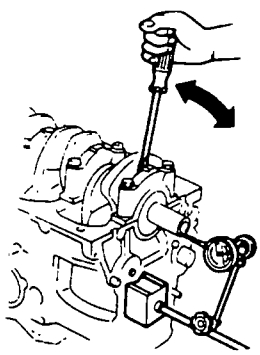
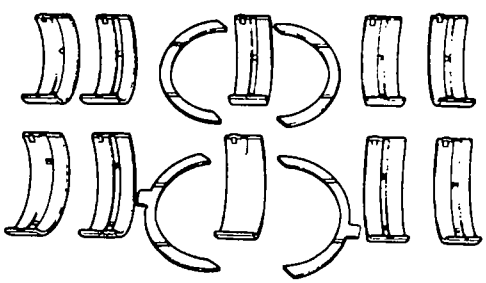


Figure 7.



4. Position the Plastigauge atop the journals in the axial direction. (See Figure 4)
5. Install the lower main bearings and the main bearing caps according to the number and the direction of the arrow on the cap.
6. Tighten the main bearing cap bolts in two or three steps in the order shown in (Figure 5).
Tightening torque:
108-115 Nm, (11.0-11.7 m-kg, 80-85 ft-lb)

7. Remove the main bearing caps, and measure the Plastigage at each journal at the widest point for the smallest clearance, and at the narrowest point for the largest clearance.
8. If oil clearance exceeds specification, grind the crankshaft and install undersize main bearings.
Clearance: mm (in)
Standard: 0.058-0.092 (0.0023-0.0036)
Maximum: 0.12 (0.005)

2. Apply a liberal amount of clean engine oil to the main bearings, thrust bearings, and main journals.
3. Install the crankshaft and the main bearing caps according to the cap number and arrow mark.

4. Tighten the main bearing cap bolts in two or three steps in the order shown in (Figure 5).

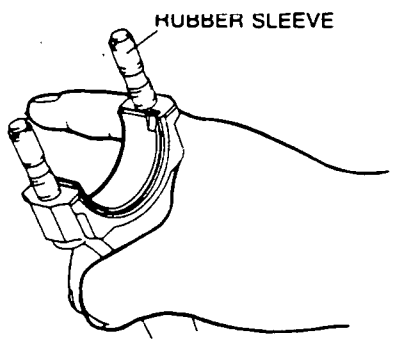
Tightening torque:
108-115 Nm, (11.0-11.7 m-kg, 80-85 ft lb).
5. Measure the crankshaft end play.

End play:
Standard: 0.14-0.39mm (0.0055-0.0154 in)
Maximum: 0.40mm (0.016 in)

6. If the end play exceeds the maximum, gring the crankshaft and install an oversize thrust bearing or replace the crankshaft and thrust bearing. (See Figure 7)

Thrust bearing width:
Standard: 2.275-2.325mm (0.0896-0.0915 in)
0.178mm (0.0070 in) oversize:
2.453-2.503mm (0.0966-0.0985 in)

Figure 1.

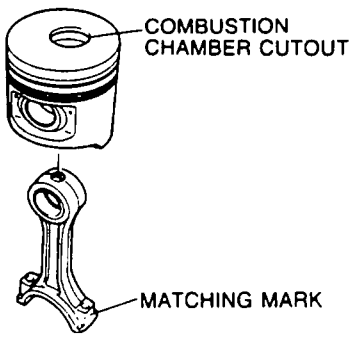


Piston and Connecting Rod

Caution:

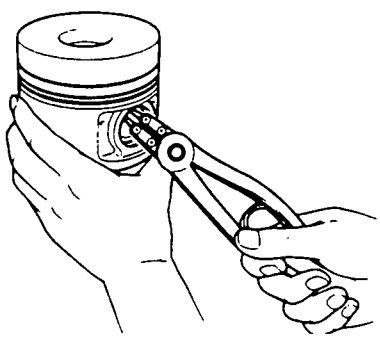
*** Protect the connecting rod bolts with rubber sleeves to prevent damage to the crankpin journal. (See Figure 1)**

Figure 2.



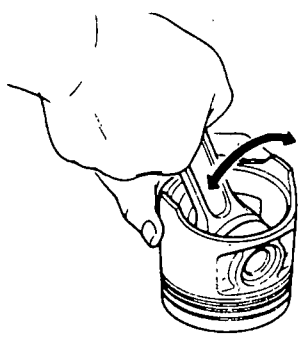
1. Install one piston pin clip into the clip groove in the piston.
2. Assemble the piston and the connecting rod so that the piston combustion chamber cutout and the connecting rod mark are facing in the same direction. (See Figure 2)
3. Heat the piston to 50-60°C (122-140°F).
4. Apply clean engine oil to the piston pin.
5. Install the piston pin from the side opposite theclip. If the pin cannot be installed somthgly, replace the piston and/or connecting rod.

Figure 3.



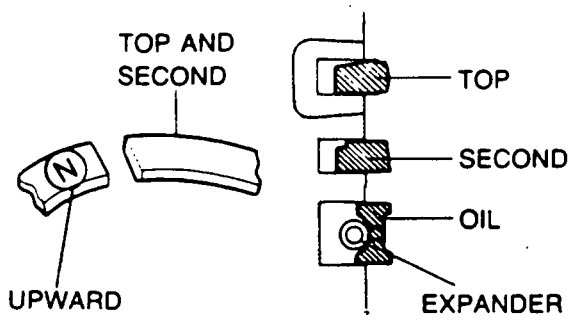
6. Install the second clip into the clip groove in the piston. (See Figure 3)

Figure 4.



7. Check the oscillation torque of the connecting rod. If the large end does not drop by it's own weight, replace the piston, connecting rod, and/ or piston pin. (See Figure 4)

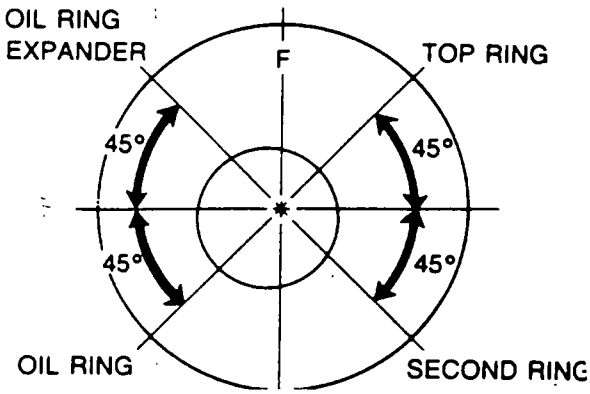
Figure 5.



8. Apply clean engine oil to the piston rings.
9. Install the coil expander under the oil ring and set the end gaps at approximately 90° apart.
10. Install the oil ring to the piston.

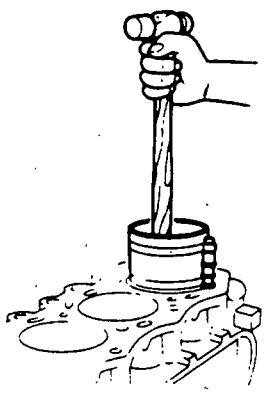
Caution:
*** The top and second rings must be installed with the N mark facing upward. (See Figure 5)**

Figure 6.



11. Using a piston ring expander, install the second ring to the piston, then install the top ring.
12. Verify that the piston rings tun smoothly.
13. Position the end gaps of the rings as shown in Figure 6.
14. Apply clean engine oil to the cylinder liner walls and pistons.
15. Check the piston rings for correct end gap
16. Insert each piston assembly into the cylinder block with the marks (Y or Z) facing the front of the engine. Using a piston ring compressor. (See Figure 7).

Figure 7.



17. Remove the rubber sleeves from the connecting rod bolts.
18. Measure the connecting rod bearing oil clearance.

Caution:
*** Align the marks on the cap and the connecting rod when installing the connecting rod cap.**

(1) Remove all foreign material and oil from the journals and bearings.

Caution:
*** Do not rotate the crankshaft when measuring the oil clearances.**

(2) Position Plastigage atop the journals in the axial direction. (See Figure 8)
(3) Install the connecting rod bearing cap with the marks aligned.
(4) Tighten the nuts in two to three steps.

Tightening torque:
80-88 Nm, (8.2-9.0 m-kg, 59-65 ft-lb)

Figure 8.

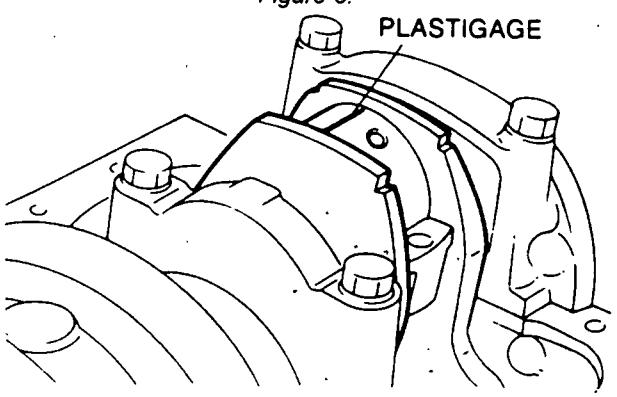
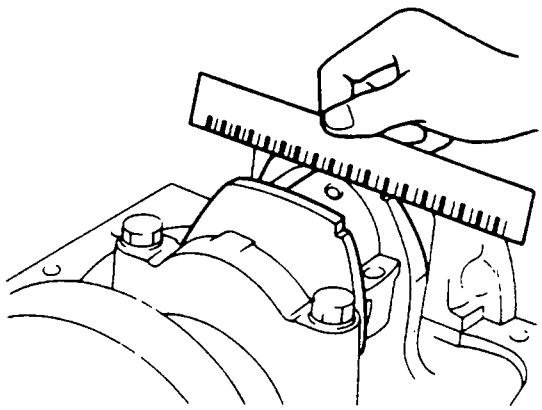


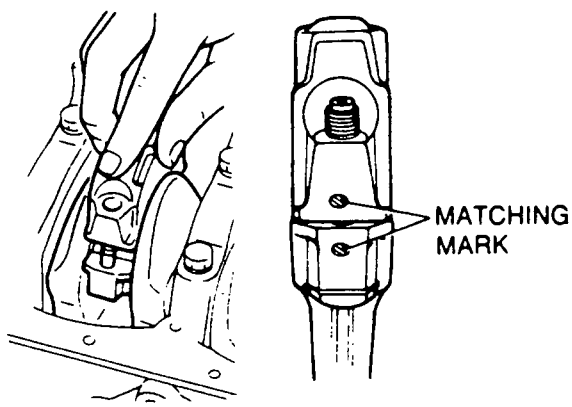
Figure 9.



(5). Loosen the connecting rod nuts.
(6). Remove the connecting rod caps, and measure the Plastigageat each journal at the widest point for the smallest clearance, and at the narrowest point for the largest clearance. (See Figure 9)
(7). If oil clearance exceeds specification, grind the crankshaft and install undersize main bearings.

Oil clearance: mm (in)
0.038-0.074 (0.0015-0.0029)
Maximum: 0.10mm (0.004 in)

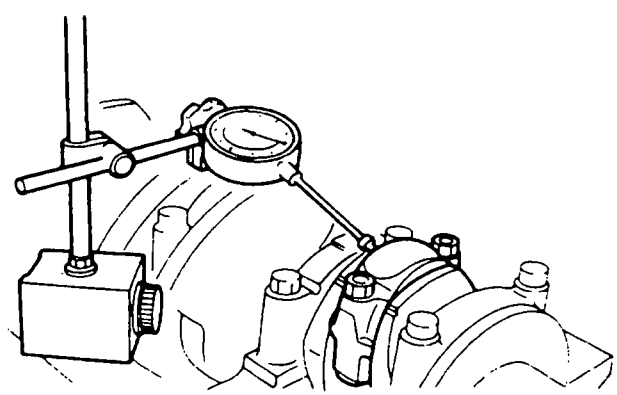
Figure 10.



19. Apply a liberal amount of clean engine oil to the connecting rod bearings and crankpin jopurnals.
20. Install the connecting rod bearings and caps with the marks aligned, and tighten the nuts in two or three steps. (Figure 10)

Tightening torque:
80-88 Nm, (8.2-9.0 m-kg, 59-65 ft-lb)

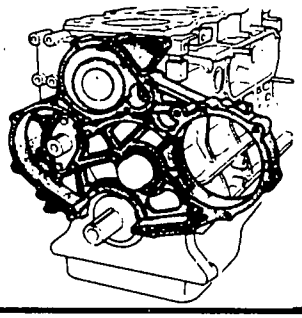
Figure 11.



21. Measure the connecting rod side clearance. (See Figure 11)
Side Clearance: mm (in)
Standard: 0.239-0.330 (0.0094-0.0130)
Maximum: 0.40 (0.016)

22. If the clearance exceeds the maximum, replace the connecting rod cap.

Figure 1.

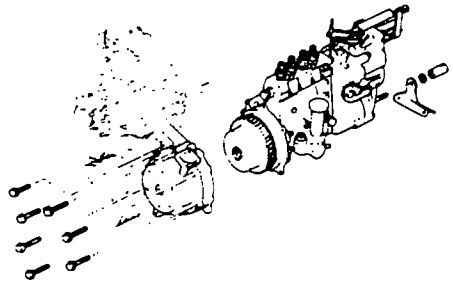


Timing Gear Case

1. Install the timing gear case and a new gasket. (See Figure 1)

Tightening torque:
19-25 Nm (1.9-2.6 m-kg, 14-19 ft-lb)

Figure 2

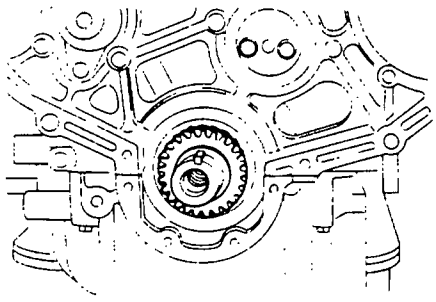


Fuel Injection Pump

1. Install the fuel injection pump. (See Figure 2)

Tightening torque:
22-30 Nm, (2.2-3.1 m-kg, 16-22 ft-lb)

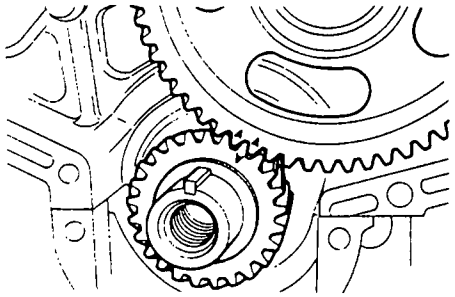
Figure 3.



