

# ENGINE MECHANICAL SYSTEM (D4DD)

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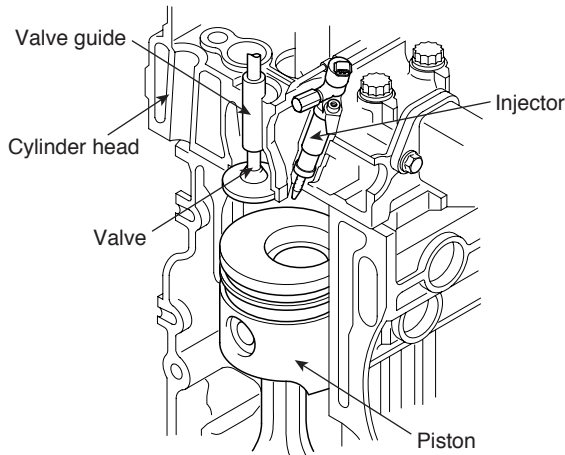
# GENERAL

## DESCRIPTION EFA0EBB7

### COMBUSTION

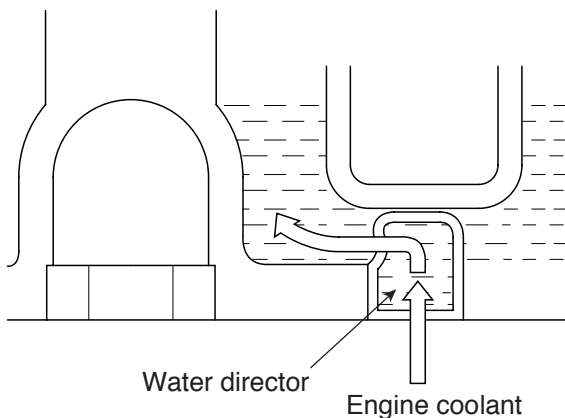
#### CHAMBER

1. Combustion chamber consists of cylinder head, piston, injector installed to the cylinder head and valve.



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2. Fuel is supplied to supply pump through the fuel filter installed to the frame. Fuel is also supplied to injectors through injection pipe No. 1, 2, 3 and 4 in common rail assembly.
3. Combustion is accomplished when fuel is injected directly into combustion chamber, at that time explosion pressure applies to the piston directly.
4. For better efficient cooling of combustion chamber, water director is press-fit under cylinder head floor, which induces the coolant flow.



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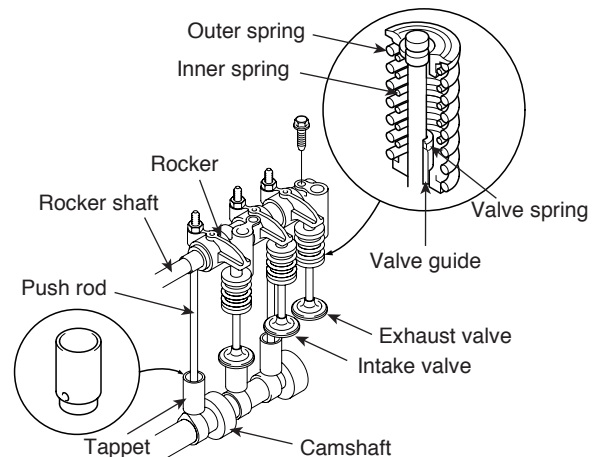
### VALVE MECHANISM

1. Heat resistant steel with surface treatment is used for intake and exhaust valve. The valve seat angle is  $45^\circ$ .
2. Valve stem seal, installed to the stem, adjusts the lubricant amount on the sliding surface of valve and valve guide.

#### NOTE

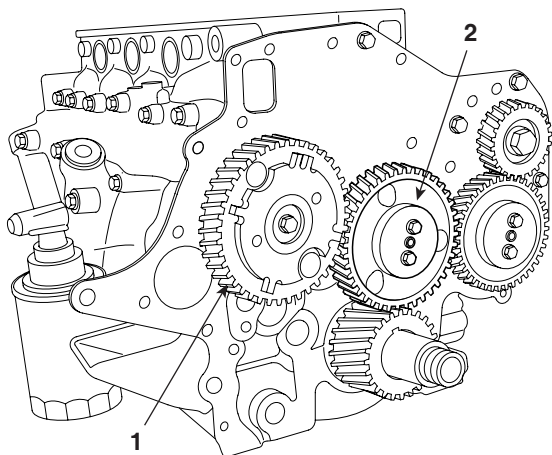
*Valve guide with carbon cutter is used for exhaust valve.*

3. Valve spring consists of two valve springs having irregular pitches. The coil directions of inner and outer springs are opposite each other.
4. Rocker shaft is hollow cylindrical rod, whose each end are sealed with sealing cap. Inner space of the shaft is an engine oil passage.
5. Steel ball is installed to the lower end of push rod and rocker assembly is installed to upper end.
6. Tappet has a cylindrical shape. As enlarging the contacting surface contacted with camshaft, it helps to prevent partial wear and to increase its durability.



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7. Camshaft assembly (1) consists of cam sensor plate, thrust plate, cam and journal. Camshaft gear is coupled with the idler gear A (2).

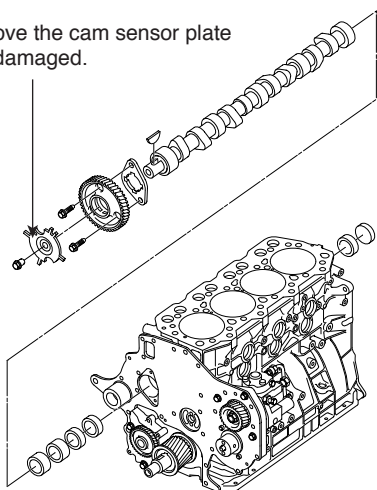


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**CRANKCASE AND CYLINDER SLEEVE**

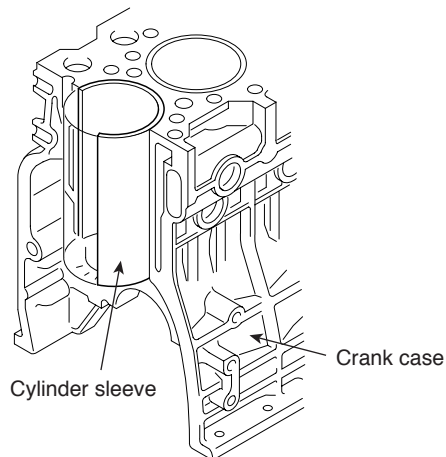
1. Crankcase is manufactured firmly with cast iron to prevent stress concentration and deformation.
2. The 5 camshaft bushes are installed to the camshaft bore of the crankcase. To facilitate the removal and installation of camshaft, inner diameter of bush is tapered to the rear side.

Do not remove the cam sensor plate unless it is damaged.



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3. Cylinder sleeve made of special cast iron is pressed fit into the crankcase.



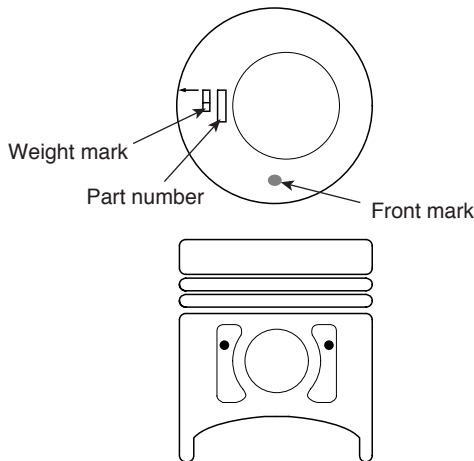
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**PISTON**

1. Piston pin type is full float type and piston pin is offset from thrust.
2. Marks on the piston indicate weight, part number and oversize. The front mark indicates the front direction of the engine.

**NOTE**

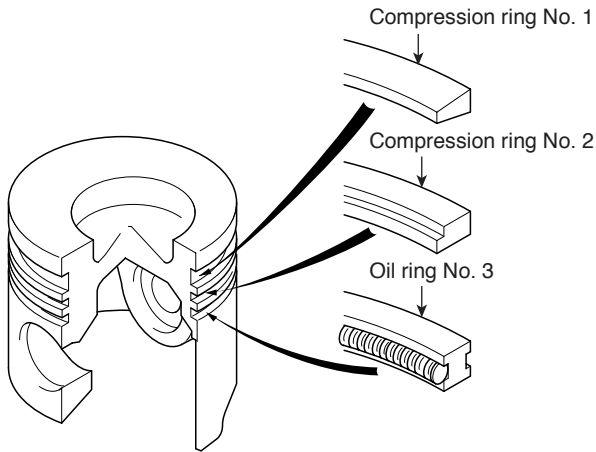
When assembling a piston, let the arrow mark (→) faced to the center of cylinder head bolt hole.



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**PISTON RING**

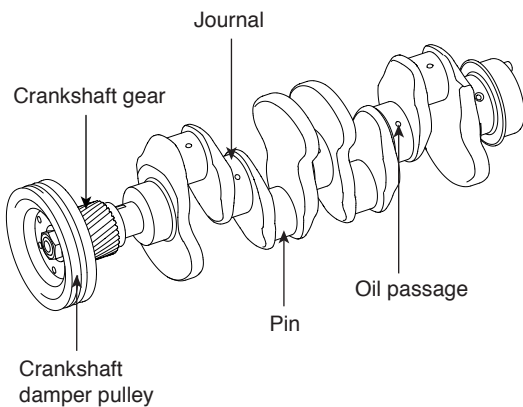
Piston has two compression rings and one oil ring. All sliding surfaces of rings are coated with hardened chrome.



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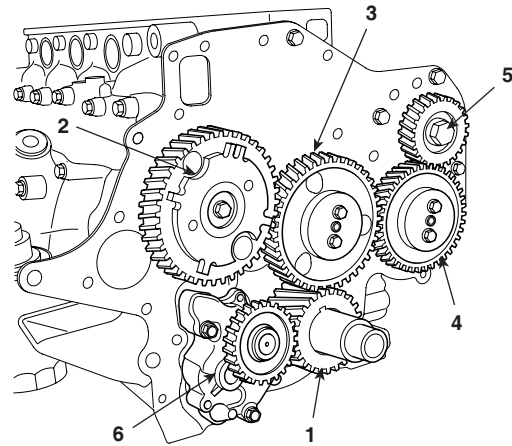
**CRANKSHAFT**

1. Crankshaft is forged with high-strength alloy built in with balance weight.
2. Pin, journal and oil seal sliding-surface are hardened with high frequency heat treatment to raise the resistance against frictional wear.
3. Through oil passage at the pin and journal, oil lubricates main bearing. Oil flows to the pin for the lubrication of connecting rod bearing.
4. Crankshaft pulley and crankshaft gear are installed at the front end of crankshaft. The crankshaft pulley drives alternator and water pump using V-belt.
5. Crankshaft damper pulley absorbs the distorting vibration of crankshaft.



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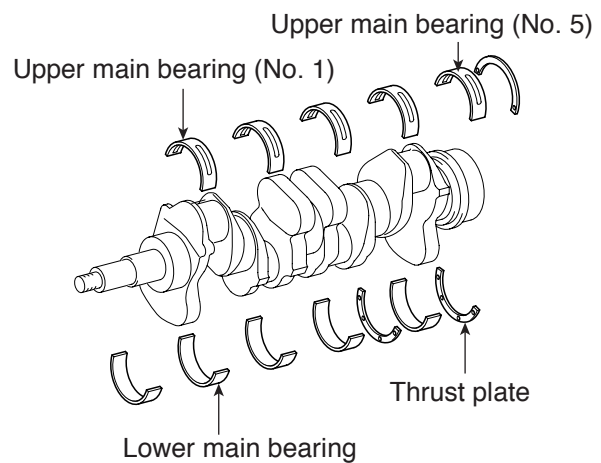
6. Crankshaft gear (1) drives camshaft gear (2), idler gear A (3), idler gear B (4), supply pump gear (5) and oil pump gear (6).



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**CRANKSHAFT MAIN BEARING**

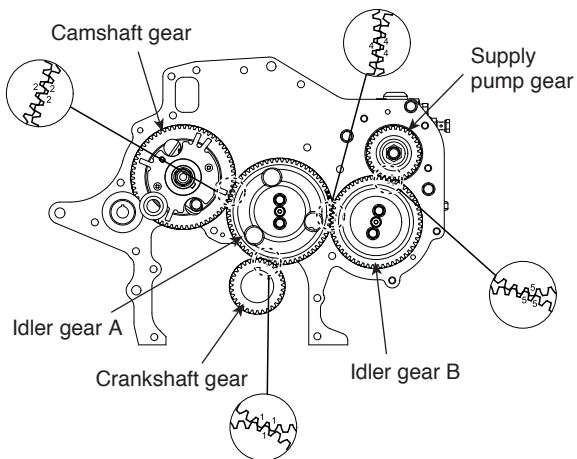
Upper main bearing has oil groove and oil hole which matches with oil hole of the crankshaft. Divided type thrust plate is installed to the both ends of the last bearing (No.5).



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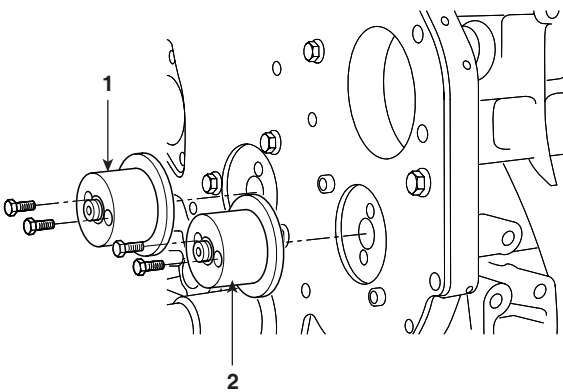
**TIMING GEAR**

1. Timing gear is installed in the timing gear case at the front of engine.
2. Each gear is helical gear manufactured with high precision and its surface is treated by heat to enhance the durability.
3. Timing marks are marked on the gear. When assembling, by aligning the timing marks, gears can be engaged correctly.



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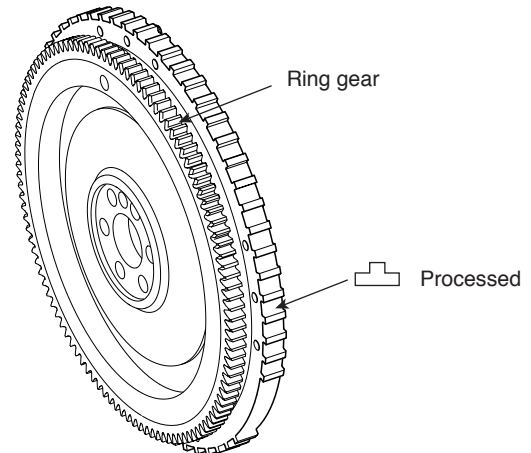
4. Bushes are press-fit into idler gear, which rotates idler shaft A (1) and idler shaft B (2). Idler shaft and gear oil hole provides oil passage to lubricate bush and gear.



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**FLYWHEEL**

1. Flywheel is made of forged iron. Pilot bearing of transmission drive pinion is disposed at the center portion. Ring gear which can be geared with starter pinion is pressed fit at the circumferential of the flywheel.
2. Processed is formed at the outer diameter of the flywheel to measure the engine rpm.



SUDEM7014L

SPECIFICATION ECC41378

Items	Standard ( [ ] indicates standard diameter)	Limit	Corrective action
General Type Cylinder inner diameter Cylinder stroke Displacement Compression ratio Firing order Maximum output  Maximum torque  Compression pressure (at 200rpm)	Serial 4-cylinder 4stroke common rail system 104mm 115mm 3,907cc 17.5 : 1 1-3-4-2 140ps/2800rpm (HD65, 72,78 Narrow) 140ps/2800rpm (HD65, 72,78 Wide) 140ps/2800rpm (County) 38kgf.m/1600rpm (HD65, 72,78 Narrow) 38kgf.m/1600rpm (HD65, 72,78 Wide) 38kgf.m/1600rpm (County) 26kg/cm <sup>2</sup>	20kg/cm <sup>2</sup>	Adjustment (As the difference between cylinders is within 4kg/cm <sup>2</sup> )
Valve timing Intake valve open (BTDC) Intake valve close (ABDC) Exhaust valve open(BBDC) Exhaust valve close (ATDC)	19° 53° 60° 16°		
Valve Intake valve length Exhaust valve length Outer diameter of intake valve stem Outer diameter of exhaust valve stem Valve face angle Thickness (margin) of intake/exhaust valve head Valve clearance (when engine is cold)	137mm 137mm 8.960~8.975mm 8.925~8.940mm 45° 1.5mm 0.4mm	8.85mm 8.85mm 1.2mm	
Gap between valve stem and valve guide Intake Exhaust	[9] 0.04~0.06mm [9] 0.07~0.10mm	0.15mm 0.2mm	Replace
Valve guide length Intake Exhaust	64mm 71.5mm		
Valve sinkage Intake Exhaust	0.75~1.25mm 0.75~1.25mm	1.5mm 1.5mm	Valve seat Replace insert
Push rod run out	—	0.4mm	Replace
Valve seat width Intake Exhaust	2.6~3.0mm 1.8~2.2mm	3.6mm 2.8mm	Replace

Items	Standard ([ ] indicates standard diameter)	Limit	Corrective action
Outer side valve Spring Free height Load installed Winding direction Out of squareness Inner side valve spring Free length Load installed Winding direction Out of squareness	66.1mm 26.5~29.3kg To the right 1.5mm 60.0mm 11.5~12.7kg Left side 1.5mm	63mm 23.7kg 2.1mm 57mm 10.3kg 2.1mm	Replace
Cylinder block Cylinder bore Torsion of upper crankcase Flatness of gasket surface Out of squareness of gasket surface Clearance between tappet and crankcase tappet hole	104.00~104.03mm Below 0.07mm 0.07mm 0.05mm [28] 0.045~0.096mm	0.2mm 0.2mm	Replace
Clearance between piston ring and piston ring groove No.1 ring No.2 ring Oil ring	0.106~0.170mm 0.07~0.11mm 0.03~0.07mm	0.2mm 0.15mm 0.15mm	Replace the piston ring
Piston ring end gap No.1 ring No.2 ring Oil ring	0.25~0.40mm 0.50~0.65mm 0.20~0.40mm	1.0mm 1.5mm 1.0mm	Replace
Average protrusion of piston Gasket grade A Gasket grade B Gasket grade C	0.466~0.526mm 0.526~0.588mm 0.588~0.648mm		Measure the average protrusion and replace the gasket with the corresponding grade gasket
Piston Piston outer diameter Clearance between piston and cylinder sleeve	103.91~103.92mm 0.080~0.130mm		Repair with oversize or replace
Piston pin Outer diameter of piston pin Clearance between piston pin and piston pin hole Clearance between piston pin and connecting rod end bush	37.994~38.00mm 0.007~0.021mm [38] 0.025~0.046mm	0.05mm 0.1mm	Replace Replace bush
Cylinder sleeve Inner diameter Out of roundness Out of cylinderness	104.00~104.03mm 0.005mm 0.015mm	100.25mm Below 0.01mm Below 0.03mm	Repair with oversize or replace
Cylinder head Flatness of cylinder head bottom Length from cylinder head top to bottom	Below 0.1mm 94.9~95.1mm	0.2mm 94.6mm	Repair or replace

Items	Standard ( [ ] indicates standard diameter)	Limit	Corrective action
Connecting rod Connecting rod twist and distortion Oil clearance Connecting rod bearing Free length of connecting rod bearing Bearing crush (measured load 600kg) Connecting rod endplay	— 0.04~0.099mm — 34.53~34.57mm 0.15~0.45mm	0.05mm 0.2mm Min. 69.5mm — 0.6mm	Repair or replace
Camshaft Intake cam max. length Intake cam min. length Intake cam lift Exhaust cam max. length Exhaust cam min. length Exhaust cam lift Camshaft endplay Clearance between camshaft journal and bushing	47.105mm 39.910mm 7.195mm 46.979mm 39.658mm 7.321mm 0.05~0.22mm Stamp mark #1,2,3,4 ([54.5] 0.04~0.09mm) Stamp mark #5 ([53] 0.04~0.09mm)	0.3mm 0.15mm	Replace busing
Crankshaft Out of roundness of pin and journal Out of cylindricity of pin and journal Crankshaft distortion (measured at journal No.1 and No.5) Crankshaft endplay	Below 0.01mm Below 0.006mm Below 0.02mm 0.10~0.26mm	0.03mm 0.03mm 0.05mm 0.4mm	Replace thrust plate
Crankshaft main bearing Oil clearance (#1, 2, 4, 5) Oil clearance (#3) Free length Bearing crush( measured load 500kgf)	0.036~0.098mm 0.056~0.118mm — 41.061~41.101mm	0.15mm 0.15mm Min 69.5mm —	Replace
Timing gear backlash Crankshaft gear and idler gear A Idler gear A and cam shaft gear Idler gear A and idler gear B Idler gear B and supply pump gear Camshaft gear and power steering pump gear Crankshaft gear and oil pump gear Power steering pump gear and vacuum pump gear	0.062~0.159mm 0.068~0.175mm 0.062~0.160mm 0.073~0.169mm 0.075~0.160mm 0.049~0.169mm 0.075~0.160mm		Repair or replace
Idler gear endplay	0.05~0.22mm	0.3mm	Replace thrust plate
Clearance between idler busing and idler shaft	[45] 0.025~0.06mm	0.1mm	Replace busing
Flywheel Distortion of frictional surface Height of frictional surface Run-out of frictional surface (while installed)	Below 0.05mm 24.5mm Below 0.1mm	0.2mm 23.5mm 0.2mm	Repair or replace



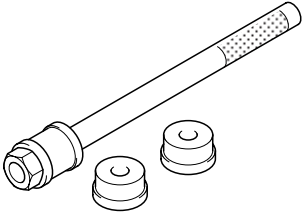
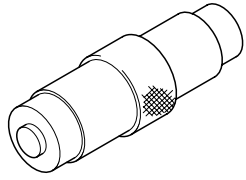
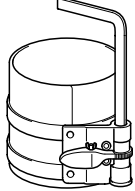
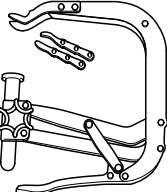
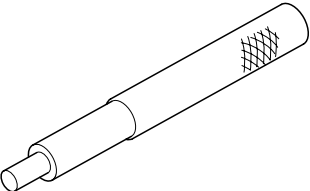
## TIGHTENING TORQUE

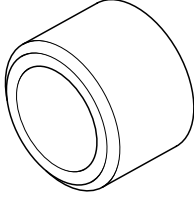
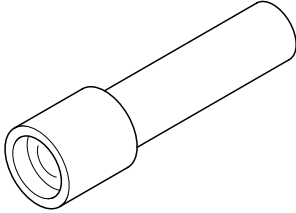
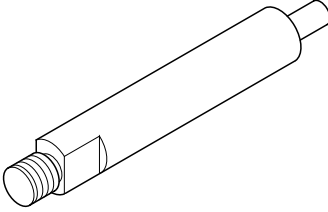
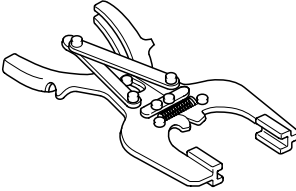
Items (diameter × length)		Screw size O.D×pitch (mm)	Nm	kgf.m	lb-ft
Cylinder block	Main bearing cap bolt	M14×2.0	49+90°	5.0+90°	36.4+90°
	Front plate flange bolt(8 ×16)	—	18.6~27.4	1.9~2.8	13.8~20.4
	Rear oil seal slinger flange bolt(6×12)	—	7.8~11.8	0.8~1.2	5.8~8.7
	Supply pump side timing gear case mounting bolt	—	18.6~27.4	1.9~2.8	13.8~20.4
	Supply pump flange bolt	—	16.7~25.5	1.7~2.6	12.4~18.9
	Oil jet check valve	M12×1.25	29.4	3.0	21.8
	Rear plate flange bolt(10×22)	M10×1.5	63.7	6.5	47.3
	Rear stiffener bracket flange bolt(8 ×55)	—	18.6~27.4	1.9~2.8	13.8~20.4
	Rear stiffener bracket flange bolt (10×90)	—	38.2~58.8	3.9~6.0	28.4~43.6
	Engine mounting bracket mounting bolt	—	32.3~49	3.3~5.0	24~36.4
	Crankcase oil line set screw	M10×1.5	24.5	2.5	18.2
Lubrication system	Oil strainer flange bolt(8 ×16)	—	18.6~27.4	1.9~2.8	13.8~20.4
	Oil strainer flange bolt (8 ×40)	—	18.6~27.4	1.9~2.8	13.8~20.4
	Oil pan mounting flange bolt (8×12)	M8×1.2	18.6~27.4	1.9~2.8	13.8~20.4
	Oil level gauge mounting flange bolt(8×16)	—	18.6~27.4	1.9~2.8	13.8~20.4
	Oil pan drain plug	M14×1.5	34.3~39.2	3.5~4.0	25.4~29.1
	Oil filter element	M26×1.5	19.6	2.0	14.5
	Oil cooler by-pass	M16×1.5	19.6	2.0	14.5
	Oil cooler relief valve	M16×1.5	19.6	2.0	14.5
	Oil cooler drain plug	M14×1.5	34.3	3.5	25.4
	Oil cooler mounting flange bolt	—	18.6~27.4	1.9~2.8	13.8~20.4
	Oil line flange bolt	—	7.8~11.8	0.8~1.2	5.8~8.7
	Oil line eyebolt	—	18.6~22.5	1.9~2.3	13.8~16.7
	Idler gear oil supply pipe	—	18.6~22.5	1.9~2.3	13.8~16.7
	Turbo charger oil pipe eyebolt	—	18.6~22.5	1.9~2.3	13.8~16.7
	Turbo charger oil pipe flange bolt(8×16)	—	18.6~27.4	1.9~2.8	13.8~20.4
Oil pump	Oil pump mounting flange bolt(8 ×55)	—	18.6~27.4	1.9~2.8	13.8~20.4
Cylinder head	Cylinder head mounting bolt	M14×2.0	147+90°	15.0+90°	109+90°
	Cylinder head stud (10×25)	—	34.3	3.5	25.4
	Cylinder head stud (10×48)	—	34.3	3.5	25.4

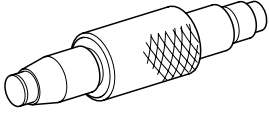
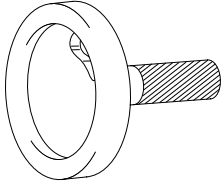
Items (diameter × length)		Screw size O.D×pitch (mm)	Nm	kgf.m	lb-ft
Fan and pulley	Fan clutch mounting flange bolt (8)	—	21.6~32.3	2.2~3.3	16~24
	Fan clutch spring washer bolt(8×25)	—	16.7~25.5	1.7~2.6	12.4~18.9
	Fan flange nut (6)	—	3.9~5.9	0.4~0.6	2.9~3.6
Thermostat housing	Thermostat cover case flange bolt	—	21.6~32.3	2.2~3.3	16~24
	Engine coolant temperature sensor and gauge	—	29.4~39.2	3.0~4.0	21.8~29.1
	Thermostat case flange bolt(10×25)	—	35.3~52.9	3.6~5.4	26.2~39.3
Timing system	Timing gear case flange bolt	M8×1.25	18.6~27.4	1.9~2.8	13.8~20.4
	Rocker cover mounting flange bolt	M8×1.25	12.7~15.7	1.3~1.6	9.5~11.6
	Cam plate and thrust plate flange bolt	—	18.6~27.4	1.9~2.8	13.8~20.4
	Cam plate and oil drain plug	—	58.8~78.4	6.0~8.0	43.6~58.2
	Camshaft gear flange bolt	—	18.6~27.4	1.9~2.8	13.8~20.4
	Idler gear A, B mounting bolt	M8×1.25	18.6~27.4	1.9~2.8	13.8~20.4
	Supply pump of flower valve	—	7.8~12.7	0.8~1.3	5.8~9.5
Bleeder system	Blow-by return pipe and blow-by hose Protect clip flange nut	— —	9.8~14.7	1.0~1.5	7.3~10.9
	Oil separate mounting flange bolt	—	18.6~27.4	1.9~2.8	13.8~20.4
	PCV blow-by return coating clip flange bolt	—	7.8~11.8	0.8~1.2	5.8~8.7
	Blow-by return pipe mounting flange bolt	—	35.3~52.9	3.6~5.4	26.2~39.3
Alternator and vacuum pump	Alternator adjust plate mounting bolt(10×20)	—	35.3~52.9	3.6~5.4	26.2~39.3
	Alternator adjust shaft mounting nut (10)	—	18.6~27.4	1.9~2.8	13.8~20.4
	Alternator assembly mounting bolt	M12×134	78.4~107.8	8.0~11	58.2~80
	Vacuum pump pipe tightening bolt	M6×14	3.9~5.9	0.4~0.6	2.9~3.6
	Vacuum pump mounting flange bolt	M8×16	18.6~27.4	1.9~2.8	13.8~20.4
Piston and connecting rod	Connecting rod and connecting rod bearing cap mounting bolt	M12.5×1.25	29.4+90°	3.0+90°	21.8+90°
Flywheel and damper pulley	Flywheel mounting bolt	M14×1.5	39.2+40°	4.0+40°	29.1+40°
	Crankshaft damper pulley mounting nut	M24×1.5	588	60	436
Starter motor	Mounting flange bolt (12×25)	—	78.4~107.8	8.0~11.0	58.2~80
	Mounting flange bolt (12×55)	—	37.2~53.9	3.8~5.5	27.6~40
	Mounting flange bolt (12)	—	37.2~53.9	3.8~5.5	27.6~40
Glow plug	Glow plug harness flange nut	—	3.9~5.9	0.4~0.6	2.9~3.6
	Plain washer nut	—	1~1.5	0.1~0.15	0.7~1.1

