ENGINE MECHANICAL

SECTION EM

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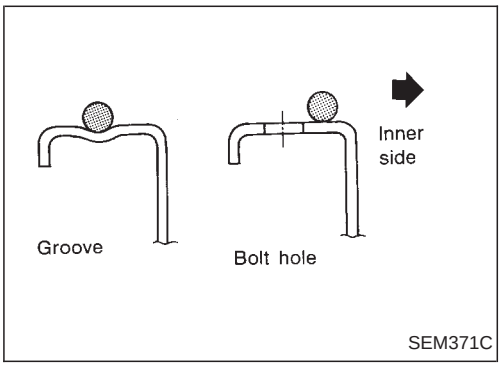
Parts Requiring Angular Tightening

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



Liquid Gasket Application Procedure

a. Before applying liquid gasket, use a scraper to remove all traces of old liquid gasket from mating surface.

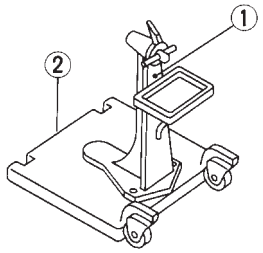
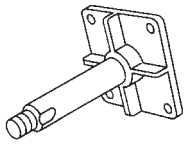
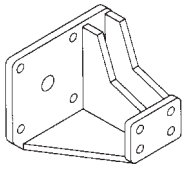
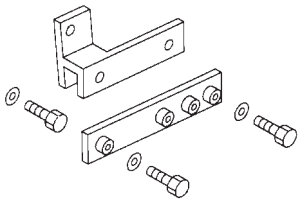
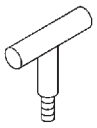
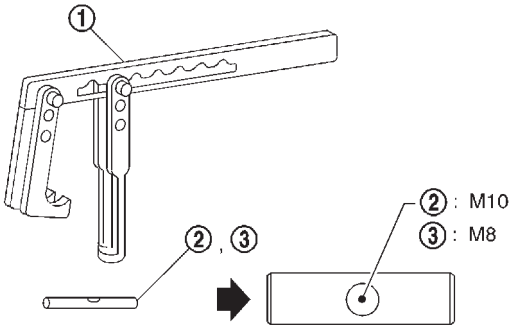
b. Apply a continuous bead of liquid gasket to mating surfaces. (Use Genuine Liquid Gasket or equivalent.)
- **Be sure liquid gasket is specified width (for oil pan) 3.5 to 4.5 mm (0.138 to 0.177 in) for gasoline engine.**
- **Be sure liquid gasket is 2.0 to 3.0 mm (0.079 to 0.118 in) wide in areas except oil pan for TB and RD series engines and 2.5 to 3.5 mm (0.098 to 0.138 in) for TD series engine.**

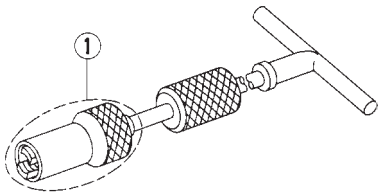
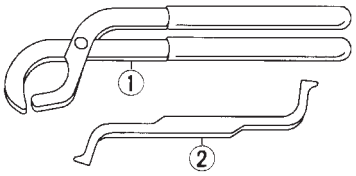
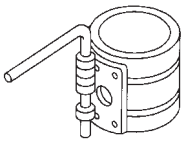
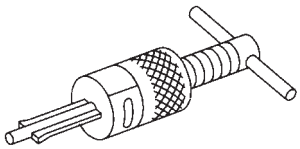
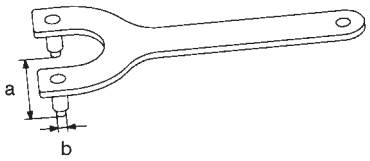
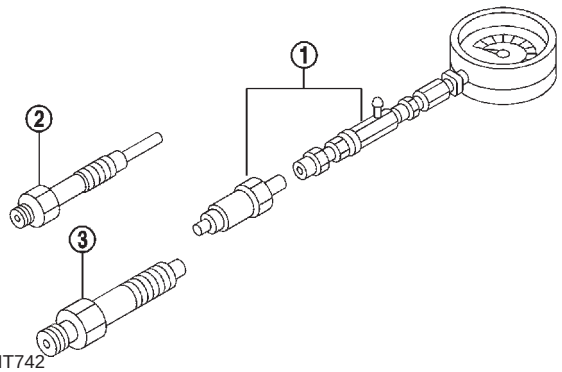
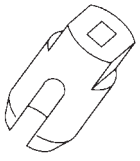
c. Apply liquid gasket to inner surface around hole perimeter area.
(Assembly should be done within 5 minutes after coating.)

d. Wait at least 30 minutes before refilling engine oil and engine coolant.

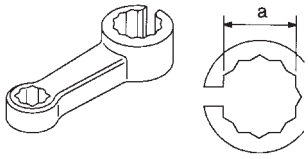
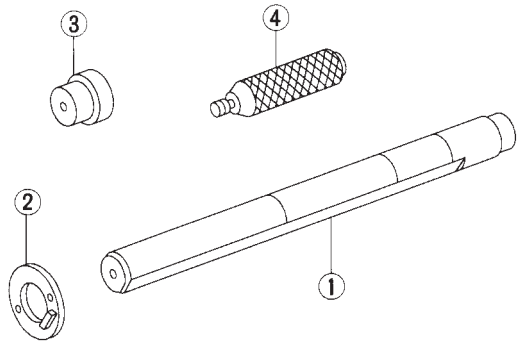
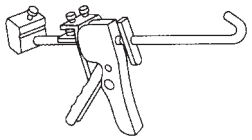
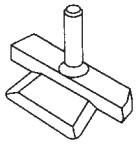
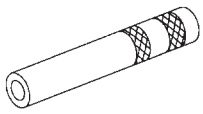
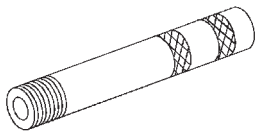
SPECIAL SERVICE TOOLS

* Special tool or commercial equivalent

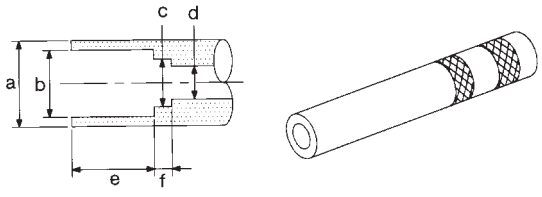
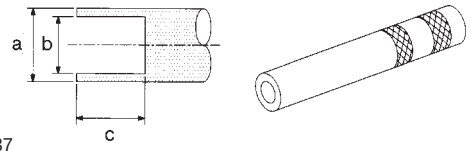
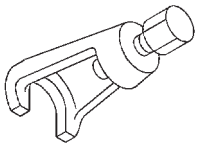
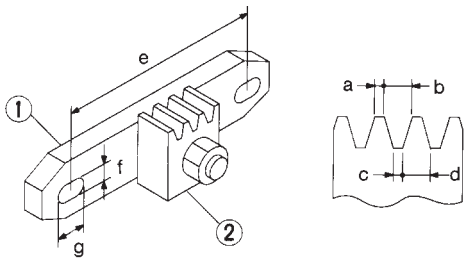
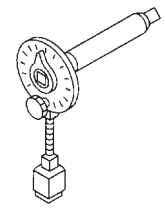
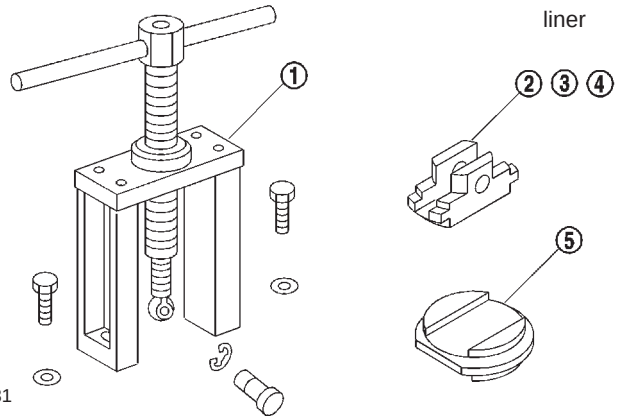
Tool number Tool name	Description		Engine application		
			TB	RD	TD
ST0501S000* Engine stand assembly ① ST05011000 Engine stand ② ST05012000 Base	 NT042	Disassembling and assembling	X	X	X
KV10106500* Engine stand shaft	 NT028		X	X	X
KV11104800* Engine sub-attachment	 NT577		X	—	X
KV1011070 Engine sub-attachment	 NT582		—	X	—
KV10111200* Adapter	 NT687	Disassembling and assembling valve components	X	—	X
KV101092S0 Valve spring compressor ① KV10109210 Compressor ② KV10109220 Adapter	 NT718	Disassembling and assembling valve components	X	X	X

Tool number Tool name	Description		Engine application		
			TB	RD	TD
KV10107902 Valve oil seal puller ① KV10116100 Valve oil seal puller adapter	 NT605		—	X	X
KV101151S0 Lifter stopper set ① KV10115110 Camshaft pliers ② KV10115120 Lifter stopper	 NT041	Changing shims	—	X	—
EM03470000* Piston ring compressor	 NT044	Installing piston assembly into cylinder bore	X	X	X
ST16610001* Pilot bushing puller	 NT045	Removing crankshaft pilot bushing	X	X	X
KV10109300 Puller holder	 NT628	**a = 68 mm (2.68 in)** **b = 8 mm (0.31 in) dia.**	—	X	X
① ED19601000 Compression gauge ② ED19600600 Compression gauge adapter (for glow plug hole) ③ ED19600700 Compression gauge adapter (for injector hole)	 NT742	Checking compression pressure	—	X	X
KV11100300 Nozzle holder socket	 NT563		—	X	—

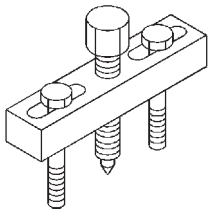
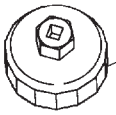
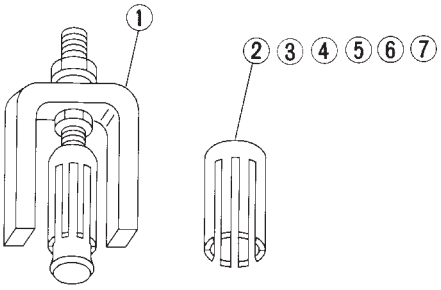
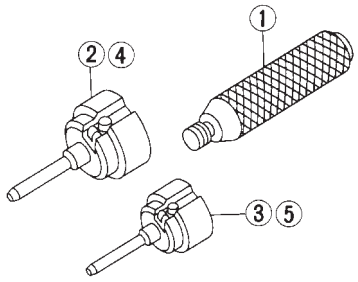
* Special tool or commercial equivalent

Tool number Tool name	Description		Engine application		
			TB	RD	TD
KV10114400 Heated oxygen sensor wrench	 NT636	Loosening or tightening heated oxygen sensor **a = 22 mm (0.87 in)**	X	—	—
KV111045S0 Cam bushing replacer set ① KV11104510 Replacer bar ② KV11104520 Guide plate ③ KV11104530 Adapter (1st bushing) ④ ST15243000 Drift	 NT258	Removing and installing cam bushing	X	—	X
WS39930000* Tube presser	 NT052	Pressing the tube of liquid gasket	X	X	X
KV10111100 Seal cutter	 NT046	Removing oil pan	X	—	X
KV10113000 Valve oil seal drift	 NT027	Installing valve oil seal	X	—	—
KV10107501 Valve oil seal drift	 NT741		—	X	—

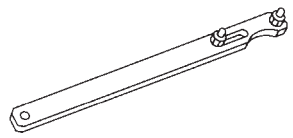
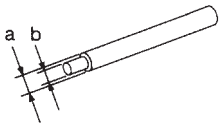
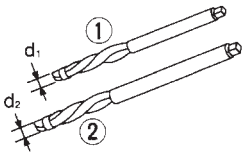
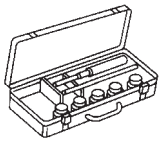
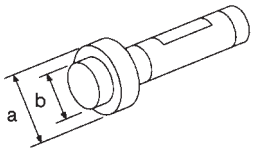
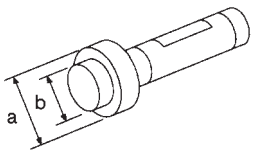
* Special tool or commercial equivalent

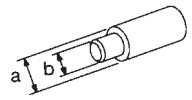
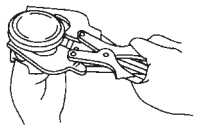
Tool number Tool name	Description		Engine application		
			TB	RD	TD
KV11105300 Valve oil seal drift	 NT602	Installing valve oil seal **a: 20 (0.79) dia.** **b: 14.6 (0.575) dia.** **c: 13.3 (0.524) dia.** **d: 8.5 (0.335) dia.** **e: 17.5 (0.689)** **f: 4.5 (0.177)** Unit: mm (in)	—	—	X
KV11105400* Valve guide drift	 NT637	Installing valve guide **a: 20 (0.79) dia.** **b: 12.2 (0.480) dia.** **c: 16 (0.63)** Unit: mm (in)	—	—	X
ST29020001 Steering gear arm puller	 NT725	Removing pitman arm	X	—	—
KV111033S0 Engine stopper ① KV10105610 Stopper plate ② KV10105630 Stopper gear	 NT616	Preventing crankshaft from rotating **a: 3 (0.12)** **b: 6.4 (0.252)** **c: 2.8 (0.110)** **d: 6.6 (0.260)** **e: 119 (4.69)** **f: 12 (0.47)** **g: 18 (0.71)** Unit: mm (in)	X	X	X
KV10112100 Angle wrench	 NT014	Tightening bolts for bearing cap, cylinder head, etc.	—	—	X
① KV11104010 Cylinder liner tool ② KV11104020 Adapter for removing ③ KV11104700 Adapter for removing ④ KV11104110 Adapter for removing ⑤ KV11104030 Adapter for installing	 NT681	Removing and installing cylinder liner	— — — — —	— — — — —	X — — X X

* Special tool or commercial equivalent

Tool number Tool name	Description	Engine application		
		TB	RD	TD
KV11103000* Injection pump drive gear puller	Removing drive gear  NT676	—	—	X
KV10106001* Oil filter wrench	Removing oil filter  15 faces, inner span: 92.5 mm (3.642 in) (Face to opposite corner) NT690	—	—	X
① KV11101110 Valve seat remover ② KV11103510 Adapter (Intake) ③ KV11103520 Adapter (Exhaust) ④ KV11104910 Adapter (Intake) ⑤ KV11104920 Adapter (Exhaust) ⑥ KV11103610 Adapter (Intake) ⑦ KV11103620 Adapter (Exhaust)	Removing valve seat  NT251	— — — — — — —	— — — — — — —	X — — — — X X
① ST15243000 Valve seat drift ② KV11103710 Adapter (Intake) ③ KV11103720 Adapter (Exhaust) ④ KV11103810 Adapter (Intake) ⑤ KV11103820 Adapter (Exhaust)	Installing valve seat  NT252	— — — — —	— — — — —	X — — — —

COMMERCIAL SERVICE TOOLS

Tool name	Description		Engine application		
			TB	RD	TD
Pulley holder	 NT035	Holding camshaft pulley while tightening or loosening camshaft bolt	X	—	—
Valve guide drift	 NT015	Removing and installing valve guide **Intake & Exhaust** **TB and TD engines** **a = 11.5 mm (0.453 in) dia.** **b = 7.6 mm (0.299 in) dia.** **RD engine** **a = 11.5 mm (0.453 in) dia.** **b = 6.5 mm (0.256 in) dia.**	X	X	X
Valve guide reamer	 NT016	Reaming valve guide ① or hole for oversize valve guide ② **Intake & Exhaust** **TB engine** **d_1 = 8.0 mm (0.315 in) dia.** **d_2 = 12.2 mm (0.480 in) dia.** **RD engine** **d_1 = 7.000 mm (0.2756 in) dia.** **d_2 = 11.19 mm (0.4406 in) dia.** **TD engine** **d_1 = 8.0 mm (0.315 in) dia.**	X	X	X
Valve seat cutter set	 NT048	Finishing valve seat dimensions	X	X	X
Front oil seal drift	 NT049	Installing front oil seal **TB engine** **a = 80 mm (3.15 in) dia.** **b = 58 mm (2.28 in) dia.** **RD engine** **a = 52 mm (2.05 in) dia.** **b = 41 mm (1.61 in) dia.**	X	X	—
Rear oil seal drift	 NT049	Installing rear oil seal **a = 100 mm (3.94 in) dia.** **b = 78 mm (3.07 in) dia.**	—	X	—

Tool name	Description		Engine application		
			TB	RD	TD
Piston pin drift	 NT074	Removing and installing piston pin **a = 22.5 mm (0.886 in) dia.** **b = 12.5 mm (0.492 in) dia.**	X	X	—
Piston ring expander	 NT030	Removing and installing piston ring	X	X	X

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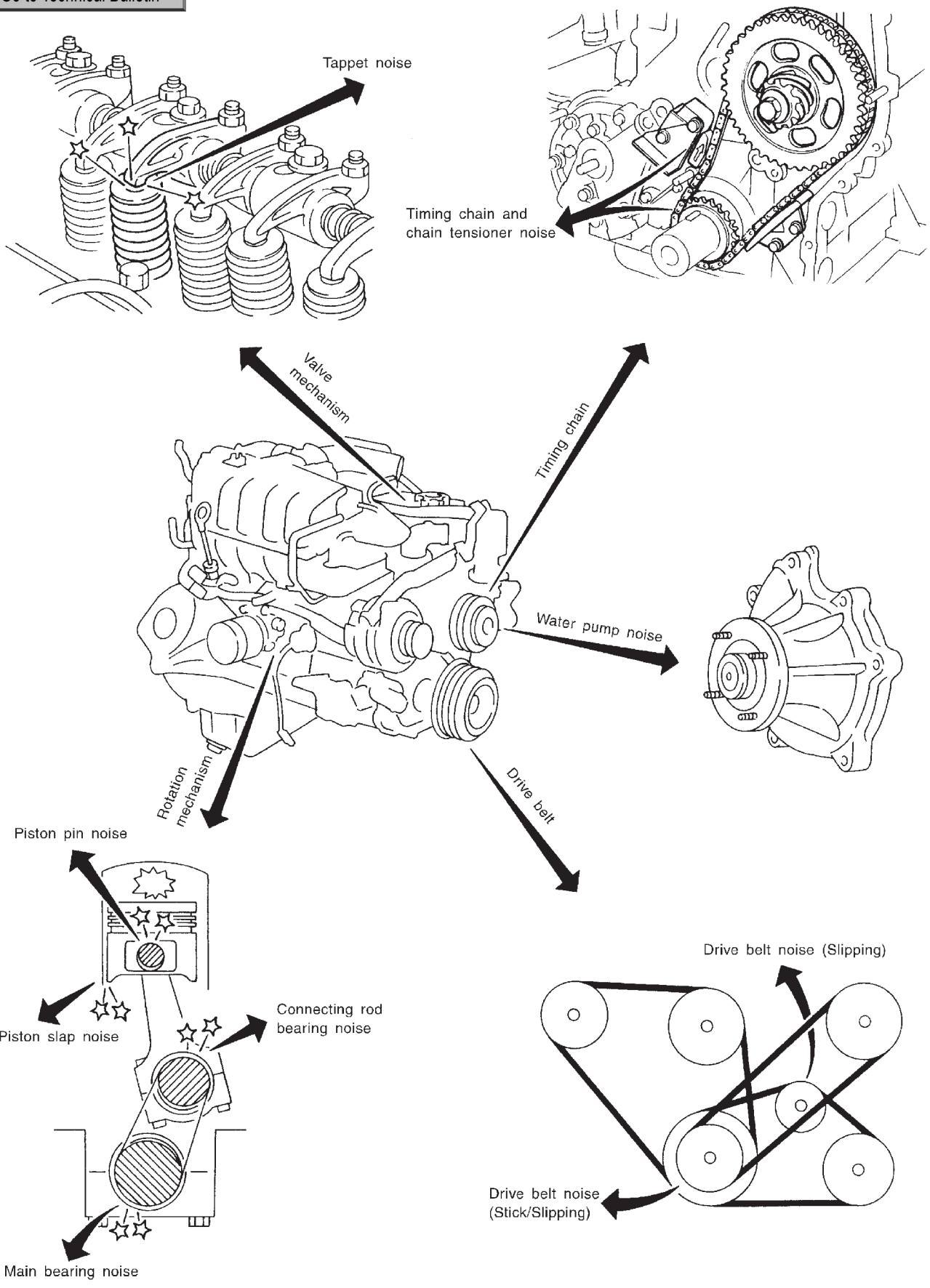


SEM735F

NVH Troubleshooting Chart — Engine Noise

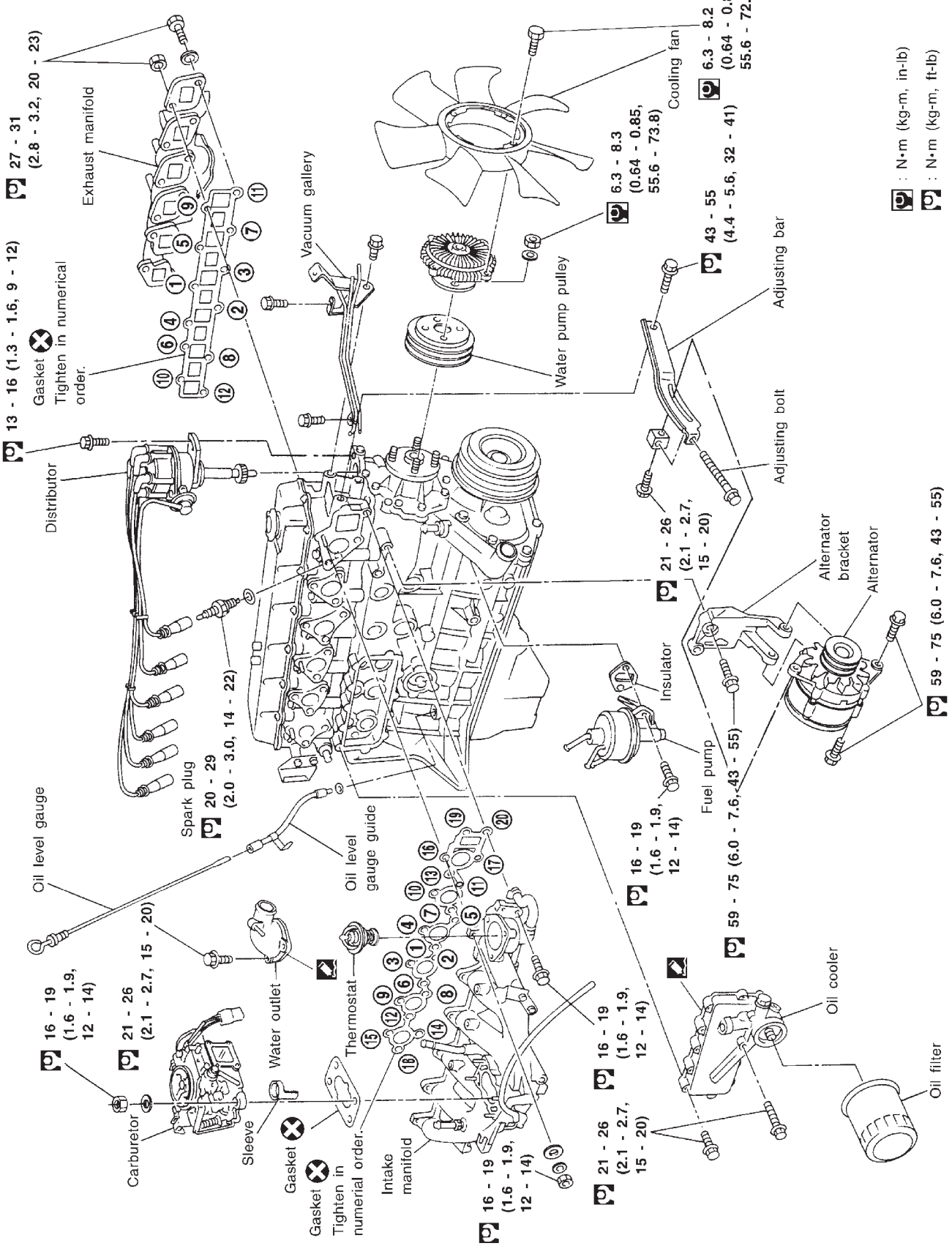
Use the chart below to help you find the cause of the symptom.
1. Locate the area where noise occurs.
2. Confirm the type of noise.
3. Specify the operating condition of engine.
4. Check specified noise source.

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-47
	Rattle	C	A	—	A	B	C	Camshaft bearing noise	Camshaft journal clearance Camshaft runout	EM-60, 61
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-54, 59
	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-55, 54
	Knock	A	B	C	B	B	B	Connecting rod bearing noise	Connecting rod bushing clearance (Small end) Connecting rod bearing clearance (Big end)	EM-59, 58
	Knock	A	B	—	A	B	C	Main bearing noise	Main bearing oil clearance Crankshaft runout	EM-57
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-25, 28, 31, 34
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”)

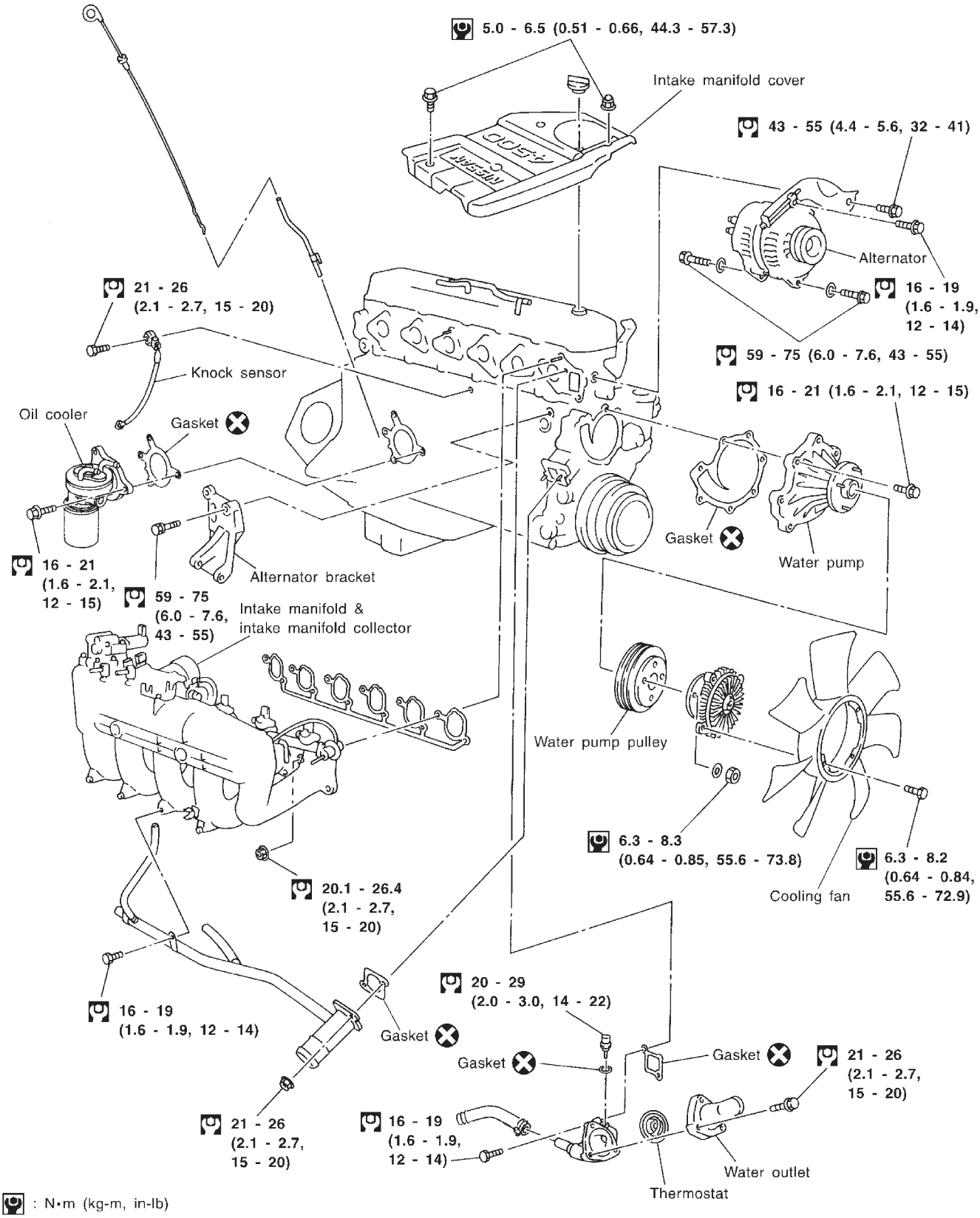
A: Closely related B: Related C: Sometimes related —: Not related

SEC. 110•140•150•160•170•210•213•220•221•230



SEM776F

SEC. 210•211•230•226•140

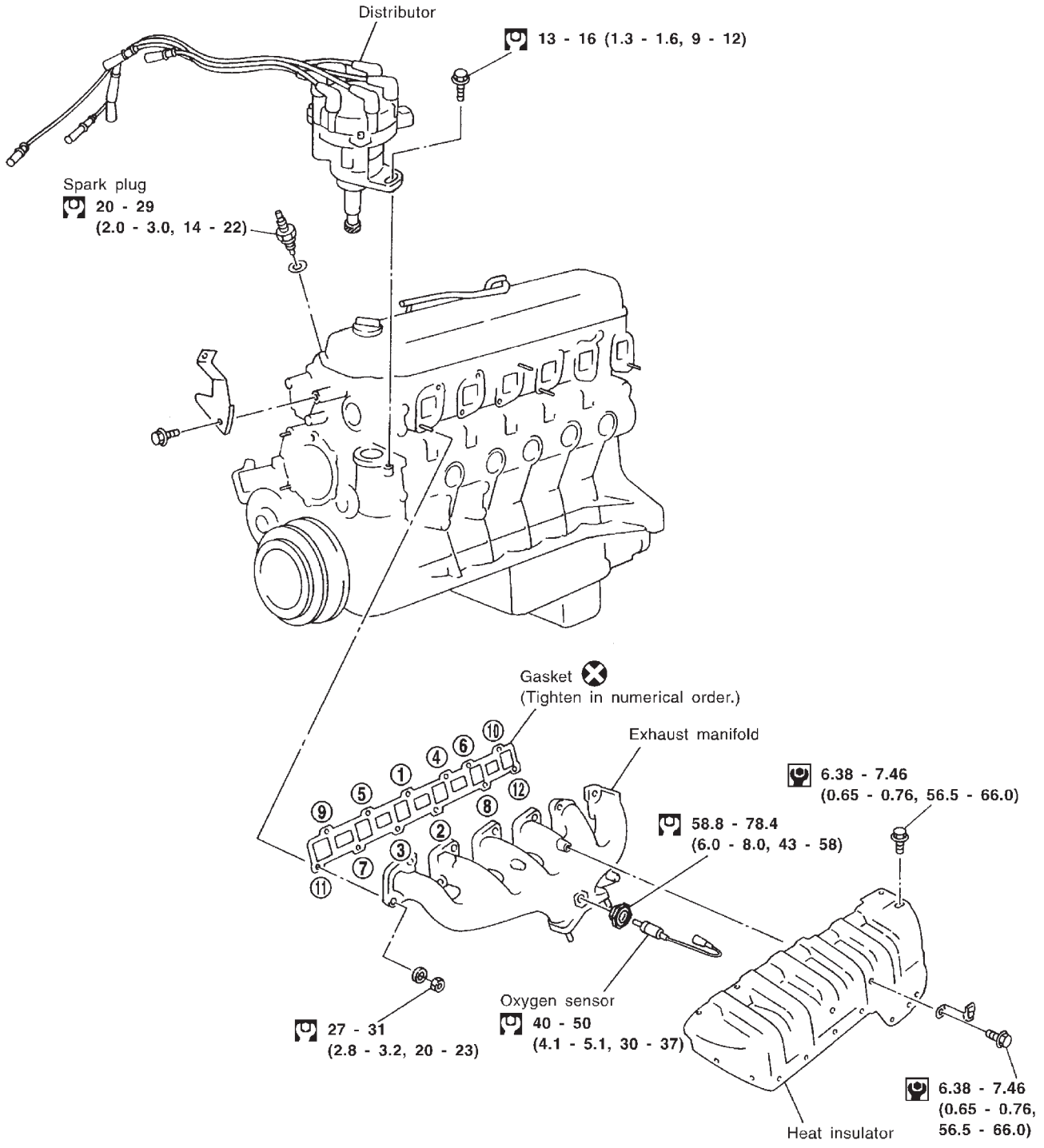


: N•m (kg-m, in-lb)

: N•m (kg-m, ft-lb)

SEM736F

SEC. 140•210•220•221

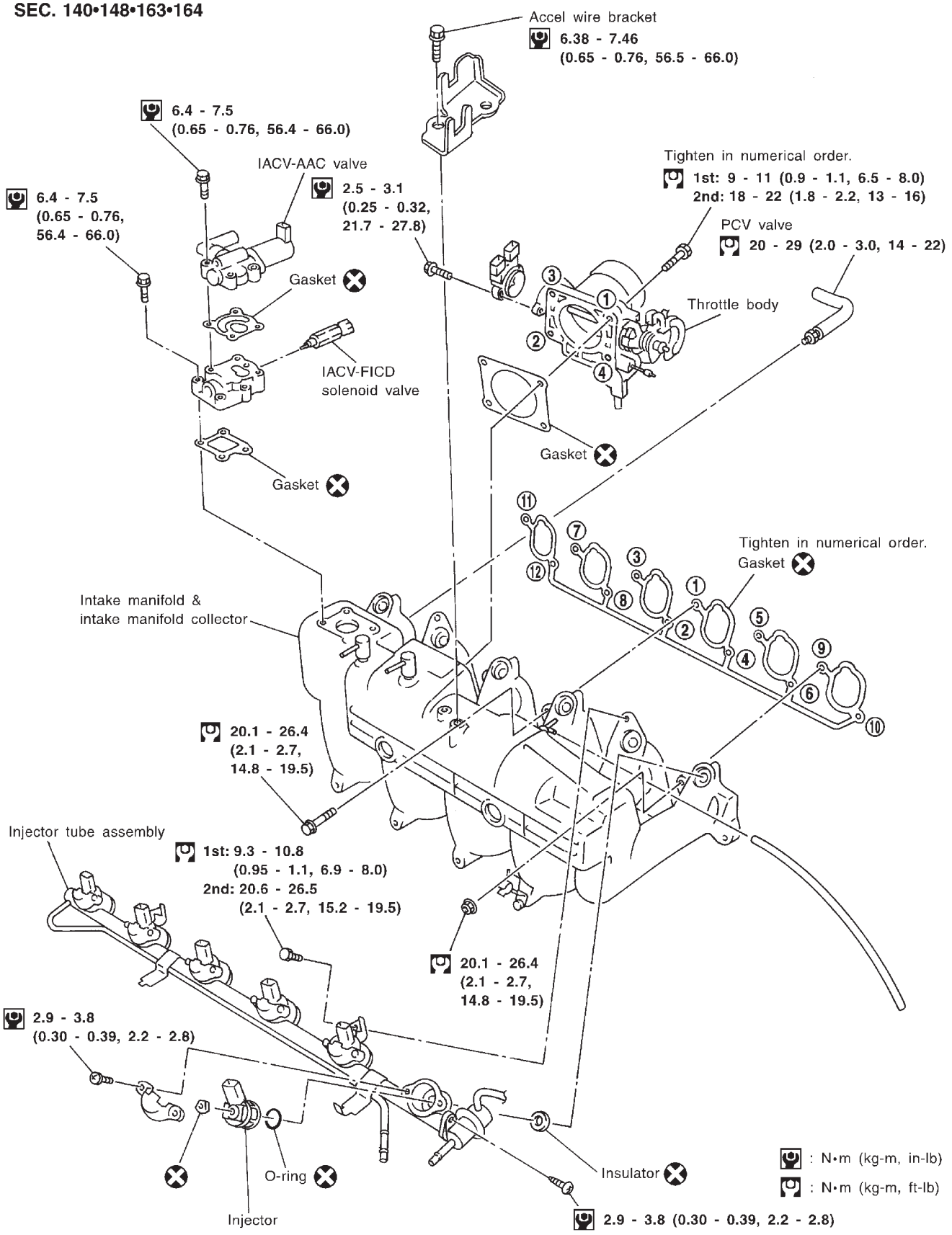


: N•m (kg-m, in-lb)

: N•m (kg-m, ft-lb)

SEM737F

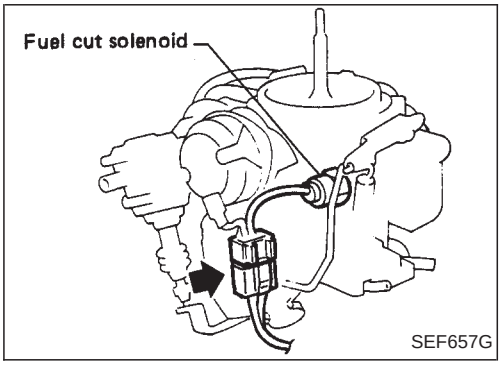
SEC. 140•148•163•164



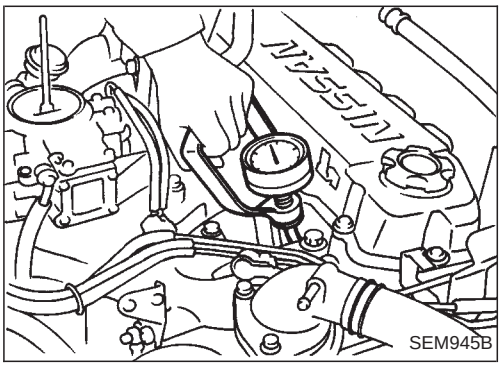
SEM738F

Measurement of Compression Pressure

1. Warm up engine.
2. Turn ignition switch OFF.
3. Remove air cleaner and all spark plugs.
4. Disconnect distributor center cable.



5. Disconnect fuel cut solenoid valve connector.



6. Attach a compression tester to No. 1 cylinder.
7. Depress accelerator pedal fully to keep throttle valve wide open.
8. Crank the engine and record the highest gauge indication.
9. Repeat the measurement on each cylinder as shown below.

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

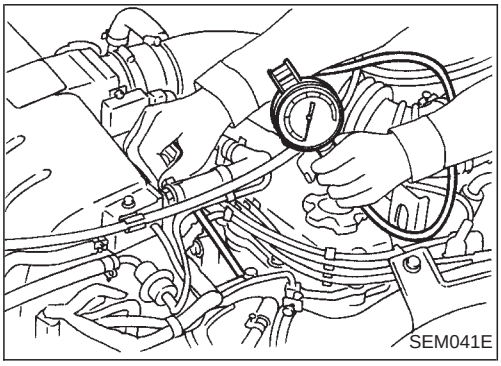
Compression pressure: kPa (bar, kg/cm^2, psi)/rpm
Standard
1,177 (11.77, 12.0, 171)/200
Minimum
883 (8.83, 9.0, 128)/200
Difference limit between cylinders:
98 (0.98, 1.0, 14)/200

10. If cylinder compression in one or more cylinders is low, pour a small amount of engine oil into cylinders through the spark plug holes and retest compression.

- **If adding oil helps the compression, piston rings may be worn or damaged. If so, replace piston rings after checking piston.**
- **If pressure stays low, a valve may be sticking or seating improperly. Inspect and repair valve and valve seat. (Refer to SDS.) If valve or valve seat is damaged excessively, replace them.**
- **If compression in any two adjacent cylinders is low and if adding oil does not help the compression, there is leakage past the gasket surface. If so, replace cylinder head gasket.**

Measurement of Compression Pressure

1. Warm up engine.
2. Turn ignition switch OFF.
3. Release fuel pressure.
   Refer to “Releasing Fuel Pressure” in EC section.
4. Remove air cleaner and all spark plugs.
5. Disconnect distributor center cable.



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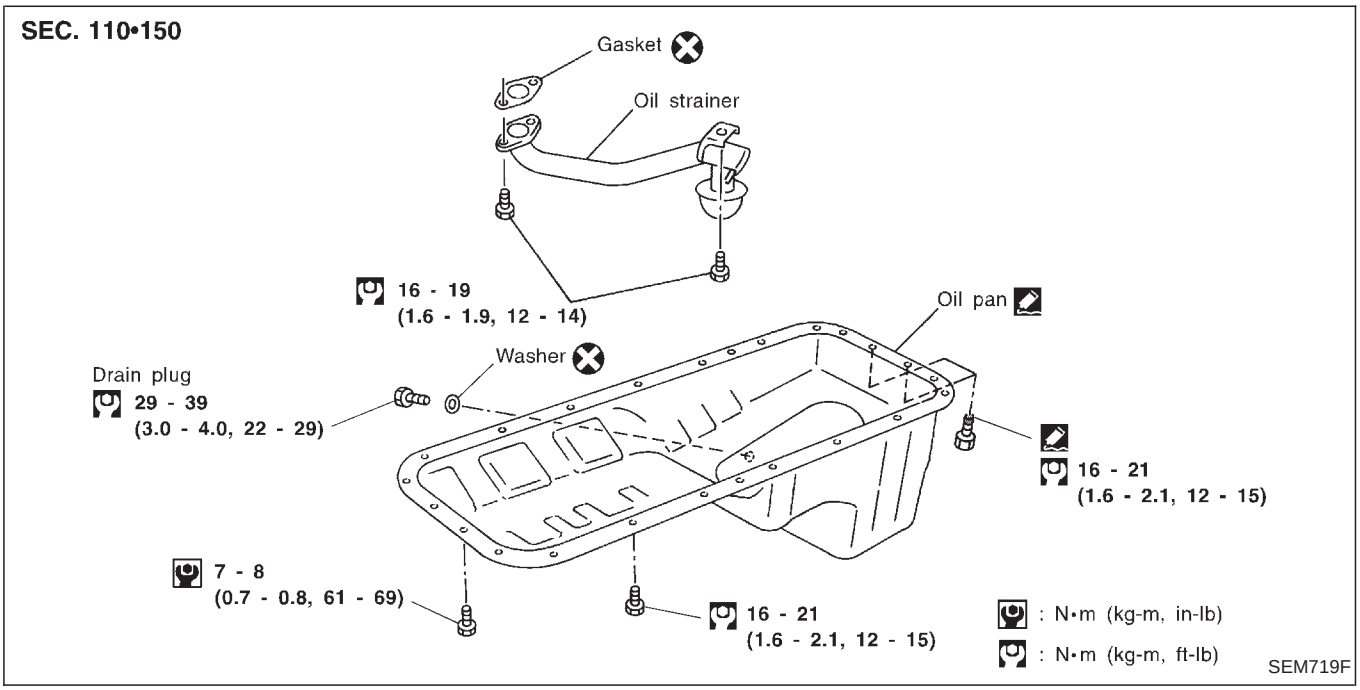
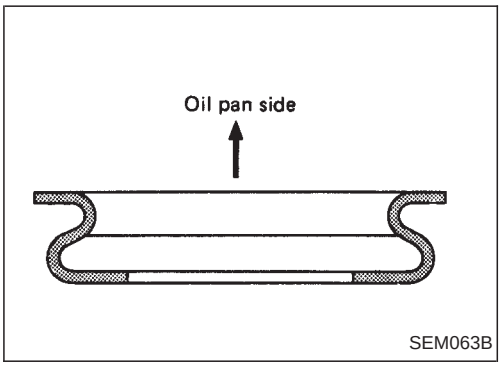
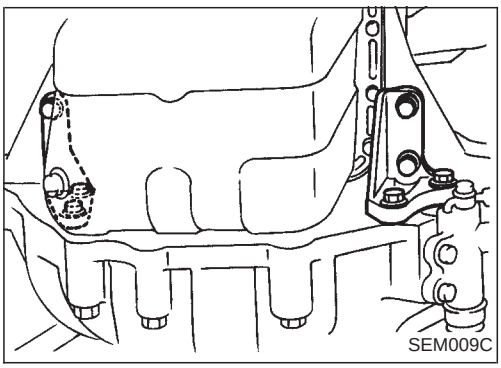


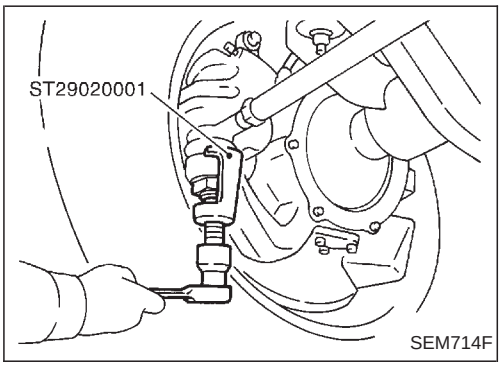


Removal

1. Drain engine oil.
- When installing drain plug washer, make sure it faces correct direction.

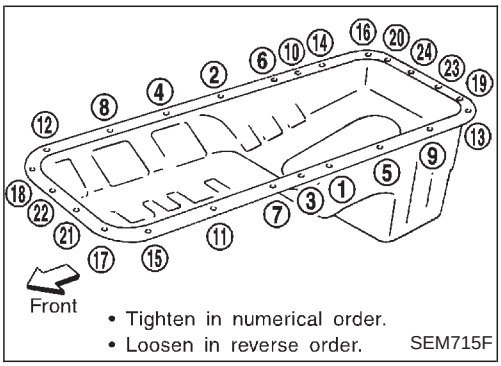


2. Remove engine gussets.

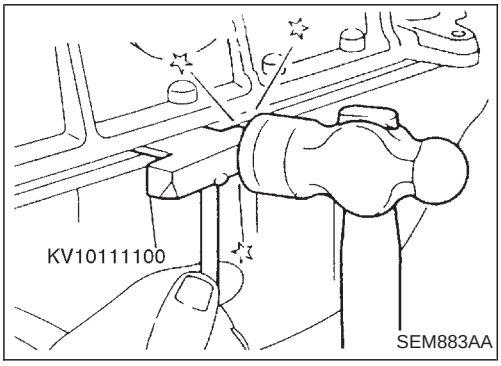


3. Remove left side of the tie rod end.

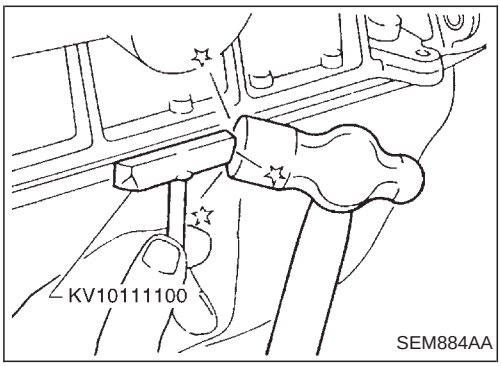
Removal (Cont'd)



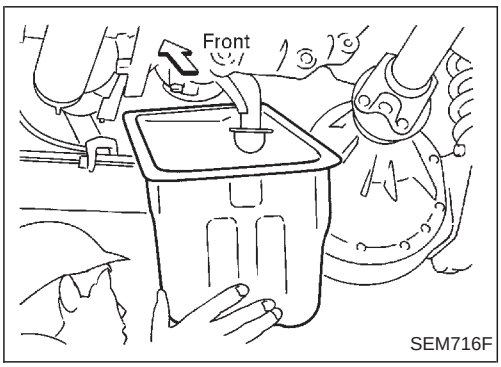
4. Remove oil pan bolts in numerical order.



5. Insert Tool between cylinder block and oil pan.
- **Do not insert screwdriver, or oil pan flange will be deformed.**
- **Do not insert Tool into rear oil seal retainer portion; otherwise, it will be damaged.**

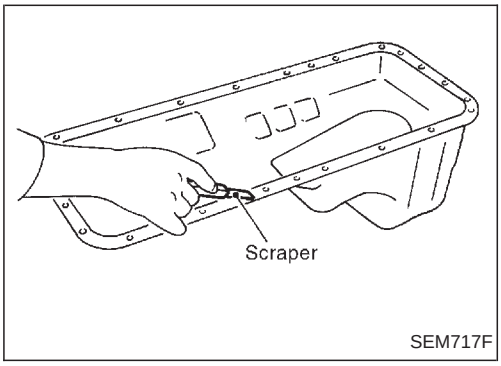


6. Slide Tool by tapping its side with a hammer.



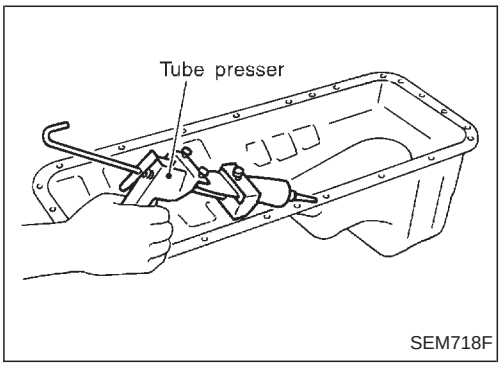
7. Remove oil pan.

Installation



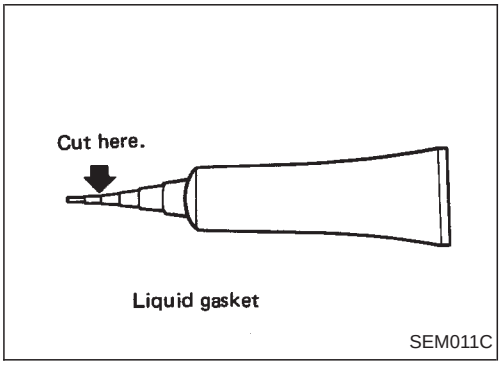
1. Before installing oil pan, remove all traces of liquid gasket from mating surface using a scraper.
- **Also remove traces of liquid gasket from mating surface of cylinder block.**

Installation (Cont'd)



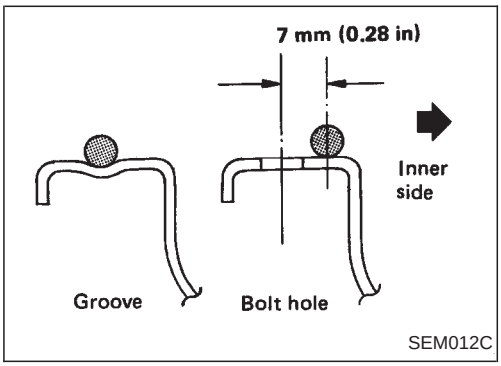
SEM718F

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



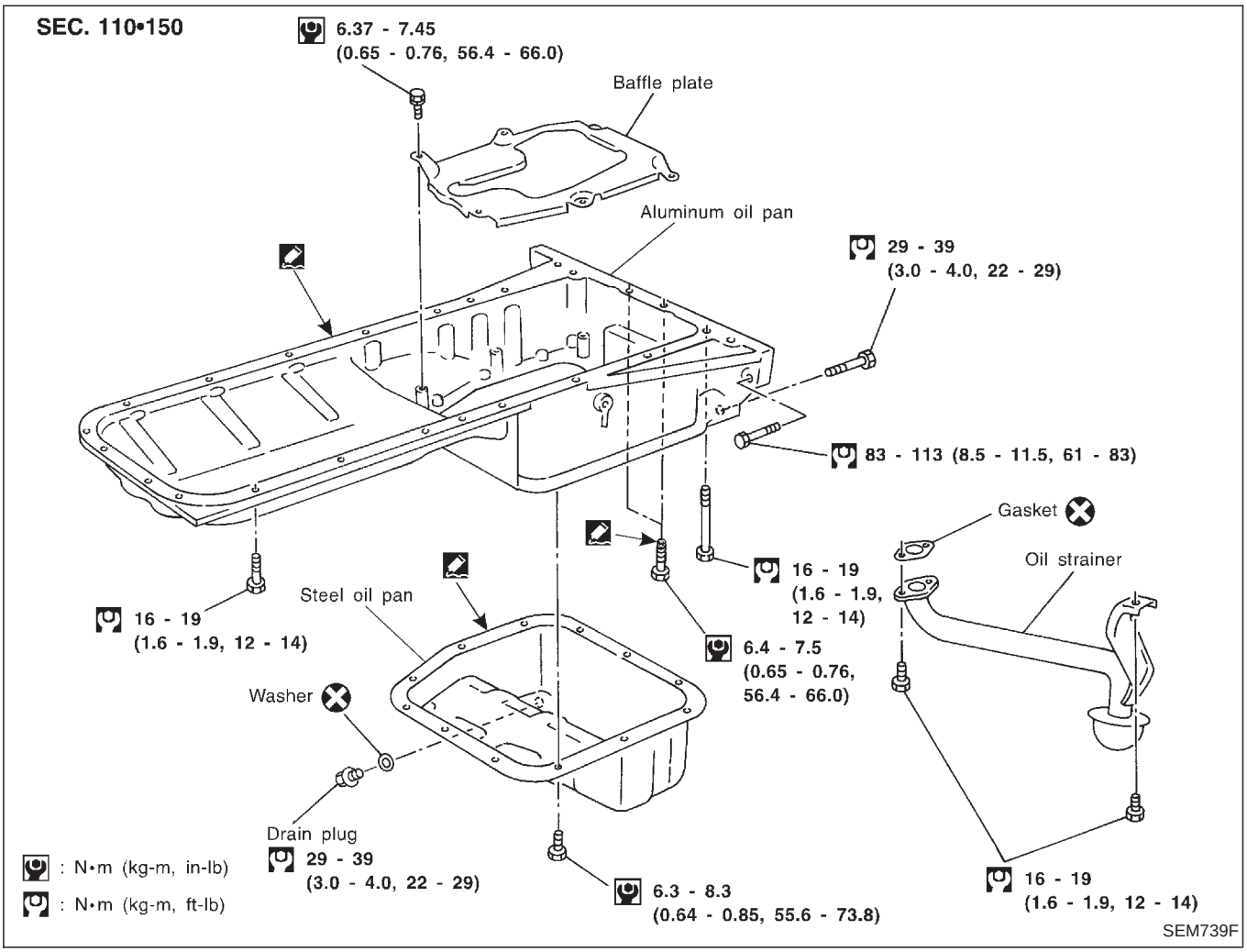
SEM011C

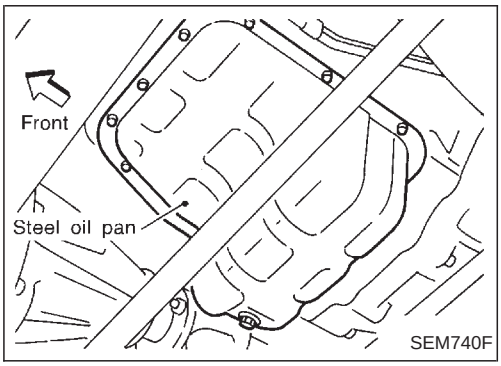
- **Be sure liquid gasket is 3.5 to 4.5 mm (0.138 to 0.177 in) wide.**



SEM012C

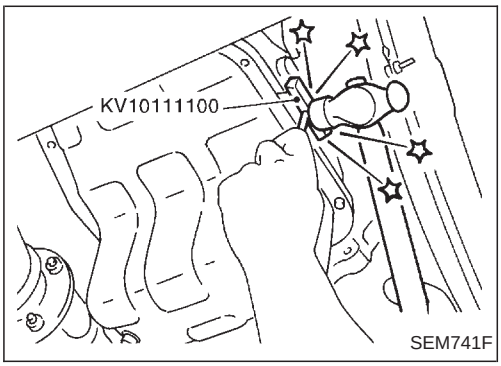
3. Apply liquid gasket to inner sealing surface instead of surface where there is no groove at bolt hole.
- **Attaching should be done within 5 minutes after coating.**
4. Install oil pan.
- Install parts in reverse order of removal.
- **Wait at least 30 minutes before refilling engine oil.**





Removal

1. Remove engine undercover.
2. Drain engine oil.
3. Remove steel oil pan bolts.

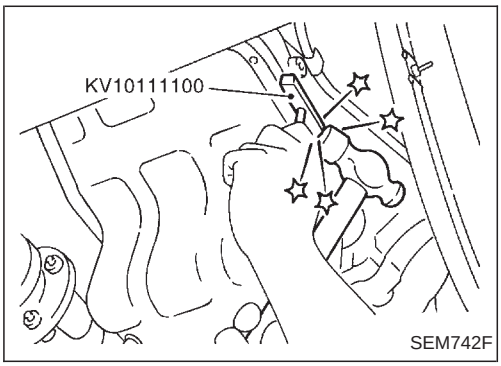


4. Remove steel oil pan.

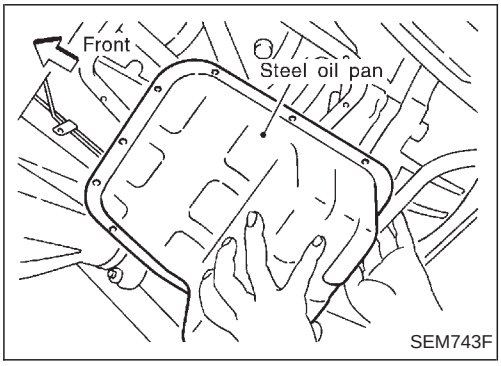
a. Insert Tool between aluminum oil pan and steel oil pan.

- **Be careful not to damage aluminum mating surface.**
- **Do not insert screwdriver, or oil pan flange will be deformed.**

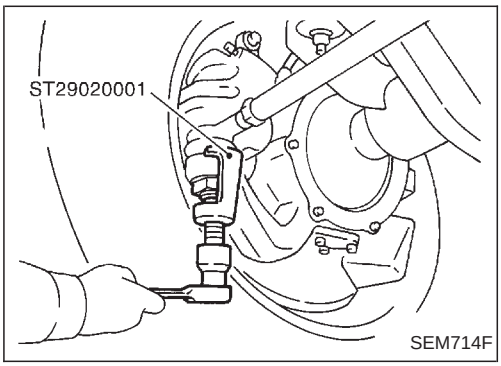
Removal (Cont'd)



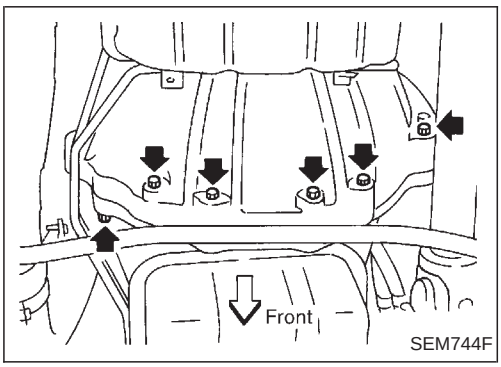
b. Slide Tool by tapping on the side of the Tool with a hammer.



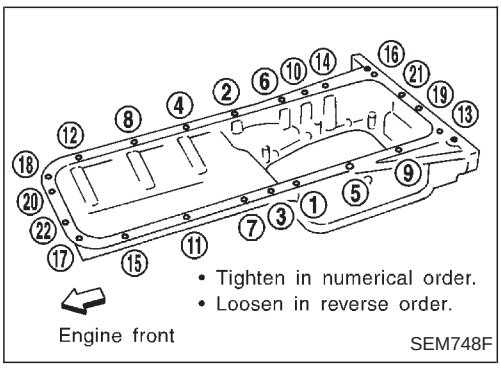
5. Remove steel oil pan.



6. Remove left side of the tie rod end.

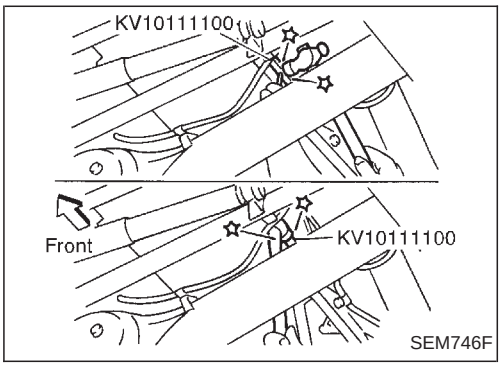


7. Remove transmission bolts.



8. Remove aluminum oil pan bolts.

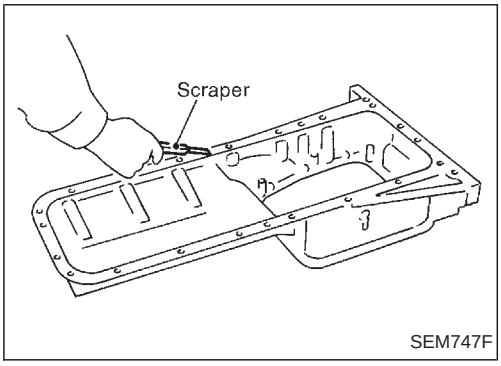
Removal (Cont'd)



9. Remove aluminum oil pan.
- **Be careful not to damage aluminum mating surface.**
- **Do not insert screwdriver, or oil pan flange will be deformed.**

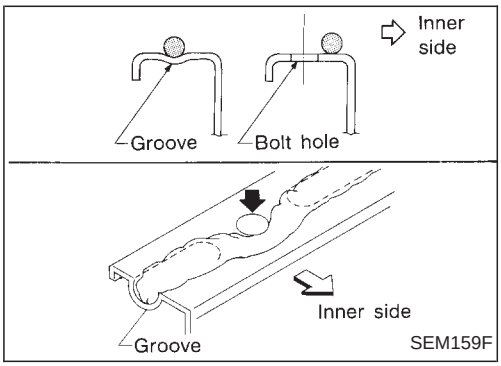
10. Remove oil strainer.

Installation

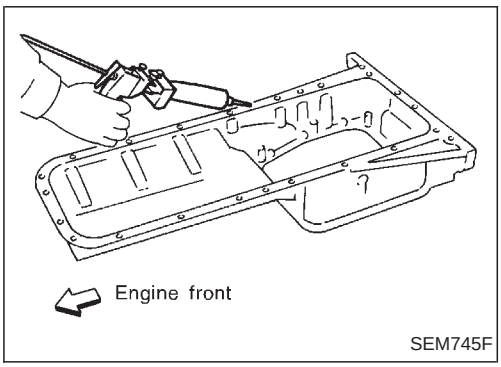


1. Install aluminum oil pan.

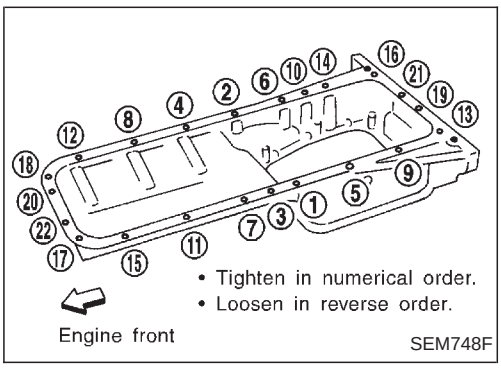
a. Use a scraper to remove all traces of liquid gasket from mating surfaces.
- Also remove traces of liquid gasket from mating surface of cylinder block, front cover and steel oil pan.
- **Remove old liquid gasket from the bolt hole and thread.**



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

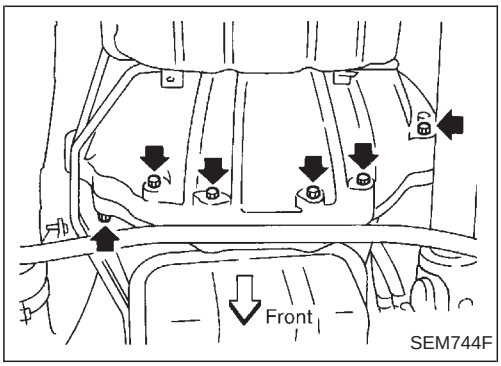


c. Apply liquid gasket to inner sealing surface as shown in figure.
- **Be sure liquid gasket is 3.5 to 4.5 mm (0.138 to 0.177 in).**
- **Attaching should be done within 5 minutes after coating.**



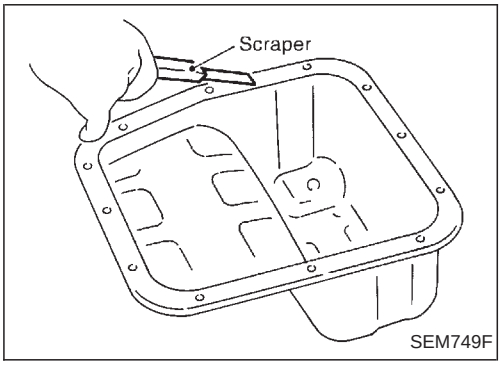
d. Install oil strainer.
e. Install aluminum oil pan.
- Tighten bolts in numerical order.
- **Wait at least 30 minutes before refilling engine oil.**

Installation (Cont'd)



SEM744F

2. Install the transmission bolts.

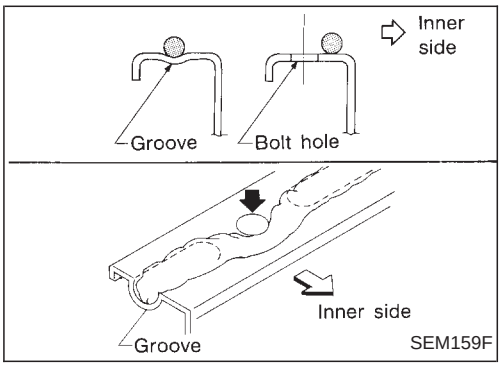


SEM749F

3. Install steel oil pan.

a. Use a scraper to remove all traces of liquid gasket from mating surfaces.

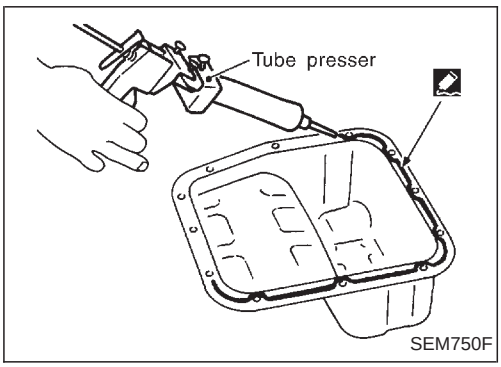
- Also remove traces of liquid gasket from mating surface of aluminum oil pan.



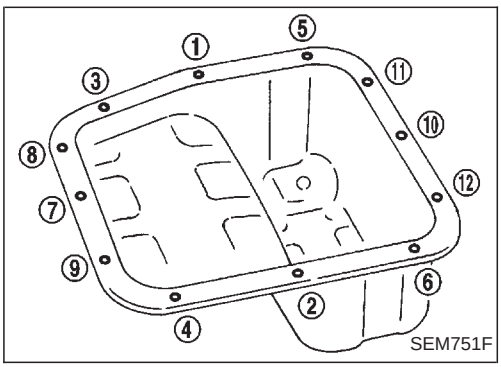
SEM159F

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

- **Use Genuine Liquid Gasket or equivalent.**
- **Be sure liquid gasket is 3.5 to 4.5 mm (0.138 to 0.177 in) wide.**
- **Attaching should be done within 5 minutes after coating.**



SEM750F



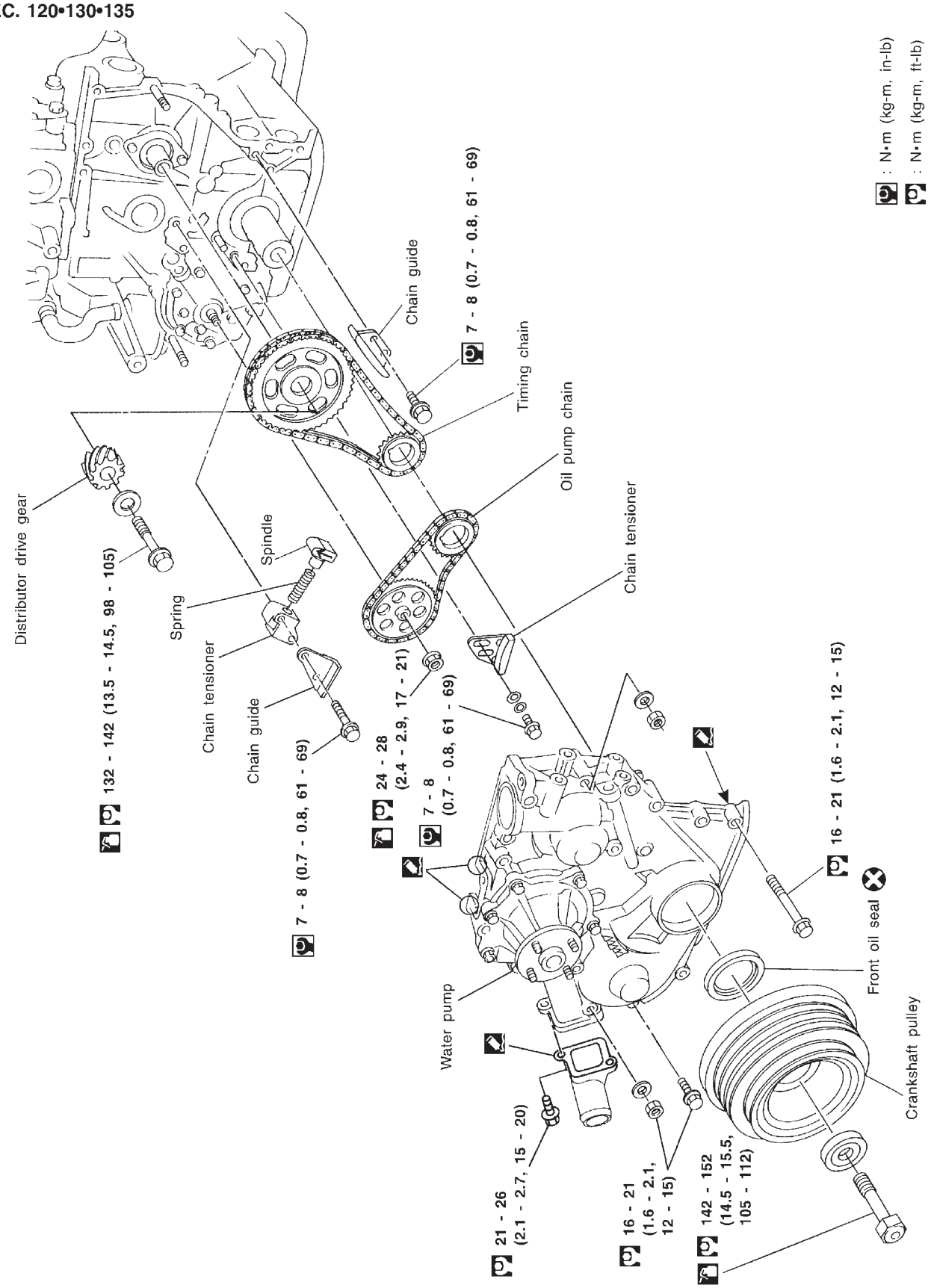
SEM751F

c. Install steel oil pan.

- **Tighten in numerical order as shown in the figure.**
- **Wait at least 30 minutes before refilling engine oil.**

4. Install left side of the tie rod end.

SEC. 120•130•135



SEM720F

CAUTION:

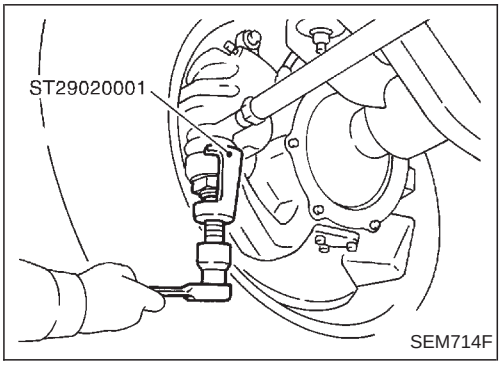
- **After removing timing chain, do not turn crankshaft and camshaft separately, or valves will strike piston heads.**
- **When tightening camshaft bolt, oil pump sprocket nuts and crankshaft pulley bolt, apply new engine oil to the threaded portions and seat surfaces of bolts or nuts.**

Removal

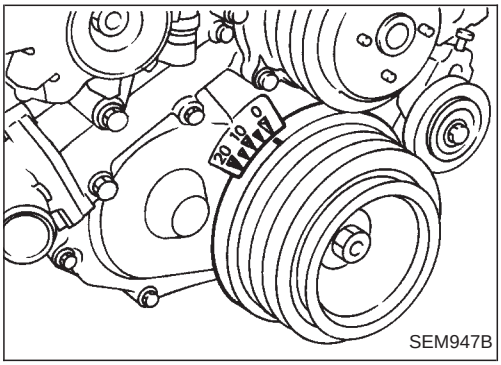
1. Disconnect battery terminal.
2. Drain engine oil.
3. Drain coolant from radiator and cylinder block.
   Refer to MA section (“Changing Engine Coolant”, “ENGINE MAINTENANCE”).

Be careful not to spill coolant on drive belts.

4. Remove the following belts.
   - Power steering drive belt
   - Alternator drive belts
   - Compressor drive belt
5. Remove radiator and radiator shroud.
6. Remove fan coupling with fan.
7. Remove power steering pump and power steering bracket.
8. Remove A/C compressor idler pulley.
9. Remove alternator and alternator bracket.

