

SECTION **EM****MODIFICATION NOTICE:**

- VG30E engine has been added.
- EGR system has been added to TD27 engine for Singapore.

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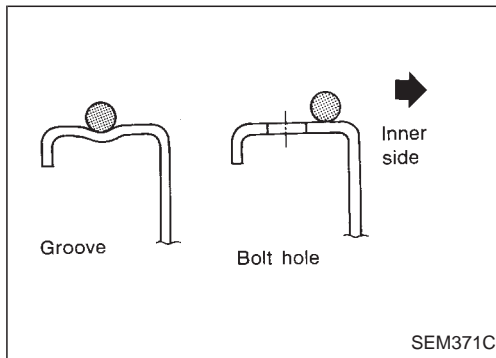
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Parts Requiring Angular Tightening

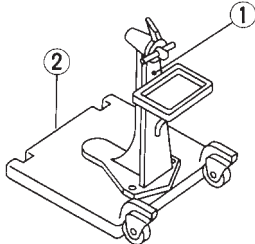
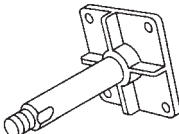
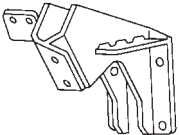
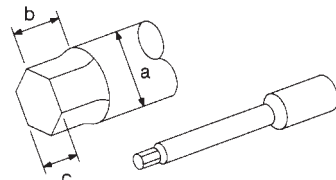
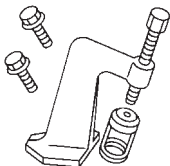
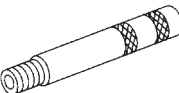
- Some important engine parts are tightened using an angular tightening method rather than a torque setting method.
- If these parts are tightened using a torque setting method, dispersal of the tightening force (axial bolt force) will be two or three times that of the dispersal produced by using the 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.
- 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 (for 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 area.
(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

Tool number Tool name	Description
ST0501S000 Engine stand assembly ① ST05011000 Engine stand ② ST05012000 Base	Disassembling and assembling  NT042
KV10106500 Engine stand shaft	 NT028
KV10110001 Engine sub-attachment	 NT032
ST10120000 Cylinder head bolt wrench	Loosening and tightening cylinder head bolt a: 13 (0.51) dia. b: 12 (0.47) dia. c: 10 (0.39) Unit: mm (in)  NT583
KV10110600 Valve spring compressor	Disassembling and assembling valve components  NT033
KV10107501 Valve oil seal drift	Installing valve oil seal  NT025

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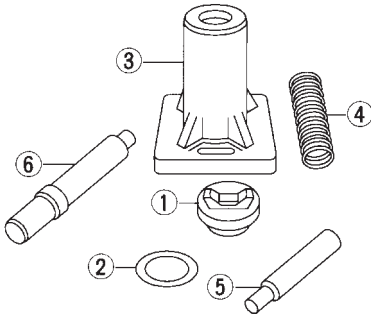
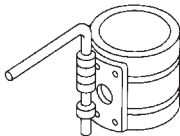
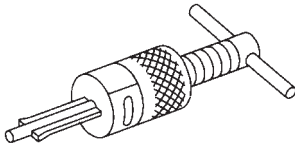
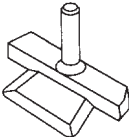
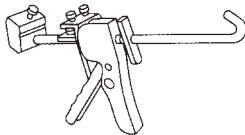
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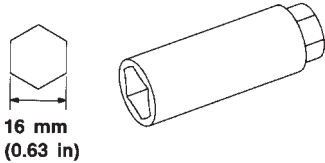
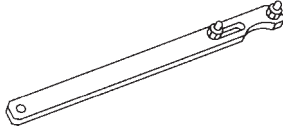
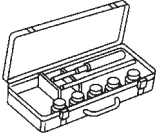
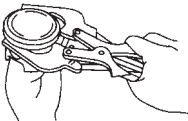
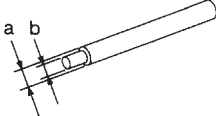
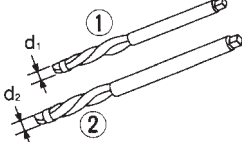
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Special Service Tools (Cont'd)

Tool number Tool name	Description
KV10110300 Piston pin press stand assembly ① KV10110310 Cap ② KV10110330 Spacer ③ ST13030020 Press stand ④ ST13030030 Spring ⑤ KV10110340 Drift ⑥ KV10110320 Center shaft	<p>Disassembling and assembling piston with connecting rod</p>  <p>NT036</p>
EM03470000 Piston ring compressor	<p>Installing piston assembly into cylinder bore</p>  <p>NT044</p>
ST16610001 Pilot bushing puller	<p>Removing crankshaft pilot bushing</p>  <p>NT045</p>
KV10111100 Seal cutter	<p>Removing oil pan</p>  <p>NT046</p>
WS39930000 Tube presser	<p>Pressing the tube of liquid gasket</p>  <p>NT052</p>

Commercial Service Tools

Tool name	Description
Spark plug wrench	<p>Removing and installing spark plug</p>  <p>16 mm (0.63 in)</p> <p>NT047</p>
Pulley holder	<p>Holding camshaft pulley while tightening or loosening camshaft bolt</p>  <p>NT035</p>
Valve seat cutter set	<p>Finishing valve seat dimensions</p>  <p>NT048</p>
Piston ring expander	<p>Removing and installing piston ring</p>  <p>NT030</p>
Valve guide drift	<p>Removing and installing valve guide</p>  <p>NT015</p> <p>Intake: a: 10.5 mm (0.413 in) dia. b: 6.6 mm (0.260 in) dia. Exhaust: a: 11.5 mm (0.453 in) dia. b: 7.6 mm (0.299 in) dia.</p>
Valve guide reamer	<p>Reaming valve guide ① or hole for oversize valve guide ②</p>  <p>NT016</p> <p>Intake: d₁ = 7.0 mm (0.276 in) dia. d₂ = 11.2 mm (0.441 in) dia. Exhaust: d₁ = 8.0 mm (0.315 in) dia. d₂ = 12.2 mm (0.480 in) dia.</p>

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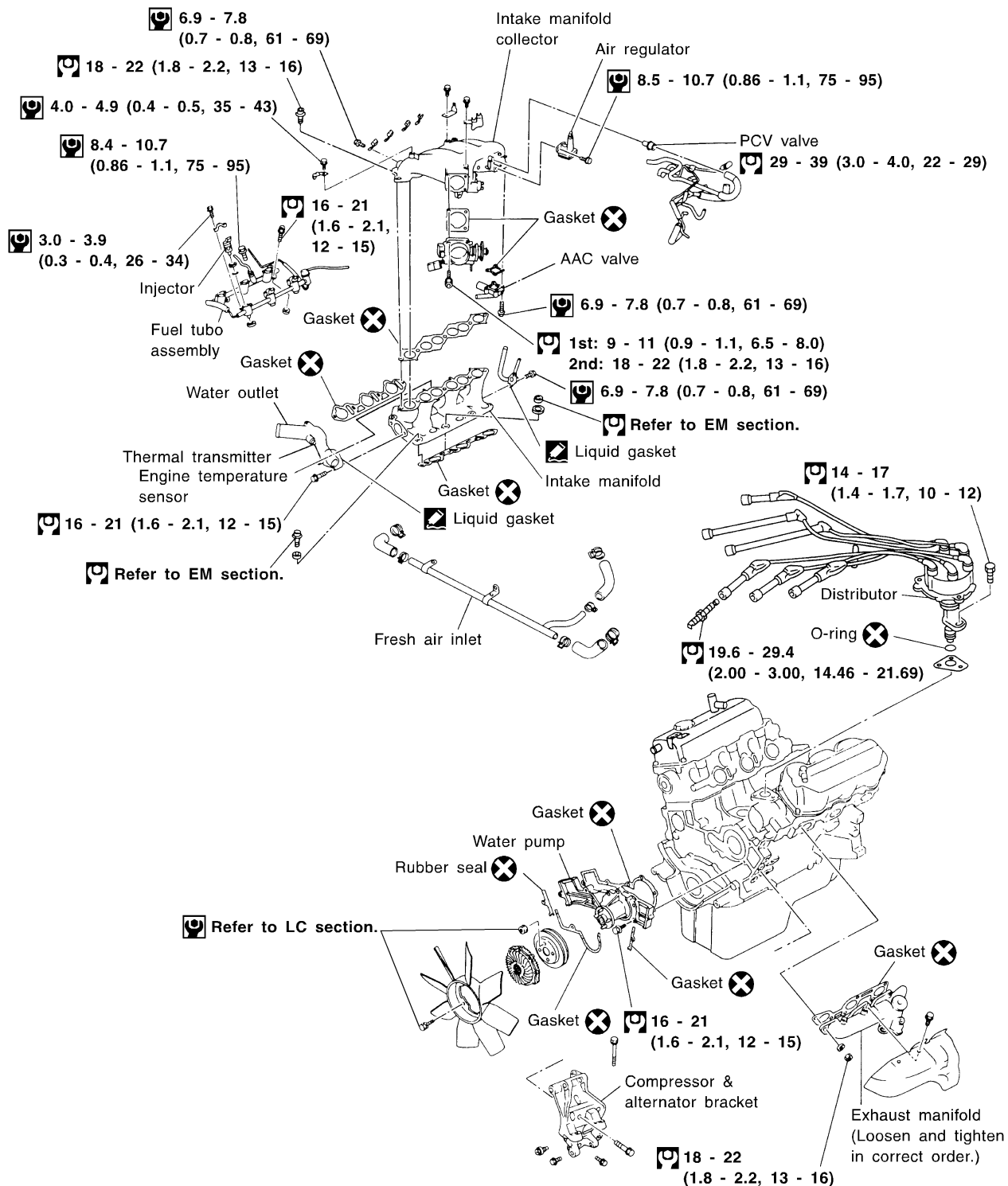
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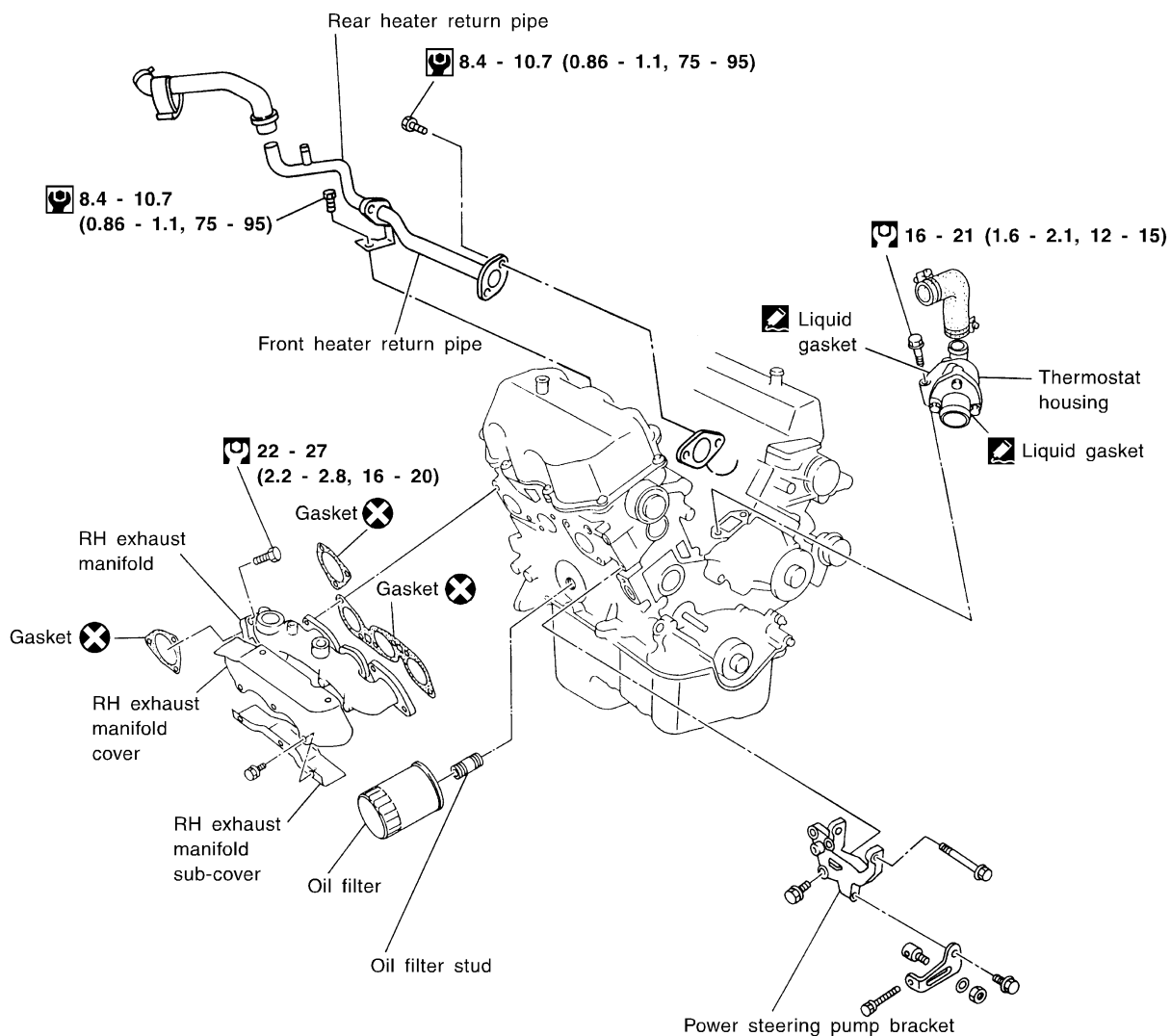
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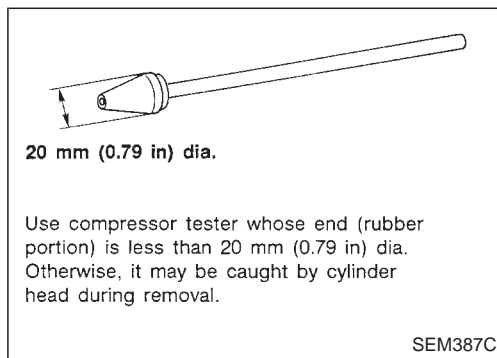
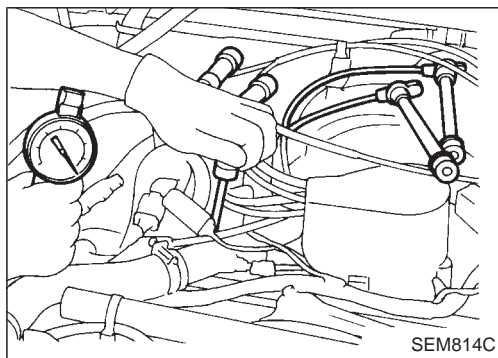
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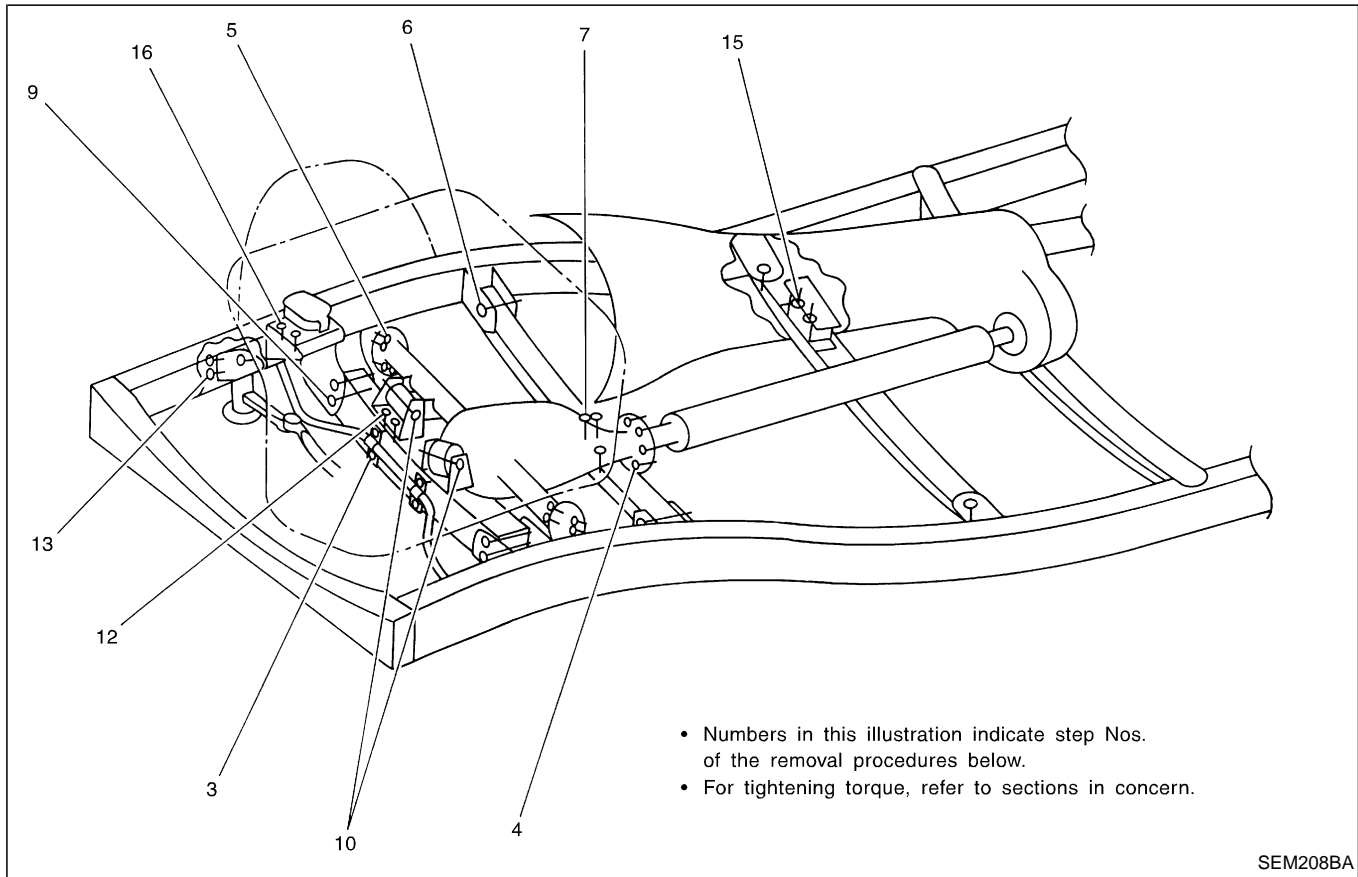
Measurement of Compression Pressure

1. Warm up engine.
 2. Turn ignition switch off.
 3. Release fuel pressure.
Refer to "Fuel Pressure Release" in EC section.
 4. Remove all spark plugs.
 5. Disconnect distributor center cable.
-
6. Attach a compression tester to No. 1 cylinder.
 7. Depress accelerator pedal fully to keep throttle valve wide open.
 8. Crank engine and record highest gauge indication.
 9. Repeat the measurement on each cylinder as shown above.
- **Always use a fully-charged battery to obtain specified engine revolution.**
Compression pressure: kPa (bar, kg/cm², psi)/300 rpm

Standard
1,196 (11.96, 12.2, 173)
Minimum
883 (8.83, 9.0, 128)
Difference limit between cylinders
98 (0.98, 1.0, 14)
10. If cylinder compression in one or more cylinders is low, pour a small amount of engine oil into cylinders through spark plug holes and retest compression.
- **If adding oil helps compression, piston rings may be worn or damaged. If so, replace piston rings after checking piston.**
 - **If pressure stays low, a valve may be sticking or seating improperly. Inspect and repair valve and valve seat. Refer to SDS, EM-54 and EM-55. If valve or valve seat is damaged excessively, replace them.**
 - **If compression in any two adjacent cylinders is low and if adding oil does not help compression, there is leakage past the gasket surface. If so, replace cylinder head gasket.**



Removal

**WARNING:**

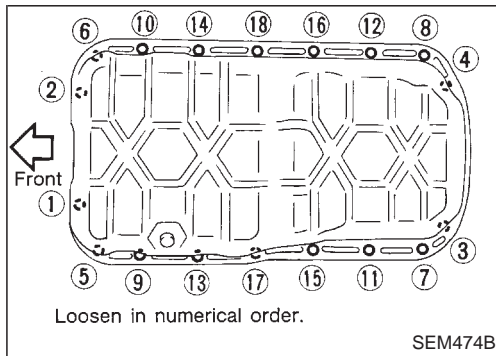
- Place vehicle on a flat and solid surface.
- Place chocks at front and rear of rear wheels.
- You should not remove oil pan until exhaust system and cooling system have completely cooled off. Otherwise, you may burn yourself and/or fire may break out in the fuel line.
- When remove front and/or rear engine mounting bolts or nuts, lift up slightly engine for safety work.

CAUTION:

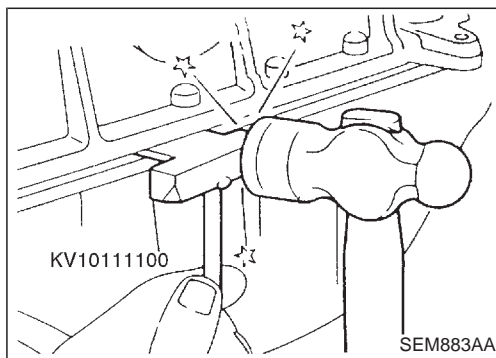
- In lifting engine, be careful not to hit against adjacent parts, especially against accelerator wire casing end, brake tube and brake master cylinder.
 - For tightening torque, refer to AT, MT and PD sections.
1. Remove undercover.
 2. Drain engine oil.
 3. Remove front propeller shaft from front differential carrier.
 4. Remove front drive shaft fixing bolts (RH & LH).
 5. Remove front differential carrier member bolt (RH & LH).
 6. Remove front differential carrier fixing bolts and support it.
 7. Remove front differential carrier bleeder hose.
 8. Remove differential front mounting bolts (RH & LH).
 9. Remove front differential carrier.
 10. Remove front differential carrier mounting bracket.
 11. Remove idler arm.
 12. Remove starter motor.
 13. Remove transmission to rear engine mounting bracket nuts (RH & LH).

Removal (Cont'd)

14. Remove engine mounting bolts or nuts (RH & LH).
15. Remove engine gussets.
16. Lift up engine.
If necessary, disconnect exhaust tube.

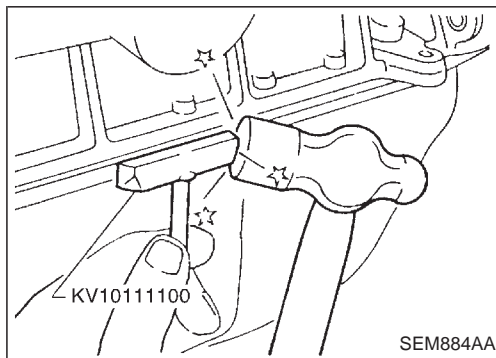


17. Remove oil pan bolts.

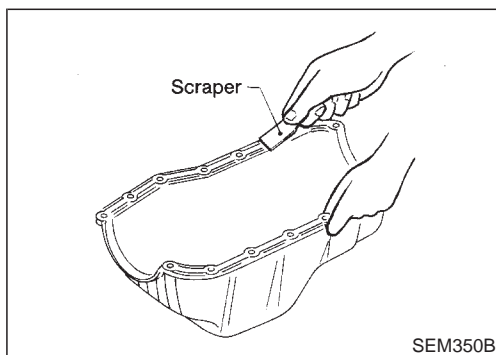


18. Remove oil pan.

- (1) Insert Tool between cylinder block and oil pan.
 - Do not drive seal cutter into oil pump or rear oil seal retainer portion, or aluminum mating face will be damaged.
 - Do not insert screwdriver, or oil pan flange will be deformed.

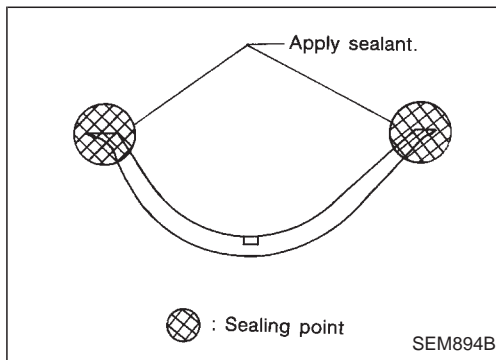


- (2) Slide Tool by tapping its side with a hammer, and remove oil pan.