Items (diameter × length)		Screw size O.D×pitch (mm)	Nm	kgf.m	lb-ft
Intake manifold	Actuator mounting flange bolt	—	7.8~11.8	0.8~1.2	5.8~8.7
	Butterfly valve shaft mounting nut (8)	—	16.7~27.4	1.7~2.8	12.4~20.4
	Intake manifold front hanger mounting flange bolt (10×20)	—	32.3~49	3.3~5.0	24~36.4
	Intake manifold mounting flange bolt (8 ×20)	—	18.6~27.4	1.9~2.8	13.8~20.4
Exhaust manifold	Exhaust manifold heater protector cover mounting bolt	M8×1.25	11.8	1.2	8.7
	Exhaust manifold assembly self lock Flange nut	M10×1.25	41.2	4.2	30.5
Engine cover	Top shield bolt screw	—	7.8~11.8	0.8~1.2	5.8~8.7
Turbo charger	Turbo charger and intake pipe clamp band	M9×2.5	3.9	0.4	2.9
	Turbo charger oil pipe eyebolt	M8×1.25	11.8	1.2	8.7
Fuel system	Fuel suction hose	—	14.7~19.6	1.5~2.0	10.9~14.5
	Common rail fuel return B mounting screw	—	16.7~22.5	1.7~2.3	12.4~16.7
	Fuel return A and fuel supply hose protect clip flange bolt	—	9.8~19.6	1.0~2.0	7.3~14.5
	Fuel return A and rear plate clamp plate bolt	—	3.9~5.9	0.4~0.6	2.9~3.6
	Injector pipe (No.1, 2, 3, 4)	—	39.2~49	4.0~5.0	29.1~36.4
	Injector nozzle bridge bolt	—	30.4~34.3	3.1~3.5	22.5~25.4
	Common rail bracket Flange bolt	—	21.6~32.3	2.2~3.3	16~24
	Pipe (between supply pump and common rail)	—	39.2~49	4.0~5.0	29.1~36.4
Sensor	Engine speed sensor mounting bolt	—	7.8~11.8	0.8~1.2	5.8~8.7
	Cam speed sensor mounting bolt	—	7.8~11.8	0.8~1.2	5.8~8.7
	Booster pressure sensor (M.A.P) mounting bolt	—	7.8~11.8	0.8~1.2	5.8~8.7

## SPECIAL TOOL E2E65F7D

Tool (part no. and part name)	Shape	Usage
09212-41200 Camshaft bushing remover and installer	 <p style="text-align: right;">KDDEM5015A</p>	Installation and removal of camshaft bushing
09246-41000 Idler gear bushing puller	 <p style="text-align: right;">KDDEM5016A</p>	Installation and removal of connecting rod bushing
09222-83200 Piston guide clamp	 <p style="text-align: right;">KDDEM5017A</p>	Installation of piston
09222-83300 Valve spring compressor	 <p style="text-align: right;">KDDEM5018A</p>	Installation and removal of valve cotter
09221-41100 Valve guide remover	 <p style="text-align: right;">KDDEM5019A</p>	Removal of valve guide

Tool (part no. and part name)	Shape	Usage
09221-41150 Valve guide installer	 KDD5020A	Installation of valve guide (Use together with 09211-41100)
09222-45100 Valve stem seal installer	 KDD5021A	Installation of valve stem seal
09353-45100 Air compressor adapter	 KDD5022A	Measurement of compression pressure
09222-83200 Piston ring tool	 KDD5023A	Installation and removal of piston ring

Tool (part no. and part name)	Shape	Usage
09222-45000 Rocker bush puller	 KDDEM5024A	Installation and removal of rocker bush
09211-41000 Oil seal slinger installer	 KDDEM5025A	Installation and removal of crankshaft rear oil seal slinger

## DIAGNOSIS E252285B

Symptom	Possible cause	Maintenance
Compression pressure is excessively low	Cylinder head Gasket is melt Piston ring is worn or damaged Piston or cylinder is damaged Valve seat worn or damaged	Replace gasket (check the status of head surface, block head) Replace the ring Repair or replace piston or cylinder block Repair or replace valve or seat ring
Oil pressure is excessively low	Engine oil depleted Oil pressure switch fail Oil filter clogged Oil pump gear or case is worn Engine oil viscosity is low Oil relief valve stuck (open) Excessive bearing clearance	Add engine oil Replace oil pressure switch Replace the filter with new one Replace the gear or case Replace engine oil Repair valve Replace the bearing
Oil pressure is excessively high	Oil relief valve stuck (close)	Repair the relief valve
Connecting rod noise or main bearing noise	Improper oil supply Low oil pressure Low engine oil viscosity Excessive bearing clearance	Check the engine oil level Refer to 'oil pressure is excessively low' Replace engine oil Replace the bearing
Excessive engine vibration	Engine mounting bolt is loose Transmission mounting bolt is loose Cross member bolt is loose Engine mounting rubber is damaged Transmission mounting rubber is damaged	Retighten Retighten Retighten Replace Replace
Engine coolant level is low	Engine coolant leak Radiator core joint is damaged Radiator and heater hose corroded and cracked Radiator cap valve or spring setting is defective Thermostat defect Water pump defect	Replace
Radiator is clogged	Foreign substance intrusion into engine coolant	Replace
Engine coolant temperature is abnormally high	Thermostat is defective Radiator cap is defective Cooling system flow is defective Drive belt is loose Water pump is defective Temperature wiring is defective Radiator fan is defective Engine coolant is low	Replace Replace Replace Adjust or Replace Replace Repair or replace Repair or replace Add coolant
Engine coolant temperature is abnormally low	Thermostat is defective Temperature wiring is defective	Replace Repair or replace
Oil cooling system leaks	Hose or pipe connection is loose Hose and pipe is cracked or damaged	Retighten Replace
Radiator fan is inoperative	Damage	Repair or replace

Symptom	Possible cause	Maintenance
Exhaust gas leaks	Connection is loose Pipe or muffler is damaged	Retighten Repair or replace
Unusual noise	Baffle plate inside the muffler fell off Rubber hanger is damaged Pipe or muffler interferes with the body Pipe or muffler is damaged	Replace Replace Repair Repair or replace

## ADJUSTMENT E148032F

### COMPRESSION PRESSURE

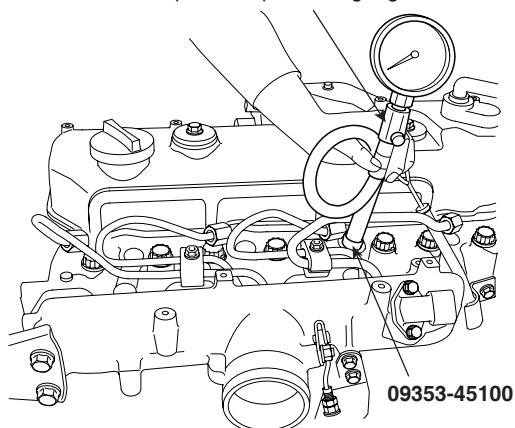
- Before performing on-vehicle inspection, check to see whether engine oil, starter motor and battery are in normal condition.
- Start the engine and warm up until the coolant temperature reaches 80~90°C.
- Stop the engine and remove the ECM fuse.
- Remove all injectors from cylinder head.

#### CAUTION

**Be careful that foreign materials do not intrude through the injector installation hole.**

- Crank the engine to remove the foreign materials from cylinders.
- Install compression gauge adaptor (09353-45100) together with gasket and then, connect the compression gauge.

Compression pressure gauge



SUDEM7015L

- Crank the engine and measure the compression pressure.

#### CAUTION

- Take care that fuel is not injected.
- Since compression pressure varies depending on the engine speed, be careful in measuring.
- Since worn amounts of each cylinder are different, measure the pressure at all cylinders.

- Measure the compression pressure of all cylinders to see if all compression pressures are within the limit.

Items		Standard	Limit	Corrective action
Compression pressure (200rpm)	Each cylinder	26kg/cm <sup>2</sup>	20kg/cm <sup>2</sup>	Check
	Difference between cylinders	—	4kg/cm <sup>2</sup>	Check

- If the compression pressure difference of any cylinder exceeds the limit, fill some engine oil through injector hole and measure the compression pressure of the cylinder again.

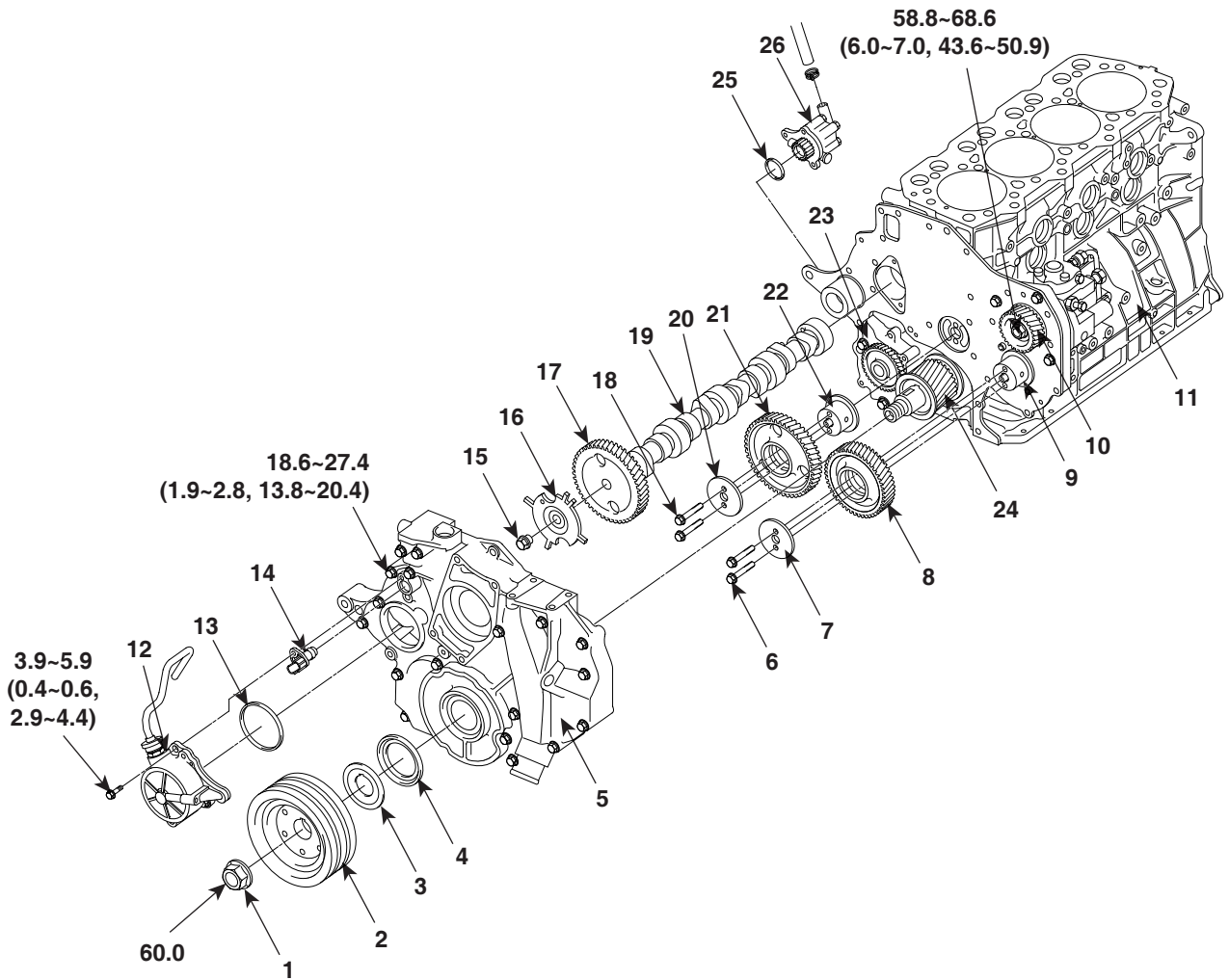
- If the compression pressure increases, it indicates that the piston, piston ring or cylinder wall is worn or damaged.
- If the compression pressure does not increase, it indicates that valve is stuck, valve contact is poor or pressure is leaking through the cylinder head gasket.



# TIMING SYSTEM

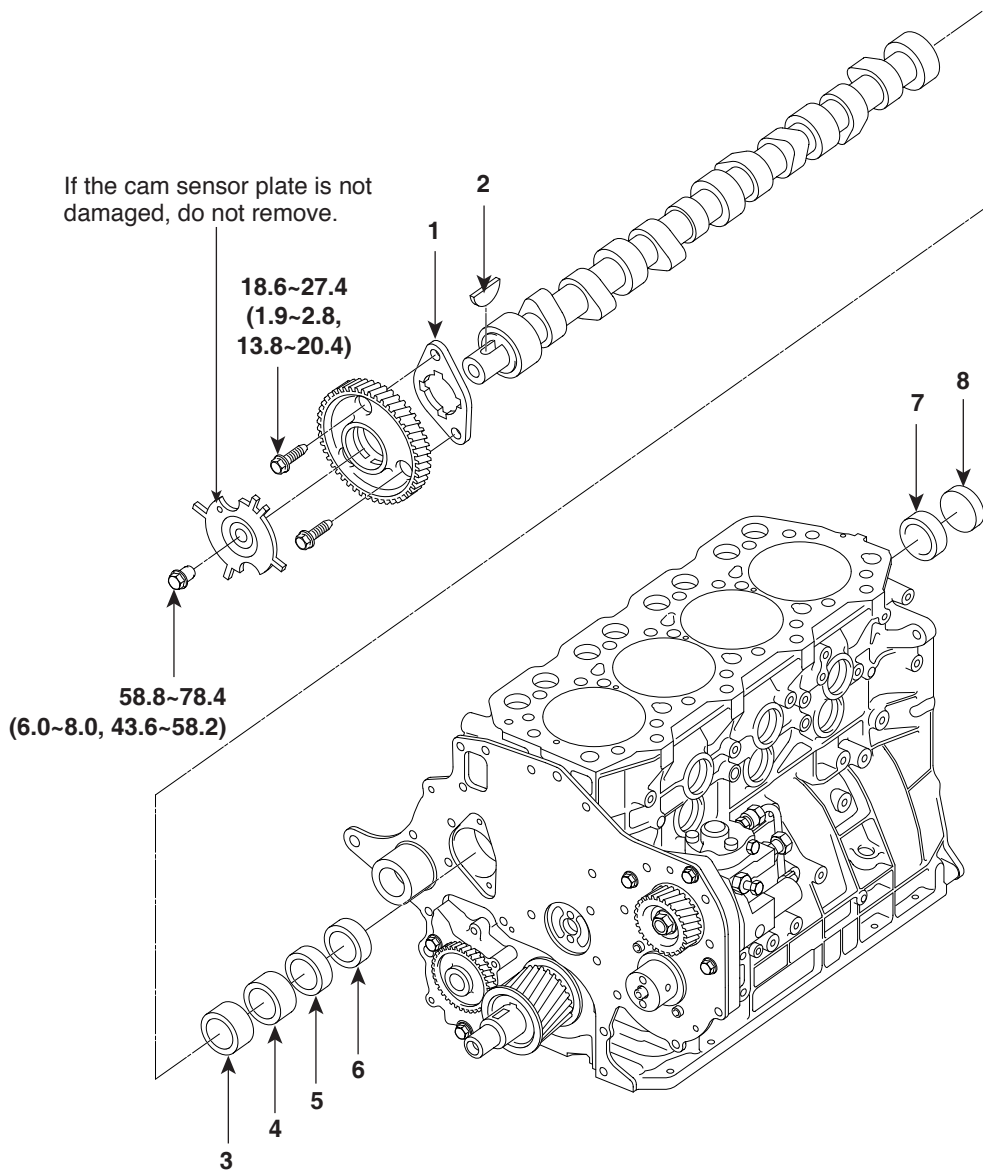
## TIMING GEAR ASSEMBLY

### COMPONENTS E2F63E1E



- |                                 |                                |                             |
|---------------------------------|--------------------------------|-----------------------------|
| 1. Crankshaft damper pulley nut | 11. Crankcase                  | 20. Thrust plate            |
| 2. Crankshaft damper pulley     | 12. Vacuum pump                | 21. Idler gear A            |
| 3. Front oil slinger            | 13. O-ring                     | 22. Idler shaft             |
| 4. Front oil seal               | 14. Camshaft sensor            | 23. Oil pump gear           |
| 5. Timing gear case             | 15. Oil drain plug             | 24. Crankshaft gear         |
| 6. Idler gear B mounting bolt   | 16. Cam sensor plate           | 25. O-ring                  |
| 7. Thrust plate                 | 17. Camshaft gear              | 26. Power steering oil pump |
| 8. Idler gear B                 | 18. Idler gear A mounting bolt |                             |
| 9. Idler shaft                  | 19. Camshaft                   |                             |
| 10. Supply pump gear            |                                |                             |

Tightening Torque : Nm (kgf.m, lb-ft)

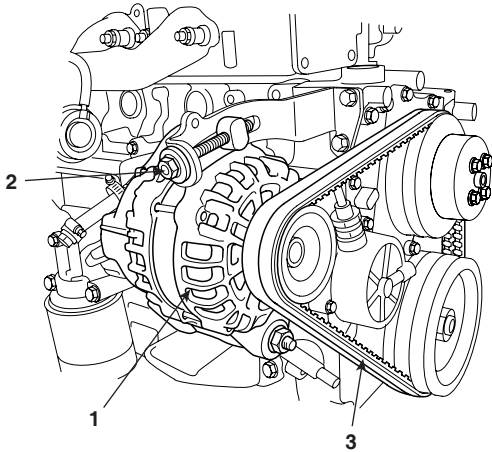


1. Thrust plate
2. Semicircular key
3. No.1 camshaft bush
4. No.2 camshaft bush
5. No.3 camshaft bush
6. No.4 camshaft bush
7. No.5 camshaft bush
8. Sealing cap

Tightening Torque : Nm (kgf.m, lb-ft)

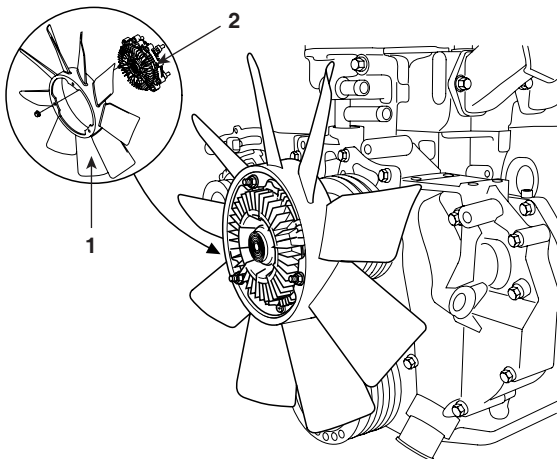
**REMOVAL** E812C03D

1. Loosen the alternator (1) tensioner screw (2) and remove the V-belt(3).



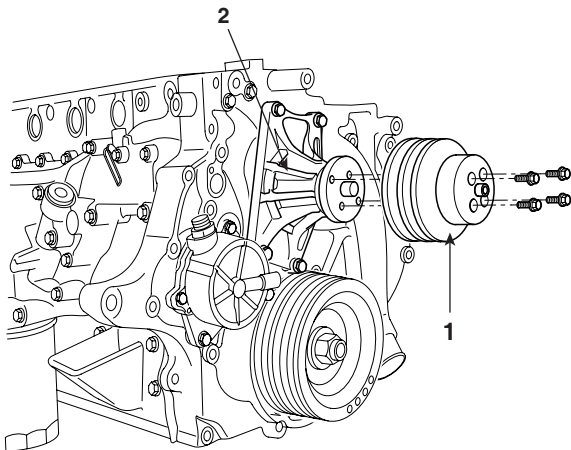
SUDEM7018L

2. Remove the cooling fan (1) and auto cooling fan coupling (2).



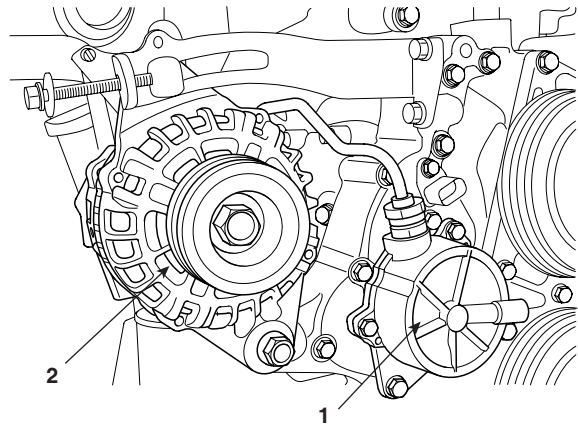
SUDEM7019L

3. Remove the water pump pulley (1) and water pump assembly (2).



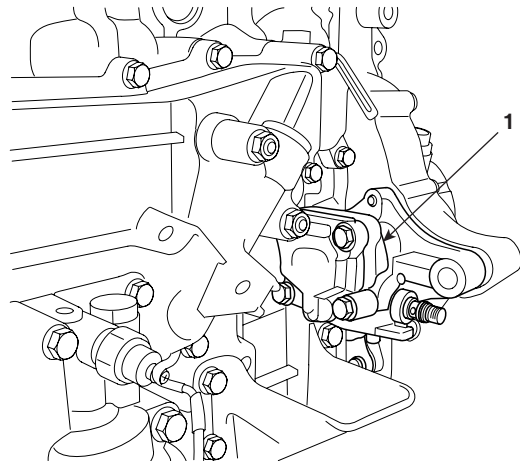
SUDEM7020L

4. Remove the vacuum pump (1) and alternator assembly (2).



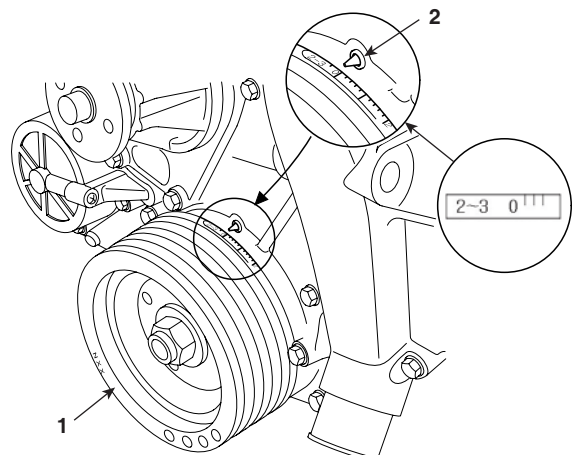
SUDEM7021L

5. Remove the power steering pump (1).



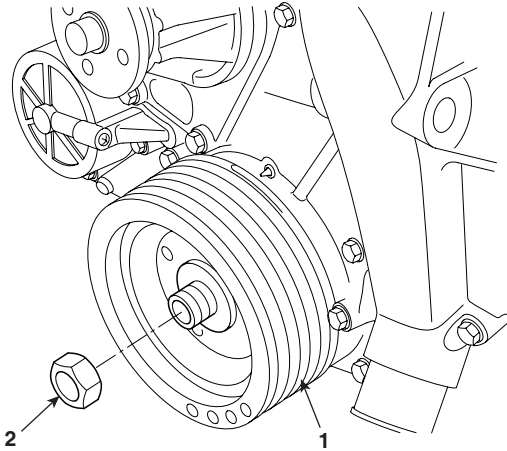
SUDEM7022L

6. Align the timing mark "0" of crankshaft damper pulley (1) with the indicator (2) of the timing gear case. Then, cylinder No. 1 is positioned at TDC of compression stroke.



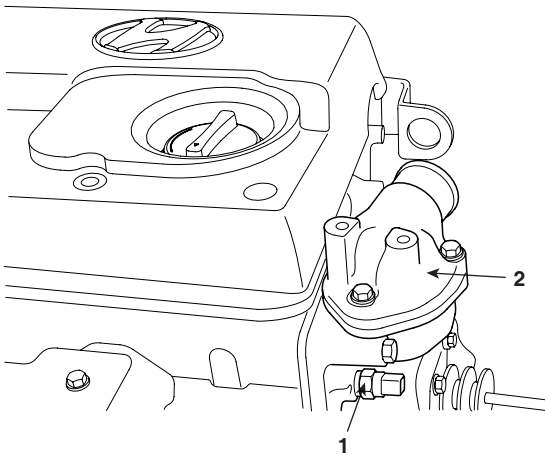
SUDEM7023L

7. Remove the crankshaft damper pulley nut (2) and remove the crankshaft damper pulley (1).



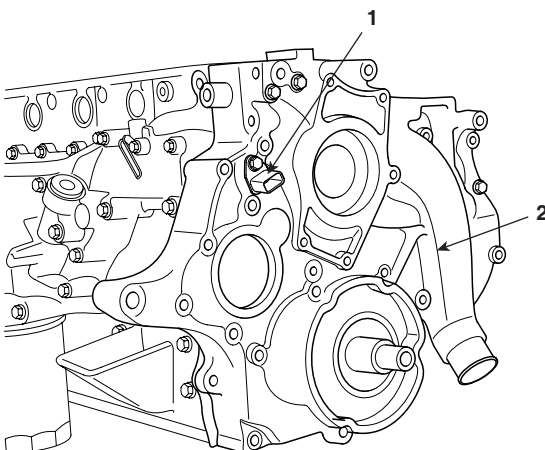
SUDEM7024L

8. Remove the engine coolant temperature sensor (1) connector and remove the thermostat housing (2) from the cylinder head.



SUDEM7025L

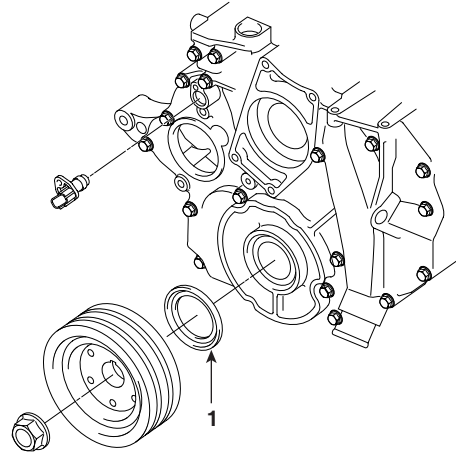
9. Remove the cam speed sensor (1) from the timing gear case and then remove the timing gear case (2).



SUDEM7026L

 **NOTE**

Check the front oil seal (1) state. If it is normal, do not remove it.

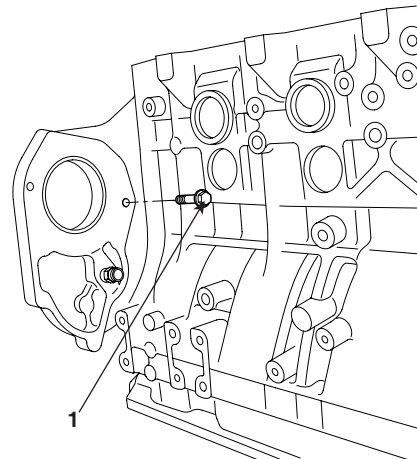


SUDEM7027L

 **CAUTION**

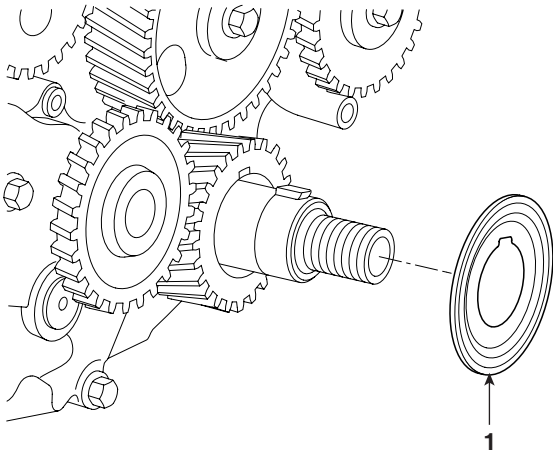
Before removing the timing gear case, remove timing gear case mounting bolt (1) at the supply pump first.

