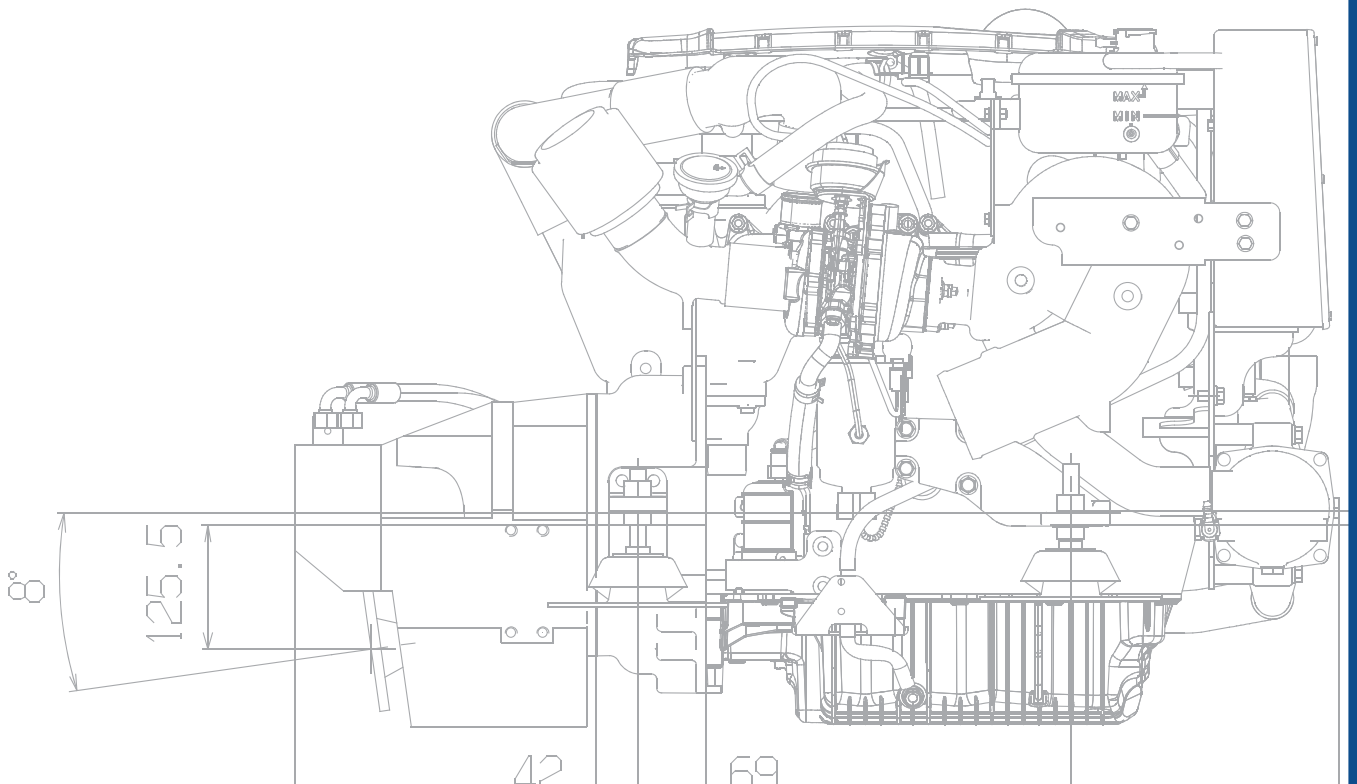


WORKSHOP MANUAL

for

D Engine Series



Applicable to D170S, D170P, D170J, D150S, D150P model

Service Department. Technical Information Edition 1st

Engine Mechanical System

General

Cooling System

Timing System

Cylinder Head Assembly

Engine Block

Lubrication System

Intake and Exhaust System

Coupling System

General Information

Specifications

Description	Specification	Limit
General		
Type	In-line, Single Overhead Camshaft	
Number of cylinders	4	
Bore	87mm	
Stroke	92mm	
Total displacement	2,188cc	
Compression ratio	17.3: 1	
Firing order	1 – 3 – 4 – 2	
Valve timing		
Intake valve		
Opens (BTDC)	7°	
Closes (ATDC)	35°	
Exhaust valve		
Opens (BTDC)	52°	
Closes (ATDC)	6°	
Camshaft		
Intake	34.697mm	
Exhaust	34.570mm	
Journal O.D	27.947 ~27.96mm	
Bearing oil clearance	0.040 ~ 0.074mm	
End play	0.05 ~ 0.15mm	
Valve		
Valve length		
Intake	95.5~95.9 mm	
Exhaust	95.2~95.6 mm	
Stem O.D		
Intake	5.933~5.953mm	
Exhaust	5.905~5.925mm	
Face angle	45.5°~46°	
Thickness of valve head (margin)		
Intake	1.5 ~ 1.7mm	
Exhaust	1.2 ~ 1.4mm	

Description	Specification	Limit
Valve stem to valve guide clearance		
Intake	0.22 ~ 0.067mm	
Exhaust	0.050 ~ 0.095mm	
Valve guide		
Length		
Intake	36.25 ~ 36.75mm	
Exhaust	36.25 ~ 36.75mm	
Valve seat		
Width of seat contact		
Intake	0.95~1.25mm	
Exhasut	0.8825~1.0825mm	
Seat angle	44° ~ 46°	
Valve spring		
Free length	38.8mm	
Load	21.25±1.3kg/32mm	
Cylinder block		
Cylinder bore	87mm	
Flatness of head gasket surface	0.030mm (0.00118in.) for width 0.096mm (0.00378in.) for length 0.012mm (0.00047in.) / 50x50mm	
Piston		
O.D	86.92 ~ 86.95mm	
Piston to cylinder clearance	0.05 ~ 0.08mm	
Ring groove width		
No.1	2.43 ~2.445mm	
No 2	2.06 ~ 2.08mm	
Oil	3.02 ~ 3.04mm	
Piston ring		
Side clearance		
No.1	0.098 ~ 0.137mm	
No.2	0.065 ~ 0.110mm	
Oil ring	0.01 ~ 0.07mm	
End gap		
No.1	0.25 ~ 0.40mm	
No.2	0.40 ~ 0.60mm	
Oil ring side rail	0.20 ~ 0.40mm	
Piston pin O.D	27.995 ~ 28.000mm	
Connecting rod		
Connecting rod bearing oil clearance	0.024 ~ 0.042mm	
Crankshaft main bearing oil clearance	0.024 ~ 0.042mm	

Description	Specification	Limit
Crankshaft		
Journal O.D	60.002 ~ 60.020mm	
Pin O.D	50.008 ~ 50.026mm	
Out of round of journal and pin	Less than 0.0035mm	
Taper of journal and pin	Less than 0.06mm	
End play	0.09 ~ 0.32mm	
Flywheel		
Runout	0.45mm/Φ200	
Engine oil		
Oil quantity(Total)	5.6L(5.9 US qt, 4.9 Imp qt)	When replacing a short engine or a block assembly
Oil quantity(Excluding oil filter)	4.4L(4.6 US qt, 3.9 Imp qt)	When replacing an oil pan only
Oil quantity(Drain and refill including oil filter)	4.9L(5.2 US qt, 4.3 Imp qt)	
Oil pump		
Oil pump performance [oil temp. is 95~105℃ (203~221°F, SAE 10W-30)] & Engine rpm 1500	More than 25L/min 4.0kgf/cm ²	
Tip clearance	0.12 ~ 0.20mm	
Radial clearance	0.13 ~ 0.23mm	
Side clearance	0.02 ~ 0.07mm	
Relief spring		
Free length	47.5mm	
Opening pressure	570±50kPa	
Silent shaft		
Front journal diameter	27.99 ~ 28.01mm	
Rear journal diameter	41.99 ~ 42.01mm	
Oil clearance		
Front	0.050 ~ 0.090mm	
Rear	0.050 ~ 0.090mm	
Cooling method		
Cooling system quantity	Forced circulation with sea water pump 6.5L(6.8 US qt, 5.71 Imp qt)	
Thermostat		
type	Wax pellet type with jiggle valve	

Description	Specification	Limit
Normal opening temperature	85°C (185°F)	
Opening temperature range	83.5 ~ 86.5°C (182 ~ 188°F)	
Full opening temperature	95 °C	
Reserver tank cap	107.9 ± 14.7kPa (1.1±0.15kg/cm², 15.64±2.13psi)	
Air filter		
Type	Dry type	
Element	Metal Mash cloth type	
Suspension system	Rubber mount	
Coolant tempreature sensor		
Type	Thermister type	
Resistance		
20°C (68°F)	2.45 ± 0.14kΩ	
80°C (176°F)	0.3222kΩ	
SERVICE STANDARDS		
Standard value		
Coolant concentration		
Tropical area	30%	
Other area	40%	
LUBRICANT		
Engine oil	ACEA : C3(CPF EQUIPPED VEHICLE ACEA : B4 or API CH-4 ABOVE(NON CPF VEHICLE)	SAE 15W-40 (ABOVE -15°C)
		SAE 10W-30 (-20°C ~ 40°C)
		SAE 5W-30 (-25°C ~ 40°C)
		SAE 0W-30 (BELOW 10°C)*1 *2
*1. Restricted to driving condition and area		*2. Not recommended for sustained high speed
SEALANT		
Engine coolant temperature sensor	3M No.1324 or equivalent	
Oil pressure switch	3M ATD No. 8660 or Three bond TB 2403	
Bed plate	OMNI FIT FD20, DREIBOND 5105 or HYLOMAR 3000	
NOTE		
O.D. = Outer Diameter		I.D. = Inner Diameter
		O.S. = Oversize Diameter
		U.S. = Undersize Diameter

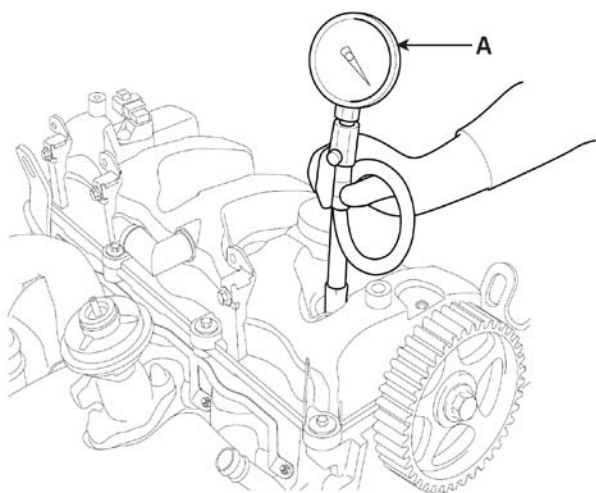
Tightening Torques

Items	N.m	kgf.m	lbf.ft
Engine system			
High fuel pipe(rail→pump) mounting nut	24.5 ~ 28.4	2.5 ~ 2.9	18.1 ~ 21.0
Damper pulley mounting bolt	29.4 ~ 33.3	3.0 ~ 3.4	21.7 ~ 24.6
Engine support bracket, RH	44.1 ~ 49.0	4.5 ~ 5.0	32.5 ~ 36.2
Engine support bracket, LH	29.4 ~ 33.3	3.0 ~ 3.4	21.7 ~ 24.6
Relief plug	41.2 ~ 51.0	4.2 ~ 5.2	30.4 ~ 37.6
Balance shaft assembly mounting bolt	52.0 ~ 55.9	5.3 ~ 5.7	38.3 ~ 41.2
Seawater pump support bracket bolt	42.2 ~ 53.9	4.3 ~ 5.5	31.1 ~ 39.8
Starter motor mounting bolt	42.2 ~ 53.9	4.3 ~ 5.5	31.1 ~ 39.8
Cylinder head bolt	49.0+120°+90°	5.0+120°+90°	46.6+120°+90°
Cylinder head cover mounting bolt(10mm)	7.8 ~ 9.8	0.8 ~ 1.0	5.8 ~ 7.2
Cylinder head cover mounting bolt(12mm)	21.6 ~ 25.5	2.2 ~ 2.6	15.9 ~ 18.8
Airfilter clamp	6.8 ~ 7.8	0.7 ~ 0.8	5~5.75
Injector holder bolt	7.8 ~ 10.8	0.8 ~ 1.1	5.8 ~ 8.0
Camshaft bearing cap bolt	26.5 ~ 29.4	2.7 ~ 3.0	19.5 ~ 21.7
Camshaft sprocket mounting bolt	122.6 ~ 140.2	12.5 ~ 14.3	90.4 ~ 103.4
Connecting rod cap bolt	24.5 + 90°	2.5 + 90°	18.1 + 90°
Crankshaft bed plate bolt(15mm)	27.5 ~ 31.4+120°	2.8 ~ 3.2+120°	20.3 ~ 23.1+120°
Crankshaft bed plate bolt(12mm)	33.3 ~ 37.3	3.4 ~ 3.8	26.4 ~ 27.5
Crankshaft sprocket bolt	196.1 ~ 205.9	20.0 ~ 21.0	144.7 ~ 151.9
Crankshaft pulley bolt	29.4 ~ 33.3	3.0 ~ 3.4	21.7 ~ 24.6
Crankshaft position sensor mounting bolt	3.9 ~ 5.9	0.4 ~ 0.6	2.9 ~ 4.3
Fly wheel	68.6 ~ 78.5	7.0 ~ 8.0	50.6 ~ 57.5
Timing system			
Timing auto tensioner bolt	49.0 ~ 53.9	5.0 ~ 5.5	36.2 ~ 39.8
Upper cover mounting bolt	7.8 ~ 11.8	0.8 ~ 1.2	5.8 ~ 8.7
Rear cover mounting bolt	7.8 ~ 11.8	0.8 ~ 1.2	5.8 ~ 8.7
Idler mounting bolt	44.1 ~ 48.1	4.5 ~ 4.9	32.5 ~ 35.4
Auto tensiner adjustable bolt	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Lower cover mounting bolt	7.8 ~ 11.9	0.8 ~ 1.2	5.8 ~ 8.7

Items	N.m	kgf.m	lbf.ft
Lubrication system			
Oil level gauge mounting bolt	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Oil screen mounting bolt	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Oil jet mounting bolt	8.8 ~ 12.7	0.9 ~ 1.3	6.5 ~ 9.4
Oil pan drain plug	34.3 ~ 44.1	3.5 ~ 4.5	25.3 ~ 32.5
Oil pan bolt	9.8 ~ 7.8	1.0 ~ 1.2	7.2 ~ 8.7
Oil pump mounting bolt	19.6 ~ 26.5	2.0 ~ 2.7	14.5 ~ 19.5
Oil pump cover bolt	7.8 ~ 9.8	0.8 ~ 1.0	5.8 ~ 7.2
Oil pressure switch	14.7 ~ 21.6	1.5 ~ 2.2	10.8 ~ 15.9
Oil filter	22.6 ~ 24.5	2.3 ~ 2.5	16.6 ~ 18.1
Oil cooler return pipe bracket mounting bolt(10mm)	7.8 ~ 9.8	0.8 ~ 1.0	5.8 ~ 7.2
Oil cooler return pipe bracket mounting bolt(12mm)	19.6 ~ 24.5	2.0 ~ 2.5	14.5 ~ 18.1
Cooling system			
Water pump mounting bolt(10mm)	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Water pump mounting bolt(14mm)	47.1 ~ 51.0	4.8 ~ 5.2	34.7 ~ 37.6
Heat exchanger mounting bolt	44.1~ 48.1	4.5~4.9	32.5 ~35.4
Intercooler mounting bolt	8.8 ~ 10.8	0.9 ~ 1.1	6.5 ~ 8.0
Gear oilcooler mounting bolt	44.1~ 48.1	4.5~4.9	32.5 ~35.4
Engine water coolant temperature sensor	19.6 ~ 23.5	2.0 ~ 2.4	14.5 ~ 17.4
Thermostat inlet mounting bolt, nut	19.6 ~ 24.5	2.0 ~ 2.5	14.5 ~ 18.1
Intake & exhaust system			
Exhaust elbow nuts	26.5 ~ 29.4	2.7 ~ 3.0	19.5 ~ 21.7
Cylinder head and exhaust manifold nuts	24.5 ~ 37.3	2.5 ~ 3.8	18.1 ~ 27.5
Turbo charger support bolt	34.3 ~ 44.1	3.5 ~ 4.5	25.3 ~ 32.5
Intake manifold mounting nuts & bolt	19.6 ~ 25.5	2.0 ~ 2.6	14.5 ~ 18.8

Compression pressure inspection

1. Check the engine oil, starter motor and the battery normal condition.
2. Warm up the engine until the normal operating temperature becoming 80~95℃ (176~203°F).
3. Turn the engine off, and then remove the air filter assembly.
4. Remove the Engine Control Unit (ECU).
5. Remove the injector. (Refer to Injector in FLC Group).
6. While cranking the engine, remove impurity from the cylinder.
7. Install the pressure gauge (00200-0T004, 00200-0T050) to the injector hall.



8. While cranking the engine, measure the compression pressure.

Compression pressure

Standard pressure:

2,549kPa (26.0kgf/cm², 369psi) - 260rpm

Minimum pressure:

2,255kPa (23.0kgf/cm², 327psi)

9. Check the power balance between all cylinders is within limit by repeating steps 7) through 8) for each cylinder.

Limit:

Each cylinder pressure 294kPa (3.0kgf/cm², 42psi)

10. If the cylinder compression in 1 or more cylinders is low, pour a small amount of engine oil into the cylinder through the injector hole and repeat steps through for cylinders with low compression. Repeat steps 7) through 9) for each cylinder.

1) If adding oil helps the compression, it is likely that the piston rings and/or cylinder bore are worn or damaged.

2) If pressure stays low, a valve may be sticking or seating is improper, or there may be leakage past the gasket.

11. In case of remove the injection nozzle when measure cylinder compressed pressure replace gasket and holder with new one and tighten them
Tightening torque

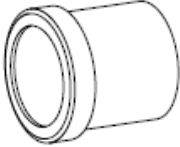
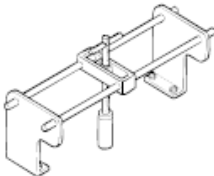
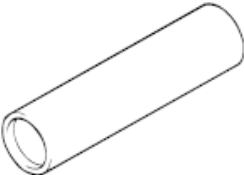

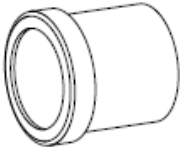
Troubleshooting

Symptom	Suspect	Remedy
Engine misfire with abnormal internal lower engine noises.	Loose or improperly installed engine flywheel.	Repair or replace the flywheel as required.
	Worn piston rings (Oil consumption may or may not cause the engine to misfire.)	Inspect the cylinder for a loss of compression. Repair or replace as required.
	Worn crankshaft thrust bearings.	Replace the crankshaft and bearings as required.
Engine misfire with abnormal valve train noise.	Stuck valves (Carbon buildup on the valve stem can cause the valve not to close properly.)	Repair or replace as required
	Excessive worn or mis-aligned timing belt	Replace the timing belt and sprocket as required.
	Worn camshaft lobes.	Replace the camshaft and valve lifters.
Engine misfire with coolant consumption.	<ul style="list-style-type: none"> Faulty cylinder head gasket and/or cranking or other damage to the cylinder head and engine block cooling system. Coolant consumption may not cause the engine to overheat. 	<ul style="list-style-type: none"> Inspect the cylinder head and engine block for damage to the coolant passages and/or a faulty head gasket. Repair or replace as required.
Engine misfire with excessive oil consumption.	Worn valves, valve guides and/or valve stem oil seals.	Repair or replace as required.
	Worn piston rings. (Oil consumption may or may not cause the engine to misfire)	<ul style="list-style-type: none"> Inspect the cylinder for a loss of compression. Repair or replace as required.
Engine noise on start-up, but only lasting a few seconds.	Incorrect oil viscosity.	<ul style="list-style-type: none"> Drain the oil Install the correct viscosity oil.
	Worn crankshaft thrust bearing.	<ul style="list-style-type: none"> Inspect the thrust bearing and crankshaft. Repair or replace as required.
Upper engine noise, regardless of engine speed.	Low oil pressure.	Repair or replace as required.
	Broken valve spring.	Replace the valve spring
	Worn or dirty valve lifters.	Replace the valve lifters.
	Stretched or broken timing belt and/or damaged sprocket teeth.	Replace the timing belt and sprockets.
	Worn timing chain tensioner, if applicable.	Replace the timing chain tensioner as required.
	Worn camshaft lobes.	<ul style="list-style-type: none"> Inspect the camshaft lobes. Replace the timing camshaft and valve lifters as required.
	Worn valve guides or valve stems.	Inspect the valves and valve guides, then repair as required.
	Stuck valves. (Carbon on the valve stem or valve seat may cause the valve to stay open.)	Inspect the valves and valve guides, then repair as required.

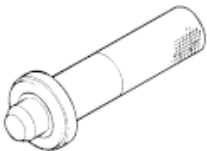


Symptom	Suspect	Remedy
Lower engine noise, regardless of engine speed.	Low oil pressure.	Repair or replace damaged components as required.
	Loose or damaged flywheel.	Repair or replace the flywheel.
	Damaged oil pan, contacting the oil pump screen.	<ul style="list-style-type: none"> Inspect the oil pan. Inspect the oil pump screen. Repair or replace as required.
	Oil pump screen loose, damage or restired.	<ul style="list-style-type: none"> Inspect the oil pump screen. Repair or replace as required.
	Excessive piston-to-cylinder bore clearance.	<ul style="list-style-type: none"> Inspect the piston and cylinder bore. Repair as required.
	Excessive piston pin-to bore clearance.	<ul style="list-style-type: none"> Inspect the piston, piston pin and the connecting rod. Repair or replace as required.
	Excessive connecting rod bearing clearance	Inspect the following components and repair as required. <ul style="list-style-type: none"> The connecting rod bearings. The connecting rods. The crankshaft. The crankshaft journal.
	Excessive crankshaft bearing clearance	Inspect the following components and repair as required. <ul style="list-style-type: none"> The crankshaft bearings. The crankshaft journals.
	Incorrect piston, piston pin and connecting rod installation	<ul style="list-style-type: none"> Verify the piston pins and connecting rods are installed correctly. Repair as required.
Engine noise under load	Low oil pressure	Repair or replace as required.
	Excessive connecting rod bearing clearance	Inspect the following components and repair as required. <ul style="list-style-type: none"> The connecting rod bearings. The connecting rods. The crankshaft
	Excessive crankshaft bearing clearnace	Inspect the following components, and repair as required. <ul style="list-style-type: none"> The crankshaft bearings. The crankshaft journals. The cylinswe block crankshaft bearing bore.

Symptom	Suspect	Remedy
Engine will not crank-crankshaft will not rotate	Hydraulically cylinder <ul style="list-style-type: none"> Coolant/antifreeze in cylinder. Oil in cylinder. Fuel in cylinder 	<ol style="list-style-type: none"> 1. Remove injectors and check for fluid. 2. Inspect for broken head gasket. 3. Inspect for cranked engine block or cylinder head. 4. Inspect for a sticking fuel injector and/or leaking fuel regulator.
	Broken timing chain and/or timing chain gears.	<ol style="list-style-type: none"> 1. Inspect timing chain and gears. 2. Repair as required.
	Material cylinder <ul style="list-style-type: none"> Broken valve Piston material Foreign material 	<ol style="list-style-type: none"> 1. Inspect cylinder for damaged components and/or foreign materials. 2. Repair or replace as required.
	Seized crankshaft or connecting rod bearings.	<ol style="list-style-type: none"> 1. Inspect crankshaft and connecting rod bearing. 2. Repair as required.
	Bent or broken connecting rod.	<ol style="list-style-type: none"> 1. Inspect connecting rods. 2. Repair as required.
	Broken crankshaft	<ol style="list-style-type: none"> 1. Inspect crankshaft. 2. Repair as required.

Special Service Tools

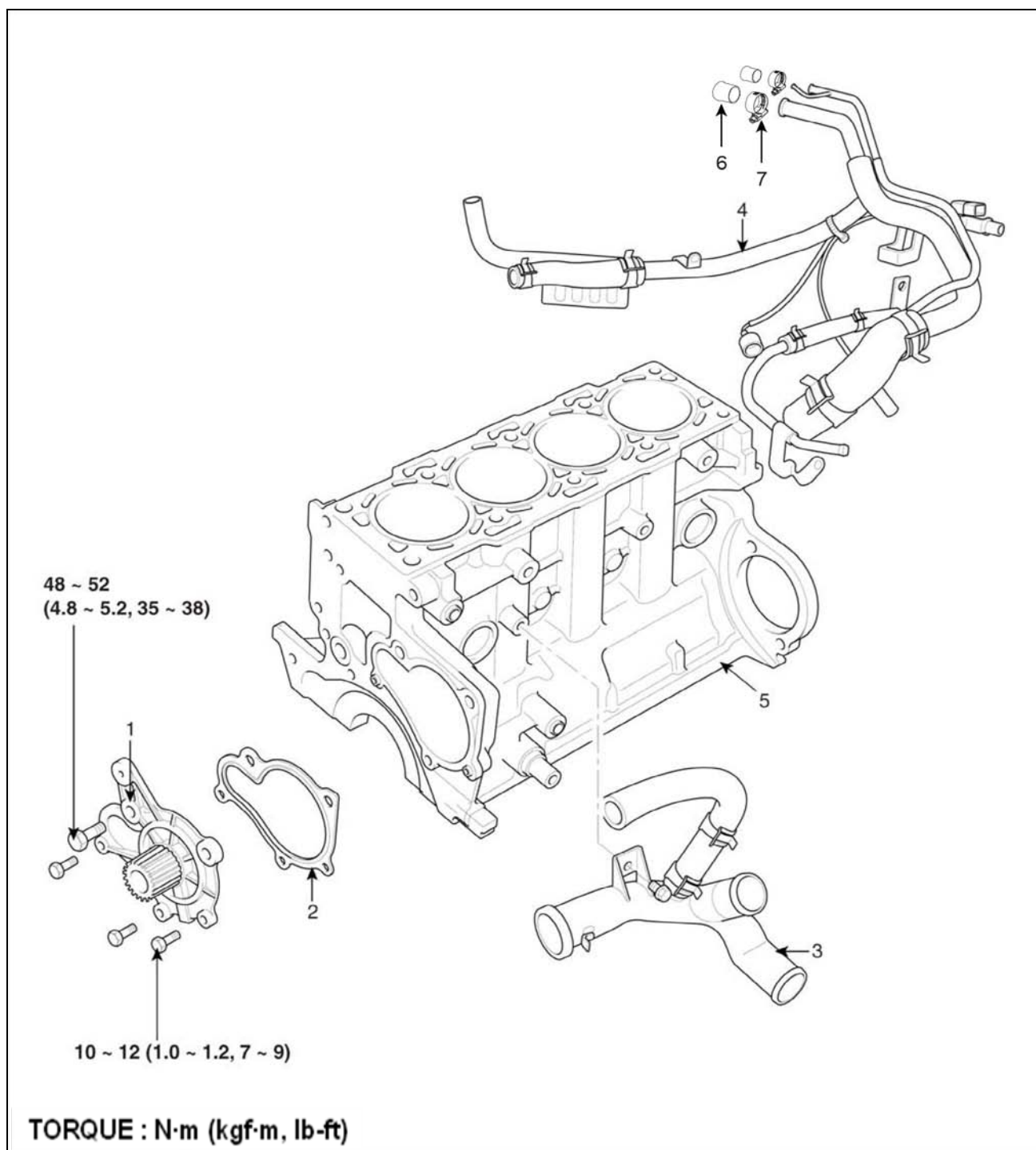
Tool (Number and name)	Illustration	Use
Camshaft oil seal installer (00200-0T052)	 ACIE003A	Installation of the camshaft oil seal
Valve spring compressor (00200-0T053)	 ACIE004A	Removal and installation of intake and exhaust valves
Valve stem oil seal installer (00200-0T054)	 ACIE005A	Installation of valve stem oil seals
Crankshaft rear oil seal installer (00200-0T055)	 ACIE006A	Installation of the crankshaft rear oil seal
Front case oil seal installer (00200-0T051)	 ACIE003A	Installation of the front case oil seal

Special Service Tools

Tool (Number and name)	Illustration	Use
Injector oil seal installer (00200-0T056)	 ACIE007A	Installation of the injector oil seal
Compression gauge & adapter (00200-0T004) (00200-0T050)	 ACIE002A	Checking engine compression pressure
Oil filter wrench (00200-0T057)	 ACIE008A	Removal and installation of spin on type oil filter

Cooling system

Components



1. Water pump

2. Gasket

3. Water inlet pipe

4. Heater hose & pipe

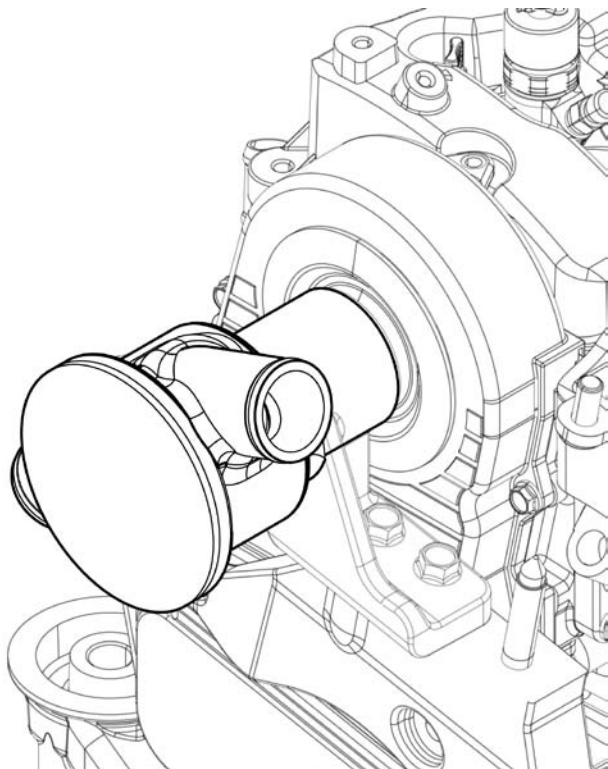
5. Cylinder block

6. Rubber plug

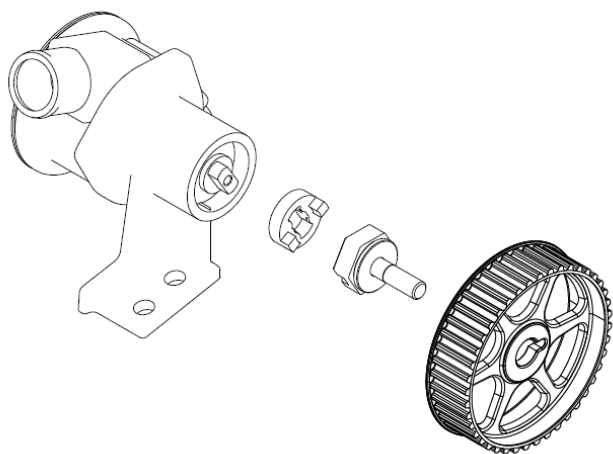
7. Clamp

Removal

Sea water pump



1. Remove clamps and hoses connect to sea water pump inlet and outlet.
2. Remove two bolts fixing cylinder block.
3. Remove impeller housing cover.



4. Remove impeller inside the seawater pump using tools.

Tightening torque

Mounting bolt

63.7 ~ 68.6N.m (6.5 ~ 7.0kgf.m, 47.0 ~ 50.6lb-ft)

Cam bolt

122.6 Nm (12.5 kgf.m)

5. Check the condition of impeller and bushing.
6. Check the condition of shaft, shaft coupler and cam bolt
7. Apply soap water on impeller when assembling the impeller and reassemble towards rotation direction.

● CAUTION

Take CAUTION in order the direction of curved fan to be in the right direction when using the impeller.

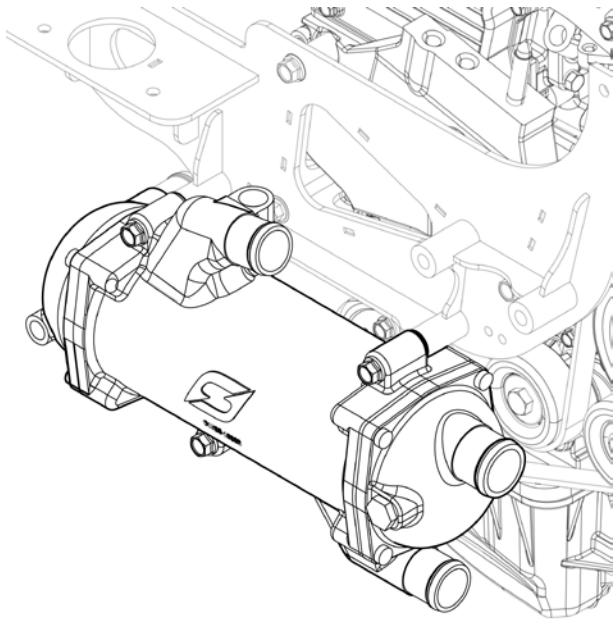
8. Reassemble aligning axis of impeller shaft and engine cam bolt.
9. Apply lubricant O-rings on inserting parts and cover and assemble.

● CAUTION

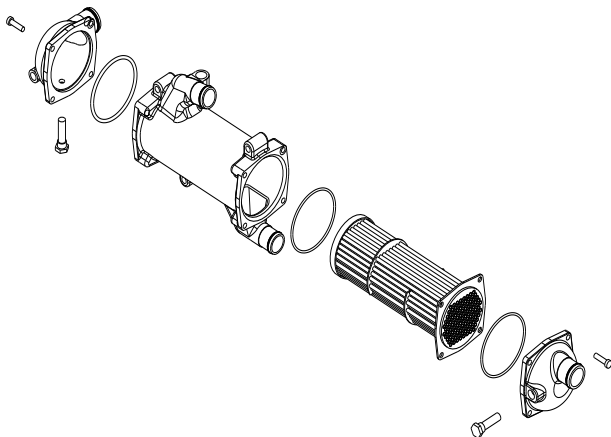
Make sure you use new O-ring after seawater pump reassemble.

10. Tighten seawater pump with two bolts.
11. Place hoses and clamps.
12. Complete the reassembly and start the ignition. Then check any oil leakage out of shaft.

Heat exchanger



1. Open the drain plug to remove engine coolant in heat exchanger.
2. Remove all hoses and clamps connected to heat exchanger.



Tightening torque

44.1 ~ 49.0N.m (4.5 ~ 5.0kgf.m, 32.5 ~ 36.2lb-ft)

3. Unscrew three bolts fixing heat exchanger.
4. Use L-wrench and remove end cap on both sides.
5. Use soft hammer and remove heat exchanger from housing.

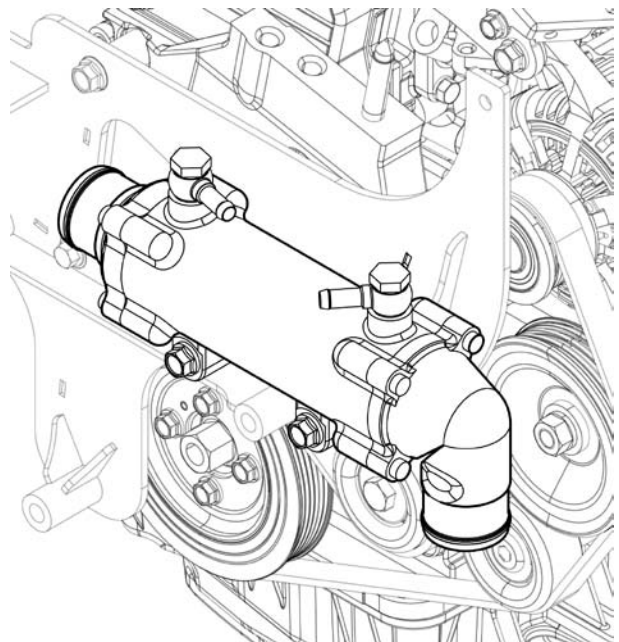
6. Check condition of O-ring on both end cap.
7. Check if there is engine coolant and sea water mixture inside the heat exchanger.
8. Check fin and tube condition.
9. Check anode condition.

• CAUTION

Take CAUTION avoid cooler fin damage.

10. Clean housing and heat exchanger and install heat exchanger into housing.
11. Install new O-ring on both sides.
12. Check the direction of end cap on both sides for assembly.
13. Install new anode.

Oil cooler

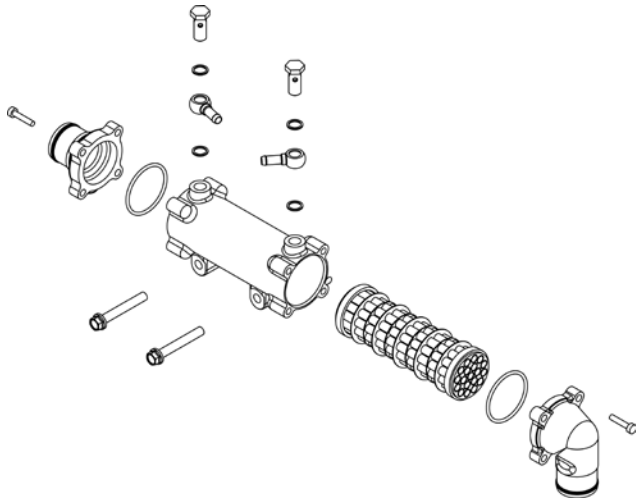


1. Drain hydraulic oil in reserve oil tank and line and disassemble power steering pump
2. Remove hoses and clamps connected to pumps
3. Unscrew three bolts fixing cooler

Tightening torque

44.1 ~ 49.0N.m (4.5 ~ 5.0kgf.m, 32.5 ~ 36.2lb-ft)

4. Use L-wrench and remove end cap on both sides.
5. Remove intercooler out of housing using soft hammer.



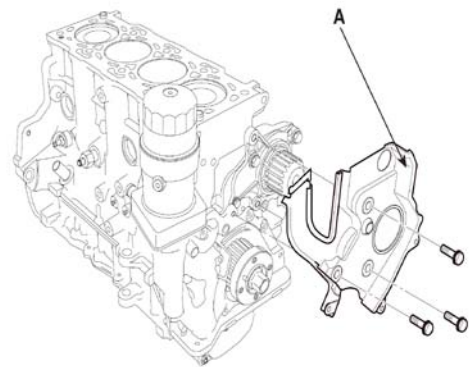
● CAUTION

Take CAUTION avoid intercooler fin damage.

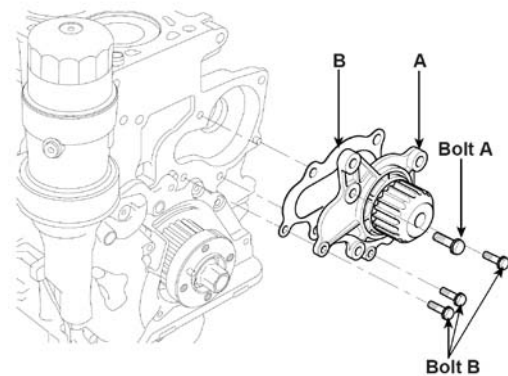
6. Clean housing and intercooler and heat exchanger into housing.
7. Install new O-ring.
8. Check the direction of end cap on both sides for assembly.

Water pump

1. Remove the timing belt. (Refer to Timing system in this group)
2. Remove the timing belt rear cover (A).



3. Remove the water pump (A) with the gasket (B) by removing four bolts. (One bolt a and three bolt B)



4. Inspect, repair and clean the mating surface on the engine block.
5. Install the water pump, with a new gasket in the reverse order of removal.

Tightening torque

For timing belt rear cover

7.8 ~ 11.8N.m (0.8 ~ 1.2kgf.m, 5.8 ~ 8.7lb-ft)

For water pump

Bolt A: 47.1 ~ 51.0N.m (4.8 ~ 5.2kgf.m, 34.7 ~ 37.6lb-ft)

Bolt B: 9.8 ~ 11.8N.m (1.0 ~ 1.2kgf.m, 7.2 ~ 8.7lb-ft)

6. Clean the spilled engine coolant.

Inspection

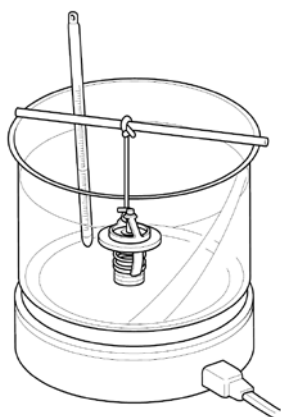
Thermostat

Replace the thermostat if it is open at room temperature.

To test closed thermostat:

1. Suspend the thermostat in a container of water.

Do not let the thermometer touch the bottom of the hot container.



2. Heat the water and check the temperature with the thermometer. Check the temperature at which the thermostat first opens, and at which it is fully open.

3. Measure the lift height of the thermostat when it is fully open.

Standard thermostat

Lift height: above 8.0mm (0.31in)

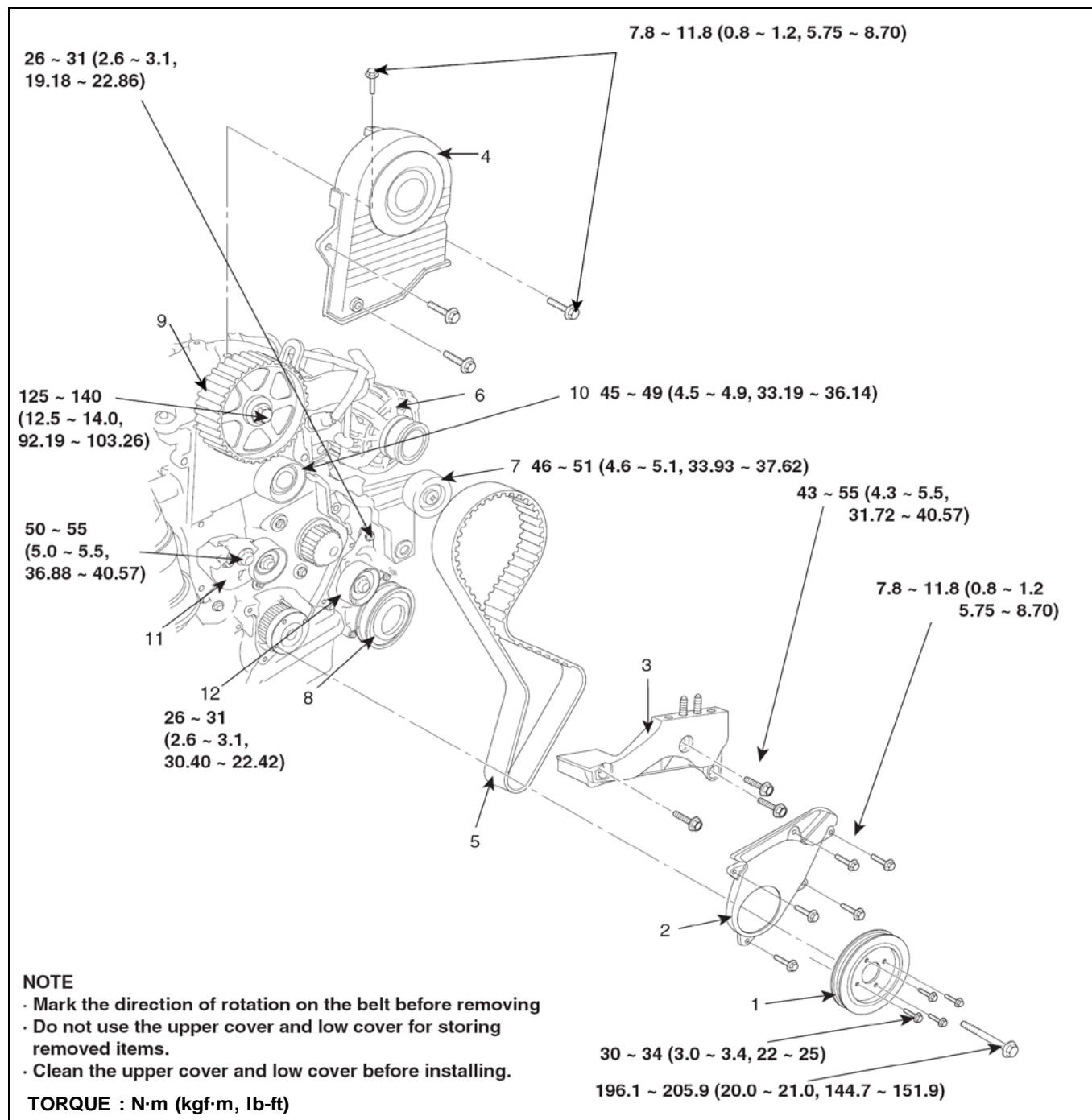
Starts opening: $85 \pm 1.5^{\circ}\text{C}$ ($185 \pm 34.7^{\circ}\text{F}$)

Fully open: 100°C (212°F)

Timing system

Timing belt

Components

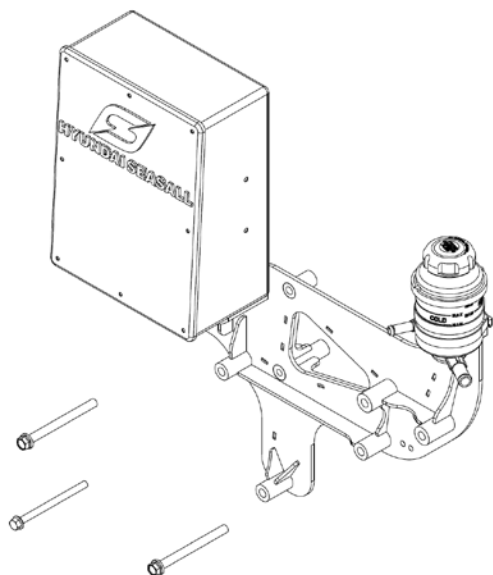


1. Damper pulley
2. Timing belt lower cover
3. Seawater pump support bracket
4. Timing belt upper cover
5. Timing belt
6. Alternator and vacuum pump assembly

7. Idler
8. Air conditioning compressor
9. Camshaft sprocket
10. Timing belt idler
11. Timing belt tensioner
12. Drive belt tensioner

Removal

Main-bracket



1. Stop the engine completely and remove the main bracket.

● CAUTION

Turn the ignition key switch to "OFF" position or disconnect the battery cable while removing the bracket.

2. Open the drain plug of intercooler and heat exchanger. The drain sea water and engine coolant.
3. Disconnect all hoses and clamps connected to the intercooler and heat exchanger.
4. Remove the low pressure fuel pump.
5. Remove the oil exchange pump.

Tightening torque:

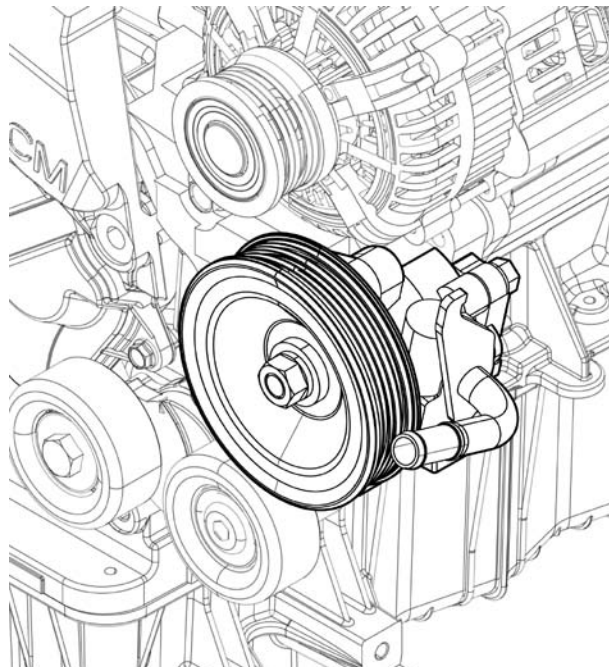
M8: 24.5 ~ 29.4N.m (2.5 ~ 3.0kgf.m, 18.1 ~ 21.7lb-ft)

M10: 44.1 ~ 49.0N.m (4.5 ~ 5.0kgf.m, 32.5 ~ 36.2lb-ft)

6. Remove the engine harness.
7. Remove bolts connected to support bracket.
8. Remove bolts connected to engine block.

9. Make sure you use the right bolts with right size.

Power steering pump



1. Drain hydraulic oil in reserve oil tank and line and disassemble power steering pump.
2. Remove hoses and clamps connected to pumps.
3. Loosen auto tensioner and remove belt engaged with pulleys.
4. Remove bolts fixing pump.
5. Install new O-ring of all hydraulic lines.
6. Pump disassemble is disallowed and install new assay when it is not working properly.
7. Using other oil except steering hydraulic oil may cause noise or pump malfunction.

● CAUTION

Never reuse secondary O-ring or oil.

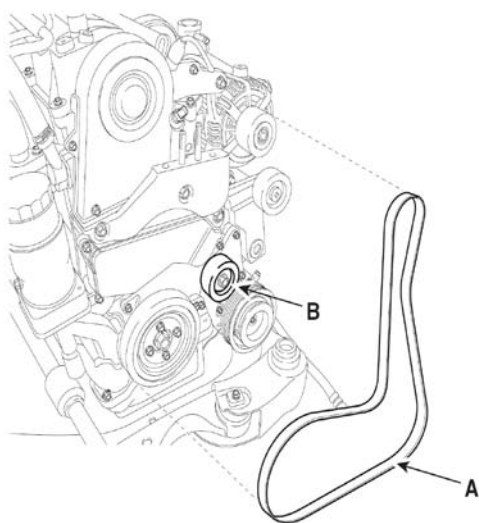
8. Check oil level after assembling the pump and supply oil gradually.
9. Check the level of reserve tank.

10. Turn the ignition key after oil supply and check noise and belt condition.

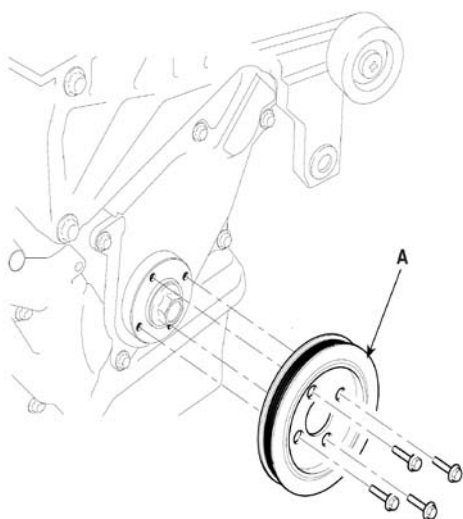
Timing system

1. Remove the side cover.

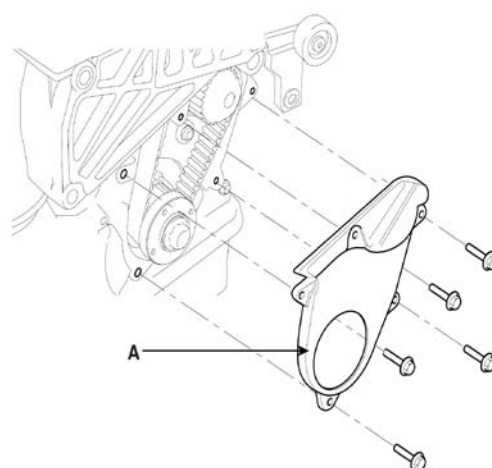
2. The tensioner (B) should be lifted up to remove the drive belt (A)



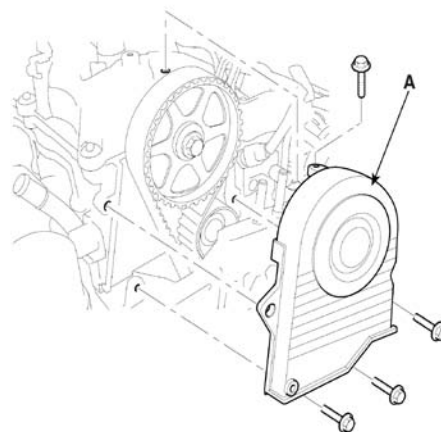
3. Remove the crankshaft pulley (A).



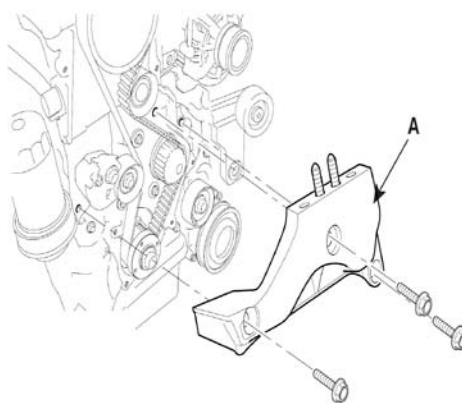
4. Remove the timing belt lower cover (A).



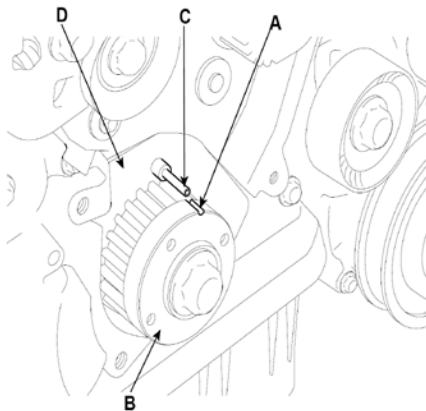
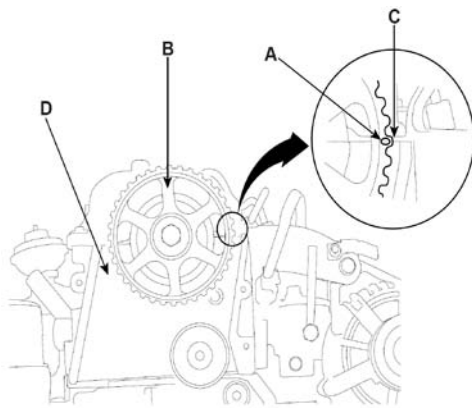
5. Remove the timing belt upper cover (A).



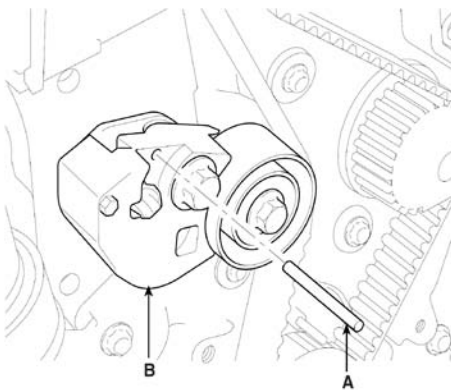
6. Remove the seawater pump support bracket (A).



