GENERAL INFORMATION

GENERAL

GENERAL

GENERAL EC6254B9

HOW TO READ DISASSEMBLY AND REASSEMBLY DRAWINGS

1. The part names and numbers in the drawings match the ones in the text. The parts are numbered in the order of disassembly.

2. The items to be inspected during disassembly are shown in the disassembly drawings.

3. All torque specifications for the tightening in the reassembly drawings may be regarded as "dry" unless "wet" is specified.

DEFINITION OF TERMINOLOGIES

Unless otherwise specified, all dimensions for the following values in the illustration represent mm even if the unit is not explicitly expressed.

1. Nominal Value (Abbr.: NV)
   It shows dimension of an individual part, relative clearance between parts of standard performance. This value, however, does not necessarily coincide with design value as it is rounded off to fall within limits necessary for inspection.

2. Repair Limit (Abbr.: RL)
   It shows the specified value, in which repair is needed. Repair means adjustment, grinding or replacement such as bushings, metals and others, selection of oversize, selection of shim thickness, etc.

3. Service Limit (Abbr.: SL)
   It shows the specified value, in which parts replacement with new ones is needed.

4. Basic Diameter (Abbr.: BD)
   It shows nominal diameter of part to be measured.

5. Tightening Torque (Abbr.: T)
   It shows tightening torque of bolts or nuts.

UNIT

The SI unit is used. Metric notation is also presented in parentheses.

NOTE, WARNING AND CAUTION

1. Note
   This refers to a piece of useful information to the customers.

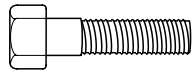
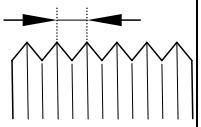
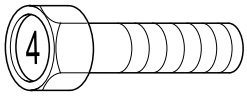
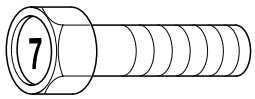
2. Caution
   This refers to Information about activities that may cause damage to the vehicle.

3. Warning
   This refers to Information about activities that may cause injury or damage to the driver, passengers or other personnel.

CONVERSION TABLE FOR FOOT-POUND UNITS INTO SI UNITS

Unit	Unit symbol of	foot-pound unit	Conversion rate
Weight	kg g	lbs oz	1 kg = 2.2046 lbs 1 g = 0.035274 oz
Length	m mm	ft. in.	1 mm = 3.2808 ft. 1 mm = 0.03937 in
Volume	lit. cc	gal. oz	1 lit. = 0.2642 gal. (U.S.) 0.220 gal. (Imp.) 1 cc = 0.033814 oz (U.S.) 0.035195 oz (Imp.).
Force	N (Newton)	lbf	1 N = 0.2248 lbf
Pressure	kPa (kilopascal)	lbf/in.^{2}	1 kPa = 0.145 lbf/in.^{2} 1 kPa = 0.2953 in.Hg
Stress	N/cm^2	lbf/in.^{2}	1 N/cm^2= 1.45 lbf/in.^{2}
Moment of force	Nm	lbf.ft	1 Nm = 0.7375 lbf.ft
Output	kW (kilowatt)	HP	1 kW = 1.34 HP
Temperature	°C	°F	T°C = (1.8 t°C + 32)°F

TIGHTENING TORQUE TABLE OF STANDARD PARTS

Bolt nominal diameter	Pitch (mm)	Torque Nm (kg.cm, lb.ft)	
		Head Mark 4	Head Mark 7
 ECBGI5001A	 ECBGI5002A	 ECBGI5003A	 ECBGI5004A
M5	0.8	3~4 (30~40, 2.2~2.9)	5~6 (50~60, 3.6~4.3)
M6	1.0	5~6 (50~60, 3.6~4.3)	9~11 (90~110, 6.5~8.0)
M8	1.25	12~15 (120~150, 9~11)	20~25 (200~250, 14.5~18.0)
M10	1.25	25~30 (250~300, 18~22)	30~50 (300~500, 22~36)
M12	1.25	35~45 (350~450, 25~33)	60~80 (600~800, 43~58)
M14	1.5	75~85 (750~850, 54~61)	120~140 (1,200~1,400, 85~100)
M16	1.5	110~130 (1,100~1,300, 54~61)	180~210(1,800~2,100, 130~150)
M18	1.5	160~180 (1,600~1,800, 116~130)	260~300(2,600~3,000, 190~215)
M20	1.5	220~250 (2,200~2,500, 160~180)	360~420 (3,600~4,200, 260~300)
M22	1.5	290~330 (2,900~3,300, 210~240)	480~550(4,800~5,500, 350~400)
M24	1.5	360~420 (3,600~4,200, 260~300)	610~700 (6,100~7,000, 440~505)

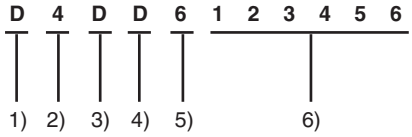
NOTE

1. *The torques shown in the table are standard values under the following conditions :*
   - *Nuts and bolts are made of galvanized steel bar.*
   - *Galvanized plain steel washers are inserted.*
   - *All nuts, bolts and plain washers are dry.*

2. *The torques in the table are not applicable under following conditions:*
   - *When spring washers, toothed washers and other similar parts are inserted.*
   - *If plastic parts are fastened.*
   - *If self-tapping screws or self-locking nuts are used.*
   - *If threads and surfaces are coated with oil.*

3. *If you reduce the torques in the table to the percentage indicated below-under the following conditions, it will be the standard value.*
   - *If spring washers are used : 85%*
   - *If threads and bearing surfaces are stained with oil : 85%*

ENGINE IDENTIFICATION NUMBER EXAMPLE :



SUDGI7001L

1) D : DIESEL ENGINE
   G : GASOLINE ENGINE
   C : CNG ENGINE

2) 4 : 4 CYCLE 4 CYLINDER
   6 : 4 CYCLE 6 CYLINDER
   8 : 4 CYCLE 8 CYLINDER

3) Engine development order

4) Engine version

5) Model year
   X : 1999 Y : 2000 1 : 2001 2 : 2002 3 : 2003
   4 : 2004 5 : 2005 6 : 2006 7 : 2007 8 : 2008

6) Product serial number.
   000001 ~ 999999

GENERAL PRECAUTIONS FOR SERVICING E78344D4

PROTECTION OF THE VEHICLE

Always make sure to cover fenders, seats, and floor areas before commencing service works.

CAUTION

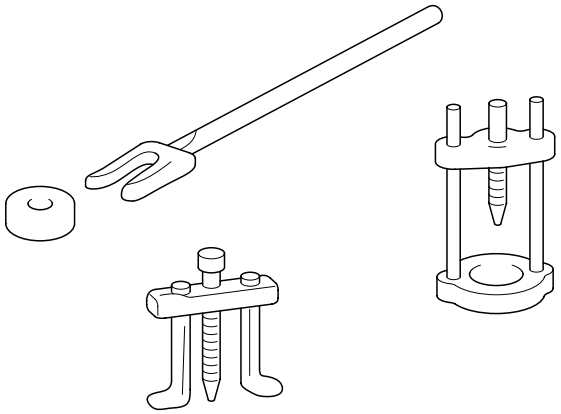
The support rod must be inserted into the hole near the edge of the hood whenever you inspect the engine compartment to prevent the hood from falling and possible resulting injury.
Make sure that the support rod has been released before closing the hood. Always check to make sure the hood is firmly latched before driving the vehicle.

PREPARATION OF TOOLS AND MEASURING EQUIPMENT

Be sure that all necessary tools and measuring equipment are available before starting work.

SPECIAL TOOLS

Use special tools when they are required.



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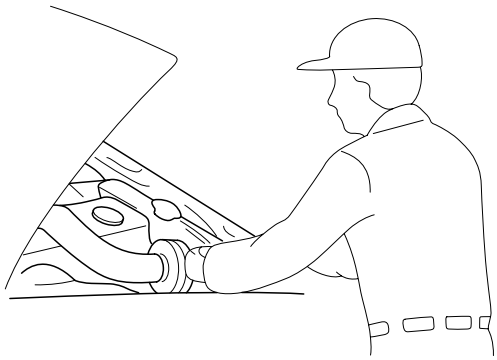
REMOVAL OF PARTS

First find the cause of the problem and then determine to remove or disassemble before starting the servicing works.



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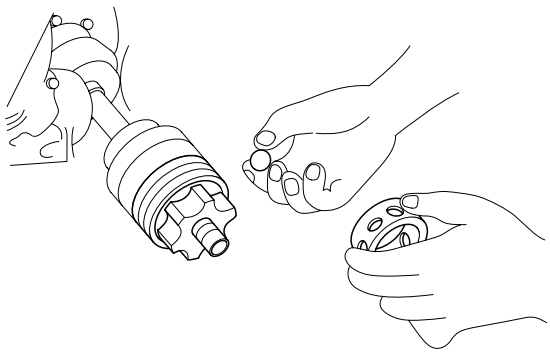
DISASSEMBLY

If the disassembly procedure is complex, requiring many parts to be disassembled, all parts should be disassembled in a right way so that the performance or external appearances are not affected.

1. Inspection of parts
   Each part, when removed, should be carefully inspected for malfunction, deformation, damage, or any other problems.



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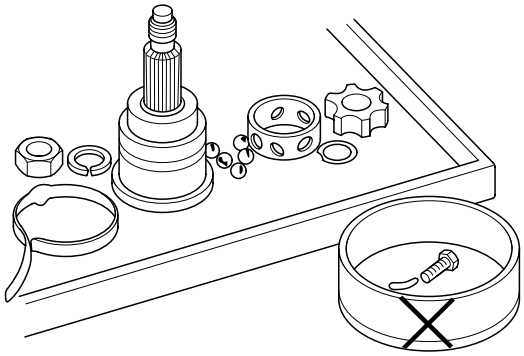
2. Arrangement of parts
   All parts disassembled should be arranged deliberately for the purpose of effective reassembly.



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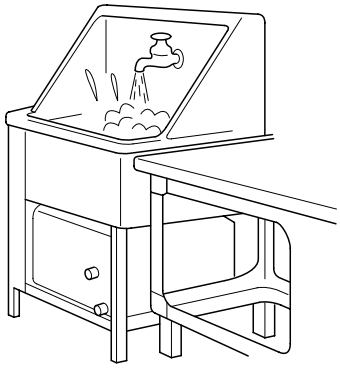
3. Cleaning parts for reuse
   Be sure to separate the parts to be reused for easy indetification.



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PARTS

When replacing parts, be sure to use HYUNDAI genuine parts.

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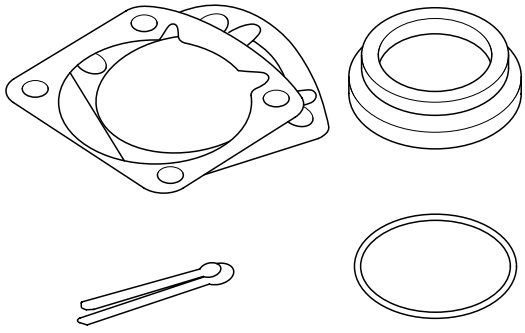
REPLACEMENT

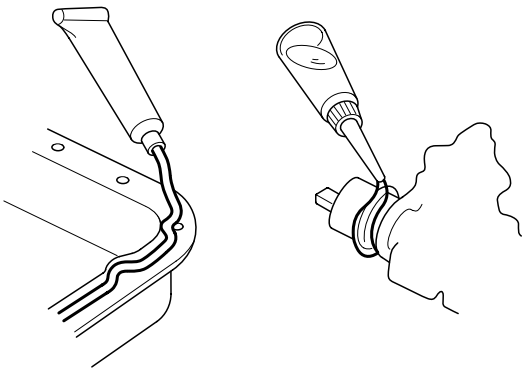
Standard values such as torques and adjustments must be strictly observed in the all parts reassembly.
If removed, some of the following parts must be replaced with new ones depending on their installing positions.

1. Oil seals
2. Gaskets
3. O-rings
4. Lock washers
5. Cotter pins (split pins)
6. Plastic nuts



ECBGI5012A

7. Sealant should be applied to gaskets.
8. Oil should be applied to the moving components of parts.
9. Specified oil or grease should be applied to the prescribed locations (oil seals, etc.) before assembly.



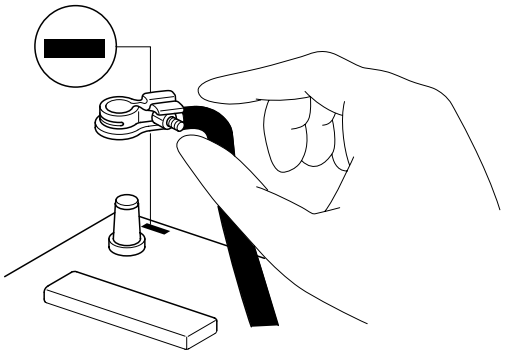
ECBGI5013A

ADJUSTMENT

Use gauges and testers to adjust the parts correctly to the specification.

ELECTRICAL SYSTEM

1. Be sure to disconnect the battery cable from the negative (-) terminal of the battery.
2. Never pull on the wires when disconnecting connectors.
3. Connectors will sound click when the connector is securely locked.
4. Carefully handle sensors and relays. Be careful not to drop them or touch other parts.



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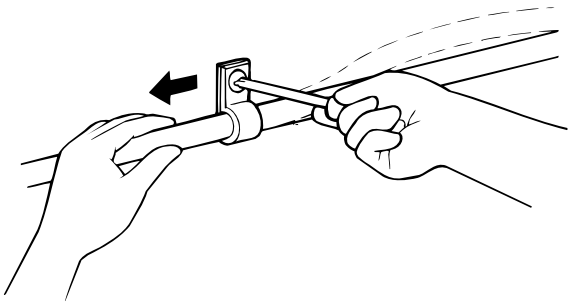
CHECKING CABLES AND WIRES

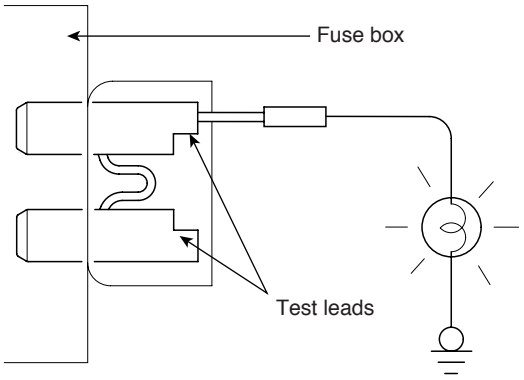
1. Check to see if the terminal is tightened correctly.
2. Check to see if terminals and wires are corroded by battery electrolyte, etc.
3. Check terminals and wires for any short circuits.
4. Check wire insulation and coating for any damage, cracks or degrading.
5. Check to see if the conductive parts of terminals contact other metallic parts (vehicle body and other parts).
6. Check the grounding of parts to ensure the complete continuity between their installing bolt(s) and the vehicle's body.
7. Check to see if the wiring is correct.
8. Check to see if the wiring is clamped to prevent contact with sharp corners of the vehicle body or heat exposed parts (exhaust manifold, etc.)
9. Check to see if the wiring is clamped firmly to provide enough clearance to the fan from pulley, fan belt and other revolving or moving parts.
10. Check to see if the wiring has some space so that it can vibrate between fixed and moving parts such as the vehicle body and the engine.



ECBGI5015A

CHECKING FUSES

A blade type fuse test leads are provided to allow fuse check without removing it from the fuse box. The fuse is good if the test lamp lights up when one lead is connected to the test leads (one at a time) and the other lead is grounded. (Turn on the ignition switch so that the fuse circuit becomes operative)



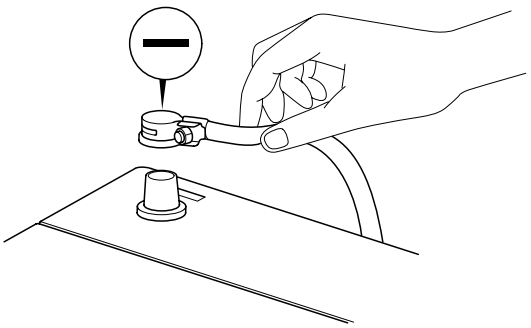
ECBGI5016A

SERVICING THE ELECTRICAL SYSTEM

1. Prior to servicing the electrical system, be sure to turn off the ignition switch and disconnect the battery ground cable.

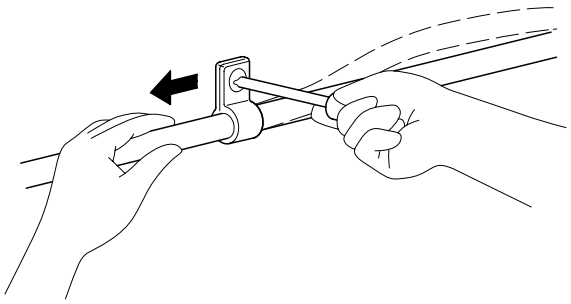
   NOTE

   When performing MFI or ELC system diagnosis, if the battery cable is removed, then, any diagnostic trouble code retained by the computer will be cleared. There fore, if necessary, read the diagnostic trouble code before removing the battery cable.



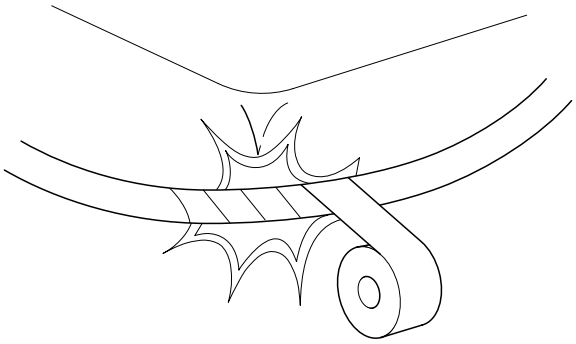
ECBGI5017A

2. Secure the wiring harnesses with clamps so that there is no slack. However, allow some slack or distance for the wiring harness from vibrating parts, which crosses the engine or other vibrating parts of the vehicle. Allow wiring harness some slack or distance so that it does not contact with any of the adjacent parts, and then, secure the harness by using a clamp.



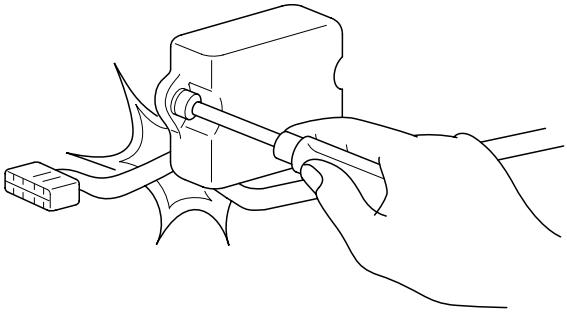
ECBGI5018A

3. If any section of a wiring harness interferes with the edge of parts, or corners, wrap the section of the harness with tape or something similar in order to protect if from damage.



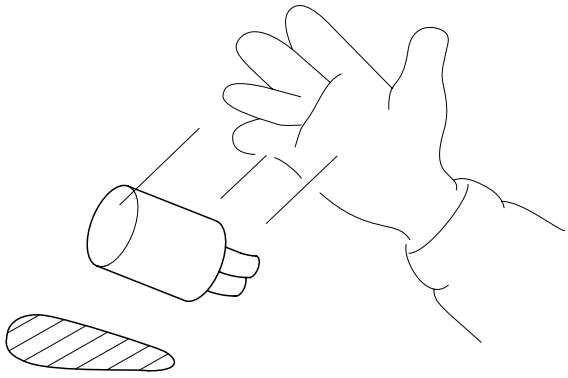
ECBGI5019A

4. When installing any parts, be careful not to pinch or damage any of the wiring harness.



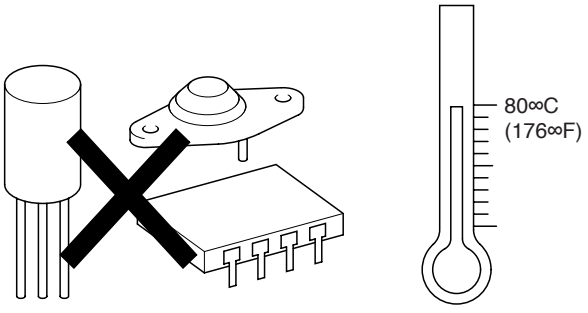
ECBGI5020A

5. Never throw relays, sensors or electrical parts, or expose them to strong shock.



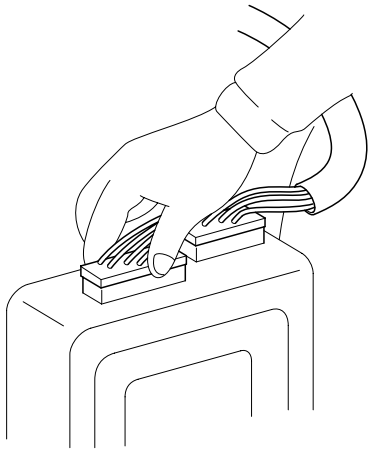
ECBGI5021A

6. The electronic parts used in the computer, relays, etc. are subject to thermal damage easily. If any service work is needed that may cause the temperature to exceed 80°C (176°F), remove the electronic parts beforehand.



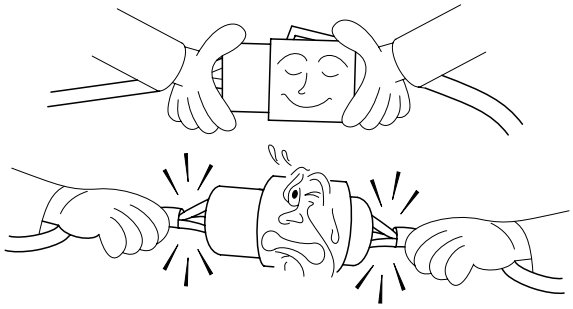
ECBGI5022A

7. Loose connectors may cause problems. Make sure that the connectors are always securely fastened.



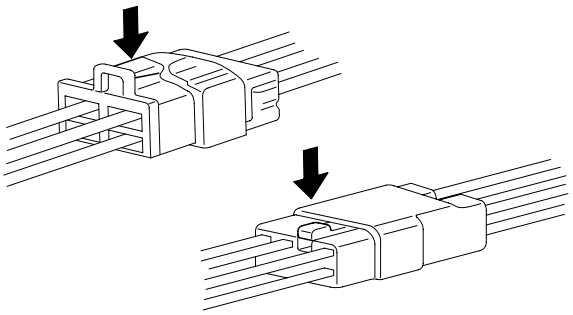
ECBGI5023A

8. When disconnecting a connector, be sure to grip only the connector, not the wires.



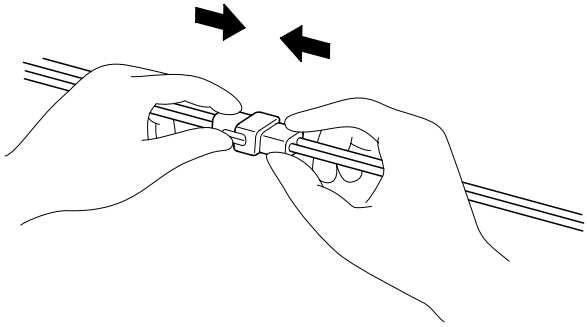
ECBGI5024A

9. Disconnect the connectors by pressing the catches in the arrow direction as shown in the illustration.



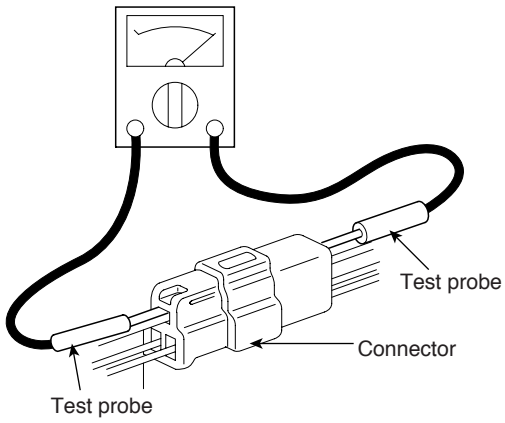
ECBGI5025A

10. Connect connectors by inserting the catches, until they make a clicking sound.



ECBGI5026A

11. When using a circuit tester to check continuity or voltage on connector terminals, insert the test probe into the harness side. If the connector is a sealed connector, insert the test probe through the hole in the rubber cap until contacts the terminal, taking care not to damage the insulation of the wires.



ECBGI5027A

ENGINE MECHANICAL SYSTEM (D4DD)

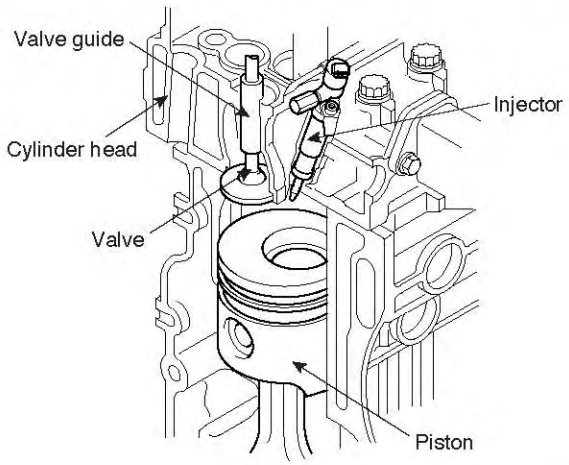
GENERAL

DESCRIPTION EFA0EBB7

COMBUSTION

CHAMBER

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

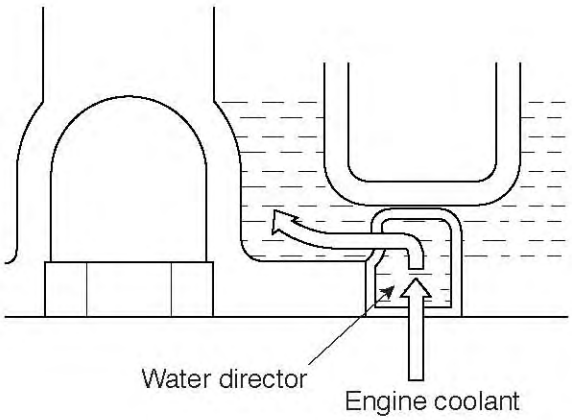


SUDEM7001L

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.



SUDEM7002L

VALVE MECHANISM

1. Heat resistant steel with surface treatment is used for intake and exhaust valve. The valve seat angle is 45°.

2. Valve stem seal, installed to the stem, adjusts the lubricant amount on the sliding surface of valve and valve guide.

NOTE

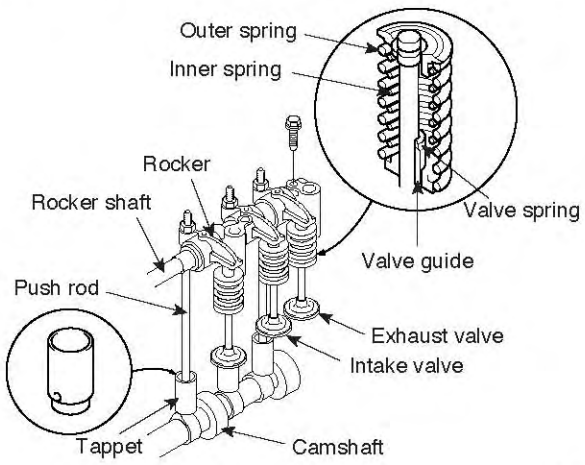
Valve guide with carbon cutter is used for exhaust valve.

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.

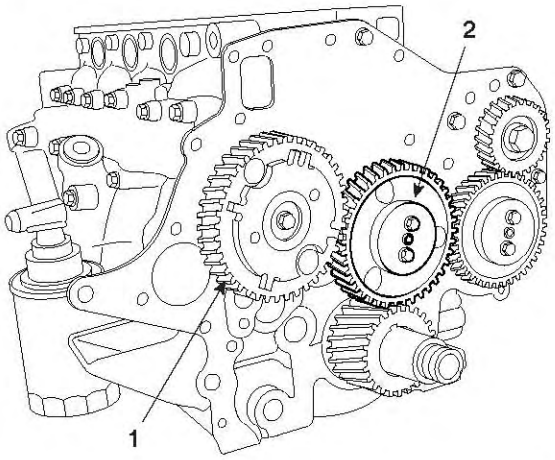
5. Steel ball is installed to the lower end of push rod and rocker assembly is installed to upper end.

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.



SUDEM7003L

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

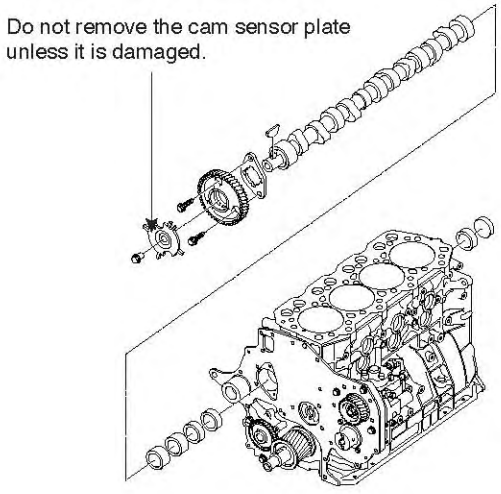


SUDEM7004L

CRANKCASE AND CYLINDER SLEEVE

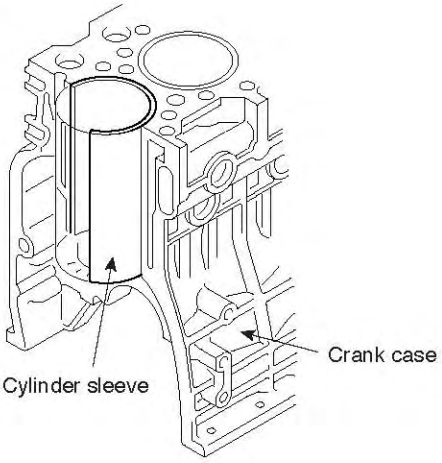
1. Crankcase is manufactured firmly with cast iron to prevent stress concentration and deformation.

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.



SUDEM7005L

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



SUDEM7006L

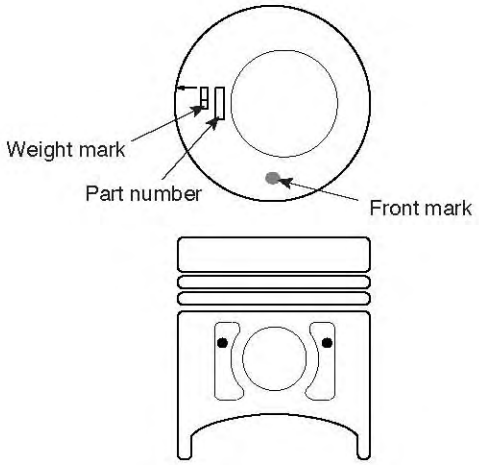
PISTON

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

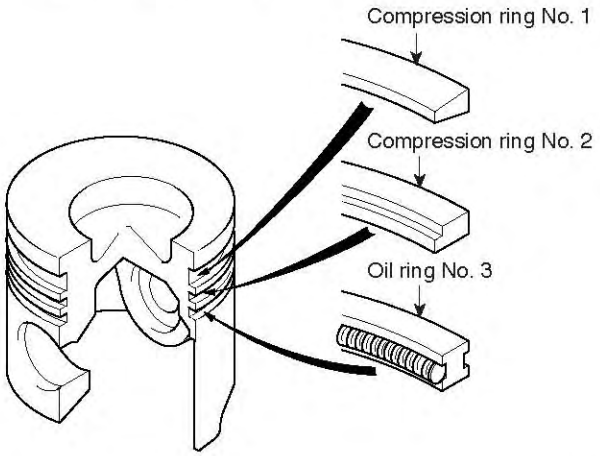
When assembling a piston, let the arrow mark (→) faced to the center of cylinder head bolt hole.



SUDEM7007L

PISTON RING

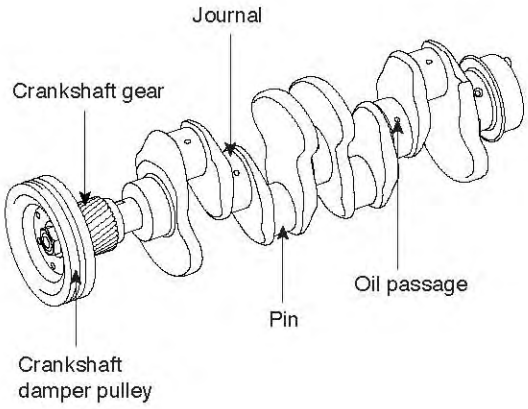
Piston has two compression rings and one oil ring. All sliding surfaces of rings are coated with hardened chrome.



SUDEM7008L

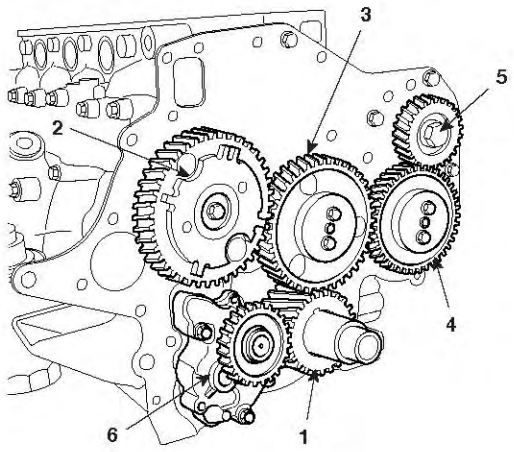
CRANKSHAFT

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.



SUDEM7009L

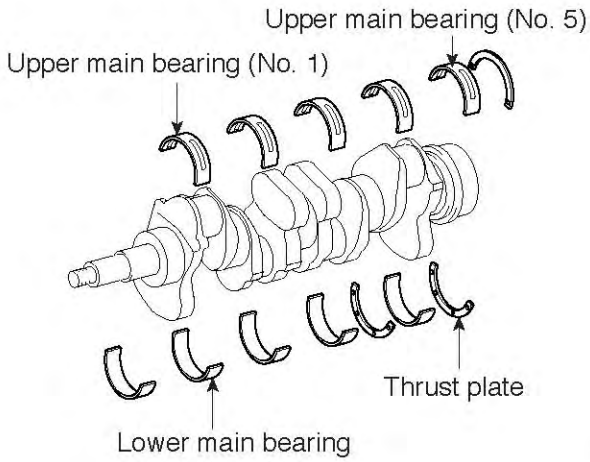
6. Crankshaft gear (1) drives camshaft gear (2), idler gear A (3), idler gear B (4), supply pump gear (5) and oil pump gear (6).



SUDEM7010L

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).



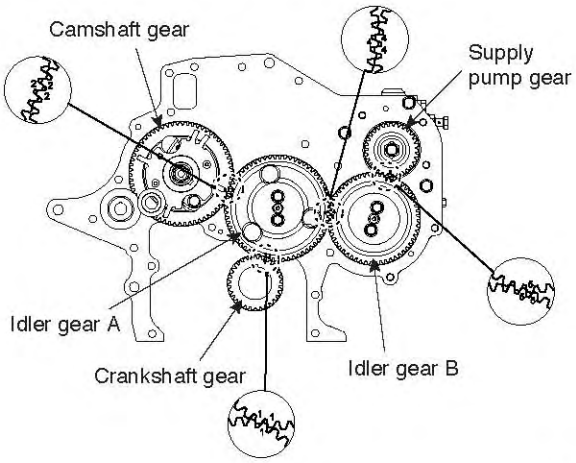
SUDEM7011L

TIMING GEAR

1. Timing gear is installed in the timing gear case at the front of engine.

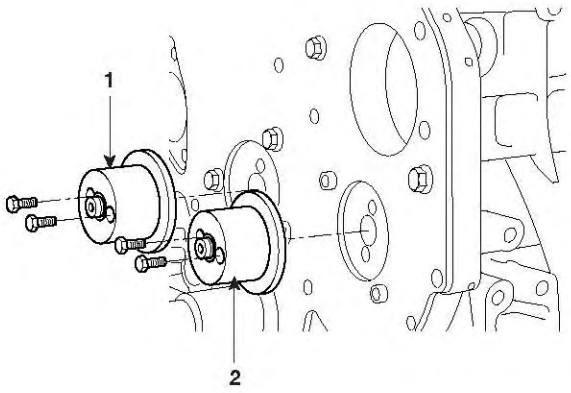
2. Each gear is helical gear manufactured with high precision and its surface is treated by heat to enhance the durability.

3. Timing marks are marked on the gear. When assembling, by aligning the timing marks, gears can be engaged correctly.



SUDEM7012L

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.

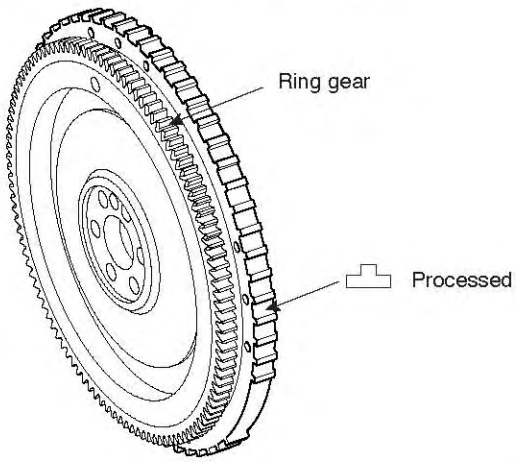


SUDEM7013L

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	Serial 4-cylinder 4stroke common rail system		
Cylinder inner diameter	104mm		
Cylinder stroke	115mm		
Displacement	3,907cc		
Compression ratio	17.5 : 1		
Firing order	1-3-4-2		
Maximum output	100ps/2300rpm (D4DD-C5) 92ps/2300rpm (D4DD-C3,C4)		
Maximum torque	38kgf.m/1600rpm (D4DD-C5) 33kgf.m/1600rpm (D4DD-C3,C4)		
Compression pressure (at 200rpm)	26kg/cm²	20kg/cm²	Adjustment (As the difference between cylinders is within 4kg/cm²)
Valve timing			
Intake valve open (BTDC)	19°		
Intake valve close (ABDC)	53°		
Exhaust valve open(BBDC)	60°		
Exhaust valve close (ATDC)	16°		
Valve			
Intake valve length	137mm		
Exhaust valve length	137mm		
Outer diameter of intake valve stem	8.960~8.975mm	8.85mm	
Outer diameter of exhaust valve stem	8.925~8.940mm	8.85mm	
Valve face angle	45°		
Thickness (margin) of intake/exhaust valve head	1.5mm	1.2mm	
Valve clearance (when engine is cold)	0.4mm		
Gap between valve stem and valve guide			
Intake	[9] 0.04~0.06mm	0.15mm	Replace
Exhaust	[9] 0.07~0.10mm	0.2mm	
Valve guide length			
Intake	64mm		
Exhaust	71.5mm		
Valve sinkage			
Intake	0.75~1.25mm	1.5mm	Valve seat Replace insert
Exhaust	0.75~1.25mm	1.5mm	
Push rod run out	—	0.4mm	Replace
Valve seat width			
Intake	2.6~3.0mm	3.6mm	Replace
Exhaust	1.8~2.2mm	2.8mm	

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

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

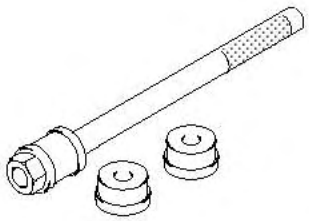
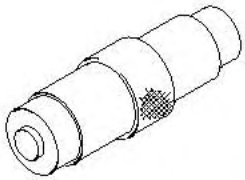
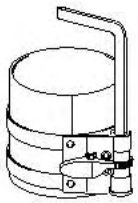
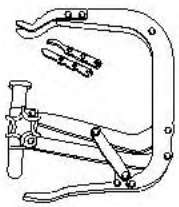
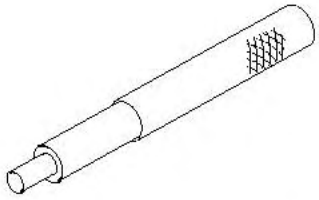
TIGHTENING TORQUE

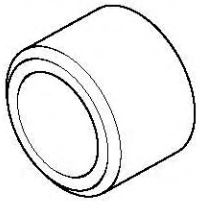
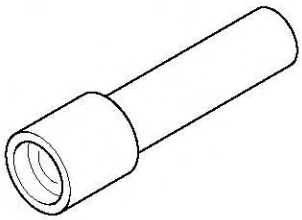
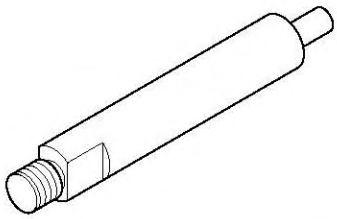
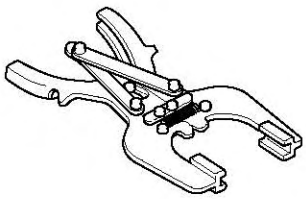
Items (diameter × length)		Screw size O.D×pitch (mm)	Nm	kgf.m	lb-ft
Cylinder block	Main bearing cap bolt	M14×2.0	49+90°	5.0+90°	36.4+90°
	Front plate flange bolt(8 ×16)	–	18.6~27.4	1.9~2.8	13.8~20.4
	Rear oil seal slinger flange bolt(6×12)	–	7.8~11.8	0.8~1.2	5.8~8.7
	Supply pump side timing gear case 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

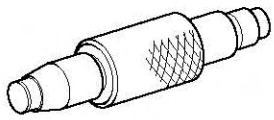
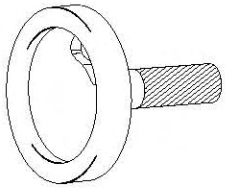
Items (diameter × length)		Screw size O.D×pitch (mm)	Nm	kgf.m	lb-ft
Fan and pulley	Fan clutch mounting flange bolt (8)	–	21.6~32.3	2.2~3.3	16~24
	Fan clutch spring washer bolt(8×25)	–	16.7~25.5	1.7~2.6	12.4~18.9
	Fan flange nut (6)	–	3.9~5.9	0.4~0.6	2.9~3.6
Thermostat housing	Thermostat cover case flange 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	 KDDEM5015A	Installation and removal of camshaft bushing
09246-41000 Idler gear bushing puller	 KDDEM5016A	Installation and removal of connecting rod bushing
09222-83200 Piston guide clamp	 KDDEM5017A	Installation of piston
09222-83300 Valve spring compressor	 KDDEM5018A	Installation and removal of valve cotter
09221-41100 Valve guide remover	 KDDEM5019A	Removal of valve guide

Tool (part no. and part name)	Shape	Usage
09221-41150 Valve guide installer	 KDDEM5020A	Installation of valve guide (Use together with 09211-41100)
09222-45100 Valve stem seal installer	 KDDEM5021A	Installation of valve stem seal
09353-45100 Air compressor adapter	 KDDEM5022A	Measurement of compression pressure
09222-83200 Piston ring tool	 KDDEM5023A	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

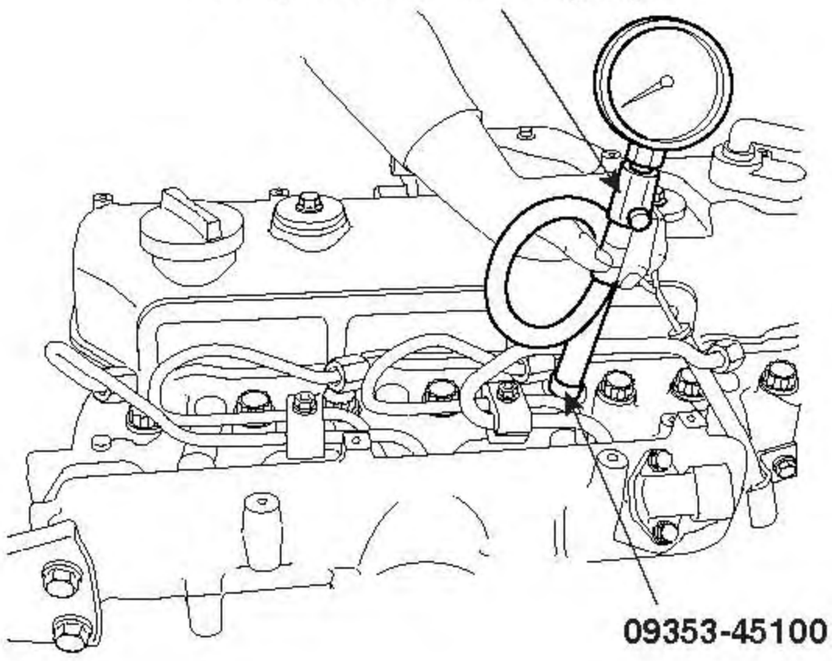
1. Before performing on-vehicle inspection, check to see whether engine oil, starter motor and battery are in normal condition.
2. Start the engine and warm up until the coolant temperature reaches 80~90°C.
3. Stop the engine and remove the ECM fuse.
4. Remove all injectors from cylinder head.

   ⚠ ***CAUTION***

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

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

Compression pressure gauge



SUDEM7015L

7. Crank the engine and measure the compression pressure.

   ⚠ ***CAUTION***

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

8. 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/cm²	20kg/cm²	Check
	Difference between cylinders	—	4kg/cm²	Check

9. 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.

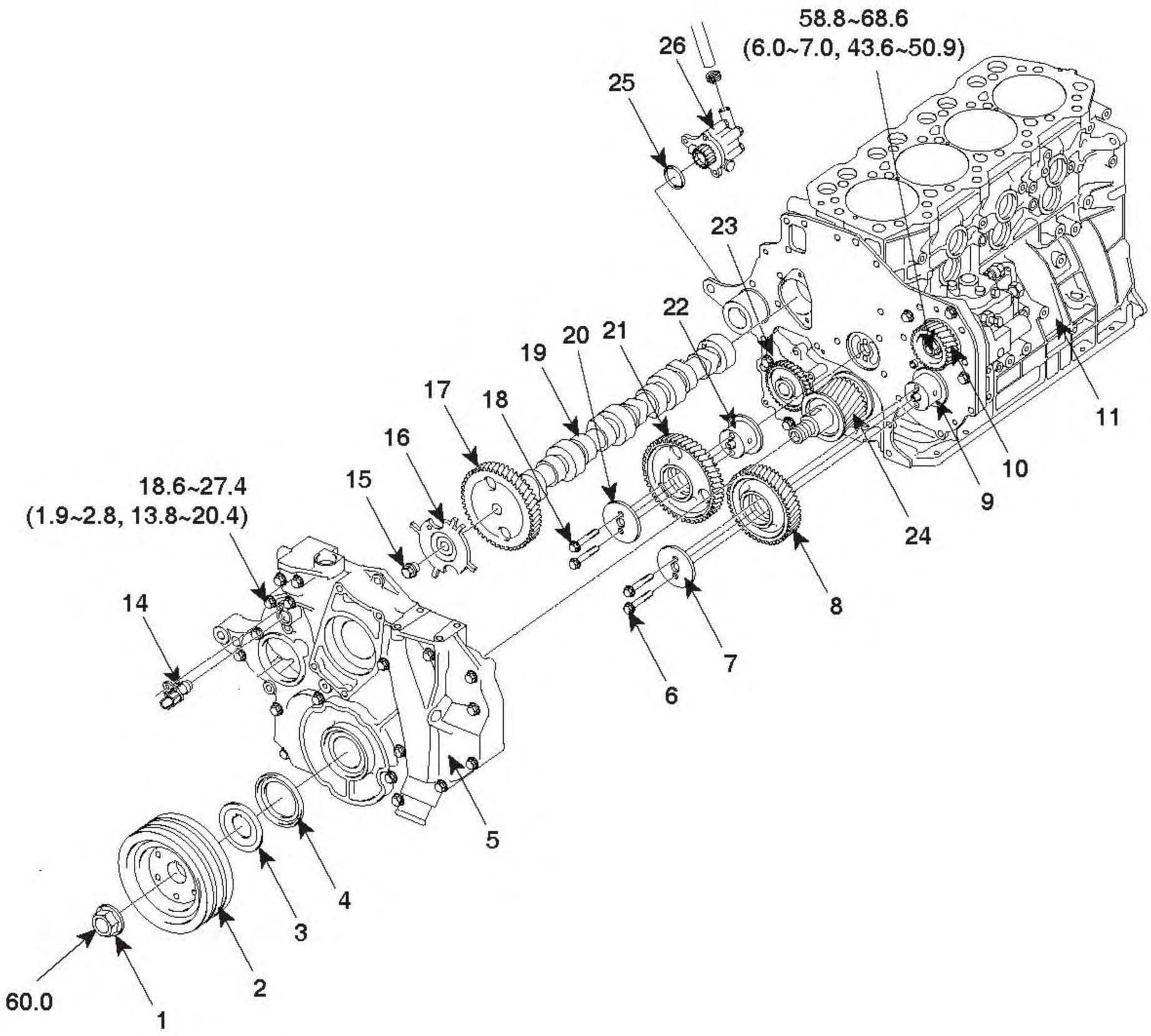
   1) If the compression pressure increases, it indicates that the piston, piston ring or cylinder wall is worn or damaged.

   2) 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

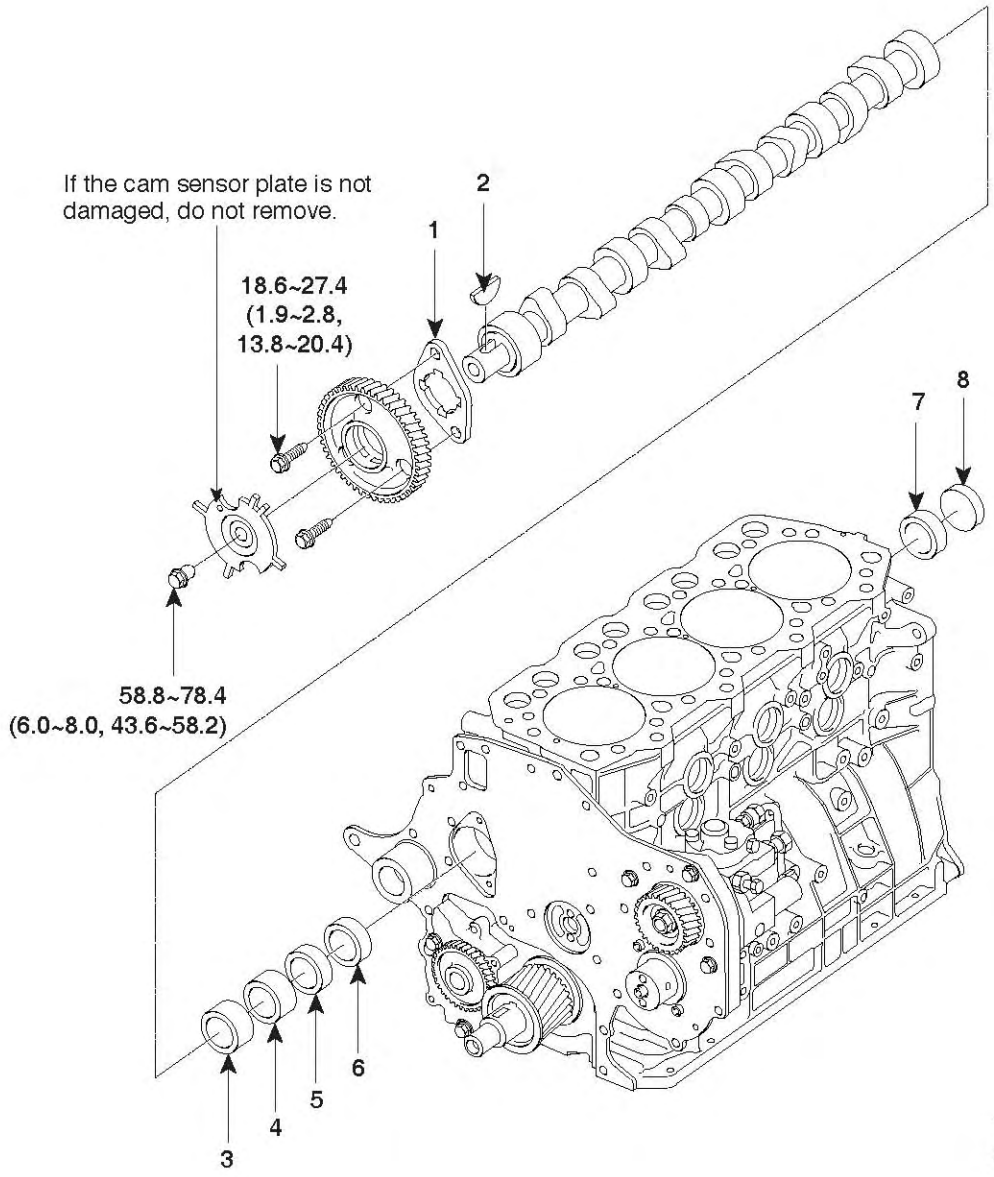


1. Crankshaft damper pulley nut
2. Crankshaft damper pulley
3. Front oil slinger
4. Front oil seal
5. Timing gear case
6. Idler gear B mounting bolt
7. Thrust plate
8. Idler gear B
9. Idler shaft
10. Supply pump gear
11. Crankcase

14. Camshaft sensor
15. Oil drain plug
16. Cam sensor plate
17. Camshaft gear
18. Idler gear A mounting bolt
19. Camshaft
20. Thrust plate
21. Idler gear A
22. Idler shaft
23. Oil pump gear
24. Crankshaft gear
25. O-ring
26. Power steering oil pump

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

SUDEM7016L



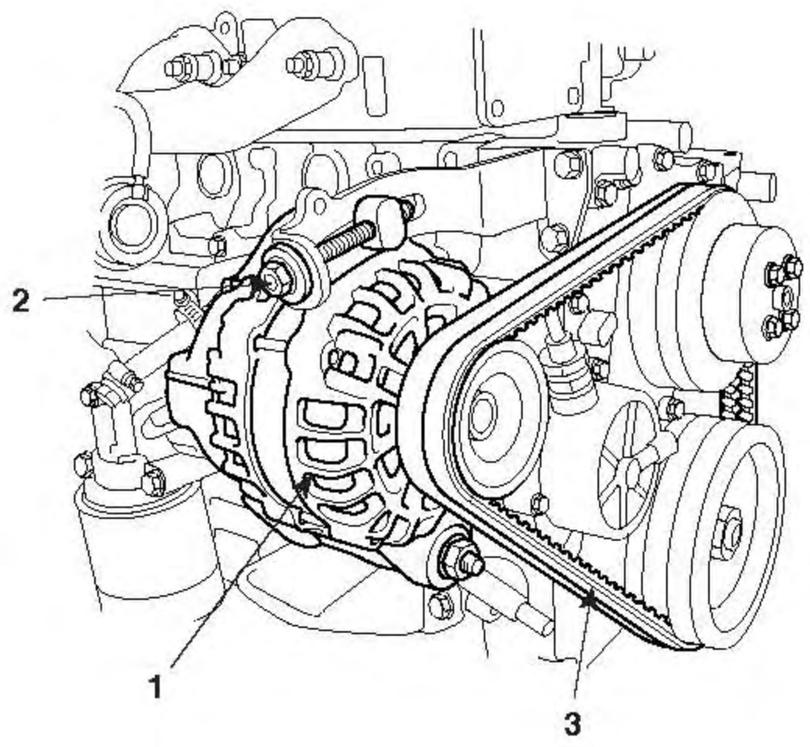
1. Thrust plate
2. Semicircular key
3. No.1 camshaft bush
4. No.2 camshaft bush
5. No.3 camshaft bush
6. No.4 camshaft bush
7. No.5 camshaft bush
8. Sealing cap

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

SUDEM7017L

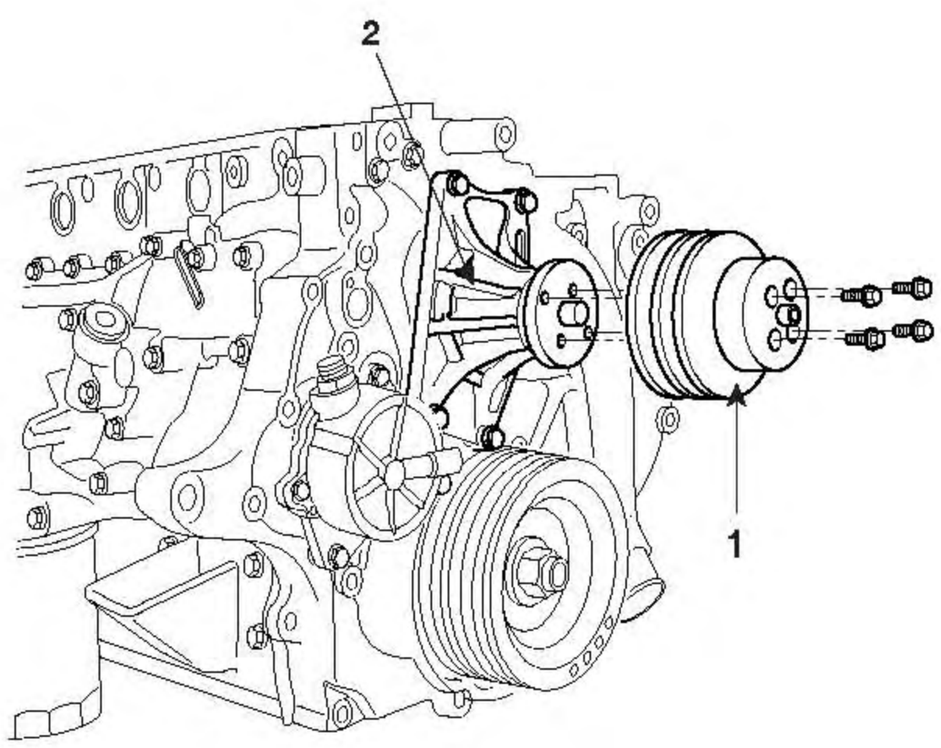
REMOVAL E812C03D

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

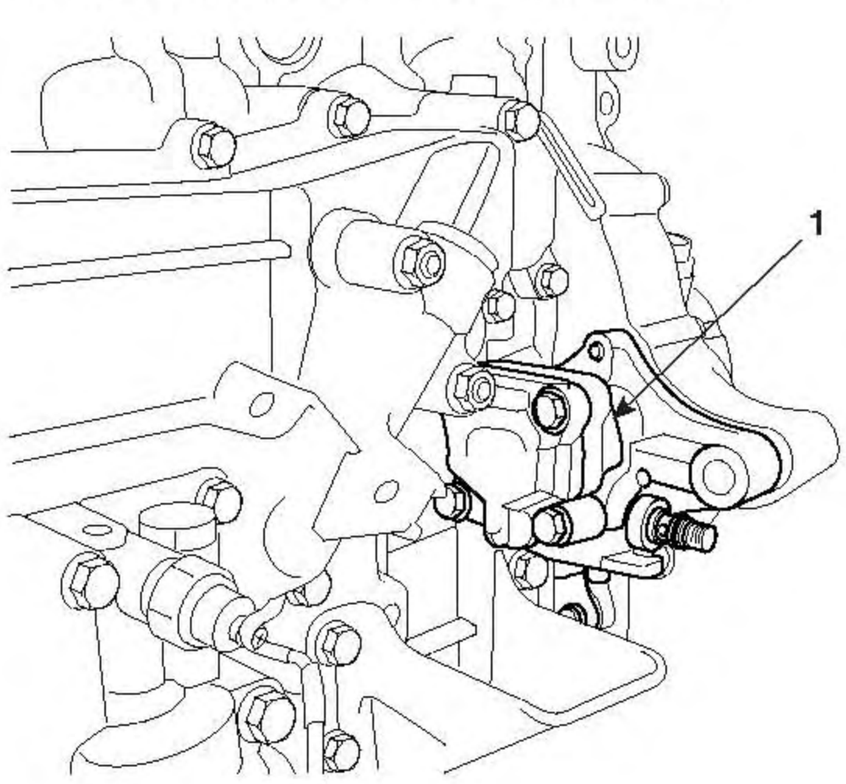


SUDEM7018L

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

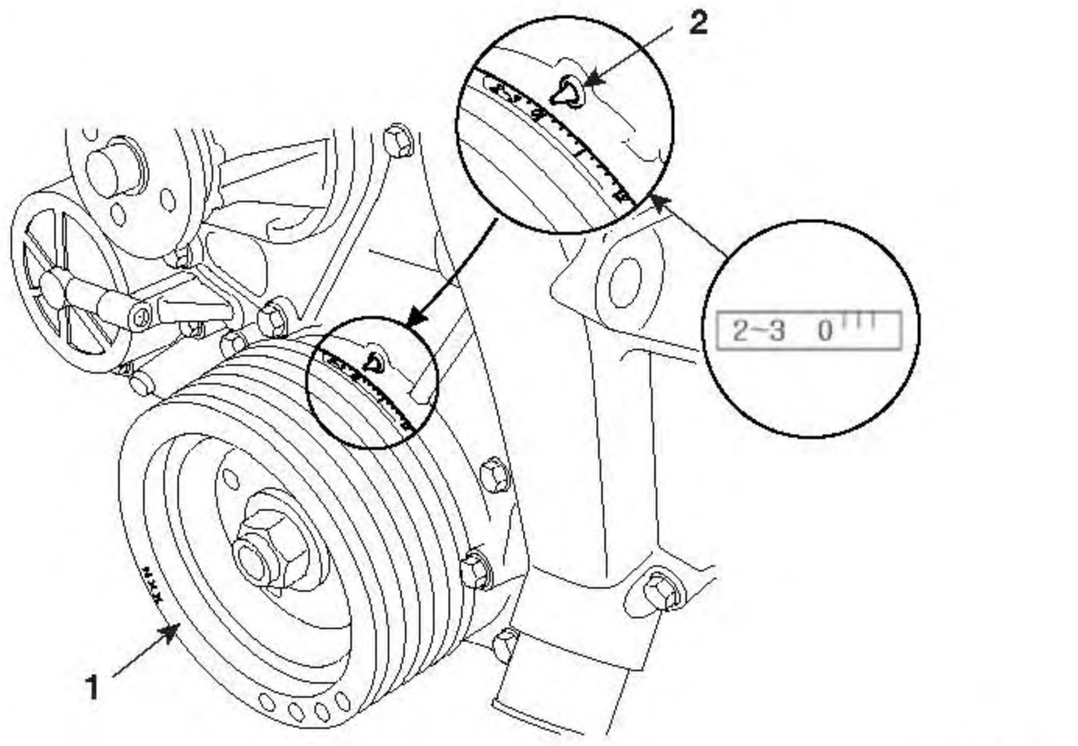


3. Remove the power steering pump (1).



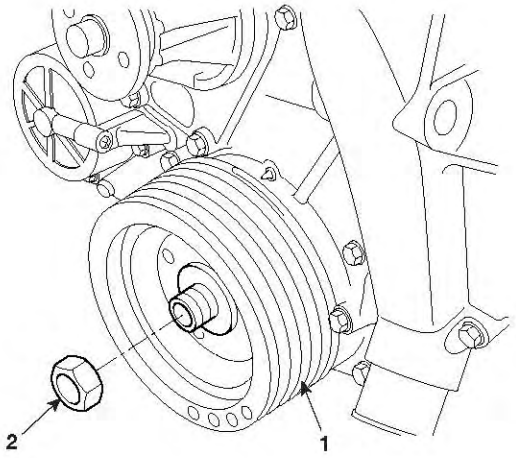
SUDEM7022L

4. 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.



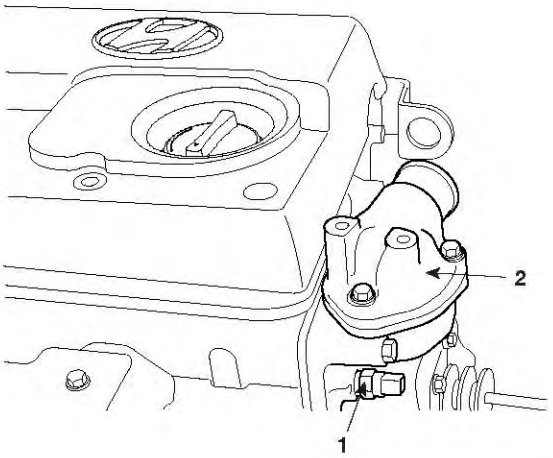
SUDEM7023L

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



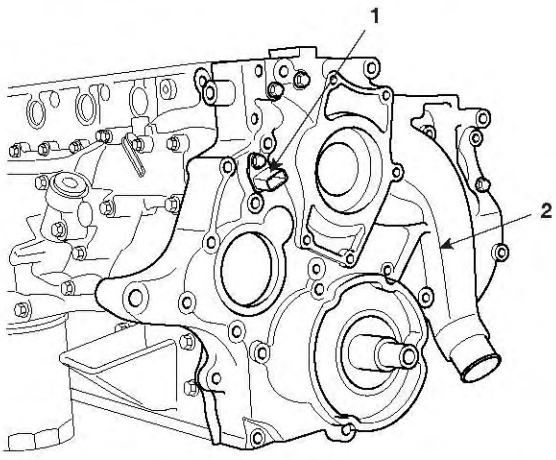
SUDEM7024L

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



SUDEM7025L

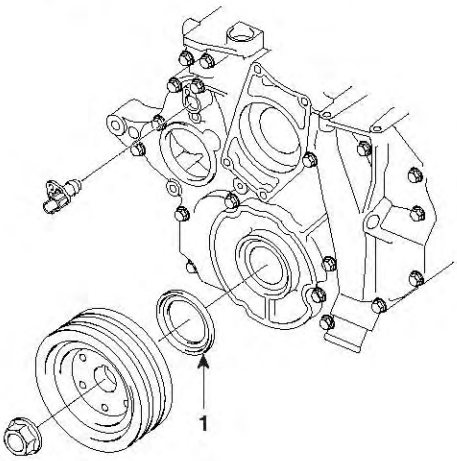
9. Remove the cam speed sensor (1) from the timing gear case and then remove the timing gear case (2).



SUDEM7026L

NOTE

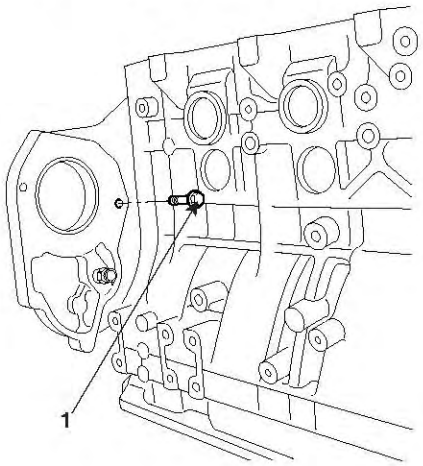
Check the front oil seal (1) state. If it is normal, do not remove it.



SUDEM7027L

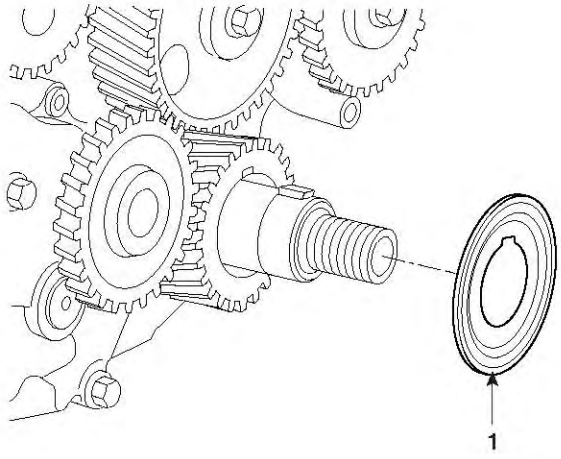
CAUTION

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.



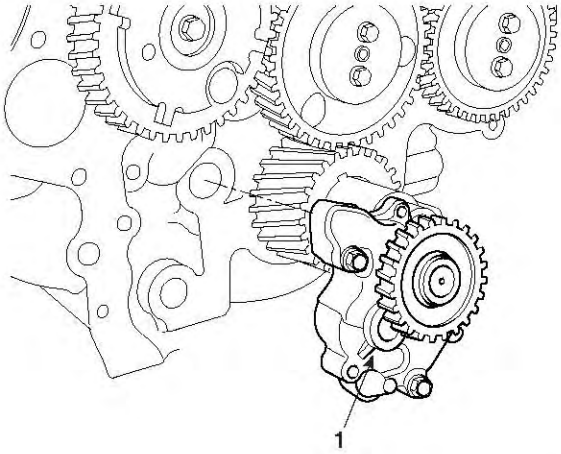
SUDEM7028L

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



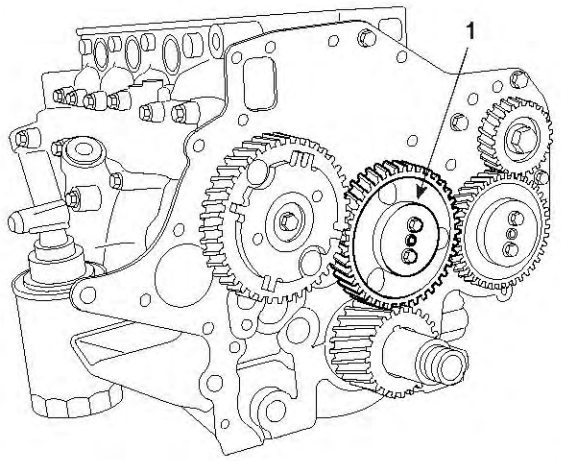
SUDEM7029L

11. Remove the oil pump gear (1).



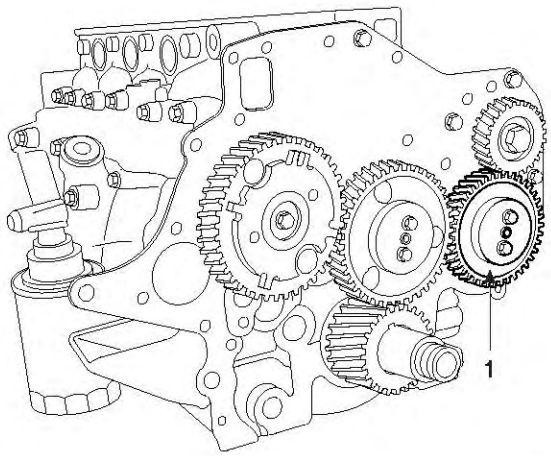
SUDEM7030L

12. Remove the idler gear A (1).



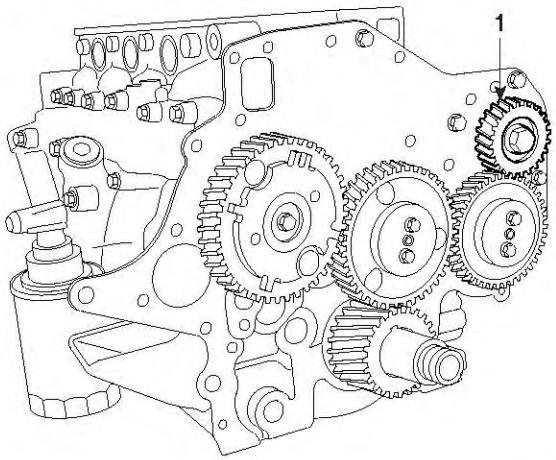
SUDEM7031L

13. Remove the idler gear B (1).



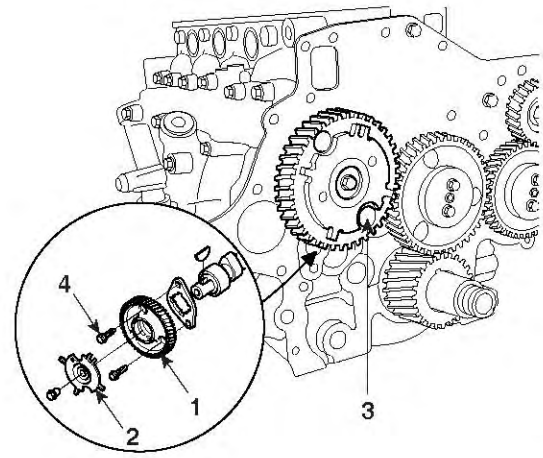
SUDEM7032L

14. Remove the supply pump gear (1).



SUDEM7033L

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

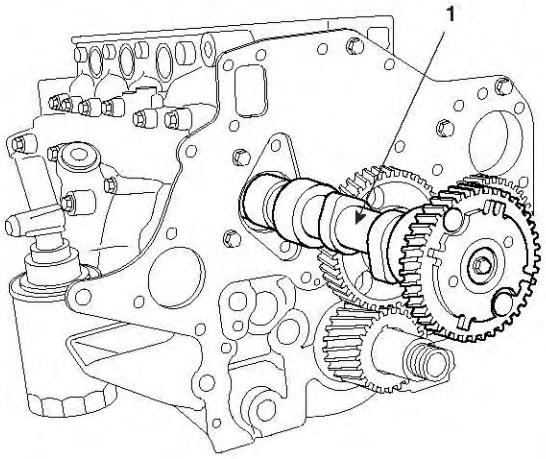


SUDEM7034L

NOTE

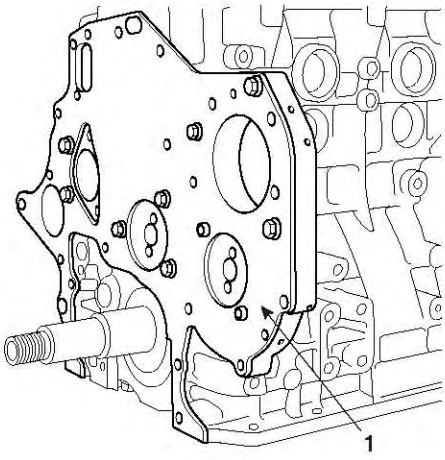
Do not remove the cam sensor plate (2), if it is not damaged.

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



SUDEM7035L

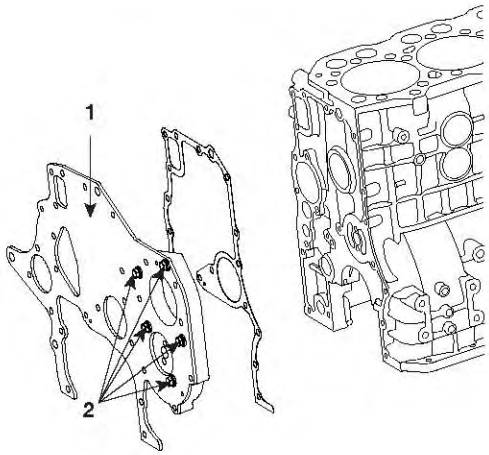
16. Remove the front plate (1).



SUDEM7036L

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.

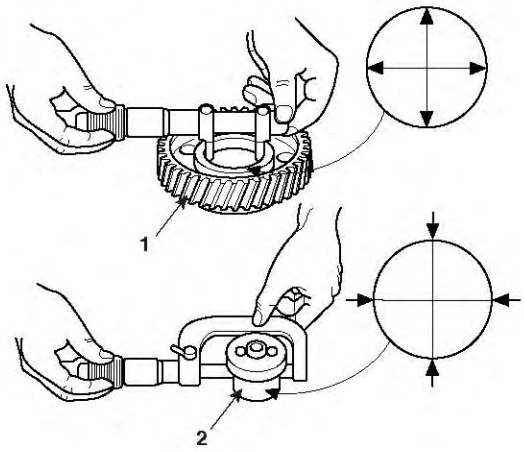


SUDEM7037L

INSPECTION EB5EDDCB

1. 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



SUDEM7038L

2. 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

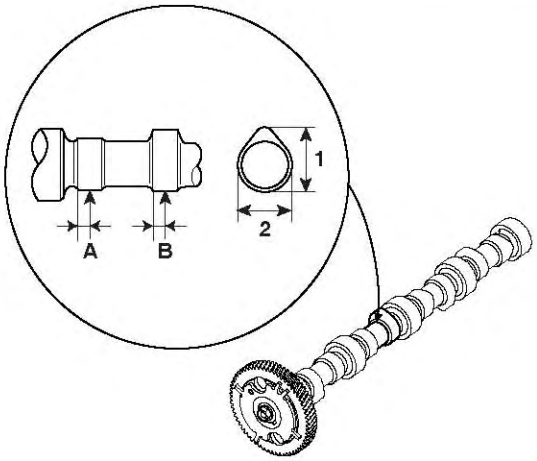
Unit: mm

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.

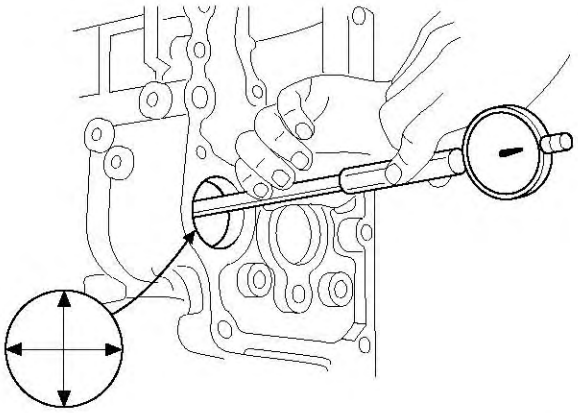
Measuring position	A	B
	6.5mm	6.5mm



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



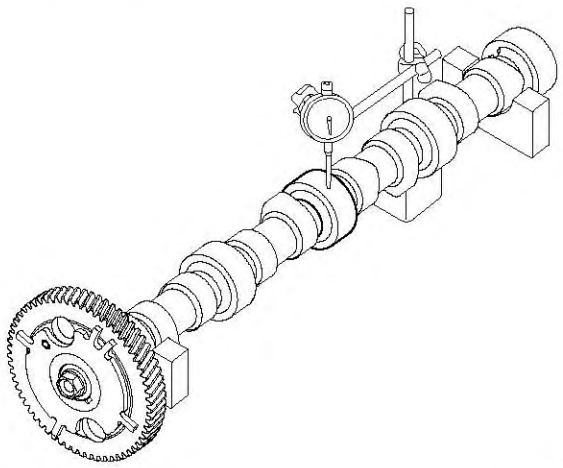
SUDEM7040L

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

Distortion of camshaft: 0.02mm

NOTE

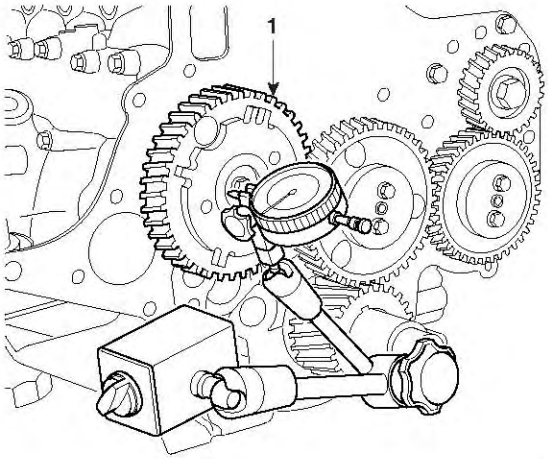
Place the camshaft on the precision block and turn the camshaft in1 revolution. And read the dial indicator. The distortion of the camshaft is a half of the measurement.



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

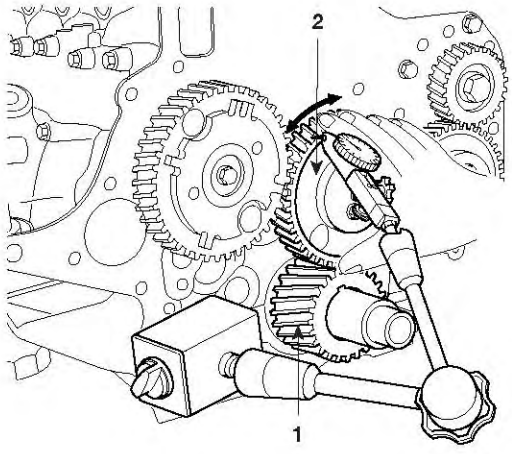
6. Measure the backlash of each gear and replace it if necessary.

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)

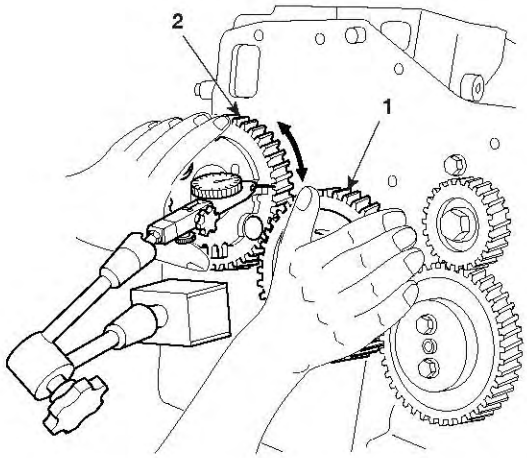
Reference: 0.062~0.159mm



SUDEM7043L

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

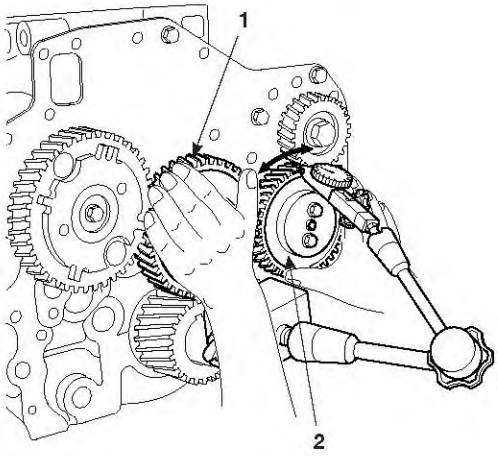
Reference: 0.068~0.175mm



SUDEM7044L

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

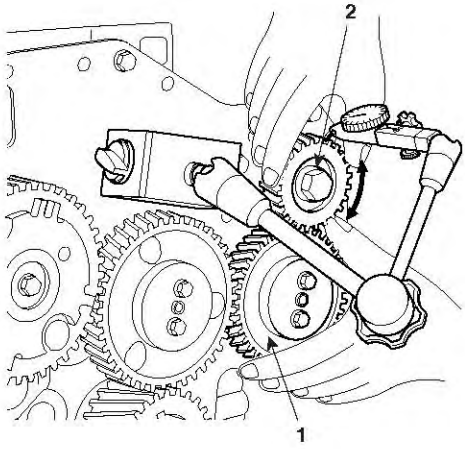
Reference: 0.062~0.160mm



SUDEM7045L

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

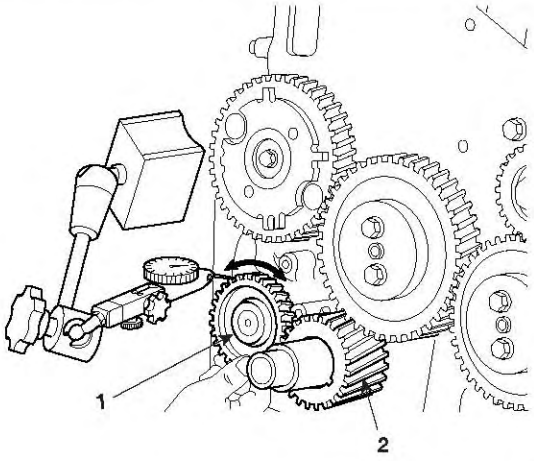
Reference: 0.073~0.169mm



SUDEM7046L

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

Reference: 0.049~0.169mm



SUDEM7047L

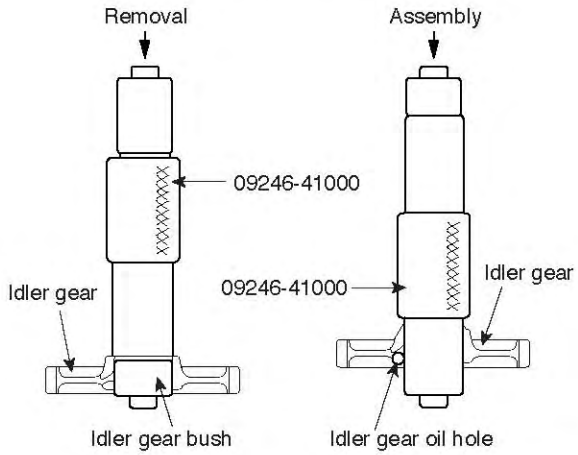
REPLACEMENT EF56BCEF

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

   CAUTION

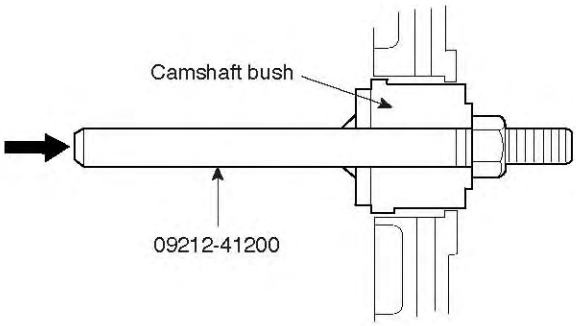
   a. When assembling the bush, align the bush oil hole with gear oil hole.

   b. Check to see whether the clearance between bush and idler gear shaft satisfies the reference.



SUDEM7048L

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



SUDEM7049L

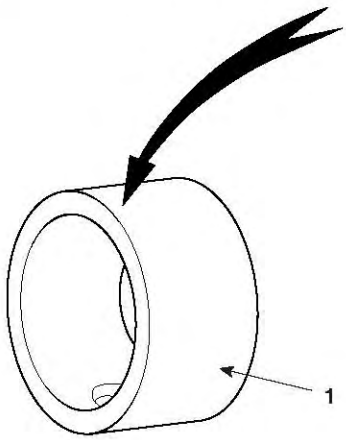
c. Install the camshaft bush (1).

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

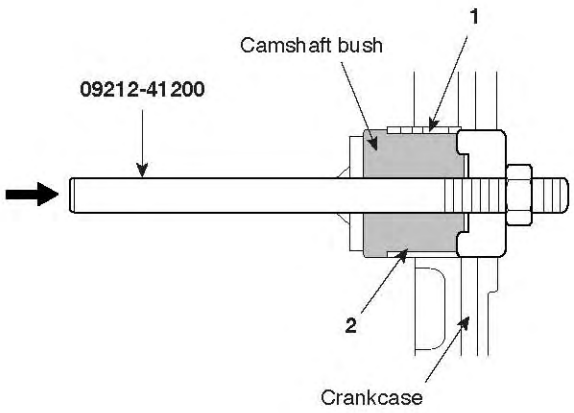


SUDEM7050L

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

NOTE

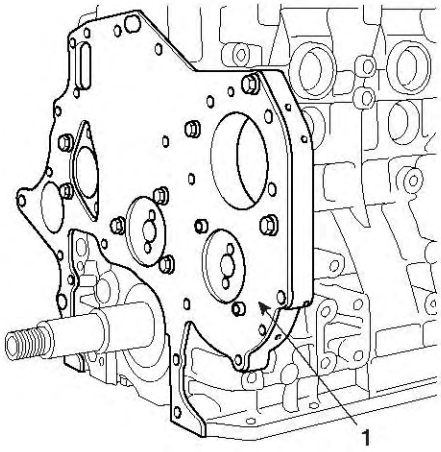
When installing the camshaft bushing, align the oil hole of bush with crankcase oil hole (2).