If the mounting bolt at the supply pump is not removed, timing gear case will not be removed.



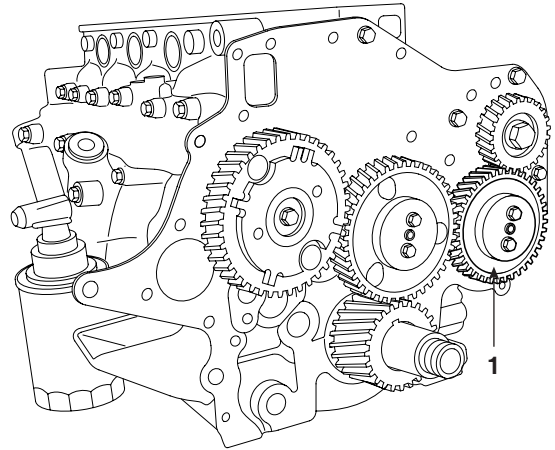
SUDEM7028L

10. Remove the front oil seal slinger (1).



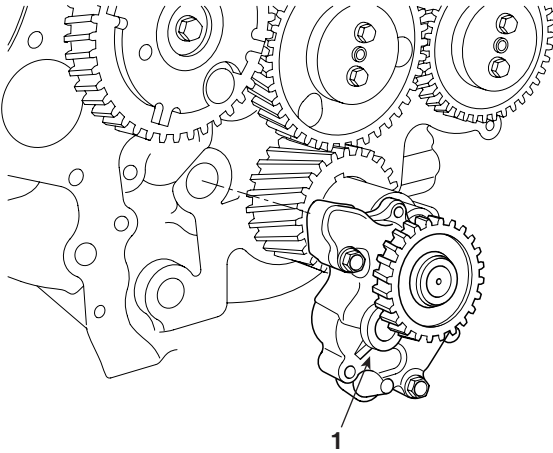
SUDEM7029L

13. Remove the idler gear B (1).



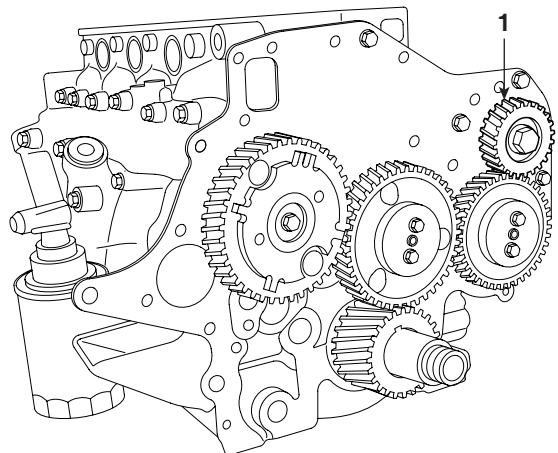
SUDEM7032L

11. Remove the oil pump gear (1).



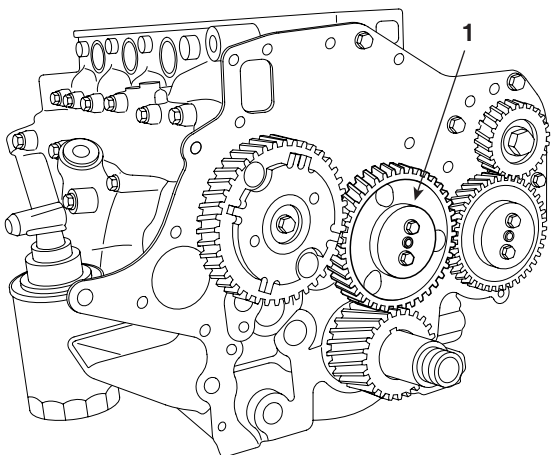
SUDEM7030L

14. Remove the supply pump gear (1).



SUDEM7033L

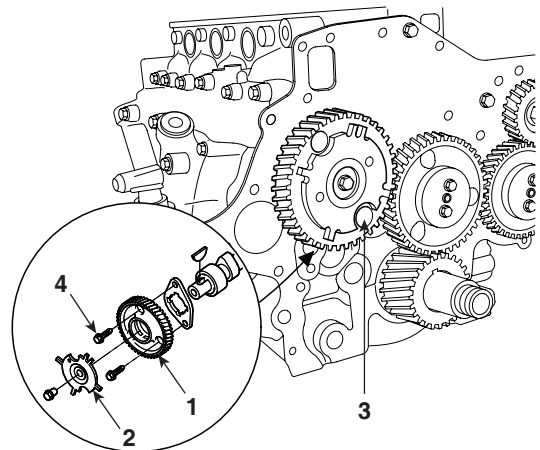
12. Remove the idler gear A (1).



SUDEM7031L

15. Remove the camshaft assembly.

- 1. Remove the thrust plate-mounting bolt (4) through cam sensor plate (2) hole (3) of camshaft gear (1).

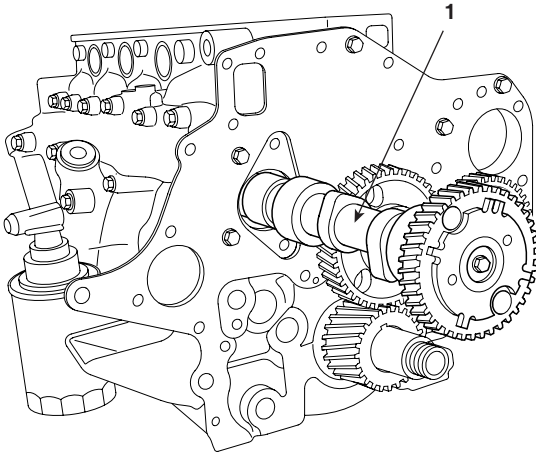


SUDEM7034L

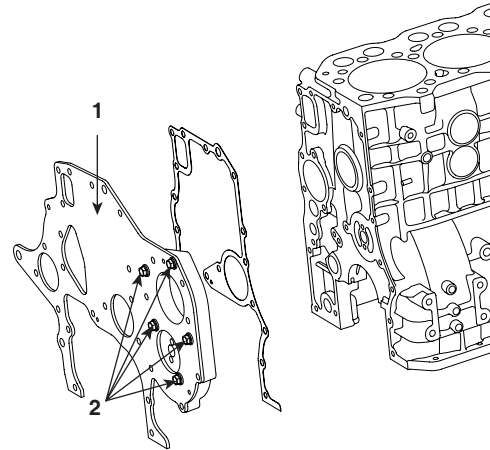
 **NOTE**

Do not remove the cam sensor plate (2), if it is not damaged.

- When removing the camshaft assembly (1), handle cam bush carefully not to be damaged.



SUDEM7035L



SUDEM7037L

**INSPECTION** EB5EDDCB

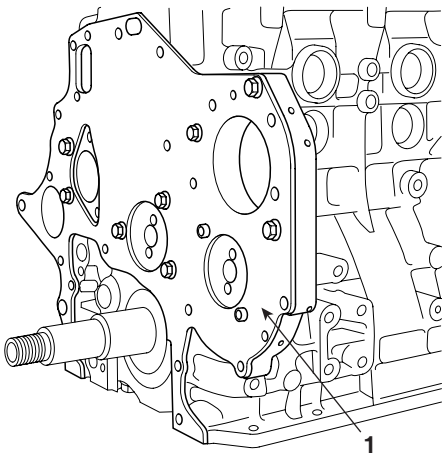
- Measure inner diameter of idler gear (1) and outer diameter of idler shaft (2). If the gap exceeds the limit, replace the idler gear bush.

---

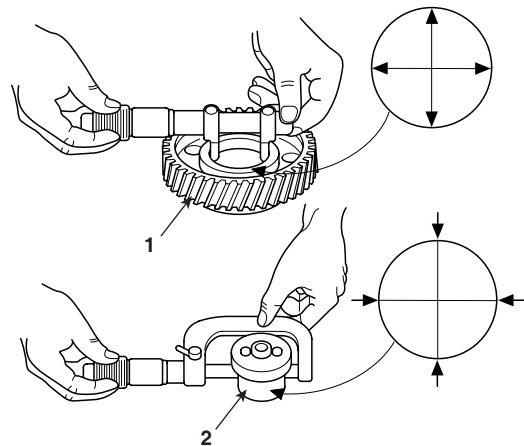
Reference gap between idler bush and idler shaft ([ ] indicates reference diameter): [45] 0.025~0.06mm  
Limit: 0.1mm

---

- Remove the front plate (1).



SUDEM7036L



SUDEM7038L

 **CAUTION**

When removing the front plate (1), do not remove the bolts (2) processed with spacers. If they were removed, assemble them based on the dowel pin and then sealant must be applied between front plate and spacers.

- Measure cam max (1) and min diameter (2). Replace the camshaft assembly, if it exceeds the limit.

 **NOTE**

The difference between the max and min diameter is the lift of the cam



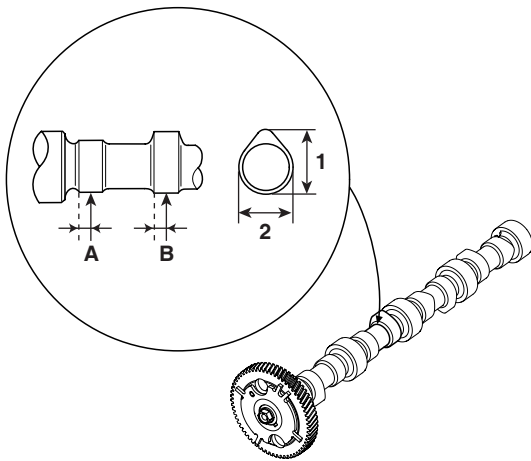
Unit: mm

Items	Min cam diameter (2)	Max cam diameter (1)	Cam lift
Intake cam	39.910	47.105	7.195
Exhaust cam	39.658	46.979	7.321

**! CAUTION**

Since taper cam is used, measure it as shown in the figure.

Measuring position	A	B
	6.5mm	6.5mm



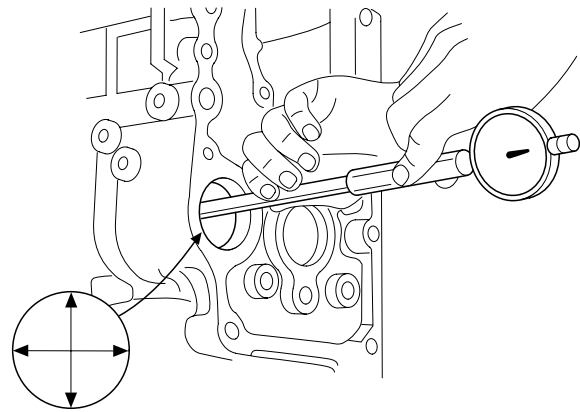
SUDEM7039L

3. Measure the outer diameter of camshaft journal and the inner diameter of camshaft bush in the crankcase. If the gap exceeds the limit, repair the camshaft bushing with oversize.

---

Outer diameter of camshaft journal  
 Journal No. # 1, 2, 3 and 4: 54.44~54.46 mm  
 Journal No. # 5: 52.94~52.96 mm  
 Inner diameter of camshaft bushing  
 Journal # 1, 2, 3 and 4: 54.5mm  
 Journal # 5: 53mm  
 Gap between camshaft journal and bushing  
 Reference: [54.5] 0.04~0.09mm  
               [53] 0.04~0.09mm  
 Limit: 0.15mm

---



SUDEM7040L

4. Measure the distortion of camshaft. If it exceeds the limit, replace or repair it with press.

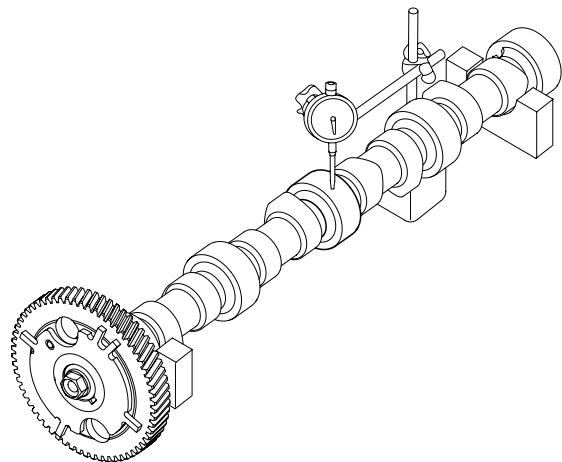
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Distortion of camshaft: 0.02mm

---

**NOTE**

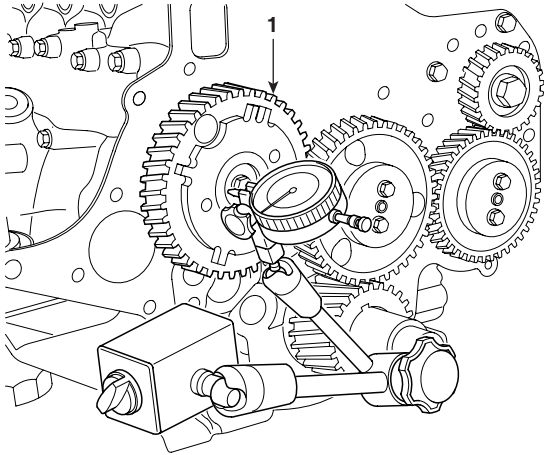
Place the camshaft on the precision block and turn the camshaft in 1 revolution. And read the dial indicator. The distortion of the camshaft is a half of the measurement.



SUDEM7041L

5. Measure the camshaft (1) endplay. If it exceeds the limit, repair or replace it.

Camshaft endplay  
 Reference: 0.05mm~0.22mm  
 Limit: 0.3mm



SUDEM7042L

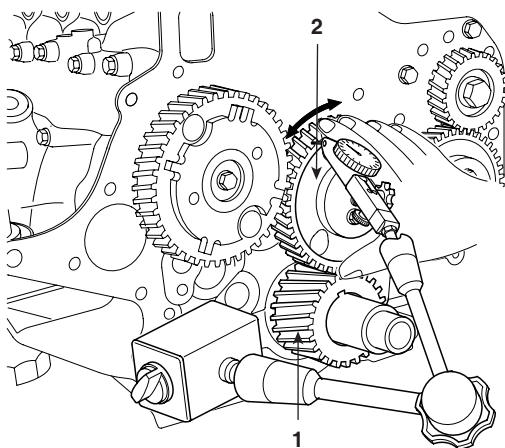
6. Measure the backlash of each gear and replace it if necessary.

**NOTE**

When measuring the backlash, fix the gear contacting the corresponding gear and move the gear to the left and right to measure the backlash.

- a. Crankshaft gear (1) and idler gear A (2)

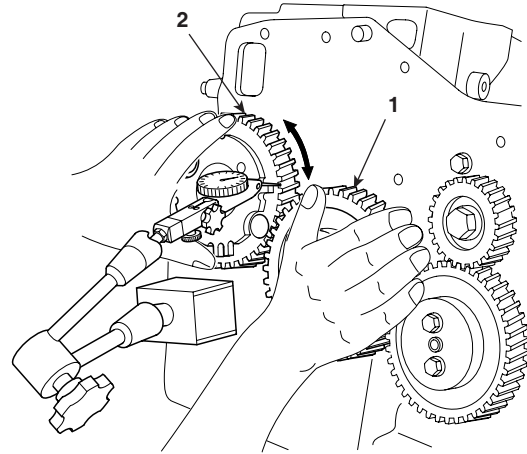
Reference: 0.062~0.159mm



SUDEM7043L

- b. Idler gear A (1) and camshaft gear (2)

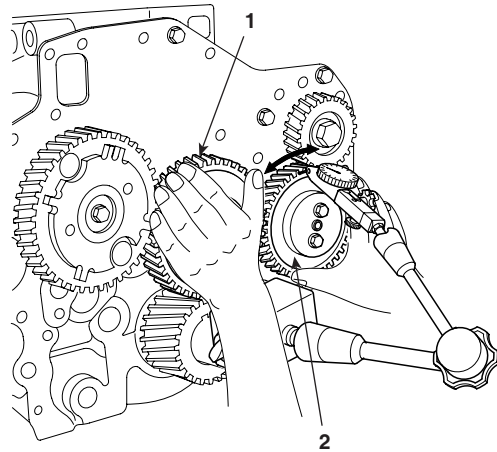
Reference: 0.068~0.175mm



SUDEM7044L

- c. Idler gear A (1) and idler gear B (2)

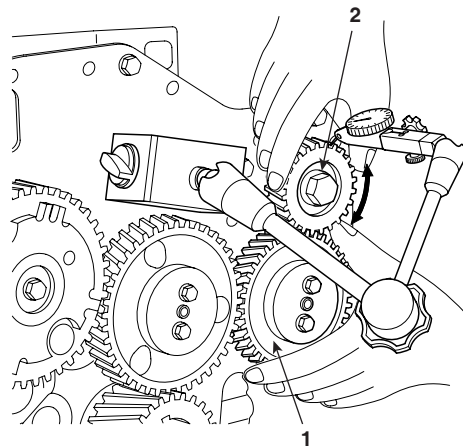
Reference: 0.062~0.160mm



SUDEM7045L

- d. Idler gear B (1) and supply pump gear (2)

Reference: 0.073~0.169mm

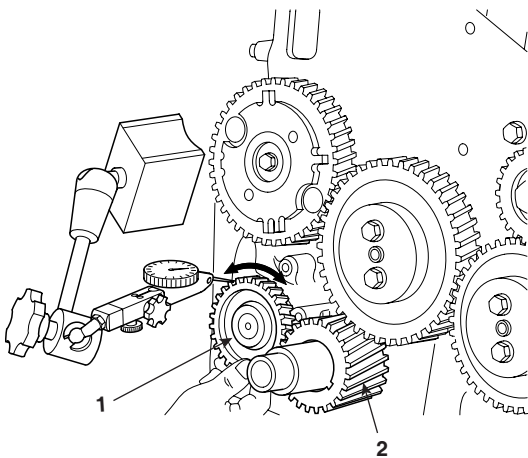


SUDEM7046L



- e. Oil pump gear (1) and crankshaft gear (2)

Reference: 0.049~0.169mm



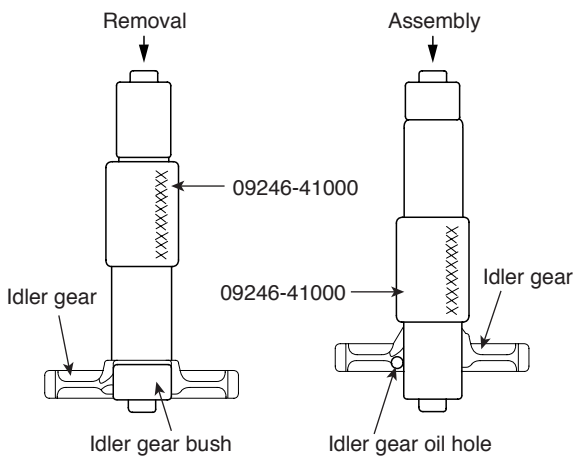
SUDEM7047L

**REPLACEMENT** EF56BCEF

1. Replacement of idler gear bush  
Replace idler gear bush using the special tool (09246-41000).

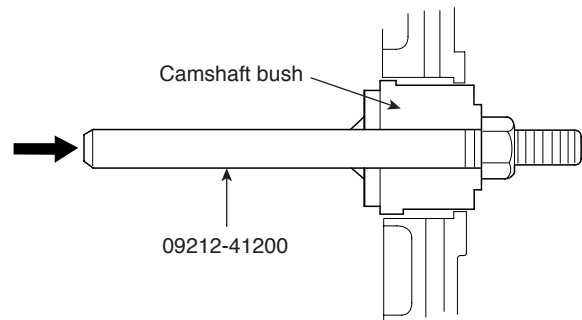
**CAUTION**

- When assembling the bush, align the bush oil hole with gear oil hole.*
- Check to see whether the clearance between bush and idler gear shaft satisfies the reference.*



SUDEM7048L

2. Replacement of camshaft bush
  - Remove the sealing cap from the crankcase camshaft hole.
  - Remove the camshaft bush using the special tool (09212-41200).



SUDEM7049L

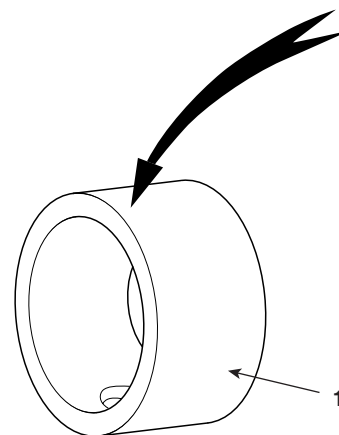
- c. Install the camshaft bush (1).

**NOTE**

When assembling camshaft bush, distinguish the bush by the number marked outside, which tells the installing position. If the marked numbers are illegible, measure the inner diameter and width of the bush.

Unit: mm

Bush No. (From the front of engine)	Carved mark	Outer diameter	Inner diameter	Width
No.1	1	58.519	54.5	33
No.2	2	58.269	54.5	22
No.3	3	58.019	54.5	22
No.4	4	57.769	54.5	22
No.5	5	57.019	53.0	22

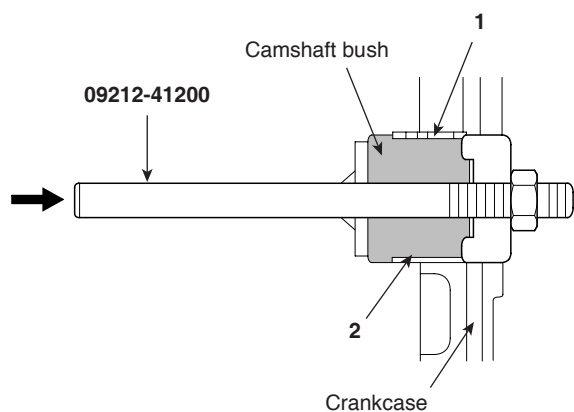


SUDEM7050L

- d. Press fit the bush using the special tool (09212 - 41200) so that the camshaft bush end aligns crankcase end.

**NOTE**

When installing the camshaft bushing, align the oil hole of bush with crankcase oil hole (2).

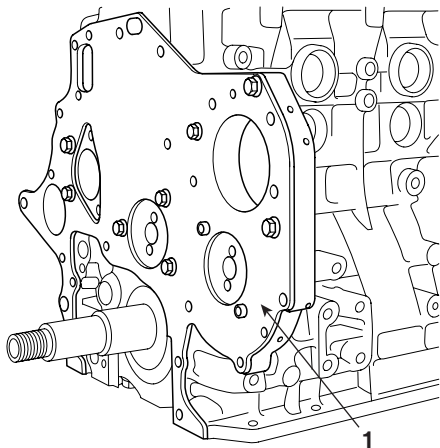


SUDEM7051L

## INSTALLATION

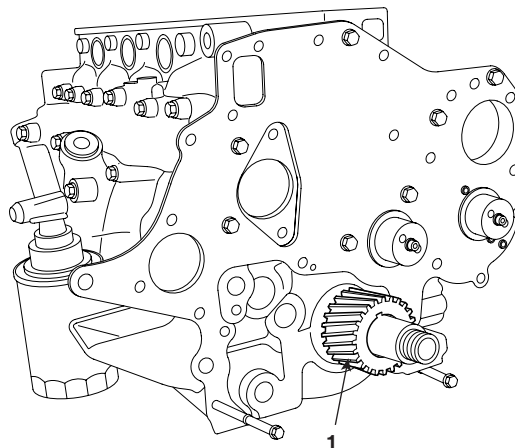
EEFAD1F1

1. Install the front plate (1).



SUDEM7052L

2. Install the crankshaft gear (1).

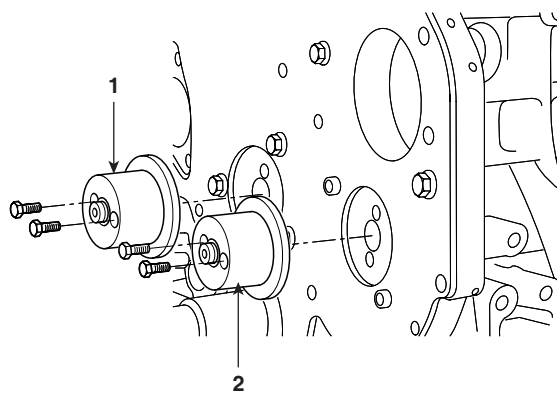


SUDEM7053L

3. Install the idler shaft A (1) and idler shaft B (2).

**CAUTION**

- When installing the idler shaft A and B, do not tighten the mounting bolts at once.
- After installing the idler shaft A and B, check to see whether the shaft rotates smoothly.

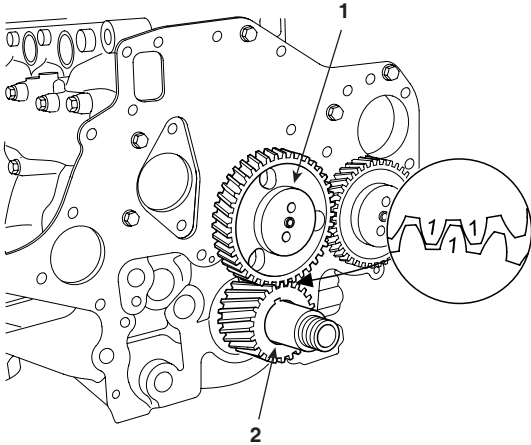


SUDEM7054L

4. Install idler gear A and B.

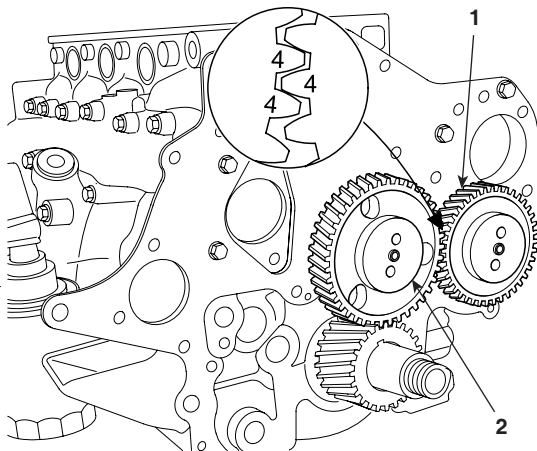
**! CAUTION**

a. *When installing, align the timing mark "1" of idler gear A (1) with the timing mark "1" of crankshaft gear (2).*



SUDEM7055L

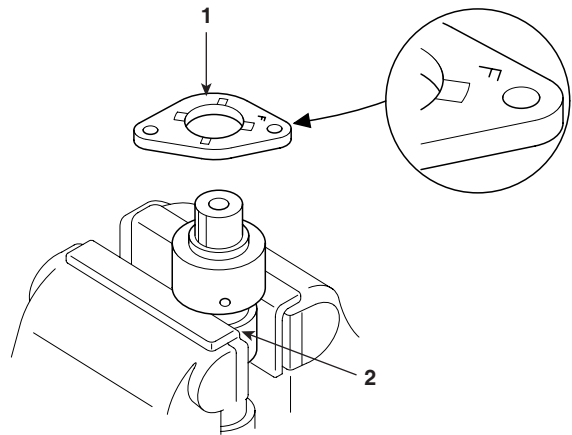
b. *When installing, align the timing mark "4" of idler gear B (1) with the timing mark "4" of idler gear A (2).*



SUDEM7056L

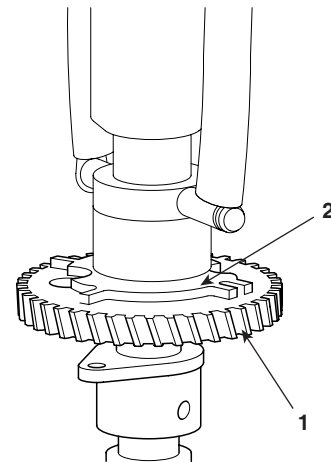
5. Install the camshaft gear assembly.

a. Install the thrust plate (1) so that the "F" mark of its oil hole faces to the camshaft gear (2).



SUDEM7057L

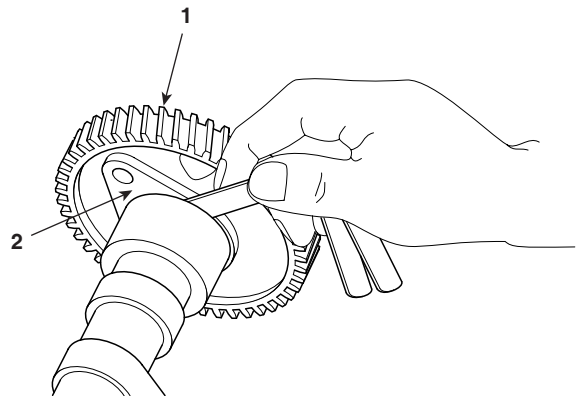
b. Press fit the camshaft gear assembly (1) of the cam plate (2) so that it faces outward.



