ENGINE MECHANICAL

SECTION EM

MODIFICATION NOTICE:

- KA24DE engine information has been added for Europe.
  For information not included here, refer to information for KA24DE engine in D22 Supplement-II Service Manual (SM9E-D22BG0).
- YD25DDTi engine has newly been added.
- ZD30DDT engine has newly been added.

CONTENTS

CONTENTS (Cont'd)

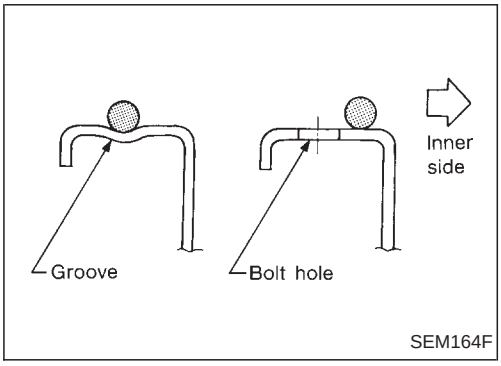
Parts Requiring Angular Tightening

- Use an angle wrench for the final tightening of the following engine parts:

a) Cylinder head bolts
b) Main bearing cap bolts (YD series)
c) Connecting rod cap nuts (KA and YD series)
d) Crankshaft pulley bolt (YD series)

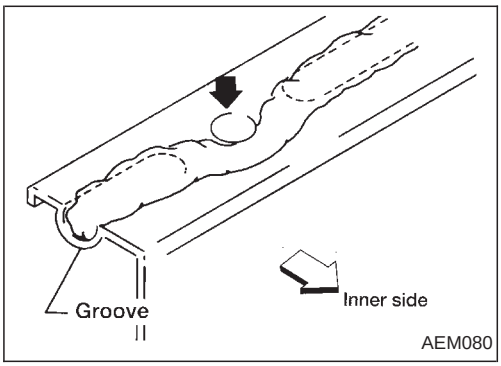
- Do not use a torque value for final tightening.
- The torque value for these parts are for a preliminary step.
- Ensure thread and seat surfaces are clean and coated with engine oil.

Liquid Gasket Application Procedure



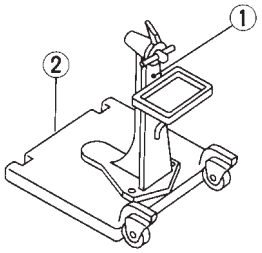
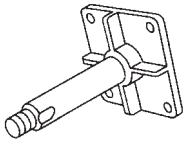
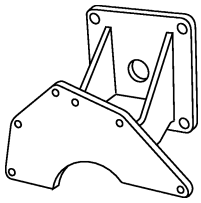
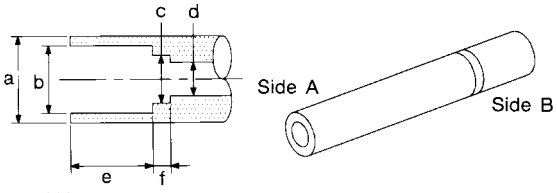
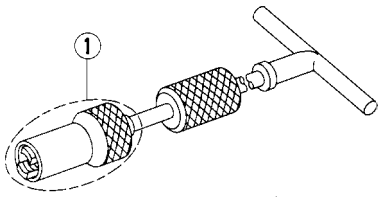
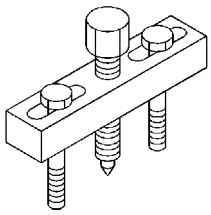
1. **Use a scraper to remove all traces of old liquid gasket from mating surfaces and grooves. Also, completely clean any oil from these areas.**
2. **Apply a continuous bead of liquid gasket to mating surfaces. (Use Genuine Liquid Gasket or equivalent.)**

- Be sure liquid gasket diameter is as specified in this manual.

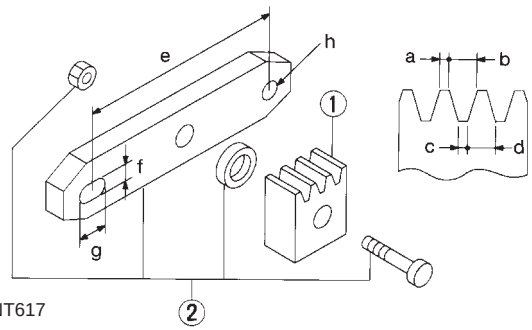
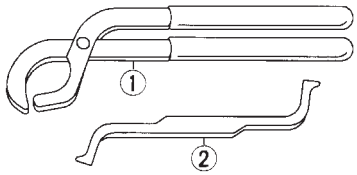
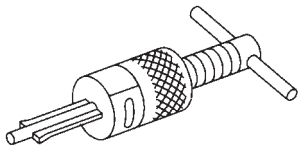
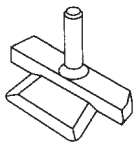
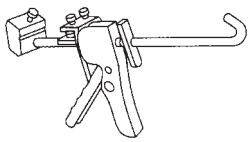
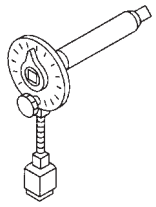
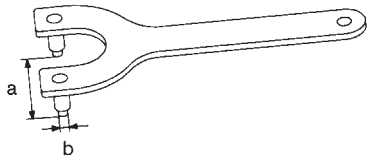


3. **Apply liquid gasket around the inner side of bolt holes (unless otherwise specified).**
4. **Assembly should be done within 5 minutes after coating.**
5. **Wait at least 30 minutes before refilling engine oil and engine coolant.**

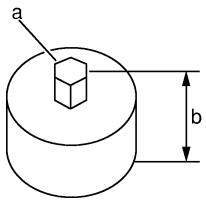
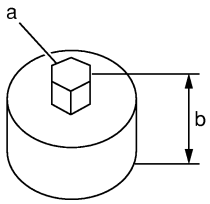
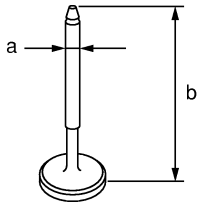
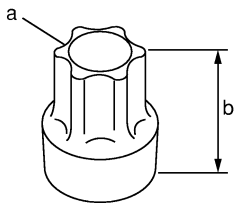
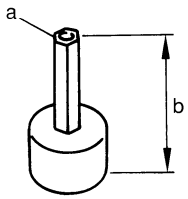
Special Service Tools (YD25DDTi engine)

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
KV11105900 Engine sub-attachment	KV10115900 has been replaced with KV10106500.  NT799
KV10115600 Valve oil seal drift	Installing valve oil seal **Use side A.** **Side A** **a: 20 (0.79) dia.** **b: 13 (0.51) dia.** **c: 10.3 (0.406) dia.** **d: 8 (0.31) dia.** **e: 10.7 (0.421)** **f: 5 (0.20)** Unit: mm (in)  NT603
KV10107902 Valve oil seal puller 1 KV10116100 Valve oil seal puller adapter	Removing valve oil seal  NT605
KV11103000 Injection pump drive gear puller	Removing crankshaft pulley  NT676

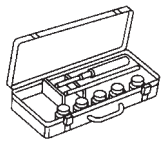
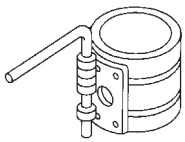
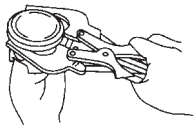
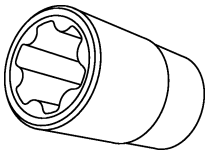
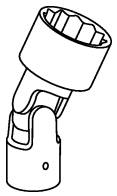
Special Service Tools (YD25DDTi engine) (Cont'd)

Tool number Tool name	Description	
KV101056S0 Ring gear stopper 1 KV10105630 Adapter 2 KV10105610 Plate	 NT617	Preventing crankshaft from rotating **a: 3 (0.12)** **b: 6.4 (0.252)** **c: 2.8 (0.110)** **d: 6.6 (0.260)** **e: 107 (4.21)** **f: 14 (0.55)** **g: 20 (0.79)** **h: 14 (0.55) dia.** Unit: mm (in)
KV101151S0 Lifter stopper set 1 KV10115110 Camshaft pliers 2 KV10115120 Lifter stopper	 NT041	Changing valve lifter shims
ST16610001 Pilot bushing puller	 NT045	Removing crankshaft pilot bushing
KV10111100 Seal cutter	 NT046	Removing steel oil pan and rear timing chain case
WS39930000 Tube presser	 NT052	Pressing the tube of liquid gasket
KV10112100 Angle wrench	 NT014	Tightening bolts for bearing cap, cylinder head, etc.
KV10109300 Pulley holder	 NT628	**a: 68 mm (2.68 in)** **b: 8 mm (0.31 in) dia.**

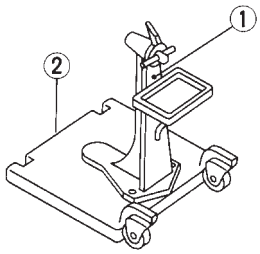
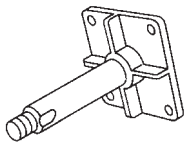
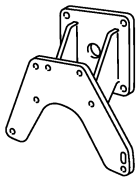
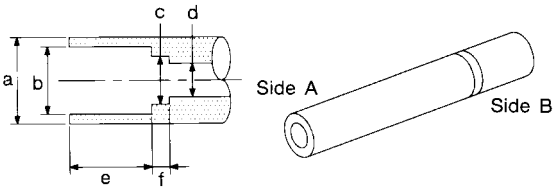
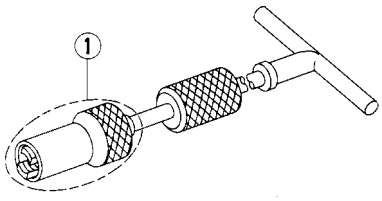
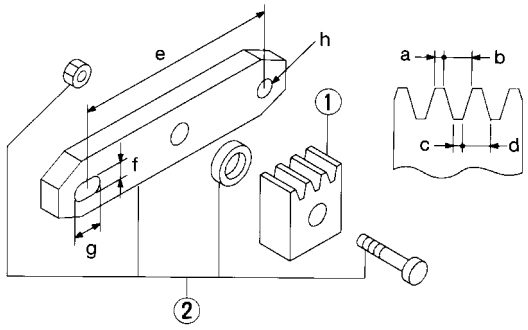
Special Service Tools (YD25DDTi engine) (Cont'd)

Tool number Tool name	Description	
KV11106010 Hexagon wrench	 NT801	**a: 5 mm (0.20 in) (Face to face)** **b: 20 mm (0.79 in)**
KV11106020 Hexagon wrench	 NT803	**a: 6 mm (0.24 in) (Face to face)** **b: 20 mm (0.79 in)**
KV11106030 Positioning stopper pin	 NT804	**a: 6 mm (0.24 in) dia.** **b: 80 mm (3.15 in)**
KV11106040 TORX wrench	 NT805	**a: T70** **b: 26 mm (1.02 in)**
KV11106050 Hexagonal wrench	 SBIA0224E	**a: 6 mm (0.24 in) (Face to face)** **b: 42 mm (1.65 in)** Removing and installing mounting bolts of fuel injection pump sprocket

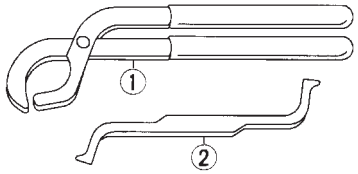
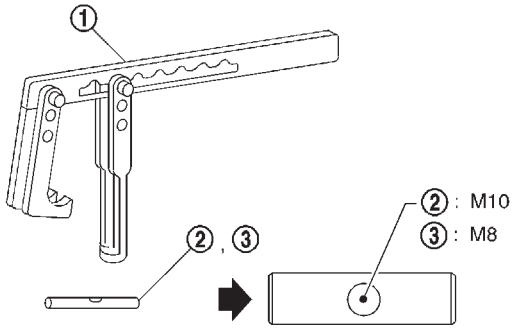
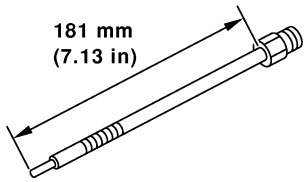
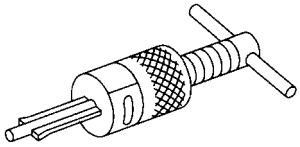
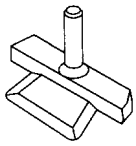
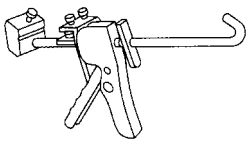
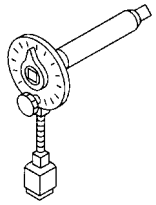
Commercial Service Tools (YD25DDTi engine)

Tool name	Description	
Valve seat cutter set	 NT048	Finishing valve seat dimensions
Piston ring compressor	 NT044	Installing piston assembly into cylinder bore
Piston ring expander	 NT030	Removing and installing piston ring
TORX socket	 NT807	
Standard Universal	 NT808	

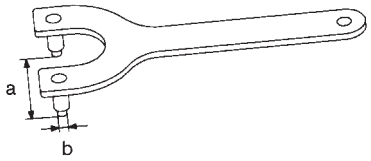
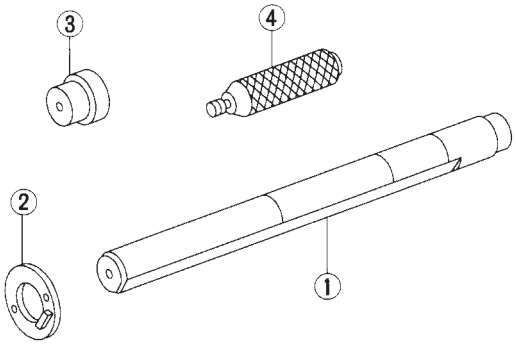
Special Service Tools (ZD30DDT engine)

Tool number Tool name	Description	
ST0501S000 Engine stand assembly ① ST05011000 Engine stand ② ST05012000 Base	 NT042	Disassembling and assembling
KV10106500 Engine stand shaft	 NT028	
KV11106101 Engine sub-attachment	 NT819	
KV10115600 Valve oil seal drift	 NT603	Installing valve oil seal **Use side A.** **Side A** **a: 20 (0.79) dia.** **b: 13 (0.51) dia.** **c: 10.3 (0.406) dia.** **d: 8 (0.31) dia.** **e: 10.7 (0.421)** **f: 5 (0.20)** Unit: mm (in)
KV10107902 Valve oil seal puller ① KV10116100 Valve oil seal puller adapter	 NT605	Removing valve oil seal
KV101056S0 Ring gear stopper ① KV10105630 Adapter ② KV10105610 Plate	 NT617	Preventing crankshaft from rotating **a: 3 (0.12)** **b: 6.4 (0.252)** **c: 2.8 (0.110)** **d: 6.6 (0.260)** **e: 107 (4.21)** **f: 14 (0.55)** **g: 20 (0.79)** **h: 14 (0.55) dia.** Unit: mm (in)

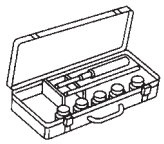
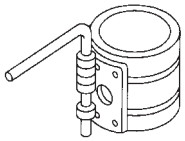
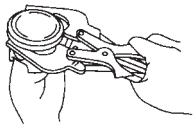
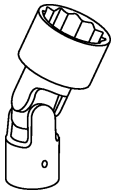
Special Service Tools (ZD30DDT engine) (Cont'd)

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

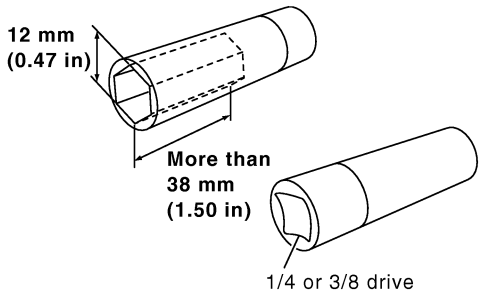
Special Service Tools (ZD30DDT engine) (Cont'd)

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

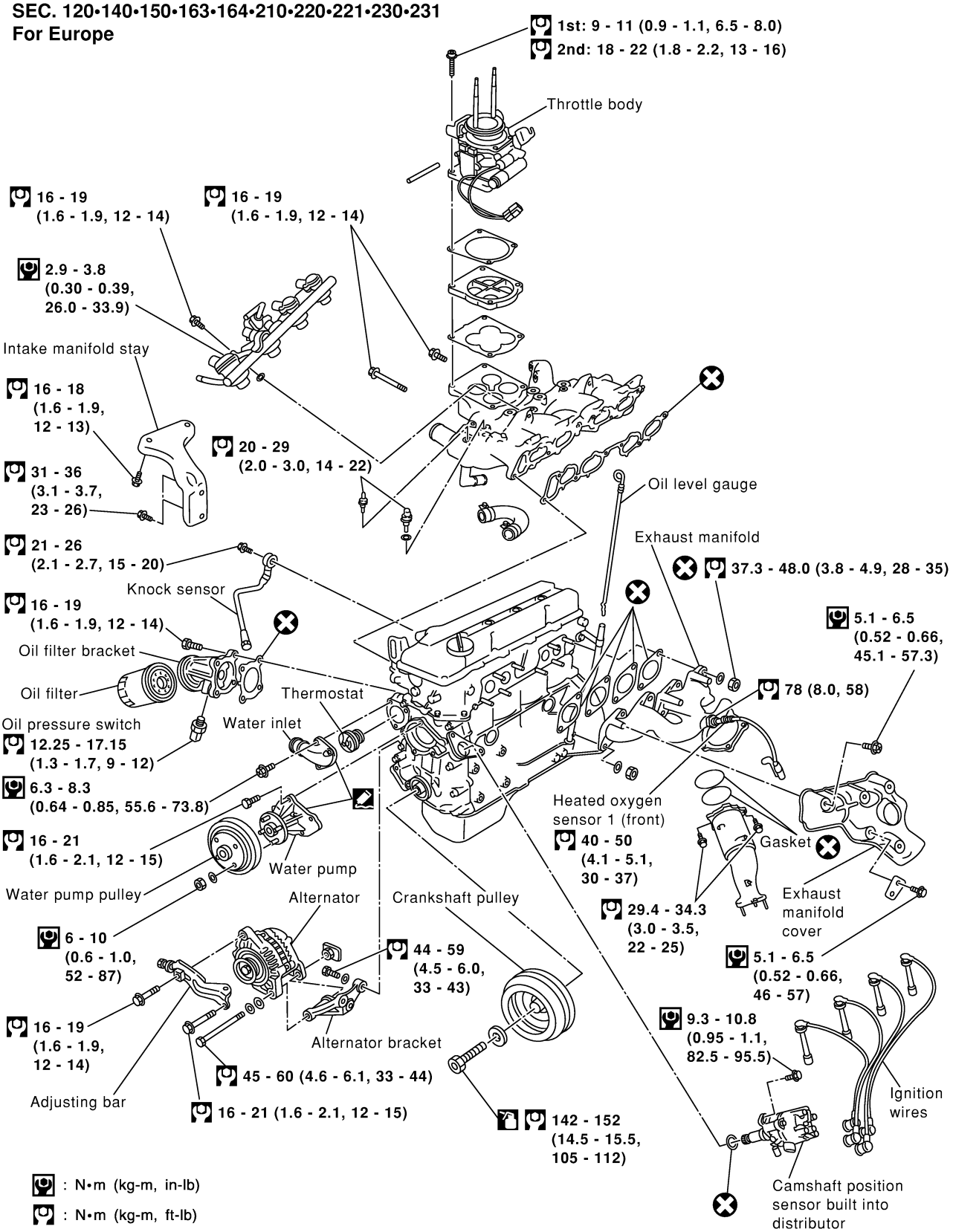
Commercial Service Tools (ZD30DDT engine)

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

Commercial Service Tools (ZD30DDT engine) (Cont'd)

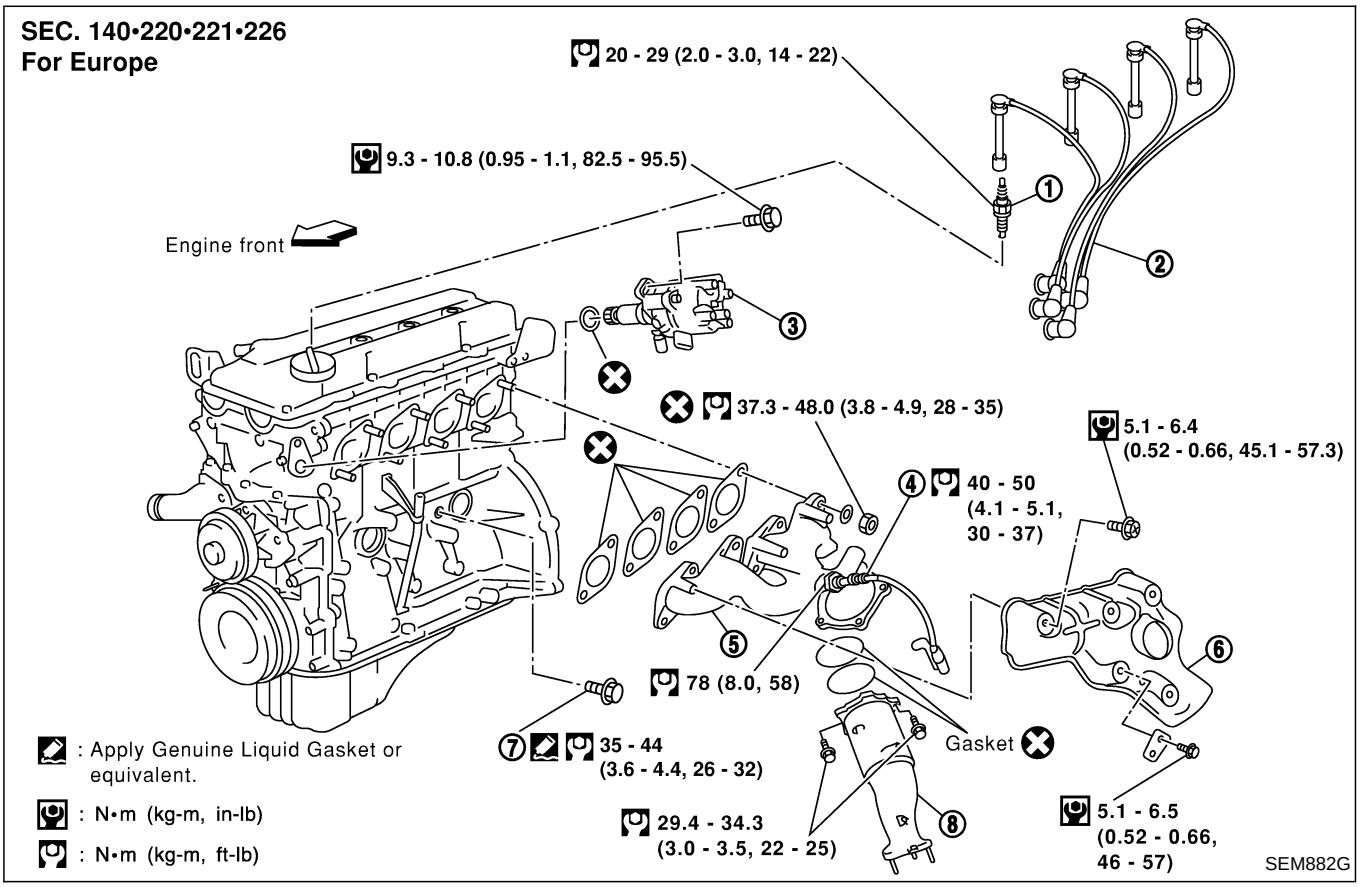
Tool name	Description
Deep socket (12 mm)	Removing and installing glow plugs  NT821

SEC. 120•140•150•163•164•210•220•221•230•231
For Europe



: N•m (kg-m, in-lb)
: N•m (kg-m, ft-lb)
: Apply Genuine Liquid Gasket or equivalent.
: Lubricate with new engine oil.

SEM881G

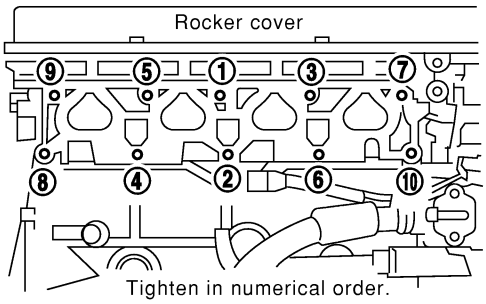


① Spark plug
② Ignition wire
③ Camshaft position sensor built into distributor
④ Heated oxygen sensor 1 (front)
⑤ Exhaust manifold
⑥ Exhaust manifold cover
⑦ Water drain plug
⑧ TWC (manifold)

For Europe

Intake manifold

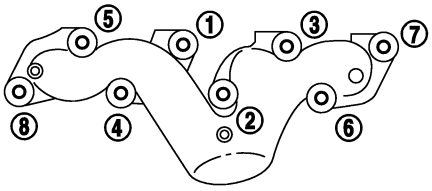
Engine front



Tighten in numerical order.
Loosen in reverse order.

15.7 - 18.6 (1.6 - 1.9, 11.6 - 13.7)

Exhaust manifold

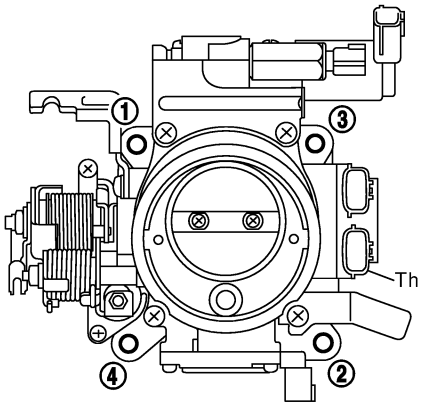


Tighten in numerical order.
Loosen in reverse order.

37.3 - 48.0 (3.8 - 4.9, 27.5 - 35.4)

: N•m (kg-m, ft-lb)

Throttle body



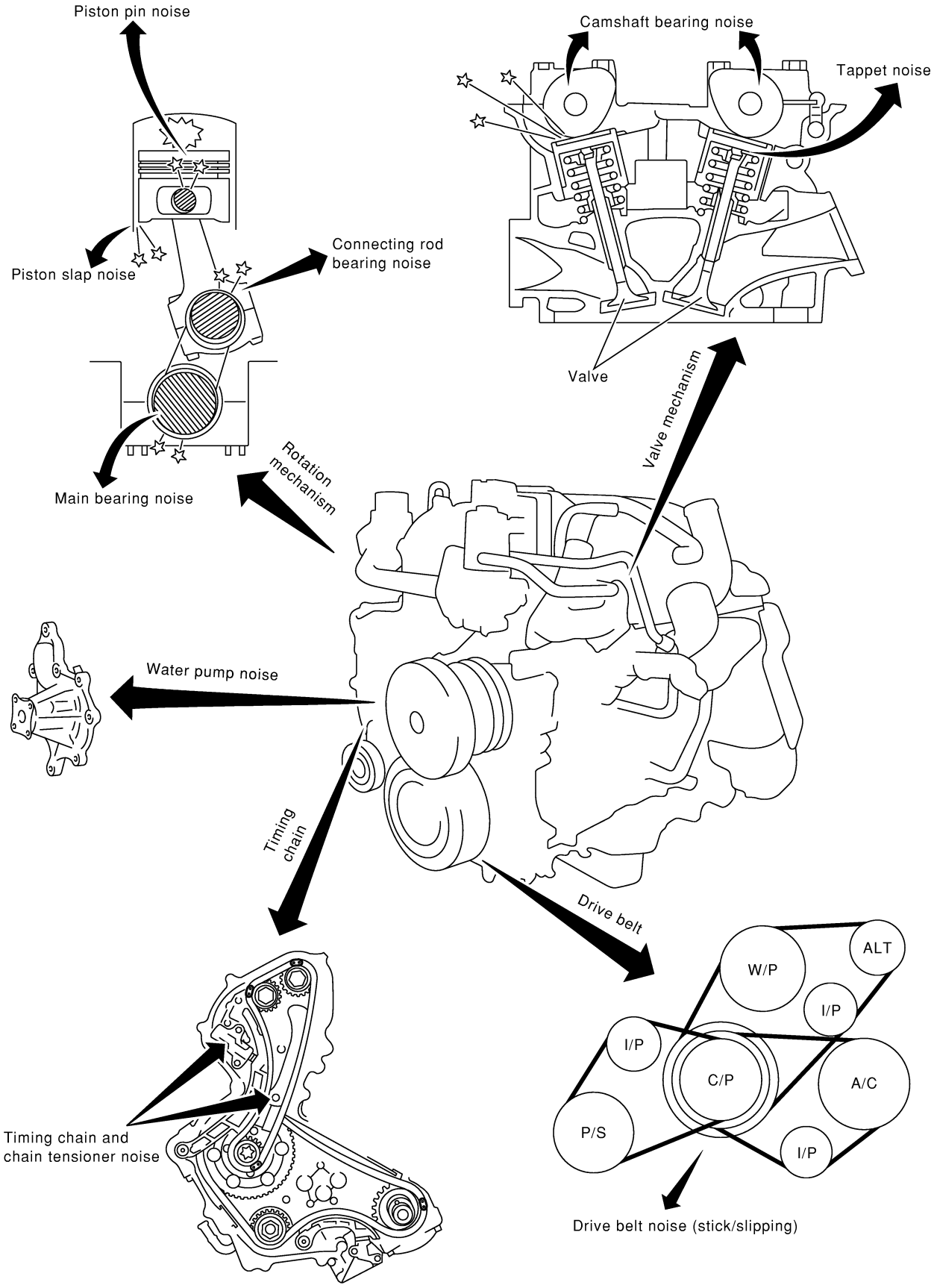
Tighten in numerical order.
Loosen in reverse order.

1st: 9 - 11 (0.9 - 1.1, 6.5 - 8.0)

2nd: 18 - 22 (1.8 - 2.2, 13 - 16)

SEM883G

NVH Troubleshooting — Engine Noise



SEM862G

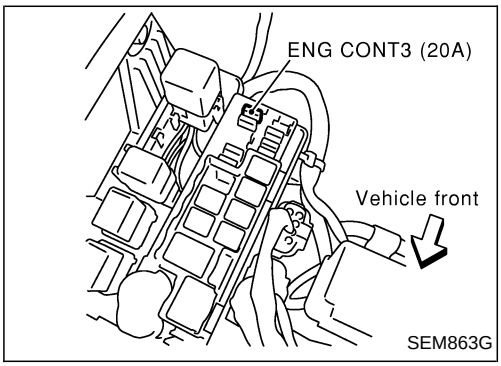
NVH Troubleshooting — Engine Noise (Cont'd)

Use the chart below to help you find the cause of the symptom.
1. Locate the area where noise occurs.
2. Confirm the type of noise.
3. Specify the operating condition of engine.
4. Check specified noise source.

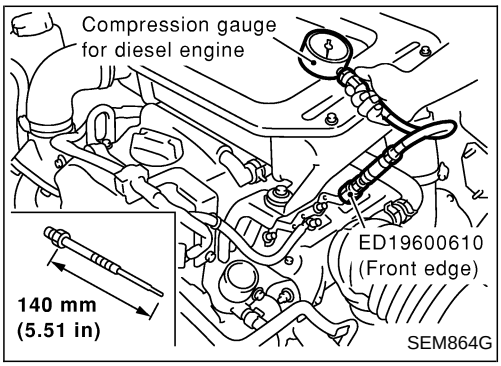
If necessary, repair or replace these parts.

Location of noise	Type of noise	Operating condition of engine						Source of noise	Check item	Reference page
		Before warm-up	After warm-up	When starting	When idling	When racing	While driving			
Top of engine Rocker cover Cylinder head	Ticking or clicking	C	A	—	A	B	—	Tappet noise	Valve clearance	EM-63
	Rattle	C	A	—	A	B	C	Camshaft bearing noise	Camshaft journal clearance Camshaft runout	EM-54, 54
Crankshaft pulley Cylinder block (Side of engine) Oil pan	Slap or knock	—	A	—	B	B	—	Piston pin noise	Piston and piston pin clearance Connecting rod bushing clearance	EM-75, 84
	Slap or rap	A	—	—	B	B	A	Piston slap noise	Piston-to-bore clearance Piston ring side clearance Piston ring end gap Connecting rod bend and torsion	EM-75, 75, 77, 76
	Knock	A	B	C	B	B	B	Connecting rod bearing noise	Connecting rod bushing clearance (Small end) Connecting rod bearing clearance (Big end)	EM-84, 81
	Knock	A	B	—	A	B	C	Main bearing noise	Main bearing oil clearance Crankshaft runout	EM-79, 79
Front of engine Timing chain cover	Tapping or ticking	A	A	—	B	B	B	Timing chain and chain tensioner noise	Timing chain cracks and wear Timing chain tensioner operation	EM-27, 30
Front of engine	Squeaking or fizzing	A	B	—	B	—	C	Other drive belts (Sticking or slipping)	Drive belts deflection	MA section ("Checking Drive Belts", "ENGINE MAINTENANCE")
	Creaking	A	B	A	B	A	B	Other drive belts (Slipping)	Idler pulley bearing operation	
	Squall Creak	A	B	—	B	A	B	Water pump noise	Water pump operation	LC section ("Water Pump Inspection", ENGINE COOLING SYSTEM")

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



1. Warm up engine.
2. Turn ignition switch OFF.
3. Using CONSULT-II, make sure no error codes are indicated for self-diagnosis items. Refer to “Trouble Diagnosis — INDEX” in EC section.
- Do not disconnect CONSULT-II until the end of this operation; it will be used to check engine rpm and for error detection at the end of this operation.
4. Disconnect the negative battery terminal.
5. To prevent fuel from being injected during inspection, remove fuel injection pump fuse [ENG CONT3 (20A)] from fuse box on the right side of engine compartment.
6. Remove glow plugs from all the cylinders.
- **Before removal, clean the surrounding area to prevent entry of any foreign materials into the engine.**
- **Carefully remove glow plugs to prevent any damage or breakage.**
- **Handle with care to avoid applying any shock to glow plugs.**



7. Install adapter (SST) to installation holes of glow plugs and connect compression gauge for diesel engine.
   : 18 - 21 N·m (1.8 - 2.2 kg-m, 13 - 15 ft-lb)
8. Connect battery negative terminal.
9. Set the ignition switch to “START” and crank. When gauge pointer stabilizes, read compression pressure and engine rpm. Repeat the above steps for each cylinder.
- **Always use a fully-charged battery to obtain specified engine speed.**

Unit: kPa (bar, kg/cm^2, psi)/rpm

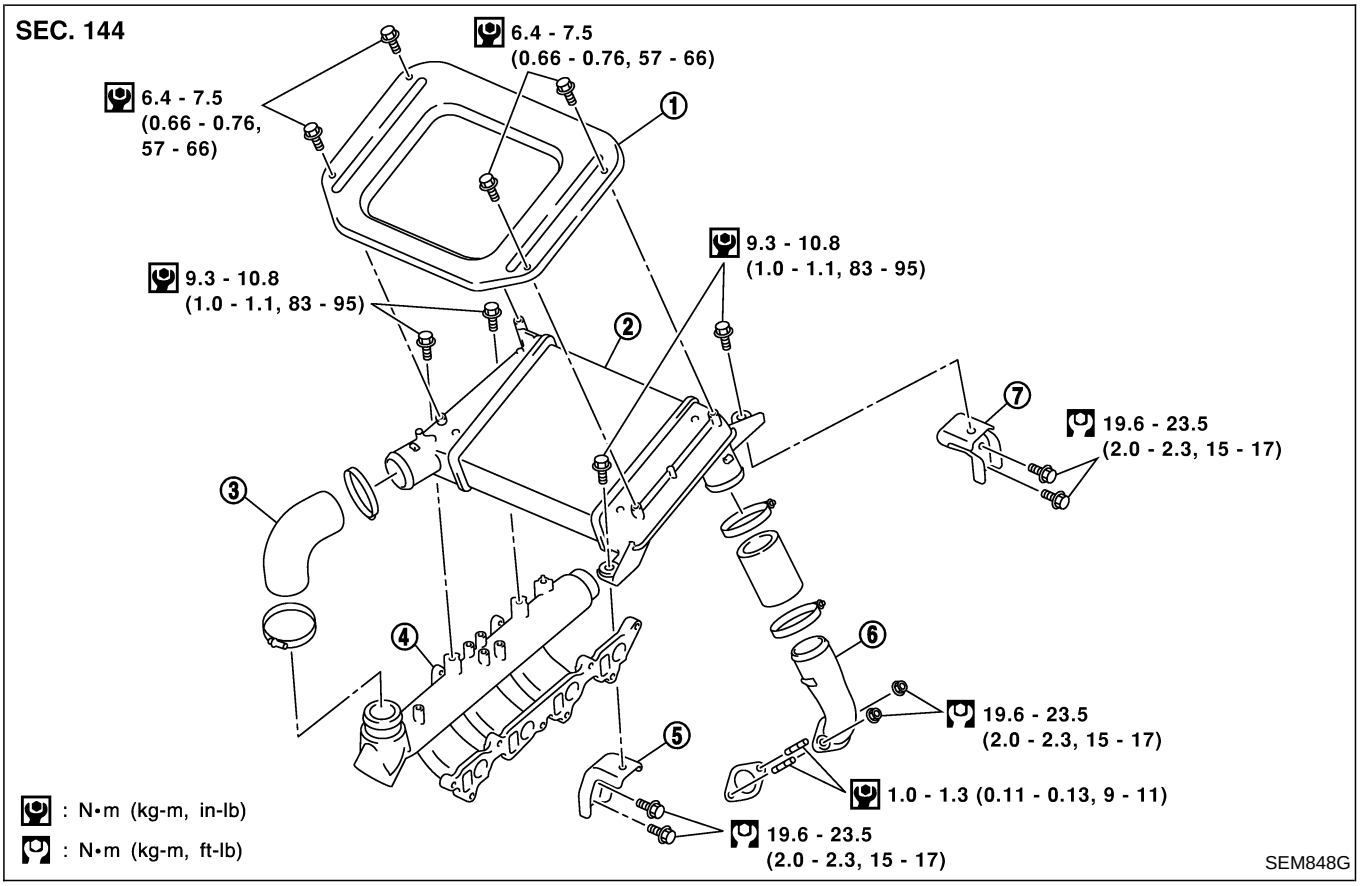
Standard	Minimum	Difference limit between cylinders
3,100 (31.00, 31.6, 45.0)/200	2,500 (25.00, 25.5, 363)/200	490 (4.90, 5.0, 71)/200

- When engine rpm is out of the specified range, check the specific gravity of battery liquid. Measure again under corrected conditions.
- If engine rpm exceeds the limit, check valve clearance and combustion chamber components (valves, valve seats, cylinder head gaskets, piston rings, pistons, cylinder bores, cylinder block upper and lower surfaces) and measure again.

10. Complete this operation as follows:

a. Turn the ignition switch to “OFF”.
b. Disconnect battery negative terminal.
c. Install glow plugs.
d. Install fuel injection pump fuse [ENG CONT3 (20A)].
e. Connect battery negative terminal.
f. Using CONSULT-II make sure no error code is indicated for items of self- diagnosis. Refer to “Trouble Diagnosis — INDEX” in EC section.

Removal and Installation



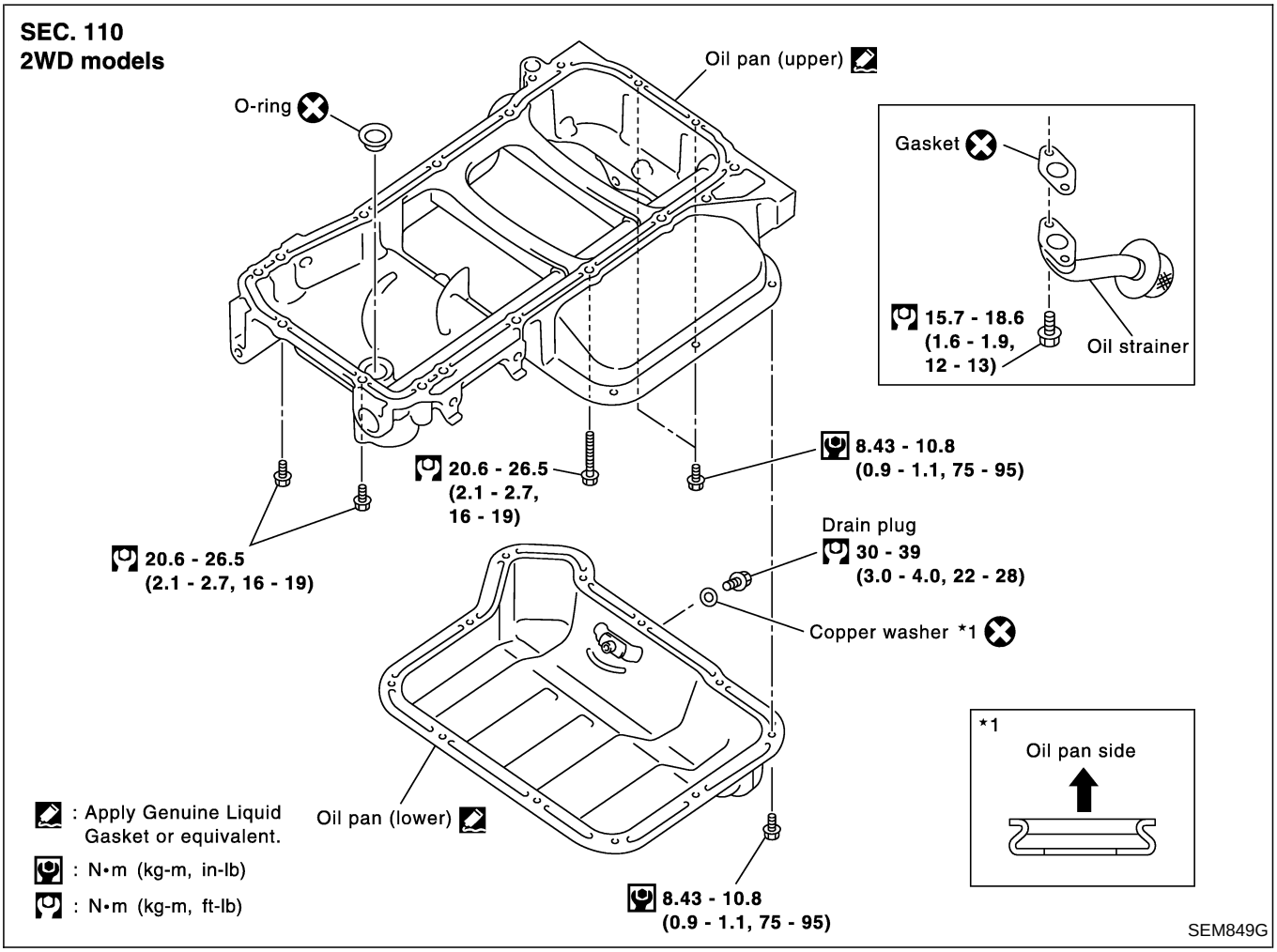
1. Charge air cooler cover
2. Charge air cooler
3. Air inlet hose
4. Intake manifold
5. Bracket
6. Air inlet pipe
7. Bracket

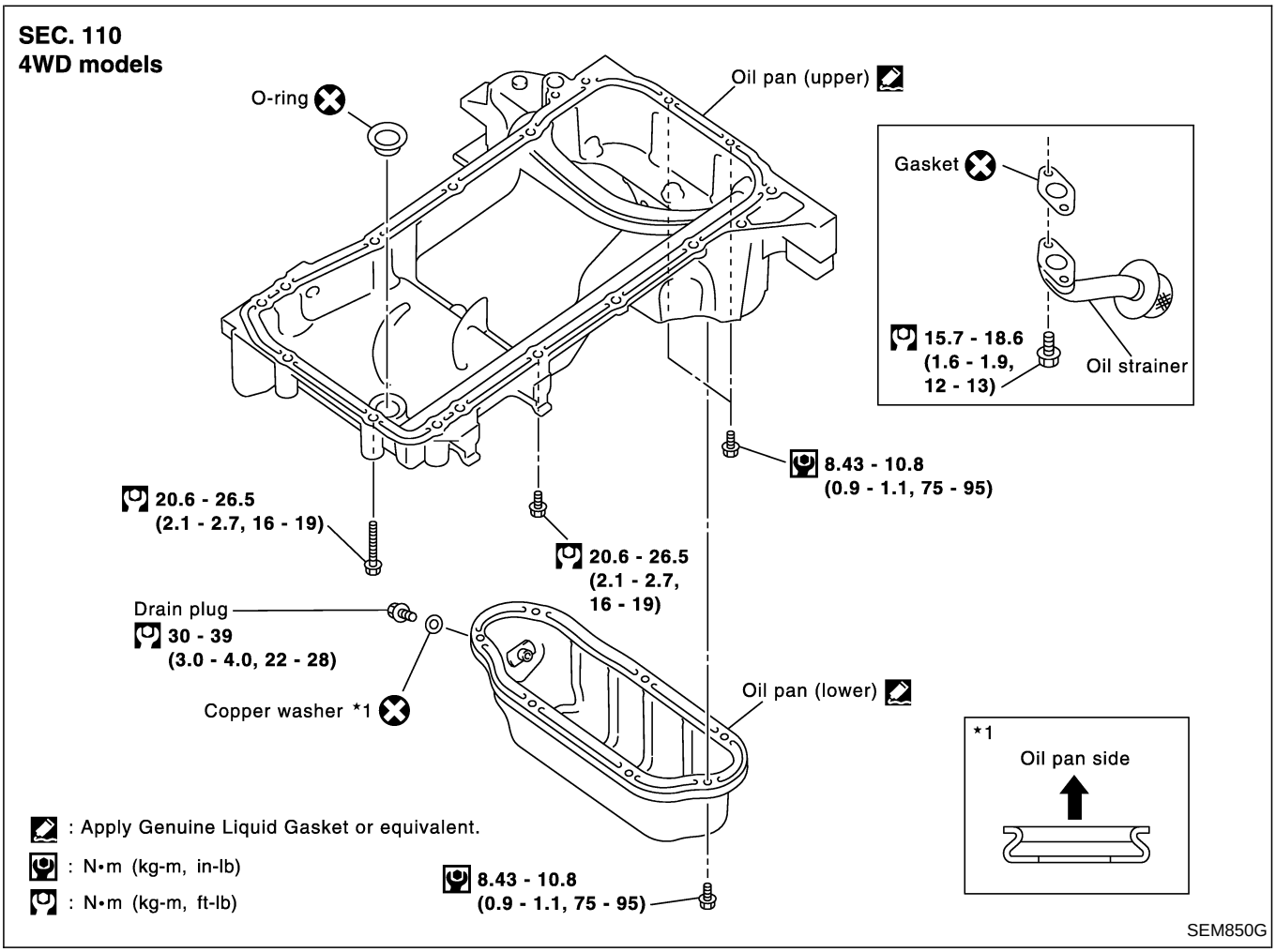
Inspection

Check air passages of charge air cooler core and fins for clogging, leaks or deformation. Clean or replace charge air cooler if necessary.

- **Be careful not to deform core fins.**
- **For cleaning procedure of charge air cooler core, refer to "CHECKING RADIATOR" in LC section.**

Components


SEC. 110
2WD models
Oil pan (upper)
O-ring
Gasket
15.7 - 18.6
(1.6 - 1.9,
12 - 13)
Oil strainer
8.43 - 10.8
(0.9 - 1.1, 75 - 95)
20.6 - 26.5
(2.1 - 2.7,
16 - 19)
20.6 - 26.5
(2.1 - 2.7, 16 - 19)
Drain plug
30 - 39
(3.0 - 4.0, 22 - 28)
Copper washer *1
*1
Oil pan side
Oil pan (lower)
: Apply Genuine Liquid Gasket or equivalent.
: N•m (kg-m, in-lb)
: N•m (kg-m, ft-lb)
8.43 - 10.8
(0.9 - 1.1, 75 - 95)
SEM849G

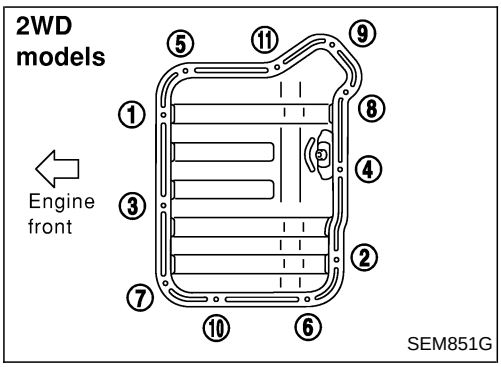


Removal

WARNING:

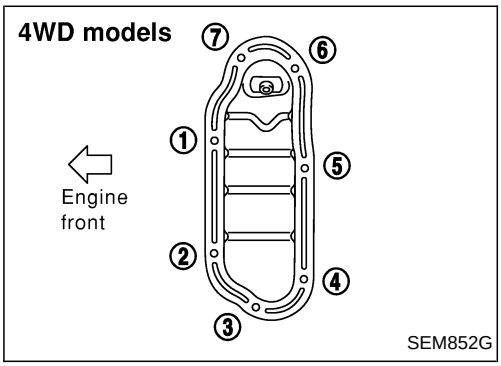
To avoid danger of being scalded, never drain engine oil when engine is hot.

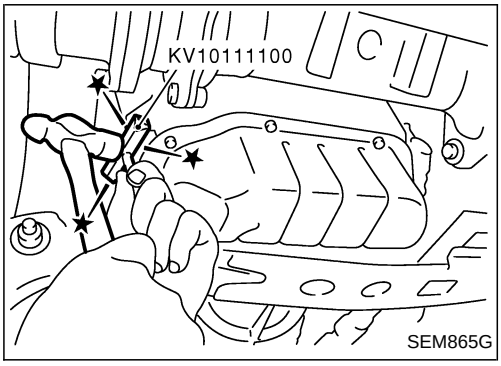
1. Raise vehicle and support it with safety stands.
2. Remove engine under cover.
3. Drain engine oil.



4. Remove lower oil pan bolts.
- Loosen bolts in the reverse order of that shown in the figure.

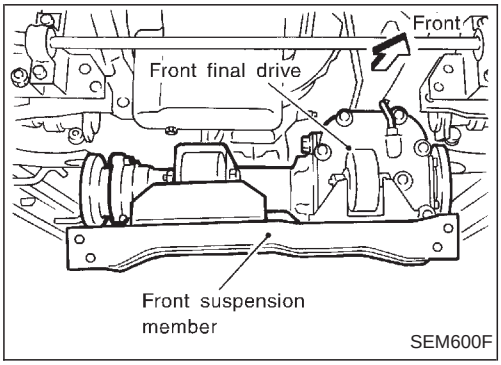
Removal (Cont'd)



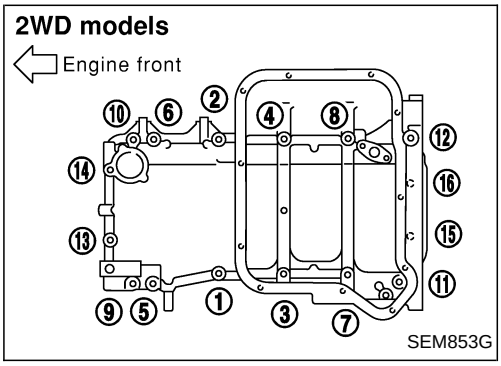


5. Remove lower oil pan.
a. Insert Tool between upper oil pan and lower oil pan.
- **Be careful not to damage aluminum mating surface.**
- **Do not insert screwdriver, or oil pan flange will be deformed.**

b. Slide Tool by tapping on the side of the Tool with a hammer.
c. Remove lower oil pan.
6. Remove oil strainer.
7. Remove air conditioner compressor and bracket.
8. Remove left side of the tie rod end — 2WD models only.

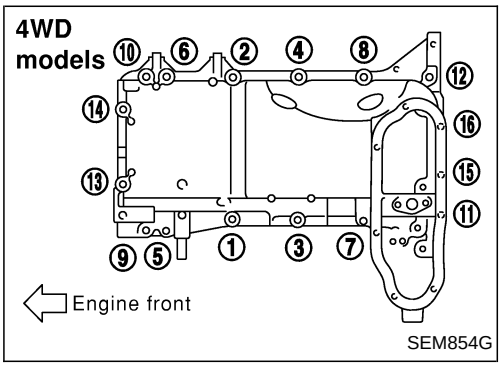


9. Remove front final drive together with differential mounting member. Refer to PD section ("Removal and Installation", "Front final drive") — 4WD models only.
10. Remove front suspension member bolt (RH & LH) — 4WD models only.



11. Remove upper oil pan bolts in reverse order shown.

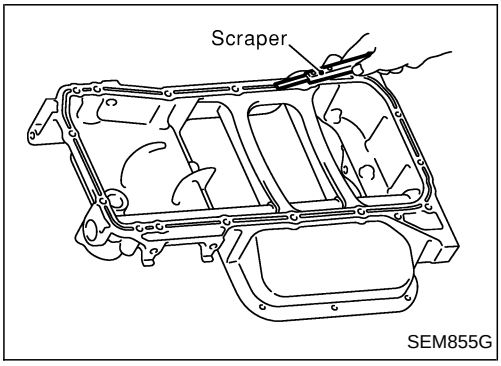
Removal (Cont'd)



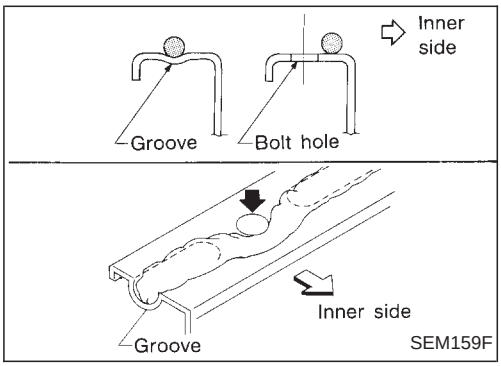
12. Remove upper oil pan.
a. Insert an appropriate size tool into the notch of upper oil pan.
- **Be careful not to damage aluminum mating surface.**
- **Do not insert screwdriver, or oil pan flange will be deformed.**

b. Pry off upper oil pan by moving the tool up and down.
c. Remove upper oil pan.
- **Be careful to prevent No. 15 and 16 blots from falling into transaxle case.**

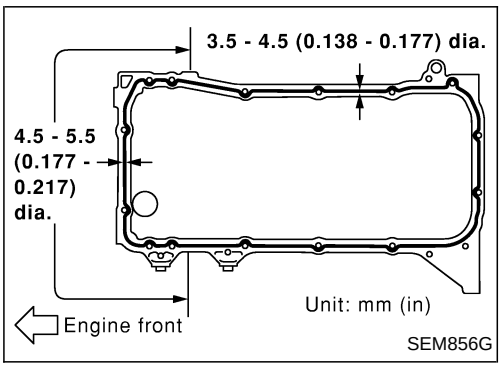
Installation



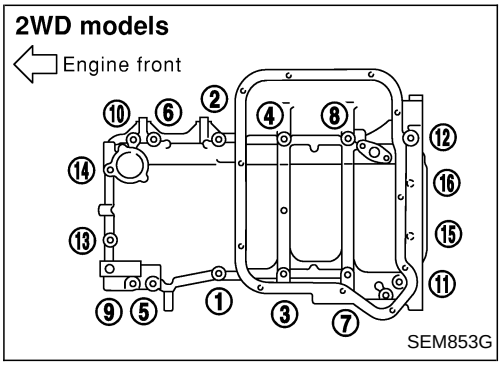
1. Install upper oil pan.
a. Use a scraper to remove old liquid gasket from mating surfaces.
- **Also remove old liquid gasket from mating surface of cylinder block, front cover and lower oil pan.**
- **Remove old liquid gasket from the bolt hole and thread.**



b. Apply a continuous bead of liquid gasket to mating surface of aluminum oil pan.
- **Use Genuine Liquid Gasket or equivalent.**



- **Apply liquid gasket to areas shown in the figure.**
- **Be sure liquid gasket is 3.5 to 4.5 mm (0.138 to 0.177 in) or 4.5 to 5.5 mm (0.177 to 0.217 in) wide as shown in the figure. (Be careful that the diameter of the silicon bead is different around the front.)**
- **Assembly should be done within 5 minutes after coating.**

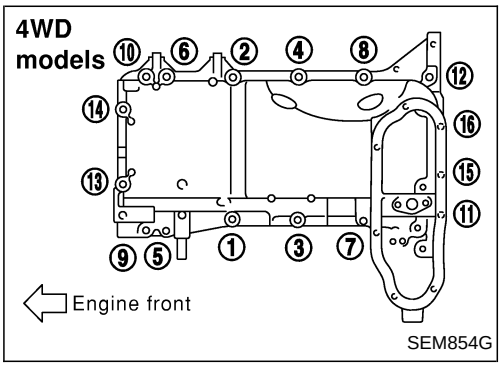


c. Install upper oil pan.
- Tighten bolts in numerical order.
- Bolt dimensions vary depending on the installation location. Refer to the following and use appropriate bolts.

2WD models:

M6 x 12 mm (0.47 in): Bolt No. 11, 14
M6 x 30 mm (1.18 in): Bolt No. 15, 16
M8 x 25 mm (0.98 in): Bolt No. 1, 5, 9, 13
M8 x 60 mm (2.36 in): Bolt No. 2, 3, 4, 6, 7, 8, 10, 12

Installation (Cont'd)



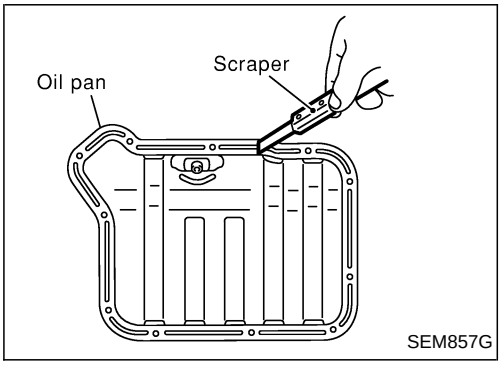
SEM854G

4WD models:

M6 x 30 mm (1.18 in): Bolt No. 15, 16
M8 x 25 mm (0.98 in): Bolt No. 1, 2, 4, 5, 8, 9
M8 x 60 mm (2.36 in): Bolt No. 3, 6, 7, 10, 11, 12, 13, 14

- The shank length under the bolt neck above is the length of the threaded part (pilot portion not included).

2. Install air conditioner compressor and bracket.
   : 56.9 - 65.7 N·m (5.9 - 6.7 kg-m, 42 - 48 ft-lb)
3. Install drive belts.
4. Install oil strainer.

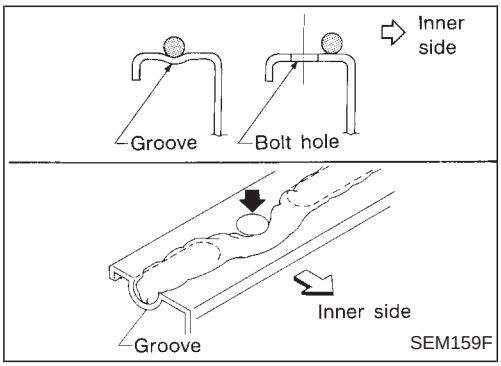


SEM857G

5. Install lower oil pan.

a. Use a scraper to remove old liquid gasket from mating surfaces.

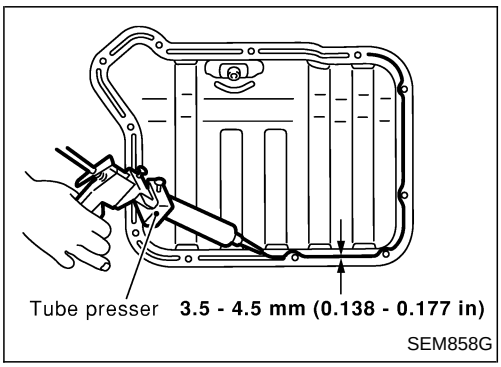
- **Also remove old liquid gasket from mating surface of upper oil pan.**



SEM159F

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

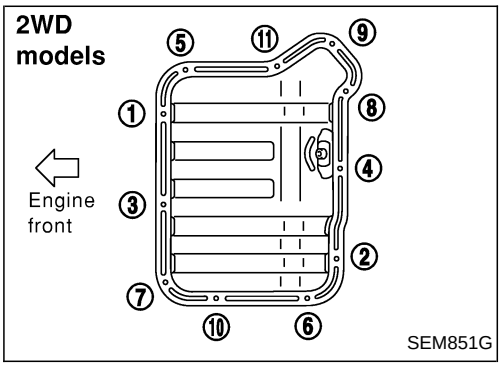
- **Use Genuine Liquid Gasket or equivalent.**

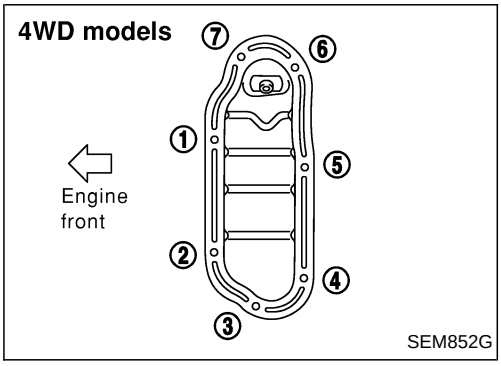


SEM858G

- **Be sure liquid gasket is 3.5 to 4.5 mm (0.138 to 0.177 in) wide.**
- **Assembly should be done within 5 minutes after coating.**

Installation (Cont'd)





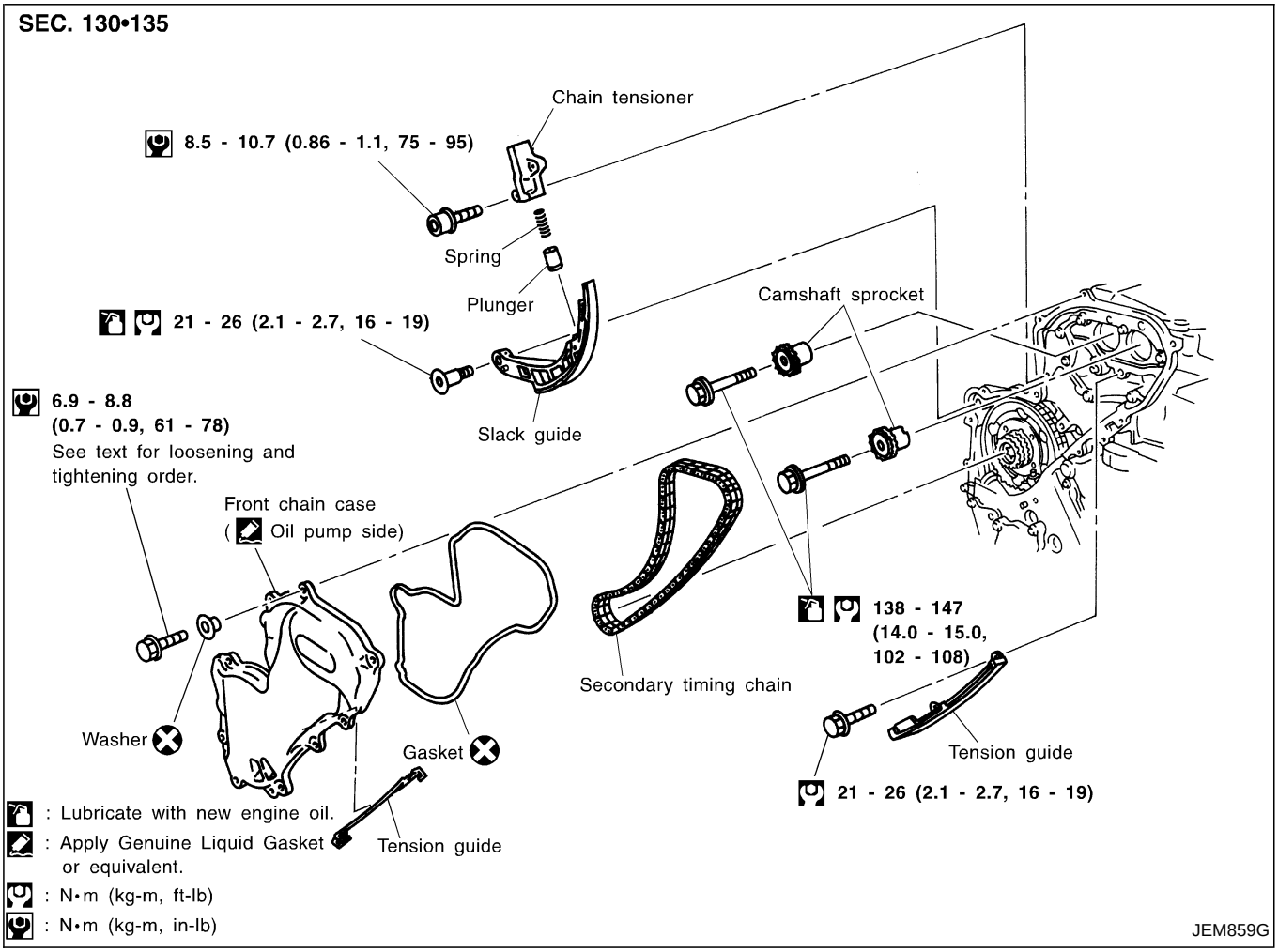
c. Install lower oil pan.
- **Tighten in numerical order shown in the figure.**
- **Wait at least 30 minutes before refilling engine oil.**

6. Install in the reverse order of removal.

Secondary Timing Chain

CAUTION:

- **After removing timing chain, do not turn crankshaft and camshaft separately, or valves will strike piston heads.**
- **When installing camshafts, chain tensioners, oil seals, or other sliding parts, lubricate contacting surfaces with new engine oil.**
- **Apply new engine oil to bolt threads and seat surfaces when installing camshaft sprockets, crankshaft pulley, and camshaft brackets.**
- **Do not spill engine coolant on drive belts.**

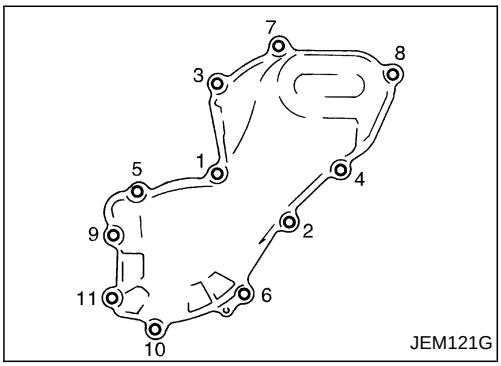


REMOVAL

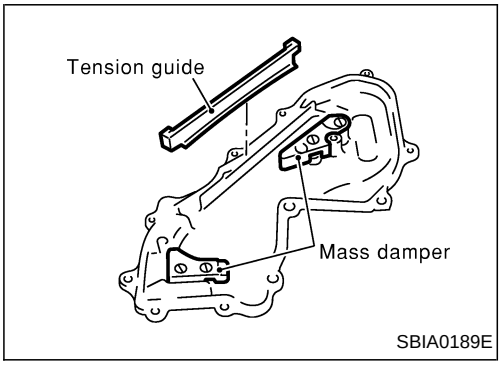
- For preparative work for removing/installing secondary timing chain to remove/install fuel injection pump, refer to EC section, “Electronic control fuel injection pump”.
- To prepare for removing/installing secondary timing chain to remove/install camshaft, refer to EM-51, “CAMSHAFT”.

1. Drain engine oil.
2. Drain coolant by removing cylinder block drain plugs. Refer to LC section, “Changing Engine Coolant”.
3. Remove EGR guide tube.
4. Remove radiator upper and lower hoses.
5. Remove radiator shroud and radiator. Refer to LC section, “REMOVAL AND INSTALLATION”, “Radiator”.

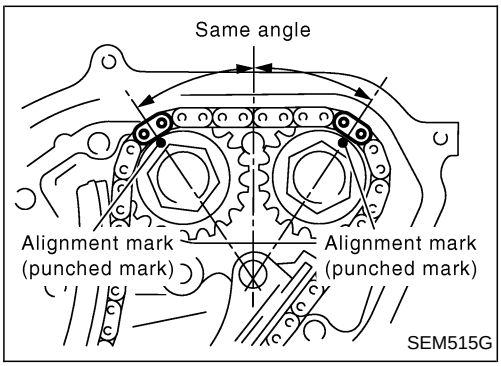
Secondary Timing Chain (Cont'd)



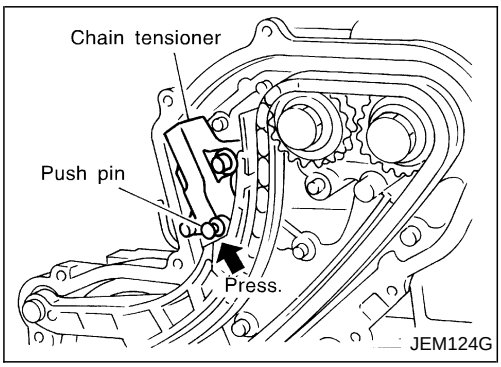
6. Remove front chain case.
- Move power steering fluid reservoir tank from the bracket.
- Loosen fixing bolts in the reverse order of that shown in the figure and remove them.
- Remove all bolts with the rubber washer as space is limited for pulling them out.



CAUTION:
- **While front chain case is removed, cover openings to prevent entry of foreign material into engine.**
- **Do not remove two mass dampers on the back of cover.**

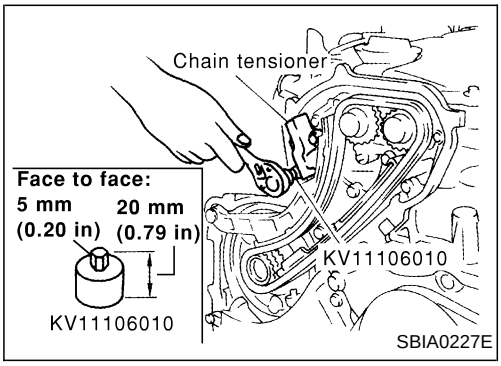


7. Set the No. 1 piston to TDC on its compression stroke.
- Turn crankshaft pulley clockwise so that the alignment mark (punched mark) on each camshaft sprocket is positioned as shown in the figure.
- **No position indicator is provided on the crankshaft pulley.**
- **When installing, color coded links on the secondary timing chain can be used as alignment marks. Marking may not be necessary for removal; however, make alignment marks as required because the alignment mark on fuel injection pump sprocket may not be easy to see.**



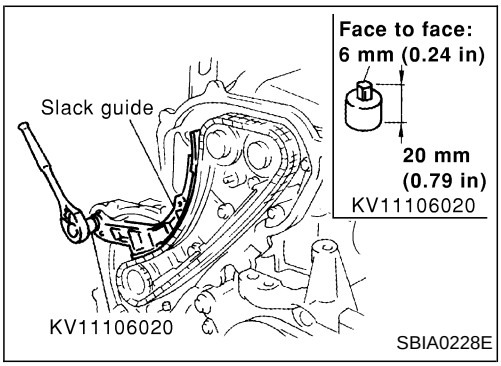
8. Remove chain tensioner.

a. Push the plunger of chain tensioner and keep it pressed with a push pin.