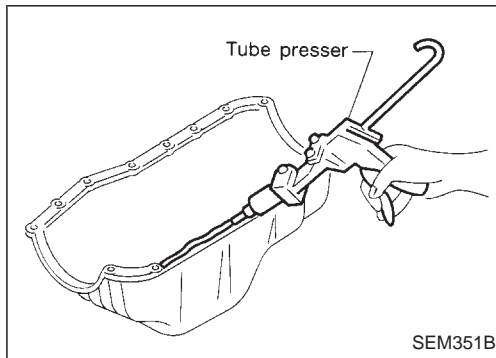
**Installation**

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

Installation (Cont'd)

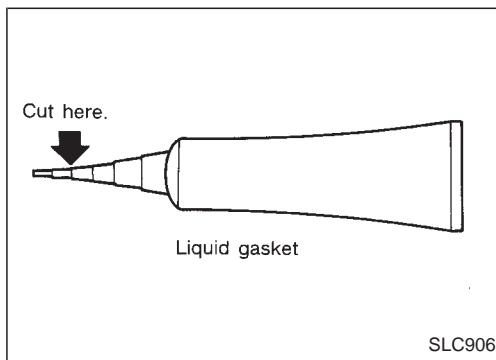


2. Apply sealant to oil pump gasket and rear oil seal retainer gasket.

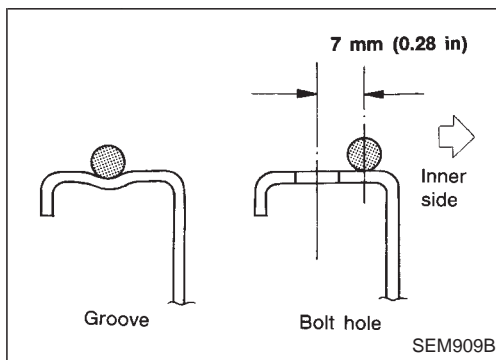


3. Apply a continuous bead of liquid gasket to mating surface of oil pan.

- **Use Genuine Liquid Gasket or equivalent.**



- Be sure liquid gasket is 3.5 to 4.5 mm (0.138 to 0.177 in) wide.



4. Apply liquid gasket to inner sealing surface as shown in figure.

- Attaching should be done within 5 minutes after coating.

5. Install oil pan.

- **Install bolts/nuts in their reverse order of removal.**
- **Wait at least 30 minutes before refilling engine oil.**

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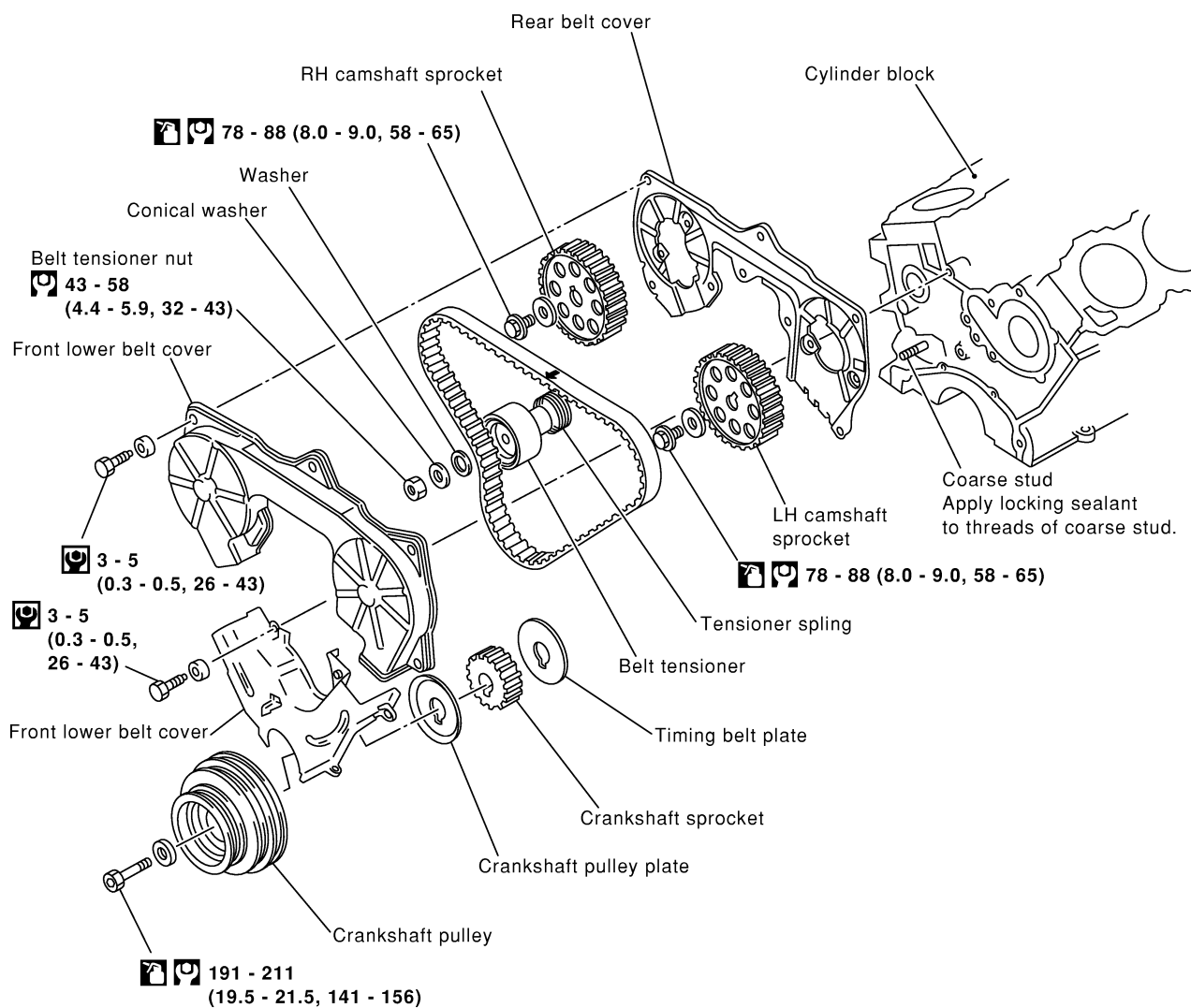
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CAUTION:

- Do not bend or twist timing belt.
- After removing timing belt, do not turn crankshaft and camshaft separately because valves will strike piston heads.
- Make sure that timing belt, camshaft sprocket, crankshaft sprocket and belt tensioner are clean and free from oil and water.
- Installation should be carried out when engine is cold.

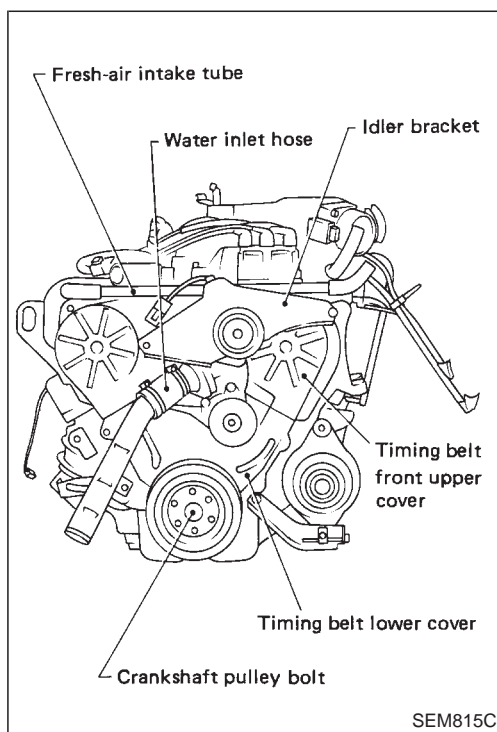
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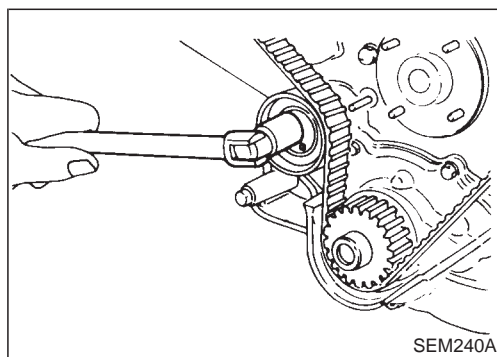
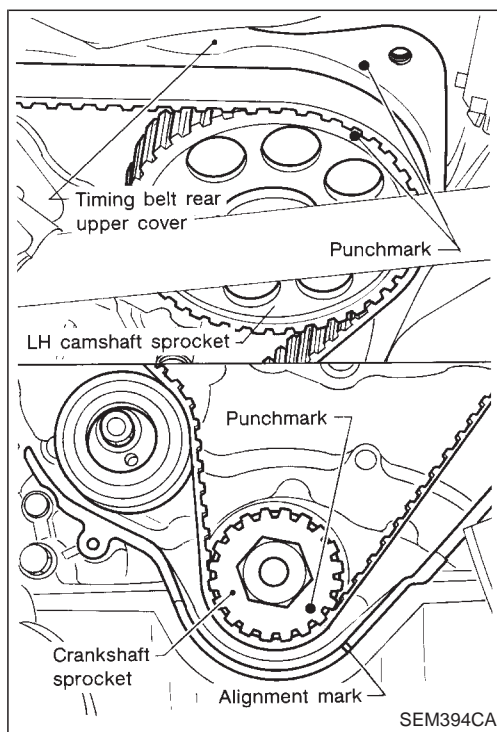
: Lubricate with new engine oil.

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Removal

1. Remove engine undercover.
2. Drain engine coolant from radiator.
3. Remove radiator. (Refer to "Radiator" in LC section.)
4. Remove engine cooling fan and water pump pulley.
5. Remove the following belts.
 - Power steering pump drive belt
 - Compressor drive belt
 - Alternator drive belt
6. Remove all spark plugs.
7. Remove distributor protector.
8. Remove compressor drive belt idler bracket.
9. Remove fresh-air intake tube for rocker cover.
10. Remove water hose for thermostat housing.
11. Remove crankshaft pulley bolt.
12. Remove crankshaft pulley with a suitable puller.
13. Remove front upper and lower belt covers.

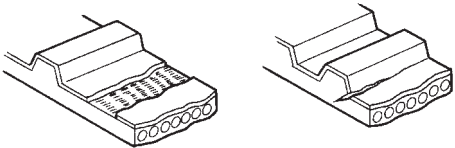
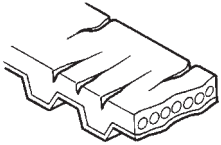
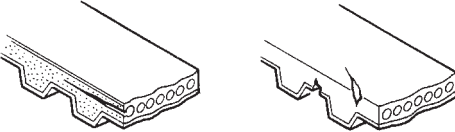
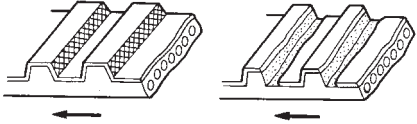


14. Set No. 1 piston at TDC on its compression stroke by rotating crankshaft.
 - Align punchmark on LH camshaft sprocket with punchmark on timing belt upper rear cover.
 - Align punchmark on crankshaft sprocket with notch on oil pump housing.
 - Temporarily install crank pulley bolt on crankshaft so that crankshaft can be rotated.

15. Loosen timing belt tensioner nut, turn tensioner, then remove timing belt.

Inspection

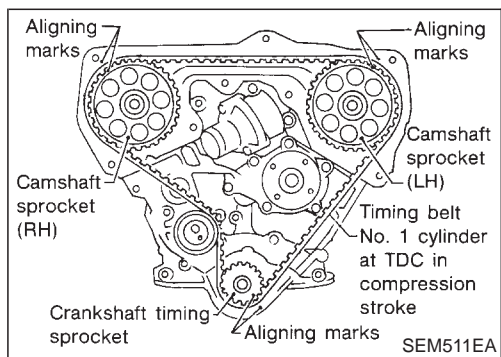
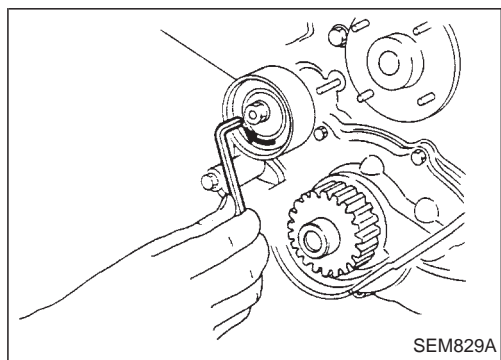
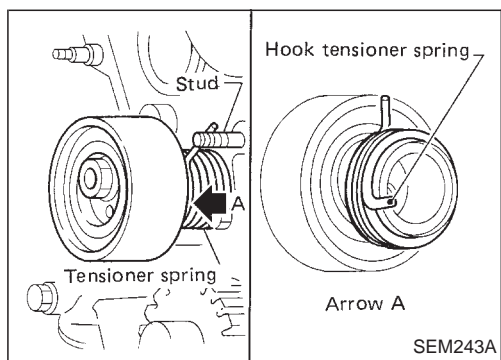
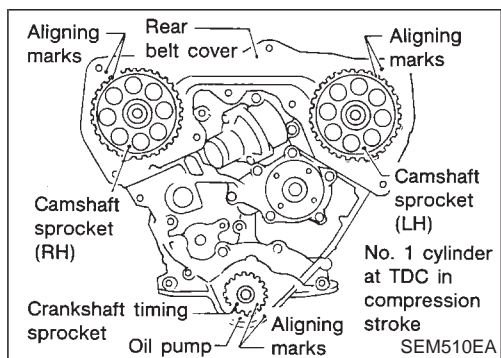
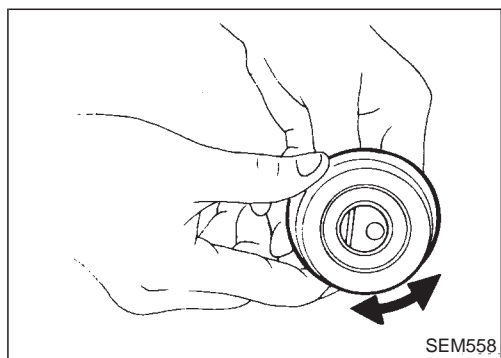
Visually check the condition of timing belt.
Replace if any abnormality is found.

Item to check	Problem	Cause
Tooth is broken/tooth root is cracked.	 SEM394A	<ul style="list-style-type: none"> Camshaft jamming Distributor jamming Damaged camshaft/crankshaft oil seal
Back surface is cracked/worn.	 SEM395A	<ul style="list-style-type: none"> Tensioner jamming Overheated engine Interference with belt cover
Side surface is worn.	 SEM396A <ul style="list-style-type: none"> Belt corners are worn and round. Wicks are frayed and coming out. 	<ul style="list-style-type: none"> Improper installation of belt Malfunctioing crankshaft pulley plate/timing belt plate
Teeth are worn.	 Rotating direction SEM397A <ul style="list-style-type: none"> Canvas on tooth face is worn down. Canvas on tooth is fluffy, rubber layer is worn down and faded white, or weft is worn down and invisible. 	<ul style="list-style-type: none"> Poor belt cover sealing Coolant leakage at water pump Camshaft not functioning properly Distributor not functioning properly Excessive belt tension
Oil/Coolant or water is stuck to belt.	—	<ul style="list-style-type: none"> Poor oil sealing of each oil seal Coolant leakage at water pump Poor belt cover sealing

Inspection (Cont'd)

BELT TENSIONER AND TENSIONER SPRING

1. Check belt tensioner for smooth turning.
2. Check condition of tensioner spring.



Installation

1. Confirm that No. 1 piston is set at TDC on its compression stroke.

2. Install tensioner and tensioner spring.

If a stud is once removed, apply locking sealant to threads of the stud on the cylinder block before installing.

3. Turn tensioner fully clockwise with hexagon wrench, and temporarily tighten lock nut.

4. Set timing belt.

(1) Align white lines on timing belt with punchmarks on camshaft sprockets and crankshaft sprocket.

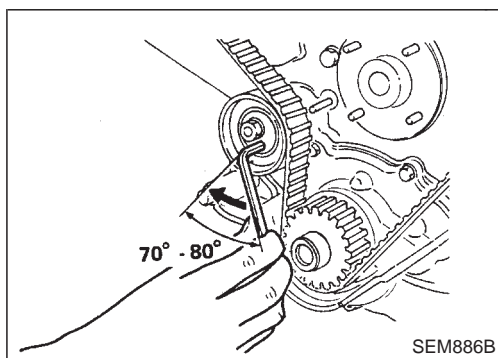
(2) Point arrow on timing belt toward front belt cover.

Number of teeth (reference):

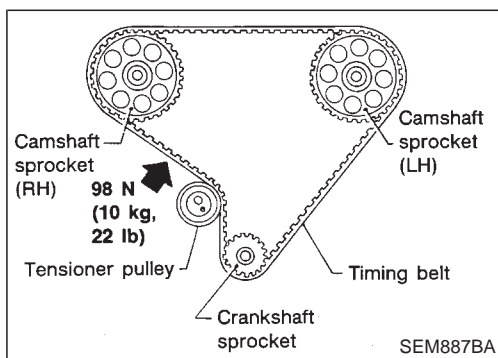
Number of timing belt teeth		133
Number of teeth between timing marks	Between LH and RH camshaft sprockets	40
	Between LH camshaft sprocket and crankshaft timing sprocket	43

Installation (Cont'd)

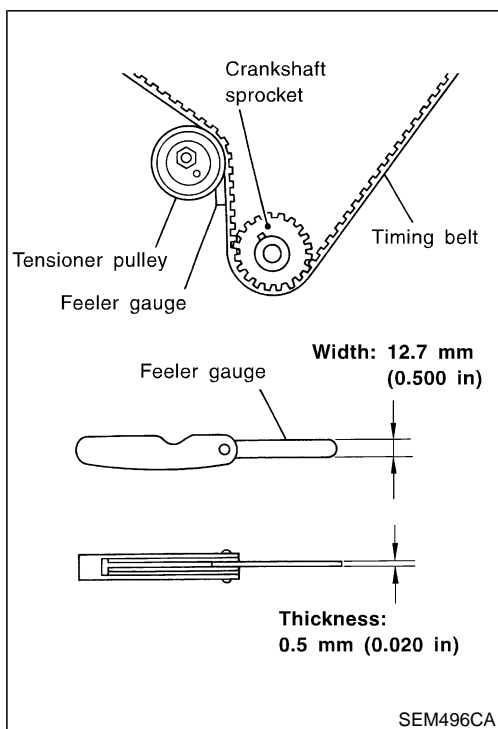
5. Loosen tensioner lock nut, keeping tensioner steady with hexagon wrench.



6. Turn tensioner 70 to 80 degrees clockwise with hexagon wrench, and temporarily tighten lock nut.
7. Turn crankshaft clockwise at least 2 times, then slowly set No. 1 piston at TDC on its compression stroke.

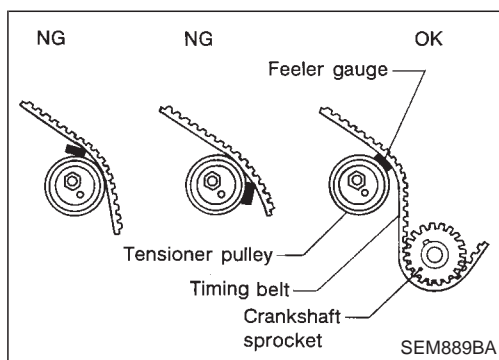


8. Push middle of timing belt between RH camshaft sprocket and tensioner pulley with force of 98 N (10 kg, 22 lb).
9. Loosen tensioner lock nut, keeping tensioner steady with hexagon wrench.



10. Set feeler gauge as shown in figure which is 0.5 mm (0.020 in) thick and 12.7 mm (0.500 in) wide.

Installation (Cont'd)



11. Turn crankshaft clockwise, and set feeler gauge as shown in figure.

- Timing belt will move about 2.5 teeth.

12. Tighten tensioner lock nut, keeping tensioner steady with hexagon wrench.

13. Turn crankshaft clockwise or counterclockwise, and remove feeler gauge.

14. Turn crankshaft clockwise at least 2 times, then slowly set No. 1 piston at TDC on its compression stroke.

15. Install lower and upper belt covers.

Tension Adjustment

2WD models		Tightened parts	Section	Parts tightened with bolts
		Bolt A (6 pcs.) Rubber washer Belt cover front (lower)	①, ②, ③, ④, ⑤, ⑭	①, ②, ③, ④: Cylinder block ⑤, ⑭: Compressor bracket
		Bolt B (1 pc.) Rubber washer Belt cover front (lower) Water pump mounting bolts	⑥	Water pump mounting bolt
		Bolt C (4 pcs.) Belt cover (rear)	⑦, ⑧, ⑨, ⑩	Cylinder head
		Bolt A (7 pcs.) Rubber washer Belt cover front (upper) Belt cover (rear) Welded nut (4 pcs.)	⑮, ⑯, ⑰, ⑱, ⑲, ⑲, ⑲, ⑲	⑮, ⑯, ⑰, ⑱: Welded nuts ⑲, ⑲: Cylinder head ⑲: Water outlet

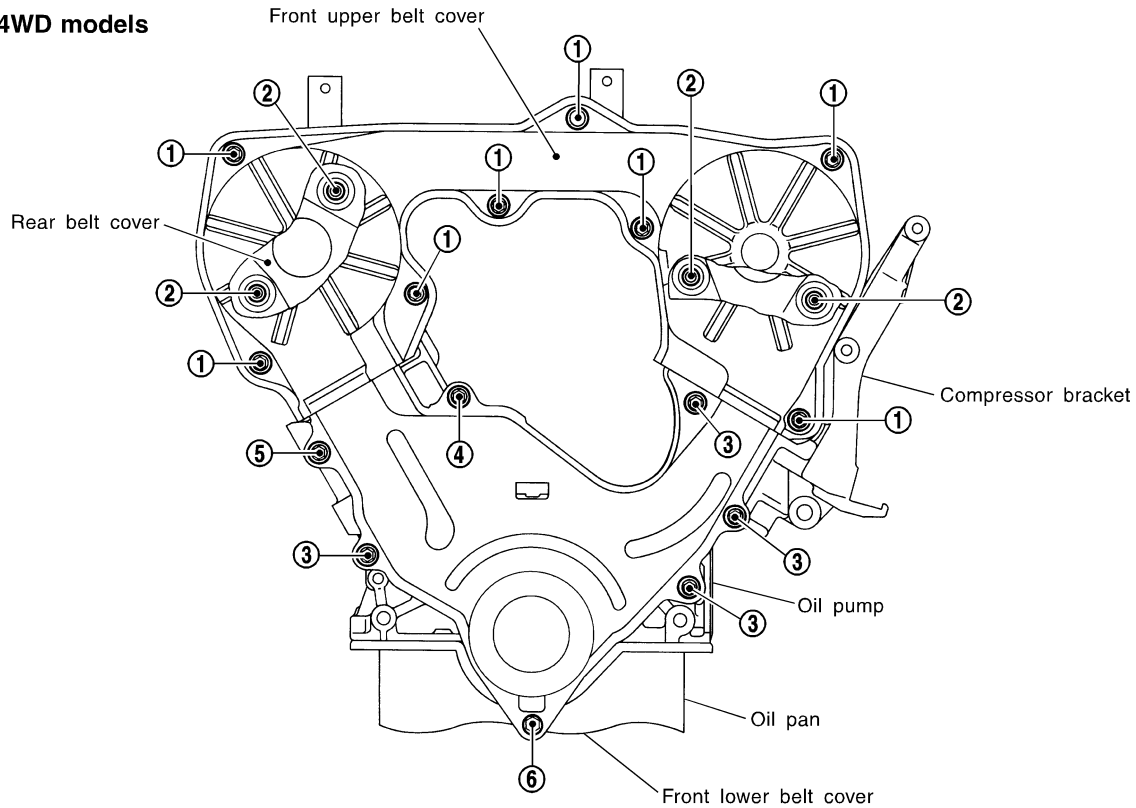
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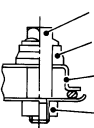
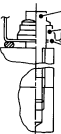
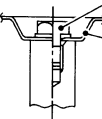

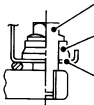
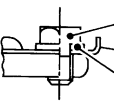
TIMING BELT

Tension Adjustment (Cont'd)

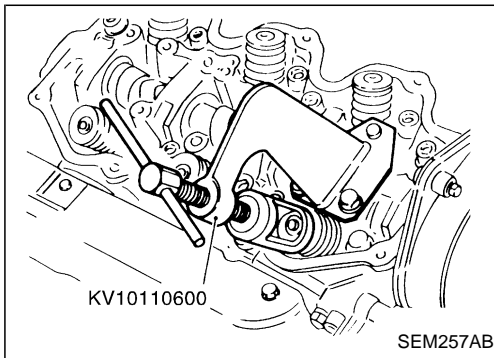
VG30E

4WD models

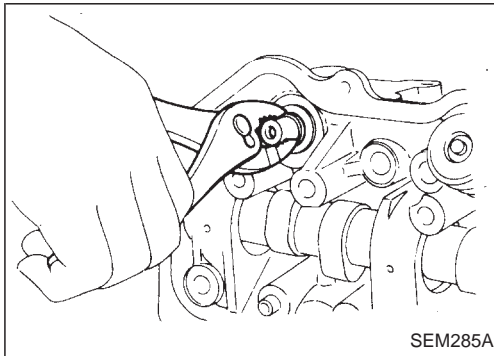


No.	Tightened parts		No.	Tightened parts	
①	 <p>Bolt Rubber washer Front upper belt cover Welded nut</p>	8 pcs.	④	 <p>Bolt Rubber washer Front lower belt cover</p>	1 pc.
②	 <p>Hexagon bolt with washer Rear belt cover</p>	4 pcs.	⑤	 <p>Bolt Rubber washer Front lower belt cover</p>	1 pc.
③	 <p>Bolt Rubber washer Front lower belt cover</p>	4 pcs.	⑥	 <p>Bolt Front lower belt cover Lock spring washer</p>	1 pc.