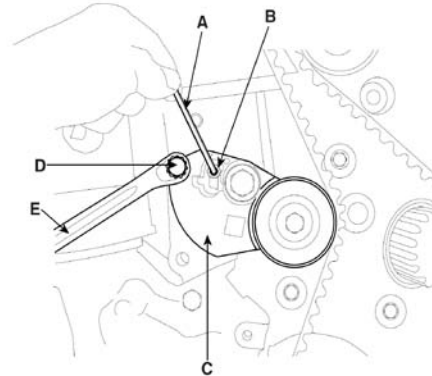
7. Align the timing marks (A, B) on the camshaft sprocket (C) and the crankshaft sprocket (D) with the marks (E,F) on the cylinder head (G) and the oil pump housing (H) with rotating the engine.



8. Insert a pin (A) into the aligned holes in the auto-tensioner (B).



9. Using a hexagonal wrench (5mm) (A), loosen the Stop bolt (B). And then, turning the auto-tensioner (C) Clock- wise fully with the boss bolt (D) and 12mm spanner (E), retighten the stop bolt (B).



10. Remove the timing belt.

NOTICE

To be prepared in case the removed belt is used, mark an arrow on the timing belt in the direction of rotation before removing it.

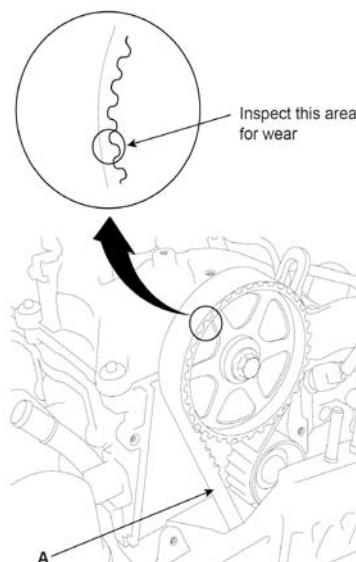
Inspection

1. Remove the upper cover.
2. Inspect the timing belt (A) for cracks and oil or coolant soaking.

NOTICE

Replace the belt if oil or coolant soaked.

Remove any oil or solvent that gets on the belt



Sprockets, tensioner, idler

1. Check the camshaft sprocket.

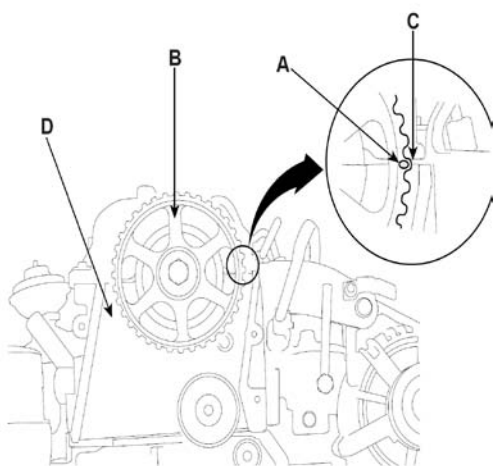
Camshaft sprocket, crankshaft, tensioner pulley and idler pulley for abnormal wear cracks or damage replace as necessary.

2. Inspect the tensioner pulley and the idler pulley for easy and smooth rotation and check for play or noise. Replace as necessary.

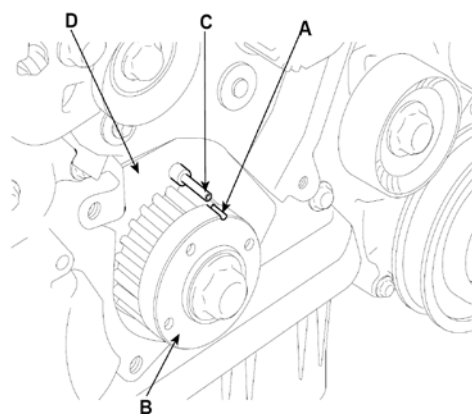
3. Replace the pulley if there is a grease leak from its bearing.

Installation

1. Align the timing mark (A) on the camshaft sprocket (B) with the mark(C) on the cylinder head (D).



2. Align the timing mark (A) on the crankshaft sprocket (B) with the pin (C) press fitted in the oil pump housing (D).

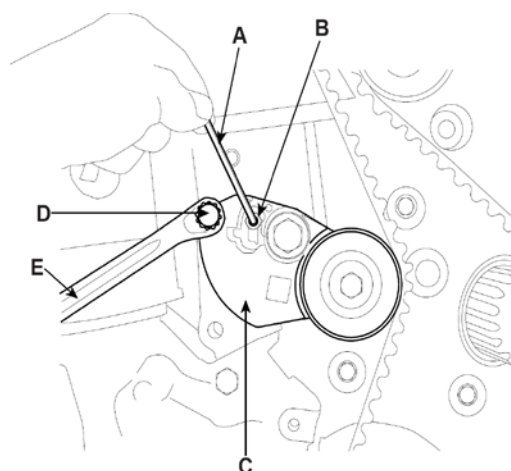


3. Install the timing belt.

- 1) Install the timing belt (A) tightly in the sequence shown.

① Timing belt drive pulley(B) (crankshaft) → ② Water pump pulley(C) ③ Timing belt idler(D) → ④ Camshaft sprocket(E) → ⑤ Timing belt tensioner (f)

- 2) Turn the auto-tensioner (C) counterclockwise fully to install the timing belt using the boss bolt (D) and spanner (E).



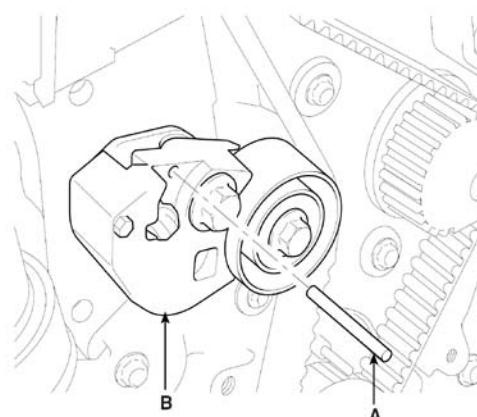
- 3) rotate the crankshaft by hand 2 complete revolutions (clockwise) to take up any slack and set to TDC (Top Dead Center).

- 4) Using a hexagonal wrench, install the stop bolt.

Tightening torque:

10 ~ 12N.m (1.0 ~ 1.2 kgf.m, 7 ~ 9lb-ft)

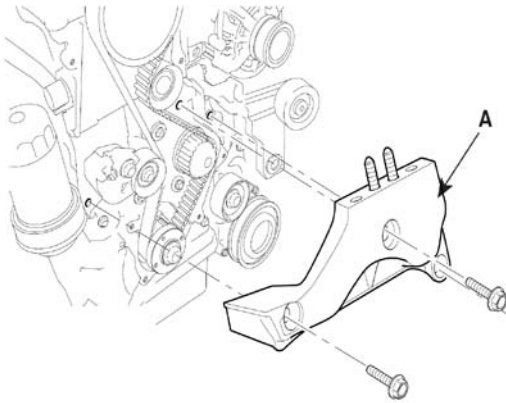
- 5) Remove the fixing pin (A)



4. Install the seawater pump support bracket (A).

Tightening torque:

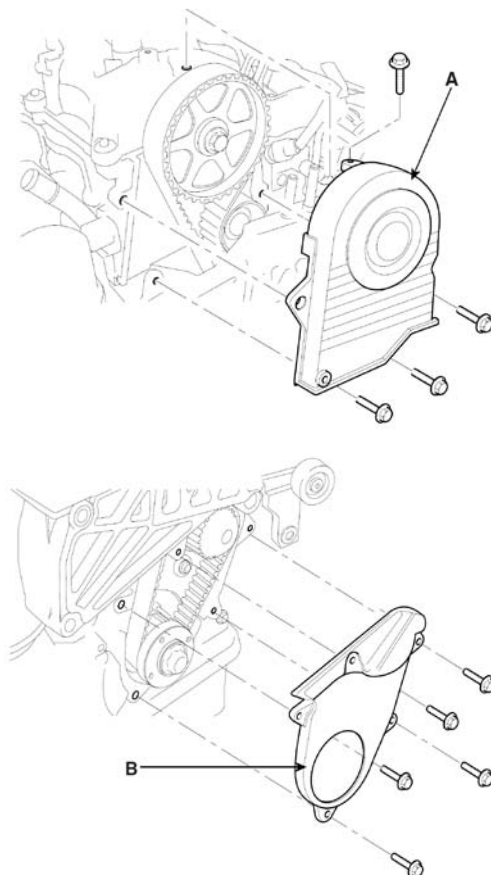
43 ~ 55N.m (4.3 ~ 5.5kgf.m, 31.72 ~ 40.57lb-ft)



5. Install the timing belt upper cover (A) and lower cover (B).

Tightening torque:

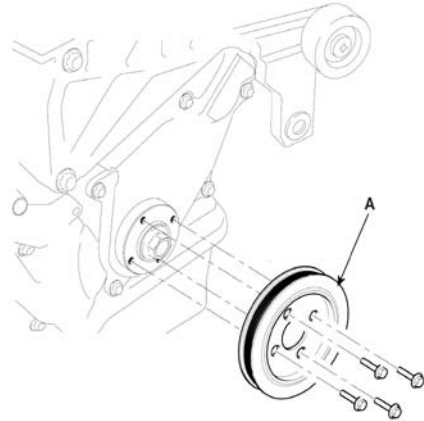
7.8 ~ 11.8N.m (0.8 ~ 1.2kgf.m, 5.75 ~ 8.70lb-ft)



6. Install the crankshaft pulley (A).

Tightening torque:

30 ~ 34N.m (3.0 ~ 3.4kgf.m, 22 ~ 25lb-ft)



7. Install the engine mounting bracket (A)

Tightening torque:

Nut (C), Bolt (D): 63.7 ~ 83.4N.m (6.5 ~ 8.5kgf.m, 47.0 ~ 61.5lb-ft)

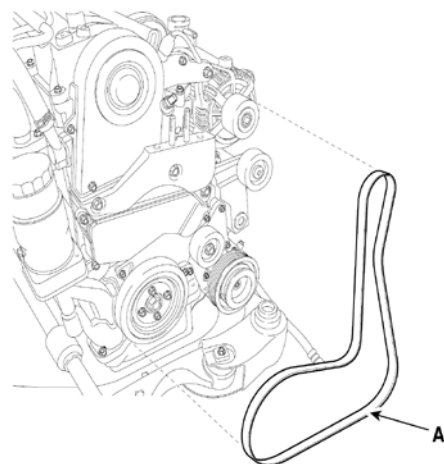
Nuts (E): 49.0 ~ 63.7N.m (5.0 ~ 6.5kgf.m, 36.2 ~ 47.0lb-ft)

Bolt (F): 7.8 ~ 9.8N.m (0.8 ~ 1.0kgf.m, 5.8 ~ 7.2lb-ft)

8. Install the drive belt(A), following the sequence below.

Alternator → Idler → Crankshaft pulley → Tensioner.

The tensioner should be lifted up to install the drive belt(A).

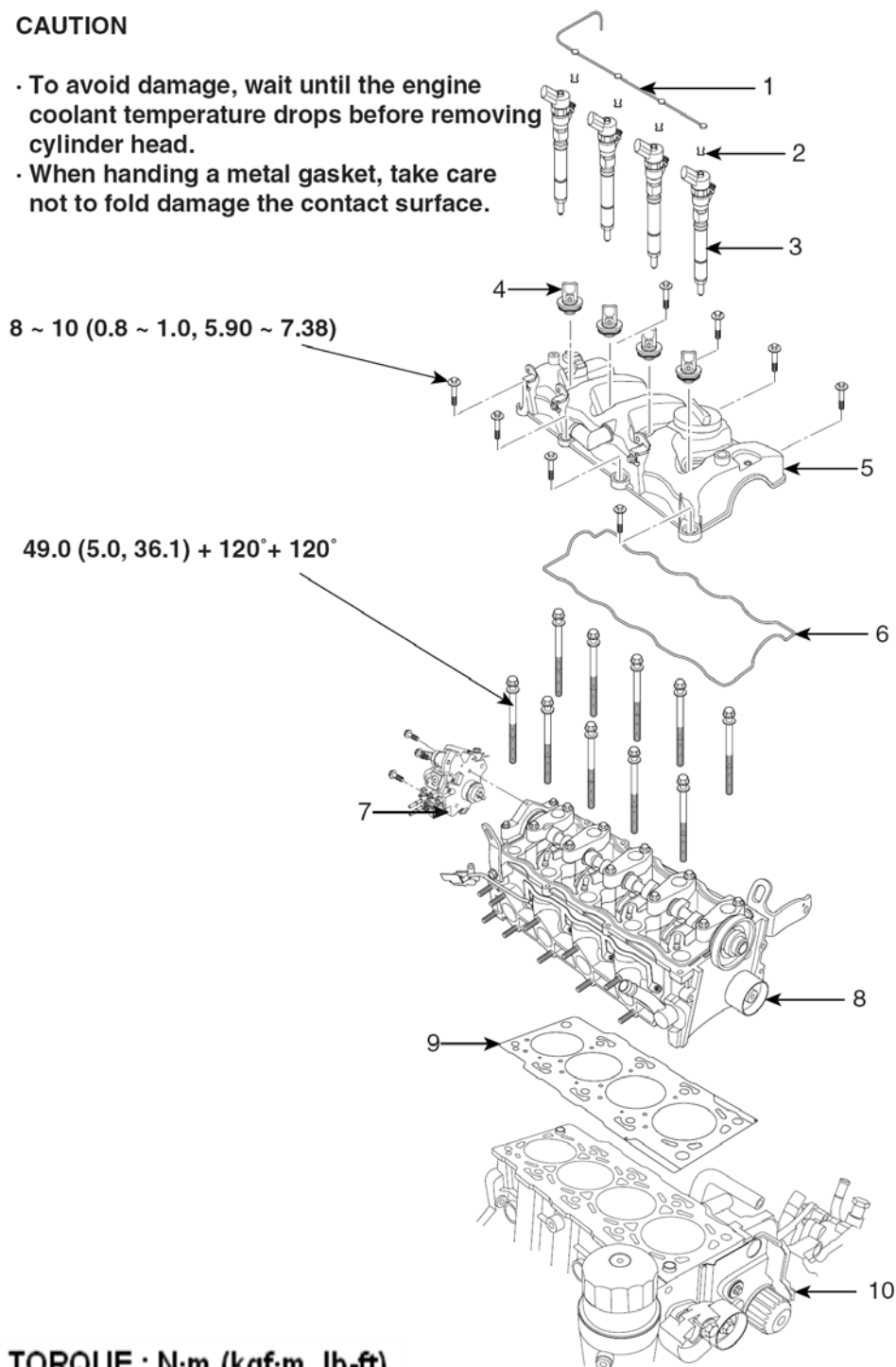


9. Install the side cover

Cylinder head assembly

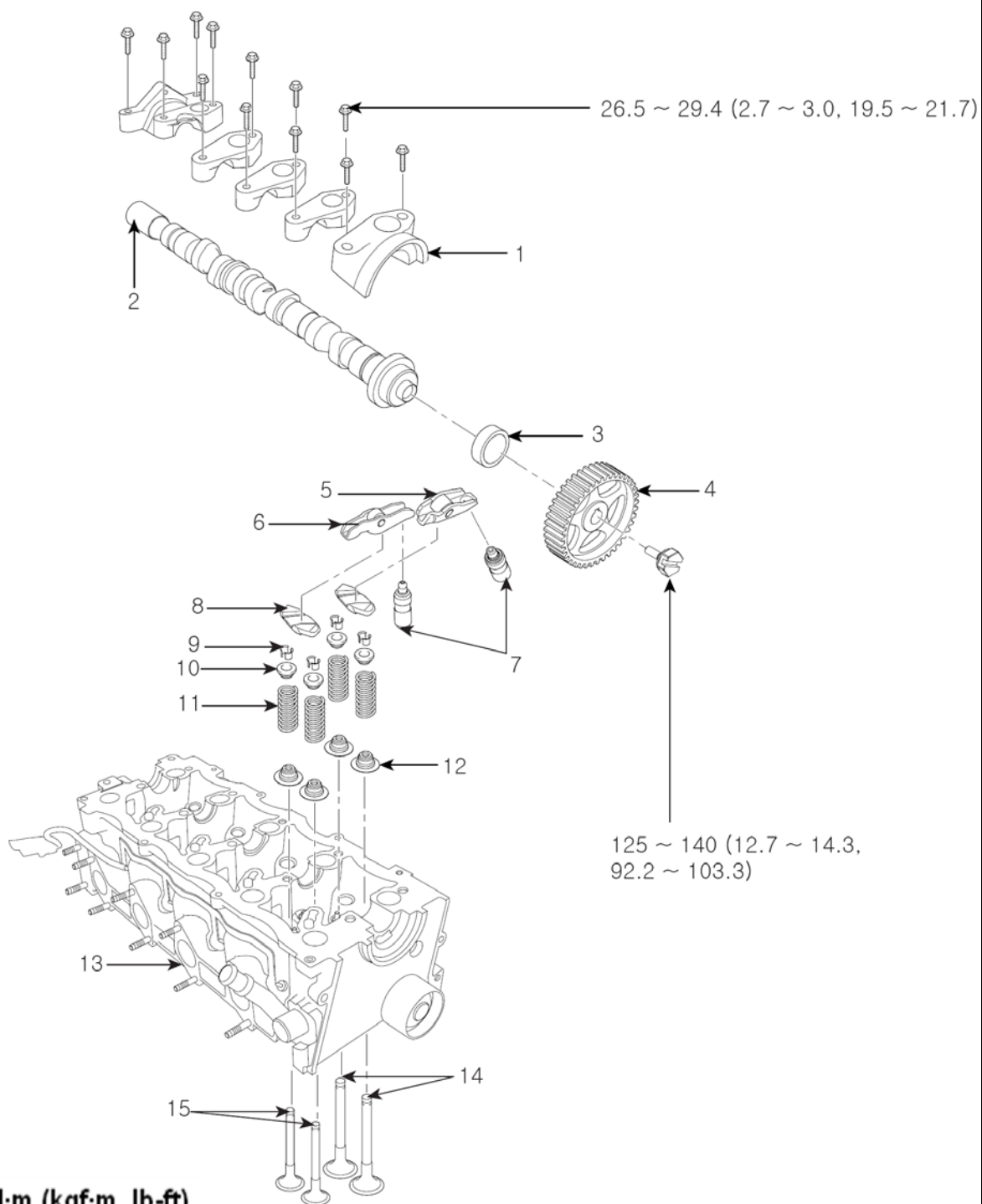
CAUTION

- To avoid damage, wait until the engine coolant temperature drops before removing cylinder head.
- When handling a metal gasket, take care not to fold damage the contact surface.



TORQUE : N·m (kgf·m, lb·ft)

- | | |
|-------------------------------|--------------------------------|
| 1. Fuel return hose | 6. Cylinder head cover gasket |
| 2. Cilp | 7. High pressure pump assembly |
| 3. Injector | 8. Cylinder head |
| 4. Injector installation plug | 9. Cylinder head gasket |
| 5. Cylinder head cover | 10. Cylinder block assembly |



1. Camshaft bearing cap

2. Camshaft

3. Oil seal

4. Camshaft sprocket

5. Intake cam follower

6. Exhaust cam follower

7. Lash adjuster

8. Valve cap

9. Valve spring retainer lock

10. Valve spring retainer

11. Valve spring

12. Valve stem seal

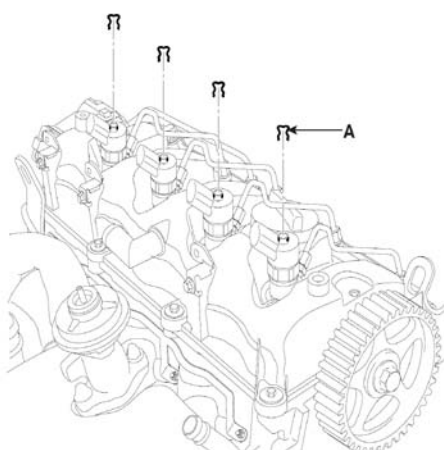
13. Cylinder head

14. Intake valves

15. Exhaust valves

Removal

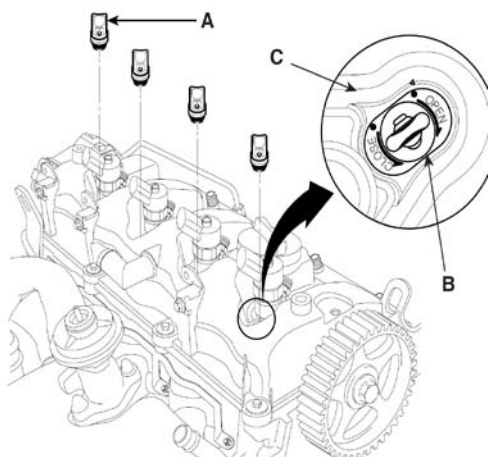
1. Before removing the cylinder head, the timing belt should be removed first. (Refer to Timing system in this group)
2. Remove injector connector.
3. Disconnect the fuel return hose after removing the clips (A).



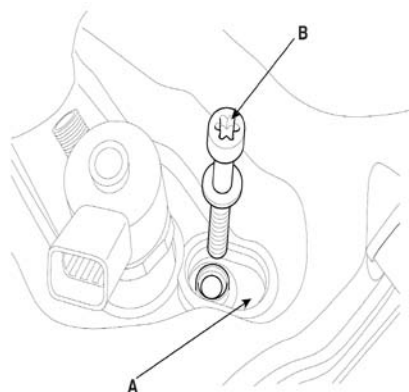
4. Remove the fuel tube.

(Refer to Fuel pump in FLC group)

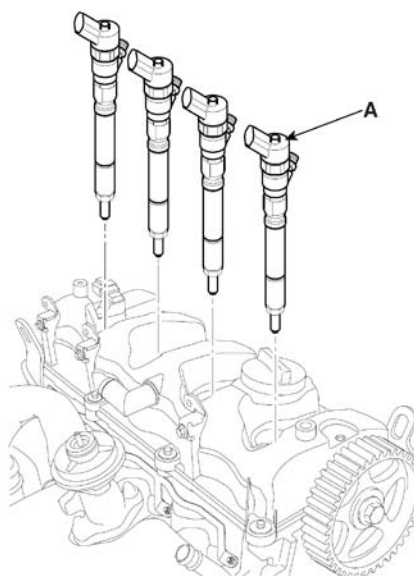
5. Remove the plugs (A).
 - a. Pull the plug up slightly. (more than 1mm)
 - b. Rotate the plug 90 clockwise.
 - c. Remove the plug with inserting a (-) driver between the plug assy(B) and the cylinder head cover(C).



6. Remove the injector holder bolt using the T 40 wrench.

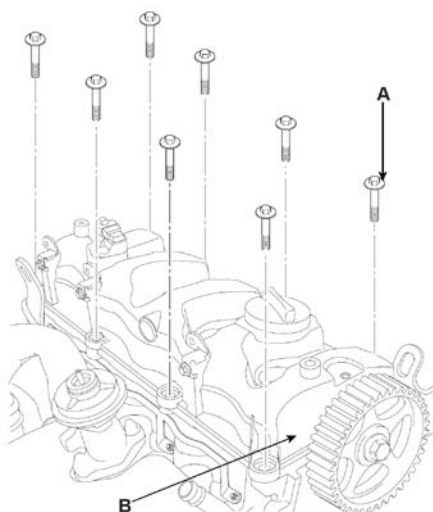


7. Pull the injector holders with the bolts.
8. Remove the injectors (A).



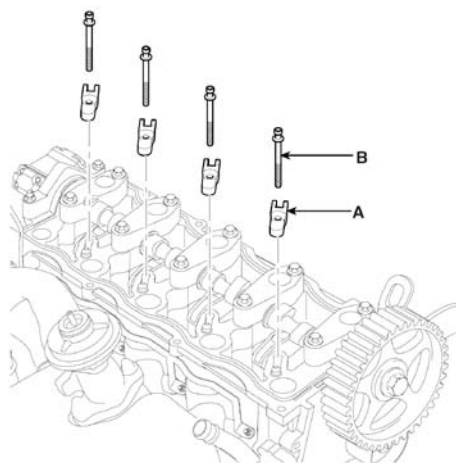
- a. Disconnect the camshaft position sensor.
- b. Remove the wiring bracket.
- c. Remove the pipe between the oil pan.
- d. Remove the fuel line hose bolt.

9. Remove the cylinder head cover mounting bolts(A,B).

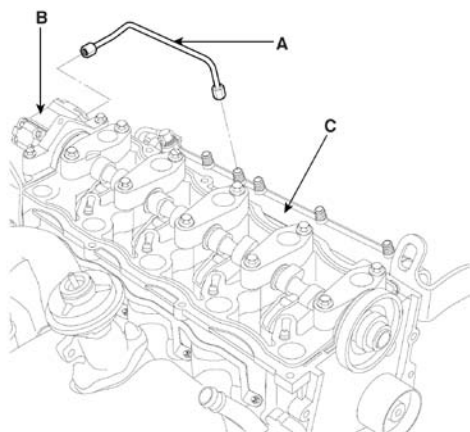


10. Remove the cylinder head cover.

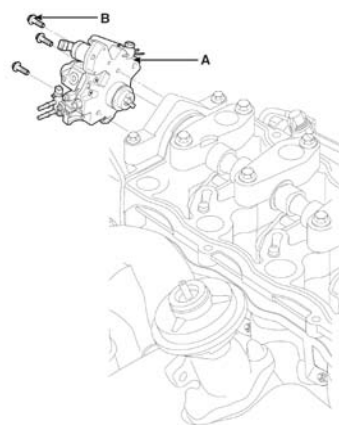
11. Remove the injector holders (A) with the bolts (B).



12. Remove the metal tube (A) between the high pressure pump (B) and the common rail (C).



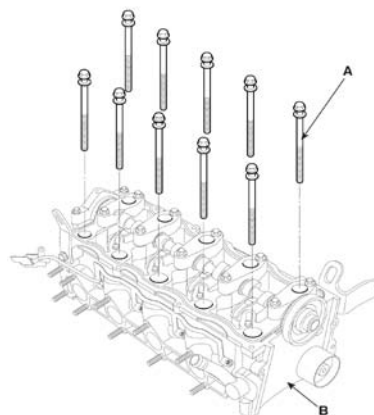
13. Remove the high pressure pump (A) after removing the mounting bolts(B).



14. Remove the exhaust manifold and the intake manifold.

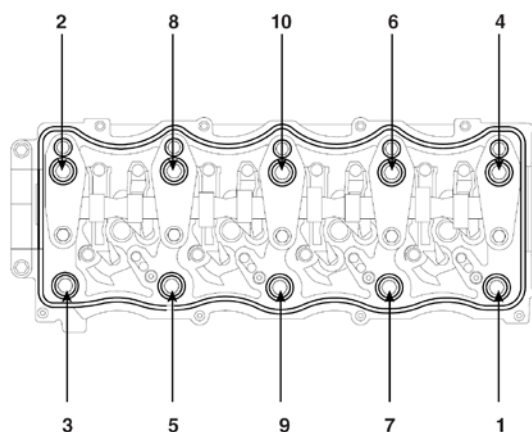
(Refer to intake and exhaust system in this group).

15. Remove the cylinder head bolts (A), then remove the cylinder head (B).



● CAUTION

To prevent warpage, unscrew the bolts in sequence 1/3 turn at a time: repeat the sequence until all bolts are loosened



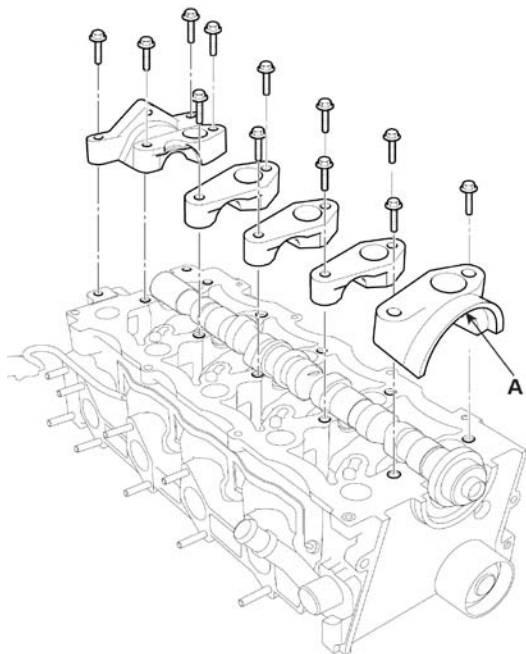
Disassembly

NOTICE

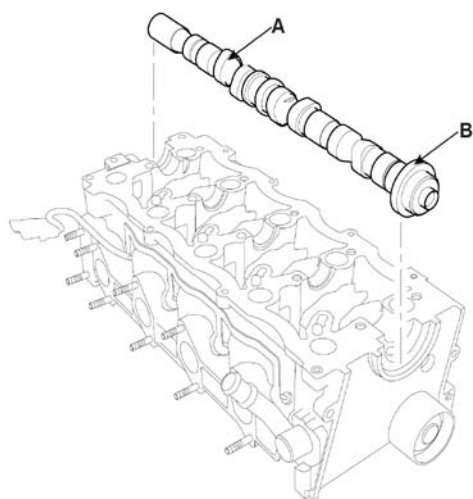
- Identify parts as they are removed to ensure reinstallation in original locations.
- Inspect camshafts.

1. Remove the engine hangers, the knock bushes and the studs.

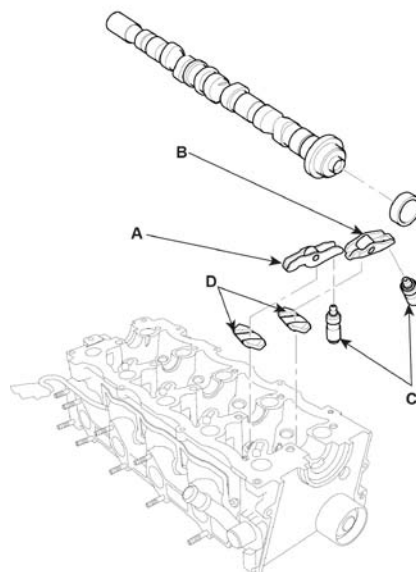
2. Remove the camshaft bearing caps (A).



3. Remove the camshaft (A) with the oil seal(B).



4. Remove the Intake/Exhaust cam followers(A, B).



5. Remove the lash adjusters (C).

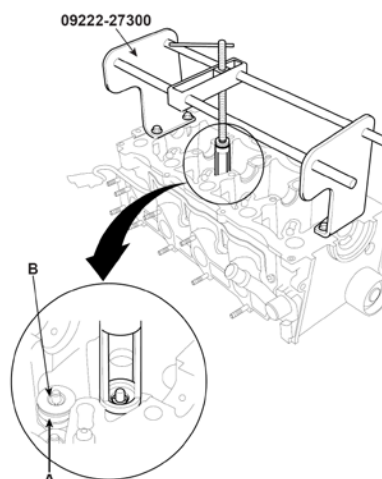
6. Remove the valve caps (D).

7. Using an appropriate-sized socket and plastic mallet, lightly tap the valve retainer to loosen the valve retainer locks before installing the valve spring compressor.

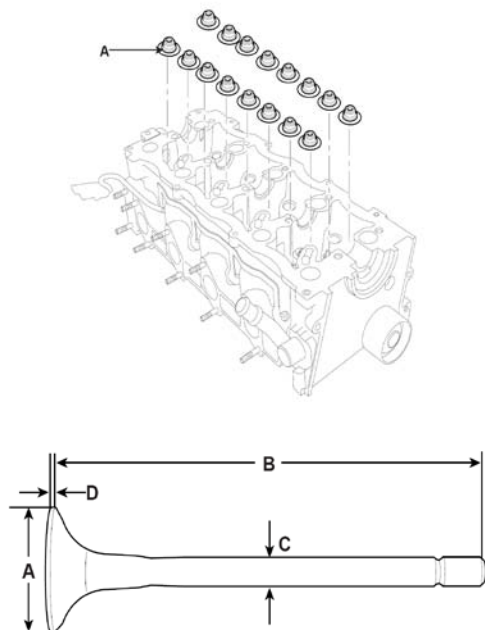
NOTICE

Identify valves and valve springs as they are removed so that each item can be reinstalled in its original position

8. Using the SST (00200-0T053), compress the valve spring(A) in order to remove the valve spring retainer locks(B).



9. Remove the valve stem seals(A).



Intake Valve Dimensions

A Standard (New):

28.5 ~ 28.7mm (1.1220 ~ 1.1299in)

B Standard (New):

94.0 ~ 94.2mm (3.7008 ~ 3.7087in)

C Standard (New):

5.933~5.953mm (0.2336~0.0669in)

D Standard (New):

1.5 ~ 1.7mm (0.0591 ~ 0.0669in)

Exhaust Valve Dimensions

A Standard (New):

24.3 ~ 24.5mm (0.9567 ~ 0.9646in)

B Standard (New):

94.0 ~ 94.2mm (3.7008 ~ 3.7087in)

C Standard (New):

5.905~5.925mm (0.2325~0.2333in)

D Standard (New):

1.2 ~ 1.4mm (0.0472 ~ 0.0551in)

Inspection

Camshaft

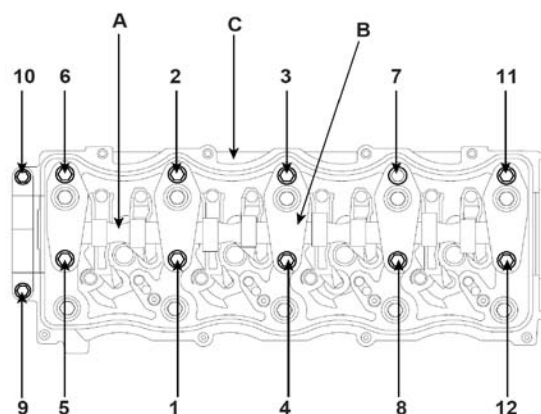
NOTICE

Do not rotate the camshaft during inspection.

1. Put the camshaft (A) and the camshaft bearing caps (B) on the cylinder head (C), then tighten the bolts to the specified torque with the following sequence below.

Specified torque

26.5 ~ 29.4N.m (2.7 ~ 3.0kgf.m, 19.5 ~ 21.7lb-ft)

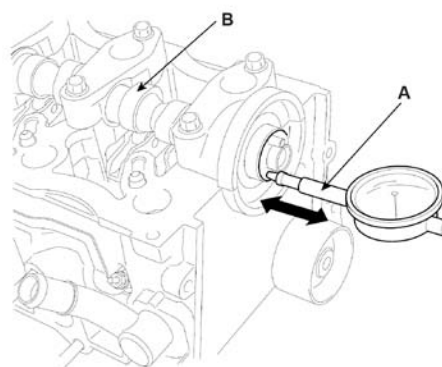


2. Seat the camshaft by pushing it toward the rear of the cylinder head.

3. Zero the dial indicator (A) against the end of the camshaft (B). Push the camshaft (B) back and forth, and read the end play.

Camshaft End Play

Standard (New): 0.05 ~ 0.15mm (0.002 ~ 0.006in)



4. Remove the bolts, then remove the camshaft bearing caps from the cylinder head (A).

- Lift the camshaft (B) out of the cylinder head(A), wipe it clean. Replace the camshaft if any lobes are pitted, cored, or excessively worn.

- Clean the camshaft bearing surfaces in the cylinder head then set the camshaft back in place.

- Place a plastic gauge strip(C) across each journal.

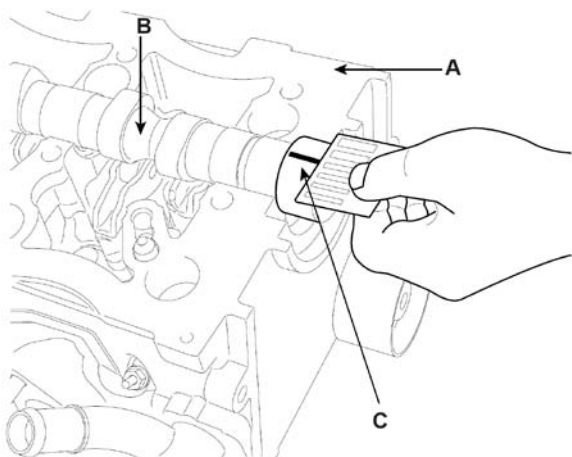
5. Install the camshaft bearing caps and tighten the bolts to the specified torque.

6. Remove the camshaft bearing caps, then measure the widest portion of the plastic gage(C) on each journal.

Camshaft-to-Camshaft bearing cap oil clearance

Standard (New)

0.040 ~ 0.074mm (0.0020 ~ 0.0029in)



7. If the camshaft-to-camshaft bearing cap oil clearance is out of tolerance :

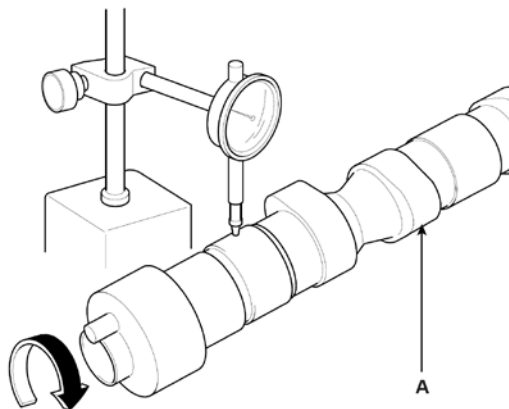
- And the camshaft(A) has already been replaced, you must replace the cylinder head.
- If the camshaft has not been replaced, first check the total run out with the camshaft supported on V-blocks.

Camshaft Total Run out

Standard (New)

0.035mm (0.0014in) for No.2 and4

0.050mm (0.0019in) for No.3



- If the total runout of the camshaft is within tolerance replace the cylinder head.

- If the total runout is out of tolerance, replace the camshaft and recheck the camshaft-to-camshaft bearing cap oil clearance. If the oil clearance is still out of tolerance, replace the cylinder head.

8. Check the cam height wear.

[Standard]

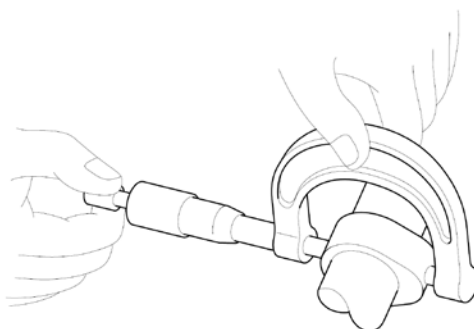
Intake : 34.697mm (1.366in)

Exhaust : 34.570mm (1.361in)

[Limit]

Intake : 34.197mm (1.346in)

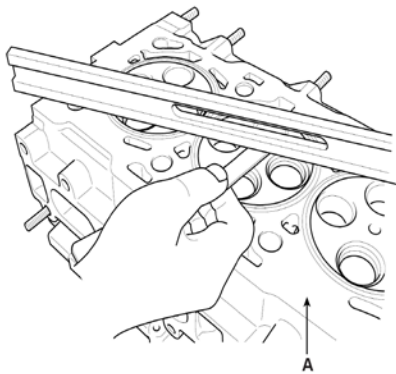
Exhaust : 34.070mm (1.341in)



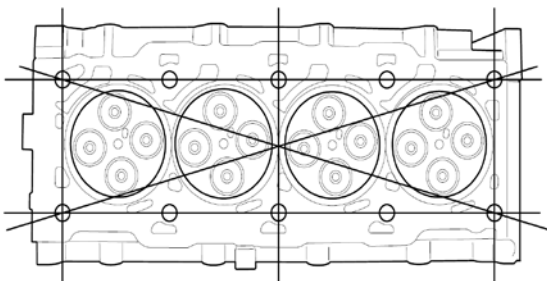
Cylinder head

Check the cylinder head (A) for warpage.

- If warpage is less than 0.03mm (0.0012in) for width, 0.09mm (0.0035in) for length and 0.012mm (0.0035in) for 1mm x51mm, cylinder head is in good condition.
- If warpage is over the standard value, replace the cylinder head.



Measure along edges and three ways across center.

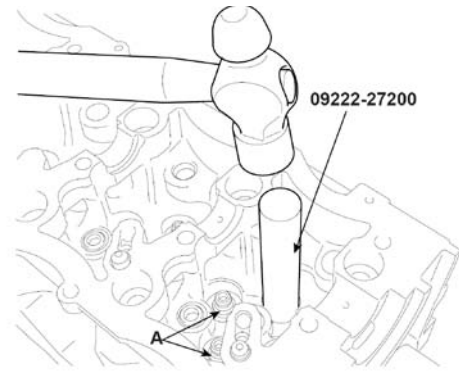


Reassembly

NOTICE

Prior to reassembling, cylinder head assembly shall be cleaned sufficiently to remove scrap and crust. (Clean holes with special care)

1. Using the SST(00200-0T054) insert the valve stem seals(A).

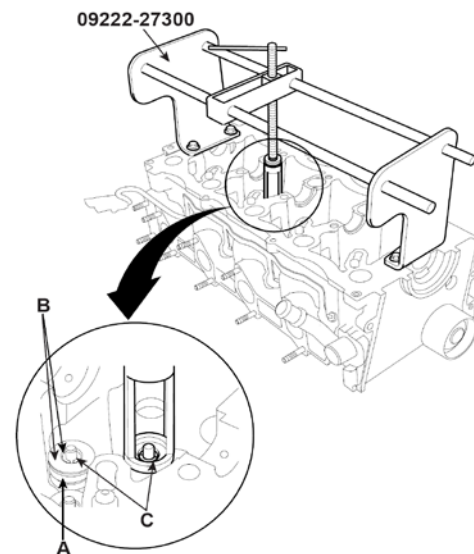


2. Insert the valves through the valve stem seals.

NOTICE

Make sure the valves move up and down smoothly.

3. Install the valve spring (A) and valve spring retainer (B), then install the SST (00200-0T053, the valve spring compressor). Compress the spring (A) and install the valve spring retainer lock (C).



4. Lightly tap the end of each valve stem two or three times with a plastic mallet to ensure proper seating of the valve and valve spring retainer locks.

NOTICE

Tap the valve stem only along its axis so you do not bend the stem.

5. Assembly of lash adjuster.

1) Until installing, lash adjuster shall be held upright so that gas oil in lash adjuster should not spill and assured that dust does not adhere to adjuster.

2) Lash adjust shall be inserted tenderly to the cylinder head not to spill gas oil from lash adjuster. In case of spilling air bent shall be done in accordance with the air bent procedure below.

NOTICE

Air bent procedure

1. In case of lash adjuster alone. Stroke-lash adjuster in gas oil 4~5 times by pushing its cap while pushing the ball down slightly by hard steel wire. Take care not to severely push hard steel wire down since ball is several grams.

2. After installed on engine Lash adjuster might give out unusual noise if air is mingled. Apply slow racing from idle to 3,000rpm (Approximately one minute per one racing) and the air shall be removed from adjuster. Therefore noise can be extinguished.

6. Install the valve-caps.

7. Put the cam. followers on the lash adjusters and valve caps.

8. After wiping down the camshaft and camshaft seal in the cylinder head, lubricate both surfaces and install the camshaft with engine oil.

9. Confirm that cam followers are located on lash adjusters and their rollers are in touch with camshaft.

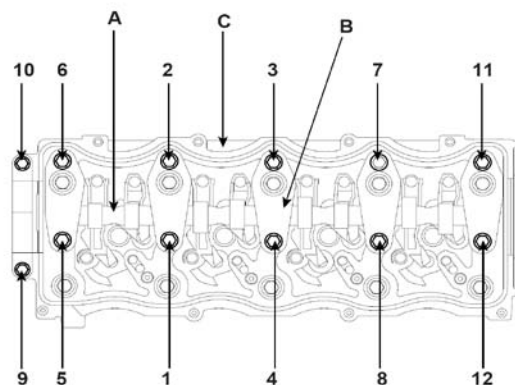
10. In assembly camshaft bearing cap, to the cylinder head with the cylinder block, all pistons should be in the idle position between TDC (Top Dead Center) and BDC(Bottom dead Center) because valves come out of the bottom surface of the cylinder head.

11. Install the bolts loosely.

12. Tighten each bolt two turns at a time in the sequence shown below to ensure that the cam followers do not bind on the valves.

Tightening torque

26.5 ~ 29.4N.m (2.7 ~ 3.0kgf.m, 19.5 ~ 21.7lb-ft)



Installation

Install the cylinder head in the reverse order of removal

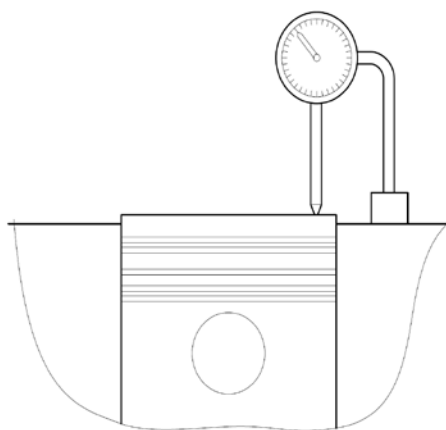
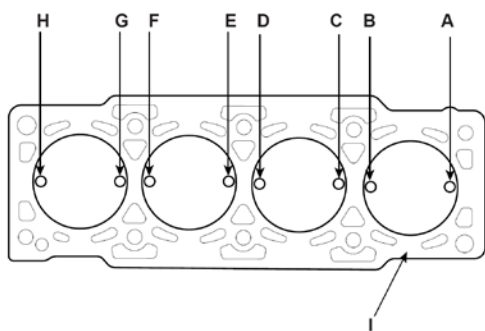
NOTICE

- Always use a new head gasket.
- Cylinder head and cylinder block surface must be clean.
- Turn the crankshaft so the No.1 piston is at TDC(Top Dead Center).

1. Cylinder head dowel pins must be aligned.

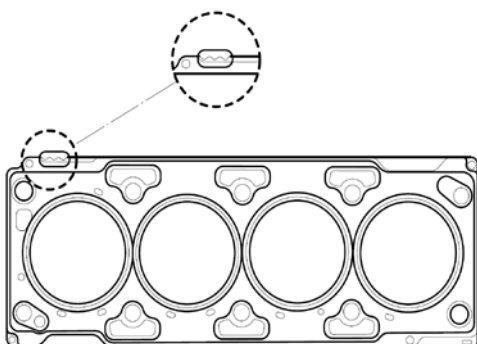
2. Select the cylinder head gasket.

1) Measure the piston protrusion from the upper cylinder block face (I) on 8 places (A ~ H) at T.D.C. Measure on the crankshaft center line considering the piston migration.



2) Install the gasket so that the identification mark faces toward the flywheel side.

3) Select the gasket in the table below using the average value of piston protrusions. Although even the only 1 point is over than the each rank limit, use 1 rank upper gasket than specified in the table below.



3. Position the cylinder head assembly over the gasket.

4. Tighten the cylinder head bolts slightly.

5. Install the camshaft sprocket, aligning the timing mark.

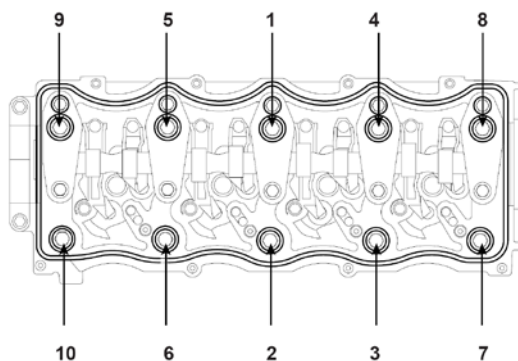
Tightening torque

124.5 ~ 144.2N.m (12.7 ~ 14.7kgf.m, 91.9 ~ 106.3lb-ft)

6. Tighten the bolts to the specified torque

Tightening torque

49.0N.m (5.0kgf.m, 46.6lb-ft) + 120° + 90°



NOTICE

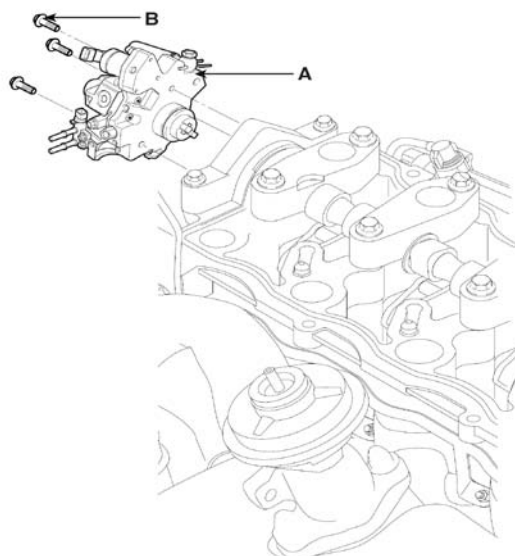
▪ Tightening sequence of cylinder head bolt should be confirmed to the upper drawing.

▪ Cylinder head bolt must be replaced.

7. Install the high pressure pump assembly (A).

Tightening torque

24.5 ~ 34.3N.m (2.5 ~ 3.5kgf.m, 18.0 ~ 25.3lb-ft)



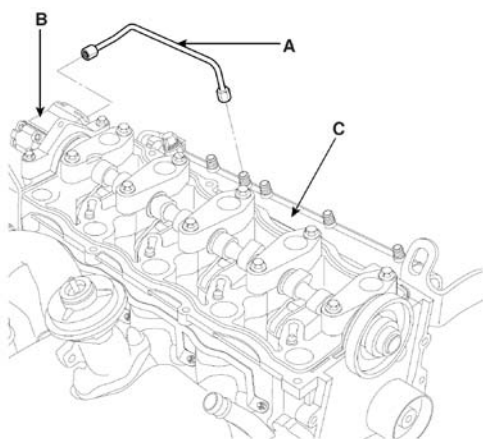
8. Install the intake/exhaust manifold assemblies.

(Refer to Intake and exhaust system in this group)

9. Install the metal tube(A) between the high pressure pump(B) and the common rail (C).

Tightening torque

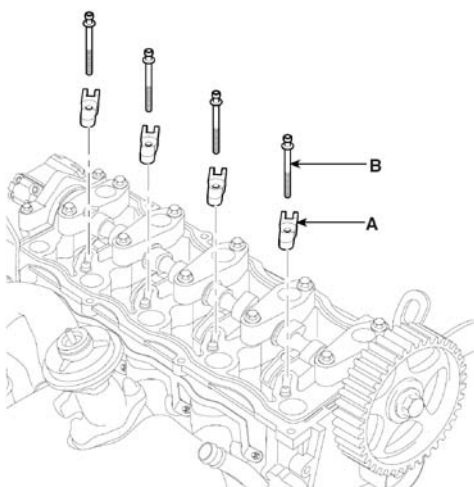
24.5 ~ 28.4N.m (2.5 ~ 2.9kgf.m, 18.0 ~ 20.9lb-ft)



10. If it is necessary to replace the oil seals on the cylinder head cover for injectors, use the SST (00200-0T056).

11. Install the camshaft oil seal with use the SST(00200-0T052)

12. Install the injector holder (A).



13. Install the head cover gasket in the groove of the cylinder head cover.

NOTICE

- Cylinder head cover gasket must be replaced.
- Before installing the head cover gasket, thoroughly clean the seal and the groove.

14. Apply liquid gasket to the head cover gasket at the four corners of the recesses.

NOTICE

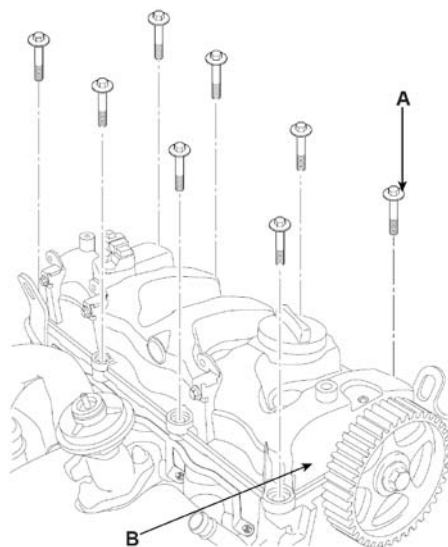
- Use liquid gasket LOCTITE 5699 or TH1212D.
- Check that the mating surface are clean and dry before applying liquid gasket.
- Do not install the parts if five minutes or more have elapsed since applying liquid gasket. Instead, reapply liquid gasket after removing old residue.
- After assembly, wait at least 30 minutes before filling the engine with oil.

15. Install the cylinder head cover bolts (A, B).

Tighten torque

(A): 21 ~ 25N.m (2.2 ~ 2.6kgf.m, 15.9 ~ 18.8lb-ft)

(B): 8 ~ 10N.m (0.8 ~ 1.0kgf.m, 5.9 ~ 7.38lb-ft)



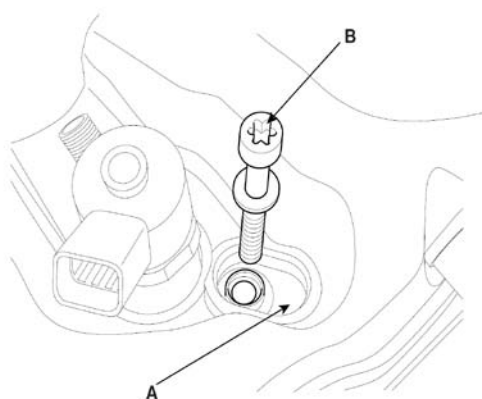
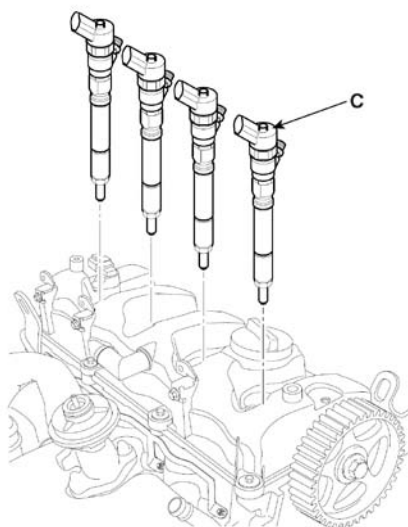
NOTICE

After assembly, wait at least 30 minutes before filling the engine with oil.