SUDEM7058L

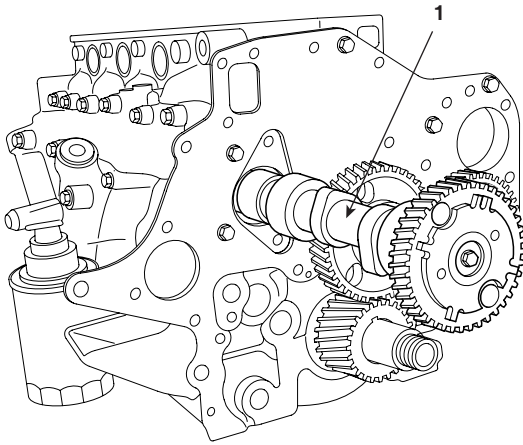
c. Measure the endplay between camshaft gear (1) and thrust plate (2) and install them as the clearance to be within the reference.

Reference: 0.05~0.22mm



SUDEM7059L

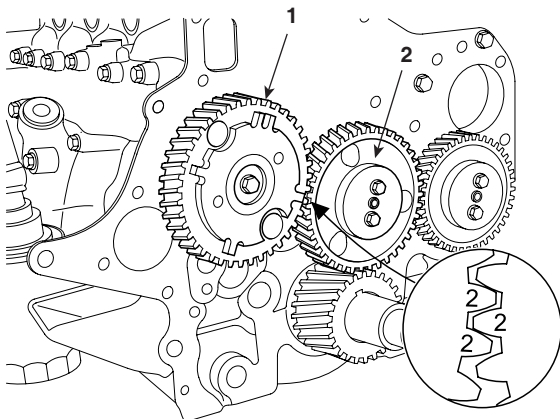
- d. Install the camshaft assembly (1) to the crankcase.



SUDEM7060L

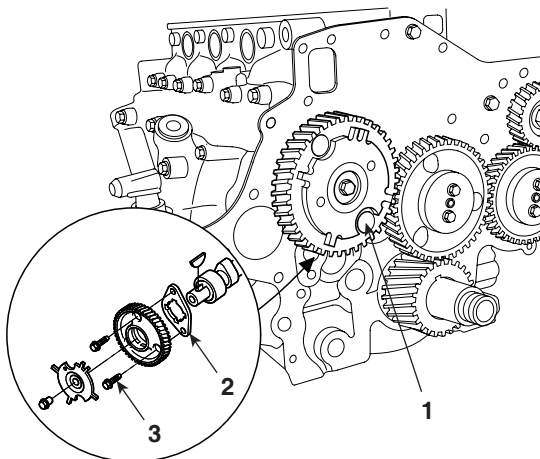
**! CAUTION**

When installing, align the timing mark "2" of camshaft gear A (1) with the timing mark "2" of idler gear A (2).



SUDEM7061L

- e. Install the thrust plate (2) mounting bolt (3) through the hole of camshaft cam plate hole (1).

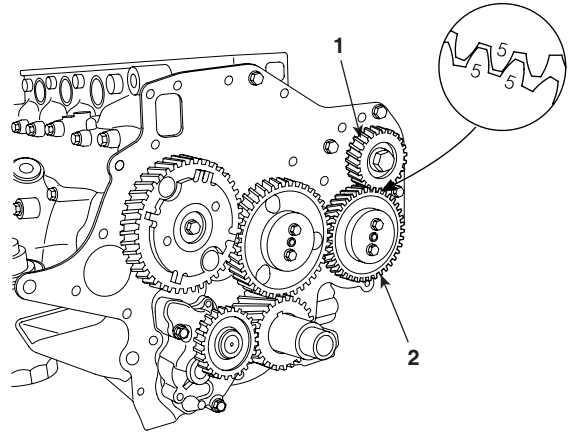


SUDEM7062L

6. Install the supply pump gear.

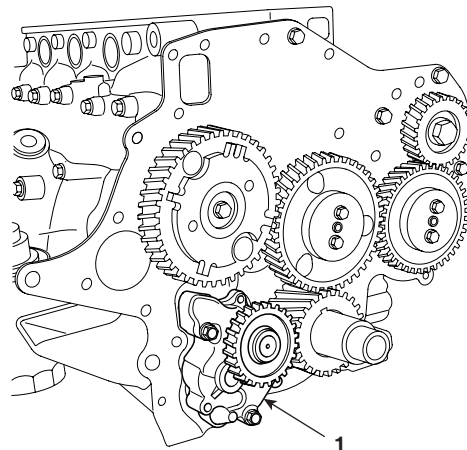
**! CAUTION**

When installing, align the timing mark "5" of supply pump (1) with the timing mark "5" of idler gear B (2).



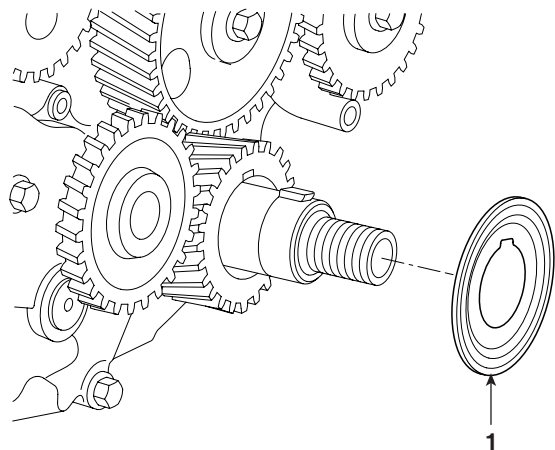
SUDEM7063L

7. Install the oil pump gear (1).



SUDEM7064L

8. Install the front oil seal slinger (1).



SUDEM7065L

9. Install the front timing gear case (1).

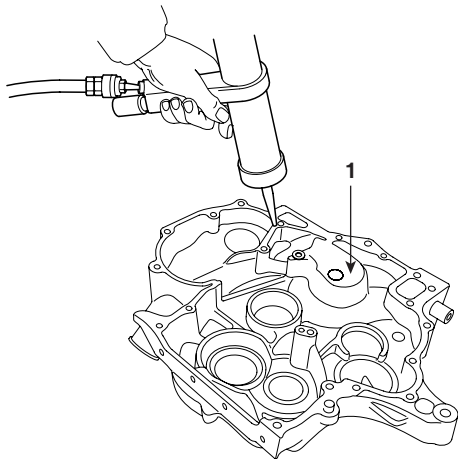
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Tightening torque: 21.6~32.3 Nm  
(2.2~3.3 kgf.m, 16~24 lb-ft)

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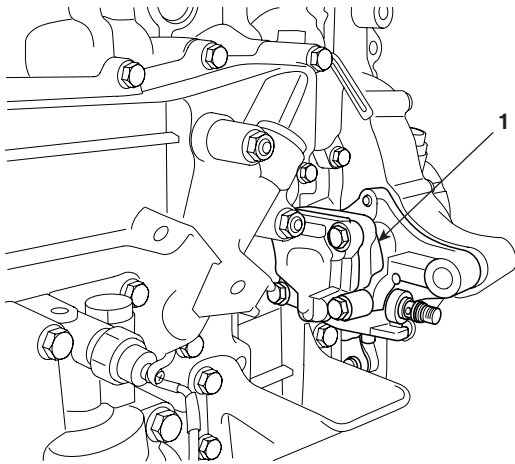
**! CAUTION**

- a. Apply the Loctite #5699 or equivalent on the assembly surface of timing gear case (1), and then assemble it within 3 minutes.
- b. Do not start the engine within 1 hour after installing the timing gear case.



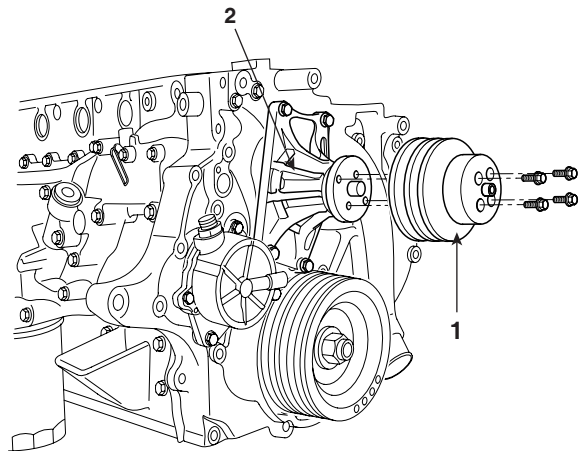
SUDEM7066L

10. Install the power steering pump (1).



SUDEM7067L

11. Install the water pump pulley (1) and water pump assembly (2).



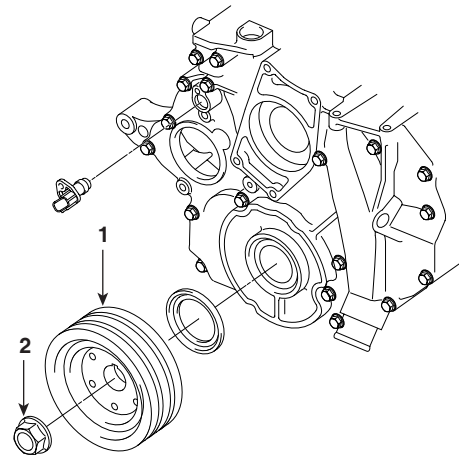
SUDEM7068L

12. Install the crankshaft damper pulley (1) and damper pulley mounting nut (2).

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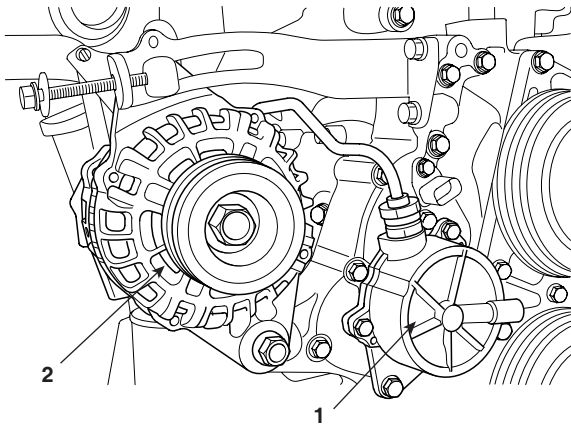
Tightening torque: 588 Nm  
(60 kgf.m, 436 lb-ft)

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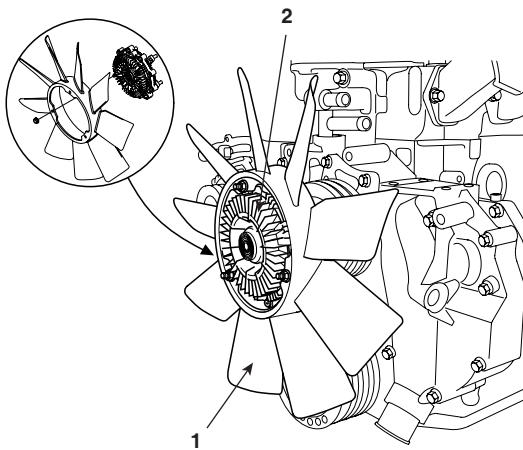
SUDEM7069L

13. Install the vacuum pump (1) and alternator assembly (2).



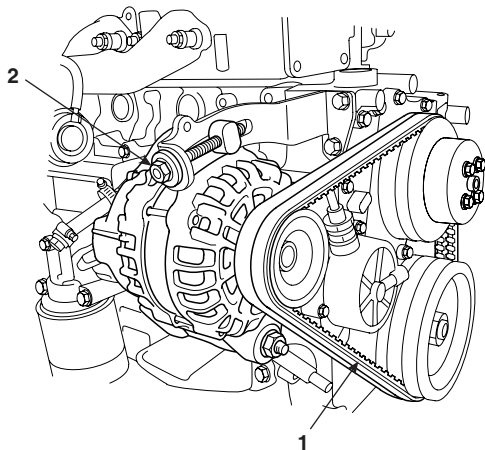
SUDEM7070L

14. Install the cooling fan (1) and automatic cooling fan coupling (2).



SUDEM7071L

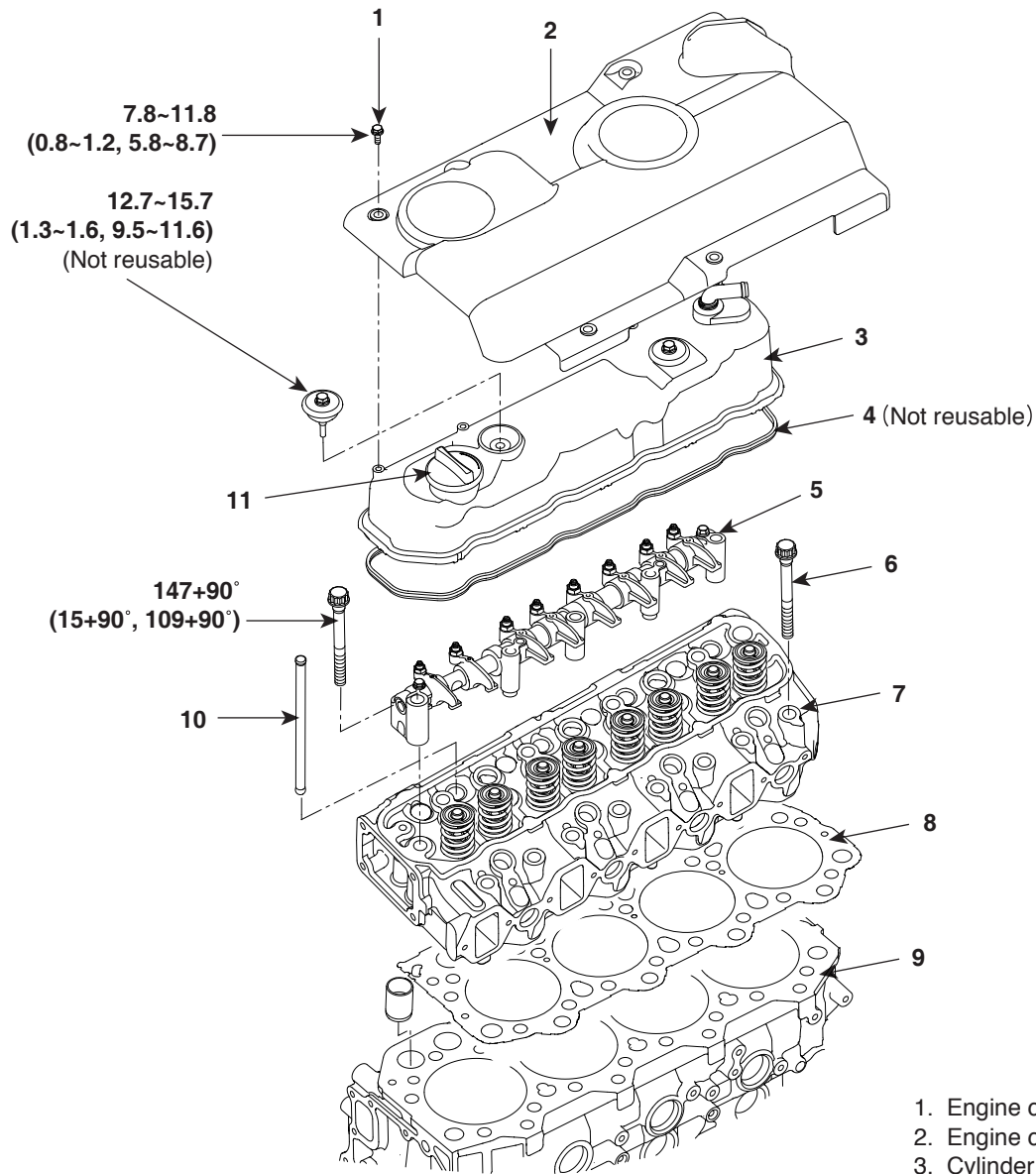
15. Install the V-belt (1). Adjust the belt tension using the tension adjusting screw (2) of alternator.



SUDEM7072L

# CYLINDER HEAD ASSEMBLY

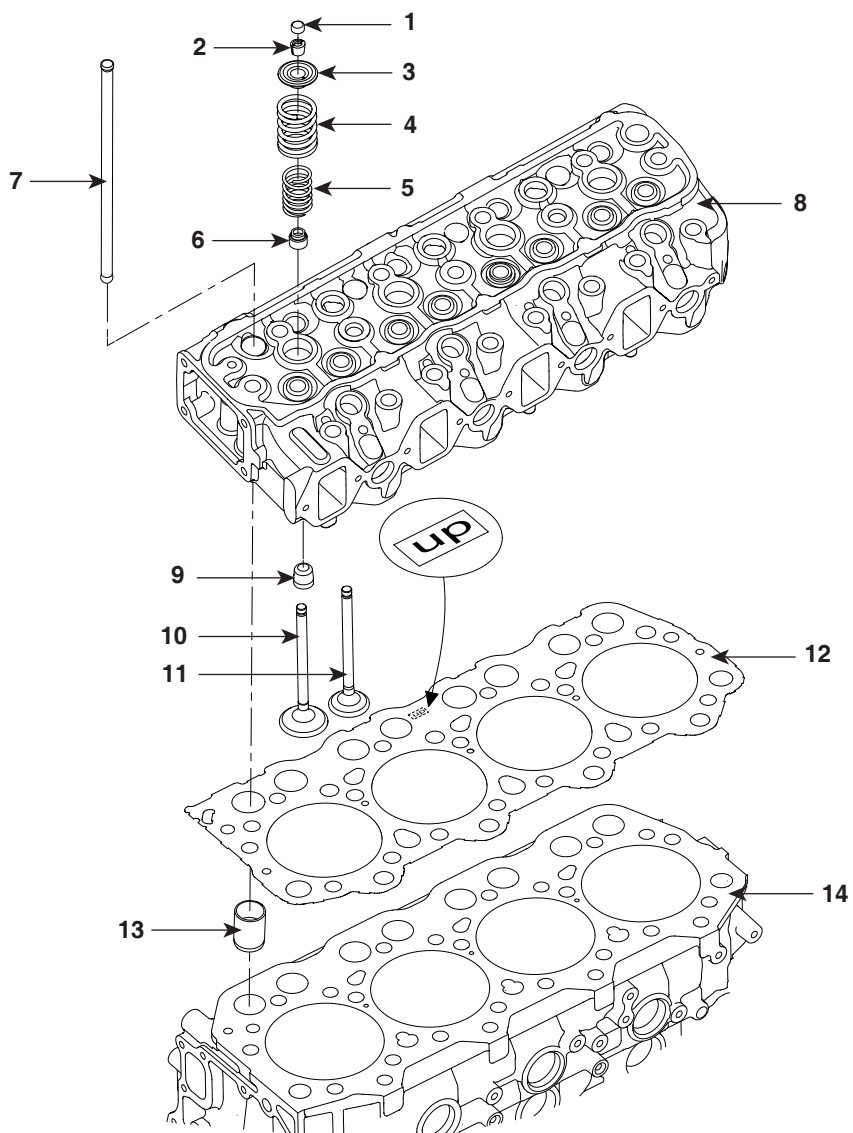
COMPONENTS E248774A



- 1. Engine cover bolt
- 2. Engine cover
- 3. Cylinder head cover
- 4. Cylinder head cover gasket
- 5. Rocker and bracket assembly
- 6. Cylinder head bolt
- 7. Cylinder head assembly
- 8. Cylinder head gasket
- 9. Crank case
- 10. Push rod
- 11. Oil filler cap

Tightening Torque : Nm (kgf.m, lb-ft)



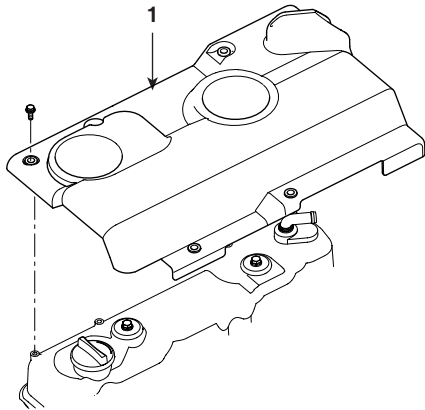


- |                      |                          |
|----------------------|--------------------------|
| 1. Valve cap         | 8. Cylinder head         |
| 2. Valve cotter      | 9. Water director        |
| 3. Valve retainer    | 10. Intake valve         |
| 4. Outer side spring | 11. Exhaust valve        |
| 5. Inner side spring | 12. Cylinder head gasket |
| 6. Valve stem seal   | 13. Tappet               |
| 7. Push rod          | 14. Crankcase            |



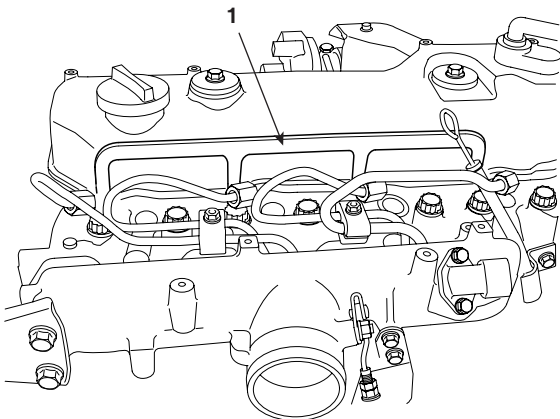
**REMOVAL** EDE5E369

1. Remove the engine cover(1) from the cylinder head cover.



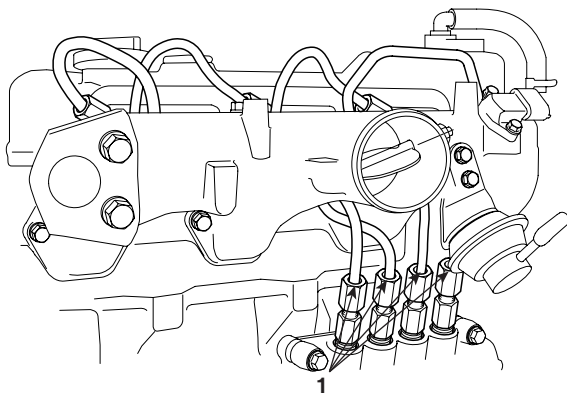
SUDEM7280L

2. Remove the glow plug and glow plug plate (1).



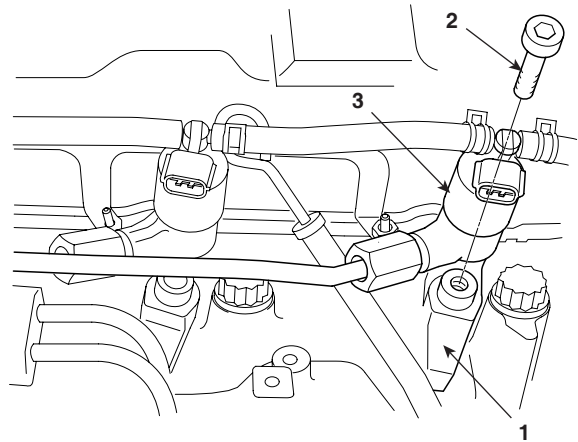
SUDEM7076L

3. Remove the injection pipe(1) No 1, 2, 3 and 4 running from the common rail assembly to the injector.



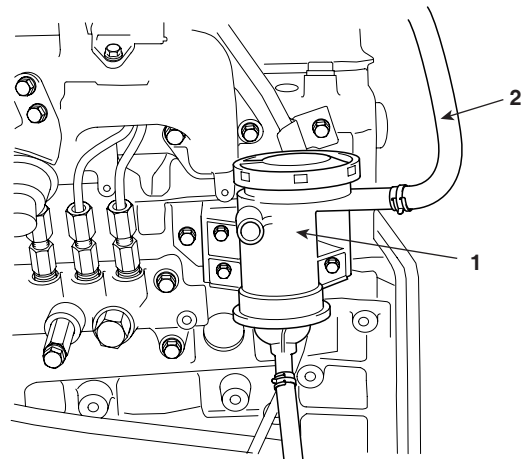
SUDEM7077L

4. Loosen the hexa-bolt (2) of injector nozzle bridge (1) and remove the injector (3).



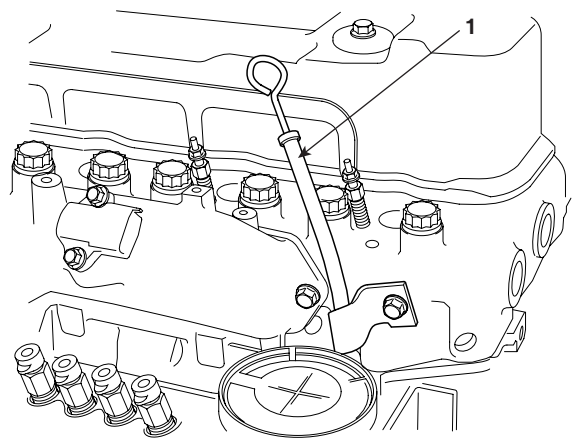
SUDEM7078L

5. Remove the oil separator (1) and blow-by hose (2)



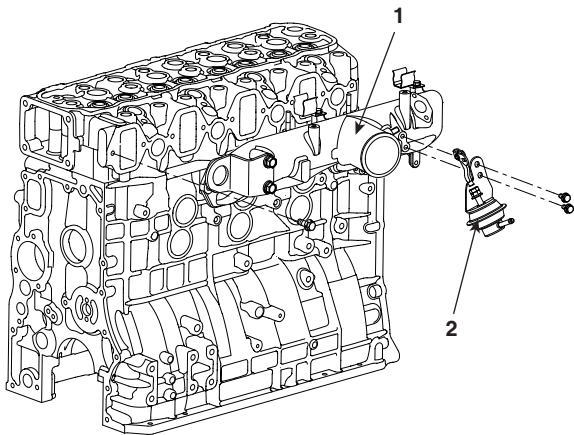
SUDEM7079L

6. Remove the oil level gauge (1).



SUDEM7080L

7. Remove the intake manifold assembly (1).

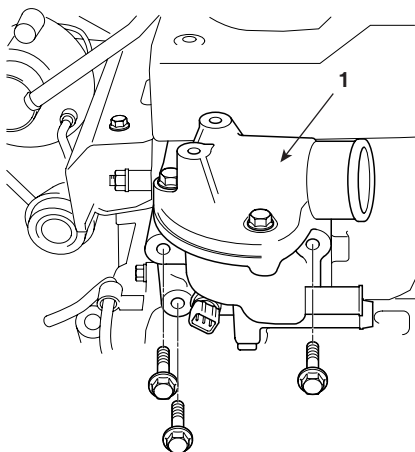


SUDEM7081L

**NOTE**

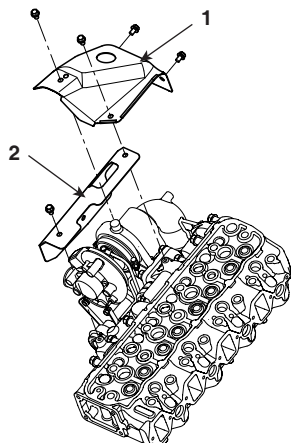
Do not remove the actuator (2) of the intake manifold if its operation is normal.

