ENGINE MECHANICAL

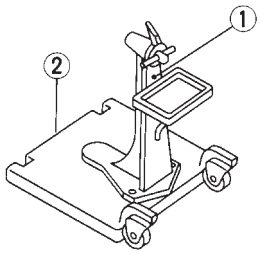
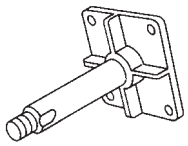
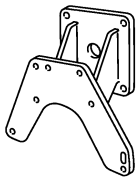
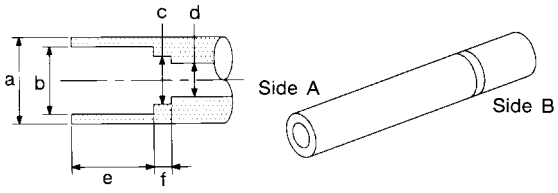
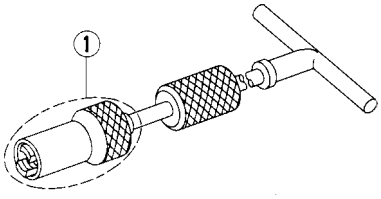
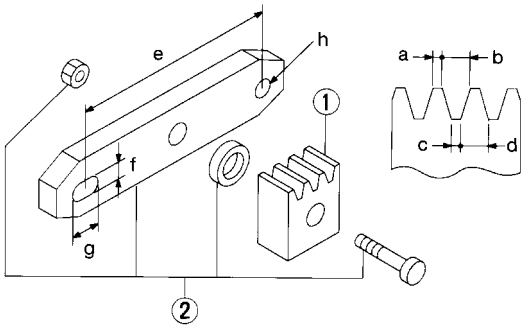
SECTION EM

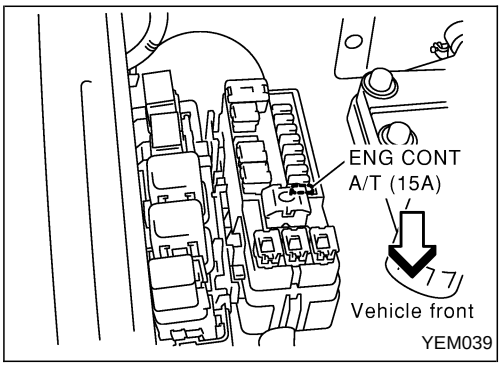
CONTENTS

ZD

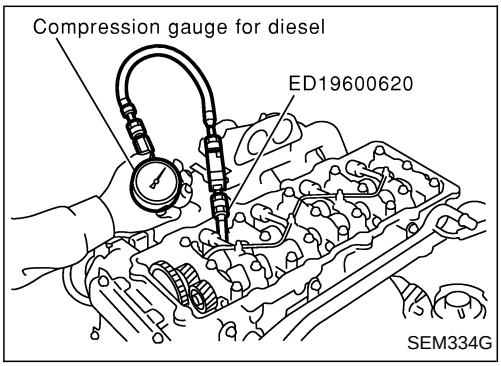
CONTENTS (Cont'd)

Special Service Tools

Tool number Tool name	Description	
ST0501S000 Engine stand assembly ① ST05011000 Engine stand ② ST05012000 Base	 NT042	Disassembling and assembling
KV10106500 Engine stand shaft	 NT028	
KV11106101 Engine sub-attachment	 NT819	
KV10115600 Valve oil seal drift	 NT603	Installing valve oil seal **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)
KV10107902 Valve oil seal puller ① KV10116100 Valve oil seal puller adapter	 NT605	Removing valve oil seal
KV101056S0 Ring gear stopper ① KV10105630 Adapter ② KV10105610 Plate	 NT617	Preventing crankshaft from rotating **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)



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.
   : 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/cm^2, psi)/rpm

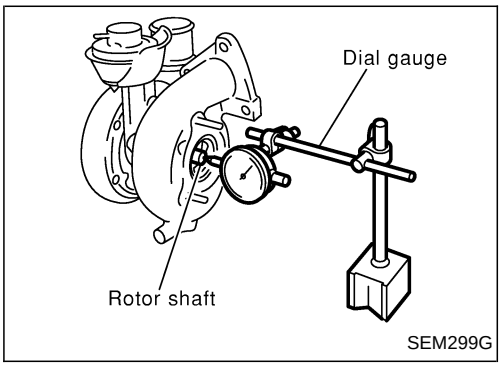
Standard	Minimum	Difference limit between cylinders
2,942 (29.42, 30.0, 427)/200	2,452 (24.52, 25.0, 356)/200	294 (2.94, 3.0, 43)/200

- 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”.

