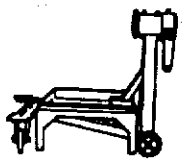
Engine Mechanical System

SPECIAL SERVICE TOOLS

Engine
Special service tools

0K130 990 007

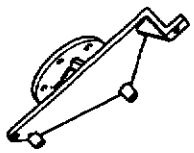
Engine stand



Used to disassemble and assemble engine.

0K410 101 004

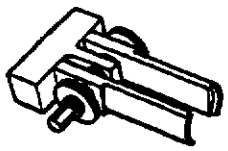
Hanger, engine stand



Used to disassemble and assemble engine.

0K993 120 004

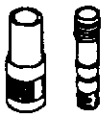
Pivot, valve spring lifter



Used to remove and install valve.

0K710 120 004

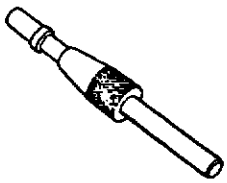
Installer, valve seal



Used to install valve seal.

0K130 160 010

Centering tool, clutch disc



Used to install clutch disc and clutch cover.

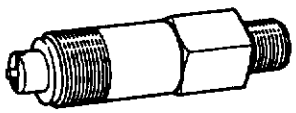
0K552 111 001

Holder, camshaft pulley

Used to install camshaft pulley.

0K552 131 002

Adapter, compression gauge



Used to measure compression pressure.

0K993 120 001

Arm, valve spring lifter

Used to remove and install valve.

Problem	Possible Cause	Action to be taken
White smoke out of exhaust	Usually caused by water vapor, which is a normal by product of combustion on cold days. Excessive white smoke with engine warmed up could be caused by a failed cylinder head or intake gasket, could also be cracked block, cylinder head or intake manifold.	None required Repair or replace
Black smoke out of exhaust	Malfunction of fuel system Malfunction of emission system	Refer to section FL, fuel system Refer to section EC, emission control system
Abnormal combustion	Sticking or burned valve Weak or broken valve spring Carbon accumulation in combustion chamber	Replace Replace Eliminate the carbon
Poor idling	Malfunction of fuel system Malfunction of emission system Uneven cylinder compression Poor valve to valve seat contact Broken valve spring Failed cylinder head gasket	Refer to section FL, fuel system Refer to section EC, emission control system Repair Repair or replace Repair Replace
Turbocharger noise	Contaminated air cleaner element Foreign material in intake duct or compressor housing Foreign material between intake manifold and compressor Foreign material in engine exhaust system Carbon deposit on turbine housing Interference between turbocharger rotating parts Loose connecting parts of intake and exhaust system	Replace Clean Clean Clean Clean Repair or replace Tighten
Engine knocks when hot and at idle **Slight noise at idle, becomes louder as engine speed is increased**	Loose or worn accessory drive belt/tensioner Improper oil viscosity Excessive piston pin clearance Connecting rod alignment Insufficient piston to bore clearance Faulty timing belt tensioner or guide Loose damper pulley Valve spring clicking on cap, off square or broken Excessive stem to guide clearance Excessive valve seat runout Holed exhaust pipe	Replace if necessary Install proper oil viscosity for expected temperature Install new piston pin and/or connecting rod Check and replace Hone and fit new pistons Replace Tighten or replace Repair or replace Repair Repair Replace
Engine knoks when cold	Excessive piston to wall clearance Loose or broken damper pulley	Replace Tighten or replace
Knock increase with torque	Excessive piston to bore clearance Bent connecting rod	Replace piston Replace
Engine has heavy knock when hot and torque is applied	Broken damper pulley Accessory belts too tight or damaged Belt tensioner damaged Flywheel cracked or loose clutch plate Excessive main bearing clearance Excessive rod bearing clearance	Replace Adjust or replace belt Replace Replace flywheel or clutch plate Repair Repair

Problem	Possible Cause	Action to be taken
Engine has light knock when hot and under light load conditions	Improper timing Piston pin and/or connecting rod Poor quality fuel Exhaust leak at manifold Excessive rod bearing clearance	Check timing Replace Replace Tighten or replace Repair
Engine knocks on initial start up and knock lasts only a few seconds	Improper oil viscosity	Install proper oil viscosity for expected temperature
Interference of turbocharger, poor rotation	Damaged compressor blades due to external cause Interference of turbine and compressor blades with housing Excessive deposit on compressor housing or wheel Excessive carbon deposit on the back of turbine blade Burn out of center housing	Repair or replace Repair or replace Clean or repair Clean or repair Replace
Leakage from turbocharger turbine shaft	Excessive initial oil applying Blocked crankcase breather Obstacle in turbocharger oil drain line Burn out of center housing Wear on turbocharger bearing, bearing bore or shaft journal Excessive crankcase oil	Burn it normally Repair Clean and repair Clean and replace Repair or replace Correct oil amount
Leakage from turbocharger compressor	Contaminated air cleaner element Blocked duct between compressor and air cleaner Loose compressor and intake system connecting duct Leakage from intake manifold Obstacle in turbocharger oil drain line Blocked blowby passage in crankcase Worn or damaged compressor blades Wear or turbocharger bearing bore, bearing or shaft journal	Replace Repair Tighten Repair Repair or replace Repair Clean or replace Replace
Wear on turbocharger bearing, bore or shaft journal	Contaminated oil Insufficient oil supply Obstacle in turbocharger oil supply line Plugged oil filter Poor oil pump operation	Replace Check Check and repair Replace Check and repair

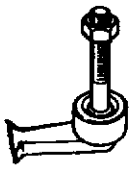
0K993 120 006

Remover, valve seal

Used to remove valve seal.

0K590 111 001

Ring gear brake set



Used to prevent engine rotation.

0K130 111 004

Holder, coupling flange

Used to remove camshaft gear.

SYMPTOM-RELATED DIAGNOSTIC PROCEDURE

Engine

Diagnostic chart

Problem	Possible Cause	Action to be taken
Insufficient power smoke generation	Insufficient compression caused by: 1. Contaminated air cleaner element 2. Loose hose connection between compressor and intercooler 3. Leakage from intake manifold 4. Leakage from exhaust manifold 5. Leakage from turbocharger mounting flange 6. Interference between turbocharger compressor turbine and case 7. Blocked duct between air cleaner and turbocharger compressor 8. Blocked duct between compressor and intake manifold 9. Interference between intake and exhaust manifolds 10. Leakage from valve seat 11. Seized valve stem 12. Weak or broken valve spring 13. Failed cylinder head gasket 14. Cracked or distorted cylinder head 15. Sticking, damaged, or worn piston ring 16. Cracked or worn piston	
	Malfunction of fuel system	Refer to section FL, fuel system
	Slipping clutch	Refer to section CH, clutch
	Wrong tire size	Refer to section SS, wheel and tires
	Restricted exhaust system	Refer to section EM-IE, exhaust system
Excessive oil consumption	Abnormal engine oil viscosity	Replace
	Leakage from turbocharger compressor (adhesion of oil to housing or wheel)	Repair
	Leakage turbocharger turbine	Repair
	Worn or sticking piston ring or groove	Replace
	Worn piston or cylinder	Repair or replace
	Bad valve seal	Replace
	Worn valve stem or guide	Replace
Engine cranks normally, but does not start	Malfunction of fuel system	Refer to section FL, fuel system
	Malfunction of electrical system	Refer to section EE, starting system
	Restricted exhaust system	Refer to section EM-IE, exhaust system
	Timing belt and/or related parts	Replace
	Low compression	
	Camshaft worn	
Blue smoke out of exhaust	Usually caused by oil burning in the combustion chamber from: worn rings, worn valve guides, worn valve seals or failed cylinder head gasket	Replace
	Contaminated air cleaner element	
	Loose hose connection between compressor and intercooler	Tighten
	Leakage from intake manifold	Repair
	Blocked oil filter	Replace
	Blocked duct between air cleaner and turbocharger compressor	Repair
	Leakage from turbocharger compressor	Repair

SPECIFICATION

Engine

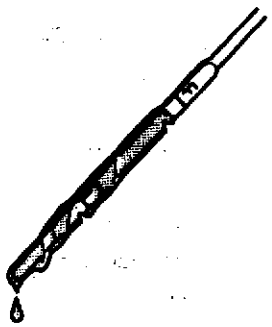
Specification

Item \ Engine model			J3 COMMON RAIL SYSTEM
Type			Diesel, 4-Cycles
Number of cylinders			4-Cylinder in-line
Combustion chamber			Re-entrant
Displacement cu. in (cc)			177 (2902)
Bore and stroke in (mm)			3.82 X 3.85 (97.1 X 98)
Compression ratio			19.3
Compression pressure psi (kPa, kg/cm²)-rpm			426.6 (2943, 30) - 200
Valve timing	Intake	Open	BTDC 26°
		Closed	ABDC 50°
	Exhaust	Open	BBDC 50°
		Closed	ATDC 29°
Valve clearance(cold engine) in (mm)		Intake	0 : Maintenance-free
		Exhaust	0 : Maintenance-free
Idle speed rpm			800 ±100
Injection order			1-3-4-2

ON-VEHICLE SERVICE PROCEDURE

Engine oil

1. Be sure the vehicle is on level ground.
2. Warm up the engine to normal operating temperature and stop it.
3. Wait for 5 minutes.
4. Remove the oil level gauge and check the oil level and condition.



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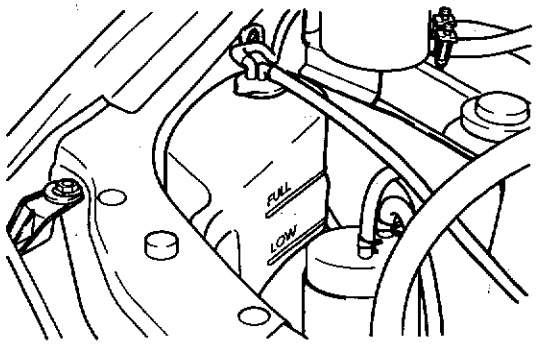
5. Add or replace oil if necessary.

Engine coolant

Coolant level

⚠ **WARNING**
A) NEVER REMOVE THE RADIATOR CAP WHILE THE ENGINE IS HOT.
B) WRAP A THICK CLOTH AROUND THE CAP WHEN REMOVING IT.

1. Verify that the coolant level is near the radiator filler neck.
2. Check that the level in the coolant reservoir is between the "Full" and "Low" marks.



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3. Add coolant if necessary.

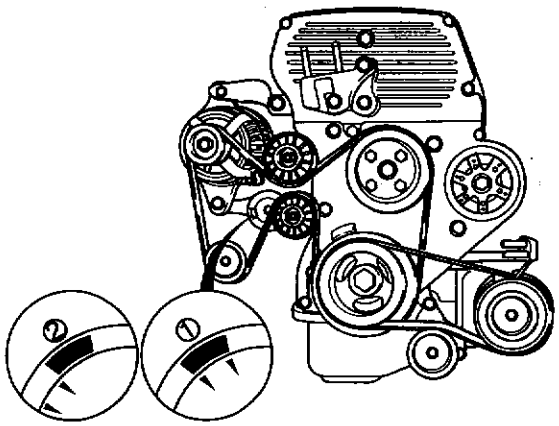
Coolant quality

1. Verify that there is no build up of rust or scale around the radiator cap of radiator filler neck.
2. Verify that the coolant is free of oil.
3. Replace the coolant if necessary.

Drive belt

Inspection

1. Check the drive belts for wear, cracks, and fraying. Replace if necessary.
2. Verify that the drive belts are correctly mounted on the pulleys.
3. Verify that "▼" mark of auto-tensioner align "▮ ▮" mark. If two marks align as shown ①, the tension of auto-tensioner is good. If not align as shown ②, re-install the auto-tensioner or replace the drive belt.



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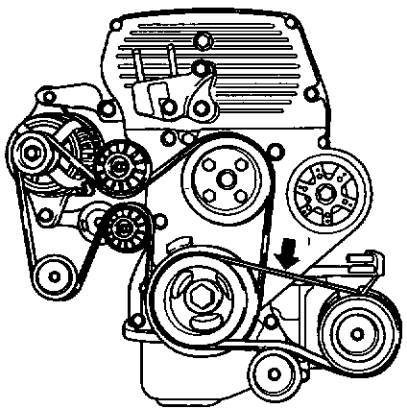
4. Check the A/C drive belt deflection by applying moderate pressure (22 lb, 98 N, 10 kg) midway between the pulleys.



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Caution

a) Measure the belt deflection between the pulleys.

b) Consider the belt as a new one if it has been used on a running engine for less than five minutes.

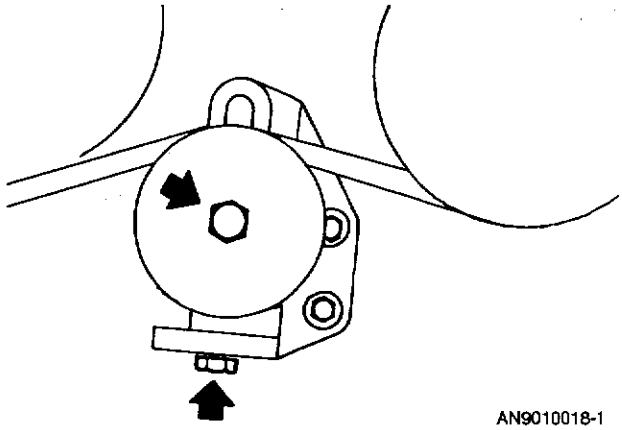
c) Check the belt deflection when the engine is cold or at least 30 minutes after the engine is stopped.

A/C belt deflection:

New one: 0.28~0.35 in (7~9 mm)

Used one: 0.35~0.43 in (9~11 mm)

Adjustment



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1. Loosen the idler pulley mounting bolt.
2. Adjust the belt deflection by turning the adjusting bolt.

Deflection (When applying 22 lb, 98 N, 10 kg)

New one: 0.28~0.35 in (7~9 mm)

Used one: 0.35~0.43 in (9~11 mm)

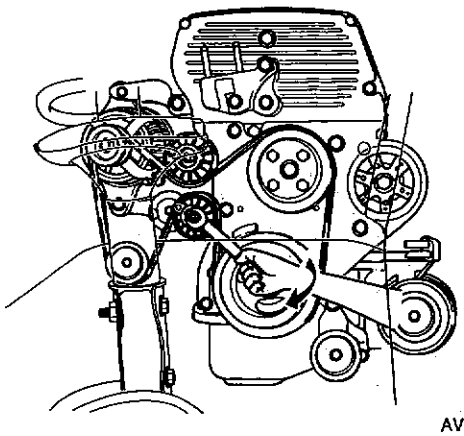
3. After making the adjustment, tighten the idler pulley mounting bolt.

Tightening torque:

28~38 lb-ft (37~52N•m, 3.8~5.3 kg-m)

Replacement

1. Raise the vehicle and support it with safety stands.
2. Remove the RH side wheel.
3. Loosen the idle pulley mounting bolt.
4. Remove the A/C drive belt.
5. Lower the auto tensioner with spanner and then remove the drive belt.



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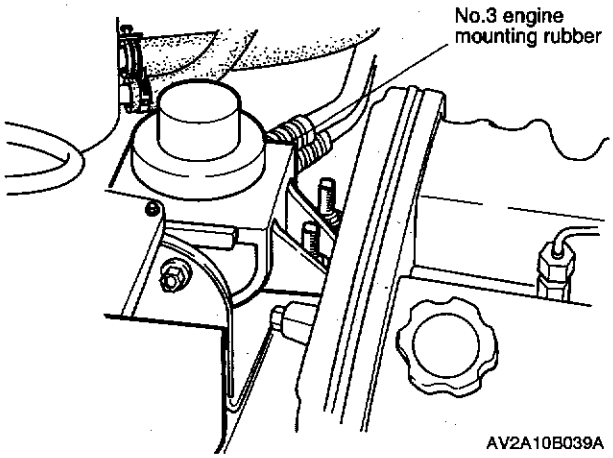
6. Lower the auto tensioner with spanner and then install the drive belt.
7. Install the A/C drive belt.
8. Check the A/C drive belt deflection. (*Refer to Inspection and Adjustment, page EM-9)*

Timing belt

Removal

1. Raise vehicle and support it with safety stands.
2. Remove the radiator upper hose.
3. Remove the fuel filter hoses still connected.
4. Remove the No.3 engine mounting rubber.



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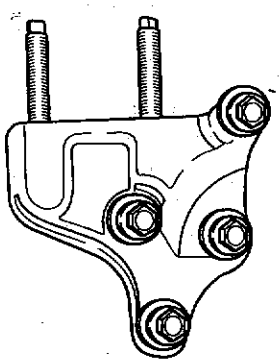
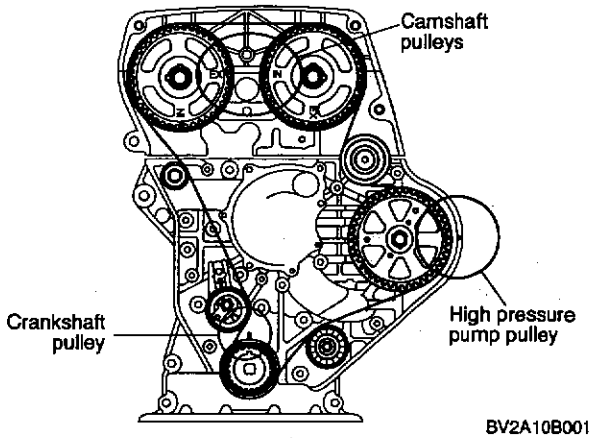
5. Remove the No.3 engine mounting bracket.



AV2A10B040

6. Remove the RH side wheel.
7. Remove the A/C drive belt.
8. Remove the drive belt.*(Refer to Drive belt replacement, page EM-9)*
9. Remove the auto tensioner.
10. Remove the water pump pulley.
11. Remove the crankshaft pulley.
12. Remove the upper timing belt cover.
13. Remove the lower timing belt cover.
14. Rotate crankshaft and align timing mark on timing belt pulley with timing mark on engine block.