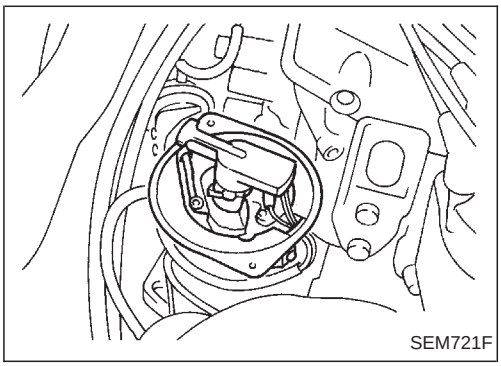


10. Remove left side of the tie rod end.
11. Remove oil pan. (Refer to “Removal” of OIL PAN, EM-18.)

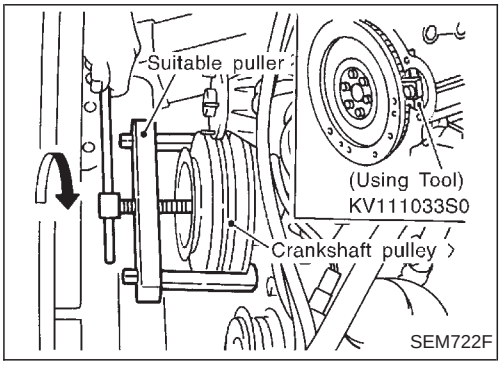


12. Set No. 1 piston at TDC on its compression stroke.

Removal (Cont'd)

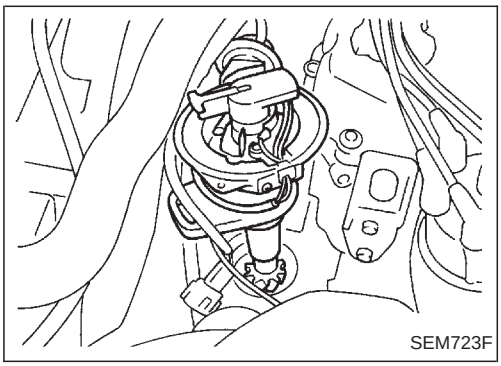

SEM721F

13. Remove crankshaft pulley bolt.
14. Remove crankshaft pulley with a suitable puller.

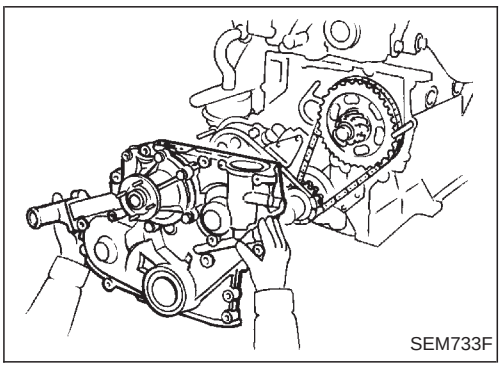


SEM722F

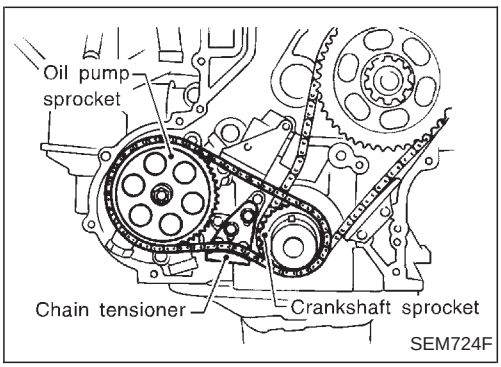
15. Remove distributor.


SEM723F

16. Remove front cover assembly.

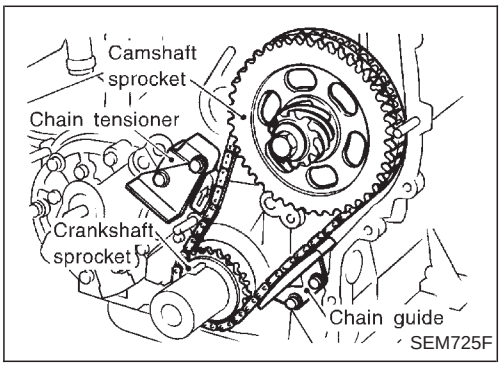

SEM733F

17. Remove the following parts.
- Chain tensioner
- Oil pump chain and sprocket



SEM724F

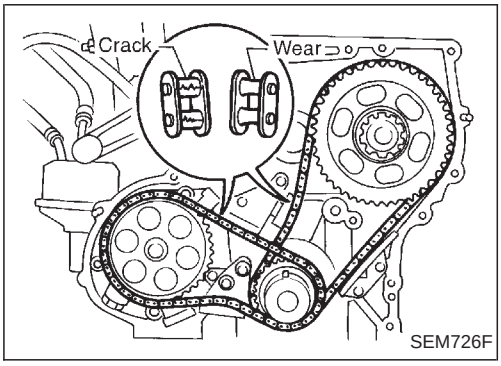
Removal (Cont'd)



18. Remove the following parts.
- Chain tensioner
- Chain guides
- Timing chain and sprocket

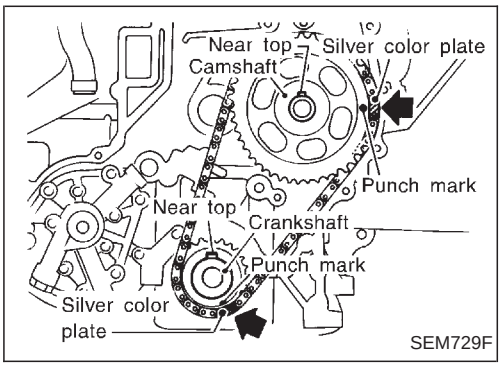
Carefully remove chain tensioner. Otherwise, spring may fall.

Inspection

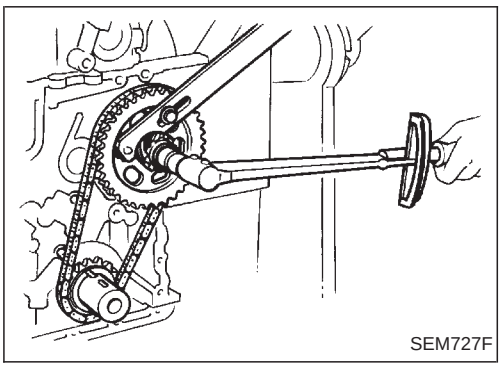


Check for cracks and excessive wear at roller links. Replace if necessary.

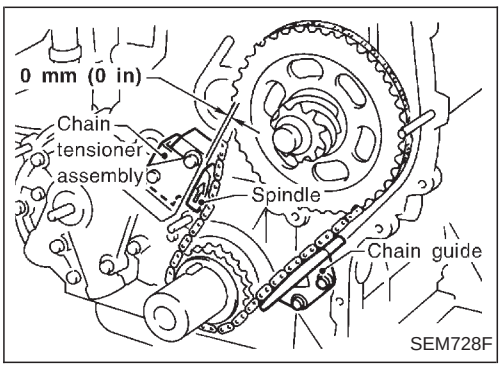
Installation



1. Install camshaft sprocket and timing chain.
- Confirm that No. 1 cylinder is set at TDC on its compression stroke.
- **Set timing chain by aligning its mating marks with those of crankshaft sprocket and camshaft sprocket.**

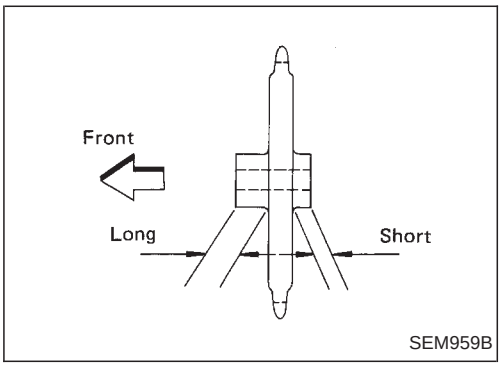


2. Tighten camshaft sprocket bolt.



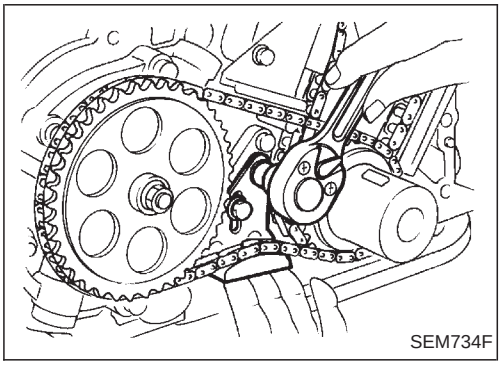
3. Install chain tensioner and chain guides.
- **Adjust protrusion of timing chain tensioner spindle to 0 mm (0 in) with slack chain guide.**

Installation (Cont'd)

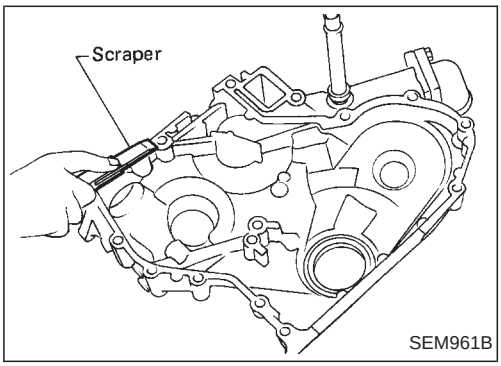


SEM959B

4. Install oil pump sprocket and oil pump chain.

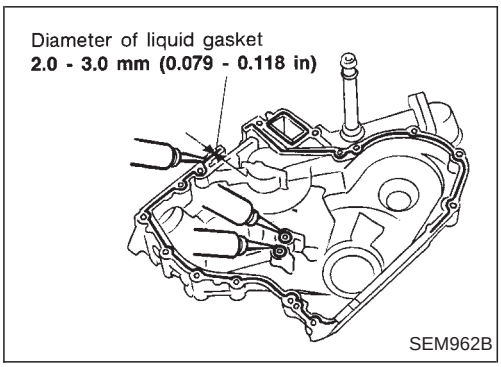

SEM734F

5. Install oil pump chain tensioner.
   Tighten bolts while applying pressure to oil pump chain with one hand.



SEM961B

6. Before installing front cover, remove all traces of liquid gasket from mating surface using a scraper.



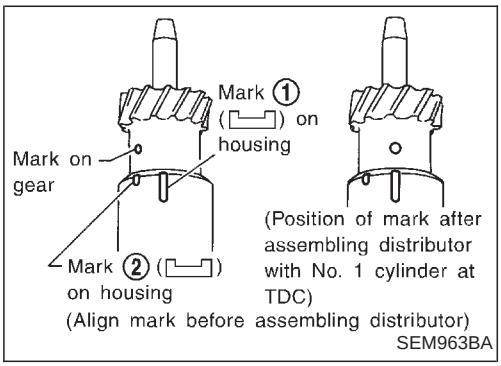
SEM962B

7. Apply a continuous bead of liquid gasket to front cover.
   - **Use Genuine Liquid Gasket or equivalent.**

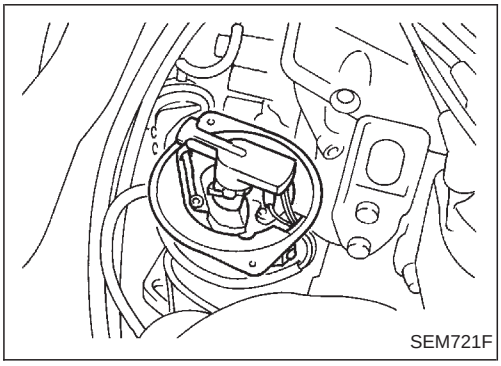
   a. Coat of liquid gasket should be maintained within 2.0 to 3.0 mm (0.079 to 0.118 in) dia. range.
   b. Attach front cover to cylinder block within 5 minutes after coating.
   c. Wait at least 30 minutes before refilling engine oil or starting engine.

8. Install front cover.
   Be careful not to damage cylinder head gasket.
9. Install oil pan.
   Refer to Installation of OIL PAN.
10. Install crankshaft pulley.

Installation (Cont'd)

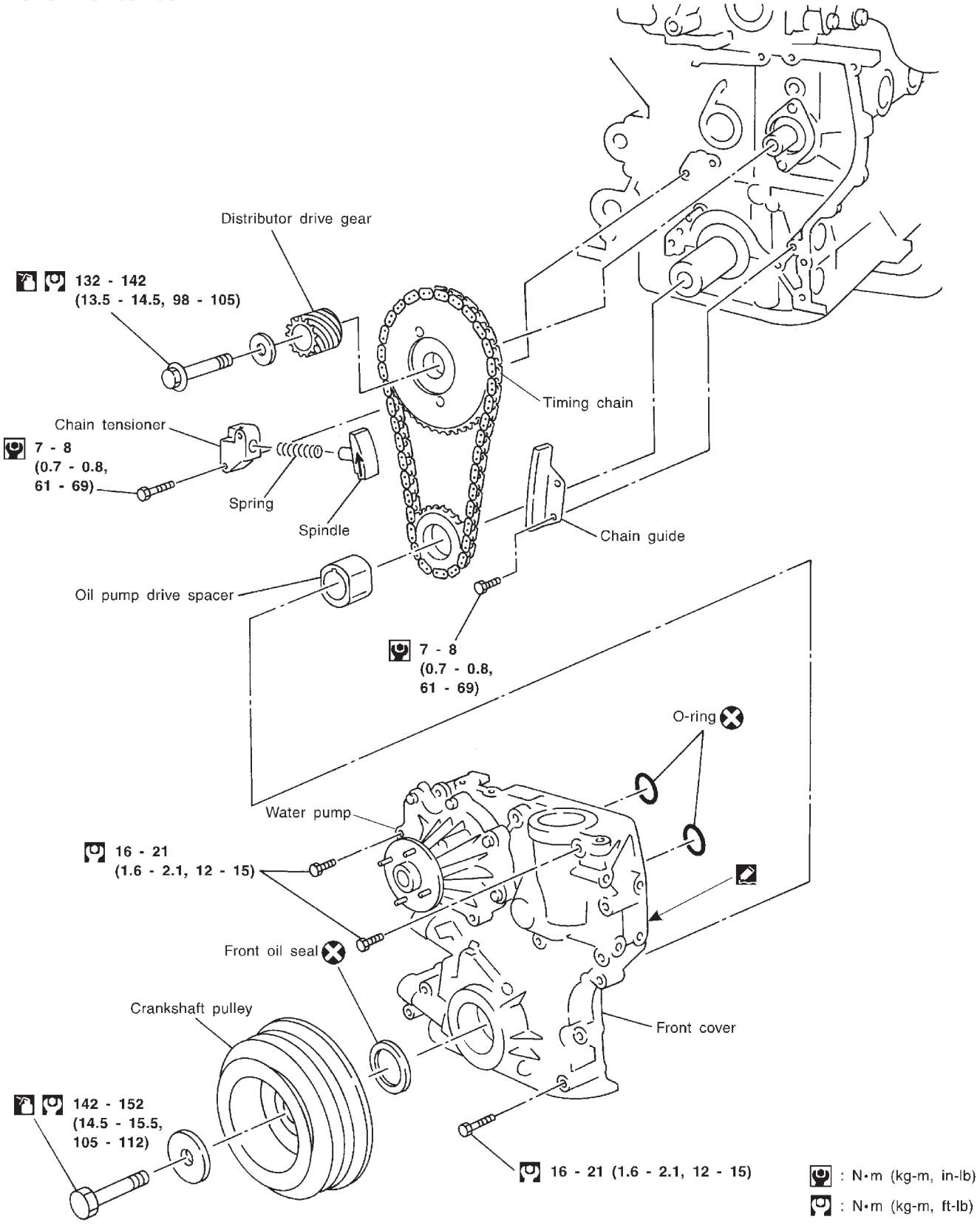


11. Install distributor.
    Set the distributor gear position.
    [Be sure mark ② (⌐¬) on housing is aligned with mark on gear.]



12. Make sure that No. 1 cylinder is set at TDC and that distributor rotor is set at No. 1 cylinder spark position.

SEC. 120•130•135



SEM752F

CAUTION:

- **After removing timing chain, do not turn crankshaft and camshaft separately, or valves will strike piston heads.**
- **When tightening camshaft bolt and crankshaft pulley bolt, apply new engine oil to the threaded portions and seat surfaces of bolts or nuts.**

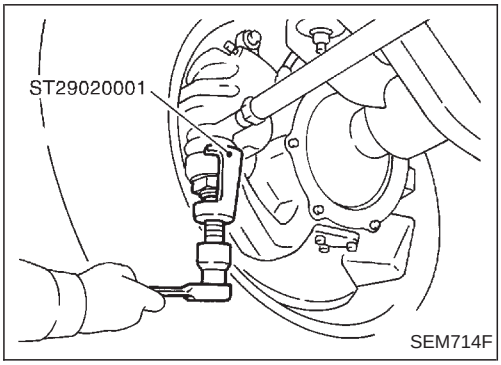
Removal

1. Disconnect battery terminal.
2. Drain engine oil.
3. Drain coolant from radiator and cylinder block.
   Refer to MA section (“Changing Engine Coolant”, “ENGINE MAINTENANCE”).

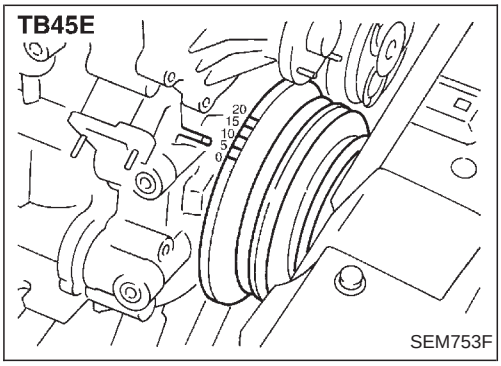
Be careful not to spill coolant on drive belts.

4. Remove the following belts.
- Power steering drive belt
- Alternator drive belts
- Compressor drive belt

5. Remove radiator and radiator shroud.
6. Remove fan coupling with fan.
7. Remove power steering pump and power steering bracket.
8. Remove A/C compressor idler pulley.
9. Remove alternator and alternator bracket.

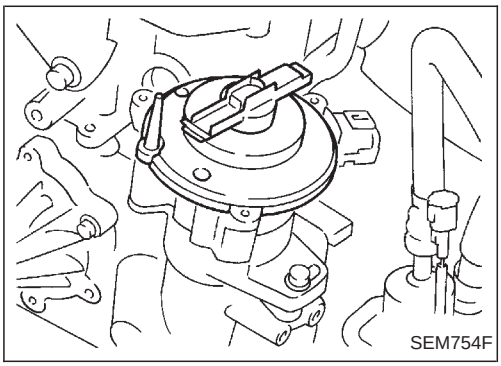


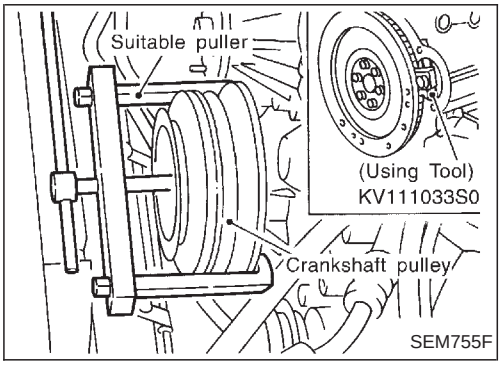
10. Remove left side of the tie rod end.
11. Remove oil pans. Refer to “Removal” of OIL PAN.



12. Set No. 1 piston at TDC on its compression stroke.

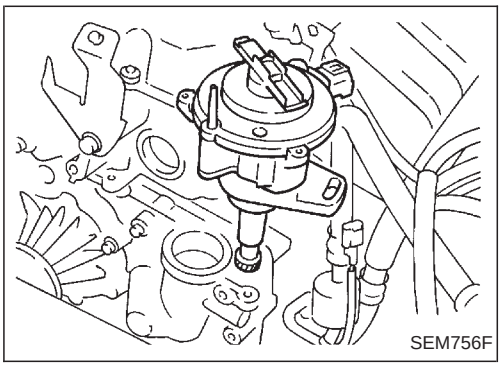
Removal (Cont'd)


SEM754F

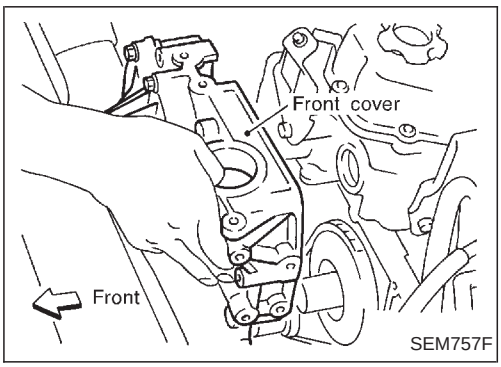


SEM755F

13. Remove crankshaft pulley bolt.
14. Remove crankshaft pulley with a suitable puller.

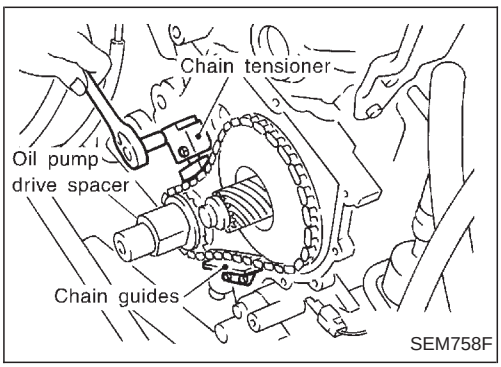

SEM756F

15. Remove distributor.



SEM757F

16. Remove front cover assembly.

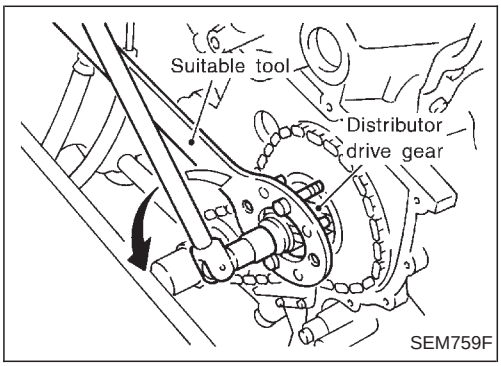


SEM758F

17. Remove the following parts.
- Chain tensioner
- Chain guides
- Oil pump drive spacer

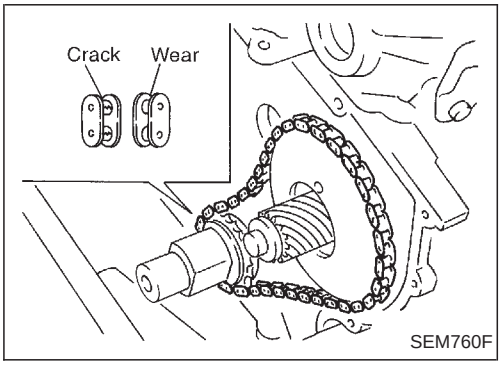
Carefully remove chain tensioner. Otherwise, spring may fall.

Removal (Cont'd)



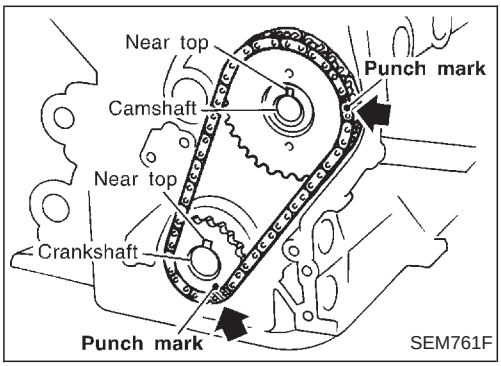
18. Remove oil pump drive spacer.
19. Remove camshaft sprocket bolt and distributor drive gear.
20. Remove crankshaft sprocket, camshaft sprocket and timing chain.
21. Remove O-rings from front cover.

Inspection

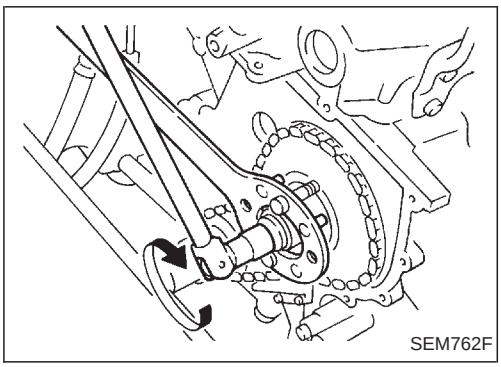


Check for cracks and excessive wear at roller links. Replace if necessary.

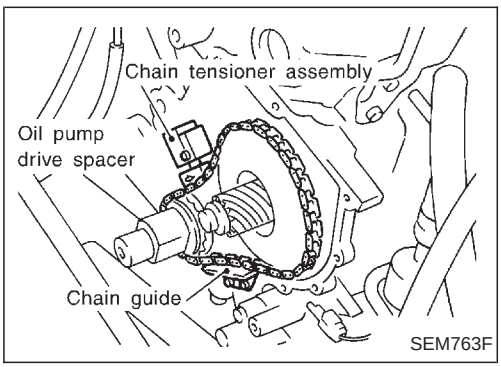
Installation



1. Install crankshaft sprocket, camshaft sprocket and timing chain.
- Confirm that No. 1 cylinder is set at TDC on its compression stroke.
- **Set timing chain by aligning its mating marks with those of crankshaft sprocket and camshaft sprocket.**

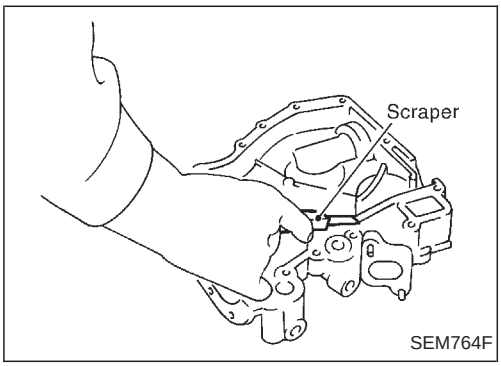


2. Install distributor drive gear.
3. Tighten camshaft sprocket bolt.

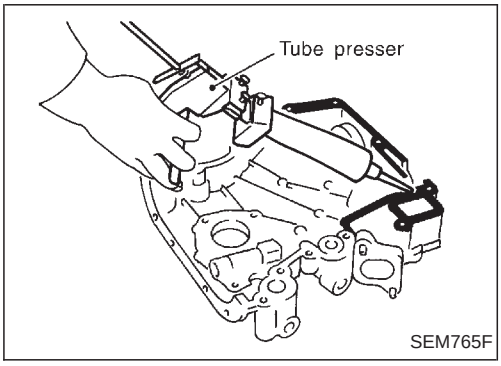


4. Install chain tensioner and chain guides.
5. Install oil pump drive spacer.

Installation (Cont'd)

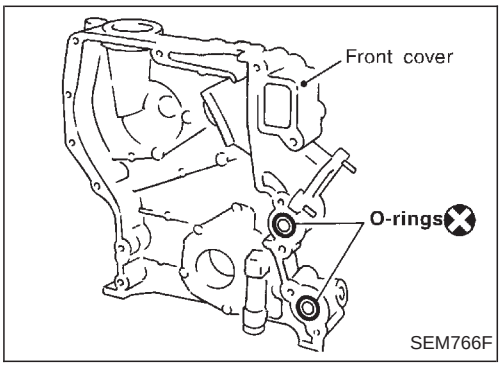


6. Before installing front cover, remove all traces of liquid gasket from mating surface using a scraper.



7. Apply a continuous bead of liquid gasket to front 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 front cover to cylinder block within 5 minutes after coating.
c. Wait at least 30 minutes before refilling engine oil or starting engine.



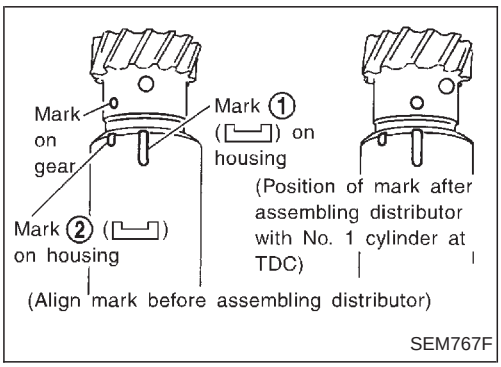
8. Install O-rings on front cover.
9. Install front cover.

Be careful not to damage cylinder head gasket.

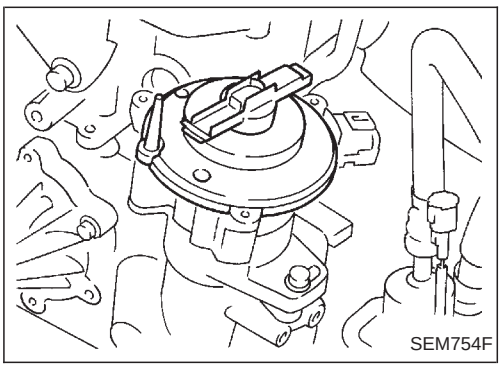
10. Install oil pan.

Refer to Installation of OIL PAN.

11. Install crankshaft pulley.



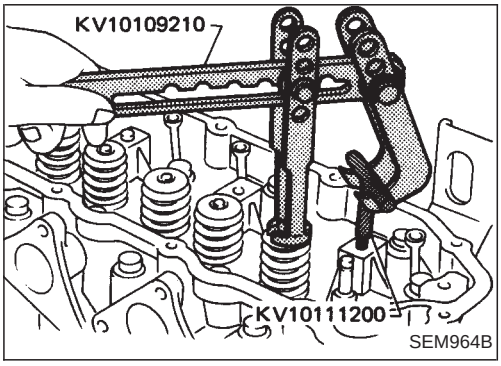
12. Install distributor.
Set the distributor gear position.
[Be sure mark ② (⌴) on housing is aligned with mark on gear.]



13. Make sure that No. 1 cylinder is set at TDC and that distributor rotor is set at No. 1 cylinder spark position.

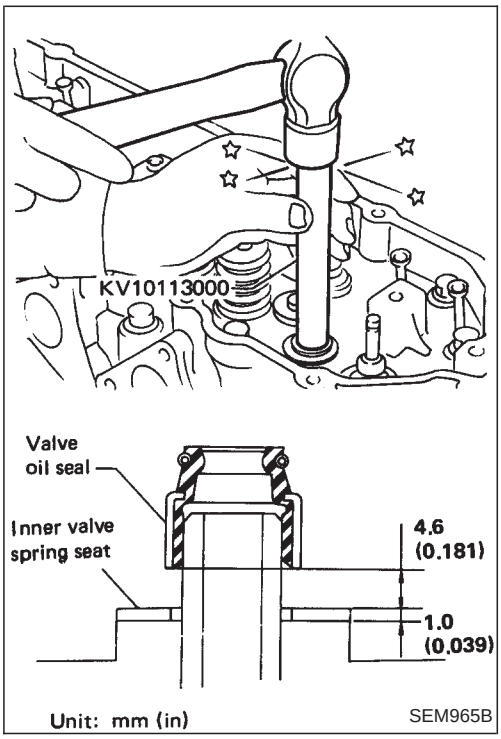
VALVE OIL SEAL

1. Remove air cleaner and air duct.
2. Remove rocker cover.
3. Remove rocker shaft assembly.



4. Remove valve springs and valve oil seals with Tool.

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

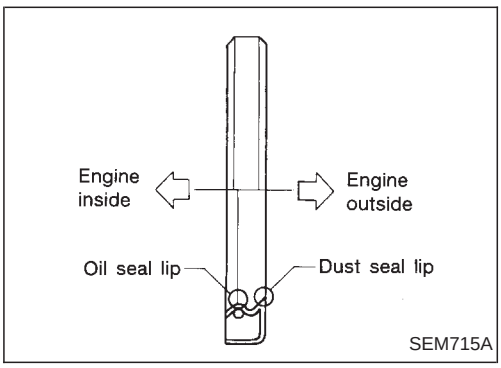


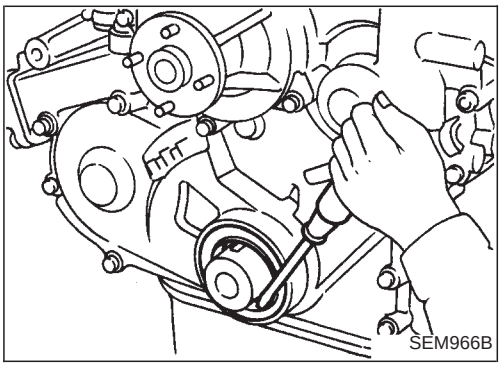
5. Apply engine oil to new valve oil seal and install it with Tool.

- **Before installing valve oil seal, install inner valve spring seat.**

OIL SEAL INSTALLING DIRECTION

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



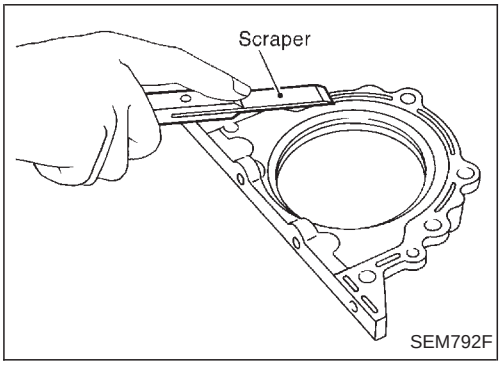

SEM966B

CRANKSHAFT FRONT OIL SEAL

1. Remove radiator and radiator shroud.
2. Remove drive belts.
3. Remove cooling fan.
4. Remove crankshaft pulley.
5. Remove crankshaft oil seal.

- **Be careful not to damage sealing surfaces of crankshaft.**

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

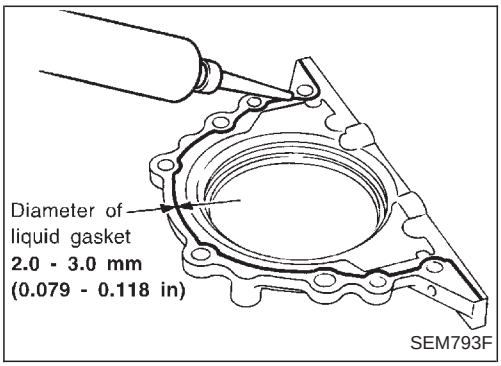


SEM792F

REAR OIL SEAL

1. Remove clutch cover assembly. Refer to CL section.
2. Remove flywheel or drive plate.
3. Remove rear oil seal retainer assembly.
4. Remove traces of liquid gasket using scraper.

- **Replace oil seal and retainer assembly as a single unit.**



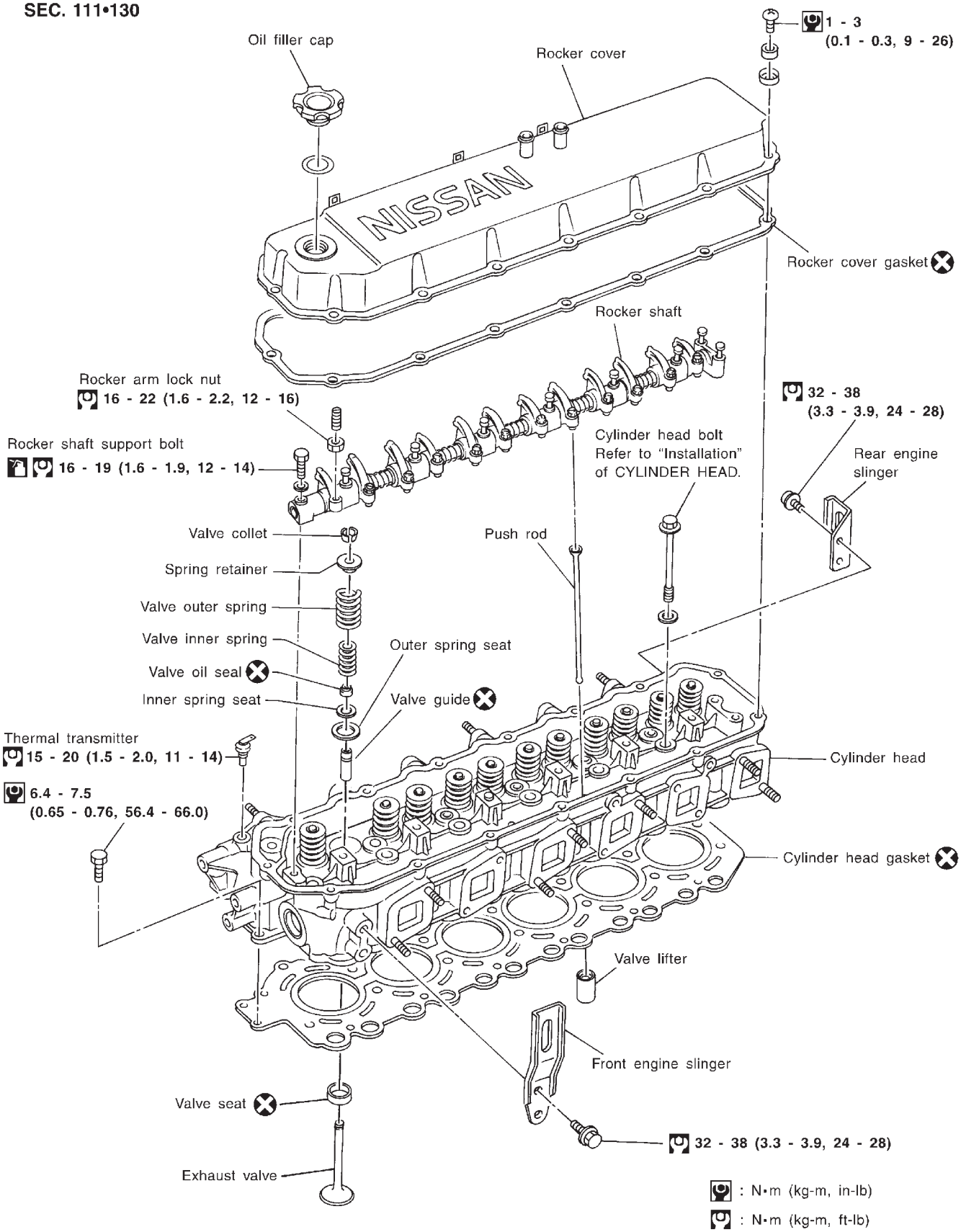
SEM793F

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

- **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 oil seal retainer to cylinder block within 5 minutes after coating.
c. Wait at least 30 minutes before refilling engine oil or starting engine.

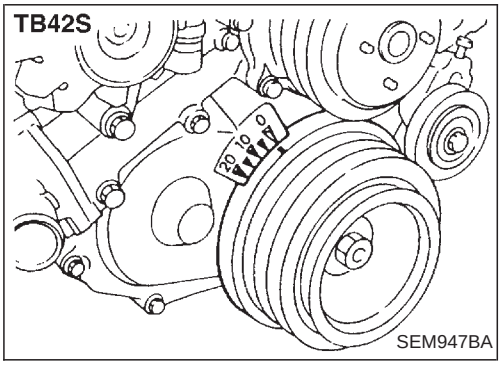
SEC. 111•130

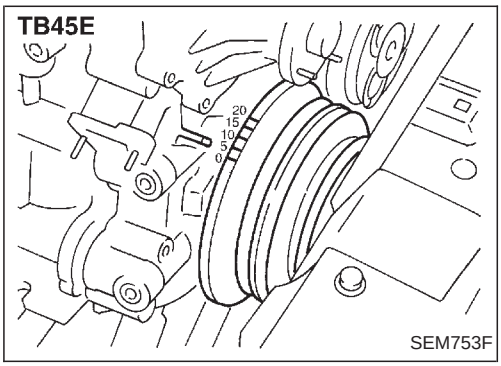


SEM774F

CAUTION:

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





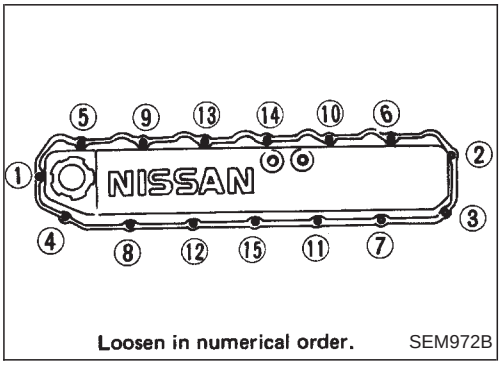
Removal

1. Release fuel pressure. Refer to “Releasing Fuel Pressure” in EC section, TB45E engine.
2. Drain coolant from radiator and cylinder block. Refer to MA section (“Changing Engine Coolant”, “ENGINE MAINTENANCE”).

Be careful not to spill coolant on drive belts.

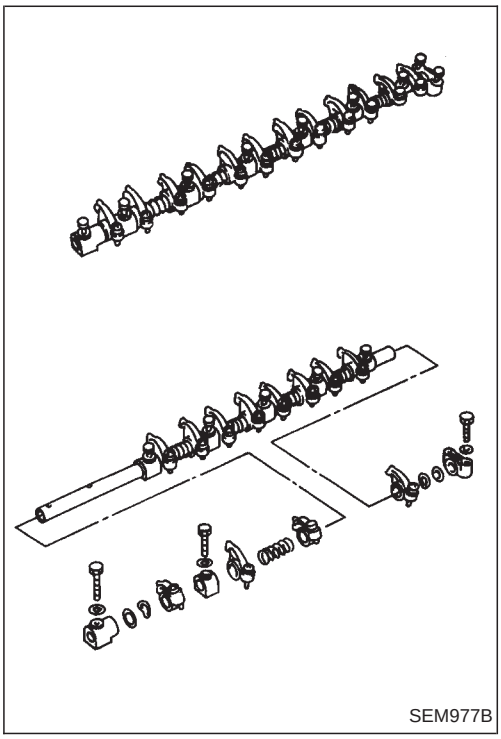
3. Remove the following parts.
- Air cleaner and duct
- Disconnect vacuum hoses, harness, water hoses and fuel hose
- Disconnect high tension wires from spark plugs
- Disconnect accelerator wire
- Alternator adjusting bar

4. Disconnect front exhaust tube from exhaust manifold.
5. Set No. 1 piston at TDC on its compression stroke.



6. Remove rocker cover.
- Loosen rocker cover bolts in numerical order.

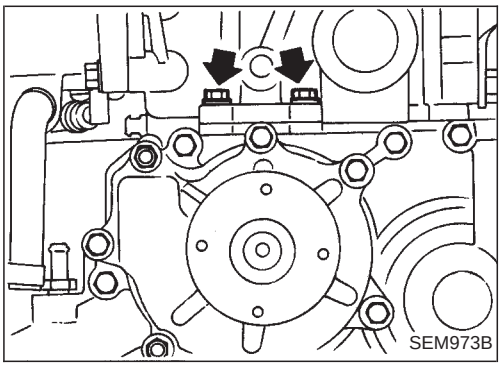
Removal (Cont'd)


SEM977B

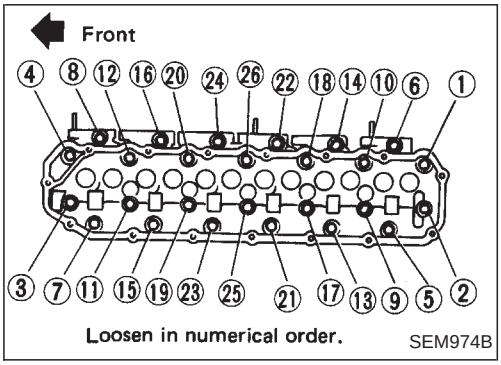
7. Remove rocker shaft with rocker arms.

Before removal, fully loosen valve clearance adjusting screws. The bolts should be loosened in two or three steps.

8. Remove push rods.


SEM973B

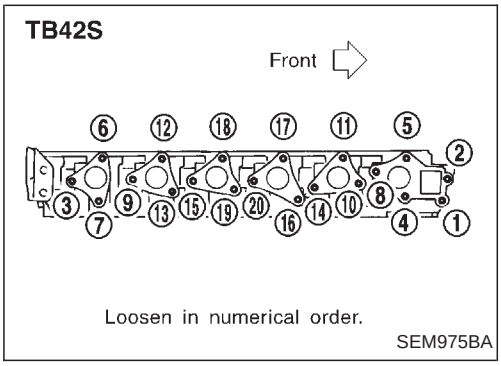
9. Remove front cover tightening bolts to cylinder head.



SEM974B

10. Remove cylinder head with manifolds.

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



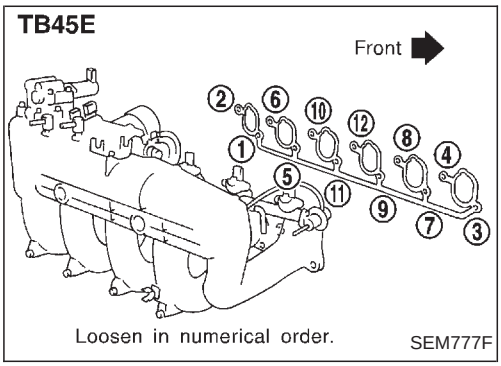
SEM975BA

Disassembly

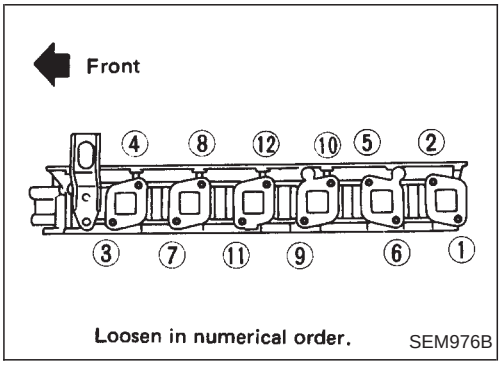
1. Remove intake manifold.

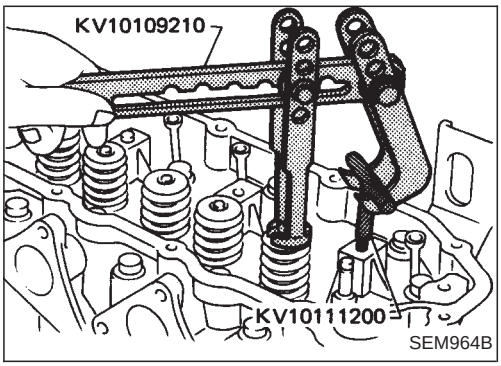
- Loosen intake manifold bolts in numerical order.

Disassembly (Cont'd)



2. Remove exhaust manifold.
- Loosen exhaust manifold bolts in numerical order.





3. Remove valve springs and valve oil seals with Tool.

Inspection

CYLINDER HEAD DISTORTION

Head surface flatness:

Less than 0.07 mm (0.0028 in)

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

Resurfacing limit:

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

Amount of cylinder head resurfacing is "A".

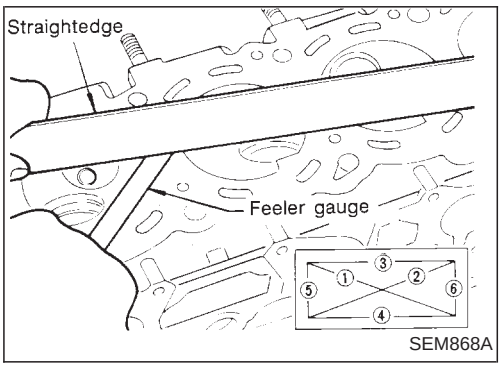
Amount of cylinder block resurfacing is "B".

The maximum limit is as follows:

A + B = 0.2 mm (0.008 in)

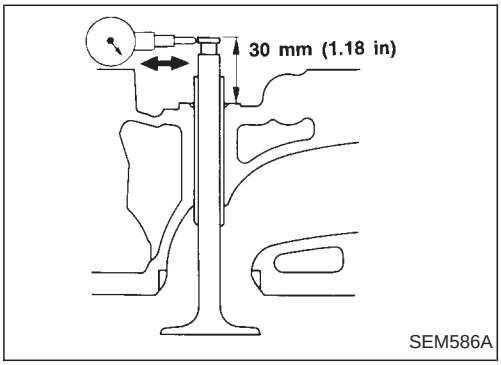
Nominal cylinder head height:

116.57 - 116.97 mm (4.5894 - 4.6051 in)

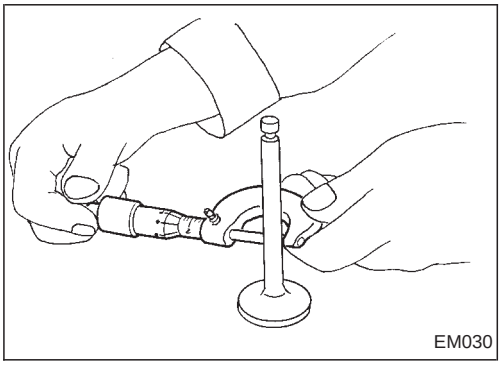


Inspection (Cont'd)

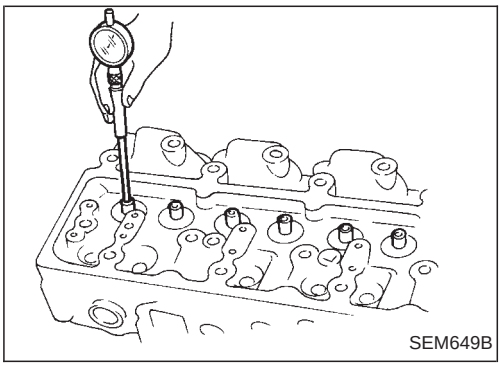
VALVE GUIDE CLEARANCE



1. Measure valve deflection in a parallel direction with rocker arm. (Valve and valve guide mostly wear in this direction.)
   Valve deflection limit (Dial gauge reading):
   0.2 mm (0.008 in)

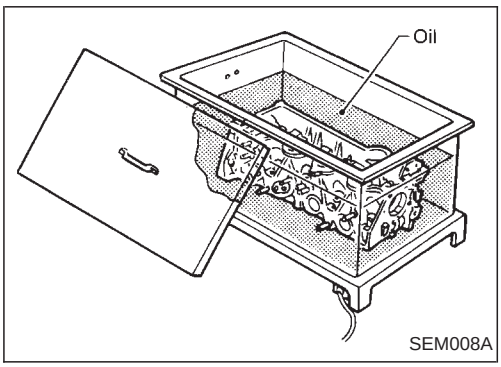


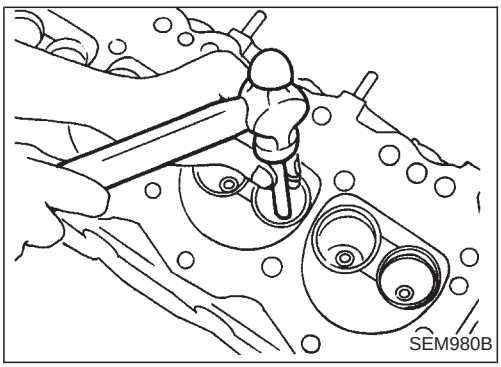
2. If it exceeds the limit, check valve to valve guide clearance.
(1) Measure valve stem diameter "d" and valve guide inner diameter.
(2) Check that clearance is within the specification.
   Valve to valve guide clearance limit:
   0.1 mm (0.004 in)
(3) If it exceeds the limit, replace valve or valve guide.



VALVE GUIDE REPLACEMENT

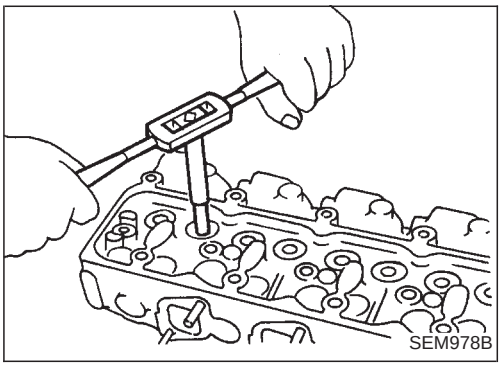
1. To remove valve guide, heat cylinder head to 150 to 160°C (302 to 320°F).



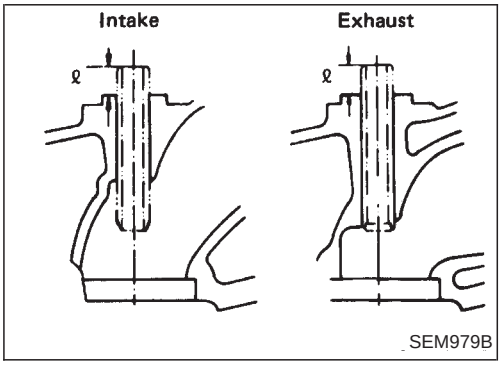


2. Drive out valve guide with a press [under a 20 kN (2 t, 2.2 US ton, 2.0 Imp ton) pressure] or hammer and suitable tool.

Inspection (Cont'd)

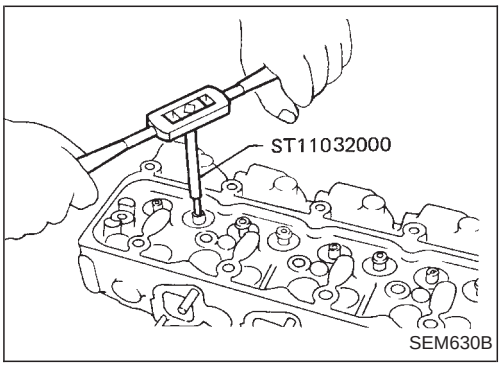

SEM978B

3. Ream cylinder head valve guide hole.
   Valve guide hole diameter (for service parts):
   Intake and exhaust
   12.233 - 12.244 mm (0.4816 - 0.4820 in)



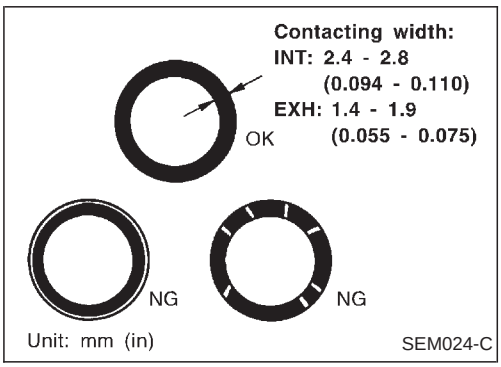
SEM979B

4. Heat cylinder head to 150 to 160°C (302 to 320°F) and press service valve guide onto cylinder head.
   Projection "ℓ":
   11.7 - 12.3 mm (0.461 - 0.484 in)



SEM630B

5. Ream valve guide.
   Finished size:
   Intake and exhaust
   8.000 - 8.018 mm (0.3150 - 0.3157 in)



SEM024-C

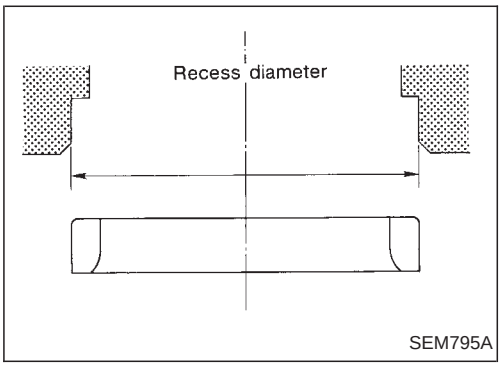
VALVE SEATS

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

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

Inspection (Cont'd)

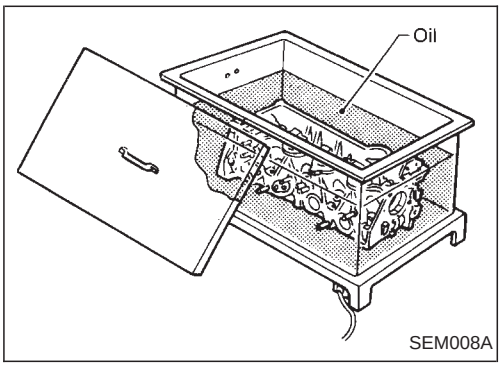
REPLACING VALVE SEAT FOR SERVICE PARTS



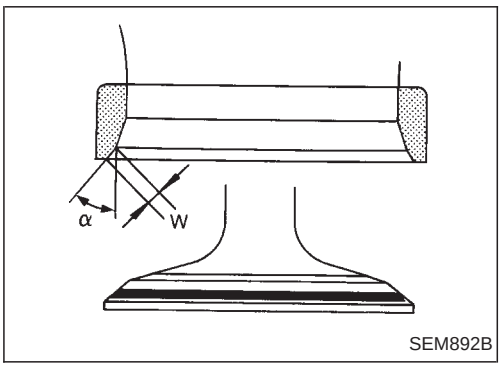
1. Bore out old seat until it collapses. The machine depth stop should be set so that boring cannot continue beyond the bottom face of the seat recess in cylinder head.
2. Ream cylinder head recess.

Reaming bore for service valve seat
Oversize [0.5 mm (0.020 in)]:
Intake
48.500 - 48.516 mm (1.9094 - 1.9101 in)
Exhaust
40.500 - 40.516 mm (1.5945 - 1.5951 in)

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

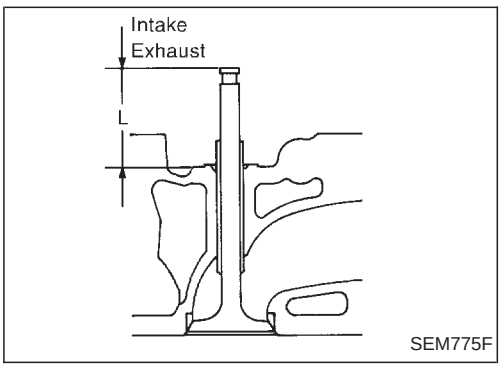


3. Heat cylinder head to 150 to 160°C (302 to 320°F).
4. Press fit valve seat until it seats on the bottom.



5. Cut or grind valve seat using suitable tool at the specified dimensions as shown in SDS.
6. After cutting, lap valve seat with an abrasive compound.
7. Check valve seating condition.

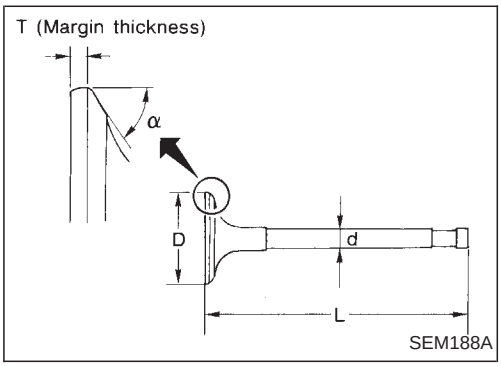
Seat face angle "α": 45 deg.
Contacting width "W":
Intake
1.08 - 1.51 mm (0.0425 - 0.0594 in)
Exhaust
1.41 - 1.89 mm (0.0555 - 0.0744 in)



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
46.14 mm (1.8165 in)
Exhaust
46.30 mm (1.8228 in)

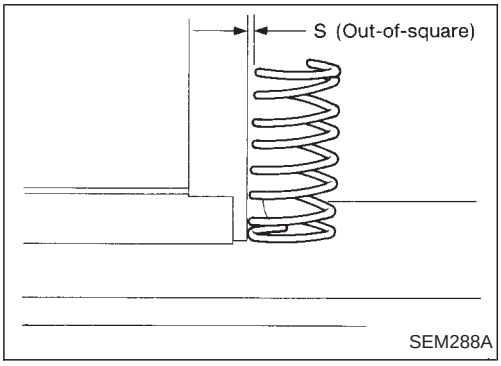
Inspection (Cont'd)



VALVE DIMENSIONS

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

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

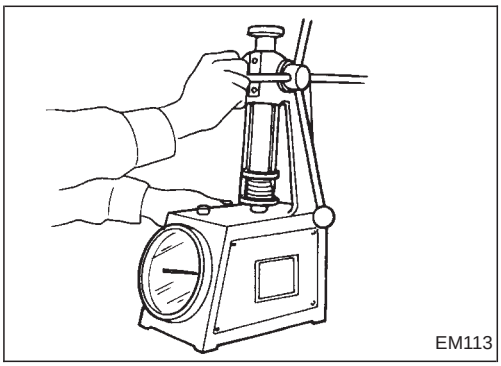


VALVE SPRING SQUARENESS

1. Measure "S" dimension.

Out-of-square:
Outer
TB42S
Less than 2.2 mm (0.087 in)
TB45E
Less than 2.1 mm (0.083 in)
Inner
TB42S, TB45E
Less than 1.9 mm (0.075 in)

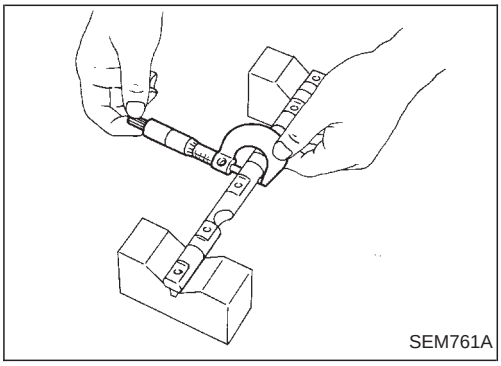
2. If it exceeds the limit, replace spring.



VALVE SPRING PRESSURE HEIGHT

Check valve spring pressure height.

Pressure height: mm/N (mm/kg, in/lb)
Outer
TB42S
30.0/512.9 (30.0/52.3, 1.181/115.3)
TB45E
27.7/611.0 (27.7/62.3, 1.091/137.4)
Inner
TB42S
25.0/255.0 (25.0/26.0, 0.984/57.3)
TB45E
24.7/305.5 (24.7/31.15, 0.972/68.7)

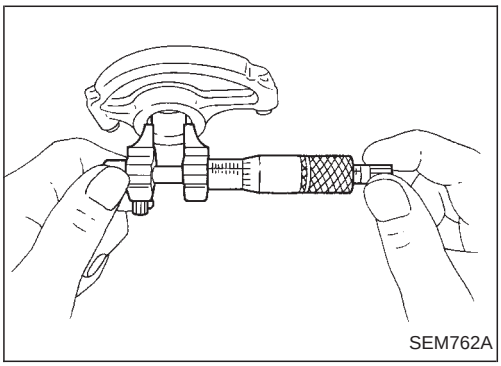


ROCKER SHAFT AND ROCKER ARM

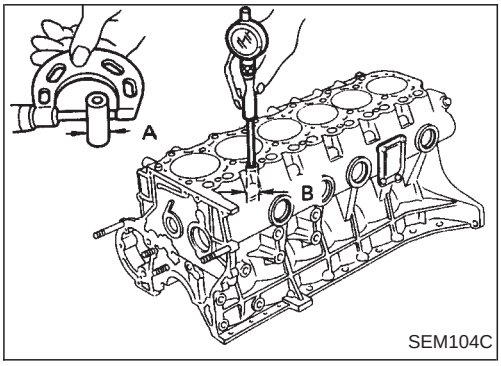
1. Check rocker shaft for scratches, seizure and wear.
2. Check outer diameter of rocker shaft.

Diameter:
19.988 - 20.000 mm (0.7869 - 0.7874 in)

Inspection (Cont'd)


SEM762A

3. Check inner diameter of rocker arm.
   Diameter:
   20.020 - 20.038 mm (0.7882 - 0.7889 in)
   Rocker arm to shaft clearance:
   0.020 - 0.050 mm (0.0008 - 0.0020 in)



SEM104C

VALVE LIFTER AND PUSH ROD

Valve lifter

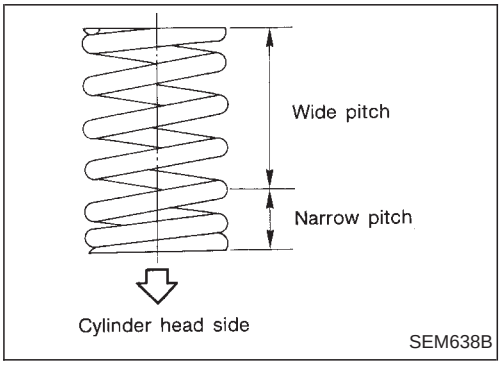
1. Check valve lifters for excessive wear on the face.
2. Replace with new ones if worn beyond repair.

a. Valve lifter end should be smooth.

b. Valve lifter to lifter hole clearance:
   Standard
   0.030 - 0.073 mm (0.0012 - 0.0029 in)
   Limit
   Less than 0.20 mm (0.0079 in)
   Valve lifter outer diameter "A":
   Standard
   24.960 - 24.970 mm (0.9827 - 0.9831 in)
   Cylinder block valve lifter hole diameter "B":
   Standard
   25.000 - 25.033 mm (0.9843 - 0.9855 in)

Push rod

1. Inspect push rod for excessive wear on the face.
2. Replace if worn or damaged beyond repair.
3. Check push rod for bend using a dial gauge.
   Maximum allowable bend
   (Total indicator reading):
   Less than 0.5 mm (0.020 in)

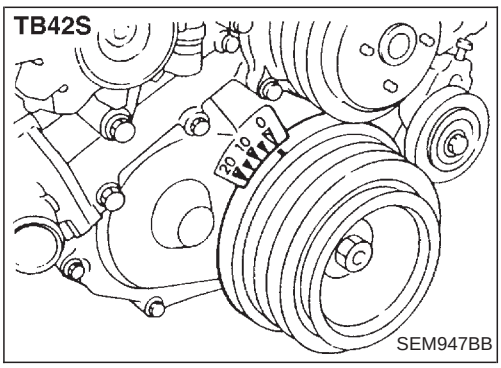


SEM638B

Assembly

1. Install valve component parts.

- **Always use new valve oil seal. Refer to OIL SEAL REPLACEMENT.**
- **Before installing valve oil seal, install inner spring seat.**
- **Install outer valve spring (uneven pitch type) with its narrow pitch side toward cylinder head side.**



SEM947BB

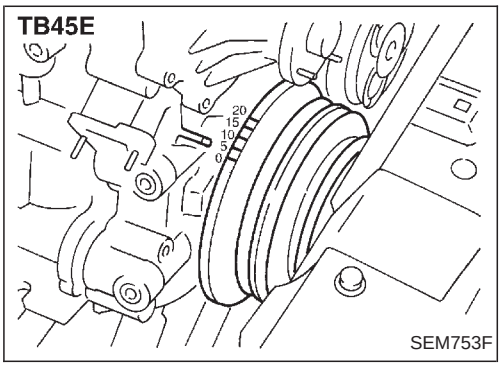
2. Install intake and exhaust manifolds.
   Tighten manifold bolts and nuts in two or three steps in reverse order of removal.

Refer to "Removal".

Installation

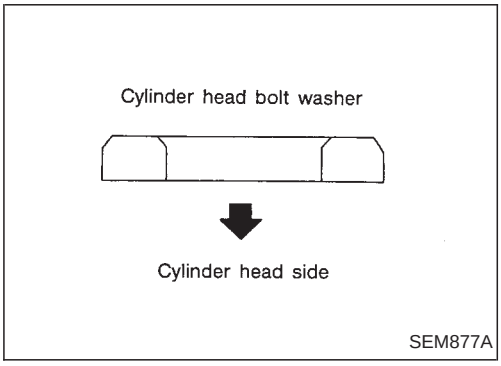
1. Set No. 1 piston at TDC on its compression stroke.

Installation (Cont'd)



SEM753F

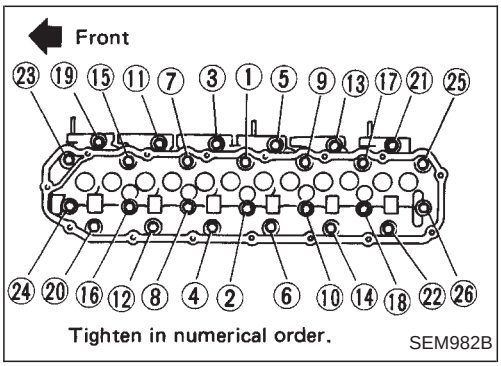
2. Install cylinder head with new gasket.
- **Be sure to install washers between bolts and cylinder head.**
- **Do not rotate crankshaft and camshaft separately, or valves will hit piston heads.**



SEM877A

3. Tighten cylinder head bolts in numerical order.
- **Tightening procedure**

(1) Tighten all bolts to 29 N·m (3.0 kg-m, 22 ft-lb).
(2) Tighten all bolts from 57 to 67 N·m (5.8 to 6.8 kg-m, 42 to 49 ft-lb).
(3) Loosen all bolts completely.
(4) Tighten all bolts to 29 N·m (3.0 kg-m, 22 ft-lb).
(5) Turn all bolts 69 to 74 degrees clockwise or if angle wrench is not available, tighten all bolts from 64 to 74 N·m (6.5 to 7.5 kg-m, 47 to 54 ft-lb).



SEM982B

4. Install push rods and rocker shaft with rocker arms.
5. Adjust valve clearance.

Valve clearance:

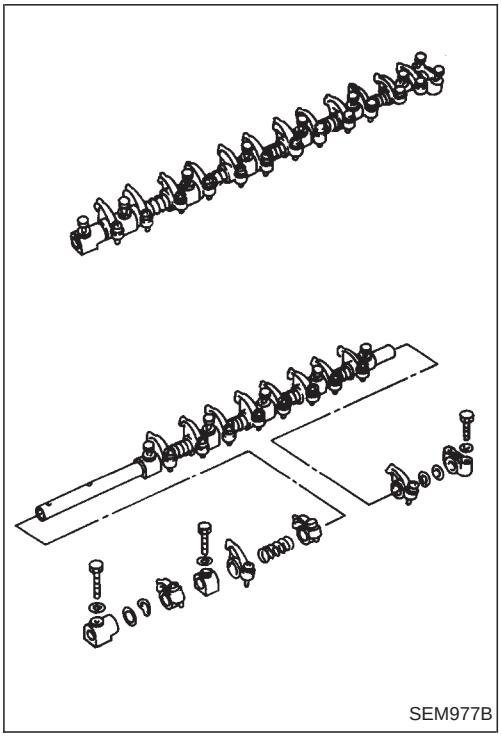
Unit: mm (in)

	TB42S, TB45E	TB42S	TB45E
	*Cold	Hot	
Intake	0.20 (0.008)	0.38 (0.015)	0.35 (0.014)
Exhaust	0.20 (0.008)	0.38 (0.015)	0.35 (0.014)

* At temperature of approximately 20°C (68°F)

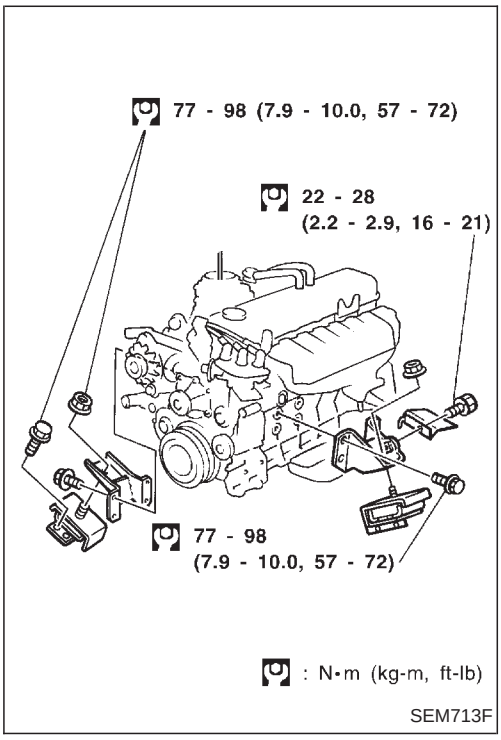
Whenever valve clearances are adjusted to cold specifications, check that the clearances satisfy hot specifications and adjust again if necessary.

Refer to MA section.


SEM977B

Installation (Cont'd)

6. Install rocker cover.
   Tighten rocker cover bolts in reverse order of removal.
Refer to "Removal".



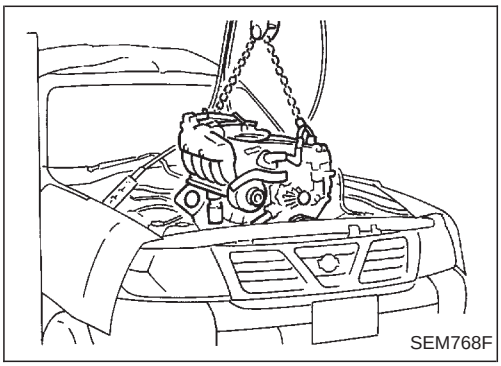
SEM713F

WARNING:

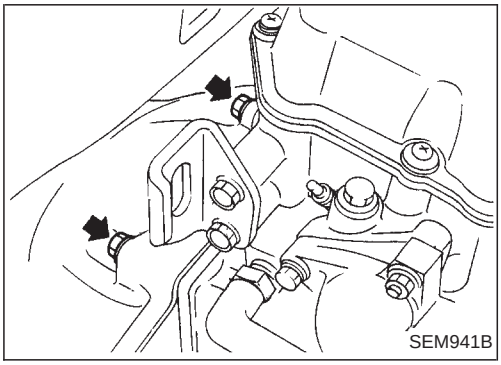
- **Situate vehicle on a flat and solid surface.**
- **Place chocks at front and back of rear wheels.**
- **Do not remove engine until exhaust system has completely cooled off.**
  Otherwise, you may burn yourself and/or fire may break out in the fuel line.
- **For safety during subsequent steps, the tension of wires should be slackened against the engine.**
- **Before disconnecting fuel hose, release fuel pressure from fuel line.**
  Refer to "Releasing Fuel Pressure" in EC section.
- **Be sure to hoist engine in a safe manner.**

CAUTION:

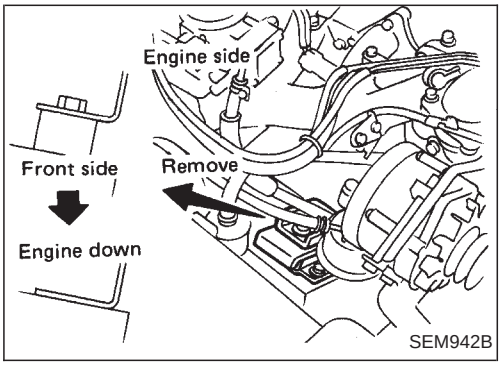
- **When lifting engine, be careful not to strike adjacent parts, especially accelerator wire casing, brake lines, and brake master cylinder.**
- **In hoisting the engine, always use engine slingers in a safe manner.**
- **For engines not equipped with engine slingers, attach proper slingers and bolts described in the PARTS CATALOG.**


SEM768F

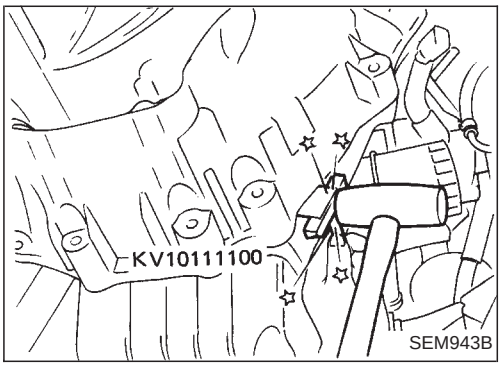
- Remove engine after disconnecting from transmission.