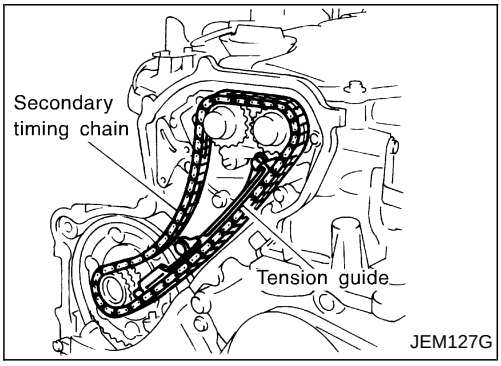


b. Using a hexagon-head wrench [face to face: 5 mm (0.20 in), SST], remove bolts to remove chain tensioner.

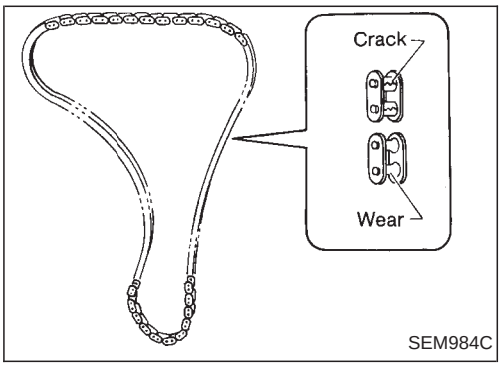
Secondary Timing Chain (Cont'd)



9. Remove timing chain slack guide.
- Using a hexagon-head wrench [face to face: 6 mm (0.24 in), SST], remove bolt to remove timing chain slack guide.

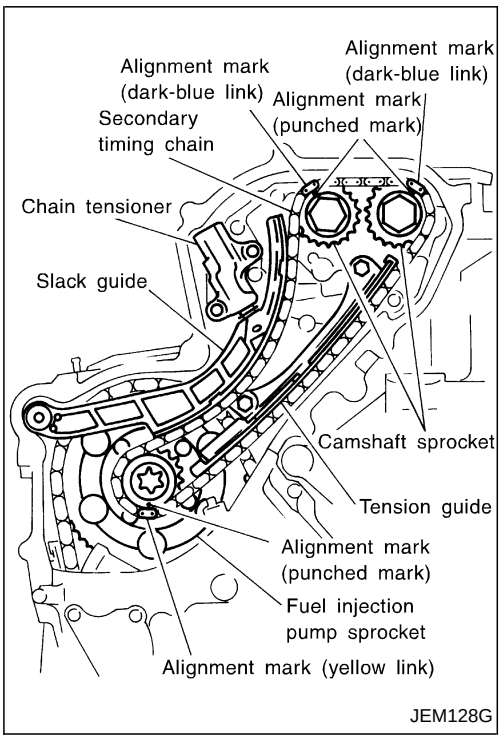


10. Remove timing chain tension guide.
11. Remove secondary timing chain.
- Timing chain alone can be removed without removing sprockets.



INSPECTION

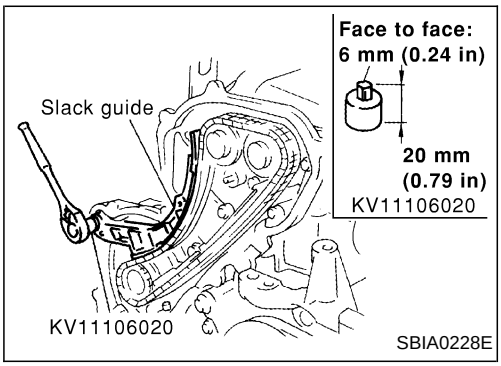
Check for cracks and excessive wear at roller links. Replace chain if necessary.



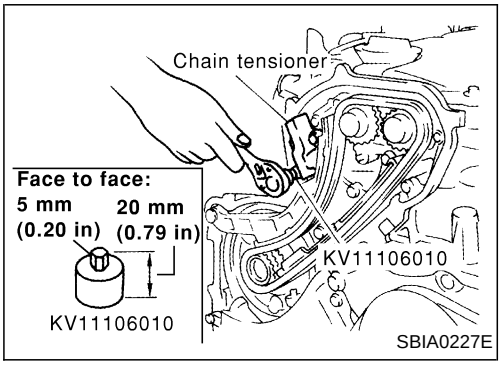
INSTALLATION

1. Install secondary timing chain.
- When installing, match the alignment marks on sprockets with color coded alignment marks (colored links) on the chain.
2. Install timing chain tension guide.
- The upper bolt has a longer shank than the lower bolt.

Secondary Timing Chain (Cont'd)



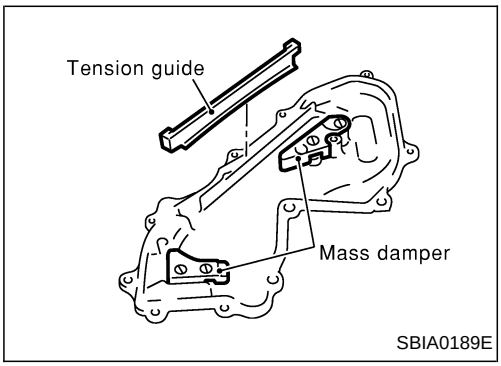
3. Using a hexagon-head wrench [face to face: 6 mm (0.24 in), SST], install timing chain slack guide.



4. Install chain tensioner.

a. Push the plunger of the chain tensioner. While holding it with a push pin, install the chain tensioner.
b. Using a hexagon-head wrench [face to face: 5 mm (0.20 in), SST], tighten bolts.
c. Pull out the push pin, etc. holding the plunger.

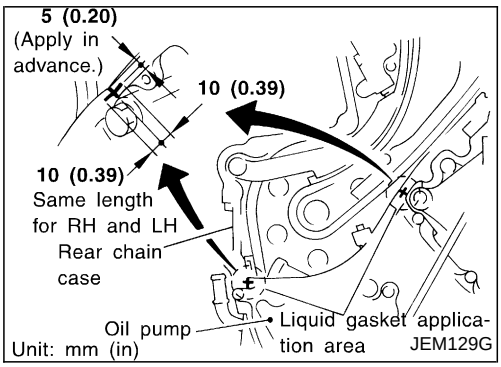
- **Check again that the alignment marks on the sprockets and the colored alignment marks on the timing chain are aligned.**



5. Install front chain case.

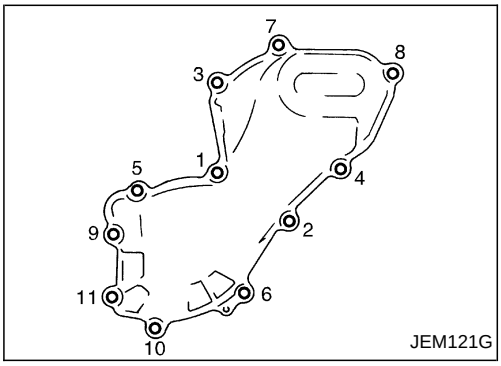
a. Install tension guide on the back surface of front chain case.

- Hold front chain case vertically when installing. Tension guide may come off if front chain case is tilted.



b. Apply specified liquid gasket (Refer to EM-3, "Liquid Gasket Application Procedure".) on both ends of arched area (locations where rear chain case is adjoined) as shown in the figure.
c. Install new chain case gasket to chain case groove.
d. Install front chain case.

- When installing, align dowel pin on oil pump case with the pin hole.



- Install all bolts with the rubber washer to the front chain case.

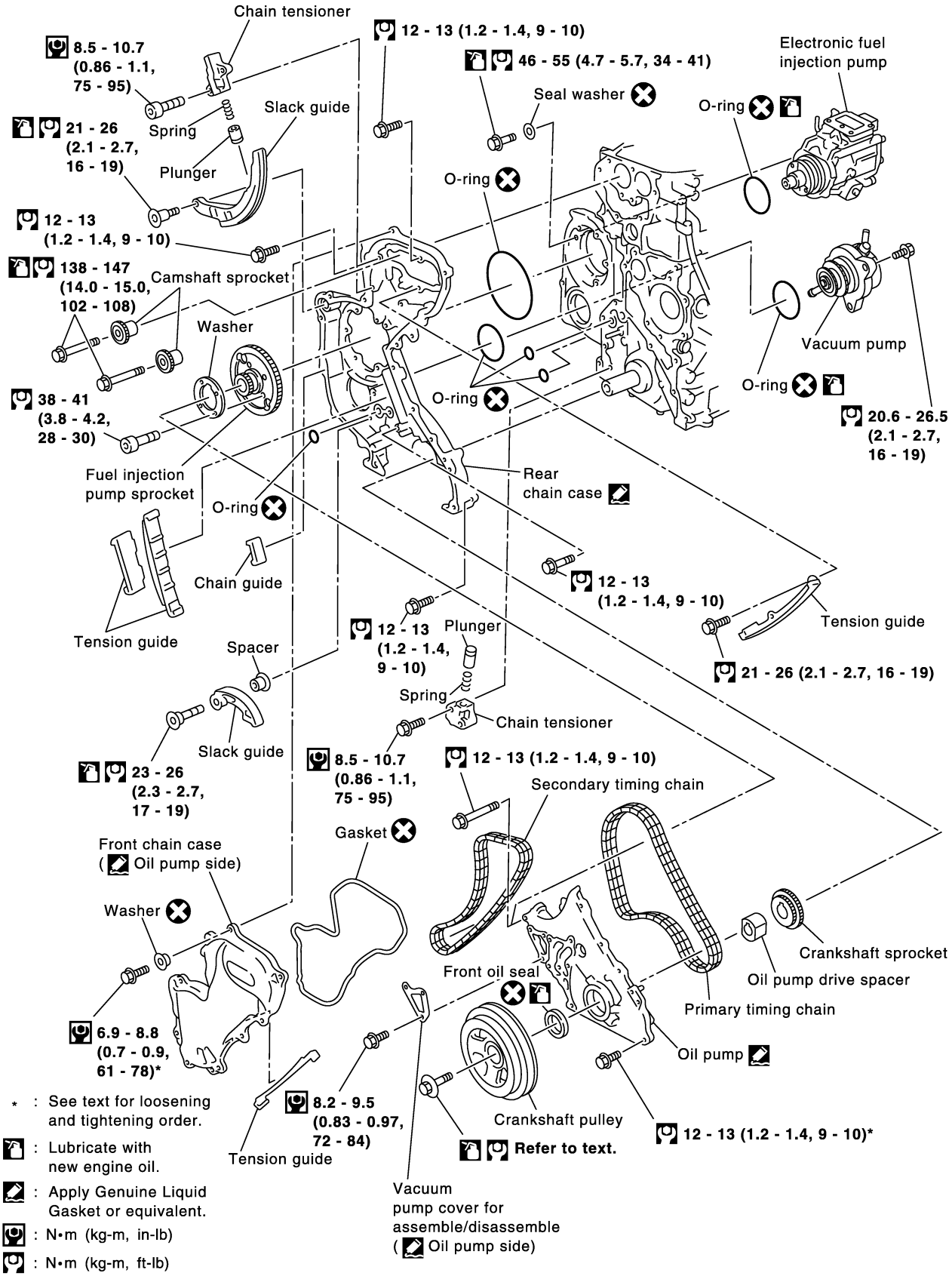
e. Tighten fixing bolts in the numerical order shown in the figure.
f. After tightening all the bolts, re-tighten in the No. 1, 2, and 6 bolts.

Secondary Timing Chain (Cont'd)

6. Hereafter, install in the reverse order of removal.

Primary Timing Chain

SEC. 120•130•135•186



SEM860G

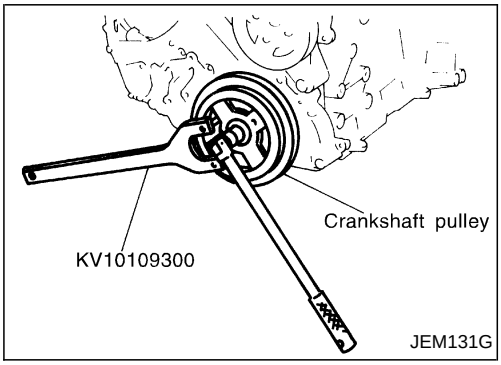
Primary Timing Chain (Cont'd)

CAUTION:

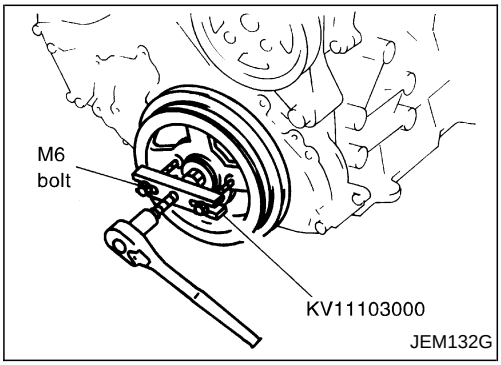
- **After removing timing chain, do not turn crankshaft and camshaft separately, or valves will strike piston heads.**
- **When installing camshafts, chain tensioners, oil seals, or other sliding parts, lubricate contacting surfaces with new engine oil.**
- **Apply new engine oil to bolt threads and seat surfaces when installing camshaft sprockets, crankshaft pulley, and camshaft brackets.**
- **Do not spill engine coolant on drive belts.**

REMOVAL

1. Remove charge air cooler and bracket.
2. Remove rocker cover. Refer to EM-49, "Removal and Installation", "ROCKER COVER".
3. Remove EGR guide tube.
4. Remove radiator shroud and radiator. Refer to LC section, "REMOVAL AND INSTALLATION", "Radiator".
5. Remove idler pulley, idler pulley bracket and drive belts.
6. Remove upper and lower oil pans. Refer to EM-19, "Removal and Installation", "OIL PAN".
7. Remove injection tube.
   Refer to EC section, "Injection Tube and Injection Nozzle".
8. Remove secondary timing chain and associated parts.
   Refer to EM-25, "Secondary Timing Chain".
9. When removing rear chain case, remove camshaft sprockets.
   Refer to EM-51, "CAMSHAFT".

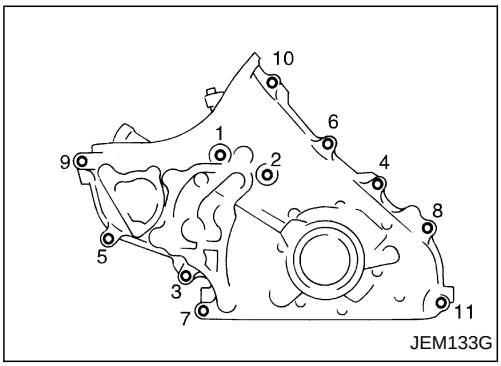


10. Remove crankshaft pulley.
a. Hold crankshaft pulley with the pulley holder (SST).
b. Loosen crankshaft pulley fixing bolt and pull out the bolt approximately 10 mm (0.39 in).



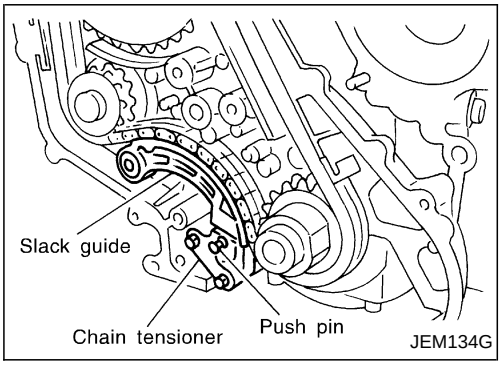
c. Using pulley puller (SST), remove crankshaft pulley.
- Use two M6 (0.24 in) bolts with approx. 60 mm (2.36 in) shank length for securing crankshaft pulley.

Primary Timing Chain (Cont'd)



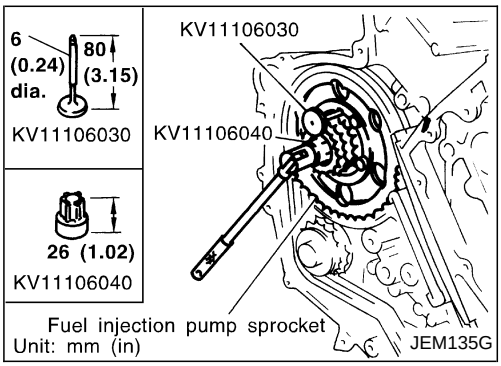
11. Remove oil pump.
- Loosen bolts in the reverse order of that shown in the figure and remove them.
- Use seal cutter (SST) etc. for removal.

12. Remove front oil seal from oil pump.
- Punch out the seal off from the back surface of the oil pump using a flat-bladed screwdriver.
- **Be careful not to damage the oil pump.**



13. Remove chain tensioner.
- When removing chain tensioner, push the sleeve of chain tensioner and keep it pressed with a push pin, etc.

14. Remove timing chain slack guide.

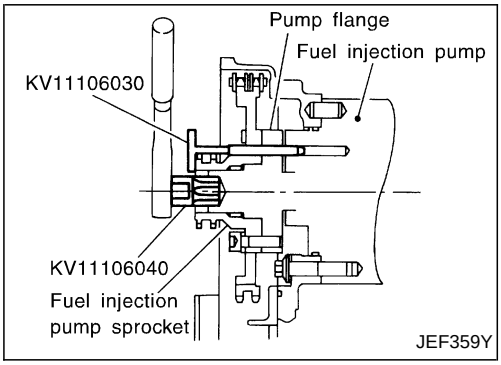


15. Hold fuel injection pump sprocket.

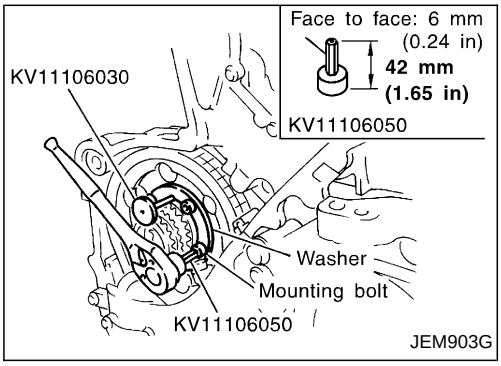
a. Insert positioning stopper pin (SST) into the hole 6 mm (0.24 in) in the diameter on the fuel injection pump sprocket.

b. Using a TORX wrench (SST), turn pump shaft little by little to adjust the position of fuel injection pump sprocket so that the holes align.

c. Insert the positioning stopper pin through fuel injection pump sprocket to the fuel injection pump body to fix the sprocket.
- Insert the positioning stopper pin until its flange contacts the fuel injection pump sprocket.

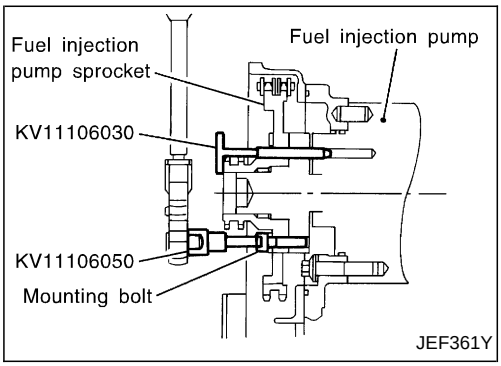


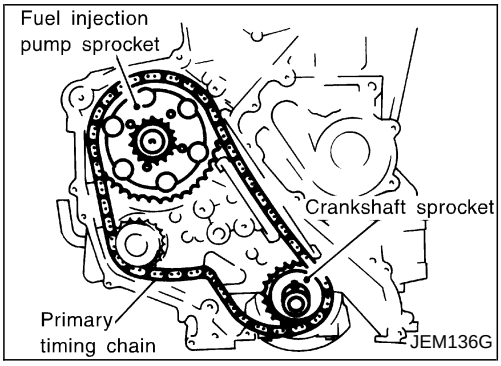
d. Remove the torx wrench (SST).



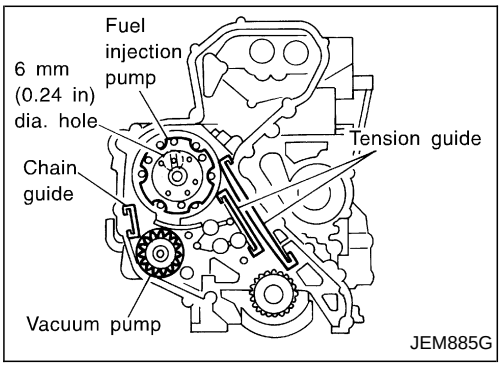
16. Using the hexagon wrench [face to face: 6 mm (0.24 in), long-type] (SST), remove the mounting bolts of the fuel injection pump sprocket.
- It is not necessary to remove the washer of the fuel injection pump sprocket.

Primary Timing Chain (Cont'd)

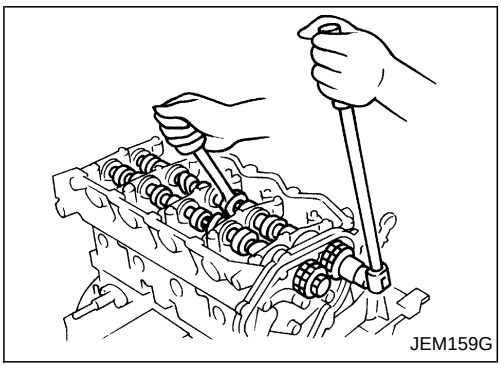




17. Remove primary timing chain with fuel injection pump sprocket and crankshaft sprocket.

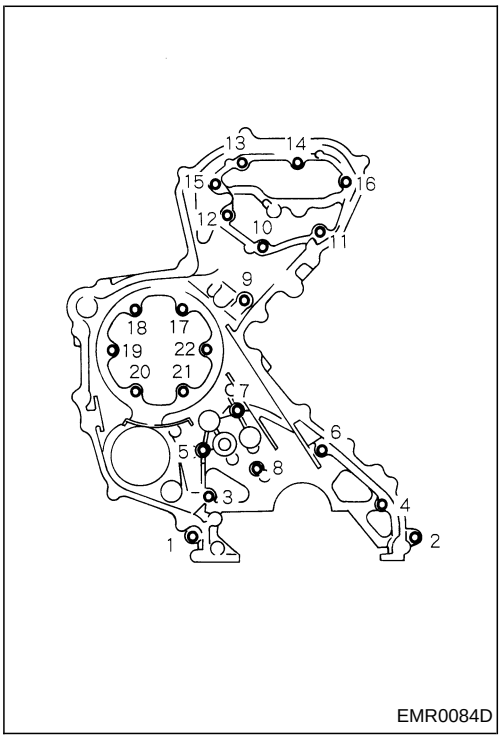


18. Remove chain guide and tension guides.
19. Remove vacuum pump.



20. Remove camshaft sprockets.
- Loosen the camshaft sprockets installation bolts by fixing the hexagon portion of the camshaft.

Primary Timing Chain (Cont'd)



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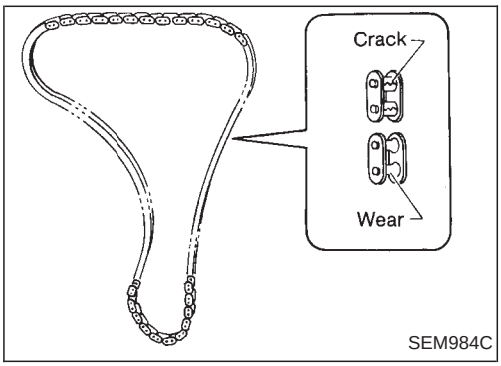
21. Remove rear chain case.
- Loosen fixing bolts in the reverse order of that shown in the figure and remove them.
- Use seal cutter (SST) for removal.

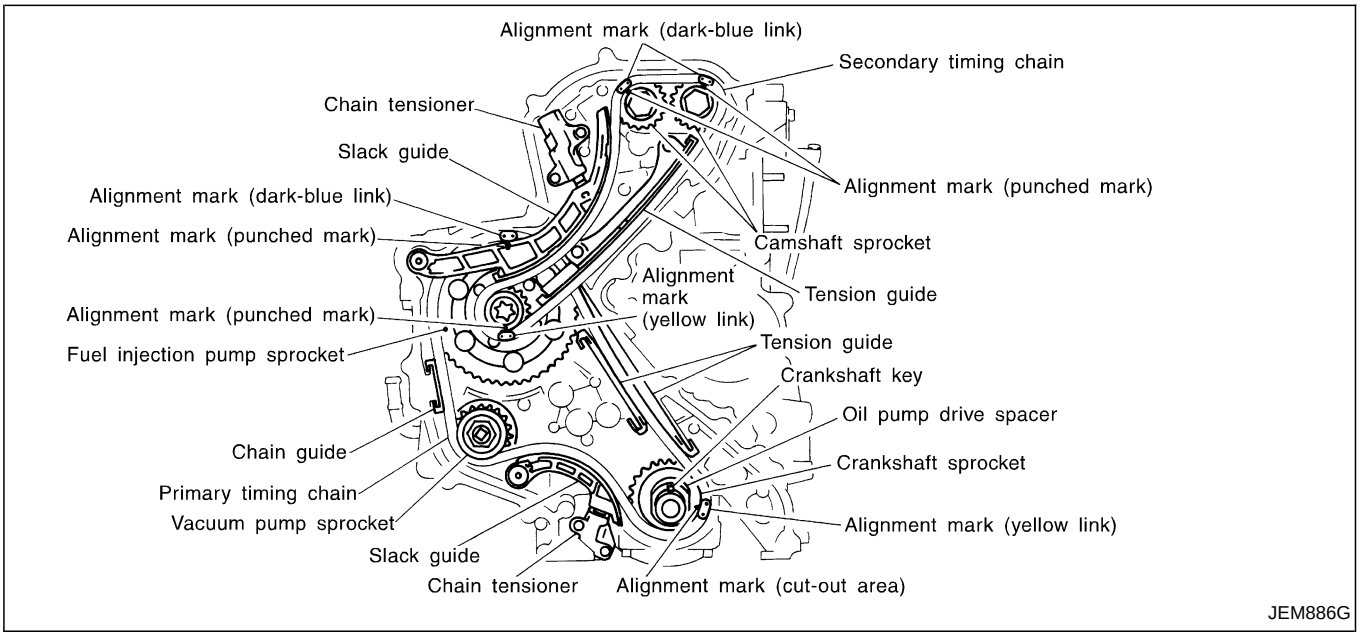


SEM984C

INSPECTION

Check for cracks and excessive wear at roller links. Replace chain if necessary.

INSTALLATION



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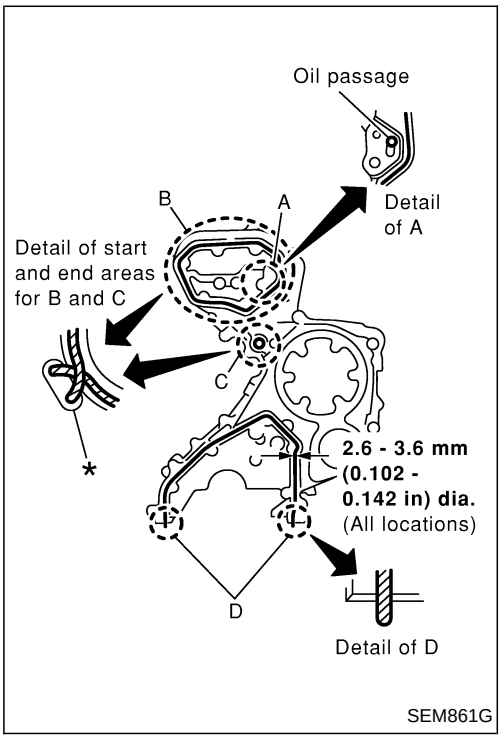
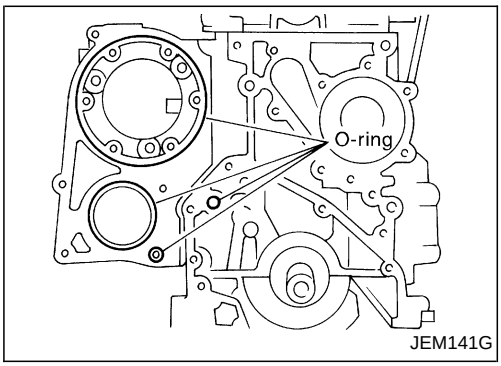
Primary Timing Chain (Cont'd)

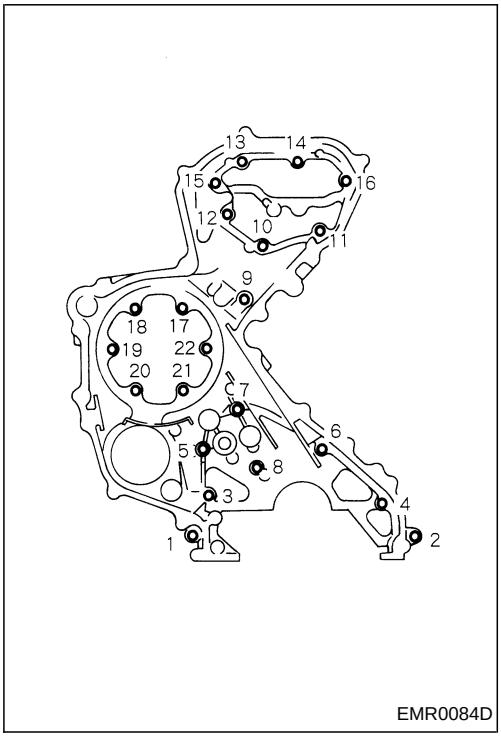


1. Install rear chain case.

a. Apply a continuous bead of specified liquid gasket (Refer to EM-3, "Liquid Gasket Application Procedure".) on locations shown in the figure.
A: Apply bead so that it does not protrude into the oil passage.
B, C: Minimize overlapping area of bead, by start and end areas of bead as shown in the figure. Apply so that the portion marked * comes at an external location but cannot be viewed externally after engine assembly.
D: Leave the start and end areas of the bead slightly protruding from the case surface.



b. Install four O-rings to the grooves of the cylinder block and fuel injection pump bracket.

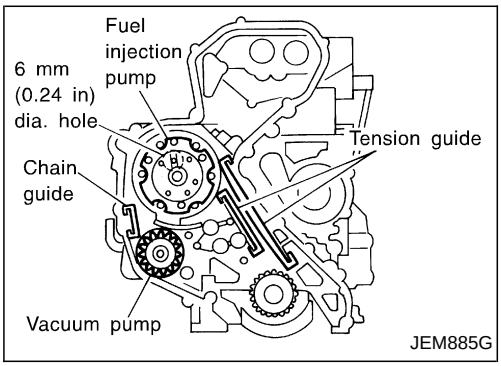


c. Install rear chain case.
- When installing, align the dowel pin with the pin hole.

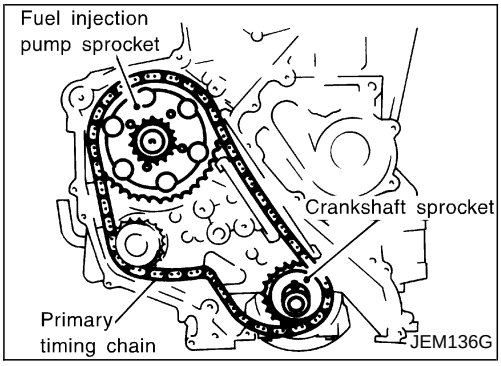
d. Tighten bolts in the numerical order shown in the figure.
- Install the following four types of bolts, referring to the figure.
  16 mm (0.63 in): Bolt No. 1, 2, 16, 17, 18, 19, 20, 21, 22
  20 mm (0.79 in): Bolt No. 3, 4, 6, 9, 10, 11, 13, 14
  25 mm (0.98 in): Bolt No. 12, 15
  35 mm (1.38 in): Bolt No. 5, 7, 8
- The shank length under the bolt neck above is the length of threaded part (pilot portion not included).

e. After tightening all the bolts, re-tighten in the same order.

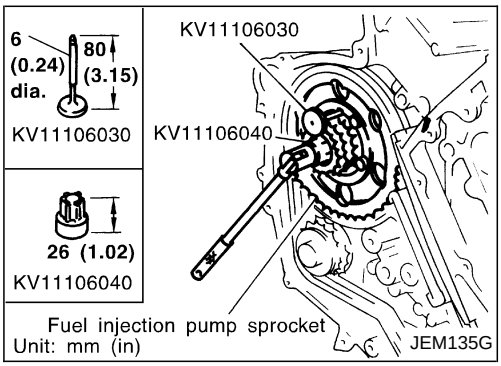
Primary Timing Chain (Cont'd)



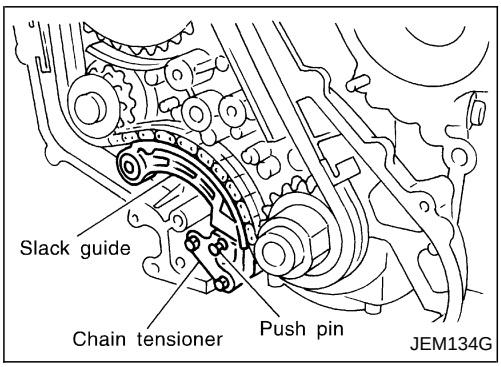
2. Install vacuum pump.
- Before installing, make sure the notch on the fuel injection pump flange and the hole 6 mm (0.24 in) in diameter on the pump body are aligned.
3. Install chain guide and tension guides.
4. Install crankshaft sprocket, aligning it with the crankshaft key on the far side.



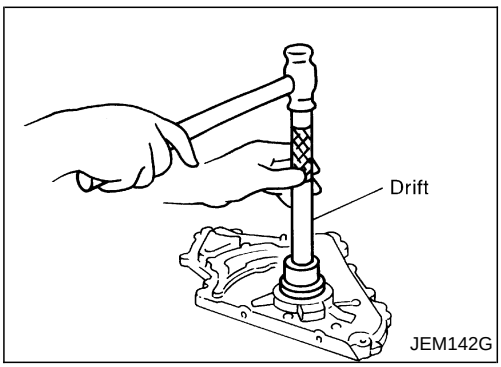
5. Install primary timing chain with fuel injection pump sprocket.
- When installing, match the alignment marks on sprockets with color coded alignment marks (colored links) on the chain.
- Install fuel injection pump sprocket washer with the surface marked "F" (front mark) facing the front of the engine.
6. Install timing chain onto vacuum pump sprocket and through chain guide.



7. Use the positioning stopper pin (SST) to hold the fuel injection pump sprocket and install the bolt for mounting the sprocket.
- Using a TORX wrench (SST), turn the pump shaft little by little to adjust the position of the pump flange. Insert positioning stopper pin (SST) into the hole 6 mm (0.24 in) in diameter on the fuel injection pump sprocket so that the stopper pin goes through the pump flange to the pump body. While the stopper pin is in place, install the bolt.

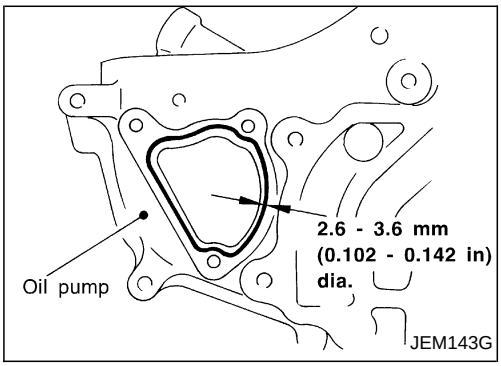


8. Install timing chain slack guide.
9. Install chain tensioner.
- Push the plunger of the chain tensioner. While keeping plunger pressed down with a push pin, etc., install the chain tensioner.
- After installation, pull out the push pin holding the plunger.
- **Check again that the alignment marks on the sprockets and the colored alignment marks on timing chain are aligned.**

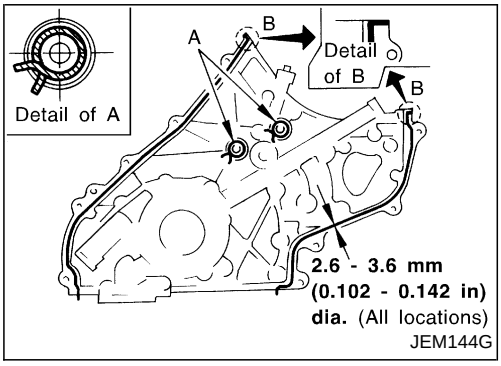


10. Install front oil seal to oil pump.
- Using a suitable drift [62 mm (2.44 in) dia.], force fit the seal until it hits the bottom.
- **Do not touch lips of oil seal. Make sure seal surfaces are free of foreign materials.**

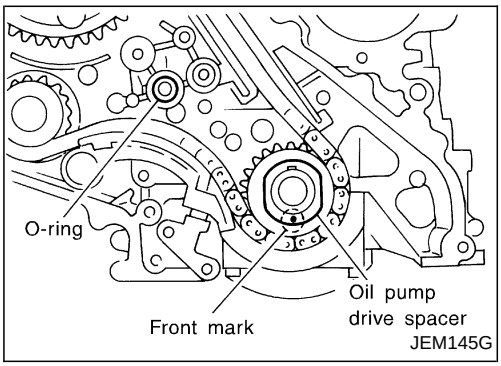
Primary Timing Chain (Cont'd)



11. Install vacuum pump cover (for vacuum pump removal/installation opening) to oil pump if cover is removed.
- Apply a continuous bead of specified liquid gasket (Refer to EM-3, "Liquid Gasket Application Procedure".) as shown in the figure.
- Apply liquid gasket on oil pump-side surface.

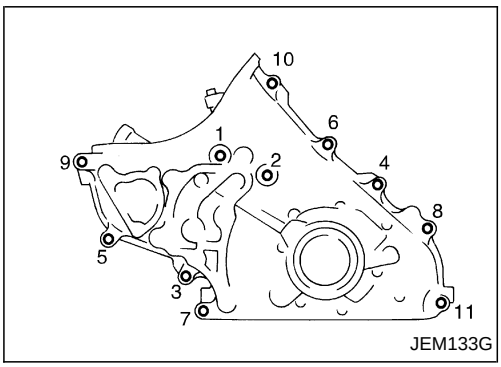


12. Install oil pump.
a. Apply a continuous bead of specified liquid gasket (Refer to EM-3, "Liquid Gasket Application Procedure".) on locations shown in the figure.
A: Leave the start and end areas of the bead slightly protruding from the surface.
B: Apply liquid gasket along upper end surface of oil pump.



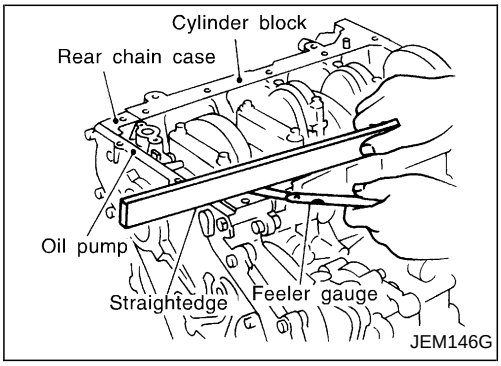
b. Install oil pump drive spacer to crankshaft.
- Install with the front mark (punched mark) facing the front of the engine.

c. Install O-ring into the groove of rear chain case.



d. Install oil pump.
- When installing, align the inner rotor in the direction of the two facing flats of the oil pump drive spacer.
- When installing, align the dowel pin with the pin hole.

e. Tighten fixing bolts in the numerical order shown in the figure.
f. After tightening all the bolts, re-tighten in the same order.



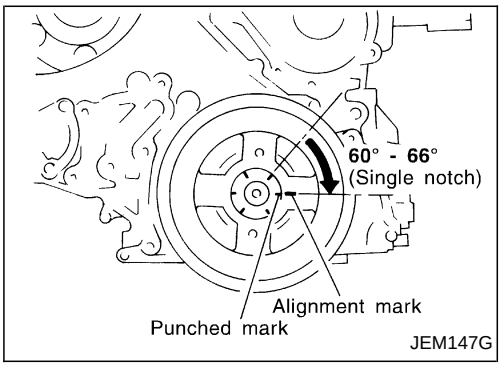
13. Check gaps on upper oil pan mounting surface.
- Using straightedge and feeler gauge, measure gaps between the locations of the following parts:

Standard:

Oil pump and rear chain case
−0.14 to 0.14 mm (−0.0055 to 0.0055 in)
Rear chain case and cylinder block
−0.25 to 0.13 mm (−0.0098 to 0.0051 in)

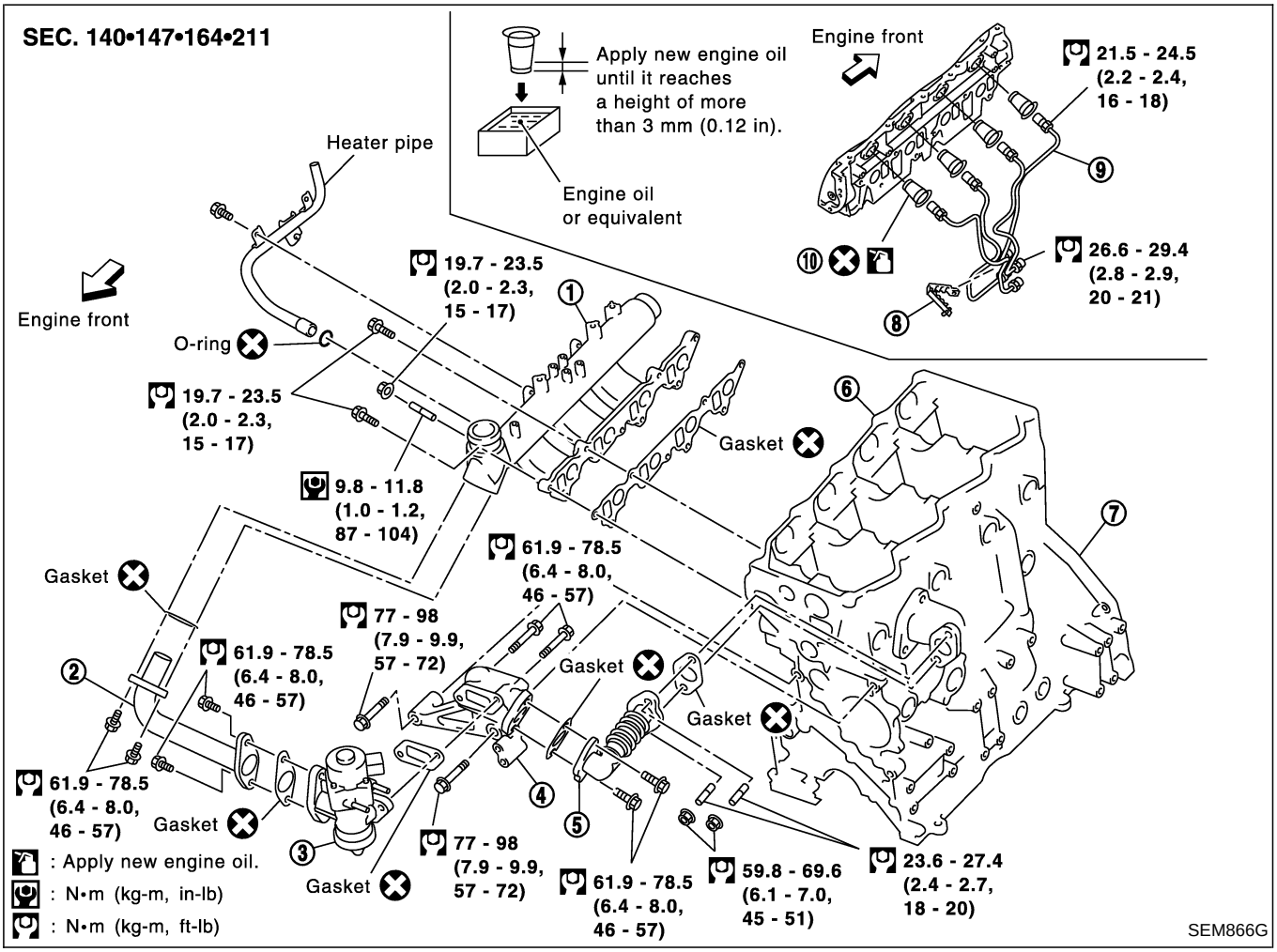
- If the measured value is out of the above range, install again.

Primary Timing Chain (Cont'd)



14. Install crankshaft pulley.
a. Install crankshaft pulley to crankshaft.
b. Hold crankshaft pulley with the pulley holder (SST).
c. Tighten bolt to 20 to 29 N·m (2.0 to 3.0 kg-m, 15 to 21 ft-lb).
d. Put an alignment mark on crankshaft pulley that aligns with one of the punched marks on the bolt.
e. Tighten fixing bolt another 60° - 66° [target: 60° (turn by one notch)].
15. Install secondary timing chain and the associated parts.
Refer to EM-27, "Secondary Timing Chain", "INSTALLATION".
16. Install in the reverse order of removal hereafter.

Removal and Installation

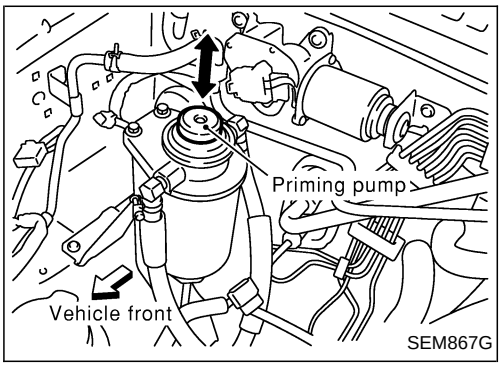


1. Intake manifold
2. EGR guide tube
3. EGR volume control valve
4. EGR spacer
5. EGR tube
6. Cylinder head
7. Cylinder block
8. Injection tube clamp
9. Injection tube
10 Injection nozzle oil seal

REMOVAL

1. Drain engine coolant. Refer to LC section, “Changing engine coolant”.
2. Remove charge air cooler. Refer to EM-18, “Removal andInstallation”.
3. Remove EGR volume control valve, EGR spacer and EGR guide tube.
4. Remove fuel injection tubes and intake manifold.

Removal and Installation (Cont'd)



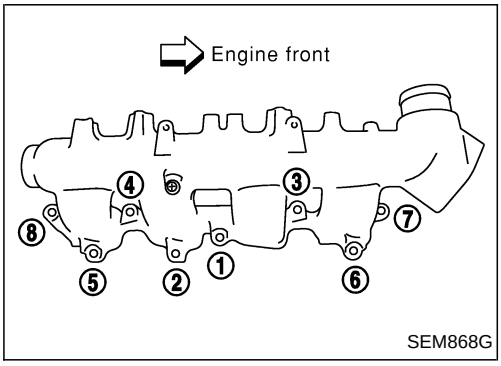
FUEL PIPING

Removal

- To prevent fuel from flowing out, plug the opening of the hose with a blind plug after disconnection.
- **Be careful not to spill fuel in the engine compartment.**

Installation

After repairing, bleed air in pipes by shifting priming pump up and down until the touch is heavy.
For further air bleeding, crank engine while operating priming pump up and down. Do not crank engine more than 10 seconds at a time.



INTAKE MANIFOLD

Removal

- Loosen bolts and nuts in the reverse order of that shown in the figure.

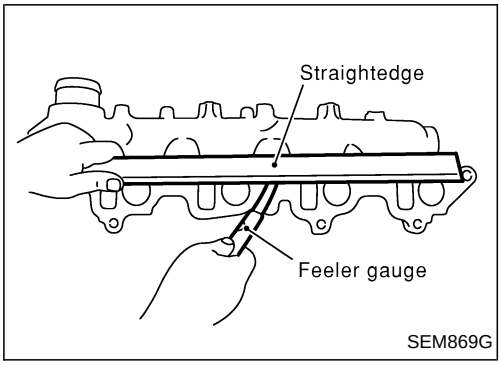
Installation

- When stud bolts come off, install with the following torque:
  : 10 - 11 N·m (1.0 - 1.2 kg-m, 87 - 104 in-lb)
- Tighten fixing bolts in the numerical order shown in the figure.

EGR VOLUME CONTROL VALVE

- **Handle with care avoiding any shocks.**
- **Do not disassemble or adjust.**

Inspection

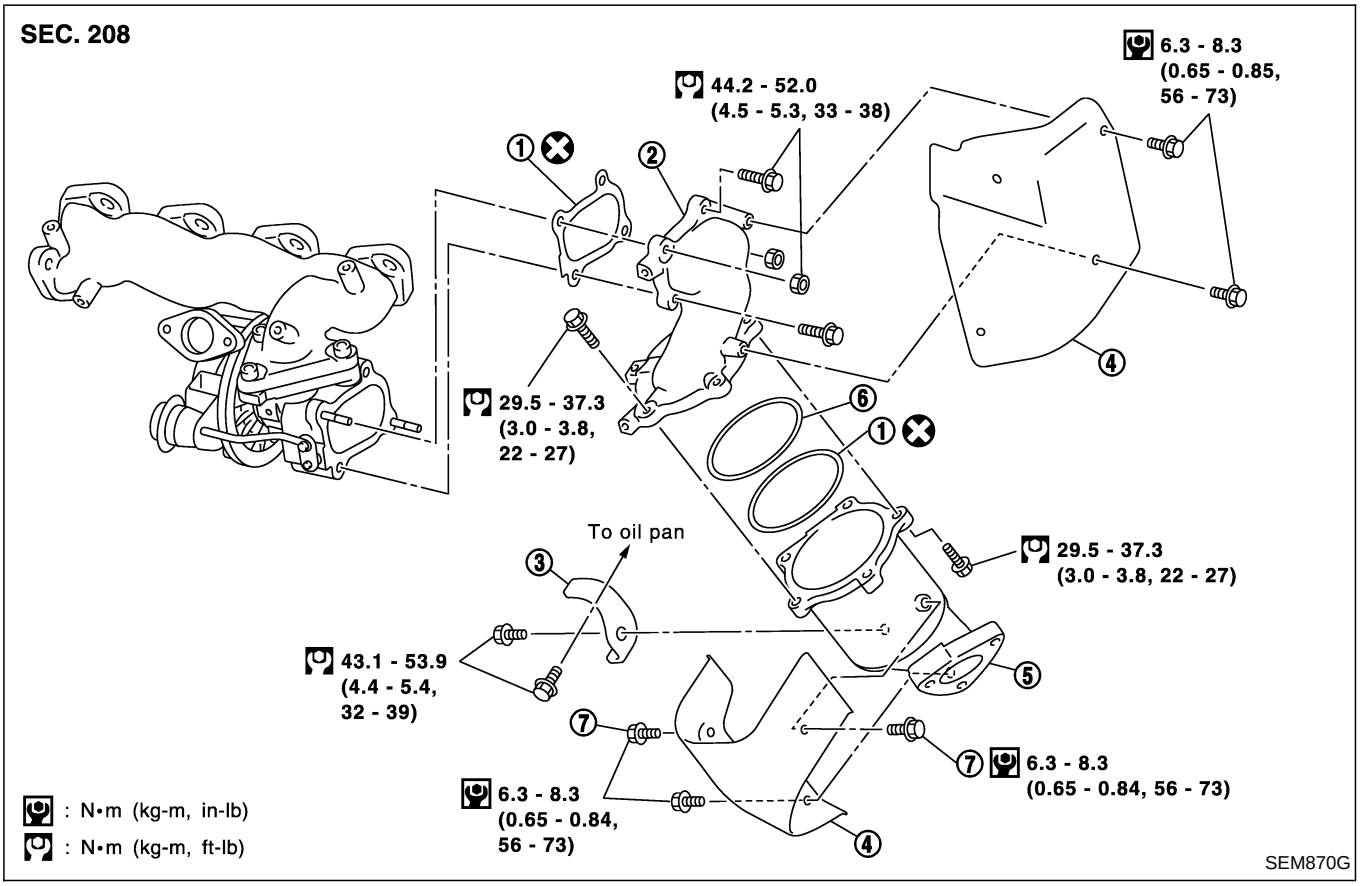


INTAKE MANIFOLD

Check distortion on the mounting surface with a straightedge and feeler gauge.

Limit: 0.1 mm (0.004 in)

Removal and Installation



1. Gasket
2. Exhaust outlet
3. Gusset
4. Insulator
5. Catalyst
6. Gasket cap
7. Locking pin

PREPARATIVE WORK

Remove the following parts.

- Charge air cooler
- Air duct, air inlet pipe
- Catalyst insulators
- Exhaust manifold cover
- Exhaust front tube (disconnect)
  Refer to FE section, “Removal and Installation”, “EXHAUST SYSTEM”.
- Oil inlet tube
- Exhaust manifold
- Catalyst converter and turbocharger assembly

CATALYST

Removal

CAUTION:
Do not disassemble.

Installation

Install two locking pins into both sides of the catalyst. Be careful not to confuse locking pins with insulator mounting bolts.

Catalyst locking pin:
Flange bolt (black)
Insulator mounting bolt:
Washer bolt (silver or yellow)

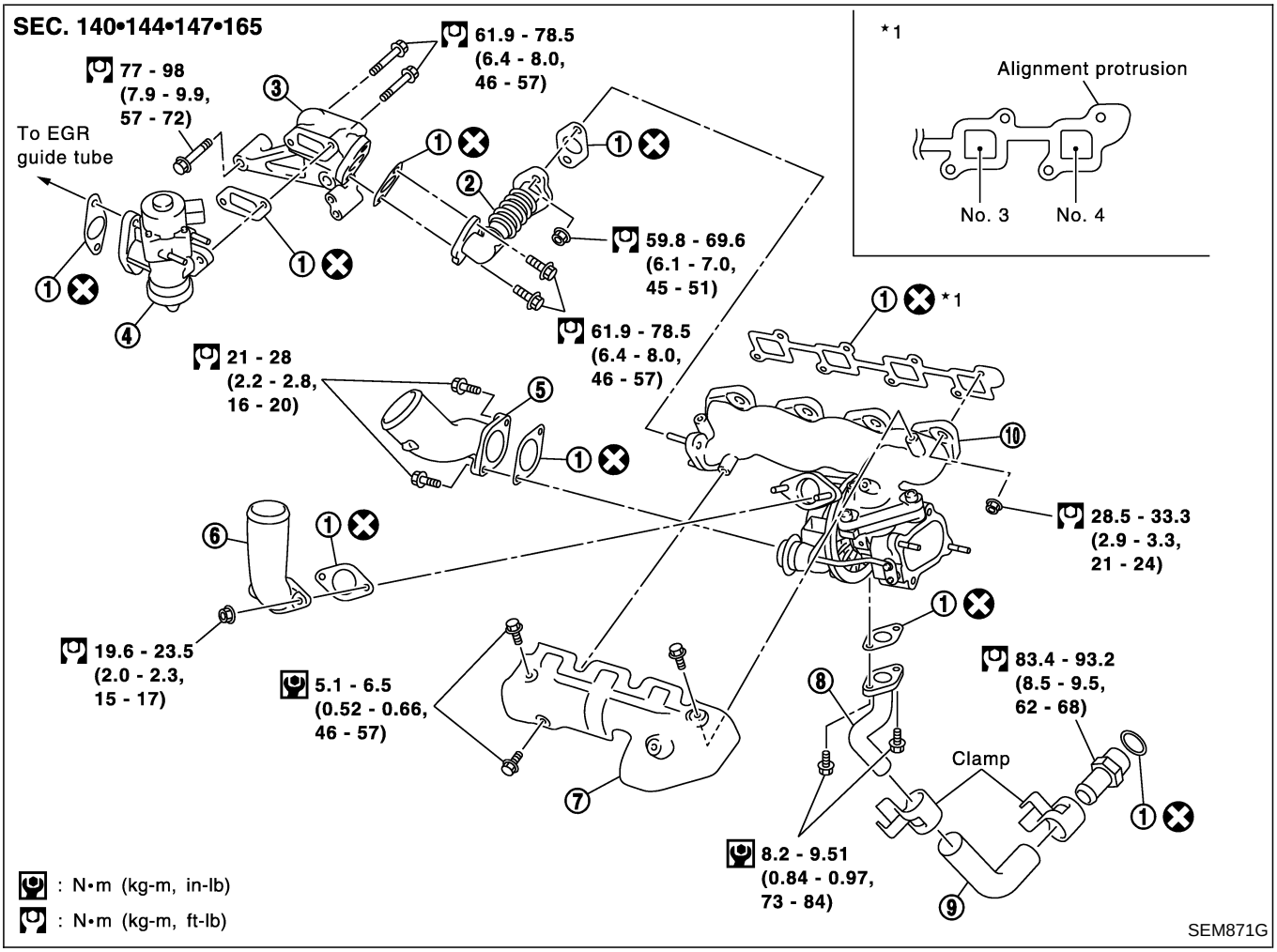
Removal and Installation (Cont'd)

GUSSET

Installation

Pushing gussets against the oil pan and the catalyst, temporarily tighten the mounting bolt. And then tighten it to the specified torque.

Removal and Installation



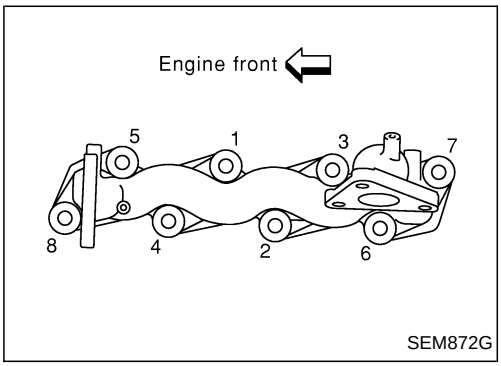
1. Gasket
2. EGR tube
3. EGR spacer
4. EGR volume control valve
5. Air inlet pipe
6. Air inlet
7. Exhaust manifold cover
8. Oil outlet tube
9. Oil return hose
10. Exhaust manifold and turbocharger assembly

PREPARATIVE WORK

Remove the following parts.

- Charge air cooler
- Air duct, air inlet pipe
- Catalyst insulators
- Exhaust manifold cover
- Exhaust front tube (disconnect)
  Refer to FE section, “Removal and Installation”, “EXHAUST SYSTEM”.
- Oil inlet and outlet tubes
- Exhaust manifold cover
- Catalyst and turbocharger assembly (Put aside until exhaust manifold is removed.)

Removal and Installation (Cont'd)



EXHAUST MANIFOLD AND TURBOCHARGER

Removal

- Loosen exhaust manifold mounting nuts in the reverse order specified in the figure.
- After removing exhaust manifold, catalyst and turbocharger assembly is pulled out.

CAUTION:

Be careful not to deform each turbocharger piping when pulling out the assembly.

Installation

- When a stud bolt is removed, tighten it to the following torque:
  : 12.7 - 16.7 N·m (1.3 - 1.7 kg-m, 10 - 12 ft-lb)
- Tighten the exhaust manifold mounting nuts in the following procedure:

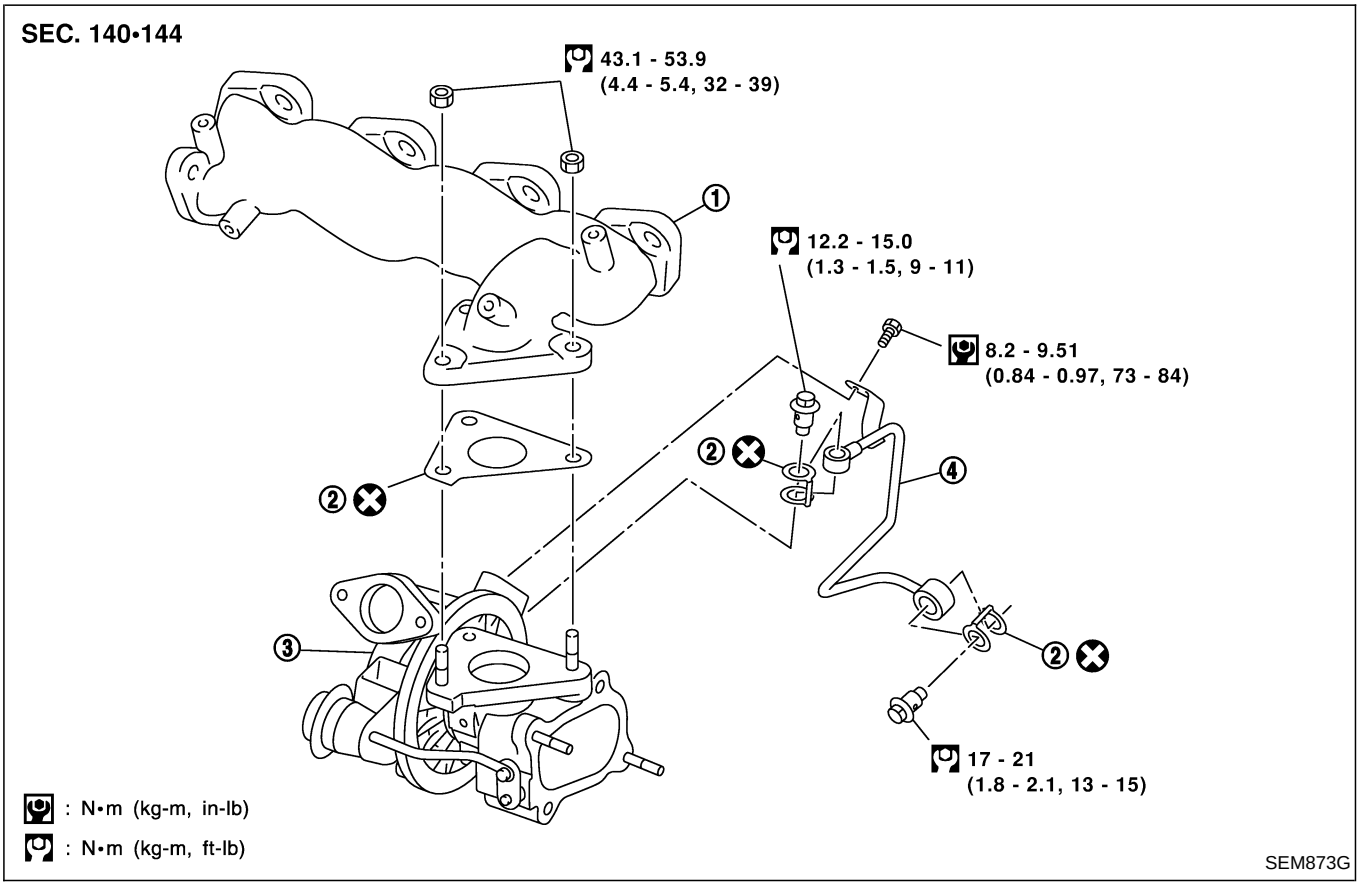
a) Tighten the nuts in the order specified in the figure.
b) Re-tighten the nuts 1 to 4.

EXHAUST MANIFOLD GASKET

Installation

Install the gasket so that the alignment protrusion faces the No. 4 port.

Disassembly and Assembly



1. Exhaust manifold
2. Gasket
3. Turbocharger
4. Oil inlet tube

TURBOCHARGER

Disassembly

After applying penetration lubricant (Lucen, etc.) to the mounting nuts, check for the penetration of the lubricant, and then loosen the nuts to remove.

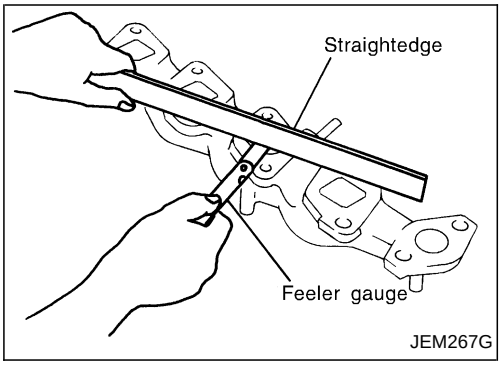
CAUTION:

Do not disassemble or adjust the turbocharger body.

Assembly

When a stud bolt is removed, tighten it to the following torque:

: 24 - 27 N·m (2.4 - 2.8 kg-m, 18 - 20 ft-lb)



Inspection

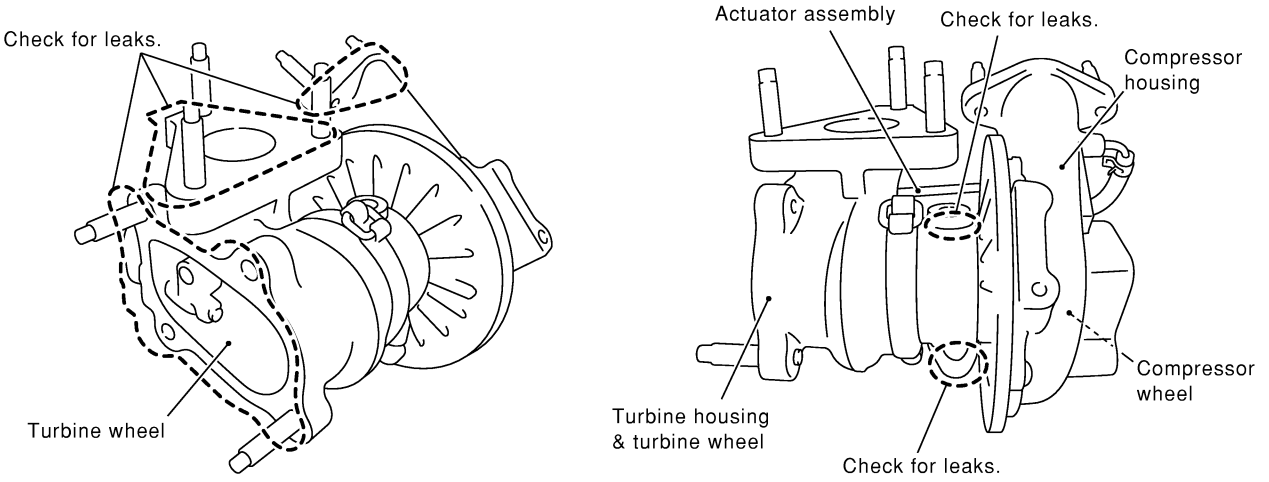
Exhaust Manifold

Check the distortion on the mounting surface in the six directions using a straightedge and a feeler gauge.

Limit: 0.3 mm (0.012 in)

Inspection (Cont'd)

TURBOCHARGER

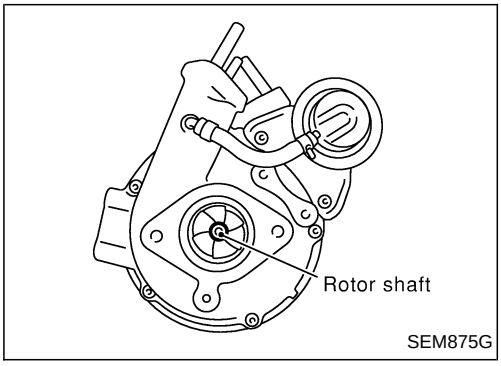


CAUTION:

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

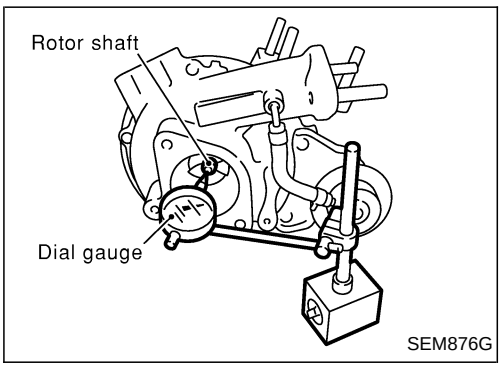
Suction side: Between turbocharger and air cleaner

Exhaust side: Between turbocharger and catalyst



Rotor Shaft

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

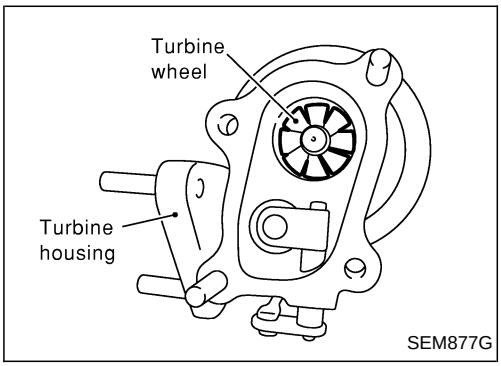


Rotor Shaft End Play

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

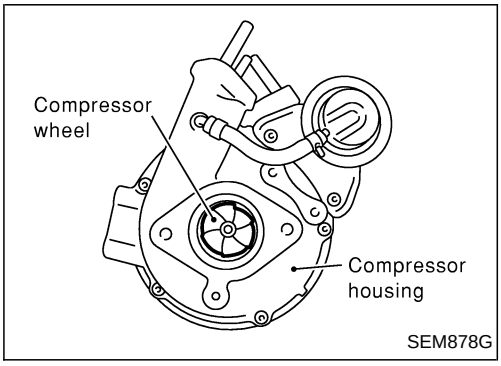
- Check that the rotor shaft does not interfere with the compressor housing.

