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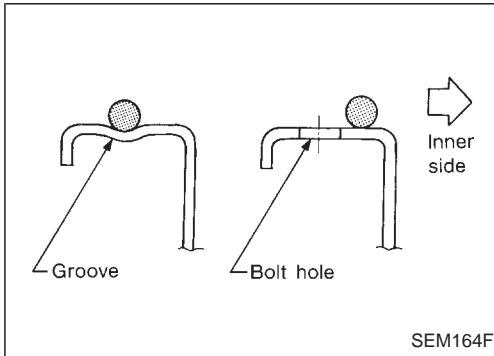
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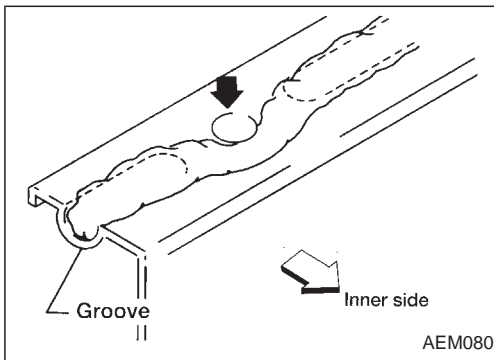
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Parts Requiring Angular Tightening

- Use an angle wrench for the final tightening of the cylinder head bolts.
- Do not use a torque value for final tightening.
- The torque value for these parts are for a preliminary step.
- Ensure thread and seat surfaces are clean and coated with engine oil.



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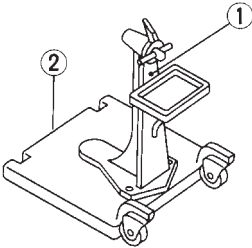
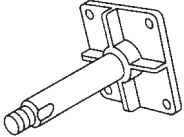
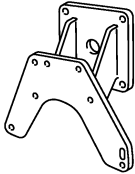
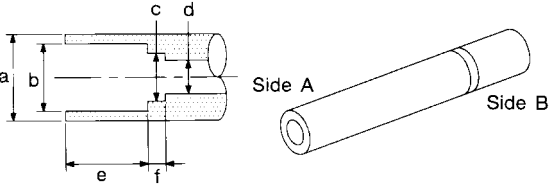
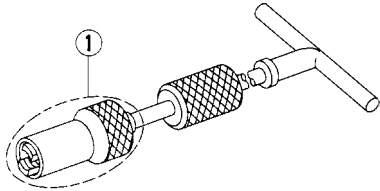
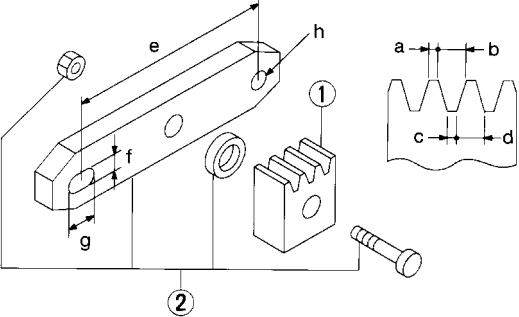


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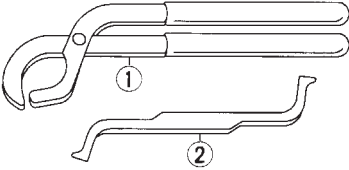
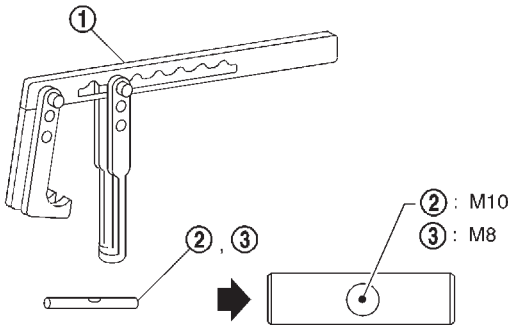
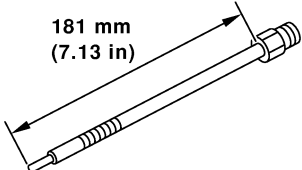
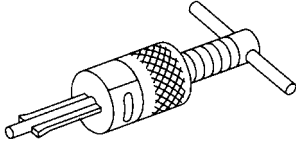
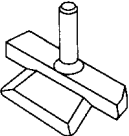
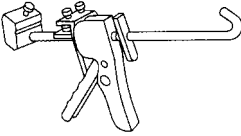
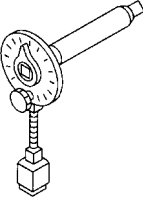
Liquid Gasket Application Procedure

1. Use a scraper to remove old liquid gasket from mating surfaces and grooves. Also, completely clean any oil from these areas.
2. Apply a continuous bead of liquid gasket to mating surfaces. (Use Genuine Liquid Gasket or equivalent.)
 - Be sure liquid gasket diameter is as specified.
3. Apply liquid gasket around the inner side of bolt holes (unless otherwise specified).
4. Assembly should be done within 5 minutes after coating.
5. Wait at least 30 minutes before refilling engine oil and engine coolant.

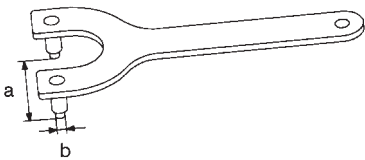
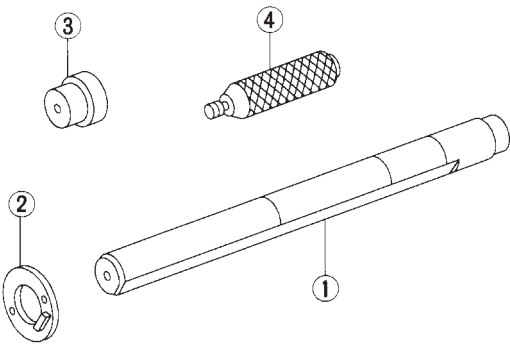
Special Service Tools

Tool number Tool name	Description
ST0501S00 Engine stand assembly ① ST05011000 Engine stand ② ST05012000 Base	 <p>Disassembling and assembling</p> <p>NT042</p>
KV10106500 Engine stand shaft	 <p>NT028</p>
KV11106101 Engine sub-attachment	 <p>NT819</p>
KV10115600 Valve oil seal drift	 <p>Installing valve oil seal</p> <p>Use side A. Side A a: 20 (0.79) dia. b: 13 (0.51) dia. c: 10.3 (0.406) dia. d: 8 (0.31) dia. e: 10.7 (0.421) f: 5 (0.20) Unit: mm (in)</p> <p>NT603</p>
KV10107902 Valve oil seal puller ① KV10116100 Valve oil seal puller adapter	 <p>Removing valve oil seal</p> <p>NT605</p>
KV101056S0 Ring gear stopper ① KV10105630 Adapter ② KV10105610 Plate	 <p>Preventing crankshaft from rotating</p> <p>a: 3 (0.12) b: 6.4 (0.252) c: 2.8 (0.110) d: 6.6 (0.260) e: 107 (4.21) f: 14 (0.55) g: 20 (0.79) h: 14 (0.55) dia. Unit: mm (in)</p> <p>NT617</p>

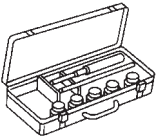
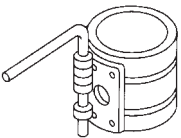
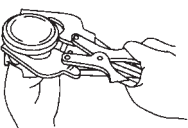
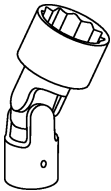
Special Service Tools (Cont'd)

Tool number Tool name	Description
KV101151S0 Lifter stopper set ① KV10115110 Camshaft pliers ② KV10115120 Lifter stopper	 <p>NT041</p> <p>Changing shims</p>
KV101092S0 Valve spring compressor ① KV10109210 Compressor ② KV10109220 Adapter	 <p>NT718</p> <p>Disassembling and assembling valve components</p>
ED19600620 Compression gauge adapter	 <p>NT820</p> <p>Checking compression pressure</p>
ST16610000 Pilot bushing puller	 <p>NT045</p> <p>Removing crankshaft pilot bushing</p>
KV10111100 Seal cutter	 <p>NT046</p> <p>Removing steel oil pan and rear timing chain case</p>
WS39930000 Tube presser	 <p>NT052</p> <p>Pressing the tube of liquid gasket</p>
KV10112100 Angle wrench	 <p>NT014</p> <p>Tightening bolts for bearing cap, cylinder head, etc.</p>

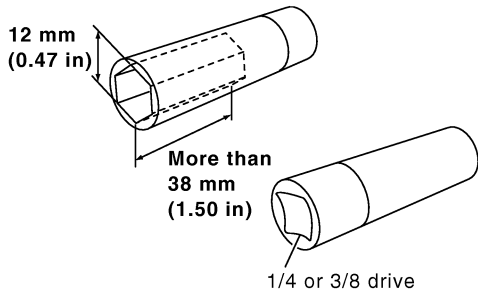
Special Service Tools (Cont'd)

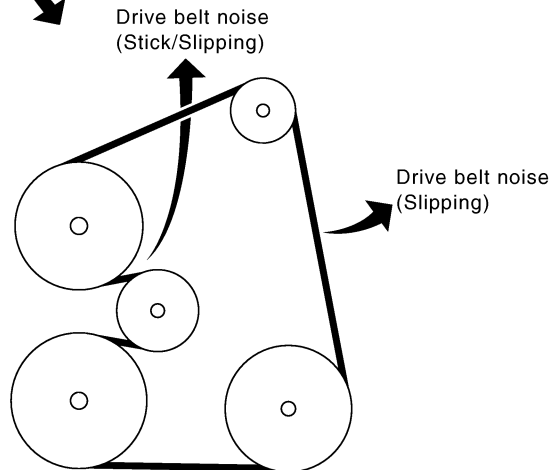
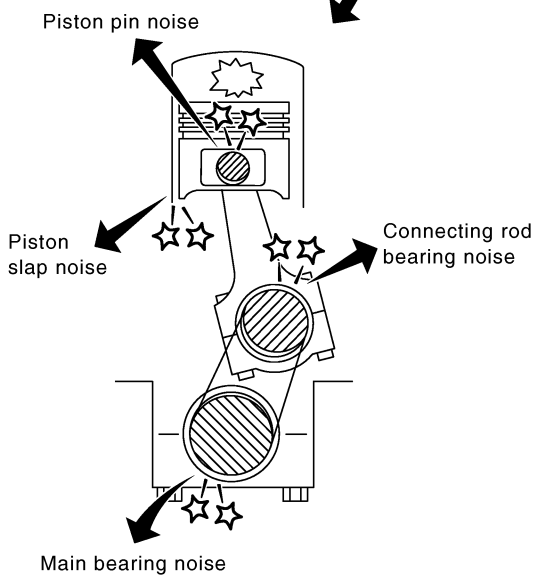
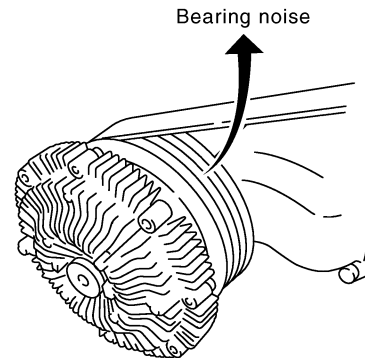
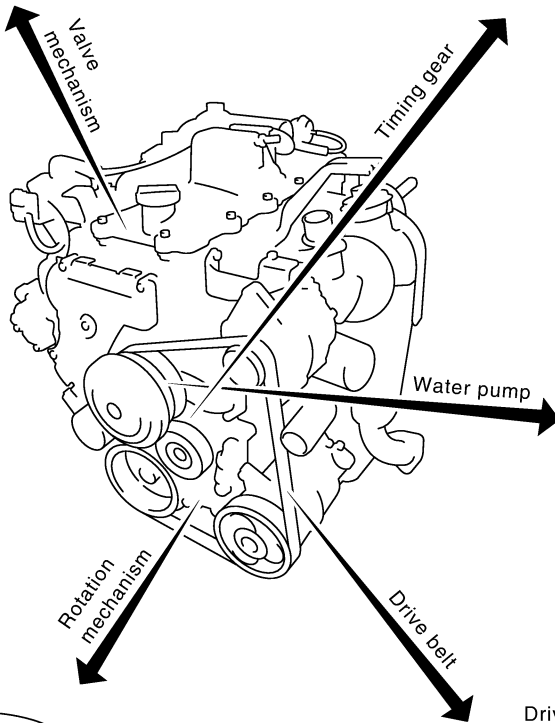
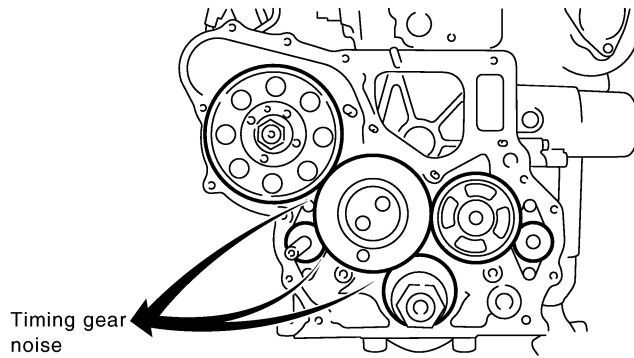
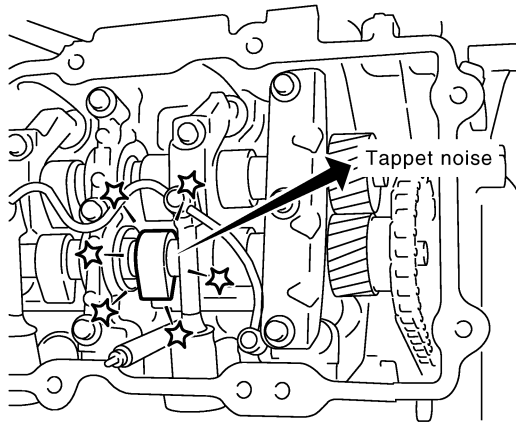
Tool number Tool name	Description
KV10109300 Pulley holder	 <p>NT628</p> <p>a: 68 mm (2.68 in) b: 8 mm (0.31 in) dia.</p>
KV111045S1 Balancer shaft bearing replacer set ① KV11104510 Replacer bar ② KV11104521 Guide plate ③ KV11104530 Adapter (Front bearing) ④ ST15243000 Drift	 <p>NT258</p> <p>Removing and installing balancer shaft bearing</p>

Commercial Service Tools

Tool name	Description
Valve seat cutter set	 <p>NT048</p> <p>Finishing valve seat dimensions</p>
Piston ring compressor	 <p>NT044</p> <p>Installing piston assembly into cylinder bore</p>
Piston ring expander	 <p>NT030</p> <p>Removing and installing piston ring</p>
Standard Universal	 <p>NT808</p> <p>Removing and installing transmission mount</p>

Commercial Service Tools (Cont'd)

Tool name	Description
Deep socket (12 mm)	<p data-bbox="1013 191 1370 226">Removing and installing glow plugs</p>  <p data-bbox="444 514 505 541">NT821</p>



NVH Troubleshooting Chart — Engine Noise

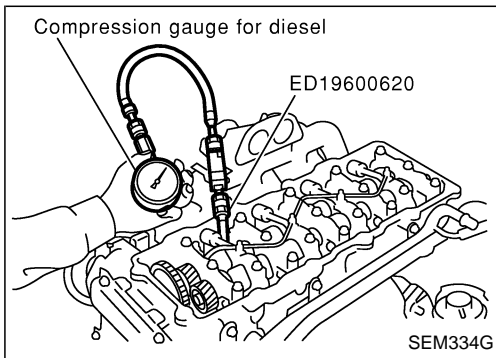
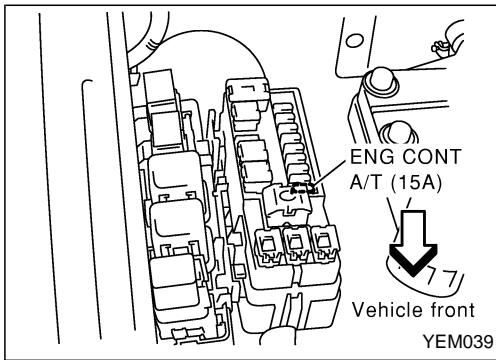
Use the chart below to help you find the cause of the symptom.

1. Locate the area where noise occurs.
2. Confirm the type of noise.
3. Specify the operating condition of engine.
4. Check specified noise source.

If necessary, repair or replace these parts.

Location of noise	Type of noise	Operating condition of engine						Source of noise	Check item	Reference page
		Before warm-up	After warm-up	When starting	When idling	When racing	While driving			
Top of engine Rocker cover Cylinder head	Ticking or clicking	C	A	—	A	B	—	Tappet noise	Valve clearance	MA section ("Adjusting Intake & Exhaust Valve Clearance", "ENGINE MAINTENANCE")
	Rattle	C	A	—	A	B	C	Camshaft bearing noise	Camshaft bushing clearance Camshaft runout	EM-31, 31
Crankshaft pulley Cylinder block (Side of engine) Oil pan	Slap or knock	—	A	—	B	B	—	Piston pin noise	Piston and piston pin clearance Connecting rod bushing clearance	EM-71, 73
	Slap or rap	A	—	—	B	B	A	Piston slap noise	Piston-to-bore clearance Piston ring side clearance Piston ring end gap Connecting rod bend and torsion	EM-75, 72, 72, 73
	Knock	A	B	C	B	B	B	Connecting rod bearing noise	Connecting rod bushing clearance (Small end) Connecting rod bearing clearance (Big end)	EM-73, 77
	Knock	A	B	—	A	B	C	Main bearing noise	Main bearing oil clearance Crankshaft runout	EM-78, 76
Front of engine Timing gear cover	Tapping or ticking	A	A	—	B	B	B	Timing gear noise	Timing gear backlash	EM-41
Front of engine	Squeaking or fizzing	A	B	—	B	—	C	Other drive belts (Sticking or slipping)	Drive belts deflection	MA section ("Checking Drive Belts", "ENGINE MAINTENANCE")
	Creaking	A	B	A	B	A	B	Other drive belts (Slipping)	Idler pulley bearing operation	MA section ("Checking Drive Belts", "ENGINE MAINTENANCE")
	Squall Creak	A	B	—	B	A	B	Water pump bearing noise	Water pump bearing operation	LC section ("Water Pump Inspection", "ENGINE COOLING SYSTEM")

A: Closely related B: Related C: Sometimes related —: Not related



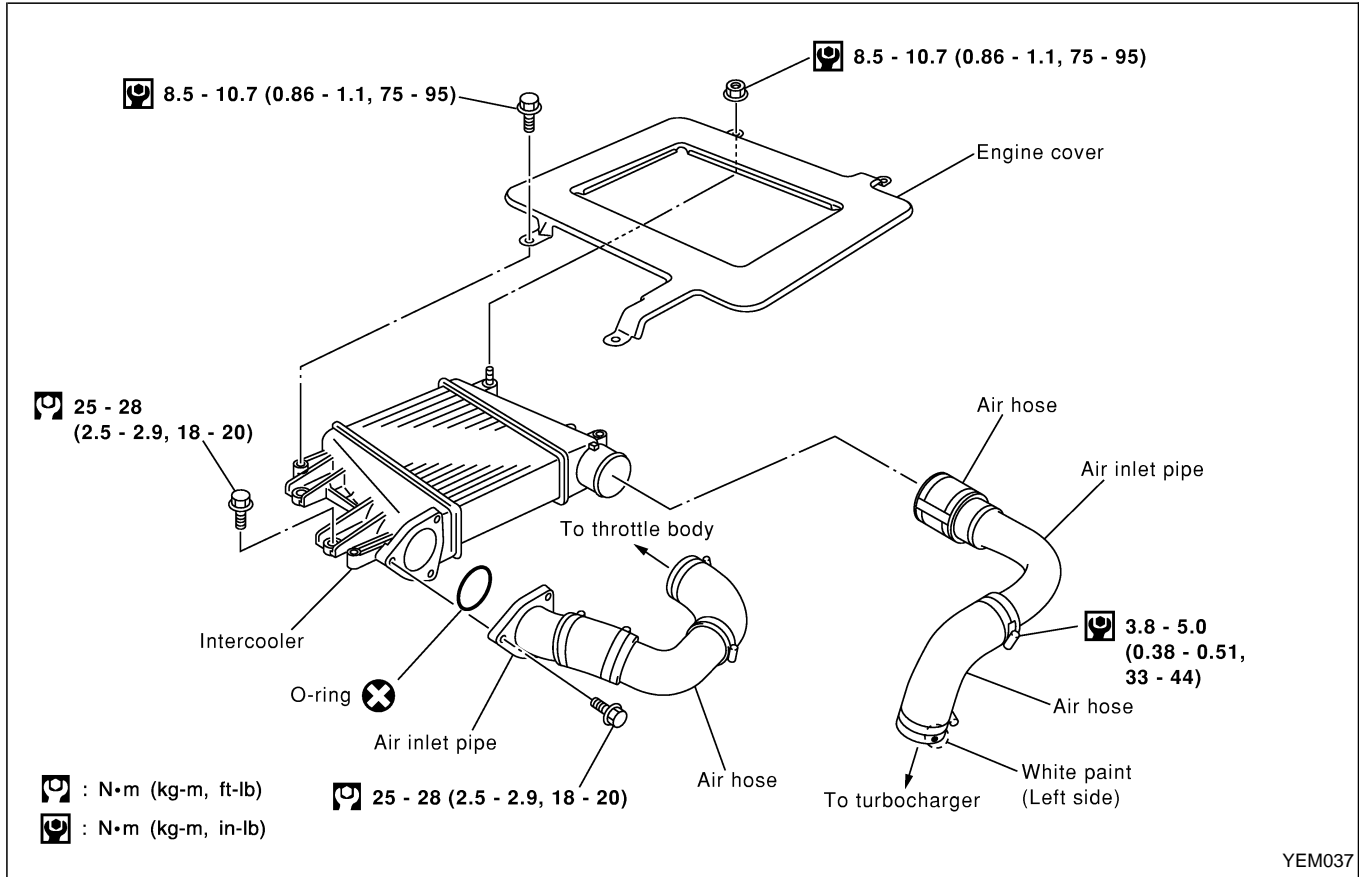
1. Warm up engine.
2. Turn ignition switch OFF.
3. Using CONSULT-II, make sure no error codes are indicated for self-diagnosis items. Refer to EC section, "Fuel Pressure Release".
 - Do not disconnect CONSULT-II until the end of this operation; it will be used to check engine rpm and for error detection at the end of this operation.
4. Disconnect the negative battery terminal.
5. Remove the following parts.
 - Intercooler
 - Throttle body
 - Rocker cover
6. To prevent fuel from being injected during inspection, remove fuel injection pump fuse [ENG CONT A/T (15A)] from fuse box on the right side of engine compartment.
7. Remove glow plugs from all the cylinders.
 - **Before removal, clean the surrounding area to prevent entry of any foreign materials into the engine.**
 - **Carefully remove glow plugs to prevent any damage or breakage.**
 - **Handle with care to avoid applying any shock to glow plugs.**
8. Install adapter (SST) to installation holes of glow plugs and connect compression gauge for diesel engine.
 - **Torque: 15 - 19 N·m (1.5 - 2.0 kg-m, 11 - 14 ft-lb)**
9. Connect battery negative terminal.
10. Set the ignition switch to "START" and crank. When gauge pointer stabilizes, read compression pressure and engine rpm. Repeat the above steps for each cylinder.
 - **Always use a fully-charged battery to obtain specified engine speed.**

Unit: kPa (bar, kg/cm², psi)/rpm

Standard	Minimum	Difference limit between cylinders
2,942 (29.42, 30.0, 427)/ 200	2,452 (24.52, 25.0, 356)/ 200	294 (2.94, 3.0, 43)/200

- When engine rpm is out of the specified range, check the specific gravity of battery liquid. Measure again under corrected conditions.
 - If engine rpm exceeds the limit, check valve clearance and combustion chamber components (valves, valve seats, cylinder head gaskets, piston rings, pistons, cylinder bores, cylinder block upper and lower surfaces) and measure again.
11. Complete this operation as follows:
 - a. Turn the ignition switch to "OFF".
 - b. Disconnect battery negative terminal.
 - c. Replace glow plug oil seals and install glow plugs.
 - d. Install fuel injection pump fuse [ENG CONT A/T (15A)].
 - e. Connect battery negative terminal.
 - f. Using CONSULT-II make sure no error code is indicated for items of self-diagnosis. Refer to EC section, "Trouble Diagnosis — Index".

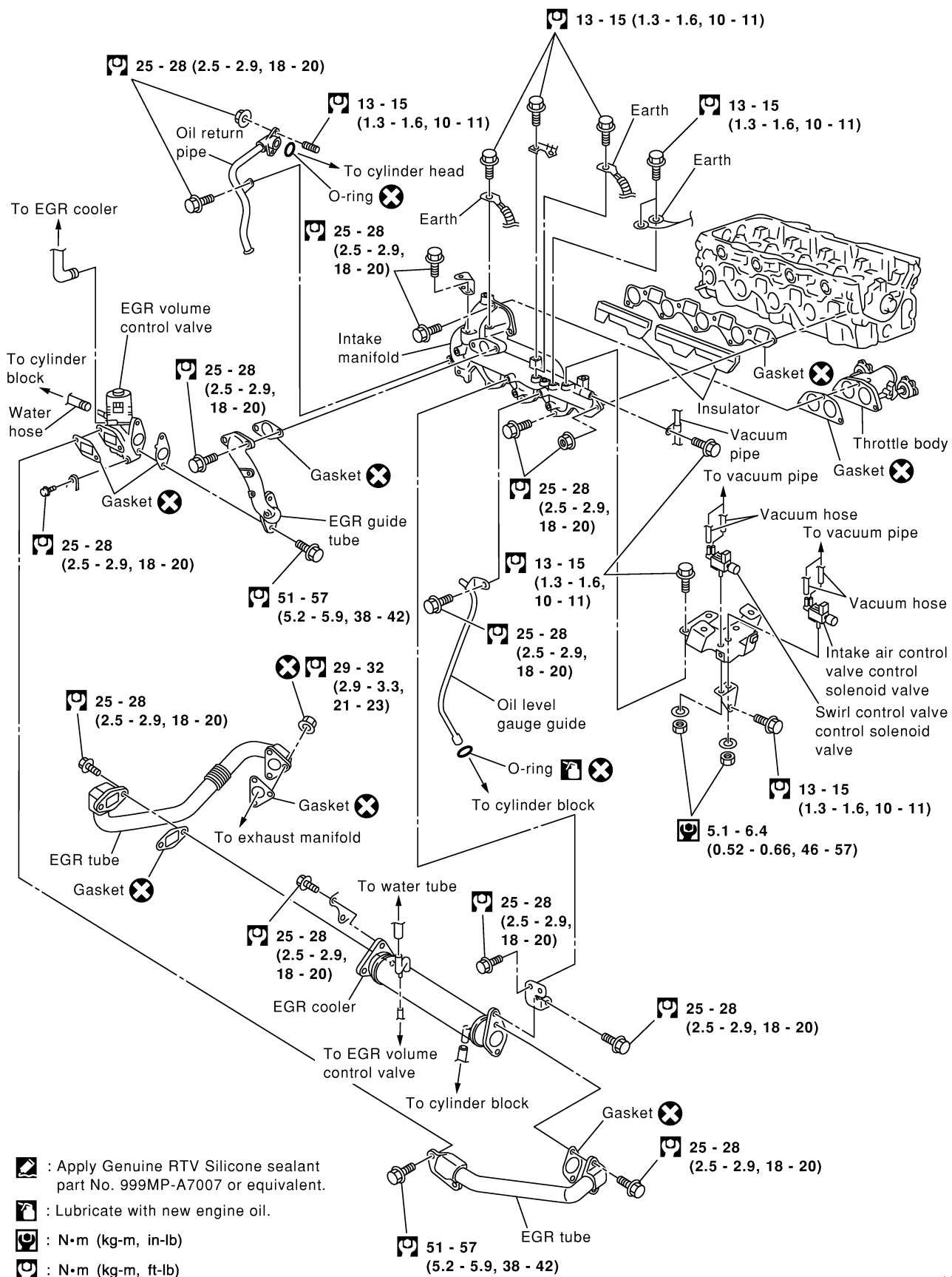
Removal and Installation



CAUTION:

To avoid damaging intercooler core when flushing intercooler with high pressure water, apply water straight to the core face.

Removal and Installation

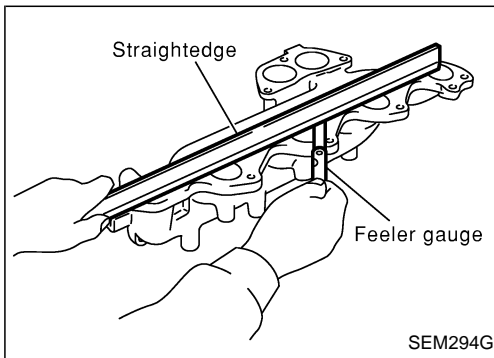
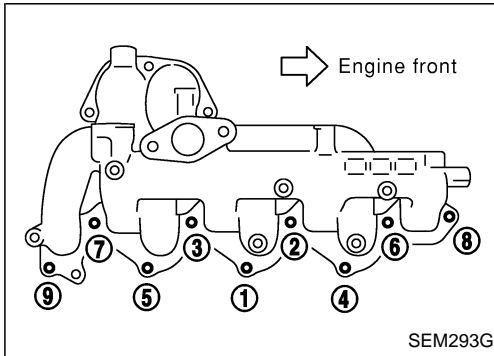


Removal and Installation (Cont'd)

REMOVAL

1. Remove the following parts.
 - Drain engine coolant. Refer to MA section, "Changing Engine Coolant".
 - Remove engine cover. Refer to the figure at left.
 - Remove intercooler.
 - Remove air hose (on throttle body side).
 - Remove injection tube.
 - Remove or relocate wires/harnesses and tubes/pipes.

2. Remove intake manifold in the reverse order of that shown in the figure.



Inspection

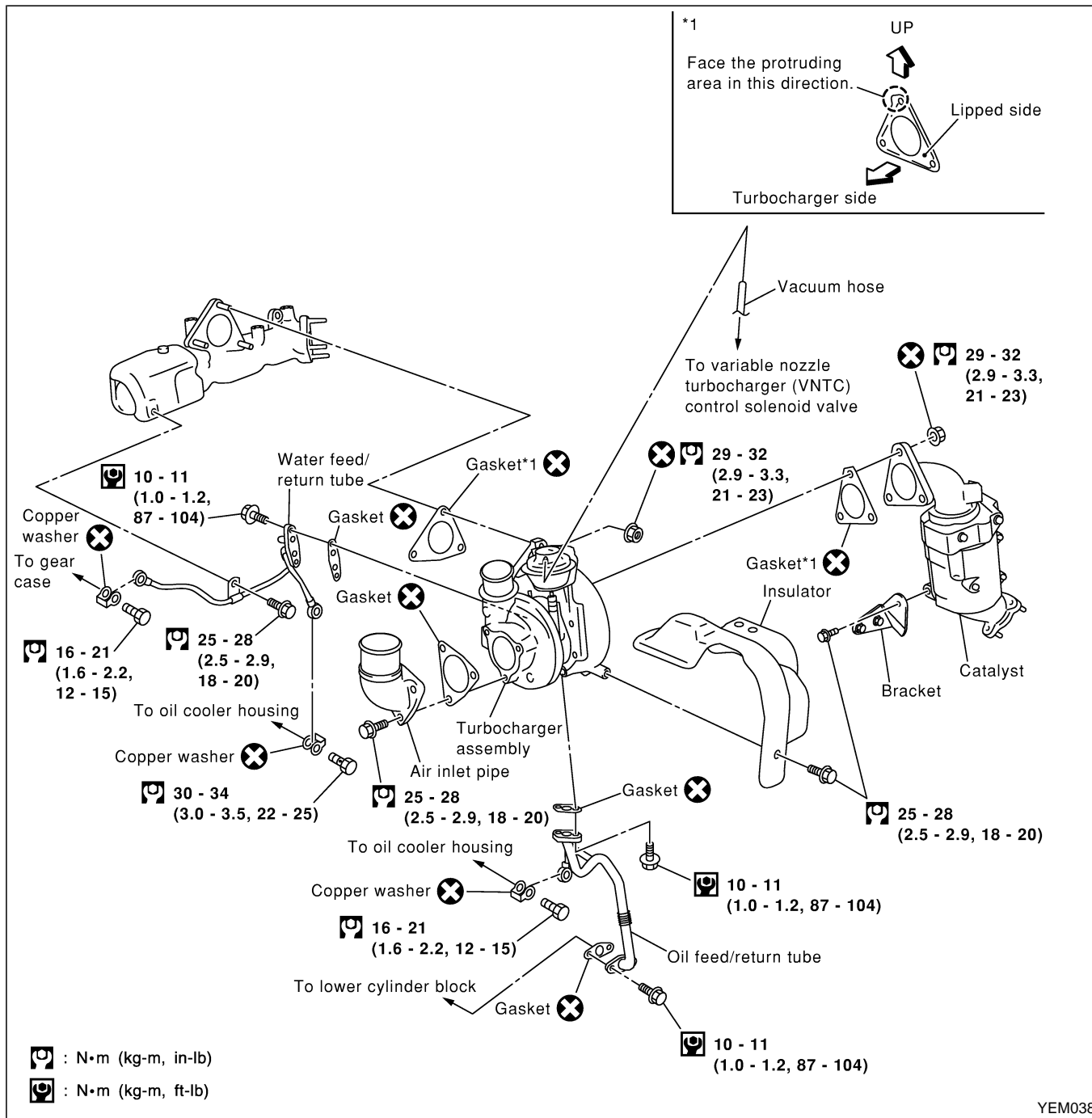
Clean surface of intake manifold.
 Use a reliable straightedge and feeler gauge to check the flatness of intake manifold surface.

**Intake manifold surface flatness:
 Limit 0.2 mm (0.008 in)**

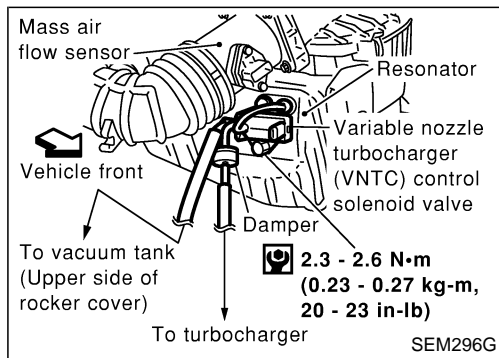
INSTALLATION

1. Tighten intake manifold in the numerical order shown in the figure.
⊙: **25 - 28 N·m (2.5 - 2.9 kg-m, 18 - 20 ft-lb)**
2. Install in the reverse order of removal.

Removal and Installation



YEM038



REMOVAL

1. Remove the following parts.
 - Undercover
 - Under guard
 - Engine coolant (drain)
Refer to MA section, "Changing Engine Coolant".
 - Exhaust front tube
Refer to FE section, "Removal and Installation", "EXHAUST SYSTEM".
 - Remove wires, harnesses, tubes and pipes.

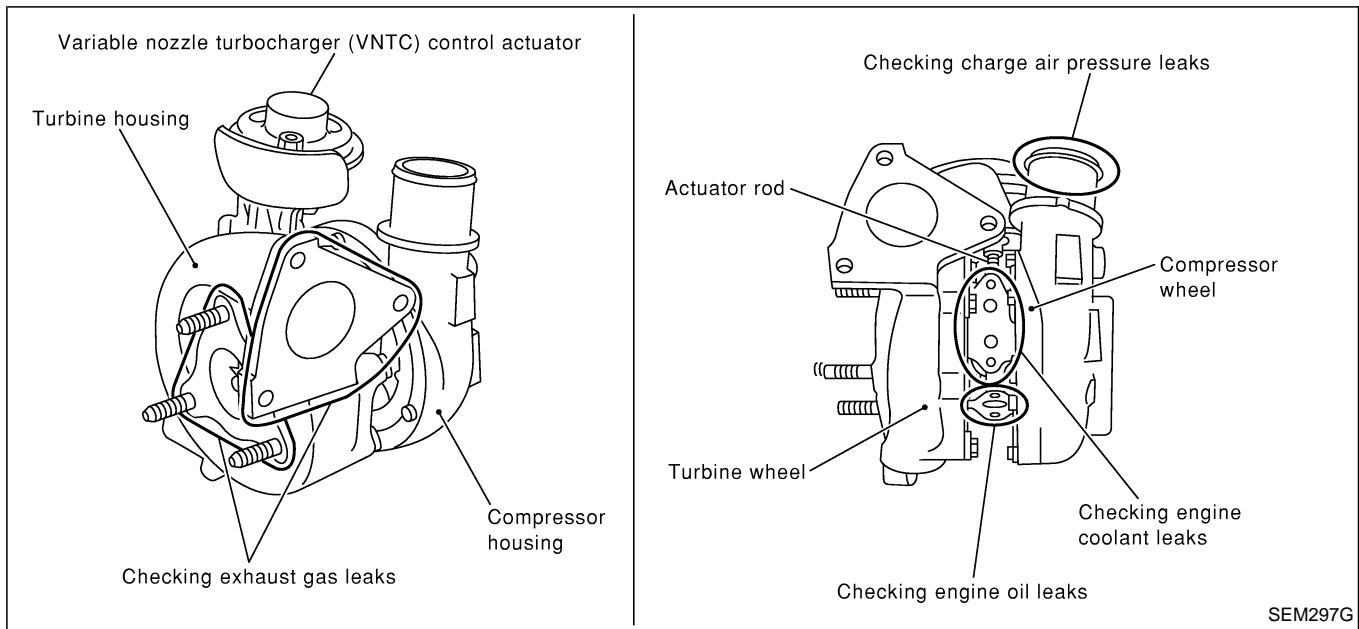
Removal and Installation (Cont'd)

2. Remove catalyst.

CAUTION:
Do not disassemble catalyst.

Inspection

TURBOCHARGER

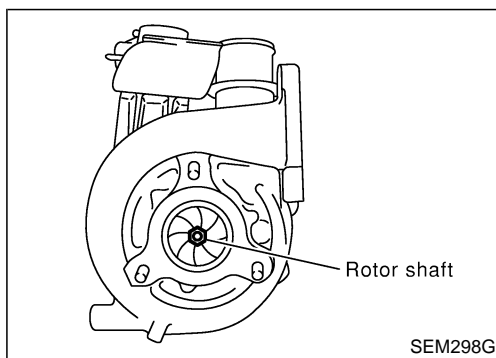


CAUTION:

When the compressor wheel, turbine wheel, or rotor shaft is damaged, remove all the fragments and foreign matter left in the following passages in order to prevent a secondary failure:

Suction side: Between turbocharger and intercooler

Exhaust side: Between turbocharger and catalytic converter



Rotor shaft

- Check that the rotor shaft rotates smoothly without any resistance when it is rotated by your fingertips.
- Check that the rotor shaft is not loose when it is moved vertically or horizontally.

Standard value for rotor shaft oil clearance:

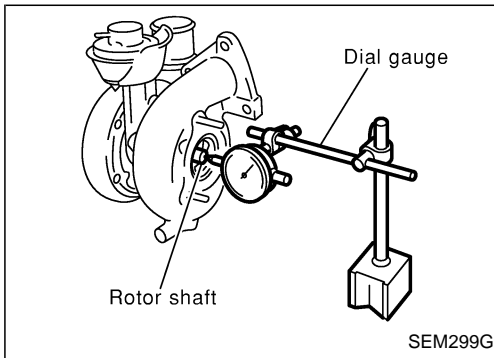
0.086 - 0.177 mm (0.0034 - 0.0070 in)

Inspection (Cont'd)

Rotor shaft end play

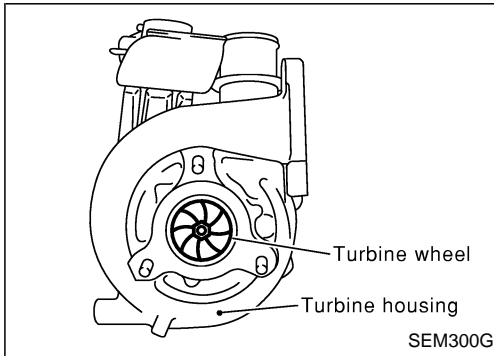
Place a dial gauge at the rotor shaft end in the axial direction to measure the end play.

Standard: 0.044 - 0.083 mm (0.0017 - 0.0033 in)



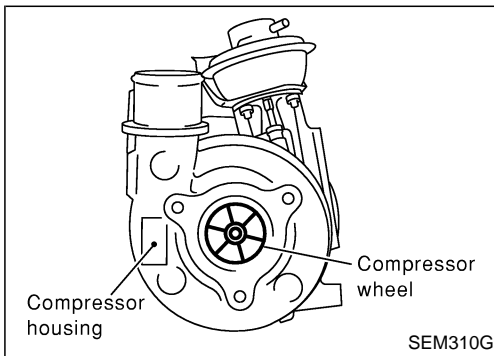
Turbine wheel

- Check that there is no oil adhesion.
- Check that there is no carbon accumulation.
- Check that blades of the turbine wheel are not bent or broken.
- Check that the turbine wheel does not interfere with the turbine housing.



Compressor wheel

- Check that there is no oil adhesion inside the air inlet.
- Check that the compressor wheel does not interfere with the compressor housing.
- Check that the wheel is not bent or broken.



VNT control actuator

- Connect the handy pump to the actuator, and check that the rod strokes smoothly in compliance with the following pressure.
- First, apply the inspection negative pressure of about -66.7 kPa (-667 mbar, -500 mmHg, 19.69 inHg), and then measure the values while reducing the negative pressure to 0.

Standard (Vacuum pressure/rod stroke amount):

-46.9±1.3 kPa (-469±13 mbar, -352±10 mmHg,

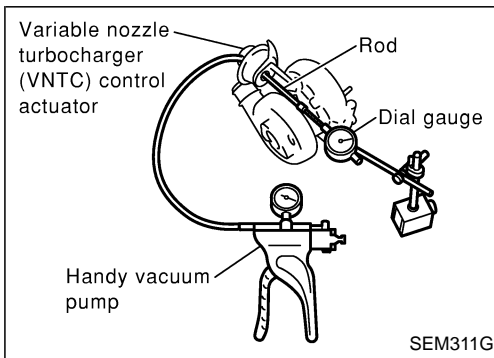
-13.86±0.39 inHg)/0.2 mm (0.008 in)

-30.8±0.7 kPa (-308±7 mbar, -231±5 mmHg,

-9.09±0.20 inHg)/5.0 mm (0.197 in)

Approximately -22.7 kPa (-227 mbar, -170 mmHg,

-6.69 inHg)/Rod stroke end



Inspection (Cont'd)

Trouble diagnosis of turbocharger

Preliminary check:

Check that the VNT control valve system has no malfunction. Refer to EC section, "ECM Terminals and Reference Value" in "TROUBLE DIAGNOSIS — GENERAL DESCRIPTION".


- Check that the engine oil level is between MIN and MAX of the dipstick. (When the engine oil amount is more than MAX, the oil flows into the inlet duct through the blow-by gas passage, and the turbocharger is misjudged failure.)
- Ask the customer if he/she always runs the vehicle in idle engine speed to cool the oil down after driving.
- Replace the turbocharger assembly when any malfunction is found after unit inspections specified in the table below.
- If no malfunction is found after the unit inspections, judge that the turbocharger body has no failure. Check the other parts again.

Inspection item	Inspection result	Symptom (when each inspection item meets each inspection result)			
		Oil leakage	Smoke	Noise	Insufficient power/acceleration failure
Turbine wheel	Oil leaks.	△	◎	△	△
	Carbon is accumulated.	△	◎	○	○
	Friction with housing.	△	○	◎	○
	Blades are bent or broken.			◎	◎
Compressor wheel	Inside the air inlet is seriously contaminated by oil.	○	○		
	Friction with housing.	△	○	◎	○
	Blades are bent or broken.			◎	◎
After checking both turbine and compressor, inspect rotor shaft end play.	There is resistance when the rotor shaft is rotated by your fingertips.		△	△	○
	The rotor shaft sometimes does not rotate by your fingertips.				◎
	There is too much play in the bearing.	△	△	○	△
Oil return port	Carbon or sludge is accumulated in the waste oil hole.	△	◎	△	△
Operation of VNT control actuator	<ul style="list-style-type: none"> ● The actuator does not operate smoothly when vacuum pressure is gradually applied. ● Stroke amount is not in compliance with the vacuum pressure. 		○		◎

◎: Large possibility
 ○: Medium possibility
 △: Small possibility

INSTALLATION

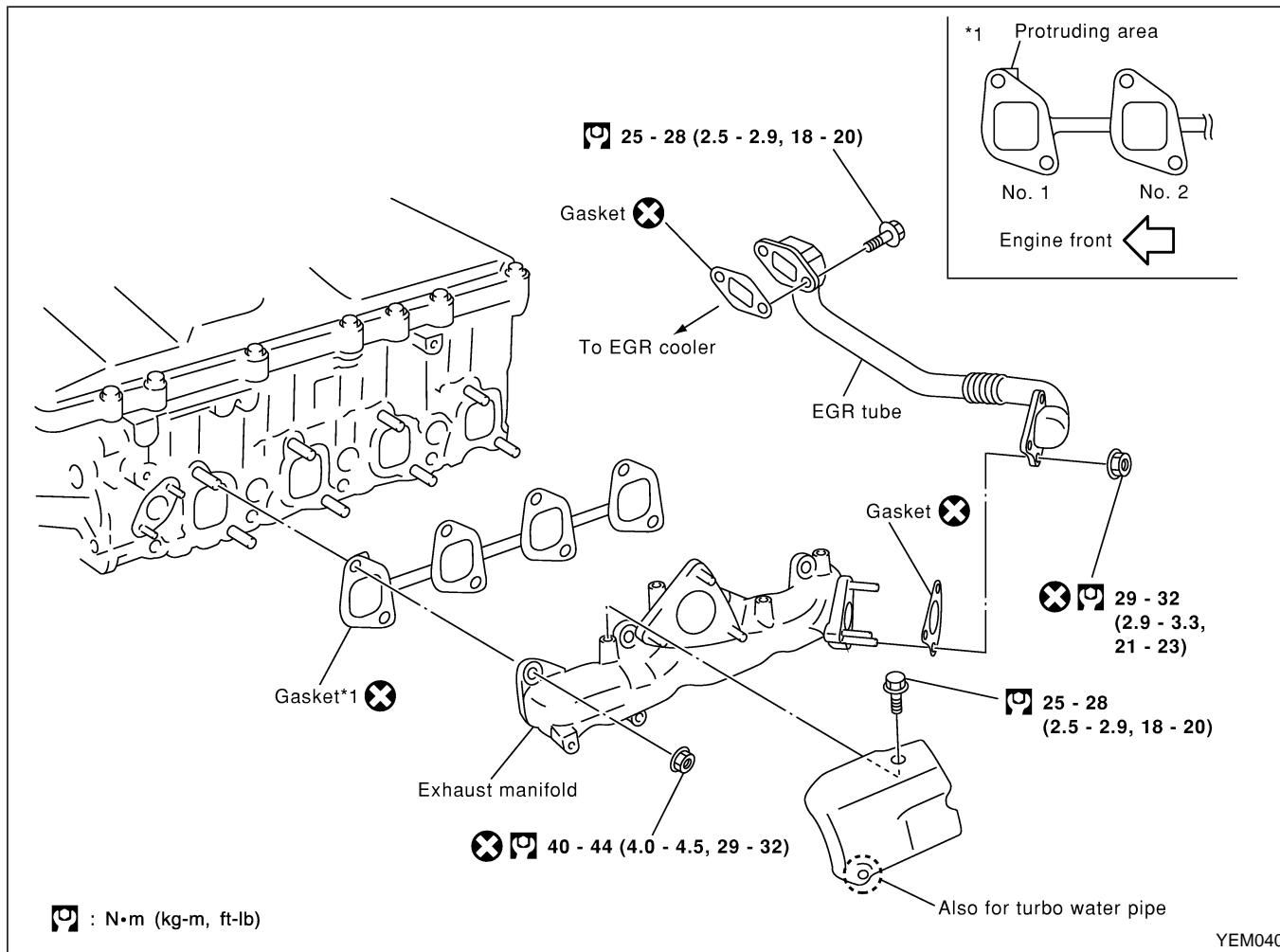
1. Install catalyst.

: **29 - 39 N·m (2.9 - 3.3 kg-m, 21 - 23 ft-lb)**

Place the protruding area of the gasket between the turbocharger and the exhaust outlet upwards, and install the lipped side to the turbocharger side. Refer to the figure, EM-14.

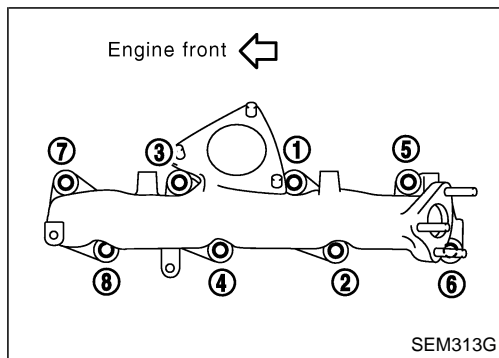
2. Install in the reverse order of removal.

Removal and Installation

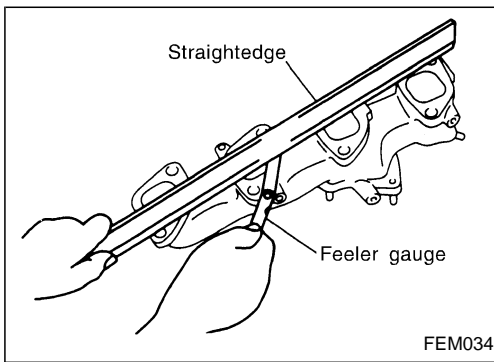


REMOVAL

1. Remove the following parts.
 - Refer to "PREPARATIVE WORK" in "CATALYST AND TURBOCHARGER", EM-14.
 - Remove catalytic converter.
 - Remove turbocharger.



2. Loosen nuts holding the exhaust manifold in the reverse order of that shown in the figure.



Inspection


EXHAUST MANIFOLD

Check distortion on mounting surface with straightedge and feeler gauge.

Limit: 0.2 mm (0.008 in)

INSTALLATION

1. Tighten exhaust manifold holding nuts in the numerical order shown in the figure.

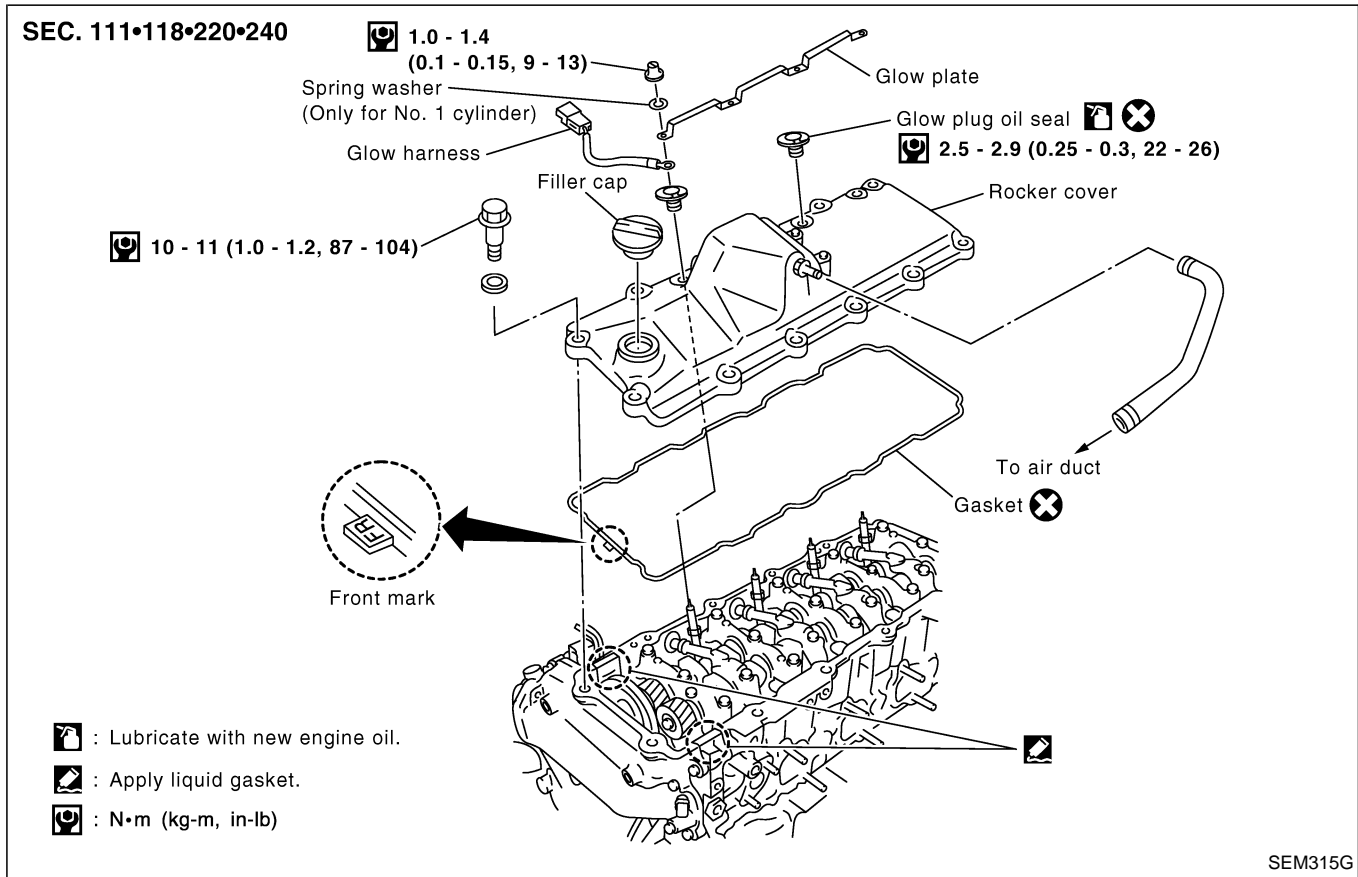
: 40 - 44 N·m (4.0 - 4.5 kg-m, 29 - 32 ft-lb)

NOTE:

Install gasket so that the protruding tab (mark for correct installation) is positioned on the side of No. 1 port (front side). Refer to component structure diagram on the previous page.