16. Insert the injectors (C), moving back the injector holders (A) with the bolts(B).

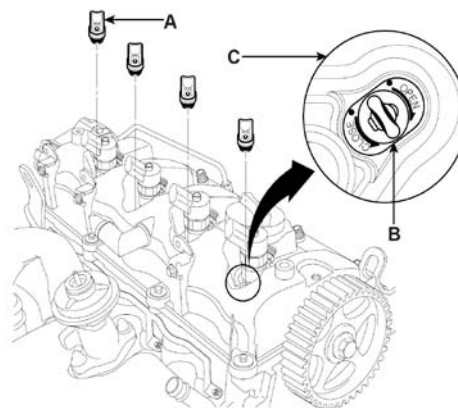
Tighten torque:

24.5 ~ 28.4N.m (2.5 ~ 2.9kgf.m, 18.1 ~ 21.0lb-ft)



17. Install the injector holder bolts (A) using the torque wrench (B)

18. Install the injector plug (A)



A. Make sure that the stopper of the plug faces 'OPEN' side Otherwise pull and rotate the plug Clock-wise so the stopper should face 'OPEN' side.

b. Apply the engine oil on the head cover mating surface or the gasket of the plug.

c. Insert the plugs in the head cover.

d. Rotate the plug inserted counterclockwise 90°

e. After installation, rotate the plug clockwise. If it is rotated, repeat the step a ~ d.

NOTICE

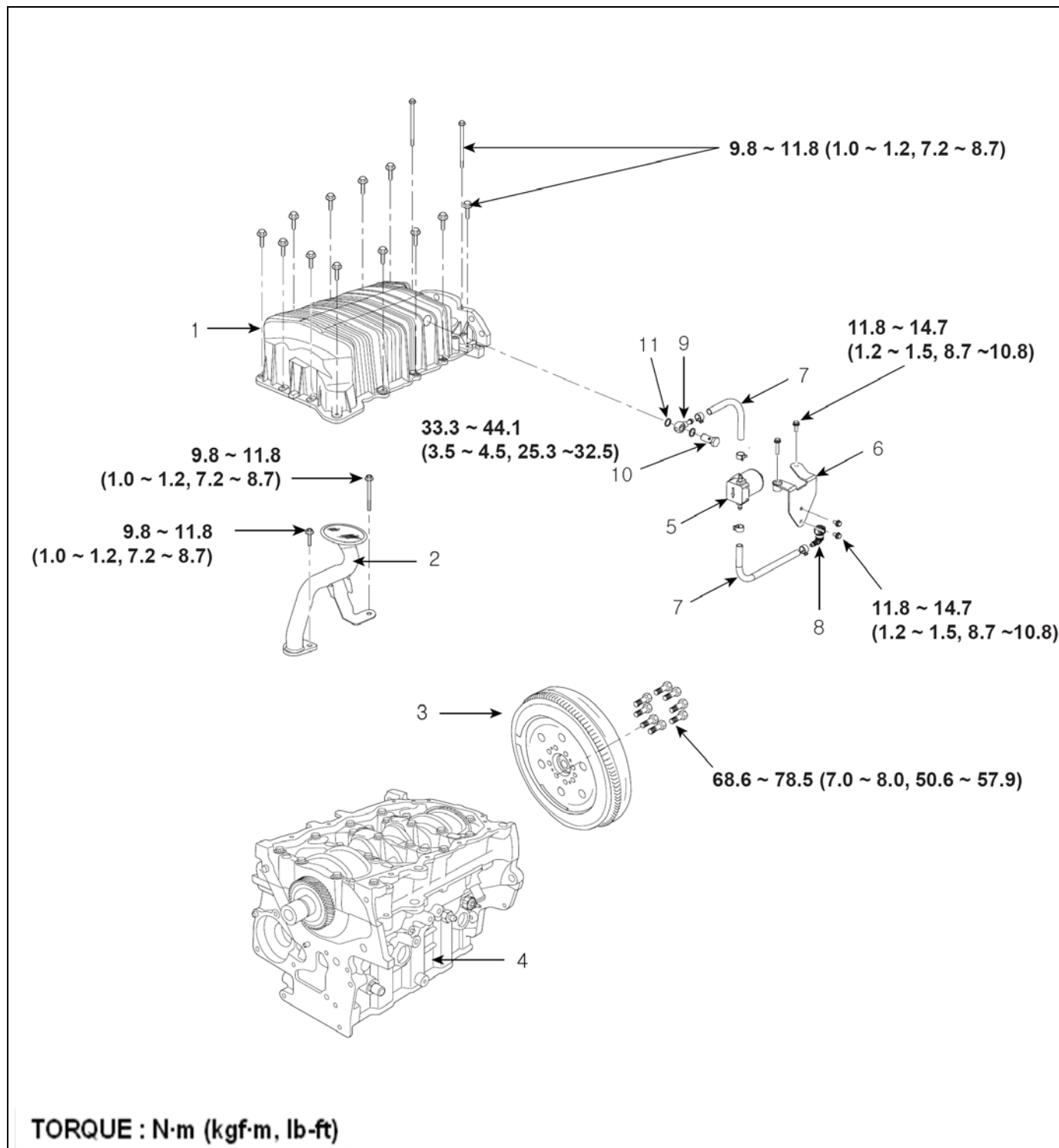
Plug gasket must be replaced.

19. Install the fuel tube. (Refer to Injector in FLC group)

20. Install the timing belt. (Refer to Timing system in this group)

Engine block

Components



1. Oil pan

2. Oil screen

3. Flywheel

4. Cylinder block assembly

5. Oil extraction pump

6. Bracket - Oil extraction pump

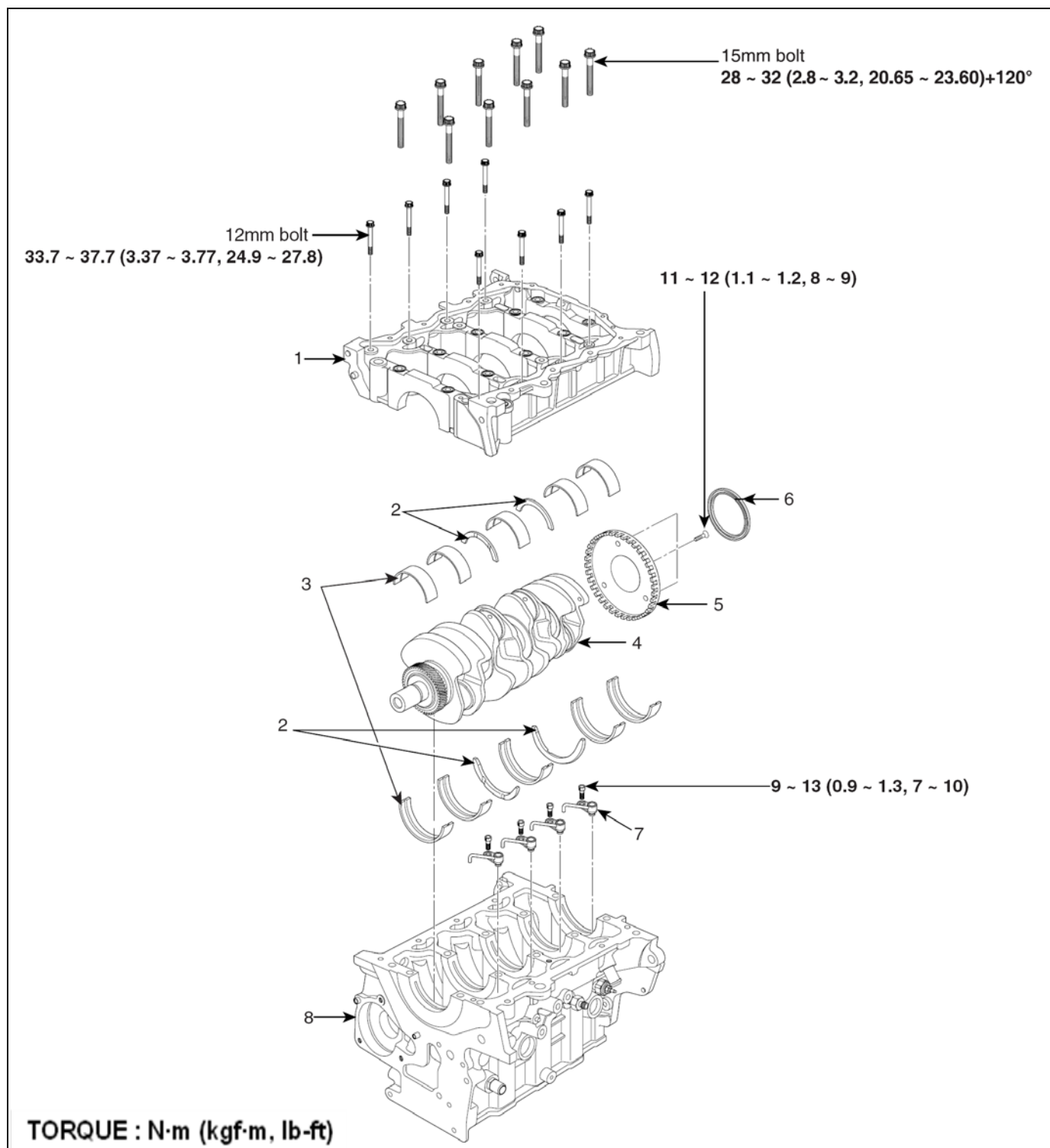
7. Hose

8. Double-lock Q/connector 90 elbow

9. Joint-eye

10. Bolt-eye

11. Washer-plain(cooper)



1. Bad pate assembly

2. Center bearings

3. Main bearings

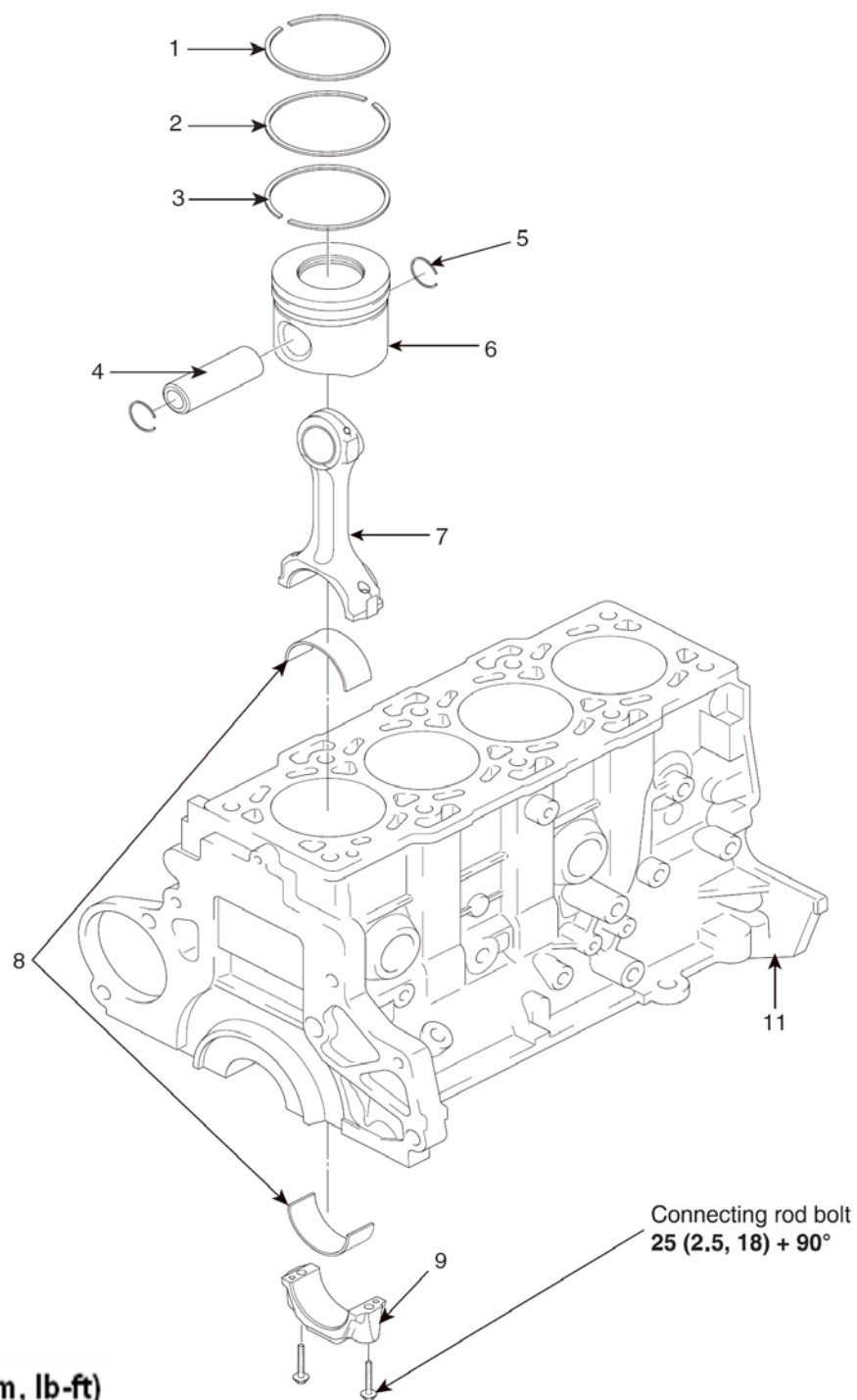
4. Crankshaft

5. Crankshaft position sensor wheel

6. Crankshaft rear oil seal

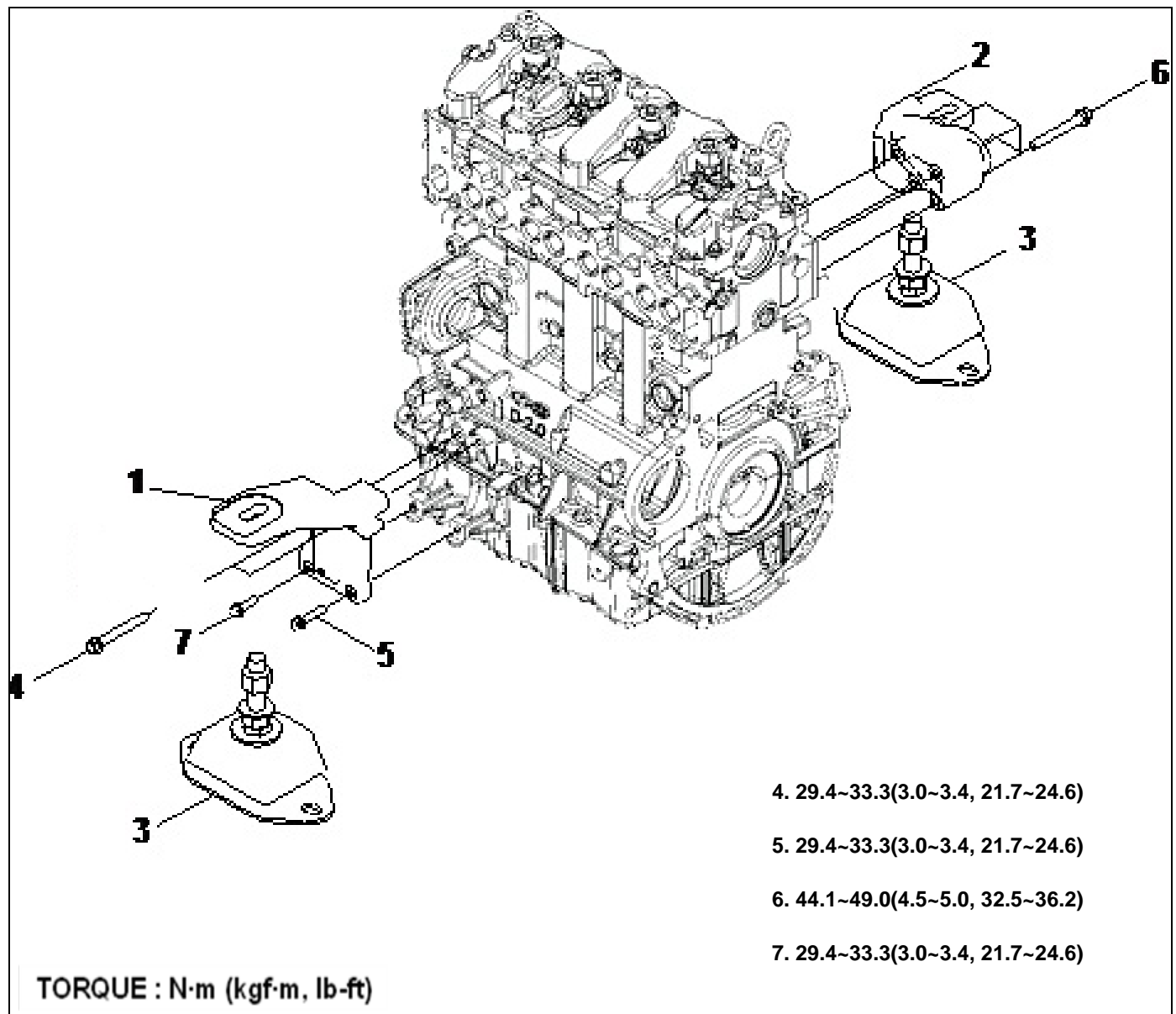
7. Piston cooling jet (Oil jet)

8. Cylinder block assembly



1. Piston ring No. 1
2. Piston ring No. 2
3. Oil ring
4. Piston pin
5. Snap ring

6. Piston
7. Connecting rod
8. Connecting rod bearings
9. Connecting rod bearing cap
10. Cylinder block assembly

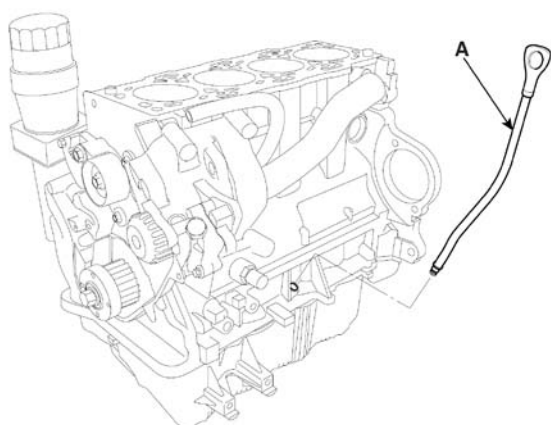


- 1. Engine support bracket, LH
- 2. Engine support bracket, RH
- 3. Engine mount insulator
- 4. Flange bolt
- 5. Flange bolt

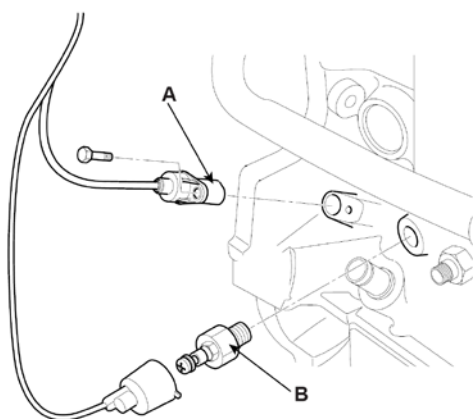
- 6. Flange bolt
- 7. Flange bolt

Removal

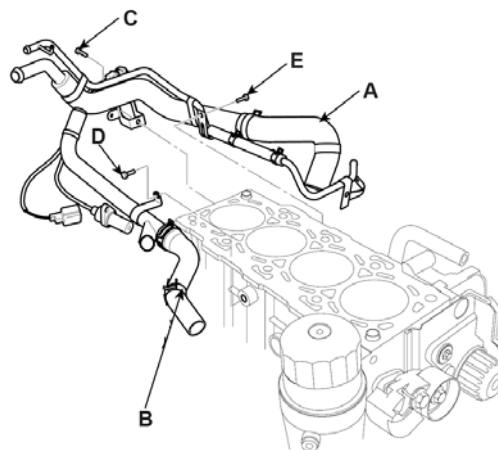
1. Remove the alternator. (Refer to Alternator in EEC Group)
2. Remove the intake and the exhaust manifold (Refer to Intake and exhaust system in this Group)
3. Remove the engine support bracket.
4. Remove the timing belt. (Refer to Timing system in this Group)
5. Remove the cylinder head assembly. (Refer to Cylinder head assembly in this Group)
6. Remove the engine oil level gauge (A).



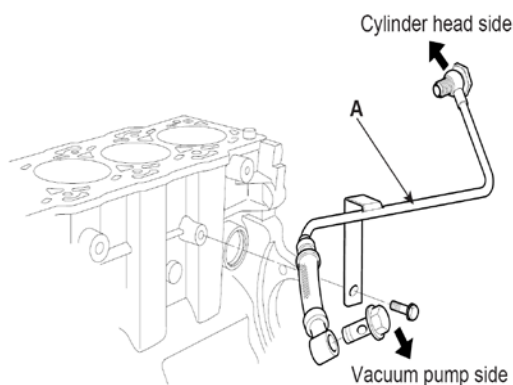
7. Remove the Crankshaft Position Sensor (CKP) (A) and the oil pressure switch (B).



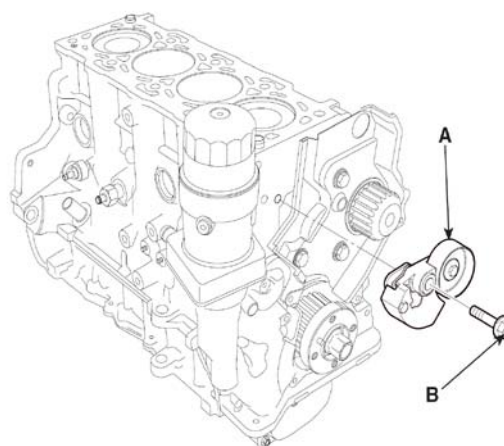
8. Remove the heater and oil cooler return pipe assembly (A) after loosening the hose clamps (B) and the bolts (C, D, E)



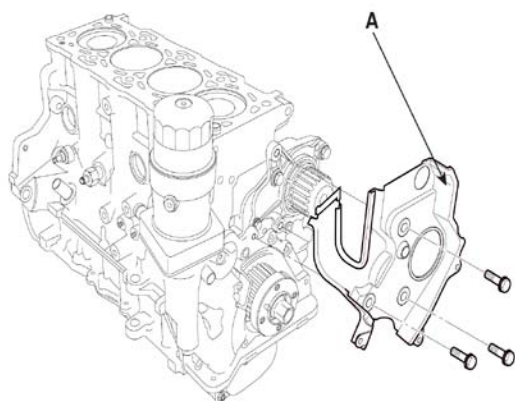
9. Remove the tube (A) between the vacuum pump and the cylinder head.



10. Remove alternator lower bracket.
11. Remove the water inlet pipe assembly (A) by loosening a bolt (B) and clamps
12. Remove the auto-tensioner (A) by loosening the bolt (B).



13. Remove the timing belt rear cover (A).

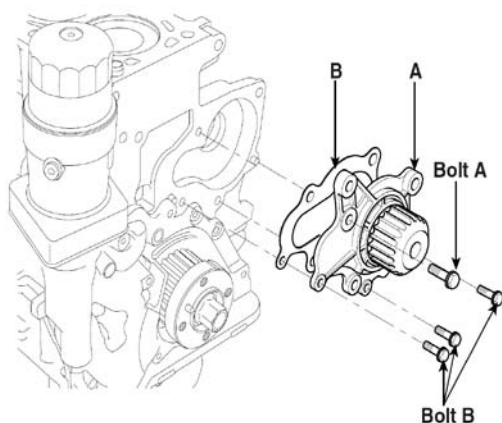


● **CAUTION**

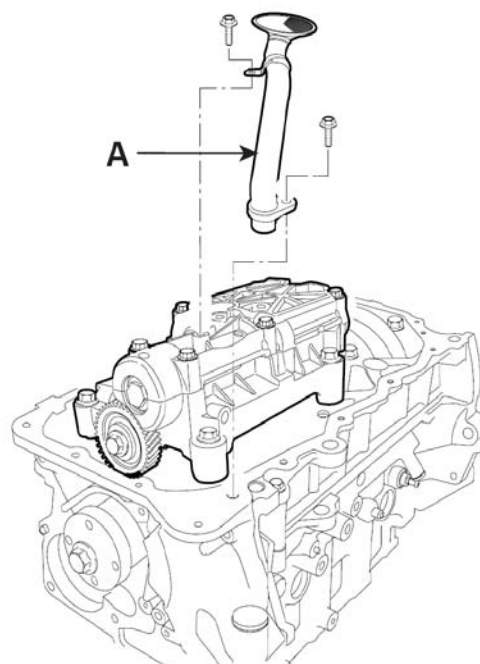
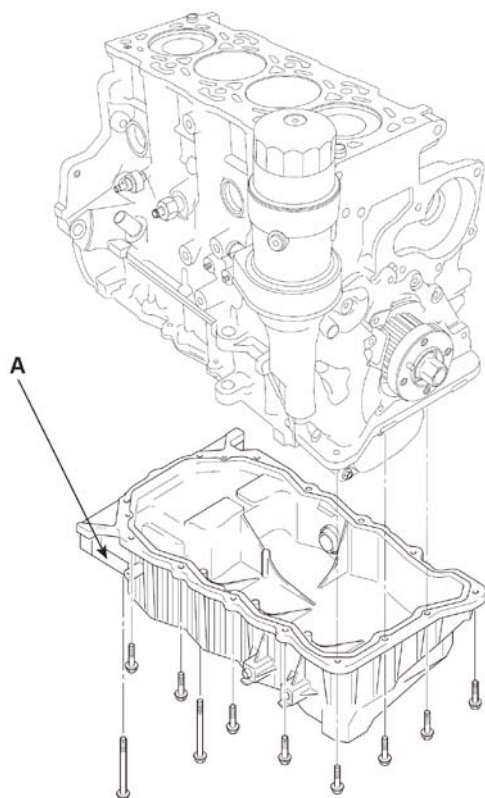
- Insert the SST between the oil pan and the ladder frame by tapping it with a plastic hammer in the direction of ① arrow.
- After tapping the SST with a plastic hammer along the direction of ② arrow around more than 2/3 edge of the oil pan, remove it from the ladder frame.
- Do not turn over the SST abruptly without tapping. It is result in damage of the SST.

16. Remove oil screen(A) for removal of oil pump assembly

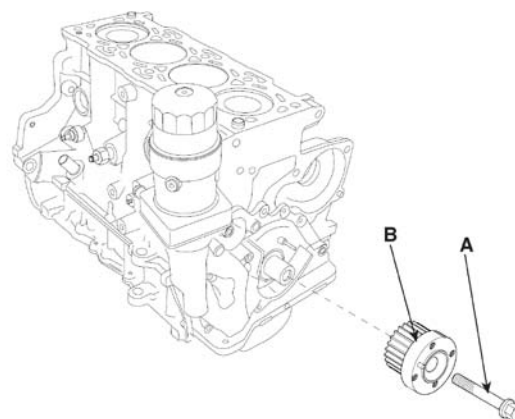
14. Remove the water pump assembly (A) with the gasket (B).



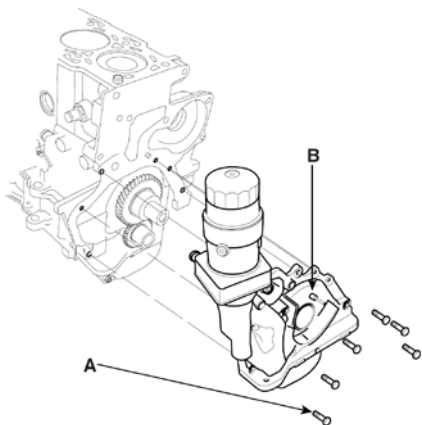
15. Remove the oil pan (A).



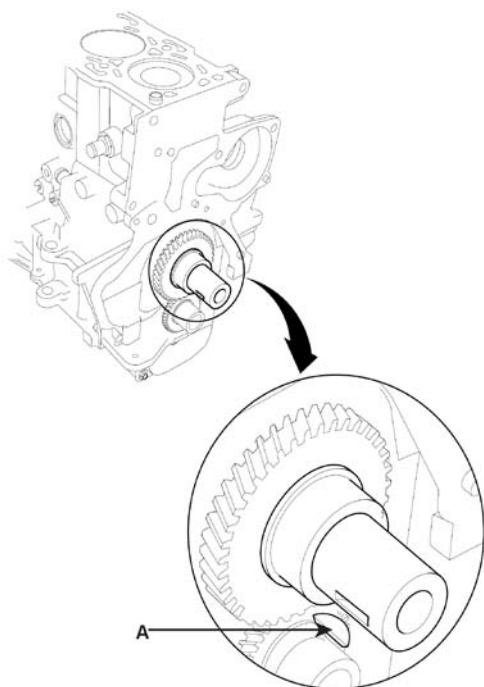
17. Remove the crankshaft bolts (A), and then separates the crankshaft sprocket (B).



18. Remove the oil-pump assembly (B) by loosening the bolts (A).



19. Remove the crankshaft key (A).



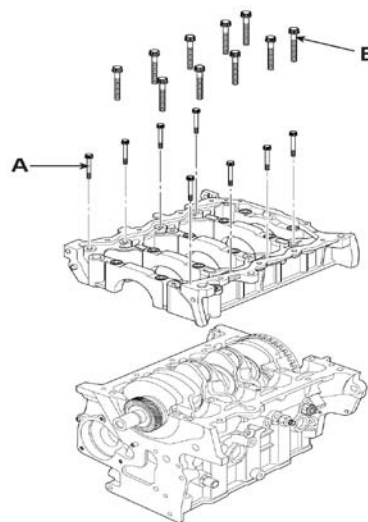
Disassembly

1. Remove the bed plate assembly.

- Remove the bolts (A).

To prevent war page, unscrew the bolts in sequence 1/3 turn at a time: repeat the sequence until all bolts are loosened.

- Remove the bolts (B).



2. Remove the connecting rod bearing caps (A) and bearings (B).

- After removing No. 1 and 4 connecting rod bearing caps and turn the crankshaft No. 2 and 3 crankpins are at the top.

- Remove the rest bearing caps and bearings.

- Keep all caps/bearings in order.

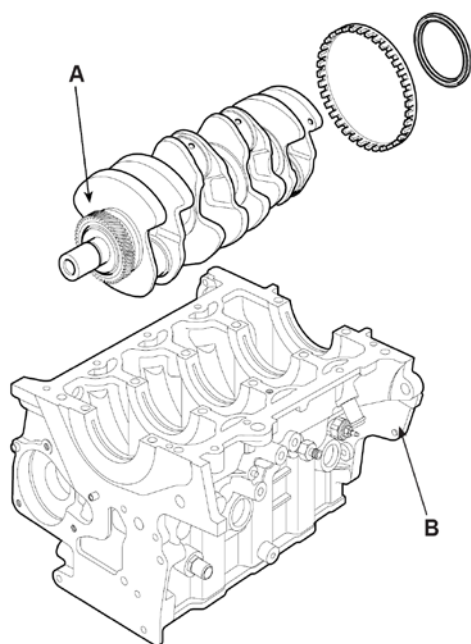
3. If you can feel a ridge of metal or hard carbon around the top of each cylinder, remove it with a ridge reamer. Follow the reamer manufacturer's instructions. If the ridge is not removed, it may damage the pistons as they are pushed out.

4. Drive out the piston assembly from the engine block.

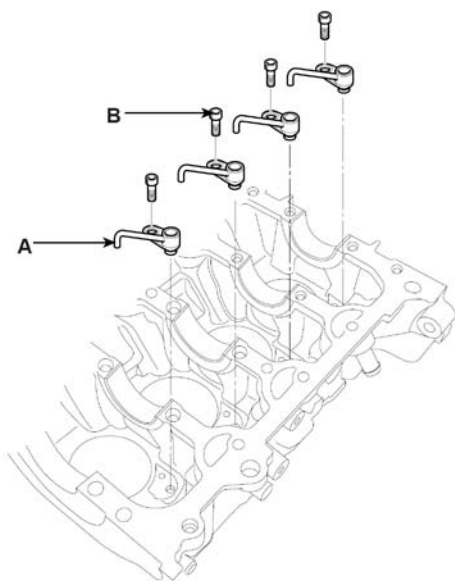
a. Reinstall the connecting rod bearings and caps after removing each piston/connecting rod assembly.

b. To avoid mix up on reassembly, mark each piston/connecting rod assembly with its cylinder number.

5. Lift the crankshaft (A) out of the cylinder block (B), being careful not to damage the journals.



6. Remove the piston oil jet (A) by loosening the hexagonal bolt (B) with a hexagonal wrench.



Inspection

Flywheel

1. Inspect ring gear teeth for wear or damage.
2. Flywheel bolts should be free from detrimental flaws.

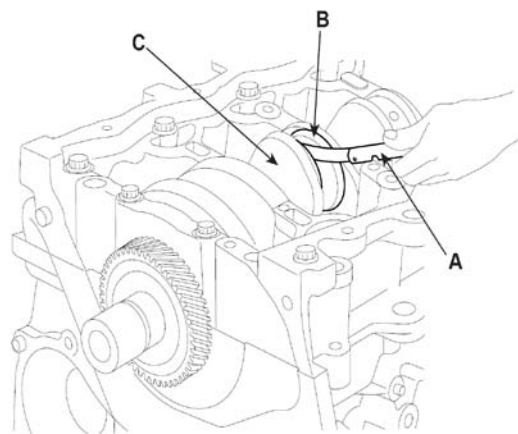
Connecting rod and crankshaft end play

1. Measure the connecting rod end play with a feeler gauge(A) between the connecting rod(B) and crankshaft(C).

Connecting Rod End play

Standard (New): 0.10 ~ 0.35mm (0.004 ~ 0.014in)

Service Limit: 0.40mm (0.016in)



2. If the connecting rod end play is out-of-tolerance, install a new connecting rod, and recheck. If it is still out-of-tolerance, replace the crankshaft.

3. If the end play is excessive. Replace parts as necessary

Main bearing clearance

1. To check main bearing-to-journal oil clearance, remove the bed plate, the crankshaft and the bearing halves.
2. Clean each main journal and bearing half with a clean shop towel.
3. Cut plastic gauge to the same length as the width of the bearing.
4. Place one strip of plastic gauge across each main journal on the cylinder block and the bed plate, avoiding the oil holes.
5. Reinstall the bearings, crankshaft and bed plate then torque the bolts to the specified value.

NOTICE

Do not rotate the crankshaft during inspection.

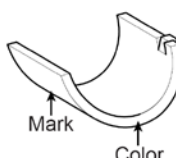
6. Remove the bed plate and bearings again and measure the widest part of the plastic gauges with a calibrated scale on which an arrow of marks has been printed.

Main bearing-to-journal Oil Clearance

Standard (valve)

0.024 ~ 0.042mm (0.0009 ~ 0.0017in)

NOTICE*Discrimination of crankshaft main bearing*

Discrimination		SIZE (Thickness of bearing)	Place of identification mark
Class	Mark		
E	YEL-LOW	1.987~1.990mm (0.0782~0.0783in)	 LCIF047A
D	GREEN	1.987~1.990mm (0.0781~0.0782in)	
C	-	1.981~1.984mm (0.0780~0.0781in)	
B	BLACK	1.978~1.981mm (0.0779~0.0780in)	
A	BLUE	1.975~1.978mm (0.0778~0.0779in)	

7. If the plastic gauge measure too wide or too narrow, remove the crankshaft, and remove the upper half of the bearing. Install a new, complete bearing with the same color code(s), and recheck the clearance. Do not file, shim, or scrape the bearings to adjust clearance.

8. If the plastic gauge shows the clearance is still incorrect, try the next larger or smaller bearing (the color listed above or below that one), and check again. If the proper clearance cannot be obtained by using the appropriate larger or smaller bearings, replace the crankshaft and start over.

Rod bearing clearance

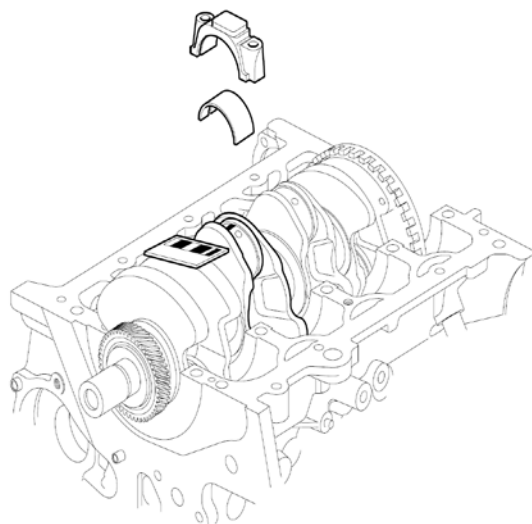
1. Remove the connecting rod cap and bearing half.
2. Clean the crankshaft rod journal bearing half with a clean shop towel.
3. Place plastic gauge across the rod journal.
4. Reinstall the bearing half and cap, and torque the bolt.

NOTICE*Do not rotate the crankshaft during inspection.*

5. Remove the rod cap and bearing half and measure the widest part of the plastic gauge.

Connecting Rod Bearing-to-Journal Oil


Clearance : 0.024 ~ 0.042mm (0.0009 ~ 0.0017in)



6. If the plastic gauge measure too wide or too narrow, remove the upper half of the bearing, install a new,

complete bearing with the same color code(s), and recheck the clearance. Do not file, shim, or scrape the bearings or the caps to adjust clearance.

NOTICE*Discrimination of connecting rod bearing*

Discrimination		Size (Thickness of bearing)	Place of Identification
Class	Mark		
E	YEL-LOW	1.484 ~ 1.487mm (0.0584~0.0585in)	 LCIF047A
D	GREEN	1.481 ~ 1.484mm (0.0584~0.0585in)	
C	WHITE	1.478 ~ 1.481mm (0.0582~0.0583in)	
B	BLACK	1.475 ~ 1.478mm (0.0581~0.0582in)	
A	BLUE	1.472 ~ 1.475mm (0.0580~0.0581in)	

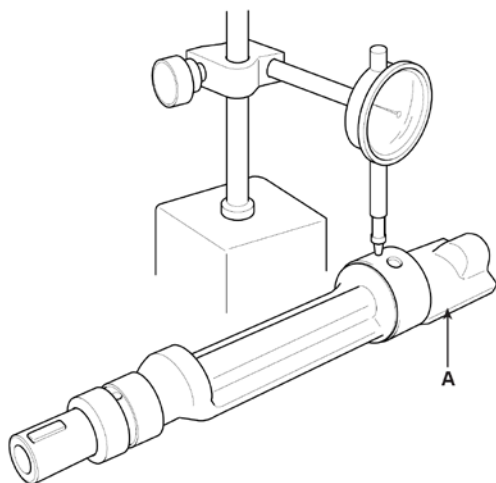
7. If the plastic gauge shows the clearance is still incorrect, try the next larger or smaller bearing (the color listed above or below that one), and check clearance again. If the proper clearance cannot be obtained by using the appropriate larger or smaller bearing, replace the crankshaft and start over.

Balancer shafts

1. Measure runout on the journals of each balancer shaft(A) to make sure the balancer shafts are not bent.

Balancer Shaft Total Indicated Runout

Standard (New): 0.025mm (0.00098in)



2. Measure the diameters of the journals on the balancer shafts(A).

Journal Diameter

Standard (New)

No. 1 journal :

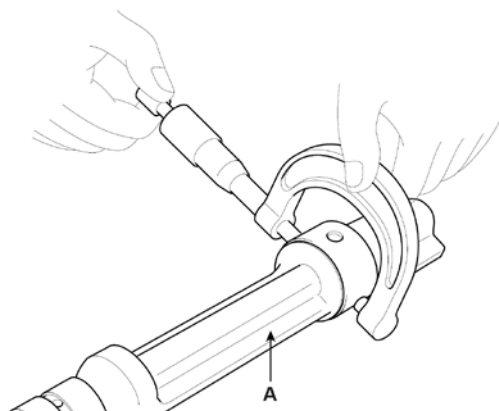
19.980 ~ 19.993mm (0.7866 ~ 0.7871in)

No. 2 journal :

27.99 ~ 28.01mm (1.1020 ~ 1.1028in)

No. 3 journal :

41.99 ~ 42.01mm (1.6531 ~ 1.6539in)



3. Measure the inner diameters of the bearings for the balancer shafts.

Bearing Inner Diameter

Standard (New)

No. 1 journal :

20.00 ~ 20.02mm (0.7874 ~ 0.7882in)

No. 2 journal :

28.06 ~ 28.08mm (1.1047 ~ 1.1055in)

No. 3 journal :

42.06 ~ 42.08 (1.6559 ~ 1.6567in)

4. Calculate the shaft-to-bearings oil clearances.

Bearing I.D - journal O.D = oil clearance

Shaft-to-Bearings Oil clearance

Standard (New)

No. 1 journal :

0.007 ~ 0.041mm (0.00028 ~ 0.00161in)

No. 2 journal :

0.050 ~ 0.090mm (0.00197 ~ 0.00354in)

No. 3 journal :

0.050 ~ 0.090mm (0.00197 ~ 0.00354in)

Crankshaft straightness

NOTICE

- Clean the crankshaft oil passages with pipe cleaners or a suitable brush.
- Check the keyway and threads.

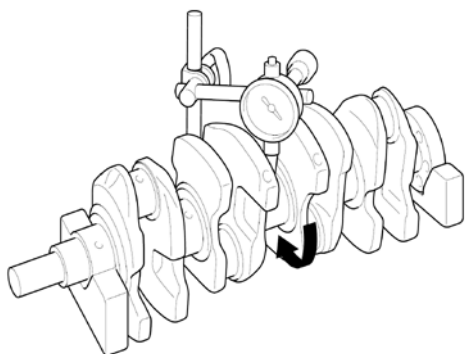
1. Support the crankshaft with V-blocks.

2. Measure runout on all main journals to make sure the crank is not bent. Rotate the crank shaft two complete revolutions. The difference between

measurements on each journal must not be more than the standard value.

Crankshaft Total Indicator Runout

Standard (New): 0.06mm (0.002in) max.

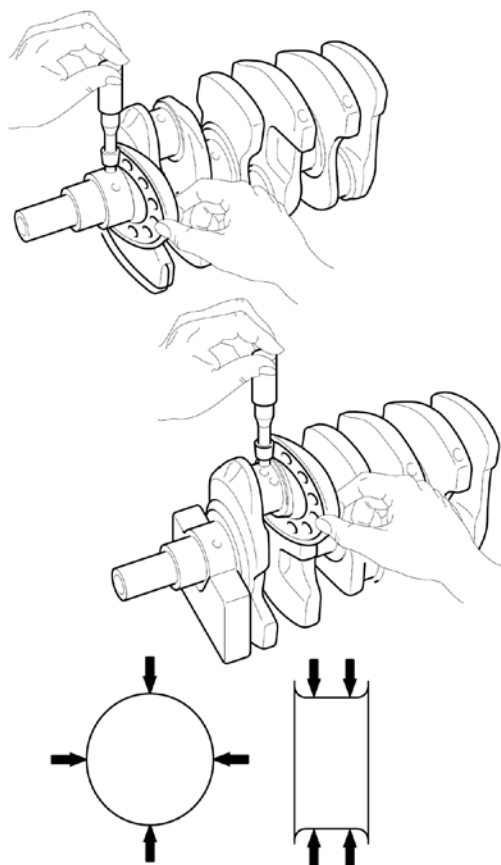


Out-of-Round and Taper

1. Measure out-of-round at the middle of each rod and main journal in two places. The difference between measurements on each journal must not be more than the service limit.

Journal Out-of-Round

Standard (New): 0.0035mm (0.0001in) max.



2. Measure taper at the edge of each rod and main journal. The difference between measurements on each Journal must not be more than the serve limit.

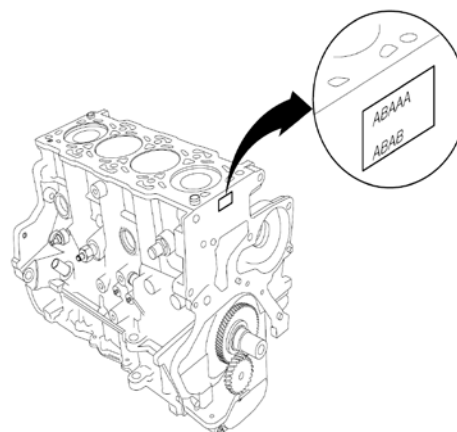
Journal Taper

Standard (New): 0.006mm (0.0002in) max

Block and piston

1. Check the piston for distortion or cracks.

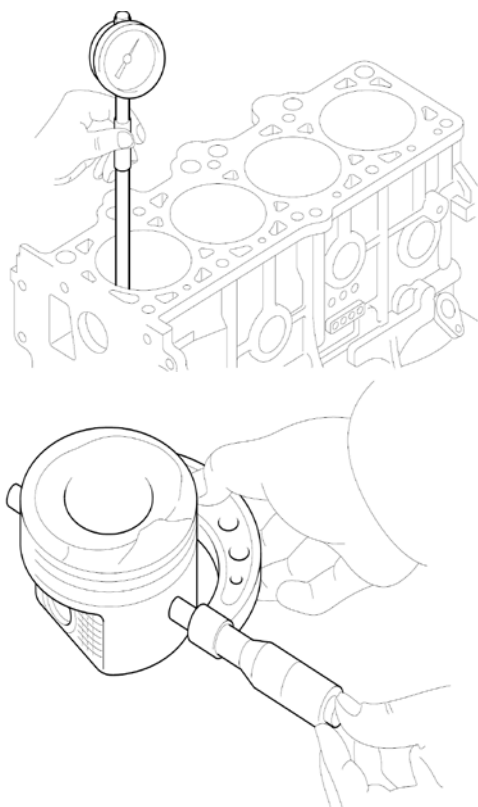
2. Measure the piston diameter at a point 10mm (0.4in) from the bottom of the skirt. There are three standard size pistons (A, B and C). The letter is stamped on the top of the piston. Letters are also stamped on the block as cylinder bore sizes.



Piston Diameter and Cylinder Bore

Standard value :

Grade	A	B	C
Piston outer Diameter	86.92 ~ 86.93mm (3.4220 ~ 3.4224in)	86.93 ~ 86.94mm (3.4224 ~ 3.4228in)	86.94 ~ 86.95mm (3.4228 ~ 3.4232in)
Cylinder Bore	87.00 ~ 87.01mm (3.4252 ~ 3.4256in)	87.01 ~ 87.02mm (3.4256 ~ 3.4260in)	87.02 ~ 87.03mm (3.4260 ~ 3.4263in)
Clearance	0.070~0.090mm (0.0028~0.0035in)		



3. Measure wear and taper in direction X and Y at three levels in each cylinder as shown. If measurements in any cylinder are beyond the cylinder bore standard value, replace the block.

Oversize

0.25 : 83.250 ~ 83.280mm (3.2776 ~ 3.2787in)

0.50 : 83.500 ~ 83.530mm (3.2874 ~ 3.2886in)

Bore Taper

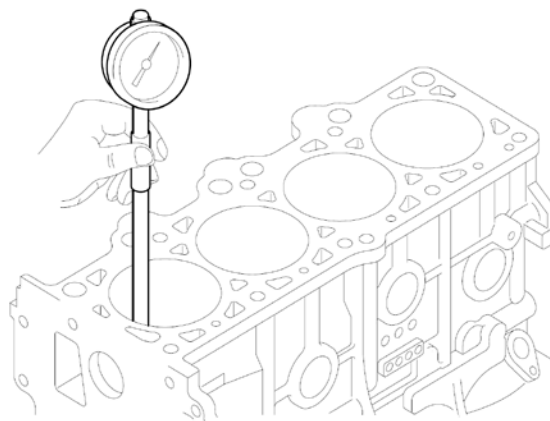
Limit : (Difference between first and third measurement)

0.01mm (0.0004in) MAX.

Level 1 : No. 1 piston ring position at TDC(Top Dead Center).

Level 2 : Center of cylinder.

Level 3: Bottom of cylinder.



4. Scored or scratched cylinder bores must be honed.

5. Check the top of the block for warpage. Measure along the edges and across the center.

Engine Block Warpage

Standard (New)

0.042mm (0.00165in) for width

0.096mm (0.00378in) for length

0.012mm (0.00047in)/50×50mm

Service Limit : 0.10mm (0.004in)

6. Calculate the difference between the cylinder bore diameter and the piston diameter. If the clearance is near or exceeds the standard value, inspect the piston and cylinder block for excessive wear.

Piston-to-Cylinder Clearance

Standard (New):

0.070 ~ 0.090mm (0.0028 ~ 0.0035in)

Oversize Piston Diameter :

0.25 : 83.170 ~ 83.200mm (3.2744 ~ 3.2756in)

0.50 : 83.420 ~ 83.450mm (3.2882 ~ 3.2881in)

Cylinder honing

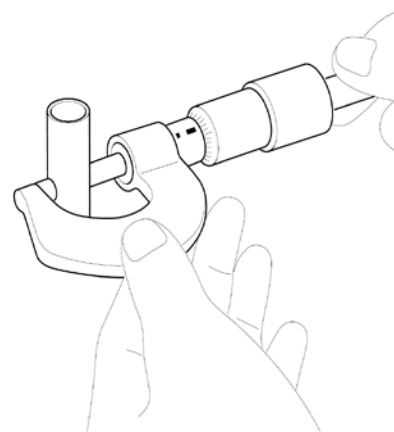
Only a scored or scratched cylinder bore must be honed.

1. Measure the cylinder bores. If the block is to be reused, hone the cylinders and remeasure the bores.

2. Hone the cylinder bores with honing oil and a fine stone. Do not use stones that are worn or broken.

3. When honing is complete, thoroughly clean the engine block of all metal particles. Wash the cylinder bores with hot soapy water, then dry and oil them immediately to prevent rusting. Never use solvent, it will redistribute the grit on the cylinder walls.

4. If scoring or scratches are still present in the cylinder bores after honing to the service limit, rebore the cylinder block. Some light vertical scoring and scratching is acceptable if it is not deep enough to catch your fingernail and does not run the full length of the bore



5. Zero the dial indicator to the piston pin diameter.

6. Check the difference between the piston pin diameter and piston pin hole diameter in the piston.

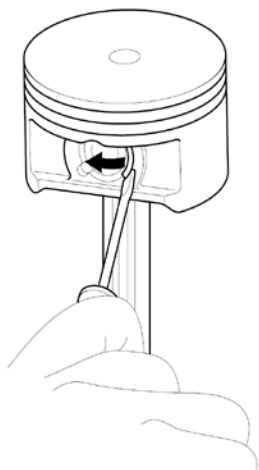
Piston, pin and connecting rod

1. Apply engine oil to the piston pin snap rings and turn them in the ring grooves.

NOTICE

Take care not to damage the ring grooves.

2. Remove both snap rings(A) carefully so they do not go flying or get lost. Wear eye protection.



3. Remove the piston pin and the connecting rod assembly.

4. Measure the diameter of the piston pin.

Piston Pin Diameter

Standard (New)

27.995 ~ 28.000mm (1.1022 ~ 1.1024in)

Piston Pin-to-Piston Clearance

Standard (New)

0.015 ~ 0.030mm (0.00059 ~ 0.00118in)

7. Measure the piston pin-to-connecting rod clearance.

Piston Pin-to-Connecting Rod Clearance

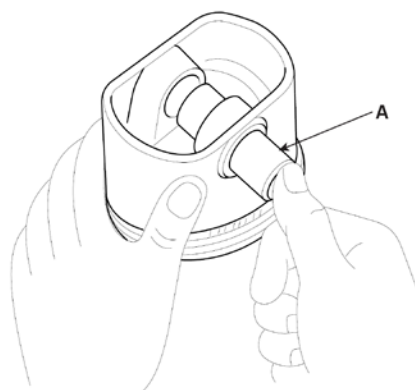
Standard (New)

0.022 ~ 0.039mm (0.00087 ~ 0.00154in)

8. Set a snap ring in one side of piston pin hole.

9. Before inserting the piston pin, apply a sufficient amount of the lubricant oil to the outer surface of the piston, the inner surface of the piston pin hole and the small end bore of the connecting rod.

10. Insert the piston pin(A). Assembly the piston and connecting rod with the embossed front marks on the same side.



NOTICE

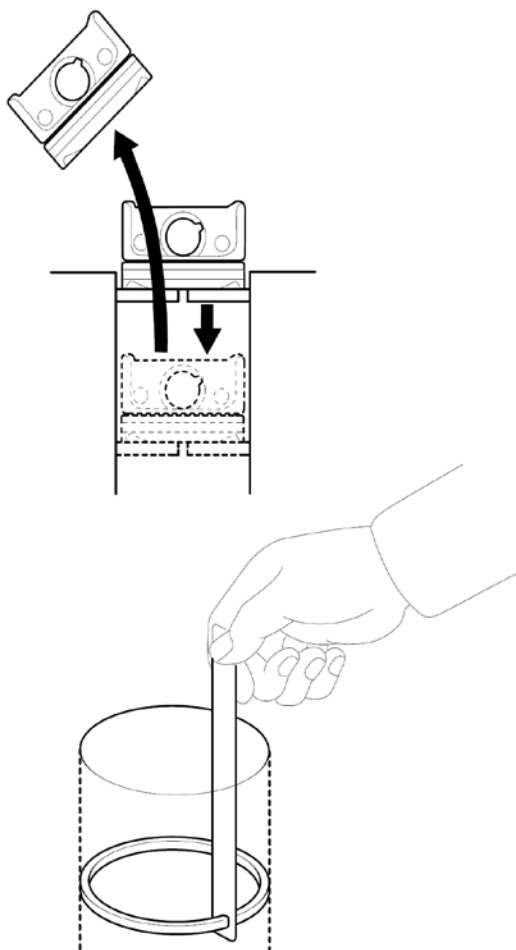
The front mark of the piston is embossed on the piston whereas some letters are located on a side surface of the connecting rod as the front mark.

CAUTION

- Be sure to keep the small end bore, piston pin hole and piston pin undamaged and unscratched when inserting the piston pin.
- Set the snap rings to be sure for contacting with the groove of the piston pin hole.

Piston ring

1. Using a piston, push a new ring into the cylinder bore.



2. Measure the piston ring end-gap(B) with a feeler gauge :

- If the gap is too small, check to see if you have the proper rings for your engine.
- If the gap is too large, recheck the cylinder bore diameter against the wear limits.

If the bore is over the service limit, the cylinder block must be re-bored.

Piston ring end-gap**Top ring**

Standard (New): 0.20 ~ 0.35mm (0.008 ~ 0.014in)

Second Ring

Standard (New): 0.40 ~ 0.50mm (0.016 ~ 0.024in)

Oil Ring

Standard (New): 0.20 ~ 0.40mm (0.008 ~ 0.016in)

3. Using a ring expander, remove the old piston rings.

4. Clearance all ring grooves thoroughly with a squared-off broken ring or ring groove cleaner with a blade to fit the piston grooves.