Crankshaft Timing Gear

1. Align the Woodruff key, and install the crankshaft gear. (See Figure 3)
2. Install the friction gear, friction gear spring, and oil deflector.

Figure 4.

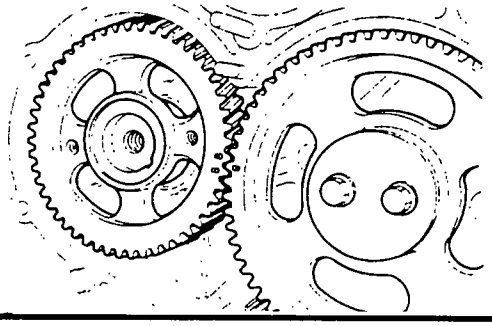


Idler Gear

1. Install the idler gear spindle.
2. Align the marks, and install the idler gear an thrust plate. (See Figure 4)

Tightening torque:
23-31 Nm, (2.3-3.2 m-kg, 17-23 ft-lb)

Figure 5.

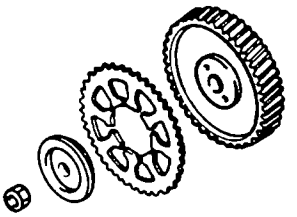


Camshaft Gear and Injection Pump Gear

1. Align the marks, and install the camshaft lock plate, and friction gear. (See Figure 5)

Tightening torque:
63-93 Nm, (6.4-9.5 m-kg, 46-69 ft-lb)

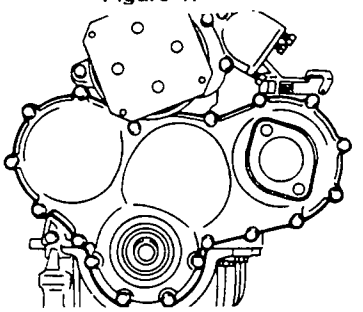
Figure 6.



2. Align the timing marks, install the injection pump gear, then install the friction gear and lock plate.

Tightening torque:
39-69 Nm, (4.0-7.0 m-kg, 29-51 ft-lb)

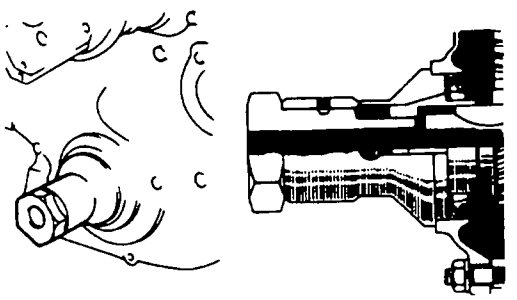
Figure 1.



Timing Gear Cover
1. Install the timing gear cover and a new gasket. (See Figure 1)

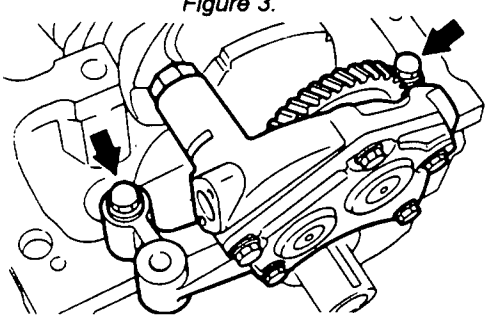
Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)
2. Apply a small amount of engine oil to the lip of the new seal.
3. Push the oil seal slightly in by hand.

Figure 2.



Caution:
*** The oil seal must be pressed in until it is 6.5mm (0.26 in) inside the edge of the timing gear cover.**
4. Press the oil seal in evenly with a block of wood or a suitable pipe and a hammer. (See Figure 2)

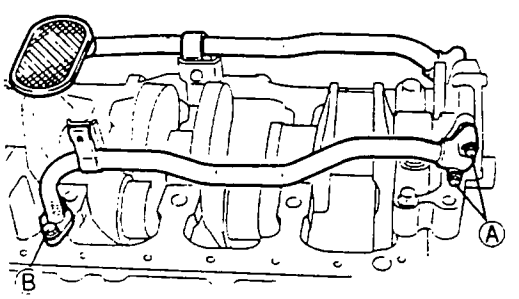
Figure 3.



Oil Pump
1. Apply clean engine oil to the oil pump driven gear.
2. Install the oil pump. (See Figure 3)

Tightening torque:
37-53 Nm, (3.8-5.4 m-kg, 27-39 ft-lb)

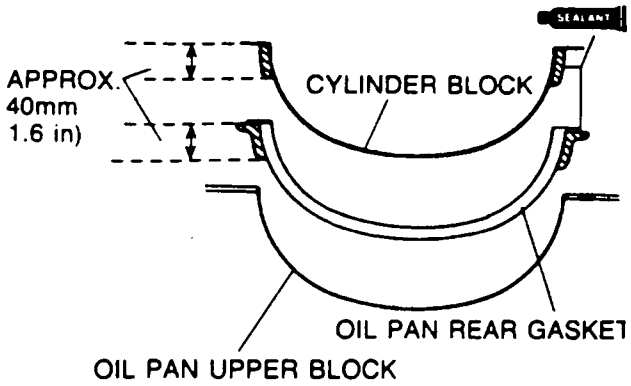
Figure 4.



Oil Strainer and Pipe
1. Install the oil strainer and new gasket. (See Figure 4)

Tightening torque:
7.8-11 Nm, (80-110 cm-kg, 69-95 in-lb)
2. Install the oil pipe and a new gasket (oil pump side) and a new O-ring (cylinder block side).
Tightening torque:

Figure 5.



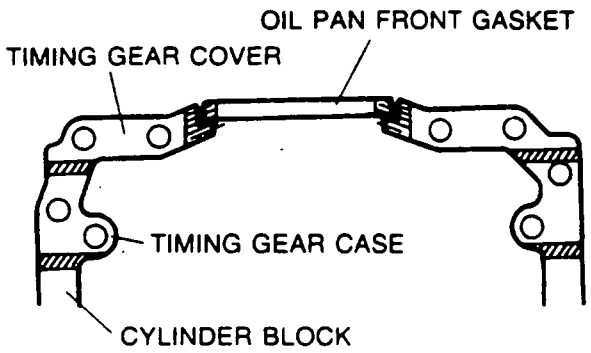
Oil Pan Upper Block

Caution:

*** The oil pan upper block must be secured within 30 minutes after the sealant is spplied.**

1. Apply the silicone sealant as shown to the shaded areas of a new oil pan gasket (front and rear).
2. Install the gaskets onto the cylinder block. (See Figure 5)

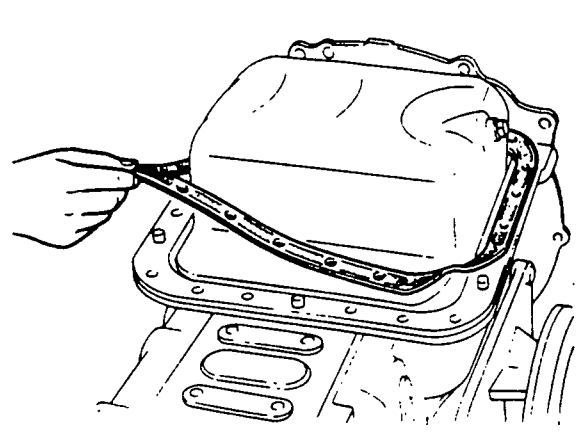
Figure 6.



3. Apply silicone sealant to the shaded areas of the cylinder block.
4. Install the oil pan upper block and a new gasket. (See Figure 6)

Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

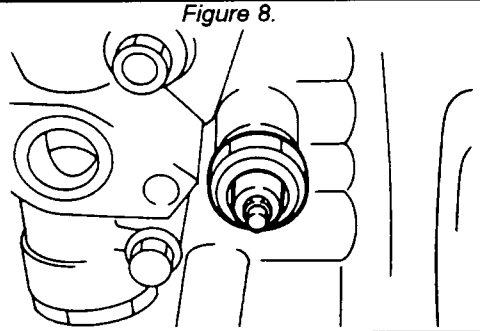
Figure 7.



Oil Pan

1. Install the oil pan and a new gasket. (See Figure 7)
2. Install the stiffener.

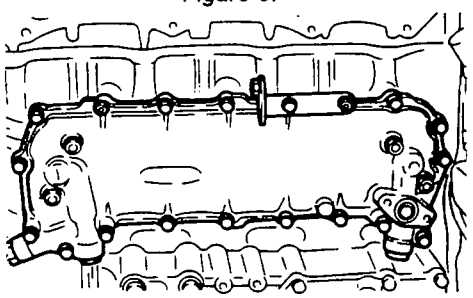
Figure 8.



Oil Pressure Switch
1. Install the oil pressure switch. (Figure 8)

Tightening torque:
12-18 Nm, (120-180 cm-kg, 104-156 in-lb)

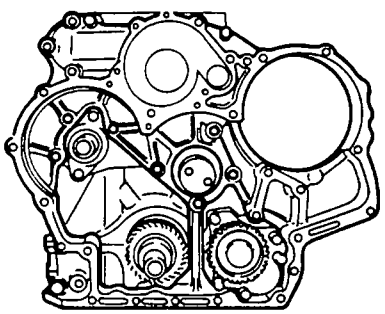
Figure 9.



Oil Cooler
Install the oil cooler and a new gasket. (See Figure 9)

Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

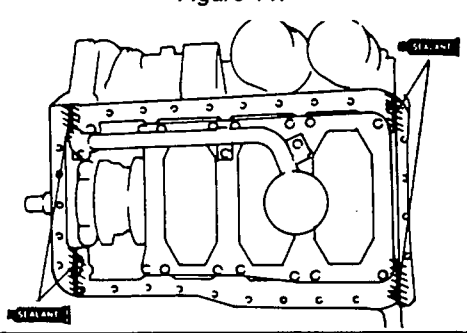
Figure 10.



Timing Gear Case.
1. Install the timing gear case. (See Figure 10)

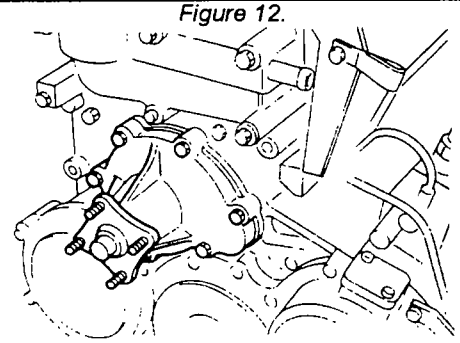
Tightening Torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

Figure 11.



2. Apply silicone sealant as shown to the shaded areas of the timing gear case and the cylinder block. (See Figure 11)

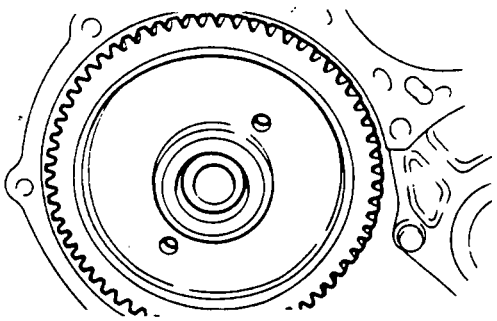
Figure 12.



Water Pump
1. Install the water pump and a new gasket.

Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

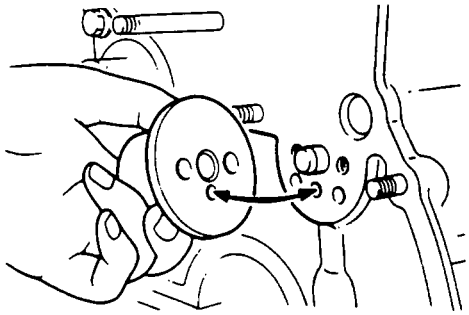
Figure 1.



Timing Gear Train

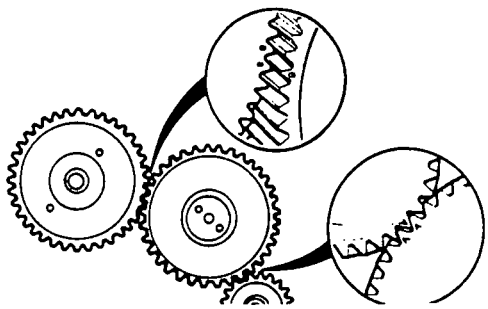
1. Align the woodruff key, and install the cam gear. (See Figure 1)

figure 2.



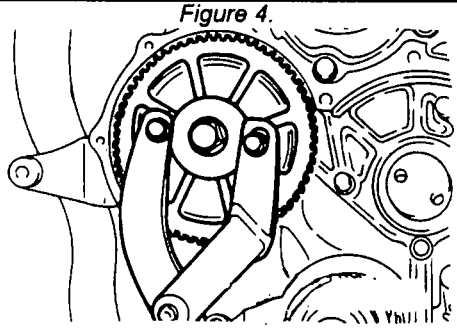
2. Align the idler gear spindle oil hole and the cylinder block oil hole. (See Figure 2)

Figure 3.



3. Install the idler gear as shown in Figure 3.

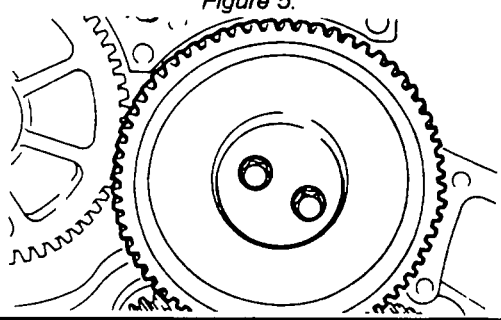
Figure 4.



4. Install the friction plate and washer to the cam gear, and affix themwith a coupling flange holder. (See Figure 4)
5. Install and tighten the lock bolt.