2. Install in the reverse order of removal.

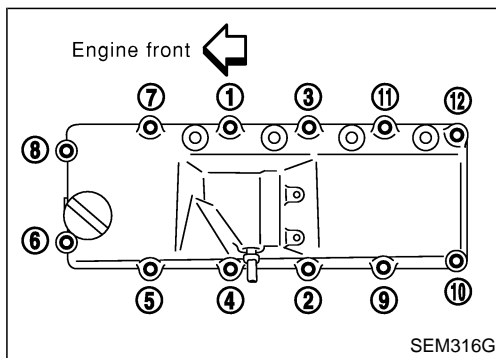
Removal and Installation



REMOVAL

1. Remove the following parts.

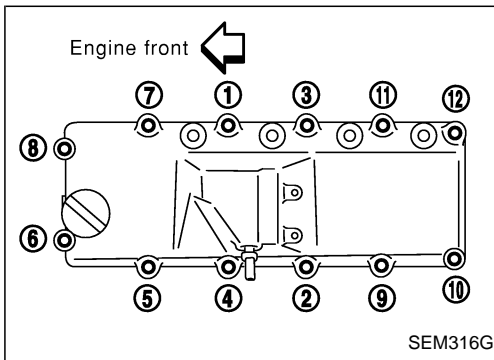
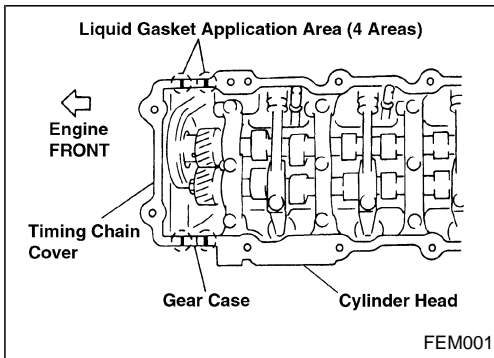
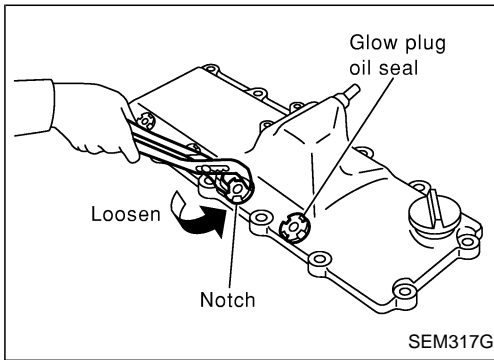
- Engine cover
- Intercooler
- Air inlet pipe
- Throttle body
- Wires, harnesses, tubes and pipes



2. Loosen holding bolts in the reverse order of that shown in the figure and remove.
3. Remove rocker cover to the direction of glow plug tilt.
4. Remove glow plug oil seals.

Removal and Installation (Cont'd)

INSTALLATION



1. Temporarily tighten holding bolts in the numerical order shown in the figure.

2. Apply Three Bond 1207C (KP510 00150) to the area shown in the figure.

3. Use a scraper to remove old liquid gasket.

4. Apply once more.

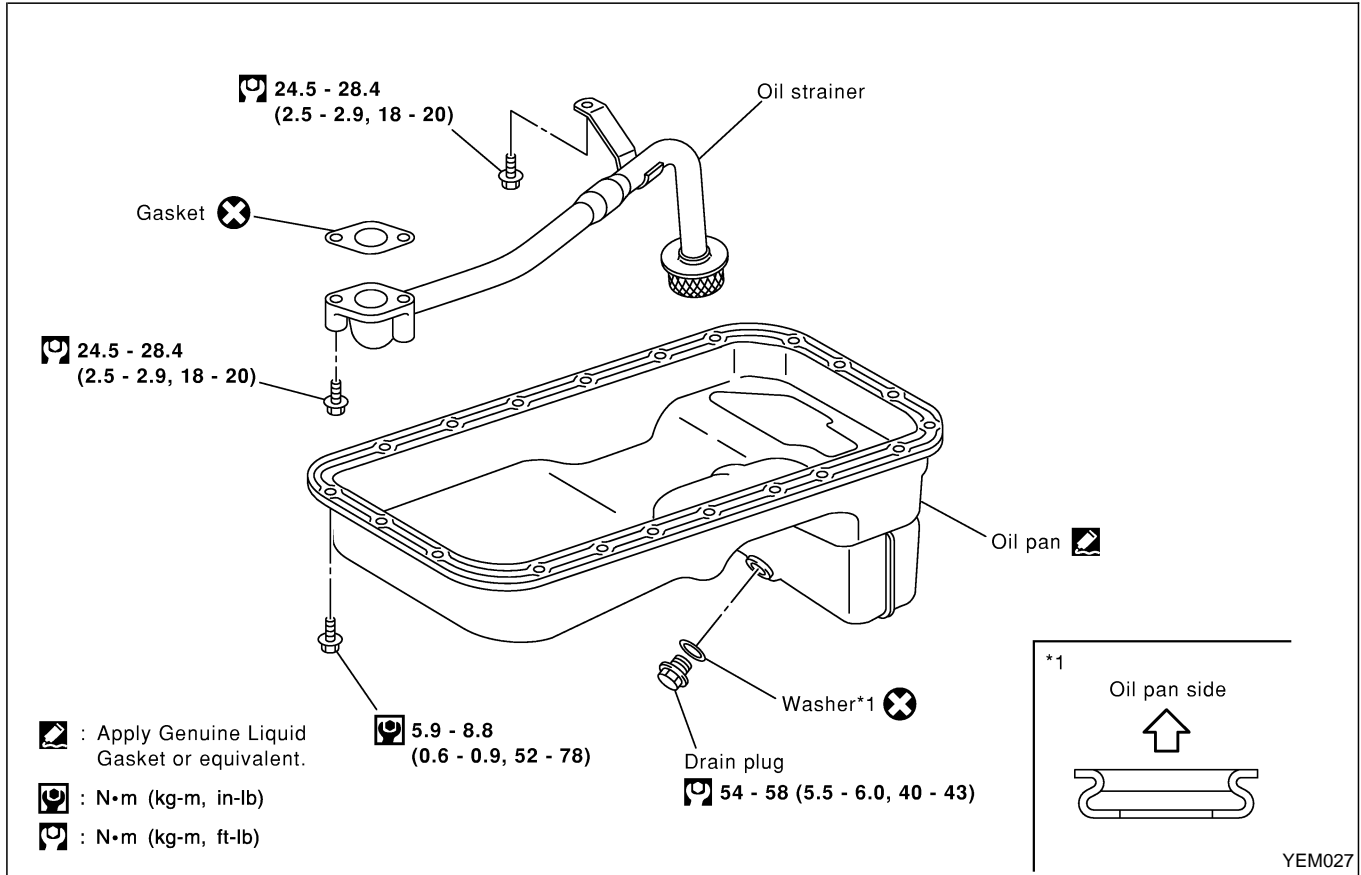
5. Apply engine oil to glow plug oil seals and install them.

6. Tighten holding bolts in the numerical order shown in the figure.

7. Re-tighten to the same torque in the same order as above.

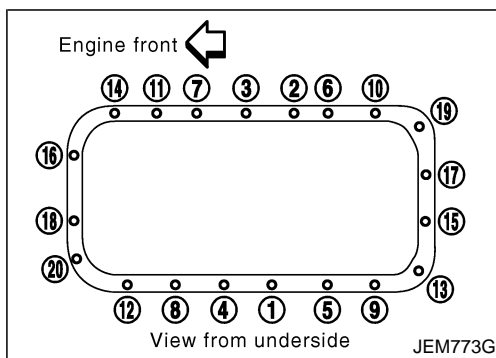
8. Install in the reverse order of removal.

Removal and Installation



REMOVAL

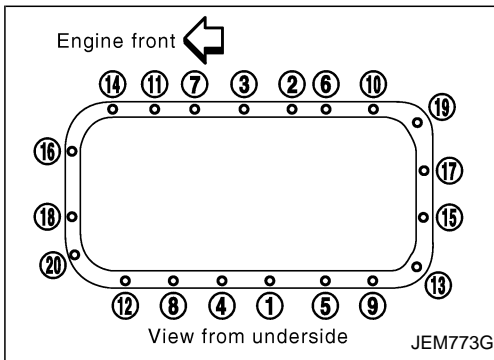
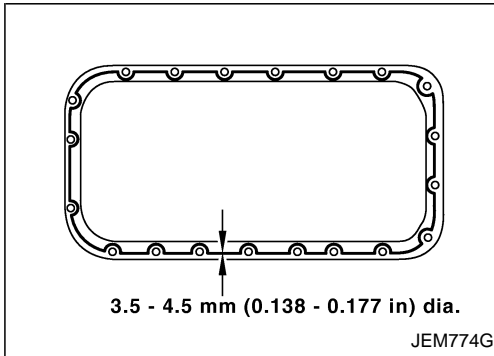
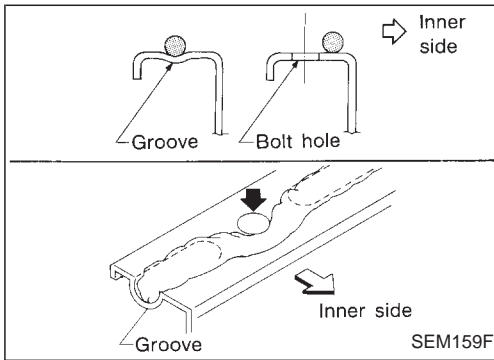
1. Drain engine oil.
2. Remove the following parts.
 - Under guard
 - Crossmember, differential member, front final drive assembly
 - Engine gusset



3. Loosen and remove oil pan installation bolts in reverse order of numbers in the figure.
4. Use a seal cutter (special service tool) to cut away liquid gasket and remove oil pan.
5. Remove oil strainer.

Removal and Installation (Cont'd)

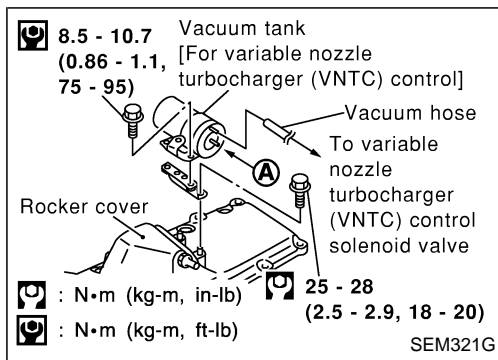
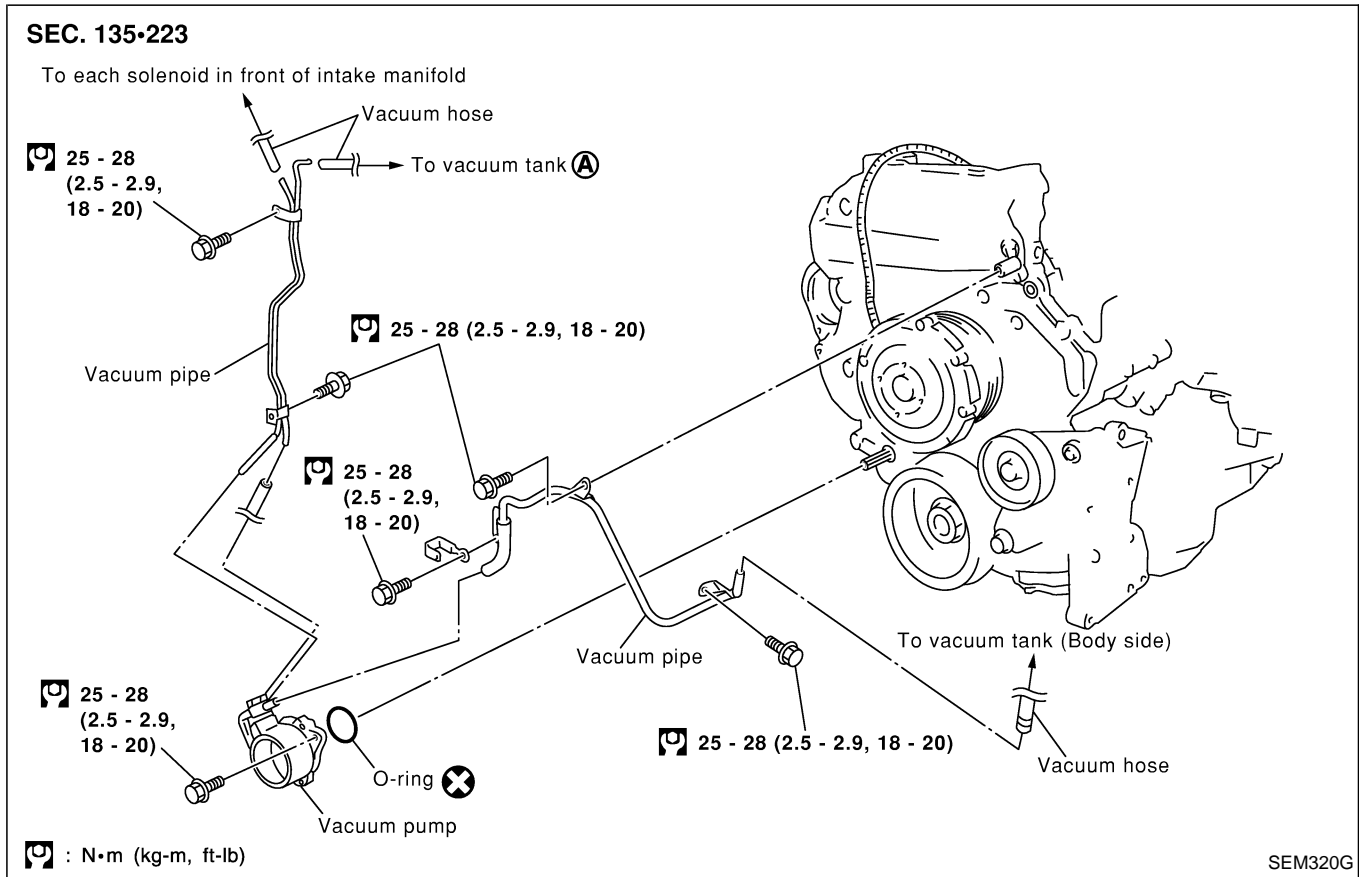
INSTALLATION



1. Install oil strainer.
2. Install oil pan.
 - a. Use a scraper to remove all traces of liquid gasket from mating surfaces.
 - Also remove traces of liquid gasket from mating surface of cylinder block, front cover.
 - **Remove old liquid gasket from the bolt hole and thread.**
 - b. Apply a continuous bead of liquid gasket to mating surface of oil pan.
 - **Use Genuine Liquid Gasket or equivalent.**
 - **Apply liquid gasket to the groove on the mating surface.**
 - **Allow 8 mm (0.31 in) clearance around center of bolt holes.**
 - c. Apply liquid gasket to inner sealing surface as shown in figure.
 - **Be sure liquid gasket is 2.0 to 3.0 mm (0.079 to 0.188 in).**
 - **Attaching should be done within 5 minutes after coating.**

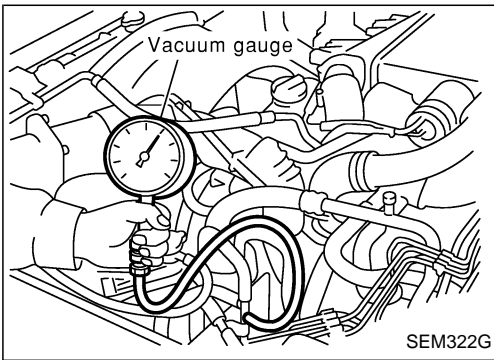
2. Tighten the mounting bolts in the order shown in the figure. Then tighten in the same order to the torque stated.
3. The torque of the installation bolts will differ depending on position.
4. Install in the reverse order of removal.

Removal and Installation



REMOVAL

1. Remove the following parts.
 - Radiator under side
 - Radiator shroud
 - Cooling fan
 - Chain cover front side
 - A/T cooler hose (Disconnect)
 - Vacuum hose
 - Intercooler cover (When removing vacuum tank)
2. Remove the installation bolts and pull the vacuum pump from the engine front directly.
3. If it is difficult to remove from the spline shaft connection, tap lightly with a plastic hammer.

Removal and Installation (Cont'd)**INSPECTION**

1. Remove the vacuum hose. Connect the vacuum gauge through the 3-way connector. Otherwise, remove the welch valve of the vacuum pipe and attach the vacuum gauge directly. (The illustration shows the second method.)
 - Remove an appropriate part to measure the vacuum pump load pressure directly and install the vacuum gauge. Refer to the figure.
2. Start the engine, and measure the load pressure with the engine idling.

Vacuum pressure:**Standard**

-93.3 to -101.3 kPa (-933 to -1,013 mbar, -700 to -760 mmHg, -27.56 to -29.92 inHg)

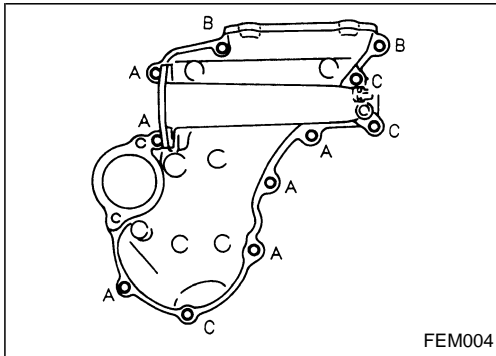
3. If outside the standard value, make sure that there is no intake of air within the circuit and measure again.
4. Replace the vacuum pump if still outside the standard value.

INSTALLATION

- Install in the reverse order of removal.

Removal (Cont'd)

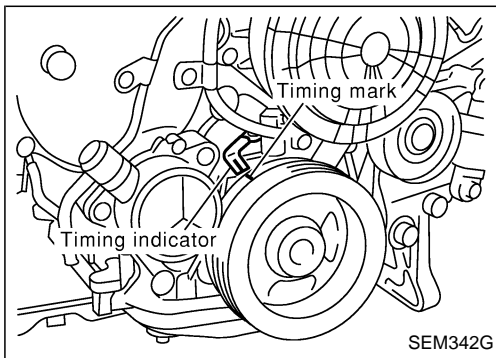
2. Move the following parts.
 - TDC sensor harness
 - Power steering oil pump



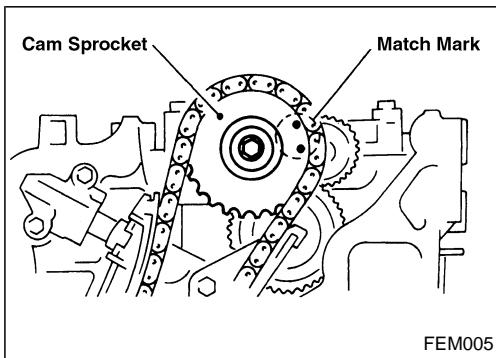
3. Remove the chain cover.
 - Remove the holding bolts A to C shown in the figure.

CAUTION:

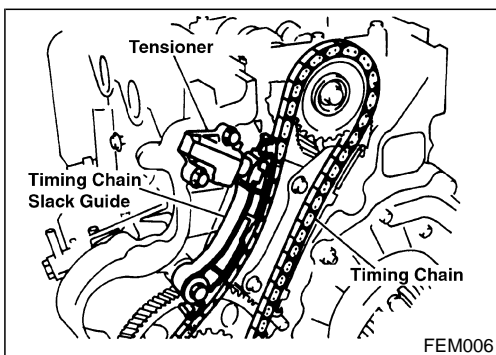
While the chain cover is removed, be careful not to allow entry of dust or foreign objects.



4. Set the No. 1 cylinder to the TDC.
 - 1) Turn the crankshaft pulley clockwise, and match the timing indicator of the gear case to the timing mark of the crankshaft pulley.



- 2) Make sure that the cam sprocket match mark is in the position shown in the figure.
 - If the match mark is not in position, turn the crankshaft pulley once more and position it.
 - When removing at No. 1 cylinder TDC, each sprocket and chain is fitted using the match mark, therefore there is no need to apply any match marks beforehand.



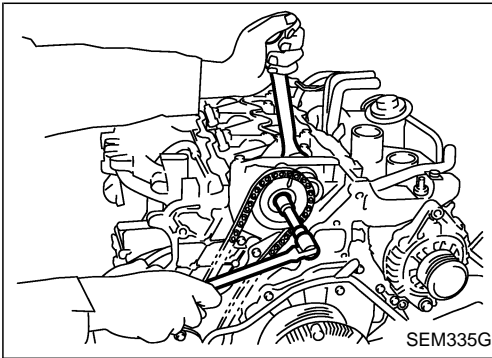
5. Remove the chain tensioner.
 - 1) Loosen upper and lower holding bolts.
 - 2) Holding the chain tensioner in your hand, remove the upper holding bolt and release the spring tension.
 - 3) Remove the lower holding bolt, then remove the chain tensioner.
 - The chain tensioner does not have a mechanism which prevents the ejection of the plunger. (It does have a mechanism which prevents the plunger from returning.)

CAUTION:

Be careful not to drop the plunger and spring.

TIMING CHAIN

Removal (Cont'd)



6. Remove the timing chain slack guide.
7. Remove the timing chain with cam sprocket.
 - Loosen the cam sprocket holding bolt by fixing the hexagonal portion of the intake manifold side camshaft with a spanner, etc.
 - If the spill tube is not removed, fix the hexagonal portion of the exhaust manifold side camshaft.

CAUTION:

Do not loosen the holding bolt by using the tension of the chain.

8. Remove the timing chain tension guide.

Installation

1. Install the timing chain tension guide.
2. Install the cam sprocket and the timing chain together.
 - Install by aligning the sprocket and timing chain match marks.
 - Tighten the cam sprocket holding bolt by fixing the hexagonal portion of the camshaft.

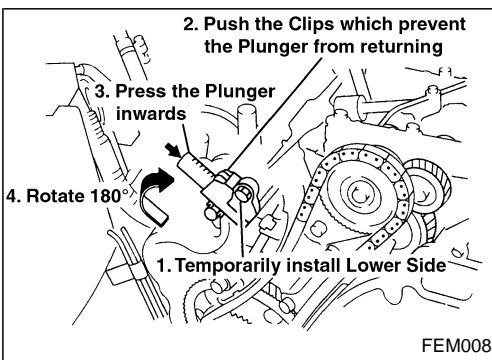
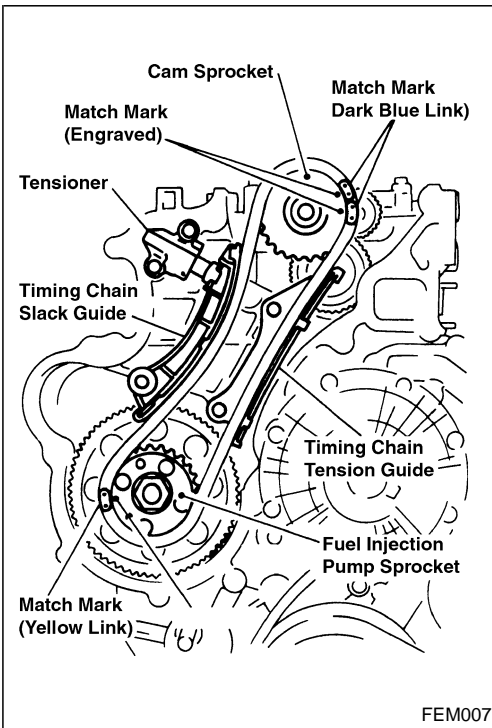
CAUTION:

Do not tighten in the holding bolt using the tension of the chain.

3. Install the timing chain slack guide.

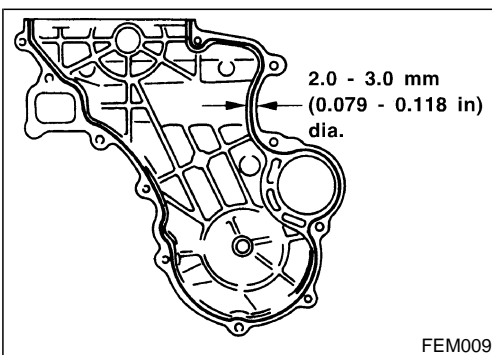
CAUTION:

When the holding bolt is tightened to the specified torque, there is a gap between the guide and bolt. Do not over-tighten.



4. Install the chain tensioner.

- 1) With the chain tensioner in the position shown in the figure (with the plunger on the outer side), temporarily tighten the holding bolt.
- 2) Press the plunger into the tensioner body while pressing on the clips which prevent the plunger from returning.
- 3) Install the upper side holding bolt while holding the plunger down with your finger and rotating it 180 degrees.
- 4) Tighten the holding bolt to the specified torque.

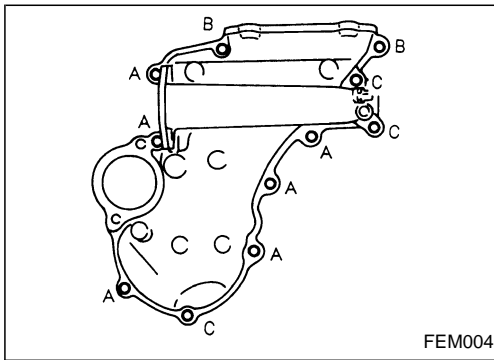


5. Install the chain cover.

- 1) Before installing chain cover, remove all traces of liquid gasket from mating surface using a scraper.
- 2) Apply a continuous bead of liquid gasket to chain cover.
 - **Use Genuine Liquid Gasket or equivalent.**
 - a. **Coat of liquid gasket should be maintained within 2.0 to 3.0 mm (0.079 to 0.118 in) dia. range.**
 - b. **Attach chain cover to gear case within 5 minutes after coating.**
 - c. **Wait at least 30 minutes before refilling engine oil or starting engine.**

TIMING CHAIN

Installation (Cont'd)



3) Install the chain cover.

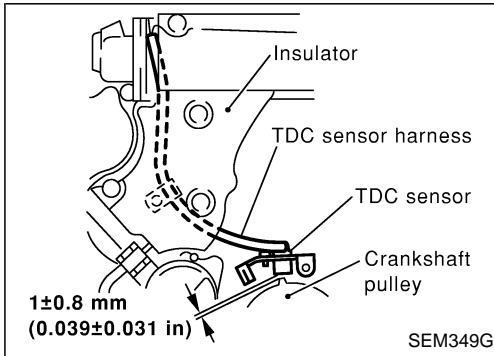
- The dimension below the neck of the holding bolt will vary depending on the part.

Dimension below the neck:

A: 20 mm (0.79 in)

B: 50 mm (1.97 in)

C: 60 mm (2.36 in)

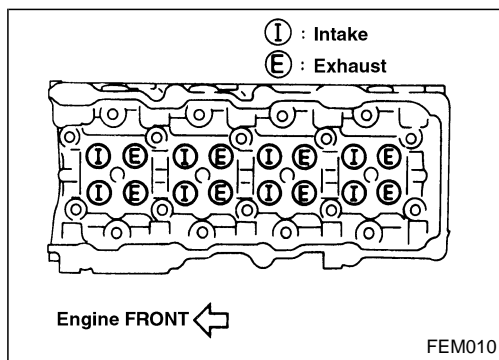
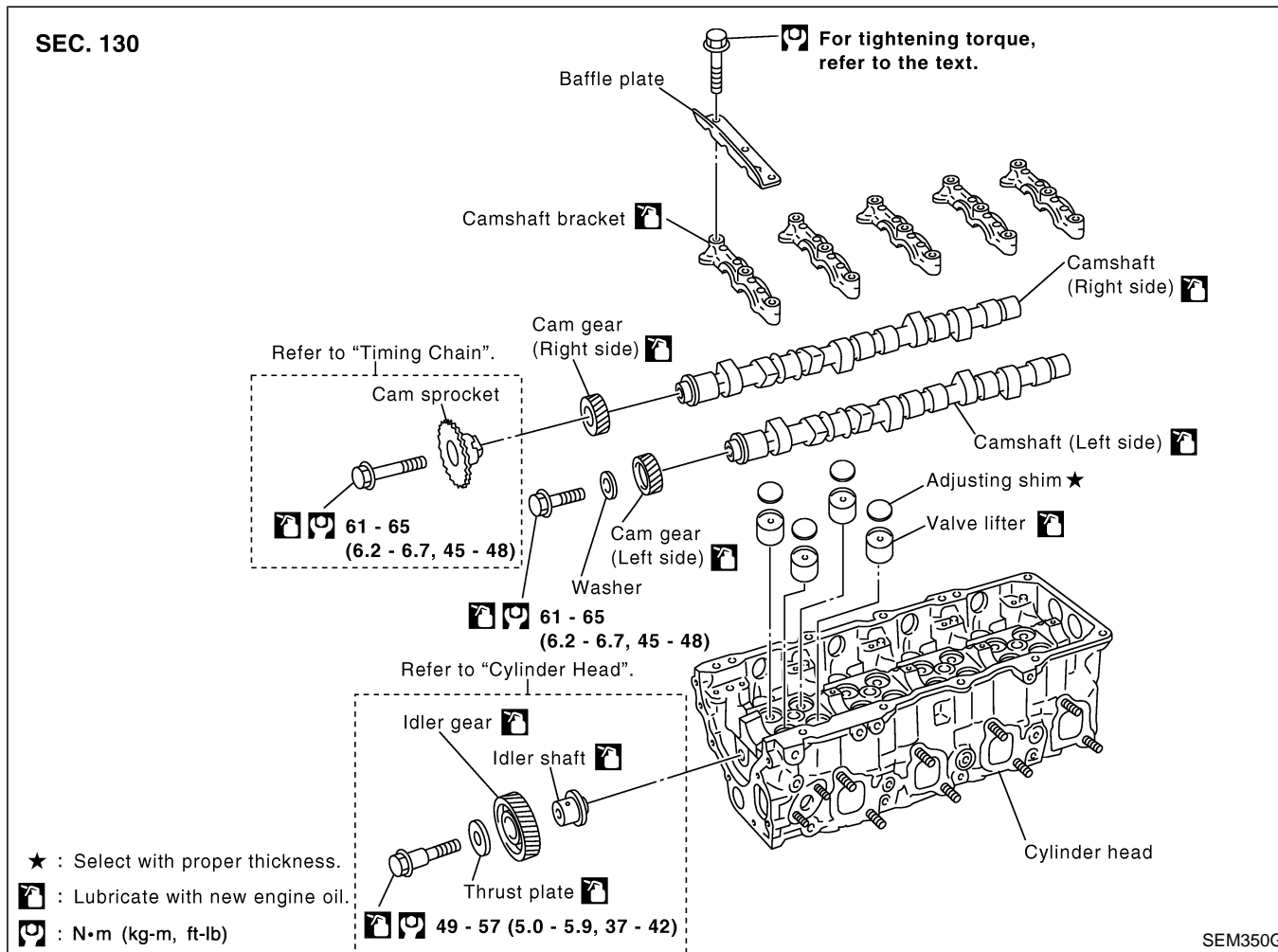


6. Install by following all removal procedures in reverse.

CAUTION:

- Arrange the TDC sensor harness in the position shown in the figure.
- Make sure that the harness has no deflection around the vicinity of the crankshaft pulley when installing the clamp.

Removal and Installation

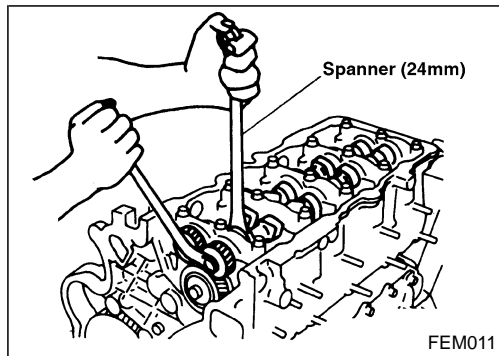


- This engine will have a different valve arrangement from normal DOHC 4-valve type engines. As both camshafts on this engine have intake and exhaust cams, in this chapter they are named as follows:

Camshaft (Right side): Intake manifold side camshaft

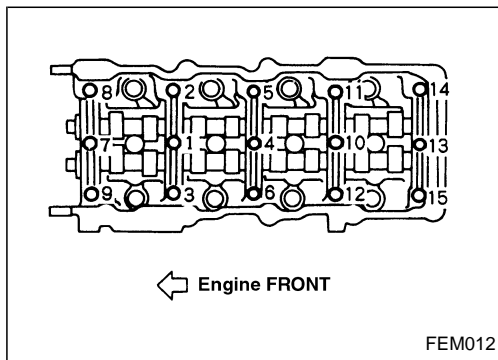
Camshaft (Left side): Exhaust manifold side camshaft

- The same parts are used for the right and left sides.
- Refer to the figure for intake and exhaust valve arrangement. (The camshafts have, alternately, either an intake valve or an exhaust valve.)



Removal

1. Set the No. 1 cylinder at TDC, then remove the chain case, timing chain and other parts in connection. Refer to "TIMING CHAIN", EM-26.
2. Remove the cam gear.
 - Loosen the cam gear installation bolt by fixing the hexagonal portion of the camshaft.
 - The idler gear cannot be removed at this point as the gear case is in the way. (The cylinder head can be removed as a single unit.)



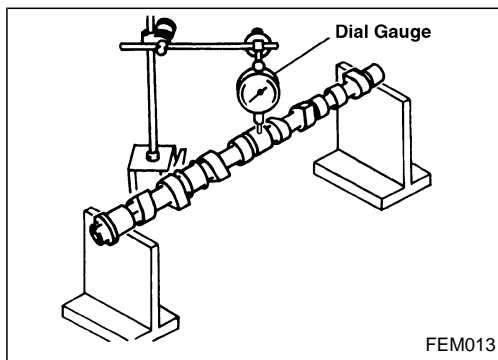
Removal (Cont'd)

3. Remove injection tube and injection nozzle assembly. Refer to EC section, "Injection Tube and Injection Nozzle" in "BASIC SERVICE PROCEDURE".
4. Remove the camshaft.
 - Place distinguishing marks on the right and left sides with paint.
 - Loosen and remove the installation bolt in reverse order shown in the figure.
5. Remove the adjusting shim and valve lifter.
 - Remove by taking notice of the installation position, and place outside engine in order to prevent confusion.

Inspection

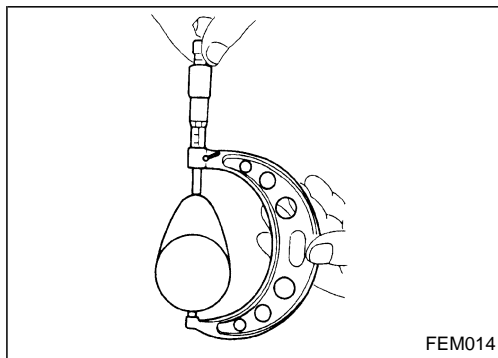
VISUAL CHECK OF CAMSHAFT

- Check the camshaft for one sided wear or scratches.
- Replace the camshaft if there are abnormalities.



CAMSHAFT RUNOUT

- Prepare V-block on a flat surface and secure camshaft journals No. 1 and No. 5.
- Set the dial gauge vertically on journal No. 3.
- Rotate camshaft in one direction by hand, then read needle movement on dial indicator.
Camshaft bend value is 1/2 of needle movement.
Limit: 0.02 mm (0.0008 in)



HEIGHT OF CAM NOSE

Measure by using a micrometer.

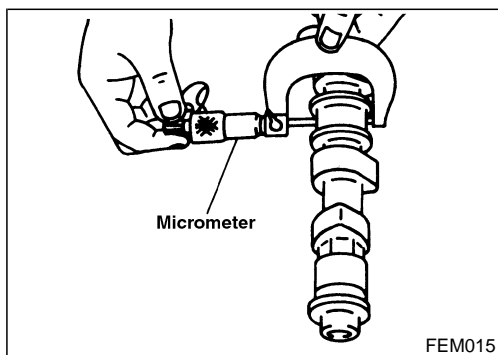
Standard:

Intake

40.488±0.02 mm (1.5940±0.0008 in)

Exhaust

40.850±0.02 mm (1.6083±0.0008 in)



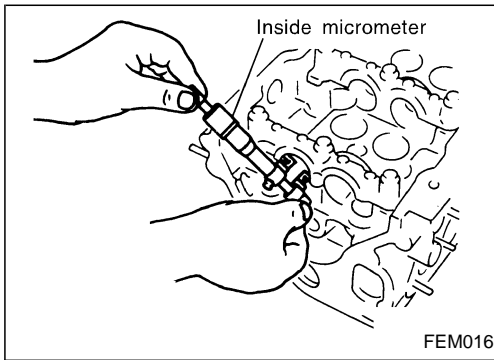
CAMSHAFT OIL CLEARANCE

Measure by using a micrometer.

Cam journal outer diameter:

Standard

29.931 - 29.955 mm (1.1784 - 1.1793 in) dia.



Inspection (Cont'd)

CAMSHAFT BRACKET INNER DIAMETER

- Install camshaft bracket and tighten bolts to the specified torque.
- Measure inner diameter of camshaft bracket using an inside micrometer.

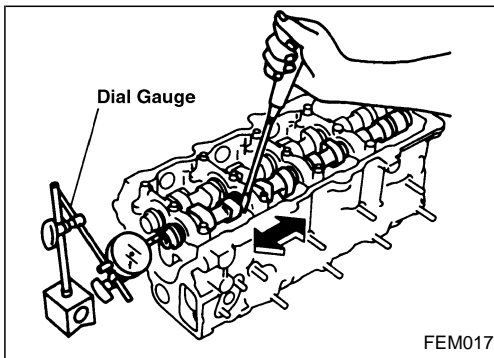
Standard: 30.000 - 30.021 mm (1.1811 - 1.1819 in) dia.

CAMSHAFT OIL CLEARANCE CALCULATIONS

Oil clearance = Cam bracket inner diameter – Cam journal outer diameter

Standard: 0.045 - 0.090 mm (0.0018 - 0.0035 in) dia.

- If it exceeds the standard value, refer to the standard value of each unit, then replace the camshaft and/or cylinder head.
- As the camshaft bracket is manufactured with the cylinder head, it is impossible to replace only the camshaft bracket.



CAMSHAFT END PLAY

- Set the dial gauge to the front end of the camshaft. Measure the end play by moving the camshaft in the direction of the axle.

Standard: 0.065 - 0.169 mm (0.0026 - 0.0067 in)

Limit: 0.2 mm (0.0079 in)

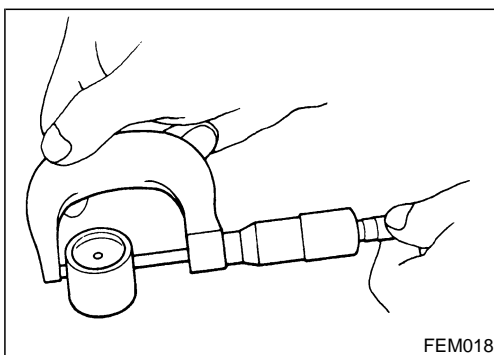
- If end play exceeds the limit, replace camshaft and measure camshaft end play again.
- If end play still exceeds the limit after replacing camshaft, replace cylinder head.

VISUAL INSPECTION OF VALVE LIFTER

Check lifter side for any signs of wear or damage. Replace if there are any abnormalities.

VISUAL INSPECTION OF ADJUSTING SHIM

Check cam nose contact and sliding surfaces for wear and scratches. Replace if there are any abnormalities.



VALVE LIFTER CLEARANCE

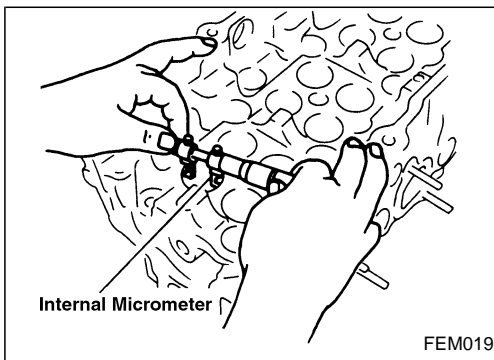
Measure the outer diameter of the valve lifter with a micrometer.

Standard: 34.450 - 34.465 mm (1.3563 - 1.3569 in) dia.

Inspection (Cont'd)**VALVE LIFTER BORE DIAMETER**

Measure the bore diameter of the cylinder head valve lifter with an inside micrometer.

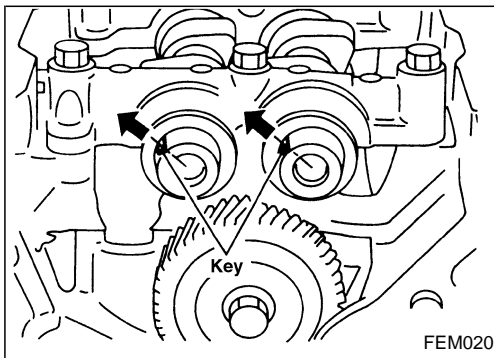
Standard: 34.495 - 34.515 mm (1.3581 - 1.3589 in) dia.

**VALVE LIFTER CLEARANCE CALCULATIONS**

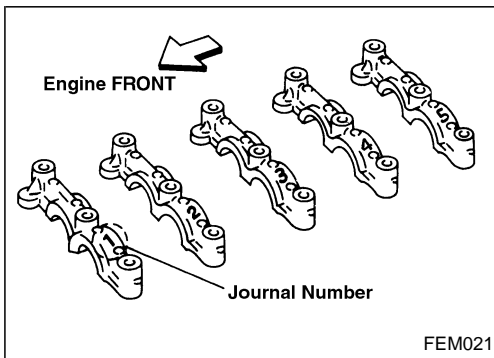
Clearance = Valve lifter bore diameter – Valve lifter outer diameter

Standard: 0.030 - 0.065 mm (0.0012 - 0.0026 in)

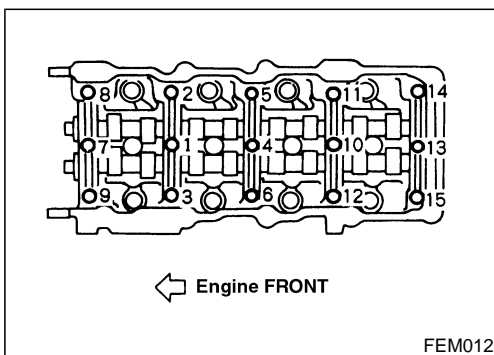
If it exceeds the standard value, refer to the outer diameter and bore diameter standard values and replace valve lifter and/or cylinder head.

**Installation**

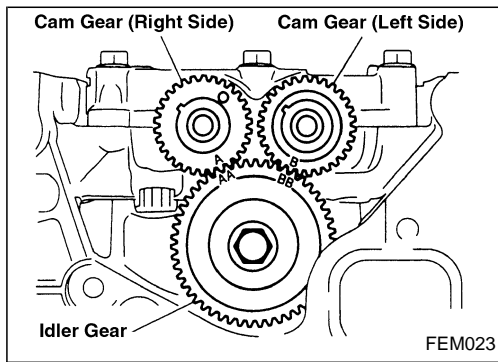
1. Install the valve lifter and adjusting shim.
 - Make sure that these are installed in the same position as before the removal process.
2. Install the camshaft.
 - Follow the distinguishing marks that were placed on in the removal process.
 - Face the key in the direction shown in the figure.



3. Install the camshaft bracket.
 - Refer to the camshaft bracket upper side journal No. and install.
 - Looking from the exhaust manifold side (left side of engine), install in the direction that the journal number can be read correctly.
 - Place baffle plate onto upper face of No. 1 camshaft bracket, and tighten together.

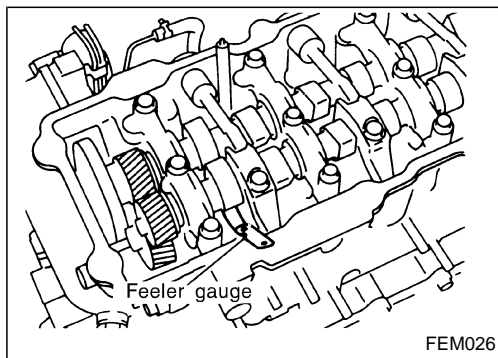
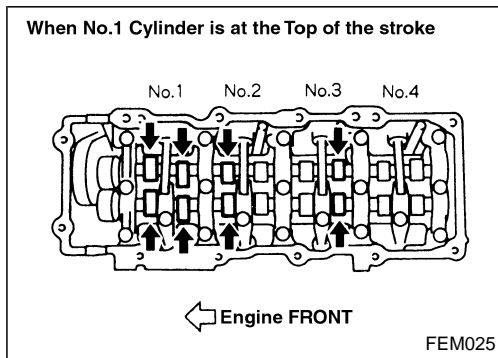
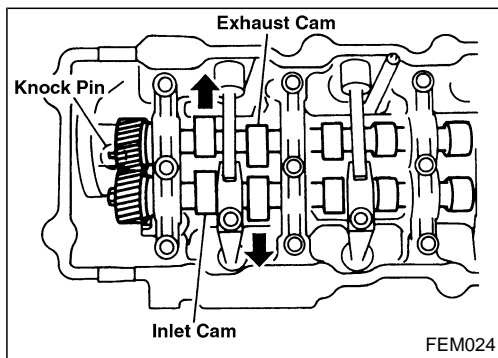
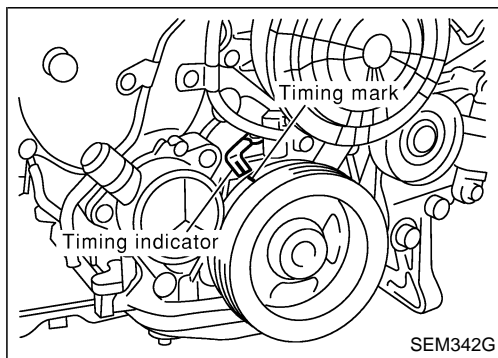
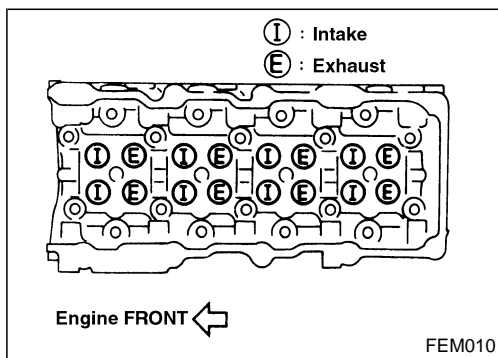


4. Tighten the installation bolts in numerical order in the figure.
 - 1) Tighten to 10 to 14 N·m (1.0 to 1.5 kg·m, 8 to 10 ft·lb).
 - Make sure that the thrust portion of the camshaft is fitted properly in the head installation side.
 - 2) Tighten to 20 to 23 N·m (2.0 to 2.4 kg·m, 15 to 17 ft·lb).

Installation (Cont'd)

5. Install the cam gear.
 - Align the match marks, and install the idler gear and each cam gear to the position shown in the figure.
 - Tighten the cam gear installation bolt by fixing the hexagonal portion of the camshaft.

6. Install the timing chain, all other related parts and chain cover. Refer to "TIMING CHAIN", EM-26.
7. After installing the timing chain, check and adjust the valve clearance before installing the spill tube. Refer to "VALVE CLEARANCE", EM-35.
8. Install in the reverse order of removal.



Inspection

- When the camshaft or parts in connection with valves are removed or replaced, and a fault has occurred (poor starting, idling, or other faults) due to the misadjustment of the valve clearance, inspect as follows.
- Inspect and adjust when the engine is cool (at normal temperature).
- Be careful of the intake and exhaust valve arrangement. (The valve arrangement is different from that in a normal engine.) (The camshafts have, alternately, either an intake valve or an exhaust valve.)

1. Remove the following parts.
 - Intercooler cover
 - Intercooler
 - Rocker cover
2. Set the No. 1 cylinder at TDC.
 - 1) Rotate the crankshaft pulley clockwise, and align the TDC mark of the crankshaft pulley with the timing indicator of the TDC sensor bracket.
 - 2) Confirm that the cam nose of the No. 1 cylinder and the knock pin of the cam sprocket is in the position shown in the figure.
 - Rotate the crankshaft pulley again if not in the position shown in the figure.

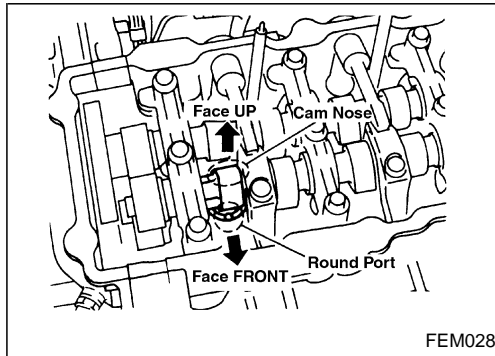
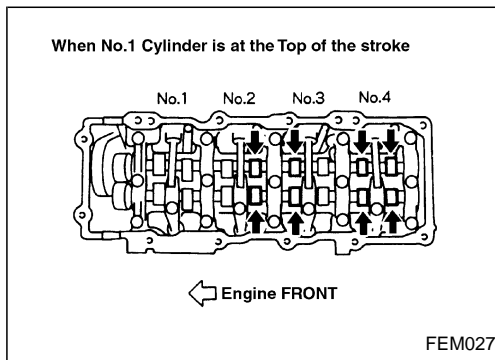
3. While referring to the figure, measure the valve clearance in the circled area of the table below.

Measuring point	No. 1		No. 2		No. 3		No. 4	
	INT	EXH	INT	EXH	INT	EXH	INT	EXH
When the No. 1 cylinder is in the TDC	○	○	○			○		

- The injection order is 1-3-4-2.
- Measure the valve clearance using a JIS high grade feeler gauge when the engine is cool (at normal temperature).

Standard:

Intake and exhaust
0.35±0.05 mm (0.0138±0.0020 in)
- 4. Set the No. 4 cylinder at TDC by rotating the crankshaft clockwise once.



Inspection (Cont'd)

5. While referring to the figure, measure the valve clearance in the circled area of the table below.

Measuring point	No. 1		No. 2		No. 3		No. 4	
	INT	EXH	INT	EXH	INT	EXH	INT	EXH
When the No. 4 cylinder is in the TDC				○	○		○	○

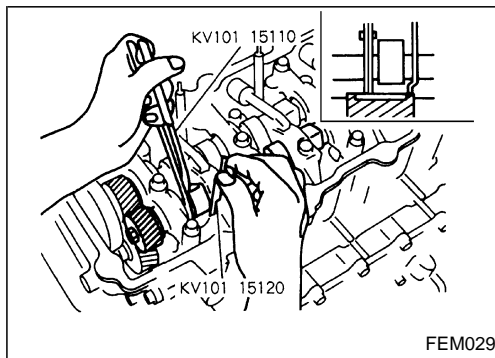
6. If the valve clearance is outside the specification, adjust as follows.

Adjustments

- Remove the adjusting shim for parts which are outside the specified valve clearance.
1. Remove the spill tube.
 2. Extract the engine oil on the upper side of the cylinder head (for the air gun used in step 7).
 3. Rotate the crankshaft to face the cam for adjusting shims that are to be removed upward.
 4. Grip the camshaft with camshaft pliers (SST), the using the camshaft as a support point, push the adjusting shim downward to compress the valve spring.

CAUTION:

Do not damage the camshaft, cylinder head, or the outer circumference of the valve lifter.

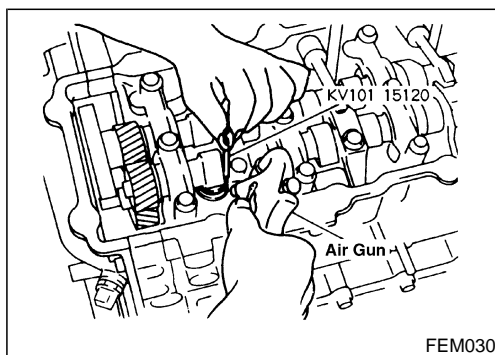


5. With the valve spring in a compressed state, remove the camshaft pliers (SST) by securely setting the outer circumference of the valve lifter with the end of the lifter stopper (SST).

- Hold the lifter stopper by hand until the shim is removed.

CAUTION:

Do not retrieve the camshaft pliers forcefully, as the camshaft will be damaged.



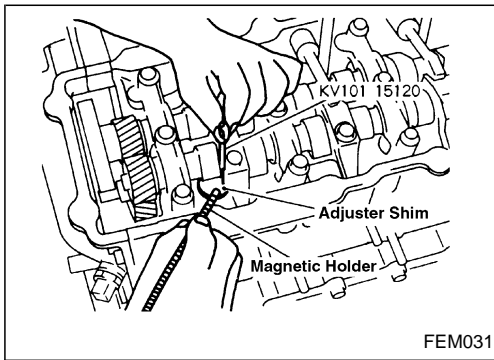
6. Move the rounded hole of the adjusting shim to the front with a very thin screwdriver.

- When the adjusting shim on the valve lifter will not rotate smoothly, restart from step 4 with the end of the lifter stopper (SST) touching the adjusting shim.
7. Remove the adjusting shim from the valve lifter by blowing air through the rounded hole of the shim with an air gun.

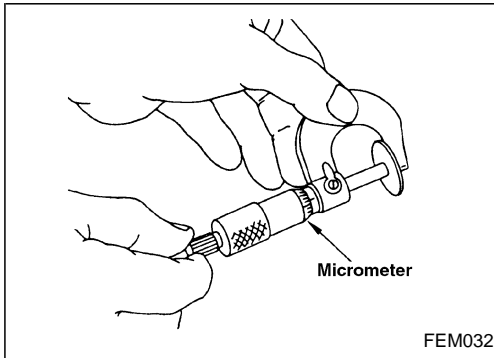
CAUTION:

To prevent any remaining oil from being blown around, thoroughly wipe the area clean and wear protective goggles.

Adjustments (Cont'd)



FEM031



FEM032

8. Remove the adjusting shim by using a magnetic hand.

9. Measure the thickness of the adjusting shim using a micrometer.

- Measure near the center of the shim (the part that touches the cam).

10. Select the new adjusting shim from the following methods.

Calculation method of the adjusting shim thickness:

$$t = t_1 + (C_1 - C_2)$$

t = Adjusting shim thickness

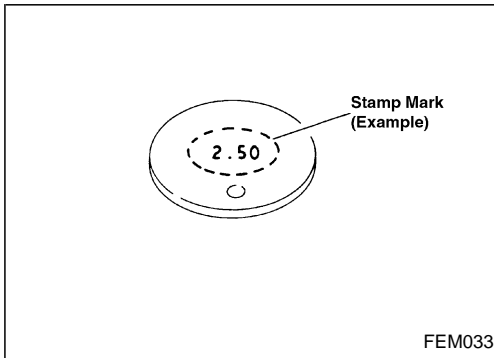
t₁ = Thickness of the removed shim

C₁ = Measured valve clearance

C₂ = Specified valve clearance

[when the engine is cool (at normal temperature)]

0.35 mm (0.0138 in)



FEM033

- New adjusting shims have the thickness stamped on the rear side.

Stamped	Shim thickness	mm (in)
2.35	2.35	(0.0925)
2.40	2.40	(0.0945)
.	.	.
.	.	.
3.05	3.05	(0.1201)

- The thickness of the adjusting shim ranges from 2.35 to 3.05 mm (0.0925 to 0.1201 in), where in the space of 0.05 mm (0.0020 in). There are 15 types of shims available.

11. Fix the selected adjusting shim to the valve lifter.

CAUTION:

Place the stamped side of the adjusting shim to the valve lifter.

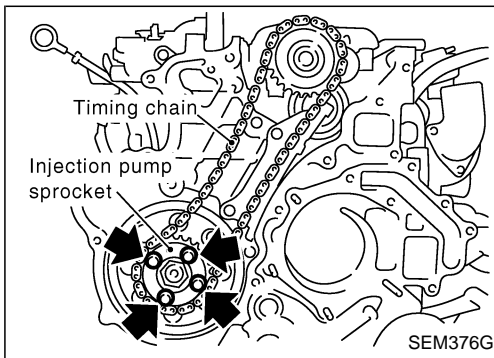
12. Compress the valve spring using the camshaft pliers and remove the lifter stopper (SST).

13. Rotate the crankshaft 2 to 3 times by hand.

14. Confirm that the valve clearance is within the specification.

Removal

1. Remove the engine assembly.
Refer to "ENGINE REMOVAL", EM-63.
2. Place the engine on an engine stand (SST).
Refer to "CYLINDER BLOCK", EM-67.
3. Remove the following.
 - Auto tensioner bracket
 - Air conditioner bracket
 - Alternator bracket
 - Oil tube
 - Vacuum pump
 - Rocker cover
 - Oil pan (upper, lower)
 - Injection tube
 - Spill tube
 - High pressure nozzle assembly



4. Remove the chain cover, timing chain and other parts in connection.
Before removing timing chain, remove injection pump sprocket with No. 1 cylinder being positioned at TDC. Refer to the figure. Refer to "TIMING CHAIN", EM-26.