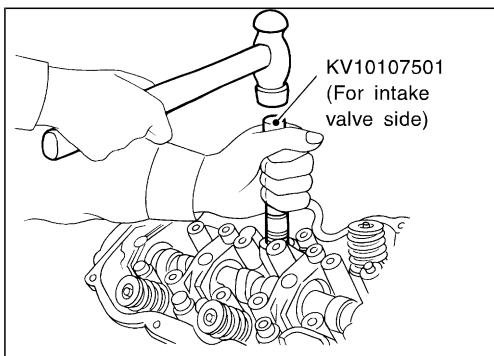
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**VALVE OIL SEAL**

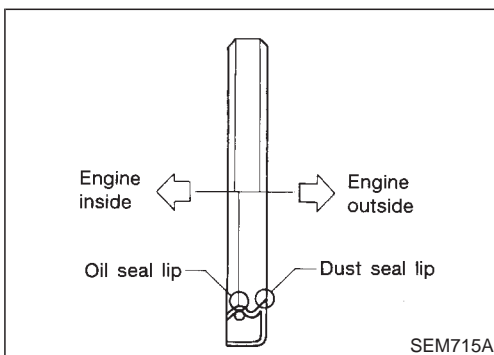
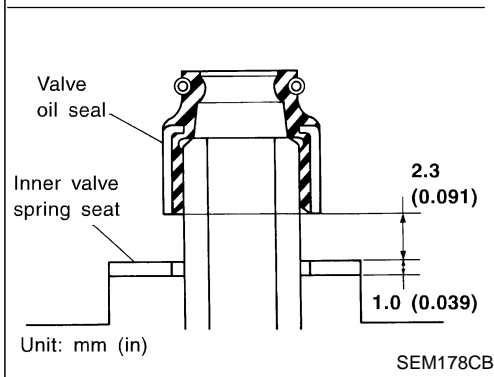
1. Remove rocker cover.
2. Remove rocker shaft assembly and valve lifters with valve lifter guide.
3. Remove valve springs and valve oil seal.
 - Piston concerned should be set at TDC to prevent valve from falling.
 - When removing intake side valve oil seal, use Tool or suitable tool.

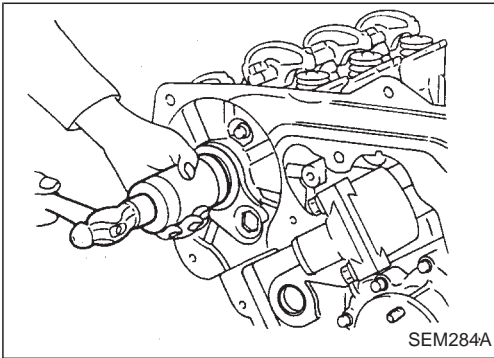


- When removing exhaust side valve oil seal, pull it out with suitable tool.

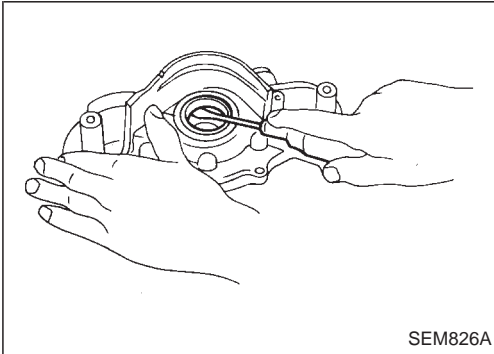


4. Apply engine oil to new valve oil seal and install it.
 - Before installing valve oil seal, install inner valve spring seat.
 - When installing intake side valve oil seal, use Tool.
 - When installing exhaust side valve oil seal, set it by hand.

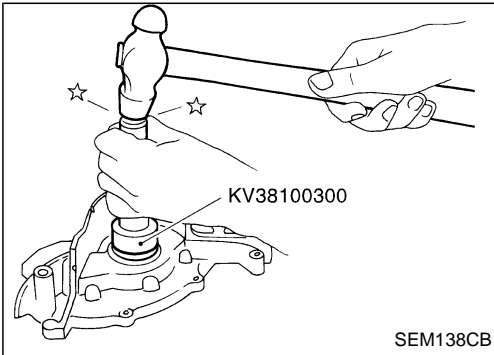
**OIL SEAL INSTALLING DIRECTION**

**CAMSHAFT OIL SEAL**

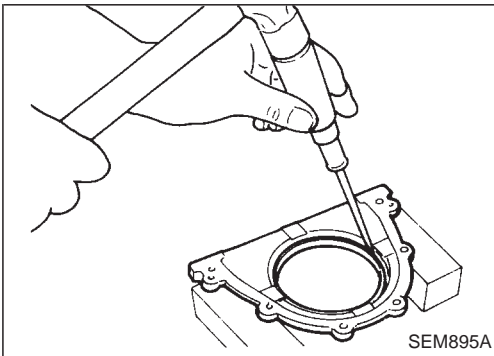
1. Remove timing belt.
 2. Remove camshaft sprocket.
 3. Remove camshaft.
 4. Remove camshaft oil seal.
- Be careful not to scratch camshaft.**
5. Apply engine oil to new camshaft oil seal.

**FRONT OIL SEAL**

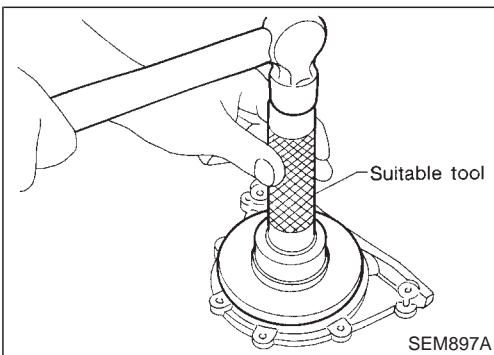
1. Remove timing belt and crankshaft sprocket.
2. Remove oil pump assembly.
3. Remove front oil seal from oil pump body.



4. Apply engine oil to new oil seal and install it using suitable tool.

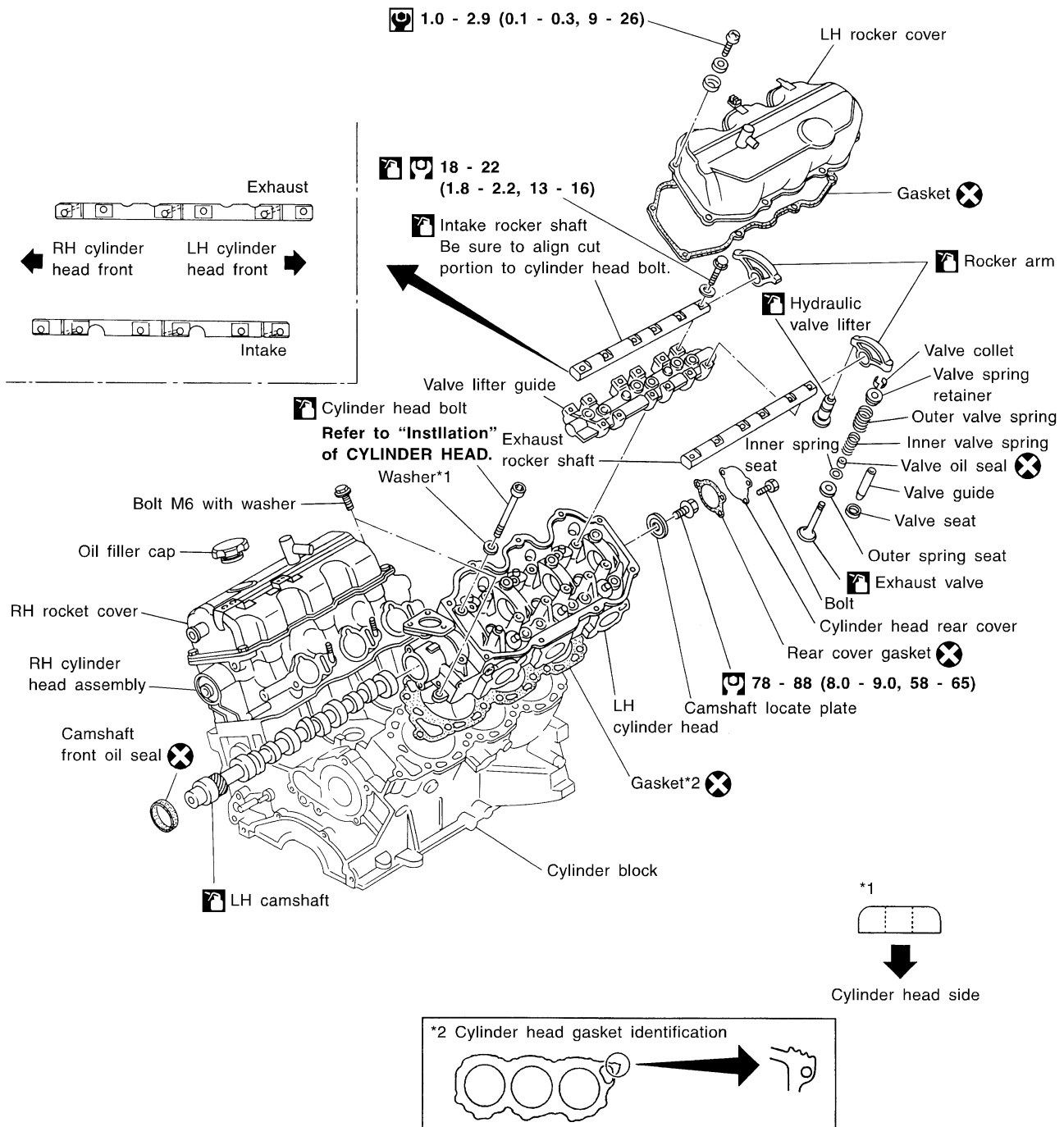
**REAR OIL SEAL**

1. Remove flywheel or drive plate.
2. Remove rear oil seal retainer.
3. Remove rear oil seal from retainer.



4. Apply engine oil to new oil seal and install it using suitable tool.
5. Install rear oil seal retainer with a new gasket to cylinder block.

SEC. 102•111•130



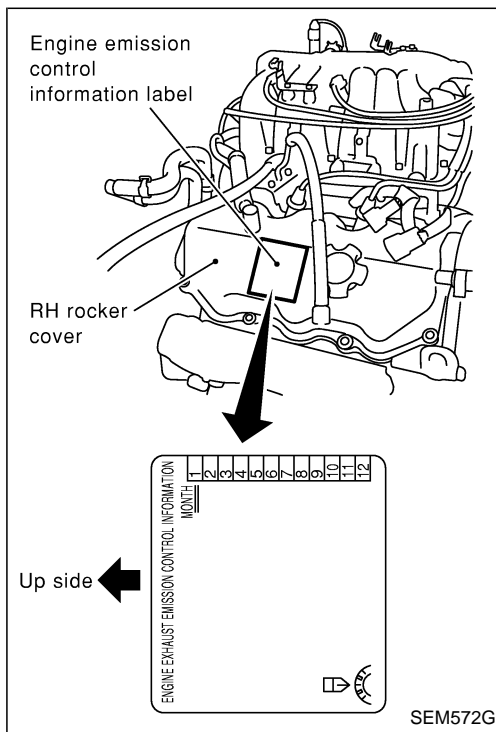
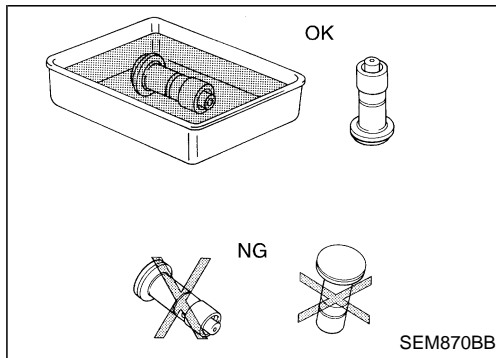
: N•m (kg-m, in-lb)

: N•m (kg-m, ft-lb)

: Lubricate with new engine oil.

CAUTION:

- When installing sliding parts such as rocker arms, camshaft and oil seal, be sure to apply new engine oil on their sliding surfaces.
- When tightening cylinder head bolts and rocker shaft bolts, apply new engine oil to thread portions and seat surfaces of bolts.



- If hydraulic valve lifter is kept on its side, there is a risk of air entering it. After removal, always set hydraulic valve lifter straight up, or when laying it on its side, have it soak in new engine oil.
- Do not disassemble hydraulic valve lifter.
- Attach tags to valve lifters so as not to mix them up.
- An engine emission control information label is attached on the RH rocker cover.
- When overhauling, such as when replacing bare engine, always attach the label after performing the engine maintenance.
- Attach a new label when replacing the RH rocker cover. (Do not reuse the old one.)
- Follow the description about the engine maintenance on the label when replacing the old label with new one.
- On the column for the month in the label, punch the month when the engine maintenance is performed.

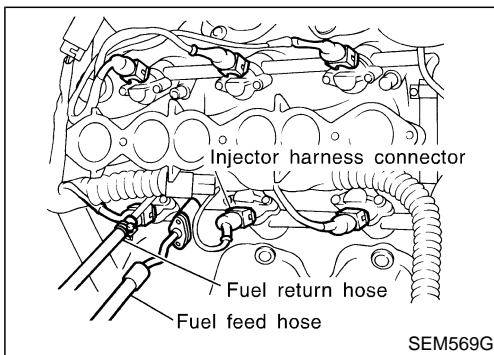
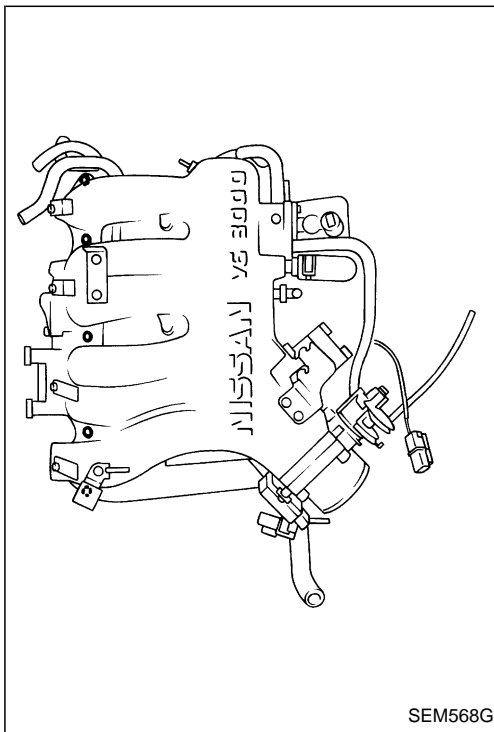
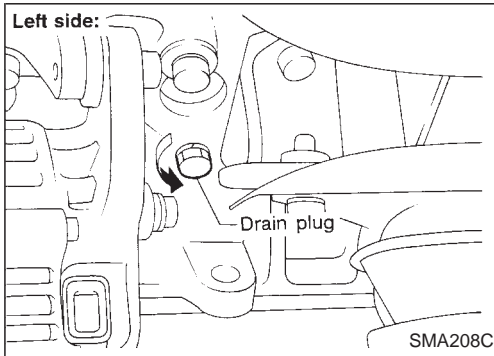
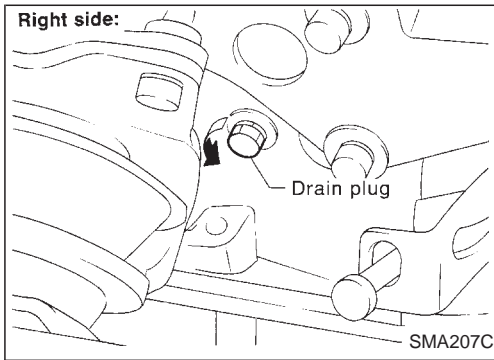
Label color:

M/T models	Gold
A/T models	Silver

Removal

1. Release fuel pressure.
Refer to "Fuel Pressure Release" in EC section.
2. Remove timing belt.
Refer to "Removal", "TIMING BELT", EM-13.

Removal (Cont'd)



3. Drain coolant by removing drain plugs from both sides of cylinder block.

4. Separate accelerator control wire from intake manifold collector.
5. Remove intake manifold collector from engine. The following parts should be disconnected to remove intake manifold collector.
 - a. Harness connectors for
 - IACV-AAC valve
 - Throttle position sensor and throttle position switch
 - Air regulator
 - b. Water hoses from collector
 - c. Heater hoses
 - d. PCV hose from RH rocker cover
 - e. Vacuum hoses for
 - Canister
 - Master brake cylinder
 - Pressure regulator
 - f. Purge hose from canister
 - g. Earth harnesses
 - h. Air duct hose

6. Remove fuel feed and fuel return hoses from injector fuel tube assembly.
7. Disconnect all injector harness connectors.
8. Remove injector fuel tube assembly.

GI

MA

EM

LC

EC

FE

CL

MT

AT

TF

PD

FA

RA

BR

ST

RS

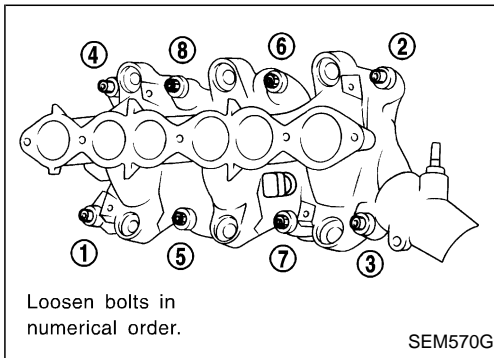
BT

HA

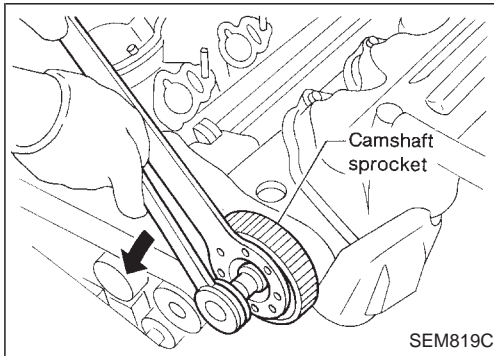
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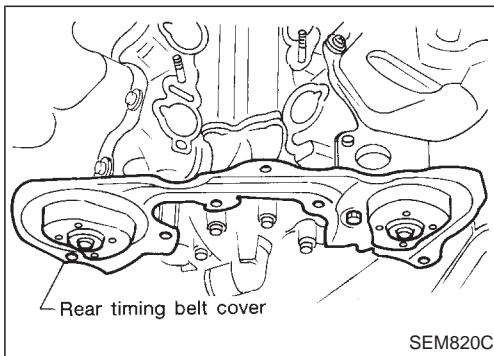
Removal (Cont'd)



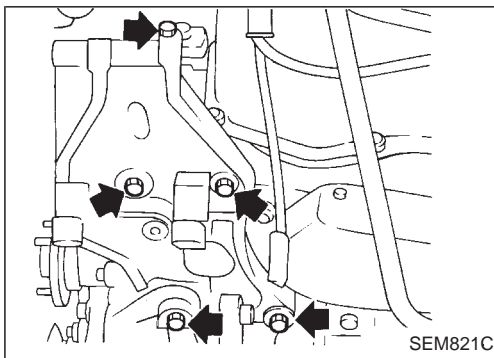
9. Remove intake manifold from engine.
The following parts should be disconnected to remove intake manifold.
 - a. Engine coolant temperature switch harness connector
 - b. Thermal transmitter harness connector
 - c. Water hose from thermostat housing



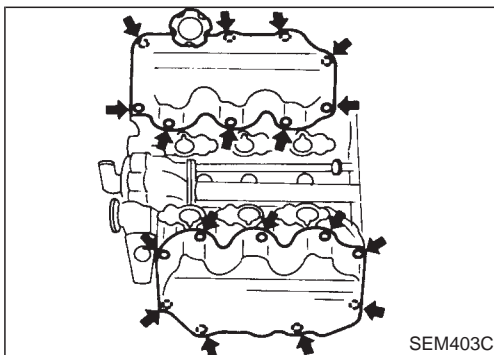
10. Remove both camshaft sprockets.



11. Remove rear timing belt cover.
12. Remove distributor and ignition wires.
After pulling out distributor from cylinder head, do not rotate distributor rotor.
13. Remove harness clamp from RH rocker cover.
14. Remove front exhaust tube from exhaust manifold.



15. Remove compressor from its bracket.
16. Remove alternator from its bracket.
17. Remove compressor and alternator bracket.

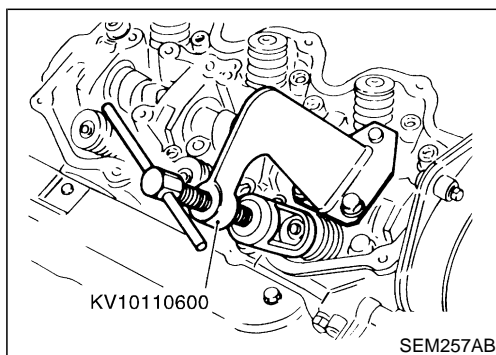
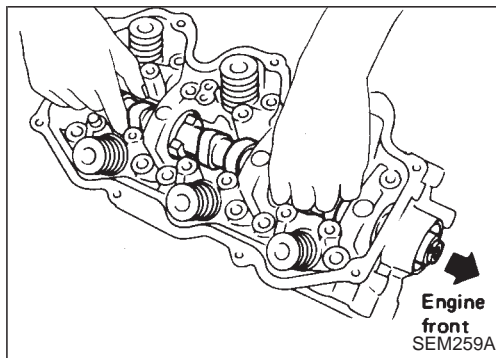
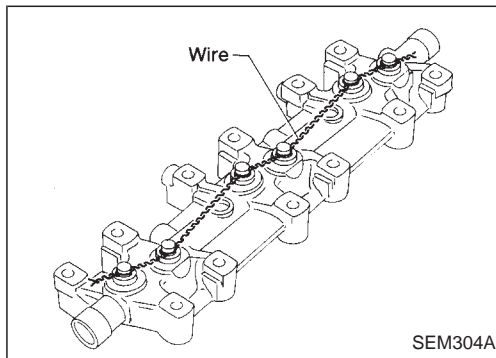
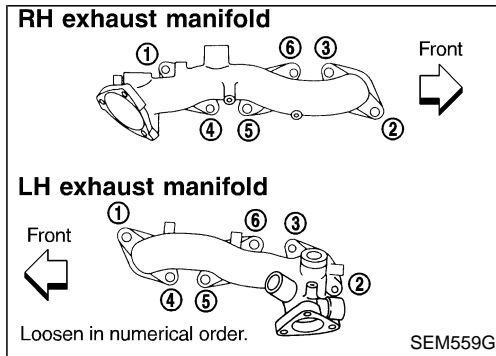
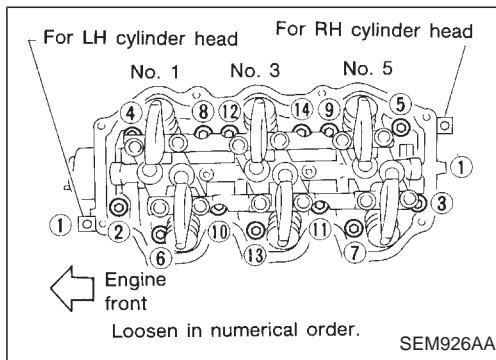


18. Remove both rocker covers.

Removal (Cont'd)

19. Remove cylinder head with exhaust manifold.

- Head warpage or cracking could result from removing in incorrect order.
- Cylinder head bolts should be loosened in two or three steps.



