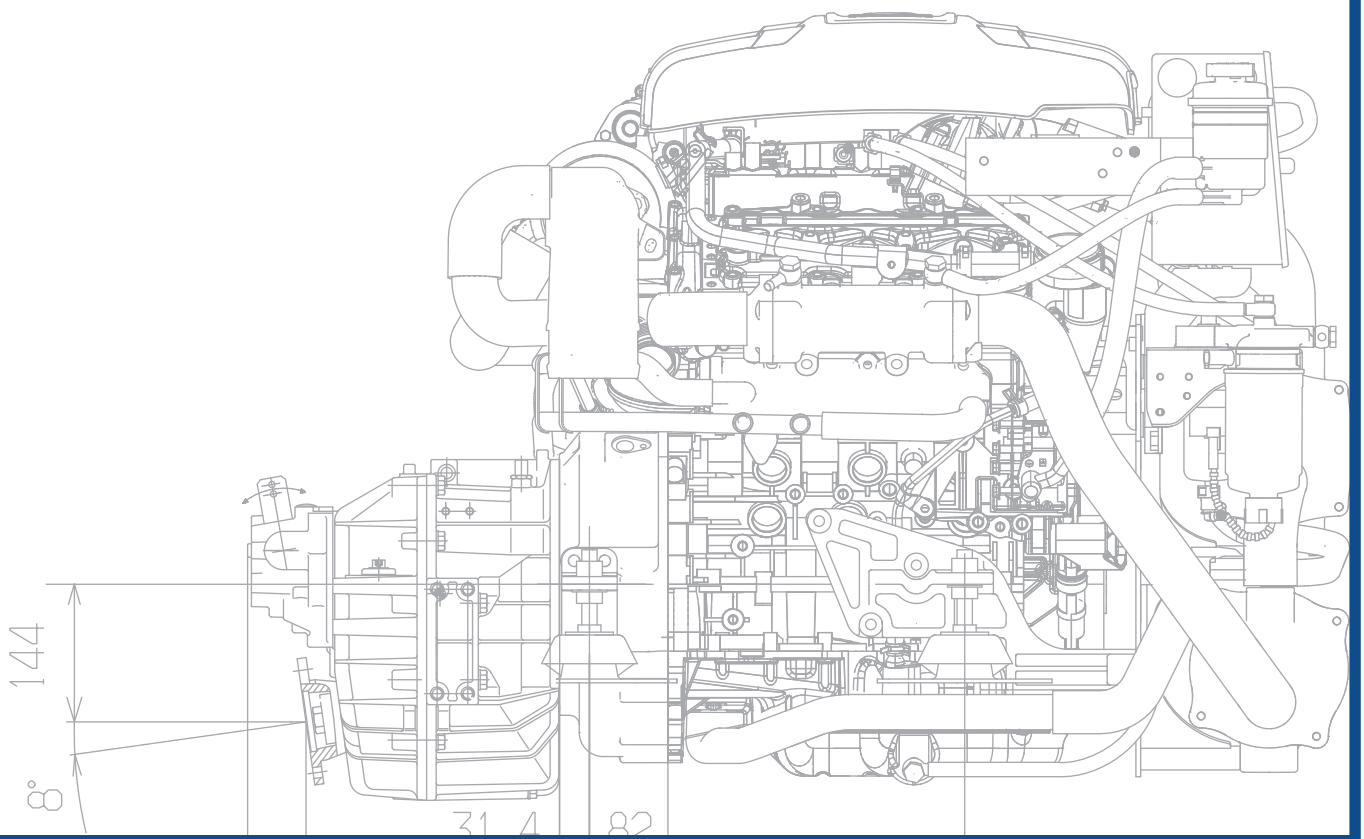
HYUNDAI SEASALL

WORKSHOP MANUAL

for

S Engine Series



Applicable to S250S, S250P, S250J, S220S, S220P model

Service Department. Technical Information Edition 1st

Engine Mechanical System

General Information

Specifications

Description			Specifications	Limit
General				
Type			V-type, DOHC	
Number of cylinder			6	
Bore			84.0mm(3.3071 in.)	
Stroke			89.0mm(3.5039 in.)	
Total displacement			2,959 cc	
Compression ratio			17.3 ± 0.5 : 1	
Idle rpm			680 RPM	
Firing order			1-2-3-4-5-6	
Valve timing				
Intake valve	Opens		BTDC 13°	
	Closes		ABDC 34°	
Exhaust valve	Opens		BBDC 55°	
	Closes		ATDC 15°	
Cylinder head				
Flatness of cylinder head gasket surface			0.05mm(0.0020 in.) 0.03mm(0.0012in.) - 100mm×100mm 0.01mm(0.0004in.) - 20mm×20mm	
Flatness of manifold gasket surface	Intake		0.016mm(0.0006in.) 0.013mm(0.0005in.) - 25mm×25mm	
	Exhaust		0.016mm(0.0006in.) 0.013mm(0.0005in.) - 25mm×25mm	
Camshaft				
Cam height	LH camshaft	Intake	36.000 ~ 40.152mm(1.4173~1.5808in.)	
		Exhaust	36.000 ~ 40.477mm(1.4173~1.5936in.)	
	RH camshaft	Intake	36.000 ~ 40.152mm(1.4173~1.5808in.)	
		Exhaust	36.000 ~ 40.477mm(1.4173~1.5936in.)	
Journal outer diameter	LH camshaft	Intake	24.947 ~ 24.960mm(0.9822~0.9827in.)	
		Exhaust		
	RH camshaft	Intake		
		Exhaust		
Bearing oil clearance			0.040 ~ 0.074mm(0.0016~0.0029in.)	
End play			0.05 ~ 0.15mm(0.0020~0.0059in.)	
Valve				

Specifications

Description		Specifications	Limit
Valve length	Intake	99.3mm(3.9094in.)	
	Exhaust	99.3mm(3.9094in.)	
Stem outer diameter	Intake	5.960 ~ 5.975mm(0.2346~0.2352in.)	
	Exhaust	5.955 ~ 5.970mm(0.2344~0.2350in.)	
Face angle		45.00° ~ 45.25°	
Thickness of valve-head (margin)	Intake	1.5mm(0.0590in.)	
	Exhaust	1.5mm(0.0590in.)	
Valve stem to valve guide clearance	Intake	0.025 ~ 0.052mm(0.0010~0.0020in.)	
	Exhaust	0.030 ~ 0.057mm(0.0012~0.0022in.)	
Valve guide			
Inner diameter	Intake	6.000 ~ 6.012mm(0.2362~0.2367in.)	
	Exhaust	6.000 ~ 6.012mm(0.2362~0.2367in.)	
Length	Intake	36.25 ~ 36.75mm(1.4272~1.4468in.)	
	Exhaust	36.25 ~ 36.75mm(1.4272~1.4468in.)	
Valve spring			
Free length		48.2mm(1.8976in,)	
Load		175±8N/33.5mm	
		278±20N/24.8mm	
Out of squareness		1.5° or less	3°
Valve seat			
Seat angle	Intake	44.5° ~ 45°	
	Exhaust	44.5° ~ 45°	
Valve contacting wi-dth	Intake	1.39 ~ 1.43mm(0.0547~0.0563in.)	
	Exhaust	1.39 ~ 1.43mm(0.0547~0.0563in.)	
Piston			
Piston outer diameter		83.926 ~ 83.956mm3.3042~3.3053in.)	
Piston to cylinder clearance		0.064 ~ 0.084mm(0.0025~0.0033in.)	
Ring groove width	No. 1 ring groove	2.434 ~ 2.454mm(0.0958~0.0966in.)	
	No. 2 ring groove	1.82 ~ 1.84mm(0.0717~0.0724in.)	
	Oil ring groove	3.02 ~ 3.04mm(0.1189~0.1197in.)	
Piston ring			
Side clearance	No. 1 ring	0.102 ~ 0.146mm(0.0040~0.0057in.)	
	No. 2 ring	0.08 ~ 0.12mm(0.0031~0.0047in.)	
	Oil ring	0.03 ~ 0.07mm(0.0012~0.0028in.)	

Specifications

Description		Specifications	Limit
End gap	No. 1 ring	0.20 ~ 0.35mm(0.0079~0.0138in.)	
	No. 2 ring	0.40 ~ 0.60mm(0.0157~0.0236in.)	
	Oil ring	0.25 ~ 0.50mm(0.0098~0.0197in.)	
Piston pin			
Piston pin outer diameter		30.994 ~ 31.000mm(1.2202~1.2205in.)	
Piston pin hole inner diameter		31.014 ~ 31.021mm(1.2210~1.2213in.)	
Piston pin hole clearance		0.014 ~ 0.027mm(0.0006~0.0011in.)	
Connecting rod small end bore inner diameter		31.020 ~ 31.031mm(1.2212~1.2216in.)	
Connecting rod small end bore hole clearance		0.020 ~ 0.037mm(0.0008~0.0014in.)	
Connecting rod			
Connecting rod big end bore inner diameter		66.500 ~ 66.518mm(2.6181~2.6188in.)	
Connecting rod bearing oil clearance		0.024 ~ 0.058mm(0.0009~0.0023in.)	
Side clearance between connecting rod and pistion		0.007 ~ 0.024mm(0.0003~0.0009in.)	
Crankshaft			
Main journal outer diameter		75.982 ~ 76.000mm(2.9914~2.9921in.)	
Pin journal outer diameter		63.482 ~ 63.500mm(2.4993~2.5000in.)	
Main bearing oil clearance		0.030 ~ 0.048mm(0.0012~0.0019in.)	
End play		0.1 ~ 0.3mm(0.0039~0.0118in.)	
Cylinder block			
Cylinder bore inner diameter		84.000 ~ 84.030mm(3.3071~3.3083in.)	
Cylinder block journal bore inner diameter		80.000 ~ 80.018mm(3.1496~3.1503in.)	
Flatness of gasket surface		0.042mm(0.0017in.) or less (width) 0.096mm(0.0038in.) or less (length) 0.012mm(0.0005in.) or less (50mm×50mm)	
Engine oil			
Oil quantity (Total)		7.3L (7.71 US qt, 6.42 Imp qt)	When replacing a short engine or a block assembly
Oil quantity (Excluding oil filer)		5.8L (6.13 US qt, 5.10 Imp qt)	When replacing an oil pan only
Oil quantity (Drain and refill including oil filter)		6.8L (7.19US qt, 6.00 Imp qt)	