SEM941B

(1) Before removing two mounting bolts from upper side of transmission, remove front engine mounts and lower engine to the level of the front mount.

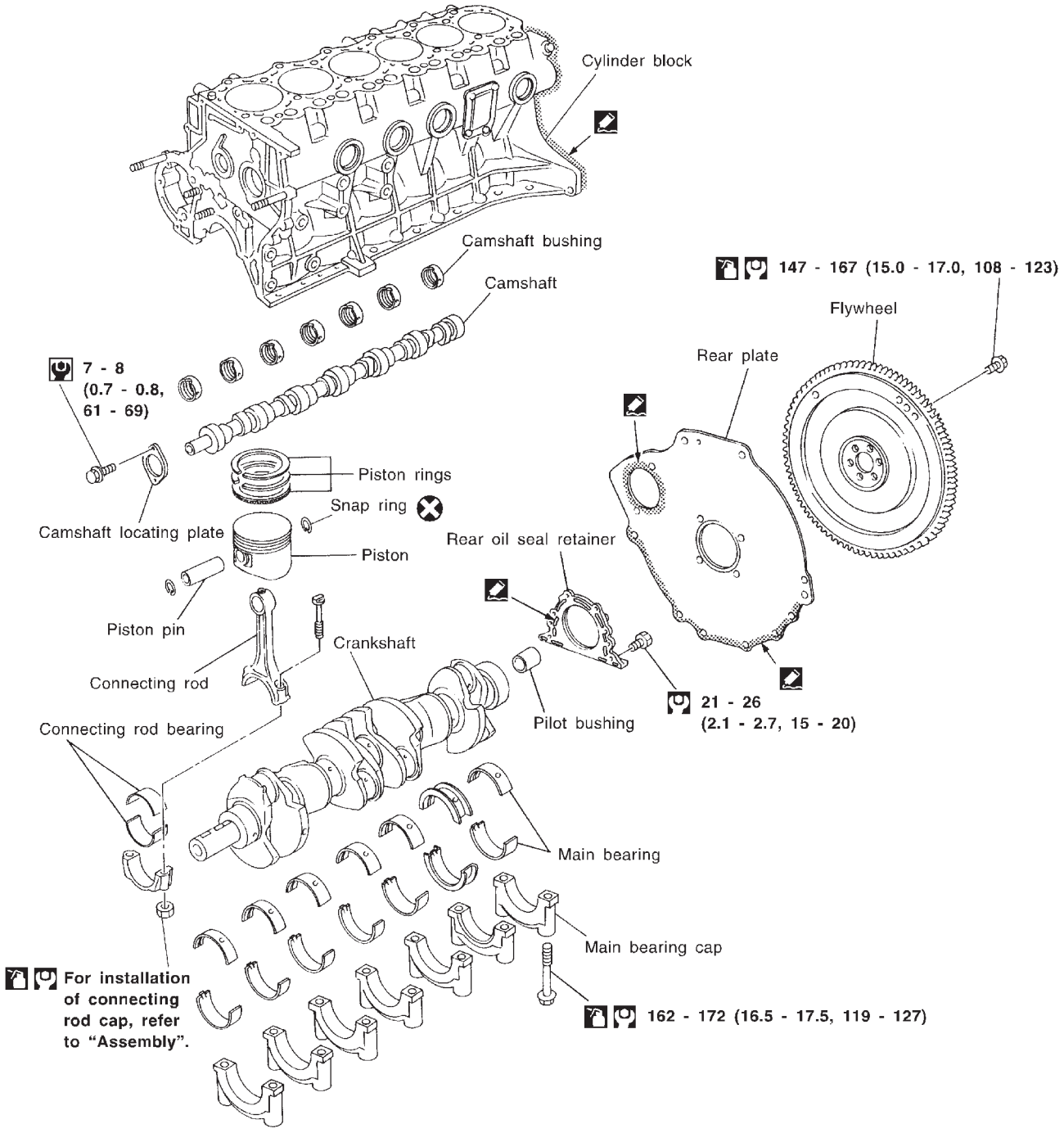


SEM942B



(2) Before separating transmission and rear plate, remove transmission mounting bolts. Position Tool into mating surface of transmission and rear plate, and slide it along mating surface.

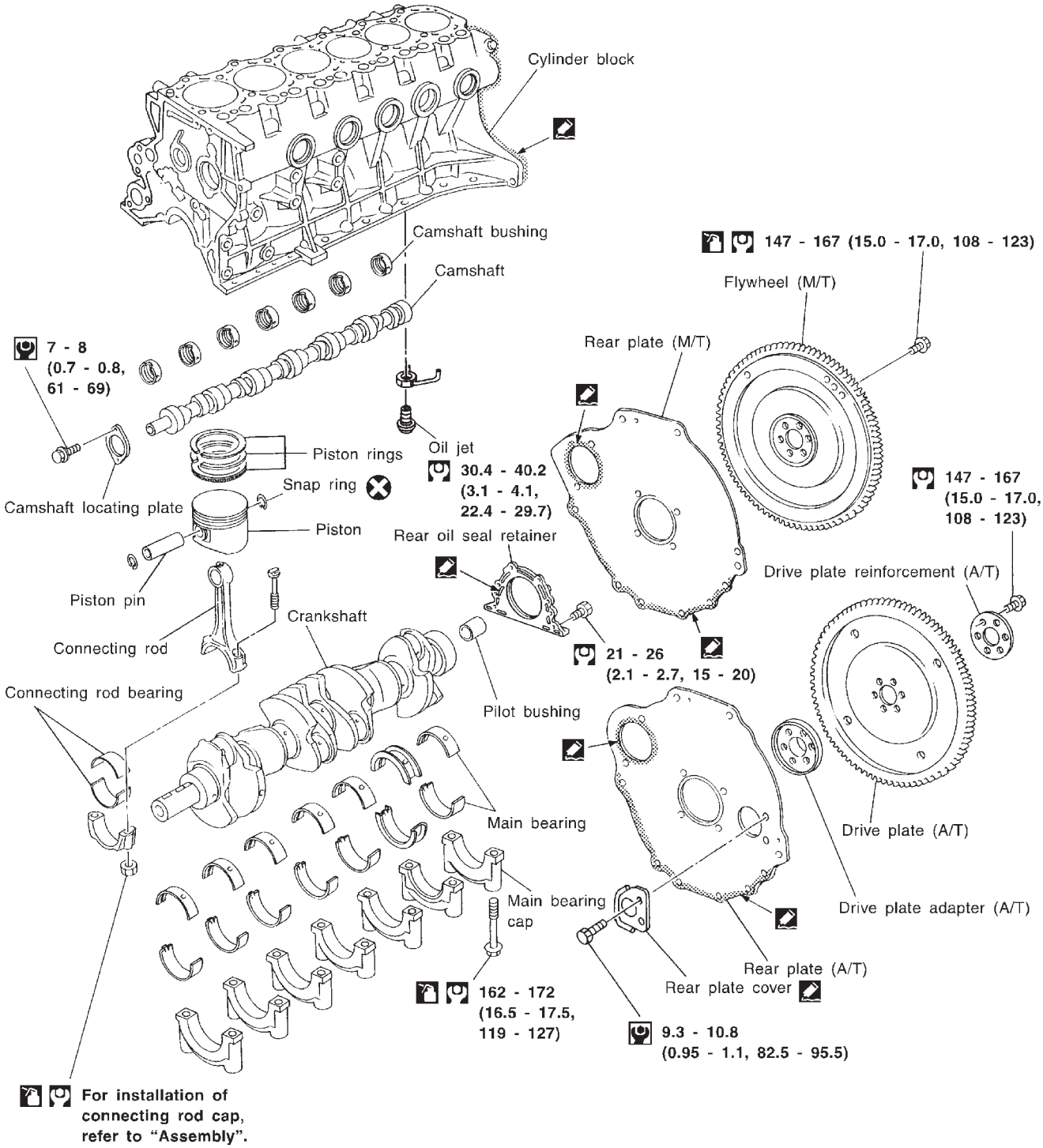
SEC. 110•120•130



: N•m (kg-m, in-lb)
: N•m (kg-m, ft-lb)

SEM730F

SEC. 110•120•130



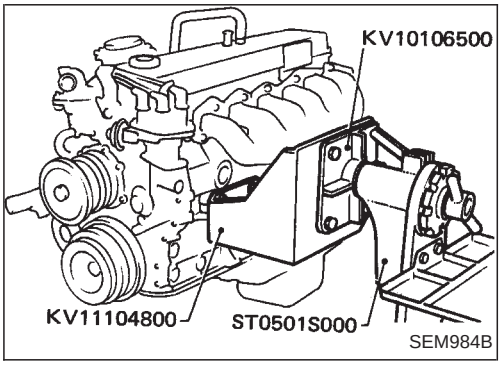
: N•m (kg-m, in-lb)

: N•m (kg-m, ft-lb)

SEM771F

CAUTION:

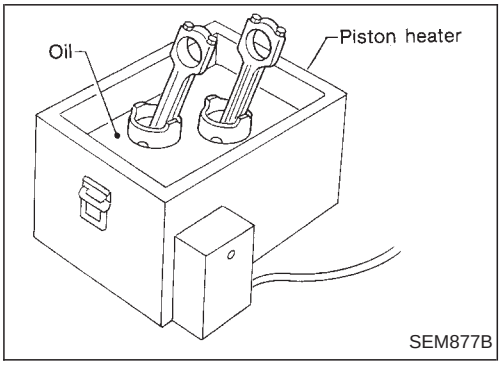
- **When installing sliding parts such as bearings and pistons, be sure to apply engine oil on the sliding surfaces.**
- **Place the removed parts such as bearings and bearing caps in their proper order and direction.**
- **When tightening connecting rod bolts, main bearing cap bolts and flywheel bolts,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



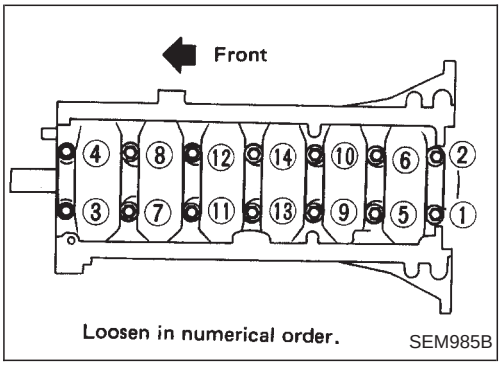
Disassembly

PISTON AND CRANKSHAFT

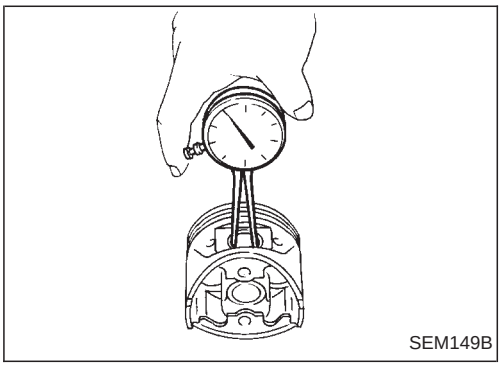
1. Place engine on work stand.
2. Drain coolant and remove water pump.
3. Drain oil.
4. Remove oil pan and oil strainer.
5. Remove distributor.
6. Remove front cover.
7. Remove oil pump chain. (TB42S only)
8. Remove timing chain.
9. Remove rocker cover.
10. Remove rocker shaft with rocker arms and push rods.
11. Remove cylinder head.
12. Remove valve lifters and camshaft.

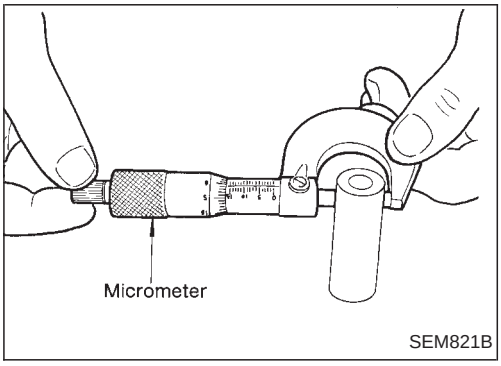


13. Remove pistons.
- When disassembling piston and connecting rod, remove snap rings first, then heat piston to 60 to 70°C (140 to 158°F) or use piston pin press stand at room temperature.

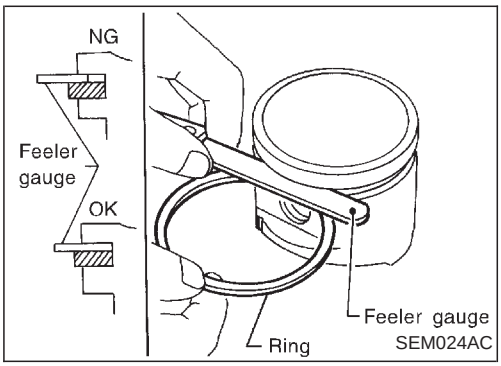


14. Remove bearing cap and crankshaft.
- **Before removing bearing cap, measure crankshaft end play.**

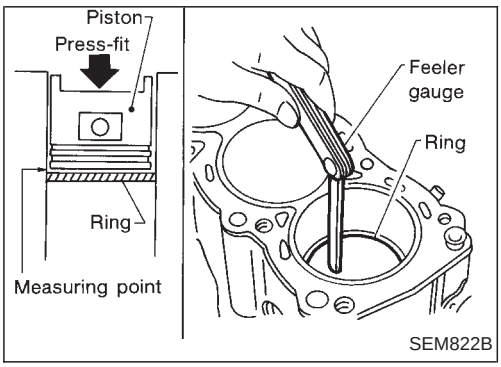

SEM149B



SEM821B



SEM024AC



SEM822B

Inspection

PISTON AND PISTON PIN CLEARANCE

1. Measure inner diameter of piston pin hole “dp”.
   Standard diameter “dp”:
   TB42S
   22.987 - 22.999 mm (0.9050 - 0.9055 in)
   TB45E
   22.993 - 23.005 mm (0.9052 - 0.9057 in)
2. Measure outer diameter of piston pin “Dp”.
   Standard diameter “Dp”:
   22.989 - 23.001 mm (0.9051 - 0.9055 in)
3. Calculate piston pin clearance.
   TB42S
   −0.007 to 0.003 mm (−0.0003 to 0.0001 in)
   TB45E
   −0.001 to 0.009 mm (−0.0000 to 0.0004 in)

If it exceeds the limit, replace piston assembly with pin.

PISTON RING SIDE CLEARANCE

Side clearance:
Top ring
0.040 - 0.073 mm (0.0016 - 0.0029 in)
2nd ring
0.030 - 0.063 mm (0.0012 - 0.0025 in)
Oil ring
0.065 - 0.135 mm (0.0026 - 0.0053 in)
Max. limit of side clearance (Top and 2nd rings):
0.1 mm (0.004 in)

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

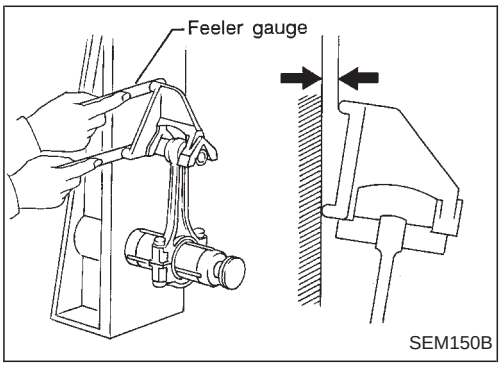
PISTON RING GAP

Standard ring gap:
Top ring
0.30 - 0.45 mm (0.0118 - 0.0177 in)
2nd ring
0.30 - 0.45 mm (0.0118 - 0.0177 in)
Oil ring
0.20 - 0.60 mm (0.0079 - 0.0236 in)
Max. limit of ring gap:
1.5 mm (0.059 in)

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

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

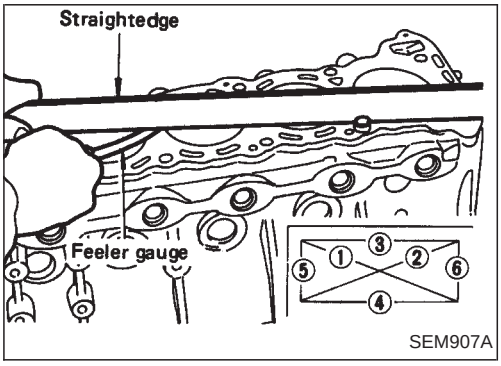
Inspection (Cont'd)



CONNECTING ROD BEND AND TORSION

Bend:
Limit 0.15 mm (0.0059 in)
per 100 mm (3.94 in) length
Torsion:
Limit 0.3 mm (0.012 in)
per 100 mm (3.94 in) length

If it exceeds the limit, replace connecting rod assembly.

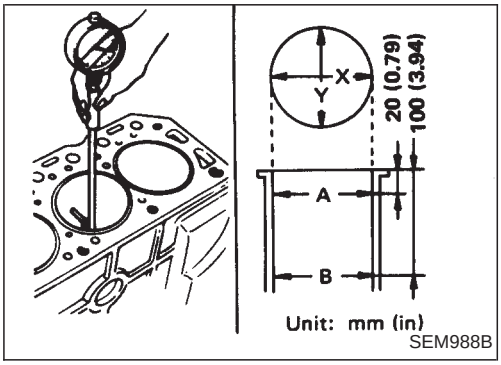


CYLINDER BLOCK DISTORTION AND WEAR

1. Clean upper face of cylinder block and measure the distortion.
   Limit: 0.10 mm (0.0039 in)
2. If out of specification, resurface it.
   The resurfacing limit is determined by the cylinder head resurfacing in engine.

Amount of cylinder head resurfacing is "A".
Amount of cylinder block resurfacing is "B".
The maximum limit is as follows:
A + B = 0.2 mm (0.008 in)
Nominal cylinder block height
from crankshaft center:
254.95 - 255.05 mm (10.0374 - 10.0413 in)

3. If necessary, replace cylinder block.



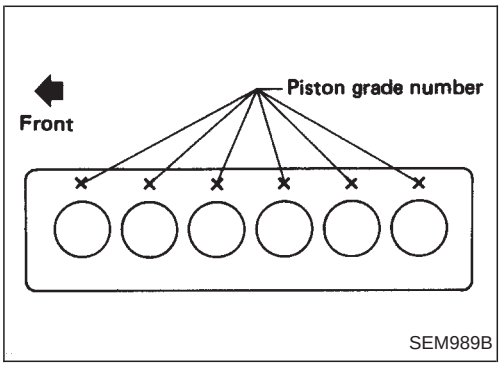
PISTON-TO-BORE CLEARANCE

Method A (Using bore gauge and micrometer)

1. Using a bore gauge, measure cylinder bore for wear, out-of-round or taper.
   Standard inner diameter:
   TB42S
   96.000 - 96.050 mm (3.7795 - 3.7815 in)
   TB45E
   99.500 - 99.550 mm (3.9173 - 3.9193 in)
   Wear limit:
   0.20 mm (0.0079 in)
   Out-of-round (X − Y) standard:
   0.015 mm (0.0006 in)
   Taper (A − B) standard:
   0.010 mm (0.0004 in)

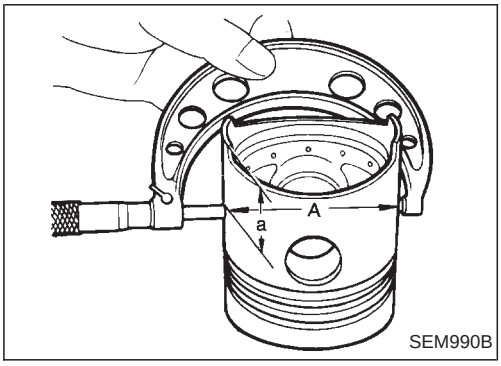
   If it exceeds the limit, rebore all cylinders. Replace cylinder block if necessary.
2. Check for scratches or seizure. If seizure is found, hone it.

Inspection (Cont'd)



SEM989B

- **If cylinder block or piston is replaced with a new one, select piston of the same grade number punched on cylinder block upper surface.**



SEM990B

3. Measure piston skirt diameter.
   Piston diameter "A":
   Refer to SDS.
   Measuring point "a" (Distance from the bottom):
   20 mm (0.79 in)
4. Check that piston-to-bore clearance is within the specification.
   Piston-to-bore clearance "B":
   TB42S
   0.015 - 0.035 mm (0.0006 - 0.0014 in)
   TB45E
   0.030 - 0.050 mm (0.0012 - 0.0020 in)
5. Determine piston oversize according to amount of cylinder wear.

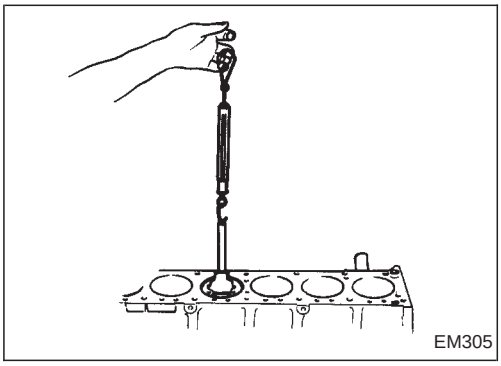
Oversize pistons are available for service. Refer to SDS.

6. Cylinder size is determined by adding piston-to-bore clearance to piston diameter "A".
   Rebored size calculation:
   D = A + B − C
   where, D: Bored diameter
   A: Piston diameter as measured
   B: Piston-to-bore clearance
   C: Honing allowance 0.02 mm (0.0008 in)
7. Install main bearing caps, and tighten to the specified torque to prevent distortion of cylinder bores in final assembly.
8. Cut cylinder bores.

- **When any cylinder needs boring, all other cylinders must also be bored.**
- **Do not cut too much out of the cylinder bore at a time. Cut only 0.05 mm (0.0020 in) or so in diameter at a time.**

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

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

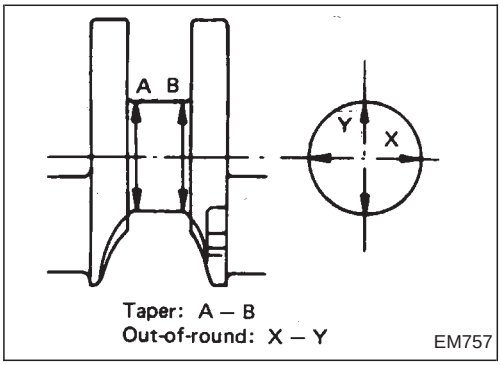

EM305

Method B (Using feeler gauge)

Measure the extracting force by pulling feeler gauge straight upward.

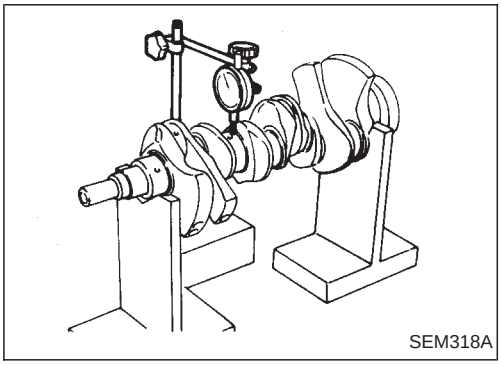
Feeler gauge thickness:
0.04 mm (0.0016 in)
Extracting force:
2.0 - 14.7 N (0.2 - 1.5 kg, 0.4 - 3.3 lb)

Inspection (Cont'd)

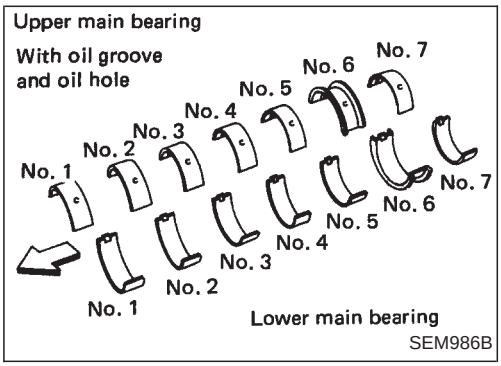


CRANKSHAFT

1. Check crankshaft main and pin journals for score, bias, wear or cracks.
2. With a micrometer, measure journals for taper and out-of-round.
   Out-of-round (X − Y):
   Less than 0.0025 mm (0.0001 in)
   Taper (A − B):
   Less than 0.0025 mm (0.0001 in)



3. Measure crankshaft runout.
   Runout (Total indicator reading):
   Less than 0.20 mm (0.0079 in)

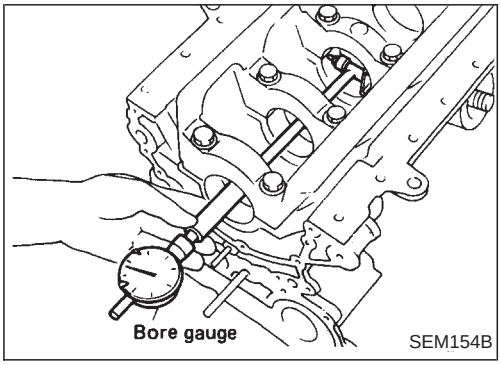


BEARING CLEARANCE

Method A (Using bore gauge and micrometer)

Main bearing clearance

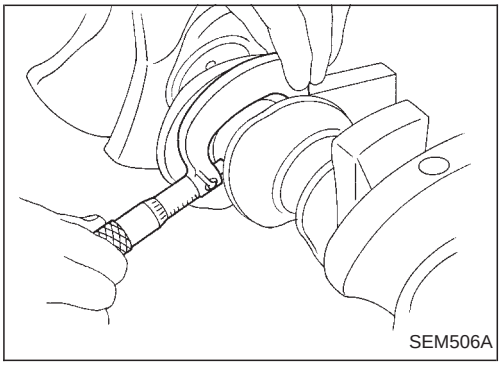
1. Set main bearings in their proper positions on cylinder block and main bearing cap.



2. Install main bearing cap to cylinder block.

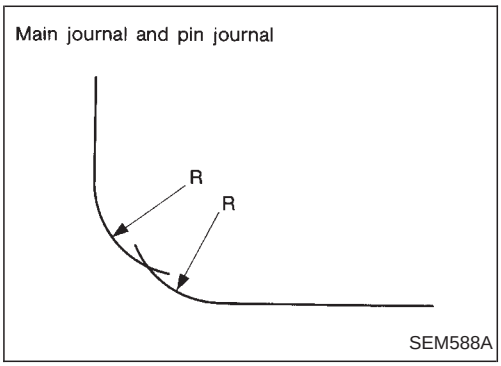
Tighten all bolts in correct order in two or three stages.

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



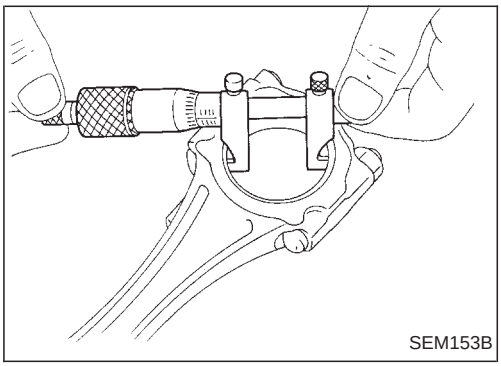
4. Measure outer diameter "Dm" of crankshaft main journal.
5. Calculate main bearing clearance.
   Main bearing clearance = A − Dm
   Standard: 0.030 - 0.087 mm (0.0012 - 0.0034 in)
   Limit: 0.09 mm (0.0035 in)
6. If it exceeds the limit, replace bearing.
7. If the clearance cannot be adjusted within the standard of any bearing, grind crankshaft journal and use undersized bearing.

Inspection (Cont'd)



a. When grinding crank pin and crank journal, fillets should be finished as shown in the figure.
   R: Main journal
   2.5 - 2.6 mm (0.098 - 0.102 in)
   Pin journal
   3.0 - 3.1 mm (0.118 - 0.122 in)
b. Refer to SDS for grinding crankshaft and available service parts.

8. If crankshaft, cylinder block and main bearings are replaced with new ones, check that the clearance of main bearing is within specifications.

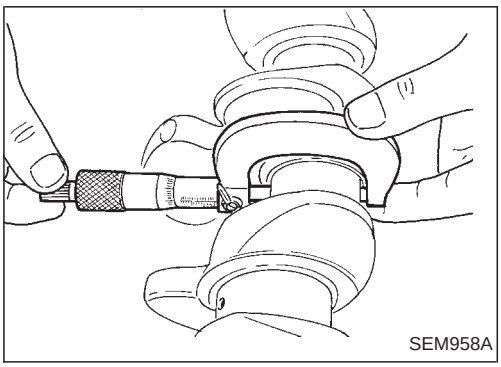


CONNECTING ROD BEARING CLEARANCE (Big end)

1. Install connecting rod bearing to connecting rod and cap.
2. Install connecting rod cap to connecting rod.

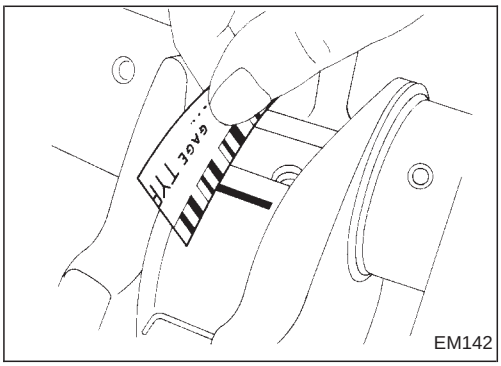
Tighten bolts to the specified torque.

3. Measure inner diameter "C" of bearing.



4. Measure outer diameter "Dp" of crankshaft pin journal.
5. Calculate connecting rod bearing clearance.
   Connecting rod bearing clearance = C − Dp
   Standard: 0.027 - 0.061 mm (0.0011 - 0.0024 in)
   Limit: 0.09 mm (0.0035 in)
6. If it exceeds the limit, replace bearing.
7. If the clearance cannot be adjusted within the standard of any bearing, grind crankshaft journal and use undersized bearing. Refer to step 7 of "MAIN BEARING CLEARANCE".

Inspection (Cont'd)



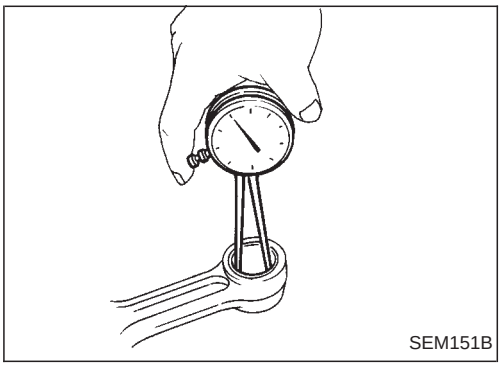
EM142

Method B (Using plastigage)

CAUTION:

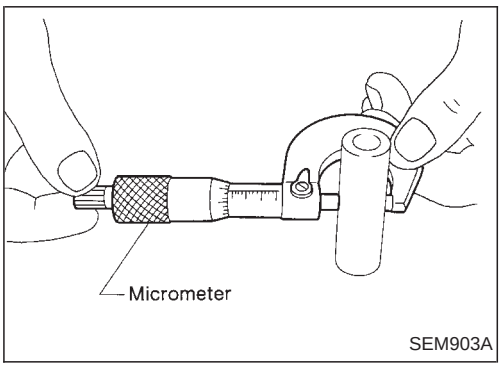
- **Do not turn crankshaft or connecting rod while the plastigage is being inserted.**
- **When bearing clearance exceeds the specified limit, ensure that the proper bearing has been installed. Then if excessive bearing clearance exists, use thicker main bearing or undersized bearing so that the specified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

Main bearing clearance:
Standard
0.051 - 0.097 mm (0.0020 - 0.0038 in)
Limit
0.1 mm (0.004 in)
Connecting rod bearing clearance:
Standard
0.040 - 0.074 mm (0.0016 - 0.0029 in)
Limit
0.1 mm (0.004 in)


SEM151B

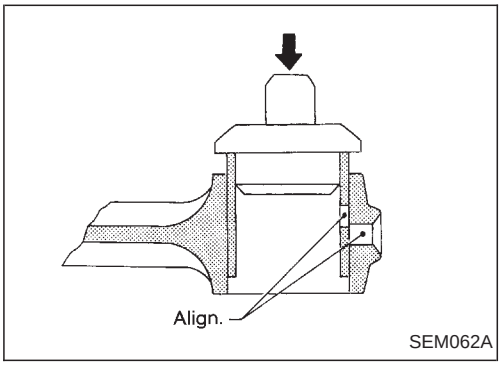
CONNECTING ROD BUSHING CLEARANCE (Small end)

1. Measure inner diameter "C" of bushing.



SEM903A

2. Measure outer diameter "Dp" of piston pin.
3. Calculate connecting rod bearing clearance.
   C − Dp = 0.005 - 0.017 mm (0.0002 - 0.0007 in)
   If it exceeds the limit, replace connecting rod bushing and/or piston set with pin.



SEM062A

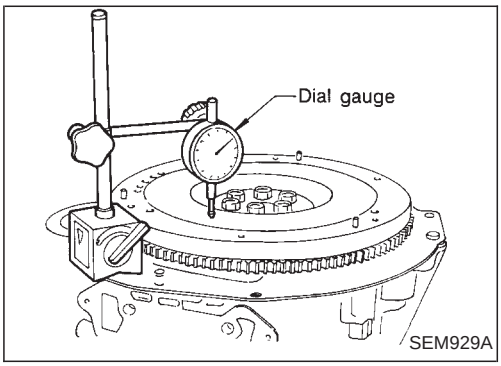
REPLACEMENT OF CONNECTING ROD SMALL END BUSHING

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

Be sure to align the oil holes.

2. After driving in the small end bushing, ream the bushing.
   Small end bushing inside diameter:
   Finished size
   23.000 - 23.012 mm (0.9055 - 0.9060 in)

Inspection (Cont'd)



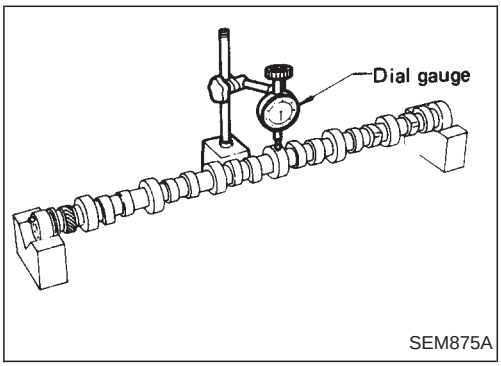
FLYWHEEL OR DRIVE PLATE RUNOUT

Runout (Total indicator reading):
Flywheel (M/T model)
0.1 mm (0.004 in) or less
Drive plate (A/T model)
0.1 mm (0.004 in) or less

If runout exceeds the limit, replace flywheel or drive plate.

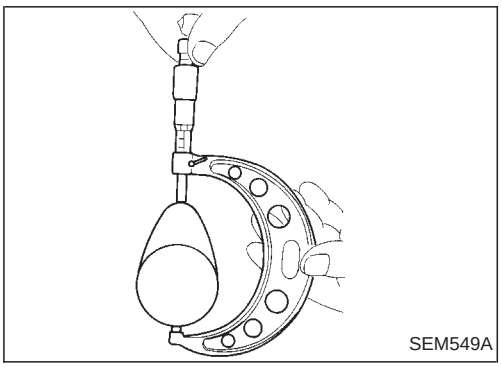
CAMSHAFT VISUAL CHECK

Check camshaft for scratches, seizure and wear.



CAMSHAFT RUNOUT

1. Measure camshaft runout at the center journal.
   Runout (Total indicator reading):
   Limit 0.06 mm (0.0024 in)
2. If it exceeds the limit, replace camshaft.

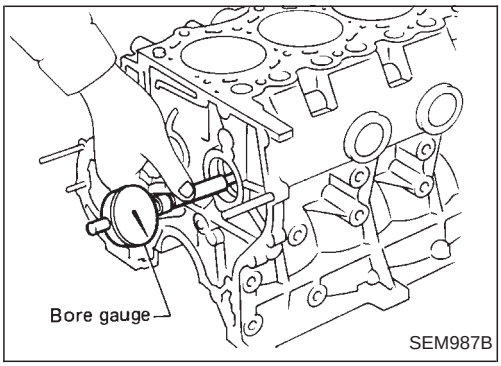


CAMSHAFT CAM HEIGHT

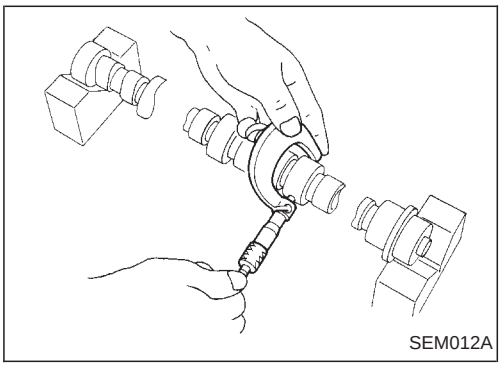
1. Measure camshaft cam height.
   Standard cam height:
   TB42S
   42.311 - 42.561 mm (1.6658 - 1.6756 in)
   TB45E
   42.126 - 42.376 mm (1.6585 - 1.6683 in)
   Cam wear limit:
   0.15 mm (0.0059 in)
2. If wear is beyond the limit, replace camshaft.

Inspection (Cont'd)

CAMSHAFT JOURNAL CLEARANCE

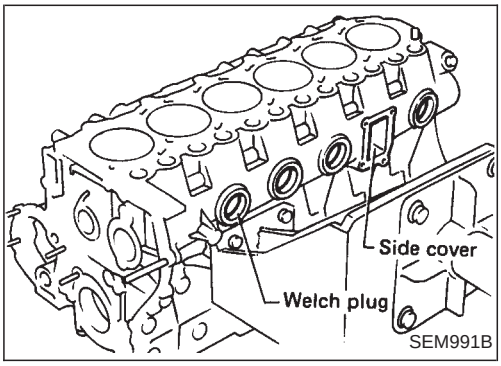


1. Measure the inner diameter of camshaft bushings.
   Standard inner diameter:
   Front
   50.76 - 50.83 mm (1.9984 - 2.0012 in)
   2nd
   50.56 - 50.63 mm (1.9905 - 1.9933 in)
   3rd
   50.36 - 50.43 mm (1.9827 - 1.9854 in)
   4th
   50.16 - 50.23 mm (1.9748 - 1.9776 in)
   5th
   49.96 - 50.03 mm (1.9669 - 1.9697 in)
   6th
   49.76 - 49.83 mm (1.9591 - 1.9618 in)
   Rear
   49.56 - 49.63 mm (1.9512 - 1.9539 in)



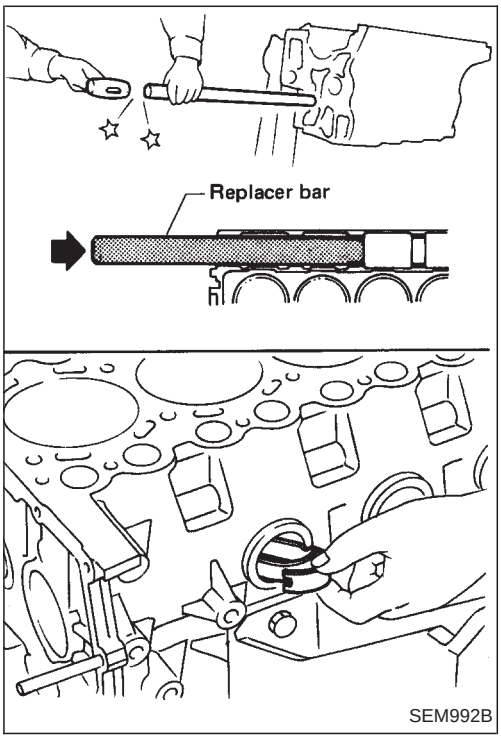
2. Measure the outer diameter of camshaft journal.
   Standard outer diameter:
   Front
   50.721 - 50.740 mm (1.9969 - 1.9976 in)
   2nd
   50.521 - 50.540 mm (1.9890 - 1.9898 in)
   3rd
   50.321 - 50.340 mm (1.9811 - 1.9819 in)
   4th
   50.121 - 50.140 mm (1.9733 - 1.9740 in)
   5th
   49.921 - 49.940 mm (1.9654 - 1.9661 in)
   6th
   49.721 - 49.740 mm (1.9575 - 1.9583 in)
   Rear
   49.521 - 49.540 mm (1.9496 - 1.9504 in)
3. If the clearance exceeds the limit, replace camshaft and/or camshaft bushings.
   Camshaft journal clearance limit:
   0.15 mm (0.0059 in)

REPLACING CAMSHAFT BUSHING

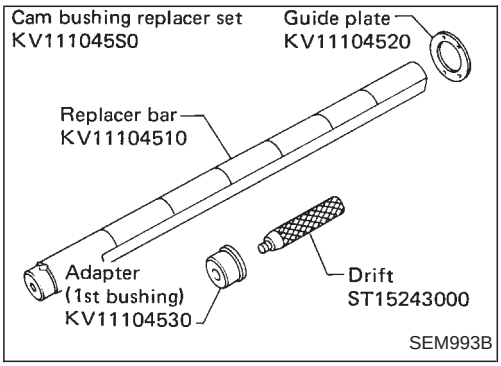


1. Remove welch plugs and side cover.

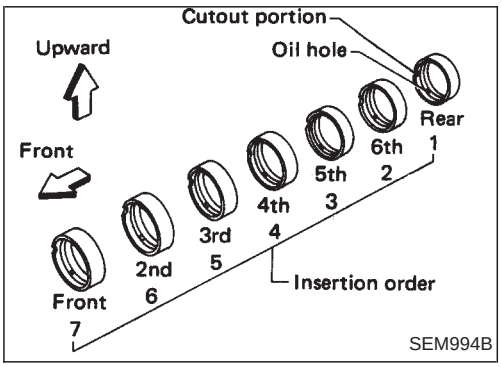
Inspection (Cont'd)



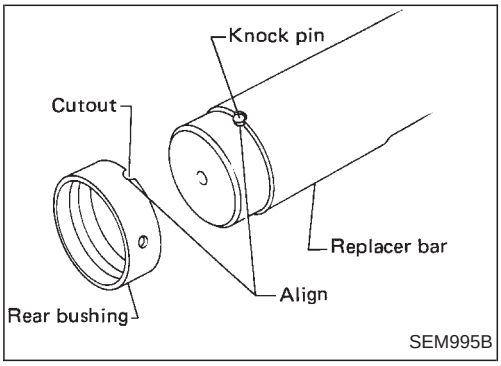
2. Using Tool, remove camshaft bushings from engine. Some bushings must be broken in order to remove.



3. Using Tool, install camshaft bushings as follows:

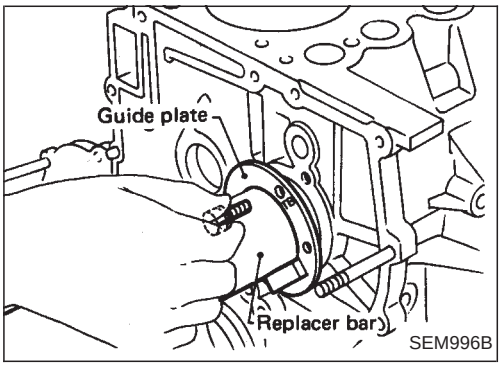


(1) Install camshaft bushings in the order of "rear", "6th", "5th", "4th", "3rd", "2nd" and "front". All bushings must be installed from the front.
(2) Face the cutout rightward and toward the front of engine during installation.



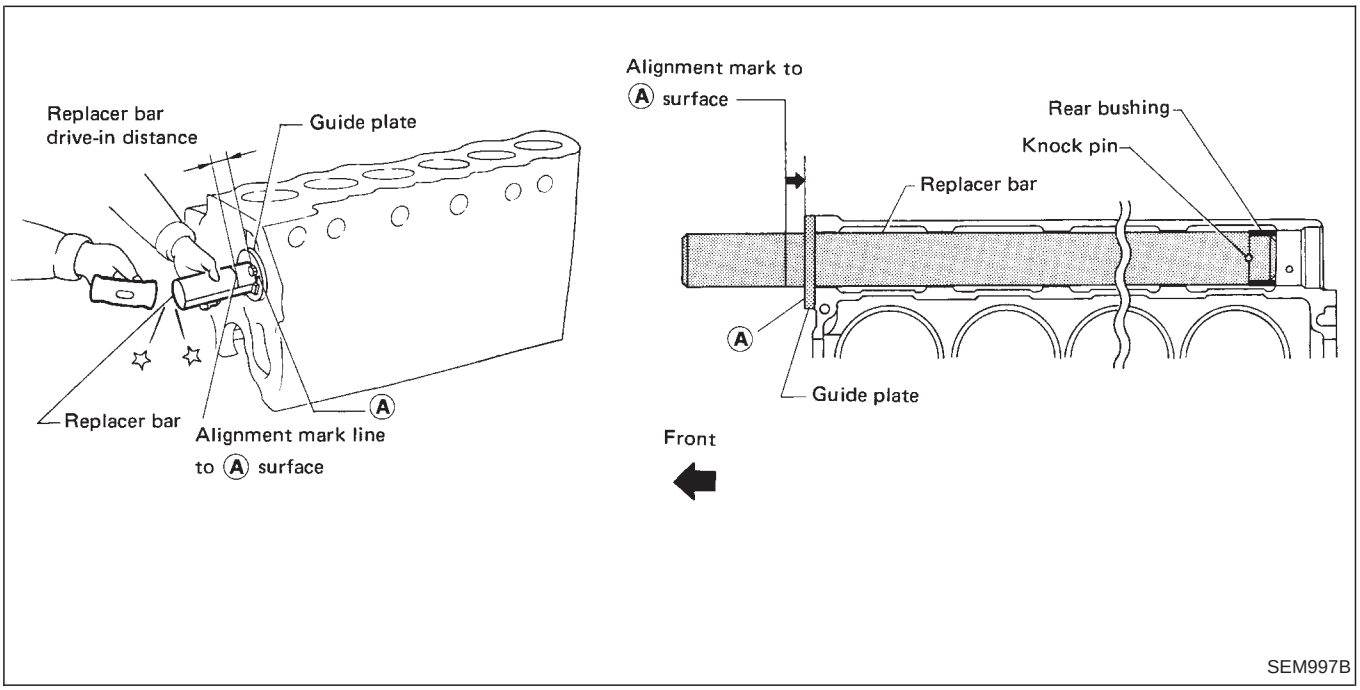
(3) Rear camshaft bushing
Align the cutout of rear bushing with knock pin of replacer bar before installation.

Inspection (Cont'd)



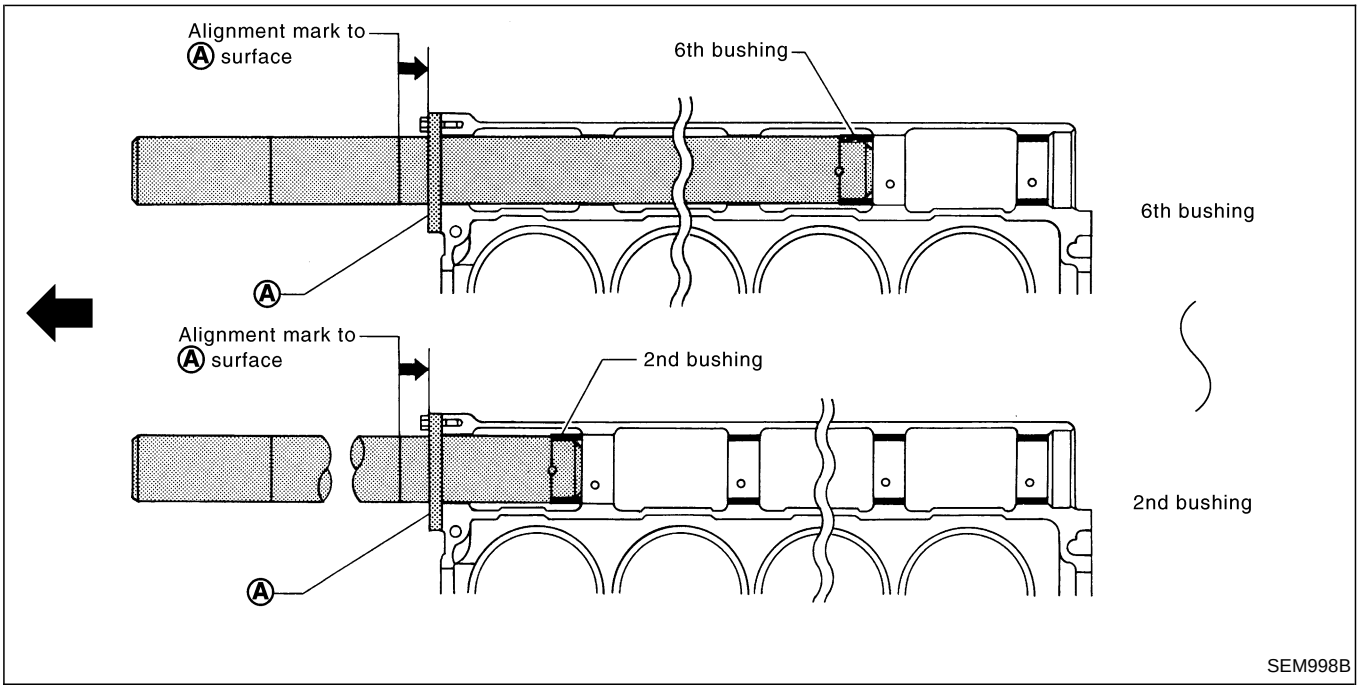
Insert rear bushing with replacer bar into cylinder block.
Install guide plate with bolt holes (on the "TB" mark side) facing upper side of cylinder block. Tighten bolts.

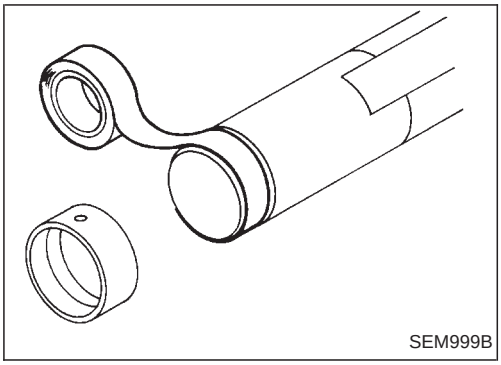
Drive replacer bar until the alignment mark on replacer bar is aligned with the end of guide plate.
Remove replacer set.
After installation, check that oil holes 4.3 mm (0.169 in) dia. in camshaft bushings are aligned with oil holes 6 mm (0.24 in) dia. in the cylinder block.



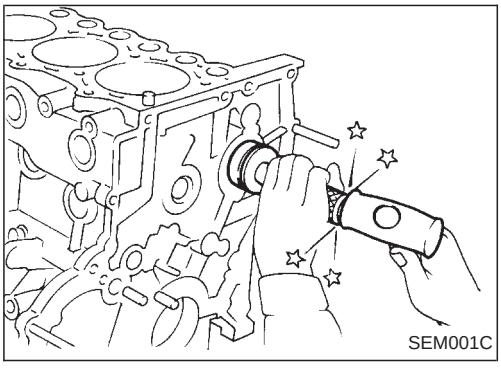
Inspection (Cont'd)

(4) 6th, 5th, 4th, 3rd and 2nd camshaft bushings
Install in the same manner as rear camshaft bushing.



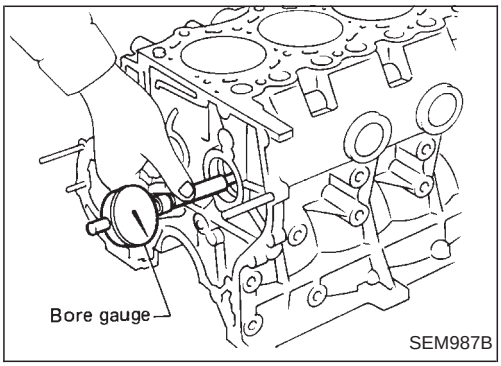


When setting 6th through 2nd bushings on replacer bar, tape the bar to prevent movement.

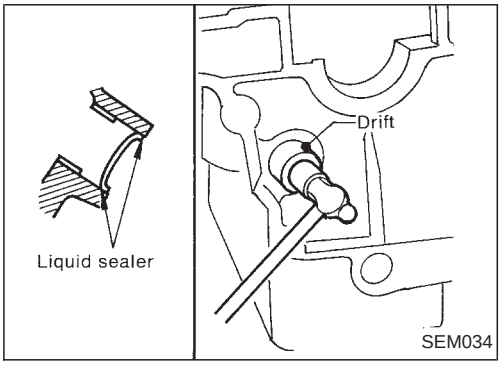


(5) Front camshaft bushing
Using 1st bushing adapter, position front camshaft bushing so that oil hole in cylinder block is aligned with oil hole in bushing.

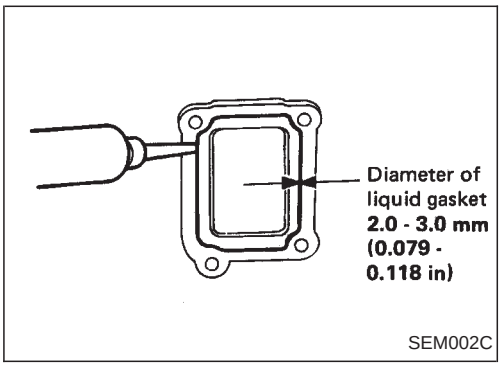
Inspection (Cont'd)



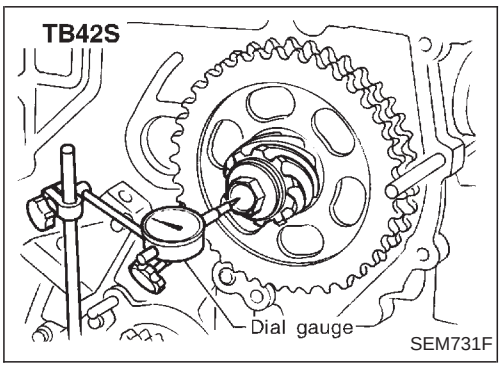
4. Check camshaft bushing inner diameter.



5. Install new welch plugs with a drift.
Apply liquid sealer.

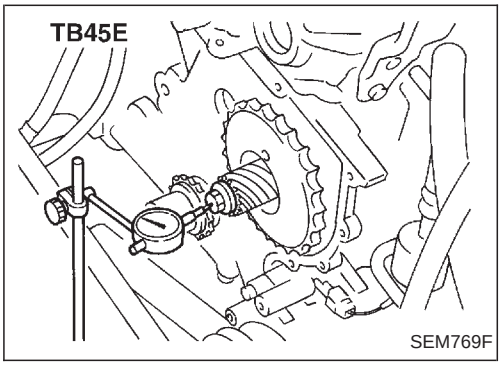


6. Install side cover. (TB42S only)
Apply liquid gasket.
- **Use Genuine Liquid Gasket or equivalent.**



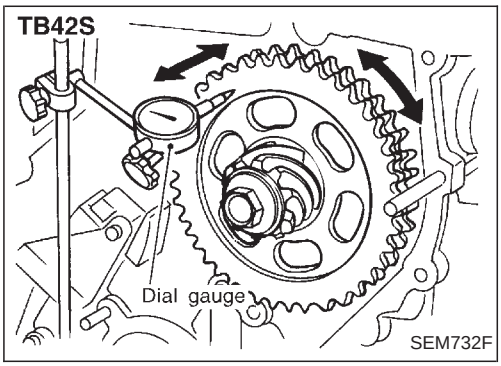
CAMSHAFT END PLAY

1. Install camshaft in cylinder block.
2. Measure camshaft end play.
   Camshaft end play:
   Standard
   0.08 - 0.28 mm (0.0031 - 0.0110 in)
   Limit
   0.05 mm (0.0020 in)
3. If end play exceeds the limit, replace locating plate.

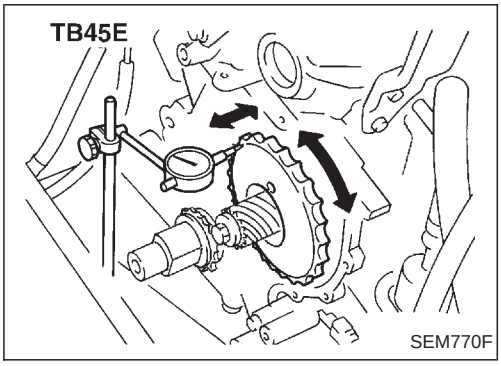


Inspection (Cont'd)

CAMSHAFT SPROCKET RUNOUT

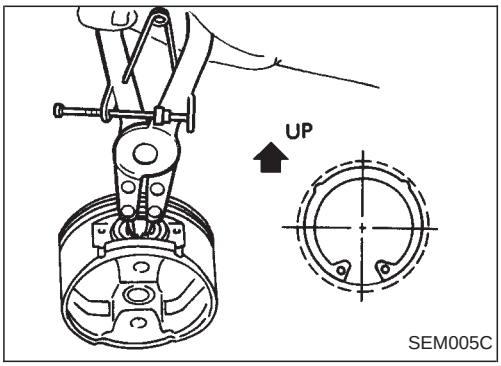


1. Install sprocket on camshaft.
2. Measure camshaft sprocket runout.
   Runout (Total indicator reading):
   Limit
   0.02 mm (0.0008 in)
3. If it exceeds the limit, replace camshaft sprocket.



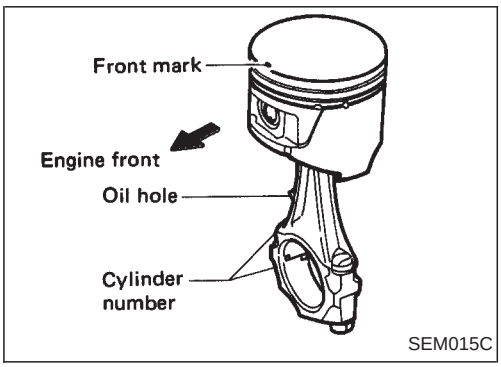
Assembly

PISTON



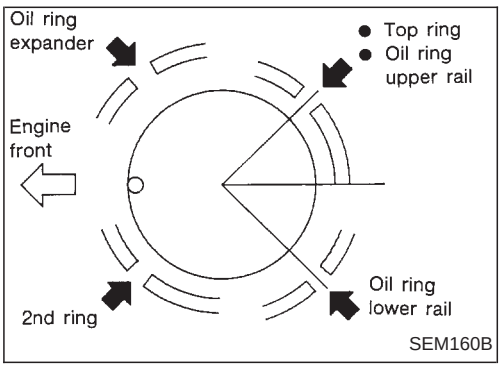
1. Install a new snap ring on one side of the piston pin hole.

Ensure that ends of snap ring face down and fit properly into groove.



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

- **Align the direction of piston and connecting rod.**
- **Numbers stamped on connecting rod and cap correspond to each cylinder.**

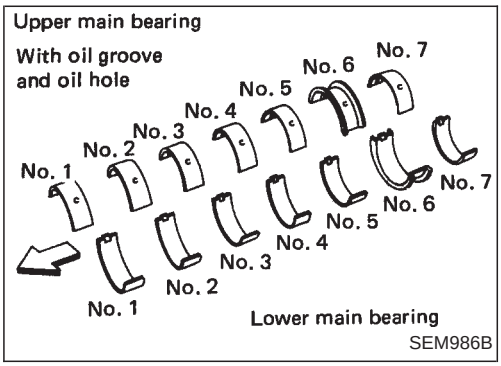


- **After assembly, make sure piston swings smoothly.**

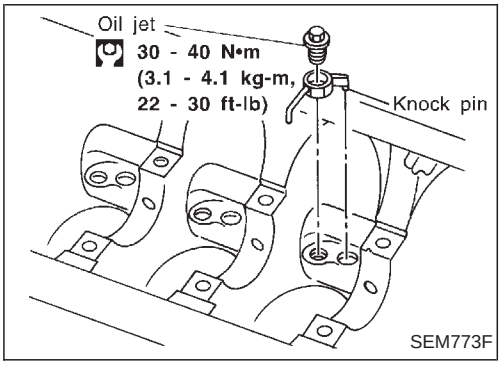
3. Set piston rings as shown.

Assembly (Cont'd)

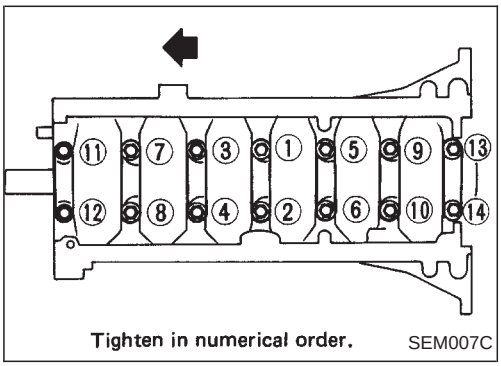
CRANKSHAFT



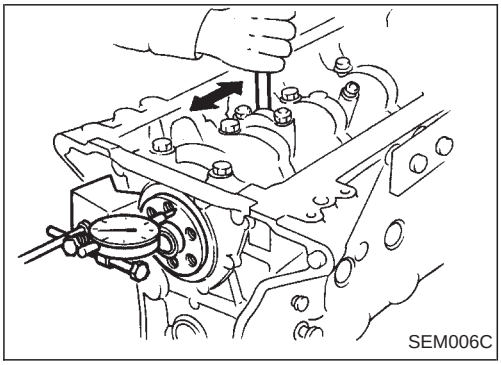
1. Set main bearings in their proper positions on cylinder block and main bearing cap.
- **Do not confuse upper and lower sides of main bearings.**



2. Install the oil jet. (TB45E engine only)
- **Insert the oil jet knock pin into the knock pin hole on the cylinder block, and tighten fixing bolt.**



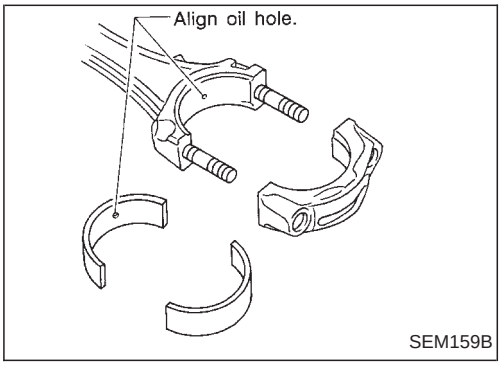
3. Install crankshaft and main bearing caps and tighten bolts to the specified torque.
- **Prior to tightening bearing cap bolts, place bearing cap in its proper position by shifting crankshaft in the axial direction.**
- **Tighten bearing cap bolts gradually in two or three stages start with the center bearing and move outward sequentially.**
- **After securing bearing cap bolts, make sure crankshaft turns smoothly by hand.**



4. Measure crankshaft end play.

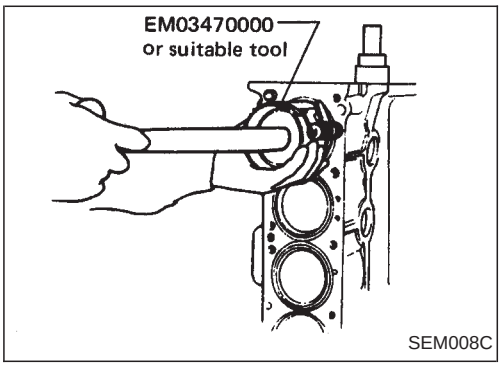
Crankshaft end play:
Standard
0.05 - 0.17 mm (0.0020 - 0.0067 in)
Limit
0.3 mm (0.012 in)

If end play exceeds the limit, replace No. 6 bearing.

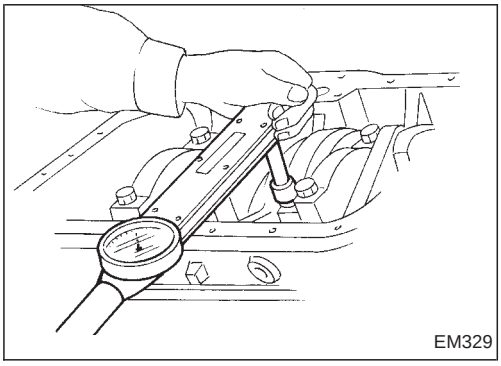


5. Install connecting rod bearings in connecting rods and connecting rod caps.
- Confirm that correct bearings are used. **Refer to "Inspection".**
- Install bearings so that oil hole in connecting rod aligns with oil hole of bearing.

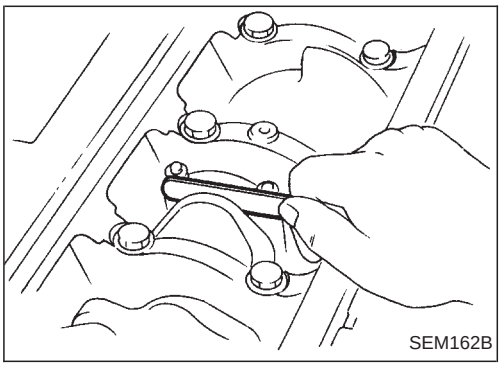
Assembly (Cont'd)



6. Install pistons with connecting rods.
(1) Install them into corresponding cylinders with Tool.
- **Be careful not to scratch cylinder wall by connecting rod.**
- **Arrange so that front mark on piston head faces toward front of engine.**

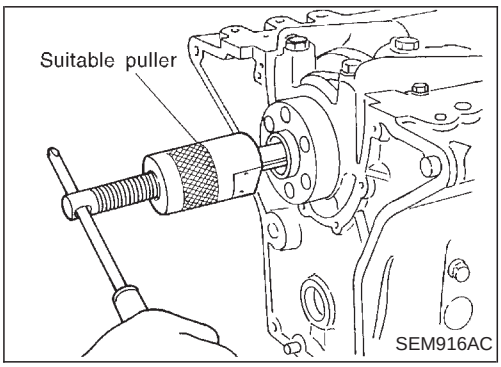


(2) Install connecting rod bearing caps.
Tighten connecting rod bearing cap nuts to the specified torque.
: Connecting rod bearing nut
(1) Tighten to 38 to 40 N·m
(3.9 to 4.1 kg-m, 28 to 30 ft-lb)
(2) Tighten to 67 to 71 N·m
(6.8 to 7.2 kg-m, 49 to 52 ft-lb)
or if you have an angle wrench, tighten bolts 40 to 45 degrees clockwise.

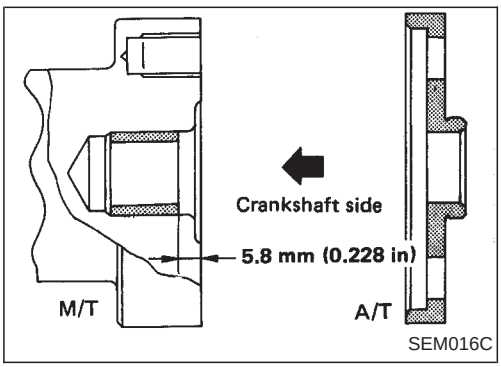


7. Measure connecting rod side clearance.
Connecting rod side clearance:
Standard
0.20 - 0.30 mm (0.0079 - 0.0118 in)
Limit
0.40 mm (0.0157 in)
If clearance exceeds the limit, replace connecting rod and/or crankshaft.

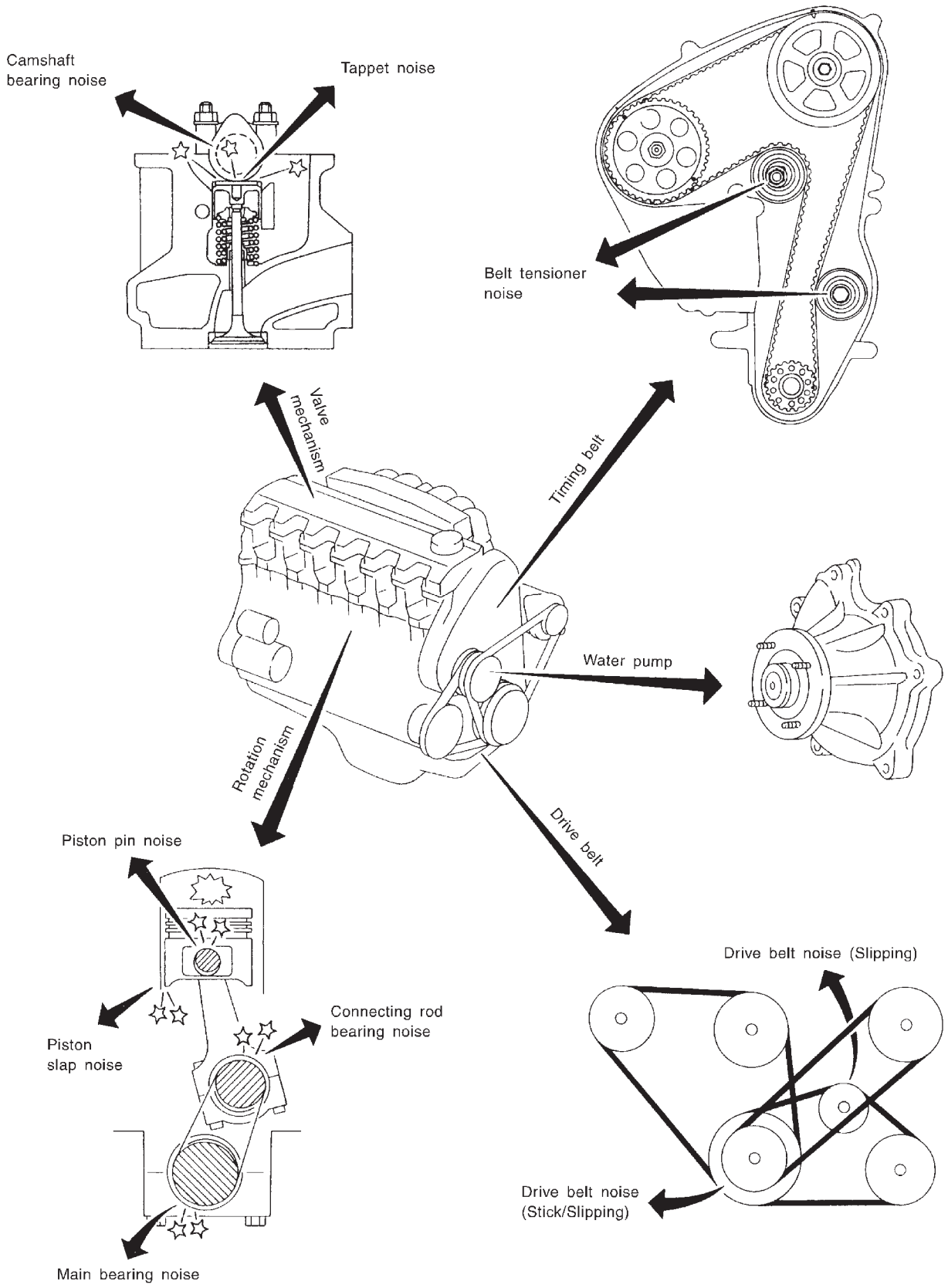
REPLACING PILOT BUSHING



1. Remove pilot bushing (M/T) or pilot converter (A/T).



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


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

SEM808F

NVH Troubleshooting Chart — Engine Noise

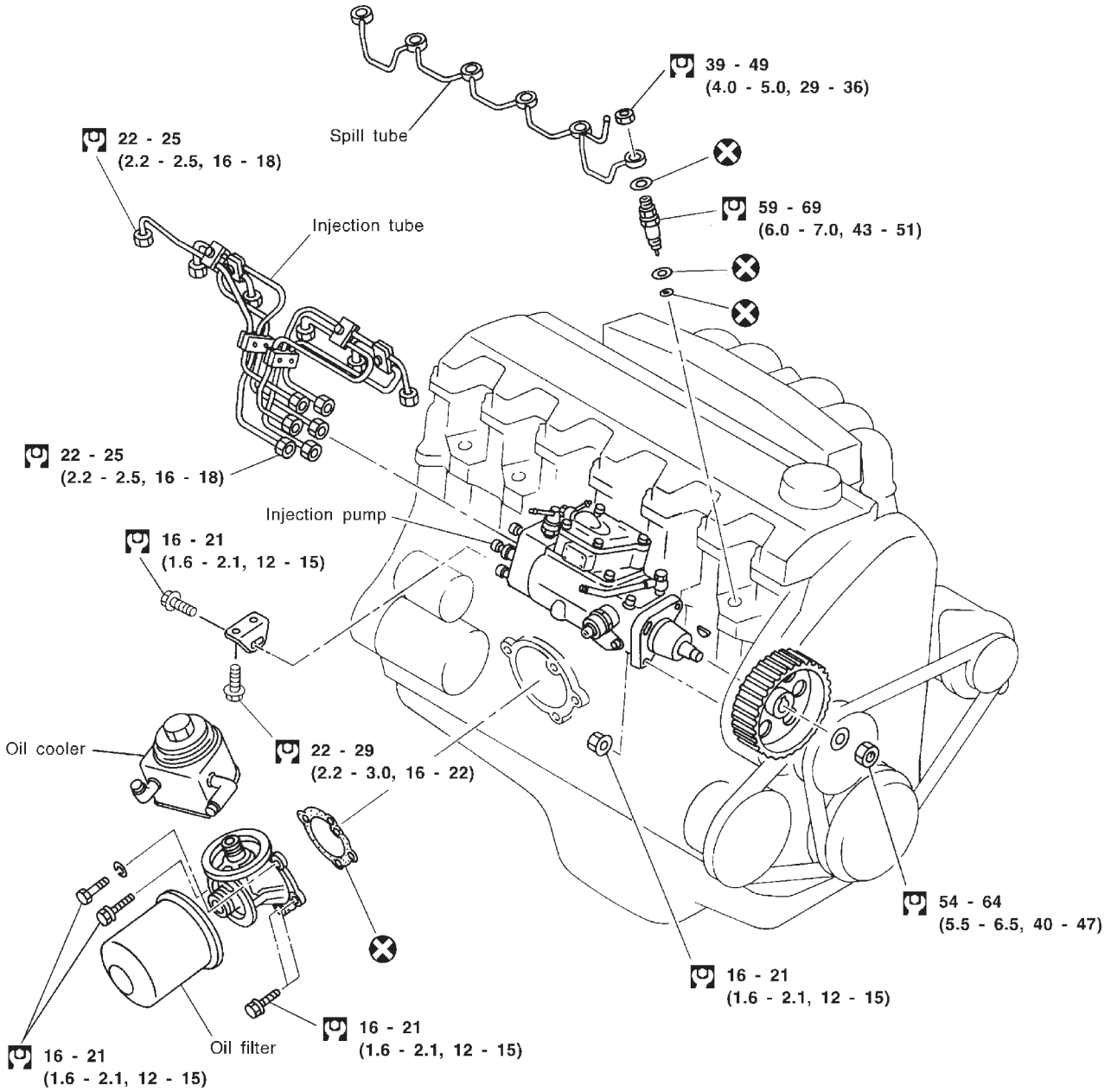
Use the chart below to help you find the cause of the symptom.
1. Locate the area where noise occurs.
2. Confirm the type of noise.
3. Specify the operating condition of engine.
4. Check specified noise source.