Top ring groove

1.915 ~ 1.945mm (0.07539 ~ 0.07657in)

2nd ring groove

2.060 ~ 2.080mm (0.08110 ~ 0.08189in)

Oil ring groove

3.020 ~ 3.040mm (0.11889 ~ 0.00968in)

File down a blade if necessary.

Do not use a wire brush to clean the ring grooves, or cut the ring grooves deeper with cleaning tools.

NOTICE

If the piston is to be separated from the connecting rod, do not install new rings yet.

5. Install the piston rings.

Piston Ring Dimensions**Top Ring (Standard)**

Width : 2.95 ~ 3.25mm (0.116 ~ 0.128in)

Thickness : 2mm (0.079in)

Second Ring (Standard)

Width: 3.60 ~ 3.90mm (0.142 ~ 0.154in)

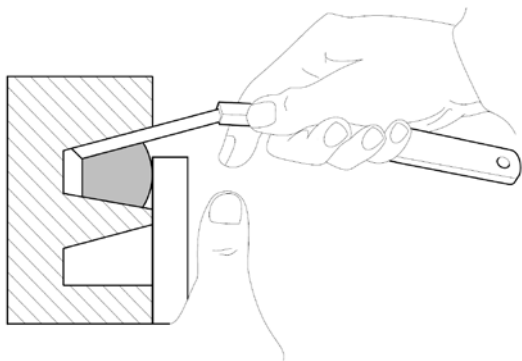
Thickness: 1.970 ~ 1.995mm (0.078 ~ 0.079in)

6. After installing a new set of rings, measure the ring-to groove clearances:

Top Ring Clearance

Standard (New)

0.083 ~ 0.137mm (0.00327 ~ 0.00529in)



Second Ring Clearance

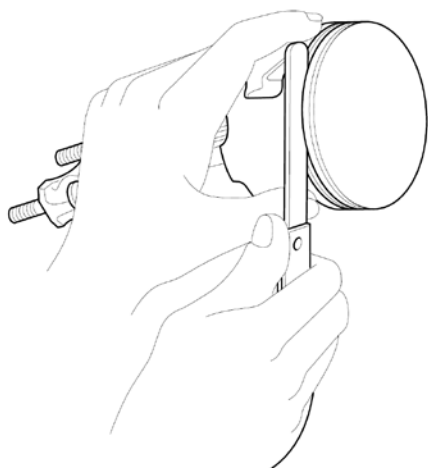
Standard (New)

0.065 ~ 0.110mm (0.00256 ~ 0.00433in)

Oil Ring Clearance

Standard (New)

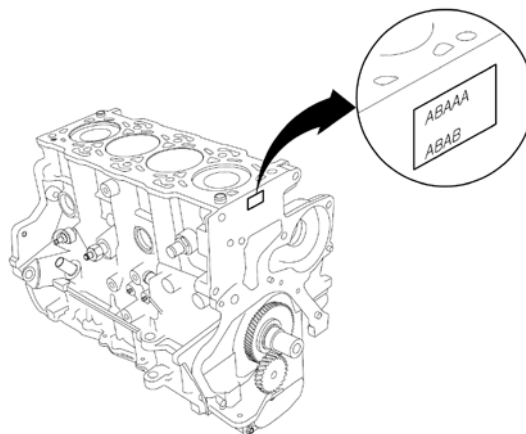
0.03 ~ 0.07mm (0.00118 ~ 0.00275in)



Replacement

Main bearing selection

1. Letters have been stamped on the end of the block as a code for the size of each of the 5 main journal bores. Write down the crank bore codes. If you can't read the codes because of accumulated dirt and dust, do not scrub them with a wire brush or scraper. Clean them only with solvent or detergent

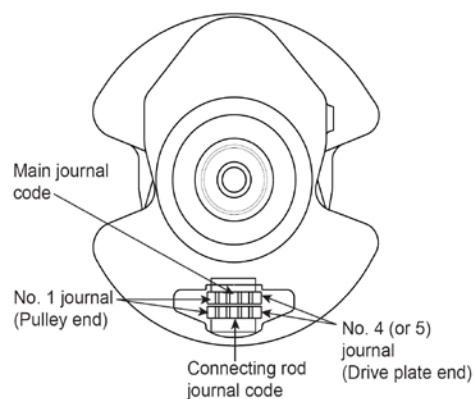


Discrimination of cylinder block

Discrimination		SIZE (Inside diameter of crank bore)
Class	Mark	
A	A	Ø64mm(2.5197in) (0 ~ +0.006mm) (0 ~ +0.0002in)
B	B	Ø64mm(2.5197in) (+0.006 ~ +0.012mm) (+0.0002~0.0005in)
C	C	Ø64mm(2.5197in) (+0.012 ~ +0.018mm) (+0.0005~0.0007in)

2. The main Journal Codes are stamped on the No.1 web.

Main Journal Code Locations



Discrimination of crank shaft

Discrimination		SIZE (Outside diameter of main journal)
Class	Mark	
I	A	Ø60mm(2.3622in) (+0.014 ~ +0.020mm) (+0.0006~+0.0008in)
II	B	Ø60mm(2.3622in) (+0.008 ~ +0.014mm) (+0.0003~0.0006in)
III	C	Ø60mm(2.3622in) (+0.002 ~ +0.008mm) (+0.0001~+0.0003in)

3. Use the crank bore codes and crank journal codes to select the appropriate replacement bearings from the following table.

NOTICE

- Color code is on the edge of the bearing. Refer to the table in the step 6 of the main bearing clearance inspection.
- When using bearing halves of different colors, it does not matter which color is used in the top or bottom.

Installing procedure of bearing

Shaft bore combination		Bearing mark	Oil clearance
Shaft mark	Bore mark		
I (A)	A (A)	A (BLUE)	0.024 ~ 0.042mm (0.0009 ~ 0.0017in)
	B (B)	B (BLACK)	
	C (C)	C (-)	
II (B)	A (A)	B (BLACK)	
	B (B)	C (-)	
	C (C)	D (GREEN)	
III (C)	A (A)	C (-)	
	B (B)	D (GREEN)	
	C (C)	E (YELLOW)	

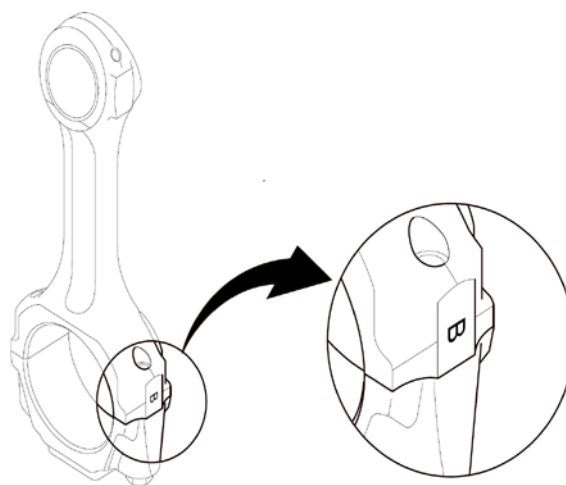
Rod bearing selection

1. Inspect each connecting rod for cracks and heat damage.

2. Each rod has to clearance range from 0 to 0.018mm (0.0007in), in 0.006mm (0.0002in) increments, depending on the size of its big end bore. It's then stamped with a letter (A, B or C) indicating the range.

You may find any combination of letters in any engine.

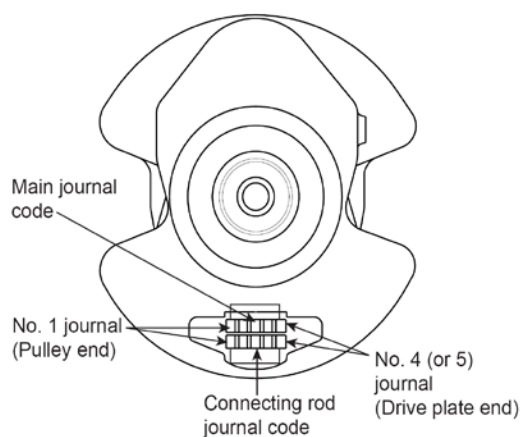
If you can't read the code because of an accumulation of oil and varnish, do not scrub them with a wire brush or scraper. Clean them only with solvent or detergent.

**NOTICE**

Discrimination connecting rod

Discrimination		SIZE (Inside diameter of connecting rod big end bore)
Class	Mark	
A	A	Ø 53mm(2.0866in) (0 ~ +0.006mm) (0~+0.0002in)
B	B	Ø 53mm(2.0866in) (+0.006 ~ +0.012mm) (+0.0002~0.0005in)
C	C	Ø 53mm(2.0866in) (+0.012 ~ +0.018mm) (0.0005~0.0007in)

3. The connecting Rod Journal Codes are stamped on the No. 1 web.



Discrimination of crank shaft pin

Discrimination		SIZE (Outside diameter of pin)
Class	Mark	
I	A	Ø50mm(1.9685in) (+0.020 ~ +0.026mm) (+0.0008~+0.0010in)
II	B	Ø50mm(1.9685in) (+0.014 ~ +0.020mm) (+0.0006~+0.0008in)
III	C	Ø50mm(1.9685in) (+0.008 ~ +0.014mm) (+0.0003~+0.0006in)

4. Use the big end bore codes and rod journal codes to select appropriate replacement bearings from the following table.

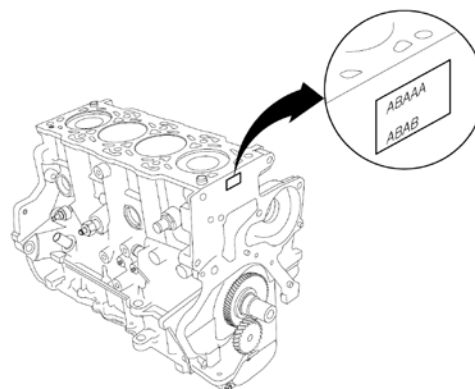
NOTICE

Color code is on the edge of the bearing.
Refer to the table in the step 5 of rod bearing clearance inspection.

Shaft bore combination		Bearing mark	Oil clearance
Sahft mark	Bore mark		
I	A (A)	A (BLUE)	0.024 ~ 0.042 mm (0.0009 ~ 0.0017in)
	B (B)	B (BLACK)	
	C (C)	C (WHITE)	
II	A (A)	B (BLACK)	
	B (B)	C (WHITE)	
	C (C)	D (GREEN)	
III	A (A)	C (WHITE)	
	B (B)	D (GREEN)	
	C (C)	E (YELLOW)	

Piston selection

1. Letters have been stamped on the end of the block as a code for the size of each 5 main journal bores. Write down the crank bore codes.



Discrimination		SIZE (Inside diameter of cylinder bore)
Class	Mark	
A	A	Φ87.00~87.01mm (3.4252~3.4256in)
B	B	Φ87.01~87.02mm (3.4256~3.4260in)
C	C	Φ87.02~87.03mm (3.4260~3.4263in)

2. Check the piston code for a size. The letter is stamped on the top of piston

Discrimination		SIZE (Outside diameter of piston)
Class	Mark	
A	A	Φ86.92~86.93mm (3.4220~3.4224in)
B	B	Φ86.93~86.94mm (3.4224~3.4228in)
C	C	Φ86.94~86.95mm (3.4228~3.4232in)

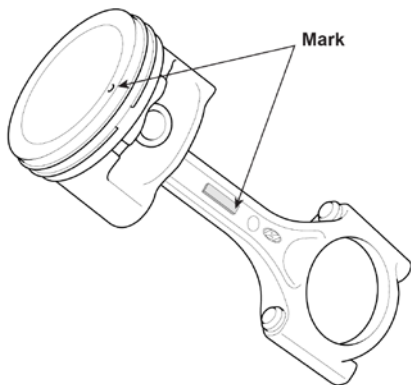
3. Select the piston which is same class with cylinder bore code.

Clearance	0.070~0.090mm (0.0028~0.0035in)
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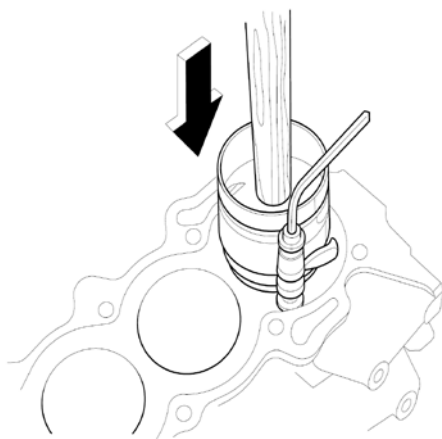
Reassembly

Piston

1. Remove the connecting rod caps then install the ring compressor and check that the bearing is securely in place.
2. Position the marks facing the timing belt side of the engine.



3. Position the piston in the cylinder and tap it in using the wooden handle of hammer. Maintain downward force on the ring compressor to prevent the rings from expanding before entering the cylinder bore.



4. Stop after the ring compressor pops free, and check the connecting rod-to-crank journal alignment before pushing the piston into place.
5. Check the connecting rod bearing clearance with Plastic gauge.
6. Apply engine oil to the bolt threads, then install the rod caps with bearings.

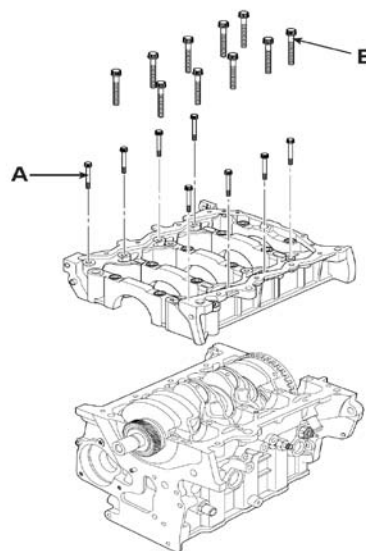
Crankshaft and balancer

1. Install the oil jets, tightening the hexagon socket head bolts with the torque 9 ~ 13Nm (0.9 ~ 1.3kgf.m, 6.5 ~ 9.4lb-ft)
2. Apply a coat of engine oil to the main bearings.
3. Install the bearing halves in the engine block.
4. Hold the crankshaft so rod journal No. 2 and rod journal No. 3 are straight up.
5. Lower the crankshaft into the block.
6. Install the bearing halves in the bed plate after applying a coat of engine oil.
7. Install the bed plate(C) to the cylinder block after applying the sealant (omni FIT FD2.0, DREIBOND 5105 or HYLOMAR 3000).

Tightening torque

15mm (B) 27.5 ~ 31.4N.m + (2.8 ~ 3.2kgf.m, 20.3 ~ 23.1lb-ft) + 120°

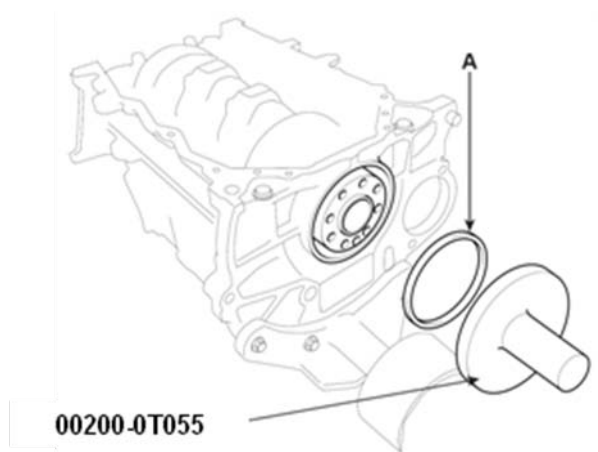
12mm (A) 33.3 ~ 37.3N.m (3.4 ~ 3.8kgf.m, 24.6 ~ 27.5lb-ft)



8. Rotate the crankshaft clockwise to be seated properly.
9. Check the main bearing clearance with plastic gauge.
10. Install the piston and connecting rod assemblies.

- a. Apply coat of engine oil to the connecting rod bearings.
- b. Install the bearing halves in the connecting rods.
- c. Insert the assemblies into the cylinder bores.
- d. Install the connecting rod caps and bolts finger tight
- e. Rotate the crankshaft clock wise, seat the journals into connecting rod No.2 and connecting rod No.3. Install the connecting rod caps and bolts finger tight. Install caps so the bearing recess is on the same side as the recess in the rod.
- f. Check the connecting rod bearing clearance with plastic gage.
- g. Apply engine oil to the bolt threads, then install the rod caps within bearings and torque the bolts to $25\text{N.m} + 90^\circ$ ($2.5\text{kgf.m} + 90^\circ$, $18.44\text{lb-ft} + 90^\circ$).

11. Using the SST (00200-0T055), install the crankshaft oil seal(A) squarely.



12. Clean and dry the mating surfaces. Apply a light coat of oil to the crankshaft and to the lip of the seal.

Installation

1. Clean and dry the oil pump mating surface.
2. Install the oil pump
 - a. Install a new crankshaft oil seal in the oil pump.
 - b. Apply liquid gasket evenly to the block mating surface of the oil pump.

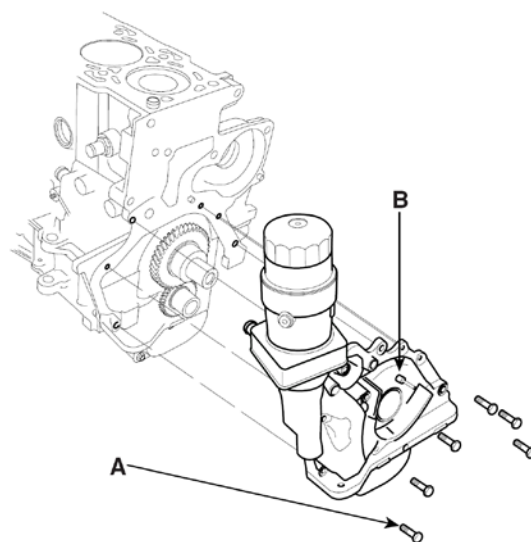
Standard liquid gaskets (or sealants)

LOCTITE5900 or TB1217H

- Apply liquid gasket in a wide bead : $2.5 \pm 0.5\text{m}$
 - Apply the liquid gasket without stopping.
 - Assemble the oil pump within 5 minutes after applying.
- c. Grease the lips of the oil seals.
 - d. Align the oil pump gear with the crankshaft drive gear and install the oil pump(B).

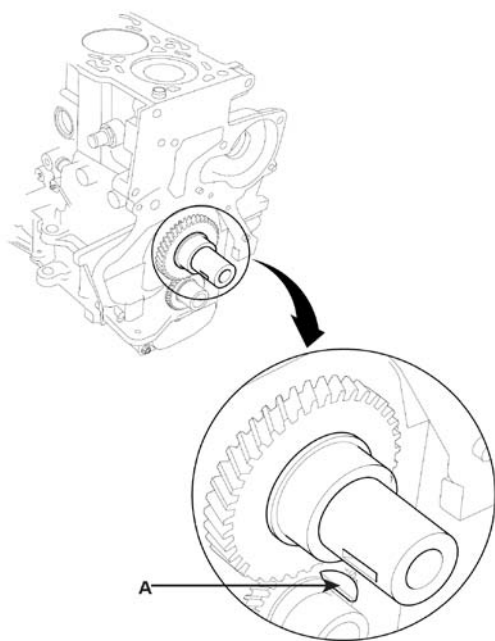
Tightening torque(A)

$19.6 \sim 26.5\text{N.m}$ ($2.0 \sim 2.7\text{kgf.m}$, $14.5 \sim 19.51\text{lb-ft}$)



e. Clean the excess grease off the crankshaft and check the seals for distortion.

3. Install the crankshaft key(A) on the crankshaft assembly



4. Insert the crankshaft sprocket(B) then tighten the crankshaft bolt(A).

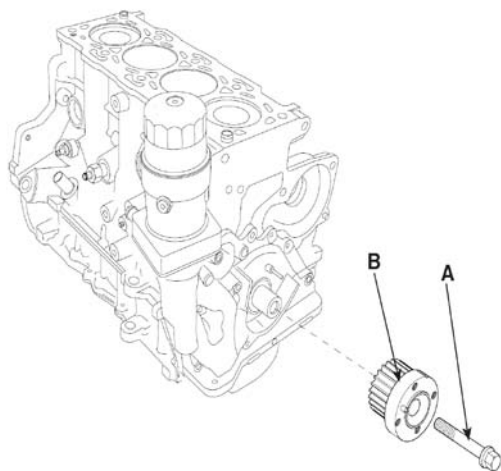
Tightening torque

196.1 ~ 205.9N.m

(20.0 ~ 21.0kgf.m, 144.7 ~ 151.9lb-ft)

NOTICE

Align the timing mark on the sprocket.



5. Install oil screen.

NOTICE

The bolt B should be tightened after the installation of the bolt A.

6. Clean and dry the bed plate and the oil pan mating surfaces.

7. Apply liquid gasket evenly to the bed plate mating surface of the oil pan. Install the oil pan.

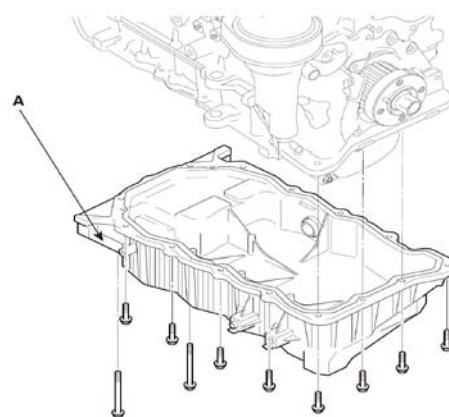
NOTICE

- Standard liquid gasket: *LOCTITE 5900 or TB1217H*
- Assemble the oil pan in 5minutes after applying the liquid gasket.
- Apply liquid gasket in a 3mm wide bead without stopping.
- The clearance between the liquid gasket end and the flange inner end at T-joint should be 2~3mm(2places)

8. Tighten the bolt in two or three steps. In the final step, tighten all bolts.

Tightening torque

9.8 ~ 11.8N.m (1.0 ~ 1.2kgf.m, 7.2 ~ 8.7lb-ft)



NOTICE

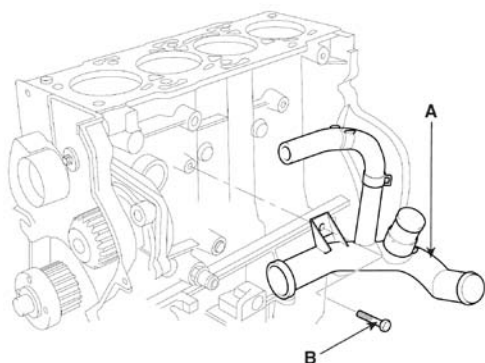
After installing the oil pump assembly and the oil pan, remove the oil cooler and fill the 50cc engine oil.

9. Install water pump (A) with new gasket (B).

10. Install the water inlet pipe assembly(A), tightening the bolt(B).

Tightening torque

19.6 ~ 26.5N.m (2.0 ~ 2.5kgf.m, 14.5 ~ 19.5lb-ft)



11. Install the heater and oil cooler return pipe (A) assembly.

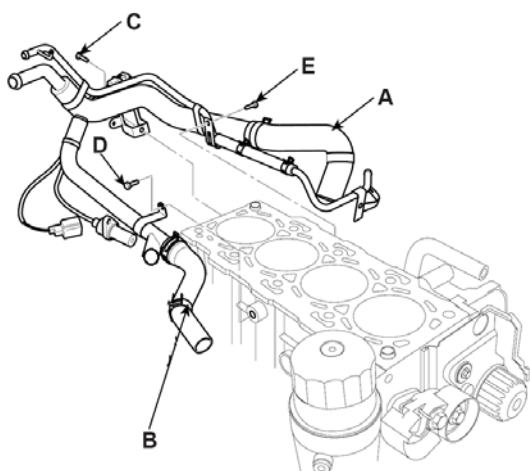
Tightening torque

Rear side bolt and left side bolt(C, D)

19.6 ~ 26.5N.m (2.0 ~ 2.5kgf.m, 14.5 ~ 19.5lb-ft)

Right side bolt(E)

7.8 ~ 9.8N.m (0.8 ~ 1.0kgf.m, 5.8 ~ 7.2lb-ft)

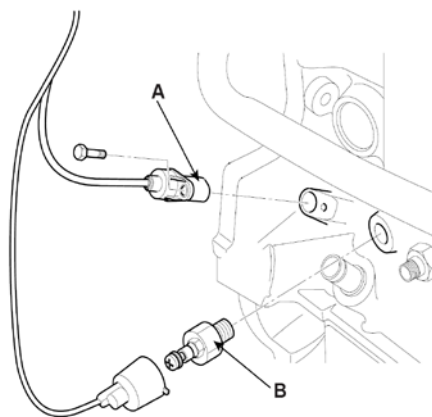


12. Install the Crankshaft Position Sensor (CKP)(A) and the oil pressure switch (B).

Tightening torque

(A): 3.9 ~ 5.9N.m (0.4 ~ 0.6kgf.m, 2.9 ~ 4.3lb-ft)

(B): 14.7 ~ 21.6N.m (1.5 ~ 2.2kgf.m, 10.8 ~ 15.9lb-ft)



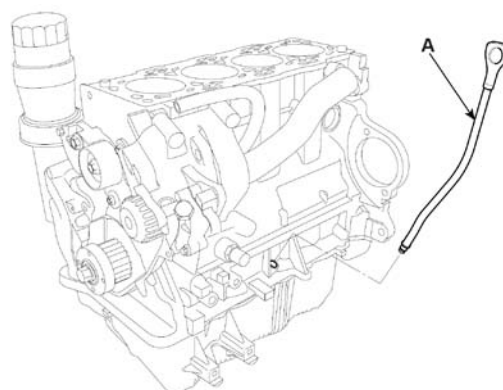
13. Install the cylinder head assembly. (Refer to Cylinder head assembly in this group)

14. Install the intake/exhaust manifold assemblies. (Refer to Intake and exhaust system in this group)

15. Install the oil level gauge (A).

Tightening torque

9.8 ~ 11.8N.m (1.0 ~ 1.2kgf.m, 7.2 ~ 8.7lb-ft)



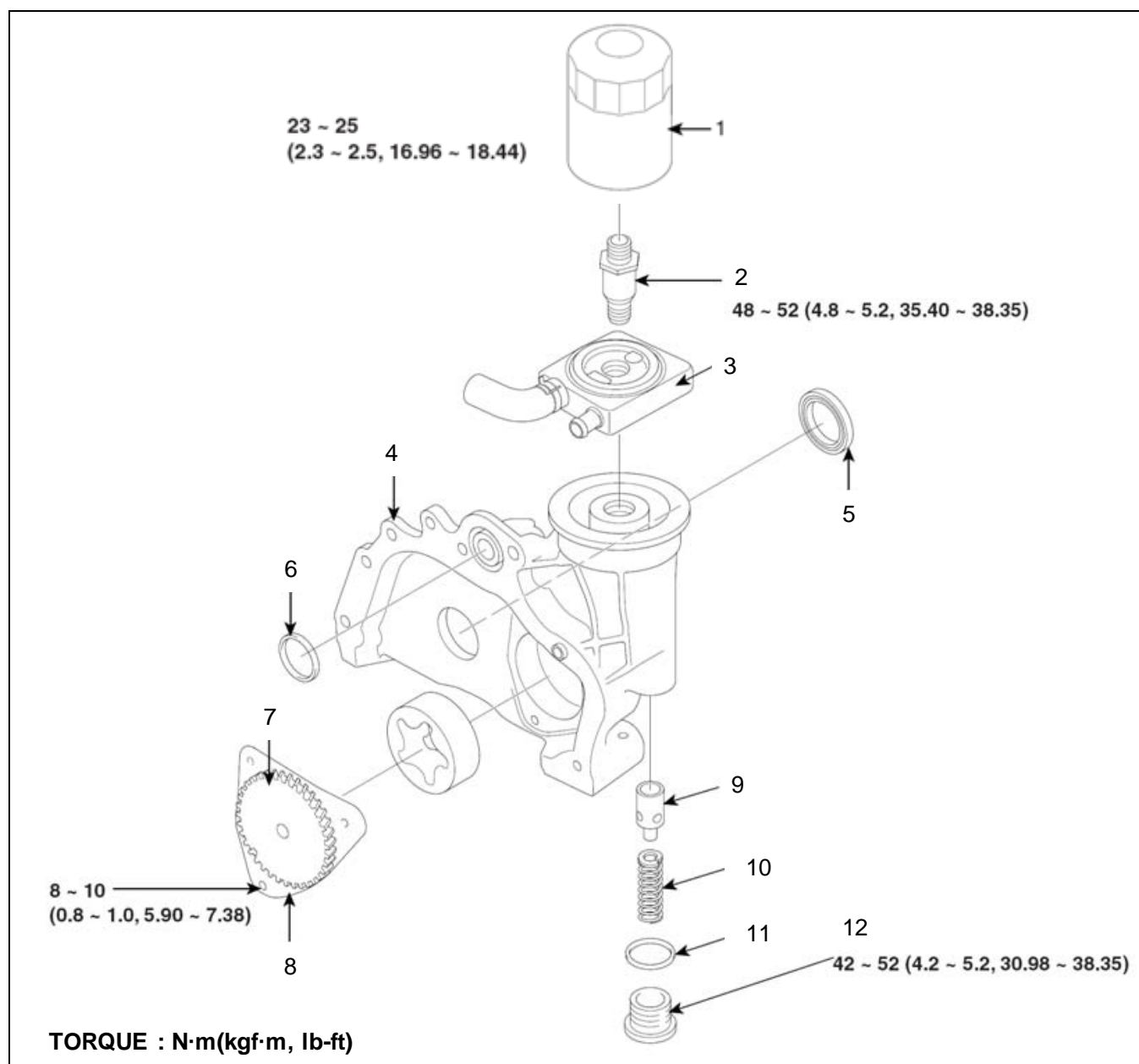
NOTICE

Apply engine oil to O-ring before assembly.

16. Install the timing belt. (Refer to Timing system in this group)

Lubrication system

Components



1. Oil filter assembly

2. Oil filter fitting

3. Oil cooler

4. Oil pump housing

5. Oil seal

6. O-ring

7. Oil pump drive gear

8. Oil pump cover

9. Relief plunger

10. Relief spring

11. Relief cap washer

12. Relief cap

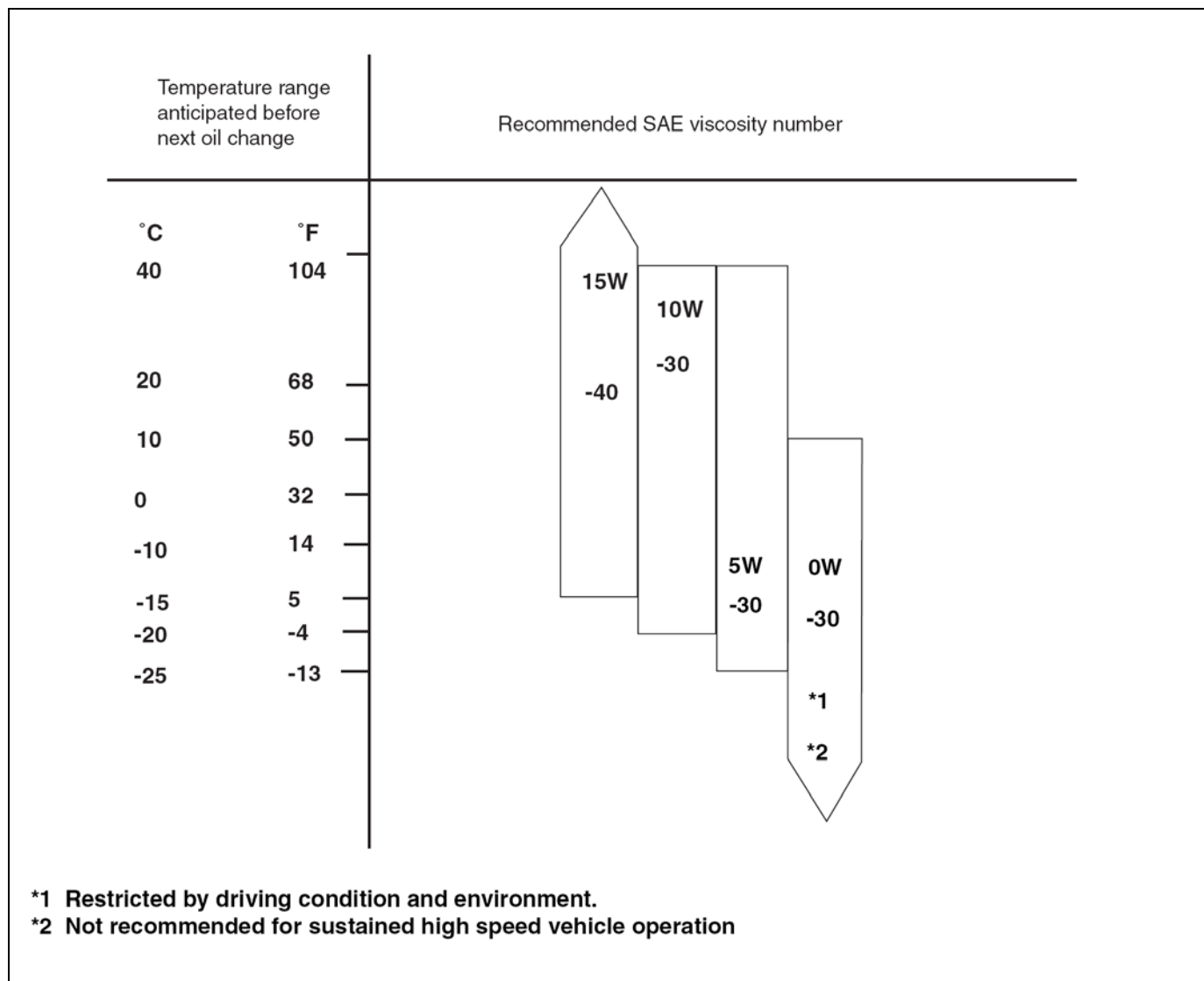
Inspection

Selection OF ENGINE OIL

Recommended ACEA classification: C3 (CPF equipped vehicle)

Recommended ACEA classification: B4 or API CH4 above (Non CPF vehicle)

Recommended SAE VISCOSITY GRAD



For best performance and maximum protection of all types of operation, selection only those lubricants which:

- 1) Satisfy the requirement of the ACEA or API classification.
- 2) Have the proper SAE grade number for expected ambient temperature range.

Lubricants which do not have both SAE grade number and an API or ACEA service classification on the container should not be used.

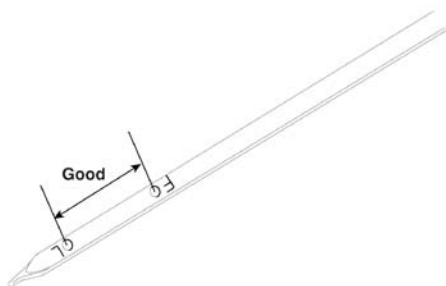
Engine oil

1. Turn the engine off.
2. The oil level should be between the 'L' and 'F' marks on the dipstick, then.

If low, check for leakage and add oil up to the "F" mark.

NOTICE

When refill the engine oil, use the same type engine oil with current engine oil.

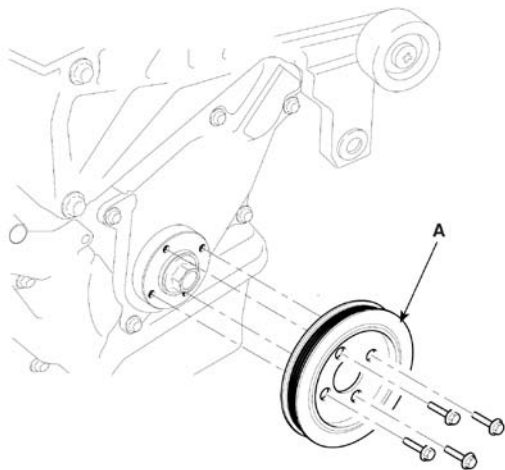


3. Check the oil for deterioration, entry of coolant or fuel, and engine oil viscosity.

Removal

Oil pump

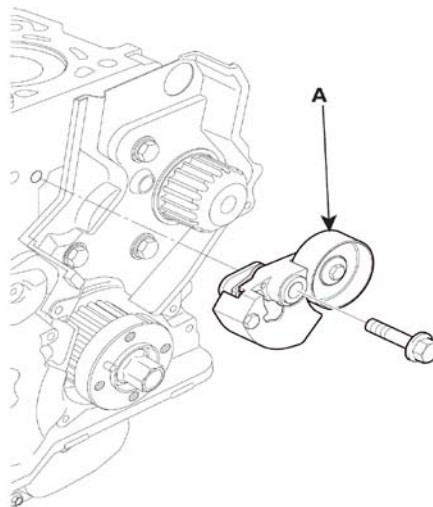
1. Drain the engine oil.
2. Remove the crankshaft pulley (A).



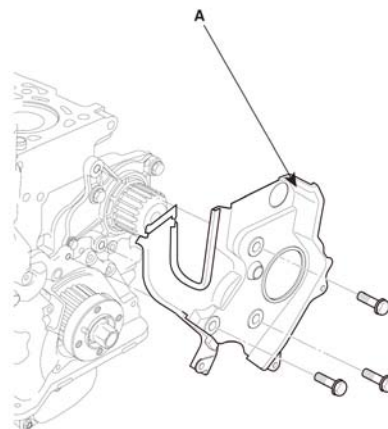
3. Remove the timing belt.

(Refer to Timing system in this group)

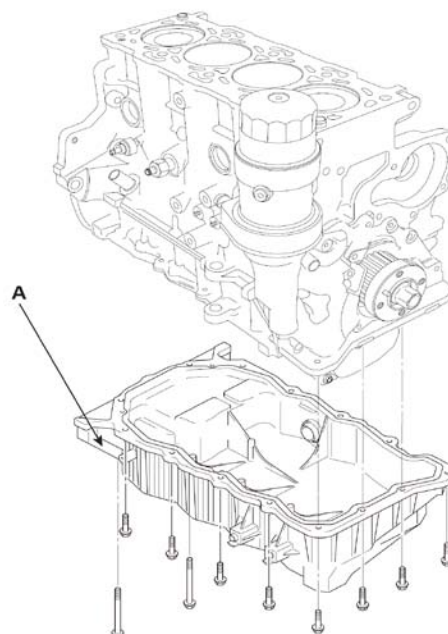
4. Remove the timing belt auto tensioner (A).



5. Remove the timing rear cover (A).



6. Separate oil pan (A).



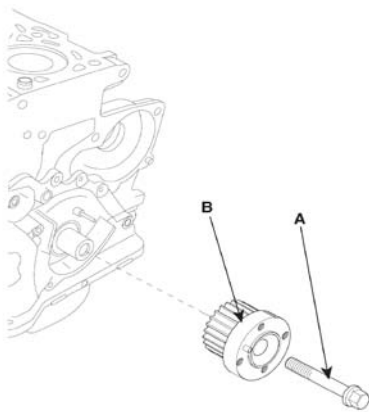
● **CAUTION**

- Insert the SST between the oil pan and the ladder frame by tapping it with a plastic hammer in the direction of ① arrow.
- After tapping the SST with a plastic hammer along the direction of ② arrow around more than 2/3 edge of the oil pan, remove it from the ladder frame.
- Do not turn over the SST abruptly without tapping.

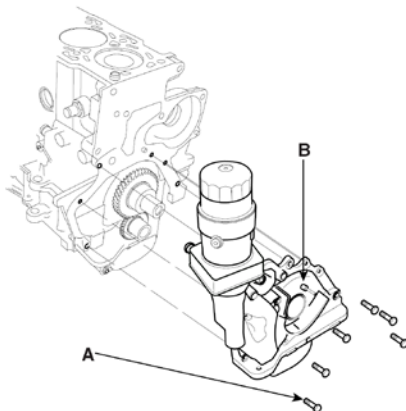
It is result in damage of the SST.

7. Remove the oil screen.

8. Remove the crankshaft sprocket (B) with bolt (A).



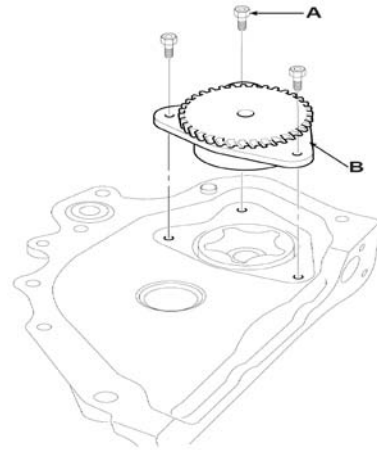
9. Remove the mounting bolts (A) and the oil pump assembly (B).



Disassembly

Oil pump

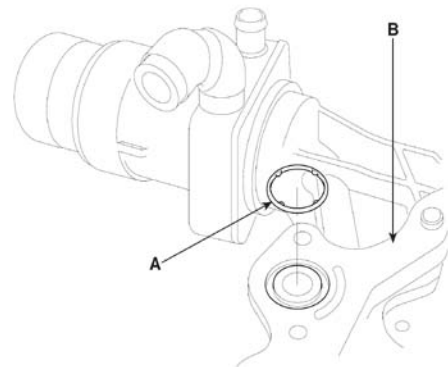
1. Remove the three hexagon socket head bolts (A) from the oil pump covers (B).



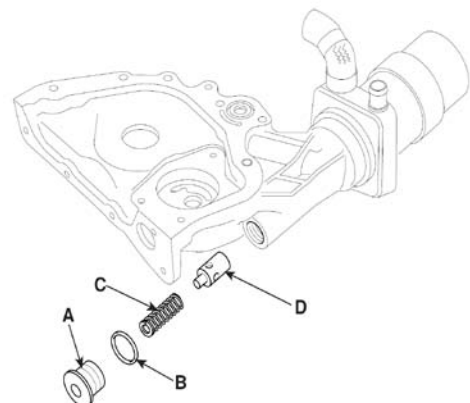
2. Remove the out rotor from the oil pump housing.

3. Remove the old oil seals from the oil pump housing.

4. Remove the O ring (A) from the oil pump housing.

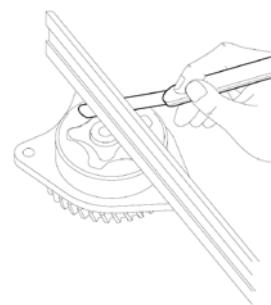


5. Remove the relief cap (A), relief cap washer (B), relief spring (C) and relief plunger (D).



6. Remove the oil filter. Refer to the engine oil filter replacement.

7. Remove the oil cooler and hose assembly after separating the oil filter fitting.



Inspection

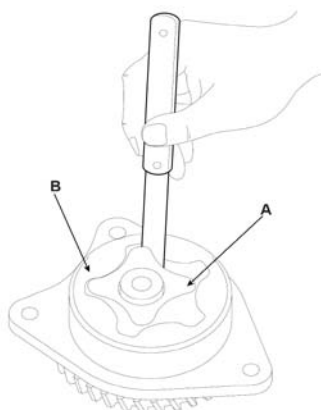
Oil pump

1. Check the inner-to-outer rotor tip clearance between the inner rotor (A) and outer rotor (B). If the inner-to-outer rotor clearance exceeds the service limit, replace the inner and outer rotors.

Inner Rotor-to-Outer Rotor tip Clearance

Standard (New)

0.12~0.20mm (0.00472~0.00787in)



2. Check the housing-to-rotor axial clearance between the rotor and oil pump cover housing. If the housing-to-rotor axial clearance exceeds the service limit, replace the set of inner and outer rotors and/or the pump housing.

Housing-to-Rotor Axial Clearance

Standard (New)

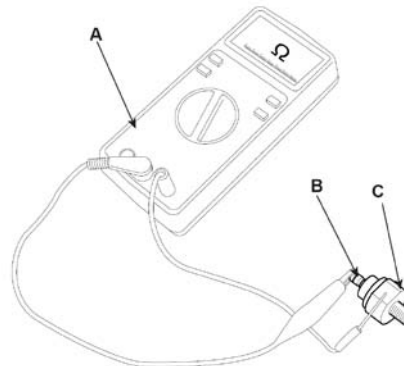
0.020 ~ 0.070mm (0.00079 ~ 0.00276in)

3. Inspect both rotors and the oil pump cover housing for scoring or other damage. Replace parts if necessary.

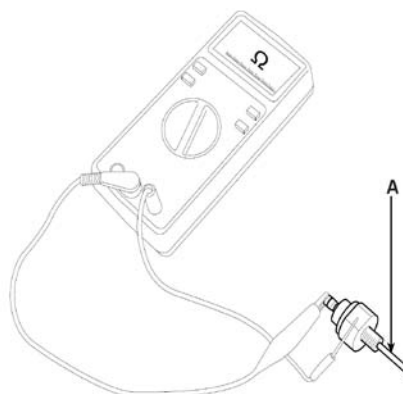
Oil pressure switch

1. Remove the oil pressure switch from the engine block.

2. Connect a tester (ohm range) between the terminal and the body of the switch to check for continuity. The switch is normal if there is continuity. If there are no continuity, replace the switch.



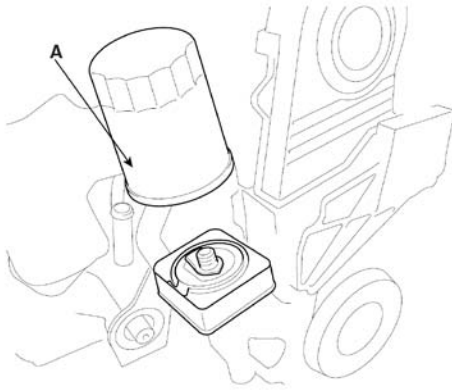
3. Insert a thin rod in the oil hole of the switch and push it in lightly. The switch is normal if no continuity is detected (infinite resistance on the tester). If there is continuity, replace the switch.



Replacement

Engine oil filter

1. Remove the oil filter (A) with the SST (00200-0T057, the oil filter wrench).



2. Inspect the threads and the packing on the apply a light coat of new oil filter. Wipe off the seat.

3. Install the new oil filter by hand.

4. After the packing seats, tighten the oil filter clockwise with the SST (00200-0T057).

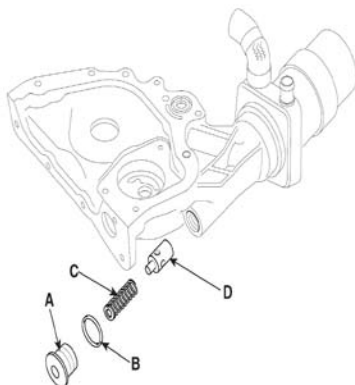
Reassembly

Oil pump

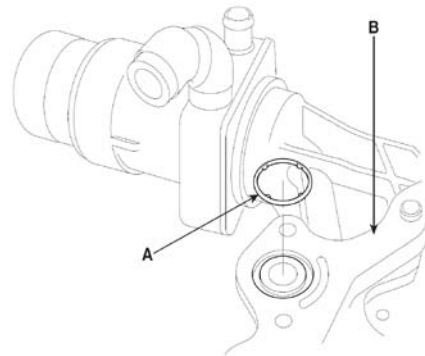
1. Insert the relief plunger (D), the relief spring (C) and the relief cap washer (B). Then torque the relief cap (A).

Tightening torque

41.2 ~ 51.0N.m (4.2 ~ 5.2kgf.m, 30.4 ~ 37.6lb-ft)

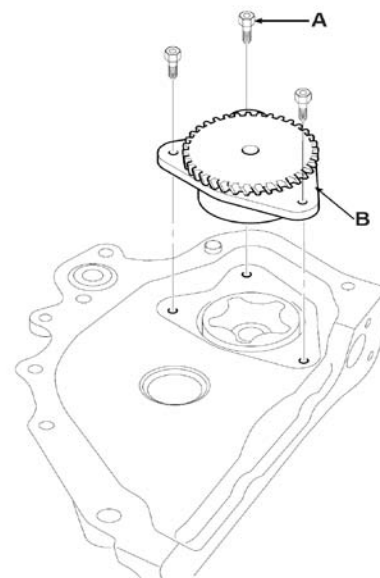


2. Install the new O ring (A) to the oil pump housing (B) after applying engine oil.



3. Assemble the inner/outer rotors with engine oil the drive gear and the oil pump cover.

4. Install the oil pump cover (B) assembly to the oil pump housing with the three hexagon socket head bolts (A).



5. The oil seal which was disassembled in Disassembly step is recommended to be installed after the installation of the crankshaft.

Installation

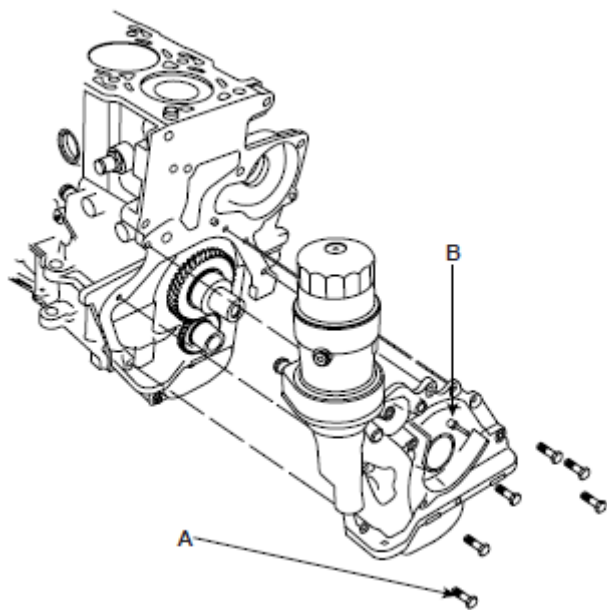
1. Install the oil pump assembly and the oil pan on the cylinder block.

Tightening torque

19.6 ~ 26.5N.m (2.0 ~ 2.7kgf.m, 14.5 ~ 19.5lb-ft)

NOTICE

Standard liquid gasket: LOCTITE 5900 or TB1217H



2. Install the oil screen.

3. Install the oil pan.

Tightening torque

9.8 ~ 11.8N.m (1.0 ~ 1.2kgf.m, 7.2 ~ 8.7lb-ft)

NOTICE

Standard liquid gasket: LOCTITE 5900 or TB1217H
Assemble the oil pan in 5 minutes after applying the liquid gasket. Apply liquid gasket in a 3mm wide bead without stopping. The clearance between the liquid gasket end and the flange inner end at T-joint should be 2 ~ 3mm. (2places)

4. Fill the engine oil in the room below the oil cooler (50cc).

5. Tightening the oil filter fitting, install the oil cooler and hose assembly.

NOTICE

Before assembling the oil cooler apply engine oil on the O-ring.