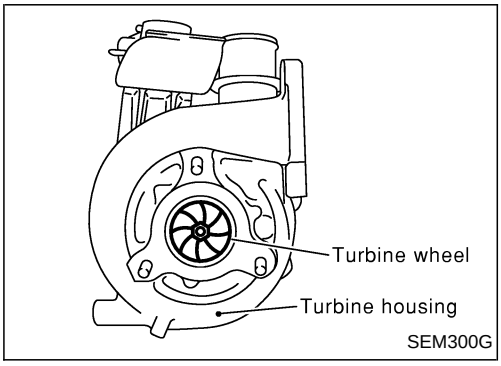
Inspection (Cont'd)



Rotor shaft end play

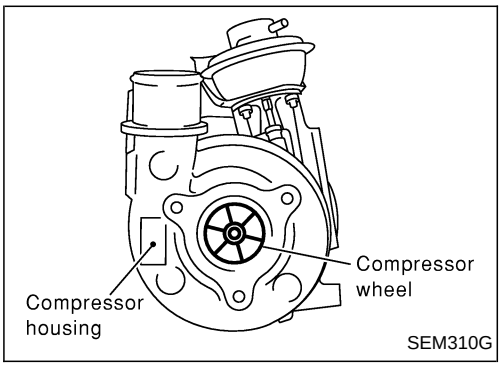
Place a dial gauge at the rotor shaft end in the axial direction to measure the end play.

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



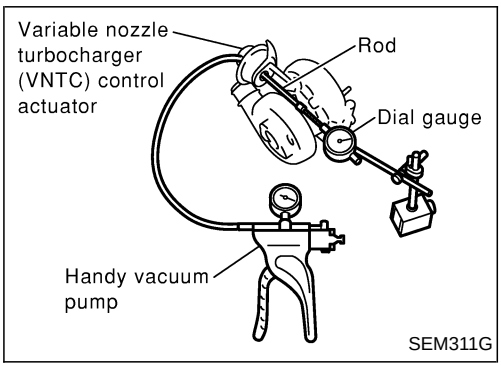
Turbine wheel

- 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):

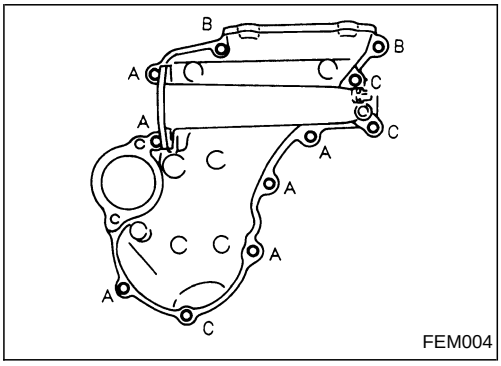
  −46.9±1.3 kPa (−469±13 mbar, −352±10 mmHg, −13.86±0.39 inHg)/0.2 mm (0.008 in)

  −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

Removal (Cont'd)

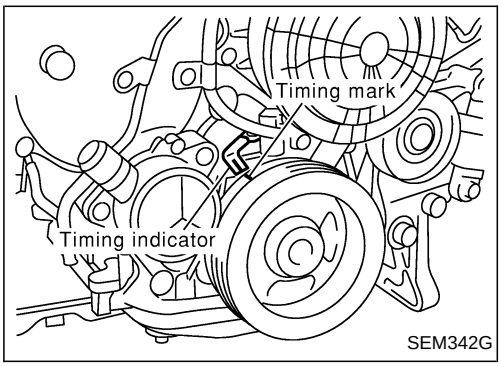
2. Move the following parts.
- TDC sensor harness
- Power steering oil pump



FEM004

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

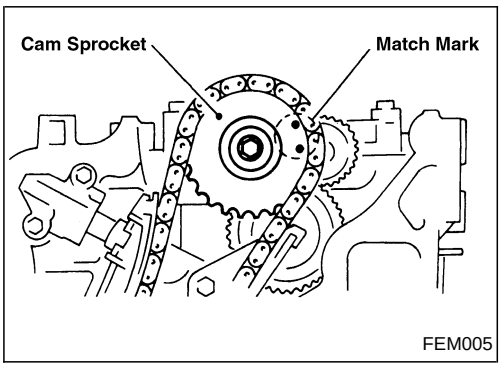
CAUTION:
While the chain cover is removed, be careful not to allow entry of dust or foreign objects.