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-103
	Rattle	C	A	—	A	B	C	Camshaft bearing noise	Camshaft journal clearance Camshaft runout	EM-99
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-109, 115
	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-110, 111
	Knock	A	B	C	B	B	B	Connecting rod bearing noise	Connecting rod bushing clearance (Small end) Connecting rod bearing clearance (Big end)	EM-114, 115
	Knock	A	B	—	A	B	C	Main bearing noise	Main bearing oil clearance Crankshaft runout	EM-113
Timing belt cover	Whine or hissing	C	A	—	A	A	—	Timing belt noise (too tight)	Loose timing belt Belt contacting case	EM-80
	Clatter	A	B	—	C	A	—	Timing belt noise (too loose)		
Front of engine	Squeaking or fizzing	A	B	—	B	—	C	Other drive belts (Sticking or slipping)	Drive belts deflection	*1
	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	*2

A: Closely related B: Related C: Sometimes related —: Not related
*1: MA section (“Checking Drive Belts”, “ENGINE MAINTENANCE”)
*2: LC section (“Water Pump Inspection”, “ENGINE COOLING SYSTEM”)

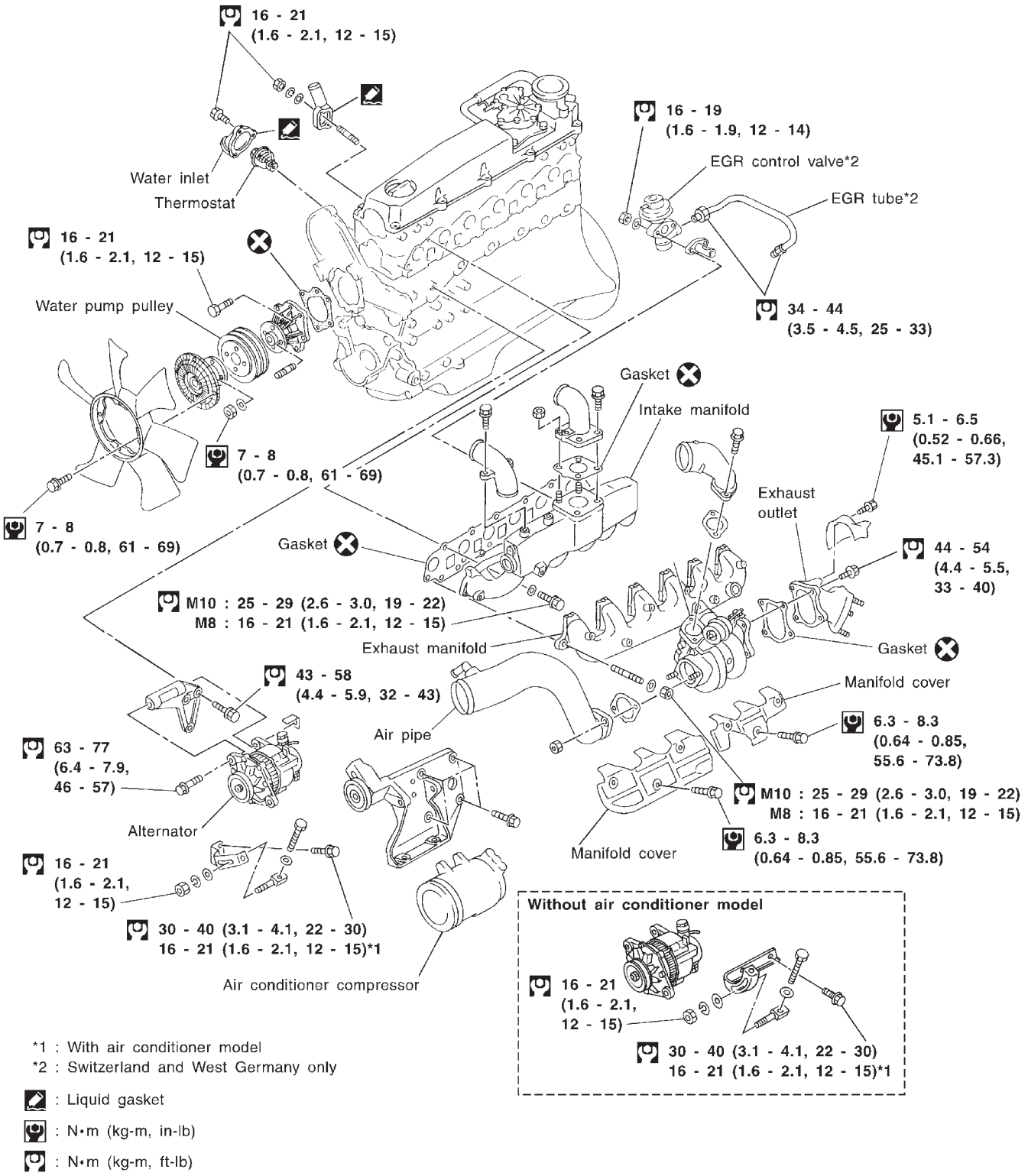
SEC. 150•185•186•213



: N•m (kg-m, ft-lb)

SEM780F

SEC. 120•144•147•210•211•230



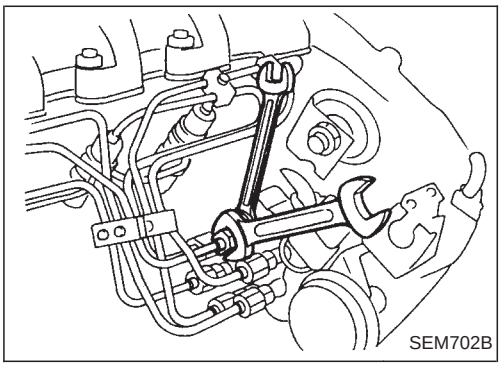
*1 : With air conditioner model
*2 : Switzerland and West Germany only

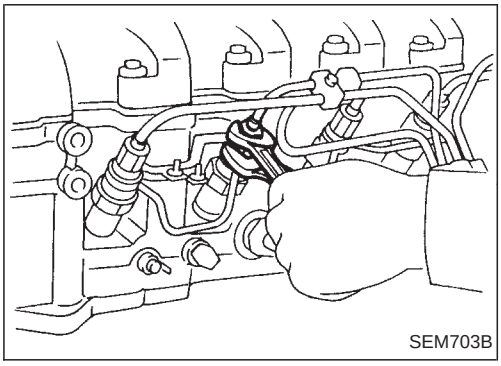
: Liquid gasket

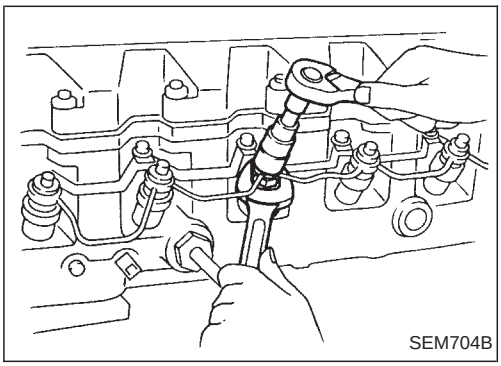
: N•m (kg-m, in-lb)

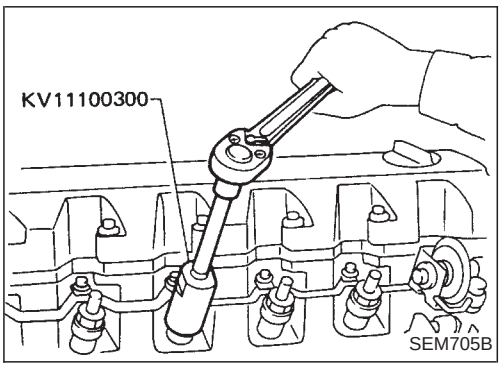
: N•m (kg-m, ft-lb)

SEM781F

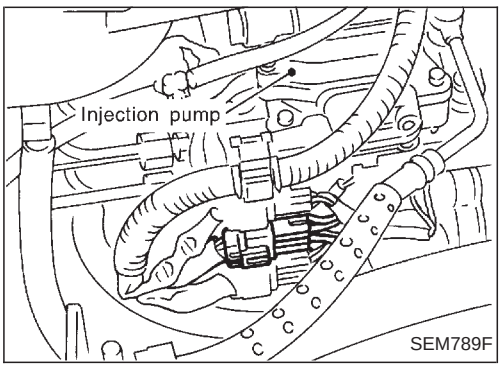

SEM702B


SEM703B


SEM704B



SEM705B



SEM789F

Measurement of Compression Pressure

1. Warm up engine to normal operating temperature.
2. Disconnect injection tube on nozzle side and loosen injection tubes on pump side. Release clamps on injection tubes.

- **Use two wrenches to prevent delivery holder on pump side from loosening.**

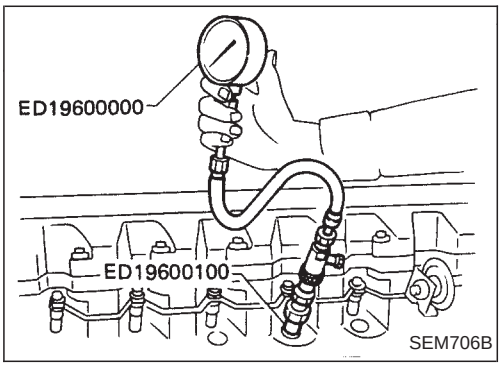
3. Remove spill-tube assembly.

- **To prevent spill tube from breaking, remove it by gripping nozzle holder.**

4. Remove all injection nozzles using Tool or a suitable tool.

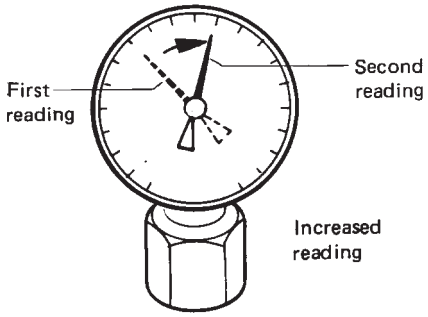
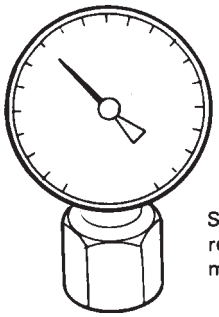
5. Turn ignition switch OFF and disconnect harness connector (black colored) at injection pump.

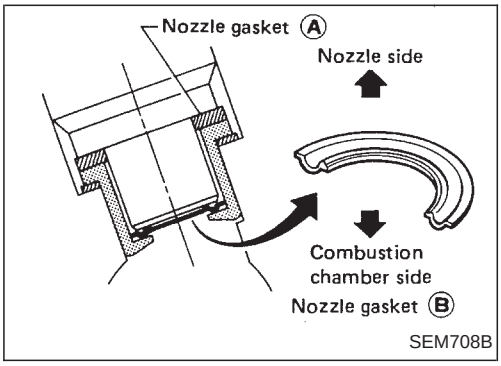
Measurement of Compression Pressure (Cont'd)



6. Fit compression gauge adapter to cylinder head.

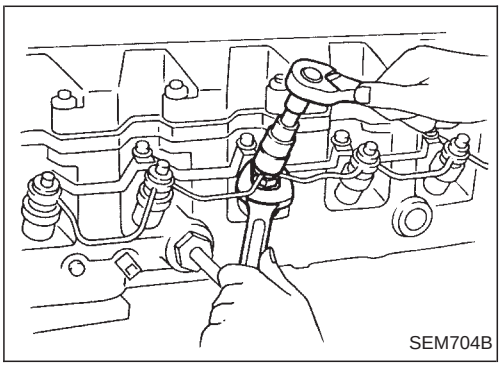
7. Crank engine and read gauge indication.
   Crank speed: 200 rpm
   Compression pressure:
   Standard
   3,040 kPa (30.4 bar, 31 kg/cm^2, 441 psi)
   Limit
   2,452 kPa (24.5 bar, 25 kg/cm^2, 356 psi)
   Differential limit between cylinders
   490 kPa (4.9 bar, 5 kg/cm^2, 71 psi)
8. If the pressure appears low, pour about 3 mℓ (0.11 Imp fl oz) of engine oil through nozzle holes and repeat test.
   For indications of test, refer to the following table.

Gauge indication during tests	Trouble diagnosis
 SEM857	● Piston rings are worn or damaged.
 SEM858	● If two adjacent cylinders are low, gasket is damaged. ● Valve is sticking. ● Valve seat or valve contact surface is incorrected.

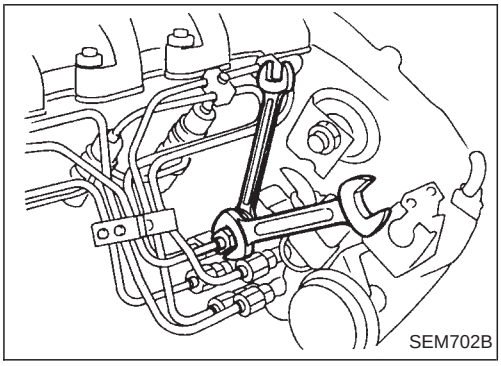


9. Replace nozzle gaskets and install injection nozzles.
New nozzle gasket installation direction is as shown.
Nozzle to cylinder head:
: 59 - 69 N·m
(6.0 - 7.0 kg-m, 43 - 51 ft-lb)

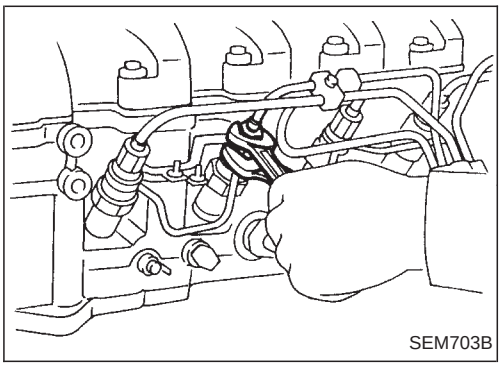
Measurement of Compression Pressure (Cont'd)


SEM704B

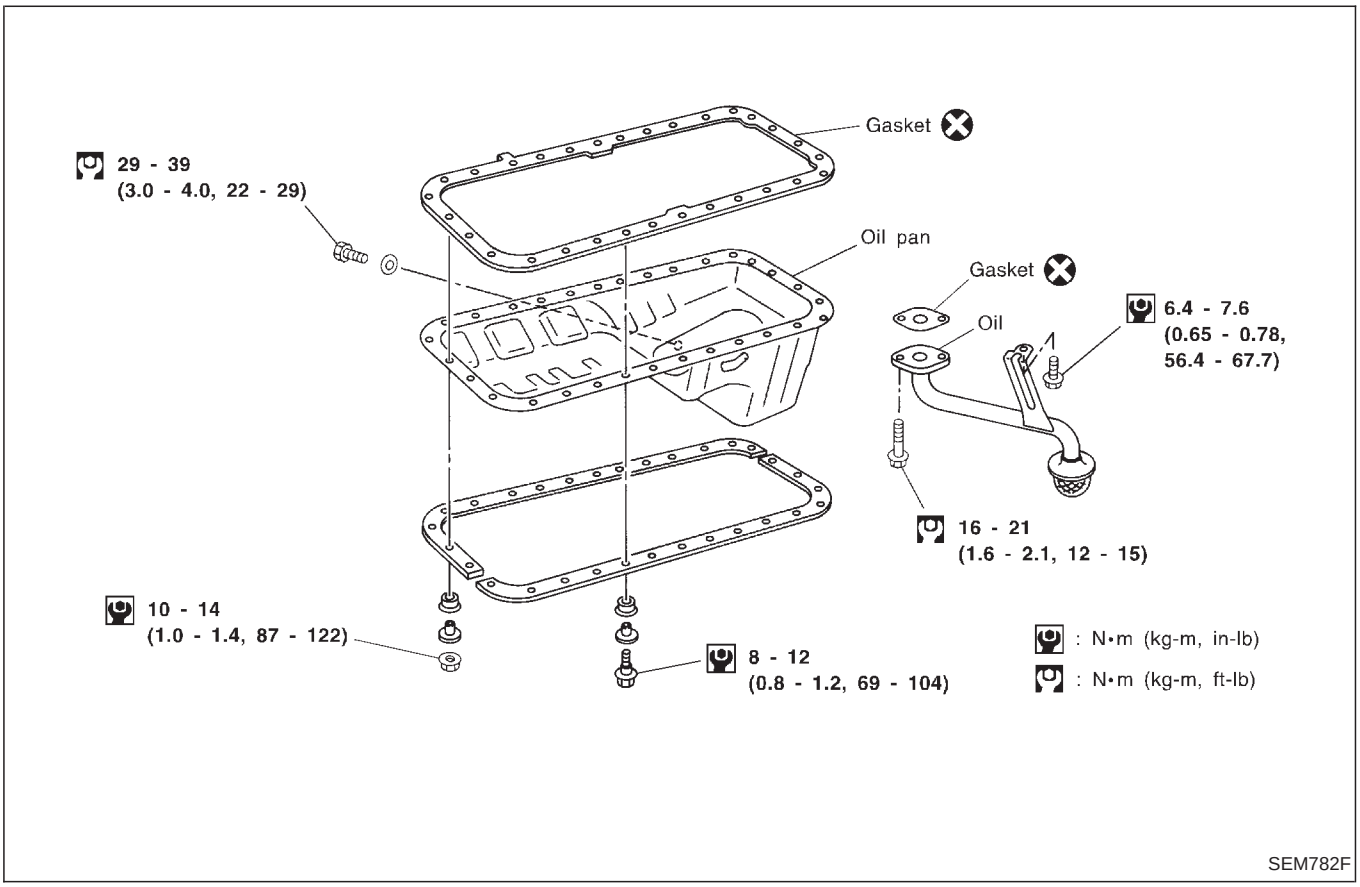
10. Install spill tube by holding nozzle holder.
    Spill tube nut:
    : 39 - 49 N·m
    (4 - 5 kg-m, 29 - 36 ft-lb)

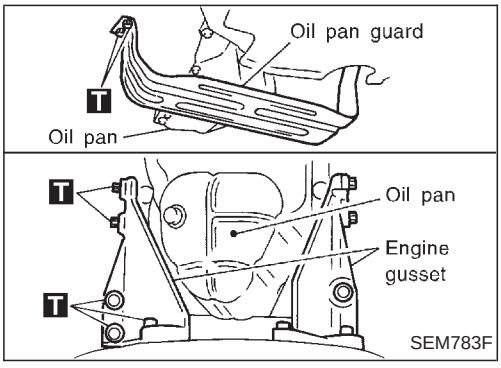

SEM702B

11. Install injection tubes using two wrenches as shown.
    Injection tube:
    : 22 - 25 N·m
    (2.2 - 2.5 kg-m, 16 - 18 ft-lb)


SEM703B

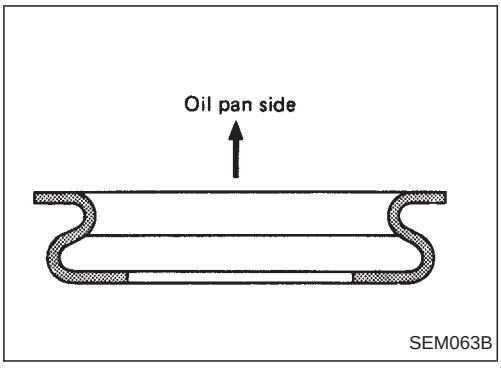
12. Initialize the ECM.
    Refer to EC section ("HOW TO ERASE DTC").





Removal

1. Remove oil pan guard.

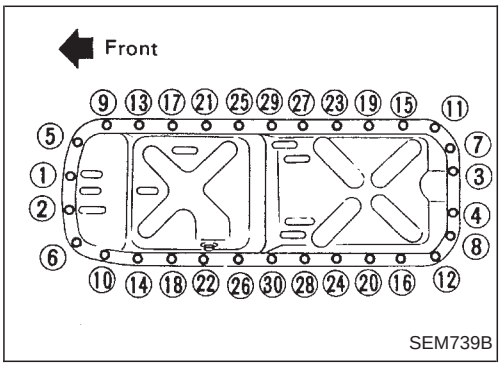


2. Drain engine oil.

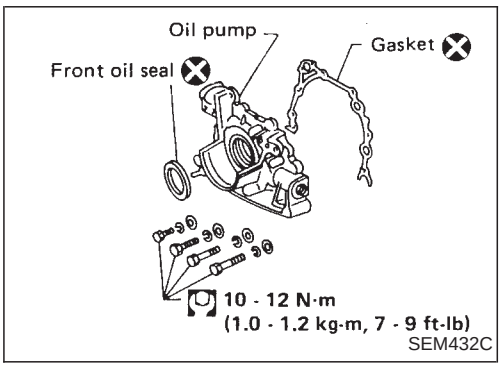
- When installing drain plug washer, ensure it faces in correct direction.
- Discard oil drain plug washer and install a new one.

Drain plug:
: 29 - 39 N·m (3.0 - 4.0 kg-m, 22 - 29 ft-lb)

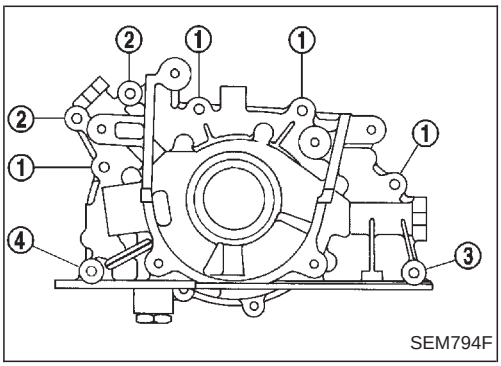
Removal (Cont'd)



3. Remove engine gussets and oil pan bolts.
- Remove bolts/nuts in numerical order shown in figure, alternating left and right ones toward the center.



4. Remove oil pump assembly.



Installation

Always install with new oil seal.

1. Install oil pump assembly.

Location	Bolt length mm (in)
①	20 (0.79)
②	35 (1.38)
③	45 (1.77)
④	55 (2.17)

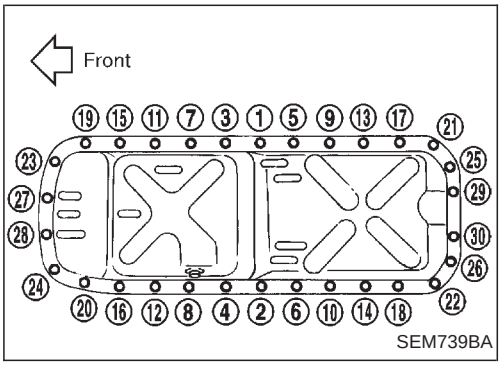
2. Install oil pan. Tighten bolts in the order shown in the figure.
- **Always replace oil pan gaskets with new ones when reassembling.**
- **Install oil pan gasket after cleaning the contacting surface.**
- **Oil pan bolts/nuts:**

  Bolt

  : 8 - 12 N·m (0.8 - 1.2 kg-m, 69 - 104 in-lb)

  Nut

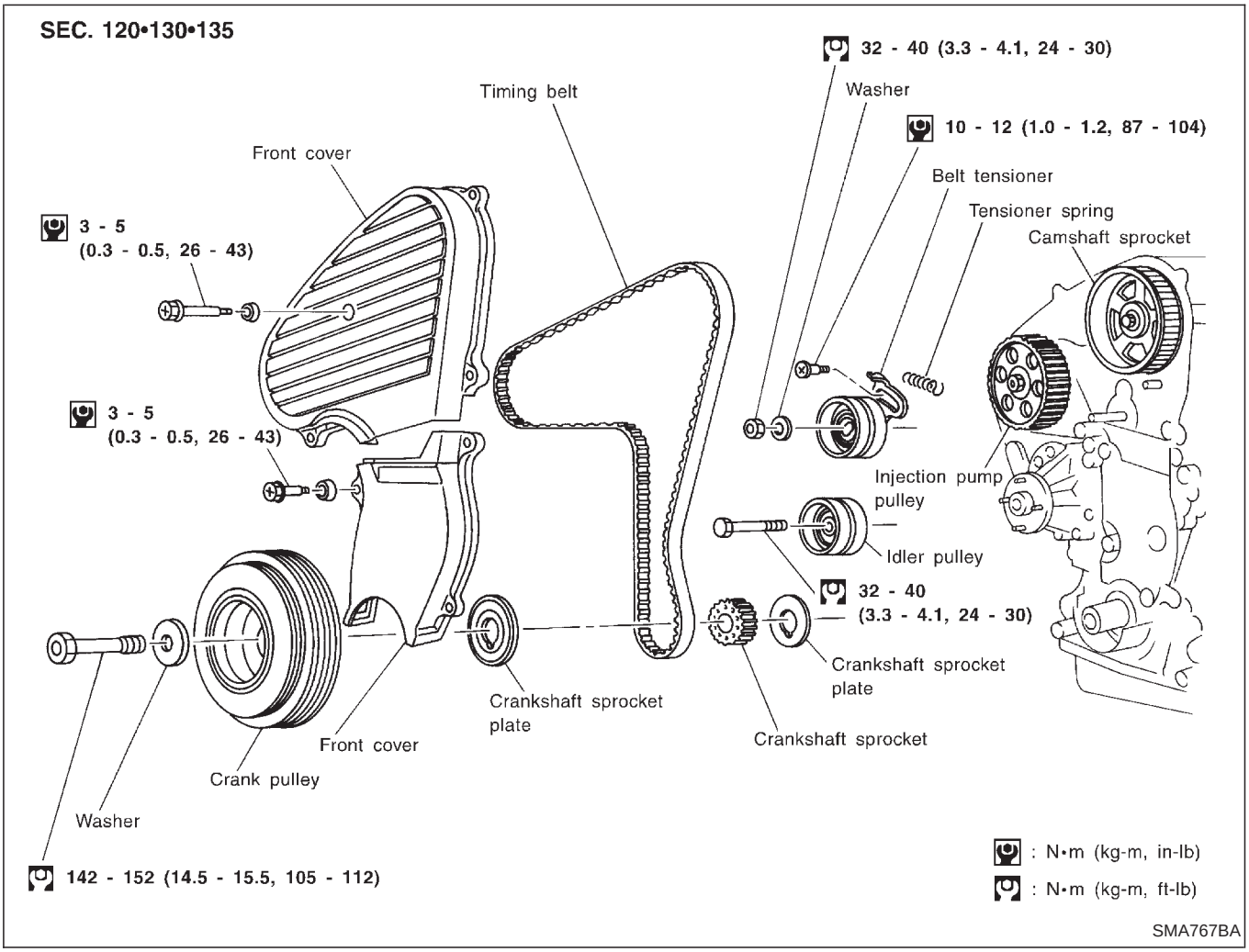
  : 10 - 14 N·m (1.0 - 1.4 kg-m, 87 - 122 in-lb)



3. Install engine gusset and oil pan guard.

CAUTION:

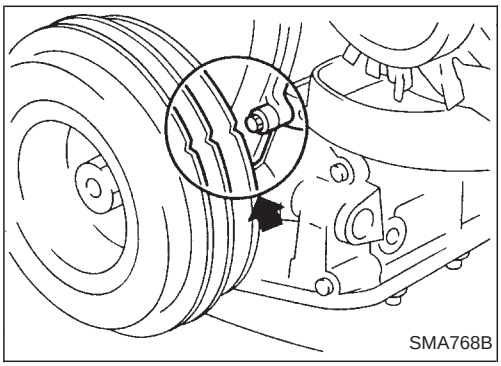
- **Do not bend or twist timing belt.**
- **After removing timing belt, do not turn crankshaft and camshaft separately because valves will strike piston heads.**
- **Make sure that timing belt, camshaft sprocket, crankshaft sprocket, idler pulley, injection pump pulley and belt tensioner are clean and free from oil and water.**
- **Align white lines on timing belt with punch mark on camshaft sprocket, crankshaft sprocket and injection pump pulley.**
- **Installation should be carried out when engine is cold.**



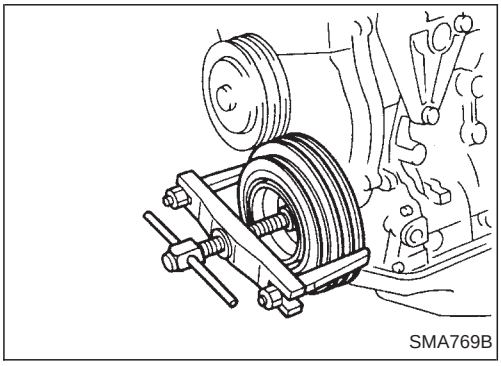
Removal

1. Remove radiator shroud.
2. Remove the following belts.
   - Power steering drive belt
   - A/C compressor drive belt
   - Alternator drive belt
3. Remove cooling fan coupling and water pump pulley.

Removal (Cont'd)


SMA768B

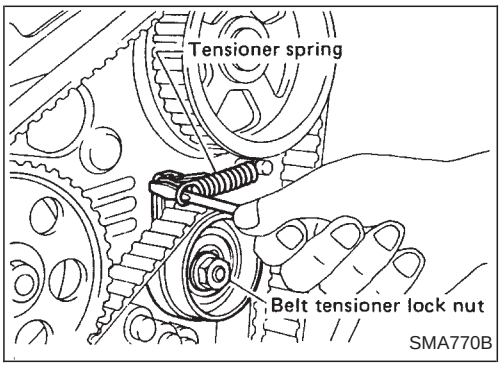
4. Set No. 1 cylinder at bottom dead center (BDC) on its expansion stroke, as shown.


SMA769B

5. Remove the starter motor and wipe off the liquid gasket remaining on the connecting part.
6. Install the ring gear stopper using the bolt holes for fixing the starter motor.
7. Remove crankshaft pulley using puller.

Be sure to securely attach puller jaws. Attach jaws only to the rear side of pulley.

8. Remove front cover.



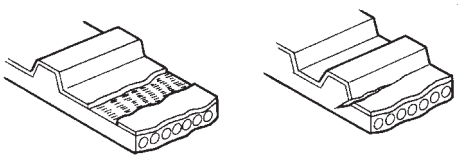
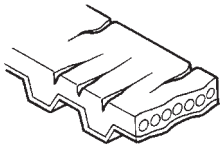
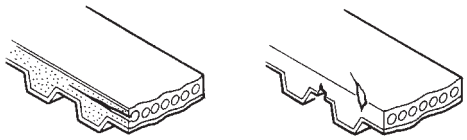
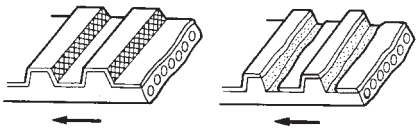
SMA770B

9. Remove tensioner spring and loosen belt tensioner lock nut.
10. Remove timing belt.

After removing timing belt, do not turn crankshaft and camshaft separately, because valves will strike piston heads.

Inspection

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

Item to check	Problem	Cause
Tooth is broken/tooth root is cracked.	 SEM394A	• Camshaft jamming • Distributor jamming • Damaged camshaft/crankshaft oil seal
Back surface is cracked/ worn.	 SEM395A	• Tensioner jamming • Overheated engine • Interference with belt cover
Side surface is worn.	 • Belt corners are worn and round. • Wicks are frayed and coming out. SEM396A	• Improper installation of belt • Malfunctioning crankshaft pulley plate/timing belt plate
Teeth are worn.	 Rotating direction • Canvas on tooth face is worn down. • Canvas on tooth is fluffy, rubber layer is worn down and faded white, or weft is worn down and invisible. SEM397A	• Poor belt cover sealing • Coolant leakage at water pump • Camshaft not functioning properly • Distributor not functioning properly • Excessive belt tension
Oil/Coolant or water is stuck to belt.	—	• Poor oil sealing of each oil seal • Coolant leakage at water pump • Poor belt cover sealing

Installation

1. Confirm that No. 1 cylinder is set at BDC on its expansion stroke as follows:

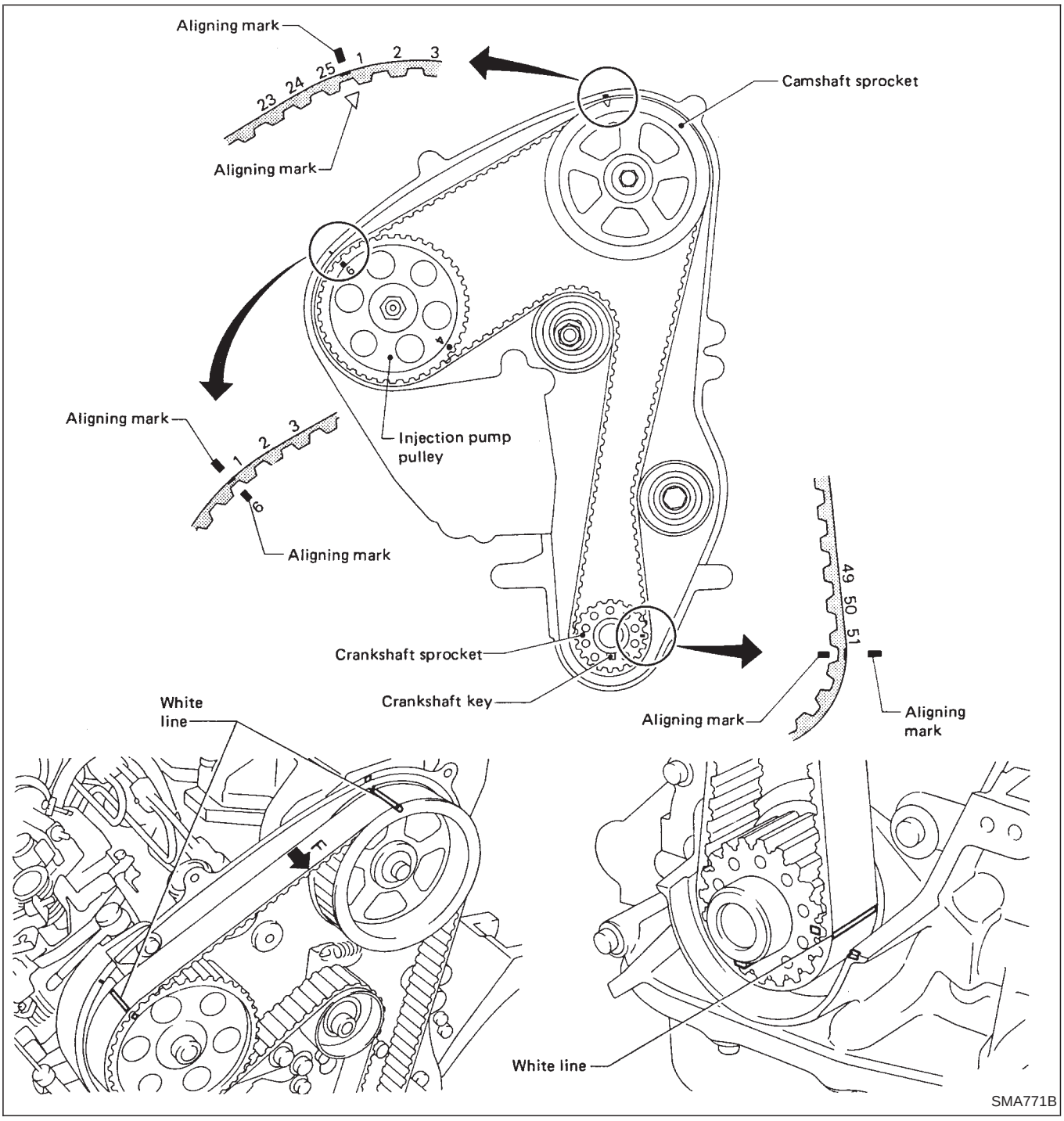
Confirm that crankshaft key is at the bottom.

2. Set timing belt.

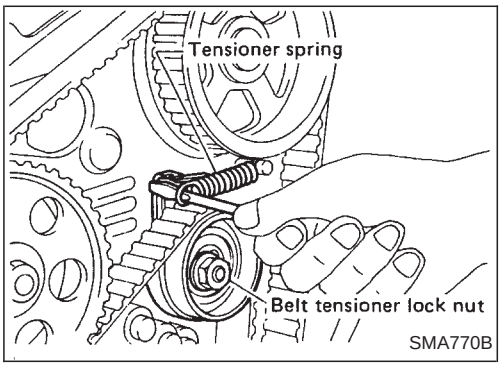
a. Ensure timing belt, sprockets and pulleys are clean and free from oil or water. Do not bend or twist timing belt too much.

b. Align white lines on timing belt with matching mark on camshaft sprocket, crankshaft sprocket and injection pump pulley.

c. Point arrow on timing belt toward front.



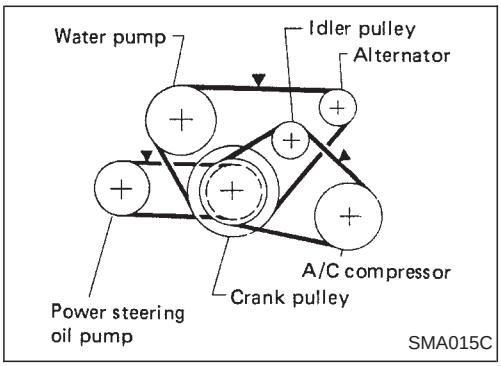
Installation (Cont'd)



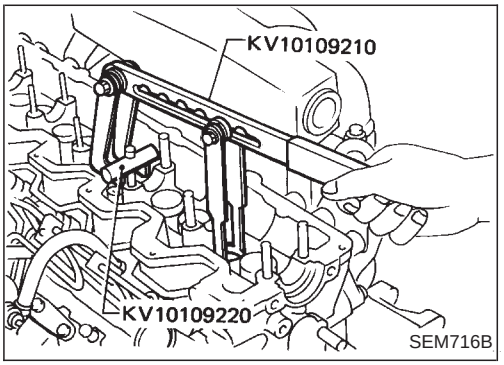
3. Install tensioner spring and tighten belt tensioner lock nut.
   : 32 - 40 N·m
   (3.3 - 4.1 kg-m, 24 - 30 ft-lb)

4. Install front cover.
5. Install crankshaft pulley.
6. Install water pump pulley and cooling fan coupling.
7. Apply liquid gasket to the connecting surface and install the starter motor.

Use Genuine Liquid Gasket or equivalent.

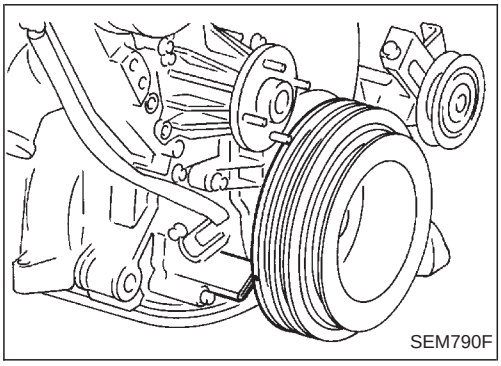


8. Install drive belts and check drive belt deflections by pushing midway between pulleys.
   Refer to MA section ("Checking Drive Belts").



VALVE OIL SEAL

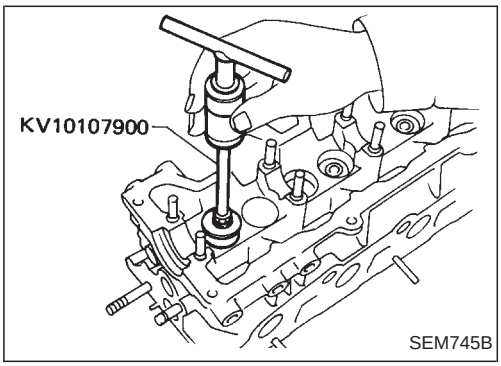
1. Remove timing belts.
2. Remove camshaft sprocket and back covers.
3. Remove camshaft brackets by loosening bracket nuts from center to outside in two or three stages.
4. Remove camshaft oil seals and camshaft.



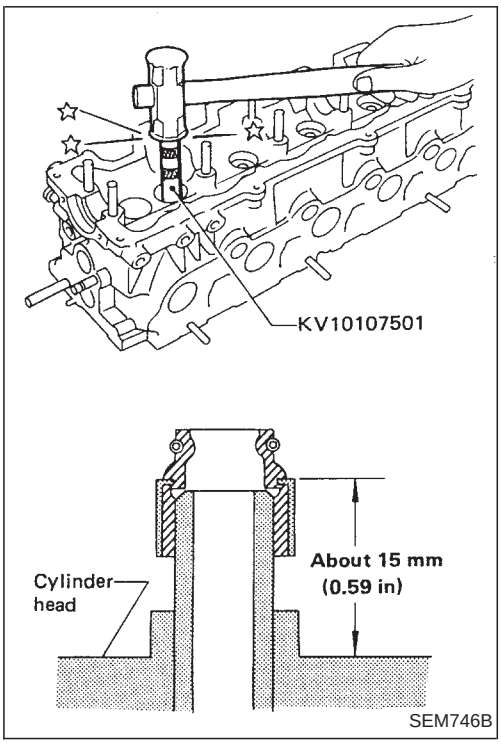
5. Remove valve lifters and mark order No. on each lifter.
6. Replace valve oil seal according to the following procedure.

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

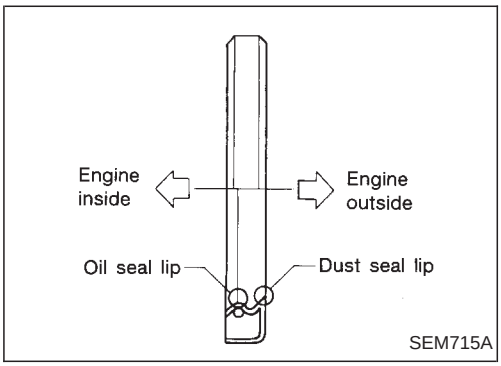
1) Set No. 1 cylinder at TDC.



2) Remove valve springs and valve oil seals for No. 1 and No. 6 cylinders. Valve spring seats should not be removed.

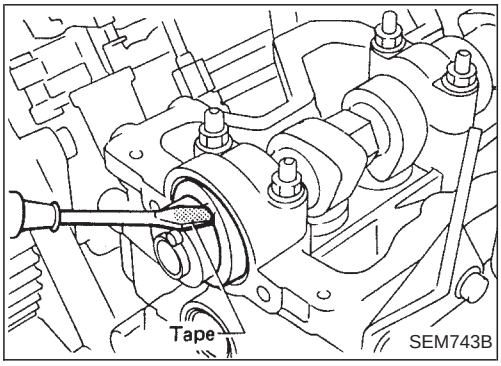


3) Install new valve oil seals for No. 1 and No. 6 cylinders as illustrated. Reinstall valve springs. (narrow pitch side toward cylinder head)
4) Install valve spring retainers on intake valves and valve rotators on exhaust valves, and remount valve assembly.
5) Set No. 2 cylinder at TDC.
6) Replace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



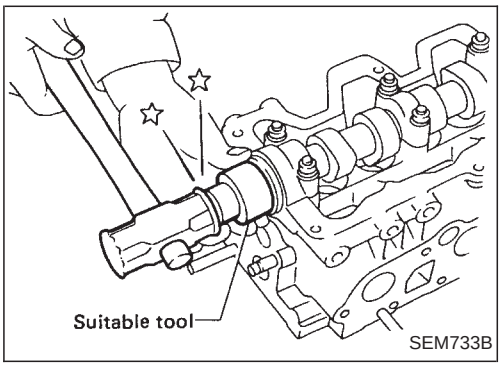
CAMSHAFT AND CRANKSHAFT OIL SEAL INSTALLING DIRECTION AND MANNER

- **When installing camshaft and crankshaft oil seals, be careful to install them correctly, as shown in the figure.**
- **Apply engine oil to oil seal lip, outer face, camshaft and bracket.**
- **Wipe off excess oil after installing oil seal.**

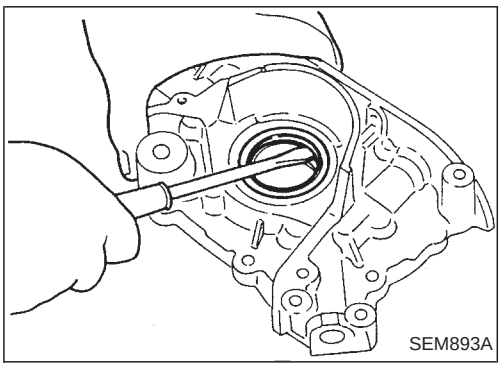


CAMSHAFT OIL SEALS

1. Remove timing belts, sprockets and back covers.
2. Pull out oil seal with a suitable tool.

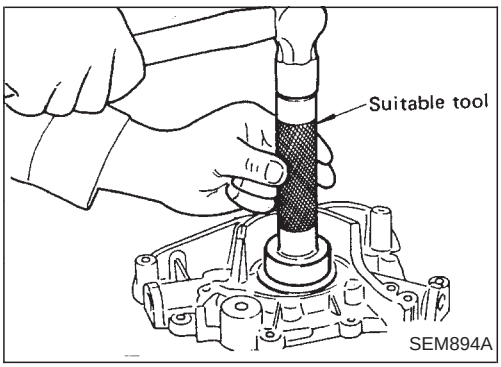


3. Install new oil seals with a suitable tool.

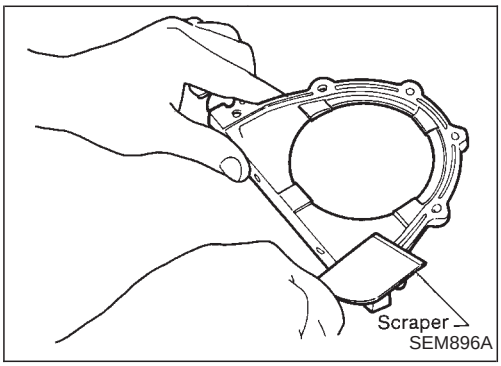


CRANKSHAFT FRONT OIL SEAL

1. Remove valve timing belt and crankshaft sprocket.
2. Remove oil pan and oil pan gasket.
3. Remove oil pump assembly.
4. Remove front oil seal with a suitable tool.

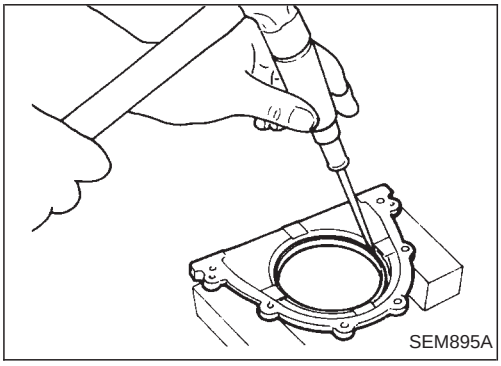


5. Apply engine oil to new oil seal and install oil seal using a suitable tool.

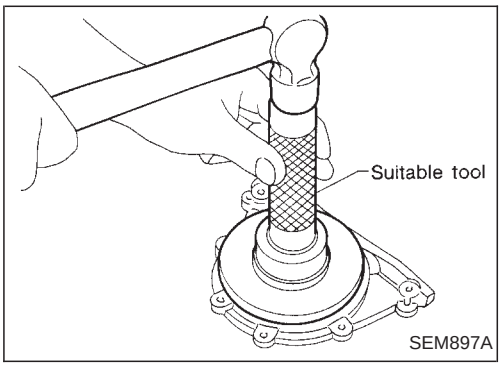


CRANKSHAFT REAR OIL SEAL

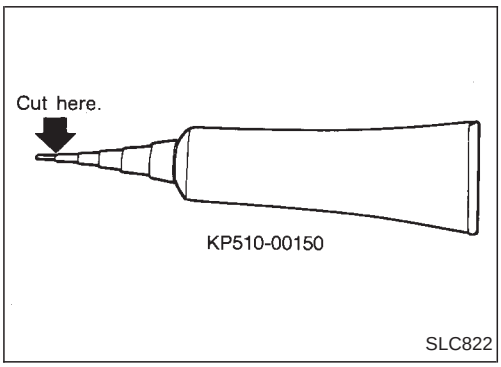
1. Remove transmission assembly. (Refer to “REMOVAL AND INSTALLATION” in MT section.)
2. Remove clutch cover assembly.
3. Remove flywheel and rear plate.
4. Remove oil pan and oil pan gasket.
5. Remove oil seal retainer assembly.
6. Remove traces of liquid gasket using a scraper.



7. Remove rear oil seal from retainer.

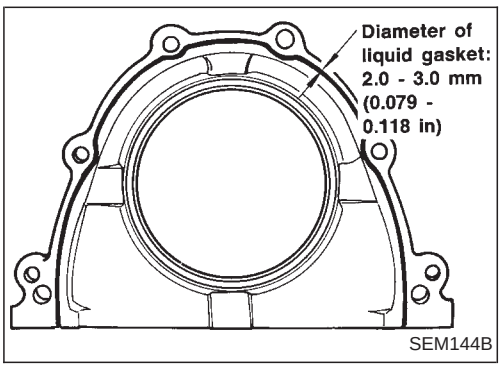


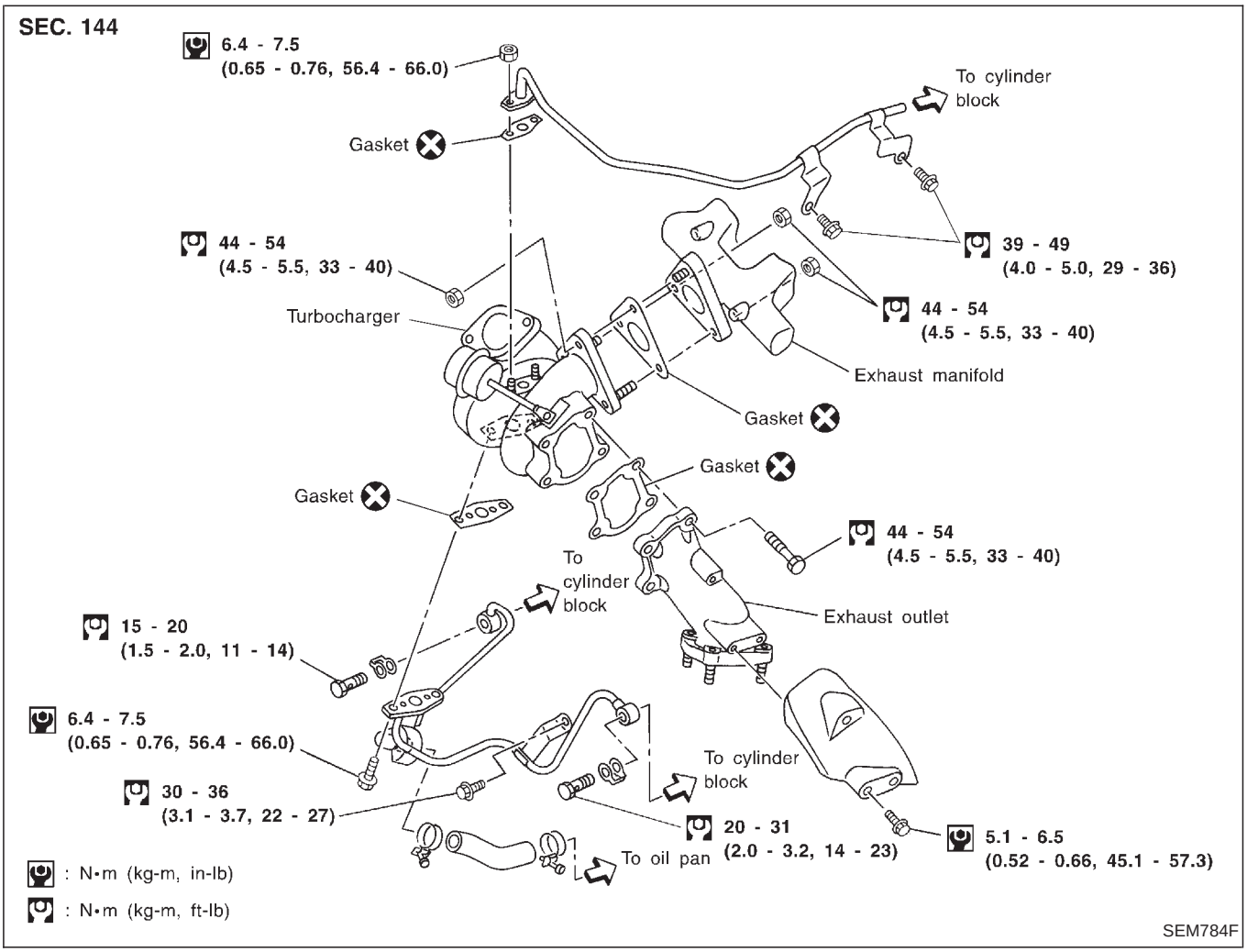
8. Apply engine oil to new oil seal and install oil seal using a suitable tool.



9. 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.



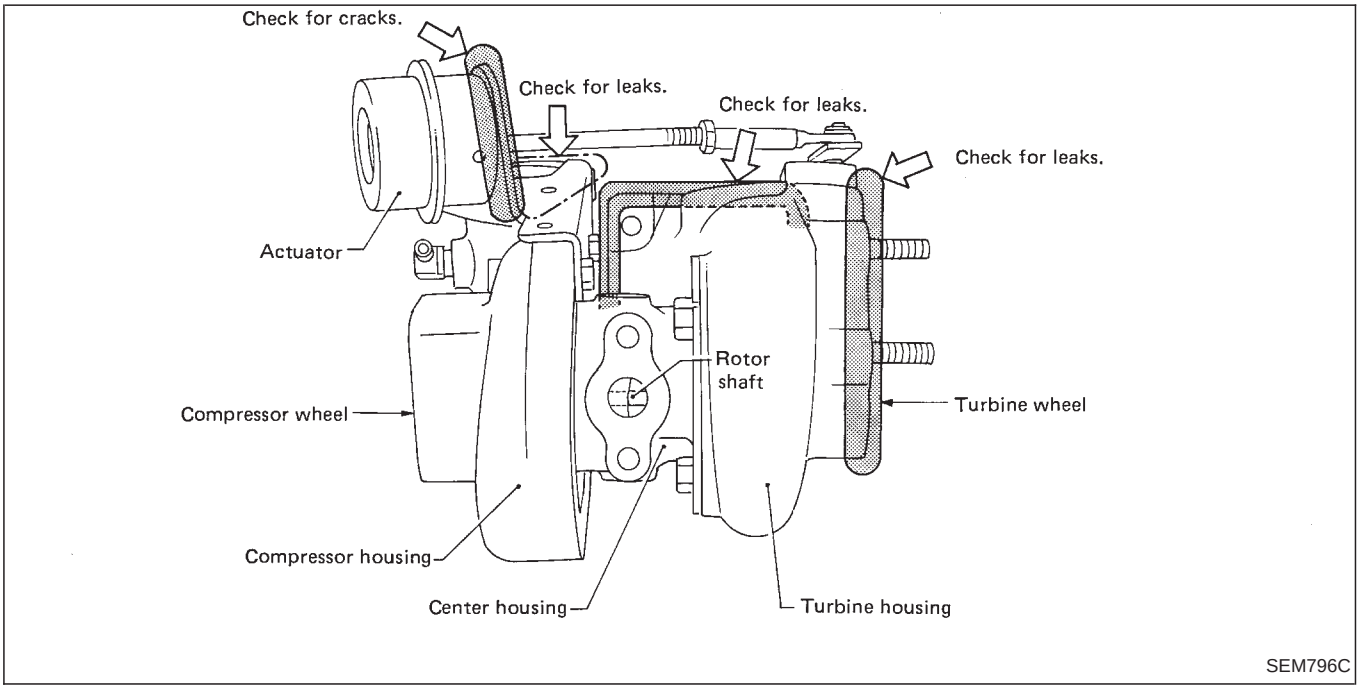


Removal and Installation

1. Drain engine coolant.
2. Remove the following:
- Air duct and hoses
- Air intake pipe
- EGR pipe
- Heat shield plates
- Intake manifold
- Front (exhaust) tube
- Oil tube and water tube
3. Remove exhaust manifold with turbocharger from cylinder head.
4. When installing turbocharger to exhaust manifold, securely tighten nuts and lock the nuts.

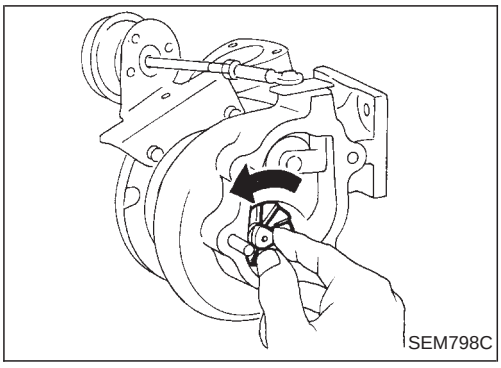
- **Turbocharger should not be disassembled.**

Inspection



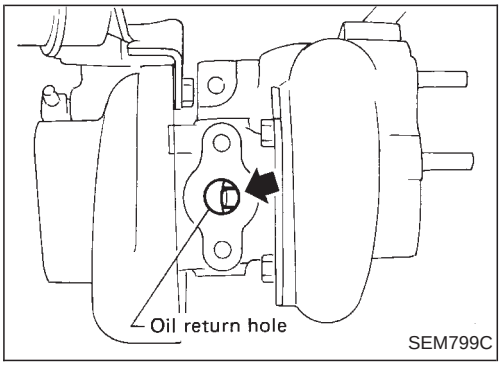
OIL AND WATER TUBES

Check tubes for clogging.



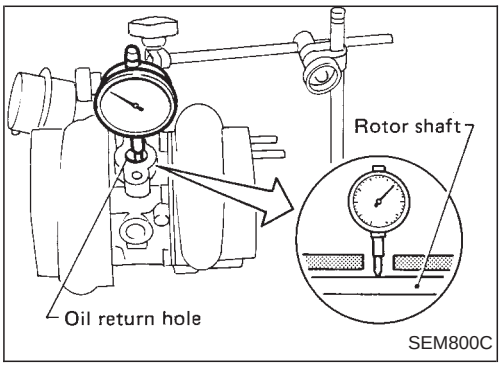
ROTOR SHAFT

1. Check rotor shaft for smooth rotating.



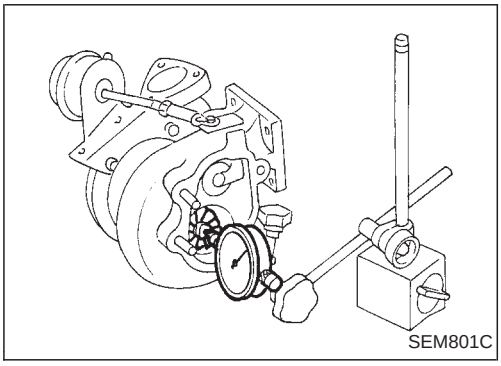
2. Check rotor shaft for carbon deposits.

Inspection (Cont'd)

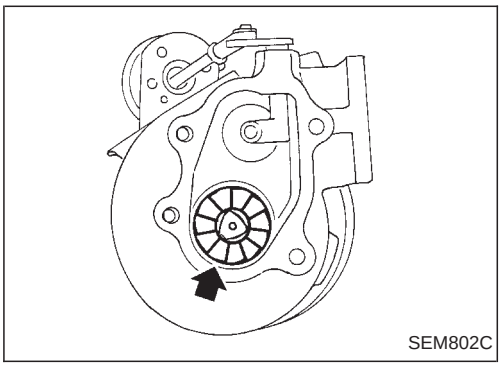


SEM800C

3. Measure runout of rotor shaft.
   Runout (Total indicator reading):
   0.056 - 0.127 mm (0.0022 - 0.0050 in)

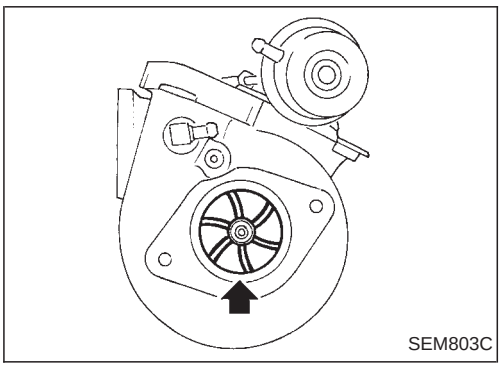

SEM801C

4. Measure end play of rotor shaft.
   End play:
   0.013 - 0.097 mm (0.0005 - 0.0038 in)


SEM802C

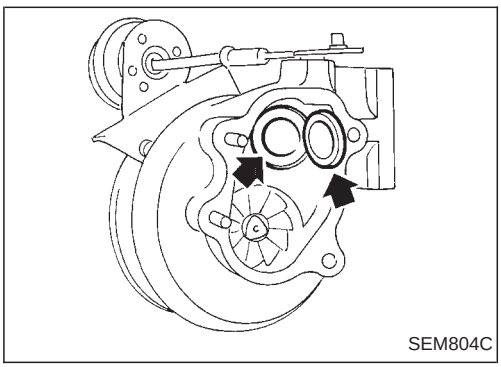
TURBINE WHEEL

Check turbine wheel for the following:
- Oil
- Carbon deposits
- Deformed fins
- Contact with turbine housing


SEM803C

COMPRESSOR WHEEL

Check compressor wheel for the following:
- Oil
- Deformed fins
- Contact with compressor housing

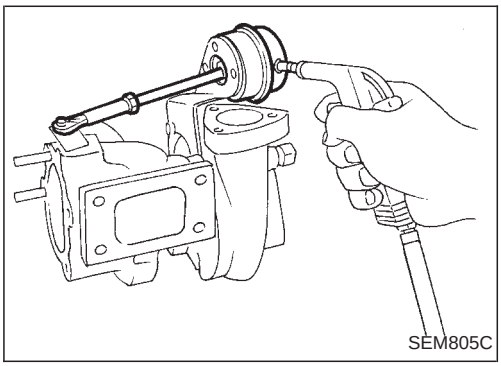

SEM804C

WASTEGATE VALVE

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

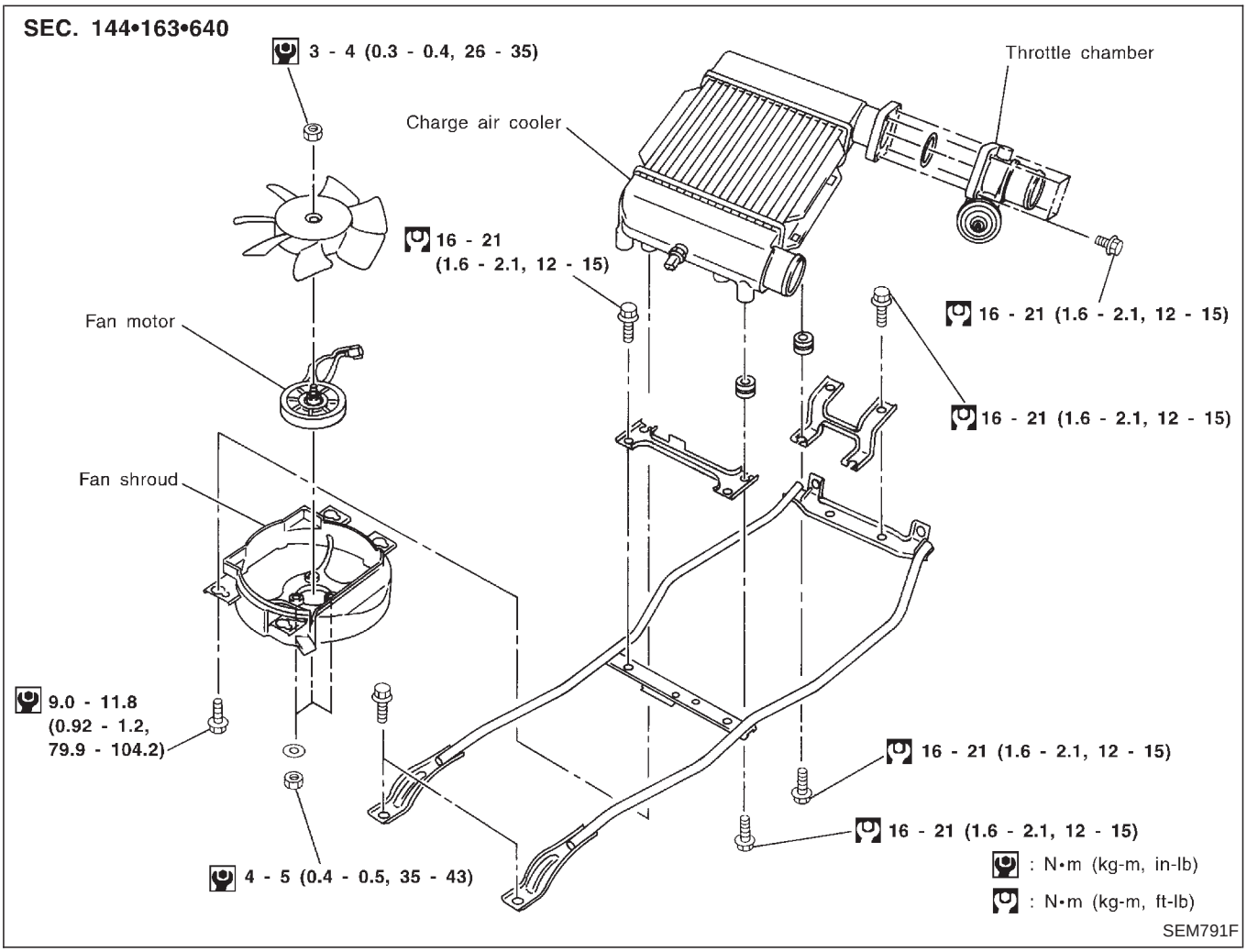
Inspection (Cont'd)

WASTEGATE VALVE ACTUATOR

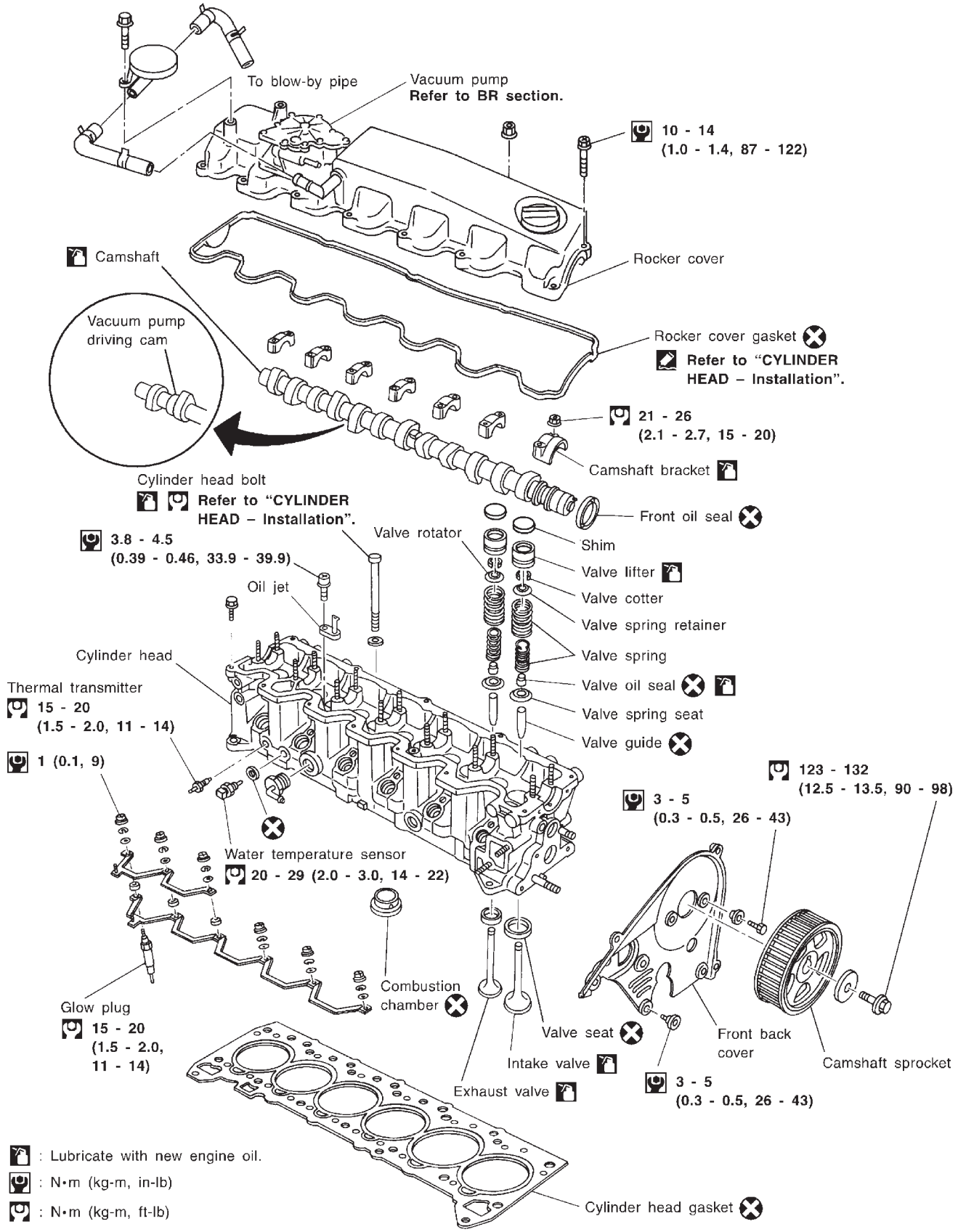

SEM805C

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 108 to 118 kPa (1.08 to 1.18 bar, 1.1 to 1.2 kg/cm^2, 16 to 17 psi).**


SEC. 144•163•640
3 - 4 (0.3 - 0.4, 26 - 35)
Throttle chamber
Charge air cooler
16 - 21
(1.6 - 2.1, 12 - 15)
16 - 21 (1.6 - 2.1, 12 - 15)
Fan motor
16 - 21 (1.6 - 2.1, 12 - 15)
Fan shroud
9.0 - 11.8
(0.92 - 1.2,
79.9 - 104.2)
16 - 21 (1.6 - 2.1, 12 - 15)
16 - 21 (1.6 - 2.1, 12 - 15)
4 - 5 (0.4 - 0.5, 35 - 43)
: N•m (kg-m, in-lb)
: N•m (kg-m, ft-lb)
SEM791F

SEC. 111•118•130•135•210•252



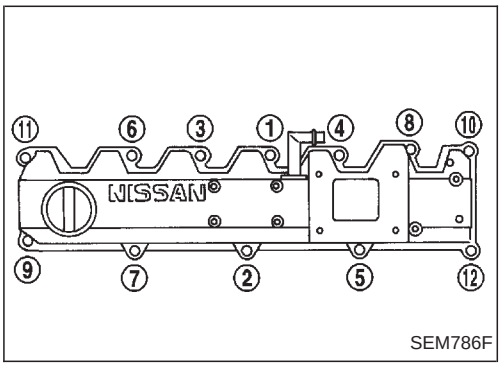
SEM785F

CAUTION:

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

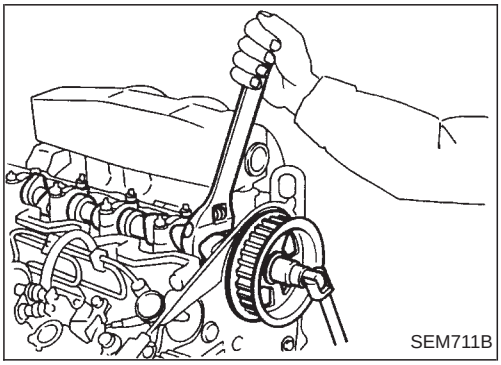
Removal

1. Remove charge air cooler assembly.
2. Set No. 1 cylinder at BDC on its expansion stroke.
3. Drain engine coolant from drain plugs on cylinder block and radiator.
4. Remove air cleaner and/or air duct.
5. Remove timing belt.