CAUTION:

After removing timing chain, never rotate crankshaft, or the piston will push the valve up and damage the valve.

- Do not paint the match mark on the timing chain beforehand as the No. 1 cylinder is set at the TDC during assembly.

5. Remove the TDC sensor.

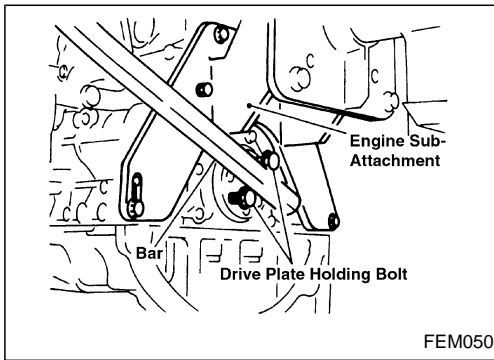
CAUTION:

- Do not drop or hit the sensor.
- Store in a clean place free of iron filings, etc.
- Do not place near any magnetic equipment.

6. Remove the water pump.
Refer to "WATER PUMP" in LC section.
7. Remove the water inlet.

TIMING GEAR

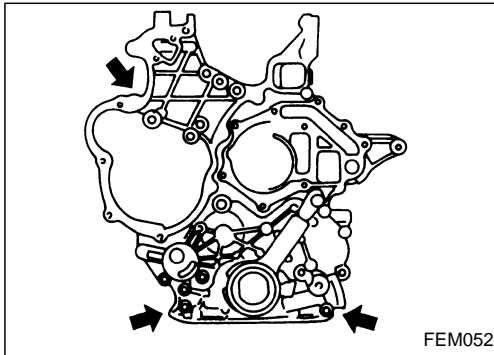
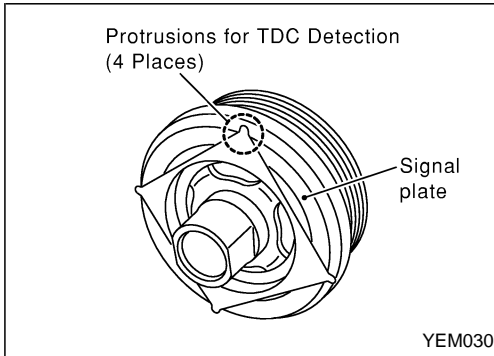
Removal (Cont'd)



8. Remove the crankshaft pulley.
 - To fix the crankshaft, clamp the bar between the drive plate holding bolts, and set by touching the engine sub-attachment (SST).
 - As another method, set by clamping a hammer handle, etc. in the counterweight portion of the crankshaft.

CAUTION:

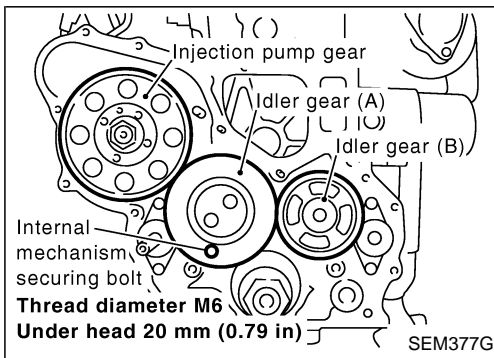
- Do not damage the crankshaft.
- Make sure that no foreign objects get inside the engine.
- Do not damage or magnetize the signal detection protrusions of the crankshaft pulley.
- After removing timing chain, never rotate crankshaft, or the piston will push the valve up and damage the valve.




9. Remove the gear case.
 - Using the grooved places shown in the figure, remove the gear case by using a screwdriver and a seal cutter (SST).
10. Remove the front oil seal from the gear case by using a screwdriver.

CAUTION:

Do not damage the gear case.



11. Fix the internal mechanism setting bolt [part No.: 81-20620-28, screw dia.: M6, dimension below neck: 20 mm (0.79 in)] to the bolt hole of the idler gear (A) and tighten to the specification.

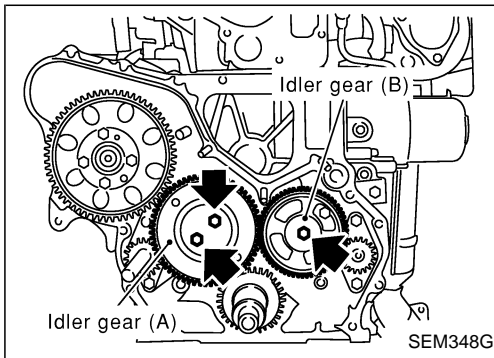
 : 2.5 - 3.4 N·m (0.25 - 0.35 kg·m, 22 - 30 in·lb)

CAUTION:

- Only use the genuine setting bolt, or the idler gear (A) will be damaged.
- Do not rotate the crankshaft as the head of the setting bolts interferes with the gear case.
- Do not remove the setting bolt from the idler gear (A) until the timing chain and all of the parts in connection have been installed.
- If these bolts are not installed, internal mechanism will disengage after the idler gear is removed. This will prohibit the idler gear from being reusable.

TIMING GEAR

Removal (Cont'd)

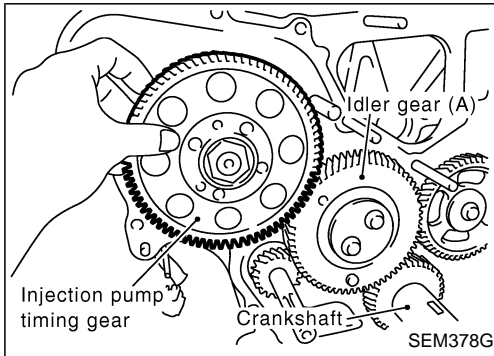


12. Remove the idler gears (A) and (B).

- Check the backlash of each gear before removing. Refer to "BACKLASH OF EACH GEAR", "Inspection".

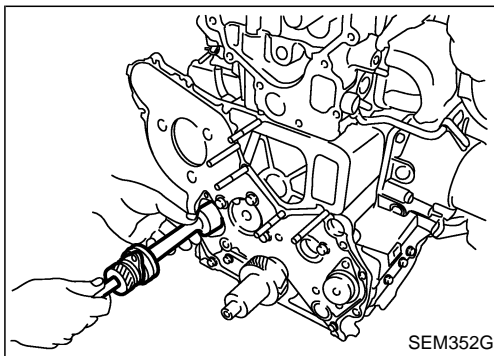
CAUTION:

- Do not loosen the internal mechanism setting bolt of the idler gear (A). (The idler gear cannot be reused when the internal mechanism is released.)
- During removal of the idler gears (A) and (B), do not face the rear side downward as the idler shaft will drop.



13. Set the fuel injection timing gear with the pulley holder (SST).

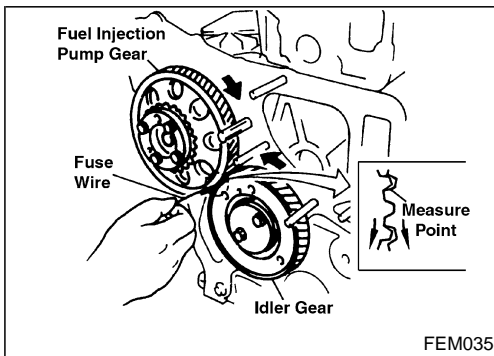
14. Remove injection pump timing gear.



15. Extract the balancer shaft taking care not to damage the inner bushes of the cylinder block.

16. Remove the fuel injection pump.

17. Remove the front plate.



Inspection

BACKLASH OF EACH GEAR

Method using a fuse wire

- Tighten the holding bolts of each gear to specification.
- Place a wire in the biting area of the teeth between the gears to be checked, rotate the crankshaft in the operating direction so that the wire is taken inwards.
- Measure the crushed area of the wire with a micrometer.

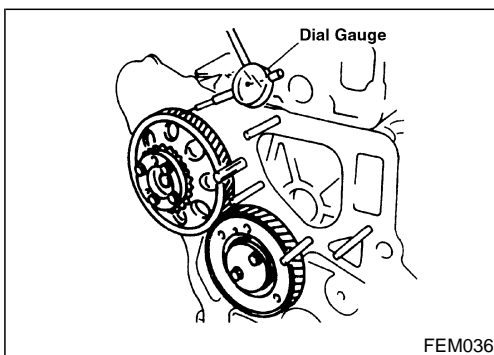
Method using dial gauge

- Tighten the holding bolts of each gear to specification.
- Place the dial gauge on the tooth surface area of the gear to be checked.
- With the other gear in a set position, measure the dial gauge value while moving the gear left and right.

Standard: 0.07 - 0.11 mm (0.0028 - 0.0043 in)

Limit: 0.20 mm (0.0079 in)

- If it exceeds the limit, replace the gear and measure again.
- If it exceeds the limit again, check for the installation condition of the gear driving parts, wear of shaft and gear, and oil clearance.



Inspection (Cont'd)

IDLER GEAR END PLAY

- Tighten the holding bolts to the specification.
- Measure the clearance between the gear plate and idler gear using a feeler gauge.

Unit: mm (in)

	Standard	Limit
Idler gear (A)	0.06 - 0.12 (0.0024 - 0.0047)	0.15 (0.0059)
Idler gear (B)		

- If it exceeds the limit, replace the idler gear, shaft, and gear plate.

IDLER GEAR OIL CLEARANCE

- Measure the inner diameter (d1) of the idler gear shaft.

Standard:

Idler gear (A)

43.000 - 43.020 mm (1.6929 - 1.6937 in) dia.

Idler gear (B)

28.600 - 28.620 mm (1.1260 - 1.1268 in) dia.

- Measure the outer diameter (d2) of the idler shaft.

Standard:

Idler gear (A)

42.959 - 42.975 mm (1.6913 - 1.6919 in) dia.

Idler gear (B)

28.567 - 28.580 mm (1.1247 - 1.1252 in) dia.

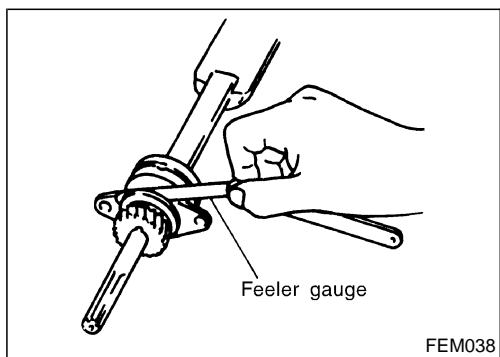
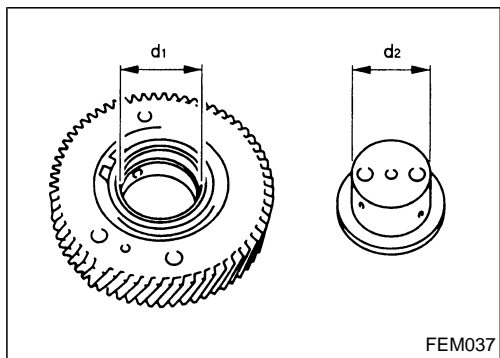
- Calculate the oil clearance.

Clearance = d1 - d2

Unit: mm (in)

	Standard	Limit
Idler gear (A)	0.025 - 0.061 (0.0010 - 0.0024)	0.2 (0.0079)
Idler gear (B)		

- If it exceeds the limit, refer to each standard specification and replace the idler gear and/or shaft.



BALANCER SHAFT END PLAY

- Measure the clearance between the plate and gear using a feeler gauge.

Standard: 0.07 - 0.22 mm (0.0028 - 0.0087 in)

- If it exceeds the specification, replace the balancer shaft assembly.
- As the gears are press-fitted, there are no setting for individual parts.

Inspection (Cont'd)

BALANCER SHAFT OIL CLEARANCE

Outer diameter of balancer shaft journal

Measure the outer diameter of the balancer shaft journal with a micrometer.

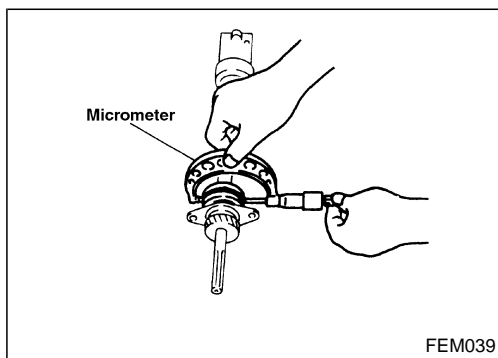
Standard:

Front side

50.875 - 50.895 mm (2.0029 - 2.0037 in) dia.

Rear side

50.675 - 50.695 mm (1.9951 - 1.9959 in) dia.



Inner diameter of balancer shaft bearing

Measure the inner diameter of the balancer shaft bearing using a bore gauge.

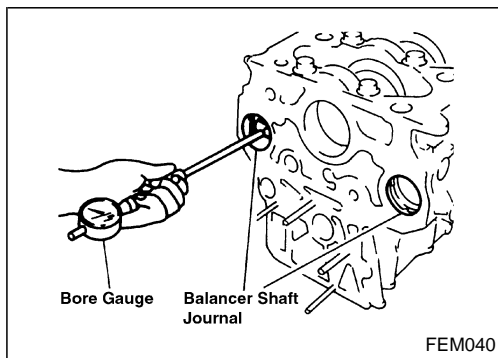
Standard:

Front side

50.940 - 51.010 mm (2.0055 - 2.0083 in) dia.

Rear side

50.740 - 50.810 mm (1.9976 - 2.0004 in) dia.

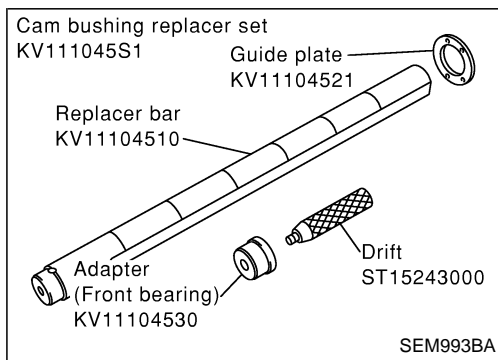


Oil clearance calculations

Oil clearance = Bearing inner diameter – Journal outer diameter

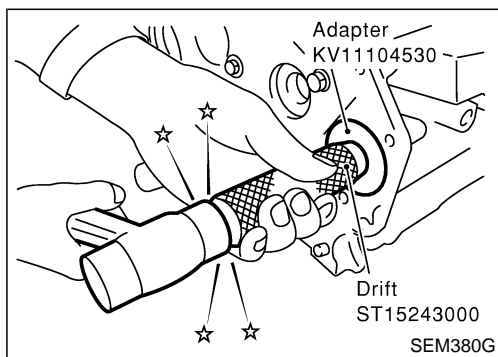
Standard: 0.045 - 0.135 mm (0.0018 - 0.0053 in)

Limit: 0.180 mm (0.0071 in)



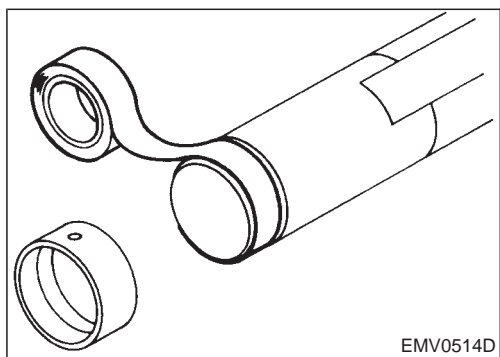
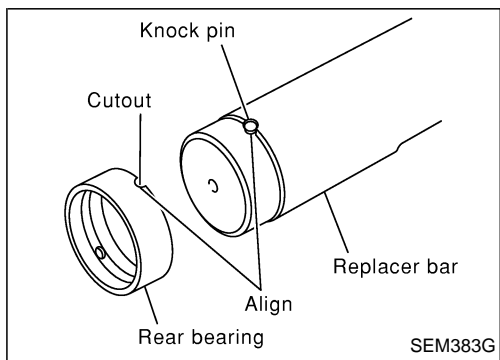
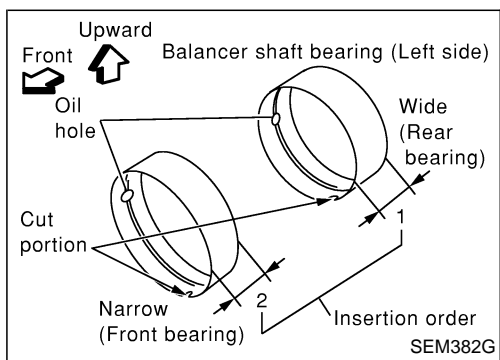
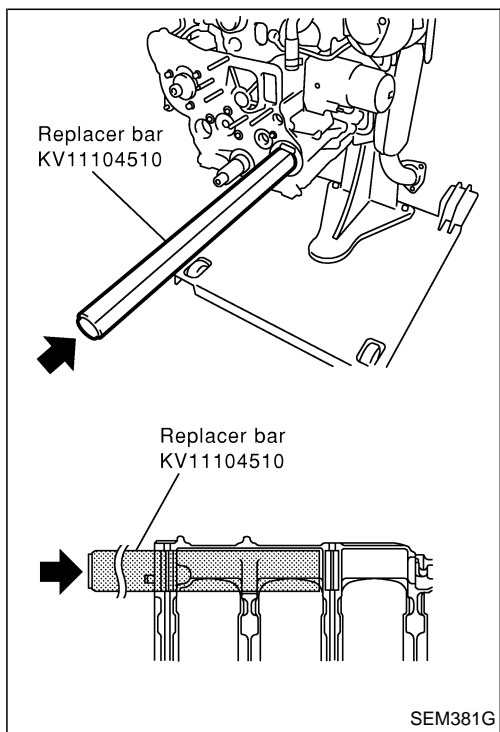
BALANCER SHAFT BEARING REMOVAL AND INSTALLATION

1. Remove balancer shaft front bearing.



Inspection (Cont'd)

2. Using Tool, remove balancer shaft rear bearing from engine.



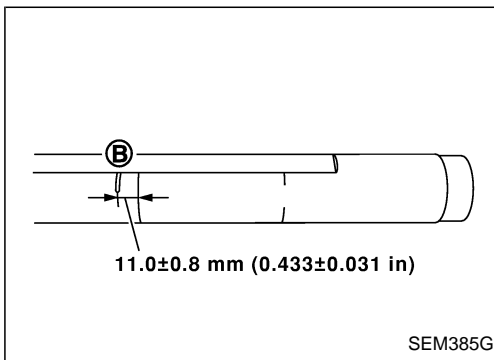
3. Install the rear and front balancer shaft bearings.
 - Install from the cylinder block hole to the rear journal and then the front journal.
 - Install the groove of the balancer shaft bearing facing the front and the under right direction.
(Align the guide plate and bar knock pin and then force in the balancer shaft bearing.)

- Align the balancer shaft bearing groove with the knock pin of the bar (SST) and install the balancer shaft bearing.)

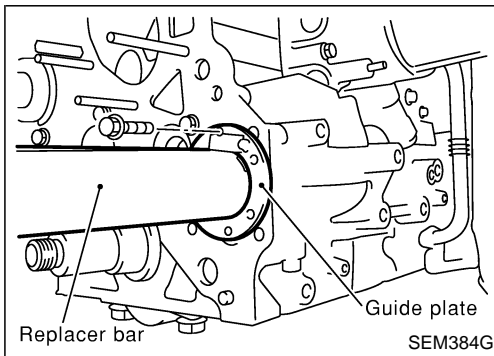
- On rear journals, so the bearing does not get out of position, wrap tape around the bar.

TIMING GEAR

Inspection (Cont'd)



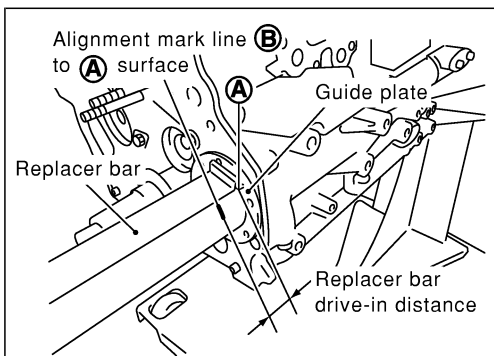
- Make an alignment mark 11.0±0.8 mm (0.433±0.031 in) from the bar No. 2 engraved line with a marker pen. This alignment mark (B) will be the point to where the rear bearing is pushed.



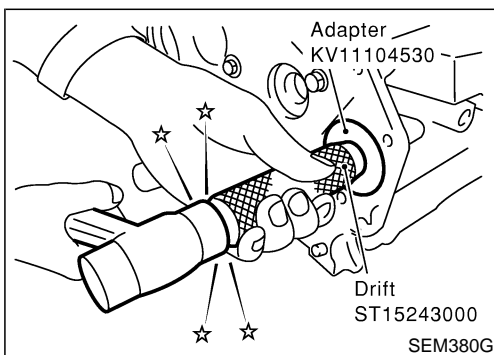
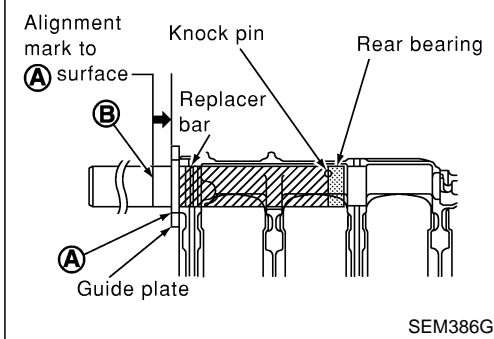
- Insert the bar with the bearing installed into the cylinder block and install the guide plate (SST).
- Align the guide plate with the ZD engraving and install the bolts.

CAUTION:

Use a washer of the same thickness used on the front plate to prevent the guide plate from bending.



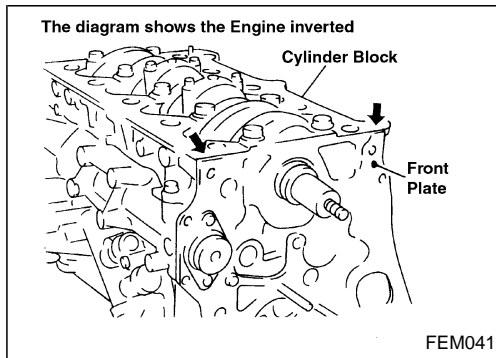
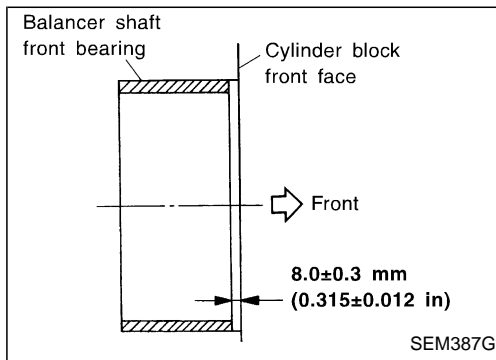
- Push the engraved bar alignment mark (B) to the same position of the guide plate tip (A).
- After all the journals have been installed, make sure that all the journal and cylinder block oil holes are aligned.



4. Install the front balancer shaft bearing.
 - Align the journal and cylinder block oil holes.
 - Use a drift (SST) to force in the tip of the journal to 8.0±0.3 mm (0.315±0.012 in) inside the cylinder block.
 - After installing the journal, make sure that the journal and cylinder block oil holes are aligned.

TIMING GEAR

Inspection (Cont'd)



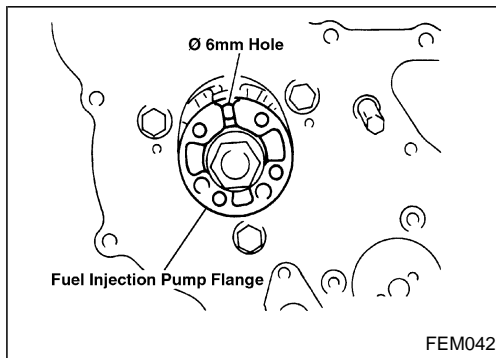
Installation

1. Install the front plate.
 - 1) Install the O-ring and gasket to the cylinder block.
 - 2) Install the front plate.
 - Lightly tap with a hammer if the dowel pin cannot be inserted easily.

CAUTION:

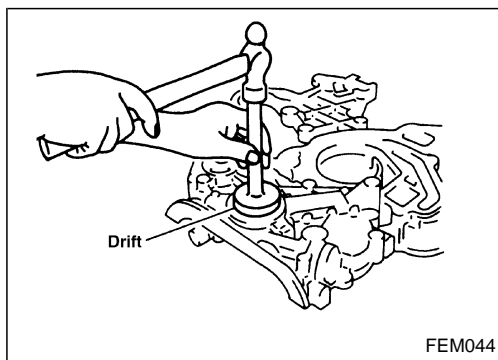
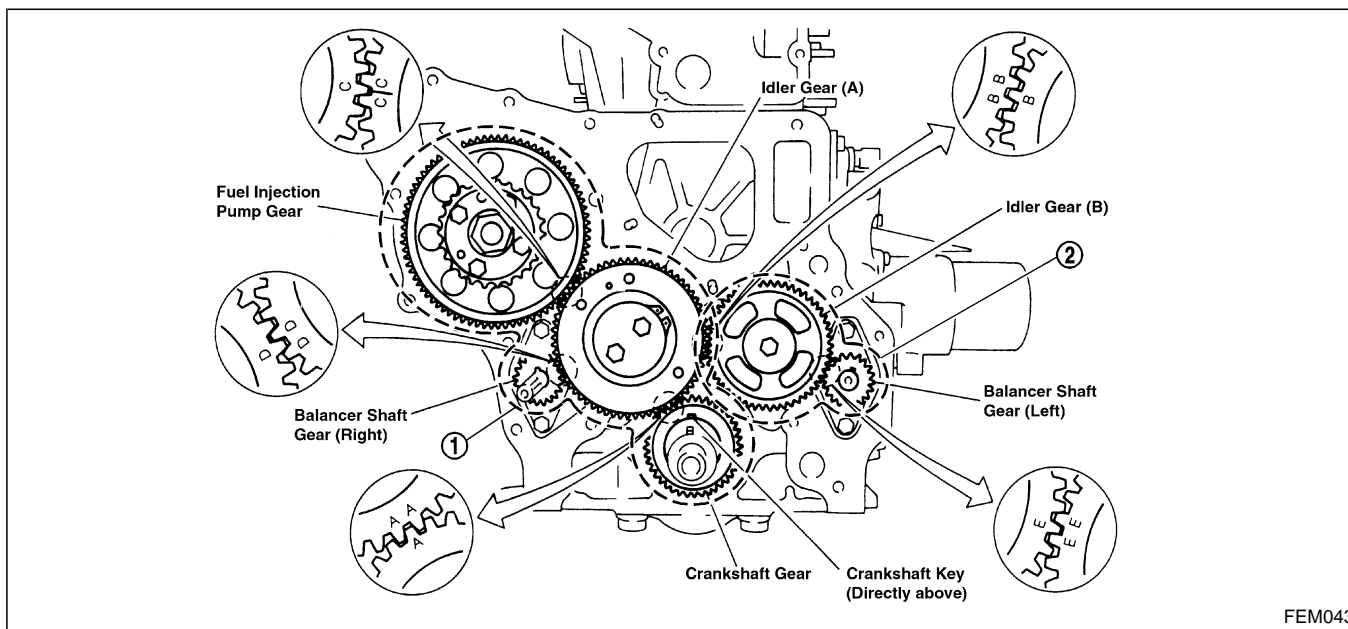
Make sure that the O-ring does not pop out.

- 3) Apply Three Bond 1207C (KP510 00150) with a spreader between the cylinder block plate under the cylinder block (oil pan side) and the front plate (shown by the arrows in the figure).



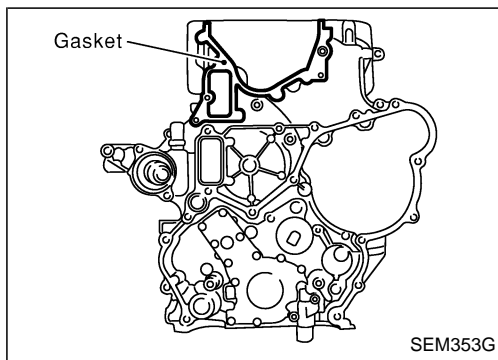
2. Install the fuel injection pump.
 - After installing the front plate, align the 6 mm (0.24 in) dia. hole of the pump flange and the 6 mm (0.24 in) dia. hole position of the pump body.
3. Install each timing gear.
 - Align the match marks of the timing gears by referring to the figure below.
 - When installing timing gear, follow the order (① , ②) shown in the dotted box in the figure below to facilitate installation.

Installation (Cont'd)

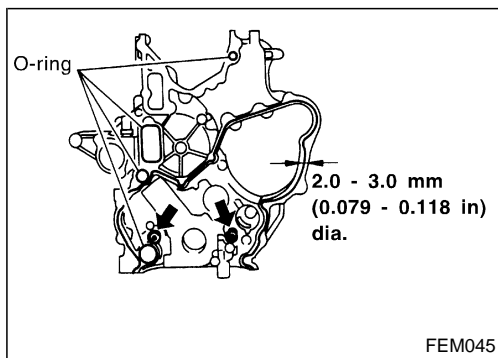


4. Install the front oil seal to the gear case.
 - Apply engine oil to the fitting side.
 - Evenly insert the front oil seal using a drift [outer dia.: approx. 64 mm (2.52 in)] completely.

CAUTION:
Make sure the oil seal does not spill off the end side of the gear case.



5. Install the gear case.
 - 1) Before installing gear case, remove all traces of liquid gasket from mating surface using a scraper.
 - 2) Align gasket with dowel and install.



- 3) Install the O-rings to the gear case.
 - The O-ring at the top position shown in the figure can be installed in during cylinder head installation.
- 4) Apply a continuous bead of liquid gasket to gear case.
 - **Use Genuine Liquid Gasket or equivalent.**
 - a. Coat of liquid gasket should be maintained within 2.0 to 3.0 mm (0.079 to 0.118 in) dia. range.
 - b. Attach gear case to cylinder block within 5 minutes after coating.
 - c. Wait at least 30 minutes before refilling engine oil or starting engine.

TIMING GEAR

Installation (Cont'd)

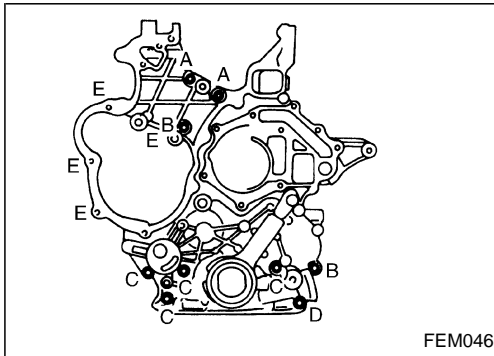
CAUTION:

Apply the liquid gasket around the bolt holes shown by the arrows in the figure.

- 4) Install the gear case.
 - Tap the area around the dowel pin with a plastic hammer if it cannot be inserted easily.

CAUTION:

Do not pop out the O-rings.



- 5) Install the holding bolt referring to the figure.

Dimension below neck:

A: 25 mm (0.98 in)

B: 30 mm (1.18 in)

C: 50 mm (1.97 in)

D: 80 mm (3.15 in)

E: 20 mm (0.79 in)

- 6) Install the holding bolts from the rear side of the front plate.

6. Install the crankshaft pulley.

- Insert by aligning the 2 sides of the oil pump with the 2 sides of the shaft on the rear side of the crankshaft pulley.

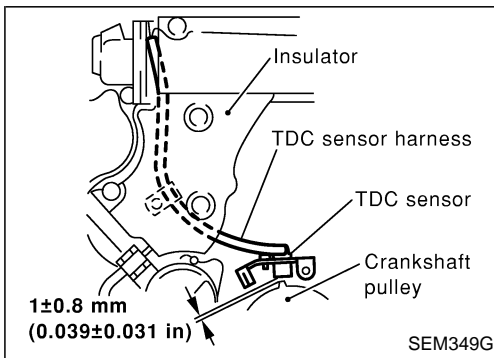
CAUTION:

Do not damage the oil seal lip when inserting.

- Refer to EM-40, "Removal" for the crankshaft setting procedures when tightening the holding nut.

7. Install the water pump.

- Install it before installing the TDC sensor. Refer to "Water Pump" in LC section.



8. Install the TDC sensor.

- Align the bracket knock pin with the hole on the gear case side and tighten the holding bolt.
- Confirm that the clearance between the end of the sensor and the signal detection protrusion of the crankshaft pulley is within the specification.

Standard: 1 ± 0.8 mm (0.039 ± 0.031 in)

- Arrange the TDC sensor harness to the position shown in the figure.

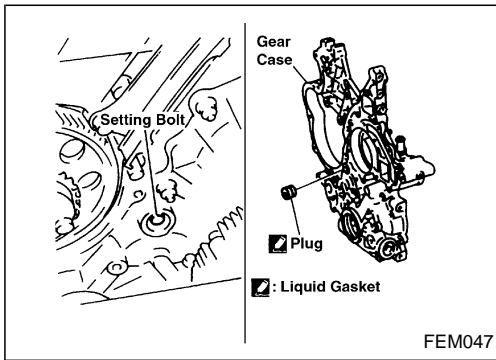
CAUTION:

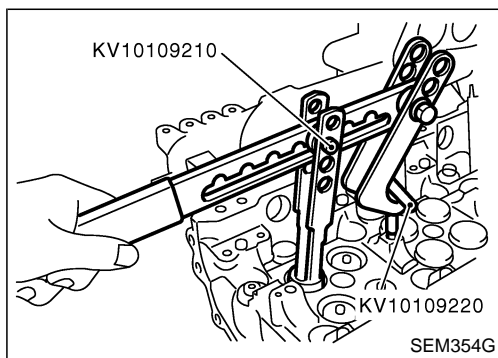
Confirm that the harness has no deflection around the crankshaft pulley when installing the clamp.

9. Install the timing chain, other parts in connection with the timing chain, and the chain cover. Refer to EM-26, "TIMING CHAIN".

Installation (Cont'd)

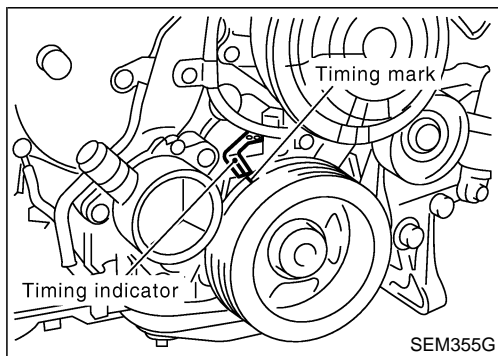
10. Remove the internal mechanism setting bolt of the idler gear (A).
11. Apply liquid gasket to the plug thread.
12. Install in the reverse order of removal.





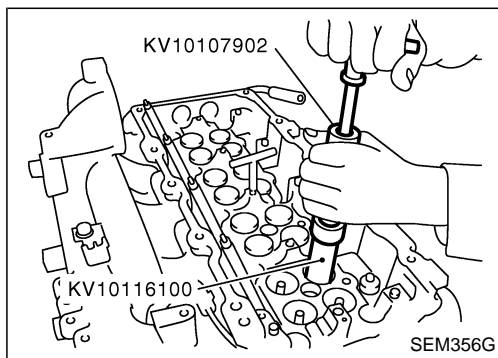
VALVE OIL SEAL

1. Remove timing chain. Refer to EM-26, "TIMING CHAIN".
2. Remove injection nozzle assembly. Refer to "Injection Tube and Injection Nozzle" in "BASIC SERVICE PROCEDURE" in EC section.
3. Remove camshaft. Refer to EM-30, "CAMSHAFT".

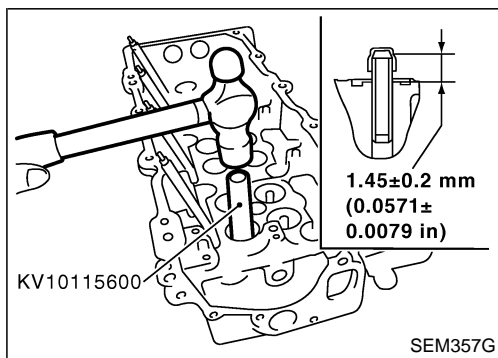


4. Remove valve lifters and mark order No. on each lifter.
5. Replace valve oil seal according to the following procedure.
When replacing valve oil seal, set the corresponding piston at TDC. Failure to do so causes the valve to drop into the cylinder.

1) Set No. 1 cylinder at TDC.



2) Remove valve springs and valve oil seals for No. 1 and No. 4 cylinders. Valve spring seats should not be removed.



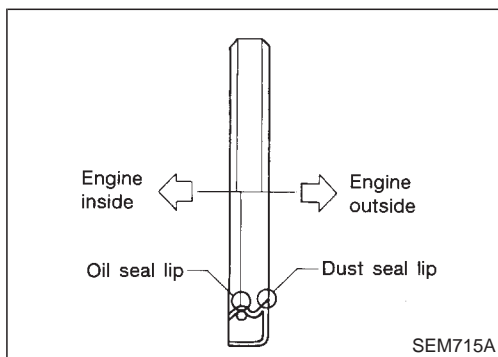
3) Install new valve oil seals for No. 1 and No. 4 cylinders as illustrated. Reinstall valve springs. (pink paint side toward cylinder head)

4) Install valve spring retainers on intake valves and valve rotators on exhaust valves, and remount valve assembly.

5) Set No. 2 cylinder at TDC.

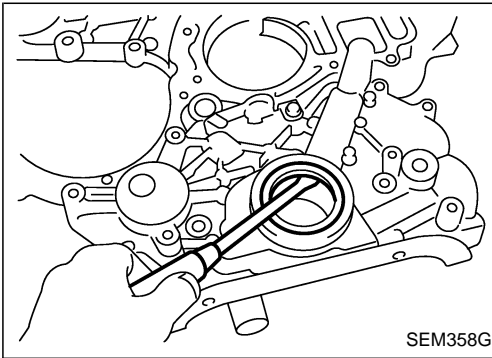
6) Replace valve oil seals for No. 2 and No. 3 cylinders according to steps 2) and 3).

7) Install valve lifters in original positions.



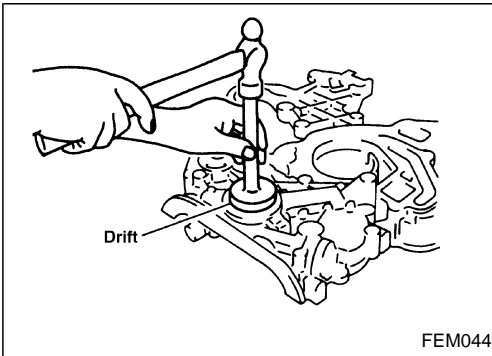
CRANKSHAFT OIL SEAL INSTALLING DIRECTION AND MANNER

- When installing crankshaft oil seals, be careful to install them correctly, as shown in the figure.
- Wipe off excess oil after installing oil seal.



CRANKSHAFT FRONT OIL SEAL

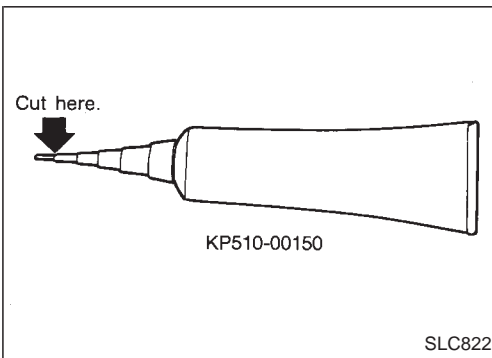
1. Remove the front cover. Refer to "TIMING GEAR".
2. Remove front oil seal with a suitable tool.



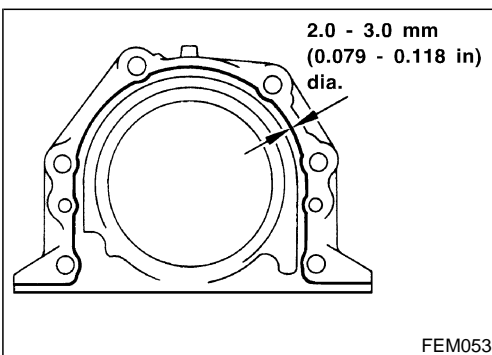
3. Apply engine oil to new oil seal and install oil seal using a suitable tool.

CRANKSHAFT REAR OIL SEAL

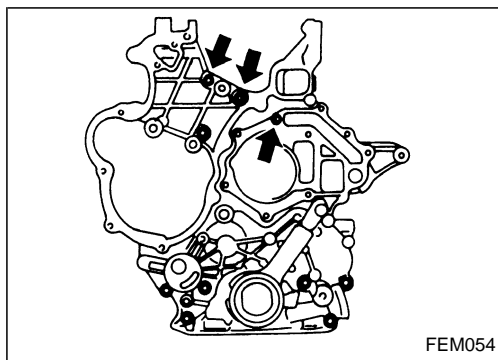
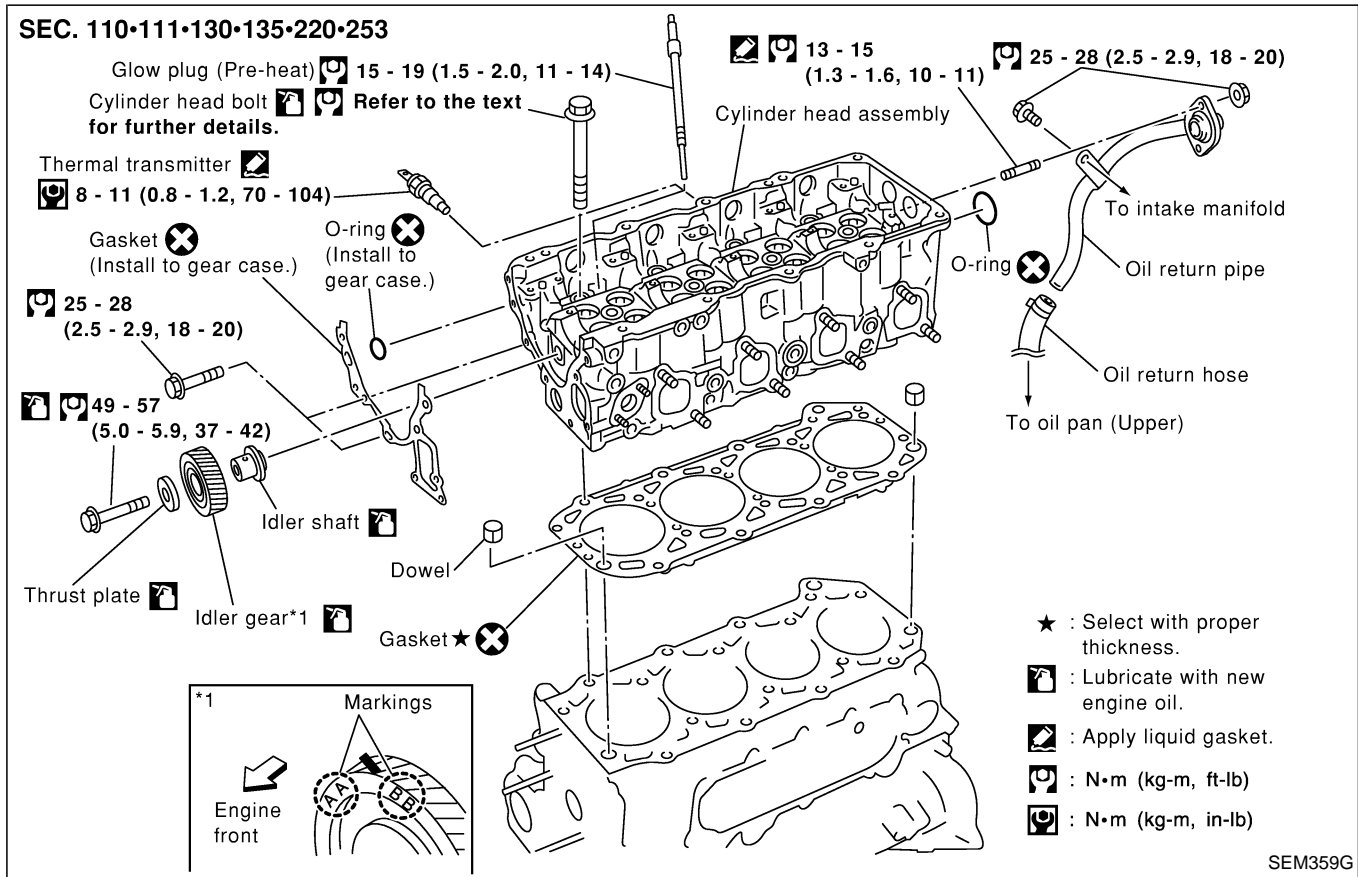
1. Remove oil pan assembly. Refer to EM-22, "OIL PAN".
2. Remove clutch cover assembly.
3. Remove flywheel and rear plate.
4. Remove oil seal retainer assembly.



5. Apply a continuous bead of liquid gasket to rear oil seal retainer.
 - a. Coat of liquid gasket should be maintained within 2.0 to 3.0 mm (0.079 to 0.118 in) dia. range.
 - b. Attach oil seal retainer to cylinder block within five minutes after coating.
 - c. Wait at least 30 minutes before refilling engine oil or starting engine.
 - d. Use Genuine Liquid Gasket or equivalent.



Removal and Installation

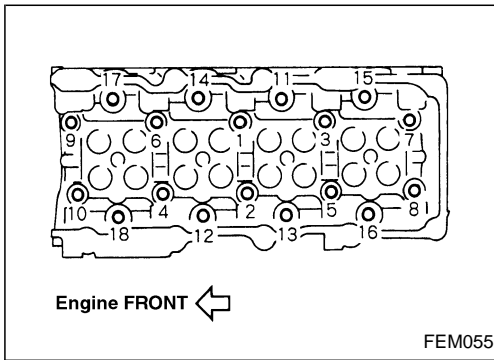


Removal

1. Remove the following. (Refer to corresponding chapter for detailed auxiliary work.)
 - Drain coolant
 - Rocker cover
 - Injection tube
 - Spill tube
 - High pressure injection nozzle assembly
 - Timing chain
 - Camshaft
 - Catalytic converter
 - Turbocharger assembly
 - Exhaust manifold
2. Remove mounting bolts of the gear case and water pump as shown by arrows in the figure.
3. Remove oil return pipe from the rear side of cylinder head.
4. Remove intake manifold.

CYLINDER HEAD

Removal (Cont'd)

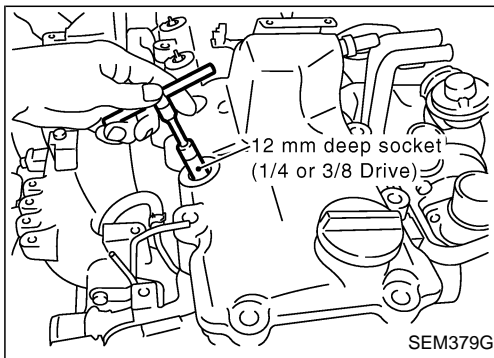


5. Remove cylinder head assembly.

- Loosen and remove mounting bolts in the reverse order shown in the figure.
- Lift up the cylinder head assembly to avoid interference with dowel pins located between the block and head, and remove cylinder head assembly.

CAUTION:

- Do not drop the O-ring located between the front of cylinder head and the rear of gear case into the engine.
- Remove glow plug in advance to avoid damage as the tip of the glow plug projects from the bottom of the cylinder head, or, place wood blocks beneath both ends of the cylinder head to keep the cylinder bottom from any contact.



● For glow plug removal, the following shall be noted.

CAUTION:

- To avoid breakage, do not remove glow plug unless necessary.
- Perform continuity test with glow plug installed.
- Keep glow plug from any impact. (Replace if dropped from a height 10 cm (3.94 in) or higher.)
- Do not use air impact wrench.

6. Remove idler gear.

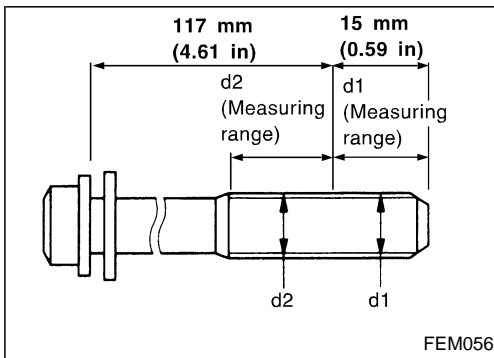
CAUTION:

While removing idler gear, keep the rear of idler gear facing up to prevent idler shaft from falling.

Inspection

CYLINDER HEAD BOLT DEFORMATION (ELONGATION)

- Using micrometer, measure the outer diameters d1 and d2 of bolt thread as shown in the figure.
- If the necking point can be identified, set it as measuring point d2.
- Calculate the difference between d1 and d2.
Limit: 0.15 mm (0.0059 in)



IDLER GEAR END PLAY

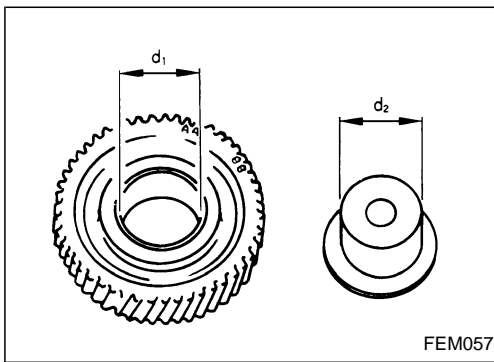
- Tighten mounting bolts to the specified torque.
- Using feeler gauge, measure the clearance between gear plate and idler gear.
Standard: 0.07 - 0.14 mm (0.0028 - 0.0055 in)
Limit: 0.2 mm (0.0079 in)
- If the measured value exceeds the limit value, replace idler gear, shaft, and gear plate.

CYLINDER HEAD

Inspection (Cont'd)

IDLER GEAR OIL CLEARANCE

- Measure the inner diameter (d_1) of idler gear shaft hole.
Standard: 26.000 - 26.020 mm (1.0236 - 1.0244 in)
- Measure the outer diameter (d_2) of idler shaft.
Standard: 25.967 - 25.980 mm (1.0223 - 1.0228 in)
- Calculate gear clearance.
Clearance = $d_1 - d_2$
Standard: 0.023 - 0.053 mm (0.0009 - 0.0021 in)

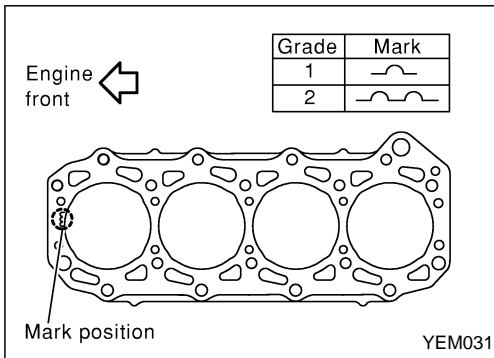


Installation

1. Install cylinder head gasket.
- Cylinder head gasket to be installed is selected by its thickness through the following procedure.

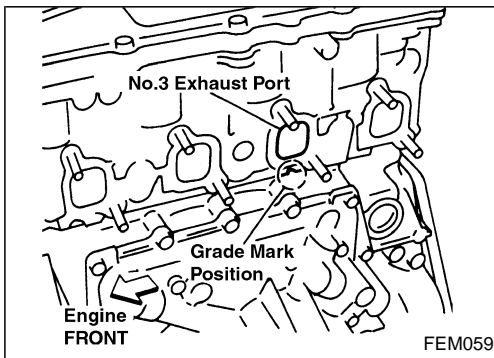
When replacing gasket only

- Install gasket with same thickness as the one removed.
- Gasket thickness is identified by the number of notches located on rear-left side.



Grade	Gasket thickness* mm (in)	No. of notches
1	0.65 (0.0256)	1
2	0.70 (0.0276)	2

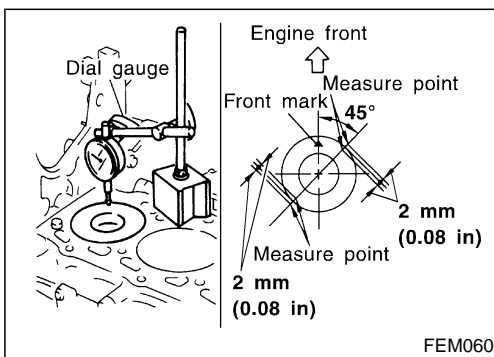
*: Thickness of gasket tightened with head bolts



- The number of notches can be checked at the position shown in the figure before cylinder head is removed. (It is necessary to remove exhaust manifold.)

When repairing/replacing the following

- When the top of cylinder block or crankshaft pin/journal is ground, or
 - When cylinder block, piston, connecting rod, or crankshaft is replaced
- 1) Move piston toward TDC.
 - 2) Position dial indicator on cylinder block as shown in the figure, and adjust the needle to "0".
 - 3) Move dial indicator stand aside, and position the dial indicator to the measuring point as shown in the figure.
 - 4) Rotate crankshaft slowly, and read the value on dial indicator at piston's maximum height.
 - 5) Repeat above procedure at 2 positions of each cylinder (8 positions in total for 4 cylinders), and select the appropriate gasket by comparing the maximum crown depression with the table.



Installation (Cont'd)

Unit: mm (in)

Grade	Piston crown depression	Gasket thickness*1	No. of notches
1	Less than -0.078 (-0.0031)*2	0.65 (0.0256)	1
2	More than -0.078 (-0.0031)*3	0.70 (0.0276)	2

*1: Thickness of gasket tightened with head bolts

*2: Indicates values such as -0.080 mm (-0.0031 in).

*3: Indicates values such as -0.075 mm (-0.0030 in).

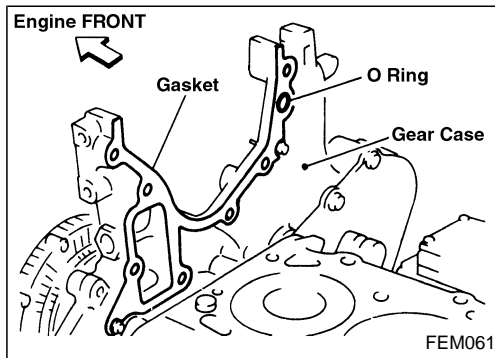
2. Install idler gear and idler shaft.

- Check that the counter marks with cam gear, "AA" and "BB", are located on the front side of the engine.

Refer to EM-52.

CAUTION:

Since idler gear cannot be installed or removed with cylinder head assembly mounted on the engine because of interference with gear case, make sure that there are no reverse installations or uninstalled parts.

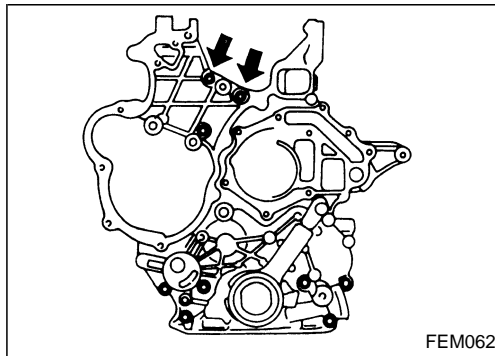


3. Install cylinder head assembly.

- 1) Attach gasket onto the rear of gear case.
- 2) Install O-ring to the rear of gear case.
- 3) Align cylinder head assembly with dowel pin of cylinder block and install.

CAUTION:

- Make sure the O-ring does not fall off. Be careful not to drop the O-ring.
- Do not damage gasket located at the front.