Specifications

Description		Specifications	Limit
Oil quality	ACEA	Above B4	Service oil quality should confirm to ACEA or API classification
	API	Above CH-4	
	SAE	15W-40	-15℃ above
		10W-30	-20℃ ~ 40℃
		5W-30	-25℃ ~ 40℃
		0W-30	10℃ below
Oil pressure(at idle)		0.8kg/㎠ (7.85kPa, 1.14psi)	
Cooling system			
Cooling method		Forced circulation with sea water pump	
Coolant quantity		12L (12.68US qt, 10.56lmp qt)	
Thermostat	Type	Wax pellet type	
	Opening temperature	82±2℃(176.0~183.2˚F) (Lift : 0.35mm(0.0138in)	
	Full opening temperature	92℃(197.6˚F) (Lift : 10mm(0.3939in) or more)	
Turbochager			
EVGT cooling method		Sea water cooling type	
Actuator		Electrical	
Turbine	Control type	Variable Geometry Turbocharger(VGT)	

Tightening Torques

Item	N·m	Kgf·m	lb-ft
Cylinder block			
Oil jet mounting	29.4~34.3	3.0~3.5	21.7~25.3
Connecting rod cap bolt	27.5~31.4+88°~92°	2.8~3.2+88°~92°	20.3~23.1+88°~92°
Bedplate bolt	61.8~65.7+120°~124°	6.3~6.7+120°~124°	45.6~48.5+120°~124°
Flywheel	127.4~137.2	13.0~14.0	94.0~101.3
Timing system			
Drive belt tensioner upper mounting	82.6~84.3	7.4~8.6	53.6~62.2
Drive belt tensioner lower mounting	28.4~34.3	2.9~3.5	21.0~25.3
Timing chain case bolt(M6)	7.8~11.8	0.8~1.2	5.8~8.7
Timing chain case bolt(M8)	19.6~25.5	2.0~2.6	14.5~18.8
High pressure fuel pump	64.7~74.5	6.6~7.6	47.7~55.0
Timing chain tensioner lever bolt	19.6~23.5	2.0~2.4	14.5~17.4
Timing chain guide bolt	7.8~11.8	0.8~1.2	5.7~8.7
Damper pulley bolt	186.3~205.9+58°~62°	19.0~21.0+58°~62°	137.4~151.9+58°~62°
Alternator bracket	19.6~26.5	2.0~2.7	14.5~19.5
Alternator	29.4~41.2	3.0~4.2	21.7~30.4
Front chain cover bolt(M6)	7.8~11.8	0.8~1.2	5.8~8.7
Front chain cover bolt(M8)	19.6~25.5	2.0~2.6	14.5~18.8
Chain cap assembly bolt	7.8~11.8	0.8~1.2	5.8~8.7
Drive belt idler	34.3~44.1	3.5~4.5	25.3~32.5
Idler pulley	34.3~44.1	3.5~4.5	25.3~32.5
Cylinder head			
Fuel feed and return tube	9.8~11.8	1.0~1.2	7.2~8.7
Engine hanger bolt	19.6~26.5	2.0~2.7	14.5~19.5
Water outlet fitting	9.8~11.8	1.0~1.2	7.2~8.7
Cylinder head cover bolt	9.8~11.8	1.0~1.2	7.2~8.7
Camshaft bearing ladder bolt	13.7~15.7	1.4~1.6	10.1~11.6

Tightening Torques

Item	N·m	kgf·m	lb-ft
Camshaft position sensor mounting	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Cylinder head bolt	58.8 + 88°~92° +118°~122°	6.0 + 88°~92° +118° ~122°	43.4 + 88°~92° +118°~122°
Cooling system			
Water pump pulley bolt	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Water pump bolt	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Thermostat housing	19.6 ~ 26.5	2.0 ~ 2.7	14.5 ~ 19.5
Water outlet duct bolts	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Lubrication system			
Oil pump assembly	19.6 ~ 26.5	2.0 ~ 2.7	14.5~ 19.5
Oil pump chain tensioner	7.6~ 11.8	0.8 ~ 1.2	5.8 ~ 8.7
Baffle plate	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Oil filter and cooler assembly	19.6 ~ 26.5	2.0 ~ 2.7	14.5 ~ 19.5
Oil gauge bracket	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Oil filter cap	24.5	2.5	18.1
Upper oil pan bolt 1	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Upper oil pan bolt 2	29.4 ~ 33.3	3.0 ~ 3.4	21.7 ~ 24.6
Lower oil pan bolt	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Oil pan drain plug	34.3 ~ 44.1	3.5 ~ 4.5	25.3 ~ 32.5
Oil screen bolt	14.7 ~ 21.6	1.5 ~ 2.2	10.8 ~ 15.9
Intake and exhaust system			
Inlet lower manifold assembly	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Inlet upper manifold assembly	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Turbocharger oil return pipe bolt	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Turbocharger oil feed pipe nut	18.6 ~ 25.5	1.9 ~ 2.6	13.7 ~ 18.8
Turbocharger oil feed pipe eyebolt	26.5 ~ 32.4	2.7 ~ 3.3	19.5 ~ 23.9
Turbocharger oil feed pipe mounting bolt	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Turbocharger mounting bolt	29.4 ~ 34.3	3.0 ~ 3.5	21.7 ~ 35.3
Turbocharger and exhaust pipe assembly mounting bolt	40.2 ~ 53	4.1 ~ 5.5	29.7 ~ 39.8
Turbocharger and exhaust pipe assembly mounting bolt	29.4 ~ 34.3	3.0 ~ 3.5	21.7 ~ 25.3
Exhaust manifold mounting	29.4 ~ 34.3	3.0 ~ 3.5	21.7 ~ 25.3

Compression Pressure Inspection

✍ **NOTICE**

• If the there is lack of power, excessive oil consumption or poor fuel economy, measure the compression pressure.

• Whenever removing injectors for compression pressure inspection replace the gaskets with new ones and tighten them with the specified torque.

1. Warm up engine until the normal operating temperature (80~95°C (176-203°F)).

2. Remove the injectors. (Refer to Injector in FL Group)

3. Check the cylinder compression pressure.

1) Insert a compression gauge SST(00200-0T004, 00200-0T005) into the injector hole.

2) Fully open the throttle.

3) While cranking the engine, measure the compression pressure.

✍ **NOTICE**

Always use a fully charged battery to obtain engine speed of 220rpm or more

. 4) Repeat step 1) though 3) for each cylinder

✍ **NOTICE**

This measurement must be done in as short a time as possible.

Compression pressure :

2,745.85kPa (28.0kg/cm², 398.25psi) (220 rpm)

Minimum pressure :

2,255.52kPa (23.0kg/cm², 327.14psi)

5) If the cylinder compression in 1 or more cylinders is low, pour a small amount of engine oil into the cylinder through the spark plug hole and repeat step1) through 3) for cylinders with low compression.

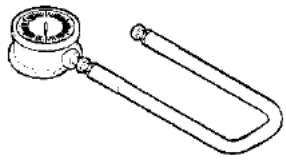
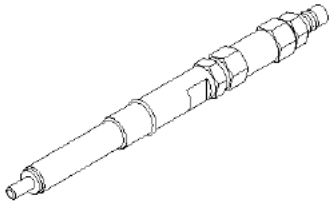
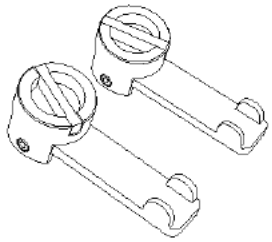
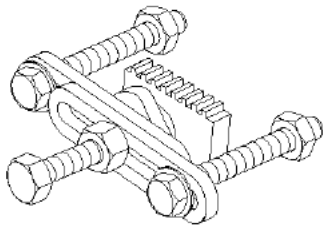
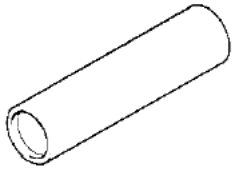
• If adding oil helps the compression, it is likely that the piston rings and / or cylinder bore are worn or damaged.

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

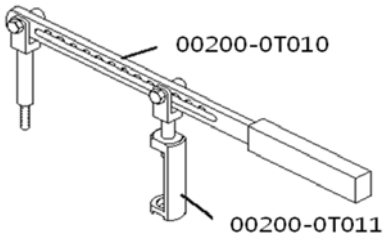
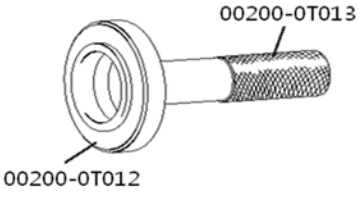
• If pressure doesn't rise despite dropping oil on the pistons because of low pressure in the neighboring cylinders, it can be caused by a poor cylinder head gasket or stained oil or coolant in the cylinder head.