8. Remove the thermostat housing (1).



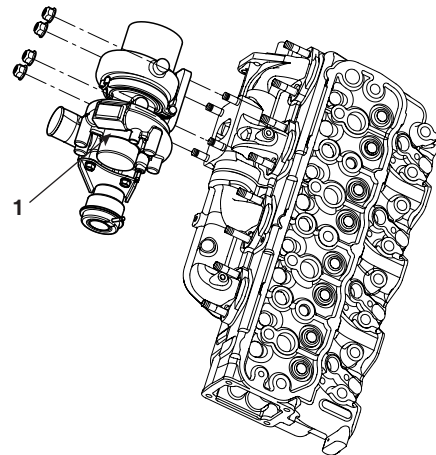
SUDEM7082L

9. Remove the turbocharger heater protector cover (1) and exhaust manifold heater protector cover (2).



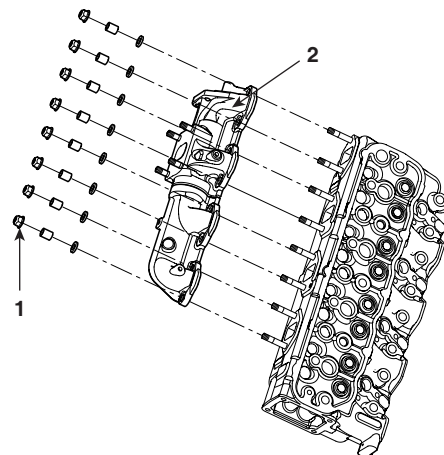
SUDEM7083L

10. Remove the turbocharger assembly (1) from the cylinder head.



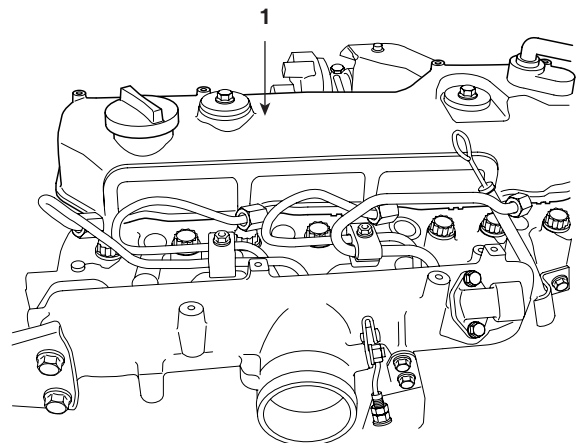
SUDEM7084L

11. Loosen the exhaust manifold mounting nut (1) and then remove exhaust manifold (2).



SUDEM7085L

12. Remove the cylinder head cover (1).

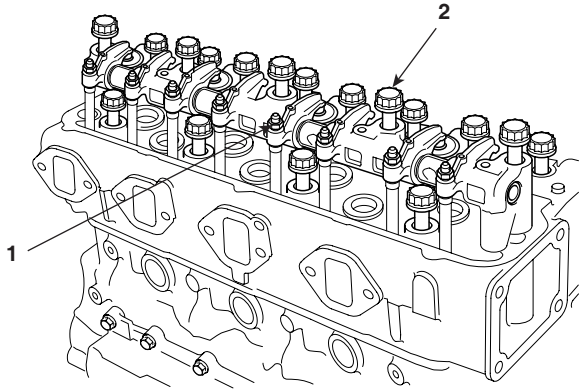


SUDEM7086L

13. Remove the cylinder head bolts.

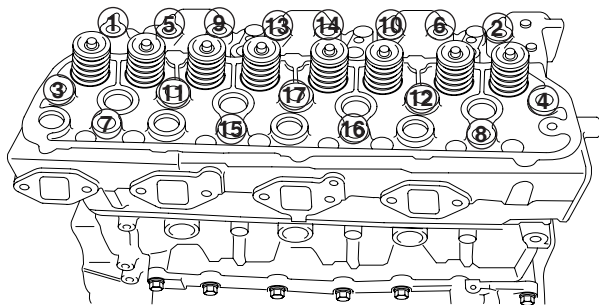
**NOTE**

- a. Since push rod is pressing the rocker, loosen the rocker adjusting screws (1) to remove the cylinder head bolts (2).



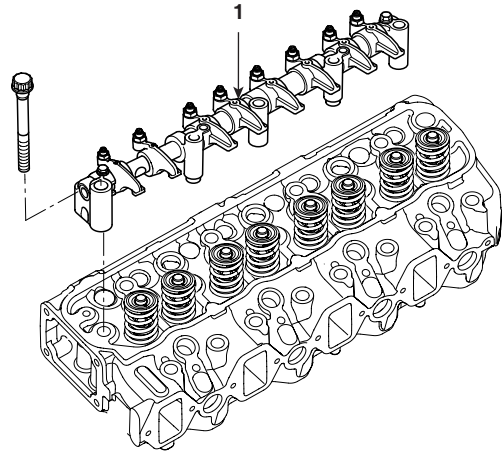
SUDEM7087L

- b. When removing the cylinder head bolts, remove them according to the sequence as shown in the following figure.



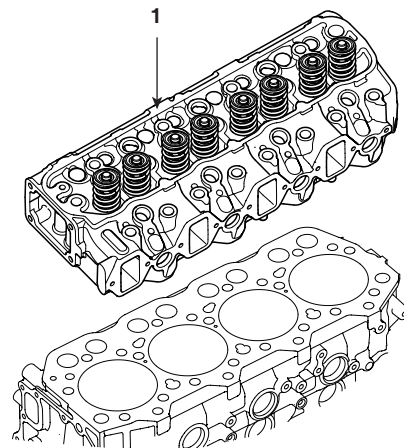
SUDEM7088L

14. Remove the rocker arm and rocker bracket assembly (1).



SUDEM7089L

15. Remove the cylinder head assembly (1).

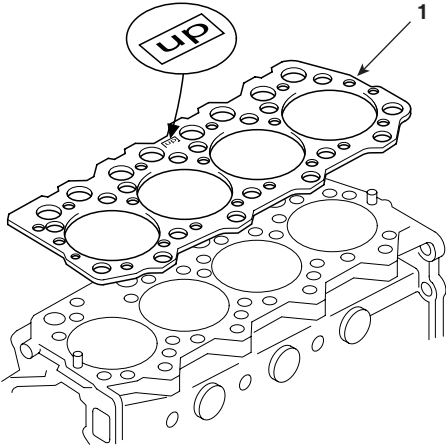


SUDEM7090L

16. Remove the cylinder head gasket (1).

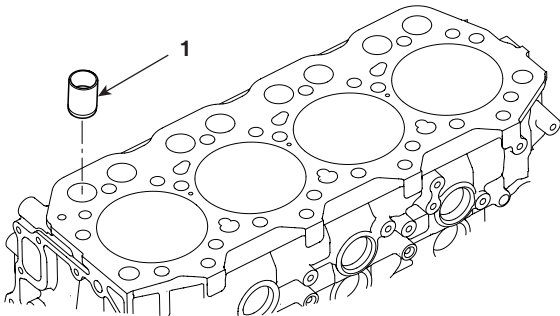
**CAUTION**

When removing the cylinder head gasket, be careful not to damage the cylinder head and crankcase.



SUDEM7091L

17. Remove the valve tappet (1).

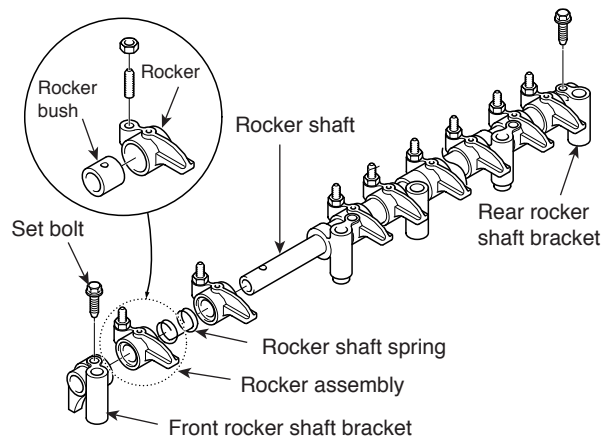


SUDEM7092L

## DISASSEMBLY ECC7ED4F

### ROCKER AND ROCKER SHAFT BRACKET ASSEMBLY

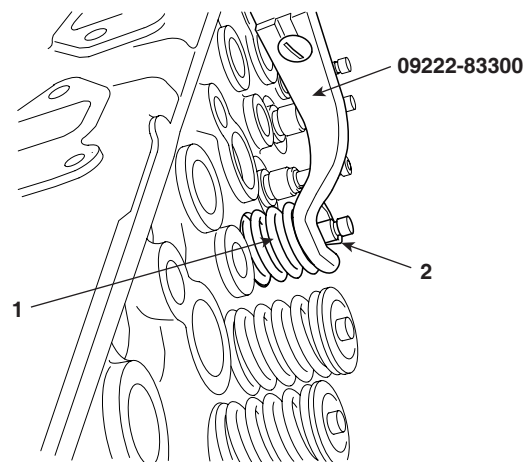
1. Remove the set bolt from the front rocker shaft bracket.
2. Remove the front and rear rocker shaft bracket.
3. Remove the rocker assembly.
4. Remove the rocker shaft spring from the rocker shaft.
5. Remove the rocker shaft bracket No.2, 3 and 4 and then, remove the rocker shaft.



SUDEM7093L

### VALVE AND CYLINDER HEAD ASSEMBLY

1. Remove the valve cotter (2) with pushing the valve spring (1) evenly using the special tool (09222-83300).

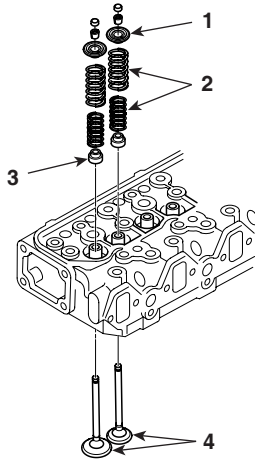


SUDEM7094L

- Remove the retainer (1), valve spring (2), valve stem seal (3) and intake and exhaust valve from the cylinder head.

**CAUTION**

*Valve stem seal should be replaced with new one.*

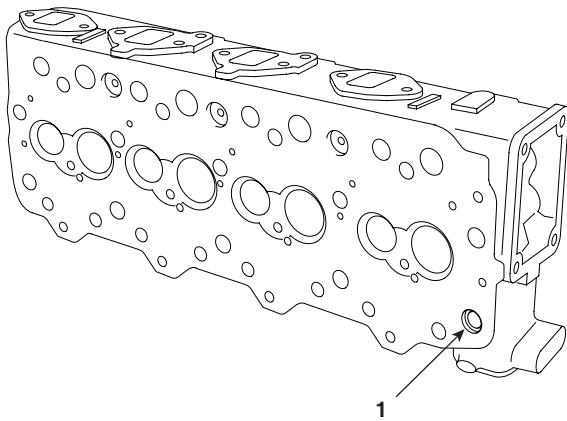


SUDEM7095L

- Remove the water director (1) from the cylinder head.

**NOTE**

*If water director is corroded, remove it. If not, leave it.*

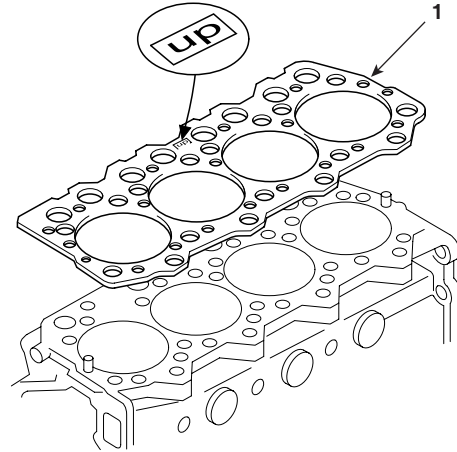


SUDEM7096L

- Remove the cylinder gasket (1).

**CAUTION**

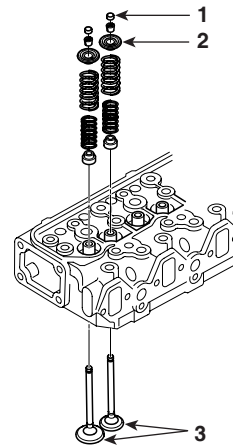
*When removing the cylinder head gasket, check the cylinder head and crankcase for any damage.*



SUDEM7097L

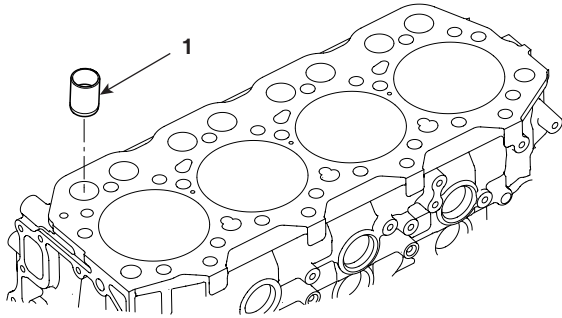
**INSPECTION** E5264C2D

- Check to see whether valve cap (1) and retainer (2) have any irregular wear.
- Check the intake and exhaust valve (3) for any stuck, crack or damage.



SUDEM7098L

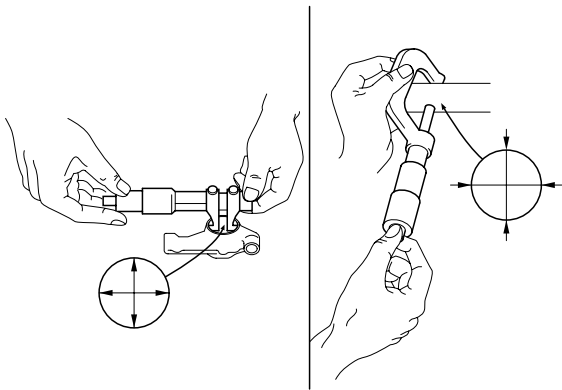
3. Check the valve tappet (1) for any damage or wear.



SUDEM7099L

4. Measure the rocker inner diameter and rocker shaft outer diameter. Replace the bush of rocker, if the gap exceeds the limit.

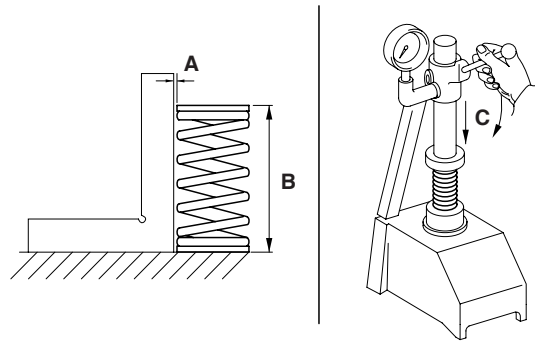
Items	Standard	Limit
Inner diameter of rocker bush	18.980~18.993mm	—
Outer diameter of rocker shaft	19.05~19.09mm	—
Gap	0.06~0.11mm	0.2mm



SUDEM7100L

5. Inspect the out of squareness (A), free length (B), load installed (C) of valve spring, replace it if any of them exceeds the limit.

Items		Standard	Limit
Outer side Valve spring	Free length	66.1mm	63mm
	Load installed	27.9±1.4kg	23.7kg
	Out of squareness	1.5mm	2.1mm
Inner side Valve spring	Free length	60mm	57mm
	Load installed	12.1±0.6kg	10.3kg
	Out of squareness	1.5mm	2.1mm

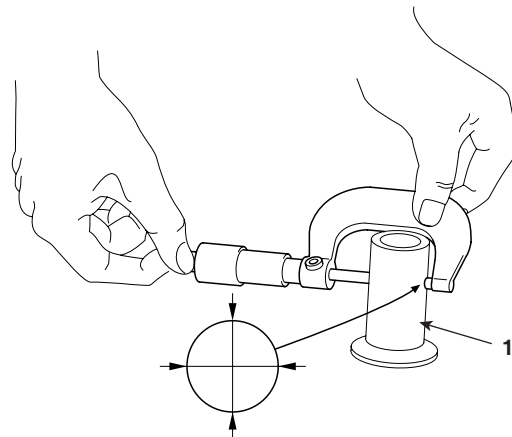


SUDEM7101L

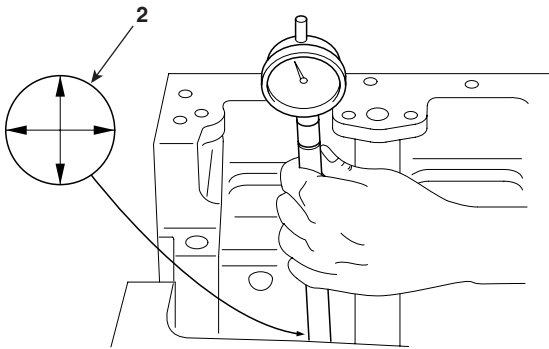
6. Measure the outer diameter of tappet (1) and inner diameter of crankcase tappet hole (2). Replace the tappet if the gap exceeds the limit.

Reference: 0.045~0.096mm

Limit: 0.2mm



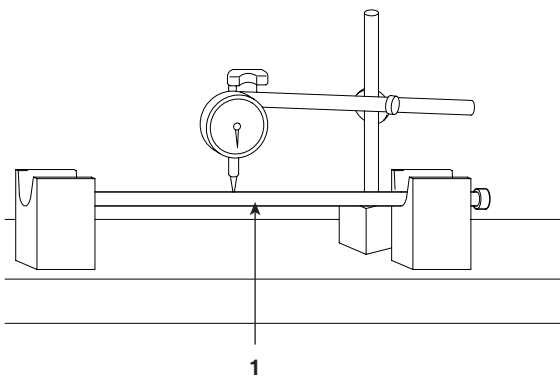
SUDEM7102L



SUDEM7103L

7. Measure the run-out of push rod (1). Replace it if it exceeds the limit.

Limit of pushrod run-out: 0.4mm



SUDEM7104L

8. Measure the deformation of cylinder head bottom face. If the measurement exceeds the limit, repair it with surface grinder or replace it.

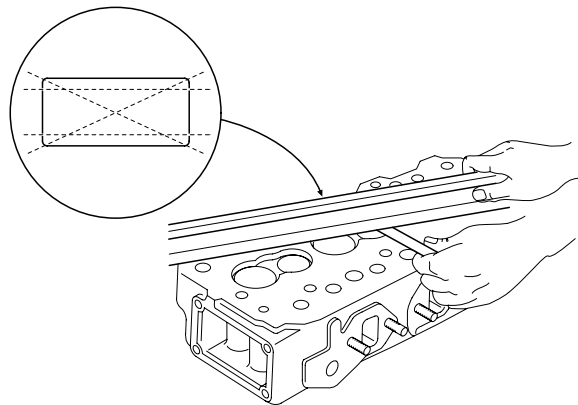
Flatness of cylinder head

Reference: 0.05mm

Limit: 0.2mm

**NOTE**

Deformation of cylinder head bottom is measured at the position as shown in the following figure.



SUDEM7105L

9. Measure the outer diameter of valve stem. If the measurement is below the limit, replace the valve stem.

Outer diameter of valve stem

– Intake valve

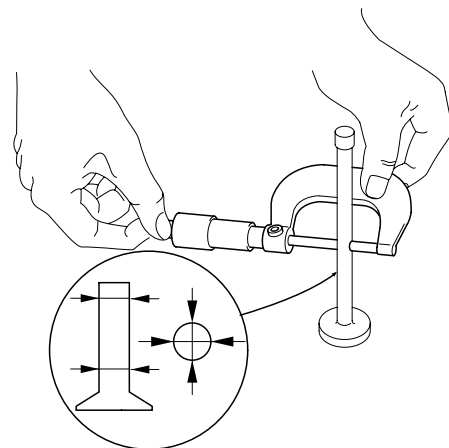
Reference : 8.96~8.97mm

Limit : 8.85mm

– Exhaust valve

Reference : 8.93~8.94mm

Limit : 8.85mm



SUDEM7106L

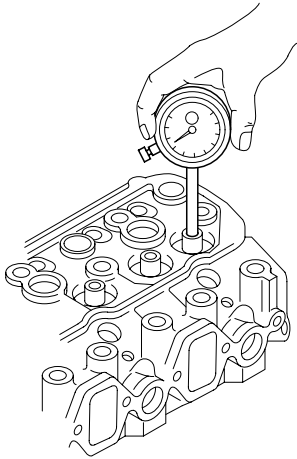


10. Measure the inner diameter of valve guide and outer diameter of valve stem. If the clearance exceeds the limit, replace the valve guide.

---

Clearance between valve stem and valve guide

- Intake  
Reference: 0.04~0.06mm  
Limit: 0.15mm
  - Exhaust  
Reference: 0.07~0.10mm  
Limit: 0.2mm
- 



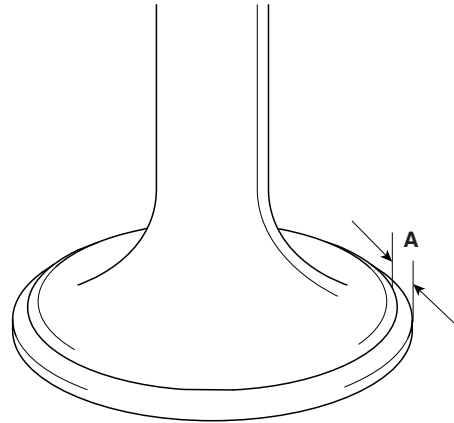
SUDEM7107L

- c. Measure the seat contact area (A).

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Area of the valve seat contact

- Intake  
Reference: 2.8± 0.2mm  
Limit: 3.6mm
  - Exhaust  
Reference: 2.0± 0.2mm  
Limit: 2.8mm
- 

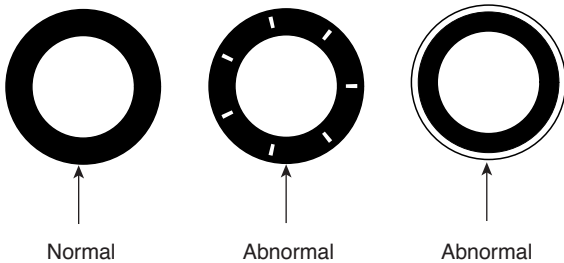


SUDEM7109L

11. Check the contacting state of valve seat and valve.
- a. Apply light blue coating on the valve surface.
  - b. Check the valve contacting state by pressing the valve to the valve seat.

 **CAUTION**

***Be careful that valve does not turn, when valve seat is pressed by valve.***



SUDEM7108L



**REPLACEMENT** E03FAF94

**REPLACEMENT OF ROCKER BUSH**

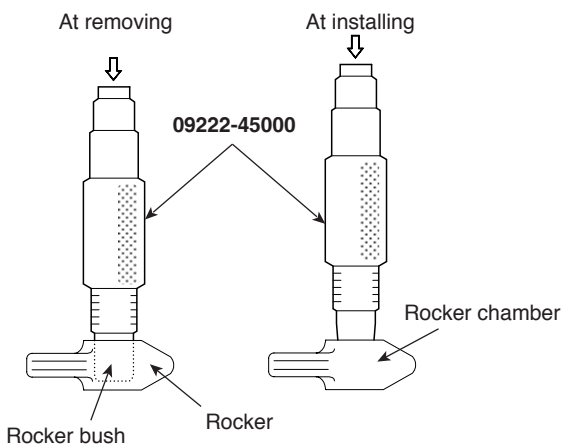
1. Remove the bush from rocker using the special tool (09222-45000).
2. Press fit the bush into rocker using the special tool (09222-45000).

**NOTE**

When pressing fit bush into rocker, let the chamber side of the rocker be inserted first.

**CAUTION**

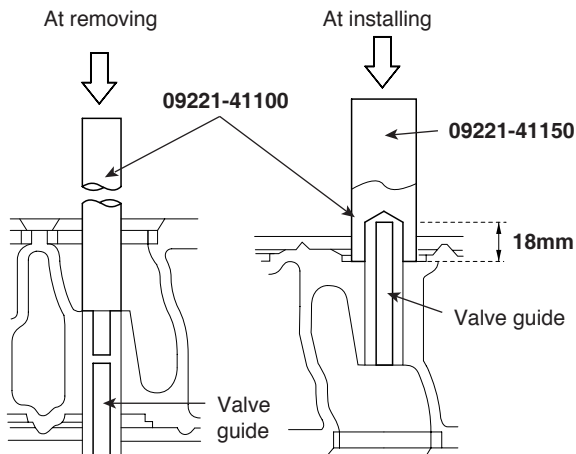
When pressing fit, align the bush oil hole with rocker oil hole.



SUDEM7110L

**REPLACEMENT OF VALVE GUIDE**

Remove the valve guide using the special tool (09221-41100). Install the valve guide using the special tool (09221-41150, 09221-41100).



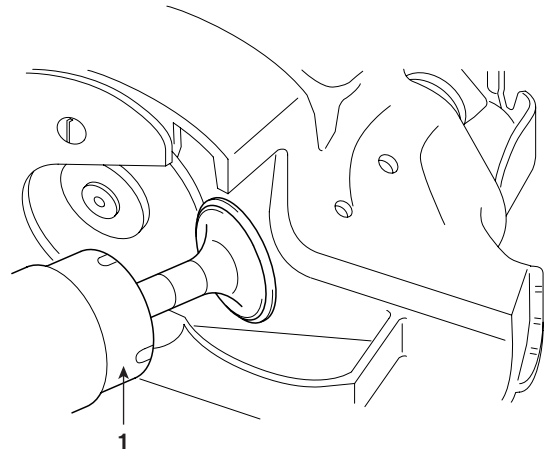
SUDEM7111L

**VALVE SEAT REPAIR**

1. Repair the valve face using valve refacer (1).

**CAUTION**

Valve seat angle is 45°.

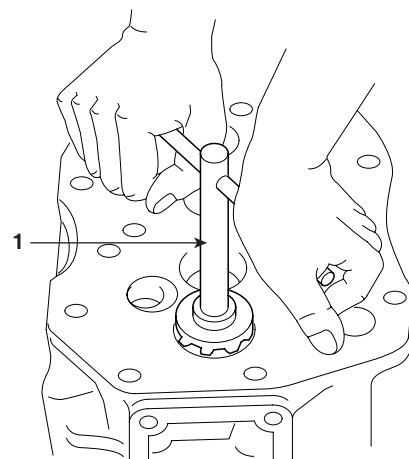


SUDEM7112L

2. To repair the valve seat, use the valve seat cutter or valve seat grinder (1). After grinding, insert the #400 or equivalent sand paper between cutter and valve seat and grind lightly.

**CAUTION**

Repair the valve seat width and valve sinkage to satisfy the specified limit.

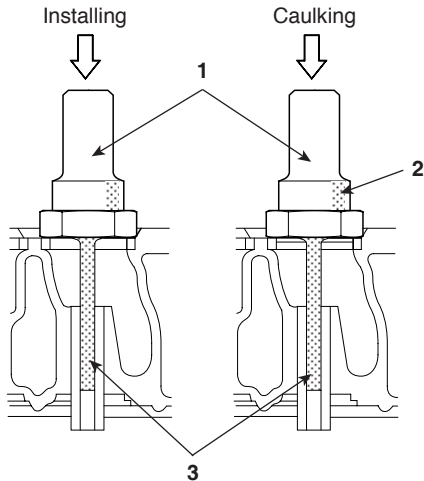


SUDEM7113L

3. Install the valve seat using the caulking tool body (1) and locking ring (2).

**CAUTION**

Press the valve seat (3) with the chamfered side of the locking ring. And then, caulk it to the cylinder head as the ring faces the other side.



SUDEM7114L

4. Grind the seat width (A) and valve sinkage (B) to be within the standard.  
Valve and valve seat should touch evenly all over the surface.

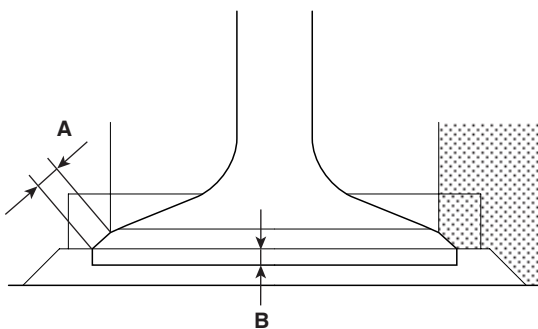
Valve seat width (A)

Reference: 2.6~3.0mm (Intake)  
1.8~2.2mm (Exhaust)

Limit: 3.6mm (Intake)  
2.8mm (Exhaust)

Valve sinkage (B)

Reference: 1.5mm  
Limit: 1.2mm

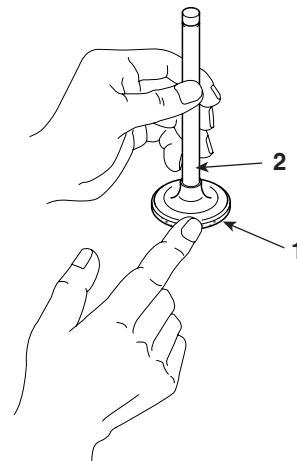


SUDEM7115L

5. Apply the compound evenly over the valve seat surface (1).

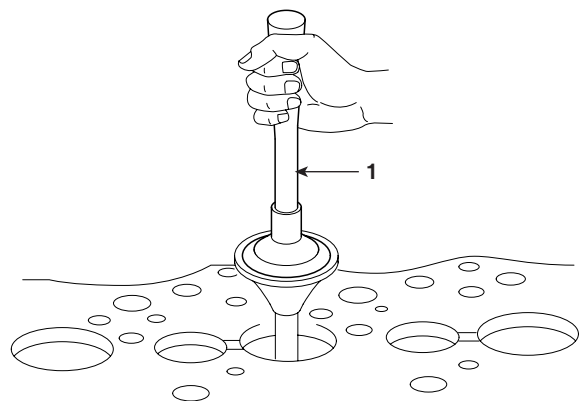
**CAUTION**

- Valve stem (2) should be free from any compound. Use the medium mesh (mesh between 120 and 150) compound at first and finish the grinding with the fine mesh compound (above 200 mesh)
- Mix the compound with some engine oil to apply evenly.



SUDEM7116L

6. Place the valve on the valve seat using the valve lapper (1). Tap the valve with turning the valve slightly. Clean the compound with diesel or equivalent. Apply the engine oil and check whether the contact surface is securely positioned.