SUDEM7051L

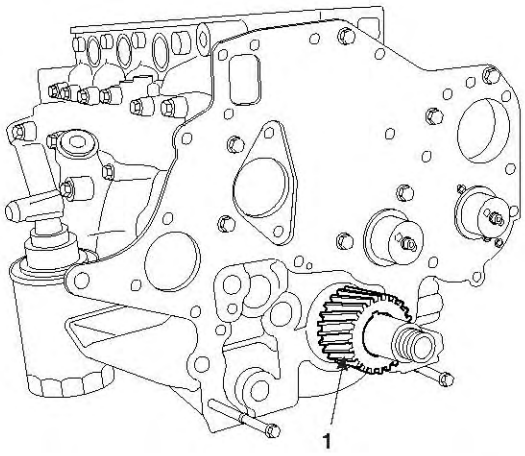
INSTALLATION EEFAD1F1

1. Install the front plate (1).



SUDEM7052L

2. Install the crankshaft gear (1).

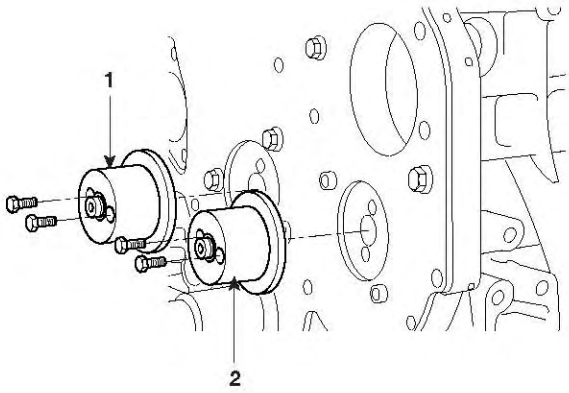


SUDEM7053L

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

CAUTION

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

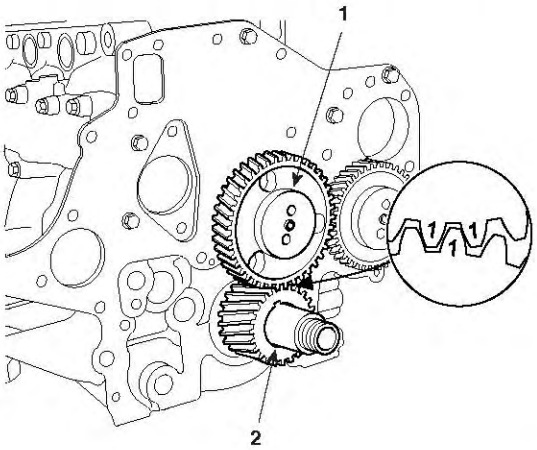


SUDEM7054L

4. Install idler gear A and B.

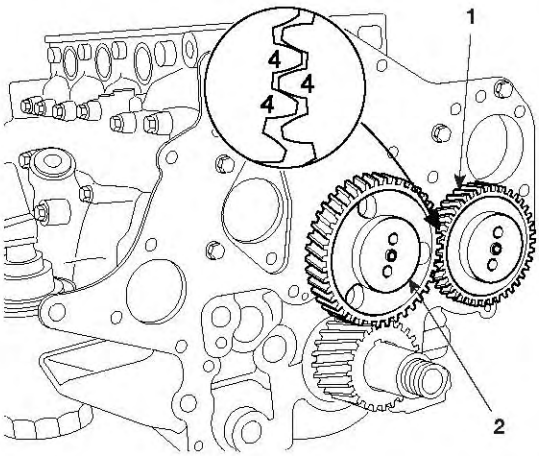
CAUTION

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



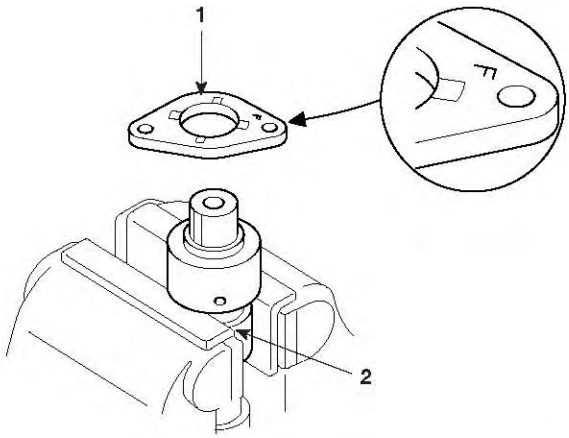
SUDEM7055L

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



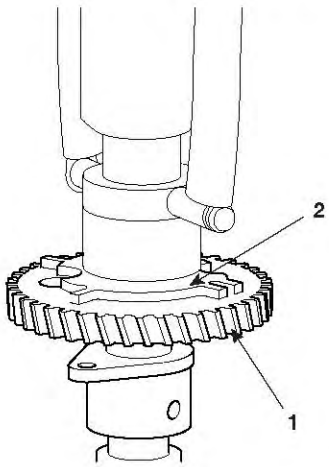
SUDEM7056L

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

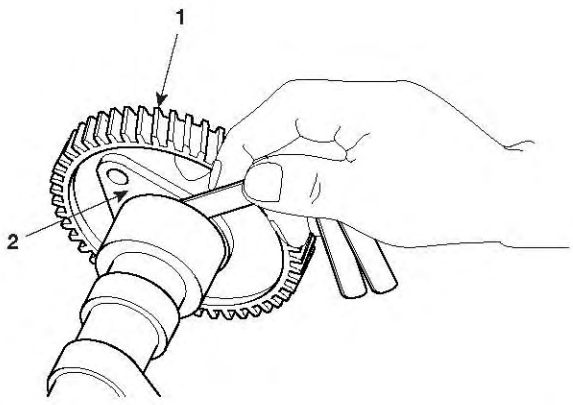
b. Press fit the camshaft gear assembly (1) of the cam plate (2) so that it faces outward.



SUDEM7058L

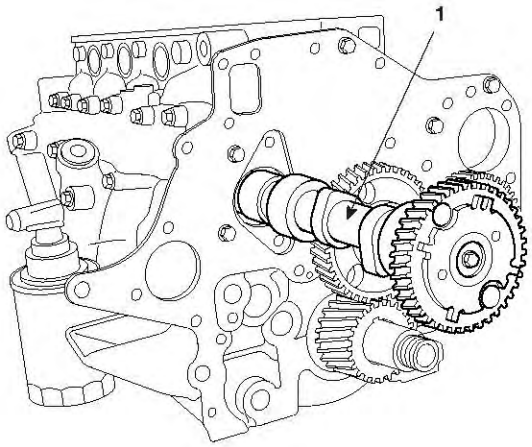
c. Measure the endplay between camshaft gear (1) and thrust plate (2) and install them as the clearance to be within the reference.

Reference: 0.05~0.22mm



SUDEM7059L

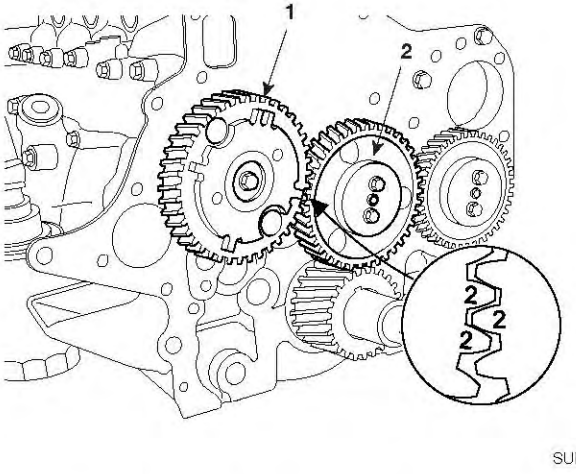
d. Install the camshaft assembly (1) to the crankcase.



SUDEM7060L

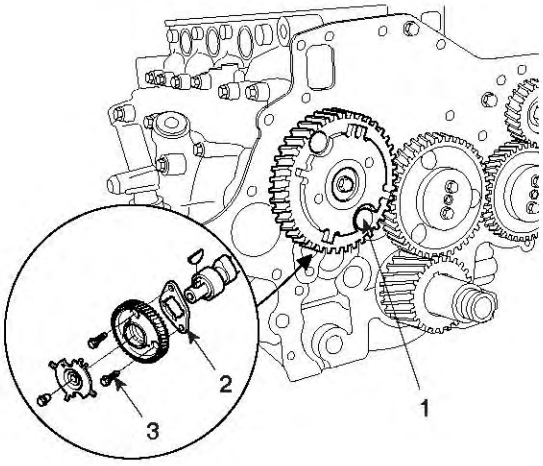
⚠ CAUTION

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).

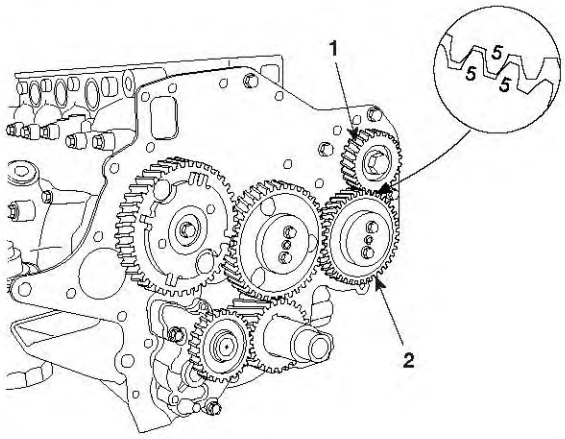


SUDEM7062L

6. Install the supply pump gear.

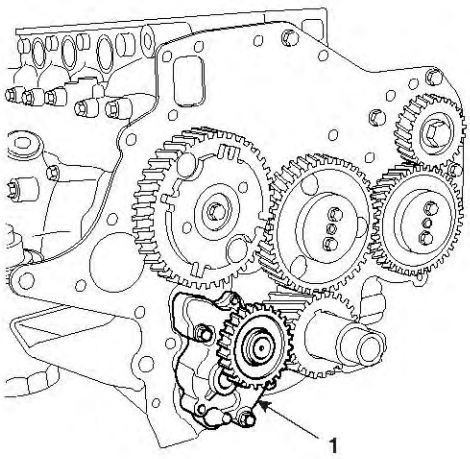
⚠ CAUTION

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



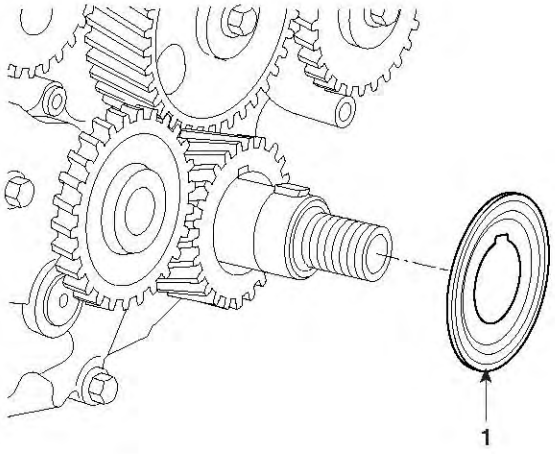
SUDEM7063L

7. Install the oil pump gear (1).



SUDEM7064L

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



SUDEM7065L

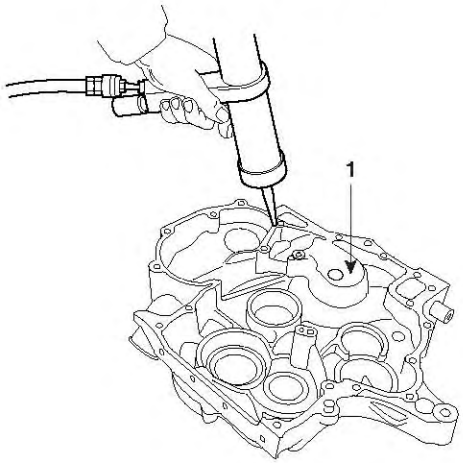
9. Install the front timing gear case (1).

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

⚠ ***CAUTION***

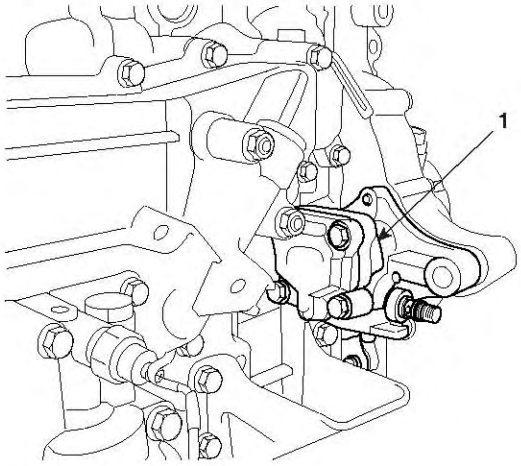
a. Apply the Loctite #5699 or equivalent on the assembly surface of timing gear case (1), and then assemble it within 3 minutes.

b. Do not start the engine within 1 hour after installing the timing gear case.



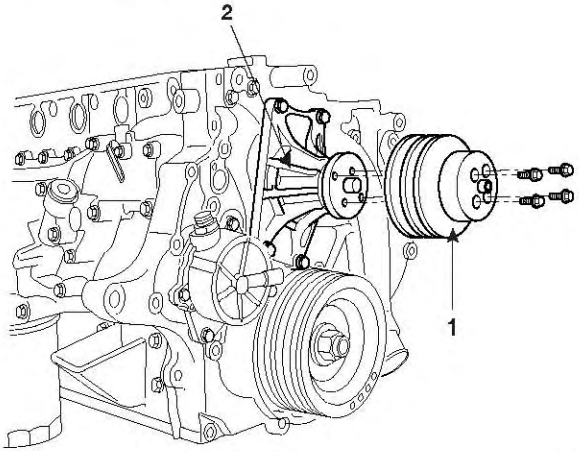
SUDEM7066L

10. Install the power steering pump (1).



SUDEM7067L

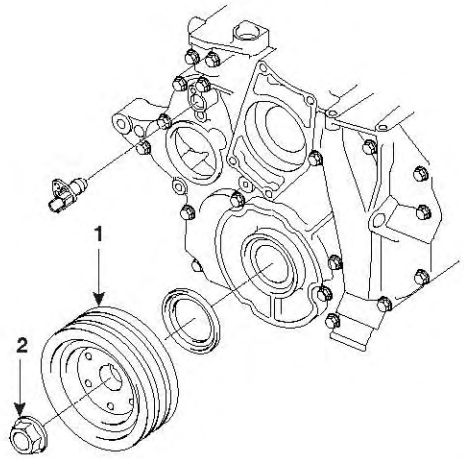
11. Install the water pump pulley (1) and water pump assembly (2).



SUDEM7068L

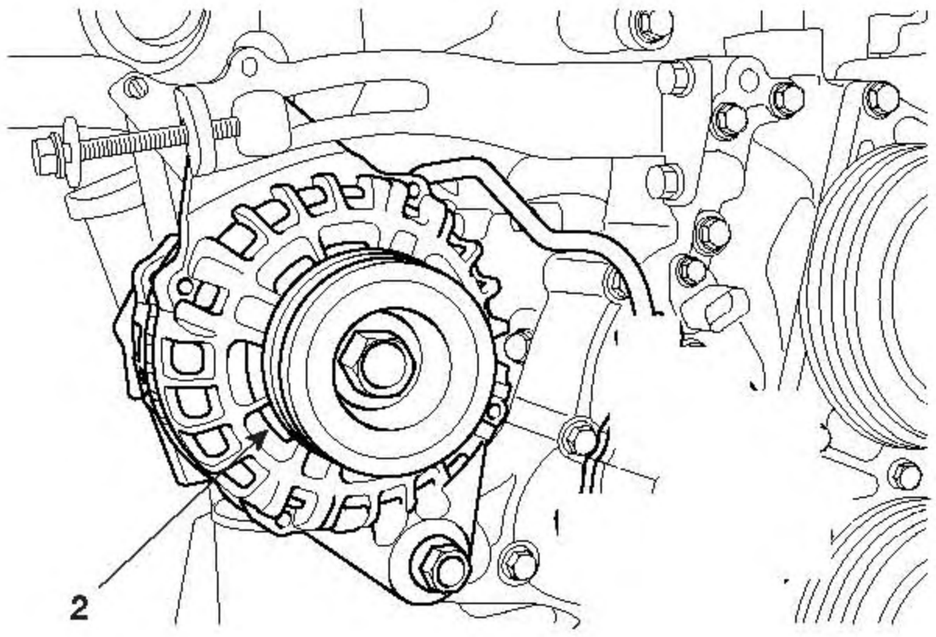
12. Install the crankshaft damper pulley (1) and damper pulley mounting nut (2).

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



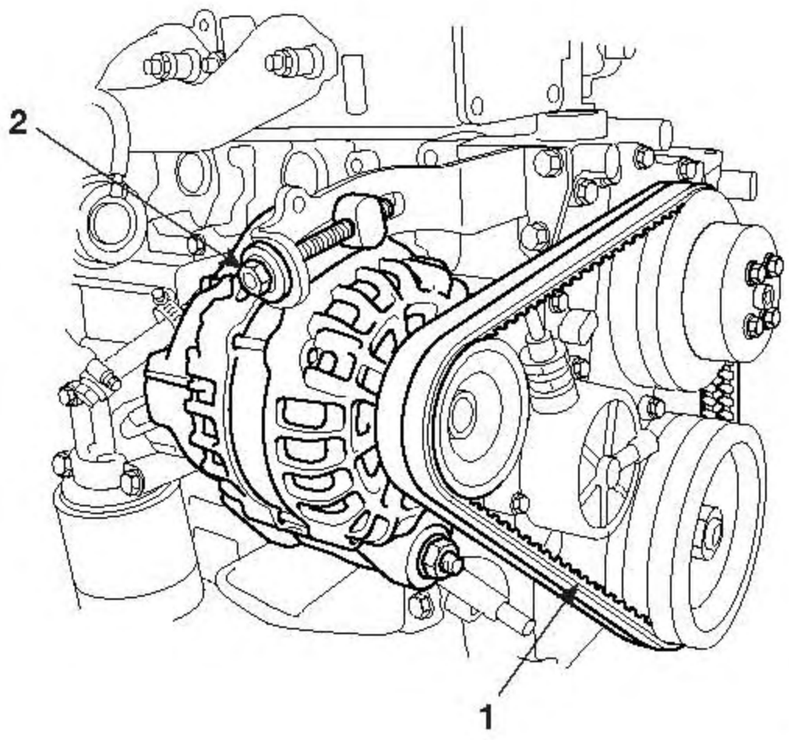
SUDEM7069L

13. Install the alternator assembly (2).



SUDEM7070L

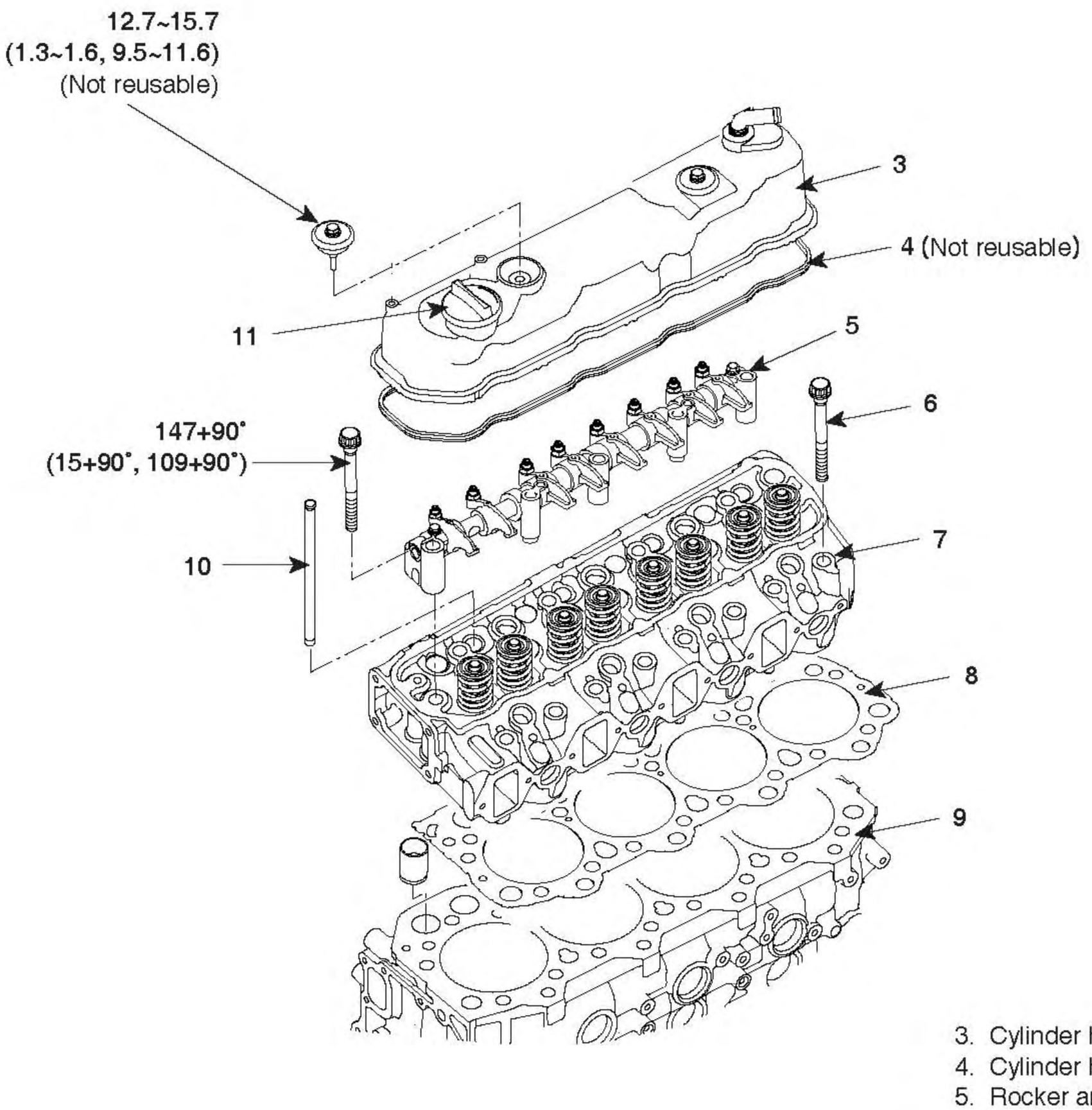
14. Install the V-belt (1). Adjust the belt tension using the tension adjusting screw (2) of alternator.



SUDEM7072L

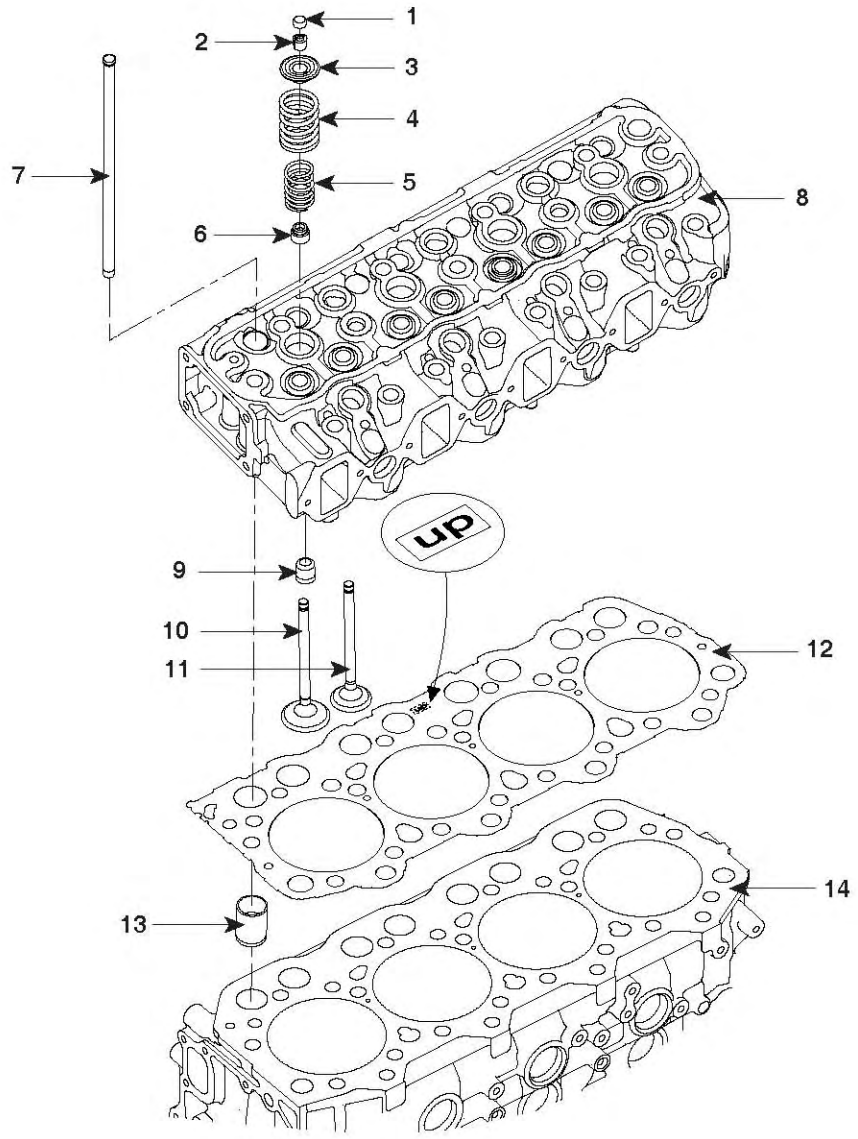
CYLINDER HEAD ASSEMBLY

COMPONENTS E248774A



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

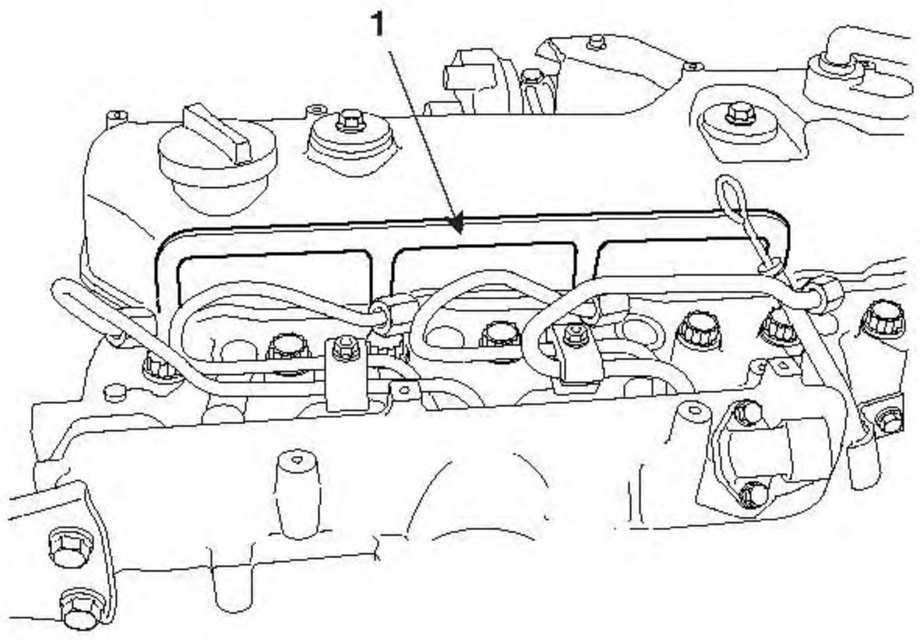
3. Cylinder head cover
4. Cylinder head cover gasket
5. Rocker and bracket assembly
6. Cylinder head bolt
7. Cylinder head assembly
8. Cylinder head gasket
9. Crank case
10. Push rod
11. Oil filler cap



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

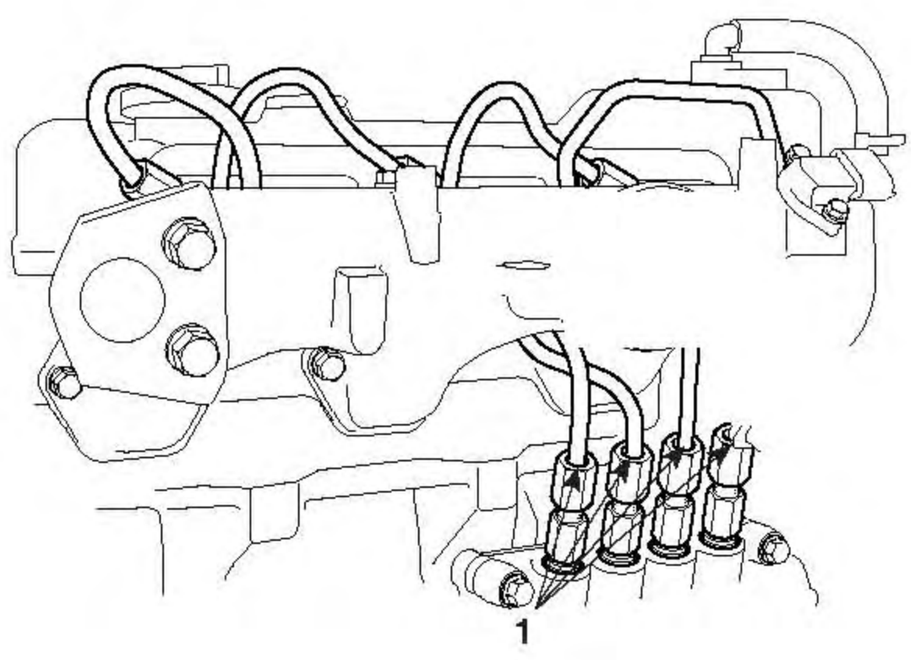
REMOVAL EDE5E369

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



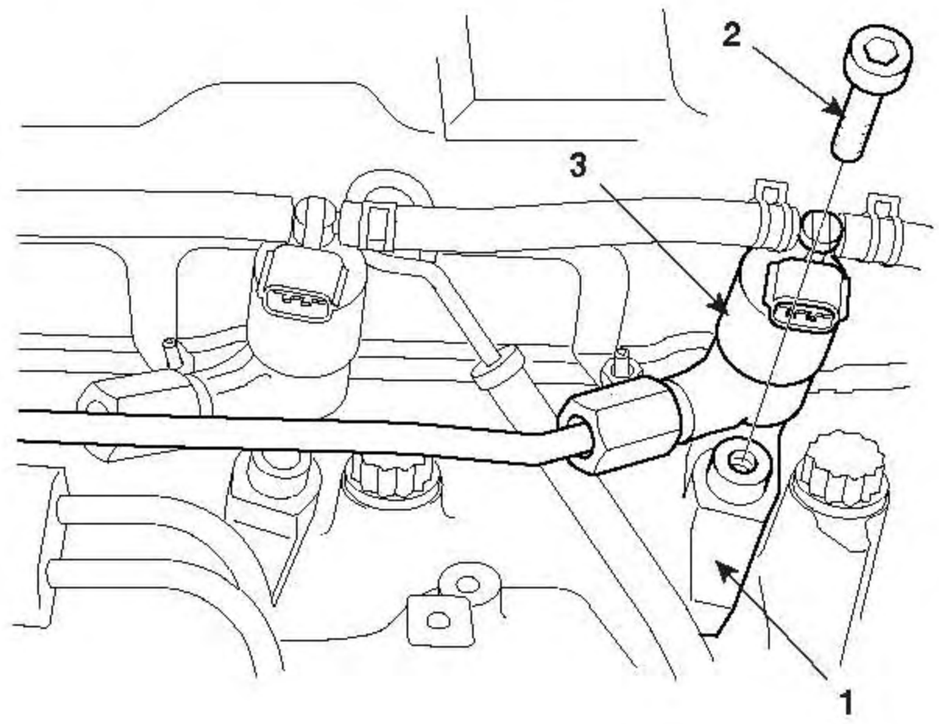
SUDEM7076L

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



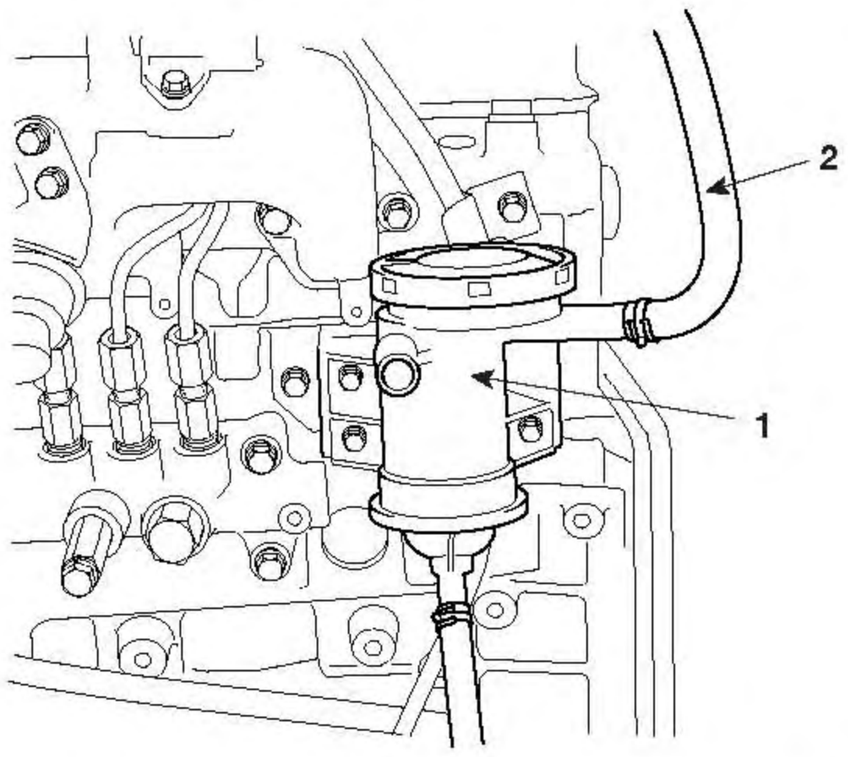
SUDEM7077L

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



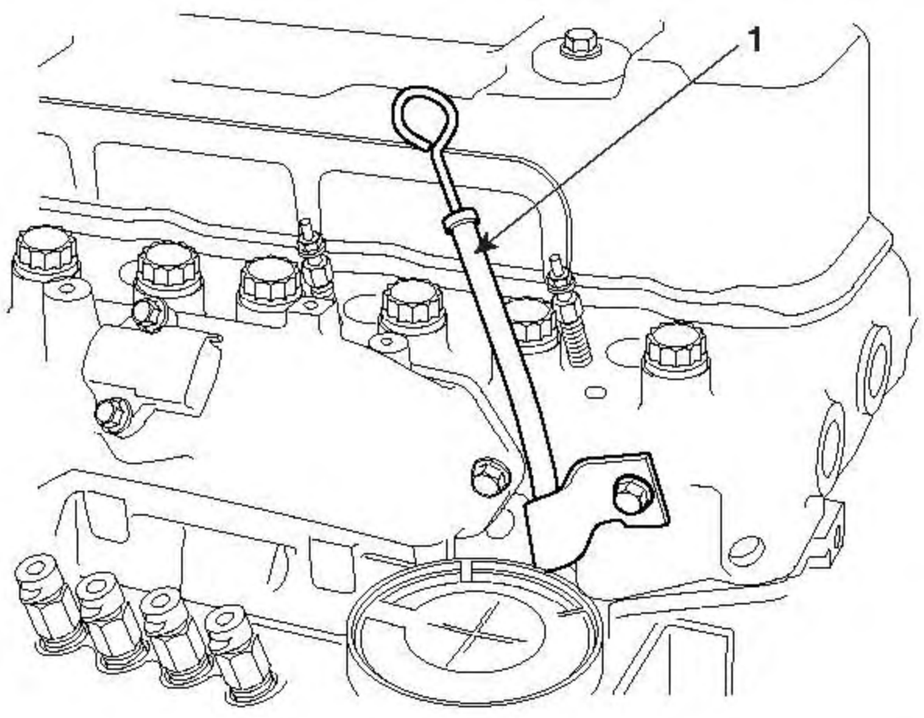
SUDEM7078L

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



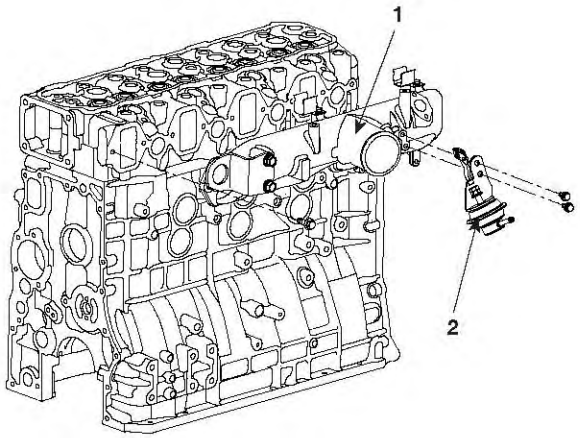
SUDEM7079L

6. Remove the oil level gauge (1).



SUDEM7080L

7. Remove the intake manifold assembly (1).

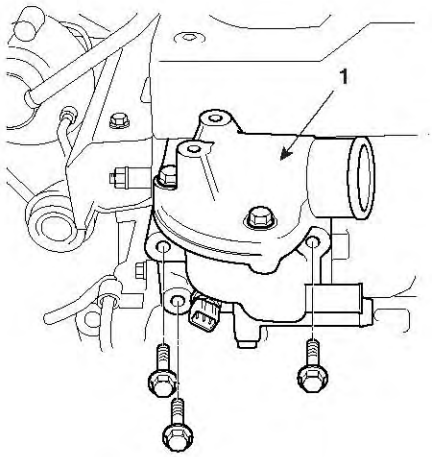


SUDEM7081L

NOTE

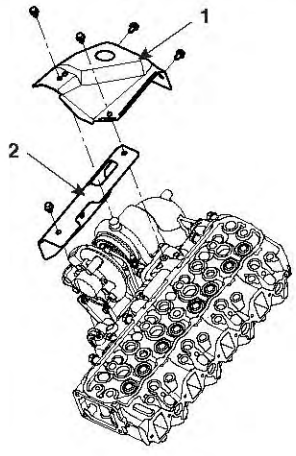
Do not remove the actuator (2) of the intake manifold if its operation is normal.

8. Remove the thermostat housing (1).



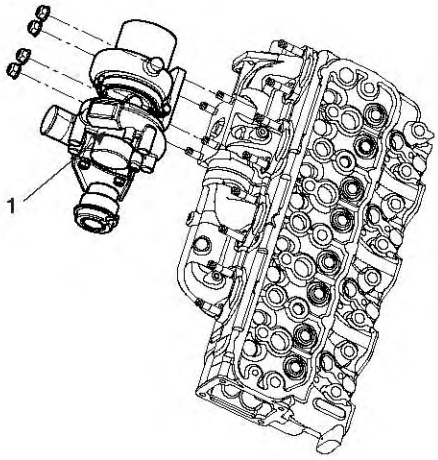
SUDEM7082L

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



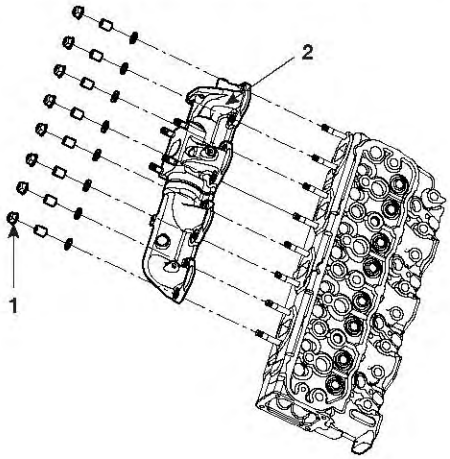
SUDEM7083L

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



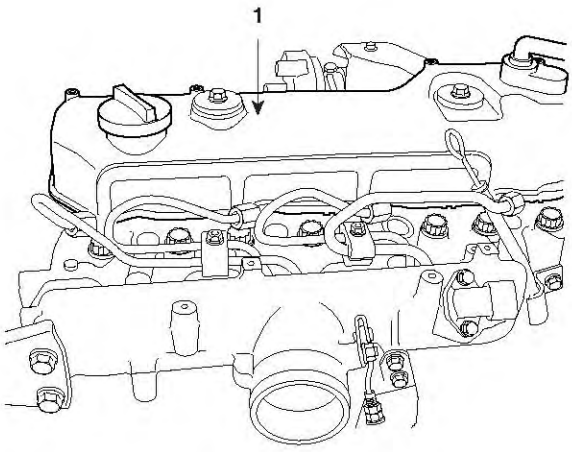
SUDEM7084L

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



SUDEM7085L

12. Remove the cylinder head cover (1).

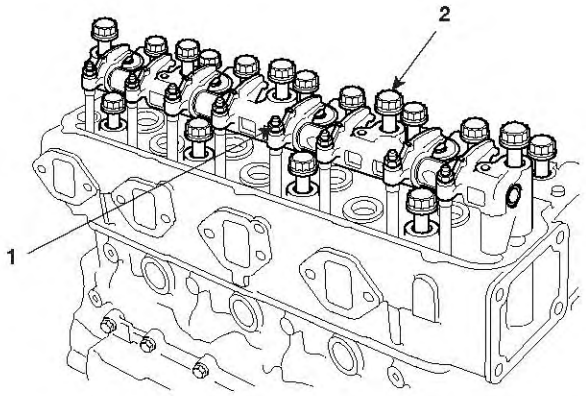


SUDEM7086L

13. Remove the cylinder head bolts.

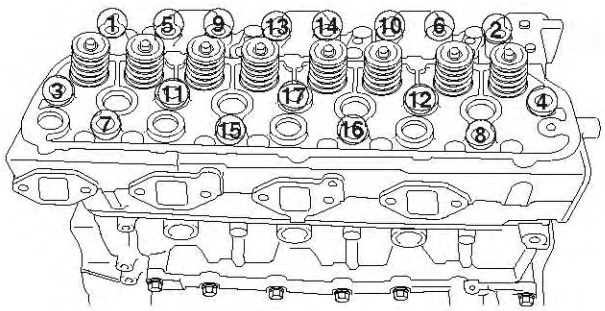
NOTE

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



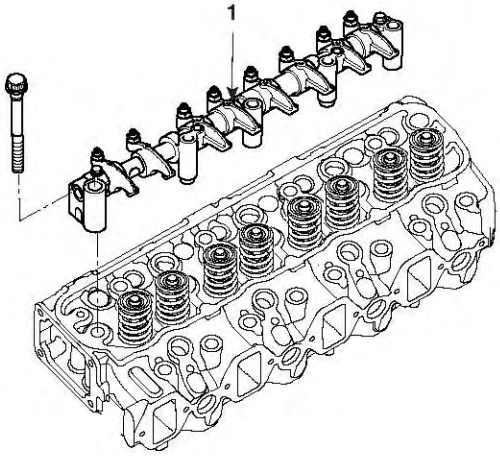
SUDEM7087L

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



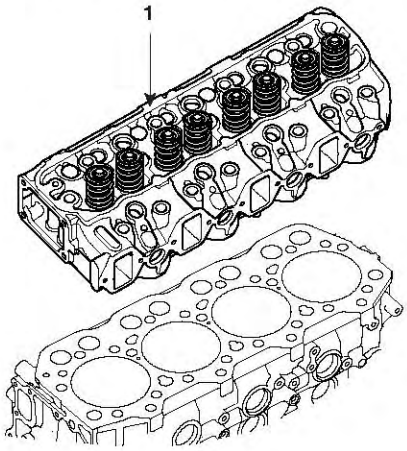
SUDEM7088L

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



SUDEM7089L

15. Remove the cylinder head assembly (1).

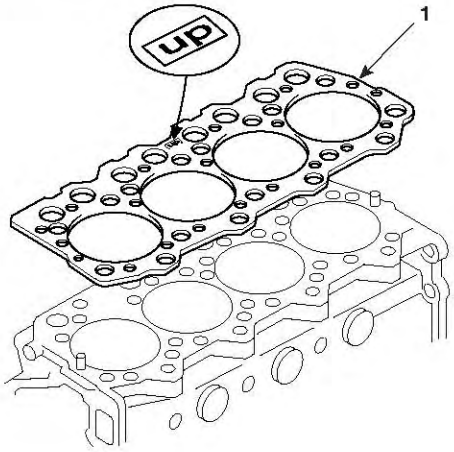


SUDEM7090L

16. Remove the cylinder head gasket (1).

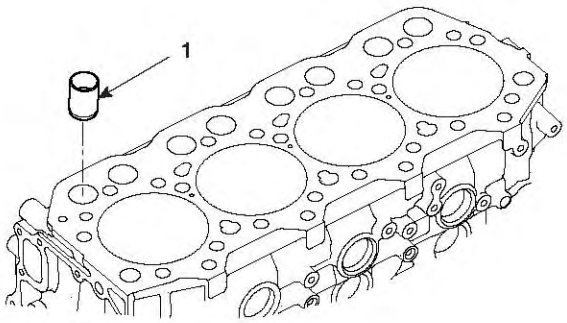
CAUTION

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



SUDEM7091L

17. Remove the valve tappet (1).

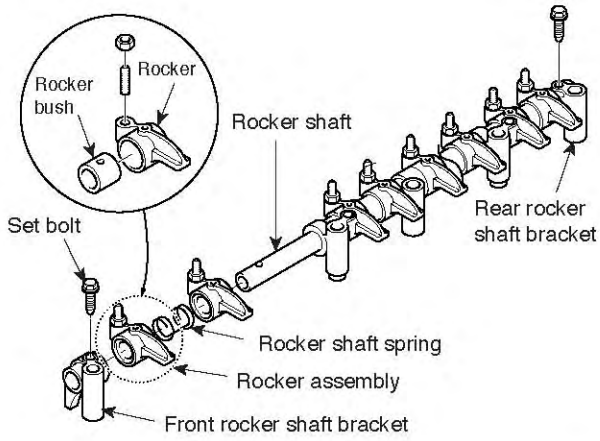


SUDEM7092L

DISASSEMBLY ECC7ED4F

ROCKER AND ROCKER SHAFT BRACKET ASSEMBLY

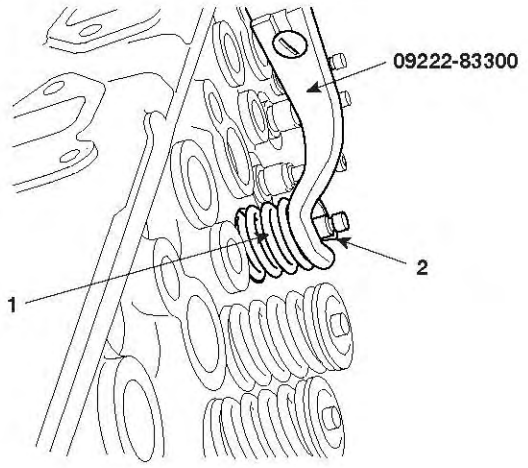
1. Remove the set bolt from the front rocker shaft bracket.
2. Remove the front and rear rocker shaft bracket.
3. Remove the rocker assembly.
4. Remove the rocker shaft spring from the rocker shaft.
5. Remove the rocker shaft bracket No.2, 3 and 4 and then, remove the rocker shaft.



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).

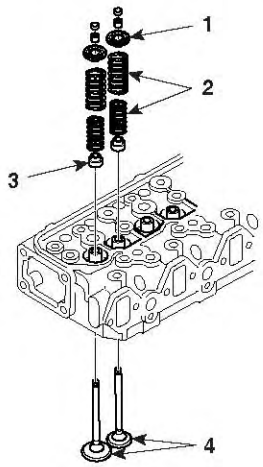


SUDEM7094L

2. 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.

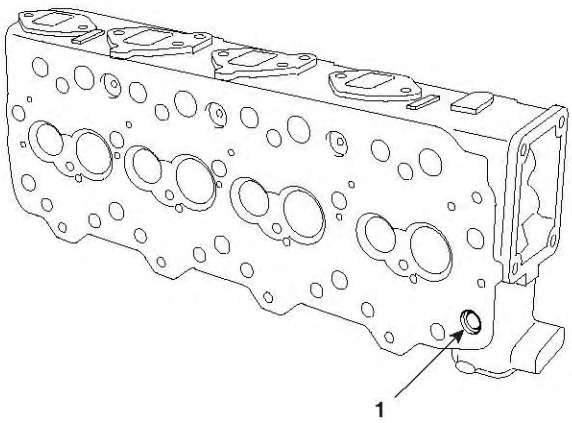


SUDEM7095L

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

NOTE

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

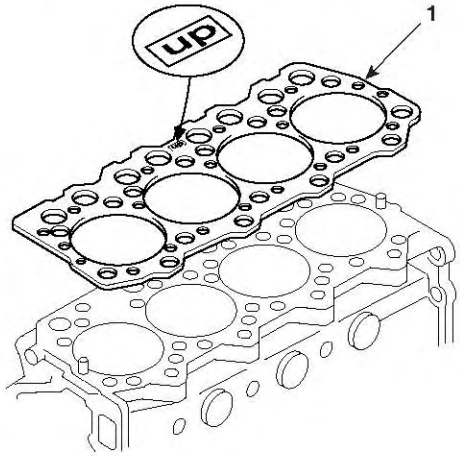


SUDEM7096L

4. Remove the cylinder gasket (1).

CAUTION

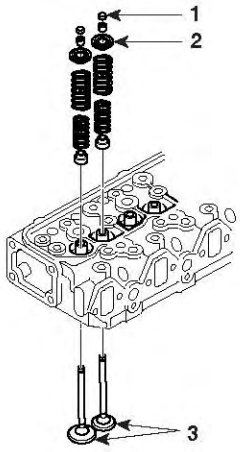
When removing the cylinder head gasket, check the cylinder head and crankcase for any damage.



SUDEM7097L

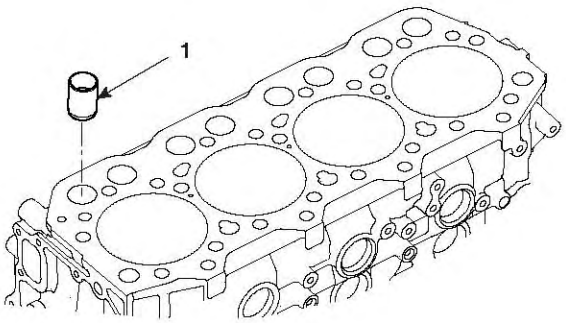
INSPECTION E5264C2D

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



SUDEM7098L

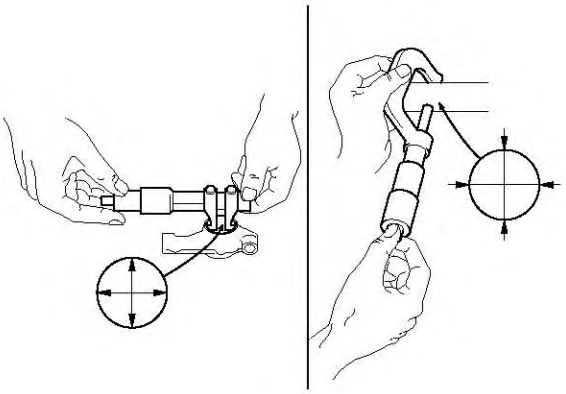
3. Check the valve tappet (1) for any damage or wear.



SUDEM7099L

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

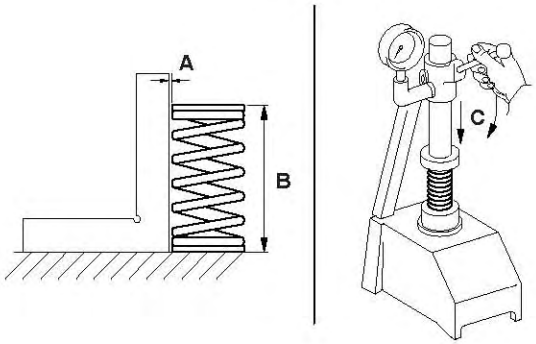
Items	Standard	Limit
Inner diameter of rocker bush	18.980~18.993mm	—
Outer diameter of rocker shaft	19.05~19.09mm	—
Gap	0.06~0.11mm	0.2mm



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.

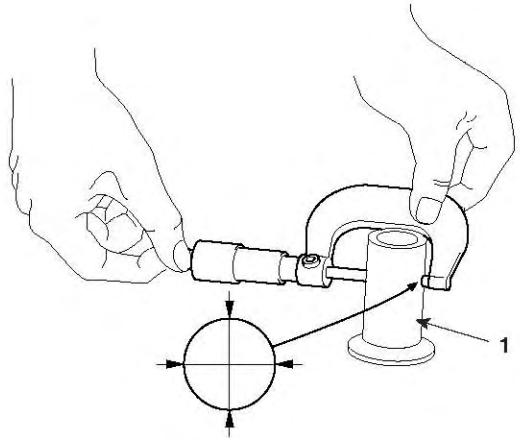
Items		Standard	Limit
Outer side Valve spring	Free length	66.1mm	63mm
	Load installed	27.9±1.4kg	23.7kg
	Out of squareness	1.5mm	2.1mm
Inner side Valve spring	Free length	60mm	57mm
	Load installed	12.1±0.6kg	10.3kg
	Out of squareness	1.5mm	2.1mm



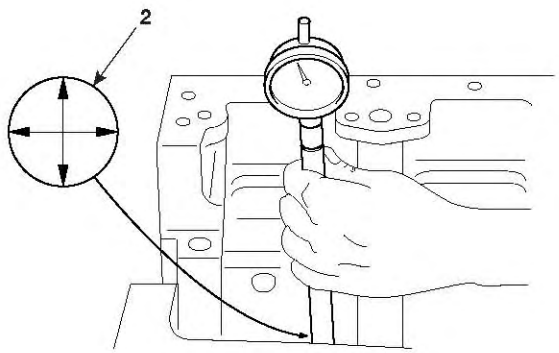
SUDEM7101L

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



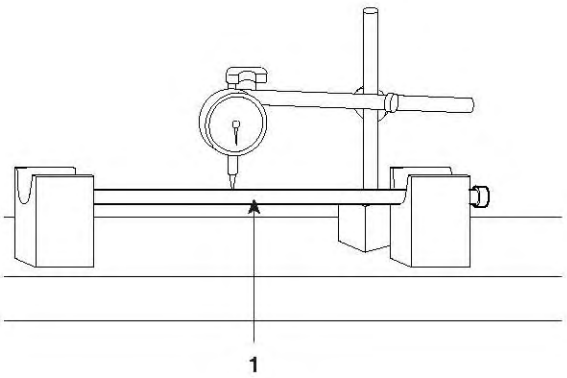
SUDEM7102L



SUDEM7103L

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

Limit of pushrod run-out: 0.4mm



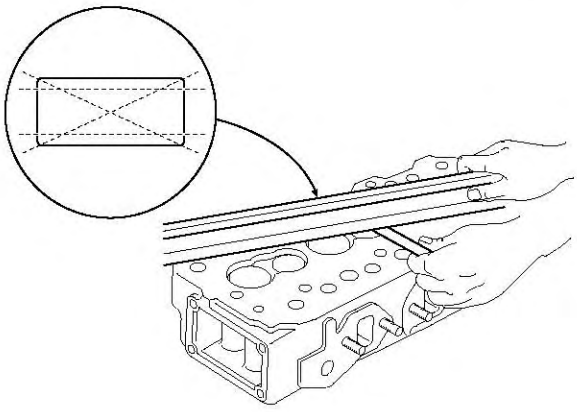
SUDEM7104L

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

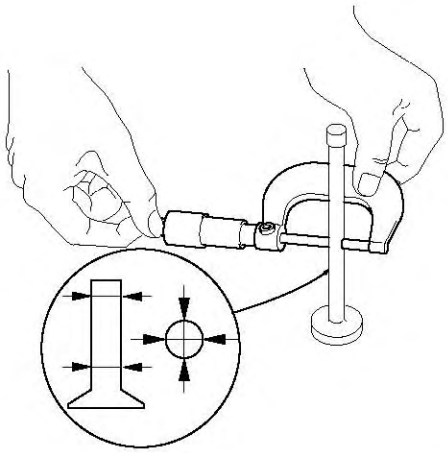
Deformation of cylinder head bottom is measured at the position as shown in the following figure.



SUDEM7105L

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

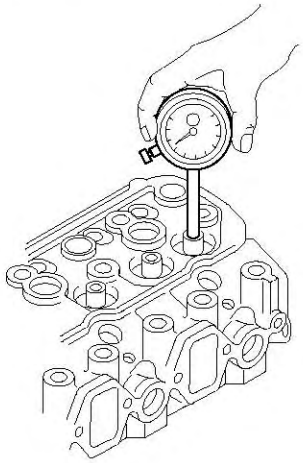
Outer diameter of valve stem
- Intake valve
  Reference : 8.96~8.97mm
  Limit : 8.85mm
- Exhaust valve
  Reference : 8.93~8.94mm
  Limit : 8.85mm



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

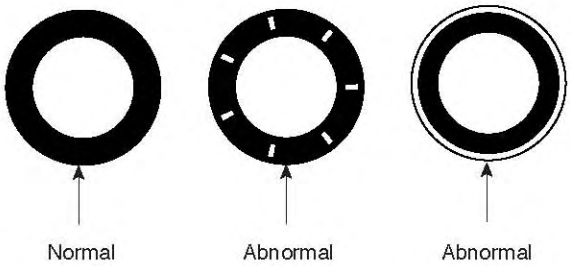


SUDEM7107L

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

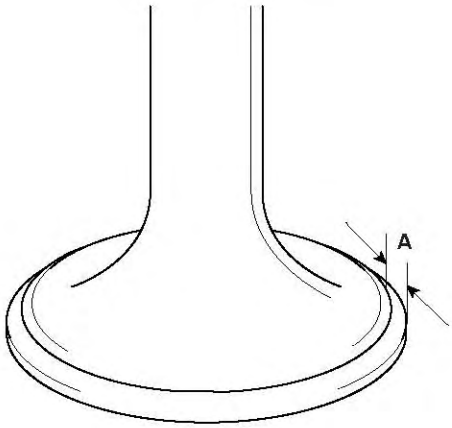
Be careful that valve does not turn, when valve seat is pressed by valve.



SUDEM7108L

c. Measure the seat contact area (A).

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

REPLACEMENT E03FAF94

REPLACEMENT OF ROCKER BUSH

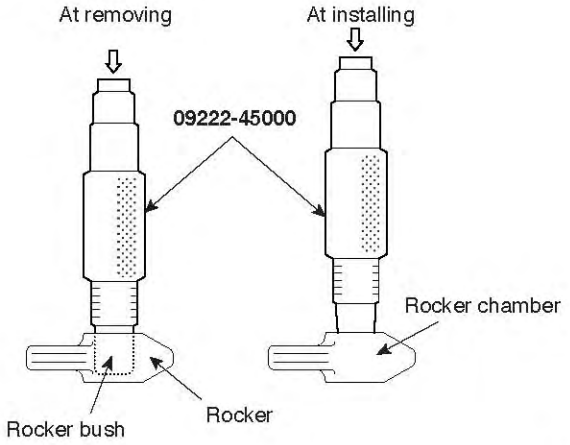
1. Remove the bush from rocker using the special tool (09222-45000).
2. Press fit the bush into rocker using the special tool (09222-45000).

NOTE

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

CAUTION

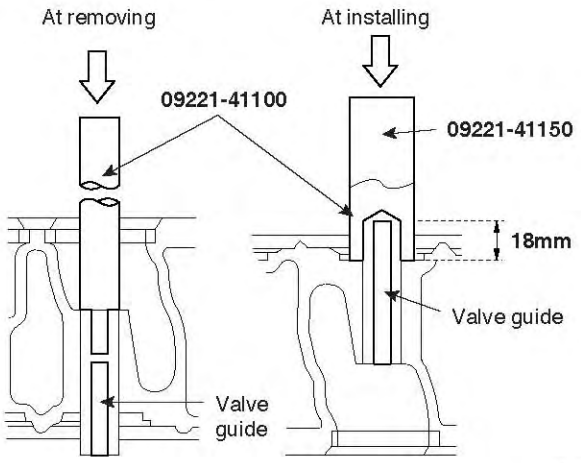
When pressing fit, align the bush oil hole with rocker oil hole.



SUDEM7110L

REPALCEMENT 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).



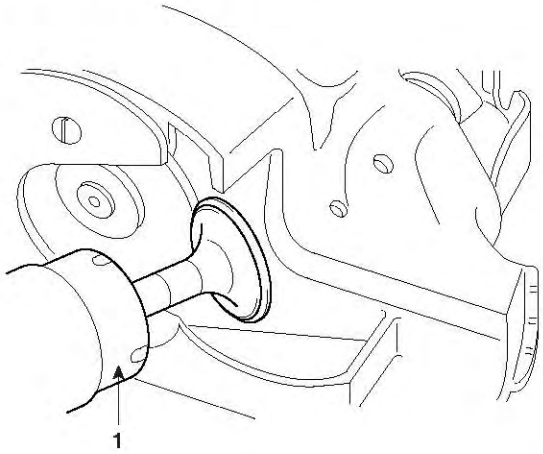
SUDEM7111L

VALVE SEAT REPAIR

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

CAUTION

Valve seat angle is 45°.

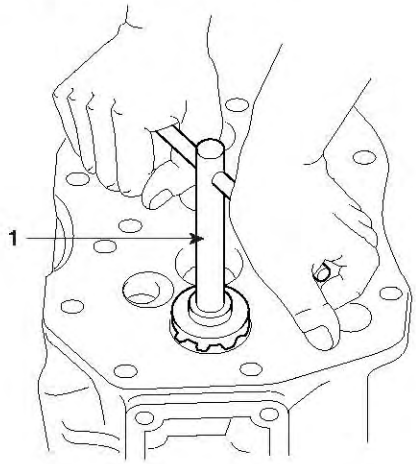


SUDEM7112L

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.

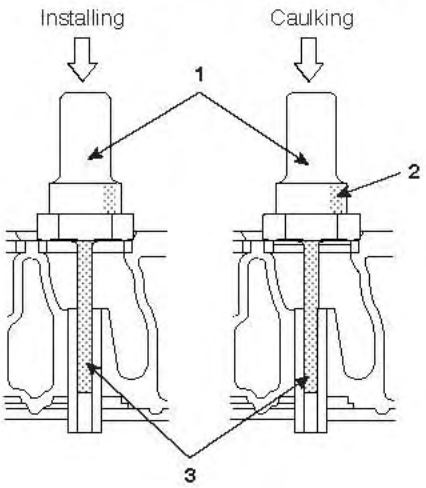


SUDEM7113L

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

⚠ CAUTION

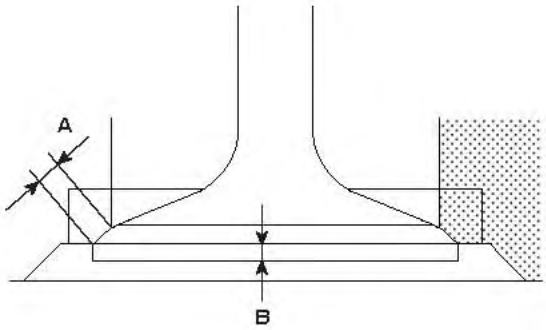
Press the valve seat (3) with the chamferred side of the locking ring. And then, caulk it to the cylinder head as the ring faces the other side.



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

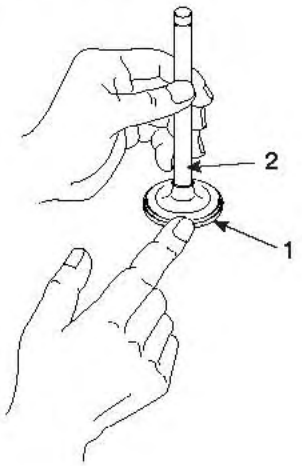


SUDEM7115L

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

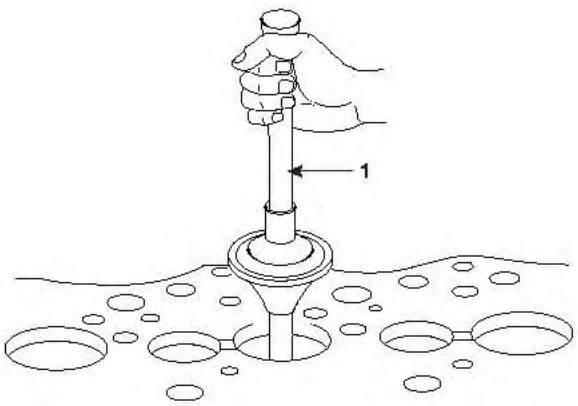
⚠ CAUTION

a. 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)
b. 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.



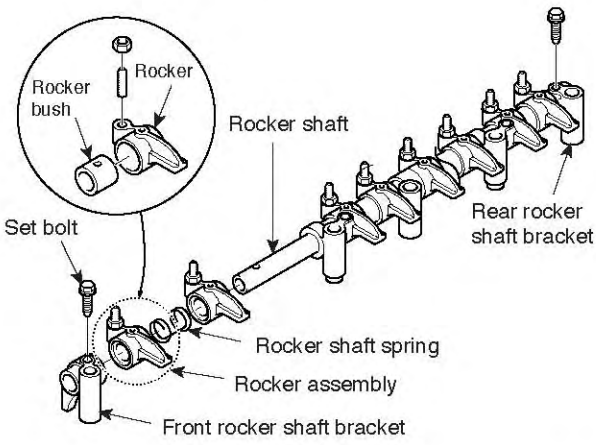
SUDEM7117L

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.

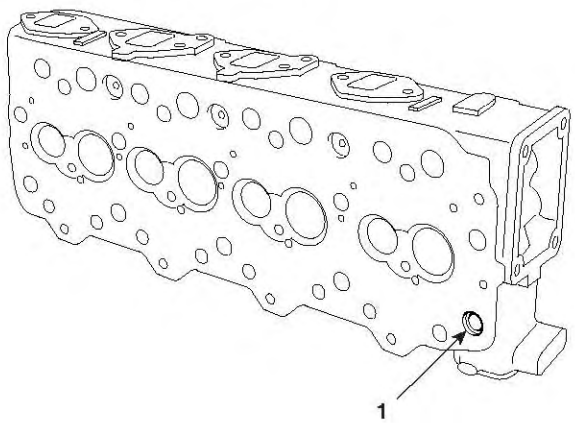
Tightening torque: 7.8~11.8 Nm (0.8~1.2 kgf.m, 5.8~8.7 lb-ft)



SUDEM7093L

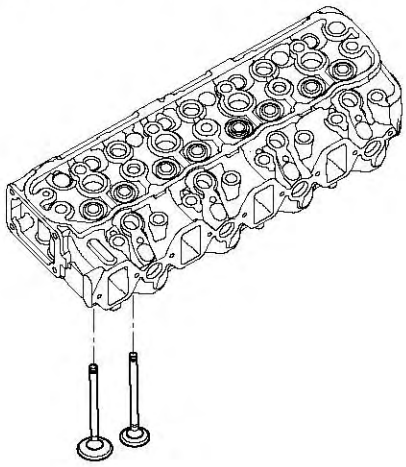
VALVE AND CYLINDER HEAD ASSEMBLY

1. Install the water director to the cylinder head.



SUDEM7096L

2. Install the intake and exhaust valve.

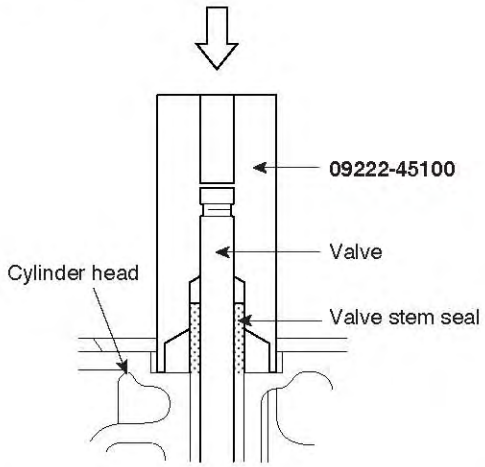


SUDEM7118L

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

NOTE

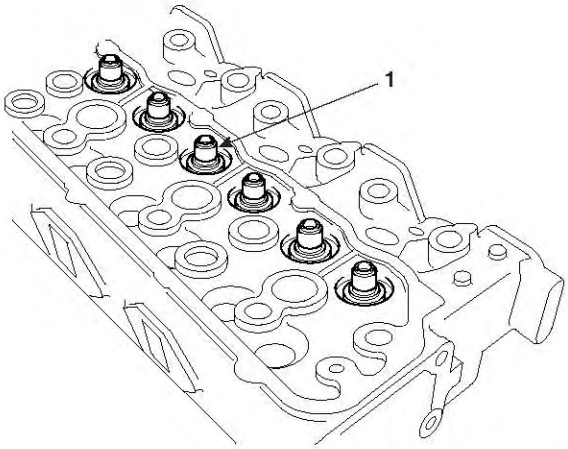
Tap the seal until the special tool (09222-45100) contacts the cylinder head.



SUDEM7119L

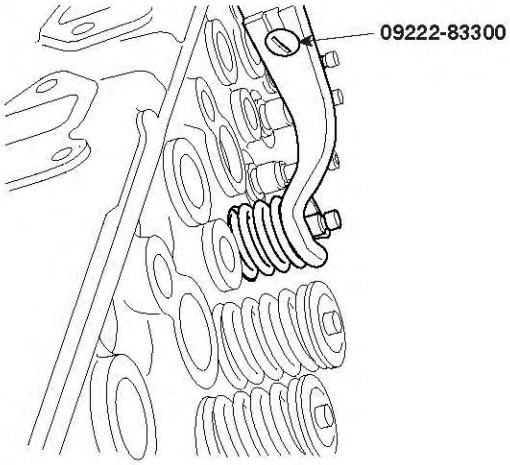
CAUTION

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



SUDEM7120L

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



SUDEM7121L

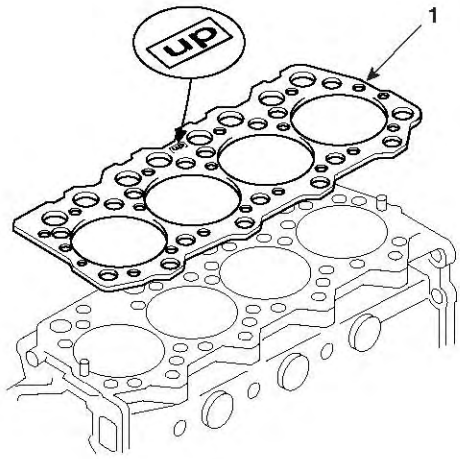
INSTALLATION EDA3BF2F

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.

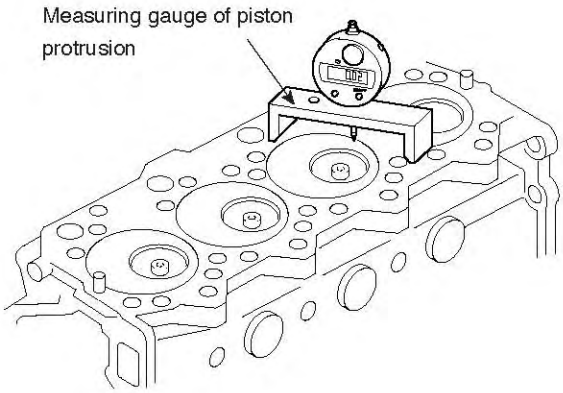


SUDEM7097L

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

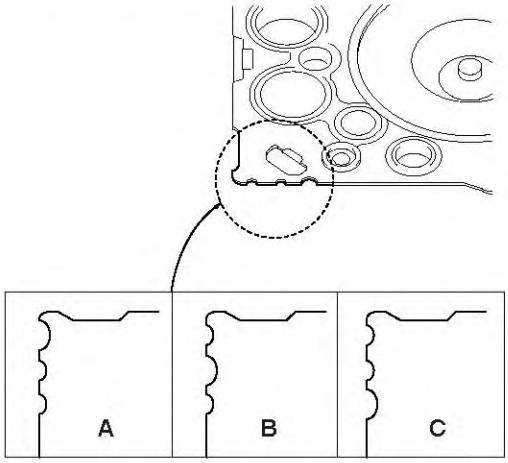
Unit : mm



SUDEM7122L

NOTE

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



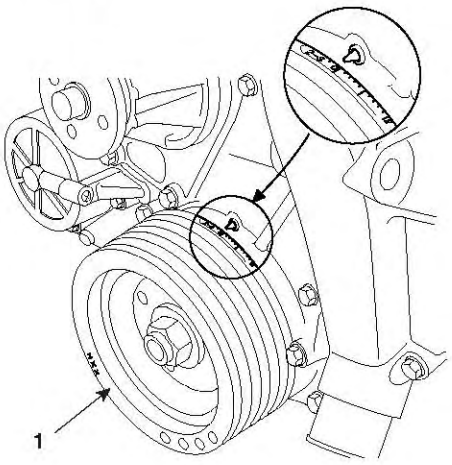
SUDEM7123L

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 comopression stroke of cylinder No. 1).



SUDEM7124L

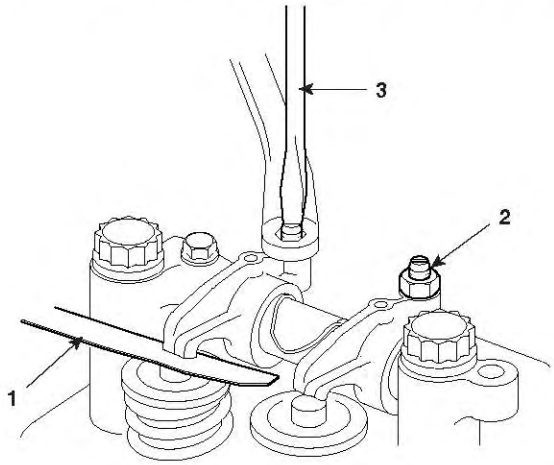
2) At the TDC of compression stroke of cylinder No. 1, check and adjust the clearance of the valve with "O" mark at the following table. And then, turn the crankshaft in one turn to check and adjust the valve clearance of remaining valves with "X"mark.

Cylinder No.	1		2		3		4	
Valve	Intake	Exhaust	Intake	Exhaust	Intake	Exhaust	Intake	Exhaust
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.

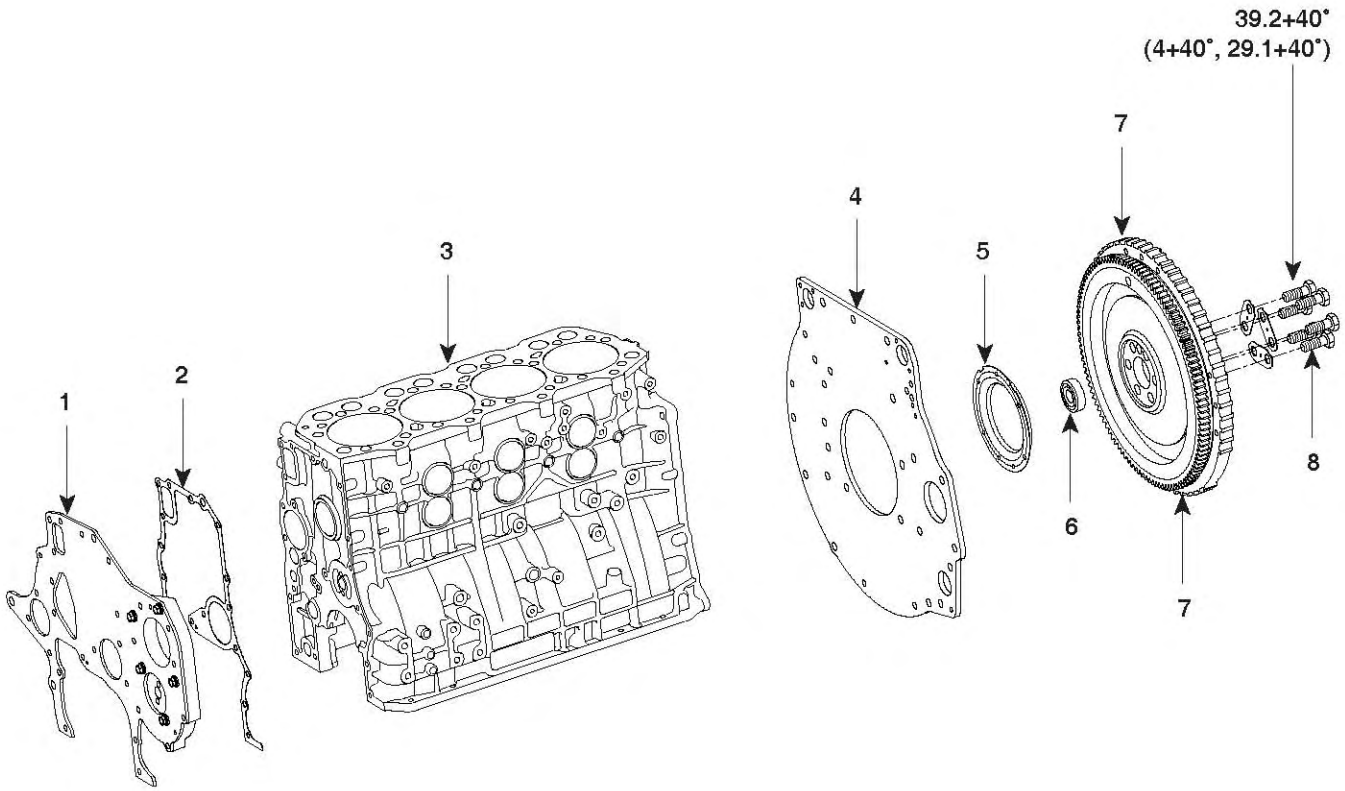


SUDEM7125L

CRANKCASE

FLYWHEEL

COMPONENTS E60B5C72

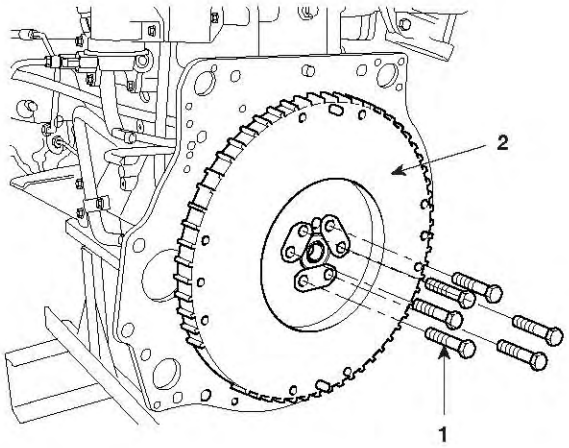


1. Front plate
2. Gasket
3. Crankcase
4. Rear plate
5. Rear oil seal
6. Pilot bearing
7. Flywheel
8. Flywheel mounting bolt

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

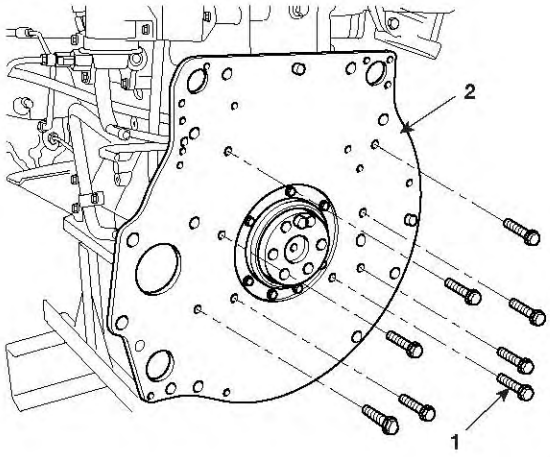
REMOVAL EECFB3A9

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



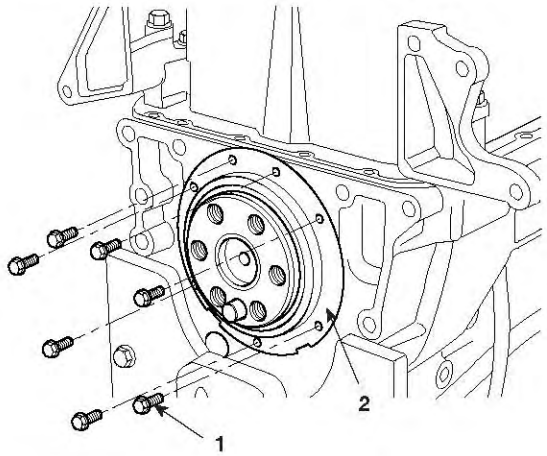
SUDEM7127L

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



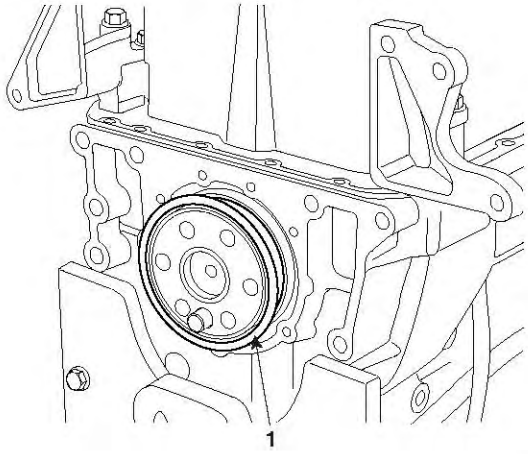
SUDEM7128L

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).