4. Reinstall the injectors. (Refer to Injector in FL Group)

Special Service Tools

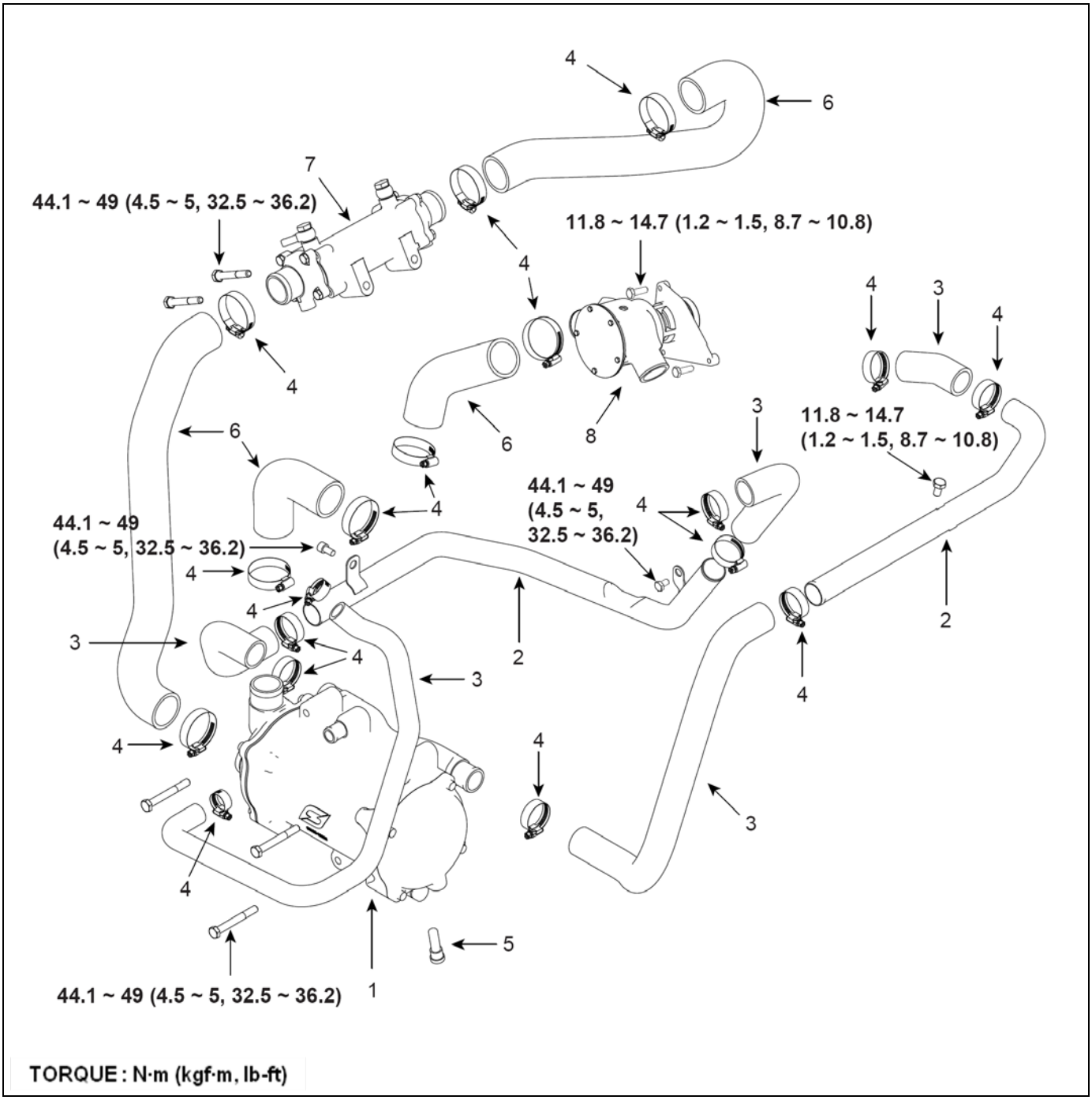
Tool (Number and name)	Illustration	Use
Compression gauge (00200-0T004)	 LCGF148A	Checking engine compression pressure
Compression gauge adapter (00200-0T005)	 LCGF060A	Checking engine compression pressure
Camshaft locking tool (00200-0T006)	 SENEM7091D	Fixation of timing chain and camshaft sprocket
Flywheel stopper (00200-0T007)	 SHDEM6201D	Removal and installation of crankshaft pulley bolt.
Valve stem oil seal installer (00200-0T008)	 LCAC030D	Installation of valve stem oil seals

Special Service Tools

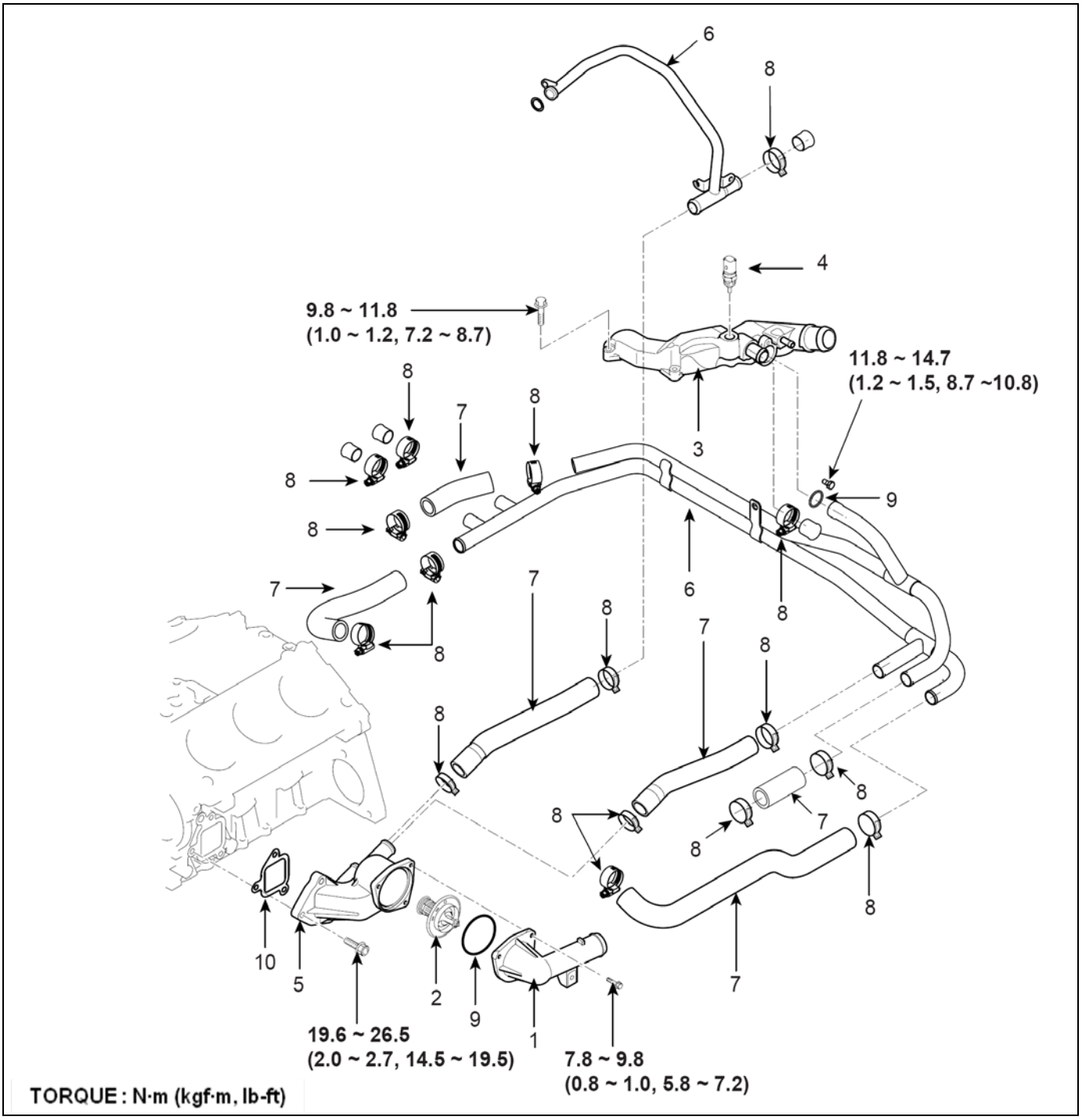
Tool (Number and name)	Illustration	Use
Valve spring compressor (00200-0T010) Valve spring compressor adapter (00200-0T011)	 LCGF059A	Removal and installation of intake and exhaust valves
Crankshaft rear oil seal installer (00200-0T013) Handle (00200-0T012)	 SENEM7233D	Installation of crankshaft rear oil seal

Cooling system

Components



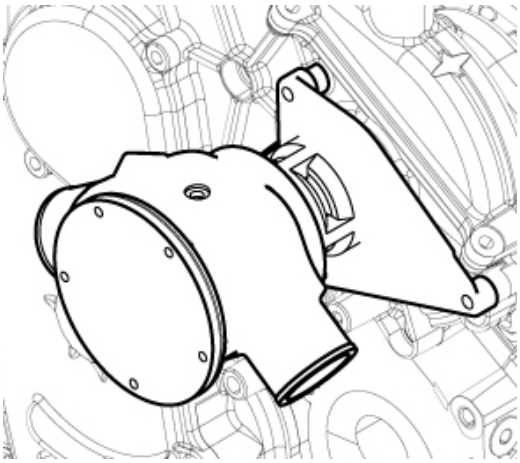
1. Heat exchanger assembly
2. Coolant pipe
3. Coolant hose
4. Clamp
5. Anode
6. Raw water hose
7. Oil cooler assembly
8. Sea water pump



1. Coolant Inlet fitting
2. Thermostat assembly
3. Coolant outlet duct
4. Coolant temp. sensor
5. Coolant temp. control assembly
6. Coolant pipe
7. Coolant hose
8. Clamp
9. O- ring
10. Gasket

Removal

Seawater Pump



1. Remove clamps and hoses connect to sea water pump inlet and outlet.
2. Remove three bolts fixing cylinder block.

Tightening torque:

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

3. Remove impeller housing cover.
4. Remove impeller inside the seawater pump using tools.
5. Check the condition of impeller and bushing.
6. Check the condition of cam
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.