Disassembly

1. Remove exhaust manifolds from cylinder head.

2. Remove rocker shafts with rocker arms.

Bolts should be loosened in two or three steps.

3. Remove hydraulic valve lifters and lifter guide.

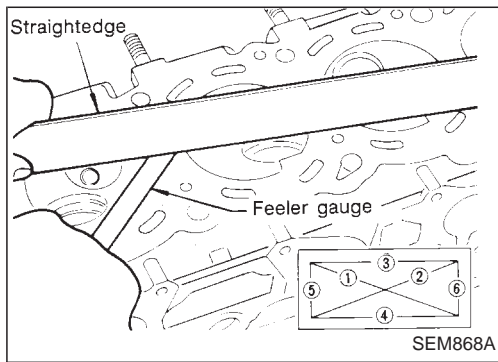
- Hold hydraulic valve lifters with wire so that they will not drop from lifter guide.

4. Remove oil seal and camshaft.

- Before removing camshaft, measure camshaft end play.

5. Remove valve components with Tool.

6. Remove valve oil seals with Tool or a suitable tool.



Inspection

CYLINDER HEAD DISTORTION

Head surface flatness:

Less than 0.1 mm (0.004 in)

If beyond the specified limit, replace it or resurface it.

Resurfacing limit:

The resurfacing limit of cylinder head is determined by the cylinder block resurfacing in an engine.

Amount of cylinder head resurfacing is "A".

Amount of cylinder block resurfacing is "B".

The maximum limit is as follows:

$A + B = 0.2 \text{ mm (0.008 in)}$

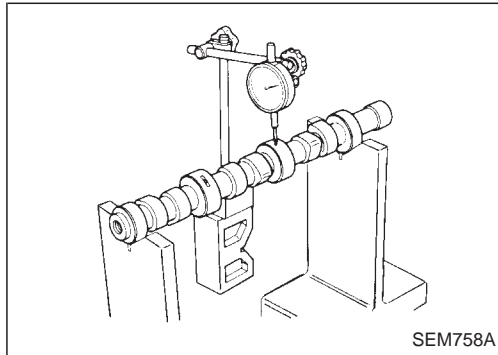
After resurfacing cylinder head, check that camshaft rotates freely by hand. If resistance is felt, cylinder head must be replaced.

Nominal cylinder head height:

106.8 - 107.2 mm (4.205 - 4.220 in)

CAMSHAFT VISUAL CHECK

Check camshaft for scratches, seizure and wear.



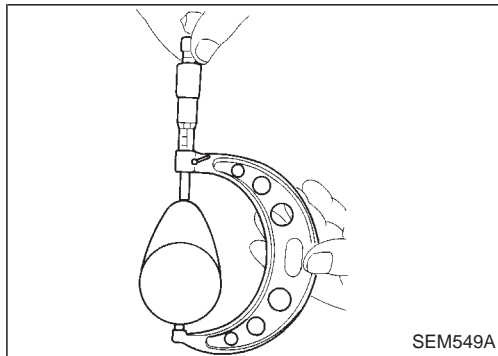
CAMSHAFT RUNOUT

1. Measure camshaft runout at the center journal.

Runout (Total indicator reading):

Limit 0.1 mm (0.004 in)

2. If it exceeds the limit, replace camshaft.



CAMSHAFT CAM HEIGHT

1. Measure camshaft cam height.

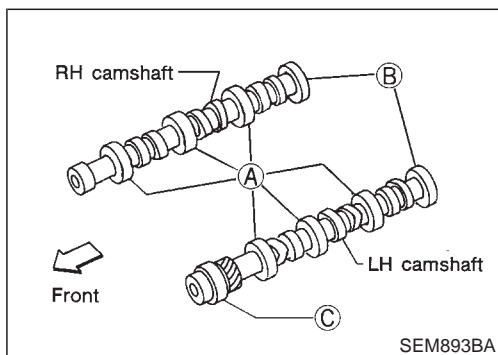
Standard cam height:

39.537 - 39.727 mm (1.5566 - 1.5641 in)

Cam wear limit:

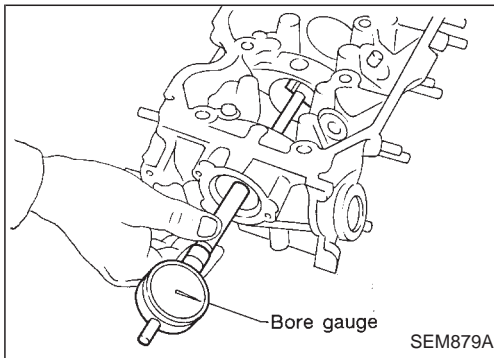
0.15 mm (0.0059 in)

2. If wear is beyond the limit, replace camshaft.



CAMSHAFT JOURNAL CLEARANCE

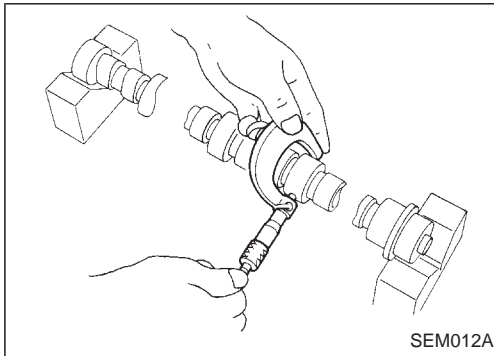
Inspection (Cont'd)



1. Measure inner diameter of camshaft bearing.

Standard inner diameter:

- A** 47.000 - 47.025 mm (1.8504 - 1.8514 in)
B 42.500 - 42.525 mm (1.6732 - 1.6742 in)
C 48.000 - 48.025 mm (1.8898 - 1.8907 in)



2. Measure outer diameter of camshaft journal.

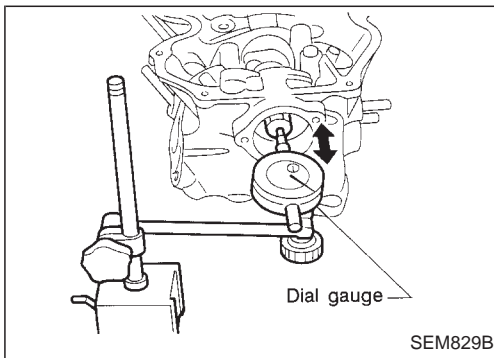
Standard outer diameter:

- A** 46.920 - 46.940 mm (1.8472 - 1.8480 in)
B 42.420 - 42.440 mm (1.6701 - 1.6709 in)
C 47.920 - 47.940 mm (1.8866 - 1.8874 in)

3. If clearance exceeds the limit, replace camshaft and/or cylinder head.

Camshaft journal clearance limit:

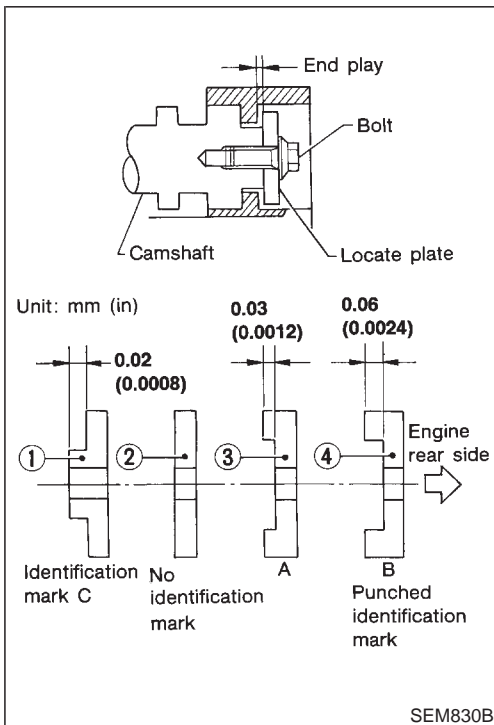
0.15 mm (0.0059 in)

**CAMSHAFT END PLAY**

1. Install camshaft and locate plate in cylinder head.
2. Measure camshaft end play.

Camshaft end play:

Standard 0.03 - 0.06 mm (0.0012 - 0.0024 in)



3. If it is out of the specified range, select thickness of camshaft locate plate to obtain standard specified end play.

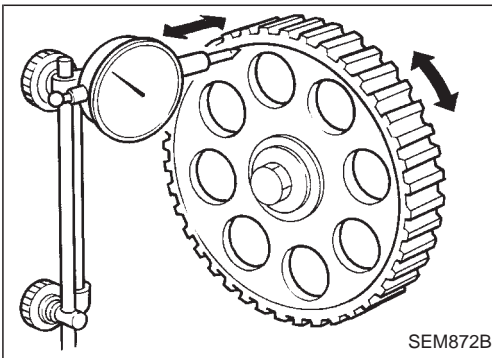
Example:

When camshaft end play is 0.08 mm (0.0031 in) with camshaft locate plate ②, replace camshaft locate plate ② with camshaft locate plate ③ to set the end play at 0.05 mm (0.0020 in).

Inspection (Cont'd)

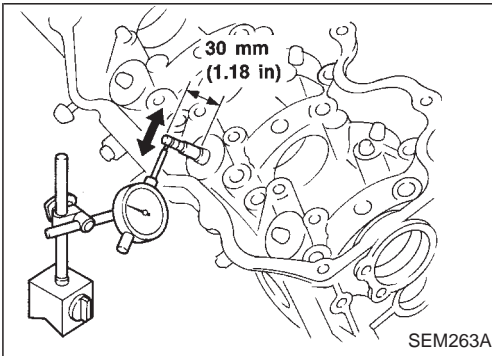
CAMSHAFT SPROCKET RUNOUT

1. Install sprocket on camshaft.
2. Measure camshaft sprocket runout.
Runout (Total indicator reading):
Limit 0.1 mm (0.004 in)
3. If it exceeds the limit, replace camshaft sprocket.



VALVE GUIDE CLEARANCE

1. Measure valve deflection in a right-angled direction with camshaft. (Valve and valve guide mostly wear in this direction.)
Valve deflection limit (Dial gauge reading):
0.20 mm (0.0079 in)



2. If it exceeds the limit, check valve to valve guide clearance.
 - a. Measure valve stem diameter and valve guide inner diameter.
 - b. Check that clearance is within specification.

Valve to valve guide clearance

$$= \text{Valve guide inner diameter}$$

$$- \text{Valve stem diameter}$$

Intake:

0.020 - 0.053 mm (0.0008 - 0.0021 in)

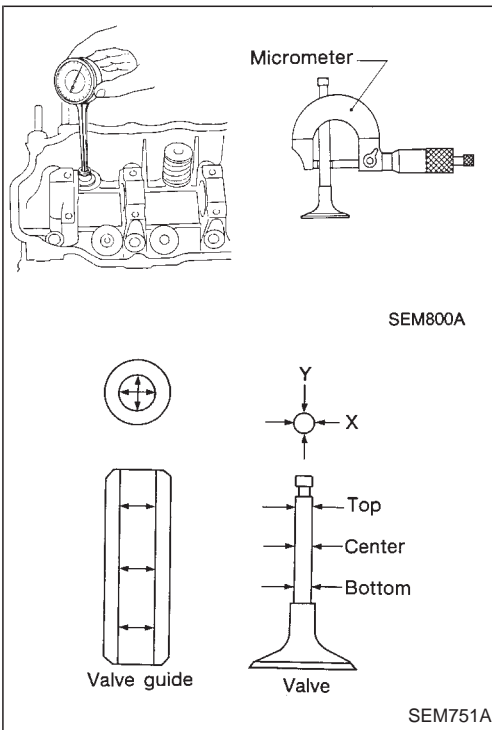
Exhaust:

0.030 - 0.056 mm (0.0012 - 0.0022 in)

Limit:

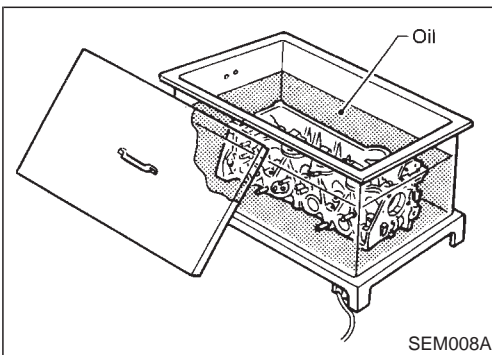
0.10 mm (0.0039 in)

- c. If it exceeds the limit, replace valve or valve guide.

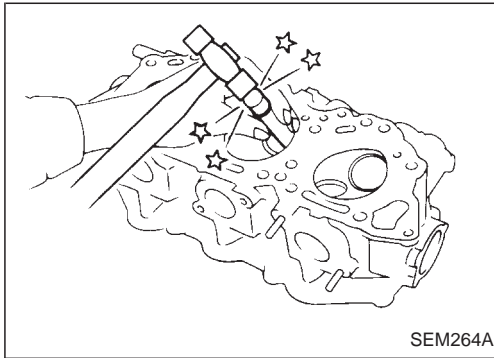


VALVE GUIDE REPLACEMENT

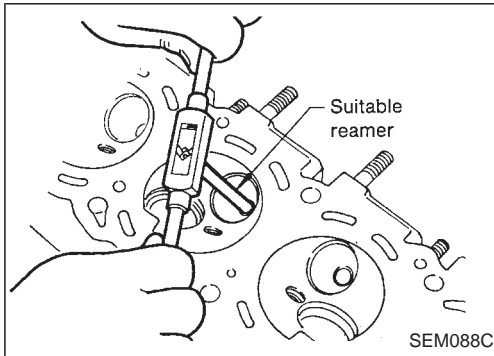
1. To remove valve guide, heat cylinder head to 150 to 160°C (302 to 320°F) by soaking it in heated oil.



Inspection (Cont'd)



2. Drive out valve guide with a press [under a 20 kN (2 ton, 2.2 US ton, 2.0 Imp ton) pressure] or hammer and suitable tool.



3. Ream cylinder head valve guide hole.

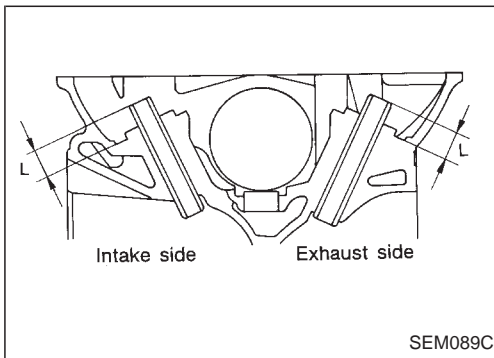
**Valve guide hold diameter
(for service parts):**

Intake

11.175 - 11.196 mm (0.4400 - 0.4408 in)

Exhaust

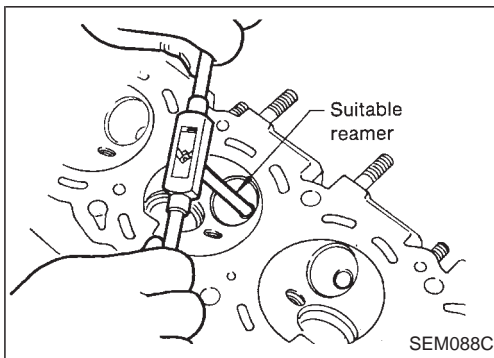
12.175 - 12.196 mm (0.4793 - 0.4802 in)



4. Heat cylinder head to 150 to 160°C (302 to 320°F) and press service valve guide onto cylinder head.

Projection "L":

13.2 - 13.4 mm (0.520 - 0.528 in)



5. Ream valve guide.

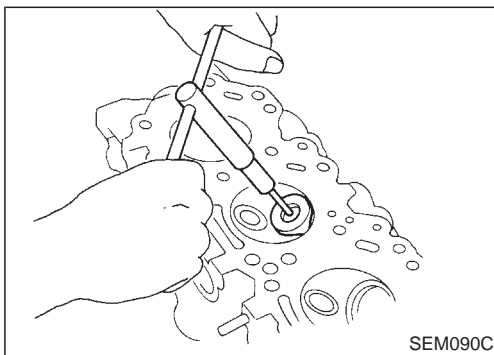
Finished size:

Intake

7.000 - 7.018 mm (0.2756 - 0.2763 in)

Exhaust

8.000 - 8.018 mm (0.3150 - 0.3157 in)



VALVE SEATS

Check valve seats for any evidence of pitting at valve contact surface, and reseal or replace if it has worn out excessively.

- **Before repairing valve seats, check valve and valve guide for wear. If they have worn, replace them. Then correct valve seat.**
- **Cut with both hands to maintain a uniform cutting surface.**

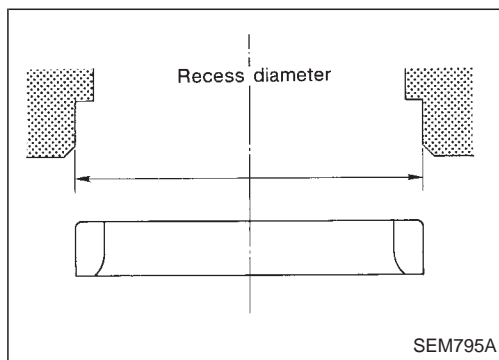
Inspection (Cont'd)

REPLACING VALVE SEAT FOR SERVICE PARTS

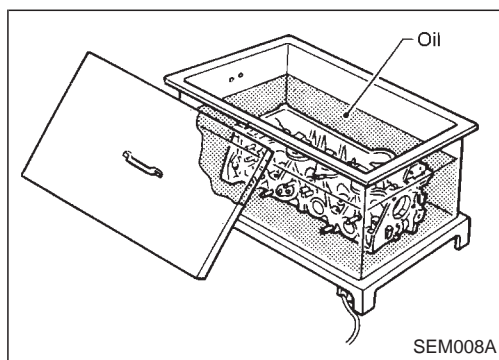
1. Bore out old seat until it collapses. The machine depth stop should be set so that boring cannot continue beyond the bottom face of the seat recess in cylinder head.
2. Ream cylinder head recess.

Reaming bore for service valve seat**Oversize [0.5 mm (0.020 in)]:****Intake****44.500 - 44.516 mm (1.7520 - 1.7526 in)****Exhaust****37.500 - 37.516 mm (1.4764 - 1.4770 in)**

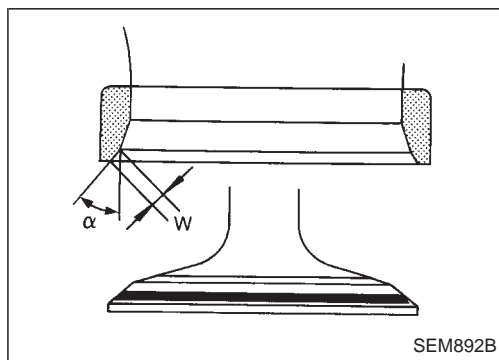
Reaming should be done in circles concentric to the valve guide center so that valve seat will have the correct fit.



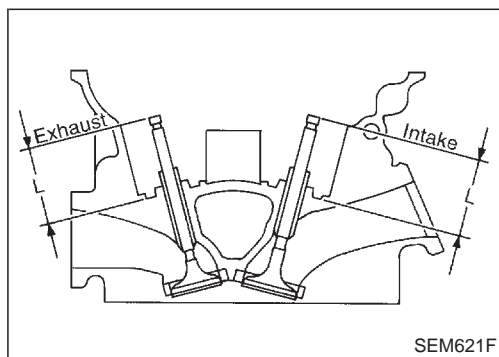
SEM795A



SEM008A



SEM892B



SEM621F

3. Heat cylinder head to 150 to 160°C (302 to 320°F) by soaking it in heated oil.
4. Press fit valve seat until it seats on the bottom.

5. Cut or grind valve seat using suitable tool at the specified dimensions. Refer to SDS, EM-55.
6. After cutting, lap valve seat with abrasive compound.
7. Check valve seating condition.

		Intake	Exhaust
Seat face angle " α "	degree	45	45
Contacting width "W"	mm (in)	1.75 (0.0689)	1.7 (0.067)

8. Use a depth gauge to measure the distance between the mounting surface of the cylinder head spring seat and the valve stem end. If the distance is shorter than specified, repeat step 5 above to adjust it. If it is longer, replace the valve seat with a new one.

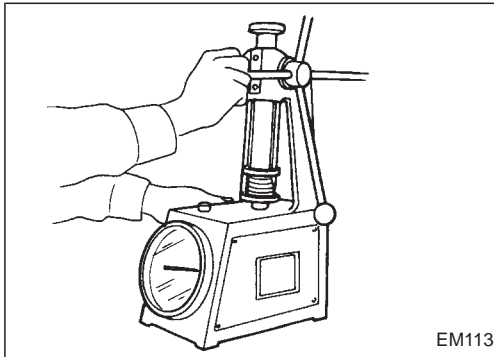
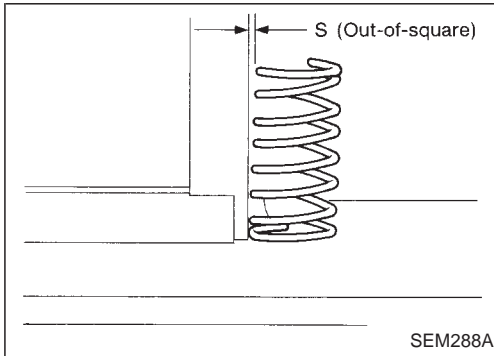
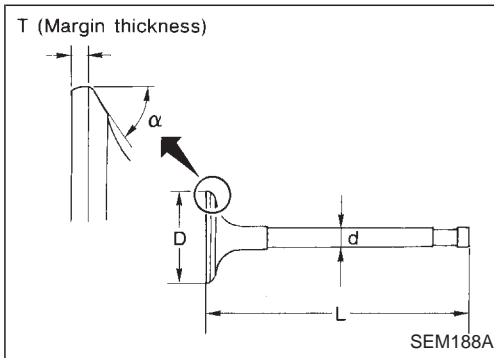
Valve seat resurface limit "L":**Intake****44.7 - 44.9 mm (1.7598 - 1.7677 in)****Exhaust****45.4 - 45.6 mm (1.7874 - 1.7953 in)**

Inspection (Cont'd)

VALVE DIMENSIONS

Check dimensions in each valve. For dimensions, refer to SDS, EM-54. When valve head has been worn down to 0.5 mm (0.020 in) in margin thickness, replace valve.

Grinding allowance for valve stem tip is 0.2 mm (0.008 in) or less.



VALVE SPRING

Squareness

1. Measure "S" dimension.

Out-of-square:

Outer

Less than 2.2 mm (0.087 in)

Inner

Less than 1.9 mm (0.075 in)

2. If it exceeds the limit, replace spring.

Pressure

Check valve spring pressure.

Pressure: N (kg, lb) at height mm (in)

Standard

Outer

523.7 (53.4, 117.7) at 30.0 (1.181)

Inner

255.0 (26.0, 57.3) at 25.0 (0.984)

Limit

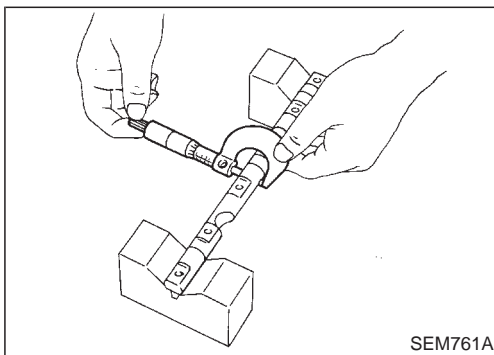
Outer

More than 228.5 (23.3, 51.4) at 25.0 (0.984)

Inner

More than 225.6 (23.0, 50.7) at 25.0 (0.984)

If it exceeds the limit, replace spring.