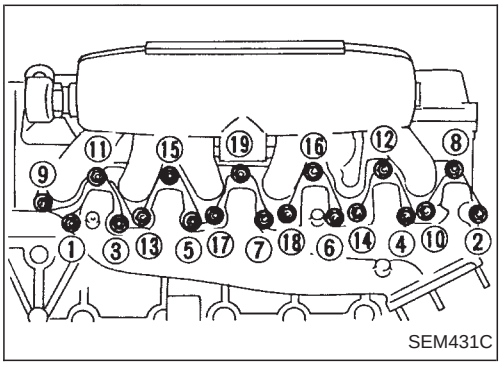


SEM786F

6. Remove rocker cover securing bolts/nuts in numerical order shown in figure.
   To install rocker cover, tighten bolts/nuts in reverse order of removal. Tighten in two or three stages.


SEM711B

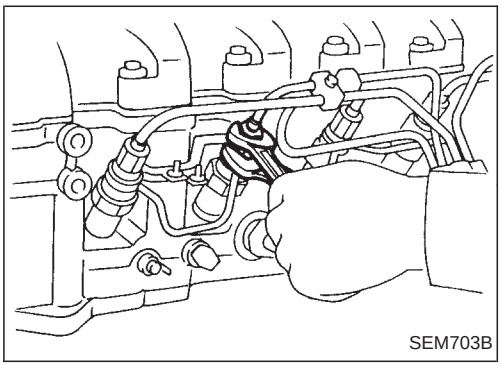
7. Remove camshaft sprocket, injection pump drive sprocket and back cover.
8. Disconnect exhaust manifold from exhaust tube.



SEM431C

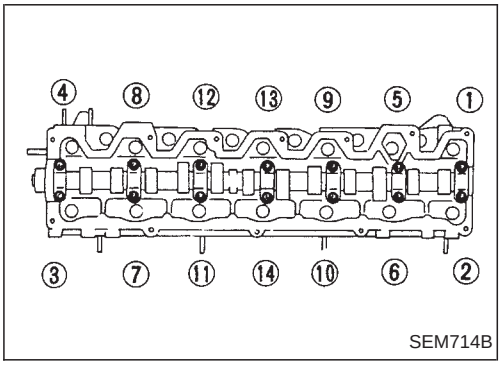
9. Remove intake and exhaust manifold.
   To install manifolds, tighten bolts/nuts in reverse order of removal. Tighten in two or three stages.

Removal (Cont'd)


SEM703B

10. Remove fuel injection tube assembly and spill tube.
11. Remove cylinder head bolts in numerical order and remove cylinder head.

Disassembly



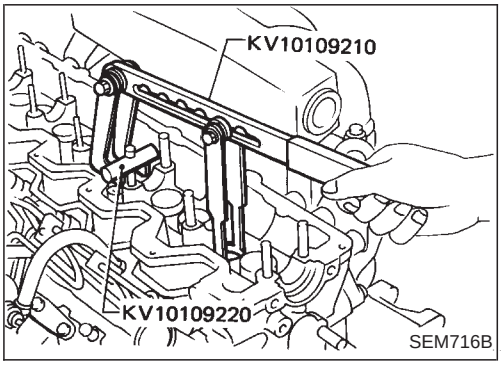
SEM714B

1. Remove following parts:

a. Thermostat housing
b. Engine slinger
c. Glow plate and glow plugs

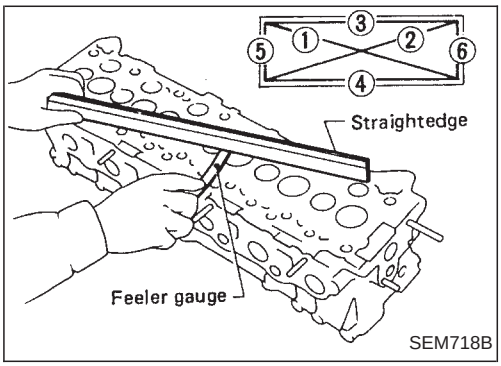
2. Remove camshaft bracket securing nuts in numerical order shown in figure in two or three stages.
   To install camshaft bracket caps, tighten nuts in reverse order of removal. Tighten in two or three stages.

3. Remove camshaft and oil seal.
4. Remove valve lifters.



SEM716B

5. Remove valve component parts with tool.



Inspection

CYLINDER HEAD DISTORTION

Warpage of surface:

Less than 0.1 mm (0.004 in)

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

Resurfacing limit:

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

Amount of cylinder head resurfacing is "A".

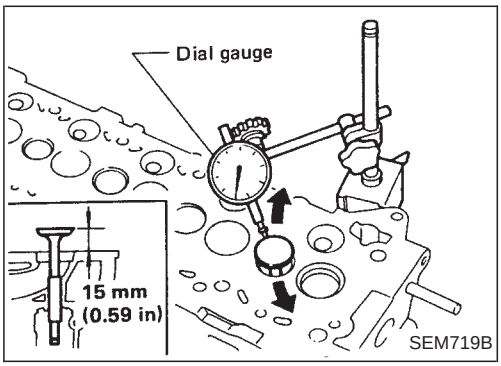
Amount of cylinder block resurfacing is "B".

The maximum limit is as follows:

A + B = 0.1 mm (0.004 in)

Nominal cylinder head height:

139.9 - 140.1 mm (5.508 - 5.516 in)



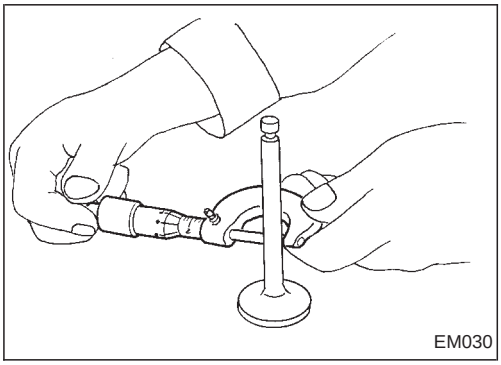
VALVE GUIDE CLEARANCE

1. Insert the valve stem into the valve guide and move it back, forth and slide it.
   If valve stem makes a clatter and moves back and forth excessively out of line, or if it does not slide well, replace valve or valve guide, or both.
2. Install valve stem into the valve guide.
3. Measure the deflection.

   Stem to guide deflection limit:

   0.1 mm (0.004 in)

   (Half of dial gauge reading)



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

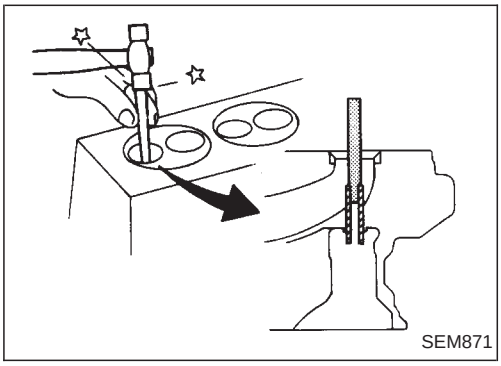
(1) Measure valve stem diameter and guide inner diameter.

(2) Check that clearance is within the specification.

Valve to valve guide clearance limit:

0.1 mm (0.004 in)

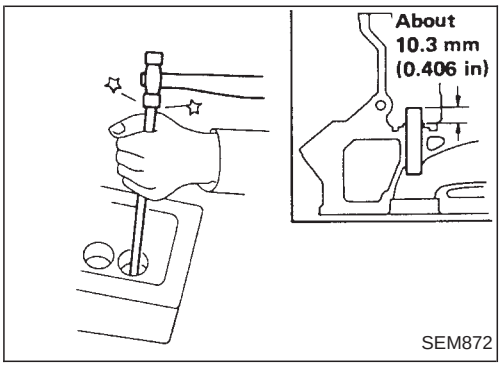
(3) If it exceeds the limit, replace valve or valve guide.



VALVE GUIDE REPLACEMENT

1. Heat cylinder head 150 to 160°C (302 to 320°F) in oil.
2. Remove the guide with suitable tool.

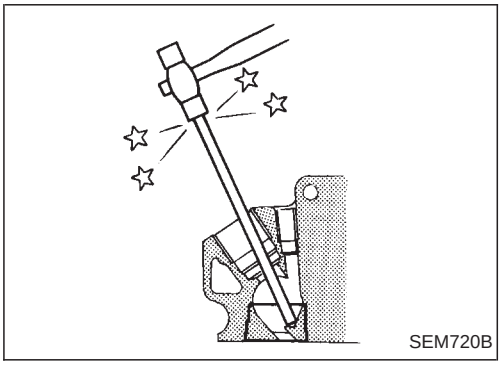
Inspection (Cont'd)



SEM872

3. Drive in the new guide until it projects out 10.3 mm (0.406 in).
4. Ream the bore using suitable tool.

Reaming bore:
7.000 - 7.018 mm (0.2756 - 0.2763 in)

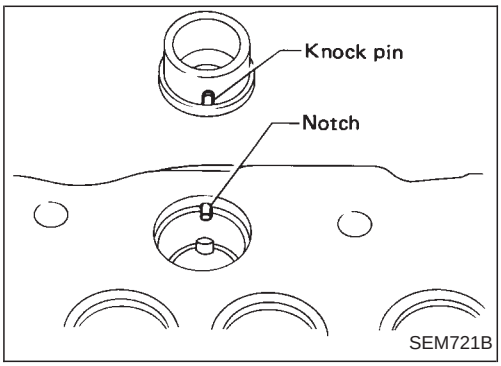

SEM720B

COMBUSTION CHAMBER REPLACEMENT

Usually combustion chamber should not be removed. However, if there are cracks or extensive damage, it should be replaced.

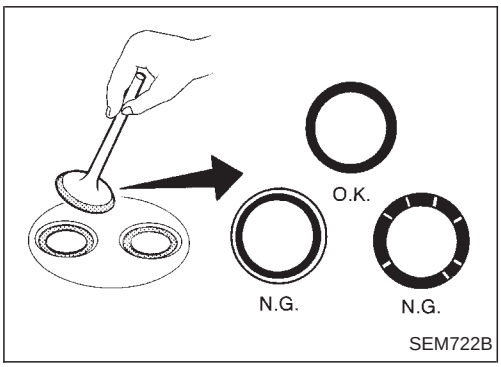
1. Remove glow plug connecting plate, glow plugs and injection nozzle.
2. Remove combustion chamber so that cylinder head will not be damaged.

Be careful not to scratch inside of nozzle hole.



SEM721B

3. Install combustion chamber.
(1) Heat cylinder head 150 to 160°C (302 to 320°F) in oil.
(2) Align combustion chamber knock pin with cylinder head notch, and install it into cylinder head using a plastic-tip hammer.



SEM722B

VALVE SEATS

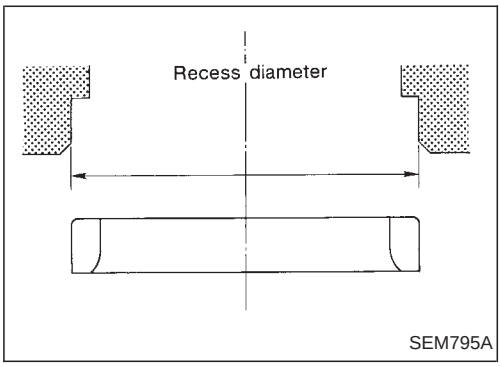
1. Check valve and valve seat for contact.
Coat the valve face with prussian red lead. If contact is wrong, correct valve seat. If the valve red lead appears 360° around face, the valve stem and face are concentric. If not, repair or replace valve.

2. Check valve seats for any evidence of pitting on valve contact surface, and reseat or replace if worn out excessively.
Correct valve seat surface.

- **When repairing valve seat, check valve and valve guide for wear beforehand. If worn, replace them. Then correct valve seat.**
- **Cut with both hands to uniform the cutting surface.**

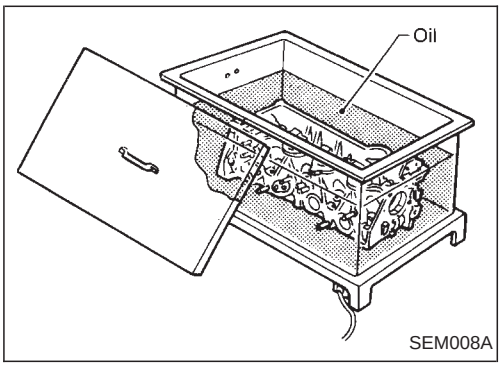
Inspection (Cont'd)

VALVE SEAT REPLACEMENT



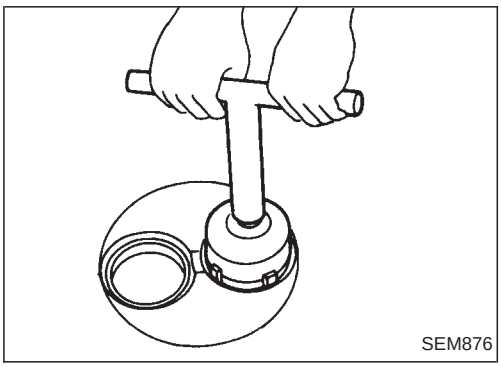
1. Bore out old seat until it collapses.
   The machine depth stop should be set so that boring cannot continue beyond the bottom face of the seat recess in cylinder head.
2. Ream the cylinder head recess.
   Reaming bore for service valve seat
   [Oversize 0.5 mm (0.020 in)]:
   Intake
   40.954 - 40.932 mm (1.6124 - 1.6115 in)
   Exhaust
   34.954 - 34.932 mm (1.3761 - 1.3753 in)

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



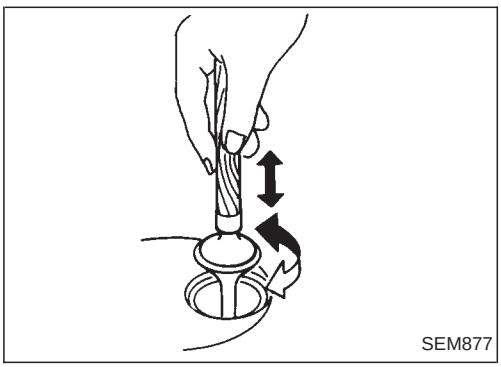
3. Heat cylinder head to a temperature of 150 to 160°C (302 to 320°F) and press fit seat until it seats on the bottom.
4. Install valve seat.

When replacing valve seat, valve should also be replaced.



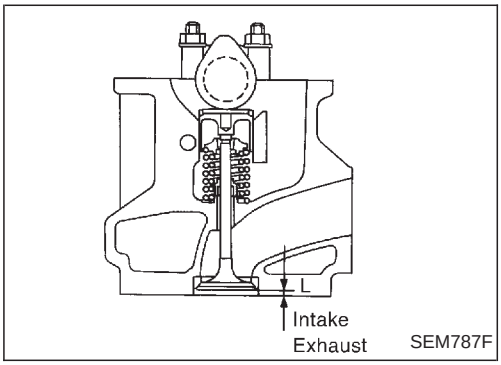
5. Cut or grind valve seat using suitable tool at the specified dimensions as shown in SDS.

The cutting should be done with both hands for uniform cutting.

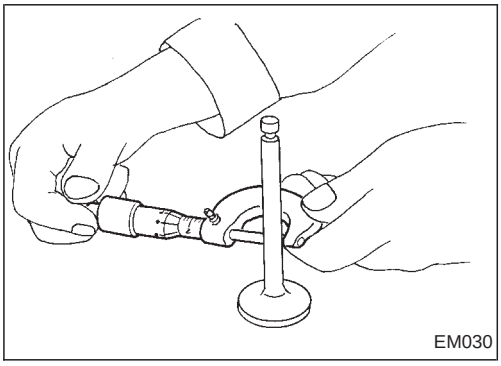


6. Apply small amount of fine grinding compound to valve contacting face and put valve into guide.
   Lap valve against its seat until proper valve seating is obtained.
   Remove valve and then clean valve and valve seat.

Inspection (Cont'd)

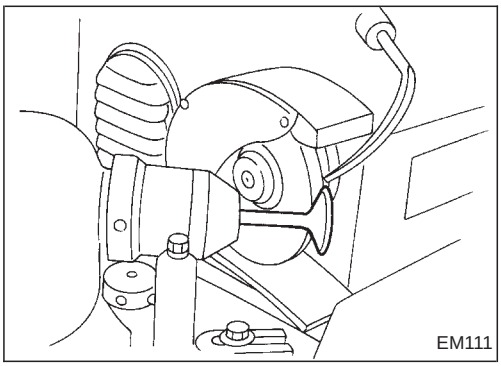


7. Measure distance from cylinder head surface to intake and exhaust valves. If specified distance is exceeded, replace valve(s) or valve seat(s).
   Specified distance: mm (in)
   Standard
   −0.069 to 0.269 (−0.0027 to 0.0106)



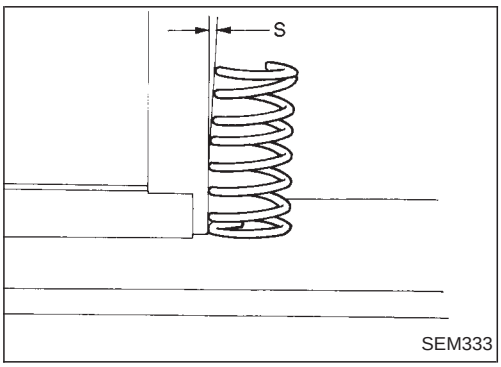
VALVE DIMENSIONS

1. Check dimensions in each valve. For dimensions, refer to SDS.
2. Correct or replace any valve that is out of tolerance.



3. Valve face or valve stem end surface should be refaced by using a valve grinder.

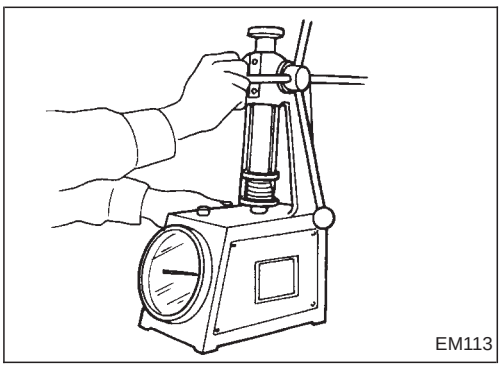
When valve head has been worn down to 0.5 mm (0.020 in) in margin thickness, replace the valve.
Grinding allowance for valve stem tip is 0.2 mm (0.008 in) or less.



VALVE SPRING SQUARENESS

Check valve spring for squareness using a steel square and surface plate.
If spring is out-of-square "S" more than specified limit, replace with new one.

Out-of-square:
Outer
Less than 1.9 mm (0.075 in)
Inner
Less than 1.6 mm (0.063 in)

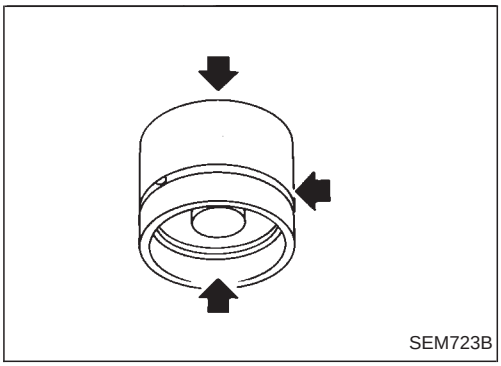


VALVE SPRING PRESSURE LOAD

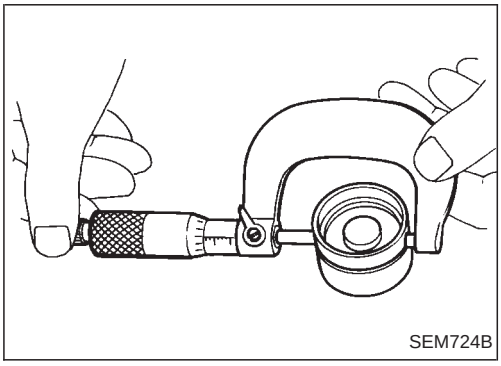
Measure the free length and the tension of each spring. If the measured value exceeds the specified limit, replace spring. Refer to SDS.

Inspection (Cont'd)

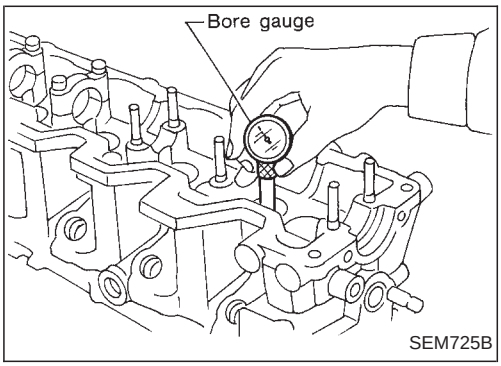
VALVE LIFTER


SEM723B

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


SEM724B

2. Check diameter of a valve lifter.
   Outer diameter:
   34.960 - 34.975 mm (1.3764 - 1.3770 in)



SEM725B

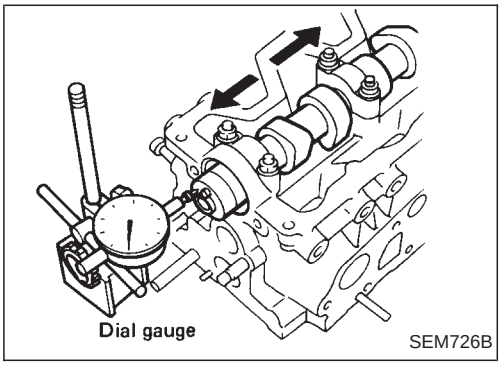
3. Check valve lifter guide bore.
   Bore diameter:
   34.998 - 35.018 mm (1.3779 - 1.3787 in)
   Standard clearance:
   0.023 - 0.058 mm (0.0009 - 0.0023 in)

If valve lifters are noisy, check valve lifter.
(1) Depress plunger forcibly with your finger.
If it moves about 1 mm (0.04 in), it indicates air is inside valve lifter.
(2) Reinstall valve lifter.
(3) Bleed air by running engine at 2,400 rpm under no-load for about 20 minutes.

CAUTION:
When camshaft is removed to install, remove or inspect hydraulic valve lifters, do not start engine for at least 30 minutes after reinstalling camshaft. (Wait until hydraulic valve lifters have reached their set lengths.) Before starting engine, rotate crankshaft by hand to ensure pistons do not interfere with valves.

(4) Next check to ensure all air is bled. [Refer to step (1) above.]
(5) If there is still air, replace valve lifter.

Inspection (Cont'd)



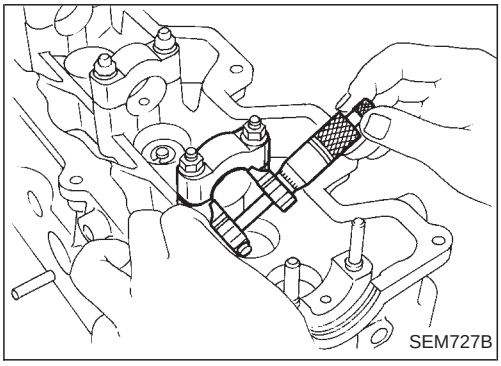
CAMSHAFT VISUAL CHECK

Check camshaft for scratches, seizure and wear.

CAMSHAFT END PLAY

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

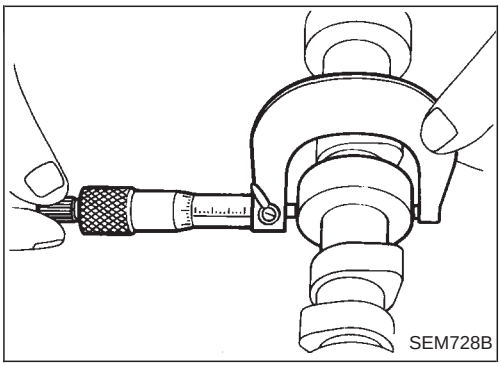
Camshaft end play:
0.065 - 0.169 mm (0.0026 - 0.0067 in)



CAMSHAFT JOURNAL CLEARANCE

1. Measure the inner diameter of camshaft bearing.

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

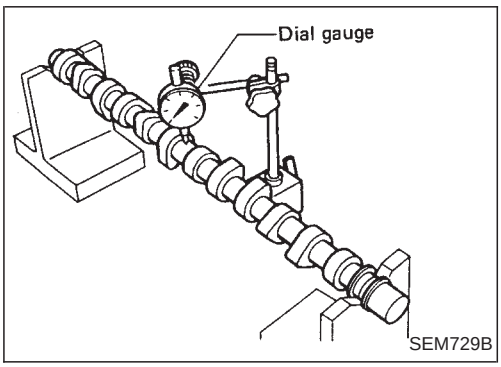


2. Measure the outer diameter of camshaft journal.

Standard outer diameter:
29.935 - 29.955 mm (1.1785 - 1.1793 in)

If the clearance is greater than the maximum, replace camshaft and/or cylinder head.

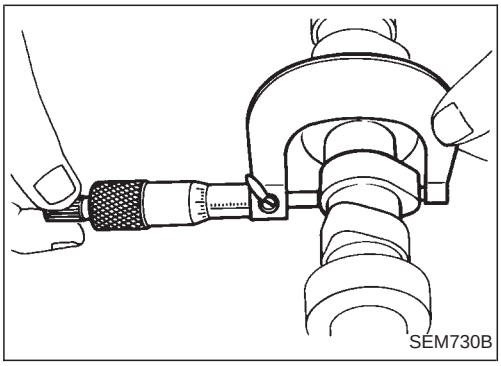
Maximum clearance:
0.045 - 0.086 mm (0.0018 - 0.0034 in)



CAMSHAFT RUNOUT

Camshaft runout [TIR (Total Indicator Reading)]:
Limit 0.02 mm (0.0008 in)

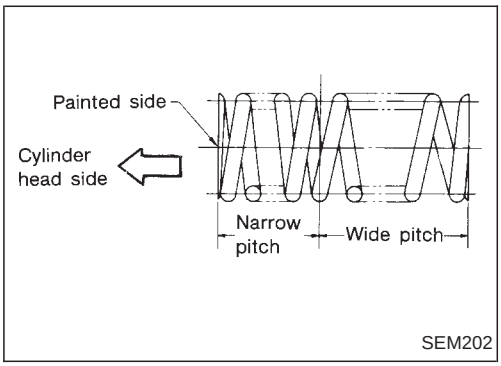
If beyond the limit, replace.



CAMSHAFT CAM HEIGHT

Standard cam height:
Intake
48.005 - 48.195 mm (1.8900 - 1.8974 in)
Exhaust
49.505 - 49.695 mm (1.9490 - 1.9565 in)
Cam wear:
Limit 0.15 mm (0.0059 in)

If wear is beyond the limit, replace.



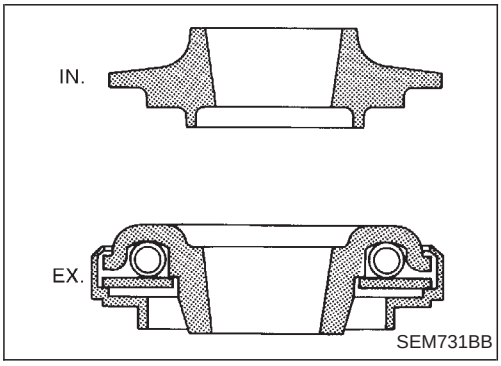
Assembly

1. Install valve component parts.

Install valve spring with its narrow pitch side toward cylinder head side.

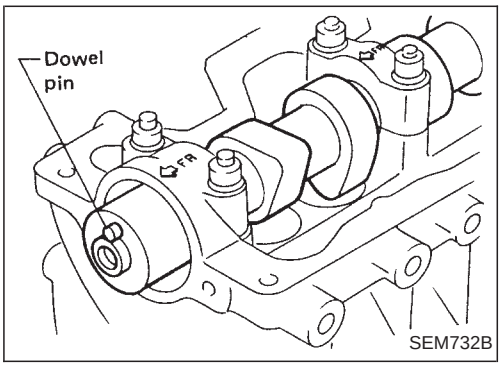
a. When installing valve, apply engine oil on the valve stem and lip of valve oil seal.

b. Check whether the valve face is free from foreign matter.



c. Install valve spring retainers on the intake side and valve rotators on the exhaust side.

d. Valve rotators cannot be disassembled.



2. Set camshaft.

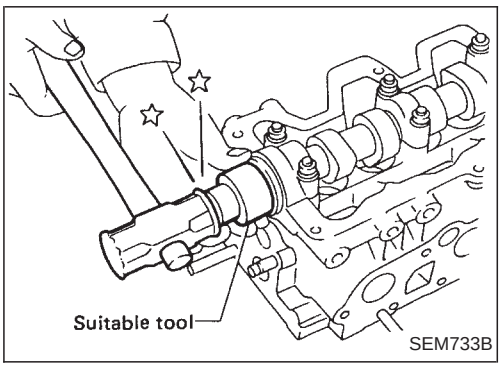
Set camshaft so that dowel pin faces up.

3. Install cam bracket caps so that front mark faces forward.

Cam bracket nut (Tighten in two or three stages):

: 21 - 26 N·m

(2.1 - 2.7 kg-m, 15 - 20 ft-lb)



4. Apply engine oil to new oil seal and install it.

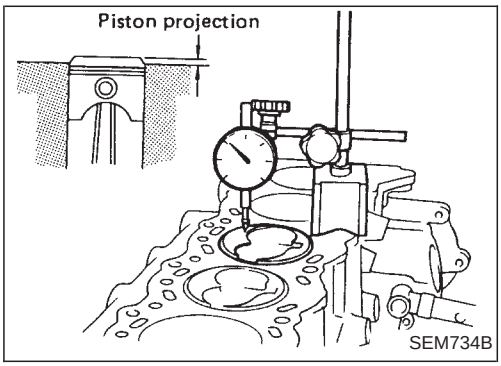
Installation

1. Install cylinder head gasket.

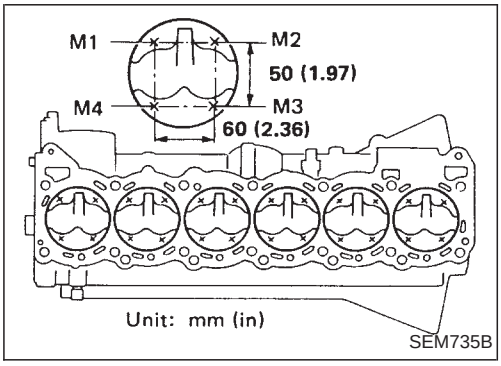
a. When replacing only cylinder head gasket, install same grade gasket as the one formerly used.

b. When replacing or repairing cylinder block, cylinder head, piston, connecting rod and crankshaft, select gasket as follows:

Installation (Cont'd)



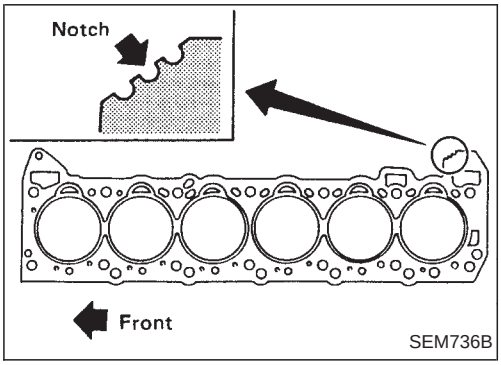
Step 1:
Measure piston projection.
1) Set dial gauge on cylinder block surface to zero.
2) Set dial gauge at measuring point of piston, being careful not to disturb its zero setting.



3) Set each piston at its Top Dead Center. With piston held in that position, measure its projections at four points, M1, M2, M3 and M4, and record measured values.

Be sure to measure the projection at four points for every cylinder as shown.

Step 2:
Calculate the average value of measured projections for each cylinder.
Step 3:
Calculate the average value of projections for all pistons.
Step 4:
Round off the average value.
Step 5:
Determine the gasket thickness, referring to chart A.



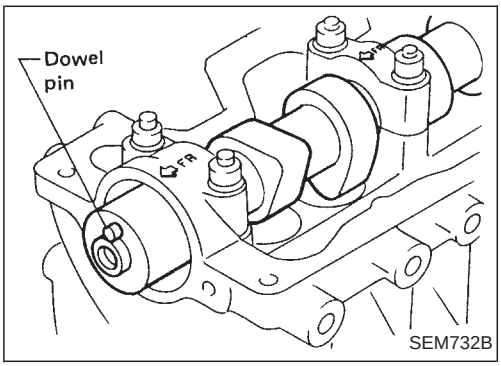
Relation between piston projection and cylinder head gasket (Chart A)

Unit: mm (in)

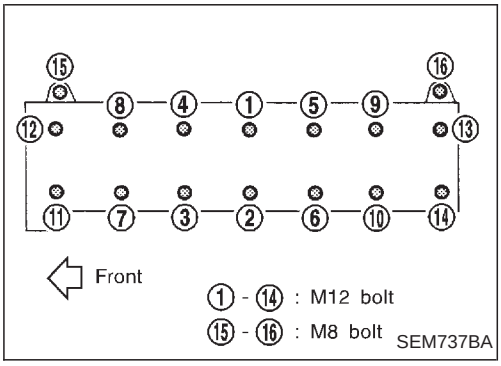
Grade	Average values piston projections	Gasket thickness	Number of identifications
A	Less than 0.79 (0.0311)	1.42±0.05 (0.0559±0.0020)	1
B	0.79 - 0.875 (0.0311 - 0.0344)	1.50±0.05 (0.0591±0.0020)	2
C	More than 0.875 (0.0344)	1.58±0.05 (0.0622±0.0020)	3

Step 6:
Check to see if the average value of each projection in step 2 is larger than the max. value of the standard projection (of selected gasket) plus 0.08 mm (0.0031 in).
Step 7:
If it is, use gasket that is 1 grade thicker.
If it is not, use gasket that was selected in step 4.

Installation (Cont'd)



2. Install cylinder head.
(1) Make sure that No. 1 cylinder is at Bottom Dead Center.
(2) Make sure that No. 1 cam of camshaft is at BDC on its expansion stroke.



(3) Tighten cylinder head bolts to the specified torque in the sequence as follows:

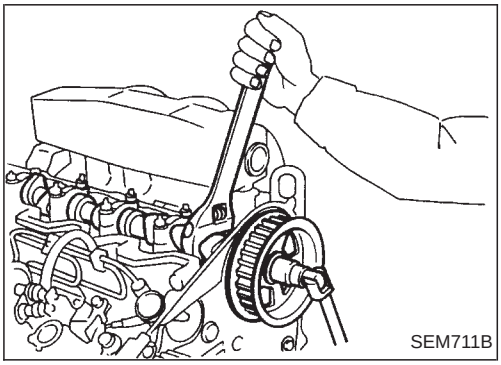
- **Tightening procedure.**

M12 bolt

1st **Tighten all bolts to 29 N·m (3.0 kg-m, 22 ft-lb).**
2nd **Tighten all bolts to 113 N·m (11.5 kg-m, 83 ft-lb).**
3rd **Loosen all bolts completely.**
4th **Tighten all bolts to 29 N·m (3.0 kg-m, 22 ft-lb).**
5th **Tighten all bolts to 118 to 127 N·m (12.0 to 13.0 kg-m, 87 to 94 ft-lb) or if you have an angle wrench, turn all bolts 100 to 105 degrees clockwise.**

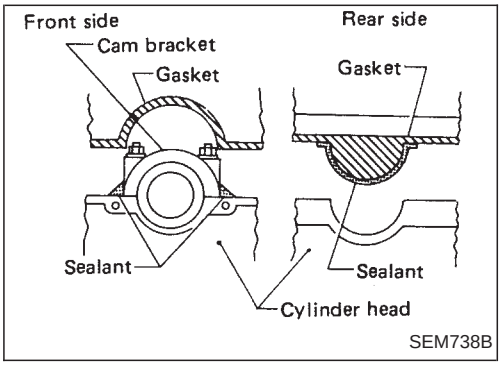
M8 bolt

16 - 21 N·m (1.6 - 2.1 kg-m, 12 - 15 ft-lb)



3. Install front back cover and camshaft pulley.

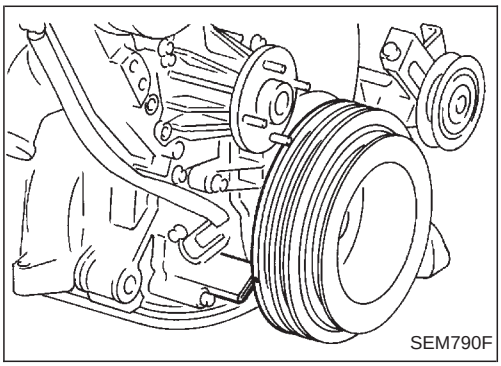
Front back cover:
: 3 - 5 N·m
(0.3 - 0.5 kg-m, 26 - 43 in-lb)
Camshaft pulley:
: 123 - 132 N·m
(12.5 - 13.5 kg-m, 90 - 98 ft-lb)



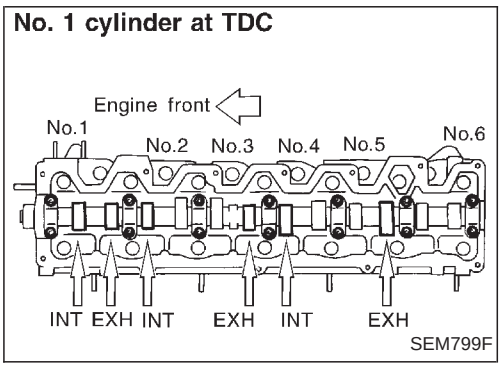
4. Install timing belt. Refer to "Replacing Timing Belt" in section MA.
5. Install rocker cover. Refer to EM-92.

Apply sealant to rocker cover gasket as shown.
Do not apply too much sealant.

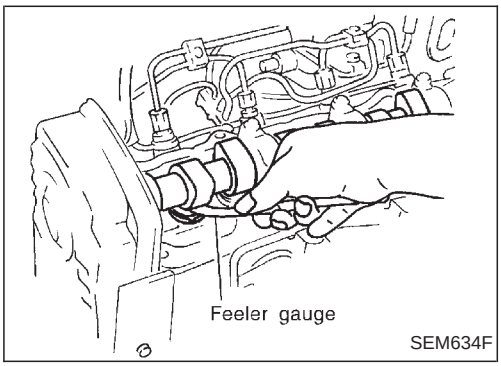
6. Install intake and exhaust manifold. Refer to EM-92.


SEM790F

No. 1 cylinder at TDC

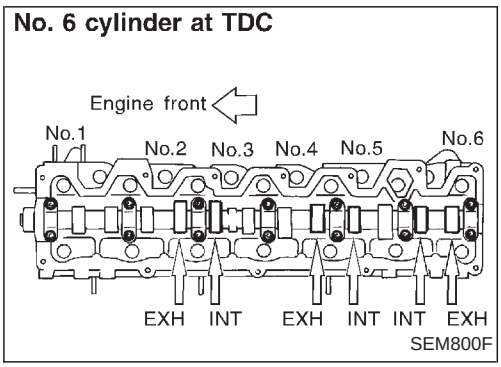


SEM799F



SEM634F

No. 6 cylinder at TDC



SEM800F

Checking

Check valve clearance while engine is warm and not running.

1. Remove rocker cover.
2. Set No. 1 cylinder at TDC on its compression stroke.
- Align pointer with TDC mark on crankshaft pulley.
- Check that valve lifters on No. 1 cylinder are loose and valve lifters on No. 6 are tight.

  If not, turn crankshaft one revolution (360°) and align as described above.

3. Check only those valves shown in the figure.

	No. 1		No. 2		No. 3		No. 4		No. 5		No. 6	
	INT	EXH	INT	EXH	INT	EXH	INT	EXH	INT	EXH	INT	EXH
No. 1 cylinder at TDC	○	○	○			○	○			○		

- 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 (Hot):

  Intake

  0.28 - 0.38 mm (0.011 - 0.015 in)

  Exhaust

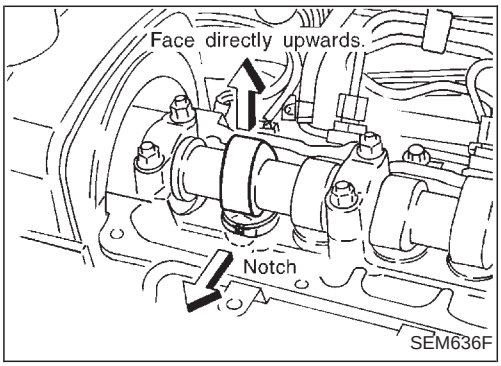
  0.32 - 0.42 mm (0.013 - 0.017 in)

4. Turn crankshaft one revolution (360°) and align mark on crankshaft pulley with pointer.
5. Check only those valves shown in the figure.

	No. 1		No. 2		No. 3		No. 4		No. 5		No. 6	
	INT	EXH	INT	EXH	INT	EXH	INT	EXH	INT	EXH	INT	EXH
No. 6 cylinder at TDC				○	○			○	○		○	○

- Use the same procedure as mentioned in step 4.

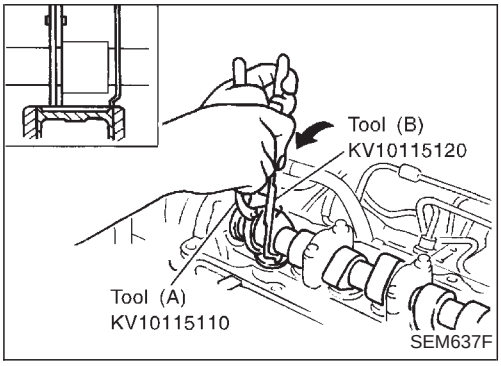
6. If all valve clearances are within specification, install the following parts:
- Rocker cover



Adjusting

Adjust valve clearance while engine is cold.

1. Turn crankshaft. Position cam lobe upward on camshaft for valve that must be adjusted.



2. Place Tool (A) around camshaft as shown in figure.

Before placing Tool (A), rotate notch toward center of cylinder head. (See figure.) This will simplify shim removal later.

CAUTION:

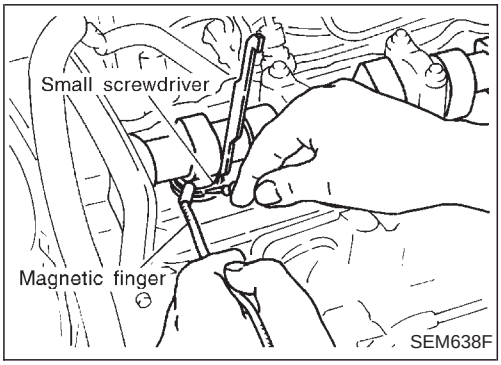
Be careful not to damage cam surface with Tool (A).

3. Rotate Tool (A) (See figure.) so that valve lifter is pushed down.
4. Place Tool (B) between camshaft and 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).**

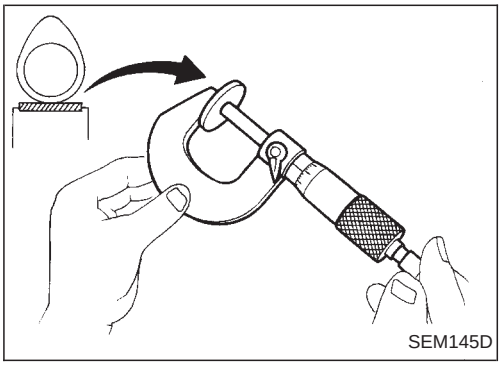
5. Remove Tool (A).



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

- Use a micrometer to 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
S = Standard valve clearance



Unit: mm (in)

HOT	Intake	0.28 - 0.38 (0.0110 - 0.0150)
	Exhaust	0.32 - 0.42 (0.0126 - 0.0165)
COLD	Intake	0.26 - 0.34 (0.0102 - 0.0134)
	Exhaust	0.30 - 0.38 (0.0118 - 0.0150)

Intake:

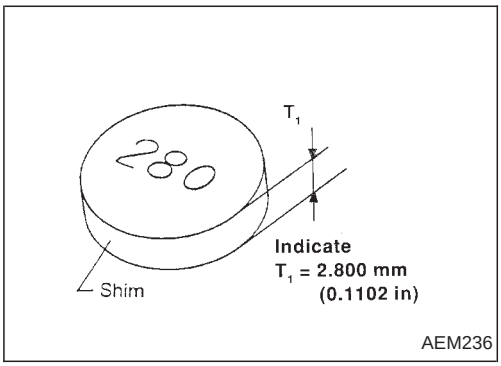
$$N = R + [M - S]$$

Exhaust:

$$N = R + [M - S]$$

Shims are available in 15 sizes from 2.20 mm (0.0866 in) to 2.90 mm (0.1142 in), in steps of 0.05 mm (0.0020 in).

Adjusting (Cont'd)



- Select the closest size shim to the calculated thickness. Refer to chart in SDS, EM-171.

8. Install new shim using a suitable tool.
- **Install with the surface on which the thickness is stamped facing down.**
9. Place Tool (A) as explained in steps 2 and 3.
10. Remove Tool (B).
11. Remove Tool (A).
12. Recheck valve clearance.

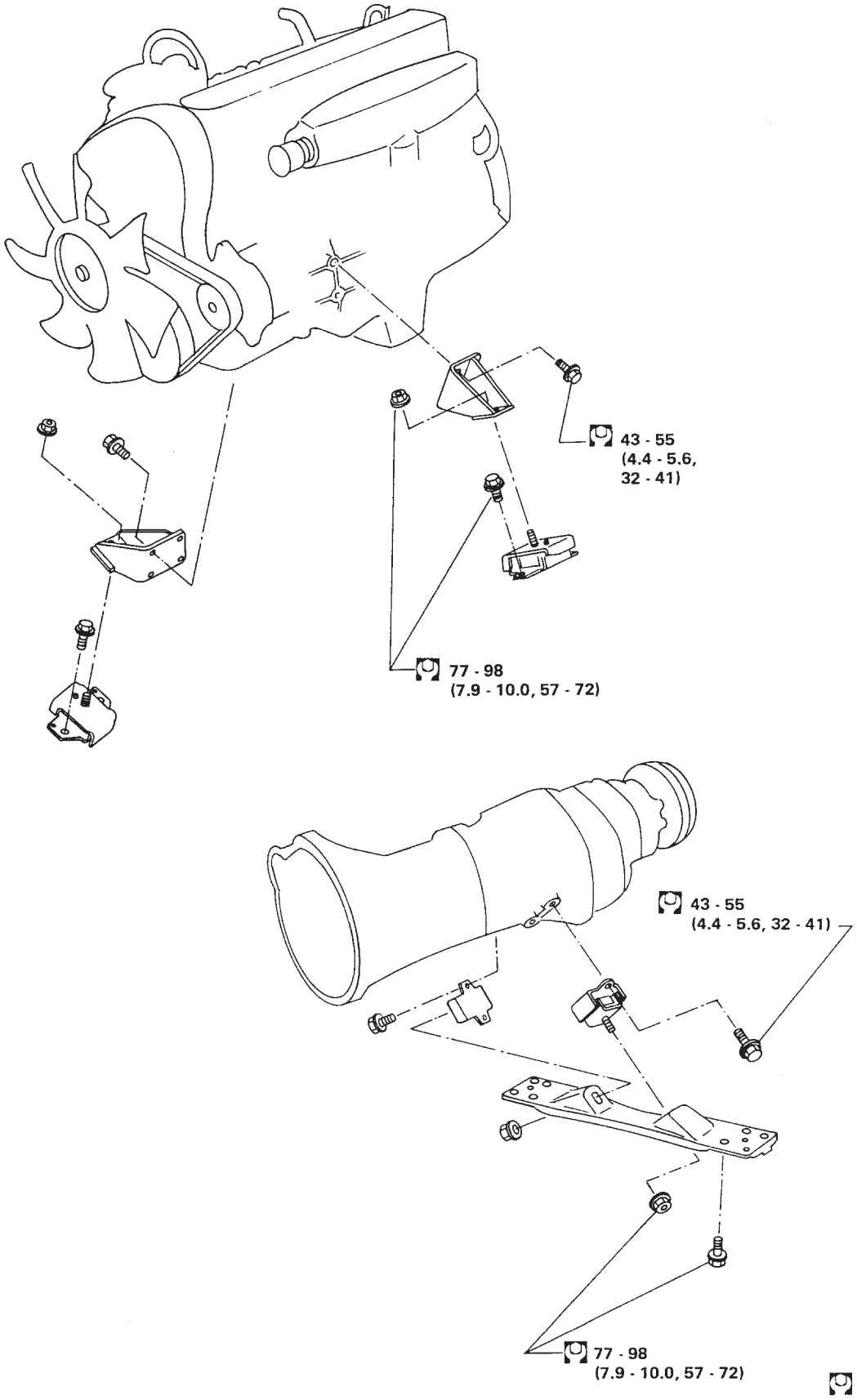
Valve clearance:

Unit: mm (in)

	For adjusting	
	Hot	Cold* (reference data)
Intake	0.28 - 0.38 (0.011 - 0.015)	0.26 - 0.34 (0.010 - 0.013)
Exhaust	0.32 - 0.42 (0.013 - 0.017)	0.30 - 0.38 (0.012 - 0.015)

*: At a temperature of approximately 20°C (68°F)

Whenever valve clearances are adjusted to cold specifications, check that the clearances satisfy hot specifications and adjust again if necessary.


43 - 55
(4.4 - 5.6,
32 - 41)
77 - 98
(7.9 - 10.0, 57 - 72)
43 - 55
(4.4 - 5.6, 32 - 41)
77 - 98
(7.9 - 10.0, 57 - 72)
: N·m (kg-m, ft-lb)

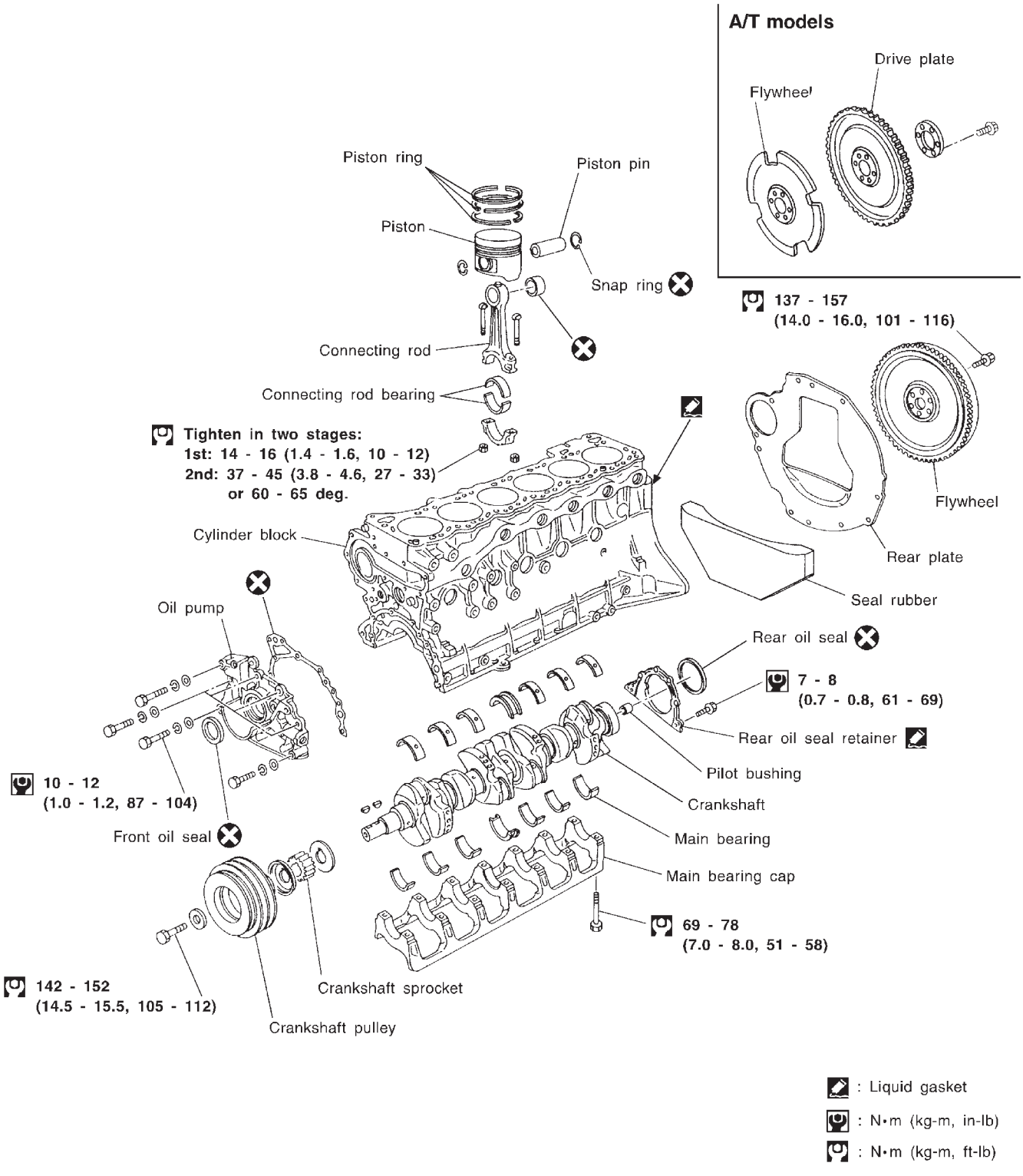
SEM433C

Removal

1. Remove engine, transmission and transfer's undercovers, oil pan guard and hood.
2. Drain engine coolant.
3. Remove charge air cooler assembly.
4. Remove vacuum hoses, fuel tubes, harnesses, and connectors and so on.
5. Remove radiator assembly.
6. Remove drive belts.
7. Remove power steering oil pump, alternator and air conditioner compressor.
8. Remove starter motor assembly.
9. Remove front exhaust tube.
10. Remove transmission from vehicle.
    Refer to MT section.
11. Hoist engine with engine slingers and remove engine mounting bolts from both sides.
12. Remove engine from vehicle.

Installation

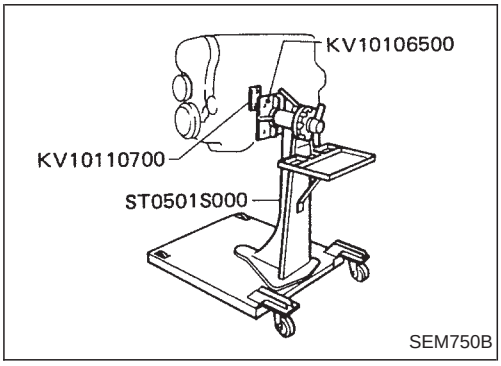
- Install in reverse order of removal.


A/T models
Drive plate
Flywheel
Piston ring
Piston pin
Piston
Snap ring
Connecting rod
Connecting rod bearing
137 - 157
(14.0 - 16.0, 101 - 116)
Tighten in two stages:
1st: 14 - 16 (1.4 - 1.6, 10 - 12)
2nd: 37 - 45 (3.8 - 4.6, 27 - 33)
or 60 - 65 deg.
Cylinder block
Flywheel
Rear plate
Seal rubber
Oil pump
Rear oil seal
7 - 8
(0.7 - 0.8, 61 - 69)
Rear oil seal retainer
Pilot bushing
Crankshaft
Main bearing
Main bearing cap
10 - 12
(1.0 - 1.2, 87 - 104)
Front oil seal
69 - 78
(7.0 - 8.0, 51 - 58)
142 - 152
(14.5 - 15.5, 105 - 112)
Crankshaft sprocket
Crankshaft pulley
: Liquid gasket
: N•m (kg-m, in-lb)
: N•m (kg-m, ft-lb)

SEM788F

CAUTION:

- **When installing sliding parts such as bearings and pistons, apply engine oil to the sliding surfaces.**
- **Place removed parts, such as bearings and bearing caps, in their proper order and direction.**
- **When installing connecting rod bolts and main bearing cap bolts, apply new engine oil to threads and seating surfaces of nuts.**
- **Do not allow any magnetic materials to contact the ring gear teeth of drive plate.**

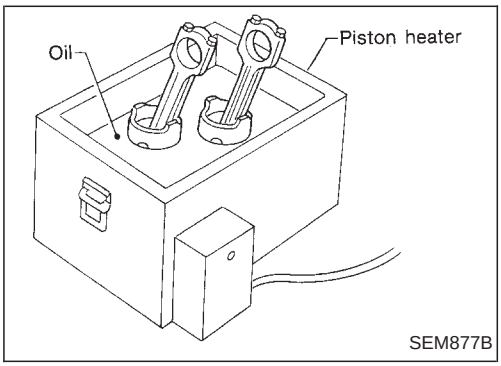


SEM750B

Disassembly

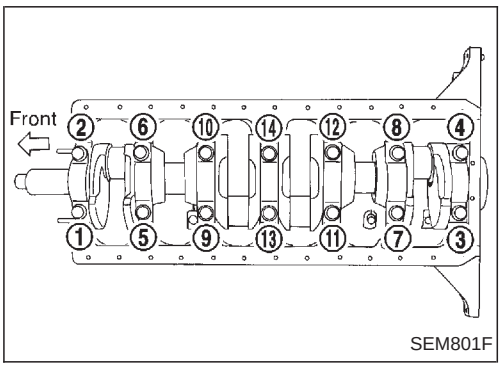
PISTON AND CRANKSHAFT

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



SEM877B

8. Remove pistons with connecting rod.
- To disassemble piston and connecting rod, remove snap ring first. Then heat piston to 60 to 70°C (140 to 158°F) and use piston pin press to remove pin.
- **When piston rings are not replaced, make sure that piston rings are mounted in their original positions.**
- **When replacing piston rings, if there is no punchmark, install with either side up.**

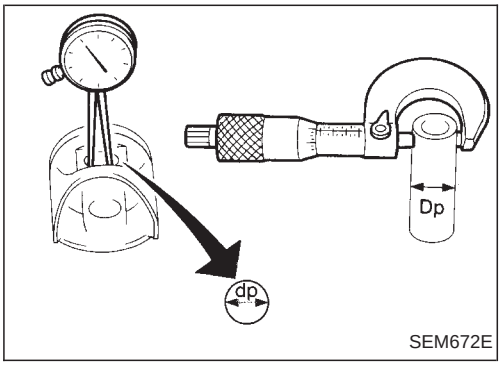


SEM801F

9. Remove bearing cap bolts and main bearing caps in the order shown, then remove crankshaft.
- **Loosen bolts in two or three steps.**

Inspection

PISTON AND PISTON PIN CLEARANCE



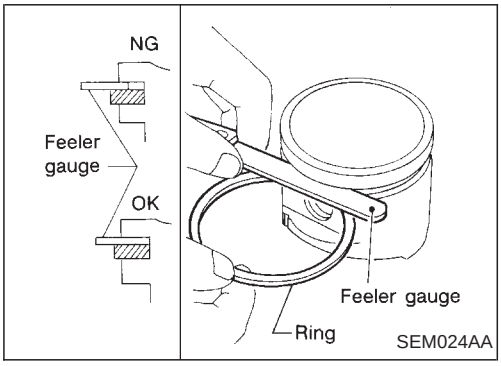
SEM672E

1. Measure inner diameter of piston pin hole “dp”.
   Standard diameter “dp”:
   26.995 - 27.005 mm (1.0628 - 1.0632 in)

Inspection (Cont'd)

2. Measure outer diameter of piston pin "Dp".
   Standard diameter "Dp":
   26.994 - 27.000 mm (1.0628 - 1.0630 in)
3. Calculate piston pin clearance.
   dp − Dp = −0.004 to 0 mm (−0.0002 to 0 in)

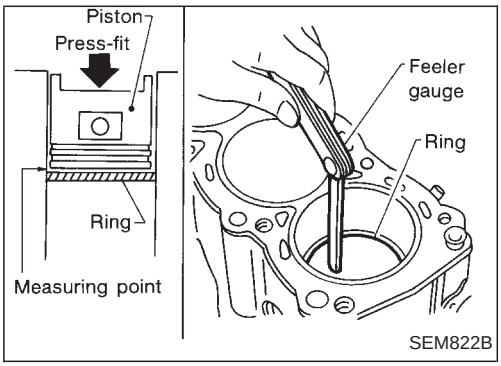
If it exceeds the above value, replace piston assembly with pin.



PISTON RING SIDE CLEARANCE

Side clearance:
Top ring
0.060 - 0.093 mm (0.0024 - 0.0037 in)
2nd ring
0.040 - 0.073 mm (0.0016 - 0.0029 in)
Max. limit of side clearance:
0.1 mm (0.004 in)

If out of specification, replace piston ring. If clearance exceeds maximum limit with new ring, replace piston.

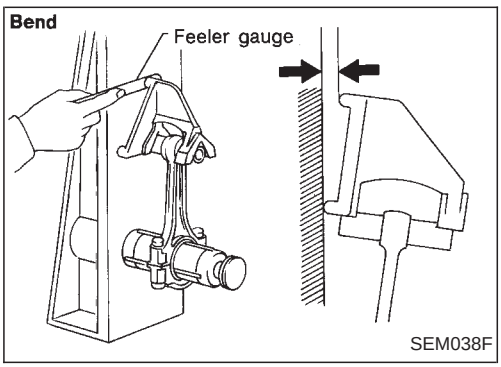


PISTON RING END GAP

End gap:
Top ring
0.20 - 0.28 mm (0.0079 - 0.0110 in)
2nd ring
0.20 - 0.46 mm (0.0079 - 0.0181 in)
Oil ring
0.30 - 0.56 mm (0.0118 - 0.0220 in)
Max. limit of ring gap:
0.4 mm (0.016 in)

If out of specification, replace piston ring. If gap still exceeds maximum limit with new ring, rebore cylinder and use oversized piston and piston rings. Refer to SDS, EM-173.

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

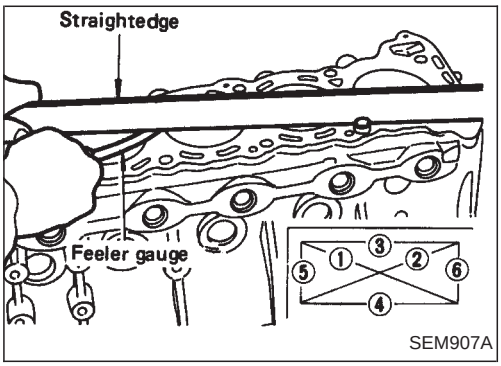


CONNECTING ROD BEND AND TORSION

Bend:
Limit 0.025 mm (0.0010 in)
per 100 mm (3.94 in) length
Torsion:
Limit 0.025 mm (0.0010 in)
per 100 mm (3.94 in) length

If it exceeds the limit, replace connecting rod assembly.

Inspection (Cont'd)



CYLINDER BLOCK DISTORTION AND WEAR

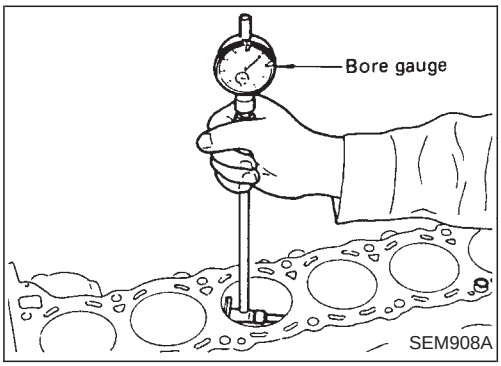
1. Clean upper surface of cylinder block. Using a reliable straightedge and feeler gauge, check the flatness of cylinder block surface.
- Check along six positions as shown in figure.

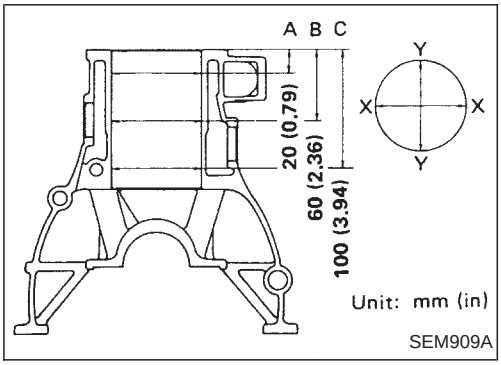
Limit:
0.10 mm (0.0039 in)

2. If out of specification, resurface it.
The limit for cylinder block resurfacing is determined by the amount of cylinder head resurfacing.

Amount of cylinder head resurfacing is "A".
Amount of cylinder block resurfacing is "B".
The maximum limit is as follows:
A + B = 0.2 mm (0.008 in)
Nominal cylinder block height from crankshaft center:
227.40 - 227.50 mm (8.9527 - 8.9567 in)

3. If necessary, replace cylinder block.





PISTON-TO-BORE CLEARANCE

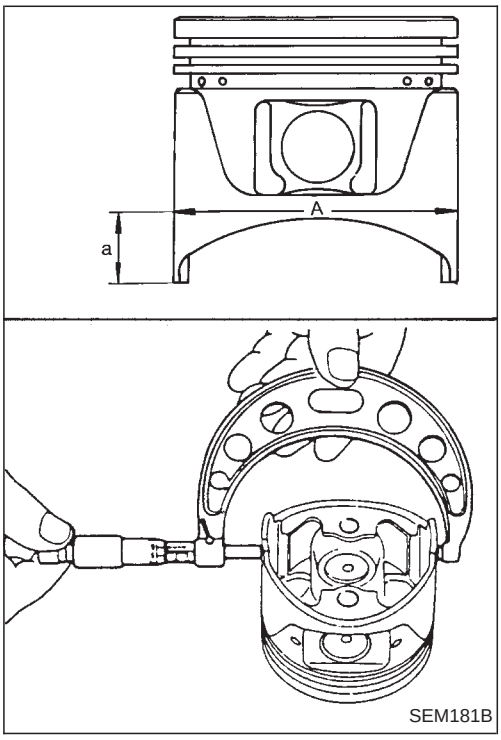
1. Using a bore gauge, measure cylinder bore for wear, out-of-round and taper.

Standard inner diameter "Db":
85.000 - 85.030 mm (3.3465 - 3.3476 in)
Wear limit:
0.20 mm (0.0079 in)
Out-of-round (X − Y):
Less than 0.015 mm (0.0006 in)
Taper (A − B or A − C):
Less than 0.010 mm (0.0004 in)

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

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

Inspection (Cont'd)

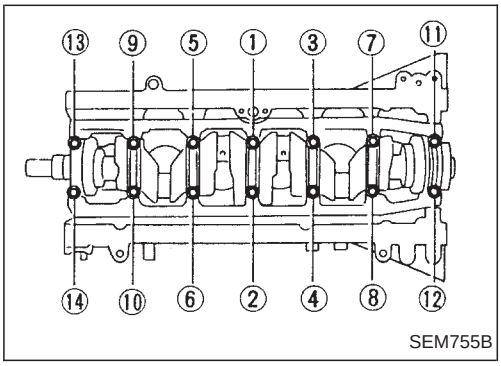


SEM181B

3. Measure piston skirt diameter.
   Piston diameter "A":
   Refer to SDS, EM-172.
   Measuring point "a" (Distance from the bottom):
   18 mm (0.71 in)
4. Check that piston-to-bore clearance is within specification.
   Piston-to-bore clearance "B" = Bore measurement "C" − Piston diameter "A":
   0.025 - 0.045 mm (0.0010 - 0.0018 in)
5. Determine piston oversize according to amount of cylinder wear.

Oversize pistons are available for service. Refer to SDS, EM-172.

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)



SEM755B

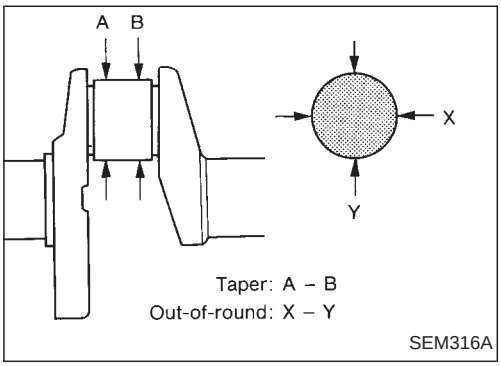
7. Install main bearing cap and tighten bolts to 90 to 100 N·m (9.2 to 10.2 kg-m, 67 to 74 ft-lb). This will prevent distortion of cylinder bores.
8. Cut cylinder bores.

- **When any cylinder needs boring, all other cylinders must also be bored.**
- **Do not cut too much out of cylinder bore at a time. Cut only 0.05 mm (0.0020 in) or so at a time.**

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

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

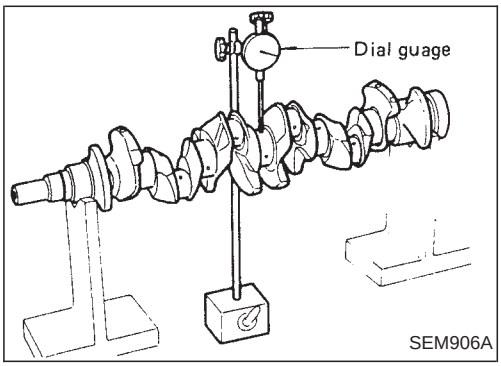
Inspection (Cont'd)



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):
Main journal
Less than 0.005 mm (0.0002 in)
Pin journal
Less than 0.0025 mm (0.0001 in)
Taper (A − B):
Main journal
Less than 0.005 mm (0.0002 in)
Pin journal
Less than 0.0025 mm (0.0001 in)



3. Measure crankshaft runout.

Runout (Total indicator reading):
Standard Less than 0.025 mm (0.0010 in)
Limit 0.05 mm (0.0020 in)

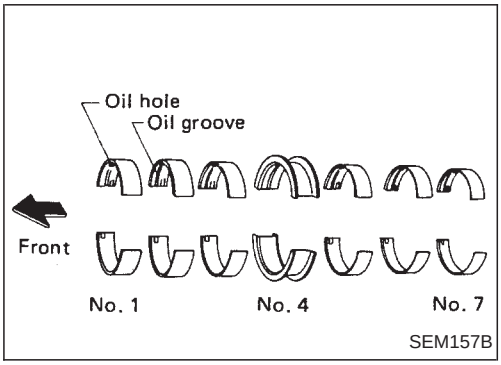
BEARING CLEARANCE

- Use Method A or Method B. Method A is preferred because it is more accurate.

Method A (Using bore gauge and micrometer)

Main bearing

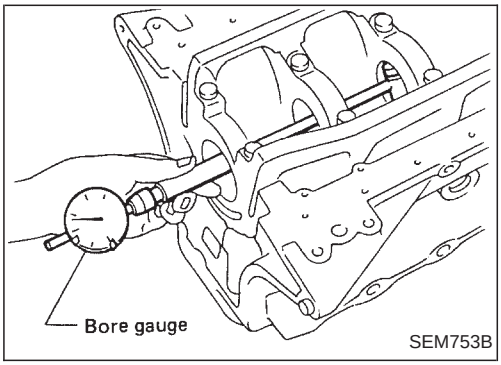
1. Set main bearings in their proper positions on cylinder block and main bearing cap.



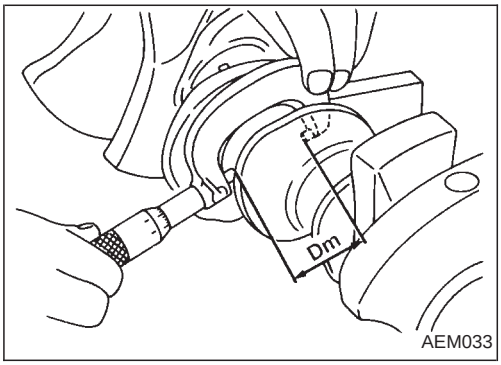
2. Install main bearing cap to cylinder block.

Tighten all bolts in correct order in two or three stages. Refer to EM-116.