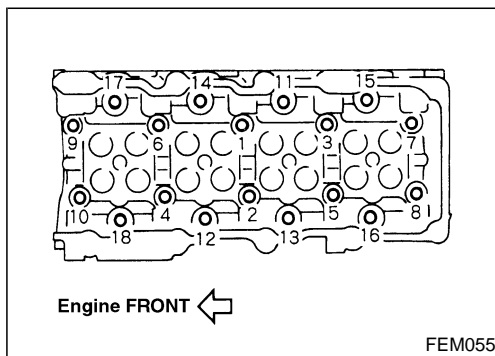
4. Position cylinder head assembly close to the rear of the gear case.

- 1) Install cylinder head bolts to the front and rear of cylinder head respectively, and tighten to the specified torque.

: 40 - 49 N·m (4.0 - 5.0 kg-m, 29 - 36 ft-lb)

- 2) Loosen cylinder head bolts completely.
- 3) Install gear case mounting bolts to 2 positions shown by arrows in the figure, and tighten to the specified torque.

: Less than 9.8 N·m (1.0 kg-m, 87 in-lb)



5. Tighten cylinder head bolts in the order indicated in the figure.

- 1) Apply engine oil to installation bolt threads and washers.
- 2) Tighten bolts to 98 to 102 N·m (10.0 to 10.5 kg-m, 73 to 75 ft-lb).
- 3) Loosen bolts completely until the torque becomes 0 N·m (0 kg-m, 0 in-lb).

CAUTION:

For procedure 3), loosen bolts in the reverse order as indicated in the figure.

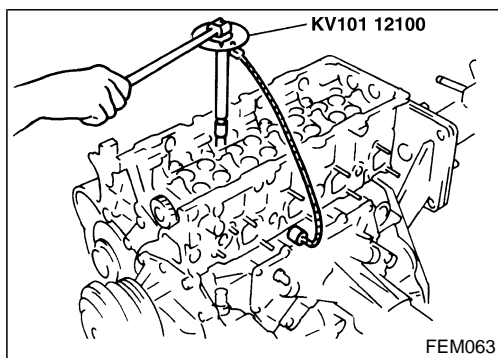
- 4) Tighten bolts to 40 to 44 N·m (4.0 to 4.5 kg-m, 29 to 32 ft-lb).
- 5) Tighten bolts at the angle of 90 to 95° (target is 95°). (Angle tightening)

Installation (Cont'd)

6) Once again, tighten bolts at the angle of 90 to 95° (target is 95°). (Angle tightening)

CAUTION:

Perform the following procedure to check turning angle of angle tightening, and do not judge by visual check.



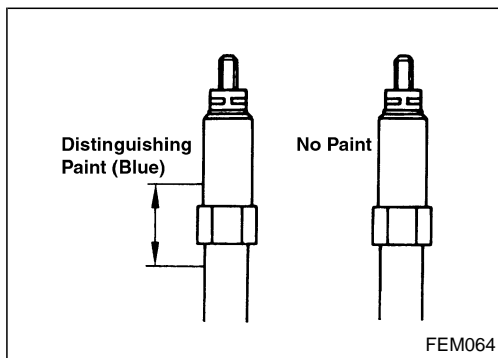
ANGLE TIGHTENING PROCEDURE

With protractor

- Make counter marks on the bolt head of cylinder head and cylinder head surface with paint, and check the turning angle.

With angle wrench (SST)

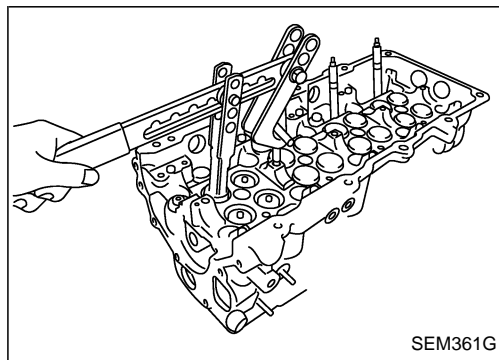
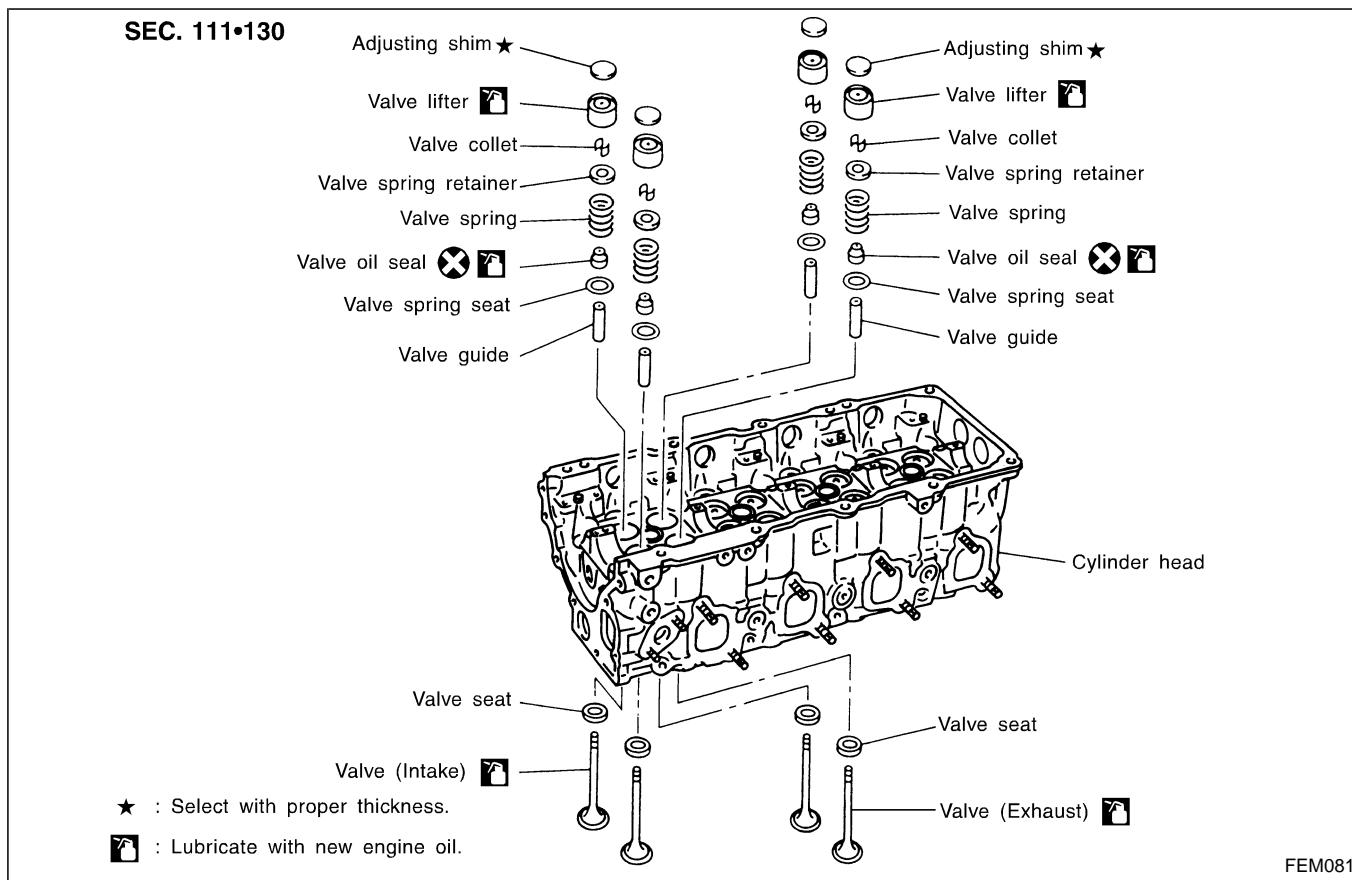
- Check the turning angle using angle indicator of angle wrench.
6. Loosen gear case mounting bolts which were tightened in 3) of procedure 4, retighten them to the specified torque.



7. Install glow plug.
- 2 different types (manufacturers) of glow plugs are provided in parallel. (Refer to the figure for identification.)
 - Do not install 2 different types of glow plugs in the engine. Make sure that the same glow plugs are installed.
 - Using reamer, remove the carbon adhering to the installation hole of glow plug, and install glow plug.

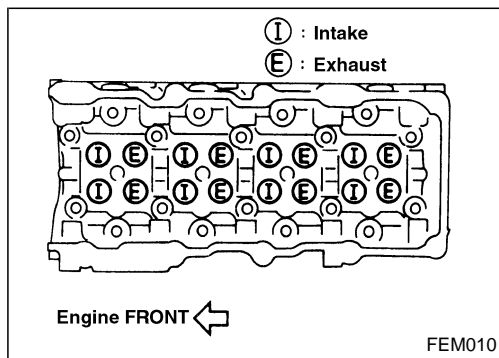
Installation (Cont'd)

8. Install oil return pipe to the rear side of the cylinder head.
 - When reinstalling a stud bolt, apply Three Bond 1207C (KP510 00150) to the thread of the bolt.



Disassembly

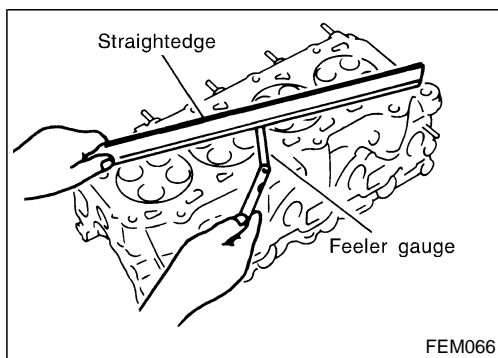
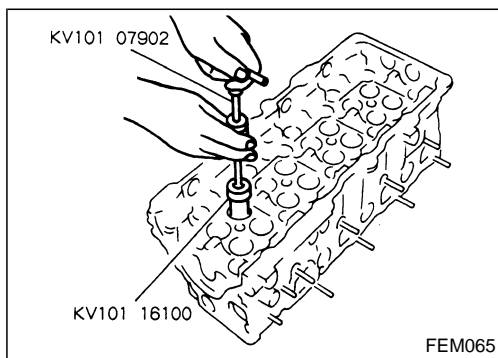
1. Remove adjusting shims and valve lifters. Check the installation positions, and keep them to avoid being confused.
2. Using valve spring compressor (SST), compress valve spring. Using magnetic hand, remove valve collets.
3. Remove valve spring retainers and valve springs.
4. Remove valves as pressing valve stems toward combustion chamber.



- Before removing the valve, check the valve guide clearance. (Refer to EM-58.)
- Check installation positions, and keep them to avoid being confused.
- Refer to the figure for intake/exhaust valve positions. (Intake and exhaust valve driving cams are provided alternately for each camshaft.)

Disassembly (Cont'd)

5. Remove valve oil seals using valve oil seal puller (SST).
6. Remove valve spring seats.
7. Before removing valve spring seats, perform valve seat contact check. (Refer to EM-60.)
8. Before removing valve guides, perform valve guide clearance check. (Refer to below.)

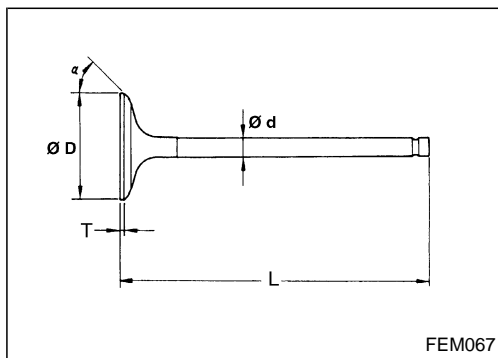


Inspection

CYLINDER HEAD DISTORTION

Using straightedge and feeler gauge, check the bottom of the cylinder head for distortion.

Limit: 0.2 mm (0.008 in)



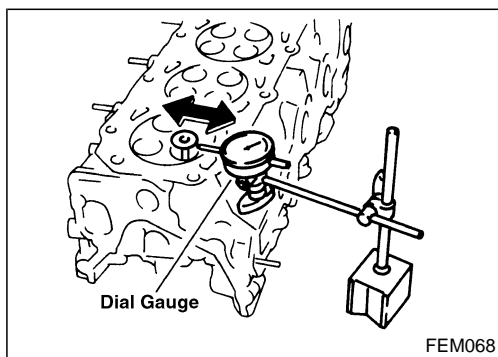
VALVE DIMENSION

Using micrometer, measure the dimensions of each part.

Standard

Unit: mm (in)

	Intake valve	Exhaust valve
L	113.5 (4.4685)	113.5 (4.4685)
T	1.5 (0.0591)	1.5 (0.0591)
ϕd	6.962 - 6.977 (0.2741 - 0.2747)	6.945 - 6.960 (0.2734 - 0.2740)
ϕD	31.9 - 32.1 (1.2559 - 1.2638)	29.9 - 30.1 (1.1772 - 1.1850)
α (degree)	45°00' - 45°30'	45°00' - 45°30'



VALVE GUIDE CLEARANCE

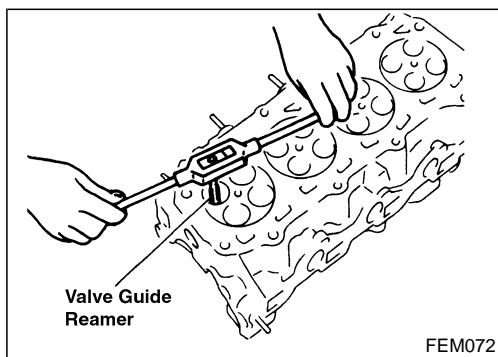
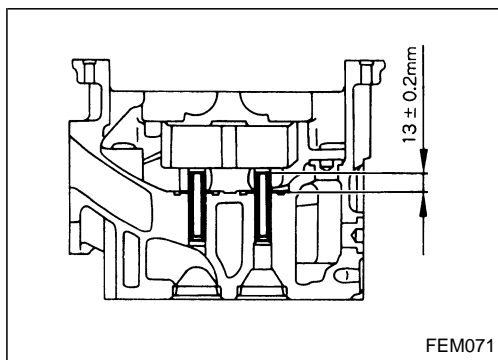
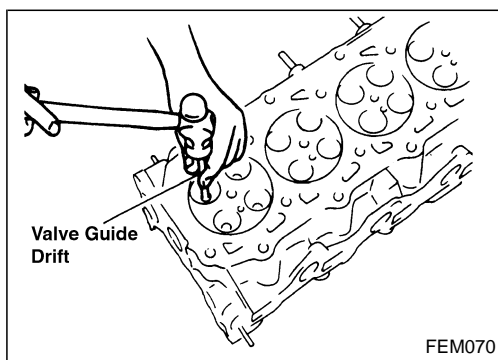
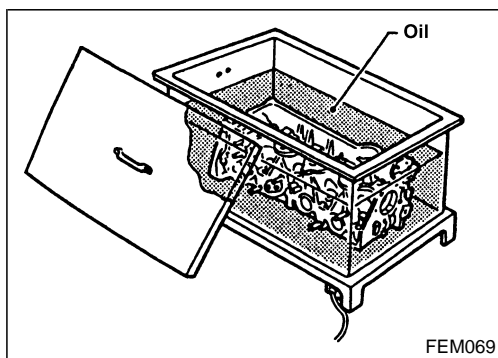
- Perform the inspection before removing valve guides.
- Check that the valve stem diameter is within specifications.
- Push valve approximately 25 mm (0.98 in) toward combustion chamber, move valve toward dial indicator to measure valve movement.
- Valve guide clearance is 1/2 of movement on dial indicator.

Inspection (Cont'd)

Unit: mm (in)

	Standard	Limit
Intake	0.023 - 0.053 (0.0009 - 0.0021)	0.18 (0.0071)
Exhaust	0.040 - 0.070 (0.0016 - 0.0028)	0.10 (0.0039)

- If the measured value exceeds the limit, replace valve guide.



VALVE GUIDE REPLACEMENT

- There is no setup for oversized valve guide.
1. Heat cylinder head to 110 to 130°C (230 to 266°F) in oil bath.
 2. Using valve guide drift (multi-purpose tool: for 7.0 mm dia.), tap valve guides out from the combustion chamber side.
 3. Heat cylinder head to 110 to 130°C (230 to 266°F) in oil bath.
 4. Using valve guide drift (multi-purpose tool: for 7.0 mm dia.), press fit valve guides from camshaft side, referring to the dimension shown in the figure.
 5. Using valve guide reamer (multi-purpose tool), perform reaming to the press-fitted valve guides.

Reaming specifications:
Intake/Exhaust
7.000 - 7.015 mm (0.2756 - 0.2762 in)

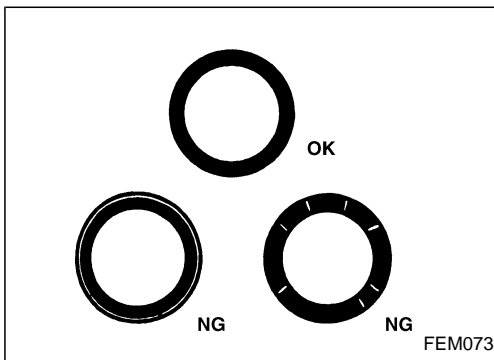
CYLINDER HEAD

Inspection (Cont'd)

VALVE SEAT CONTACT

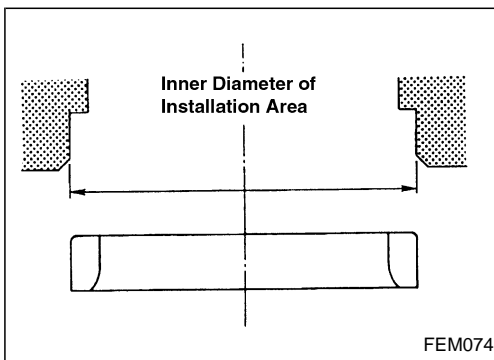
Check valve for any evidence of pitting at valve contact surface, and reseat or replace if worn out excessively.

- When repairing valve seats, check valve and valve guide for wear beforehand. If worn, replace them. Then correct valve seat.
- The cutting should be done with both hands for uniform cutting.



VALVE SEAT REPLACEMENT

- When removing valve seat, replace it with oversized [0.5 mm (0.0020 in)] valve seat.
1. Cut valve seat to make it thin, and pull it out.



2. Machine cylinder head inner diameter at valve seat installation position.

Machining dimension:

Intake

33.500 - 33.515 mm (1.3189 - 1.3195 in) dia.

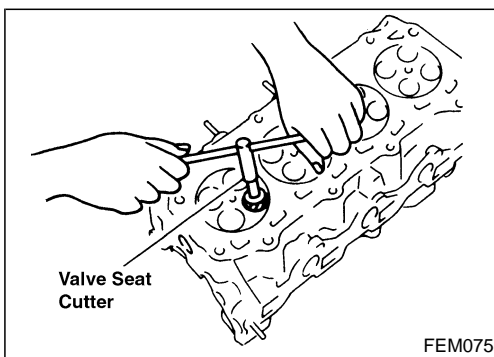
Exhaust

31.995 - 32.010 mm (1.2596 - 1.2602 in) dia.

3. Heat cylinder head to approximately 110 to 130°C (230 to 266°F) in oil bath.
4. After cooling valve seats sufficiently with dry ice, press fit it to cylinder head.

CAUTION:

Do not touch the cooled valve seats directly by hand.



5. Using valve seat cutter (multi-purpose tool), finish processing referring to the dimensions shown in the figure.

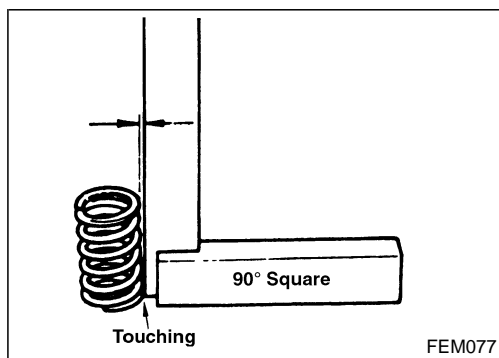
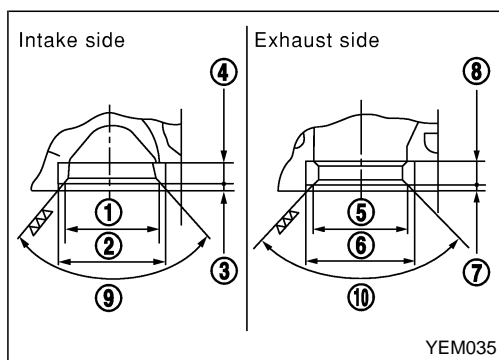
CAUTION:

When using valve seat cutter, grasp cutter handle with both hands, press cutter onto contacting face all around, and cut thoroughly. If cutter is pressed unevenly or repeatedly, the valve seat surface may be damaged.

6. Using compound, perform valve fitting.
7. Check again to make sure that contacting status is satisfactory.

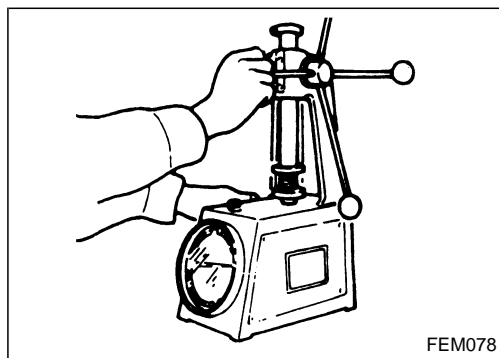
Inspection (Cont'd)

For details of values (① to ⑩), refer to EM-87, "Valve Seat" in "SERVICE DATA AND SPECIFICATIONS (SDS)".

**VALVE SPRING RIGHT ANGLE**

Position a straightedge to valve spring, turn the spring, and measure the maximum clearance value between top surface of spring and the straightedge

Limit: 2.4 mm (0.0945 in)

**VALVE SPRING FREE LENGTH AND COMPRESSIVE LOAD**

Using valve spring tester, check the following.

Free length: 55.43 mm (2.1823 in)

Installation height: 40.8 mm (1.6063 in)

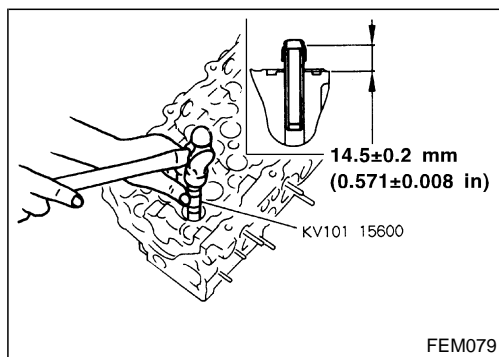
Installation load: 180 - 206 N (18.4 - 21.0 kg, 40.6 - 46.3 lb)

Height at valve open: 32.3 mm (1.2717 in)

Load at valve open: 336 - 372 N (34.3 - 37.9 kg, 75.6 - 83.6 lb)

Assembly

1. Install valve guides, referring to EM-60, "VALVE SEAT REPLACEMENT".
2. Install valve seats, referring to EM-60, "VALVE SEAT CONTACT".



3. Using valve oil seal drift (SST), install valve oil seals referring to the dimension shown in the figure.

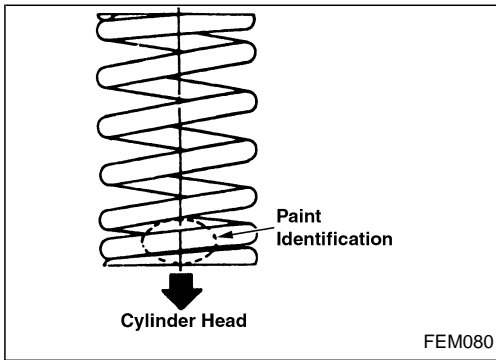
- The figure shows the dimension before valve spring seats are installed.

4. Install valve spring seats.

5. Install valves.

- Install the valves with bigger openings to intake valve side.

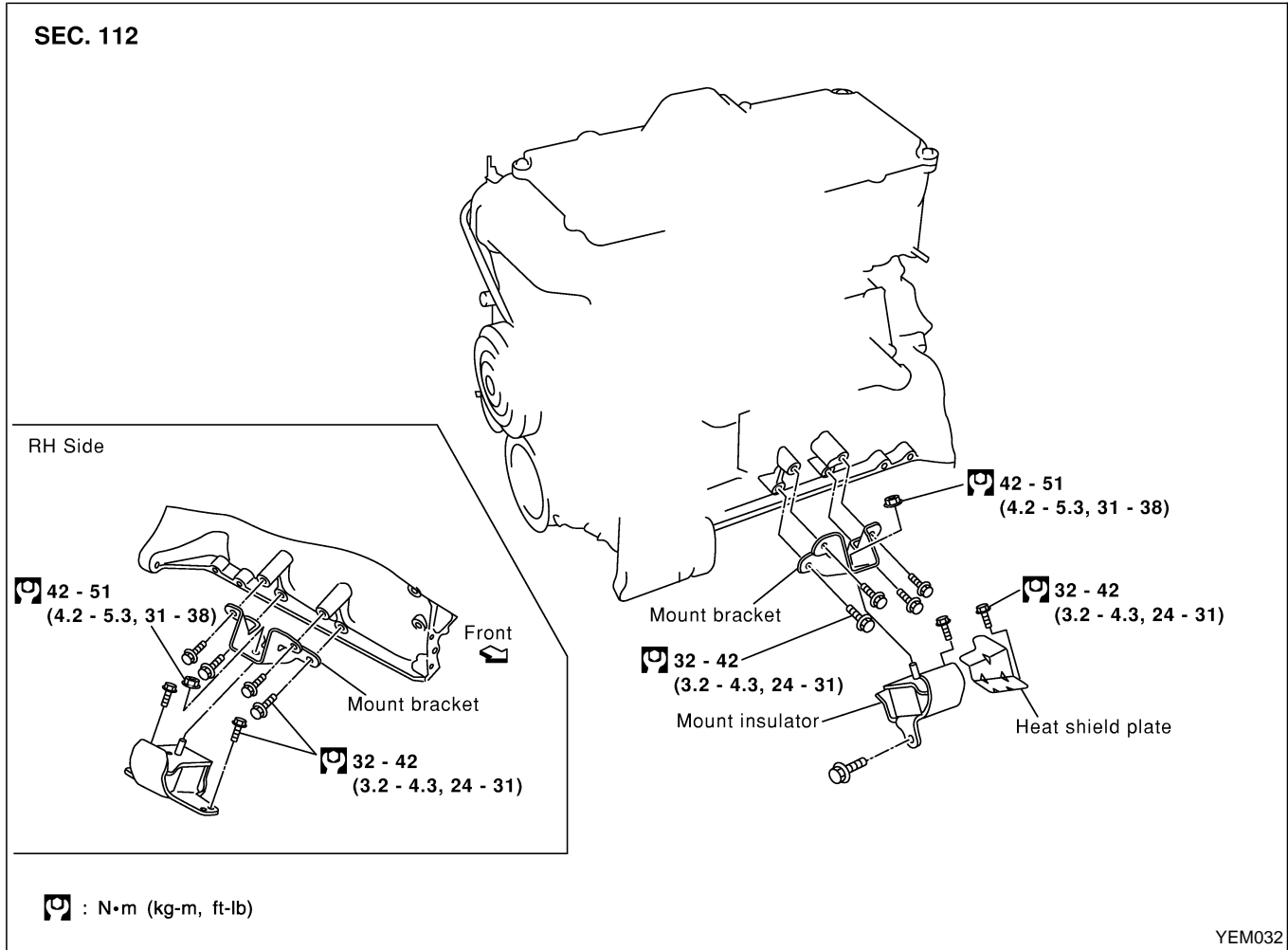
- Note that valve layout here is different from that of conventional the engine.

Assembly (Cont'd)

6. Install valve spring.
 - When installing valve spring, make sure that a smaller pitch side (identification paint-applied side) faces the cylinder head.
Identification color: pink
7. Install valve spring retainers.
8. Using valve spring compressor (SST), compress valve springs. Using magnetic hand, install valve collets.
 - After installing valve collets, tap the stem end using a plastic hammer, and check the installation status.
9. Install valve lifters and adjusting shims to the same positions as before.

Precautions

- Do not perform operation unless it is perfectly safe.
- Do not start operation unless the exhaust system and coolant are cooled down.
- Lift the engine at the designated support points only.
- Perform operations for the items other than the engine body, referring to the applicable sections.



- Refer to MT section and AT section for rear mount.

Removal

- After removing transmission, hoist the engine and remove it.

Preparation

1. Drain coolant from radiator drain plugs.
2. Remove the following parts.
 - Engine hood
 - Undercover
 - Under protector
 - Battery
 - Intercooler
 - Radiator shroud
 - Radiator
 - Accessory belt
 - Cooling fan
 - Exhaust front tube

Removal (Cont'd)

Engine room (Left)

3. Remove air duct and air cleaner case.
4. Disconnect vacuum hose to the vehicle on the engine.
5. Disconnect harness connectors from alternator and air compressor.
6. Remove alternator.
7. After removing refrigerant, remove pipes of air compressor and inlet/outlet.
8. Disconnect heating hose, install blank cap to hose to prevent coolant from leaking.
9. Remove heating pipe.
10. Remove heat insulator.
11. Remove catalytic converter.

Engine room (Right)

12. Remove power steering reservoir tank from bracket, and fix it to the vehicle with a rope.

CAUTION:

Keep the reservoir tank level when fixing to prevent oil leak.

13. Remove fuel feed and return hoses.

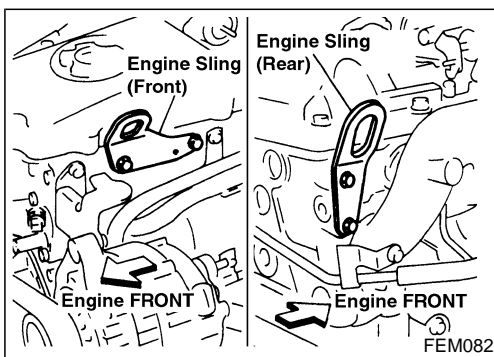
CAUTION:

Install blank caps immediately to avoid fuel leakage.

14. Remove all harness connectors on the engine, and move harnesses to the side of the vehicle.

Vehicle underfloor

15. Remove starter motor.
16. Detach A/T oil cooler pipes from oil pan. (A/T model)
17. Remove rear propeller shaft.
18. Remove mounting bolts to secure the engine to transmission.
 - 1) Remove torque converter installation bolt. (A/T model)
 - 2) Lift transmission bottom with transmission jack, and remove rear mount members from the vehicle.
 - 3) Lower transmission with the jack, and remove upper mounting bolts securing the engine to transmission.
 - 4) Lift transmission with the jack, and reinstall rear mount members to the vehicle.
 - 5) Position the jack to the front side of transmission.
 - 6) Remove remaining mounting bolts securing the engine to transmission.



Removal operation

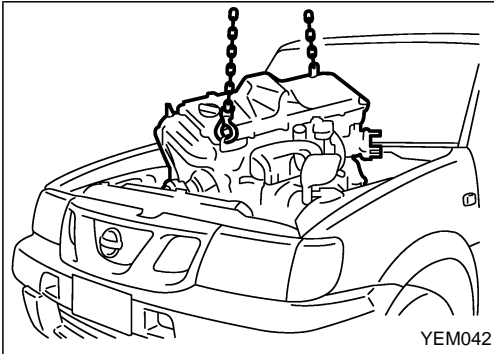
19. Remove air conditioner high pressure pipes at the rear of the engine room.
 - This is due to some inconvenience in the rear slinger installation.
20. Install the engine slingers (standard service part) to front-left and rear-right.
 - ⊙: 25 - 28 N-m (2.5 - 2.9 kg-m, 18 - 20 ft-lb)

WARNING:

For engines without engine slingers, attach proper slingers and bolts described in the PARTS CATALOG.

Removal (Cont'd)

21. Hook hoists to slingers to secure the position.
22. Remove installation nuts for left and right engine mount insulators.



23. While adjusting position frequently, hoist and remove the engine.

CAUTION:

- While performing operation, check that all necessary wires and pipes are disconnected.
- Avoid interference with parts on the vehicle.

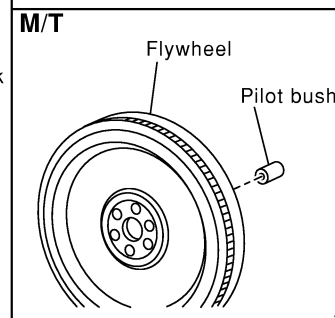
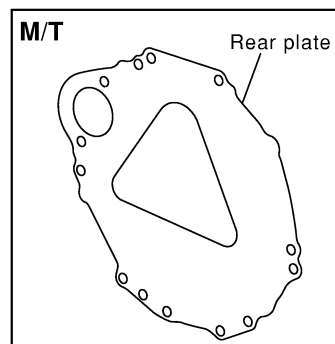
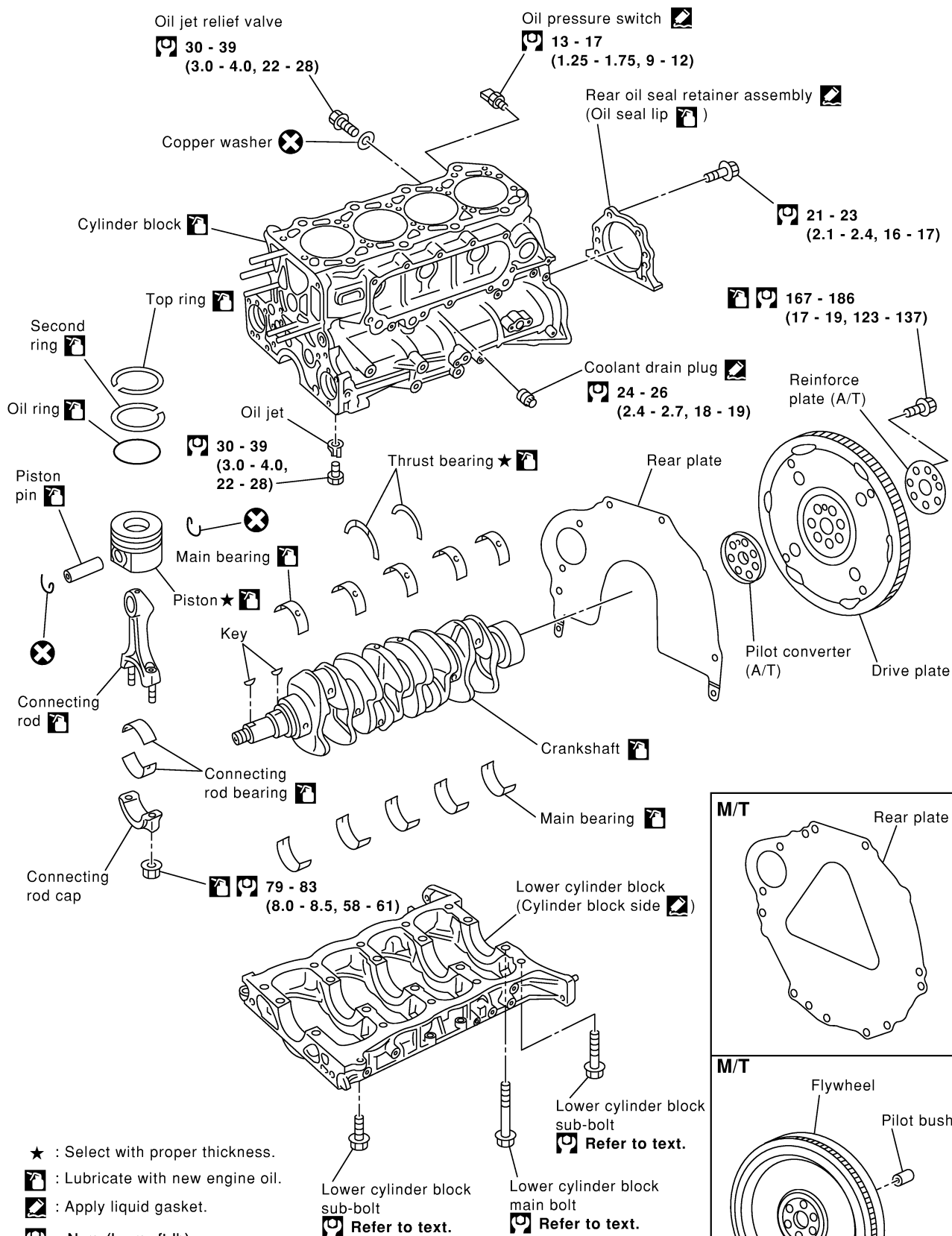
Installation

Install the engine in the reverse order of the removal procedure.

- Keep each mount insulator from oil adherence and damage.
- While keeping each mount insulator free from twisting, tighten mounting bolts and nuts for the engine mount.

Inspection

- Before starting the engine, check coolant level and grease amount, and if necessary, refill them to the specified level.
- Start the engine, and check that there is no abnormal noise or vibration.
- Warm up the engine to the sufficient temperature, and check that there is no leakage of coolant, greases, fuel, or exhaust gas.



- ★ : Select with proper thickness.
- : Lubricate with new engine oil.
- : Apply liquid gasket.
- : N·m (kg-m, ft-lb)
- : N·m (kg-m, in-lb)

YEM033

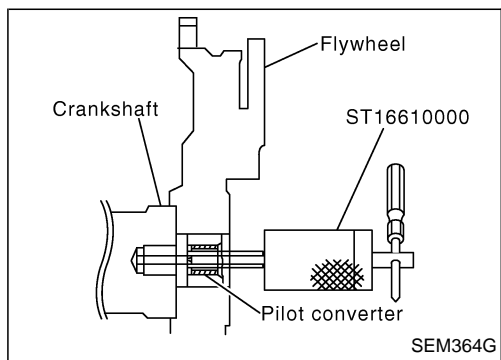
Selection Procedure for Selective Part Combination

Location	Selective part combination	Item	Method
Cylinder block - piston	Piston and piston assembly (Part No. is given to a piston and piston pin as a set.)	Piston grade (Piston outer diameter)	Refer to "Selective combination chart".

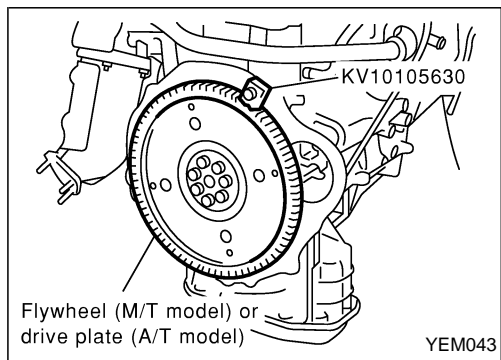
- Identification grade stamped on each part represents initial dimension of new part. This grade will not be applied to a reused part.
- Measure correct dimensions of a reused or modified part, then refer to "Selective combination chart" in this manual to identify the grade.
- Refer to the applicable pages for measurement method for each part, standards for reuse, and selecting method for selective part combination.

Disassembly

1. Remove engine assembly from vehicle.
Refer to EM-63, "ENGINE REMOVAL".



2. Remove pilot bushing from flywheel using pilot bearing puller (SST), if necessary (M/T model).
3. Install engine to engine stand (SST).

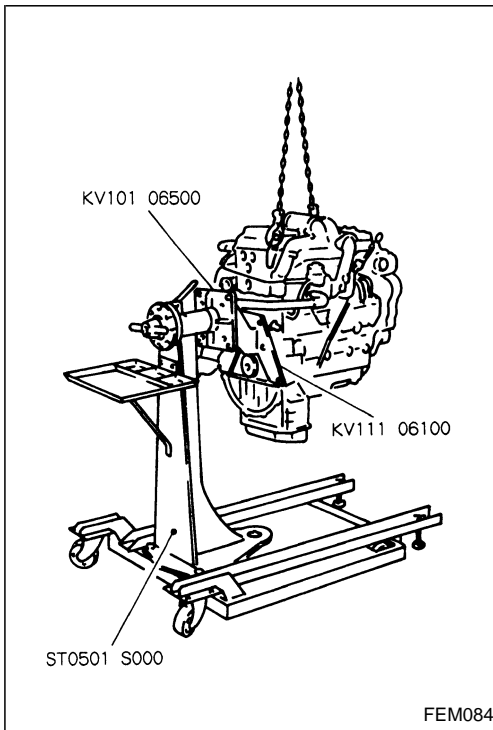
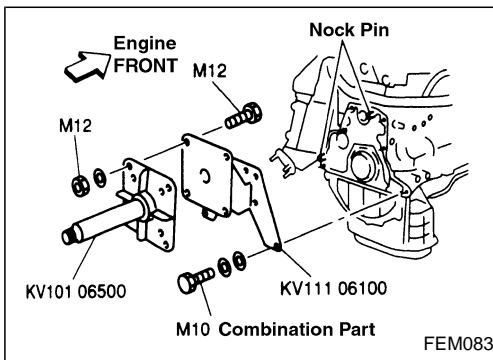


- 1) Remove flywheel (M/T model) or drive plate (A/T model).
 - Using ring gear stopper (SST), secure ring gear, and remove mounting bolts.

CAUTION:

Do not disassemble flywheel.

- Flywheel has a two-piece structure. When being pressed forward/backward, or twisted in rotating direction, transmission-side mass will be moved with audible sound. This is not a problem.
- 2) Remove pilot converter (A/T model) and rear plate.

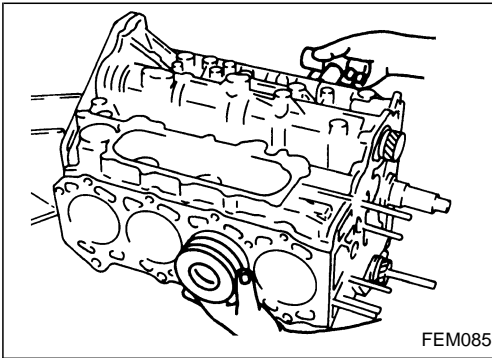
CYLINDER BLOCK**Disassembly (Cont'd)**

- 3) Install engine sub-attachment (SST) to the rear side of cylinder block.
 - Align knock pin on cylinder block with pin hole on attachment to install engine sub-attachment.
 - Mounting bolts are provided with engine sub-attachment.
- 4) Install engine attachment (SST).
 - Use commercially available M12 mounting bolts and nuts (4 sets) with strength grade of 9T (minimum).
- 5) Hoist engine and install it to the engine stand (SST).
 - Engine attachment and engine sub-attachment can be installed to engine stand before engine installation.
4. Drain engine oil and coolant from engine.
5. Remove the following parts and related parts. (Only major parts are listed.)
 - Accessory belt
 - Catalytic converter
 - Turbocharger
 - Exhaust manifold
 - Injection tube
 - Intake manifold
 - Rocker cover
 - Oil pan (upper/lower)
 - Water pump
 - Thermostat and water pipes
 - Vacuum pump
 - Injection tube
 - Timing chain
 - Electronic high pressure fuel injection pump
 - Timing gear
 - High pressure injection nozzle assembly
 - Camshaft
 - Cylinder head
 - Oil cooler
 - Accessory and accessory brackets

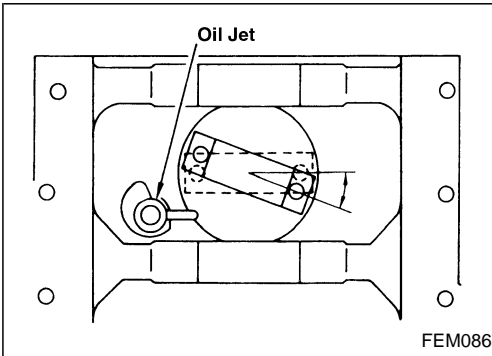
6. Remove rear oil seal and retainer assembly.
 - Insert flat-bladed screwdriver between lower cylinder block and rear oil seal retainer to remove the assembly.
 - No part No. is given to oil seal.

CYLINDER BLOCK

Disassembly (Cont'd)



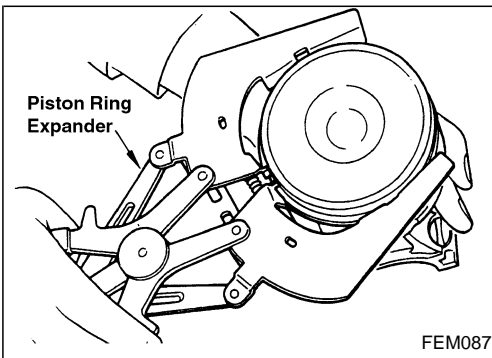
7. Remove piston and connecting rod assembly.
 - Before removing piston and connecting rod assembly, check connecting rod side clearance. Refer to EM-71, "CONNECTING ROD SIDE CLEARANCE".
- 1) Move crankshaft pin to be removed to approximately BDC.
- 2) Remove connecting rod caps.
- 3) Using the grip of a hammer, press the piston and connecting rod assembly out to cylinder head side.



CAUTION:

When removing the piston and connecting rod assembly, prevent the big end of the connecting rod from interfering with the oil jet.

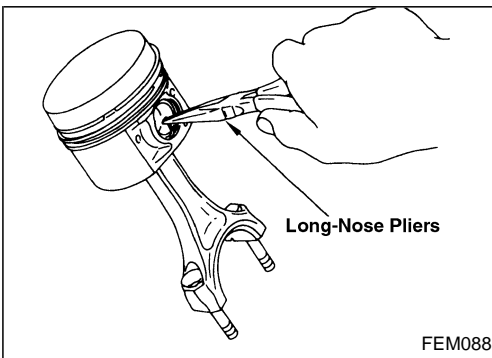
8. Remove connecting rod bearings from connecting rods and caps.
 - Keep them by cylinder to avoid confusion.



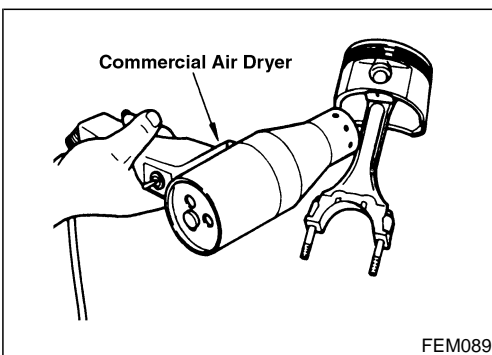
9. Remove piston rings from pistons using piston ring expander (multi-purpose tool).

CAUTION:

- When removing, prevent pistons from being damaged.
- Do not expand piston rings excessively. This may damage the piston rings.



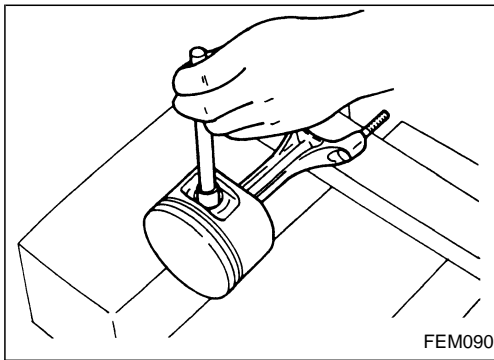
10. Remove pistons from connecting rods.
 - 1) Using long nose pliers, remove snap rings.



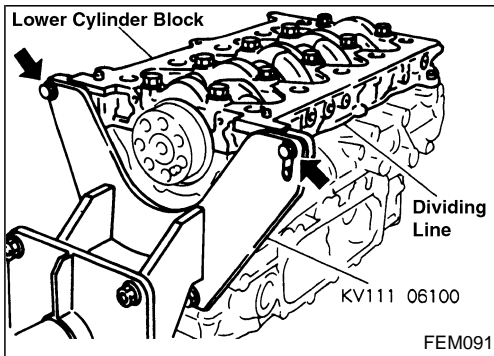
- 2) Using industrial dryer, heat pistons up to 60 to 70°C (140 to 158°F).

CYLINDER BLOCK

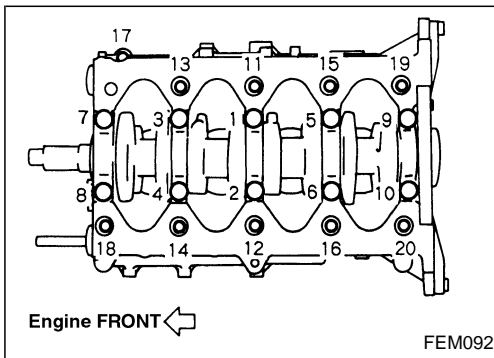
Disassembly (Cont'd)



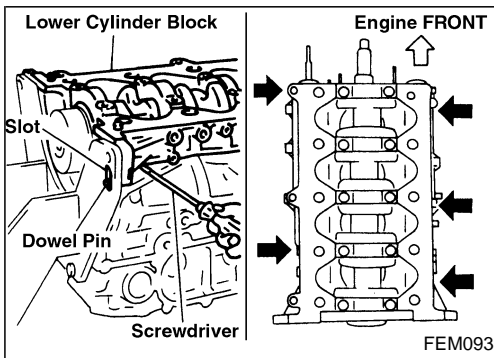
- 3) Using rod with outer diameter of 30 mm (1.18 in), press piston pins out.



11. Remove lower cylinder block.
- The lower cylinder block is the lower part of the cylinder block, which works as the main bearing cap (beam) and oil pan mounting face.
- 1) Remove mounting bolts for engine sub-attachment shown by arrows in the figure.



- 2) Loosen and remove mounting bolts in the reverse order shown in the figure.



- 3) Insert flat-bladed screwdriver into 5 locations shown by arrows in the figure. Lift lower cylinder block evenly, and remove liquid gasket.

CAUTION:

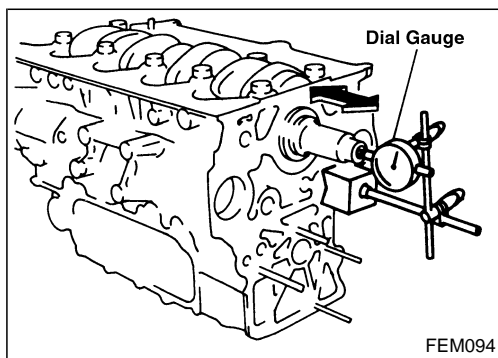
Prevent mating faces from being damaged.

- 4) When removing lower cylinder block, use slot to prevent dowel pin from interfering with engine sub-attachment.
- No part No. is given to lower cylinder block, because it is machined with the cylinder block.

12. Remove crankshaft.
13. Remove main bearings and thrust bearings from cylinder block and lower cylinder block.

CAUTION:

Check mounting positions. Keep them to avoid confusion.



Inspection

CRANKSHAFT END PLAY

- Using dial indicator, measure crankshaft travel amount by moving the crankshaft forward or backward, or
- Using feeler gauge, measure crankshaft travel amount with the lower cylinder block removed.

Standard: 0.055 - 0.140 mm (0.0022 - 0.0055 in)

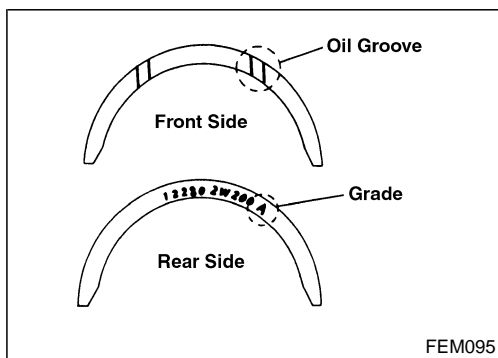
Limit: 0.250 mm (0.0098 in)

- If measured value exceeds the limit, select appropriate thrust bearings.

Unit: mm (in)

Grade symbol	Thickness of thrust bearing
A	2.275 - 2.325 (0.0896 - 0.0915)
B	2.300 - 2.350 (0.0906 - 0.0925)
C	2.325 - 2.375 (0.0915 - 0.0935)
OS 020	2.475 - 2.525 (0.0974 - 0.0994)

- OS 020 has part No. of 12280 2W215 and OS 0.20 marked on bearing surface.



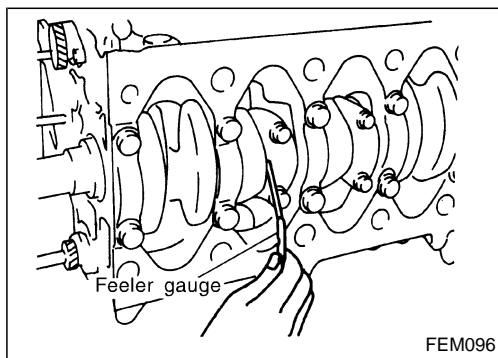
CONNECTING ROD SIDE CLEARANCE

- Using feeler gauge, measure side clearance between connecting rod and crank arm.

Standard: 0.10 - 0.22 (0.0039 - 0.0087 in)

Limit: 0.22 mm (0.0087 in)

- If measured value exceeds the limit, replace connecting rod and repeat measurement.
- If measured value still exceeds the limit, replace crankshaft.

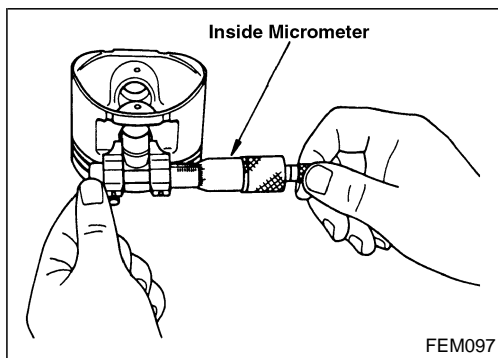


PISTON TO PISTON PIN CLEARANCE

Piston pin hole inner diameter

Using inside micrometer, measure piston pin hole inner diameter.

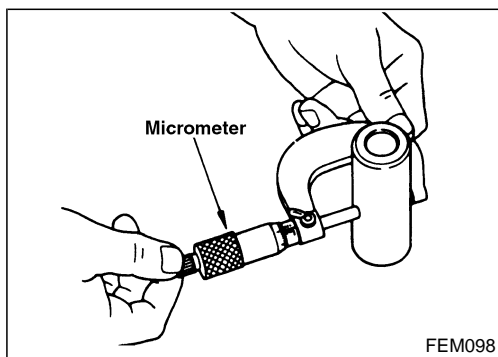
Standard: 32.997 - 33.005 mm (1.2991 - 1.2994 in) dia.



Piston pin outer diameter

Using micrometer, measure piston pin outer diameter.

Standard: 32.993 - 33.000 mm (1.2989 - 1.2992 in) dia.



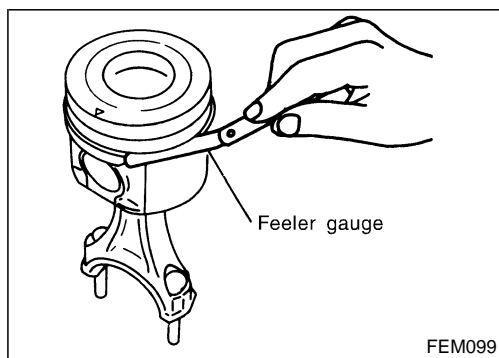
Inspection (Cont'd)

Calculation of piston to piston pin clearance

Piston pin clearance = Piston pin hole inner diameter – Piston pin outer diameter

**Standard: –0.003 (Tightening clearance) to 0.012 mm
(–0.0001 to 0.0005 in)**

If out of specifications, replace piston and piston pin assembly.