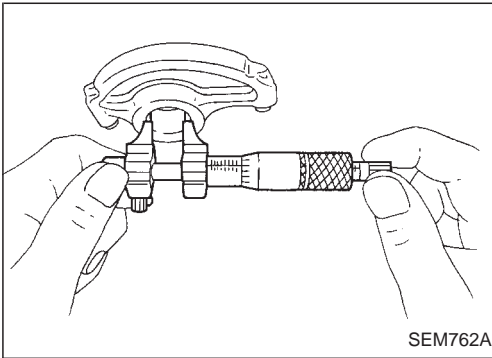
ROCKER SHAFT AND ROCKER ARM

1. Check rocker shafts for scratches, seizure and wear.
2. Check outer diameter of rocker shaft.

Diameter:

17.988 - 18.000 mm (0.7082 - 0.7087 in)

Inspection (Cont'd)



3. Check inner diameter of rocker arm.

Diameter:

18.007 - 18.028 mm (0.7089 - 0.7098 in)

Rocker arm to shaft clearance

= Inner diameter of rocker arm

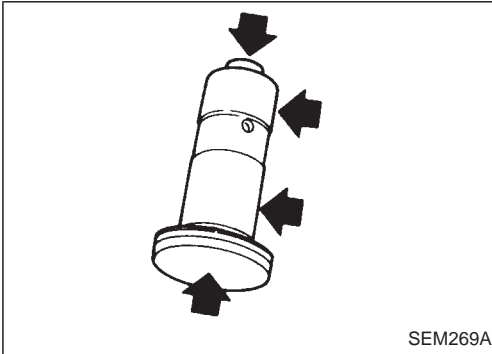
- Outer diameter of rocker shaft

0.007 - 0.040 mm (0.0003 - 0.0016 in)

- Keep rocker arm with hydraulic valve lifter standing to prevent air from entering hydraulic valve lifter when checking.

HYDRAULIC VALVE LIFTER

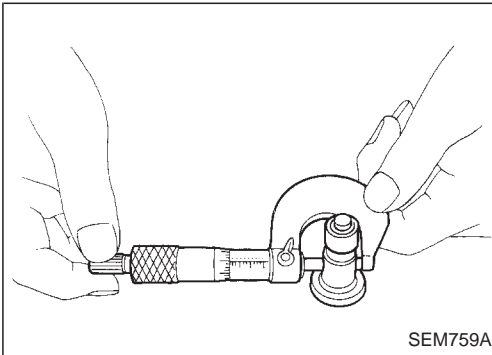
1. Check contact and sliding surfaces for wear or scratches.



2. Check diameter of valve lifter.

Outer diameter:

15.947 - 15.957 mm (0.6278 - 0.6282 in)



3. Check valve lifter guide inner diameter.

Inner diameter:

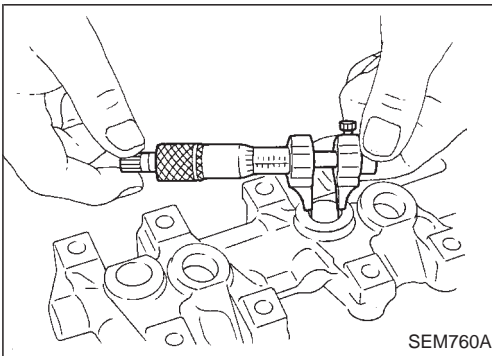
16.000 - 16.013 mm (0.6299 - 0.6304 in)

Standard clearance between valve lifter and lifter guide

= Lifter guide inner diameter

- Valve lifter outer diameter

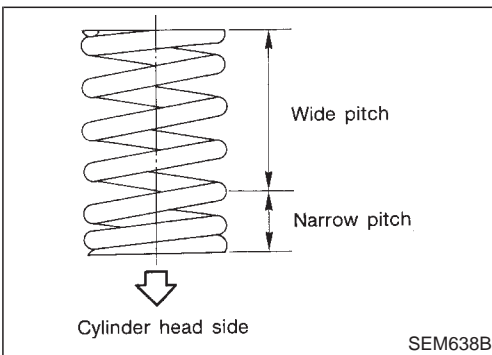
0.043 - 0.066 mm (0.0017 - 0.0026 in)



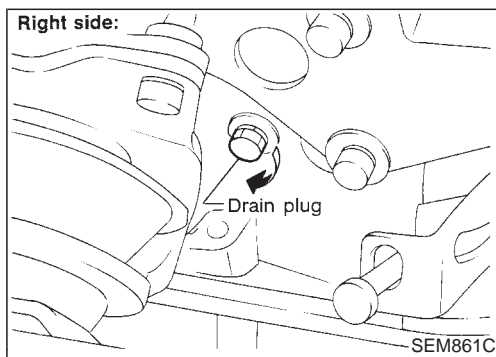
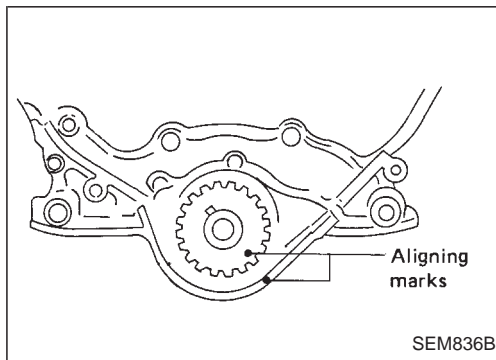
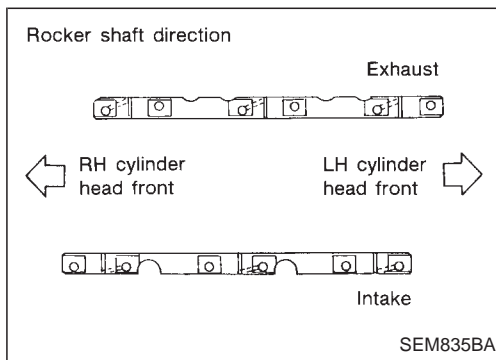
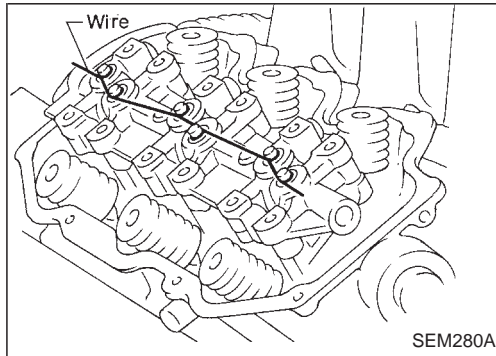
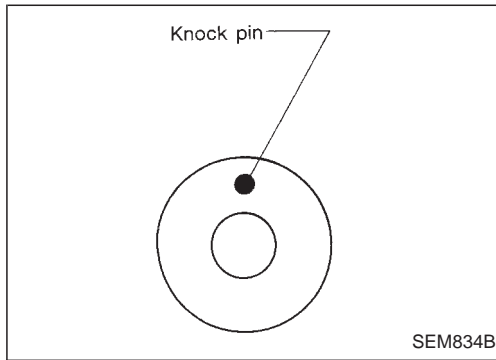
Assembly

1. Install valve component parts.

- Always use new valve oil seal. Refer to EM-19, "OIL SEAL-REPLACEMENT".
- Before installing valve oil seal, install inner valve spring seat.
- Install outer valve spring (uneven pitch type) with its narrow pitch side toward cylinder head side.
- After installing valve component parts, use plastic hammer to lightly tap valve stem tip to assure a proper fit.



Assembly (Cont'd)



2. Install camshafts, locate plates and cylinder head rear covers.

- Set knock pin of camshaft at the top.

3. Install valve lifters into valve lifter guide.

- Assemble valve lifters to their original position and hold all valve lifters with wire to prevent lifters from falling off.
- After installing them, remove the wire.

4. Install rocker shafts with rocker arms.

- Tighten bolts gradually in two or three stages.
- Before tightening, be sure to set camshaft the lobe at the position where lobe is not lifted.

- Set No. 1 piston at TDC on its compression stroke and tighten rocker shaft bolts for No. 2, No. 4 and No. 6 cylinders.
- Set No. 4 piston at TDC on its compression stroke and tighten rocker shaft bolts for No. 1, No. 3 and No. 5 cylinders.

5. Install exhaust manifold to cylinder head in reverse order of removal.

Installation

1. Set No. 1 piston at TDC on its compression stroke as follows:

- Align crankshaft sprocket aligning mark with mark on oil pump body.
- Confirm that knock pin on camshaft is set at the top.

2. Install both drain plugs.

- Apply sealant to drain plug threads.

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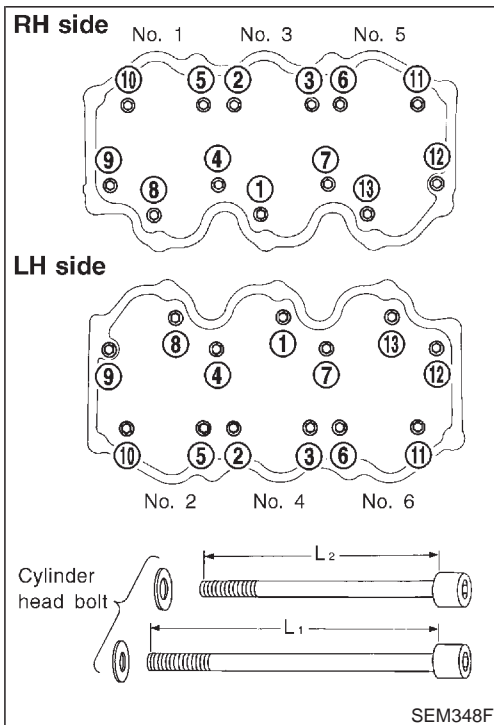
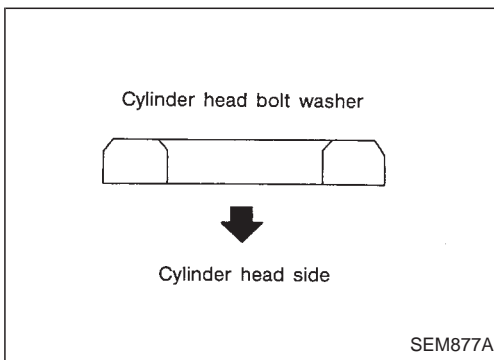
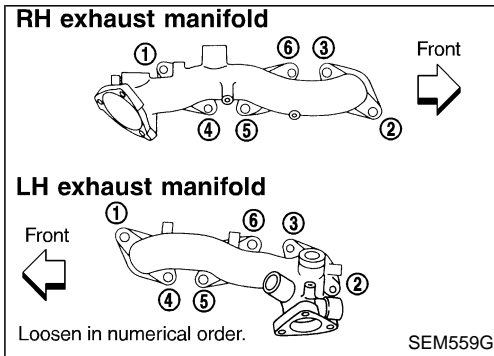
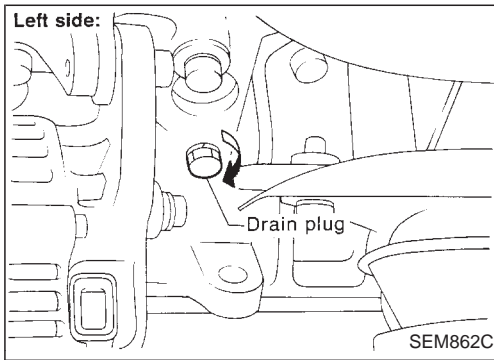
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CYLINDER HEAD Installation (Cont'd)

VG30E



3. Install exhaust manifolds to cylinder head.

4. Install cylinder head with new gasket.

- Be sure to install washers between bolts and cylinder head.
- Do not rotate crankshaft and camshaft separately, or valves will hit piston heads.

5. Tighten cylinder head bolts in numerical order using an angle wrench (ST10120000).

Apply engine oil to threads and seating surfaces of cylinder head bolts before installing them.

- Cylinder head bolts for 4, 7, 9 and 12 are longer than the others.

L₁: 127 mm (5.00 in) for 4, 7, 9 and 12

L₂: 106 mm (4.17 in) for others

- Install intake manifold and cylinder head at the same time using the following procedure:

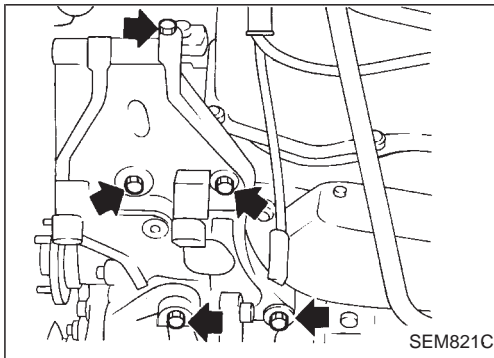
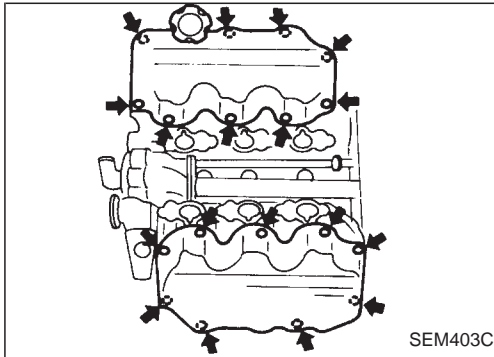
- Tighten cylinder head bolts to 29 N·m (3.0 kg-m, 22 ft-lb).
- Tighten cylinder head bolts to 59 N·m (6.0 kg-m, 43 ft-lb).
- Loosen cylinder head bolts completely.
- Tighten cylinder head bolts to 10 N·m (1.0 kg-m, 7 ft-lb).
- Tighten intake manifold bolts and nuts to 4 N·m (0.4 kg-m, 2.9 ft-lb).
- Tighten intake manifold bolts and nuts to 18 N·m (1.8 kg-m, 13 ft-lb).
- Tighten intake manifold bolts and nuts to 16 to 20 N·m (1.6 to 2.0 kg-m, 12 to 14 ft-lb).
- Loosen intake manifold bolts and nuts completely.
- Tighten cylinder head bolts to 29 N·m (3.0 kg-m, 2.2 ft-lb).

Installation (Cont'd)

- j. Turn cylinder head bolts to 60 to 65 degrees clockwise. If an angle wrench is not available, tighten cylinder head bolts to 54 to 64 N·m (5.5 to 6.5 kg-m, 40 to 47 ft-lb).
- k. Tighten cylinder head sub-bolts to 9.0 to 11.8 N·m (0.92 to 1.20 kg-m, 6.7 to 8.7 ft-lb).
- l. Tighten intake manifold bolts and nuts to 4 N·m (0.4 kg-m, 2.9 ft-lb).
- m. Tighten intake manifold bolts and nuts to 9 N·m (0.9 kg-m, 6.5 ft-lb).
- n. Tighten intake manifold bolts and nuts to 8 to 10 N·m (0.8 to 1.0 kg-m, 5.8 to 7 ft-lb).
- **If only intake manifold is removed and to be used again, install it using the following procedure:**
 - a. Tighten all bolts and nuts to 4 N·m (0.4 kg-m, 2.9 ft-lb).
 - b. Tighten all bolts and nuts to 9 N·m (0.9 kg-m, 6.5 ft-lb).
 - c. Tighten all bolts and nuts to 8 to 10 N·m (0.8 to 1.0 kg-m, 5.8 to 7 ft-lb).

CAUTION:

If replacing intake manifold with a new one, cylinder head gasket must also be replaced with a new one. Refer to step 4.

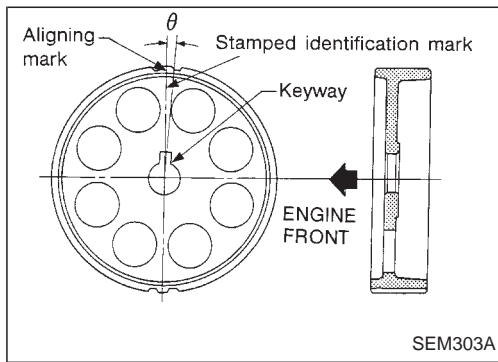


- 6. Install both rocker covers.

- 7. Install compressor and alternator bracket.
- 8. Install alternator.
- 9. Install compressor.

- 10. Install exhaust front tube to exhaust manifold.

Installation (Cont'd)



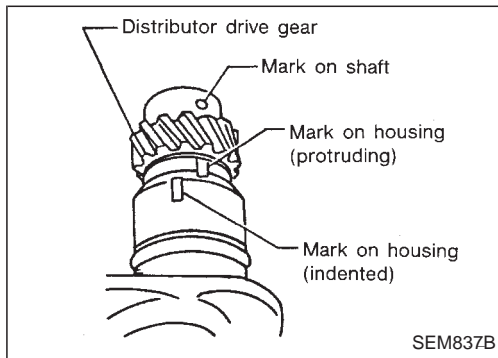
11. Install rear belt cover and camshaft sprocket.

- RH camshaft sprocket and LH camshaft sprocket are different parts. Be sure to install them in the correct location.

	Identification mark	θ
RH camshaft sprocket	R3	$0^{\circ}53'$
LH camshaft sprocket	L3	$-3^{\circ}27'$

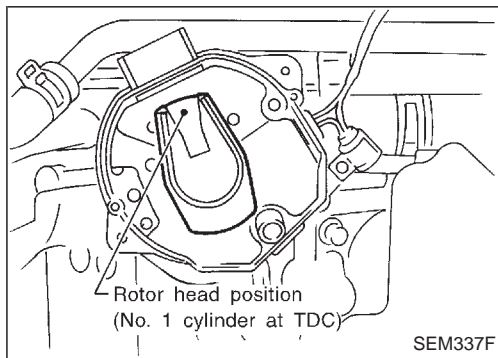
12. Install timing belt and adjust belt tension.

Refer to "Installation", "TIMING BELT", EM-15.

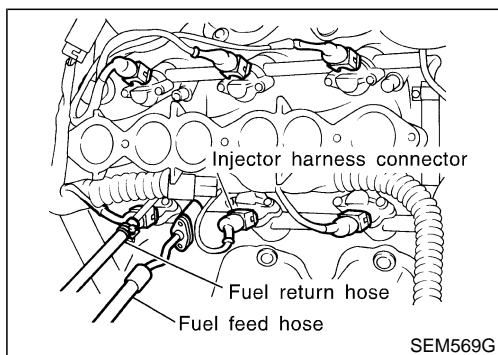


13. Install distributor.

- Align mark on shaft with protruding mark on housing.



- After installing, confirm that distributor rotor head is set as shown in figure.



14. Install injector fuel tube assembly.

15. Connect all injector harness connectors.

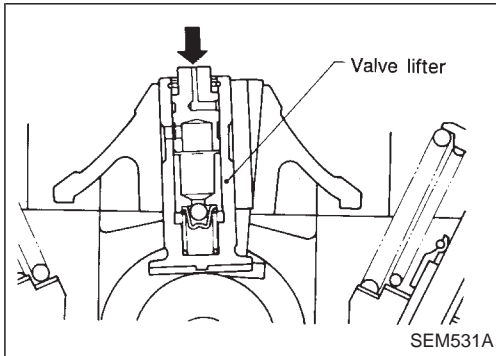
16. Install fuel feed and fuel return hoses to injector fuel tube assembly.

Installation (Cont'd)

17. Install intake manifold collector.

Install all parts which were removed in step 5 under "Removal".
Refer to EM-23.

18. Install accelerator control wire.



19. Check hydraulic valve lifter.

a. Push plunger forcefully with your finger.

● **Be sure to check it with rocker arm in its free position (not on the lobe).**

b. If valve lifter moves more than 1 mm (0.04 in), air may be inside it.

c. Bleed air off by running engine at 1,000 rpm under no load for about 10 minutes.

d. If hydraulic valve lifters are still noisy, replace them and bleed air off again in the same manner as in step 19 (c).

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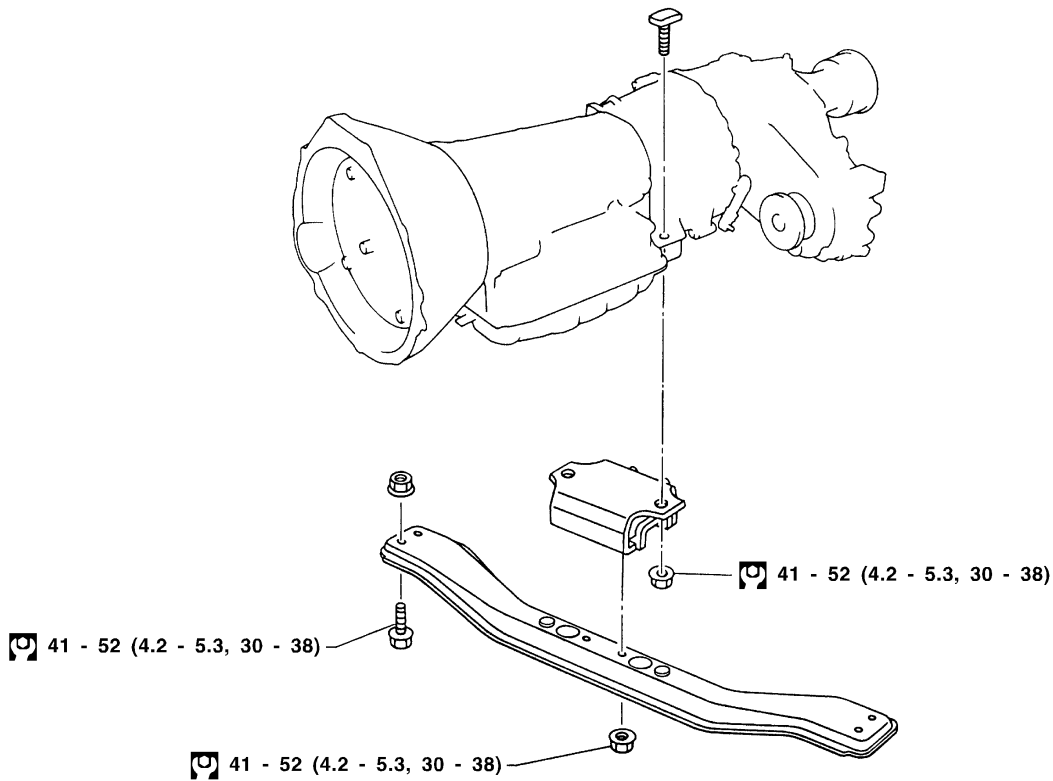
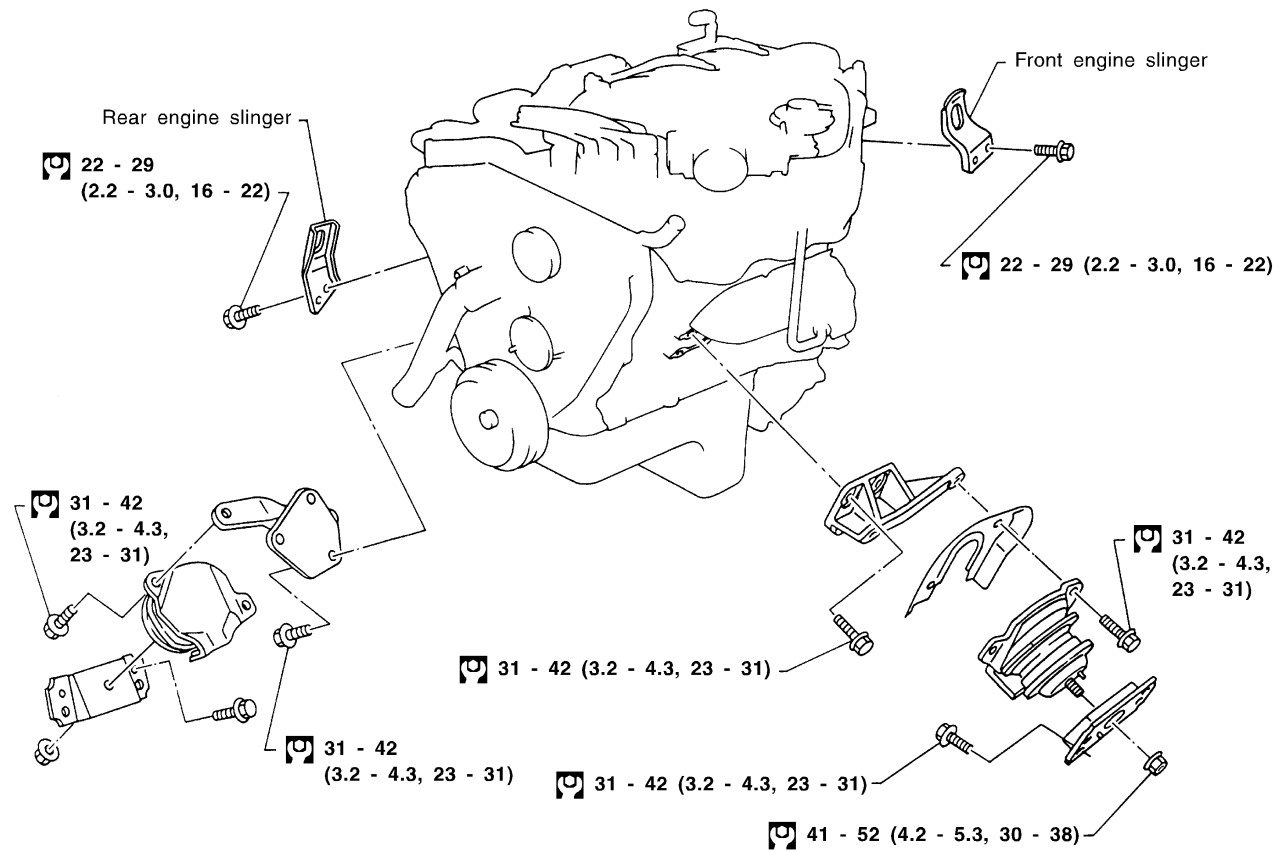
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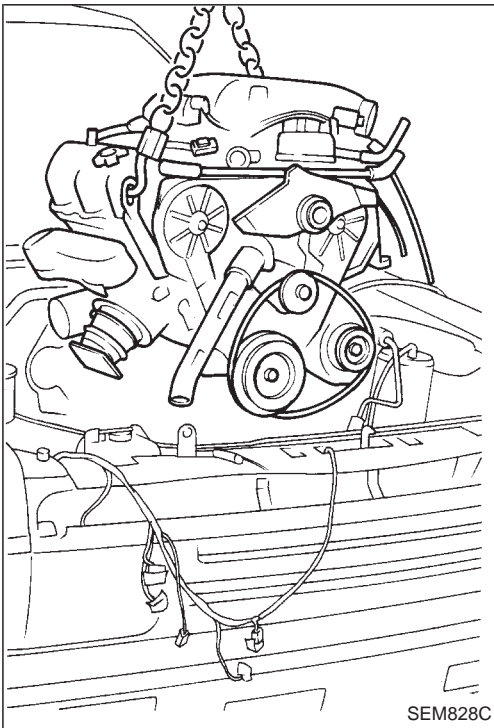
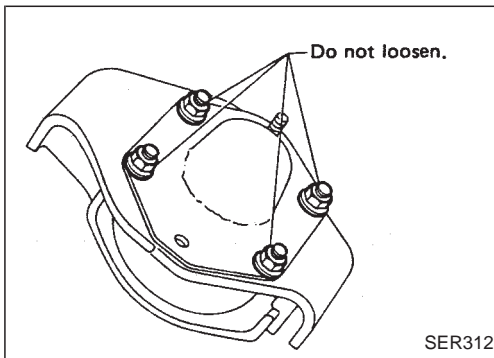