SEM342G

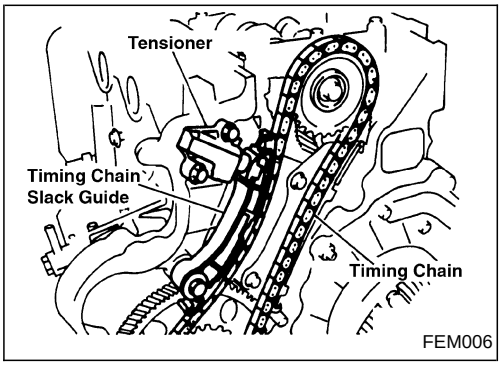
4. Set the No. 1 cylinder to the TDC.

1) Turn the crankshaft pulley clockwise, and match the timing indicator of the gear case to the timing mark of the crankshaft pulley.



FEM005

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.



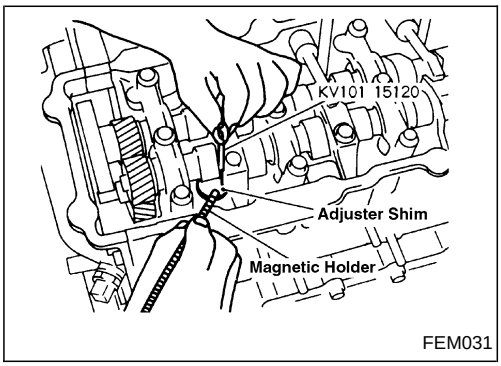
FEM006

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.)

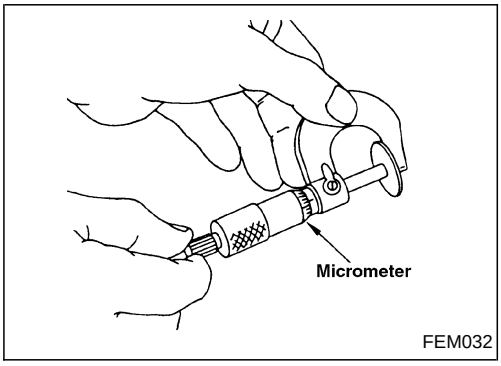
CAUTION:
Be careful not to drop the plunger and spring.

Adjustments (Cont'd)



FEM031

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



FEM032

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

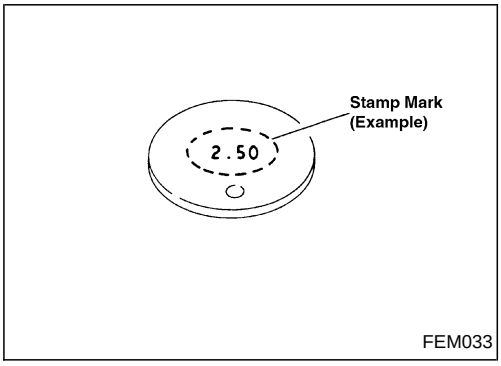
t_1 = Thickness of the removed shim

C_1 = Measured valve clearance

C_2 = 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.