Inspection (Cont'd)



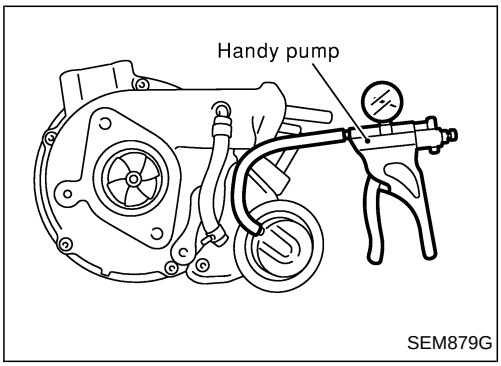
Turbine Wheel

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



Compressor Wheel

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



Wastegate Valve Actuator

- Connect the handy pump to the actuator, and check that the rod strokes smoothly in compliance with the following pressure.
- Pressure to be applied at actuator part to move rod end as follows:

  Standard (Pressure/rod stroke amount):

  143.7 - 152.9 kPa (1,437 - 1,529 mbar, 1,077.8 - 1,146.8 mmHg, 42.4 - 45.1 inHg)/2.0 mm (0.0787 in)
  161.4 - 174.8 kPa (1,614 - 1,748 mbar, 1,210.5 - 1,311.0 mmHg, 47.7 - 51.6 inHg)/4.0 mm (0.157 in)

Inspection (Cont'd)

Trouble Diagnosis of Turbocharger

Preliminary check:

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

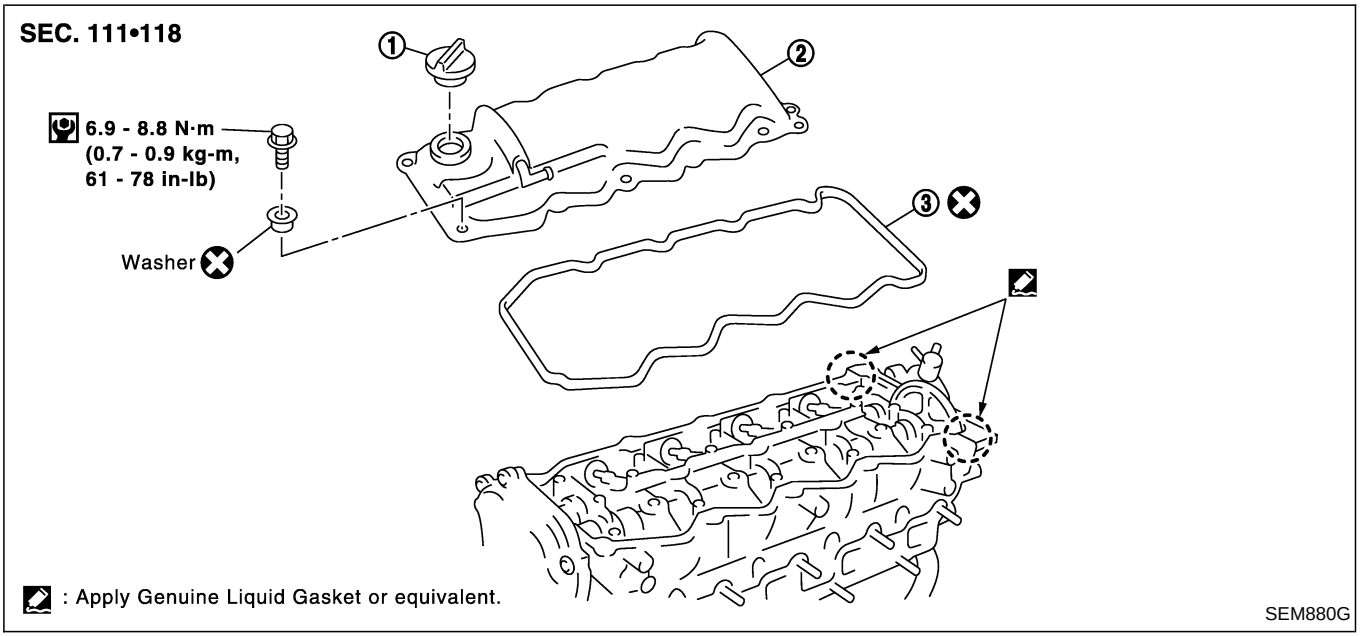
Inspection item	Inspection result	Symptom (when each inspection item meets each inspection result)			
		Oil leakage	Smoke	Noise	Insufficient power/ acceleration failure
Turbine wheel	Oil leaks.	△	◎	△	△
	Carbon is accumulated.	△	◎	○	○
	Friction with housing.	△	○	◎	○
	Blades are bent or broken.			◎	◎
Compressor wheel	Inside the air inlet is seriously contaminated by oil.	○	○		
	Friction with housing.	△	○	◎	○
	Blades are bent or broken.			◎	◎
After checking both turbine and compressor, inspect rotor shaft end play.	There is resistance when the rotor shaft is rotated by your fingertips.		△	△	○
	The rotor shaft sometimes does not rotate by your fingertips.				◎
	There is too much play in the bearing.	△	△	○	△
Oil return port	Carbon or sludge is accumulated in the waste oil hole.	△	◎	△	△

◎: Large possibility

○: Medium possibility

△: Small possibility

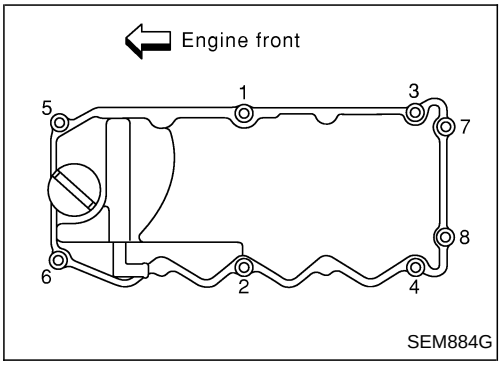
Removal and Installation



1. Oil filler cap
2. Rocker cover
3. Gasket

PREPARATIVE WORK

Remove the engine following parts.
- Charge air cooler
- Charge air cooler bracket



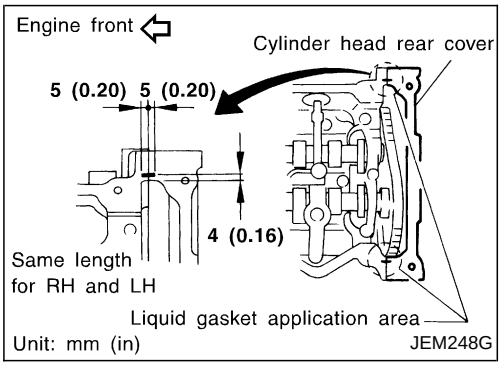
ROCKER COVER

Removal

Loosen bolts in the reverse order of that shown in the figure and remove.

Installation

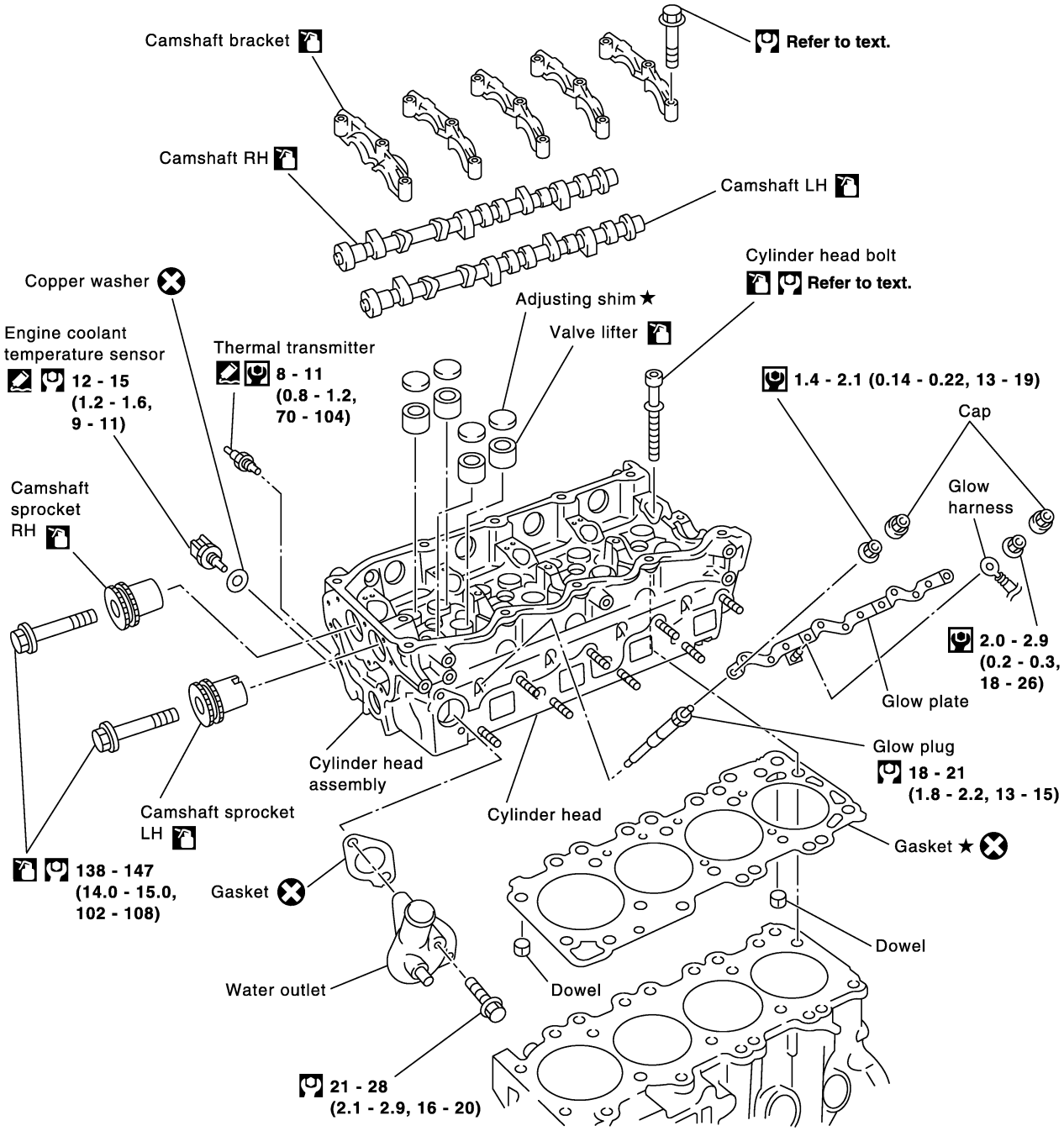
- Tighten bolts in the numerical order shown in the figure.
- Re-tighten to the same torque in the same order as above.



- Apply 3.0 mm (0.118 in) dia. of specified liquid gasket (Refer to EM-3, “Liquid Gasket Application Procedure”.) on locations shown in the figure.
- Install in the reverse order of removal.

Components

SEC. 111•210•220•253



★ : Select with proper thickness.

: Lubricate with new engine oil.

: Apply Genuine Liquid Gasket or equivalent.

: N•m (kg-m, ft-lb)

: N•m (kg-m, in-lb)

SEM887G

Components (Cont'd)

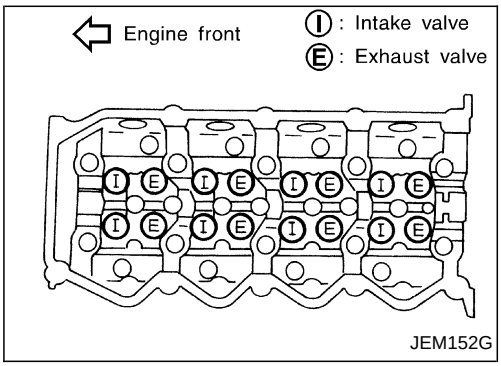
CAUTION:

- **When installing camshafts, chain tensioners, oil seals, or other sliding parts, lubricate contacting surfaces with new engine oil.**
- **Apply new engine oil to threads and seat surfaces when installing cylinder head, camshaft sprocket, crankshaft pulley, and camshaft bracket.**
- **Attach tags to valve lifters so as not to mix them up.**

Removal

1. Drain engine coolant. Refer to LC section, "Changing Engine Coolant".
2. Remove exhaust manifold, Turbocharger. Refer to EM-43, "Removal and Installation".
3. Remove intake manifold. Refer to EM-39, "Removal and Installation".

- **Apply paint to camshaft sprockets for alignment during installation.**



JEM152G

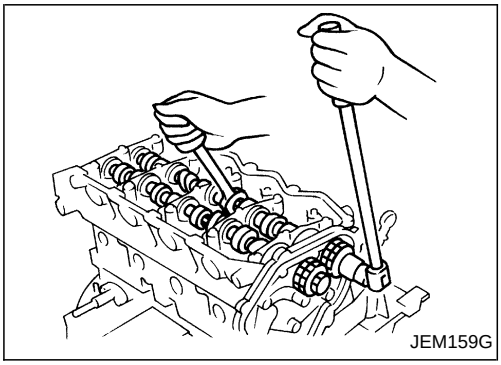
CAMSHAFT

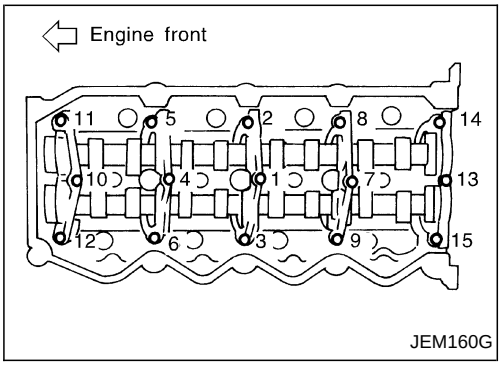
1. Remove the following parts referring to appropriate part in this section.

- Charge air cooler cover
- Charge air cooler and charge air cooler bracket
- EGR guide tube and EGR spacer
- Rocker cover
- Spill tube
- Injection tube
- Injection nozzle oil seal
- High pressure injection nozzle assembly
- Secondary timing chain and associated parts

2. Remove camshaft sprockets.

- Holding the hexagonal part of the camshaft with a wrench having 21 mm (0.83 in) width between facing flats, loosen the bolt of the camshaft sprocket.


JEM159G



JEM160G

3. Remove camshafts.

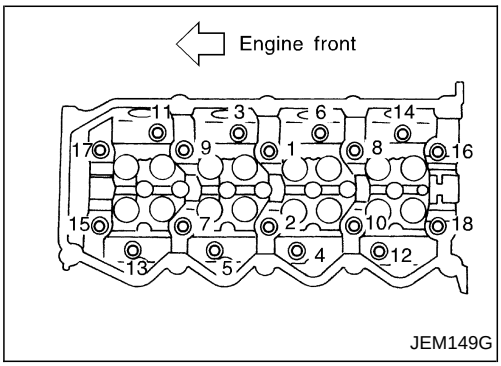
- Loosen bolts of the camshaft bracket in several stages in the reverse order of that shown in the figure, and remove them.

4. Remove adjusting shims and valve lifters.

- Confirm the correct location of each part removed. Store them so they do not get mixed up.
- **For re-installation, be sure to put mark on camshaft bracket before removal.**

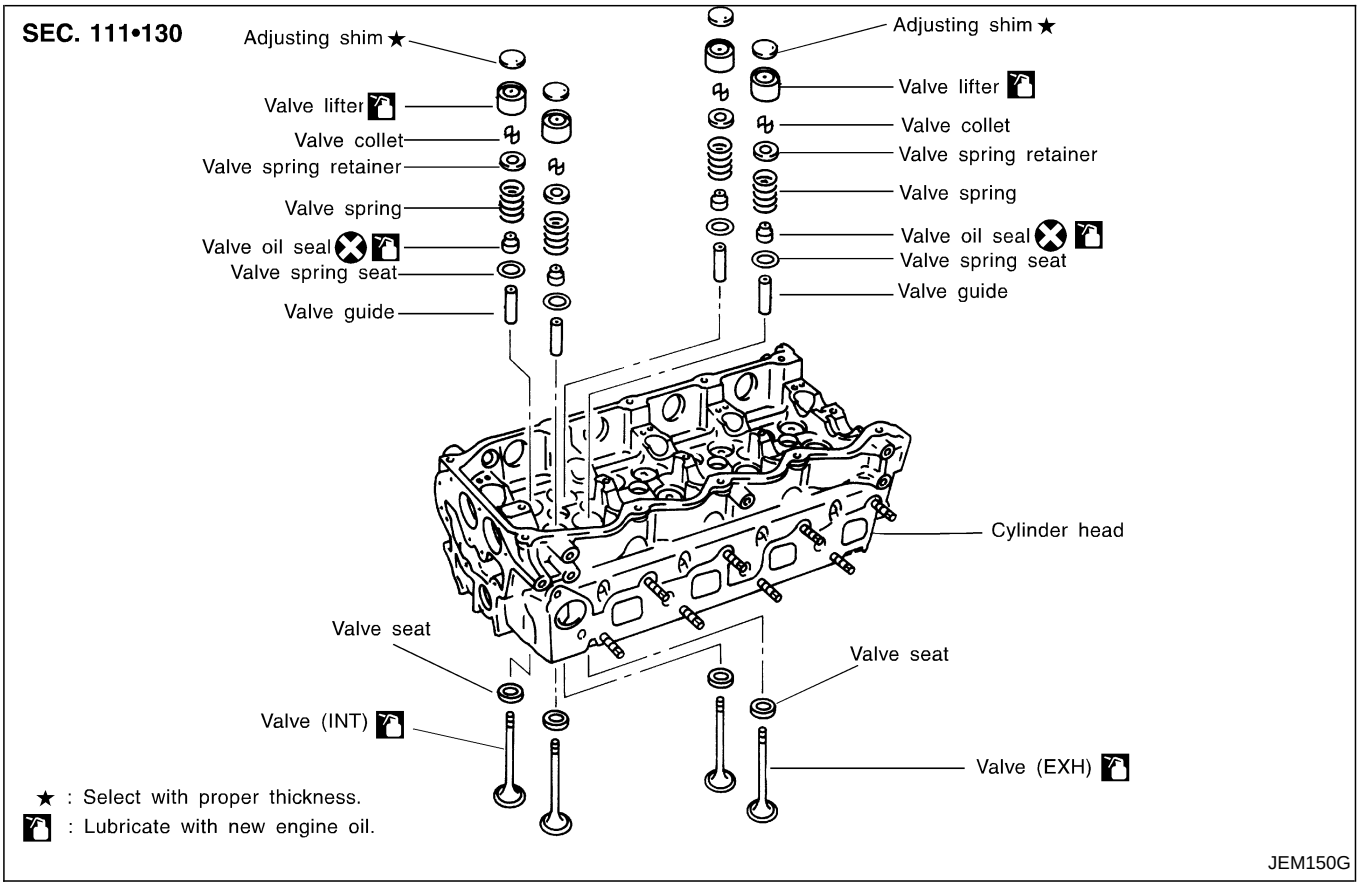
Removal (Cont'd)

CYLINDER HEAD

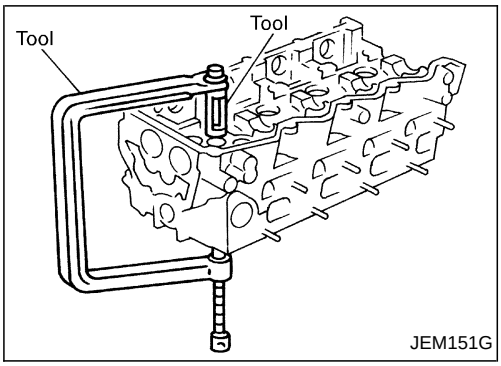


- Loosen bolts in the reverse order of that shown in the figure and remove them.
- **Be careful not to damage the tips of glow plugs projecting out of the bottom surface of the cylinder head. To avoid damage to glow plugs, either remove them beforehand, or support cylinder head with wooden blocks to create a space below the bottom surface.**

Disassembly

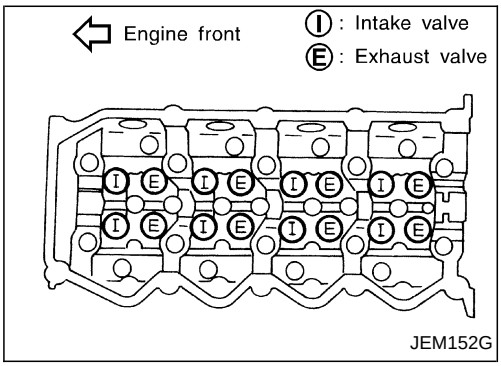


1. Remove adjusting shims and valve lifters. Confirm the correct location of each part removed. Store them in order to avoid mixing them up.

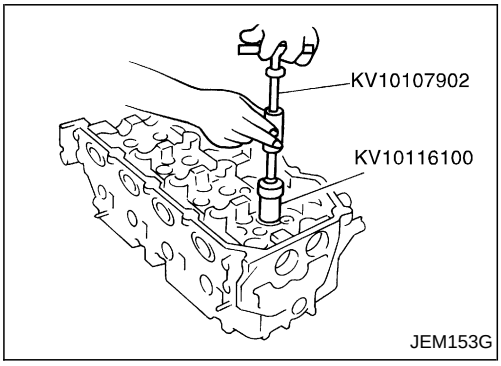


2. Remove valve collets.
- Compress valve spring with a valve spring compressor, and remove valve collet with a magnet hand.
3. Remove valve spring retainers, and valve springs.
4. Push valve stem toward combustion chamber and remove valve.
- Before removing valves, check valve guide clearance. Refer to EM-55, "VALVE GUIDE CLEARANCE".
- Confirm the correct location of each valve. Store them so they do not get mixed up.

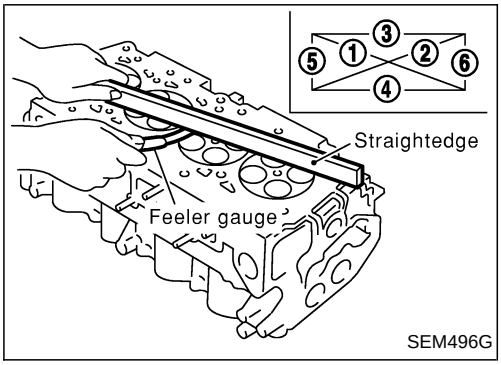
Disassembly (Cont'd)



- For the locations and arrangement of intake and exhaust valves, refer to the figure.



5. Remove valve oil seals.
- Use a valve oil seal puller (SST) for removal.
6. Remove valve spring seats.
7. When removing valve seats, check valve seat contact. Refer to EM-57.
8. Before removing valve guides, check valve guide clearance. Refer to EM-55, "VALVE GUIDE CLEARANCE".
9. Remove glow plugs.
- **To avoid damage, glow plugs should be removed only when required.**
- **Handle with care to avoid applying shock. (When dropped from approx. 100 mm (3.94 in) or higher, always replace with a new one.)**



Inspection

CYLINDER HEAD DISTORTION

Clean surface of cylinder head. Use a reliable straightedge and feeler gauge to check the flatness of cylinder head surface. Check along six positions shown in the figure.

Head surface flatness: Limit 0.04 mm (0.0016 in)

If beyond the specified limit, resurface or replace it.

The limit for cylinder head resurfacing is determined by the cylinder block resurfacing.

Resurfacing limit:

Amount of cylinder head resurfacing is "A".

Amount of cylinder block resurfacing is "B".

The maximum limit: A + B = 0.07 mm (0.0028 in)

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

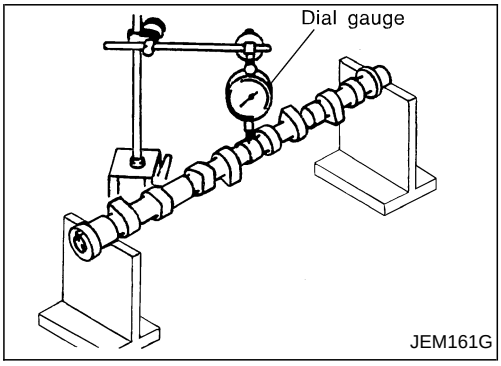
Nominal cylinder head height:

153.9 - 154.1 mm (6.059 - 6.067 in)

Inspection (Cont'd)

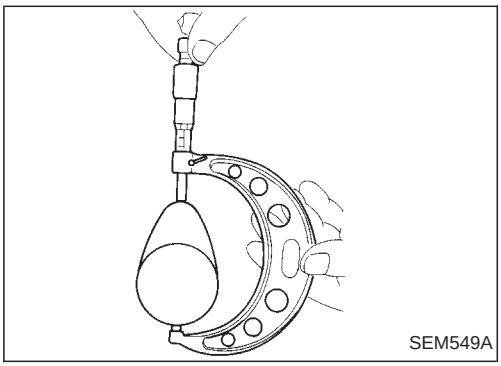
CAMSHAFT VISUAL CHECK

Check camshaft for scratches, seizure and wear.



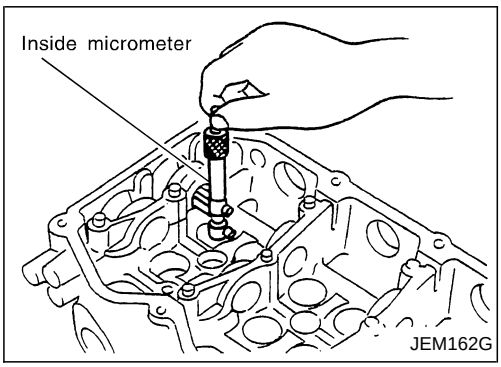
CAMSHAFT RUNOUT

1. Place V-blocks on a work bench and support camshaft at No. 1 and No. 5 journal.
2. Set dial gauge perpendicularly at camshaft No. 3 journal.
3. Turn camshaft by hand in one direction and read runout on dial gauge.
   Runout (Total indicator reading):
   Limit 0.02 mm (0.0008 in)
4. If it exceeds the limit, replace camshaft.



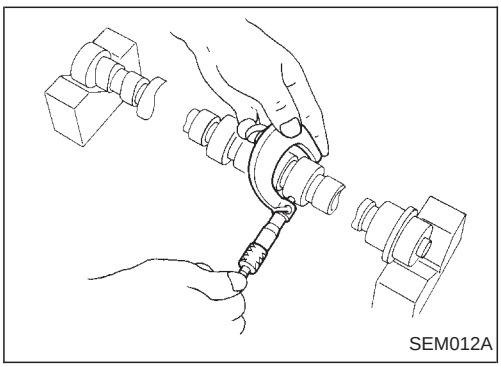
CAMSHAFT CAM HEIGHT

1. Measure camshaft cam height.
   Standard cam height:
   Intake
   39.505 - 39.695 mm (1.5553 - 1.5628)
   Exhaust
   39.905 - 40.095 (1.5711 - 1.5785)
   Cam wear limit:
   0.15 mm (0.0059 in)
2. If wear is beyond the limit, replace camshaft.



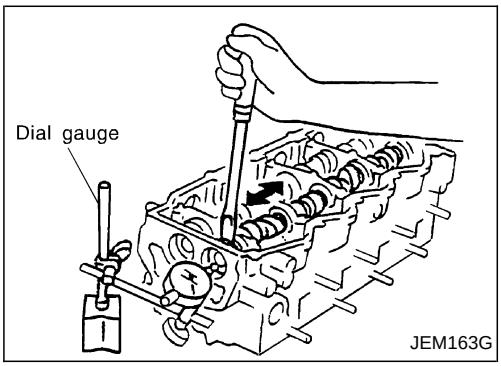
CAMSHAFT JOURNAL CLEARANCE

1. Install camshaft bracket and tighten bolts to the specified torque.
2. Measure inner diameter of camshaft bearing.
   Standard inner diameter:
   No. 1: 30.500 - 30.521 mm (1.2008 - 1.2016 in)
   No. 2, 3, 4, 5: 24.000 - 24.021 mm (0.9449 - 0.9457 in)



3. Measure outer diameter of camshaft journal.
   Standard outer diameter:
   No. 1: 30.435 - 30.455 mm (1.1982 - 1.1990 in)
   No. 2, 3, 4, 5: 23.935 - 23.955 mm (0.9423 - 0.9431 in)
4. If clearance exceeds the limit, replace camshaft and/or cylinder head.
   Camshaft journal clearance:
   Standard
   No. 1 - 5: 0.045 - 0.086 mm (0.0018 - 0.0034 in)
   Limit
   0.045 - 0.086 mm (0.0018 - 0.0034 in)

Inspection (Cont'd)

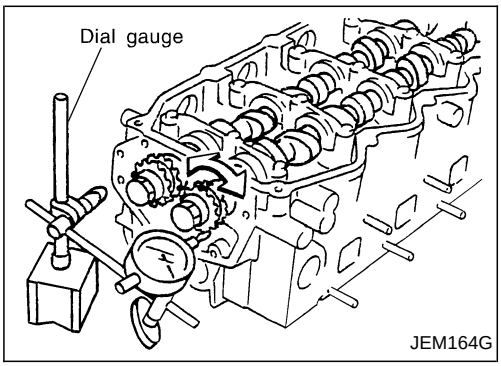


CAMSHAFT END PLAY

1. Install camshaft in cylinder head.
2. Measure camshaft end play.

Camshaft end play:
Standard
0.070 - 0.148 mm (0.0028 - 0.0058 in)
Limit
0.24 mm (0.0094 in)

- If the value exceeds the limit, replace camshaft and measure again.
- If the measurement exceeds the limit again, replace cylinder head.

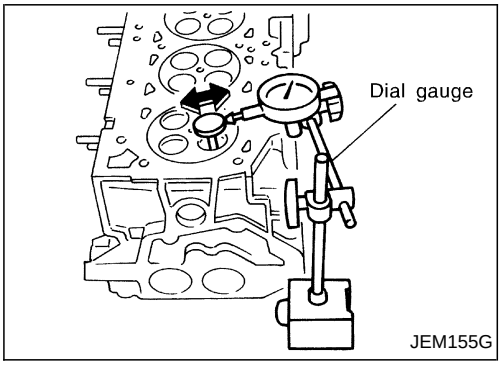


CAMSHAFT SPROCKET RUNOUT

1. Install sprocket on camshaft.
2. Measure camshaft sprocket runout.

Runout (Total indicator reading):
Less than 0.15 mm (0.0059 in)

3. If it exceeds the limit, replace camshaft sprocket.



VALVE GUIDE CLEARANCE

1. Check that valve stem diameter is within the specified range.
2. Push out valve approx. 25 mm (0.98 in) toward combustion chamber. Swing valve in the direction of the dial gauge to measure the runout.

- This inspection should be performed before removing valve guides.
- Half of the runout reading on the dial gauge is the valve guide clearance.

Standard:
Intake 0.020 - 0.053 mm (0.0008 - 0.0021 in)
Exhaust 0.040 - 0.073 mm (0.0016 - 0.0029 in)

3. If it exceeds the limit, check valve to valve guide clearance.

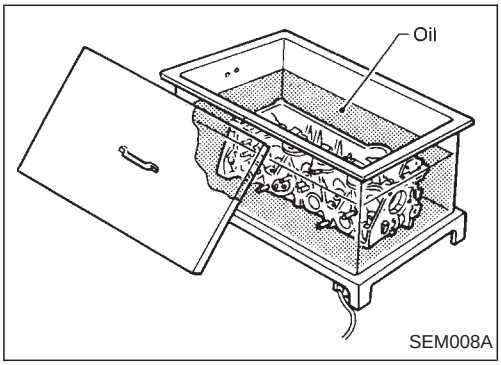
a. Measure valve stem diameter and valve guide inner diameter.
b. Check that clearance is within specification.

Valve to valve guide clearance limit:
Intake 0.08 mm (0.0031 in)
Exhaust 0.1 mm (0.004 in)

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

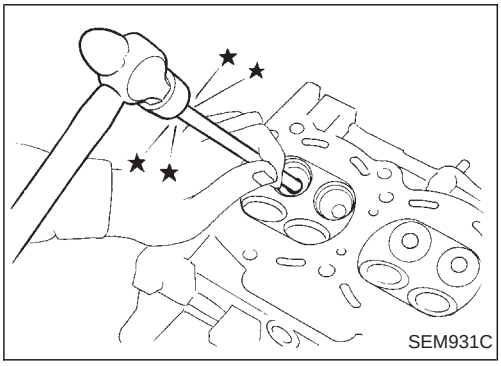
Inspection (Cont'd)

VALVE GUIDE REPLACEMENT

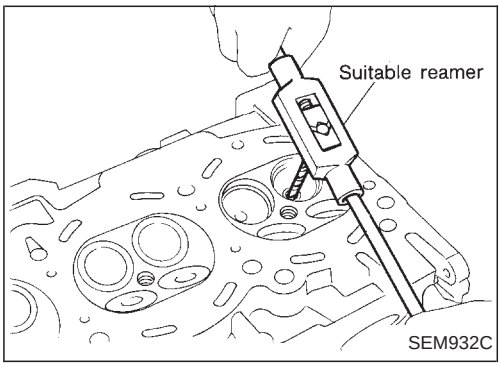


- When a valve guide is removed, replace with an oversized [0.2 mm (0.008 in)] valve guide.

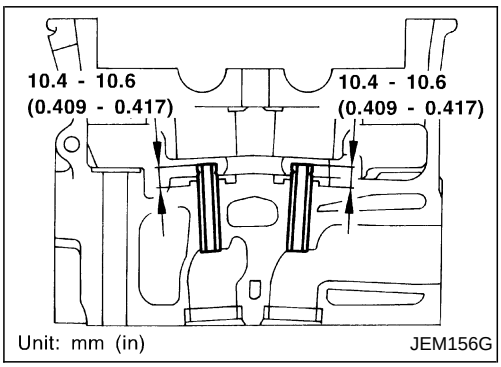
1. To remove valve guide, heat cylinder head to 110 to 130°C (230 to 266°F) by soaking in heated oil.



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.

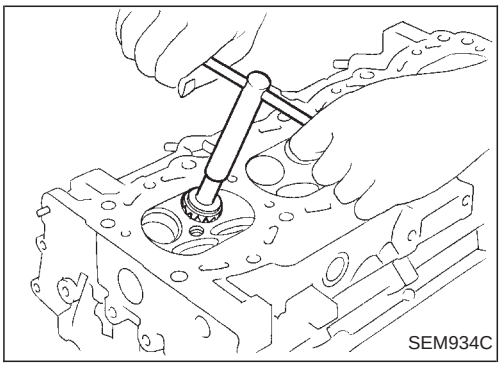


3. Ream cylinder head valve guide hole.
   Valve guide hole diameter (for service parts):
   10.175 - 10.196 mm (0.4006 - 0.4014 in)



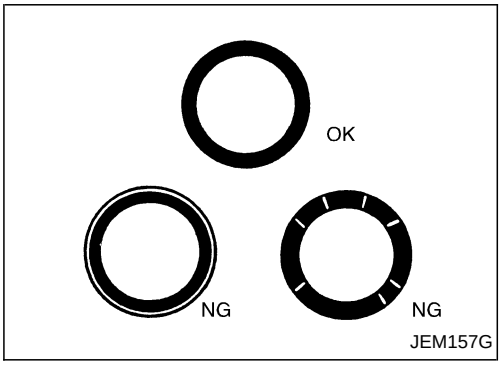
4. Heat cylinder head to 110 to 130°C (230 to 266°F) and press service valve guide onto cylinder head.
   Projection "L":
   10.4 - 10.6 mm (0.409 - 0.417 in)
5. Ream valve guide.
   Finished size:
   6.000 - 6.018 mm (0.2362 - 0.2369 in)

Inspection (Cont'd)

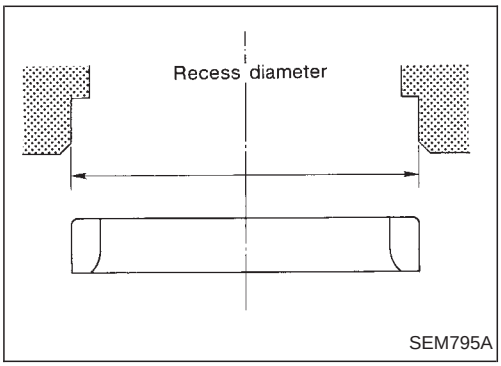

SEM934C

VALVE SEATS

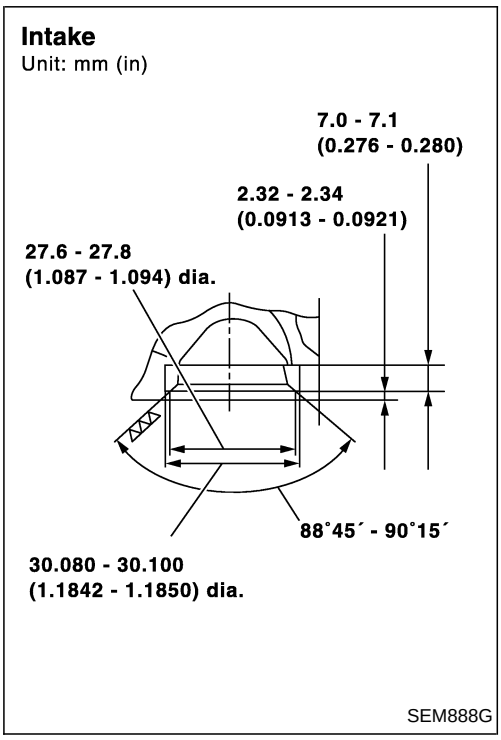
- Before starting this check, confirm that the dimensions of valve guides and valves are as specified.
- Apply red lead primer on contacting surfaces of valve seat and of valve face to examine the conditions of contacting surfaces.
- Check that the paint on contacting surfaces is continuous along the entire circumference.
- If there are abnormal indications, grind the valve and check the contact again. If abnormal indications still persist, replace valve seat.



JEM157G



SEM795A



SEM888G

REPLACING VALVE SEAT FOR SERVICE PARTS

1. Bore out old seat until it collapses. Boring should not continue beyond the bottom face of the seat recess in cylinder head. Set the machine depth stop to ensure this.
2. Ream cylinder head recess for service valve seat.
   Oversize [0.5 mm (0.020 in)]:
   Intake 30.500 - 30.516 mm (1.2008 - 1.2014 in)
   Exhaust 29.500 - 29.516 mm (1.1614 - 1.1620 in)
   Be sure to ream in circles concentric to the valve guide center.
   This will enable valve seat to fit correctly.
3. Heat cylinder head to 110 to 120°C (230 to 248°F) by soaking in heated oil.
4. Sufficiently cool valve seat with dry ice. Force fit valve seat into cylinder head.

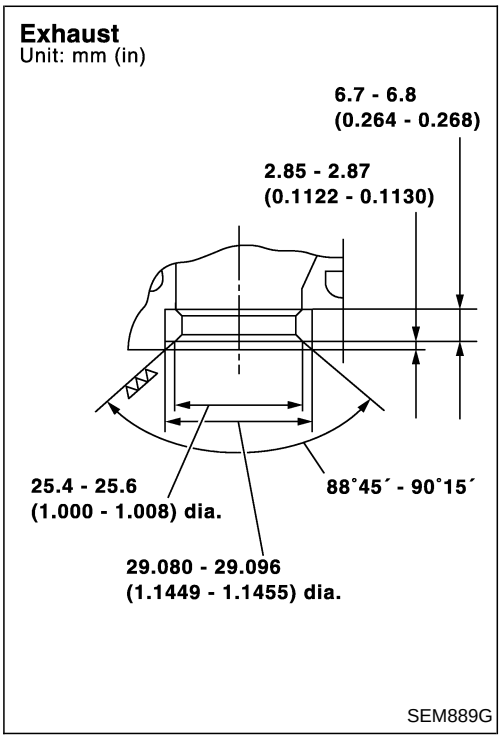
WARNING:
Do not touch cold valve seat with your bare hands.

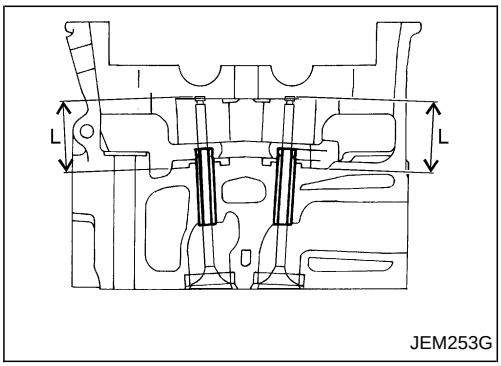
5. Cut or grind valve seat using suitable tool to the specified dimensions as shown in SDS (EM-170).

CAUTION:
Use the valve seat cutter properly. Securely gripping the cutter handle with both hands, press the cutter down onto the entire circumference of the contacting surface and finish cutting at one time. Improper pressing of the cutter or cutting in several steps may result in staged surface on the valve seat.

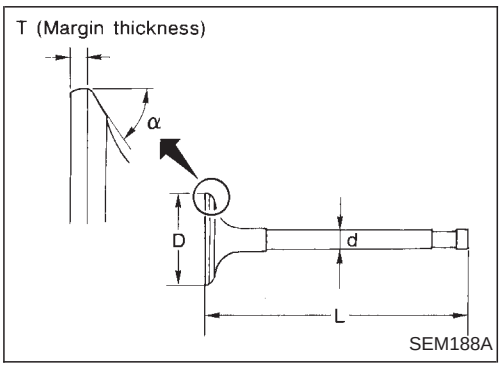
6. After cutting, lap valve seat with abrasive compound.
7. Check valve seating condition. Refer to EM-57, "Valve Seats".

Inspection (Cont'd)



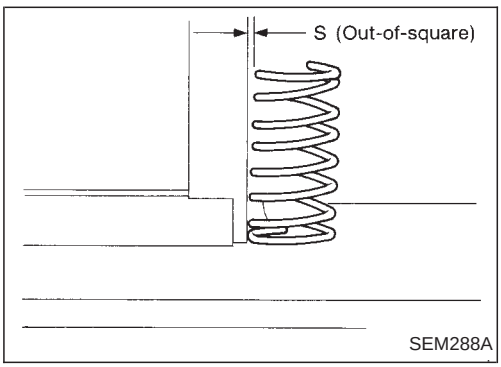


8. Use a depth gauge to measure the distance between the mounting surface of the cylinder head spring seat and the valve stem end. If the distance is shorter than specified, repeat step 5 above to adjust it. If it is longer, replace the valve seat with a new one.
   Valve seat resurface limit "L":
   Intake 36.53 - 36.98 mm (1.4382 - 1.4559 in)
   Exhaust 36.53 - 37.01 mm (1.4382 - 1.4571 in)



VALVE DIMENSIONS

Check dimensions of each valve. For dimensions, refer to SDS (EM-167).
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.

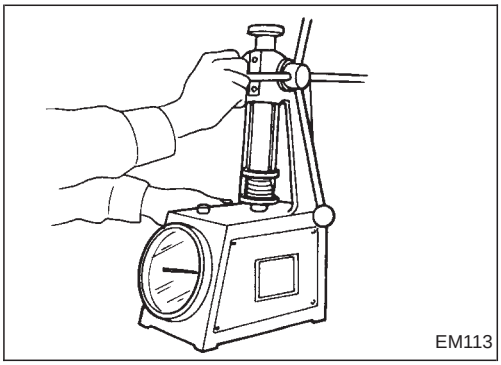


VALVE SPRING

Squareness

1. Measure dimension "S".
   Out-of-square "S":
   Limit 1.9 mm (0.075 in)
2. If it exceeds the limit, replace spring.

Inspection (Cont'd)


EM113

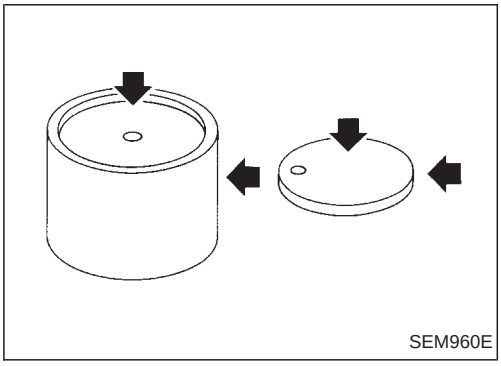
Pressure

Check valve spring pressure at specified spring height.

Standard:

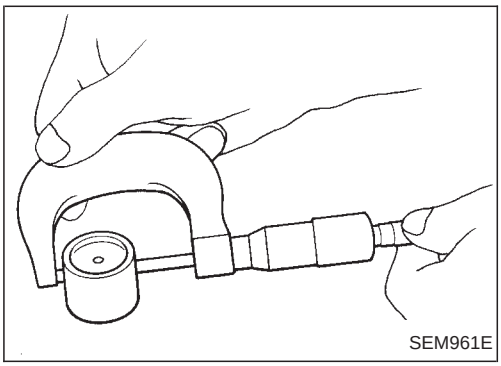
Free height 43.7 mm (1.720 in)
Installation height 32.82 mm (1.2921 in)
Installation load 184 - 208 N (18.77 - 21.22 kg, 41.4 - 46.8 lb)
Height during valve open 24.82 mm (0.9772 in)
Load with valve open 320 - 360 N (32.65 - 36.73 kg, 71.9 - 80.9 lb)

If it exceeds the standard, replace spring.


SEM960E

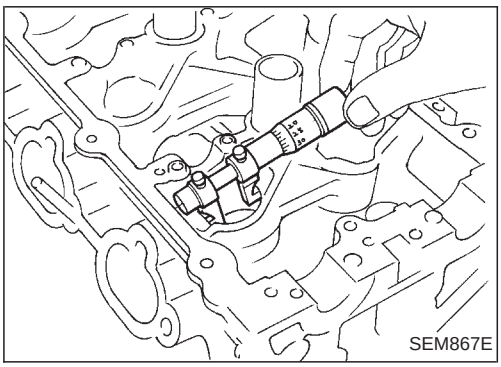
VALVE LIFTER

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


SEM961E

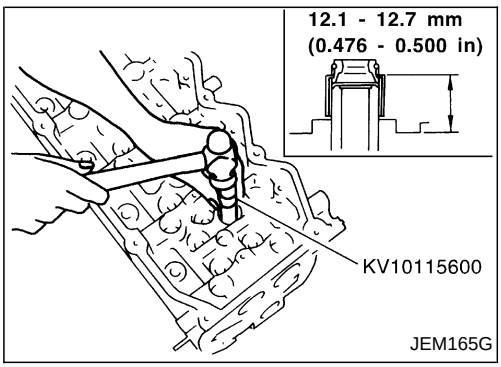
2. Check diameter of valve lifter and valve lifter guide bore.

Valve lifter outer diameter:
29.960 - 29.975 mm (1.1795 - 1.1801 in)


SEM867E

Lifter guide bore diameter:
30.000 - 30.021 mm (1.1811 - 1.1819 in)
Clearance between lifter and lifter guide:
Standard 0.025 - 0.061 mm (0.0010 - 0.0024 in)

- If the value is out of the range, replace valve lifter and/or cylinder head, referring to the specified values for the outer diameter and bore diameter.



JEM165G

Assembly

1. Install valve oil seal.

- Using valve oil seal drift (SST), install so that the dimension shown in the figure is obtained. The dimension in the figure shows the dimension before the valve spring seat is installed.
- Different parts should be used depending on the valve oil seal location. Identify by the rubber color.
  For intake: Black
  For exhaust: Brown
- **Always use new valve oil seal.**
- **Before installing valve oil seal, install valve spring seat.**

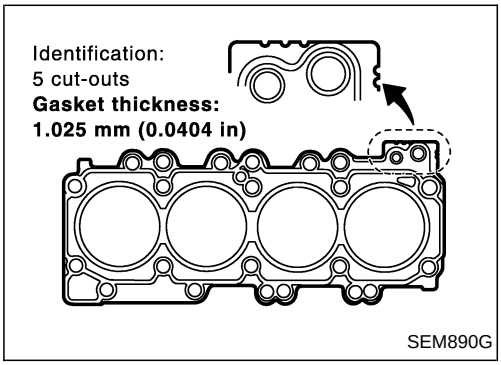
Assembly (Cont'd)

2. Install other valve component parts. Refer to "Disassembly", EM-52.

- After installing valve collets, tap valve stem tip with plastic hammer to assure a proper fit.

Installation

- **Before installation, remove old liquid gasket from mating surface of all liquid gasket applied parts.**



CYLINDER HEAD GASKET SELECTION

- Select and install cylinder head gasket with appropriate thickness according to the following procedure:

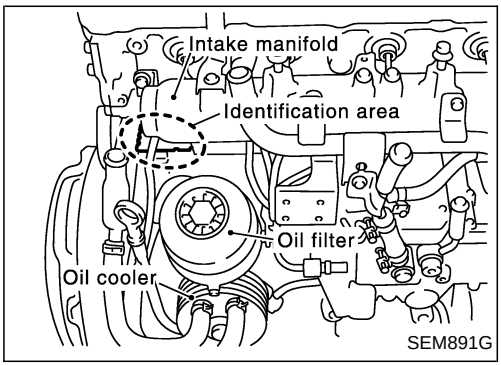
When replacing gasket alone:

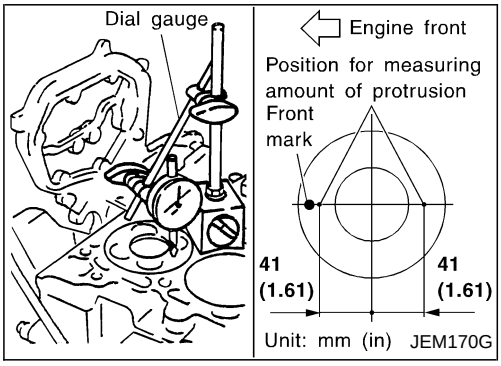
- Install a gasket with the same thickness as that of the one removed.
- Identify the thickness of gasket by the number of cut-outs and holes on the rear RH side.

Gasket thickness* mm (in)	Number of grade	Number of cut-outs
0.900 (0.0354)	1	0
0.925 (0.0364)	2	1
0.950 (0.0374)	3	2
0.975 (0.0384)	4	3
1.000 (0.0394)	5	4
1.025 (0.0404)	6	5

*: Measured with head bolts tightened

Installation (Cont'd)





- Gasket thickness can be identified at the location shown in the figure by the numbers of cut-outs before removal.

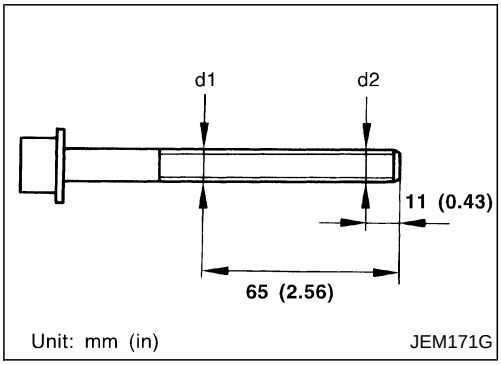
When the following parts have been repaired/replaced:

- With cylinder block upper surface and/or crankshaft pin journal ground
- With cylinder block, pistons, connecting rods, and/or crankshaft replaced

1. Set piston at a point close to TDC.
2. Set a dial gauge at the location as shown in the figure. Turning crankshaft gradually, set the gauge scale to "0" where the piston protrusion is maximized.
3. Move the dial gauge stand so that the tip of dial gauge can contact the cylinder block. Read the difference.
4. Measure at two locations per cylinder, that is eight locations for four cylinders. Select gasket based on the maximum protrusion of eight measurements.

Piston protrusion mm (in)	Gasket thickness* mm (in)	Identification
		Number of cut-outs
Less than 0.255 (0.0100)	0.900 (0.0354)	0
Less than 0.255 - 0.280 (0.0100 - 0.0110)	0.925 (0.0364)	1
Less than 0.280 - 0.305 (0.0110 - 0.0120)	0.950 (0.0374)	2
Less than 0.305 - 0.330 (0.0120 - 0.0130)	0.975 (0.0384)	3
Less than 0.330 - 0.355 (0.0130 - 0.0140)	1.000 (0.0394)	4
More than 0.355 (0.0140)	1.025 (0.0404)	5

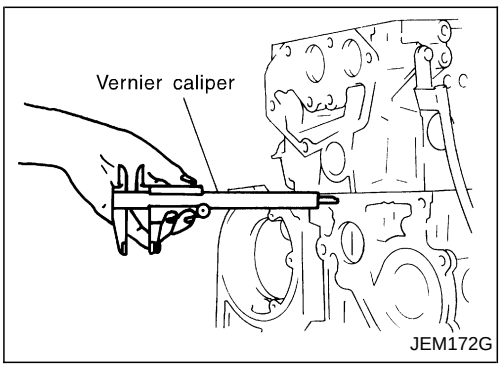
*: Measured with head bolts tightened



CYLINDER HEAD BOLT DEFORMATION CHECK

- Measure the outer diameter of threaded area, d1 and d2, at the points specified in the figure.
- When the necked point is identified at a point other than specified points, measure at the point as d1.
- Calculate the difference between d1 and d2. If the value exceeds the limit, replace with new ones.

  Limit: 0.15 mm (0.0059 in)

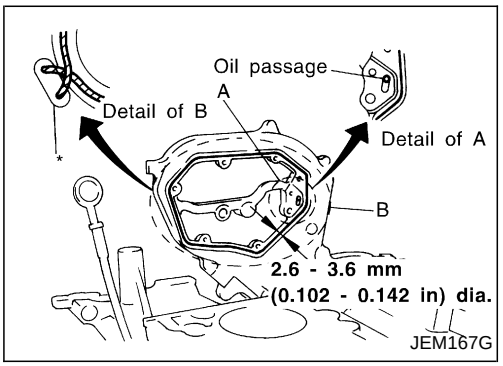


CYLINDER HEAD-TO-BLOCK DIFFERENCE CHECK

- After installing cylinder head, measure dimension from the front end surface of cylinder block to that of cylinder head.

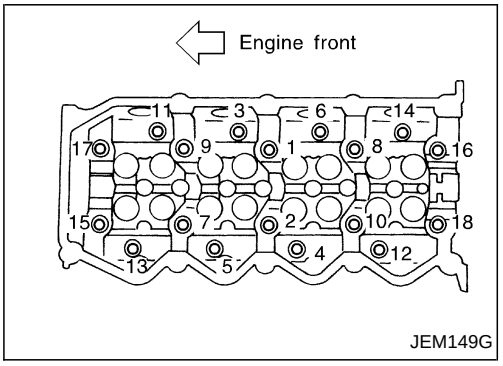
  Standard: 23.53 - 24.07 mm (0.9264 - 0.9476 in)
- If the difference is out of the range, check fitting of dowel pins and cylinder head.

Installation (Cont'd)



LIQUID GASKET APPLICATION ON REAR CHAIN CASE

Apply a continuous bead of specified liquid gasket (Refer to EM-3, "Liquid Gasket Application Procedure".) on the surface shown in the figure.
A: Apply bead so that it does not protrude into oil passage.
B: Minimize the overlapping area of the bead, with start and end areas of bead as shown in the figure.
Apply so that the portion marked * comes at an external location but cannot be viewed externally after engine is assembled.

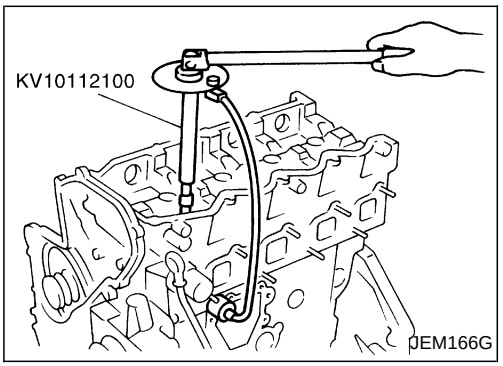


CYLINDER HEAD INSTALLATION

- Tighten bolts in numerical order as shown in the figure according to the following procedure:

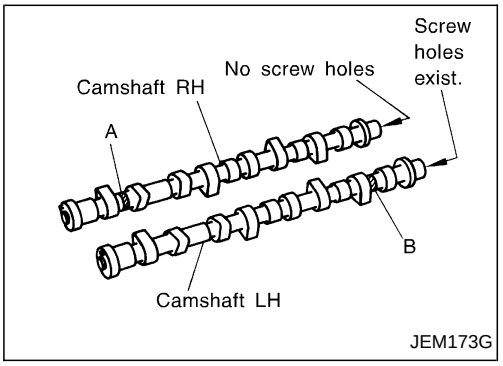
1. Apply engine oil to bolt threads and seat surfaces.
2. Tighten bolts to 35 to 44 N·m (3.5 to 4.5 kg-m, 26 to 32 ft-lb).
3. Tighten 180° to 185° [target: 180°] (angular tightening).
4. Loosen completely to 0 N·m (0 kg-m, 0 in-lb) in the reverse order of that shown in the figure.
5. Tighten bolts to 35 to 44 N·m (3.5 to 4.5 kg-m, 26 to 32 ft-lb).
6. Tighten 90° to 95° [target: 90°] (angular tightening).
7. Tighten another 90° to 95° [target: 90°] (angular tightening).

- **When an angle wrench is not used, paint an alignment mark on the head of cylinder head bolt and cylinder head surface before tightening. Check the angle with a protractor.**



GLOW PLUG INSTALLATION

- **To avoid damage, glow plugs should be removed only when required.**
- **Handle with care to avoid applying shock. (When dropped from approx. 100 mm (3.94 in) or higher, always replace with a new one.)**
- **Before installing, remove carbon depositing on mounting hole of glow plug with a reamer.**

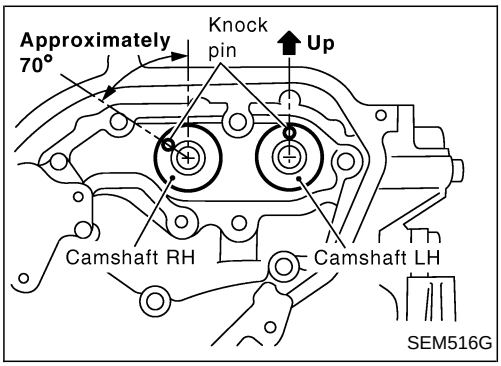


CAMSHAFT INSTALLATION

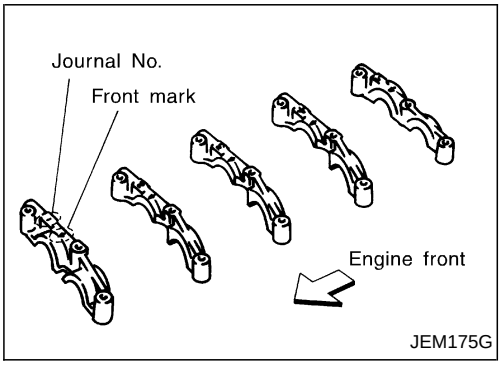
1. Install valve lifters and adjusting shims.
- Install in the correct locations (the same places as before removal).
2. Install camshafts.
- Identify camshafts by the paint position and screw hole at the rear end.

Camshaft RH: Paint is at position A without screw hole.
Camshaft LH: Paint is at position B with screw hole.

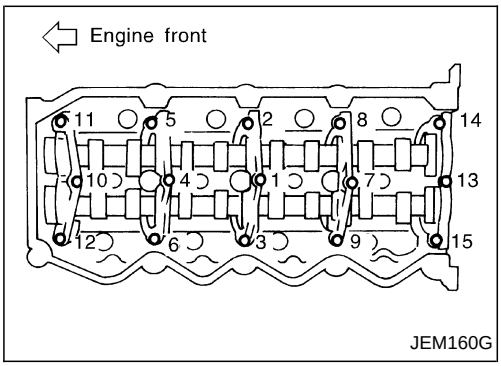
Installation (Cont'd)



- Install so that knock pins are positioned in the directions shown in the figure.



3. Install camshaft brackets.
- Install correctly, identifying brackets by the journal No. and front mark on top surface.



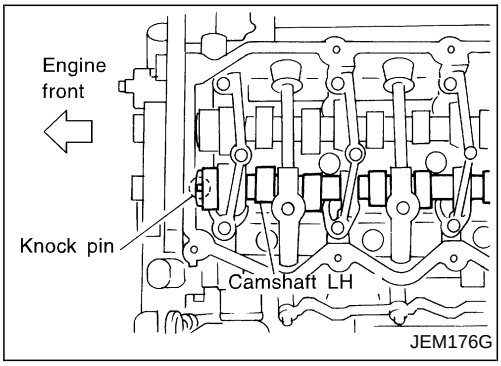
4. Tighten bolts in the order shown in the figure according to the following procedure:

a. Tighten to 2.0 N·m (0.2 kg-m, 17 in-lb).
- Make sure camshaft thrusting parts (on rear side) securely fit in their mating parts on the cylinder head.

b. Tighten to 6 N·m (0.6 kg-m, 52 in-lb).
c. Tighten to 12 to 13 N·m (1.2 to 1.4 kg-m, 9 to 10 ft-lb).

5. Install camshaft sprockets.
- Camshaft sprockets are commonly used for RH and LH.
- Align camshaft sprocket and dowel pin on camshaft, and install.
- Holding the hexagonal part of camshaft with a wrench, tighten bolt securing camshaft sprocket.

6. Before installing spill tube after installing secondary timing chain, check and adjust valve clearance. Refer to EM-63, "Valve Clearance".
7. Hereafter, install in the reverse order of removal.



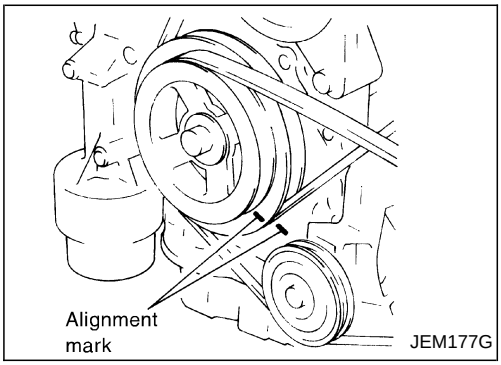
Valve Clearance

CHECKING

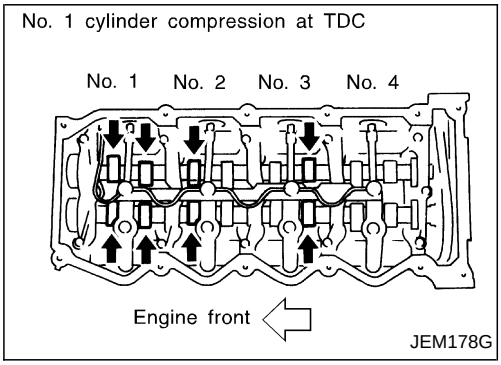
Check valve clearance while engine is cold and not running.

1. Set the No. 1 piston to TDC on its compression stroke.
- Turn crankshaft pulley clockwise so that the knock pin on camshaft LH faces straight above. (No position indicator, etc. is provided on the crankshaft pulley.)

Valve Clearance (Cont'd)

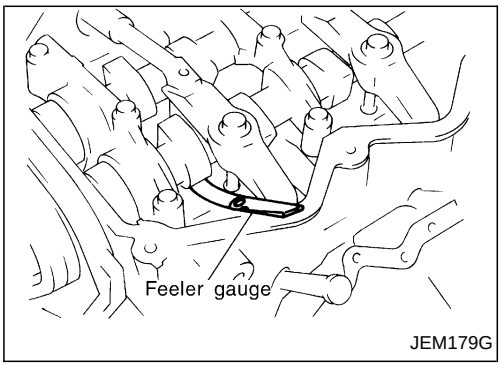


2. Put an alignment mark with paint, etc. on the crankshaft pulley and on the oil pump as an angle indicator.



3. Check only those valves shown in the figure.

Crank position	Valve							
	No. 1		No. 2		No. 3		No. 4	
	INT	EXH	INT	EXH	INT	EXH	INT	EXH
No. 1 TDC (Compression stroke)	○	○	○			○		



- Using a feeler gauge, measure clearance between valve lifter and camshaft.
- Record any valve clearance measurements which are out of specification. They will be used later to determine the required replacement adjusting shim.

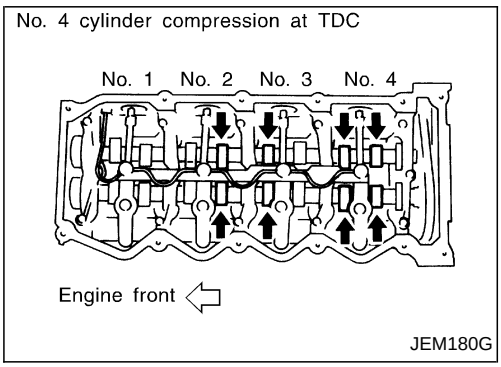
Valve clearance for checking (Cold):

Intake

0.24 - 0.32 mm (0.009 - 0.013 in)

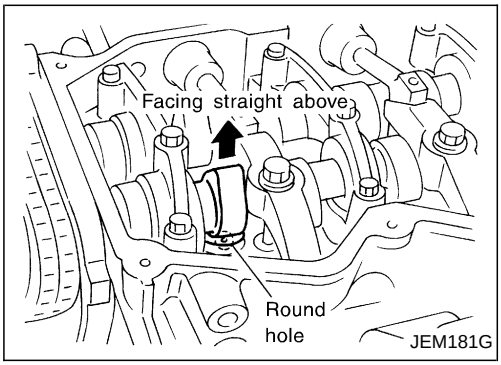
Exhaust

0.26 - 0.34 mm (0.010 - 0.013 in)



4. Rotate crankshaft clockwise by one turn to set the No. 4 piston to TDC on the compression stroke.
5. Check only those valves shown in the figure.

Crank position	Valve							
	No. 1		No. 2		No. 3		No. 4	
	INT	EXH	INT	EXH	INT	EXH	INT	EXH
No. 4 TDC (Compression stroke)				○	○		○	○



ADJUSTING

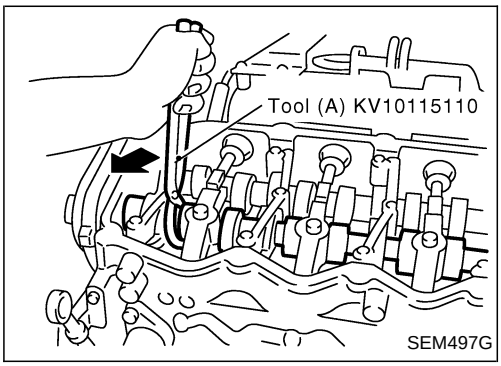
Adjust valve clearance while engine is cold.

1. Turn crankshaft, to position cam lobe on camshaft of valve that must be adjusted upward.
2. Place Tool (A) around camshaft as shown in figure.
   Before placing Tool (A) (SST), rotate notch toward center of cylinder head (See figure.), to simplify shim removal later.

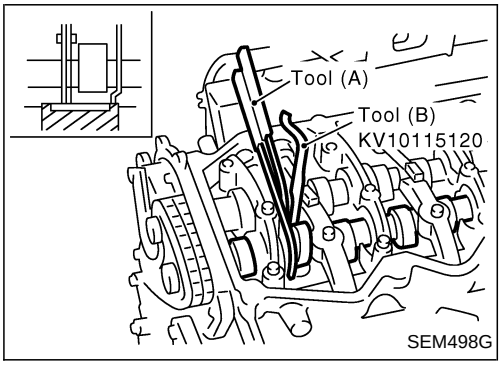
CAUTION:

Be careful not to damage cam surface with Tool (A).

Valve Clearance (Cont'd)



3. Rotate Tool (A) (See figure.) so that valve lifter is pushed down.

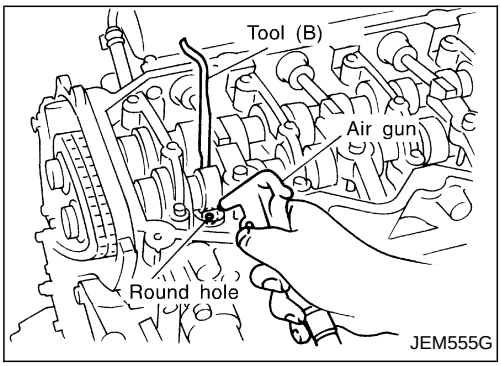


4. Place Tool (B) (SST) between camshaft and the edge of the valve lifter to retain valve lifter.

CAUTION:

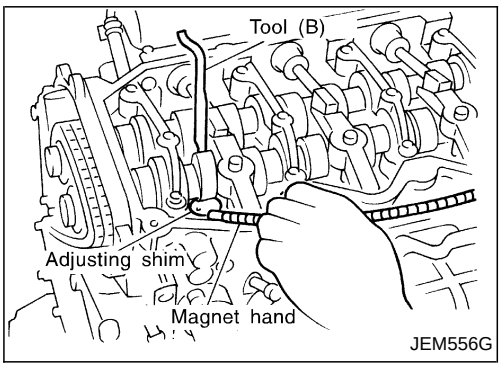
- **Tool (B) must be placed as close to camshaft bracket as possible.**
- **Be careful not to damage cam surface with Tool (B).**

5. Remove Tool (A).



6. Blow air into the hole to separate adjusting shim from valve lifter.

- **To avoid engine oil spills, wipe off oil fully beforehand. Wear safety goggles, etc. during work if necessary.**



7. Remove adjusting shim using a small screwdriver and a magnetic finger.
8. Determine replacement adjusting shim size following formula.

- Using a micrometer determine thickness of removed shim.
- Calculate thickness of new adjusting shim so valve clearance comes within specified values.

R = Thickness of removed shim
N = Thickness of new shim
M = Measured valve clearance

Intake:

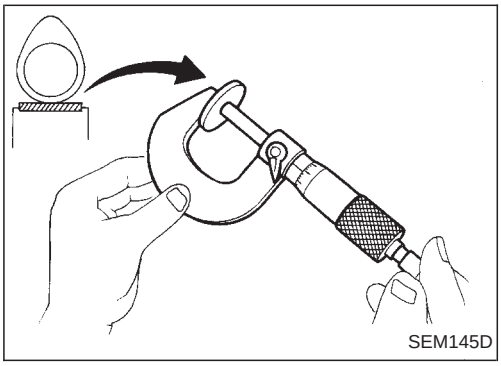
N = R + [M − 0.28 mm (0.0110 in)]

Exhaust:

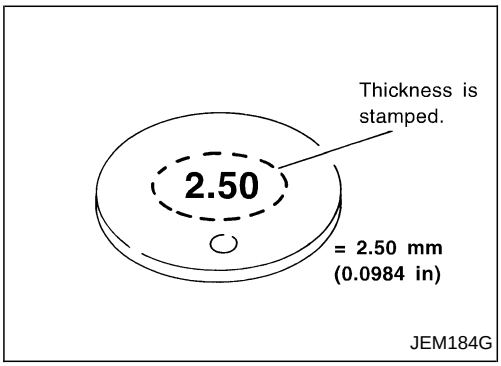
N = R + [M − 0.30 mm (0.0118 in)]

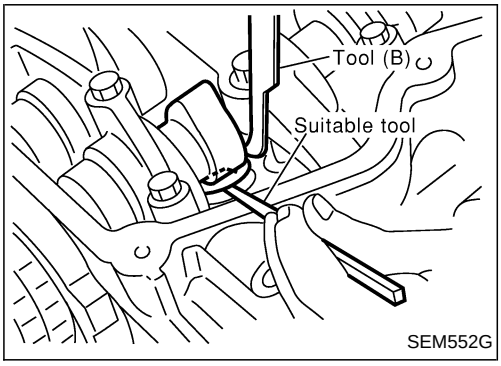
Shims are available in 33 sizes from 2.10 mm (0.0827 in) to 2.74 mm (0.1079 in), in steps of 0.02 mm (0.0008 in).

- Select new shim with thickness as close as possible to calculated value.