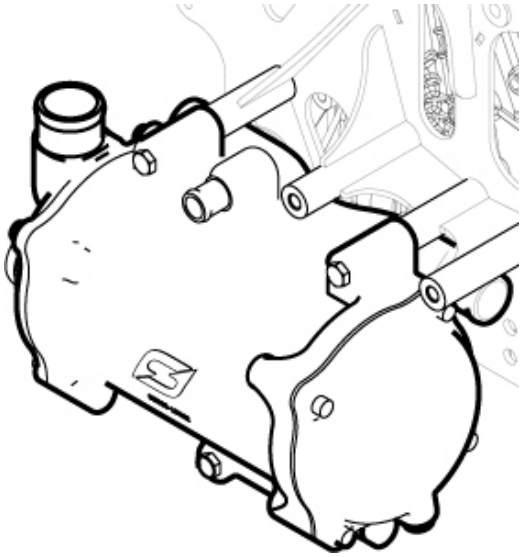
8. Reassemble aligning axis of impeller shaft and engine cam.
9. Apply lubricant O-rings on inserting parts and cover and assembly.

◉ CAUTION

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

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

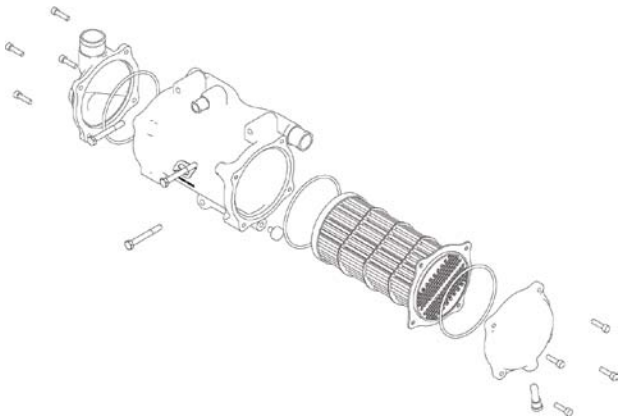
Heat Exchanger



1. Open the drain plug to remove engine coolant from heat exchanger.
2. Remove all hoses and clamps connected to heat exchanger.
3. Unscrew three bolts fixing heat exchanger.

Tightening torque:

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



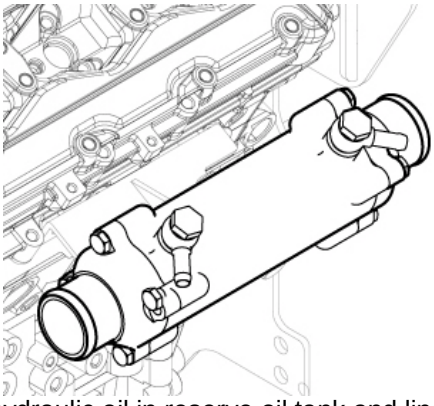
4. Use L-wrench and remove end cap on both sides.
5. Use soft hammer and remove heat exchanger from housing.
6. Check condition of O-ring on both end cap.
7. Check if there is engine coolant and sea water mixture inside the heat exchanger.
8. Check tube condition.
9. Check anode condition.

◉ **CAUTION**

Make sure heat exchanger tubes are not damaged.

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.

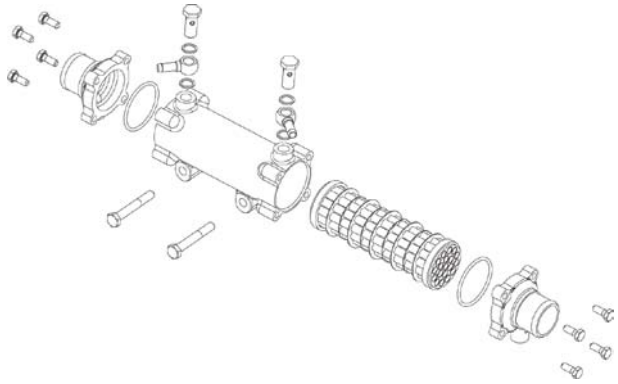
Oil cooler



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

Tightening torque:

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



4. Use L-wrench and remove end cap on both sides.
5. Remove tube bundle 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 oil cooler
8. Check the condition of oil cooler tube bundle

◉ **CAUTION**

Take CAUTION avoid oil cooler tube damage.

9. Clean housing and assemble tube bundle with new O-ring.

Water Pump

1. Drain engine coolant

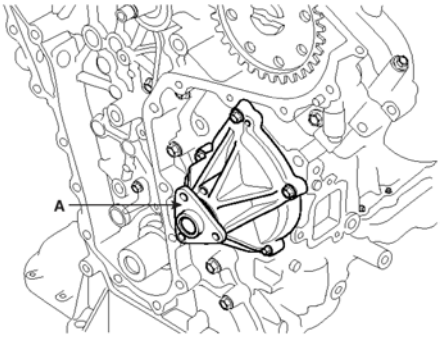
☢ **WARNING**

The system is under high pressure when the engine is hot. To avoid danger of releasing scalding engine coolant, remove the cap only when the engine is cool.

2. Remove the drive belt.
3. Remove the water pump(A).

Tightening torque:

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



4. Installation is in the reverse order of removal.

Thermostat

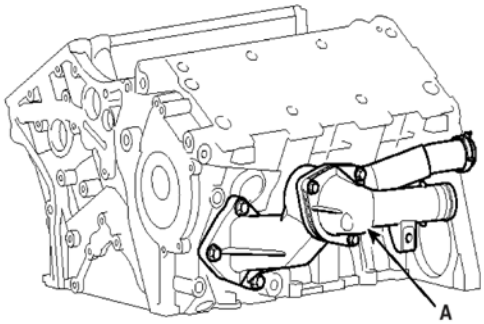
✍ NOTICE

Disassembly of the thermostat would have an adverse effect, causing a lowering of cooling efficiency.

1. Drain the engine coolant so its level is below thermostat.
2. Remove the thermostat with its gasket after taking off the water inlet fitting (A) from the engine coolant control assembly.

Tightening torque:

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



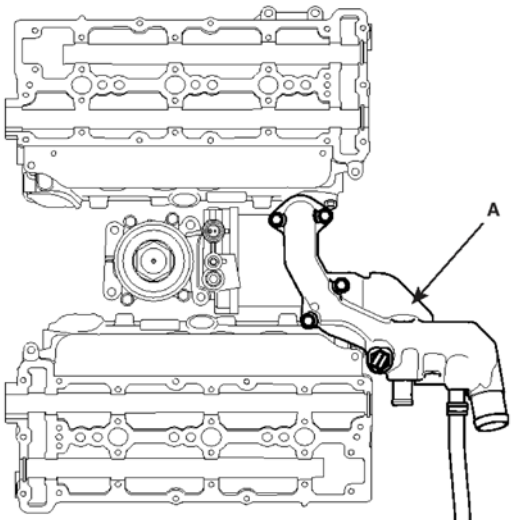
3. Installation is in the reverse order of removal. Water Outlet Duct and Fitting

Water outlet and fitting

1. Remove the intake and the exhaust manifold system.
2. Remove the water outlet duct(A).

Tightening torque:

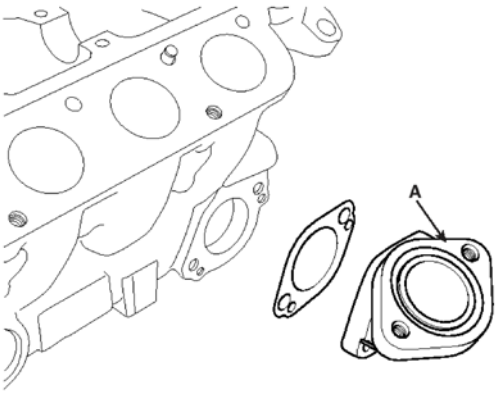
9.8 ~ 11.8Nm (1.0 ~ 1.2kgf.m, 7.2 ~ 8.7lb-ft)



3. Loosen the oil cooler mounting bolts for space of the outlet fitting's removal.
4. Remove the water outlet fitting(A).

Tightening torque:

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



Engine Coolant Control Assembly

1. Drain engine coolant.

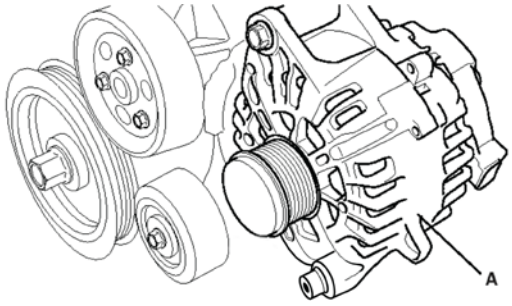
☢ WARNING

The system is under high pressure when the engine is hot. To avoid danger of releasing scalding engine coolant, remove the cap only when the engine is cool.

2. Remove the drive belt.
3. Remove the alternator (A).

Tightening torque:

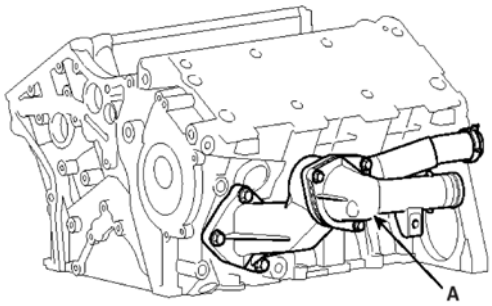
29.4 ~ 41.2Nm (3.0 ~ 4.2kgf.m, 21.7 ~ 30.4lb-ft)



4. Remove the engine coolant control assembly(A).

Tightening torque:

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



5. Installation is in the reverse order of removal.

Check Engine Coolant Level at Reservoir

1. The engine coolant level should be between the 'MAX' and 'MIN' lines, when the engine is cold. If low, check for leaks and add quality-qualified engine coolant. If you can't get any quality-qualified coolant, add similar high quality mono-ethylene glycol based non-silicate, non-amine, non-nitrite, and non-borate coolant or equivalent to 'MAX' line.