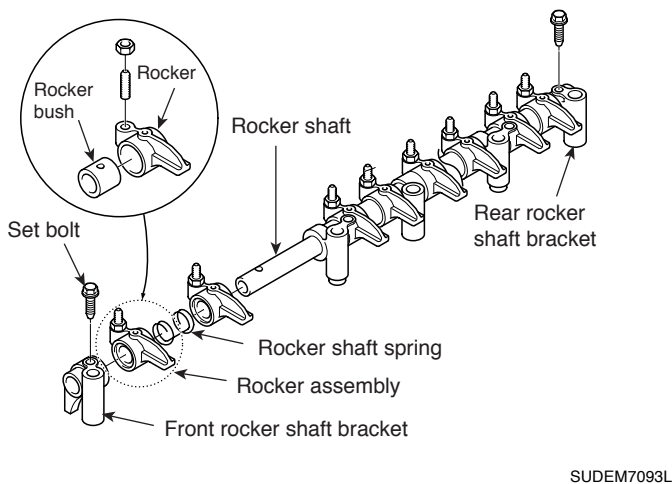
SUDEM7117L

**REASSEMBLY** EBF48CA7

**ROCKER AND ROCKER SHAFT ASSEMBLY**

1. Install rocker shaft bracket No. 1, 2, 3 and 4 to the rocker shaft.
2. Install the rocker shaft spring.
3. Apply engine oil on the rocker bush, and then install the bush to the rocker.
4. Install the rocker assembly.
5. Install the front and rear rocker shaft bracket.
6. Install the front and rear rocker shaft bracket set bolts.

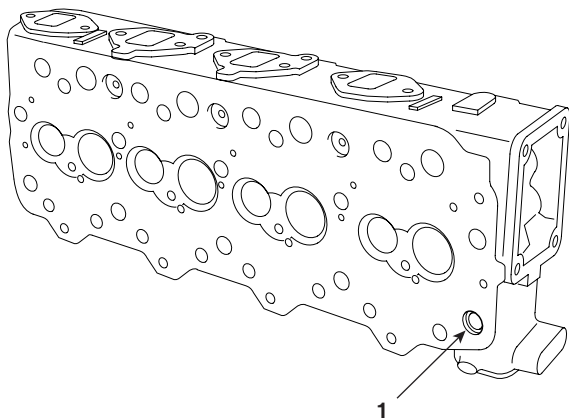
Tightening torque: 7.8~11.8 Nm  
(0.8~1.2 kgf.m, 5.8~8.7 lb-ft)



SUDEM7093L

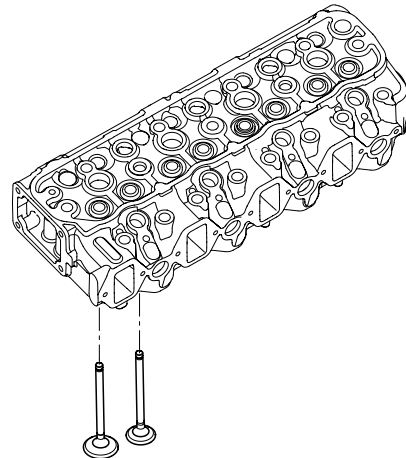
**VALVE AND CYLINDER HEAD ASSEMBLY**

1. Install the water director to the cylinder head.



SUDEM7096L

2. Install the intake and exhaust valve.

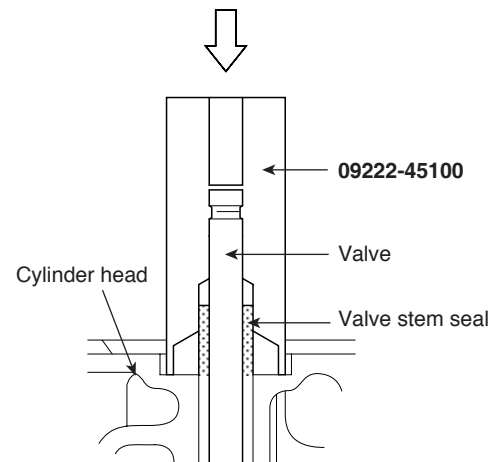


SUDEM7118L

3. Apply the engine oil on the valve stem seal lip and install the valve stem seal using the special tool (09222-45100).

**NOTE**

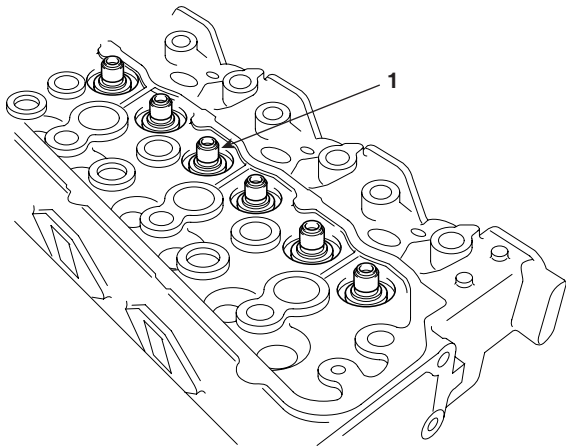
Tap the seal until the special tool (09222-45100) contacts the cylinder head.



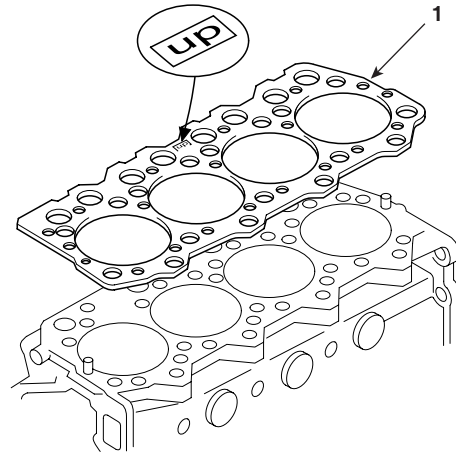
SUDEM7119L

**CAUTION**

When installing the valve stem seal (1), use the new one.

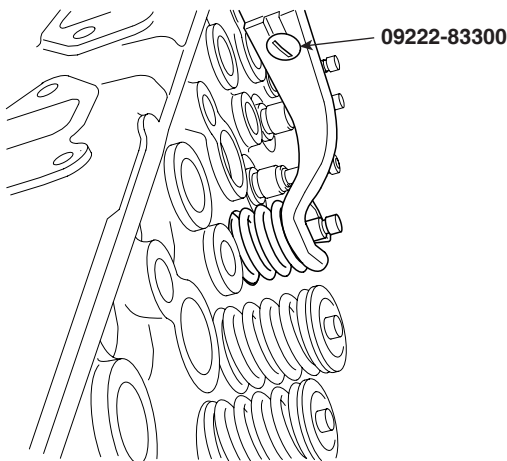


SUDEM7120L



SUDEM7097L

4. Install the retainer, valve spring and valve cotter using the special tool (09222-83300).



SUDEM7121L

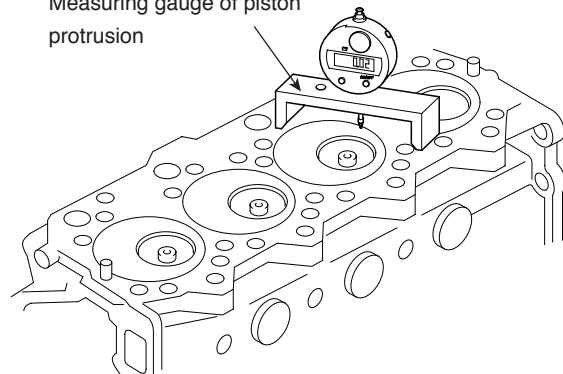
- b. **Selection and assembly of cylinder head gasket.**

Select the cylinder head gasket according to the piston protrusion amount.

Average piston protrusion	Gasket size	Gasket thickness
0.466~0.526	A	1.35±0.03
0.526~0.588	B	1.40±0.03
0.588~0.648	C	1.45±0.03

Unit : mm

Measuring gauge of piston protrusion



SUDEM7122L

**INSTALLATION** EDA3BF2F

1. Assembly is performed in the reverse order of disassembly.
2. Installation of cylinder head gasket.

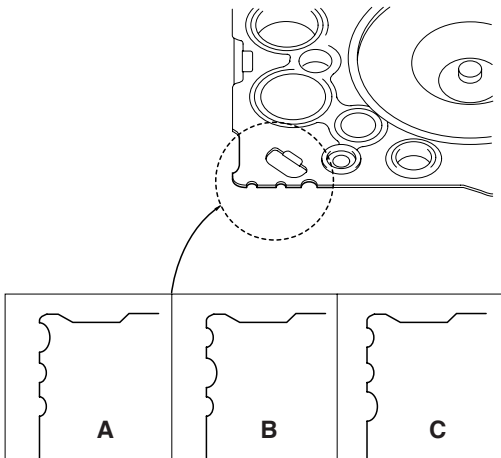
**CAUTION**

When installing the cylinder head gasket (1), cylinder head installing surface should be free from any impurities or foreign materials such as oil.

- a. Assemble the cylinder head so that "UP" mark of the cylinder head gasket faces to the cylinder head.

**NOTE**

If the max protrusion of the piston is 0.05mm more than average protrusion, then use the grade up (A→B) gasket.



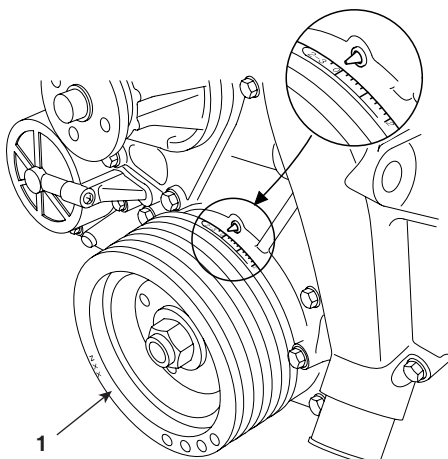
SUDEM7123L

3. Checking and adjusting of valve clearance

**NOTE**

Check and adjust the valve clearance while the engine is cold.

- 1) Crank the engine with the cranking handle and align the needle to "0" position of crankshaft damper pulley (side marked with No. 1 through 4). Or align it to the "0" position of crankshaft damper pulley (side marked No. 2 to 3). (This is at the TDC of compression stroke of cylinder No. 1).



SUDEM7124L

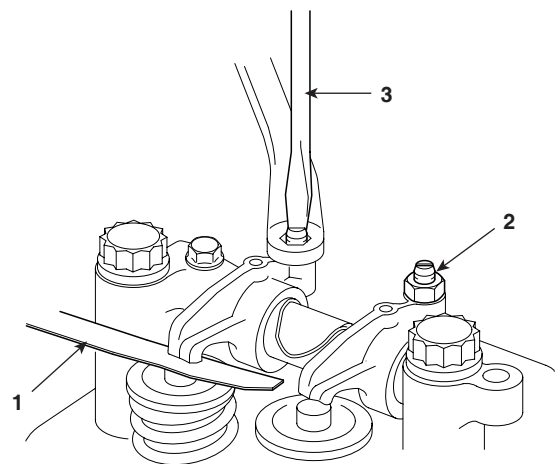
- 2) At the TDC of compression stroke of cylinder No. 1, check and adjust the clearance of the valve with "O" mark at the following table. And then, turn the crankshaft in one turn to check and adjust the valve clearance of remaining valves with "X" mark.

Cylinder No.	1		2		3		4	
	In-take	Ex-haust	In-take	Ex-haust	In-take	Ex-haust	In-take	Ex-haust
TDC of No.1	○	○	○			○		
TDC of No.4				×	×		×	×

- 3) Measure the clearance between rocker and valve cap using the thickness gauge.
  - a. If the valve clearance exceeds the reference value, loosen the lock nut (2) and adjust the clearance with thickness gauge by turning the adjusting screws.
  - b. After the valve clearance adjustment, fix the adjusting screw using the screw drive (3) and fasten the lock nut securely.

**NOTE**

Make sure to check whether the valve clearance satisfies the reference after valve clearance adjustment.

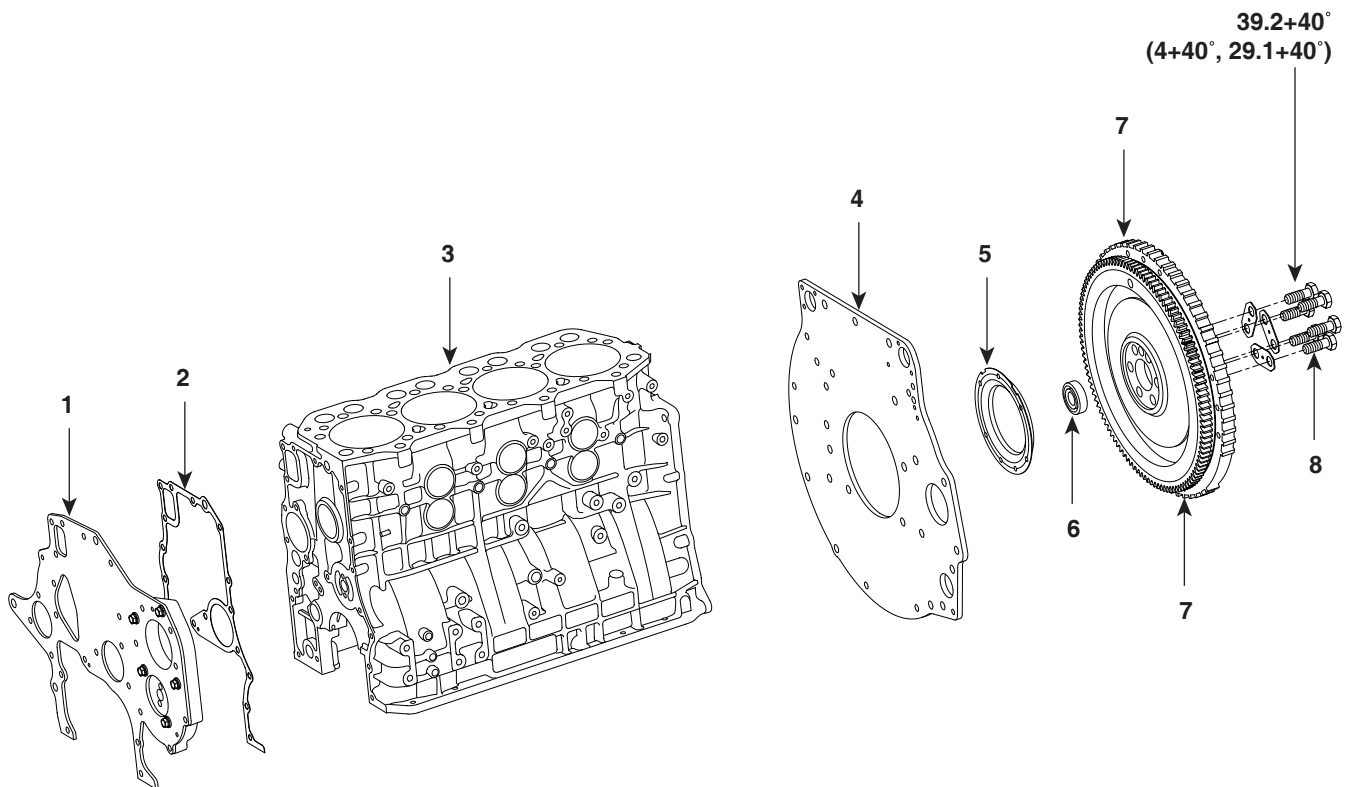


SUDEM7125L

# CRANKCASE

## FLYWHEEL

### COMPONENTS E60B5C72

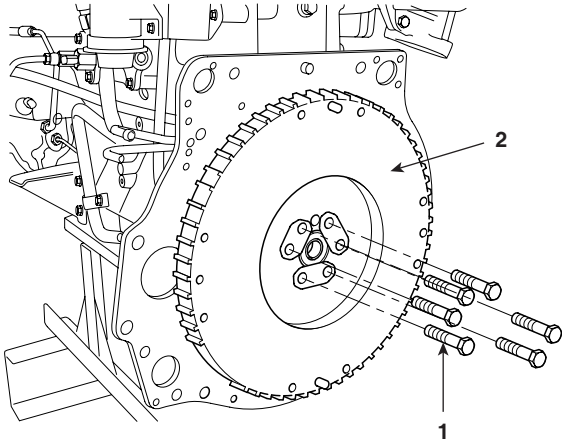


1. Front plate
2. Gasket
3. Crankcase
4. Rear plate
5. Rear oil seal
6. Pilot bearing
7. Flywheel
8. Flywheel mounting bolt

Tightening Torque : Nm (kgf.m, lb-ft)

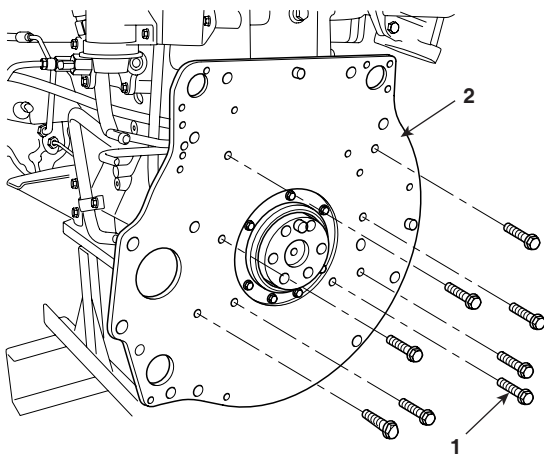
**REMOVAL** EECFB3A9

1. Remove the flywheel mounting bolt (1), and then remove the flywheel (2).



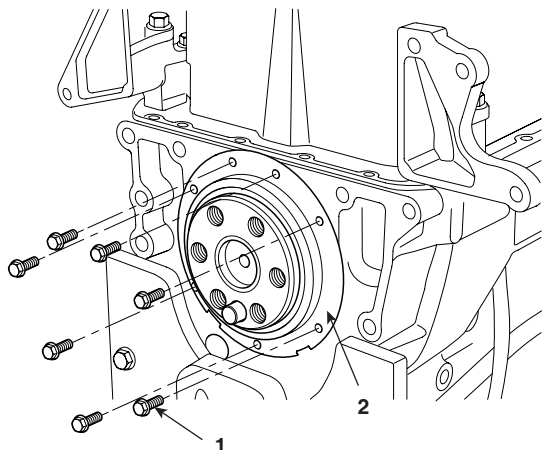
SUDEM7127L

2. Remove the rear plate mounting bolt (1), and then remove the rear plate (2).



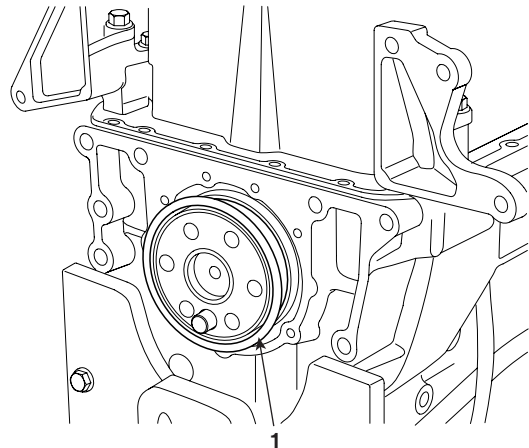
SUDEM7128L

3. Remove the rear oil seal mounting bolt (1), and then remove the rear oil seal (2).



SUDEM7129L

4. Remove the rear oil seal slinger (1).



SUDEM7130L

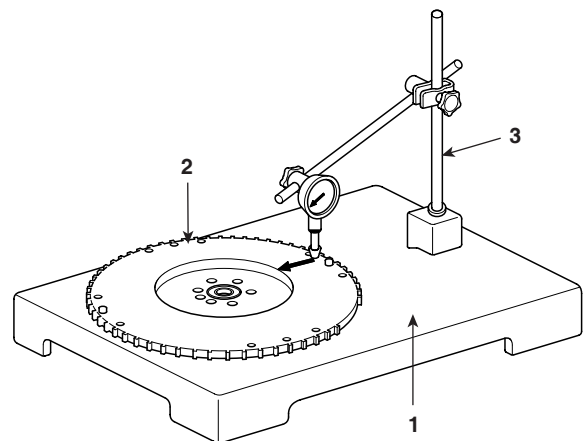
**INSPECTION** EE08EBFD

1. Distorsion check of frictional surface
  - a. Put the flywheel (2) on the precision table (1) and set up the dial indicator (3).
  - b. Move the dial indicator on the flywheel frictional surface to measure the distortion.
  - c. If the distortion of the frictional surface exceeds the limit, regrind the frictional surface.

---

Distorsion of the frictional surface  
 Reference: Below 0.05mm  
 Limit: 0.2mm

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SUDEM7131L

2. Repair of the frictional surface  
Repair the frictional surface with the surface grinder.

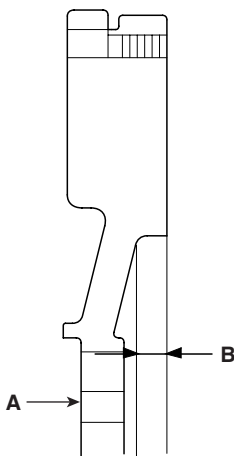
**CAUTION**

- a. After repairing the frictional surface, check whether the frictional surface is parallel with surface A within 0.1mm.  
b. Check the frictional surface (size B) whether its height is within the limit.

Height to the frictional surface (B)

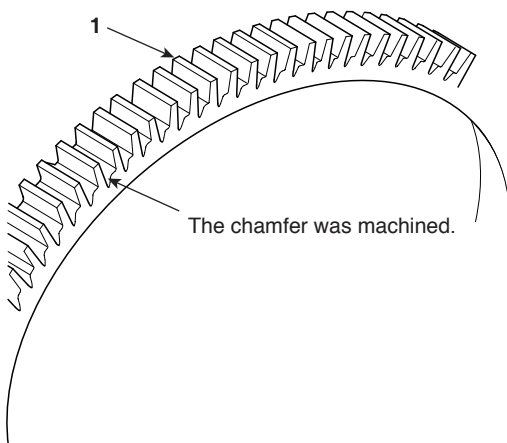
Reference: 24.5mm

Limit: 23.5mm



SUDEM7132L

3. Replacement of flywheel ring gear
- a. When removing the ring gear (1), heat the ring gear evenly using acetylene torch or equivalent tools and then remove the ring gear by tapping the circumference with rod or hammer.
- b. When installing, heat the ring gear with piston heater for 3 minutes (about 100°C). And then, insert the ring gear so that the un-chamfered gear faces to flywheel.

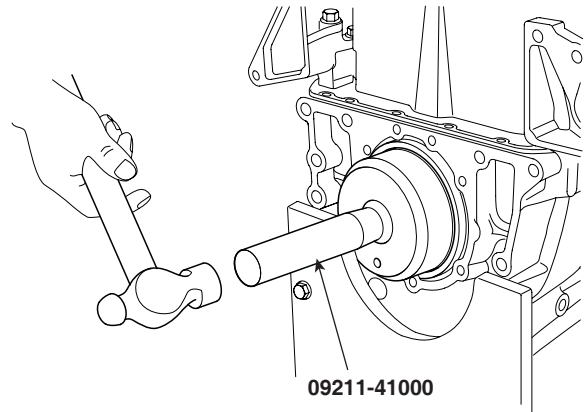


SUDEM7279L

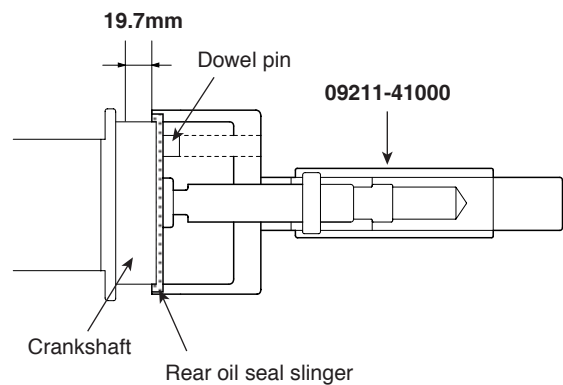
## INSTALLATION

E561D9B1

1. Install the rear oil seal slinger using the special tool (09211-41000).



SUDEM7133L



SUDEM7134L

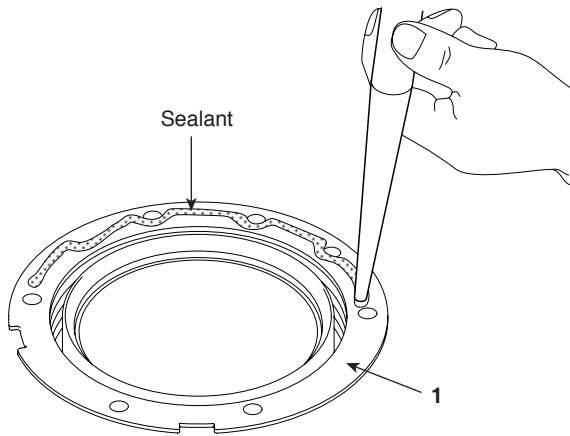


2. Apply the sealant (Loctite #5699) to the rear oil seal (1), and then install the rear oil seal.

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Tightening torque: 7.8~11.8 Nm  
(0.8~1.2 kgf.m, 5.8~8.7 lb-ft)

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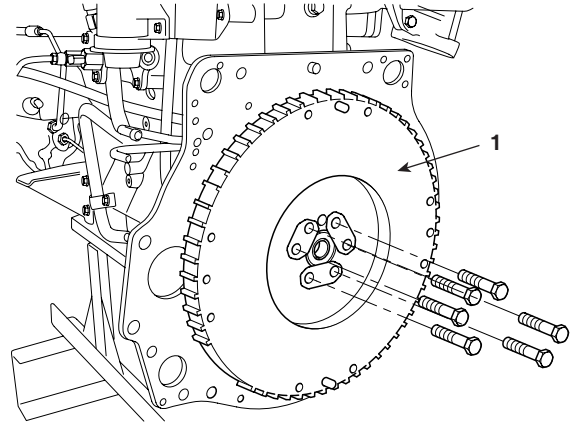
SUDEM7135L

4. Install the flywheel (1).

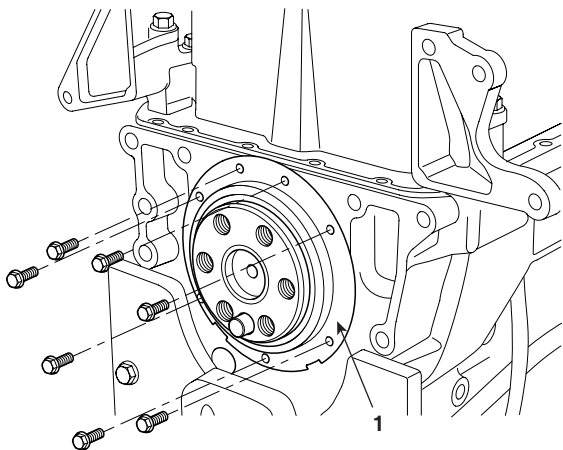
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Tightening torque: 39.2Nm+40°  
(4.0kgf.m+40°, 29.1 lb-ft+40°)

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SUDEM7138L



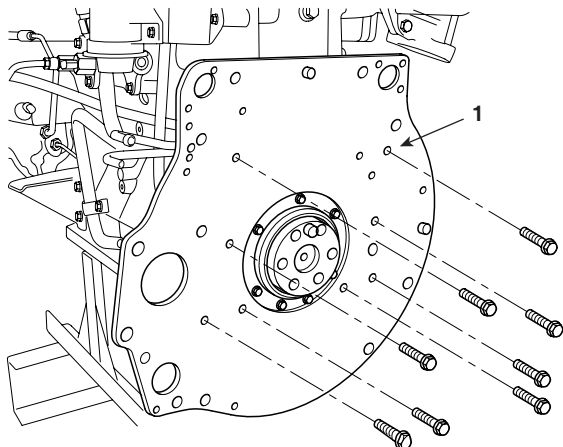
SUDEM7136L

3. Install the rear plate (1).

---

Tightening torque: 63.7 Nm  
(6.5 kgf.m, 47.3 lb-ft)