Valve Clearance (Cont'd)





9. Install new shim using a suitable tool.
- **Install with the surface on which the thickness is stamped facing down.**

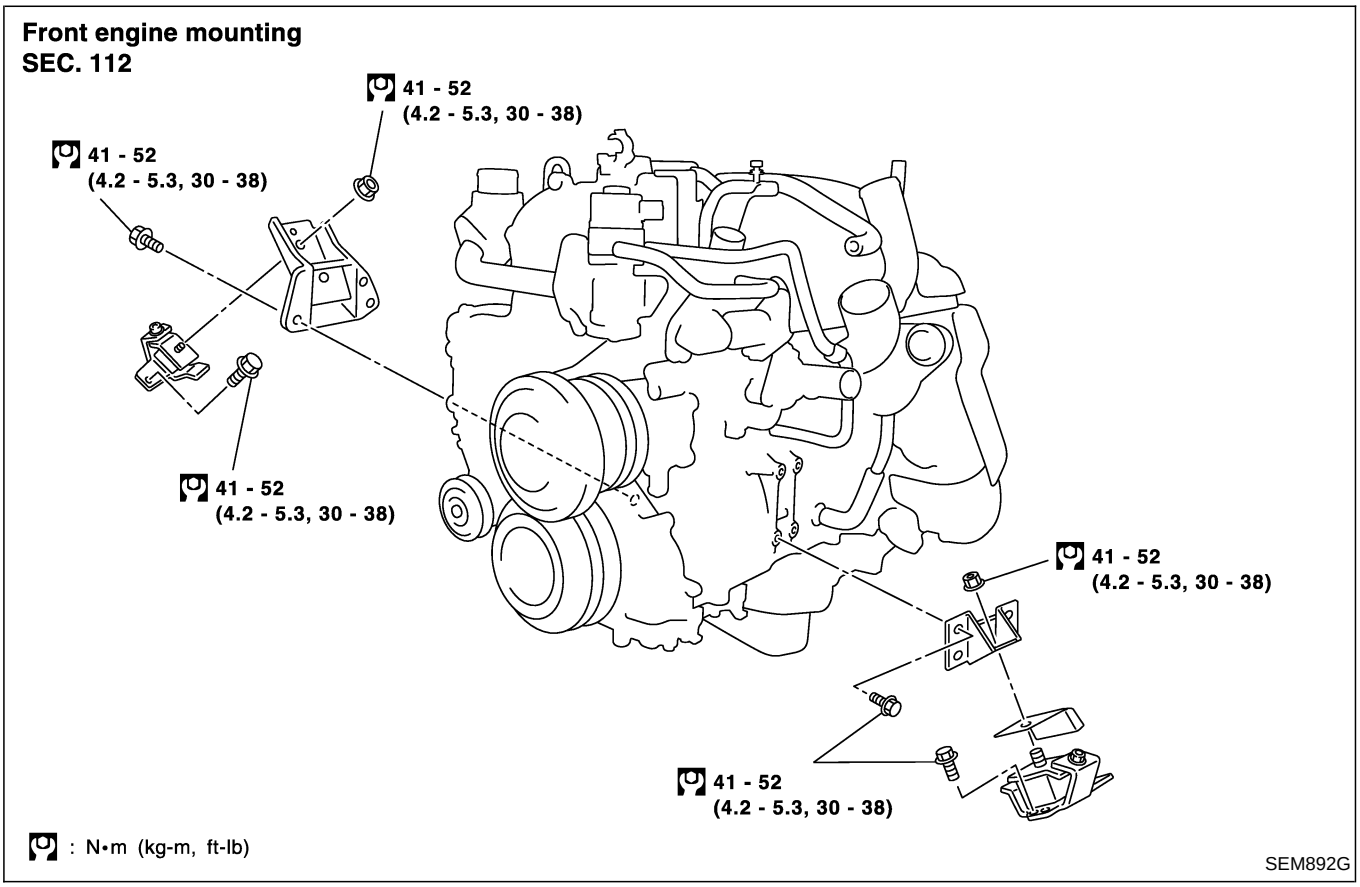
10. Place Tool (A) as mentioned in steps 2 and 3.
11. Remove Tool (B).
12. Remove Tool (A).
13. Recheck valve clearance.

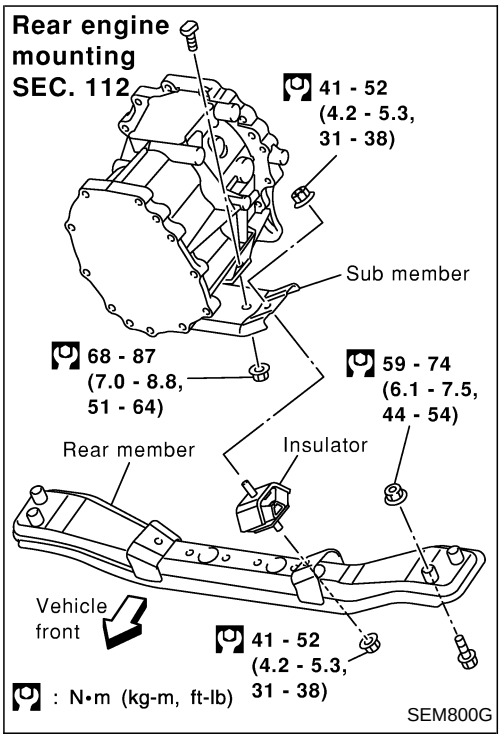
Valve clearance:

Unit: mm (in)

	Cold	Hot* (reference data)
Intake	0.24 - 0.32 (0.009 - 0.013)	0.29 - 0.37 (0.011 - 0.015)
Exhaust	0.26 - 0.34 (0.010 - 0.013)	0.33 - 0.41 (0.013 - 0.016)

*: Approximately 80°C (176°F)





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.
- 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 the following: Accelerator wire casing, brake lines, and brake master cylinder.
- In hoisting the engine, always use engine slingers in a safe manner.
- For 4WD models, apply sealant between engine and transmission. Refer to MT section ("Removal and Installation").
- For tightening torque, refer to M/T and PD sections.
- Before separating engine and transmission, remove the crankshaft position sensor (TDC sensor) from the assembly.
- Always pay extra attention not to damage edge of crankshaft position sensor (TDC sensor) or ring gear teeth.

Removal

Preparation

1. Drain coolant from radiator drain plugs.
2. Remove the following parts.

- Engine hood
- Charge air cooler
- Under protector
- Battery
- Radiator shroud
- Radiator
- Accessory belt
- Cooling fan
- Exhaust front tube

Engine room (Left)

3. Remove air duct and air cleaner case.
4. Disconnect harness connectors from alternator and air conditioner compressor.
5. Remove alternator.
6. Remove installation bolts. Relocate air conditioner compressor. Use a rope to temporarily anchor it to vehicle side.
7. Disconnect and relocate heating hose, install blank cap to hose to prevent coolant from leaking.
8. Remove heat insulator.

Engine room (Right)

9. Remove fuel feed and return hoses.

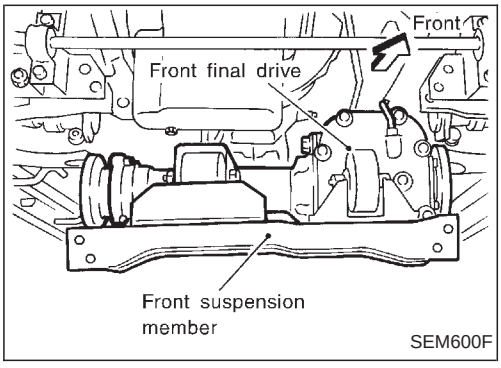
CAUTION:

Install blank caps immediately to avoid fuel leakage.

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

Vehicle underfloor

11. Remove starter motor.
12. Remove front propeller shaft.
13. Remove front final drive together with differential mounting member. Refer to PD section (“Removal and Installation”, “Front final drive”) — 4WD models only.

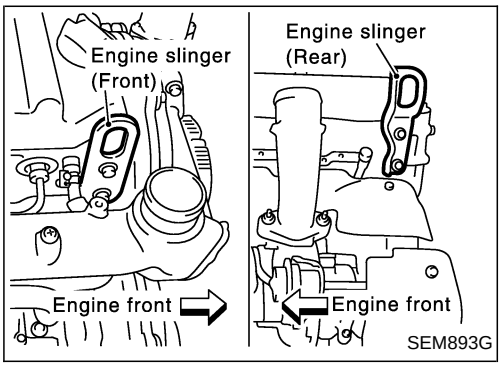


14. Remove mounting bolts to secure the engine to transmission.

1) Lift transmission with the jack, and reinstall rear mount members to the vehicle.
2) Position the jack to the front side of transmission.
3) Remove remaining mounting bolts securing the engine to transmission.

Removal (Cont'd)

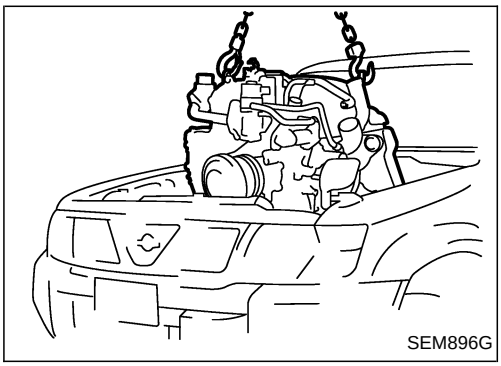
Removal operation



15. Install the engine slingers (standard service part) to front-left and rear-right.
    : 29.5 - 37.3 N·m (3.0 - 3.8 kg-m, 22 - 27 ft-lb)

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

16. Hook hoists to slingers to secure the position.
17. Remove installation nuts for left and right engine mount insulators.
18. Remove crankshaft position sensor (TDC sensor) from transmission.



19. Separate engine and transmission, remove the engine.

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

Installation

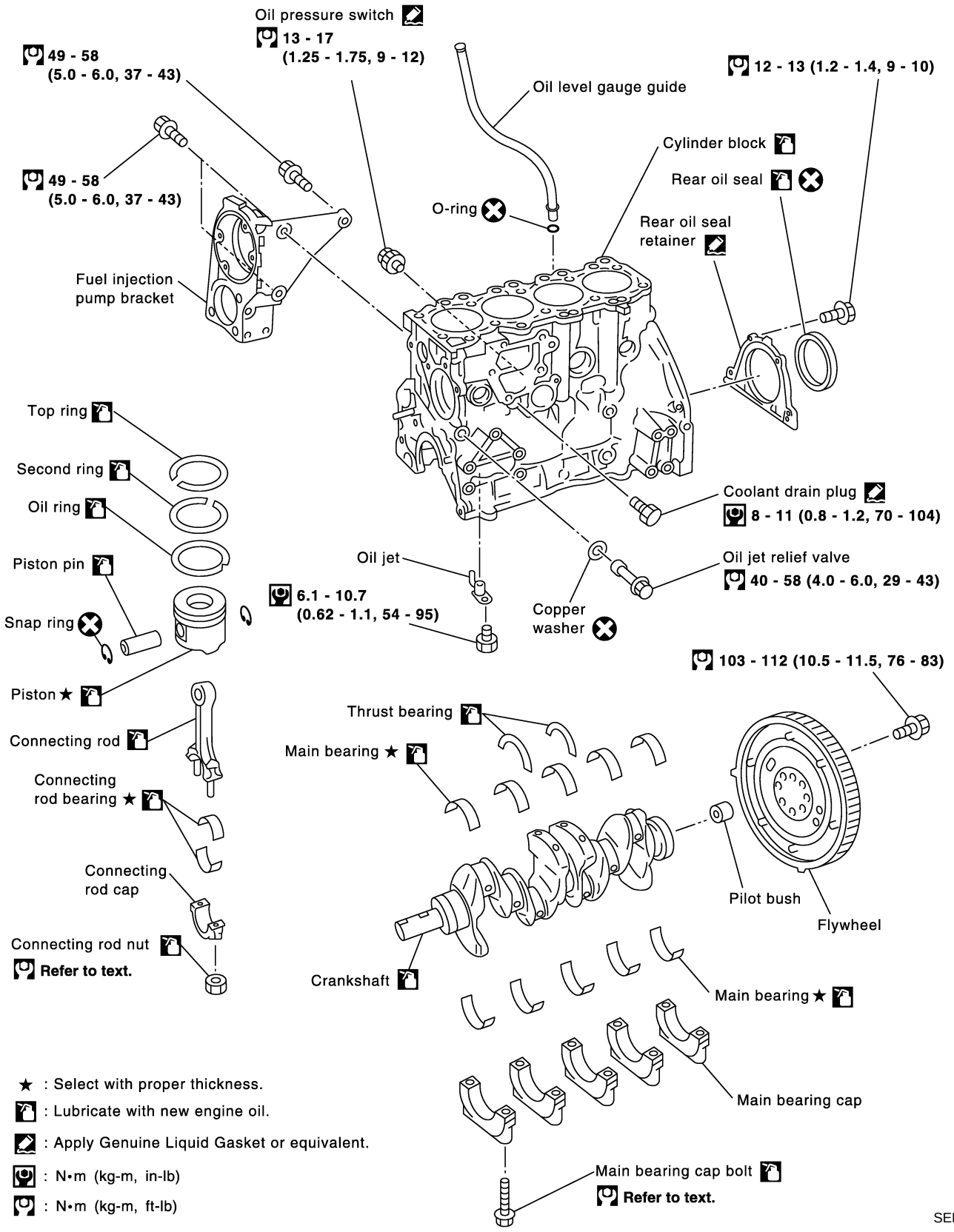
Install the engine in the reverse order of the removal procedure.
- Keep each mount insulator from oil adherence and damage.
- As for a location with positioning pin, insert the pin correctly to the hole of mating part.
- While keeping each mount insulator free from twisting, tighten mounting bolts and nuts for the engine mount.

Inspection

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

Components

SEC. 110•120•186



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Removal and Installation

CAUTION:

- **When installing bearings, pistons, or other sliding parts, lubricate contacting surfaces with new engine oil.**
- **Place removed parts such as bearings and bearing caps in their proper order and direction.**
- **When installing connecting rod nuts, and main bearing cap bolts, apply new engine oil to threads and seating surfaces.**
- **Do not allow any magnetic materials to contact the signal plate of flywheel.**
- **Do not remove the signal plate at back.**
- **Do not place the signal plate side facing under.**
- **Handle with care so as not to damage the signal plate [especially four places on protrusions for signal of crank position sensor (TDC sensor)].**

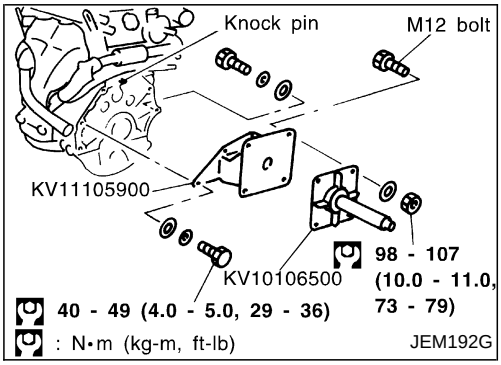
Disassembly

PISTON AND CRANKSHAFT

1. Remove engine. Refer to “ENGINE REMOVAL”, EM-67.
2. Place engine on a work stand.

a. Remove flywheel.

- Hold ring gear with ring gear stopper (KV10105630, KV10105610). Then, loosen securing bolts with TORX socket (size: Q8 E20, Commercial Service Tool) and remove them. As an alternative method, hold the crankshaft pulley with a pulley holder (SST) to remove the flywheel.



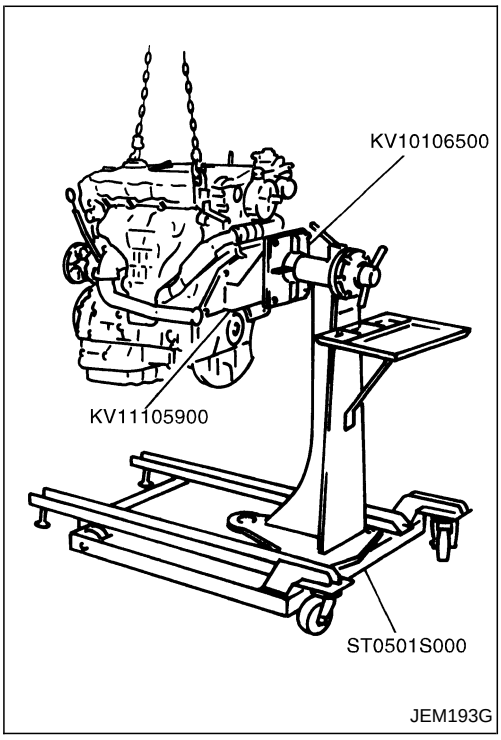
b. Install engine sub-attachment (SST) to rear surface of cylinder block.

- To install, align the hole on the sub-attachment with the knock pin on the cylinder block.
- The engine sub-attachment has five bolts.

c. Install engine attachment (SST).

- The four sets of bolts and nuts are multi-purpose products.

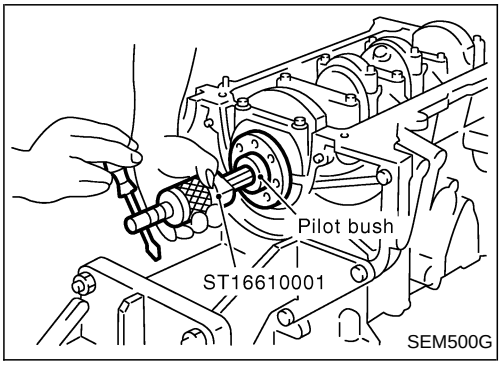
Disassembly (Cont'd)



d. Hoist up engine and install it on the engine stand (SST).
- Another method is to set engine sub-attachment and engine attachment on engine stand beforehand, and then, install engine.

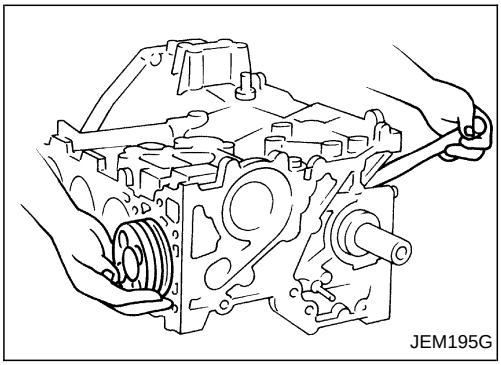
3. Drain engine oil and coolant from engine.
4. Remove the following and the associated parts:
- Exhaust manifold
- Turbocharger assembly
- Injection tube
- Intake manifold
- Water pump
- Oil pan (upper and lower)
- EGR volume control valve and EGR tube & EGR guide tube assembly
- Secondary timing chain
- Fuel injection pump
- Primary timing chain
- Rocker cover
- Vacuum pump
- High pressure injection nozzle assembly
- Camshaft
- Cylinder head
- Thermostat, water pipes
- Oil cooler
- Auxiliary component brackets

5. Remove fuel injection pump bracket.



6. If the replacement of pilot bushing is necessary, remove it with pilot bushing puller (SST).
7. Remove rear oil seal retainer.
- Insert a flat-bladed screwdriver between main bearing cap and rear oil seal retainer to remove retainer.

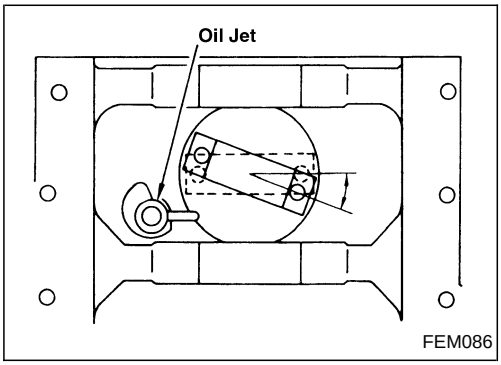
8. Remove rear oil seal from rear oil seal retainer.
- Punch out with a flat-bladed screwdriver.
- **Be careful not to damage rear oil seal retainer.**



9. Remove piston and connecting rod assembly.

a. Set crankshaft pin of the removal location at a position close to BDC.
b. Remove connecting rod cap.
c. Push piston and connecting rod assembly toward cylinder head using a hammer handle.
- Before removing piston and connecting rod assembly, check connecting rod side clearance. Refer to EM-74, "CONNECTING ROD SIDE CLEARANCE".

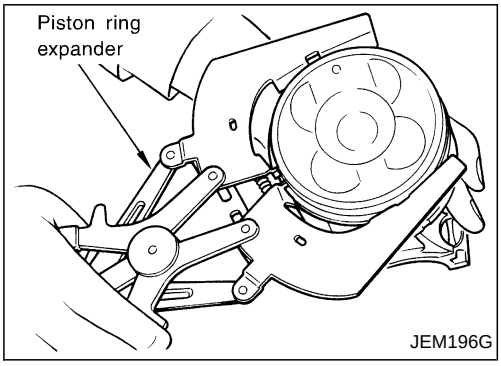
Disassembly (Cont'd)



CAUTION:

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

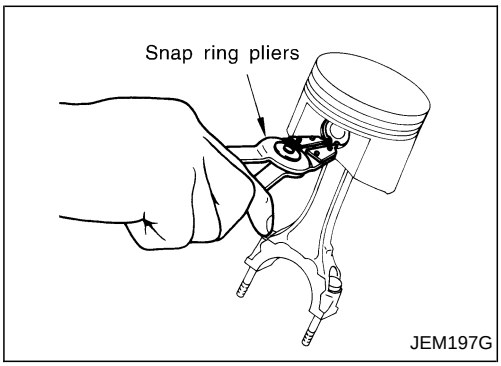
10. Remove connecting rod bearings from connecting rod and connecting rod cap.
- Store the removed parts in sets by the cylinder No. to avoid mixing them up.



11. Remove piston rings from pistons.
- Use piston ring expander (Commercial Service Tool).
- **Avoid scratching pistons during removal.**
- **Be careful not to damage piston rings by expanding excessively.**

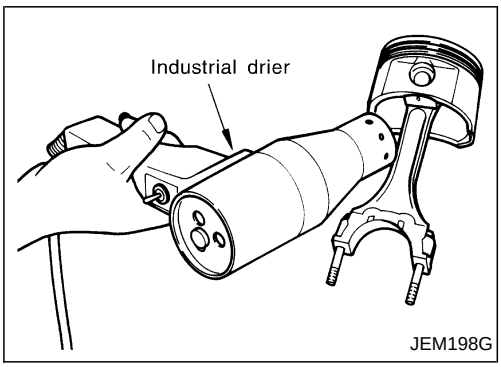
CAUTION:

- **When piston rings are not replaced, make sure that piston rings are mounted in their original positions.**

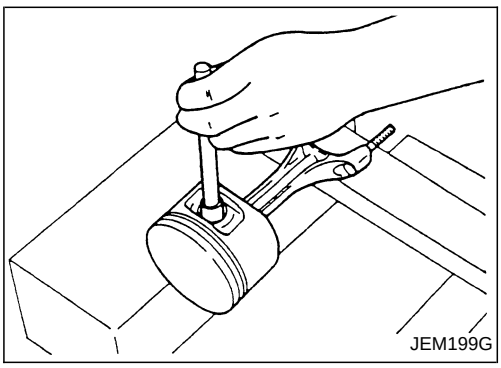


12. Remove piston from connecting rod.

a. Remove snap rings using snap ring pliers.

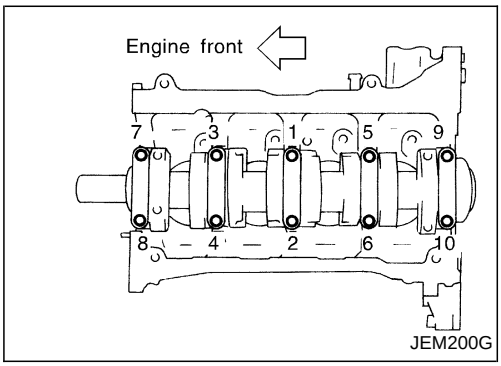


b. With an industrial drier, heat pistons to 60 to 70°C (140 to 158°F).

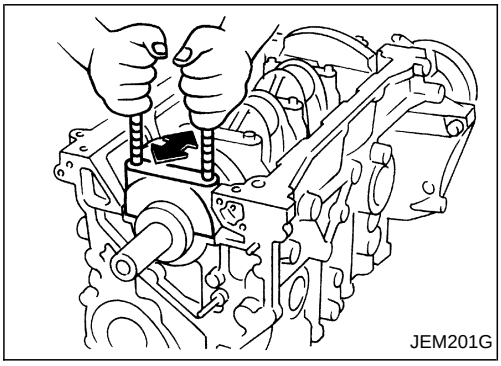


c. Push out piston pin with a rod approx. 26 mm (1.02 in) in diameter.

Disassembly (Cont'd)



13. Remove main bearing cap bolts.
- With a TORX socket (size: E-14, Commercial Service Tool), loosen main bearing cap bolts in several stages in the reverse order of that shown in the figure and remove them.
- Before loosening main bearing cap bolts, measure crankshaft end play. Refer to EM-74, "CRANKSHAFT END PLAY".



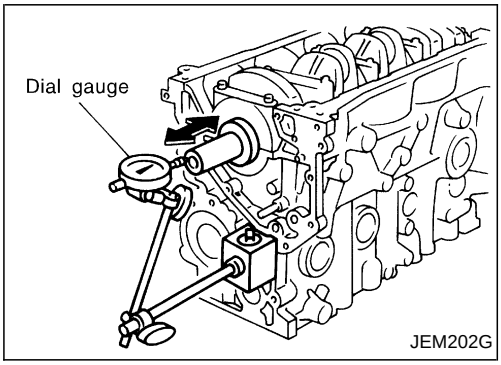
14. Remove main bearing caps.
- Using main bearing cap bolts, remove by rocking bearing cap back and forth.

15. Remove crankshaft.
16. Remove main bearings and thrust bearings from cylinder block and main bearing caps.
- **Check the correct installation locations of removed parts. Store them so they do not get mixed up.**

17. Remove oil jet.
18. Remove oil jet check valve.

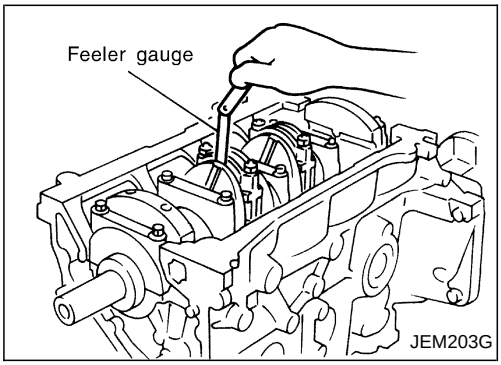
Inspection

CRANKSHAFT END PLAY



- Measure the moving distance of the crankshaft with the dial gauge when the crankshaft is moved fully forward or backward.
  Standard: 0.085 - 0.25 mm (0.0033 - 0.0098 in)
  Limit: 0.30 mm (0.0118 in)
- If the value exceeds the limit, replace thrust bearings with new ones and measure again. If the measurement exceeds the limit again, replace crankshaft with a new one.

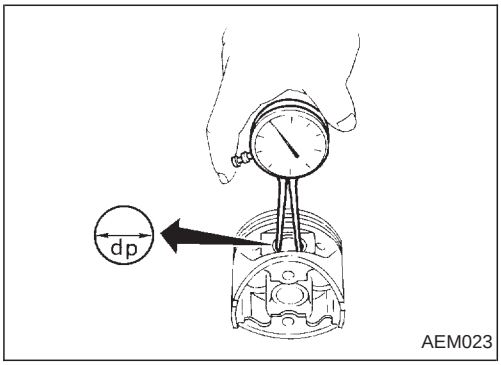
CONNECTING ROD SIDE CLEARANCE



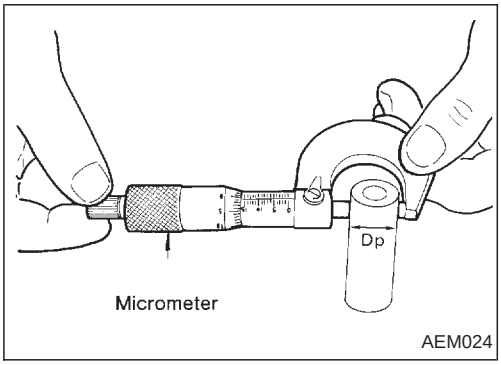
- Measure the side clearance between connecting rod and crank arm with feeler gauge.
  Standard: 0.200 - 0.350 mm (0.0079 - 0.0138 in)
  Limit: 0.4 mm (0.016 in)
- If the value exceeds the limit, replace connecting rod and measure again. If the measurement exceeds the limit again, replace the crankshaft.

Inspection (Cont'd)

PISTON AND PISTON PIN CLEARANCE



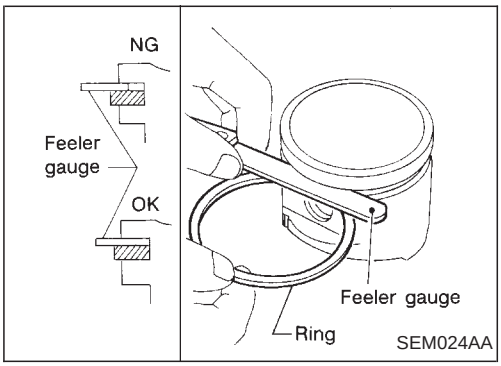
1. Measure inner diameter of piston pin hole "dp".
   Standard diameter "dp":
   27.997 - 28.005 mm (1.1022 - 1.1026 in)



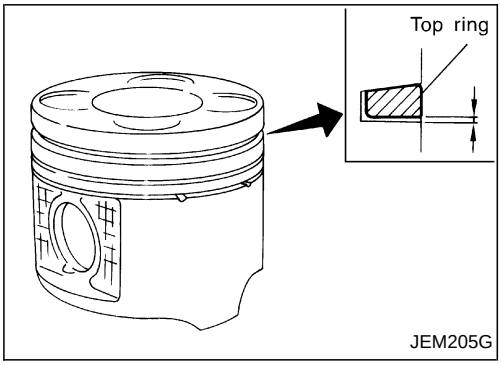
2. Measure outer diameter of piston pin "Dp".
   Standard diameter "Dp":
   27.994 - 28.000 mm (1.1021 - 1.1024 in)
3. Calculate interference fit of piston pin to piston.
   Dp − dp = 0.002 - 0.006 mm (0.0001 - 0.0002 in)

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

PISTON RING SIDE CLEARANCE

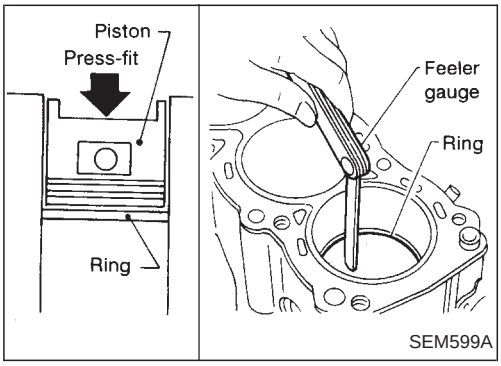


Side clearance:
Top ring
0.050 - 0.090 mm (0.0020 - 0.0035 in)
2nd ring
0.050 - 0.090 mm (0.0020 - 0.0035 in)
Oil ring
0.030 - 0.070 mm (0.0012 - 0.0028 in)
Max. limit of side clearance:
Top ring 0.1 mm (0.004 in)
2nd ring 0.1 mm (0.004 in)



- To measure top ring side clearance, align the outer circumferences of the ring and piston while pressing ring upward against the upper surface of the ring groove. Under this condition, measure the clearance between ring and bottom surface of the ring groove.
- If out of specification, replace piston ring. If clearance exceeds maximum limit with new ring, replace piston.

PISTON RING END GAP



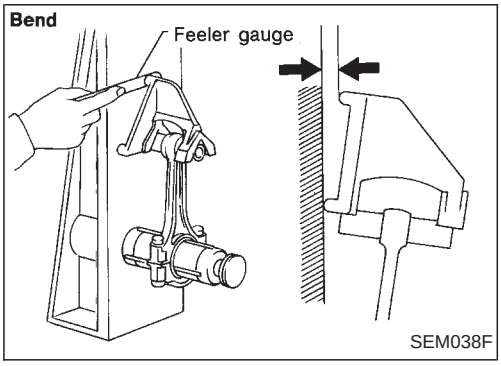
End gap:
Top ring 0.21 - 0.31 mm (0.0083 - 0.0122 in)
2nd ring 0.37 - 0.52 mm (0.0146 - 0.0205 in)
Oil ring 0.30 - 0.55 mm (0.0118 - 0.0217 in)
Max. limit of ring gap:
Top ring 1.0 mm (0.039 in)
2nd ring 1.0 mm (0.039 in)
Oil ring 1.0 mm (0.039 in)

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

Inspection (Cont'd)

Refer to SDS (EM-172).

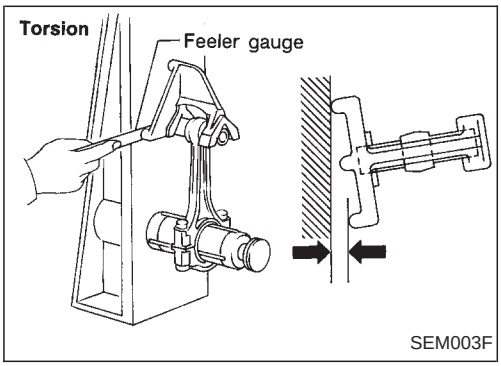
- When replacing the piston, check the cylinder block surface for scratches or seizure. If scratches or seizure is found, hone or replace the cylinder block.

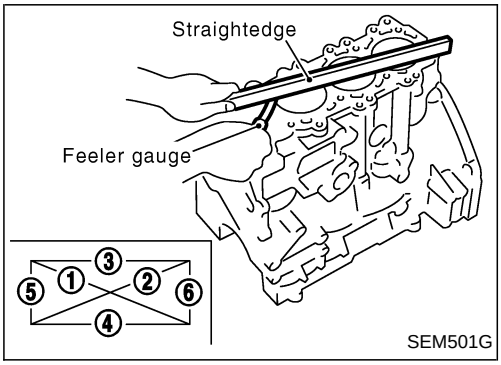


CONNECTING ROD BEND AND TORSION

Bend:
Limit 0.12 mm (0.0047 in)
per 100 mm (3.94 in) length
Torsion:
Limit 0.12 mm (0.0047 in)
per 100 mm (3.94 in) length

If it exceeds the limit, replace connecting rod assembly.



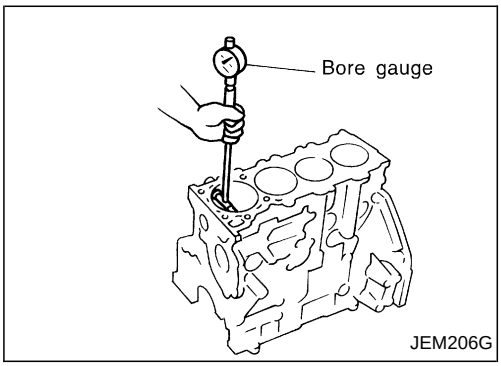


CYLINDER BLOCK DISTORTION AND WEAR

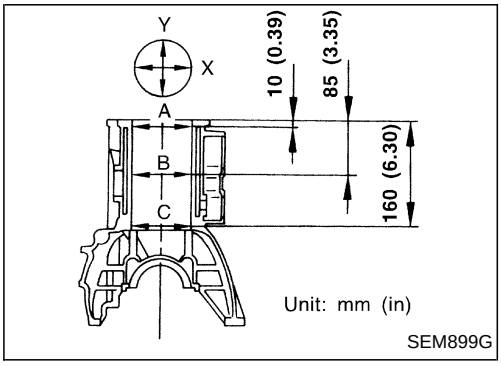
- Clean upper surface of cylinder block. Use a reliable straightedge and feeler gauge to check the flatness of cylinder block surface. Check along six positions shown in the figure.
  Distortion limit: 0.04 mm (0.0016 in)
- If out of specification, resurface it. The limit for cylinder block resurfacing is determined by cylinder head resurfacing in engine.
  Resurfacing limit:
  Amount of cylinder head resurfacing is "A".
  Amount of cylinder block resurfacing is "B".
  The maximum limit is as follows:
  A + B = 0.07mm (0.0028 in)
  Nominal cylinder block height from crankshaft center:
  252.95 - 253.05 mm (9.9586 - 9.9626 in)
- If necessary, replace cylinder block.

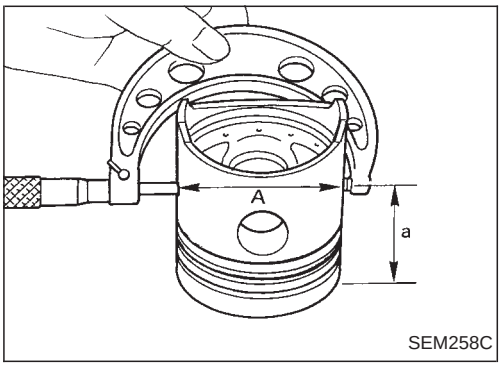
Inspection (Cont'd)

PISTON-TO-BORE CLEARANCE



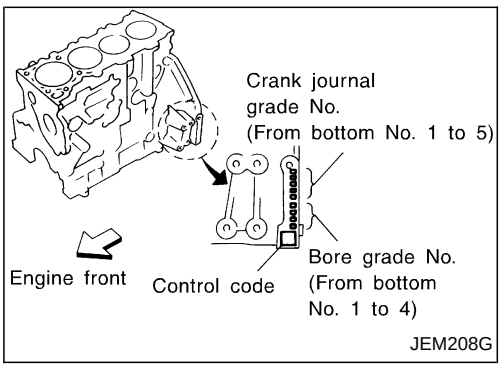
1. Using a bore gauge, measure cylinder bore in X and Y directions at A, B and C for wear, out-of-round and taper.
   Cylinder bore inner diameter:
   Standard
   89.000 - 89.030 mm (3.5039 - 3.5051 in)
   Wear limit
   0.07 mm (0.0028 in)
   If it exceeds the limit, rebore all cylinders. Replace cylinder block if necessary.
   Out-of-round (X − Y):
   Limit 0.015 mm (0.0006 in)
   Taper (C − A):
   Limit 0.010 mm (0.0004 in)
2. Check for scratches and seizure. If seizure is found, hone it.





3. Measure piston skirt diameter.
   Piston diameter "A":
   Standard
   88.940 - 88.970 mm (3.5016 - 3.5027 in)
   Measuring point "a" (Distance from the top):
   59.0 mm (2.323 in)
4. Check that piston-to-bore clearance is within specification.

- Calculate the clearance by using outer diameter at piston skirt and inner diameter of cylinder (direction of X, point B):
  Piston-to-bore clearance = Cylinder bore − Piston diameter "A"
  Standard [at room temperature 20°C (68°F)]:
  0.050 - 0.070 mm (0.0020 - 0.0028 in)
- If the value is out of the specified range, replace piston and piston pin assembly.

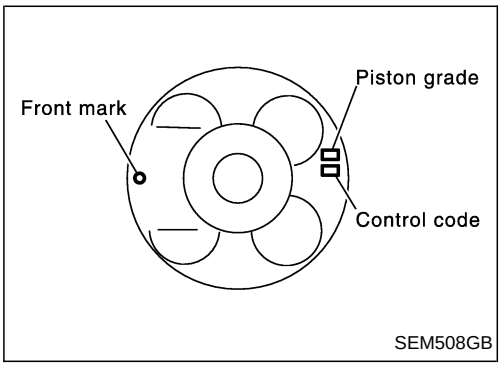


- If cylinder block or pistons are replaced with new ones, select piston as follows:

When using a new cylinder block:

- Identify the cylinder bore grade (No. 1, 2, or 3) on LH surface at the rear of cylinder block and select a piston of the same grade.
- The part No. of piston is specified together with the piston pin as an assembly.

Inspection (Cont'd)



When re-using a removed cylinder block:

- Measure the inner diameter of the cylinder block bore.
- Determine the bore grade by comparing the measurement with the values under "Cylinder bore ID" of the table below. Choose a piston of the same grade.

Selective fitting for piston:

Unit: mm (in)

Grade (punched)	1	2	3
Cylinder bore ID	89.000 - 89.010 (3.5039 - 3.5043)	89.010 - 89.020 (3.5043 - 3.5047)	89.020 - 89.030 (3.5047 - 3.5051)
Piston OD	88.940 - 88.950 (3.5016 - 3.5020)	88.950 - 88.960 (3.5020 - 3.5024)	88.960 - 88.970 (3.5024 - 3.5027)

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

- **For oversize pistons, 0.25 and 0.5 OS [0.25 mm (0.0098 in), 0.5 mm (0.0197 in) oversize] are available as service parts. Refer to SDS, EM-172. When using an oversize piston, hone cylinder so that the clearance between piston and cylinder becomes the specified value. Be sure to use appropriate oversize piston ring for the oversize piston.**

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)

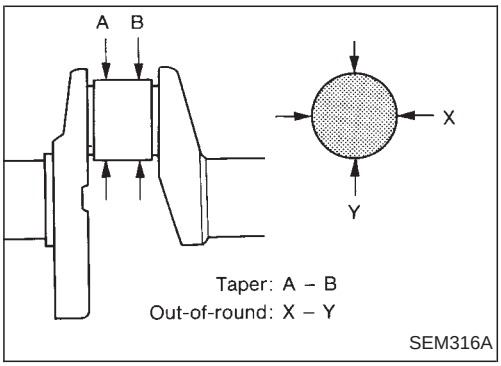
7. Cut cylinder bores.

- **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.**

8. Hone cylinders to obtain specified piston-to-bore clearance.
9. Measure finished cylinder bore for out-of-round and taper.

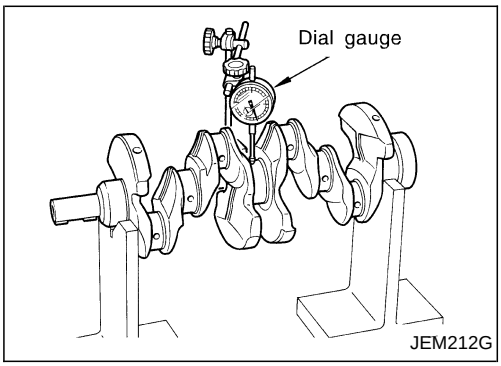
- **Measurement should be done after cylinder bore cools down.**

Inspection (Cont'd)

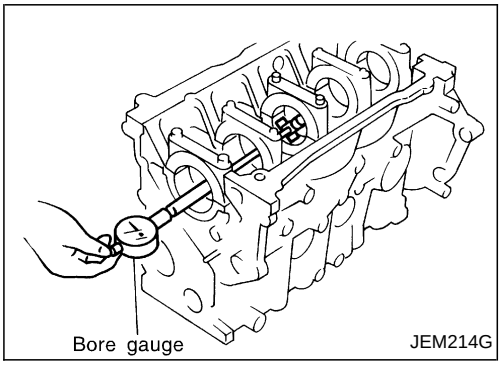


CRANKSHAFT

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):
   Standard
   0.003 mm (0.0001 in)
   Limit
   0.005 mm (0.0002 in)
   Taper (A − B):
   Standard
   0.003 mm (0.0001 in)
   Limit
   0.005 mm (0.0002 in)

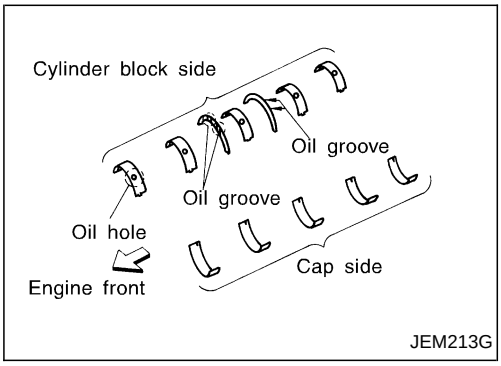


3. Measure crankshaft runout at No. 3 (center) journal.
   Runout (Total indicator reading):
   Standard 0.05 mm (0.0020 in)
   Limit 0.10 mm (0.0039 in)



MAIN BEARING HOUSING INNER DIAMETER

- Without installing main bearings, install main bearing caps, and tighten bolts to the specified torque.
- Measure the inner diameter of main bearing housing with a bore gauge.
  Standard:
  66.654 - 66.681 mm (2.6242 - 2.6252 in) dia.
- If the measurement is out of the specified range, replace cylinder block and main bearing caps.



BEARING CLEARANCE

- Use either of the following two methods, however, method "A" gives more reliable results and is preferable.

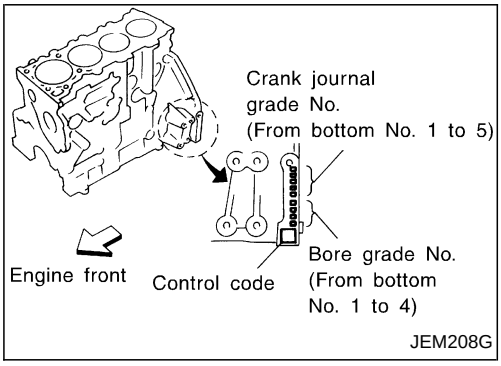
Method A (Using bore gauge & micrometer)

Main bearing

1. Install main bearings to the cylinder block and bearing cap, and tighten the bolts to the specified torque. Then, measure the inner diameter of the main bearings.
   Oil clearance = Bearing ID − Crankshaft journal OD
   Standard: 0.039 - 0.066 mm (0.0015 - 0.0026 in)

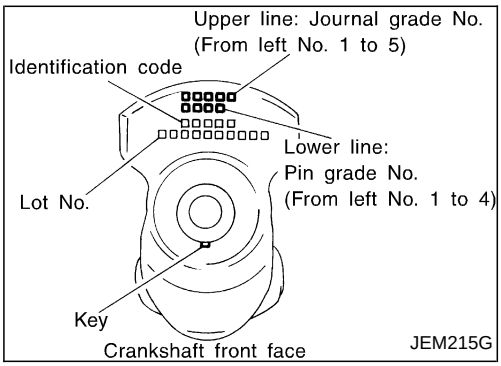
Inspection (Cont'd)

2. If the value is out of the specified range, select main bearings to obtain the specified oil clearance, based on the measurements of the main bearing housing inner diameter and crankshaft journal outer diameter.



When using a new cylinder block and crankshaft:

1) Identify the bearing housing grade (No. 0, 1, or 2) on LH surface at the rear of the cylinder block, and locate the applicable grade on the "Grade" row in the table below.
2) Identify the journal grade (No. 0, 1, or 2) on the front surface of the crankshaft, and locate the applicable grade under the "Grade" column on the table.
3) The main bearing to be used (STD 0 to STD 4) can be located in the cell where the row and column cross.



When re-using removed cylinder block and crankshaft:

1) Measure the inner diameter of cylinder block main bearing housing.
2) Locate the applicable cell where the measurement falls, on "Cylinder block main bearing housing ID" row on the table.
3) Measure the outer diameter of the crankshaft journal.
4) Locate the applicable cell where the measurement falls, under "Crankshaft journal OD" column on the table.
5) The main bearing to be used (STD 0 to STD 4) can be located in the cell where the row and column cross.

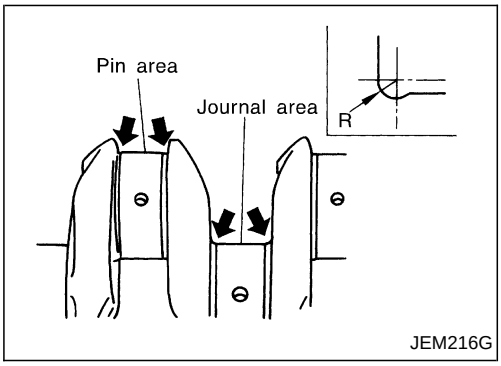
Inspection (Cont'd)

Selective fitting for main bearing

Unit: mm (in)

Cylinder block main bearing housing ID			66.654 - 66.663 (2.6242 - 2.6245)	66.663 - 66.672 (2.6245 - 2.6249)	66.672 - 66.681 (2.6249 - 2.6252)
Crankshaft journal OD	Grade (punched)		0	1	2
62.967 - 62.975 (2.4790 - 2.4793)	0	• Bearing grade No. • Bearing thickness • Oil clearance • Identification color	STD 0 1.816 - 1.820 (0.0715 - 0.0717) 0.039 - 0.066 (0.0015 - 0.0026) Black	STD 1 1.820 - 1.824 (0.0717 - 0.0718) 0.039 - 0.066 (0.0015 - 0.0026) Brown	STD 2 1.824 - 1.828 (0.0718 - 0.0720) 0.039 - 0.066 (0.0015 - 0.0026) Green
62.959 - 62.967 (2.4787 - 2.4790)	1	• Bearing grade No. • Bearing thickness • Oil clearance • Identification color	STD 1 1.820 - 1.824 (0.0717 - 0.0718) 0.039 - 0.066 (0.0015 - 0.0026) Brown	STD 2 1.824 - 1.828 (0.0718 - 0.0720) 0.039 - 0.066 (0.0015 - 0.0026) Green	STD 3 1.828 - 1.832 (0.0720 - 0.0721) 0.039 - 0.066 (0.0015 - 0.0026) Yellow
62.951 - 62.959 (2.4784 - 2.4787)	2	• Bearing grade No. • Bearing thickness • Oil clearance • Identification color	STD 2 1.824 - 1.828 (0.0718 - 0.0720) 0.039 - 0.066 (0.0015 - 0.0026) Green	STD 3 1.828 - 1.832 (0.0720 - 0.0721) 0.039 - 0.066 (0.0015 - 0.0026) Yellow	STD 4 1.832 - 1.836 (0.0721 - 0.0723) 0.039 - 0.066 (0.0015 - 0.0026) Blue

3. When the specified oil clearance is not obtained with standard size main bearings, use undersized bearings.
   - When an undersized bearing is used, measure the inner diameter of the bearing while the bearing is installed. Grind crankshaft journal so that the specified oil clearance is obtained.

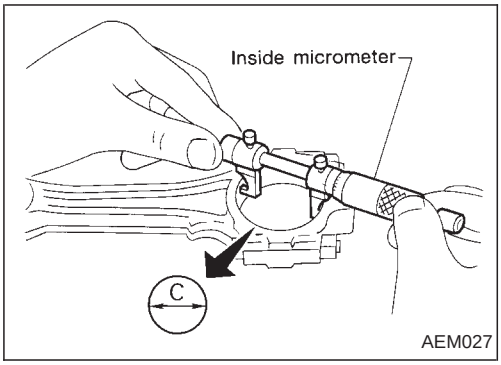


Undersize bearing

Unit: mm (in)

Size	Thickness
US 0.25 (0.0098)	1.949 - 1.953 (0.0767 - 0.0769)

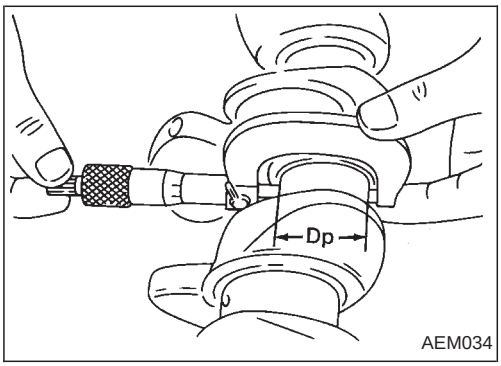
CAUTION:
When grinding the crankshaft journal to use an undersize bearing, avoid damaging the fillet R.



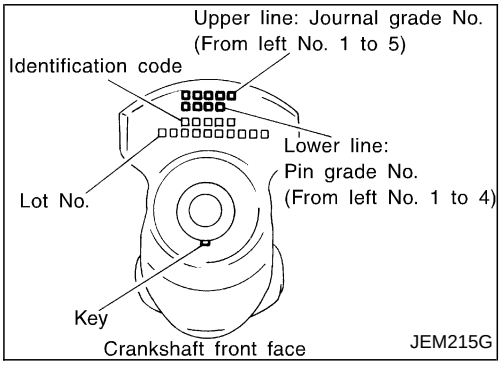
Connecting Rod Bearing (Big end)

1. Install connecting rod bearing to connecting rod and cap.
2. Install connecting rod cap to connecting rod.
   Tighten bolts to the specified torque.
3. Measure inner diameter "C" of connecting rod.
   Inner diameter:
   Standard 55.000 - 55.013 mm (2.1654 - 2.1659 in)

Inspection (Cont'd)



4. Measure outer diameter "Dp" of each crankshaft pin journal.
5. Calculate connecting rod bearing clearance.
   Connecting rod bearing clearance = C − Dp
   Standard: 0.031 - 0.061 mm (0.0012 - 0.0024 in)
6. If it exceeds the standard, replace bearing.



When using a new crankshaft and connecting rods:

- Identify the pin diameter grade (No. 0, 1, or 2) on front surface of crankshaft and select the connecting rod bearings of the same grade.
- There is no grading for the inner diameter of the big end of the connecting rod.

When re-using the removed crankshaft and connecting rods:

- Measure the inner diameter of the big end of the connecting rod and make sure it is within the specified range.
- Measure the outer diameter of the crankshaft pin.
- Determine the crankshaft pin grade by comparing the measurement with the values under the column "Crankshaft pin OD" of the table below. Choose the bearings of the same grade.

Selective fitting for connecting rod bearing

Unit: mm (in)

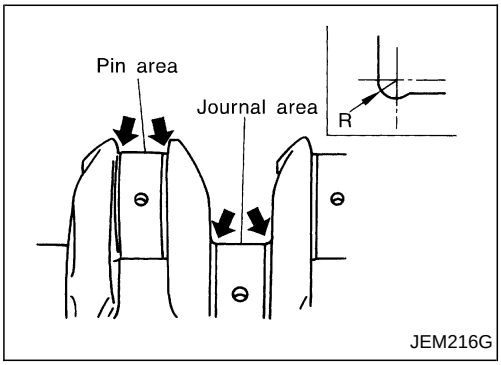
Connecting rod big end ID		55.000 - 55.013 (2.1654 - 2.1659)	
Crankshaft pin OD	Grade (punched)	0 (no punching)	
51.968 - 51.974 (2.0460 - 2.0462)	0	• Bearing grade No. • Bearing thickness • Oil clearance • Identification color	STD 0 1.492 - 1.496 (0.0587 - 0.0589) 0.031 - 0.061 (0.0012 - 0.0024) Black
51.961 - 51.968 (2.0457 - 2.0460)	1	• Bearing grade No. • Bearing thickness • Oil clearance • Identification color	STD 1 1.496 - 1.500 (0.0589 - 0.0591) 0.031 - 0.061 (0.0012 - 0.0024) Brown
51.954 - 51.961 (2.0454 - 2.0457)	2	• Bearing grade No. • Bearing thickness • Oil clearance • Identification color	STD 2 1.500 - 1.504 (0.0591 - 0.0592) 0.031 - 0.061 (0.0012 - 0.0024) Green

7. If clearance cannot be adjusted within the standard of any bearing, grind crankshaft journal and use undersized bearing.

- When an undersized bearing is used, measure the inner diameter of the bearing while the bearing is installed. Grind the pins so that the specified oil clearance is obtained.

Inspection (Cont'd)

Undersize bearing

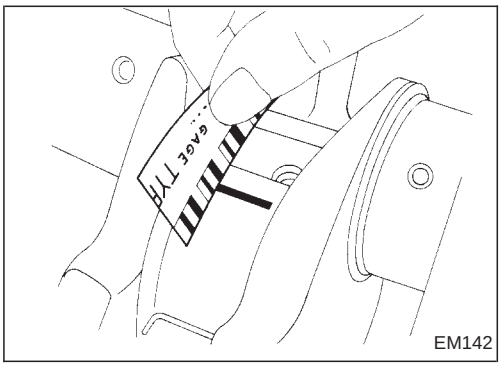


JEM216G

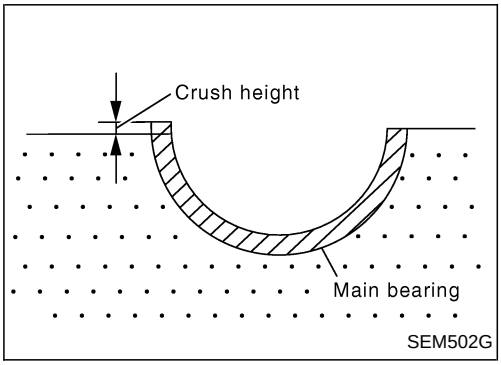
Unit: mm (in)

Size	Thickness
US 0.08 (0.0031)	1.536 - 1.540 (0.0605 - 0.0606)
US 0.12 (0.0047)	1.556 - 1.560 (0.0613 - 0.0614)
US 0.25 (0.0098)	1.621 - 1.625 (0.0638 - 0.0640)

CAUTION:
When grinding the crankshaft journal to use an undersize bearing, avoid damaging the fillet R.
Standard dimension R:
1.5 - 1.7 mm (0.0591 - 0.0669 in)


EM142

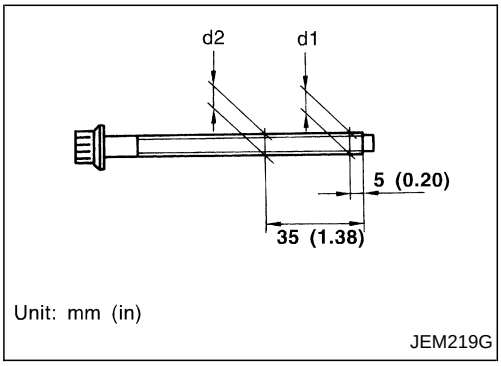
Method B (Using plastigage)
CAUTION:
- **Do not turn crankshaft or connecting rod while plastigage is being inserted.**
- **When bearing clearance exceeds the specified limit, ensure that the proper bearing has been installed. If incorrect bearing clearance exists, use a thicker or undersized main bearing to ensure specified clearance.**



SEM502G

MAIN BEARING CRUSH HEIGHT

- When the bearing cap is removed after being tightened to the specified torque with main bearings installed, the tip end of bearing must protrude.
  Standard: There must be crush height.
- If the standard is not met, replace main bearings.

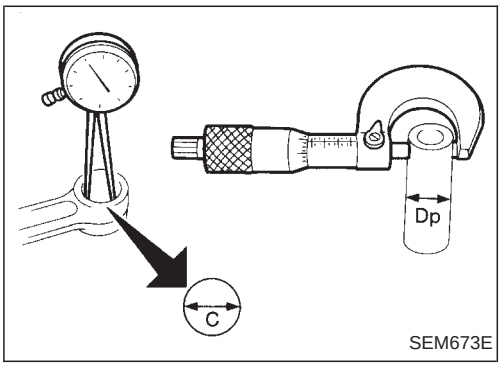


Unit: mm (in)
JEM219G

MAIN BEARING CAP BOLT DEFORMATION

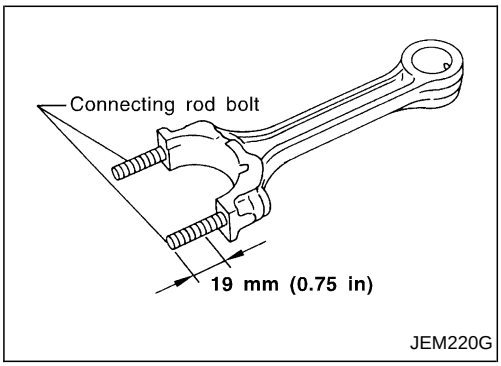
- Measure the outer diameter of threaded area, d1 and d2, at the points specified in the figure.
- When the necked point is identified at a point other than where specified, measure at the point as d2.
- Calculate the difference between d1 and d2.
  Limit: 0.13 mm (0.0051 in)

Inspection (Cont'd)



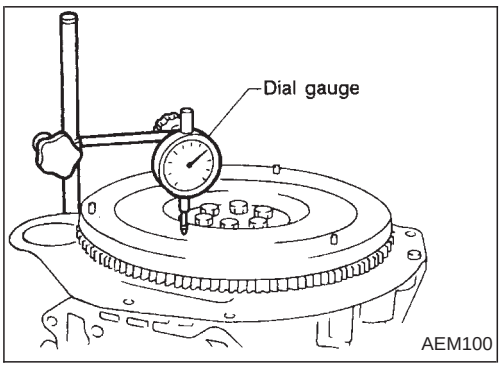
CONNECTING ROD BUSHING CLEARANCE (SMALL END)

1. Measure inner diameter "C" of bushing.
   Inner diameter "C":
   Standard 28.026 - 28.038 mm (1.1034 - 1.1039 in)
2. Measure outer diameter "Dp" of piston pin.
   Outer diameter "Dp":
   Standard 27.994 - 28.000 mm (1.1021 - 1.1024 in)
3. Calculate connecting rod bushing clearance.
   Connecting rod bushing clearance = C − Dp
   Standard: 0.026 - 0.044 mm (0.0010 - 0.0017 in)
   Limit: 0.057 mm (0.0022 in)
   If it exceeds the limit, replace connecting rod assembly and/or piston set with pin.



CONNECTING ROD BOLT DEFORMATION

- Install nuts to connecting rod bolts. Check that the nut can be screwed smoothly on bolt threads by hand to the last thread on the bolt.
- If the nut does not screw in smoothly, measure the outer diameter of the bolt thread at the point specified in the figure.
- If a necked point is identified, measure at that point.
  Standard: 8.90 - 9.00 mm (0.3504 - 0.3543 in) dia.
  Limit: 8.75 mm (0. 3445 in) dia.
- If the measurement exceeds the limit, replace connecting rod bolts and nuts.

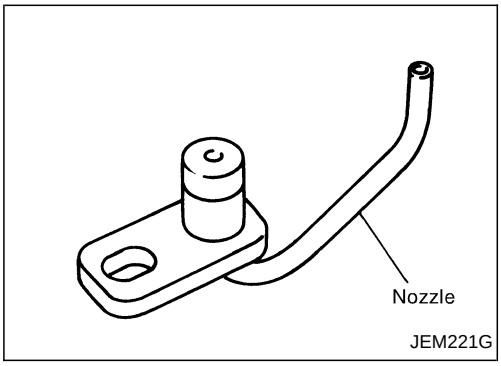


FLYWHEEL RUNOUT

Runout (Total indicator reading):
Less than 0.15 mm (0.0059 in)

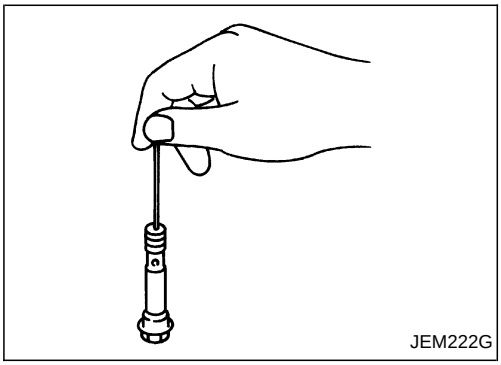
CAUTION:

- **The signal plate is built into the flywheel assembly. Be careful not to damage the signal plate, especially the teeth.**
- **Check the signal plate for deformation or cracks.**
- **Never place the flywheel assembly with the signal plate facing down.**
- **Keep any magnetized objects away from the signal plate.**
- **Do not allow any magnetic materials to contact the signal plate teeth.**



OIL JET

- Check nozzle for deformation or damage.
- Check oil passage for obstruction by blowing in air on nozzle side.
- If abnormality is found, clean or replace.


JEM222G

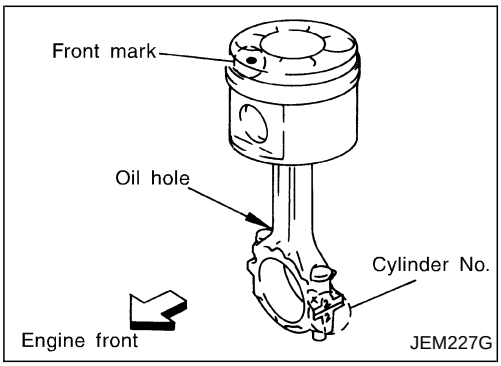
OIL JET RELIEF VALVE

Using a clean resin rod, press down on the check valve inside relief valve. Check for appropriate bounce/repulsion and smooth operation.

Assembly

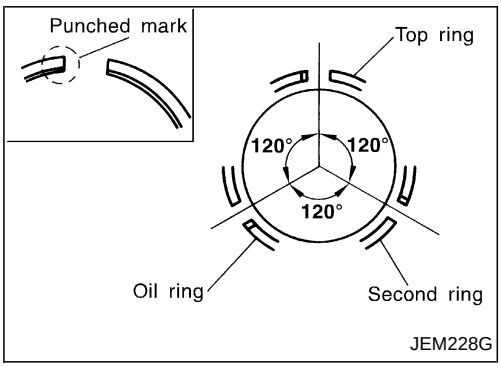
PISTON

1. With using snap ring pliers, install snap rings to grooves at the rear side of the piston.
- Install securely to fully fit into the groove.
2. Install piston to the connecting rod.
- Heat the piston with an industrial drier to 60 to 70°C (140 to 158°F) so that the piston pin can be easily inserted by finger. Then, insert the piston pin from the front of the piston into the piston and into the connecting rod.



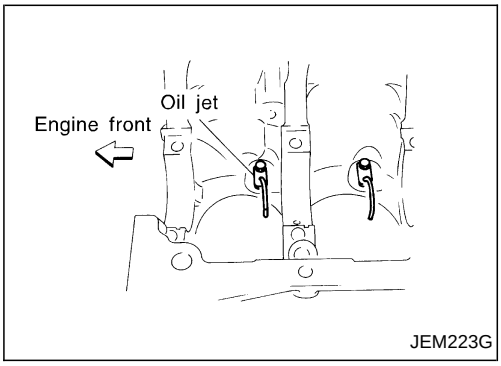
JEM227G

- Assemble so that the front mark on the piston top surface and cylinder No. stamped on connecting rod are positioned as shown in the figure.
3. Install snap ring on piston front.
- Refer to step 1. above for notes for installation.
- After installing, check that the connecting rod moves smoothly.
4. Install piston rings using piston ring expander (Commercial Service Tool).
- **Be extremely careful to avoid any damage to the piston.**



JEM228G

- Install top ring and second ring with the punched surface facing upward.
  Identification mark:
  Top ring R
  Second ring 2R
- Install rings so that three closed gap position 120° apart one another.
- Closed gaps do not need to face in a specific directions, as long as each are positioned 120° apart.

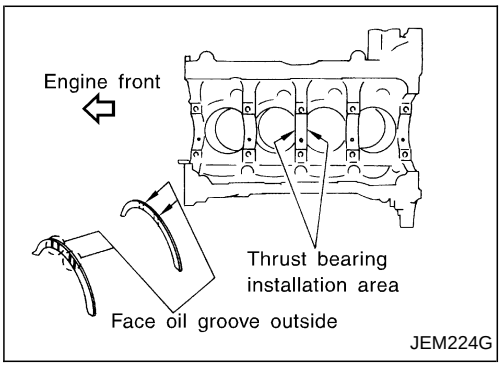


JEM223G

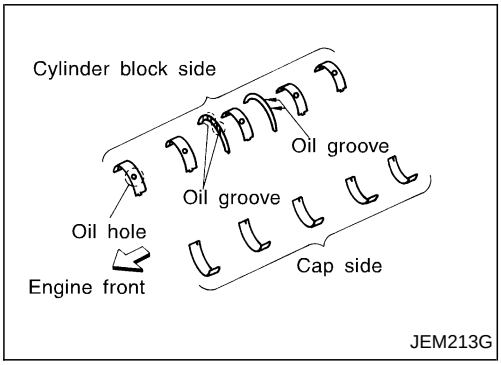
CRANKSHAFT

1. Blow air sufficiently into the coolant passage, oil passage in the cylinder block, inside of crankshaft case, and inside of cylinder bores to remove any foreign materials.
2. Install oil jet relief valves.
3. Install oil jets.

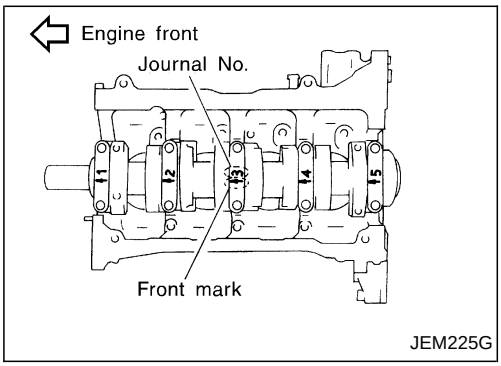
Assembly (Cont'd)



4. Install main bearings and thrust bearings.
a. Remove debris, dust, and oil from the locations on the cylinder block and main bearing caps where bearings are installed.
b. Install thrust bearing on each side of cylinder block No. 3 housing.
- Install thrust bearings with oil groove facing in the direction of the crankshaft arm (outside).

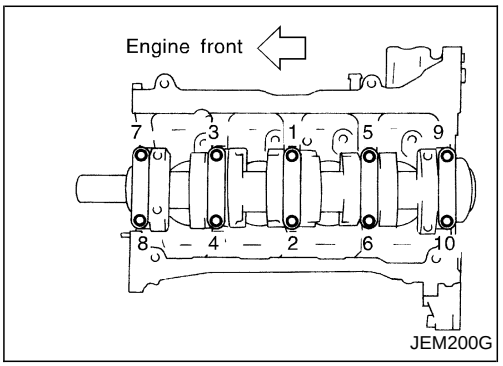


c. Be sure to install main bearings in the correct direction.
- Make sure those with oil holes or oil grooves are mounted on the cylinder block side, and those without oil holes or oil grooves are on the main cap side.
- Before installing, apply engine oil on the front (inner) surfaces of bearings. Do not apply oil to the back surfaces, but thoroughly clean them.
- Align stopper notches on bearings and install.
- Check the oil holes on cylinder block and those on bearings are aligned.



5. Install crankshaft to cylinder block.
- Make sure crankshaft rotates smoothly by hand.
6. Install main bearing caps.
- Identify main bearing caps by the punched mark. Install correctly, matching the journal No. on the bearing cap and the journal, with the front mark facing forward.
- Main bearing caps are commonly processed with the cylinder block. Therefore, caps and cylinder block should be replaced as a set.

Assembly (Cont'd)

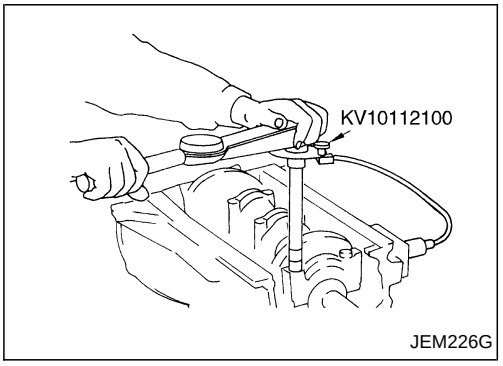


7. Check the main bearing cap bolts for deformation.
   Refer to EM-83, "MAIN BEARING CAP BOLT DEFORMATION".
8. Tighten the main bearing cap bolts according to the following procedure:

a. Apply engine oil to the threaded part and seat surface of each bolt.
b. Tighten to 25 to 30 N·m (2.5 to 3.1 kg-m, 18 to 22 ft-lb) in the numerical order shown in the figure.
c. Put alignment marks (with paint) on each bolt and the main bearing cap, all in the same direction. (when using a protractor)
d. Then, tighten 90° to 95° [target: 90°].

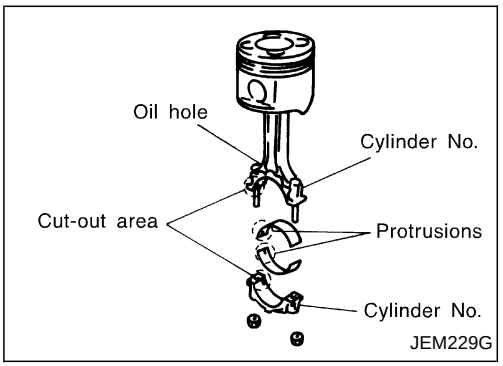
- **Always use either an angle wrench (SST) or protractor during angular tightening. Avoid tightening based on visual checks alone.**
- **After tightening bolts to specified torque, make sure that crankshaft rotates smoothly.**
- **Check crankshaft end play. Refer to EM-74, "CRANKSHAFT END PLAY".**

9. Check the outer diameter of connecting rod bolts. Refer to EM-84, "CONNECTING ROD BOLT DEFORMATION".
10. Install piston to connecting rod.