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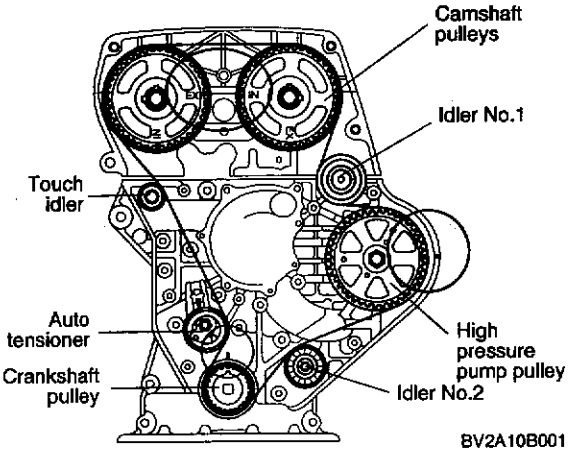
15. Remove the auto tensioner.
16. Remove the timing belt.

Replacement

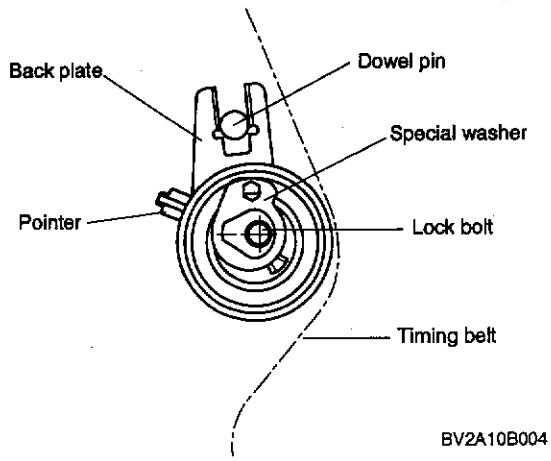
1. Check that timing mark on timing belt pulley, camshaft pulley and high pressure pump pulley is aligned with timing mark on engine.



2. Install the timing belt.
   1) The timing belt is installed in sequence crank shaft pulley, idler No.2, high pressure pump pulley, idler No.1 and camshaft pulley.

✱ *Notice*
   a) The auto-tensioner must be mounted onto the engine after the timing belt is installed.
   b) Keep the tension of timing belt when install timing belt.

3. Install the auto-tensioner.
   1) Install the auto-tensioner as shown illust. The dowel pin has to be located between the tensioner fork (back plate).



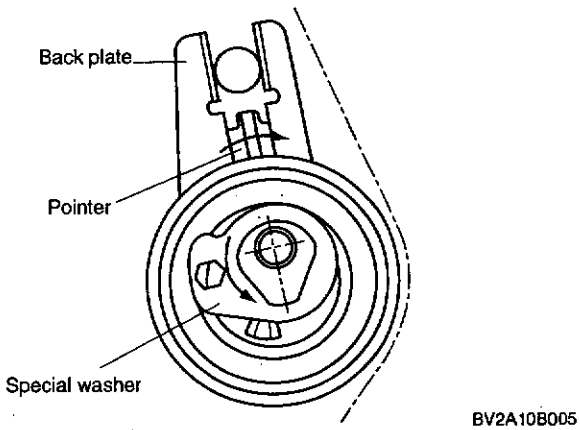
   2) Pretighten the auto-tensioner.

Tightening torque:
2.9lb-ft (3.9N•m , 0.4kg-m)

✱ *Notice*
   a) Oil must not get in contact with the tensioner. The tensioner has to be replaced by a new one, if it is oily.
   b) The positions of the pointer, the back plate and the special washer are in accordance to the illust.

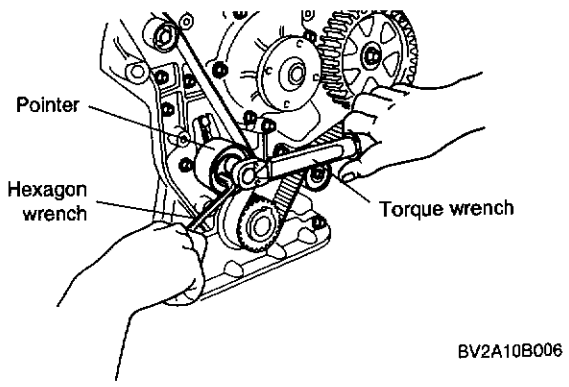
4. Check again if the alignment marks of camshafts, crankshaft and high pressure pump are aligned with the marks on the timing case.

5. Adjust the auto-tensioner, and then tighten it.
   1) Align the pointer to the back plate by rotating the special washer in counter-clockwise using the hexagon wrench as shown illust.



   2) Tighten the auto-tensioner lock bolt with holding the special washer by the hexagon wrench when the pointer is aligned with the back plate.

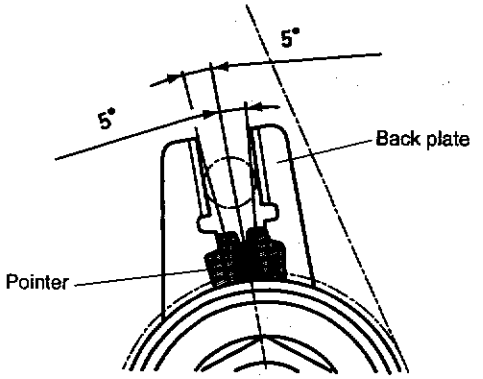
Tightening torque :
17.4lb-ft (23.5N•m , 2.4kg-m)



   3) Remove the hexagon wrench.

✱ *Notice*
If the pointer can not be aligned with the back plate, then a new belt has to be used.

6. Rotate the crankshaft two full revolutions in clockwise to align the TDC mark.
7. Check again if the alignment marks of camshafts, crankshaft and high pressure pump are aligned with the marks on the timing case.
8. Check the alignment of the pointer and back plate.



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Allowance misalignment : ±5°

9. If the misalignment between pointer and back plate is bigger than ±5°, repeat step 4~8.
10. Install the upper and lower timing belt cover.

Tightening torque:
5.1~7.2 lb-ft (6.9~9.8 N•m, 70~100 kg-cm)

11. Install the crankshaft pulley.

Tightening torque:
253~289 lb-ft (343~392 N•m, 35~40 kg-m)

12. Install the water pump pulley.

Tightening torque:
13.0~20.9 lb-ft (17.6~28.4 N•m, 1.8~2.9 kg-m)

13. Install the auto tensioner.

Tightening torque:
13.0~20.9 lb-ft (17.6~28.4 N•m, 1.8~2.9 kg-m)

14. Install the drive belt and A/C drive belt.
(Refer to Drive belt, page EM-9)
15. Install the RH side wheel.

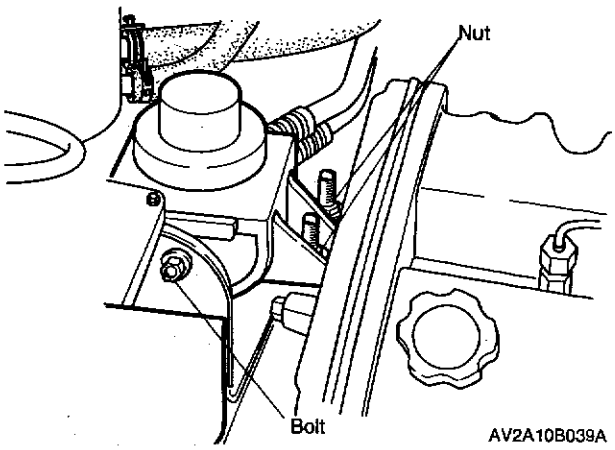
Tightening torque:
65~79 lb-ft (88~108 N•m, 9.0~11.0 kg-m)

16. Install the No.3 engine mounting bracket.

Tightening torque:
26.7~39.8 lb-ft (36.2~53.9 N•m, 3.7~5.5 kg-m)

17. Install the No.3 engine mounting rubber.

Tightening torque:
Nut: 49.1~68.7 lb-ft (66.7~93.1 N•m, 6.8~9.5 kg-m)
Bolt: 62.9~86.0 lb-ft (85.3~116.7 N•m, 8.7~11.9 kg-m)



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18. Install the fuel filter.
19. Install the radiator hose.
20. Fill engine coolant with specified type and amount.*(Refer to section EM-CL, Cooling system)*
21. Start engine and then check for leaks.

Compression pressure

Inspection

1. Warm up the engine upto the normal operating temperature, then stop the engine and disconnect the connector of fuel cut solenoid.
2. Remove all injection pipes, nozzles and washers.
3. Attach the **SST** to the nozzle hole.
4. Measure the compression pressure during cranking.

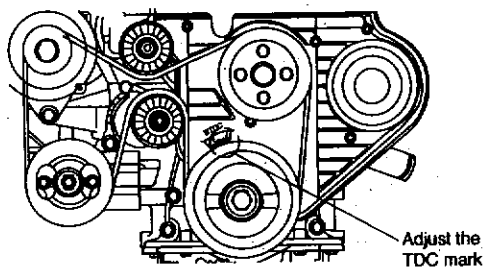
Item \ Engine model		J3 COMMON RAIL SYSTEM
Compression pressure psi (kPa, kg/cm²)-rpm	Normal	426.6(2943, 30)-200
	Limit	383.9(2649, 27)-200
Cylinder-to-cylinder pressure difference psi (kPa, kg/cm²)		below 42.7(294,3.0)

5. Do above step 3~4 again for each cylinder.
6. If the measure value is below the limit, consider it as abrasion or damage of piston and piston ring, misalignment of valve, damage of gasket, and etc..

Ladder frame

Removal

1. Remove oil pan. *(Refer to section EM-LU, Lubrication system)*
2. Adjust the V groove TDC mark on the outside of pulley to the TDC mark "T" on the timing cover, by rotating the crank shaft pulley.



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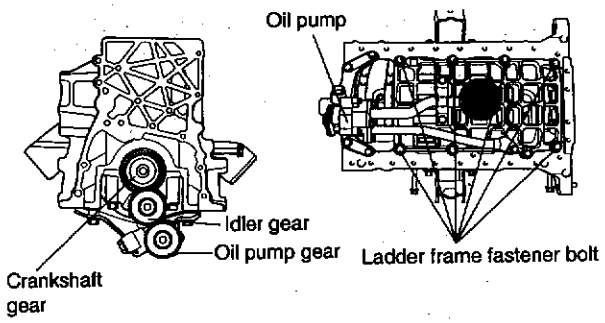
3. When disassembling ladder frame, separate the oil feeding pipe from the oil pump by loosening the oil feeding pipe bolt.



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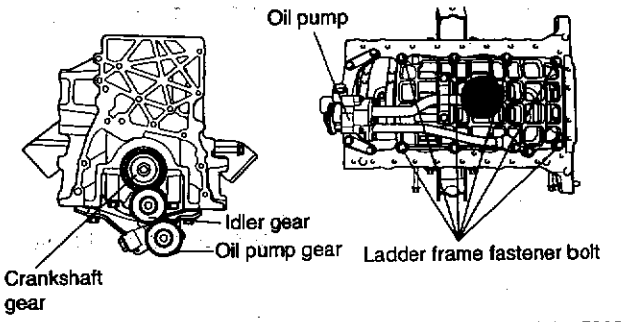
4. Loosen the ladder frame fastener bolt. Remove ladder frame.

Replacement

1. Install the ladder frame into block. Check the dowel pin of ladder frame is matched with lower surface of block and insert the oil level gauge into the ladder frame hole.

Tightening torque (ladder frame bolt):
32.5 lb-ft (44 N•m, 4.5 kg-m)

2. Install crankshaft sprocket and oil pump sprocket.
3. Install the oil feeding pipe into the ladder frame, oil pump and block and then tighten bolts.



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4. Install the oil pan. *(Refer to section EM-LU, Lubrication system)*
5. Fill engine oil with specified type and amount. *(Refer to section EM-LU, Lubrication system)*
6. Start engine and then check for leaks.

DISASSEMBLY, INSPECTION AND REASSEMBLY PROCEDURE

✱ *Notice*

a) Code all identical parts(such as pistons, piston rings, connecting rods, and valve springs) so that they can be reinstalled in the cylinder from which they were removed.

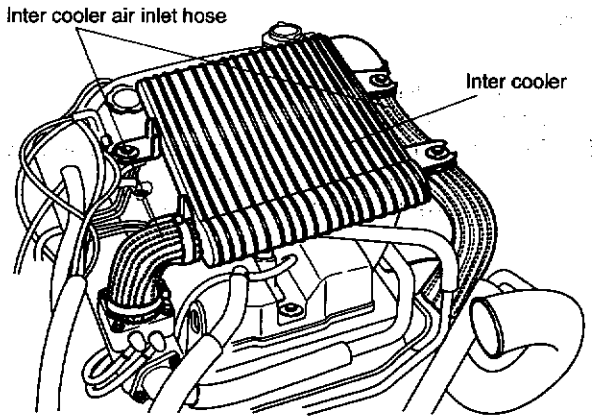
b) Clean the parts with steam, blow off any remining water with compressed air.

c) Care should be taken during the disassembly of any part or system to study its order of assembly. Any deformation, wear or damage should also be noted.

Auxiliary parts

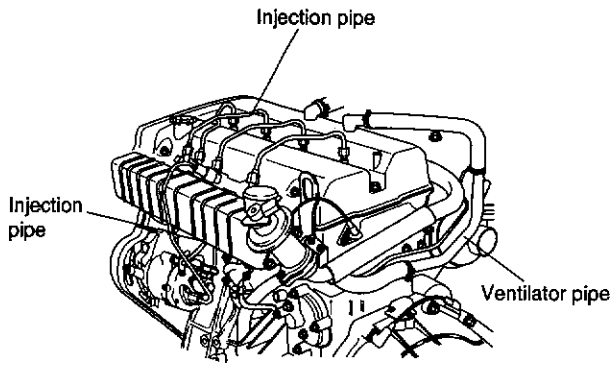
Disassembly

1. Remove inter cooler cover.
2. Remove inter cooler and inter cooler air inlet hose.



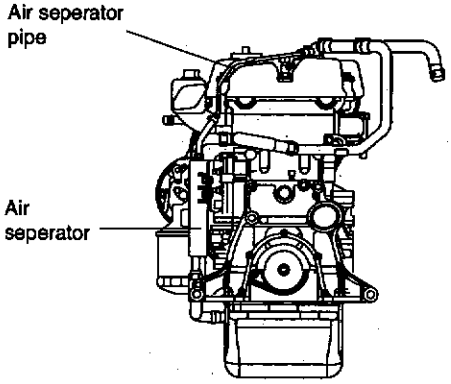
AV2A10B052

3. Remove engine harness.
4. Remove ventilator hose.
5. Remove fuel injection pipe.



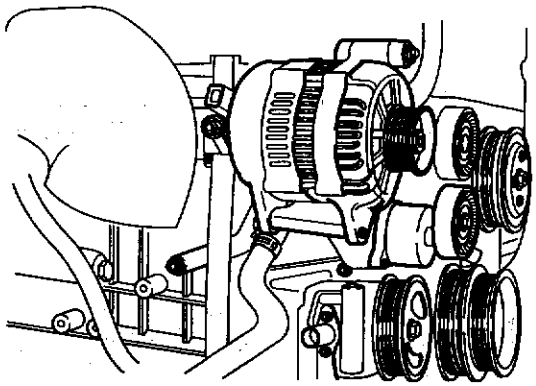
EFL0FL011

6. Remove air separator and air separator hose/pipe.



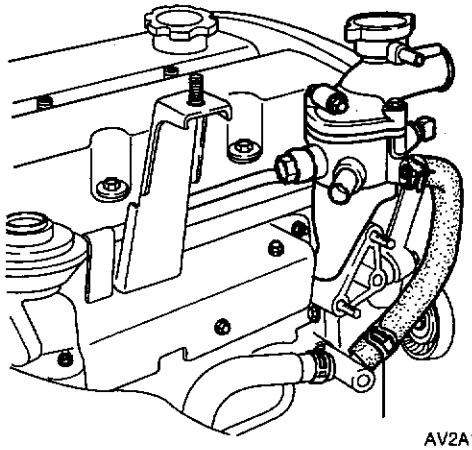
EFL0FL060

7. Remove ventilation pipe and hose.
8. Remove lower water hose from cylinder block.
9. Remove EGR pipe.
10. Remove alternator, hose, alternator bracket and auto tensioner.



AV2A10B056

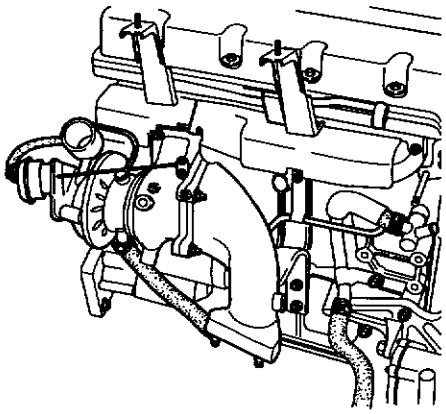
11. Remove thermostat housing assembly.



AV2A10B057

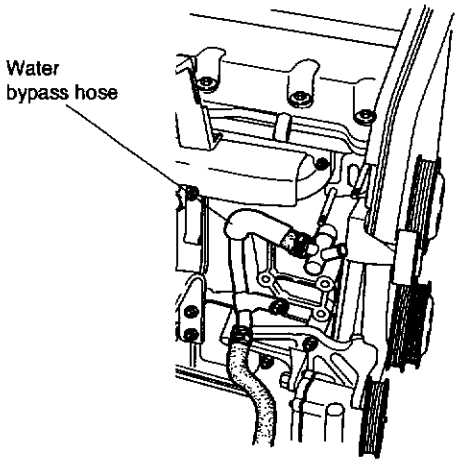
12. Remove turbo charger insulator.