Check Engine Coolant Quality

1. Wait until engine is cool, and then carefully remove the cap.
2. Check if there is any excessive deposit of rust or scale around the cap.
3. If excessive dirty, clean the cooling system and replace coolant.
4. Reinstall the cap.

Troubleshooting

Water Pump

Symptoms		Possible Causes		Remedy
Coolant leakage	• From the bleed hole of the water pump	Visually check	• Check leaks after about ten-minute warming up.	• If coolant still leaks, replace a water pump.
				• If leakage stops, reuse the water pump (Do not replace the pump with a new one).
	• From gaskets or bolts		• Check the tightening of the water pump mounting bolts.	• Retighten the mounting bolts.
			• Check damage of gaskets or inflow of dust.	• Replace the gasket and clean dust off.
	• From outer surface of water pump		• Check the material or any cracks of the water pump.	• Poor material. If any crack found, replace the water pump.
Noise	• From bearings • From mechanical seals • Impeller interference	Inspection with a stethoscope	• After starting the engine, check noise with a stethoscope.	• If there is no noise, reuse the water pump (do not replace it).
				• If there is any noise from the water pump, remove the drive belt and recheck.
		Inspection after removing a drive belt	• After removing a water pump and a drive belt, check noise again.	• If there is noise, reuse the water pump. Check other drive line parts.
				• If there is no noise, replace the water pump with a new one.
		Inspection after removing a water pump	• After removing a water pump and a drive belt, check noise again.	• If there is any interference between them, replace the water pump with a new one.
Overheating	• Damaged impeller • Loosened impeller	Loosened impeller	• Corrosion of the impeller wing	• Check engine coolant. • Poor coolant quality / Maintenance check
			• Impeller seperation from the shaft	• Replace the water pump.

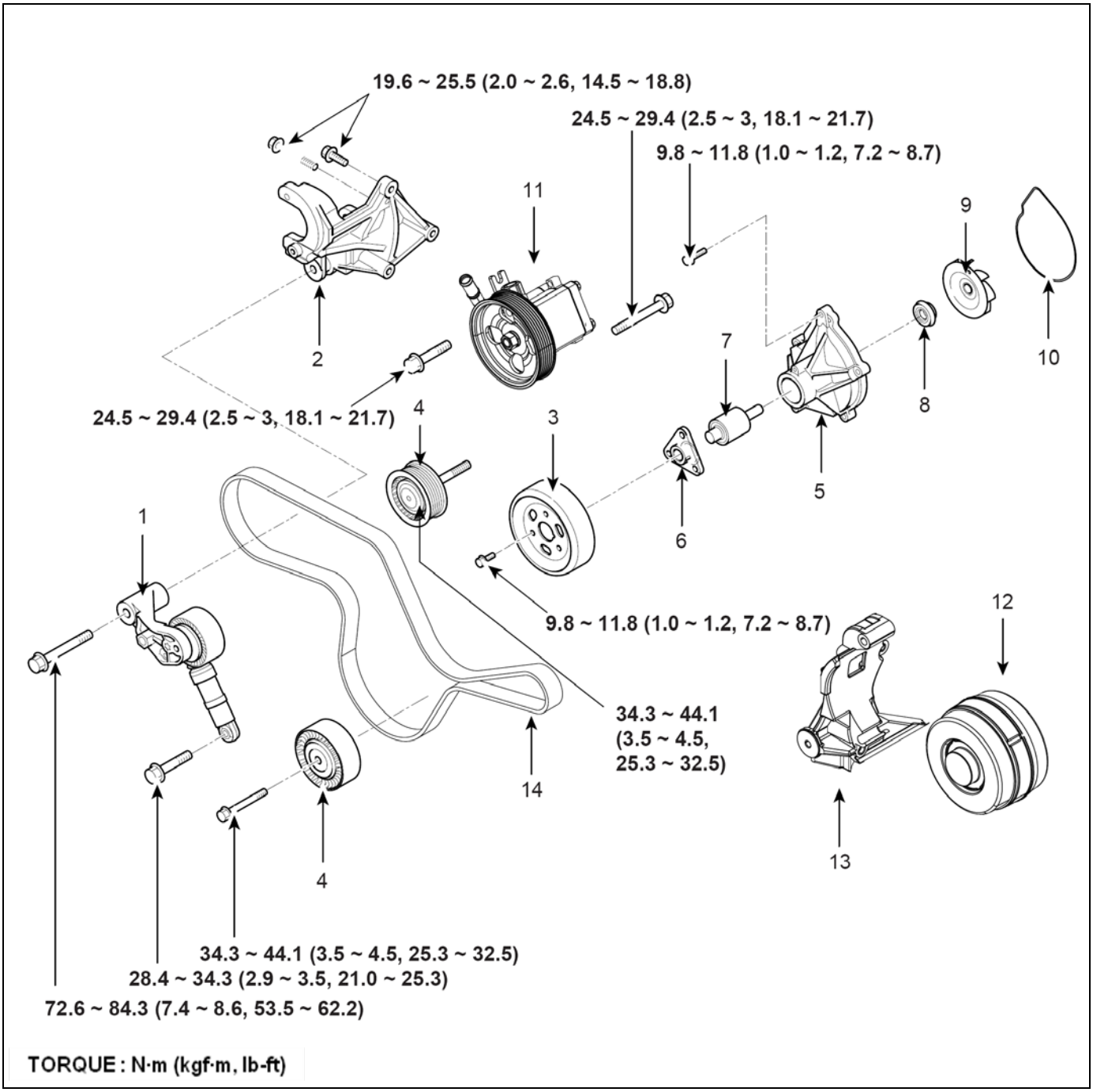
Thermostat

Symptoms		Possible Causes		Remedy
Coolant leakage	• From the thermostat gasket	Check the mounting bolts	• Check the torque of the mounting bolts	• Retighten the bolts and check leakage again.
		Check the gasket for damage	• Check gasket or seal for damage	• Replace gaskets and reuse the thermostat.
Cooled excessively	• Low heater performance (cool air blowed-out) • Thermogauge indicates 'LOW'	Visually check after removing the radiator cap.	• Insufficient coolant or leakage.	• After refilling coolant, recheck.
		GDS check & Starting engine	• Check DTCs • Check connection of the fan clutch or the fan motor. ※ If the fan clutch is always connected, there will be a noise at idle.	• Check the engine coolant sensor, wiring and connectors. • Replace the componants .
		Remove the thermostat and inspect	• Check if there are dusts or chips in the thermostat valve. • Check adherence of the thermostat.	• Clean the thermostat valve and reuse the thermostat. • Replace the thermostat, if it doesn't work properly .
Heated excessively	• Engine overheated • Thermogauge indicates 'HI'	Visually check after removing the heat-exchanger or cap.	• Insufficient coolant or leakage. ※ Be careful when removing aheat-exchanger or cap of the overheated engin. • Check leaks	• After refilling coolant, recheck. • Check the cylinder head gaskets for damage and the tightening torque of the mounting bolts.
		GDS check & Starting engine	• Check DTCs • Check the fan motor performance as temperature varies. • Check coolant in a heat exchanger • Check the water pump adherence or impeller damaged.	• Check the engine coolant sensor, wiring and connectors. • Replace the water pump, if it doesn't work properly
		Immerse the thermostat in boiling water and inspection.	• After removing the thermostat, check it works properly. ※ Check the thermostat opens at the valve opening temperature.	• Replace the thermostat, if it doesn't work properly .