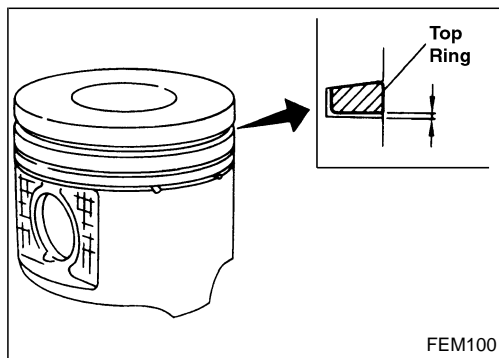


PISTON RING SIDE CLEARANCE

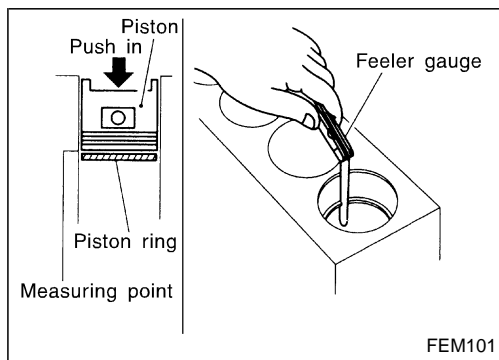
- Using feeler gauge, measure clearance between piston ring and piston ring groove.

Unit: mm (in)

	Standard	Limit
Top ring	0.05 - 0.07 (0.0020 - 0.0028)	0.5 (0.020)
Second ring	0.04 - 0.08 (0.0016 - 0.0031)	0.3 (0.012)
Oil ring	0.02 - 0.06 (0.0008 - 0.0024)	0.15 (0.0059)



- Align top ring and external surface of piston. Measure lower side clearance of top ring with top ring pressed onto upper side of ring groove.
- If side clearance exceeds the limit, replace piston ring.
- Check clearance again. If side clearance still exceeds the limit, replace piston.



PISTON RING END GAP

- Check that cylinder bore diameter is within specifications. Refer to EM-74, "PISTON TO CYLINDER BORE CLEARANCE".
- Using piston, press piston ring to cylinder mid point, and measure end gap.

Unit: mm (in)

	Standard	Limit
Top ring	0.3 - 0.45 (0.0118 - 0.0177)	1.5 (0.059)
Second ring	0.5 - 0.65 (0.0197 - 0.0256)	
Oil ring	0.25 - 0.45 (0.0098 - 0.0177)	

Inspection (Cont'd)**CONNECTING ROD BEND AND TORSION**

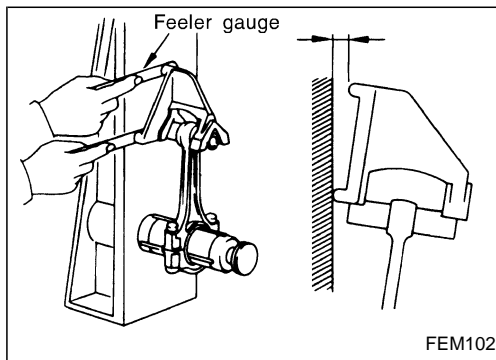
Use connecting rod aligner to check bend and torsion.

Bend limit:

0.05 mm (0.0020 in)/100 mm (3.94 in)

Torsion limit:

0.05 mm (0.0020 in)/100 mm (3.94 in)



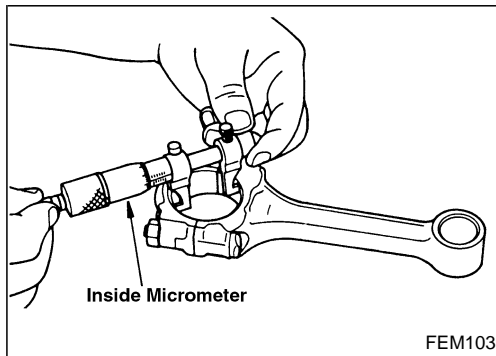
FEM102

Connecting rod big end inner diameter

Install connecting rod caps without connecting rod bearings and tighten connecting rod nuts to the specified torque. Using inside micrometer, measure connecting rod big end inner diameter.

Standard:

59.987 - 60.000 mm (2.3617 - 2.3622 in) dia.



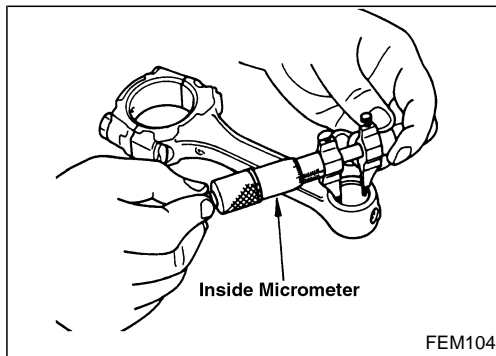
FEM103

CONNECTING ROD BUSHING OIL CLEARANCE (SMALL END)**Connecting rod small end inner diameter**

Use inside micrometer to measure small end inner diameter.

Standard:

33.025 - 33.038 mm (1.3002 - 1.3007 in) dia.



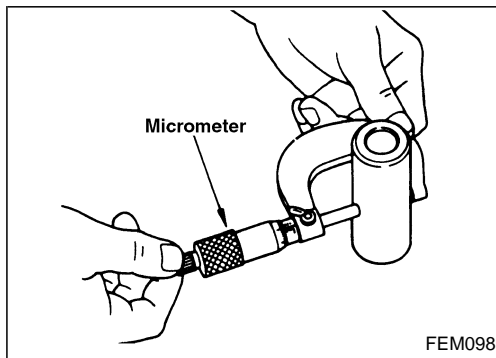
FEM104

Piston pin outer diameter

Use micrometer to measure piston pin outer diameter.

Standard:

32.993 - 33.000 mm (1.2989 - 1.2992 in) dia.



FEM098

Calculation of connecting rod bushing clearance

Connecting rod small end bushing clearance = Connecting rod small end inner diameter - Piston pin outer diameter

Standard:

0.025 - 0.045 mm (0.0010 - 0.0018 in)

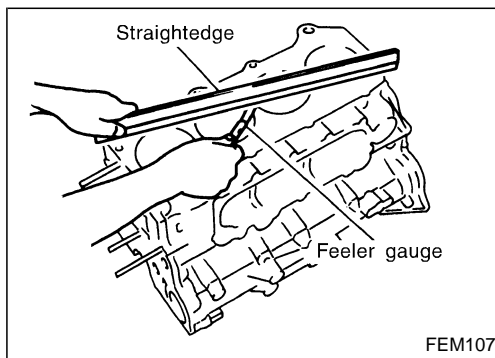
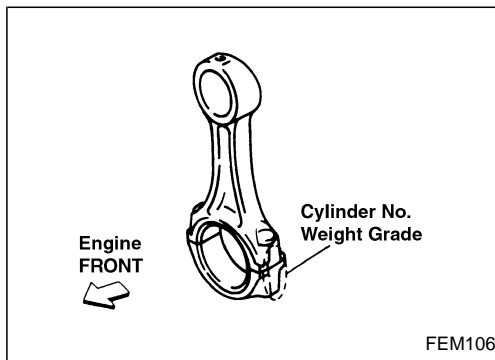
- If out of specifications, replace connecting rod and/or piston and piston pin assembly.

CYLINDER BLOCK

Inspection (Cont'd)

- New connecting rods are classified into 8 weight classes at factory. The same class connecting rods are used on a engine.

Weight grade symbol	Weight class g (oz)
H	1,261 - 1,264 (44.5 - 44.6)
I	1,264 - 1,267 (44.6 - 44.7)
K	1,267 - 1,270 (44.7 - 44.8)
L	1,270 - 1,273 (44.8 - 44.9)
M	1,273 - 1,276 (44.9 - 45.0)
O	1,276 - 1,279 (45.0 - 45.1)
P	1,279 - 1,282 (45.1 - 45.2)
S	1,282 - 1,285 (45.2 - 45.3)



CYLINDER BLOCK TOP SURFACE DISTORTION

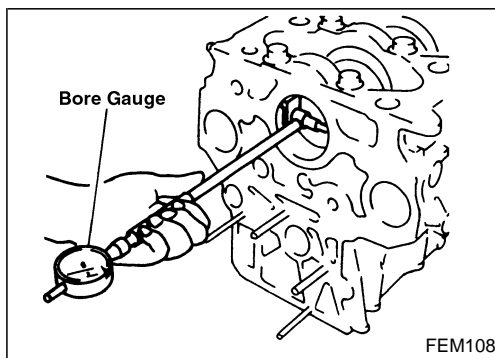
- Using scraper, remove gasket installed onto cylinder block surface. Remove contamination such as oil, scale, and carbon.

CAUTION:

Keep broken pieces of gasket clear of oil and coolant passages.

- Use straightedge and feeler gauge to check block upper surface for distortion.

Limit: 0.1 mm (0.004 in)



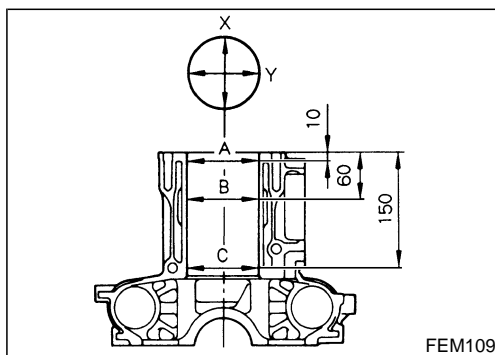
MAIN BEARING HOUSING INNER DIAMETER

- Install main bearing caps without main bearings. Tighten mounting bolts to the specified torque.
- Use bore gauge to measure main bearing housing inner diameter.

Standard:

74.981 - 75.000 mm (2.9520 - 2.9528 in) dia.

- If out of specification, replace cylinder block and lower cylinder block.



PISTON TO CYLINDER BORE CLEARANCE

Cylinder bore inner diameter

- Using bore gauge, measure cylinder inner diameters at 6 positions; top, middle, and bottom (A, B, C) in 2 directions (X, Y).

Cylinder inner diameter (Standard):

96.000 - 96.030 mm (3.7795 - 3.7807 in) dia.

Wear limit: 0.2 mm (0.008 in)

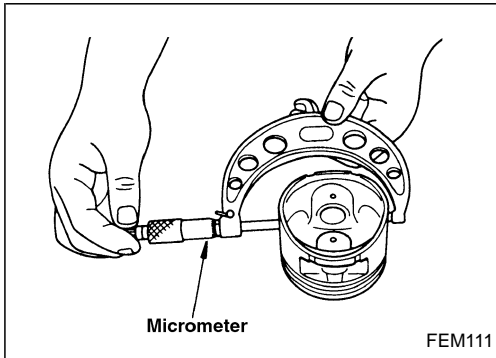
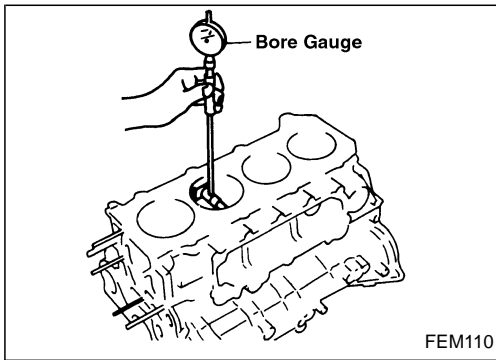
Out-of-round limit (X - Y): 0.02 mm (0.0008 in)

Taper limit (A - C): 0.02 mm (0.0008 in)

CYLINDER BLOCK

Inspection (Cont'd)

- If clearance exceeds the limit, or any flaws or seizures are found on inner surface of cylinder, hon or bore the applicable cylinder.



Piston outer diameter

Use micrometer to measure piston skirt outer diameter.

Measurement position:

10 mm (0.39 in) upper from the lower end of piston

Standard:

95.950 - 95.980 mm (3.7776 - 3.7787 in) dia.

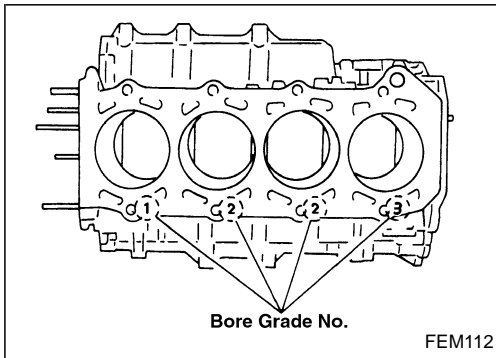
Calculation of piston to piston bore clearance

- Calculate using piston skirt outer diameter and cylinder inner diameter (direction X, position B).
Clearance = Cylinder inner diameter – Piston skirt outer diameter

Specifications at room temperature [20°C (68°F)]:

0.040 - 0.060 mm (0.0016 - 0.0024 in)

- If out of specification, replace piston and piston pin assembly.



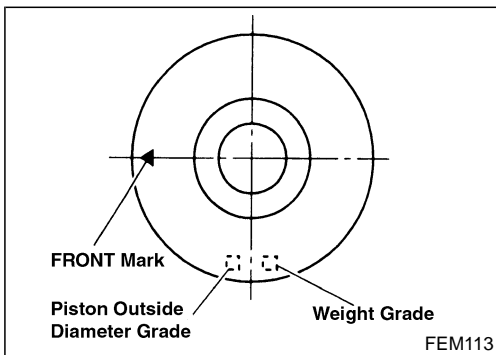
SELECTIVE PISTON COMBINATION

When using new cylinder block

- Confirm cylinder bore grade (1, 2, 3) on left upper surface of cylinder block, and refer to "Selective combination chart" below to select appropriate piston.
- Part No. is given to a piston and piston pin as a set.

When re-using an old cylinder block

1. Measure cylinder block bore inner diameter.
2. Referring to "Cylinder block bore inner diameter" in "Selective combination chart", select appropriate piston according to cylinder bore grade.



Inspection (Cont'd)

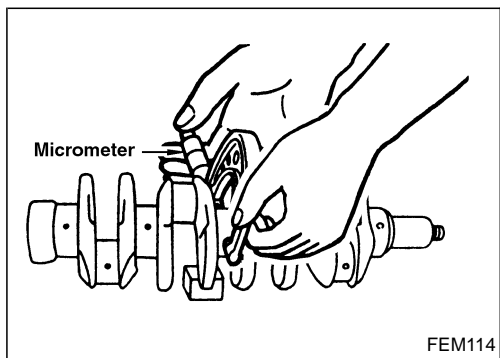
Selective combination chart

Unit: mm (in)

○: Preferable combination △: Allowable combination X: NG combination			Piston grade	
			1	2
			95.950 - 95.960 (3.7776 - 3.7779)	95.960 - 95.970 (3.7779 - 3.7783)
Cylinder bore grade (Cylinder block bore inner diameter)	1	96.000 - 96.010 (3.7795 - 3.7799)	○	X
	2	96.010 - 96.020 (3.7799 - 3.7803)	△	○
	3	96.020 - 96.030 (3.7803 - 3.7807)	△	○

- Piston grade 3 (95.980/95.970) is applicable at factory only.
- New pistons are classified into 4 weight classes at factory. The same class pistons are used on a engine.

Weight grade symbol	Weight class g (oz)
E	600 - 605 (21.2 - 21.3)
F	605 - 610 (21.3 - 21.5)
G	610 - 615 (21.5 - 21.7)
H	615 - 620 (21.7 - 21.9)



CRANKSHAFT JOURNAL OUTER DIAMETER

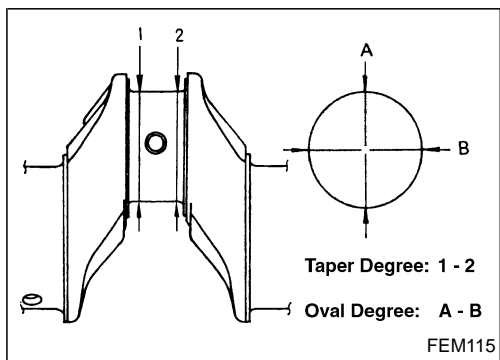
Use micrometer to measure journal outer diameter.

Standard: 70.907 - 70.920 mm (2.7916 - 2.7921 in) dia.

CRANKSHAFT PIN OUTER DIAMETER

Use micrometer to measure pin outer diameter.

Standard: 56.913 - 56.926 mm (2.2407 - 2.2412 in) dia.

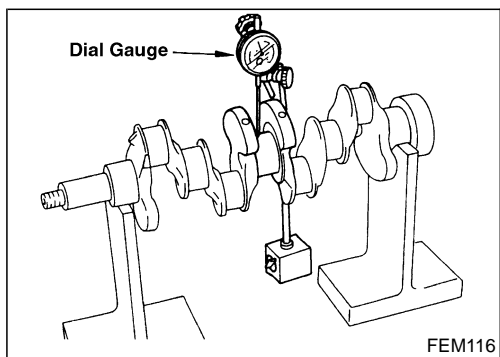


CRANKSHAFT OUT-OF-ROUND AND TAPER

- Using micrometer, measure each journal and pin at 4 points shown in the figure.
- Out-of-round value is indicated by difference in dimensions between directions A and B at points 1 and 2.
- Taper value is indicated by difference in dimensions between points 1 and 2 in directions A and B.

Out-of-round limit: 0.01 mm (0.0004 in)

Taper limit: 0.01 mm (0.0004 in)



CRANKSHAFT RUNOUT

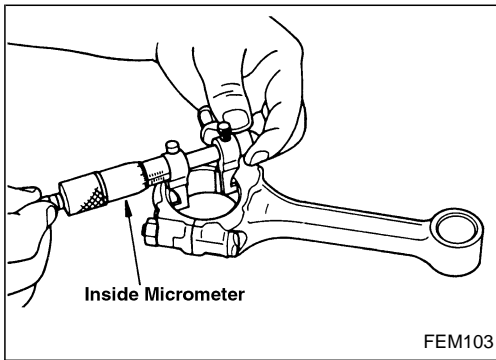
- Place V-block onto surface plate to support journals at both ends of crankshaft.
- Position dial indicator vertically onto No. 3 journal.
- Rotate crankshaft to read needle movement on dial indicator.
- Crankshaft bend value is 1/2 of needle movement.

Limit: 0.03 mm (0.0012 in)

Inspection (Cont'd)

CONNECTING ROD BEARING OIL CLEARANCE

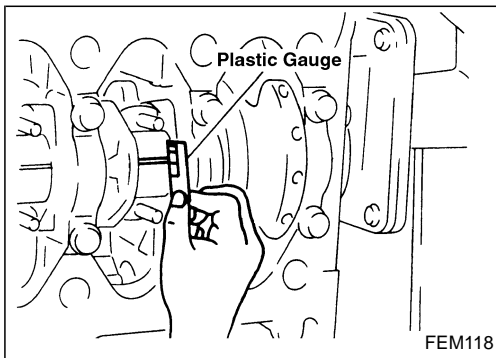
Method by measurement



- Install connecting rod bearings to connecting rods and caps, and tighten connecting nuts to the specified torque. Use inside micrometer to measure connecting rod bearing inner diameter. Bearing clearance = Connecting rod bearing inner diameter – Crankshaft pin outer diameter

Standard: 0.035 - 0.077 mm (0.0014 - 0.0030 in)

- If out of specifications, check connecting rod big end inner diameter and crankshaft pin outer diameter, and select appropriate connecting rod bearing to adjust clearance to specifications. Refer to “Connecting rod bearing undersize list” on the next page.



Method using plastigage

- Remove contamination such as oil, dust completely from crankshaft pins and each bearing surface.
- Cut plastigage slightly shorter than bearing width, place it in crankshaft direction, avoiding oil holes.
- Install connecting rod bearings to caps, and tighten connecting rod nuts to the specified torque.

CAUTION:

Never rotate crankshaft.

- Remove connecting rod caps and bearings, and measure plastigage width using scale on plastigage bag.

CAUTION:

If out of specification, take same action mentioned in “Method by measurement”.

Undersize bearing usage

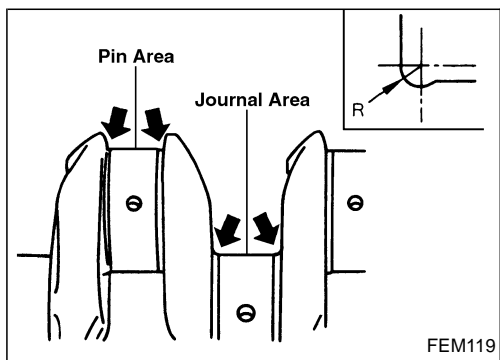
- If bearing clearance is out of specifications for connecting rod bearings in standard size, use undersize bearings.
- When using undersize bearings, measure bearing inner diameter with bearing installed, and grind pins to adjust clearance to specification.

Inspection (Cont'd)

Connecting rod bearing undersize list

Unit: mm (in)

Size	Thickness
US 0.25 (0.0098)	1.630 - 1.638 (0.0642 - 0.0645)
US 0.50 (0.0197)	1.755 - 1.763 (0.0691 - 0.0694)
US 0.75 (0.0295)	1.880 - 1.888 (0.0740 - 0.0743)
US 1.00 (0.0394)	2.005 - 2.013 (0.0789 - 0.0793)



CAUTION:

When grinding crank pins to use undersize bearings, avoid damaging corners of fillet.

Corner dimension (Standard):

Pin

3.3 - 3.7 mm (0.130 - 0.146 in)

Journal

2.8 - 3.2 mm (0.110 - 0.126 in)

MAIN BEARING OIL CLEARANCE

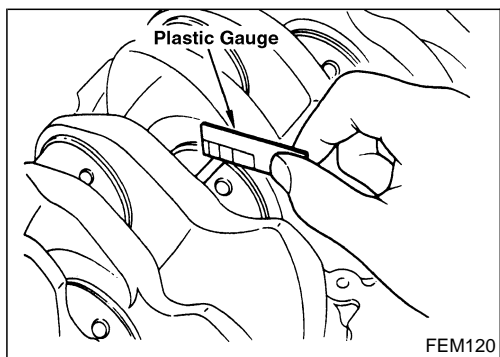
Method by measurement

- Install main bearings to cylinder block and bearing caps, and tighten bearing cap bolts to the specified torque. Measure main bearing inner diameter.

Bearing clearance = Bearing inner diameter – Crankshaft journal outer diameter

Standard: 0.035 - 0.083 mm (0.0014 - 0.0033 in)

- If out of specification, check main bearing housing inner diameter and crankshaft journal outer diameter, and select appropriate main bearing to adjust clearance to specifications. Refer to “Main bearing undersize list” on the next page.



Method using plastigage

- Remove contamination such as oil, dust completely from crankshaft journals and each bearing surface.
- Cut plastigage slightly shorter than bearing width, place it in crankshaft direction, avoiding oil holes.
- Install main bearings to caps, and tighten connecting rod nuts to the specified torque.

CAUTION:

Never rotate crankshaft.

- Remove bearing caps and bearings, and measure plastigage width using scale on plastigage bag.

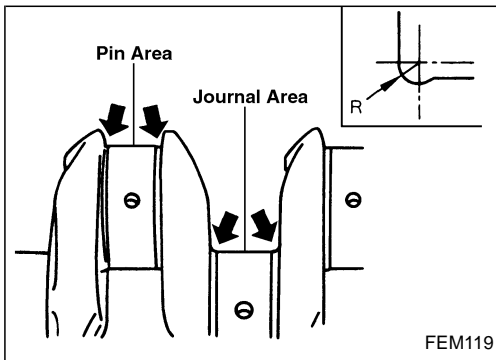
Inspection (Cont'd)

CAUTION:

If out of specification, take same action mentioned in “Method by measurement”.

Undersize bearing usage

- If bearing clearance is out of specifications for main bearings in standard size, use undersize bearings.
- When using undersize bearings, measure bearing inner diameter with bearing installed, and grind crank journals to adjust clearance to specification.



Main bearing undersize list

Unit: mm (in)

Size	Thickness
US 0.25 (0.0098)	2.130 - 2.138 (0.0839 - 0.0842)
US 0.50 (0.0197)	2.255 - 2.263 (0.0888 - 0.0891)
US 0.75 (0.0295)	2.380 - 2.388 (0.0937 - 0.0940)
US 1.00 (0.0394)	2.505 - 2.513 (0.0986 - 0.0989)

CAUTION:

When grinding crank journals to use undersize bearings, avoid damaging corners of fillet.

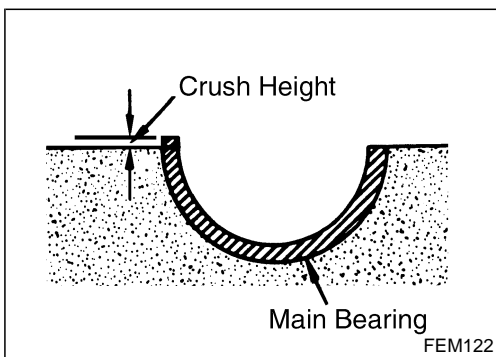
Corner dimension (Standard):

Pin

3.3 - 3.7 mm (0.130 - 0.146 in)

Journal

2.8 - 3.2 mm (0.110 - 0.126 in)

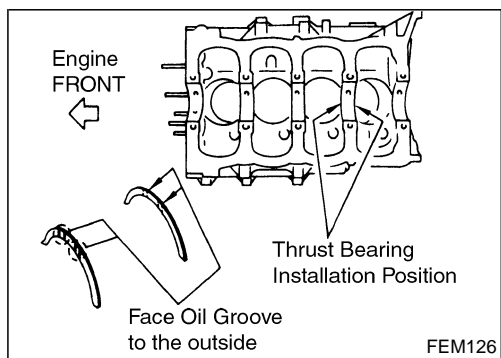


MAIN BEARING CRUSH HEIGHT

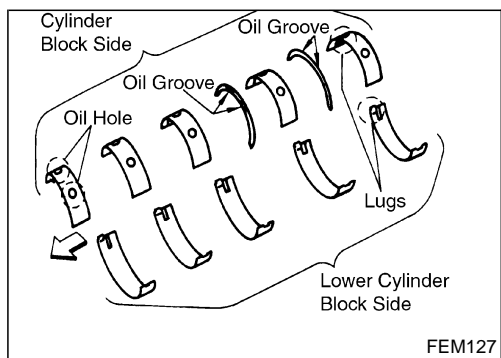
- Tighten bearing caps to the specified torque with main bearings installed, and remove caps. The bearing end must then be higher than the flat surface.
Standard: Crush height must exist.
- If out of specification, replace main bearings.

Assembly

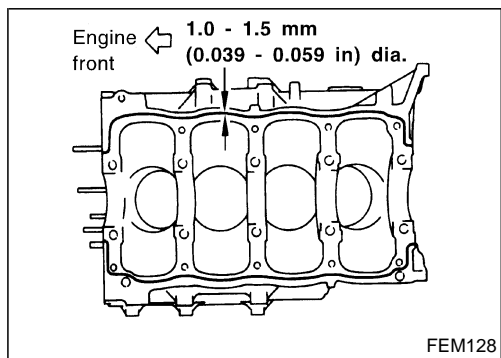
1. Blow air sufficiently to inside coolant passage, oil passage, crankcase, and cylinder bore to remove foreign matter.



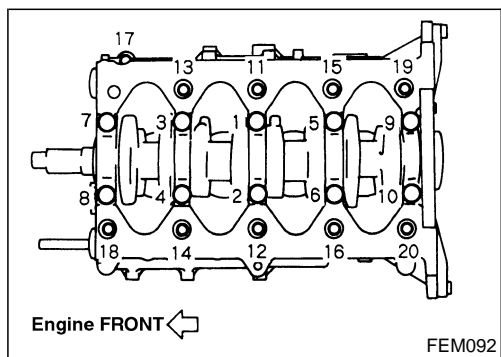
2. Install main bearings and thrust bearings.
 - 1) Remove contamination, dust and oil from bearing mounting positions on cylinder block and main bearing caps.
 - 2) Install thrust bearings on both sides of No. 4 housing on cylinder block.
 - Install thrust bearings with oil groove facing to crankshaft arm (outside).



- 3) Being careful with the direction, install main bearings.
 - Install main bearings with the oil holes and grooves onto the cylinder block side, and those without oil holes and grooves onto the lower cylinder block side.
 - While installing bearings, apply engine oil to bearing surfaces (inside). Do not apply oil to rear surfaces, but clean them completely.
 - Align stopper notches on bearings to install them.
 - Check that the oil holes on the cylinder block body are mated with the oil hole positions on the bearings.



3. Install crankshaft to cylinder block.
 - While rotating crankshaft by hand, check for smooth rotation.
4. Install lower cylinder block.
 - Apply a continuous bead of liquid gasket to lower cylinder block as shown in the figure.
 - Using slots on engine sub-attachment, install the lower cylinder block to the cylinder block, avoiding interference of dowel pins.



5. Tighten lower cylinder mounting bolts to the torque shown below in 3 consecutive steps in the order shown in the figure.

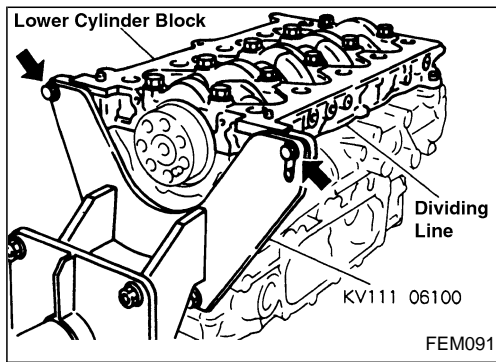
Unit: N·m (kg·m, ft·lb)

	Main bolt (Nos. 1 - 10)	Sub-bolt (Nos. 11 - 20)
1st	20 (2.0, 14)	98 (10, 72)
2nd	98 (10, 72)	20 (2.0, 14)
3rd	167 - 176 (17 - 18, 123 - 130)	40 - 46 (4.0 - 4.7, 29 - 33)

- Sub-bolt No. 17 has shorter length than that of other sub-bolts.

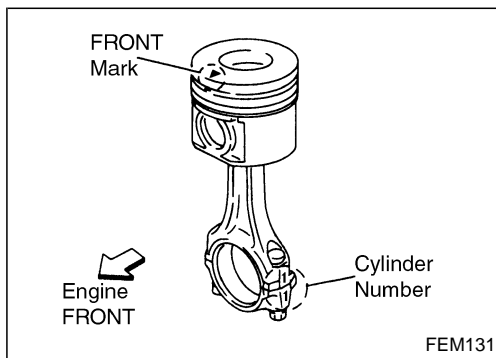
CYLINDER BLOCK

Assembly (Cont'd)



6. Install mounting bolts for engine sub-attachment shown by arrows in the figure.
 - After tightening bolts to the specified torque, check crankshaft for smooth rotation.
 - Check crankshaft end play. Refer to EM-71, "CRANKSHAFT END PLAY".

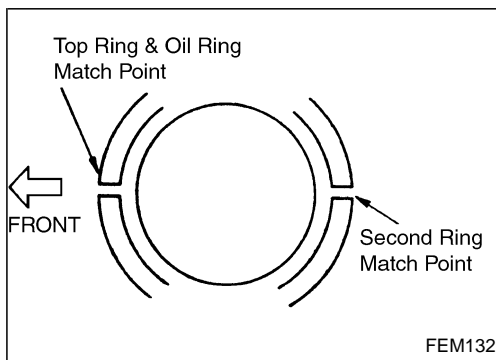
7. Install pistons to connecting rod.
 - 1) Using long nose pliers, install snap rings to grooves on piston rear side.
 - Fit snap rings correctly into grooves.
 - 2) Install pistons to connecting rods.
 - Using industrial dryer, heat pistons up to approx. 60 to 70°C (140 to 158°F) until piston pin can be pressed down by finger touch. Then insert piston pins into piston and connecting rod from front side of piston toward rear.



- Assemble piston and connecting rod with front mark of piston crown and cylinder No. stamped on connecting rod being positioned as shown in the figure.
- 3) Install snap rings to front side of pistons.
 - Refer to above 1) for precaution on snap ring installation.
 - After installation, check connecting rods for smooth movement.
 8. Use piston ring expander (multi-purpose tool) to install piston rings.

CAUTION:

When installing, prevent piston from being damaged.

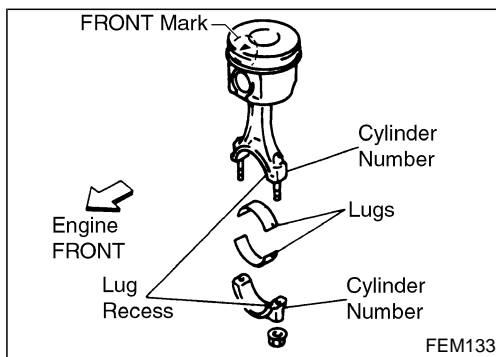


- Install top ring and second ring with stamped surfaces facing upward.

Identification stamp:

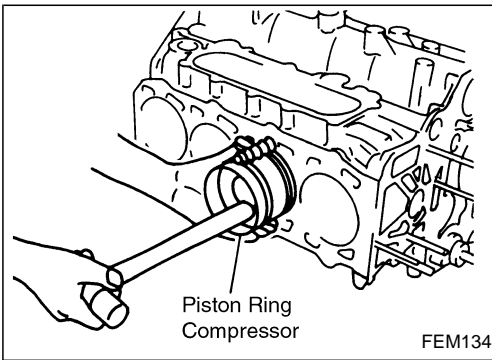
Top ring: R

Second ring: RN



9. Install connecting rod bearings to connecting rods and caps.
 - While installing connecting rod bearings, apply engine oil to bearing surfaces (inside). Do not apply oil to rear surfaces, but clean them completely.
 - Align stoppers on connecting rod bearings with connecting rod stopper notches to install connecting rod bearings.

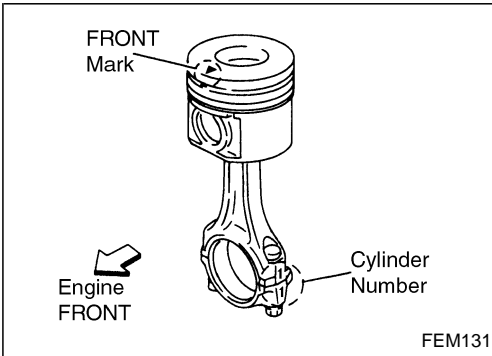
Assembly (Cont'd)



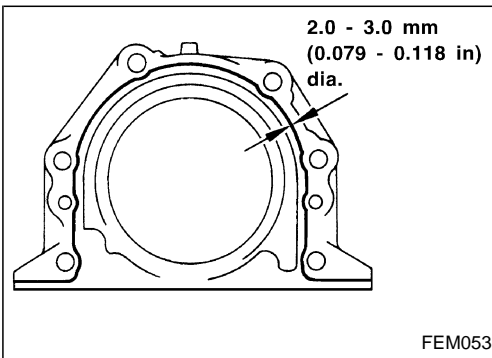
10. Install piston and connecting rod assembly to crankshaft.
 - Move crankshaft pin to be removed to BDC.
 - Align cylinder position with cylinder No. on connecting rod to install piston and connecting rod assembly.
 - Using piston ring compressor (multi-purpose tool), install piston and connecting rod assembly with front mark on piston crown facing toward the front side of engine.

CAUTION:

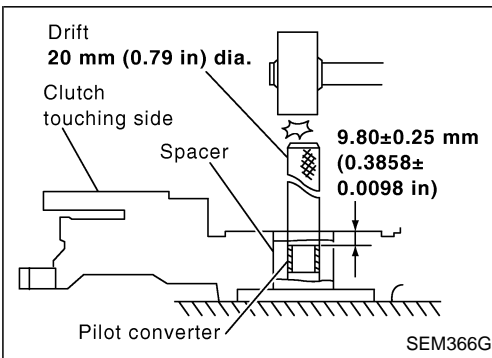
When installing piston and connecting rod assembly, prevent the big end of connecting rod from interfering with oil jet.



11. Install connecting rod caps and mounting nuts.
 - Align cylinder No. stamped on connecting rod with that on cap to install connecting rod cap.
 - After tightening nuts, check crankshaft for smooth rotation.
 - Check connecting rod side clearance. Refer to EM-71, "CONNECTING ROD SIDE CLEARANCE".



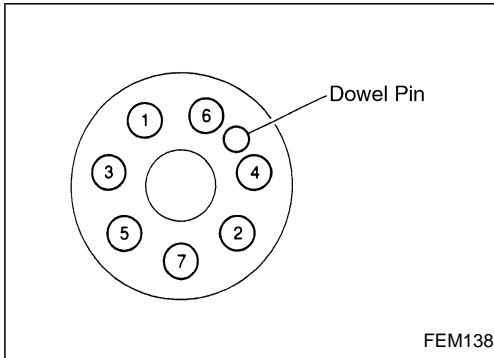
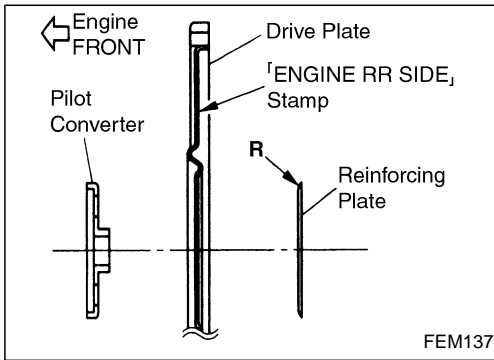
12. Install rear oil seal and retainer assembly.
 - Apply a continuous bead of liquid gasket to rear oil seal and retainer assembly as shown in the figure.



13. Press fit pilot bushing into flywheel (M/T model).
 - 1) Using drift with outer diameter of 35 mm, press fit spacer until it is in contact with the flywheel to prevent displacement at removal.
 - 2) Using drift with outer diameter of 20 mm, press fit pilot bushing by the length shown in the figure.

14. Install rear plate.
15. Install removed parts to engine in the reverse order of disassembly.
16. Remove engine from engine stand.

Assembly (Cont'd)



17. Install flywheel (M/T model) or drive plate (A/T model).

- Install pilot converter, drive plate, and reinforcing plate in direction shown in the figure.
- Using the same method as disassembly, secure crankshaft and tighten mounting bolts.

- Tighten mounting bolts for flywheel or drive plate in order shown in the figure.

General Specifications

Cylinder arrangement		In-line 4
Displacement	cm ³ (cu in)	2,953 (180.19)
Bore and stroke	mm (in)	96 x 102 (3.78 x 4.02)
Valve arrangement		DOHC
Firing order		1-3-4-2
Number of piston rings	Compression	2
	Oil	1
Number of main bearings		5
Compression ratio		17.9

Compression Pressure

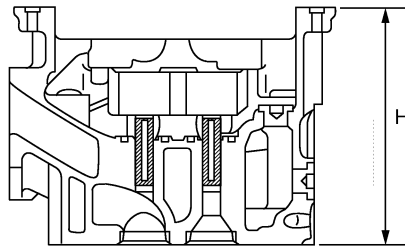
Unit: kPa (bar, kg/cm², psi)/200 rpm

Compression pressure	Standard	2,942 (29.42, 30.0, 427)
	Minimum	2,452 (24.52, 25.0, 356)
	Differential limit between cylinders	294 (2.94, 3.0, 43)

Cylinder Head

Unit: mm (in)

	Standard	Limit
Head surface distortion	Less than 0.05 (0.0020)	0.2 (0.008)



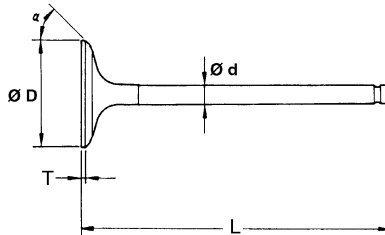
Nominal cylinder head height:
H = 156.9 - 157.1 mm (6.177 - 6.185 in)

SEM368G

Valve

VALVE

Unit: mm (in)



FEM067

Valve (Cont'd)

Valve head diameter "D"	Intake	31.9 - 32.1 (1.256 - 1.264)
	Exhaust	29.9 - 30.1 (1.177 - 1.185)
Valve length "L"	Intake	113.5 (4.4685)
	Exhaust	113.5 (4.4685)
Valve stem diameter "d"	Intake	6.962 - 6.977 (0.2741 - 0.2747)
	Exhaust	6.945 - 6.960 (0.2734 - 0.2740)
Valve seat angle "α"	Intake	45°00' - 45°30'
	Exhaust	
Valve margin "T"	Intake	1.5 (0.059)
	Exhaust	1.5 (0.059)
Valve stem end surface grinding limit		Less than 0.2 (0.008)

VALVE CLEARANCE

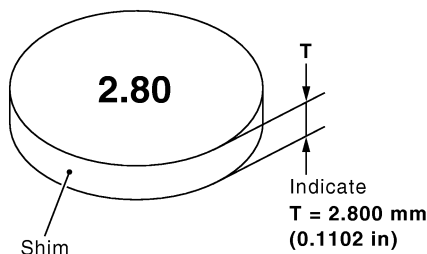
Unit: mm (in)

	Cold
Intake	0.30 - 0.40 (0.0118 - 0.0157)
Exhaust	0.30 - 0.40 (0.0118 - 0.0157)

*: Approximately 80°C (176°F)

AVAILABLE SHIMS

Thickness mm (in)	Identification mark
2.35 (0.0925)	2.35
2.40 (0.0945)	2.40
2.45 (0.0965)	2.45
2.50 (0.0984)	2.50
2.55 (0.1004)	2.55
2.60 (0.1024)	2.60
2.65 (0.1043)	2.65
2.70 (0.1063)	2.70
2.75 (0.1083)	2.75
2.80 (0.1102)	2.80
2.85 (0.1122)	2.85
2.90 (0.1142)	2.90
2.95 (0.1161)	2.95
3.00 (0.1181)	3.00
3.05 (0.1201)	3.05



Valve (Cont'd)

VALVE SPRING

Free height	mm (in)	55.43 (2.1823)
Pressure	N (kg, lb) at height mm (in)	354 (36.1, 79.6) at 32.3 (1.2717)
Out-of-square	mm (in)	2.4 (0.094)

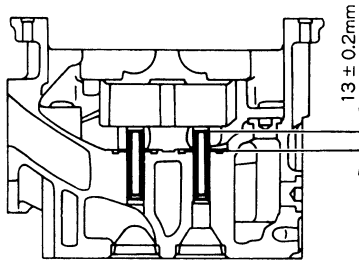
VALVE LIFTER

Unit: mm (in)

Valve lifter outer diameter	34.450 - 34.465 (1.3563 - 1.3569)
Lifter guide inner diameter	34.495 - 34.515 (1.3581 - 1.3589)
Clearance between lifter and lifter guide	0.030 - 0.065 (0.0012 - 0.0026)

VALVE GUIDE

Unit: mm (in)

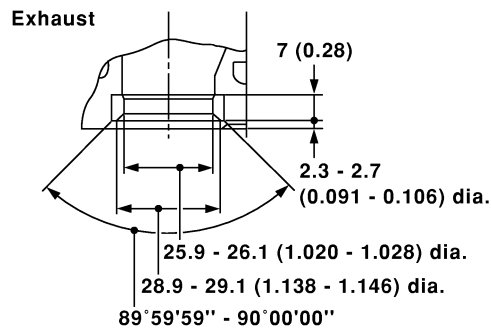
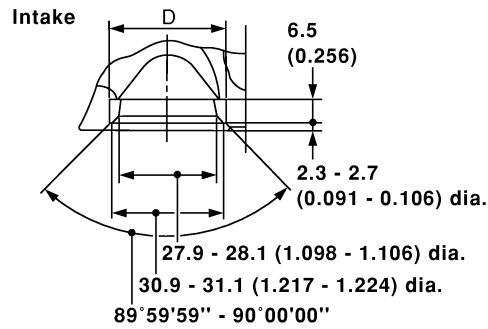


FEM071

		Standard
Valve guide	Outer diameter	11.023 - 11.034 (0.4340 - 0.4344)
	Inner diameter (Finished size)	7.000 - 7.015 (0.2756 - 0.2762)
Cylinder head valve guide hole diameter		10.975 - 10.996 (0.4321 - 0.4329)
Interference fit of valve guide		0.027 - 0.059 (0.0011 - 0.0023)
		Standard
Stem to guide clearance	Intake	0.023 - 0.053 (0.0009 - 0.0021)
	Exhaust	0.040 - 0.070 (0.0016 - 0.0028)
Valve deflection limit		0.2 (0.0079)
Projection length		12.8 - 13.2 (0.5309 - 0.5197)

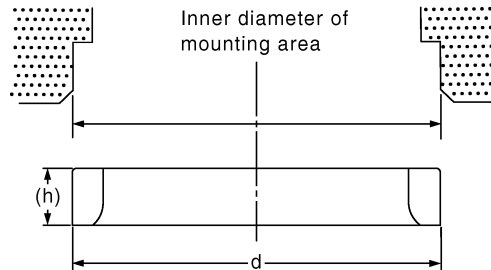
Valve Seat

Unit: mm (in)

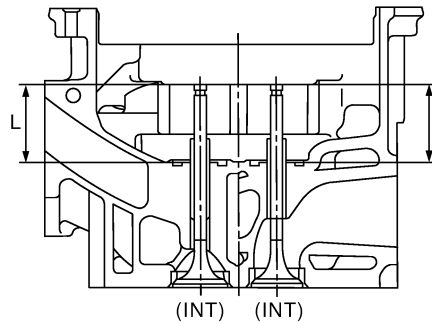


Unit: mm (in)

SEM374G



SEM373G



SEM375G

		Standard	Service
Cylinder head seat recess diameter (D)	Intake	33.000 - 33.015 (1.2992 - 1.2998)	33.500 - 33.515 (1.3189 - 1.3195)
	Exhaust	31.495 - 31.510 (1.2400 - 1.2405)	31.995 - 32.010 (1.2596 - 1.2602)
Valve seat interference fit	Intake	0.050 - 0.078 (0.0020 - 0.0031)	
	Exhaust	0.040 - 0.066 (0.0016 - 0.0026)	

Valve Seat (Cont'd)

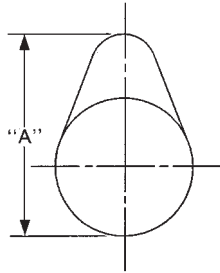
Valve seat outer diameter (d)	Intake	33.065 - 33.078 (1.3018 - 1.3023)	33.565 - 33.578 (1.3215 - 1.3220)
	Exhaust	31.550 - 31.561 (1.2421 - 1.2426)	32.050 - 32.061 (1.2618 - 1.2622)
Height (h)	Intake	6.75 - 6.85 (0.2657 - 0.2697)	6.75 - 6.85 (0.2657 - 0.2697)
	Exhaust	7.35 - 7.45 (0.2894 - 0.2933)	7.35 - 7.45 (0.2894 - 0.2933)
Depth (L)	Intake	43.65 - 44.35 (1.7185 - 1.7461)	
	Exhaust	43.65 - 44.35 (1.7185 - 1.7461)	

Camshaft and Camshaft Bearing

Unit: mm (in)

	Standard	Limit
Camshaft journal to bearing clearance	0.045 - 0.090 (0.0018 - 0.0035)	0.09 (0.0035)
Inner diameter of camshaft bearing	30.000 - 30.021 (1.1811 - 1.1819)	—
Outer diameter of camshaft journal	29.931 - 29.955 (1.1784 - 1.1793)	—
Camshaft runout [TIR*]	—	0.02 (0.0008)
Camshaft sprocket runout [TIR*]	Less than 0.15 (0.0059)	—
Camshaft end play	0.065 - 0.169 (0.0026 - 0.0067)	0.2 (0.008)

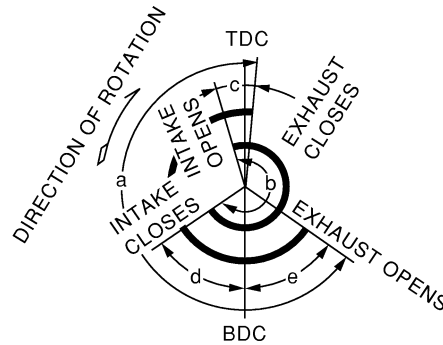
*: Total indicator reading



EM671

Cam height "A"	Intake	40.468 - 40.508 (1.5932 - 1.5948)
	Exhaust	40.830 - 40.870 (1.6075 - 1.6091)
Wear limit of cam height		0.15 (0.0059)

Valve timing



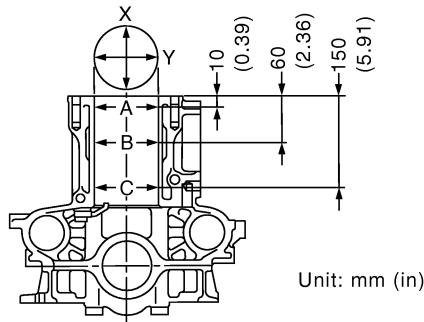
SEM372G

Unit: degree

a	b	c	d	e
234	220	10	34	50

Cylinder Block

Unit: mm (in)



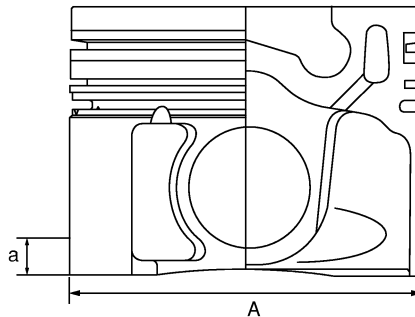
SEM370G

Surface flatness	Standard		Less than 0.03 (0.0012)
	Limit		0.10 (0.0039)
Cylinder bore	Inner diameter	Standard	Grade No. 1 96.000 - 96.010 (3.7795 - 3.7799)
			Grade No. 2 96.010 - 96.020 (3.7799 - 3.7803)
		Grade No. 3 96.020 - 96.030 (3.7803 - 3.7807)	
		Wear limit	0.20 (0.0079)
Out-of-round (X - Y)			Less than 0.02 (0.0008)
Taper (A - B - C)			Less than 0.02 (0.0008)
Main journal inner diameter (Without bearing)			74.981 - 75.000 (2.9520 - 2.9528)
Difference in inner diameter between cylinders	Limit		Less than 0.05 (0.0020)

Piston, Piston Ring and Piston Pin

AVAILABLE PISTON

Unit: mm (in)



SEM369G

Piston skirt diameter "A"	Standard	Grade No. 1 95.950 - 95.960 (3.7776 - 3.7779)
		Grade No. 2 95.960 - 95.970 (3.7779 - 3.7783)
		Grade No. 3 95.970 - 95.980 (3.7783 - 3.7787)
"a" dimension		10 (0.39)
Piston pin hole diameter		32.997 - 33.005 (1.2991 - 1.2994)
Piston clearance to cylinder block		0.040 - 0.060 (0.0016 - 0.0024)

Piston, Piston Ring and Piston Pin (Cont'd)

PISTON RING

Unit: mm (in)

		Standard	Limit
Side clearance	Top	0.05 - 0.07 (0.0020 - 0.0028)	0.5 (0.020)
	2nd	0.04 - 0.08 (0.0016 - 0.0031)	0.3 (0.012)
	Oil ring	0.02 - 0.06 (0.0008 - 0.0024)	0.15 (0.0059)
End gap	Top	0.30 - 0.45 (0.0118 - 0.0177)	1.5 (0.059)
	2nd	0.50 - 0.65 (0.0197 - 0.0256)	1.5 (0.059)
	Oil (rail ring)	0.25 - 0.45 (0.0098 - 0.0177)	1.5 (0.059)

PISTON PIN

Unit: mm (in)

Piston pin outer diameter		32.993 - 33.000 (1.2989 - 1.2992)
Interference fit of piston pin to piston		-0.003 to 0.012 (-0.0001 to 0.0005)
Piston pin to connecting rod bushing clearance	Standard	0.025 - 0.045 (0.0010 - 0.0018)
	Limit	0.045 (0.0018)

*: Values measured at ambient temperature of 20°C (68°F)

Connecting Rod

Unit: mm (in)

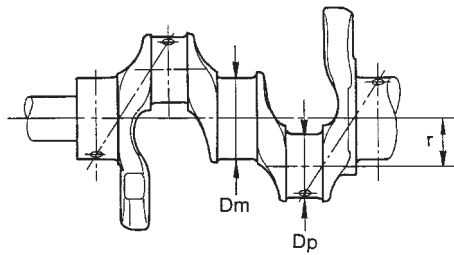
Center distance		154.5 (6.083)
Bend [per 100 (3.94)]	Limit	0.05 (0.0020)
Torsion [per 100 (3.94)]	Limit	0.05 (0.0020)
Connecting rod small end inner diameter		35.087 - 36.000 (1.3814 - 1.4173)
Piston pin bushing inner diameter*		33.025 - 33.038 (1.3002 - 1.3007)
Connecting rod big end inner diameter		59.987 - 60.000 (2.3617 - 2.3622)
Crankshaft journal bearing inner diameter*		70.955 - 70.990 (2.7935 - 2.7949)
Side clearance	Standard	0.10 - 0.22 (0.0039 - 0.0087)
	Limit	0.22 (0.0087)

*: After installing in connecting rod

Crankshaft

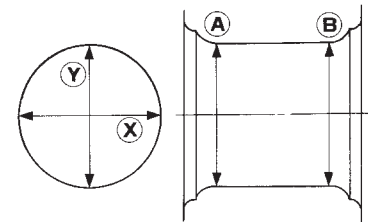
Unit: mm (in)

Main journal dia. "Dm"		70.907 - 70.920 (2.7916 - 2.7921)
Pin journal dia. "Dp"	Grade No. 0	56.913 - 56.926 (2.2407 - 2.2412)
Center distance "r"		50.95 - 51.05 (2.0059 - 2.0098)
Out-of-round (X - Y)	Standard	Less than 0.01 (0.0004)
Taper (A - B)	Standard	Less than 0.01 (0.0004)
Runout [TIR*]	Standard	Less than 0.01 (0.0004)
	Limit	Less than 0.03 (0.0012)
Free end play	Standard	0.055 - 0.140 (0.0022 - 0.0055)
	Limit	0.25 (0.0098)



SEM645

Out-of-round (X - Y)
Taper (A - B)

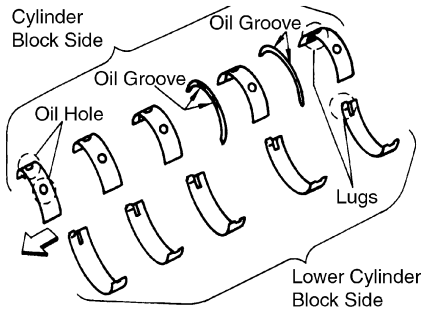


EM715

*: Total indicator reading

Available Main Bearing

UNDERSIZE



FEM127

Size	Thickness "T" mm (in)	Width "W" mm (in)	Main journal diameter "Dm"
Standard	2.005 - 2.013 (0.0789 - 0.0793)	25.74 - 26.00 (1.0134 - 1.0236)	Grind so that bearing clearance is the specified value.
US 025	2.130 - 2.138 (0.0839 - 0.0842)		
US 050	2.255 - 2.263 (0.0888 - 0.0891)		
US 075	2.380 - 2.388 (0.0937 - 0.0940)		
US 100	2.505 - 2.513 (0.0986 - 0.0989)		

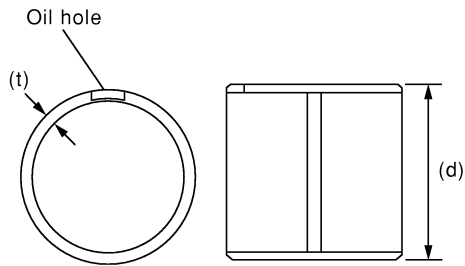
Available Connecting Rod Bearing

CONNECTING ROD BEARING

Grade number	Thickness "T" mm (in)	Width "W" mm (in)
Standard	1.505 - 1.513 (0.0593 - 0.0596)	25.9 - 26.1 (1.020 - 1.028)
US 025	1.630 - 1.638 (0.0642 - 0.0645)	
US 050	1.755 - 1.763 (0.0691 - 0.0694)	
US 075	1.880 - 1.888 (0.0740 - 0.0743)	
US 100	2.005 - 2.013 (0.0789 - 0.0793)	

BALANCER SHAFT BUSH

Unit: mm (in)



SEM371G

Balancer shaft bearing journal diameter	Front	50.940 - 51.010 (2.0055 - 2.0083)
	Rear	50.740 - 50.810 (1.9976 - 2.0004)
Balancer shaft journal outer diameter	Front	53.980 - 54.010 (2.1252 - 2.1264)
	Rear	53.780 - 53.810 (2.1173 - 2.1185)
Balancer shaft journal oil clearance	Standard	0.045 - 0.135 (0.0018 - 0.0053)
	Limit	0.180 (0.0071)
Balancer shaft bush outer diameter (d)	Front	54.090 - 54.130 (2.1295 - 2.1311)
	Rear	53.890 - 53.930 (2.1216 - 2.1232)
Thickness (t)	Front	0.2 - 0.4 (0.008 - 0.016)
	Rear	0.2 - 0.4 (0.008 - 0.016)

Miscellaneous Components

Unit: mm (in)

Flywheel runout [TIR]*	Less than 0.15 (0.0059)
Drive plate runout [TIR]*	Less than 0.1 (0.0039)

*: Total indicator reading

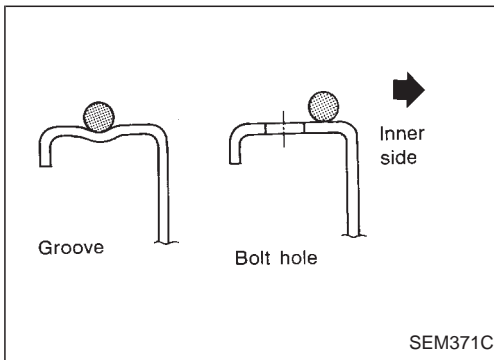
BEARING CLEARANCE

Unit: mm (in)

Main bearing clearance	Standard	0.035 - 0.083 (0.0014 - 0.0033)
Connecting rod bearing clearance	Standard	0.035 - 0.077 (0.0014 - 0.0030)

Parts Requiring Angular Tightening

- Some important engine parts are tightened using an angular-tightening method rather than a torque setting method.
- If these parts are tightened using a torque setting method, dispersal of the tightening force (axial bolt force) will be two or three times that of the dispersal produced by using the correct angular-tightening method.
- Although the torque setting values (described in this manual) are equivalent to those used when bolts and nuts are tightened with an angular-tightening method, they should be used for reference only.
- To assure the satisfactory maintenance of the engine, bolts and nuts must be tightened using an angular-tightening method.
- Before tightening the bolts and nuts, ensure that the thread and seating surfaces are clean and then coated with engine oil.
- The bolts and nuts which require the angular-tightening method are as follows:
 - (1) Cylinder head bolts
 - (2) Connecting rod cap nuts

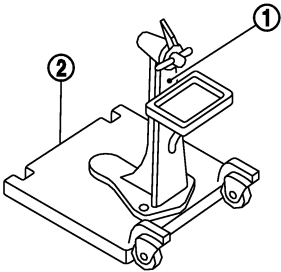
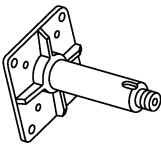
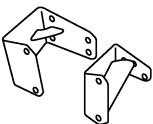
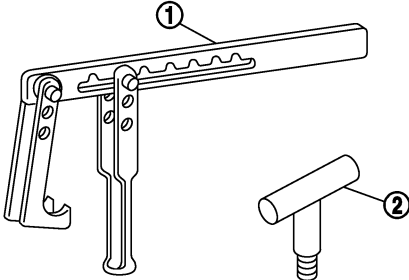
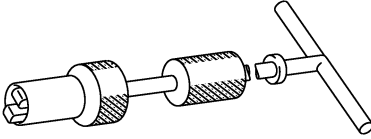
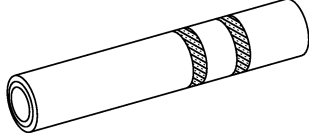
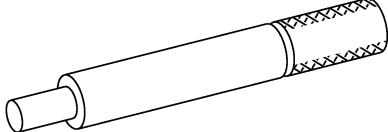


Liquid Gasket Application Procedure

- a. Before applying liquid gasket, use a scraper to remove all traces of old liquid gasket from mating surface and grooves, and then completely clean any oil stains from these portions.
- b. Apply a continuous bead of liquid gasket to mating surfaces. (Use Genuine Liquid Gasket or equivalent.)
 - Be sure liquid gasket is 3.5 to 4.5 mm (0.138 to 0.177 in) wide (oil pan).
 - Be sure liquid gasket is 2.0 to 3.0 mm (0.079 to 0.118 in) wide (in areas except oil pan).
- c. Apply liquid gasket to inner surface around hole perimeter. (Assembly should be done within 5 minutes after coating.)
- d. Wait at least 30 minutes before refilling engine oil and engine coolant.