13. Remove turbo charger assembly.



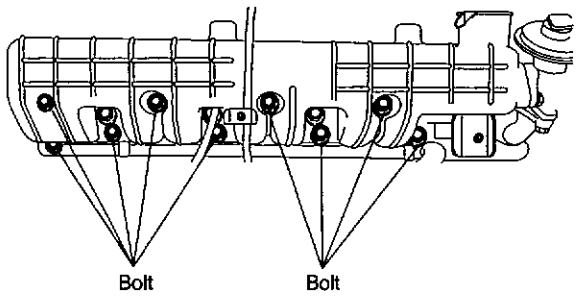
AV2A10B058A

14. Remove water bypass hose and water bypass pipe.



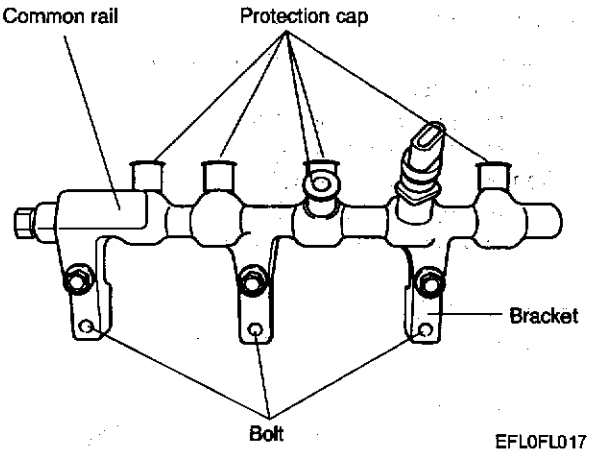
AV2A10B059

15. Remove power steering pump bracket.
16. Remove exhaust manifold insulator, exhaust manifold and gasket.
17. Remove EGR valve and gasket.
18. Remove intake manifold and gasket.



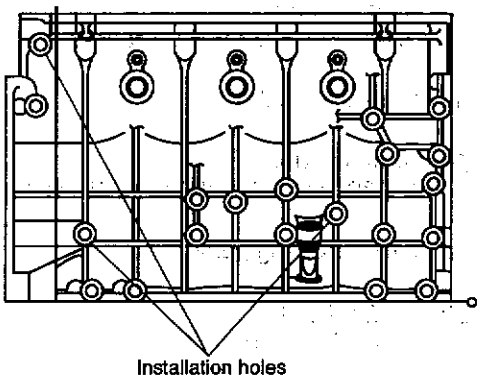
EFL0FL052

19. Remove common rail.(Refer to section FL)



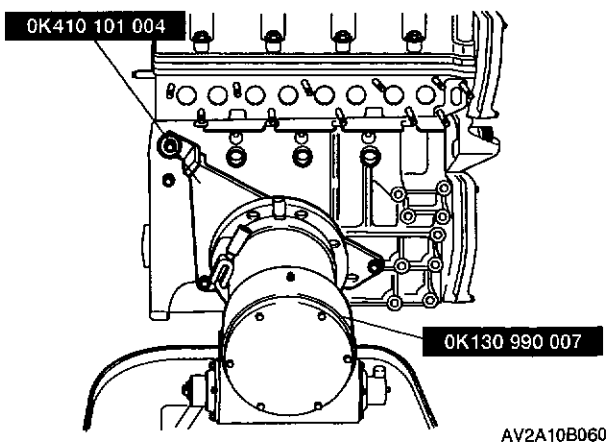
EFL0FL017

20. Install **SST (0K410 101 004)** to engine.



AV2A10B037

21. Mount engine on the **SST (0K130 990 007)**.



AV2A10B060

Reassembly

Assembly will be performed in the reverse order.

Timing belt cover

Disassembly

1. Remove No.3 engine mounting bracket.
2. Remove water pump pulley.
3. Remove power steering pump.
4. Remove crankshaft pulley.
5. Remove idler and bracket.
6. Remove upper timing belt cover.
7. Remove lower timing belt cover.

Reassembly

1. Install upper and lower timing belt cover.

   Tightening torque:
   5.1~7.2 lb-ft (6.9~9.8 N•m, 0.7~1.0 kg-m)

2. Install idler and bracket.

   Tightening torque:
   27.5~38.3 lb-ft (37.2~51.9 N•m, 3.8~5.3 kg-m)

3. Install crankshaft pulley.

   Tightening torque:
   253~289 lb-ft (343~392 N•m, 35~40 kg-m)

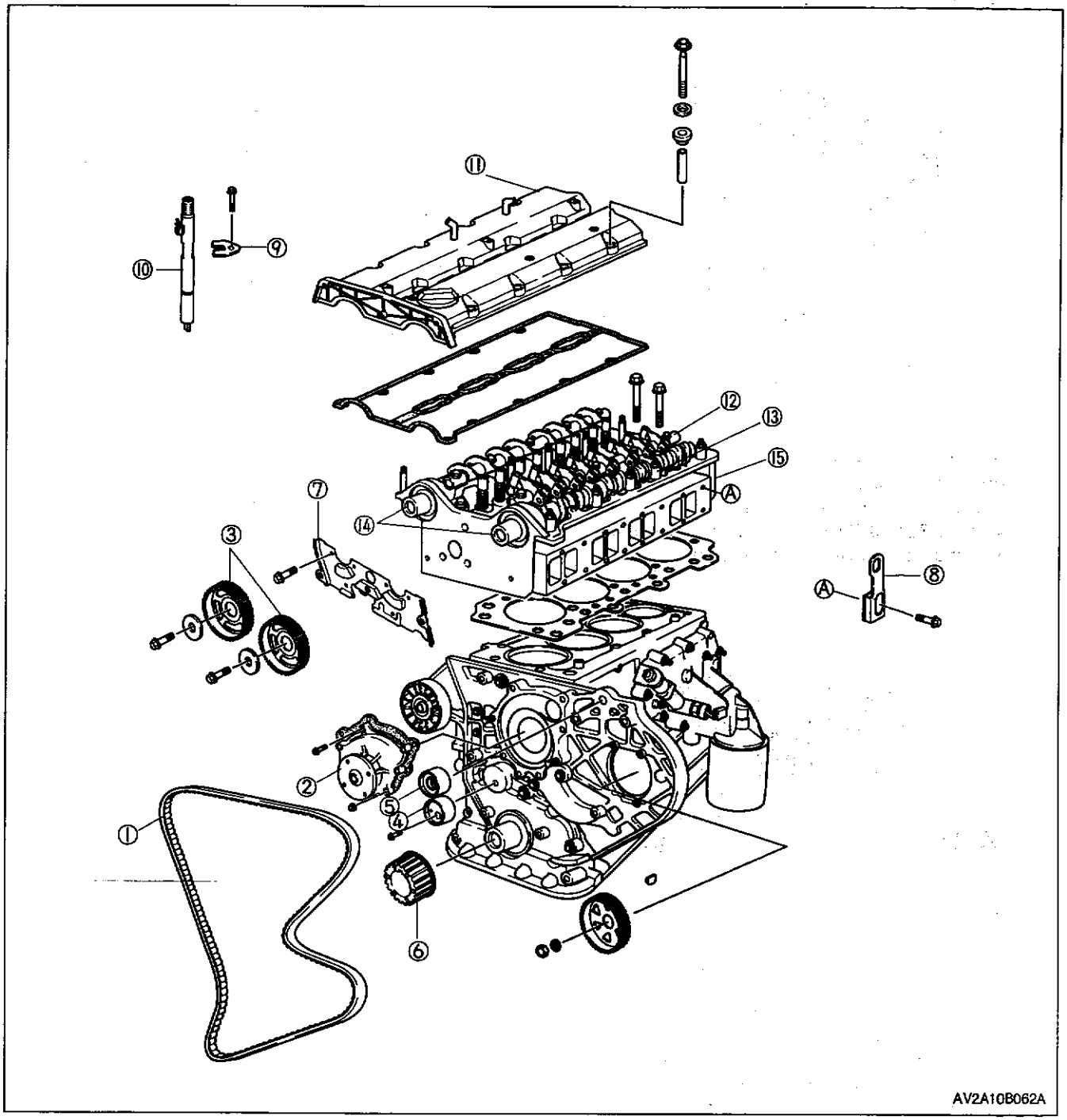
4. Install power steering pump.

   Tightening torque:
   21.7~28.9 lb-ft (29.4~39.2 N•m, 3.0~4.0 kg-m)

5. Install No.3 engine mounting bracket.

   Tightening torque:
   49.2~68.7 lb-ft (66.6~93.1 N•m, 6.8~9.5 kg-m)

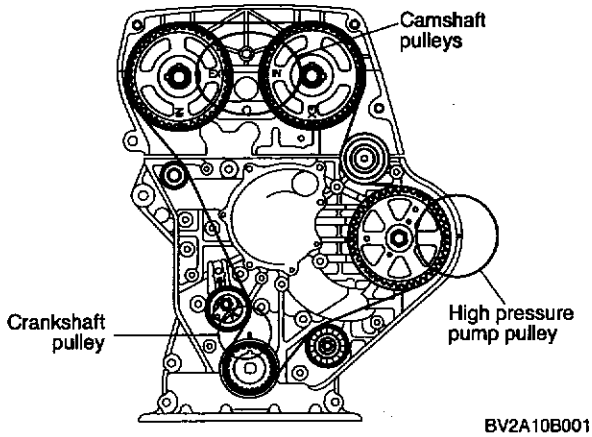
Timing belt



(1) Timing belt
(2) Water pump
(3) Camshaft pulley
(4) Tensioner
(5) Idler
(6) Timing belt pulley
(7) Upper plate assembly
(8) Engine hanger
(9) Injector bracket
(10) Injector
(11) Cylinder head cover
(12) Rocker arm shaft assembly
(13) Camshaft cap
(14) Camshaft
(15) Cylinder head

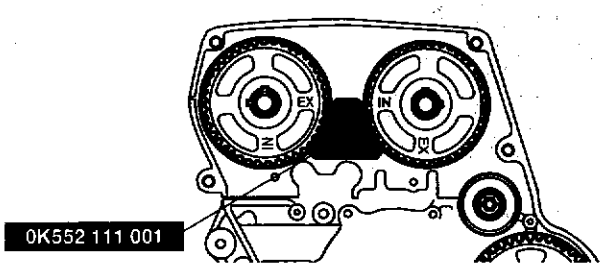
Disassembly

1. Rotate crankshaft and align timing mark on timing belt pulley with timing mark on engine block.



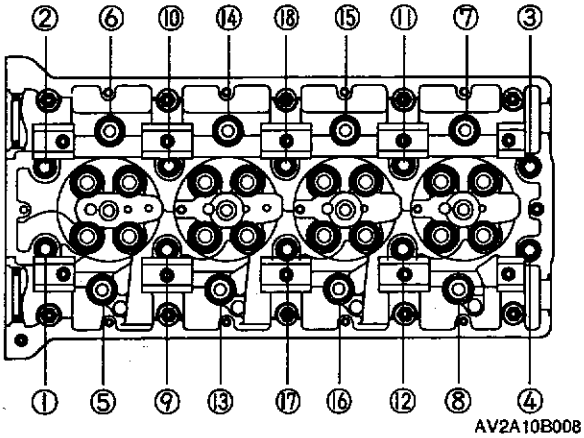
BV2A10B001

2. Remove the auto tensioner.
3. Remove the timing belt.
4. Remove the high pressure pump.
5. Install the **SST (0K552 111 001)** as shown in the figure and the remove the camshaft pulley.



AV2A10B022

6. Remove the idler.
7. Remove the timing belt pulley.
8. Remove the upper plate assembly.
9. Remove the engine hanger.
10. Remove the injector bracket and injector.
11. Remove the cylinder head cover.
12. Remove the rocker arm shaft assembly.
13. Remove the camshaft cap and camshaft.
14. Remove the cylinder head bolts in the order shown in the figure.



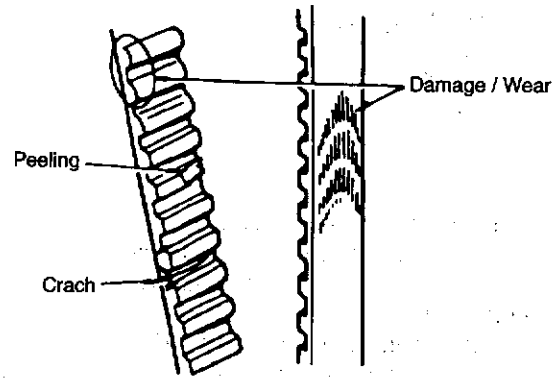
AV2A10B008

Inspection

Front timing belt

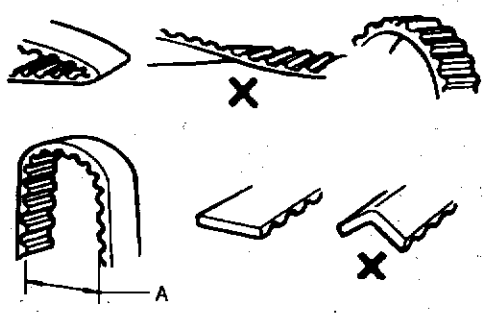
✱ *Notice*
a) Never forcefully twist, turn inside out or bend timing belt.
b) Do not allow oil or grease to come in contact with timing belt.

1. Replace timing belt if it is contaminated with oil or grease.
2. Check timing belt for uneven wear, fraying, peeling, cracking and hardening. Replace timing belt if necessary.



ABT010217

3. Bend timing belt into a "U" shapes as shown in figure. Distance "A" must be at least 1.0 in (25 mm).



ABT010216

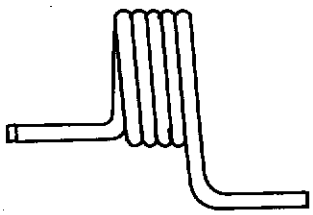
Camshaft pulleys and timing belt pulley

✱ *Notice*
Do not clean pulleys with cleaning fluids. If needed, use a soft cloth to wipe them clean, and avoid scratching the pulleys as it will affect integrity of the timing belt.

1. Check pulley teeth for wear, deformities and other damage. Replace pulleys if necessary.

Tensioner spring

1. Check the tensioner spring. Replace tensioner spring if necessary.

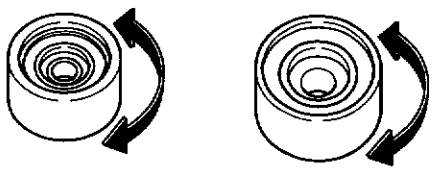


AV2A10B083

Tensioner and idler

✱ *Notice*
Do not clean tensioner pulley or idler pulley with cleaning fluids. If needed, use a soft rag to wipe them clean. Avoid scratching tensioner pulley or idler pulley as it can affect integrity of timing belt.

1. Check tensioner pulley and idler pulley for smooth rotation and proper sound. Replace tensioner pulley and idler pulley if necessary.

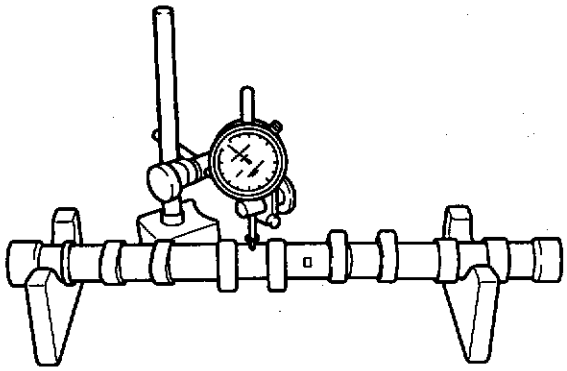


AV2A10B064

Camshaft

1. Set front and rear camshaft bearing journals on V-blocks.
2. Position a dial indicator on center bearing journal and zero dial.
3. Rotate camshaft in V-blocks and check runout.

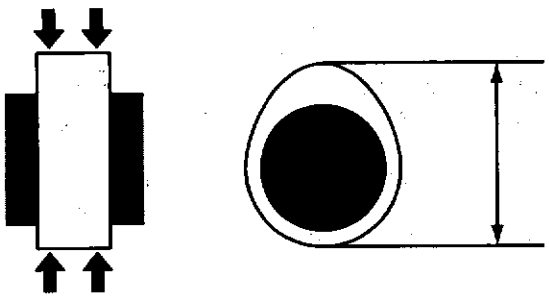
Runout: 0.0031 in (0.08 mm) maximum



AV2A10B066

4. Check camshaft for uneven wear patterns, cracks, or damage.
5. Measure cam lobe heights at two points as shown.

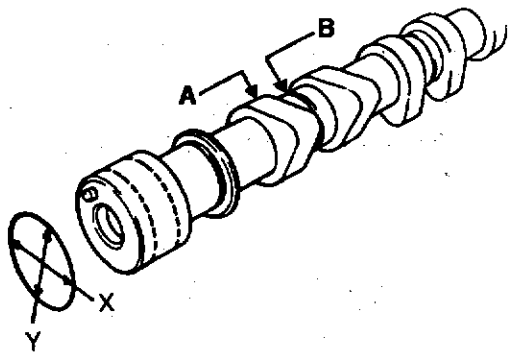
Lobe height
Intake : 0.8857 in (22.497 mm)
Exhaust : 0.8894 in (22.593 mm)



AV2A10B067

6. Check camshaft bearing journal diameter (X and Y directions) on both sides (A and B) of journal as shown in figure.

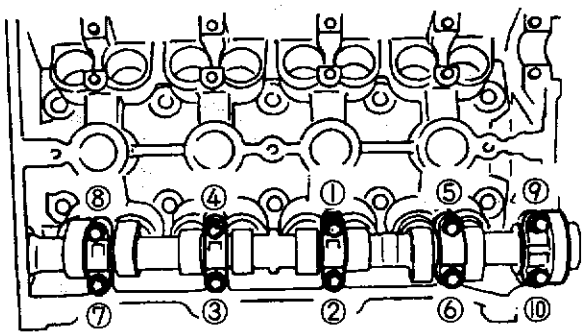
Minimum diameter:
1.1000~1.1032 in (27.941~27.960 mm)



BSX010B089A

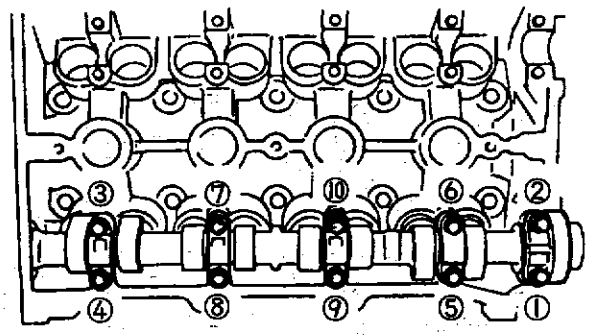
7. Replace camshafts if necessary.
8. Measure camshaft journal oil clearance.
9. Remove all foreign material and oil from journals and bearing surfaces.
10. Set camshafts onto cylinder head.
11. Position plastigage® on journals in axial direction.
12. Do not rotate camshafts.
13. Install camshaft caps according to cap number and arrow mark.
14. Install cap nuts. Tighten them in five or six steps in order shown.