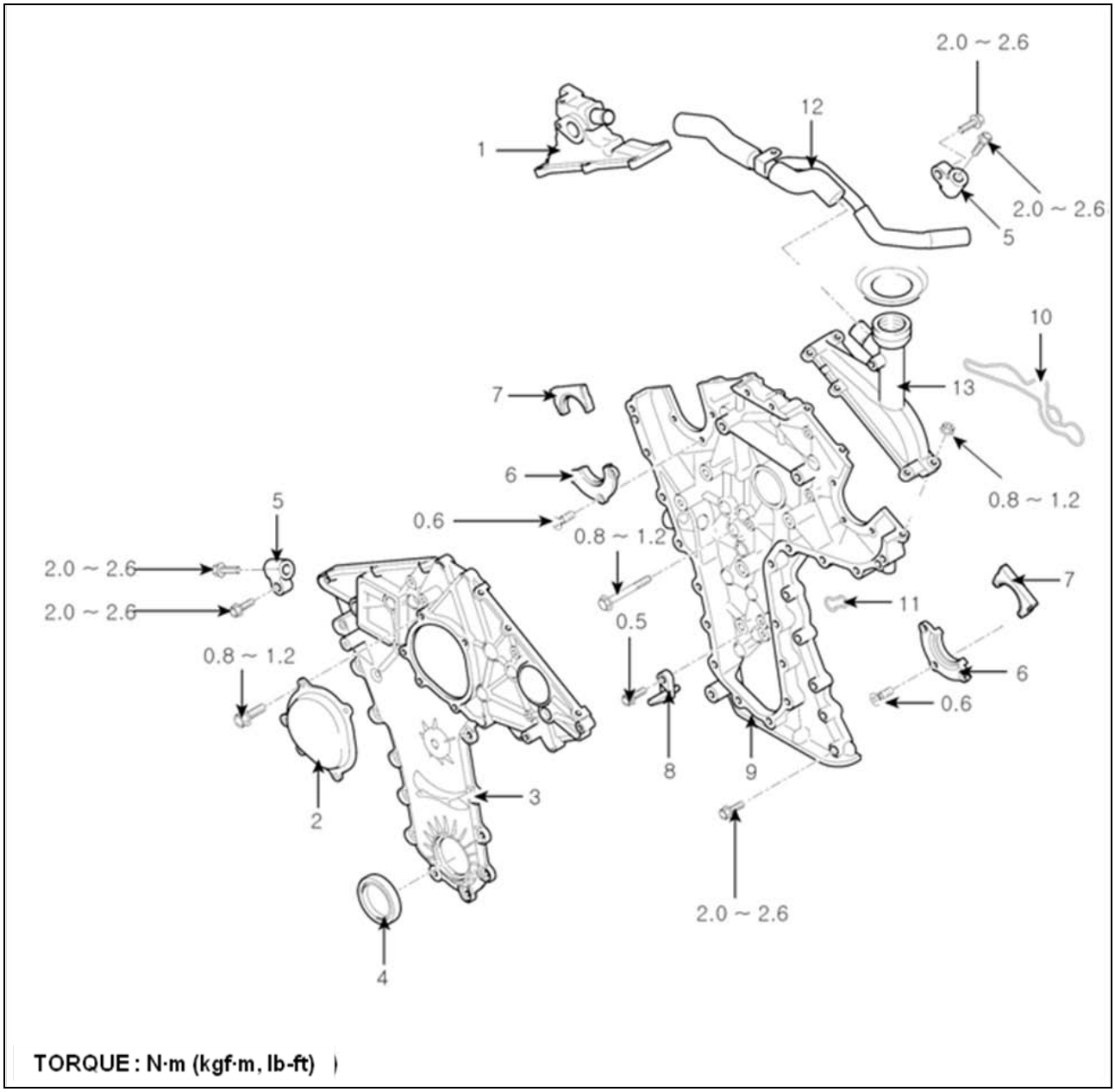
Timing System

Timing Chain

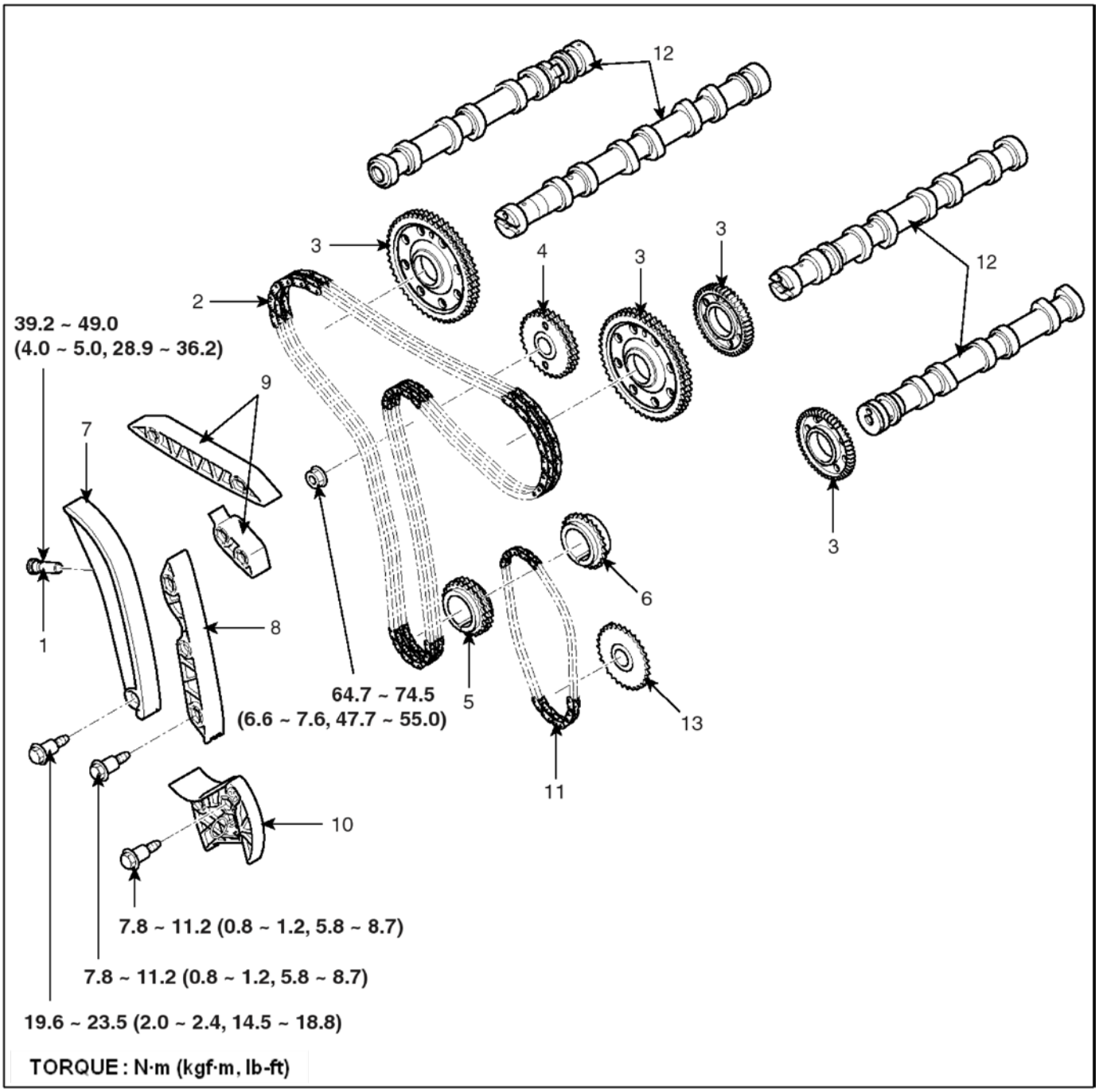
Components



1. Tensioner assembly
2. Bracket- tensioner
3. Water pump pulley
4. Stay - tensioner bracket
5. Water pump
6. Water pump pulley flange
7. Water pump bearing
8. Seal unit
9. Water pump impeller
10. Water pump gasket
11. P/S oil pump
12. Alternator
13. Bracket- alternator
14. Drive belt



1. Cap Assembly-chain case
2. High pressure pump cover
3. Chain front cover
4. Front oil seal
5. Bolt guide
6. Lower head seal
7. Upper head seal
8. Chain oil jet
9. Chain case
10. Upper O-ring
11. Lower O-ring
12. Hose assembly
13. Chain case cap



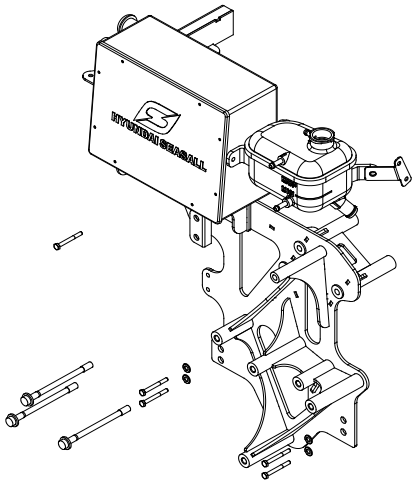
1. Hydraulic tensioner
2. Timing chain
3. Camshaft sprocket
4. High pressure pump sprocket
5. Crankshaft sprocket
6. Oil pump sprocket
7. Tensioner lever
8. Lower chain guide
9. Upper chain guide
10. Oil pump chain tensioner
11. Oil pump chain
12. Camshaft
13. Oil pump drive sprocket

Removal

Main Bracket Assembly

✍ **NOTICE**

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



1. Remove the engine harness.
2. Remove bolts connected to support bracket.

Tightening Torque:

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

3. Remove bolts connected to engine block.

Tightening Torque:

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

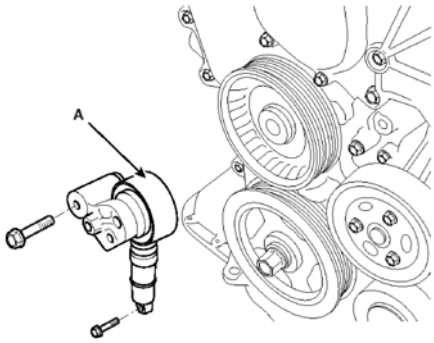
Engine Timing System

1. Compressing the tensioner with a wrench in a left hand by turning it clockwise, start removing the drive belt from the water pump side idler.

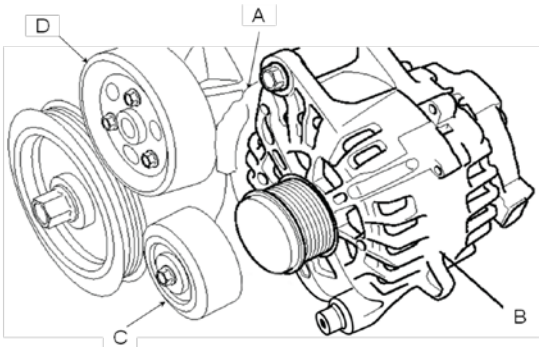
✍ **NOTICE**

Conform to what is described above because tension of the belt in this engine is higher than ones of other engines for preventing a slip

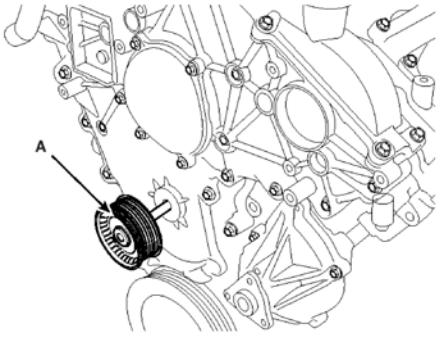
2. Remove the drive belt tensioner(A).