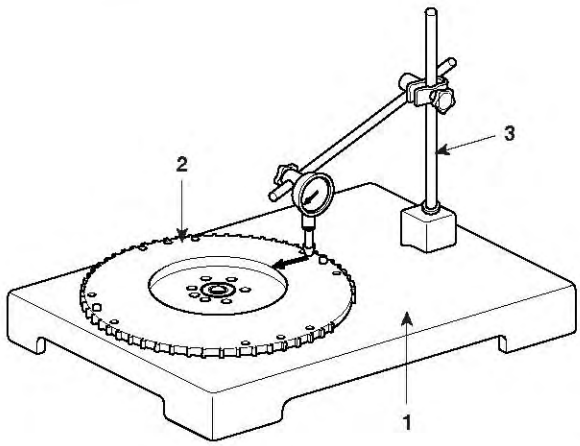


SUDEM7130L

INSPECTION EE08EBFD

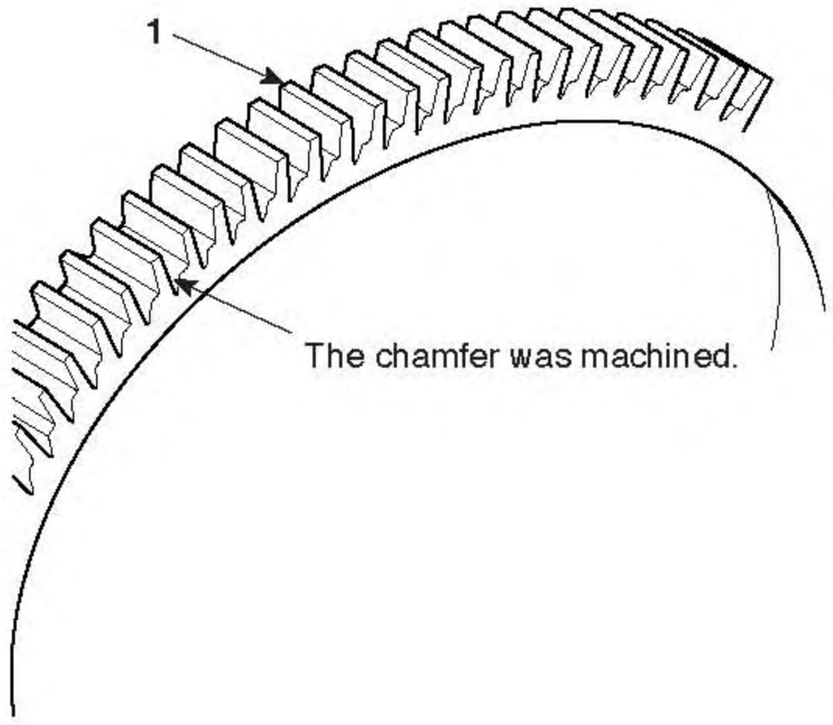
1. Distorsion check of frictional surface
   a. Put the flywheel (2) on the precision table (1) and set up the dial indicator (3).
   b. Move the dial indicator on the flywheel frictional surface to measure the distortion.
   c. If the distortion of the frictional surface exceeds the limit, regrind the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

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



SUDEM7131L

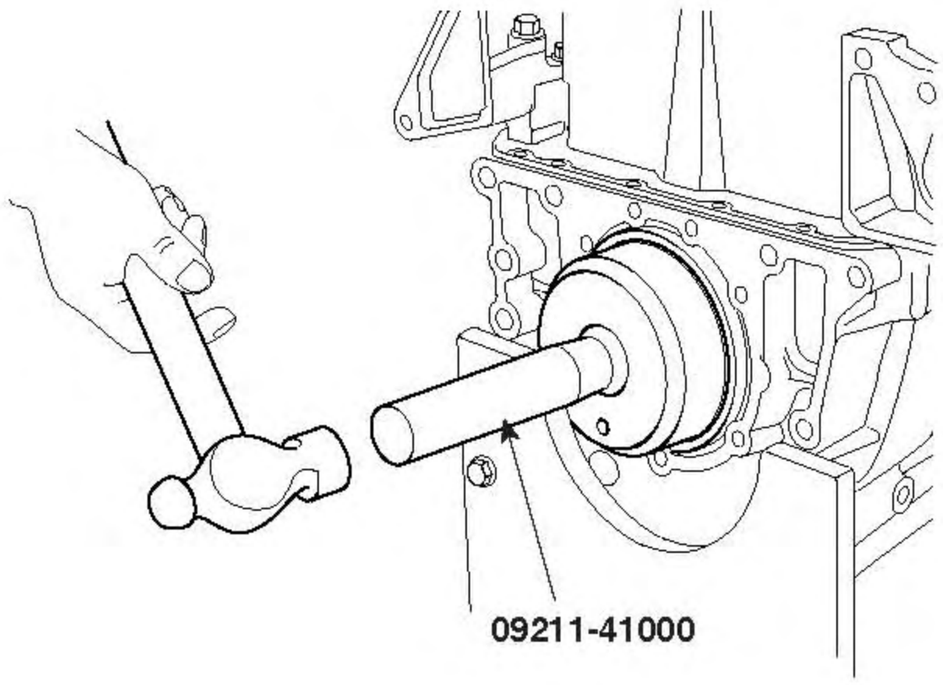
2. Replacement of flywheel ring gear
   a. When removing the ring gear (1), heat the ring gear evenly using acetylene torch or equivalent tools and then remove the ring gear by tapping the circumference with rod or hammer.
   b. When installing, heat the ring gear with piston heater for 3 minutes (about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



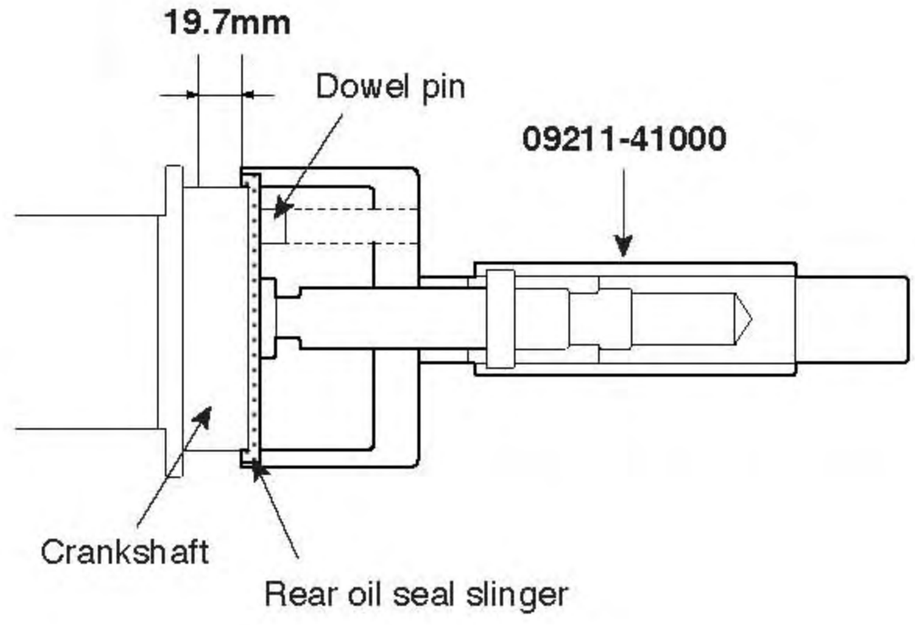
SUDEM7279L

INSTALLATION E561D9B1

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



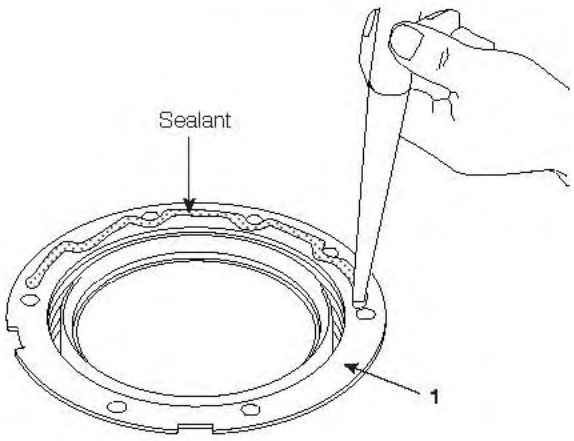
SUDEM7133L



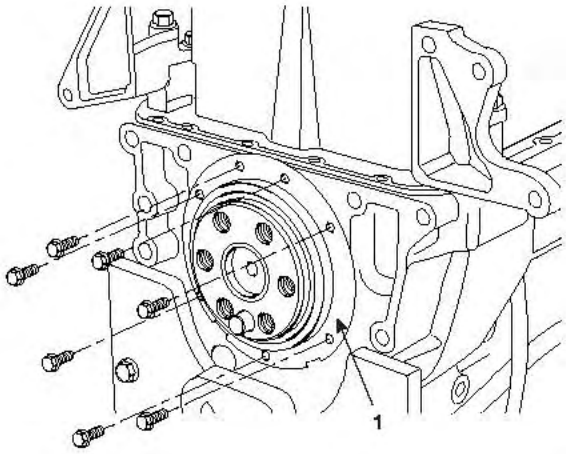
SUDEM7134L

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

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



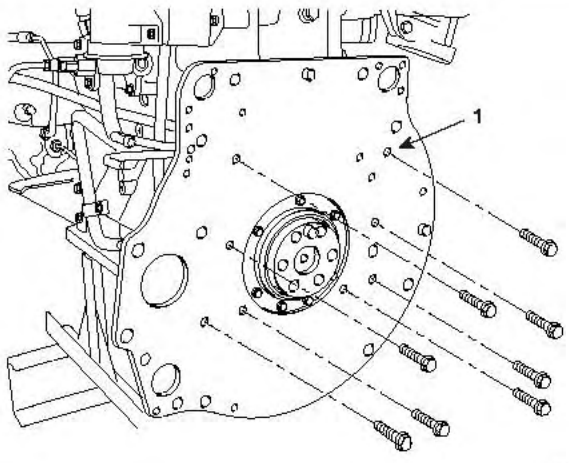
SUDEM7135L



SUDEM7136L

3. Install the rear plate (1).

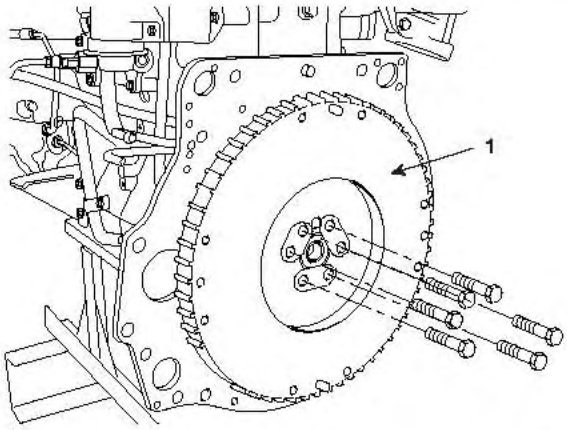
Tightening torque: 63.7 Nm
(6.5 kgf.m, 47.3 lb-ft)



SUDEM7137L

4. Install the flywheel (1).

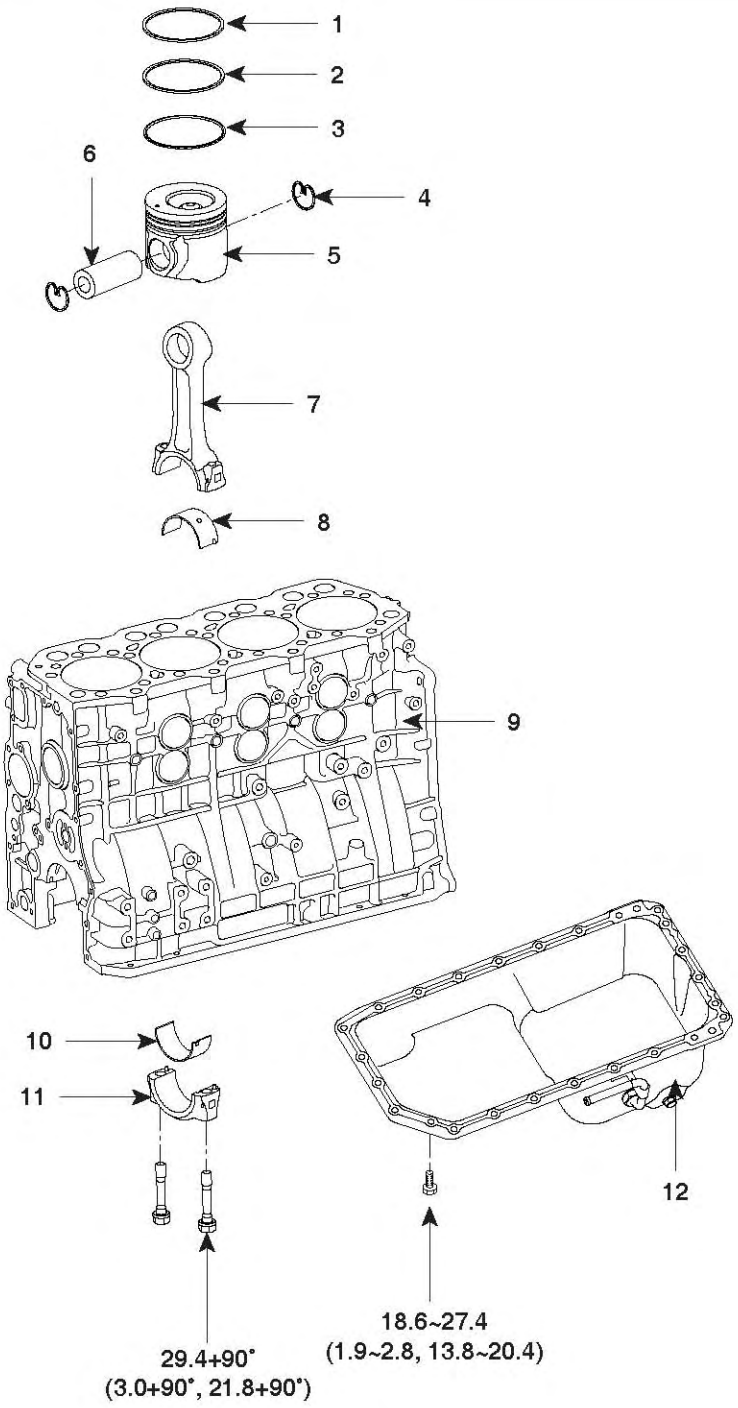
Tightening torque: 39.2Nm+40°
(4.0kgf.m+40°, 29.1 lb-ft+40°)



SUDEM7138L

CYLINDER BLOCK ASSEMBLY

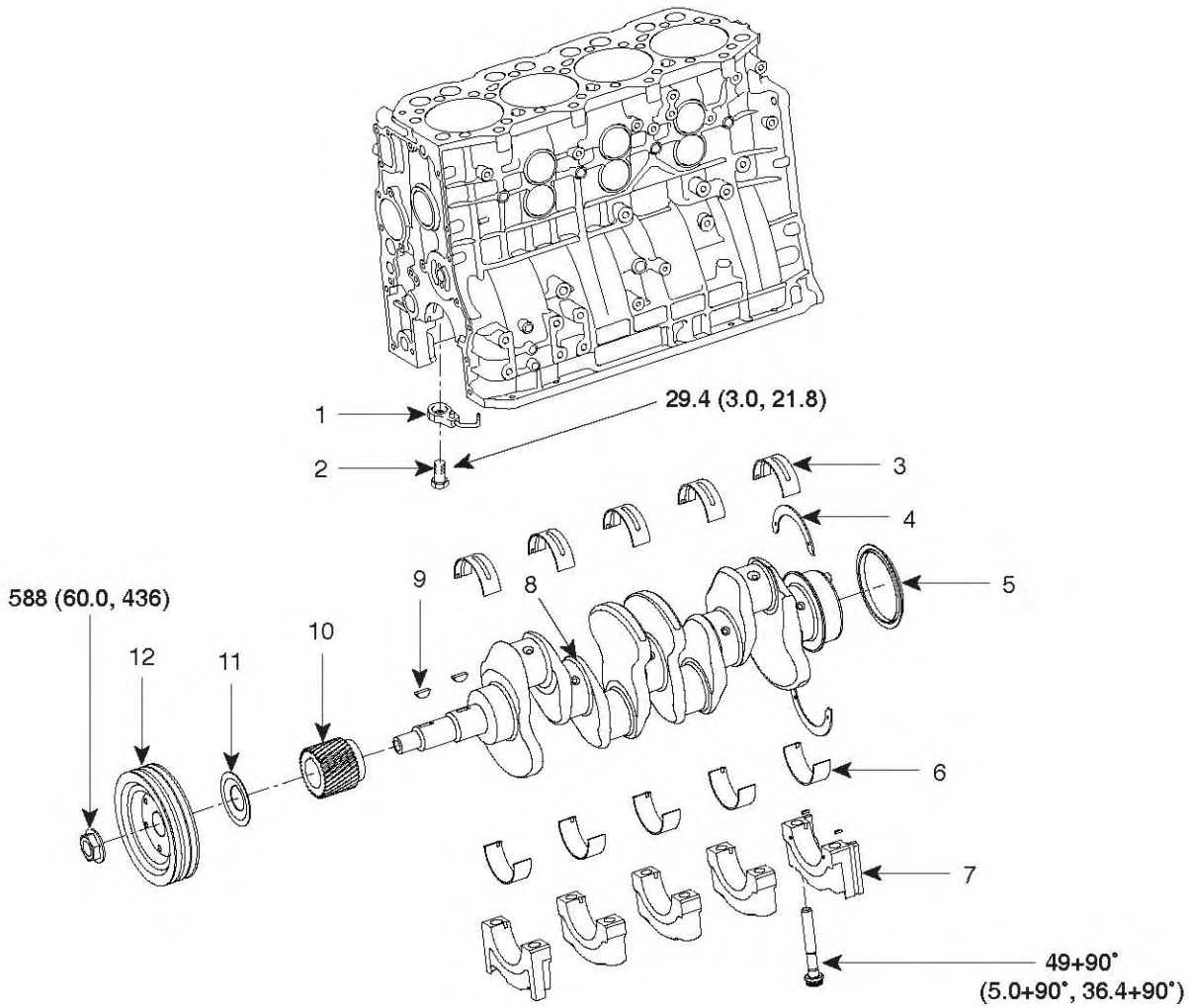
COMPONENTS EBC859AD



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)**

SUDEM7139L



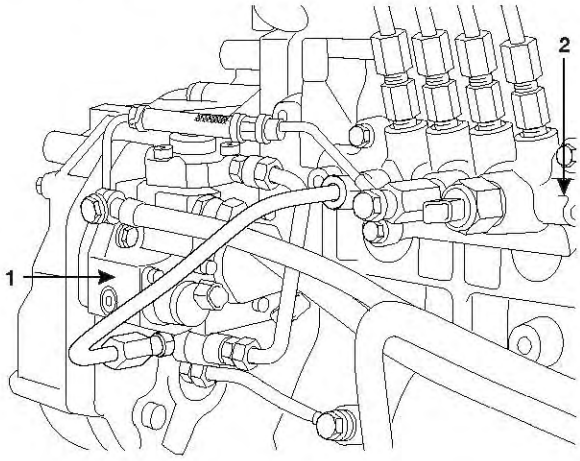
1. Oil jet
2. Oil jet mounting bolt
3. Upper main bearing
4. Thrust plate
5. Rear oil seal slinger
6. Lower main bearing
7. Main bearing cap
8. Crankshaft assembly
9. Semicircular key
10. Crankshaft gear
11. Front oil seal slinger
12. Crankshaft pulley

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

SUDEM7140L

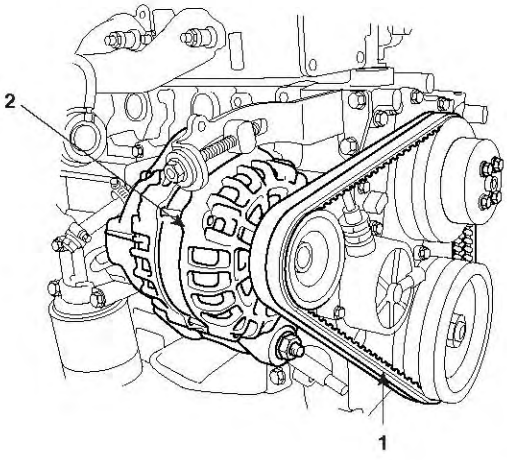
REMOVAL EE4DAE0F

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



SUDEM7281L

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

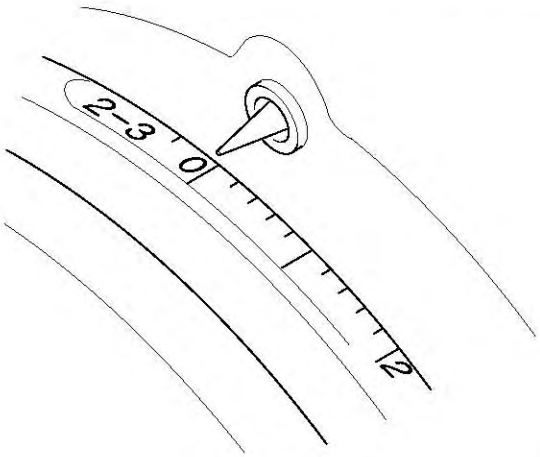


SUDEM7142L

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

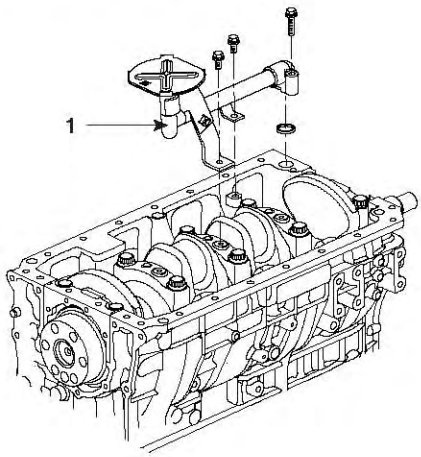
NOTE

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



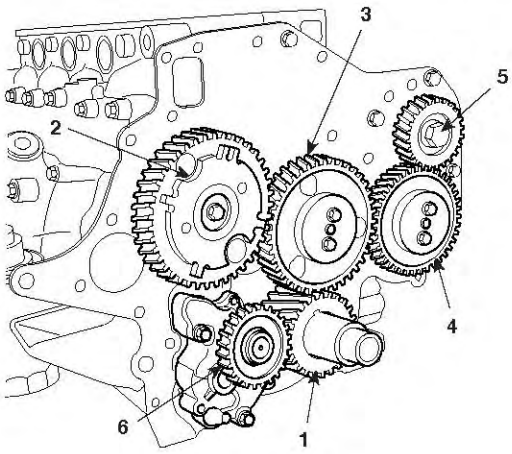
SUDEM7143L

8. Remove oil cooler assembly.



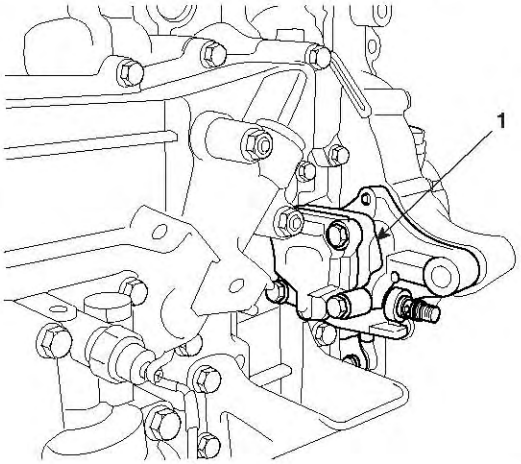
SUDEM7144L

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.



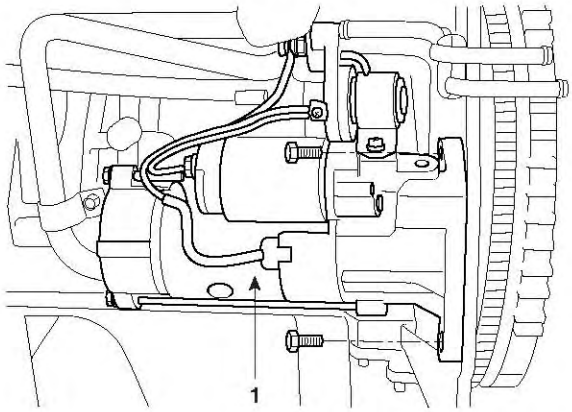
SUDEM7145L

10. Remove the power steering pump (1).



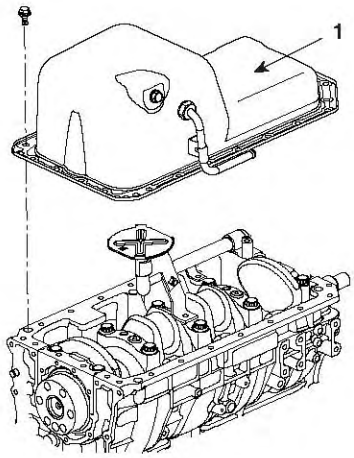
SUDEM7146L

11. Remove the starter motor assembly (1).



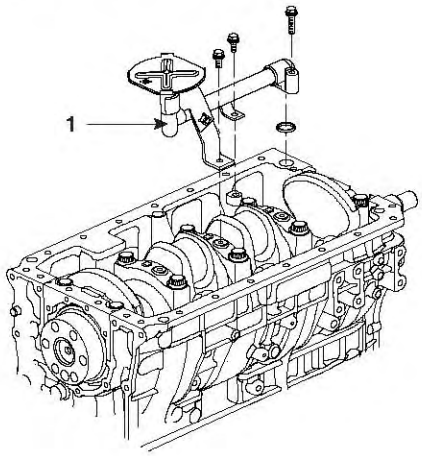
SUDEM7147L

12. Remove the oil pan (1).



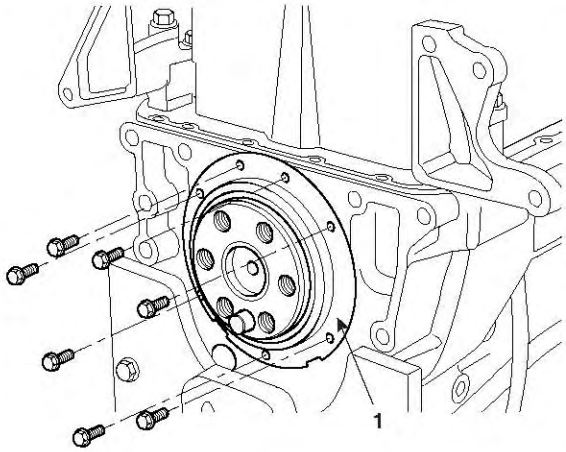
SUDEM7148L

13. Remove the oil strainer (1).

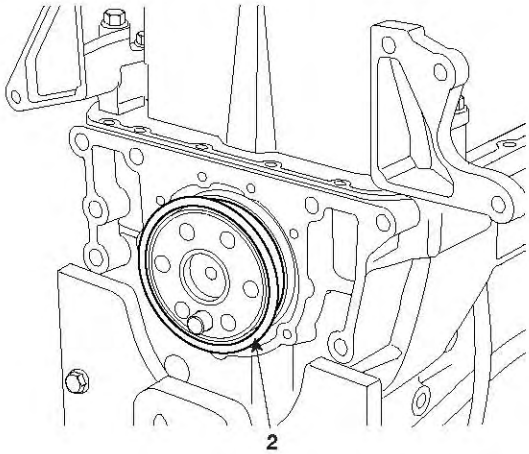


SUDEM7149L

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



SUDEM7150L

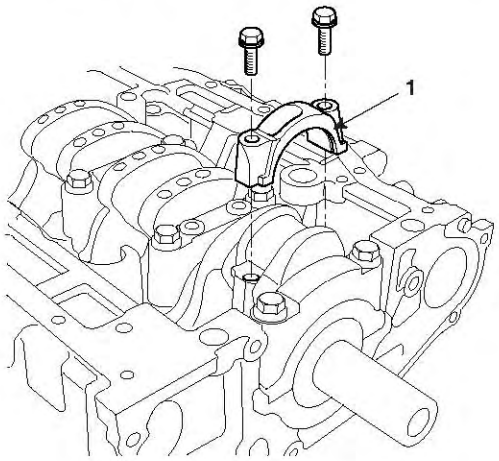


SUDEM7151L

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

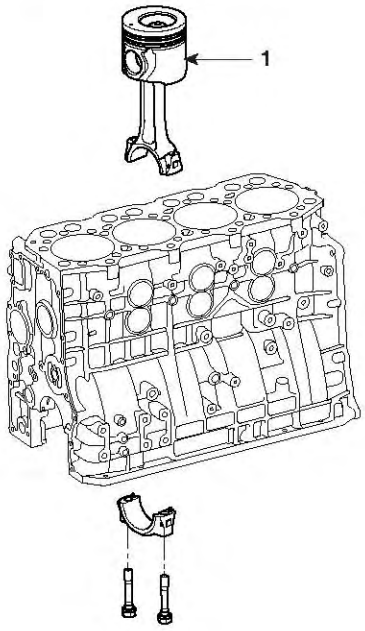
NOTE

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



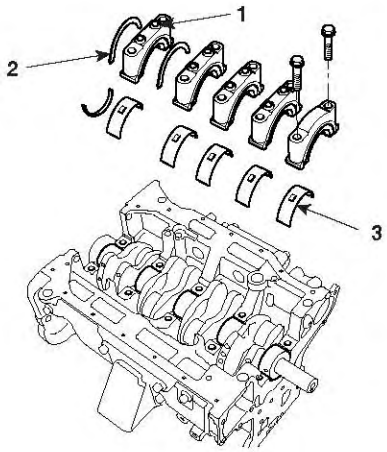
SUDEM7152L

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



SUDEM7153L

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

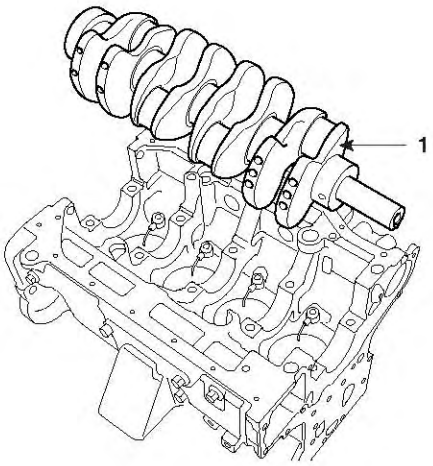


SUDEM7154L

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

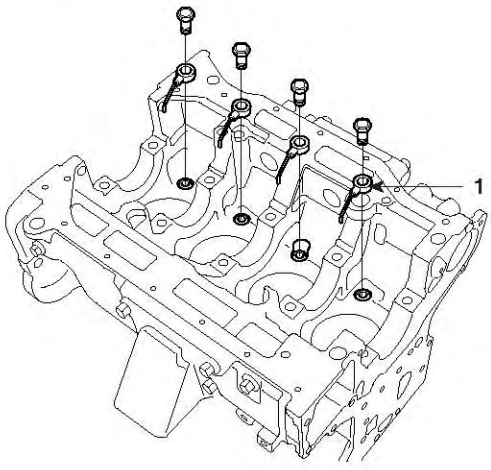
CAUTION

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



SUDEM7155L

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

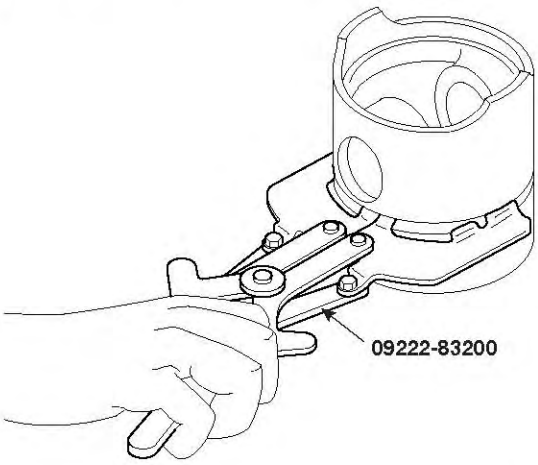


SUDEM7156L

DISASSEMBLY E190BEAB

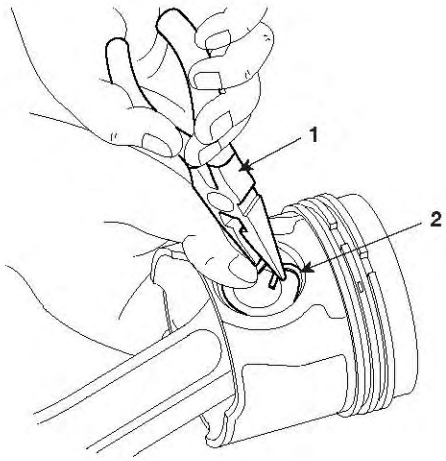
PISTON AND CONNECTING ROD ASSEMBLY

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



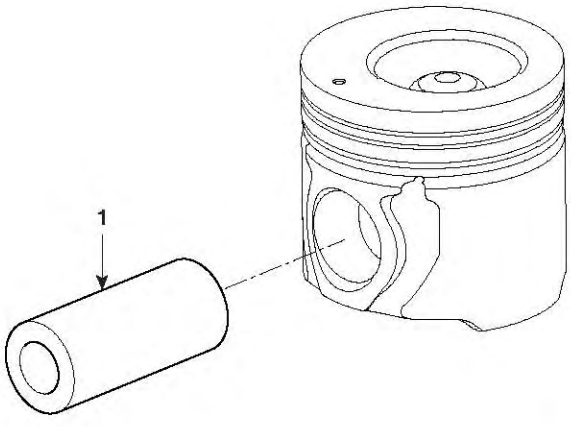
SUDEM7157L

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



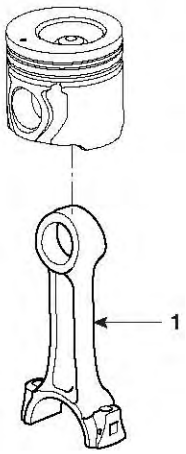
SUDEM7158L

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.

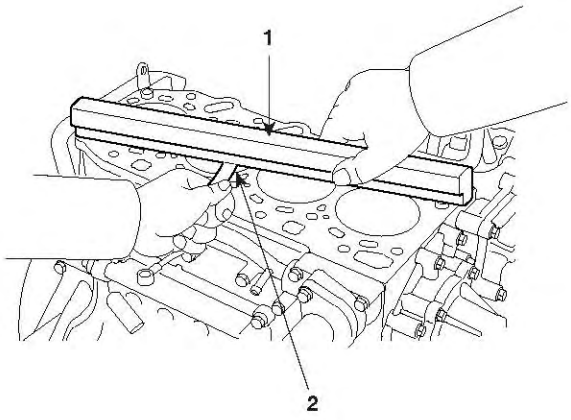
NOTE

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.

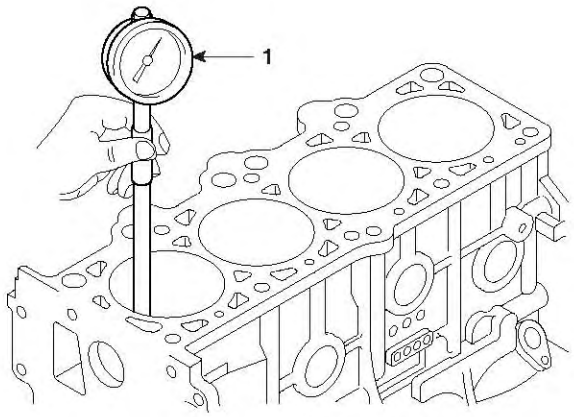
Clearance between piston and cylinder sleeve :
0.080~0.130mm

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).

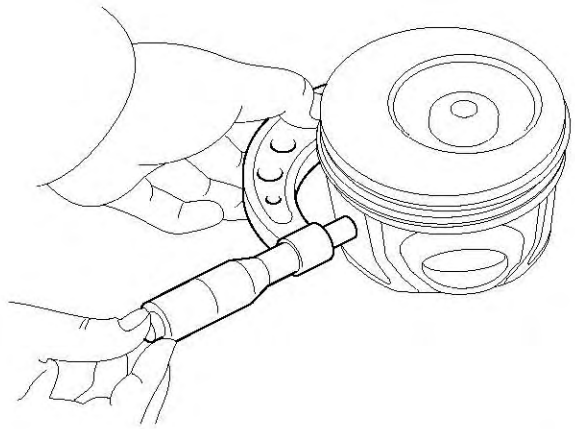
Inner diameter of cylinder sleeve: 104.00~104.03mm



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

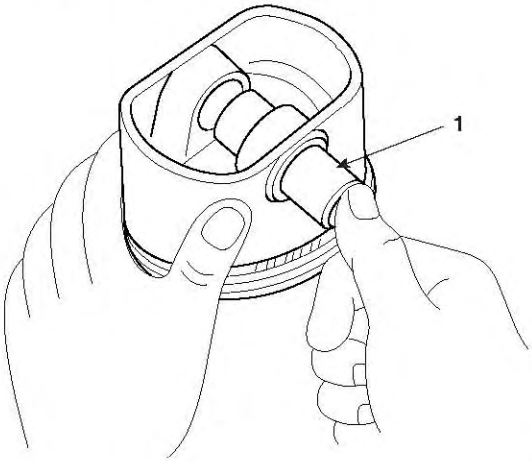


SUDEM7163L

PISTON

1. Check each piston to see whether it is damaged.

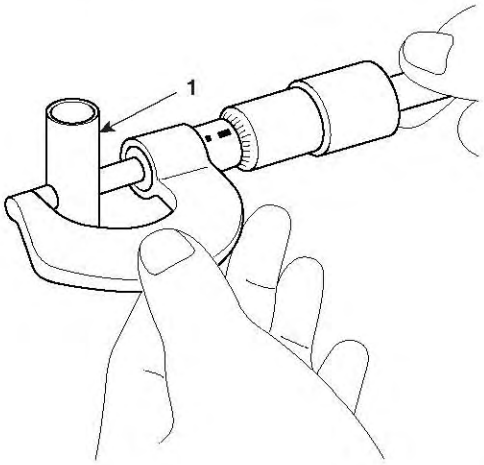
2. Check whether the piston pin (1) is installed correctly in the piston hole.
   If any defect is found, replace the piston and piston pin as an assembly.
   Piston pin should slide into the piston hole smoothly when it is pushed by hand.



SUDEM7164L

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

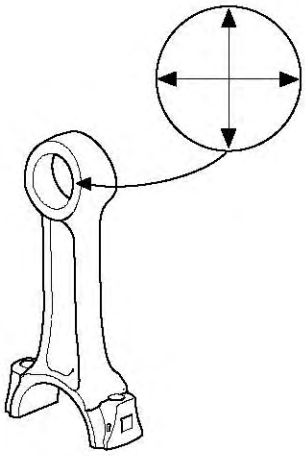
Inner diameter of piston boss: 38mm
Outer diameter of piston pin: 38mm
Clearance Reference: 0.007~0.021mm
Clearance Limit: 0.05mm



SUDEM7165L

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

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



SUDEM7166L

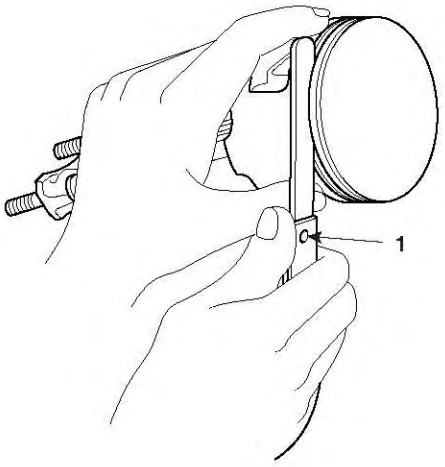
PISTON RING

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.

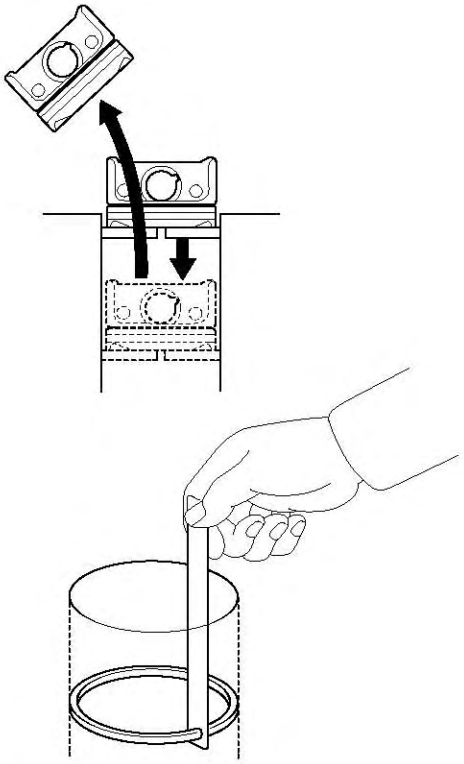
Piston ring	Standard	Limit
Ring No.1	0.106~0.170mm	0.2mm
Ring No.2	0.07~0.11mm	0.15mm
Oil ring	0.03~0.07mm	0.15mm



SUDEM7167L

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

Piston ring end gap
Ring No.1: 0.25~0.40mm
Ring No.2: 0.50~0.65mm
Oil ring: 0.20~0.40mm



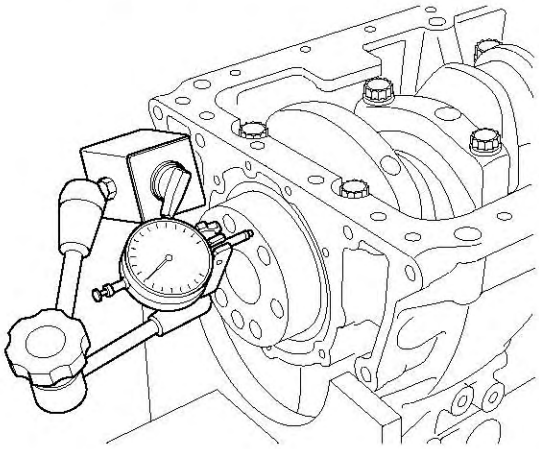
SUDEM7168L

CRANKSHAFT

1. Measure the endplay of crankshaft.

Crankshaft endplay
Reference :0.10~0.26mm
Limit: 0.4mm

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

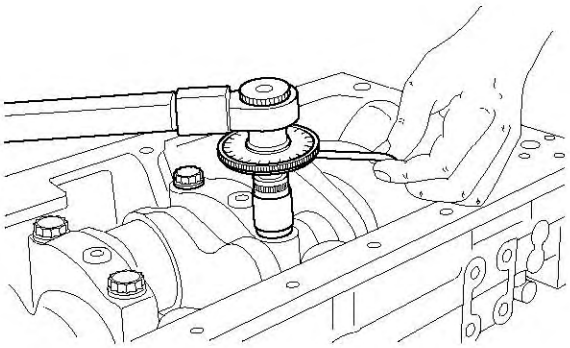
2. Measure the oil gap of crankshaft main bearing.
   a. Remove the main bearing cap.
   b. Measure the oil gap of main bearing.

   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.

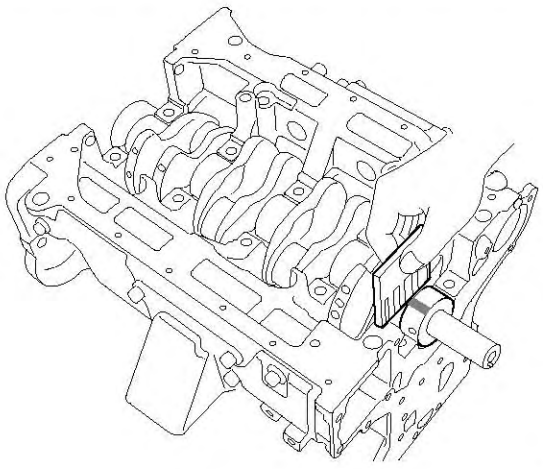
Tightening torque: 49.0 Nm+90°
(5.0kgf.m+90°, 36.4 lb-ft+90°)



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

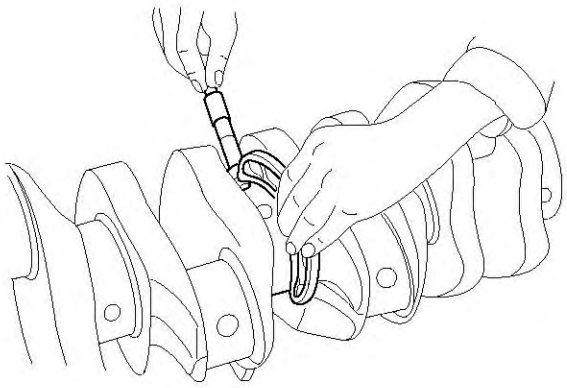


SUDEM7171L

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



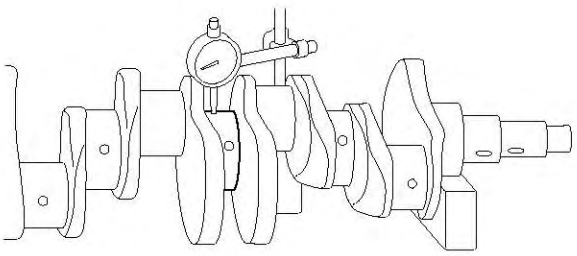
SUDEM7172L

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.

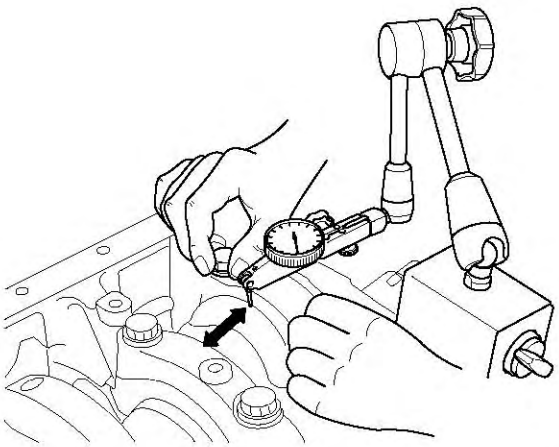


SUDEM7173L

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.

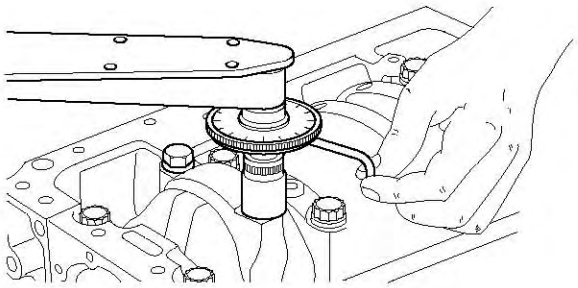
Connecting rod endplay
Reference: 0.15~0.45mm
Limit: 0.6mm



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.

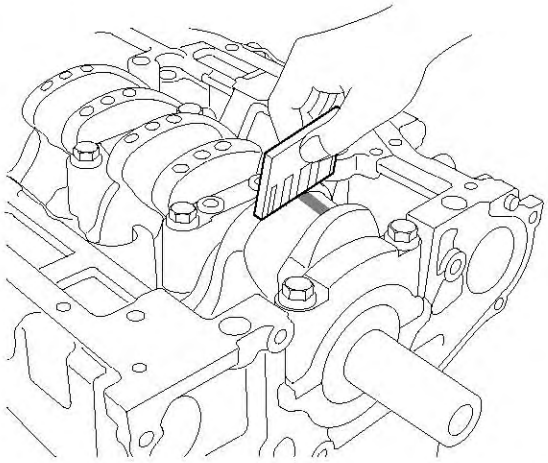
Tightening torque: 29.4 Nm+90°
(3.0kgf.m+90°, 21.8 lb-ft+90°)



SUDEM7175L

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

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



SUDEM7176L

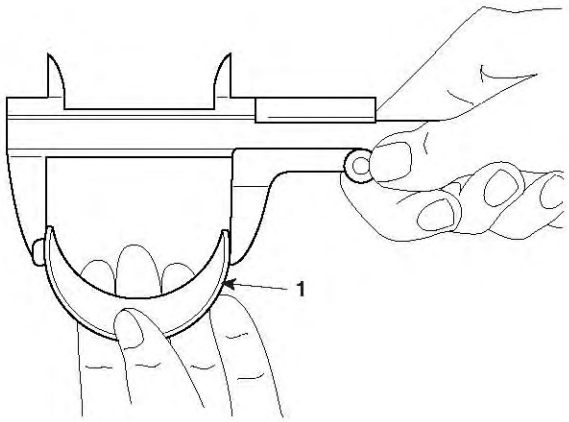
   e. If the oil gap is excessively large, replace the connecting rod bearing.

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.

Length of the connecting rod bearing
Limit: above 69.5mm

⚠ ***CAUTION***

Bearing should not be artificially expanded to reuse.

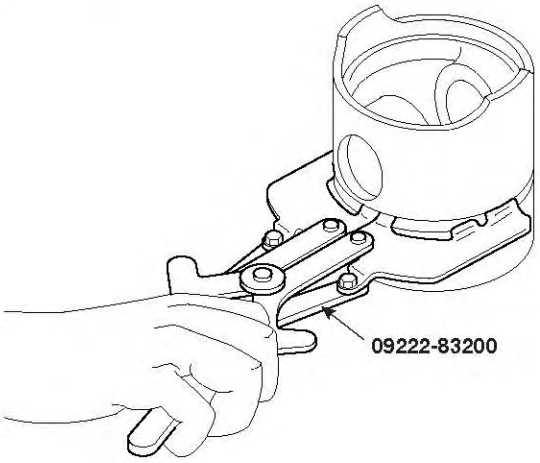


SUDEM7177L

REASSEMBLY E49D5D90

PISTON AND CONNECTING ROD ASSEMBLY

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

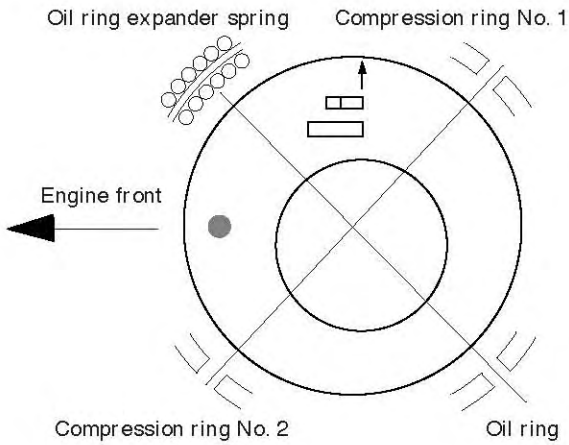


SUDEM7178L

NOTE

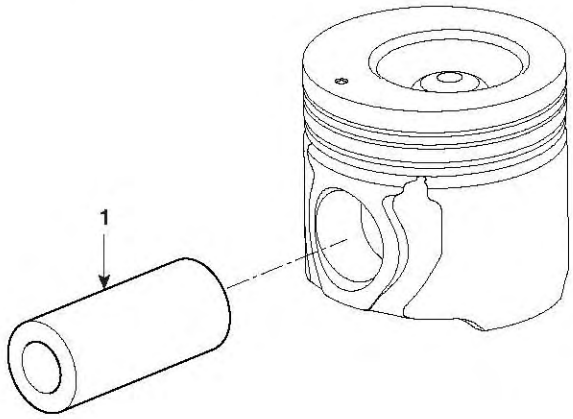
a. Install the piston ring so that open end of the piston ring faces to the direction shown in the figure.

b. Install the oil ring expander spring to be positioned at 180° direction with the oil ring end. Otherwise, expander spring may be loosened.



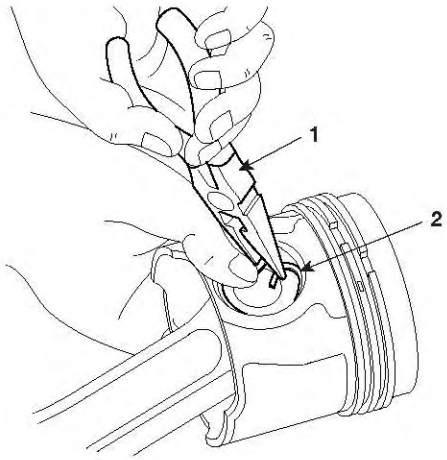
SUDEM7179L

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



SUDEM7180L

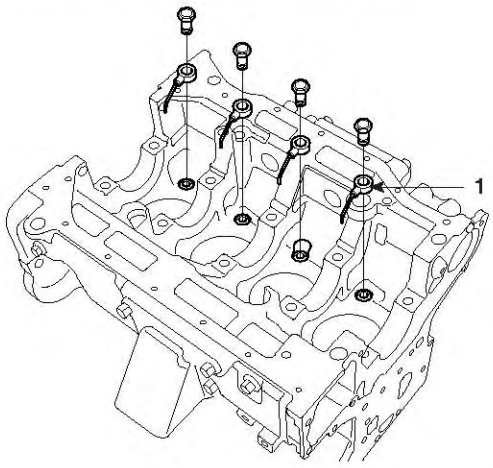
3. Install the piston pin snap ring (2) using snap ring pliers (1).



SUDEM7181L

INSTALLATION EE5ABFA8

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

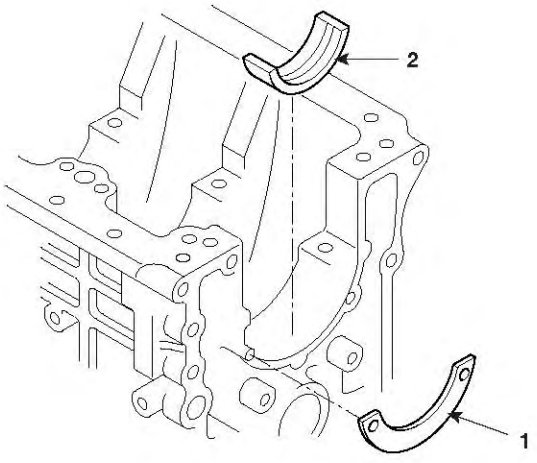


SUDEM7182L

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

CAUTION

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

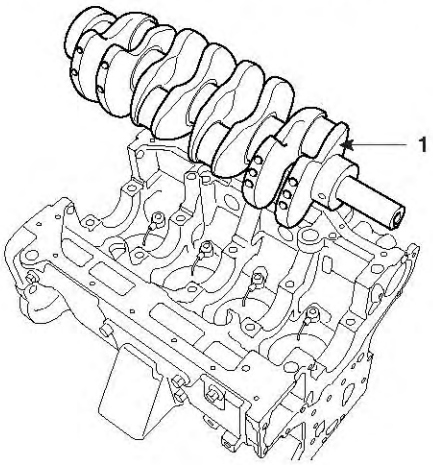


SUDEM7183L

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

CAUTION

Handle crankshaft carefully not to be damaged.



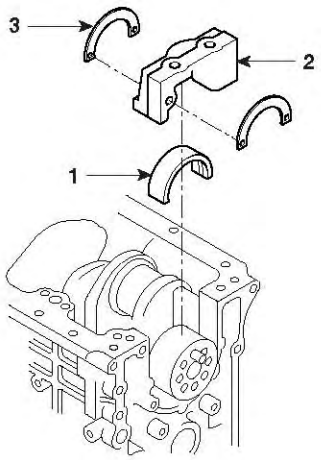
SUDEM7184L

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.

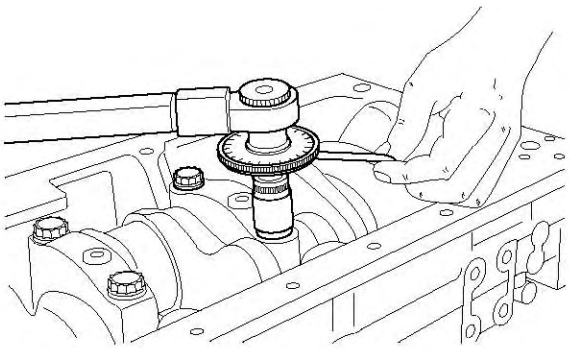
   b. Install thrust plate (3) to the rear-bearing cap.



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°)

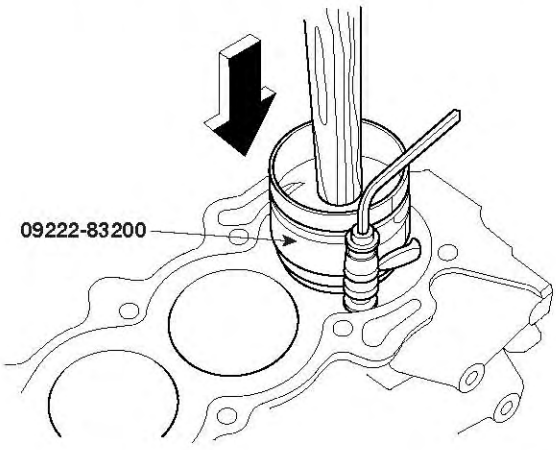


SUDEM7186L

5. Install piston and connecting rod assembly.

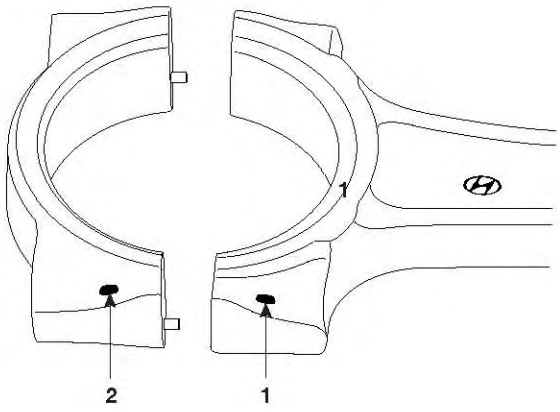
⚠ ***CAUTION***

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



SUDEM7187L

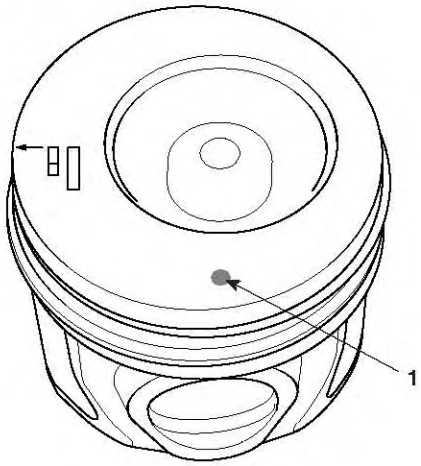
b. When installing connecting rod cap, align mark (1) on connecting rod big end cap with mark (2) on connecting rod cap.



SUDEM7188L

c. When installing piston, assemble it so that front mark (1) of the piston faces to the front side.

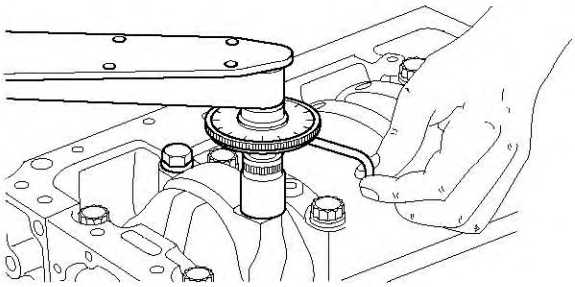
d. Assemble so that the arrow mark (→) of piston head faces to the center of cylinder head bolt hole.



SUDEM7189L

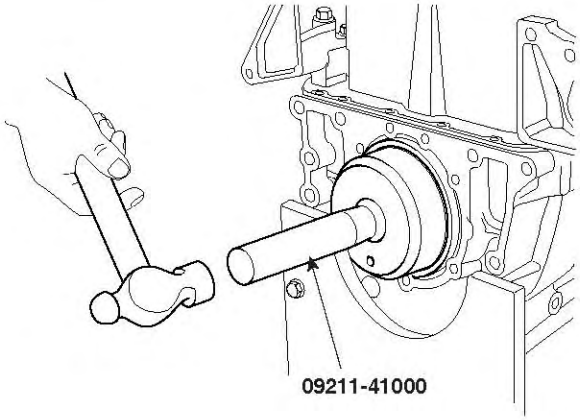
e. Tighten the connecting rod cap with specified torque.

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



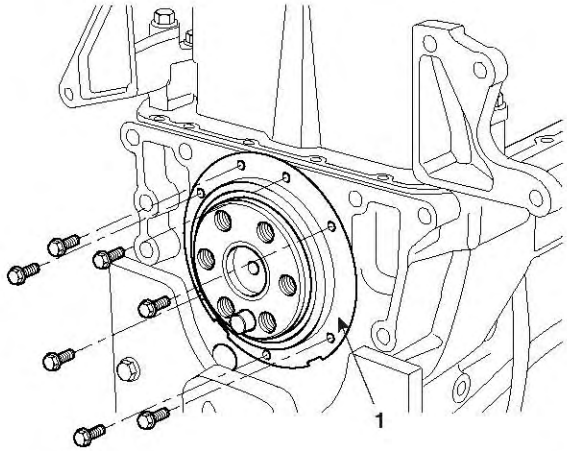
SUDEM7190L

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



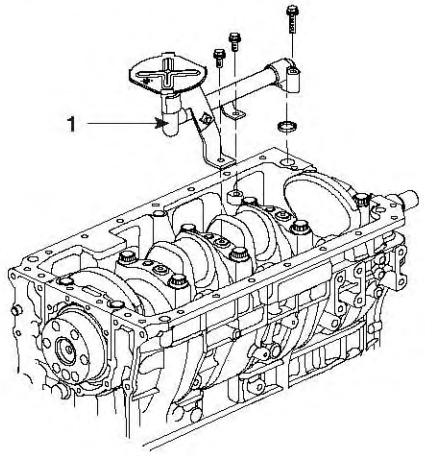
SUDEM7191L

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



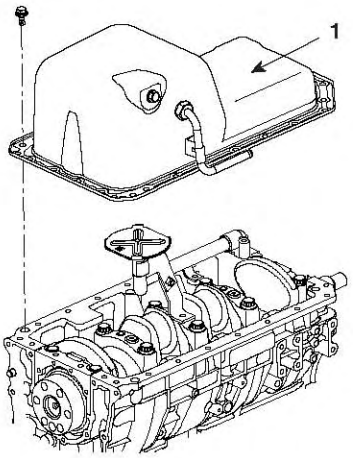
SUDEM7192L

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.

INTAKE AND EXHAUST SYSTEM

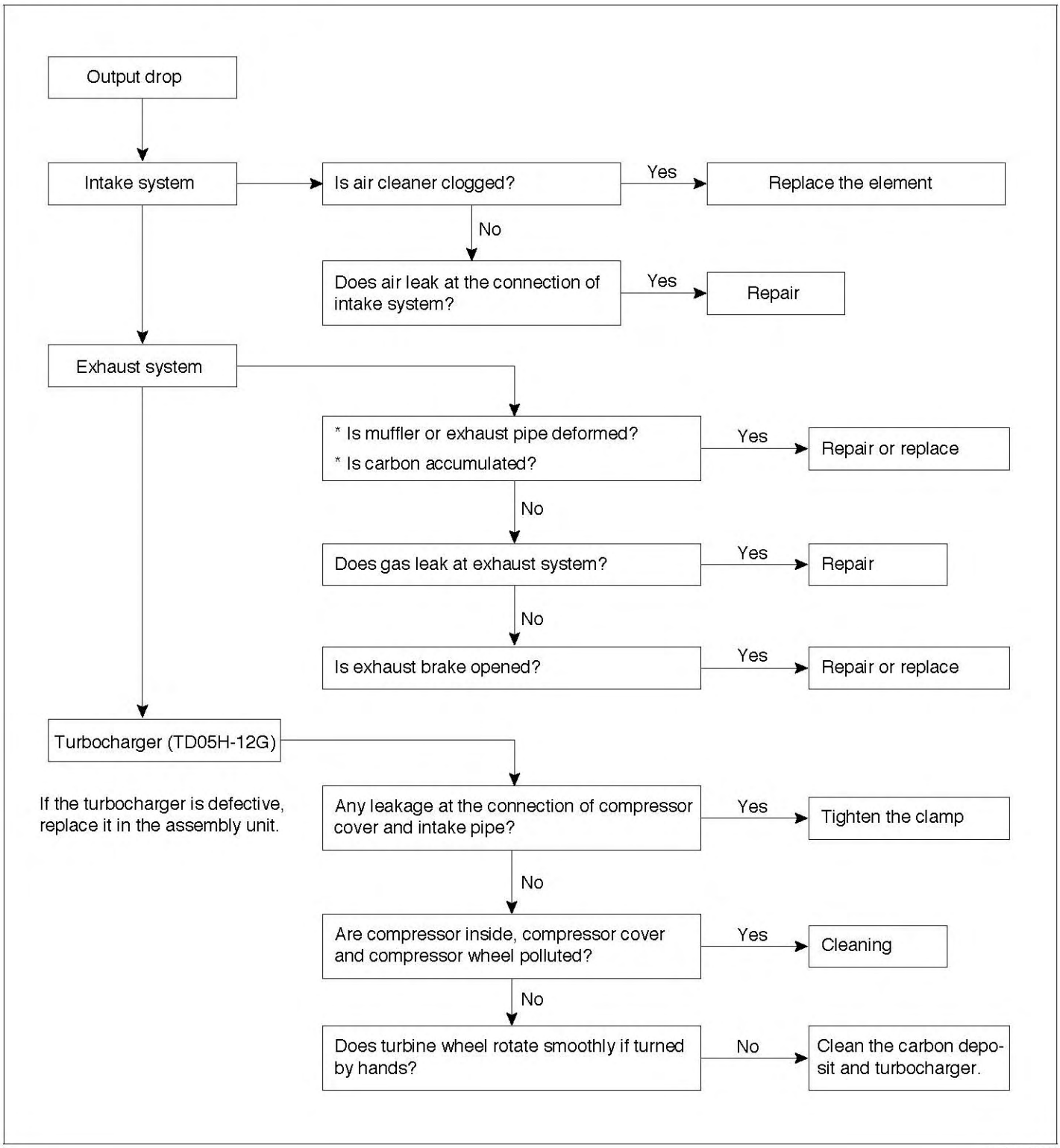
SPECIFICATIONS E08C8904

Items		Specifications
Air cleaner type		Dry type
Element type		Paper type
Turbocharger	type	Turbocharger (TD04HL-11T-6)
	Length	168mm
	Width	154mm
	Height	165mm
	Max rpm allowed	170,000 rpm
	Maximum exhaust gas temperature	760°C

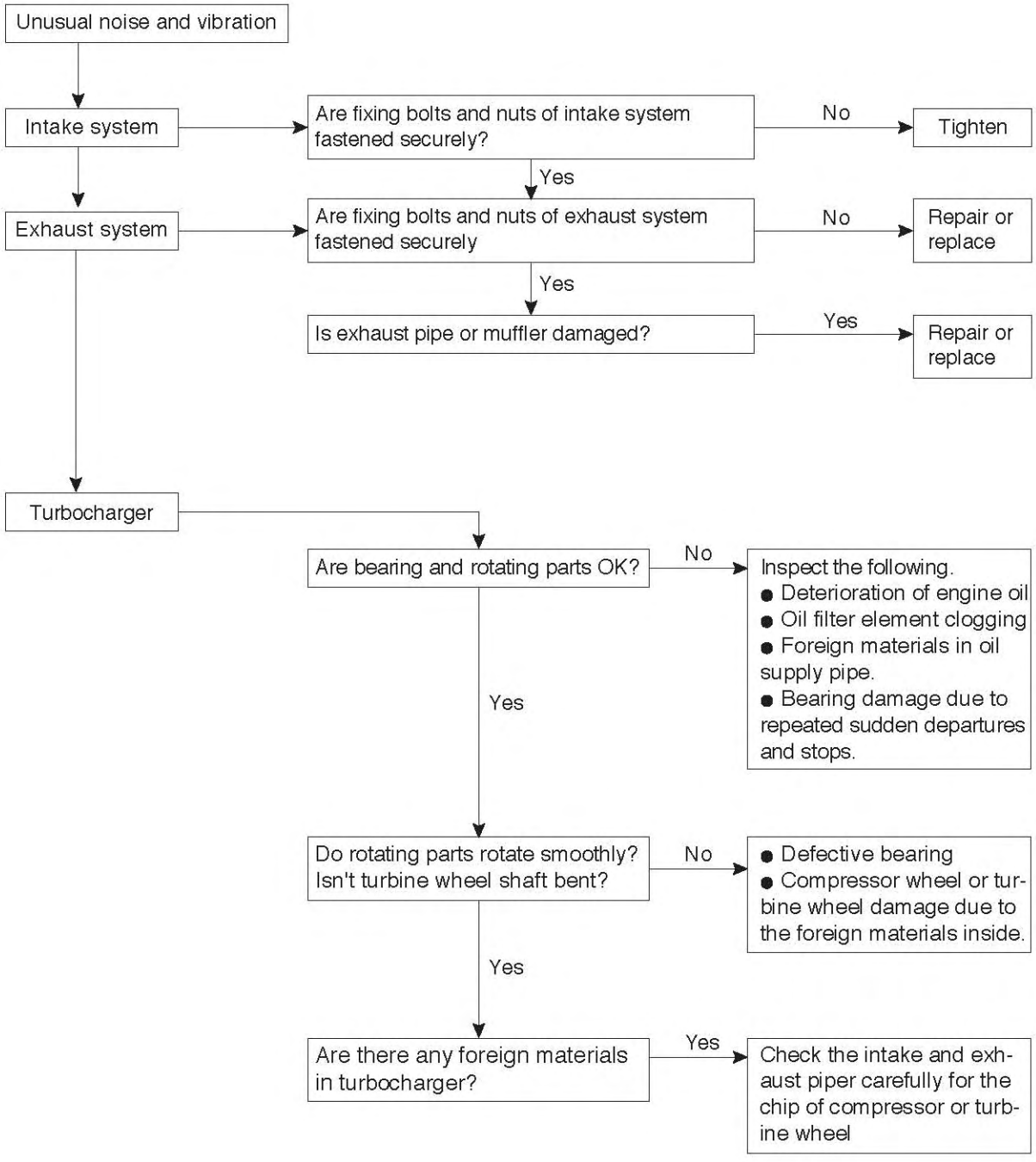
TIGHTENING TORQUE

Items (Diameter×Length)		Screw size O.D×pitch (mm)	Nm	kgf.m	lb-ft
Tur-bocharger	Turbocharger and intake pipe clamp band	M9×2.5	3.9	0.4	2.9
	Turbocharger oil pipe eyebolt	M8×1.25	16.7	1.7	12.4
Intake manifold	Actuator mounting flange bolt	M6×1.0	7.8~11.8	0.8~1.2	5.8~8.7
	Butterfly valve shaft mounting nut (8)	M8×1.25	16.7~25.5	1.7~2.6	12.4~18.9
	Intake manifold front hanger mounting flange bolt(10×20)	M10×1.5	32.3~49	3.3~5.0	24~36.4
	Intake manifold mounting flange bolt(8 ×20)	M8×1.25	18.6~27.4	1.9~2.8	13.8~20.4
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

TROUBLESHOOTING EBA6A66F



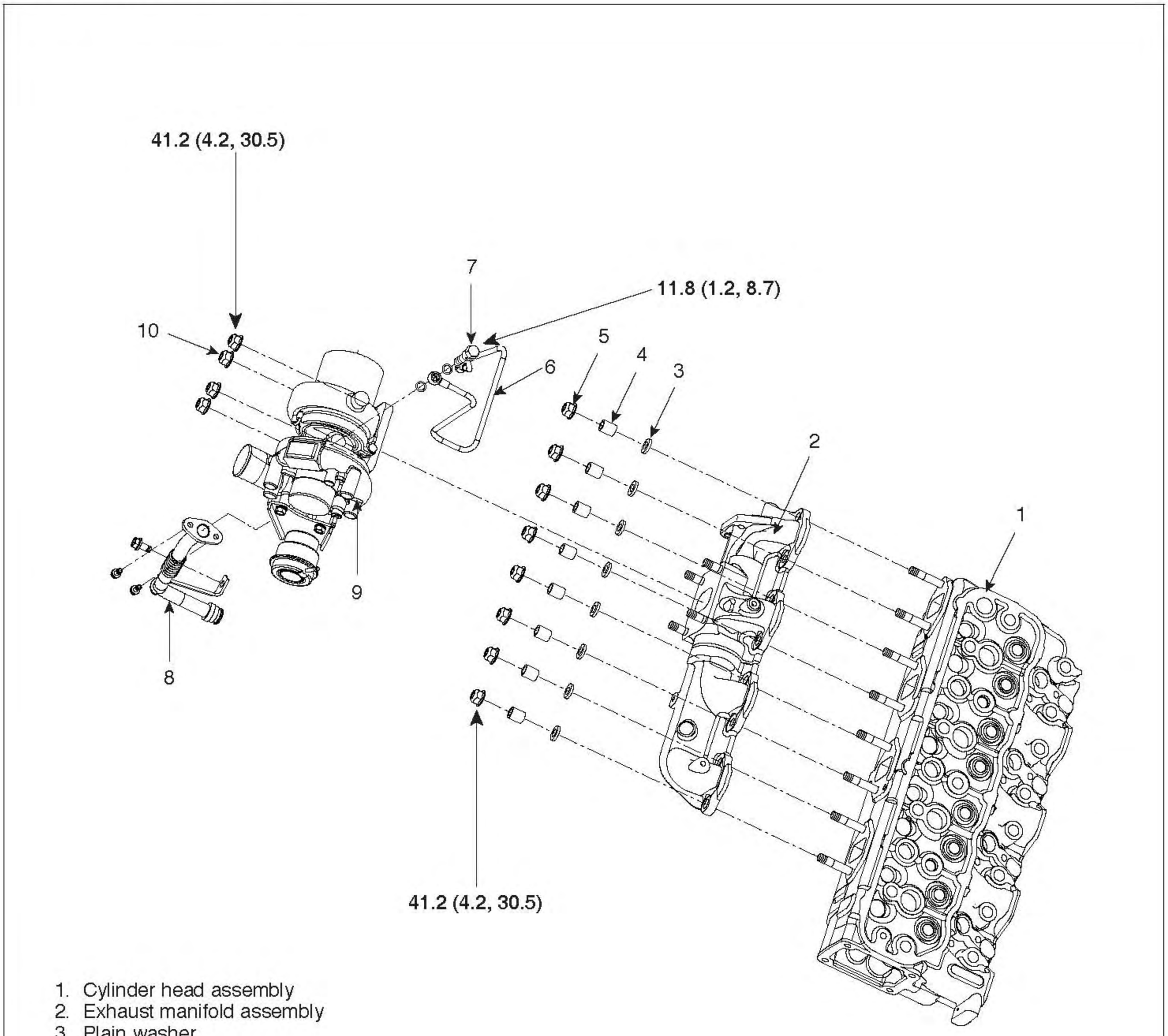
SUDEM7195L


Unusual noise and vibration
Intake system
Are fixing bolts and nuts of intake system fastened securely?
No
Tighten
Yes
Exhaust system
Are fixing bolts and nuts of exhaust system fastened securely
No
Repair or replace
Yes
Is exhaust pipe or muffler damaged?
Yes
Repair or replace
Turbocharger
Are bearing and rotating parts OK?
No
Inspect the following.
● Deterioration of engine oil
● Oil filter element clogging
● Foreign materials in oil supply pipe.
● Bearing damage due to repeated sudden departures and stops.
Yes
Do rotating parts rotate smoothly? Isn't turbine wheel shaft bent?
No
● Defective bearing
● Compressor wheel or turbine wheel damage due to the foreign materials inside.
Yes
Are there any foreign materials in turbocharger?
Yes
Check the intake and exhaust piper carefully for the chip of compressor or turbine wheel

SUDEM7196L

TURBOCHARGER

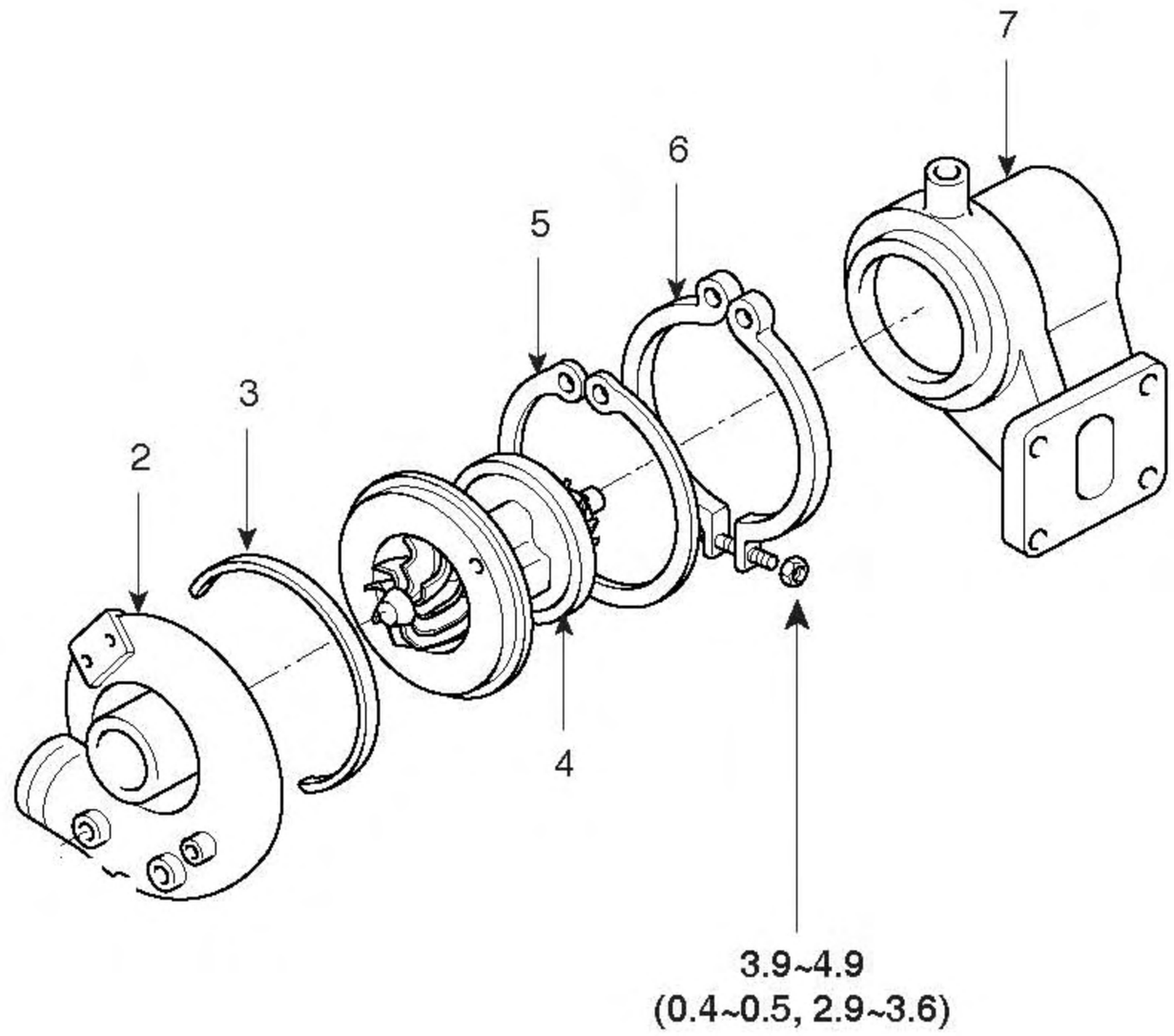
COMPONENTS E2B39DEE



1. Cylinder head assembly
2. Exhaust manifold assembly
3. Plain washer
4. Distance piece
5. Exhaust manifold self lock flange nut (M10x1.25)
6. Oil pipe
7. Turbocharger oil pipe eye bolt (M8x1.25)
8. Oil return pipe
9. Turbocharger assembly
10. Self lock flange nut

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

SUDEM7197L

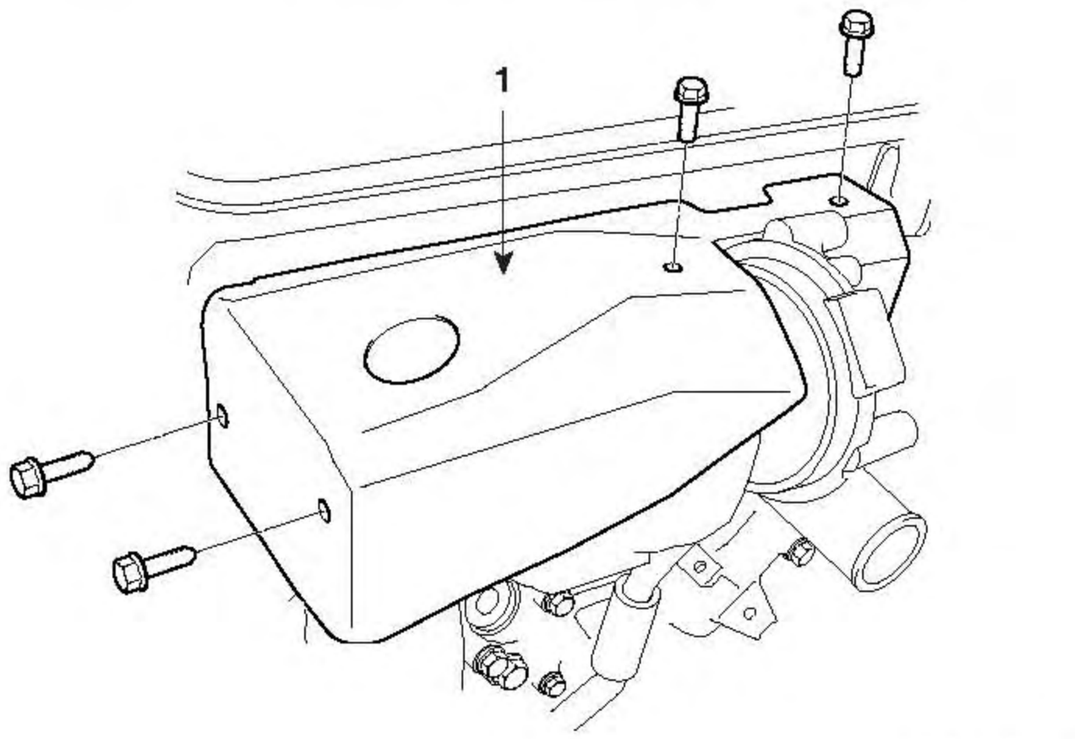


2. Compressor cover
3. O-ring
4. Cartridge assembly
5. Snap ring
6. Coupling
7. Turbine housing

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

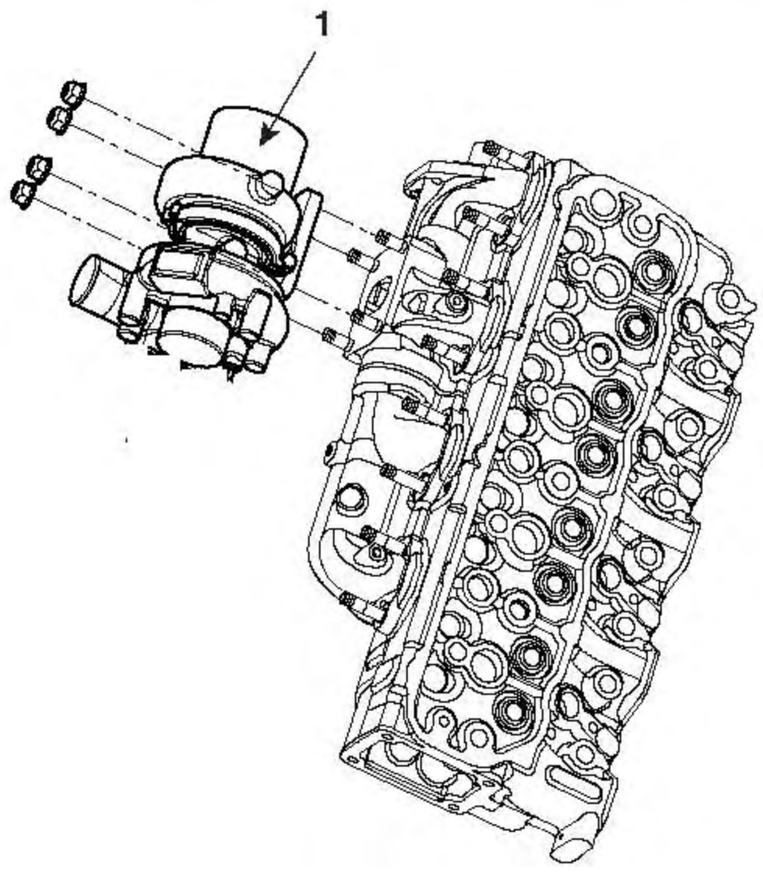
REMOVAL E90F3479

1. Remove the turbocharger heater protector cover (1).



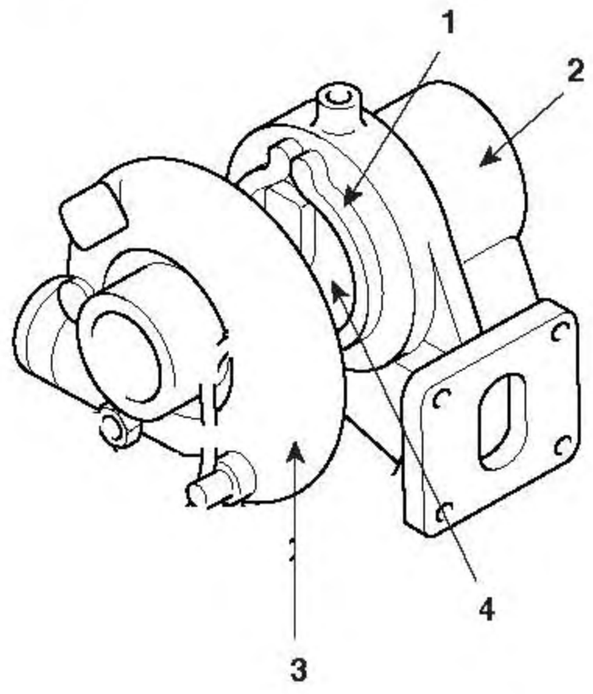
SUDEM7199L

2. Remove the turbocharger assembly (1).



SUDEM7200L

3. Make an aligning mark on the coupling (1), turbine housing (2), compressor cover (3), and cartridge assembly (4).



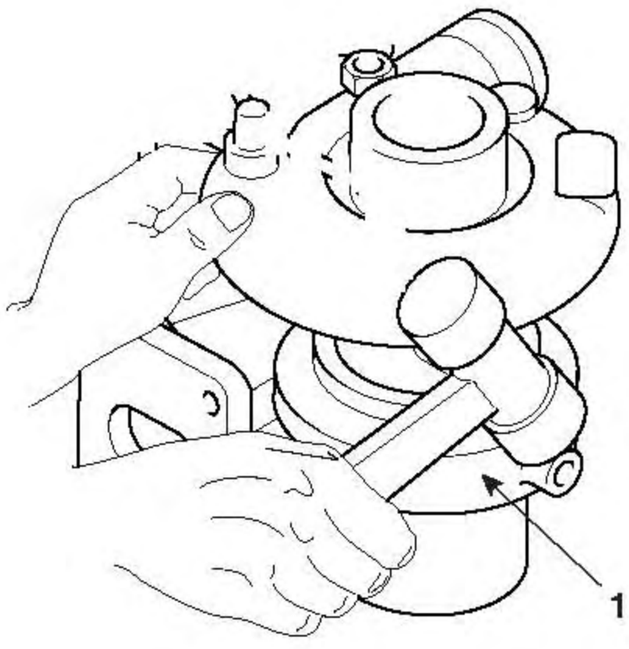
SUDEM7201L

4. Remove the turbine housing(1).

⚠ ***CAUTION***

a. Lightly tap the housing circumference with rubber hammer so that turbine housing is not damaged.

b. Since turbine wheel blade is easily bent, exercise care when removing the housing.



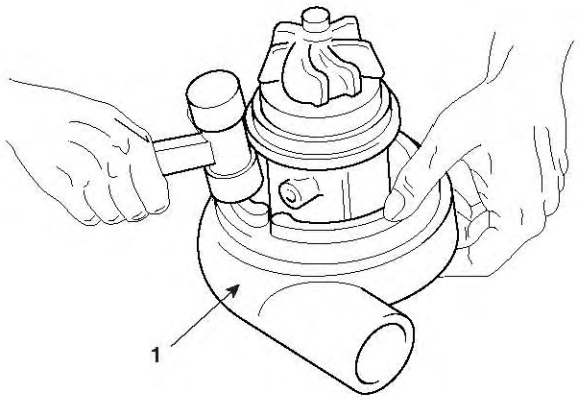
SUDEM7202L

5. Remove the compressor cover (1).

CAUTION

a. Lightly tap the compressor cover circumference with rubber hammer so that compressor cover is not damaged.

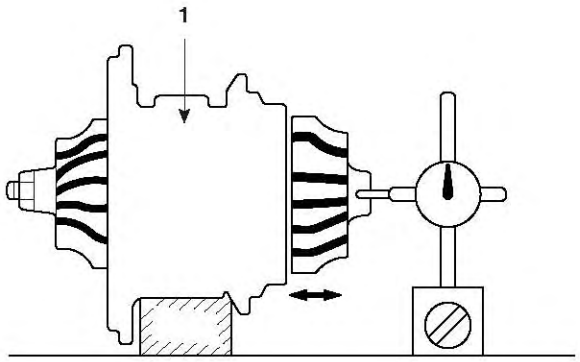
b. Since compressor wheel blade is easily bent, exercise care when removing the compressor cover.



SUDEM7203L

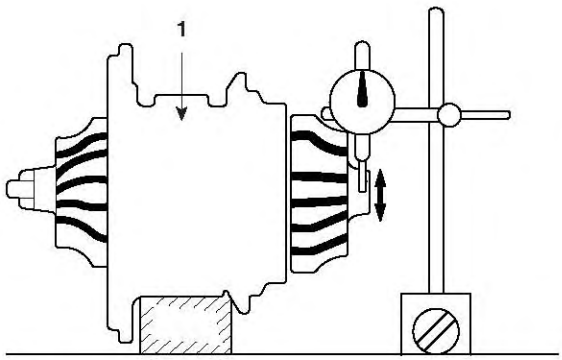
INSPECTION EFAE8284

1. Measure the shaft directional clearance of shaft and turbine wheel assembly. If the measurement exceeds the limit, replace the cartridge assembly (1).



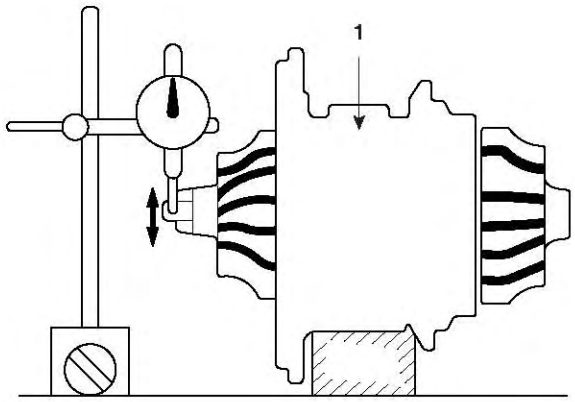
SUDEM7204L

2. Check the shaft directional clearance of shaft and turbine wheel assembly.
   a. Check the clearance of turbine wheel side. If the measurement exceeds the limit, replace the cartridge assembly (1).



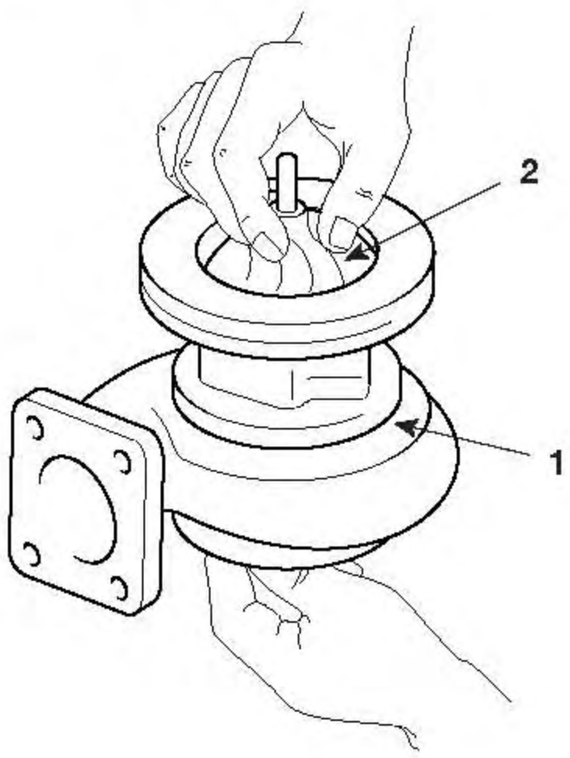
SUDEM7205L

   b. Inspect the clearance of compressor wheel side. If the measurement exceeds the limit, replace the cartridge assembly (1).



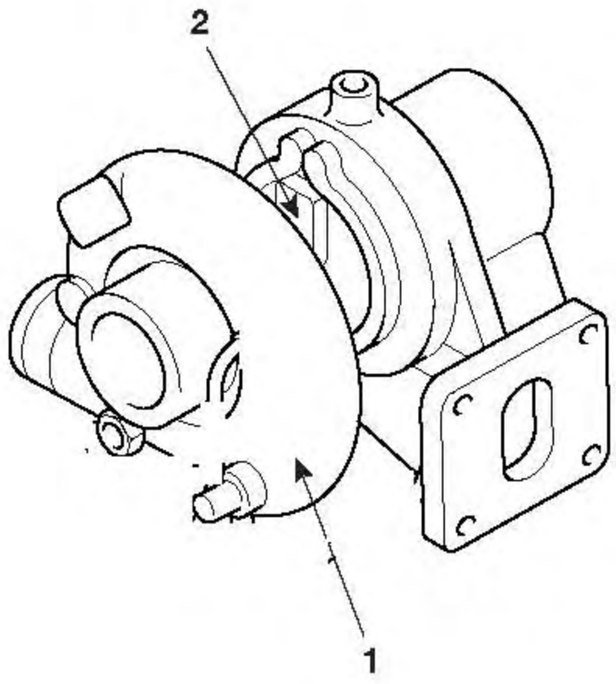
SUDEM7206L

3. After assembling the turbocharger assembly (1), turn each wheel (2) to see if it rotates smoothly.



SUDEM7207L

4. When assembling turbocharger assembly (1), fill with the engine oil through the oil hole (2) so that each part operates smoothly.