Tightening torque:
13.0~19.5 lb-ft (17.6~26.5 N·m, 1.8~2.7 kg-m)



AS2A10107

15. Loosen camshaft cap nuts in five or six steps in order shown.
16. Remove camshaft caps.

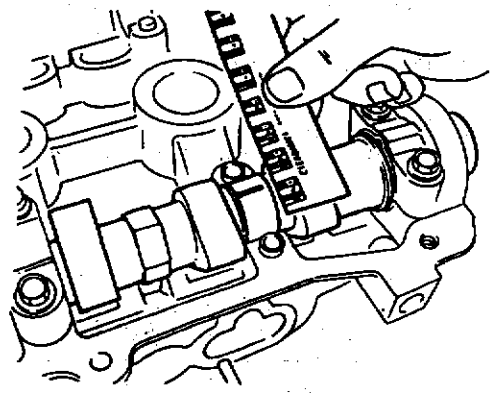


AS2A10107

17. Measure oil clearances.

Oil clearance:
0.0016~0.0031 in (0.04~0.08 mm)

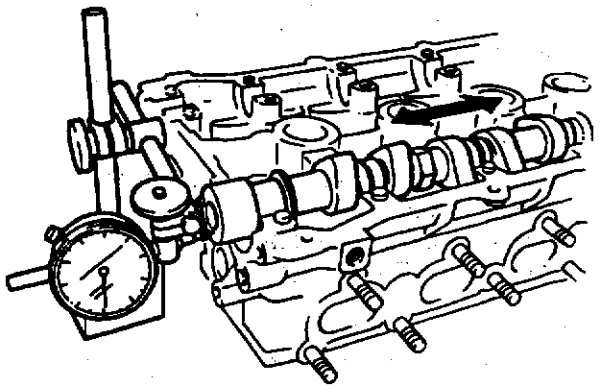
18. If oil clearance exceeds specification, replace cylinder head.



BSX010B093

19. Install camshafts.
20. Place a dial indicator against end of camshaft.
21. Using a prying tool, move camshaft as far forward as possible.
22. Zero dial.
23. Using prying tool, move camshaft as far rearward as possible.
24. Check gauge to determine how much end play is present.

End play:
0.0031~0.0046 in (0.08~0.11 mm)



BSX010B094

Rocker arm and rocker arm shaft

1. Measure the rocker arm inner diameter.

Inner diameter:
0.7862~0.7874 in (19.97~20.00 mm)

2. Measure the rocker arm shaft outer diameter.

Outer diameter:
0.7875~0.7866 in (19.959~19.980 mm)

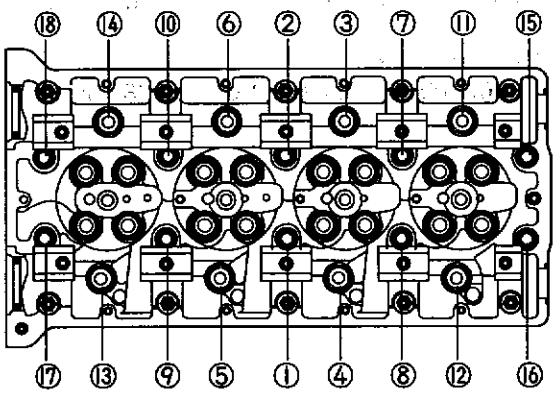
Reassembly

1. Remove all foreign material from the top of the cylinder block.
2. Place the new cylinder head gasket in position.

Caution
Measure the length of cylinder head bolt, replace if necessary.
Long bolt: 5.2 in (132 mm)
Short bolt: 3.7 in (93 mm)

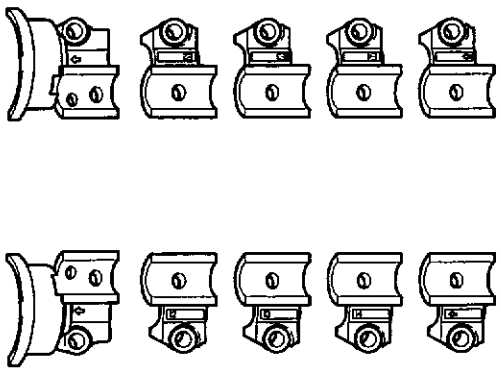
3. Install the cylinder head.
4. Apply an engine oil into the surface and thread of cylinder head bolt, and install the cylinder head bolts to the cylinder head.
5. Tighten the cylinder head bolts in the order shown in the figure.

Tightening torque:
Angle contorl
Long bolt: 25.32 lb-ft (34.3 N•m, 3.5 kg-m)+45°+70°
Short bolt: 25.32 lb-ft (34.3 N•m, 3.5 kg-m) +40°+45°



AV2A10B008

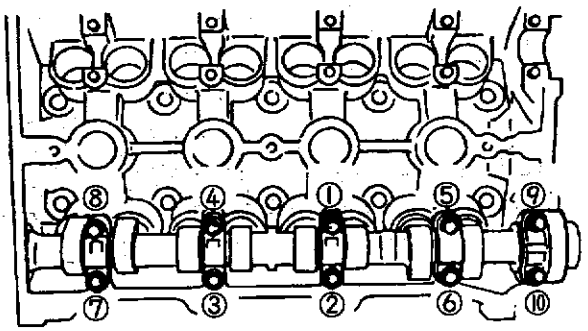
6. Remove all foreign material and oil from the journals and bearing surface.
7. Set the camshaft onto the cylinder head.
8. Install the camshaft caps according to the cap number and arrow mark.



AV2A10B065

9. Install the camshaft cap nuts and tighten them in two or three steps in the order shown in the figure.

Tightening torque:
13.0~19.5 lb-ft (17.6~26.5 N•m, 1.8~2.7 kg-m)

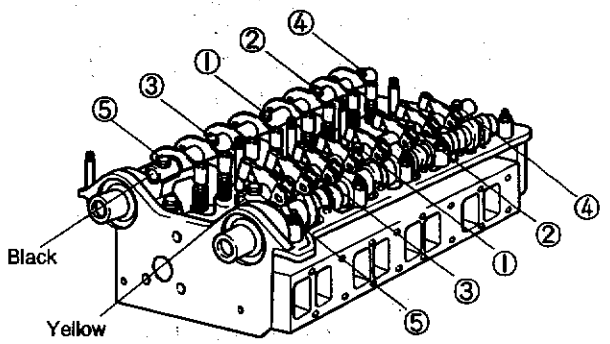


AS2A10107

✱ *Notice*
Do not exchange intake rocker arm shaft and exhaust rocker arm shaft each other.
- *Intake side: Yellow*
- *Exhaust side: Black*

10. Install the intake rocker arm shaft and exhaust rocker arm shaft and tighten them in two or three steps in the order shown in the figure.

Tightening torque:
13.0~19.5 lb-ft (17.6~26.5 N•m, 1.8~2.7 kg-m)



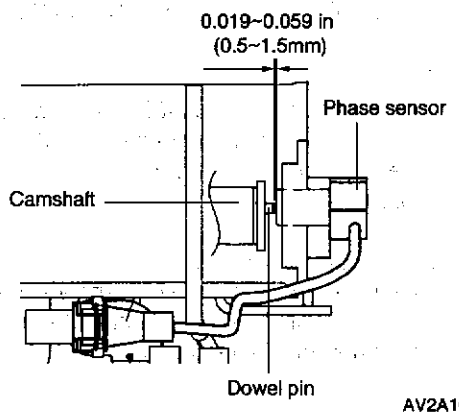
AV2A10B025

11. Install the cylinder head cover.

Tightening torque:
5.1~6.5 lb-ft (6.9~8.8 N•m, 70~90 kg-cm)

✱ *Notice*
Inspect clearance between dowel pin of camshaft end and phase sensor, before install cylinder head cover.

Clearance: 0.019~0.059in (0.5~1.5mm)



AV2A10B084

12. Install the injector and install the injector bracket. (Refer to section FL)

Tightening torque:
14.5~15.9 lb-ft (19.6~21.6 N•m, 2.0~2.2 kg-m)

13. Install the front and rear engine hanger.
14. Install the upper plate assembly.
15. Install the idlers.

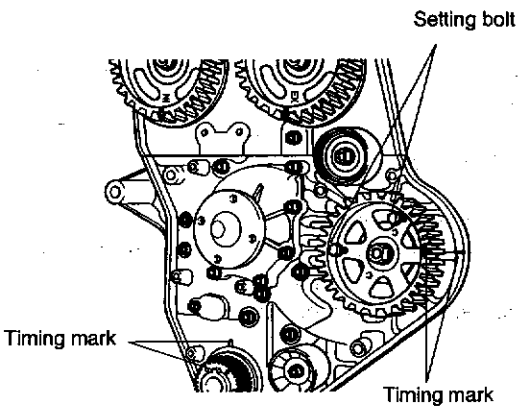
Tightening torque :
29.7lb-ft (40.2N•m , 4.1kg-m)

✱ *Notice*
Be careful that the idlers does not change.
Idler No.1(ø 2.36in(ø 60mm)),Idler No.2(ø 2.16in (ø 55mm))

16. Install the high pressure pump.
    1) Tighten the high pressure pump assembly fixing bolts after installed the high pressure pump to the timing case.

Tightening torque :
15.9~18.8lb-ft (21.6~25.5N•m , 2.2~2.6kg-m)

    2) Pre-tighten the high pressure pump pulley lock nut after installed the high pressure pump pulley to the high pressure pump shaft with key.
    3) Fix the high pressure pump pulley by used to two setting bolts, after aligned the high pressure pump pulley timing mark as shown illust.



BV2A10B002A

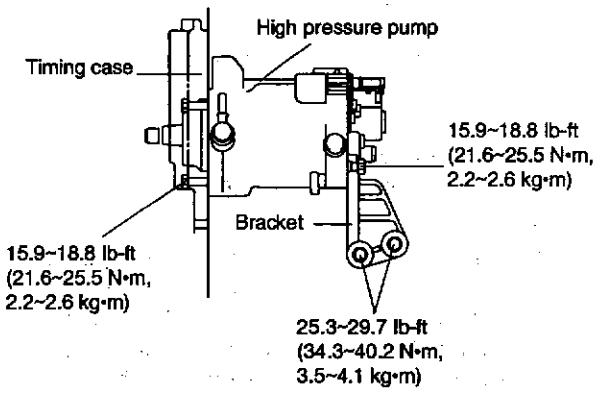
    4) Tighten the high pressure pump pulley lock nut.

Tightening torque :
47.0lb-ft (63.7N•m , 6.5kg-m)

    5) Install the high pressure pump bracket to the high pressure pump and cylinder block.

Caution
First tighten the cylinder block side bolts and then second tighten the pump side bolts after checking that there is no clearance between bracket and pump.

Tightening torque :
Pump side :
15.9~18.8lb-ft (21.6~25.5N•m , 2.2~2.6kg-m)
Cylinder block side :
25.3~29.7lb-ft (34.3~40.2N•m , 3.5~4.1kg-m)

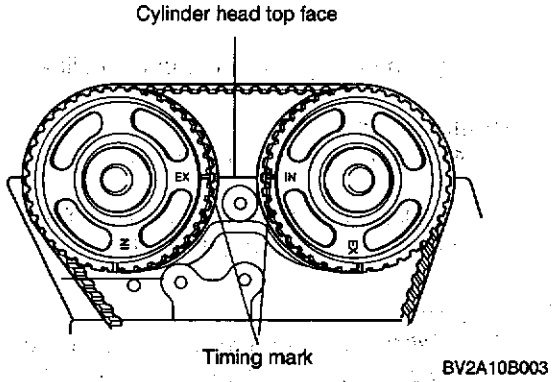


17. Align the crankshaft pulley timing mark.

Caution
When the crankshaft is rotated without timing belt, could damage piston and valve. Before assemble the cylinder head, align TDC for No.1 piston.

18. Align the camshaft pulley timing mark.
    1) Align "EX"mark of the left camshaft pulley and "IN" mark of the right camshaft pulley to the cylinder head top face as shown illust

Caution



When the camshaft is rotated without timing belt, could damage piston and valve. Before assemble the cylinder head, align the camshaft pulley timing mark

    2) Install the camshaft fixing tool (SST) between two camshaft pulleys.
    3) Tighten the camshaft pulley lock nut.

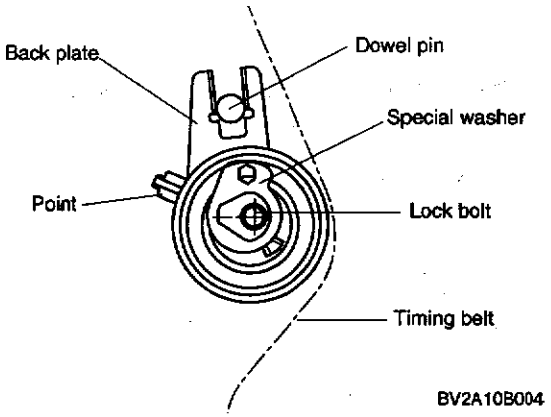
Tightening torque :
47.0lb-ft (63.7N•m , 6.5kg-m)

    4) Remove the camshaft fixing tool (SST).

19. Install the timing belt.
    1) The timing belt is installed in sequence crank shaft pulley, idler No.2, high pressure pump pulley, idler No.1 and camshaft pulley.

✱ *Notice*
a) The auto-tensioner must be mounted onto the engine after the timing belt is installed.
b) Keep the tension of timing belt when install timing belt.

20. Install the auto-tensioner.
    1) Install the auto-tensioner as shown illust. The dowel pin has to be located between the tensioner fork (back plate).



    2) Pretighten the auto-tensioner.

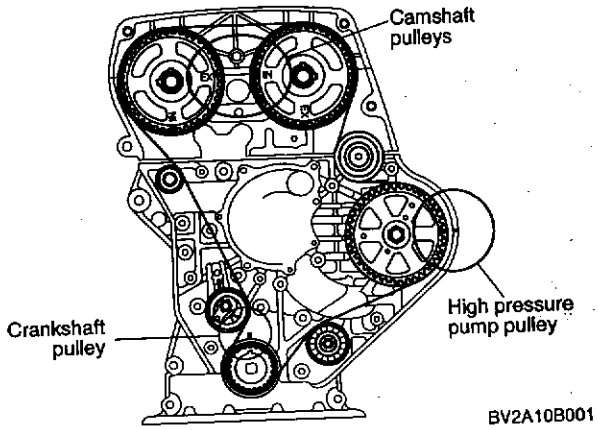
Tightening torque :
2.9lb-ft (3.9N•m , 0.4kg-m)

✱ *Notice*
a) Oil must not get in contact with the tensioner. The tensioner has to be replaced by a new one, if it is oily.
b) The positions of the pointer, the back plate and the special washer are in accordance to the illust.

21. Install the touch idler.

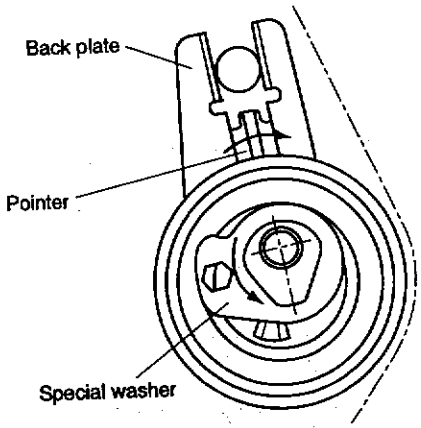
Tightening torque :
17.4lb-ft (23.5N•m , 2.4kg-m)

22. Remove two setting bolts from the high pressure pump pulley.
23. Check again if the alignment marks of camshafts, crankshaft and high pressure pump are aligned with the marks on the timing case.



BV2A10B001

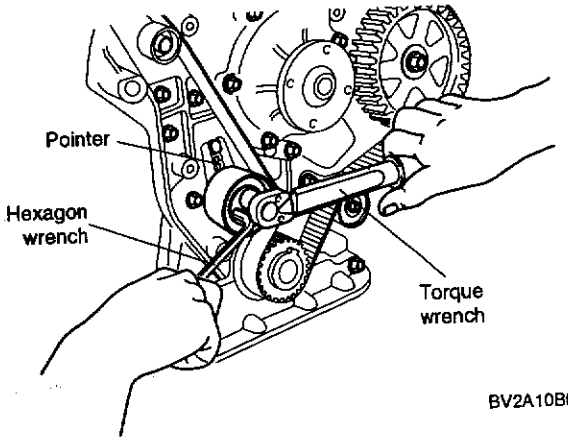
24. Adjust the auto-tensioner, and then tighten it.
    1) Align the pointer to the back plate by rotating the special washer in counter-clockwise using the hexagon wrench as shown illust.



BV2A10B005

    2) Tighten the auto-tensioner lock bolt with holding the special washer by the hexagon wrench when the pointer is aligned with the back plate.

Tightening torque :
17.4lb-ft (23.5N•m , 2.4kg-m)

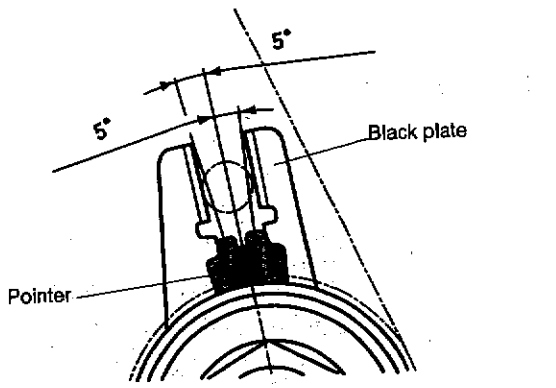


BV2A10B006

    3) Remove the hexagon wrench.

✱ *Notice*
If the pointer can not be aligned with the back plate, then a new belt has to be used.

25. Rotate the crankshaft two full revolutions in clockwise to align the TDC mark.
26. Check again if the alignment marks of camshafts, crankshaft and high pressure pump are aligned with the marks on the timing case.
27. Check the alignment of the pointer and back plate.