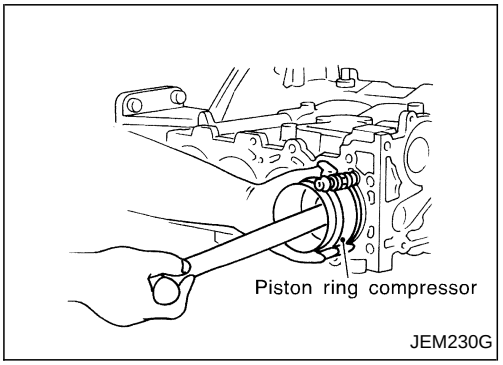
11. Install connecting rod bearing to connecting rod and connecting rod cap.

- Before installing, apply engine oil on the front (inner) surface of bearing. Do not apply oil to the back surface, but thoroughly clean it.
- Align stopper notches on connecting rod and protrusions on bearing and install.



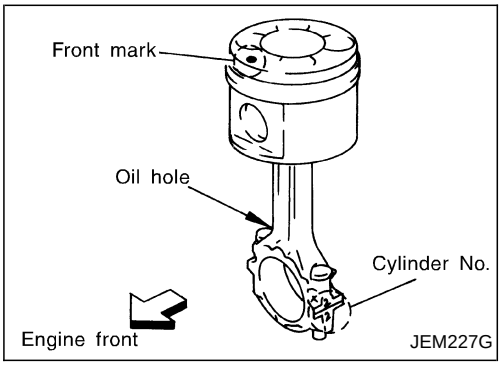
12. Install piston and connecting rod assembly to crankshaft.

- Set crankshaft pin of the installation location at BDC.
- Match the cylinder No. of connecting rod to the location of cylinder.
- Using piston ring compressor (Commercial Service Tool), install so that the front mark on the piston top surface faces in the direction of engine front.

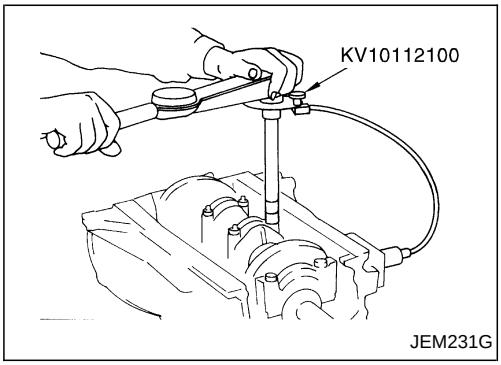


13. Install connecting rod caps.

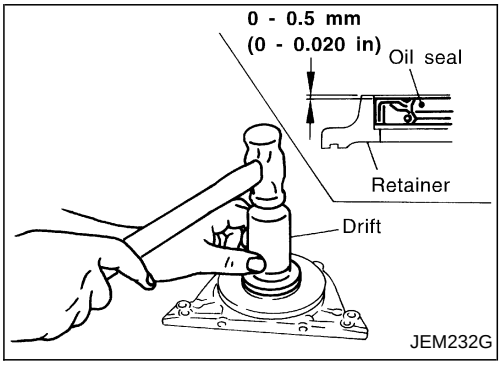
- Match the cylinder No. punched on connecting rod and that on cap.
- Make sure that the front mark on connecting rod cap faces towards the front of the engine.



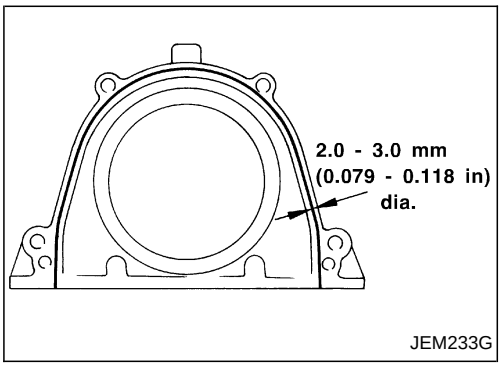
Assembly (Cont'd)



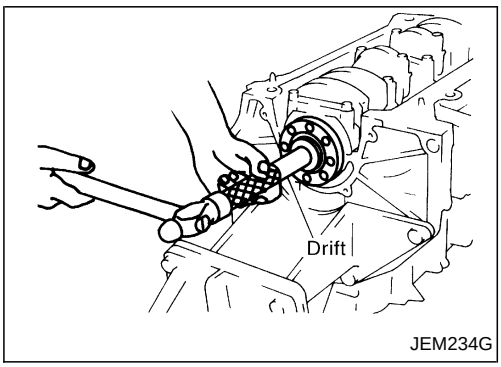
14. Tighten connecting rod nuts according to the following procedure:
a. Apply engine oil on bolt threads and seat surface of nuts.
b. Tighten to 29 to 30 N·m (2.9 to 3.1 kg-m, 21 to 22 ft-lb).
c. Loosen completely to 0 N·m (0 kg-m, 0 in-lb).
d. Tighten to 19 to 20 N·m (1.9 to 2.1 kg-m, 14 to 15 ft-lb).
e. Tighten 120° to 125° [target: 120°]. (angular tightening)
- **Always use either an angle wrench (SST) or protractor during angular tightening. Avoid tightening based on visual checks alone.**
- After tightening nuts, check that crankshaft rotates smoothly.
- Check connecting rod side clearance. Refer to EM-74, "CONNECTING ROD SIDE CLEARANCE".



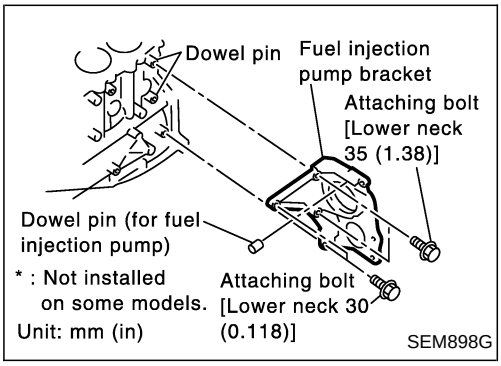
15. Force fit rear oil seal into rear oil seal retainer.
- Using a drift [105 mm (4.13 in) dia.], force fit so that the dimension is as specified in the figure.
- Avoid inclined fitting. Force fit perpendicularly.



16. Install rear oil seal retainer.
- Apply a continuous bead of specified liquid gasket (Refer to EM-3, "Liquid Gasket Application Procedure".) on locations shown in the figure.



17. Install pilot bushing.
- Force fit with the drift [approx. 19 mm (0.75 in) dia.].



18. Install fuel injection pump bracket.
- Align the bracket with the dowel pins on the block to install.
- The two bolts used for dowel pins have a longer shanks than the other two.
- Check the protruding distance of the dowel pin for fuel injection pump.

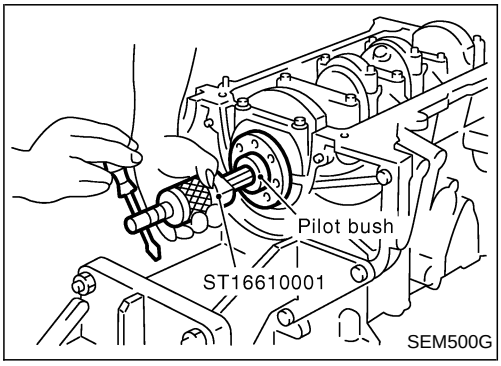
Standard: 13.0 - 15.0 mm (0.512 - 0.591 in)

19. Install parts to the engine in the reverse order of disassembly.
- Tighten bolts securing brackets of auxiliary components (A/C compressor, alternator) to the specified torque.

: 57 - 65 N·m (5.8 - 6.7 kg-m, 42 - 48 ft-lb)

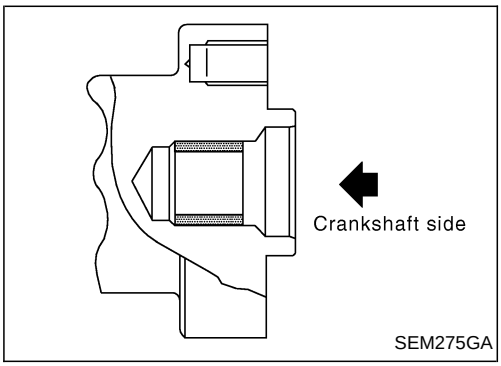
Assembly (Cont'd)

20. Remove engine from engine stand in the reverse order of assembly.
21. Install flywheel.
- Holding ring gear with ring stopper (SST), tighten securing bolts with TORX-socket (size: Q8 E20, Commercial Service Tool).
- Tighten bolts uniformly in a crisscross manner.

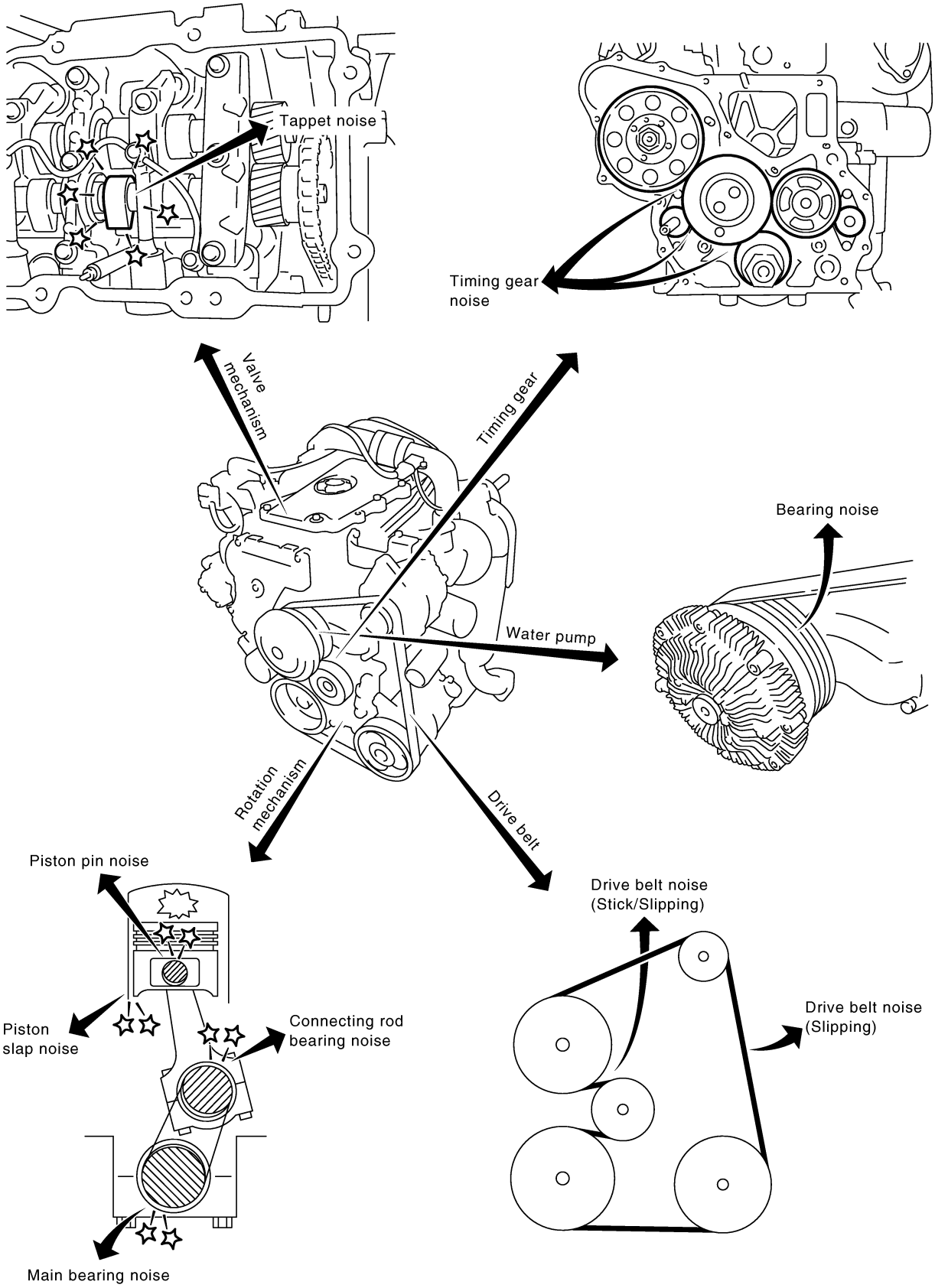


REPLACEMENT OF PILOT BUSHING

1. Remove pilot bushing using tool or suitable tool.



2. Install pilot bushing as shown.


Tappet noise
Timing gear noise
Valve mechanism
Timing gear
Water pump
Bearing noise
Rotation mechanism
Drive belt
Piston pin noise
Piston slap noise
Connecting rod bearing noise
Main bearing noise
Drive belt noise (Stick/Slipping)
Drive belt noise (Slipping)

SEM761G

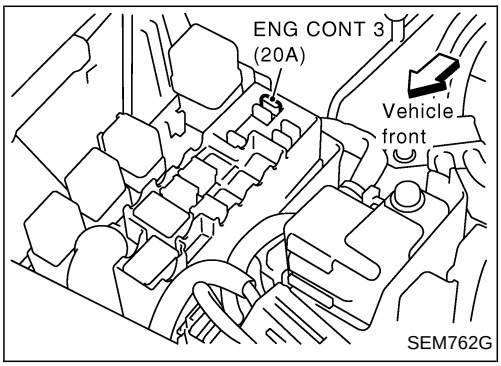
NVH Troubleshooting Chart — Engine Noise

Use the chart below to help you find the cause of the symptom.
1. Locate the area where noise occurs.
2. Confirm the type of noise.
3. Specify the operating condition of engine.
4. Check specified noise source.

If necessary, repair or replace these parts.

Location of noise	Type of noise	Operating condition of engine						Source of noise	Check item	Reference page
		Before warm-up	After warm-up	When starting	When idling	When racing	While driving			
Top of engine Rocker cover Cylinder head	Ticking or clicking	C	A	—	A	B	—	Tappet noise	Valve clearance	EM-116
	Rattle	C	A	—	A	B	C	Camshaft bearing noise	Camshaft oil clearance Camshaft runout	EM-112, 112
Crankshaft pulley Cylinder block (Side of engine) Oil pan	Slap or knock	—	A	—	B	B	—	Piston pin noise	Piston to piston pin clearance Connecting rod bushing oil clearance (Small end)	EM-151, 153
	Slap or rap	A	—	—	B	B	A	Piston slap noise	Piston to cylinder bore clearance Piston ring side clearance Piston ring end gap Connecting rod bend and torsion	EM-154, 152, 152, 153
	Knock	A	B	C	B	B	B	Connecting rod bearing noise	Connecting rod bushing oil clearance (Small end) Connecting rod bearing oil clearance (Big end)	EM-153, 157
	Knock	A	B	—	A	B	C	Main bearing noise	Main bearing oil clearance Crankshaft runout	EM-158, 156
Front of engine Timing gear cover	Tapping or ticking	A	A	—	B	B	B	Timing gear noise	Timing gear backlash	EM-122
Front of engine	Squeaking or fizzing	A	B	—	B	—	C	Drive belts (Sticking or slipping)	Drive belts deflection	MA section (“Checking Drive Belts”, “ENGINE MAINTENANCE”)
	Creaking	A	B	A	B	A	B	Drive belts (Slipping)	Idler pulley bearing operation	
	Squall Creak	A	B	—	B	A	B	Water pump bearing noise	Water pump bearing operation	LC section (“Water Pump Inspection”, “ENGINE COOLING SYSTEM”)

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



1. Warm up engine.
2. Turn ignition switch OFF.
3. Using CONSULT-II, make sure no error codes are indicated for self-diagnosis items. Refer to EC section, “TROUBLE DIAGNOSIS — GENERAL DESCRIPTION”.

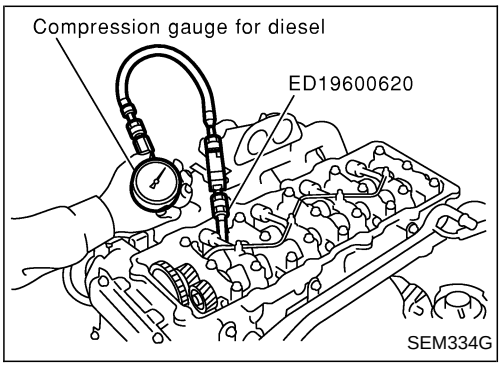
- Do not disconnect CONSULT-II until the end of this operation; it will be used to check engine rpm and for error detection at the end of this operation.

4. Disconnect the negative battery terminal.
5. Remove the following parts.

- Throttle body
- Rocker cover

6. To prevent fuel from being injected during inspection, remove fuel injection pump fuse [ENG CONT3 (20A)] from fuse box on the right side of engine compartment.
7. Remove glow plugs from all the cylinders.

- **Before removal, clean the surrounding area to prevent entry of any foreign materials into the engine.**
- **Carefully remove glow plugs to prevent any damage or breakage.**
- **Handle with care to avoid applying any shock to glow plugs.**



8. Install adapter (SST) to installation holes of glow plugs and connect compression gauge for diesel engine.
   : 15 - 19 N·m (1.5 - 2.0 kg-m, 11 - 14 ft-lb)
9. Connect battery negative terminal.
10. Set the ignition switch to “START” and crank. When gauge pointer stabilizes, read compression pressure and engine rpm. Repeat the above steps for each cylinder.

- **Always use a fully-charged battery to obtain specified engine speed.**

Unit: kPa (bar, kg/cm^2, psi)/rpm

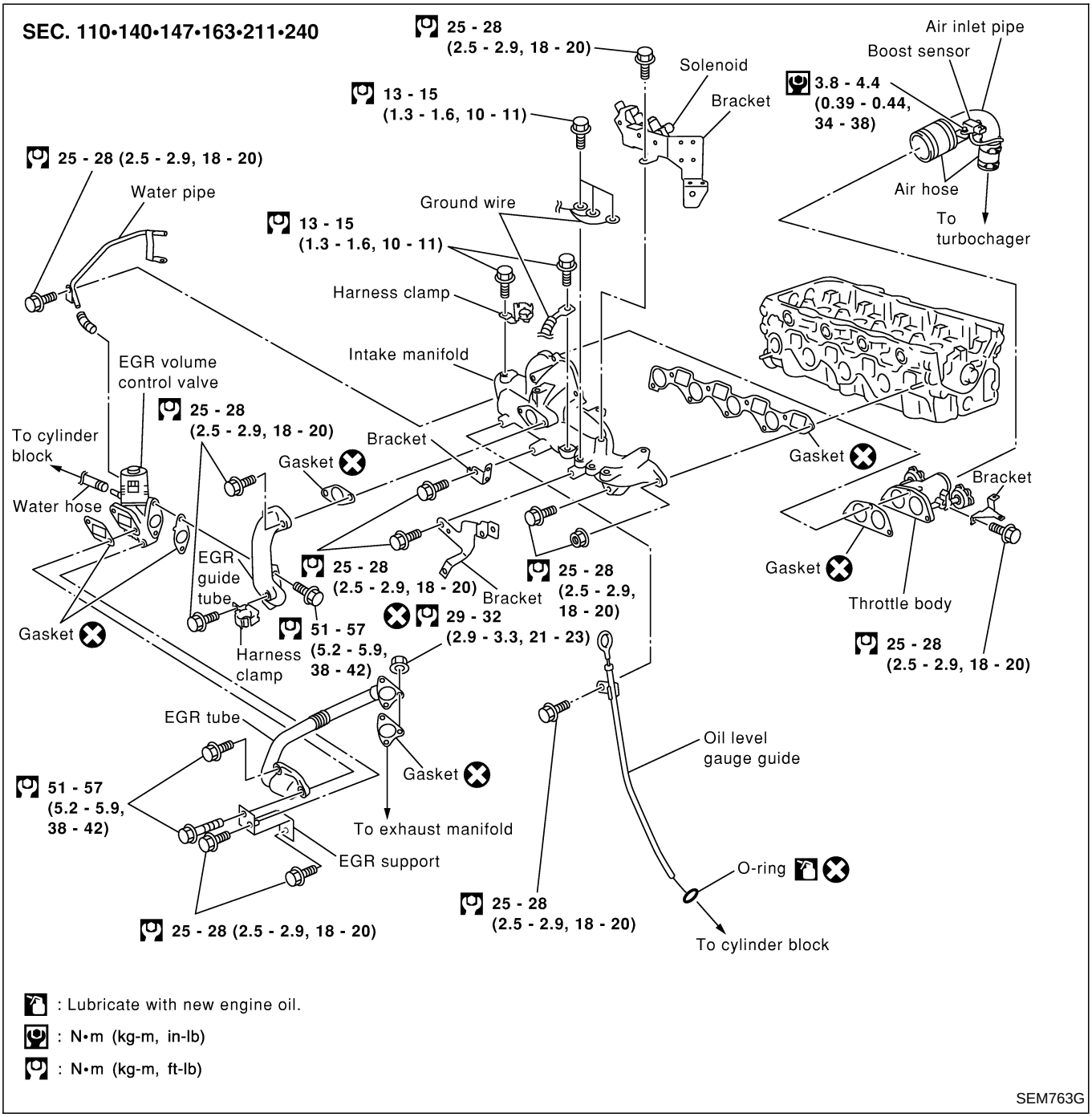
Standard	Minimum	Difference limit between cylinders
2,942 (29.42, 30.0, 427)/200	2,452 (24.52, 25.0, 356)/200	294 (2.94, 3.0, 43)/200

- When engine rpm is out of the specified range, check the specific gravity of battery liquid. Measure again under corrected conditions.
- If engine rpm exceeds the limit, check valve clearance and combustion chamber components (valves, valve seats, cylinder head gaskets, piston rings, pistons, cylinder bores, cylinder block upper and lower surfaces) and measure again.

11. Complete this operation as follows:

a. Turn the ignition switch to “OFF”.
b. Disconnect battery negative terminal.
c. Replace glow plug oil seals and install glow plugs.
d. Install fuel injection pump fuse [ENG CONT3 (20A)].
e. Connect battery negative terminal.
f. Using CONSULT-II make sure no error code is indicated for items of self-diagnosis. Refer to EC section, “TROUBLE DIAGNOSIS — INDEX”.

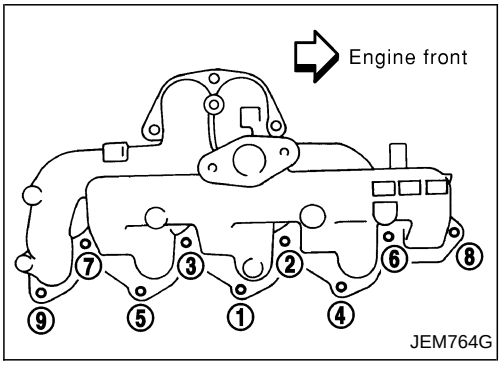
Removal and Installation



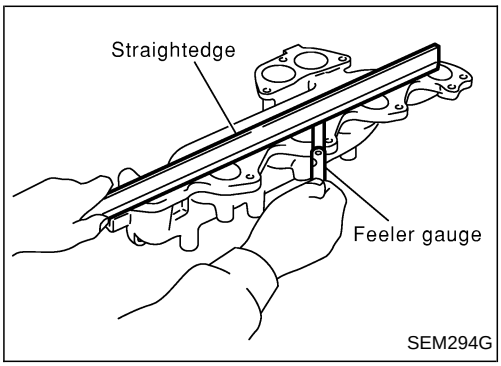
Removal and Installation (Cont'd)

REMOVAL

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



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

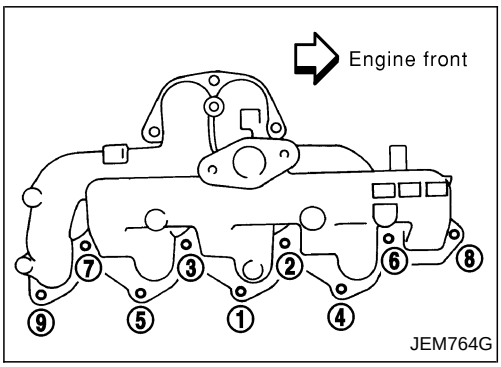


Inspection

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

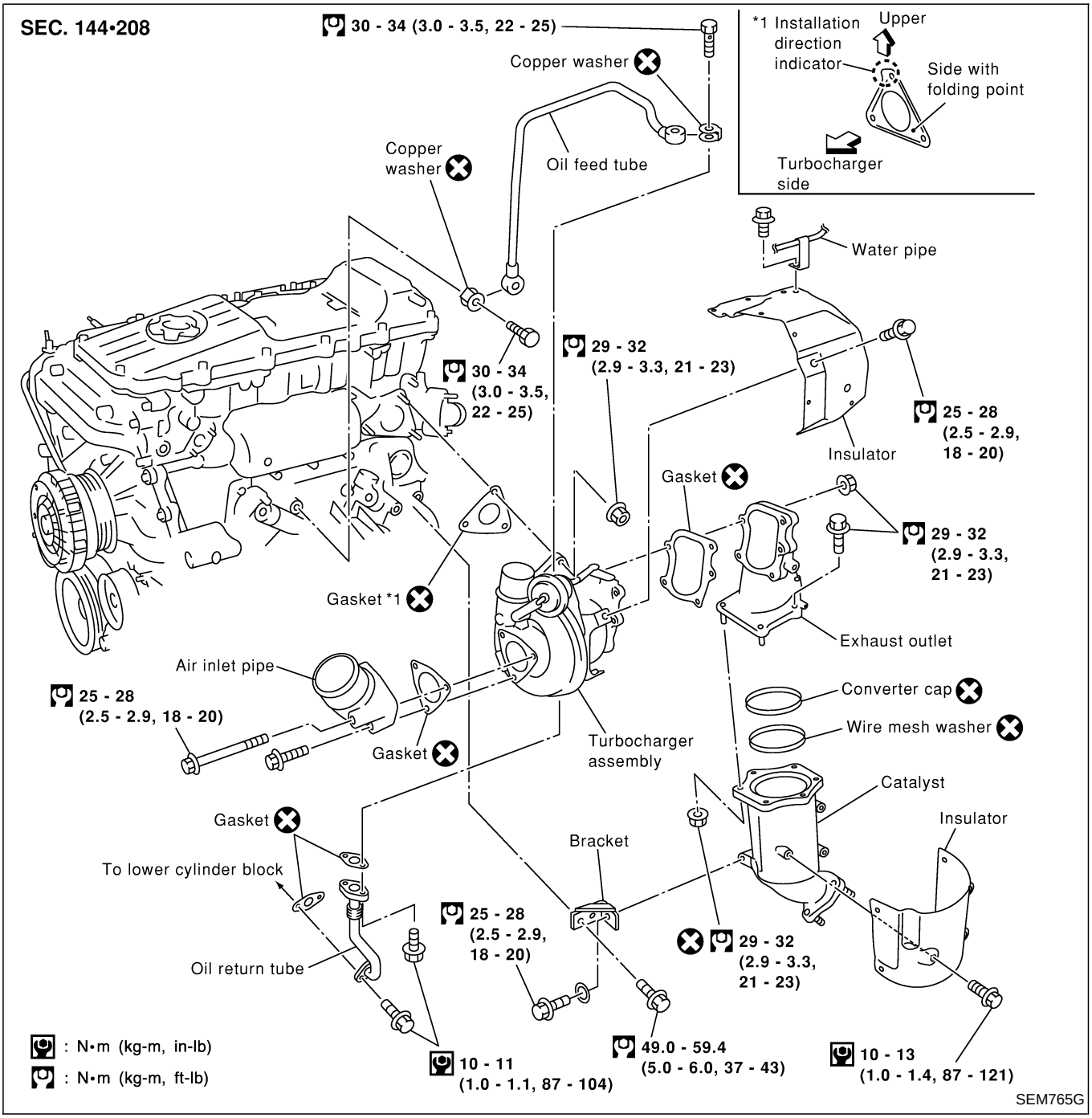
Intake manifold surface flatness:
Limit 0.2 mm (0.008 in)

INSTALLATION



1. Tighten intake manifold in the numerical order shown in the figure.
2. Install in the reverse order of removal.

Removal and Installation



REMOVAL

1. Remove the following parts.
- Air cleaner case, air hose
- Air inlet hose
- Exhaust front tube
  Refer to FE section, “Removal and Installation”, “EXHAUST SYSTEM”.
- Remove wires, harnesses, tubes and pipes.

Removal and Installation (Cont'd)

2. Remove catalyst.

CAUTION:

Do not disassemble catalyst.

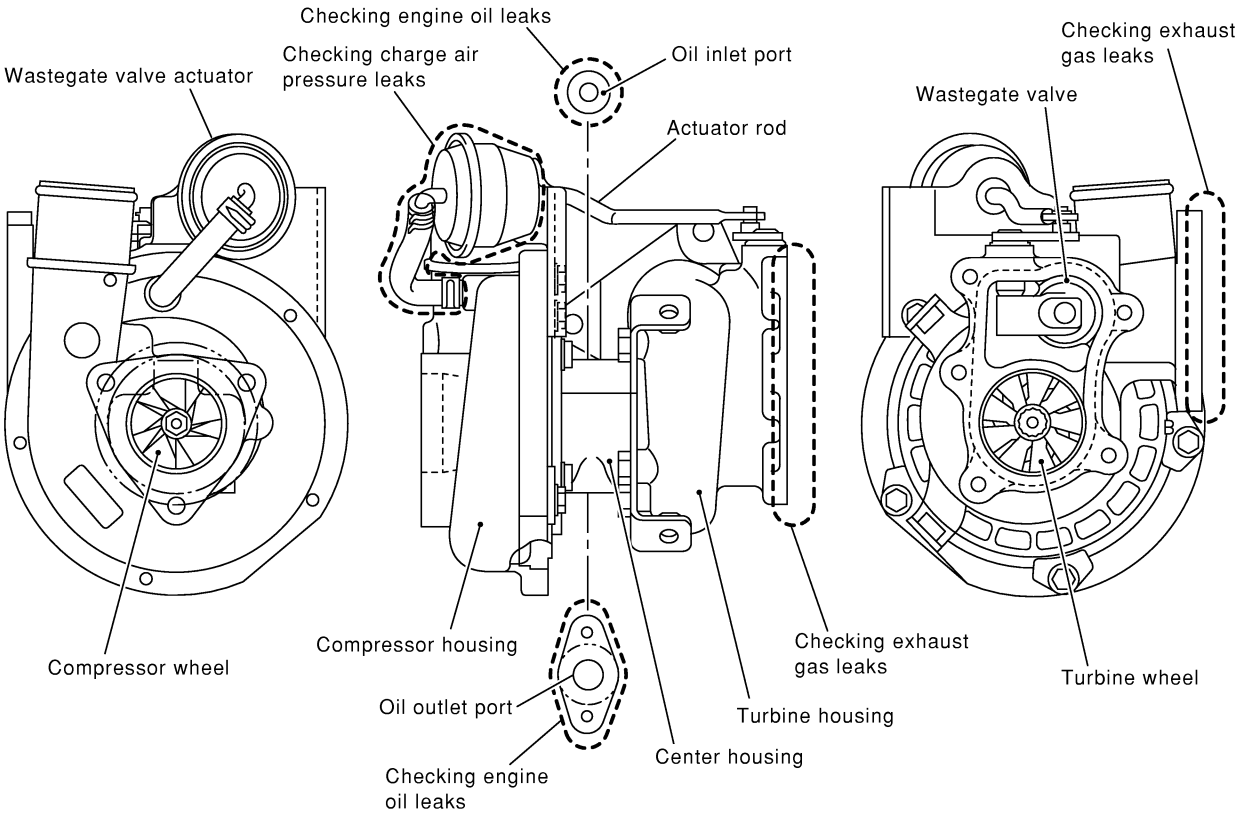
3. Remove oil feed tube and oil return tube.
4. Remove turbocharger.

CAUTION:

Turbocharger must not be disassembled.

Inspection

TURBOCHARGER



CAUTION:

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

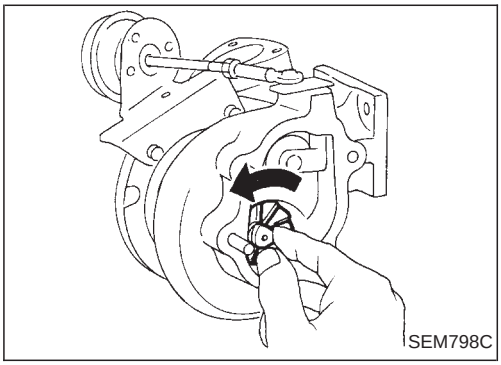
Suction side: Between turbocharger and intake manifold

Exhaust side: Between turbocharger and catalyst

NOTE:

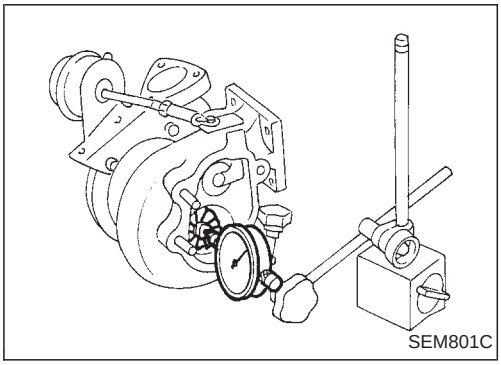
Figures which follow are intended to explain inspection procedures. (Shapes of parts may differ from those of actual parts.)

Inspection (Cont'd)


SEM798C

Rotor shaft

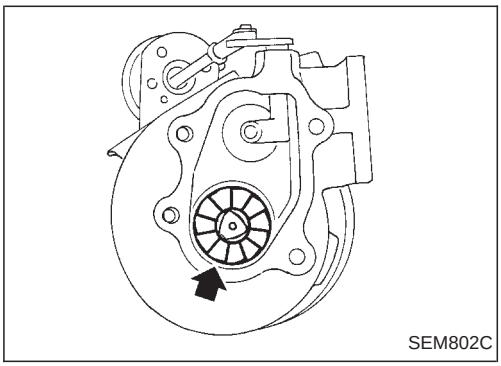
- Check that the rotor shaft rotates smoothly without any resistance when it is rotated by your fingertips.
- Check that the rotor shaft is not loose when it is moved vertically or horizontally.


SEM801C

Rotor shaft end play

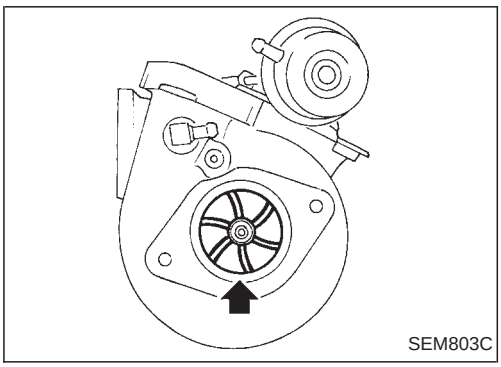
Place a dial gauge at the rotor shaft end in the axial direction to measure the end play.

Standard: 0.002 - 0.006 mm (0.0001 - 0.0002 in)


SEM802C

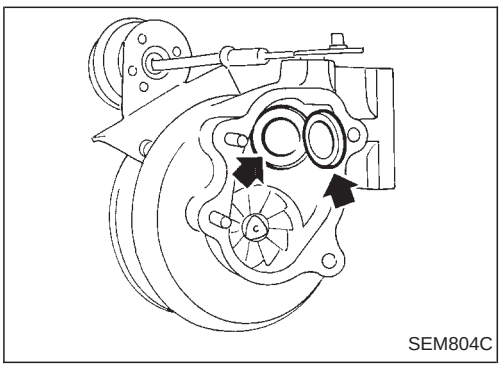
Turbine wheel

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


SEM803C

Compressor wheel

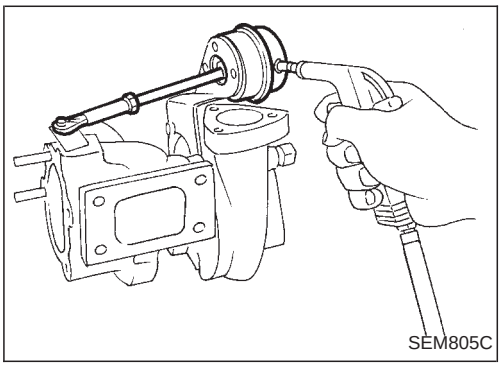
- Check that there is no oil adhesion inside the air inlet.
- Check that the compressor wheel does not interfere with the compressor housing.
- Check that the wheel is not bent or broken.


SEM804C

WASTEGATE VALVE

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

Inspection (Cont'd)


SEM805C

WASTEGATE VALVE ACTUATOR

Apply air pressure to wastegate valve actuator and check it for smooth movement.

- **Do not keep applying air pressure to the actuator.**
- **The air pressure should be in the range of 142.3 to 147.7 kPa (1.42 to 1.48 bar, 1.451 to 1.507 kg/cm^2, 20.7 to 21.4 psi).**

  Standard value for actuator rod operating pressure [when stroke is 1.5 mm (0.059 in)]:

  142.3 - 147.7 kPa (1.42 - 1.48 bar, 1.451 - 1.507 kg/cm^2, 20.7 - 21.4 psi)

Inspection (Cont'd)

Trouble diagnosis of turbocharger

Preliminary check:

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

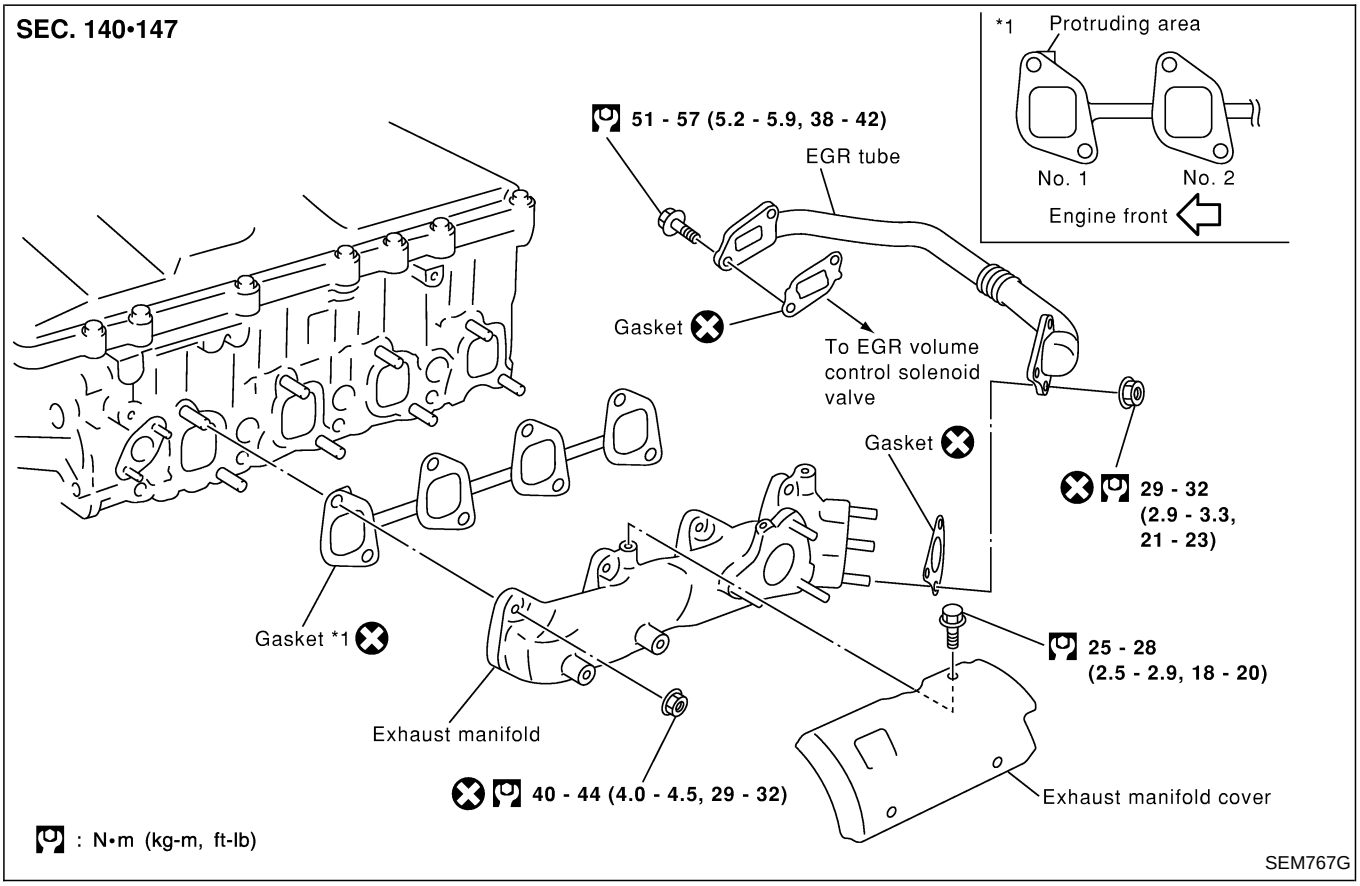
Inspection item	Inspection result	Symptom (when each inspection item meets each inspection result)			
		Oil leakage	Smoke	Noise	Insufficient power/ acceleration failure
Turbine wheel	Oil leaks.	△	◎	△	△
	Carbon is accumulated.	△	◎	○	○
	Friction with housing.	△	○	◎	○
	Blades are bent or broken.			◎	◎
Compressor wheel	Inside the air inlet is seriously contaminated by oil.	○	○		
	Friction with housing.	△	○	◎	○
	Blades are bent or broken.			◎	◎
After checking both turbine and compressor, inspect rotor shaft end play.	There is resistance when the rotor shaft is rotated by your fingertips.		△	△	○
	The rotor shaft sometimes does not rotate by your fingertips.				◎
	There is too much play in the bearing.	△	△	○	△
Oil return port	Carbon or sludge is accumulated in the waste oil hole.	△	◎	△	△
Wastegate valve operation	● Valve does not open smoothly when inspection pressure is gradually applied. ● Valve does not close smoothly when inspection pressure is removed.				◎

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

INSTALLATION

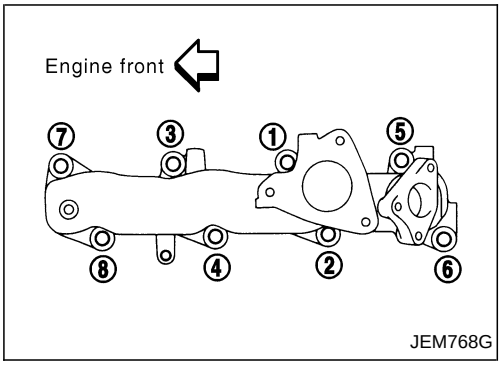
1. Install turbocharger.
   - For direction of gasket installation, refer to "Removal and Installation", EM-95.
2. Install oil feed tube and oil return tube.
3. Install catalyst.
4. Install in the reverse order of removal.

Removal and Installation

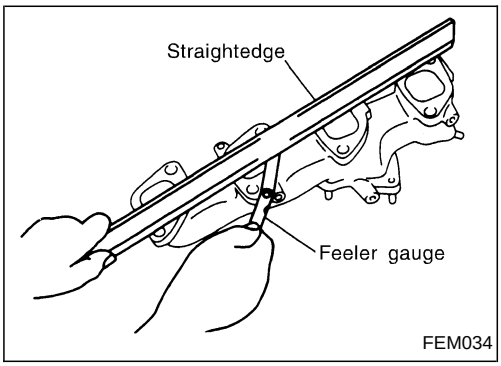


REMOVAL

1. Remove the following parts.
- Refer to “PREPARATIVE WORK” in “CATALYST AND TURBOCHARGER”, EM-95.
- Remove catalyst.
- Remove turbocharger.



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

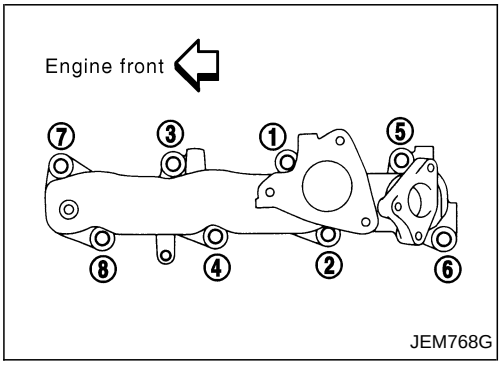


Inspection

EXHAUST MANIFOLD

Check distortion on mounting surface with straightedge and feeler gauge.

Limit: 0.2 mm (0.008 in)



INSTALLATION

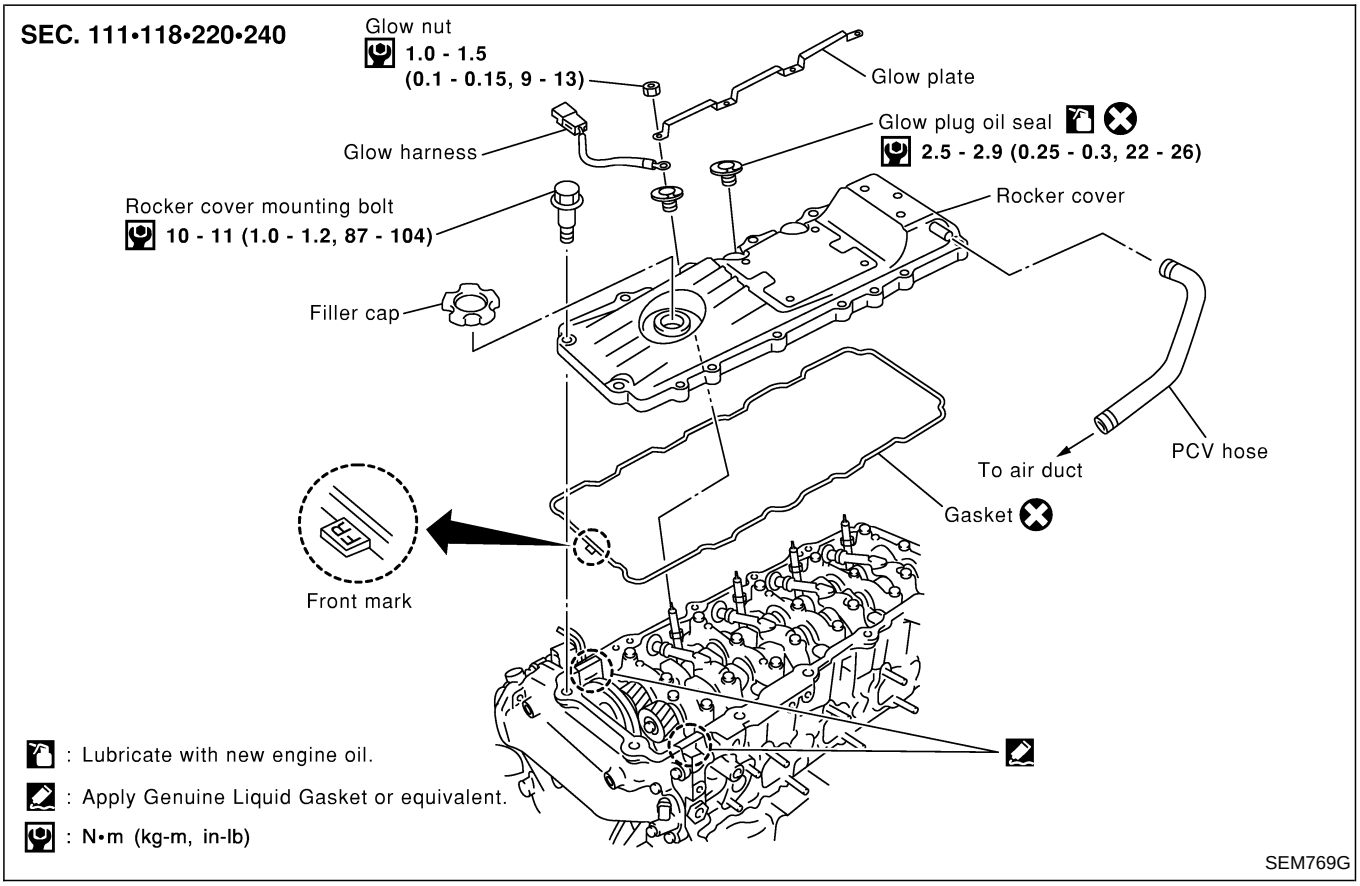
1. Tighten exhaust manifold nuts in the numerical order shown in the figure.

NOTE:

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

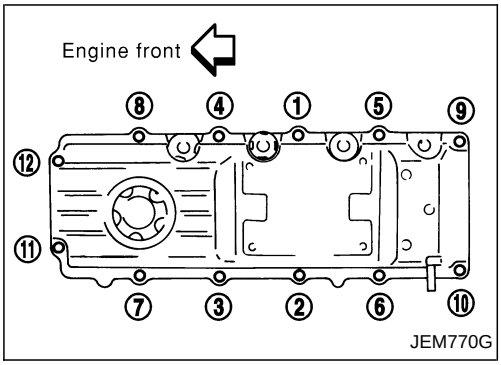
2. Install in the reverse order of removal.

Removal and Installation



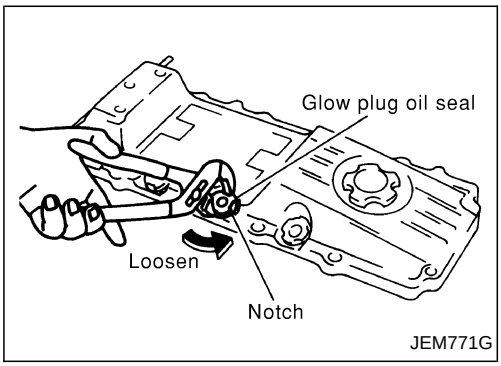
REMOVAL

1. Remove the following parts.
- Air inlet pipe
- Throttle body
- Wires, harnesses, tubes and pipes

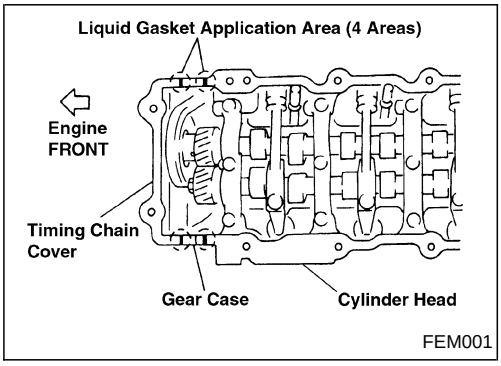


2. Loosen holding bolts in the reverse order of that shown in the figure and remove.
3. Remove rocker cover to the direction of glow plug tilt.

Removal and Installation (Cont'd)

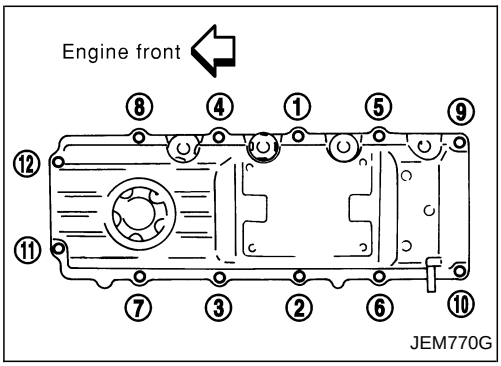


4. Remove glow plug oil seals.



INSTALLATION

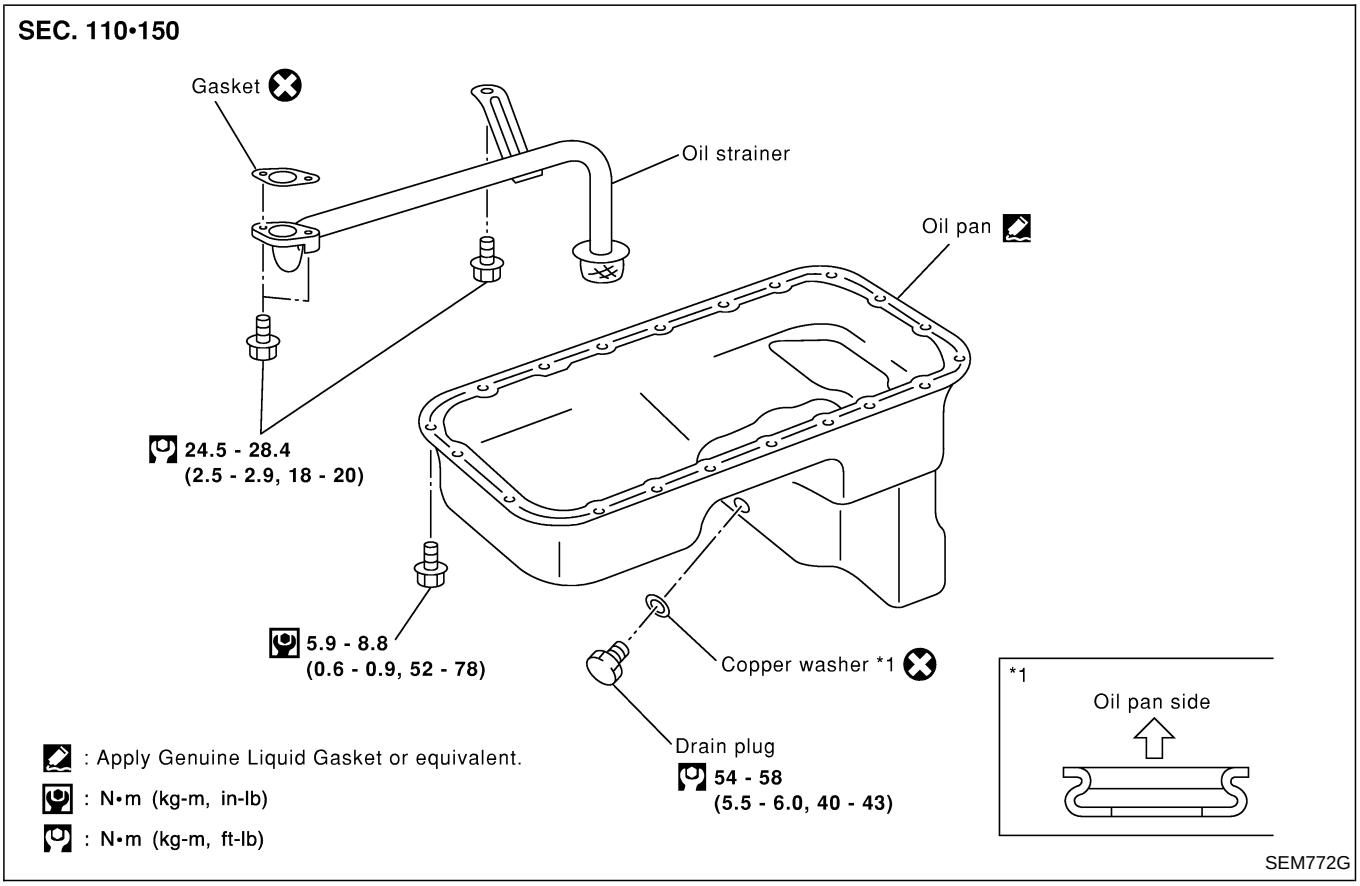
1. Temporarily tighten holding bolts in the numerical order shown in the figure.
2. Install glow plug oil seal.
3. Apply Genuine Liquid Gasket or equivalent to the area shown in the figure.
4. Use a spatula or similar tool to apply liquid gasket so that gaps between mating faces are filled.
5. Apply additional liquid gasket so that it mounds on top.
6. Apply engine oil to glow plug oil seals and install them.



7. Tighten mounting bolts in the numerical order shown in the figure.
8. Re-tighten to the same torque in the same order as above.

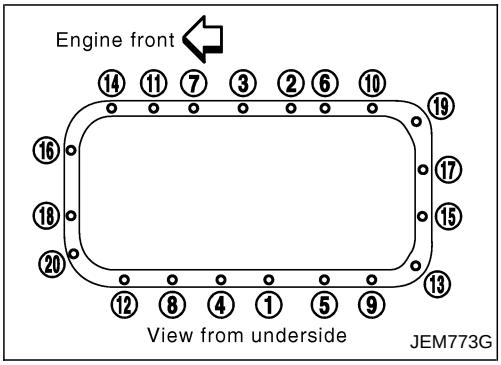
9. Install in the reverse order of removal hereafter.

Removal and Installation



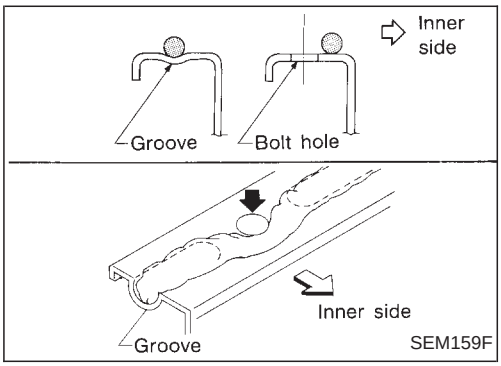
REMOVAL

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



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

Removal and Installation (Cont'd)



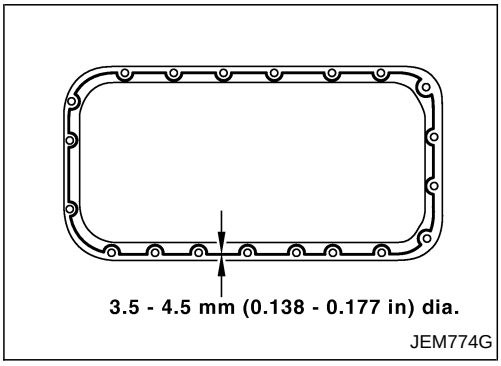
INSTALLATION

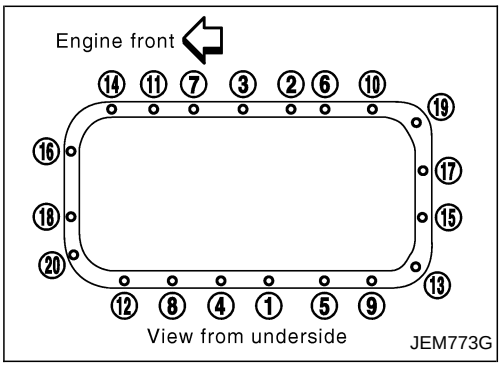
1. Install oil strainer.
2. Install oil pan.

a. Use a scraper to remove all traces of liquid gasket from mating surfaces.
- Also remove traces of liquid gasket from mating surface of cylinder block, front cover.
- **Remove old liquid gasket from the bolt hole and thread.**

b. Apply a continuous bead of liquid gasket to mating surface of oil pan.
- **Use Genuine Liquid Gasket or equivalent.**
- **Apply liquid gasket to the groove on the mating surface.**
- **Allow 8 mm (0.31 in) clearance around center of bolt holes.**

c. Apply liquid gasket to inner sealing surface as shown in figure.
- **Be sure liquid gasket is 2.0 to 3.0 mm (0.079 to 0.188 in).**
- **Attaching should be done within 5 minutes after coating.**

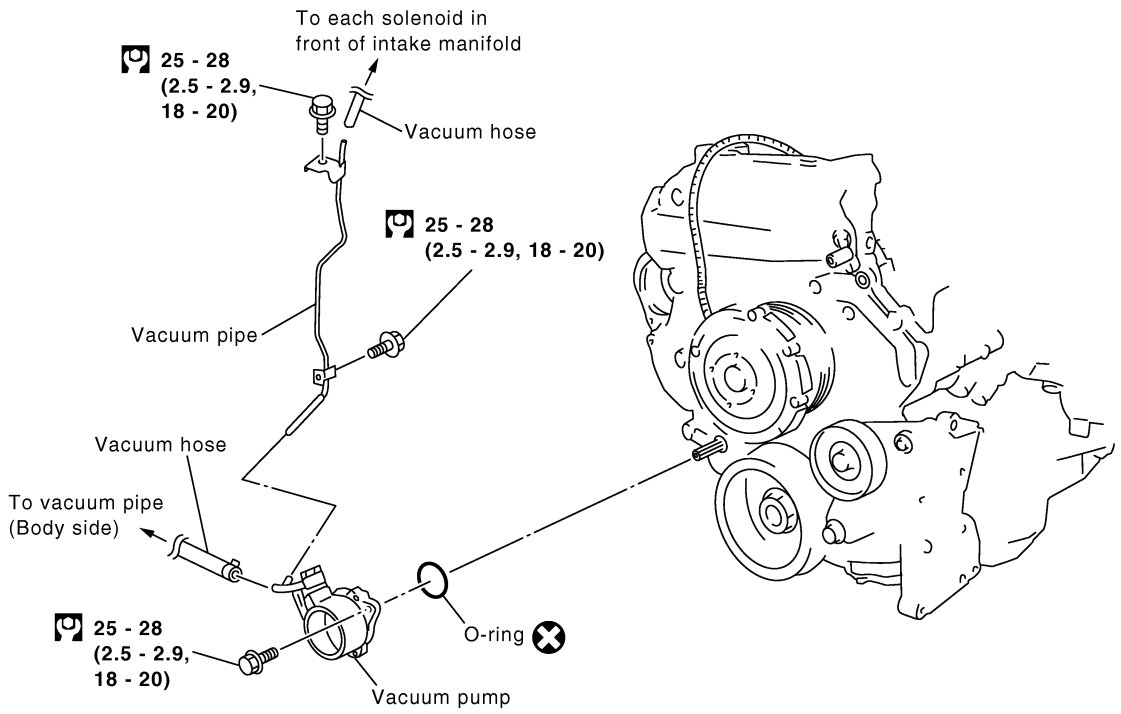




2. Tighten the mounting bolts in the order shown in the figure. Then tighten in the same order to the torque stated.
3. The torque of the installation bolts will differ depending on position.
4. Install in the reverse order of removal.

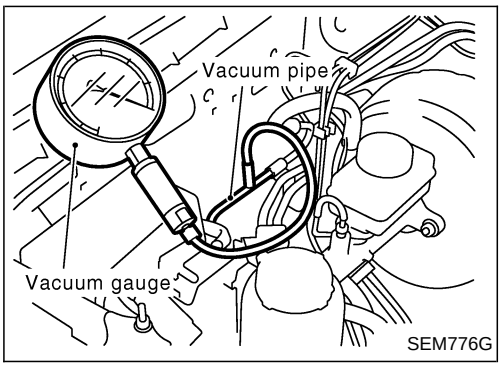
Removal and Installation

SEC. 135•223



REMOVAL

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



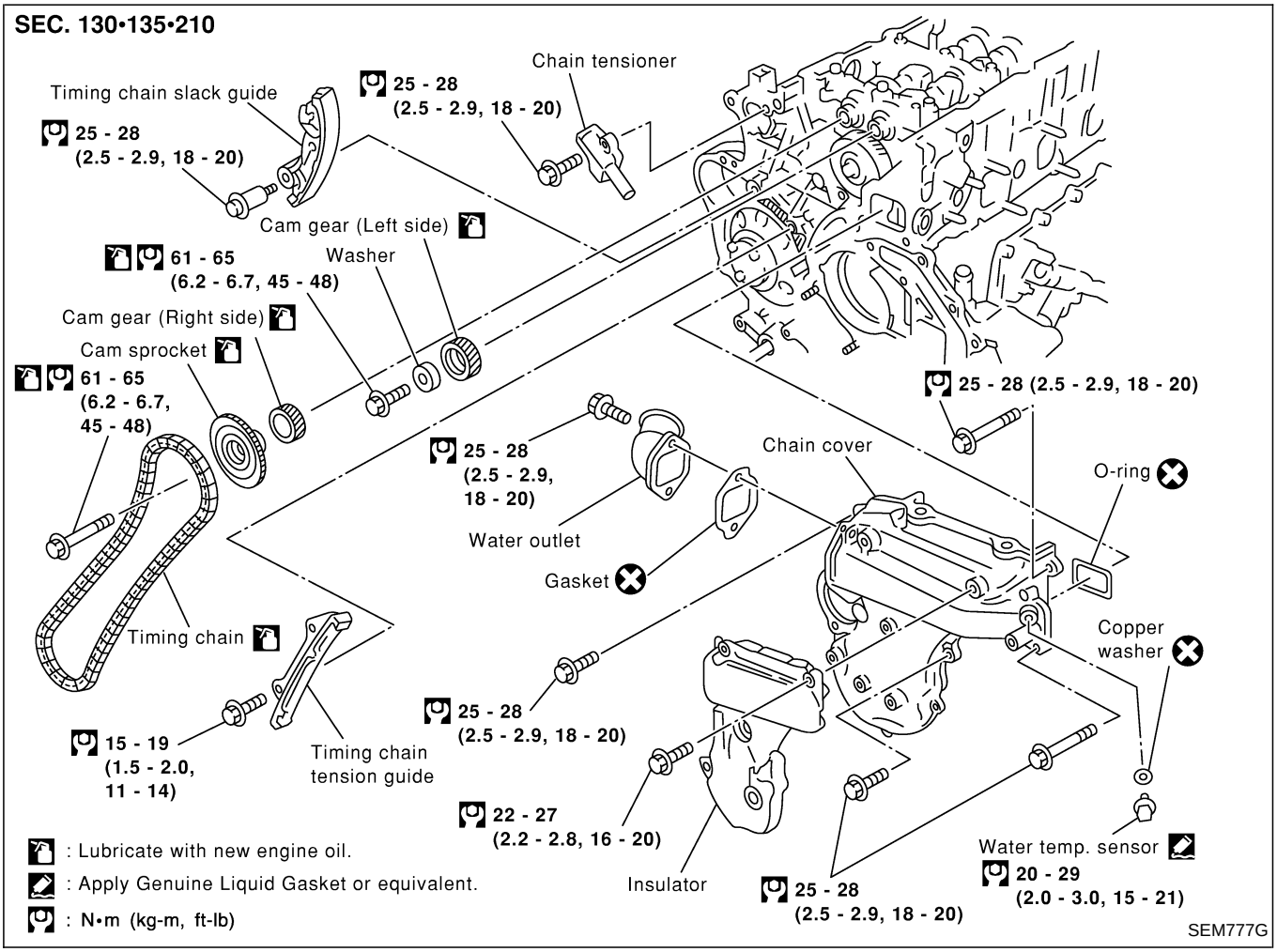
INSPECTION

1. Remove the vacuum hose. Connect the vacuum gauge through the 3-way connector. Otherwise, remove the welch plug of the vacuum pipe and attach the vacuum gauge directly. (The illustration shows the second method.)
2. Start the engine, and measure the vacuum pressure with the engine idling.
   Vacuum pressure:
   Standard
   −93.3 to −101.3 kPa (−933 to −1,013 mbar, −700 to −760 mmHg, −27.56 to −29.92 inHg)
3. If outside the standard value, make sure that there is no intake of air within the circuit and measure again.
4. Replace the vacuum pump if still outside the standard value.

INSTALLATION

- Install in the reverse order of removal.

Removal and Installation



CAUTION:

As the internal mechanism of the idler gear must first of all, and always, be set by a bolt when removing the timing chain before removing the fuel injection pump and timing gear, follow the procedures in EC section, "Electronic controlled fuel injection pump", "BASIC SERVICE PROCEDURE".

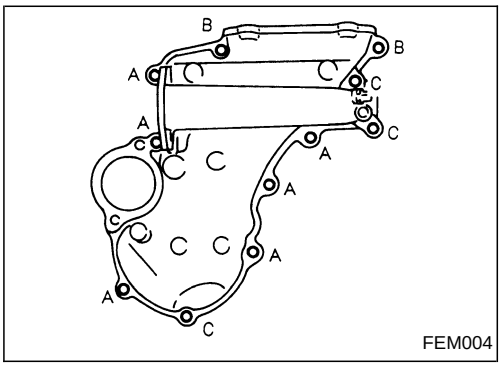
- This chapter will deal with the summary of removing the timing chain before removing the camshaft and cylinder head.

Removal

1. Remove the following parts.
- Air inlet pipe
- Throttle body
- Rocker cover
- Spill tube
- Coolant (Drain)
- Radiator upper hose
- Water outlet
- Radiator shroud
- Cooling fan
- Drive belt
- Vacuum pump

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

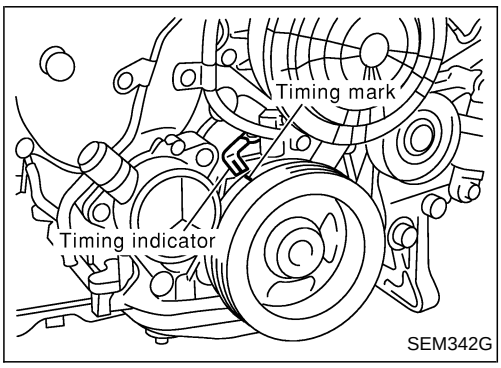
Removal (Cont'd)



FEM004

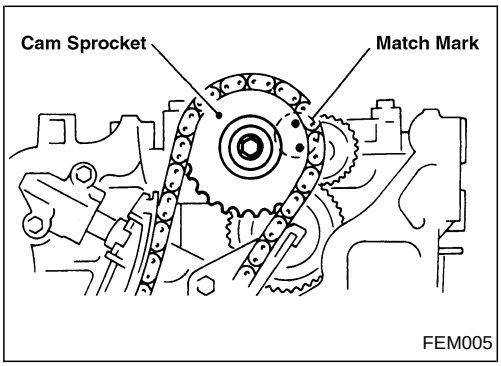
3. Remove the chain cover.
- Remove the mounting bolts A to C shown in the figure.