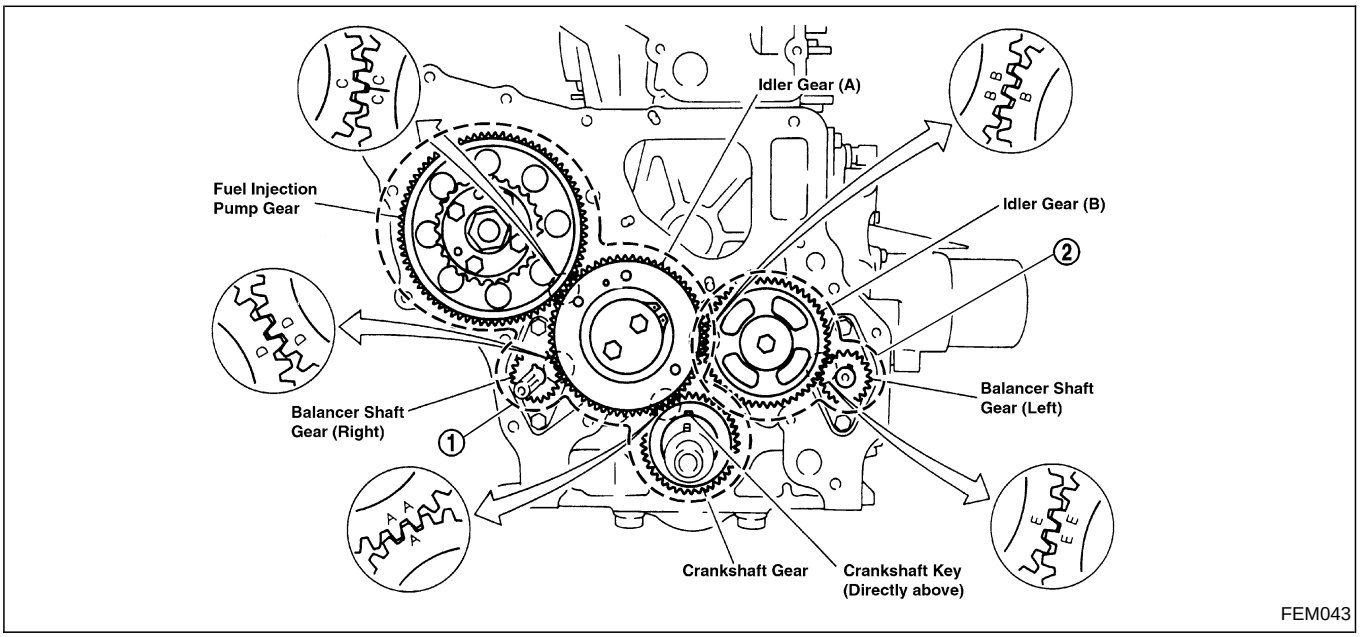
11. Fix the selected adjusting shim to the valve lifter.

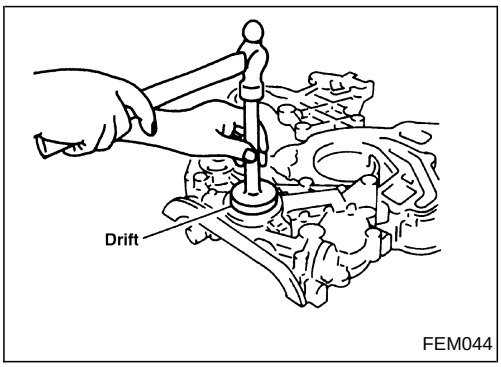
CAUTION:

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.

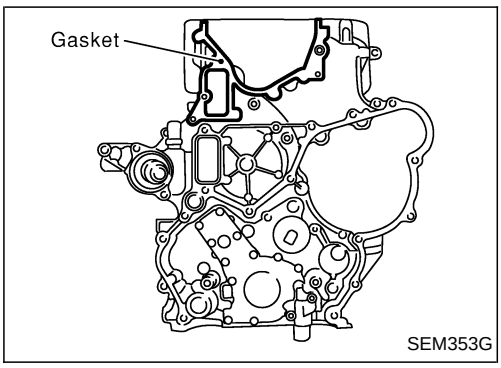
Installation (Cont'd)



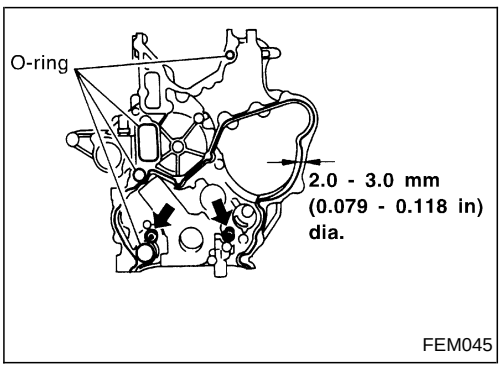


4. Install the front oil seal to the gear case.
- Apply engine oil to the fitting side.
- Evenly insert the front oil seal using a drift [outer dia.: approx. 64 mm (2.52 in)] completely.