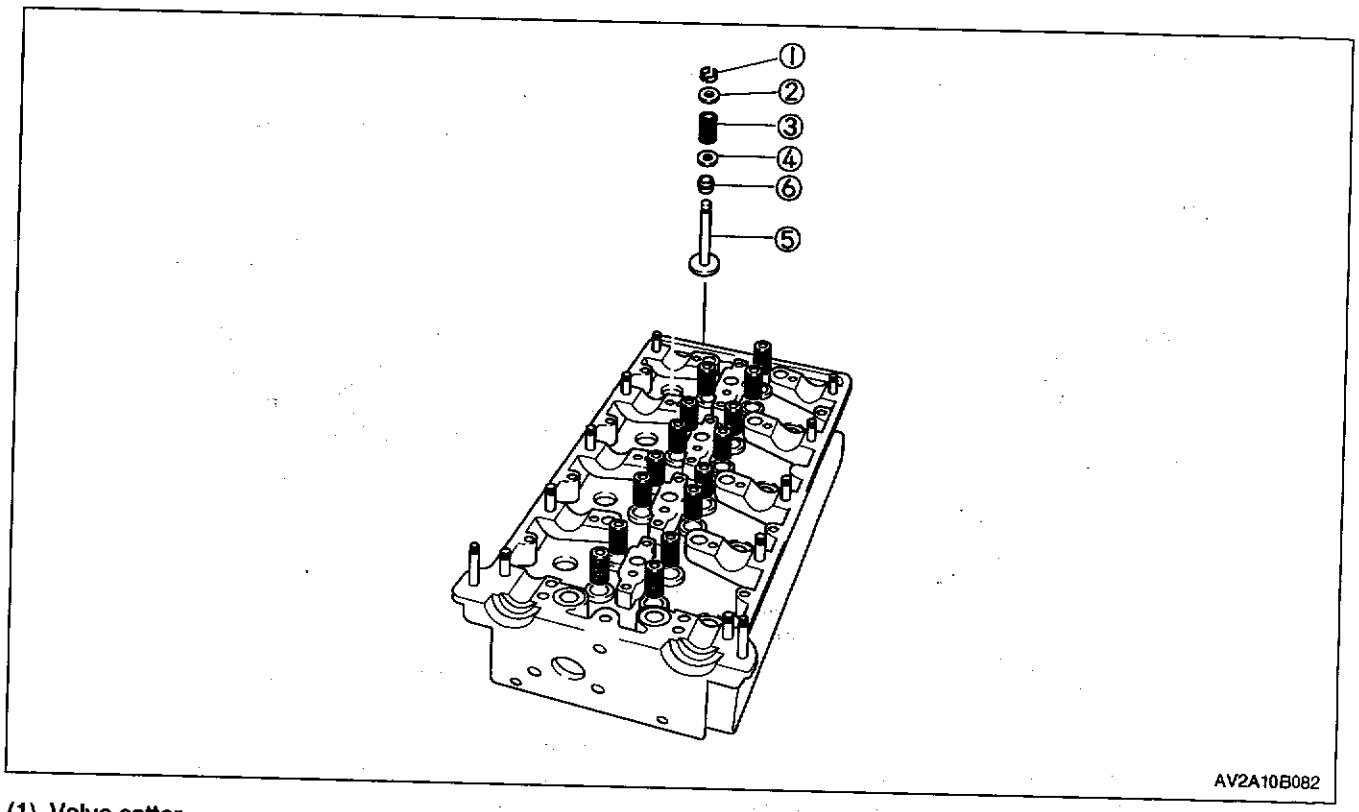


BV2A10B007

Allowance misalignment : ±5°

28. If the misalignment between pointer and back plate is bigger than (±5°), repeat step 23~27.

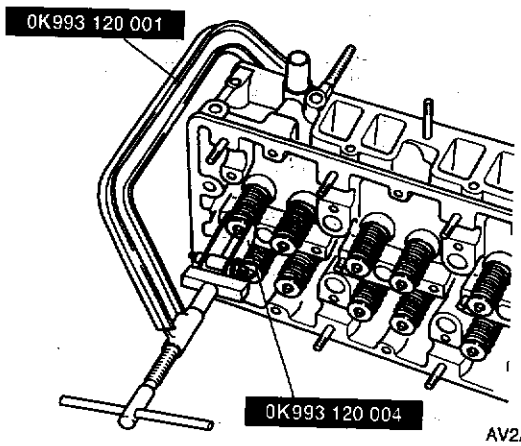
Cylinder head



(1) Valve cotter
(2) Valve spring upper seat
(3) Valve spring
(4) Valve spring lower seat
(5) Valve
(6) Valve seal

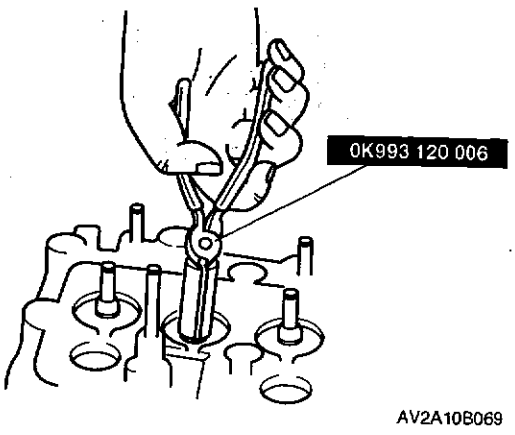
Disassembly

1. Remove the valve cotter by using the **SST (0K993 120 001 / 0K993 120 004)**.



2. Remove the valve spring upper seat, valve spring, valve spring lower seat and valve.

3. Pull the valve seal out by using the **SST (0K993 120 006)**.



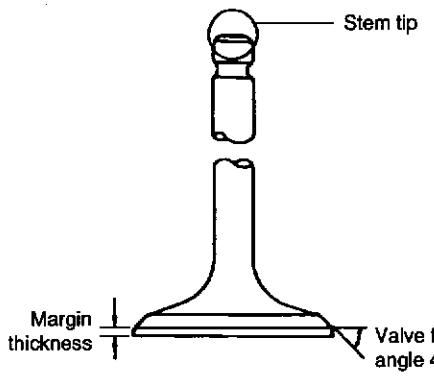
Inspection

Valve mechanism

1. Inspect each valve for following:
   a. Damaged or bent valve stem
   b. Rough or damaged face
   c. Damaged or unevenly worn stem tip

2. Resurface or replace valve as needed.

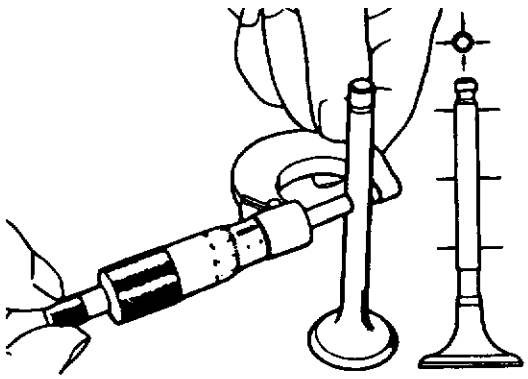
   Margin thickness
   Intake: 0.047 in (1.2 mm)
   Exhaust: 0.043 in (1.1 mm)



BSX010A110

3. Measure diameter of each valve stem.

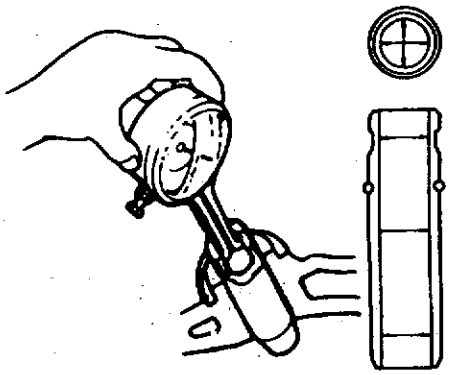
   Diameter
   Intake: 0.2742~0.2748 in (6.965~6.980 mm)
   Exhaust: 0.2734~0.2740 in (6.945~6.960 mm)



BSX010A111

4. Measure inside diameter of each valve guide at points shown in figure.

   Diameter intake and exhaust valve guide:
   0.2759~0.2767 in (7.010~7.030 mm)

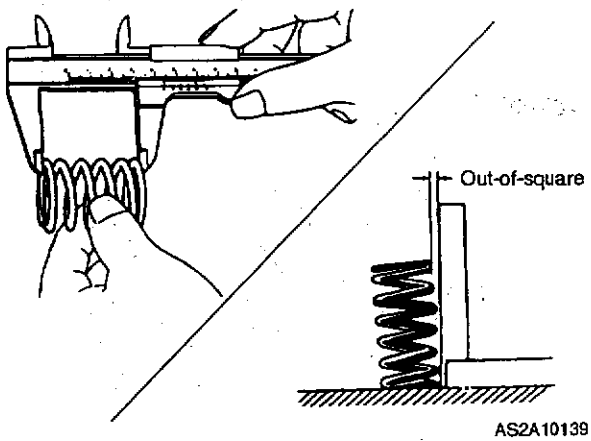


BSX010A112

Valve spring

1. Inspect each valve spring for cracks and damage.
2. Measure free length and out-of-square. Replace valve springs as needed.

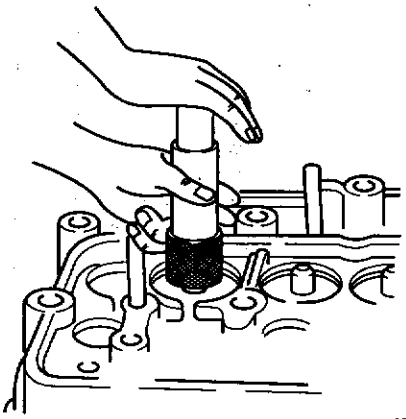
   Free length: 2.066 in (52.47 mm)
   Out-of-square: 2° maximum



AS2A10139

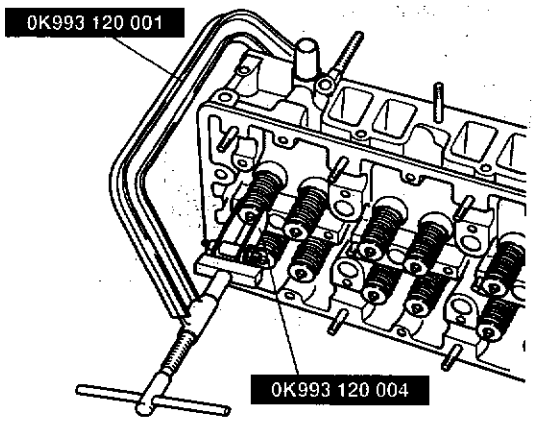
Reassembly

1. By using the proper tool, press the valve seal.



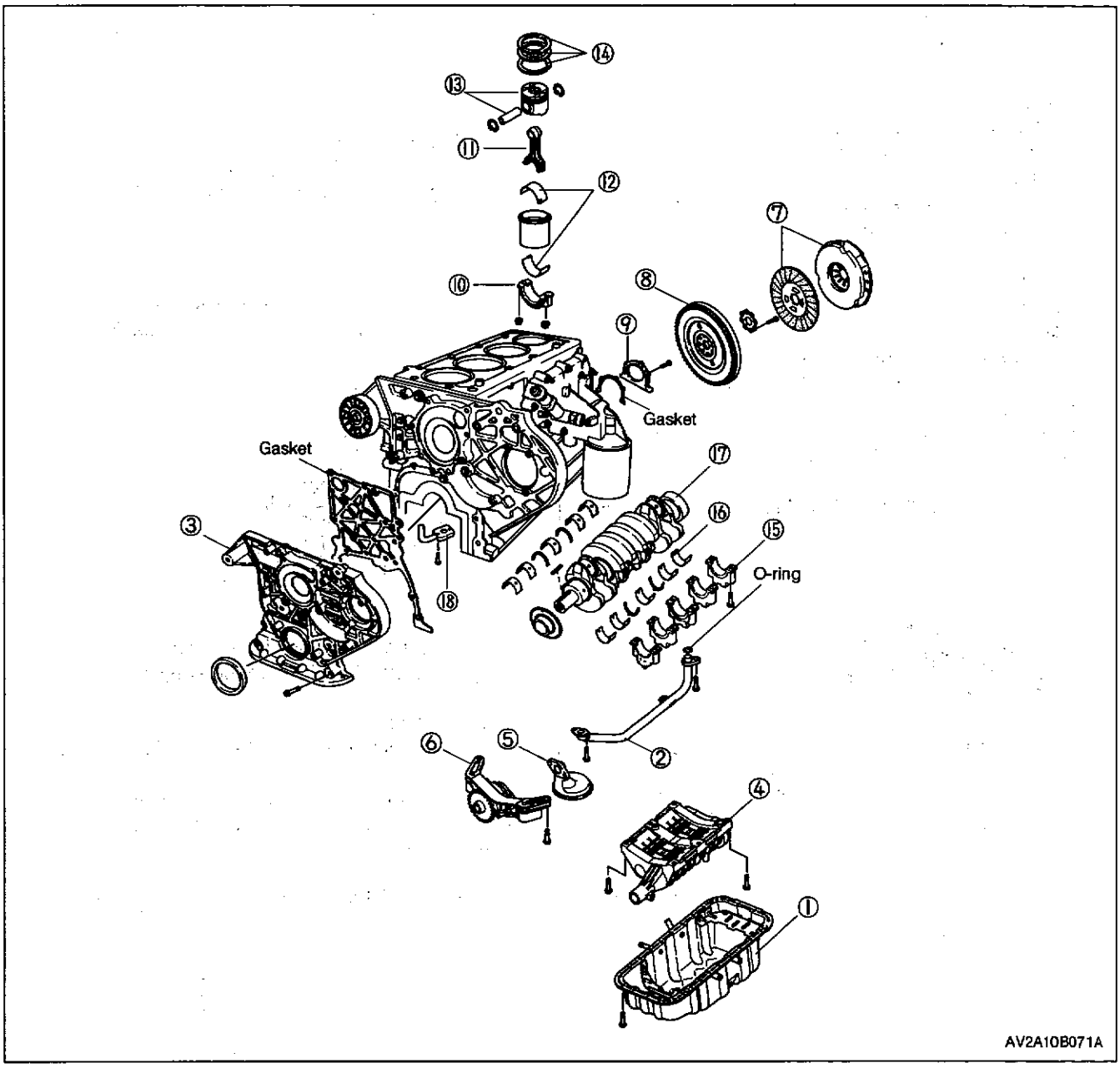
AV2A10B070

2. Install the valve, valve spring lower seat, valve spring and valve spring upper seat.
3. By using **SST (0K993 120 001 / 0K993 120 004)**, compress the valve spring and place the valve cotter securely.
4. By using a plastic hammer, tap the stem lightly to assure proper fit.



AV2A10B068

Cylinder block



(1) Oil pan
(2) Oil feed pipe
(3) Timing belt case
(4) Ladder frame
(5) Oil strainer
(6) Oil pump
(7) Clutch cover and clutch disc (MTX only)
(8) Flywheel (MTX only)
(9) Rear cover
(10) Connecting rod cap
(11) Connecting rod
(12) Main bearing
(13) Piston and piston pin
(14) Piston rings
(15) Main bearing cap
(16) Main bearing
(17) Crankshaft
(18) Oil jet

Disassembly

1. Remove the clutch cover, clutch disc and flywheel.
2. Remove the oil pan mounting bolts.
3. Remove oil pan with a screwdriver or suitable tool.

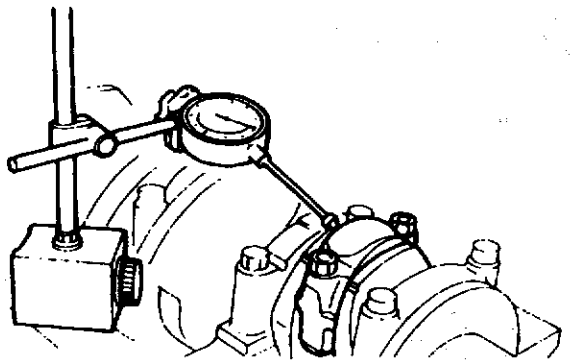
Caution

a) Do not force tools between cylinder block and oil pan as this may damage sealing surface.

b) Do not damage sealing surface when removing old sealant.

4. Remove the oil feed pipe.
5. Remove the timing belt case.
6. Remove the ladder frame.
7. Remove the oil strainer and oil pump.
8. Remove the lever, tensioner and guide.
9. Remove the rear cover.
10. Before removing the connecting rod, measure the connecting rod side clearance.

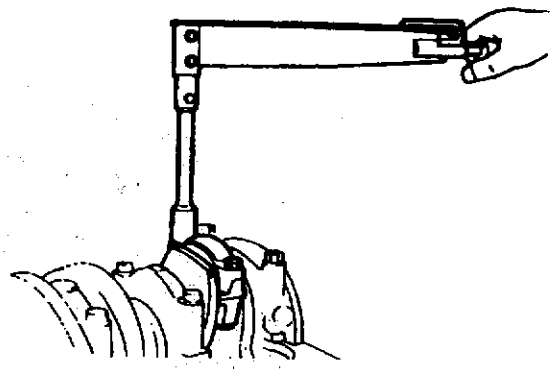
Side clearance: 0.0055~0.0153 in (0.14~0.39 mm)



AN9010052

11. Remove connecting rod cap.
12. Measure the connecting rod bearing oil clearance.
    1) Remove all foreign material and oil from the crank pin and bearing surface.
    2) Position Plastigage atop the crank pin in the axial direction.
    3) Install the connecting rod cap and tighten.

Tightening torque:
Tighten 50.6 lb-ft (68.6 N•m, 7.0 kg-m), tighten 21.7 lb-ft (29.4 N•m, 3.0 kg-m) and then tighten 90°.



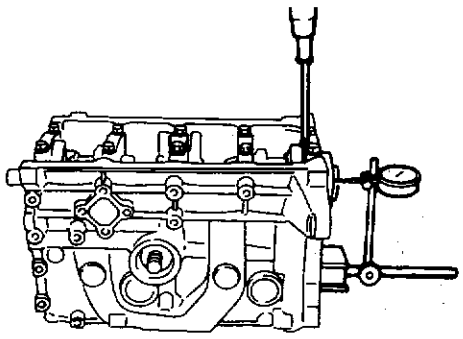
AN9010049

    4) Loosen the connecting rod cap nuts.
    5) Measure the oil clearance at each crank pin.