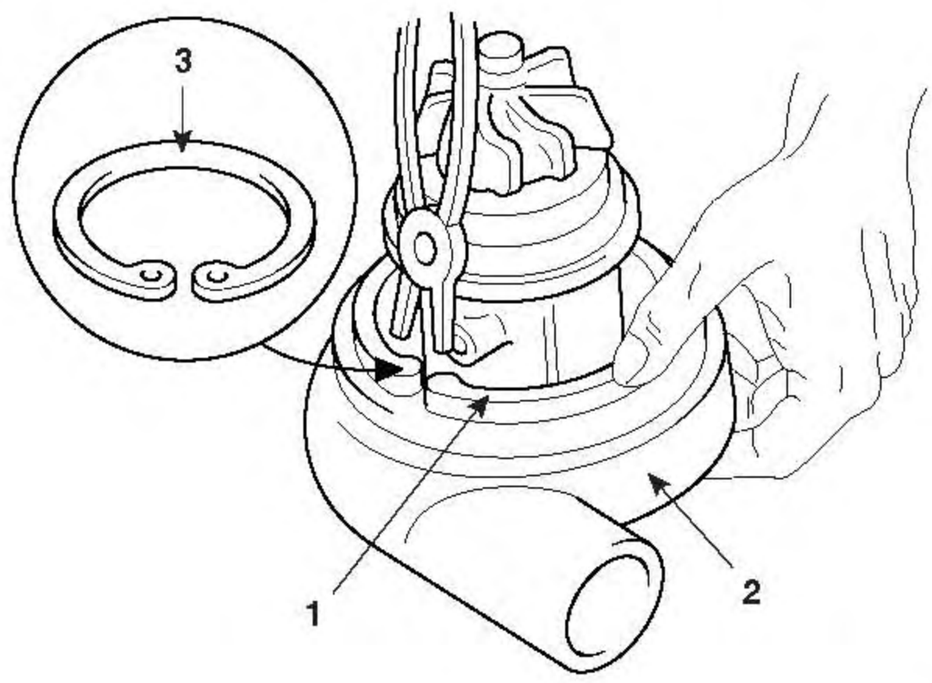
SUDEM7208L

INSTALLATION E50867FF

1. When assembling the snap ring (1) to compressor cover (2), assemble it so that the snap ring taper side (3) faces up.

⚠ *CAUTION*

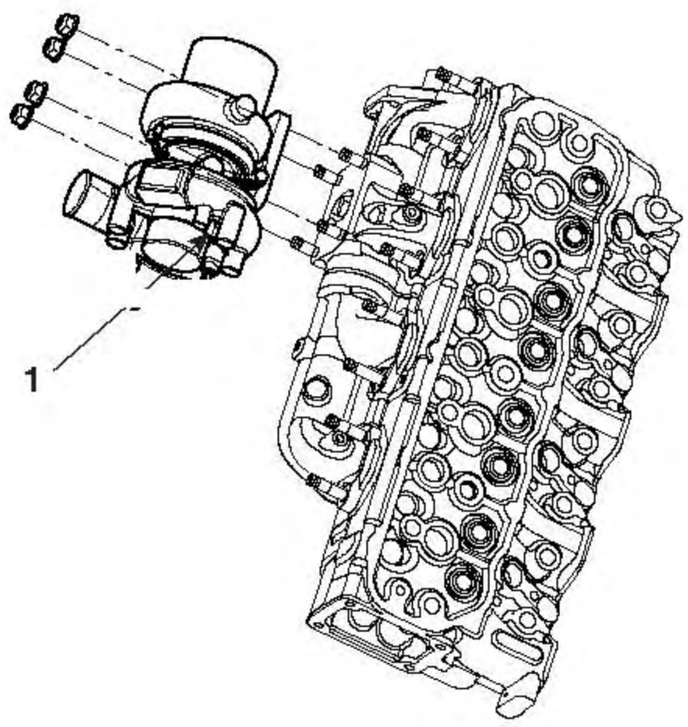
When installing the snap ring, install it to the compressor cover by holding the snap with one hand.



SUDEM7209L

2. Install the turbocharger assembly (1).

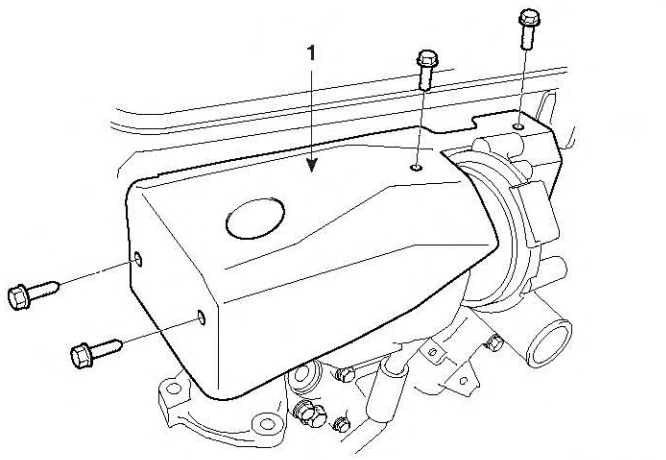
Tightening torque:	41.2 Nm (4.2kgf.m, 30.5 lb-ft)



SUDEM7210L

3. Install the turbocharger heater protector cover (1).

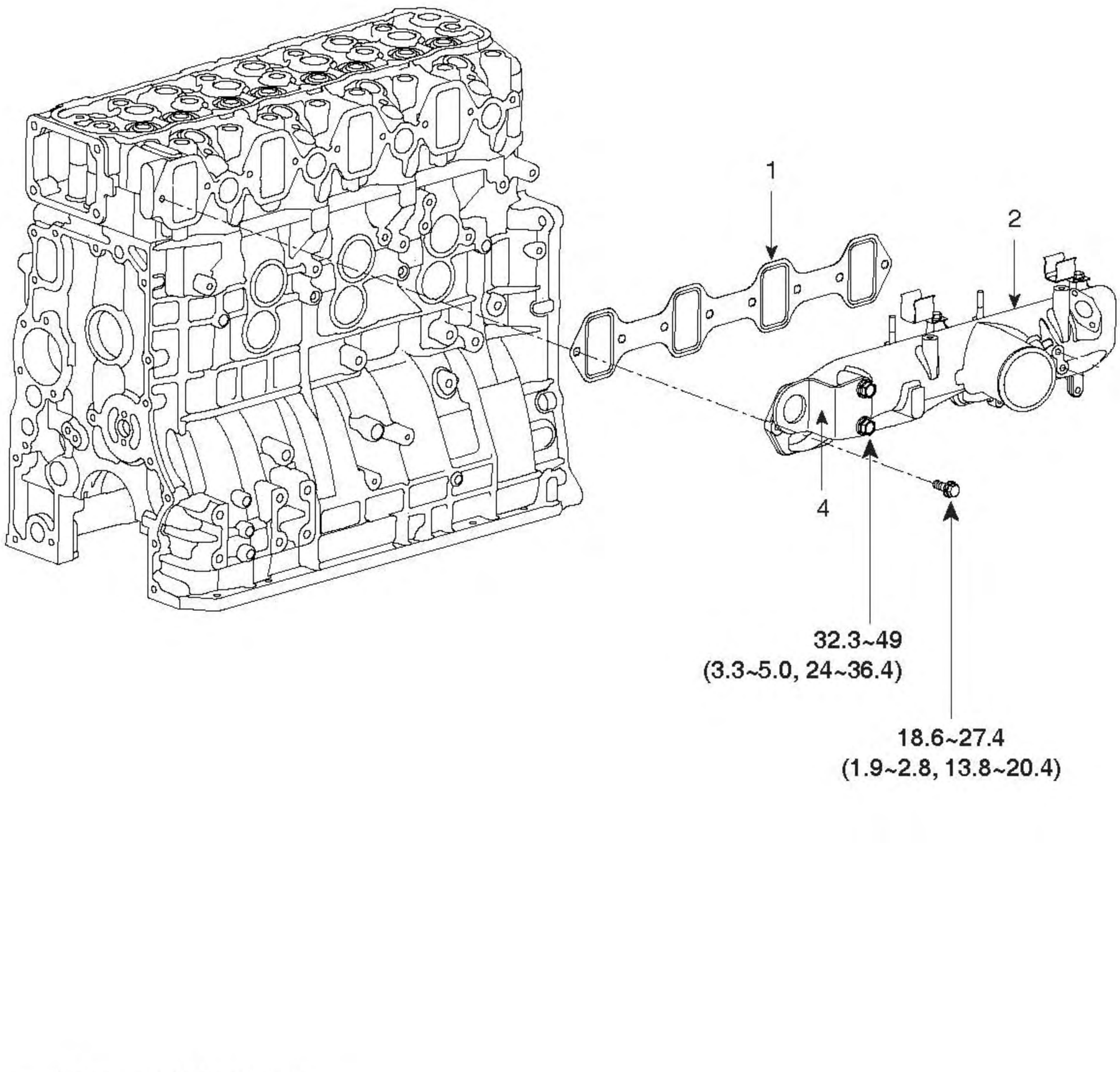
Tightening torque: 11.8 Nm
(1.2kgf.m, 8.7 lb-ft)



SUDEM7211L

INTAKE MANIFOLD

COMPONENTS EDBED9AC

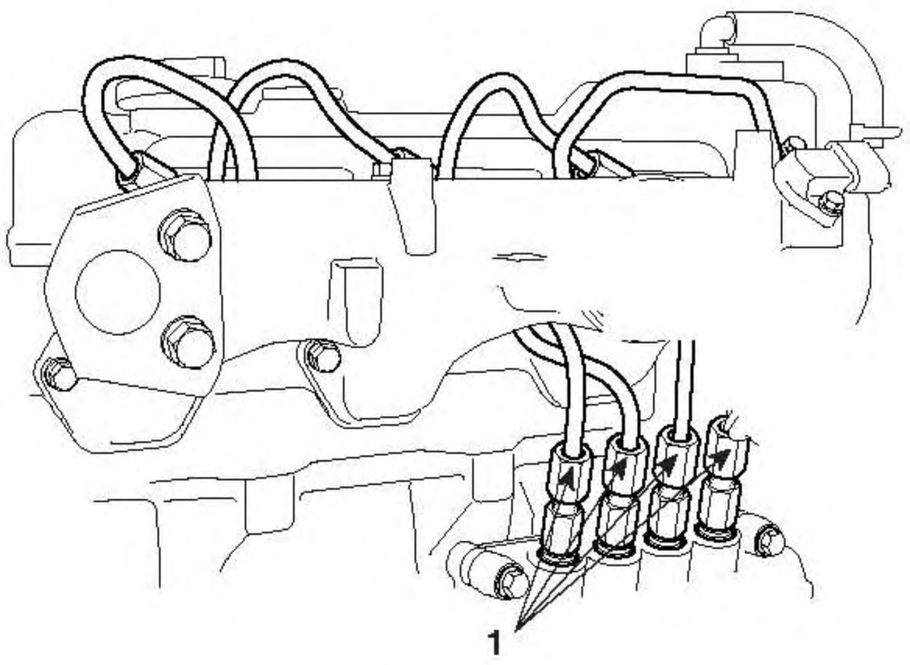


1. Intake manifold gasket
2. Intake manifold assembly
3. Actuator
4. Intake manifold front hanger

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

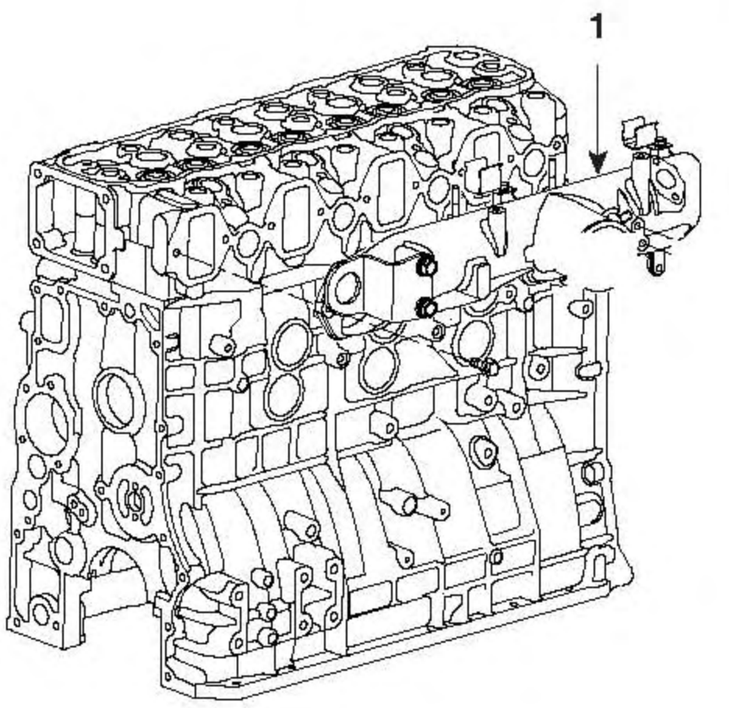
REMOVAL EEA818FD

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



SUDEM7213L

2. Remove the Intake manifold assembly (1).

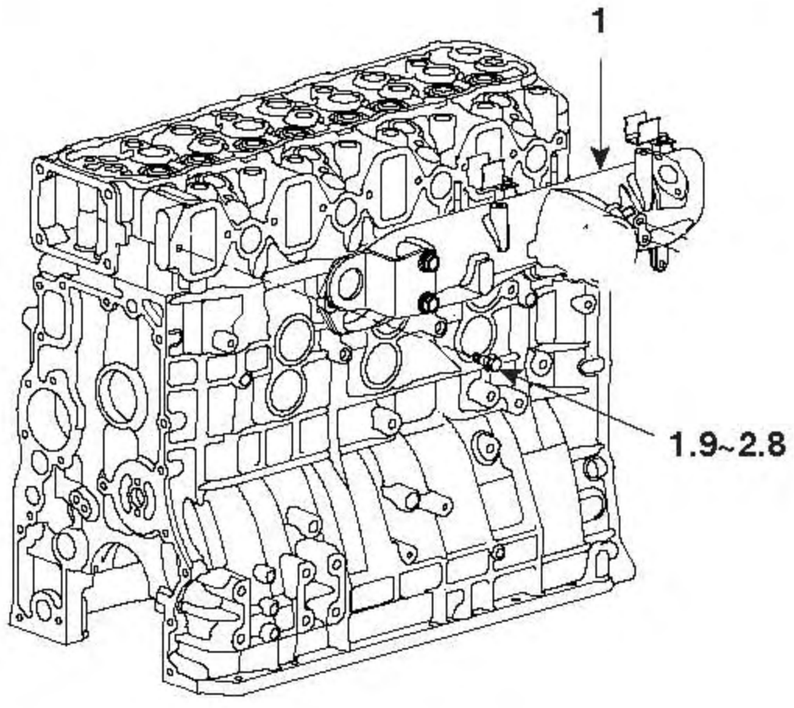


SUDEM7214L

INSTALLATION EE8BA5EE

1. Install the intake manifold (1).

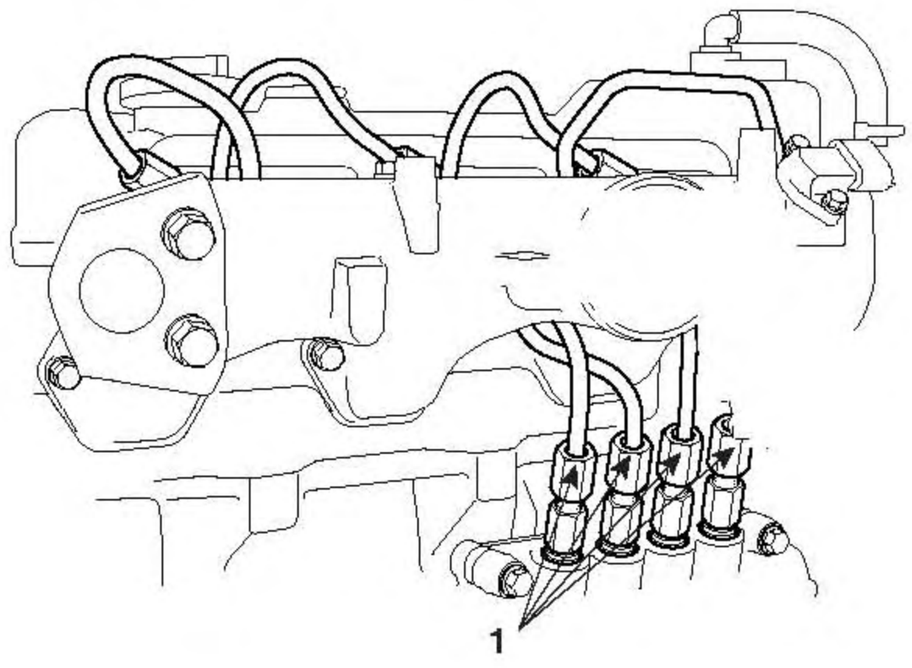
Tightening torque: 18.6~27.4 Nm
(1.9~2.8kgf.m, 13.8~20.4 lb-ft)



SUDEM7216L

2. Install the injection pipe (1) No.1, 2,3 and 4.

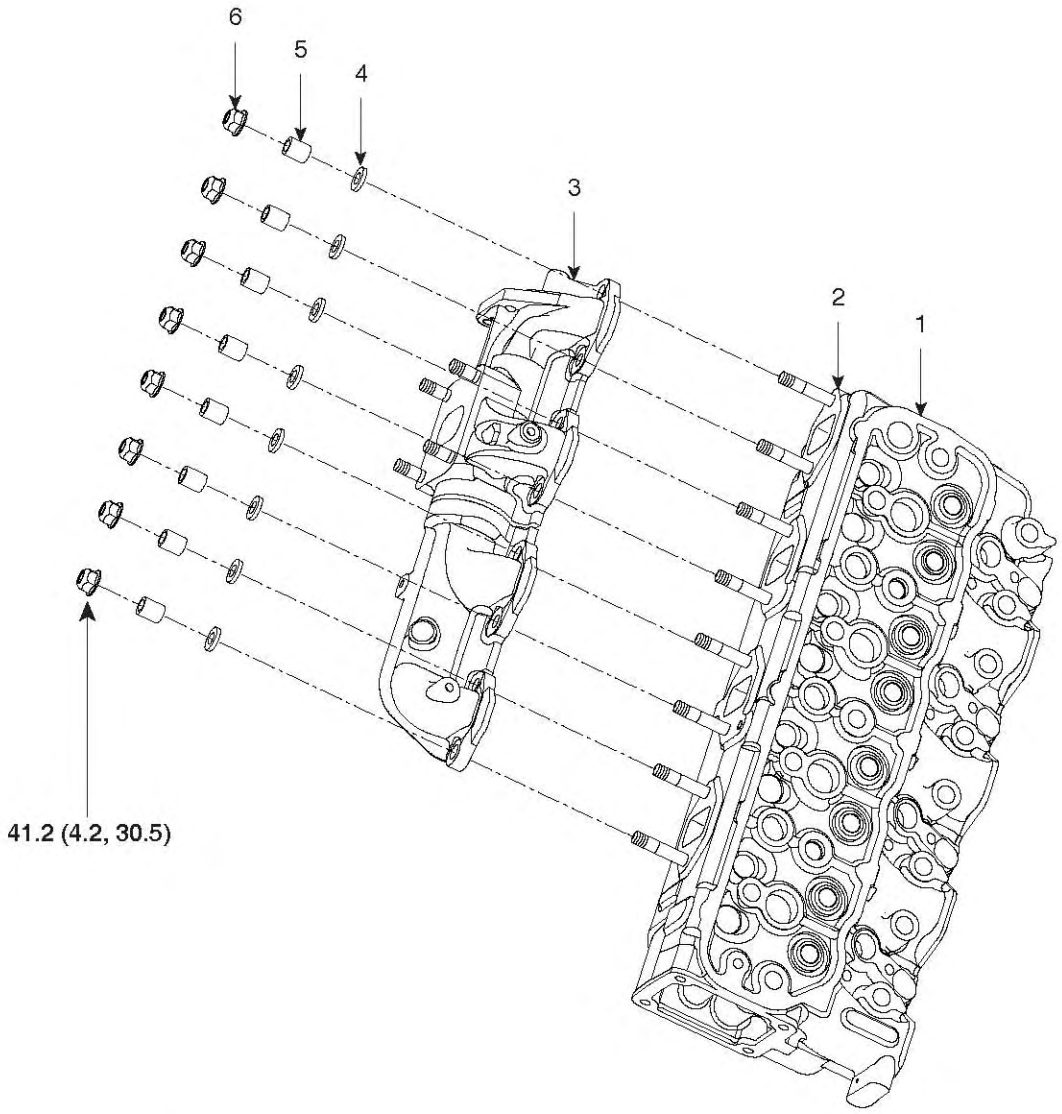
Tightening torque: 39.2~49 Nm
(4.0~5.0kgf.m, 29.1~36.4 lb-ft)



SUDEM7218L

EXHAUST MANIFOLD

COMPONENTS E6A9EE49



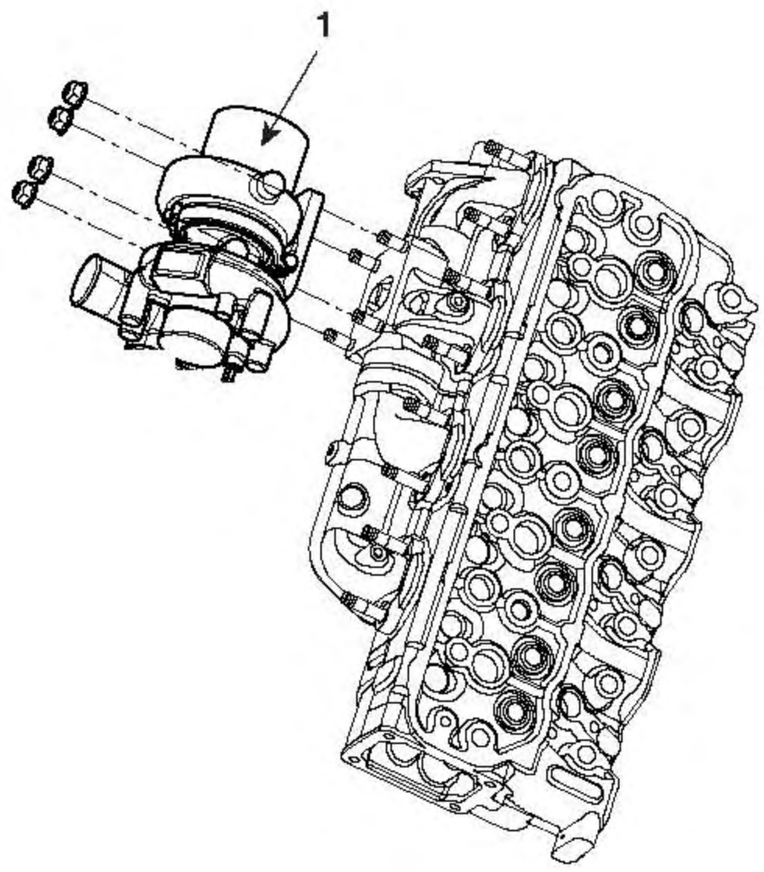
1. Cylinder head assembly
2. Exhaust manifold gasket
3. Exhaust manifold assembly
4. Plain washer
5. Distance piece
6. Exhaust manifold self lock flange nut (M10x1.25)

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

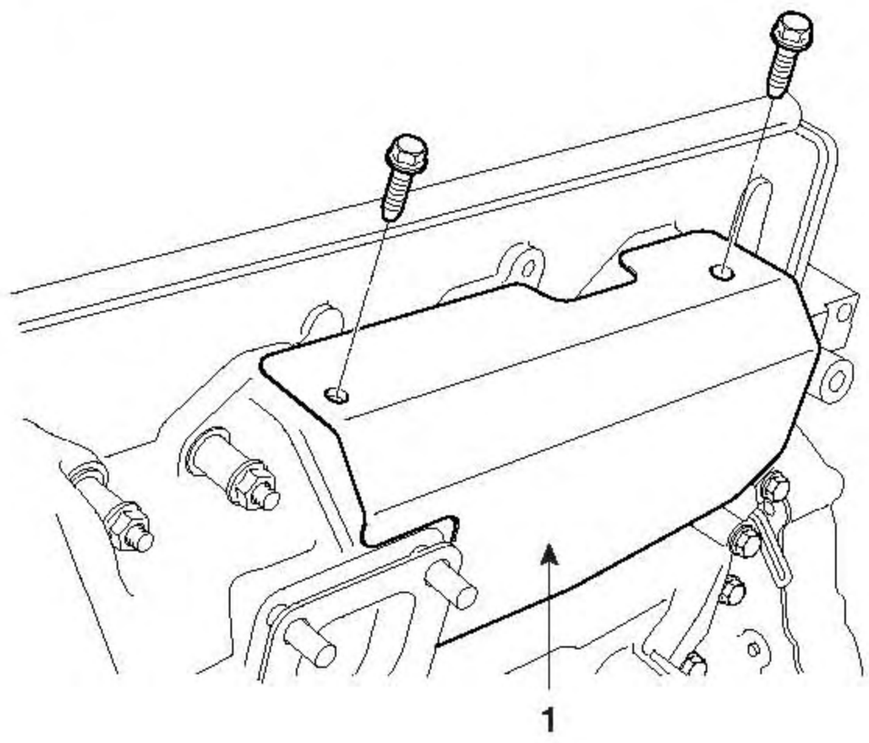
SUDEM7219L

REMOVAL E670C1A1

1. Remove the turbocharger assembly.

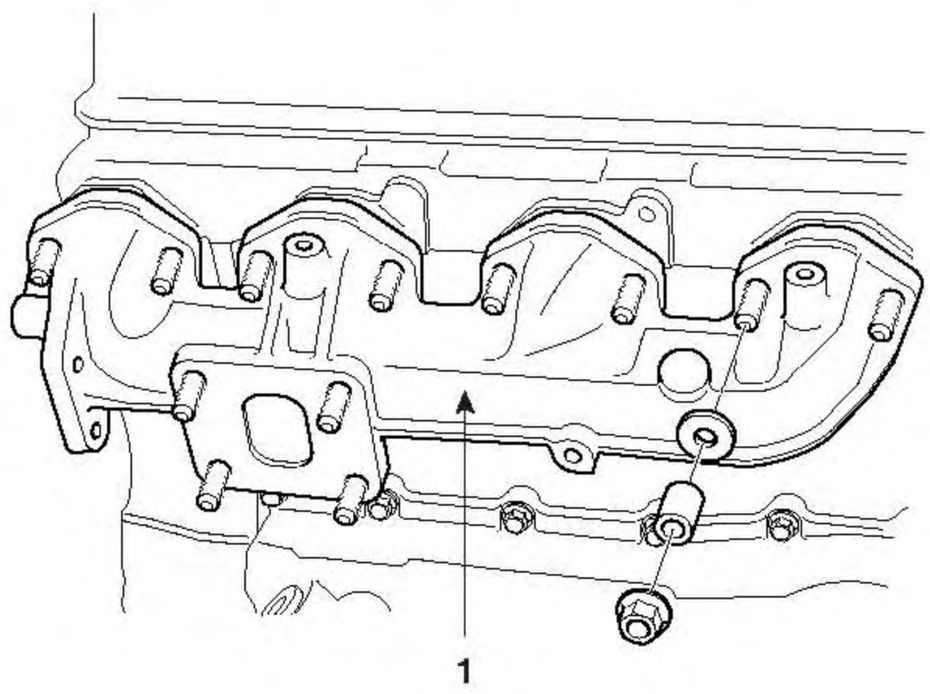


2. Remove the exhaust manifold heater protector cover (1).



SUDEM7222L

3. Remove the exhaust manifold assembly (1).

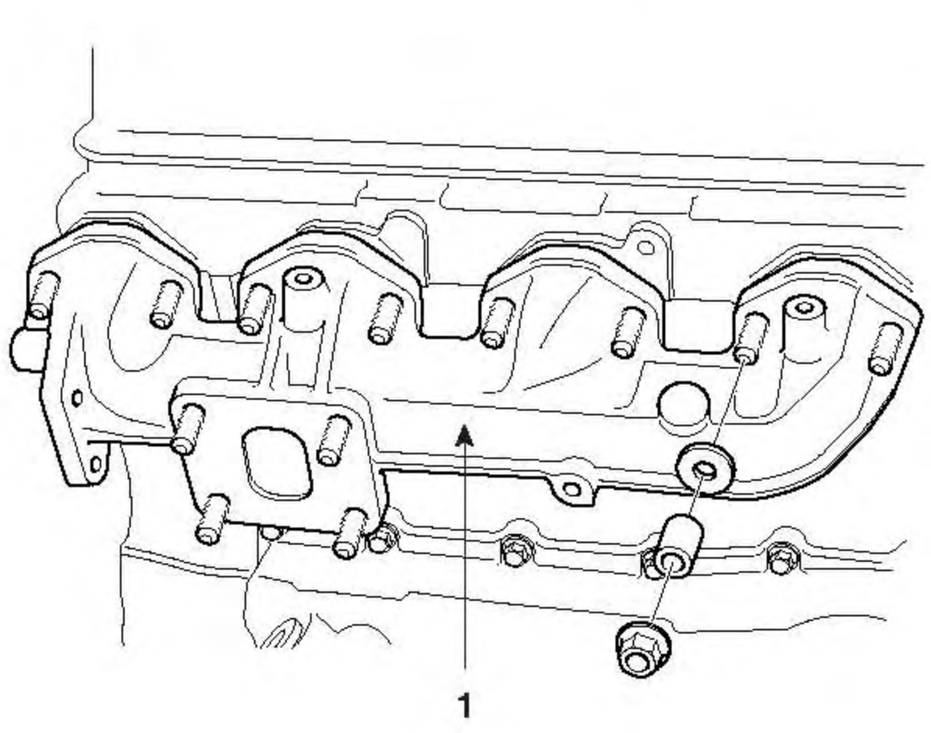


SUDEM7223L

INSTALLATION EFDF4E9E

1. Install the exhaust manifold assembly (1).

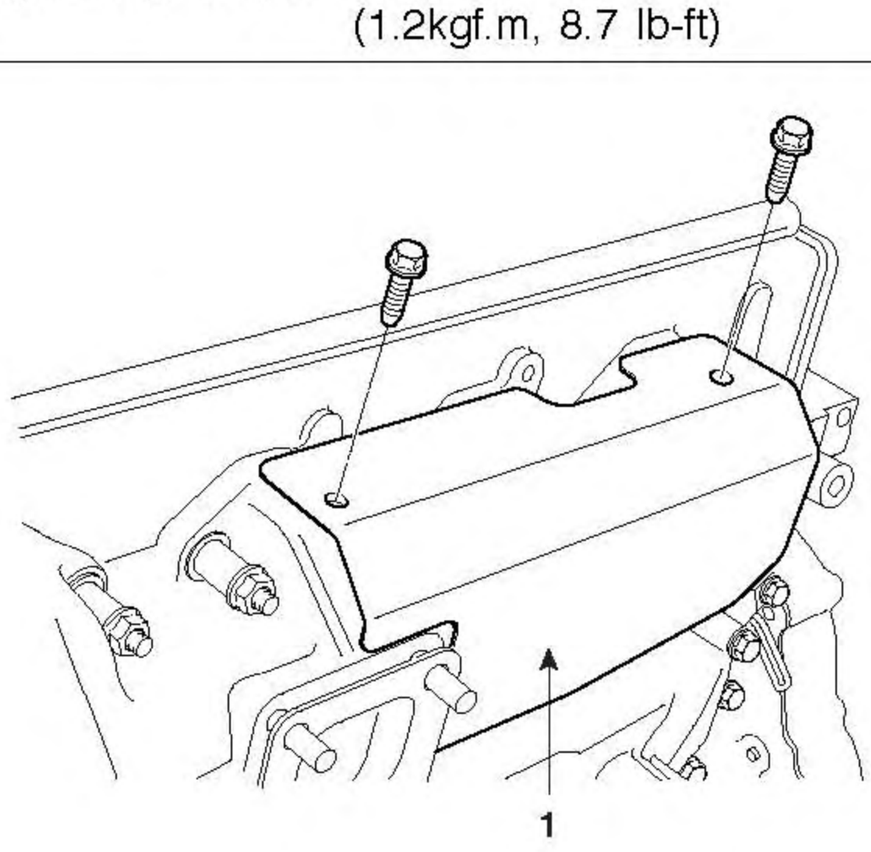
Tightening torque: 41.2Nm
(4.2kgf.m, 30.5 lb-ft)



SUDEM7223L

2. Install the exhaust manifold heater protector cover (1).

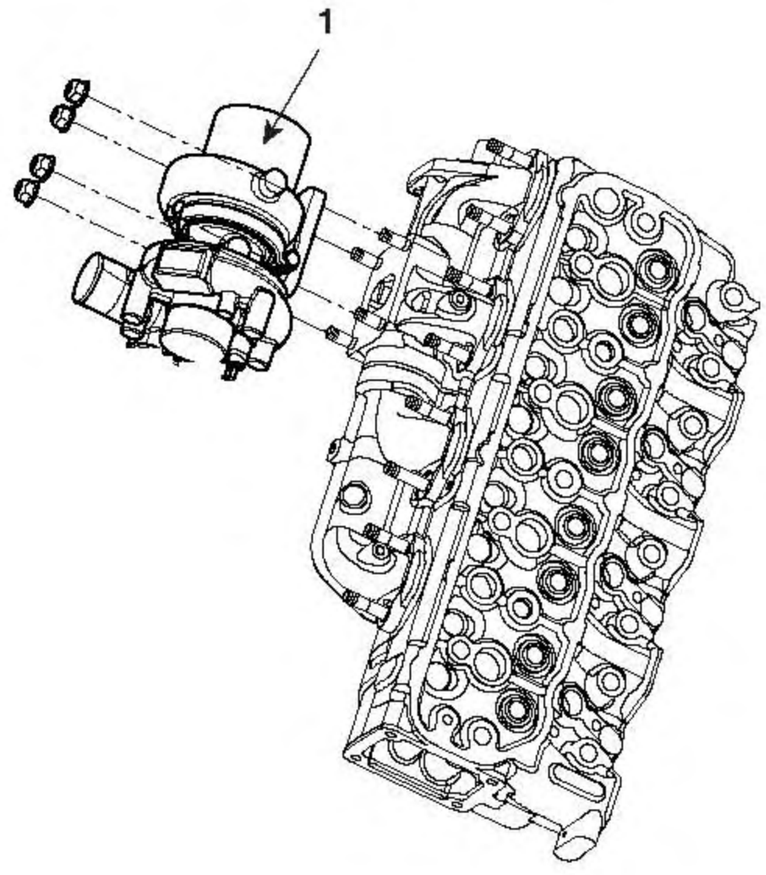
Tightening torque: 11.8Nm
(1.2kgf.m, 8.7 lb-ft)



SUDEM7222L

3. Install the turbocharger assembly.

Tightening torque: 41.2Nm
(4.2kgf.m, 30.5 lb-ft)



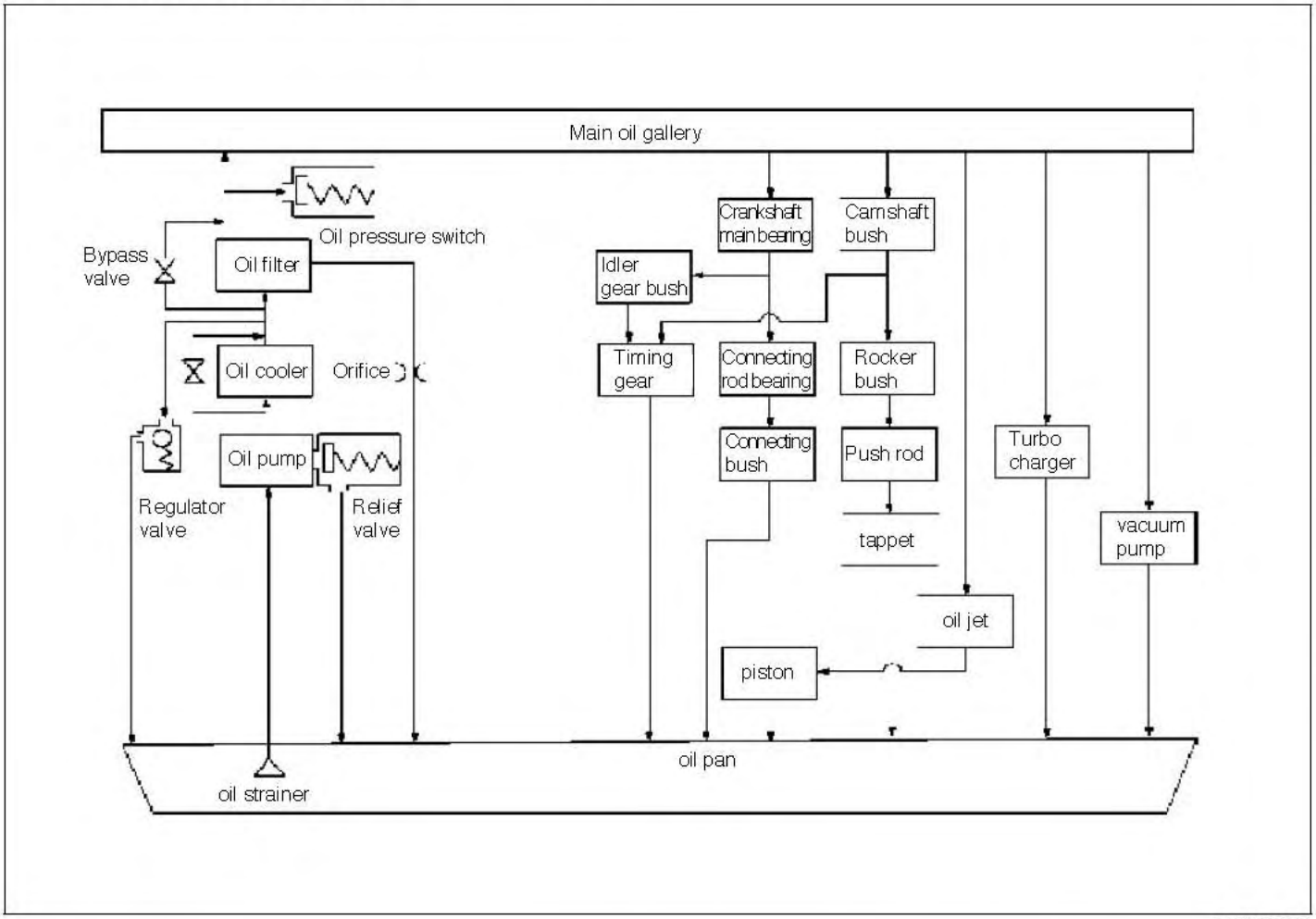
SUDEM7221L

LUBRICATION SYSTEM

DESCRIPTION E3DF9F3D

FLOW CHART OF LUBRICATION SYSTEM

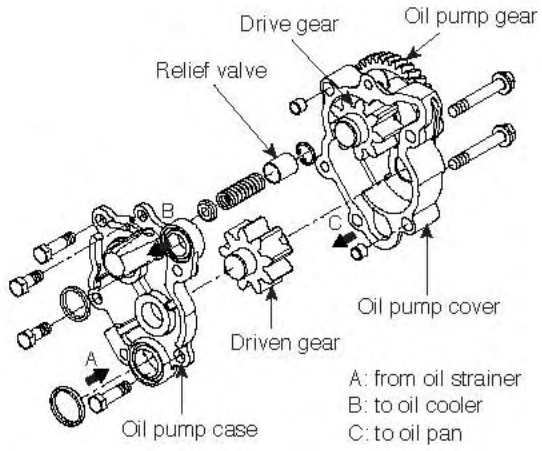
Engine is lubricated by a gear-type oil pump that forces engine oil through the oil cooler and oil filter into the engine for lubrication of various engine parts.



SUDEM7228L

OIL PUMP

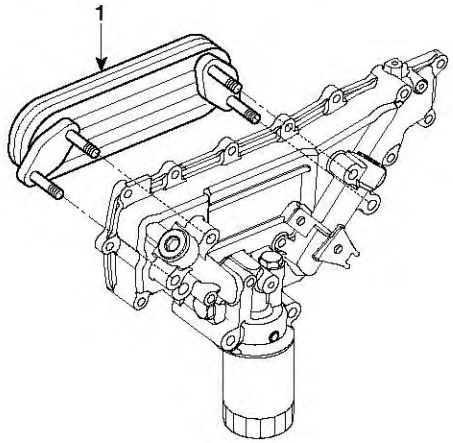
The oil pump, of a gear type, is driven by the crankshaft rotation engaged with oil pump gear. And the relief valve is installed to the oil pump so that it prevents the excessive pressure by bypassing the engine oil to oil pan when the oil pressure exceeds the specification.



SUDEM7229L

OIL COOLER

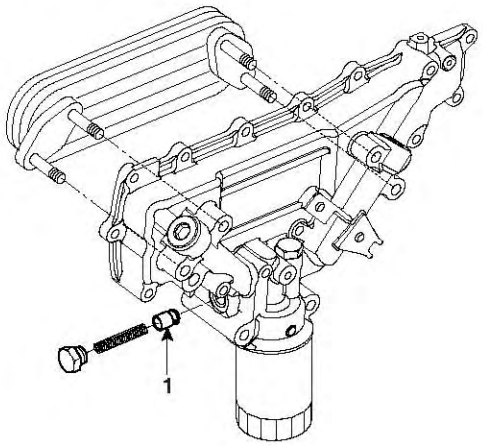
Oil cooler is equipment for heat exchange between the coolant and oil fed from the crankcase water jacket and oil pump, respectively. The oil cooler has a bypass valve that opens when the element (1) becomes clogged.



SUDEM7230L

BYPASS VALVE

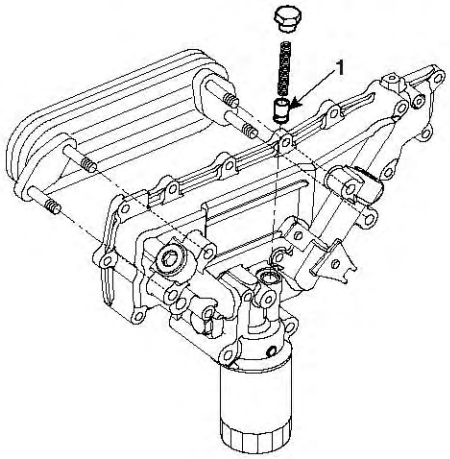
When the oil viscosity is high (in cold) or oil path shows high resistance depending on the element load, the bypass valve (1) opens and oil goes directly to oil filter without passing oil cooler.



SUDEM7231L

REGULATOR VALVE

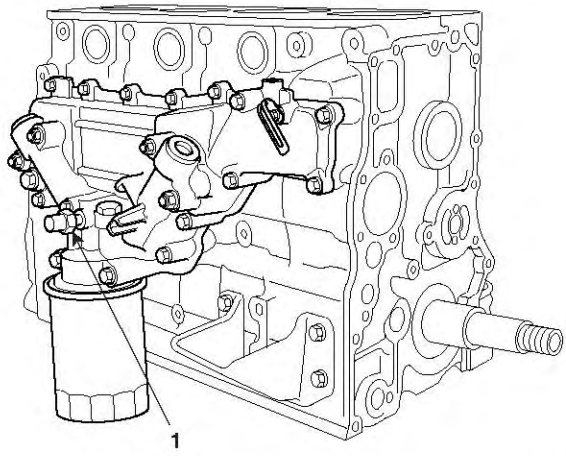
When oil pressure in main oil gallery exceeds the specification, regulator valve (1) opens and some engine oil drains to the oil pan to adjust the oil pressure.



SUDEM7232L

OIL PRESSURE SWITCH

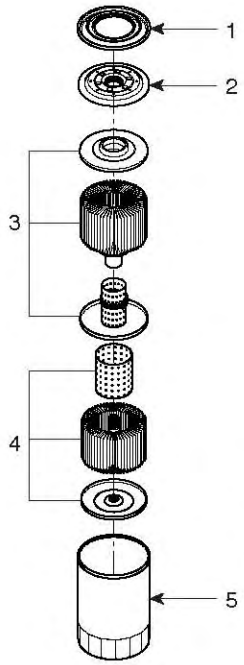
If the pressure of engine oil which is sent to the main oil gallery is below the specification, the built-in relay in the oil pressure switch (1) is closed, then the warning lamp in the instrument panel is on to inform the driver of abnormal pressure.



SUDEM7233L

OIL FILTER

Oil filter uses a spin-on type paper element, in which full flow filter and bypass filter are integrated. Bypass valve is assembled to the bottom of the filter. If the element is loaded, valve opens so that engine oil goes to oil main gallery without passing through the element to prevent engine overload.



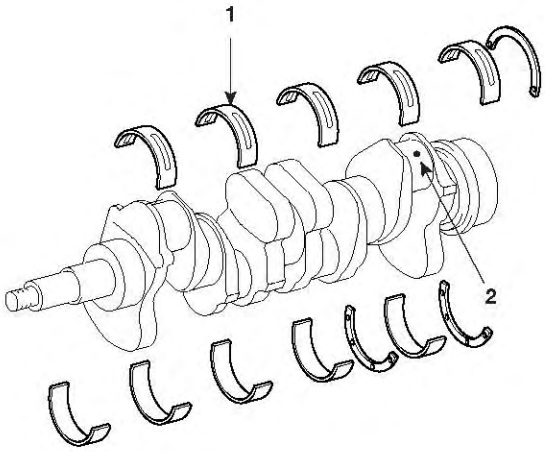
1. Out packing
2. Seaming cap
3. Bypass element assembly
4. Full-flow element assembly
5. Housing

SUDEM7234L

LUBRICATION OF PARTS

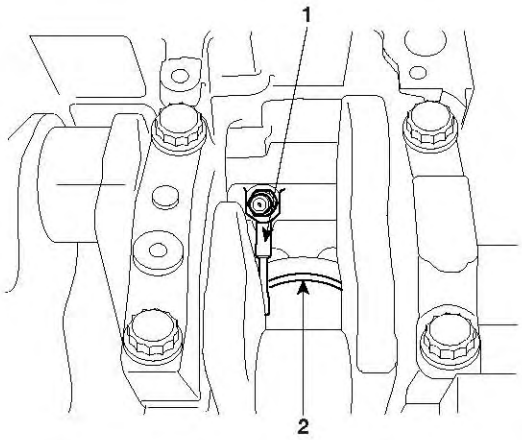
The engine oil routed from the oil filter to oil main gallery lubricates all engine parts as detailed below before returning to the oil pan.

1. Main bearing and connecting rod bearing
   a. There is an oil passage (1) provided from the oil main gallery to each main bearing. The oil flows through the oil hole (2) to lubricate the main bearing and passes through the oil passage drilled into the crankshaft to lubricate the connecting rod bearings.



SUDEM7235L

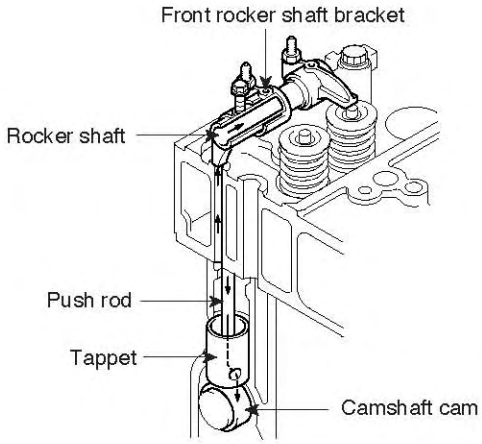
   b. The Oil jet (1), installed at each cylinder oil main passage, injects engine oil into the piston (2) to cool the piston. This oil jet has a check valve which is opened/closed by the specified oil pressure, it prevents oil flow and oil pressure from decreasing at low pressure.



SUDEM7236L

2. Camshaft
   Camshaft bushings are lubricated by the oil flowing through the oil passages leading from the oil main gallery to each bushing.

3. Valve mechanism
   The engine oil that has lubricated No. 1 camshaft bushing passes through the oil hole and pipe provided at the top portion of crankcase to the cylinder head. The engine oil then goes through the front rocker shaft bracket into the rocker shaft, lubricating each rocker bushing. At the same time, it lubricates valve cap and valve stem of the rocker. The oil then passes through the push rod holes in the cylinder head and crankcase to lubricate the tappets and camshaft cams before returning to the oil pan.



SUDEM7237L

SPECIFICATION EADD3E2D

OIL COOLER

Item	Specification
Bypass valve open	3.5~4.5kg/cm²(361~419kpa)
Regulator oil pump valve open	5~7kg/cm²(490~686kpa)

OIL PUMP

Item		Specification
Head gear	Module	2.0
	Pressure angle	20°
	N0. of gear teeth	36
	distortion angle	19.5°
	Backlash (mm)	0.049~0.151
Pump rotation (rpm)		550~3100
Oil Temperature (°C)		-25~130
Oil in use		SAE 10W~30W
Injection pressure MPa (kgf/cm²)		0.4(4)
Injection amount (ℓ /min)		25
Relief valve operating pressure MPa (kgf/cm²)		1.1±0.1 (11±1)

OIL FILTER

Item	Specification
Filtration capacity	Full-flow : above 1700cm³ By-pass : above 2400cm³
Pressure loss	Below 0.5kgf/cm²
Bypass opening pressure MPa (kgf/cm²)	98±20 (1.0±0.2)
Bypass pressure loss MPa (kgf/cm²)	157±20 (1.6±0.2)

LUBRICANT

Item	Types	Oil grade	Oil viscosity (temperature applied)	Oil capacity
Engine oil	API classification grade CF—4 or more SAE 10W-30	Grade CF-4 or more	1) 0~40°C : SAE 30 2) above -10°C: SAE 20W-40 3) above -15°C: SAE 15W-40 4) -20~40°C : SAE 10W-30 5) below 10°C: SAE 15W-30	Oil pan : 8ℓ Total capacity : 9ℓ

SERVICE STANDARD

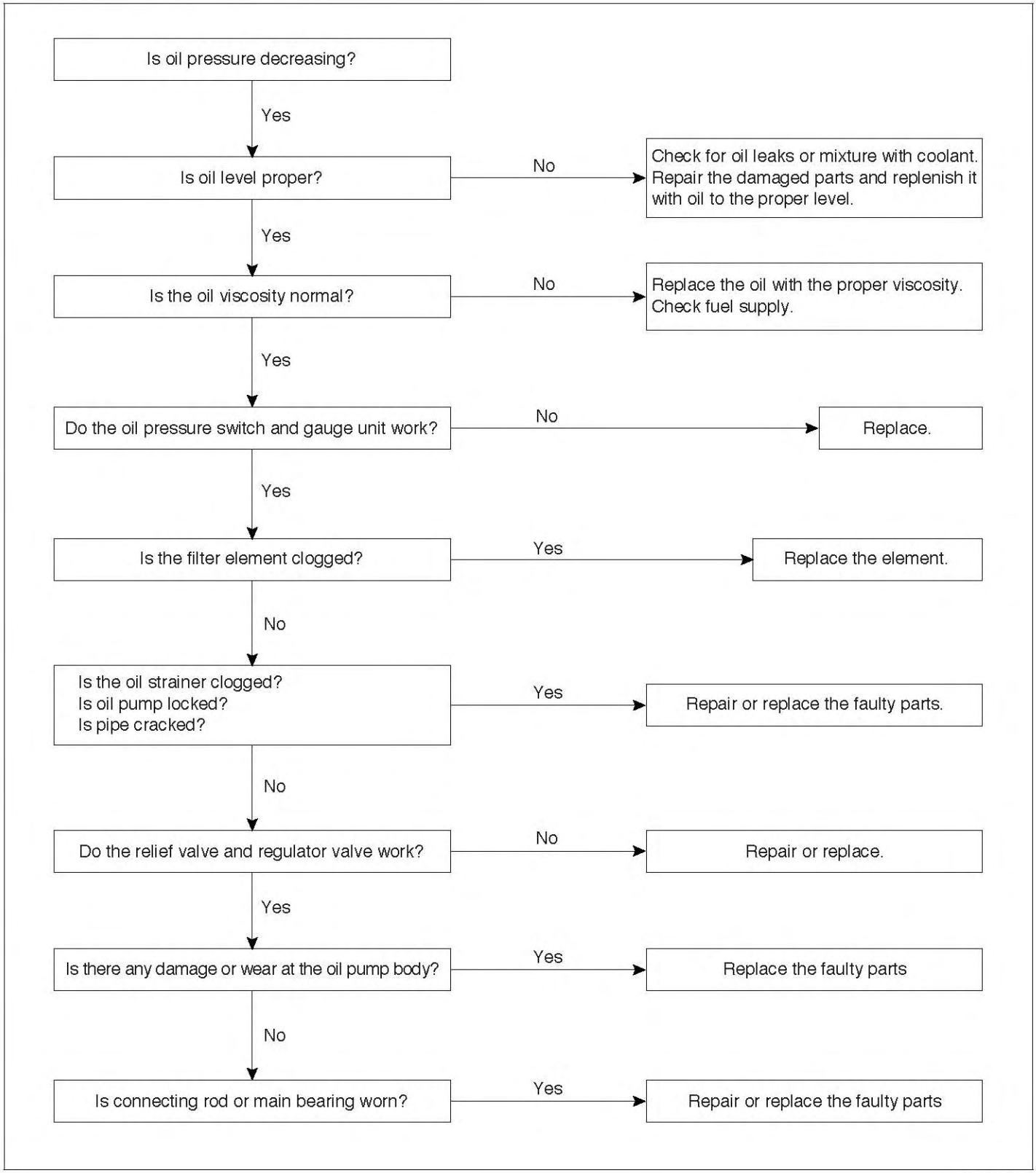
Item		Nominal value ([ ] indicates base diameter)	Limit	Corrective action and remarks
Oil pressure (oil temperature 70~90℃)	At idle	1~5kg/cm²	0.5kg/cm²	Adjust
	At max speed	3~5kg/cm²	2kg/cm²	Adjust
Oil pump	Oil pump case and gear teeth end clearance	0.10~0.19	0.2	Replace
	Difference between oil pump case depth and gear height (sinkage)	0.01~0.07	0.18	Replace
	Driven gear to driven shaft clearance	[20]0.04~0.07	0.15	Replace
	Drive gear end play	0.03		
	Relief valve opening pressure	10~12kg/cm²		Replace
Oil cooler	Bypass valve pressure	3.5~4.5kg/cm²		Replace
	Opening pressure of regulator valve	5.0~7.0kg/cm²		Replace

Unit : mm

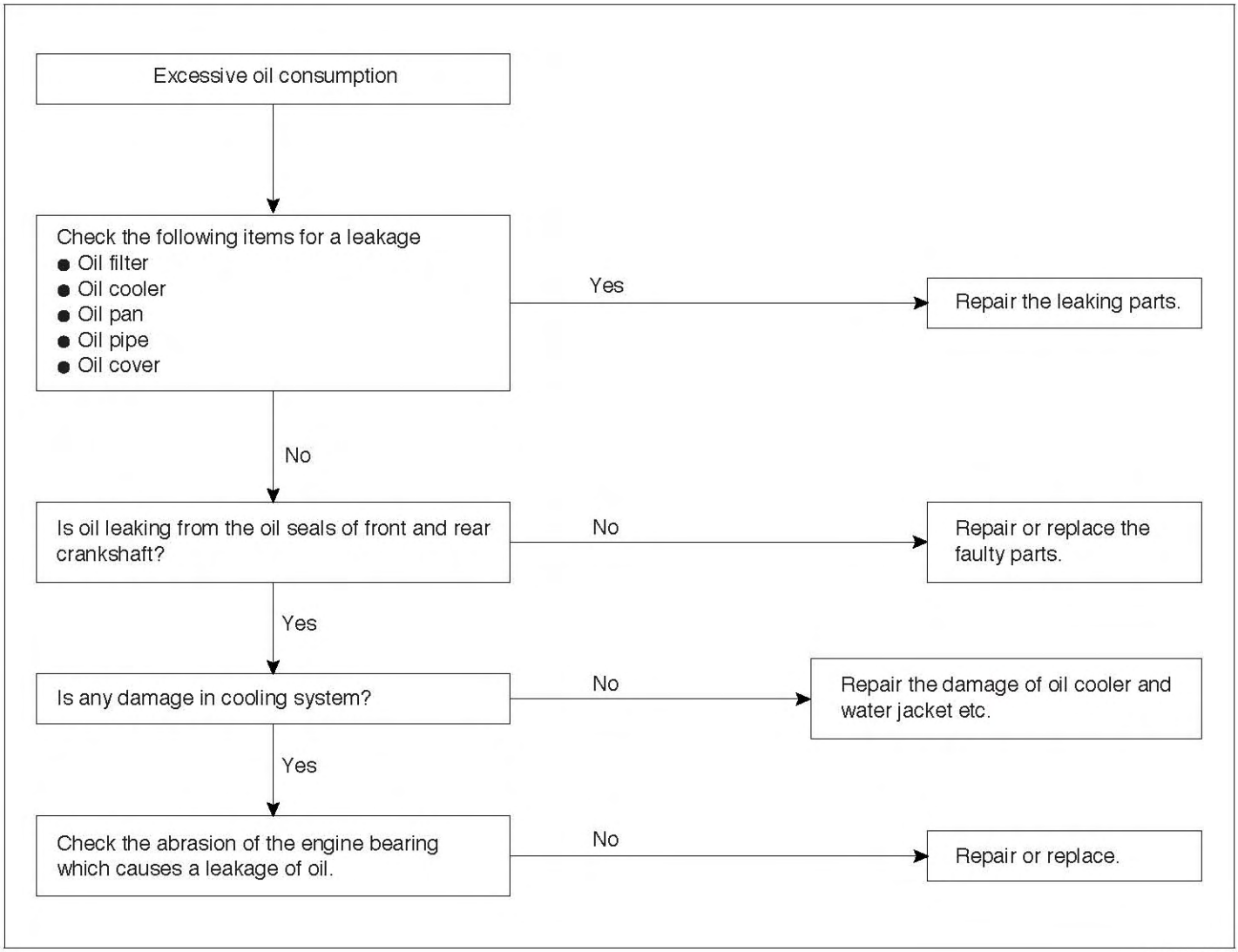
TIGHTENING TORQUE

Item (Diameter × length)	Size OD × pitch (mm)	Nm	kgf.m	lb-ft
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 bypass	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	34.3~44.1	3.5~4.5	25.4~32.7
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 eye bolt	-	18.6~22.5	1.9~2.3	13.8~16.7
Idler gear oil supply pipe	-	58.8~83.3	6.0~8.5	43.6~61.8
Turbo oil pipe eye bolt	-	18.6~22.5	1.9~2.3	13.8~16.7
Turbo oil pipe flange bolt (8 ×16)	-	18.6~27.4	1.9~2.8	13.8~20.4
Oil pump mounting flange bolt (8 ×55)	-	18.6~27.4	1.9~2.8	13.8~20.4

TROUBLESHOOTING EBA1856F



SUDEM7238L


Excessive oil consumption
Check the following items for a leakage
● Oil filter
● Oil cooler
● Oil pan
● Oil pipe
● Oil cover
Yes
Repair the leaking parts.
No
Is oil leaking from the oil seals of front and rear crankshaft?
No
Repair or replace the faulty parts.
Yes
Is any damage in cooling system?
No
Repair the damage of oil cooler and water jacket etc.
Yes
Check the abrasion of the engine bearing which causes a leakage of oil.
No
Repair or replace.

SUDEM7239L

ADJUSTMENT ECFE874F

ENGINE OIL INSPECTION

1. Park the vehicle on the flat surface.
2. Stop the engine.

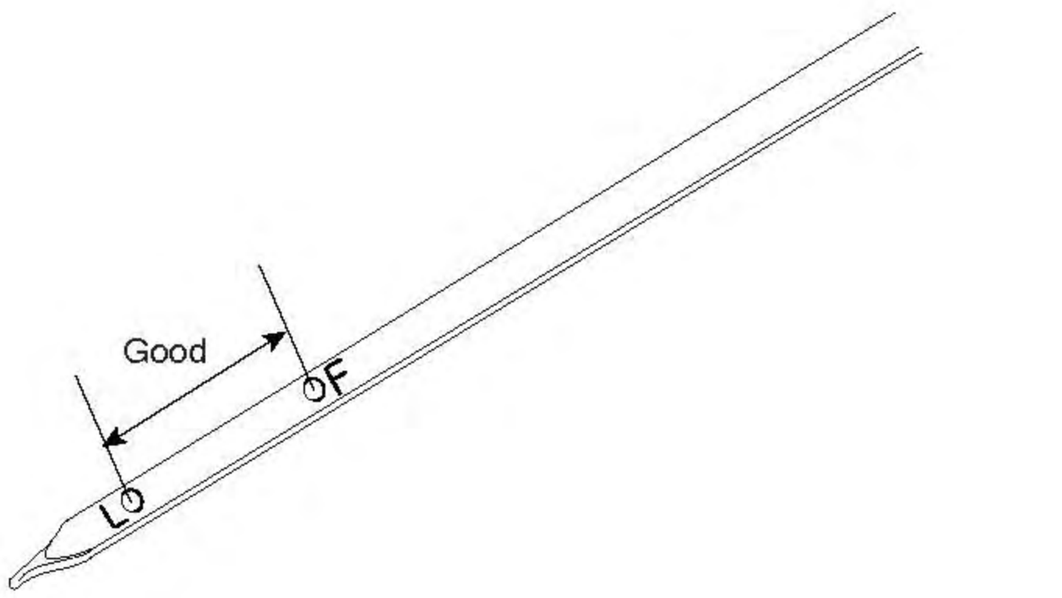
NOTE

a. Warm up the engine for minutes if the vehicle has not been inspected.
b. Stop the engine and wait for 5 minutes at least to measure the oil level.

3. If the oil level is below L mark of the gauge, refill the oil up to mark F.

NOTE

When refilling, oil should be same kind with the one in the pan.

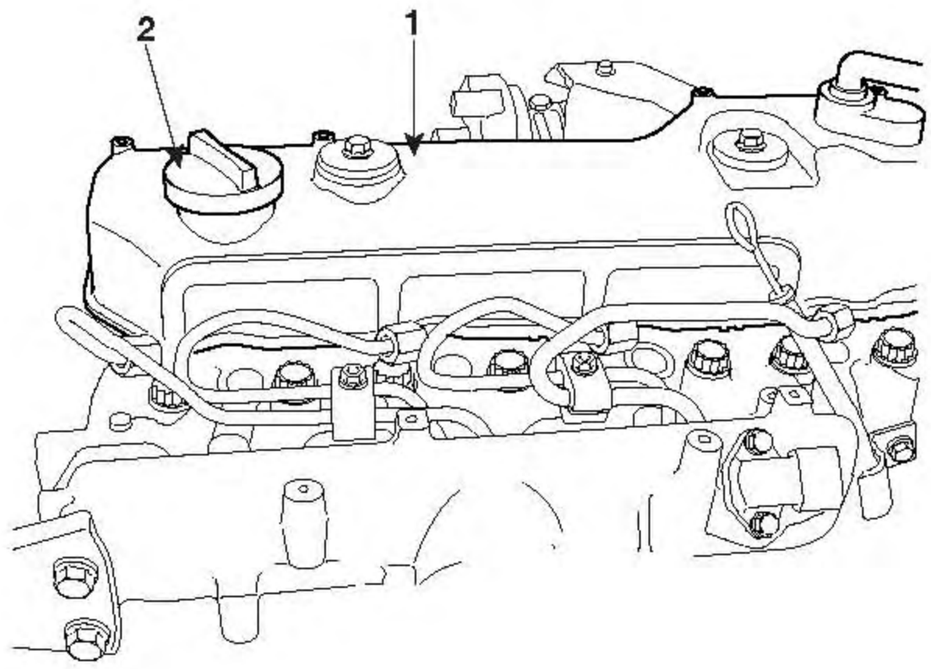


SUDEM7240L

4. Check the oil for pollution, mixture with coolant and viscosity.

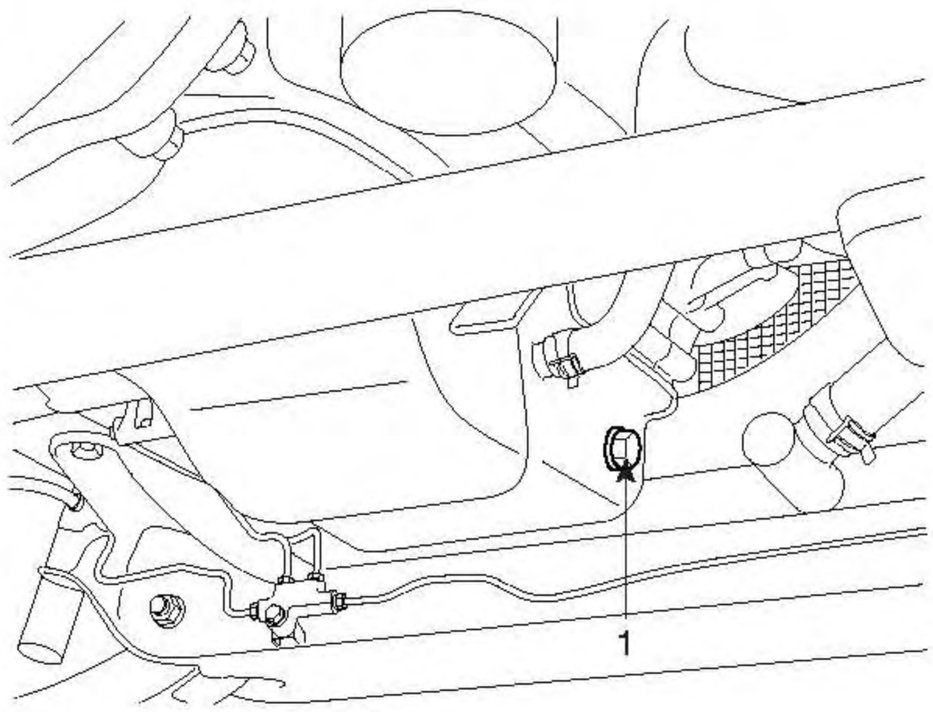
ENGINE OIL CHANGE

1. Stop the engine after warming up and remove the oil filler cap (2) on the cylinder head cover(1).



SUDEM7241L

2. Loosen the drain plug (1) of oil pan to drain engine oil.



SUDEM7242L

3. Tighten the drain plug with the specified torque.

Tightening torque : 34.3~44.1 Nm (3.5 ~ 4.5kgf.m, 25.4~32.7 lb-ft)

CAUTION

If oil drain plug is not tightened to the specified torque or gasket is reused, it may cause oil leakage or thread wear. Be sure to replace the gasket with new one at every oil change.

4. Fill in the new engine oil into the oil filler.

NOTE

Overfilling may cause oil saturation or pressure drop.

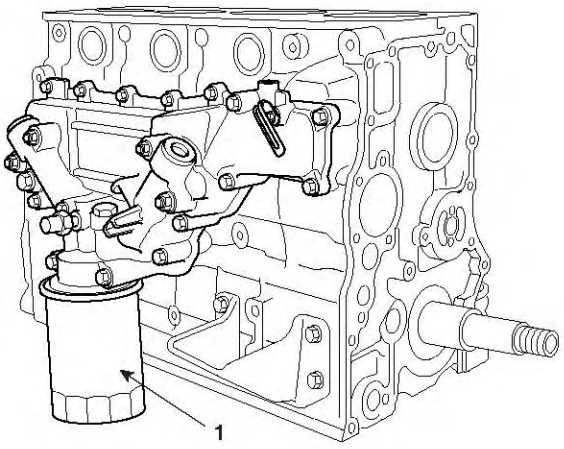
Oil capacity
Oil pan : 8ℓ
Total capacity : 9ℓ

5. Close oil filler cap.
6. Start the engine.
7. Stop the engine and check the oil level. Refill the engine oil if necessary.

OIL FILTER REPLACEMENT

1. Remove the oil filter (1) using oil filter wrench.
2. Apply engine oil on the gasket surface before installing oil filter.
3. Install the oil filter with the specified torque.

Tightening torque : 17.6~21.6 Nm
(1.8~2.2 kgf.m, 13.1~16.0 lb-ft)



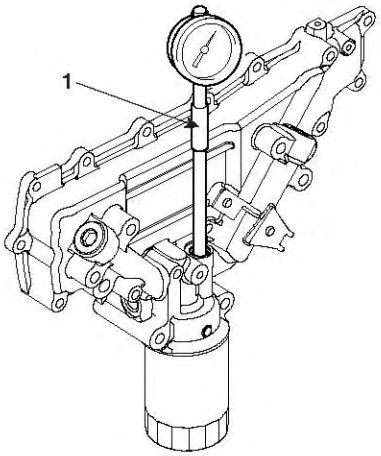
SUDEM7243L

4. Start the engine and check the oil leakage.
5. Stop the engine and check oil level. Refill engine oil as needed.

OIL PRESSURE CHECK

Remove regulator valve assembly and install pressure gauge (1). Warm up the engine until the temperature reaches 70~90°C. Measure the oil pressure at idle speed and max speed. If the readings are below the limit, disassemble and check the lubrication system.

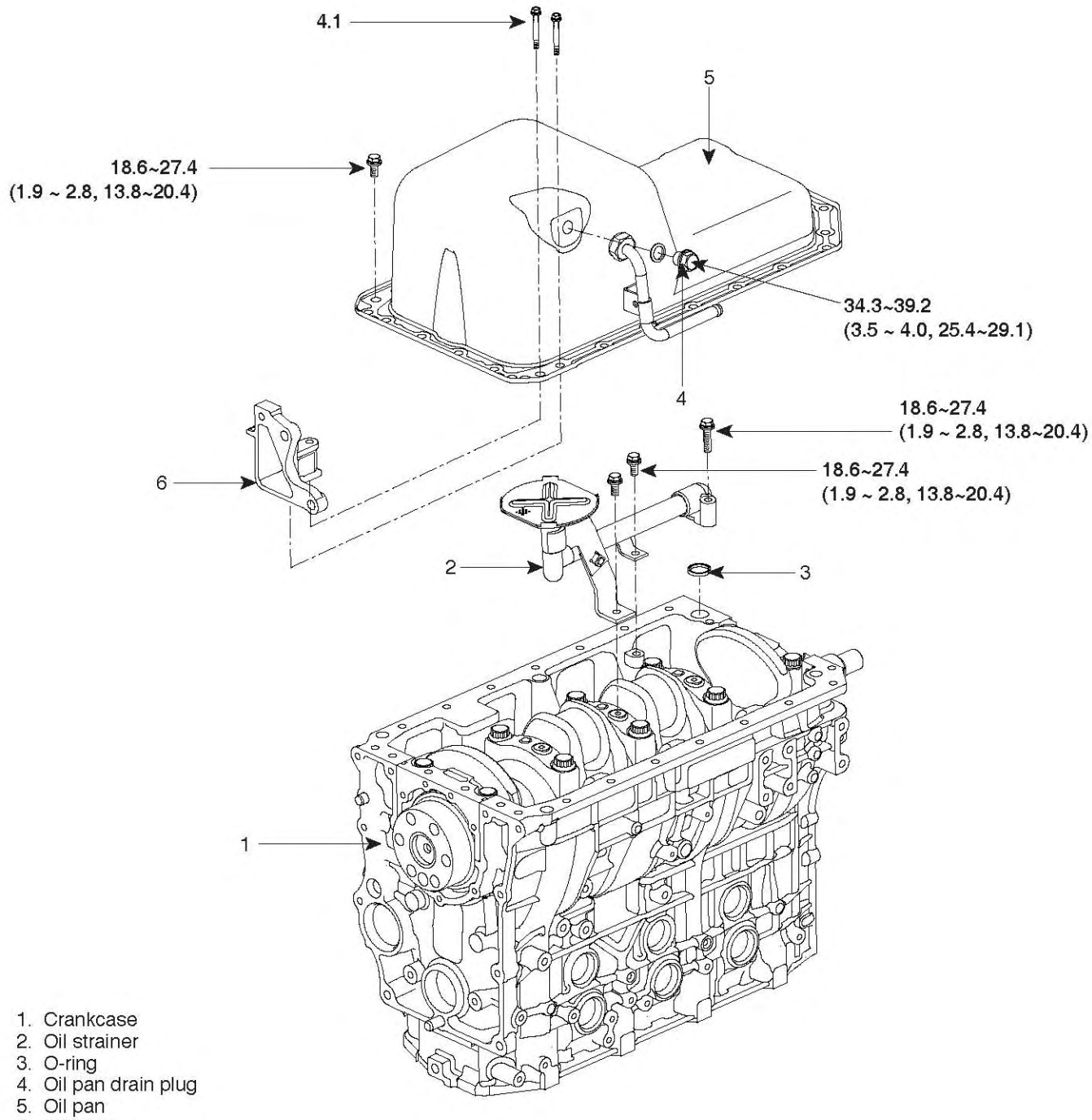
Item	Standard	Limit
No load min rpm	1.5kg/cm²	0.5kg/cm²
No load max rpm	3~5kg/cm²	2kg/cm²



SUDEM7244L

OIL PUMP

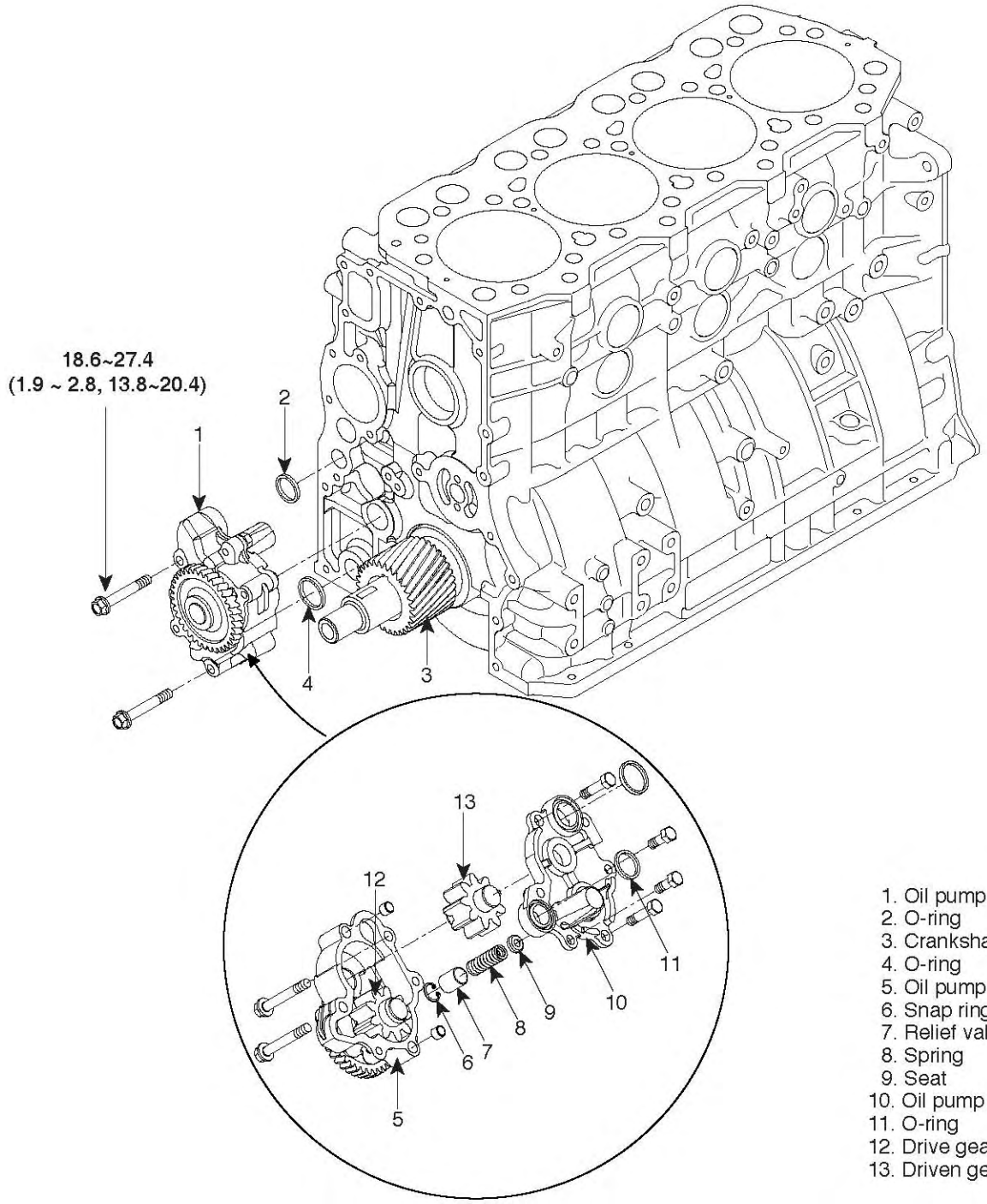
COMPONENTS E68A3564



1. Crankcase
2. Oil strainer
3. O-ring
4. Oil pan drain plug
5. Oil pan
6. Stiffener

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

SUDEM7245L



1. Oil pump assembly
2. O-ring
3. Crankshaft gear
4. O-ring
5. Oil pump case assembly
6. Snap ring
7. Relief valve
8. Spring
9. Seat
10. Oil pump cover
11. O-ring
12. Drive gear
13. Driven gear

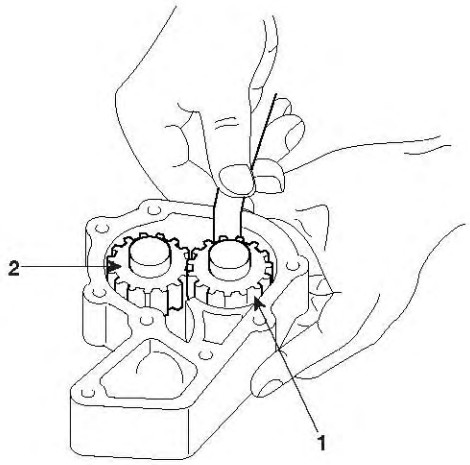
Tightening Torque : **Nm (kgf.m, lb-ft)**

SUDEM7246L

DISASSEMBLY EE5D4AF9

1. If the clearance between the end of the drive (1) and driven gear (2) and oil pump case exceeds the limit, replace those parts.

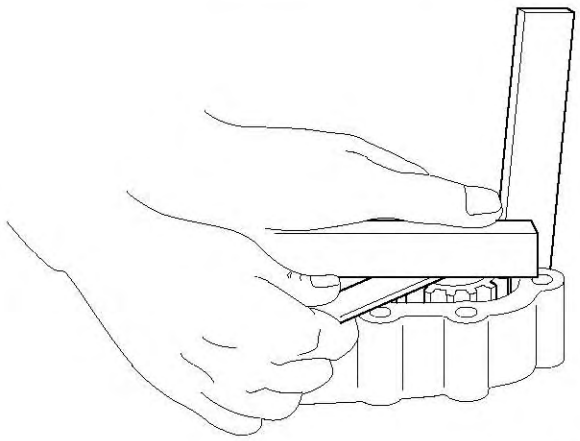
Clearance between oil pump case and gear tooth end
Standard : 0.10~0.19mm
Limit : 0.2mm



SUDEM7247L

2. Measure the difference between the drive and driven gears tooth end height and the oil pump case depth. If the measurement exceeds the limit, replace the parts.

Difference between oil pump case and gear tooth end height.
(Sinkage)
Standard : 0.01~0.07mm
Limit : 0.18mm



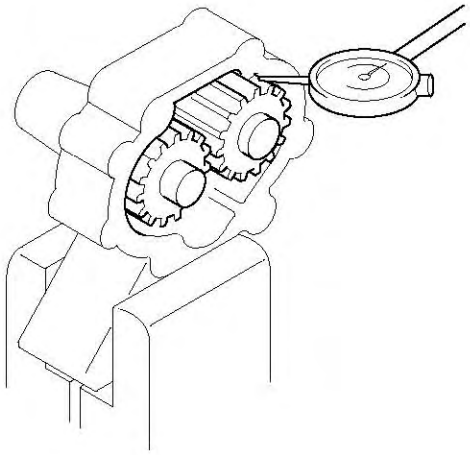
SUDEM7248L

3. Measure the clearance between driven gear and driven shaft. If the clearance exceeds the limit, replace the parts.

Clearance between driven gear and driven shaft
Standard : 0.04~0.07mm
Limit : 0.15mm

4. Measure the play of drive gear end, if the measurement exceeds the limit, replace the parts.

Standard play of drive gear end :
0.03mm



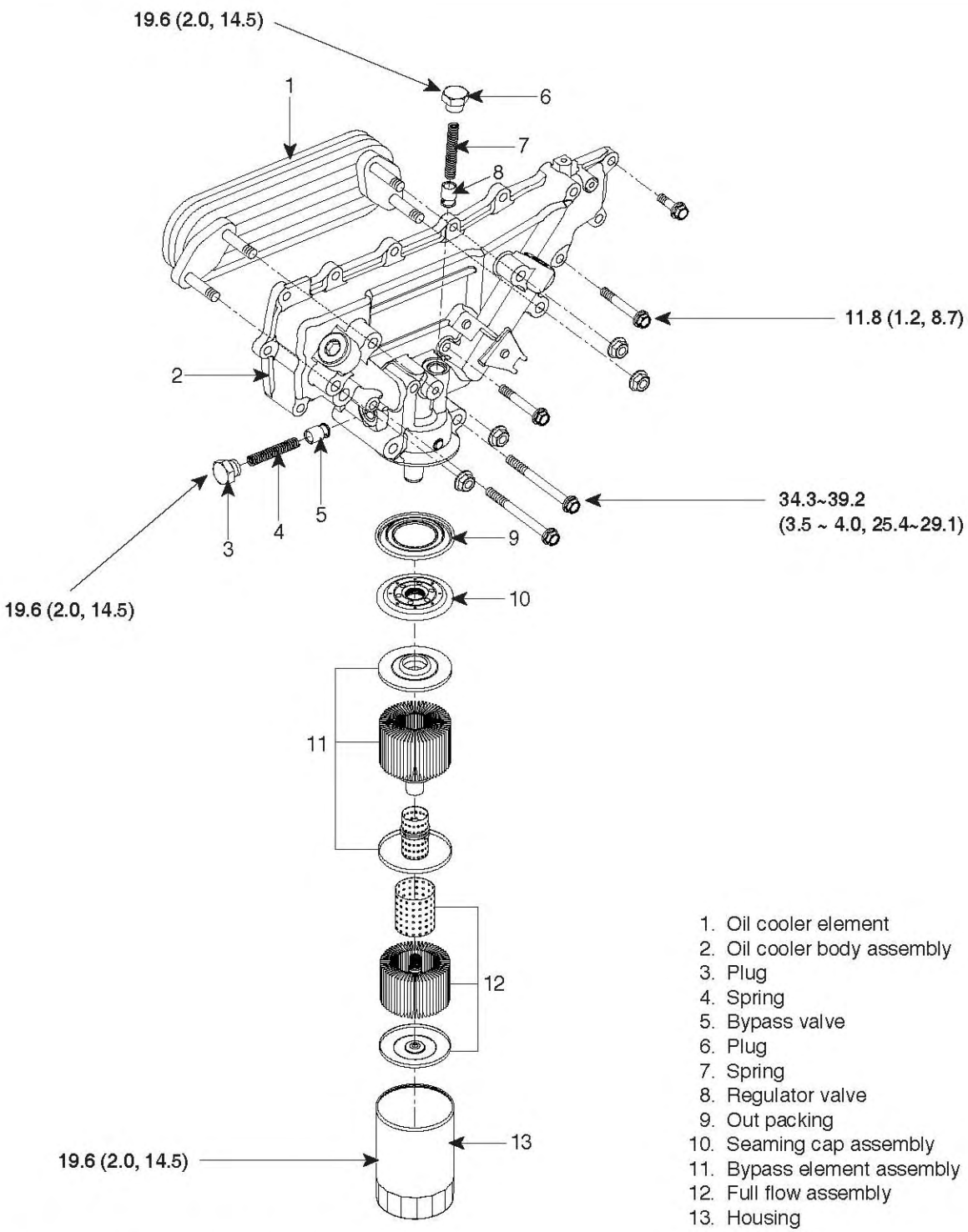
SUDEM7249L

5. Check the opening pressure of relief valve, replace the parts if they exceeds the limit.

Standard of relief valve opening pressure :
10~12kg/cm²

OIL COOLER

COMPONENTS E221CA2C



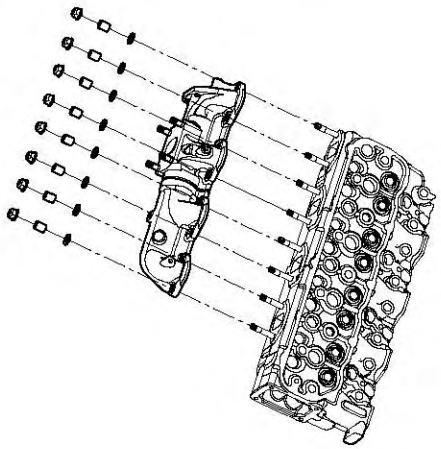
1. Oil cooler element
2. Oil cooler body assembly
3. Plug
4. Spring
5. Bypass valve
6. Plug
7. Spring
8. Regulator valve
9. Out packing
10. Seaming cap assembly
11. Bypass element assembly
12. Full flow assembly
13. Housing

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

SUDEM7250L

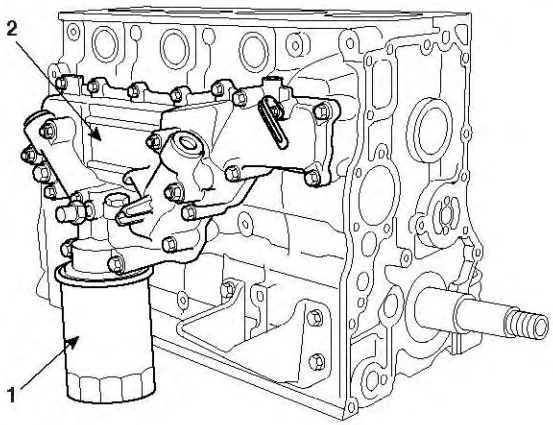
DISASSEMBLY EEA50548

1. Remove the exhaust manifold.



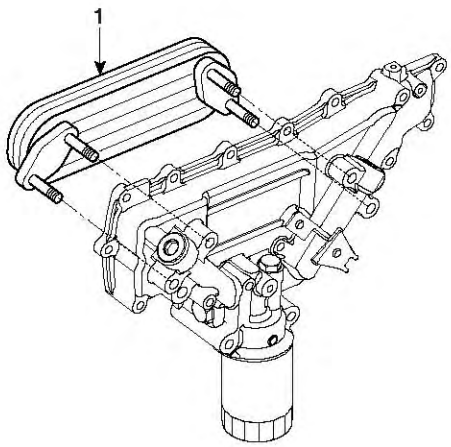
SUDEM7251L

2. Remove the oil filter (1) and oil cooler assembly (2).



SUDEM7252L

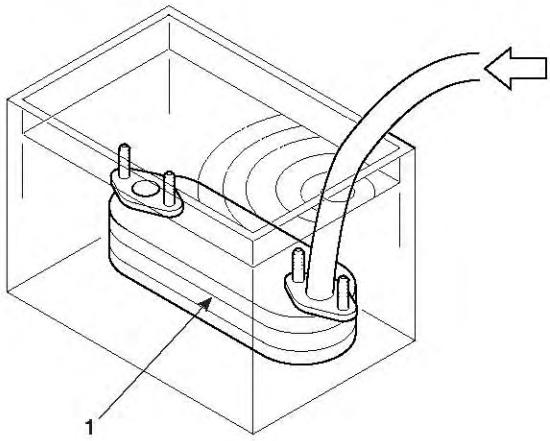
3. Disassemble oil cooler element (1) from oil cooler.