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.

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

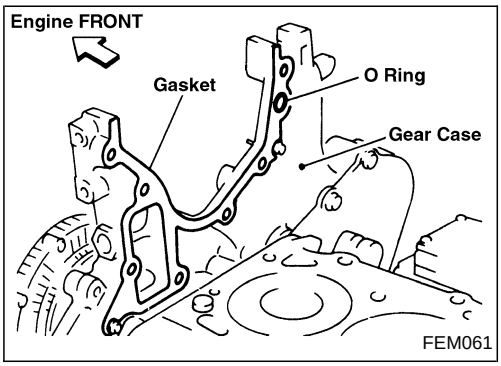
*1: Thickness of gasket tightened with head bolts
*2: Indicates values such as −0.080 mm (−0.0031 in).
*3: Indicates values such as −0.075 mm (−0.0030 in).

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:

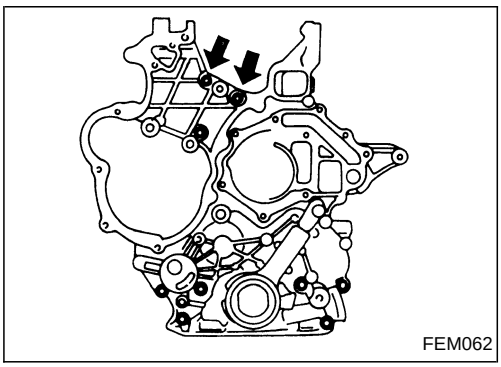
Since idler gear cannot be installed or removed with cylinder head assembly mounted on the engine because of interference with gear case, make sure that there are no reverse installations or uninstalled parts.



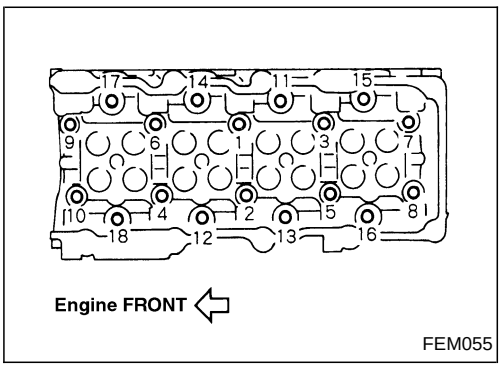
3. Install cylinder head assembly.
1) Attach gasket onto the rear of gear case.
2) Install O-ring to the rear of gear case.
3) Align cylinder head assembly with dowel pin of cylinder block and install.

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).

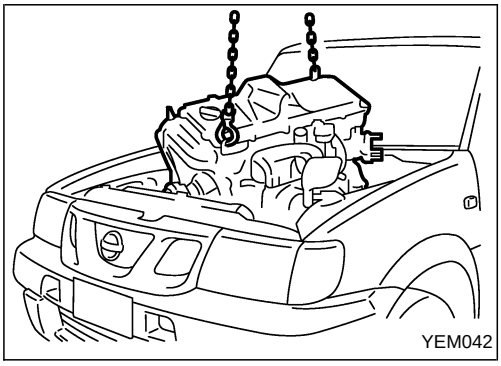
CAUTION:

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)

Removal (Cont'd)

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


YEM042

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

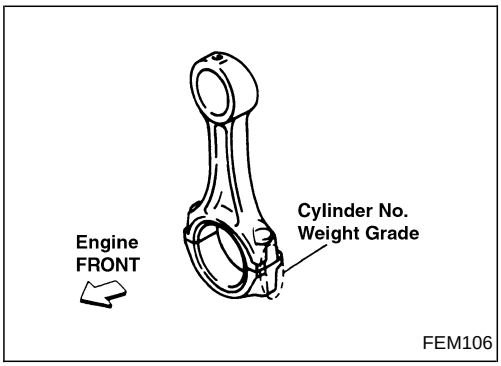
Install the engine in the reverse order of the removal procedure.