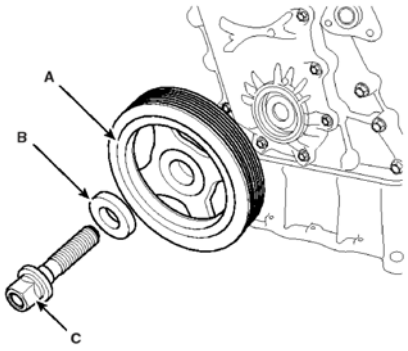
3. Remove the power steering bracket.
4. Remove the water pump pulley (D).
5. Remove the drive belt idler(C).
6. Remove the alternator (B) with its bracket (A).



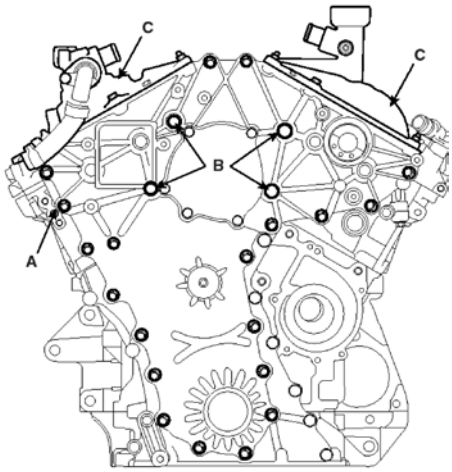
7. Remove the engine hanger.
8. Remove the water pump pulley bolt.
9. Remove the water pump pulley (A).



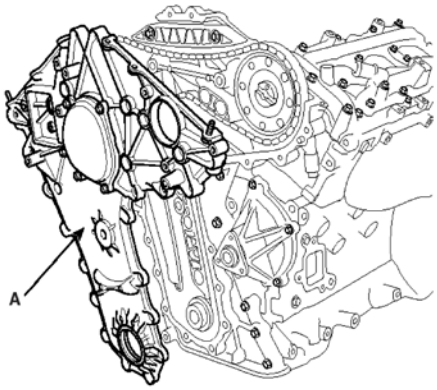
10. Remove the crankshaft pulley (A) with its washer (B) and mounting bolt(C).



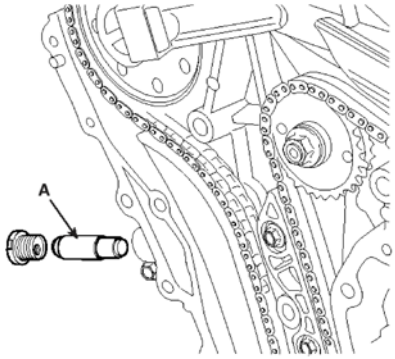
11. Remove the chain caps(C) and loosens the front chain cover mounting bolts (A-20EA, B-4EA).



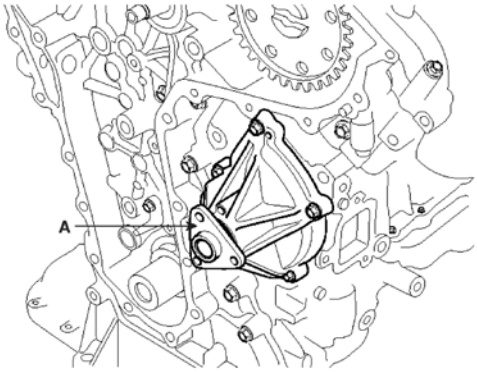
12. Remove the front chain cover(A).



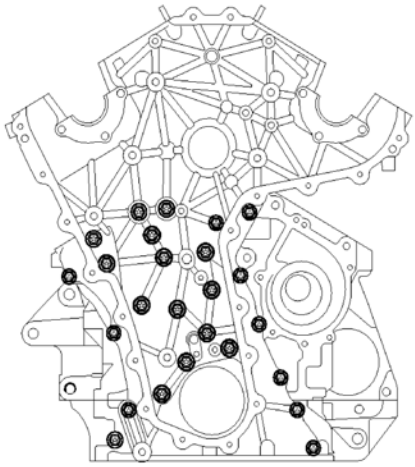
13. Remove the hydraulic tensioner(A).



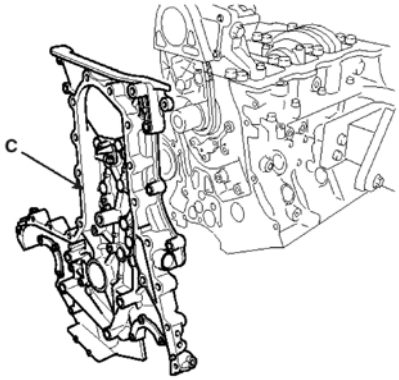
14. Remove the timing chain with the chain guide and the tensioner lever.
15. Remove the high pressure fuel pump sprocket (A).
16. Remove the upper head seal.
17. Remove the water pump (A) with its gasket.



18. Remove the high pressure pump.
19. Remove the chain case mounting bolts.

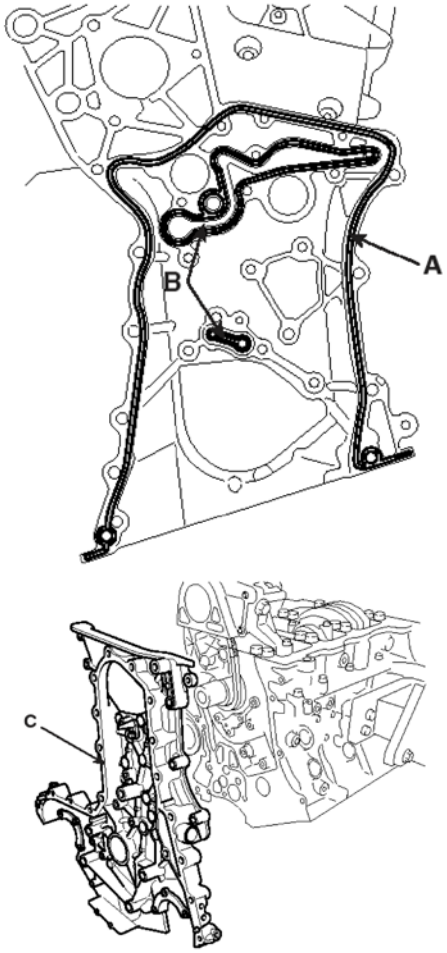


20. Remove the chain case assembly(C).



Installation

Applying sealant (A) on the groove and checking the O-rings (B) seated firmly, install the chain case assembly(C) within fifteen minutes.

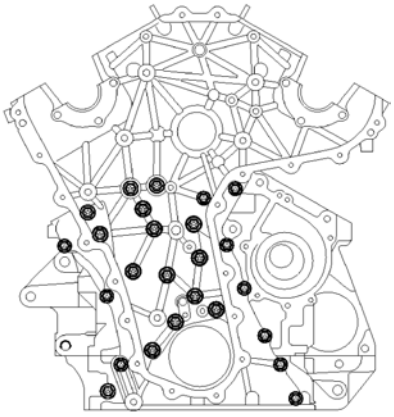


2. Tighten the chain case mounting bolts with the specified torque.

Tightening Torque:

13.7 ~ 17.7Nm (1.4 ~ 1.8kgf.m, 10.1 ~ 13.0lb-ft) - 6×16(★)

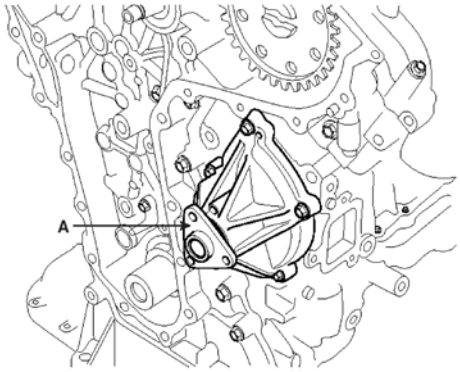
19.6 ~ 25.5Nm (2.0 ~ 2.6kgf.m, 14.5 ~ 18.8lb-ft) - 8×35(▲)



3. Install the water pump(A) with a new gasket.

Tightening Torque:

9.8 ~ 11.8Nm (1.0 ~ 1.2kgf.m, 7.2 ~ 8.7lb-ft) - 6×16(★)



4. Install the high pressure pump.
5. Applying sealant, install the upper head seal.
6. Install the high pressure fuel pump sprocket (A).

Tightening Torque:

64.7 ~ 74.5Nm (6.6 ~ 7.6kgf.m, 47.7 ~ 55.0lb-ft)

7. Install the timing chain (B), aligning the timing marks (E) on the camshaft sprocket(C) and the crankshaft sprocket (D).
8. After timing chain's installation, fix the camshaft system by using the SST (00200-0T006).
9. Install the chain guide (F) and the tensioner lever (G).

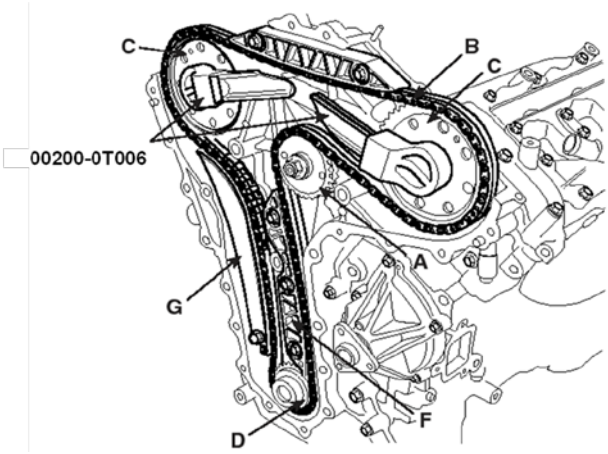
Tightening Torque:

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

19.6 ~ 23.5Nm (2.0 ~ 2.4kgf.m, 14.5 ~ 17.4lb-ft) - tensioner lever

NOTICE

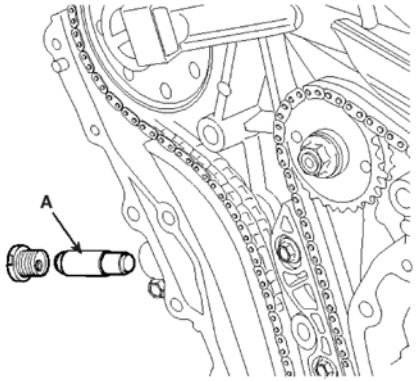
If you have difficulty in installing of the lower chain guide, turn the drive plate or move the SST a little bit.