SUDEM7253L

INSPECTION EC9C5BDC

1. Cover oil cooler element (1) and connect hose to the engine oil filler. And immerse it into the water tank.
2. Apply air pressure of 3kg/cm² to hose side and check the oil cooler element.
3. Check air leakage. If air leaks, replace the oil cooler element.

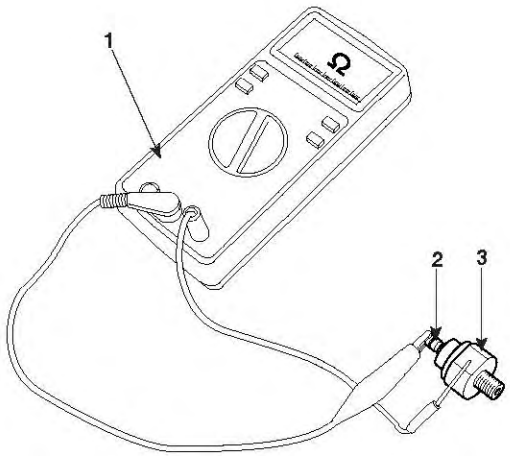


SUDEM7254L

4. Check the pressure of oil cooler bypass valve and regulator valve opening pressure. Replace them if necessary.

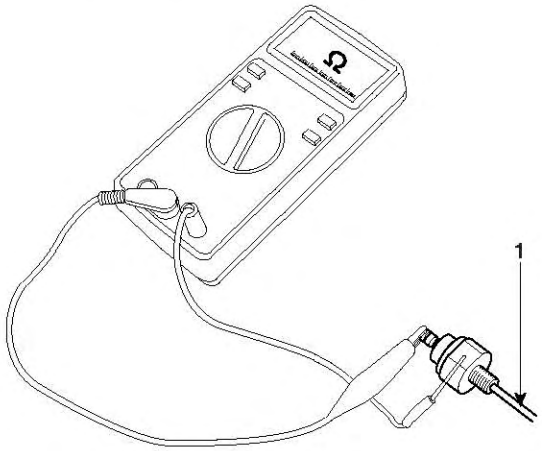
Bypass valve pressure : 3.5~4.5kg/cm²
Regulator valve opening pressure : 5.0~7.0kg/cm²

5. Oil pressure switch inspection
   a. Remove oil pressure switch from oil cooler.
   b. Check the continuity between oil pressure switch terminal (2) and body(3) using a tester(1). If there is no continuity, replace the switch.



SUDEM7255L

c. Insert the slim rod (1) into oil hole of oil pressure switch and check the continuity.
If there is continuity, replace the parts because it is faulty.



SUDEM7256L

CLEANING

1. Check the oil path and bypass valve of the oil cooler element for carbon deposits and sludge formation. If contaminated, wash it in cleaning oil.
2. If much scale is evident on the element and cover, clean it.

REASSEMBLY EC45CF49

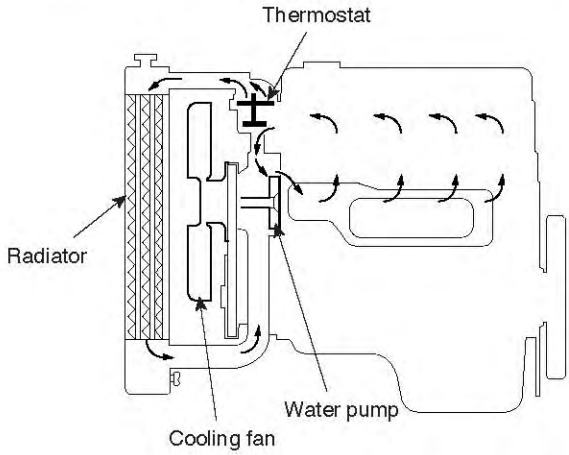
Assembly is made in the reverse order of disassembly. When installing oil cooler, align oil cooler with the oil pump installation surface.

COOLING SYSTEM

DESCRIPTION EC3B53CC

COOLING SYSTEM

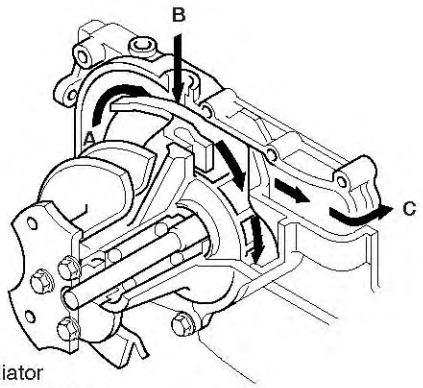
Water pump cools down the engine by circulating the coolant forcibly as shown in the illustration below.



SUDEM7257L

WATER PUMP

Water pump, a centrifugal type, is driven by the V-belt from the crankshaft pulley. A unit seal is installed between impeller and water pump that prevents leakage of coolant.
There is a drain hole provided at the bottom of the water pump case, which ensures that water should leak from the unit seal, does not enter bearings. The water pump is mounted on the timing gear case provided with a suction pipe and swirl chamber.
An Impeller, pressed fit into the one end of water pump shaft, has the combination blade, which feeds coolant under pressure into the engine.



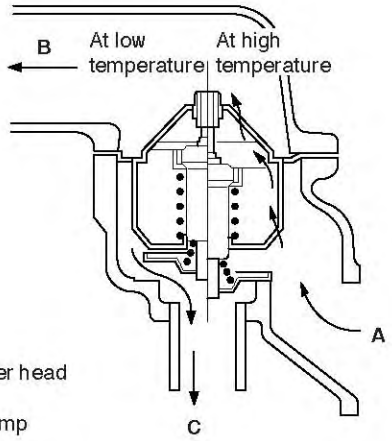
A; from the radiator
B: from the thermostat
C: to the crank case

SUDEM7258L

THERMOSTAT

1. The thermostat, of a bottom bypass configuration, has a valve controlled by a special wax enclosed in a pellet.

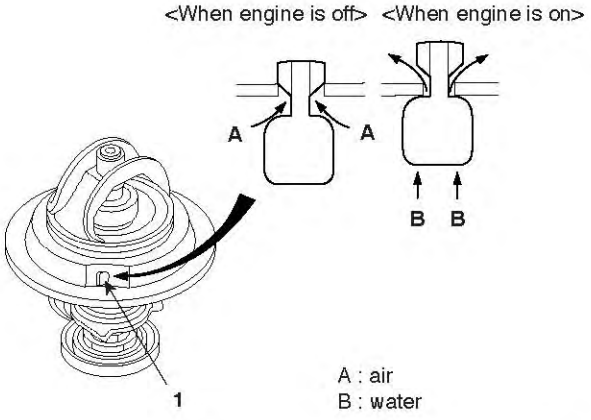
2. The wax changes from solid to liquid as it is heated, involving volumetric change for regulation the flow of coolant.
   The valve position changes depending on the coolant temperatures regulate the flow rate of coolant into the radiator and water pump (bypass side), thus controlling coolant temperature.



A : from cylinder head
B : to radiator
C : to water pump

SUDEM7259L

3. A jiggle valve is installed in the air plug hole of thermostat, which heats up the coolant temperature rapidly to put the engine temperature to the normal one.
   When engine stops, and coolant flows as jiggle valve falls down by its weight so that air in the engine is led to radiator through the clearance between the jiggle valve and the breather hole.
   When the engine starts, coolant flow into the radiator and jiggle valve is pushed up by the water pressure.
   As a result, valve covers the air plug hole to prevent the coolant from leaking through the hole.



A : air
B : water

SUDEM7260L

SPECIFICATION EC630CCE

Item		Specification
Cooling method		Water cooling, forced circulation
Coolant capacity		20ℓ (includes engine, radiator and heater)
Water pump	Type	Volute pump
	Drive	V-belt
V-belt	Quantity	2EA
Thermostat	Type	Wax-pellet, bottom bypass (installed with jiggle valve)
	Valve opening Temperature	82℃

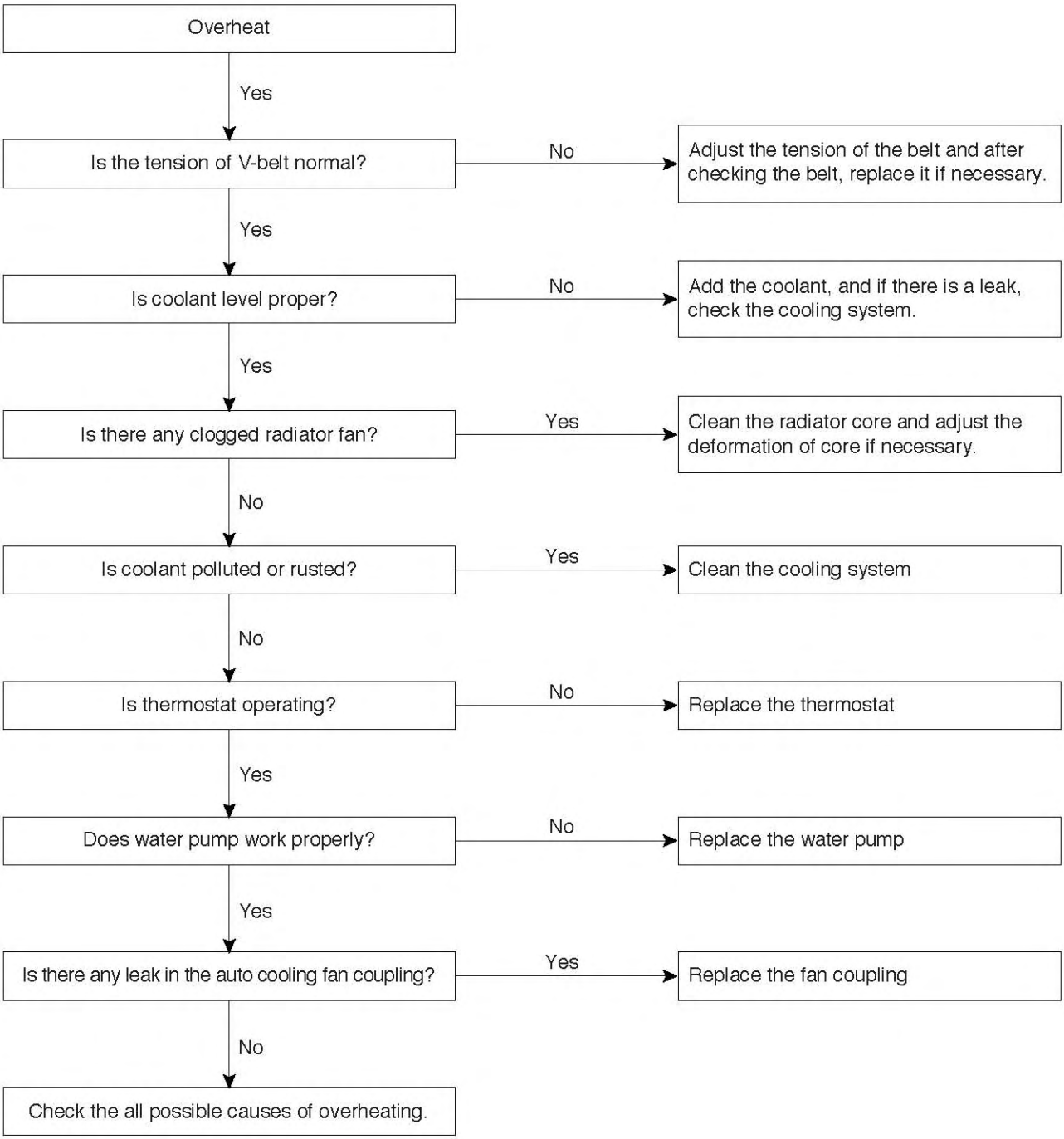
SERVICE STANDARDS

Item			Nominal value (〔 〕 indicates base diameter)	Limit	Correction and remarks
Fan rotation (Autocool fan coupling)			-	More than 2~3 revs.	Replace
Water pump	Interference between pump shaft and flange		〔17〕 0.08~0.10mm	Up to 2 times	Replace
	Gap between pump shaft and impeller		〔13〕 0.03~0.06mm		Replace
	Pump case to impeller installed dimension		20.8~21.7mm		Replace
Thermostat	Valve opening temperature		80~84℃		Replace
	Valve lift / temperature		Above 10 / 95℃		Replace
Radiator	Pressure cap opening pressure	nominal	0.83~1.10kg/cm²		Replace
		negative	Below 0.05kg/cm²		
	Radiator check pressure		1.4kg/cm²		Replace
Reservoir tank inner pressure			0.5kg/mm²		Replace
V-belt deflection	Between alternator and water pump		12~16mm		adjust
	Between power steering pump and crankshaft pulley		4~6mm		adjust
	Air-con compressor and tension pulley		16~20mm		adjust

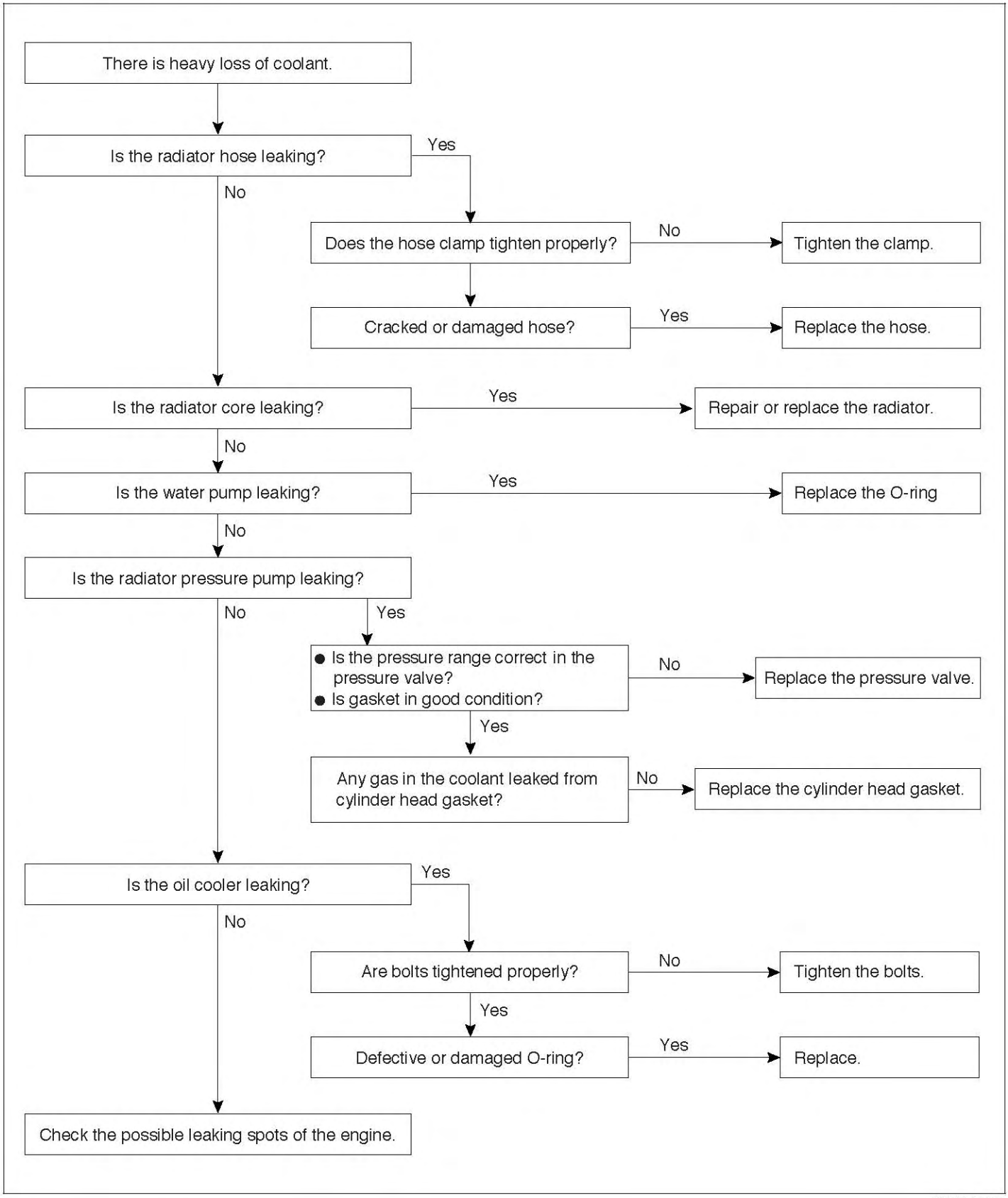
TIGHTENING TORQUE

Description (diameter x length)	Screw size OD×Pitch (㎜)	Nm	kgf.m	lb-ft
Thermostat cover case flange bolt	M8×1.25	21.6~32.3	2.2~3.3	16~24
Coolant temperature sensor and gauge	PT 3/8	29.4~39.2	3.0~4.0	21.8~29.1
Thermostat case flange bolt(10×25)	M10×1.5	35.3~52.9	3.6~5.4	26.2~39.3
Alternator adjusting plate mounting bolt(10×20)	-	35.3~52.9	3.6~5.4	26.2~39.3
Alternator adjusting shaft mounting nut (10)	-	18.6~27.4	1.9~2.8	13.8~20.4

TROUBLE SHOOTING E37CE1A7



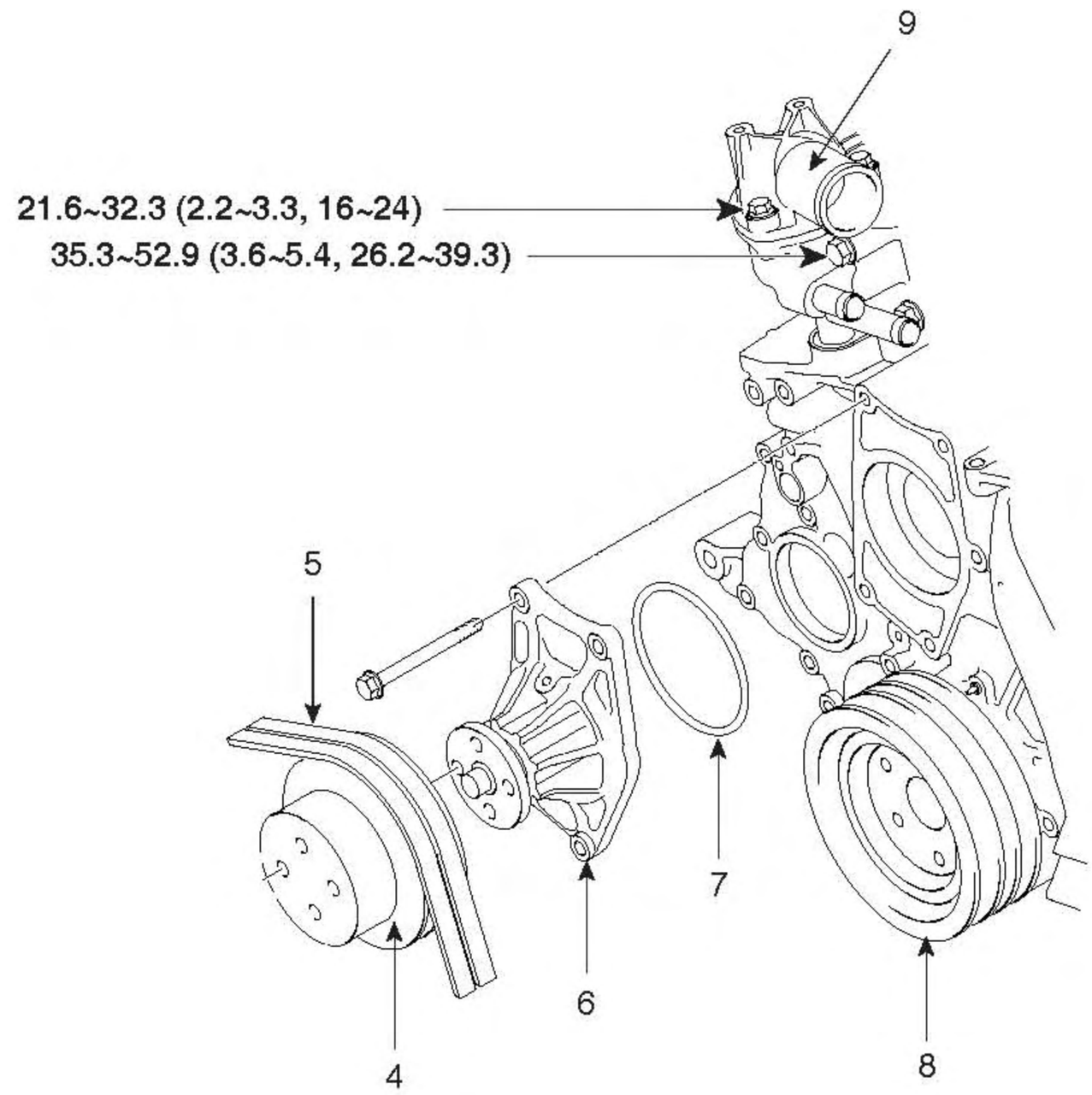
SUDEM7265L


There is heavy loss of coolant.
Is the radiator hose leaking?
Yes
No
Does the hose clamp tighten properly?
No
Tighten the clamp.
Cracked or damaged hose?
Yes
Replace the hose.
Is the radiator core leaking?
Yes
Repair or replace the radiator.
No
Is the water pump leaking?
Yes
Replace the O-ring
No
Is the radiator pressure pump leaking?
No
Yes
● Is the pressure range correct in the pressure valve?
● Is gasket in good condition?
No
Replace the pressure valve.
Yes
Any gas in the coolant leaked from cylinder head gasket?
No
Replace the cylinder head gasket.
Is the oil cooler leaking?
Yes
No
Are bolts tightened properly?
No
Tighten the bolts.
Yes
Defective or damaged O-ring?
Yes
Replace.
Check the possible leaking spots of the engine.

SUDEM7266L

WATER PUMP

COMPONENTS E27DE054



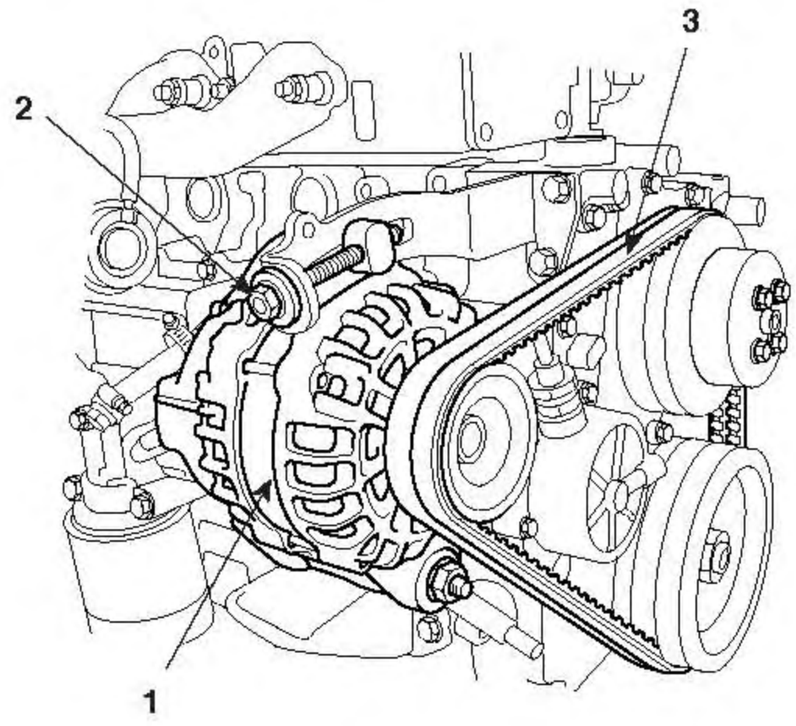
4. Water pump pulley
5. V-belt
6. Water pump assembly
7. O-ring
8. Crankshaft damper pulley
9. Thermostat housing

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

SUDEM7267L

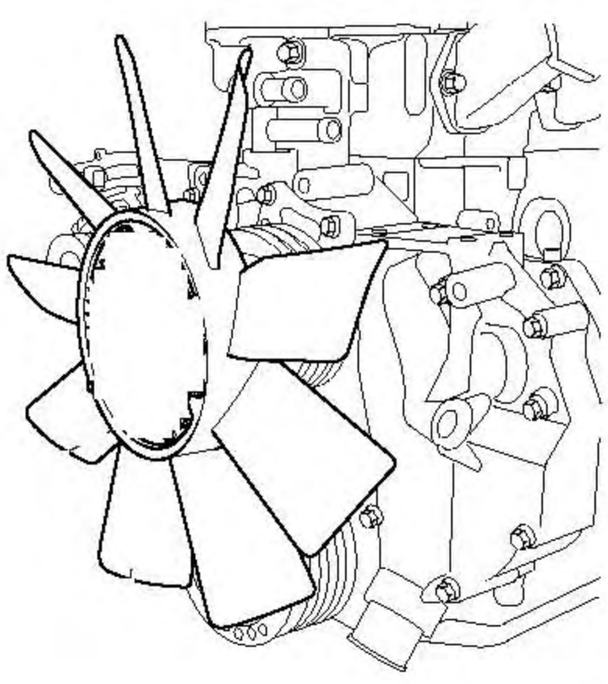
REMOVAL E9DD1BEE

1. Remove the coolant drain plug and drain the coolant.
2. Loosen the alternator (1) tension adjusting screw (2) and remove V-belt (3).



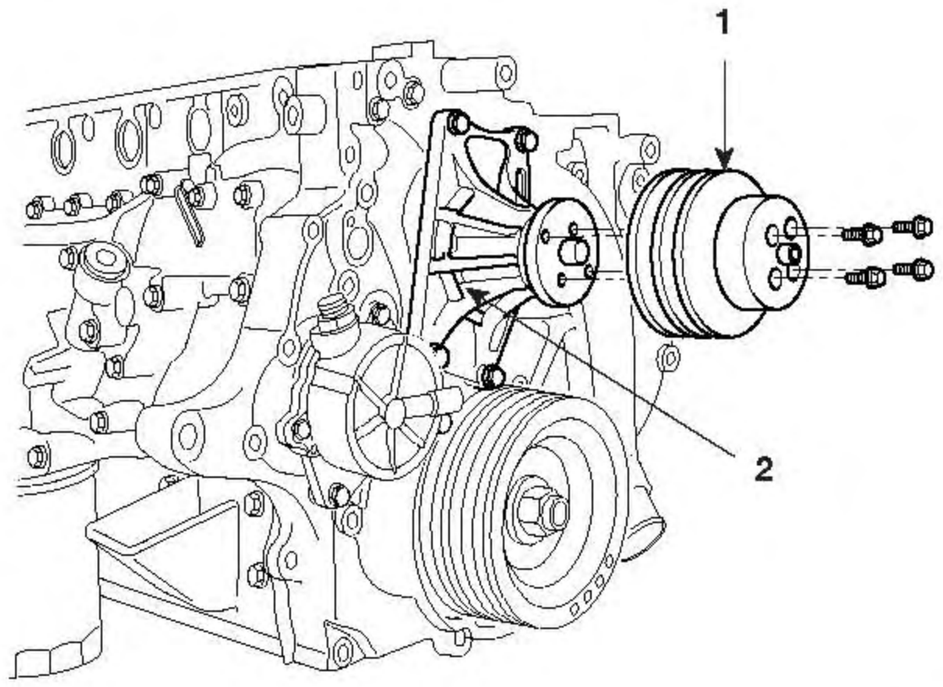
SUDEM7268L

3. Remove the cooling fan



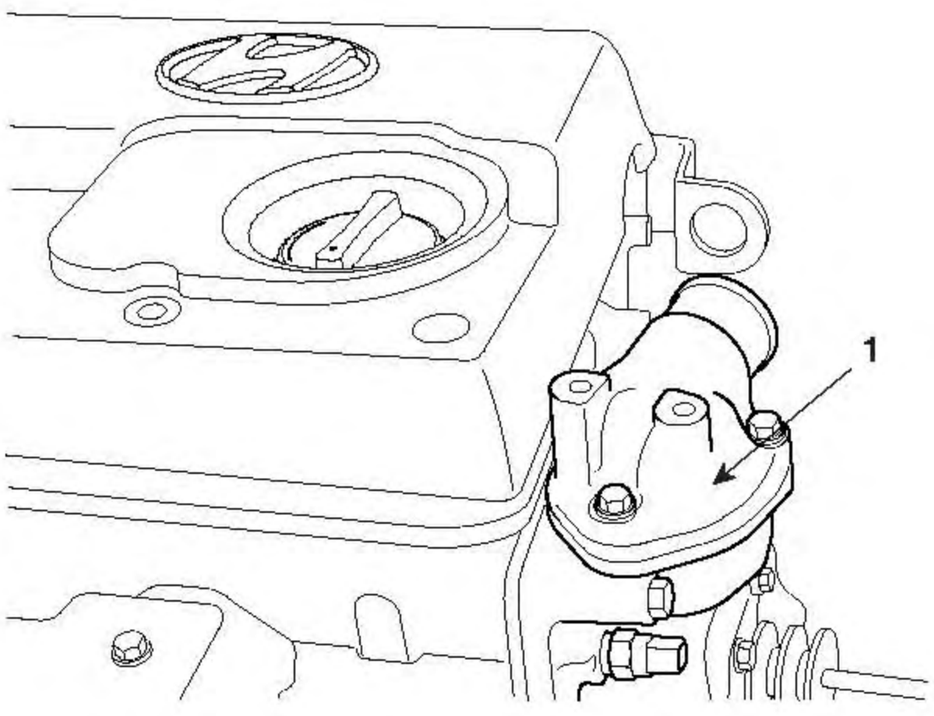
SUDEM7269L

4. Remove water pump pulley(1) and water pump assembly(2).



SUDEM7270L

5. Disassemble the coolant temperature sensor connector and remove the thermostat housing(1) from the cylinder head.
   a. Remove the thermostat cover.
   b. Remove the thermostat.
   c. Disassemble the bypass pipe from the thermostat case.
   d. Remove the coolant temperature sensor.



SUDEM7271L

INSPECTION EE28BF77

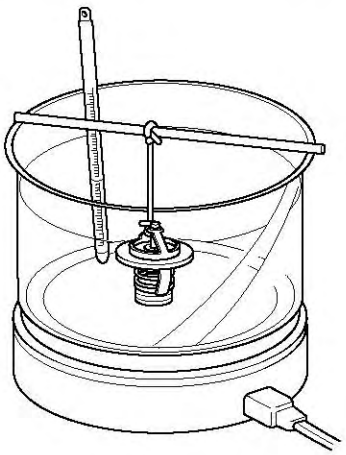
WATER PUMP

1. Inspect the crack, damage, and wear of the parts, and replace the water pump, if necessary.
2. Inspect the bearing to see any damage, unusual noise, and poor revolution, and replace it, if necessary.
3. Check the leakage of the seal unit and replace the water pump, if necessary.

THERMOSTAT

1. Heat the water to see if the thermostat valve operates properly.
2. Measure the temperature when the valve starts opening and is fully open.

Item	Specification
Valve opening temperature	80~84°C
Valve lift / temperature	more than 10 / 95°C



SUDEM7272L

V-BELT TENSION CHECK

Adjust the belt tension to obtain the specified belt deflection when the center of each belt is pressed hard with a force of 10 kgf.

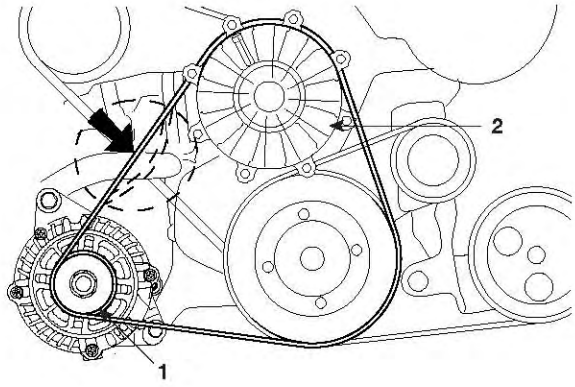
Deflection between the alternator(1) and water pump(2) : 12~16mm

CAUTION

a. Since a slack belt may cause overheating or undercharge, adjust the tension to the specification.

b. An excessively tight belt may result in possible damages of the belt or bearing.

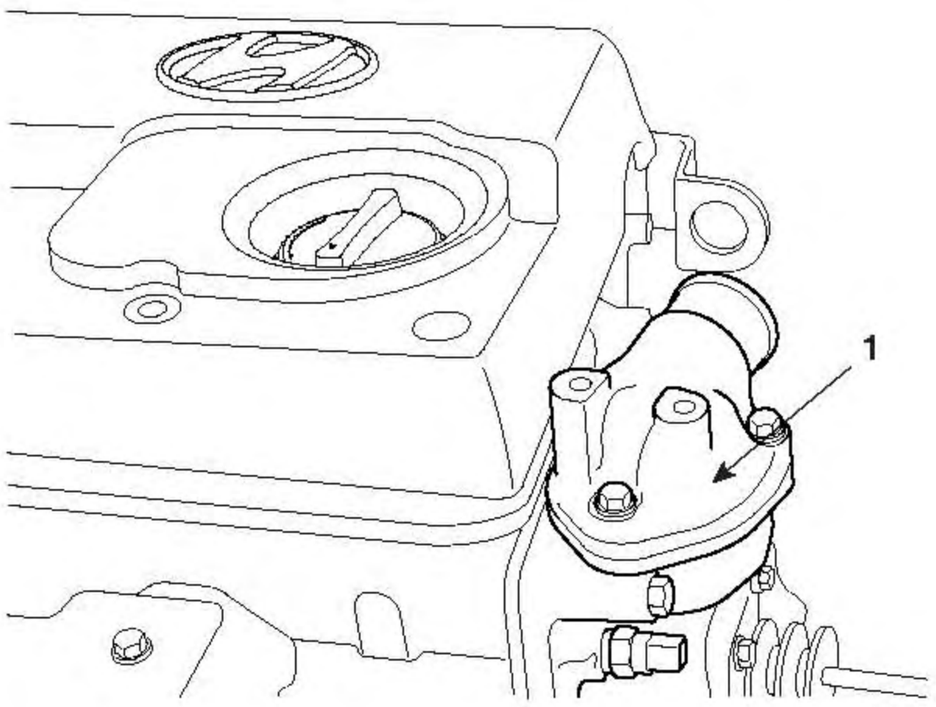
c. All of two V-belts should be replaced as a complete set.



SUDEM7273L

INSTALLATION EBC443E9

1. Install thermostat housing(1) to the cylinder head.



SUDEM7271L

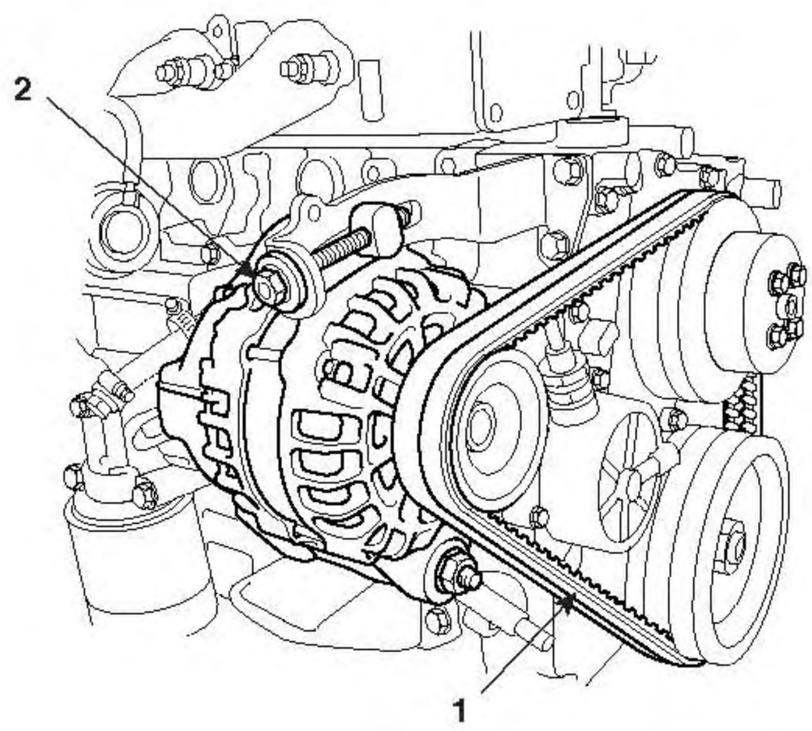
2. Install the water pump(1) and water pump pulley(2) to the timing gear case.

Tightening torque : 16.7~25.5 Nm
(1.7~2.6kgf.m, 12.4~18.9 lb-ft)

SUDEM7274L

3. Install the V-belt(1) and adjust the tension using the alternator mounting nuts and adjusting bolts(2).

V-belt tension ; 12~16mm deflection (with a force of 10kg)



SUDEM7275L

ENGINE ELECTRI-CAL SYSTEM (D4DD)

GENERAL

SPECIFICATION EE4279FF

STARTING SYSTEM

Item			Specification
Starter	Type		Pre-engaged drive(Assistance drive)
	Rated output		24V-5.0KW
	No. of pinion teeth		9
	Rotation direction		Clockwise from pinion side
	No of ring gear teeth		114
	Input angle of pinion		20°
	Center distance between ring gear and pinion		187.2mm
	No load test	Terminal voltage	23V
		Max. current	95A, MAX
		Min. RPM	3,300rpm, MIN
		Magnetic switch operating voltage	Below 16V
	Load test	Terminal voltage	18.5V
		Terminal current	400A
		Min RPM	2.6kgf.m / 1,250rpm, MIN
	Characteristic of assurance output	Terminal voltage	9V
		Max. current	1,400A
		Max rotation force	7 .0kgf.m, MIN

CHARGING SYSTEM

Item		Specification
Alternator	Type	3 phase alternate current commutator type
	Rated output	24V-50A
	Rated RPM	5,000rpm
	RPM in use	8,000rpm
	Regulator type	IC regulator
	Adjusted regulator voltage [at 20°C]	28~29V

NOTE

- *Cold Cranking Ampere: It refers to the current that the battery can supply for 30 seconds with maintaining the 7.2V terminal voltage at a specific temperature.*
- *Reserve Capacity: It refers to the total time duration in which the battery can supply 25A current at a temperature of 26.7 °C with maintaining the min. terminal voltage of 10.5V.*

PRE-HEATING SYSTEM

Item		Specification
Preheating plug	Rated voltage	23V
	Resistance	4Ω
	Temperature increase	It takes 8 ± 1.5 sec to reach 800°C when DC 23V is applied. The temperature should be 1050±80°C at 30 seconds after DC 23V is applied.
	Heater relay fuse	127A

SERVICE STANDARDS EB8EEF3E

Item		Nominal value (Base diameter in [ ])			Limit	Corrective action
Starter Motor	Commutator OD	32mm			31mm	Replace
	Commutator run out	-			Above 0.5mm	Correct or replace
	Brush length	-			7.5mm	Replace
	Brush spring pressure	-			2.0~3.8kgf	Replace
	Pinion gap	3.0mm			-	Adjust with packing
Alterna-tor(24V~50A)	Output charac-teristics(27V)	Output current (A)		Revolution (rpm)	-	-
		At cold cranking	At hot cranking			
		(27)	Above 22	1500		
		(48)	Above 38	2500		
		(55)	Above 45	5000		

TIGHTENING TORQUE

Item	Nm	kgf.m	lb-ft
Alternator adjusting shaft mounting nut	18.6~27.4	1.9~2.8	13.8~20.4
Alternator adjusting plate mounting bolt	35.3~52.3	3.6~5.4	26.2~39.3
Alternator assembly mounting bolt	78.4~107.8	8.0~11	58.2~80
Starter motor mounting bolt (upper)	78.4~107.8	8.0~11	58.2~80
Starter motor mounting bolt (lower)	37.2~53.9	3.8~5.5	27.6~40
Vacuum pump mounting bolt	18.6~27.4	1.9~2.8	13.8~20.4
Vacuum pump pipe and oil cooler flange bolt	3.9~5.9	0.4~0.6	2.9~4.4
Pre-heater plug mounting nut	1~1.5	0.1~0.15	0.7~1.1

TROUBLESHOOTING EBC9F925

ALTERNATOR

Troubles	Possible causes	Corrective action
Charge warning lamp is not turned on when ignition switch is ON state.	Fuse is broken.	Replace the fuse
	Bulb is broken.	Replace the bulb
	Loose wiring connection	Retighten the loose connection
	Wrong connection of L-S terminals	Check and replace wiring or replace the voltage regulator.
Charge warning lamp does not turn off even after the engine is started. (When battery needs to be charged frequently).	Drive belt is loose or worn.	Replace the drive belt
	Fuse is broken.	Replace the fuse
	Fusible link is broken.	Replace the fusible link
	Voltage regulator or alternator is defective.	Replace the alternator
	Wiring is defective.	Repair or replace the wiring
	Battery cable is corroded or worn.	Repair or replace the battery cable
Battery is overcharged.	Voltage regulator is defective (charge warning lamp is on).	Replace the voltage regulator
	Defective of voltage sensing wiring	Replace the wiring
Battery is discharged.	Drive belt is loose or worn.	Replace the drive belt
	Wiring connector is loose or circuit is short.	Retighten the loose connection or Repair the wiring.
	Fusible link is short.	Replace the fusible link
	Poor grounding	Repair
	Voltage regulator is defective (charge warning lamp is on).	Check the alternator
	Battery is exhausted.	Check the battery

STARTER

Troubles	Possible causes	Corrective action
Engine does not crank.	Battery voltage is low	Charge or replace the battery.
	Battery cable is loose, corroded or worn.	Repair or replace the cable.
	Fusible link is short	Replace the fusible link.
	Starter is defective	Replace the starter.
	Ignition switch is defective.	Replace the ignition switch.
Cranking is slow.	Battery voltage is low.	Charge or replace the battery.
	Battery cable is loose, corroded or worn.	Repair or replace the cable.
	Starter is defective.	Replace the starter.
Starter keeps rotating	Starter is defective.	Replace the starter.
	Ignition switch is defective.	Replace the ignition switch.
Starter motor operates but engine does not crank.	Wiring is short	Repair or replace the wire.
	Pinion gear teeth are worn or damaged or motor is defective.	Replace the starter.
	Ring gear teeth are worn or damaged.	Replace the flywheel gear or torque converter.

PRE-HEATER

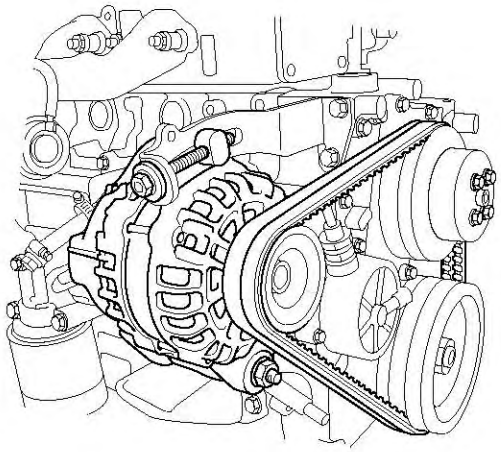
Troubles	Possible cause	Corrective action
Engine does not start when the coolant temperature is below 0°C.	Wiring connection is loose or wiring is defective. Coolant sensor is defective. Pre-heater plug is defective. Pre-heater control unit is defective.	Repair the wiring or tighten the connection. Replace the coolant temperature sensor. Replace the pre-heater plug Replace the unit.
If engine stops after 1st explosion or idle is unstable when the coolant temperature is below 0°C.	Connection is loose or wiring is defective. Pre-heating plug is defective. Pre-heating plug relay is defective.	Correct or tighten the wiring or connection. Replace the pre-heater plug Replace the relay
Pre-heating indicator remains off	Lamp is short. Connection is loose or wiring is cracked. Wiring is short. Pre-heater control unit is defective.	Replace the lamp Replace the wiring or tighten the connection. Replace the wiring Replace the unit

CHARGING SYSTEM

DESCRIPTION E9B357D5

ALTERNATOR

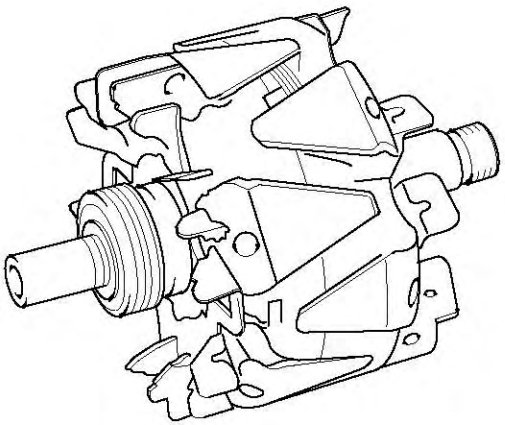
Alternator is of a built-in type with an IC regulator. A brush holder is installed in the rear bracket.
When IC regulator fails, regulator assembly should be replaced because the voltage cannot be controlled.



KOD4DD1A

ROTOR

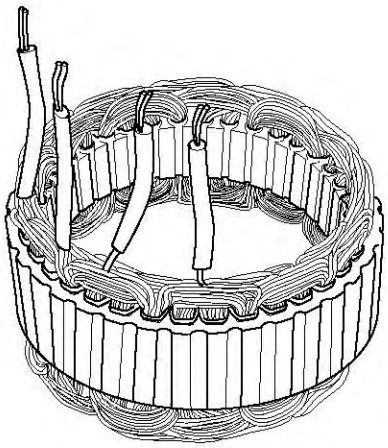
When the rotor is driven by the rotation of the pulley, the current flows from the brush to rotor coil through slip ring. Then, rotor core becomes an electro-magnetic.



EBKD008A

STATOR

Stator core forms the magnetic flux path together with rotor core. The magnetic flux in the stator core is affected by the passage of the rotor core field so that electricity is generated as each rotor core rotates.



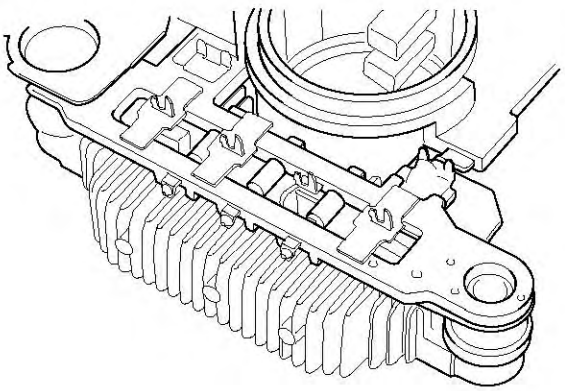
EBKD008B

COMMUTATOR

Commutator comprises of 3 pairs of diodes (6 in total) and 2 heat sinks. It converts AC output of the stator to DC power.

REGULATOR

Regulator assembly comprises of IC regulator, brush and brush spring. It stabilizes the output varying according to the engine rpm.



FD4DD01A

ADJUSTMENT E852A18E

VOLTAGE DROP TEST OF ALTERNATOR OUTPUT WIRE

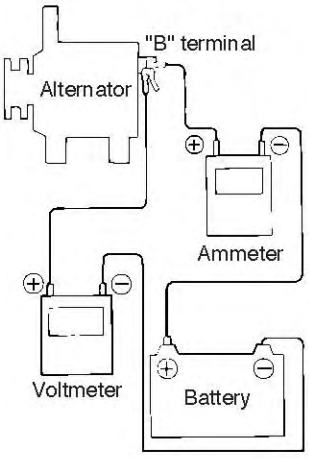
This is a test to check the wiring between " B" terminal of alternator and (+) terminal of battery.

1. Preparation works
   1) Turn the ignition switch off.
   2) Remove the ground cable of the battery.
   3) Disconnect the alternator output wire from the " B" terminal of alternator.
   4) Connect a DC ammeter (0~150A) between " B" terminal and the disconnected output wire. Connect the (+) and (-) lead wires of the ammeter to " B" terminal and the disconnected output wire, respectively.

CAUTION

If clamp type ammeter is used, current can be measured without disconnecting the harness.

   5) Connect a digital voltmeter between alternator " B" terminal and (+) terminal of the battery. Connect the (+) and (-) lead wires of the voltmeter to " B" terminal and (-) terminal of the battery, respectively.
   6) Connect the battery ground cable.



SUDEE7001L

2. Test
   1) Start the engine.
   2) With turning ON/OFF the headlight, adjust the engine speed as the ammeter indicator points 20A. At that time, measure the voltage.
3. Result
   1) It is normal if the measured voltage is within the specification.

Test Reference voltage: Max 0.2V.

   2) If the measured voltage exceeds the reference, wiring may be defective. Therefore, check the wiring between " B" terminal of the alternator and fusible link, and between alternator and (+) terminal of the battery.
   3) In addition, before the secondary test, check the looseness at the connection and the discoloration of harness due to the overheating. Repair them.
   4) Turn the light and ignition switch "OFF" after the test.
   5) Disconnect the battery ground cable.
   6) Disconnect the ammeter and voltmeter used for the test.
   7) Connect the alternator output lead wire to the " B" terminal of the alternator.
   8) Connect the battery ground cable.

OUTPUT CURRENT TEST

This test is to check whether the alternator output current coincides with the rated current.

1. Preparation works

CAUTION

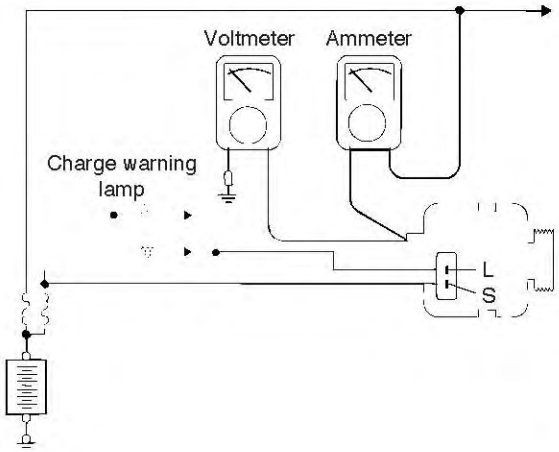
When the output current is measured, use the battery discharged a little bit. It is difficult to perform the accurate test with the fully charged battery because of insufficient load.

a. Turn the ignition switch " OFF" .
b. Disconnect the battery ground cable.
c. Disconnect the alternator output wire from " B terminal of the alternator.
d. Connect a DC ammeter (0~150A) to " B" terminal and the disconnected output wire.
Connect (+) lead wire and (-) lead wire to " B" terminal and output wire, respectively.

CAUTION

Since it has high voltage, make sure to tighten the connection completely using bolts and nuts not clips.

e. Connect the voltmeter (0~20V) between " B" terminal and ground terminal. Connect (+)lead wire to " B" terminal and (-) lead wire to ground terminal at the proper position.
f. Connect engine tachometer. And then connect battery ground cable.



SUDEE7002L

2. Test

1) Check to see if the voltmeter indicates the same voltage value with battery voltage.
If voltmeter indicates 0V, it means wiring between " B" terminal of alternator and (-) terminal of battery may be disconnected. Otherwise, it means fusible link is short or ground is poor.

2) Start the engine and turn the headlight switch " ON."

3) Set the headlight on " High" and place the heater blower switch at " HIGH." Measure the max output current by accelerating the engine speed up to 2500rpm.

NOTE

Since charging current drops down rapidly after engine is started, perform this test quickly to get accurate max current.

3. Result

1) Measured value from the ammeter should be greater than the limit value. Despite that the alternator output wire is normal, if the measured-value is low, remove the alternator and check it.

Output current: 70% of the rated current

CAUTION

- ***Rated output current is shown on the identification plate attached on the alternator body.***
- ***Since output current varies depending on the electric load of the alternator and ambient temperature, it is difficult to get the rated output current if the electric load of the vehicle is low. In that case, turn the headlight on to result in the battery discharging or increase the electric load by using additional light from other vehicle.***
- ***Since rated output current cannot be measured when the temperature of alternator and ambient temperatures are too high, you should lower the temperature before the secondary test.***

2) After completing the output current test, lower the engine speed down to the idle rpm and turn the ignition switch " OFF."

3) Disconnect the battery ground cable.

4) Remove ammeter, voltmeter and tachometer.

5) Connect alternator output wire to " B" terminal of the alternator.

6) Connect the battery ground cable.

ADJUSTING VOLTAGE AND LRC FUNCTION TEST, TROUBLE-DIAGNOSIS FUNCTION TEST

This test is to check to see whether the voltage regulator controls the voltage properly.

1. Preparation

   1) Check the battery installed on the vehicle whether it is fully charged.

   2) Turn the ignition switch " OFF."

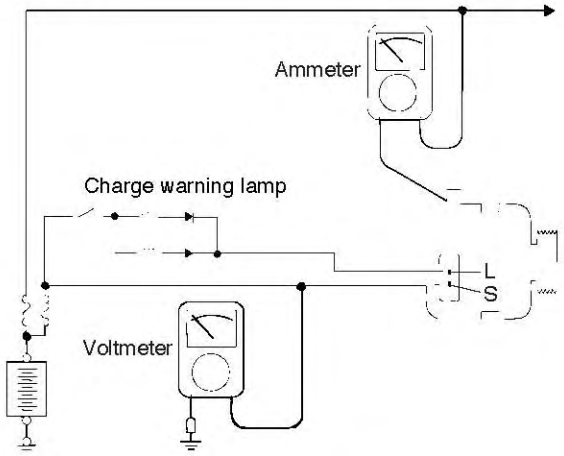
   3) Disconnect the battery ground cable.

   4) Connect a digital voltmeter between the ground cable and " L" or " S" terminal of alternator. Connect (+) lead wire to " L" or " S" terminal using special tool " wire-harness connector." Connect (-) lead wire to proper ground wire or (-) terminal of the battery.

   5) Disconnect alternator output wire from " B" terminal of the alternator.

   6) Connect the DC ammeter (0~150A) in serial between " B" terminal and the disconnected output wire.
   Connect (-) lead wire of ammeter to the disconnected output wire.

   7) Install engine tachometer. Connect battery ground cable.



SUDEE7003L

2. Test

   1) Turn the ignition switch " ON" and check to see whether voltmeter indicates the reference value. If voltmeter indicates 0V, it means wire between " B" terminal of alternator and (+) terminal of battery is disconnected. Otherwise, it means fusible link is burned out.

   2) Start the engine. Turn the light and all other accessory switches " ON" .

   3) Increasing the engine speed up to 2500rpm, read the voltmeter when alternator output current drops to 10A.

   4) Keep the engine speed at idle rpm and turn off the externally applied load (various electric instruments).

   5) Then, apply the externally applied load momentarily. (load current of 15A or more)

   6) Read the voltmeter before the externally applied load is applied. Measure the time taken until the voltage after the external load is applied is equal to the voltage before the external load is applied.

   7) In addition, charging lamp turns on if " S" terminal wire is opened with the idle load only. If the charging lamp does not turn on, it means that voltage regulator is defective.

3. Result

1) If the voltmeter reading agrees with the table of the adjusting voltage, the voltage regulator is normally operating. If the voltage value is larger than the reference value, the voltage regulator or alternator is defective.

NOTE

Maximum ambient temperature should be lower than 90°C.
(However, 100°C is acceptable within 10 minutes.)

Ambient temperature of voltage regulator (°C)	Adjust voltage (V)
20	28~29V

2) It is normally operating if it is 2~7 seconds to take until the voltage after the external load is applied is equal to the voltage before the external load is applied

3) After the test, adjust the engine speed to idle rpm, and turn the ignition switch " OFF" .

4) Disconnect the battery ground cable.

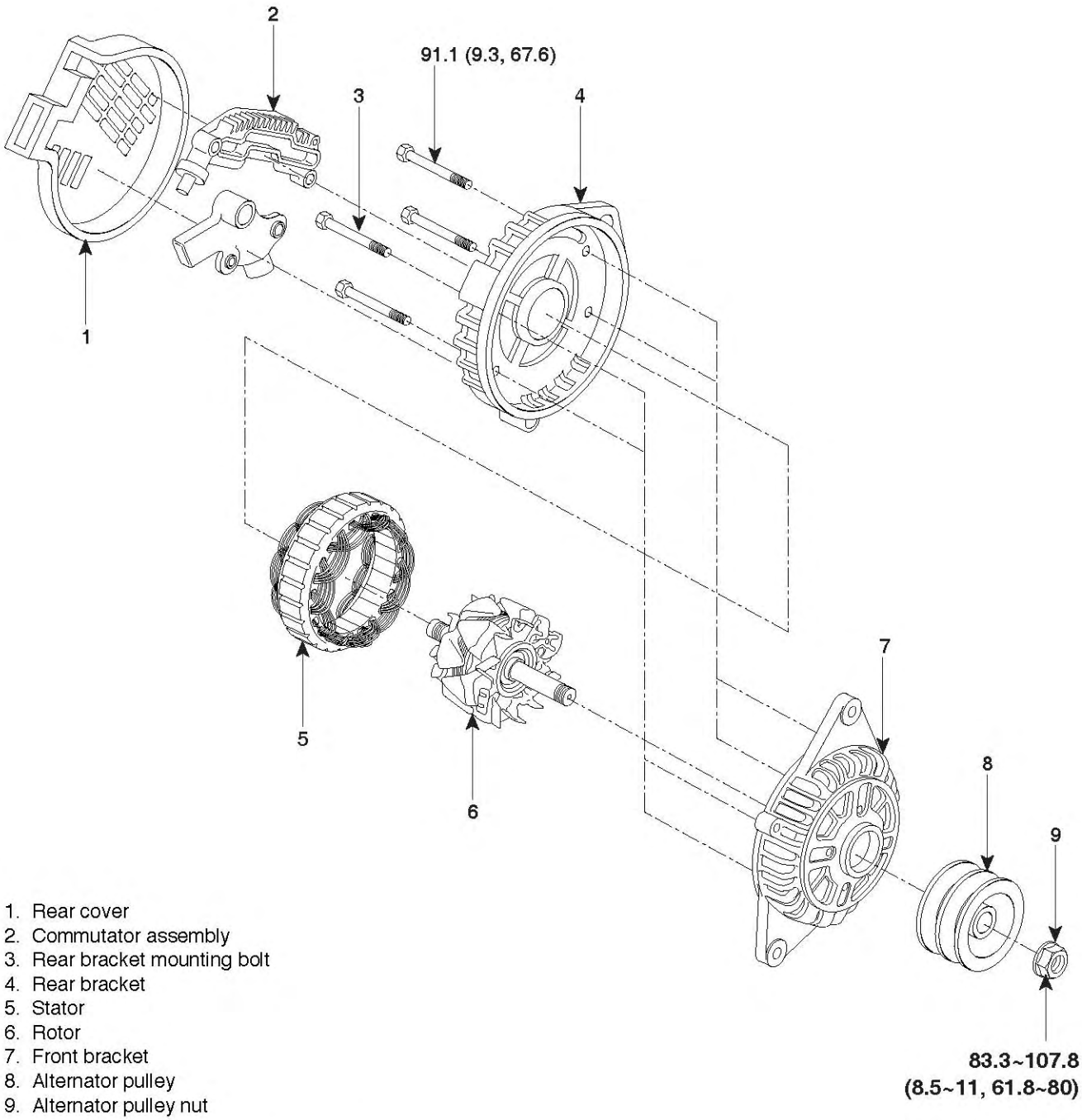
5) Remove ammeter, voltmeter and engine tachometer.

6) Connect alternator output wire to " B" terminal of alternator.

7) Connect the battery ground cable.

ALTERNATOR

COMPONENTS E2C32AAD



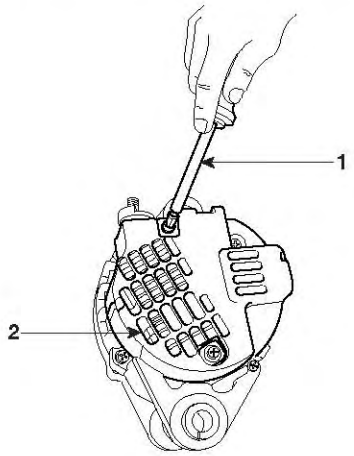
1. Rear cover
2. Commutator assembly
3. Rear bracket mounting bolt
4. Rear bracket
5. Stator
6. Rotor
7. Front bracket
8. Alternator pulley
9. Alternator pulley nut

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

SUDEE7004L

DISASSEMBLY E88A8B47

1. Remove rear cover (2) using a drive (1).



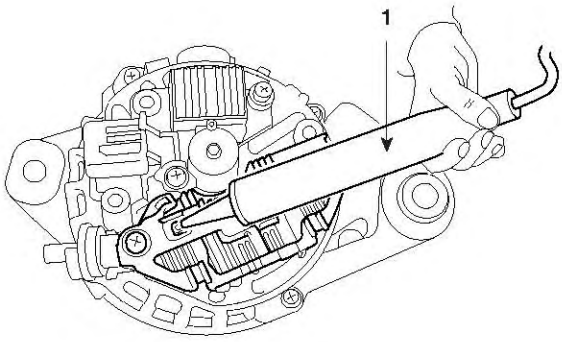
SUDEE7011L

2. Remove the end portions of the 4 stator coils soldered to the commutator main diodes using a soldering tool.

CAUTION

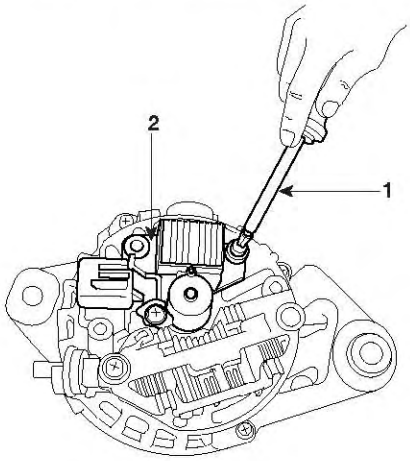
a. Do not overheat the diodes for a long time when soldering or unsoldering.

b. Be careful not to apply excessive force to stator coils soldered to diodes.



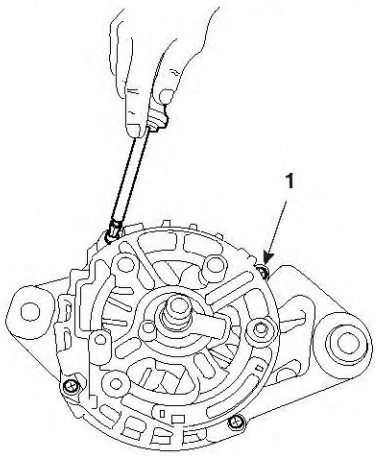
SUDEE7012L

3. Remove the commutator mounting screws using a drive (1) so as to disassemble the commutator (2).



SUDEE7013L

4. Remove 4 rear-bracket-through-bolts.



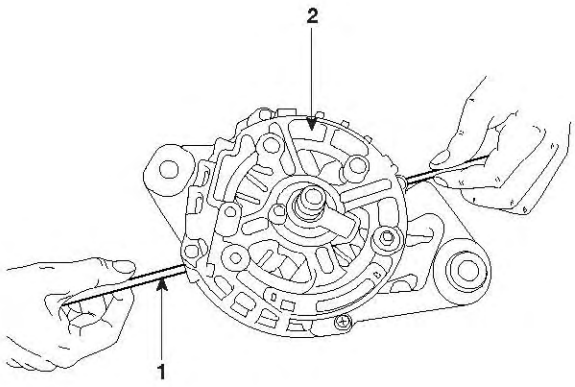
SUDEE7014L

NOTE

When removing rear bracket, insert (-) drive (1) into the groove of the through bolt and then separate the rear bracket.

CAUTION

Be careful not to damage the parts when removing rear bracket.

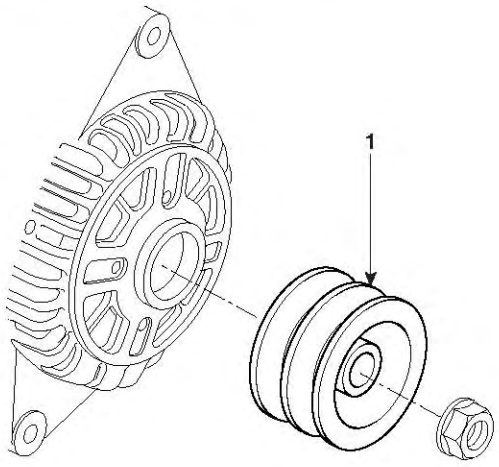


SUDEE7015L

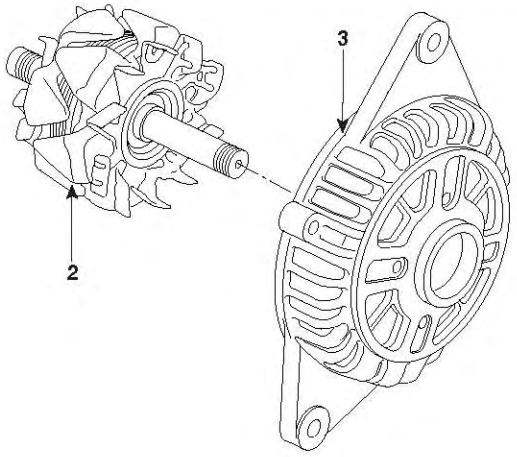
5. Remove the pulley(1) using air tool and disassemble the rotor(2) and the front bracket(3).

CAUTION

Be careful not to be injured from the rotor rotation when removing the pulley.

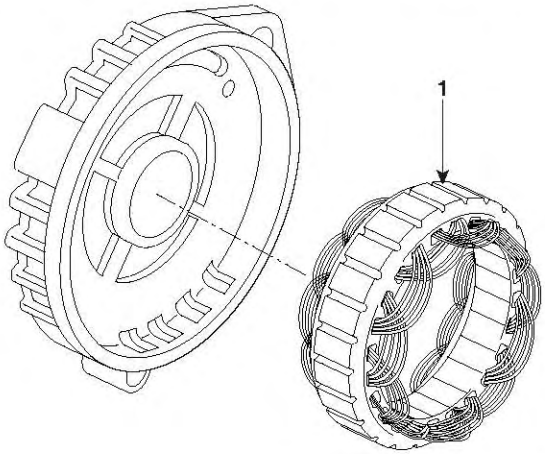


SUDEE7016L



SUDEE7017L

6. Remove the stator (1) from the rear bracket.

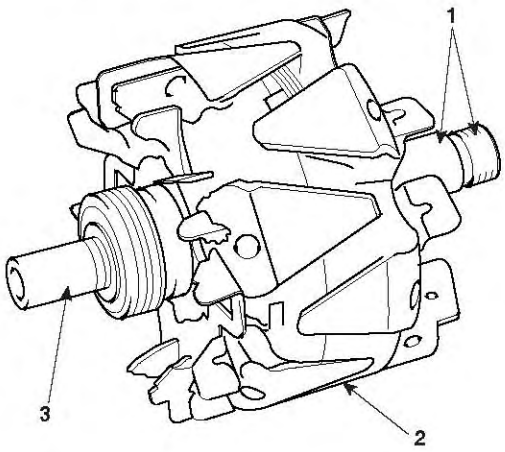


SUDEE7018L

INSPECTION E4C9FEA4

ROTOR INSPECTION

1. Check for continuity between slip rings (1). Replace the rotor if there is no continuity.

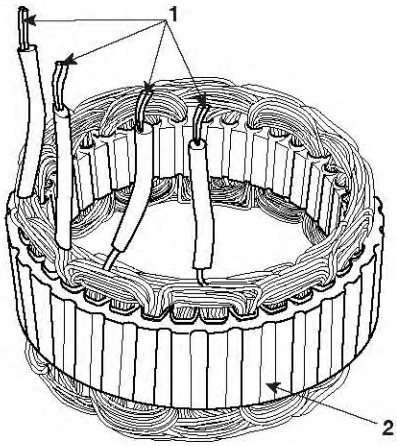


SUDEE7019L

2. Check for the continuity between slip ring (1) and rotor (2), and between slip ring (1) and shaft (3). Replace the rotor if there is continuity each other.

STATOR INSPECTION

1. Check for continuity between lead wires (1). Replace the stator if there is no continuity.



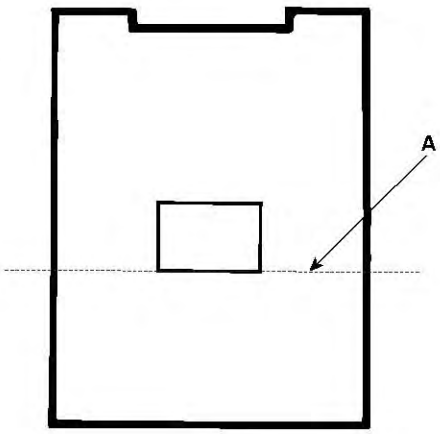
SUDEE7020L

2. Check for continuity between lead wire (1) and coil core (2). Replace the stator if there is continuity.

BRUSH INSPECTION

1. Replace the brush if it is worn exceeding to the limit (A).

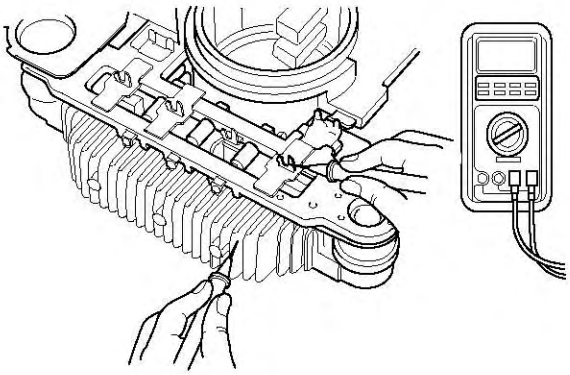
2. Unsolder the lead wire of the brush to separate the brush and spring. When assembling new parts, push the lead wire and solder it so that it fits in the brush holder.



SUDEE7021L

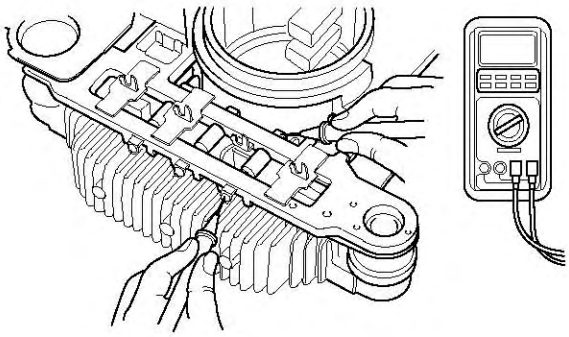
REGULATOR INSPECTION

1. When continuity is tested between (+) regulator and stator coil lead connector, rheostat must show that the electric current flows in one way. If the electric current flows in both ways, replace the regulator assembly because it means that the diode is short.



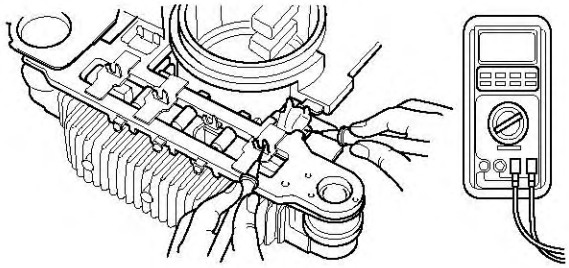
SUDEE7022L

2. When continuity is tested between (-) regulator and stator coil lead connector, rheostat must show that the electric current flows in one way. If the electric current flows in both ways, replace the regulator assembly because it means that the diode is short.



SUDEE7023L

3. When continuity is tested among 4 diodes with rheostat, it must show that the electric current flows in one way. If the electric current flows in both ways, replace the heat sink assembly because it means that the diode is short.



SUDEE7024L

REASSEMBLY E8EA71CE

Assembly is performed in the reverse order of disassembly.

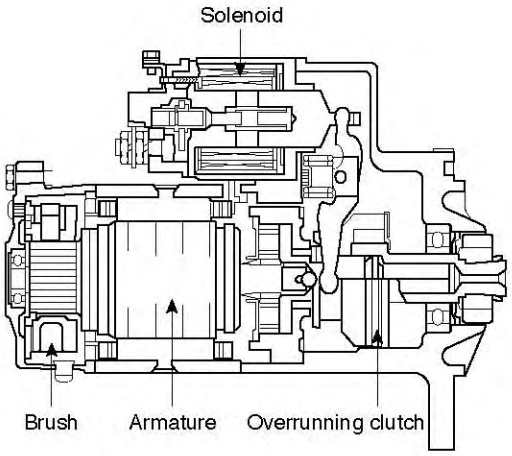
NOTE

When assembling commutator, fix the brush with wire. Assemble the commutator after fixing the brush with wires through small hole of the commutator. Then, remove the wire before assembling the rear cover.

STARTING SYSTEM

DESCRIPTION EDE17AF4

The starting system includes battery, starter motor, solenoid switch, ignition switch, inhibitor switch, ignition lock switch, connection wires and battery cable. When the ignition key is turned to the " START" position, electric current flows so that an electric power is supplied to the starter motor' s solenoid coil. After that, solenoid plunger and clutch shift lever are activated.
Then the clutch pinion engages to the ring gear so that the engine is cranked. In order to prevent damage caused by excessive rotation of the starter armature when the engine starts, the clutch pinion gear overruns.



SUDEE7005L

STARTER CIRCUIT TROUBLE DIAGNOSIS

NOTE

Battery should be fully charged and in good condition.

1. Remove supply pump relay from fuse box.
2. For A/T, with the shift lever at N or P position (A/T), and for M/T, with the clutch pedal being depressed (M/T), turn the ignition switch to START.

NOTE

1. *If the starter cranks the engine successfully, starting system is normal. If the starter fails to crank the engine, go to next step to check.*
2. *When the ignition switch returns to " ON" position from " START" after the switch is released, if the pinion gear is not disengaged from ring gear, check the following items.*

a. Check solenoid plunger and switch for any troubles.
b. Check pinion gear or overrunning clutch for any damage.

3. Check the connection state of each battery, terminals, the connection state between battery (-) cable and the body, the engine ground cable, the connection state of the starter " B" terminal and any corroded portion. And, then crank the engine again.

NOTE

If the starter cranks the engine, poor connection is the cause for the trouble. Then, the starting system is now normal. If it fails to crank again, go to next step to continue the checking.

4. After disconnect the connector from " S" terminal of starter solenoid, connect the " B" terminal of solenoid to the " S" terminal of solenoid using jump wire.

NOTE

If starter cranks the engine, go to next step to continue checking. Otherwise, remove the starter to repair or replace if necessary.

5. Check the following items until an open circuit is found.
   a. Check the connectors and wires between the interior fuse box and the ignition switch, and the connectors and wires between the interior fuse box and the starter.
   b. Check the ignition switch.
   c. Check the shift range switch and connector and the ignition lock switch and connector.
   d. Check the starter relay.

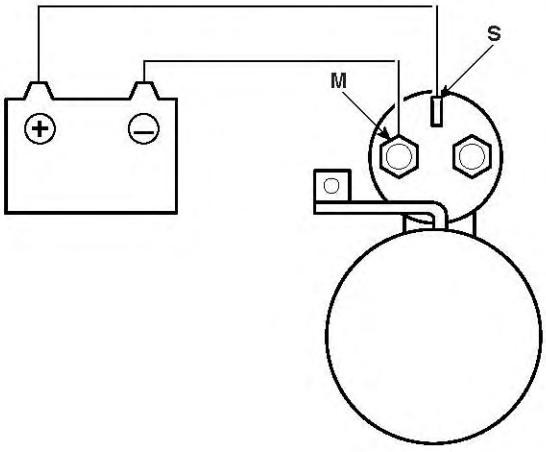
INSPECTION E5B3E8A5

PINION GAP

1. Remove field coil from " M" terminal of magnetic switch.
2. Connect the battery between " S" and " M" terminal of magnetic switch.

CAUTION

Do not try continually the connection longer than 10 seconds to prevent coil from being burned out.



SUDEE7025L

3. Slightly push the protruded pinion with hand and measure the returns (moving distance). This distance is the pinion gap.
4. If the pinion gap exceeds the reference value, increase or decrease the number of fiber washers between the magnetic switch and the front bracket to adjust the gap to the reference value. Pinion gap decreases as the number of washer is increased.

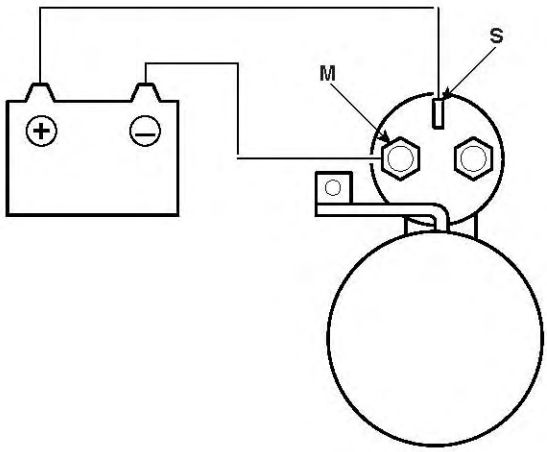
Reference value : 3.0mm

PULL-IN COIL TEST IN THE MAGNETIC SWITCH

Pull-in coil is normal if the plunger is inserted and then the pinion pops out when the battery is connected between " S" and " M" terminals of magnetic switch. If it does not pop out, replace the magnetic switch.

CAUTION

- ***When this test is performed, remove the connector from " M" terminal.***
- ***Do not try continually the connection longer than 10 seconds.***



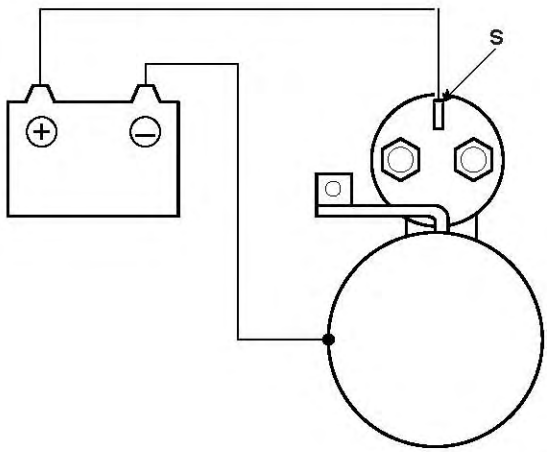
SUDEE7026L

HOLDING COIL SUPPORT TEST IN THE MAGNETIC SWITCH

Pull out the pinion to the stopper position by hand as battery is connected between " S" terminal of magnetic switch and body. If pinion returns when it is released, holding coil is normally functioning.

CAUTION

Do not try continually the connection longer than 10 seconds.



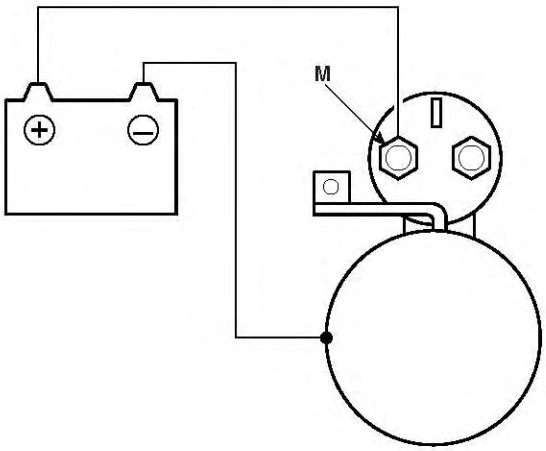
SUDEE7027L

MAGNETIC SWITCH RETURN TEST

Pull out the pinion to the stopper position by hand as battery is connected between " M" terminal of magnetic switch and body. If pinion returns immediately when it is released, both coils are normally functioning.

CAUTION

Do not try continually the connection longer than 10 seconds.



SUDEE7028L

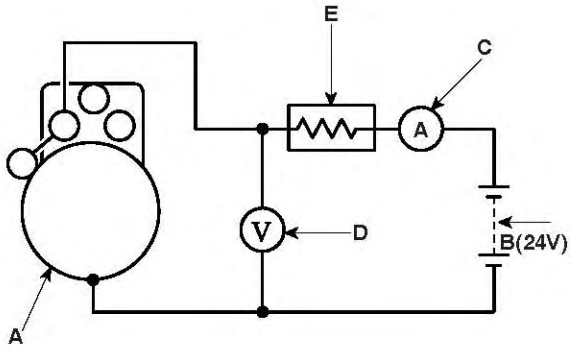
UNLOADING TEST

1. Connect starter motor (A), battery (B), ammeter(C), voltmeter (D) and rheostat (E) as shown in the following figure.
2. Turn the switch ON with setting the rheostat at max. If starter motor rotates smoothly, then the starter motor is normal.

CAUTION

a. The wires should be thick as possible and all terminals should be tightened securely.

b. If the starter motor operates for a long time, then the rotation speed drops down because the battery may be discharged. Do not operate it longer than 10~15 seconds at once.



SUDEE7029L

3. If the current and rpm are not in accordance with the standards, perform troubleshooting as to the following table.

Troubles	Possible cause
High current and low rpm. Torque is not enough strong.	Metal portion is damaged or oil is polluted Armature core and pole piece are worn Armature coil is short
High current and no rotation.	Armature switch is connected to the ground Armature coil or field coil is connected to the ground Metal portion is melted
No current and no rotation.	Armature coil or field coil is broken Brush and pigtail are broken Poor contact between brush and commutator due to the stain or biotite etc.
Low current and rotation. (Torque is not so strong.)	Poor contact at field coil connection (However, if only shunt coil is short or poorly connected, rotation will be high.)
High current and high rotation. (Torque is not so strong.)	Feed coil is short

PREHEATING SYSTEM

PREHEATING PLUG

INSPECTION EAFFB528

PRE-HEATING SYSTEM OPERATING INSPECTION

1. Conditions before inspection : battery voltage is 24V coolant temperature is below 30°C (or perform the test as the coolant temperature sensor is disconnected.)
2. Connect the voltmeter between glow plug plate and plug body (earth).
3. Turn the ignition switch ON and read the voltmeter value.
4. If the pre-heating indication lamp lights for about 6 seconds and indicates battery voltage for about 36 seconds after ignition switch is turned ON, the system is normal.
   (When coolant temperature is 20 °C)

⚠ CAUTION

Time for electric current varies depending on the coolant temperature.

5. After checking No.3, set the ignition switch to START position.
6. If the battery voltage is generated during engine cranking and for about 6 seconds after start, the system is normal.
   (When coolant temperature is 20 °C)

RELATION BETWEEN GLOW PLUG TEMPERATURE (RESISTANCE) AND TIME FOR ELECTRIC CURRENT.

1. It takes approximately 8 ±1.5 seconds to heat the glow plug up to 800°C when glow plug is cold with the battery voltage of DC 23V or more.
2. Apply the battery voltage of DC 23V. After 30 seconds, the temperature should be less than 1050±80°C.

GLOW PLUG INSPECTION

1. Check glow plug plate for rust.
2. Check glow plug for any damage.

⚠ CAUTION

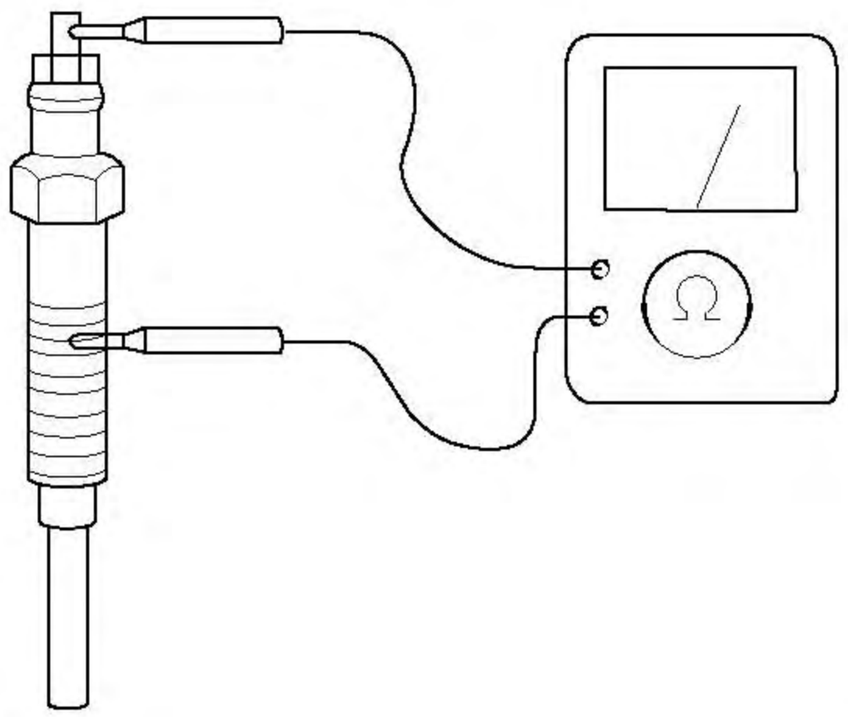
Do not use the plug if it has been dropped from the height of 10cm or more.

3. Check the resistance between terminal of each glow plug (NO.1~NO.4) and body.

Reference value : 4Ω

⚠ CAUTION

As glow plug resistance is very small, remove any oil from plug surface before measuring the resistance.