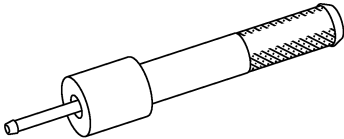
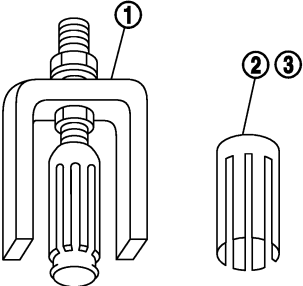
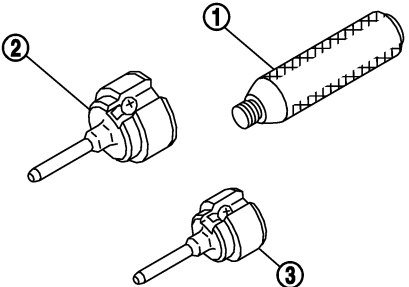
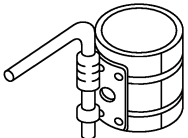
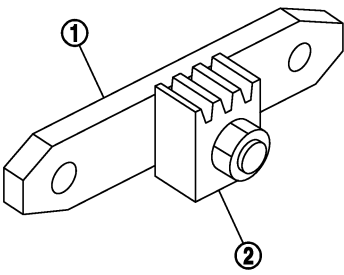
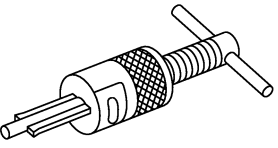
Special Service Tools

*: Special tool or commercial equivalent

Tool number Tool name	Description	
ST0501S000* Engine stand assembly ① ST05011000 Engine stand ② ST05012000 Base		Disassembling and assembling
KV10106500* Engine attachment		
KV11103200* Engine sub-attachment		
① KV10109210* Valve spring compressor ② KV10111200* Adapter		Disassembling and assembling valve components
KV10107900* Valve oil seal puller		Disassembling valve oil seal
KV11103400 Valve oil seal drift		Installing valve oil seal
ST11033000* Valve guide drift		Removing valve guide

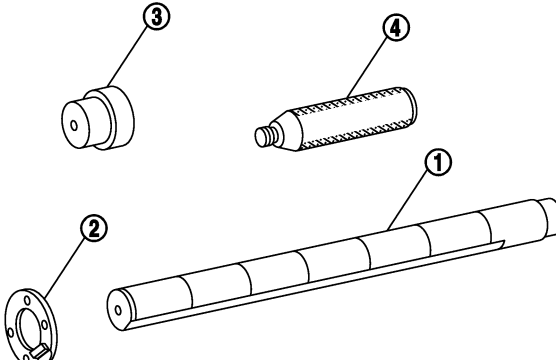
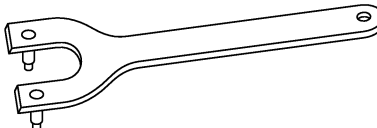
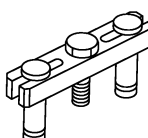
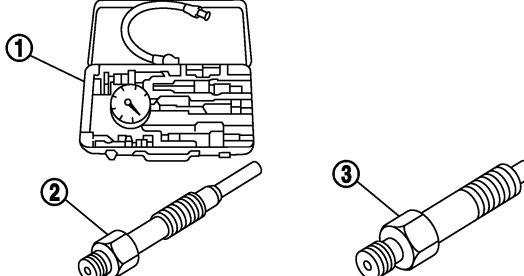
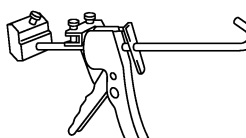
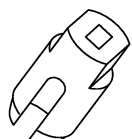
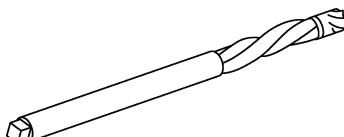
Special Service Tools (Cont'd)

*: Special tool or commercial equivalent

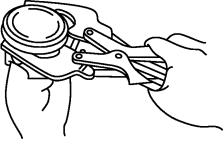
Tool number Tool name	Description
KV11103900* Valve guide drift	 <p>Installing valve guide</p>
① KV11101110 Valve seat remover ② KV11103610 Adapter (Intake) ③ KV11103620 Adapter (Exhaust)	 <p>Removing valve seat</p>
① ST15243000 Valve seat drift ② KV11103810 Adapter (Intake) ③ KV11103820 Adapter (Exhaust)	 <p>Installing valve seat</p>
EM03470000* Piston ring compressor	 <p>Installing piston into cylinder</p>
KV111033S0 Engine stopper ① KV11103310 Stopper plate ② KV10105630 Stopper gear	 <p>Preventing crankshaft from rotating</p>
ST16610001* Pilot bushing puller	 <p>Removing pilot bushing</p>

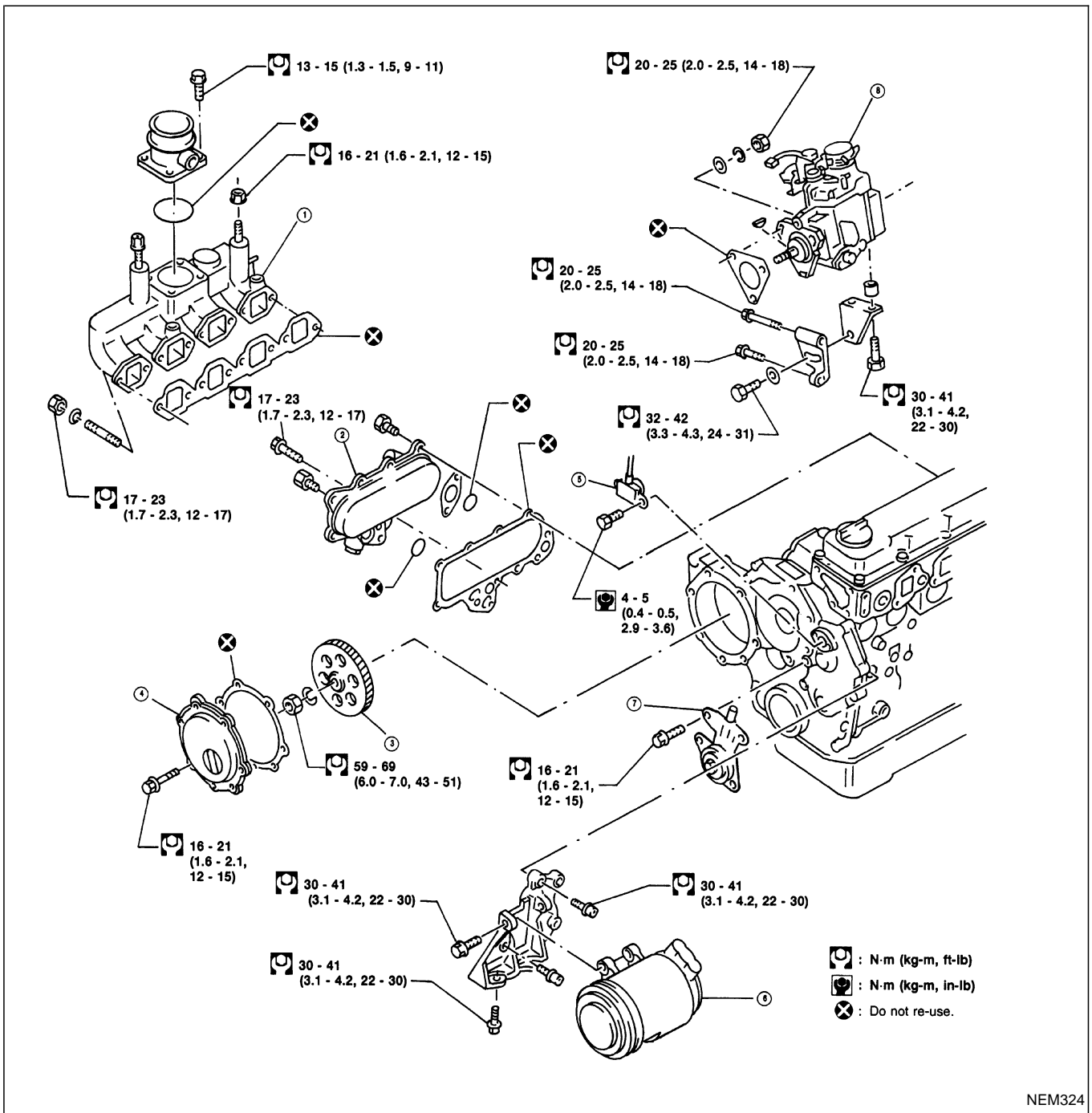
Special Service Tools (Cont'd)

*: Special tool or commercial equivalent

Tool number Tool name	Description
KV111045SO Cam bushing replacer set ① KV11104510 Replacer bar ② KV1104520 Guide plate ③ KV11104530 Adapter (1st bushing) ④ ST15243000 Drift	 <p>Removing cam bushing or installing cam bushing</p>
KV10109300* Injection pump drive gear holder	 <p>Preventing drive gear from rotating</p>
KV11103000* Injection pump drive gear puller	 <p>Removing drive gear</p>
① ED19601000 Compression gauge ② ED19600600 Compression gauge adapter (for glow plug hole) ③ ED19600700 Compression gauge adapter (for injector hole)	 <p>Checking compression pressure</p>
WS39930000* Tube presser	 <p>Pressing the tube of liquid gasket</p>
KV119E0030 Nozzle holder socket	 <p>Removing and installation injection nozzle assembly</p>
ST11032000* Valve guide reamer 8.0 mm (0.315 in) dia.	 <p>Reaming valve guide</p>

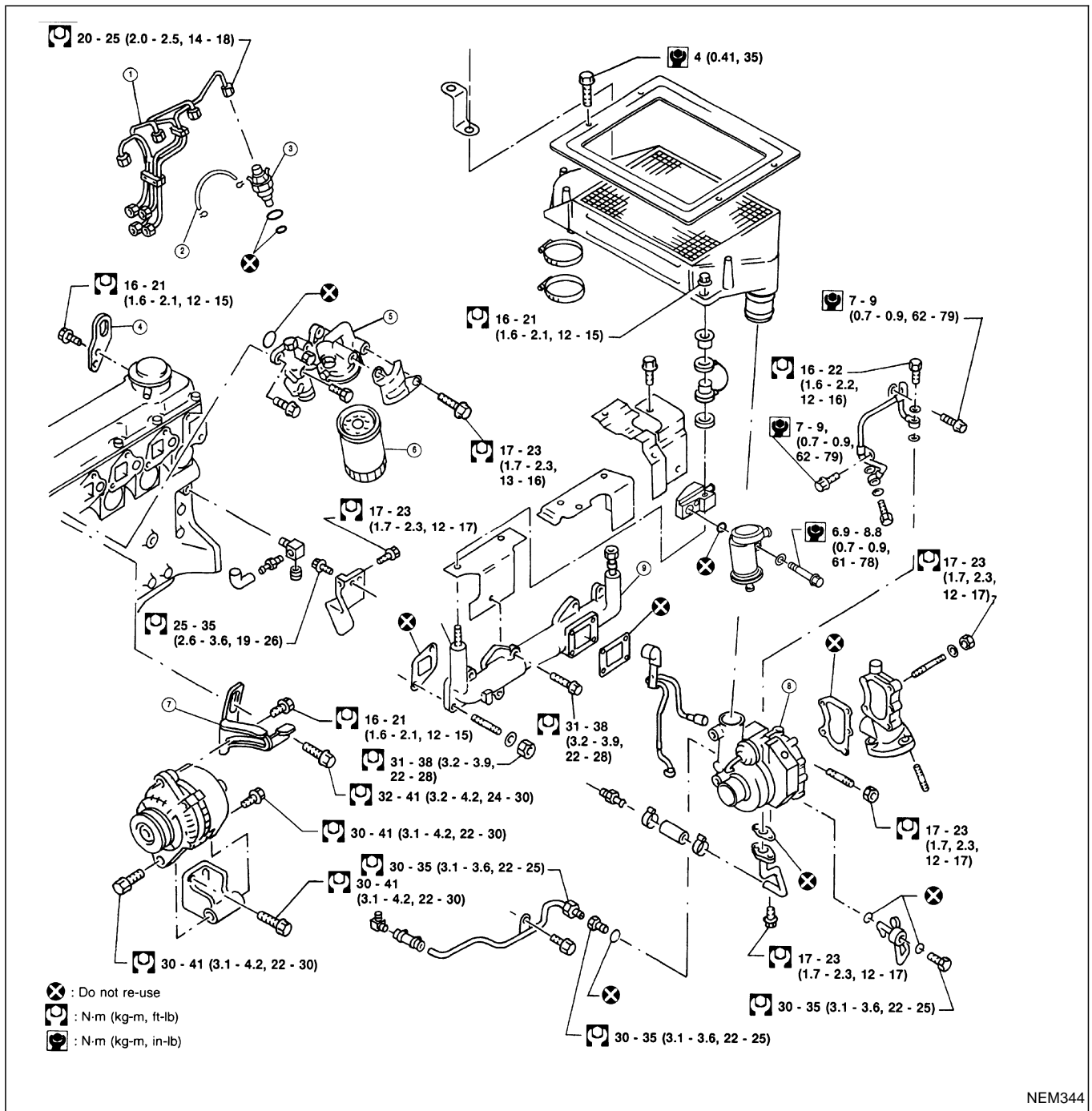
Commercial Service Tools

Tool name	Description
Piston ring expander	 <p data-bbox="1057 254 1414 281">Removing and installing piston ring</p>



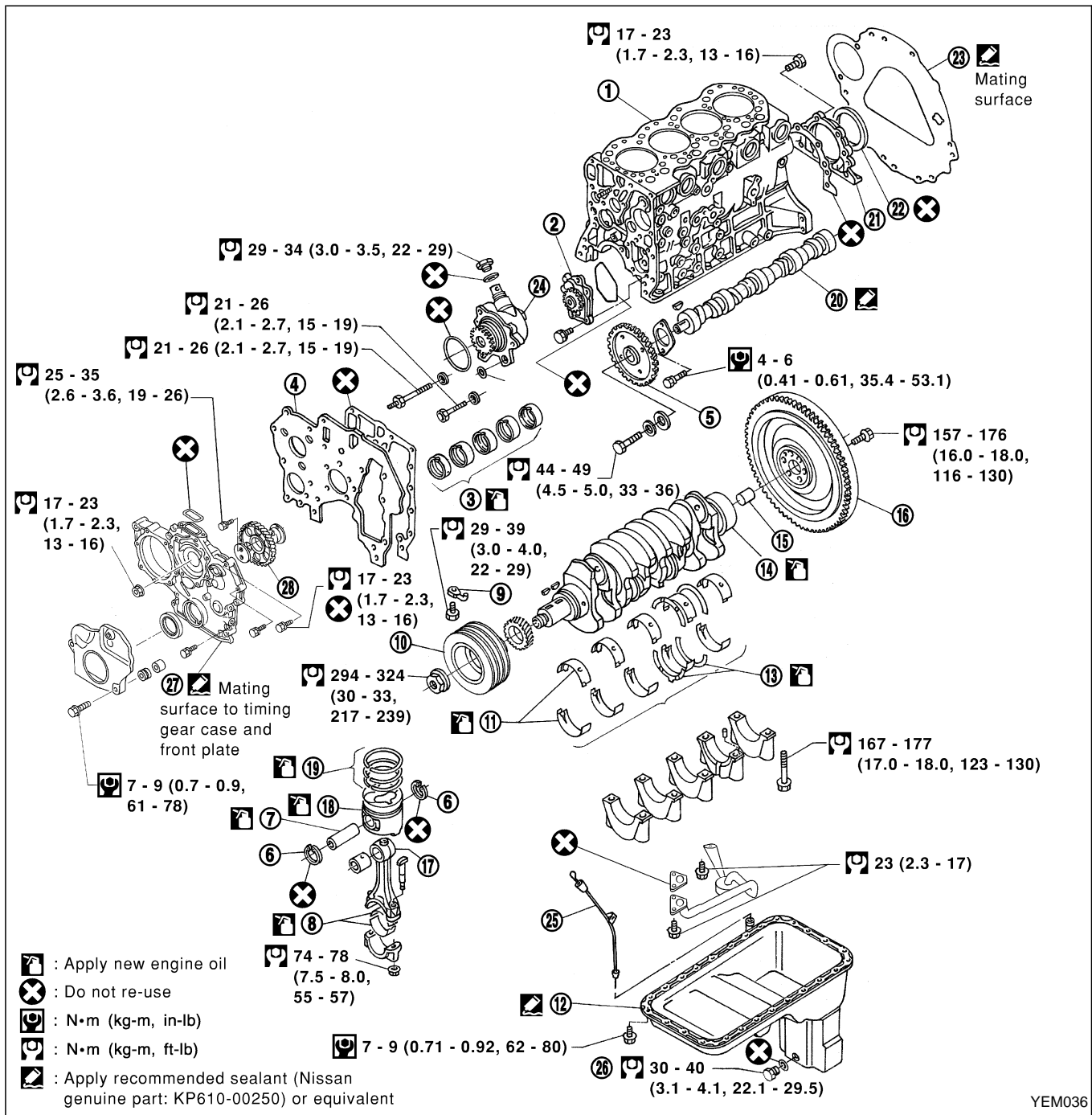
NEM324

- | | | |
|-----------------------------|------------------------------|-----------------------------|
| ① Intake manifold | ④ Dust cover | ⑦ Idler pulley |
| ② Oil cooler | ⑤ Engine revolution sensor | ⑧ Electronic injection pump |
| ③ Injection pump drive gear | ⑥ Air conditioner compressor | |



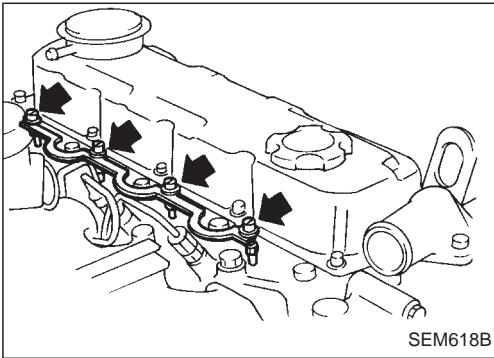
NEM344

- | | | |
|--------------------|----------------------|---|
| ① Injection tube | ④ Engine slinger | ⑦ Alternator adjusting bar & engine slinger |
| ② Spill tube | ⑤ Oil filter bracket | ⑧ Turbocharger |
| ③ Injection nozzle | ⑥ Oil filter | ⑨ Exhaust manifold |



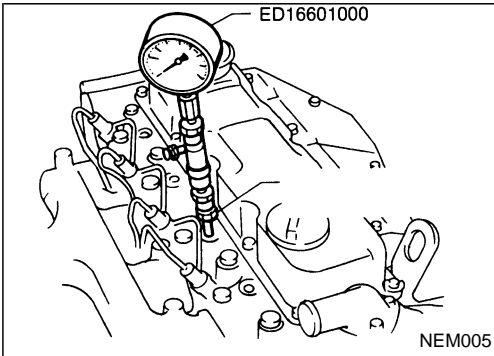
YEM036

- | | | |
|--------------------------|------------------|--------------------------|
| ① Cylinder block | ⑪ Main bearing | ⑳ Camshaft |
| ② Oil pump | ⑫ Oil pan | ㉑ Rear oil seal retainer |
| ③ Camshaft bushing | ⑬ Thrust washer | ㉒ Rear oil seal |
| ④ Front plate | ⑭ Crankshaft | ㉓ Rear plate |
| ⑤ Camshaft gear | ⑮ Pilot bushing | ㉔ Vacuum pump |
| ⑥ Snap ring | ⑯ Flywheel | ㉕ Dipstick |
| ⑦ Piston pin | ⑰ Connecting rod | ㉖ Drain plug |
| ⑧ Connecting rod bearing | ⑱ Piston | ㉗ Timing gear case |
| ⑨ Oil jet | ⑲ Piston ring | ㉘ Idler gear |
| ⑩ Crank pulley | | |



Measurement of Compression Pressure

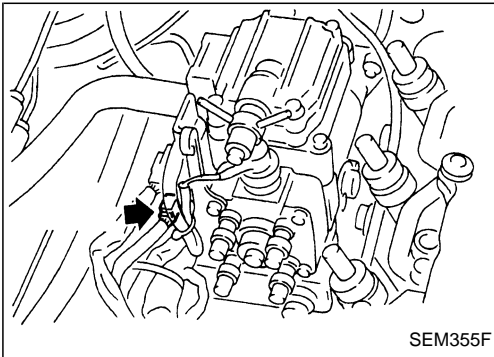
1. Warm up engine and switch off the ignition switch.
2. Remove glow plate and glow plugs.



3. Fit compression gauge adapter to cylinder head.

Compression gauge adapter:

: 15 - 20 N·m
(1.5 - 2.0 kg-m, 11 - 14 ft-lb)



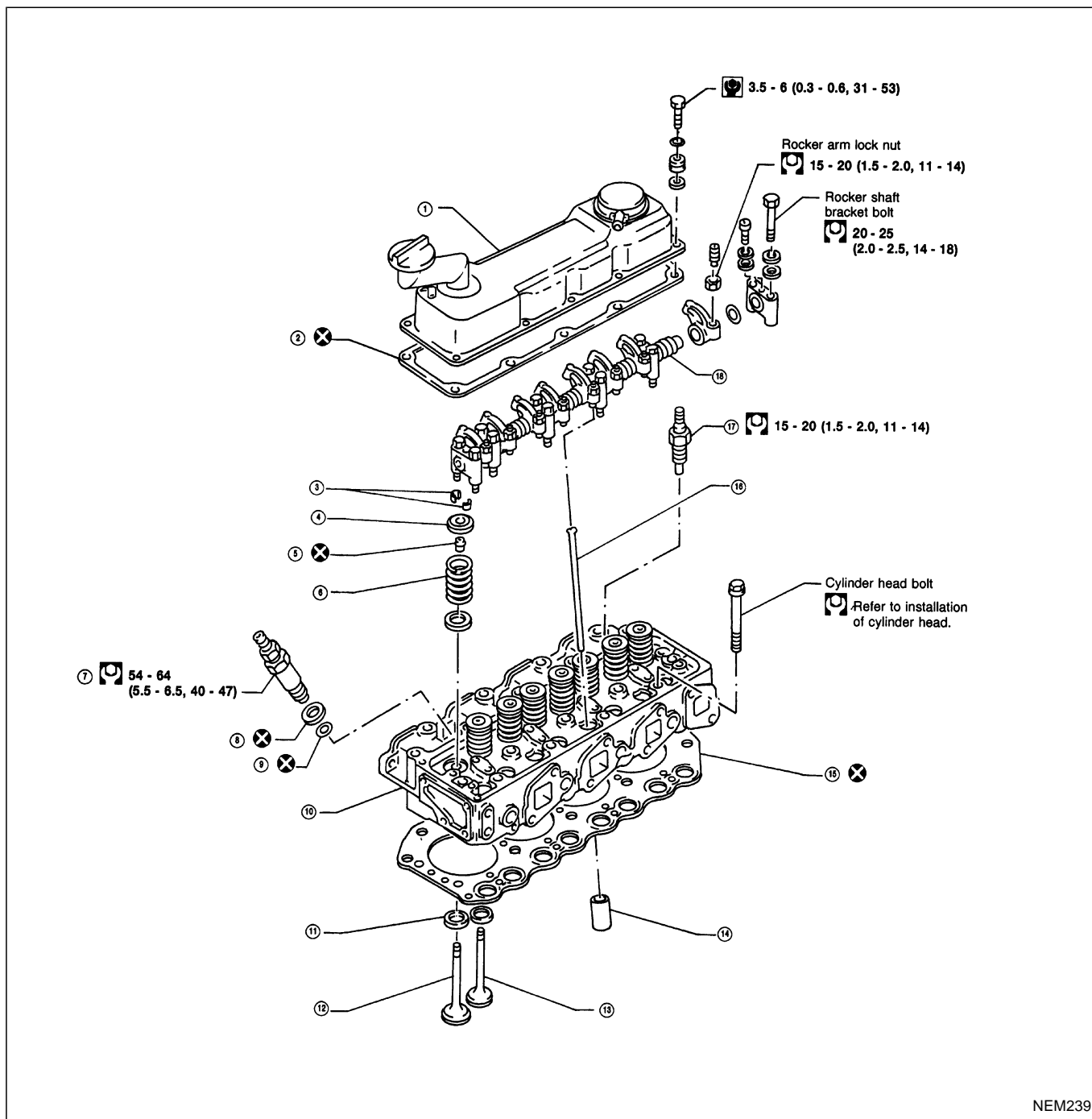
4. Ensure the ignition switch is in the "LOCK" position and disconnect harness connector (gray colored) from injection pump.
5. Crank engine, then read gauge indication.
 - **Always use a fully-charged battery to obtain specified engine revolution.**
 - **Engine compression measurement should be made as quickly as possible.**

Compression pressure:

Unit: kPa (bar, kg/cm², psi)/200 rpm

Standard	2,942 (29.4, 30, 427)
Minimum	2,452 (24.5, 25, 356)
Differential limit between cylinders	294 (2.9, 3, 43)

6. If cylinder compression in one or more cylinders is low, pour a small amount of engine oil into cylinders through the glow holes and retest compression.
 - **If adding oil helps the compression pressure, piston rings may be worn or damaged.**
 - **If pressure stays low, valve may be sticking or seating incorrectly.**
 - **If cylinder compression in any two adjacent cylinders is low, and if adding oil does not help the compression, there is leakage past the gasket surface.**
Leakage past the cylinder gasket can result in oil and water becoming mixed in the engine block cooling and lubrication chambers.

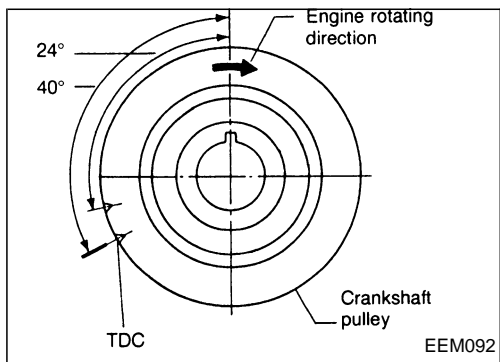


NEM239

- ① Rocker cover
- ② Rocker cover gasket
- ③ Valve cotter
- ④ Spring retainer
- ⑤ Valve oil seal
- ⑥ Valve spring
Valve spring ring

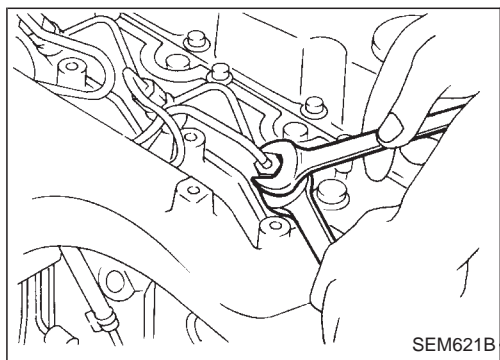
- ⑦ Injection nozzle holder
- ⑧ Nozzle washer
- ⑨ Nozzle gasket
- ⑩ Cylinder head
- ⑪ Valve seat
- ⑫ Intake valve

- ⑬ Exhaust valve
- ⑭ Valve lifter
- ⑮ Cylinder head gasket
- ⑯ Push rod
- ⑰ Glow plug
- ⑱ Rocker shaft

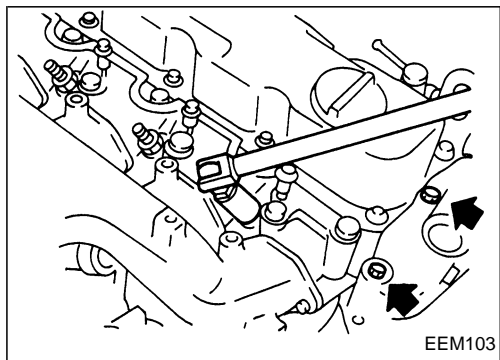


Removal

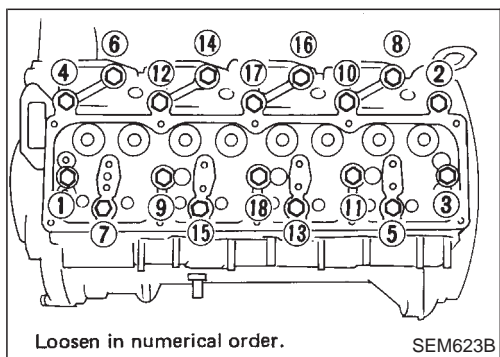
1. Set No. 1 cylinder at TDC on its compression stroke.
2. Drain engine coolant from drain plugs on cylinder block and radiator.
3. Remove air cleaner and intercooler components.
4. Remove the following parts:
 - Water temperature connectors
 - Throttle chamber vacuum hoses
 - EGR valve vacuum hose
 - Connectors located on the intake manifold
 - Connector located on the thermostat housing
 - Heater tubes
 - Connectors of the injection pump
5. Remove alternator adjusting bolt.
6. Disconnect exhaust manifold from front exhaust tube.
7. Remove turbocharger oil and water tubes.
8. Remove turbocharger bracket bolts.
9. Disconnect radiator outlet hose and thermostat housing water inlet hose.



10. Remove fuel injection tube assembly and spill tube.



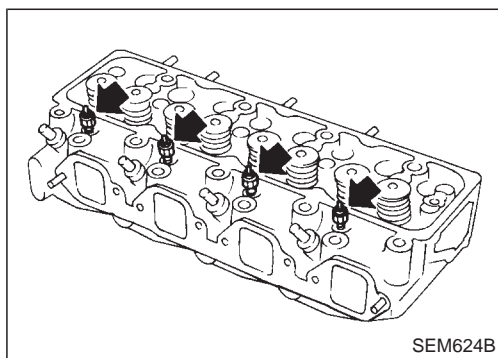
11. Remove injection nozzle holder from first cylinder with a special tool (KV119E0030). Remove injection nozzles from cylinders 2, 3 and 4 using a deep socket wrench.
12. Remove thermostat housing bolts shown at left.
13. Remove rocker cover and ventilation hose.
14. Remove rocker shaft with rocker arms.
15. Remove push rods.



16. Remove cylinder head bolts in numerical order and remove cylinder head.
- Head warpage or cracking could result from removing in incorrect order.**

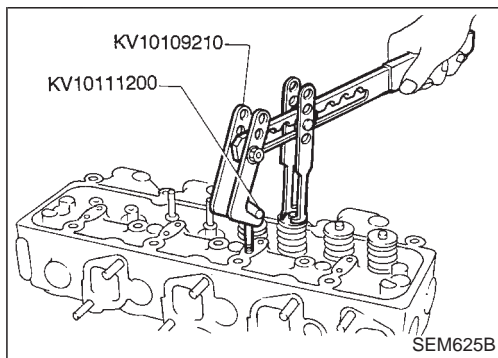
Loosen in numerical order.

SEM623B

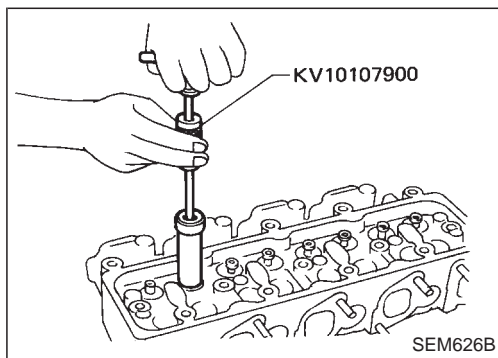


Disassembly

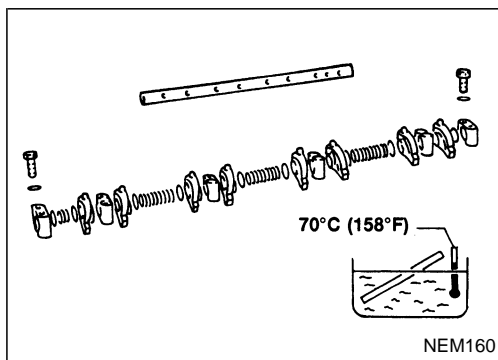
1. Remove following parts:
 - EGR tube
 - Intake manifold
 - Heat shield plates
 - Exhaust manifold
 - Thermostat housing
 - Alternator adjusting bar & engine slinger
 - Glow plate and glow plugs



2. Remove valve component parts with Tool.

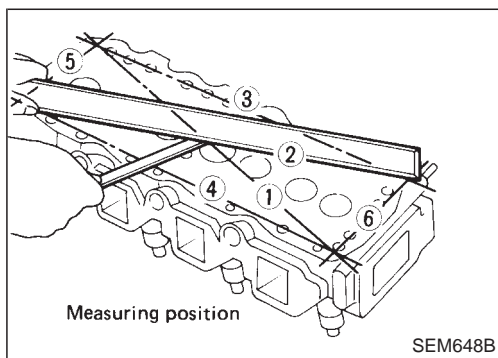


3. Remove valve oil seals with Tool.



4. Disassemble rocker shaft assembly.
 - a. Remove rocker shaft lock bolt.
 - b. Remove valve rocker and rocker shaft bracket.

If it is difficult to remove rocker shaft brackets, immerse rocker shaft assembly in oil of 70°C (158°F) for a few minutes and then remove brackets.



Inspection

CYLINDER HEAD DISTORTION

Cylinder head distortion:

Standard

Less than 0.07 mm (0.0028 in)

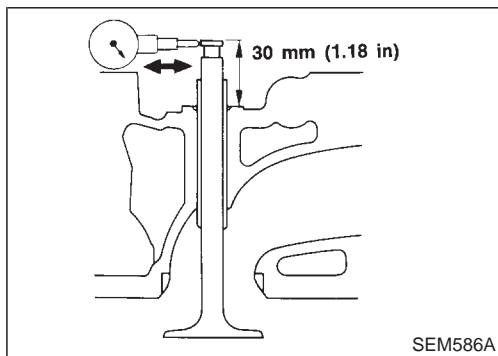
Limit

0.2 mm (0.008 in)

If beyond the specified limit, correct with a surface grinder.

Cylinder head minimum height:

89.7 mm (3.531 in)



VALVE GUIDE CLEARANCE

- Valve guide clearance should be measured parallel with rocker arm. (Generally, a large amount of wear occurs in this direction.)

Valve to guide clearance:

Limit

Intake 0.15 mm (0.0059 in)

Exhaust 0.20 mm (0.0079 in)

Maximum allowable deflection

(Dial indicator reading)

Intake 0.30 mm (0.0118 in)

Exhaust 0.40 mm (0.0157 in)

- To determine the correct replacement part, measure valve stem diameter and valve guide inner diameter.

Valve stem diameter:

Standard

Intake

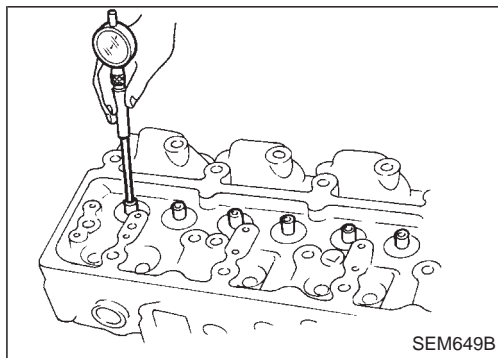
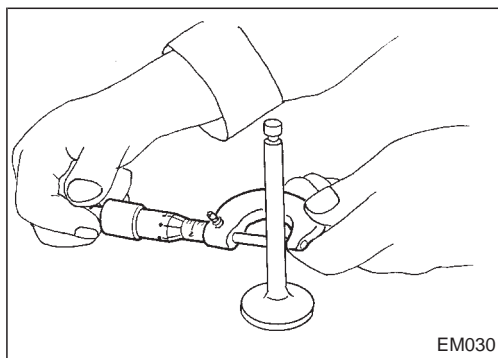
7.965 - 7.980 mm (0.3135 - 0.3142 in)

Exhaust

7.945 - 7.960 mm (0.3128 - 0.3134 in)

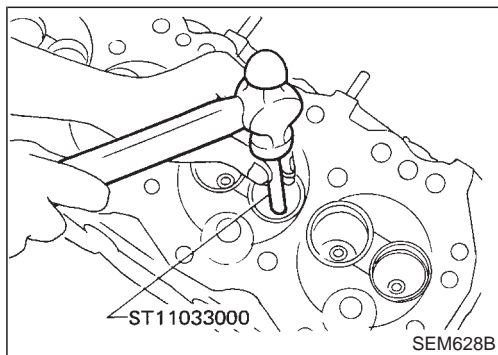
Valve guide inner diameter:

8.000 - 8.015 mm (0.3150 - 0.3156 in)

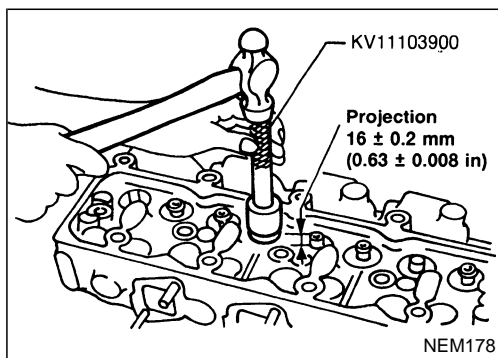


VALVE GUIDE REPLACEMENT

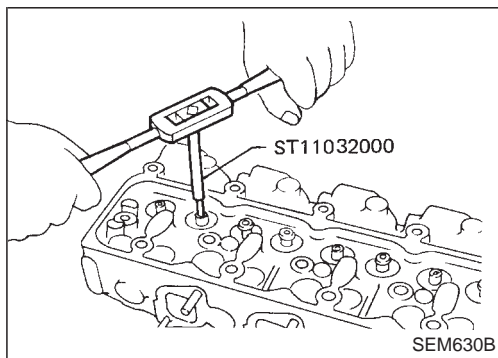
1. Heat cylinder head 150 to 160°C (302 to 320°F) in oil.
2. Drive out valve guide with a hammer and suitable tool.



Inspection (Cont'd)



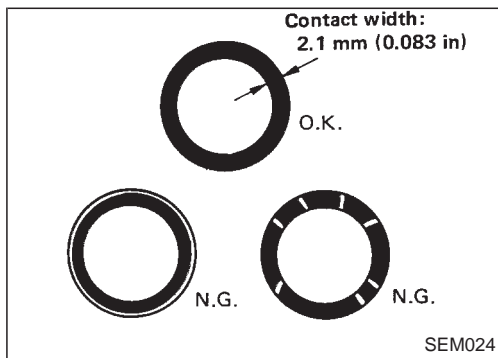
3. Press service valve guide into cylinder head using suitable tool until the guide projects out 16±0.2 mm (0.63±0.08 in).



4. Ream valve guide.

Finished size:

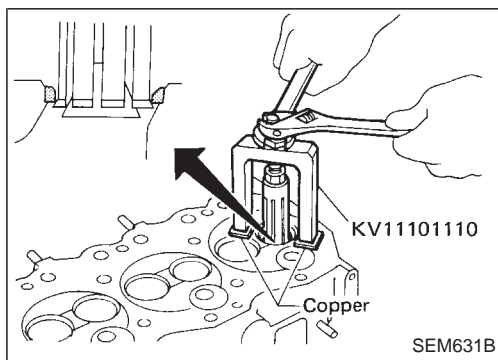
8.000 - 8.015 mm (0.3150 - 0.3156 in)



VALVE SEATS

Check valve for any evidence of pitting at valve contact surface, and reseat or replace if worn out excessively.

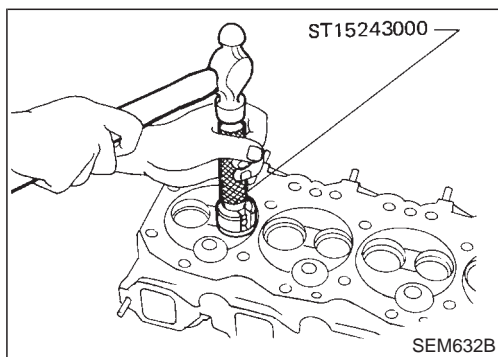
- **When repairing valve seats, check valve and valve guide for wear beforehand. If worn, replace them. Then correct valve seat.**
- **The cutting should be done with both hands for uniform cutting.**



REPLACING VALVE SEAT FOR SERVICE PARTS

1. Before out old seat until it collapses or remove valve seats with Tool.

Place a copper seat between contact surface of Tool and cylinder head.



2. Place new valve seats on dry ice and allow them to cool for five minutes.

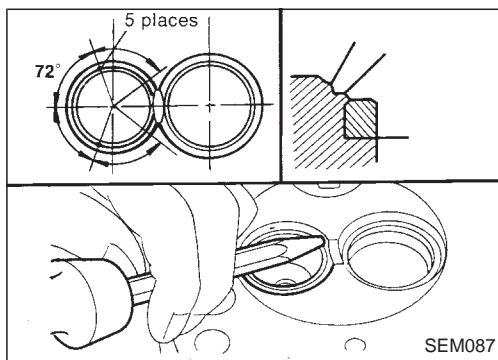
WARNING:

Do not touch cooled valve seats with bare hand.

3. Heat cylinder head to 80°C (176°F).

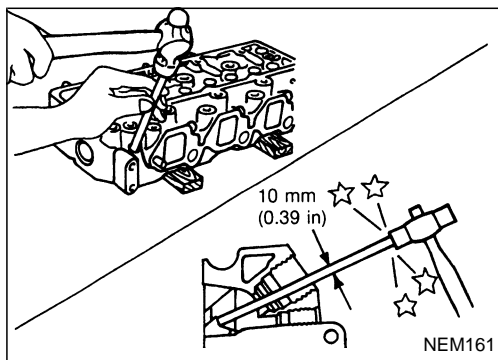
4. Install cooled valve seats on cylinder head with Tool.

Inspection (Cont'd)



5. Stake exhaust valve seat at five places with punch.
When staking valve seat, select different places than those staked before.

6. Cut or grind valve seat using suitable tool at the specified dimensions. Refer to SDS.
7. After cutting, lap valve seat with a lapping compound.
8. Check contact condition of valve seat.



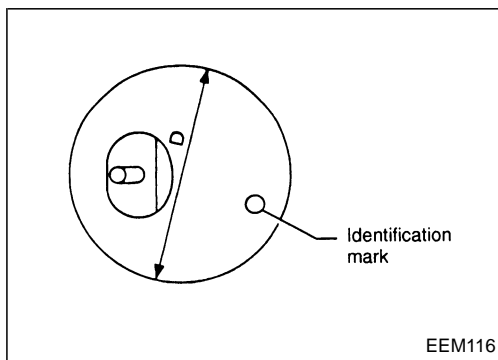
COMBUSTION CHAMBER

Check combustion chamber for cracks and other damage. If necessary, replace.

REPLACING COMBUSTION CHAMBER

Usually combustion chamber should not be removed.

1. Remove combustion chamber so that cylinder head cannot be damaged.



2. Install combustion chamber.

● **Identification of combustion chambers**

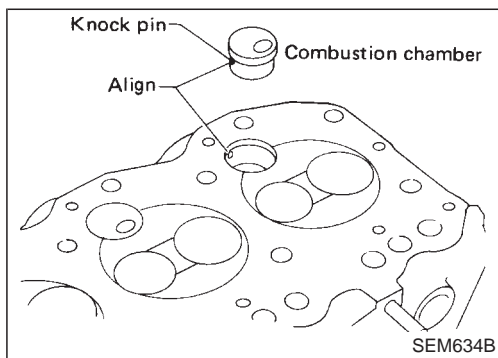
Identification mark (on combustion chamber)	Outer diameter "D" mm (in)
2	37 (1.46)

- (1) Cool combustion chamber with dry ice for approximately 5 to 10 minutes.

WARNING:

Do not touch cooled combustion chamber with bare hands.

Inspection (Cont'd)

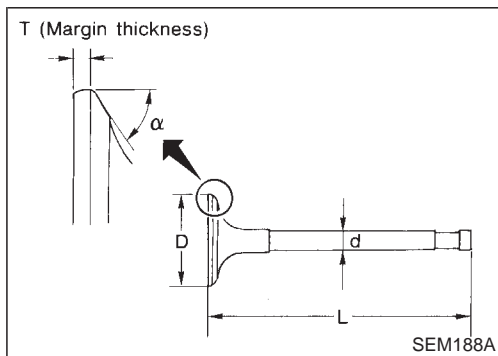


- (2) Align combustion chamber knock pin with cylinder head notch, and drive in combustion chamber with a soft hammer.
3. Check amount of protrusion of combustion chamber.

Protrusion:

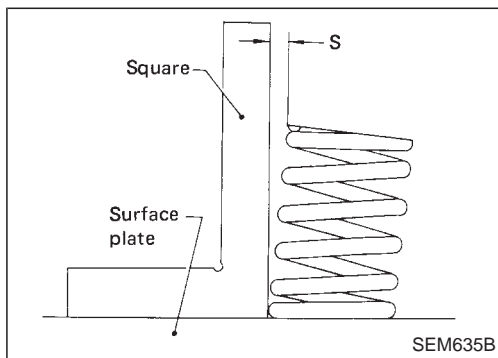
Standard

Less than 0.10 mm (0.0039 in)



VALVE DIMENSIONS

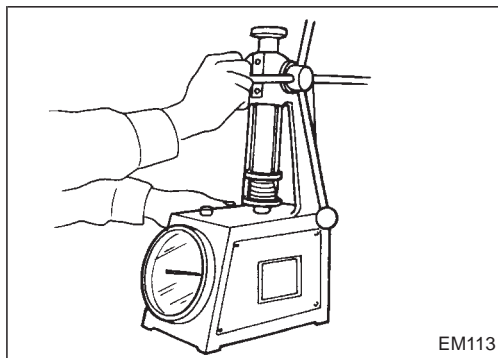
Check dimensions in each valve. For dimensions, refer to SDS. **When valve head has been worn down to 0.5 mm (0.020 in) in margin thickness, replace the valve.** Grinding allowance for valve stem tip is 0.2 mm (0.008 in) or less.



VALVE SPRING SQUARENESS

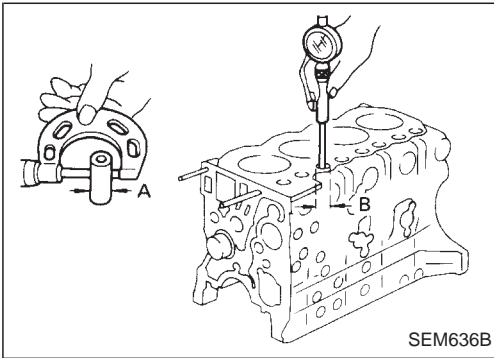
Out-of-square "S":

Less than 2.0 mm (0.079 in)



VALVE SPRING PRESSURE

Refer to SDS.

Inspection (Cont'd)**VALVE LIFTER AND PUSH ROD****Valve lifter**

1. Check valve lifters for excessive wear on the surfaces.
2. Replace with new ones if worn beyond repair.

- a. **Valve lifter end should be smooth.**
- b. **Valve lifter to lifter hole clearance:**

Standard

0.030 - 0.073 mm (0.0012 - 0.0029 in)

Limit

Less than 0.20 mm (0.0079 in)

Valve lifter outer diameter "A":**Standard**

25.960 - 25.970 mm (1.0220 - 1.0224 in)

Cylinder block valve lifter hole diameter "B":**Standard**

26.000 - 26.033 mm (1.0236 - 1.0249 in)

Push rod

1. Inspect push rod for excessive wear on the surfaces.
2. Replace if worn or damaged beyond repair.
3. Check push rod for bend using a dial gauge.

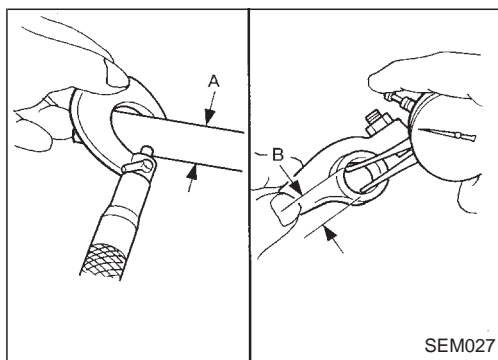
Maximum allowable bend**(Total indicator reading):**

Less than 0.5 mm (0.020 in)

ROCKER SHAFT AND ROCKER ARM

1. Check valve rockers, brackets and rocker shafts for scoring, wear or distortion. Replace if necessary.

Inspection (Cont'd)



2. Check clearance between valve rockers and rocker shaft. If specified clearance is exceeded, replace affected valve rockers or shaft.

Specified clearance:

Limit

Less than 0.15 mm (0.0059 in)

Rocker shaft outer diameter "A":

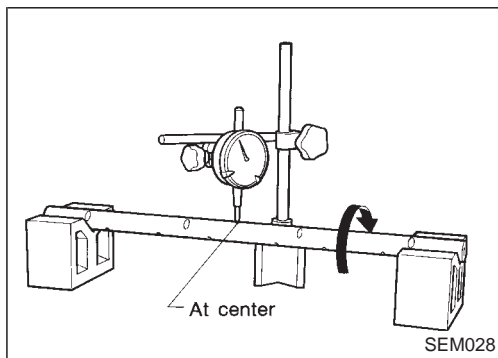
Standard

19.979 - 20.000 mm (0.7866 - 0.7874 in)

Rocker arm inner diameter "B":

Standard

20.014 - 20.035 mm (0.7880 - 0.7888 in)



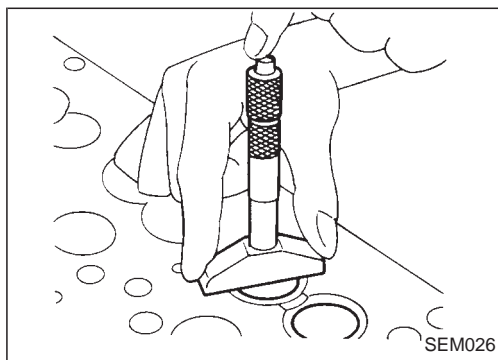
3. Check rocker shaft bend at its center. If bend is greater than specified limit, replace rocker shaft.

Rocker shaft bend

(Total indicator reading):

Limit

Less than 0.3 mm (0.012 in)



MEASURING CYLINDER HEAD TO VALVE DISTANCE

Measure distance from cylinder head surface to intake and exhaust valves. If specified distance is exceeded, replace valve(s) or valve seat(s).