Tightening torque:
63-93 Nm, (6.4-9.5m-kg, 46-69 ft-lb)

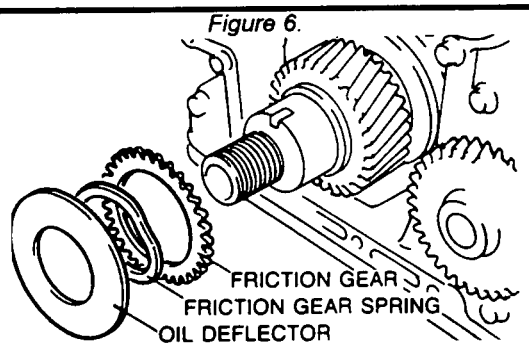
Figure 5.



6. Install the idler gear and thrust plate as shown in Figure 5.

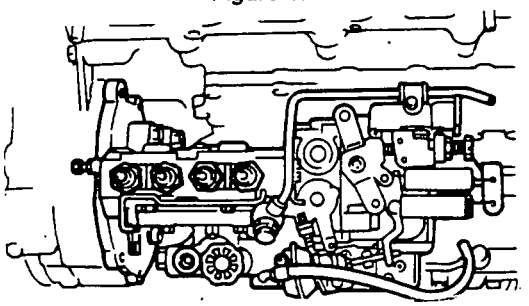
Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

Figure 6.



7. Install the friction gear, gear spring and oil deflector on the crankshaft. (See Figure 6)

Figure 1.

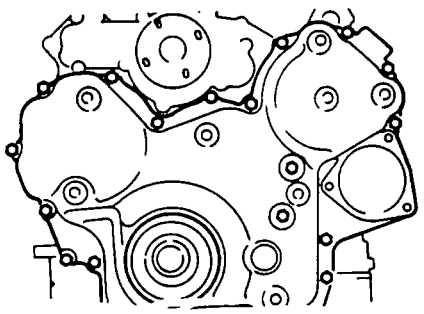


Fuel Injection Pump

1. Align the marks of the idler gear and the injection pump gear.
2. Install the fuel injection pump. (See Figure 1)

Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

Figure 2.

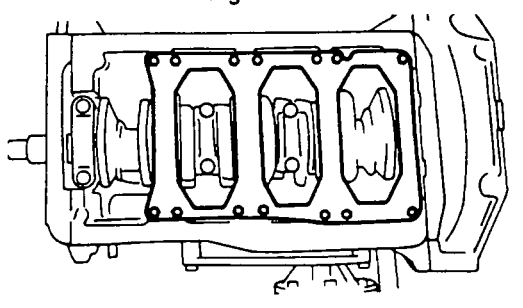


Timing Gear Cover

1. Install the timing gear coverand a new gasket. (See Figure 2)

Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

Figure 3.

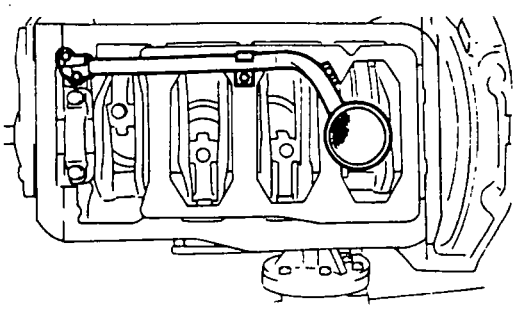


Stiffening Plate

1. Install the stiffening plate (See Figure 3)

Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

Figure 4.

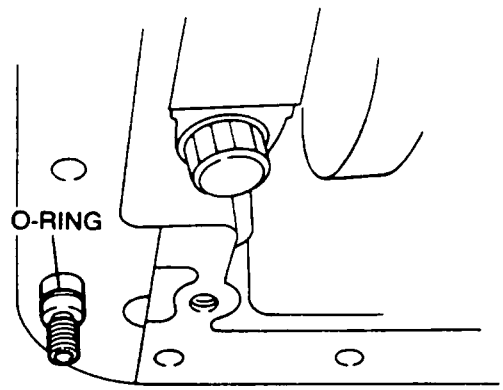


Oil Strainer

1. Install the oil strainer and a new gasket.

Tightening torque:
7.8-11 Nm, (80-110 cm-kg, 69-95 in-lb)

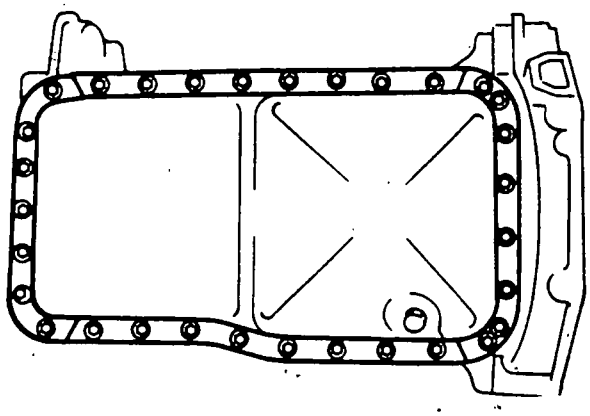
Figure 5.



Oil Pan

1. Install the oil pan (See Figure 5)

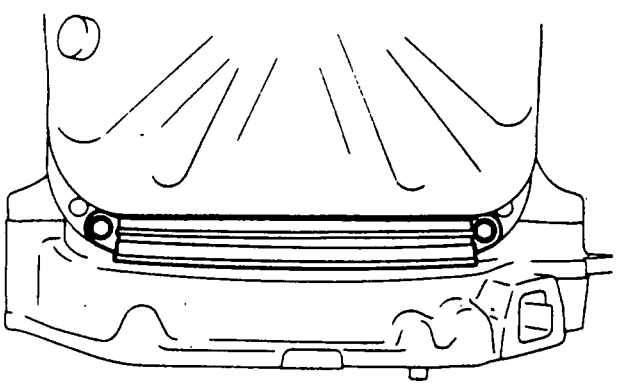
Figure 6.



2. Install a new gasket. (See Figure 6)
3. Install the oil pan.
4. Install the stiffener and a new gasket.

Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

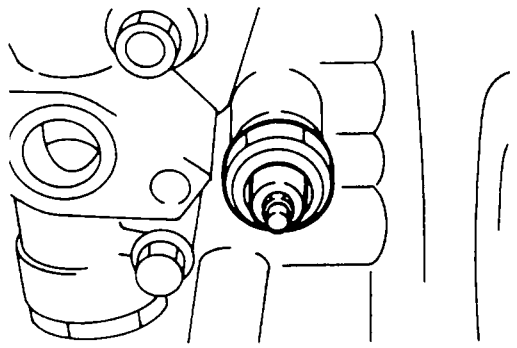
Figure 7.



5. Install the seal plate. (See Figure 7)

Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

Figure 1.

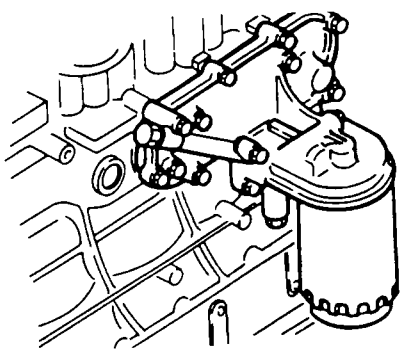


Oil Pressure Switch

1. Install the oil pressure switch. (See Figure 1)

Tightening torque:
12-18 Nm, (120-180 cm-kg, 104-156 in-lb)

Figure 2.



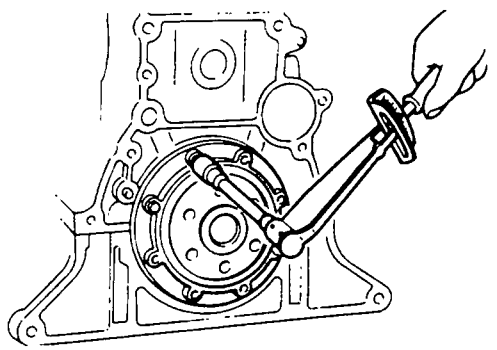
Oil Cooler, Oil Filter

1. Install the oil cooler and a new gasket. (See Figure 2)

Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

2. Apply a small amount of clean engine oil to the rubber seal of the new filter.
3. Install the oil filter and tighten it by hand until the rubber contacts the base.

Figure 3.

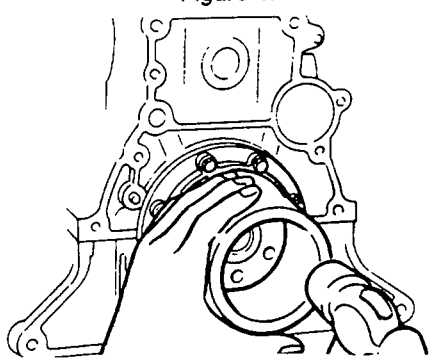


Rear Oil Seal Cap

1. Install the rear oil seal cap and a new gasket. (See Figure 3)

Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

Figure 4.

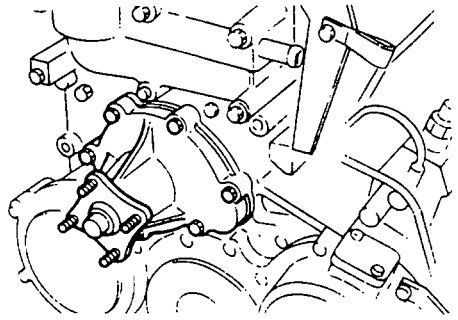


2. Apply a small amount of clean engine oil to the lip of the new oil seal.
3. Push the oil seal slightly in by hand.

Caution:
*** The oil seal must be pressed in until it is flush with the edge of the rear oil seal cap.**

4. Press the oil seal in evenly with a suitable pipe and a hammer. (See Figure 4)

Figure 5.

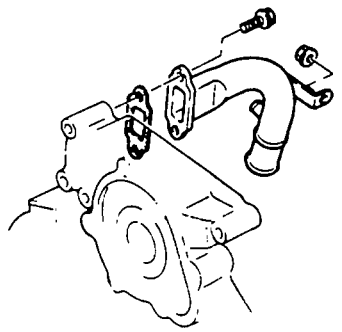


Water Pump

1. Install the water pump and a new gasket. (See Figure 5)

Tightening torque:
16-23 Nm, (1.6-2.3 m-kg, 12-17 ft-lb)

Figure 6.

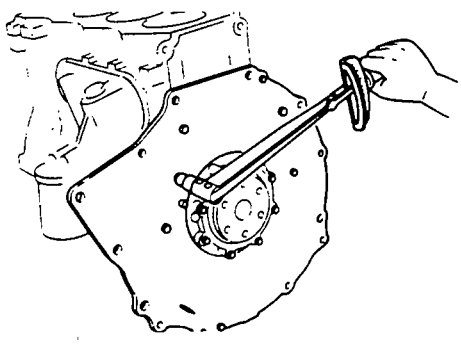


Water Inlet Pipe

1. Install the water inlet pipe and a new gasket as shown in Figure 6.

Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

Figure 7.

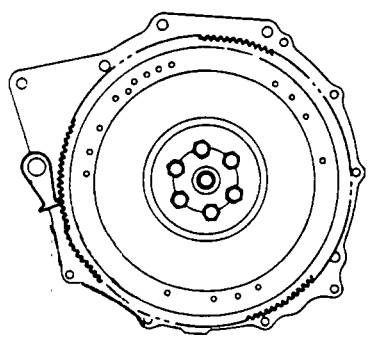


End Plate

Install the end plate. (See Figure 7)

Tightening torque:
32-47 Nm, (3.3-4.8 m-kg, 24-35 ft-lb)

Figure 8.



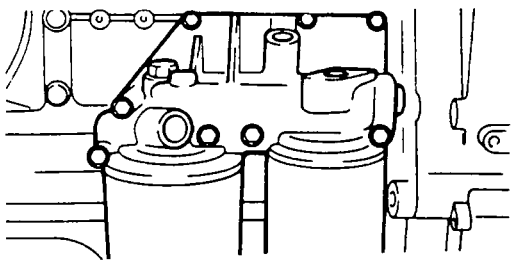
Flywheel

1. Apply clean engine oil to the bolt threads and seat faces.
2. Set the flywheel onto the crankshaft, and loosely install the bolts.
3. Hold the flywheel with the (ring gear brake). (See Figure 8)
4. Tighten the bolts in two or three steps in the order shown in the figure.

tightening torque:
177-196 Nm, (18.0-20.0 m-kg, 130-145 ft-lb)

ASSEMBLY

Figure 1.

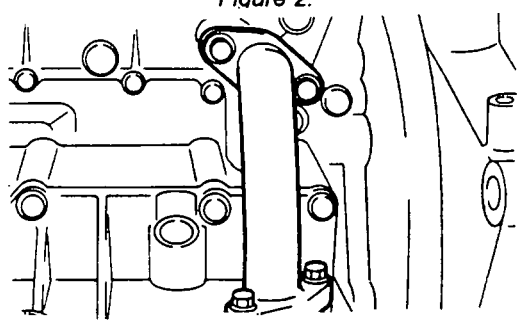


Oil Filter Assembly

1. Install the oil filter and a new gasket. (See Figure 1)

Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

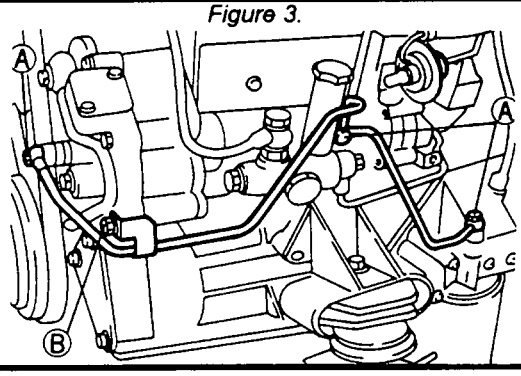
Figure 2.



2. Install the oil pipe and a new o-ring. (See Figure 2)

Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

Figure 3.

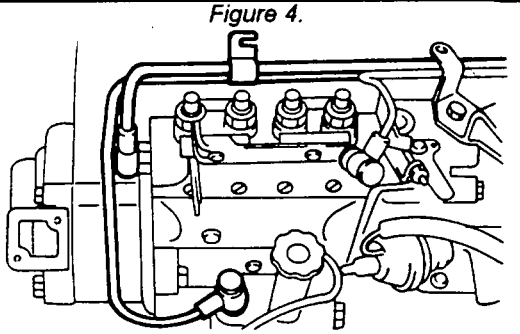


Injection Pump Oil Pipe

1. Install the injection pump oil pipe. (See Figure 3)

Tightening torque:
A: 9.8-13 Nm, (100-130 cm-kg, 87-113 in-lb)
B: 19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

Figure 4.