SUDEE7054L

FUEL SYSTEM

GENERAL

SPECIFICATION EE637DFF

Items			Specification
Sensors	BPS (Booster Pressure sensor)	Supply voltage	5V
		Operating voltage	4.5~5.5V
		Operating temperature	-40~125°C
		Operating pressure	32.5~284kpa (244~2130mmHg)
		Current	MAX. 10mA
	IAT (Intake Air Temperature) sensor	Type	Thermistor type
		Resistance	2.31~2.56kΩ [at 20°C(68°F)]
			0.30~0.34kΩ [at80°C(176°F)]
	WTS (Water temperature sensor)	Type	Thermistor type
		Resistance	2.31~2.59kΩ [at 20°C(68°F)]
			0.314~0.331k Ω [at 80°C(176°F)]
	TDC sensor	Type	Hall sensor type
	CKP sensor	Type	Magnetic type
	APS (Accel position sensor)	Type	Variable resistance type (Potentia meter type)
		Voltage	5V±1%
		Current	10mA MAX.
	Fuel pressure sensor	Type	Piezo electricity type
Actuator	Injector	Type	Electromagnetic type
		Resistance	0.45Ω
Supply control valve	SCV	Current	When operating : below 1.29A When stopped: below 1.16A
High-pressure side fuel pressure		Max pressure	1800bar
Supply pump		Type	Included into high pressure pump, mechanical type
		Power	Mechanical gear type
Fuel filter		Type	Filter type

SEALANT

Engine Coolant Temperature Sensor	Three Bond 2310 or equivalent

TIGHTENING TORQUE EFADB751

Items	N.m	Kgf.m	lb.ft
Common rail installation	21.6-32.4	2.2-3.3	15.9-23.9
Engine Coolant Temperature sensor	29.4-39.2	3.0-4.0	21.6-28.9
Pipe (rail -injector 1/2/3/4)	39.2-49	4.0-5.0	29-36.2
Injector clamping bolt	30.4-34.3	3.1-3.5	22.4-25.3
Supply pump fixing bolt	18.6-27.5	1.9-2.8	13.7-20.3
TDC- bolt	7.9-11.8	0.8-1.2	5.8-8.7
CKP- bolt	7.9-11.8	0.8-1.2	7.9-11.8
Pipe (high pressure pump - rail)	39.2-49	4.0-5.0	29-36.2
Supply pump nut	58.8-68.7	6.0-7.0	43.4-50.6

TROUBLESHOOTING E5DFFBFF

FUEL INJECTION SYSTEM

Troubles	Possible causes	Corrective actions
Engine does not crank.	Poor tightening of supply pump nut.	Remove the supply pump and check nut tightening.
	Defective SCV of supply pump	Replace
	Low cranking speed	Repair the starter or charge or replace battery.
	Low voltage to glow plug system	If the test light turns on indicating low voltage when it turns " ON" , check relay and wiring.
	Defective glow plug	Replace the glow plug
	Air in the fuel system	Air bleeding of fuel system
	Injection pipe is connected incompletely.	Connect the pipe correctly
	Improper injection timing	Check ECU
	Poor injection	Check, replace injector
	Mechanical defect of engine	Compression test, repair engine
	Simultaneous failures of TDC sensor and CKP sensor	Check and tighten correctly Replace

Troubles	Possible causes	Corrective actions
Idle is improper or idle speed is unstable or irregular	Loose fuel hose connection between filter and supply pump.	Tighten or repair.
	Air in the fuel system	Air bleeding of fuel system
	Fuel filter is clogged. Or fuel supply is no good because fuel line or injection pipe leaks, pinched or pressed.	Check hose or fuel line. Replace fuel filter.
	Poor injection	Check, replace injector.
	Improper injection timing	Check ECU.
	Mechanical defect of engine	Compression test, repair engine.
	Defective supply pump	Let the engine at idle after replacing pump.
	Engine defect at high gear range	Observe appropriate shift speed.
Exhaust gas (Black, blue, white)	Engine temperature stays below engine operation temperature.	Check rail pressure and cooling system. Replace thermostat.
	Abnormal at max RPM	Check and replace supply pump.
	Defective Injection nozzle	Check and repair or replace.
	Improper injection timing	Check ECU.
	Exhaust system malfunction	Check if deformed or clogged.
	Mechanical defect of the engine	Compression test, repair engine.
	Defective supply pump	Replace pump.
	Non-input of QR code value	Check the input of QR code value. Check if it matches the QR value on the injector.
Engine lacks power, acceleration is delayed(Speedometer is normal, no clutch slip)	Accel pedal malfunction	- Check the history of trouble codes, check rail pressure. (Target value, Actual value) - Input the improved ECU data
	Defective max. rpm	Check and replace supply pump
	Air cleaner element polluted	Clean or replace.
	Fuel filter is clogged. Or fuel supply is no good because fuel line or injection pipe leaks, pinched or pressed.Or fuel filter leaks	Check fuel line and hose, replace fuel filter.
	Air in the fuel system	Air bleeding of fuel system
	Defective injector nozzle	Check, repair or replace.
	Improper injection timing	Check ECU.
	Mechanical defect of engine	Compression test, repair engine.
	Defective supply pump	Check after replacing pump.

Troubles	Possible causes	Corrective actions
Excessive fuel consumption	Air cleaner filter is polluted	Clean, replace air cleaner element.
	Fuel leaks	Check, replace or tighten every connection of hose and pipe.
	Return pipe and hose are clogged	Check and replace the return line, blow air if clogged and drain the fuel.
	Defective injection nozzle	Check. Repair or replace.
	Mechanical defect of engine	Compression test, replace engine.
	Defective supply pump	Replace pump.

ENGINE CONTROL

Troubles	Possible causes	Corrective actions
Engine will not turn off	Injector wiring short	Check injector wiring.
	Starting switch harness is damaged	Replace.

ENGINE STARTING SYSTEM

Troubles	Possible causes	Corrective actions
Engine does not crank	Defective supply pump/defective SCV	Replace
	Low battery voltage	Recharge or replace the battery.
	Battery cable connection is loose, corroded or worn	Replace or retighten.
	Fusible link is swelled	Replace the fusible link.
	Defective starter motor	Repair
	Defective injector	Replace
Cranking speed is low	Low battery voltage	Recharge or replace the battery.
	Battery cable connection is loose, corroded or worn	Repair or replace.
	Defective starter motor	Replace
Starter motor continues to run.	Defective starter motor	Replace
	Defective ignition switch	Replace the ignition switch.
Starter motor runs but engine is not cranking.	Defective wiring	Repair wiring.
	Starter motor, pinion gear damaged	Repair starter motor.
	Ring gear damaged	Replace flywheel or torque converter gear.

FUEL TANK AND FUEL LINE

Troubles	Possible causes	Corrective actions
Poor engine performance due to insufficient fuel supply	Fuel pipe is twisted or broken	Repair or replace.
	Fuel pipe or hose is clogged	Clean or replace.
	Fuel filter is clogged	Replace.
	Water intrudes into fuel filter.	Replace fuel filter or clean fuel tank or fuel line.
	Foreign materials intrude in fuel tank. Fuel tank is corroded.	Clean or replace.
	Defective supply pump operation	Replace assembly.
Fuel filter warning lamp blinks.	Excessive water is in fuel filter.	Drain the water collected in the fuel filter. (Loosen the drain plug at the bottom of fuel filter.)

TROUBLESHOOTING PROCEDURE

Troubles / Check items	Engine does not crank	Restart after engine stop	Hard to crank the engine	Stay in high rpm (without any accel pedal pressing)	Knocking during acceleration (during warm-up)	Vibrates at idle	Lacks of power	Poor engine operation, ignition fail, knocking	Bucking (sudden movement)
Self-diagnosis	1	1	1	1	1	1	1	1	1
Vehicle supply voltage	2		2					9	3
Main relay	3	3	3					11	4
Fuse/plug wire harness	4	2						8	2
Terminal 46 (Ignition ON/OFF signal)	5	4	4					10	5
CKP sensor	6		6			15		12	
Run out of fuel	7								
Wrong fuel	8	5	7			2	3	3	
Fuel shortage								2	
Air mixture in fuel	9	6	8			3		4	
Low pressure circuit (fuel)	10	7	12			4	4	7	
High pressure circuit (fuel)	14	8	13			12	14	17	
Fuel filter	11		9			5	5	5	
Supply pump	16		11					6	
Fuel pre-heater	12		10			6	6		
Wrong injector connection	13		16		3	11	17	13	
Injector	15	9			4	9	13	14	
Mechanical components (Pressure valve gap, compression etc)	19		18				16	18	8
Defective ECU	20								
TDC sensor	22		5						
Water temperature sensor (WTS)			14		2		15		
Coolant loss									
Glow plug system	21		16						

SUDFL7001L

Troubles / Check items	Engine does not crank	Restart after engine stop	Hard to crank the engine	Stay in high rpm (without any accel pedal pressing)	Knocking during acceleration (during warm-up)	Vibrates at idle	Lacks of power	Poor engine operation, ignition fail, knocking	Bucking (sudden movement)
Self diagnosis	1	1	1	1	1	1	1	1	1
Rail pressure sensor (RPS)	18		15			10	11	15	
Accel position sensor (APS)				2			7		
Mechanical defect of accel				3			8		
Booster pressure sensor						8	12		
Air filter is clogged			17			7	2		
Defective turbo charger							9		
Waist gate valve connection							10		
Check the valve tension								16	
Clutch switch									6
Brake switch									7
Vehicle speed signal									7
Check the Oil level									
Radiator fan									
Radiator is defective or clogged									
Defective IG switch									
AC pressure SW									
AC SW									
Plug adhesion			6						
Leaks at the connection of turbo and intake manifold			6				11		

SUDFL7002L

Troubles / Check items	Engine overruns, accel	White/blue smoke	Discharging black smoke	Engine overheat	Engine stop is impossible with ignition key	Diagnostic lamp remains on or blinking	AC is not turn on
Self diagnosis	1	1	1	1	1	1	1
Vehicle voltage supply							
Main relay							
Fuse/plug wire harness					4	2	2
Terminal 15 (Ignition ON/OFF signal)					3		
CKP sensor							
Run out of fuel							
Wrong fuel				2			
Fuel shortage							
Air into the fuel		3					
Fuel filter		4					
Supply pump							
Fuel pre-heater		5					
Wrong injector connection							
Injector							
Mechanical components (Pressure valve gap, compression etc)			5	7			
Defective ECU					5		
TDC sensor							
Water Temperature Sensor (WTS)	6	2	4	3			5
Coolant loss				6			
Glow plug system							

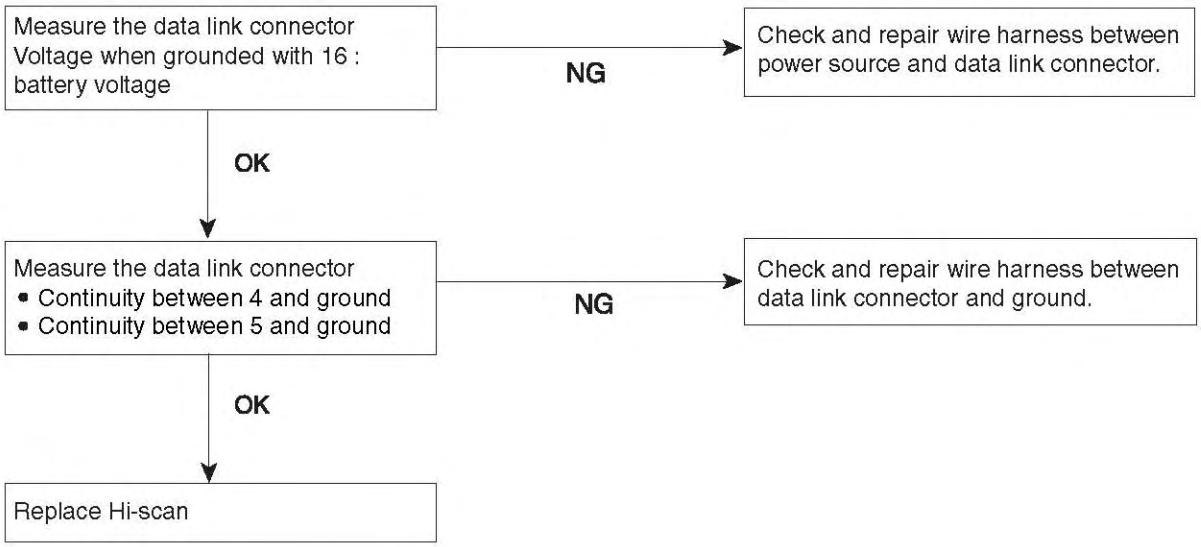
SUDFL7003L

Troubles / Check items	Engine overruns, accel	White/blue smoke	Discharging black smoke	Engine overheat	Engine stop is impossible with ignition key	Diagnostic lamp remains on or blinking	AC is not turn on
Rail pressure sensor (RPS)							
Accel position sensor (APS)	3						6
Mechanical defect of accel	2						
Booster pressure sensor			3				
Air filter is clogged			2				
Defective turbo charger	4						
Waist gate valve connection	5						
Check the valve tension							
Clutch switch							
Brake switch							
Vehicle speed signal							
Check the oil level		6					
Radiator fan				4			
Radiator is defective or clogged				5			
Defective IG switch					2		
AC pressure SW							4
AC SW							3
Plug adhesion							
Leaks at the connection of turbo and In-manifold							

SUDFL7004L

TROUBLESHOOTING PROCEDURE

When communication with diagnosis equipment is not possible
(Communication with any system is not possible)

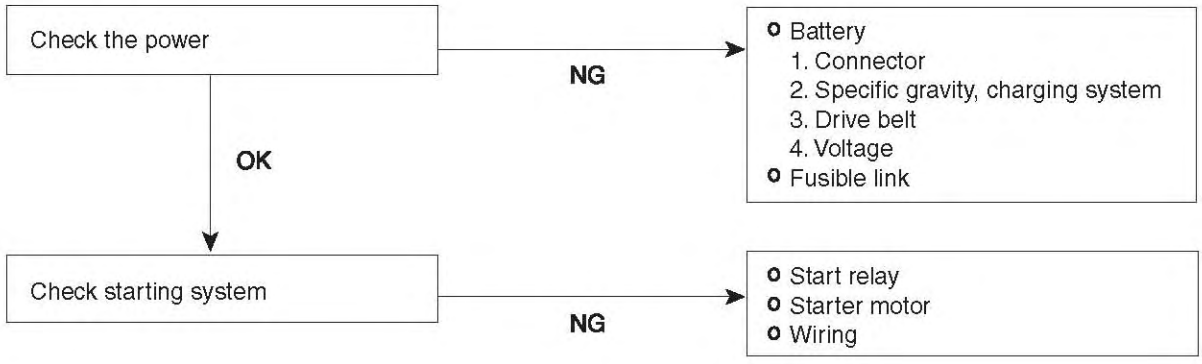


SUDFL7005L

When communication between diagnosis equipment and ECU is not possible

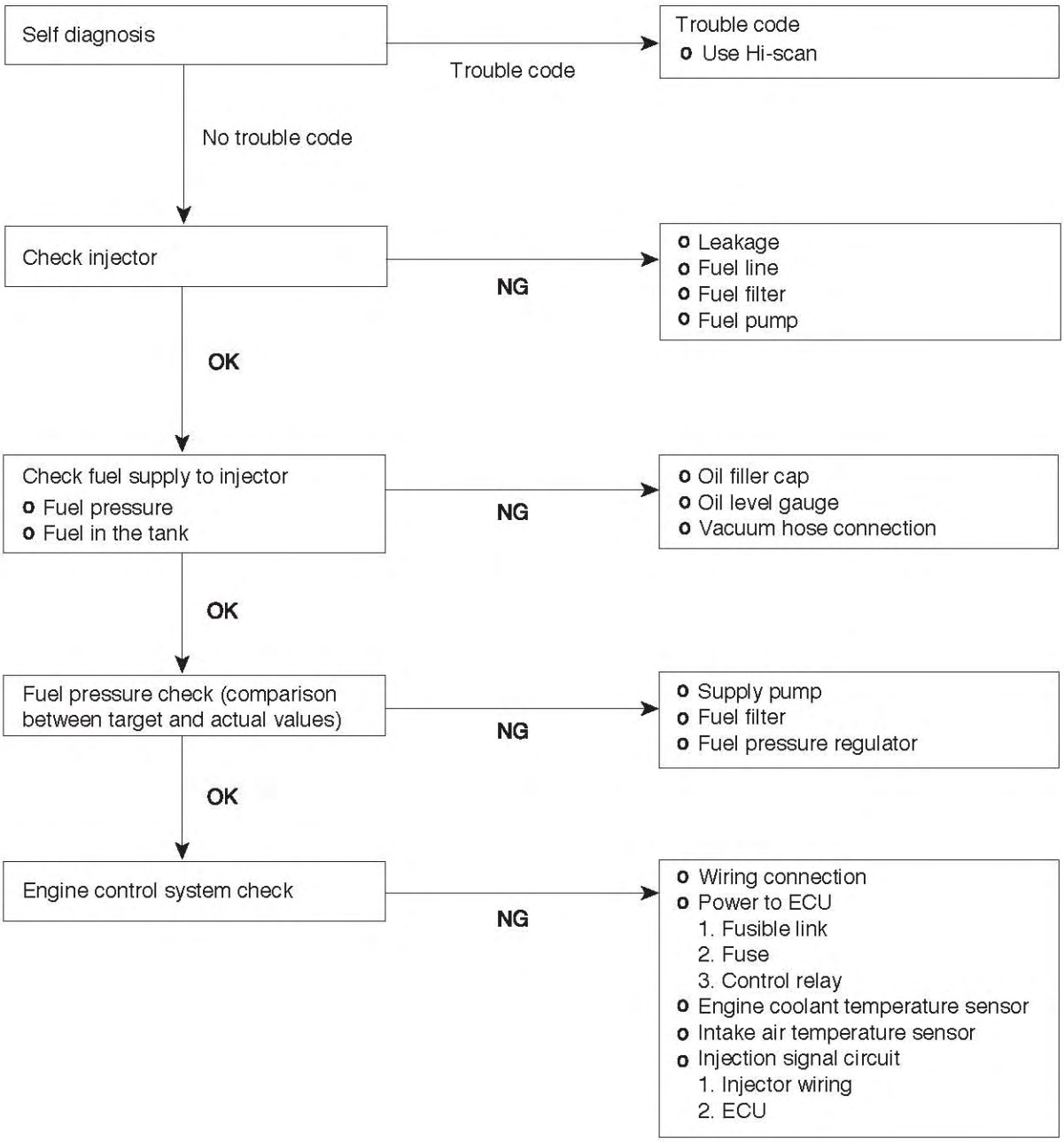
Trouble symptoms	Probable causes
It shows at least one of the following symptoms. • When power is not supplied to ECU . • ECU ground circuit is defective • Defectives on ECU • Wrong communication line between ECU and Hi-scan	• Power supply circuit to ECU is broken. • ECU is out of order. • Circuit between ECU and DLC is open.

Engine is not start.



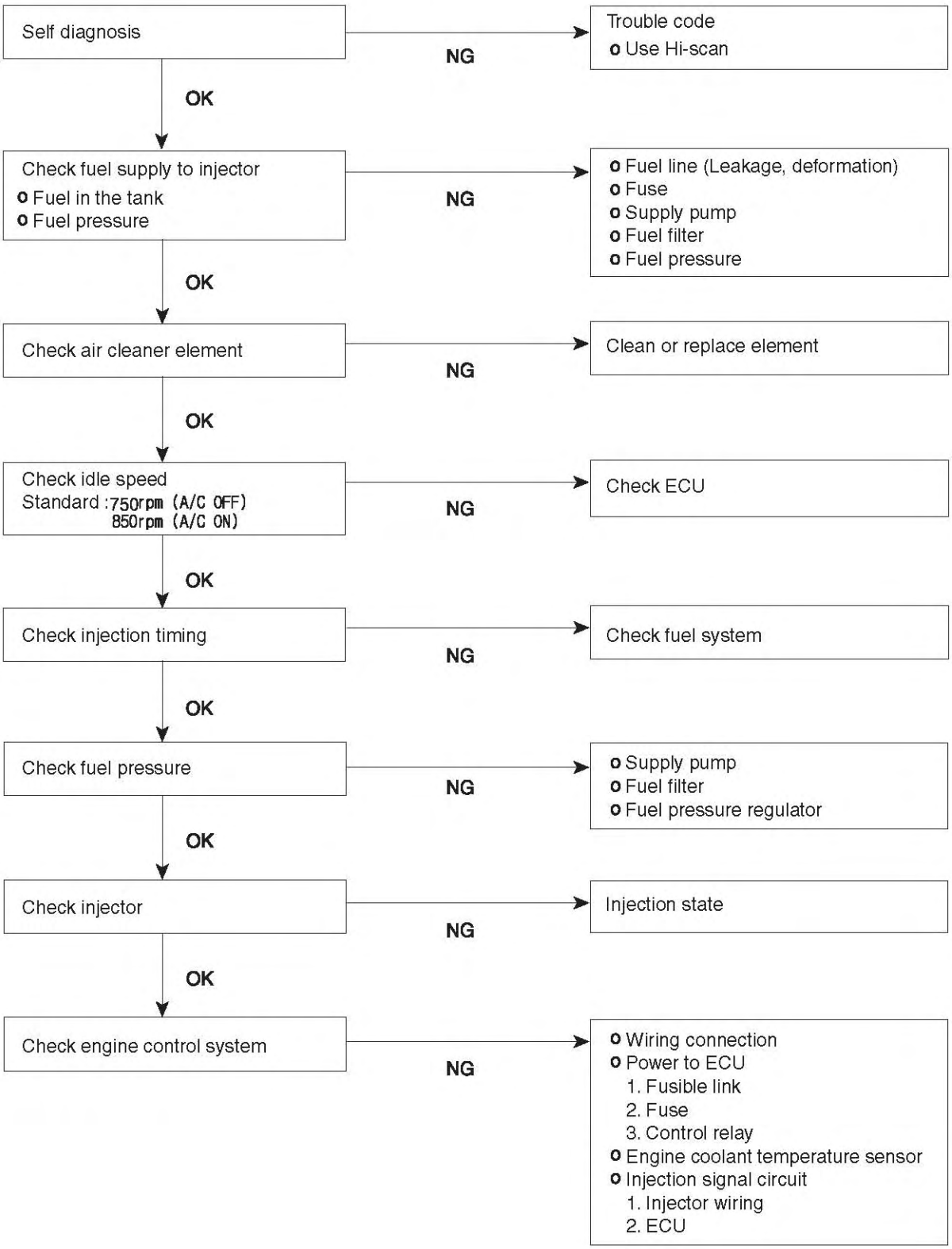
SUDFL7006L

Hard to start the engine.(cranking is possible)



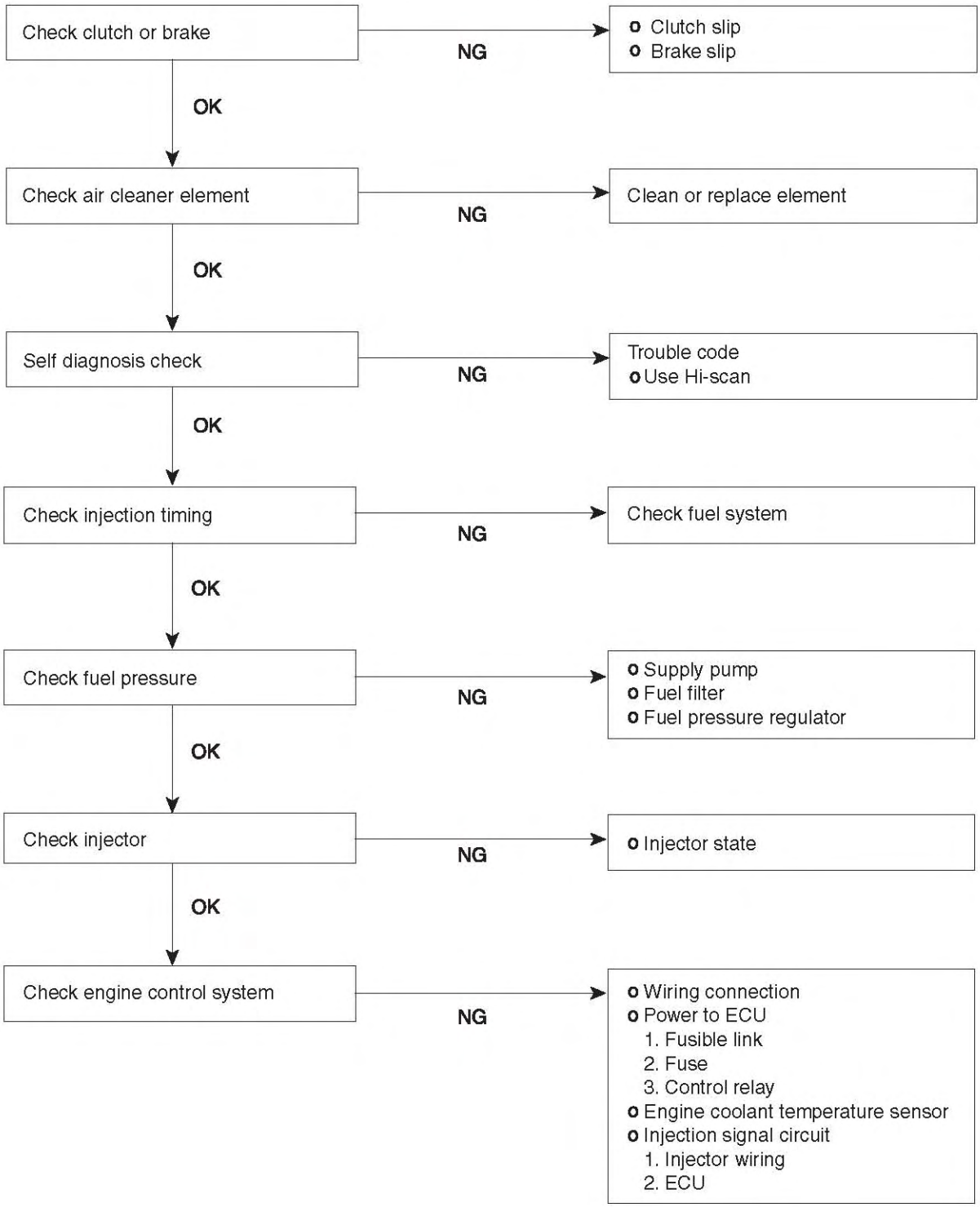
SUDFL7007L

Unstable idle or engine stall.



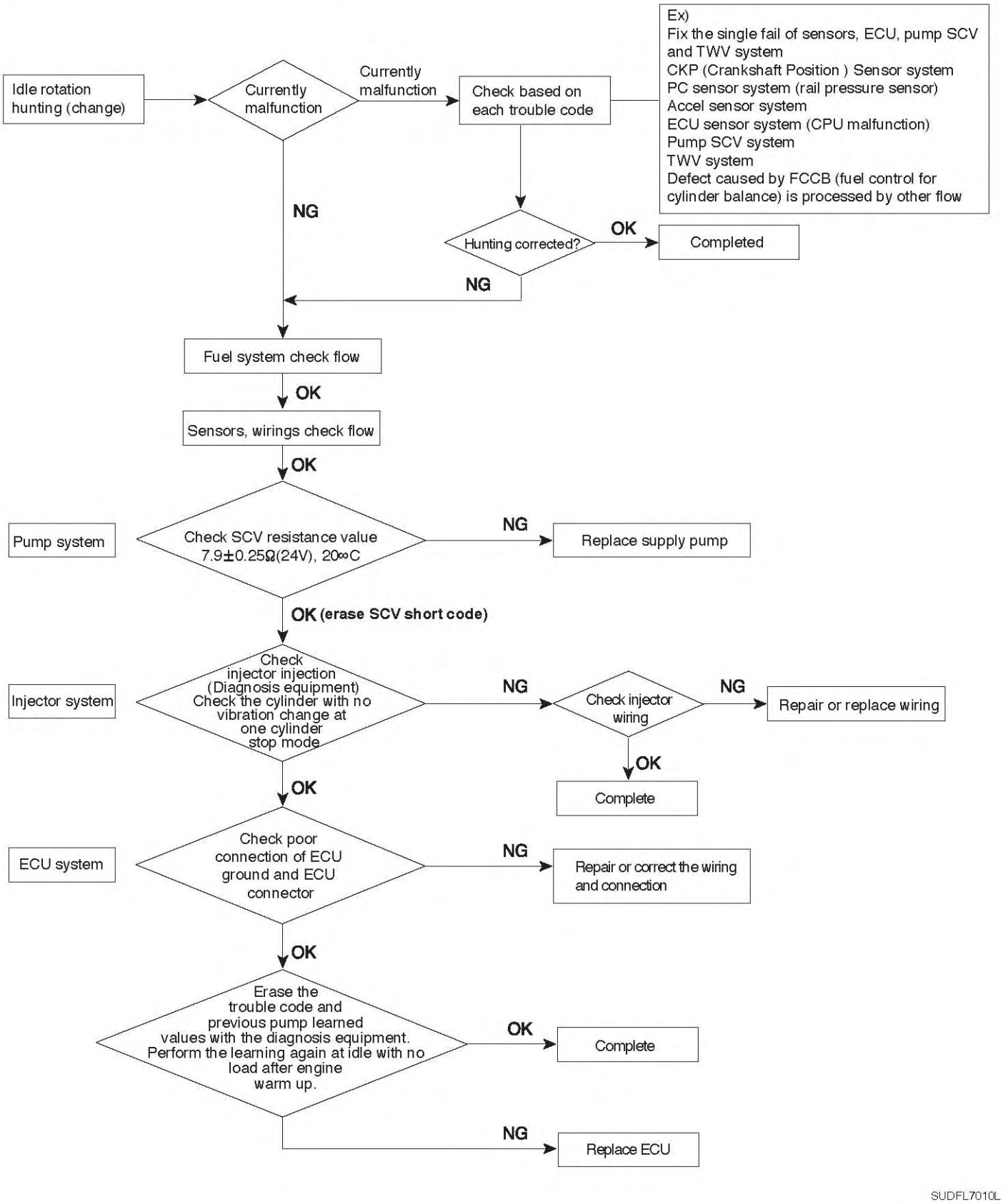
SUDFL7008L

Engine hesitation or poor acceleration



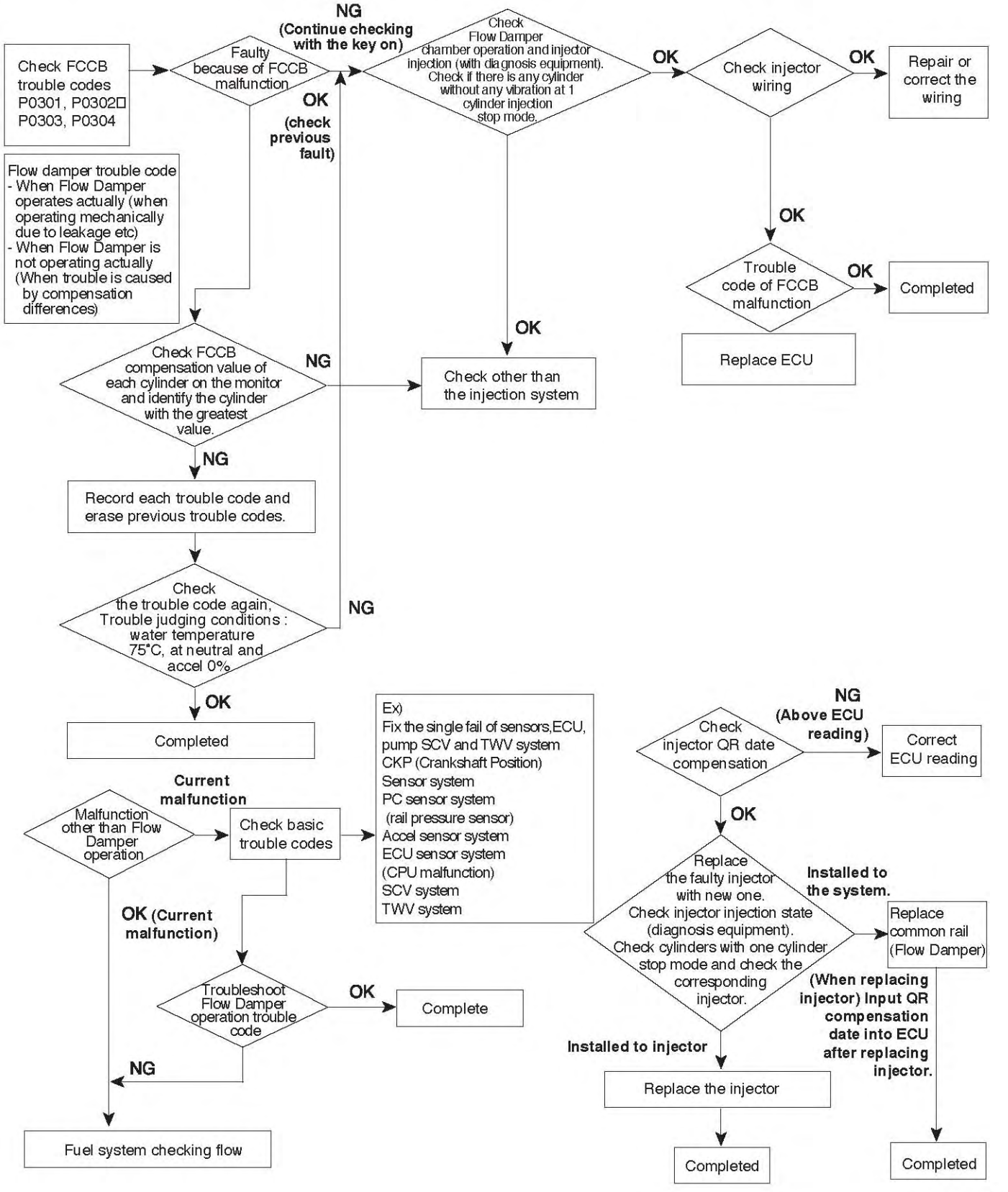
SUDFL7009L

Trouble diagnosis flow when HUNTING is occurred

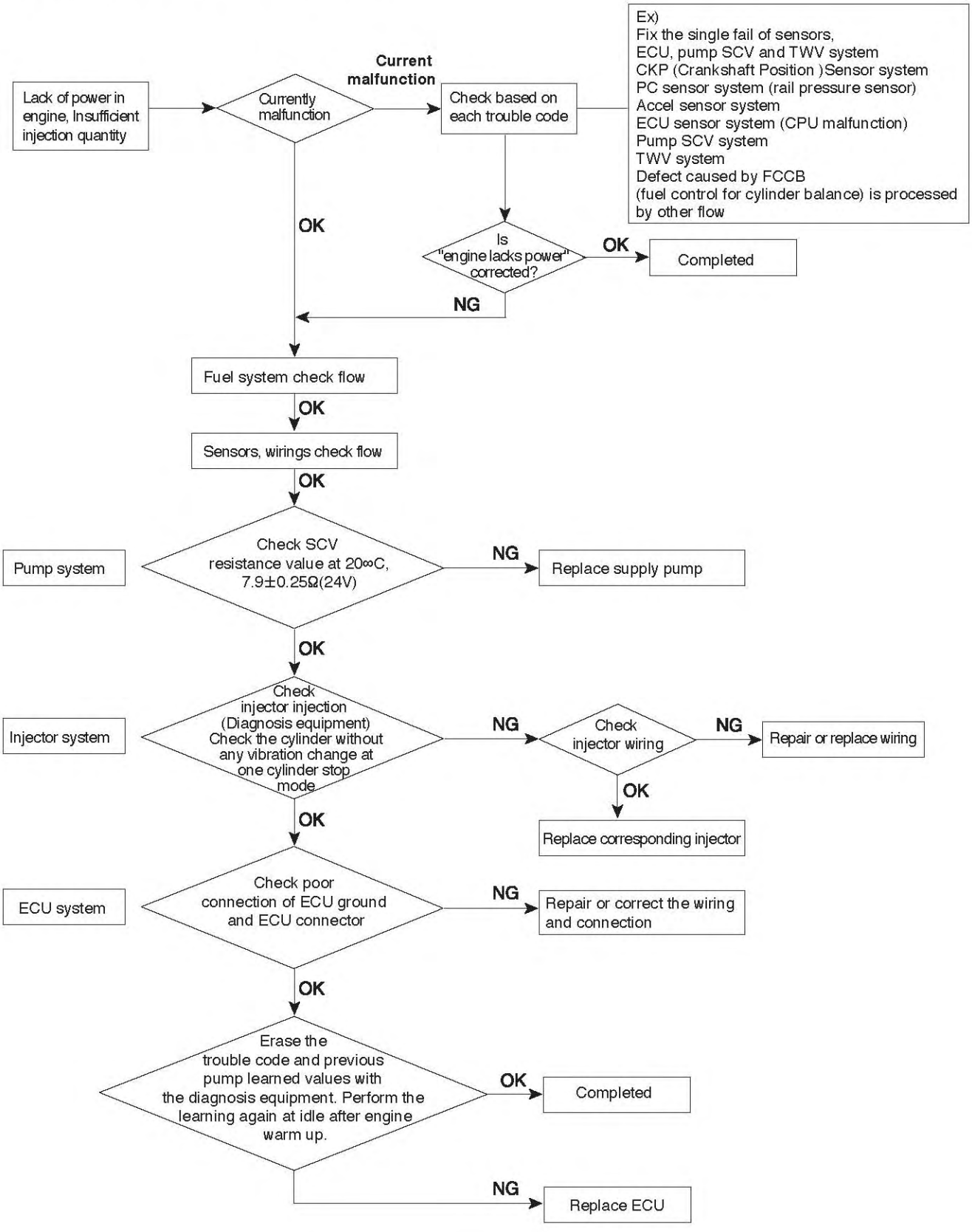


SUDFL7010L

Trouble diagnosis flow when FCCB(Fuel control cylinder balance) fails

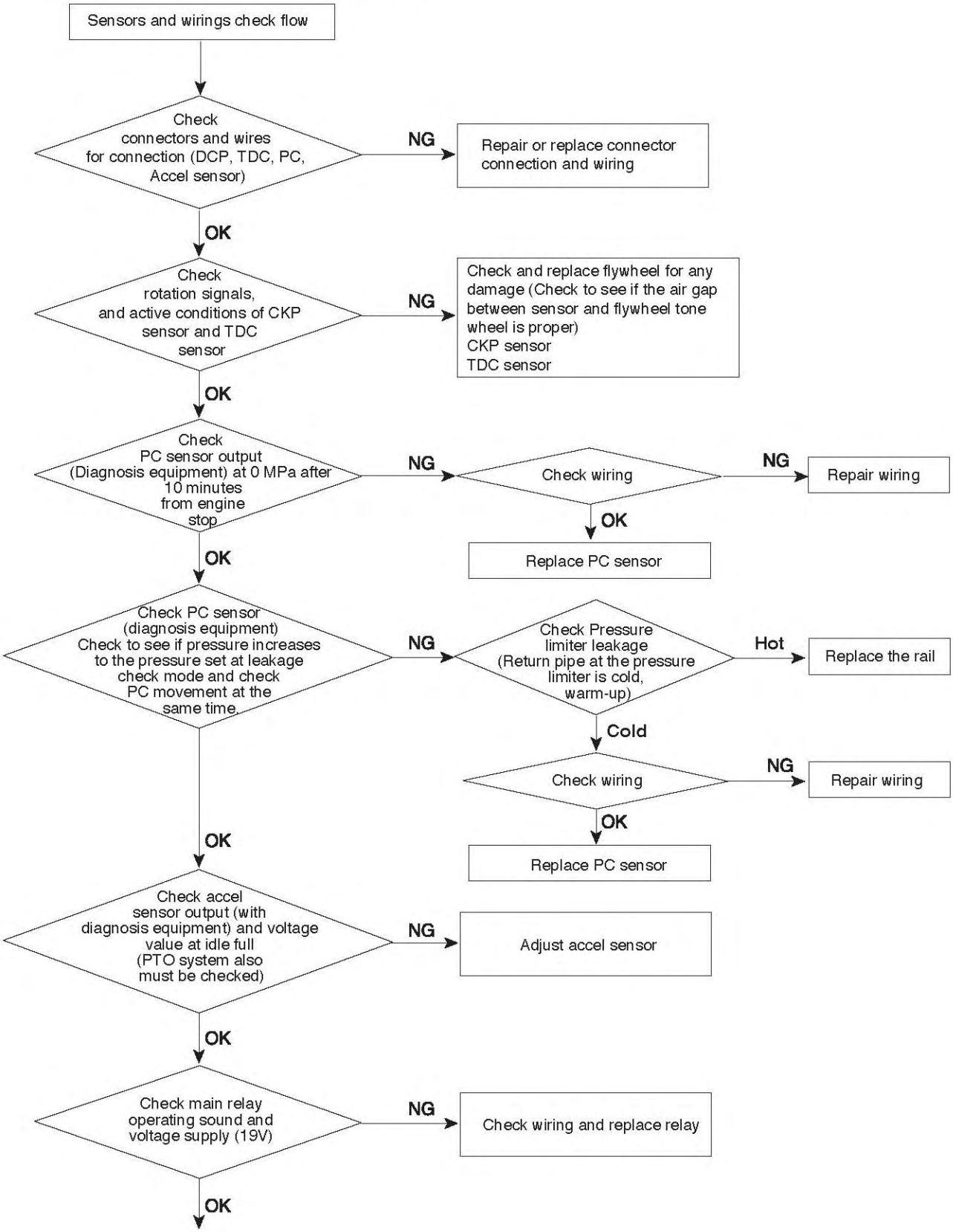


Trouble diagnosis flow when engine is lack of power



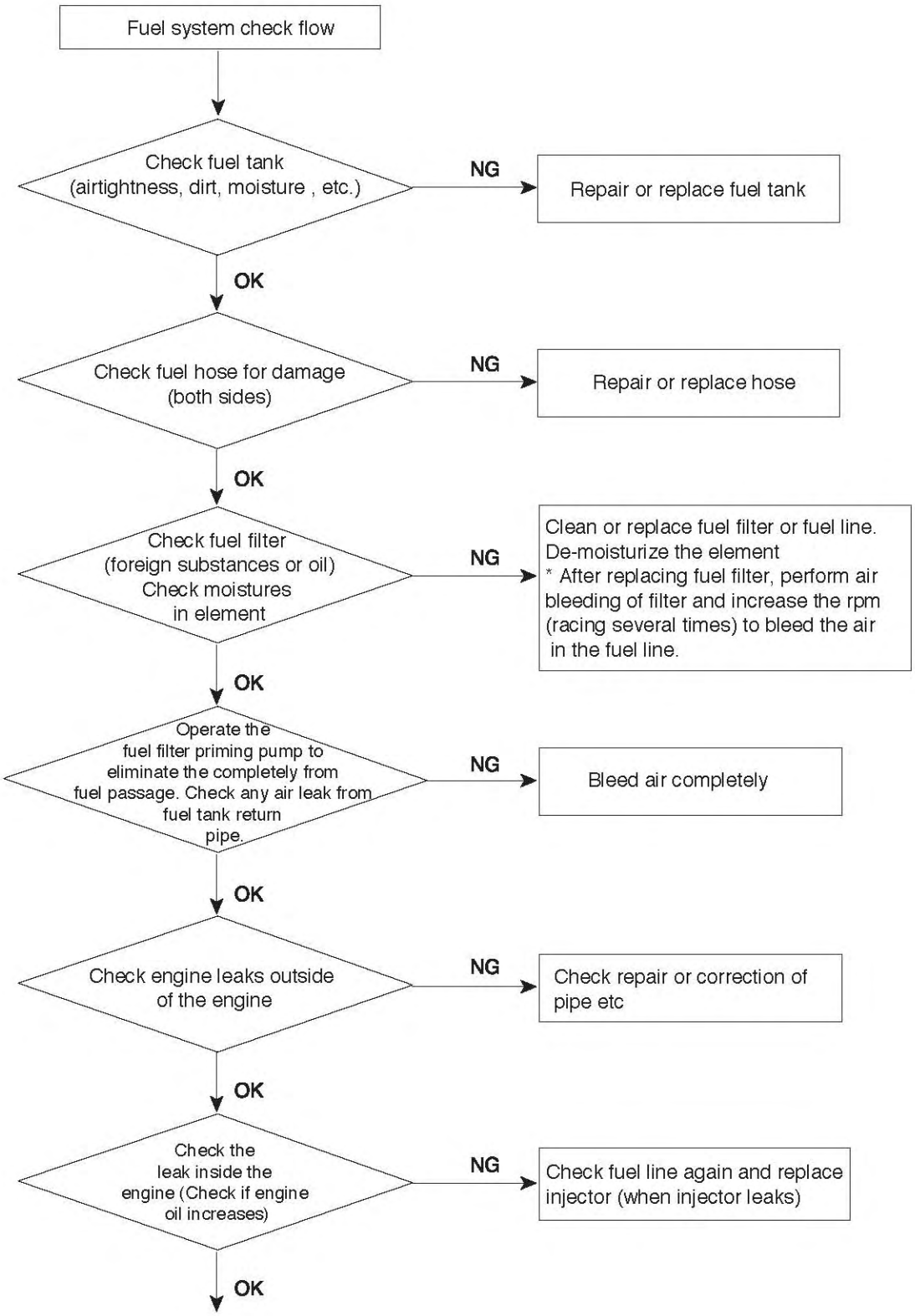
SUDFL7012L

Trouble diagnosis flow in systems of sensors and wirings



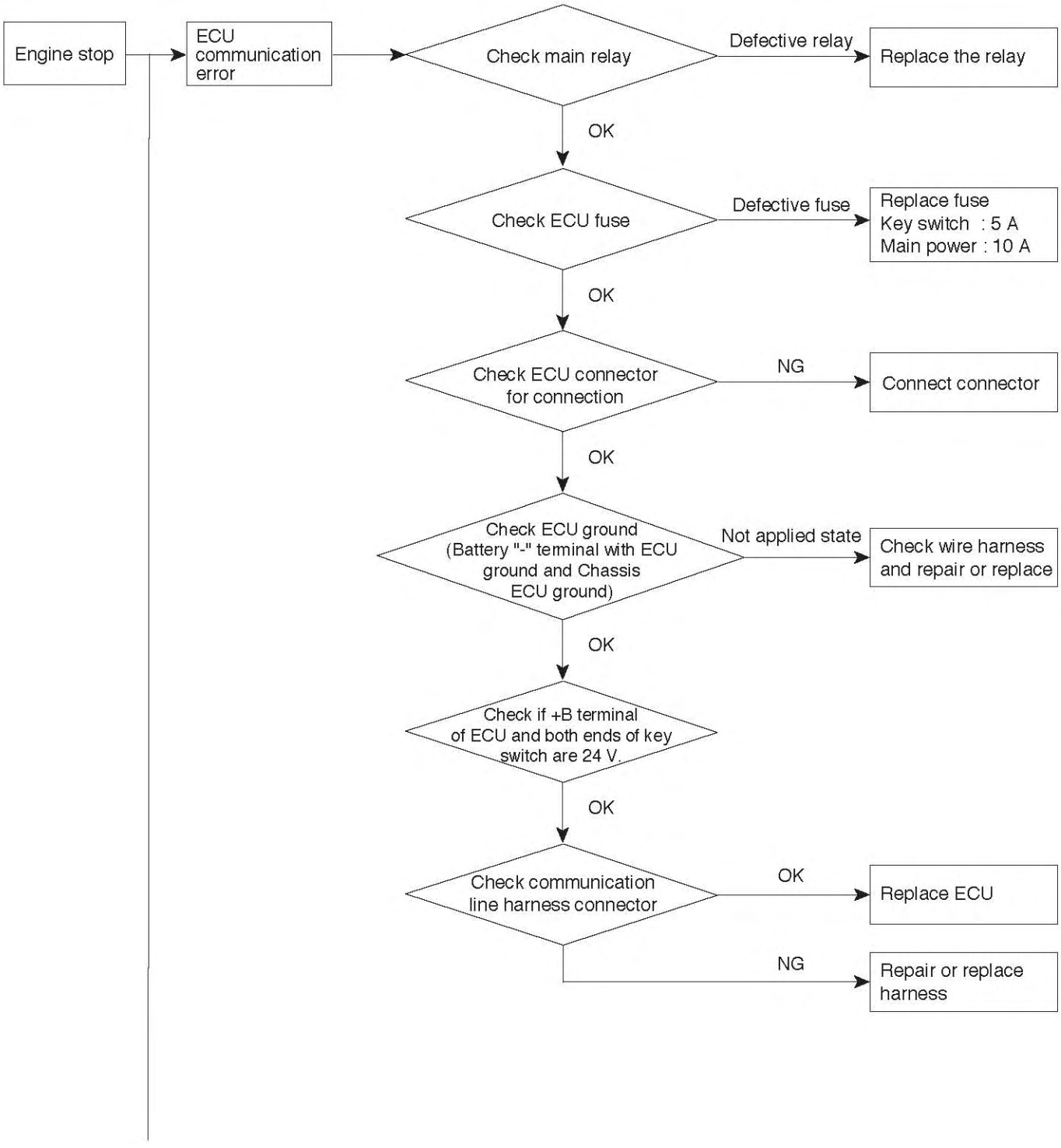
SUDFL7013L

Trouble diagnosis flow in fuel system

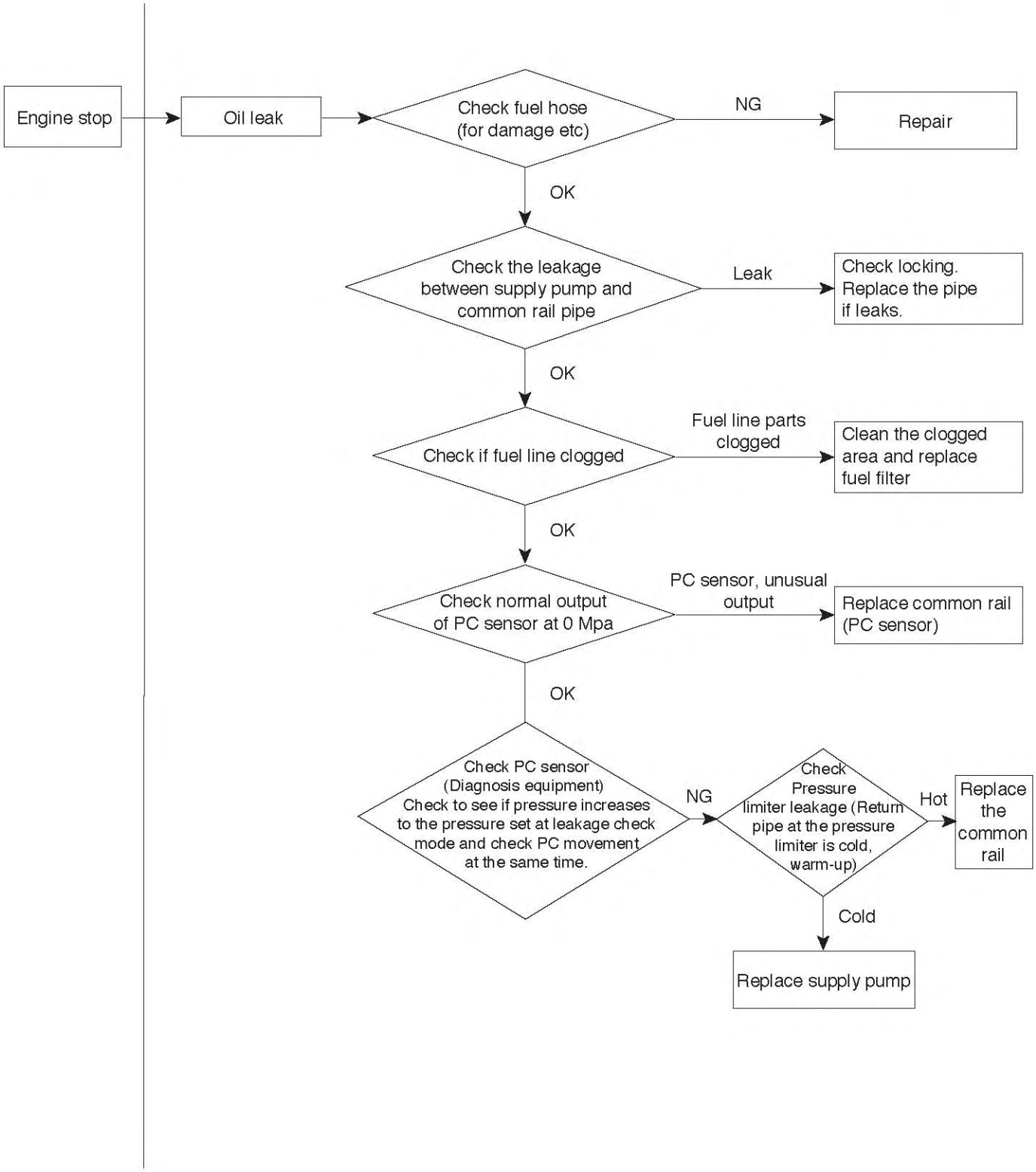


SUDFL7014L

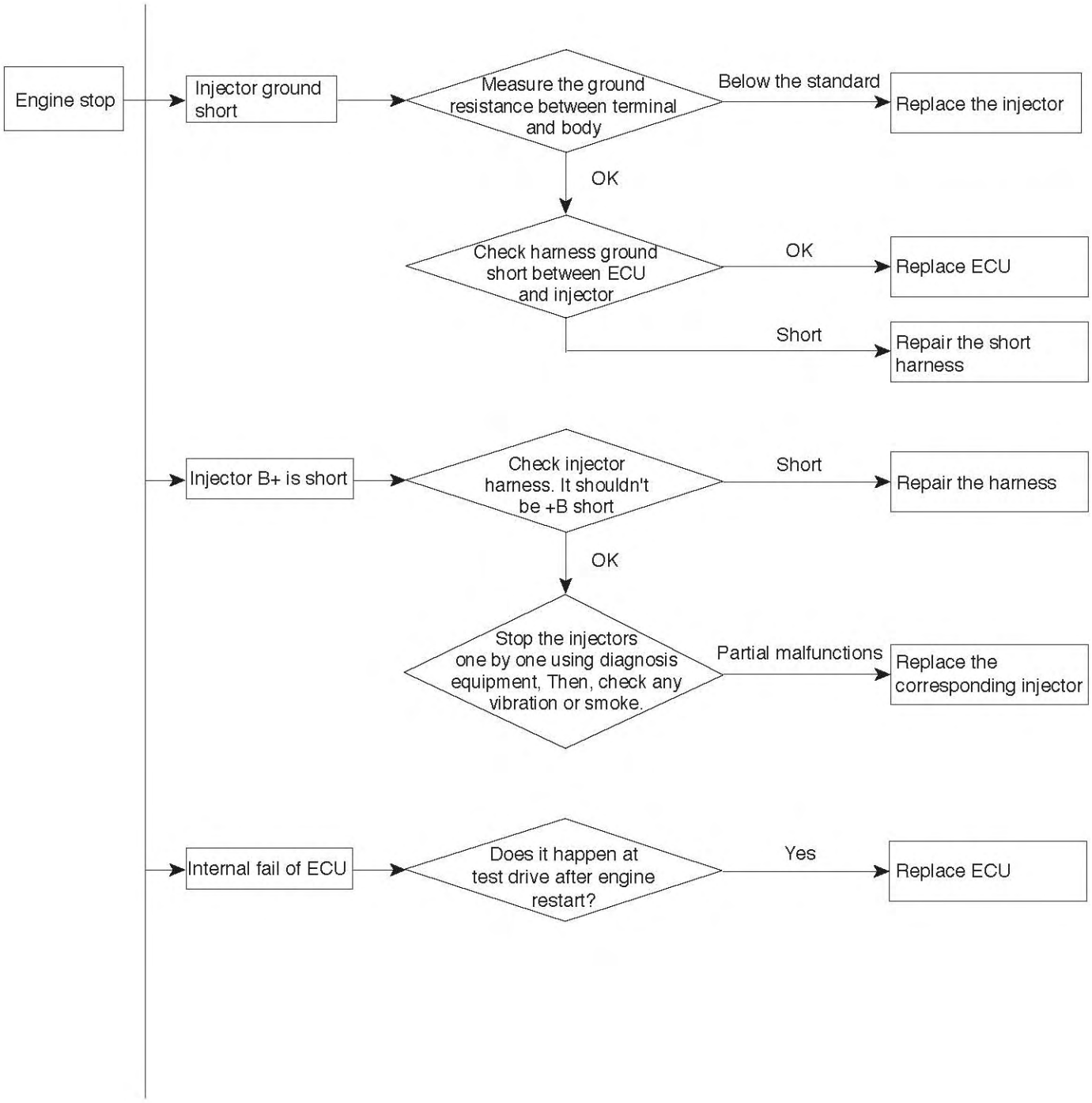
Trouble diagnosis flow for engine stall



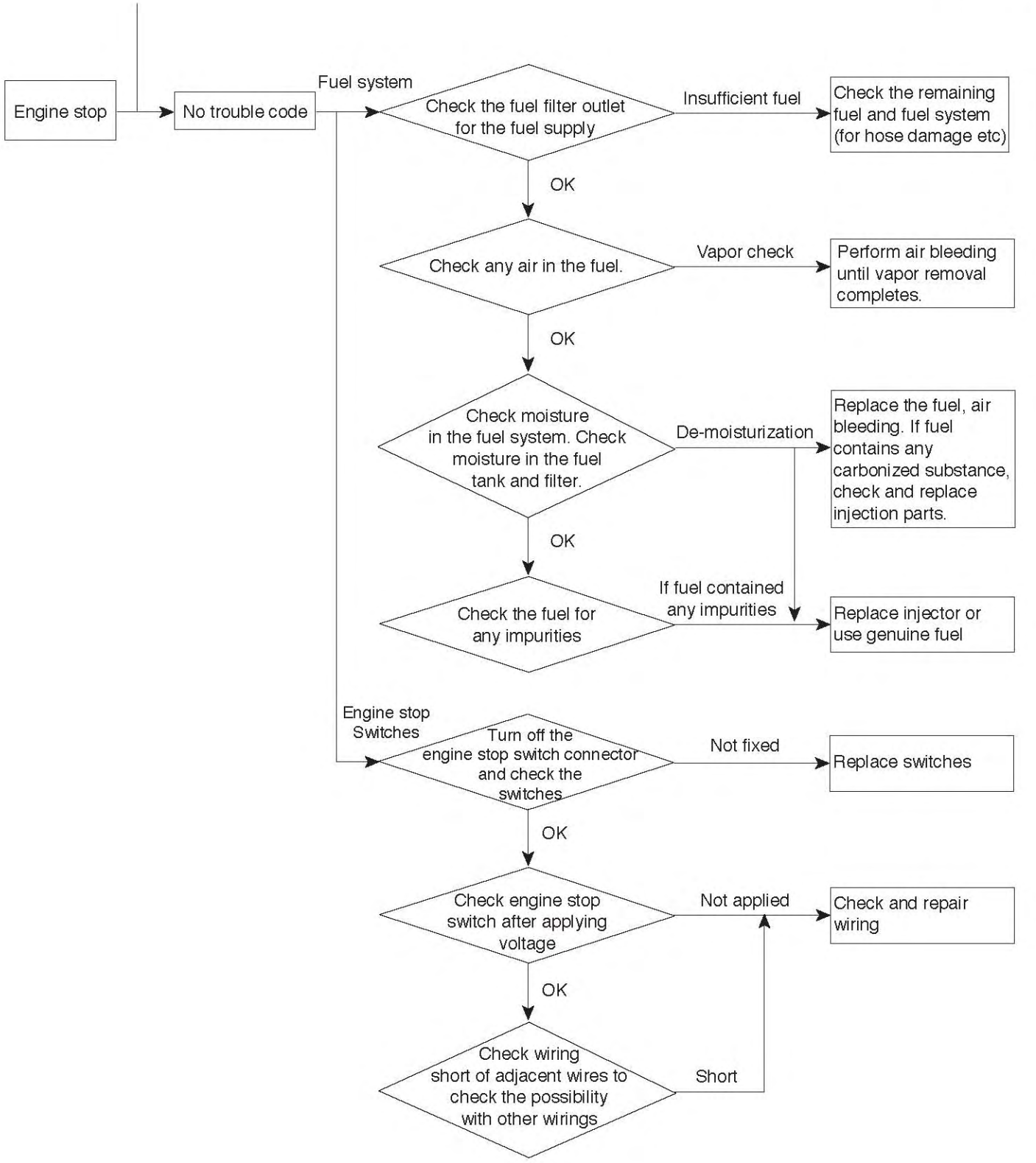
SUDFL7015L


Engine stop
Oil leak
Check fuel hose (for damage etc)
NG
Repair
OK
Check the leakage between supply pump and common rail pipe
Leak
Check locking. Replace the pipe if leaks.
OK
Check if fuel line clogged
Fuel line parts clogged
Clean the clogged area and replace fuel filter
OK
Check normal output of PC sensor at 0 Mpa
PC sensor, unusual output
Replace common rail (PC sensor)
OK
Check PC sensor (Diagnosis equipment) Check to see if pressure increases to the pressure set at leakage check mode and check PC movement at the same time.
NG
Check Pressure limiter leakage (Return pipe at the pressure limiter is cold, warm-up)
Hot
Replace the common rail
Cold
Replace supply pump

SUDFL7016L


Engine stop
Injector ground short
Measure the ground resistance between terminal and body
Below the standard
Replace the injector
OK
Check harness ground short between ECU and injector
OK
Replace ECU
Short
Repair the short harness
Injector B+ is short
Check injector harness. It shouldn't be +B short
Short
Repair the harness
OK
Stop the injectors one by one using diagnosis equipment, Then, check any vibration or smoke.
Partial malfunctions
Replace the corresponding injector
Internal fail of ECU
Does it happen at test drive after engine restart?
Yes
Replace ECU

SUDFL7017L


Engine stop
No trouble code
Fuel system
Check the fuel filter outlet for the fuel supply
Insufficient fuel
Check the remaining fuel and fuel system (for hose damage etc)
OK
Check any air in the fuel.
Vapor check
Perform air bleeding until vapor removal completes.
OK
Check moisture in the fuel system. Check moisture in the fuel tank and filter.
De-moisturization
Replace the fuel, air bleeding. If fuel contains any carbonized substance, check and replace injection parts.
OK
Check the fuel for any impurities
If fuel contained any impurities
Replace injector or use genuine fuel
Engine stop Switches
Turn off the engine stop switch connector and check the switches
Not fixed
Replace switches
OK
Check engine stop switch after applying voltage
Not applied
Check and repair wiring
OK
Check wiring short of adjacent wires to check the possibility with other wirings
Short

SUDFL7018L

ENGINE CONTROL SYSTEM-ELECTRONIC

DESCRIPTION E6C5CA2B

INSPECTION OF THE DIESEL CONTROL SYSTEM

If the components of the diesel control system (sensor, ECM, injector etc) has a problem, the proper amount of fuel for various engine-operating conditions is not supplied so that the following situations can occur.

1. Engine is hard to start or does not start at all.
2. Idling is unstable.
3. Engine drive performance is bad.
   If any of the above conditions are met, first perform a routine diagnosis that includes basic engine checks (ignition system malfunction, incorrect engine adjustment etc). Then, inspect the components of the diesel control system with multi-purpose tester or digital multi-meter.

⚠ ***CAUTION***

- ***Before removing or installing any part, read the diagnostic trouble codes and then, disconnect the battery negative (-) terminal.***
- ***Before disconnecting the cable from battery terminal, turn the ignition switch to OFF. If the battery cable is removed or connected during engine operation or the situation in which the ignition switch is ON, then the ECU semiconductor could be damaged resulting in inaccurate operation.***

SELF-DIAGNOSIS

The ECU sends the input/output signals (some signals at all times and the others under specified conditions). When some time elapse after the first detection of unusual signal, the ECU judges an irregularity and it records the diagnostic trouble code. And then it outputs the signal to the self-diagnosis output terminal. The diagnosis results can be checked by the Hi-scan. In addition, Diagnostic Trouble Codes (DTC) will be directly backed up by the battery so that it will remain in the ECU even if the ignition switch is turned off. The diagnostic trouble codes will, however, be erased when battery terminal or ECU connector is disconnected.

⚠ ***CAUTION***

If a sensor connector is disconnected with being the ignition switch turned ON, the diagnostic trouble code (DTC) is recorded in most diesel control unit. In this case, if the battery negative terminal (-) is disconnected for 15 seconds or more, then the diagnosis memory will be erased.

SELF-DIAGNOSIS CHECKING PROCEDURE

- Since diagnosis memory is erased if the battery or the ECU connector is disconnected, don't disconnect the battery just until the diagnostic trouble codes are completely read and recorded safely.
- It is most desirable to erase the diagnostic trouble codes using Hi-scan after completing check and repair. After disconnecting ground cable from the battery negative (-) terminal for 15 seconds or more, reconnect the cable and check if the trouble codes have been erased. (At this time, ignition switch must be turned off).

INSPECTION PROCEDURE (WITH HI-SCAN)

1. Turn off the ignition switch
2. Connect the Hi-scan connector to the connector of DLC (Data Link Connector) of the trouble diagnosis as shown in the following figure.
3. Turn the ignition switch ON.
4. Check the diagnostic code using Hi-scan.
5. Repair the parts having faulty shown in the diagnosis chart.
6. Erase the diagnostic trouble codes.
7. Disconnect the Hi-scan.

⚠ ***CAUTION***

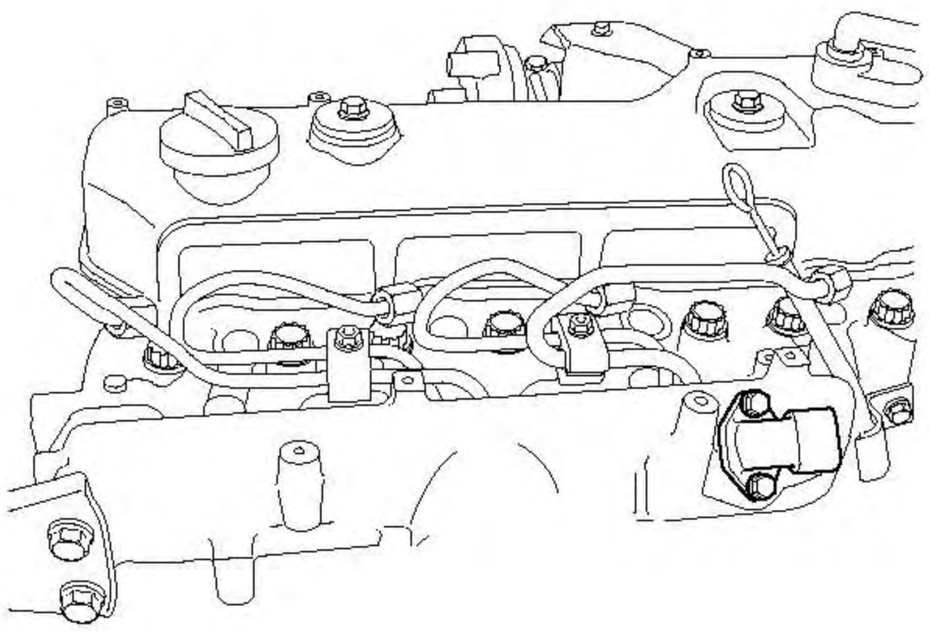
- ***When the battery voltage is excessively low, diagnostic trouble codes cannot be read. Be sure to check the battery for voltage and the charging system before starting the test.***
- ***When using a tester manufactured by other company, operate the tester by referring to the manual of the company.***

- ***When erasing the diagnostic trouble codes, use Hi-scan if possible. Though DTC can be erased by disconnecting the battery terminal, doing so, the data for learning control in ECU would be erased at the same time.***

DIESEL CONTROL UNIT

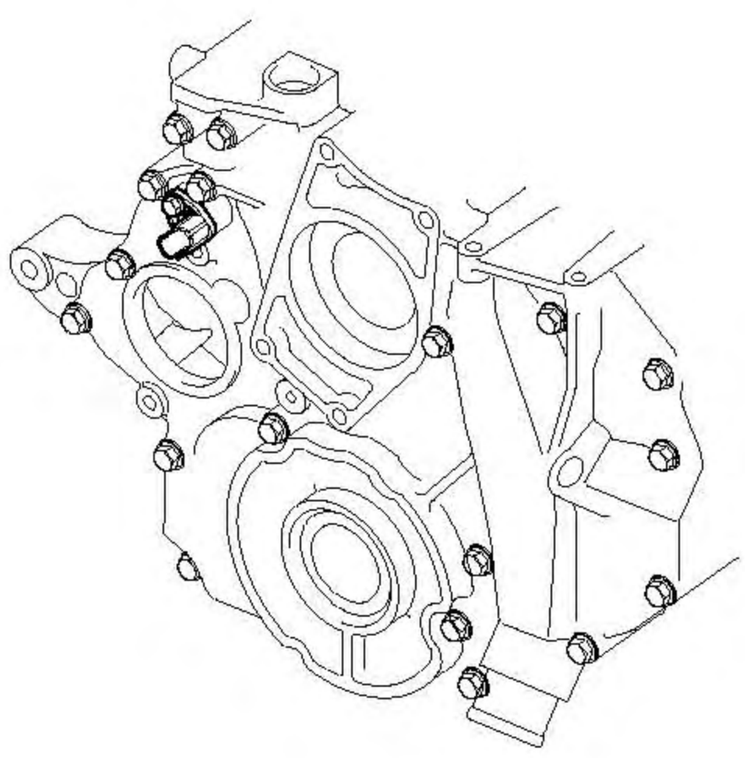
COMPONENT LOCATION

1. Intake air temperature sensor and intake air pressure sensor



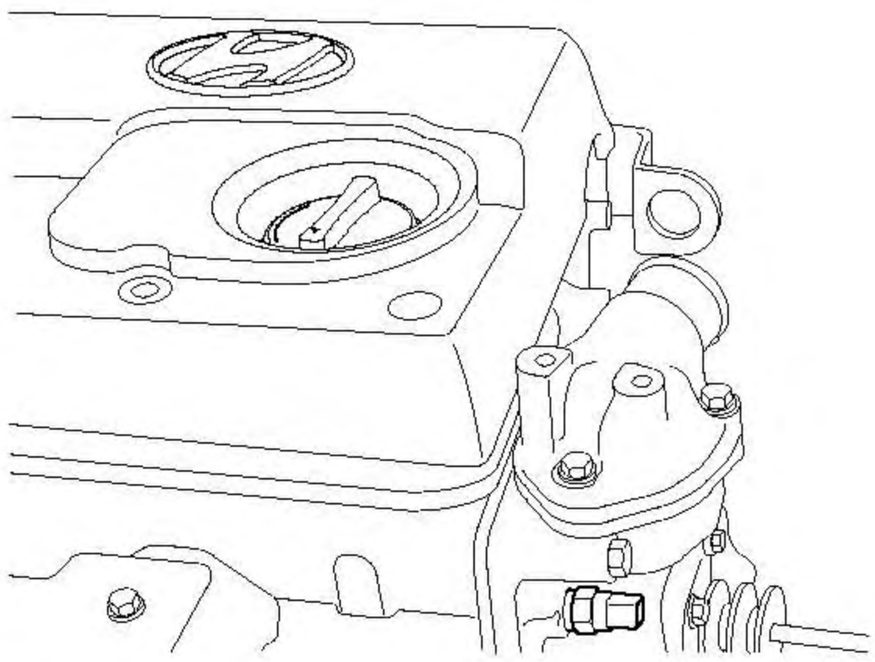
KDDFL5020A

2. Camshaft position sensor



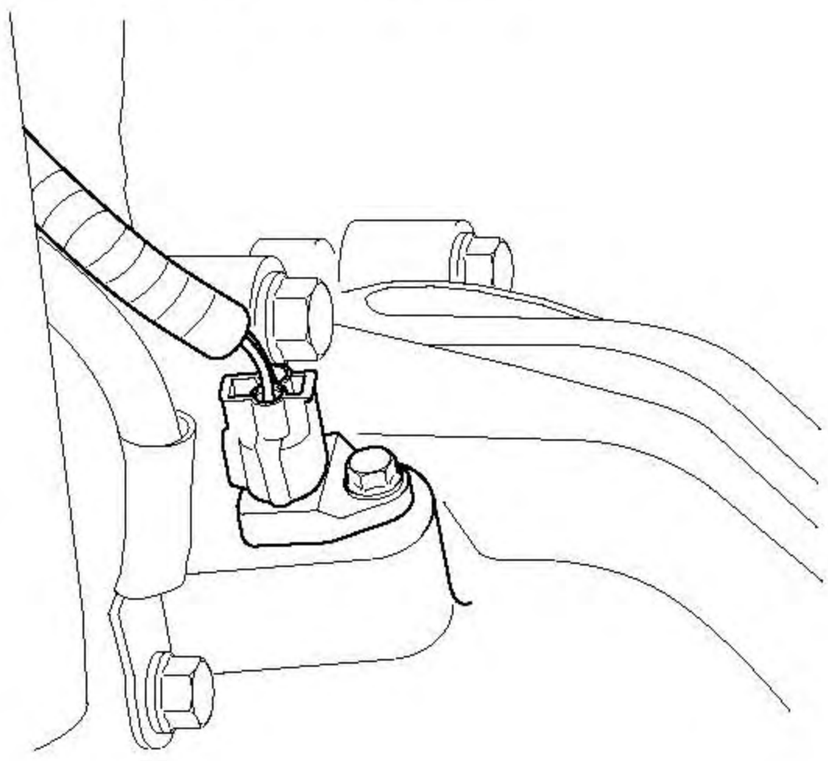
KDDFL5021A

3. Engine Coolant Temperature sensor



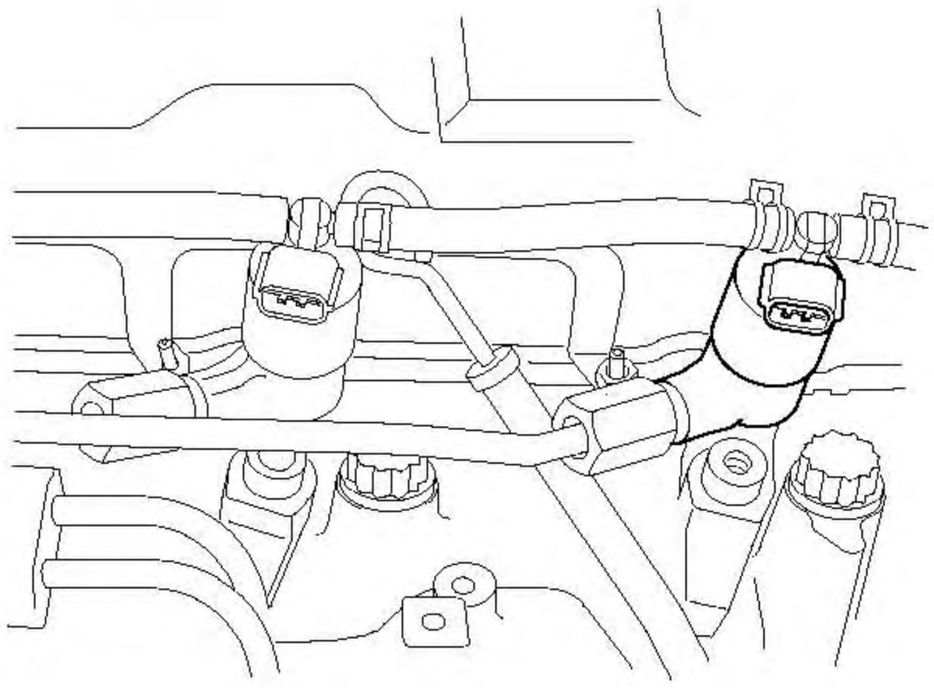
KDDFL5022A

4. Crankshaft position sensor



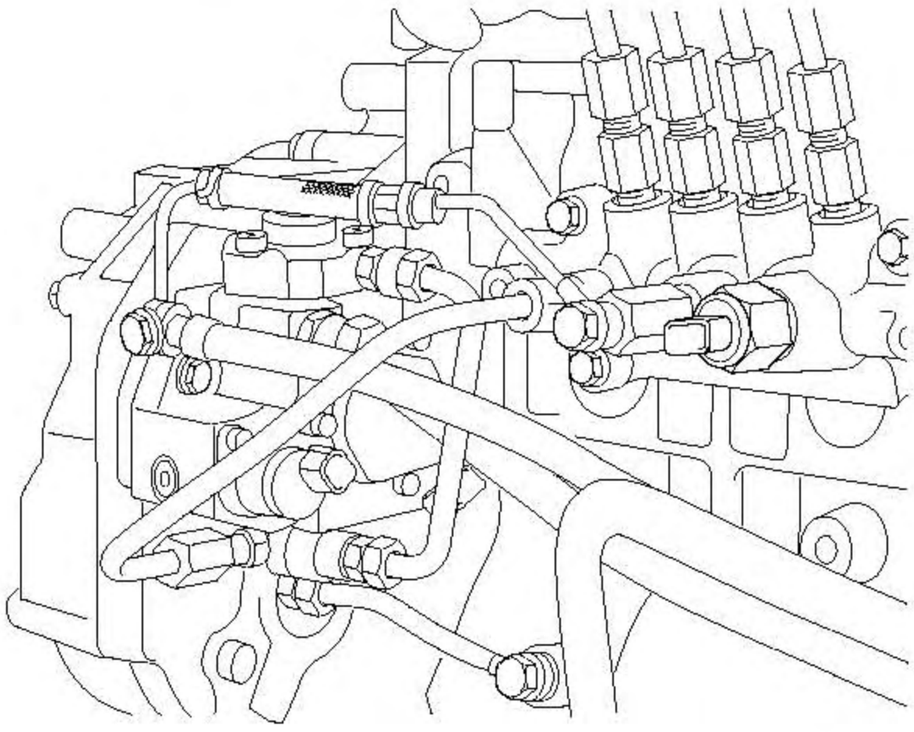
KDDFL5023A

5. Injector



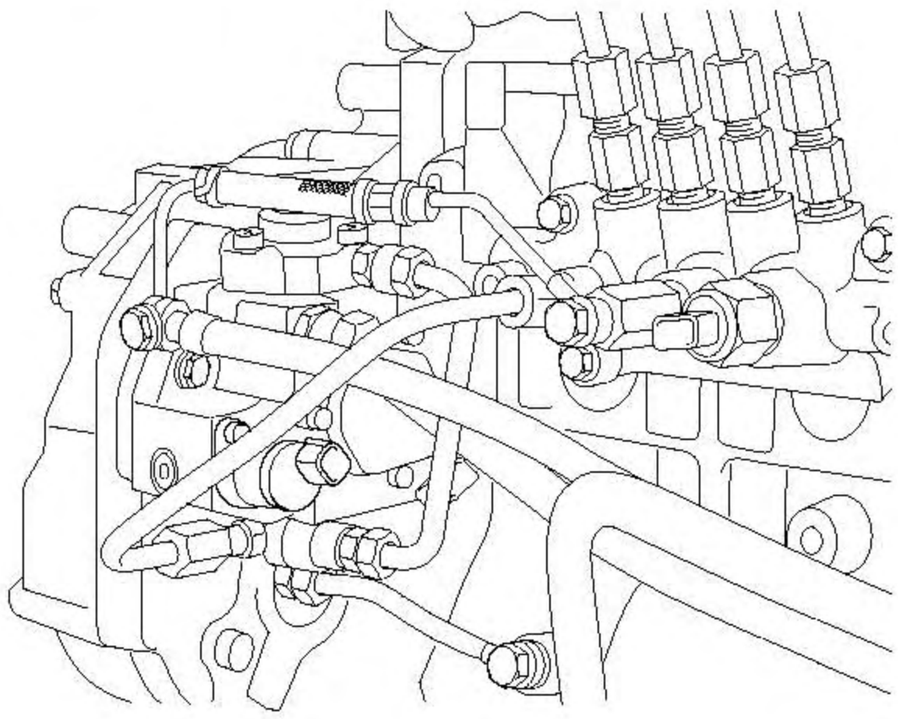
KDDFL5024A

6. Rail pressure sensor



KDDFL5025A

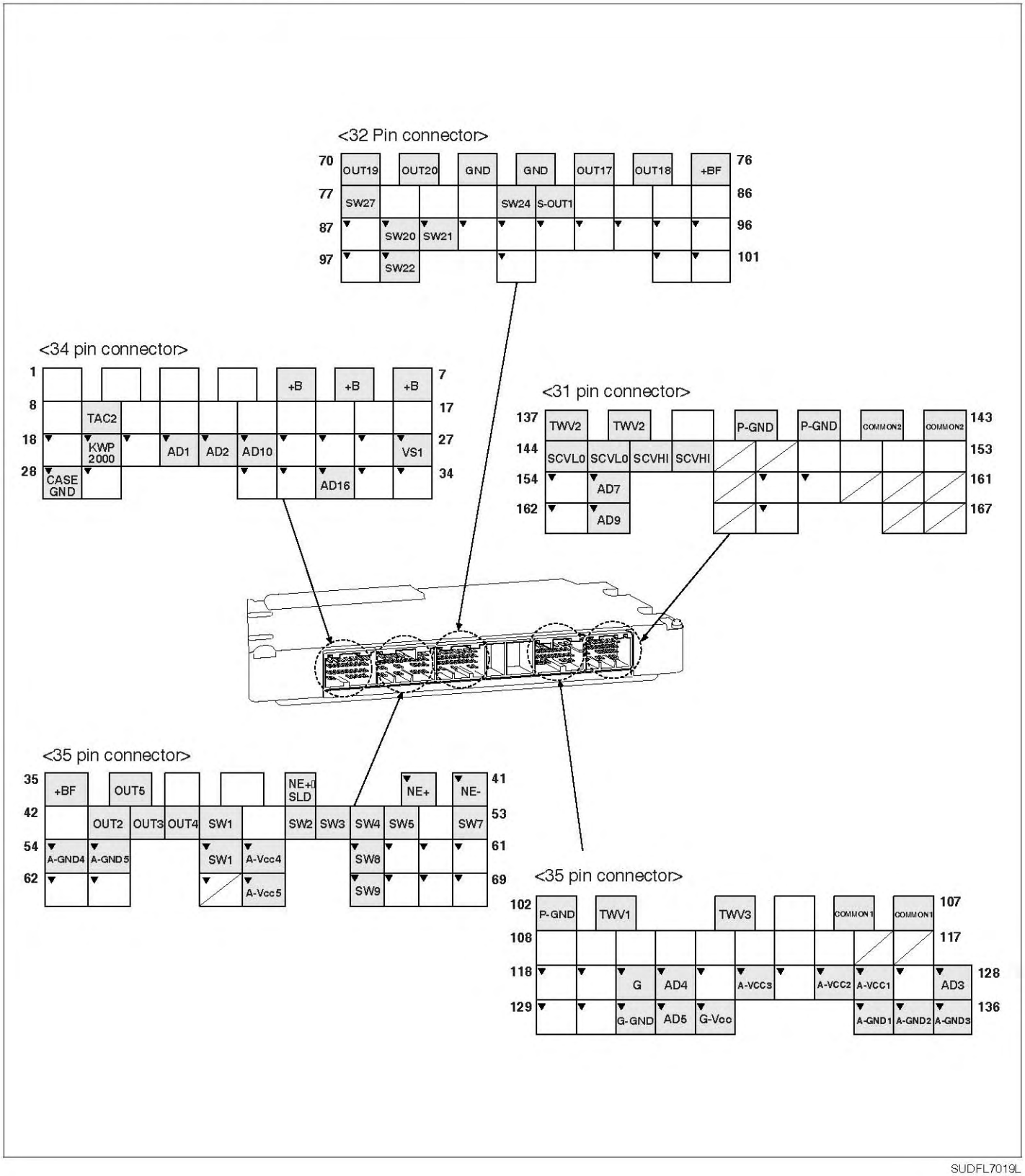
7. Supply Control Valve (SCV)



KDDFL5026A

ENGINE CONTROL UNIT(ECU)

ECU PIN CONNECTOR E99CEEBA



SUDFL7019L

<34 pin connector>

Terminal	Terminal name	Function	Connection part
1	-	-	-
2	-	-	-
3	-	-	-
4	-	-	-
5	+B	Battery (+) via fuse (A)	Main relay
6	+B	Battery (+) via fuse (A)	Main relay
7	+B	Battery (+) via fuse (A)	Main relay
8	-	-	-
9	TAC2	Engine speed signal (sent to speedometer)	Speedometer (TACHOMETER)
10	-	-	-
11	-	-	-
12	-	-	-
13	-	-	-
14	-	-	-
15	-	-	-
16			
17			
18	-	-	-
19	KWP 2000	K-LINE	
20	-	-	-
21	AD1	Accelerator pedal position sensor 1 signal	Accelerator pedal position sensor
22	AD2	Accelerator pedal position sensor 2 signal	Accelerator pedal position sensor
23			
24	-	-	-
25	-	-	-
26	-	-	-
27			
28	CASE GND	ECU CASE grounded	ECU CASE
29	-	-	-
30	-	-	-
31	-	-	-
32	AD16	Intake air temperature sensor signal	Intake air temperature sensor
33	-	-	-
34	-	-	-

SUDFL7020L

<35 pin connector>

Terminal	Terminal name	Function	Connection parts
35	+BF	+B FOR FLYBACK	
36			
37	-	-	-
38	-	-	-
39	NE-SLD	Sealed ground of engine RPM sensor	-
40	NE+	Engine RPM sensor (+)	-
41	NE-	Engine RPM sensor (-)	-
42	-	-	-
43	OUT2	Overheater warning lamp	-
44			-
45	OUT4	Glow lamp	-
46	SW1	Key switch	-
47	-	-	-
48	SW2	Starter switch	-
49			-
50			
51	SW5	Idle up switch	-
52		-	-
53			
54	A-GND4	Booster pressure sensor GND	-
55	A-GND5	Engine coolant temperature, Fuel temperature, Intake air temperature, PTO(HD65,72,78), Door interlock (County)	-
56	SW1	GND	-
57			-
58	SW8	Key switch	Idle switch
59	-	Booster pressure sensor power	-
60	-	Idle switch	-
61	-	-	-
62	-	-	-
63	-	-	-
64			
65		-	-
66	-		-
67	-	Neutral switch	-
68	-	-	-
69	-	-	-

SUDFL7021L

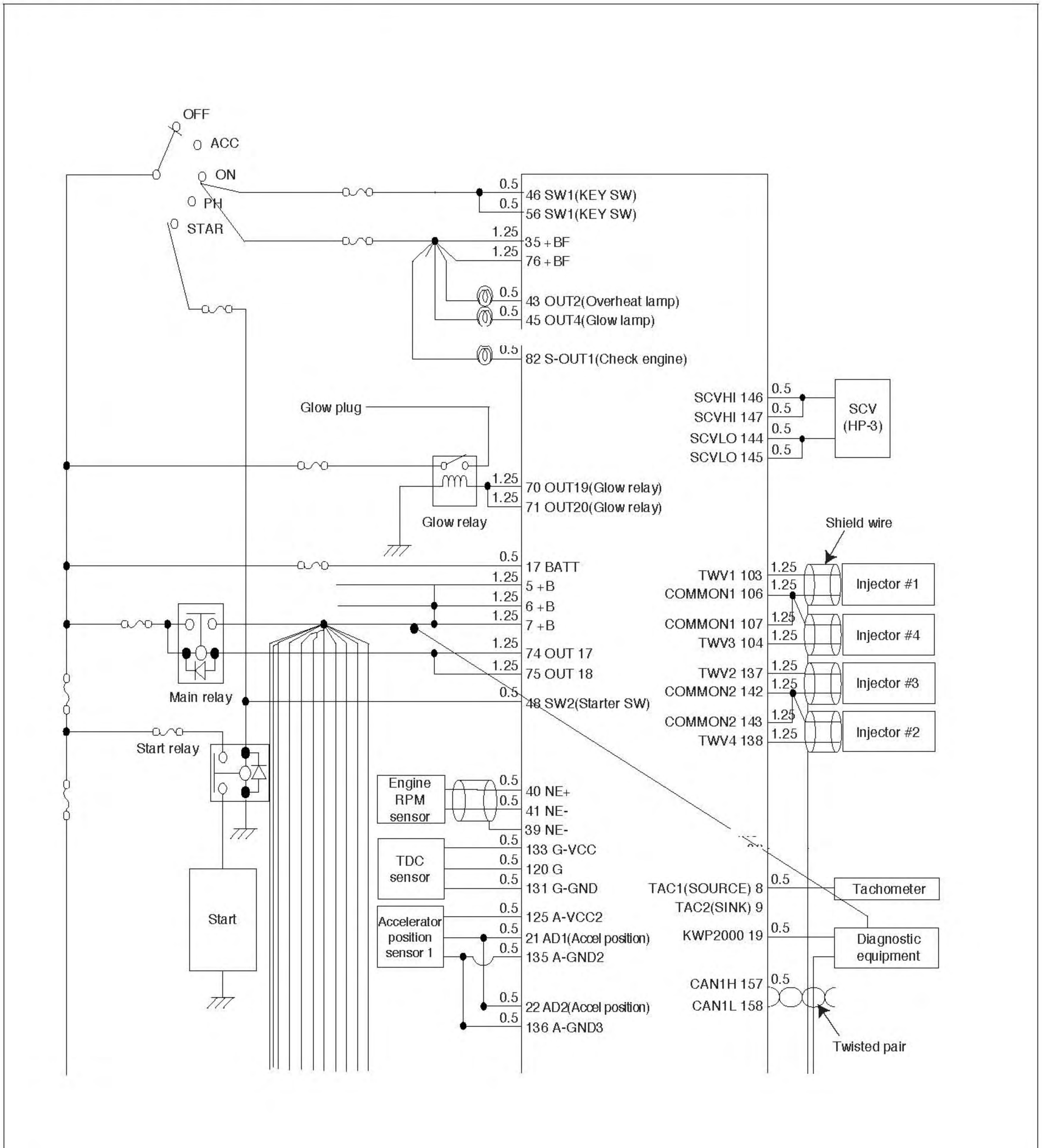
<32 pin connector>

Terminal	Terminal name	Function	Connection parts
70	OUT19	Glow relay	-
71	OUT20	Glow relay	-
72	GND	Signal GND	-
73	GND	Signal GND	-
74	OUT17	Main relay	-
75	OUT18	Main relay	-
76	+BF	+B	-
77			-
78	-	-	-
79	-	-	-
80	-	-	-
81			-
82	S-OUT1	Engine check lamp	-
83	-	-	-
84	-	-	-
85	-	-	-
86			
87	-	-	-
88			-
89			-
90	-	-	-
91	-	-	-
92	-	-	-
93	-	-	-
94	-	-	-
95	-	-	-
96	-	-	-
97	-	-	-
98	-	-	-
99	-	-	-
100	-	-	-
101	-	-	-

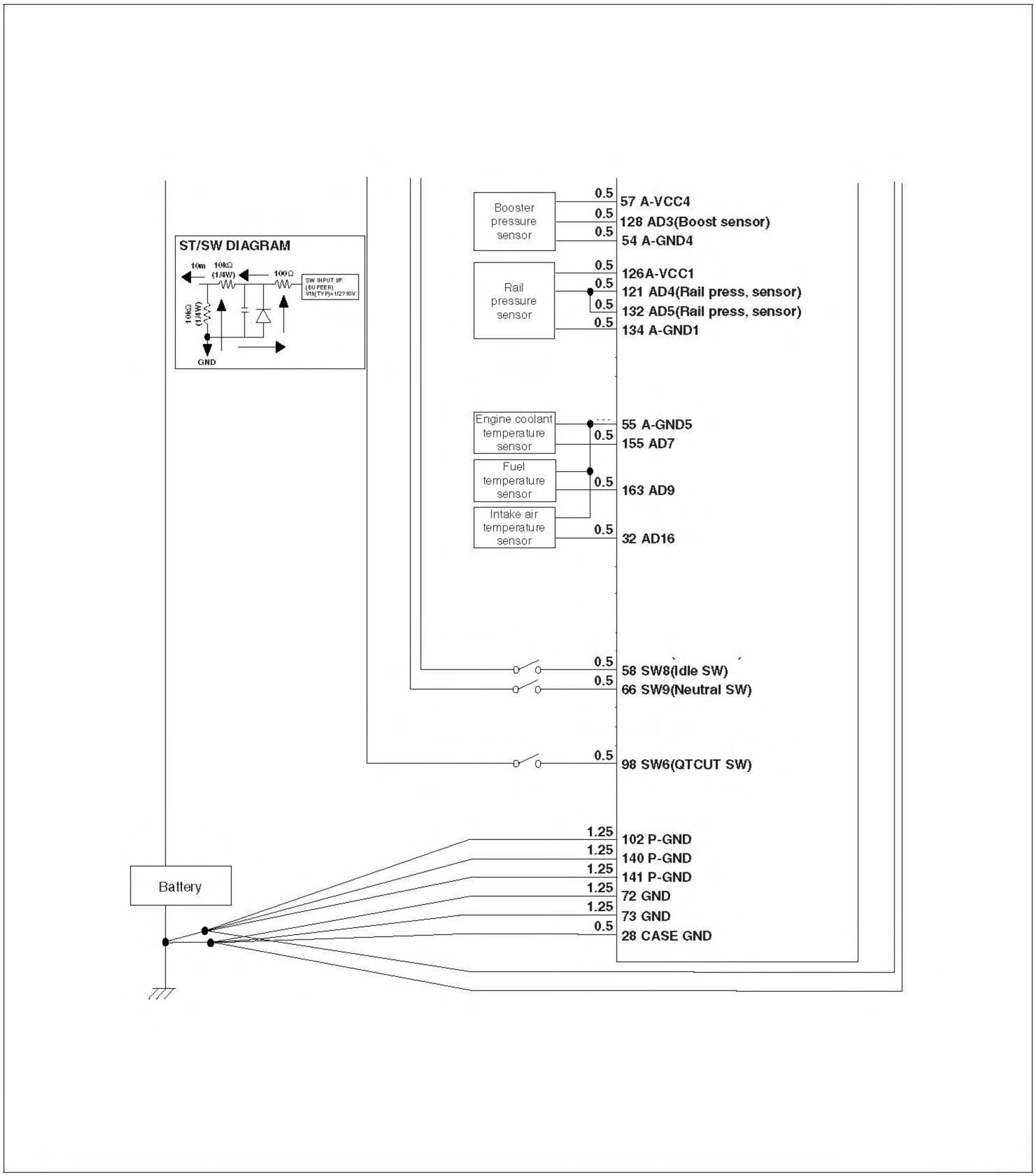
<35 pin connector>

Terminal	Terminal name	Function	Connection parts
102	P-GND	Power GND	-
103	TWV1	Injector 1	-
104	TWV3	Injector 3	-
105	-	-	-
106	COMMON1	Injector Power 1	-
107	COMMON1	Injector Power 1	-
108	-	-	-
109	-	-	-
110	-	-	-
111	-	-	-
112	-	-	-
113	-	-	-
114	-	-	-
115	-	-	-
116			
117			
118	-	-	-
119	-	-	-
120	G	Cam speed sensor signal 1	-
121	AD4	Common rail pressure sensor 1	-
122	-	-	-
123	A-VCC3	Accelerator position sensor 2 power	-
124	-	-	-
125	A-VCC2	Accelerator position sensor 1 power	-
126	A-VCC1	Common rail pressure sensor power	-
127	-	-	-
128	AD3	Booster pressure sensor signal	-
129	-	-	-
130	-	-	-
131	G-GND	Cam speed sensor GND	-
132	AD5	Common rail pressure sensor 2	-
133	G-VCC	Cam speed sensor power	-
134	A-GND1	Common rail pressure sensor GND	-
135	A-GND2	Accelerator position sensor 1 GND	-
136	A-GND3	Accelerator position sensor 2 GND	-

ECU CIRCUIT DIAGRAM E844D6D4



SUDFL7025L


ST/SW DIAGRAM
10m
10kΩ (1/4W)
100Ω
SW INPUT I/F (BU FEER) Vth(TYP)=1/2?10V
10kΩ (1/4W)
GND
Booster pressure sensor
0.5
57 A-VCC4
0.5
128 AD3(Boost sensor)
0.5
54 A-GND4
Rail pressure sensor
0.5
126A-VCC1
0.5
121 AD4(Rail press, sensor)
0.5
132 AD5(Rail press, sensor)
0.5
134 A-GND1
Engine coolant temperature sensor
55 A-GND5
0.5
155 AD7
Fuel temperature sensor
0.5
163 AD9
Intake air temperature sensor
0.5
32 AD16
0.5
58 SW8(Idle SW)
0.5
66 SW9(Neutral SW)
0.5
98 SW6(QTCUT SW)
Battery
1.25
102 P-GND
1.25
140 P-GND
1.25
141 P-GND
1.25
72 GND
1.25
73 GND
0.5
28 CASE GND

SUDFL7026L

REMOVAL E2B6DEC9

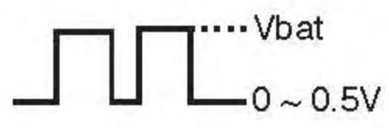
1. After the engine stops, wait for about 30 seconds.
2. Disconnect the battery ground line.
3. Remove ECU connector wiring sequentially.
4. Loosen ECU bracket fixing bolt and remove ECU.