Tightening torque

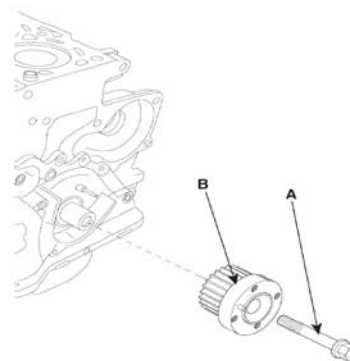
47.1 ~ 51.0N.m (4.8 ~ 5.2kgf.m, 34.7 ~ 37.6lb-ft)

6. Install the oil filter after applying engine oil on The O-ring.

7. Install the crankshaft sprocket (B) with bolt (A).

Tightening torque

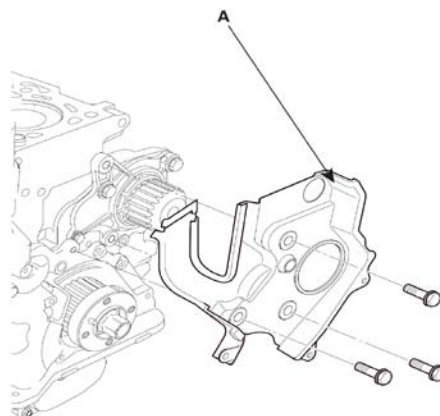
196.1 ~ 205.9N.m (20.0 ~ 21.0kgf.m, 144.7 ~ 151.9lb-ft)



8. Install the timing belt rear cover (A).

Tightening torque

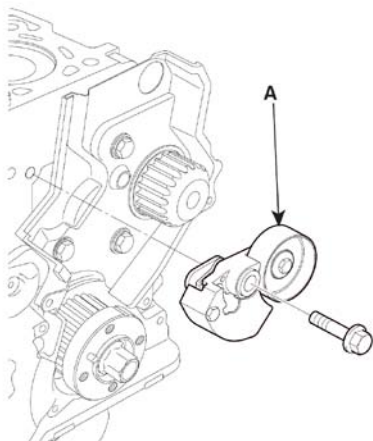
7.8 ~ 11.8N.m (0.8 ~ 1.2kgf.m, 5.8 ~ 8.7lb-ft)



9. Install the auto tensioner (A).

Tightening torque

49.0 ~ 53.9N.m (5.0 ~ 5.5kgf.m, 36.2 ~ 39.8lb-ft)

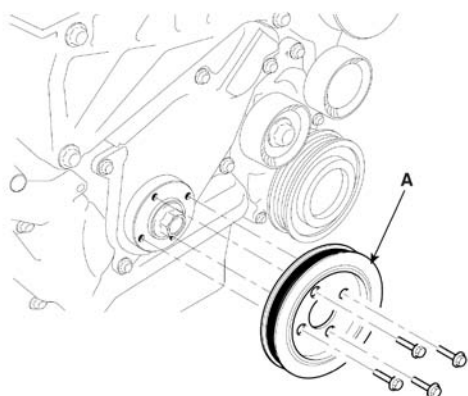


10. Install timing belt. (Refer to Timing system in this group)

11. Install the crankshaft pulley (A).

Tightening torque

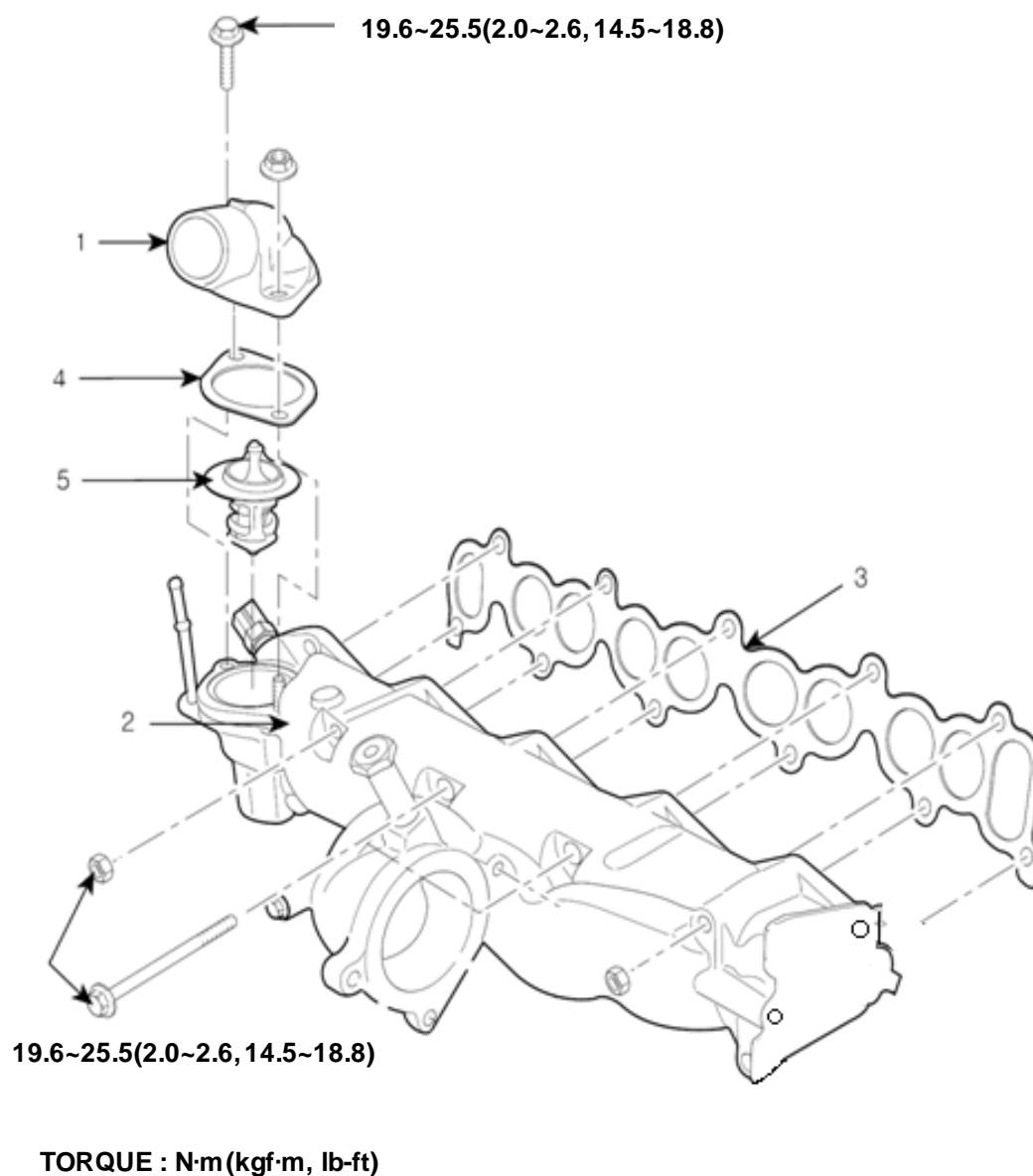
29.4 ~ 33.3N.m (3.0 ~ 3.4kgf.m, 21.7 ~ 24.6lb-ft)



Intake and exhaust system

Intake manifold

Components



1. Thermostat housing

2. Intake manifold

3. Gasket – Intake manifold

4. Gasket - Thermostat

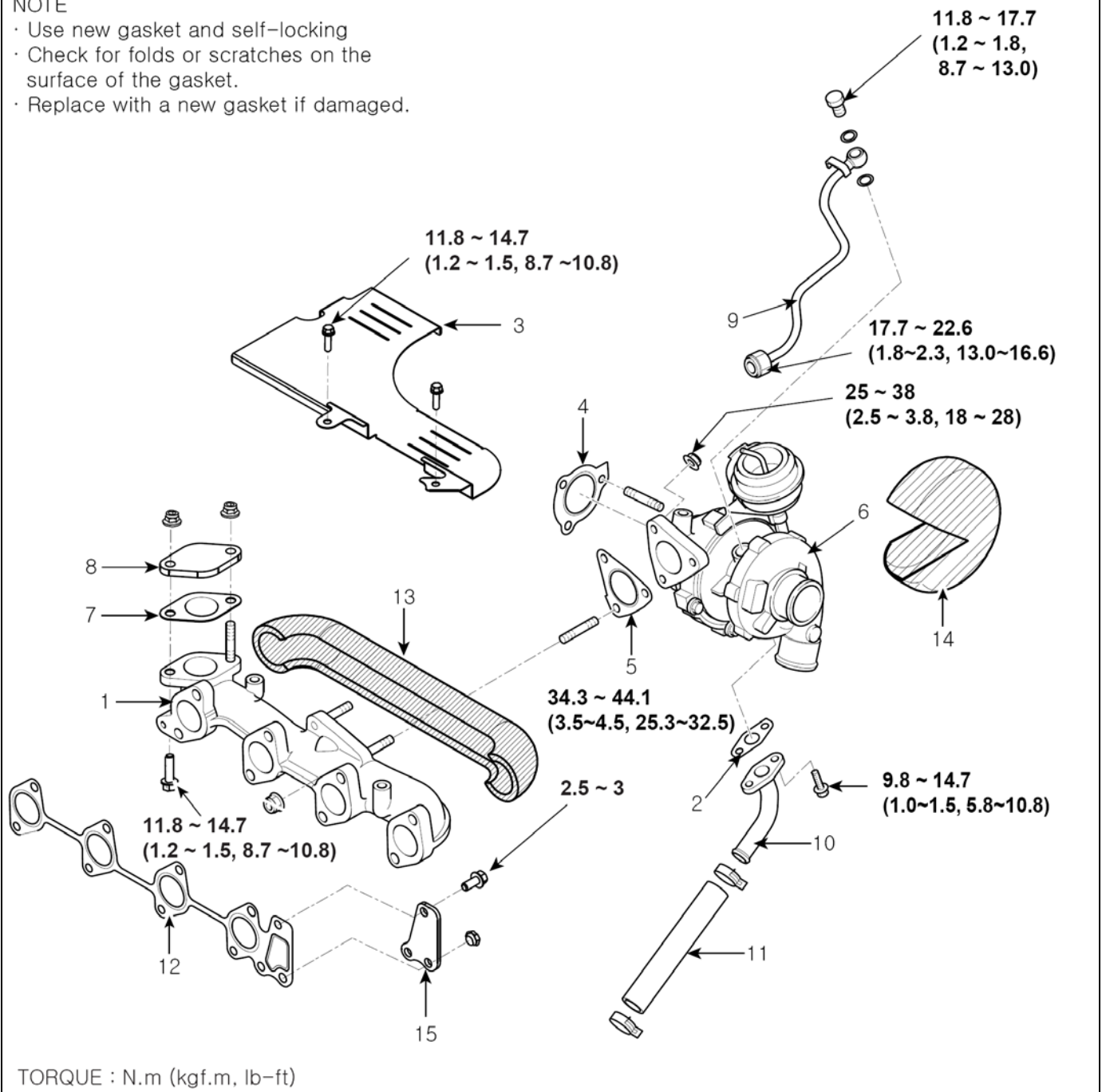
5. Thermostat

Exhaust manifold

Components

NOTE

- Use new gasket and self-locking
- Check for folds or scratches on the surface of the gasket.
- Replace with a new gasket if damaged.



1. Exhaust manifold

2. Turbo charger oil drain gasket

3. Heat cover

4. Turbo charger exhaust gasket

5. Turbo charger intake gasket

6. Turbo charger[C.P.F vehicle]

7. Gasket-EGR

8. Ex. mani closer plate 1

9. Oil feed pipe

10. Oil drain pipe

11. Oil drain hose

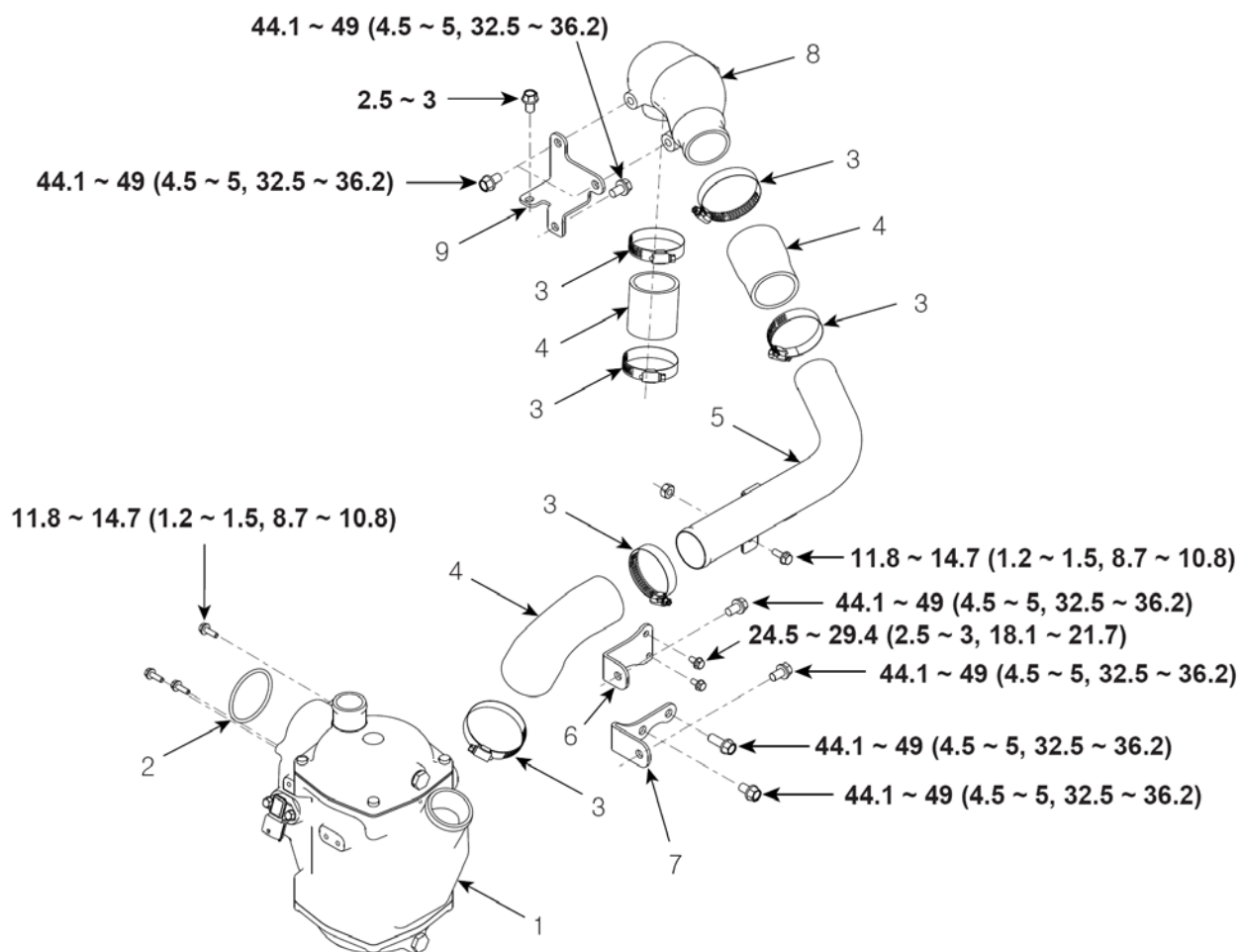
12. Exhaust manifold gasket

13. Heat protector-Ex. mani

14. Heat protector-T/C

15. Ex, manifold closer plate 2

Intercooler Components



TORQUE : N.m (kgf.m, lb-ft)

- 1. Intercooler Assembly
- 2. O-ring
- 3. Clamp

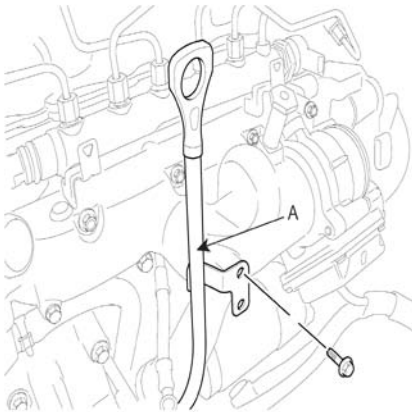
- 4. Hose
- 5. Pipe
- 6. Upper BRKT-Intercooler

- 7. Lower BRKT-Intercooler
- 8. Intake chamber
- 9. BRKT-intake chamber

Removal

Intake manifold

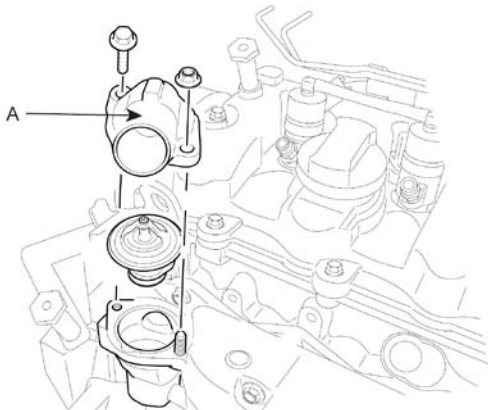
1. Remove the alternator.
2. Remove the intercooler hose
3. Disconnect the booster pressure sensor
4. Disconnect the engine wire harness connectors from intake manifold side.
5. Remove oil level gauge.



6. Remove the thermostat housing (A).

Tightening torque:

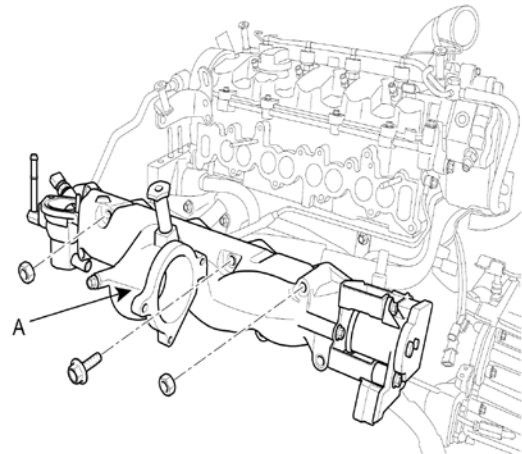
20 ~ 25N.m (2.0 ~ 2.5kgf.m, 15 ~ 18lb-ft)



7. Remove the intake manifold (A).

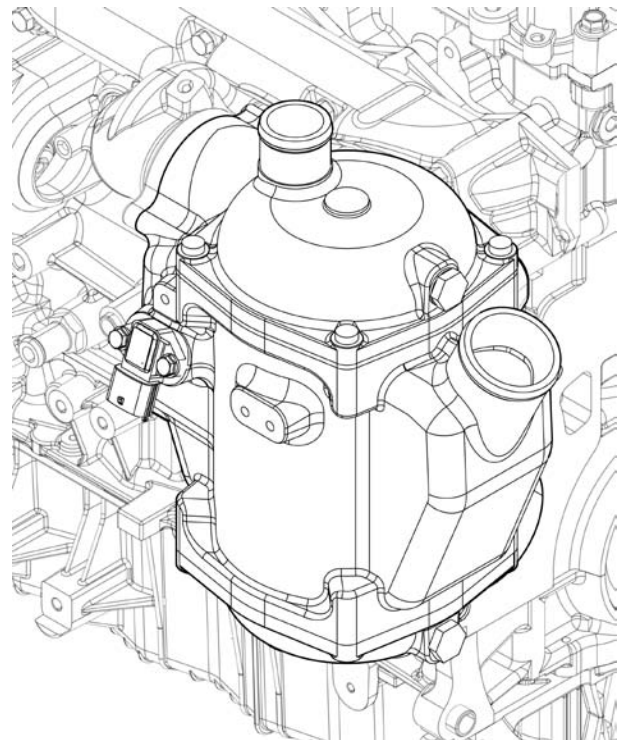
Tightening torque:

14.7 ~ 21.6N.m (1.5 ~ 2.2kgf.m, 10.8 ~ 15.9lb-ft)



8. Installation is in the reverse order of removal.

Intercooler

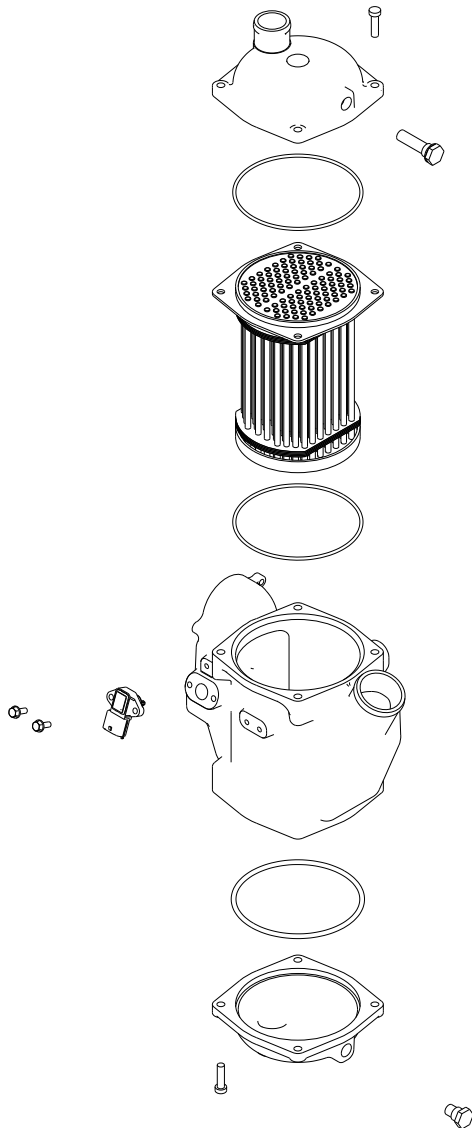


1. Open the drain plug and drain seawater inside the intercooler.
2. Remove all clamps on intercooler and hoses.

Tightening torque:

11.8 ~ 14.7N.m (1.2 ~ 1.5kgf.m, 8.7 ~ 10.8lb-ft)

3. Unscrew three bolts fixing intercooler.



4. Use L-wrench and remove end cap on both sides.
5. Remove intercooler out of housing using soft hammer.
6. Check the condition of O-ring on both end cap.
7. Check to see any sea water intake into intercooler.
8. Check the condition of intercooler fin and tube.
9. Check anode condition.

● **CAUTION**

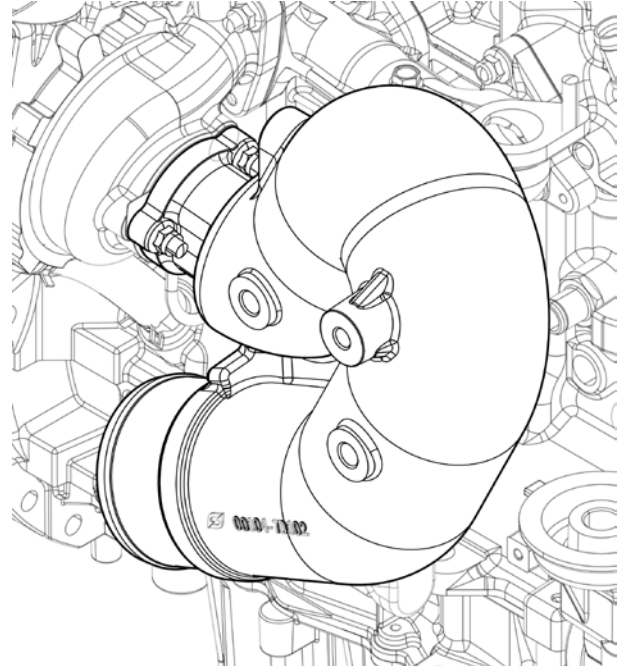
Take CAUTION avoid cooler fin damage.

10. Clean housing and intercooler and heat exchanger into housing.
11. Install new O-ring.

12. Check the direction of end cap on both sides for assembly.

13. Install new anode.

Exhaust elbow



1. Stop the engine completely and remove exhaust elbow.

Tightening torque:

M8: 26.5 ~ 29.4N.m (2.7 ~ 3.0kgf.m, 19.5 ~ 21.7lb-ft)

2. It is essential that elbow has completely cooled off.

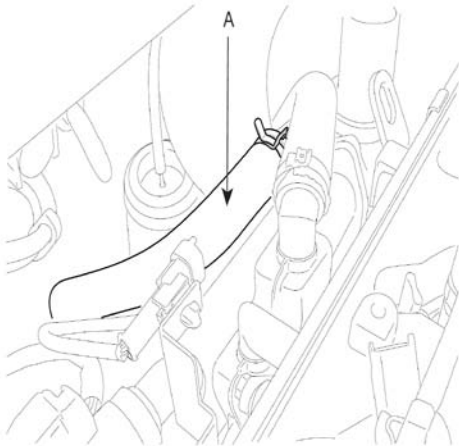
● **CAUTION**

Contacts with elbow after engine operation may cause serious injury when elbow has not cooled off.

3. Remove nuts connected to turbo.
4. Remove brackets connected to exhaust elbow.
5. Remove bellows.
6. Check studs and nuts are proper for reassembly.

Exhaust manifold

1. Remove the intercooler hose
2. Remove the air intake hose clamp
3. Disconnect the engine wire harness



4. Remove the turbo charger air intake hose and VGT actuator hose.

5. Remove the cooler assy.

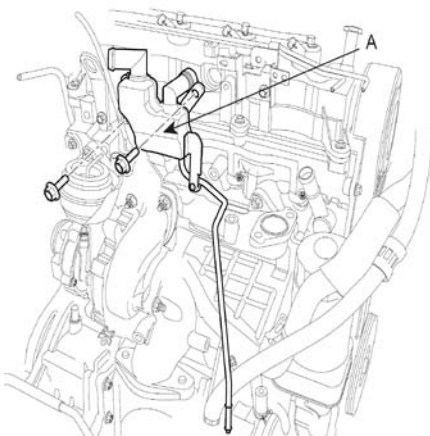
Tightening torque:

19.6 ~ 26.5N.m (2.0 ~ 2.7kgf.m, 14.5 ~ 19.5lb-ft)

6. Remove the oil separator.

Tightening torque:

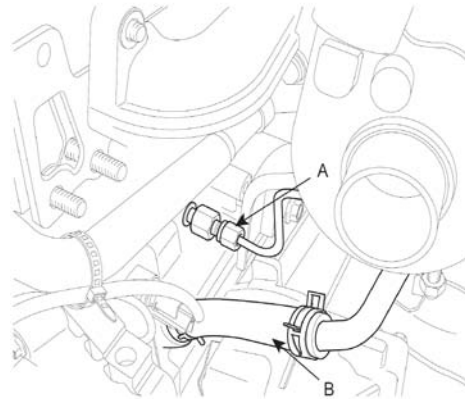
7.8 ~ 11.8N.m (0.8 ~ 1.2kgf.m, 5.8 ~ 8.7lb-ft)



7. Remove the turbo charger oil supply pipe and oil return hose

Tightening torque:

17.7 ~ 22.65N.m (1.8~2.37kgf.m, 13.0~16.6lb-ft)



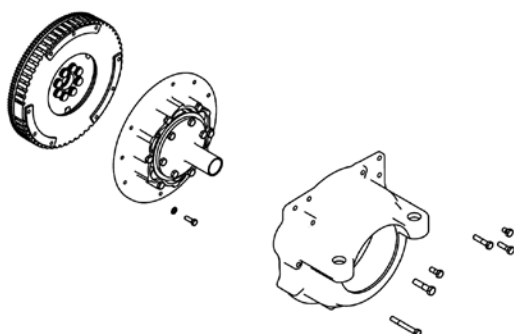
Install the exhaust manifold in the reverse order of removal

Coupling System

NOTICE

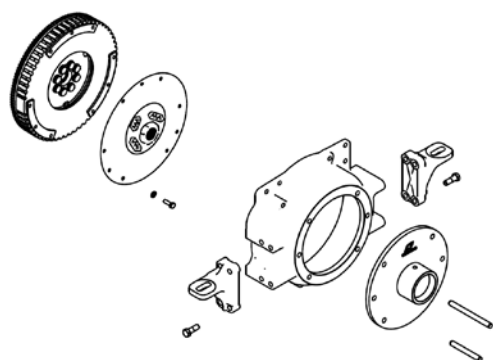
Use locking compound LOCTITE 243 on threads.

Stern Drive



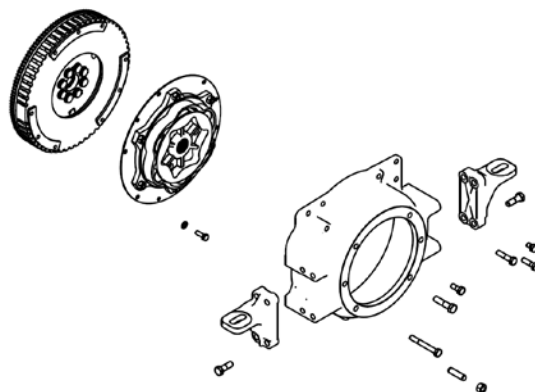
1. Loosen 13 bolts
2. Loosen 6 bolts, Remove coupling

Water-Jet



1. Loosen 13 bolts
2. Loosen 6 bolts, Remove coupling

Shaft Drive



1. Loosen 13 bolts
2. Loosen 6 bolts, Remove coupling

Tightening Torque:

M8: 24.5 ~ 29.4Nm (2.5 ~ 3.0kgf.m, 18.1 ~ 21.7lb-ft)

M10: 44.1 ~ 49.0Nm (4.5 ~ 5.0kgf.m, 32.5 ~ 36.2lb-ft)

M12: 63.7 ~ 68.6Nm (6.5 ~ 7kgf.m, 47.0 ~ 50.6lb-ft)

Engine Electrical System

General

Charging System

Starting System

Preheating System

General Information

specifications

Charging system

Item		Specifications
Alternator	Rated voltage	12V, 120A
	Speed	1,000 ~ 12,000 rpm
	Voltage regulator	I.C regulator built-in type
	Regulator setting voltage	14.4 ± 0.3V (AT 20°C full charged battery)
	Temperature compensation	-10 ± 3mV/°C
Battery	Type	CMF 80 AH
	Cold cranking amperage at -18°C (0°F)	630A
	Reserve capacity	130min
	Specific gravity at 20°C (77°F)	1.280 ± 0.01

Starting system

Item			Specifications
Starter	Type		Reduction drive (with planetary gear)
	Rated voltage		12V, 2.0KW
	No. of pinion teeth		9
	No-load characteristics	Voltage	11.5V
		Amperage	120A, MAX
		Speed	4,000rpm, MIN
	Commutator diameter	Standard	35 mm (1.378 in)
		Limit	
	Undercut depth	Standard	0.7 mm (0.028 in)
		Limit	

Preheating system

Item		Specifications
Glow plug	Rated voltage	DC 11V
	Current	16A ± 1.5A after 4 seconds loading at rated voltage
Glow plug relay	Rated voltage	DC 12V
	Operating voltage range	DC 9V ~ DC 16V
	Operating temperature range	-40°C ~ 120°C
	Rated load current	DC 12V, 70A

Troubleshooting

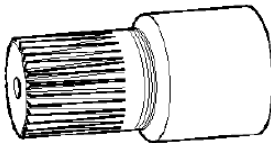
Charging system

Symptom	Suspect Area	Remedy
Charging warning indicator does not light with ignition switch "ON" and engine off	Fuse blown Light burned out Wiring connection loose Electronic voltage regulator	Check fuses Replace light Tighten loose connections Replace voltage regulator
Charging warning indicator does not go out with engine running (Battery requires frequent recharging)	Drive belt loose or worn Battery cables loose, corroded or worn Fuse blown Fusible link blown Electronic voltage regulator or generator Wiring	Adjust tension or replace drive belt Repair or replace cables Check fuses Replace fusible link Test generator Repair wiring
Engine hesitates/poor acceleration Overcharge	Drive belt loose or worn Wiring connection loose or open circuit Fusible link blown Poor grounding Electronic voltage regulator or generator Worn battery Electronic voltage regulator Voltage sensing wire	Adjust tension or replace drive belt Tighten loose connection or repair wiring Replace fusible link Repair Test generator, if faulty, repair or replace Replace battery Replace voltage regulator Repair wire

Starting system

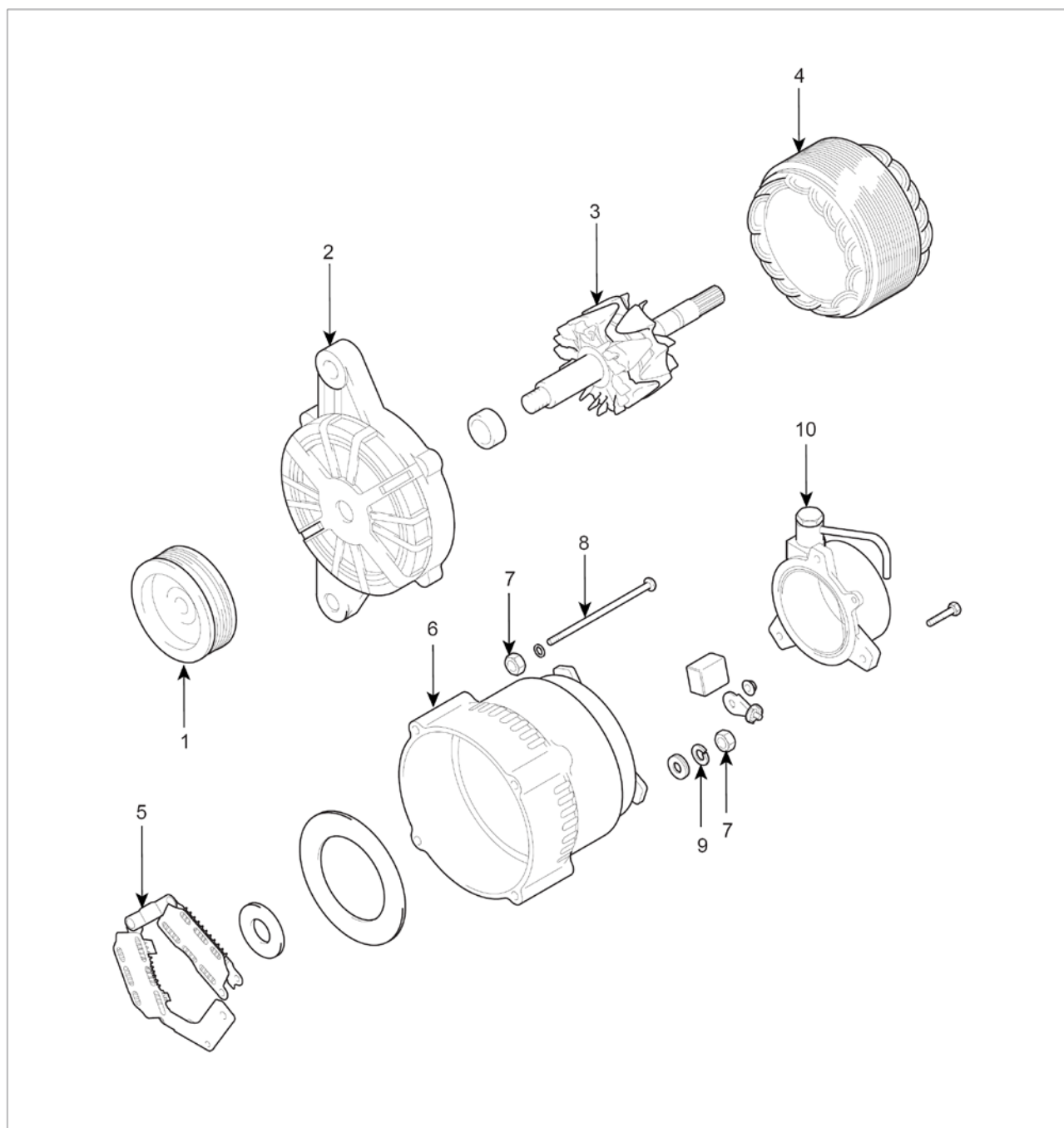
Symptom	Suspect Area	Remedy
Engine will not crank	Battery charge low Battery cables loose, corroded or worn out Transaxle range switch (Vehicle with automatic transaxle only) Fusible link blown Starter motor faulty Ignition switch faulty	Charge or replace battery Repair or replace cables Adjust or replace switch Replace fusible link Repair starter motor Inspect
Engine cranks slowly	Battery charge low Battery cables loose, corroded or worn out Starter motor	Charge or replace battery Repair or replace cables Repair starter motor
Starter keeps running	Starter motor Ignition switch	Repair starter motor Inspect
Starter spins but engine will not crank	Short in wiring Pinion gear teeth broken or starter motor Ring gear teeth broken	Repair wiring Repair starter motor Replace flywheel ring gear or torque converter

Special Service Tools

Tool (Number and name)	Illustration	Use
Alternator pulley remover wrench (00200 - 0T017)	 EBDD700A	Removal and installation of alternator pulley

Charging System

Alternator

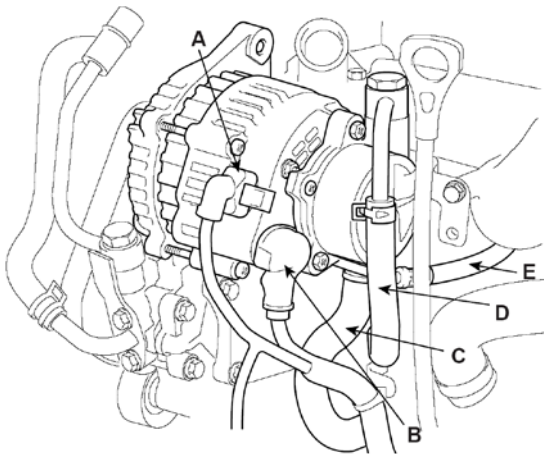


- 1. Pulley
- 2. Front frame assembly
- 3. Rotor
- 4. Stator
- 5. Brush & Regulator assembly

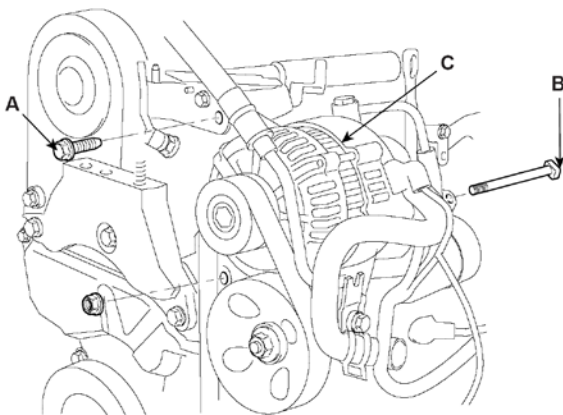
- 6. Rear frame assembly
- 7. Nuts
- 8. Through bolts
- 9. Washer
- 10. Pump assembly

Replacement

1. Disconnect the battery negative terminal first then the positive terminal.
2. Remove the drive belt
3. Disconnect the alternator connector(A) and "B" terminal cable(B) from the alternator. disconnect the vacuum pump oil drain hose(D), vacuum pump oil feed hose(D) and vacuum hose(E).



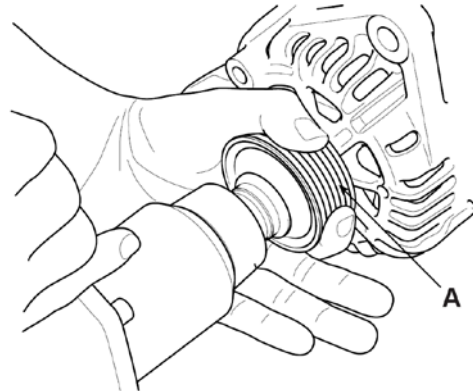
4. Remove the alternator bolt(A), bolt(B) and through bolt(C), then remove the alternator. 3.0 ~ 4.2 kgf.m



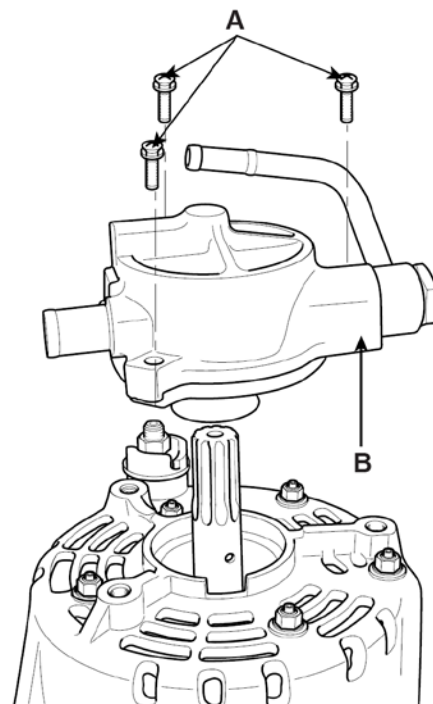
5. Installation is in the reverse order of removal

Disassembly

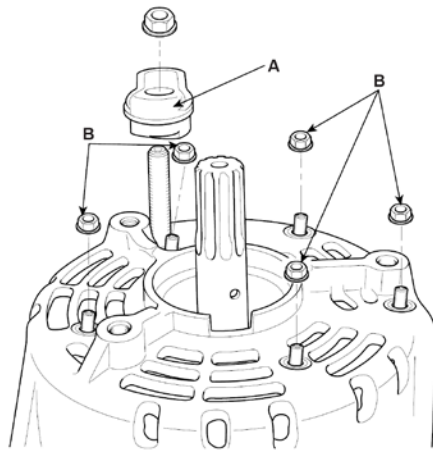
1. Remove the pulley(A).



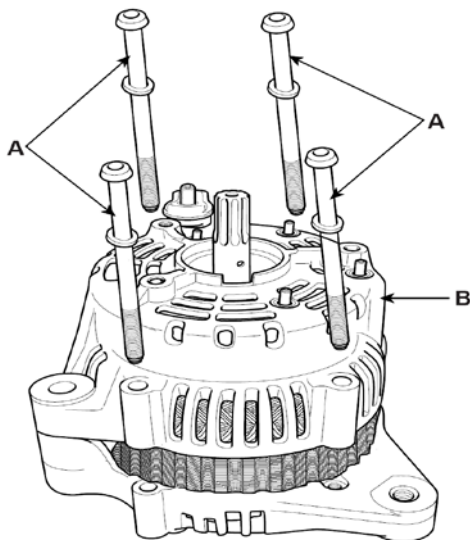
2. After loosening the three bolts(A), Remove the vacuum pump(B).



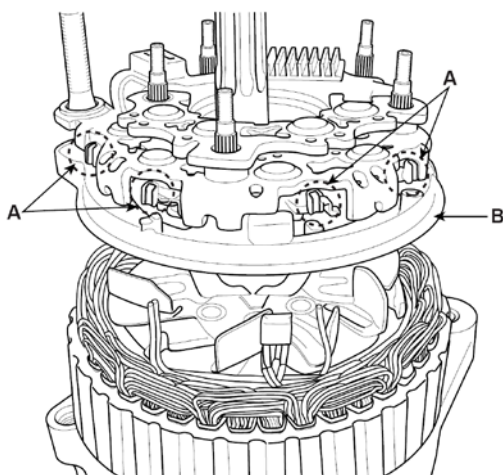
3. Remove the B terminal insulator(A) and loosen the five rear cover mounting nuts(B)



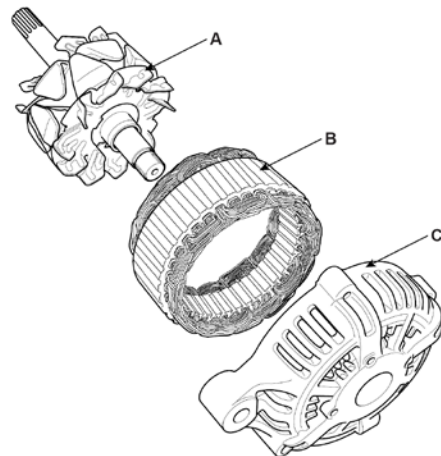
4. After loosening the four through bolts(A), remove the rear cover(B).



5. After removing the weld between the stator lead and diode lead(A), remove the regulator assembly (B).



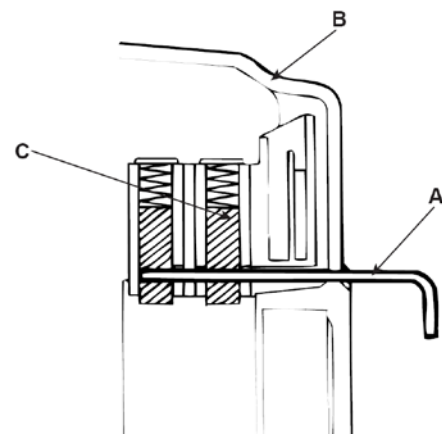
6. Separate the rotor(A), stator(B), and front cover(C).



Installation

Installation is the reverse of removal.

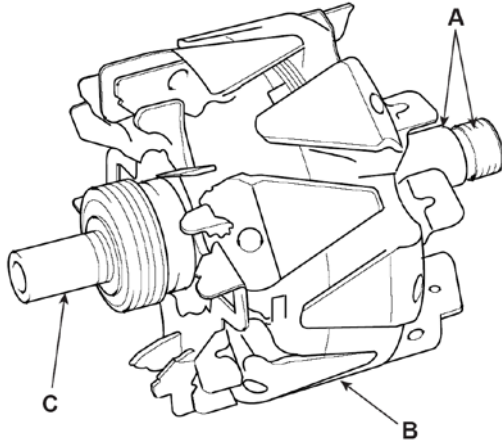
1. Before install the rotor to the rear bracket, fix the brush(C) by inserting the wire(A) to the rear bracket(B) hole.
2. Remove the wire(A) after assembly the rotor.



Inspection

Inspect rotor

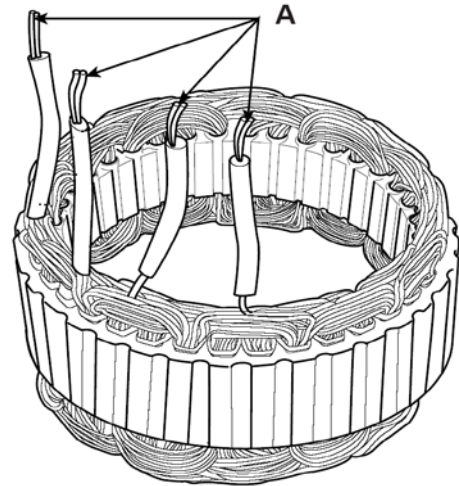
1. Check that there is continuity between the slip rings(A).



2. Check that there is no continuity between the slip rings and the rotor(B) or rotor shaft(C).
3. If the rotor fails either continuity check, replace the alternator.

Inspect stator

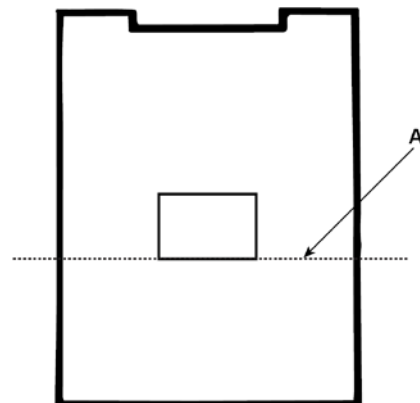
1. Check that there is continuity between each pair of leads(A).



2. Check that there is no continuity between each lead and the coil core.
3. If the coil fails either continuity check, replace the generator.

Inspect Brush

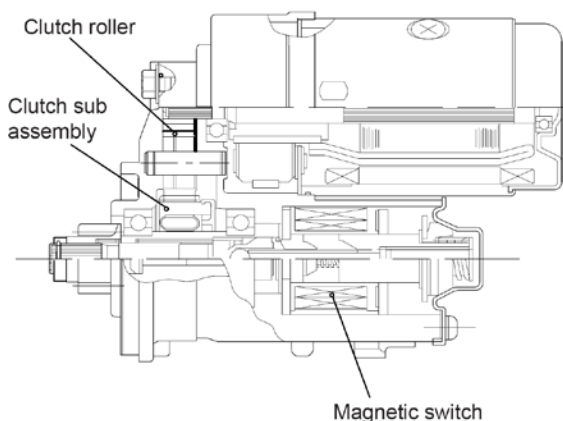
1. Brushes that are worn out, or oil-soaked, should be replaced.



Starting System

When the ignition key is turned to the start position, current flows and energizes the starter motor's solenoid coil.

The solenoid plunger and clutch shift lever are activated, and the clutch pinion engages the ring gear. The contacts close and the starter motor cranks. In order to prevent damage caused by excessive rotation of the starter armature when the engine starts, the clutch pinion gear overruns.



Troubleshooting

1. Remove the fuel pump relay(A) from the fuse box.
2. With the shift lever in N or P (A/T) or clutch pedal pressed (M/T), turn the ignition switch to "START"
If the starter normally cranks the engine, starting system is OK. If the starter will not crank the engine at all, go to next step.

If it won't disengage from the ring gear when you release key, check for the following until you find the cause.

- Solenoid plunger and switch malfunction.
- Dirty pinion gear or damaged overrunning clutch.

3. Check the battery condition. Check electrical connections at the battery, battery negative cable

connected to the body, engine ground cables, and the starter for looseness and corrosion. Then try starting the engine again.

If the starter cranks normally the engine, repairing the loose connection repaired the problem. The starting system is now OK.

If the starter still does not crank the engine, go to next step.

4. Disconnect the connector from the S-terminal of solenoid. Connect a jumper wire from the B-terminal of solenoid to the S-terminal of solenoid.

If the starter cranks the engine, go to next step.

If the starter still does not crank the engine, remove the starter, and repair or replace as necessary.

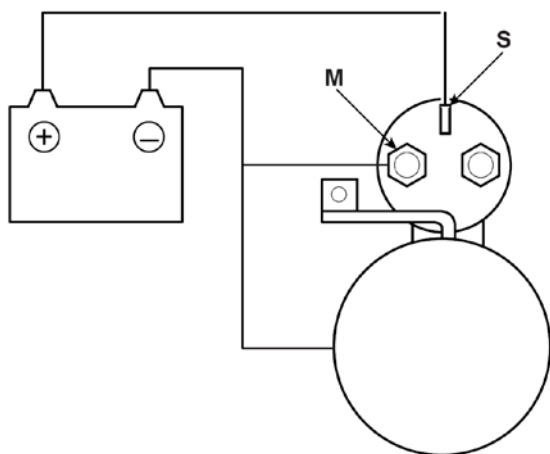
5. Check the following items in the order listed until you find the open circuit.

- Check the wire and connectors between the driver's under-dash fuse/relay box and the ignition switch, and between the driver's under-dash fuse/relay box and the starter.
- Check the ignition switch (Refer to BE group - ignition system)
- Check the transaxle range switch connector or ignition lock switch connector.
- Inspect the starter relay.

Starter Solenoid Test

1. Disconnect the field coil wire from the M-terminal of solenoid switch.

2. Connect a 12V battery between S-terminal and the starter body



3. Connect the field coil wire to the M-terminal.

CAUTION

This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning.

4. If the pinion moves out, the pull-in coil of solenoid is working properly. If the pinion does not move, replace the solenoid.

5. Disconnect the field coil wire from the M-terminal.

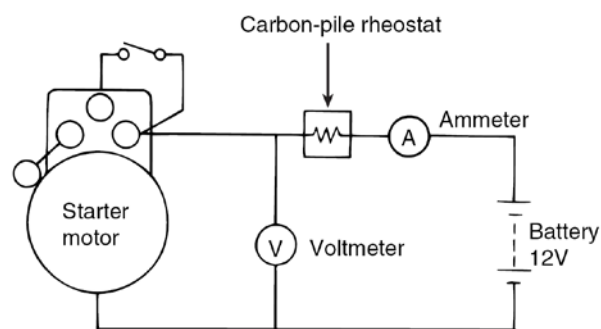
6. If the pinion has moved out, the hold-in coil of the solenoid is working properly. If the pinion moves in, replace the solenoid

Free running test

1. Place the starter motor in a vise equipped with soft jaws and connect fully-charged 12-volt battery to starter motor as follows :

2. Connect a test ammeter (100-ampere scale) and carbon pile rheostat shown in the illustration.

3. Connect a voltmeter (15-volt scale) across starter motor.



4. Rotate carbon pile to the off position.

5. Connect the battery cable from battery's negative post to the starter motor body.

6. Adjust until battery voltage shown on the voltmeter reads 11 volts.

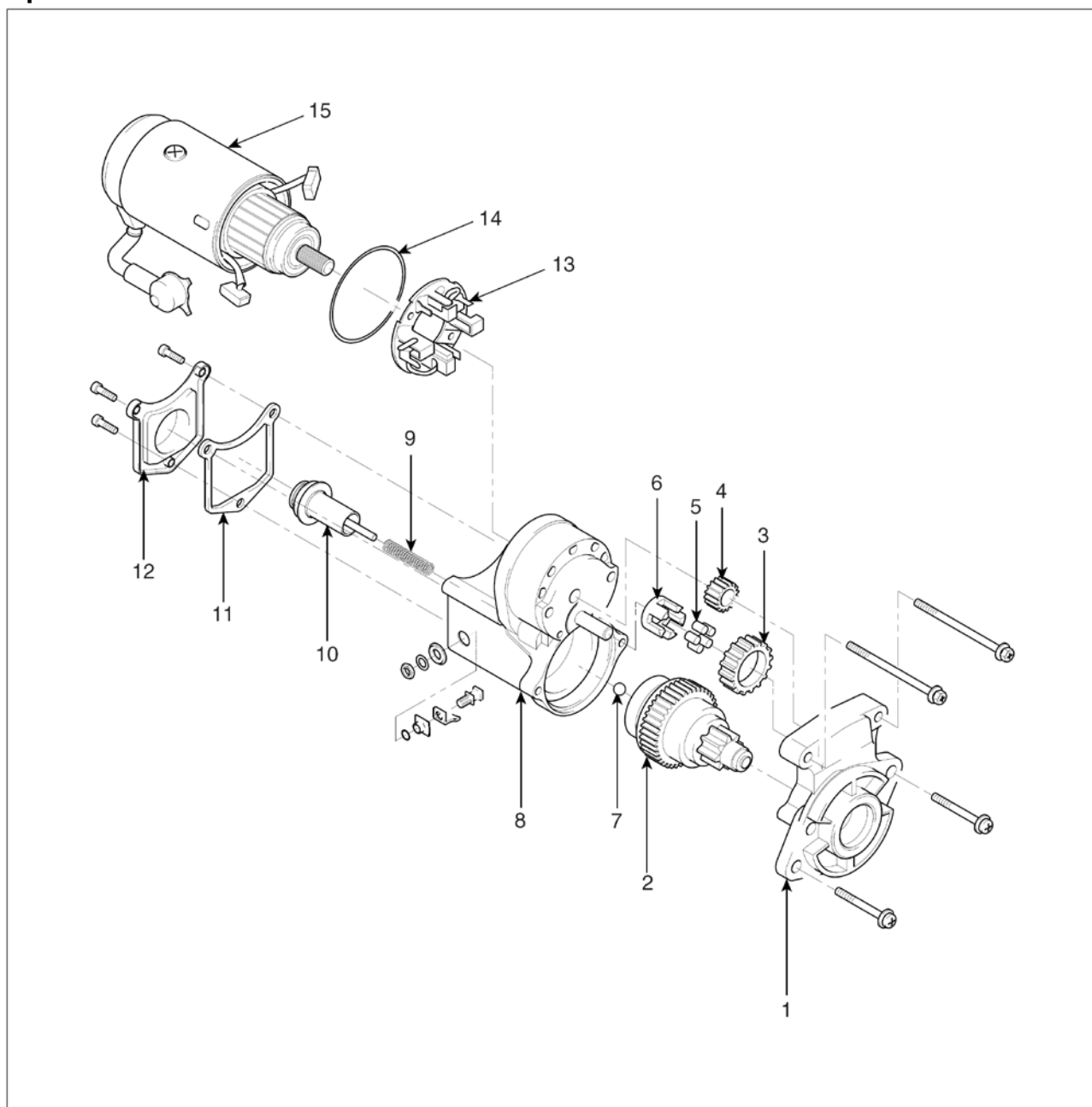
7. Confirm that the maximum amperage is within the specifications and that the starter motor turns smoothly and freely :

Current : 120A Max

Speed : 4000 RPM

Starter motor

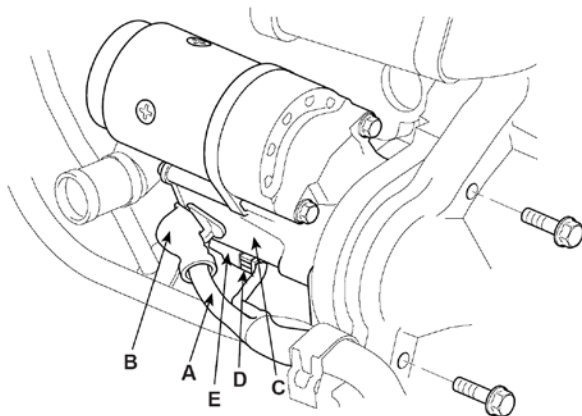
Components



- | | |
|------------------------|---------------------------|
| 1. Front bracket | 9. Coil spring |
| 2. Clutch sub assembly | 10. Magnetic switch |
| 3. Idle gear | 11. Packing |
| 4. Driver gear | 12. Rear cover |
| 5. Clutch roller | 13. Brush holder assembly |
| 6. Retainer | 14. O-ring |
| 7. Steel ball | 15. Yoke assembly |
| 8. Housing | |

Removal

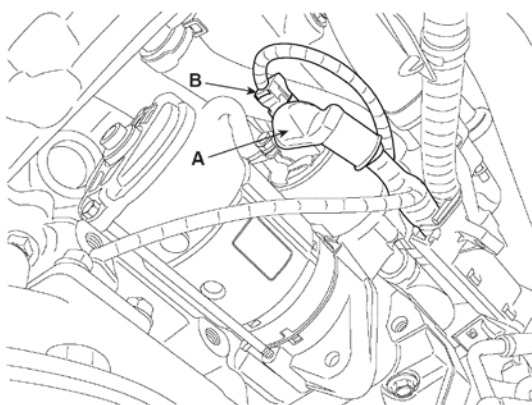
1. Disconnect the battery negative cable.
2. Disconnect the starter cable(A) from the B terminal on the solenoid, then disconnect the connector(B) from the S terminal.