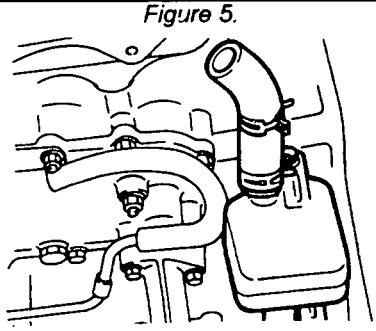


Fuel Pipe

1. Install the fuel pipe. (See Figure 4)

Tightening torque:
9.8-13 Nm, (100-130 cm-kg, 87-113 in-lb)

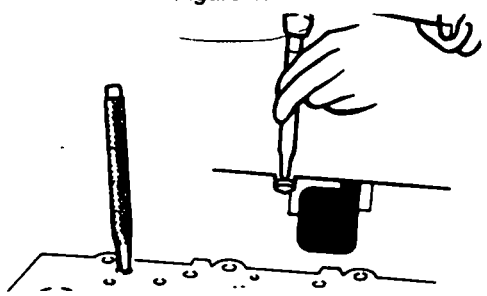
Figure 5.



PCV Chamber

1. Install the PCV chamber. (See Figure 5)

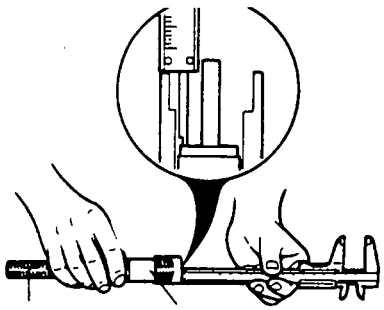
Figure 1.



Combustion Chamber Insert

1. Place the insert into position of the cylinder head and adjust the position in relation to the welsh washer. Set the welsh washer with the projected portion directed toward the cylinder head gasket side.
2. Calk the welsh washer by lightly striking its center with a punch. (See Figure 1)

Figure 2.



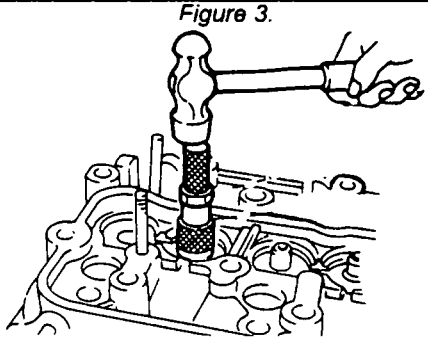
Valve Guide

1. Assemble the verneer caliper so that depth L is as specified. (See Figure 2)

Depth L: 15.2-15.4 mm (0.598-0.606 in)

2. Tighten the locknut.

Figure 3.

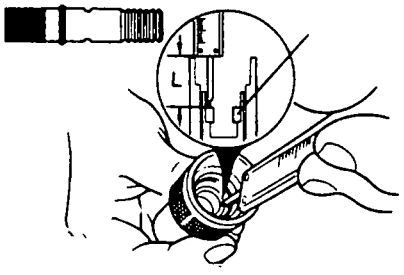


3. Tap the valve guide in from the side opposite the combustion chamber until the valve guide installer contacts the cylinder head. (Figure 3)
4. Verify that the valve guide height is within specification.

Height: 15.2-15.4 mm, (0.598-0.606 in)

5. If not within specification, repeat steps 1-4.

Figure 4.

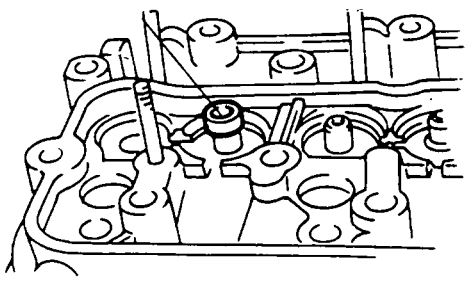


Valve Seal

1. Assemble the valve guide installer depth is as specified.

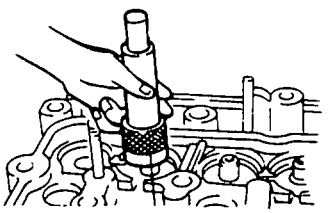
Depth L: 16.5-16.9 mm, (0.650-0.665 in)

Figure 5.



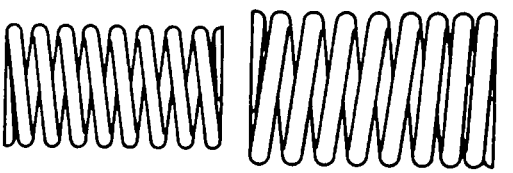
2. Slide the valve seal onto the valve guide.
3. Set the installation tool against the valve seal. (See Figure 5)

Figure 6.



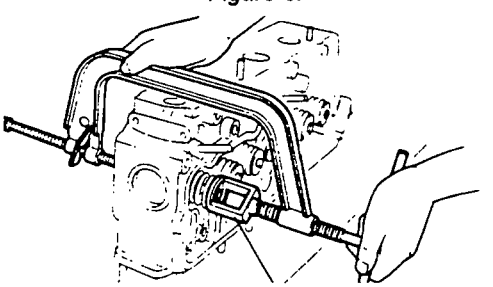
Caution:
*** Do not use a hammer.**
4. Press the valve seal on until the installation tool touches the cylinder head. (See Figure 6)

Figure 7.



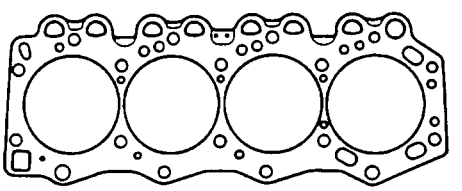
Valve, Valve Spring and Valve Spring Seat
1. Install the lower spring seat.
2. Install the valve.
3. Install the valve springs, (outer and inner) and the upper spring seat. (See Figure 7)

Figure 8.



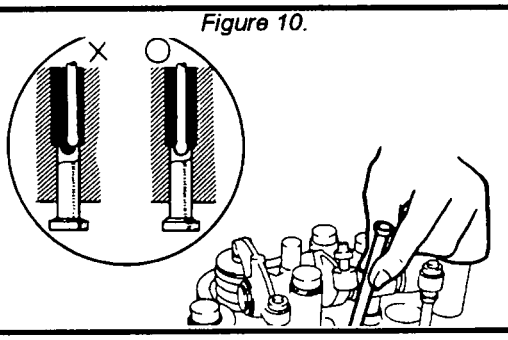
4. Compress the valve spring with a coventional valve spring compressor. (Figure 8)
5. Install the valve keepers.
6. Remove the valve spring compressor.
7. Tap the end of the valve stem lightly two or three times with a plastic hammer to verify that the keepers are fully seated.
8. Install the valve stem caps.

Figure 9.



Cylinder Head Gasket (Figure 9)
1. Remove all foreign material from the deck of the cylinder block.
2. Place the new cylinder head gasket in position.

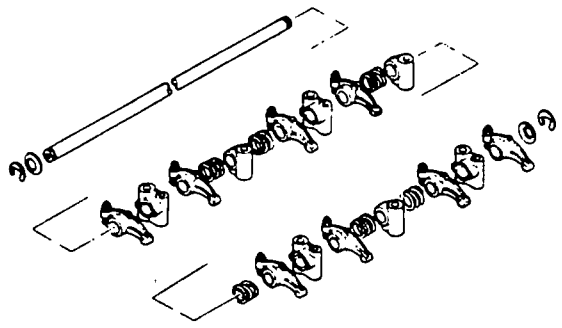
Figure 10.



Cylinder Head
1. Install the cylinder head assembly.
2. Apply clean engine oil to the push rod.
3. Install the push rods as shown in Figure 10.

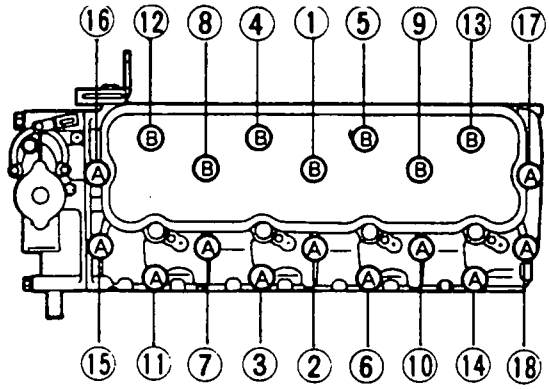
Caution:
*** Verify that the ends of the push rods are properly set into the tappets.**

Figure 11.



4. Apply clean engine oil to the rocker arms and shaft.
5. Assemblr the rocker arms, springs, and shaft. (See Figure 11)
6. Install the rocker arm and shaft assembly onto the cylinder head.

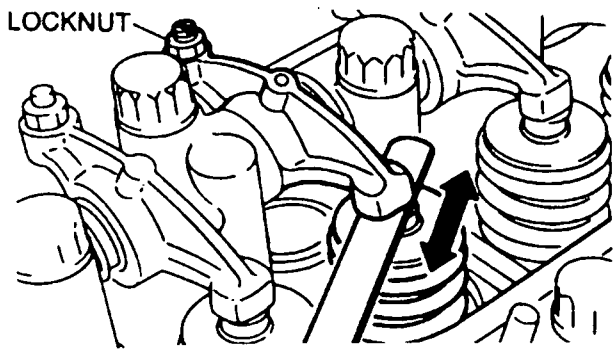
Figure 12



Caution:
*** Verify that the rocker arms and push rods are properly engaged while tightening.**
8. Apply clean engine oil to the bolt threads and seat faces.
9. Install the cylinder head bolts.
10. Tighten the bolts in two or three steps in the order shown in Figure 12.

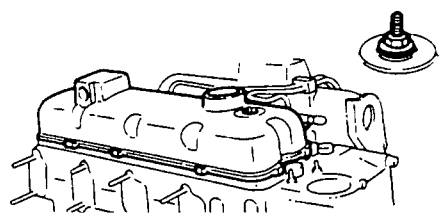
Tightening torque:
116-123 Nm, (11.8-12.5 m-kg, 43 ft-lb)

Figure 13.



11. Adjust the valve clearance. (See Figure 13)

Figure 1.



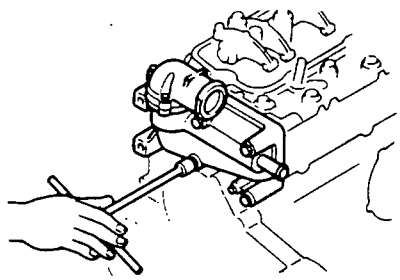
Cylinder Head Cover

1. Install the cylinder head cover and a new gasket.

Tightening torque:
2.0-3.4 Nm, (20-35 cm-kg, 17-30

2. Install the oil filler cap.

Figure 2.

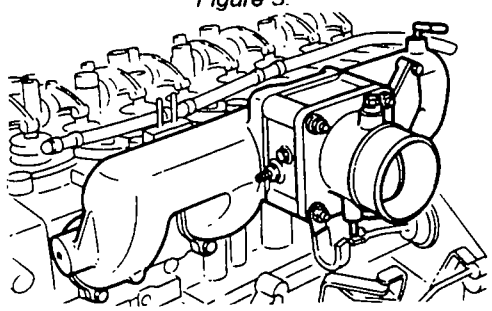


Water Outlet Housing

1. Install the water outlet housing and a new gasket. (See Figure 2)

Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

Figure 3.

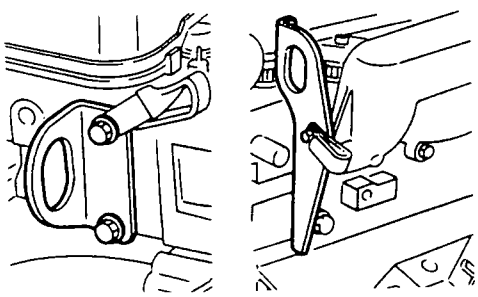


Intake Manifold Assembly

1. Install the intake manifold assembly and a new gasket. (See Figure 3)

Tightening torque:
16-24 Nm, (1.9-2.6 m-kg, 12-17 ft-lb)

Figure 4.



Engine Hanger

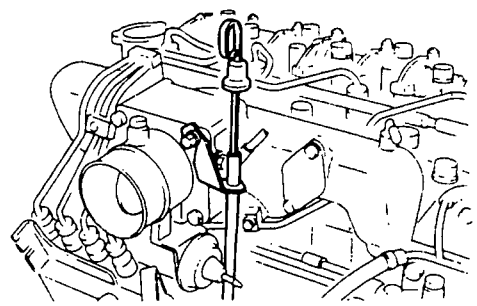
1. Install the front (right) engine hanger.

Tightening torque:
37-52 Nm, (3.8-5.3 m-kg, 27-38 ft-lb)

2. Install front (left) engine hanger.

Tightening torque:
64-89 Nm, (6.5-9.1 m-kg, 47-66 ft-lb)

Figure 5.



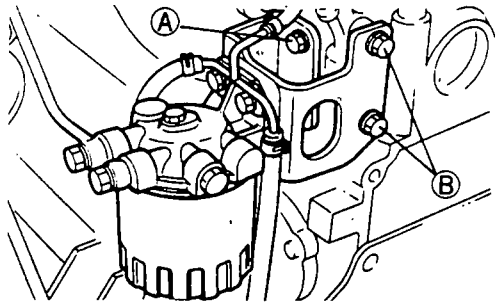
Oil Level Gauge and Guide Pipe

1. Apply clean engine oil to a new O-ring and install the oil level gauge guide pipe. (See Figure 5).

Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

2. Install the oil level gauge

Figure 6.



Fuel Filter Body

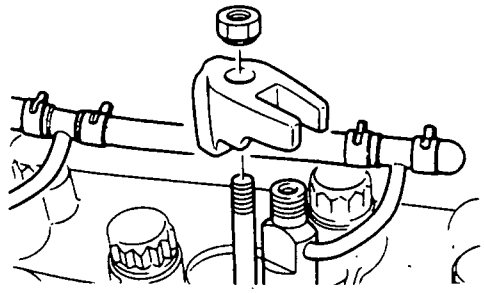
1. Install rear engine hanger (fuel filter bracket)

Tightening torque:
A: 19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)
B: 37-50 Nm, (3.8-5.1 m-kg, 27-37 ft-lb)

2. Install the fuel filter body. (See Figure 6)

Tightening torque: 37-50 Nm, (3.8-5.1 kg, 27-37 ft-lb)

Figure 7.