⚠ ***CAUTION***

When replacing ECU with new one, ECU data corresponding to the vehicle should be reprogrammed and injector QR code value should be inputted according to the process of the diagnosis. Otherwise, engine performance could be deteriorated and there may have problems in the emission gas.

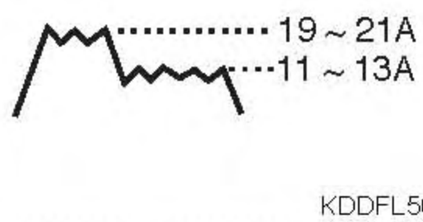
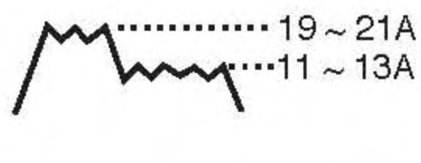
INSPECTION E712FAA9

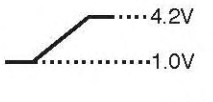
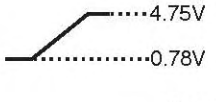
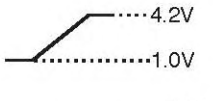
CHECK SHEET OF ENGINE ECU PIN

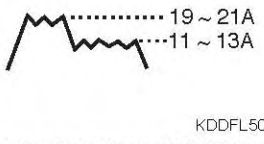
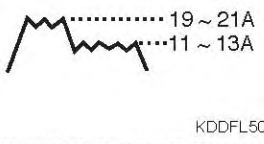
Pin NO.	Check items	Condition	Input/output signal		Remarks
			Type	LEVEL (normal→operating)	
1	NA				
2	NA				
3	NA				
4	NA				
5	Battery (+) via fuse (A)	IG. ON	DC	Battery voltage	
6	Battery (+) via fuse (A)	IG. ON	DC	Battery voltage	
7	Battery (+) via fuse (A)	IG. ON	DC	Battery voltage	
8	NA				
9	Engine speed signal	Engine drive	Pulse	 KDDFL5086A	
10	NA				
11	NA				
12	NA				
13	NA				
14	NA				
15	NA				
16	-				
17	-				
18	NA				
19	Trouble diagnosis K-LINE		Analogue	Communication signal	
20	NA				
21	Accelerator pedal position sensor 1 signal	IG. ON(idle)	Analogue	0.6V ~ 0.85V	
		IG. ON (WOT)	Analogue	3.75V ~ 3.95V	
22	Accelerator pedal position sensor 2 signal	IG. ON(idle)	Analogue	0.6V ~ 0.85V	
		IG. ON (WOT)	Analogue	3.75V ~ 3.95V	
23	NA				
24	NA				
25	NA				
26	NA				
27	NA				

Pin NO.	Check items	Condition	Input/output signal		Remarks
			Type	LEVEL (normal→operating)	
28	ECU CASE ground		DC	Below 0.5V	
29	NA				
30	NA				
31	NA				
32	Intake air temperature sensor	IG. ON(20°C)	Analogue	Above 0.791V	0.116KΩ ~ 48.14KΩ
		IG. ON(40°C)	Analogue	Below 0.406V	
33	NA				
34	NA				
35	+B FOR FLYBACK	IG ON	DC	Battery voltage	
36	NA				
37	NA				
38	NA				
39	Engine RPM sensor shield ground		DC	Below 0.5V	
40	Engine RPM sensor +	Engine drive	Sine wave		
41	Engine RPM sensor -	Engine drive	Sine wave		
42	-				
43	Overheat warning lamp	Coolant temperature above 115	DC	Battery voltage > below 0.5V	
44	NA				
45	Glow lamp	IG ON	DC	Battery voltage > below 0.5V	
46	Key switch	IG ON	DC	Below 0.5V > Battery voltage	
47	NA				
48	Starter switch	At starting	DC	Below 0.5V > Battery voltage	
49					
50	-				
51					
52	NA				
53					
54	Booster pressure sensor GND		DC	Below 0.5V	

Pin NO.	Check items	Condition	Input/output signal		Remarks
			Type	LEVEL (normal→operating)	
55	Coolant temperature, Fuel temperature, Intake air temperature		DC	Below 0.5V	
56	Key switch		DC	Below 0.5V > Battery voltage	
57	Booster pressure sensor power	IG ON	DC	5V	
58	Idle switch	IG ON	DC	Battery voltage > below 0.5V	
59	NA				
60	NA				
61	NA				
62	NA				
63	NA				
64	-				
65					HD65,72,78 only
66	Neutral switch	IG.ON	DC	Battery voltage > below 0.5V	
67	NA				
68	NA				
69	NA				
70	Glow relay	IG.ON	DC	Below 0.5V > Battery voltage	
71	Glow relay	IG.ON	DC	Below 0.5V > Battery voltage	
72	Signal GND		DC	Below 0.5V	
73	Signal GND		DC	Below 0.5V	
74	Main relay	IG.ON	DC	Battery voltage > below 0.5V	
75	Main relay	IG.ON	DC	Battery voltage > below 0.5V	
76	+B	IG.ON	DC	Below 0.5V > Battery voltage	
77					
78	NA				
79	NA				
80	NA				

Pin NO.	Check items	Condition	Input/output signal		Remarks
			Type	LEVEL (normal→operating)	
81	Air-con idle up switch	IG.ON	DC	Below 0.5V > Battery voltage	
82	Engine check lamp	IG.ON	DC	Battery voltage > below 0.5V	
83	NA				
84	NA				
85	NA				
86	-				
87	NA				
88	Idle down switch	IG.ON	DC	Below 0.5V > Battery voltage	
89					
90	NA				
91	NA				
92	NA				
93	NA				
94	NA				
95	NA				
96	NA				
97	NA				
98	-				
99	NA		DC	Below 0.5V > Battery voltage	
100	NA				
101	NA				
102	Power GND		DC	Below 0.5V	
103	Injector 1	engine drive(injector operation)	Analogue		
104	Injector 3	engine drive(injector operation)	Analogue		
105	NA				
106	Injector COMMON 1	engine drive(injector operation)	Analogue		

Pin NO.	Check items	Condition	Input/output signal		Remarks
			Type	LEVEL (normal→operating)	
107	Injector COMMON 1	engine drive(injector operation)	Analogue		
108	NA				
109	NA				
110	NA				
111	NA				
112	NA				
113	NA				
114	NA				
115	NA				
116	-				
117	-				
118	NA				
119	NA				
120	Cam speed sensor signal	IG ON	Spherical wave		
121	Common rail pressure sensor 1	IG ON	Analogue	 KDDFL5089A	IDLE=1.72V level(45MPa)
122	NA				
123	Accelerator position sensor 2 Power	IG ON	DC	5V	
124	NA	IG ON			
125	Accelerator position sensor 1 Power	IG ON	DC	5V	
126	Common rail pressure sensor power	IG ON	DC	5V	
127	NA				
128	Boost pressure sensor signal	IG ON		 KDDFL5090A	
129	NA				
130	NA				
131	CAM speed sensor GND		DC	Below 0.5V	
132	Commonrail pressure sensor 2	IG ON	Analogue	 KDDFL5089A	IDLE=1.72V level(45MPa)
133	CAM speed sensor power	IG ON	DC	5V	

Pin NO.	Check items	Condition	Input/output signal		Remarks
			Type	LEVEL (normal→operating)	
134	Common rail pressure sensor GND		DC	Below 0.5V	
135	Accel position sensor 1 GND		DC	Below 0.5V	
136	Accel position sensor 2 GND		DC	Below 0.5V	
137	Injector 2	Engine drive (injector)	Analogue	 KDDFL5088A	
138	Injector 4	Engine drive (injector)	Analogue	 KDDFL5088A	
139	NA				
140	Power GND		DC	Below 0.5V	
141	Power GND		DC	Below 0.5V	
142	Injector COMMON 2	Engine drive (injector)	Analogue		
143	Injector COMMON 2	Engine drive (injector)	Analogue		
144	HP3.4 LO	Engine drive	Analogue		
145	HP3.4 LO	Engine drive	Analogue		
146	HP3.4 HI	Engine drive	Analogue		
147	HP3.4 HI	Engine drive	Analogue		
148	-				
149	-				
150	NA				
151	NA				
152	NA				
153	NA				
154	NA				
155	Water temperature sensor signal	IG. ON(20°C)	Analogue	Above 2.5V	0.12KΩ ~ 48.14KΩ
		IG. ON(40°C)	Analogue	Below 0.527V	
156	-				
157	NA				
158	NA				
159	-				
160	-				

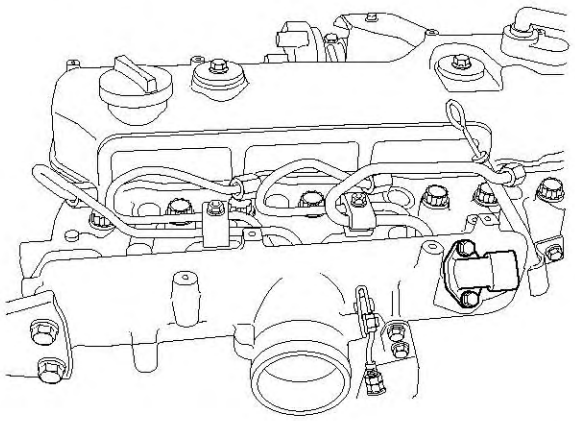
Pin NO.	Check items	Condition	Input/output signal		Remarks
			Type	LEVEL (normal→operating)	
161	NA				
162	NA				
163	Fuel temperature sensor signal	IG. ON(20℃)	Analogue	Above 2.38V	0.11KΩ ~ 25.4KΩ
		IG. ON(40℃)	Analogue	Below1.5V	
164	NA				
165	NA				
166	-				
167	NA				

INTAKE AIR TEMPERATURE SENSOR

INSPECTION E6C0EA2F

ATS (AIR TEMPERATURE SENSOR) HARNESS INSPECTION PROCEDURE

Refer to P0113, P0112 DTC inspection procedures.



KDDFL5039A

SENSOR INSPECTION

1. Check the sensor resistance using multi-tester.
2. Measure the resistance between intake air temperature sensor and terminal.

Condition	Temperature (°C)	Resistance (kΩ)
Ignition switch ON	-40	39.260
	-30	22.960
	-20	13.850
	-10	8.609
	0	5.499
	+10	3.604
	+20	2.420
	+30	1.662
	+40	1.116
	+50	0.835
	+60	0.609
	+70	0.452
	+80	0.340
	+90	0.261
	+100	0.202
	+110	0.159
	+120	0.127
	+130	0.102

3. If the resistance exceeds the normal range, replace the intake air temperature sensor assembly.

NOTE

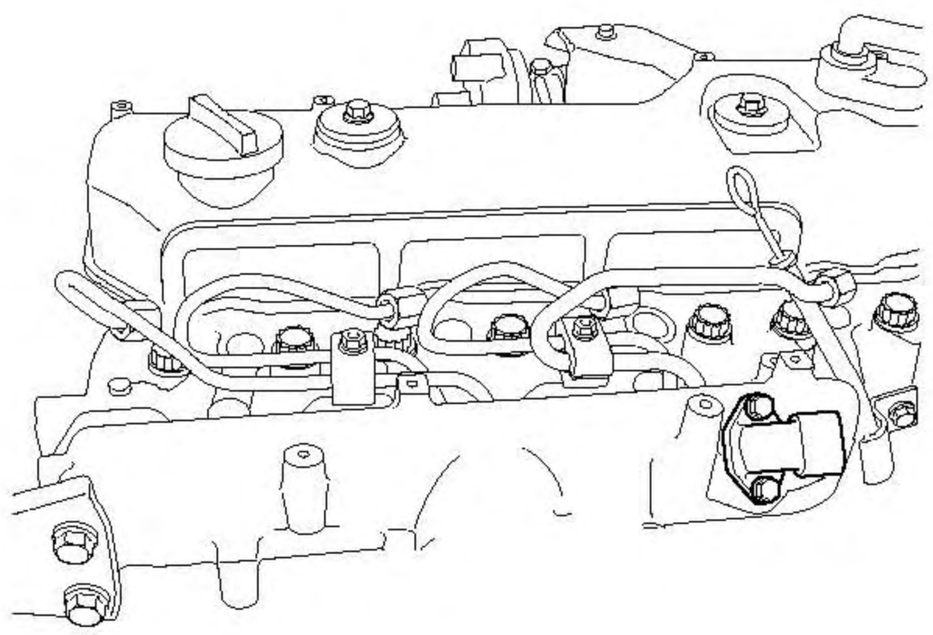
Intake air temperature sensor is a built-in type assembled with the intake air pressure sensor.

INTAKE AIR PRESSURE SENSOR

INSPECTION EC7A9BF1

INTAKE PRESSURE SENSOR HARNESS INSPECTION PROCEDURE

Refer to P0236, P0237, and P0238 DTC inspection procedures.



KDDFL5039A

SENSOR INSPECTION

1. Check the sensor resistance using multi-tester.
2. Measure the voltage of intake air pressure sensor.

Condition	Intake air pressure [kPa(mmHg)]	Voltage (V)
at starting	32.5 (244)	0.5
	50 (375)	0.78±0.095
	70 (525)	1.096±0.075
	270 (2025)	4.277±0.075
	284 (2130)	4.5
	300 (2250)	4.75±0.095

3. If the resistance exceeds the normal range, replace the intake air pressure sensor assembly.

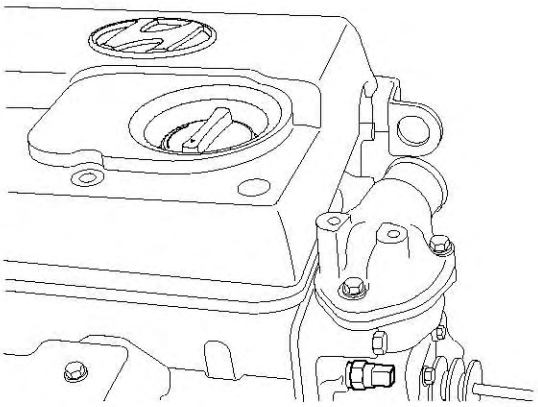
NOTE

Intake air pressure sensor is a built-in type assembled with the intake air temperature sensor.

COOLANT TEMPERATURE SENSOR

INSPECTION E94CF58B

Engine coolant temperature sensor is a resistance type sensor, which is installed on the engine coolant passage of intake manifold. Based on the output voltage of this sensor, ECU determines the engine temperature and supplies the optimal fuel quantity to injector when engine is cold.



KDDFL5040A

TROUBLESHOOTING HINT

If the idle speed is not proper or the engine causes smoke at warm up, the engine coolant temperature sensor is defective.

HARNESS INSPECTION PROCEDURE

Refer to P0117, P0118, P0217 DTC inspection procedures.

SENSOR INSPECTION

Check items	Data display	Checking condition	Coolant temperature	Specification (Hi-scan)
Coolant temperature sensor	Sensor temperature	Ignition switch: ON or engine is started	-20°C	-20°C
			0°C	0°C
			20°C	20°C
			40°C	40°C
			80°C	80°C

INSPECTION METHOD USING A MULTI-TESTER

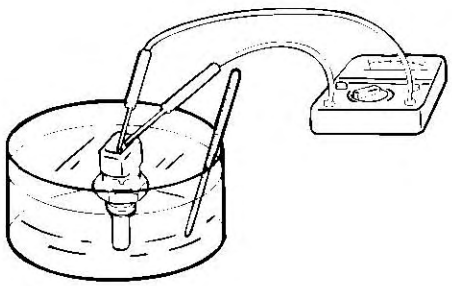
1. Remove engine coolant temperature sensor from the coolant passage of the cylinder head.
2. Immerse the temperature sensing part of engine coolant temperature sensor into the hot water and check the resistance.

   1) Engine coolant temperature sensor

Temperature (°C)	Resistance (KΩ)
-40	48.14
-20	14.13~16.83
0	5.790
20	2.31~2.59
40	1.148
60	0.586
80	0.322
100	0.1884
110	0.1451~0.1491
120	0.1163

   2) Gauge unit

Temperature (°C)	Resistance (KΩ)
60	125
85	42.6~54.2
110	22.1~26.2
125	15.2



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3. If the measurement shows great difference from the specification, replace the sensor.

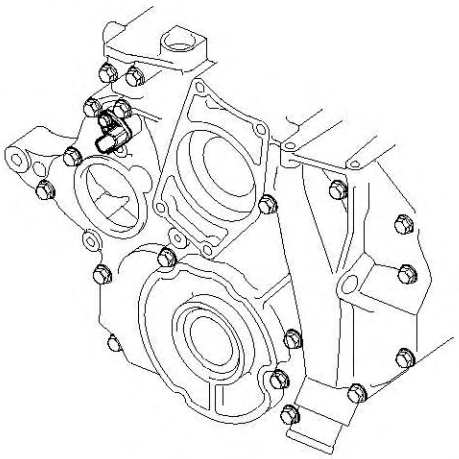
INSTALLATION EBA8E766

1. Apply locktite 962T or the equivalent around the bolt.
2. Install coolant temperature sensor and tighten with specified torque. Specification Torque: 3.0~4.0kgf.m
3. Connect the harness connector correctly.

CAMSHAFT POSITION SENSOR

INSPECTION E64A0EFE

TDC sensor senses the TDC (Top Dead Center) of compression strokes of cylinder No. 1 and 4, and then it transforms it to pulse signals and then inputs it to ECU. Then, ECU sets the fuel injection sequence based on the signals. Crank angle sensor senses each crank angle (piston position) and transforms it to pulse signals and then inputs it to ECU. Then, ECU calculates the engine speed based on the signals and adjusts the fuel injection timing and ignition timing.



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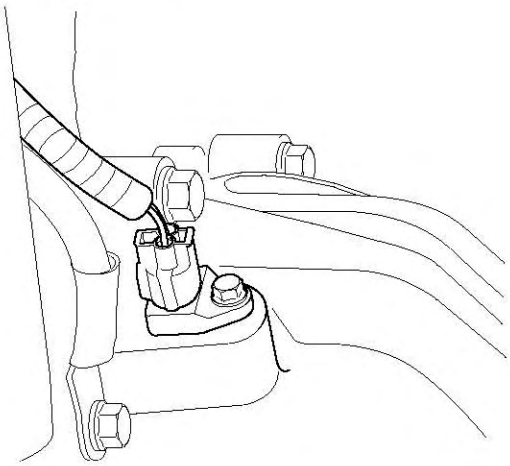
WIRING HARNESS INSPECTION

Refer to P0340 DTC inspection procedure.

CRANKSHAFT POSITION SENSOR

INSPECTION E6A5E801

Piston position in the combustion chamber is critical to define the starting of injection timing. All engine pistons are connected to crankshaft by connecting rod. Sensor on crankshaft can supply the information concerning all piston positions. Revolution speed is defined by the crankshaft revolution number per minute. Important input factors are treated by ECU using the signal from induction type crankshaft speed sensor.



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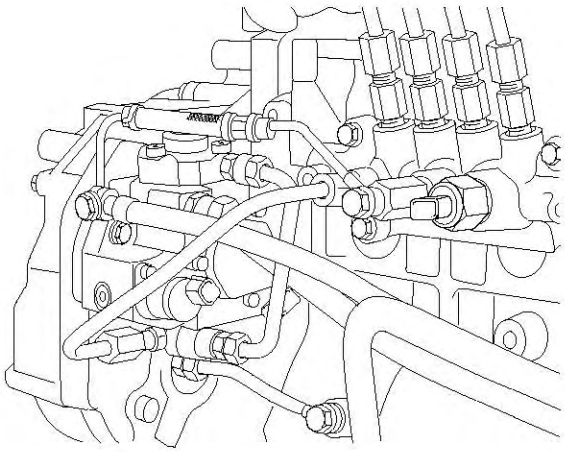
HARNESS INSPECTION PROCEDURE

Refer to P0335 DTC inspection procedures

RAIL PRESSURE SENSOR

INSPECTION EAF96E08

In order to output a voltage signal corresponding to the applied pressure to the ECM, the rail pressure sensor must measure the instant pressure in the rail. The fuel flows to the rail pressure sensor through an inlet of the rail. The end of rail pressure sensor is sealed off by the sensor diaphragm. Pressurized fuel reaches the sensor's diaphragm through a blind hole. The sensor element (semiconductor device) for converting the pressure to an electric signal is mounted on this diaphragm. The signal generated by the sensor is inputted to an evaluation circuit, which amplifies the measuring signal and sends it to the ECU.



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SENSOR INSPECTION

Check items	Rail pressure value
Data display	Rail pressure value
Display condition	Engine idle
Rail pressure	35~50MPa
Normal value (Hi-scan)	40MPa

NOTE

Check the rail pressure with diagnosis equipment after engine has been warmed up enough.

Coolant temperature : 85 ± 3°C,
Fuel temperature : 35 ± 3°C

HARNESS INSPECTION PROCEDURE

Refer to P0192, P0193, and P0194 DTC inspection procedure.

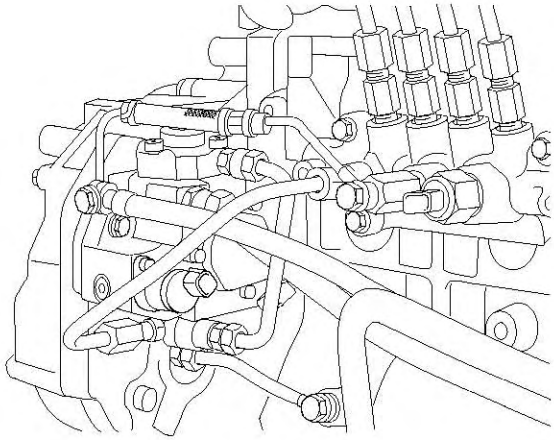
SENSOR INSPECTION

1. If the rail pressure sensor fails, replace the common rail assembly.
2. Tightening torque of common rail bracket flange bolt is 2.2~3.3kgf.m.

SUPPLY CONTROL VALVE

INSPECTION EBDE1F9E

SCV is solenoid type valve, in which ECU controls the valve opening and closing time and the pumping start time. To meet the target rail pressure, pump fuel amount is controlled by the current supplied to SCV. When SCV is closed, fuel path is shut so as to compress the fuel. And then, compressed fuel is supplied to common rail. If fuel pressure decreases, SCV opens and fuel is supplied for pumping.



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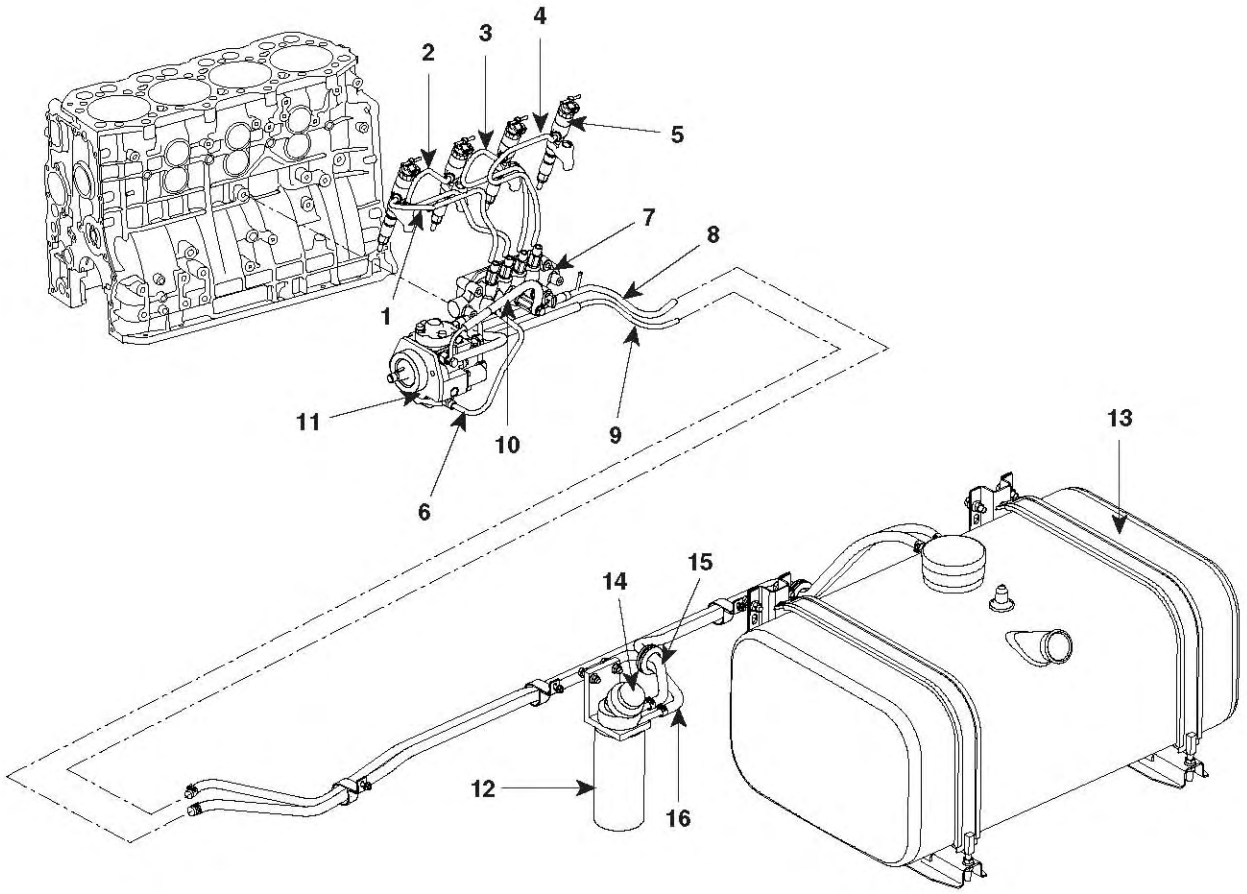
HARNESS INSPECTION PROCEDURE

Refer to P0627, P0629, and P1190 DTC procedure.

FUEL DELIVERY SYSTEM-ELECTRONIC

COMPONENTS E8FE0D1C



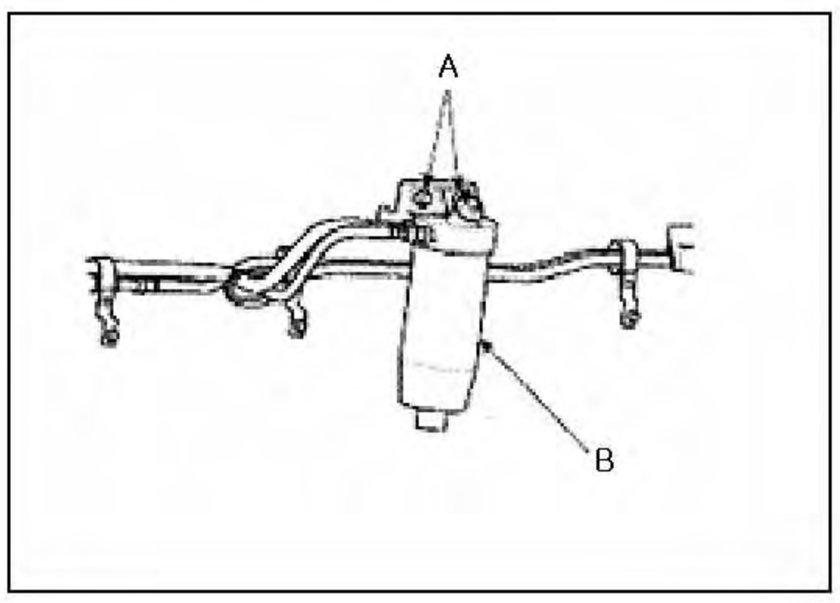
1. Injection Pipe No.1
2. Injection Pipe No.2
3. Injection Pipe No.3
4. Injection Pipe No.4
5. Injector assembly
6. Injection pipe (Pipe from pump to common rail)
7. Common rail assembly
8. Fuel return tube
9. Fuel suction tube
10. Fuel leak off hose
11. Supply pump assembly
12. Fuel filter assembly
13. Fuel tank
14. Air bleeding pump
15. Fuel hose in
16. Fuel hose out

FUEL FILTER

REPLACEMENT E683BBD6

REMOVAL

1. Remove fuel hose in and out.
2. Remove thermo switch and heater sensor.
3. Remove two mounting bolts (A) and fuel filter assembly (B).



INSTALLATION

Installation is the reverse order of removal.

INSPECTION E03E7792

1. General check
   a. Crack, bending, deformation, deterioration and clogging of hose or pipe
   b. Clogging or damage of fuel filter

2. When the filter has to be checked
   a. When the fuel in the tank is drained out and then replenished again for maintenance reasons
   b. When fuel filter is replaced
   c. When fuel main hose (pipe) is removed
      - Loosen the air plug of fuel filter.
      - Cover air plug hole with cotton cloth and keep pumping until it stops bubble.
      - When bubbles are removed completely, fasten the air plug and continue to pump until pump operation effort feels heavy.

3. Water drain from the fuel filter
   When water-warning lamp of fuel filter is turned on, it indicates that fuel filter is filled with water. So that water should be drained by the following sequence.

⚠ ***CAUTION***

If the vehicle is driven without draining the water despite the warning lamp is on, it may cause fatal trouble to the supply pump and injector.

   a. Turn the water drain sensor about half way to drain the water.

⚠ ***CAUTION***

Since water drains even if the plug is not fully loosened, water removal sensor should not be fully loosened.

   b. If diesel fuel drains after water has been drained completely, fasten the water drain sensor by hand.

ASSEMBLY E3BE335D

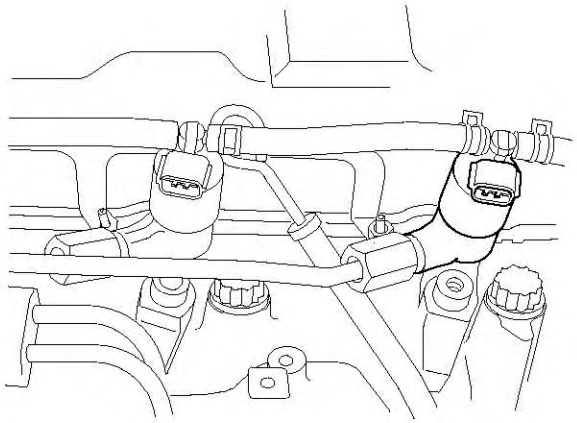
1. Apply oil to fuel filter cartridge and install it to the fuel filter head.

Fuel filter cartridge tightening torque: 1.0~1.5kgf.m

2. Perform [pump learning initialization] with diagnosis equipment after replacing fuel filter. Refer to [pump learning initialization] procedure when replacing ECU.

INJECTOR

COMPONENTS E8620F1A



[Caution]
o Since common rail fuel injection system operates at high pressure {1600bar}, a special caution should be exercised.
o While engine is running or within 1 minute after engine stops, no works should be made in relation to common rail fuel injection system.
o In particular, as the injector solenoid generates high temperature heat, do not touch it with bare hands. Start the service works only when engine has been cooled down enough after engine stops.
o Always keep the safety precautions.
o Ensure working area cleans all the time, and place the removed injector on the clean cloth. And pay attention to injector nozzle so that it is not polluted by foreign materials.
o Remove the protective caps for injector and fuel hose immediately just before performing the installation.
o When installing or removing injector, clean the injector contacting portion and replace O-ring and nozzle gasket with new one.
o Apply diesel to the O-ring of the injector before inserting them into the cylinder head.
o Install injector to the cylinder head vertically and install it correctly not to cause any damage such as shock.
o Observe bolts tightening torque when inserting and tightening the injector.
o Never reuse the high-pressure fuel pipe.

CLEANING E6D7F1DD

Clean the injector as follows to be reused.

1. Clean the injector by setting the injector vertically to the clean container.
2. Remove dust or dirt from the injector body and nozzle sealing with clean cloth if necessary.

REMOVAL E0ABA95D

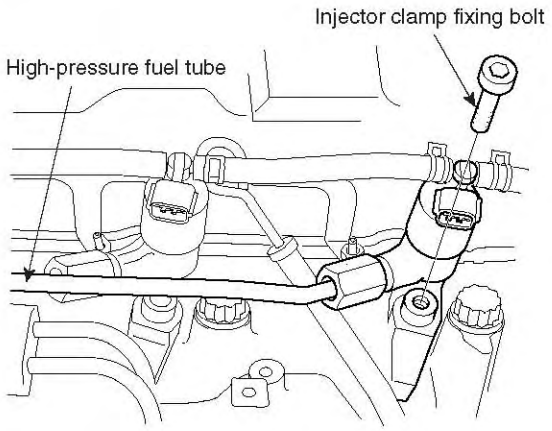
1. Stop the engine.
2. Remove negative (-) terminal of the battery.

   NOTE

   The ignition key should be turned OFF.
3. Pull off the injector connector.

   CAUTION

   - ***Connector should be connected and disconnected after the ignition switch is turned off.***
   - ***When installing connector, be sure to check clicking sound of connectors.***
   - ***Do not extremely bend or squeeze the cable.***
4. Remove high-pressure fuel tube (rail injector).
5. At first, pull off the fixing clip and then remove the injector return line.
6. Loosen injector clamp fixing bolt and remove the injector.



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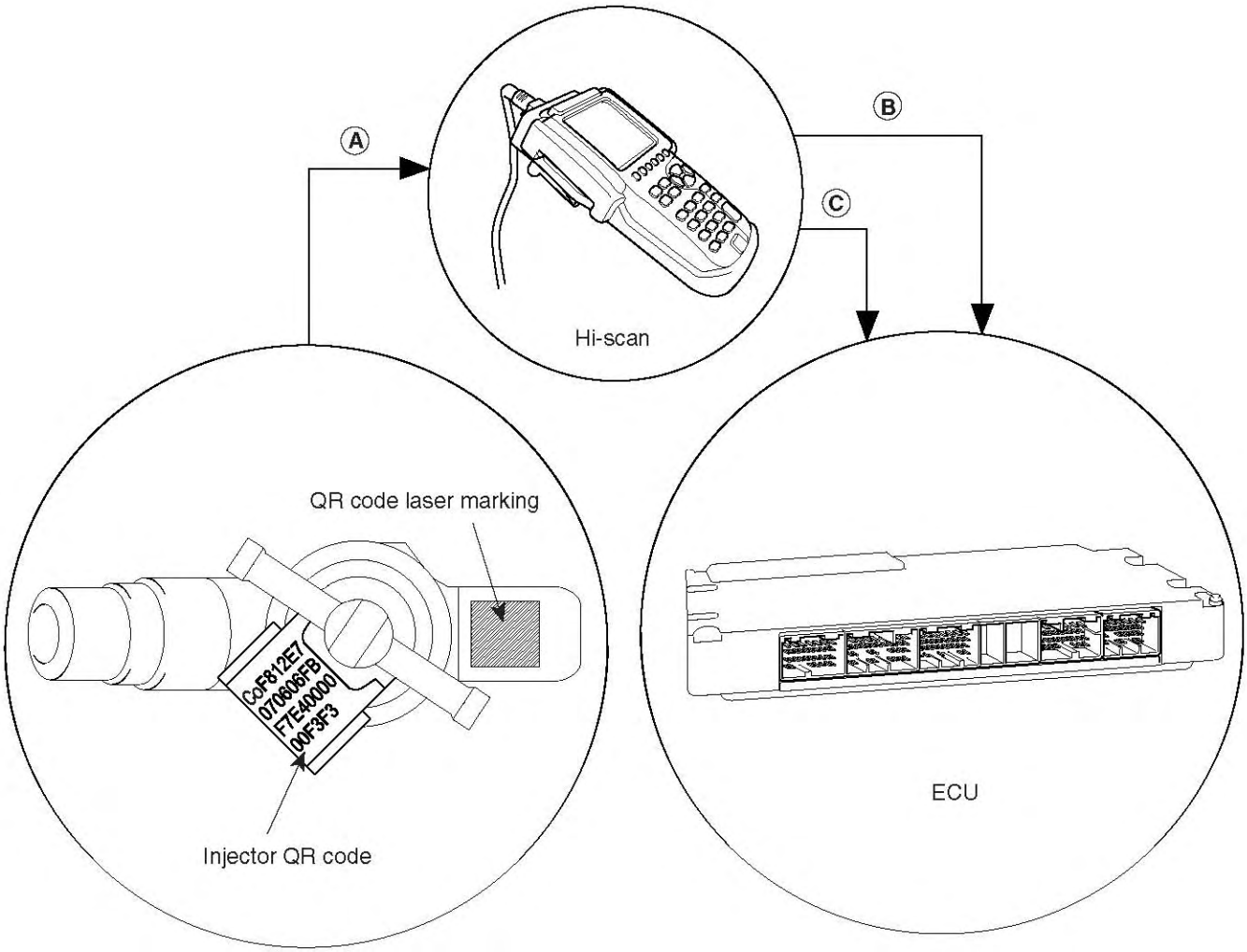
CAUTION

When removing injector, stop the engine and wait until the engine cools down enough. Since solenoid surface has high temperature, cool it down enough before starting the service work.

REPLACEMENT EA5BE41C

INJECTOR AND ECU



Reference

(A) : Input injector QR code into Hi-scan

(B) : Using Hi-scan, input injector QR adjusting value into ECU

(C) : Reprogram ECU using Hi-scan when replacing ECU

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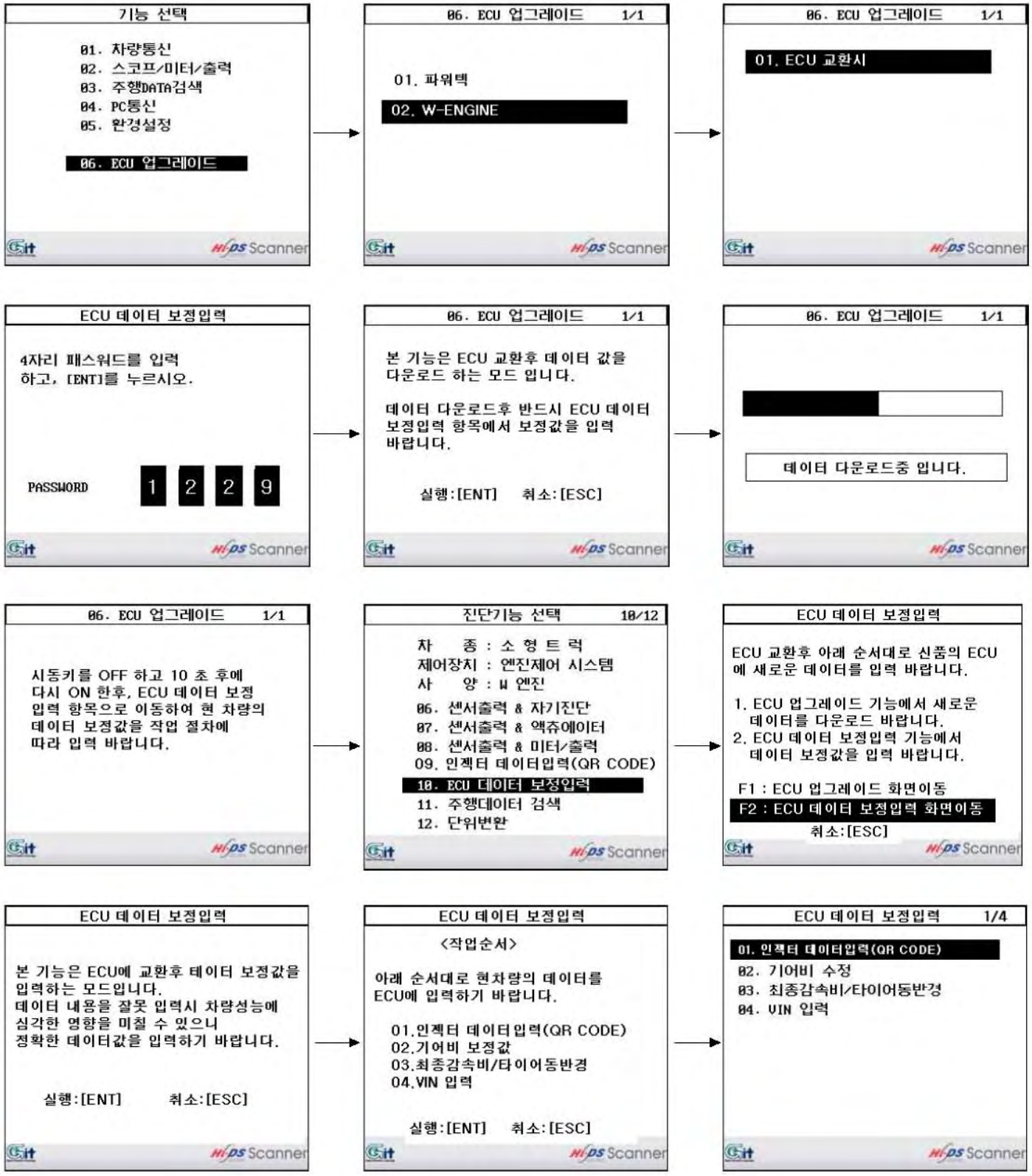
WORKFLOW WHEN REPLACING ECU



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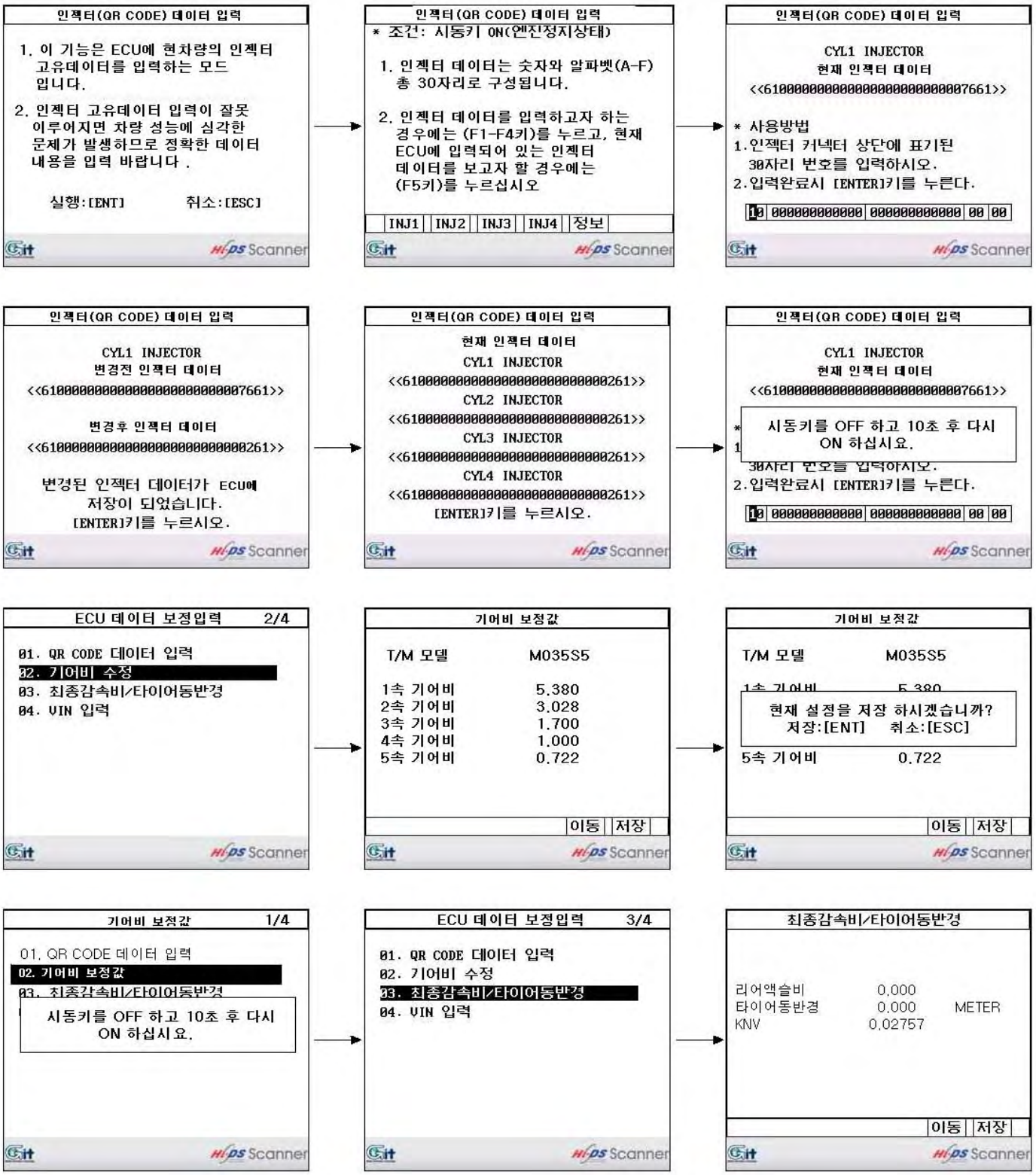
인젝터(QR CODE) 데이터 입력
1. 이 기능은 ECU에 현차량의 인젝터 고유데이터를 입력하는 모드 입니다.
2. 인젝터 고유데이터 입력이 잘못 이루어지면 차량 성능에 심각한 문제가 발생하므로 정확한 데이터 내용을 입력 바랍니다 .
실행:[ENT] 취소:[ESC]
인젝터(QR CODE) 데이터 입력
* 조건: 시동키 ON(엔진정지상태)
1. 인젝터 데이터는 숫자와 알파벳(A-F) 총 30자리로 구성됩니다.
2. 인젝터 데이터를 입력하고자 하는 경우에는 (F1-F4키)를 누르고, 현재 ECU에 입력되어 있는 인젝터 데이터를 보고자 할 경우에는 (F5키)를 누르십시오
INJ1 INJ2 INJ3 INJ4 정보
인젝터(QR CODE) 데이터 입력
CYL1 INJECTOR
현재 인젝터 데이터
<<610000000000000000000000000007661>>
* 사용방법
1.인젝터 커넥터 상단에 표기된 30자리 번호를 입력하시오.
2.입력완료시 [ENTER]키를 누른다.
인젝터(QR CODE) 데이터 입력
CYL1 INJECTOR
변경전 인젝터 데이터
<<610000000000000000000000000007661>>
변경후 인젝터 데이터
<<610000000000000000000000000000261>>
변경된 인젝터 데이터가 ECU에 저장이 되었습니다.
[ENTER]키를 누르시오.
인젝터(QR CODE) 데이터 입력
현재 인젝터 데이터
CYL1 INJECTOR
<<610000000000000000000000000000261>>
CYL2 INJECTOR
<<610000000000000000000000000000261>>
CYL3 INJECTOR
<<610000000000000000000000000000261>>
CYL4 INJECTOR
<<610000000000000000000000000000261>>
[ENTER]키를 누르시오.
인젝터(QR CODE) 데이터 입력
CYL1 INJECTOR
현재 인젝터 데이터
<<610000000000000000000000000007661>>
시동키를 OFF 하고 10초 후 다시 ON 하십시오.
2.입력완료시 [ENTER]키를 누른다.
ECU 데이터 보정입력 2/4
01. QR CODE 데이터 입력
02. 기어비 수정
03. 최종감속비/타이어둘반경
04. VIN 입력
기어비 보정값
T/M 모델 M035S5
1속 기어비 5.380
2속 기어비 3.028
3속 기어비 1.700
4속 기어비 1.000
5속 기어비 0.722
이동 저장
기어비 보정값
T/M 모델 M035S5
현재 설정을 저장 하시겠습니까?
저장:[ENT] 취소:[ESC]
5속 기어비 0.722
이동 저장
기어비 보정값 1/4
01. QR CODE 데이터 입력
02. 기어비 보정값
03. 최종감속비/타이어둘반경
시동키를 OFF 하고 10초 후 다시 ON 하십시오.
ECU 데이터 보정입력 3/4
01. QR CODE 데이터 입력
02. 기어비 수정
03. 최종감속비/타이어둘반경
04. VIN 입력
최종감속비/타이어둘반경
리어액슬비 0.000
타이어둘반경 0.000 METER
KNV 0.02757
이동 저장

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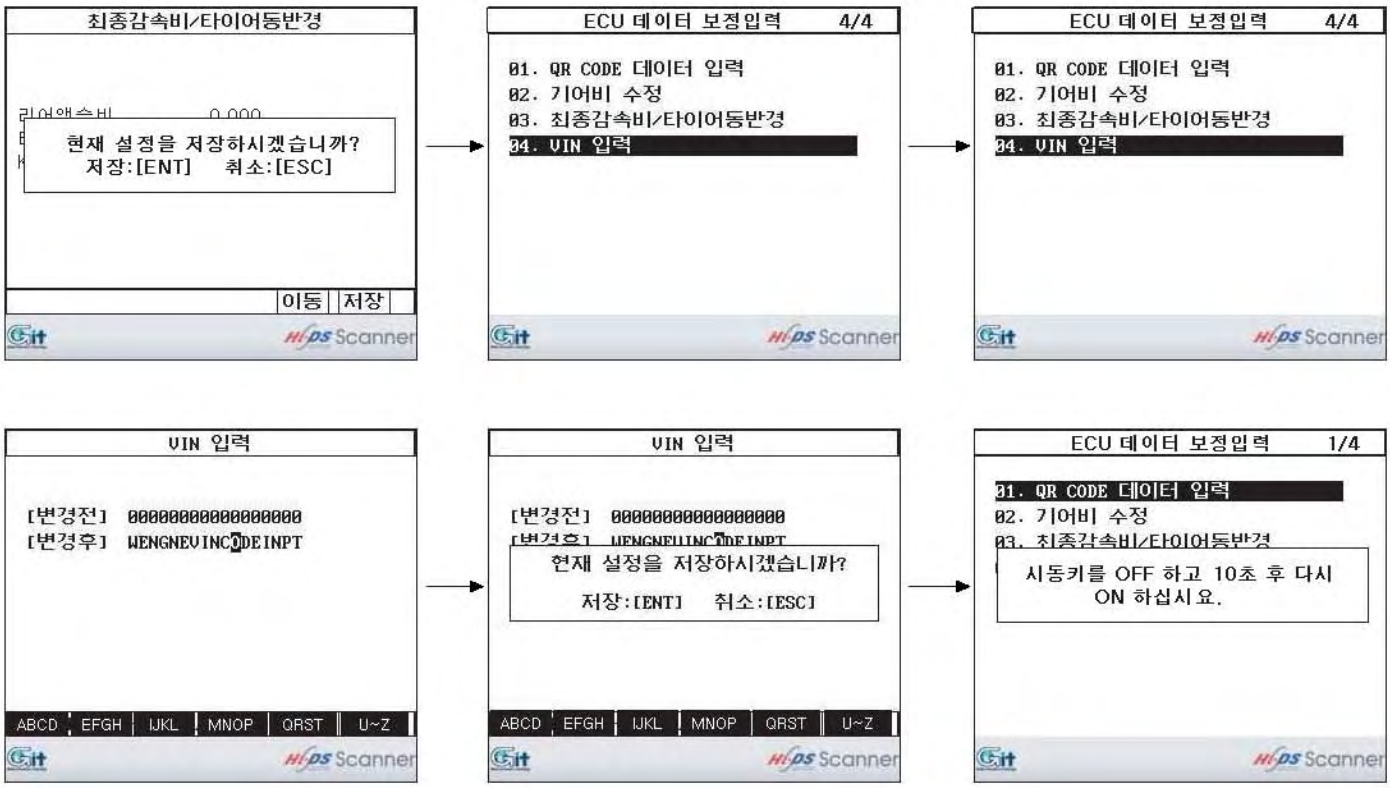

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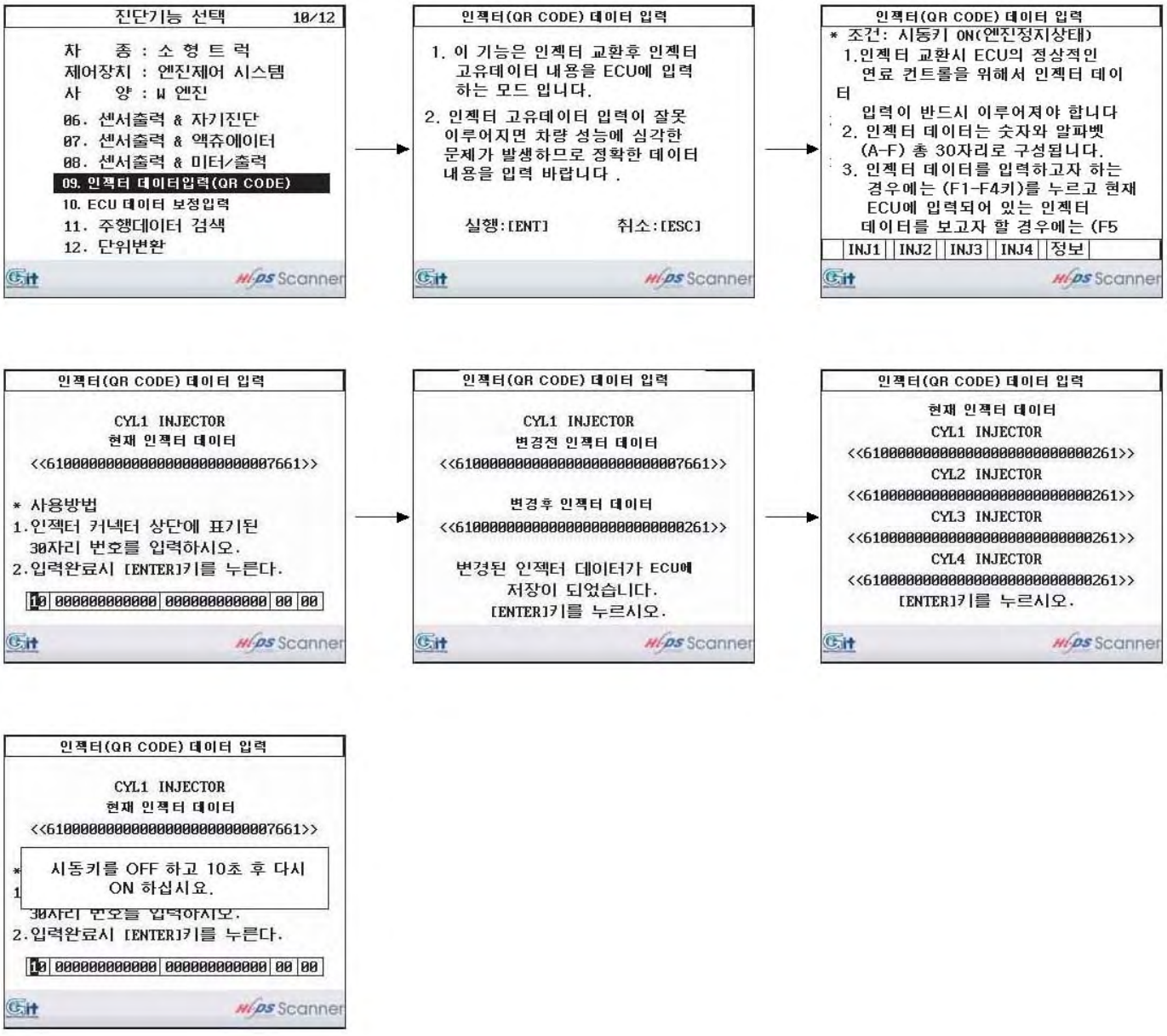
CAUTION

When ECU data input is done after ECU replacement, the [pump learning initialization] should be performed.

WORK FLOW WHEN REPLACING INJECTOR.



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INJECTOR REPLACEMENT

1. Remove the injector according to the removal procedure.
2. Install new injector.
3. Before connecting wiring connector to injector after installing injector, record the QR compensation value on the top of the injector connector.
4. Input the QR compensation value into ECU after connecting injector connector and turning the key on. And then, input the previously recorded compensation value in the order of the cylinders.

⚠ *CAUTION*

When replacing injector, the QR compensation value of injector must be inputted. If compensation value marked is not inputted into ECU, the engine performance can be deteriorated and there may have problems in the emission gas.

If the input of QR compensation value is missing or incorrect, check engine warning lamp may turn on or engine power may decrease.

1) If input is not performed: DTC P0602
2) If input is incorrect: DTC P0611
3) If QR value is invalid: DTC P0612

ECU REPLACEMENT

1. Key must be turned off before replacing ECU. Otherwise, ECU may be inoperative or have troubles.
2. When replacing ECU, ECU data of the corresponding vehicle must be inputted using a Hi-scan. Refer to the instruction on the Hi-scan for the detailed procedure.
3. When replacing ECU, QR compensation value of the currently installed injector should be inputted using a Hi-scan.
4. When inputting injector QR compensation value, key must be turned on.
5. As for the input of the injector QR compensation value, refer to the instruction of Hi-scan.
6. When the input of injector QR compensation value is completed, turn the ignition key off and turn it on again after hearing relay clicking sound (about 10 seconds later).
7. Perform [pump learning initialization] in the 'actuator test items.'

⚠ *CAUTION*

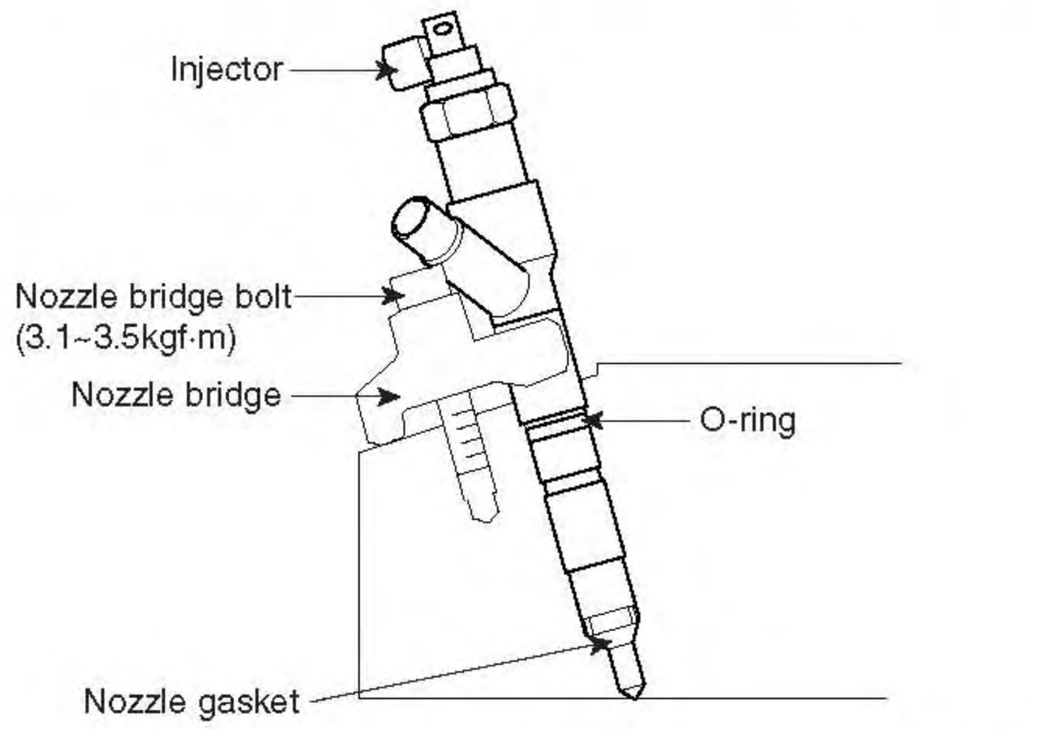
When replacing injector or ECU, the QR compensation value of injector must be inputted. If compensation value is not inputted into ECU, the engine performance could be deteriorated and there may have problems in the emission gas.

If the input of QR compensation value is missing or incorrect, check engine warning lamp may turn on or engine power may decrease.

1) If input is not made: DTC P0602
2) If input is incorrect: DTC P0602

INSTALLATION EDCDD2C1

1. The ignition key must be turned off.
2. Install new O-ring to the injector.
3. Install new nozzle gasket to the injector nozzle.



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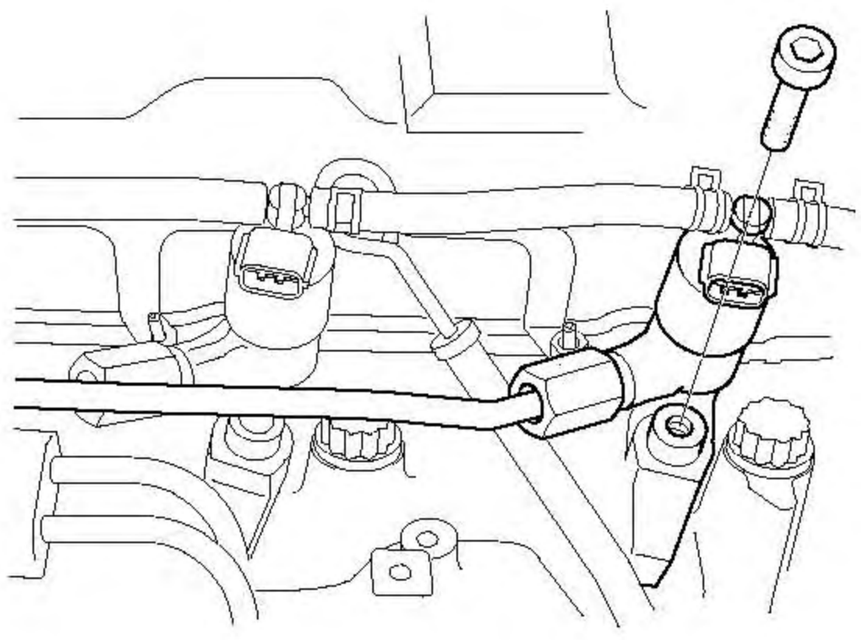
4. Install an injector clamp-mounting bolt.

Tightening torque: 3.1~3.5kgf.m



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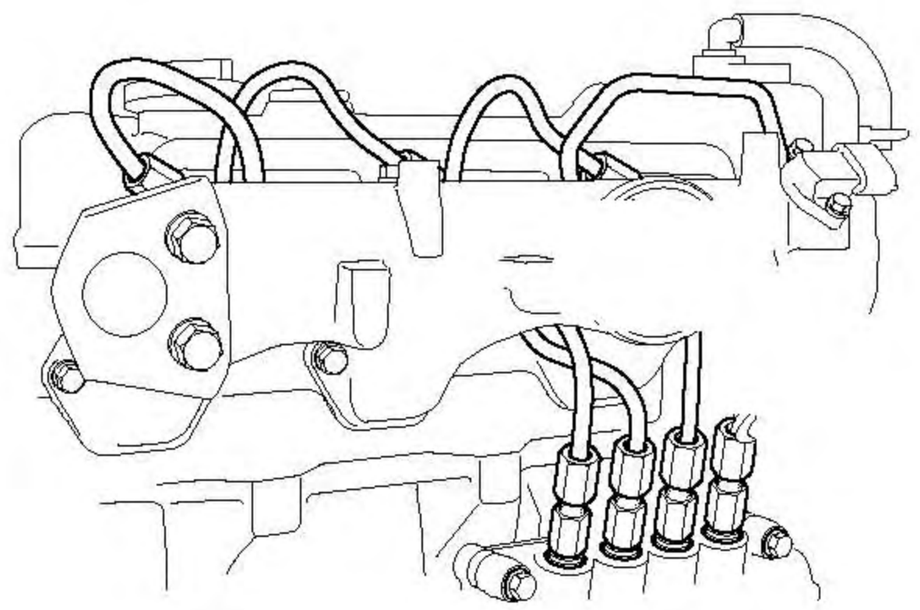
5. Install injector and injection pipe No. 1,2,3 and 4 between rails.

Tightening torque: 4.0~4.5kgf.m



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CAUTION

- ***Fix the injector securely with the injector clamp and then, install high-pressure fuel pipe.***
- ***When installing high-pressure pipe, assemble the nut tentatively to both sides of injector and rail.***
- ***After tentative assembly, tighten the nut in accordance with the specified torque.***
- ***Do not apply excessive force nor use unauthorized tools.***

6. Fix the fuel return hose. Never fix without fixing clip.
7. Install the injector connector.

NOTE

Install the connector #1, 2, 3 and 4 naturally under the high-pressure pipe.

8. Start the engine and check the high-pressure fuel line for any leakage of oil.

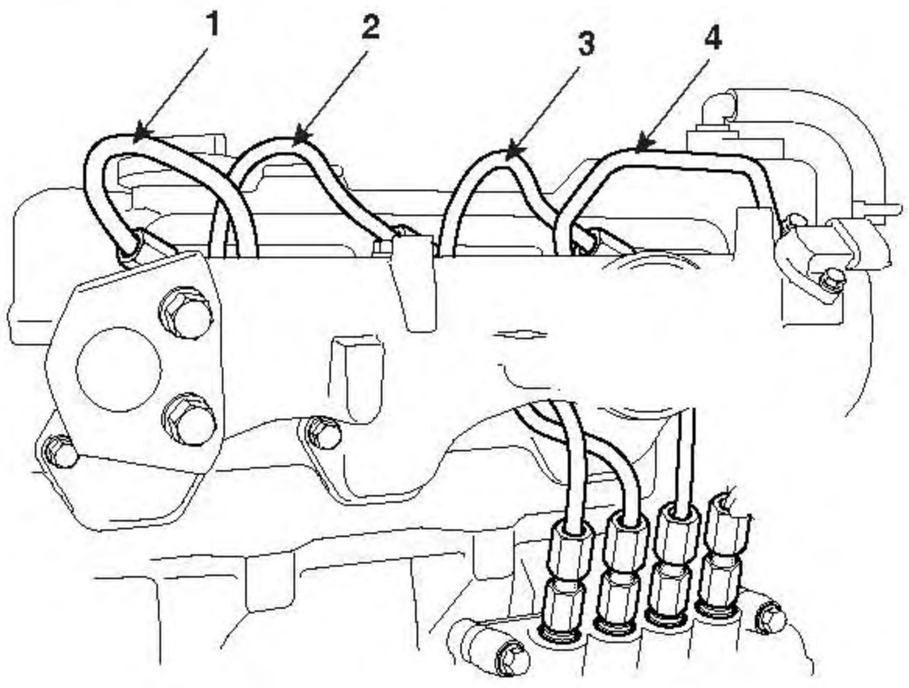
NOTE

If common rail fuel injection system leaks despite of the correct tightening torque, then components must be replaced.

COMMON RAIL ASSEMBLY

REMOVAL E7DFFA5E

1. Remove the high-pressure pipe (1~4) connecting rail and injector.



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2. Remove the injector pipe (1) connecting high-pressure pipe to common rail.

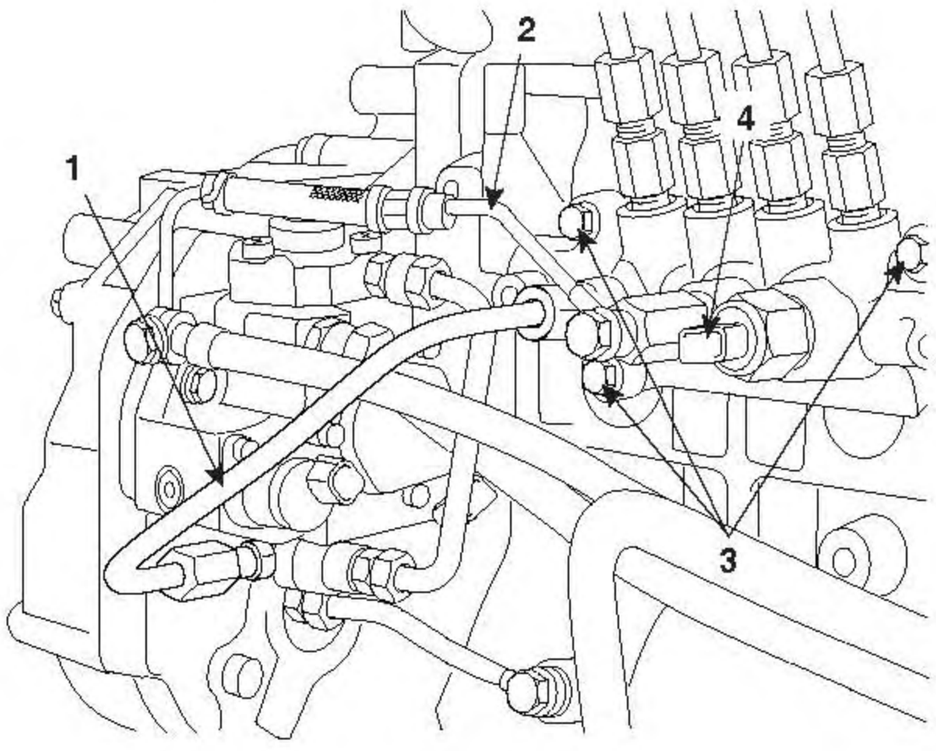
3. Remove return fuel hose (2).

4. Remove the rail pressure sensor (4).

⚠ *CAUTION*

Take care so that the fuel remaining in the rail may not leak.

5. Loosen the common rail pressure sensor mounting bolt (3) and remove the common rail assembly.



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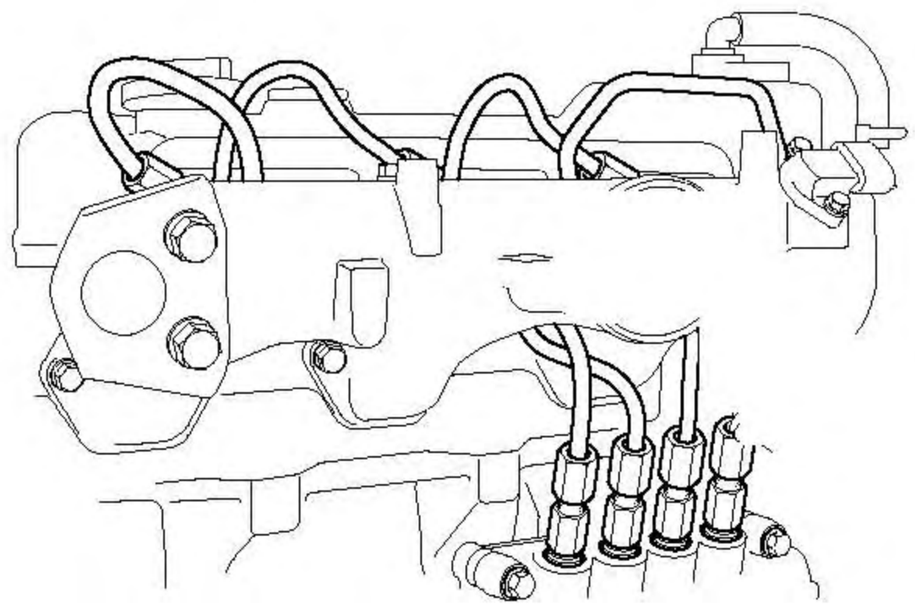
INSTALLATION E330ACBA

1. Install the mounting bolt of the common rail assembly.

Tightening torque: 2.2~3.3kgf.m

2. Fasten high-pressure fuel pipe.

Tightening torque: 4.0~5.0kgf.m



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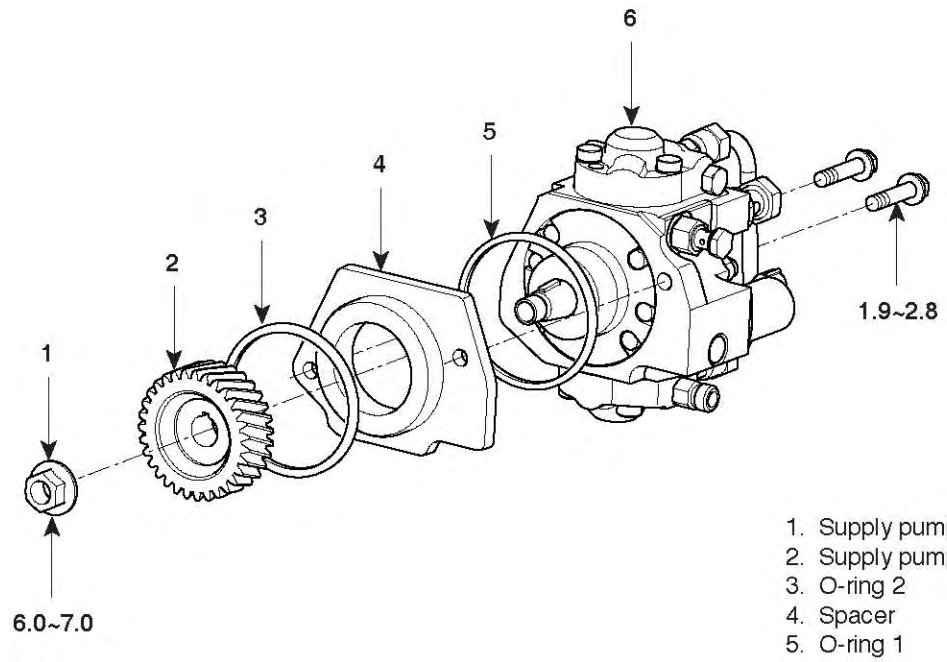
INJECTION PUMP-ELECTRONIC

SUPPLY PUMP

COMPONENT EB50E1EA



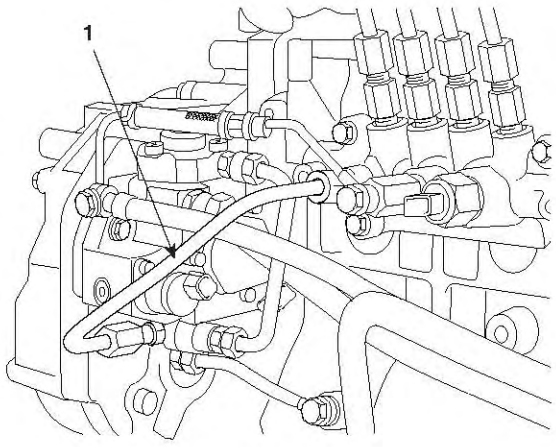
1. Supply pump mounting nut
2. Supply pump gear
3. O-ring 2
4. Spacer
5. O-ring 1
6. Supply pump

Tightening torque : **kgf.m**

SUDFL7036L

REMOVAL E33A46B5

1. Disconnect the high-pressure pipe (1) connected between supply pump and rail.

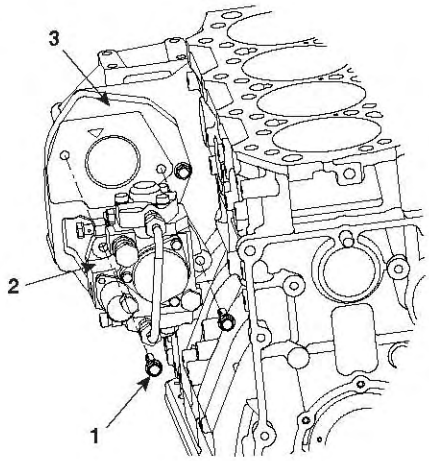


KDDFL5064A

2. Remove supply pump mounting bolt (1).
3. Remove the pump (2) from timing gear case (3).

NOTE

When removing supply pump, remove pump, spacer, and supply pump gear from the assembly.



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INSTALLATION EDEEBE40

1. Rotate the crankshaft to align the engine No. 1 cylinder at the TDC (Top Dead Center) position.

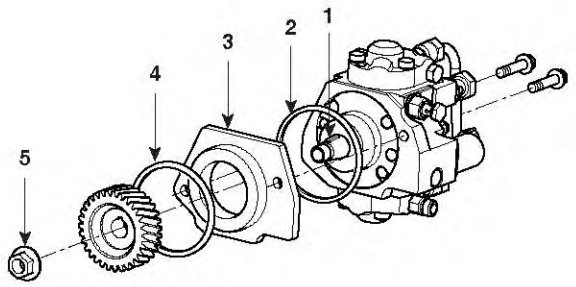
2. Before installing the pump, assemble the following parts at first.
   a. Place the key groove (1) of the pump at the center of the top.
   b. Insert the O-ring into the pump, and insert the spacer (3) into pump shaft.
   c. Insert the O-ring 2(4) onto spacer and inset the supply pump gear.

3. Tighten the nut (5) with tightening torque.

Tightening torque: 6.0~7.0kgf.m

CAUTION

If they are not fastened with the specified torque, supply pump and gear may be loosened so that the engine may be damaged or engine may stop.



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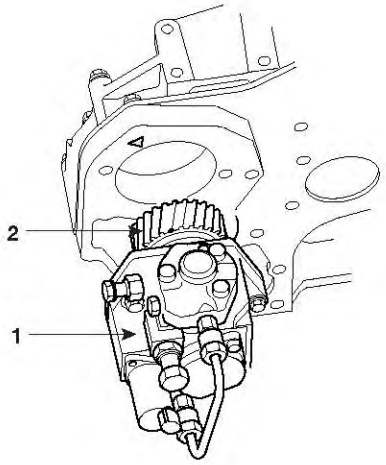
4. Insert the pump assembly (1) and gear (2) into the timing gear case.
   At this time, insert it as the * mark of the supply pump gear tooth aligns to ▽ mark of timing gear case.

NOTE

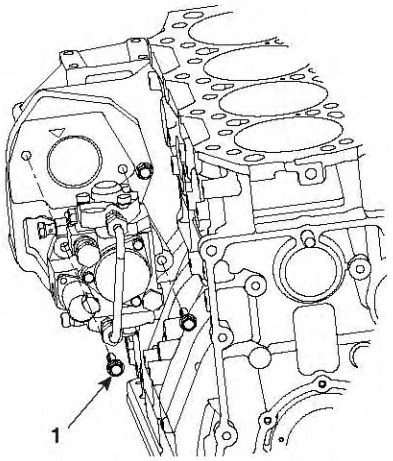
*Be sure to align the * mark at the top of gear tooth to the ▽ mark of timing gear case. Otherwise, the engine performance could be deteriorated and there may have problems in the emission gas.*



KDDFL5067A

5. Fasten the bolt (1) with the tightening torque after installing pump.

Tightening torque: 1.9~2.8kgf.m



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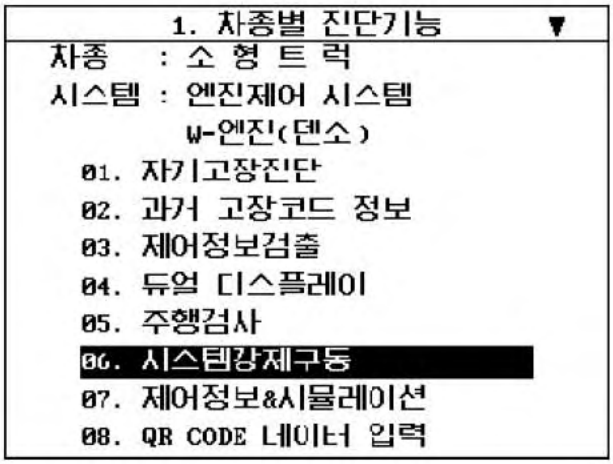
6. When replacing the pump with a new one, delete the learned value of previous pump inside the ECU and be sure to perform [pump learning initialization] in the 'actuator test items' to initialize the learning of the new pump.