Oil clearance:
0.00169~0.00303 in (0.043~0.077 mm)

13. Remove the connecting rod and piston.
14. Before removing the main bearing cap, measure the crankshaft end play.

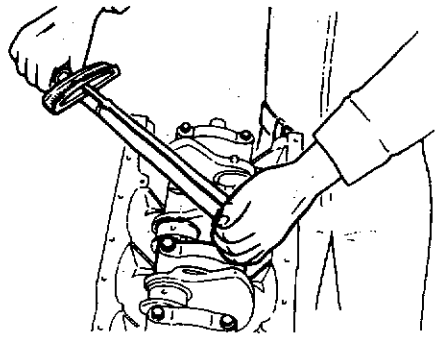
End play: 0.0055~0.0153 In (0.14~0.39 mm)



AN7010A165

15. Remove main bearing cap.
16. Measure the main bearing oil clearance
    1) Remove all foreign material and oil from the journals and bearing surface.
    2) Position Plastigage atop the journals in the axial direction.
    3) Install the main bearing cap and tighten as shown in the figure.

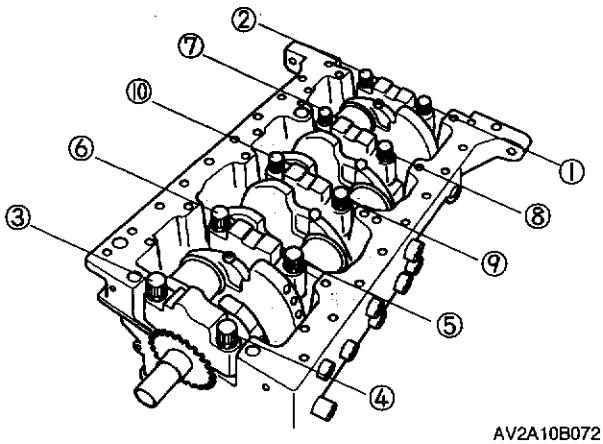
    Tightening torque:
    Pretighten 54.97 lb-ft (74.5 N•m, 7.6 kg-m), and then tighten 60°.



AN7010A164

    4) Loosen the main bearing cap bolts and remove main bearing cap.
    5) Measure the oil clearance at each journal.

    Oil clearance:
    No.1,2,4,5: 0.00177~0.00311 in (0.045~0.079 mm)
    No.3: 0.00267~0.00397 in (0.068~0.101 mm)
17. Loosen the main bearing cap bolts in two or three steps in the order shown in the figure.
18. Remove the main bearing cap, main bearing and crankshaft.



AV2A10B072

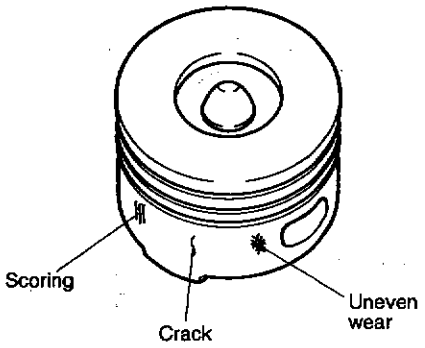
19. Remove the balance shaft and thrust plate.
20. Remove the balance gear.
21. Remove the oil jet.
22. Remove the snap ring with snap ring pliers and then remove the piston pin.
23. Using a piston ring expander, remove piston rings.

Inspection

Piston

✱ *Notice*
Replacing a piston also requires replacing piston rings.

1. Check circumference of piston for damage, scoring, or unusual wear patterns. Replace piston as needed.

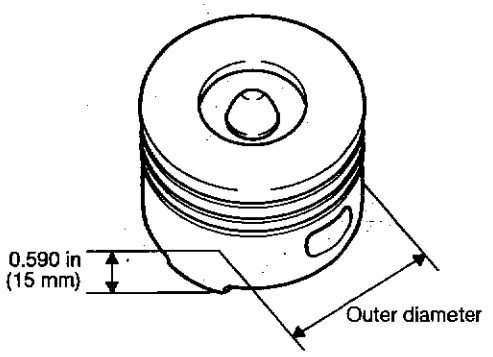


AV2A10B073

2. Check outside diameter of each piston at a 90° right angle to piston pin, 0.16 in (15 mm) above lower end of piston.

    Piston diameter
    A grade: 3.8195~3.8201 in (97.015~97.030 mm)
    B grade: 3.8201~3.8207 in (97.030~97.045 mm)

✱ *Notice*
If piston is collapsed or bell mounthed, replace piston.

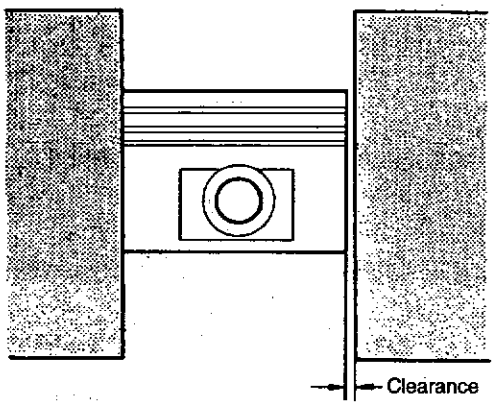


AV2A10B074

3. Check piston-to-cylinder liner wall clearance by subtracting piston diameter from the largest cylinder liner wall diameter, at each cylinder.

   Clearance: 0.0028~0.0039 in (0.070~0.098 mm)

4. If clearance exceeds maximum, replace piston or cylinder liner.

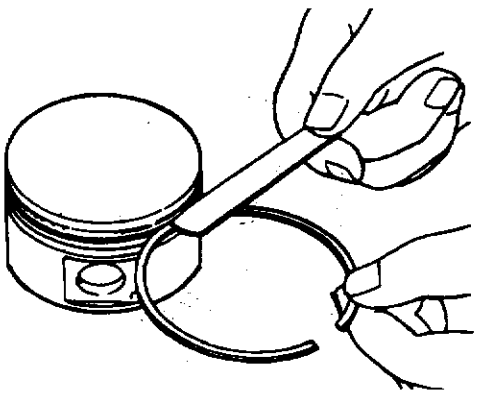


AS2A10080

Piston rings

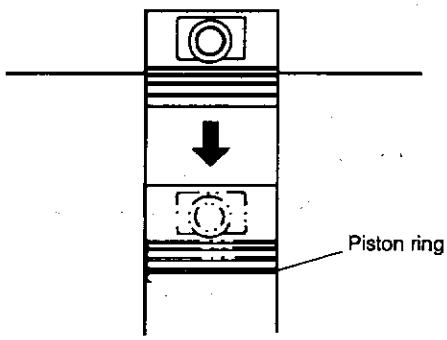
1. Insert a new piston ring into a piston ring groove and check piston ring-to-side clearance. Piston ring groove clearance.

   Piston ring groove clearance:
   Top ring: 0.0029~0.0040 in (0.076~0.102 mm)
   Second ring: 0.0016~0.0031 in (0.040~0.080 mm)
   Oil ring: 0.0012~0.0028 in (0.030~0.070 mm)
   Limit: 0.0118 in (0.30 mm)



AS2A10081

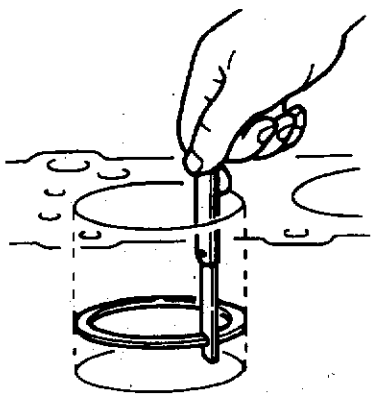
2. If clearance exceeds the limit, replace piston.
3. Inspect piston rings for damage, abnormal wear, or breakage.
4. Replace piston rings if necessary.
5. Insert piston ring into cylinder by hand.
6. Square ring in cylinder by inverting a piston into cylinder and pushing ring to the bottom of its travel in cylinder liner.



AS2A10081

7. Place a feeler gauge in end gap and check end gap clearance.

   End gap clearance:
   Top ring: 0.0118~0.0177 in (0.30~0.45 mm)
   Second ring: 0.0157~0.0217 in (0.40~0.55 mm)
   Oil rail: 0.0079~0.0157 in (0.20~0.40 mm)
   Limit: 0.0591 in (1.50 mm)



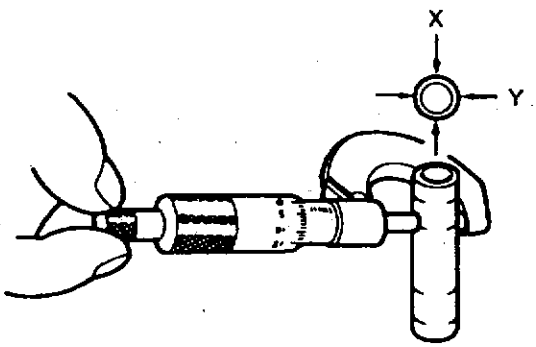
ABT010208

8. Replace piston ring if necessary.

Piston pin

1. Measure each piston pin diameter at X and Y direction at four locations shown.

   Diameter: 1.2596~1.2598 in (31.994~32.000 mm)

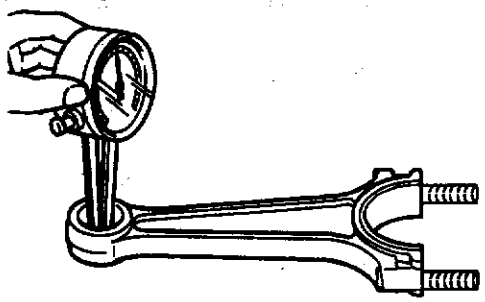


AS2A10142

Connecting rod

1. Check connecting rod bushing inside diameter.

   Inside diameter:
   1.2603~1.2611 in (32.012~32.033 mm)

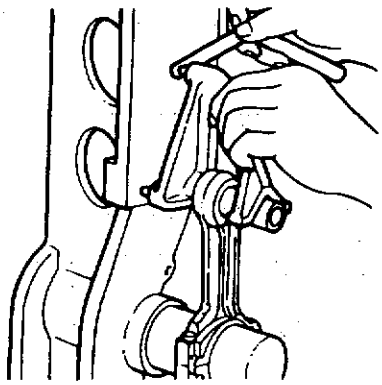


AS2A10143A

2. Subtract piston pin diameter from connecting rod bushing inside diameter to determine piston pin fit.

   Clearance: 0.0005~0.0015 In (0.012~0.039 mm)

3. If clearance is not within specification, replace connecting rod bushing.
4. Check each connecting rod for bending.



ABT010210

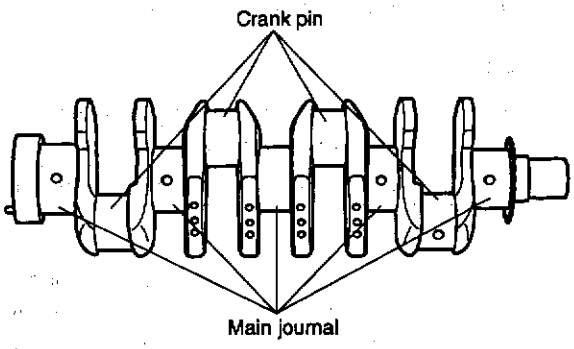
5. Replace connecting rods if necessary.

✱ *Notice*
Connecting rods must always be replaced as an assembly. Rod cap, rod, bolts and nuts are a matched set.

Crankshaft

1. Check crankshaft bearing and crank pin journals for damage and scoring.
2. Check oil holes for clogging.
3. Set crankshaft on V-blocks.
4. Measure crankshaft run-out at center journal. Replace crankshaft if it is not within specification.

   Run-out: 0.0055~0.0154 in (0.14~0.39 mm)



AV2A10B075

Pin journal bearing selection

1. Check the connecting rod big-end bore size code.

✱ *Notice*
The code is carved on connecting rod cap bolt hole side.

Connecting rod big-end bore diameter

Grade	Connecting rod big-end bore diameter
1	2.39499~2.39523 in (60.833~60.839 mm)
2	2.39523~2.39550 in (60.839~60.846 mm)

Crankshaft pin journal diameter:
2.24827~2.24898 in (57.106~57.124 mm)

2. Choose the proper pin journal bearing as below table.

Pin journal bearing clearance:
0.00138~0.00272 in (0.035~0.069 mm)

Pin journal bearing selection table

Connecting rod grade	Pin journal bearing grade	Oil clearance
1	Blue	0.00146~0.00272 in (0.037~0.069 mm)
2	Red	0.00138~0.00268 in (0.035~0.068 mm)

✱ *Notice*
Painting mark is located on the bearing side face.

Pin journal bearing thickness

Color	Pin journal bearing thickness
Blue	0.07213~0.07228 in (1.832~1.836 mm)
Red	0.07228~0.07244 in (1.836~1.840 mm)

3. Position properly upper bearing and lower bearing to connecting rod and connecting rod cap and then install connecting rod and connecting rod cap to crankshaft pin journal

Tightening torque:
Tighten 50.6 lb-ft (68.6 N•m, 7.0 kg-m), tighten 21.7 lb-ft (29.4 N•m, 3.0 kg-m) and then tighten 90°.

Main journal bearing selection

1. Check the cylinder block main bearing bore size code.

✱ *Notice*
The code is located on the side of ladder frame bolt hole.

Cylinder block main bearing bore diameter

Code	Cylinder block main bearing bore diameter
A	2.91598~2.91633 in (74.066~74.075 mm)
•	2.91633~2.91669 in (74.075~74.084 mm)
C	2.91669~2.91700 in (74.084~74.092 mm)

2. Check the crankshaft main journal size code.

✱ *Notice*
The code is located on the between main journal and pin journal.

Crankshaft main journal diameter

Code	Crankshaft main journal diameter	
	No. 1, 2, 4, 5	No. 3
A	2.75570~2.75598 in (69.995~70.002 mm)	2.75483~2.75511 in (69.973~69.980 mm)
•	2.75598~2.75625 in (70.002~70.009 mm)	2.75511~2.75539 in (69.980~69.987 mm)
C	2.75625~2.75649 in (70.009~70.015 mm)	2.75539~2.75562 in (69.987~69.993 mm)

3. Choose the proper main journal bearing in below table.

Main journal bearing selection table

		Cylinder block main bearing bore size code		
		A	•	C
Crankshaft main journal size code	A	Brown	Black	Black
	•	Green	Brown	Black
	C	Yellow	Green	Brown

Main journal bearing clearance:
No.1,2,4,5: 0.00146~0.00280 in (0.037~0.071 mm)
No.3: 0.00232~0.00366 in (0.059~0.093 mm)

Main journal bearing thickness

Color	Main journal bearing thickness
Black	0.07925~0.07945 in (2.013~2.018 mm)
Brown	0.07905~0.07925 in (2.008~2.013 mm)
Green	0.07886~0.07905 in (2.003~2.008 mm)
Yellow	0.07866~0.07886 in (1.998~2.003 mm)

4. Position properly upper bearing and lower bearing to cylinder block and main bearing cap.
5. Set crankshaft to cylinder block and then install main bearing cap to cylinder block.

Tightening torque:
Pretighten 54.97 lb-ft (74.5 N•m, 7.6 kg-m), and then tighten 60°.

Cylinder liner and piston selection

1. Check the cylinder bore inner diameter size code of cylinder block.

✱ *Notice*
The code is carved on the top of each cylinder.

Cylinder bore inner diameter

Code	Cylinder bore inner diameter
Y	3.9966~3.9971 in (101.513~101.526 mm)
X	3.9960~3.9966 in (101.500~101.513 mm)

2. Choose the proper cylinder liner as below table.

Clearance between cylinder liner and cylinder bore of cylinder block :
0.0003~0.0013 in (0.007~0.033 mm)

Cylinder liner selection table

Cylinder bore size code	Cylinder liner mark	Oil clearance
Y	3Y - Yellow	0.0003~0.0013 in (0.007~0.033 mm)
Y	3Y - Blue	0.0003~0.0013 in (0.007~0.033 mm)
X	3X - Yellow	0.0003~0.0013 in (0.007~0.033 mm)
X	3X - Blue	0.0003~0.0013 in (0.007~0.033 mm)

Piston selection table

Cylinder liner mark	Piston mark	Oil clearance
Yellow	B	0.0028~0.0039 in (0.070~0.098 mm)
Blue	A	0.0028~0.0039 in (0.070~0.098 mm)

✱ *Notice*
The mark for outer diameter is carved on the out surface of liner and for inner diameter is painted on the top of liner.

Cylinder liner outer diameter and inner diameter

Code	Outer diameter	Color	Inner diameter
3Y	3.9958~3.9963 in (101.493~101.506 mm)	Yellow	3.8234~3.8239 in (97.115~97.128 mm)
3Y	3.9958~3.9963 in (101.493~101.506 mm)	Blue	3.8228~3.8233 in (97.100~97.113 mm)
3X	3.9953~3.9958 in (101.480~101.493 mm)	Yellow	3.8234~3.8239 in (97.115~97.128 mm)
3X	3.9953~3.9958 in (101.480~101.493 mm)	Blue	3.8228~3.8233 in (97.100~97.113 mm)

Piston outer diameter

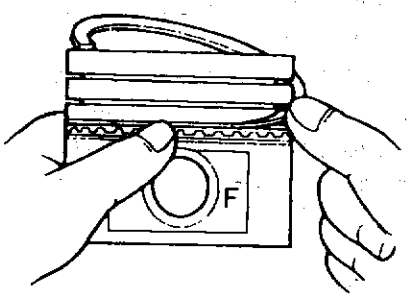
Code	Piston outer diameter
A	3.8195~3.8201 in (97.015~97.030 mm)
B	3.8201~3.8207 in (97.030~97.045 mm)

Reassembly

✱ *Notice*
a) Clean all parts before reassembly.
b) Apply new engine oil to all sliding and rotating parts.