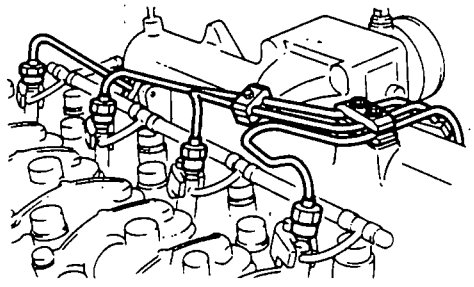


Injection Nozzle and Nozzle Holder

1. Install the injection nozzle and a new O-ring.
2. Install the injection nozzle holder. (See Figure 7)

Tightening torque:
46-54 Nm, (4.7-5.5 m-kg, 34-40 ft-lb)

Figure 8.



Injection Pipe

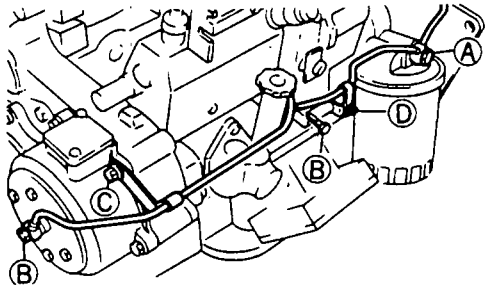
1. Install the injection pipe as shown in Figure 8.

Tightening torque:
20-25 Nm, (2.0-2.5 m-kg, 14-18 ft-lb)

2. Install the injection pipe clip.

Tightening torque:
4.4-6.4 Nm, (45-65 cm-kg, 39-56 in-lb)

Figure 9.

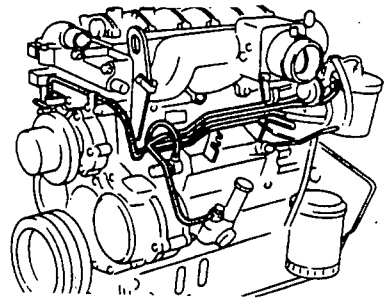


Fuel Pipe

1. Install the fuel pipe as shown in Figure 9.

Tightening torque:
Connect bolt:
29-34 Nm, (3.0-3.5 m-kg, 22-25 ft-lb)
Bracket:
7.8-11 Nm, (80-110 cm-kg, 69-95 in-lb)

Figure 10.

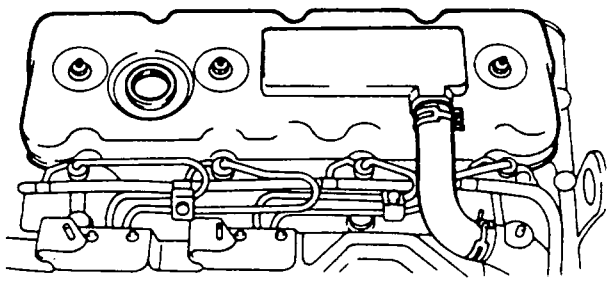


Fuel Filter Body

1. Install the fuel filter body.

Tightening torque:
A: 22-30 Nm, (2.2-3.1 m-kg, 16-22 ft-lb)
B: 16-24 Nm, (1.6-2.4 m-kg, 12-17 ft-lb)
C: 19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

Figure 11.

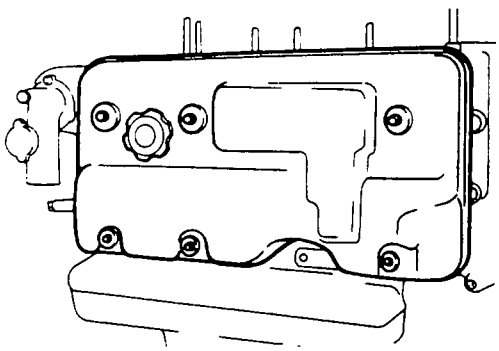


Cylinder Head Cover

1. Install the cylinder head cover and a new gasket as shown in Figure 11.

Tightening torque:
3.4-5.4 Nm, (35-55 cm-kg, 30-48 in-lb)

Figure 12.



Seal Cover

1. Install the seal cover as shown in Figure 12.

Tightening torque:
2.0-3.4 Nm, (20-35 cm-kg, 17-30 in-lb)

2. Install the filler cap.

OIL COOLER

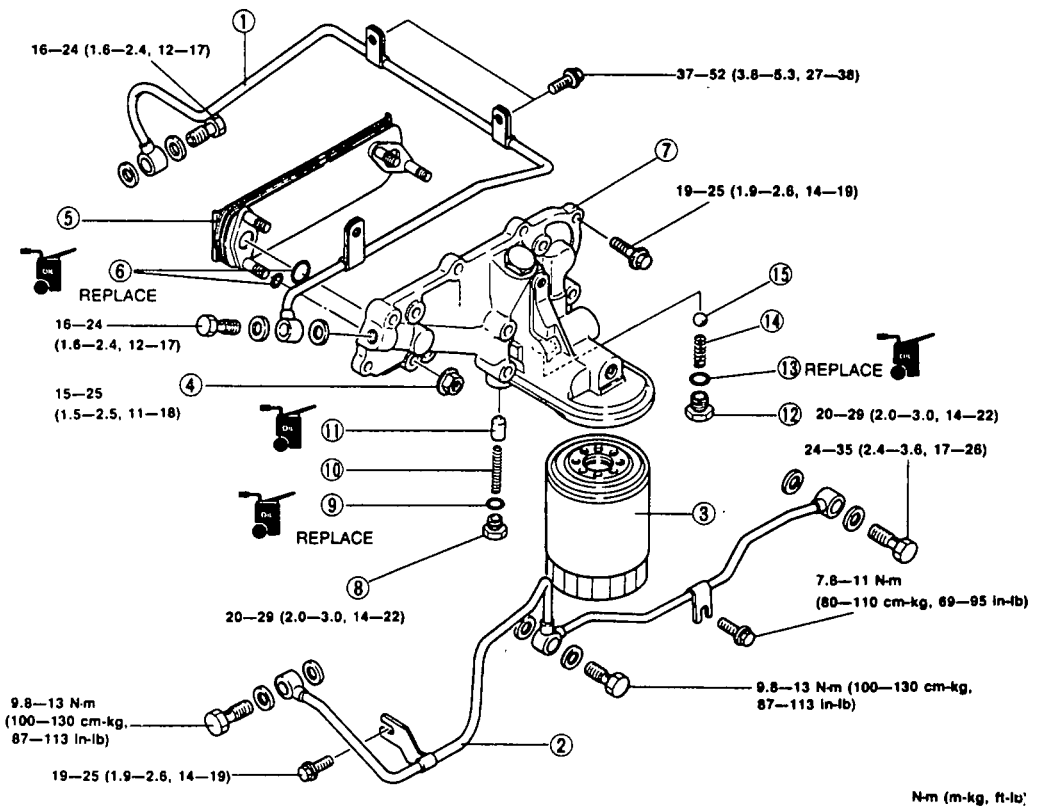
Removal and Installation

1. Disconnect the negative battery cable.
2. Drain the engine oil.
3. Drain the engine coolant.
4. Remove in the order shown in the figure
5. Install in the reverse order of removal.

Steps After Installation

1. Fill the radiator with the specified amount and type of engine coolant.
2. Fill with the amount and type of engine oil.
3. Connect the negative battery cable.
4. Start the engine and check for leaks.
5. Check the engine oil and coolant levels.

Oil Cooler Exploded View



1. Oil pipe (Oil bypass filter)
2. Oil pipe (Fuel injection pump)
3. Oil filter
4. Oil cooler installation nut
5. Oil cooler
6. O-ring
7. Oil cooler cover
8. Screw
9. O-ring
10. Pressure spring
11. Control plunger
12. Screw
13. O-ring
14. Relief valve spring
15. Steel ball

ASSEMBLY

OIL PAN

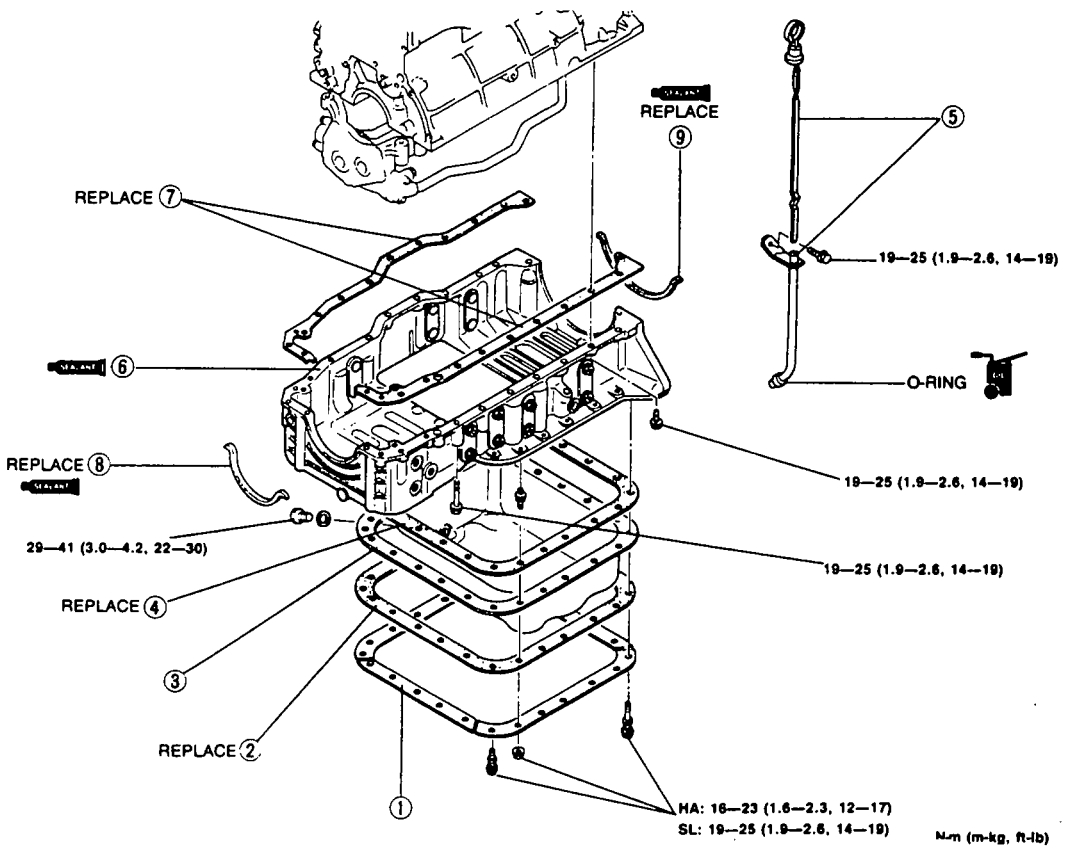
Removal and Installation

1. Disconnect the negative battery cable.
2. Drain the engine oil.
3. Remove in the order shown in the figure.
4. Installin the reverse order of removal, referring to installation note.

Steps After Installation

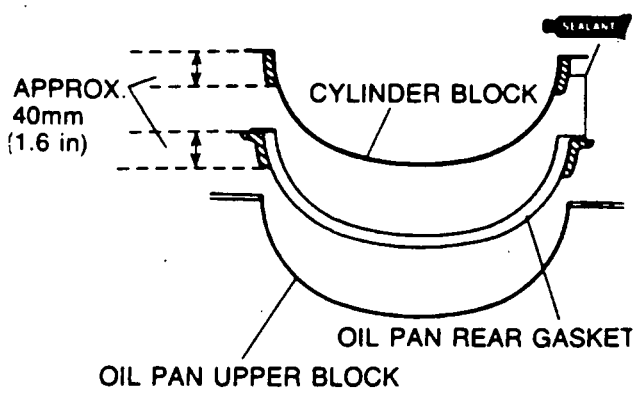
1. Fill with the specifiedamount and type of engine oil.
2. Connect the negative battery cable.
3. Start the engine and check for leaks.
4. Check the oil level and add oil if necessary.

Oil Pan Exploded View



1. Stiffener
2. Rubber gasket
3. Oil pan
4. Rubber gasket
5. Oil level gauge and pipe
6. Oil pan upper block
7. Gasket
8. Oil pan gasket, front
9. Oil pan gasket, rear

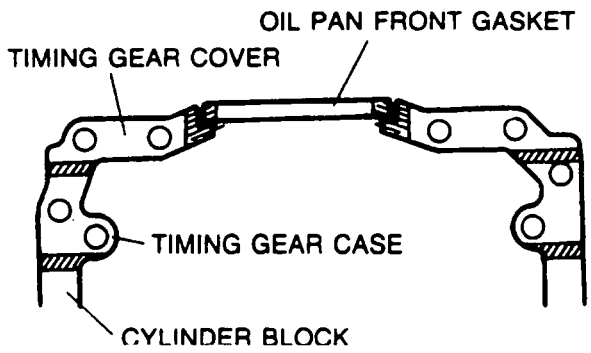
Figure 1.



OIL PAN
Installation Note
Oil pan gasket, rear

Caution:
*** The oil pan upper block must be secured within 30 minutes after the sealant is applied to the oil pan rear gasket.**
1. Apply silicone sealant to the shaded areas of the new oil pan rear gasket.
2. Install the oil pan rear gasket to the oil pan upper block.

Figure 2.