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



Inspection (Cont'd)

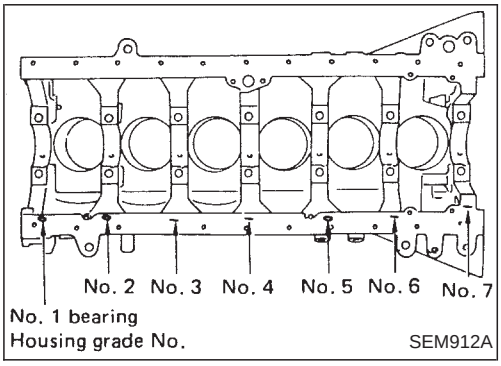


4. Measure outer diameter "Dm" of each crankshaft main journal.
5. Calculate main bearing clearance.

Main bearing clearance = A − Dm:
Standard 0.036 - 0.063 mm (0.0014 - 0.0025 in)
Limit 0.12 mm (0.0047 in)

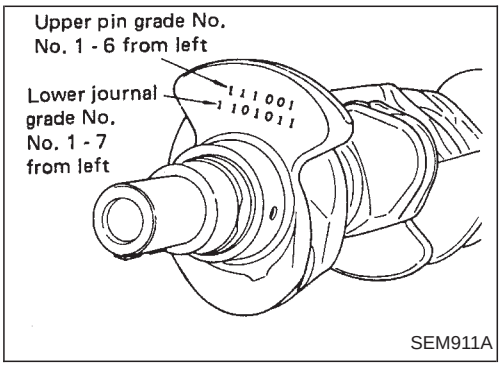
If it exceeds the limit, replace bearing.

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



- If crankshaft or cylinder block is replaced, select thickness of main bearings as follows:

a. Grade number of each cylinder block main journal is punched on the respective cylinder block. These numbers are punched in either Arabic or Roman numerals.

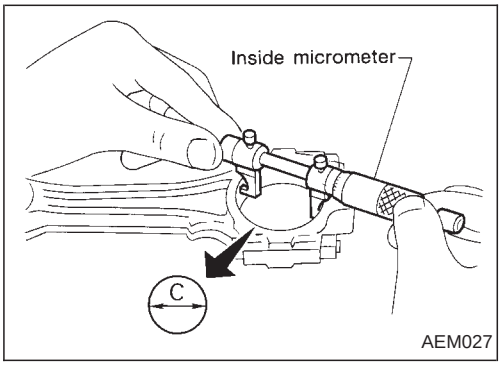


b. Grade number of each crankshaft main journal is punched on the respective crankshaft. These numbers are punched in either Arabic or Roman numerals.
c. Select main bearing with suitable thickness according to the following table.

Main bearing grade number:

Main journal grade number		0	1	2
Crankshaft journal grade number	0	0	1	2
	1	1	2	3
	2	2	3	4

For example:
Main journal grade number: 1
Crankshaft journal grade number: 2
Main bearing grade number = 1 + 2 = 3



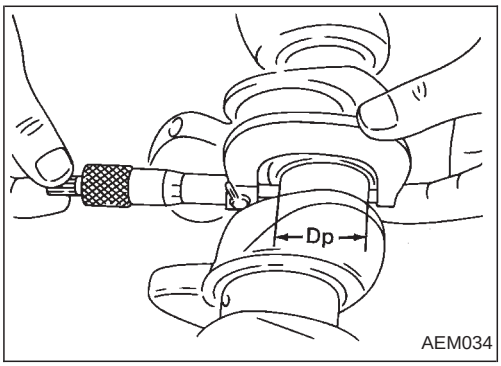
Connecting rod bearing (Big end)

1. Install connecting rod bearing to connecting rod and cap.
2. Install connecting rod cap to connecting rod.

Tighten bolts to the specified torque. Refer to EM-137.

3. Measure inner diameter "C" of each bearing.

Inspection (Cont'd)



AEM034

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

Connecting rod bearing clearance = C − Dp:
Standard
0.014 - 0.054 mm (0.0006 - 0.0021 in)
Limit
0.090 mm (0.0035 in)

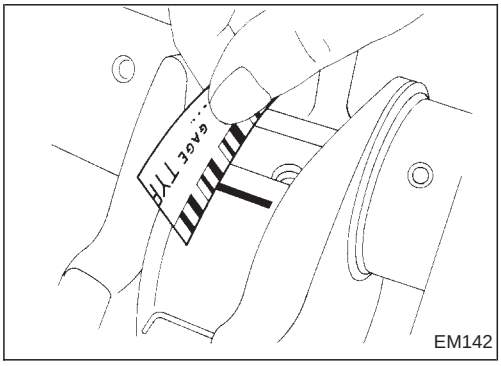
If it exceeds the limit, replace bearing.

- If it still exceeds the limit even with a new bearing, regrind crank pin and use undersized bearings.
- **Refer to SDS for regrinding crankshaft and available service parts.**

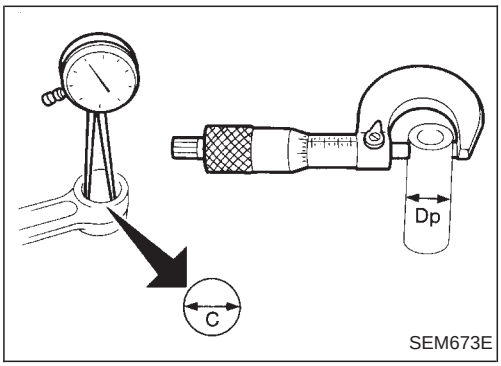
Method B (Using plastigage)

CAUTION:

- **Do not turn crankshaft or connecting rod while plastigage is being inserted.**
- **If incorrect bearing clearance exists, use a thicker or undersized main bearing to ensure specified clearance.**


EM142

CONNECTING ROD BUSHING CLEARANCE (Small end)



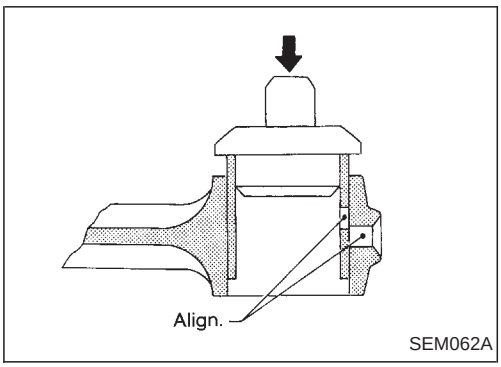
SEM673E

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

Connecting rod bushing clearance = C − Dp
Standard:
0.025 - 0.044 mm (0.0010 - 0.0017 in)

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

REPLACEMENT OF CONNECTING ROD BUSHING (Small end)



SEM062A

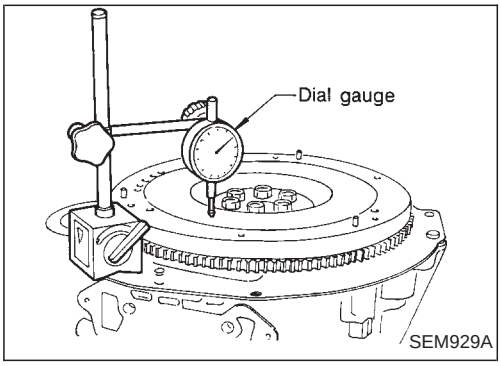
1. Drive in small end bushing until it is flush with end surface of rod.

Be sure to align the oil holes.

2. Ream the bushing so that clearance with piston pin is within specification.

Clearance between connecting rod bushing and piston pin:
0.005 - 0.017 mm (0.0002 - 0.0007 in)

FLYWHEEL/DRIVE PLATE RUNOUT

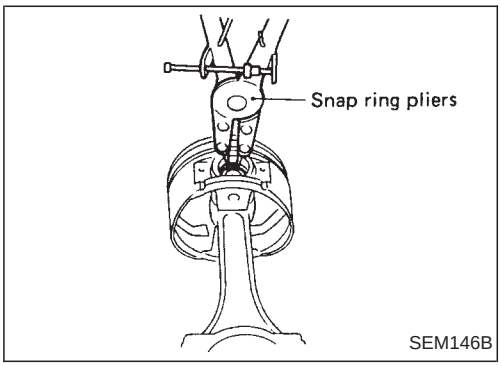


SEM929A

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

CAUTION:

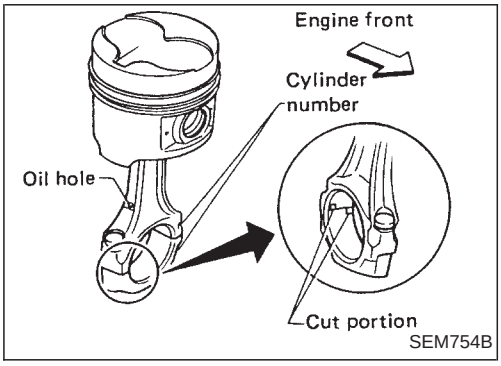
- **Be careful not to damage the ring gear teeth.**
- **Check the drive plate for deformation or cracks.**
- **Do not allow any magnetic materials to contact the ring gear teeth.**
- **Do not resurface drive plate. Replace as necessary.**



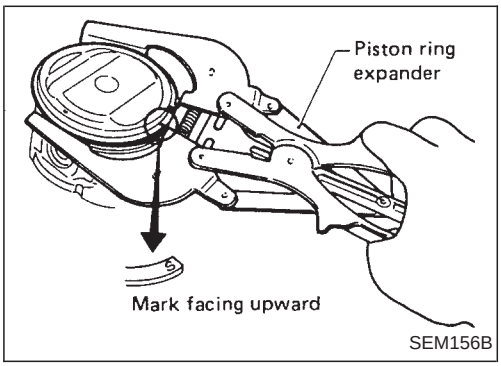
Assembly

PISTON

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

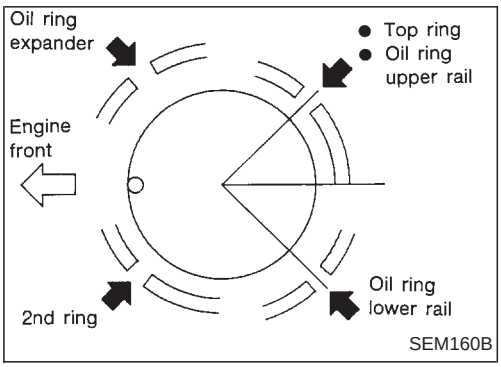


2. Heat piston to 60 to 70°C (140 to 158°F) and assemble piston, piston pin, connecting rod and new snap ring.
- **Align the direction of piston and connecting rod.**
- **Numbers stamped on connecting rod and cap correspond to each cylinder.**
- **After assembly, make sure connecting rod swings smoothly.**



3. Set piston rings as shown.

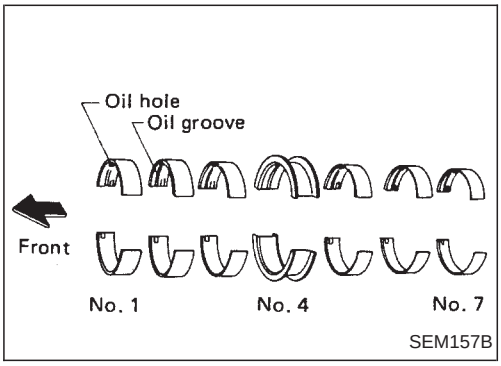
CAUTION:
- **When piston rings are not replaced, make sure that piston rings are mounted in their original positions.**
- **Install new piston rings either side up if there is no punch-mark.**



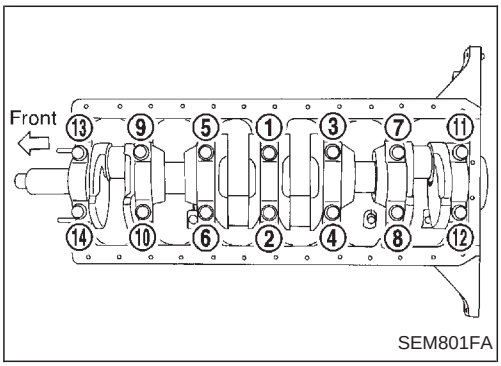
- **Align piston rings so that end gaps are positioned as shown.**

CRANKSHAFT

1. Set main bearings in their proper positions on cylinder block and main bearing cap.
- **Confirm that correct main bearings are selected by using Method A or Method B. Refer to EM-113.**
- **Apply new engine oil to bearing surfaces.**

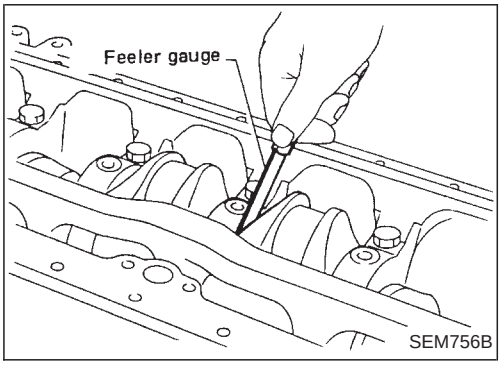


Assembly (Cont'd)



SEM801FA

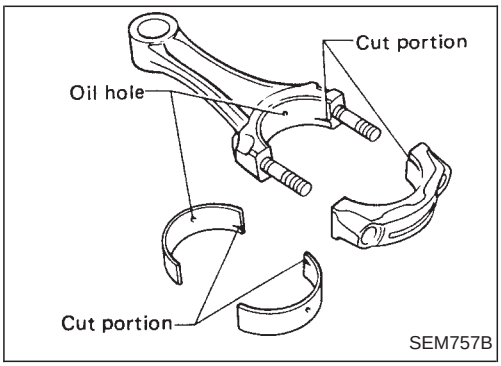
2. Install crankshaft and main bearing caps and tighten bolts to the specified torque.
- **Apply new engine oil to the bolt thread and seat surface.**
- **Prior to tightening bearing cap bolts, shift crankshaft back and forth to properly seat the bearing cap.**
- **Tighten bearing cap bolts gradually in two or three steps. Start with center bearing and move outward as shown in figure.**
- **After securing bearing cap bolts, make sure crankshaft turns smoothly by hand.**



SEM756B

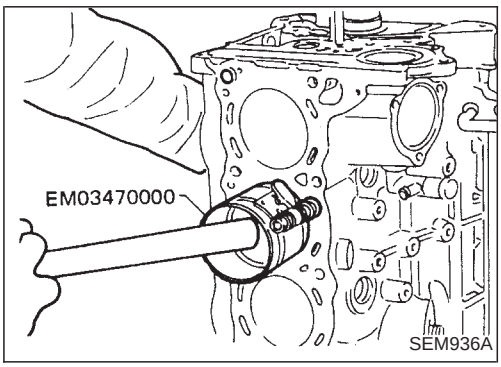
3. Measure crankshaft end play.
Crankshaft end play:
Standard
0.050 - 0.18 mm (0.0020 - 0.0071 in)
Limit
0.30 mm (0.0118 in)

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



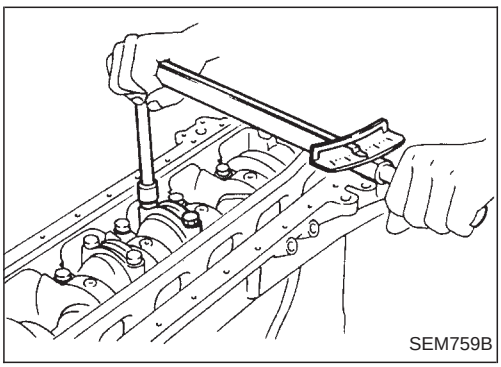
SEM757B

4. Install connecting rod bearings in connecting rods and connecting rod caps.
- **Confirm that correct bearings are selected. Refer to "Connecting rod bearing (Big end)", EM-114.**
- **Install bearings so that oil hole in connecting rod aligns with oil hole of bearing.**
- **Apply new engine oil to bearing surfaces, bolt threads and seating surfaces.**



SEM936A

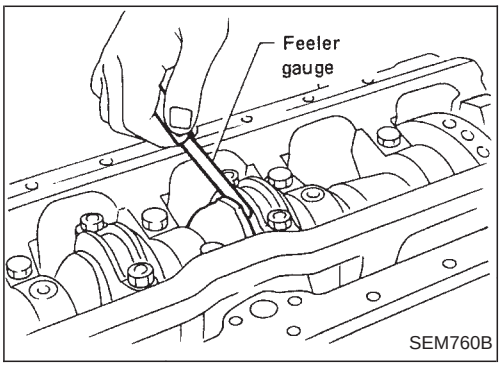
5. Install pistons with connecting rods.
a. Install them into corresponding cylinders with Tool.
- **Make sure connecting rod does not scratch cylinder wall.**
- **Make sure connecting rod bolts do not scratch crankshaft pin journals.**
- **Arrange so that front mark on piston head faces toward front of engine.**
- **Apply new engine oil to piston rings and sliding surface of piston.**


SEM759B

b. Install connecting rod caps.
- **Apply new engine oil to bolt threads and nut seating surfaces.**

Tighten connecting rod cap nuts using the following procedure.
(1) Tighten to 14 to 16 N·m (1.4 to 1.6 kg-m, 10 to 12 ft-lb).
(2) Turn nuts 60 to 65° clockwise with an angle wrench. If an angle wrench is not available, tighten nuts to 37 to 45 N·m (3.8 to 4.6 kg-m, 27 to 33 ft-lb).

Assembly (Cont'd)



6. Measure connecting rod side clearance.

Connecting rod side clearance:

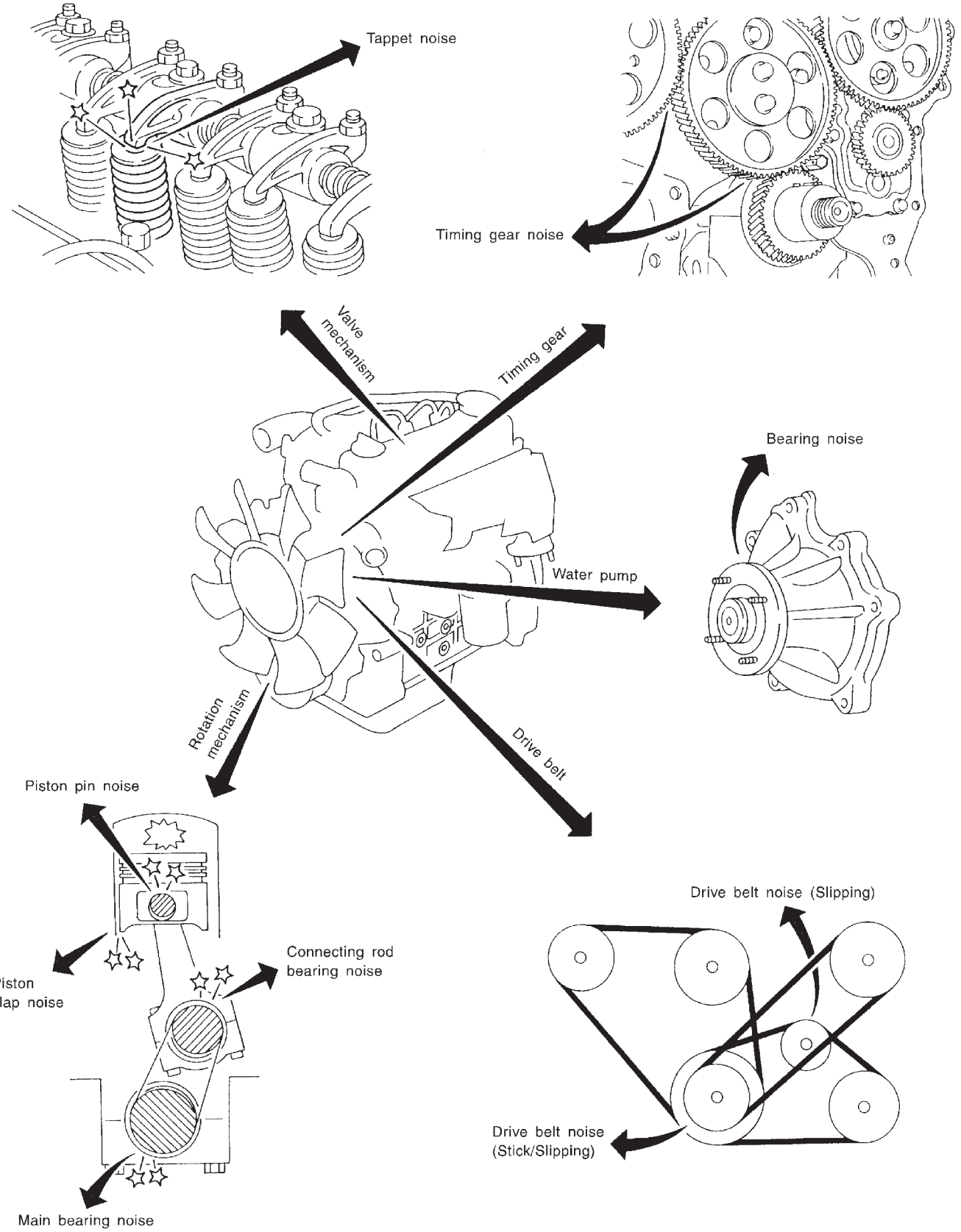
Standard

0.20 - 0.30 mm (0.0079 - 0.0118 in)

Limit

0.40 mm (0.0157 in)

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


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

SEM806F

NVH Troubleshooting Chart — Engine Noise

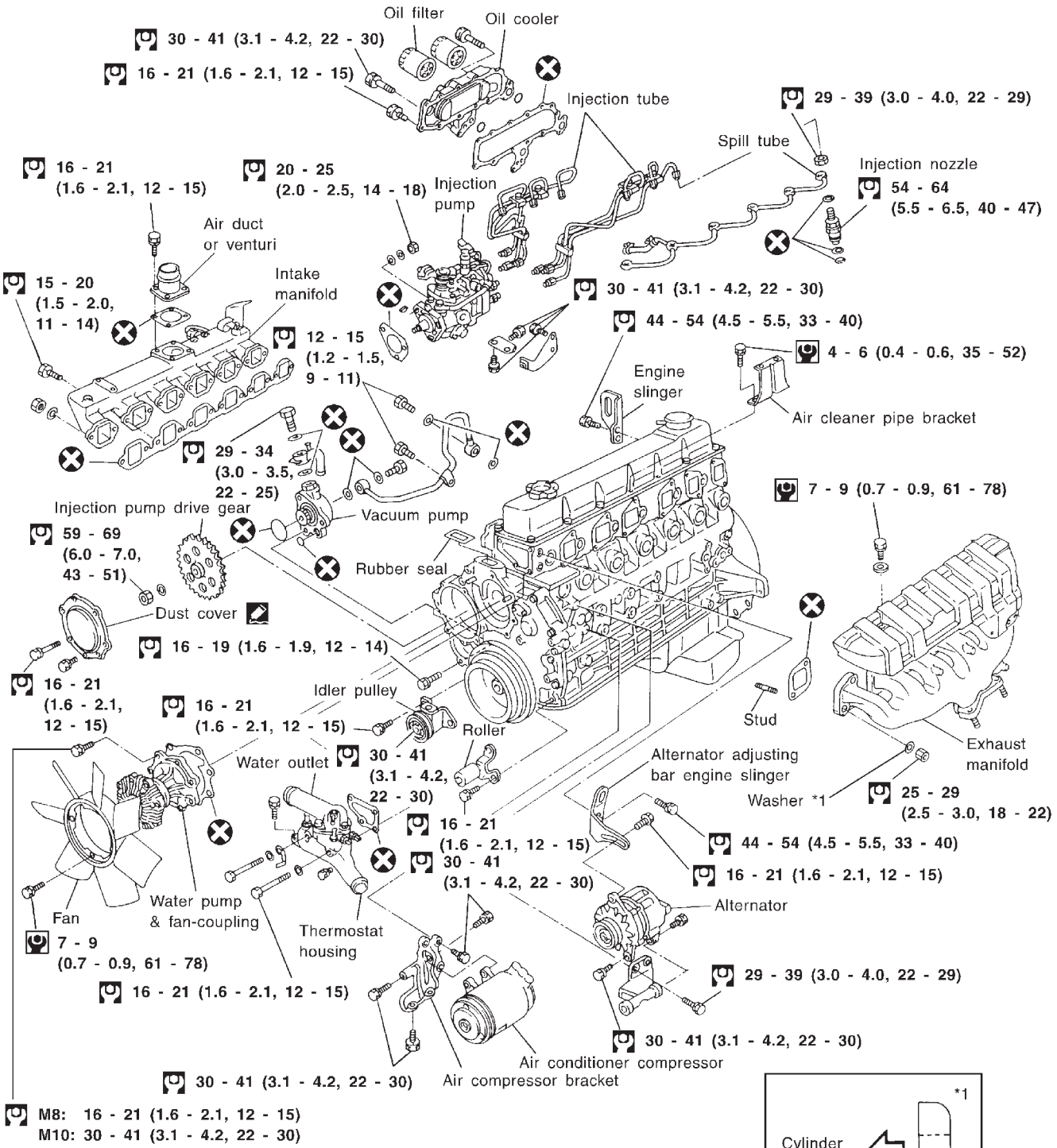
Use the chart below to help you find the cause of the symptom.
1. Locate the area where noise occurs.
2. Confirm the type of noise.
3. Specify the operating condition of engine.
4. Check specified noise source.

If necessary, repair or replace these parts.

Location of noise	Type of noise	Operating condition of engine						Source of noise	Check item	Reference page
		Before warm-up	After warm-up	When starting	When idling	When racing	While driving			
Top of engine Rocker cover Cylinder head	Ticking or clicking	C	A	—	A	B	—	Tappet noise	Valve clearance	MA section (“Adjusting Intake & Exhaust Valve Clearance”, “ENGINE MAINTE-NANCE”)
	Rattle	C	A	—	A	B	C	Camshaft bearing noise	Camshaft bushing clearance Camshaft runout	EM-152, 155
Crankshaft pulley Cylinder block (Side of engine) Oil pan	Slap or knock	—	A	—	B	B	—	Piston pin noise	Piston and piston pin clear-ance Connecting rod bushing clearance	EM-146, 148
	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-145, 146, 148
	Knock	A	B	C	B	B	B	Connecting rod bearing noise	Connecting rod bushing clearance (Small end) Connecting rod bearing clearance (Big end)	EM-148, 147
	Knock	A	B	—	A	B	C	Main bear-ing noise	Main bearing oil clearance Crankshaft runout	EM-147, 149
Front of engine Timing gear cover	Tapping or ticking	A	A	—	B	B	B	Timing gear noise	Timing gear backlash	EM-151
Front of engine	Squeaking or fizzing	A	B	—	B	—	C	Other drive belts (Stick-ing or slip-ping)	Drive belts deflection	MA section (“Checking Drive Belts”, “ENGINE MAINTE-NANCE”)
	Creaking	A	B	A	B	A	B	Other drive belts (Slip-ping)	Idler pulley bearing operation	
	Squall Creak	A	B	—	B	A	B	Water pump bearing noise	Water pump bearing opera-tion	LC section (“Water Pump Inspection”, “ENGINE COOLING SYSTEM”)

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

SEC. 135•140•185•186•210•213

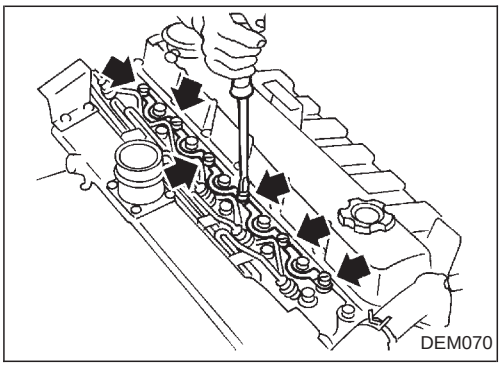


: N•m (kg-m, in-lb)

: N•m (kg-m, ft-lb)

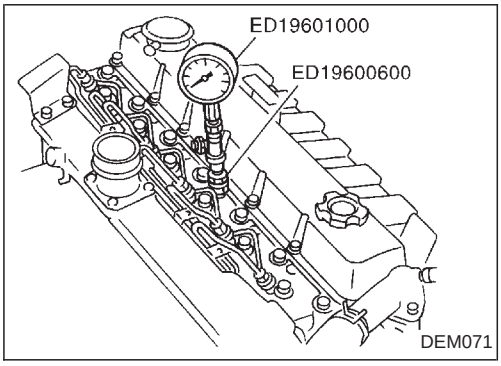
: Apply recommended sealant
(Nissan genuine part: KP610-00250) or equivalent.

DEM092


DEM070

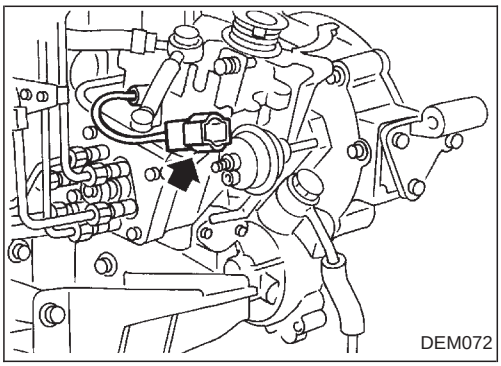
Measurement of Compression Pressure

1. Warm up engine.
2. Stop engine. Remove glow plate and glow plugs.



DEM071

3. Fit compression gauge adapter to cylinder head.
   Compression gauge adapter:
   : 15 - 20 N·m (1.5 - 2.0 kg-m, 11 - 14 ft-lb)


DEM072

4. Disconnect fuel cut solenoid wire connector.
5. Crank engine, then read gauge indication.

- **Engine compression measurement should be made as quickly as possible.**

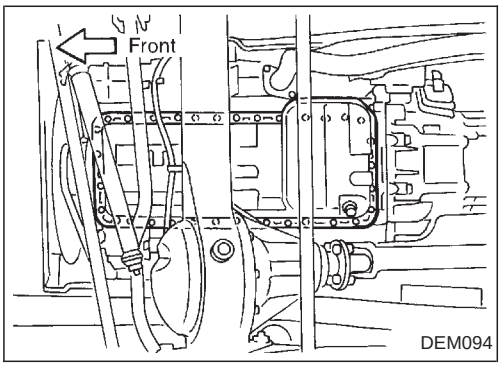
Compression pressure:

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

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

6. If cylinder compression in one or more cylinders is low, pour a small quantity of engine oil into cylinders through the glow holes and retest compression.

- **If adding oil helps the compression pressure, chances are that piston rings are worn or damaged.**
- **If pressure stays low, valve may be sticking or seating improperly.**
- **If cylinder compression in any two adjacent cylinders is low, and if adding oil does not help the compression, there is leakage past the gasketed surface.**
  Oil and water in combustion chambers can result from this problem.



Removal

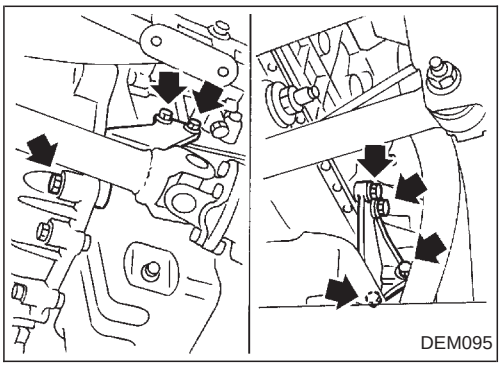
WARNING:

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

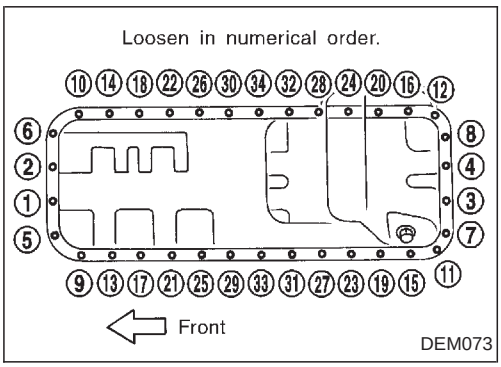
CAUTION:

- **In lifting engine, be careful not to hit against adjacent parts, especially against accelerator wire casing end, brake tube and brake master cylinder.**
- **For tightening torque of engine mounting parts and engine gussets, refer to EM-139 and MT section.**

1. Drain engine oil.

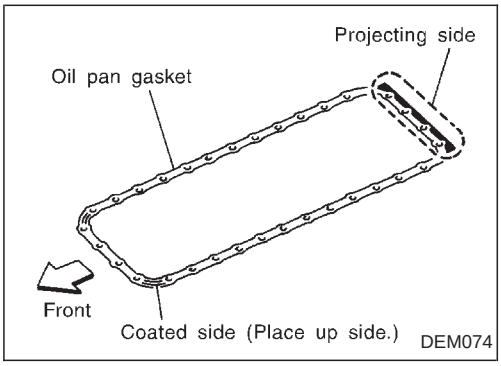


2. Remove engine gussets.



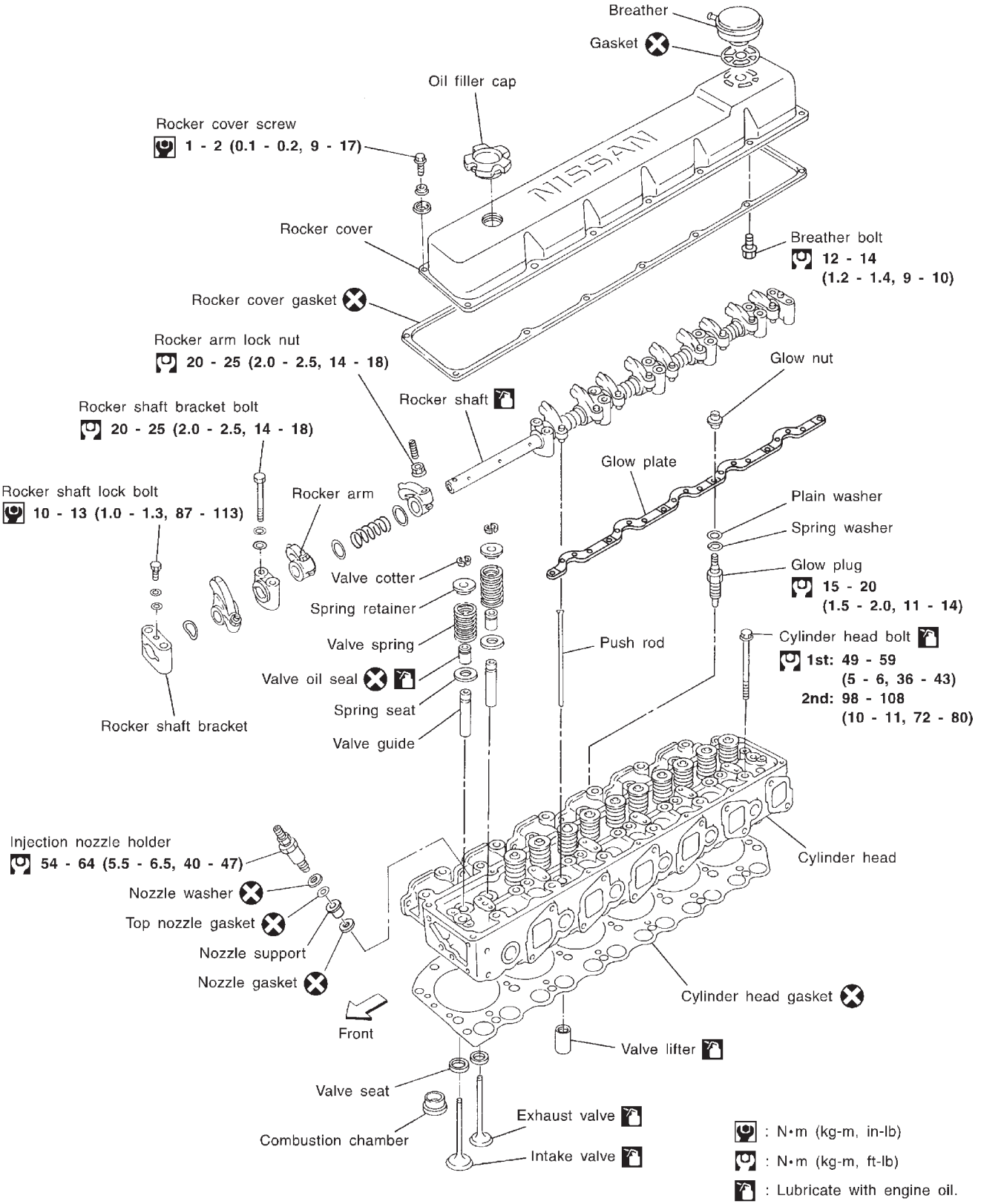
3. Remove oil pan bolts in the order shown.

Installation



1. Install the oil pan gasket with the coated surface facing the cylinder block and the projecting side facing the rear of the engine.
2. Tighten all bolts in reverse order of removal. For tightening torque of oil pan and correct installing direction of drain plug washer, refer to EM-141.

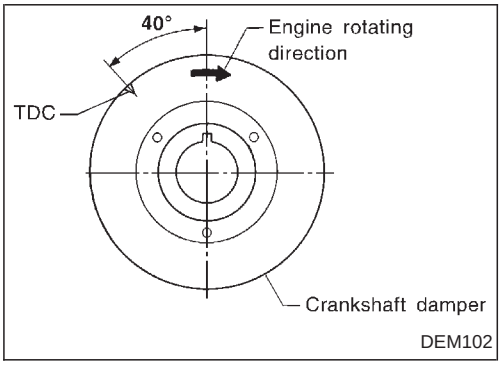
SEC. 111•130•185•220



DEM085

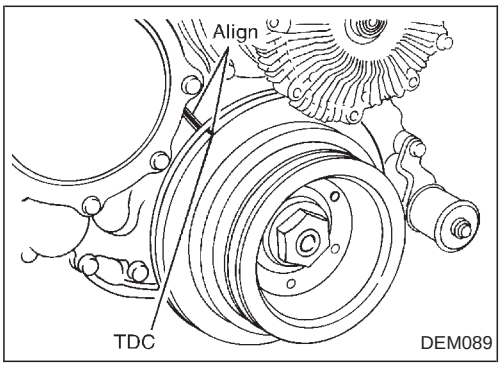
CAUTION:

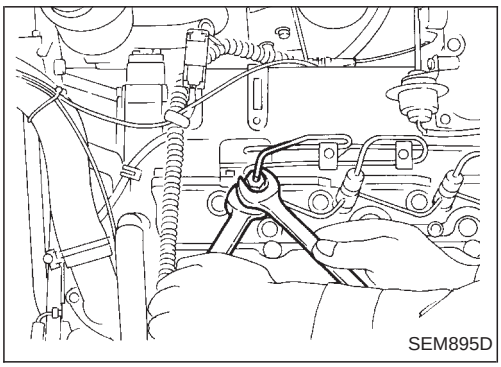
- **When installing sliding parts such as rocker arms, camshaft and oil seal, be sure to apply new engine oil on their sliding surfaces.**
- **When tightening cylinder head bolts and rocker shaft bolts, apply new engine oil to thread portions and seat surfaces of bolts.**



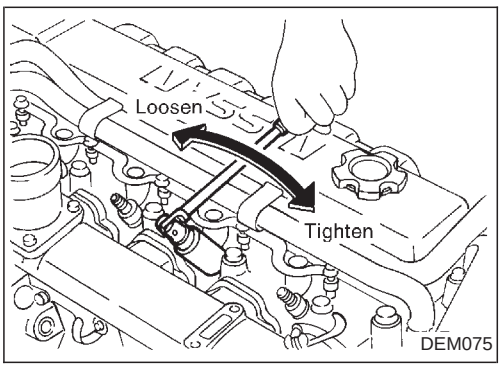
Removal

1. Set No. 1 cylinder at TDC (top dead center) on its compression stroke.
2. Drain engine coolant from drain plugs on cylinder block and radiator.
3. Remove air cleaner and/or air duct.
4. Remove alternator adjusting bolt.
5. Disconnect exhaust manifold from front exhaust tube.
6. Disconnect radiator outlet hose and thermostat housing water inlet hose.



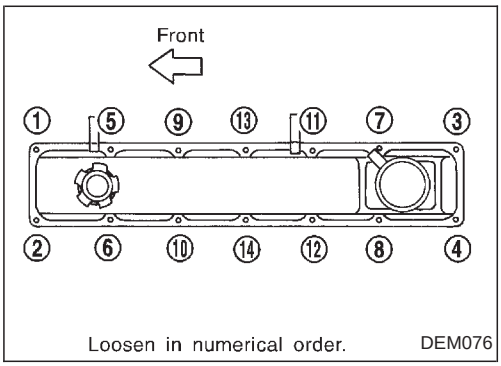


7. Remove fuel injection tube assembly and spill tube.

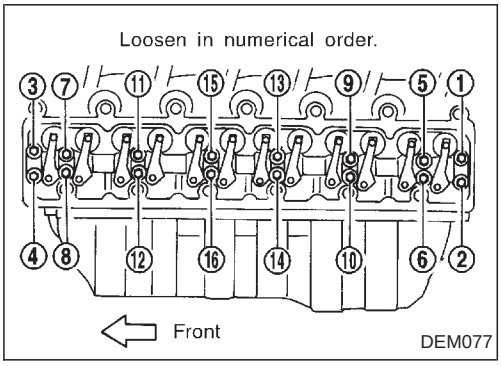


8. Remove injection nozzle holder and top nozzle gasket using deep socket wrench.

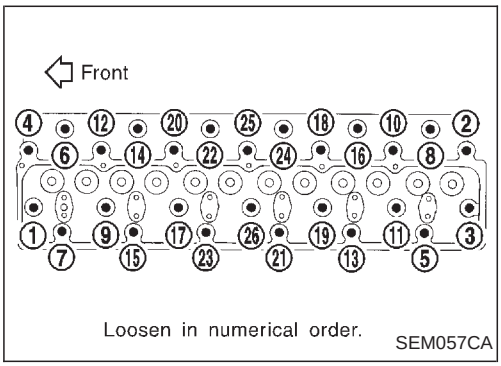
Removal (Cont'd)



9. Remove rocker cover.



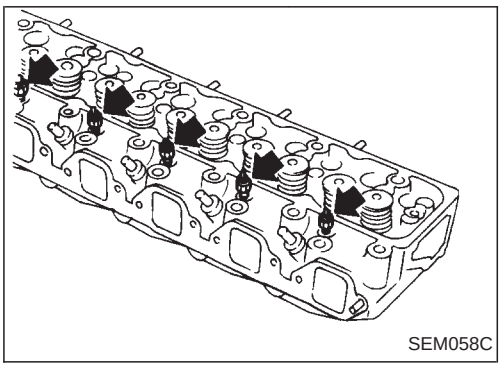
10. Remove rocker shaft with rocker arms.
11. Remove push rods.



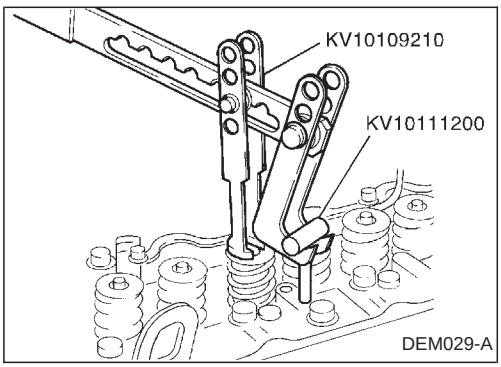
12. Remove cylinder head bolts in numerical order and remove cylinder head.

Head warpage or cracking could result from removing in incorrect order.

Disassembly

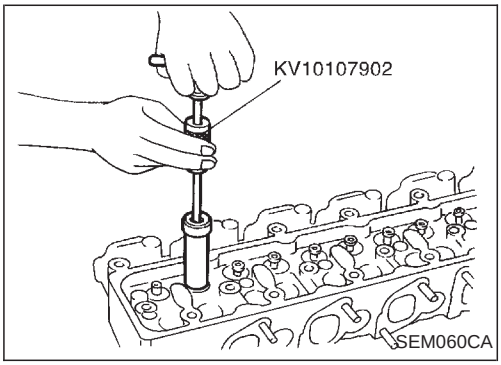


1. Remove following parts:
a. Intake manifold
b. Exhaust manifold
c. Thermostat housing
d. Alternator adjusting bar & engine slinger
e. Glow plate and glow plugs

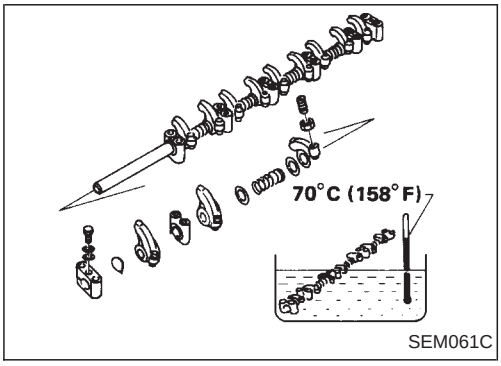


2. Remove valve component parts with Tool.

Disassembly (Cont'd)



3. Remove valve oil seals with Tool.



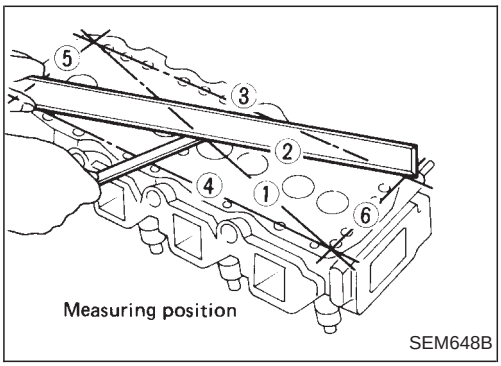
4. Disassemble rocker shaft assembly.
a. Remove rocker shaft lock bolt.
b. Remove valve rocker and rocker shaft bracket.

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

Inspection

CYLINDER HEAD DISTORTION

Cylinder head distortion: mm (in)
Standard
Less than 0.07 (0.0028)
Limit
0.2 (0.008)

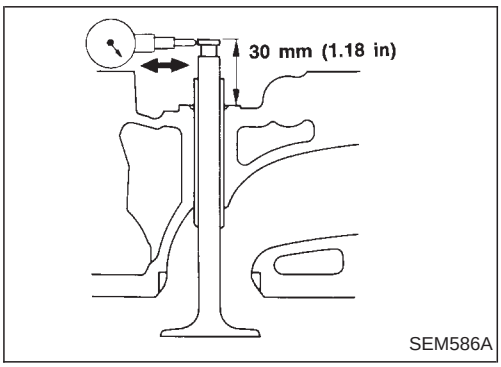


If beyond the specified limit, correct with a surface grinder. Cylinder head height should be greater than 89.7 mm (3.531 in) after surface has been ground.

VALVE GUIDE CLEARANCE

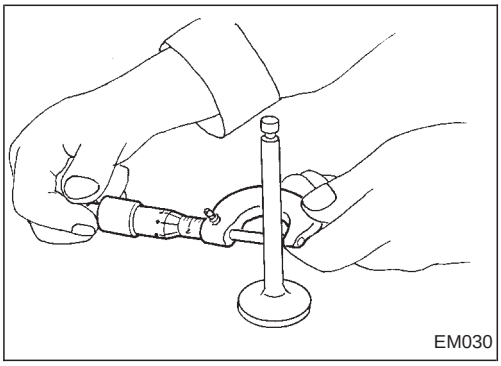
- **Valve guide clearance should be measured parallel with rocker arm. (Generally, a large amount of wear occurs in this direction.)**

Stem to guide clearance: mm (in)
Limit
Intake 0.15 (0.0059)
Exhaust 0.20 (0.0079)
Maximum allowable deflection
(Dial indicator reading)
Intake 0.30 (0.0118)
Exhaust 0.40 (0.0157)

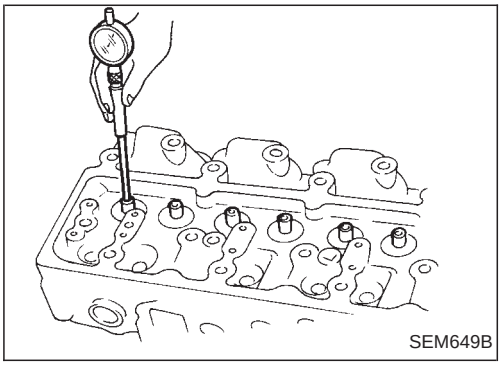


- **To determine the correct replacement part, measure valve stem diameter and valve guide inner diameter.**

Valve stem diameter: mm (in)
Standard
Intake
7.962 - 7.977 (0.3135 - 0.3141)
Exhaust
7.945 - 7.960 (0.3128 - 0.3134)



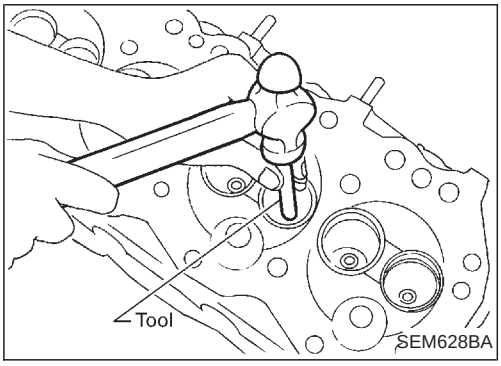
Inspection (Cont'd)



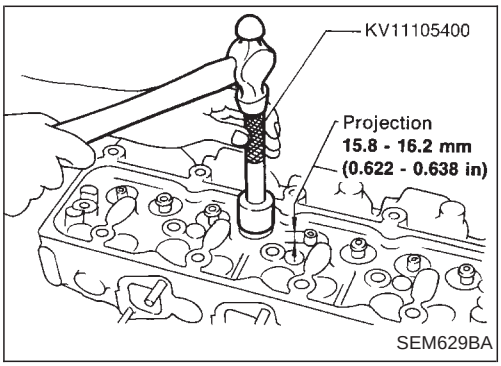
Valve guide inner diameter:
8.000 - 8.015 mm (0.3150 - 0.3156 in)

VALVE GUIDE REPLACEMENT

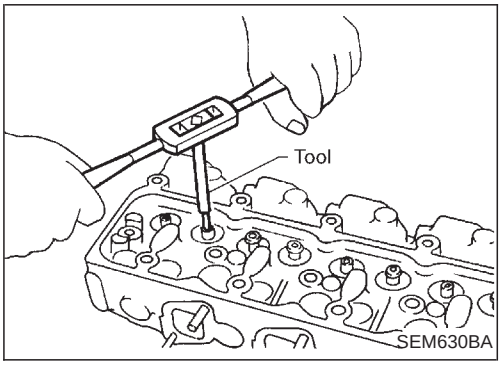
1. Drive out valve guide with a press [under a 20 kN (2 ton, 2.2 US ton, 2.0 Imp ton) pressure] or hammer, and suitable tool.



2. Press service valve guide onto cylinder head using suitable tool until the guide projects out 15.8 to 16.2 mm (0.622 to 0.638 in).



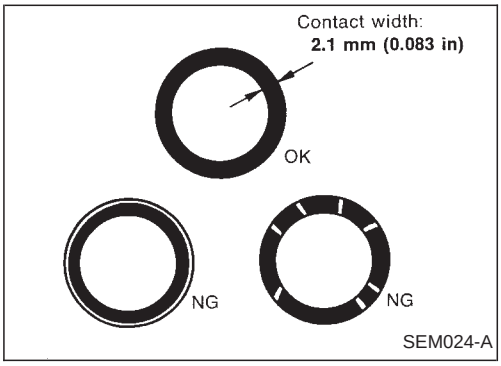
3. Ream valve guide.
   Finished size:
   8.000 - 8.015 mm (0.3150 - 0.3156 in)



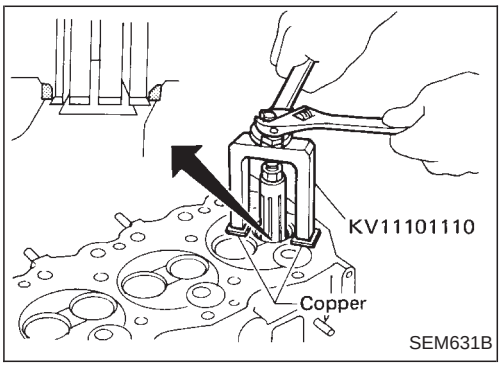
VALVE SEATS

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

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



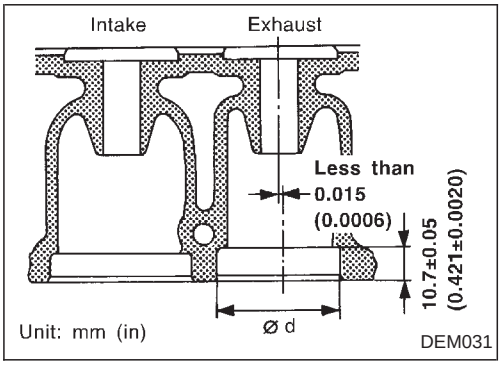
Inspection (Cont'd)



REPLACING VALVE SEAT FOR SERVICE PARTS

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

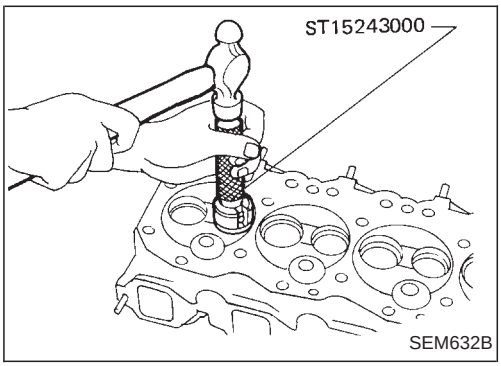
Place a copper seat between contact surface of Tool and cylinder head.



2. If the valve seat for the exhaust side is oversized, machine its mating area (on the cylinder head side) to the dimensions indicated in the table below. Refer to the figure at the left for machining procedures.

Unit: mm (in)

Oversized valve seat	Bore diameter "d"
0.2 (0.008)	39.695 - 39.710 (1.5628 - 1.5634)
0.4 (0.016)	39.895 - 39.910 (1.5707 - 1.5713)

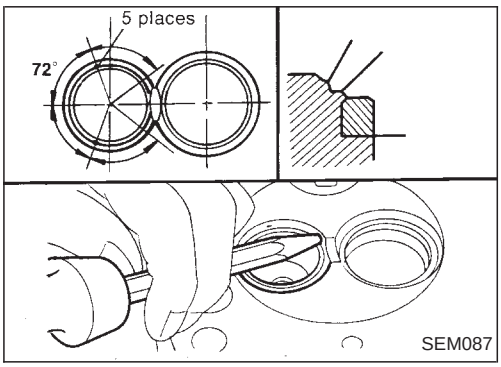


3. Place new valve seats on dry ice and allow them to cool for five minutes.

WARNING:

Do not touch cooled valve seats with bare hand.

4. Heat cylinder head to 80°C (176°F).
5. Install cooled valve seats on cylinder head with Tool.

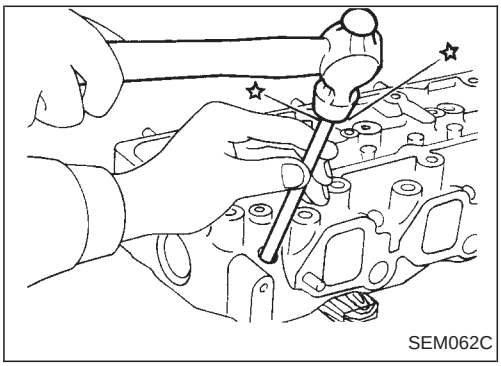


6. Stake exhaust valve seat at five places with punch.

When staking valve seat, select different places than those staked before.

7. Cut or grind valve seat using suitable tool at the specified dimensions as shown in SDS, EM-178.
8. After cutting, lap valve seat with a lapping compound.
9. Check contact condition of valve seat.

Inspection (Cont'd)


SEM062C

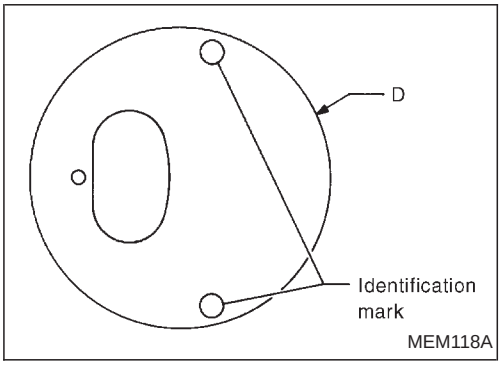
COMBUSTION CHAMBER

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

REPLACING COMBUSTION CHAMBER

Usually combustion chamber should not be removed.

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



MEM118A

2. Install combustion chamber.

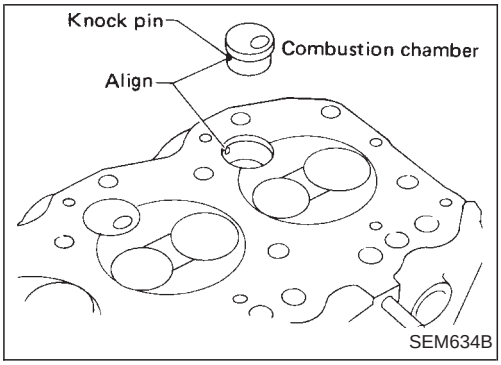
Identification of combustion chambers

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

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

WARNING:

Do not touch cooled combustion chamber with bare hand.



SEM634B

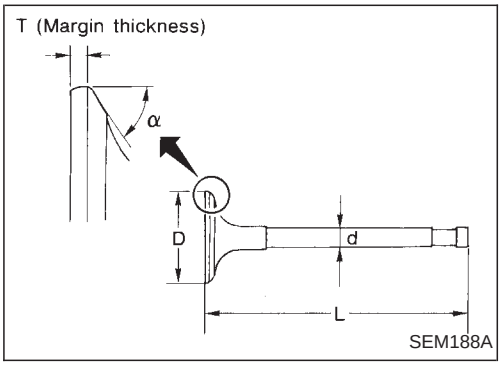
(2) Align combustion chamber knock pin with cylinder head notch, and drive in combustion chamber with a soft hammer.

3. Check amount of protrusion of combustion chamber.

Protrusion:

Standard

−0.05 to 0.10 mm (−0.0020 to 0.0039 in)



SEM188A

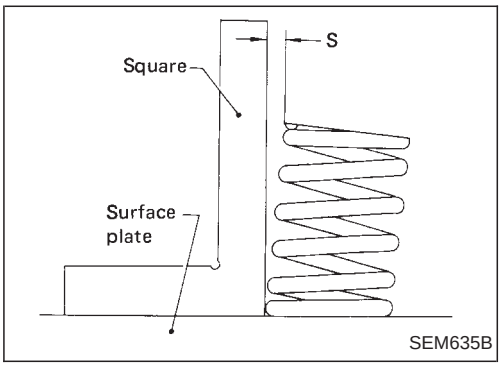
VALVE DIMENSIONS

Check dimensions in each valve. For dimensions, refer to SDS.

When valve head has been worn down to 0.5 mm (0.020 in) in margin thickness, replace the valve.

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

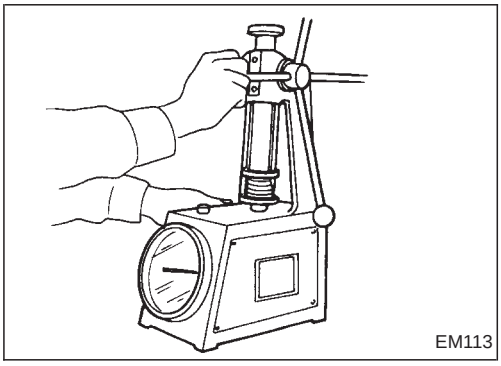
Inspection (Cont'd)



VALVE SPRING SQUARENESS

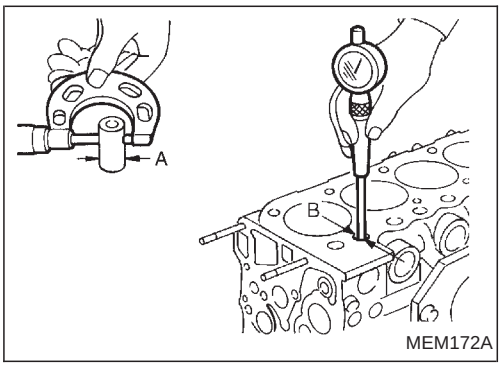
Align the valve spring with a square. Rotate the spring to measure any gap between the top of the spring and the square.

Out-of-square "S":
Less than 2.3 mm (0.091 in)



VALVE SPRING PRESSURE LOAD

Refer to SDS, EM-177.



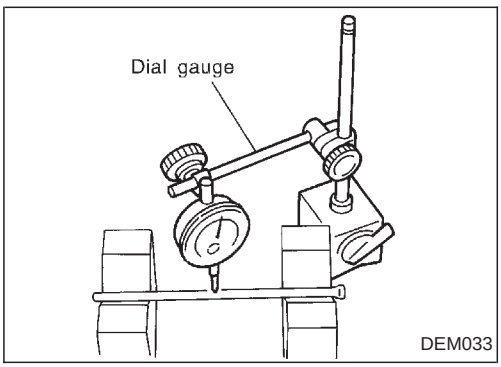
VALVE LIFTER AND PUSH ROD

Valve lifter

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

a. Valve lifter end should be smooth.

b. Valve lifter to lifter hole clearance: mm (in)
Standard
0.030 - 0.073 (0.0012 - 0.0029)
Limit
Less than 0.20 (0.0079)
Valve lifter outer diameter "A":
Standard
25.960 - 25.970 mm (1.0220 - 1.0224 in)
Cylinder block valve lifter hole diameter "B":
Standard
26.000 - 26.033 mm (1.0236 - 1.0249 in)



Push rod

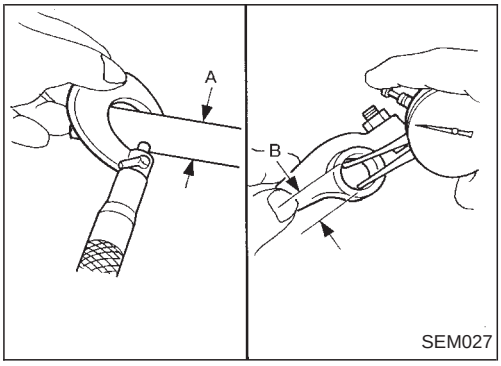
1. Inspect push rod for excessive wear on the face.
2. Replace if worn or damaged beyond repair.
3. Check push rod for bend using a dial gauge.

Maximum allowable bend
(Total indicator reading):
Less than 0.5 mm (0.020 in)

Inspection (Cont'd)

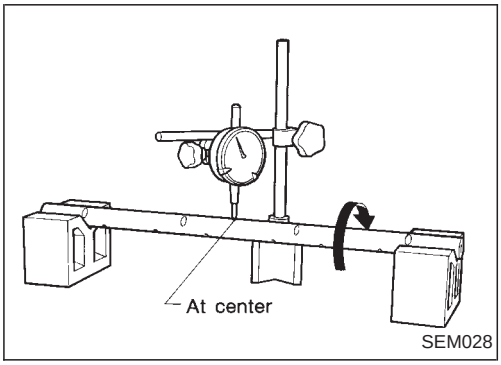
ROCKER SHAFT AND ROCKER ARM

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



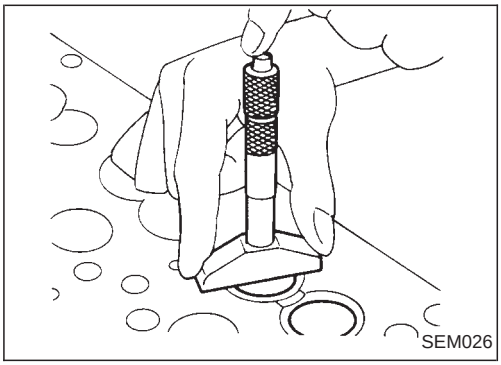
2. Check clearance between valve rockers and rocker shaft. If specified clearance is exceeded, replace affected valve rockers or shafts.

Specified clearance: mm (in)
Standard
0.014 - 0.056 (0.0006 - 0.0022)
Limit
Less than 0.15 (0.0059)
Rocker shaft outer diameter "A":
Standard
19.979 - 20.000 mm (0.7866 - 0.7874 in)
Rocker arm inner diameter "B":
Standard
20.014 - 20.035 mm (0.7880 - 0.7888 in)



3. Check rocker shaft bend at its center. If bend is within specified limit, straighten it; and if it is greater than specified limit, replace rocker shaft.

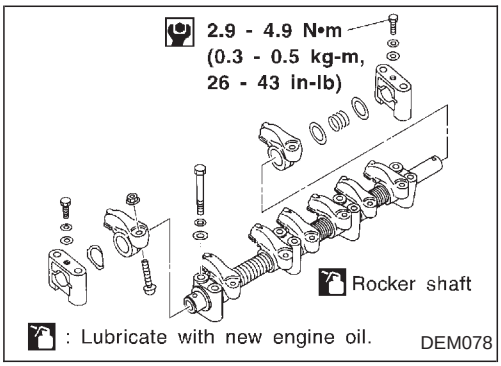
Rocker shaft bend
(Total indicator reading):
Limit
Less than 0.3 mm (0.012 in)



MEASURING CYLINDER HEAD TO VALVE DISTANCE

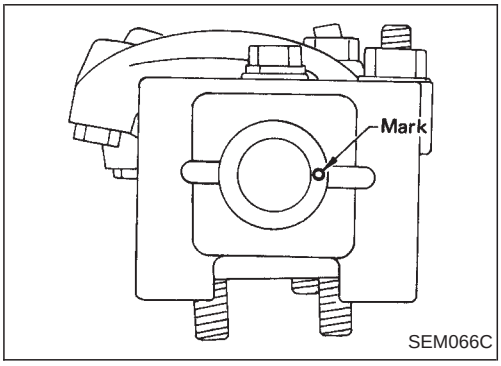
Measure distance from cylinder head surface to intake and exhaust valves. If specified distance is exceeded, replace valve(s) or valve seat(s).

Specified distance: mm (in)
Standard
Intake and Exhaust
0.7 - 1.3 (0.028 - 0.051)
Limit
Less than 1.75 (0.0689)
for intake and exhaust valves

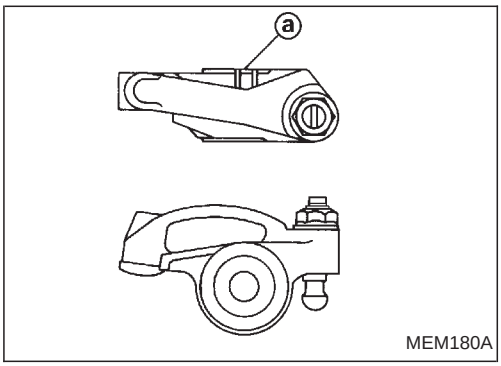


Assembly

1. Assemble rocker shaft component parts.



- **Face punch mark toward the front of the engine.**



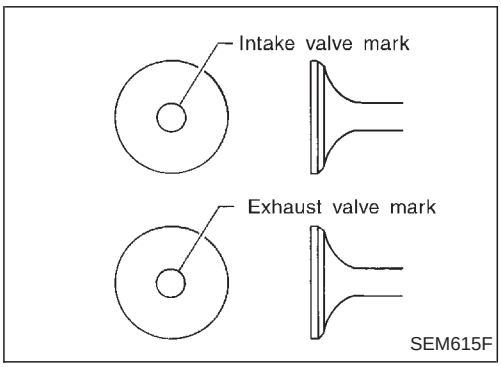
Identification of rocker arms

Identification mark (At area ⓐ on rocker arm)	For use with
Two ridges	Intake
No ridge	Exhaust

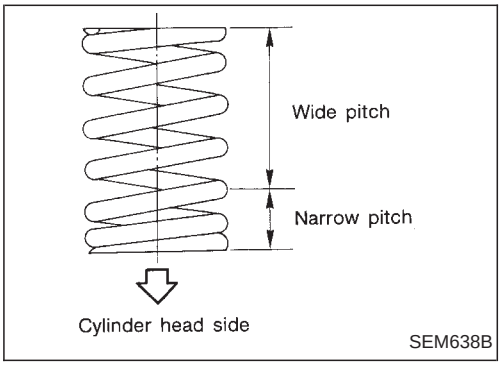
2. Install valve component parts.

Identification of valves

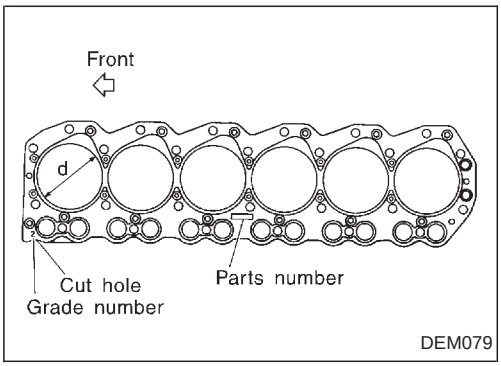
Identification mark (on intake and exhaust valve)	
Intake valve	Exhaust valve
3	C



- **Always use new valve oil seal. (Refer to EM-137.)**



- **Install valve spring (uneven pitch type) with its narrow pitch side toward cylinder head side.**



Installation

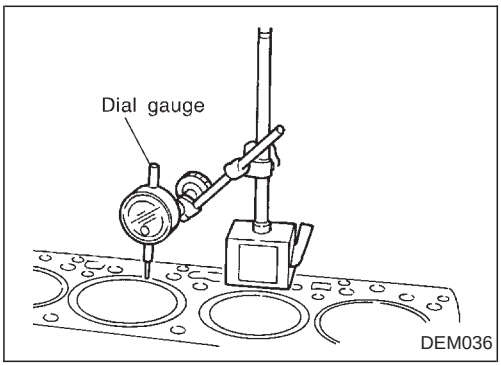
1. Install cylinder head gasket.

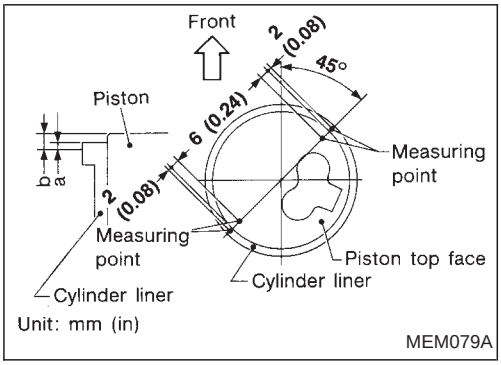
Identification of cylinder head gaskets

Identification cut hole (on cylinder head gasket)	Inner diameter "d" mm (in)
1	97.5 (3.839)

a. When replacing only cylinder head gasket, install same grade gasket as the one formerly used.

b. When replacing or repairing cylinder block, cylinder head, piston, connecting rod and crankshaft, select gasket as follows:





- **Selecting gasket thickness**

(1) Measure piston projection from cylinder block surface.

a. Measure the projection a and a′ (cylinder liner height above cylinder block) at two points in each cylinder.

b. Measure the projection b and b′ (piston height above cylinder block) at two points, when the piston is at the top dead center position.

c. Calculate the piston height projection above cylinder liner b - a (b′ - a′).

d. Average the two projections (piston height above cylinder liner) for each cylinder H_L.

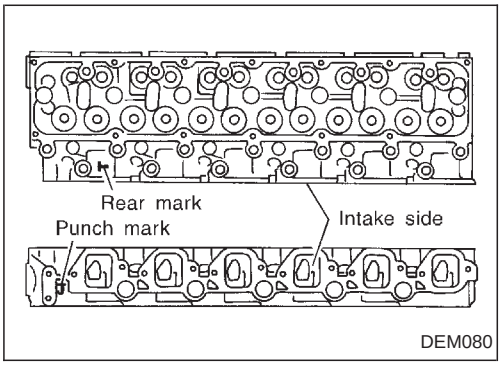
(2) Select suitable cylinder head gasket which conforms to the largest amount of projection of the four pistons.

Unit: mm (in)

Average values piston projections H_L	Gasket thickness		Gasket grade number
	New parts	In assembly	
Less than 0.118 (0.0046)	1.30 (0.0512)	1.15 (0.0453)	1
0.118 - 0.168 (0.0046 - 0.0066)	1.35 (0.0531)	1.20 (0.0472)	2
More than 0.168 (0.0066)	1.40 (0.0551)	1.25 (0.0492)	3

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

Installation (Cont'd)

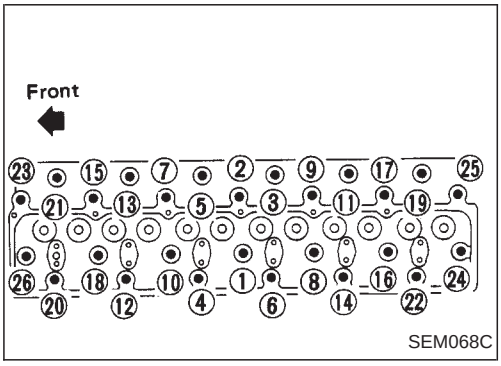


DEM080

2. Install cylinder head.

Cylinder head identification mark

Identification number (on cylinder head)	
Rear mark	Punch mark
T	—



SEM068C

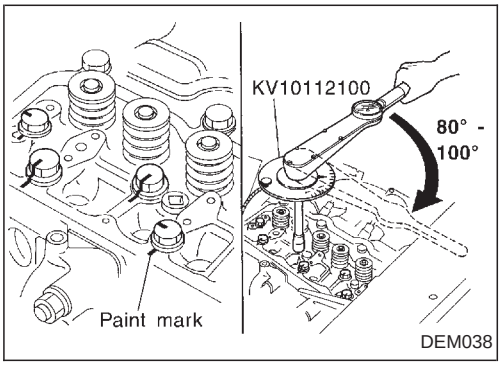
3. Apply oil to the thread portion and seat surface of bolts and tighten cylinder head bolts using Tool.