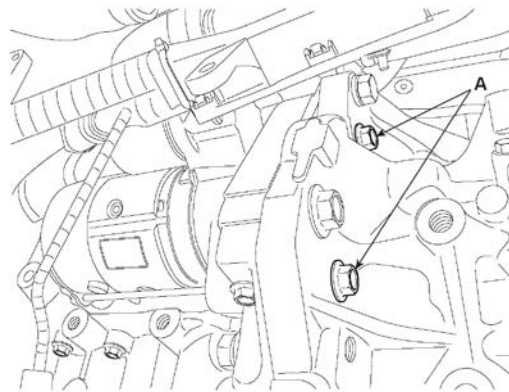
3. Remove the 2 bolts holding the starter, then remove the starter.
4. Installation is the reverse of removal. connect

Replacement

1. Disconnect the starter motor cable(A) from the B terminal of the solenoid and the connector (B) from the S terminal



2. Remove the starter by loosening the starter mounting bolts(A).



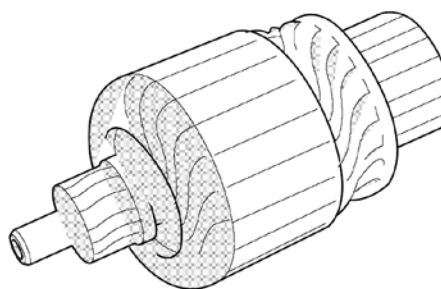
4.3 ~ 5.5 kgf.m

3. Installation is in the reverse order of remove

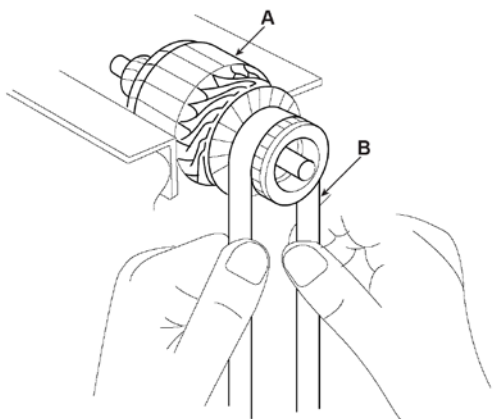
Inspection

Armature

1. Remove the starter.
2. Disassemble the starter as shown at the beginning of this procedure.
3. Inspect the armature for wear or damage from contact with the permanent magnet. If there is wear or damage, replace the armature



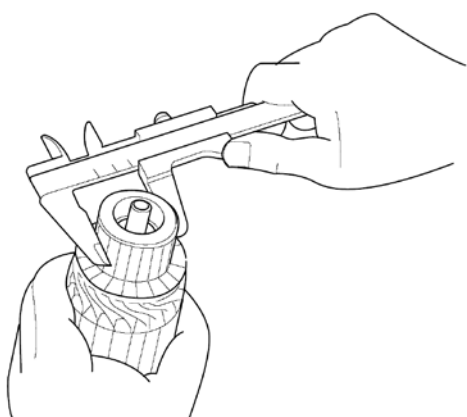
4. Check the commutator (A) surface. If the surface is dirty or burnt, resurface with emery cloth or a lathe within the following specifications, or recondition with #500 or #600 sandpaper(B).



5. Check the commutator diameter. If the diameter is below the service limit, replace the armature.

Standard (New) : 29.4 mm

Service limit: 28.8 mm

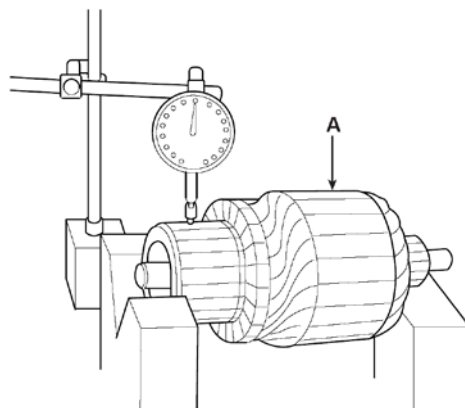


6. Measure the commutator run out.

- If the commutator run out is within the service limit, check the commutator for carbon dust or brass chips between the segments.
- If the commutator run out is not within the service limit, replace the armature.

Standard (New) : 0.02 mm(0.0008 in) (max)

Service limit : 0.05 mm(0.0020in)

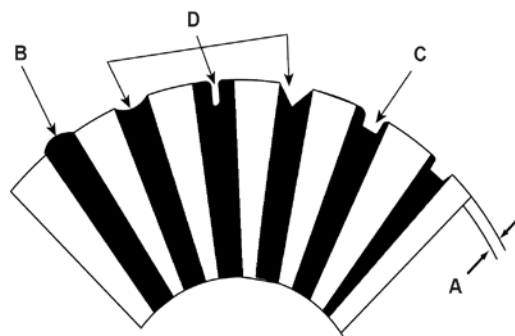


7. Check the mica depth(A). If the mica is too high(B), undercut the mica with a hacksaw blade to the proper depth. Cut away all the mica(C) between the commutator segments. The undercut should not be too shallow, too narrow, or v-shaped(D).

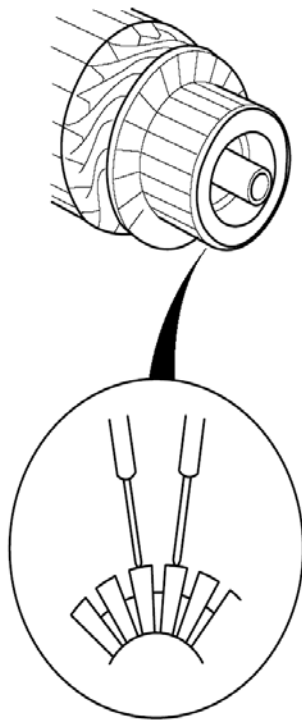
Commutator mica depth

Standard (New): 0.5 mm(0.0197in)

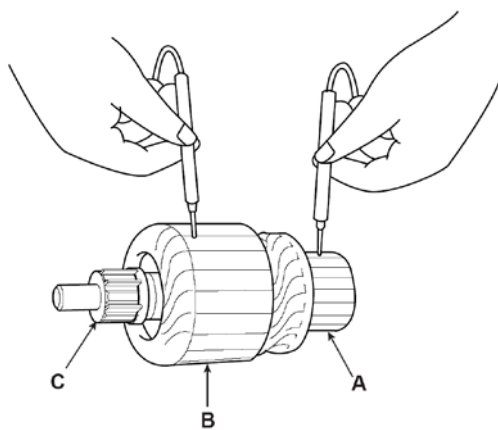
Limit : 0.2 mm(0.0079in)



8. Check for continuity between the segments of the commutator. If an open circuit exists between any segments, replace the armature.

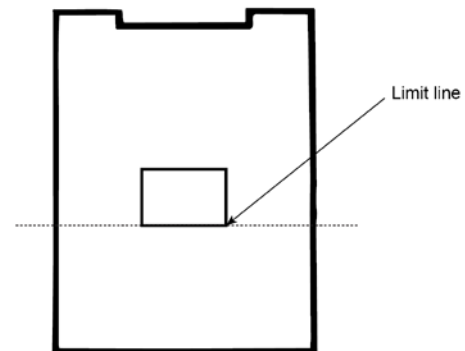


9. Check with an ohmmeter that no continuity exists between the commutator(A) and armature coil core(B), and between the commutator and armature shaft(C). If continuity exists, replace the armature.



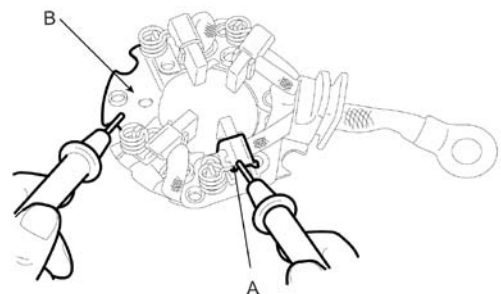
Inspect Starter Brush

Brushes that are worn out, or oil-soaked, should be replaced.



Starter Brush Holder

Check that there is no continuity between the (+) brush holder(A) and (-) plate(B). If there is continuity, replace the brush holder assembly.



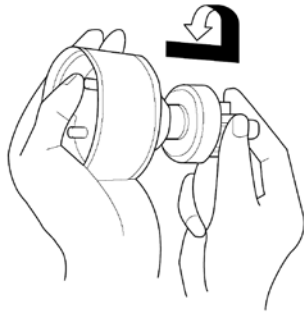
Overrunning Clutch

1. Slide the overrunning clutch along the shaft.

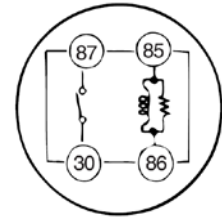
Replace it if it does not slide smoothly.

2. Rotate the overrunning clutch both ways.

Does it lock in one direction and rotate smoothly in reverse? If it does not lock in either direction of it locks in both directions, replace it.



<u>30</u>	<u>86</u>
<u>85</u>	<u>87</u>



3. If the starter drive gear is worn or damaged, replace the overrunning clutch assembly. (the gear is not available separately)

Check the condition of the flywheel or torque converter ring gear if the starter drive gear teeth are damaged.

5. If there is no continuity replace the starter relay.

6. install the ECU box cover

Cleaning

1. Do not immerse parts in cleaning solvent.

Immersing the yoke assembly and/or armature will damage the insulation wipe these parts with a cloth only.

2. Do not immerse the drive unit in cleaning solvent.

The overrun clutch is pre-lubricated at the factory and solvent will wash lubrication from the clutch.

3. The drive unit may be cleaned with a brush moistened with cleaning solvent and wiped dry with a cloth

Starter Relay

1. Remove the ECU box cover .

2. Remove the relay (A).

3. Using an ohmmeter check that is continuity

Between each terminal

Terminal	Continuity
30 - 87	NO
85 - 86	YES

4. Apply 12v to terminal 85 and ground to terminals 86
check for continuity between terminals 30 and 87.

Preheating System

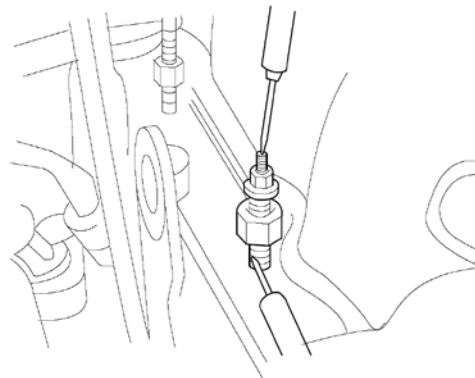
Inspection

Conditions before inspection :

Battery voltage : 12V

Cooling water temperature : Below 30°C (86°F)

(Disconnect the water temperature sensor connector).



1. Connect voltmeter between glow plug plate and plug body (ground).
2. Check indicated value on voltmeter with ignition switch ON.
3. Check that preheat indication lamp lights for about 6 seconds and indicates battery voltage (about 9V or over) for about 36 seconds immediately after ignition switch is turned on. [At cooling water temperature 20°C (68.0°F)]
4. After checking 3, set ignition switch at START position.

5. The system is normal if battery voltage (about 9V or over) is generated for about 6 seconds during engine cranking and after start operation. [at cooling water temperature 20°C (68.0°F)]

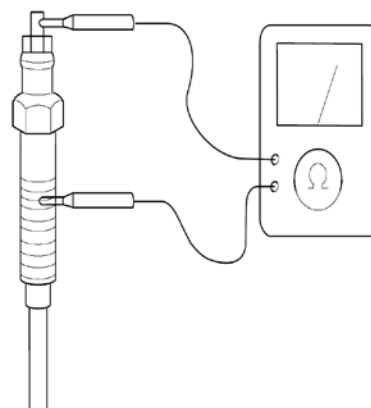
6. When the voltage or continuity time is not normal check the terminal voltage in glow control unit, and single parts

Glow Plug

1. Check the continuity between the terminal and body as illustrated. Replace if discontinuity or with large resistance.

Standard value : 0.25Ω

2. Check for rust on glow plug plate.
3. Check glow plug for damage.



Components

Glow Plug

Structure

The glow plug mainly consists of a housing in which a heating pin is pressed in. In the heating pin there are the heating spiral and the sensor spiral, both are connected in series and embedded in a ceramic mass.

Purpose

- Prior to engine starting : To make quickly available a hot surface of approximately 850°C (1562°F), where the air-fuel mixture evaporator and ignites during the compression stroke.
- While engine starting : To support the engine run-up.
- After engine starting : To improve the idle running and to reduce the emissions of blue smoke, pollutants and noise.

Inspection

The specified electrical data below are related to the nominal voltage and to an ambient temperature of $22.5\sim 23.5^{\circ}\text{C}$ ($72.5\sim 74.3^{\circ}\text{F}$) on new glow plugs.

Current Consumption

Initial current at 11V : less than 27.0A

Operating current after 5 sec : less than

Fuel System

General

Diesel Control System

Fuel Delivery System

DTC_(Diagnosis Trouble Code)

General Information

Specification

Fuel delivery system

Items	Specification	
Fuel Return System	Type	Return type
Fuel Filter	Type	High pressure type (Built in engine room)
High Pressure Fuel Pump	Type	Mechanical, Plunger Pumping Type
	Driven by	Camshaft
Fuel Pressure	Max. Pressure	1,600 bar

Sensors

BOOST PRESSURE SENSOR (BPS)

- ▷ Type: Piezo-resistive pressure sensor type
- ▷ Specification

Pressure (kPa)	Output Voltage (V)
32.5	0.5
70	1.02 ~ 1.17
140	2.13 ~ 2.28
210	3.25 ~ 3.40
270	4.20 ~ 4.35
284	4.5

INTAKE AIR TEMPERATURE SENSOR (IATS) #1

[BUILT IN filter]

- ▷ Type: Thermistor type
- ▷ Specification

Temperature [°C (°F)]	Resistance(kΩ)
-40(-40)	40.93 ~ 48.35
-20(-4)	13.89 ~ 16.03
0(32)	5.38 ~ 6.09
20(68)	2.31 ~ 2.57
40(104)	1.08 ~ 1.21
60(140)	0.54 ~ 0.62
80(176)	0.29 ~ 0.34

ENGINE COOLANT TEMPERATURE SENSOR (ECTS)

- ▷ Type: Thermistor type
- ▷ Specification

Temperature [°C (°F)]	Resistance(kΩ)
-40(-40)	48.14
-20(-4)	14.13 ~ 16.83
0(32)	5.79
20(68)	2.31 ~ 2.59
40(104)	1.15
60(140)	0.59
80(176)	0.32

CAMSHAFT POSITION SENSOR (CMPS)

- ▷ Type: Hall effect type
- ▷ Specification

Level	Output Pulse (V)
High	5V
Low	0V

Items	Specification
Air Gap	1.0 ± 0.5 mm

CRANKSHAFT POSITION SENSOR (CKPS)

▷ Type: Variable reluctance type

▷ Output Voltage (V): 0 ~ 5V

Items	Specification
Coil Resistance (Ω)	774 ~ 946 Ω [20°C (68°F)]

RAIL PRESSURE SENSOR (RPS)

▷ Type: Piezo-electricity type

▷ Specification

Test Condition	Bar	Out voltage V
Idle	200 ~ 300	0.9 ~ 1.2
3,000 rpm	450 ~ 650	1.5 ~ 1.9

FUEL TEMPERATURE SENSOR (FTS)

▷ Type: Thermistor type

▷ Specification

Temperature°C	Resistance(k Ω)
-10	8.64 ~ 10.15
20	2.35 ~ 2.65
80	0.31 ~ 0.33
120	0.11 ~ 0.12

Accelerator position sensor(APS)

▷ Type: Potentiometer type

▷ Specification

Test Condition	Output Voltage(V)	
	APS 1	APS 2
Idle	0.7 ~ 0.8	0.275 ~ 0.475
Fully depressed	3.8 ~ 4.4	1.75 ~ 2.35

WATER SENSOR

▷ Specification

Item	Specification
WARNING Level (cc)	40 ~ 60

ACTUATORS**INJECTOR**

▷ Number: 4

▷ Specification

Items	Specification
Coil Resistance (Ω)	0.33 Ω [20°C (68°F)]

FUEL PRESSURE REGULATOR VALVE

▷ Specification

Items	Specification
Coil Resistance (Ω)	2.6 ~ 3.15 Ω [20°C (68°F)]

RAIL PRESSURE REGULATOR VALVE

▷ Specification

Items	Specification
Coil Resistance (Ω)	3.42 ~ 3.78 Ω [20°C (68°F)]

VGT CONTROL SOLENOID VALVE

▷ Specification

Items	Specification
Coil Resistance (Ω)	14.7 ~ 16.1 Ω [20°C (68°F)]

Tightening Torques

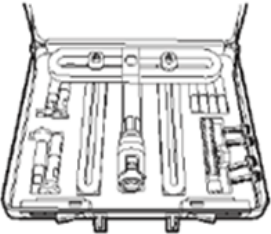
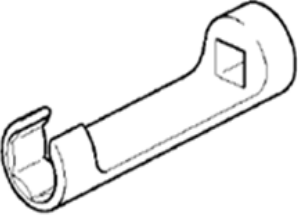
Engine control system

Item	N·m	Kgf·m	lbf·ft
Boost pressure sensor installation bolts	7.8 ~ 11.8	0.8 ~ 1.2	5.8 ~ 8.7
Engine coolant temperature sensor installation	19.6 ~ 39.2	2.0 ~ 4.0	14.5 ~ 28.9
Crankshaft position sensor installation bolt	3.9 ~ 5.9	0.4 ~ 0.6	2.9 ~ 4.3
Camshaft position sensor installation bolt	3.9 ~ 5.9	0.4 ~ 0.6	2.9 ~ 4.3
Oil pressure switch installation	14.7 ~ 21.6	1.5 ~ 2.2	10.9 ~ 15.9
Glow plug installation	9.8 ~ 13.7	1.0 ~ 1.4	7.2 ~ 10.1

Fuel delivery system

Item	N·m	Kgf·m	lbf·ft
Injector clamp installation bolt	24.5 ~ 28.4	2.5 ~ 2.9	18.1 ~ 21.0
Common rail installation bolts	19.6 ~ 26.5	2.0 ~ 2.7	14.5 ~ 19.5
High pressure fuel pump installation bolts	24.5 ~ 34.3	2.5 ~ 3.5	18.1 ~ 25.3
High pressure fuel pipe(Injector ↔ Common rail) installation nuts	24.5 ~ 28.4	2.5 ~ 2.9	18.1 ~ 21.0
High pressure fuel pipe(Common rail ↔ High pressure fuel pump) installation nuts	24.5 ~ 28.4	2.5 ~ 2.9	18.1 ~ 21.0
Low pressure fuel pump installation bolts	39.2 ~ 44.1	4.0 ~ 4.5	28.9 ~ 32.5
Fuel filter installation bolts	24.5 ~ 34.3	2.5 ~ 3.5	18.1 ~ 25.3

Special Service Tools

Tool (Number and name)	Illustration	Application
00200-0T014 Injector Remover		Removing the injector
00200-0T058 Torque Wrench Socket(14mm) 00200-0T015 Torque Wrench Socket(17mm)		Installing the high pressure fuel pipe

Basic Troubleshooting Guide

1. Bring engine to Workshop
2. Analyze Problem
About the conditions and environment relative to the issue(Make Problem Analysis Sheet)
3. Verify Symptom, and then Check DTC and Freeze Frame Data
Connect G-Scan to Diagnostic Link Connector
Never erase DTC and freeze frame data before completing step 2 MIL /DTC in Problem Analysis Sheet
4. Inspect engine Visually
Go to step 9, if you recognize the problem
5. Recreate(Simulate) Symptoms of the DTC
6. Confirm Symptoms of Problem
7. Recreate (Simulate) symptom
8. Check the DTC
9. Perform troubleshooting procedure for DTC
10. Adjust or repair the engine
11. Confirmation test
12. End

Problem Analysis Sheet

1. Engine information

Engine No.		ECU Part NO.	
Production date		ROM ID	
Run time	(hours)	Customer TEL	

2. Symptoms

<input type="checkbox"/> Unable to start	<input type="checkbox"/> Engine does not turn over <input type="checkbox"/> Incomplete combustion <input type="checkbox"/> Initial combustion does not occur
<input type="checkbox"/> Difficult to start	<input type="checkbox"/> Engine turns over slowly <input type="checkbox"/> Other _____
<input type="checkbox"/> Poor idling	<input type="checkbox"/> Rough idling <input type="checkbox"/> Incorrect idling <input type="checkbox"/> Unstable idling (High: _____ rpm, Low: _____ rpm) <input type="checkbox"/> Other _____
<input type="checkbox"/> Engine stall	<input type="checkbox"/> Soon after starting <input type="checkbox"/> After accelerator pedal depressed <input type="checkbox"/> After accelerator pedal released <input type="checkbox"/> During A/C ON <input type="checkbox"/> Shifting from N to D-range <input type="checkbox"/> Other _____
<input type="checkbox"/> Others	<input type="checkbox"/> Poor driving (Surge) <input type="checkbox"/> Knocking <input type="checkbox"/> Poor fuel economy <input type="checkbox"/> Back fire <input type="checkbox"/> After fire <input type="checkbox"/> Other _____

3. Environment

Problem frequency	<input type="checkbox"/> Constant <input type="checkbox"/> Sometimes _____ <input type="checkbox"/> Once only <input type="checkbox"/> Other _____
Weather	<input type="checkbox"/> Fine <input type="checkbox"/> Cloudy <input type="checkbox"/> Rainy <input type="checkbox"/> Snowy <input type="checkbox"/> Other _____
Temperature	<input type="checkbox"/> Approx _____ °C/°F <input type="checkbox"/> Other _____
Place	<input type="checkbox"/> Sea <input type="checkbox"/> Lake <input type="checkbox"/> Other _____
Engine operation	<input type="checkbox"/> Starting <input type="checkbox"/> Just after starting <input type="checkbox"/> Idling <input type="checkbox"/> Driving <input type="checkbox"/> Constant speed <input type="checkbox"/> Deceleration <input type="checkbox"/> Other _____

4. MIL /DTC/Alarm

MIL(Malfunction Indicator Lamp)	<input type="checkbox"/> ON <input type="checkbox"/> Sometimes lights up <input type="checkbox"/> OFF <input type="checkbox"/> Other _____
Alarm	<input type="checkbox"/> ON <input type="checkbox"/> Sometimes <input type="checkbox"/> OFF <input type="checkbox"/> Other _____
DTC	<input type="checkbox"/> DTC NO(_____)
Freeze Frame Date	

Basic inspection procedure

Measuring condition of electronic parts' resistance

The measured resistance at high temperature after engine running may be high or low. So all resistance must be measured at ambient temperature (20°C, 68°F), unless stated otherwise.

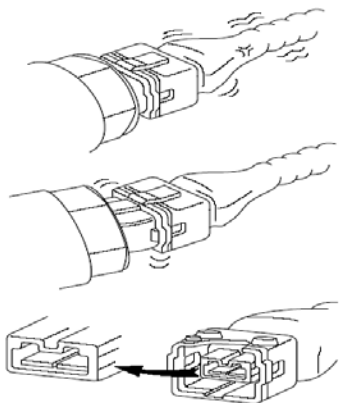
NOTICE

The measured resistance in except for ambient temperature (20°C, 68°F) is reference value.

Intermittent problem inspection procedure

Sometimes the most difficult case in troubleshooting is when a problem symptom occurs but does not occur again during testing. An example would be if a problem appears only when the vehicle is cold but has not appeared when warm. In this case, the technician should thoroughly make out a "CUSTOMER PROBLEM ANALYSIS SHEET" and recreate (simulate) the environment and condition which occurred when the vehicle was having the issue.

1. Clear Diagnostic Trouble Code (DTC).
2. Inspect connector connection, and check terminal for poor connections, loose wires, bent, broken or corroded pins, and then verify that the connectors are always securely fastened. .



3. Slightly shake the connector and wiring harness

vertically and horizontally

4. Repair or replace the component that has a problem.
5. Verify that the problem has disappeared with the road test.

● SIMULATING VIBRATION

- a. Sensors and Actuators

: Slightly vibrate sensors, actuators or relays with finger.

WARNING

Strong vibration may break sensors, actuators or Relays .

- b. Connectors and Harness

: Lightly shake the connector and wiring harness vertically and then horizontally

● SIMULATING HEAT

- a. Heat components suspected of causing the malfunction with a hair dryer or other heat source..

WARNING

- DO NOT heat components to the point where they may be damaged.
- DO NOT heat the ECM directly.

● SIMULATING WATER SPRINKLING

- a. Sprinkle water onto engine to simulate a rainy day or a high humidity condition..

WARNING

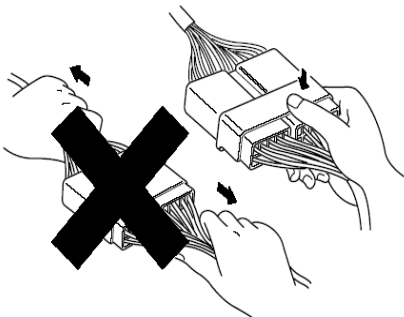
DO NOT sprinkle water directly into the engine compartment or electronic components

● SIMULATING ELECTRICAL LOAD

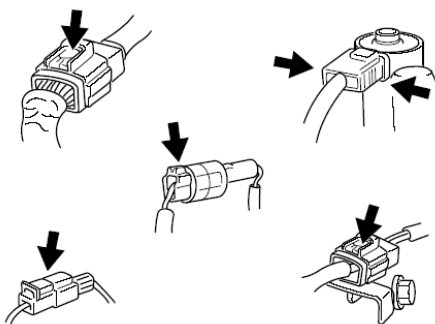
- a. Turn on all electrical systems to simulate excessive electrical loads (Radios, fans, lights, rear window defogger, etc.).

Connector inspection procedure**1. Handling of Connector**

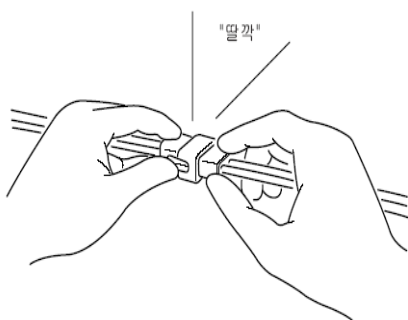
a. Never pull on the wiring harness when disconnecting connectors.



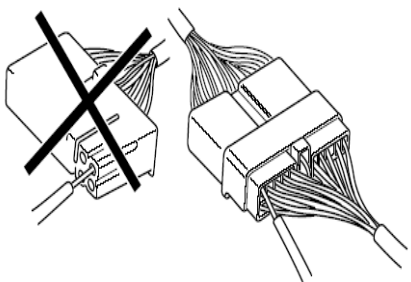
b. When removing the connector with a lock, press or pull locking lever.



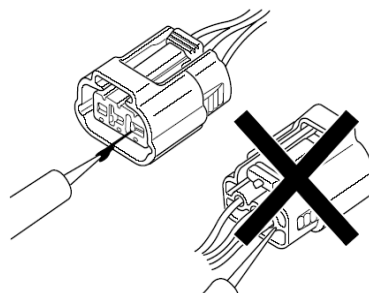
c. Listen for a click when locking connectors. This sound indicates that they are securely locked.



d. When a tester is used to check for continuity, or to measure voltage, always insert tester probe from wire harness side.



e. Check waterproof connector terminals from the connector side. Waterproof connectors cannot be accessed from harness side.

**2. Checking Point for Connector**

a. While the connector is connected:

Hold the connector, check connecting condition and locking efficiency.

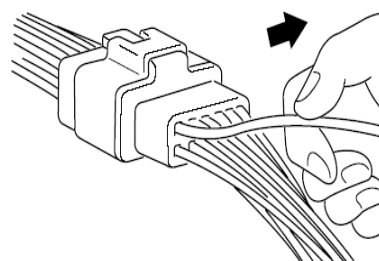
b. When the connector is disconnected:

Check missed terminal, crimped terminal or broken core wire by slightly pulling the wire harness. Visually check for rust, contamination, deformation and bend.

c. Check terminal tightening condition:

Insert a spare male terminal into a female terminal, and then check terminal tightening conditions.

d. Pull lightly on individual wires to ensure that each wire is secured in the terminal.

**3. Repair Method of Connector Terminal**

a. Clean the contact points using air gun and/or shop rag.

NOTICE

Never use sand paper when polishing the contact points, otherwise the contact point may be damaged.

b. In case of abnormal contact pressure, replace the female terminal.

Wire harness inspection procedure

1. Before removing the wire harness, check the wire harness position and crimping in order to restore it correctly.
2. Check whether the wire harness is twisted, pulled or loosened.
3. Check whether the temperature of the wire harness is abnormally high.
4. Check whether the wire harness is rotating, moving or vibrating against the sharp edge of a part.
5. Check the connection between the wire harness and any installed part.
6. If the covering of wire harness is damaged; secure, repair or replace the harness.

Electrical circuit inspection procedure

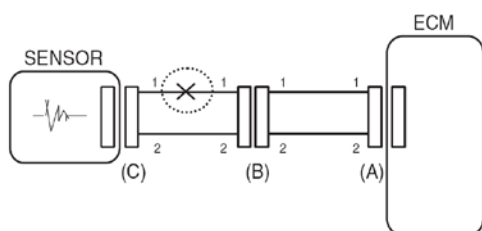
Check open circuit

1. Procedures for Open Circuit

- Continuity Check
- Voltage Check

If an open circuit occurs (as seen in [FIG. 1]), it can be found by performing Step 2 (Continuity Check Method) or Step 3 (Voltage Check Method) as shown Below.

FIG 1



2. Continuity Check Method

Specification (Resistance)

1Ω or less → Normal Circuit

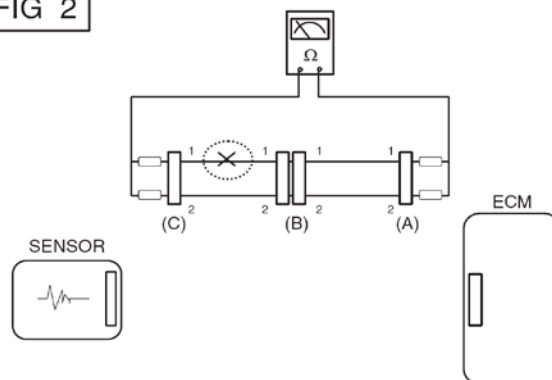
1 MΩ or Higher → Open

a. Disconnect connectors (A), (C) and measure resistance between connector (A) and (C) as shown in [FIG. 2].

In [FIG.2.] the measured resistance of line 1 and 2 is higher than 1 MΩ and below 1 Ω respectively.

Specifically the open circuit is line 1 (Line 2 is normal). To find exact break point, check sub line of line 1 as described in next step.

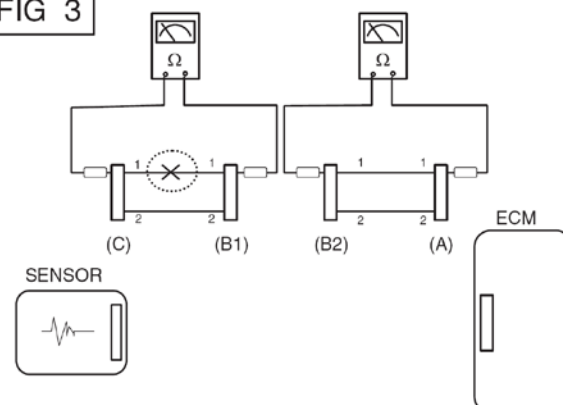
FIG 2



b. Disconnect connector (B), and measure for resistance between connector (C) and (B1) and between (B2) and (A) as shown in [FIG. 3].

In this case the measured resistance between connector (C) and (B1) is higher than 1 MΩ and the open circuit is between terminal 1 of connector (C) and terminal 1 of connector (B1).

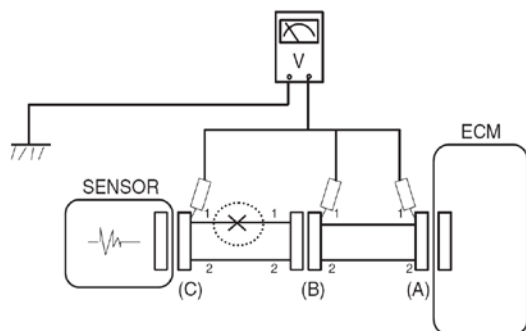
FIG 3



3. Voltage Check Method

a. With each connector still connected, measure the voltage between the chassis ground and terminal 1 of each connectors (A), (B) and (C) as shown in [FIG. 4]. The measured voltage of each connector is 5V, 5V and 0V respectively. So the open circuit is between connector (C) and (B).

FIG 4



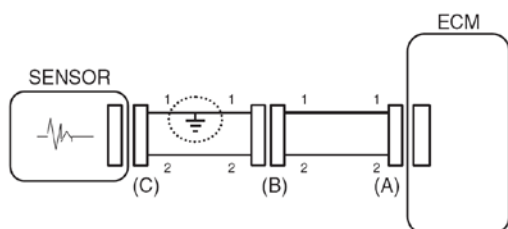
Check short circuit

1. Test Method for Short to Ground Circuit

• Continuity Check with Chassis Ground

If short to ground circuit occurs as shown in [FIG. 5], the broken point can be found by performing Step 2 (Continuity Check Method with Chassis Ground) as shown below.

FIG 5



2. Continuity Check Method (with Chassis Ground)

Specification (Resistance)

1Ω or less → Short to Ground Circuit

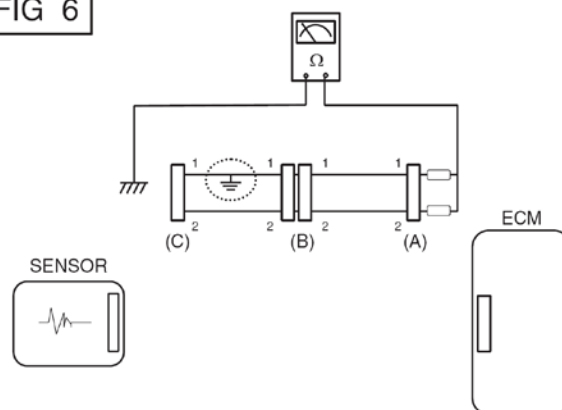
1MΩ or Higher → Normal Circuit

a. Disconnect connectors (A), (C) and measure for resistance between connector (A) and Chassis Ground

as shown in [FIG. 6].

The measured resistance of line 1 and 2 in this example is below 1 Ω and higher than 1MΩ respectively. Specifically the short to ground circuit is line 1 (Line 2 is normal). To find exact broken point, check the sub line of line 1 as described in the following step.

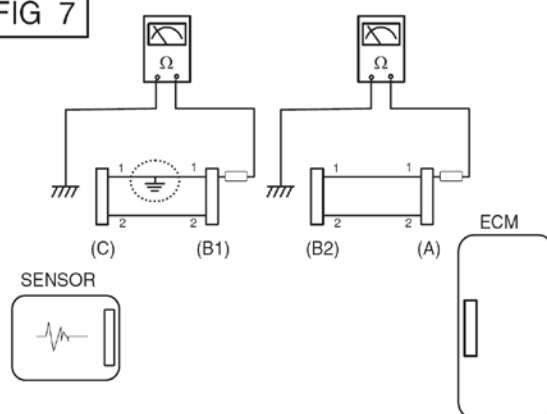
FIG 6



b. Disconnect connector (B), and measure the resistance between connector (A) and chassis ground, and between (B1) and chassis ground as shown in [FIG. 7].

The measured resistance between connector (B1) and chassis ground is 1Ω or less. The short to ground circuit is between terminal 1 of connector (C) and terminal 1 of connector (B1).

FIG 7



SYMPTOM TROUBLE SHOOTING GUIDE TABLE**(SYMPTOM 1) ENGINE DOES NOT START**

- | | |
|---|---|
| <ul style="list-style-type: none"> • Faulty starter • Not connected fuel feed line • Leakage in high pressure fuel circuit • Fuse out of order • Drift of the rail pressure sensor • Cam and crank signals missing simultaneously • Low battery voltage • Fuel pressure regulator valve contaminated, stuck, jammed • Rail pressure regulator valve contaminated, stuck, jammed • Bad fuel quality or water ingress in fuel | <ul style="list-style-type: none"> • Faulty fuel filter • Clogged low pressure fuel circuit • Clogged fuel filter • Intermittent faulty fuel line connection • Air ingress in the low pressure fuel circuit • Clogged return line of high pressure fuel pump • Low compression pressure • Leakage at the injector • Faulty low pressure fuel pump • Faulty high pressure fuel pump • Injector jammed open • ECM program error or hardware fault |
|---|---|

(SYMPTOM 2) ENGINE STARTS WITH DIFFICULTY OR STARTS AND STALLS

- | | |
|---|---|
| <ul style="list-style-type: none"> • Not connected fuel return line at injector • Leakage in high pressure fuel circuit • Fuse out of order • Clogged air filter • Faulty alternator or voltage regulator • Compensation of individual injector not adapted • No engine coolant temperature sensor signal • No rail pressure sensor signal • Low battery voltage • Fuel pressure regulator valve contaminated, stuck, jammed • Rail pressure regulator valve contaminated, stuck, jammed • Bad fuel quality or water ingress in fuel • Inversion of fuel connections (feed & return) | <ul style="list-style-type: none"> • Clogged low pressure fuel circuit • Clogged fuel filter • Oil level too high or too low • Intermittent faulty fuel line connection • Air ingress in the low pressure fuel circuit • Clogged return line of high pressure fuel pump • Faulty glow system • Low compression pressure • Clogged injector return line • Carbon deposit on the injector (sealed holes) • Injector needle stuck (injection possible over a certain pressure) • Gasoline in fuel • ECM program error or hardware fault |
|---|---|

(SYMPTOM 3) POOR STARTING WHEN

- | | |
|--|---|
| <ul style="list-style-type: none"> • Compensation of individual injector not adapted • No rail pressure sensor signal • Fuel pressure regulator valve contaminated, stuck, jammed • Rail pressure regulator valve contaminated, stuck, jammed • Clogged air filter • Air ingress in the low pressure fuel circuit • Bad fuel quality or water ingress in fuel | <ul style="list-style-type: none"> • Clogged return line of high pressure fuel pump • Clogged fuel filter • Low compression pressure • Intermittent faulty fuel line connection • Carbon deposit on the injector (sealed holes) • Injector needle stuck (injection possible over a certain pressure) • Gasoline in fuel • ECM program error or hardware |
|--|---|

(SYMPTOM 4) UNSTABLE IDLING

- Not connected fuel return line at injector
- Compensation of individual injector not adapted
- No rail pressure sensor signal
- Wiring harness open or poor connection
- Air ingress in the low pressure fuel circuit
- Bad fuel quality or water ingress in fuel
- Clogged fuel filter
- Clogged air filter
- Clogged injector return line

- Leakage in high pressure fuel circuit
- Faulty glow system
- Low compression pressure
- Poor tightening of injector clamp
- Faulty high pressure fuel pump
- Injector not adapted
- Carbon deposit on the injector (sealed holes)
- Injector needle stuck (injection possible over a certain pressure)
- Injector jammed open

(SYMPTOM 5) IDLE SPEED TOO HIGH OR TOO LOW

- No engine coolant temperature sensor signal
- Incorrect state of the electrical pack devices

- Faulty alternator or voltage regulator
- ECM program error or hardware fault

(SYMPTOM 6) BLUE, WHITE, OR BLACK SMOKES

- Compensation of individual injector not adapted
- No engine coolant temperature sensor signal
- No rail pressure sensor signal
- Fuel pressure regulator valve contaminated, stuck, jammed
- Rail pressure regulator valve contaminated, stuck, jammed
- Oil level too high or too low
- Bad fuel quality or water ingress in fuel
- Clogged air filter

- Oil suction (engine racing)
- Faulty glow system
- Low compression pressure
- Poor tightening of injector clamp
- Poor injector O-ring, no O-ring or two O-ring installed
- Injector not adapted
- Carbon deposit on the injector (sealed holes)
- Injector jammed open
- Gasoline in

(SYMPTOM 7) ENGINE RATTLING, NOISY ENGINE

- Compensation of individual injector not adapted
- No engine coolant temperature sensor signal
- Faulty glow system
- Low compression pressure
- Clogged injector return line
- No rail pressure sensor
- Poor injector washer, no washer or two washer

- installed
- Injector not adapted
- Carbon deposit on the injector (sealed holes)
- Injector needle stuck (injection possible over a certain pressure)
- Injector jammed open
- No engine coolant temperature sensor

(SYMPTOM 8) BURST NOISE

- Intermittent faulty fuel line connection
- Clogged exhaust system
- No rail pressure sensor signal
- Fuel pressure regulator valve contaminated,

- stuck, jammed
- Rail pressure regulator valve contaminated, stuck, jammed
- ECM program error or hardware fault

(SYMPTOM 9) UNTIMELY ACCELERATION/DECELERATION AND ENGINE RACING

- Blocked accelerator pedal position sensor
- Intermittent faulty fuel line connection
- Oil suction (engine racing)
- No rail pressure sensor signal
- ECM program error or hardware fault

(SYMPTOM 10) GAP WHEN ACCELERATING AND AT RE-COUPLING (RESPONSE TIME)

- Leakage in intake system
- Incorrect state of the electrical pack devices
- Blocked accelerator pedal position
- Damaged turbocharger or leakage in vacuum line
- Clogged fuel filter
- Low compression pressure
- Leakage in high pressure fuel circuit
- Fuel pressure regulator valve contaminated, stuck, jammed
- Rail pressure regulator valve contaminated, stuck, jammed
- Injector needle stuck (injection possible over a certain pressure)
- ECM program error or hardware fault

(SYMPTOM 11) ENGINE STOP

- Not connected fuel feed line
- Leakage in high pressure fuel circuit
- Fuse out of order
- Bad fuel quality or water ingress in fuel
- Clogged low pressure fuel circuit
- Clogged fuel filter
- Crank signals missing
- Fuel pressure regulator valve contaminated, stuck, jammed
- Rail pressure regulator valve contaminated, stuck, jammed
- Faulty alternator or voltage regulator
- Intermittent faulty fuel line connection
- Faulty low pressure fuel pump
- Faulty high pressure fuel pump
- Gasoline in fuel
- ECM program error or hardware fault

(SYMPTOM 12) ENGINE JUDDER

- Run out of fuel
- Not connected fuel return line at injector
- Incorrect state of the electrical pack devices
- Compensation of individual injector not adapted
- Faulty fuel filter
- Air ingress in the low pressure fuel circuit
- Bad fuel quality or water ingress in fuel
- Clogged fuel filter
- Intermittent faulty fuel line connection
- Wiring harness open or poor connection
- Faulty glow system
- Low compression pressure
- Clogged injector return line
- Poor valve clearance
- Faulty low pressure fuel pump
- Poor injector washer, no washer or two washer installed
- Carbon deposit on the injector (sealed holes)
- Injector needle stuck (injection possible over a certain pressure)
- Injector jammed open
- Gasoline in fuel
- ECM program error or hardware

(SYMPTOM 13) LACK OF POWER

- Compensation of individual injector not adapted
- Blocked accelerator pedal position sensor
- Incorrect state of the electrical pack devices
- Leakage in intake system
- Clogged air filter
- Oil level too high or too low
- Damaged turbocharger or leakage in vacuum line
- Damaged turbocharger
- Clogged fuel filter
- Leakage at the injector
- Clogged return line of high pressure fuel pump
- Clogged injector return line
- Low compression pressure
- Injector not adapted
- Carbon deposit on the injector (sealed holes)
- Poor valve clearance
- Engine coolant temperature too high
- Fuel temperature too high

(SYMPTOM 14) TOO MUCH POWER

- Compensation of individual injector not adapted
- Oil suction (engine racing)
- ECM program error or hardware fault

(SYMPTOM 15) EXCESSIVE FUEL CONSUMPTION

- Not connected fuel return line at injector
- Leakage at the Fuel pressure regulator valve
- Leakage at fuel temperature sensor
- Leakage in high pressure fuel circuit
- Leakage in intake system
- Clogged air filter
- Compensation of individual injector not adapted
- Incorrect state of the electrical pack devices
- Oil level too high or too low
- Bad fuel quality or water ingress in fuel
- Damaged turbocharger
- Low compression pressure
- Injector not adapted
- ECM program error or hardware

(SYMPTOM 16) EXHAUST SMELLS

- Oil suction (engine racing)
- Damaged turbocharger
- Oil level too high or too low
- Compensation of individual injector not adapted
- Poor tightening of injector clamp
- Poor injector washer, no washer or two washer installed
- Injector not adapted
- Carbon deposit on the injector (sealed holes)
- Injector needle stuck (injection possible over a certain pressure)
- Injector jammed open
- ECM program error or hardware fault

(SYMPTOM 17) SMOKES (BLACK, WHITE, BLUE) WHEN ACCELERATING

- Compensation of individual injector not adapted
- Clogged air filter
- Bad fuel quality or water ingress in fuel
- Oil level too high or too low
- Damaged turbocharger
- Oil suction (engine racing)
- Faulty air heater
- Low compression pressure
- Leakage in high pressure fuel circuit
- Intermittent faulty fuel line connection
- Poor tightening of injector clamp
- Poor injector O-ring, no O-ring or two O-ring installed
- Injector not adapted
- Carbon deposit on the injector (sealed holes)
- Injector needle stuck (injection possible over a certain pressure)
- Injector jammed open
- Gasoline in fuel
- ECM program error or hardware fault

(SYMPTOM 18) FUEL SMELLS

- Not connected fuel feed line
- Not connected fuel return line at injector
- Leakage at the Fuel pressure regulator valve
- Leakage at fuel temperature sensor
- Leakage at the space.
- Leakage in high pressure fuel circuit

(SYMPTOM 19) THE ENGINE COLLAPSES AT TAKE

- Blocked accelerator pedal position sensor
- Incorrect state of the electrical pack devices
- Clogged air filter
- Inversion of fuel connections (feed & return)
- Faulty fuel filter
- Bad fuel quality or water ingress in fuel
- Air ingress in the low pressure fuel circuit
- Clogged fuel filter
- Intermittent faulty fuel line connection
- No rail pressure sensor signal
- Fuel pressure regulator valve contaminated, stuck, jammed
- Rail pressure regulator valve contaminated, stuck, jammed
- Gasoline in fuel
- ECM program error or hardware fault
- Faulty accelerator pedal position sensor

(SYMPTOM 20) ENGINE DOES NOT STOP

- Stuck or worn lubrication circuit of turbocharger
- Too much engine oil
- Leakage at vacuum hose
- ECM program error or hardware fault

(SYMPTOM 21) DIFFERENT MECHANICAL NOISES

- Buzzer noise (discharge by the injectors)
- Incorrect state of the electrical pack devices
- Leakage in intake system
- Poor tightening of injector clamp
- Damaged turbocharger
- Poor valve clearance

Diesel Control System

Description

1. Engine is hard to start or does not start at all.
2. Unstable idle.
3. Poor drive ability.

NOTICE

- Before removing or installing any part, read the diagnostic trouble code and then disconnect the battery negative (-) terminal.

- Before disconnecting the cable from battery terminal, turn the ignition switch to OFF. Removal or connection of the battery cable during engine operation or while the ignition switch is ON could cause damage to the ECM.

- Checking the generator for the charging state, do not disconnect the battery '+' terminal to prevent the ECM from damage due to the voltage.

- Charging the battery with the external charger, disconnect the engine side battery terminals to prevent damage to the ECM.

Self-diagnosis

If a sensor connector is disconnected with the ignition switch turned on, the diagnostic trouble code (DTC) is recorded. In this case, disconnect the battery negative terminal (-) for 15 seconds or more, and the diagnosis memory will be erased..

Checking Procedure (Self-diagnosis)

NOTICE

• When battery voltage is excessively low, diagnostic trouble codes can not be read. Be sure to check the battery for voltage and the charging system before starting the test

• Diagnosis memory is erased if the battery or the ECM connector is disconnected. Do not disconnect the battery before the diagnostic trouble codes are completely read and recorded.

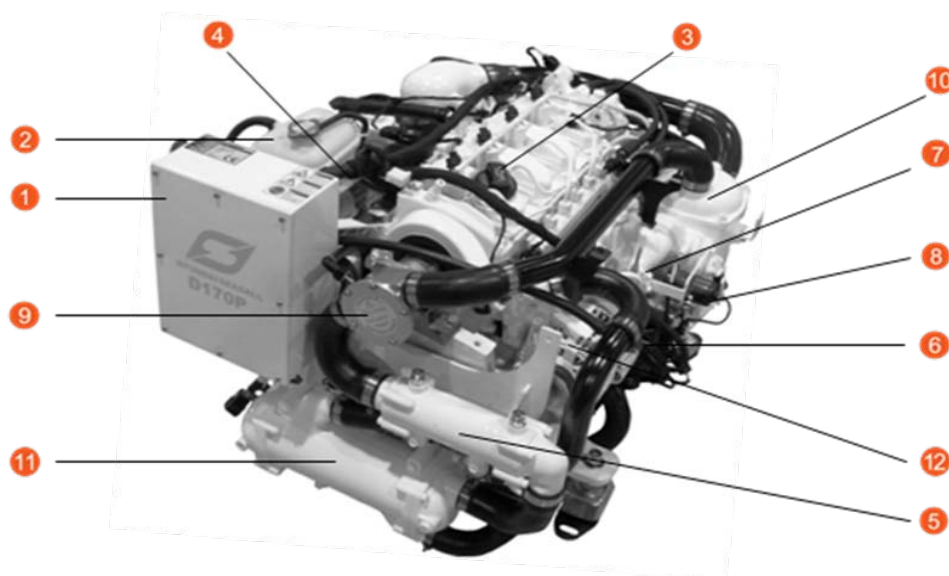
Inspection Procedure (Using Generic Scan Tool)

1. Turn OFF the ignition switch.
2. Connect the scan tool to the data link connector
3. Turn ON the ignition switch.
4. Use the scan tool to check the diagnostic trouble code. .
5. Repair the faulty part from the diagnosis chart
6. Erase the diagnostic trouble code..
7. Disconnect the GST.

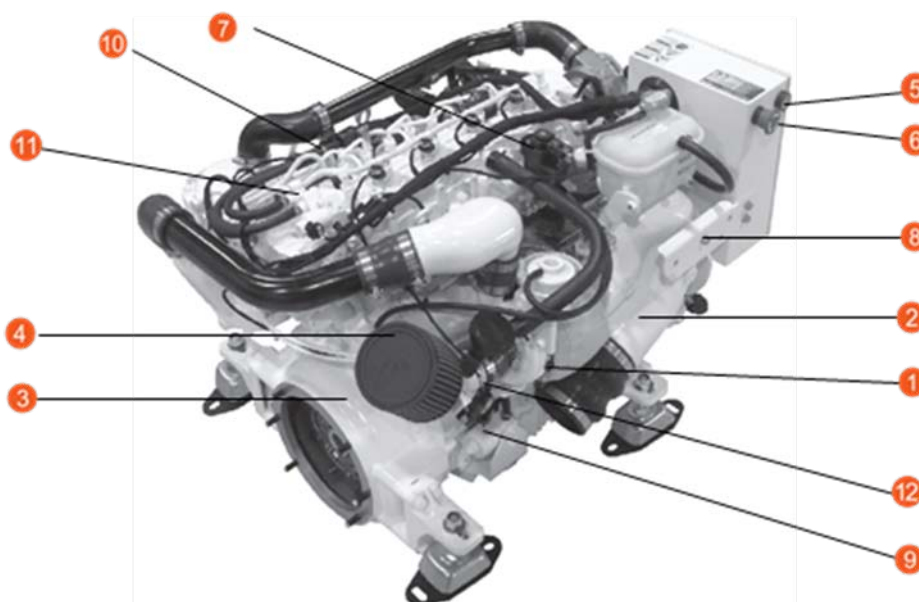
NOTICE

When deleting diagnostic trouble code, use scan tool as possible..