Oil pan upper block
1. Apply silicone to the shaded areas of the cylinder block.
2. Install the oil pan upper block and new gaskets

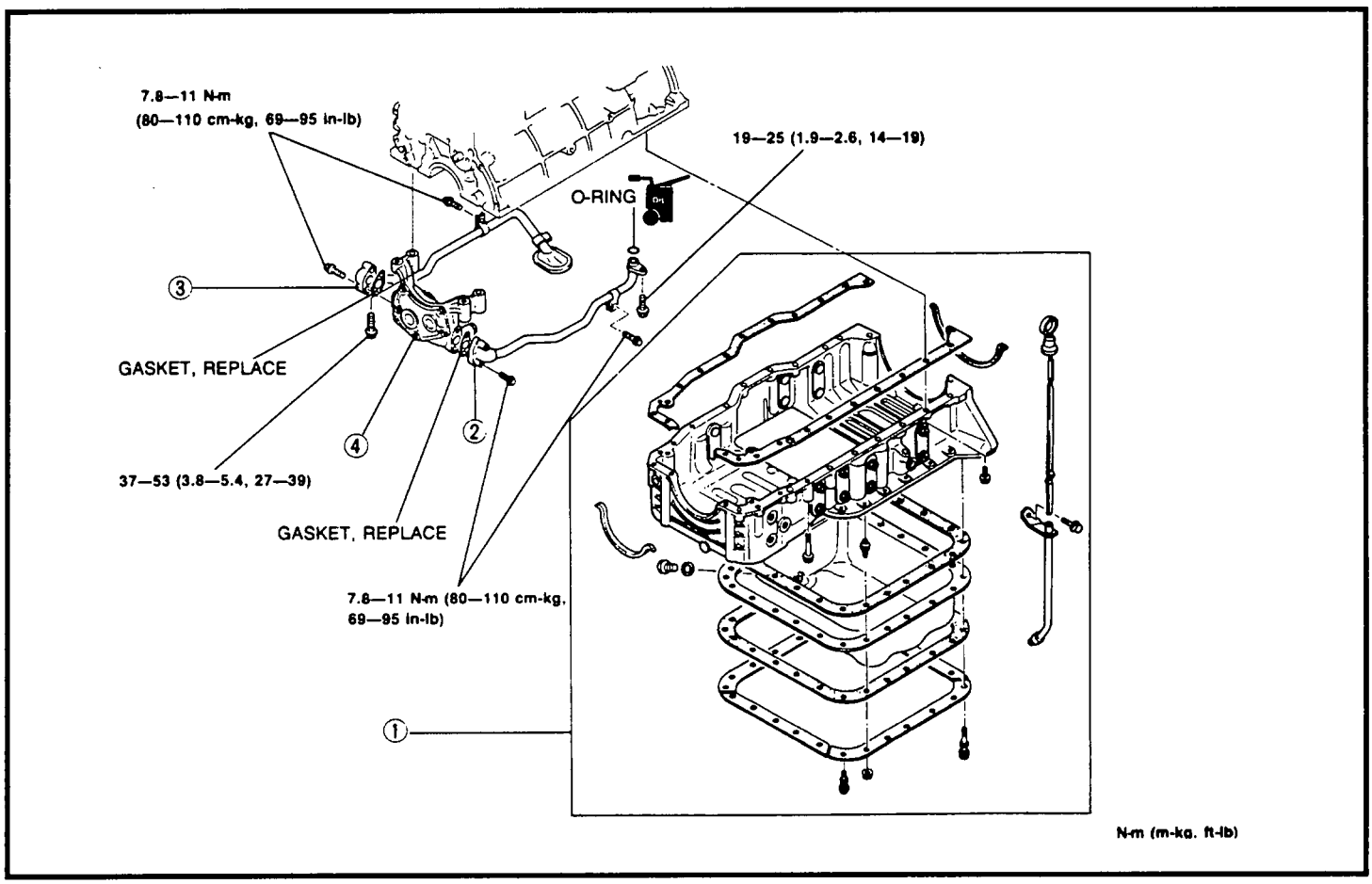
Tightening torque:
19-25 Nm, (1.9-2.6 m-kg, 14-19 ft-lb)

ASSEMBLY

OIL PUMP
Removal / Installation

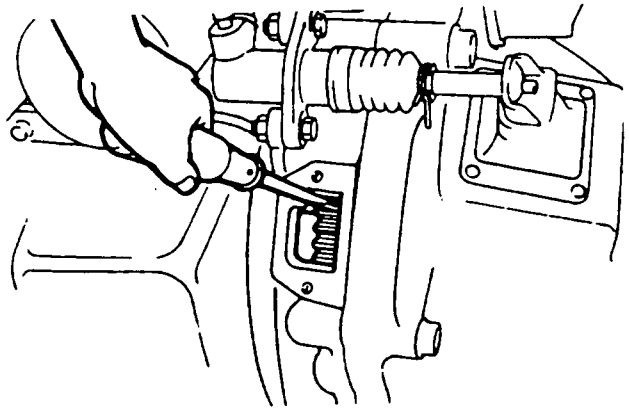
Caution:
*** Position the hose clamp in the original location on the hose, and squeeze the clamp lightly with a large pliers to ensure a good fit.**
1. Disconnect the negative battery cable.
2. Drain the engine oil.
3. Remove in the order shown in the figure, referring to **Removal Note**.
4. Install in the reverse order of removal, referring to **Installation Note**.

Steps After Installation
1. Fill with the specified amount and type of engine oil.
2. Connect the negative battery cable.
3. Start the engine and check for leaks.
4. Check the oil level and add oil if necessary.



1. Oil pan
2. Oil pipe
3. Oil strainer
4. Oil pump

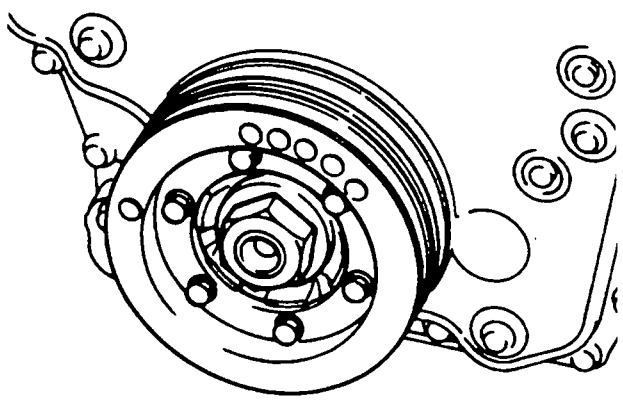
Figure 1.



OIL PUMP
Removal Note
Crankshaft pulley

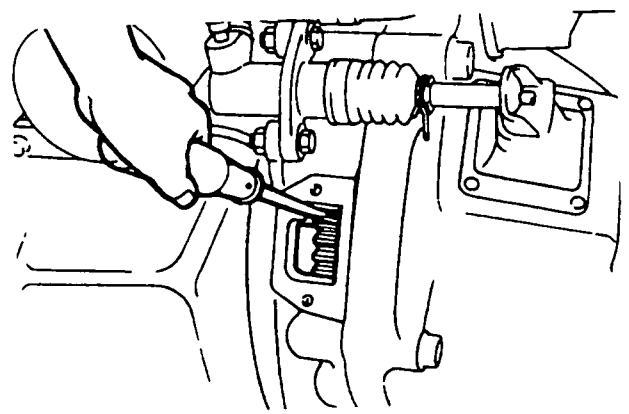
Caution:
*** This operation must be performed by two people.**
1. Remove the blind cover from the end plate.
2. Set a screwdriver or a suitable tool against the flywheel ring gear to prevent the engine from rotating.

Figure 2.



3. Loosen the pulley locknut.
4. Remove the crankshaft pulley.

Figure 3.



Installation Note
Crankshaft pulley
1. Install the crankshaft pulley.
2. Install the locknut and washer.

Caution:
*** This operation must be performed by two people.**
3. Prevent the engine from rotating and tighten the locknut.

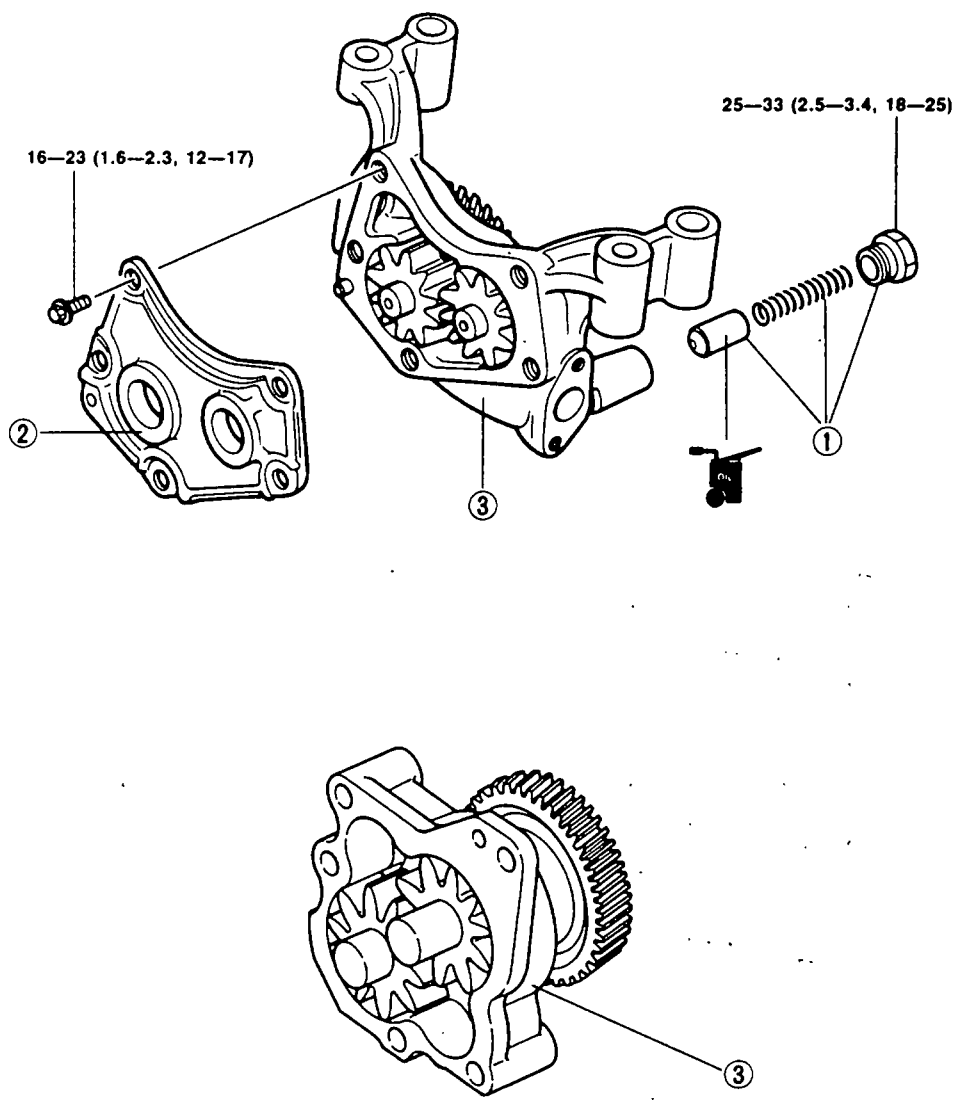
Tightening torque:
383-432 Nm, (39.0-44.0 m-kg, 282-318 ft-lb)
4. Install the blind cover to the end plate.

ASSEMBLY

OIL PUMP
Disassembly / Inspection / Assembly

Caution:
*** If a problewm is found, replace the pump as a unit.**
1. Disassemble in the order shown in the figure, referring to **Disassembly Note**.
2. Assemble in the reverse order of disassembly, referring to **Assembly Note**.

Oil Pump Assembly



1. Relief valve: (Inspect for wear or damage)
2. Pump cover
3. Pump body

Item:	Description: (specifications)
Cooling system	Water cooled, forced circulation
Coolant capacity liters (US qt, Imp qt)	12.5 (13.2, 11.0)
Water pump (type)	Centrifugal
Water pump seal	Unified mechanical seal
Thermostat type	Wax
Thermostat opening temperature °C (°F)	80.5-83.5 (177-182)
Thermostat Full open temperature °C (°F)	95 (203)
Thermostat Full open lift mm (in)	8.5 (0.33) min.

TROUBLESHOOTING GUIDE

Problem	Possible Cause	Remedy
Overheating	Coolant level insufficient	Add coolant
	Coolant leakage	Repair
	Radiator fins clogged	Clean
	Radiator cap malfunction	Replace
	Cooling fan malfunction	Replace
	Thermostat malfunction	Replace
	Water passage clogged	Clean
	Water pump malfunction	Replace
Corrosion	Impurities in coolant	Replace

ASSEMBLY

THERMOSTAT

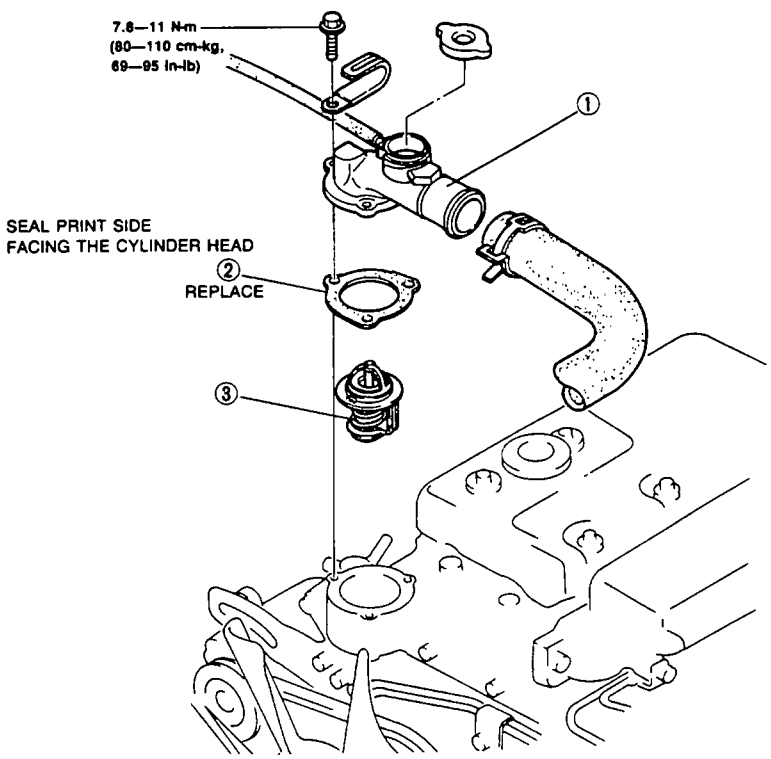
Removal / Inspection / Installation

1. Disconnect the negative battery cable.
2. Drain the engine coolant.
3. remove in the order shown in the figure.
4. Install in the reverse order of removal.