NOTE

After 10 seconds from [pump learning initialization] is completed, turn the ignition key off. (Wait for 10 seconds at key off state).

7. The ignition key should be turned off more than 10sec. later after [pump learning initialization] is completed.

8. Start the engine and let the vehicle for 10 minutes at idle.



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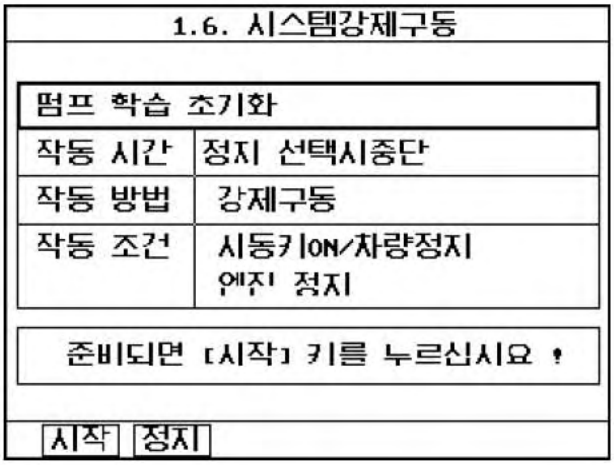


KDDFL5070A

NOTE

Above mentioned [pump learning initialization] actuator test should be performed when the pump is replaced with new one.

CAUTION

If the above mentioned [pump learning initialization] is not performed with diagnosis equipment after replacing new pump, the engine performance could be deteriorated and there may have problems in the emission gas.

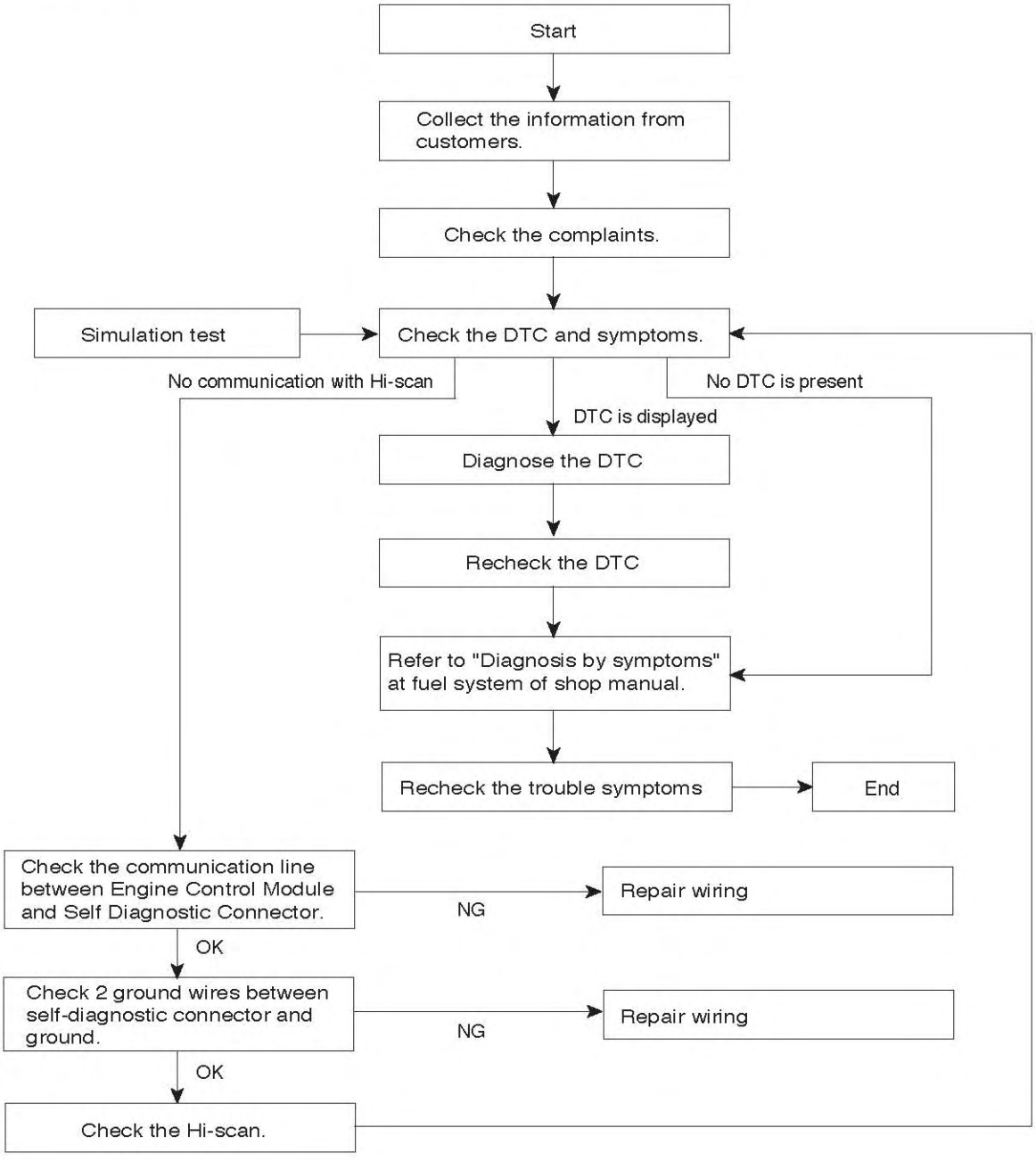
DTC TROUBLESHOOTING PROCEDURES

DESCRIPTION EFF006BD

TROUBLESHOOTING BY DIAGNOSTIC TROUBLE CODES

HOW TO USE DTC (DIAGNOSTIC TROUBLE CODE) GUIDE

Perform the following troubleshooting procedures.



SUDFL7037L

CHECKING DTC AND SYMPTOMS

Trouble diagnosis is mostly very difficult service in electronic control engine, especially, intermittent troubles are more difficult to handle. It is very important to get the information about the trouble through the dialogue with the customers to find out that how the troubles are happened under what conditions and when. Therefore, the investigation with the customers should be made prior to actual vehicle inspection. Most of the intermittent troubles happen under specific conditions and the causes will be identified easily if the symptom is recognizable.

1. Ask customers about the troubles such as symptoms, noise, driving conditions, road conditions, weather and the trouble frequencies.

2. Typically, most intermittent troubles are made by vibration, temperature change, moisture change, and wrong connection of connectors or wires. Try to find out that vehicles are affected under which conditions and what the reasons are.

3. Use the simulation test to reproduce the customer complaints.

SIMULATION TEST

If troubles are not reproducing, it is very difficult to diagnose. In this case, the trouble diagnosis can be performed by the following simulation test.

1. Vibration
   - Swing the connectors and wiring harness up and down as well as left and right.
   - Lightly tab the sensors and actuators.

2. Heat
   - Using hair driers, apply the heat to the parts assumed as the causes of the troubles.
   - Do not apply the heat excessively not so the parts as to be damaged. Especially, the engine control module should not be heated directly.

3. Moisture
   - Spray the water over the vehicle and around to simulate the rainy days or very humid weather.
   - Do not spray the water directly on the engine and the electric parts.

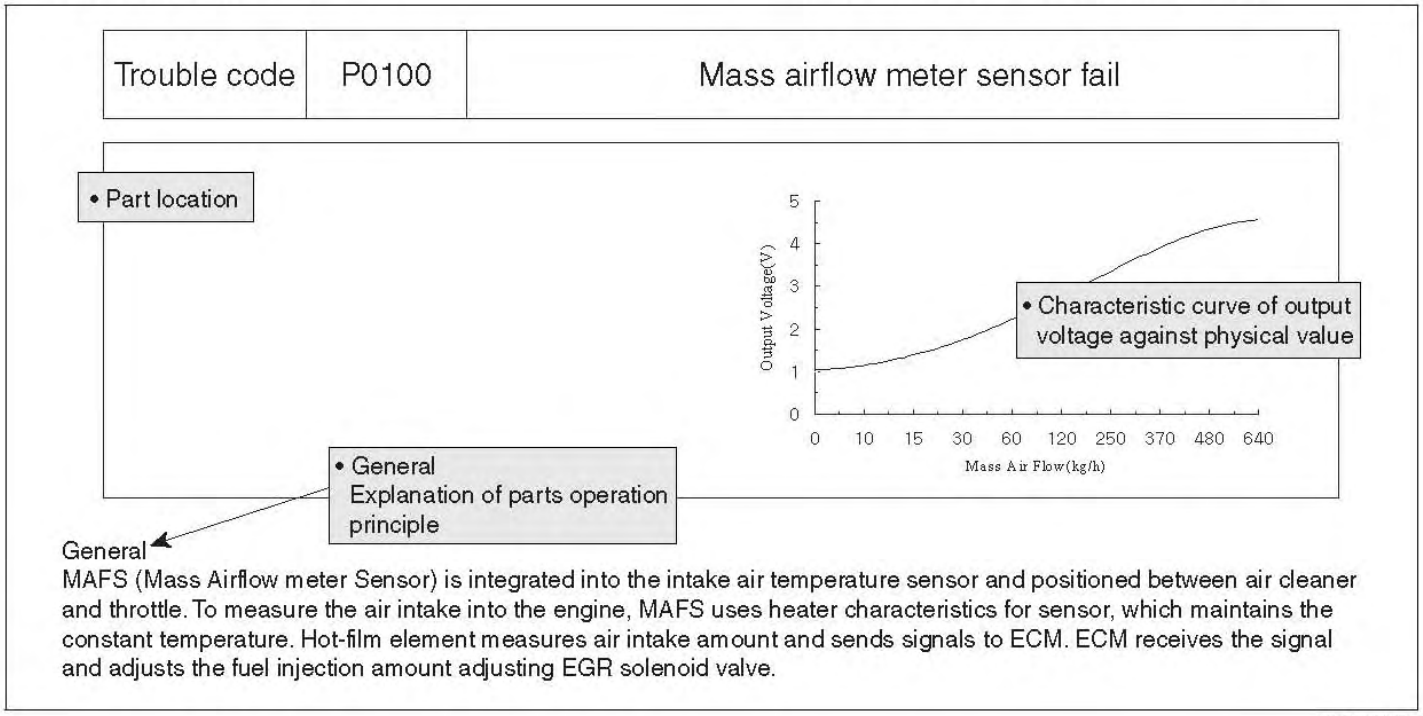
4. Electric load
   To reproduce the excessive electric load, turn the all electric system on simultaneously.

TROUBLE CODE DIAGNOSIS

Trouble code diagnosis manual consists mainly of Generals, Trouble code judging and Specifications.

GENERALS

Parts operation principles are explained. The part location and its characteristic curves are also shown.



SUDFL7036L

JUDGING CONDITIONS OF TROUBLE CODES

It shows the judging conditions of trouble codes and check items.

Judging conditions of trouble code

ï Judging conditions of trouble code

ï Check items

Trouble code	Judging conditions and fail-safe	Check items
P0100	Judging conditions ï C001 : Measured air quantity < -20 kg/h ï C002 : Measured air quantity > 800 kg/h ï C003 : Sensor supply current < 4.7 V or > 5.1 V Fail-safe ← ï Fail-safe ï Engine speed is limited.	- MAFS is short or disconnected - Mass airflow meter sensor - Engine Control Module

SUDFL7039L

SEPCIFICATIONS

It shows sensor, actuator or system specification.

Specification

MAFS	Specified value
	Engine idle
Output signal	Below 2.5V
Air flow	30 ~ 90 kg/h

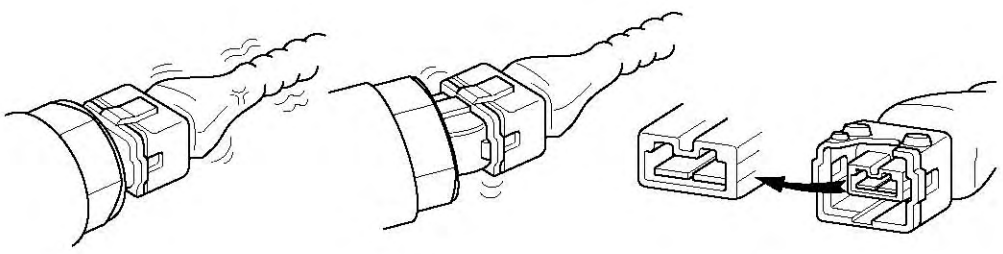
SUDFL7040L

RECHECK OF TROUBLE CODES

1. Delete the DTC by selecting 'Delete' icon at the memory of engine control module of Hi-scan or by disconnecting the battery (-) cable for about 20 seconds.
2. Start the engine and warm up the engine until it reaches normal operation temperature.
3. Make a test drive to see if the deleted DTC shows up again.
4. If the DTC is present, perform the diagnosis corresponding to the trouble code.

CHECKING PROCEDURES OF INTERMITTENT PROBLEMS.

1. Delete the DTC from the engine control module memory.
2. Check for the connector connection and check the connector terminals and wiring for damage, breakage and corrosion. Connectors should be connected securely.



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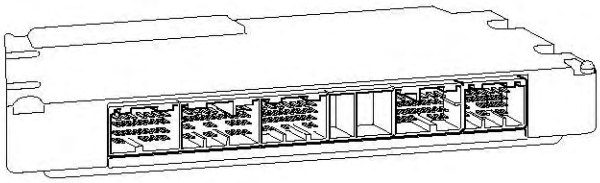
3. Perform simulation test.
4. Repair or replace defective parts or devices.
5. Check to see if the symptoms disappear by performing a test drive.

CHECKING PROCEDURES OF ENGINE CONTROL MODULE PROBLEMS

1. Turn the ignition key off.
2. Disconnect the engine control module connector, and measure the resistance between the ground terminal of the ECM and ground.
   (Normal value is lower than 1Ω)



SUDFL7041L

3. Check the connectors for connection, and check connector terminals and wiring for damage, breakage and corrosion. Connectors should be connected securely.
4. If problems are found, repair them immediately. If any problem is not shown, it may be the trouble of ECM itself.
5. Replace ECM with the normal one to see if the vehicle operates normally. If the troubles disappear, replace the ECM.

CAUTION

When replacing injector or ECM, the QR compensation value of injector should be inputted. If the compensation value is not inputted into ECM, the engine performance could be deteriorated and there may have problems in the emission gas.

SELF-DIAGNOSTIC TROUBLE CODE

Iems	Trouble code	Symptom	Warning lamp	Probable causes (No indicates ECM pin number)
Accel pedal position sensor1	P0122	Accel position sensor voltage is low	OFF	• Signal 21 is disconnected • Sensor fail
	P0123	Accel position sensor voltage is high	OFF	• Sensor fail
Accel pedal position sensor 2	P0222	Accel position sensor voltage is low.	OFF	• Signal 22 is disconnected • Sensor fail
	P0223	Accel position sensor voltage is high	OFF	• Sensor fail
Accel pedal position sensor	P1120	When accel pedal 1 and 2 are all fail.	ON	• Signal 21 and 22 are disconnected simultaneously • 123, 125 disconnected simultaneously or GND short • Signal 21 and 22 are GND • GND 135, 136 are disconnected simultaneously
Idle switch	P0226	Idle switch open and stuck	OFF	• Idle switch is melt and disconnected.
	P0225	Idle switch closed and stuck	OFF	• Idle switch is melt and stuck to switch • Terminal 58 is B+ short • Accel pedal 135, 136 are disconnected at the same time
VBB HIGH	P0563	High system voltage	ON	• Alternator voltage and regulator fail
VBB LOW	P0562	Low system voltage	OFF	• Alternator output is poor
Start switch	P0615	Starter switch is disconnected from battery	ON	• Starter switch is B+ short • Starter fails due to the starter overrun. • Starter switch input is disconnected.
Vehicle speed sensor	P0503	Vehicle speed sensor frequency fails	OFF	• Vehicle speed Sensor fail or noise generates to vehicle speed input.
	P0502	Vehicle speed sensor short or disconnected	OFF	• Wiring is disconnected, or sensor fails
	P0501	Vehicle speed sensor signal value fail	OFF	• Rapid change of vehicle speed due to surge.
Clutch switch	P0704	Clutch switch circuit fail (M/T only)	OFF	• Clutch switch fail • Clutch switch and wiring are disconnected or short to B+
Neutral switch	P0850	P/N switch fail (M/T only)	OFF	• Neutral switch and wiring are disconnected or B+ is short • Neutral switch fail
Main relay	P1616	Main relay fail(Main relay close and stuck)	OFF	• Main relay close and melt • Main relay is short to B+

Iems	Trouble code	Symptom	Warning lamp	Probable causes (No indicates ECM pin number)
SCV (Suction Control Valve)	P0629	Fuel pump circuit is short to battery	ON	• SCV (HI) pin 146, 147 are short to B+
	P0627	Fuel pump circuit is short	ON	• SCV (HI) pin 146, 147 are short to GND • SCV Internal coil is open or short • SCV (LOW) pin 144, 145 are short to GND • ECM is open in SCV circuit.
	P1190	SCV stuck	ON	• SCV fails
Fuel temperature sensor	P0183	Fuel temperature sensor voltage is high	OFF	• Fuel temperature sensor signal is open (ECM pin 163 is open) • Fuel temperature sensor fails
	P0182	Fuel temperature sensor voltage is low	OFF	• Fuel temperature sensor signal is short to GND (ECM pin 163 is short to GND)
Supply pump	P1217	Supply pump protection	ON	• SCV is stuck • SCV wiring is open
	P1218	Supply pump change	ON	• SCV is stuck • SCV wiring is open
	P1219	Supply pump fail	ON	• Pump fails (internal leakage of oil, key damage, plunger stuck)
Common rail pressure sensor	P0193	Common rail pressure sensor voltage is high	ON	• Signal pin 121 and 132 are open simultaneously • GND pin 134 is open • Pin 126 is short to terminal B+
	P0192	Common rail pressure sensor voltage is low	ON	• Pins 121, 132 are short to GND • Pin 126 (VCC) is open • When sensor fails
	P0194	Common rail pressure sensor signal value is fixed at intermediate value	ON	• When sensor fails
Common rail pressure	P0088	Common rail pressure exceeds upper limit	ON	• Overflow valve is inoperative • When actual common rail pressure is over 200 Mpa continuously due to abnormal common rail pressure during the sensor is normal.
	P0089	Common rail pressure exceeds high upper limit	ON	• Overflow valve is inoperative • When actual common rail pressure is over 200 Mpa continuously due to abnormal common rail pressure during the sensor is normal
Fuel leak	P0093	Common rail pressure sensor Malfunction fuel leak	ON	• Common rail pressure Sensor fails • Fuel leak at common rail or high-pressure line from common rail
P/L (pressure limit)	P2293	Pressure limit operates	ON	• Common rail pressure Sensor fails • When fuel pressure of rail exceeds the 221MPa

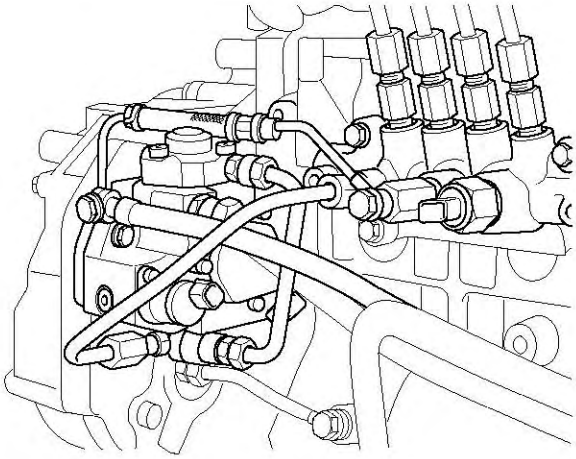
Iems	Trouble code	Symptom	Warning lamp	Probable causes (No indicates ECM pin number)
Flow damper	P1091	Cylinder No. 1 of fuel system is leaking.	OFF	• Fuel leak at fuel line of cylinder #1
	P1092	Cylinder No. 2 of fuel system is leaking	OFF	• Fuel leak at fuel line of cylinder #2
	P1093	Cylinder No. 3 of fuel system is leaking	OFF	• Fuel leak at fuel line of cylinder #3
	P1094	Cylinder No. 4 of fuel system is leaking	OFF	• Fuel leak at fuel line of cylinder #4
Injector group 1	P2148	Injector group 1 - voltage is high	ON	• Injector of cylinder NO. 1 or No. 4 fails (Pin 106 or 107 is short to B+, pin 103 and 104 are simultaneously open, pin 106 is short to B+)
	P2147	Injector group 1 - voltage is low	ON	• Pin 103 or 104 is short to GND
	P2146	Injector group 1 - circuit is open	ON	• Pin 106 or 107 is open • Pin 103, 104 are simultaneously open
Injector group 2	P2151	Injector group 2 - voltage is high	ON	• Injector of cylinder No. 1 or No.3 is abnormal (Pin 142 or 143 is short to B+, pin 137 or 138 is short to B+)
	P2150	Injector group 2 - voltage is low	ON	• Pin 137 or 138 is short to GND
	P2149	Injector group 2 - circuit open	ON	• Pin 142 or 143 is open • Pin 137 and 138 are simultaneously open
Injector NO.1	P0201	Injector #1 open/short	ON	• Pin 103 is open, injector coil is damaged
injector NO.2	P0202	injector #2 open/short	ON	• Pin 137 is open, injector coil is damaged
injector NO.3	P0203	injector #3 open/short	ON	• Pin 104 is open, injector coil is damaged
injector NO.4	P0204	injector #4 open/short	ON	• Pin 138 is open, injector coil is damaged
injector (FCCB)	P0301	Cylinder No.1 misfire is detected	OFF	-
	P0302	Cylinder No.2 misfire is detected	OFF	-
	P0303	Cylinder No.3 misfire is detected	OFF	-
	P0304	Cylinder No.4 misfire is detected	OFF	-

Iems	Trouble code	Symptom	Warning lamp	Probable causes (No indicates ECM pin number)
Intake pressure sensor	P0238	intake pressure sensor voltage is high	ON	• Sensor fails • ECM pin 57 shorts to terminal B+ • ECM pin 128 is short to terminal B+ • ECM pin 54 is open
	P0237	Intake pressure sensor voltage is low	ON	• Sensor fails • ECM pin 57 is open • ECM pin 128 is open
	P0236	Intake pressure sensor voltage is abnormal	ON	• Sensor fails
Intake temperature sensor	P0113	Intake temperature sensor voltage is high	OFF	• Pin 32 is open or short to B+ • Pin 55 is open and Sensor fails
	P0112	Intake temperature sensor voltage is low	OFF	• Pin 32 is short to GND and Sensor fails
Coolant temperature sensor	P0118	Coolant temperature sensor voltage is high	ON	• Pin 155 is open or short to B+ • Pin 55 is open and sensor fails
	P0117	Coolant temperature sensor voltage is low	ON	• Pin 155 is short to GND and Sensor fails
	P0217	Coolant temperature sensor exceeds upper limit	ON	• Engine cooling system malfunction
Crankshaft position sensor	P0335	Crankshaft position Sensor fail	ON	• Crankshaft position Sensor fails • Pin 40 and 41are open or short to GND
Cam speed sensor	P0340	Cam speed Sensor fail	ON	• Cam speed sensor fails • Pin 120 and 133 are open or short to GND • Pin 131 is short to terminal B+
Crank, cam sensor	P0385	Crankshaft position sensor and cam speed sensor fail simultaneously	OFF	• Crank, cam Sensors fail • Pin 40 and 41 are open or short to GND • Pin 120 and 133 are open or short to GND • Pin 131 is short to terminal B+
Glow plug	P1384	Glow relay ground short	OFF	• Pin 70, 71 are open or short to GND
	P1383	glow relay power short	OFF	• Pin 70, 71 are short to B+
Exhaust brake	P1231	Exhaust brake GND short	OFF	• Pin 36 is open or short to GND
	P1232	exhaust brake VB short	OFF	• Pin 36 is short to B+
CPU failure	P0607	CPU fails (IC failure)	ON	• CPU fails
	P0606	CPU malfunction (main CPU failure)	ON	• CPU fails
	P0601	Check some error	ON	• CPU data fails

Iems	Trouble code	Symptom	Warning lamp	Probable causes (No indicates ECM pin number)
QR code	P0602	QR code is not inputted	ON	• when injector QR compensation value is abnormal under QR compensation condition.
	P0611	QR data error	ON	• when injector QR compensation value is abnormal under QR compensation condition.
	P0612	QR code is not clear	ON	• QR compensation is not made
Atmospheric pressure sensor	P0108	Atmospheric pressure sensor Signal value is high	OFF	• Internal ECM atmospheric pressure Sensor fails
	P0107	Atmospheric pressure sensor signal value is low.	OFF	• Internal ECM atmospheric pressure Sensor fails
Charging circuit	P2503	Charging system - voltage is low	ON	• ECM charging condenser circuit fails
	P2504	Charging system - voltage is high.	ON	• ECM charging condenser circuit fails (overcharging)
Engine overrun	P0219	engine overrun	OFF	• Engine overrun

DTC P0088 COMMON RAIL PRESSURE EXCEEDS UPPER LIMIT
DTC P0089 COMMON RAIL PRESSURE EXCEEDS HIGH UPPER LIMIT

COMPONENT LOCATION EEFC3F47



KDDFL5084A

GENERALS EA66EAA9

Common rail pressure sensor is installed on common rail assembly. The fuel quantity is controlled to adjust the pressure by balancing the pressure measured by rail pressure sensor and the pressure requirement by engine control module (ECM).
Common rail pressure control valve is controlled by ECM and it usually remains open when the fuel is not supplied. Engine control module determines current sent to fuel pressure control valve depending on the engine speed, fuel quantity and rail pressure.

DTC JUDGING CONDITION EDAE06FB

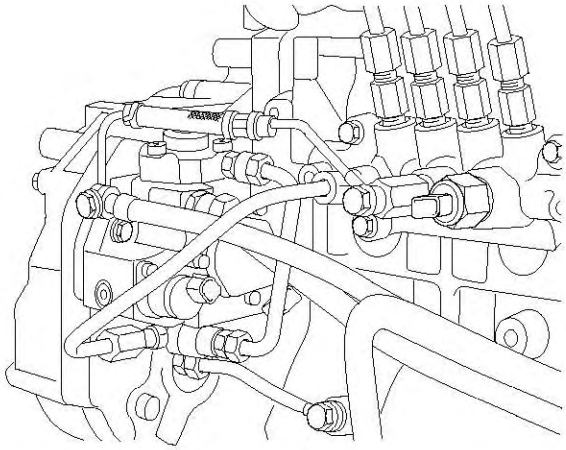
DTC	Judging condition and fail-safe	Check item
P0088	**Judging condition** • P0088: When common rail pressure continues more than 200Mpa **Judging time (returning condition)** • P0088: 2097.1ms (192.0ms) **Fail judging range** • While the vehicle is driving **Fail-safe** • Fuel pressure is limited to 40Mpa and fuel quantity is limited below 63mm³/st.	• Check to see if common rail pressure control valve circuit is open or short • Check common rail pressure control valve • Check engine control module

SPECIFICATION EB7C8049

Items	specifications
Resistance	2.07~2.53Ω

DTC P0093 C/RAIL PRESSURE SENSOR PERFORMANCE INVALID INCLUDED FUEL LEAK

COMPONENT LOCATION E34AC5E5



KDDFL5085A

GENERALS EEBBFAC5

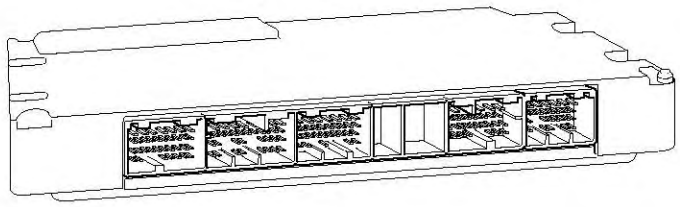
To send the voltage signal corresponding to the applied pressure to ECU, rail pressure sensor (RPS) should measure the pressure instantly at rail. Fuel flows to rail pressure sensor through the inlet from rail. Its end is sealed off by the diaphragm.
Pressurized fuel reaches the sensor diaphragm through blind hole. Sensor element (semiconductor unit) which converts pressure into electric signal is connected to diaphragm. Signal generated by the sensor is inputted into evaluation circuit, which sends the signal to ECM (Engine Control Module) after amplification.

DTC JUDGING CONDITION EF4B9498

DTC	Judging condition and fail-safe	Check item
P0093	**Judging condition** • P0093: when common rail pressure sensor fails or fuel leak at common rail or high-pressure system coming to common rail. **Judging time (returning condition)** • P0093: 180.0 CA (96.0 CA) **Fail judging range** • While the vehicle is driving	• Check sensor and fuel line • Common rail assembly • Engine control module

DTC P0107 ATOM. PRESS. SENSOR SIGNAL TOO LOW
DTC P0108 ATOM. PRESS. SENSOR SIGNAL TOO HIGH

COMPONENT LOCATION EC1CC19C



KDDFL5076A

GENERALS E401814A

Atmospheric pressure sensor, located inside the ECM (Engine Control Module), converts atmospheric pressure to current and sends it to ECM. With this signal, the status of the vehicle and the fuel ignition timing are controlled so that the vehicle performance is improved.

DTC JUDGING CONDITION EDAA94A1

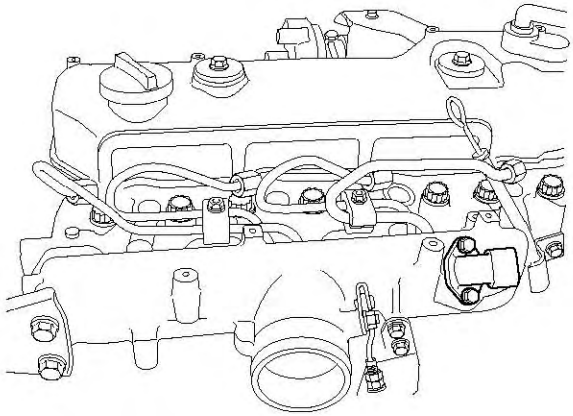
DTC	Judging condition and fail-safe	Check item
P0107 P0108	Judging condition • P0107: atmospheric pressure sensor output voltage < 1.9V • P0108: atmospheric pressure sensor output voltage > 4.3V Judging time (returning condition) • P0107: 1000.1ms (768.0ms) • P0108: 1000.1ms (768.0ms) Fail judging range • When the ignition key is on and while the vehicle is driven Fail-safe • P0107: Select default value of atmospheric pressure • P0108: Select default value of atmospheric pressure and limits the fuel below 40mm³/st. Default value = 101.3kPa (1013mbar)	• Check any tiny change of atmospheric pressure with Hi-scan. • Check if the internals of ECM have failed(Warning lamp turns on when ECM internal parts fail)

DIAGNOSIS GUIDE EADE4744

1. Since atmospheric pressure sensor is located inside the ECM, there is no special procedure for trouble diagnosing.
2. Erase the memorized DTC and perform the drive test.
3. If the deleted DTC displays again, replace the ECM with the normal one and check it again.
4. If the vehicle condition is normal, replace the ECM (engine control module).

DTC P0112 INTAKE AIR TEMP. SENSOR SIGNAL TOO LOW
DTC P0113 INTAKE AIR TEMP. SENSOR SIGNAL TOO HIGH

COMPONENT LOCATION E2BE3DE4



KDDFL5077A

GENERALS EBA0369A

Intake temperature sensor is built-in type installed in booster pressure sensor.
Electric resistance of intake temperature sensor varies as the temperature changes. In other words, it comprises of a negative characteristic thermister, in which the resistance decreases if temperature increases while the resistance increases if temperature decreases.
The 5V power of ECM (Engine Control Module) is supplied to intake temperature sensor via a resistance unit. Electric resistance of the resistance unit and thermister are converted into output signals. Based on these signals, ECM (Engine Control Module) controls fuel injection quantity and injection timing.

DTC JUDGING CONDITION EEA1EEAA

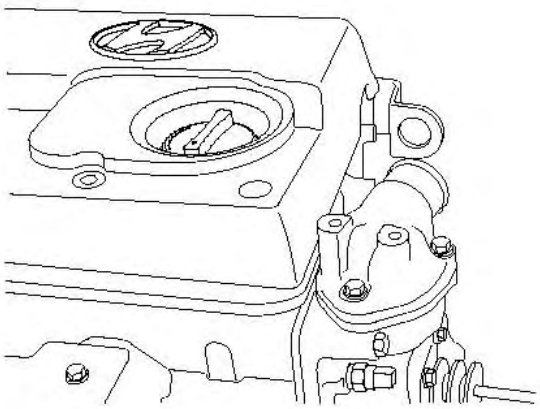
DTC	Judging condition and fail-safe	Check item
P0112 P0113	Judging condition • P0112: measured output voltage > 0.2V • P0113: measured output voltage < 4.5V Judging time (returning condition) • P0112: 2995.9ms(2995.9ms) • P0113: 2995.9ms(2995.9ms) Fail judging range • When the ignition key is on or while driving. Fail-safe • Fixed at -20°C when starting • Fixed at 25°C while driving	• P0112 1) Check if ECM pin 32 is short to ground 2) Check wiring and resistance • P0113 1) Check if ECM pin 32 is open 2) Check wiring and resistance

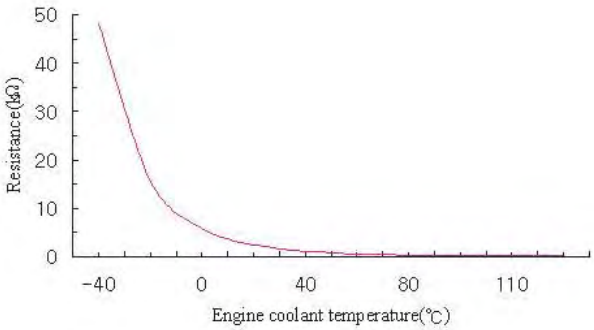
SPECIFICATION E57AAB81

Air temperature sensor	Specification						
	0°C	10°C	20°C	30°C	40°C	50°C	60°C
Electrical resistance	5384~6085Ω	3483~3900Ω	2311~2565Ω	1564~1736Ω	1077~1205Ω	758~854Ω	543~616Ω

DTC P0117 COOLANT TEMP. SENSOR SIGNAL TOO LOW
DTC P0118 COOLANT TEMP. SENSOR SIGNAL TOO HIGH
DTC P0217 COOLANT TEMP. EXCEEDS UPPER LIMIT

COMPONENT LOCATION EBFF0F08





KDDFL5078A

GENERALS E7D0EFB8

Engine Coolant Temperature sensor (ECTS), located on engine coolant passage of cylinder head, measures engine coolant temperature. Engine Coolant Temperature sensor uses the thermister, in which the resistance increases if engine coolant temperature decreases while the resistance decreases if the temperature increases.
The 5V power of ECM (Engine Control Module) is supplied to intake temperature sensor via a resistance unit. The resistance unit and thermister are connected in serial. Thermister resistance of engine coolant temperature sensor varies by Engine coolant temperature and the output voltage also varies. Information of Engine Coolant Temperature is used to control the basic fuel injection quantity and cooling fan.

DTC JUDGING CONDITION E7AB77A0

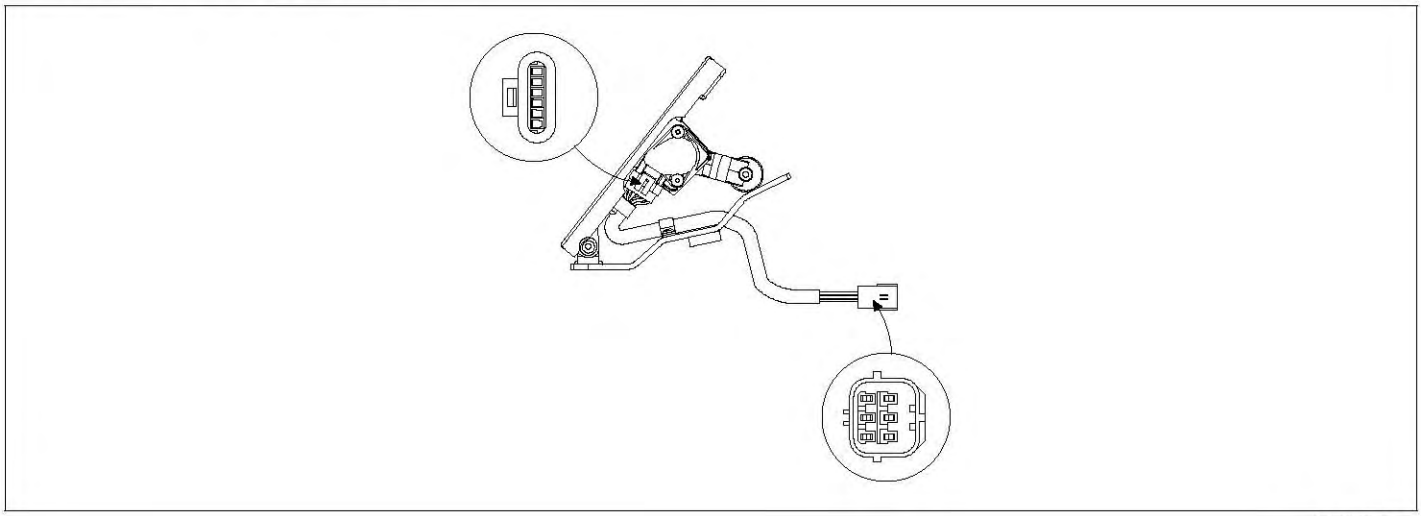
DTC	Judging condition and fail-safe	Check item
P0117 P0118 P0217	Judging condition • P0117: output voltage < 0.1V • P0118: output voltage > 4.92V • P0217: Engine coolant temperature > 115°C Judging time (returning condition) • P0117: 2995.9ms (2995.9ms) • P0118: 2995.9ms (2995.9ms) • P0217: 2995.9ms (2995.9ms) Fail judging range • When the ignition key is on or while driving Fail-safe • P0117, P0118: fixed at -20°C at starting, fixed at 80°C when driving • P0217: fuel quantity is limited below 40mm³/st.	• P0117 1) Check if ECM pin 155 is short to ground 2) Check sensors • P0118 1) Check if ECM pin 155 is open or short to terminal B+ 2) Check to see if ECM pin 155 is open 3) Check sensors • P0217: Check if engine cooling system malfunctions

SPECIFICATION E7BA600D

Engine coolant temperature	Specification				
	-20°C	20°C	20°C	40°C	80°C
Electric resistance	15.48 kΩ	5.79 kΩ	2.45 kΩ	1.148 kΩ	0.3222 kΩ

DTC P0122 ACCEL PEDAL SENSOR NO.1 SIGNAL TOO LOW
DTC P0123 ACCEL PEDAL SENSOR NO.1 SIGNAL TOO HIGH

COMPONENT LOCATION EACDEEF8



KDDFL5079A

GENERALS EADF804D

Electronic control fuel injection is performed by considering various factors such as accel pedal position etc. APS (Acceleration Position Sensor, APS) senses the acceleration status and transmits this information to ECM (engine control module). APS comprises of 2 Potentiometers (dual variable resistance type).
Power is supplied to these 2 potentiometers separately to ensure the sensing of driver's acceleration status. As the functions of the pedal setting, the voltage is generated by the potentiometer installed at the accel position sensor. Accel pedal position is calculated using programmed characteristic curve with this voltage.

DTC JUDGING CONDITION E5CFDC0B

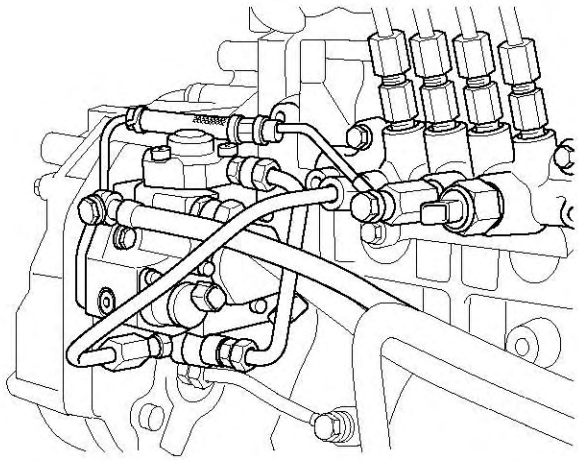
DTC	Judging condition and fail-safe	Check item
P0122 P0123	**Judging condition** • P0122: output voltage < 0.5V • P0123: output voltage > 4.2V **Judging time (returning condition)** • P0122: 1048.6ms (1048.6ms) • P0123: 524.3ms (1048.6ms) **Fail judging range** • When the ignition key is on or while driving **Fail-safe** • Normal driving is enabled by accel position sensor signal 2.	• Check if accel position sensor 1 is open or short. • Check accel position sensor. • Check ECM (Engine Control Module)

SPECIFICATION E3DCBFF9

Accel position sensor track1	Specification	
	Idle state (0%)	At full open (100%)
Output voltage	0.65V	3.85V

DTC P0182 FUEL TEMP.(PUMP) SENSOR SIGNAL TOO LOW
DTC P0183 FUEL TEMP.(PUMP) SENSOR SIGNAL TOO HIGH

COMPONENT LOCATION EB65DE06



KDDFL5084A

GENERALS EDF1AF4D

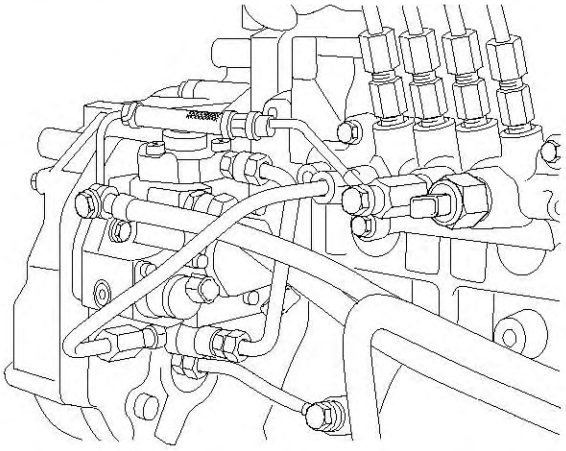
Fuel temperature sensor measures the fuel temperature and sends the information to engine control module (ECM). And then, ECM adjusts the fuel injection quantity based on this signal.

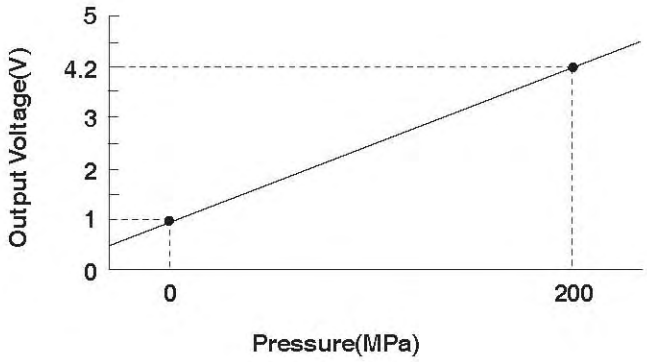
DTC JUDGING CONDITION E2E076A8

DTC	Judging condition and fail-safe	Check item
P0183 P0182	**Judging condition** • P0183: sensor output > 4.85V • P0182: sensor output < 0.15V **Judging time (returning condition)** • P0182, P0183: 4986.3ms (9986.3ms) **Fail judging range** • When the ignition key is on **Fail-safe** • Default value is selective When starting: -20°C When driving: 40°C	• P0182 1) Check to see if ECM pin 163 is short to GND. 2) Check wiring and resistance • P0183 1) Check if ECM pin 163 is open 2) Check wiring and resistance

DTC P0192 C/RAIL PRESS. SENSOR SIGNAL TOO LOW
DTC P0193 C/RAIL PRESS. SENSOR SIGNAL TOO HIGH
DTC P0194 C/RAIL PRESS. SENSOR MALFUNCTIONS

COMPONENT LOCATION E3E6F6DE





KDDFL5080A

GENERALS E0A60FFA

RPS (rail pressure sensor) converts fuel pressure (high pressure) in the rail to the voltage signal and transmits the signal to ECM (Engine Control Module). This signal is used to set the fuel quantity. The sensor element (semiconductor unit) for converting the pressure to the electric signal is connected to the diaphragm.
The sensor operates like an analog resistance. Resistance varies depending on the diaphragm change of rail pressure and then, rail pressure is converted into electric signal. Bridge circuit of diaphragm is amplified to 0.5V~4.2V(0~200MPa).

DTC JUDGING CONDITION EAAB795F

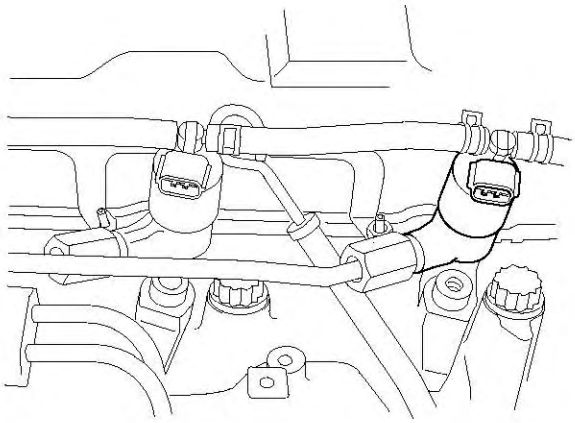
DTC	Judging condition and fail-safe	Check item
P0192 P0193 P0194	**Judging condition** • P0192: output voltage < 0.7V • P0193: output voltage > 4.7V • P0194 1) If the rail pressure sensor output voltage change is less than 0.0001V despite that target rail pressure is 20Mpa more than actual rail pressure. 2) Since there exists a difference of 1Mpa or more between target rail pressure and actual rail pressure, rail pressure sensor output voltage changes less than 0.0001V. **Judging time (returning condition)** • P0192: 200.0ms (192.0ms) • P0193: 200.0ms (192.0ms) • P0194: 16008.5ms (192.0ms) **Fail judging range** • When driving **Fail-safe** • P0192, P0193: Limit the fuel quantity below 63mm³/s when the default is 40Mpa. • P0194 : Limit the fuel quantity below 40mm³/st.	• P0192 1) Check if ECM pin 121, 126, 132 are short to ground 2) Check rail pressure sensor • P0193 1) Check if ECM pin 121, 132, 134 are open 2) Check rail pressure sensor. • Check P0194: sensor output

SPECIFICATION ECB6624B

	Specification
Rail pressure sensor	Engine idle state after warm up (Engine coolant temperature : 85 ±3°C, fuel temperature : 35 ±3°C)
Output voltage	1.7V or less
Rail pressure	45 MPa

DTC P0201 TWV1 OUTPUT OPEN LOAD INJECTOR COIL OPEN
DTC P0202 TWV3 OUTPUT OPEN LOAD INJECTOR COIL OPEN
DTC P0203 TWV5 OUTPUT OPEN LOAD INJECTOR COIL OPEN
DTC P0204 TWV2 OUTPUT OPEN LOAD INJECTOR COIL OPEN

COMPONENT LOCATION E3F04514



KDDFL5081A

GENERALS EA4200D0

Injector of the Common Rail System electronically controls the fuel quantity (ECM applies the current to the injector). Therefore, it can perform multiple injections including injection within short intervals. Injector nozzle is open when solenoid valve opens so that it directly injects the fuel into the combustion chamber. After injection, fuel returns to fuel tank via the return line.

DTC JUDGING CONDITION EEE3F9E1

DTC	Judging condition and fail-safe	Check item
P0201 P0202 P0203 P0204	**Judging condition** • P0201: When "TWV1 open" state is detected simultaneously. • P0202: When "TWV2 open" state is detected simultaneously. • P0203: When "TWV3 open" state is detected simultaneously. • P0204: When "TWV4 open" state is detected simultaneously. **Judging time (returning condition)** • P0201: 4499.0ms (1080.0ms) • P0202: 4499.0ms (1080.0ms) • P0203: 4499.0ms (1080.0ms) • P0204: 4499.0ms (1080.0ms) **Fail judging range** • When the ignition key is on **Fail-safe** • Fuel quantity is limited less than 40mm³/st • If engine is operated for a long time, as injector is failed, engine may be damaged.	• Check to see if injector coil is open • Check the injector pin resistance • Check wiring • P0201: Check to see if TWV1 (103) is open • P0202: Check to see if TWV2 (137)) is open • P0203: Check to see if TWV3 (104) is open • P0204: Check to see if TWV4 (138) is open

SPECIFICATION EF5FAFDF

Injector	Specification (20 °C)
resistance	0.3~0.6Ω

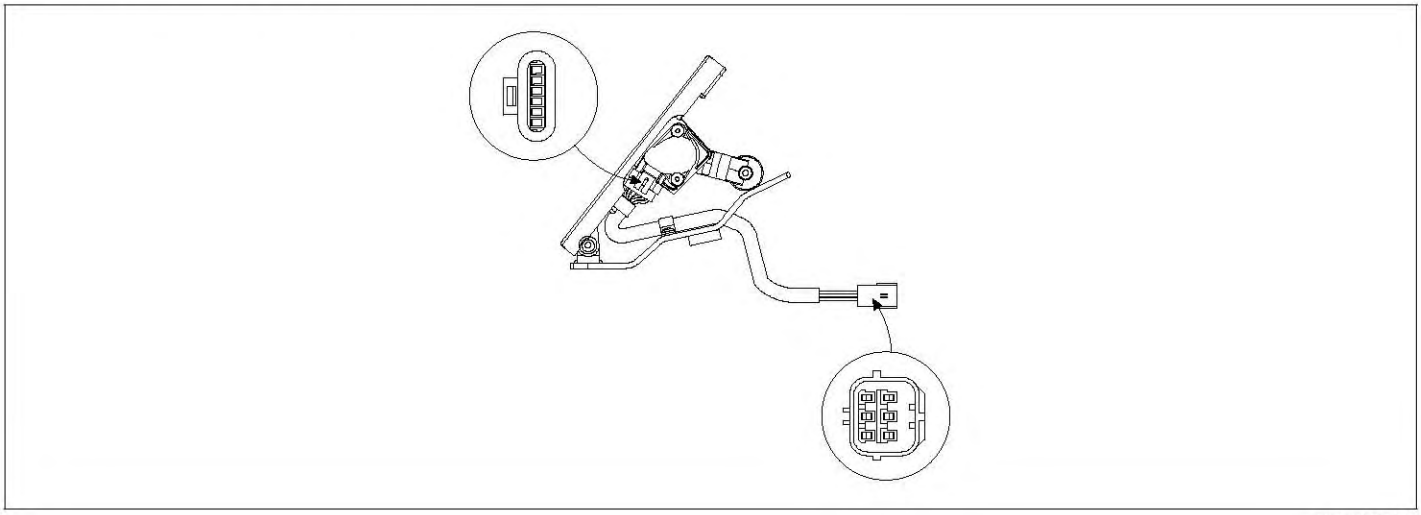
DTC P0219 ENGINE OVERRUN

DTC JUDGING CONDITION EABFBB46

DTC	Judging condition and fail-safe	Check item
P0219	**Judging condition** • P0219 : Crank position sensor≥ 4000rpm **Judging time (returning condition)** • P0219: 97.6ms (192.0ms) **Fail judging range** • While the vehicle is driving **Fail-safe** • After fuel injection above 4000rpm, fuel injection resumes when the rpm drops 3500rpm.	• Check crank position sensor

DTC P0222 ACCEL PEDAL SENSOR NO.2 SIGNAL TOO LOW
DTC P0223 ACCEL PEDAL SENSOR NO.2 SIGNAL TOO HIGH
DTC P1120 BOTH ACCEL PEDAL SENSOR SIGNAL INVALID

COMPONENT LOCATION E8E971DD



KDDFL5079A

GENERALS E7A4DFE5

Electronic control fuel injection is made by considering various factors such as accel pedal position etc. APS (Acceleration Position Sensor) senses the acceleration status and transmits the information to ECM (engine control module).
APS comprises of 2 Potentiometers (dual variable resistance type). Power is supplied to these 2 potentiometers separately to ensure the sensing of driver's acceleration status. As a function of pedal setting, voltage is generated by potentiometer installed at the accel position sensor. Accel pedal position is calculated using programmed characteristic curve with the voltage.

DTC JUDGING CONDITION EAD8FCCA

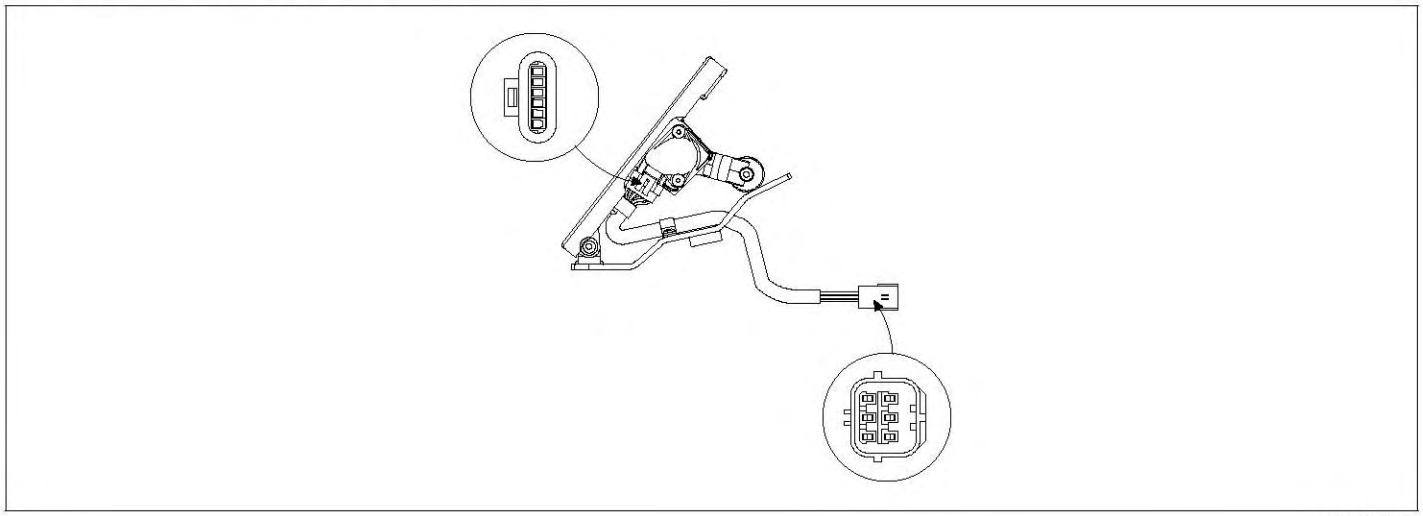
DTC	Judging condition and fail-safe	Check item
P0222 P0223 P1120	**Judging condition** • P0222: output voltage < 0.5V • P0223: output voltage > 4.2V • P1120: Accel pedal sensor signals 1 and 2 are abnormal simultaneously **Judging time (returning condition)** • P0222: 1048.6ms (1048.6ms) • P0223: 524.3ms (1048.6ms) • P1120: 524.3ms (1048.6ms) **Fail judging range** • When the ignition key is on or while the vehicle is driven **Fail-safe** • Normal driving is enabled by accel position sensor signal 1. • if idle switch is off (when accel pedal is depressed) in case of P1120, accel pedal open 50% signal is maintained (to restrict rpm rise).	• Check if accel position sensor 2 is open or short • Check accel position sensor • Check ECM (Engine Control Module)

SPECIFICATION E8CC9DCE

Accel position sensor track 2	Specification	
	Idle state (0%)	At full open (100%)
Output voltage	0.65V	3.85V

DTC P0225 IDLE SWITCH STUCK CLOSED
DTC P0226 IDLE SWITCH STUCK OPEN

COMPONENT LOCATION E4AE6C3A



KDDFL5079A

GENERALS EB16A3C0

Idle switch is installed at accel pedal position sensor. When a driver depresses the accel pedal, the signal is sent to engine control module (ECM) so that it controls the fuel injection quantity by judging that the current engine condition is accelerating or deccerlating.

DTC JUDGING CONDITION E0F895AD

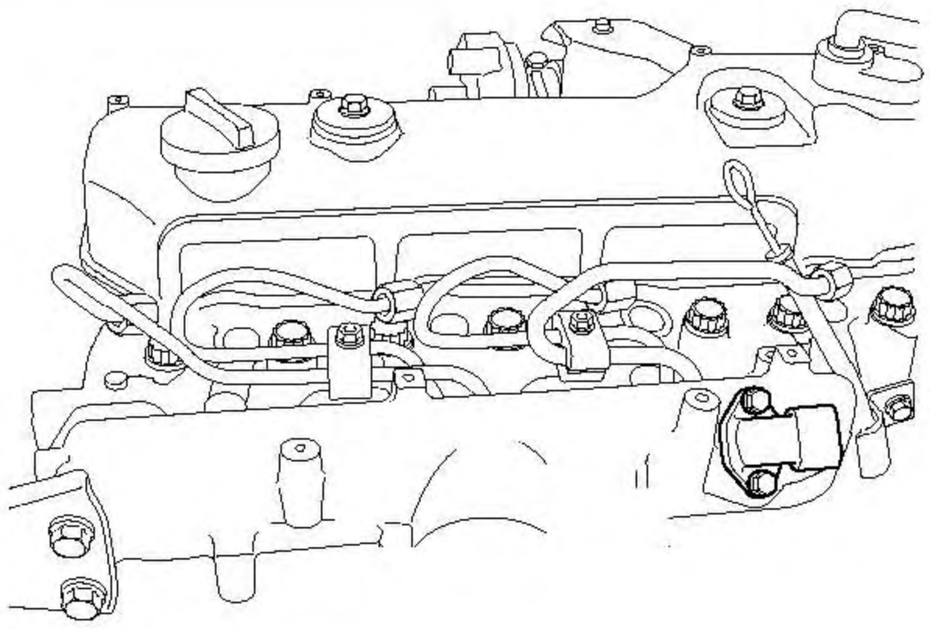
DTC	Judging condition and fail-safe	Check item
P0226 P0225	**Judging condition** • P0226: When idle switch opens even if accel pedal is released. • P0225: When idle switch remains closed even if the accel pedal is applied. **Judging time (returning condition)** • P0225, P0226: 1048.6ms (1048.6ms) **Fail judging range** • The opening of accelerator pedal is limited to 80%	• Check to see if idle switch is melt or open. • Check engine control module

SPECIFICATION E9016B8C

Items	Specifications
When accel pedal is applied	OFF (0V)
When accel pedal is released	ON (5V)

DTC P0236 BOOST PRESSURE SENSOR PERFORMANCE INVALID
DTC P0237 BOOST PRESSURE SENSOR SIGNAL TOO LOW
DTC P0238 BOOST PRESSURE SENSOR SIGNAL TOO HIGH

COMPONENT LOCATION E7E2E0CF



KDDFL5077A

GENERALS EDDB2D3D

The intake pressure sensor is integrated with the intake temperature sensor and installed on the intake manifold assembly. Intake pressure sensor measures air amount into the engine and sends the signal to ECM (engine control module). ECM (Engine control Module) receives signal from intake pressure sensor and determines injection timing and quantity.

DTC JUDGING CONDITION E960F276

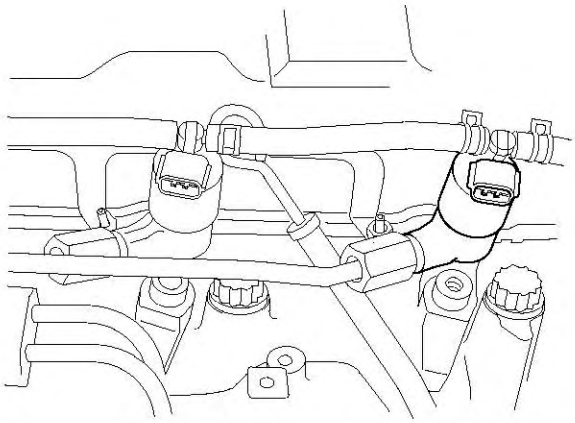
DTC	Judging condition and fail-safe	Check item
P0238 P0237 P0236	Judging condition • P0238: measured output voltage > 4.8V • P0237: measured output voltage < 0.5V • P0236: intake pressure Sensor abnormal operation (When there is no change in intake pressure value) Judging time (returning condition) • P0238: 1048.6ms (1048.6ms) • P0237: 1048.6ms (1048.6ms) • P0236: 10485.6ms (10485.6ms) Fail judging range • When ignition key is ON: P0238, P0237, P0236 • When driving: P0238, P0237, P0236 Fail-safe • Intake pressure is fixed at default value: fuel amount is limited below 40mm³/st. • Engine power limit (Fuel correction and timing stop depending on intake air pressure)	• P0238: Check ECM pin 128 and terminal B+ for short or wiring condition. • P0237: Check if ECM pin 128 is short to the ground or is broken. • P0236: Check sensor output[If output voltage remains the same, even when other sensors (atmospheric pressure, fuel pressure) are changed, it is abnormal.

SPECIFICATIONS E9BDF404

Item	Intake pressure
Output signal	1.63V
Specification (at idle condition)	70KPa (525mmHg)

DTC P0301 CYLINDER 1 FUEL SYSTEM FAILURE
DTC P0302 CYLINDER 2 FUEL SYSTEM FAILURE
DTC P0303 CYLINDER 3 FUEL SYSTEM FAILURE
DTC P0304 CYLINDER 4 FUEL SYSTEM FAILURE

COMPONENT LOCATION E887CCD6



KDDFL5081A

DTC JUDGING CONDITION ED2FBB72

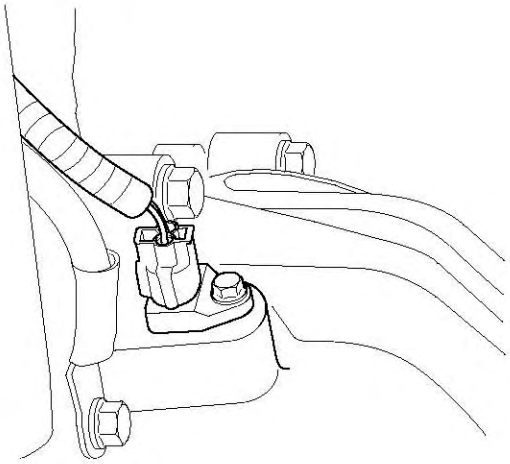
DTC	Judging condition and fail-safe	Check item
P0301 P0302 P0303 P0304	**Judging condition** • P0301: fuel quantity controlled by cylinder balance > 9mm³/st • P0302: fuel quantity controlled by cylinder balance > 9mm³/st • P0303: fuel quantity controlled by cylinder balance > 9mm³/st • P0304: fuel quantity controlled by cylinder balance > 9mm³/st **Judging time (returning condition)** • P0301, P0302, P0303, P0304: 30066.2ms (768.0ms) **Fail judging range** • When driving • If engine is operated for a long time as injector is failed, engine may be damaged.	• Check to see if injector circuit is open. • Injector • ECM (Engine Control Module)

SPECIFICATION E470AD1E

Injector	Specification (20 °C)
Resistance	0.3~0.6Ω

DTC P0335 CRANK SENSOR NO PULSE

COMPONENT LOCATION E09928FF



KDDFL5082A

GENERALS E34C5A01

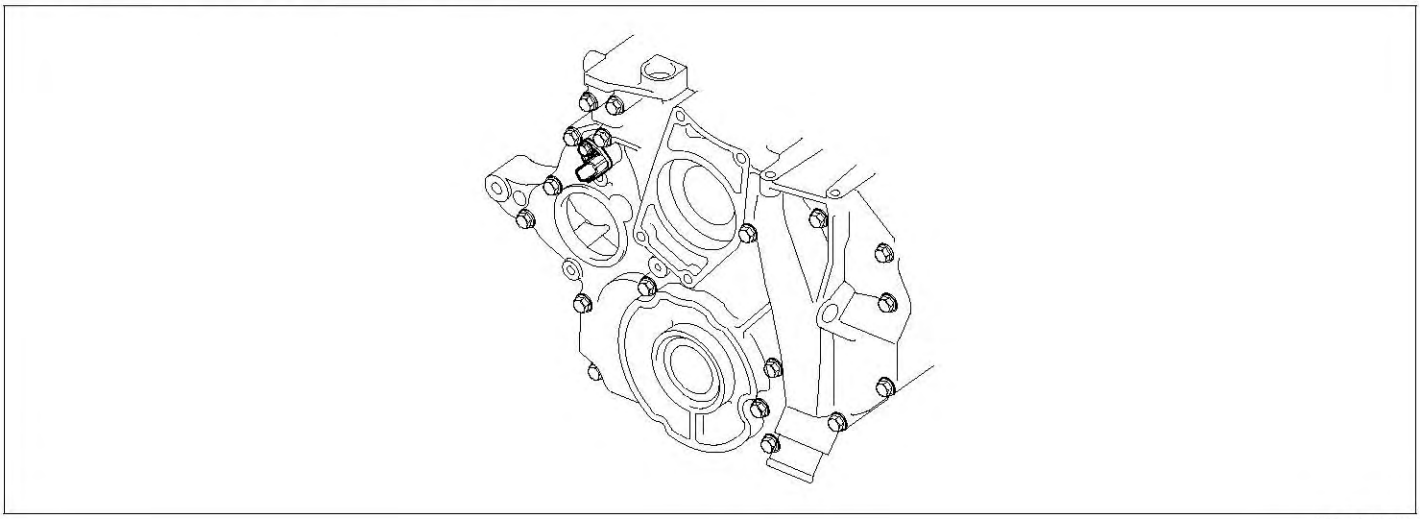
Engine piston position is used to determine fuel injection timing. Every piston of the engine is connected to crankshaft by connecting rod. CKPS senses the piston position and uses this information to find out the fuel injection timing and to calculate engine speed.
CMPS (Camshaft Position Sensor) is used to find out the TDC of compression stroke of cylinder. ECM sets fuel injection timing and injection sequence of each cylinder based on the signal.

DTC JUDGING CONDITION EB9694F6

DTC	Judging condition and fail-safe	Check item
P0335	**Judging condition** • P0335: NE pulse count of 360°CA (one engine revolution) NE pulse number is below 1. **Judging time (returning condition)** • P0335: 1800.1 CA (1800.1 CA) **Fail judging range** • When driving **Fail-safe** • Control only with G pulse of cam sensor Normal driving is possible. 1) Starting time and starting is delayed. 2) Exhaust brake operation stop	• Check sensor and wiring 1) Check to see if ECM pin 40, 41 are open 2) Check to see if ECM pin 40, 41 are short

DTC P0340 CAM SENSOR NO PULSE
DTC P0385 CRANK & CAM SENSOR NO PULSE

COMPONENT LOCATION E09D15E8



KDDFL5083A

GENERALS EB2EB4B8

Engine piston position is used to determine fuel injection timing. Every piston of the engine is connected to crankshaft by connecting rod. CKPS senses the piston position and uses the information to find out the fuel injection timing and to calculate engine speed.
CMPS (Camshaft Position Sensor) is used to find out the TDC of compression stroke of cylinder. ECM sets fuel injection timing and injection sequence of each cylinder based on this signal.

DTC JUDGING CONDITION EAEB350D

DTC	Judging condition and fail-safe	Check item
P0340 P0385	**Judging condition** • P0340: Number of G pulse is less than 1 per 360°CA (one engine revolution) • P0385: When starting or engine stalls **Fail judging range** • P0340: When driving • P0385: When driving or cranking **Fail-safe** • P0340: Starting is controlled with only NE pulse of crank position sensor 1) Starting time delay, starting, and normal driving is possible. 2) Exhaust brake operation stops. • P0385 1) Exhaust brake operation stops 2) PTO operation stops 3) Cylinder balancing stops (FCCB) 4) Engine will not start 5) Engine stops	• P0340: Check to see if ECM pin 120, 131, 133 are open or short

DTC P0501 VEHICLE SPEED SENSOR SIGNAL INVALID
DTC P0502 VEHICLE SPEED SENSOR INPUT OPEN / SHORT
DTC P0503 VEHICLE SPEED SENSOR FREQUENCY TOO HIGH

GENERALS EB0A10A6

VSS (Vehicle Speed Sensor), installed at the transmission housing, senses the tooth signal of rotating unit inside T/M and sends the signal to engine control module (ECM).
With this signal, engine control module calculates the vehicle speed and also is used for the vehicle speed display.

DTC JUDGING CONDITION E0A63010

DTC	Judging condition and fail-safe	Check item
P0501 P0502 P0503	**Judging condition** • P0501: vehicle speed signal abnormal • P0502: Tentative vehicle speed < 0.1km/h • P0503: Tentative vehicle speed > 200km/h **Judging time (returning condition)** • P0501, P502, P0503: 524.3ms (524.3ms) **Fail judging range** • When vehicle is driving **Fail-safe** • Gear shift is not recognized or PTO control is impossible.	• P0501 1) Check ECM pin 27 terminal frequency. (Check the noise intrusion) 2) Check vehicle speed sensor • P0502: Check wiring • P0503 1) Check the frequency of ECM pin 27 terminals 2) Check vehicle speed sensor

DTC P0562 VEHICLE SYSTEM VOLTAGE TOO LOW
DTC P0563 VEHICLE SYSTEM VOLTAGE TOO HIGH

GENERALS E342C3C1

Charging system consists of battery, alternator built-in with regulator, warning lamp and wires. Alternator uses diode to commutate AC current into DC current.
One side of engine control relay is connected to engine control module (ECM) to be grounded and the other side is connected to the battery. ECM (Engine Control Module) checks battery voltage for before and after engine control relay.

DTC JUDGING CONDITION E06806A3

DTC	Judging condition and fail-safe	Check item
P0562 P0563	**Judging condition** • P0562: battery voltage < 16V • P0563: battery voltage > 32V **Judging time (returning condition)** • P0562, P0563: 10485.6ms (384.0ms) **Fail judging range** • When the ignition key is on	• Battery • Charging system • Engine control module • Check the level of ECM pin 5, 6, 7

DTC P0601 CHECK SUM ERROR - FLASH AREA
DTC P0602 QR DATA IS NOT WRITTEN
DTC P0606 CPU FAULT; MAIN CPU FAULT
DTC P0607 CPU FAULT; WATCHDOG IC FAULT
DTC P0611 QR DATA ERROR
DTC P0612 QR CODE IS NOT VALID

GENERALS EB58B85B

Engine control module (ECM) detects any system failure by the checksum. All data comprise the combination of 0 and 1. The checksum is the value adding all values in this number array. System failure is detected by comparing the calculated one with the one stored in the engine control module.

DTC JUDGING CONDITION EB6CAAF4

DTC	Judging condition and fail-safe	Check item
P0601 P0602 P0606 P0607	**Judging condition** • P0601: Checksum of the values adjusted by Hi-scan is abnormal (Checksum error happens 3 times in a row.) • P0602: Data writing is impossible at EEPROM • P0606: After Power ON Reset, RUN Pulse reverse revolution never happens 5 times in a row in some specifically defined time • P0607: RUN Pulse of Watchdog IC output has no reverse resolution in some defined time. **Judging time (returning condition)** • P0601, P606, P607: 96.0ms (96.0ms) • P0602: 768.0ms (768.0ms) **Fail judging range** • When the ignition key is ON and while driving **Fail-safe** • P0601, P0606, P0607: fuel quantity is limited below 40mm³/st, PTO control is stopped. • P0602: Previous value is maintained	• Engine control module • P0601, P0606, P607 : Check CPU failure • P0602: Check and compare QR assurance and injector QR value

DIAGNOSTIC PROCEDURE E9C1DD35

- As the internal error of engine control module, there is no specific diagnostic procedure for the error.
- Installing a good ECM (Engine Control Module) temporally, check to see if the system works normally. Once the problem is solved, replace the ECM (Engine Control Module).

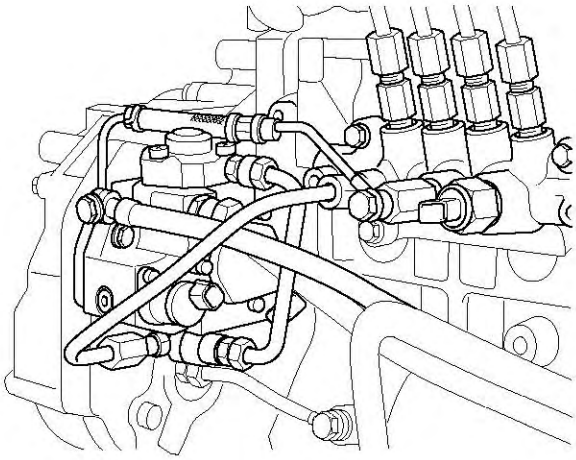
DTC P0615 START SWITCH SHORT TO BATT

DTC JUDGING CONDITION E3DC2E51

DTC	Judging condition and fail-safe	Check item
P0615	**Judging condition** • P0615 : crank position sensor≥ 300rpm **Judging time (returning condition)** • P0615: 8388.5ms (8388.5ms) **Fail judging range** • When the ignition key is on and while the vehicle is driving **Fail-safe** • To prevent the damage of starter motor, engine stops after elapse of certain time.	• Check ECM pin 48 level • Check to see if starter switch is melt

DTC P0627 SCV OUTPUT OPEN OR SHORT
DTC P0629 SCV(+) OUTPUT SHORT TO BATT
DTC P1190 SUPPLY PUMP CONTROL VALVE(SCV) STUCK

COMPONENT LOCATION EEC3DADE



KDDFL5084A

GENERALS E33B1D97

SCV (suction control valve), as a solenoid type, controls pumping start time as ECM controls valve open and close time. ECM controls pump fuel quantity by controlling current supply to SCV to meet with the target rail pressure.
When SCV closes, fuel passage is shut down so that fuel is compressed and compressed fuel is supplied to common rail. And then, if fuel pressure drops, SCV opens and fuel is suctioned for next pumping.

DTC JUDGING CONDITION EA74EA76

DTC	Judging condition and fail-safe	Check item
P0629 P0627 P1190	**Judging condition** • P0629: When SVC current duty control is below 30%, or current is above 1100mA. • P0627: When SVC current duty control is above 30%, current is below 1100mA • P1190: When the difference between target and actual pressure is above 10Mpa **Judging time (returning condition)** • P0627, P0629: 819.2ms (30.0ms) • P1190: 20164.6ms (20164.6ms) **Fail judging range** • When the ignition key is on **Fail-safe** • Engine output is limited (common rail pressure is limited)	• P0627 1) Check to see if ECM pin 144, 145, 146 and 147 are short to GND 2) Check to see if ECM and SCV wiring are open. 3) Check SCV pin resistance • P0629 1) Check to see if ECM pin 144, 145, 146 and 147 are short to B+. 2) Check to see if ECM and SCV wiring are open • P1190: Check SCV

DTC P0704 CLUTCH SWITCH CIRCUIT MALFUNCTION (MANUAL TRANSMISSION ONLY)

GENERALS ED5C388C

Clutch is located between engine and transmission. When it operates, frictional disc holds flywheel and pressure plate. It operates interlocking with flywheel. When clutch pedal is pressed, frictional disc is disengaged from flywheel by the clutch fork and then the power transmission is disconnected.
By shutting torque transfer, gear shifting can be made easily and safely. ECM monitors clutch condition with clutch switch.

DTC JUDGING CONDITION EDD46DA9

DTC	Judging condition and fail-safe	Check item
P0704	**Judging condition** • When there is no pressure change between, stop (0km/h), driving (50km/h) and stop (0km/h). **Judging time (returning condition)** • P0704: 1048.6ms (1048.6ms) **Fail judging range** • While the vehicle is driving **Fail-safe** • Exhaust brake is inoperative	• Check ECM pin 77 terminal level • Check the open and close clutch switch circuit

DTC P0850 NEUTRAL SWITCH CIRCUIT MALFUNCTION (MANUAL TRANSMISSION ONLY)

GENERALS E95557D1

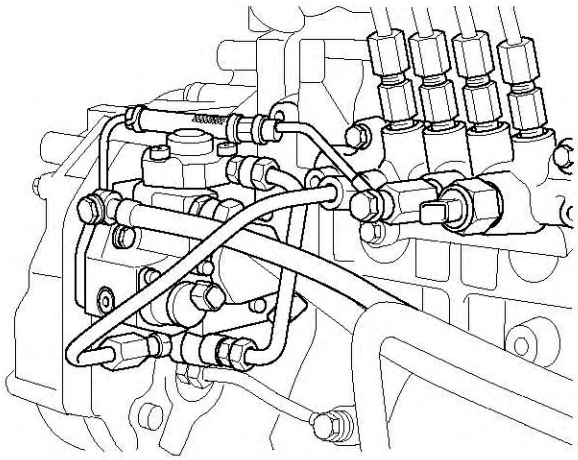
When neutral switch signal is inputted into engine control module (ECM), ECM (Engine Control Module) recognizes the current status as neutral so that it adjusts the fuel injection quantity.

DTC JUDGING CONDITION EEDA44F6

DTC	Judging condition and fail-safe	Check item
P0850	**Judging condition** • P0850: When there is no input change of neutral switch, in case the speed of the vehicle changes to 0km/h, 50km/h, 0km/h. **Judging time (returning condition)** • P0850: 1048.6ms (1048.6ms) **Fail judging range** • While the vehicle is driving **Fail-safe** • Exhaust brake is inoperative • PTO is inoperative	• Neutral switch • Check ECM pin 66 level

DTC P1217 SUPPLY PUMP PROTECTION
DTC P1218 SUPPLY PUMP EXCHANGE
DTC P1219 SUPPLY PUMP MULFUNCTION(INSUFFICIENT FLOW)

COMPONENT LOCATION EDFCACDB



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DTC JUDGING CONDITION E5AB64E5

DTC	Judging condition and fail-safe	Check item
P1217 P1218 P1219	**Judging condition** • P1217: When pump pressure exceeds the limit for the certain duration of time. • P1218: When pump pressure exceeds the limit for the certain duration of time • P1219: When supply pump transmission pressure is low. **Judging time (returning condition)** • P1217, P1218: 32.0ms (32.0ms) • P1219: 42.0 CA (42.0 CA) **Fail judging range** • While the vehicle is driving **Fail-safe** • Engine stop	• Supply pump assembly • Engine control module • SCV wiring harness

DTC P1231 EX. BRAKE MV1 OUTPUT OPEN LOAD,SHORT TO GND
DTC P1232 INJECTOR 3 SHORT CIRCUIT

GENERALS E0CA9EDE

Exhaust brake system, an auxiliary brake system of foot brake, comprises butterfly type exhaust brake unit. When exhaust brake switch is turned on, 3-way magnet valve activates to send air pressure of air tank to control cylinder of exhaust brake unit, and closes the exhaust brake valve to operate exhaust brake.

DTC JUDGING CONDITION EE7E5D42

DTC	Judging condition and fail-safe	Check item
P1231 P1232	**Judging condition** • P1231: When exhaust brake is not operating under operating condition. • P1232: When exhaust brake is operating under the condition where it should not operate. **Judging time (returning condition)** • P1231, P1232: 3004.5ms (384.0ms) **Fail judging range** • P1231: While driving • P1232: When the ignition key is on **Fail-safe** • Exhaust brake operation stopped	• P1231: Check if ECM pin 36 is open or short to GND • P1232: Check if ECM pin 36 is short to terminal B+ • Check wiring and resistance

DTC P1383 GLOW RELAY OUTPUT OPEN LOAD/SHORT TO BATT
DTC P1384 GLOW RELAY OUTPUT OPEN/SHORT TO GND

GENERALS E83FBBB6

Pre-heater plug (so called "glow plug") heats the intake air to facilitate the control of diesel fuel injection at low temperature. ECM (Engine Control Module) controls glow plug with glow plug relay depending on the engine operation status.

DTC JUDGING CONDITION EDB71874

DTC	Judging condition and fail-safe	Check item
P1384 P1383	**Judging condition** • P1384: When glow relay is inoperative under glow relay operating condition. • P1383: When glow relay is operating under the condition when glow relay should not operate. **Judging time (returning condition)** • P1383, P1384: 3000.2ms (2303.9ms) **Fail judging range** • When the ignition key is on	• P1383 : Check to see if ECM pin 19 and 20 are short to the terminal B+ • P1384 1) Check to see if ECM pin 70 and 71 are open 2) Check to see if ECM pin 70 and 71 are short to GND. • Pre-heater plug relay • Engine control module

DTC P1616 MAIN RELAY DIAGNOSTICS; MAIN RELAY STUCK CLOSED

GENERALS EBB03FC4

Engine control relay is controlled by connecting one side of engine control relay to the battery and the other side to engine control module (ECM). ECM (Engine Control Module) checks battery voltage and the voltage passing through the engine control relay.

DTC JUDGING CONDITION EFBE69AC

DTC	Judging condition and fail-safe	Check item
P1616	**Judging condition** • P1616: When main relay is still engaged even after turning the ignition key off. **Judging time (returning condition)** • P1616: 2097.1ms (2097.1ms) **Fail judging range** • When the ignition key is on **Fail-safe** • Power is inputted even after turning the key off because ECM 5, 6 and 7 are short to the terminal B+	• Check to see if main relay circuit is open or short • Check to see if main relay stuck • Check engine control module

DTC P2146 1.COM1 OUTPUT OPEN LOAD 2.BOTH TWV1 AND TWV3 AND TWV5 OPEN LOAD DTC P2147 COM1 OUTPUT SHORT TO GND /TWV1 OR 3 OR 5 OUTPUT SHORT TO GND DTC P2148 COM1 OUTPUT SHORT TO BATT /TWV1 OR 3 OR 5 OUTPUT SHORT TO BATT

DTC JUDGING CONDITION EF7D6AA5

DTC	Judging condition and fail-safe	Check item
P2148 P2147 P2146	**Judging condition** • P2148: B+ short is detected at the TWV drive circuit of common No.1. • P2147: GND short is detected at the TWV drive circuit of common No.1. • P2146: When TWV1 is open and TWV3 is open at the same time **Judging time (returning condition)** • P2148, P2147 : 2159.7 CA (1080.0 CA) • P2146 : 4499.0 CA (1080.0 CA) **Fail judging range** • When the ignition key is on **Fail-safe** • Fuel quantity is limited to fuel below 40mm³/st. • If engine is operated for a long time as injector is failed, engine may be damaged.	• P2148 1) Check to see if common 1(106,107) and terminal B+ are short 2) Check to see if TWV 1 and 3 output terminals are short to B+ 3) Check ECM pin 106,107,103,104 levels 4) Check wiring • P2147 1) Check common 1 output terminal is short to GND 2) Check TWV1 and 3 output terminal are short to B+ 3) Check the wiring • P2146 1) Check common 1 output terminal is short to B+ 2) Check TWV 1 and 3 output terminals are short to B+ 3) Check the wiring

SPECIFICATION E9BDEDDE

Injector	Specification (approximately 20 °C)
Resistance	0.3~0.6Ω

DTC P2149 COM2 OUTPUT OPEN LOAD, BOTH TWV2 AND TWV4 AND TWV6 OPEN LOAD
DTC P2150 COM2 OUTPUT SHORT TO GND,TWV2 OR 4 OR 6 OUTPUT SHORT TO GND
DTC P2151 COM2 OUTPUT SHORT TO BATT /TWV2 OR 4 OR 6 OUTPUT SHORT TO BATT

DTC JUDGING CONDITION EE602C8B

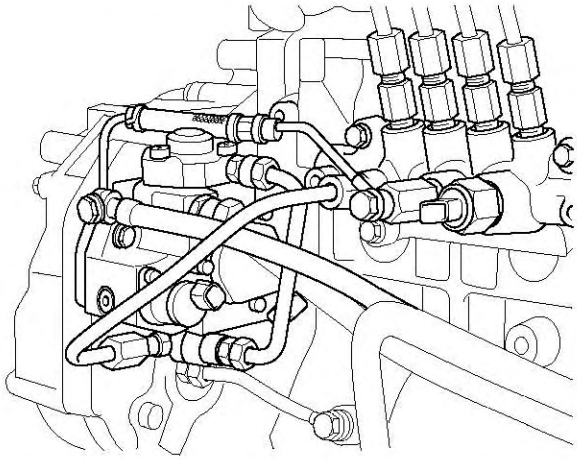
DTC	Judging condition and fail-safe	Check item
P2151 P2150 P2149	**Judging condition** • P2151: B+ short is detected from TWV drive circuit of common No.2. • P2150: GND short is detected from TWV drive circuit of common No.2. • P2149: When TWV2 and TWV4 are simultaneously broken **Judging time (returning condition)** • P2151, P2150 : 2159.7 CA (1080.0 CA) • P2149 : 4499.0 CA (1080.0 CA) **Fail judging range** • When the ignition key is on **Fail-safe** • Fuel quantity is limited below 40mm³/st. • If engine is operated for a long time as injector is failed, engine may be damaged.	• P2151 1) Check common 2(142,143) and terminal are short to B+ 2) Check TWV 2, 4 output terminal are short to B+ 3) Check the level of ECM pin 142, 143, 137, and 138 4) Wiring check • P2150 1) Check to see if common 2 output terminal is short to GND. 2) Check TWV 2, 4 and output terminal are short to GND. 3) Wiring check • P2149 1) Check to see if common 2 output terminal is short to B+. 2) Check TWV 2 and 4 output terminals are short to B+. 3) Wiring check

SPECIFICATION EEEBCE99

Injector	Specification (room temperature)
Resistance	0.3~0.6Ω

DTC P2293 P/L(PRESSURE LIMIT) ACTIVATED

COMPONENT LOCATION EBC56D49



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DTC JUDGING CONDITION EB104C10

DTC	Judging condition and fail-safe	Check item
P2293	**Judging condition** • P2293: When common rail pressure sensor fails or when fuel pressure in the rail exceeds 221Mpa **Judging time (returning condition)** • P2293: 16.0ms (96.0ms) **Fail judging range** • While the vehicle is driving **Fail-safe** • Output is decreased.	• Check sensor and fuel line • Common rail assembly • Engine control module • Rail pressure sensor • Check rail pressure (target/actual)

DTC P2503 CAPACITOR CHARGE-UP CIRCUIT MALFUNCTION (INSUFFICIENT CHARGE) DTC P2504 CAPACITOR CHARGE-UP CIRCUIT MALFUNCTION (EXCESSIVE CHARGE)

DTC JUDGING CONDITION E081FA09

DTC	Judging condition and fail-safe	Check item
P2503 P2504	**Judging condition** • P2503: When ECM charge circuit fails to supply enough current to drive an injector. • P2504: When ECM charge circuit is overcharged. **Judging time (returning condition)** • P2503, P2504: 360.0 CA (360.0 CA) **Fail judging range** • When the ignition key is on and while driving **Fail-safe** • Fuel quantity is limited below 40mm³/st. • Fuel pressure is limited to 40Mpa • PTO control is stopped	• Alternator assembly • Charging circuit • Engine control module