Specified distance:

Standard

Intake

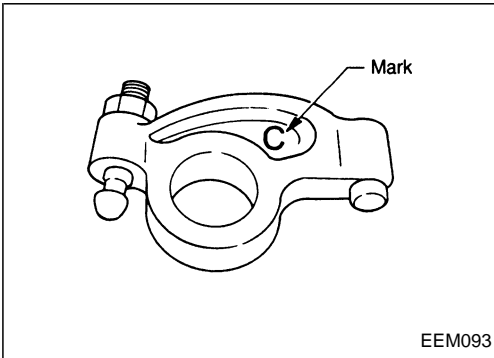
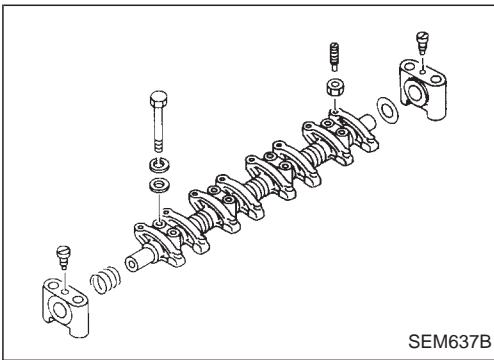
**0.79 - 1.19 mm
(0.0311 - 0.0469 in)**

Exhaust

**0.80 - 1.20 mm
(0.0315 - 0.0472 in)**

Limit

**Less than 1.75 mm (0.0689 in)
for intake and exhaust valves**



Assembly

1. Assemble rocker shaft component parts.

- Identification of rocker arms

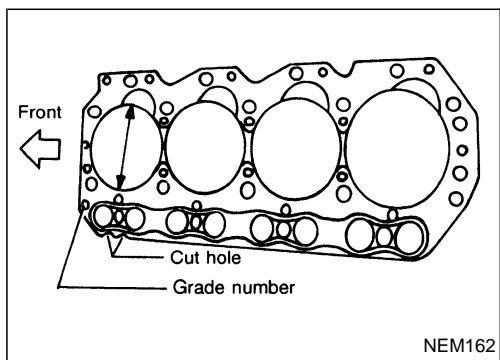
Identification mark (on rocker arm)	For use with
B	Intake valve
C	Exhaust valve

2. Install valve component parts.

- **Always use new valve oil seal. Refer to “VALVE STEM OIL SEAL”.**

- **Intake and exhaust valve springs are interchangeable.**

3. Assemble all removed parts in reverse order of disassembly.

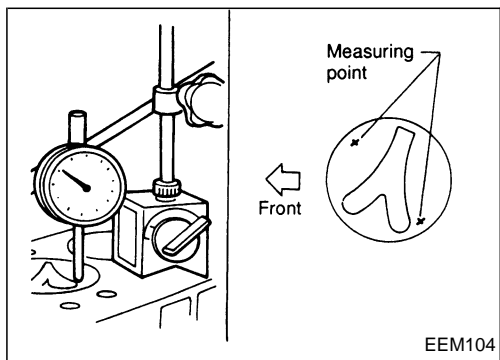


Installation

1. Install cylinder head gasket.
- **Identification of cylinder head gaskets**

Identification cut hole (on cylinder head gasket)	Inner diameter "d" mm (in)
—	97 + 0.3 (3.82 + 0.012 in)

- a. When replacing only cylinder head gasket, install same grade gasket as the one formerly used.
- b. When replacing or repairing cylinder block, cylinder head, piston, connecting rod and crankshaft, select gasket as follows:



- (1) Measure piston projection.
 - Set each piston at its Top Dead Center. With piston held in that position, measure its projections at two points.
 - Calculate the average value of the two measurements.
 - Determine the amount of projection of the other three pistons.
- (2) Select suitable cylinder head gasket which conforms to the largest amount of projection of the four pistons.

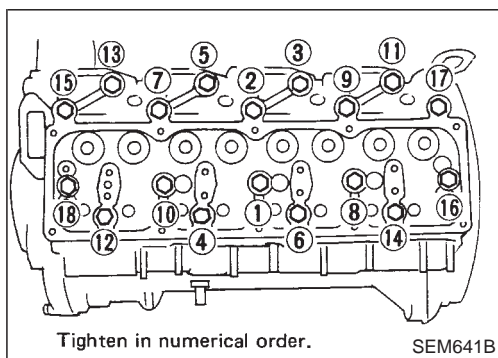
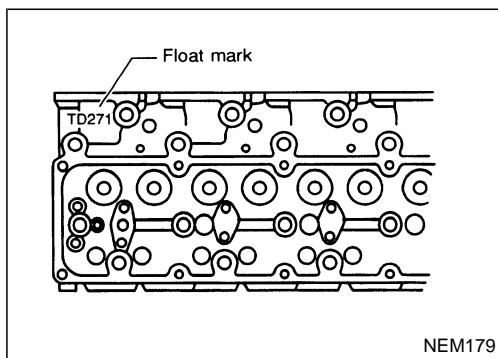
Unit: mm (in)

Average value piston projections	Gasket thickness	Gasket grade number	Part no.
Less than 0.368 (0.0145)	1.20±0.05 (0.047±0.002)	2	11044 0W800
0.368 - 0.418 (0.0145 - 0.0165)	1.25±0.05 (0.049±0.002)	3	11044 0W801
More than 0.418 (0.0165)	1.30±0.05 (0.051±0.002)	4	11044 0W802

Make sure that No. 1 piston is at TDC on its compression stroke.

Installation (Cont'd)

2. Install cylinder head.
 - **Cylinder head identification mark**



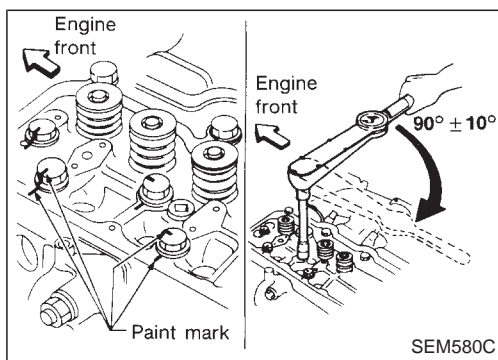
3. Apply oil to threaded portion and seat surface of bolts and tighten cylinder head bolts using Tool.

CAUTION:

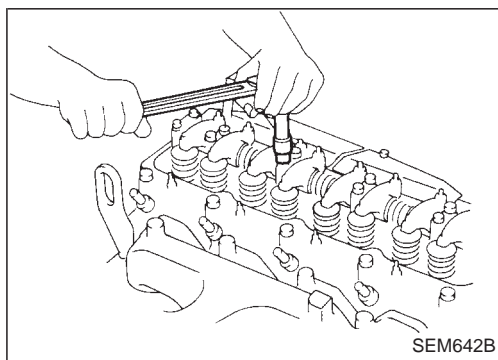
- **Tightening procedure**
 - 1st: Tighten bolts to 39 - 44 N·m (4.0 - 4.5 kg-m, 29 - 33 ft-lb)
 - 2nd: Tighten bolts to 54 - 59 N·m (5.5 - 6.0 kg-m, 40 - 43 ft-lb)

3rd:

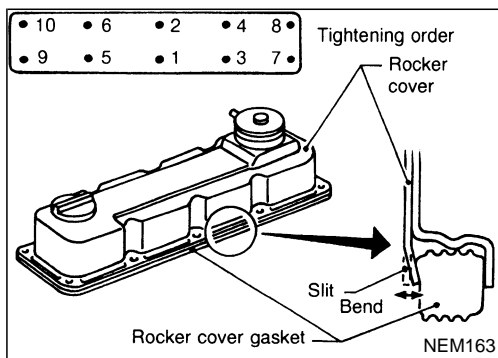
- (1) Mark exhaust side of cylinder head and cylinder head bolts with paint as shown.
- (2) Turn all bolts 90 ± 10 degrees clockwise.
- (3) Check that paint mark of each bolt is facing the front of the vehicle.



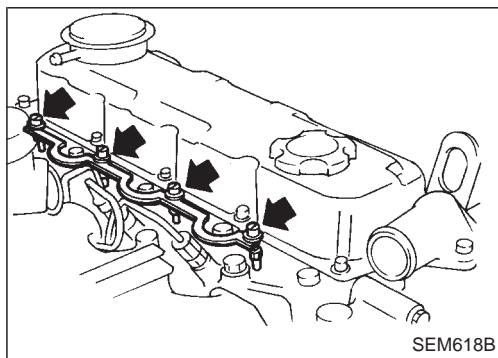
4. Apply engine oil and install push rods.
5. Install rocker shaft assembly. Adjust intake and exhaust valve clearance carefully. Refer to MA section in order to accomplish valve adjustment.



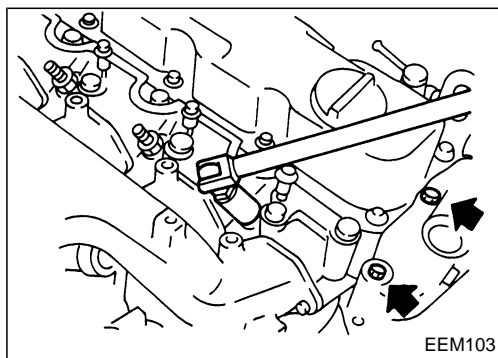
Installation (Cont'd)



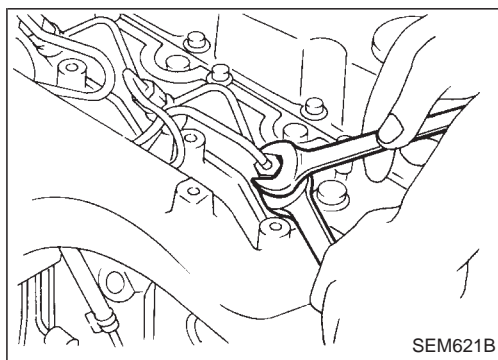
6. Install rocker cover.
 - Be sure to tighten bolts in the order shown in the illustration.
 - When replacing rocker cover gasket, bend slit of rocker cover baffle plate a little to hold the gasket. Do not twist gasket.



7. Install glow plugs and glow plate.

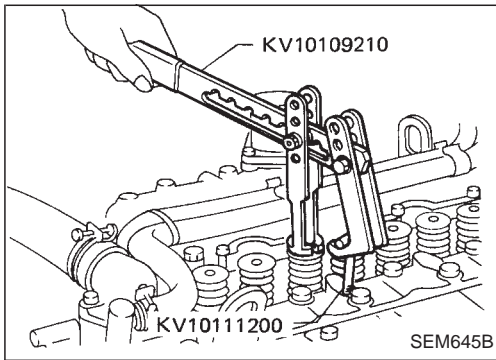


8. Install new top nozzle gasket and injection nozzle.
9. Install thermostat housing bolts shown at left.



10. Install spill tube and injection tube.
 - Spill tube nut:**
 - ☒: 39 - 49 N·m (4.0 - 5.0 kg-m, 29 - 36 ft-lb)
 - Injection tubes:**
 - ☒: 20 - 25 N·m (2.0 - 2.5 kg-m, 14 - 18 ft-lb)

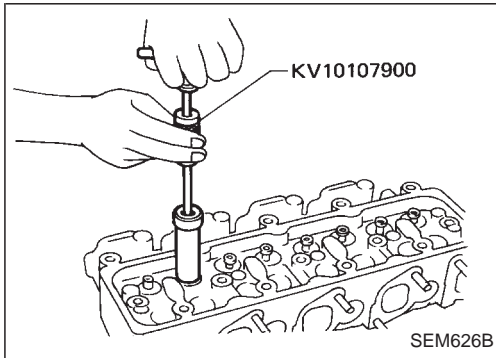
11. Connect thermostat housing water inlet hose and radiator hose.
12. Install all removed parts in reverse order of removal.
13. After assembling all disassembled parts, fill radiator and engine with new coolant up to filler opening. Refer to MA section.



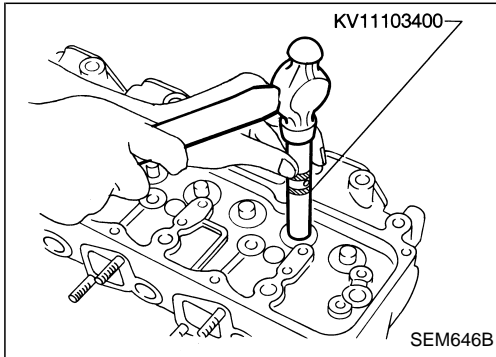
VALVE STEM OIL SEAL

1. Remove rocker cover.
2. Remove rocker shaft assembly.
3. Remove valve spring.

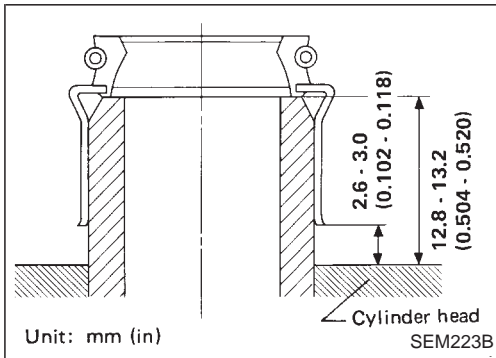
Piston concerned should be set at TDC to prevent valve from falling.

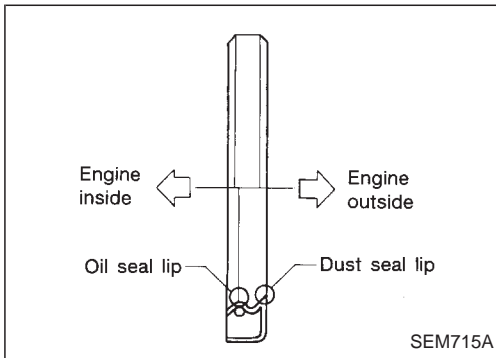


4. Remove valve oil seals.



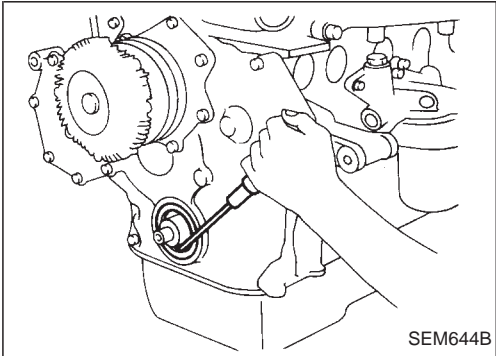
5. Apply engine oil to valve oil seal and install it in place.





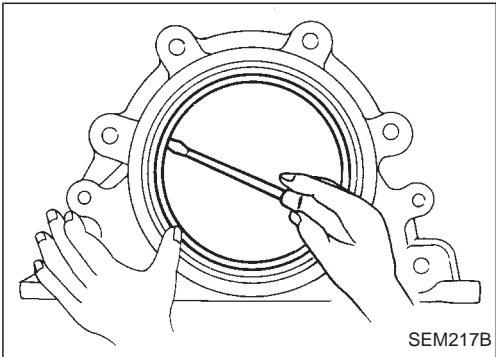
OIL SEAL INSTALLING DIRECTION

- When installing a new front or rear oil seal, make sure its mounting direction is correct.



CRANKSHAFT FRONT OIL SEAL

1. Remove protecting cover.
 2. Remove radiator shroud.
 3. Remove cooling fan.
 4. Remove drive belts.
 5. Remove crank pulley.
 6. Remove crankshaft oil seal.
- Be careful not to damage sealing surfaces of crankshaft.
7. Coat new oil seal with engine oil and install it in place.



CRANKSHAFT REAR OIL SEAL

1. Dismount transmission.
 2. Remove clutch cover assembly.
 3. Remove flywheel and rear plate.
 4. Remove oil seal retainer assembly, then remove oil seal.
- Be careful not to damage sealing surfaces of crankshaft.
5. Coat new oil seal with engine oil and install it in place.

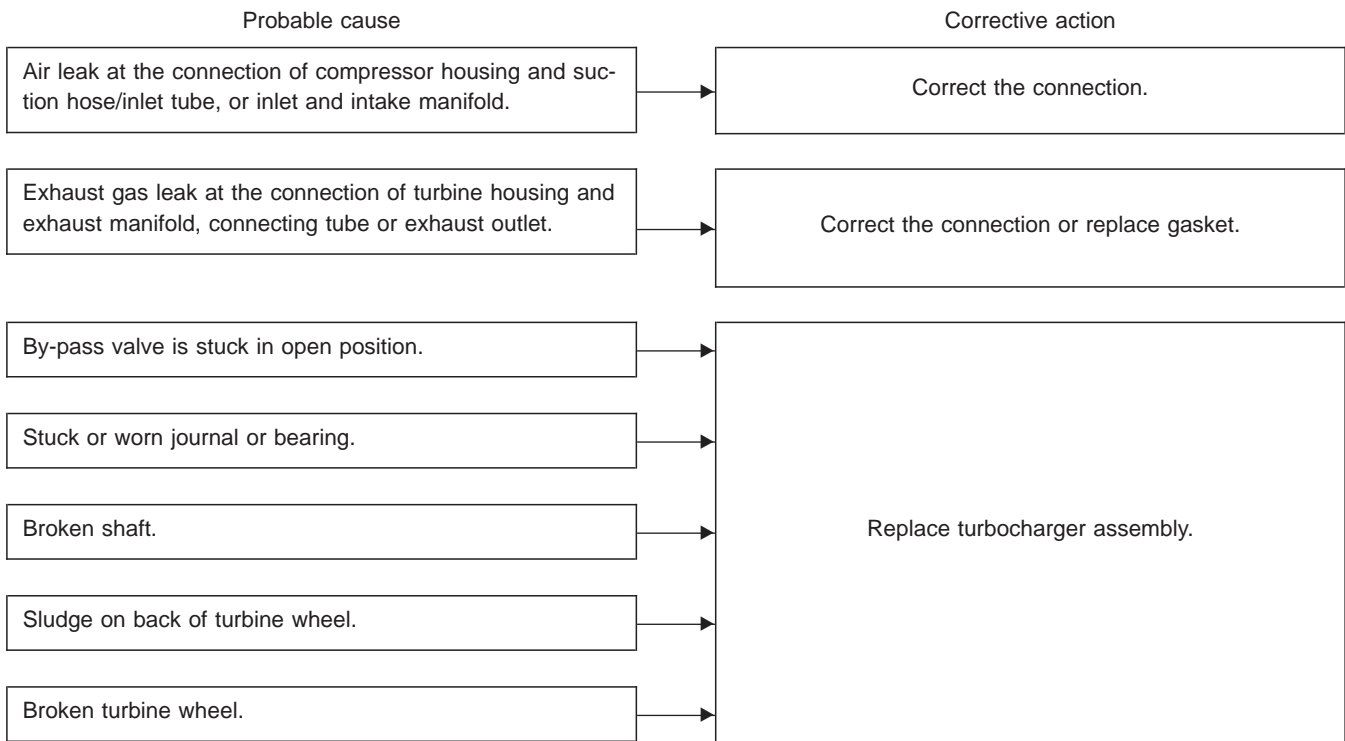
Removal and Installation

Turbocharger should not be disassembled.

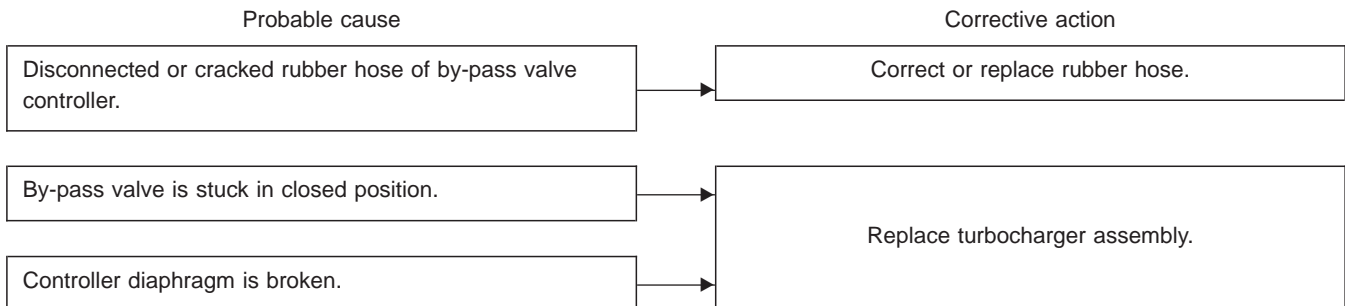
1. Drain engine coolant.
2. Remove the following:
 - Air duct and intercooler components
 - Heat shield plates
 - Exhaust front tube
 - Oil tubes
 - Water tubes
3. Remove turbocharger from exhaust manifold.
4. Remove turbocharger bracket bolts.

Inspection

Condition 1: Low engine power



Condition 2: Excessively high engine power



Inspection (Cont'd)

Condition 3: Excessively high oil consumption, or exhaust shows pale blue smoke

Probable cause

Corrective action

Oil leak at the connection of lubricating oil passage.

Correct the connection.

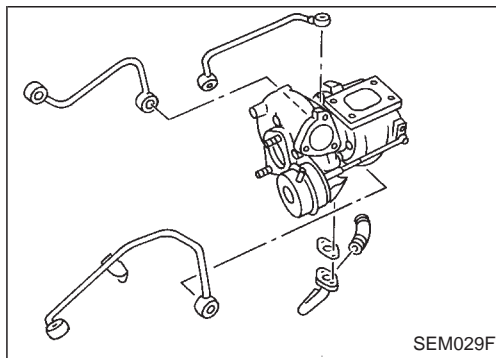
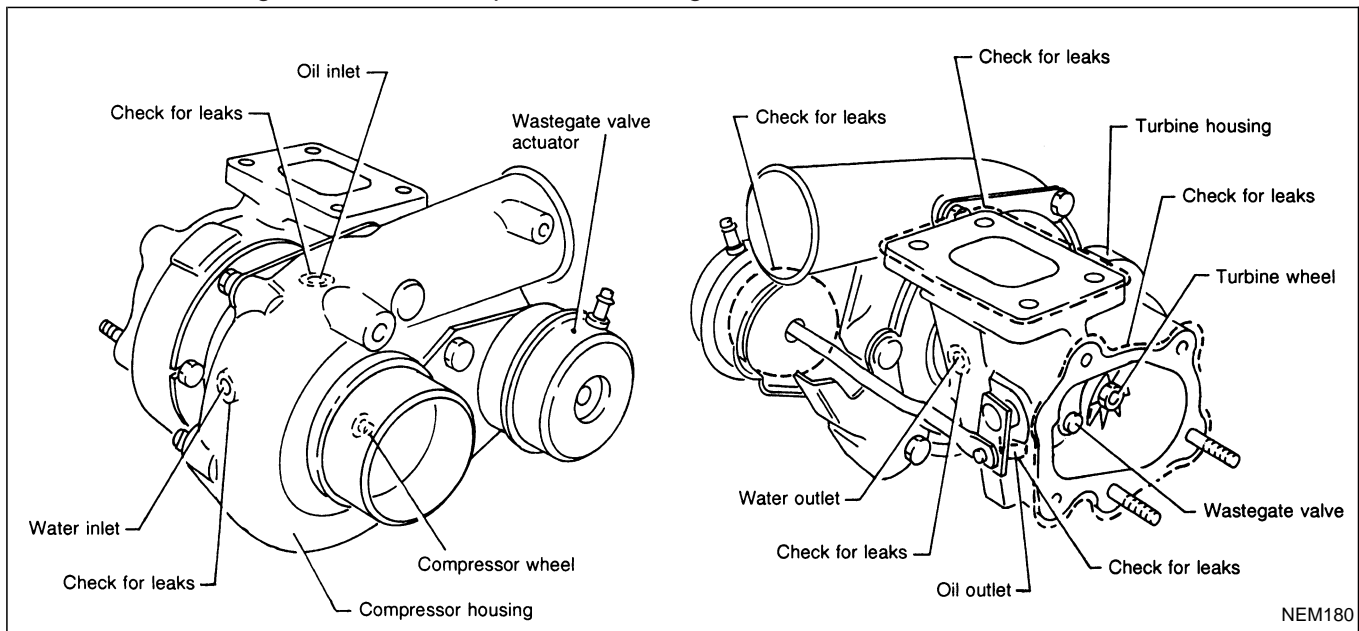
Oil leak at oil seal of turbine.

Oil leak at oil seal of compressor.

Worn journal or bearing.

Replace turbocharger assembly.

Perform the following checks. If NG, replace turbocharger unit.

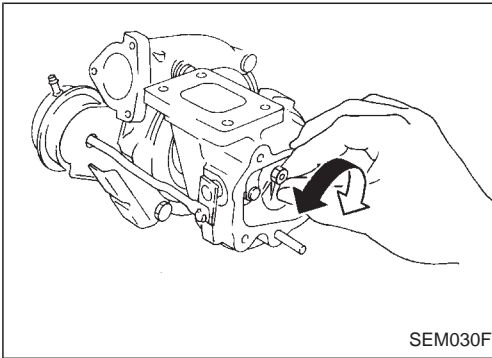


OIL AND WATER TUBES

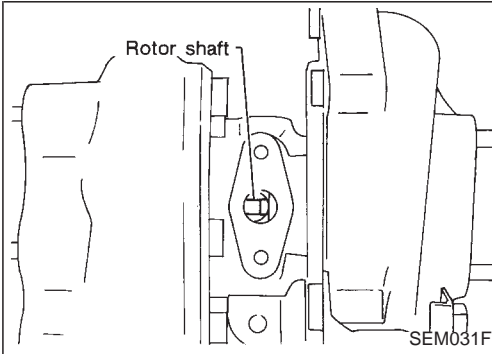
Check tubes for clogging.

Inspection (Cont'd)**ROTOR SHAFT**

1. Check rotor shaft for smooth rotation.



2. Check rotor shaft for carbon deposits.

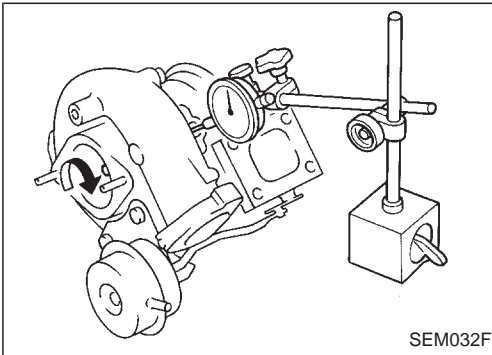


3. Measure rotor shaft runout.

Runout (Total indicator reading):

Standard

0.056 - 0.127 mm (0.0022 - 0.0050 in)



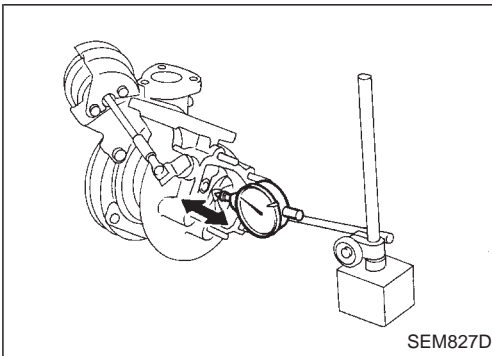
4. Measure rotor shaft end play.

End play:

Standard

0.013 - 0.097 mm (0.0005 - 0.0038 in)

- Do not allow wheels to turn when axial play is being measured.

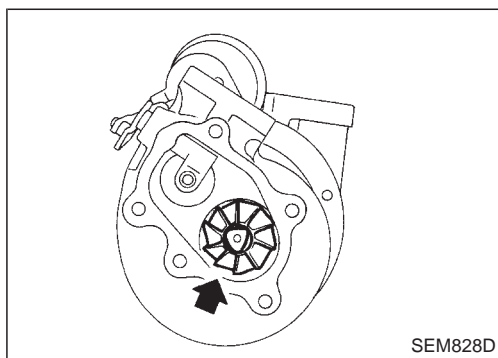


Inspection (Cont'd)

TURBINE WHEEL

Check turbine wheel for the following.

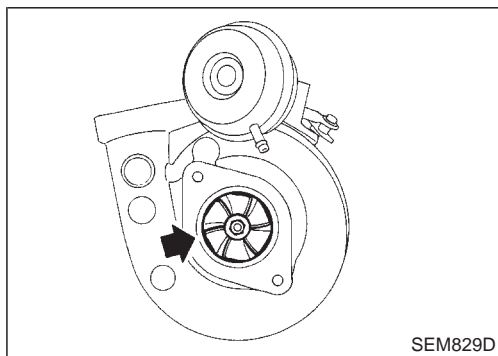
- Oil
- Carbon deposits
- Deformed fins
- Contact with turbine housing



COMPRESSOR WHEEL

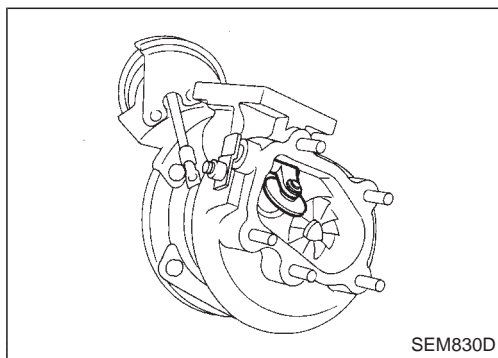
Check compressor wheel for the following.

- Oil
- Deformed fins
- Contact with compressor housing



WASTEGATE VALVE

Remove rod pin and check wastegate valve for cracks, deformation and smooth movement. Check valve seat surface for smoothness.

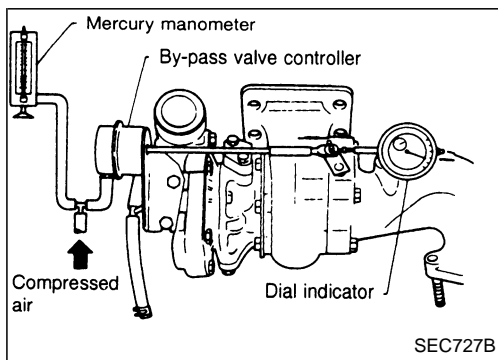


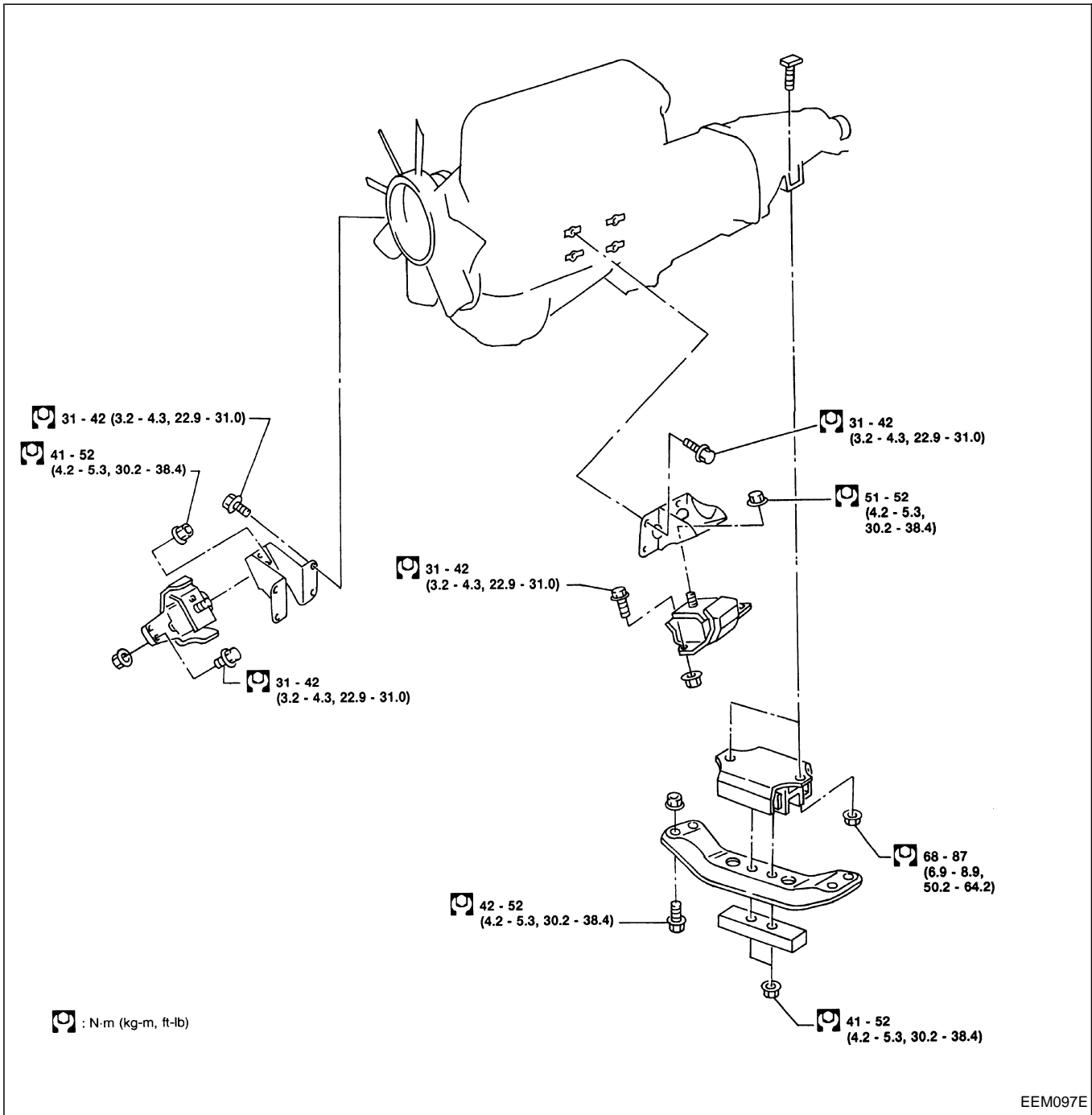
Check operation of by-pass valve controller.

- Move by-pass valve to make sure that it is not sticking or scratched.
- Measure rod end play of the by-pass valve controller.

Do not apply more than 102.6 kPa (1,026 mbar, 770 mmHg, 30.31 inHg) pressure to controller diaphragm.

**By-pass valve controller stroke/pressure:
0.38 mm (0.015 in)/92 kPa (920 mbar, 690 mmHg,
27.17 inHg)**



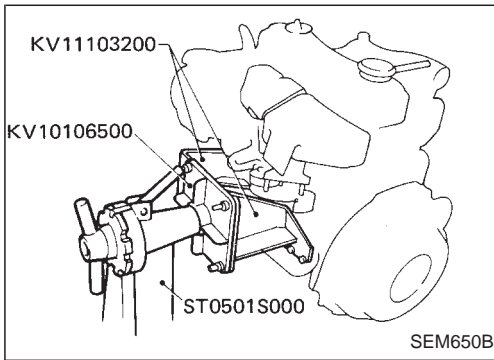


WARNING:

- a. Situate vehicle on a flat and solid surface.
- b. Place chocks at front and back of rear wheels.
- c. Do not remove engine until exhaust system has completely cooled off.
- d. For safety during subsequent steps, the tension of wires should be slackened against the engine.
- e. Be sure to hoist engine in a safe manner.
- f. For engines not equipped with engine slingers, attach proper slingers and bolts described in PARTS CATALOG.

CAUTION:

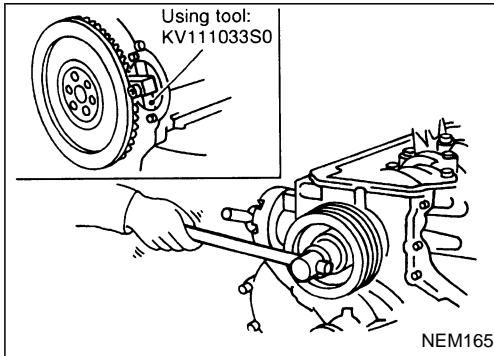
- When lifting engine, be careful not to strike adjacent parts, especially, brake lines and brake master cylinder.
- In hoisting the engine, always use engine slingers in a safe manner.



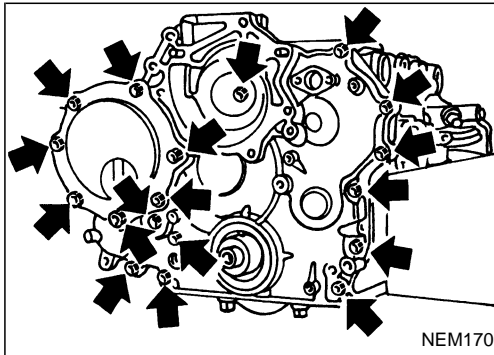
Disassembly

PISTON AND CRANKSHAFT

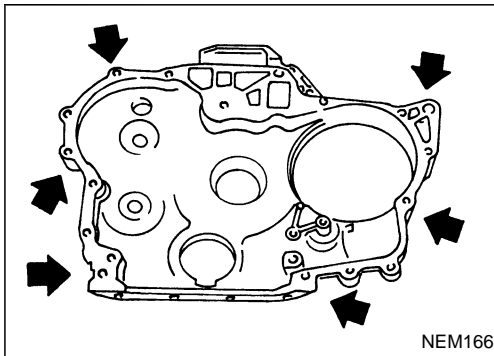
1. Remove oil filter.
2. Place engine on work stand.
3. Drain coolant and oil.
4. Remove drive belts.
5. Remove cylinder head. Refer to "CYLINDER HEAD".
6. Remove oil pan.



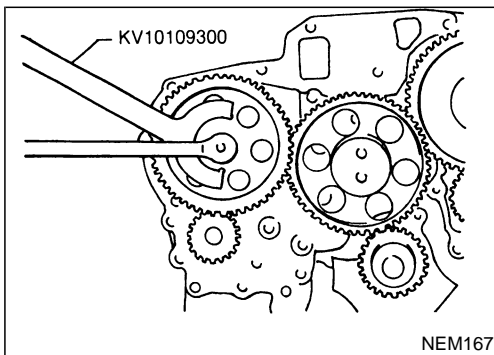
7. Remove crank pulley and timing gear plate cover.



8. Remove water pump.
9. Remove timing gear case.

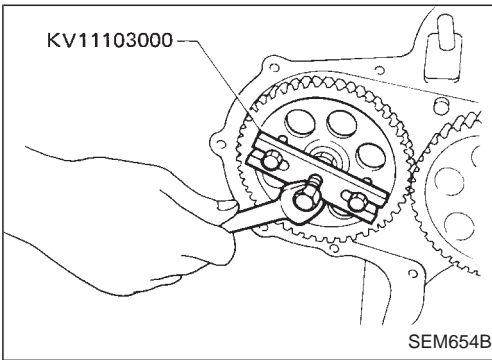


If the timing case is hard to remove due to liquid gasket, pry it off with a suitable tool at the cutout section.

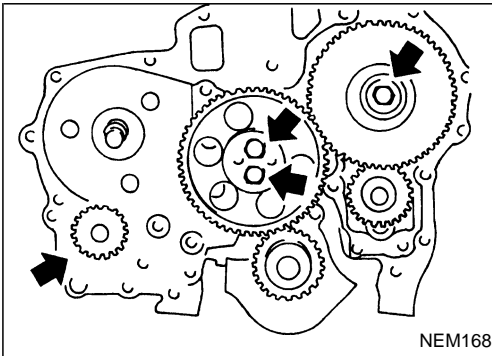


10. Remove injection pump gear nut.

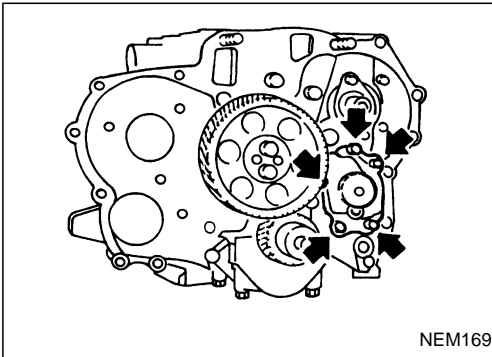
Disassembly (Cont'd)



11. Remove injection pump gear.
12. Remove injection pump.

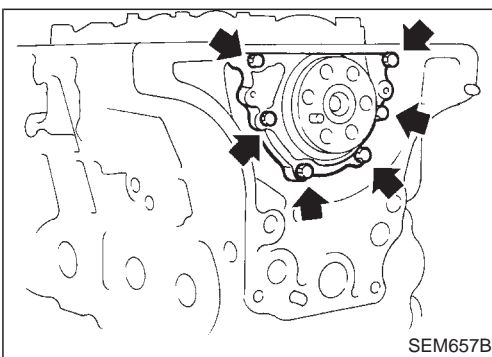


13. Remove idler gear and idler shaft.
14. Remove valve lifters, camshaft gear and camshaft.
15. Remove vacuum pump assembly.



16. Remove oil pump assembly.

17. Remove crankshaft gear.
18. Remove flywheel and rear plate.
19. Remove connecting rod caps.
20. Remove pistons.

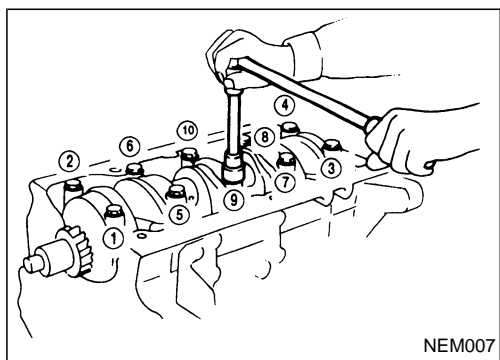


21. Remove rear oil seal retainer.
22. Remove oil strainer.

Disassembly (Cont'd)

23. Remove bearing cap and crankshaft. Loosen bearing cap nuts in numerical order, as shown at left.

Place the bearings and caps in their proper order.



NEM007

Inspection

CYLINDER BLOCK DISTORTION

1. Clean upper face of cylinder block and measure the distortion.

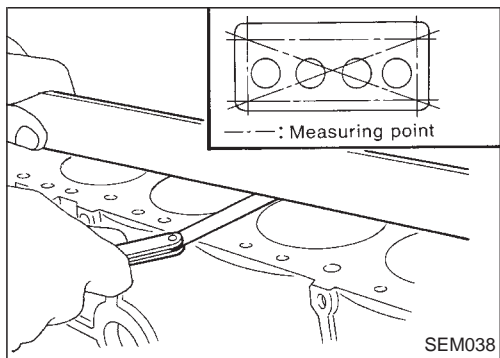
Standard:

Less than 0.05 mm (0.0020 in)

Limit:

0.2 mm (0.008 in)

2. If out of specification, resurface it.



SEM038

CYLINDER WEAR

1. Measure cylinder bore for out-of-round and taper with a bore gauge. If beyond the limit, rebore all 4 cylinders. Replace cylinder block if necessary.

Standard inside diameter:

96.000 - 96.030 mm (3.7795 - 3.7807 in)

Refer to SDS

Wear limit:

Less than 0.20 mm (0.0079 in)

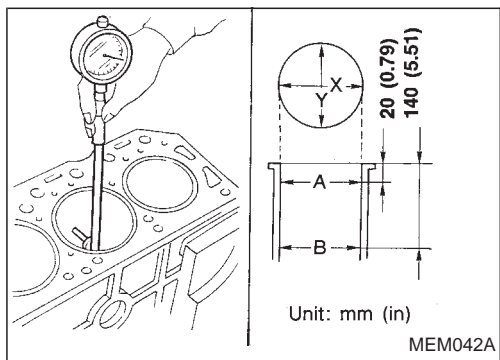
Out-of-round (X - Y) limit:

Less than 0.020 mm (0.0008 in)

Taper (A - B) limit:

0.20 mm (0.0079 in)

2. Check for scratches or abrasions. If abrasions are found, hone cylinder bore.



MEM042A

PISTON AND PISTON PIN CLEARANCE

Check clearance between pistons and piston pins.

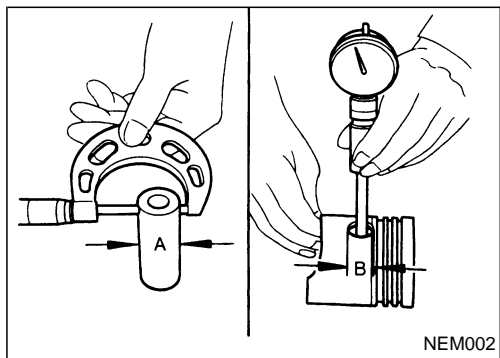
Clearance (A - B):

Standard

-0.008 to 0.007 mm (-0.0003 to 0.0003 in)

Limit

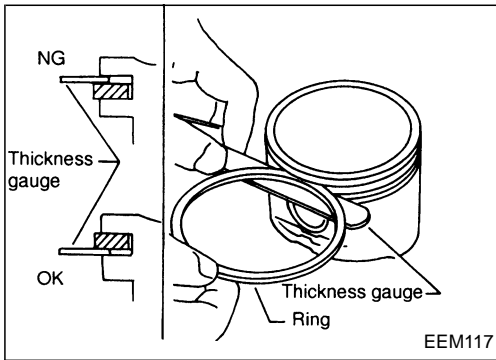
Less than 0.1 mm (0.004 in)



NEM002

Inspection (Cont'd)

PISTON RING SIDE CLEARANCE



Side clearance:

Top ring

0.00 - 0.05 mm (0.0 - 0.0020 in)

2nd ring

0.04 - 0.072 mm (0.0016 - 0.0028 in)

Oil ring

0.035 - 0.040 mm (0.0014 - 0.0016 in)

Max. limit of side clearance:

Top ring

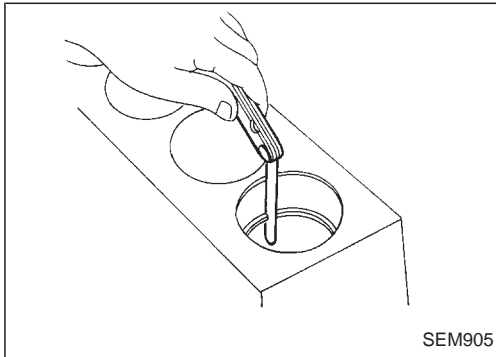
0.5 mm (0.020 in)

2nd ring

0.3 mm (0.012 in)

Oil ring

0.15 mm (0.0059 in)



PISTON RING END GAP

Standard ring gap:

Top ring

0.25 - 0.35 mm (0.0098 - 0.0138 in)

2nd ring

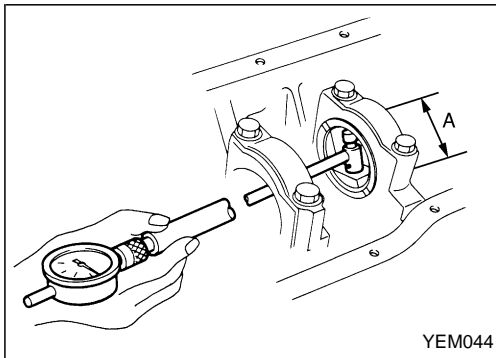
0.50 - 0.75 mm (0.0197 - 0.0295 in)

Oil ring

0.25 - 0.55 mm (0.0098 - 0.0217 in)

Max. limit of ring gap:

1.5 mm (0.059 in)



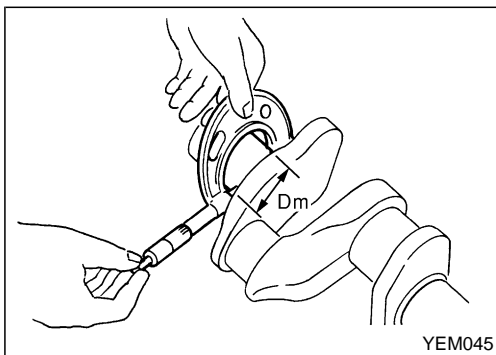
BEARING CLEARANCE

Main bearing

1. Install main bearings to cylinder block and main bearing cap.
2. Install main bearing cap to cylinder block.

Tighten all bolts in correct order and in two or three stages.

3. Measure inside diameter "A" of main bearing.



4. Measure outside diameter "Dm" of main journal in crankshaft.

Inspection (Cont'd)

- Calculate main bearing clearance.

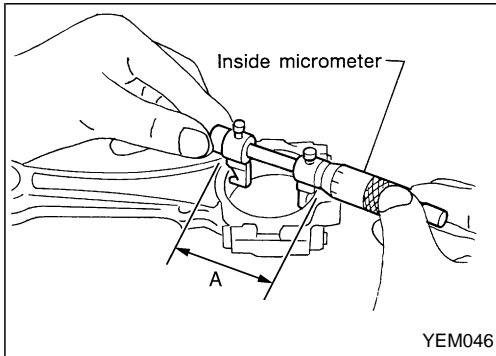
Main bearing clearance = A - Dm

Standard

0.035 - 0.087 mm (0.0014 - 0.0034 in)

Limit

Less than 0.15 mm (0.0059 in)



CONNECTING ROD BEARING (Big end)

- Install connecting rod bearing to connecting rod and cap.
 - Install connecting rod cap to connecting rod.
- Apply oil to the thread portion of bolts and seating surface of nuts.**
- Measure inside diameter "A" of bearing.
 - Measure outside diameter "Dp" of pin journal in crankshaft.
 - Calculate connecting rod bearing clearance.

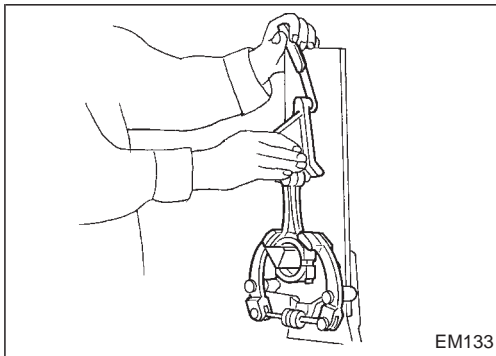
Connecting rod bearing clearance = A - Dp

Standard

**0.035 - 0.081 mm
(0.0014 - 0.0032 in)**

Limit

Less than 0.15 mm (0.0059 in)

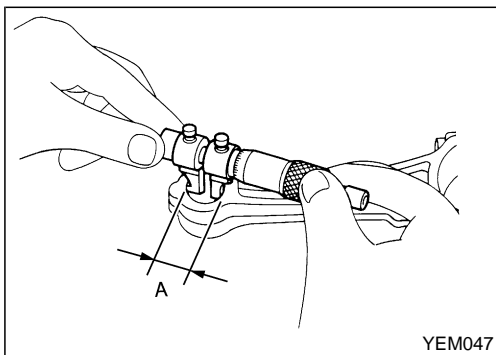


CONNECTING ROD BEND AND TORSION

Bend and torsion:

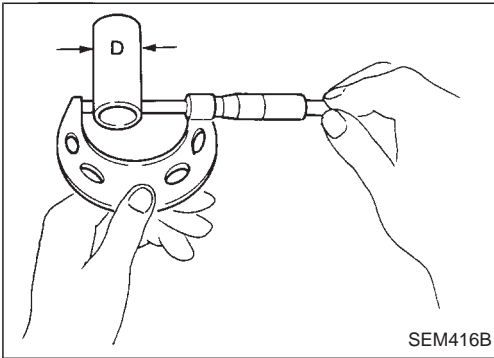
Limit

**0.15 mm (0.0059 in)
per 200 mm (7.87 in) length**



CONNECTING ROD BUSHING CLEARANCE (Small end)

- Measure inside diameter "A" of connecting rod small end bushings.

Inspection (Cont'd)

2. Measure outside diameter "D" of piston pin.
3. Calculate connecting rod small end bushing clearance.

$$\text{Connecting rod small end bushing clearance} = A - D$$

Standard

0.025 - 0.045 mm (0.0010 - 0.0018 in)

Limit

0.15 mm (0.0059 in)

REPLACEMENT OF CONNECTING ROD BUSHING (Small end)

1. Drive in the small end bushing until it is flush with the end surface of the rod.

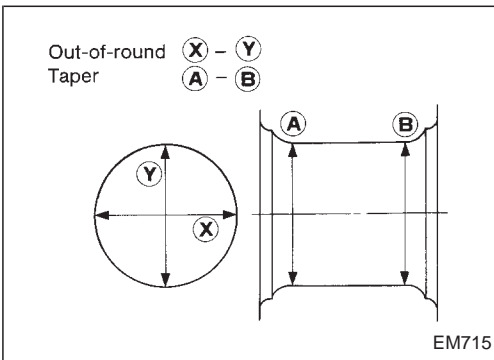
Be sure to align the oil holes.

2. After driving in the small end bushing, ream the bushing.

Small end bushing inside diameter:

Finished size

30.025 - 30.038 mm (1.1821 - 1.1826 in)

**CRANKSHAFT**

1. Check crankshaft journals and pins for score, bias, wear or cracks. If faults are minor, correct with fine emery paper.
2. Check journals and pins with a micrometer for taper and out-of-round.

Out-of-round (X - Y):

Standard

Less than 0.01 mm (0.0004 in)

Limit

0.02 mm (0.0008 in)

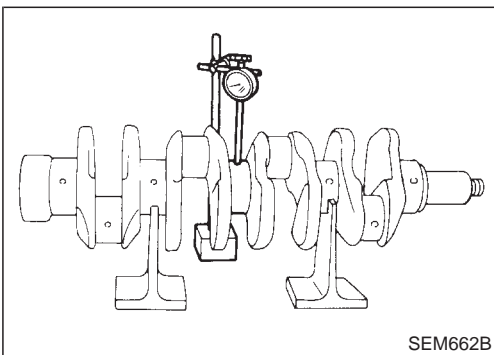
Taper (A - B):

Standard

Less than 0.01 mm (0.0004 in)

Limit

0.02 mm (0.0008 in)



3. Check crankshaft runout.

Runout (Total Indicator Reading)

Standard

0 - 0.03 mm (0 - 0.0012 in)

Limit

0.10 mm (0.0039 in)

Inspection (Cont'd)

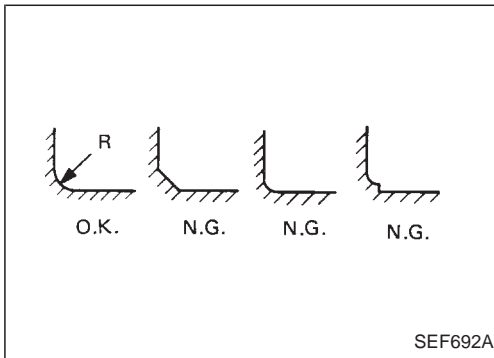
RESURFACING OF CRANKSHAFT JOURNAL AND CRANK PIN

When using undersize main bearings and connecting rod bearings, the crankshaft journals or crank pins must be finished to match the bearings.

R: Crank journal 3.0 mm (0.118 in)
Crank pin 3.5 mm (0.138 in)

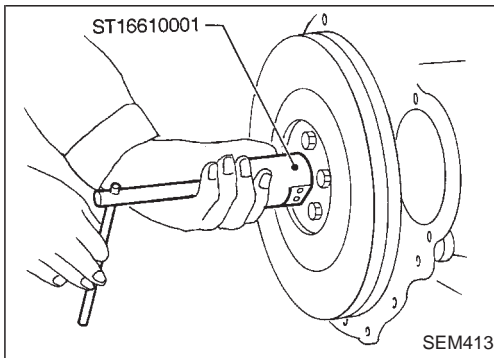
CAUTION:

- At the same time make sure that the surface width does not increase.
- Do not attempt to cut counterweight of crankshaft.



PILOT BUSHING REPLACEMENT

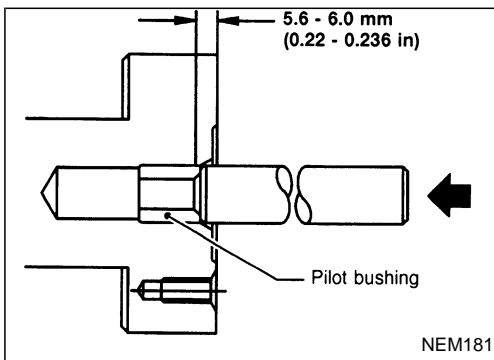
1. Pull out bushing with Tool.