- 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.

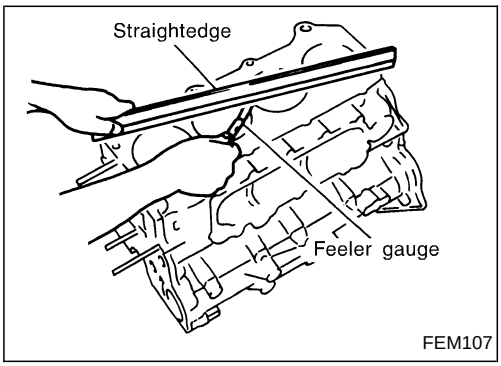
Inspection (Cont'd)



FEM106

- 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)



FEM107

CYLINDER BLOCK TOP SURFACE DISTORTION

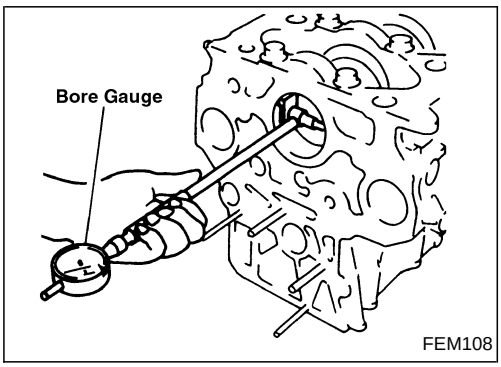
- Using scraper, remove gasket installed onto cylinder block surface. Remove contamination such as oil, scale, and carbon.

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)



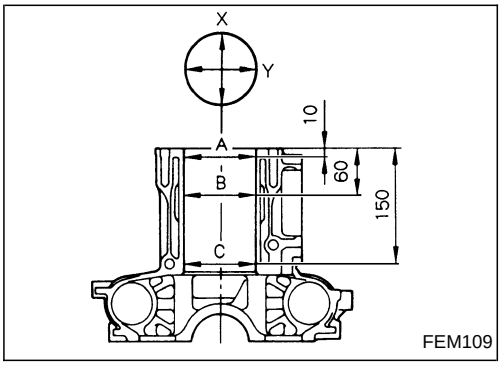
FEM108

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.



FEM109

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)

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)

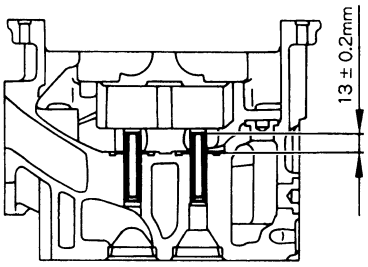
VALVE LIFTER

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)