Steps After Installation

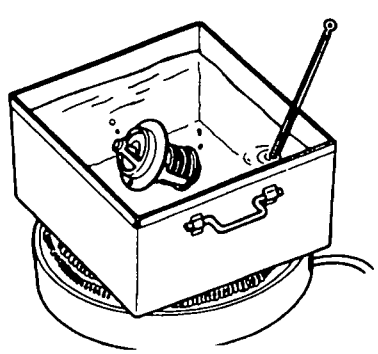
1. Fill the radiator with the specified amount and type of engine coolant.
2. Connect the negative battery cable.
3. Start the engine and check for leaks.

Thermostat Assembly



1. thermostat cover.
2. Gasket
3. Thermostat

Thermostat Test



Inspection

1. Visually check that the thermostat valve is air-tight.
2. Place the thermostat and a thermometer in water.
3. Heat the water and check the following.

Initial opening temperature:
80.5-83.5°C (177-182°F)
Full open temperature: 95°c (203°F)
Full open lift: 8.5mm (0.33 in) min.

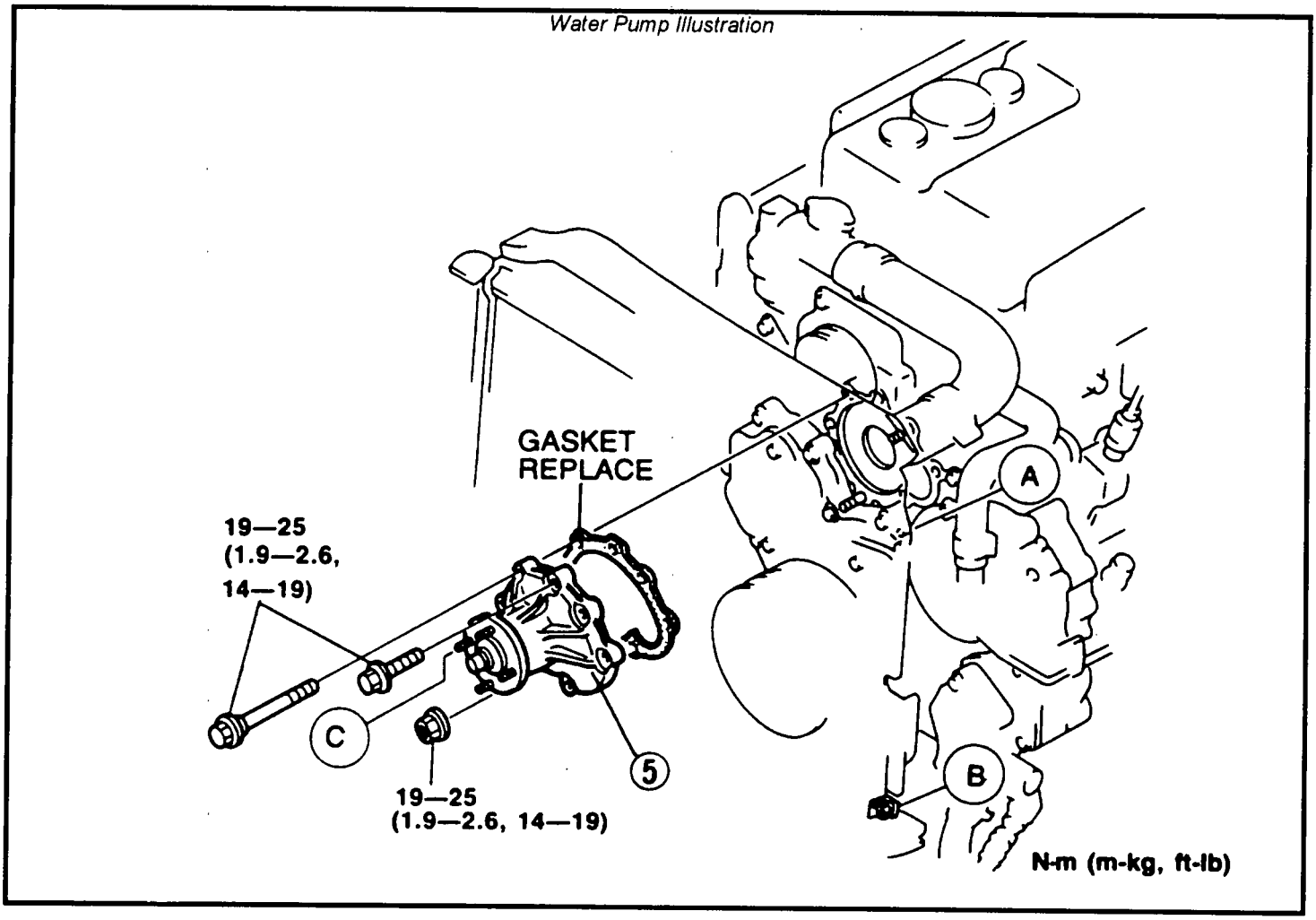
WATER PUMP
Removal / Installation

Caution:
*** Do not disassemble the water pump. If a problem is found, replace the pump as a unit.**

1. Disconnect the negative battery cable.
2. Drain the engine coolant.
3. Remove in the order shown.
4. Install in the reverse order of removal.

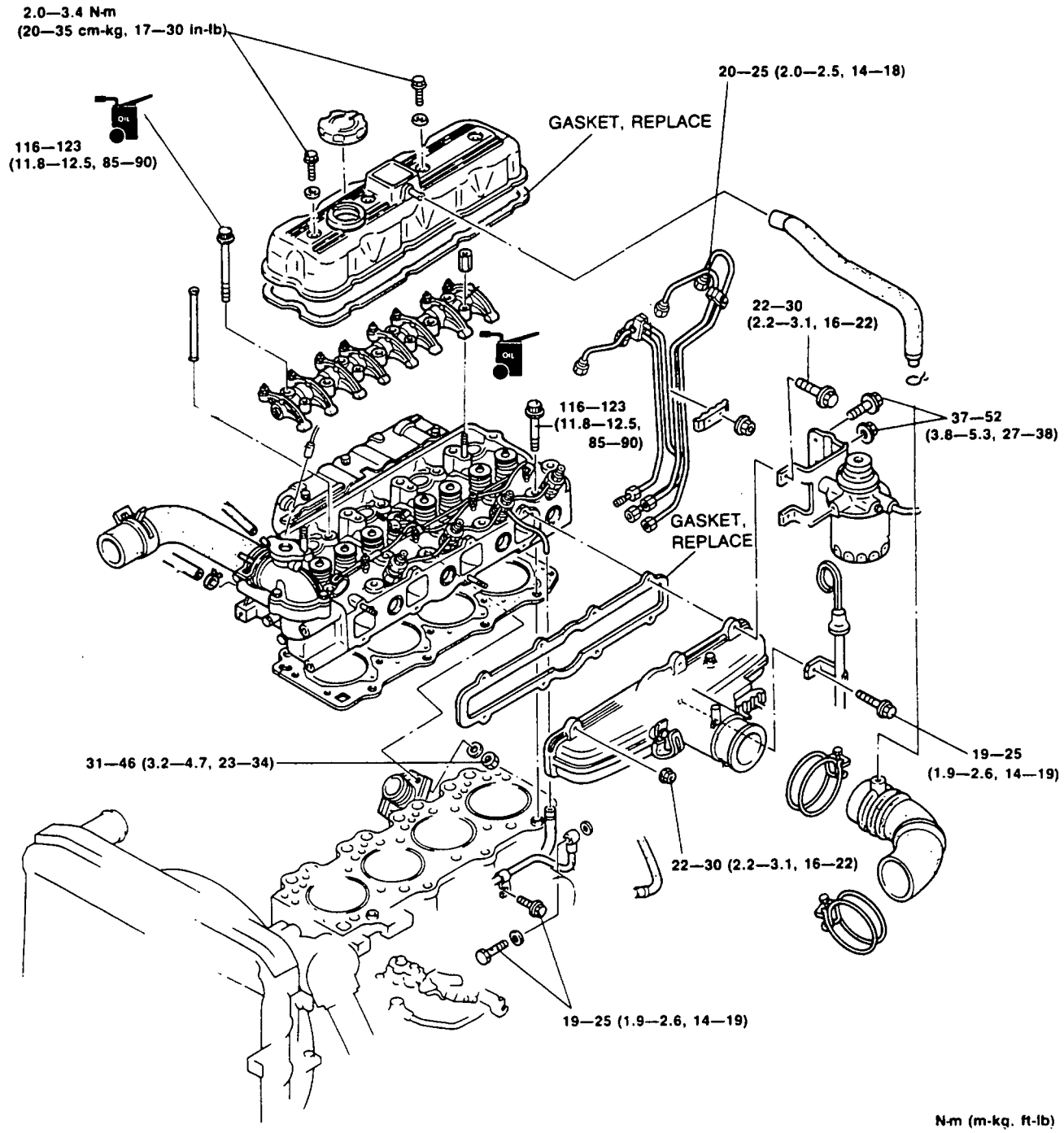
Steps After Installation
1. Fill the radiator with the specified amount and type of engine coolant.
2. Connect the negative battery cable.
3. Start the engine and check for leaks.

Water Pump Illustration

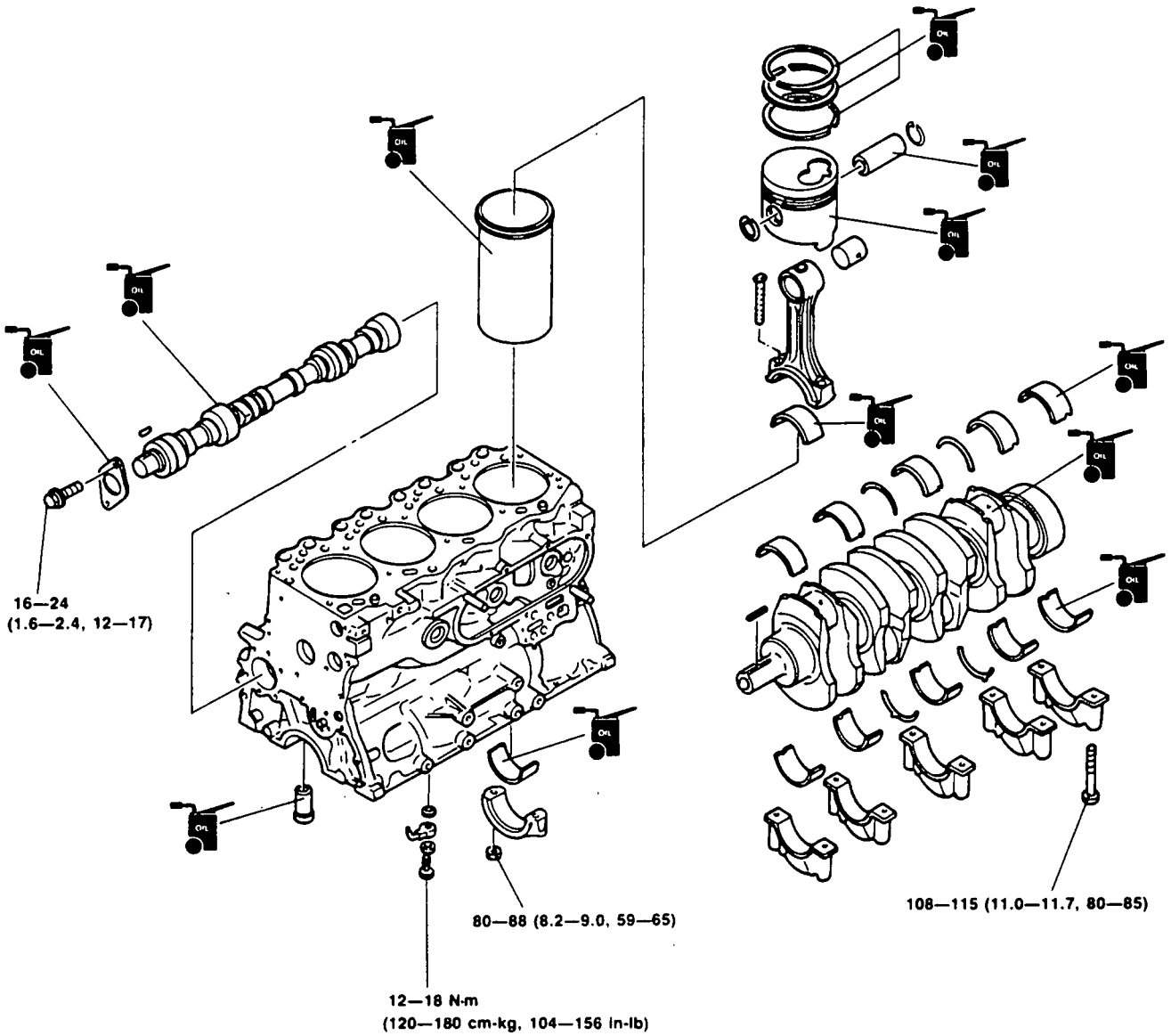


1. Radiator cowling
2. Water pump drive belt
3. Cooling fan
4. Water pump pulley
5. Water pump (inspect for cracked and damaged mounting surface, bearing condition, and leakage.