WARNING:

- Situate vehicle on a flat and solid surface.
- Place chocks at front and back of rear wheels.
- Do not remove engine until exhaust system has completely cooled off. Otherwise, you may burn yourself and/or fire may break out in fuel line.
- For safety during subsequent steps, the tension of wires should be slackened against the engine.
- Before disconnecting fuel hose, release fuel pressure from fuel line.
Refer to "Fuel Pressure Release" in EC section.
- Before removing front axle from transmission, place safety stands under designated front supporting points. Refer to GI section for lifting points and tow truck towing.
- Be sure to hoist engine and transmission in a safe manner.
- For engines not equipped with engine slingers, attach proper slingers and bolts described in PARTS CATALOG.

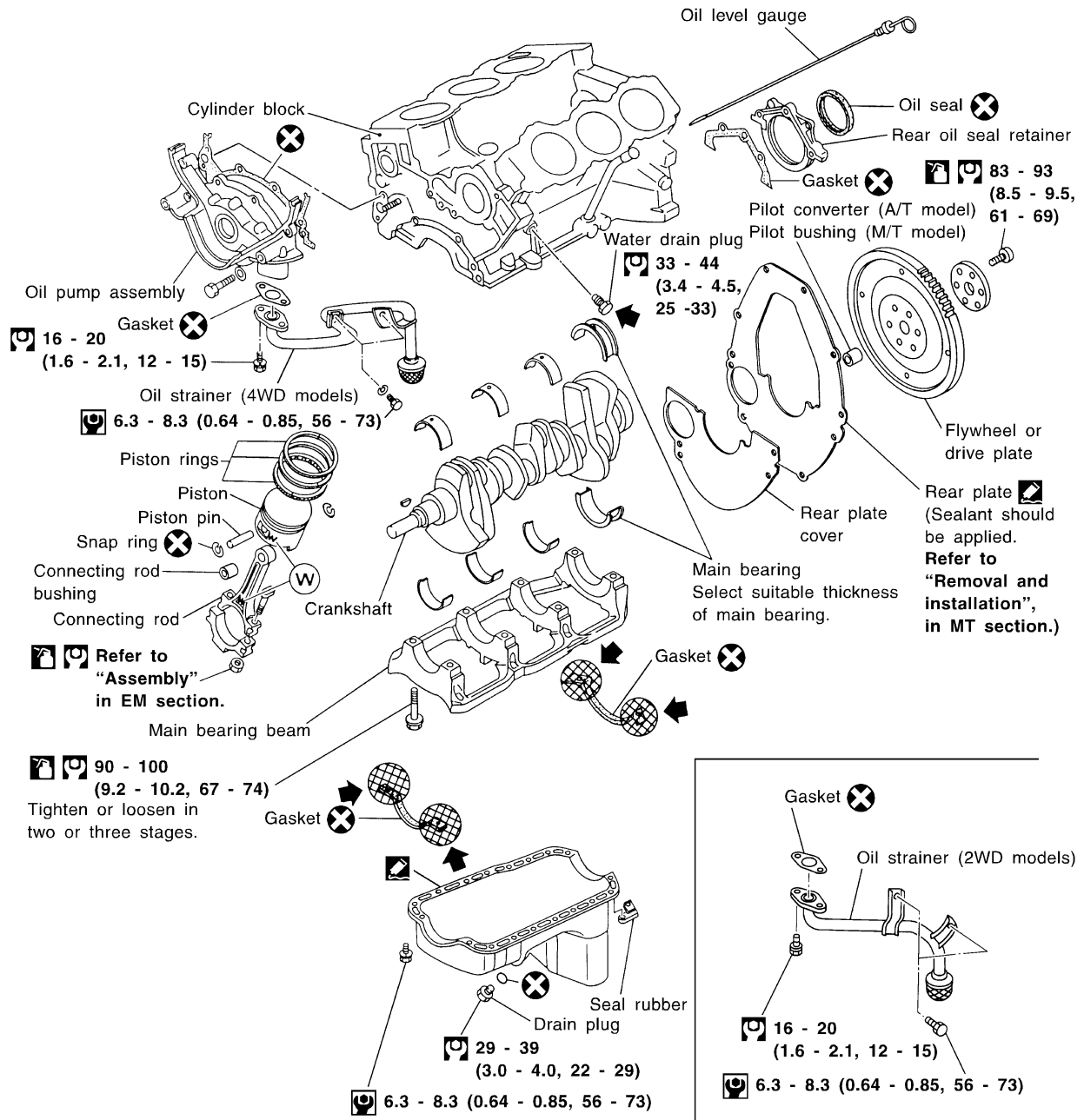
CAUTION:

- When lifting engine, be careful not to strike adjacent parts, especially accelerator wire casing, brake lines, and brake master cylinder.
- In hoisting the engine, always use engine slingers in a safe manner.
- Do not loosen front engine mounting insulator cover securing nuts.
When cover is removed, damper oil flows out and mounting insulator will not function.
For tightening torque, refer to AT, MT and PD sections.
For 4WD model, sealant should be applied between engine and transmission.
Refer to MT section.

**Removal**

1. Remove engine undercover and hood.
2. Drain engine coolant.
3. Remove vacuum hoses, fuel tubes, wires, harnesses and connectors and so on.
4. Remove radiator with shroud and cooling fan.
5. Remove drive belts.
6. Remove power steering oil pump and air conditioner compressor.
7. Remove front exhaust tube.
8. Remove transmission from vehicle.
Refer to MT and AT sections.
9. Install engine slingers.
10. Hoist engine with engine slingers and remove engine mounting bolts from both sides.
11. Remove engine from vehicle.

SEC. 110•120•150



: Apply liquid gasket.

: Apply sealant.

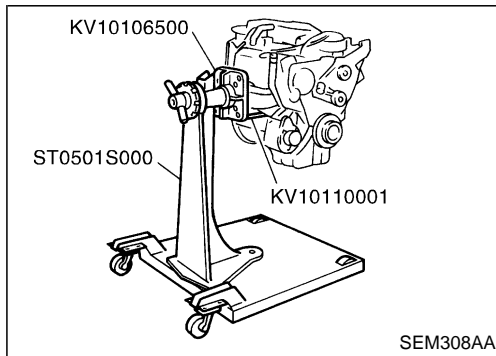
: N•m (kg-m, in-lb)

: N•m (kg-m, ft-lb)

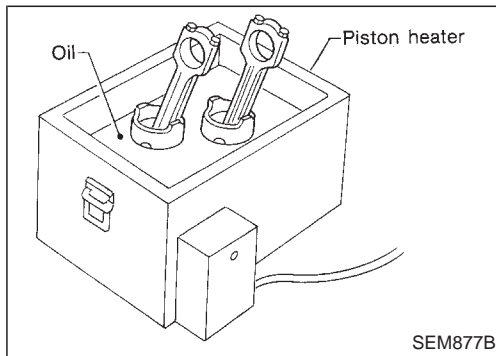
: Lubricate with new engine oil.

CAUTION:

- When installing sliding parts such as bearings and pistons, be sure to apply engine oil on the sliding surfaces.
- Place removed parts such as bearings and bearing caps in their proper order and direction.
- When tightening connecting rod bolts and main bearing cap bolts, apply engine oil to thread portion of bolts and seating surface of nuts.

**Disassembly****PISTON AND CRANKSHAFT**

1. Place engine on a work stand.
2. Drain coolant and oil.
3. Remove oil pan and oil pump.
4. Remove timing belt.
5. Remove water pump.
6. Remove cylinder head.

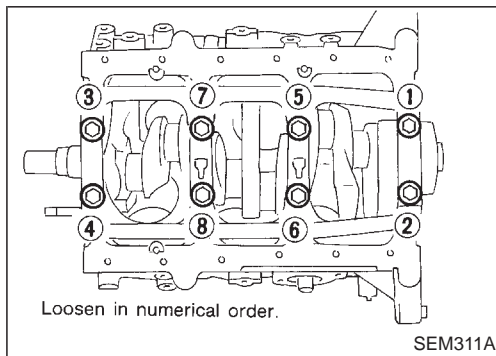


7. Remove pistons with connecting rods.

- When disassembling piston and connecting rod, remove snap ring first, then heat piston to 60 to 70°C (140 to 158°F) or use piston pin press stand at room temperature.

CAUTION:

- When piston rings are not replaced, make sure that piston rings are mounted in their original positions.
- When replacing piston rings, if there is no punchmark, install with either side up.

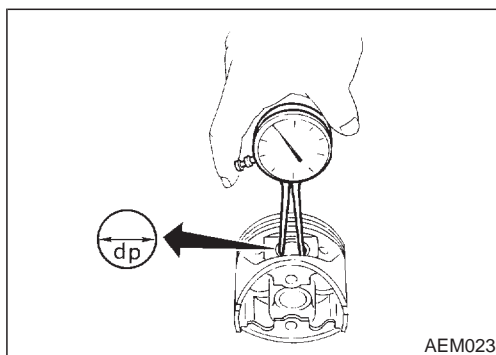


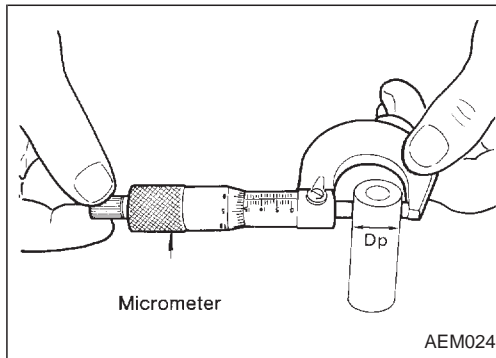
8. Remove bearing cap and crankshaft.

- Before removing bearing cap, measure crankshaft end play.
- Bolts should be loosened in two or three steps.

Inspection**PISTON AND PISTON PIN CLEARANCE**

1. Measure inner diameter of piston pin hole "dp".
Standard diameter "dp":
20.969 - 20.981 mm (0.8255 - 0.8260 in)



Inspection (Cont'd)

2. Measure outer diameter of piston pin "Dp".

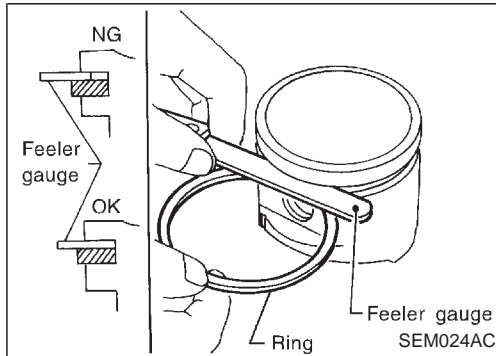
Standard diameter "Dp":

20.971 - 20.983 mm (0.8256 - 0.8261 in)

3. Calculate piston pin clearance.

dp - Dp = 0 to -0.004 mm (0 to -0.0002 in)

If it exceeds the above value, replace piston assembly with pin.

**PISTON RING SIDE CLEARANCE**

Side clearance:

Top ring

0.040 - 0.073 mm (0.0016 - 0.0029 in)

2nd ring

0.030 - 0.063 mm (0.0012 - 0.0025 in)

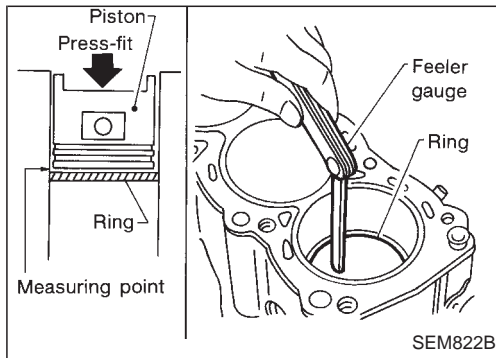
Oil ring

0.015 - 0.190 mm (0.0006 - 0.0075 in)

Max. limit of side clearance:

0.1 mm (0.004 in)

If out of specification, replace piston and/or piston ring assembly.

**PISTON RING END GAP**

End gap:

Top ring

0.21 - 0.44 mm (0.0083 - 0.0173 in)

2nd ring

0.18 - 0.44 mm (0.0071 - 0.0173 in)

Oil ring

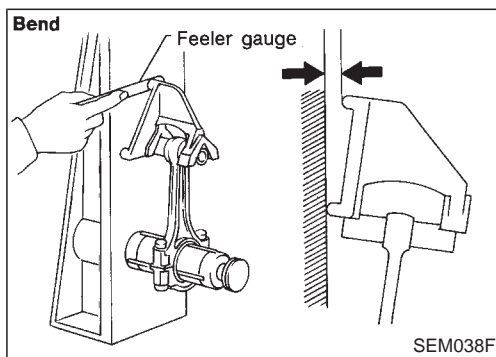
0.20 - 0.76 mm (0.0079 - 0.0299 in)

Max. limit of ring gap:

1.0 mm (0.039 in)

If out of specification, replace piston ring. If gap still exceeds the limit even with a new ring, rebore cylinder and use oversized piston and piston rings.

Refer to SDS, EM-56.

**CONNECTING ROD BEND AND TORSION**

Bend:

Limit 0.15 mm (0.0059 in)

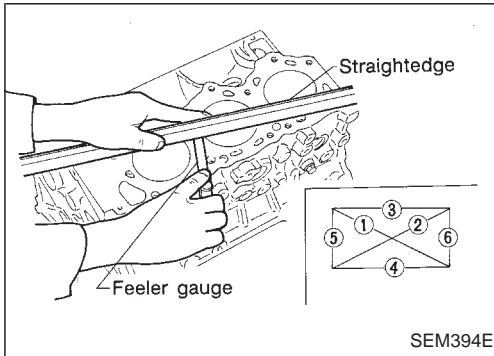
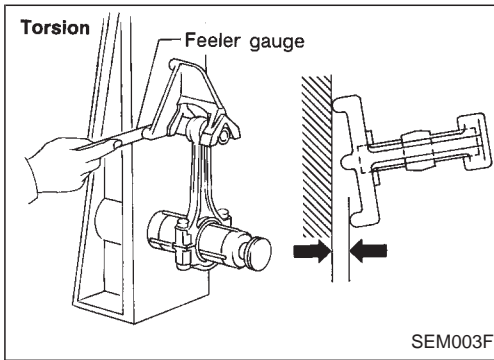
per 100 mm (3.94 in) length

Torsion:

Limit 0.30 mm (0.0118 in)

per 100 mm (3.94 in) length

If it exceeds the limit, replace connecting rod assembly.



CYLINDER BLOCK DISTORTION AND WEAR

1. Clean upper face of cylinder block and measure the distortion.
 - Check along six positions as shown in figure.

Limit:

0.10 mm (0.0039 in)

2. If out of specification, resurface it.
The resurfacing limit is determined by cylinder head resurfacing in engine.

Amount of cylinder head resurfacing is "A".

Amount of cylinder block resurfacing is "B".

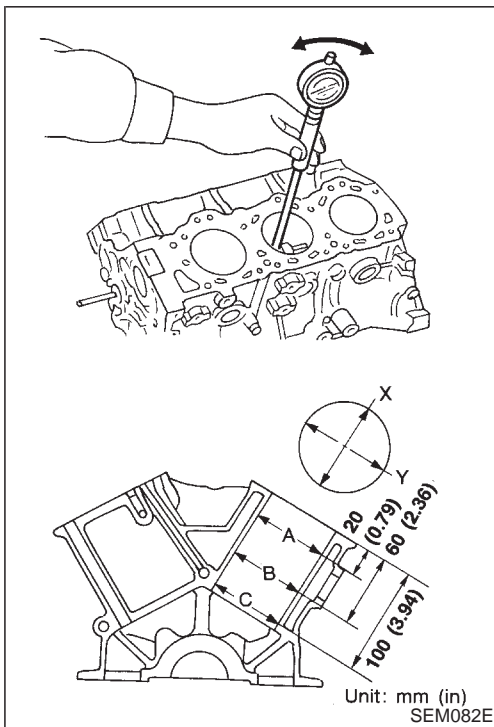
The maximum limit is as follows:

A + B = 0.2 mm (0.008 in)

**Nominal cylinder block height
from crankshaft center:**

227.60 - 227.70 mm (8.9606 - 8.9645 in)

3. If necessary, replace cylinder block.



PISTON-TO-BORE CLEARANCE

1. Using a bore gauge, measure cylinder bore for wear, out-of-round and taper.

Standard inner diameter:

87.000 - 87.030 mm (3.4252 - 3.4264 in)

Wear limit:

0.20 mm (0.0079 in)

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

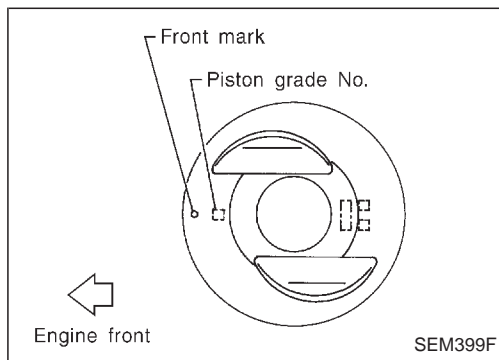
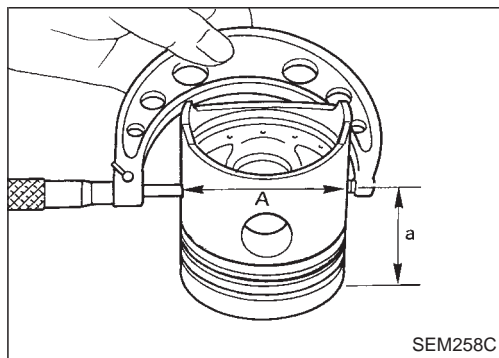
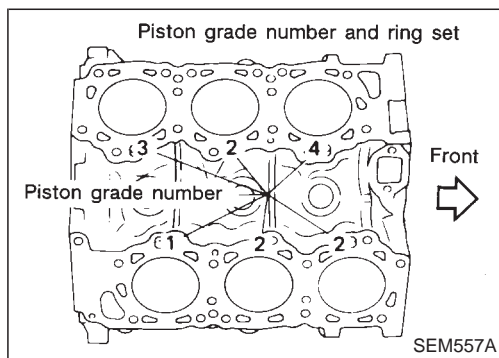
0.015 mm (0.0006 in)

Taper (A - B) limit:

0.015 mm (0.0006 in)

If it exceeds the limit, rebore all cylinders. Replace cylinder block if necessary.

2. Check for scratches and seizure. if seizure is found, hone it.



Inspection (Cont'd)

- If both cylinder block and piston are replaced with new ones, select piston of the same grade number punched on cylinder block upper surface.

3. Measure piston skirt diameter.

Piston diameter "A":

Refer to SDS, EM-57.

Measuring point "a" (Distance from the bottom):
49.0 mm (1.929 in)

4. Check that piston-to-bore clearance is within specification.

Piston-to-bore clearance "B"

= Bore measurement "C"

- Piston diameter "A"

0.025 - 0.045 mm (0.0010 - 0.0018 in)

5. Determine piston oversize according to amount of cylinder wear.

Oversize pistons are available for service. Refer to SDS, EM-57.

6. Cylinder bore size is determined by adding piston-to-bore clearance to piston diameter "A".

Rebored size calculation:

$$D = A + B - C$$

where,

D: Bored diameter

A: Piston diameter as measured

B: Piston-to-bore clearance

C: Honing allowance 0.02 mm (0.0008 in)

7. Install main bearing caps, and tighten to the specified torque to prevent distortion of cylinder bores in final assembly.