Component Location



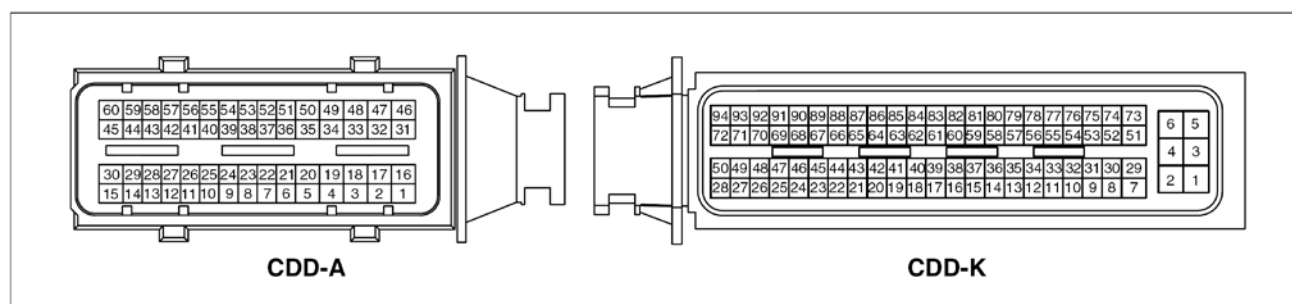
- | | |
|---------------------------|------------------------------|
| 1. ECU Box | 7. Engine oil level gauge |
| 2. Coolant Expansion Tank | 8. Acceleration Lever Sensor |
| 3. Engine Oil Cap | 9. Seawater Pump |
| 4. Engine Oil Filter | 10. Intercooler |
| 5. P/S Oil Cooler | 11. Heat Exchanger |
| 6. Fuel Pump | 12. Alternator |



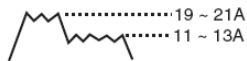
- | | |
|---------------------------------|------------------------|
| 1. VGT | 7. VGT controller |
| 2. Exhaust Elbow | 8. Shift Plate |
| 3. Bell Housing | 9. Oil Extraction Pump |
| 4. Air Filter | 10. Injector |
| 5. Engine Oil Exchange Button | 11. PRV |
| 6. Engine Emergency Stop Button | 12. BPS & IATS |

ECM (ENGINE CONTROL MODULE)

1. ECM Harness connector



CONNECTOR [CDD-A]				
Pin	Description	Type	State	Level
1	Injector (Cylinder #3) [HIGH] control output	Idle	Pulse	B+ ~ 80V
2	Injector (Cylinder #2) [HIGH] control output	Idle	Pulse	
4	Battery power	Idle	DC	Vbatt
6	Sensor ground	Idle	DC	Max. 50mV
7	Sensor shield	Idle	DC	Max. 50mV
8	Sensor ground	Idle	DC	Max. 50mV
12	Crankshaft Position Sensor (CKPS)[-] signal input	Idle	Sine Wave	Vp_p : Min.1.0V
13	Sensor power (+5V)	IG ON	DC	4.9 ~ 5.1V
16	Injector (Cylinder #1) [HIGH] control output	Idle	Pulse	Vbatt ~ 80V
17	Injector (Cylinder #4) [HIGH] control output	Idle	Pulse	
19	Battery power	IG ON	DC	Vbatt
20	CAM position Sensor ground	Idle	DC	Max. 50mV
23	Sensor ground	Idle	DC	Max. 50mV
26	Sensor power (+5V)	IG ON	DC	4.9 ~ 5.1V
27	Crankshaft Position Sensor (CKPS)[+] signal input	Idle	Sine Wave	Vp_p : Min.1.0V
28	Sensor power (+5V)	IG ON	DC	4.9 ~ 5.1V
31	Injector (Cylinder #2) [LOW] control output	Idle	Pulse	Peak Current : 19 ~ 21 A Hold Current : 11~ 13 A
33	Injector (Cylinder #4) [LOW] control output	Idle	Pulse	

34	Rail Pressure Regulator Valve control output	Idle	Pulse	Hi: Vbatt Lo: Max. 1.0V Frequency = 1kHz \pm 2%
40	Boost Pressure Sensor (BPS) signal input	IG ON	Analog	0.5 ~ 4.5V
41	Sensor ground	Idle	DC	Max. 50mV
43	Rail Pressure Sensor (RPS) signal input	IG ON	Analog	0.5 ~ 4.5V
44	Sensor ground	Idle	DC	Max. 50mV
45	Fuel Pump Relay control output	Relay OFF	DC	Vbatt
		Relay ON		Max. 1.0V
46	Injector (Cylinder #3) [LOW] control output	Idle	Pulse	Peak Current : 19 ~ 21 A Hold Current : 11~ 13 A 
47	Injector (Cylinder #1) [LOW] control output	Idle	Pulse	
49	Fuel Pressure Regulator Valve control output	Idle	Pulse	Hi: Vbatt Lo: Max. 1.0V
50	Camshaft Position Sensor (CMPS) signal input	Idle	Pulse	Hi: Vbatt Lo: Max. 1.0V
53	Intake Air Temperature Sensor (IATS) #2 signal input	Idle	Analog	0.5 ~ 4.5V
58	Engine Coolant Temperature Sensor (ECTS) signal input	Idle	Analog	0.5 ~ 4.5V

CONNECTOR [CDD-K]

1	Battery power	IG ON	DC	Vbatt
2	Power ground	Idle	DC	Max. 50 mV
3	Battery power	IG ON	DC	Vbatt
4	Power ground	Idle	DC	Max. 50 mV
5	Battery power	IG ON	DC	Vbatt
6	Power ground	Idle	DC	Max. 50 mV
8	Sensor ground	Idle	DC	Max. 50mV
9	Accelerator Position Sensor (APS) #1 signal input	C.T	Analog	0.3 ~ 0.9V
		W.O.T		4.0 ~ 4.8V
10	Sensor ground	Idle	DC	Max. 50mV
11	Fuel Temperature Sensor (FTS) signal input	IG ON	Analog	0.5 ~ 4.5V
12	Sensor ground	Idle	DC	Max. 50mV
16	Ground	Idle	DC	Max. 50mV
22	Sensor power (+5V)	IG ON	DC	4.9 ~ 5.1V
24	Sensor power (+5V)	IG ON	DC	4.9 ~ 5.1V

25	Diagnosis K-Line	When transmitting	Pulse	Hi: Min. Vbatt×80% Lo: Max. Vbatt×20%
		When receiving		Hi: Min. Vbatt×70% Lo: Max. Vbatt×30%
28	Battery power	IG ON	DC	Vbatt
29	VGT Control Solenoid Valve control output	Idle	Pulse	Hi: Vbatt Lo: Max. 0.5V
30	Sensor ground	Idle	DC	Max. 50mV
31	Accelerator Position Sensor (APS) #2 signal input	C.T	Analog	0.3 ~ 0.9V
		W.O.T		1.5 ~ 3.0V
33	Sensor ground	Idle	DC	Max. 50mV
35	Sensor ground	Idle	DC	Max. 50mV
37	Sensor ground	Idle	DC	Max. 50mV
40	Water Sensor signal input	Full of Water	Analog	Vbatt
44	Sensor power (+5V)	IG ON	DC	4.9 ~ 5.1V
45	Sensor power (+5V)	IG ON	DC	4.9 ~ 5.1V
46	Sensor power (+5V)	IG ON	DC	4.9 ~ 5.1V
48	Engine speed signal output	Idle	Pulse (4pulse/rev.)	Hi: Vbatt Lo: Max. 5V Frequency : 50~60Hz
68	Malfunction Indicator Lamp (MIL) control output	Lamp OFF	DC	Vbatt
		Lamp ON		Max. 1.0V
72	Main Relay control output	Relay OFF	DC	Vbatt
		Relay ON		Max. 1.0V
83	CAN [LOW]	Recessive	Pulse	2.0 ~ 3.0 V
		Dominant		0.5 ~ 2.25 V
84	CAN [HIGH]	Recessive	Pulse	2.0 ~ 3.0 V
		Dominant		2.75 ~ 4.5 V
89	Intake Air Temperature Sensor (IATS) #1 signal input	Idle	Analog	0.5 ~ 4.5V
93	Glow Relay control output	Relay ON	DC	Max. 1.0V

ECM replacement

1. Turn ignition switch OFF and disconnect the negative (-) battery cable.
2. Disconnect the ECM connector
3. Unscrew the ECM mounting bolts and remove the ECM.
4. Install a new ECM.

ECM problem inspection procedure

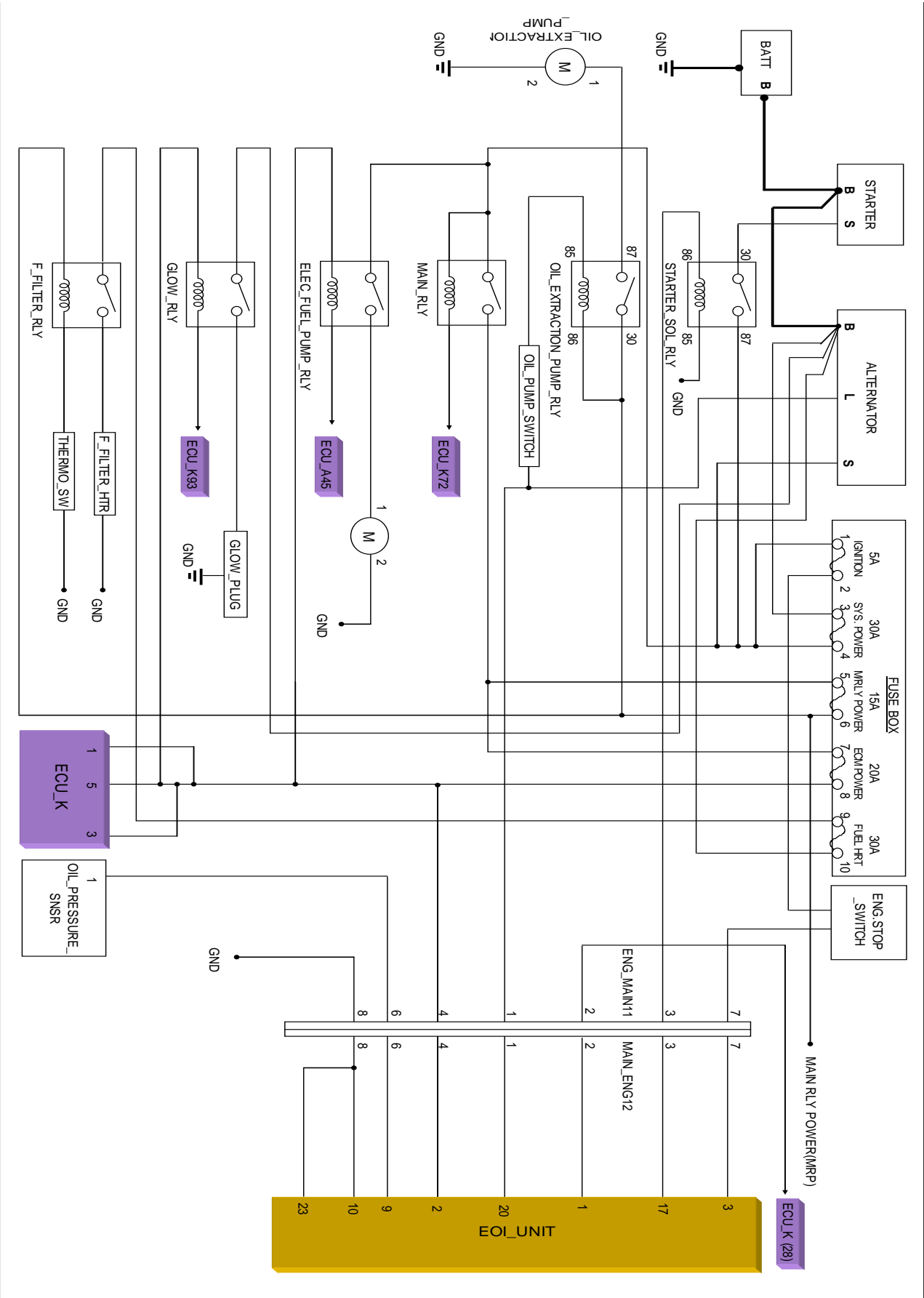
1. TEST ECM GROUND CIRCUIT: Measure resistance between ECM and chassis ground using the backside of ECM harness connector as ECM side check point.

If the problem is found, repair it.

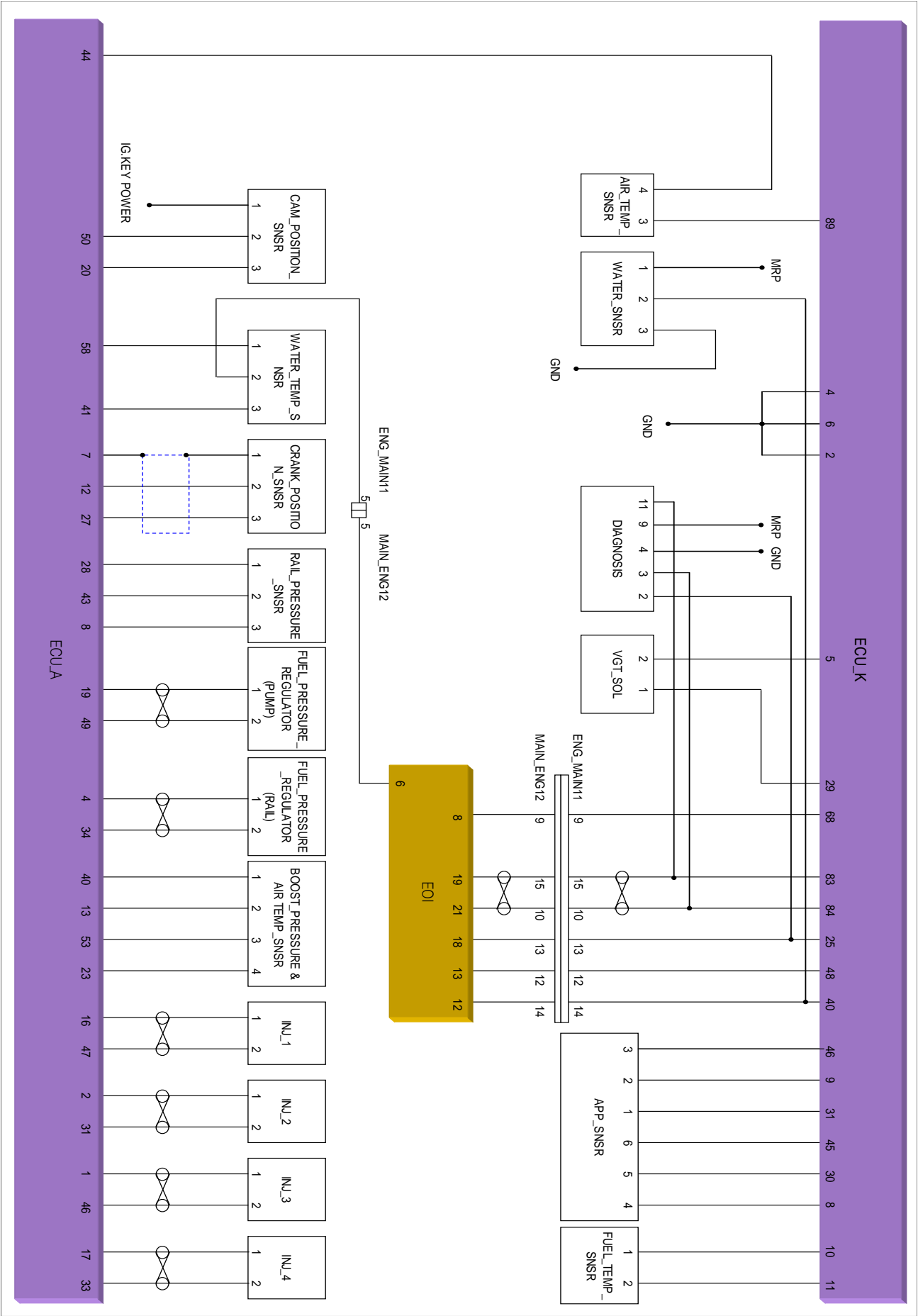
2. TEST ECM CONNECTOR: Disconnect the ECM connector and visually check the ground terminals on ECM side and harness side for bent pins or poor contact contact pressure. If the problem is found, repair it.

3. If problem is not found in Step 1 and 2, the ECM could be faulty. If so, replace the ECM with a new one, and then check the vehicle again. If the vehicle operates normally then the problem was likely with the ECM.

4. RE-TEST THE ORIGINAL ECM : Install the original ECM (may be broken) into a known-good vehicle and check the vehicle. If the problem occurs again, replace the original ECM with a new one. If problem does not occur, this is intermittent problem (Refer to INTERMITTENT PROBLEM PROCEDURE in BASIC INSPECTION PROCEDURE)



ECM Circuit Diagram-2

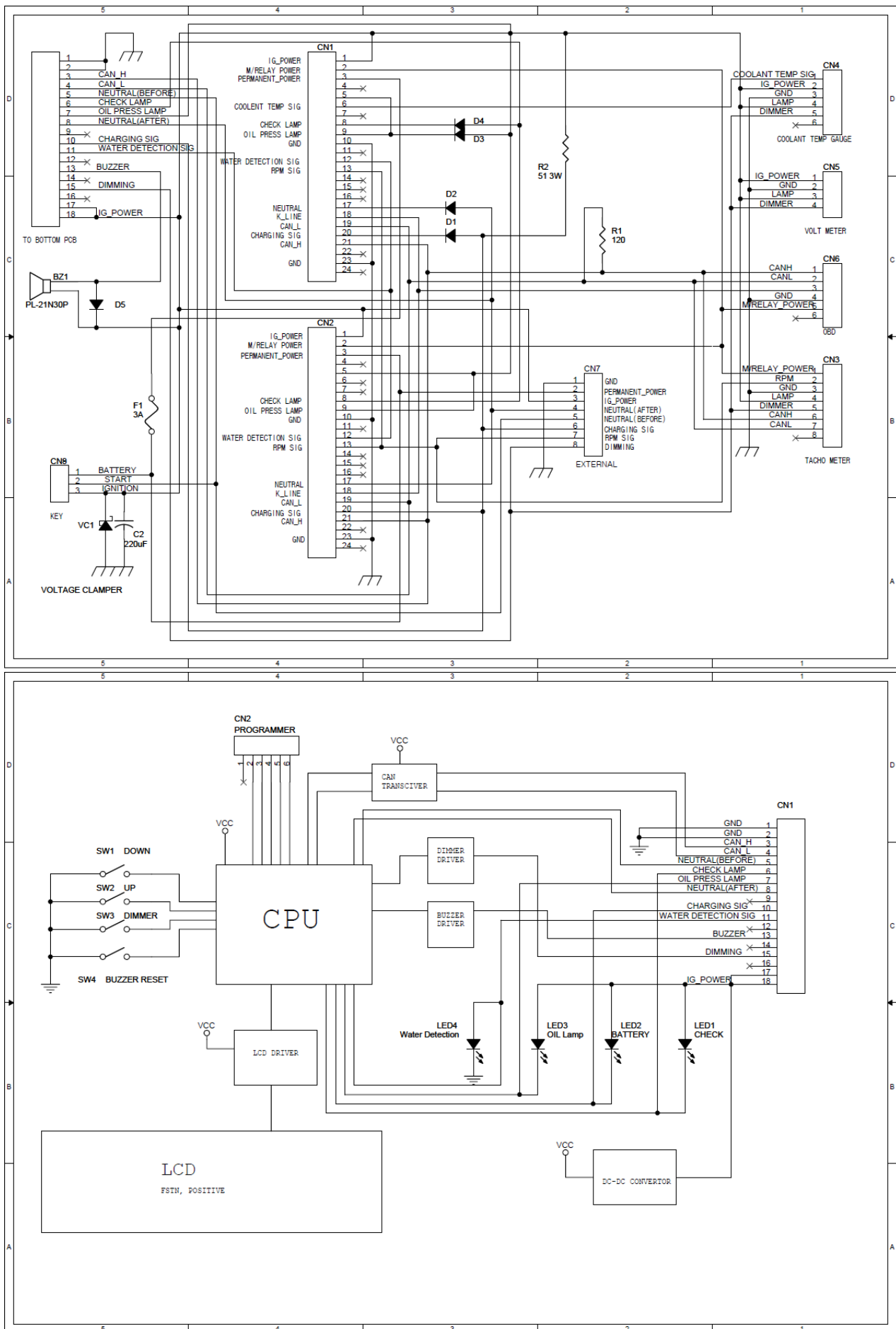


ECM Circuit Diagram-3

CONNECTOR [CDD-A]	
Pin	Description
1	Injector (Cylinder #3) [HIGH] control output
2	Injector (Cylinder #2) [HIGH] control output
4	Battery power
6	Sensor ground
7	Sensor shield
8	Sensor ground
12	Crankshaft Position Sensor (CKPS)[-] signal input
13	Sensor power (+5V)
16	Injector (Cylinder #1) [HIGH] control output
17	Injector (Cylinder #4) [HIGH] control output
19	Battery power
20	CAM position Sensor ground
23	Sensor ground
26	Sensor power (+5V)
27	Crankshaft Position Sensor (CKPS)[+] signal input
28	Sensor power (+5V)
31	Injector (Cylinder #2) [LOW] control output
33	Injector (Cylinder #4) [LOW] control output
34	Rail Pressure Regulator Valve control output
40	Boost Pressure Sensor (BPS) signal input
41	Sensor ground
43	Rail Pressure Sensor (RPS) signal input
44	Sensor ground
45	Fuel Pump Relay control output
46	Injector (Cylinder #3) [LOW] control output
47	Injector (Cylinder #1) [LOW] control output
49	Fuel Pressure Regulator Valve control output
50	Camshaft Position Sensor (CMPS) signal input
53	Intake Air Temperature Sensor (IATS) #2 signal input
58	Engine Coolant Temperature Sensor(ECTS) signal input

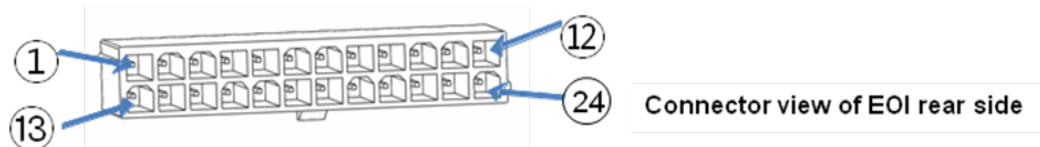
CONNECTOR [CDD-K]	
Pin	Description
1	Battery power
2	Power ground
3	Battery power
4	Power ground
5	Battery power
6	Power ground
8	Sensor ground
9	Accelerator Position Sensor (APS) #1 signal input
10	Sensor ground
11	Fuel Temperature Sensor (FTS)
12	Sensor ground
16	Ground
22	Sensor power (+5V)
24	Sensor power (+5V)
25	Diagnosis K-Line
28	Battery power
29	VGT Control Solenoid Valve control output
30	Sensor ground
31	Accelerator Position Sensor (APS) #2 signal input
33	Sensor ground
35	Sensor ground
37	Sensor ground
40	Water Sensor signal input
44	Sensor power (+5V)
45	Sensor power (+5V)
46	Sensor power (+5V)
48	Engine speed signal output
68	Malfunction Indicator Lamp (MIL) control output
72	Main Relay control output
83	CAN [LOW]
84	CAN [HIGH]
89	Intake Air Temperature Sensor (IATS) #1 signal input
93	Glow Relay control output

EOI Circuit Diagram - 1



EOI Circuit Diagram - 2

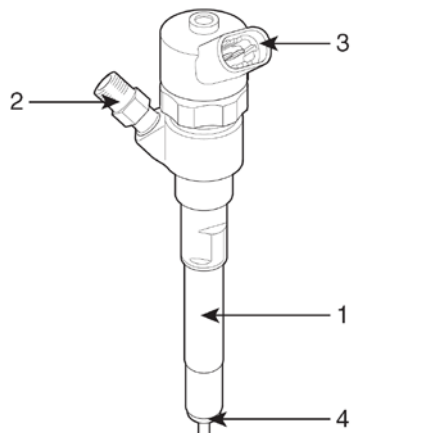
CN1(MAIN EOI CONNECTOR FROM ENGINE)



Connector [EOI]	
Pin	Description
1	Ignition power
2	Main relay power
3	Permanent power
4	Not used
5	Not used
6	Coolant temperature signal
7	Not used
8	Check lamp
9	Oil pressure signal
10	Gnd
11	Not used
12	Water detection signal
13	RPM signal
14	Not used
15	Not used
16	Not used
17	Neutral signal
18	K line
19	CAN_L
20	Changing signal
21	CAN_H
22	Not used
23	Gnd
24	Not used

Injector

Description



- | | |
|---------------|--------------|
| 1. Injector | 3. Connector |
| 2. Fuel Inlet | 4. Washer |

The start of injection and the injected fuel quantity are adjusted by electrically triggered injectors. These injectors supersede the nozzle-and-holder assembly (nozzle and nozzle-holder). Similar to the already existing nozzle holder assemblies in direct-injection (DI) diesel engines, clamps are preferably used for installing the injectors in the cylinder head. This means that the Common Rail injectors can be installed in already existing DI diesel engines without major modifications to the cylinder head

Removal

● CAUTION

• *Common Rail Fuel Injection System operates with extremely high pressure (approximately 1,600bar), so never perform any work on injection system with engine running or within 30 seconds after the engine stops.*

• *Keep cleanly the parts and the working area.*

• *Pay attention to a foreign substance.*

• *Just before installing injector, tube or hose,*

remove the protect-cap attached on them.

• *Do not remove injector except for special case.*

• *When installing Injector*

- *Wash the contact area of the injector and replace the O-ring with a new one.*

- *Spread oil on the injector O-ring.*

- *To protect damage caused by shock, vertically insert the injector into the cylinder head.*

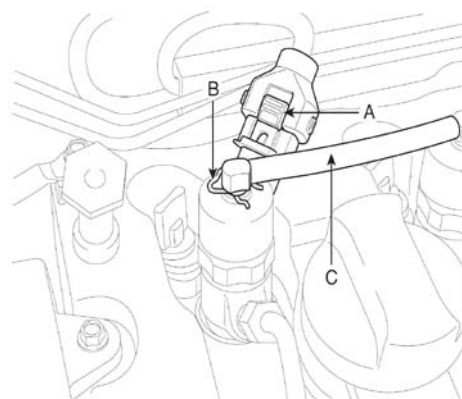
• *When installing High Pressure Fuel Pipe*

- *Do not use again the used high pressure fuel pipe.*

- *Install the flange nut correctly.*

1. Turn ignition switch OFF and disconnect the negative (-) battery cable. .

2. Disconnect the injector connector (A).

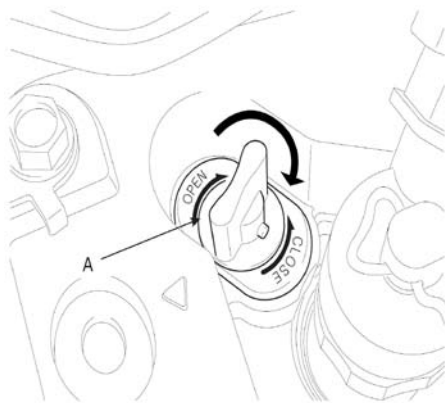


3. After removing the clip (B), disconnect the return hose (C) from the injectors.

4. Disconnect the high pressure fuel pipe (A)

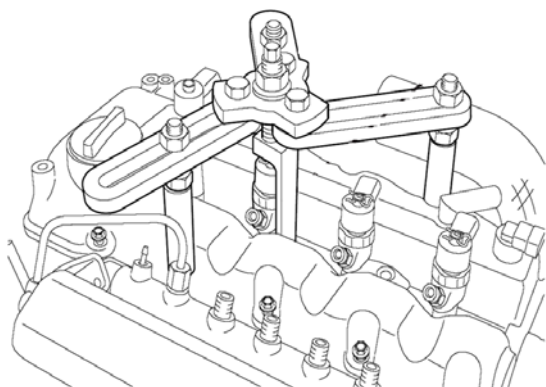
5. Rotate the lever (A) clockwise and pull it upward

6. Unscrew the clamp tightening bolt (A) and pull the injector



NOTICE

If the injector adheres to the cylinder head, use the special Service Tool (SST No. : 00200-0T014).

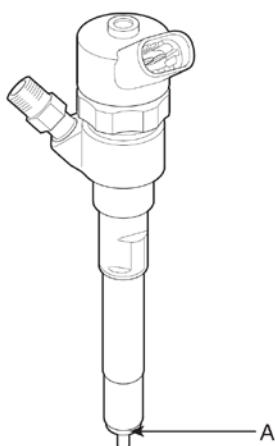


Installation

1. Installation is reverse of removal.

NOTICE

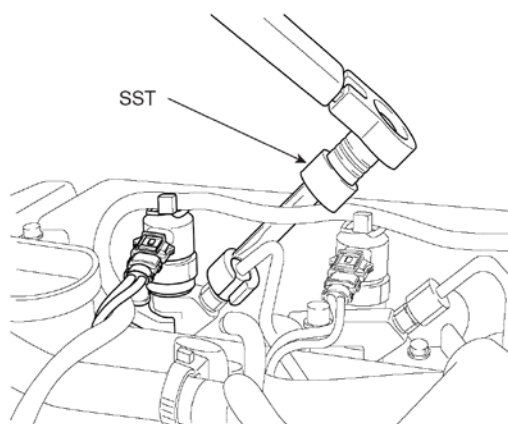
When installing the injector, **MUST REPLACE** the washer (A) and apply a grease to that.



NOTICE

When installing the high pressure fuel pipe, apply the specified tightening torques with the special service tool (Refer to below table).

-
- Injector clamp installation bolt: 24.5 ~ 28.4 N·m (2.5 ~ 2.9 kgf·m, 18.1 ~ 20.1 lbf·ft)
 - High pressure fuel pipe installation nut: 24.5 ~ 28.4 N·m (2.5 ~ 2.9 kgf·m, 18.1 ~ 20.1 lbf·ft)
-



Replacement

● CAUTION

- Common Rail Fuel Injection System operates with extremely high pressure (approximately 1,600bar), so never perform any work on injection system with engine running or within 30 seconds after the engine stops.
- Keep cleanly the parts and the working area.
- Pay attention to a foreign substance.
- Just before installing injector, tube or hose, remove the protect-cap attached on them.
- Do not remove injector except for special case.
- When installing Injector
 - Wash the contact area of the injector and replace the

O-ring with a new one.

- Spread oil on the injector O-ring.
- To protect damage caused by shock, vertically insert the injector into the cylinder head.

• **When installing High Pressure Fuel Pipe**

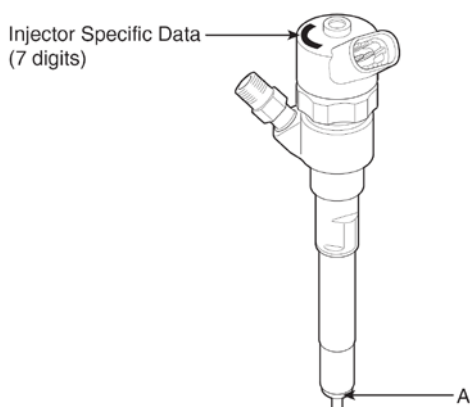
- Do not use again the used high pressure fuel pipe.
- Install the flange nut correctly.

● **CAUTION**

After replacing injector, **MUST** input the injector specific data (7 digits) of each cylinder into ECM with scan tool.

1. Remove the injector (Refer to "REMOVAL" procedure).
2. Install the injector (Refer to "INSTALLATION" procedure).
3. Perform "Injector Specific Data Input" procedure
(Refer to "INJECTOR SPECIFIC DATA INPUT" procedure)

Injector specific data input



1. Turn ignition switch OFF.
2. Connect a scan tool to Data Link Connector (DLC).
3. Turn ignition switch ON.
4. Input the injector data (7 digit)

Inspection

[COMPRESSION TEST]

1. Turn ignition switch OFF.
2. Connect a scan tool to Data Link Connector (DLC).
3. Turn ignition switch ON.
4. Perform the test in accordance with the message.

NOTICE

If a cylinder's engine speed is higher than the other cylinders, the cylinder's compression pressure is low.

[IDLE SPEED COMPARISON]

1. Turn ignition switch OFF.
2. Connect a scan tool to Data Link Connector (DLC).
3. Turn ignition switch ON.
4. Perform the test in accordance with the message

NOTICE

The injector in cylinder with significantly high (low) idle speed injects more (less) quantity than the other injectors.

[INJECTION QUANTITY COMPARISON]

1. Turn ignition switch OFF.
2. Connect a scan tool to Data Link Connector (DLC).
3. Turn ignition switch ON.
4. Perform the test in accordance with the message.

NOTICE

* (+) correction value: Injection quantity is less than the others.

* (-) correction value: Injection quantity is more than the others.

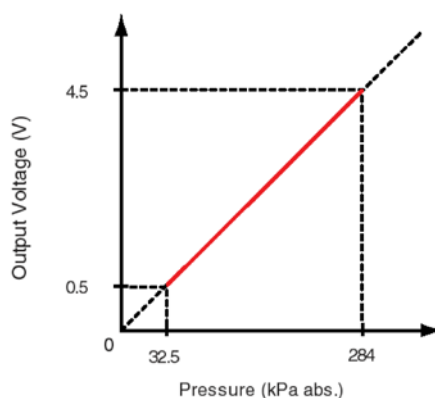
* Very high correction value: The injector may have any fault. At this time, replace the injector with a new one and perform these tests again.

Boost Pressure Sensor & IATS#2

Function And Operation Principle The Boost Pressure Sensor (BPS) is installed on the intercooler assembly and measures the pressure of the compressed air in turbocharger. By using this signal, the ECM controls the Variable Geometry Turbocharger (VGT).

Specification

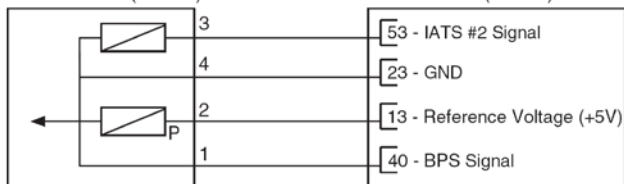
Pressure (Kpa)	Output Voltage (V)	Temperature [°C(°F)]	Resistance (kΩ)
32.5	0.5	-40(-40)	40.93 ~ 48.35
70	1.02 ~ 1.17	-20(-4)	13.89 ~ 16.03
140	2.13 ~ 2.28	0(32)	5.38 ~ 6.09
210	3.25 ~ 3.40	20(68)	2.31 ~ 2.57
270	4.20 ~ 4.35	40(104)	1.08 ~ 1.21
284	4.5	60(140)	0.54 ~ 0.62
		80(176)	0.29 ~ 0.34



[CIRCUIT DIAGRAM]

BPS & IATS #2 (CDD39)

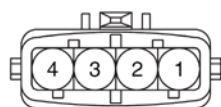
ECM (CDD-A)



[CONNECTION INFORMATION]

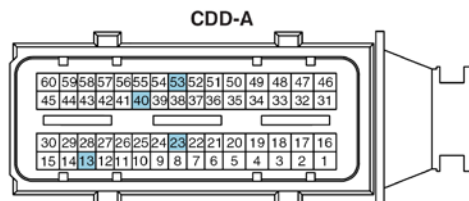
Terminal	Connected to	Function
1	ECM CDD-A (40)	BPS Signal
2	ECM CDD-A (13)	Reference Voltage (+5V)
3	ECM CDD-A (53)	IATS #2 Signal
4	ECM CDD-A (23)	Sensor ground

[HARNESS CONNECTORS]

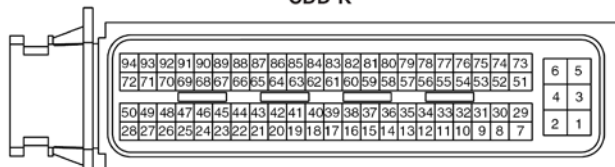


CDD39

BPS & IATS #2



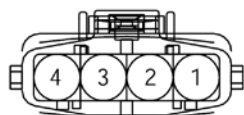
CDD-K



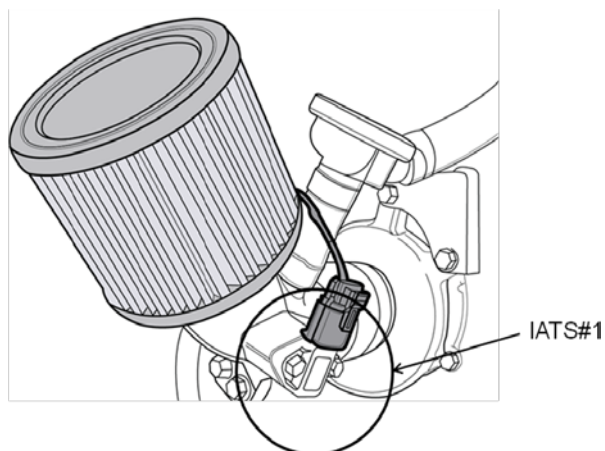
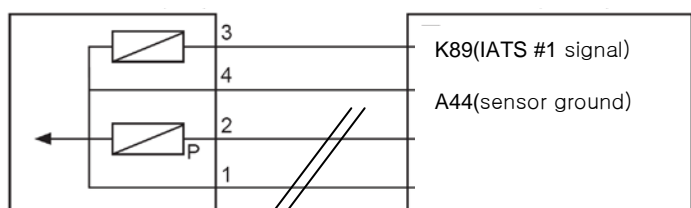
ECM

Intake Air Temperature Sensor (IATS) #1

Intake Air Temperature Sensor (IATS) uses a Negative Temperature Characteristics (NTC) thermistor and senses intake air temperature. Two intake air temperature sensors are installed in this engine.



IATS #1



Engine coolant temperature sensor (ECTS)

Inspection

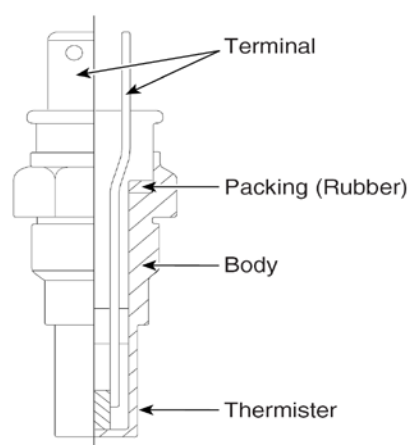
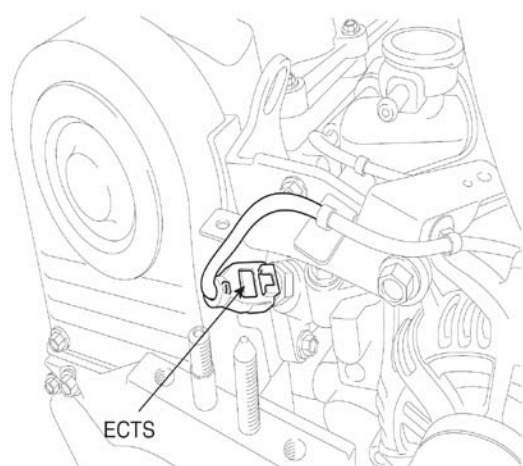
Function and operation principle

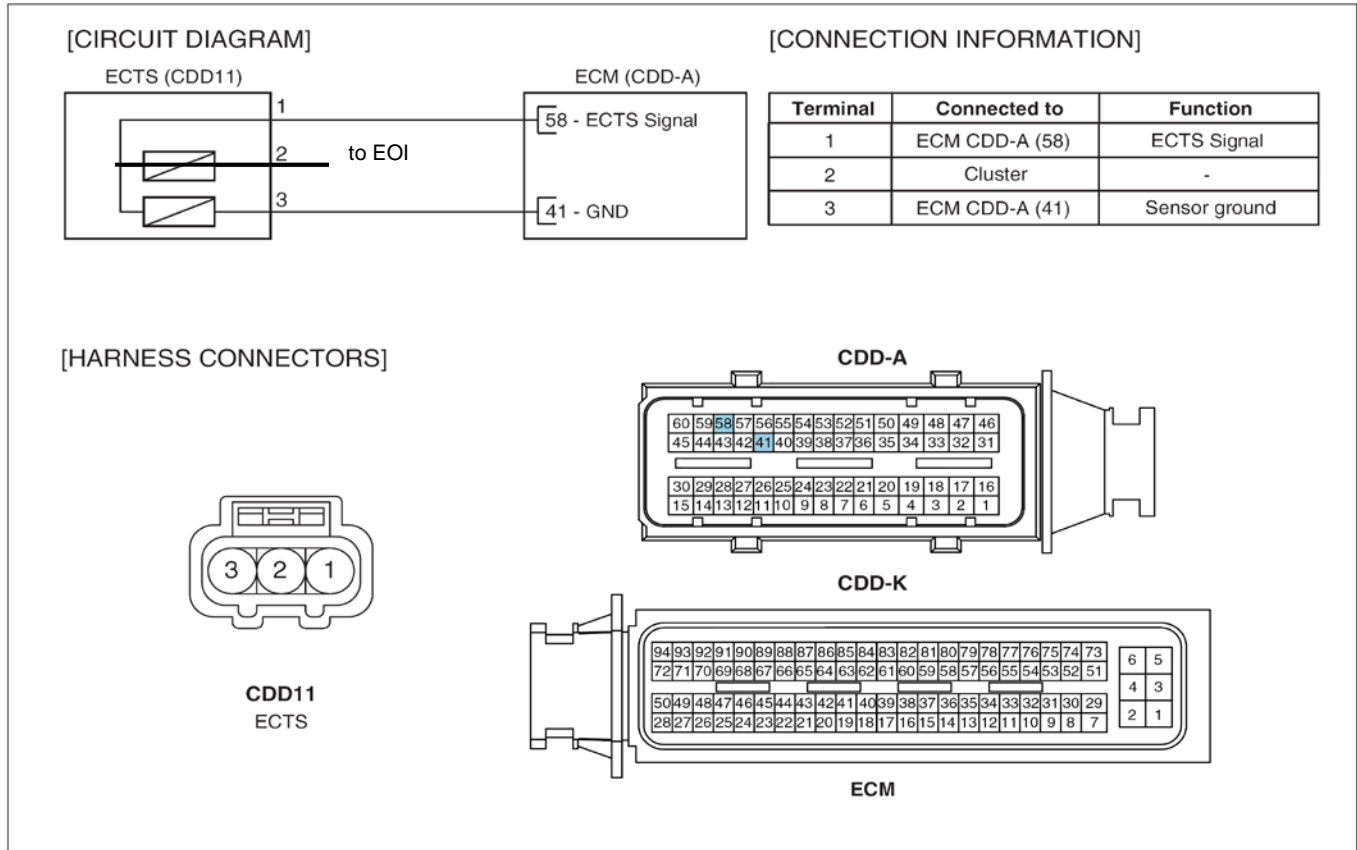
Engine Coolant Temperature Sensor (ECTS) is located in the engine coolant passage of the cylinder head for detecting the engine coolant temperature. The ECTS uses a thermistor whose resistance changes with the temperature.

The electrical resistance of the ECTS decreases as the temperature increases, and increases as the temperature decreases.

Specification

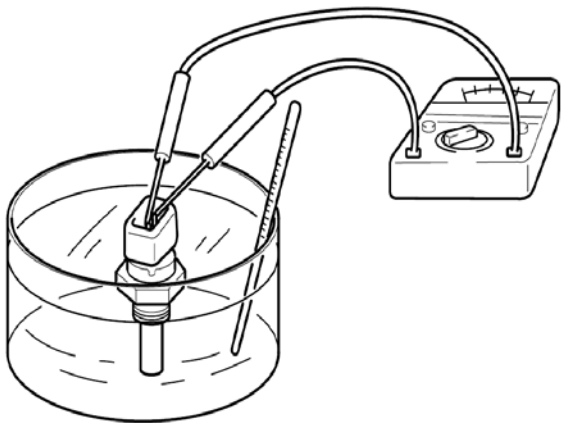
Temperature [°C (°F)]	Resistance(k Ω)
-40(-40)	48.14
-20(-4)	14.13 ~ 16.83
0(32)	5.79
20(68)	2.31 ~ 2.59
40(104)	1.15
60(140)	0.59
80(176)	0.32





Component inspection

1. Turn ignition switch OFF.
2. Disconnect the engine coolant temperature sensor connector.
3. Remove the sensor.
4. After immersing the thermistor of the sensor into engine coolant, measure resistance between ECTS signal terminal and ground terminal.
5. Check that the resistance is within the specification.

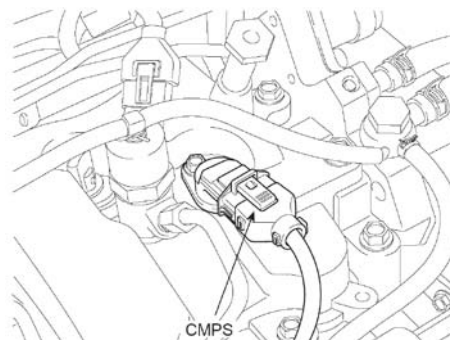


Camshaft position sensor (CMPS)

Inspection

Function and operation principle

Camshaft Position Sensor (CMPS) is a hall sensor and detects the camshaft position by using a hall element. It is related with Crankshaft Position Sensor (CKPS) and detects the piston position of the each cylinder which the CKPS can't detect. The two CMPS are installed on engine head cover and uses a target wheel installed on the camshaft. This sensor has a hall-effect IC which output voltage changes when magnetic field is made on the IC with current flow. So the sequential injection of the 4 cylinders is impossible without CMPS signal.

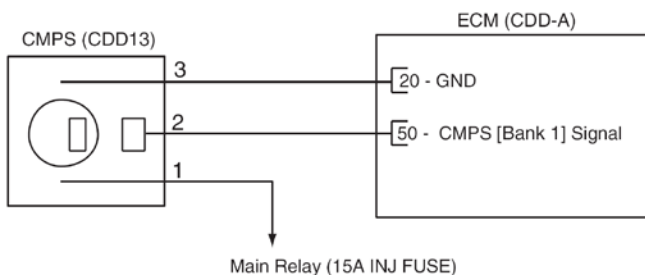


Specification

Level	Output Pulse (V)
High	12V
Low	0V

Items	Specification
Air Gap	1.5 ± 0.1 mm

[CIRCUIT DIAGRAM]



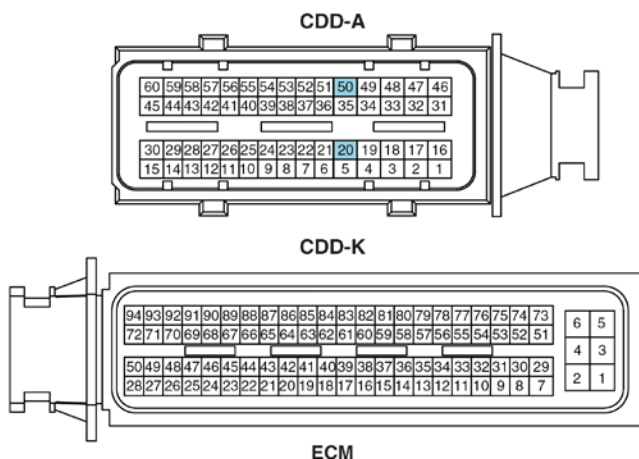
[CONNECTION INFORMATION]

Terminal	Connected to	Function
1	E/R CDD (32)	Battery Voltage
2	ECM CDD-A (50)	CMPS Signal
3	ECM CDD-A (20)	GND

[HARNESS CONNECTORS]



CDD13
CMPS

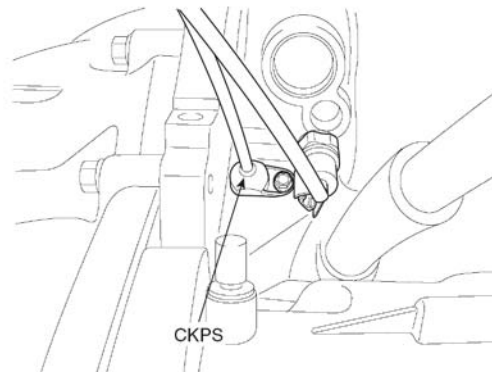


Crankshaft position sensor(CKPS)

Inspection

Function and operation principle

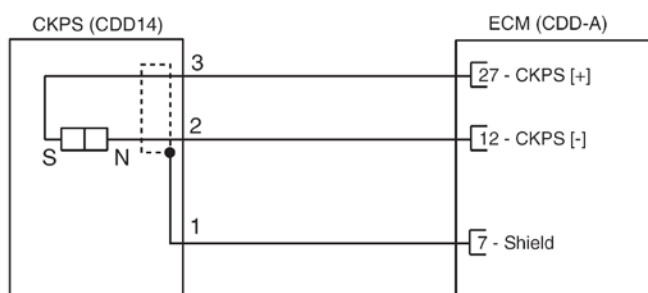
Piston position on combustion chamber is the substantial to define the starting of injection timing. All engine pistons are connected to crankshaft by connecting rod. Sensor on crankshaft can supply the information concerning all piston positions, revolution speed is defined by revolution permute of crankshaft. Prior input variable is determined at ECM by using signal induced from crankshaft position



Specification

Items	Specification
Coil Resistance (Ω)	774 ~ 946 Ω [20°C(68°F)]

[CIRCUIT DIAGRAM]



[CONNECTION INFORMATION]

Terminal	Connected to	Function
1	ECM CDD-A (7)	Sensor Shield
2	ECM CDD-A (12)	CKPS [-] Signal
3	ECM CDD-A (27)	CKPS [+] Signal

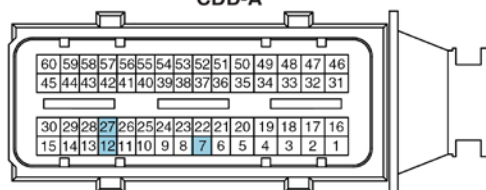
[HARNESS CONNECTORS]



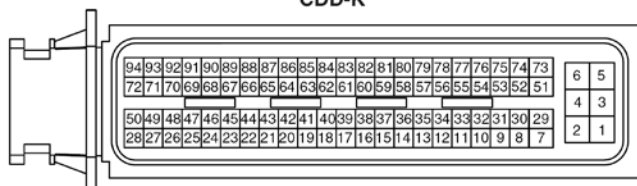
CDD14

CKPS

CDD-A



CDD-K



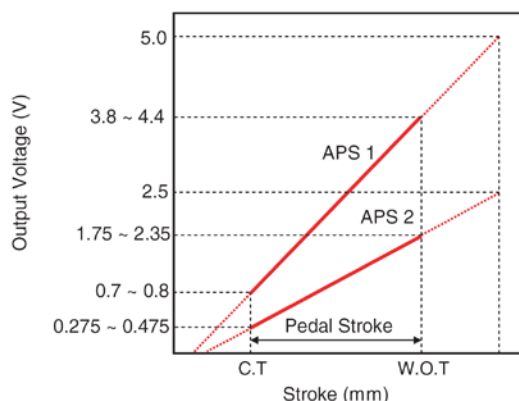
ECM

Accelerator position sensor (APS)

Inspection

Function and operation principle

The two potentiometers are supplied from distinct and different power sources so there is built in redundancy of information giving reliable driver's request information. A voltage is generated across the potentiometer in the acceleration position sensor as a function of the accelerator-pedal setting. Using a programmed characteristic curve, the pedal's position is then calculated from this voltage.

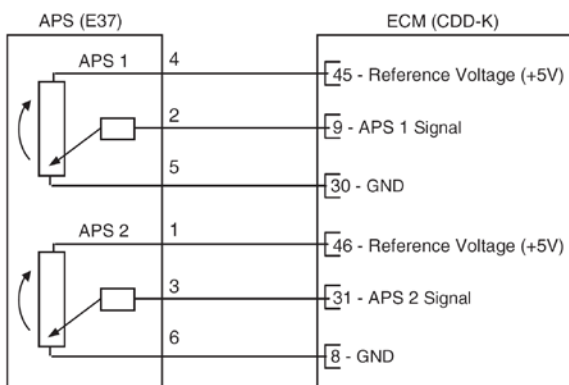


Specification

Test Condition	Output Voltage(V)	
	APS 1	APS 2
Idle	0.7 ~ 0.8	0.275 ~ 0.475
Fully depressed	3.8 ~ 4.4	1.75 ~ 2.35

Items	Specification	
	APS 1	APS 2
Potentiometer Resistance (k Ω)	0.7 ~ 1.3	1.4 ~ 2.6

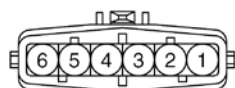
[CIRCUIT DIAGRAM]



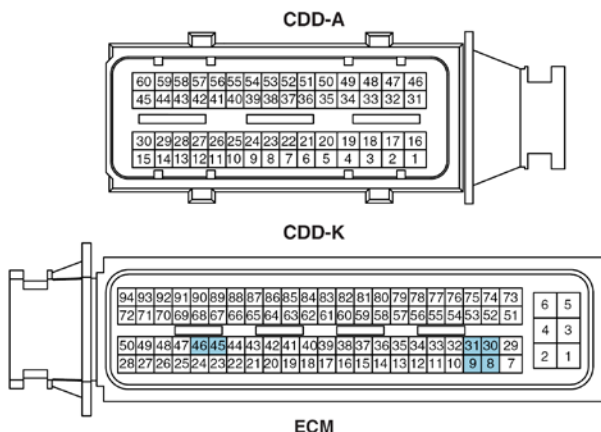
[CONNECTION INFORMATION]

Terminal	Connected to	Function
1	ECM CDD-K (31)	APS 2 Signal
2	ECM CDD-K (8)	APS 2 Ground
3	ECM CDD-K (9)	APS 1 Signal
4	ECM CDD-K (30)	APS 1 Ground
5	ECM CDD-K (45)	APS 1 Reference Voltage (+5V)
6	ECM CDD-K (46)	APS 2 Reference Voltage (+5V)

[HARNESS CONNECTORS]



E37
APS



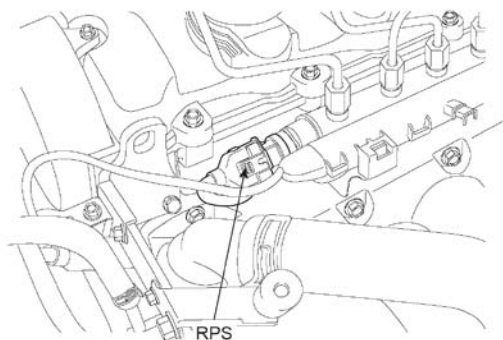
ECM

Rail pressure sensor(RPS)

Inspection

Function and operation principle

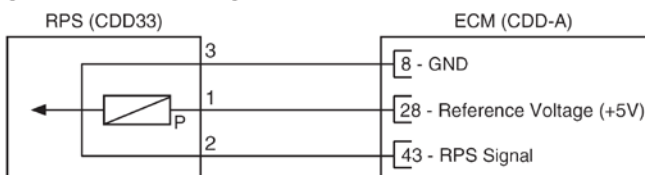
Rail Pressure Sensor (RPS) is installed at the end of the common rail and measures the instantaneous fuel pressure in the common rail by using its diaphragm. Its sensing element (semiconductor device) mounted on the diaphragm converts the fuel pressure to an electric signal.



Specification

Test Condition	Rail pressure (bar)	Output Voltage (V)
Idle	220 ~ 320	Below 1.7
Fully depressed	1,800	Approx. 4.5

[CIRCUIT DIAGRAM]



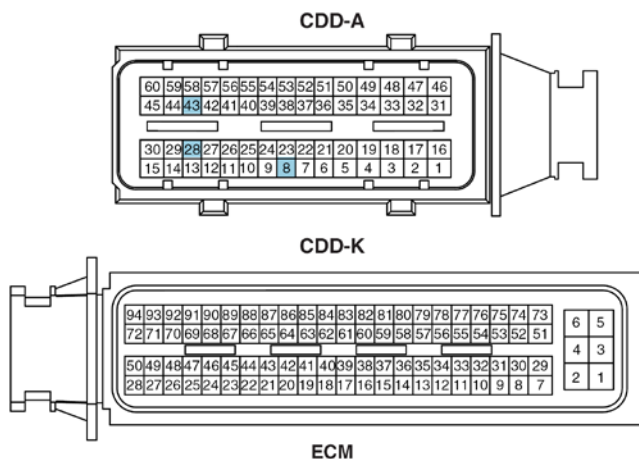
[CONNECTION INFORMATION]

Terminal	Connected to	Function
1	ECM CDD-A (28)	Reference Voltage (+5V)
2	ECM CDD-A (43)	RPS Signal
3	ECM CDD-A (8)	Sensor Signal

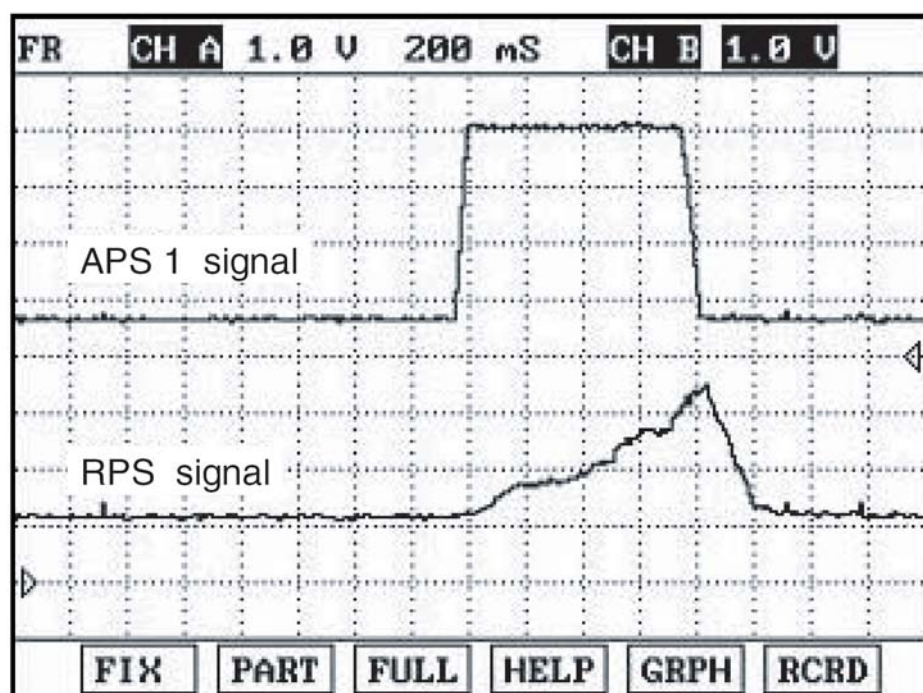
[HARNESS CONNECTORS]



CDD33
RPS



ECM

Signal wave form**Replacement**

● CAUTION

After replacing the Rail Pressure Sensor (RPS), MUST perform the "COMPONENT CHANGE ROUTINE" procedure. Otherwise trouble related with engine performance or emission control may occur until ECM learning about the component is over.