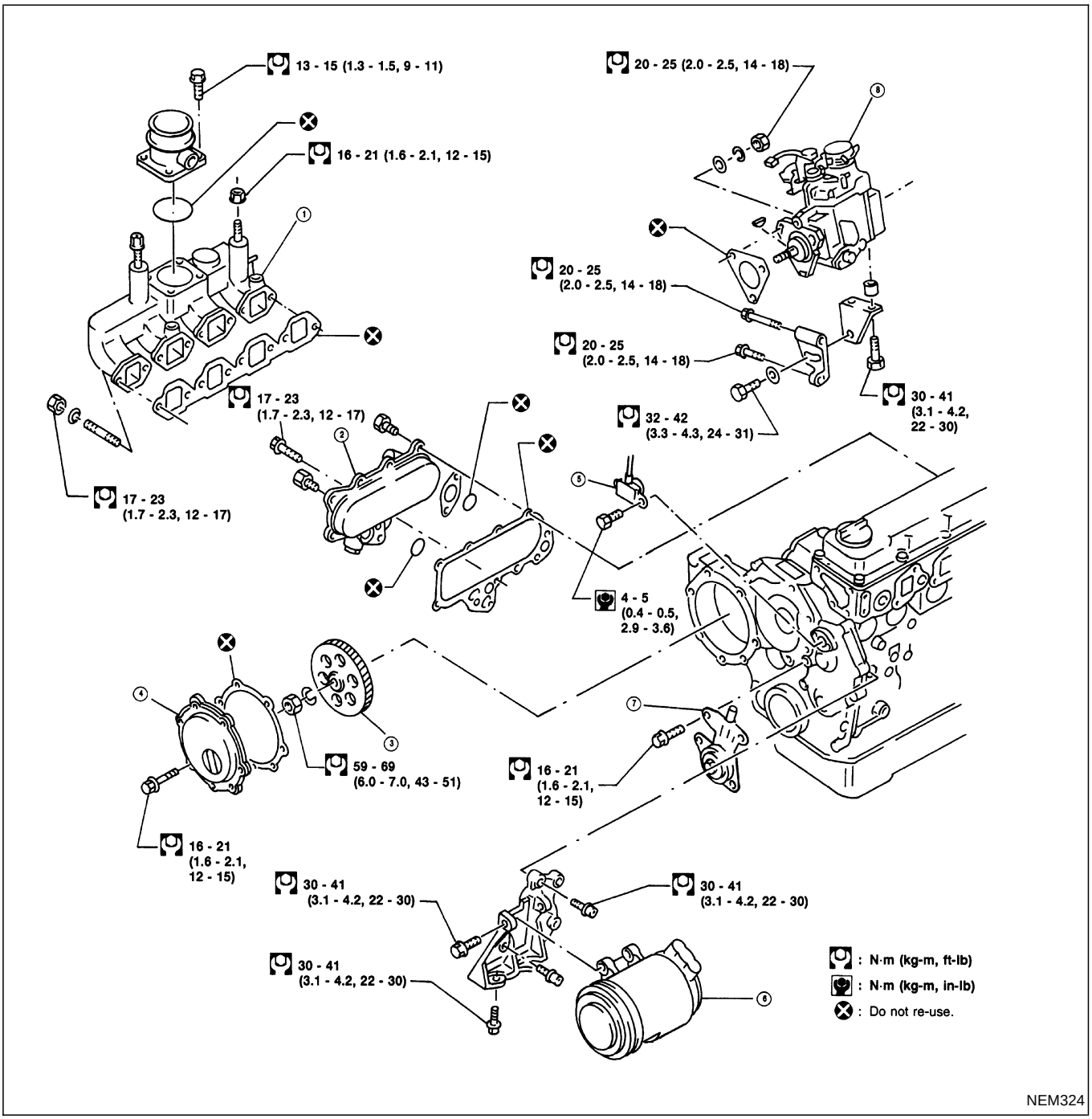
VALVE GUIDE

Unit: mm (in)



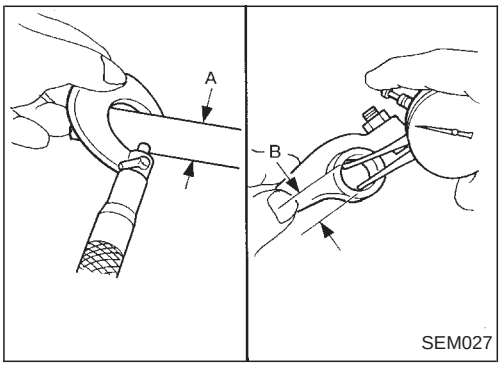
FEM071

		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)



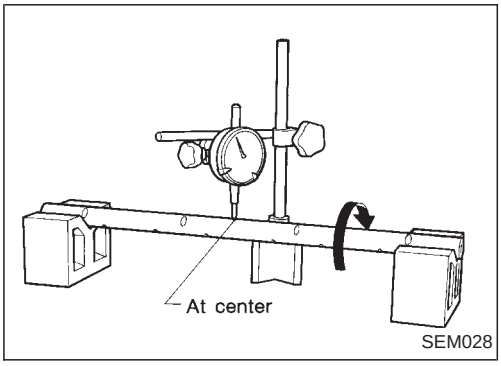
① Intake manifold
② Oil cooler
③ Injection pump drive gear
④ Dust cover
⑤ Engine revolution sensor
⑥ Air conditioner compressor
⑦ Idler pulley
⑧ Electronic injection pump

Inspection (Cont'd)



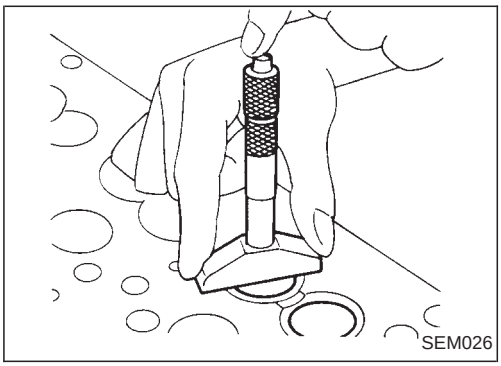
2. Check clearance between valve rockers and rocker shaft. If specified clearance is exceeded, replace affected valve rockers or shaft.