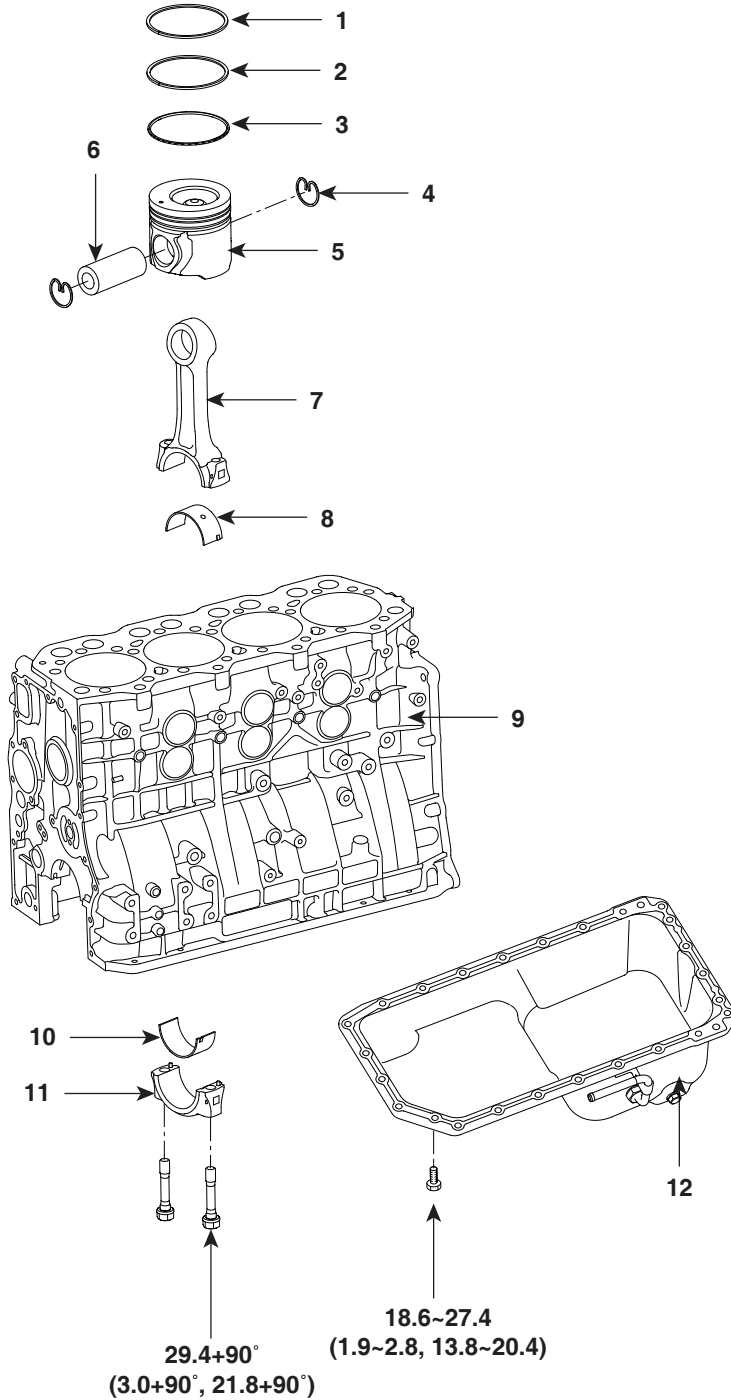
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SUDEM7137L

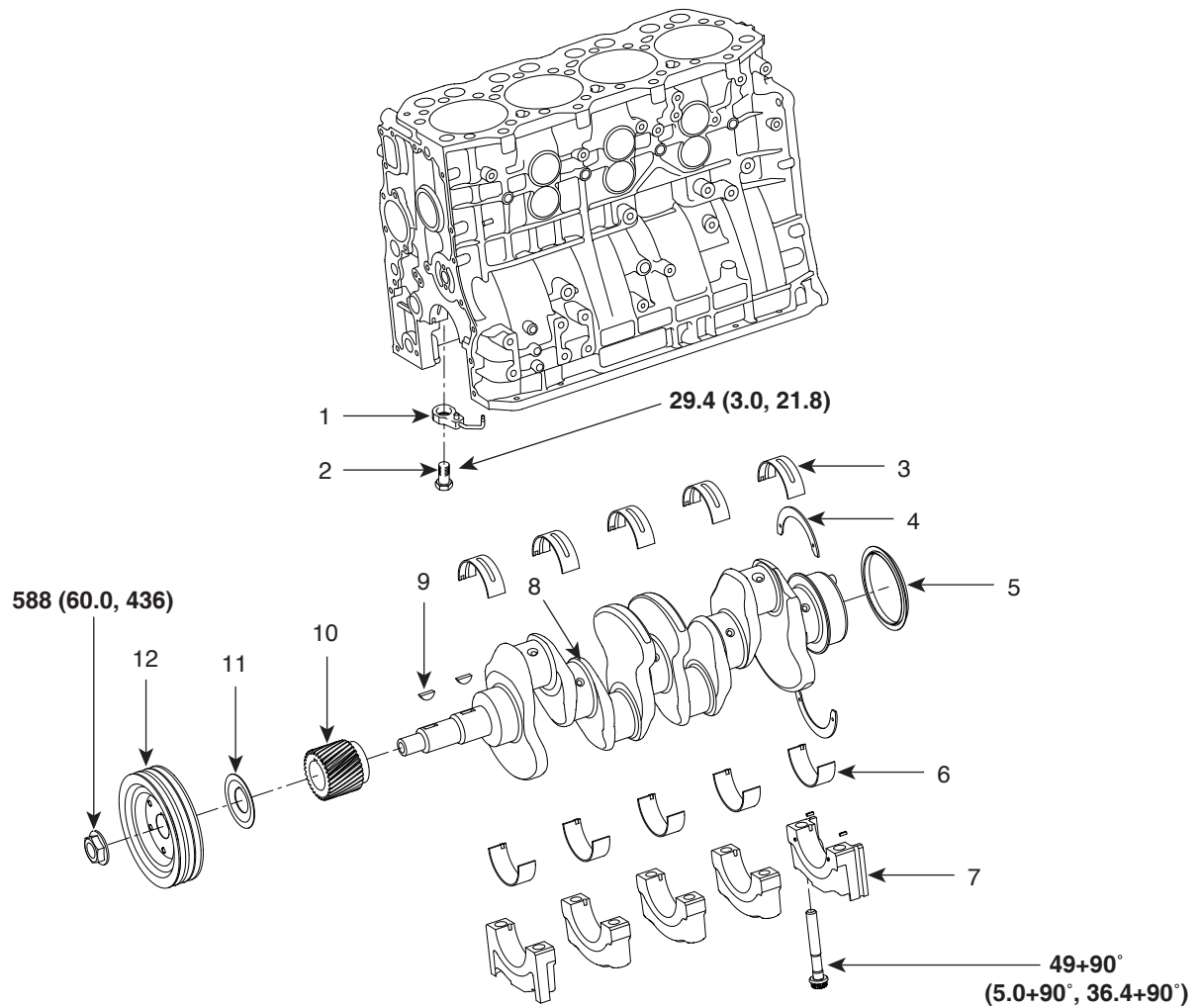
CYLINDER BLOCK ASSEMBLY

COMPONENTS EBC859AD



- 1. Compression ring No.1
- 2. Compression ring No.2
- 3. Oil ring No. 3
- 4. Snap ring
- 5. Piston
- 6. Piston pin
- 7. Connecting rod
- 8. Connecting rod upper bearing
- 9. Crankcase
- 10. Connecting rod lower bearing
- 11. Connecting rod cap
- 12. Oil pan

Tightening Torque : Nm (kgf.m, lb-ft)

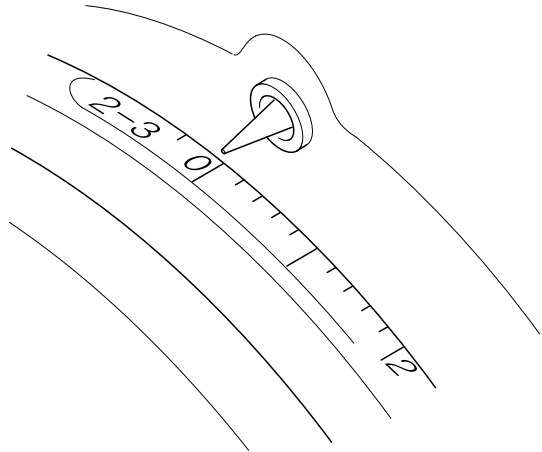


- |                          |                            |
|--------------------------|----------------------------|
| 1. Oil jet               | 7. Main bearing cap        |
| 2. Oil jet mounting bolt | 8. Crankshaft assembly     |
| 3. Upper main bearing    | 9. Semicircular key        |
| 4. Thrust plate          | 10. Crankshaft gear        |
| 5. Rear oil seal slinger | 11. Front oil seal slinger |
| 6. Lower main bearing    | 12. Crankshaft pulley      |

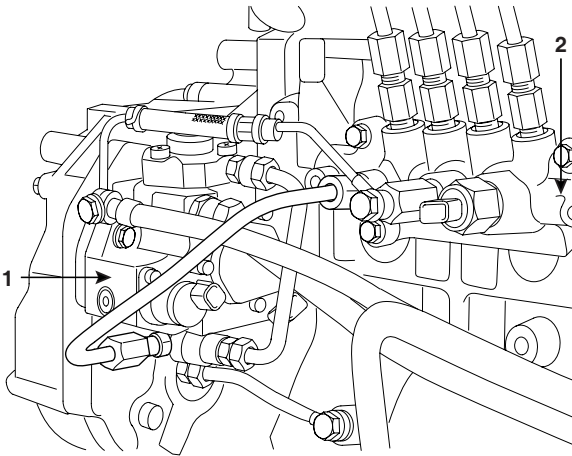
Tightening Torque : Nm (kgf.m, lb-ft)

**REMOVAL** EE4DAE0F

1. Remove the engine and transaxle.
2. Remove the flywheel and rear plate.
3. Remove the intake and exhaust manifold.
4. Remove the cylinder head assembly.
5. Remove the supply pump (1) and common rail assembly (2).

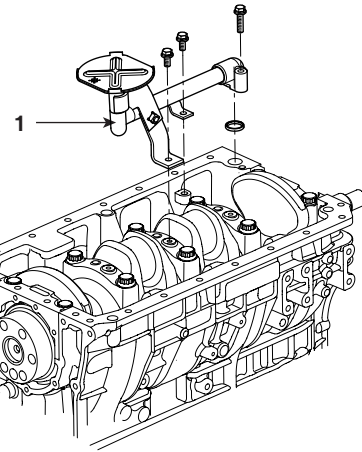


SUDEM7143L



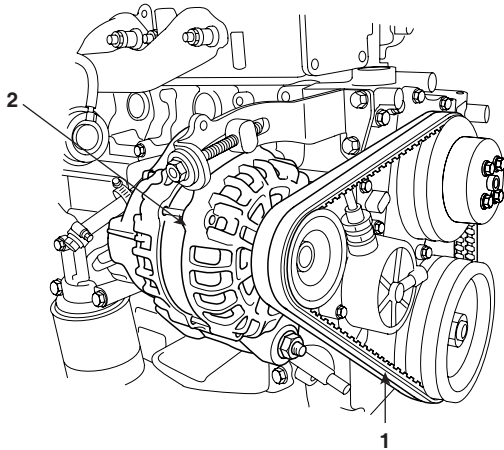
SUDEM7281L

8. Remove oil cooler assembly.



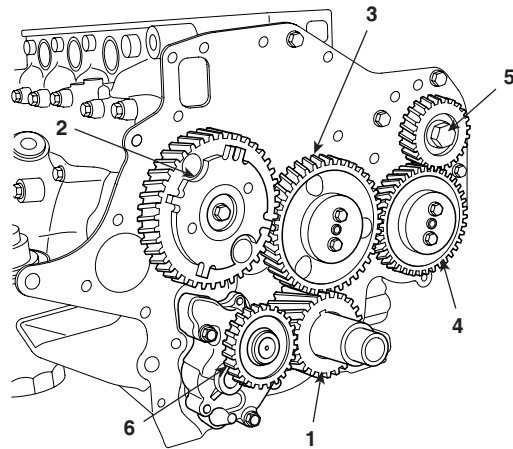
SUDEM7144L

6. Remove the V-belt (1) and remove the alternator assembly (2).



SUDEM7142L

9. Remove timing gear train [(oil pump gear (6), camshaft assembly (2), idler gear A (3), idler supply pump gear (5)), and then remove front plate.



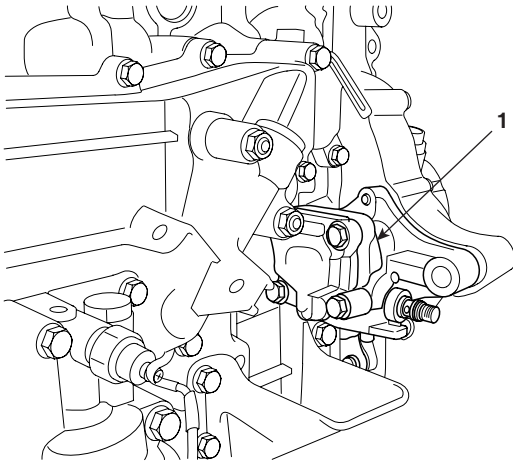
SUDEM7145L

7. Align the timing mark (2~3 side) of crankshaft damper pulley to the compression TDC of cylinder No. 1.

**NOTE**

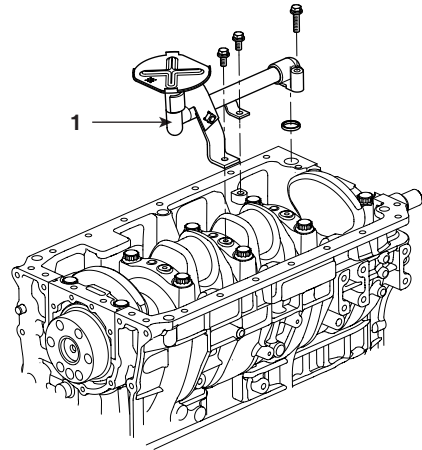
As for the removal of cooling fan pulley, crankshaft damper pulley and timing gear case, refer to the removal procedure of timing system.

10. Remove the power steering pump (1).



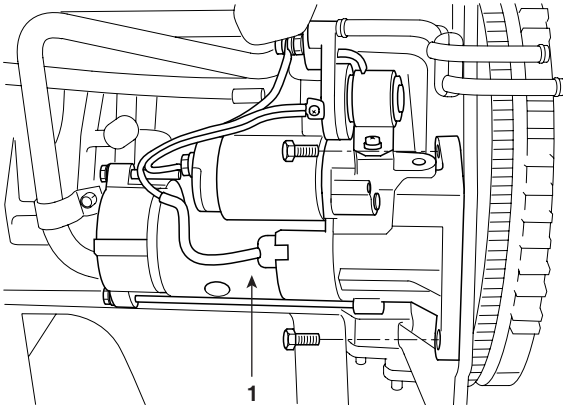
SUDEM7146L

13. Remove the oil strainer (1).



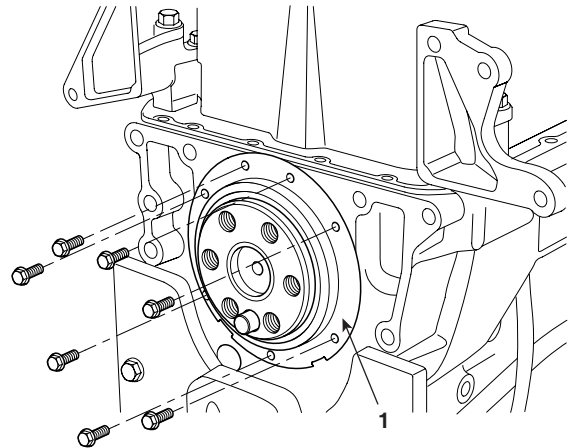
SUDEM7149L

11. Remove the starter motor assembly (1).



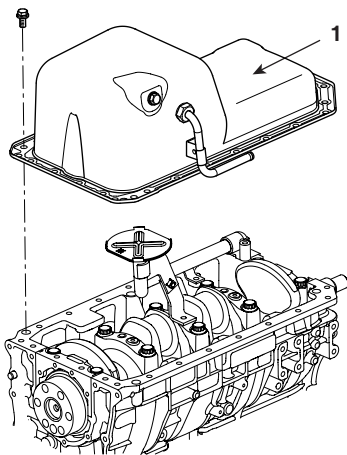
SUDEM7147L

14. Remove rear oil seal (1) and oil seal slinger (2).

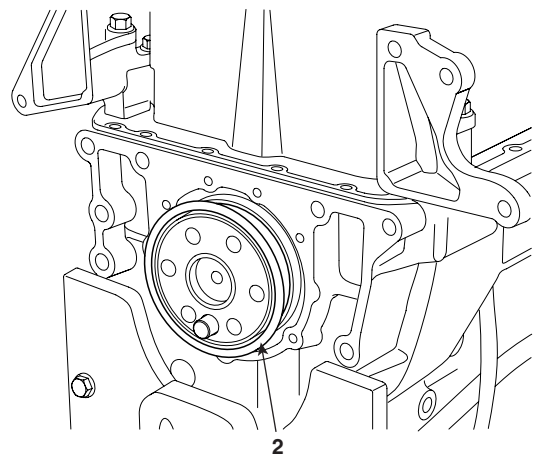


SUDEM7150L

12. Remove the oil pan (1).



SUDEM7148L

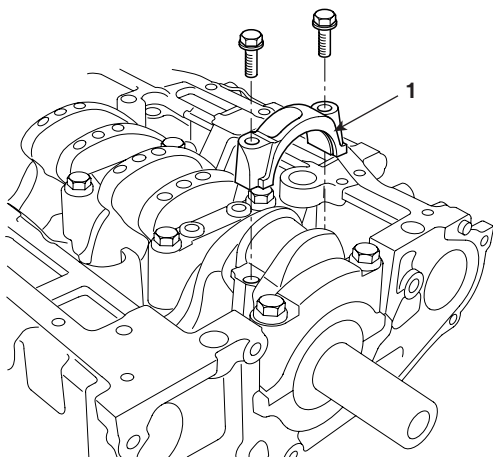


SUDEM7151L

15. Remove the connecting rod bearing cap (1).

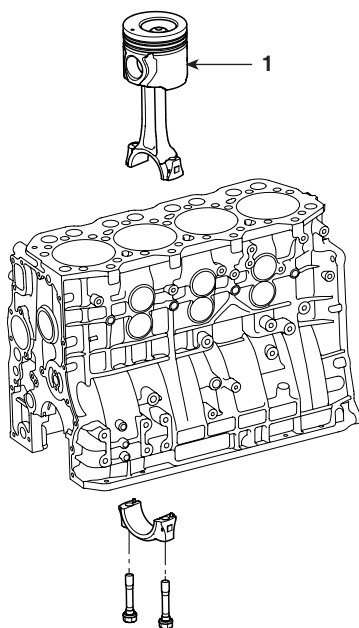
 **NOTE**

Make marks at the connecting rod and cap to be re-assembled correctly.



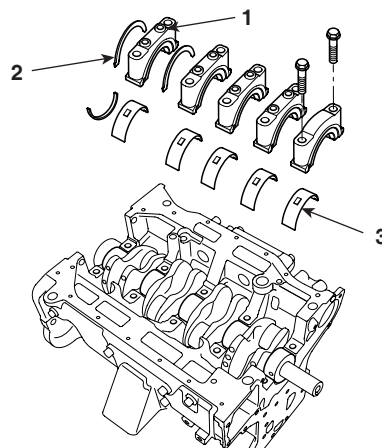
SUDEM7152L

16. Remove the piston and connecting rod assembly (1) from cylinder block.



SUDEM7153L

17. Remove the front, rear and main bearing caps.
- Remove the front bearing cap and rear end bearing cap. Remove the thrust plate (2) from the rear-bearing cap (1).
  - Remove the main bearing cap (1) and bearing (3).

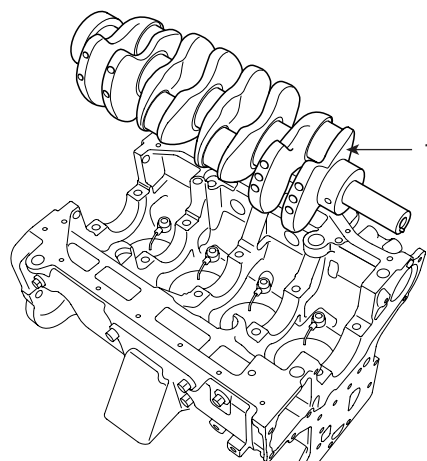


SUDEM7154L

18. Remove the crankshaft (1) from the cylinder block.

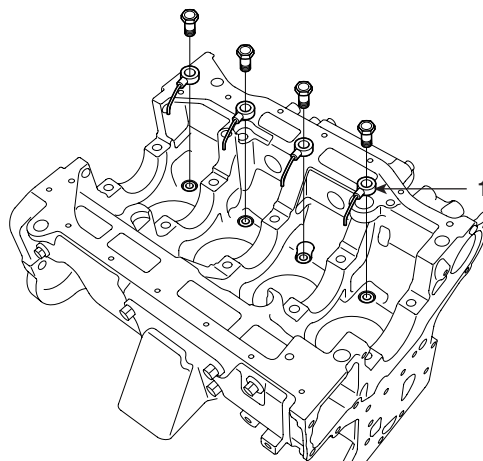
 **CAUTION**

Handle the crankshaft carefully so that the journal is not damaged.



SUDEM7155L

19. Remove the oil jet (1) from the cylinder block.

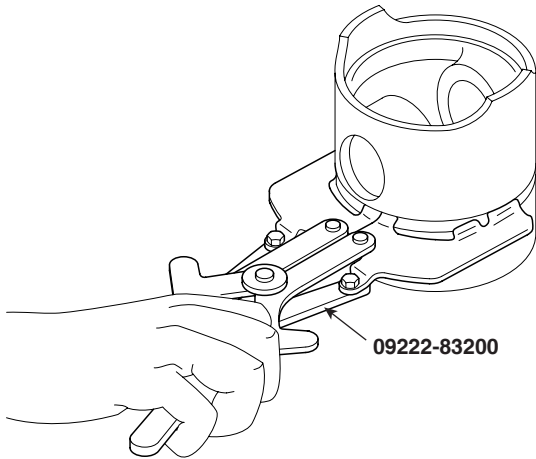


SUDEM7156L

DISASSEMBLY E190BEAB

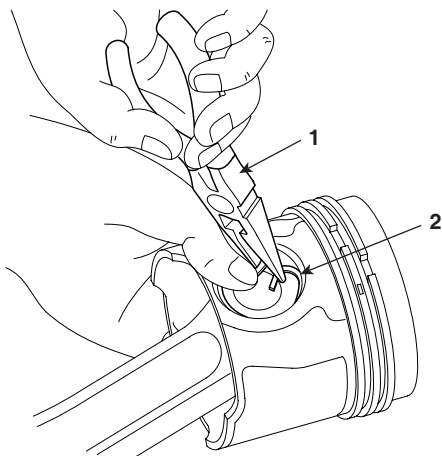
PISTON AND CONNECTING ROD ASSEMBLY

1. Remove the piston ring using the special tool (09222-83200).



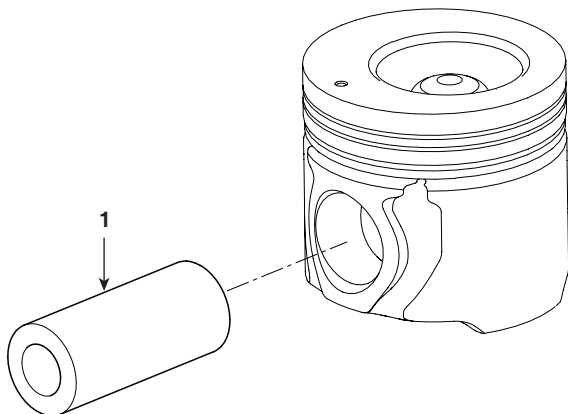
SUDEM7157L

2. Remove the piston pin snap ring (2) using the snap ring pliers (1).



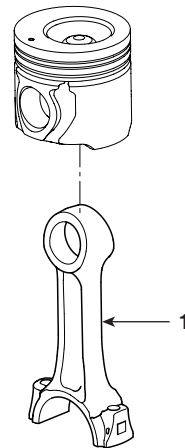
SUDEM7158L

3. Remove the piston pin (1) from the piston.



SUDEM7159L

4. Remove the connecting rod (1) from the piston.



SUDEM7160L

INSPECTION EBE61DCA

CYLINDER BLOCK

 **NOTE**

- a. Before repairing, clean each part to remove dust, oil, carbon and fur.
- b. Before cleaning the cylinder block, check water leakage or damages.
- c. Remove the adhesives at each oil hole using air brush and check whether any hole is clogged.

1. In addition to the visual check about scratch, rust and corrosion, inspect the slight scratches with precipitant. Repair or replace it if needed.
2. Measure the twist of cylinder block using straight edge (1) and thickness gauge (2). Measure them by placing the straight edge as shown in the following figure.

 **NOTE**

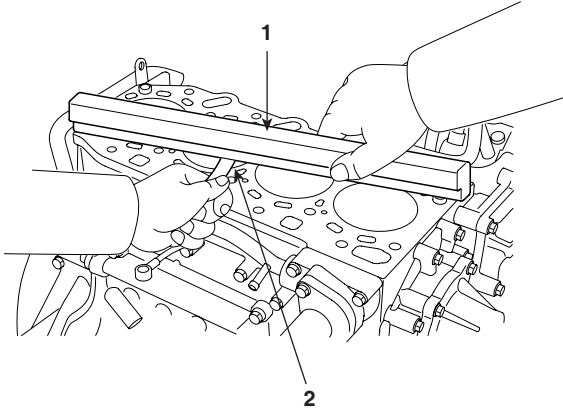
When measuring, cylinder upper block should be free from foreign materials such as gasket piece.

 **CAUTION**

When grinding the cylinder block, grind it as the piston protrusion does not exceed the reference.



Flatness figure of cylinder block  
Reference : Below 0.07mm  
Limit : 0.2mm



SUDEM7161L

3. Check the cylinder wall to see if it is cracked or damaged. If it is abnormal, repair (oversize) or replace the cylinder sleeve.
4. Measure the cylinder sleeve ID using the cylinder gauge. If it is excessively worn, repair it with oversize and replace the piston and piston ring.

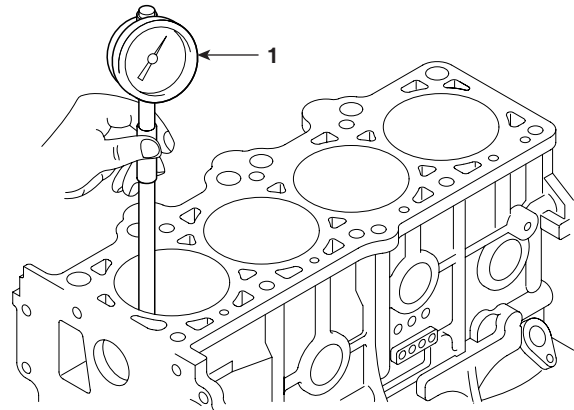
Clearance between piston and cylinder sleeve :  
0.080~0.130mm

**CAUTION**

1. **When replacing piston, piston ring should be replaced together.**
2. **Even if only one cylinder needs boring, all cylinder walls should be grinded with oversize at the same time.**
3. **Measure the most seriously worn cylinder wall and select the oversize based on the measurement.**
4. **Available oversizes are +0.25, +0.50, +0.75 and +1.00.**
5. **Piston and connection rod should be replaced with the new one which has identical weight and grade with the old one.**

- a. Measure the inner diameter of cylinder sleeve using the cylinder gauge (1).

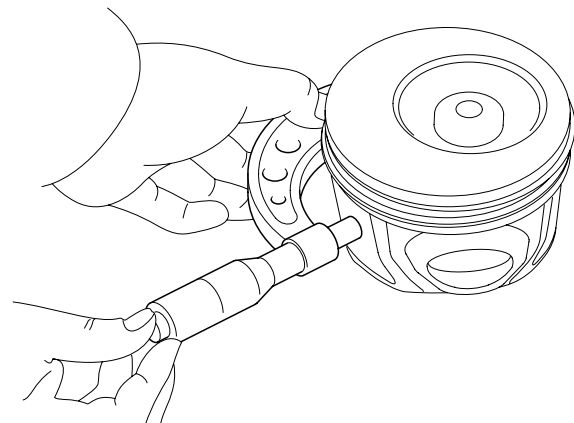
Inner diameter of cylinder sleeve: 104.00~104.03mm



SUDEM7162L

- b. Measure the outer diameter of piston skirt at the position, which is 85mm down from the upper piston.

Outer diameter of piston: 103.91~103.92mm

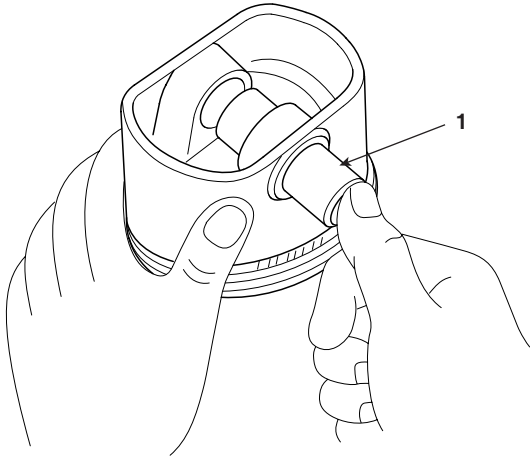


SUDEM7163L



**PISTON**

1. Check each piston to see whether it is damaged.
2. Check whether the piston pin (1) is installed correctly in the piston hole.  
If any defect is found, replace the piston and piston pin as an assembly.  
Piston pin should slide into the piston hole smoothly when it is pushed by hand.