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



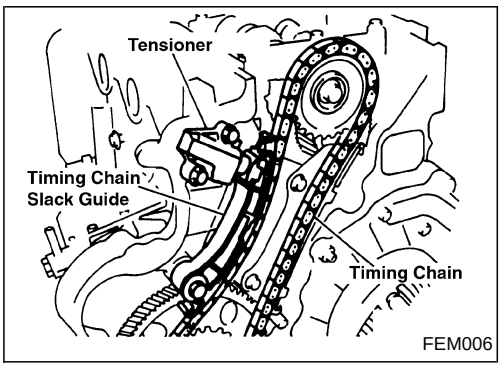
SEM342G

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



FEM005

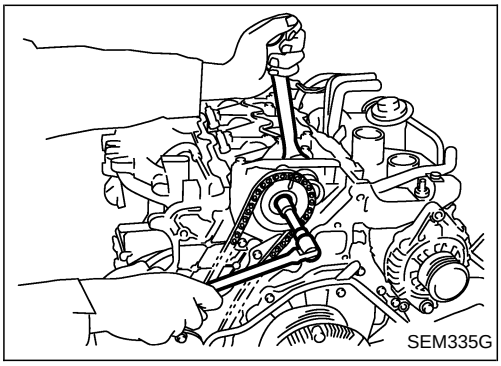
2) Make sure that the cam sprocket match mark is in the position shown in the figure.
- If the match mark is not in position, turn the crankshaft pulley once more and position it.
- When removing at No. 1 cylinder TDC, each sprocket and chain is fitted using the match mark, therefore there is no need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



FEM006

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

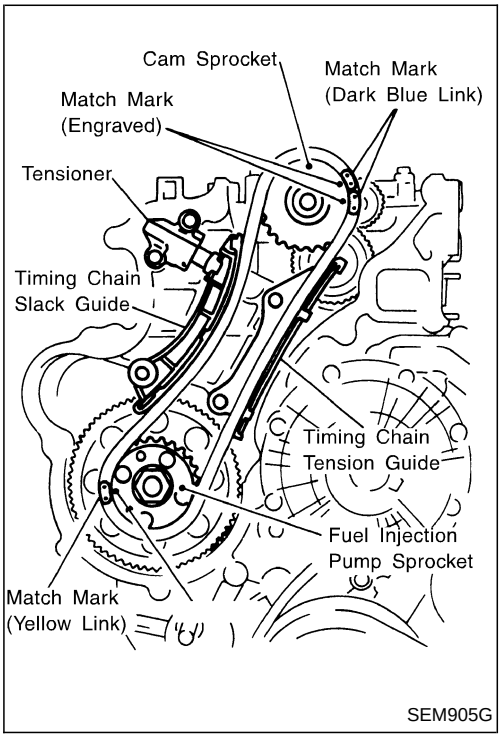
CAUTION:
Be careful not to drop the plunger and spring.


SEM335G

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

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

8. Remove the timing chain tension guide.



SEM905G

Installation

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

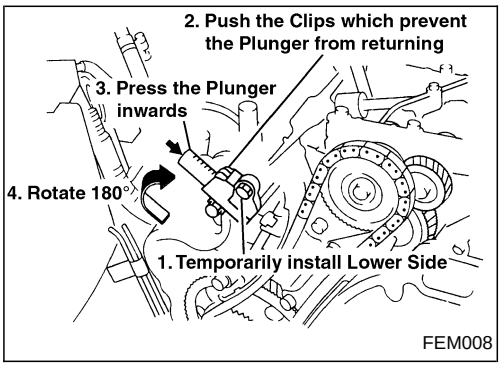
CAUTION:

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

3. Install the timing chain slack guide.

CAUTION:

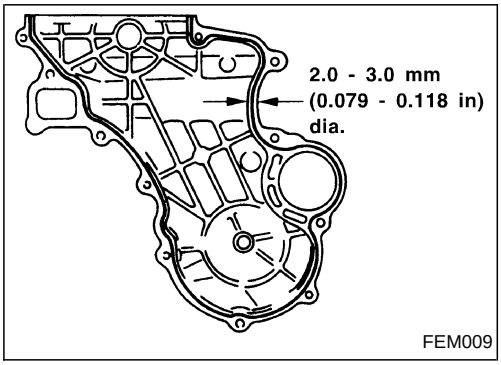
When the holding bolt is tightened to the specified torque, there is a gap between the guide and bolt. Do not over-tighten.



FEM008

4. Install the chain tensioner.

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



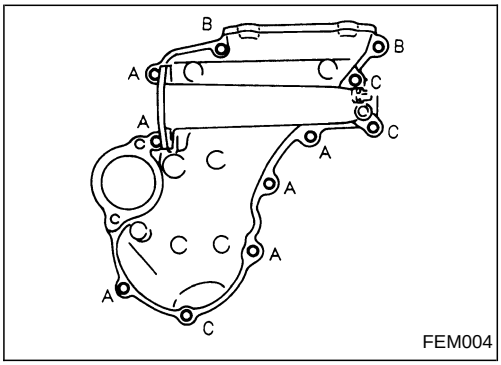
FEM009

5. Install the chain cover.

1) Before installing chain cover, remove all traces of liquid gasket from mating surface using a scraper.
2) Apply a continuous bead of liquid gasket to chain cover.

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

a. Coat of liquid gasket should be maintained within 2.0 to 3.0 mm (0.079 to 0.118 in) dia. range.
b. Attach chain cover to gear case within 5 minutes after coating.
c. Wait at least 30 minutes before refilling engine oil or starting engine.



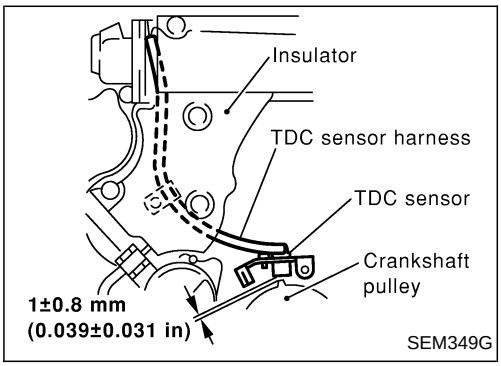
FEM004

3) Install the chain cover.

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

Dimension below the neck:
A: 20 mm (0.79 in)
B: 50 mm (1.97 in)
C: 60 mm (2.36 in)

Installation (Cont'd)

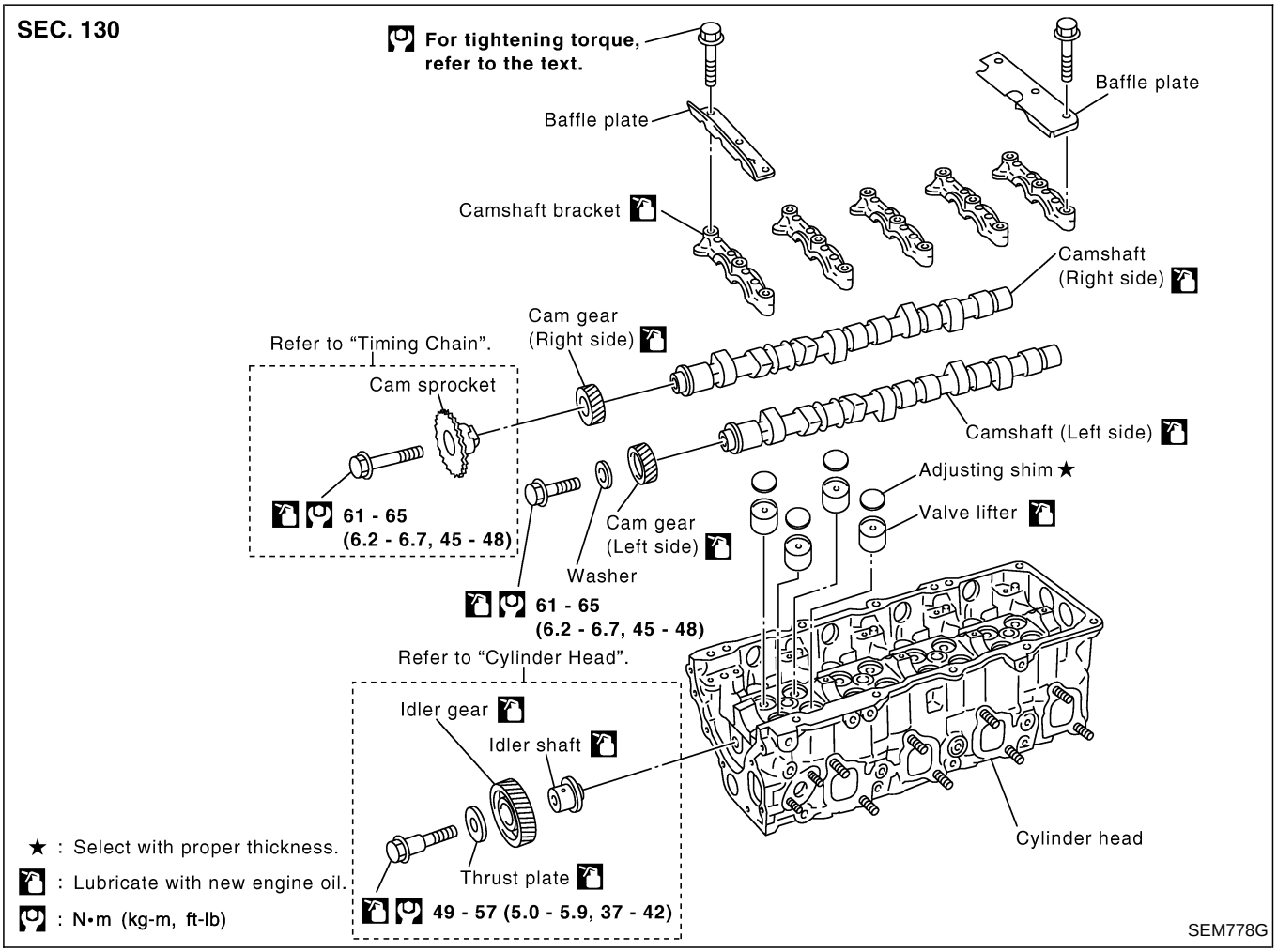


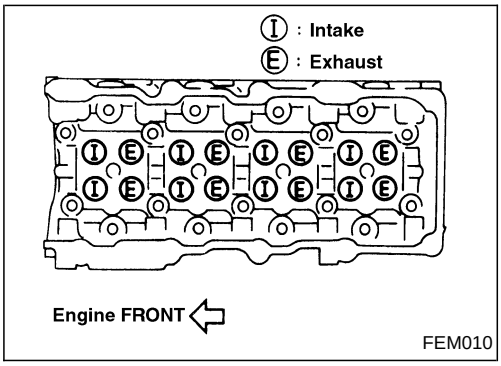
6. Install by following all removal procedures in reverse.

CAUTION:

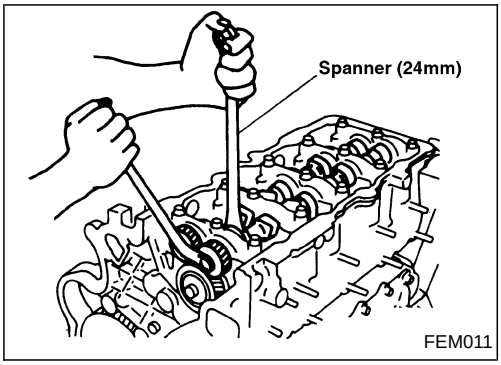
- **Arrange the TDC sensor harness in the position shown in the figure.**
- **Make sure that the harness has no deflection around the vicinity of the crankshaft pulley when installing the clamp.**

Removal and Installation





- This engine will have a different valve arrangement from normal DOHC 4-valve type engines. As both camshafts on this engine have intake and exhaust cams, in this chapter they are named as follows:
  Camshaft (Right side): Intake manifold side camshaft
  Camshaft (Left side): Exhaust manifold side camshaft
- The same parts are used for the right and left sides.
- Refer to the figure for intake and exhaust valve arrangement. (The camshafts have, alternately, either an intake valve or an exhaust valve.)

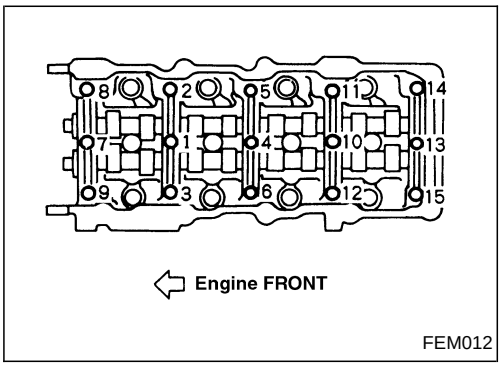


Removal

1. Set the No. 1 cylinder at TDC, then remove the chain case, timing chain and other parts in connection. Refer to "TIMING CHAIN", EM-107.
2. Remove the cam gear.

- Loosen the cam gear mounting bolt by fixing the hexagonal portion of the camshaft.
- The idler gear cannot be removed at this point as the gear case is in the way. (The cylinder head can be removed as a single unit.)

Removal (Cont'd)



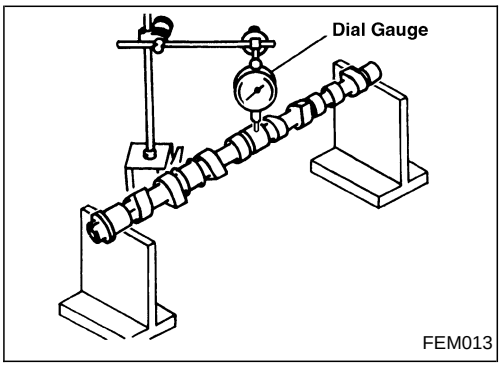
FEM012

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

Inspection

VISUAL CHECK OF CAMSHAFT

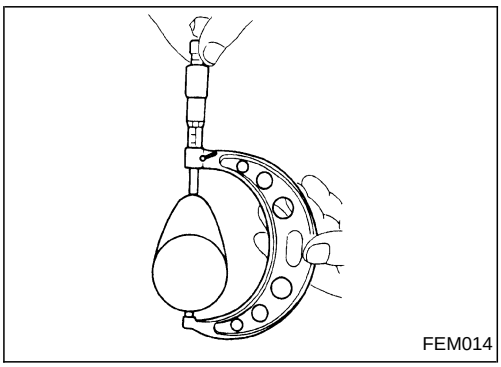
- Check the camshaft for one sided wear or scratches.
- Replace the camshaft if there are abnormalities.



FEM013

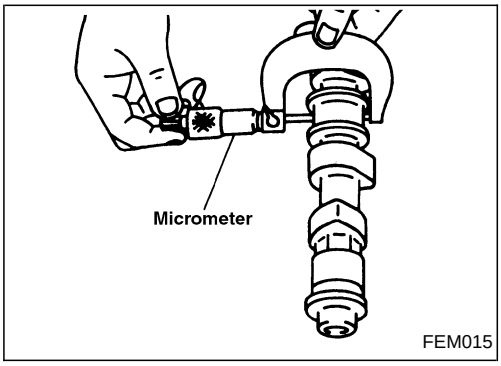
CAMSHAFT RUNOUT

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


FEM014

HEIGHT OF CAM NOSE

- Measure by using a micrometer.
  Standard:
  Intake
  40.468 - 40.508 mm (1.5932 - 1.5948 in)
  Exhaust
  40.830 - 40.870 mm (1.6075 - 1.6091 in)
  Limit: 0.15 mm (0.0059 in)
- If it exceeds the limit, replace camshaft.

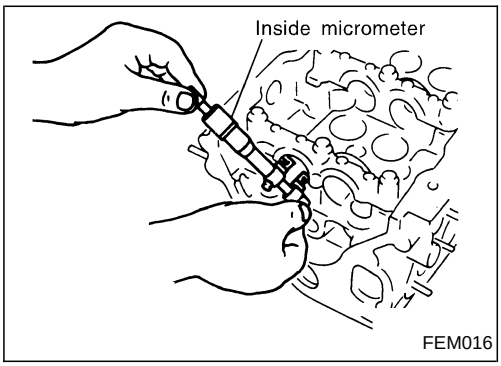


FEM015

CAMSHAFT OIL CLEARANCE

Measure by using a micrometer.
Cam journal outer diameter:
Standard
29.931 - 29.955 mm (1.1784 - 1.1793 in)

Inspection (Cont'd)



CAMSHAFT BRACKET INNER DIAMETER

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

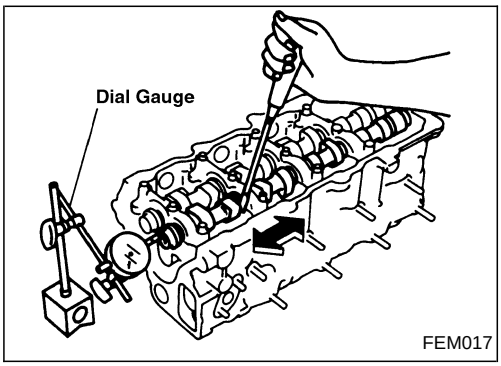
Standard: 30.000 - 30.021 mm (1.1811 - 1.1819 in)

CAMSHAFT OIL CLEARANCE CALCULATIONS

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

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

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



CAMSHAFT END PLAY

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

Standard: 0.065 - 0.169 mm (0.0026 - 0.0067 in)
Limit: 0.2 mm (0.0079 in)

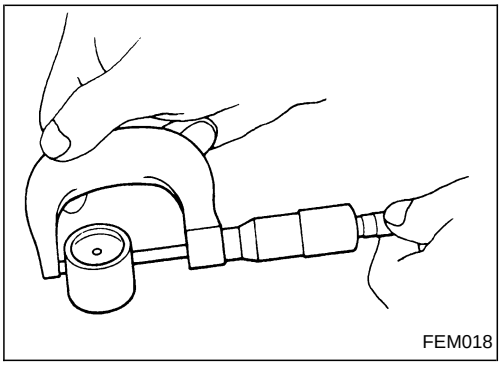
- If end play exceeds the limit, replace camshaft and measure camshaft end play again.
- If end play still exceeds the limit after replacing camshaft, replace cylinder head.

VISUAL INSPECTION OF VALVE LIFTER

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

VISUAL INSPECTION OF ADJUSTING SHIM

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

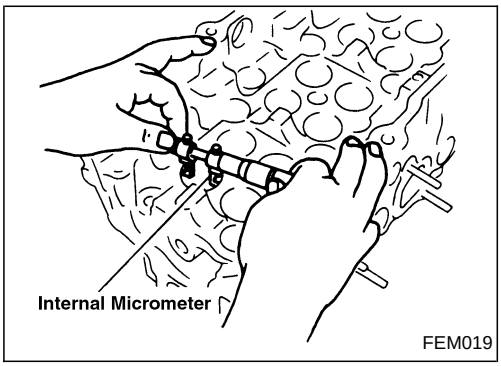


VALVE LIFTER CLEARANCE

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

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

Inspection (Cont'd)



VALVE LIFTER BORE DIAMETER

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

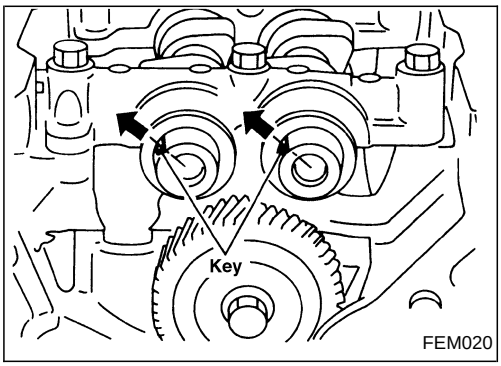
Standard: 34.495 - 34.515 mm (1.3581 - 1.3589 in)

VALVE LIFTER CLEARANCE CALCULATIONS

Clearance = Valve lifter bore diameter − Valve lifter outer diameter

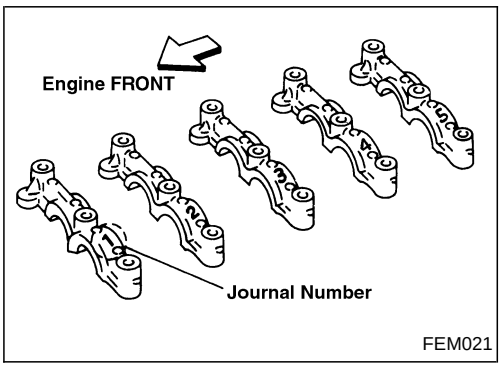
Standard: 0.030 - 0.065 mm (0.0012 - 0.0026 in)

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

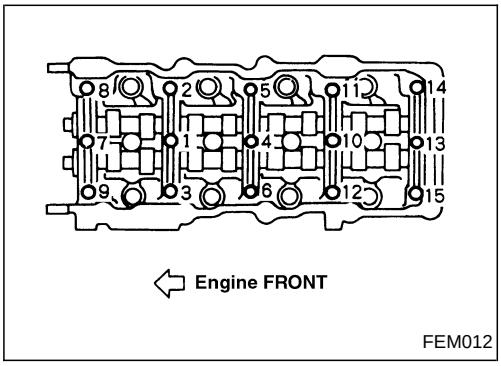


Installation

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



3. Install the camshaft bracket.
- Refer to the camshaft bracket upper side journal No. and install.
- Looking from the exhaust manifold side (left side of engine), install in the direction that the journal number can be read correctly.
- Place baffle plate onto upper face of No. 1 and No. 5 camshaft brackets, and tighten together.

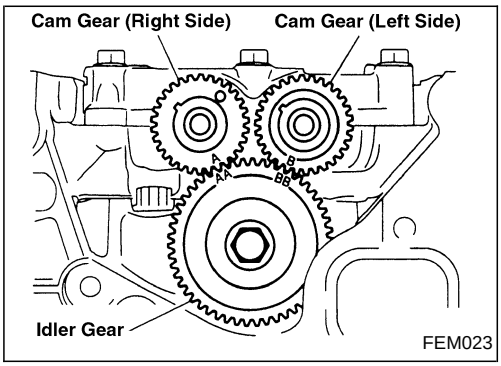


4. Tighten the installation bolts in numerical order in the figure.

1) Tighten to 10 to 14 N·m (1.0 to 1.5 kg-m, 8 to 10 ft-lb).
- Make sure that the thrust portion of the camshaft is fitted properly in the head installation side.

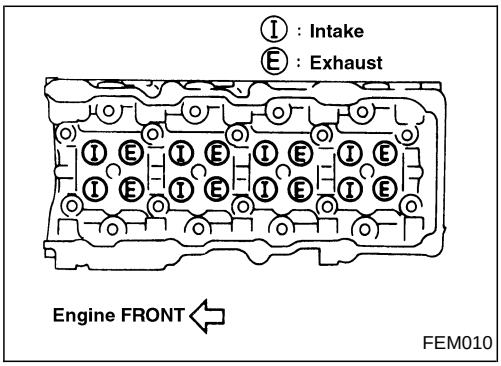
2) Tighten to 20 to 23 N·m (2.0 to 2.4 kg-m, 15 to 17 ft-lb).

Installation (Cont'd)



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

6. Install the timing chain, all other related parts and chain cover. Refer to "TIMING CHAIN", EM-107.
7. After installing the timing chain, check and adjust the valve clearance before installing the spill tube.
   Refer to "VALVE CLEARANCE INSPECTIONS AND ADJUSTMENTS", EM-116.
8. Install in the reverse order of removal.



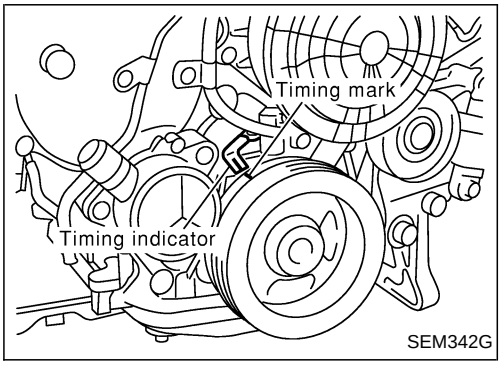
FEM010

Inspection

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

1. Remove rocker cover.
2. Set the No. 1 cylinder at TDC.

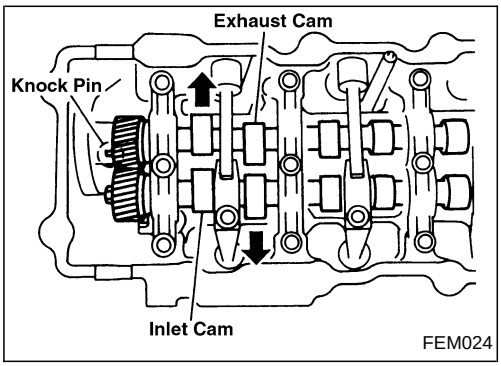
1) Rotate the crankshaft pulley clockwise, and align the TDC mark of the crankshaft pulley with the timing indicator of the TDC sensor bracket.



SEM342G

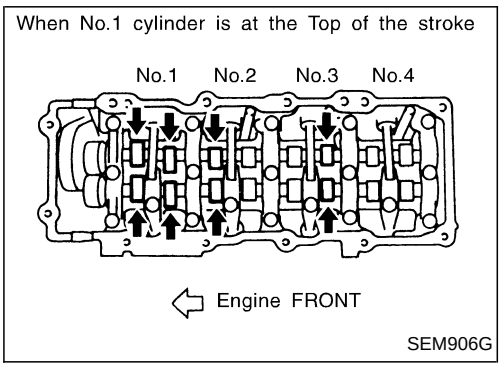
2) Confirm that the cam nose of the No. 1 cylinder and the knock pin of the cam sprocket is in the position shown in the figure.

- Rotate the crankshaft pulley again if not in the position shown in the figure.



FEM024

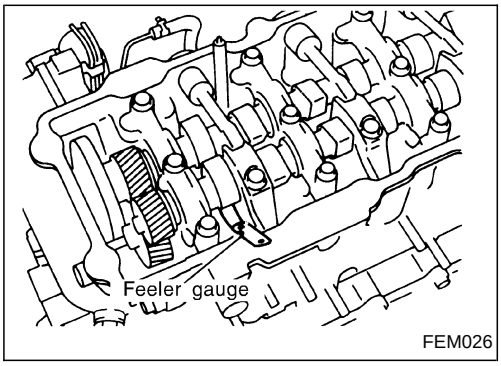
3. While referring to the figure, measure the valve clearance in the circled area of the table below.



SEM906G

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

- The injection order is 1-3-4-2.



FEM026

- Measure the valve clearance using feeler gauge when the engine is cool (at normal temperature).

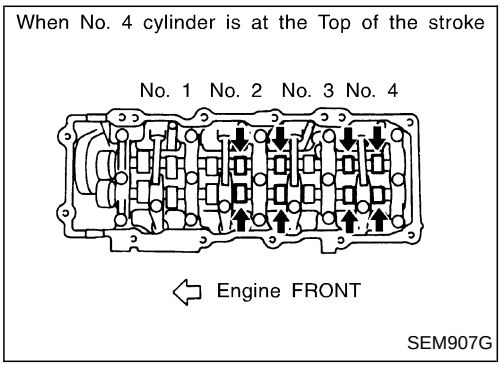
Standard:

Intake and exhaust

0.30 - 0.40 mm (0.012 - 0.016 in)

4. Set the No. 4 cylinder at TDC by rotating the crankshaft clockwise once.
5. Remove baffle plate on No. 5 camshaft bracket.

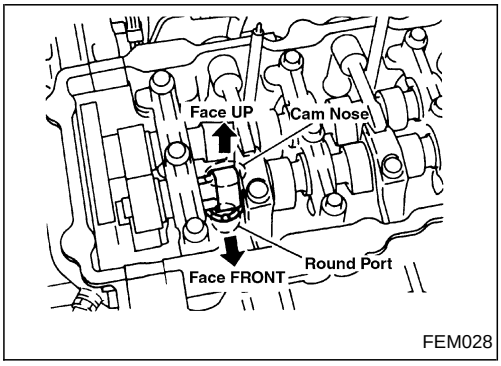
Inspection (Cont'd)



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

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

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



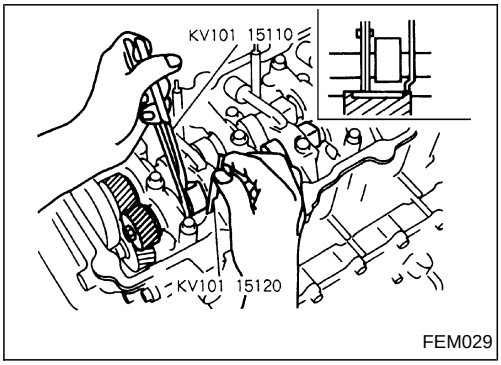
Adjustments

- Remove the adjusting shim for parts which are outside the specified valve clearance.

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

CAUTION:

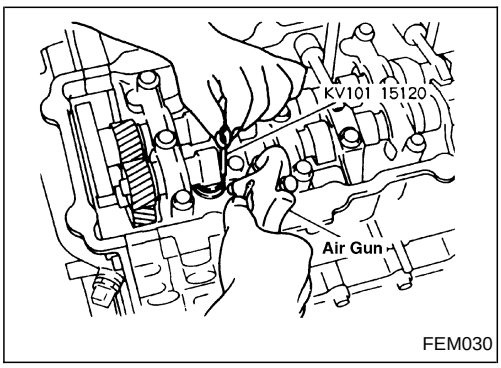
Do not damage the camshaft, cylinder head, or the outer circumference of the valve lifter.



5. With the valve spring in a compressed state, remove the camshaft pliers (SST) by securely setting the outer circumference of the valve lifter with the end of the lifter stopper (SST).
- Hold the lifter stopper by hand until the shim is removed.

CAUTION:

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



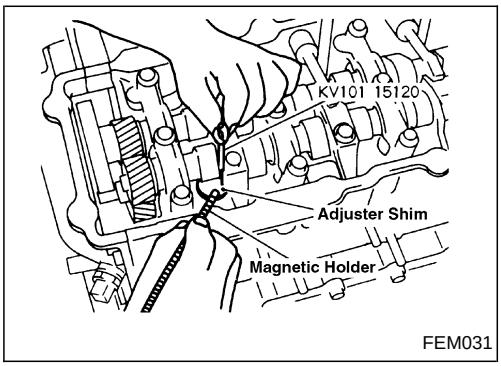
6. Move the rounded hole of the adjusting shim to the front with a very thin screwdriver.
- When the adjusting shim on the valve lifter will not rotate smoothly, restart from step 4 with the end of the lifter stopper (SST) touching the adjusting shim.

7. Remove the adjusting shim from the valve lifter by blowing air through the rounded hole of the shim with an air gun.

CAUTION:

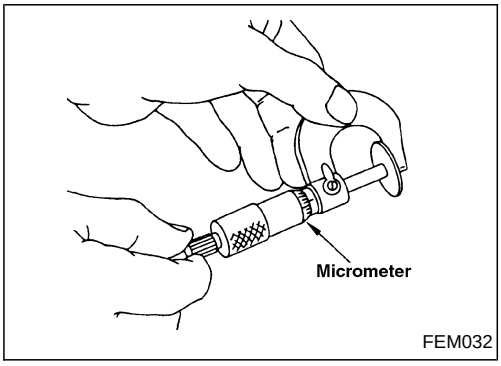
To prevent any remaining oil from being blown around, thoroughly wipe the area clean and wear protective goggles.

Adjustments (Cont'd)



FEM031

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



FEM032

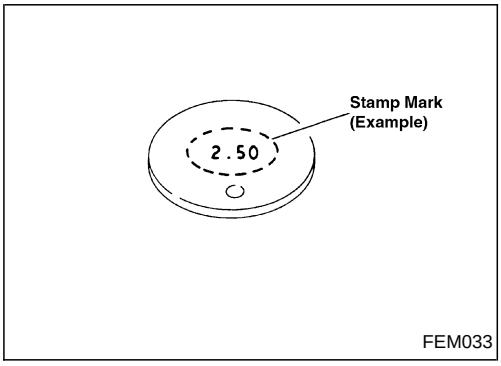
9. Measure the thickness of the adjusting shim using a micrometer.
- Measure near the center of the shim (the part that touches the cam).

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

Calculation method of the adjusting shim thickness:

$t = t_1 + (C_1 - C_2)$

t = Adjusting shim thickness
t_1 = Thickness of the removed shim
C_1 = Measured valve clearance
C_2 = Specified valve clearance
[when the engine is cool (at normal temperature)]
0.35 mm (0.0138 in)



FEM033

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

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

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

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

CAUTION:

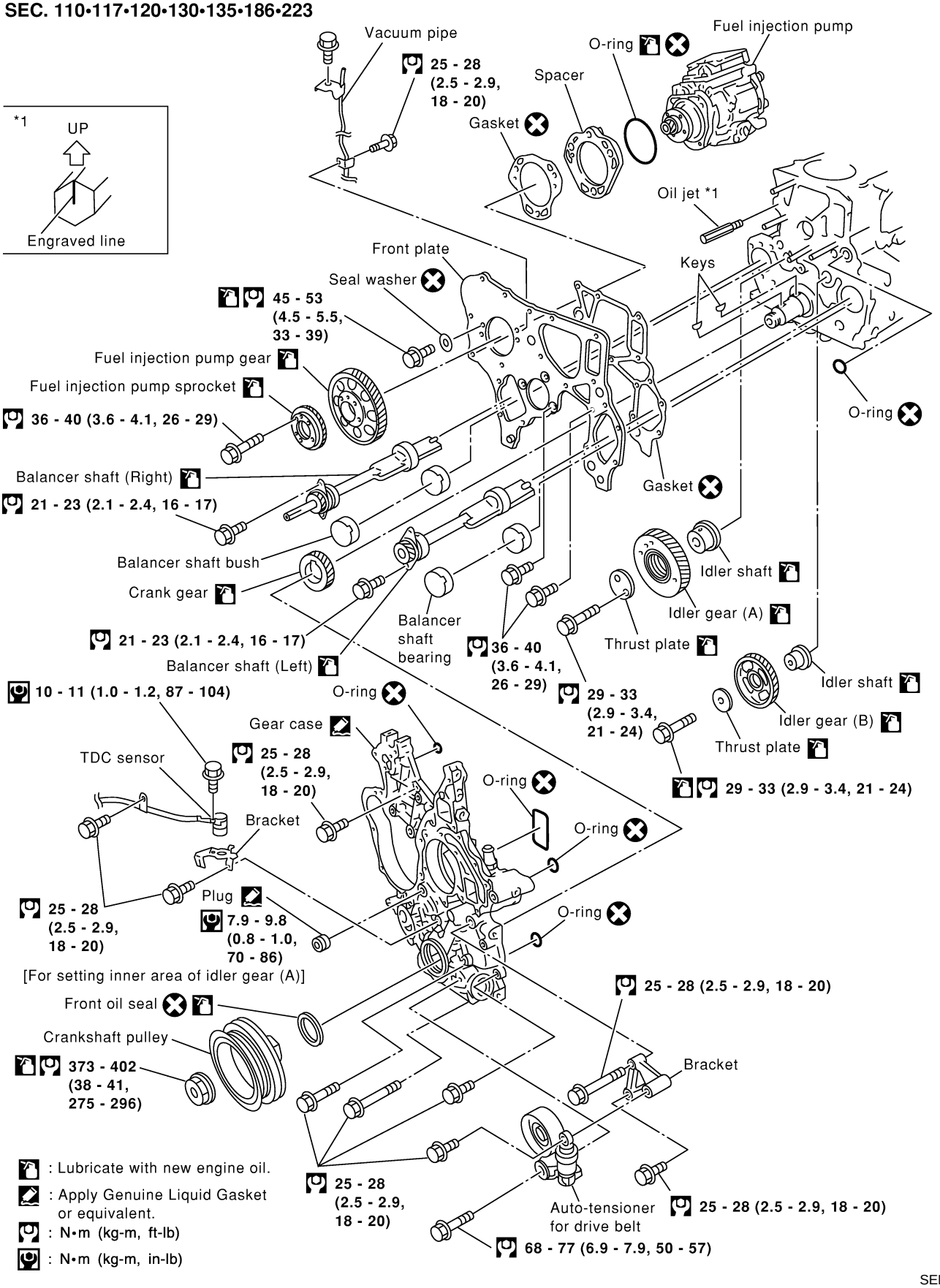
Place the stamped side of the adjusting shim to the valve lifter.

12. Compress the valve spring using the camshaft pliers and remove the lifter stopper (SST).
13. Rotate the crankshaft 2 to 3 times by hand.
14. Confirm that the valve clearance is within the specification.

Removal and Installation

2 idler gears are shown in this chapter. Idler gear (A) has scissors gear, and idler gear (B) does not.

SEC. 110•117•120•130•135•186•223



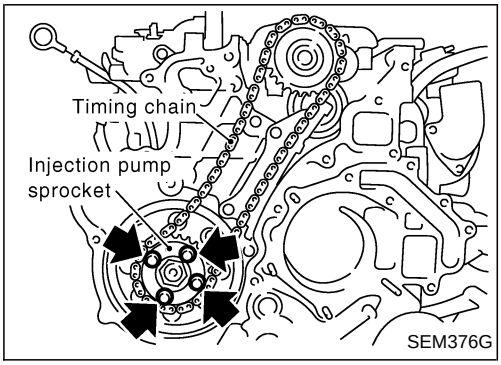
SEM779G

Removal

1. Drain coolant.
2. Remove the following parts.
- Oil pan, oil strainer
  Refer to “OIL PAN AND OIL STRAINER”, EM-104.
- Rocker cover
  Refer to “ROCKER COVER”, EM-102.
- Spill tube
  Refer to “Injection Tube and Injection Nozzle”, “BASIC SERVICE PROCEDURE” in EC section.
- Radiator hose
- Water outlet
- Radiator shroud, radiator
  Refer to “RADIATOR” in LC section.
- Cooling fan
- Drive belt
- Vacuum pump
  Refer to “VACUUM PUMP”, EM-106.
- Alternator

3. Relocate the following parts.
- Power steering oil pump
- Air conditioner compressor

4. Remove the following parts.
- Air conditioner compressor bracket
- Auxiliary drive belt auto-tensioner, idler pulley



5. Remove the chain cover, timing chain and other parts in connection.
   Before removing timing chain, remove injection pump sprocket with No. 1 cylinder being positioned at TDC. Refer to the figure. Refer to “TIMING CHAIN”, EM-107.

CAUTION:

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

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

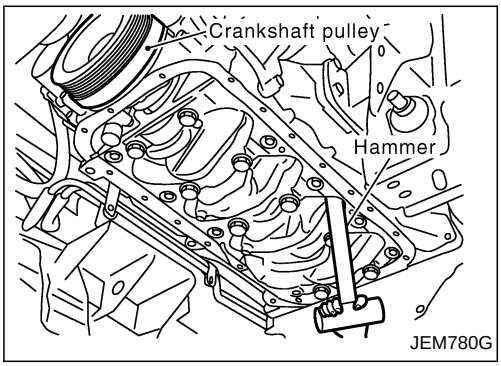
6. Remove the TDC sensor.

CAUTION:

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

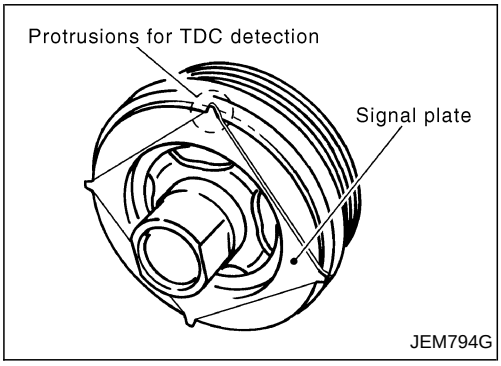
7. Remove the water pump.
   Refer to “WATER PUMP” in LC section.
8. Remove the water inlet.

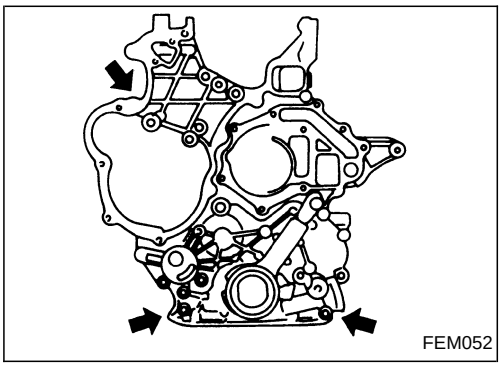
Removal (Cont'd)



9. Remove the crankshaft pulley.
- To fix the crankshaft, set by clamping a hammer handle, etc. in the counterweight portion of the crankshaft.

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

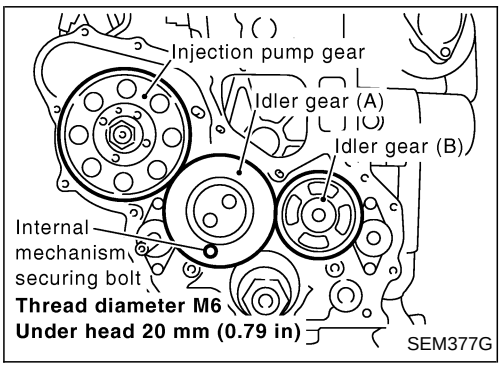




10. Remove the gear case.
- Using the grooved places shown in the figure, remove the gear case by using a screwdriver and a seal cutter (SST).

11. Remove the front oil seal from the gear case by using a screwdriver.

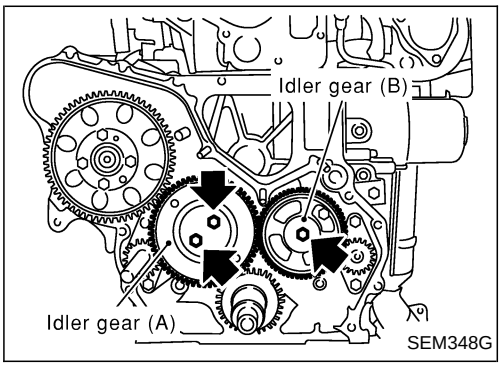
CAUTION:
Do not damage the gear case.



12. Fix the internal mechanism setting bolt [part No.: 81-20620-28, screw dia.: M6, dimension below neck: 20 mm (0.79 in), Pitch: 1.0 mm (0.039 in)] to the bolt hole of the idler gear (A) and tighten to the specification.
: 2.5 - 3.4 N·m (0.25 - 0.35 kg-m, 22 - 30 in-lb)

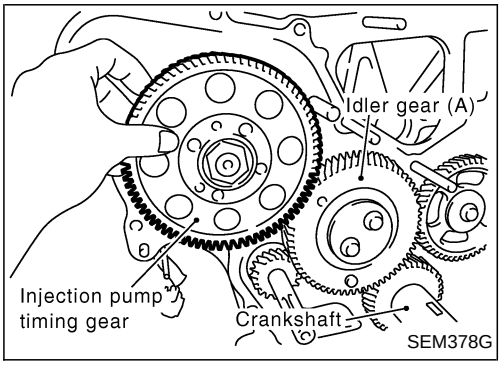
CAUTION:
- **Only use the genuine setting bolt, or the idler gear (A) will be damaged.**
- **Do not rotate the crankshaft as the head of the setting bolts interferes with the gear case.**
- **Do not remove the setting bolt from the idler gear (A) until the timing chain and all of the parts in connection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

Removal (Cont'd)

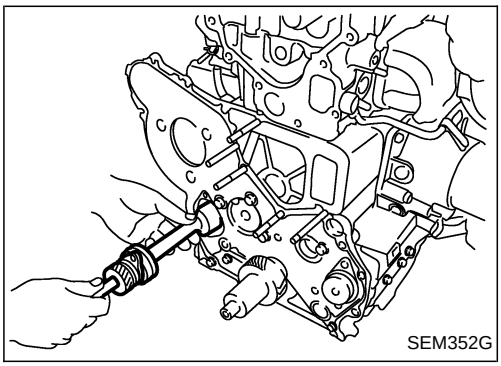


13. Remove the idler gears (A) and (B).
- Check the backlash of each gear before removing. Refer to EM-122, "BACKLASH OF EACH GEAR", "Inspection".

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



14. Set the fuel injection timing gear with the pulley holder (SST).
15. Remove injection pump timing gear.

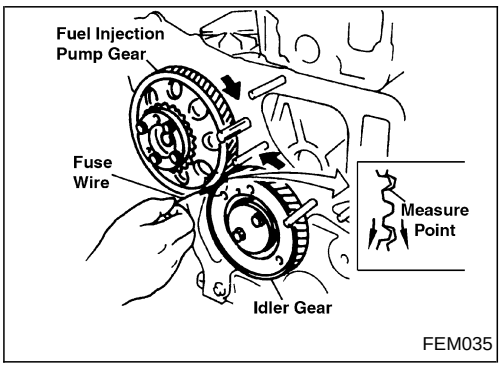


16. Extract the balancer shaft taking care not to damage the inner bushes of the cylinder block.
17. Remove the fuel injection pump.
18. Remove the front plate.

Inspection

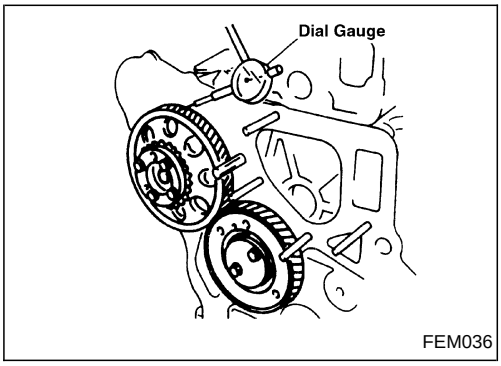
BACKLASH OF EACH GEAR

Method using a fuse wire



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

Method using dial gauge



- Tighten the mounting bolts of each gear to specification.
- Place the dial gauge on the tooth surface area of the gear to be checked.
- With the other gear in a set position, measure the dial gauge value while moving the gear left and right.
  Standard: 0.07 - 0.11 mm (0.0028 - 0.0043 in)
  Limit: 0.20 mm (0.0079 in)
- If it exceeds the limit, replace the gear and measure again.
- If it exceeds the limit again, check for the installation condition of the gear driving parts, wear of shaft and gear, and oil clearance.

Inspection (Cont'd)

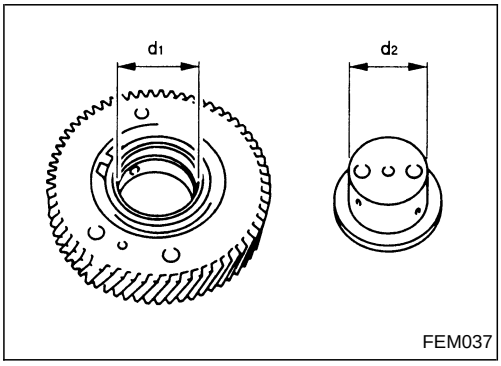
IDLER GEAR END PLAY

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

Unit: mm (in)

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

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



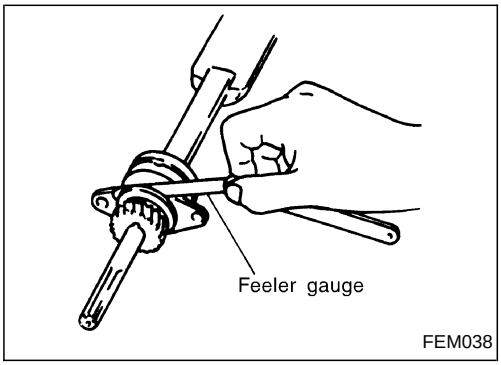
IDLER GEAR OIL CLEARANCE

- Measure the inner diameter (d1) of the idler gear shaft.
  Standard:
  Idler gear (A)
  43.000 - 43.020 mm (1.6929 - 1.6937 in)
  Idler gear (B)
  28.600 - 28.620 mm (1.1260 - 1.1268 in)
- Measure the outer diameter (d2) of the idler shaft.
  Standard:
  Idler gear (A)
  42.959 - 42.975 mm (1.6913 - 1.6919 in)
  Idler gear (B)
  28.567 - 28.580 mm (1.1247 - 1.1252 in)
- Calculate the oil clearance.
  Clearance = d1 − d2

Unit: mm (in)

	Standard	Limit
Idler gear (A)	0.025 - 0.061 (0.0010 - 0.0024)	0.2 (0.0079)
Idler gear (B)	0.020 - 0.053 (0.0008 - 0.0021)	

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

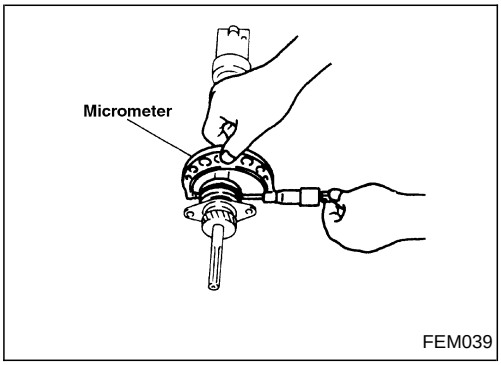


BALANCER SHAFT END PLAY

- Measure the clearance between the plate and gear using a feeler gauge.
  Standard: 0.07 - 0.22 mm (0.0028 - 0.0087 in)
- If it exceeds the specification, replace the balancer shaft assembly.
- As the gears are press-fitted, there are no setting for individual parts.

Inspection (Cont'd)

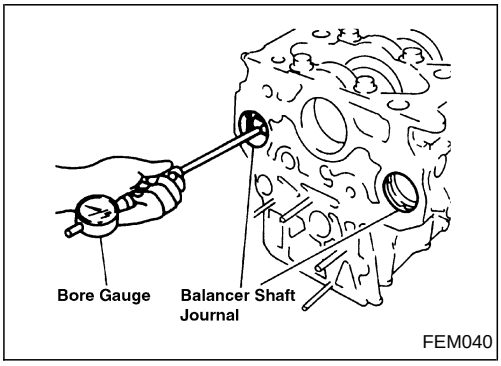
BALANCER SHAFT OIL CLEARANCE



Outer diameter of balancer shaft journal

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

Standard:
Front side
50.875 - 50.895 mm (2.0029 - 2.0037 in)
Rear side
50.675 - 50.695 mm (1.9951 - 1.9959 in)



Inner diameter of balancer shaft bearing

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

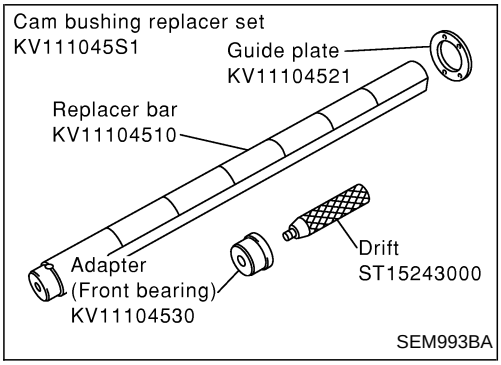
Standard:
Front side
50.940 - 51.010 mm (2.0055 - 2.0083 in)
Rear side
50.740 - 50.810 mm (1.9976 - 2.0004 in)

Oil clearance calculations

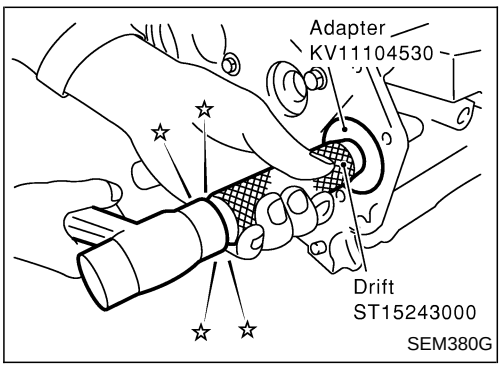
Oil clearance = Bearing inner diameter − Journal outer diameter

Standard: 0.045 - 0.135 mm (0.0018 - 0.0053 in)
Limit: 0.180 mm (0.0071 in)

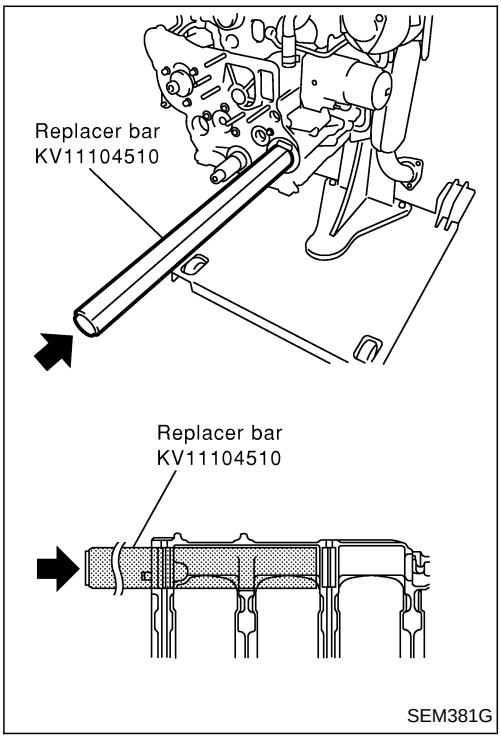
BALANCER SHAFT BEARING REMOVAL AND INSTALLATION



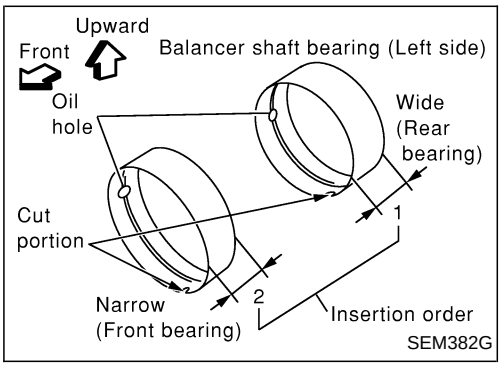
1. Remove balancer shaft front bearing.



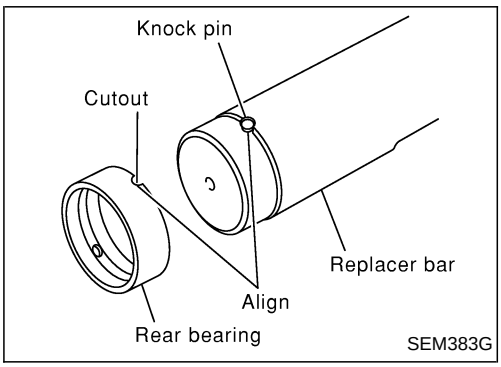
Inspection (Cont'd)



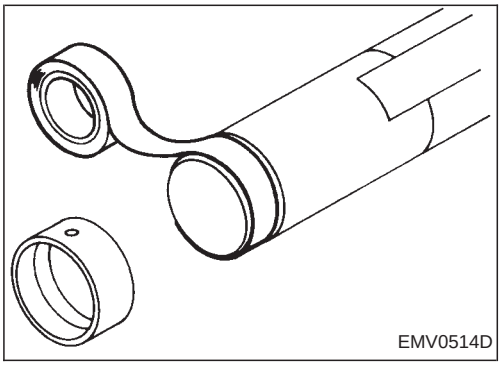
2. Using Tool, remove balancer shaft rear bearing from engine.



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

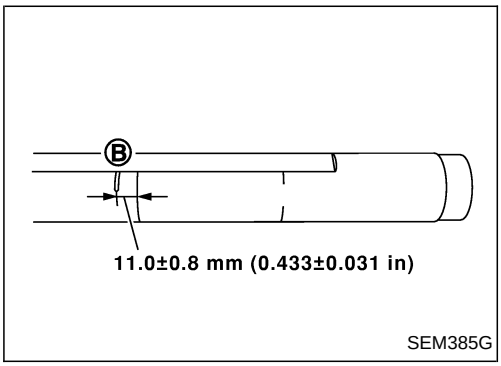


- Align the balancer shaft bearing groove with the knock pin of the bar (SST) and install the balancer shaft bearing.)

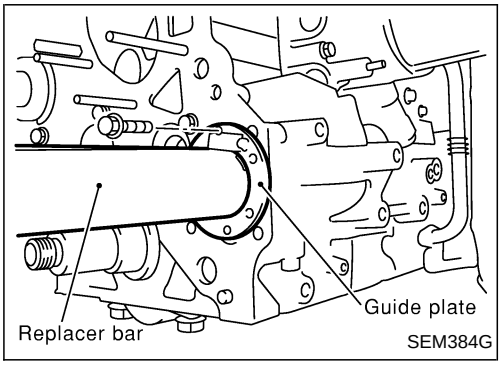


- On rear journals, so the bearing does not get out of position, wrap tape around the bar.

Inspection (Cont'd)



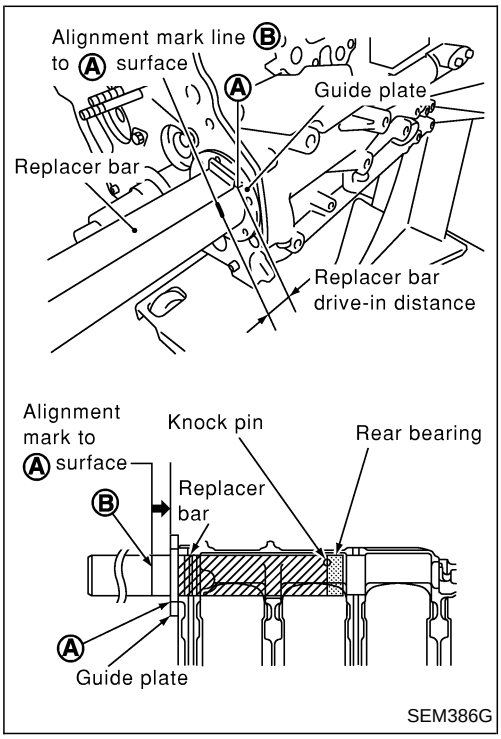
- Make an alignment mark 11.0±0.8 mm (0.433±0.031 in) from the bar No. 2 engraved line with a marker pen. This alignment mark Ⓑ will be the point to where the rear bearing is pushed.



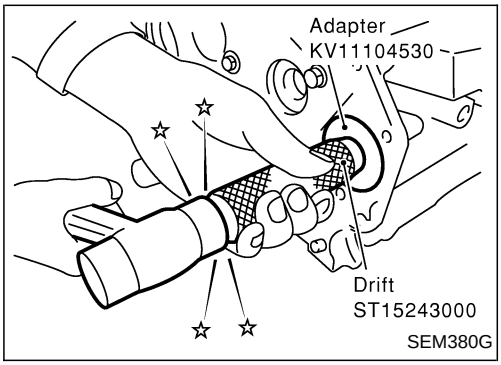
- Insert the bar with the bearing installed into the cylinder block and install the guide plate (SST).
- Align the guide plate with the ZD engraving and install the bolts.

CAUTION:

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



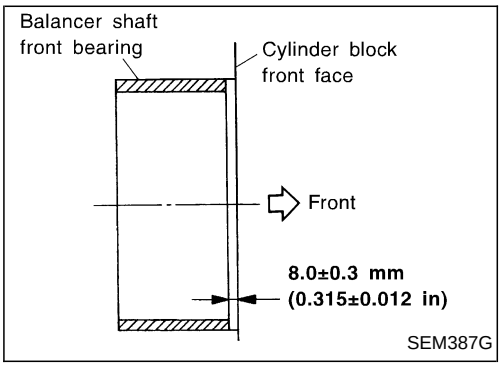
- Push the engraved bar alignment mark Ⓑ to the same position of the guide plate tip Ⓐ.
- After all the journals have been installed, make sure that all the journal and cylinder block oil holes are aligned.

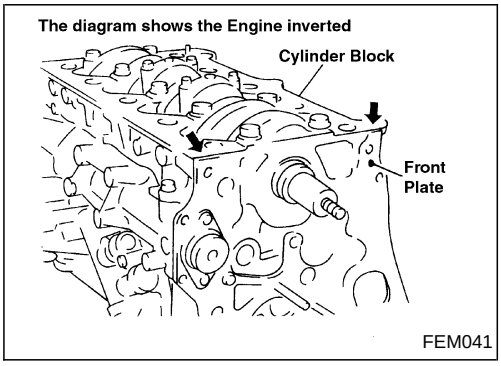


4. Install the front balancer shaft bearing.

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

Inspection (Cont'd)





Installation

1. Install the front plate.

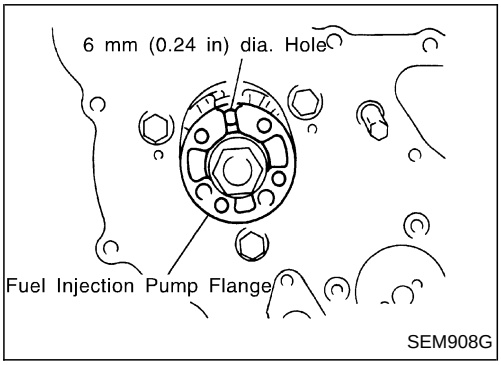
1) Install the O-ring and gasket to the cylinder block.
2) Install the front plate.

- Lightly tap with a hammer if the dowel pin cannot be inserted easily.

CAUTION:

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

3) Apply Genuine Liquid Gasket or equivalent with a spreader between the cylinder block plate under the cylinder block (oil pan side) and the front plate (shown by the arrows in the figure).



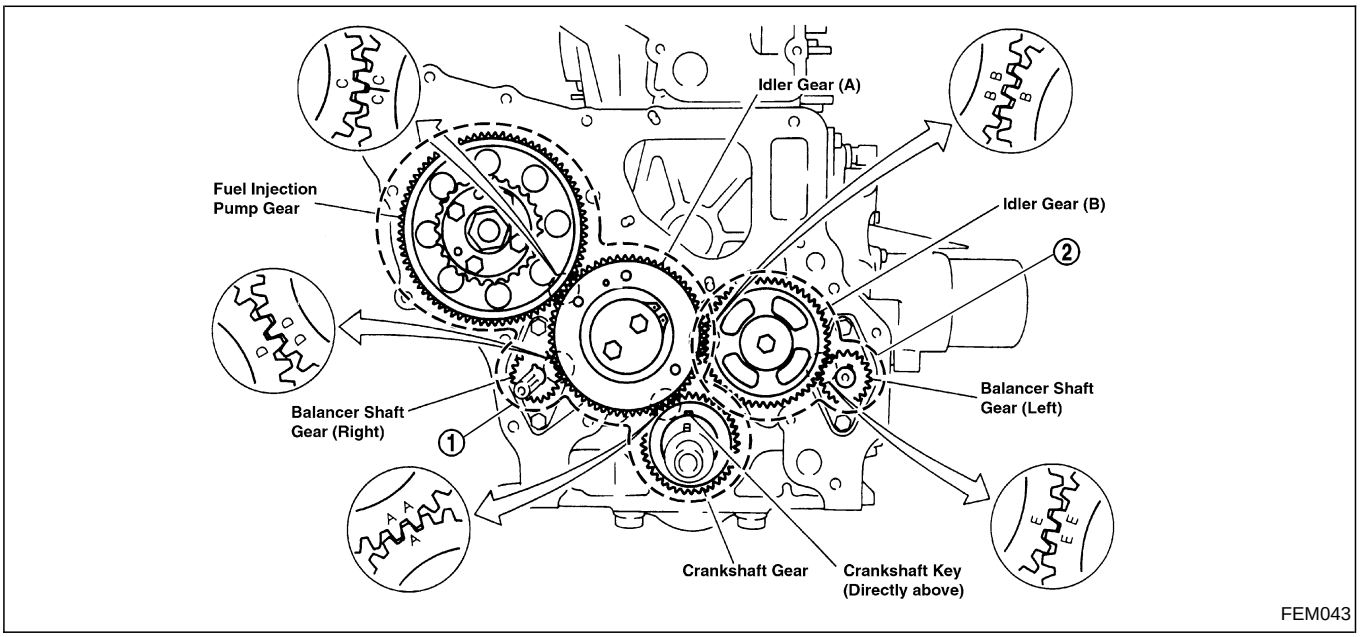
2. Install the fuel injection pump.

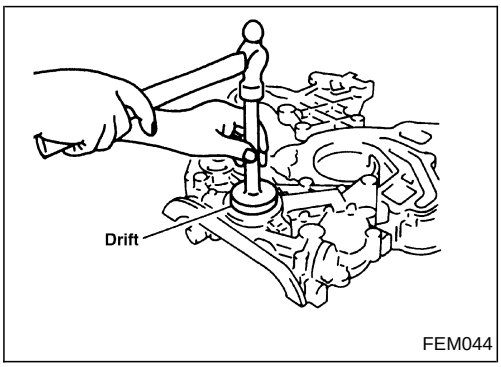
- After installing the front plate, align the 6 mm (0.24 in) dia. hole of the pump flange and the 6 mm (0.24 in) dia. hole position of the pump body.

3. Install each timing gear.

- Align the match marks of the timing gears by referring to the figure below.
- When installing timing gear, follow the order (① , ②) shown in the dotted box in the figure below to facilitate installation.

Installation (Cont'd)

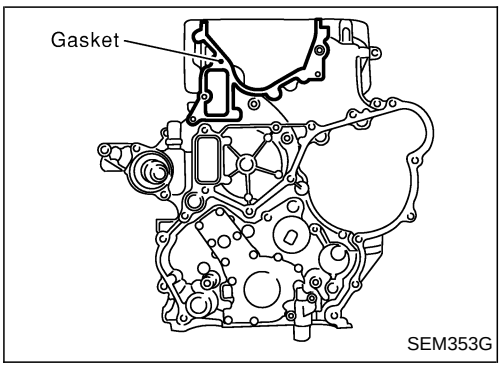




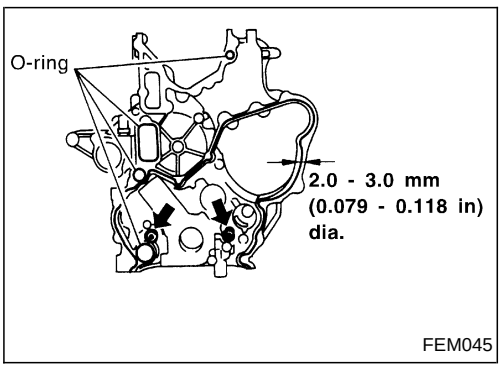
4. Install the front oil seal to the gear case.
- Apply engine oil to the fitting side.
- Evenly insert the front oil seal using a drift [outer dia.: approx. 64 mm (2.52 in)] completely.

CAUTION:

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



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



3) Install the O-rings to the gear case.
- The O-ring at the top position shown in the figure can be installed in during cylinder head installation.

4) Apply a continuous bead of liquid gasket to gear case.
- **Use Genuine Liquid Gasket or equivalent.**

a. Coat of liquid gasket should be maintained within 2.0 to 3.0 mm (0.079 to 0.118 in) dia. range.

b. Attach gear case to cylinder block within 5 minutes after coating.

c. Wait at least 30 minutes before refilling engine oil or starting engine.

Installation (Cont'd)

CAUTION:

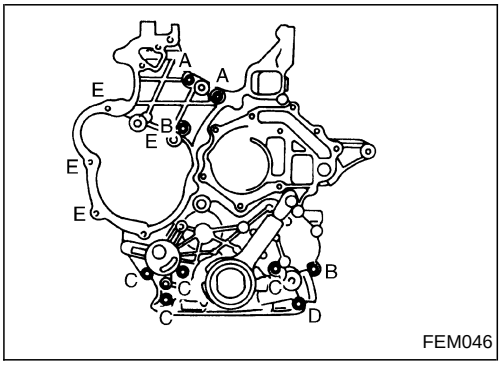
Apply the liquid gasket around the bolt holes shown by the arrows in the figure.

4) Install the gear case.

- Tap the area around the dowel pin with a plastic hammer if it cannot be inserted easily.

CAUTION:

Do not pop out the O-rings.



FEM046

5) Install the holding bolt referring to the figure.

Dimension below neck:

A: 25 mm (0.98 in)
B: 30 mm (1.18 in)
C: 50 mm (1.97 in)
D: 80 mm (3.15 in)
E: 20 mm (0.79 in)

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

6. Install the crankshaft pulley.

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

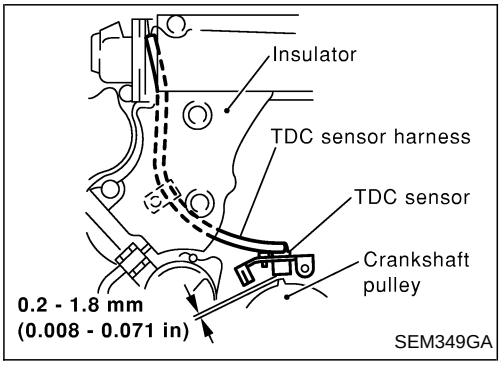
CAUTION:

Do not damage the oil seal lip when inserting.

- Refer to EM-120, "Removal" for the crankshaft setting procedures when tightening the holding nut.

7. Install the water pump.

- Install it before installing the TDC sensor. Refer to "WATER PUMP" in LC section.



SEM349GA

8. Install the TDC sensor.

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

Standard: 0.2 - 1.8 mm (0.008 - 0.071 in)

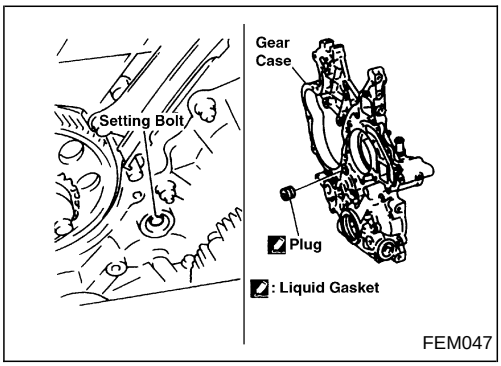
- Arrange the TDC sensor harness to the position shown in the figure.

CAUTION:

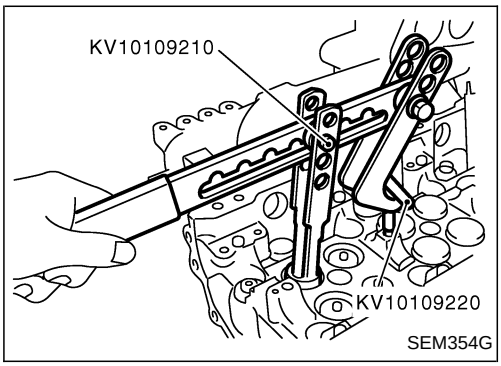
Confirm that the harness has no deflection around the crankshaft pulley when installing the clamp.

9. Install the timing chain, other parts in connection with the timing chain, and the chain cover. Refer to EM-107, "TIMING CHAIN".

Installation (Cont'd)

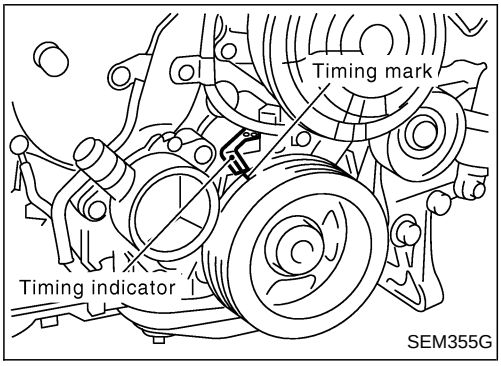


10. Remove the internal mechanism setting bolt of the idler gear (A).
11. Apply liquid gasket to the plug thread.
12. Install in the reverse order of removal.



VALVE OIL SEAL

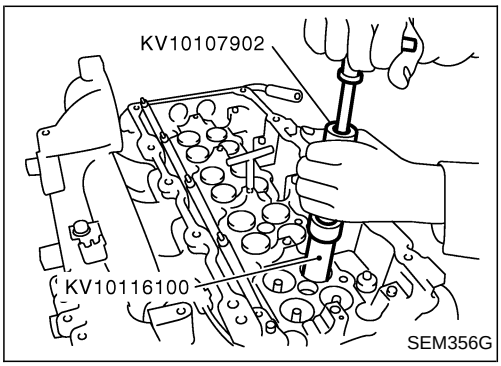
1. Remove timing chain. Refer to EM-107, “TIMING CHAIN”.
2. Remove injection nozzle assembly. Refer to “Injection Tube and Injection Nozzle” in “BASIC SERVICE PROCEDURE” in EC section.
3. Remove camshaft. Refer to EM-111, “CAMSHAFT”.