CAUTION:

- **Tightening procedure**

  1st: Tighten bolts to 39 - 44 N·m (4.0 - 4.5 kg-m, 29 - 33 ft-lb).

  2nd: Tighten bolts to 59 - 64 N·m (6.0 - 6.5 kg-m, 43 - 47 ft-lb).



DEM038

  3rd:

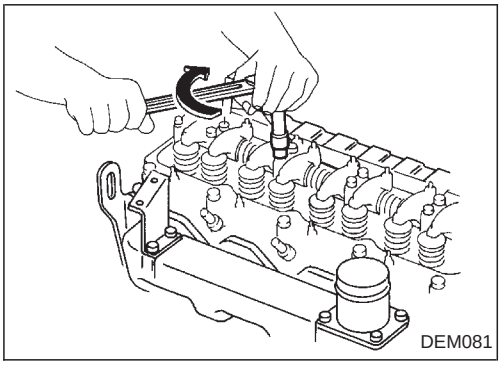
  (1) Mark exhaust side of cylinder head and cylinder head bolts with paint as shown.

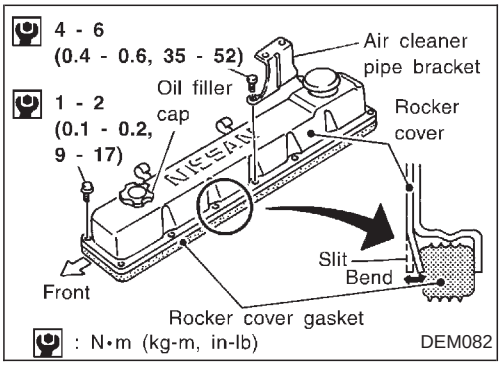
  (2) Turn all bolts 90±10 degrees clockwise.

  (3) Check that the paint mark of each bolt is facing the front of the vehicle.

  - **Always check the bolt tightening angle with an angle wrench or protractor. Do not check visually.**

4. Apply engine oil and install push rods.
5. Install rocker shaft assembly.
   Adjust intake and exhaust valve clearance tentatively.
   Refer to "Adjusting Intake and Exhaust Valve Clearance", "ENGINE MAINTENANCE" in MA section.


DEM081

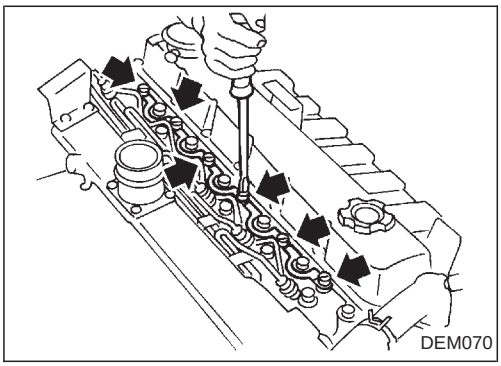


DEM082

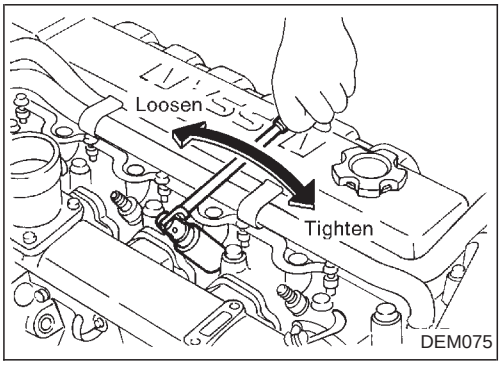
6. Install rocker cover.

- Be sure the "F" mark on rocker cover plate faces upward and is at the front end.
- When replacing rocker cover gasket, bend slit of rocker cover baffle plate a little to hold the gasket. Do not twist gasket.
- **Tighten all bolts in numeral sequence (as shown in the figure at left) to the specified torque.**
- **Tighten all bolts in reverse order of removal.**

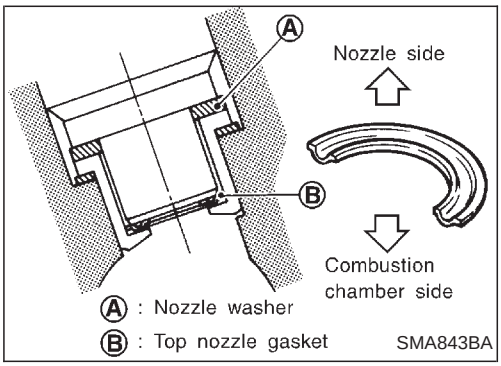
Installation (Cont'd)

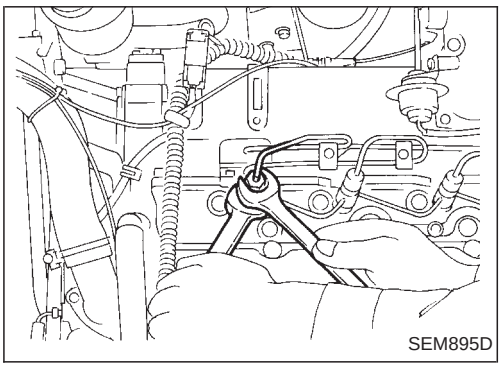


7. Install glow plugs and glow plate.



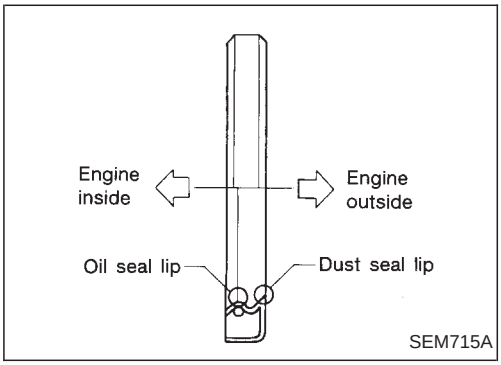
8. Install new top nozzle gasket, nozzle washer and injection nozzle.
- **Always replace nozzle gasket and washer.**





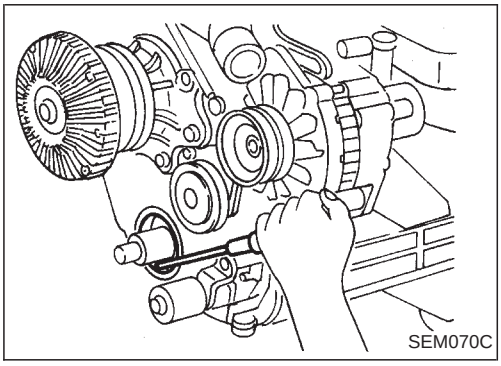
9. Install spill tube and injection tube.

10. Connect thermostat housing water inlet hose and radiator hose.
11. After assembling all disassembled parts, fill radiator and engine with new coolant up to filler opening.



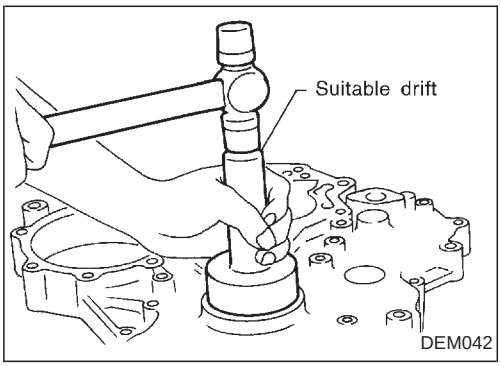
OIL SEAL INSTALLING DIRECTION

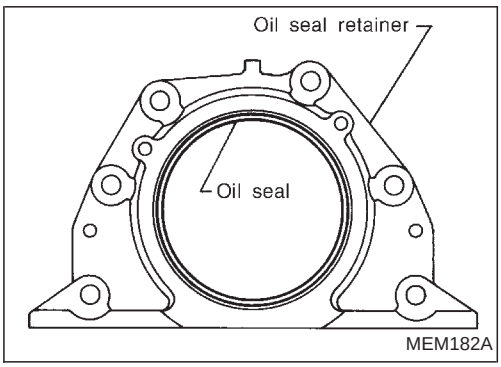
- When installing a new front or rear seal, make sure its mounting direction is correct.



CRANKSHAFT FRONT OIL SEAL

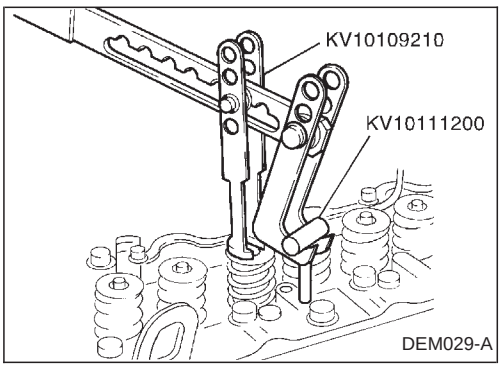
1. Remove radiator shroud.
2. Remove cooling fan.
3. Remove drive belts.
4. Remove crankshaft pulley.
5. Remove crankshaft oil seal.
- Be careful not to damage sealing surfaces of crankshaft.
6. Coat new oil seal with engine oil and install it in place.
- Press the oil seal until it contacts with the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





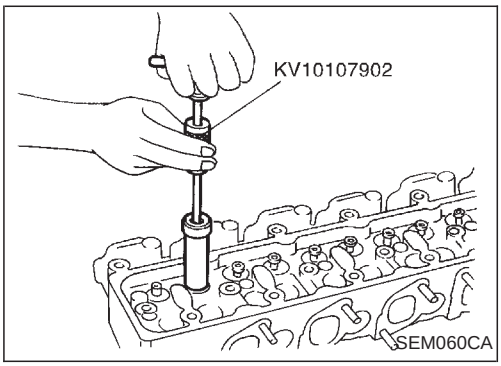
CRANKSHAFT REAR OIL SEAL

1. Dismount transmission.
2. Remove clutch cover assembly.
3. Remove flywheel and rear plate.
4. Remove oil pan and oil pan gasket.
5. Remove oil seal retainer assembly and retainer gasket.
- **Replace oil seal and retainer assembly as a single unit (mono-block type combined with oil seal).**
6. Coat oil seal with engine oil and install new oil seal retainer assembly in place.

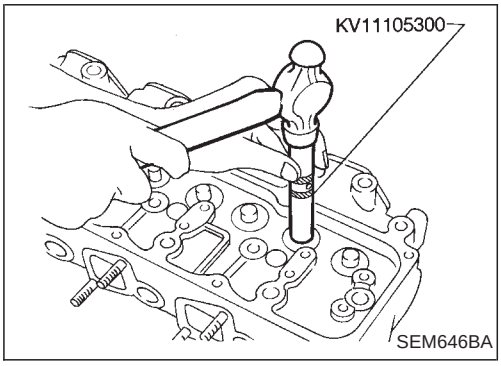


VALVE STEM OIL SEAL

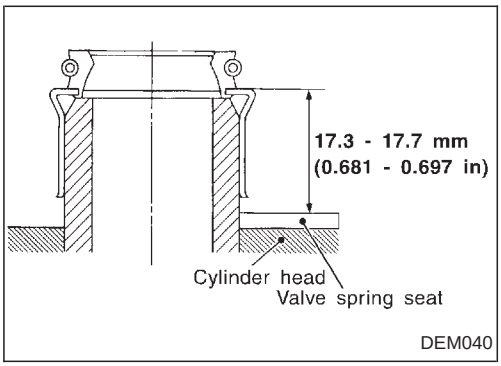
1. Remove rocker cover.
2. Remove rocker shaft assembly.
3. Remove valve spring.

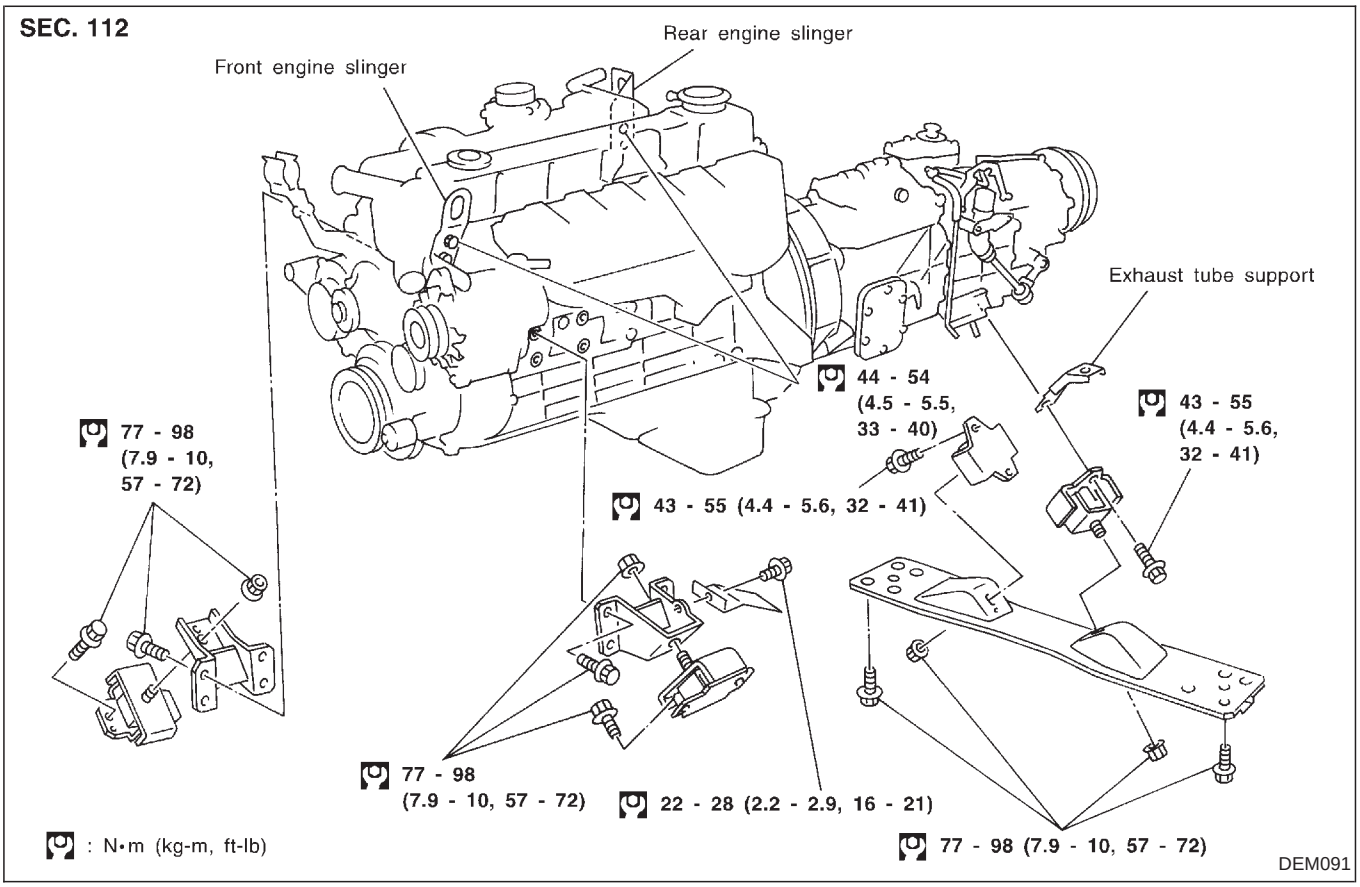


4. Remove valve oil seals.



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





WARNING:

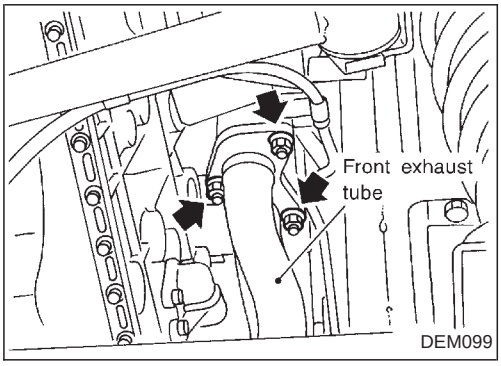
- **Position vehicle on a flat and solid surface.**
- **Place chocks at front and back of rear wheels.**
- **Do not remove engine until exhaust system has completely cooled off.**
  Otherwise, you may burn yourself and/or fire may break out in fuel line.
- **Be sure to hoist engine and transmission in a safe manner.**
- **For engines not equipped with engine slingers, attach proper slingers and bolts described in PARTS CATALOG.**

CAUTION:

- **When lifting engine, be sure to clear surrounding parts. Take special care near accelerator wire casing, brake lines and brake master cylinder.**
- **In lifting the engine, always use engine slingers in a safe manner.**
- **Apply sealant between engine and transmission. Refer to MT section (“Removal and Installation”).**

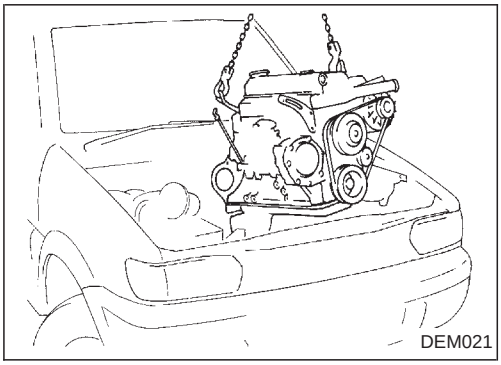
Removal

1. Remove engine undercover and hood.
2. Drain engine coolant.
3. Remove vacuum hoses, fuel tubes, wires, harnesses and connectors and so on.
4. Remove radiator, shroud and cooling fan.
5. Remove drive belts.
6. Remove power steering oil pump and air conditioner compressor.



7. Remove front exhaust tube.
Refer to FE section.

8. Remove transmission from vehicle.
Refer to MT section.
9. Install engine slingers.
10. Hoist engine with engine slingers and remove engine mounting bolts from both sides.

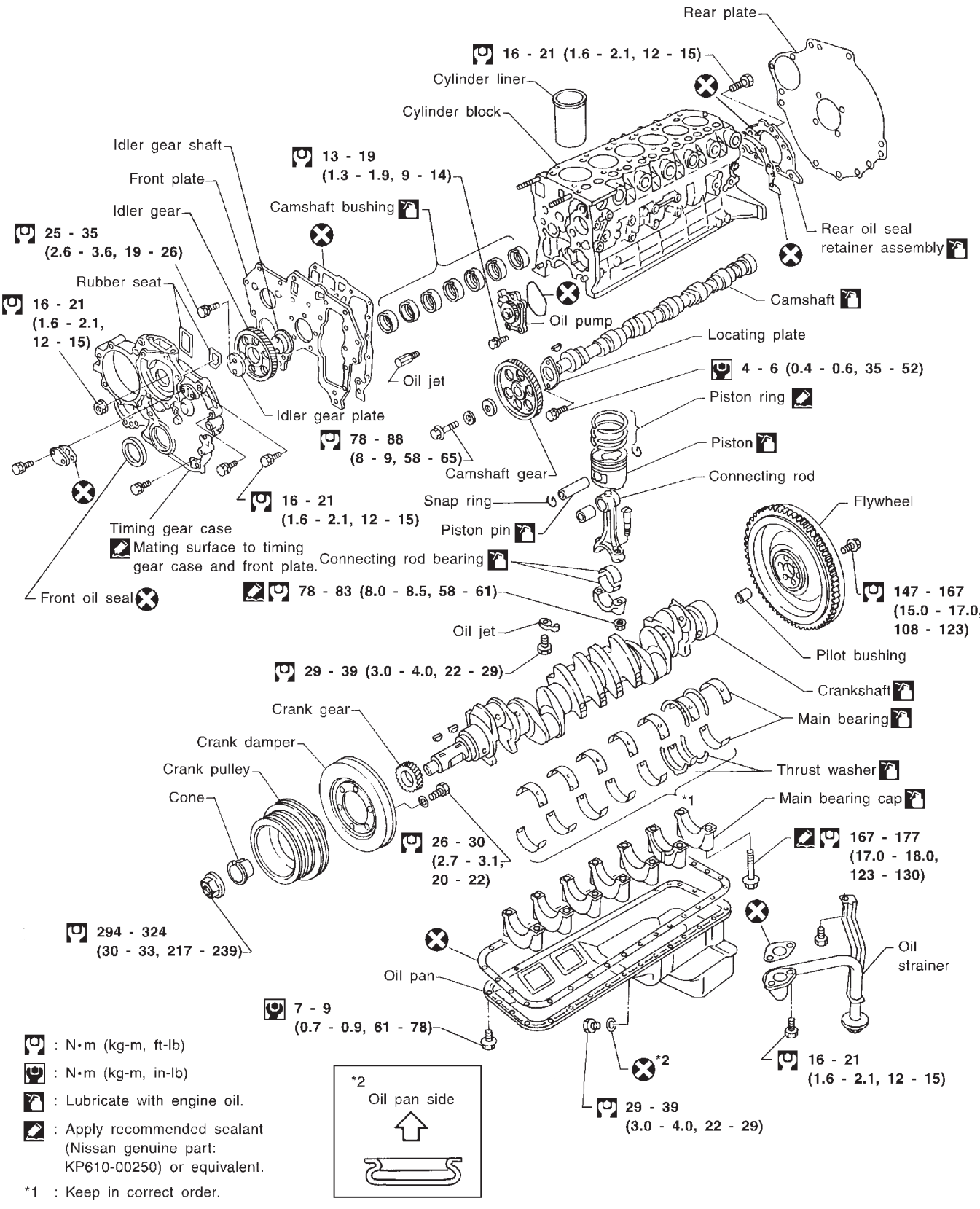


11. Remove engine from vehicle.

Installation

- Install in reverse order of removal.

SEC. 110•120•130•135•150



DEM101

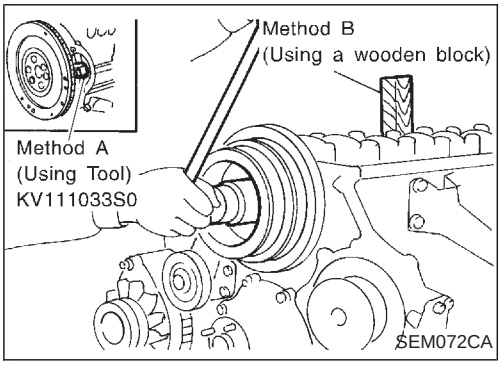
Disassembly

PISTON AND CRANKSHAFT

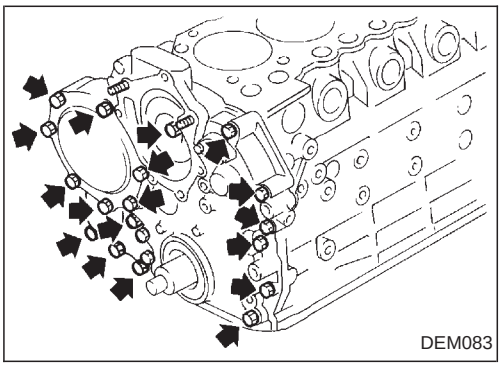
1. Remove oil filter.
2. Place engine on work stand.

- Install work stand sub-attachment to cylinder block using bolts and holes for fitting left side (exhaust manifold side) engine mounting bracket.

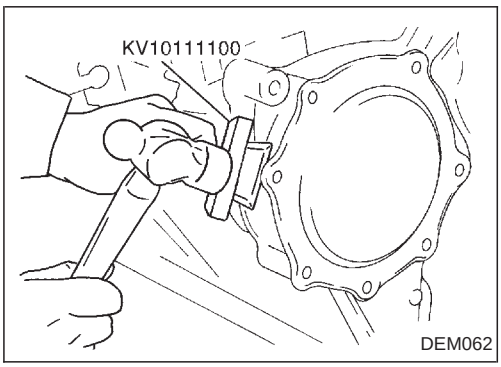
3. Drain coolant and oil.
4. Remove drive belts.
5. Remove cylinder head.
6. Remove oil pan.
7. Remove crankshaft pulley.



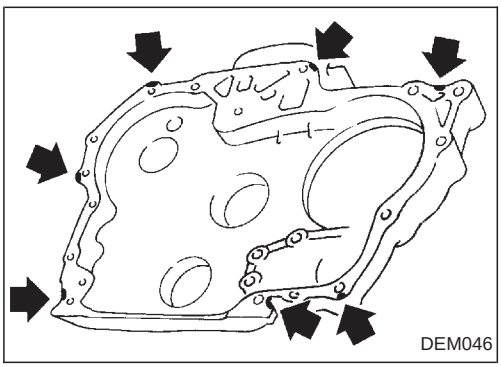
8. Remove water pump.
9. Remove timing gear case.



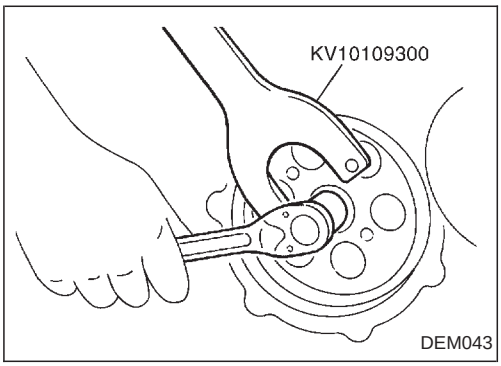
- Remove dust cover with a seal cutter.



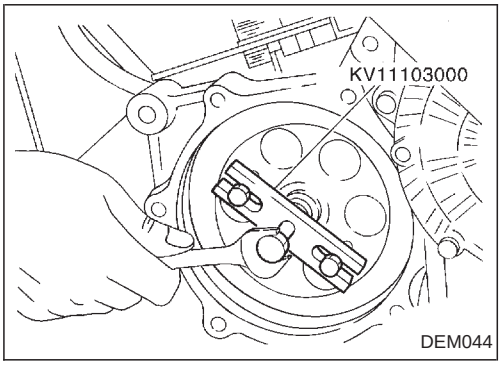
- **If the timing case is hard to remove due to liquid gasket, pry it off with a suitable tool at the cutout section.**

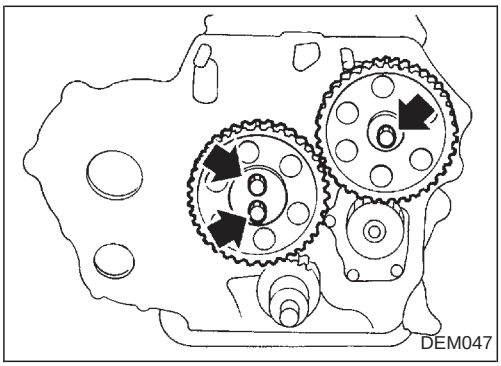


Disassembly (Cont'd)

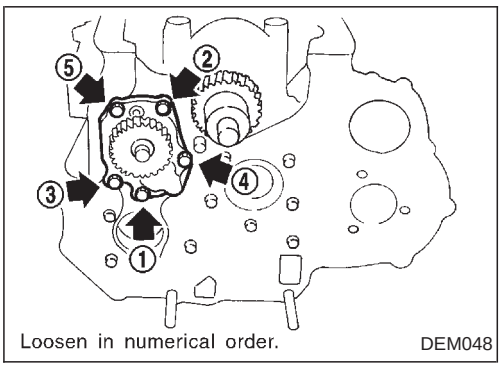


10. Remove injection pump gear.
- Be careful not to lose the woodruff key during injection pump removal.

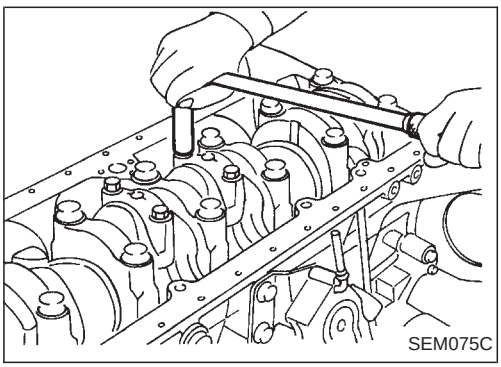




11. Remove idler gear and idler gear shaft.
12. Remove camshaft gear, camshaft and valve lifters.

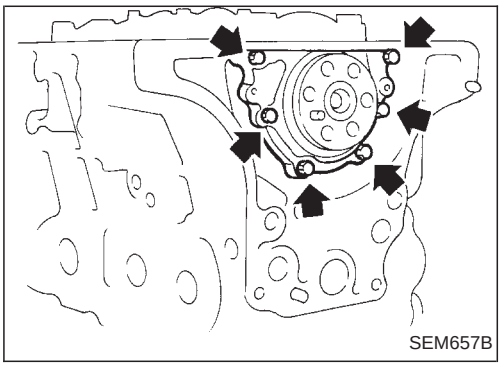


13. Remove oil pump assembly.

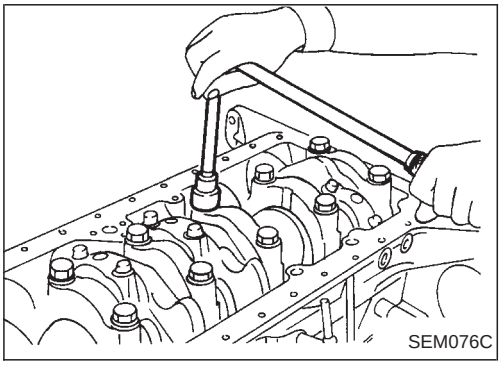


14. Remove crankshaft gear.
15. Remove flywheel and rear plate.
16. Remove connecting rod caps.
17. Remove pistons.
- Remove the connecting rod in such a way that it does not interfere with oil jet.

Disassembly (Cont'd)


SEM657B

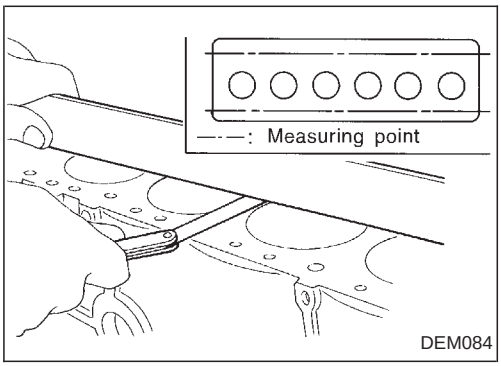
18. Remove rear oil seal retainer assembly.


SEM076C

19. Remove bearing cap and crankshaft.
Place the bearings and caps in their proper order.

Inspection and Replacement

CYLINDER BLOCK DISTORTION



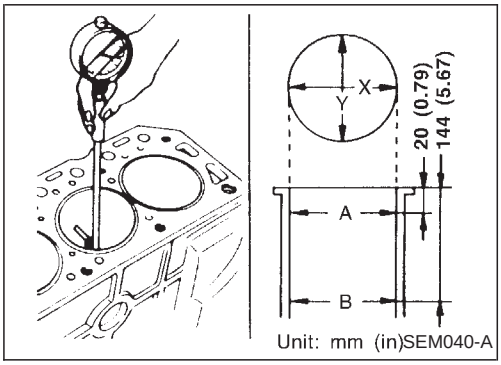
DEM084

If beyond the specified limit, replace it.

Cylinder block distortion: mm (in)
Standard
Less than 0.05 (0.0020)
Limit
0.2 (0.008)

- Remove all traces of gasket from the cylinder block. Do not allow pieces of the gasket to enter the oil and cooling water passages during gasket removal.

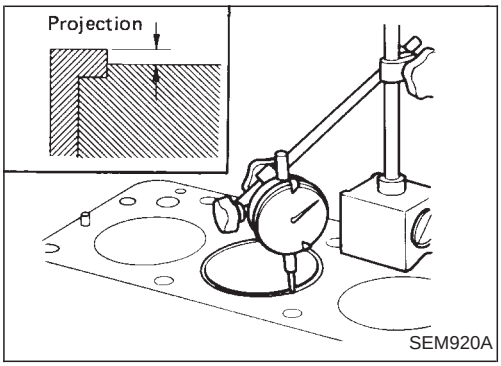
CYLINDER LINER WEAR



Unit: mm (in)SEM040-A

1. Measure cylinder liner bore for out-of-round and taper with a bore gauge. If beyond the limit, replace cylinder liner.
Standard inside diameter:
96.000 - 96.030 mm (3.7795 - 3.7807 in)
Refer to SDS, EM-179.
Wear limit:
0.20 mm (0.0079 in)
Out-of-round (X − Y) standard:
0.020 mm (0.0008 in)
Taper (A − B) standard:
0.020 mm (0.0008 in)
2. Check for scratches or seizure. If seizure is found, replace cylinder liner.

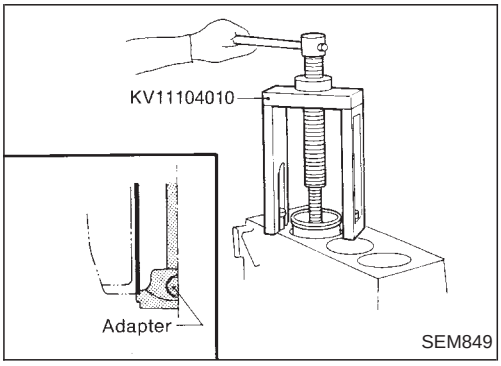
Inspection and Replacement (Cont'd)



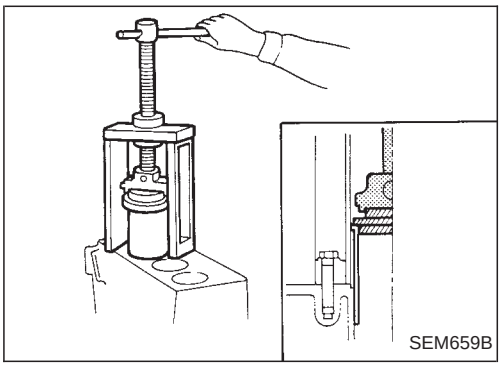
3. Check amount of projection of cylinder liner.
   Cylinder liner projection:
   Standard
   0.02 - 0.09 mm (0.0008 - 0.0035 in)
   Deviation of each cylinder:
   Less than 0.05 mm (0.0020 in)

CYLINDER LINER

Replacement

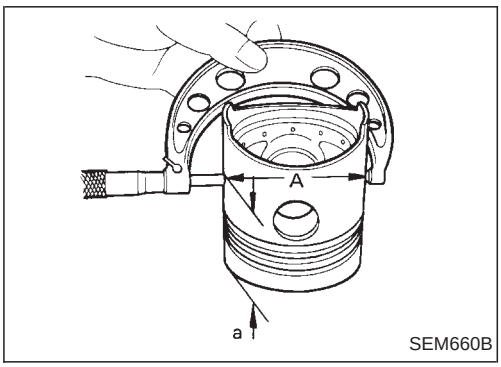


1. Remove cylinder liner with Tool.



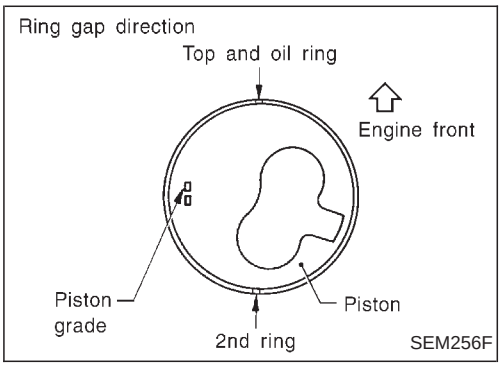
2. Install cylinder liner with Tool.
3. Check amount of projection of cylinder liner.

PISTON TO CYLINDER BORE CLEARANCE



1. Measure piston and cylinder bore diameter.
   Piston diameter "A":
   Refer to SDS, EM-179.
   Measuring point "a"
   (Distance from the top): mm (in)
   70 (2.76)
2. Check that piston clearance is within the specification.
   Piston clearance:
   0.05 - 0.07 mm (0.0020 - 0.0028 in)

Inspection and Replacement (Cont'd)

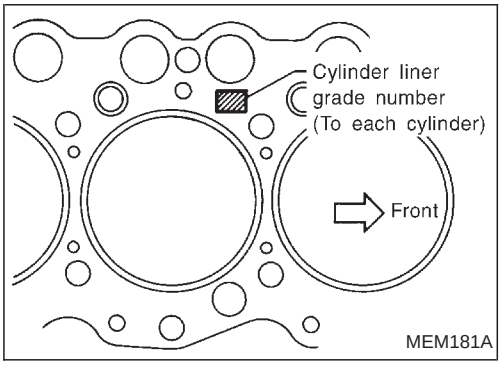


Combination of piston and cylinder bore

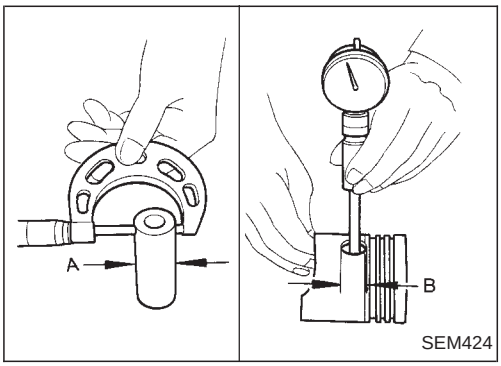
Use the same piston grade in one engine.

Cylinder bore grade number	Piston grade number		
	1	2	3
1	OK	NG	NG
2	Possible	OK	NG
3	Possible	Possible	OK

Refer to SDS, EM-179, for finding cylinder bore grade number.



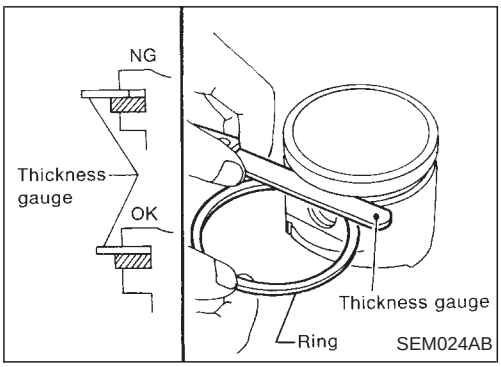
PISTON AND PISTON PIN CLEARANCE



Check clearance between pistons and piston pins.

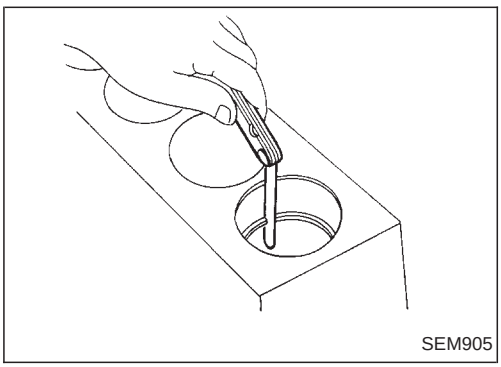
Clearance (A − B): mm (in)
Standard
−0.003 to 0.012 (−0.0001 to 0.0005)
Limit
Less than 0.10 (0.0039)

PISTON RING SIDE CLEARANCE



Side clearance: mm (in)
Top ring
0.06 - 0.10 (0.0024 - 0.0039)
2nd ring
0.04 - 0.08 (0.0016 - 0.0031)
Oil ring
0.02 - 0.06 (0.0008 - 0.0024)
Max. limit of side clearance: mm (in)
Top ring 0.50 (0.0197)
2nd ring 0.30 (0.0118)
Oil ring 0.15 (0.0059)

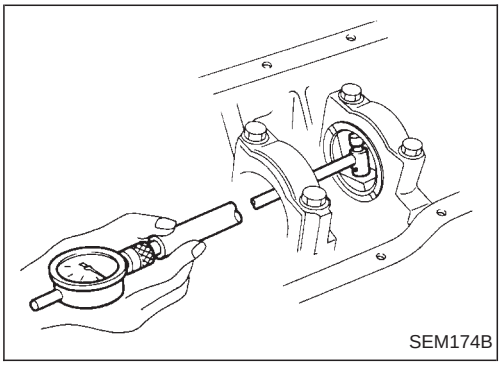
PISTON RING GAP



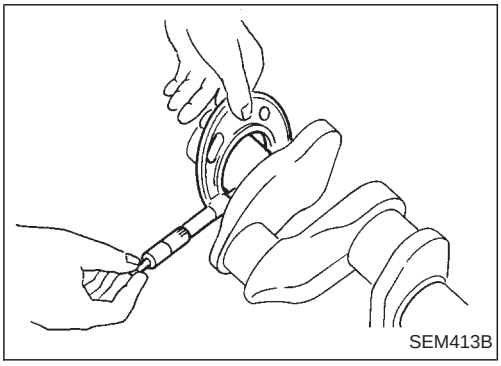
Standard ring gap: mm (in)
Top ring
0.30 - 0.45 (0.0118 - 0.0177)
2nd ring
0.50 - 0.65 (0.0197 - 0.0256)
Oil ring
0.30 - 0.50 (0.0118 - 0.0197)
Max. limit of ring gap:
1.5 mm (0.059 in)

Inspection and Replacement (Cont'd)

MAIN BEARING CLEARANCE


SEM174B

1. Install main bearings to cylinder block and main bearing cap.
2. Install main bearing cap to cylinder block.
- **Apply engine oil to the thread portion and seating surface of bolts.**
- **Tighten all bolts with specified torque in correct order and in two or three stages. Refer to EM-157.**
3. Measure inside diameter "A" of main bearing.

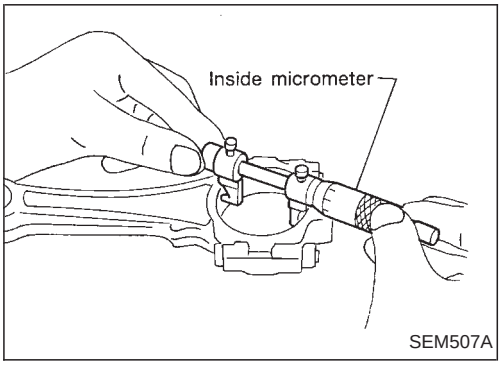

SEM413B

4. Measure outside diameter "Dm" of main journal in crankshaft.
5. Calculate main bearing clearance.
   Main bearing clearance = A − Dm
   Standard:
   0.035 - 0.087 mm (0.0014 - 0.0034 in)
   Limit:
   Less than 0.15 mm (0.0059 in)

CONNECTING ROD BEARING CLEARANCE

1. Install connecting rod bearing to connecting rod and cap.
2. Install connecting rod cap to connecting rod and tighten with specified torque.

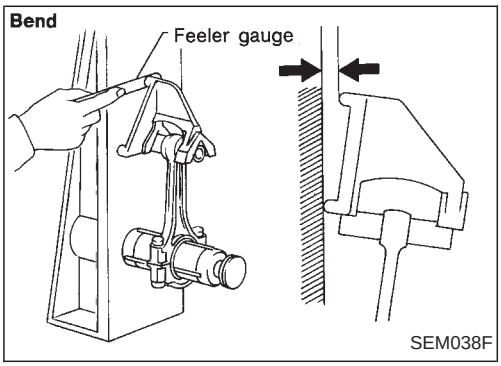
Apply engine oil to the thread portion of bolts and seating surface of nuts.



SEM507A

3. Measure inside diameter "A" of bearing.
4. Measure outside diameter "Dp" of pin journal in crankshaft.
5. Calculate connecting rod bearing clearance.
   Connecting rod bearing clearance = A − Dp
   Standard:
   0.035 - 0.081 mm (0.0014 - 0.0032 in)
   Limit:
   Less than 0.15 mm (0.0059 in)

Inspection and Replacement (Cont'd)

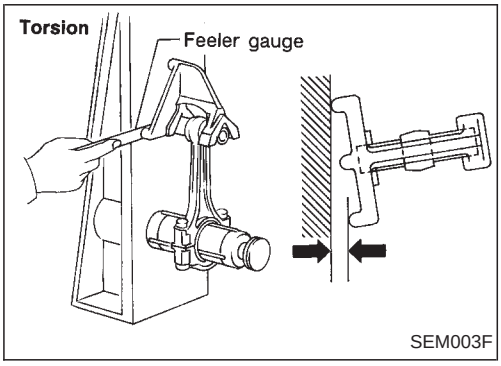


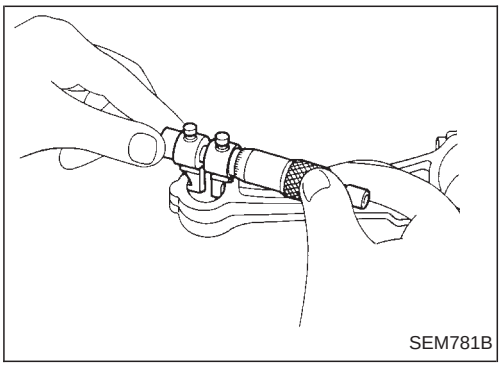
CONNECTING ROD BEND AND TORSION

Bend and torsion: mm (in)

Limit

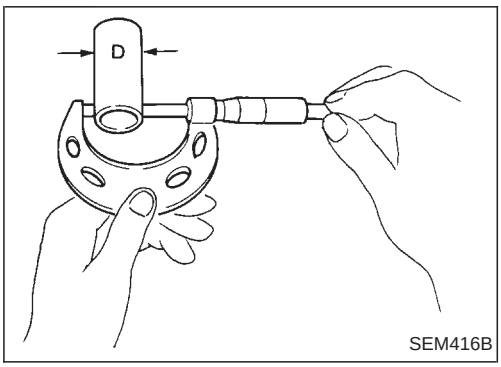
0.075 (0.0030) per 100 (3.94) length





CONNECTING ROD SMALL END BUSHING CLEARANCE

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



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

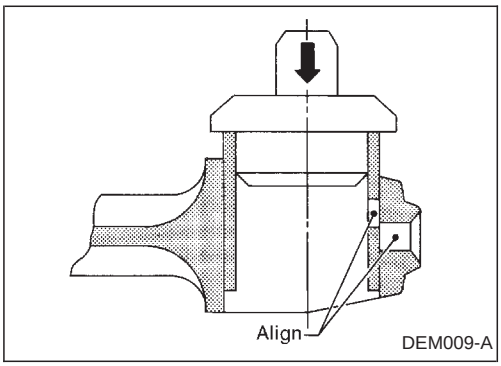
Standard:

0.025 - 0.045 mm (0.0010 - 0.0018 in)

Limit:

0.15 mm (0.0059 in)

Inspection and Replacement (Cont'd)

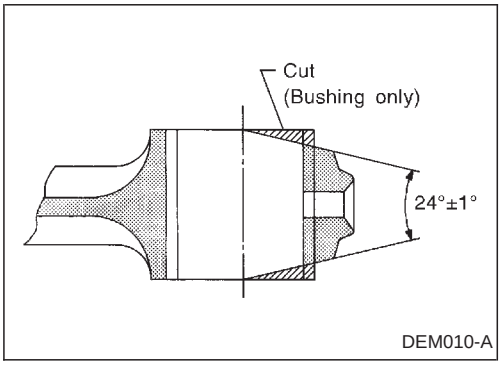


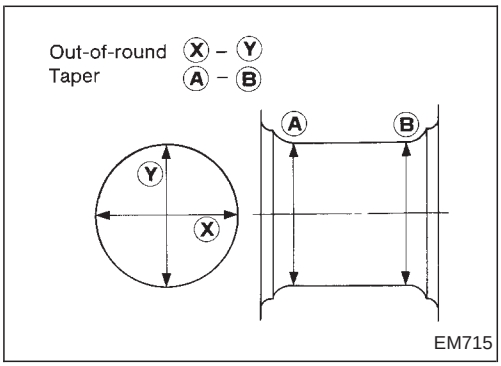
REPLACEMENT OF CONNECTING ROD SMALL END BUSHING

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

Be sure to align the oil holes.

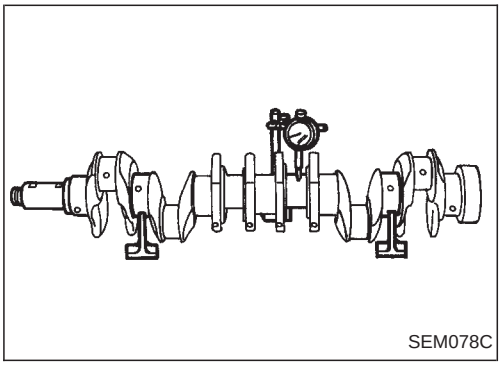
2. After driving in the small end bushing, ream the bushing.
   Small end bushing inside diameter: mm (in)
   Finished size
   30.025 - 30.038 (1.1821 - 1.1826)
3. Machine the bushing to match the tapered surface of the connecting rod small end.
4. Remove burrs from the machined bushing.





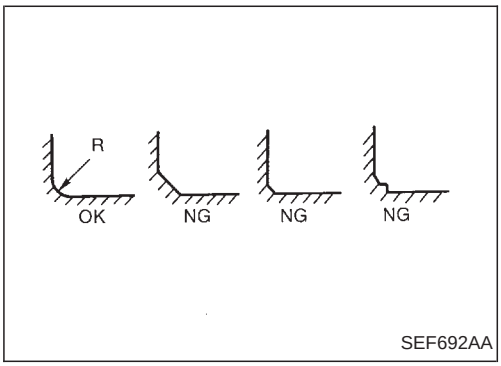
CRANKSHAFT

1. Check crankshaft journals and pins for score, bias, wear or cracks. If faults are minor, correct with fine crocus cloth.
2. Check journals and pins with a micrometer for taper and out-of-round.
   Out-of-round (X − Y): mm (in)
   Standard
   Less than 0.01 (0.0004)
   Limit
   0.02 (0.0008)
   Taper (A − B): mm (in)
   Standard
   Less than 0.01 (0.0004)
   Limit
   0.02 (0.0008)



3. Check crankshaft runout.
   Runout [TIR (Total Indicator Reading)]: mm (in)
   Standard
   0 - 0.03 (0 - 0.0012)
   Limit
   0.10 (0.0039)

Inspection and Replacement (Cont'd)



SEF692AA

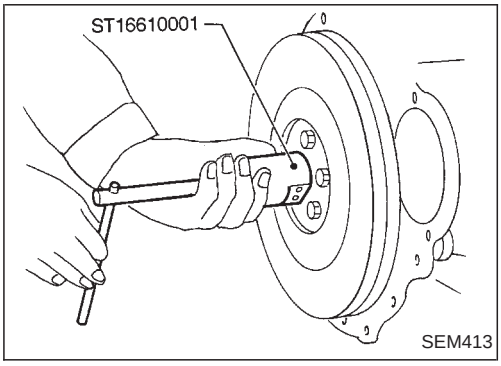
RESURFACING OF CRANKSHAFT JOURNAL AND CRANK PIN

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

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

CAUTION:

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

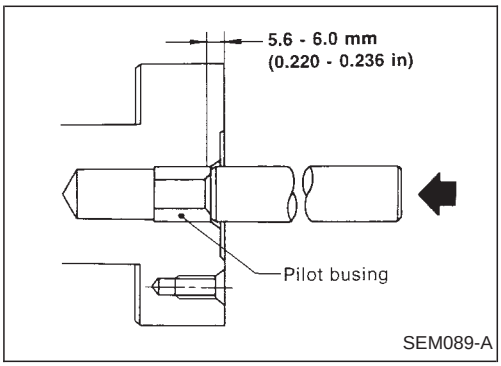


SEM413

CRANKSHAFT PILOT BUSHING

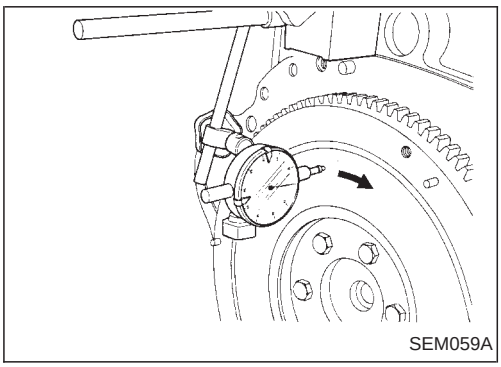
Replacement

1. Pull out bushing with Tool.



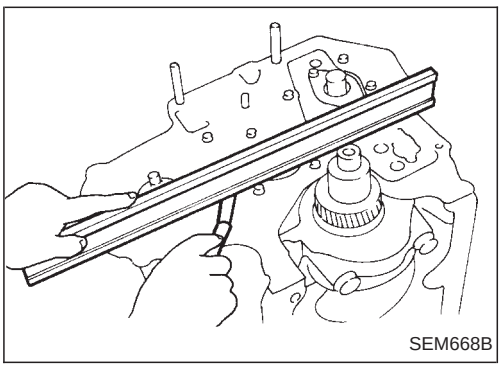
SEM089-A

2. Insert pilot bushing until distance between flange end and bushing is specified value.
   Distance:
   Approx. 5.6 - 6.0 mm (0.220 - 0.236 in)


SEM059A

FLYWHEEL RUNOUT

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


SEM668B

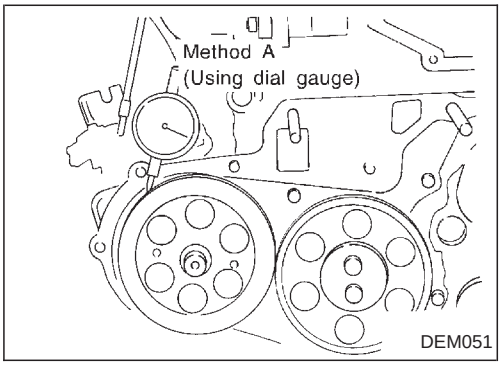
FRONT PLATE

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

Warpage limit:
0.2 mm (0.008 in)

Inspection and Replacement (Cont'd)

GEAR TRAIN

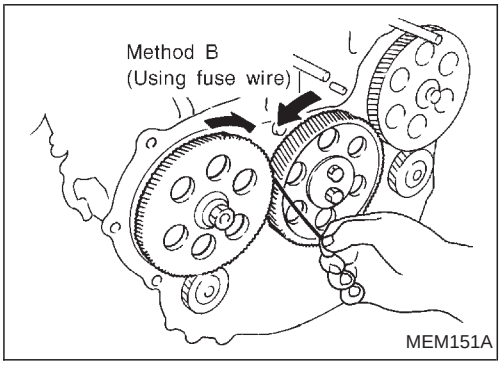


DEM051

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

1. If gear tooth and key have scratches or are excessively worn, replace gear and key.
2. Check gear train backlash before disassembling and after assembling.
   Method A (Using dial gauge)
   Method B (Using fuse wire)
   If beyond the limit, replace gear.

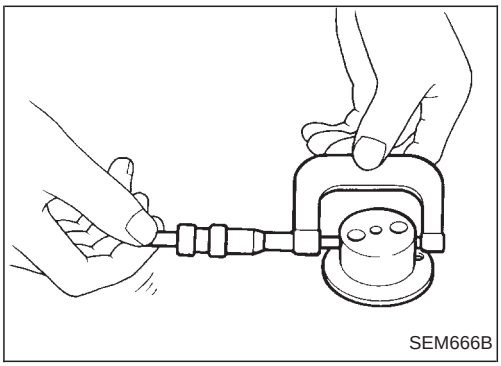
Backlash: mm (in)
Standard
0.07 - 0.11 (0.0028 - 0.0043)
Limit
0.20 (0.0079)



MEM151A

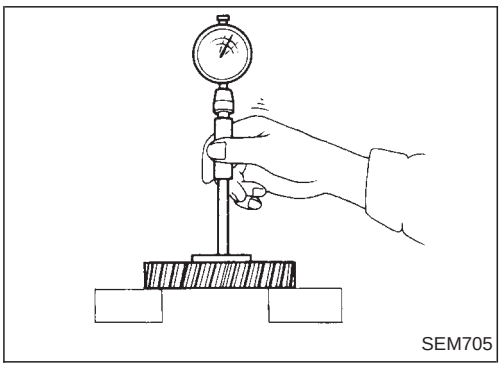
IDLER GEAR BUSHING CLEARANCE

1. Measure idler gear shaft outer diameter.


SEM666B

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

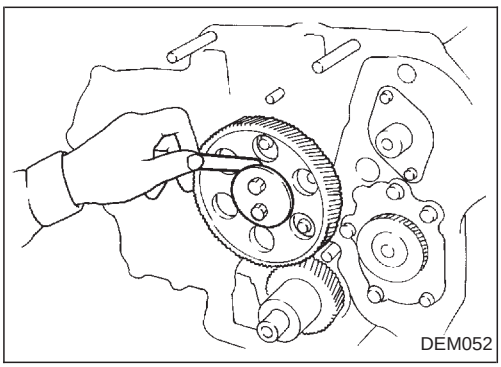
Bushing clearance: mm (in)
Standard
0.025 - 0.061 (0.0010 - 0.0024)
Limit
0.20 (0.0079)


SEM705

IDLER GEAR END PLAY

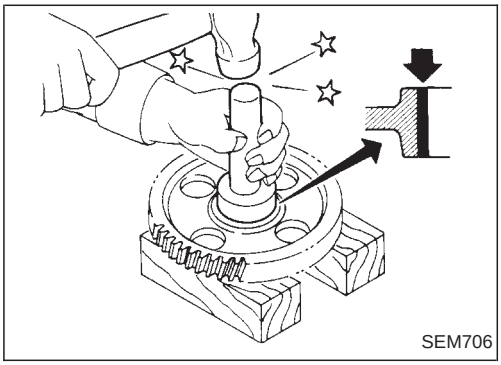
Measure idler gear end play between gear plate and gear.

Idler gear end play: mm (in)
Standard
0.03 - 0.14 (0.0012 - 0.0055)
Limit
Less than 0.3 (0.012)


DEM052

Inspection and Replacement (Cont'd)

REPLACEMENT OF IDLER GEAR BUSHING


SEM706

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

Finished size:
42.00 - 42.02 mm (1.6535 - 1.6543 in)

Idler gear shaft

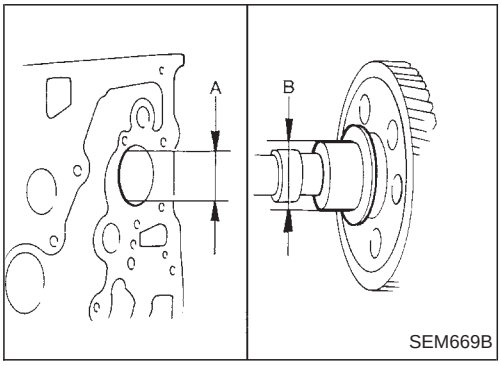
Install idler gear shaft so that oil hole of shaft faces upward.

CAMSHAFT AND CAMSHAFT BUSHING

Camshaft bushing clearance

Measure inside diameter of camshaft bushing and outside diameter of camshaft journal with a suitable gauge.

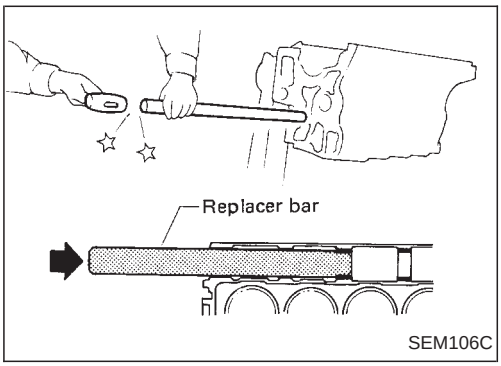
Clearance between camshaft and bushing
(A − B): mm (in)
Standard
0.020 - 0.109 (0.0008 - 0.0043)
Limit
Less than 0.15 (0.0059)



SEM669B

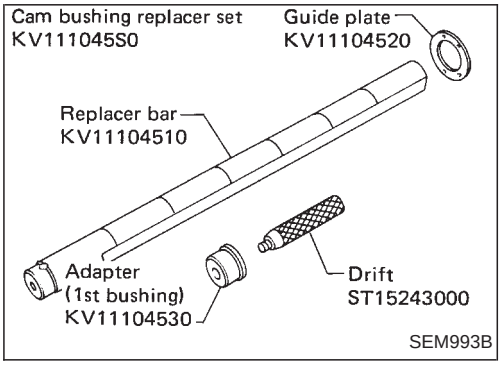
REPLACING CAMSHAFT BUSHING

1. Using Tool, remove camshaft bushings from the engine. Some bushings must be broken in order to remove.

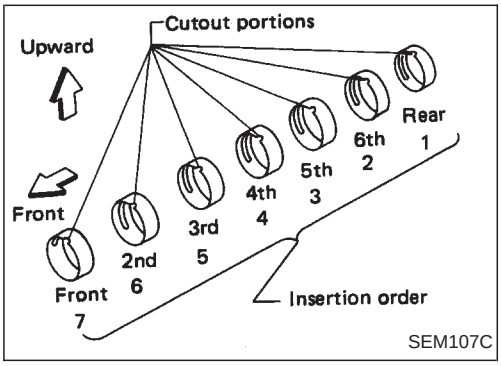


SEM106C

2. Using Tool, install camshaft bushings as follows:



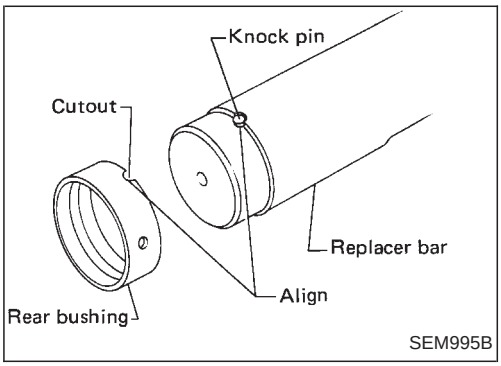
SEM993B



SEM107C

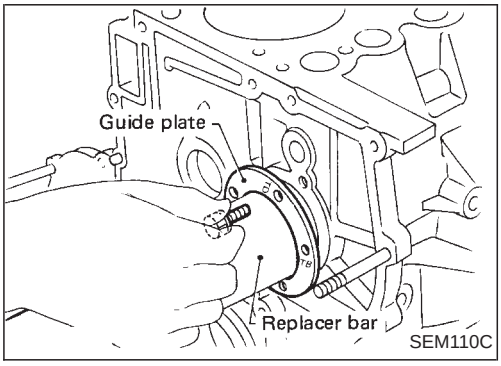
(1) Install camshaft bushings in the order of "rear", "6th", "5th", "4th", "3rd", "2nd" and "front". All bushings must be installed from the front.
(2) Face the cutout upward and toward the front of the engine during installation.

Inspection and Replacement (Cont'd)



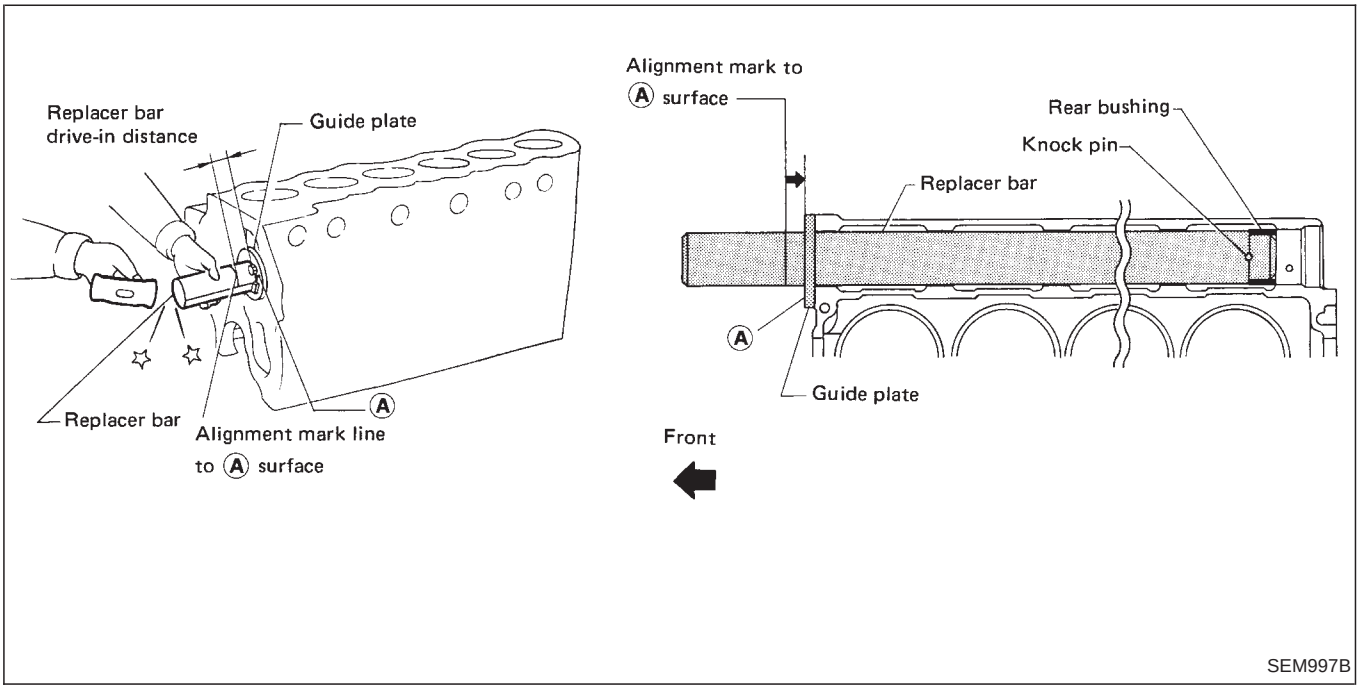
(3) Rear camshaft bushing

- Align the cutout of rear bushing with knock pin of replacer bar before installation.



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

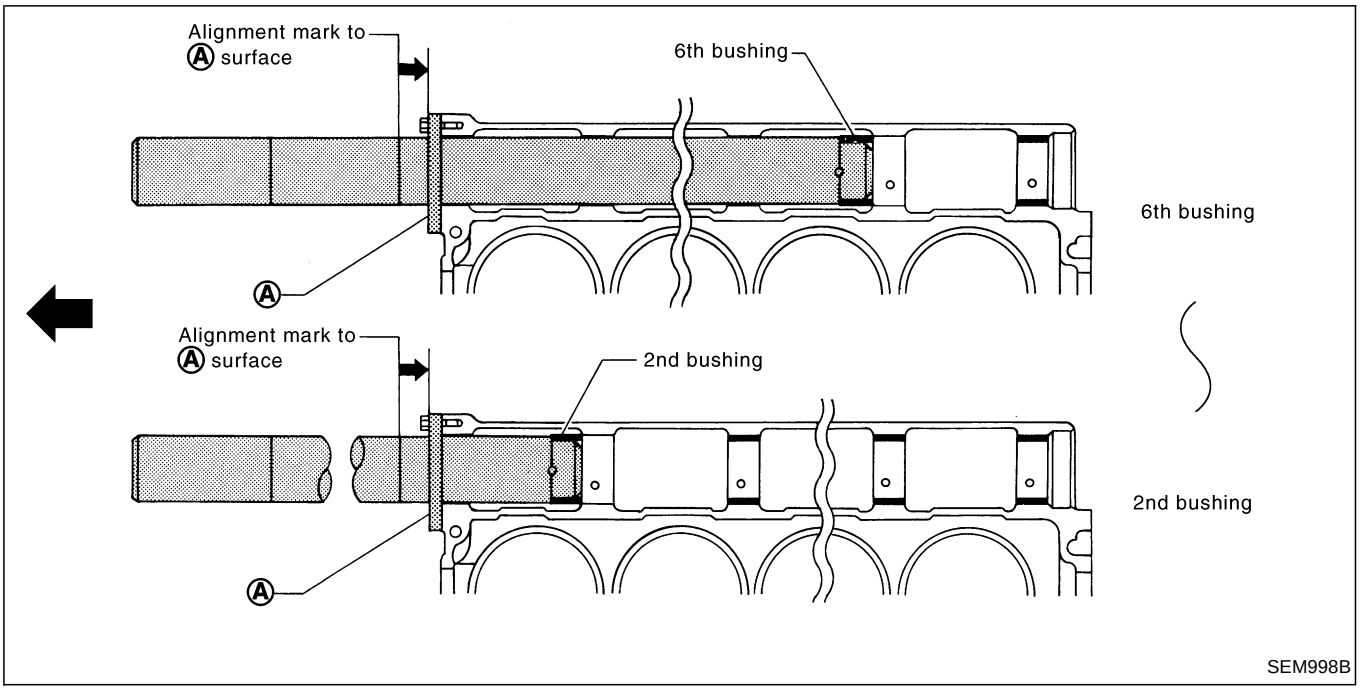
- Drive replacer bar until the alignment mark on replacer bar is aligned with the end of replacer guide.
  Remove replacer set.
  After installation, check that oil holes in camshaft bushings are aligned with oil holes in cylinder block.

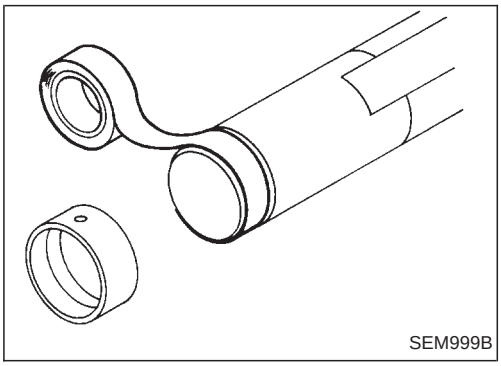


Inspection and Replacement (Cont'd)

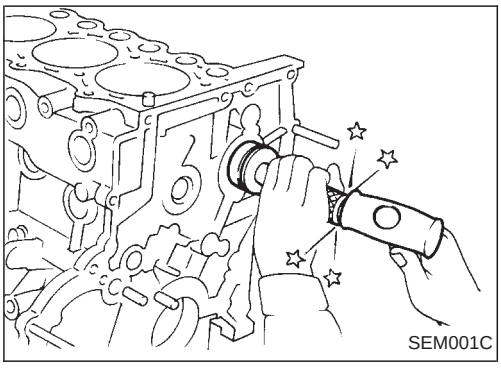
(4) 6th, 5th, 4th, 3rd and 2nd camshaft bushings

- Install in the same manner as rear camshaft bushing.



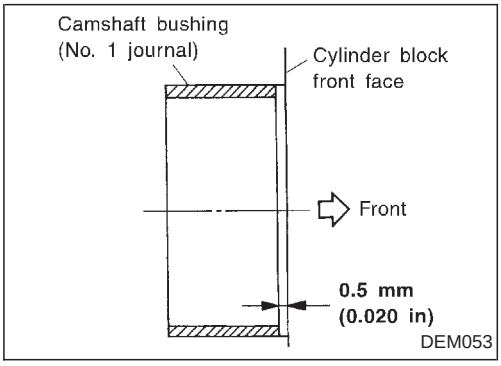


- When setting 6th through 2nd bushings on replacer bar, tape the bar to prevent movement.



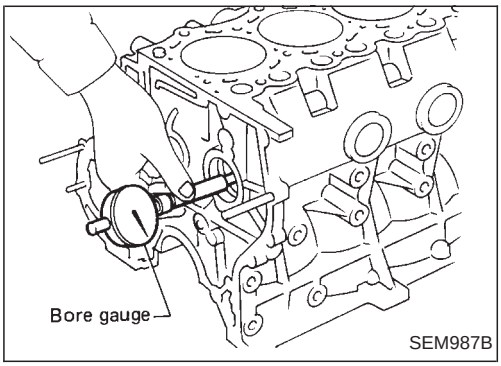
(5) Front camshaft bushing

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



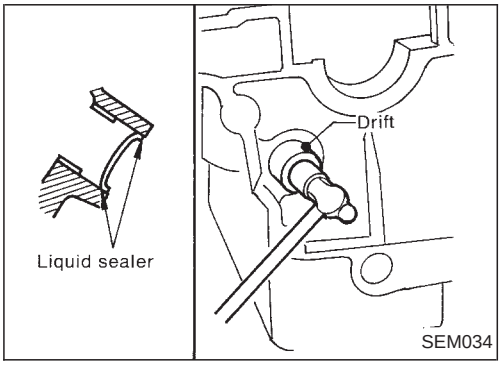
- Press the bushing until its front end is 0.5 mm (0.020 in) from the front surface of the cylinder block.

Inspection and Replacement (Cont'd)



3. Check camshaft bushing clearance.

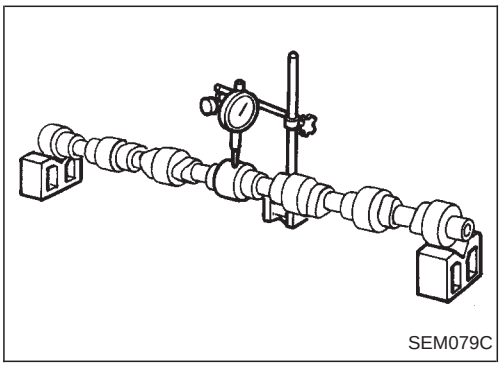
Refer to SDS, EM-178.



4. Install new welch plug into rear camshaft bushing hole with a drift.

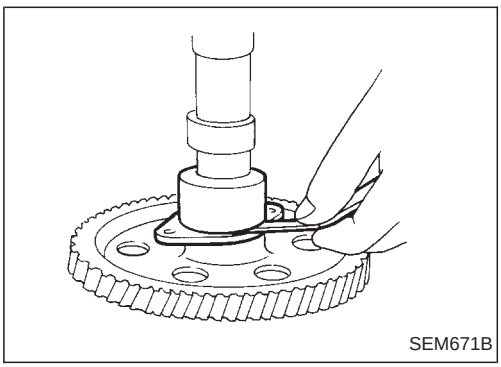
Apply liquid sealer.