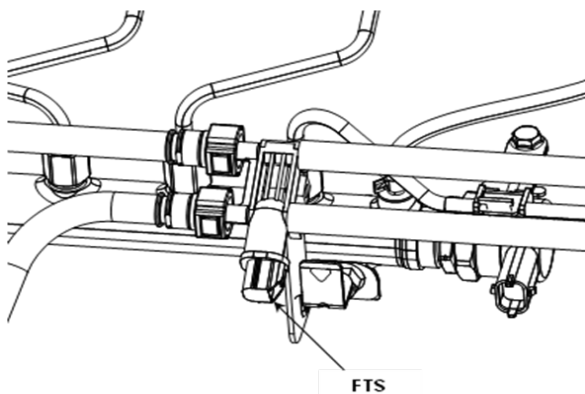
1. Turn ignition switch OFF.
2. Connect a scan tool to Data Link Connector (DLC).
3. Turn ignition switch ON.
4. Select ENGINE"
5. Select "COMPONENT CHANGE ROUTINE".
6. Select "RAIL PRESSURE SENSOR CHANGE".
7. Confirm the message, and then press "ENTER" key.
8. Confirm the "Complete" message, and then turn ignition switch OFF.
9. Wait for more than 10 seconds, and then turn ignition switch ON

Fuel temperature sensor(FTS)

Inspection

Function and operation principle

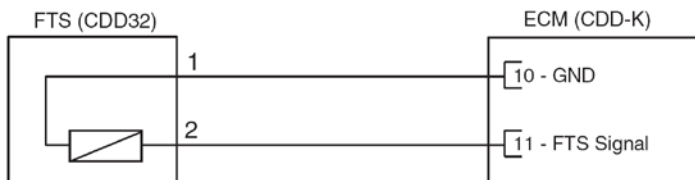
Fuel Temperature Sensor(FTS) is installed in fuel supplying line and senses the temperature of fuel supplied to high pressure pump. Fuel temperature is limited to protect fuel such as high pressure pump and injectors from damages due to rapid deterioration by vapor-lock which can occur at high temperature or destruction of oil membrane.



Specification

Temperature [$^{\circ}\text{C}$ ($^{\circ}\text{F}$)]	Resistance($\text{k}\Omega$)
-10(14)	8.64 ~ 10.15
20(68)	2.35 ~ 2.65
80(176)	0.31 ~ 0.33
120(248)	0.11 ~ 0.12

[CIRCUIT DIAGRAM]



[CONNECTION INFORMATION]

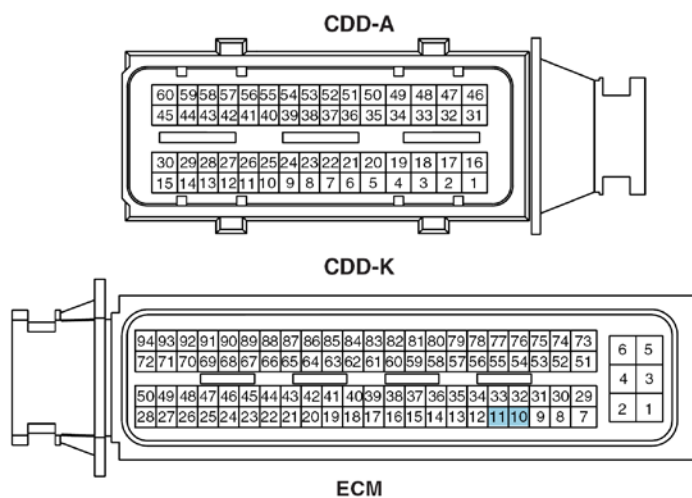
Terminal	Connected to	Function
1	ECM CDD-K (10)	Sensor ground
2	ECM CDD-K (11)	FTS Signal

[HARNESS CONNECTORS]



CDD32

FTS



ECM

Fuel pressure regulator valve

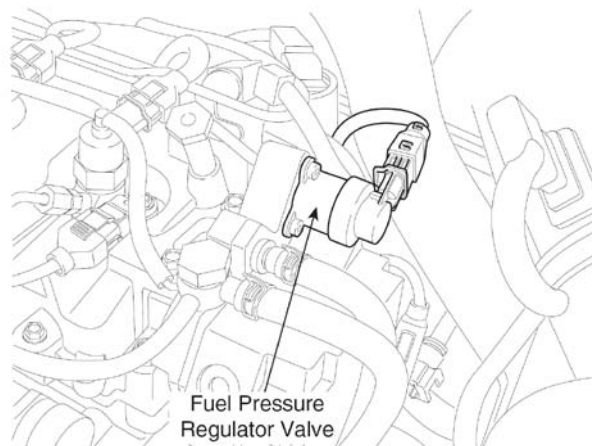
Inspection

Function and operation principle

The Fuel Pressure Regulator Valve and the Rail Pressure

Regulator Valve are installed on high pressure pump and common rail respectively. These valves control fuel inlet (feed) from fuel tank via fuel filter and outlet (return) to fuel tank of high pressure fuel circuit.

This system is called "Dual Fuel Pressure Control System" and can precisely and quickly control the fuel pressure in accordance with various engine conditions by controlling the fuel inlet and outlet simultaneously.



Specification

Items	Specification
Coil Resistance (Ω)	2.6 ~ 3.15 Ω [20°C (68°F)]

[CIRCUIT DIAGRAM]

FUEL PRESSURE
REGULATOR VALVE(CDD38)



ECM (CDD-A)

49 - Valve Control
19 - Power Supply

[CONNECTION INFORMATION]

Terminal	Connected to	Function
1	ECM CDD-A (19)	Battery Voltage (B+)
2	ECM CDD-A (49)	Valve Control

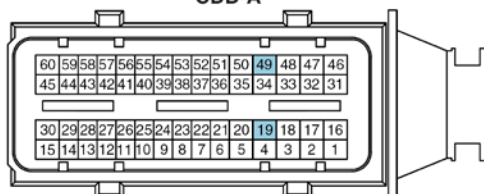
[HARNESS CONNECTORS]



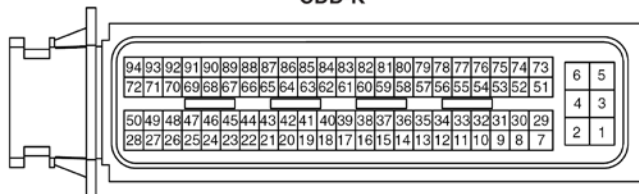
CDD38

FUEL PRESSURE REGULATOR VALVE

CDD-A



CDD-K



ECM

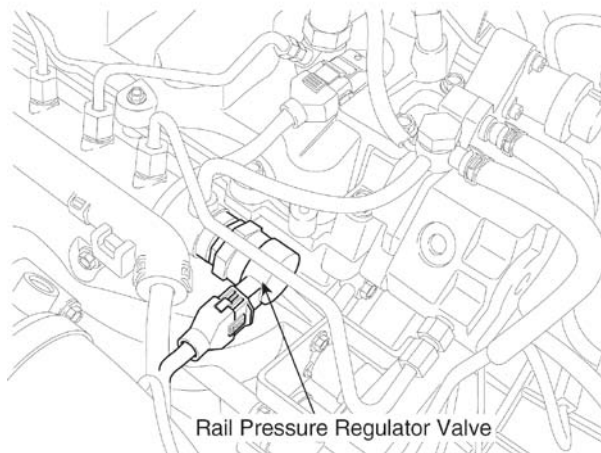
Rail pressure regulator valve

Inspection

Function and operation principle

The Fuel Pressure Regulator Valve and the Rail Pressure Regulator Valve are installed on high pressure pump and common rail respectively. These valves control fuel inlet(feed) from fuel tank via fuel filter and outlet (return) to fuel tank of high pressure fuel circuit.

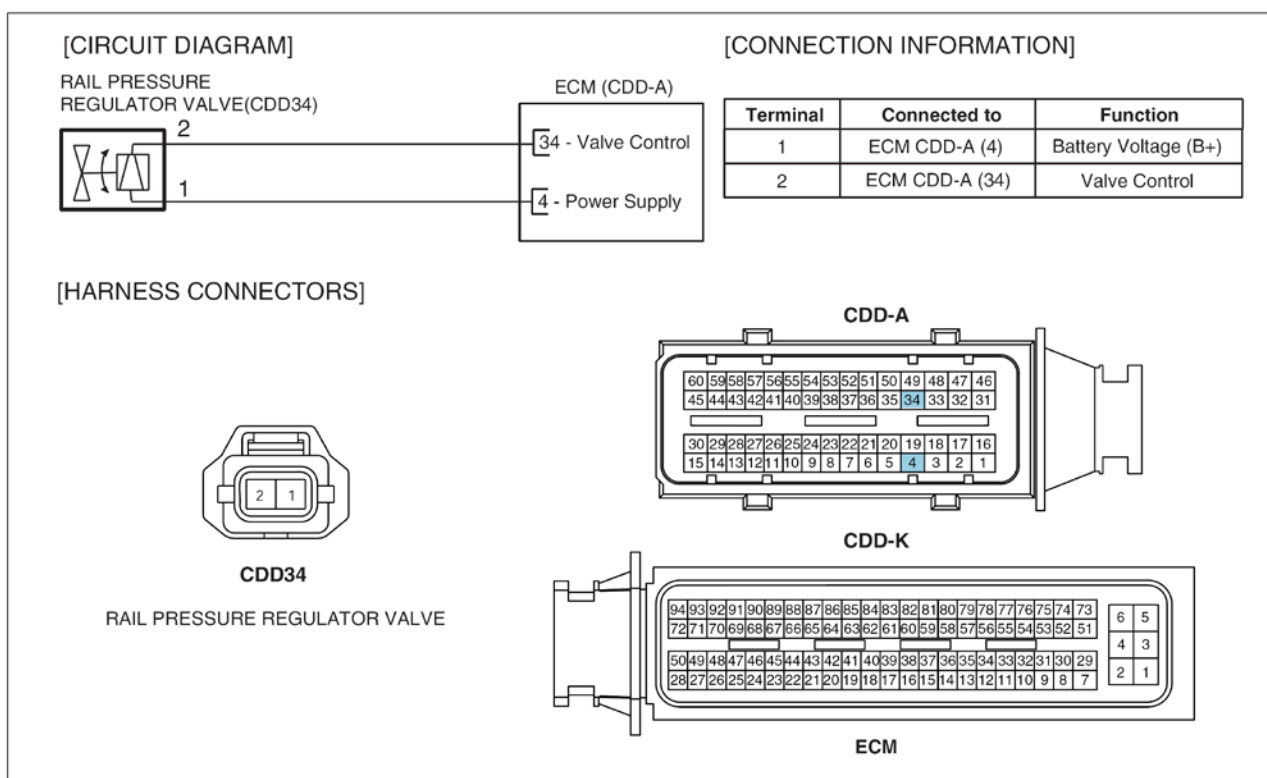
This system is called "Dual Fuel Pressure Control System" and can precisely and quickly control the fuel pressure in accordance with various engine conditions by controlling the fuel inlet and outlet simultaneously



Rail Pressure Regulator Valve

SPECIFICATION

Items	Specification
Coil Resistance (Ω)	3.42 ~ 3.78 Ω [20°C(68°F)]



Water sensor

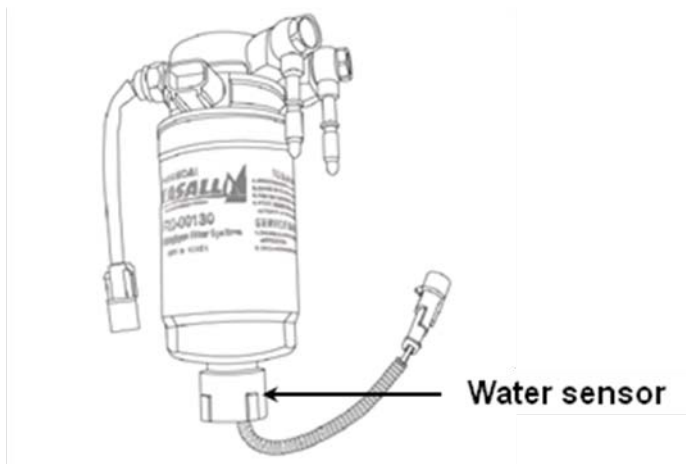
Inspection

Function and operation principle

Water Sensor is installed on bottom end of fuel filter and detects presence of water in fuel. When the water level reaches the lower level of the upper electrode, the "WATER" lamp in cluster should flash. If the water level decreases below the lower electrode, the lamp should turn off.

NOTICE

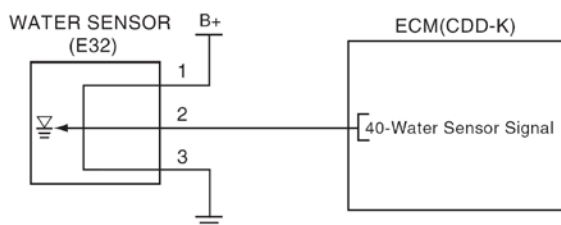
Without presence of water, the lamp should flash for 2 seconds and turn off afterward in order that this system has normal condition.



SPECIFICATION

Item	Specification
Warning Level (cc)	40 ~ 60

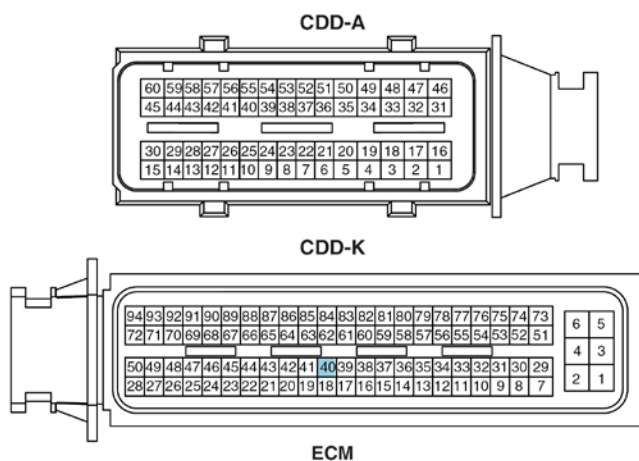
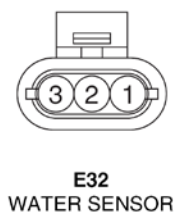
[CIRCUIT DIAGRAM]



[CONNECTION INFORMATION]

Terminal	Connected to	Function
1	Main Relay	Battery voltage(B+)
2	ECM CDD-K (40)	Sensor Signal
3	Chassis ground	Sensor ground

[HARNESS CONNECTOR]



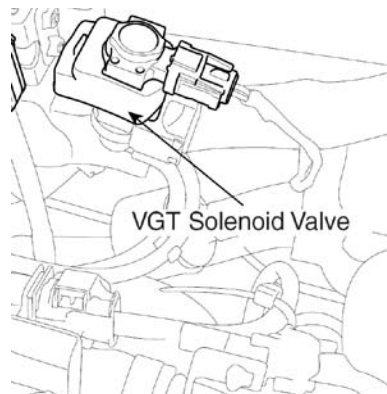
VGT control solenoid valve

Inspection

Function and operation principle

Variable Geometry Turbo-charger (VGT) is used to charge additional air into combustion chamber for improvement of combustion efficiency.

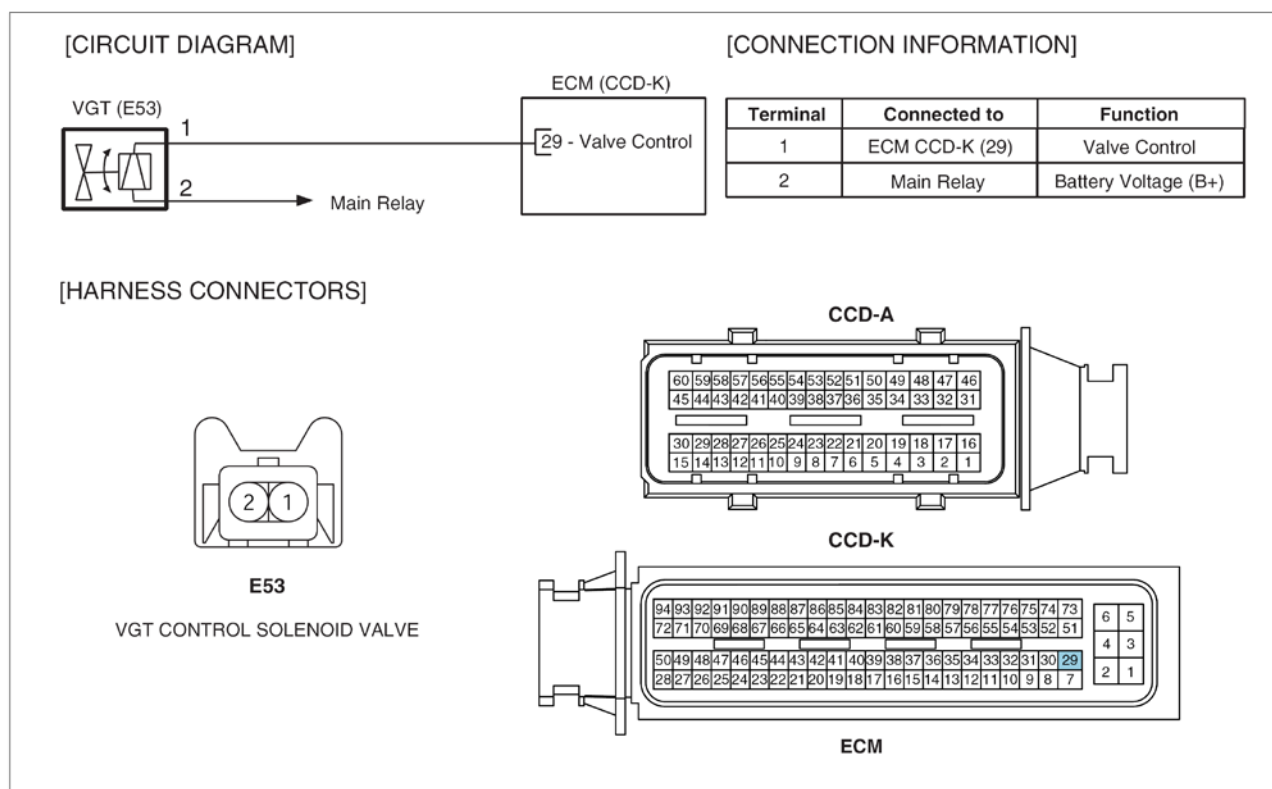
ECM controls the VGT with controlling duty of the VGT control solenoid valve according to engine load. .



SPECIFICATION

Items	Specification
Coil Resistance (Ω)	14.7 ~ 16.1Ω [20℃(68°F)]

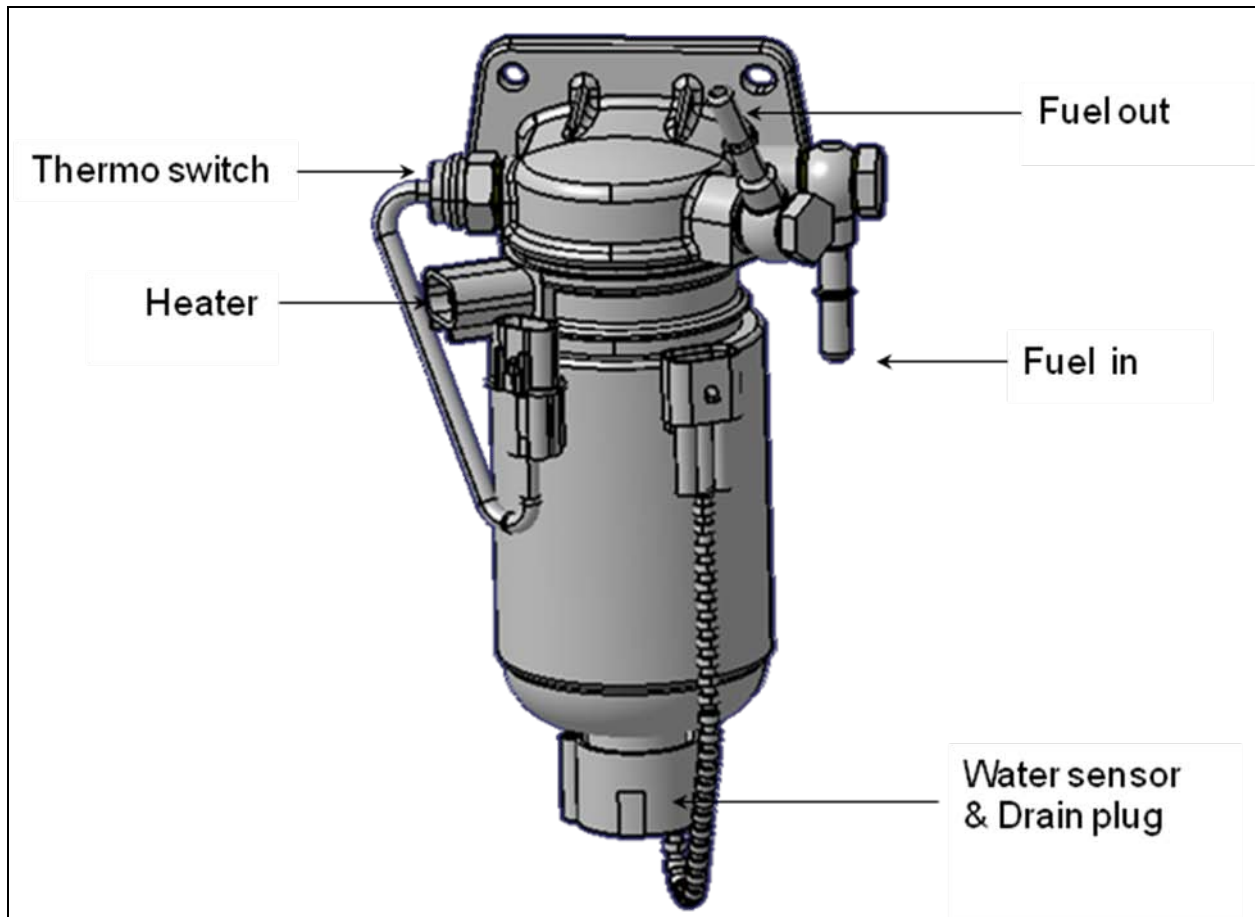
CIRCUIT DIAGRAM



Fuel Delivery System

Fuel Filter

Component



Removal

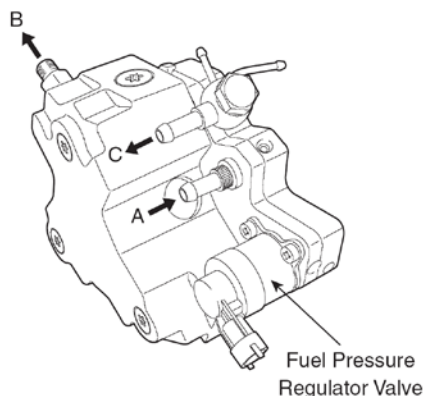
1. Turn ignition switch OFF and disconnect the negative (-) battery cable.
2. Disconnect the water sensor connector, the heater connector, and the thermostat connector.
3. Disconnect the fuel inlet tube quick-connector and the fuel outlet tube quick-connector.
4. Disconnect the injector return tube quick-connector.
5. Unscrew the fuel filter bracket installation nuts and then remove the fuel filter from the engine.

Installation

1. Installation is reverse of removal.

High pressure fuel pump

Removal



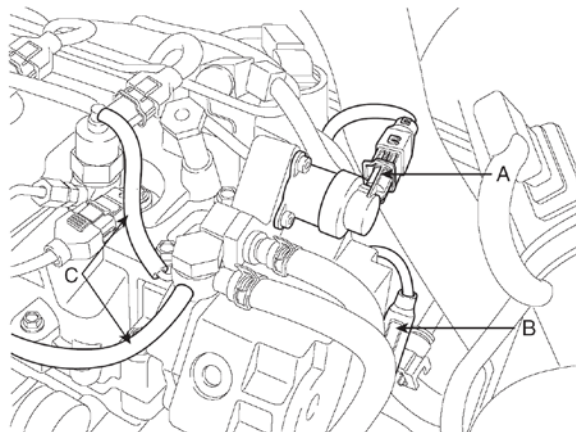
A : Fuel Inlet
(From Fuel Tank via Fuel Filter)
B : Fuel Outlet (To Common Rail)
C : Fuel Return (To Fuel Tank)

● CAUTION

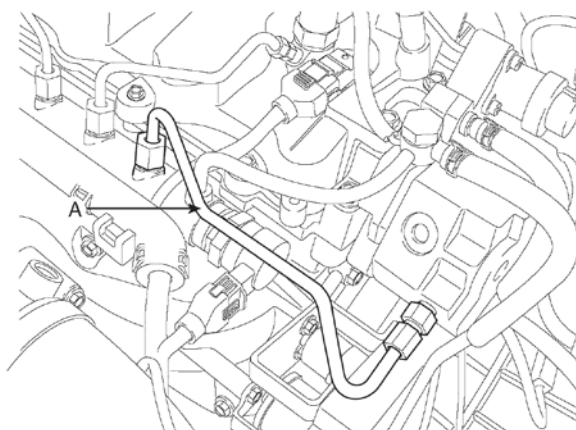
- Common Rail Fuel Injection System operates with extremely high pressure (approximately 1,600bar), so never perform any work on injection system with engine running or within 30 seconds after the engine stops
- Keep cleanly the parts and the working area.
- Pay attention to a foreign substance.
- Just before installing injector, tube or hose, remove the protect-cap attached on them.
- Do not remove injector except for special case.
- When installing Injector
 - Wash the contact area of the injector and replace the O-ring with a new one.
 - Spread oil on the injector O-ring.
 - To protect damage caused by shock, vertically insert the injector into the cylinder head.
- When installing High Pressure Fuel Pipe
 - Do not use again the used high pressure fuel pipe.
 - Install the flange nut correctly.

1. Turn ignition switch OFF and disconnect the negative (-) battery cable.

2. Disconnect the fuel pressure regulator valve connector (A) and the fuel temperature sensor Connector (B)



3. Remove the high pressure fuel pipe (A) connecting the high pressure fuel pump with the common rail.



4. Unscrew the mounting bolts (A) and remove the high pressure fuel pump (B) from the engine.

Installation

1. Installation is reverse of removal.

High pressure fuel pump installation bolts: 24.5 ~ 34.3 N·m (2.5 ~ 3.5 kgf·m, 12.1 ~ 25.3 lbf·ft)

High pressure fuel pipe installation nut: 24.5 ~ 28.4 N·m (2.5 ~ 2.9 kgf·m, 18.1 ~ 20.1 lbf·ft)

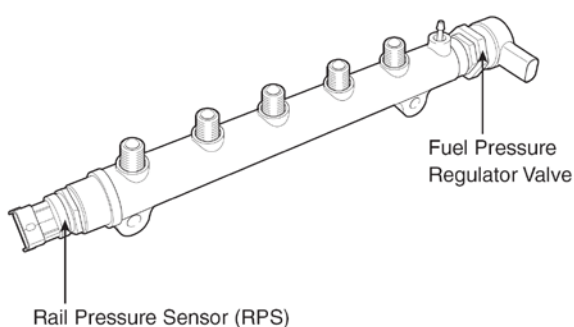
Common rail

Description

The common rail stores the fuel at high pressure. At the same time, the pressure oscillations which are generated due to the high-pressure pump delivery and the injection of fuel are damped by the rail volume. This common rail is common to all cylinders, hence its name "common rail".

Even when large quantities of fuel are extracted, the common rail maintains its inner pressure practically constant from the moment the injector opens.

In order to comply with the wide variety of engine installation conditions, the common rail with its flow limiters and the provisions for attaching rail pressure sensor, fuel pressure control valve, and pressure limiter valve is available in a number of different designs. The available common rail volume is permanently filled with pressurized fuel. The compressibility of the fuel resulting from the high pressure is utilized to achieve the accumulator effect. When fuel leaves the rail for injection, the pressure variations resulting from the pulsating fuel supply from the high-pressure pump are compensated for.



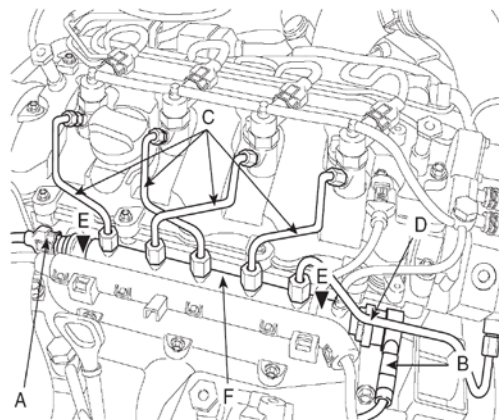
Removal

● CAUTION

- Common Rail Fuel Injection System operates with extremely high pressure (approximately 1,600bar), so never perform any work on injection system with engine running or within 30 seconds after the engine stops.
- Keep cleanly the parts and the working area.
- Pay attention to a foreign substance.

- Just before installing injector, tube or hose, remove the protect-cap attached on them.
- Do not remove injector except for special case.
- When installing Injector
 - Wash the contact area of the injector and replace the O-ring with a new one.
 - Spread oil on the injector O-ring.
 - To protect damage caused by shock, vertically insert the injector into the cylinder head.
- When installing High Pressure Fuel Pipe
 - Do not use again the used high pressure fuel pipe.
 - Install the flange nut correctly.

1. Turn ignition switch OFF and disconnect the negative (-) battery cable.



2. Disconnect the rail pressure sensor connector (A) and rail pressure regulator valve connector (B).
3. Remove the high pressure fuel pipe (C) connecting the injectors with the common rail.
4. Remove the high pressure fuel pipe (D) connecting the common rail with the high pressure fuel pump.
5. Unscrew the two mounting bolts (E) and remove the common rail (F).

Installation

1. Installation is reverse of removal.

-
- Common rail installation bolts: 19.6 ~ 26.5 N·m (2.0 ~ 2.7 kgf·m, 14.5 ~ 19.5 lbf·ft)
 - High pressure fuel pipe installation nut: 24.5 ~ 28.4 N·m (2.5 ~ 2.9 kgf·m, 18.1 ~ 20.1 lbf·ft)
-

Diagnosis Trouble Code

DTC (Diagnosis Trouble Code) LIST

NO	P code	DESCRIPTION
1	P0016	Crankshaft Position – Camshaft Position Correlation
2	P0047	Turbocharger Boost Control Solenoid Circuit Low
3	P0048	Turbocharger Boost Control Solenoid Circuit High
4	P0069	Manifold Absolute Pressure – Barometric Pressure Correlation
5	P0087	Fuel Rail/System Pressure - Too Low
6	P0088	Fuel Rail/System Pressure - Too High
7	P0089	Fuel Pressure Regulator 1 Performance
8	P0091	Fuel Pressure Regulator 1 Control Circuit Low
9	P0092	Fuel Pressure Regulator 1 Control Circuit High
10	P0097	Intake Air Temperature Sensor 2 Circuit Low
11	P0098	Intake Air Temperature Sensor 2 Circuit High
12	P0107	Atmospheric Pressure Sensor Voltage Lower Limit
13	P0108	Atmospheric Pressure Sensor Voltage Upper Limit
14	P0112	Intake Air Temperature Sensor1 Circuit Low Input
15	P0113	Intake Air Temperature Sensor1 Circuit High Input
16	P0116	Engine Coolant Temperature Circuit Range / Performance
17	P0117	Engine Coolant Temperature Circuit Low Input
18	P0118	Engine Coolant Temperature Circuit High Input
19	P0182	Fuel Temp Sensor A Circuit Low Input
20	P0183	Fuel Temp Sensor A Circuit High Input
21	P0192	Fuel Rail Pressure Sensor Circuit Low input
22	P0193	Fuel Rail Pressure Sensor Circuit High Input
23	P0194	Fuel Rail Pressure Sensor Circuit Intermittent
24	P0201	Cylinder 1 Injector Open Load
25	P0202	Cylinder 2 Injector Open Load
26	P0203	Cylinder 3 Injector Open Load
27	P0204	Cylinder 4 Injector Open Load
28	P0205	Cylinder 5 Injector Open Load
29	P0206	Cylinder 6 Injector Open Load
30	P0231	Fuel Pump Secondary Circuit Low
31	P0232	Fuel Pump Secondary Circuit High
32	P0234	Turbocharger Overboost Condition
33	P0237	Turbocharger Boost Sensor "A" Circuit Low

NO	P code	DESCRIPTION
34	P0238	Turbocharger Boost Sensor "A" Circuit High
35	P0252	Pump Pressure Regulation Valve Circuit
36	P0253	Pump Pressure Regulation Valve Circuit Low
37	P0254	Pump Pressure Regulation Valve Circuit High
38	P0261	Cylinder 1 - Injector Circuit Low
39	P0262	Cylinder 1 - Injector Circuit High
40	P0263	Cylinder 1 Contribution/Balance
41	P0264	Cylinder 2 - Injector Circuit Low
42	P0265	Cylinder 2 - Injector Circuit High
43	P0266	Cylinder 2 Contribution/Balance
44	P0267	Cylinder 3 - Injector Circuit Low
45	P0268	Cylinder 3 - Injector Circuit High
46	P0269	Cylinder 3 Contribution/Balance
47	P0270	Cylinder 4 - Injector Circuit Low
48	P0271	Cylinder 4 - Injector Circuit High
49	P0272	Cylinder 4 Contribution/Balance
50	P0273	Cylinder 5 - Injector Circuit Low
51	P0274	Cylinder 5 - Injector Circuit High
52	P0275	Cylinder 5 Contribution/Balance
53	P0276	Cylinder 6 - Injector Circuit Low
54	P0277	Cylinder 6 - Injector Circuit High
55	P0278	Cylinder 6 Contribution/Balance
56	P0299	Turbocharger Underboost
57	P0300	Random/Multiple Cylinder Misfire Detected
58	P0335	Crankshaft Position Sensor A Circuit
59	P0336	Crankshaft Position Sensor A Circuit Range/Performance
60	P0340	Camshaft Position Sensor A Circuit Malfunction
61	P0341	Camshaft Position Sensor A Circuit Range/Performance
62	P0381	Glow Plug/Heater Indicator Circuit
63	P0562	System Voltage Low
64	P0563	System Voltage High
65	P0601	Internal Control Module Memory Check Sum Error
66	P0602	Control Module Programming Error
67	P0604	Internal Control Module Random Access Memory (RAM) Error
68	P0605	Internal Control Module Read Only Memory(ROM) Error

NO	P code	DESCRIPTION
69	P0606	ECM/PCM Processor
70	P0611	Injector Circuit Error
71	P062D	Injector Bank1 Error
72	P062E	Injector Bank2 Error
73	P0642	Sensor Reference Voltage "A" Circuit Low
74	P0643	Sensor Reference Voltage "A" Circuit High
75	P0650	Malfunction Indicator Lamp(MIL) Control Circuit
76	P0652	Sensor Reference Voltage "B" Circuit Low
77	P0653	Sensor Reference Voltage "B" Circuit High
78	P0670	Glow Plug Module Control Circuit
79	P0671	Cylinder 1 Glow Plug Circuit
80	P0672	Cylinder 2 Glow Plug Circuit
81	P0673	Cylinder 3 Glow Plug Circuit
82	P0674	Cylinder 4 Glow Plug Circuit
83	P0675	Cylinder 5 Glow Plug Circuit
84	P0676	Cylinder 6 Glow Plug Circuit
85	P0683	Glow Control Module Signal
86	P0684	Glow Control Module Performance
87	P0685	ECM/PCM Power Relay Control Circuit /Open
88	P0698	Variable Swirl Actuator Voltage Lower Limit
89	P0699	Variable Swirl Actuator Voltage Upper Limit
90	P1145	Overrun Monitoring
91	P1171	Minimum Rail Pressure Exceeded
92	P1172	Maximum Rail Pressure Exceeded
93	P1173	Set Value of PCV not in Plausibility Range
94	P1185	Maximum Pressure Exceeded
95	P1186	Minimum Pressure at Engine Speed Too Low
96	P1187	Regulator Valve Stick
97	P1188	Leakage
98	P1307	Acceleration Sensor Range/Performance
99	P1308	Acceleration Sensor Circuit Low Input
100	P1309	Acceleration Sensor Circuit High Input
101	P1325	Glow Relay Malfunction
102	P1636	Voltage Regulator for Injector
103	P1652	Ignition Key No Signal

NO	P code	DESCRIPTION
104	P1653	After-Run Check Error
105	P1655	Tacho Output Fault
106	P1670	Invalid Injector IQA/C2I
107	P1671	Injector IQA Checksum Error
108	P1679	EMS Data Fail (Data frame, CS, Message error)
109	P1694	EMS Message Error
110	P1695	EMS Memory Error
111	P1697	HI-SCAN message Error
112	P2009	Intake Manifold Runner Control Circuit Low(Bank 1)
113	P2010	Intake Manifold Runner Control Circuit High(Bank 1)
114	P2015	Intake Manifold Runner Position Sensor/Switch Circuit Range/Performance
115	P2016	Intake Manifold Runner Position Sensor/Switch Circuit Low
116	P2017	Intake Manifold Runner Position Sensor/Switch Circuit High
117	P2122	Throttle/Pedal Position Sensor/Switch "D" Circuit Low Input
118	P2123	Throttle/Pedal Position Sensor/Switch "D" Circuit High Input
119	P2127	Throttle/Pedal Position Sensor/Switch "E" Circuit Low Input
120	P2128	Throttle/Pedal Position Sensor/Switch "E" Circuit High Input
121	P2138	Throttle/Pedal Position Sensor/Switch "D" / "E" Voltage Correlation
122	P2228	Barometric Pressure Circuit Low Input
123	P2229	Barometric Pressure Circuit High Input
124	P2262	Turbocharger Boost Pressure Not Detected - Mechanical
125	P2263	Turbocharger Boost System Performance
126	P2264	Water in Fuel Sensor Circuit
127	P2562	Turbocharger Boost Control Position Sensor "A" Circuit
128	P2563	Turbocharger Boost Control Position Sensor "A" Circuit Range/Performance
129	P2564	Turbocharger Boost Control Position Sensor "A" Circuit Low
130	P2565	Turbocharger Boost Control Position Sensor "A" Circuit High
131	P2566	Turbocharger Boost Control Position Sensor "A" Circuit Intermittent
132	U0001	High Speed CAN Communication Bus
133	U0100	Faults in CAN a Transmit Messages

DTC(Diagnosis Trouble Code) Description

ITEMS	DTC	DESCRIPTION	DETECTION	HEALING	CONDITION	FAIL SAFETY					NORMAL VALUES	EXPECTATION CAUSES)
						FUEL CUT OFF	RPM LIMITATION (Recreation / Commercial)	CHECK LAMP	BUZZER	DEFAULT		
VGT variable geometry turbocharger	P2263	Overheat, Overload, Learning Error, Feedback Line Error	2500 ms	2500 ms	Engine Running		● & (3000 / 2400 rpm)	●	●		<ul style="list-style-type: none"> Engine Warm Up Vgt Actuator Duty - Fullload Load 25~35% - Idle : 80% Boost Pressure - 2400~2550Hpa 	<ul style="list-style-type: none"> Overload, EVGT Cooling Circuit VGT Actuator Adaption Error VGT Actuator Performance Error
	P2563	Pwm Failure	2500 ms	2500 ms				●				<ul style="list-style-type: none"> VGT Actuator Circuit VGT Actuator
	P0048	Short Circuit Battery	1000 ms	1000 ms				●	●			<ul style="list-style-type: none"> VGT Actuator Circuit VGT Actuator
	P0047	Short Circuit Ground	1000 ms	1000 ms	lg Key On		● & (3000 / 2400 rpm)	●	●			<ul style="list-style-type: none"> VGT Actuator Circuit VGT Actuator
	P0234	Negative Governor Deviation Below Limit	5000 ms		Engine Running		● & (3000 / 2400 rpm)	●	●			<ul style="list-style-type: none"> VGT Actuator Performance Error Air Leakage Check Intercooler VGT Actuator Performance Error
GCU glow control unit	P0299	Positive Governor Deviation Above Limit	5000 ms	No Healing								<ul style="list-style-type: none"> VGT Actuator Performance Error
	P0670	No Main Supply	1000 ms	1000 ms								<ul style="list-style-type: none"> GCU Circuit
	P0683	Can Message Error	1000 ms	1000 ms	lg Key On							<ul style="list-style-type: none"> GCU CAN Communication Error
	P0671~6	Glow Plug 1.../6 Error Per Cyl	1000 ms	1000 ms								
	P2138	Plausibility With Aps2 Violated	240ms	100ms							<ul style="list-style-type: none"> *APS1, 2-APS2) < 405mv 	
APS1 accel position sensor1	P2127	Voltage Above Lower Limit	2000 ms	1010 ms								
	P2123	Voltage Above Upper Limit	180 ms	100 ms								
	P0643	Supply Voltage Above Upper Limit	100 ms	100 ms	lg Key On		● & 1250 rpm fixed	●	●	0%	<ul style="list-style-type: none"> • Idle(lever Not Activated) • APS1 : 700~800mV • APS2 : 275~475mV • Full(lever Full Activated) • APS1 : 3800~4400mV • APS2 : 1750~2350mV • Sensor Power • 4700~5135mV 	<ul style="list-style-type: none"> • APS1/2 Sensor Circuit • APS Sensor • ECM
	P0642	Supply Voltage Below Lower Limit	100 ms	100 ms								
	P2128	Voltage Above Upper Limit	180 ms	100 ms								
APS2 accel position sensor2	P0653	Supply Voltage Above Upper Limit	100 ms	100 ms								
	P0652	Supply Voltage Below Lower Limit	100 ms	100 ms								
	P0108	Voltage Above Upper Limit	800 ms	500 ms	lg Key On					1000 hPa		<ul style="list-style-type: none"> • ECM
APS atmosphere pressure sensor	P0107	Voltage Below Lower Limit	800 ms	500 ms								
	P0563	Voltage Above Upper Limit	5000ms	100 ms						7.9V	<ul style="list-style-type: none"> • above 2000 RPM 10.5V~14.5V 	<ul style="list-style-type: none"> • Charging Circuit • Alternator • Battery
BAT battery	P0562	Voltage Below Lower Limit	5000ms	100ms	lg Key On							

ITEMS	DTC	DESCRIPTION	DETECTION	HEALING	CONDITION	FAIL SAFETY					NORMAL VALUES	EXPECTATION CAUSES)
						FUEL CUT OFF	*RPM LIMITATION	CHECK LAMP	BUZZER	DEFAULT		
IDA injector quantity adjustment	P1670	Read Or While Error	Promptly	Promptly	Ig Key On							• Ipa Code Input Error
	P1671	Ima Checksum Not Valid	Promptly	Promptly								
CKPS crankshaft position sensor	R0340	No Crankshaft Signal	CKPS 8 revolution	Promptly	Engine Running	● (at starting)	● & (3300 / 2700 rpm) (after starting)	●	●		Signal Change / 1rev.	• CKPS Circuit • CKPS • CKPS
	R0341	Wrong Crankshaft Signal	Promptly	Promptly								
	R0335	No Crankshaft Signal (Engine Running)	CKPS 4 revolution	Promptly		●		●	●		• 60-2 Tooth / 1rev.	
CKPS crankshaft position sensor	R0336	Wrong Crankshaft Signal (Restart)	Promptly	Promptly	Engine Running			●	●			• CKPS Circuit • CKPS • Target Wheel Check
	R0183	Voltage Above Upper Limit	2000 ms	500 ms						40°C		
FTS fuel temperature sensor	R0182	Voltage Below Lower Limit	2000 ms	500 ms	Ig Key On							• FTS Circuit • FTS
	P2254	Water In Fuel Is Detected	4000 ms	Promptly			● & (3300 / 2700 rpm)	●	●			
ECM/HV engine control module hardware	R0602	Communication - SPI	Promptly	No Healing	Engine Running	●						• ECM
		Recovery Locked										
		Recovery Suppressed										
		Recovery Visible										
		Tpu Monitoring										
		Watch Dog Monitoring										
		Erns Internal Processor Supervision Fault										
IATS induction air temperature sensor	R0606	Adc Error	2000 ms	500 ms	IG ON						45°C	• IATS • IATS Circuit
	R0605	Ecprom										
	R0098	Voltage Above Upper Limit										
	R0097	Voltage Below Lower Limit										
EATS environment air temperature sensor	R0113	Voltage Above Upper Limit	1000 ms	500 ms	IG ON						25°C	• EATS • EATS Circuit
	R0112	Voltage Below Lower Limit	1000 ms	500 ms								

ITEMS	DTC	DESCRIPTION	DETECTION	HEALING	CONDITION	FAIL SAFETY					NORMAL VALUES	EXPECTATION CAUSES)
						FUEL CUT OFF	RPM LIMITATION	CHECK LAMP	BUZZER	DEFAULT		
Cylinder1 injector	R0201	Open Load	Promptly	Promptly	Engine Running		● & (3000 / 2400 rpm)	●	●			• Injector Circuit • Injector
	R0261	Short Circuit Ground	Promptly	Promptly		●		●	●			
	R0262	Short Circuit Battery	Promptly	Promptly								
	R0263	Defect Resistance Cylinder1, Charging/Discharging Energy Error	Promptly	Promptly			● & (3000 / 2400 rpm)					
Cylinder2 injector	R0202	Open Load	Promptly	Promptly	Engine Running		● & (3000 / 2400 rpm)	●	●			• Injector Circuit • Injector
	R0264	Short Circuit Ground	Promptly	Promptly		●		●	●			
	R0265	Short Circuit Battery	Promptly	Promptly								
	R0266	Defect Resistance Cylinder2, Charging/Discharging Energy Error	Promptly	Promptly			● & (3000 / 2400 rpm)					
Cylinder3 injector	R0203	Open Load	Promptly	Promptly	Engine Running		● & (3000 / 2400 rpm)	●	●			• Injector Circuit • Injector
	R0267	Short Circuit Ground	Promptly	Promptly		●		●	●			
	R0268	Short Circuit Battery	Promptly	Promptly								
	R0269	Defect Resistance Cylinder3, Charging/Discharging Energy Error	Promptly	Promptly			● & (3000 / 2400 rpm)					
Cylinder4 injector	R0204	Open Load	Promptly	Promptly	Engine Running		● & (3000 / 2400 rpm)	●	●			• Injector Circuit • Injector
	R0270	Short Circuit Ground	Promptly	Promptly		●		●	●			
	R0271	Short Circuit Battery	Promptly	Promptly								
	R0272	Defect Resistance Cylinder4, Charging/Discharging Energy Error	Promptly	Promptly			● & (3000 / 2400 rpm)					
Cylinder5 injector	R0205	Open Load	Promptly	Promptly	Engine Running		● & (3000 / 2400 rpm)	●	●			• Injector Circuit • Injector
	R0273	Short Circuit Ground	Promptly	Promptly		●		●	●			
	R0274	Short Circuit Battery	Promptly	Promptly								
	R0275	Defect Resistance Cylinder5, Charging/Discharging Energy Error	Promptly	Promptly			● & (3000 / 2400 rpm)					
Cylinder6 injector	R0206	Open Load	Promptly	Promptly	Engine Running		● & (3000 / 2400 rpm)	●	●			• Injector Circuit • Injector
	R0276	Short Circuit Ground	Promptly	Promptly		●		●	●			
	R0277	Short Circuit Battery	Promptly	Promptly								
	R0278	Defect Resistance Cylinder6, Charging/Discharging Energy Error	Promptly	Promptly								

ITEMS	DTC	DESCRIPTION	DETECTION	HEALING	CONDITION	FAIL SAFETY					NORMAL VALUES	EXPECTATION CAUSES)
						FUEL CUT OFF	*RPM LIMITATION	CHECK LAMP	BUZZER	DEFAULT		
Injector Bank Error	P062D	Bank 1 Error	Promptly	Promptly	Engine Running	●		●	●			<ul style="list-style-type: none"> Charging System (battery, alternator Check) ECM
	P062E	Bank 2 Error	Promptly	Promptly	Engine Running	●		●	●			
Injector Circuit	P0611	Error Path For Short-Circuit Of Charging Switch Is Detected	Promptly	Promptly	Engine Running	●		●	●			<ul style="list-style-type: none"> Injector Circuit ECM
	P0200	Injector Circuit Error	Promptly	Promptly	Ig Key On							
Check engine lamp	P0650	Short Circuit Battery	2000ms	1000ms	Engine Running						<ul style="list-style-type: none"> KEY ON & engine stop allow 3/s ON after Engine Running ON If system Error happens 	<ul style="list-style-type: none"> Lamp Circuit EOI Circuit
		Short Circuit Ground	2000ms	1000ms								
		No Load	2000ms	1000ms								
Main relay	P0685	Main Relay Does Not Open In Time	Promptly	Promptly	Engine Running							<ul style="list-style-type: none"> Main Relay Circuit Main Relay
		Main Relay Opens Too Early	Promptly	Promptly								
RPS rail pressure sensor	P0193	Voltage Above Upper Limit	200 ms	480 ms	Engine Running						360bar	<ul style="list-style-type: none"> RPS Circuit RPS AFS 2 Power Supply Circuit BPS Power Supply Circuit ECM
	P0192	Voltage Below Lower Limit	200 ms	480 ms			● & (3300 / 2700 rpm)	●	●			
	P0653	Supply Voltage Above Upper Limit	100 ms	100 ms	Engine Running							
	P0652	Supply Voltage Below Lower Limit	100 ms	100 ms								
Rail pressure Monitoring	P0087	Maximum Positive Deviation Of Rail Pressure Exceeded	1350 ms		Engine Running							<ul style="list-style-type: none"> Warm Up Idle rail pressure : 25 ± 5 Mpa Fuel Filter RPS Check PRV / Duty : 40 ± 5%
	P0088	Maximum Negative Deviation Of Rail Pressure Exceeded	2000 ms				● & (3000 / 2400 rpm)	●	●			<ul style="list-style-type: none"> Fuel Filter RPS Check PRV / Duty : 40 ± 5%
	P1171	Minimum Rail Pressure Exceeded	400 ms	No Healing		●						
	P1172	Maximum Rail Pressure Exceeded	300 ms				● & (3000 / 2400 rpm)					
ECTS engine coolant temperature sensor	P0118	Voltage Above Upper Limit	2000 ms	480 ms	Ig Key On						80℃	<ul style="list-style-type: none"> ECTS Circuit ECTS
	P0117	Voltage Below Lower Limit	2000 ms	480 ms				●	●			
	P0116	Dynamic Plausibility Error	on condition	on condition								
	P0238	Voltage Above Upper Limit	2000 ms	1000 ms								
BPS boost pressure sensor	P0237	Voltage Below Lower Limit	2000 ms	1000 ms	Ig Key On		● & (3300 / 2700 rpm)	●	●			<ul style="list-style-type: none"> BPS Circuit BPS RPS Power Supply Circuit AFS 2 Power Supply Circuit ECM
	P0069	Not Plausible With Atmospheric Pressure Sensor	3000 ms	500 ms							980hPa	
	P0653	Supply Voltage Above Upper Limit	100 ms	100 ms	Ig Key On							
	P0652	Supply Voltage Below Lower Limit	100 ms	100 ms			● & (3300 / 2700 rpm)	●	●			

ITEMS	DTC	DESCRIPTION	DETECTION	HEALING	CONDITION	FAIL SAFETY					NORMAL VALUES	EXPECTATION CAUSES)
						FUEL CUT OFF	*RPM LIMITATION	CHECK LAMP	BUZZER	DEFAULT		
IG KEY	P1652	No Terminal 15 Signal Detected	Promptly	Promptly	Engine Running							• IG Key Switch Circuit
	P0254	Short Circuit To Battery Of Metering Unit Output	220 ms	1000 ms			• & (3000 / 2400 rpm)					
		Short Circuit To Ground Of Metering Unit Output	280 ms	No Healing		•						
P-PRV / pump-pressure regulator valve	P0253	Open Load Of Metering Unit Output	220 ms	500 ms	IG Key On		• & (3000 / 2400 rpm)	•	•			• P-PRV Circuit • P-PRV
	P0252	Powerstage Error	220 ms	500 ms								
	P0092	Short Circuit To Battery Of Pressure Control Valve Output	140 ms									
	P0091	Short Circuit To Ground Of Pressure Control Valve Output	110 ms									
PRV pressure regulator valve		Open Load Of Pressure Control Valve Output	140 ms	No Healing	IG Key On	•		•	•			• PRV Circuit • PRV
	P0089	Powerstage Error	220 ms									
	U0001	Bus Off In Can	190 ms	100 ms								
CAN controller area network	U0106	Error Path For Gpc1 Message Timeout Error	500 ms	500 ms	IG Key On							• CAN Communication Circuit • CAN Module Error (ECM-GCU)

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