8. Cut cylinder bores.

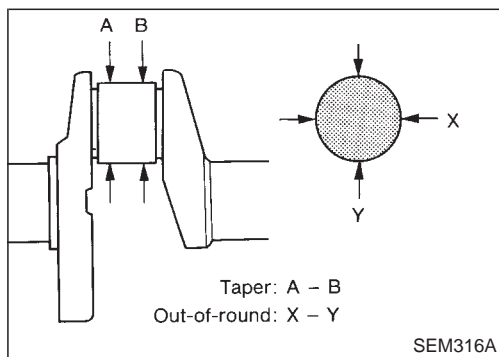
- **When any cylinder needs boring, all other cylinders must also be bored.**

- **Do not cut too much out of cylinder bore at a time. Cut only 0.05 mm (0.0020 in) or so in diameter at a time.**

9. Hone cylinders to obtain specified piston-to-bore clearance.

10. Measure finished cylinder bore for out-of-round and taper.

- **Measurement should be done after cylinder bore cools down.**



CRANKSHAFT

1. Check crankshaft main and pin journals for score, wear or cracks.

2. With a micrometer, measure journals for taper and out-of-round.

Out-of-round (X - Y):

Less than 0.005 mm (0.0002 in)

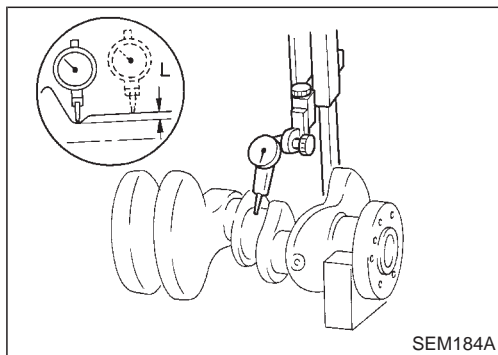
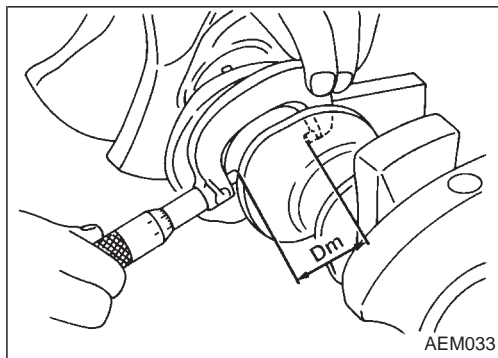
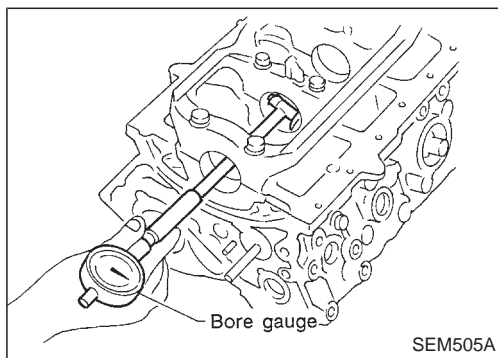
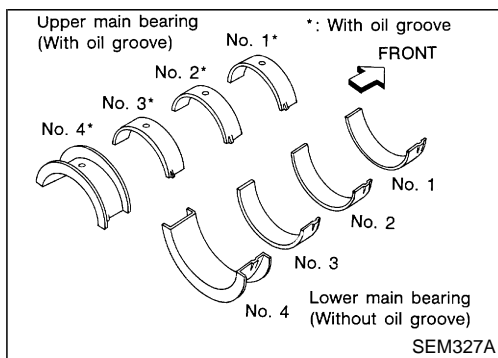
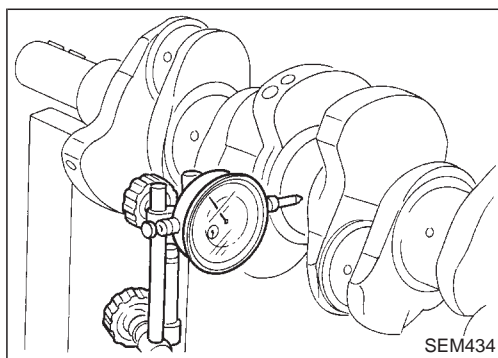
Taper (A - B):

Less than 0.005 mm (0.0002 in)

Inspection (Cont'd)

- Measure crankshaft runout.

Runout (Total indicator reading):
Less than 0.10 mm (0.0039 in)



BEARING CLEARANCE

- Either of the following two methods may be used, however, method A gives more reliable results and is preferable.

Method A (Using bore gauge & micrometer)**Main bearing**

- Set main bearings in their proper positions on cylinder block and main bearing cap.

- Install main bearing cap to cylinder block.

Tighten all bolts in correct order in two or three stages. Refer to EM-49.

- Measure inner diameter "A" of each main bearing.

- Measure outer diameter "Dm" of each crankshaft main journal.
- Calculate main bearing clearance.

$$\text{Main bearing clearance} = A - Dm$$

Standard:

0.028 - 0.055 mm (0.0011 - 0.0022 in)

Limit:

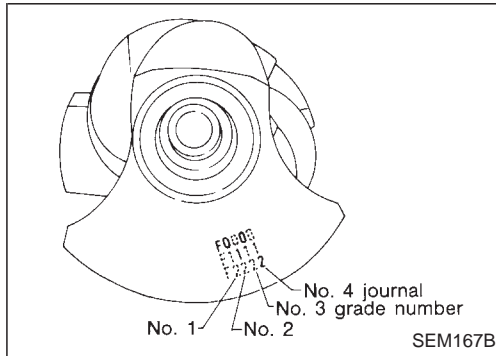
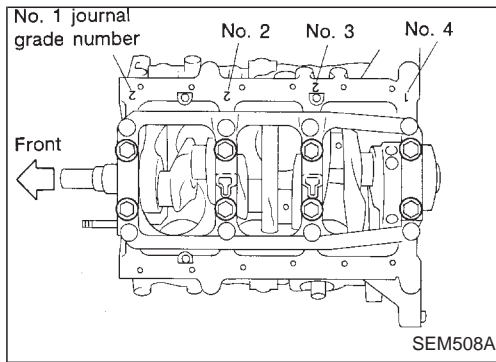
0.090 mm (0.0035 in)

- If it exceeds the limit, replace bearing.
- If clearance cannot be adjusted within the standard of any bearing, grind crankshaft journal and use undersize bearing.

- When grinding crankshaft journal, confirm that "L" dimension in fillet roll is more than the specified limit.

"L": 0.1 mm (0.004 in)

- Refer to SDS, EM-58, for grinding crankshaft and available service parts.



Inspection (Cont'd)

8. If crankshaft is reused, measure main bearing clearances and select thickness of main bearings.
If crankshaft is replaced with a new one, it is necessary to select thickness of main bearings as follows:

- Grade number of each cylinder block main journal is punched on the respective cylinder block.
- Grade number of each crankshaft main journal is punched on the respective crankshaft.
- Select main bearing with suitable thickness according to the following table.

Main bearing grade number

No. 1 main bearing

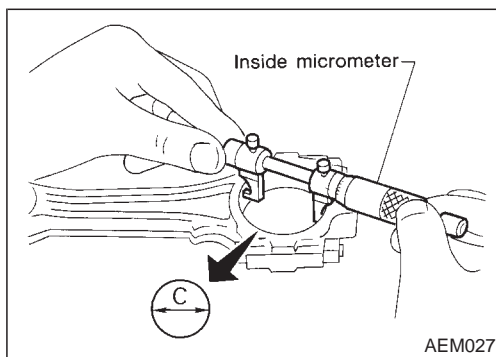
(Identification color):

Crank shaft main journal grade number	Cylinder block main journal grade number			
	3	4	5	6
3	0 (Black)	1 (Brown)	2 (Green)	3 (Yellow)
4	1 (Brown)	2 (Green)	3 (Yellow)	4 (Blue)
5	2 (Green)	3 (Yellow)	4 (Blue)	5 (Pink)
6	3 (Yellow)	4 (Blue)	5 (Pink)	6 (Purple)

No. 2, 3 and No. 4 main bearings

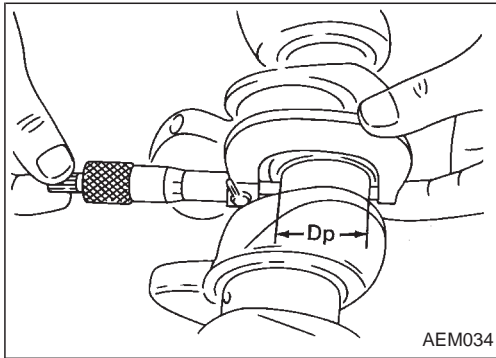
(Identification color):

		Main journal grade number		
		0	1	2
Crankshaft journal grade number	0	0 (Black)	1 (Brown)	2 (Green)
	1	1 (Brown)	2 (Green)	3 (Yellow)
	2	2 (Green)	3 (Yellow)	4 (Blue)



Connecting rod bearing (Big end)

- Install connecting rod bearing to connecting rod and cap.
- Install connecting rod cap to connecting rod.
- Tighten bolts to the specified torque. Refer to EM-50.**
- Measure inner diameter "C" of each bearing.



4. Measure outer diameter "Dp" of each crankshaft pin journal.
5. Calculate connecting rod bearing clearance.

$$\text{Connecting rod bearing clearance} = C - Dp$$

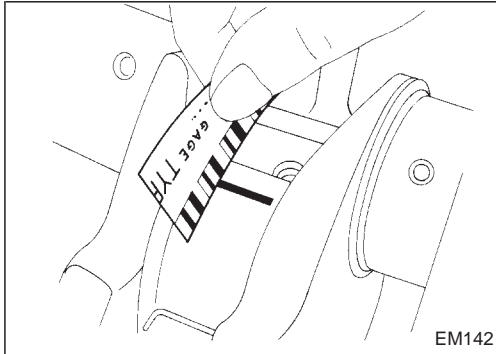
Standard:

0.014 - 0.054 mm (0.0006 - 0.0021 in)

Limit:

0.090 mm (0.0035 in)

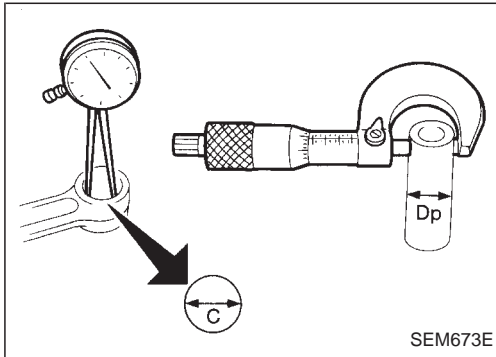
6. If it exceeds the limit, replace bearing.
7. If clearance cannot be adjusted within the standard of any bearing, grind crankshaft journal and use undersized bearing. Refer to step 7 of "Main bearing", "BEARING CLEARANCE".



Method B (Using plastigage)

CAUTION:

- Do not turn crankshaft or connecting rod while plastigage is being inserted.
- When bearing clearance exceeds the specified limit, ensure that the proper bearing has been installed. Then if excessive bearing clearance exists, use a thicker main bearing or undersized bearing so that the specified bearing clearance is obtained.



CONNECTING ROD BUSHING CLEARANCE (Small end)

1. Measure inner diameter "C" of bushing.

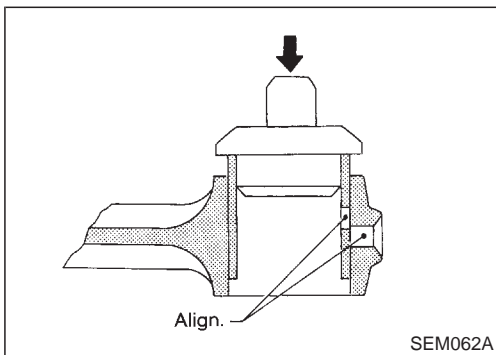
2. Measure outer diameter "Dp" of piston pin.
3. Calculate connecting rod bushing clearance.

$$\text{Connecting rod bushing clearance} = C - Dp$$

Standard: 0.005 - 0.017 mm (0.0002 - 0.0007 in)

Limit: 0.023 mm (0.0009 in)

If it exceeds the limit, replace connecting rod assembly or connecting rod bushing and/or piston set with pin.



REPLACEMENT OF CONNECTING ROD BUSHING (Small end)

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

Be sure to align the oil holes.

2. After driving in small end bushing, ream the bushing so that clearance between connecting rod bushing and piston pin is the specified value.

Clearance between connecting rod bushing and piston pin:

0.005 - 0.017 mm (0.0002 - 0.0007 in)

Inspection (Cont'd)

FLYWHEEL/DRIVE PLATE RUNOUT

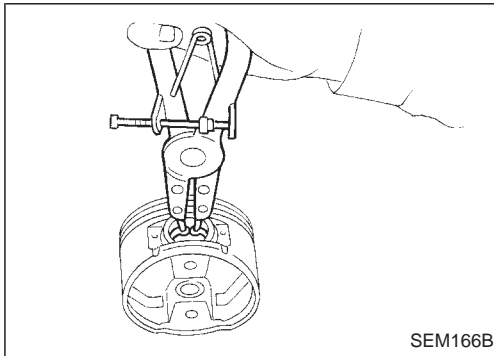
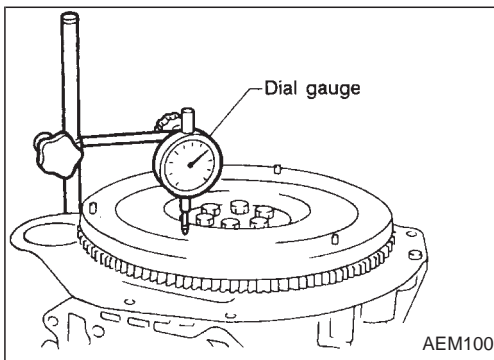
Runout (Total indicator reading):

Flywheel (M/T model)

Less than 0.15 mm (0.0059 in)

Drive plate (A/T model)

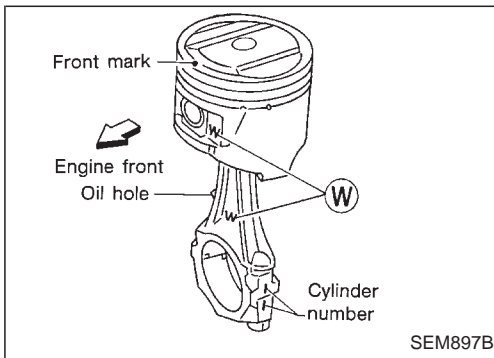
Less than 0.15 mm (0.0059 in)



Assembly

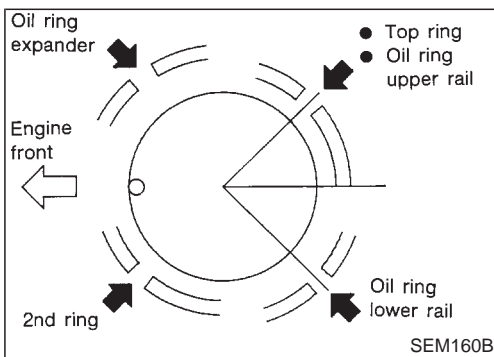
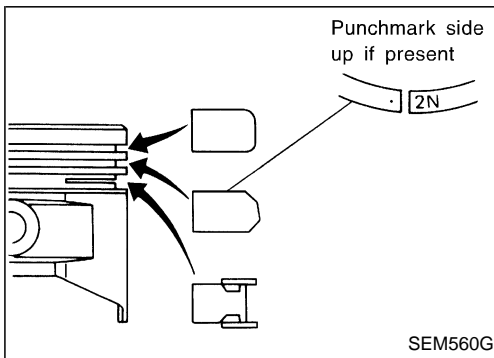
PISTON

1. Install new snap ring on one side of piston pin hole.



2. Heat piston to 60 to 70°C (140 to 158°F) and assemble piston, piston pin, connecting rod and new snap ring.

- Align the direction of piston and connecting rod.
- Numbers stamped on connecting rod and cap correspond to each cylinder.
- After assembly, make sure connecting rod swings smoothly.



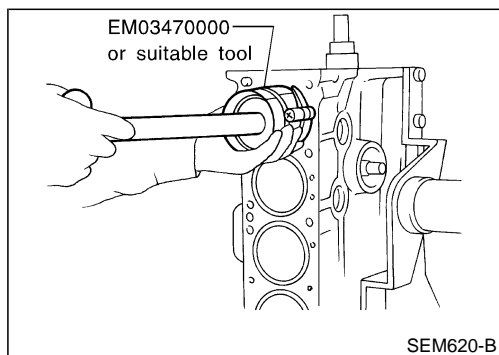
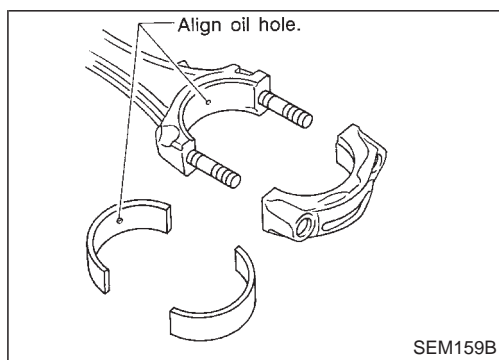
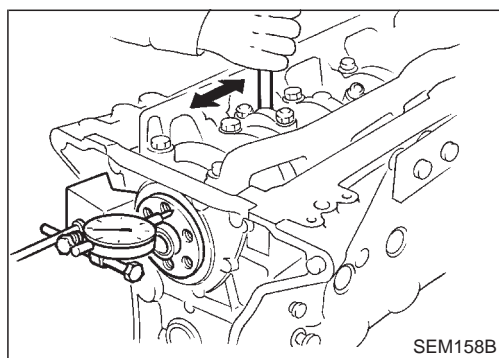
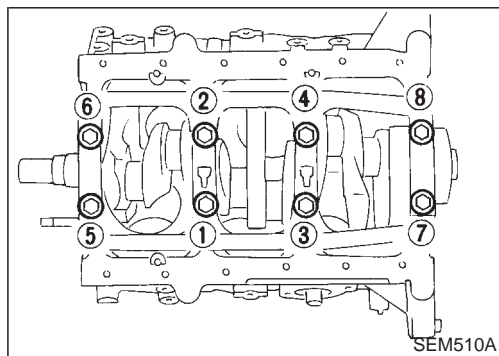
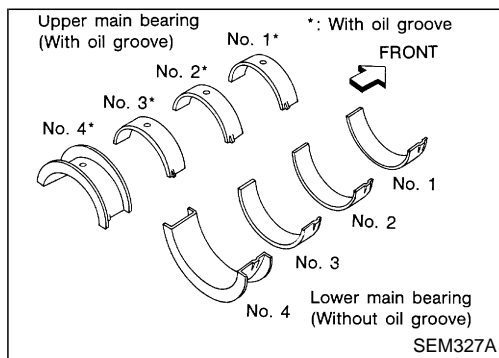
3. Set piston rings as shown.

CAUTION:

- When piston rings are not replaced, make sure that piston rings are mounted in their original positions.
- Install new piston rings either side up if there is no punchmark.
- Align piston rings so that end gaps are positioned as shown.

Assembly (Cont'd)

CRANKSHAFT



1. Set main bearings in their proper positions on cylinder block and main bearing cap.

- Confirm that correct main bearings are used. Refer to "Inspection", EM-45.

2. Install crankshaft and main bearing caps and tighten bolts to the specified torque.

- Prior to tightening bearing cap bolts, place bearing cap in its proper position by shifting crankshaft in the axial direction.
- Tighten bearing cap bolts gradually in two or three stages. Start with center bearing and move outward sequentially.
- After securing bearing cap bolts, make sure crankshaft turns smoothly by hand.
- Lubricate threads and seat surfaces of the bolts with new engine oil.

3. Measure crankshaft end play.

Crankshaft end play:

Standard

0.050 - 0.170 mm (0.0020 - 0.0067 in)

Limit

0.30 mm (0.0118 in)

If beyond the limit, replace bearing with a new one.

4. Install connecting rod bearings in connecting rods and connecting rod caps.

- Confirm that correct bearings are used.

Refer to "Inspection", EM-46.

- Install bearings so that oil hole in connecting rod aligns with oil hole of bearing.

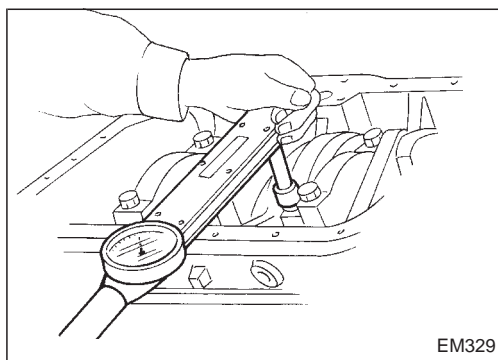
5. Install pistons with connecting rods.

- a. Install them into corresponding cylinders with Tool.

- Make sure connecting rod does not scratch cylinder wall.
- Make sure connecting rod bolts do not scratch crankshaft pin journals.

- Arrange so that front mark on piston head faces toward front of engine.

- Apply new engine oil to piston rings and sliding surface of piston.



EM329

Assembly (Cont'd)

b. Install connecting rod bearing caps.

- Lubricate threads and seat surfaces of the bolts with new engine oil.
- Apply new engine oil to bolt threads and nut seating surfaces.

Tighten connecting rod bearing cap nuts to the specified torque.

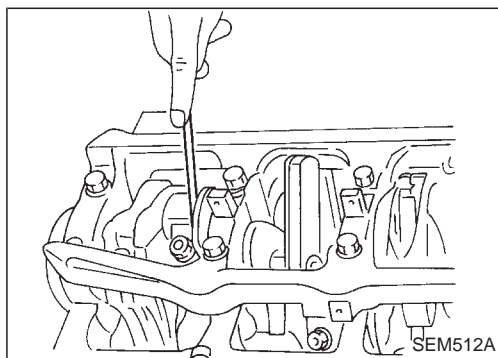
Connecting rod bearing nut

(1) Tighten to 14 to 16 N·m

(1.4 to 1.6 kg-m, 10 to 12 ft-lb).

(2) Turn nuts 60 to 65 degrees clockwise.

If an angle wrench is not available, tighten nuts to 38 to 44 N·m (3.9 to 4.5 kg-m, 28 to 33 ft-lb).