2. Insert pilot bushing until distance between flange end and bushing is specified value.

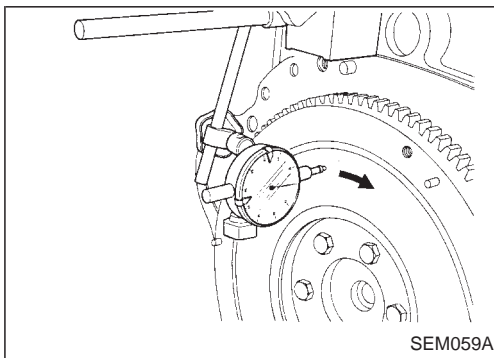
Distance:

Approx. 5.6 - 6.0 mm (0.220 - 0.236 in)



FLYWHEEL RUNOUT

Runout (Total Indicator Reading):
Less than 0.15 mm (0.0059 in)

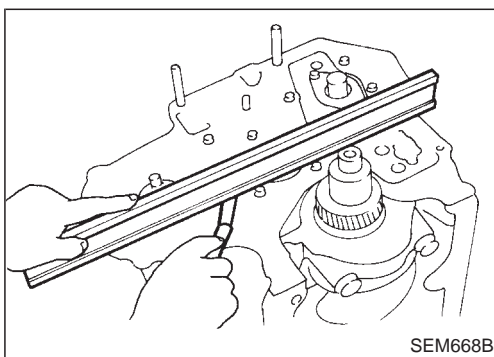


FRONT PLATE

Check front plate for warpage. If not within the limit, make flat or replace front plate.

Warpage limit:

0.2 mm (0.008 in)



Inspection (Cont'd)

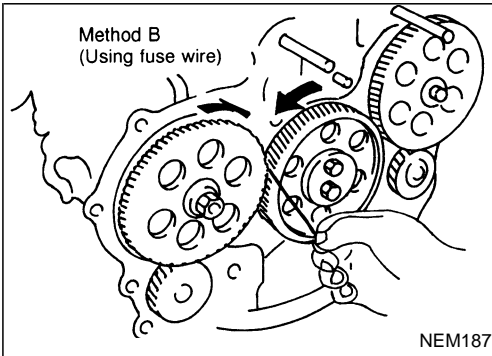
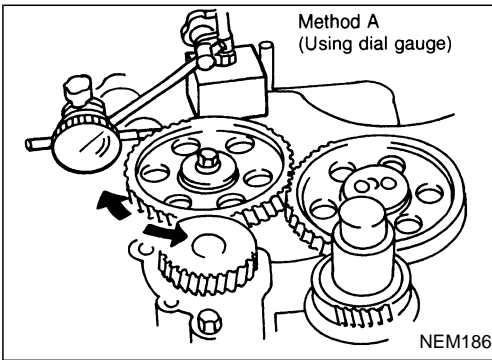
GEAR TRAIN

Camshaft drive gear, injection pump drive gear, oil pump gear, idler gear, crankshaft gear and vacuum pump gear.

1. If gear tooth and key have scratches or are excessively worn, replace gear and key.
2. Check gear train backlash before disassembling and after assembling.

Method A (Using dial gauge)

Method B (Using fuse wire)



If beyond the limit, replace gear.

Backlash:

Standard

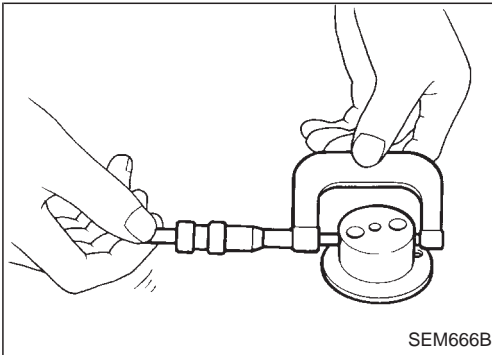
0.07 - 0.11 mm (0.0028 - 0.0043 in)

Limit

0.20 mm (0.0079 in)

IDLER GEAR BUSHING CLEARANCE

1. Measure idler gear shaft outer diameter.



2. Measure idler gear bushing inner diameter.
3. Calculate idler gear bushing clearance.

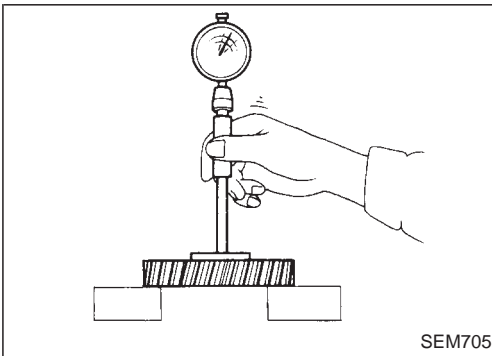
Bushing oil clearance:

Standard

0.025 - 0.061 mm (0.0010 - 0.0024 in)

Limit

0.20 mm (0.0079 in)



IDLER GEAR END PLAY

Measure idler gear end play between gear plate and gear.

Idler gear end play:

Standard

0.03 - 0.14 mm (0.0012 - 0.0055 in)

Limit

Less than 0.3 mm (0.012 in)

Inspection (Cont'd)

REPLACEMENT OF IDLER GEAR BUSHING

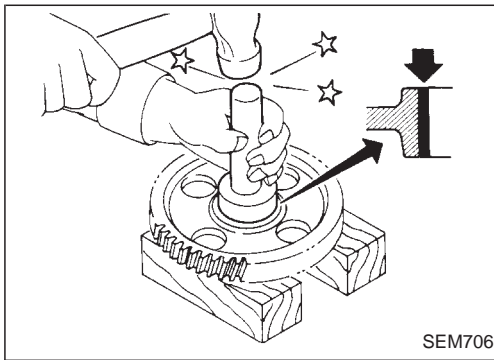
1. Use a suitable tool to replace bushing.
2. Ream idler gear bushing.

Finished size:

42.00 - 42.02 mm (1.6535 - 1.6543 in)

Idler gear shaft

Install idler gear shaft so that oil hole of shaft faces upward.



SEM706

CAMSHAFT AND CAMSHAFT BUSHING

Camshaft bushing clearance

Measure inside diameter of camshaft bushing (A) and outside diameter of camshaft journal (B) with a suitable gauge.

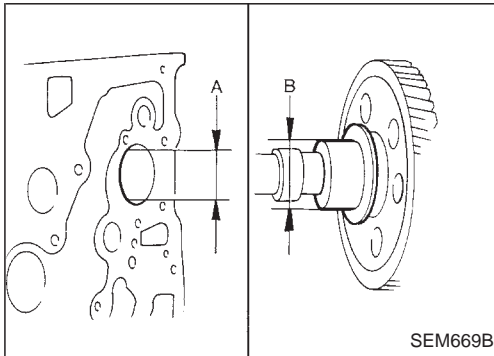
Clearance between camshaft and bushing (A – B):

Standard

**0.020 - 0.109 mm
(0.0008 - 0.0043 in)**

Limit

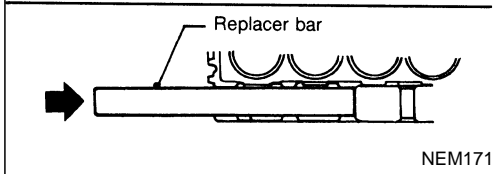
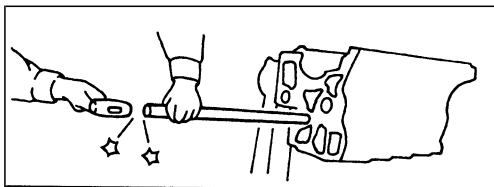
Less than 0.15 mm (0.0059 in)



SEM669B

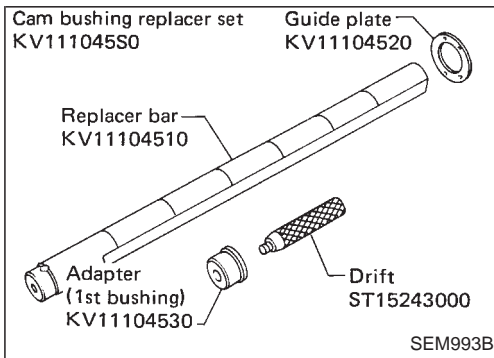
REPLACING CAMSHAFT BUSHING

1. Remove welch plug.
Using Tool, remove camshaft bushings from the cylinder block. Some bushings must be broken in order to remove.



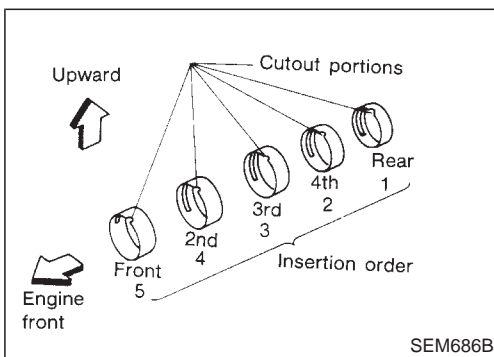
NEM171

2. Using Tool, install camshaft bushings as follows:



SEM993B

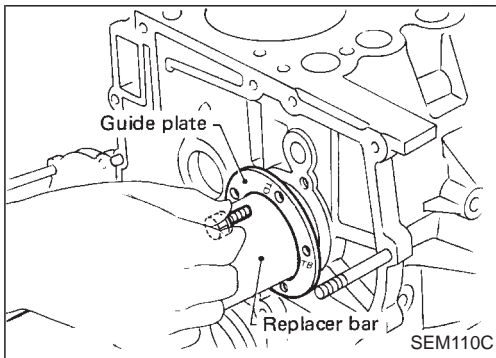
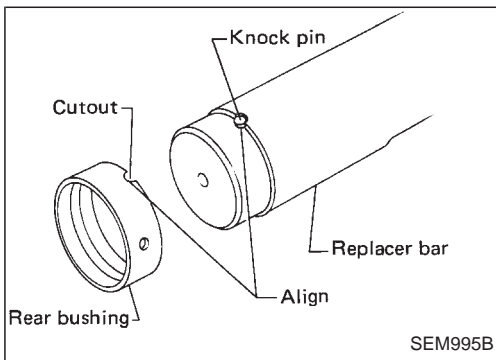
- (1) Install camshaft bushings in the order of "rear", "4th", "3rd", "2nd" and "front". All bushings must be installed from the front.
- (2) Face the cutout upward and toward the front of the engine during installation.



SEM686B

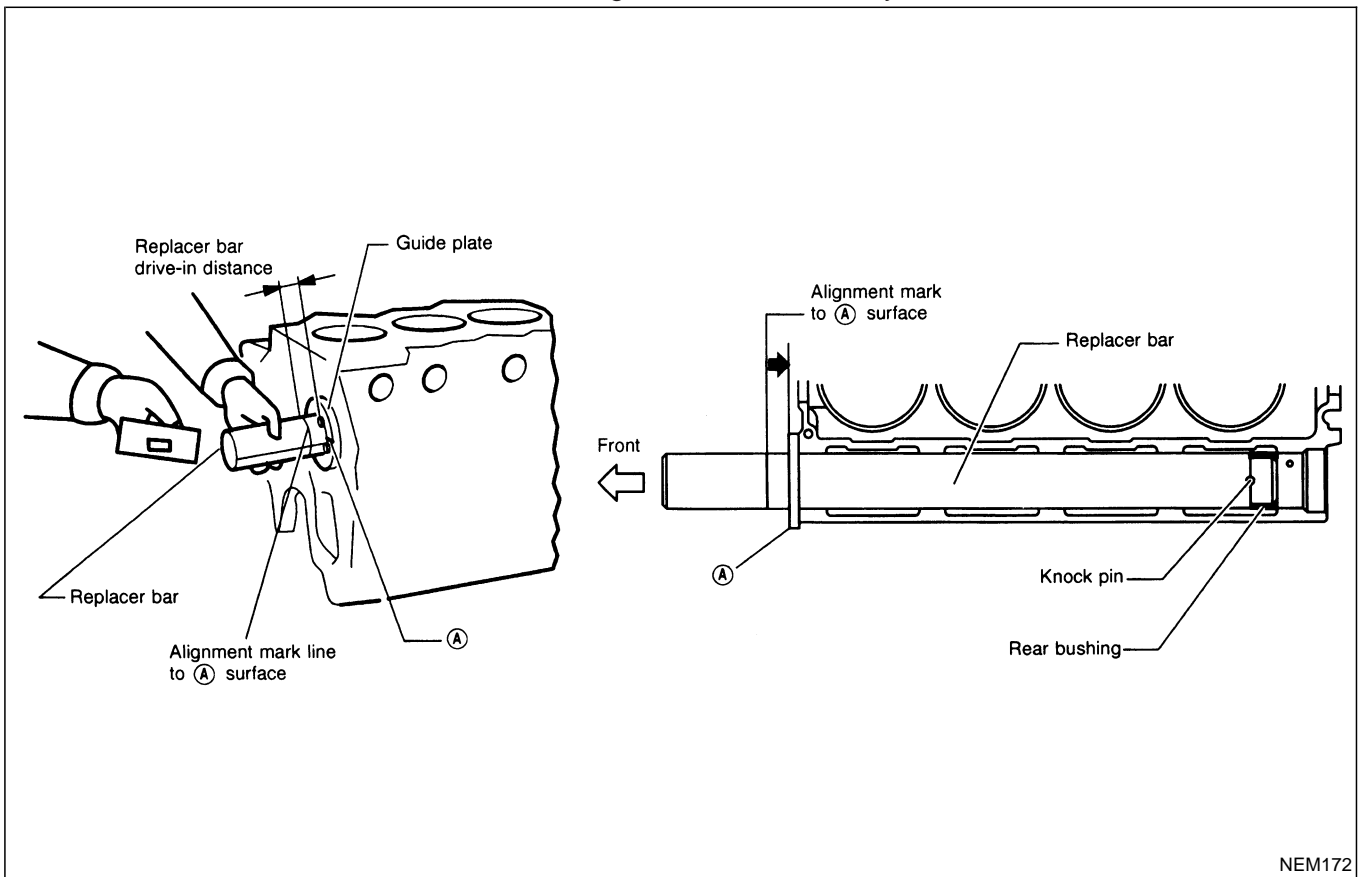
Inspection (Cont'd)

- (3) Rear camshaft bushing.
Align the cutout of rear bushing with knock pin of replacer bar before installation.



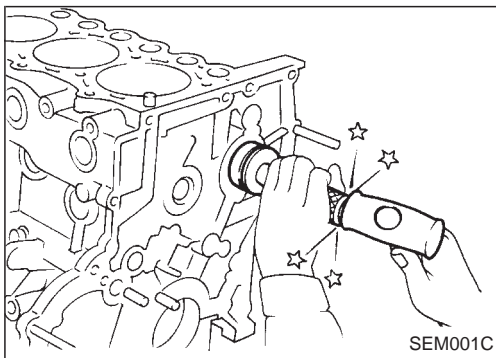
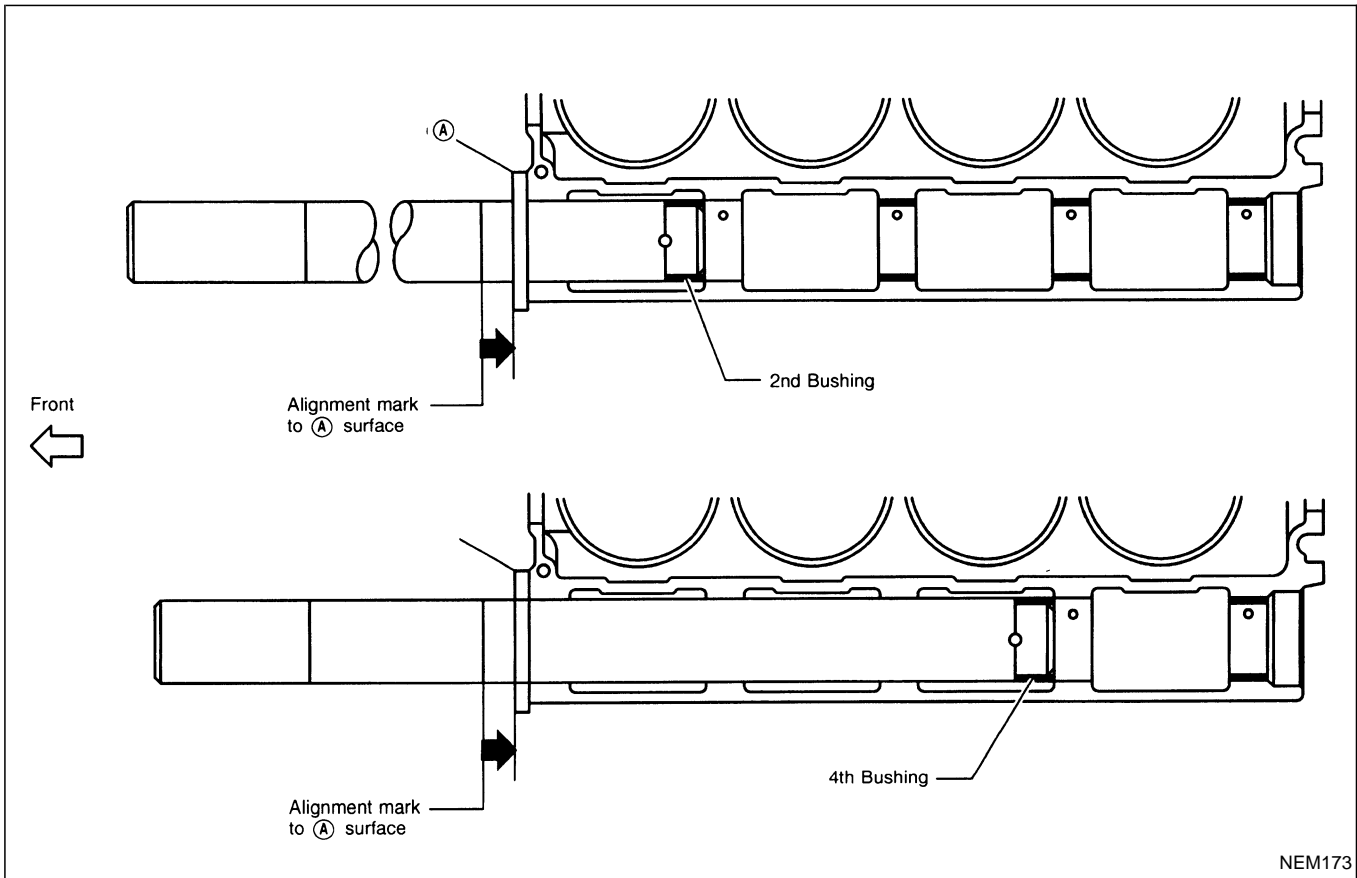
Insert rear bushing with replacer bar into the cylinder block. Install guide plate with bolt holes (on the "TD" mark side) facing upper side of cylinder block. Tighten bolts.

Drive replacer bar until the alignment mark on replacer bar is aligned with the end of replacer guide. Remove replacer set. After installation, check that oil hole in camshaft bushing are aligned with oil hole in cylinder block.

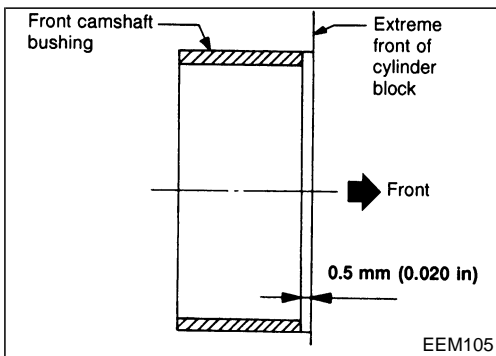


Inspection (Cont'd)

- (4) 4th, 3rd and 2nd camshaft bushings.
Install in the same manner as rear camshaft bushing.



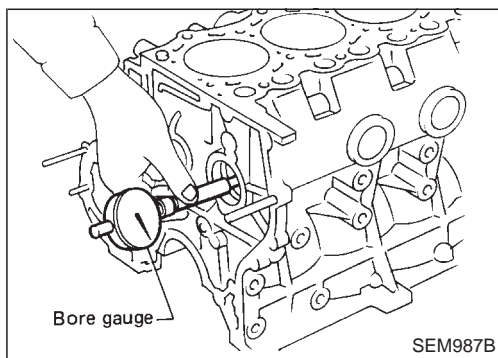
- (5) Front camshaft bushing.
Using 1st bushing adapter, position front camshaft bushing so that oil hole in cylinder block is aligned with oil hole in bushing.



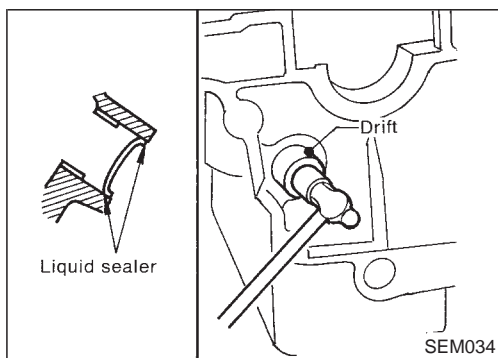
The camshaft bushing of the front side must be inserted at 0.5 mm (0.020 in) from the extreme front of cylinder block.

Inspection (Cont'd)

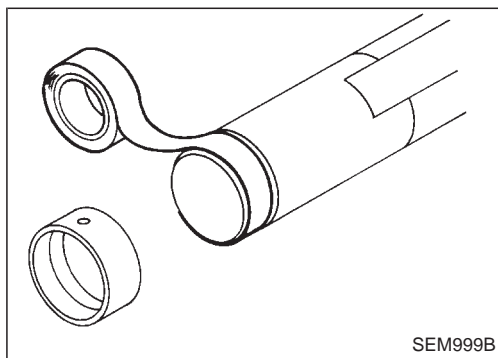
3. Check camshaft bushing clearance.



4. Install new welch plug with a drift.
Apply liquid sealer.



When setting 4th through 2nd bushings on replacer bar, tape the bar to prevent movement.



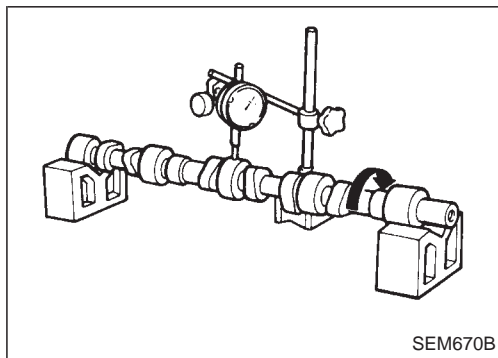
CAMSHAFT ALIGNMENT

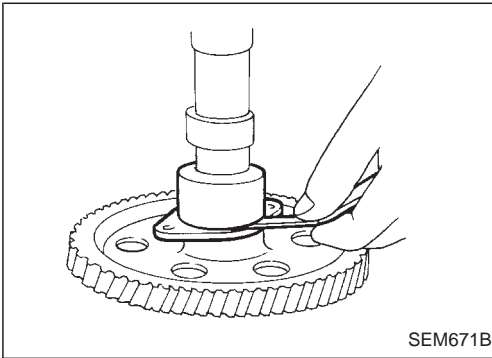
1. Check camshaft journal and cam surface for cracks, wear or damage.
If fault is beyond limit, replace.
2. Check camshaft runout at center journal.
If runout is greater than specified limit, repair or replace camshaft.

Camshaft runout
(Total indicator reading):

Standard
Less than 0.02 mm (0.0008 in)

Limit
Less than 0.06 mm (0.0024 in)



Inspection (Cont'd)

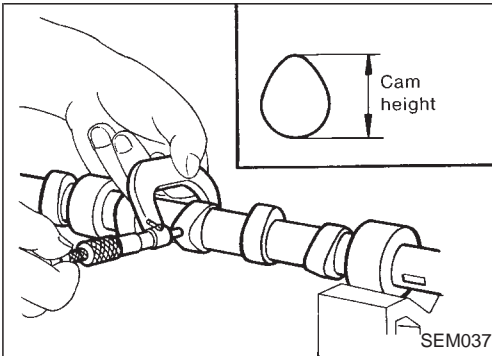
3. Measure camshaft end play between locating plate and gear. If beyond the specified limit, replace camshaft locating plate.

Camshaft end play:**Standard**

0.08 - 0.28 mm (0.0031 - 0.0110 in)

Limit

Less than 0.5 mm (0.020 in)



4. Measure camshaft cam height. If beyond the specified limit, replace camshaft.

Cam height:**Standard****Intake**

41.570 mm (1.6366 in)

Exhaust

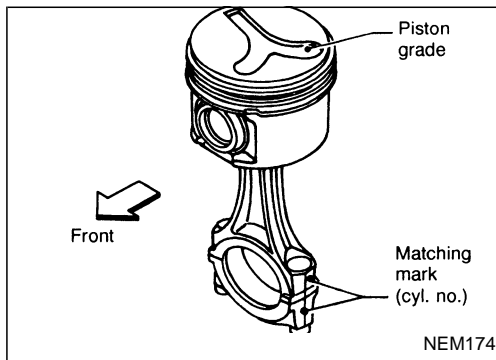
41.900 mm (1.6496 in)

Limit**Intake**

Less than 41.20 mm (1.6220 in)

Exhaust

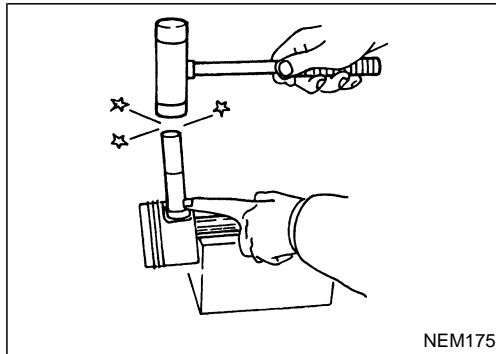
Less than 41.40 mm (1.6299 in)



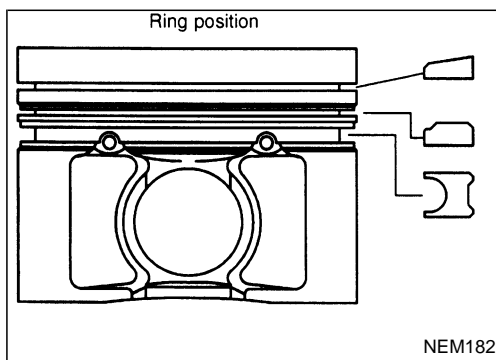
Assembly

PISTON

1. Assemble pistons, piston pins, snap rings and connecting rods.
 - a. Numbers are stamped on the connecting rod and cap corresponding to each cylinder. Care should be taken to avoid a wrong combination including bearing.



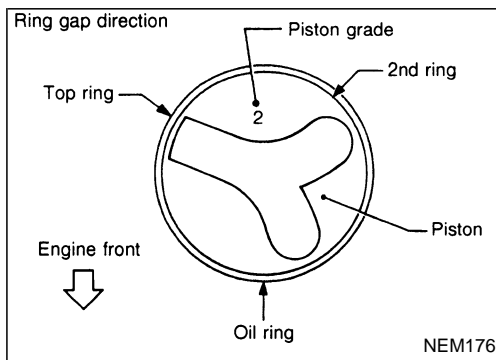
- b. When inserting piston pin in connecting rod, heat piston with a heater or hot water [approximately 60 to 70°C (140 to 158°F)] and apply engine oil to pin and small end of connecting rod.
 - c. After assembling, ascertain that piston swings smoothly.



2. Install piston assembly.

CAUTION:

- a. Stretch the piston rings just enough to fit them in the piston grooves.
- b. Be sure the manufacturer's mark faces upward.

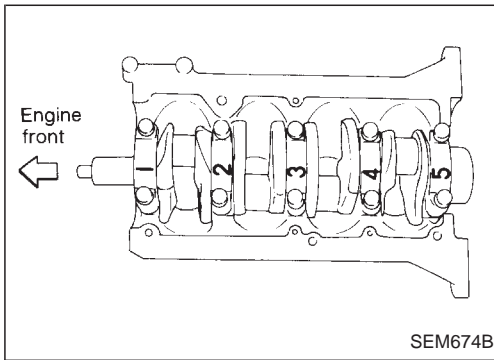


- c. Install No. 1 piston ring (oil ring) in such a way that its gap faces the direction of engine front, as shown in illustration at left; and then install 2nd and top rings so that their gap is positioned at 120° one to another.

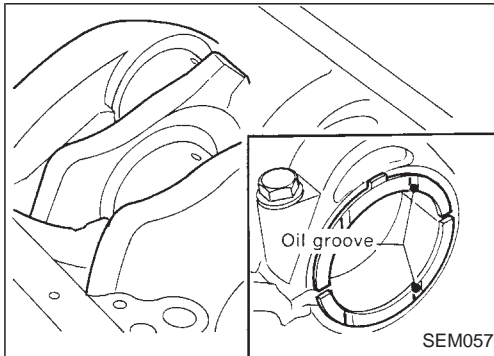
CRANKSHAFT

1. Install crankshaft.
 - (1) Set main bearings in the proper position on cylinder block.
 - a. If either crankshaft, cylinder block or main bearing is reused again, it is necessary to measure main bearing clearance.
 - b. Upper bearings have oil hole and oil groove, however lower bearings do not.

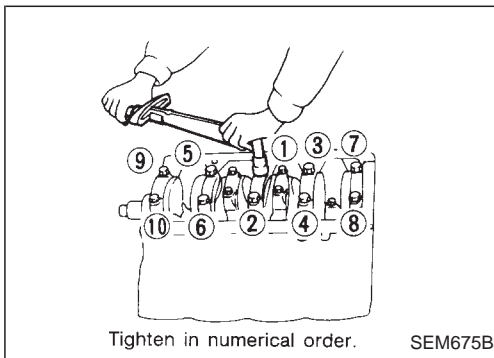
Assembly (Cont'd)



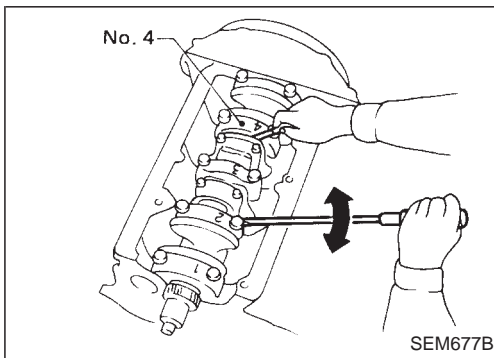
- (2) Apply engine oil to crankshaft journal and pin and install crankshaft.
- (3) Install main bearings caps.
 - a) Install main bearing cap with the lowest number facing the front of vehicle.
 - b) Apply engine oil to main bearing cap and cylinder block contact surfaces.
 - c) Install rear oil seal assembly. Apply engine oil to contact surface of rear end oil seal and crankshaft.



- (4) Install crankshaft thrust washer at the 4th journal from front. **Install thrust washer so that oil groove can face crankshaft.**



- (5) Tighten bearing cap bolts gradually in stages, starting from two to three separate stages, from center bearing and moving outward in sequence.



- (6) Measure crankshaft free end play at No. 4 bearing.

Crankshaft free end play:

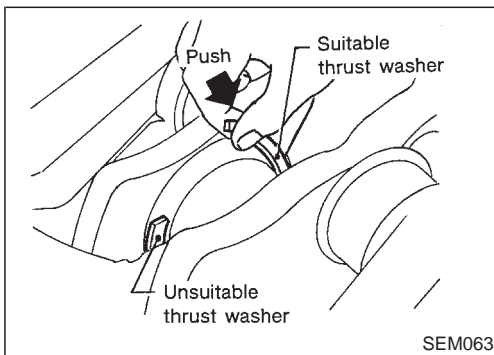
Standard

0.060 - 0.25 mm (0.002 - 0.01 in)

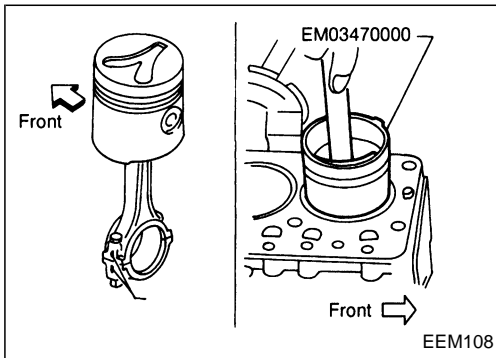
Limit

0.4 mm (0.016 in)

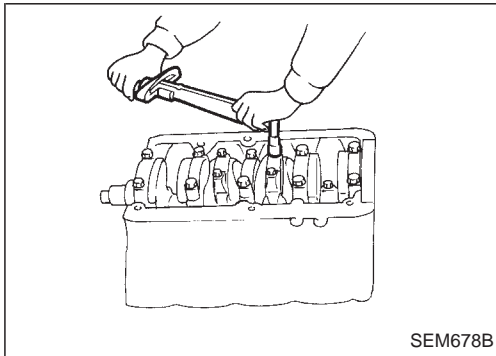
If beyond the limit, replace No. 4 main bearing thrust washer. Refer to SDS.



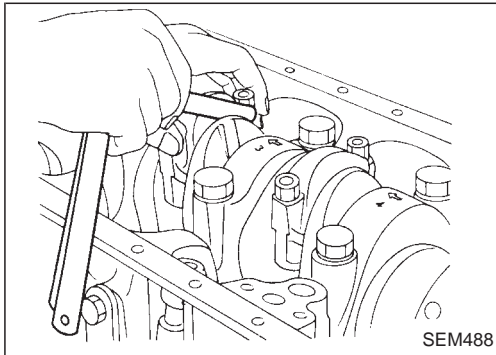
Assembly (Cont'd)



2. Install pistons with connecting rods.
 - (1) Install them into corresponding cylinder using Tool.
 - Be careful not to scratch cylinder wall with connecting rod.
 - Apply engine oil to cylinder wall, piston and bearing.
 - The leaf type combustion chamber on piston head must be facing toward the fuel pump side.



- (2) Install connecting rod bearing caps.



3. Measure connecting rod side clearance.

Connecting rod side clearance:

Standard

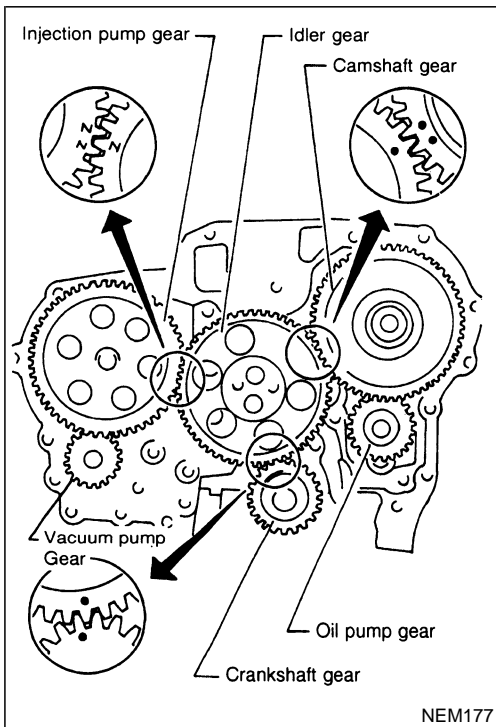
0.10 - 0.22 mm (0.0039 - 0.0087 in)

Limit

0.22 mm (0.0087 in)

If beyond the limit, replace connecting rod and/or crankshaft.

4. Install oil strainer and oil pan.
5. Install all removed parts.



GEAR TRAIN

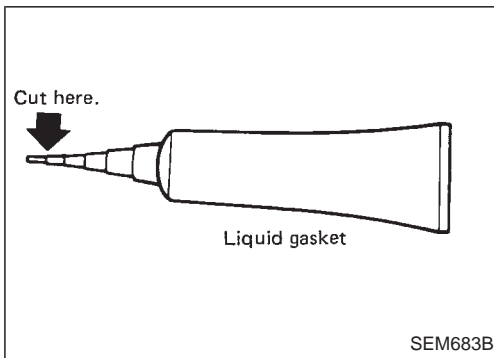
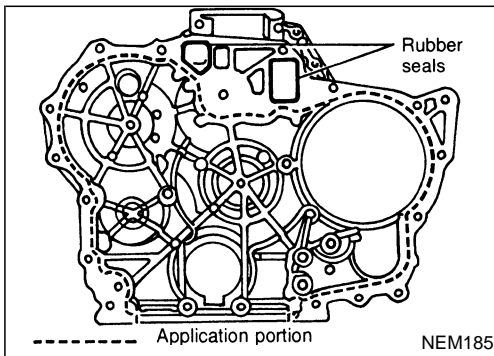
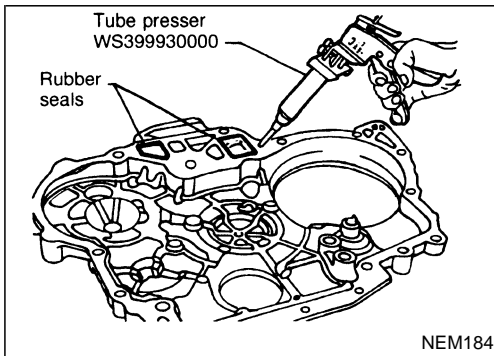
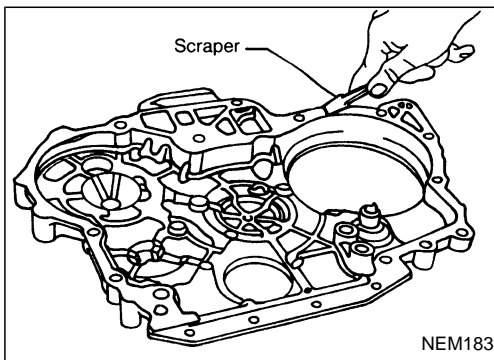
1. Set No. 1 piston at its Top Dead Center.
2. Align each gear mark and install gears.

Assembly (Cont'd)

TIMING GEAR CASE

Installation

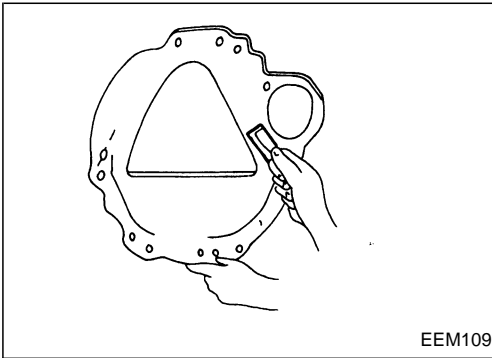
1. Before installing timing gear case, remove all traces of liquid gasket from mating surface using a scraper. Also remove traces of liquid gasket from mating surface of front plate.
2. Apply a continuous bead of liquid gasket to mating surface of timing gear case and install the two rubber seals as shown.



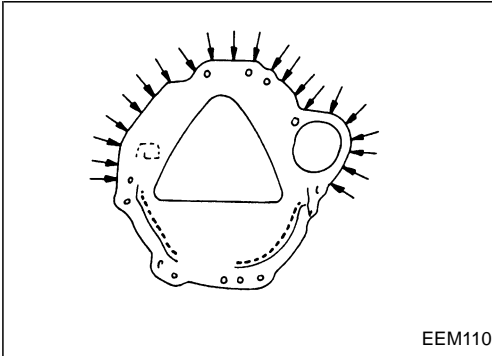
- Be sure liquid gasket is 2.5 to 3.5 mm (0.098 to 0.138 in) wide.
- Attach timing gear case to front plate within 20 minutes after coating.
- Wait at least 30 minutes before refilling engine coolant or starting engine.
- use Genuine Liquid Gasket or equivalent.

Assembly (Cont'd)**REAR PLATE****Installation**

1. Before installing rear plate, remove all traces of liquid gasket from mating surface using a scraper.
Also remove traces of liquid gasket from mating surface of cylinder block.



EEM109



EEM110

2. Apply a continuous bead of liquid gasket to mating surface of cylinder block.
3. Fit the rear plate into the cylinder block and apply liquid gasket in the area indicated by discontinuous line.
4. After the transmission is installed, apply liquid gasket in the area indicated by arrows.
5. Install all removed parts.

General Specifications

Engine model		TD27Ti
Cylinder arrangement		4, in-line
Displacement	cm ³ (cu in)	2,663 (162.5)
Bore x stroke	mm (in)	96 x 92 (3.8 x 3.6)
Valve arrangement		OHV
Firing order		1-3-4-2
Number of piston rings		
Compression		2
Oil		1
Number of main bearings		5
Compression ratio		21.9±0.2

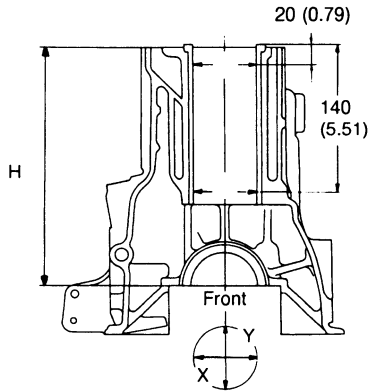
Unit: kPa (bar, kg/cm², psi)/rpm

Compression pressure		
Standard		2,942 (29.4, 30, 427)/200
Minimum		2,452 (24.5, 25, 356)/200
Differential limit between cylinders		294 (2.9, 3, 43)/200

Inspection and Adjustment

CYLINDER BLOCK AND CYLINDER LINER

Unit: mm (in)



NEM227

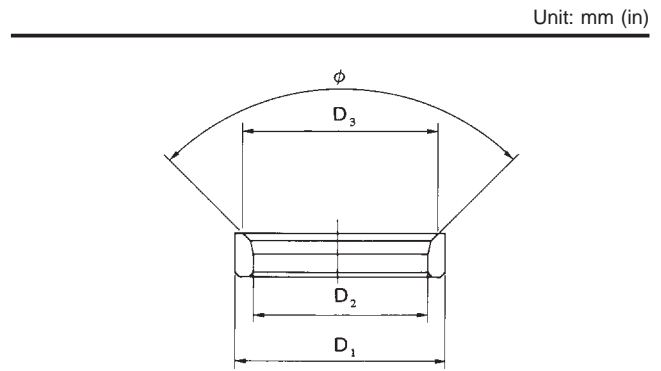
Nominal cylinder block height (H) (From crankshaft center)	549.5 - 550.5 (21.6 - 21.7)
Cylinder bore	
Inner diameter	
Standard	
Grade No. 1	96.000 - 96.010 (3.7795 - 3.7799)
Grade No. 2	96.010 - 96.020 (3.7799 - 3.7803)
Grade No. 3	96.020 - 96.030 (3.7803 - 3.7807)
Wear limit	0.20 (0.0079)
Out-of-round (X - Y)	Less than 0.020 (0.0008)
Taper (A - B)	Less than 0.20 (0.0079)
Division of each cylinder	Less than 0.05 (0.0020)

Inspection and Adjustment (Cont'd)

VALVE GUIDE

Unit: mm (in)		
	Standard	Service
Valve guide outside diameter	12.033 - 12.044 (0.4737 - 0.4742)	—
Valve guide inner diameter (Finished size)	8.00 - 8.015 (0.3150 - 0.3156)	
Cylinder head valve guide hole diameter	12.00 - 12.011 (0.4724 - 0.4729)	—
Interference fit of valve guide	0.022 - 0.044 (0.0009 - 0.0017)	
	Standard	Limit
Valve to guide clearance		
Intake	0.020 - 0.050 (0.0008 - 0.0020)	0.15 (0.0059)
Exhaust	0.04 - 0.07 (0.0016 - 0.0028)	0.20 (0.0079)
Valve deflection limit		
Intake	0.30 (0.0118)	
Exhaust	0.40 (0.0157)	

VALVE SEAT



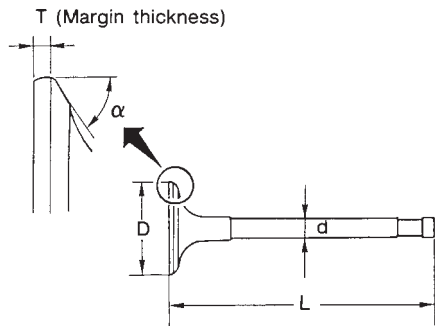
SEM953C

Intake	
Outer diameter "D ₁ "	44.535 - 44.545 (1.7533 - 1.7537)
Inner diameter "D ₂ "	38±0.1 (1.50±0.0039)
Diameter of seat "D ₃ "	42.4 - 42.6 (1.669 - 1.677)
Cylinder head valve seat diameter	44.500 - 44.515 (1.7520 - 1.7526)
Valve seat face angle "φ"	90°
Exhaust	
Outer diameter "D ₁ "	
Standard	39.535 - 39.545 (1.5565 - 1.5569)
0.2 (0.008) Oversize (Service)	39.735 - 39.745 (1.5644 - 1.5648)
0.4 (0.016) Oversize (Service)	39.935 - 39.945 (1.5722 - 1.5726)
Inner diameter "D ₂ "	32.9 - 33.1 (1.295 - 1.303)
Diameter of seat "D ₃ "	37±0.1 (1.46±0.0039)
Cylinder head valve seat diameter	
Standard	39.495 - 39.510 (1.5549 - 1.555)
0.2 (0.008) Oversize	39.695 - 39.710 (1.5628 - 1.5634)
0.4 (0.016) Oversize	39.895 - 39.910 (1.5707 - 1.5713)
Valve seat face angle "φ"	90°

Inspection and Adjustment (Cont'd)

VALVE

Unit: mm (in)



SEM188

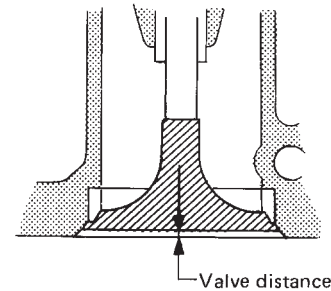
Valve head diameter "D"	
Intake	42.5 (1.67)
Exhaust	37 (1.5)
Valve length "L"	
Intake	117 (4.61)
Exhaust	
Valve stem diameter "d"	
Intake	7.965 - 7.980 (0.3136 - 0.3142)
Exhaust	7.945 - 7.960 (0.3128 - 0.3134)
Valve seat angle "α"	
Intake	45° - 45°30'
Exhaust	
Valve margin "T" limit	1.5 (0.059)
Valve stem end surface grinding limit	0.2 (0.008)
Valve clearance (Hot)	
Intake	0.25 (0.01)
Exhaust	

VALVE SPRING

Free length	mm (in)	
Painted red		53.80 (2.118)
Pressure height	mm/N (mm/kg, in/lb)	31.8/713.0 - 788.5 (31.8/72.7 - 80.4, 1.252/160.3 - 177.3)
Assembled height	mm/N (mm/kg, in/lb)	
Standard		42.3/314.8 - 361.9 (42.3/32.1 - 36.9, 1.665/70.8 - 81.4)
Limit		42.3/296.2 (42.3/30.2, 1.665/66.6)
Out of square	mm (in)	2.0 (0.079)

CYLINDER HEAD TO VALVE DISTANCE

Unit: mm (in)



SEM724C

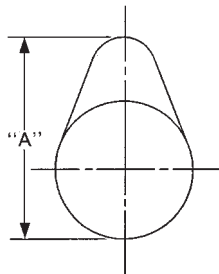
	Standard	Limit
Intake	0.79 - 1.19 (0.0311 - 0.0469)	Less than 1.75 (0.0689)
Exhaust	0.80 - 1.20 (0.0315 - 0.0472)	Less than 1.75 (0.0689)

Inspection and Adjustment (Cont'd)

CAMSHAFT AND CAMSHAFT BEARING

Unit: mm (in)

	Standard	Limit
Camshaft journal to bushing clearance	0.020 - 0.109 (0.0008 - 0.0043)	Less than 0.15 (0.0059)
Camshaft journal diameter		
Front	50.721 - 50.740 (1.9969 - 1.9976)	—
2nd	50.521 - 50.540 (1.9890 - 1.9898)	—
3rd	50.321 - 50.340 (1.9811 - 1.9819)	—
4th	50.121 - 50.140 (1.9733 - 1.9740)	—
Rear	49.921 - 49.940 (1.9654 - 1.9661)	—
Camshaft bend (Total indicator reading)	Less than 0.02 (0.0008)	Less than 0.06 (0.0024)
Camshaft end play	0.08 - 0.28 (0.0031 - 0.0110)	Less than 0.50 (0.0197)



EM671

	Standard	Limit
Cam height "A"		
Intake	41.570 (1.6366)	Less than
Exhaust	41.900 (1.6496)	Less than

VALVE LIFTER AND PUSH ROD

Unit: mm (in)

	Standard	Limit
Valve lifter outer diameter	24.960 - 24.970 (0.9827 - 0.9831)	—
Cylinder block valve lifter hole diameter	25.000 - 25.033 (0.9843 - 0.9855)	—
Valve lifter to lifter hole clearance	0.030 - 0.073 (0.0012 - 0.0029)	Less than 0.20 (0.0079)
Push rod bend (TIR)	Less than 0.3 (0.012°)	Less than 0.5 (0.020)

*: Total indicator reading

ROCKER SHAFT AND ROCKER ARM

	Standard	Limit
Rocker shaft		
Outer diameter	19.979 - 20.00 (0.7866 - 0.7874)	—
Rocker shaft bend (TIR)*	0 - 0.10 (0 - 0.0039)	less than 0.30 (0.0188)
Rocker arm		
Inner diameter	20.014 - 20.035 (0.7880 - 0.7888)	—
Clearance between rocker arm and rocker shaft	0.014 - 0.056 (0.0006 - 0.0022)	less than 0.15 (0.0059)

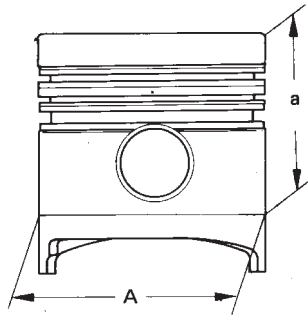
*: Total indicator reading

Inspection and Adjustment (Cont'd)

PISTON, PISTON RING AND PISTON PIN

Available piston

Unit: mm (in)



SEM778A

Piston skirt diameter "A"	
Standard	
Grade No. 1	95.890 - 95.900 (3.7752 - 3.7756)
Grade No. 2	95.900 - 95.910 (3.7756 - 3.7760)
Grade No. 3*	95.910 - 95.920 (3.7760 - 3.7764)
"a" dimension	45.2 (1.780)
Piston pin hole diameter	29.992 - 30.000 (1.1808 - 1.1811)
Piston to cylinder liner clearance	0.043 - 0.077 (0.0017 - 0.0030)
"A" dimension	69.2 (2.724)

Grade No. 3 piston is not provided as a service part.

Piston pin

Unit: mm (in)

Piston pin outer diameter	29.993 - 30.000 (1.1808 - 1.1811)
Piston pin to piston clearance	-0.008 to 0.007 (-0.0003 to 0.0003)
Piston pin to connecting rod clearance	
Standard	0.025 - 0.045 (0.0010 - 0.0018)
Limit	0.15 (0.0059P)

Piston ring

Unit: mm (in)

	Standard	Limit
Side clearance		
Top	0.00 - 0.05 (0.0 - 0.0020)	0.50 (0.0197)
2nd	0.04 - 0.072 (0.0016 - 0.0028)	0.30 (0.0118)
Oil	0.035 - 0.040 (0.0014 - 0.0016)	0.15 (0.0059)
Ring gap		
Top	0.25 - 0.35 (0.0098 - 0.014)	1.5 (0.059)
2nd	0.50 - 0.75 (0.0197 - 0.0295)	
Oil (rail ring)	0.25 - 0.55 (0.0098 - 0.0217)	

CONNECTING ROD

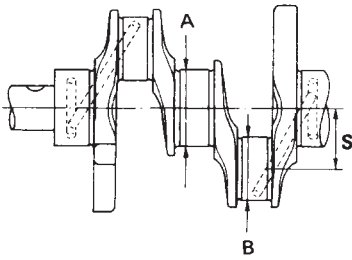
Unit: mm (in)

Center distance	156.975 - 157.025 (6.1801 - 6.1821)
Bend, torsion [per 200 (3.94)]	
Limit	0.15 (0.0059)
Piston pin bore dia.	30.025 - 30.038 (1.1821 - 1.1826)
Side clearance	
Standard	0.10 - 0.22 (0.0039 - 0.0087)
Limit	0.22 (0.0087)

Inspection and Adjustment (Cont'd)

CRANKSHAFT

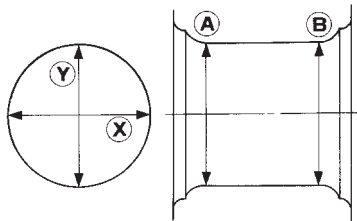
Unit: mm (in)



SEM100A

Journal diameter "A"	70.907 - 70.920 (2.7916 - 2.7921)
Pin diameter "B"	56.913 - 56.926 (2.2407 - 2.2412)
Center distance "S"	46.00 (1.8110)

Out-of-round **X - Y**
Taper **A - B**



EM715

Taper of journal and pin "A-B"	
Standard	Less than 0.01 (0.0004)
Limit	0.02 (0.0008)
Out-of-round of journal and pin "X-Y"	
Standard	Less than 0.01 (0.0004)
Limit	0.02 (0.0008)
Crankshaft bend	
Standard	0 - 0.03 (0 - 0.0012)
Limit	0.10 (0.0039)
Crankshaft end play	
Standard	0.060 - 0.25 (0.0024 - 0.0098)
Limit	0.40 (0.0157)

AVAILABLE MAIN BEARING

Bearing clearance

Unit: mm (in)

Main bearing clearance	
Standard	0.035 - 0.087 (0.0014 - 0.0034)
Limit	Less than 0.15 (0.0059)
Connecting rod bearing clearance	
Standard	0.035 - 0.081 (0.0014 - 0.0032)
Limit	Less than 0.15 (0.0059)

Mean bearing undersize

Unit: mm (in)

	Crank journal diameter
Standard	70.907 - 70.920 (2.7916 - 2.7921)
Undersize	
0.25 (0.0098)	70.657 - 70.670 (2.7818 - 2.7823)
0.50 (0.0197)	70.407 - 70.420 (2.7719 - 2.7724)
0.75 (0.0295)	70.157 - 70.170 (2.7621 - 2.7626)
1.00 (0.0394)	69.907 - 69.920 (2.7522 - 2.7528)

AVAILABLE CONNECTING ROD BEARING

Connecting rod bearing undersize

Unit: mm (in)

	Crank pin journal diameter
Standard	56.913 - 56.926 (2.2407 - 2.2412)
Undersize	
0.25 (0.0098)	56.663 - 56.676 (2.2308 - 2.2313)
0.50 (0.0197)	56.413 - 56.676 (2.2210 - 2.2313)
0.75 (0.0295)	56.163 - 56.176 (2.2111 - 2.2116)
1.00 (0.0394)	55.913 - 55.926 (2.2013 - 2.2018)

Inspection and Adjustment (Cont'd)

AVAILABLE THRUST WASHER

Unit: mm (in)

Thrust washer thickness	
Standard	2.275 - 2.325 (0.0896 - 0.0915)
Oversize	
0.20 (0.0079)	2.475 - 2.525 (0.0974 - 0.0994)
0.40 (0.0157)	2.675 - 2.725 (0.1053 - 0.1073)

MISCELLANEOUS COMPONENTS

Unit: mm (in)

Gear train	
Backlash of each gear	
Standard	0.07 - 0.11 (0.0028 - 0.0043)
Limit	0.20 (0.0079)
Flywheel	
Runout (Total indicator reading)	
	Less than 0.15 (0.0059)
Front plate	
Warping limit	
	0.2 (0.008)
Cylinder head	
Head surface distortion	
Standard	Less than 0.07 (0.0028)
Limit	0.2 (0.008)
Minimum height	89.7 (3.532)