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)

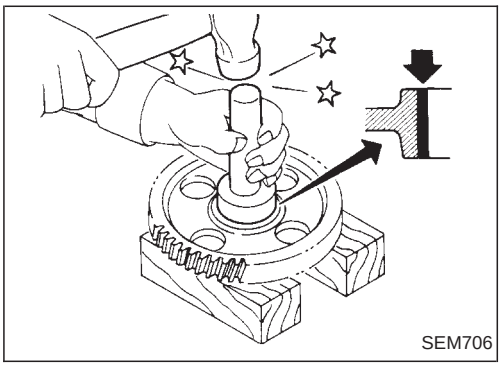


MEASURING CYLINDER HEAD TO VALVE DISTANCE

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

Inspection (Cont'd)

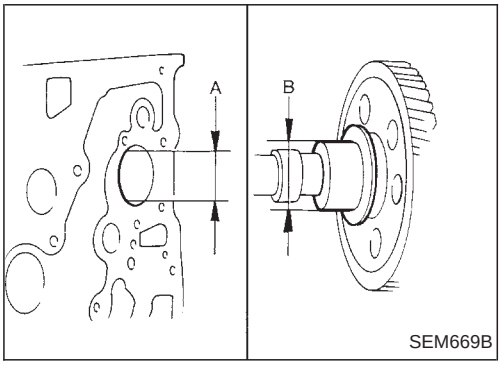

SEM706

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.



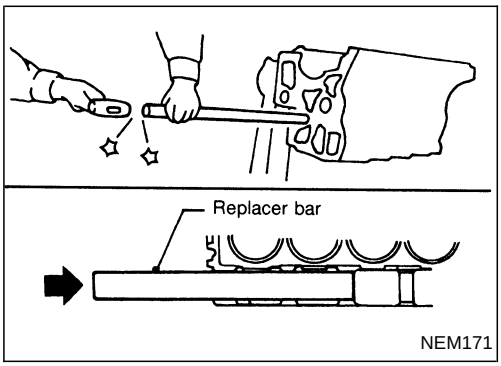
SEM669B

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.

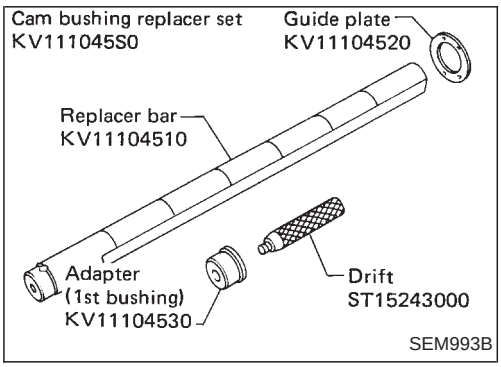
Clearance between camshaft and bushing (A − B):
Standard
0.020 - 0.109 mm
(0.0008 - 0.0043 in)
Limit
Less than 0.15 mm (0.0059 in)



NEM171

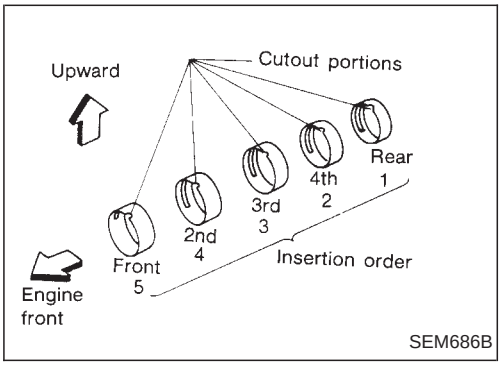
REPLACING CAMSHAFT BUSHING

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



SEM993B

2. Using Tool, install camshaft bushings as follows:



SEM686B

(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.