TORQUE SPECIFICATIONS (engine upper end)

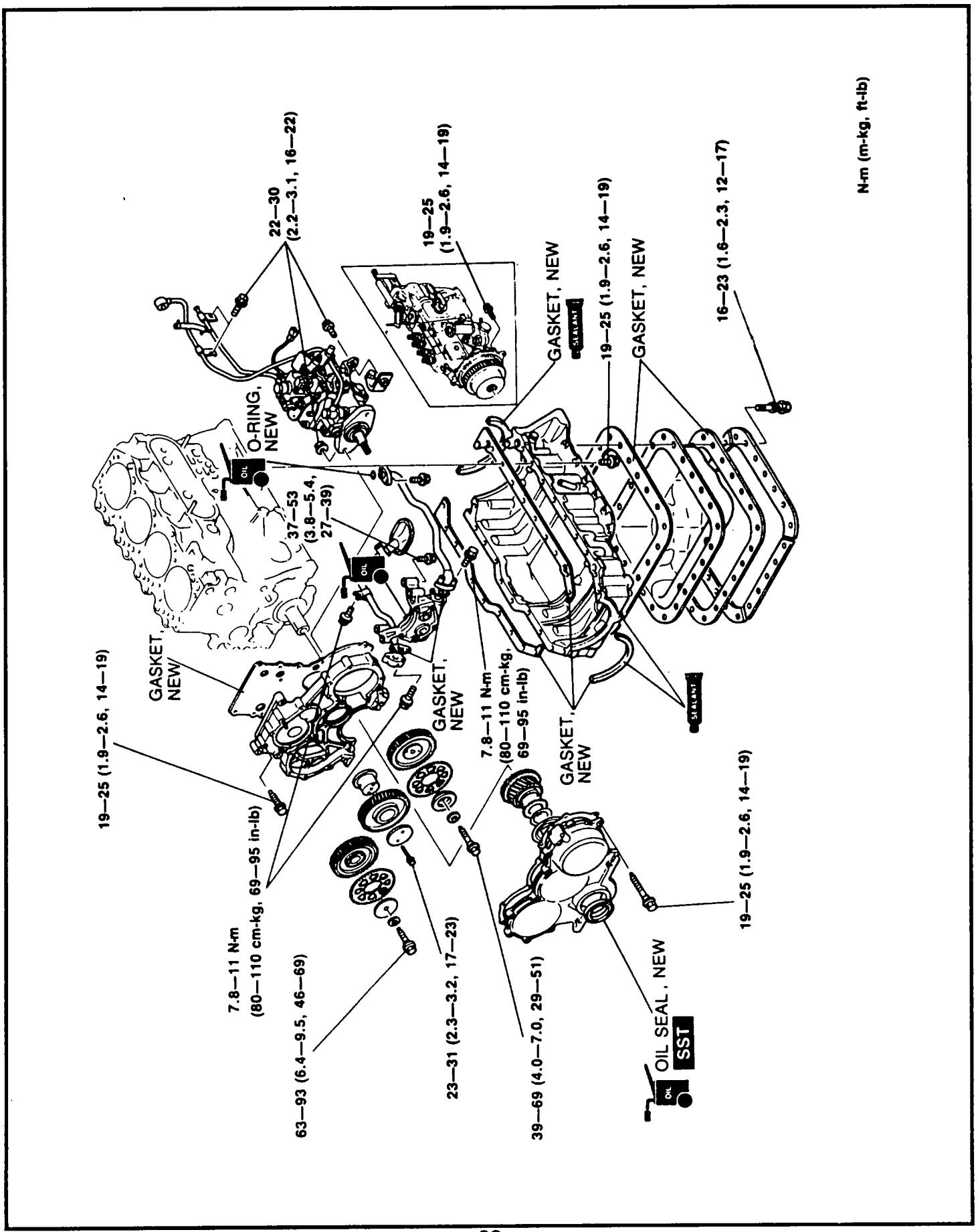


TORQUE SPECIFICATIONS (internal cylinder block)

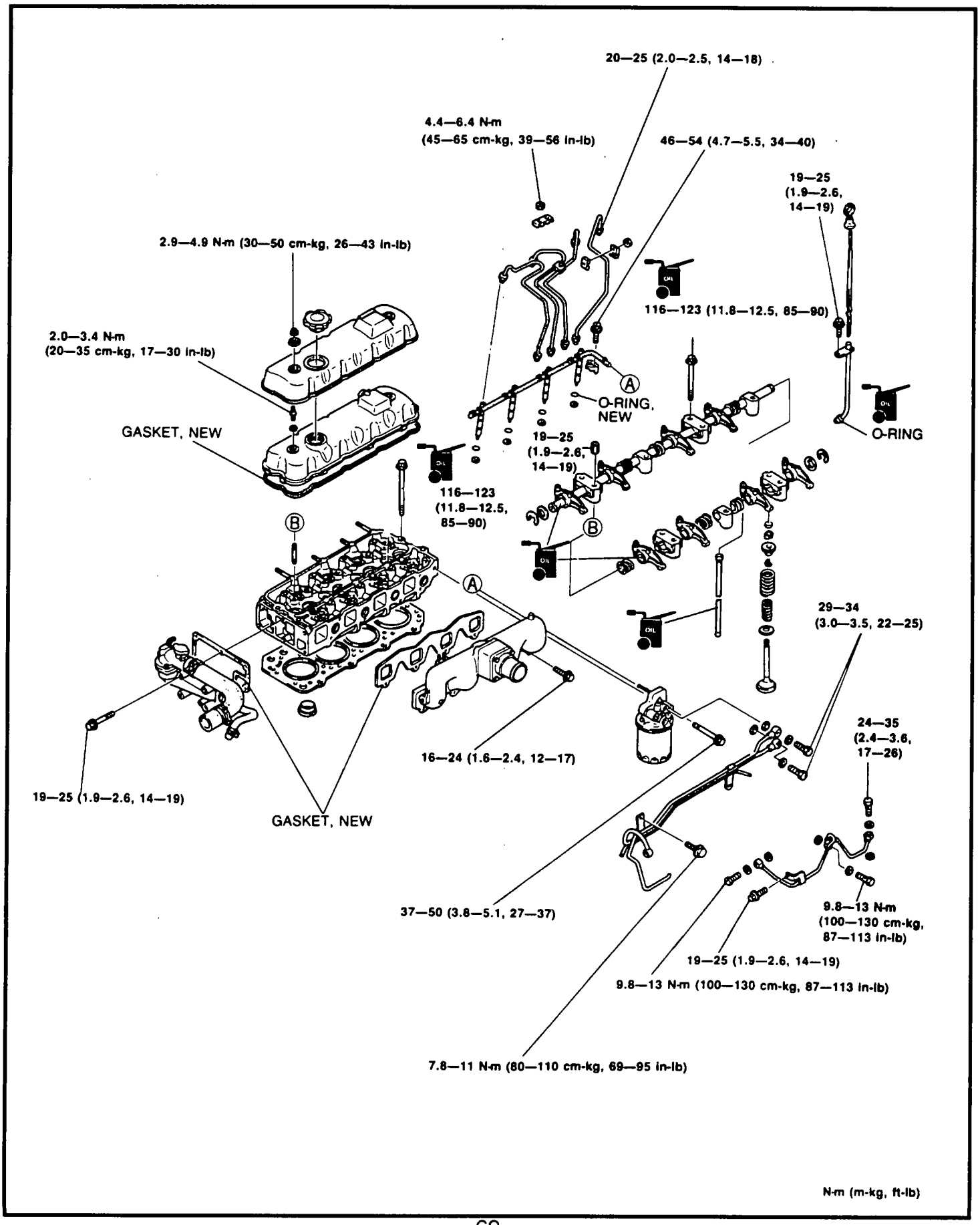


N·m (m-kg, ft-lb)

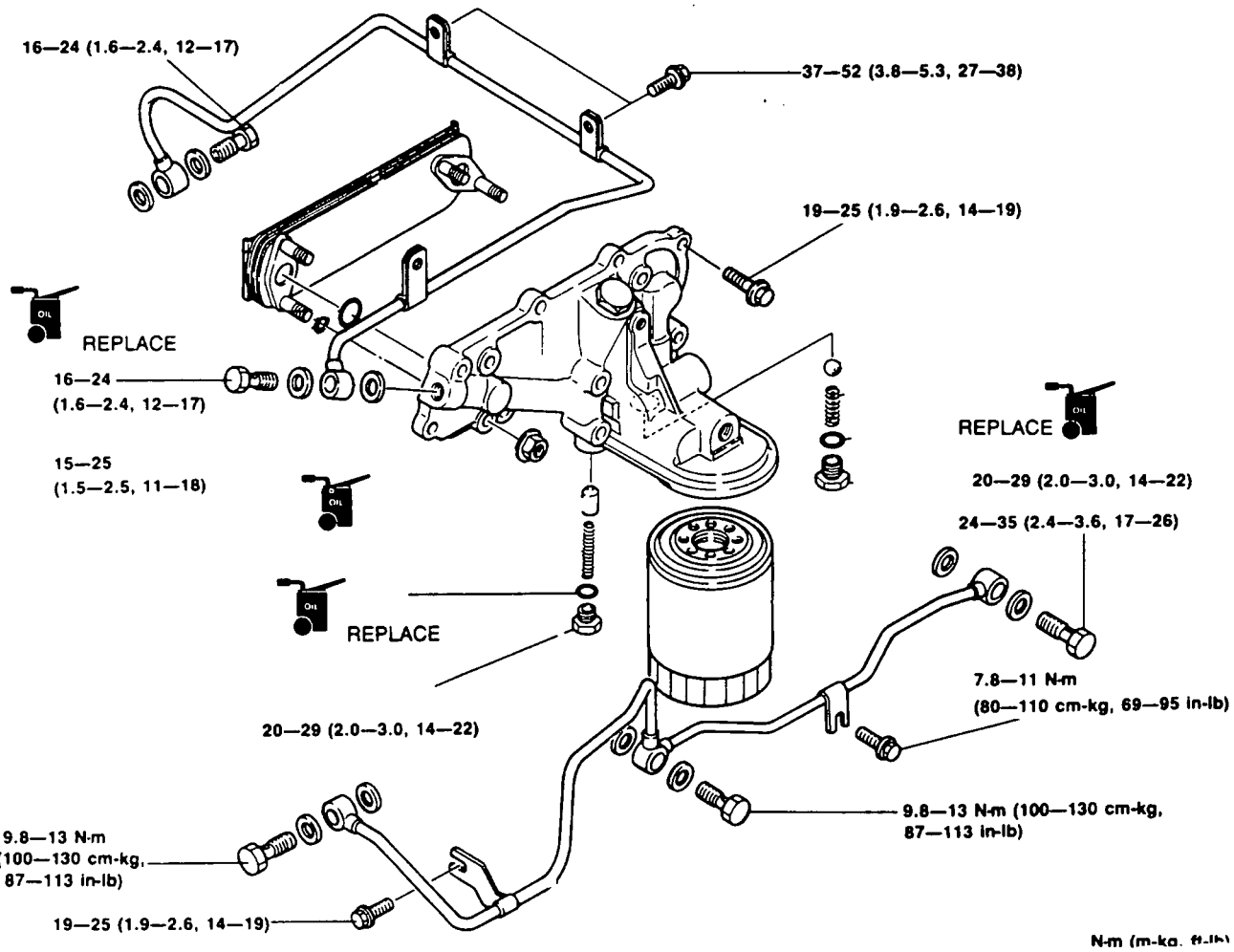
TORQUE SPECIFICATIONS (cylinder block external parts II)



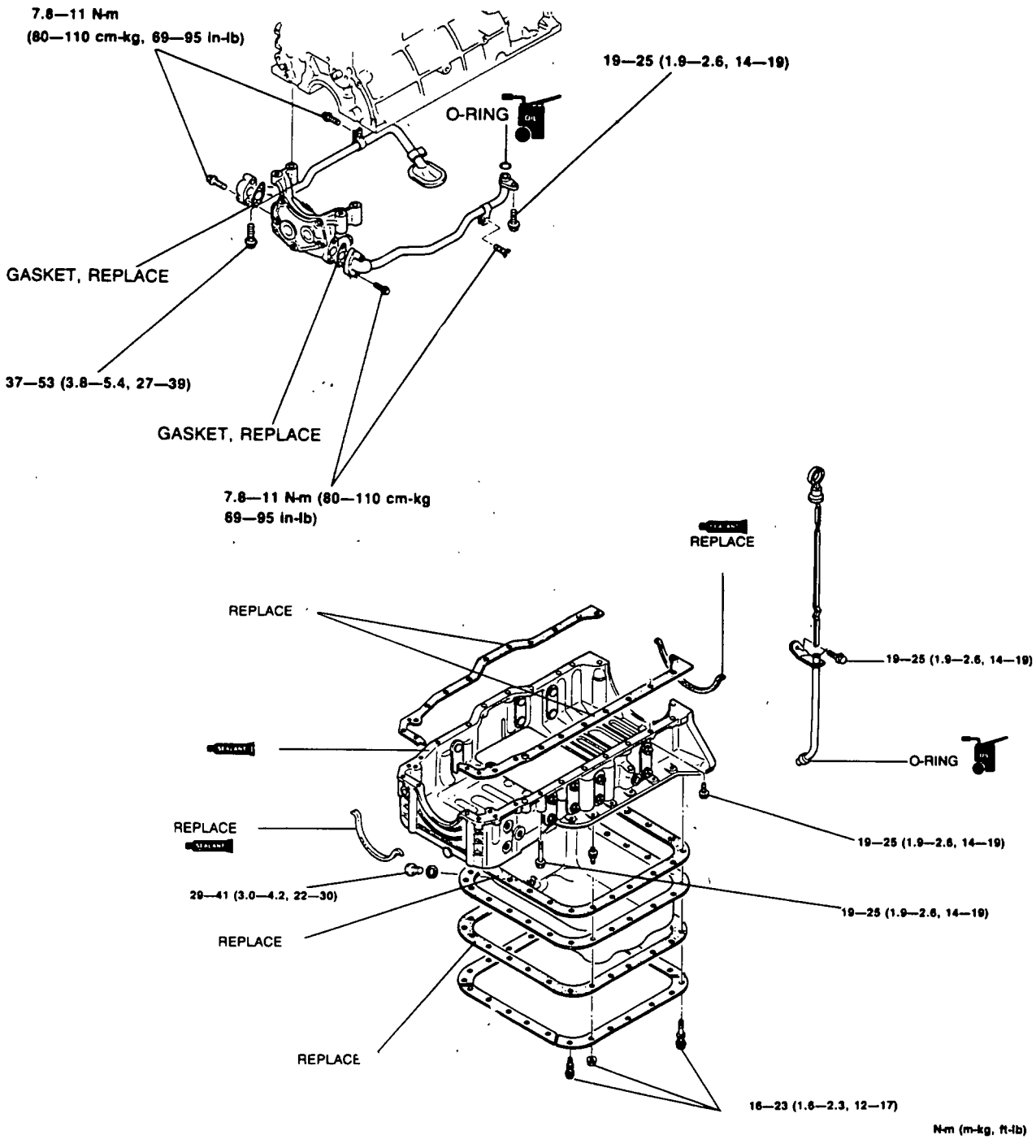
TORQUE SPECIFICATIONS (cylinder head)



TORQUE SPECIFICATIONS (oil cooler)



TORQUE SPECIFICATIONS (oil pan and pump)



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