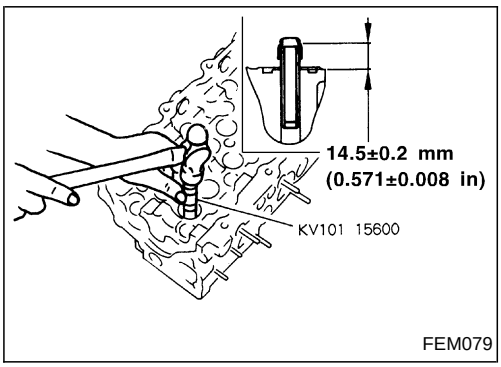
4. Remove valve lifters and mark order No. on each lifter.
5. Replace valve oil seal according to the following procedure.

When replacing valve oil seal, set the corresponding piston at TDC. Failure to do so causes the valve to drop into the cylinder.

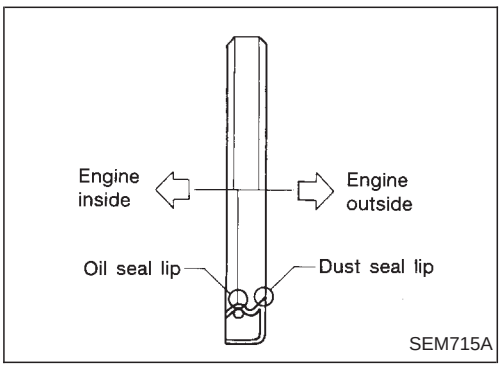
1) Set No. 1 cylinder at TDC.



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

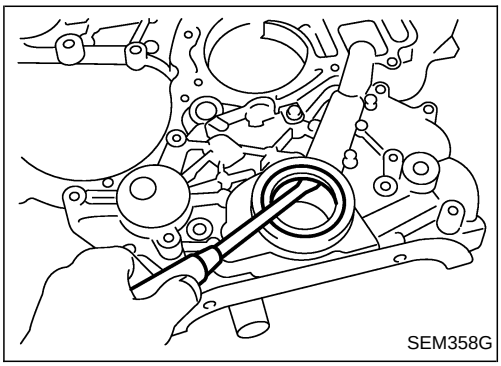


3) Install new valve oil seals for No. 1 and No. 4 cylinders as illustrated. Reinstall valve springs. (pink paint side toward cylinder head)
4) Install valve spring retainers on intake valves and valve rotators on exhaust valves, and remount valve assembly.
5) Set No. 2 cylinder at TDC.
6) Replace valve oil seals for No. 2 and No. 3 cylinders according to steps 2) and 3).
7) Install valve lifters in original positions.



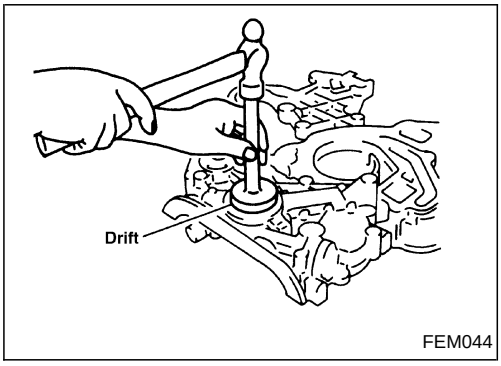
CRANKSHAFT OIL SEAL INSTALLING DIRECTION AND MANNER

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


SEM358G

CRANKSHAFT FRONT OIL SEAL

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

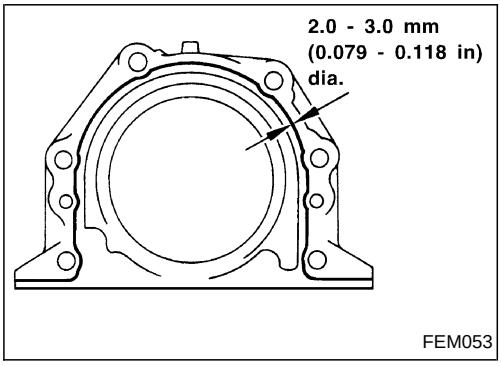


FEM044

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

CRANKSHAFT REAR OIL SEAL

1. Remove oil pan assembly. Refer to EM-104, “OIL PAN AND OIL STRAINER”.
2. Remove clutch cover assembly.
3. Remove flywheel and rear plate.
4. Remove oil seal retainer assembly.

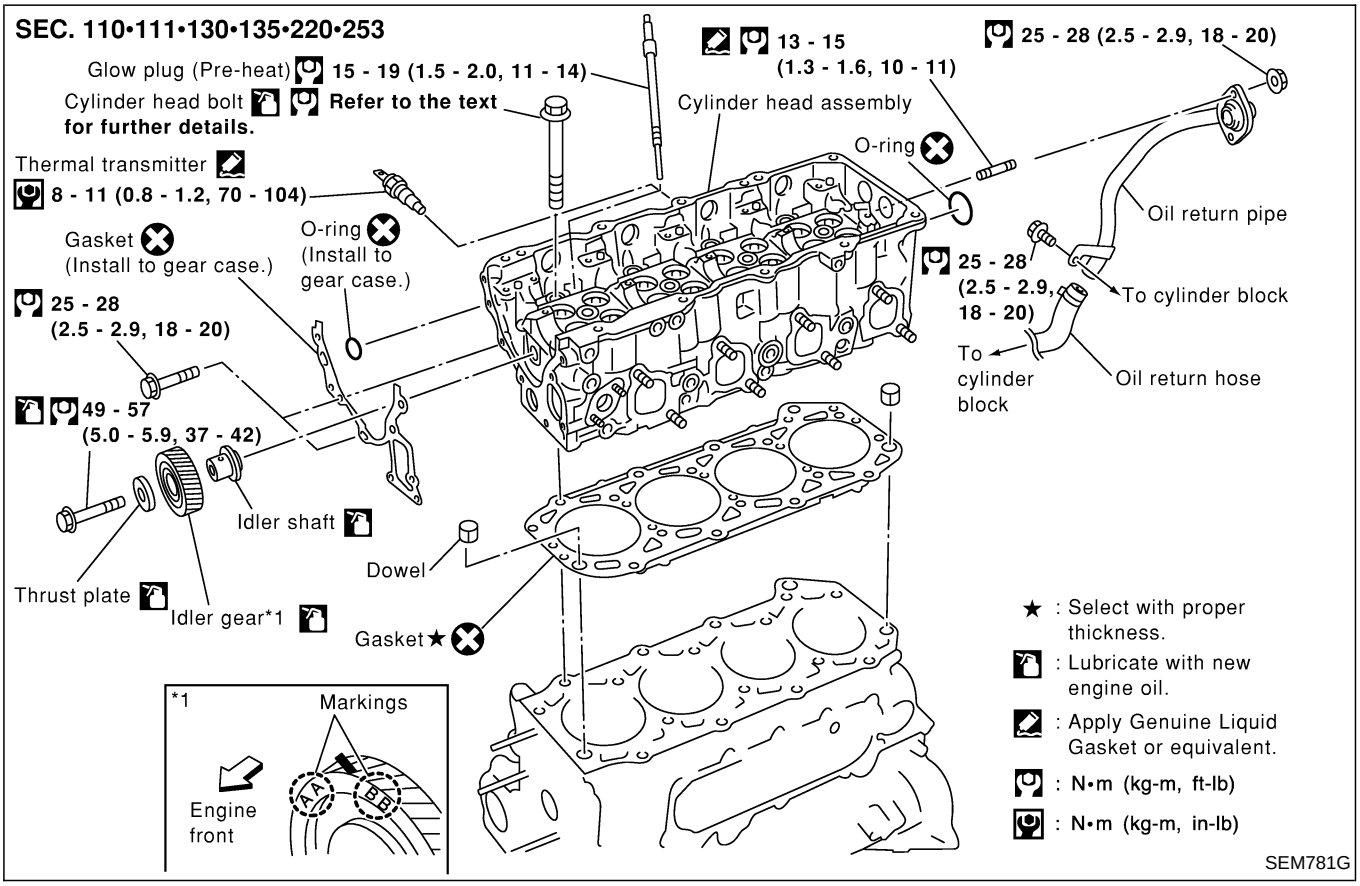


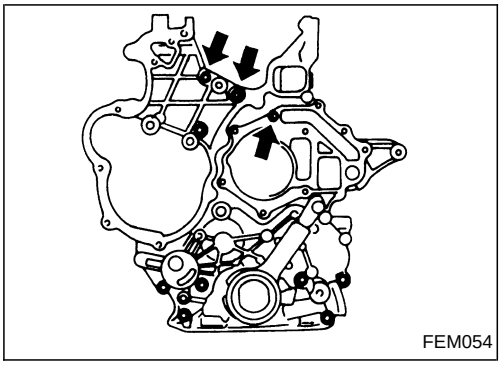
FEM053

5. Apply a continuous bead of liquid gasket to rear oil seal retainer.

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

Removal and Installation



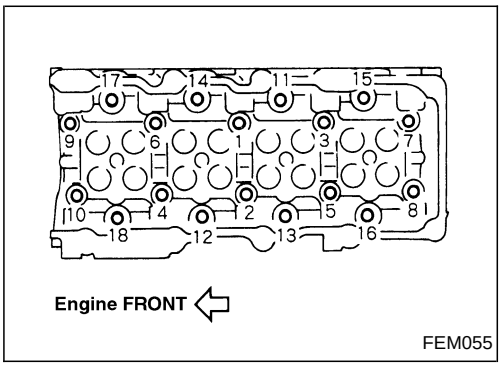


Removal

1. Remove the following. (Refer to corresponding chapter for detailed auxiliary work.)
- Drain coolant
- Rocker cover
- Injection tube
- Spill tube
- High pressure injection nozzle assembly
- Timing chain
- Camshaft
- Catalyst
- Turbocharger assembly
- Exhaust manifold
- Intake manifold

2. Remove oil return pipe from the rear side of cylinder head.
3. Remove mounting bolts of the gear case and water pump as shown by arrows in the figure.

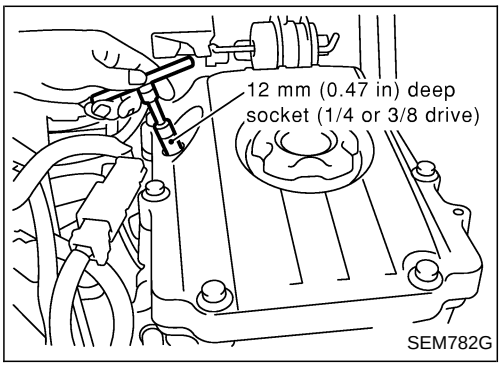
Removal (Cont'd)



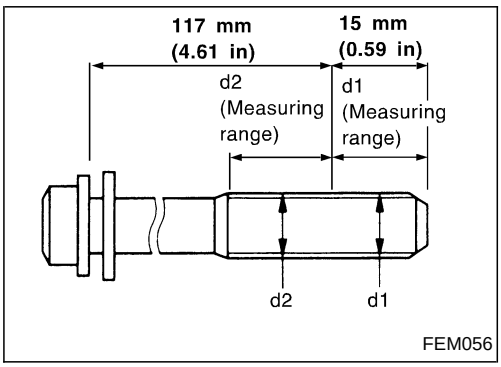
FEM055

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

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



SEM782G



FEM056

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

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

6. Remove idler gear.

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

Inspection

CYLINDER HEAD BOLT DEFORMATION (ELONGATION)

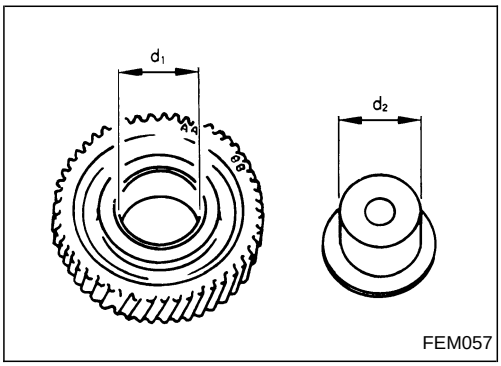
- Using micrometer, measure the outer diameters d1 and d2 of bolt thread as shown in the figure.
- If the necking point can be identified, set it as measuring point d2.
- Calculate the difference between d1 and d2.
  Limit: 0.15 mm (0.0059 in)

IDLER GEAR END PLAY

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

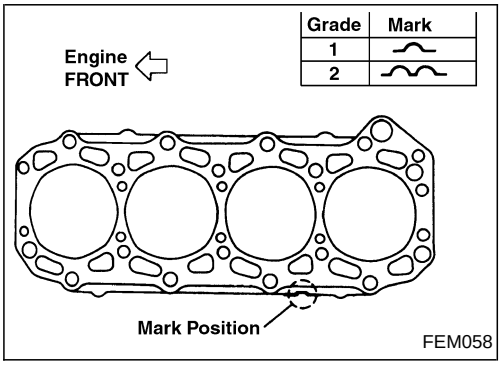
Inspection (Cont'd)

IDLER GEAR OIL CLEARANCE



FEM057

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



FEM058

Installation

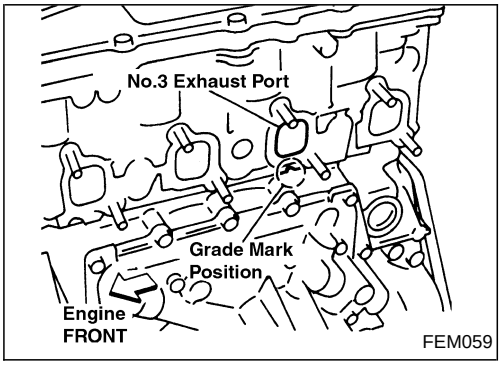
1. Install cylinder head gasket.
- Cylinder head gasket to be installed is selected by its thickness through the following procedure.

When replacing gasket only

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

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

*: Thickness of gasket tightened with head bolts



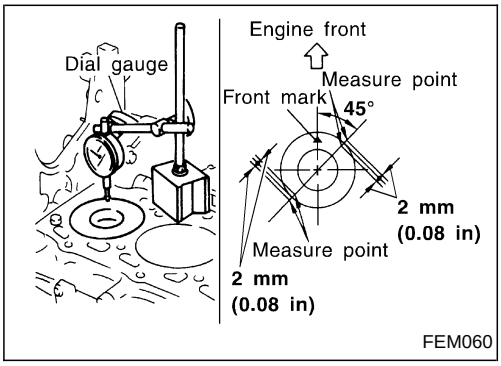
FEM059

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

When repairing/replacing the following

- When the top of cylinder block or crankshaft pin/journal is ground, or
- When cylinder block, piston, connecting rod, or crankshaft is replaced

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



FEM060

Installation (Cont'd)

Unit: mm (in)

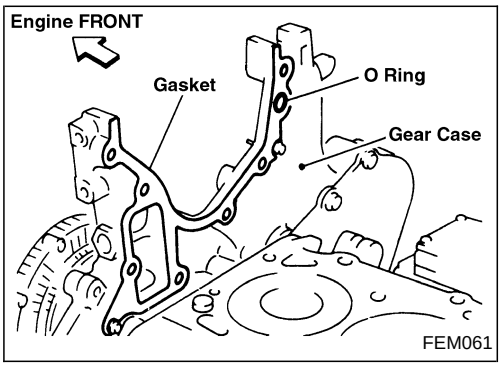
Grade	Piston crown depression	Gasket thickness*	No. of notches
1	More than 0.078 (0.0031)	0.65 (0.0256)	1
2	Less than 0.078 (0.0031)	0.70 (0.0276)	2

*: Thickness of gasket tightened with head bolts

2. Install idler gear and idler shaft.
- Check that the counter marks with cam gear, "AA" and "BB", are located on the front side of the engine.
  Refer to EM-133.

CAUTION:

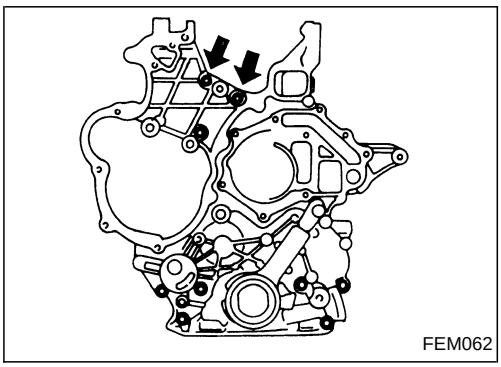
Since idler gear cannot be installed or removed with cylinder head assembly mounted on the engine because of interference with gear case, make sure that there are no reverse installations or uninstalled parts.



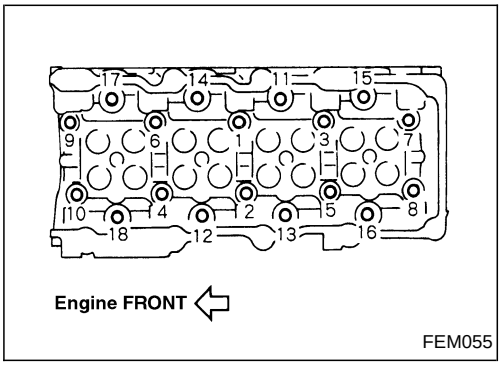
3. Install cylinder head assembly.
1) Attach gasket onto the rear of gear case.
2) Install O-ring to the rear of gear case.
3) Align cylinder head assembly with dowel pin of cylinder block and install.

CAUTION:

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



4. Position cylinder head assembly close to the rear of the gear case.
1) Install cylinder head bolts to the front and rear of cylinder head respectively, and tighten to the specified torque.
   : 40 - 49 N·m (4.0 - 5.0 kg-m, 29 - 36 ft-lb)
2) Loosen cylinder head bolts completely.
3) Install gear case mounting bolts to 2 positions shown by arrows in the figure, and tighten to the specified torque.
   : Less than 9.8 N·m (1.0 kg-m, 7 in-lb)



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

CAUTION:

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

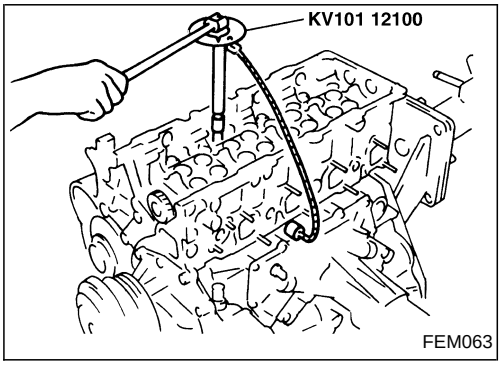
4) Tighten bolts to 40 to 44 N·m (4.0 to 4.5 kg-m, 29 to 32 ft-lb).
5) Tighten bolts at the angle of 90 to 95° (target is 95°). (Angle tightening)

Installation (Cont'd)

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

CAUTION:

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



ANGLE TIGHTENING PROCEDURE

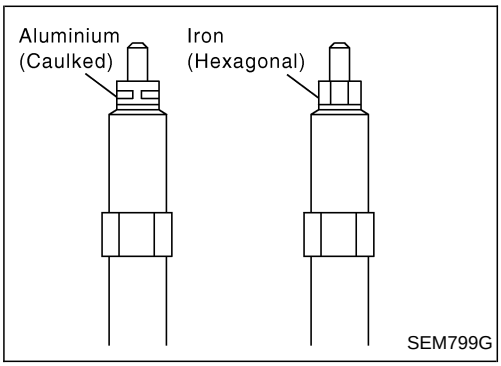
With protractor

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

With angle wrench (SST)

- Check the turning angle using angle indicator of angle wrench.

6. Loosen gear case mounting bolts which were tightened in 3) of procedure 4, retighten them to the specified torque.

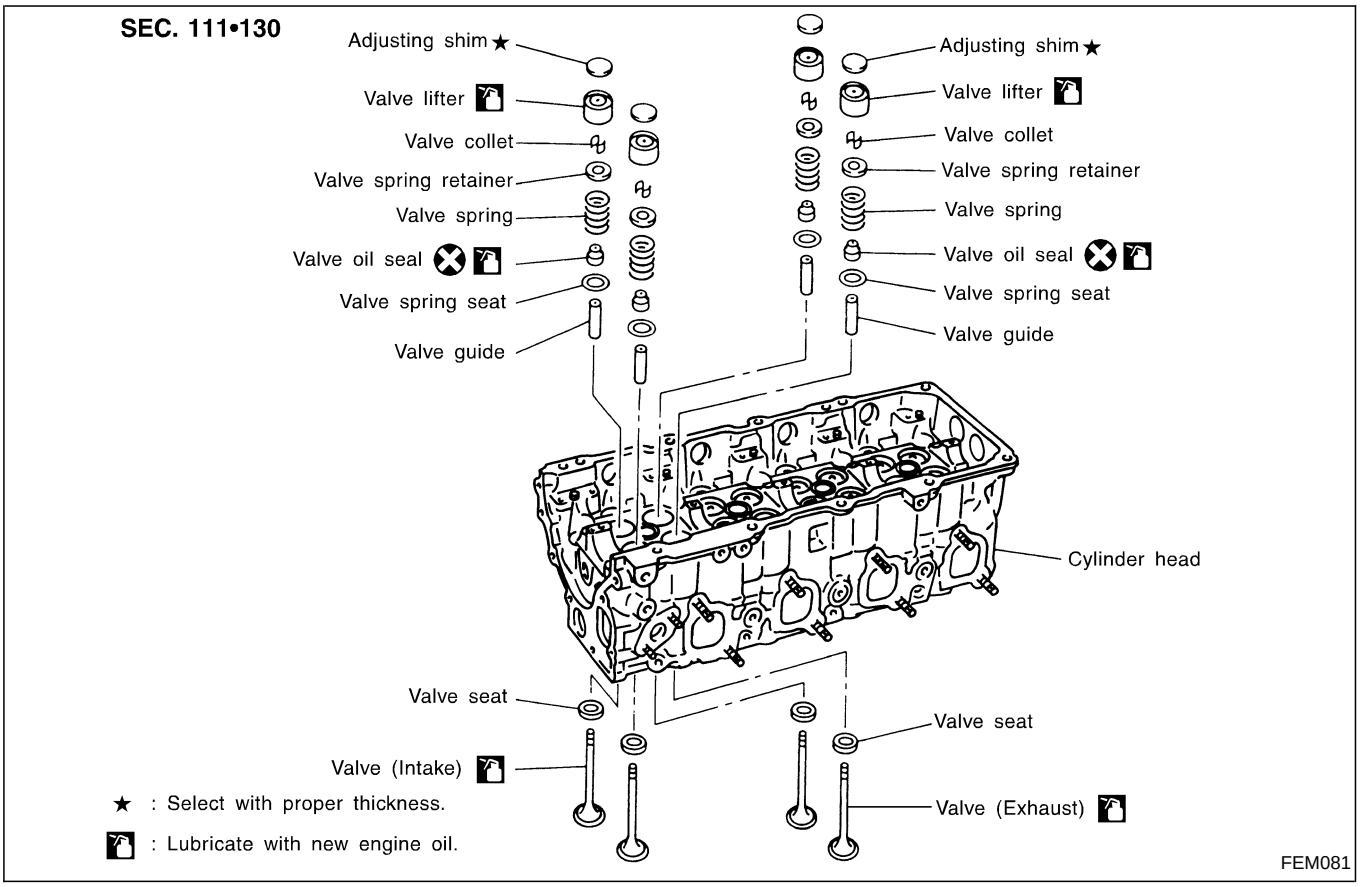


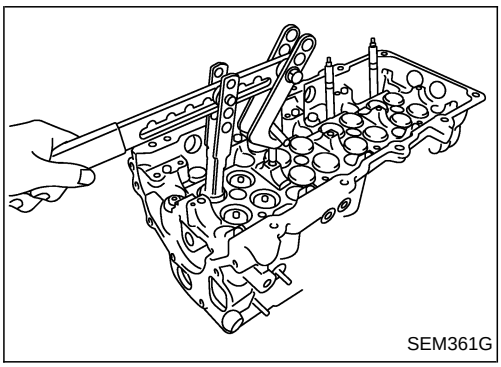
7. Install glow plug.

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

Installation (Cont'd)

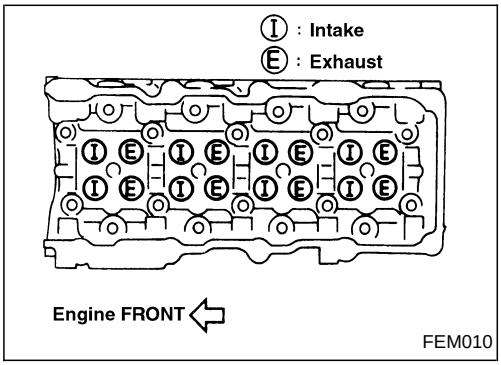
8. Install oil return pipe to the rear side of the cylinder head.
- When reinstalling a stud bolt, apply Genuine Liquid gasket or equivalent to the thread of the bolt.





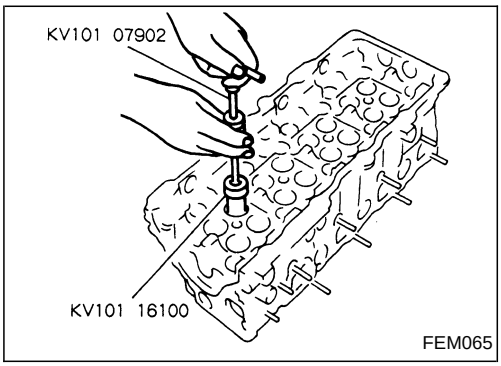
Disassembly

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



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

Disassembly (Cont'd)



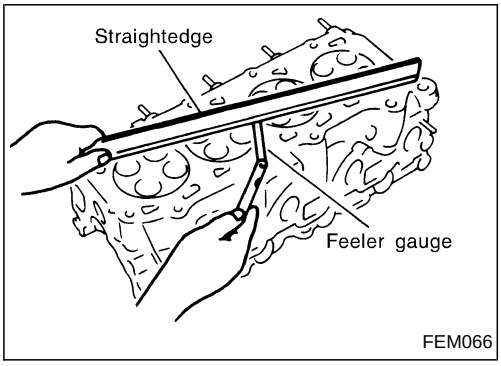
5. Remove valve oil seals using valve oil seal puller (SST).
6. Remove valve spring seats.
7. Before removing valve spring seats, perform valve seat contact check. (Refer to EM-141.)
8. Before removing valve guides, perform valve guide clearance check. (Refer to below.)

Inspection

CYLINDER HEAD DISTORTION

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

Limit: 0.2 mm (0.008 in)



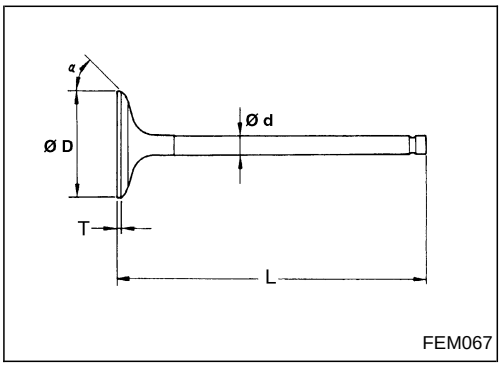
VALVE DIMENSION

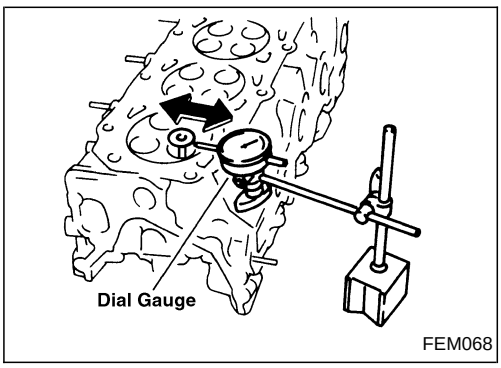
Using micrometer, measure the dimensions of each part.

Standard

Unit: mm (in)

	Intake valve	Exhaust valve
L	113.5 (4.4685)	113.5 (4.4685)
T	1.5 (0.0591)	1.5 (0.0591)
ϕd	6.962 - 6.977 (0.2741 - 0.2747)	6.945 - 6.960 (0.2734 - 0.2740)
ϕD	31.9 - 32.1 (1.2559 - 1.2638)	29.9 - 30.1 (1.1772 - 1.1850)
α (degree)	45°00′ - 45°30′	45°00′ - 45°30′





VALVE GUIDE CLEARANCE

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

Inspection (Cont'd)

Unit: mm (in)

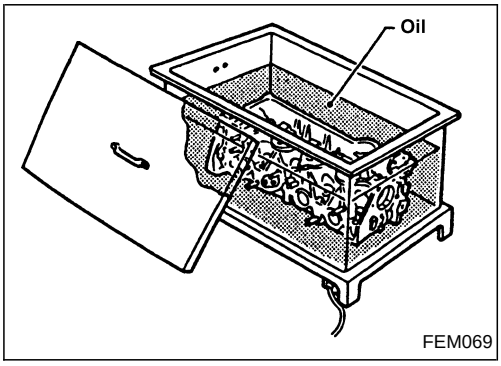
	Standard	Limit
Intake	0.023 - 0.053 (0.0009 - 0.0021)	0.18 (0.0071)
Exhaust	0.040 - 0.070 (0.0016 - 0.0028)	0.10 (0.0039)

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

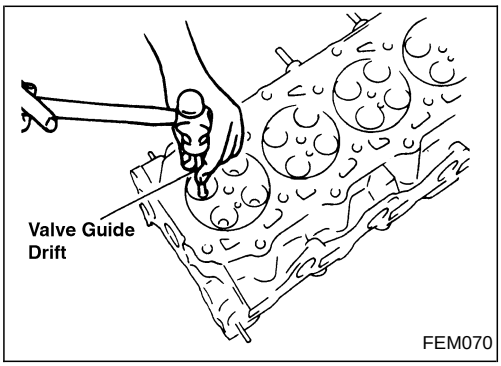
VALVE GUIDE REPLACEMENT

- There is no setup for oversized valve guide.

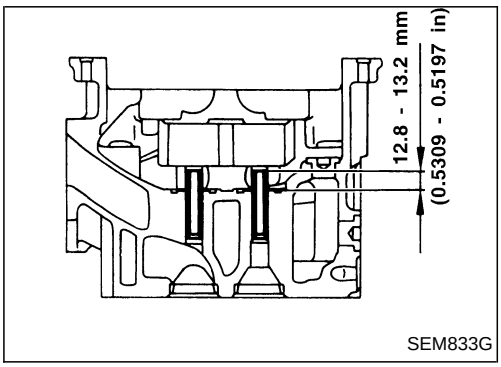
1. Heat cylinder head to 110 to 130°C (230 to 266°F) in oil bath.



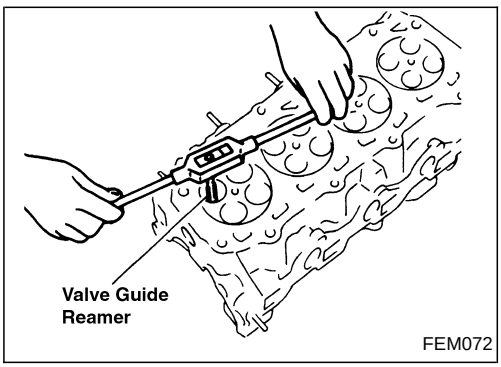
2. Using valve guide drift [multi-purpose tool: for 7.0 mm (0.276 in) dia.], tap valve guides out from the combustion chamber side.



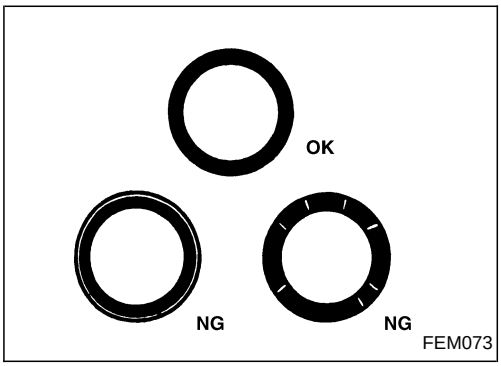
3. Heat cylinder head to 110 to 130°C (230 to 266°F) in oil bath.
4. Using valve guide drift [multi-purpose tool: for 7.0 mm (0.276 in) dia.], press fit valve guides from camshaft side, referring to the dimension shown in the figure.



5. Using valve guide reamer (multi-purpose tool), perform reaming to the press-fitted valve guides.
   Reaming specifications:
   Intake/Exhaust
   7.000 - 7.015 mm (0.2756 - 0.2762 in)



Inspection (Cont'd)



VALVE SEAT CONTACT

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

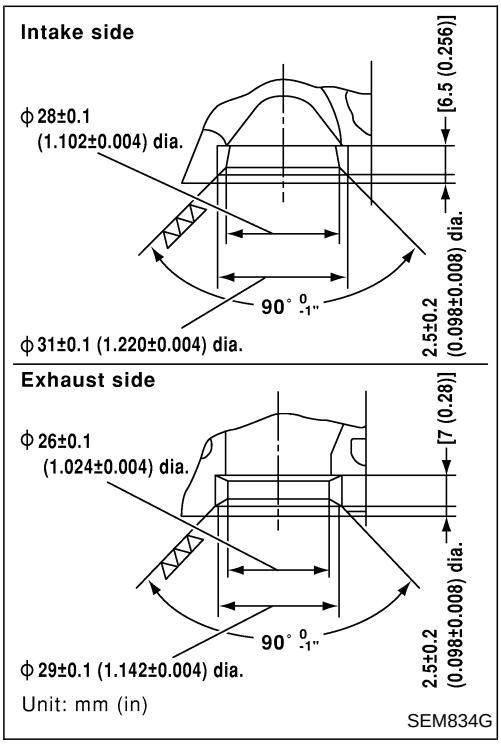
- **When repairing valve seats, check valve and valve guide for wear beforehand. If worn, replace them. Then correct valve seat.**
- **The cutting should be done with both hands for uniform cutting.**

VALVE SEAT REPLACEMENT

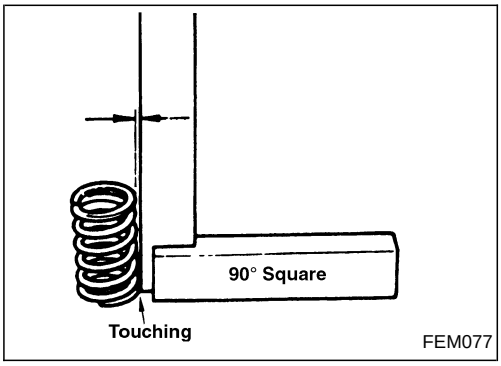
1. Cut valve seat to make it thin, and pull it out.
2. Heat cylinder head to approximately 110 to 130°C (230 to 266°F) in oil bath.
3. After cooling valve seats sufficiently with dry ice, press fit it to cylinder head.

CAUTION:
Do not touch the cooled valve seats directly by hand.

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



NOTE:
Valve seat service part has been cut to measurements in the figure.

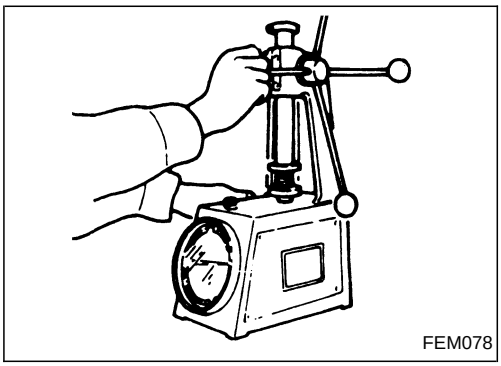


VALVE SPRING RIGHT ANGLE

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

Limit: 2.4 mm (0.0945 in)

Inspection (Cont'd)


FEM078

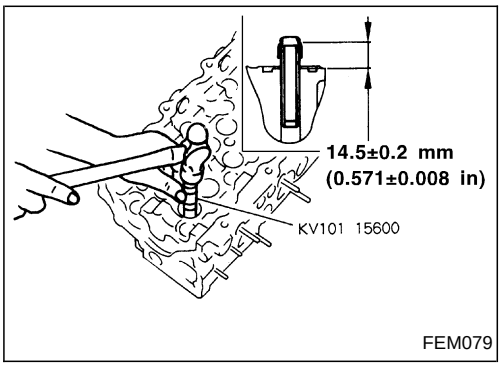
VALVE SPRING FREE LENGTH AND COMPRESSIVE LOAD

Using valve spring tester, check the following.

Free length: 55.43 mm (2.1823 in)
Installation height: 40.8 mm (1.6063 in)
Installation load: 180 - 206 N (18.4 - 21.0 kg, 40.6 - 46.3 lb)
Height at valve open: 32.3 mm (1.2717 in)
Load at valve open: 336 - 372 N (34.3 - 37.9 kg, 75.6 - 83.6 lb)

Assembly

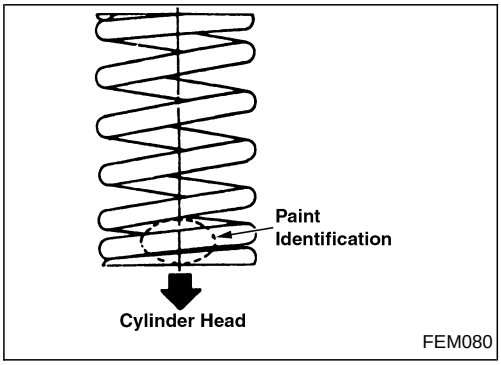
1. Install valve guides, referring to EM-141, "VALVE SEAT REPLACEMENT".
2. Install valve seats, referring to EM-141, "VALVE SEAT CONTACT".



FEM079

3. Using valve oil seal drift (SST), install valve oil seals referring to the dimension shown in the figure.
- The figure shows the dimension before valve spring seats are installed.

4. Install valve spring seats.
5. Install valves.
- Install the valves with bigger openings to intake valve side.
- Note that valve layout here is different from that of conventional the engine.



FEM080

6. Install valve spring.
- When installing valve spring, make sure that a smaller pitch side (identification paint-applied side) faces the cylinder head.

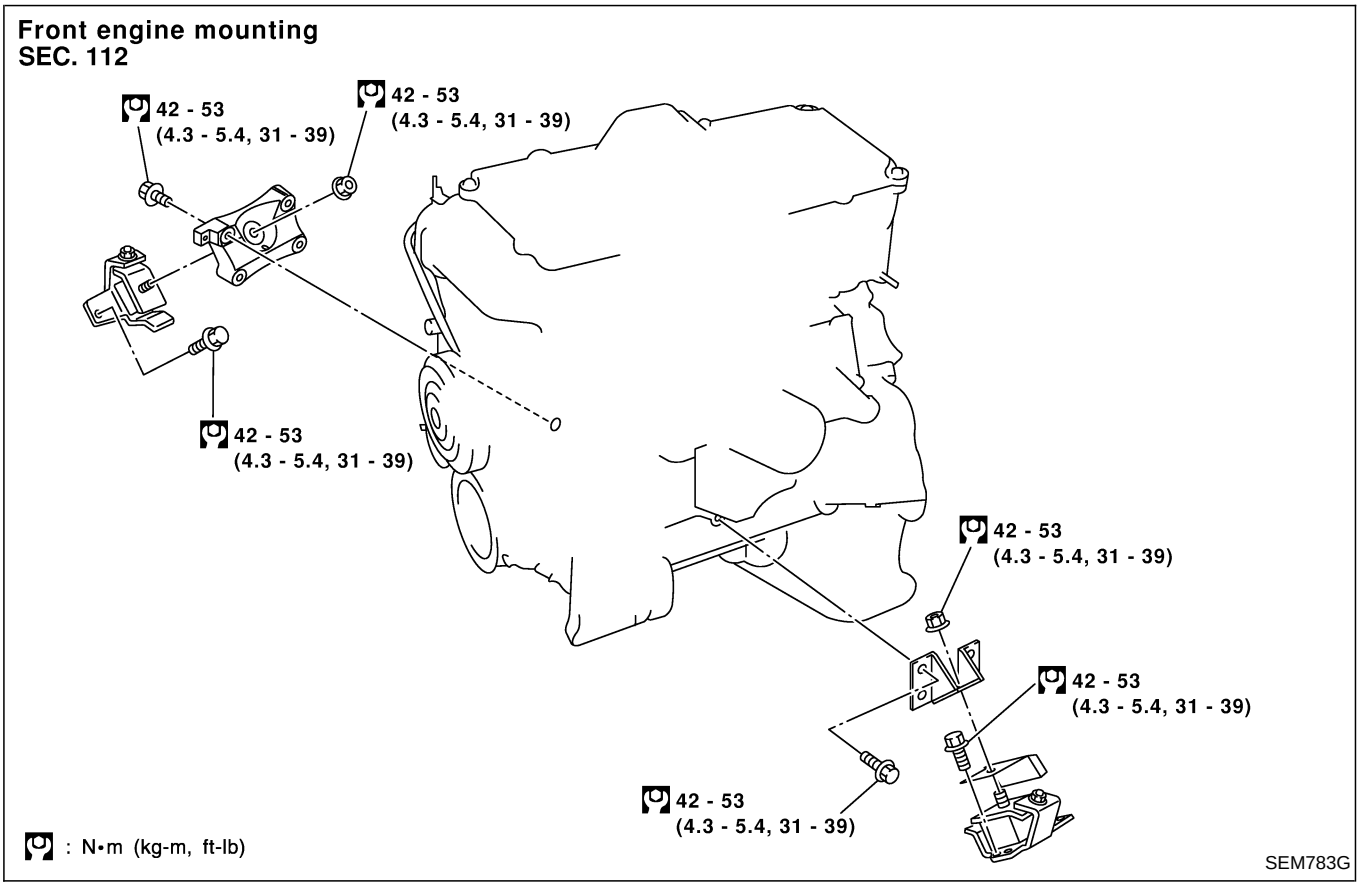
Identification color: pink

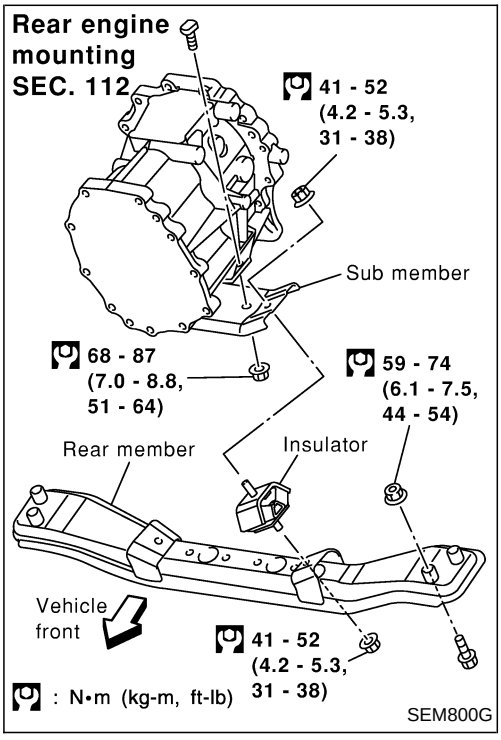
7. Install valve spring retainers.
8. Using valve spring compressor (SST), compress valve springs. Using magnetic hand, install valve collets.
- After installing valve collets, tap the stem end using a plastic hammer, and check the installation status.

9. Install valve lifters and adjusting shims to the same positions as before.

Precautions

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





Removal

Preparation

CAUTION:

For detailed work procedure, refer to corresponding chapter of this manual.

1. Drain coolant from radiator drain plugs.
2. Remove the following parts.

- Engine hood
- Under protector
- Battery
- Radiator shroud
- Radiator
- Drive belt
- Cooling fan
- Exhaust front tube

Engine room (Left)

3. Remove air duct and PCV hose.
4. Disconnect harness connectors from alternator and air conditioner compressor.
5. Remove water inlet and thermostat.
6. Remove installation bolts. Relocate air conditioner compressor. Use a rope to temporarily anchor it to vehicle side.
7. Disconnect and relocate heating hose, install blank cap to hose to prevent coolant from leaking.

Engine room (Right)

8. Remove power steering pump with its hoses installed, then put it on vehicle side holding with a rope.
9. Remove fuel feed and return hoses.

CAUTION:

Install blank caps immediately to avoid fuel leakage.

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

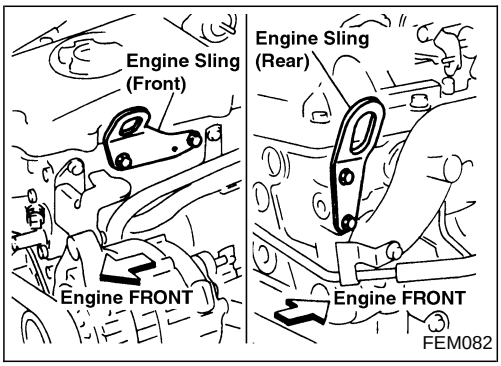
Vehicle underfloor

11. Remove crossmember.
12. Remove front final drive.
13. Remove rear propeller shaft.
14. Remove starter motor.
15. Remove mounting bolts to secure the engine to transmission.

1) Remove engine gusset.
2) Lift transmission bottom with transmission jack, and remove rear mount members from the vehicle.
3) Lower transmission with the jack, and remove upper mounting bolts securing the engine to transmission.
4) Lift transmission with the jack, and reinstall rear mount members to the vehicle.
5) Position the jack to the front side of transmission.
6) Remove remaining mounting bolts securing the engine to transmission.

Removal (Cont'd)

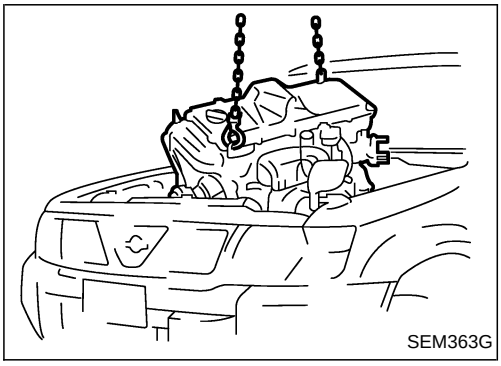
Removal operation



16. Install the engine slingers (standard service part) to front-left and rear-right.
    : 36 - 40 N·m (3.6 - 4.1 kg-m, 26 - 29 ft-lb)

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

17. Hook hoists to slingers to secure the position.
18. Remove installation bolts for left and right engine mount insulators at frame (chassis) side.



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

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

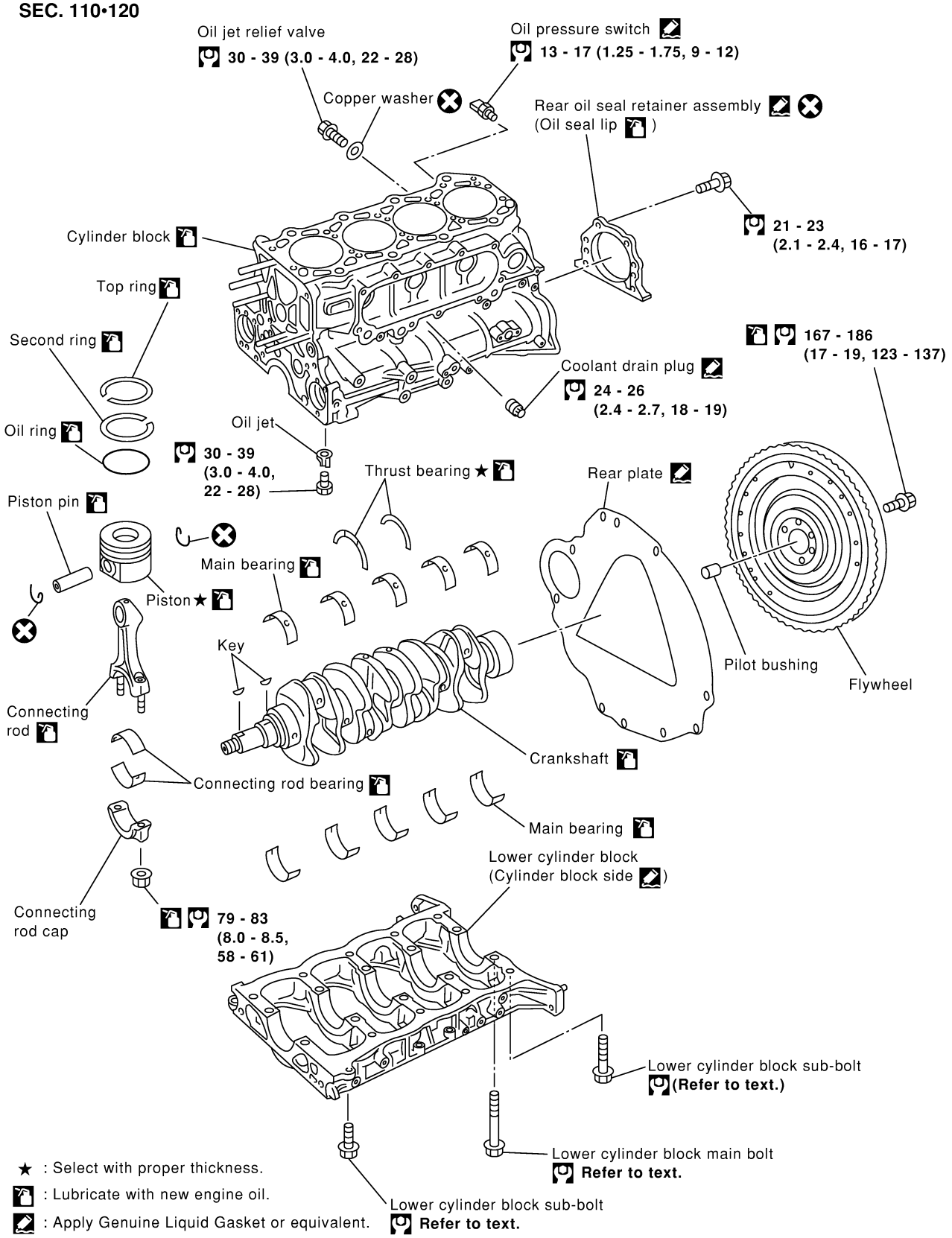
Installation

Install the engine in the reverse order of the removal procedure.
- Keep each mount insulator from oil adherence and damage.
- As for a location with positioning pin, insert the pin correctly to the hole of mating part.
- While keeping each mount insulator free from twisting, tighten mounting bolts and nuts for the engine mount.

Inspection

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

SEC. 110•120



SEM784G

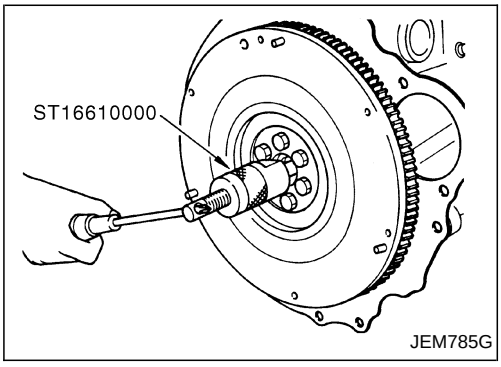
Selection Procedure for Selective Part Combination

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

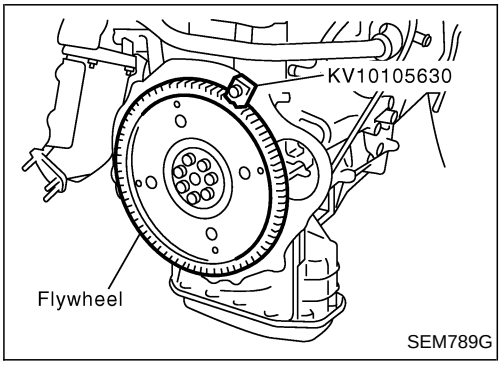
- Identification grade stamped on each part represents initial dimension of new part. This grade will not be applied to a reused part.
- Measure correct dimensions of a reused or modified part, then refer to “Selective combination chart” in this manual to identify the grade.
- Refer to the applicable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

Disassembly

1. Remove engine assembly from vehicle.
   Refer to EM-143, “ENGINE REMOVAL”.
2. Remove clutch cover and clutch disc.

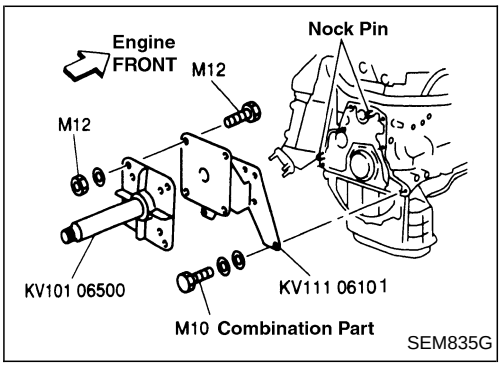


3. Remove pilot bushing from crankshaft using pilot bearing puller (SST), if necessary.



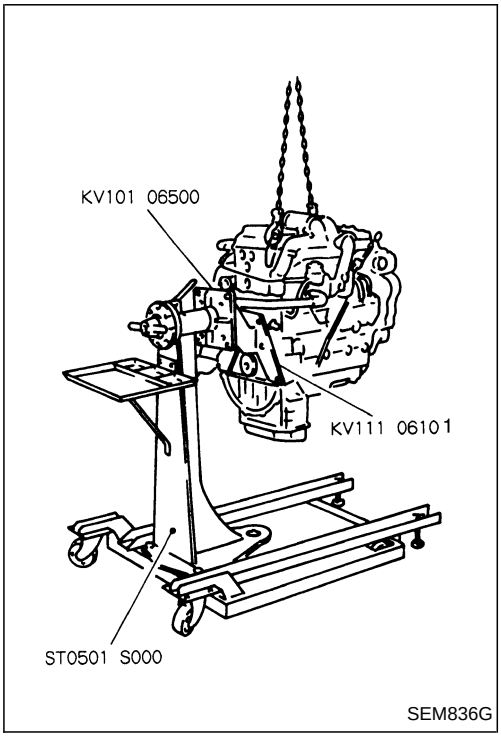
4. Install engine to engine stand (SST).
1) Remove flywheel.
- Using ring gear stopper (SST), secure ring gear, and remove mounting bolts.
2) Remove rear plate.

Disassembly (Cont'd)



3) Install engine sub-attachment (SST) to the rear side of cylinder block.
- Align knock pin on cylinder block with pin hole on attachment to install engine sub-attachment.
- Mounting bolts are provided with engine sub-attachment.

4) Install engine attachment (SST).
- Use commercially available M12 mounting bolts and nuts (4 sets) with strength grade of 9T (minimum).



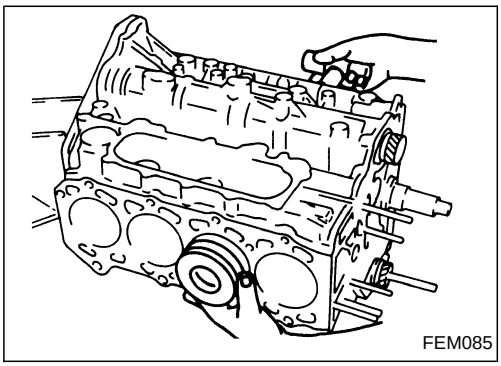
5) Hoist engine and install it to the engine stand (SST).
- Engine attachment and engine sub-attachment can be installed to engine stand before engine installation.

4. Drain engine oil and coolant from engine.
5. Remove the following parts and related parts. (Only major parts are listed.)

CAUTION:
For detailed work procedure, refer to corresponding chapter of this manual.
- Drive belt
- Catalyst
- Turbocharger
- Exhaust manifold
- Injection tube
- Intake manifold
- Rocker cover
- Oil pan
- Water pump
- Thermostat and water pipes
- Vacuum pump
- Injection tube
- Timing chain
- Electronic fuel injection pump
- Timing gear
- Injection nozzle assembly
- Camshaft
- Cylinder head
- Oil cooler
- Accessory and accessory brackets

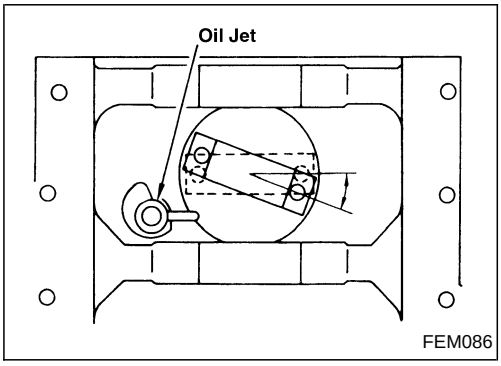
6. Remove rear oil seal and retainer assembly.
- Insert flat-bladed screwdriver between lower cylinder block and rear oil seal retainer to remove the assembly.
- No part No. is given to oil seal.

Disassembly (Cont'd)


FEM085

7. Remove piston and connecting rod assembly.
- Before removing piston and connecting rod assembly, check connecting rod side clearance.
  Refer to EM-151, "CONNECTING ROD SIDE CLEARANCE".

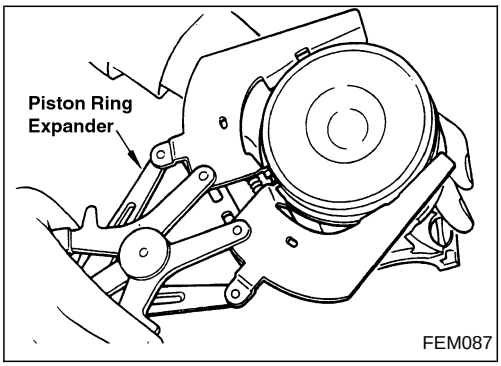
1) Move crankshaft pin to be removed to approximately BDC.
2) Remove connecting rod caps.
3) Using the grip of a hammer, press the piston and connecting rod assembly out to cylinder head side.



FEM086

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

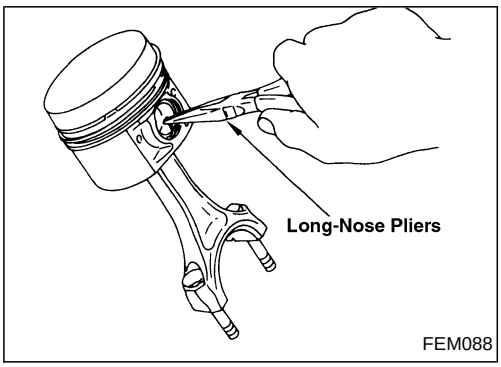
8. Remove connecting rod bearings from connecting rods and caps.
- Keep them by cylinder to avoid confusion.



FEM087

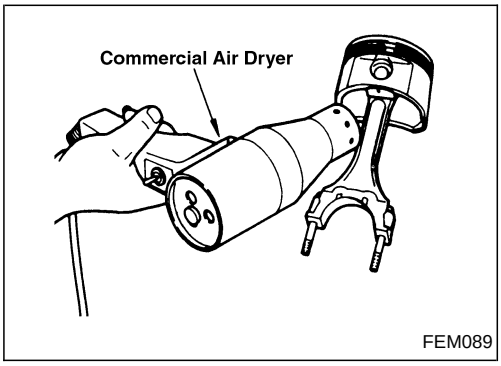
9. Remove piston rings from pistons using piston ring expander (multi-purpose tool).

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



FEM088

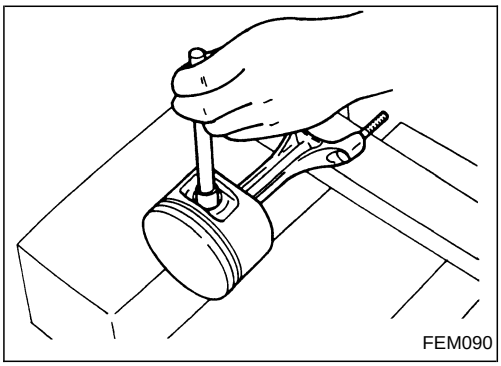
10. Remove pistons from connecting rods.
1) Using long nose pliers, remove snap rings.



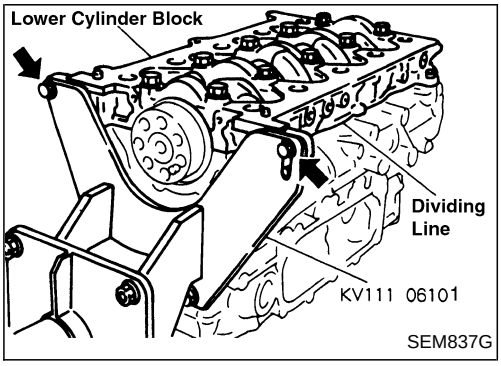
FEM089

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

Disassembly (Cont'd)


FEM090

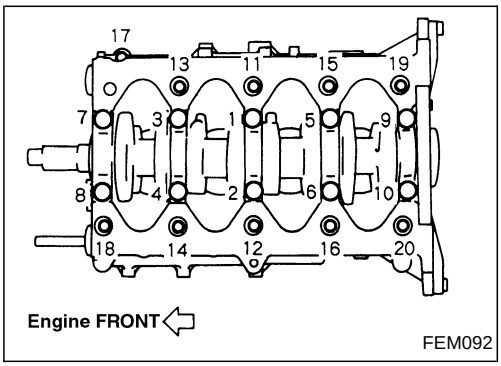
3) Using rod with outer diameter of 30 mm (1.18 in), press piston pins out.



SEM837G

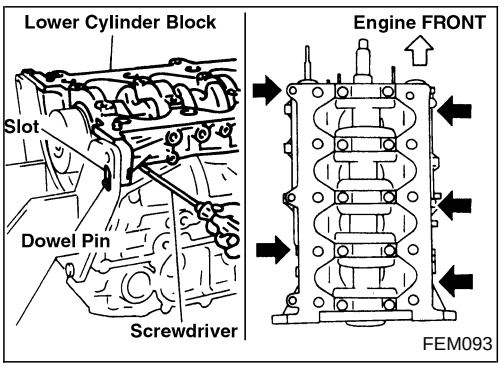
11. Remove lower cylinder block.
- The lower cylinder block is the lower part of the cylinder block, which works as the main bearing cap (beam) and oil pan mounting face.

1) Remove mounting bolts for engine sub-attachment shown by arrows in the figure.



FEM092

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



FEM093

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

CAUTION:

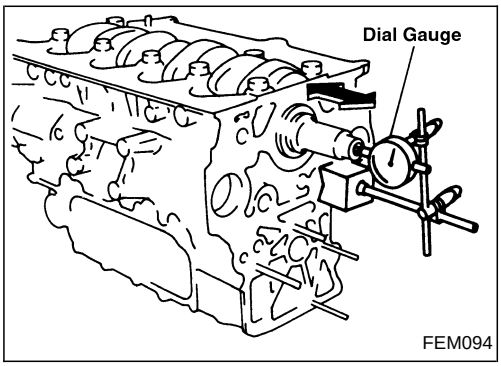
Prevent mating faces from being damaged.

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

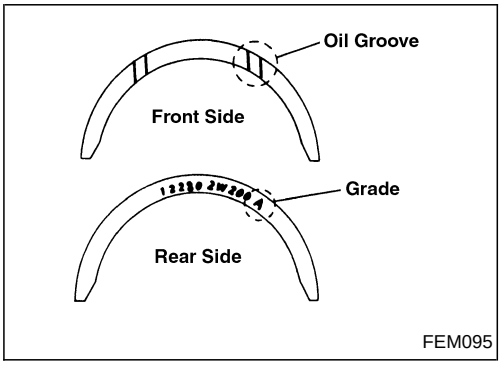
12. Remove crankshaft.
13. Remove main bearings and thrust bearings from cylinder block and lower cylinder block.

CAUTION:

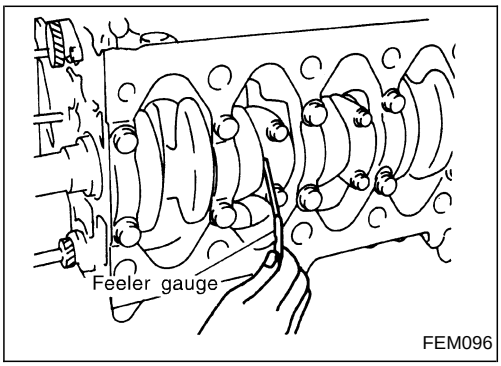
Check mounting positions. Keep them to avoid confusion.



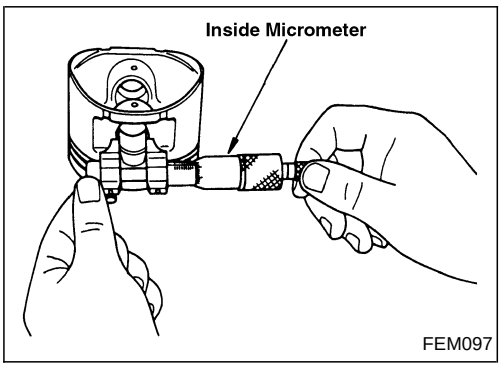
FEM094



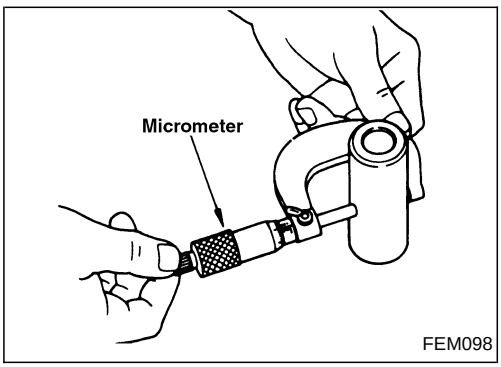
FEM095



FEM096



FEM097



FEM098

Inspection

CRANKSHAFT END PLAY

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

Standard: 0.055 - 0.140 mm (0.0022 - 0.0055 in)
Limit: 0.25 mm (0.0098 in)

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

Unit: mm (in)

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

- OS 020 has OS 0.20 mark on bearing surface.

CONNECTING ROD SIDE CLEARANCE

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

Standard: 0.10 - 0.22 (0.0039 - 0.0087 in)
Limit: 0.22 mm (0.0087 in)

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

PISTON TO PISTON PIN CLEARANCE

Piston pin hole inner diameter

Using inside micrometer, measure piston pin hole inner diameter.

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

Piston pin outer diameter

Using micrometer, measure piston pin outer diameter.

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

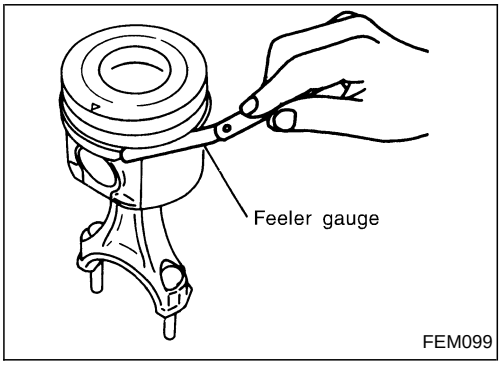
Inspection (Cont'd)

Calculation of piston to piston pin clearance

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

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

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

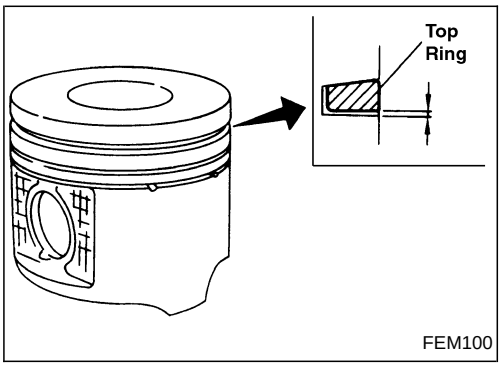


PISTON RING SIDE CLEARANCE

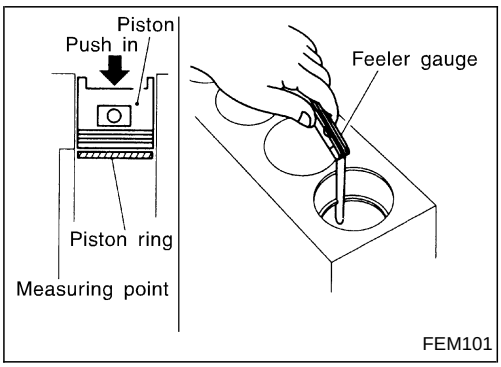
- Using feeler gauge, measure clearance between piston ring and piston ring groove.

Unit: mm (in)

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



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



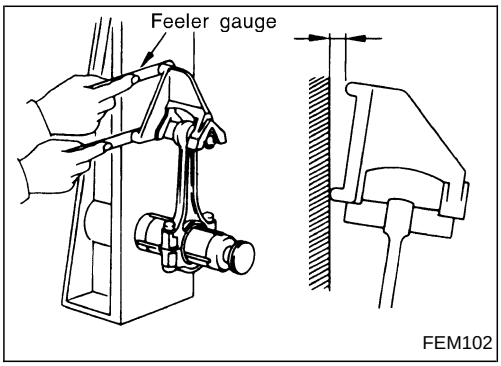
PISTON RING END GAP

- Check that cylinder bore diameter is within specifications. Refer to EM-154, "PISTON TO CYLINDER BORE CLEARANCE".
- Using piston, press piston ring to cylinder mid point, and measure end gap.

Unit: mm (in)

	Standard	Limit
Top ring	0.25 - 0.45 (0.0098 - 0.0177)	1.5 (0.059)
Second ring	0.50 - 0.65 (0.0197 - 0.0256)	
Oil ring	0.25 - 0.5 (0.0098 - 0.0197)	

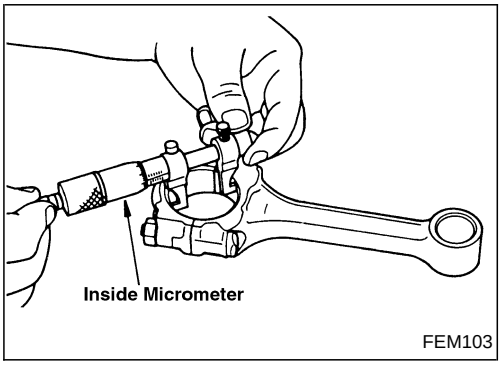
Inspection (Cont'd)



CONNECTING ROD BEND AND TORSION

Use connecting rod aligner to check bend and torsion.

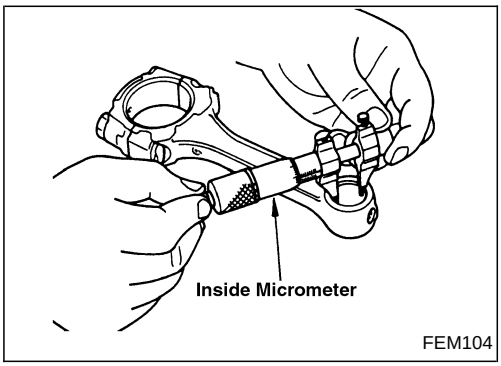
Bend limit:
0.05 mm (0.0020 in)/100 mm (3.94 in)
Torsion limit:
0.05 mm (0.0020 in)/100 mm (3.94 in)



CONNECTING ROD BIG END INNER DIAMETER

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

Standard:
59.987 - 60.000 mm (2.3617 - 2.3622 in)

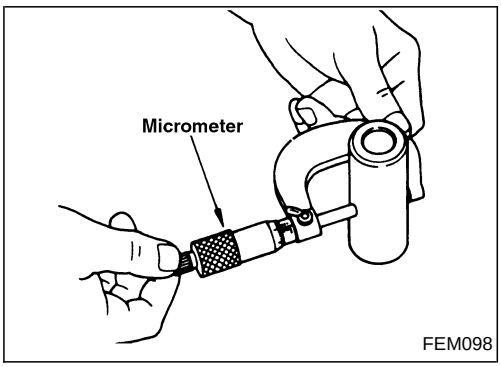


CONNECTING ROD BUSHING OIL CLEARANCE (SMALL END)

Connecting rod small end inner diameter

Use inside micrometer to measure small end inner diameter.