CAMSHAFT ALIGNMENT



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

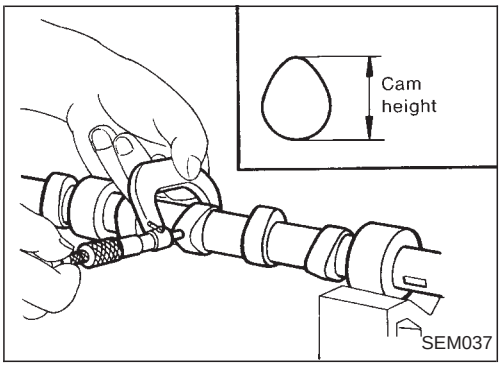
Camshaft bend
(Total indicator reading): mm (in)
Standard
Less than 0.02 (0.0008)
Limit
Less than 0.06 (0.0024)



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

Camshaft end play: mm (in)
Standard
0.08 - 0.28 (0.0031 - 0.0110)
Limit
Less than 0.5 (0.020)

Inspection and Replacement (Cont'd)



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

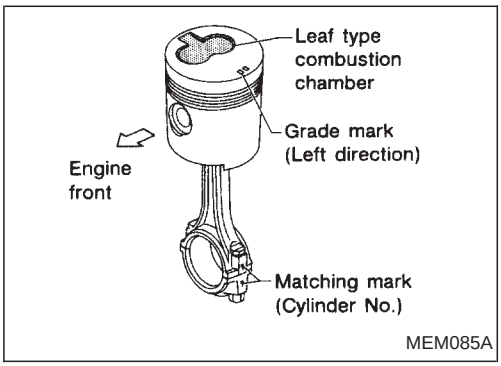
Cam height: mm (in)
Standard
Intake
41.88 - 41.92 (1.6488 - 1.6504)
Exhaust
41.88 - 41.92 (1.6488 - 1.6504)
Limit
Intake
Less than 41.40 (1.6299)
Exhaust
Less than 41.40 (1.6299)

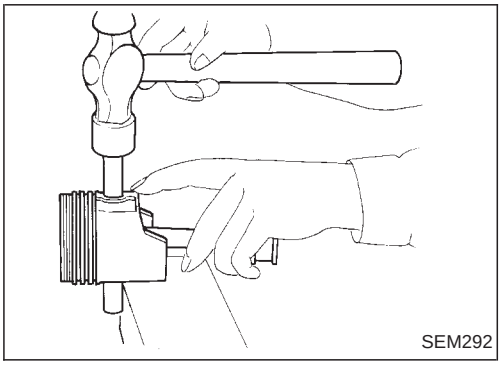
Assembly

PISTON

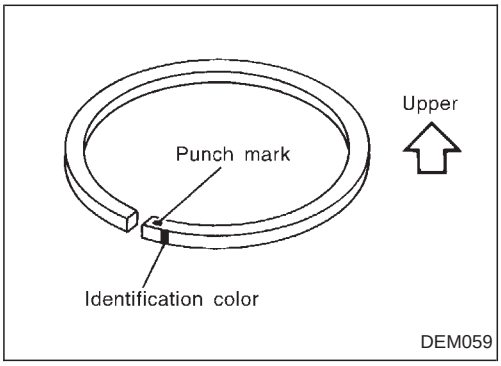
Assemble pistons, piston pins, snap rings and connecting rods.

a. Numbers are stamped on the connecting rod and cap corresponding to each cylinder. Care should be taken to avoid a wrong combination including bearing.





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



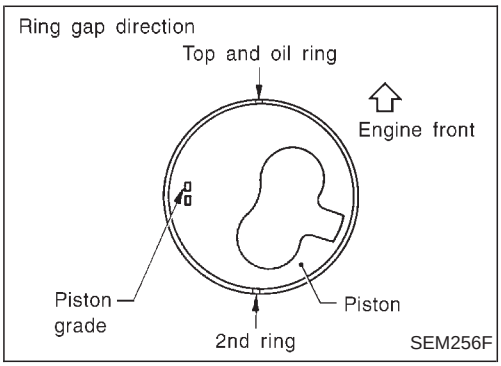
Install piston assembly.

CAUTION:

- **Stretch the piston rings only enough to fit them in the piston grooves.**
- **Always install new piston rings with the position marks facing up.**

	Identification color
Top ring	Yellow
2nd ring	Red

Assembly (Cont'd)



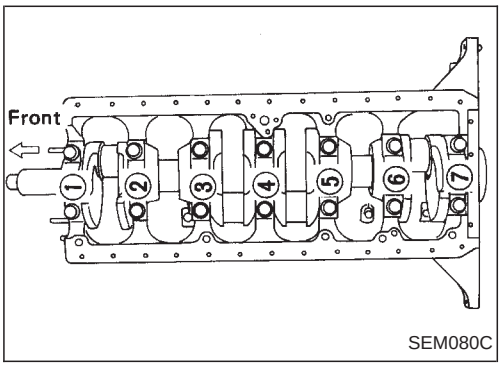
- **Install No. 1 piston ring in such a way that its gap faces the direction of the piston pin; and then install piston rings so that their gap positioned at 180° to one another.**

CRANKSHAFT

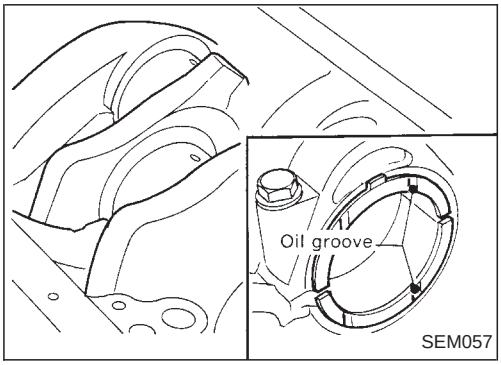
1. Install crankshaft.
(1) Set main bearings in the proper position on cylinder block.

a. If either crankshaft, cylinder block or main bearing is reused again, it is necessary to measure main bearing clearance.

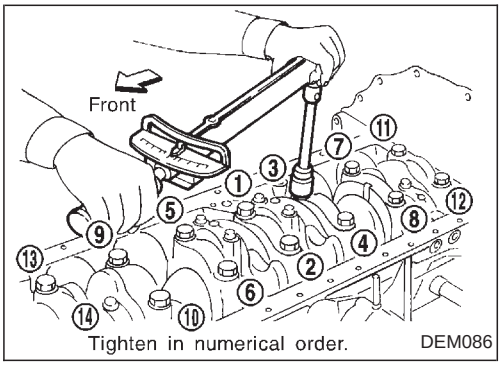
b. Upper bearings have oil hole and oil groove, however lower bearings do not.



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

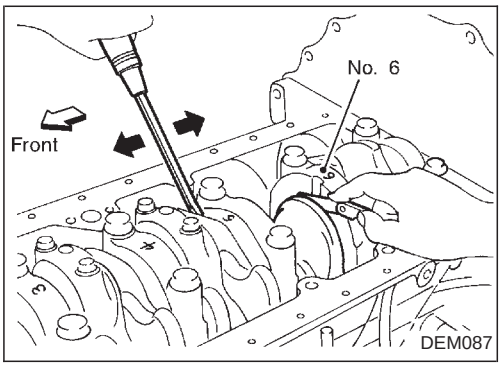


(4) Install crankshaft thrust washer at the 6th journal from front.
Install thrust washer so that oil groove can face crankshaft.



(5) Tighten main bearing cap bolts gradually in stages, starting from two to three separate stages, from center bearing and moving outward in sequence.
: 167 - 177 N·m (17.0 - 18.0 kg-m, 123 - 130 ft-lb)

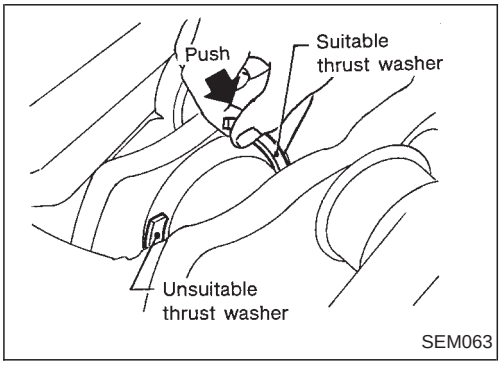
Assembly (Cont'd)



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

Crankshaft free end play: mm (in)
Standard
0.055 - 0.140 (0.0022 - 0.0055)
Limit
0.40 (0.0157)

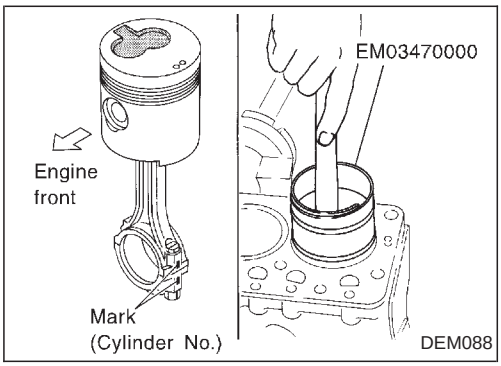
If beyond the limit, replace No. 6 main bearing thrust washer. Refer to SDS, EM-182.



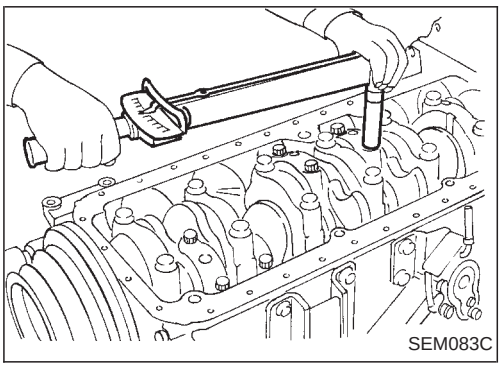
2. Install pistons with connecting rods.

(1) Install them into corresponding cylinder using Tool.

- **Be careful not to scratch cylinder wall with connecting rod.**
- **Insert the connecting rod. Do not allow the larger end to touch the oil jet.**
- **Apply engine oil to cylinder wall, piston and bearing.**
- **The leaf type combustion chamber on piston head must be at right side of engine.**



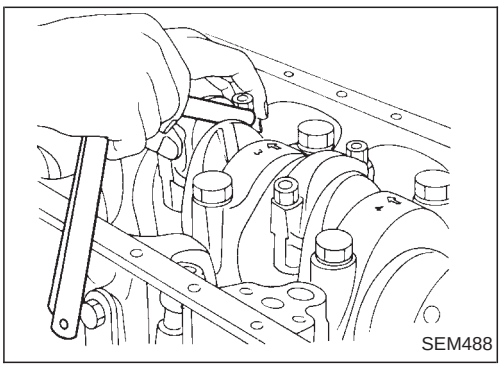
(2) Install connecting rod bearing caps.



3. Measure connecting rod side clearance.

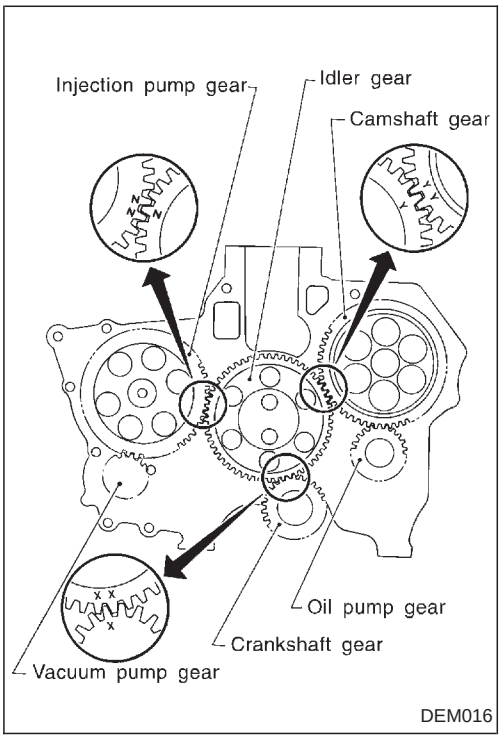
Connecting rod side clearance: mm (in)
Standard
0.10 - 0.22 (0.0039 - 0.0087)
Limit
0.22 (0.0087)

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



Assembly (Cont'd)

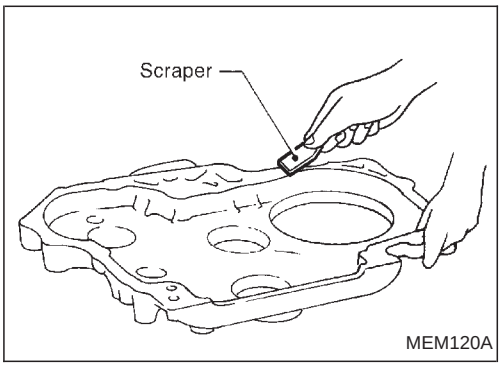
GEAR TRAIN



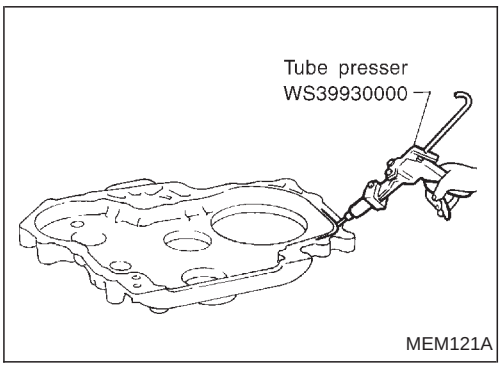
1. Set No. 1 piston at TDC on its compression stroke.
2. Align each gear mark and install gears.

TIMING GEAR CASE

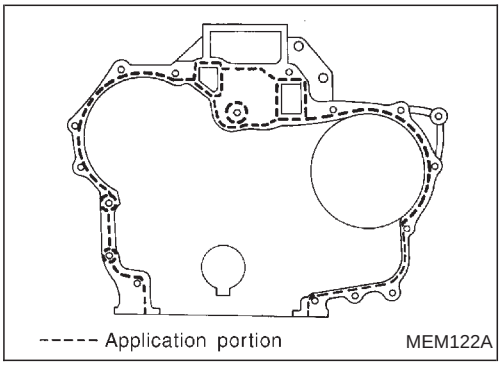
Installation



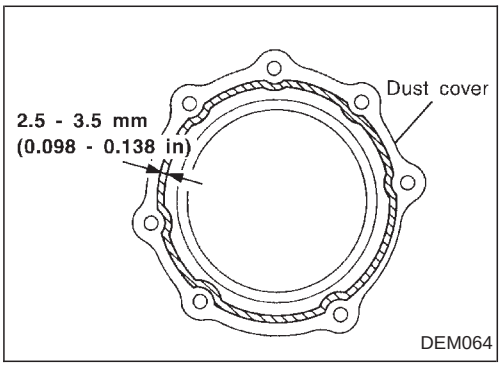
1. Before installing timing gear case, remove all traces of liquid gasket from mating surface using a scraper.
   Also remove traces of liquid gasket from mating surface of front plate.

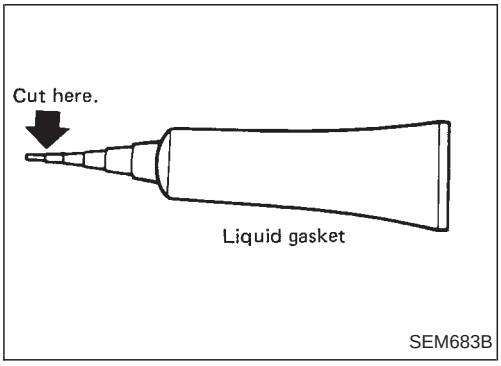


2. Apply a continuous bead of liquid gasket to mating surface of timing gear case and dust cover.



Assembly (Cont'd)





- **Be sure liquid gasket diameter is 2.5 to 3.5 mm (0.098 to 0.138 in).**
- **Attach timing gear case to front plate within 10 minutes after coating.**
- **Wait at least 30 minutes before refilling engine coolant or starting engine.**
- **Use Genuine Liquid Gasket or equivalent.**

General Specifications

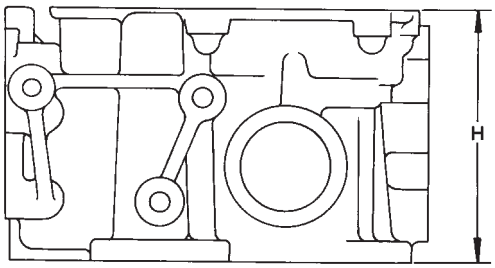
		TB42S	TB45E
Cylinder arrangement		6, in-line	
Displacement	cm^3 (cu in)	4,169 (254.39)	4,479 (273.31)
Bore and stroke	mm (in)	96 x 96 (3.78 x 3.78)	99.5 x 96.0 (3.917 x 3.780)
Valve arrangement		OHV	
Firing order		1-5-3-6-2-4	
Number of piston rings			
Compression		2	
Oil		1	
Number of main bearings		7	
Compression ratio		8.3	

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

Compression pressure	
Standard	1,177 (11.77, 12.0, 171)/200
Minimum	883 (8.83, 9.0, 128)/200
Differential limit between cylinders	98 (0.98, 1.0, 14)/200

Inspection and Adjustment

CYLINDER HEAD



SEM013C

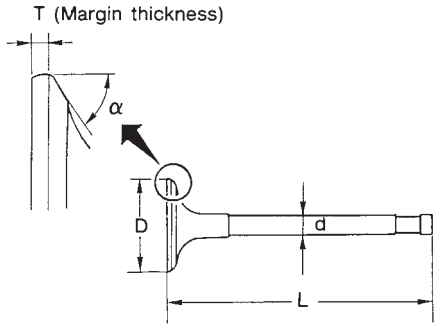
Unit: mm (in)

	Standard	Limit
Height (H)	116.57 - 116.97 (4.5894 - 4.6051)	0.2 (0.008)*
Surface distortion	Less than 0.07 (0.0028)	0.2 (0.008)

*: Total amount of cylinder head resurfacing and cylinder block resurfacing

VALVE

Unit: mm (in)



SEM188

Valve head diameter "D"	
Intake	47.0 - 47.2 (1.850 - 1.858)
Exhaust	38.0 - 38.2 (1.496 - 1.504)
Valve length "L"	
Intake	116.7 - 117.0 (4.594 - 4.606)
Exhaust	117.15 - 117.45 (4.6122 - 4.6240)
Valve stem diameter "d"	
Intake	7.965 - 7.980 (0.3136 - 0.3142)
Exhaust	7.945 - 7.960 (0.3128 - 0.3134)
Valve seat angle "α"	
Intake Exhaust	45°30′
Valve margin "T"	
Intake	1.15 - 1.45 (0.0453 - 0.0571)
Exhaust	1.35 - 1.65 (0.0531 - 0.0650)
Valve margin "T" limit	More than 0.5 (0.020)
Valve stem end surface grinding limit	Less than 0.2 (0.008)

Valve clearance

Unit: mm (in)

	TB42S, TB45E	TB42S	TB45E
	*Cold	Hot	
Intake	0.20 (0.008)	0.38 (0.015)	0.35 (0.014)
Exhaust	0.20 (0.008)	0.38 (0.015)	0.35 (0.014)

*: At temperature of approximately 20°C (68°F)

Whenever valve clearances are adjusted to cold specifications, check that the clearances satisfy hot specifications and adjust again if necessary.

Valve spring

	TB42S	TB45E
Free height mm (in)		
Outer	49.77 (1.9594)	48.02 (1.8905)
Inner	44.10 (1.7362)	42.72 (1.6819)
Pressure height mm/N (mm/kg, in/lb)		
Outer	30.0/512.9 (30.0/52.3, 1.181/115.3)	27.7/611.0 (27.7/62.3, 1.091/137.4)
Inner	25.0/255.0 (25.0/26.0, 0.984/57.3)	24.7/305.5 (24.7/31.15, 0.972/68.7)
Assembled height mm/N (mm/kg, in/lb)		
Outer	40.0/225.6 (40.0/23.0, 1.575/50.7)	
Inner	35.0/107.9 (35.0/11.0, 1.378/24.3)	
Out-of-square mm (in)		
Outer	2.2 (0.087)	2.1 (0.083)
Inner	1.9 (0.075)	1.9 (0.075)

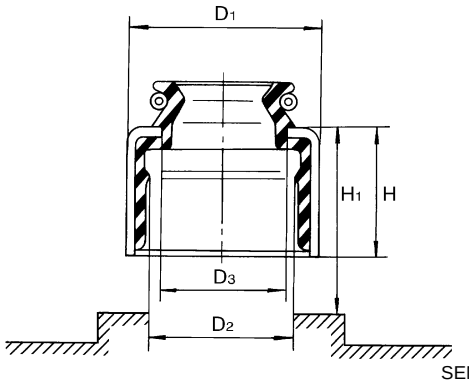
Valve lifter and push rod

Unit: mm (in)

	Standard	Limit
Valve lifter outer diameter	24.960 - 24.970 (0.9827 - 0.9831)	—
Cylinder block valve lifter hole diameter	25.000 - 25.033 (0.9843 - 0.9855)	—
Valve lifter to lifter hole clearance	0.030 - 0.073 (0.0012 - 0.0029)	0.1 (0.004)
Push rod bend (TIR)*	Less than 0.2 (0.008)	0.5 (0.020)

*: Total indicator reading

Valve oil seal



SEM736EA

	D_1 (dia.)	D_2 (dia.)	D_3 (dia.)	H	H_1
Intake side Exhaust side mm (in)	15.0 (0.591)	11.68 - 11.78 (0.4598 - 0.4638)	10.2 (0.402)	8.5 (0.335)	14.8 - 15.4 (0.583 - 0.606)

Valve guide

Unit: mm (in)

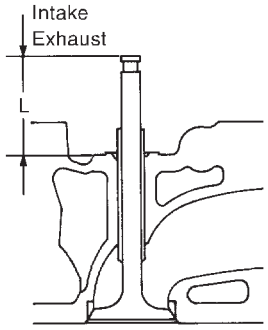
	Standard	Oversize
Valve guide		
Outer diameter		
Intake	12.015 - 12.029 (0.4730 - 0.4736)	12.233 - 12.244 (0.4816 - 0.4820)
Exhaust		
Valve guide		
Inner diameter [Finished size]		
Intake	8.000 - 8.018 (0.3150 - 0.3157)	
Exhaust		
Cylinder head valve guide hole diameter		
Intake	11.970 - 11.988 (0.4713 - 0.4720)	12.185 - 12.206 (0.4797 - 0.4806)
Exhaust		
Interference fit of valve guide		
Intake	0.027 - 0.059 (0.0011 - 0.0023)	
Exhaust		

	Standard	Max. tolerance
Stem to guide clearance		
Intake	0.020 - 0.053 (0.0008 - 0.0021)	0.1 (0.004)
Exhaust	0.040 - 0.073 (0.0016 - 0.0029)	
Valve deflection limit	—	0.2 (0.008)

Rocker shaft and rocker arm

Unit: mm (in)

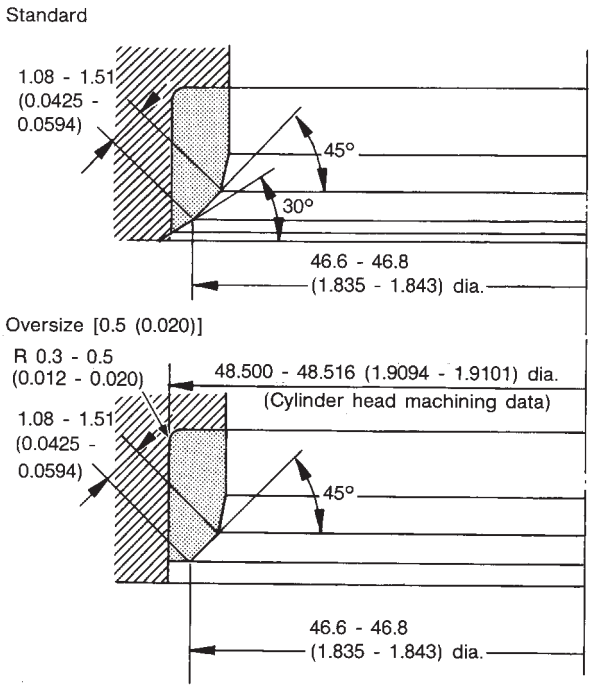
Rocker shaft	
Outer diameter	19.988 - 20.000 (0.7869 - 0.7874)
Rocker arm	
Inner diameter	20.020 - 20.038 (0.7882 - 0.7889)
Clearance between rocker arm and rocker shaft	0.020 - 0.050 (0.0008 - 0.0020)



SEM775F

Depth (L)	
Intake	46.14 (1.8165)
Exhaust	46.30 (1.8228)

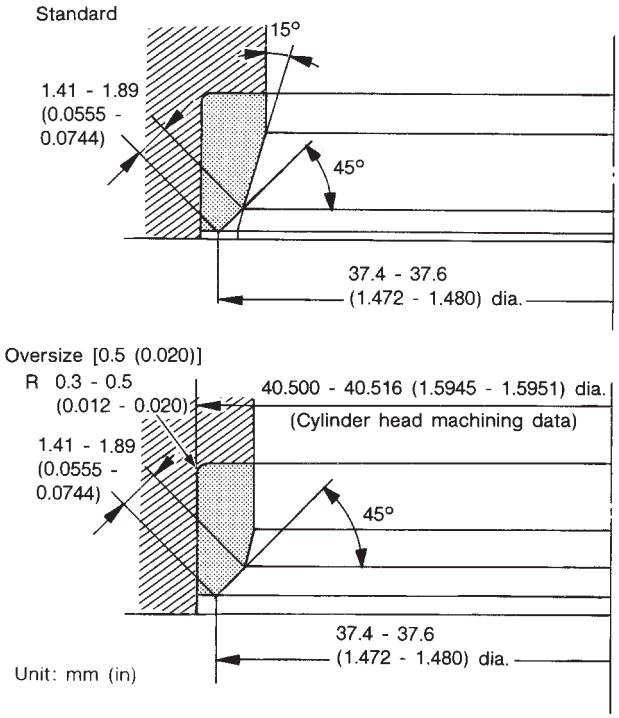
Intake valve seat



SEM755AD

Unit: mm (in)

Exhaust valve seat

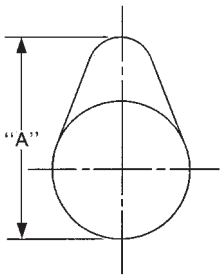


SEM108CA

CAMSHAFT AND CAMSHAFT BUSHING

Unit: mm (in)

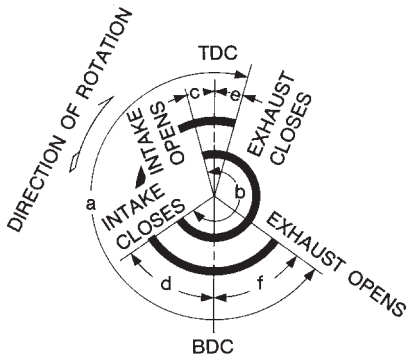
	Standard	Limit
Camshaft journal to bushing clearance [Oil clearance]	0.020 - 0.109 (0.0008 - 0.0043)	0.15 (0.0059)
Inner diameter of camshaft bushing		
Front	50.76 - 50.83 (1.9984 - 2.0012)	—
2nd	50.56 - 50.63 (1.9905 - 1.9933)	—
3rd	50.36 - 50.43 (1.9827 - 1.9854)	—
4th	50.16 - 50.23 (1.9748 - 1.9776)	—
5th	49.96 - 50.03 (1.9669 - 1.9697)	—
6th	49.76 - 49.83 (1.9591 - 1.9618)	—
Rear	49.56 - 49.63 (1.9512 - 1.9539)	—
Outer diameter of camshaft journal		
Front	50.721 - 50.740 (1.9969 - 1.9976)	—
2nd	50.521 - 50.540 (1.9890 - 1.9898)	—
3rd	50.321 - 50.340 (1.9811 - 1.9819)	—
4th	50.121 - 50.140 (1.9733 - 1.9740)	—
5th	49.921 - 49.940 (1.9654 - 1.9661)	—
6th	49.721 - 49.740 (1.9575 - 1.9583)	—
Rear	49.521 - 49.540 (1.9496 - 1.9504)	—
Camshaft bend (Total indicator reading)	Less than 0.02 (0.0008)	0.06 (0.0024)
Camshaft end play	0.08 - 0.28 (0.0031 - 0.0110)	0.5 (0.020)



EM671

	TB42S	TB45E
Cam height "A"		
Intake	42.311 - 42.561 (1.6658 - 1.6756)	42.126 - 42.376 (1.6585 - 1.6683)
Exhaust		
Wear limit of cam height	0.15 (0.0059)	

Valve timing



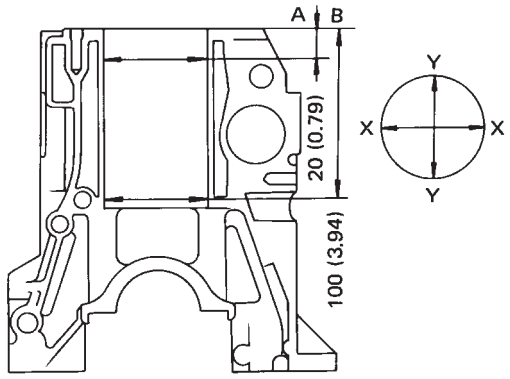
EM120

Unit: degree

	a	b	c	d	e	f
TB42S	248	248	16	52	6	62
TB45E	240	240	0	60	8	52

CYLINDER BLOCK

Unit: mm (in)



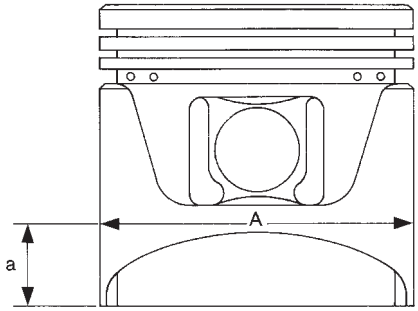
SEM014C

	TB42S	TB45E
Surface flatness		
Standard	Less than 0.03 (0.0012)	
Limit	0.10 (0.0039)	
Cylinder bore		
Inner diameter		
Standard		
Grade No. 1	96.000 - 96.010 (3.7795 - 3.7799)	99.500 - 99.510 (3.9173 - 3.9177)
Grade No. 2	96.010 - 96.020 (3.7799 - 3.7803)	99.510 - 99.520 (3.9177 - 3.9181)
Grade No. 3	96.020 - 96.030 (3.7803 - 3.7807)	99.520 - 99.530 (3.9181 - 3.9185)
Grade No. 4	96.030 - 96.040 (3.7807 - 3.7811)	99.530 - 99.540 (3.9185 - 3.9189)
Grade No. 5	96.040 - 96.050 (3.7811 - 3.7815)	99.540 - 99.550 (3.9189 - 3.9193)
Wear limit	0.20 (0.0079)	
Out-of-round (X − Y)	Less than 0.015 (0.0006)	
Taper (A − B)	Less than 0.010 (0.0004)	
Difference in inner diameter between cylinders		
Standard	Less than 0.05 (0.0020)	
Wear limit	0.20 (0.0079)	

PISTON, PISTON RING AND PISTON PIN

Available piston

Unit: mm (in)



SEM891B

	TB42S	TB45E
Piston skirt diameter "A"		
Standard		
Grade No. 1	95.975 - 95.985 (3.7785 - 3.7789)	99.460 - 99.470 (3.9157 - 3.9161)
Grade No. 2	95.985 - 95.995 (3.7789 - 3.7793)	99.470 - 99.480 (3.9161 - 3.9165)
Grade No. 3	95.995 - 96.005 (3.7793 - 3.7797)	99.480 - 99.490 (3.9165 - 3.9169)
Grade No. 4	96.005 - 96.015 (3.7797 - 3.7801)	99.490 - 99.500 (3.9169 - 3.9173)
Grade No. 5	96.015 - 96.025 (3.7801 - 3.7805)	99.500 - 99.510 (3.9173 - 3.9177)
Oversize		
0.50 (0.0197)		
(mark: "50")	96.475 - 96.525 (3.7982 - 3.8002)	99.960 - 100.010 (3.9354 - 3.9374)
1.00 (0.0394)		
(mark: "100")	96.975 - 97.025 (3.8179 - 3.8199)	100.460 - 100.510 (3.9551 - 3.9571)
"a" dimension	20 (0.79)	
Piston pin hole diameter	22.987 - 22.999 (0.9050 - 0.9055)	22.993 - 23.005 (0.9052 - 0.9057)
Piston clearance to cylinder block	0.015 - 0.035 (0.0006 - 0.0014)	0.030 - 0.050 (0.0012 - 0.0020)

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

Piston ring

Unit: mm (in)

	Standard	Limit
Side clearance		
Top	0.040 - 0.073 (0.0016 - 0.0029)	0.1 (0.004)
2nd	0.030 - 0.063 (0.0012 - 0.0025)	
Oil	0.065 - 0.135 (0.0026 - 0.0053)	
Ring gap [at master bore D = 96.000 (3.7795)]		
Top	0.30 - 0.45 (0.0118 - 0.0177)	1.5 (0.059)
2nd	0.30 - 0.45 (0.0118 - 0.0177)	
Oil	0.20 - 0.60 (0.0079 - 0.0236)	

Piston pin

Unit: mm (in)

	TB42S	TB45E
Piston pin outer diameter	22.989 - 23.001 (0.9051 - 0.9055)	
Interference fit of piston pin to piston	−0.007 to 0.003 (−0.0003 to 0.0001)	−0.001 to 0.009 (−0.0000 to 0.0004)
Piston pin to connecting rod bushing clearance	0.005 - 0.017 (0.0002 - 0.0007)	

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

CONNECTING ROD

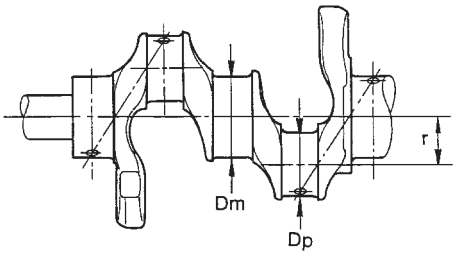
Unit: mm (in)

Center distance	166.45 - 166.55 (6.5531 - 6.5571)
Bend, torsion [per 100 (3.94)]	
Limit	Bend 0.15 (0.0059) Torsion 0.3 (0.012)
Piston pin bushing inner diameter	23.000 - 23.012 (0.9055 - 0.9060)
Connecting rod big end inner diameter	59.987 - 60.000 (2.3617 - 2.3622)
Side clearance	
Standard	0.20 - 0.30 (0.0079 - 0.0118)
Limit	0.40 (0.0157)

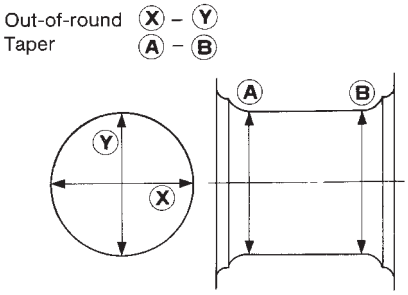
CRANKSHAFT

Unit: mm (in)

Main journal dia. "Dm"	70.897 - 70.921 (2.7912 - 2.7922)
Pin journal dia. "Dp"	56.913 - 56.926 (2.2407 - 2.2412)
Center distance "r"	48 (1.89)
Out-of-round (X − Y)	
Standard	Less than 0.0025 (0.0001)
Taper (A − B)	
Standard	Less than 0.0025 (0.0001)
Runout [TIR]	
Standard	Less than 0.20 (0.0079)
Free end play	
Standard	0.05 - 0.17 (0.0020 - 0.0067)
Limit	0.30 (0.0118)



SEM645



EM715

AVAILABLE MAIN BEARING

Unit: mm (in)

	Thickness "T"	Main journal diameter "Dm"
Standard	2.008 - 2.012 (0.0791 - 0.0792)	—
Undersize		
0.25 (0.0098)	2.133 - 2.137 (0.0840 - 0.0841)	Grind so that bearing clearance is the specified value.
0.50 (0.0197)	2.258 - 2.262 (0.0889 - 0.0891)	
0.75 (0.0295)	2.383 - 2.387 (0.0938 - 0.0940)	
1.00 (0.0394)	2.508 - 2.512 (0.0987 - 0.0989)	

AVAILABLE CONNECTING ROD BEARING

Unit: mm (in)

	Thickness "T"	Crank pin journal diameter "Dp"
Standard	1.513 - 1.517 (0.0596 - 0.0597)	—
Undersize		
0.25 (0.0098)	1.638 - 1.642 (0.0645 - 0.0646)	Grind so that bearing clearance is the specified value.
0.50 (0.0197)	1.763 - 1.767 (0.0694 - 0.0696)	
0.75 (0.0295)	1.888 - 1.892 (0.0743 - 0.0745)	
1.00 (0.0394)	2.013 - 2.017 (0.0793 - 0.0794)	

MISCELLANEOUS COMPONENTS

Unit: mm (in)

Flywheel & drive plate	
Runout [TIR]	Less than 0.1 (0.004)

Bearing clearance

Unit: mm (in)

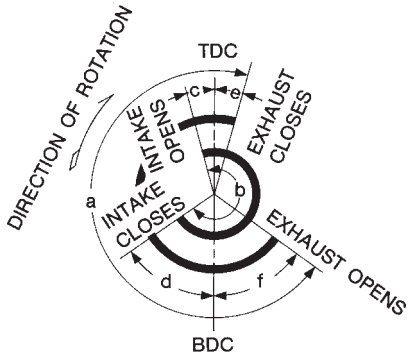
Main bearing clearance	
Standard	0.030 - 0.087 (0.0012 - 0.0034)
Limit	0.09 (0.0035)
Connecting rod bearing clearance	
Standard	0.027 - 0.061 (0.0011 - 0.0024)
Limit	0.09 (0.0035)

General Specifications

Cylinder arrangement		In-line 6
Displacement	cm^3 (cu in)	2,826 (172.44)
Bore and stroke	mm (in)	85 x 83 (3.35 x 3.27)
Valve arrangement		OHC
Firing order		1-5-3-6-2-4
Number of piston rings		
Compression		2
Oil		1
Number of main bearings		7
Compression ratio		21.8

VALVE TIMING

Without warm-up three way catalyst



EM120

Unit: degree

a	b	c	d	e	f
248	220	7	33	8	60

Inspection and Adjustment

COMPRESSION PRESSURE

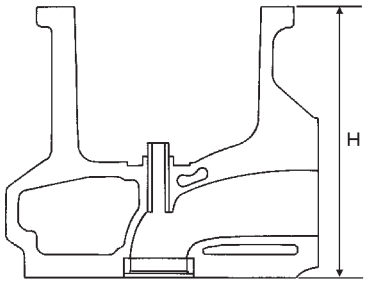
Unit: kPa (bar, kg/cm^2, psi)/200 rpm

Compression pressure	
Standard	3,040 (30.4, 31, 441)
Minimum	2,452 (24.5, 25, 356)
Differential limit between cylinders	490 (4.9, 5, 71)

CYLINDER HEAD

Unit: mm (in)

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

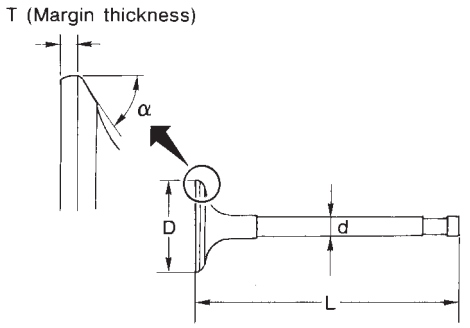


SEM795F

Nominal cylinder head height “H”	139.9 - 140.1 (5.508 - 5.516)
Resurfacing limit	0.1 (0.004)

VALVE

Unit: mm (in)



SEM188A

Valve head diameter "D"		
	Intake	39.0 - 39.3 (1.535 - 1.547)
	Exhaust	32.0 - 32.3 (1.260 - 1.272)
Valve length "L"		
	Intake	101.53 - 101.97 (3.9972 - 4.0146)
	Exhaust	101.38 - 101.82 (3.9913 - 4.0087)
Valve stem diameter "d"		
	Intake	6.965 - 6.980 (0.2742 - 0.2748)
	Exhaust	6.945 - 6.960 (0.2734 - 0.2740)
Valve seat angle "α"		
	Intake	45°15′ - 45°45′
	Exhaust	
Valve margin "T"		
	Intake	1.35 - 1.65 (0.0531 - 0.0650)
	Exhaust	1.65 - 1.95 (0.0650 - 0.0768)
Valve margin "T" limit		More than 0.5 (0.020)
Valve stem end surface grinding limit		Less than 0.2 (0.008)

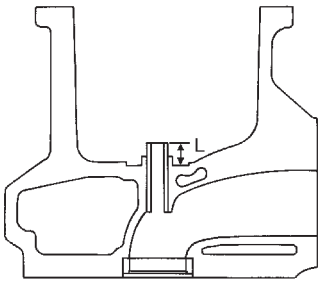
Valve lifter

Unit: mm (in)

Valve lifter diameter	34.960 - 34.975 (1.3764 - 1.3770)
Lifter guide hole diameter	34.998 - 35.018 (1.3779 - 1.3787)
Clearance between lifter and lifter guide hole	0.023 - 0.058 (0.0009 - 0.0023)

Valve guide

Unit: mm (in)



SEM796F

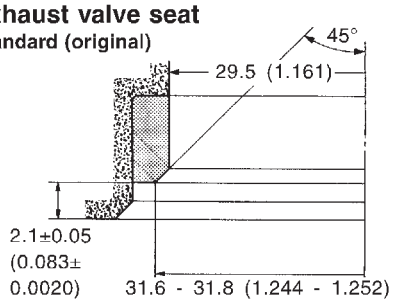
		Standard	Service
Valve guide Outer diameter	Intake	11.023 - 11.034 (0.4340 - 0.4344)	11.233 - 11.234 (0.4422 - 0.4423)
	Exhaust	11.023 - 11.034 (0.4340 - 0.4344)	11.233 - 11.234 (0.4422 - 0.4423)
Valve guide Inner diameter (Finished size)	Intake	7.000 - 7.018 (0.2756 - 0.2763)	
	Exhaust	7.000 - 7.018 (0.2756 - 0.2763)	
Cylinder head valve guide hole diameter	Intake	10.975 - 10.996 (0.4321 - 0.4329)	11.185 - 11.196 (0.4404 - 0.4408)
	Exhaust	10.975 - 10.996 (0.4321 - 0.4329)	11.185 - 11.196 (0.4404 - 0.4408)
Interference fit of valve guide		0.027 - 0.059 (0.0011 - 0.0023)	
		Standard	Limit
Stem to guide clearance	Intake	0.020 - 0.050 (0.0008 - 0.0020)	0.1 (0.004)
	Exhaust	0.040 - 0.070 (0.0016 - 0.0028)	0.1 (0.004)
Valve deflection limit		0.2 (0.008)	
Projection length "L"		10.2 - 10.4 (0.402 - 0.409)	

Inspection and Adjustment (Cont'd)

Valve seat

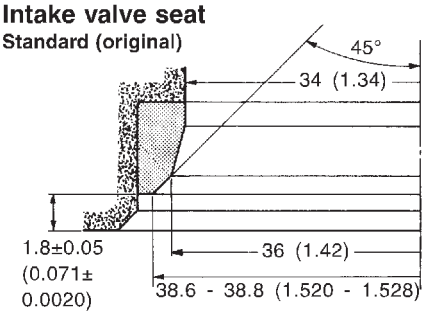
Unit: mm (in)

Exhaust valve seat
Standard (original)



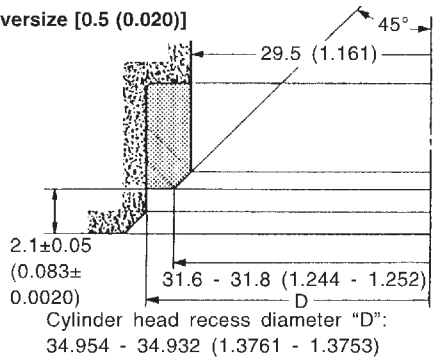
SEM788BA

Intake valve seat
Standard (original)



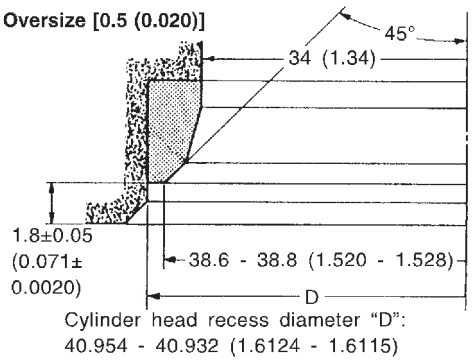
SEM773BA

Oversize [0.5 (0.020)]



SEM790BA

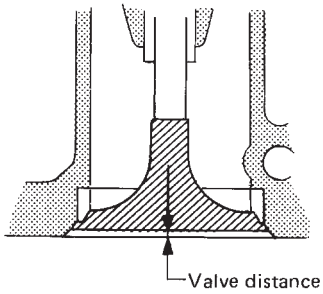
Oversize [0.5 (0.020)]



SEM789BA

Cylinder head to valve distance

Unit: mm (in)



SEM724C

	Standard
Intake	−0.069 to 0.269 (−0.0027 to 0.0106)
Exhaust	−0.069 to 0.269 (−0.0027 to 0.0106)

Valve spring

Free height	mm (in)	
Outer		42.25 (1.6634)
Inner		36.57 (1.4398)
Pressure height/Load mm/N (mm/kg, in/lb)		
Outer		25.7/437.69 (25.7/44.63, 1.012/98.41)
Inner		22.2/233.21 (22.2/23.78, 0.874/52.43)
Out-of-square	mm (in)	
Outer		1.9 (0.075)
Inner		1.6 (0.063)

Inspection and Adjustment (Cont'd)

Available shim

Thickness mm (in)	Identification mark
2.90 (0.1142)	2.90
2.85 (0.1122)	2.85
2.80 (0.1102)	2.80
2.75 (0.1083)	2.75
2.70 (0.1063)	2.70
2.65 (0.1043)	2.65
2.60 (0.1024)	2.60
2.55 (0.1004)	2.55
2.50 (0.0984)	2.50
2.45 (0.0965)	2.45
2.40 (0.0945)	2.40
2.35 (0.0925)	2.35
2.30 (0.0906)	2.30
2.25 (0.0886)	2.25
2.20 (0.0866)	2.20

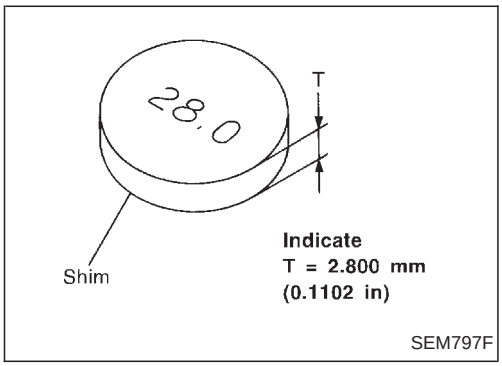
Valve clearance

Unit: mm (in)

	For adjusting	
	Hot	Cold*
Intake	0.28 - 0.38 (0.011 - 0.015)	0.26 - 0.34 (0.010 - 0.013)
Exhaust	0.32 - 0.42 (0.013 - 0.017)	0.30 - 0.38 (0.012 - 0.015)

*: At a temperature of approximately 20°C (68°F)

Whenever valve clearances are adjusted to cold specifications, check that the clearances satisfy hot specifications and adjust again if necessary.

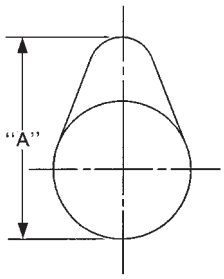


SEM797F

CAMSHAFT AND CAMSHAFT BEARING

Unit: mm (in)

	Standard	Limit
Camshaft journal to bearing clearance	0.045 - 0.086 (0.0018 - 0.0034)	0.1 (0.004)
Inner diameter of camshaft bearing	30.000 - 30.021 (1.1811 - 1.1819)	—
Outer diameter of camshaft journal	29.935 - 29.955 (1.1785 - 1.1793)	—
Camshaft runout [TIR*]	—	0.02 (0.0008)
Camshaft sprocket runout [TIR*]	Less than 0.25 (0.0098)	—
Camshaft end play	0.065 - 0.169 (0.0026 - 0.0067)	0.20 (0.0079)



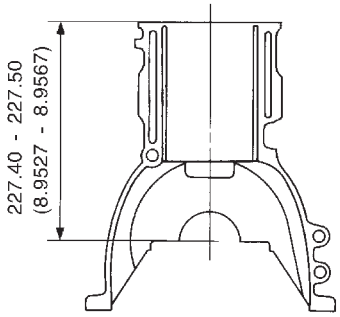
EM671

Cam height "A"	
Intake	48.005 - 48.195 (1.8900 - 1.8974)
Exhaust	49.505 - 49.695 (1.9490 - 1.9565)
Wear limit of cam height	0.15 (0.0059)
Valve lift	
Intake	8.27 (0.326)
Exhaust	9.43 (0.371)

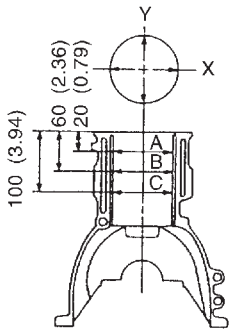
*: Total indicator reading

CYLINDER BLOCK

Unit: mm (in)



SEM964EA



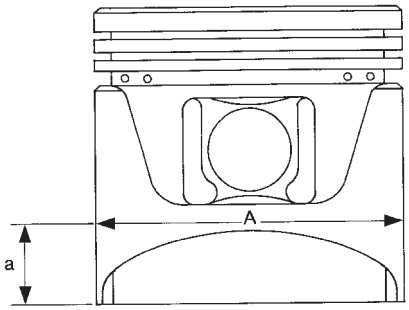
SEM686DA

Surface flatness	
Standard	Less than 0.03 (0.0012)
Limit	0.1 (0.004)
Cylinder bore	
Inner diameter	
Standard	
Grade No. 1	85.000 - 85.010 (3.3465 - 3.3468)
Grade No. 2	85.010 - 85.020 (3.3468 - 3.3472)
Grade No. 3	85.020 - 85.030 (3.3472 - 3.3476)
Wear limit	0.20 (0.0079)
Out-of-round (X − Y)	
Standard	Less than 0.015 (0.0006)
Taper (A − B and A − C)	
Standard	Less than 0.010 (0.0004)
Difference in inner diameter between cylinders	
Limit	Less than 0.05 (0.0020)
Main journal inner diameter	
Grade No. 0	58.645 - 58.654 (2.3089 - 2.3092)
Grade No. 1	58.654 - 58.663 (2.3092 - 2.3096)
Grade No. 2	58.663 - 58.672 (2.3096 - 2.3099)

PISTON, PISTON RING AND PISTON PIN

Piston

Unit: mm (in)



SEM750C

Piston skirt diameter "A"	
Standard	
Grade No. 1	84.960 - 84.970 (3.3449 - 3.3453)
Grade No. 2	84.970 - 84.980 (3.3453 - 3.3457)
Grade No. 3	84.980 - 84.990 (3.3457 - 3.3461)
0.50 (0.0197) oversize (Service)	85.460 - 85.490 (3.3646 - 3.3657)
1.00 (0.0394) oversize (Service)	85.960 - 85.990 (3.3842 - 3.3854)
"a" dimension	14.5 (0.571)
Piston clearance to cylinder block	0.030 - 0.050 (0.0012 - 0.0020)
Piston pin hole diameter	26.995 - 27.005 (1.0628 - 1.0632)

Piston ring

Unit: mm (in)

Side clearance	
Top	
Standard	0.060 - 0.093 (0.0024 - 0.0037)
Limit	0.1 (0.004)
2nd	
Standard	0.040 - 0.073 (0.0016 - 0.0029)
Limit	0.1 (0.004)
Oil	
Standard	0.030 - 0.063 (0.0012 - 0.0025)
Limit	—
Ring gap	
Top	
Standard	0.20 - 0.28 (0.0079 - 0.0110)
Limit	1.0 (0.039)
2nd	
Standard	0.38 - 0.53 (0.0150 - 0.0209)
Limit	1.0 (0.039)
Oil	
Standard	0.30 - 0.56 (0.0118 - 0.0220)
Limit	1.0 (0.039)

Piston pin

Unit: mm (in)

Piston pin outer diameter	26.994 - 27.000 (1.0628 - 1.0630)
Interference fit of piston pin to piston	0.002 - 0.006 (0.0001 - 0.0002)
Piston pin to connecting rod bushing clearance	
Standard	0.025 - 0.044 (0.0010 - 0.0017)

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

CONNECTING ROD

Unit: mm (in)

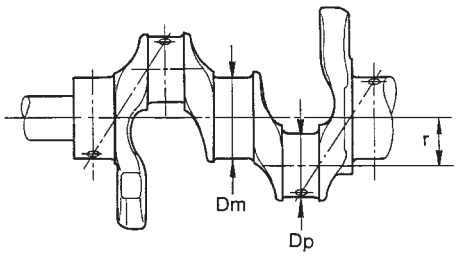
Center distance	140.0 (5.512)
Bend [per 100 (3.94)]	
Limit	0.025 (0.0010)
Torsion [per 100 (3.94)]	
Limit	0.025 (0.0010)
Connecting rod small end inner diameter	30.000 - 30.013 (1.1811 - 1.1816)
Piston pin bushing inner diameter*	27.025 - 27.038 (1.0640 - 1.0645)
Connecting rod big end inner diameter	
Grade No. 0	53.000 - 53.007 (2.0866 - 2.0869)
Grade No. 1	53.007 - 53.013 (2.0869 - 2.0871)
Side clearance	
Standard	0.20 - 0.30 (0.0079 - 0.0118)
Limit	0.40 (0.0157)

*: After installing in connecting rod

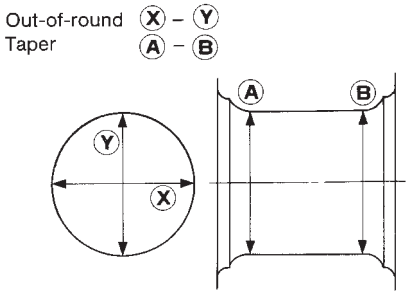
CRANKSHAFT

Unit: mm (in)

Main journal dia. "Dm"		
Grade No. 0	54.967 - 54.975 (2.1641 - 2.1644)	
Grade No. 1	54.959 - 54.967 (2.1637 - 2.1641)	
Grade No. 2	54.951 - 54.959 (2.1634 - 2.1637)	
Pin journal dia. "Dp"		
Grade No. 0	49.968 - 49.974 (1.9672 - 1.9675)	
Grade No. 1	49.961 - 49.968 (1.9670 - 1.9672)	
Center distance "r"	41.47 - 41.53 (1.6327 - 1.6350)	
Out-of-round (X − Y)		
Standard	Main journal	Less than 0.005 (0.0002)
	Pin journal	Less than 0.0025 (0.0001)
Taper (A − B)		
Standard	Main journal	Less than 0.005 (0.0002)
	Pin journal	Less than 0.0025 (0.0001)
Runout [TIR]		
Standard	Less than 0.025 (0.0010)	
Limit	Less than 0.05 (0.0020)	
Free end play		
Standard	0.05 - 0.18 (0.0020 - 0.0071)	
Limit	0.30 (0.0118)	

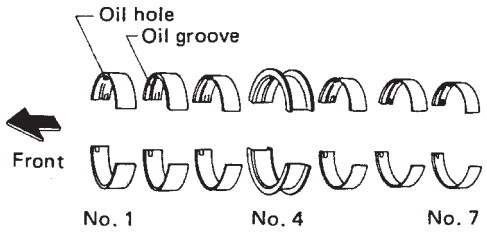


SEM645



EM715

MAIN BEARING



SEM157B

Standard

Unit: mm (in)

Grade number	Thickness "T"	Width "W"	Identification color
0	1.813 - 1.817 (0.0714 - 0.0715)	19.7 - 19.9 (0.776 - 0.783)	Black
1	1.817 - 1.821 (0.0715 - 0.0717)		Brown
2	1.821 - 1.825 (0.0717 - 0.0719)		—
3	1.825 - 1.829 (0.0719 - 0.0720)		Yellow
4	1.829 - 1.833 (0.0720 - 0.0722)		Blue

Undersize

Unit: mm (in)

Undersize	Thickness "T"	Main journal diameter "Dm"
0.25 (0.0098)	2.109 - 2.117 (0.0830 - 0.0833)	Grind so that bearing clearance is the specified value.

CONNECTING ROD BEARING

Connecting rod bearing

Standard size

Unit: mm (in)

Grade number	Thickness "T"	Width "W"	Identification color
0	1.492 - 1.496 (0.0587 - 0.0589)	19.9 - 20.1 (0.783 - 0.791)	Black
1	1.496 - 1.500 (0.0589 - 0.0591)		Yellow
2	1.500 - 1.504 (0.0591 - 0.0592)		Brown

Inspection and Adjustment (Cont'd)

Undersize

Unit: mm (in)

Undersize	Thickness "T"	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)	

Bearing clearance

Unit: mm (in)

Main bearing clearance	
Standard	0.036 - 0.063 (0.0014 - 0.0025)
Limit	0.12 (0.0047)
Connecting rod bearing clearance	
Standard	0.031 - 0.055 (0.0012 - 0.0022)
Limit	0.11 (0.0043)

MISCELLANEOUS COMPONENTS

Unit: mm (in)

Camshaft sprocket runout limit [TIR]	0.1 (0.004)
Flywheel runout limit [TIR]	0.1 (0.004)
Drive plate runout limit [TIR]	0.1 (0.004)

General Specifications

Cylinder arrangement		In-line
Number of cylinders		6
Valve arrangement		OHV
Bore x stroke	mm (in)	96.0 x 96.0 (3.780 x 3.780)
Displacement	cm^3 (cu in)	4,169 (254.39)
Firing order		1-4-2-6-3-5
Number of piston rings	Compression	2
	Oil	1
Number of main bearings		7
Compression ratio		23.1

Inspection and Adjustment

COMPRESSION PRESSURE

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

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

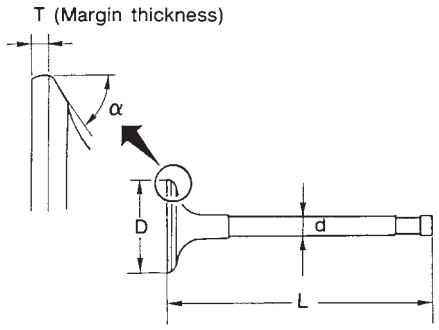
CYLINDER HEAD

Unit: mm (in)

	Standard	Limit
Head surface distortion	Less than 0.07 (0.0028)	0.2 (0.008)
Nominal cylinder head height	89.9 - 90.1 (3.539 - 3.547)	

VALVE

Unit: mm (in)



SEM188

Valve head diameter “D”	
Intake	43.4 - 43.6 (1.709 - 1.717)
Exhaust	37.9 - 38.1 (1.492 - 1.500)
Valve length “L”	
Intake	117 (4.61)
Exhaust	
Valve stem diameter “d”	
Intake	7.962 - 7.977 (0.3135 - 0.3141)
Exhaust	7.945 - 7.960 (0.3128 - 0.3134)
Valve seat angle “α”	
Intake	45° - 45°30′
Exhaust	
Valve margin “T” limit	0.5 (0.020)
Valve stem end surface grinding limit	0.2 (0.008)
Valve clearance (Hot)	
Intake	0.35 (0.0138)
Exhaust	

Inspection and Adjustment (Cont'd)

Valve guide

Unit: mm (in)

	Standard	Service
Valve guide outside diameter	12.033 - 12.044 (0.4737 - 0.4742)	—
Valve guide inner diameter (Finished size)	8.000 - 8.015 (0.3150 - 0.3156)	
Cylinder head valve guide hole diameter	12.00 - 12.011 (0.4724 - 0.4729)	—
Interference fit of valve guide	0.022 - 0.044 (0.0009 - 0.0017)	
	Standard	Max. tolerance
Stem to guide clearance		
Intake	0.023 - 0.053 (0.0009 - 0.0021)	0.15 (0.0059)
Exhaust	0.04 - 0.07 (0.0016 - 0.0028)	0.20 (0.0079)
Valve deflection limit		
Intake	0.30 (0.0118)	
Exhaust	0.40 (0.0157)	

Valve spring

Free length mm (in)	
Painted red	53.4 (2.102)
Pressure height mm/N (mm/kg, in/lb)	
Painted red	31.8/713.9 - 788.5 (31.8/72.8 - 80.4, 1.252/160.5 - 177.3)
Assembled height mm/N (mm/kg, in/lb)	
Standard	42.3/314.8 - 361.9 (42.3/32.1 - 36.9, 1.665/70.8 - 81.4)
Limit	42.3/270.7 (42.3/27.6, 1.665/60.9)
Out-of-square mm (in)	2.3 (0.091)

Valve lifter and push rod

Unit: mm (in)

	Standard	Limit
Valve lifter outer diameter	25.960 - 25.970 (1.0220 - 1.0224)	—
Cylinder block valve lifter hole diameter	26.000 - 26.033 (1.0236 - 1.0249)	—
Valve lifter to lifter hole clearance	0.030 - 0.073 (0.0012 - 0.0029)	0.20 (0.0079)
Push rod bend (TIR)*	Less than 0.3 (0.012)	0.5 (0.020)

*: Total indicator reading

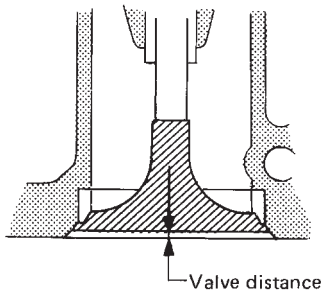
Rocker shaft and rocker arm

Unit: mm (in)

	Standard	Limit
Rocker shaft		
Outer diameter	19.979 - 20.00 (0.7866 - 0.7874)	—
Rocker shaft bend (TIR)	0 - 0.15 (0 - 0.0059)	Less than 0.30 (0.0118)
Rocker arm		
Inner diameter	20.014 - 20.035 (0.7880 - 0.7888)	—
Clearance between rocker arm and rocker shaft	0.014 - 0.056 (0.0006 - 0.0022)	0.15 (0.0059)

CYLINDER HEAD TO VALVE DISTANCE

Unit: mm (in)



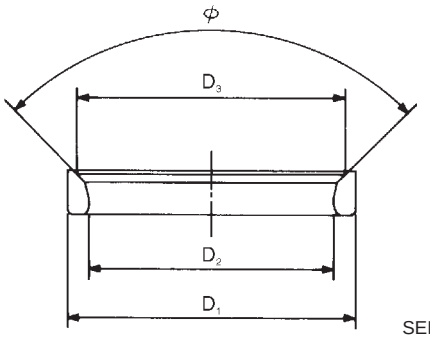
SEM724C

	Standard	Limit
Intake	0.7 - 1.3 (0.028 - 0.051)	1.75 (0.0689)
Exhaust	0.7 - 1.3 (0.028 - 0.051)	1.75 (0.0689)

Inspection and Adjustment (Cont'd)

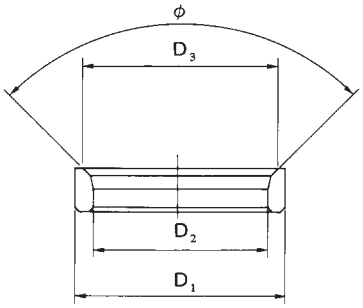
Valve seat

Unit: mm (in)



SEM258F

Intake	
Outer diameter "D_1"	44.535 - 44.545 (1.7533 - 1.7537)
Inner diameter "D_2"	37.9 - 38.1 (1.492 - 1.500)
Diameter of seat "D_3"	42.5 (1.673)
Cylinder head valve seat diameter	44.500 - 44.515 (1.7520 - 1.7526)
Valve seat face angle "ϕ"	89° - 90°



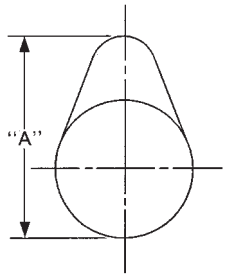
SEM953C

Exhaust	
Outer diameter "D_1"	
Standard	39.535 - 39.545 (1.5565 - 1.5569)
0.2 (0.008) Oversize (Service)	39.735 - 39.745 (1.5644 - 1.5648)
0.4 (0.016) Oversize (Service)	39.935 - 39.945 (1.5722 - 1.5726)
Inner diameter "D_2"	32.4 - 33.1 (1.276 - 1.303)
Diameter of seat "D_3"	37.0 (1.457)
Cylinder head valve seat diameter	
Standard	39.495 - 39.510 (1.5549 - 1.5555)
0.2 (0.008) Oversize	39.695 - 39.710 (1.5628 - 1.5634)
0.4 (0.016) Oversize	39.895 - 39.910 (1.5707 - 1.5713)
Valve seat face angle "ϕ"	89° - 90°

CAMSHAFT AND CAMSHAFT BEARING

Unit: mm (in)

	Standard	Limit
Camshaft journal to bushing clearance [Oil clearance]	0.020 - 0.109 (0.0008 - 0.0043)	0.15 (0.0059)
Camshaft journal diameter		
Front	50.721 - 50.740 (1.9969 - 1.9976)	—
2nd	50.521 - 50.540 (1.9890 - 1.9898)	—
3rd	50.321 - 50.340 (1.9811 - 1.9819)	—
4th	50.121 - 50.140 (1.9733 - 1.9740)	—
5th	49.921 - 49.940 (1.9654 - 1.9661)	—
6th	49.721 - 49.740 (1.9575 - 1.9583)	—
Rear	49.521 - 49.540 (1.9496 - 1.9504)	—
Camshaft bend (Total indicator reading)	Less than 0.02 (0.0008)	0.06 (0.0024)
Camshaft end play	0.08 - 0.28 (0.0031 - 0.0110)	0.50 (0.0197)

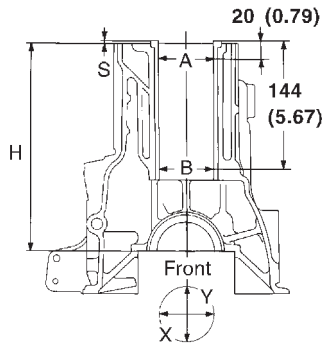


EM671

	Standard	Limit
Cam height "A"		
Intake & Exhaust	41.88 - 41.92 (1.6488 - 1.6504)	41.40 (1.6299)

CYLINDER BLOCK AND CYLINDER LINER

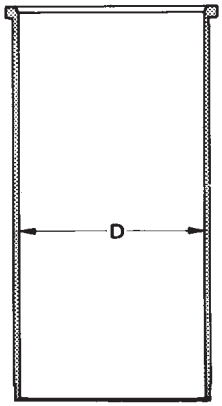
Unit: mm (in)



DEM090

Nominal cylinder block height "H" (From crankshaft center)	254.95 - 255.05 (10.0374 - 10.0413)
Surface flatness (Without cylinder liner)	
Standard	Less than 0.05 (0.0020)
Limit	0.2 (0.008)
Cylinder bore (Without cylinder liner)	
Inner diameter	
Standard	99.000 - 99.020 (3.8976 - 3.8984)
Cylinder bore	(With cylinder liner for factory)
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) standard	Less than 0.020 (0.0008)
Taper (A − B) standard	Less than 0.020 (0.0008)
Projection "S"	0.02 - 0.09 (0.0008 - 0.0035)
Deviation of each cylinder "S"	Less than 0.05 (0.0020)
Interference fit cylinder liner to block	−0.01 to 0.03 (−0.0004 to 0.0012)

Unit: mm (in)



SEM427

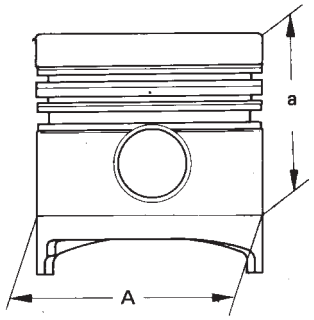
Cylinder liner diameter "D" (service)*	96.050 - 96.070 (3.7815 - 3.7823)

*: Before installing in cylinder block

PISTON, PISTON RING AND PISTON PIN

Available piston

Unit: mm (in)



SEM778A

Piston skirt diameter "A"	
Standard	
Grade No. 1	95.940 - 95.950 (3.7772 - 3.7776)
Grade No. 2	95.950 - 95.960 (3.7776 - 3.7779)
Grade No. 3*	95.960 - 95.970 (3.7779 - 3.7783)
"a" dimension	70 (2.76)
Piston pin hole diameter	29.997 - 30.005 (1.1810 - 1.1813)
Piston to cylinder liner clearance	0.05 - 0.07 (0.0020 - 0.0028)

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

Inspection and Adjustment (Cont'd)

Piston ring

Unit: mm (in)

	Standard	Limit
Side clearance		
Top	0.06 - 0.10 (0.0024 - 0.0039)	0.50 (0.0197)
2nd	0.04 - 0.08 (0.0016 - 0.0031)	0.30 (0.0118)
Oil	0.02 - 0.06 (0.0008 - 0.0024)	0.15 (0.0059)
Ring gap		
With cylinder liner for factory		
Top	0.30 - 0.45 (0.0118 - 0.0177)	
2nd	0.50 - 0.65 (0.0197 - 0.0256)	
Oil (rail ring)	0.30 - 0.50 (0.0118 - 0.0197)	
With cylinder liner for service		1.5 (0.059)
Top	0.40 - 0.60 (0.0157 - 0.0236)	
2nd	0.60 - 0.80 (0.0236 - 0.0315)	
Oil ring	0.40 - 0.65 (0.0157 - 0.0256)	

Piston pin

Unit: mm (in)

Piston pin outer diameter	29.993 - 30.000 (1.1808 - 1.1811)
Piston pin to piston clearance	
Standard	−0.003 to 0.012 (−0.0001 to 0.0005)
Limit	0.10 (0.0039)
Piston pin to connecting rod clearance	
Standard	0.025 - 0.045 (0.0010 - 0.0018)
Limit	0.15 (0.0059)

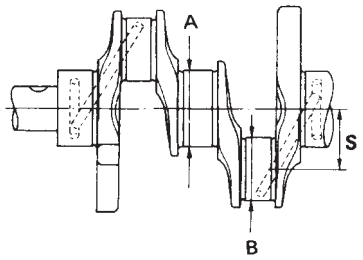
CONNECTING ROD

Unit: mm (in)

Center distance	156.975 - 157.025 (6.1801 - 6.1821)
Bend, torsion [per 100 (3.94)]	
Limit	0.075 (0.0030)
Piston pin bore dia.	30.025 - 30.038 (1.1821 - 1.1826)
Side clearance	
Standard	0.10 - 0.22 (0.0039 - 0.0087)
Limit	0.22 (0.0087)

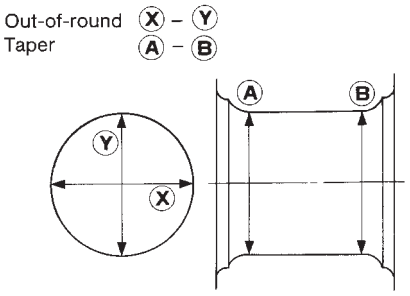
CRANKSHAFT

Unit: mm (in)



SEM100A

Journal diameter "A"	70.907 - 70.920 (2.7916 - 2.7921)
Pin diameter "B"	56.913 - 56.926 (2.2407 - 2.2412)
Center distance "S"	48.00 (1.8898)



EM715

Taper of journal and pin "A – B"	
Standard	0.01 (0.0004)
Limit	0.02 (0.0008)
Out-of-round of journal and pin "X – Y"	
Standard	0.01 (0.0004)
Limit	0.02 (0.0008)
Crankshaft bend	
Standard	0 - 0.03 (0 - 0.0012)
Limit	0.10 (0.0039)
Crankshaft end play	
Standard	0.055 - 0.14 (0.0022 - 0.0055)
Limit	0.40 (0.0157)

AVAILABLE MAIN BEARING

Bearing clearance

Unit: mm (in)

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

Main bearing undersize

Unit: mm (in)

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

AVAILABLE CONNECTING ROD BEARING

Connecting rod bearing undersize

Unit: mm (in)

	Crank pin journal diameter
Standard	56.913 - 56.926 (2.2407 - 2.2412)
Undersize	
0.25 (0.0098)	56.663 - 56.676 (2.2308 - 2.2313)
0.50 (0.0197)	56.413 - 56.426 (2.2210 - 2.2215)
0.75 (0.0295)	56.163 - 56.176 (2.2111 - 2.2116)
1.00 (0.0394)	55.913 - 55.926 (2.2013 - 2.2018)

Inspection and Adjustment (Cont'd)

AVAILABLE THRUST WASHER

Thrust washer undersize

Unit: mm (in)

	Thrust washer thickness
Standard	
Stamped mark 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)
Oversize	
0.20 (0.0079)	2.475 - 2.525 (0.0974 - 0.0994)
0.40 (0.0157)	2.675 - 2.725 (0.1053 - 0.1073)

MISCELLANEOUS COMPONENTS

Unit: mm (in)

Gear train	
Backlash of each gear	0.07 - 0.11 (0.0028 - 0.0043)
Limit	0.20 (0.0079)
Flywheel	
Runout (Total indicator reading)	Less than 0.15 (0.0059)
Front plate	
Warpage limit	0.2 (0.008)