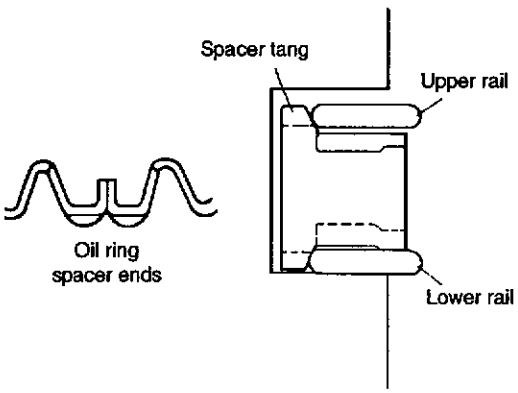
1. Install the three-piece oil rings on the pistons.
   1) Apply engine oil to the oil ring spacer and rails.
   2) Install the oil ring spacer so that the opening faces upward.
   3) Install the upper rail and lower rail.

✱ *Notice*
a) The upper rail and lower rail are the same.
b) Each rail can be installed with either face upward.



AS2A10085

2. Check that both rails are expanded by the spacer tangs as shown in figure by checking that both rails turn smoothly in both directions.



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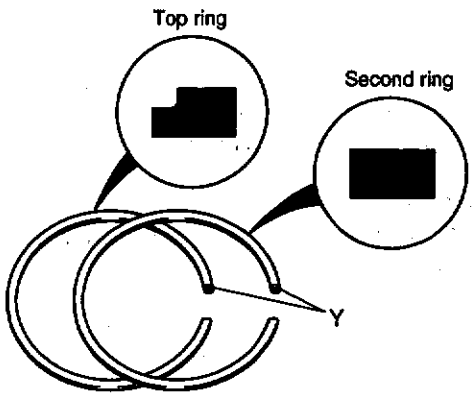
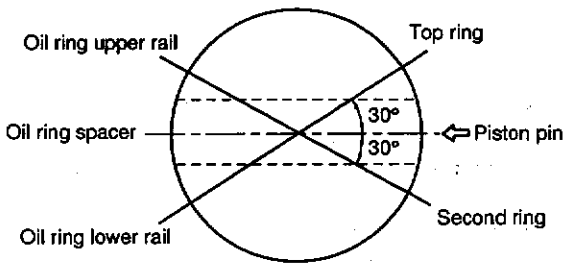
3. Install the second ring to the piston first, then install the top ring. Use piston ring expander.

✱ *Notice*
The rings must be installed with the "Y" marks facing upward.



AV2A10B076

4. Apply a liberal amount of clean engine oil to the second and top piston rings.
5. Position the opening of each ring as shown in the figure.



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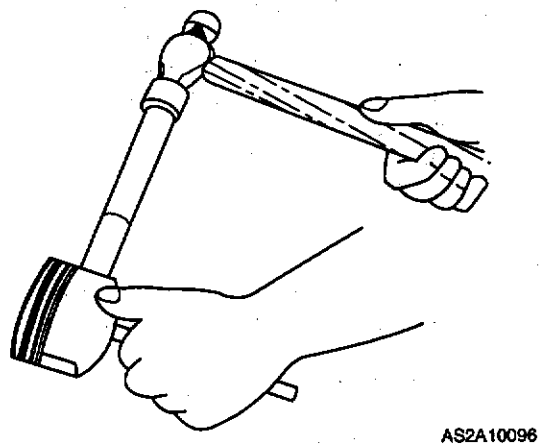
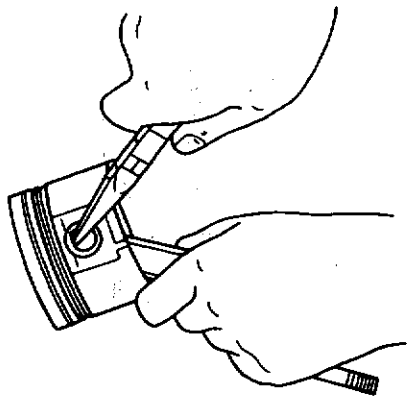
6. Install one piston pin snap ring into grooves on piston.
7. Insert connecting rod into piston and slide piston pin through piston and through connecting rod until it makes contact with the piston pin snap ring already installed.

✱ *Notice*
Verify that piston and rod are assembled in same direction as they were prior to disassembly.


AS2A10096

8. Install second piston pin snap ring grooves on opposite side of piston.


AS2A10097

9. Hold piston upright and move connecting rod back and forth. Check that rod moves freely.
10. Install the oil jet.
11. Before installing the crankshaft, inspect the main bearing oil clearance as follows.

Oil clearance Inspection

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

Caution

a) Install the grooved upper main bearings in the cylinder block.

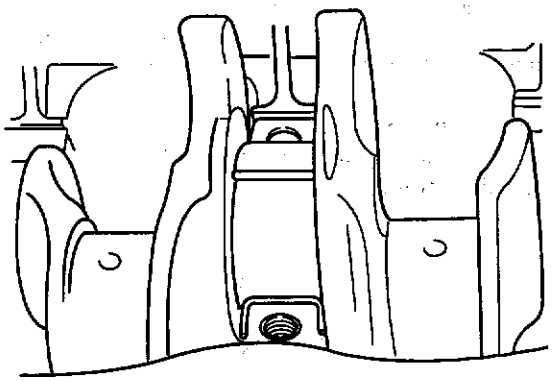
b) Install the thrust bearings with the oil groove facing the crankshaft.

(2) Install the upper main bearings and thrust bearings.
(3) Set the crankshaft in the cylinder block.

Caution

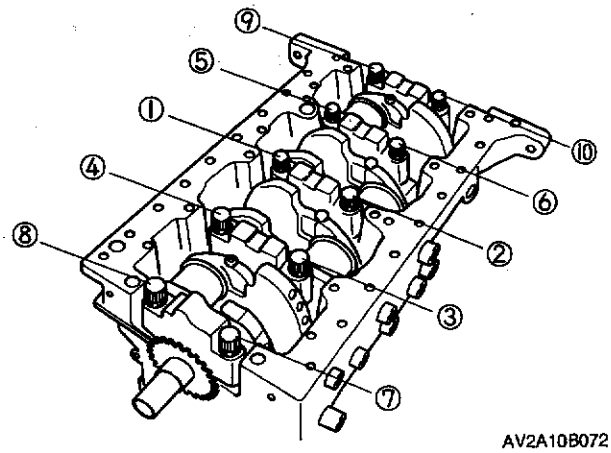
Do not rotate the crankshaft when measuring the oil clearances.

(4) Position plastigage atop the journals in the axial direction.


AV2A10B079

(5) Install the lower main bearings and the main bearing caps according to the cap number and ⇦ mark.
(6) Tighten the main bearing cap bolts in two or three steps in the order shown in the figure.

Tightening torque:
Pretighten: 54.97 lb-ft (74.5 N•m, 7.6 kg-m) and then tighten 60°



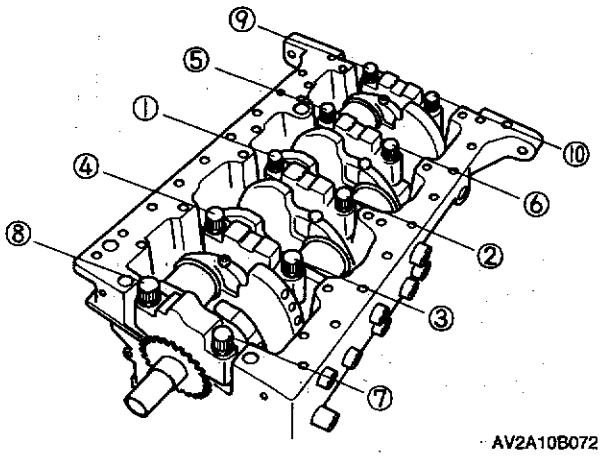
AV2A10B072

(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 the oil clearance exceeds specification, grind the crankshaft and use undersize main bearings.

Oil clearance:
No.1,2,4,5: 0.00146~0.00280 in (0.037~0.071 mm)
No.3: 0.00232~0.00366 in (0.059~0.093 mm)

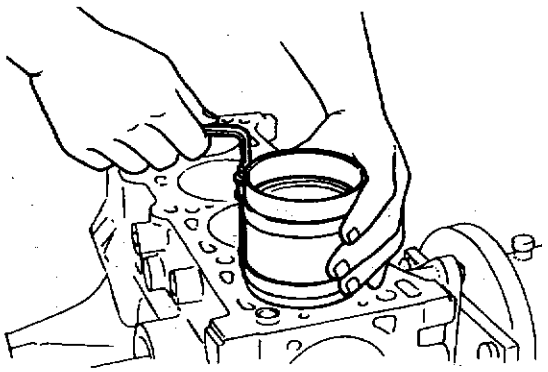
12. Apply a liberal amount of clean engine oil to the main bearings, thrust bearings and main journals.
13. Install the crankshaft and the main bearing caps according to the cap number and ⇦ mark.
14. Tighten the main bearing cap bolts in two or three steps in the order shown in the figure.

Tightening torque:
Pretighten: 54.97 lb-ft (74.5 N·m, 7.6 kg-m) and then tighten 60°.



AV2A10B072

15. Before installing the connecting rod, inspect the connecting rod bearing oil clearance as follows.
    (1) Slip piston and connecting rod assembly into a piston ring compressor.
    (2) Rotate crankshaft so that crank pin journal for specific cylinder is at its lowest point(bottom dead center).
    (3) Lower piston and connecting rod assembly until piston ring compressor makes contact with dect surface of engine block.

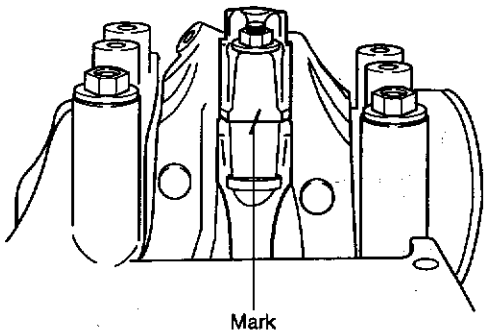

BSX010B103

    (4) Using butt end of a hammer, tap the top of piston into cylinder and continue tapping until connecting rod makes contact with crankshaft.
    (5) Install a connecting rod bearing in each connecting rod cap.
    (6) Place a piece of Plastigage® on crank pin journals.

✱ *Notice*
Align the maching marks on the cap and connecting rod when installing the connecting rod cap.

    (7) Install connecting rod caps.

Tightening torque:
Tighten 50.6 lb-ft (68.6 N·m, 7.0 kg-m), tighten 21.7 lb-ft (29.4 N·m, 3.0 kg-m) and then tighten 90°



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    (8) Loosen and remove connecting rod caps.
    (9) Check the connecting rod bearing clearance.

Oil clearance:
0.00138~0.00272 in (0.035~0.069 mm)

    (10) If oil clearance exceeds maximum oil clearance specification, grind the crankshaft and use undersized connecting rod bearings.
    (11) Apply a coat of clean engine oil to connecting rod bearing in connecting rod cap.
    (12) Install connecting rod cap and torque to specification.

Tightening torque:
Tighten 50.6 lb-ft (68.6 N·m, 7.0 kg-m), tighten 21.7 lb-ft (29.4 N·m, 3.0 kg-m) and then tighten 90°

16. Install the oil pump and oil strainer.
17. Inatall the oil feeding pipe into the ladder frame, oil pump and block, and then tighten bolts.

    Tightening torque (oil feeding pipe bolt):
    16.6 lb-ft (23 N•m, 2.3 kg-m)

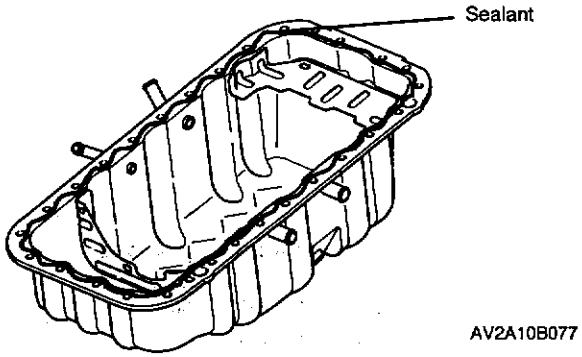
18. Install the crankshaft sprocket and oil pump sprocket.
19. Install the timing belt case.
20. Install the rear cover.

    Tightening torque:
    5.8~7.9 lb-ft (7.8~10.8 N•m, 80~110 kg-m)

21. Remove all foreign material from gasket surface.

✱ *Notice*
Install oil pan within five minutes of applying silicone sealer.

22. Apply a continuous bead of silicone sealant to oil pan contact surfaces.



23. Install the oil pan.
24. Install the flywheel, clutch disc and clutch cover.

SYMPTOM-RELATED DIAGNOSTIC PROCEDURE

Cooling system
Diagnostic chart

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

SPECIFICATION

Cooling system
Specification

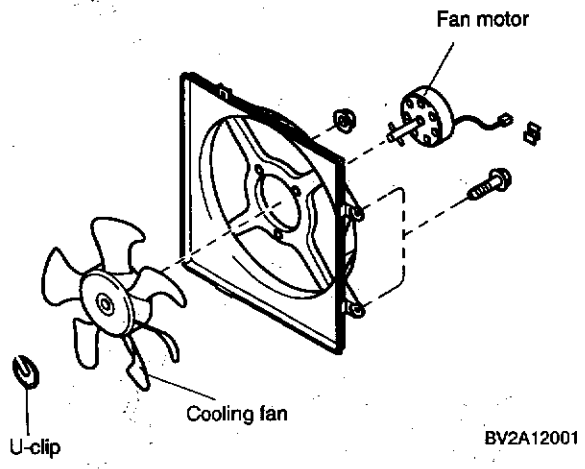
Item \ Engine model		J3 COMMON RAIL SYSTEM
Cooling system		Water-cooled, forced circulation
Coolant capacity	Us qt (liter, Imp qt)	9.93 (9.4, 8.27)
Water pump	Type	Centrifugal
Thermostat	Type	Wax
	Initial opening temperature °F (°C)	187.7~193.1 (86.5~89.5)
	Full-open temperature °F (°C)	212 (100)
	Full-open lift in (mm)	0.33 (8.5) minimum
Radiator	Type	Corrugated fin
	Cap valve opening pressure Psi (kPa, kg/cm²)	10.7~14.9 (73.6~103.0, 0.75~1.05)
Cooling fan	Type	Thermo type with plate type bimetal
	Operating temperature °F (°C)	Above 208.4 (98) - Low speed
		Above 221 (105) - High speed
	Number of blades	5
	Outer diameter in (mm)	14.4 (366)

REMOVAL AND REPLACEMENT PROCEDURE

Cooling fan motor

Removal

1. Disconnect negative battery cable.
2. Remove fresh air duct.
3. Disconnect cooling fan motor connector.
4. Remove three bolts securing cooling fan assembly.



5. Remove cooling fan assembly.
6. Remove U-clip securing cooling fan and remove cooling fan.
7. Remove nuts securing fan motor and remove fan motor.

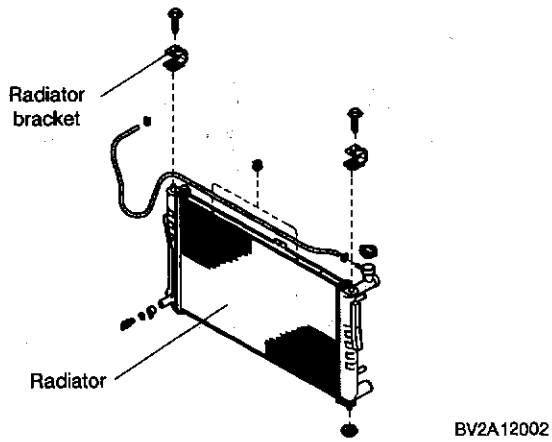
Replacement

1. Install fan motor.
2. Install cooling fan to fan motor by use of U-clip.
3. Install cooling fan assembly.
4. Reconnect cooling fan motor connector.
5. Install fresh air duct.
6. Reconnect negative battery cable.

Radiator

Removal

1. Drain engine coolant.
2. Remove cooling fan assembly.
   (Refer to cooling fan motor removal ; from step 1 to step 5.)
3. Disconnect coolant upper hose.
4. Disconnect reserve tank hose.
5. Disconnect coolant lower hose.
6. Remove radiator brackets.



7. Remove radiator.

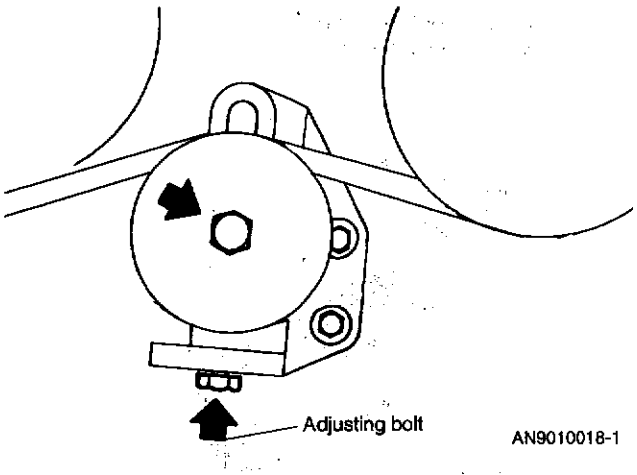
Replacement

1. Install radiator.
2. Install radiator bracket.
3. Reconnect coolant lower hose.
4. Reconnect reserve tank hose.
5. Reconnect coolant upper hose.
6. Install cooling fan assembly.
7. Refill engine coolant.