SEM512A

6. Measure connecting rod side clearance.

Connecting rod side clearance:

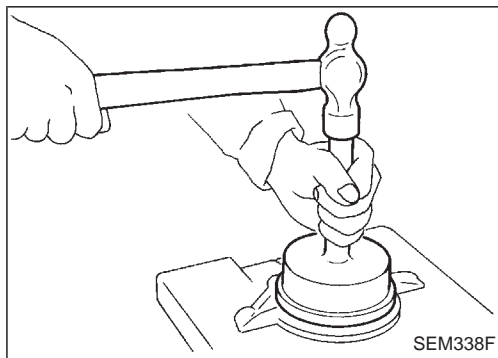
Standard

0.20 - 0.35 mm (0.0079 - 0.0138 in)

Limit

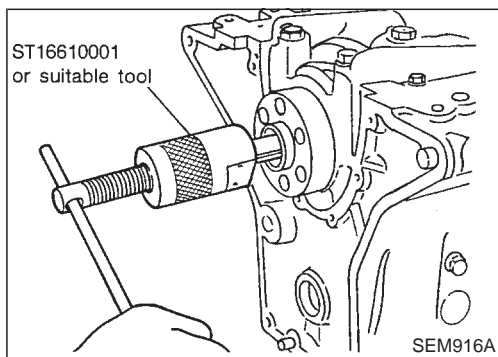
0.40 mm (0.0157 in)

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



SEM338F

7. Install rear oil seal retainer.



ST16610001
or suitable tool

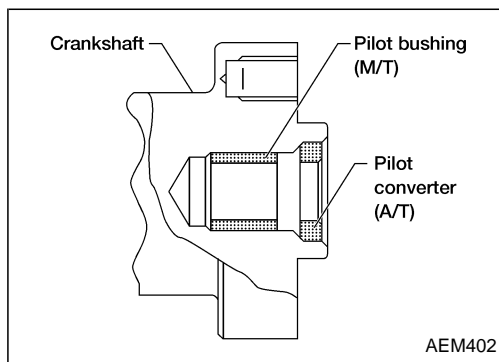
SEM916A

REPLACEMENT OF PILOT BUSHING (M/T) OR PILOT CONVERTER (A/T)

1. Remove pilot bushing (M/T) or pilot converter (A/T) using Tool or other suitable tool.

Assembly (Cont'd)

2. Install pilot bushing (M/T) or pilot converter (A/T) as shown.



GI

MA

EM

LC

EC

FE

CL

MT

AT

TF

PD

FA

RA

BR

ST

RS

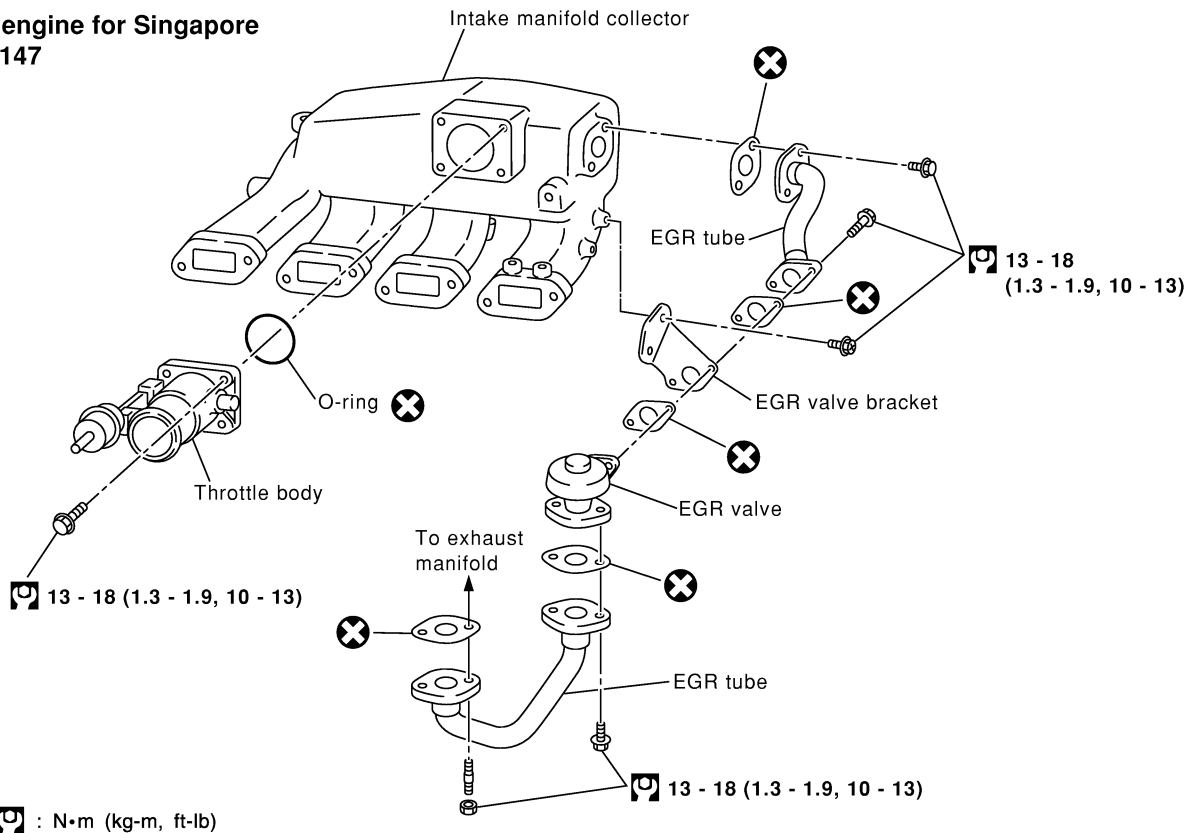
BT

HA

EL

IDX

**TD27 engine for Singapore
SEC. 147**

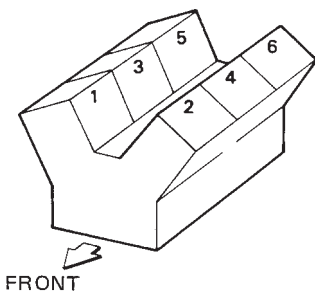


SEM597G

General Specifications

Cylinder arrangement	V-6	
Displacement	cm ³ (cu in)	2,960 (180.62)
Bore and stroke	mm (in)	87 x 83 (3.43 x 3.27)
Valve arrangement	OHC	
Firing order	1-2-3-4-5-6	
Number of piston rings		
Compression	2	
Oil	1	
Number of main bearings	4	
Compression ratio	9.0	

Cylinder number



SEM713A

COMPRESSION PRESSURE

Unit: kPa (bar, kg/cm², psi)/300 rpm

Compression pressure	
Standard	1,196 (11.96, 12.2, 173)
Minimum	883 (8.83, 9.0, 128)
Differential limit between cylinders	98 (0.98, 1.0, 14)

GI

MA

EM

LC

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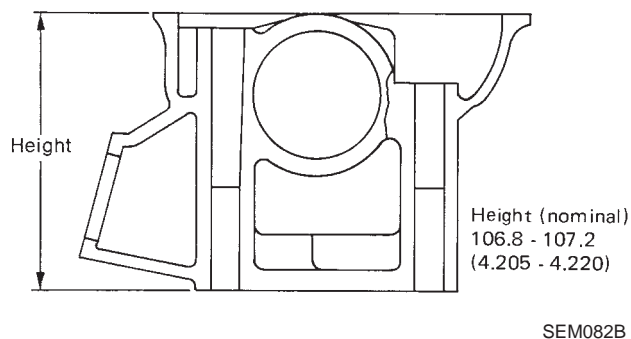
IDX

Inspection and Adjustment

CYLINDER HEAD

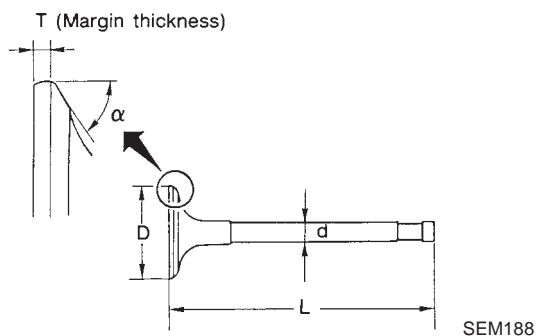
Unit: mm (in)

	Standard	Limit
Head surface distortion	Less than 0.03 (0.0012)	0.1 (0.004)



VALVE

Unit: mm (in)



Valve head diameter "D"	
Intake	42.0 - 42.2 (1.654 - 1.661)
Exhaust	35.0 - 35.2 (1.378 - 1.386)
Valve length "L"	
Intake	125.3 - 125.9 (4.933 - 4.957)
Exhaust	124.2 - 124.8 (4.890 - 4.913)
Valve stem diameter "d"	
Intake	6.965 - 6.980 (0.2742 - 0.2748)
Exhaust	7.962 - 7.970 (0.3135 - 0.3138)
Valve seat angle "α"	
Intake	45°15' - 45°45'
Exhaust	
Valve margin "T"	
Intake	1.15 - 1.45 (0.0453 - 0.0571)
Exhaust	1.35 - 1.65 (0.0531 - 0.0650)
Valve margin "T" limit	More than 0.5 (0.020)
Valve stem end surface grinding limit	Less than 0.2 (0.008)
Valve clearance	
Intake	0 (0)
Exhaust	0 (0)

Valve spring

Free height mm (in)	Outer	51.2 (2.016)
	Inner	44.1 (1.736)
Pressure N (kg, lb) at height mm (in)	Outer	523.7 (53.4, 117.7) at 30.0 (1.181)
	Inner	255.0 (26.0, 57.3) at 25.0 (0.984)
Out-of-square mm (in)	Outer	2.2 (0.087)
	Inner	1.9 (0.075)

Hydraulic valve lifter

Unit: mm (in)

Lifter outside diameter	15.947 - 15.957 (0.6278 - 0.6282)
Lifter guide inside diameter	16.000 - 16.013 (0.6299 - 0.6304)
Clearance between lifter and lifter guide	0.043 - 0.066 (0.0017 - 0.0026)

Valve guide

Unit: mm (in)

		Standard	Service
Valve guide			
Outer diameter	Intake	11.023 - 11.034 (0.4340 - 0.4344)	11.223 - 11.234 (0.4418 - 0.4423)
	Exhaust	12.023 - 12.034 (0.4733 - 0.4738)	12.223 - 12.234 (0.4812 - 0.4817)
Valve guide			
Inner diameter (Finished size)	Intake	7.000 - 7.018 (0.2756 - 0.2763)	
	Exhaust	8.000 - 8.018 (0.3150 - 0.3157)	
Cylinder head valve guide hole diameter	Intake	10.975 - 10.996 (0.4321 - 0.4329)	11.175 - 11.196 (0.4400 - 0.4408)
	Exhaust	11.975 - 11.996 (0.4715 - 0.4723)	12.175 - 12.196 (0.4793 - 0.4802)
Interference fit of valve guide	Intake	0.027 - 0.059 (0.0011 - 0.0023)	
	Exhaust		
		Standard	Max. tolerance
Stem to guide clearance	Intake	0.020 - 0.053 (0.0008 - 0.0021)	0.10 (0.0039)
	Exhaust	0.030 - 0.056 (0.0012 - 0.0022)	
Valve deflection limit		—	0.20 (0.0079)

Inspection and Adjustment (Cont'd)

Rocker shaft and rocker arm

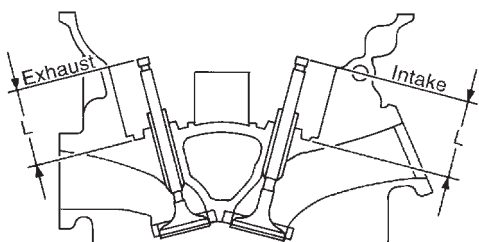
Unit: mm (in)

Rocker shaft	
Outer diameter	17.988 - 18.000 (0.7082 - 0.7087)
Rocker arm	
Inner diameter	18.007 - 18.028 (0.7089 - 0.7098)
Clearance between rocker arm and rocker shaft	0.007 - 0.040 (0.0003 - 0.0016)

VALVE SEAT

Valve seat resurface limit

Unit: mm (in)



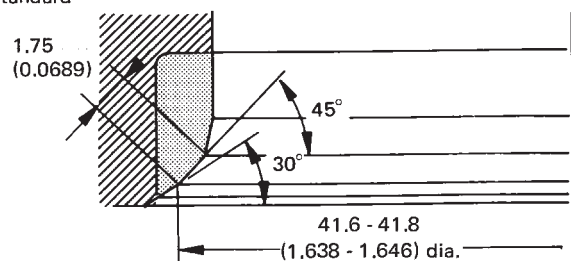
SEM621F

Valve seat resurface limit "L"

Intake	44.7 - 44.9 (1.7598 - 1.7677)
Exhaust	45.4 - 45.6 (1.7874 - 1.7953)

Intake valve seat

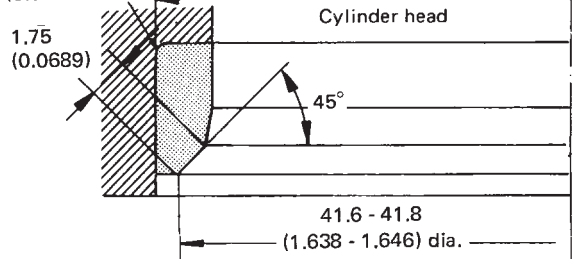
Standard



Oversize [0.5 (0.020)]

R0.3 - 0.5

(0.012 - 0.020)

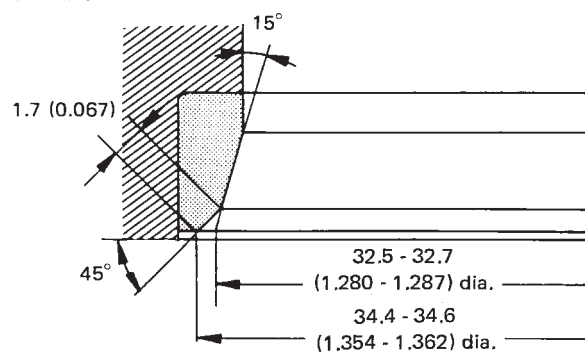


Unit: mm (in)

SEM755A

Exhaust valve seat

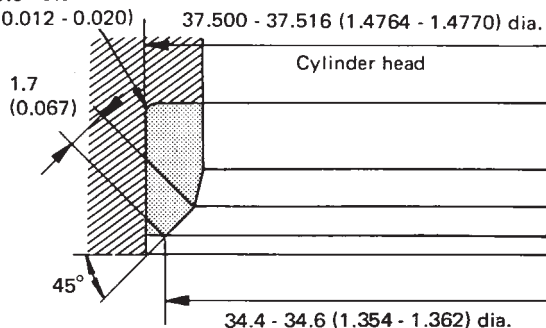
Standard



Oversize [0.5 (0.020)]

R0.3 - 0.5

(0.012 - 0.020)



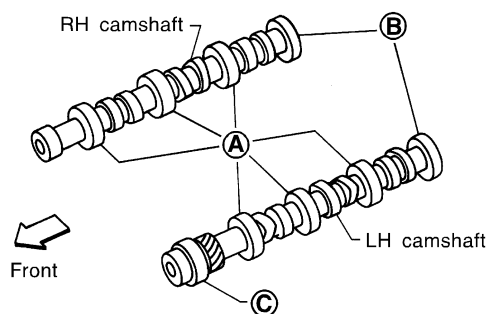
Unit: mm (in)

SEM756A

Inspection and Adjustment (Cont'd)

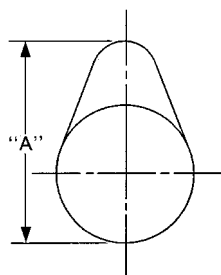
CAMSHAFT AND CAMSHAFT BEARING

Unit: mm (in)



SEM893BB

	Standard	Max. tolerance
Camshaft journal to bearing clearance	0.060 - 0.105 (0.0024 - 0.0041)	—
Inner diameter of camshaft bearing	Ⓐ: 47.000 - 47.025 (1.8504 - 1.8514)	—
	Ⓑ: 42.500 - 42.525 (1.6732 - 1.6742)	—
	Ⓒ: 48.000 - 48.025 (1.8898 - 1.8907)	—
Outer diameter of camshaft journal	Ⓐ: 46.920 - 46.940 (1.8472 - 1.8480)	—
	Ⓑ: 42.420 - 42.440 (1.6701 - 1.6709)	—
	Ⓒ: 47.920 - 47.940 (1.8866 - 1.8874)	—
Camshaft runout [TIR*]	Less than 0.04 (0.0016)	0.1 (0.004)
Camshaft end play	0.03 - 0.06 (0.0012 - 0.0024)	—

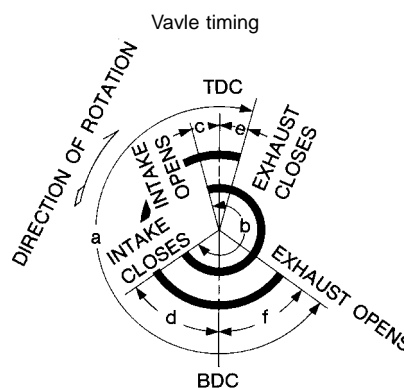


EM671

Cam height "A"

Intake	39.537 - 39.727 (1.5566 - 1.5641)
Exhaust	
Wear limit of cam height	0.15 (0.0059)

*: Total indicator reading



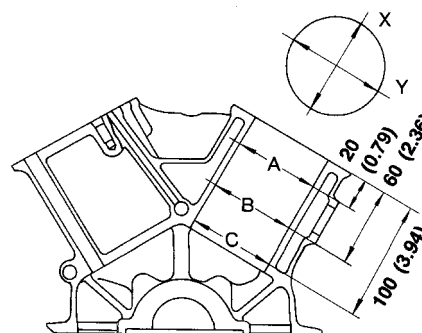
EM120

Unit: degree

a	b	c	d	e	f
248	248	10	58	10	58

CYLINDER BLOCK

Unit: mm (in)



SEM321A

Surface flatness

Standard	Less than 0.03 (0.0012)
Limit	0.10 (0.0039)

Cylinder bore

Inner diameter

Standard	
Grade No. 1	87.000 - 87.010 (3.4252 - 3.4256)
Grade No. 2	87.010 - 87.020 (3.4256 - 3.4260)
Grade No. 3	87.020 - 87.030 (3.4260 - 3.4264)
Wear limit	0.20 (0.0079)

Out-of-round (X - Y)	Less than 0.015 (0.0006)
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Taper (A - B - C)	Less than 0.015 (0.0006)
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Main journal inner diameter

No. 1 main journal

Grade No. 3	66.645 - 66.651 (2.6238 - 2.6240)
Grade No. 4	66.651 - 66.657 (2.6240 - 2.6243)
Grade No. 5	66.657 - 66.663 (2.6243 - 2.6245)
Grade No. 6	66.663 - 66.669 (2.6245 - 2.6248)

No. 2, 3 and 4 main journals

Grade No. 0	66.645 - 66.654 (2.6238 - 2.6242)
Grade No. 1	66.654 - 66.663 (2.6242 - 2.6245)
Grade No. 2	66.663 - 66.672 (2.6245 - 2.6249)

Difference in inner diameter between cylinders

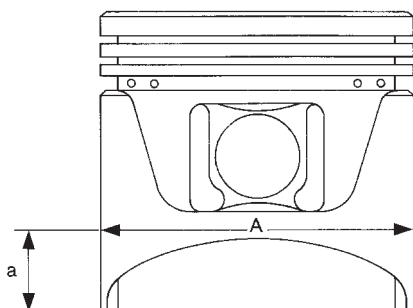
Standard	Less than 0.05 (0.0020)
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Inspection and Adjustment (Cont'd)

PISTON, PISTON RING AND PISTON PIN

Available piston

Unit: mm (in)



SEM891B

Piston skirt diameter "A"

Standard

Grade No. 1	86.965 - 86.975 (3.4238 - 3.4242)
Grade No. 2	86.975 - 86.985 (3.4242 - 3.4246)
Grade No. 3	86.985 - 86.995 (3.4246 - 3.4250)
0.25 (0.0098) oversize (Service)	87.215 - 87.265 (3.4337 - 3.4356)
0.50 (0.0197) oversize (Service)	87.465 - 87.515 (3.4435 - 3.4455)

"a" dimension 18 (0.71)

Piston pin hole diameter 20.969 - 20.981 (0.8255 - 0.8260)

Piston clearance to cylinder block 0.025 - 0.045 (0.0010 - 0.0018)

Piston ring

Unit: mm (in)

	Standard	Limit
Side clearance		
Top	0.040 - 0.073 (0.0016 - 0.0029)	0.1 (0.004)
2nd	0.030 - 0.063 (0.0012 - 0.0025)	
Oil	0.015 - 0.190 (0.0006 - 0.0075)	
Ring gap		
Top	0.21 - 0.44 (0.0083 - 0.0173)	1.0 (0.039)
2nd	0.18 - 0.44 (0.0071 - 0.0173)	
Oil (rail ring)	0.20 - 0.76 (0.0079 - 0.0299)	

Piston pin

Unit: mm (in)

Piston pin outer diameter	20.971 - 20.983 (0.8256 - 0.8261)
Interference fit of piston pin to piston	0 - 0.004 (0 - 0.0002)
Piston pin to connecting rod bushing clearance	0.005 - 0.017 (0.0002 - 0.0007)

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

CONNECTING ROD

Unit: mm (in)

Center distance	154.1 - 154.2 (6.067 - 6.071)
Bend, torsion [per 100 (3.94)]	
Limit	Bend: 0.15 (0.0059) Torsion: 0.30 (0.0118)
Piston pin bushing inner diameter*	20.982 - 20.994 (0.8261 - 0.8265)
Connecting rod big end inner diameter	53.000 - 53.013 (2.0866 - 2.0871)
Side clearance	
Standard	0.20 - 0.35 (0.0079 - 0.0138)
Limit	0.40 (0.0157)

*: After installing in connecting rod

Inspection and Adjustment (Cont'd)

CRANKSHAFT

Unit: mm (in)

Main journal dia. "Dm"

No. 1 main journal

Grade No. 3	62.969 - 62.975 (2.4791 - 2.4793)
Grade No. 4	62.963 - 62.969 (2.4789 - 2.4791)
Grade No. 5	62.957 - 62.963 (2.4786 - 2.4789)
Grade No. 6	62.951 - 62.957 (2.4784 - 2.4786)

No. 2, 3 and 4 main journals

Grade No. 0	62.967 - 62.975 (2.4790 - 2.4793)
Grade No. 1	62.959 - 62.967 (2.4787 - 2.4790)
Grade No. 2	62.951 - 62.959 (2.4784 - 2.4787)

Pin journal dia. "Dp" 49.955 - 49.974 (1.9667 - 1.9675)

Center distance "r" 41.5 (1.634)

Out-of-round (X - Y)

Standard Less than 0.005 (0.0002)

Taper (A - B)

Standard Less than 0.005 (0.0002)

Runout [TIR]

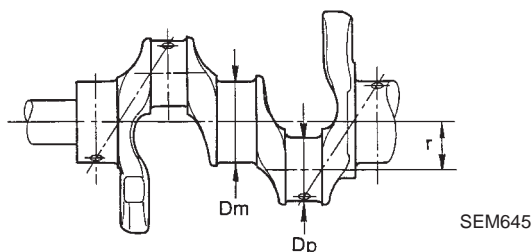
Standard Less than 0.025 (0.0010)

Limit Less than 0.10 (0.0039)

Free end play

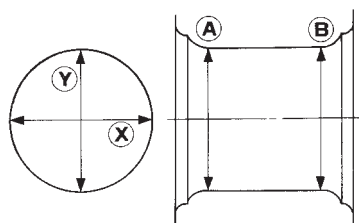
Standard 0.050 - 0.170 (0.0020 - 0.0067)

Limit 0.30 (0.0118)



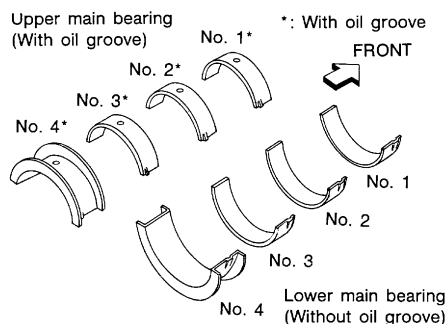
SEM645

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



EM715

AVAILABLE MAIN BEARING



SEM327A

No. 1 main bearing

Grade number	Thickness "T" mm (in)	Width "W" mm (in)	Identification color
0	1.822 - 1.825 (0.0717 - 0.0719)	22.4 - 22.6 (0.882 - 0.890)	Black
1	1.825 - 1.828 (0.0719 - 0.0720)		Brown
2	1.828 - 1.831 (0.0720 - 0.0721)		Green
3	1.831 - 1.834 (0.0721 - 0.0722)		Yellow
4	1.834 - 1.837 (0.0722 - 0.0723)		Blue
5	1.837 - 1.840 (0.0723 - 0.0724)		Pink
6	1.840 - 1.843 (0.0724 - 0.0726)		Purple

No. 2 and 3 main bearings

Grade number	Thickness "T" mm (in)	Width "W" mm (in)	Identification color
0	1.817 - 1.821 (0.0715 - 0.0717)	18.9 - 19.1 (0.744 - 0.752)	Black
1	1.821 - 1.825 (0.0717 - 0.0719)		Brown
2	1.825 - 1.829 (0.0719 - 0.0720)		Green
3	1.829 - 1.833 (0.0720 - 0.0722)		Yellow
4	1.833 - 1.837 (0.0722 - 0.0723)		Blue

No. 4 main bearing

Grade number	Thickness "T" mm (in)	Identification color
0	1.817 - 1.821 (0.0715 - 0.0717)	Black
1	1.821 - 1.825 (0.0717 - 0.0719)	Brown
2	1.825 - 1.829 (0.0719 - 0.0720)	Green
3	1.829 - 1.833 (0.0720 - 0.0722)	Yellow
4	1.833 - 1.837 (0.0722 - 0.0723)	Blue

Inspection and Adjustment (Cont'd)

Undersize

Unit: mm (in)

		Thickness "T"	Main journal diameter "Dm"
0.25 (0.0098)	No. 1 main bearing	1.956 - 1.962 (0.0770 - 0.0772)	Grind so that bearing clearance is the specified valve.
	No. 2, 3 and No. 4 main bearing	1.948 - 1.956 (0.0767 - 0.0770)	

AVAILABLE CONNECTING ROD BEARING

Connecting rod bearing undersize

Unit: mm (in)

	Thickness	Crank pin journal diameter "Dp"
Standard	1.502 - 1.506 (0.0591 - 0.0593)	49.961 - 49.974 (1.9670 - 1.9675)
Undersize		Grind so that bearing clearance is the specified value.
0.08 (0.0031)	1.542 - 1.546 (0.0607 - 0.0609)	
0.12 (0.0047)	1.562 - 1.566 (0.0615 - 0.0617)	
0.25 (0.0098)	1.627 - 1.631 (0.0641 - 0.0642)	

MISCELLANEOUS COMPONENTS

Unit: mm (in)

Flywheel/Drive plate

Runout [TIR]

Less than 0.15 (0.0059)

Bearing clearance

Unit: mm (in)

Main bearing clearance

Standard

0.028 - 0.055 (0.0011 - 0.0022)

Limit

0.090 (0.0035)

Connecting rod bearing clearance

Standard

0.014 - 0.054 (0.0006 - 0.0021)

Limit

0.090 (0.0035)

GI

MA

EM

LC

EC

FE

CL

MT

AT

TF

PD

FA

RA

BR

ST

RS

BT

HA

EL

IDX