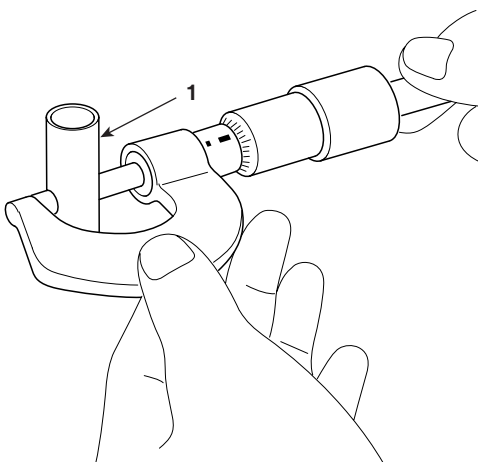
SUDEM7164L

3. Measure the clearance between piston pin and piston hole by measuring the inner diameter of piston pin (1) and piston boss.

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Inner diameter of piston boss: 38mm  
 Outer diameter of piston pin: 38mm  
 Clearance Reference: 0.007~0.021mm  
 Clearance Limit: 0.05mm

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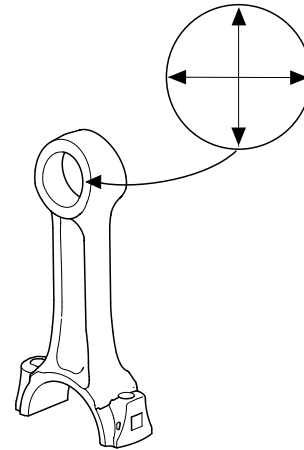
SUDEM7165L

4. Measure the clearance between piston pin and connecting rod end.

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Outer diameter of piston pin: 38mm  
 Inner diameter of connecting rod end: 38mm  
 Clearance Reference: 0.025~0.046mm  
 Clearance Limit: 0.1mm

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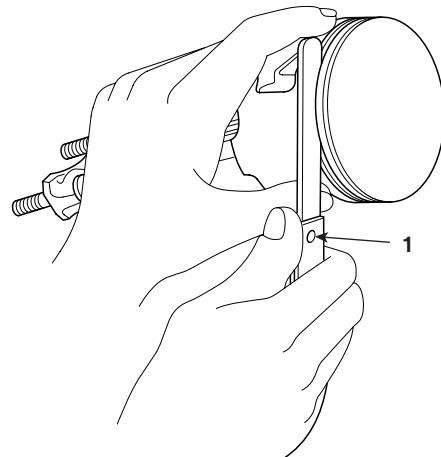


SUDEM7166L

**PISTON RING**

1. Check the piston ring for any damage, unusual wear or breakage. If damaged, replace the ring.
2. When replacing the piston, replace the piston pin together.
3. Measure the clearance between piston ring and the wall of the ring groove, using a feeler gauge.

Piston ring	Standard	Limit
Ring No.1	0.106~0.170mm	0.2mm
Ring No.2	0.07~0.11mm	0.15mm
Oil ring	0.03~0.07mm	0.15mm



SUDEM7167L

4. After installing the piston ring to the cylinder bore, push the piston ring to the vertical direction with the piston.

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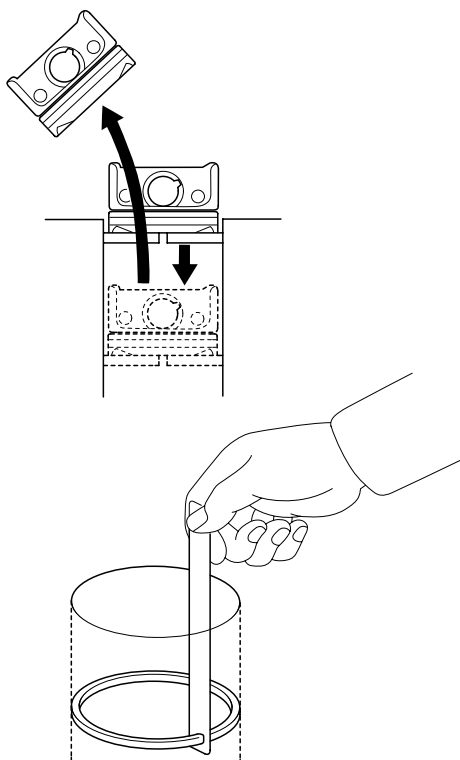
**Piston ring end gap**

Ring No.1: 0.25~0.40mm

Ring No.2: 0.50~0.65mm

Oil ring: 0.20~0.40mm

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SUDEM7168L

**CRANKSHAFT**

1. Measure the endplay of crankshaft.

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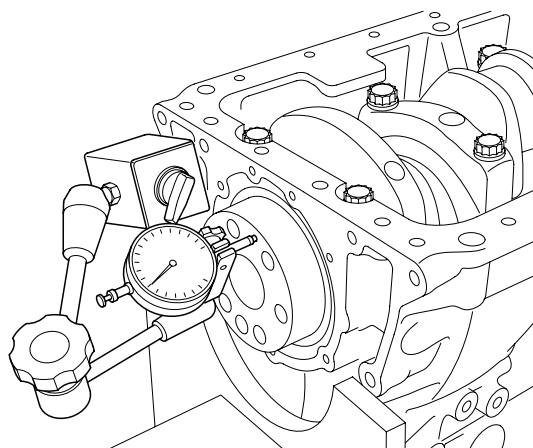
**Crankshaft endplay**

Reference :0.10~0.26mm

Limit: 0.4mm

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- a. If the endplay exceeds the limit, replace the thrust plate with the oversize.
- b. Oversizes of the thrust plate are +0.15, +0.30, and +0.45.

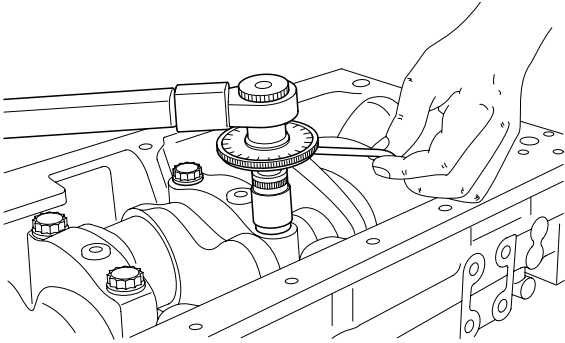


SUDEM7169L

2. Measure the oil gap of crankshaft main bearing.
  - a. Remove the main bearing cap.
  - b. Measure the oil gap of main bearing.
    - 1) Remove the oil or other foreign materials from main journal and main bearing surface.
    - 2) Place the plastic gauge along with the shaft direction of the journal.

- 3) Install the main bearing cap and fasten the bolt.

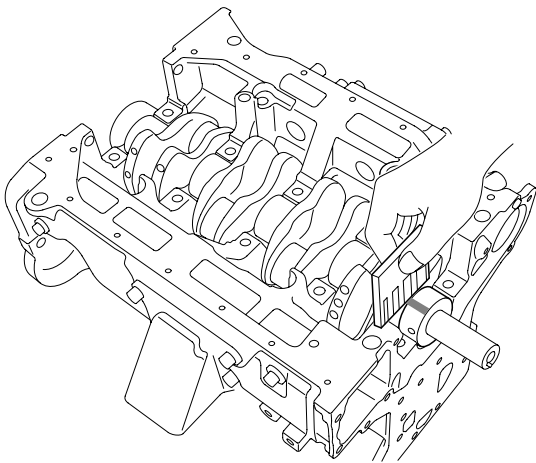
Tightening torque: 49.0 Nm+90°  
(5.0kgf.m+90°, 36.4 lb-ft+90°)



SUDEM7170L

- 4) Remove the main bearing cap and measure oil gap at each journal.

Oil gap of journal #1, 2, 4 and 5  
Reference: 0.036~0.098mm, Limit: 0.15mm  
Oil gap of journal #3  
Reference: 0.056~0.118mm, Limit: 0.15mm



SUDEM7171L

- 5) If the oil gap of the main bearing is excessively large, replace the main bearing.

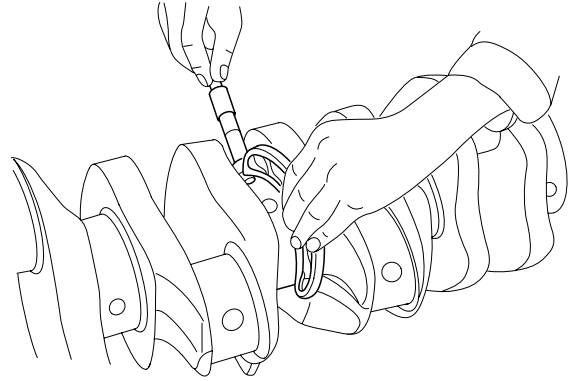
3. Measure roundness and cylindricity of crankshaft journal and pin. If the measurement exceeds the limit, repair it with under size.

Roundness of crankshaft

Reference : less than 0.01mm , Limit : 0.03mm

Cylindricity of crankshaft

Reference : less than 0.006mm , Limit : 0.03mm



SUDEM7172L

4. Check to see if the crankshaft is bent. Install the dial gauge of crankshaft center journal, and check the bending of the crankshaft.

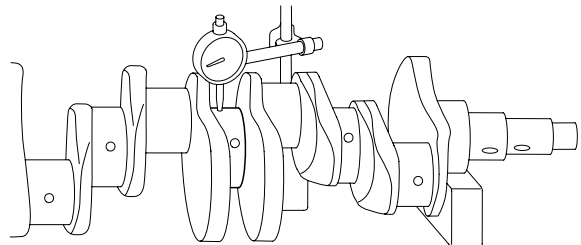
Bending of the crankshaft

Standard : Below 0.02mm

Limit : 0.05mm

**NOTE**

*Actual bending is a half of the measurement.*



SUDEM7173L

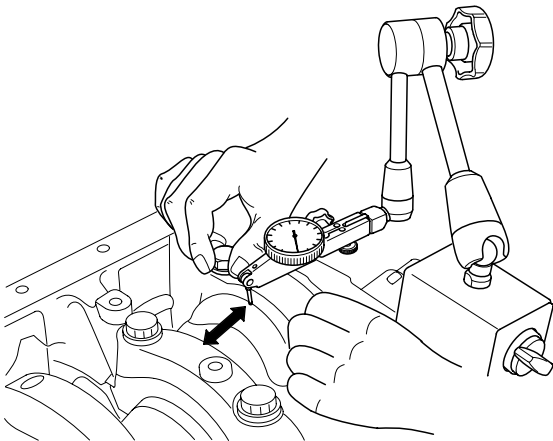
## CONNECTING ROD BEARING

1. Before removing the connecting rod cap, measure the connecting rod endplay. If the gap exceeds the reference, replace the connecting rod.

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Connecting rod endplay  
Reference: 0.15~0.45mm  
Limit: 0.6mm

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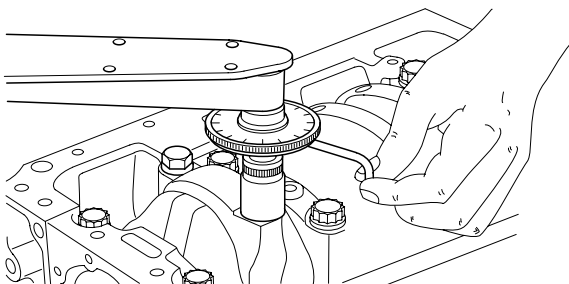
SUDEM7174L

2. Measure the oil gap of the connecting rod bearing.
  - 1) Remove the connecting rod cap.
  - 2) Measure the oil gap of the connecting rod bearing.
    - a. Remove the oil or foreign materials from pin journal and connecting rod bearing surface.
    - b. Place the plastic gauge on the shaft of pin journal along with its direction.
    - c. Install the connecting rod bearing cap and fasten the bolt.

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Tightening torque: 29.4 Nm+90°  
(3.0kgf.m+90°, 21.8 lb-ft+90°)

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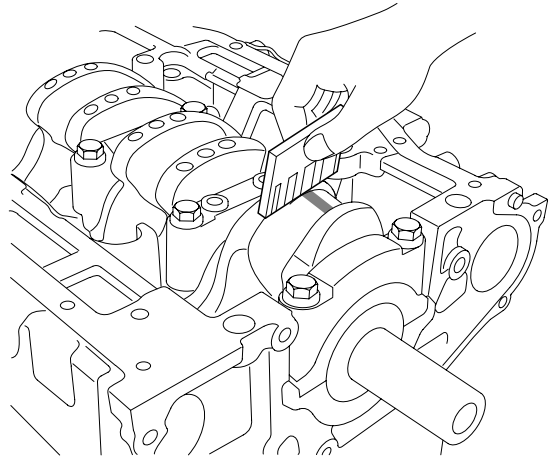
SUDEM7175L

- d. Remove the connecting rod bearing cap and measure the oil gap at each pin journal.

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Connecting rod oil gap  
Reference: 0.040~0.099mm  
Limit: 0.2mm

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SUDEM7176L

- e. If the oil gap is excessively large, replace the connecting rod bearing.
3. Length of the connecting rod bearing.  
Length of the Connecting rod bearing (1) is measured at the free state. If the measurement is below the limit, replace the upper and lower bearing.

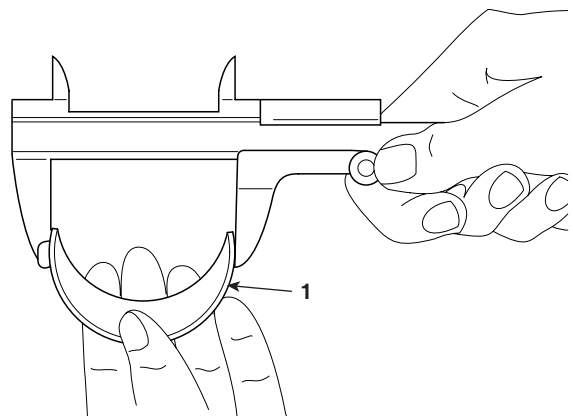
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Length of the connecting rod bearing  
Limit: above 69.5mm

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**! CAUTION**

**Bearing should not be artificially expanded to reuse.**

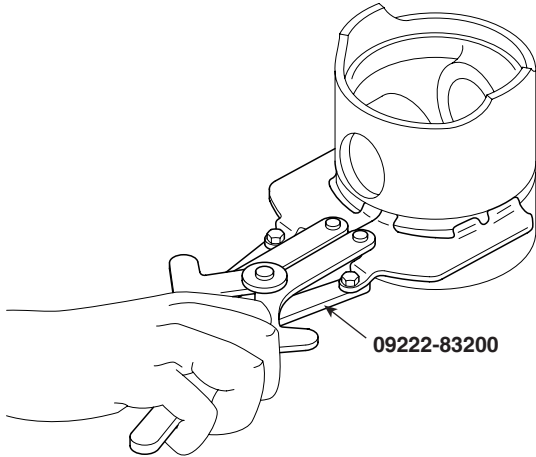


SUDEM7177L

REASSEMBLY E49D5D90

PISTON AND CONNECTING ROD ASSEMBLY

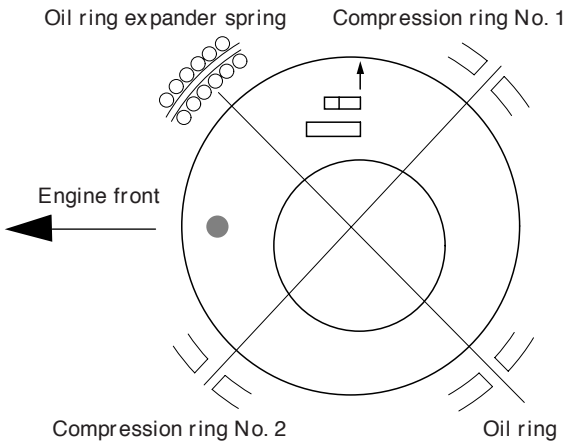
1. Install the piston ring using the special tool (09222-83200).



SUDEM7178L

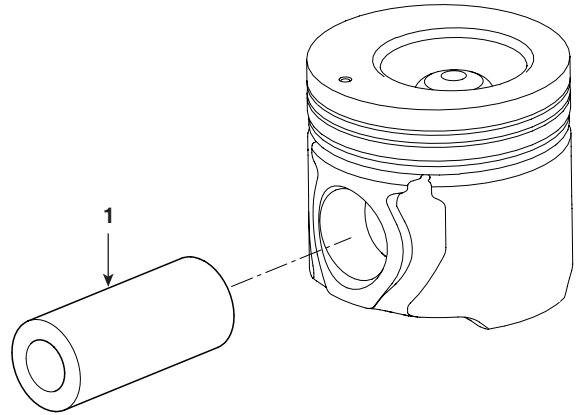
**NOTE**

- a. Install the piston ring so that open end of the piston ring faces to the direction shown in the figure.
- b. Install the oil ring expander spring to be positioned at 180° direction with the oil ring end. Otherwise, expander spring may be loosened.



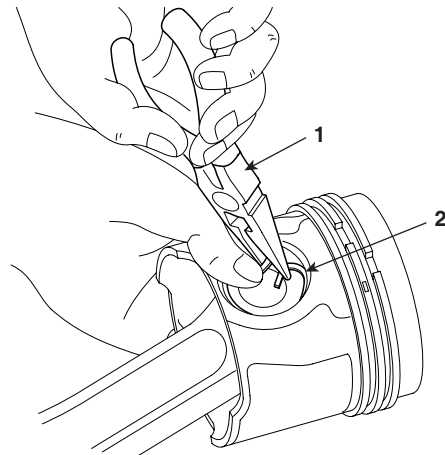
SUDEM7179L

2. Apply engine oil at the piston rod end and piston pin hole, and then install the piston pin (1).



SUDEM7180L

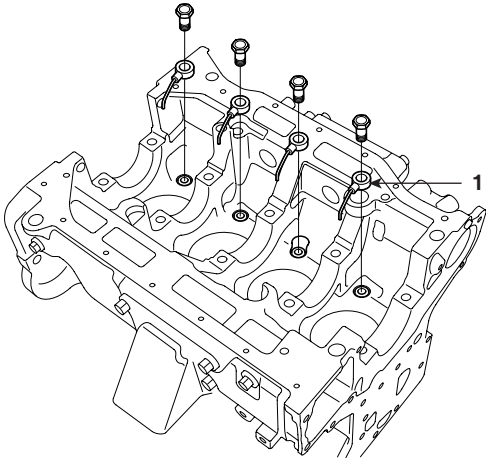
3. Install the piston pin snap ring (2) using snap ring pliers (1).



SUDEM7181L

## INSTALLATION EE5ABFA8

1. Install oil jet (1) to the cylinder block.

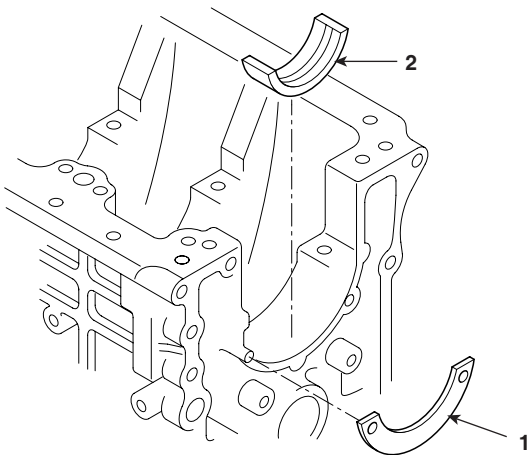


SUDEM7182L

2. Install thrust plate (1) and upper main bearing (2) to the crankcase.

### **CAUTION**

- Install the thrust plate with the oil grooveless side toward the crankcase.*
- Align the lug groove of crankcase with the lug of main bearing.*
- Since there is oil hole at upper bearing, take care not to be interchanged with lower bearing.*
- Apply engine oil on the all over the sliding surface.*

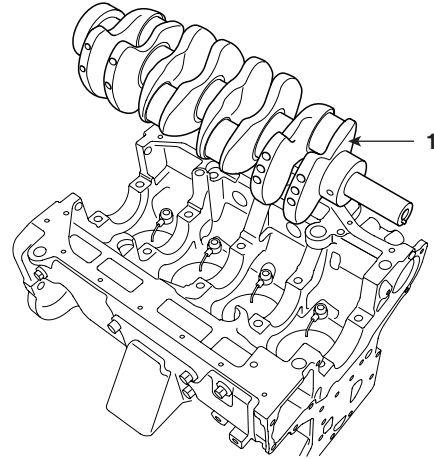


SUDEM7183L

3. Install the crankshaft (1) to the cylinder block.

### **CAUTION**

*Handle crankshaft carefully not to be damaged.*



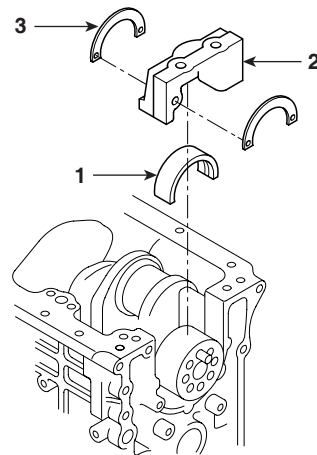
SUDEM7184L

4. Install the front, rear and main bearing caps.
  - a. Insert the lower main bearing (1) into bearing cap (2).

### **NOTE**

*Check to see whether the main bearing lug matches main bearing cap lug groove.*

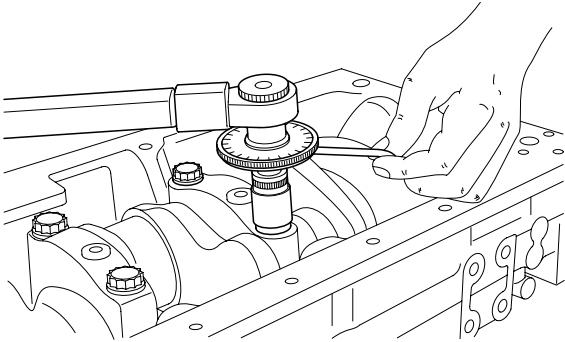
- b. Install thrust plate (3) to the rear-bearing cap.



SUDEM7185L

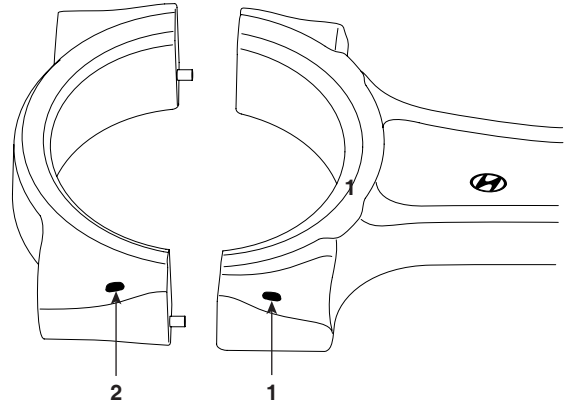
- c. Install the main bearing cap with the specified torque.

Tightening torque: 49.0 Nm+90°  
(5.0kgf.m + 90°, 36.4 lb-ft+90°)



SUDEM7186L

- b. When installing connecting rod cap, align mark (1) on connecting rod big end cap with mark (2) on connecting rod cap.

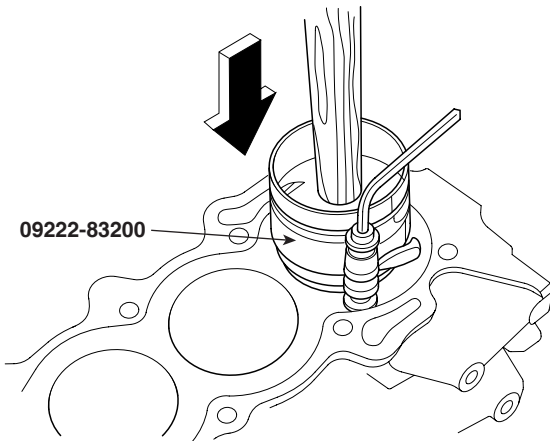


SUDEM7188L

- 5. Install piston and connecting rod assembly.

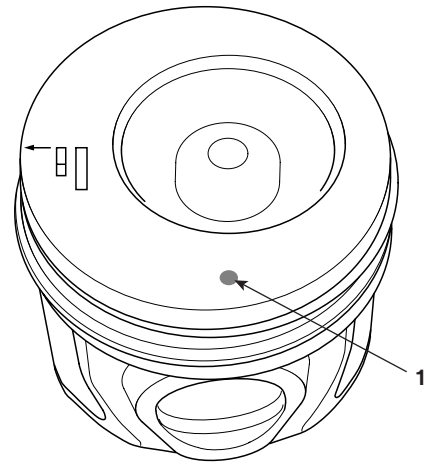
**! CAUTION**

- a. Install piston and connecting rod to the crankshaft pin journal using the special tool (09222-83200).



SUDEM7187L

- c. When installing piston, assemble it so that front mark (1) of the piston faces to the front side.
- d. Assemble so that the arrow mark (→) of piston head faces to the center of cylinder head bolt hole.



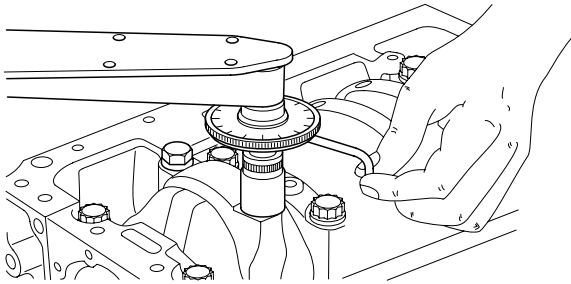
SUDEM7189L

- e. **Tighten the connecting rod cap with specified torque.**

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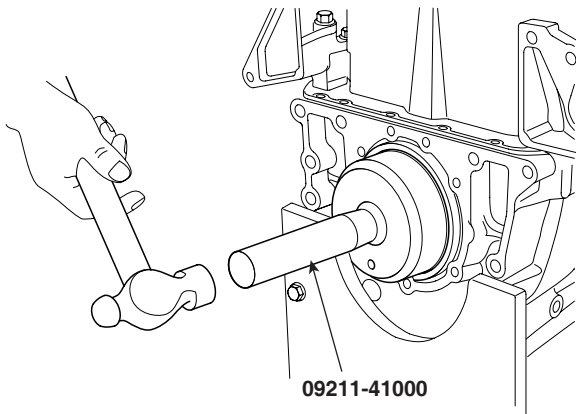
Tightening torque: 29.4 Nm+90°  
(3.0kgf.m + 90°, 21.8 lb-ft+90°)

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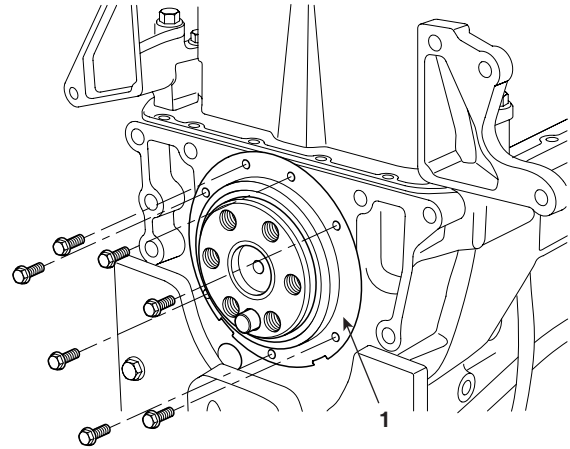
SUDEM7190L

6. Install rear oil seal slinger using the special tool (09211-41000).



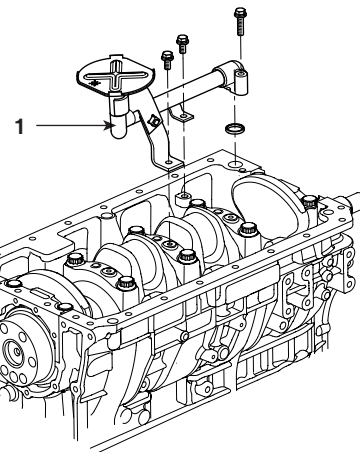
SUDEM7191L

7. Apply the sealant (Loctite #5699) to the rear oil seal, and then install the rear oil seal (1).



SUDEM7192L

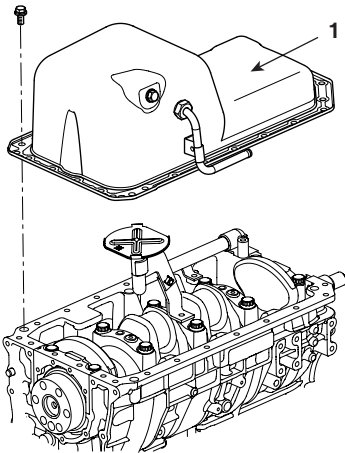
8. Install the oil strainer (1).



SUDEM7193L



9. Install the oil pan (1).



SUDEM7194L

10. After installing the cylinder block assembly, measure the piston protrusion. Install the right cylinder head gasket.

 **NOTE**

*As for the cylinder head gasket selection and assembly, refer to the cylinder head assembly procedure.*

11. Install the timing system.
12. Install the flywheel and rear plate.
13. Install the cylinder head assembly.
14. Install intake and exhaust manifold.
15. Install engine accessories.