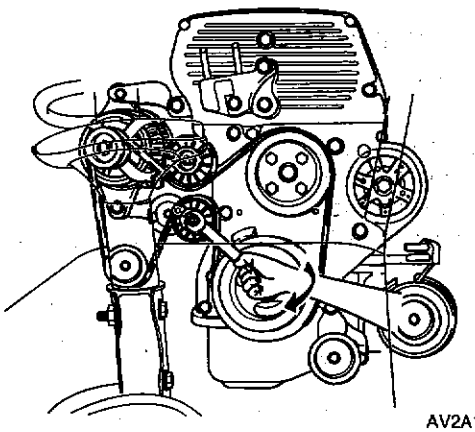
Water pump

Removal

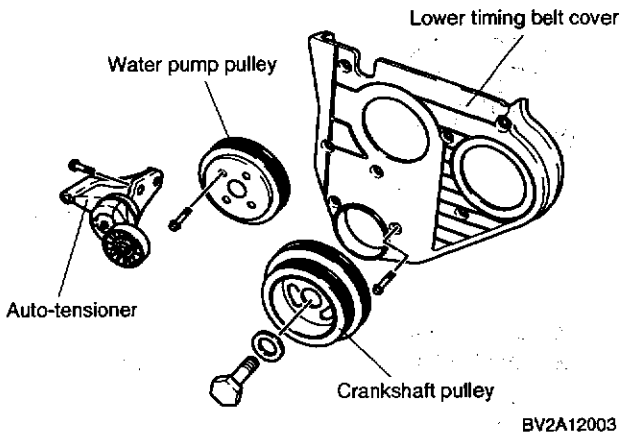
1. Drain engine coolant.
2. Raise vehicle and support it with safety stands.
3. Remove RH side wheel.
4. Loosen A/C drive belt tension by turning idler adjusting bolt.



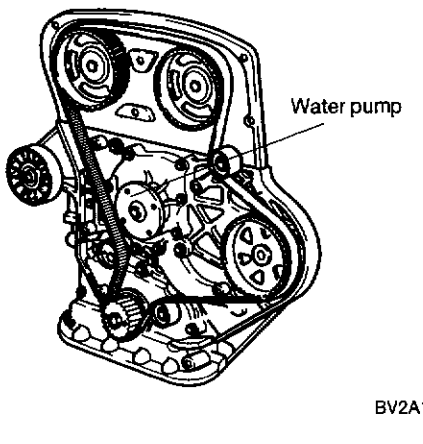
5. Remove A/C drive belt.
6. Lower auto-tensioner with spanner and then remove drive belt.



7. Remove auto-tensioner.



8. Remove water pump pulley.
9. Remove crankshaft pulley.
10. Remove lower timing belt cover.
11. Remove water pump.



Replacement

1. Install new gasket and water pump.
2. Install lower timing belt cover.

   Tightening torque:
   5.1~7.2 lb-ft (6.9~9.8 N•m, 0.7~1 kg-m)

3. Install crank shaft pulley.

   Tightening torque:
   253~289 lb-ft (343~392 N•m, 35~40 kg-m)

4. Install water pump pulley.

   Tightening torque:
   13.0~20.9 lb-ft (17.6~28.4 N•m, 1.8~2.9 kg-m)

5. Install auto-tensioner.

   Tightening torque:
   13.0~20.9 lb-ft (17.6~28.4 N•m, 1.8~2.9 kg-m)

6. Lower auto-tensioner with spanner and then install drive belt.
7. Install A/C drive belt.
8. Adjust belt deflection by turning adjusting bolt.

   Deflection (when applying 22 lb, 98 N, 10 kg)
   New one : 0.28~0.35 in (7~9 mm)
   Used one : 0.35~0.43 in (9~11 mm)

9. Install RH side wheel.

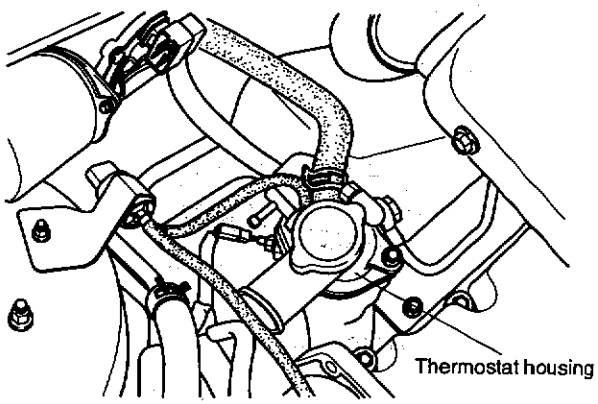
   Tightening torque:
   65~79 lb-ft (88~107 N•m, 9~11 kg-m)

10. Refill engine coolant.

Thermostat

Removal

1. Remove two bolts securing thermostat housing.



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2. Remove thermostat and gasket.
3. Replace thermostat if necessary.

Replacement

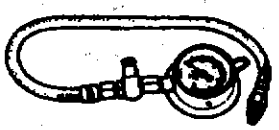
1. Install thermostat.
2. Install new gasket and thermostat housing.

SPECIAL SERVICE TOOL

Lubrication system
Special service tool

0K670 140 015

Oil pressure gauge



Used to inspect oil pressure.

SYMPTOM-RELATED DIAGNOSTIC PROCEDURE

Lubrication system
Diagnostic chart

Problem	Possible Cause	Action
Engine hard starting	Improper engine oil Insufficient engine oil	Replace Add oil
Excessive oil consumption	Internal engine wear Oil leak	*Refer to Section EM* Repair
Oil pressure drop	Insufficient oil Oil leakage Worn and/or damaged oil pump gear Worn plunger (inside oil pump) or weak spring Clogged oil strainer Excessive main bearing or connecting rod bearing clearance	Add oil Repair Replace Replace Clean *Refer to Section EM*
Warning lamp illuminates while engine is running	Oil pressure drop Malfunction of oil pressure switch Malfunction of electrical system	As described above *Inspect oil pressure switch* *Inspect electrical system*

SPECIFICATION

Lubrication system

Specification

Item \ Engine model			J3 COMMON RAIL SYSTEM
Lubrication system			Force-fed type
Oil pump	Type		Trochoid gear
	Relief pressure	psi (kPa, kg/cm²)	78.2~92.4 (539~637, 5.5~6.5)
Oil filter	Type		Full-flow type, Paper element
	Relief pressure differential	psi (kPa, kg/cm²)	11.4~17.1 (78~118, 0.8~1.2)
Oil pressure switch activation pressure		psi (kPa, kg/cm²)	2.8~4.9 (20~34, 0.2~0.35)
Oil capacity	Total (dry engine)	Us qt (liter, Imp qt)	7.50 (7.1, 6.2)
	Oil pan	Us qt (liter, Imp qt)	5.92 (5.6, 4.9)
	Oil filter	Us qt (liter, Imp qt)	0.63 (0.6, 0.5)
Engine oil			API service CF-4, CG-4 SAE 10W-30

ON-VEHICLE SERVICE PROCEDURE

Engine oil replacement

⚠ WARNING
BE CAREFUL WHEN DRAINING BECAUSE OIL IS HOT AND COULD CAUSE PERSONAL INJURY.

1. Warm engine to normal operating temperature and turn engine off. Position a suitable container under oil pan.
2. Remove oil filler cap and oil pan drain plug.
3. Allow oil to be fully drained.
4. Install drain plug with new gasket.

   Tightening torque:

   23.1~30.4 lb-ft (31.4~41.2 N•m, 3.2~4.2 kg-m)

5. Refill engine with specified type and amount of engine oil.(*Refer to specification table; page EM-LU-3*)
6. Install oil filler cap.
7. Run engine and check for leaks.
8. Check oil level by level gauge and add oil if necessary.

Oil pressure check

1. Disconnect and remove oil pressure switch.
2. Install oil pressure gauge into oil pressure switch installation hole.
3. Warm engine to normal operating temperature.
4. Run engine and note gauge readings.

   Oil pressure:

   45.5~71.1 psi (314~490 kPa, 3.2~5.0 kg/cm²)-3,000 rpm

5. If pressure is not within specification, check for cause, and repair. (*Refer to Symptom-related diagnostic procedure; page EM-LU-2.*)
6. Remove oil pressure gauge and install oil pressure switch.

   Tightening torque:
   8.7~13.0 lb-ft (11.7~17.6 N•m, 1.2~1.8 kg-m)

Oil filter replacement

1. Remove oil filter with oil filter wrench. If rubber seal is stuck to engine, remove it.
2. Apply a small amount of clean engine oil to rubber seal of new filter.
3. Install oil filter and turn it by hand until rubber seal contacts base.
4. Tighten filter 1-1/6 turns with filter wrench.

   Tightening torque:

   16~18 lb-ft (21.6~24.5 N•m, 2.2~2.5 kg-m)

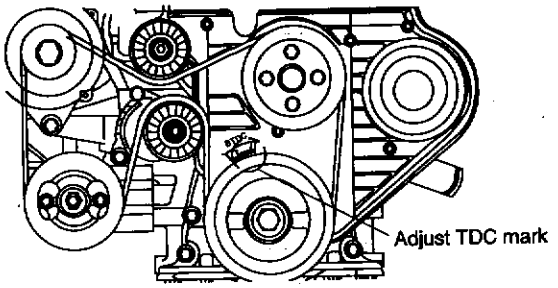
5. Start engine and check for leaks.
6. Turn engine off, and wait 5 minutes. Check oil level and add oil if necessary.

REMOVAL AND REPLACEMENT PROCEDURE

Oil pump

Removal

1. Remove oil pan.
2. Adjust V groove TDC mark on outside of pulley to TDC mark "T" on timing cover, by rotating crankshaft pulley.



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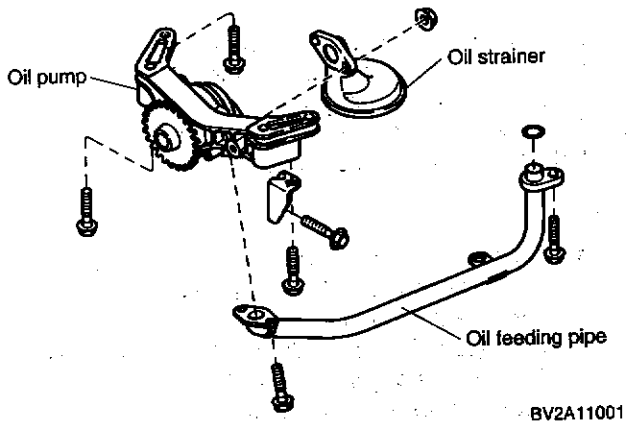
3. Remove oil feeding pipe from ladder frame.



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4. Remove oil pump with four bolts.
5. Remove oil pump.

Replacement

1. Remove oil pump after loosen the chain by push the end of chain tensioner with the chain tensioner lever.
2. Install oil feeding pipe.

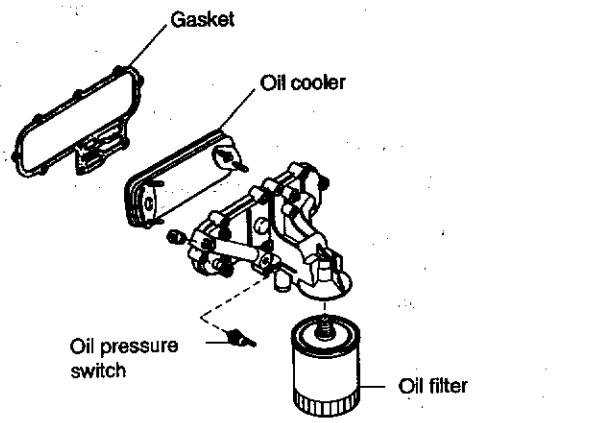
   Tightening torque:
   16.6 lb-ft (23 N·m, 2.3 kg-m)

3. Install oil pan.

Oil cooler

Removal

1. Remove fresh air duct.
2. Remove ventilator mounting bracket.



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3. Remove oil filter assembly with two nuts and eight bolts.
4. Remove four nuts securing oil cooler.
5. Remove oil cooler from oil filter assembly.

Replacement

1. Install new "O" rings and oil cooler to oil filter assembly.

   Tightening torque:
   10.8~18.0 lb-ft (14.7~24.5 N·m, 1.5~2.5 kg-m)

2. Install new gasket and oil filter assembly to cylinder block.
3. Install ventilate mounting bracket.
4. Install fresh air duct.

ON-VEHICLE SERVICE PROCEDURE

Turbocharger

After checking the turbocharger, replace the assembly in case of abnormality.

Check point	Check result	Symptom			
		Oil leak	Smoke	Abnormal noise	Lowpower, poor acceleration
Turbine rotor	Oil leakage	△	●	△	△
	Carbon deposit	△	●	○	○
	Friction with housing	△	○	●	○
	Bent or broken blade			●	●
Compressor oil	Contaminated intake inlet with oil	○	○		
	Friction with housing	△	○	●	○
	Bent or broken blade			●	●
Turbine and compressor check in both directions	Heavy or catching feeling when rotated by finger No movement when rotated		△	△	○
	Excessive looseness in bearing			○	●
	Carbon deposit in drain oil hole	△	△	○	△
Observation on oil hole	Carbon deposit in drain oil hole	△	●	△	△
Operation of waste gate valve (aircon used)	No smooth operation when applied after removing positive pressure				●

● : High possibility
○ : Medium possibility
△ : Low possibility

Turbocharger

On-vehicle Inspection

1. Warm up the engine to the normal operating temperature.
2. Disconnect the hose between the air inlet tube and the boost compensator from the air inlet side.
3. Install the pressure gauge by inserting the 3-way connector.
4. Read the maximum valve on the pressure gauge after starting the engine and increasing the engine speed.

Pressure gauge reading	Check point
No positive pressure or low pressure	• Air exhaust gas leakage • Abnormal turbocharger
Above the specified supercharging pressure (Standard value)	• Leakage by separation or breakage of actuator hose • Abnormal operation of actuator

Removal

1. Discharge the coolant.
2. After removing the air duct, keep foreign material from entering the turbocharger inlet.
3. Remove the turbocharger insulator.
4. Remove the turbocharger water outlet pipe.
5. Remove the turbocharger oil supply pipe.
6. Remove the exhaust and front pipes.
7. Remove the turbocharger inlet and outlet pipes.
8. Remove the turbocharger by loosening the turbocharger mounting bolts.

Caution

a) Don't carry the actuator by holding the actuator rod and the actuator hose.

b) Use the stud bolt of specified type when it is damaged. If one of different material is used, it may be elongated at high temperature and that can result in gas leakage.

c) The turbocharger is operated at high temperature and high speed that sufficient care should be taken on inclusion of foreign material into the oil pipe, deformation of the oil pump and etc..

d) After removing the turbocharger, attach the cap or tape on the air and exhaust gas inlets for foreign material not to be included.

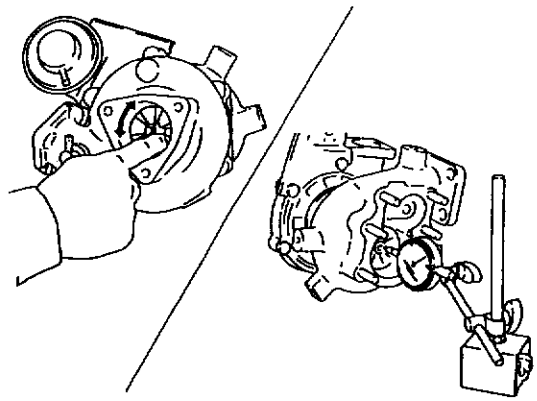
e) If the oil in the sensor housing flows out to the turbine and the compressor housing inside, it can be wrongly judged as turbocharger trouble that the turbocharger should be placed horizontally as originally mounted after removal.

Installation
Install them in the reverse order of removal.

Caution
- ***a) When installing a new turbocharger, pour small amount of oil into the lubricant inlet of the turbocharger.***
- ***b) When starting the engine, be sure to connect the lubricant supply pipe and idle it for 1~2 minutes at low speed. Then increase the engine speed after lubricant has been supplied to the turbocharger sufficiently.***

Inspection
1. Check if the rotor shaft is rotated smoothly when turned by a finger.
2. Check if there is looseness on the rotor shaft when moved up and down.
3. Install a dial gauge at the end of the shaft and check the free travel.

Free travel
0.001~0.003 in (0.026~0.074 mm)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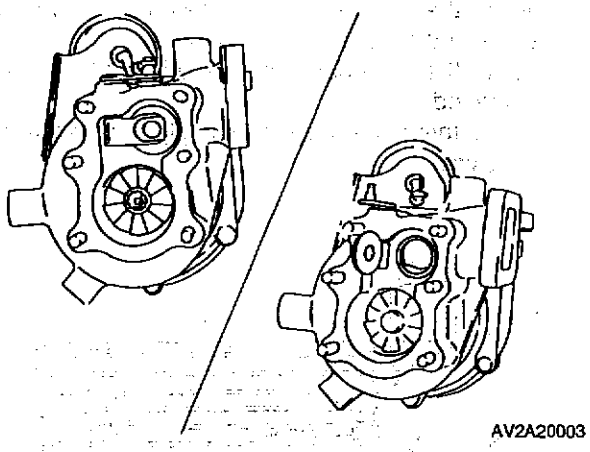
4. Check if there is oil attached or carbon deposit on the turbine or the compressor wheels.
5. Check if there is deformation or crack on the turbine or the compressor wheels.
6. Check if the turbine or the compressor wheels are interfered with housings.
7. Check if the waste gate valve is operated smoothly and if there is no deformation or crack after removing the fixing pin of the actuator rod.
8. Check if there is poor contact between the waste gate valve and the turbine housing seat.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Tuborcharger actuator
Inspection
1. Disconnect the air hose from the actuator.
2. Connect the pressure tester to one end of the actuator pipe and connect the other end to the actuator.
3. Install the dial gauge on the straight line of the actuator rod.
4. Check if the actuator is operated and if the reading of the dial gauge is moved by **0.08 in (2.0 mm)** when pressure of **1080~1170 mmHg** is applied by the pressure tester.

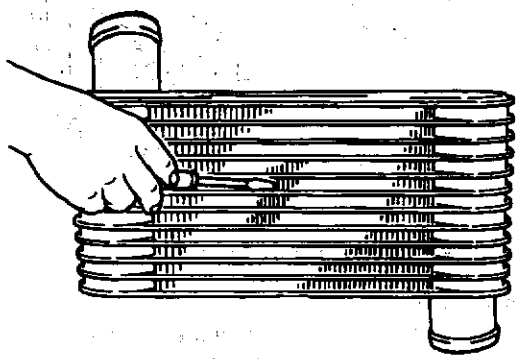
Caution
If pressure over 1.5 kg/cm² is applied, the actuator may be damaged.

5. If it is not operated or it does not reach the standard pressure, replace the actuator.

Intercooler

Inspection

1. Check if there is crack or damage on the intercooler visually and replace it if it is abnormal.
2. Check if the pin is damaged and adjust it by a driver if damaged.
3. Check if there is leakage after applying pressure of **1.5 kg/cm²**.



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