Standard:
33.025 - 33.038 mm (1.3002 - 1.3007 in)



Piston pin outer diameter

Use micrometer to measure piston pin outer diameter.

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

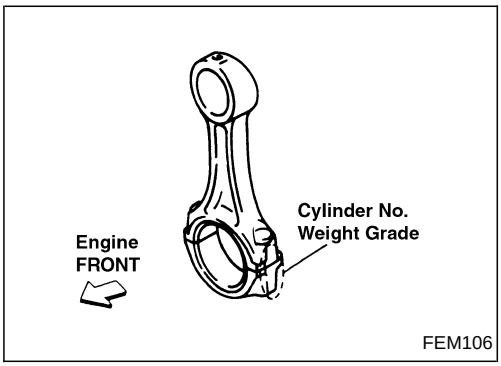
Calculation of connecting rod bushing clearance

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

Standard:
0.025 - 0.045 mm (0.0010 - 0.0018 in)

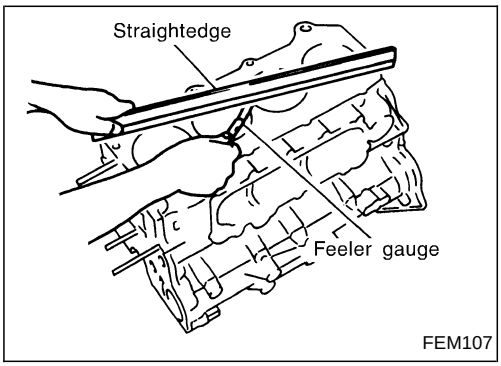
- If out of specifications, replace connecting rod and/or piston and piston pin assembly.

Inspection (Cont'd)



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

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



CYLINDER BLOCK TOP SURFACE DISTORTION

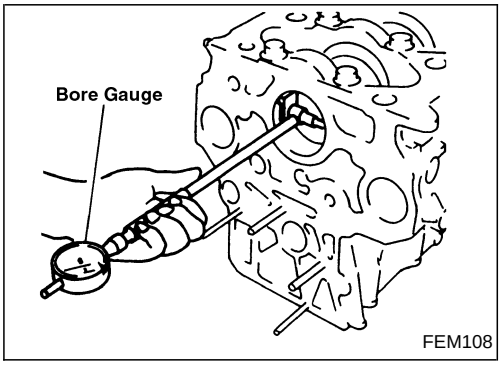
- Using scraper, remove gasket installed onto cylinder block surface. Remove contamination such as oil, scale, and carbon.

CAUTION:

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

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

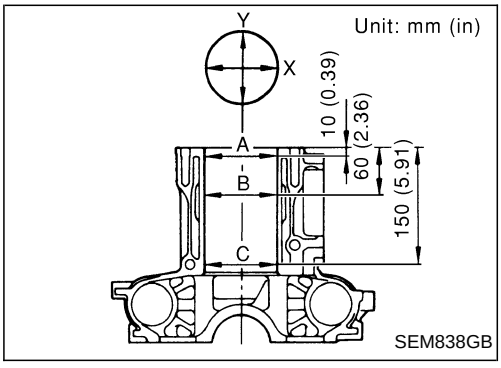
  Standard: Less than 0.03 mm (0.0012 in)
  Limit: 0.1 mm (0.004 in)



MAIN BEARING HOUSING INNER DIAMETER

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

  Standard:
  74.981 - 75.000 mm (2.9520 - 2.9528 in)
- If out of specification, replace cylinder block and lower cylinder block.



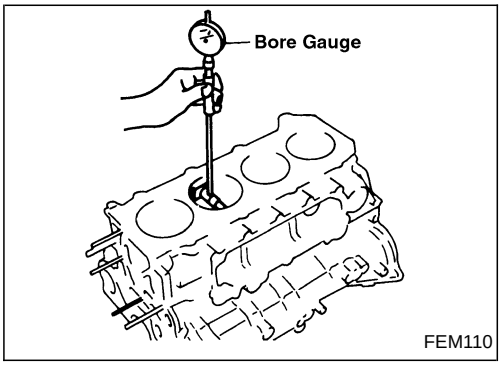
PISTON TO CYLINDER BORE CLEARANCE

Cylinder bore inner diameter

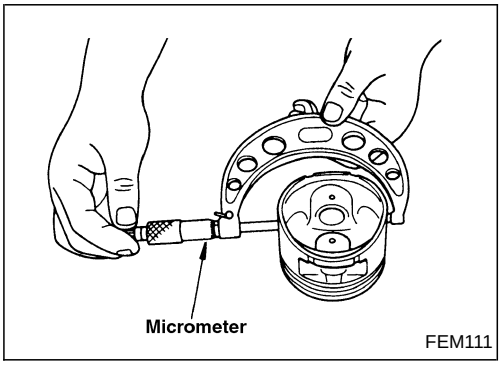
- Using bore gauge, measure cylinder inner diameters at 6 positions; top, middle, and bottom (A, B, C) in 2 directions (X, Y).

  Cylinder inner diameter (Standard):
  96.000 - 96.030 mm (3.7795 - 3.7807 in)
  Wear limit: 0.2 mm (0.008 in)
  Out-of-round limit (X - Y): less than 0.02 mm (0.0008 in)
  Taper limit (C - A): less than 0.02 mm (0.0008 in)

Inspection (Cont'd)



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



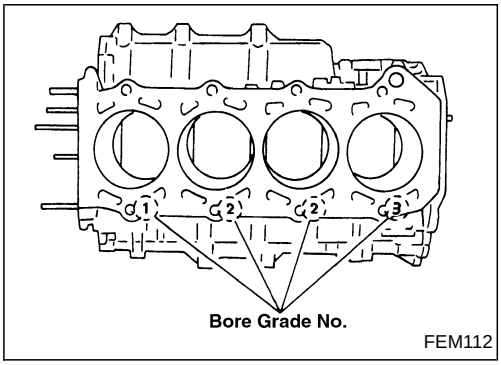
Piston outer diameter

Use micrometer to measure piston skirt outer diameter.

Measurement position:
10 mm (0.39 in) upper from the lower end of piston
Standard:
95.950 - 95.980 mm (3.7776 - 3.7787 in)

Calculation of piston to piston bore clearance

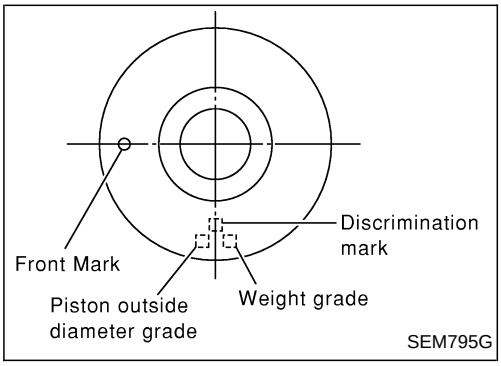
- Calculate using piston skirt outer diameter and cylinder inner diameter (direction X, position B).
  Clearance = Cylinder inner diameter − Piston skirt outer diameter
  Specifications at room temperature [20°C (68°F)]:
  0.040 - 0.060 mm (0.0016 - 0.0024 in)
- If out of specification, replace piston and piston pin assembly.



SELECTIVE PISTON COMBINATION

When using new cylinder block

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



When re-using an old cylinder block

1. Measure cylinder block bore inner diameter.
2. Referring to EM-156, "Cylinder block bore inner diameter" in "Selective combination chart", select appropriate piston according to cylinder bore grade.

Inspection (Cont'd)

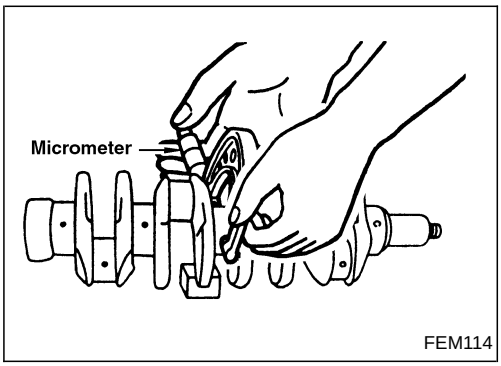
Selective combination chart

Unit: mm (in)

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

- Piston grade 3 [95.970 - 95.980 mm (3.7783 - 3.7787 in)] is applicable at factory only.
- New pistons are classified into 4 weight classes at factory. The same class pistons are used on a engine.

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



FEM114

CRANKSHAFT JOURNAL OUTER DIAMETER

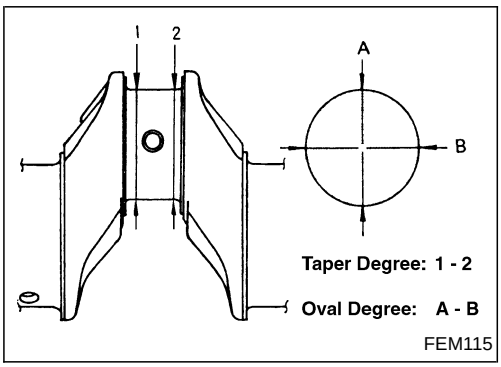
Use micrometer to measure journal outer diameter.

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

CRANKSHAFT PIN OUTER DIAMETER

Use micrometer to measure pin outer diameter.

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

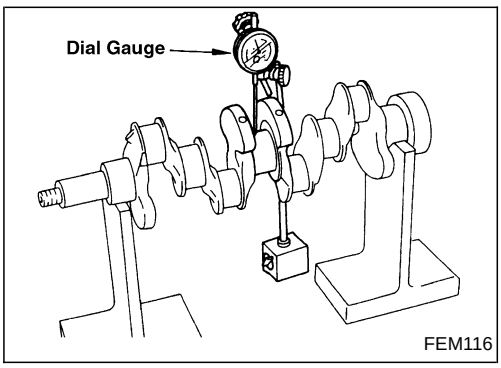


FEM115

CRANKSHAFT OUT-OF-ROUND AND TAPER

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

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



FEM116

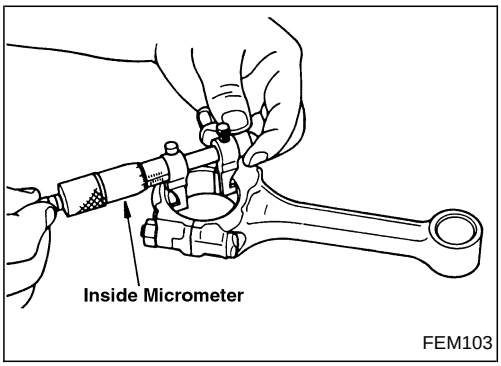
CRANKSHAFT RUNOUT

- Place V-block onto surface plate to support journals at both ends of crankshaft.
- Position dial indicator vertically onto No. 3 journal.
- Rotate crankshaft to read needle movement on dial indicator. (Total indicator reading)

Standard: Less than 0.01 mm (0.0004 in)
Limit: 0.03 mm (0.0012 in)

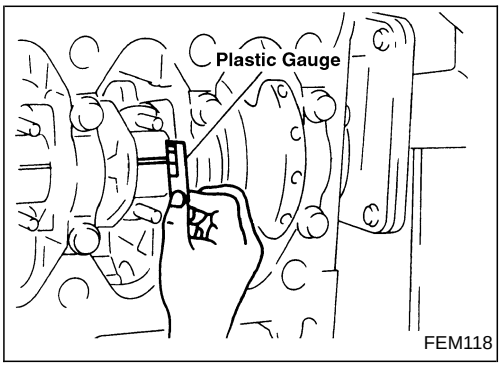
Inspection (Cont'd)

CONNECTING ROD BEARING OIL CLEARANCE



Method by measurement

- Install connecting rod bearings to connecting rods and caps, and tighten connecting nuts to the specified torque. Use inside micrometer to measure connecting rod bearing inner diameter. Bearing clearance = Connecting rod bearing inner diameter − Crankshaft pin outer diameter
  Standard: 0.035 - 0.077 mm (0.0014 - 0.0030 in)
- If out of specifications, check connecting rod big end inner diameter and crankshaft pin outer diameter, and select appropriate connecting rod bearing to adjust clearance to specifications.
  Refer to "Connecting rod bearing undersize list" on the next page.



Method using plastigage

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

CAUTION:
Never rotate crankshaft.

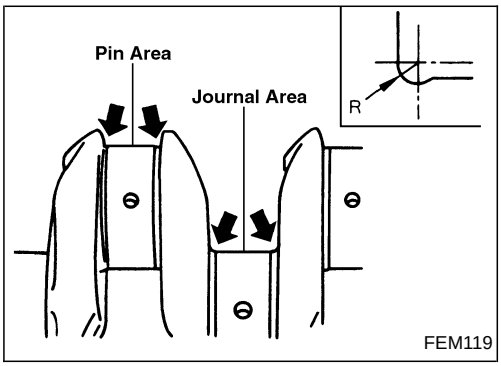
- Remove connecting rod caps and bearings, and measure plastigage width using scale on plastigage bag.

CAUTION:
If out of specification, take same action mentioned in "Method by measurement".

Undersize bearing usage

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

Inspection (Cont'd)



Connecting rod bearing undersize list

Unit: mm (in)

Size	Thickness
US 025	1.630 - 1.638 (0.0642 - 0.0645)
US 050	1.755 - 1.763 (0.0691 - 0.0694)
US 075	1.880 - 1.888 (0.0740 - 0.0743)
US 100	2.005 - 2.013 (0.0789 - 0.0793)

CAUTION:

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

Corner dimension (Standard):

Pin

3.3 - 3.7 mm (0.130 - 0.146 in)

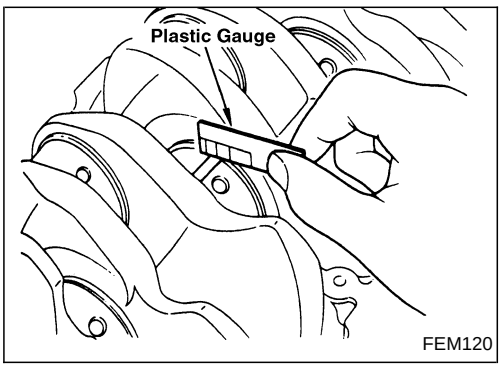
Journal

2.8 - 3.2 mm (0.110 - 0.126 in)

MAIN BEARING OIL CLEARANCE

Method by measurement

- Install main bearings to cylinder block and bearing caps, and tighten bearing cap bolts to the specified torque. Measure main bearing inner diameter.
  Bearing clearance = Bearing inner diameter − Crankshaft journal outer diameter
  Standard: 0.035 - 0.083 mm (0.0014 - 0.0033 in)
- If out of specification, check main bearing housing inner diameter and crankshaft journal outer diameter, and select appropriate main bearing to adjust clearance to specifications.
  Refer to "Main bearing undersize list" on the next page.



Method using plastigage

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

CAUTION:

Never rotate crankshaft.

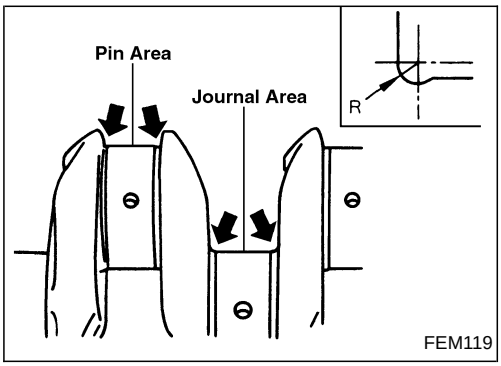
- Remove bearing caps and bearings, and measure plastigage width using scale on plastigage bag.

Inspection (Cont'd)

CAUTION:
If out of specification, take same action mentioned in "Method by measurement".

Undersize bearing usage

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



Main bearing undersize list

Unit: mm (in)

Size	Thickness
US 025	2.130 - 2.138 (0.0839 - 0.0842)
US 050	2.255 - 2.263 (0.0888 - 0.0891)
US 075	2.380 - 2.388 (0.0937 - 0.0940)
US 100	2.505 - 2.513 (0.0986 - 0.0989)

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

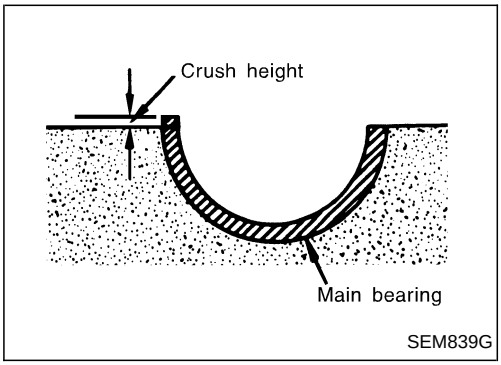
Corner dimension (Standard):

Pin

3.3 - 3.7 mm (0.130 - 0.146 in)

Journal

2.8 - 3.2 mm (0.110 - 0.126 in)



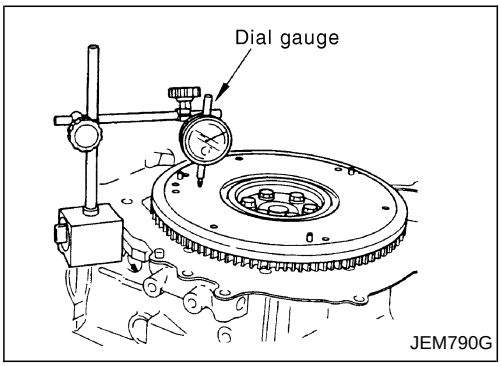
MAIN BEARING CRUSH HEIGHT

- Tighten bearing caps to the specified torque with main bearings installed, and remove caps. The bearing end must then be higher than the flat surface.

  Standard: Crush height must exist.
- If out of specification, replace main bearings.

Inspection (Cont'd)

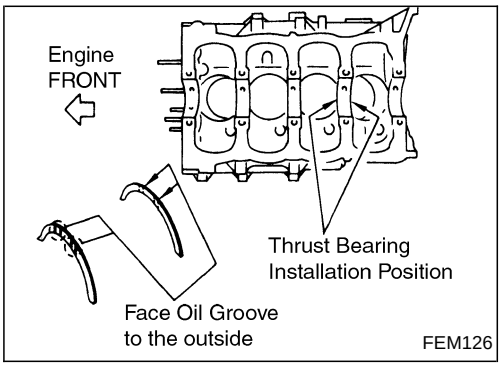
FLYWHEEL RUNOUT



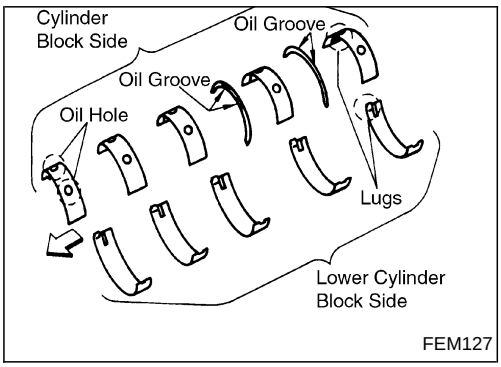
- Attach flywheel to crankshaft. Use a dial gauge to measure runout of flywheel clutch-contact surface.
- Measure at position with diameter of 240 mm (9.45 in).
  Limit: 0.1 mm (0.004 in)
- If limit value is exceeded, replace flywheel.

Assembly

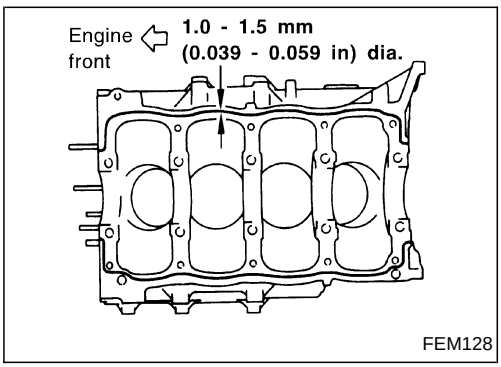
1. Blow air sufficiently to inside coolant passage, oil passage, crankcase, and cylinder bore to remove foreign matter.



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

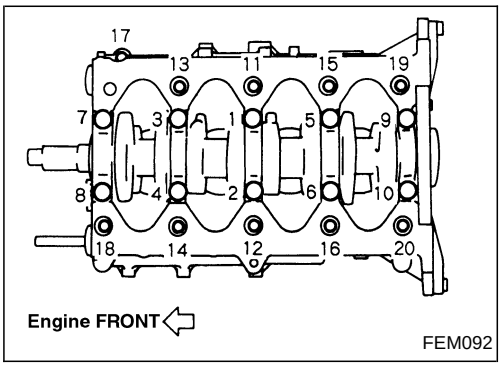


3) Being careful with the direction, install main bearings.
- Install main bearings with the oil holes and grooves onto the cylinder block side, and those without oil holes and grooves onto the lower cylinder block side.
- While installing bearings, apply engine oil to bearing surfaces (inside). Do not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



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

Assembly (Cont'd)

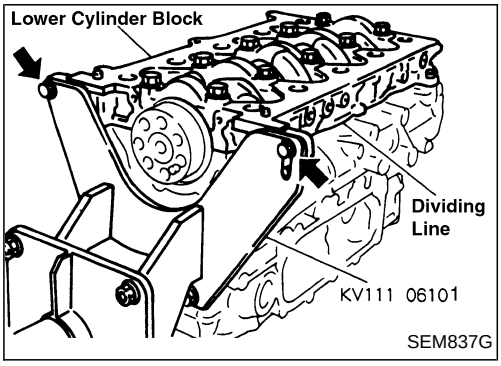


5. Tighten lower cylinder mounting bolts to the torque shown below in 3 consecutive steps in the order shown in the figure.

Unit: N·m (kg-m, ft-lb)

	Main bolt (Nos. 1 - 10)	Sub-bolt (Nos. 11 - 20)
1st	20 (2.0, 14)	9.8 (1.0, 87)
2nd	98 (10, 72)	20 (2.0, 14)
3rd	167 - 176 (17 - 18, 123 - 130)	40 - 46 (4.0 - 4.7, 29 - 33)

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

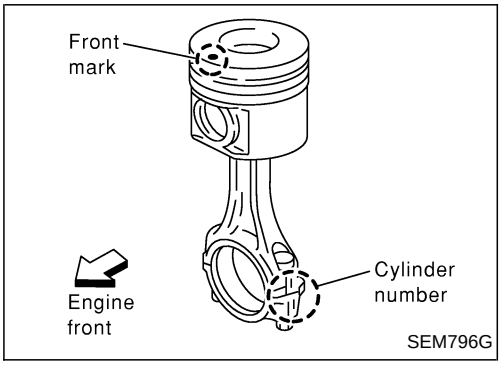


6. Install mounting bolts for engine sub-attachment shown by arrows in the figure.
- After tightening bolts to the specified torque, check crankshaft for smooth rotation.
- Check crankshaft end play.
  Refer to EM-151, "CRANKSHAFT END PLAY".

7. Install pistons to connecting rod.

1) Using long nose pliers, install snap rings to grooves on piston rear side.
- Fit snap rings correctly into grooves.

2) Install pistons to connecting rods.
- Using industrial dryer, heat pistons up to approx. 60 to 70°C (140 to 158°F) until piston pin can be pressed down by finger touch. Then insert piston pins into piston and connecting rod from front side of piston toward rear.

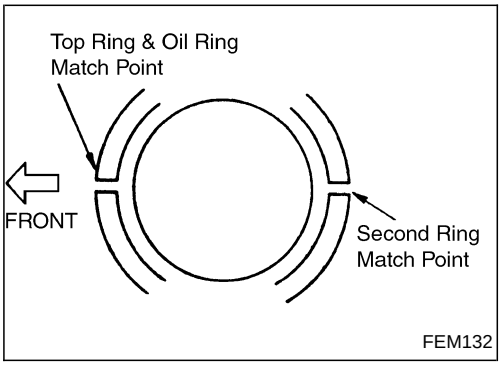


- Assemble piston and connecting rod with front mark of piston crown and cylinder No. stamped on connecting rod being positioned as shown in the figure.

3) Install snap rings to front side of pistons.
- Refer to above 1) for precaution on snap ring installation.
- After installation, check connecting rods for smooth movement.

8. Use piston ring expander (multi-purpose tool) to install piston rings.

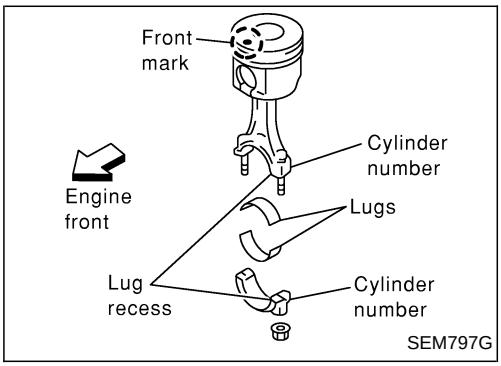
CAUTION:
When installing, prevent piston from being damaged.



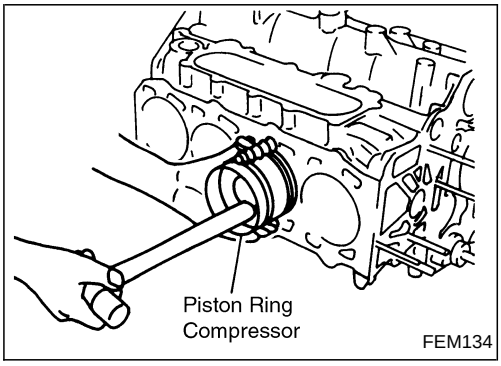
- Install top ring and second ring with stamped surfaces facing upward.

Identification stamp:
Top ring: R
Second ring: RN

Assembly (Cont'd)

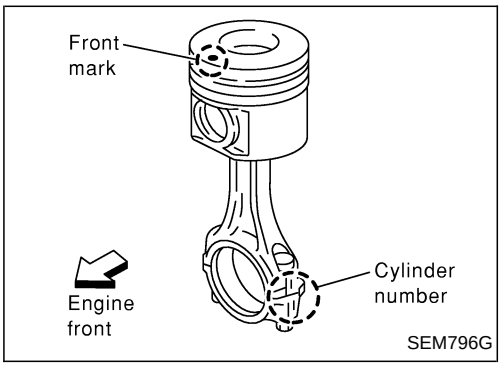


9. Install connecting rod bearings to connecting rods and caps.
- While installing connecting rod bearings, apply engine oil to bearing surfaces (inside). Do not apply oil to rear surfaces, but clean them completely.
- Align stoppers on connecting rod bearings with connecting rod stopper notches to install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

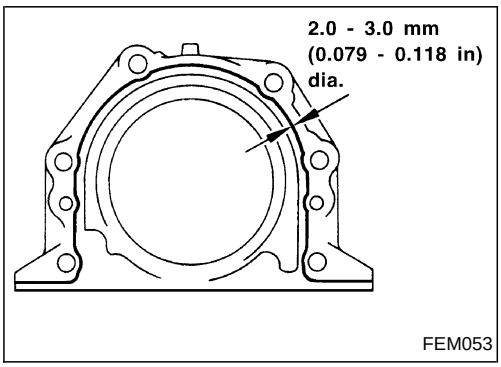


10. Install piston and connecting rod assembly to crankshaft.
- Move crankshaft pin to be removed to BDC.
- Align cylinder position with cylinder No. on connecting rod to install piston and connecting rod assembly.
- Using piston ring compressor (multi-purpose tool), install piston and connecting rod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

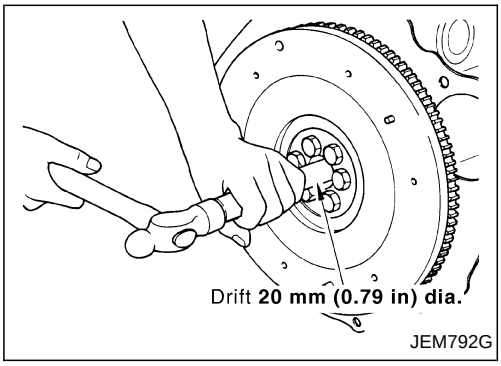
CAUTION:
When installing piston and connecting rod assembly, prevent the big end of connecting rod from interfering with oil jet.



11. Install connecting rod caps and mounting nuts.
- Align cylinder No. stamped on connecting rod with that on cap to install connecting rod cap.
- After tightening nuts, check crankshaft for smooth rotation.
- Check connecting rod side clearance.
  Refer to EM-151, "CONNECTING ROD SIDE CLEARANCE".

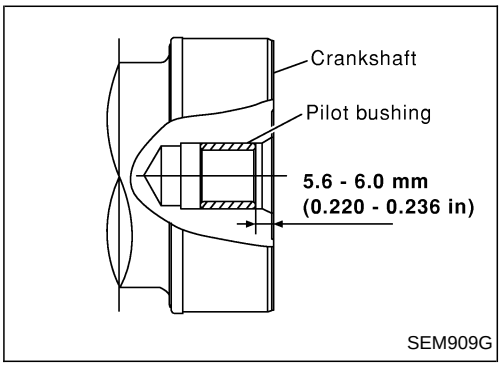


12. Install rear oil seal and retainer assembly.
- Apply a continuous bead of liquid gasket to rear oil seal and retainer assembly as shown in the figure.

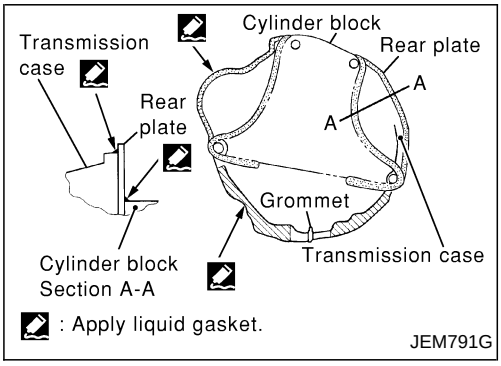


13. Attach pilot bushing.
- Use a drift with outer diameter 20 mm (0.79 in) (commercial service tool) to press-fit pilot bushing into crankshaft rear end hole.

Assembly (Cont'd)

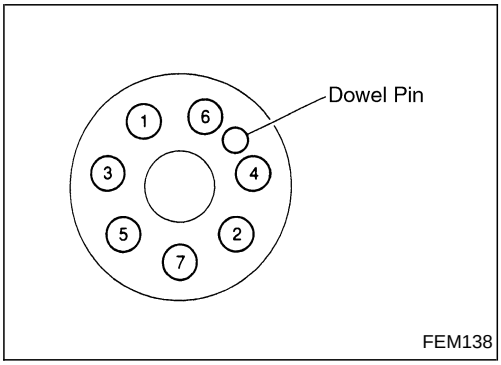


- Press fit so that position is as shown in the figure.



14. Install rear plate.
- Apply liquid gasket to positions shown in the figure, then install rear plate.

15. Install removed parts to engine in the reverse order of disassembly.
16. Remove engine from engine stand.
17. Install flywheel.
- Using the same method as disassembly, secure crankshaft and tighten mounting bolts.



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

Inspection and Adjustment

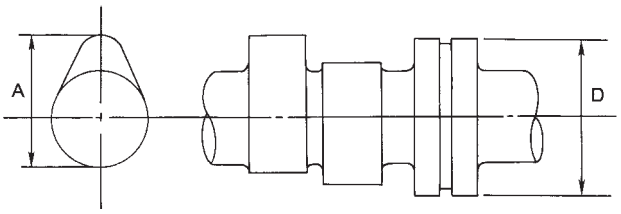
VALVE

Valve clearance adjustment

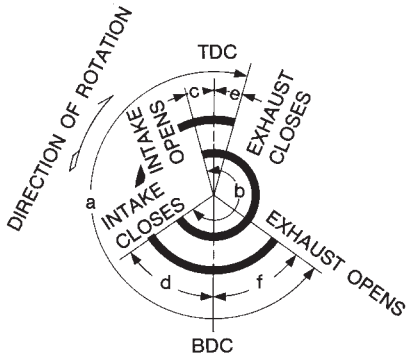
Unit: mm (in)

Valve clearance (Hot)	
Intake	0.31 - 0.39 (0.012 - 0.015)
Exhaust	0.33 - 0.41 (0.013 - 0.016) (Except for Europe) 0.39 - 0.47 (0.015 - 0.019) (For Europe)

CAMSHAFT AND CAMSHAFT BEARING



SEM568A



EM120

Unit: mm (in)

		Standard		Limit
Cam height (A)	Intake	42.505 - 42.695 (1.673 - 1.681)		—
	Exhaust	40.905 - 41.095 (1.610 - 1.618)		—
Wear limit of cam height		—		0.2 (0.008)
Camshaft journal to bearing clearance		0.045 - 0.090 (0.0018 - 0.0035)		0.12 (0.0047)
Inner diameter of camshaft bearing	#1 to #5 journals	28.000 - 28.025 (1.1024 - 1.1033)		—
Outer diameter of camshaft journal (D)	#1 to #5 journals	27.935 - 27.955 (1.0998 - 1.1006)		—
Camshaft runout*		Less than 0.02 (0.0008)		0.04 (0.0016)
Camshaft end play		0.070 - 0.148 (0.0028 - 0.0058)		0.2 (0.008)
Valve timing (Degree on crankshaft)		Except for Europe	For Europe	—
	a	216	224	
	b	232	224	—
	c	−1	−1	—
	d	53	45	—
	e	4	7	—
	f	32	37	—

* Total indicator reading

PISTON, PISTON RING AND PISTON PIN

Piston ring

Unit: mm (in)

		Standard	Limit
Side clearance	Top	0.040 - 0.080 (0.0016 - 0.0031)	0.1 (0.004)
	2nd	0.030 - 0.070 (0.0012 - 0.0028)	0.1 (0.004)
	Oil	0.065 - 0.135 (0.0026 - 0.0053)	0.1 (0.004)
Ring gap	Top	0.28 - 0.52 (0.0110 - 0.0205)	1.0 (0.039)
	2nd	0.45 - 0.69 (0.0177 - 0.0272)	1.0 (0.039)
	Oil (rail ring)	0.20 - 0.69 (0.0079 - 0.0272)	1.0 (0.039)

General Specifications

Cylinder arrangement		In-line 4
Displacement cm^3 (cu in)		2,488 (151.82)
Bore and stroke mm (in)		89.0 x 100 (3.504 x 3.937)
Valve arrangement		DOHC
Firing order		1-3-4-2
Number of piston rings	Compression	2
	Oil	1
Number of main bearings		5
Compression ratio		18.0

Compression Pressure

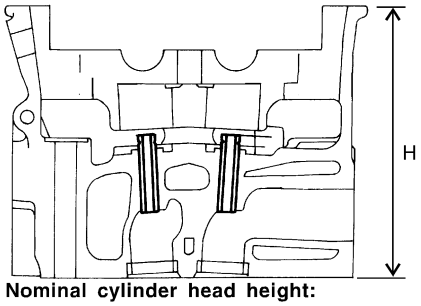
Unit: kPa (bar, kg/cm^2, psi)/200 rpm

Compression pressure	Standard	3,100 (31.00, 31.6, 45.0)
	Minimum	2,500 (25.00, 25.5, 363)
	Differential limit between cylinders	490 (4.90, 5.0, 71)

Cylinder Head

Unit: mm (in)

	Standard	Limit
Head surface distortion	Less than 0.03 (0.0012)	0.04 (0.0016)



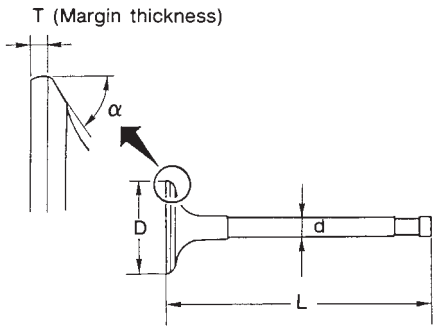
Nominal cylinder head height:
H = 153.9 - 154.1 mm (6.059 - 6.067 in)

JEM204G

Valve

VALVE

Unit: mm (in)



SEM188

Valve head diameter “D”	Intake	28.0 - 28.3 (1.102 - 1.114)
	Exhaust	26.0 - 26.3 (1.024 - 1.035)
Valve length “L”	Intake	106.72 (4.2016)
	Exhaust	106.36 (4.1874)
Valve stem diameter “d”	Intake	5.965 - 5.980 (0.2348 - 0.2354)
	Exhaust	5.945 - 5.960 (0.2341 - 0.2346)
Valve seat angle “α”	Intake	45°15′ - 45°45′
	Exhaust	
Valve margin “T”	Intake	1.38 (0.0543)
	Exhaust	1.48 (0.0583)
Valve margin “T” limit		More than 1.0 (0.039)
Valve stem end surface grinding limit		Less than 0.2 (0.008)

VALVE CLEARANCE

Unit: mm (in)

	Cold	Hot* (reference data)
Intake	0.24 - 0.32 (0.009 - 0.013)	0.29 - 0.37 (0.011 - 0.015)
Exhaust	0.26 - 0.34 (0.010 - 0.013)	0.33 - 0.41 (0.013 - 0.016)

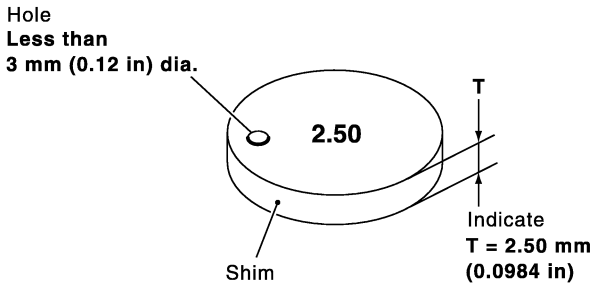
*: Approximately 80°C (176°F)

AVAILABLE SHIMS

Thickness mm (in)	Identification mark
2.10 (0.0827)	2.10
2.12 (0.0835)	2.12
2.14 (0.0843)	2.14
2.16 (0.0850)	2.16
2.18 (0.0858)	2.18
2.20 (0.0866)	2.20
2.22 (0.0874)	2.22
2.24 (0.0882)	2.24
2.26 (0.0890)	2.26
2.28 (0.0898)	2.28
2.30 (0.0906)	2.30
2.32 (0.0913)	2.32
2.34 (0.0921)	2.34

Valve (Cont'd)

2.36 (0.0929)	2.36
2.38 (0.0937)	2.38
2.40 (0.0945)	2.40
2.42 (0.0953)	2.42
2.44 (0.0961)	2.44
2.46 (0.0969)	2.46
2.48 (0.0976)	2.48
2.50 (0.0984)	2.50
2.52 (0.0992)	2.52
2.54 (0.1000)	2.54
2.56 (0.1008)	2.56
2.58 (0.1016)	2.58
2.60 (0.1024)	2.60
2.62 (0.1031)	2.62
2.64 (0.1039)	2.64
2.66 (0.1047)	2.66
2.68 (0.1055)	2.68
2.70 (0.1063)	2.70
2.72 (0.1071)	2.72
2.74 (0.1079)	2.74



SEM512G

VALVE SPRING

Free height mm (in)	Outer	43.7 (1.720)
Pressure N (kg, lb) at height mm (in)	Outer	320 - 360 (32.6 - 36.7, 71.9 - 80.9) at 24.82 (0.9772)
Out-of-square mm (in)	Outer	Limit 1.9 (0.075)

VALVE LIFTER

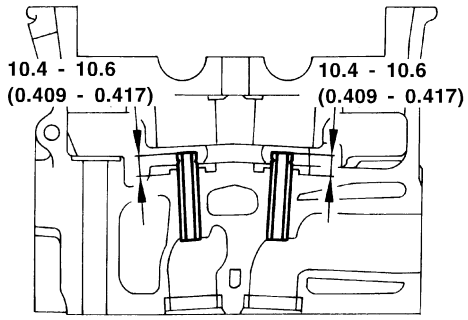
Unit: mm (in)

Valve lifter outer diameter	29.960 - 29.975 (1.1795 - 1.1801)
Lifter guide inner diameter	30.000 - 30.021 (1.1181 - 1.1819)
Clearance between lifter and lifter guide	0.025 - 0.061 (0.0010 - 0.0024)

Valve (Cont'd)

VALVE GUIDE

Unit: mm (in)



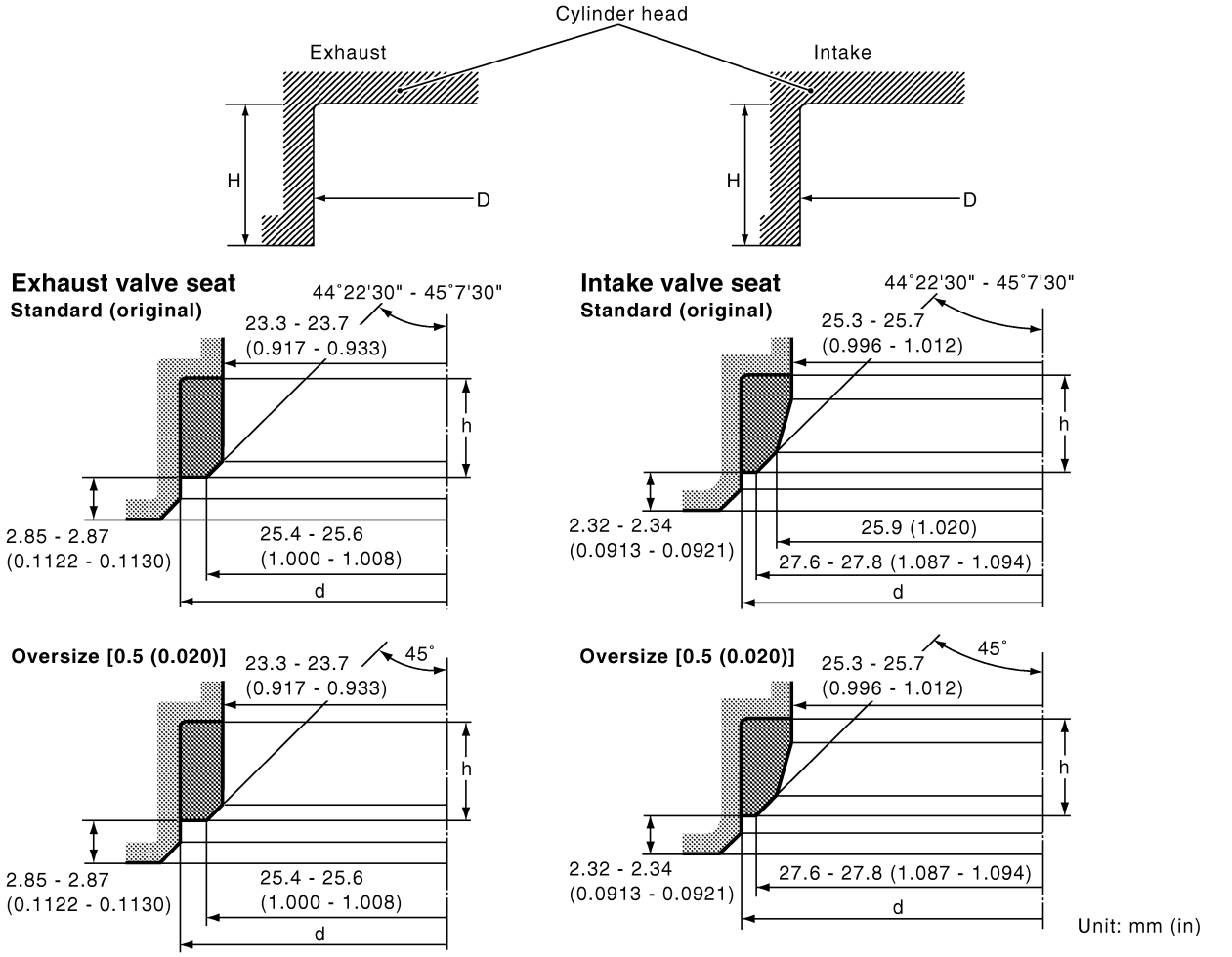
JEM156G

Unit: mm (in)

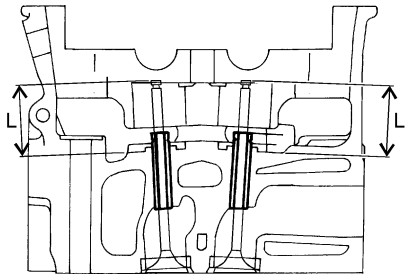
		Standard	Service
Valve guide	Outer diameter	10.023 - 10.034 (0.3946 - 0.3950)	10.223 - 10.234 (0.4025 - 0.4029)
Valve guide	Inner diameter (Finished size)	6.000 - 6.018 (0.2362 - 0.2369)	
Cylinder head valve guide hole diameter		9.975 - 9.996 (0.3927 - 0.3935)	10.175 - 10.196 (0.4006 - 0.4014)
Interference fit of valve guide		0.027 - 0.059 (0.0011 - 0.0023)	
		Standard	Limit
Stem to guide clearance	Intake	0.020 - 0.053 (0.0008 - 0.0021)	0.08 (0.0031)
	Exhaust	0.040 - 0.073 (0.0016 - 0.0029)	0.1 (0.004)
Valve deflection limit		0.15 (0.0059)	
Projection length		10.4 - 10.6 (0.409 - 0.417)	

Valve Seat

Unit: mm (in)



SEM546G



JEM253G

		Standard	Service
Cylinder head seat recess diameter (D)	Intake	30.000 - 30.016 (1.1181 - 1.1817)	30.500 - 30.516 (1.2008 - 1.2014)
	Exhaust	29.000 - 29.016 (1.1417 - 1.1424)	29.500 - 29.516 (1.1614 - 1.1620)
Valve seat interference fit	Intake	0.064 - 0.100 (0.0025 - 0.0039)	
	Exhaust	0.064 - 0.096 (0.0025 - 0.0038)	
Valve seat outer diameter (d)	Intake	30.080 - 30.100 (1.1842 - 1.1850)	30.580 - 30.600 (1.2039 - 1.2047)
	Exhaust	29.080 - 29.096 (1.1449 - 1.1455)	29.580 - 29.596 (1.1646 - 1.1652)

Valve Seat (Cont'd)

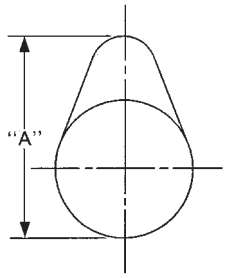
Height (h)	Intake	7.0 - 7.1 (0.276 - 0.280)	6.60 - 6.70 (0.2598 - 0.2638)
	Exhaust	6.7 - 6.8 (0.264 - 0.268)	6.3 - 6.4 (0.248 - 0.252)
Depth (H)	Intake	8.83 - 9.13 (0.3476 - 0.3594)	
	Exhaust	9.06 - 9.36 (0.3567 - 0.3685)	
Depth (L)	Intake	36.53 - 36.98 (1.4382 - 1.4559)	
	Exhaust	36.53 - 37.01 (1.4382 - 1.4571)	

Camshaft and Camshaft Bearing

Unit: mm (in)

	Standard	Limit
Camshaft journal to bearing clearance	0.045 - 0.086 (0.0018 - 0.0034)	0.045 - 0.086 (0.0018 - 0.0034)
Inner diameter of camshaft bearing	No. 1 30.500 - 30.521 (1.2008 - 1.2016) No. 2, 3, 4, 5 24.000 - 24.021 (0.9449 - 0.9457)	—
Outer diameter of camshaft journal	No. 1 30.435 - 30.455 (1.1982 - 1.1990) No. 2, 3, 4, 5 23.935 - 23.955 (0.9423 - 0.9431)	—
Camshaft runout [TIR*]	—	0.02 (0.0008)
Camshaft sprocket runout [TIR*]	Less than 0.15 (0.0059)	—
Camshaft end play	0.070 - 0.148 (0.0028 - 0.0058)	0.24 (0.0094)

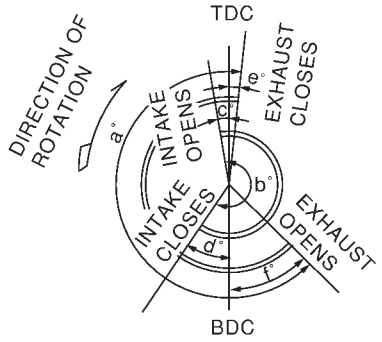
*: Total indicator reading



EM671

Cam height "A"	Intake	39.505 - 39.695 (1.5553 - 1.5628)
	Exhaust	39.905 - 40.095 (1.5711 - 1.5785)
Wear limit of cam height		0.15 (0.0059)

Valve timing



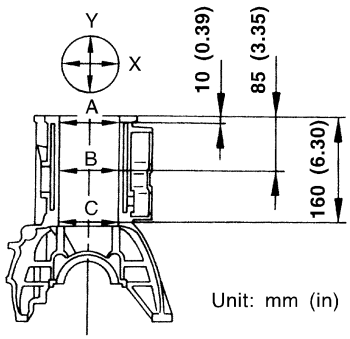
PBIC0187E

Unit: degree

a	b	c	d	e	f
224	212	2	30	−2	46

Cylinder Block

Unit: mm (in)



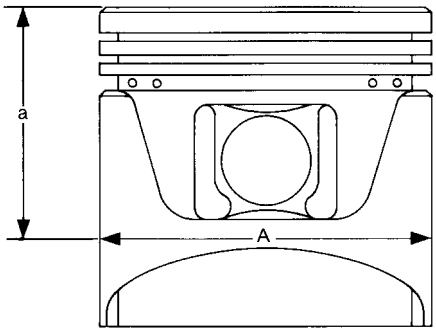
SEM899G

Surface flatness	Standard			Less than 0.03 (0.0012)
	Limit			0.04 (0.0016)
Cylinder bore	Inner diameter	Standard	Grade No. 1	89.000 - 89.010 (3.5039 - 3.5043)
			Grade No. 2	89.010 - 89.020 (3.5043 - 3.5047)
			Grade No. 3	89.020 - 89.030 (3.5047 - 3.5051)
		Wear limit		0.07 (0.0028)
Out-of-round (X − Y)				Less than 0.015 (0.0006)
Taper (C − A)				Less than 0.010 (0.0004)
Main journal inner diameter grade (Without bearing)	Grade No. 0 Grade No. 1 Grade No. 2			66.654 - 66.663 (2.6242 - 2.6245) 66.663 - 66.672 (2.6245 - 2.6249) 66.672 - 66.681 (2.6249 - 2.6252)
Difference in inner diameter between cylinders	Limit			Less than 0.05 (0.0020)

Piston, Piston Ring and Piston Pin

AVAILABLE PISTON

Unit: mm (in)



SEM882E

Piston skirt diameter “A”	Standard	Grade No. 1	88.940 - 88.950 (3.5016 - 3.5020)
		Grade No. 2	88.950 - 88.960 (3.5020 - 3.5024)
		Grade No. 3	88.960 - 88.970 (3.5024 - 3.5027)
		0.25 (0.0098) oversize (Service)	89.190 - 89.220 (3.5114 - 3.5126)
		0.50 (0.0197) oversize (Service)	89.440 - 89.470 (3.5213 - 3.5224)
“a” dimension			59.0 (2.323)
Piston pin hole diameter			27.997 - 28.005 (1.1022 - 1.1026)
Piston clearance to cylinder block			0.050 - 0.070 (0.0020 - 0.0028)

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

PISTON RING

Unit: mm (in)

		Standard	Limit
Side clearance	Top	0.050 - 0.090 (0.0020 - 0.0035)	0.1 (0.004)
	2nd	0.050 - 0.090 (0.0020 - 0.0035)	0.1 (0.004)
	Oil ring	0.030 - 0.070 (0.0012 - 0.0028)	—
End gap	Top	0.21 - 0.31 (0.0083 - 0.0122)	1.0 (0.039)
	2nd	0.37 - 0.52 (0.0146 - 0.0205)	1.0 (0.039)
	Oil (rail ring)	0.30 - 0.55 (0.0118 - 0.0217)	1.0 (0.039)

PISTON PIN

Unit: mm (in)

Piston pin outer diameter		27.994 - 28.000 (1.1021 - 1.1024)
Interference fit of piston pin to piston		0.002 - 0.006 (0.0001 - 0.0002)
Piston pin to connecting rod bushing clearance	Standard	0.026 - 0.044 (0.0010 - 0.0017)
	Limit	0.057 (0.0022)

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

Connecting Rod

Unit: mm (in)

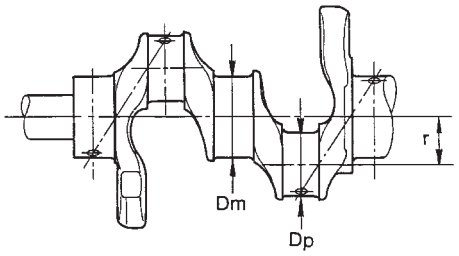
Center distance		154.47 - 154.53 (6.0815 - 6.0838)
Bend [per 100 (3.94)]	Limit	0.12 (0.0047)
Torsion [per 100 (3.94)]	Limit	0.12 (0.0047)
Connecting rod small end inner diameter		30.080 - 31.000 (1.1842 - 1.2205)
Piston pin bushing inner diameter*		28.026 - 28.038 (1.1034 - 1.1039)
Connecting rod big end inner diameter		55.000 - 55.013 (2.1654 - 2.1659)
Side clearance	Standard	0.200 - 0.350 (0.0079 - 0.0138)
	Limit	0.4 (0.016)

*: After installing in connecting rod

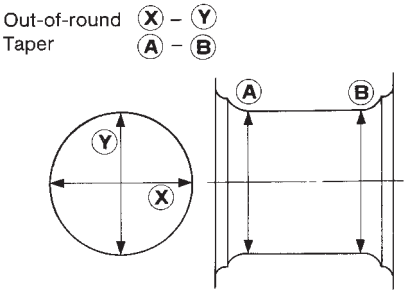
Crankshaft

Unit: mm (in)

Main journal dia. “Dm” grade	Grade No. 0 Grade No. 1 Grade No. 2	62.967 - 62.975 (2.4790 - 2.4793) 62.959 - 62.967 (2.4787 - 2.4790) 62.951 - 62.959 (2.4784 - 2.4787)
Pin journal dia. “Dp”	Grade No. 0	51.968 - 51.974 (2.0460 - 2.0462)
	Grade No. 1	51.961 - 51.968 (2.0457 - 2.0460)
	Grade No. 2	51.954 - 51.961 (2.0454 - 2.0457)
Center distance “r”		49.97 - 50.03 (1.9673 - 1.9697)
Out-of-round (X − Y)	Standard/Limit	Less than 0.003 (0.0001)/Less than 0.005 (0.0002)
Taper (A − B)	Standard/Limit	Less than 0.003 (0.0001)/Less than 0.005 (0.0002)
Runout [TIR*]	Standard	Less than 0.05 (0.0020)
	Limit	Less than 0.10 (0.0039)
Free end play	Standard	0.085 - 0.25 (0.0033 - 0.0098)
	Limit	0.30 (0.0118)



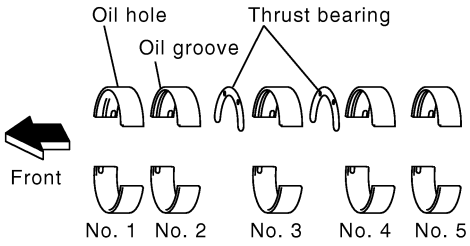
SEM645



EM715

*: Total indicator reading

Available Main Bearing



SEM255G

Grade number	Thickness “T” mm (in)	Width “W” mm (in)	Identification color
0	1.816 - 1.820 (0.0715 - 0.0717)	19.9 - 20.1 (0.783 - 0.791)	Black
1	1.820 - 1.824 (0.0717 - 0.0718)		Brown
2	1.824 - 1.828 (0.0718 - 0.0720)		Green
3	1.828 - 1.832 (0.0720 - 0.0721)		Yellow
4	1.832 - 1.836 (0.0721 - 0.0723)		Blue

Available Main Bearing (Cont'd)

UNDERSIZE

Unit: mm (in)

	Thickness	Main journal diameter "Dm"
0.25 (0.0098)	1.949 - 1.953 (0.0767 - 0.0769)	Grind so that bearing clearance is the specified value.

Available Connecting Rod Bearing

CONNECTING ROD BEARING

Grade number	Thickness "T" mm (in)	Width "W" mm (in)	Identification color (mark)
0	1.492 - 1.496 (0.0587 - 0.0589)	22.9 - 23.1 (0.902 - 0.909)	Black
1	1.496 - 1.500 (0.0589 - 0.0591)		Brown
2	1.500 - 1.504 (0.0591 - 0.0592)		Green

UNDERSIZE

Unit: mm (in)

	Thickness	Crank pin journal diameter "Dp"
0.08 (0.0031)	1.536 - 1.540 (0.0605 - 0.0606)	Grind so that bearing clearance is the specified value.
0.12 (0.0047)	1.556 - 1.560 (0.0613 - 0.0614)	
0.25 (0.0098)	1.621 - 1.625 (0.0638 - 0.0640)	

Miscellaneous Components

Unit: mm (in)

Flywheel runout [TIR]*	Less than 0.15 (0.0059)

*: Total indicator reading

BEARING CLEARANCE

Unit: mm (in)

Main bearing clearance	Standard	0.039 - 0.066 (0.0015 - 0.0026)
	Limit	0.10 (0.0039)
Connecting rod bearing clearance	Standard	0.031 - 0.061 (0.0012 - 0.0024)
	Limit	0.09 (0.0035)

General Specifications

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

Compression Pressure

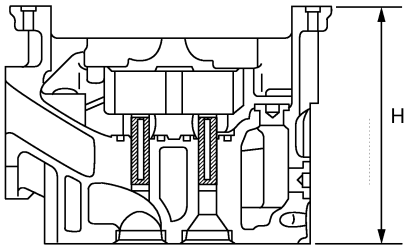
Unit: kPa (bar, kg/cm^2, psi)/200 rpm

Compression pressure	Standard	2,942 (29.4, 30.0, 427)
	Minimum	2,452 (24.5, 25.0, 356)
	Differential limit between cylinders	294 (2.94, 3.0, 43)

Cylinder Head

Unit: mm (in)

	Standard	Limit
Head surface distortion	Less than 0.03 (0.0012)	0.2 (0.008)



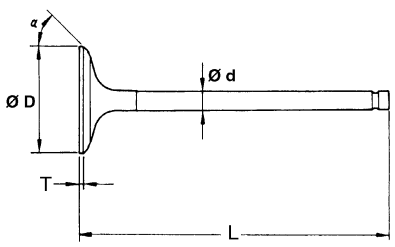
Nominal cylinder head height:
H = 156.9 - 157.1 mm (6.177 - 6.185 in)

SEM368G

Valve

VALVE

Unit: mm (in)



FEM067

Valve (Cont'd)

Valve head diameter "D"	Intake	31.9 - 32.1 (1.2559 - 1.2638)
	Exhaust	29.9 - 30.1 (1.177 - 1.185)
Valve length "L"	Intake	113.5 (4.468)
	Exhaust	113.5 (4.468)
Valve stem diameter "d"	Intake	6.962 - 6.977 (0.2741 - 0.2747)
	Exhaust	6.945 - 6.960 (0.2734 - 0.2740)
Valve seat angle "α"	Intake	45°00′ - 45°30′
	Exhaust	
Valve margin "T"	Intake	1.5 (0.059)
	Exhaust	1.5 (0.059)

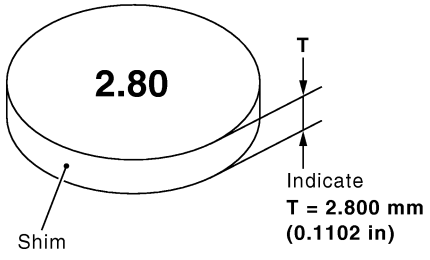
VALVE CLEARANCE

Unit: mm (in)

	Cold
Intake	0.30 - 0.40 (0.012 - 0.016)
Exhaust	0.30 - 0.40 (0.012 - 0.016)

ADJUSTING SHIMS

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



SEM252G

Valve (Cont'd)

VALVE SPRING

Free height	mm (in)	55.43 (2.1823)
Pressure	N (kg, lb) at height mm (in)	336 - 372 (34.3 - 37.9, 75.6 - 83.6) at 32.3 (1.2717)
Out-of-square	mm (in)	2.4 (0.094)

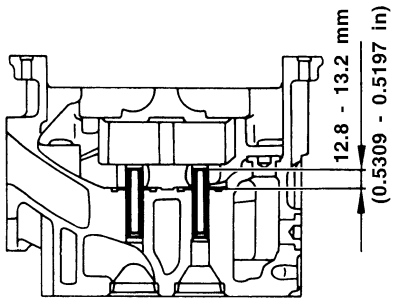
VALVE LIFTER

Unit: mm (in)

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

VALVE GUIDE

Unit: mm (in)

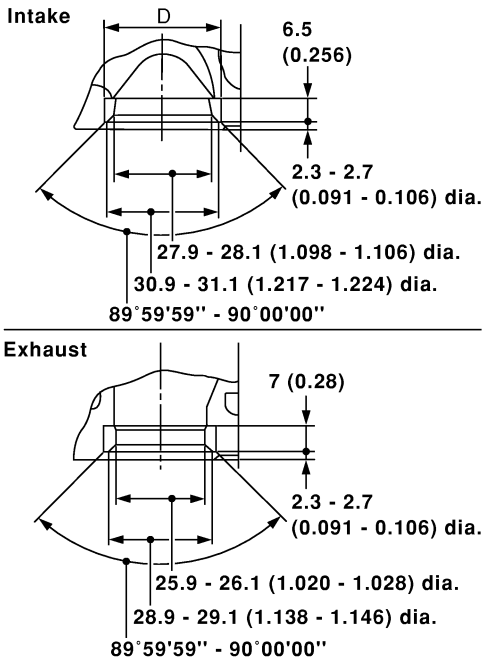


SEM833G

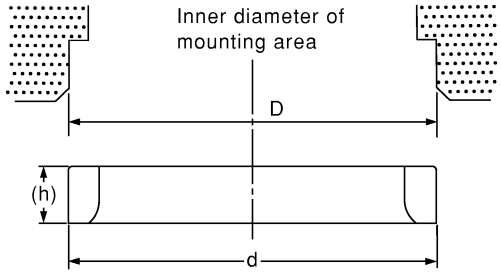
Valve guide	Outer diameter	11.023 - 11.034 (0.4340 - 0.4344)
	Inner diameter (Finished size)	7.000 - 7.015 (0.2756 - 0.2762)
Cylinder head valve guide hole diameter		10.996 - 10.975 (0.4329 - 0.4321)
Interference fit of valve guide		0.027 - 0.059 (0.0011 - 0.0023)
Stem to guide clearance	Intake	0.023 - 0.053 (0.0009 - 0.0021)
	Exhaust	0.040 - 0.070 (0.0016 - 0.0028)
Valve deflection limit	Intake	0.18 (0.0071)
	Exhaust	0.10 (0.0039)
Projection length		12.8 - 13.2 (0.5309 - 0.5197)

Valve Seat

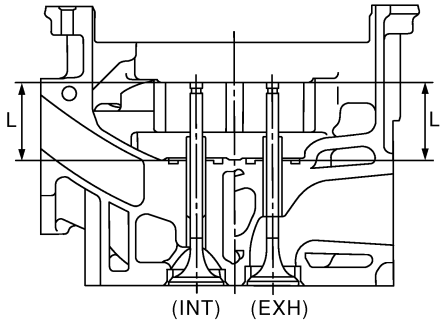
Unit: mm (in)



SEM374G



SEM373GA



SEM375GA

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

Valve Seat (Cont'd)

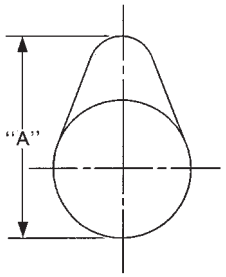
Valve seat outer diameter (d)	Intake	33.065 - 33.078 (1.3018 - 1.3023)
	Exhaust	31.550 - 31.561 (1.2421 - 1.2426)
Height (h)	Intake	6.75 - 6.85 (0.2657 - 0.2697)
	Exhaust	7.35 - 7.45 (0.2894 - 0.2933)
Depth (L)	Intake	43.65 - 44.35 (1.7185 - 1.7461)
	Exhaust	43.65 - 44.35 (1.7185 - 1.7461)

Camshaft and Camshaft Bearing

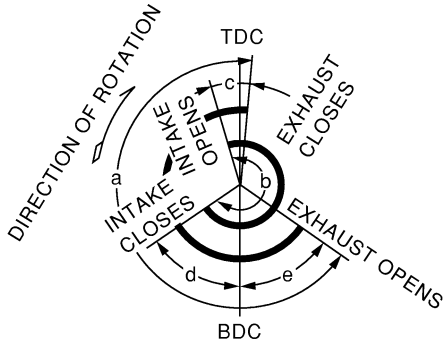
Unit: mm (in)

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

*: Total indicator reading



EM671

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

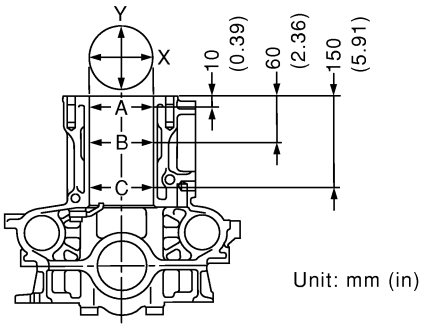
SEM372G

Unit: degree

a	b	c	d	e
234	220	10	34	50

Cylinder Block

Unit: mm (in)



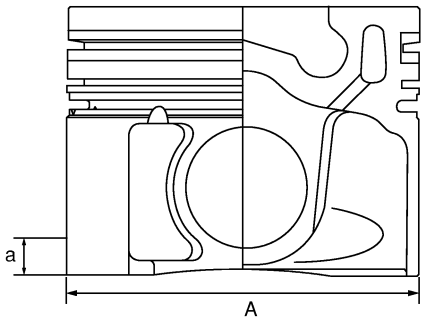
SEM370GB

Surface flatness	Standard			Less than 0.03 (0.0012)
	Limit			0.1 (0.004)
Cylinder bore	Inner diameter	Standard	Grade No. 1	96.000 - 96.010 (3.7795 - 3.7799)
			Grade No. 2	96.010 - 96.020 (3.7799 - 3.7803)
			Grade No. 3	96.020 - 96.030 (3.7803 - 3.7807)
		Wear limit		0.20 (0.0079)
Out-of-round (X − Y)				Less than 0.02 (0.0008)
Taper (C − A)				Less than 0.02 (0.0008)
Main journal inner diameter (Without bearing)				74.981 - 75.000 (2.9520 - 2.9528)
Difference in inner diameter between cylinders	Limit			Less than 0.05 (0.0020)

Piston, Piston Ring and Piston Pin

AVAILABLE PISTON

Unit: mm (in)



SEM369G

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

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

PISTON RING

Unit: mm (in)

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

PISTON PIN

Unit: mm (in)

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

Connecting Rod

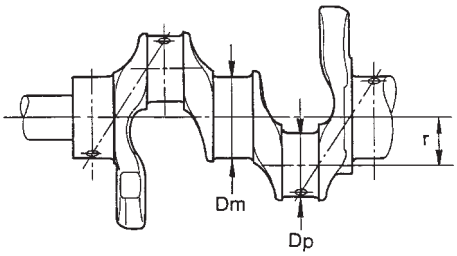
Unit: mm (in)

Center distance		154.5 (6.083)
Bend [per 100 (3.94)]	Limit	0.05 (0.0020)
Torsion [per 100 (3.94)]	Limit	0.05 (0.0020)
Connecting rod small end inner diameter		33.025 - 33.038 (1.3002 - 1.3007)
Connecting rod big end inner diameter		59.987 - 60.000 (2.3617 - 2.3622)
Side clearance	Standard	0.10 - 0.22 (0.0039 - 0.0087)
	Limit	0.22 (0.0087)

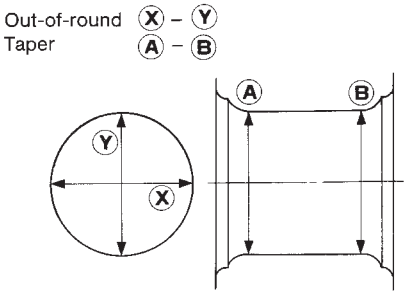
Crankshaft

Unit: mm (in)

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



SEM645

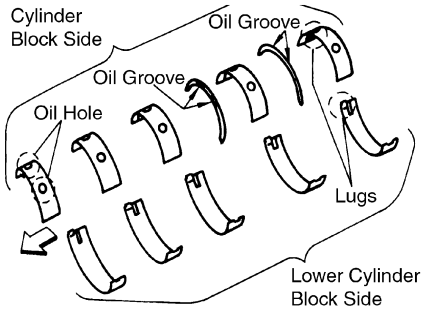


EM715

*: Total indicator reading

Available Main Bearing

UNDERSIZE



FEM127

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

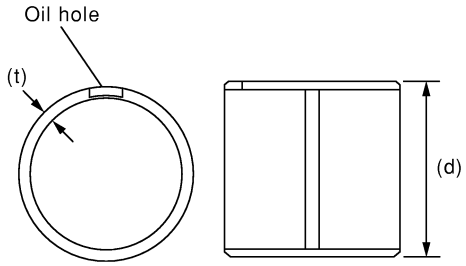
Available Connecting Rod Bearing

CONNECTING ROD BEARING

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

BALANCER SHAFT BUSHING

Unit: mm (in)



SEM371G

Balancer shaft bearing inner diameter*	Front	50.940 - 51.010 (2.0055 - 2.0083)
	Rear	50.740 - 50.810 (1.9976 - 2.0004)
Balancer shaft journal outer diameter	Front	50.875 - 50.895 (2.0029 - 2.0037)
	Rear	50.675 - 50.695 (1.9951 - 1.9959)
Balancer shaft journal oil clearance	Standard	0.045 - 0.135 (0.0018 - 0.0053)
	Limit	0.180 (0.0071)
Balancer shaft bushing outer diameter (d)	Front	54.090 - 54.130 (2.1295 - 2.1311)
	Rear	53.890 - 53.930 (2.1216 - 2.1232)

*: With cylinder block pressed-in

Miscellaneous Components

Unit: mm (in)

Flywheel runout limit [TIR]*	0.1 (0.004)

*: Total indicator reading

BEARING CLEARANCE

Unit: mm (in)

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