10.Install the hydraulic tensioner(A).

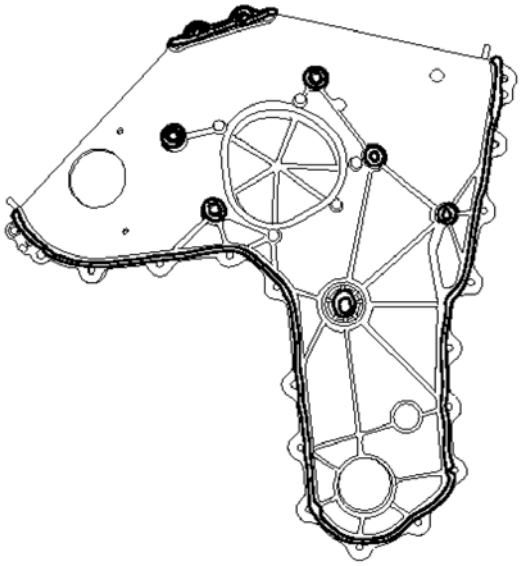
Tightening Torque:

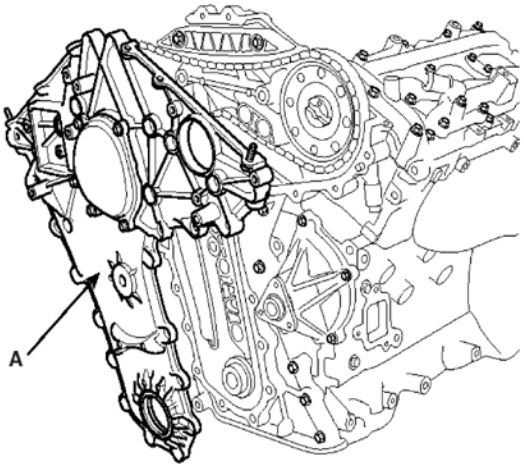
9.8 ~ 11.8Nm (1.0 ~ 1.2kgf.m, 7.2 ~ 8.7lb-ft)



11. Confirm that the timing marks are on the right position and remove the SST (00200-0T005).

12. Applying sealant on the front chain cover sealing surface, install the front chain cover within fifteen minutes.





Timing System

13. Tighten the front chain cover mounting bolts (A-20EA, B-4EA)

Tightening Torque:

7.8 ~ 11.8Nm (0.8 ~ 1.2kgf.m, 5.8 ~ 8.7lb-ft) - 20EA

19.6 ~ 25.5Nm (2.0 ~ 2.6kgf.m, 14.5 ~ 18.8lb-ft) - 4EA

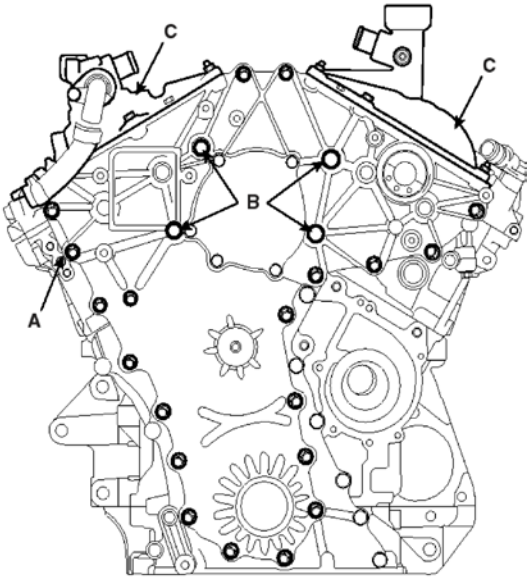
14. Applying sealant on the groove of the chain caps(C), install the caps within fifteen minutes.

Tightening Torque:

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

✍ **NOTICE**

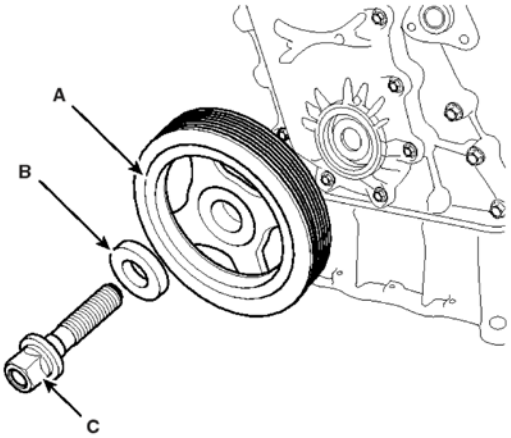
Install it after removing sealant from the camshaft bearing ladders.



15. Install the crankshaft pulley (A) with its washer (B) and tighten the mounting bolt(C).

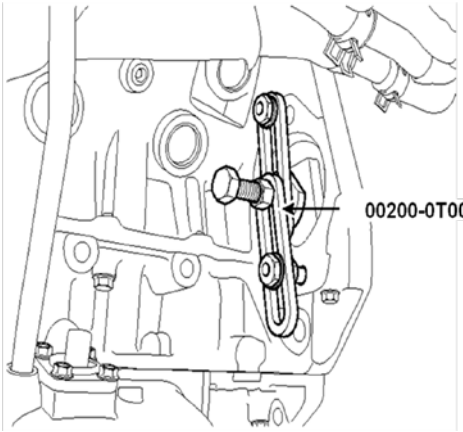
Tightening Torque:

186.3 ~ 205.9Nm (19 ~ 21kgf.m, 137.4 ~ 151.8lb-ft) + 58˚ ~ 62˚



✍ **NOTICE**

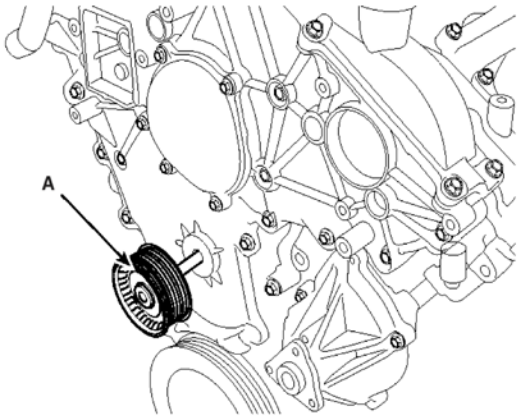
After removing the starter and installing the SST (00200-0T007), tighten the crankshaft bolt



16.Install the drive belt idler(A).

Tightening Torque:

34.3 ~ 44.1Nm (3.5 ~ 4.5kgf.m, 25.3 ~ 32.5lb-ft)



17.Install the water pump(A).

Tightening Torque:

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

18.Install the engine hanger.

Tightening Torque:

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

19.Install the alternator(B) with its bracket(A).

Tightening Torque:

29.4 ~ 41.2Nm (3.0 ~ 4.2kgf.m, 21.7 ~ 30.4lb-ft) alternator

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

20. Install the drive belt idler

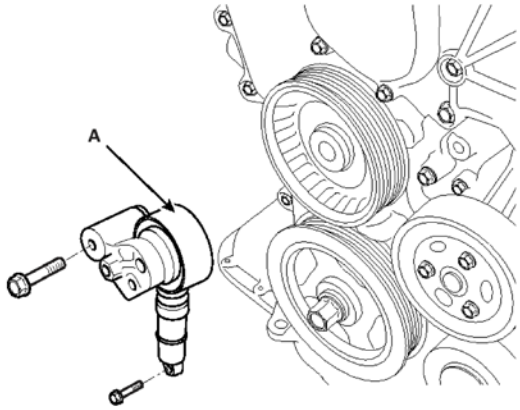
Tightening Torque:

34.3 ~44.1Nm (3.5 ~ 4.5kgf.m, 25.3 ~ 32.5lb-ft)

21.Install the water pump pulley(D).

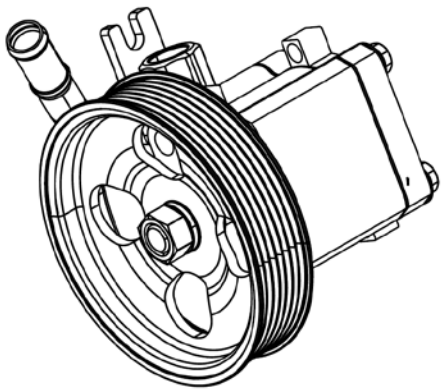
Tightening Torque:

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



22. Install the power steering bracket.

23. Install the power steering pump



1) Install new O-ring of all hydraulic lines.

2) Using other oil except steering hydraulic oil may cause noise or pump malfunction.

◉ CAUTION

Never reuse secondary O-ring or oil.

3) Check oil level after assembling the pump and supply oil gradually.

4) Check the level of reserve tank.

5) Complete the reassembly and start the ignition. Then check any oil leakage out of shaft. Replacement

24. Install the drive belt tensioner (A).

Tightening Torque:

72.6 ~ 84.3Nm (7.4 ~ 8.6kgf.m, 53.5 ~ 62.2lb-ft) - upper

28.4 ~ 34.3Nm (2.9 ~ 3.5kgf.m, 21.0 ~ 25.3lb-ft) – lower

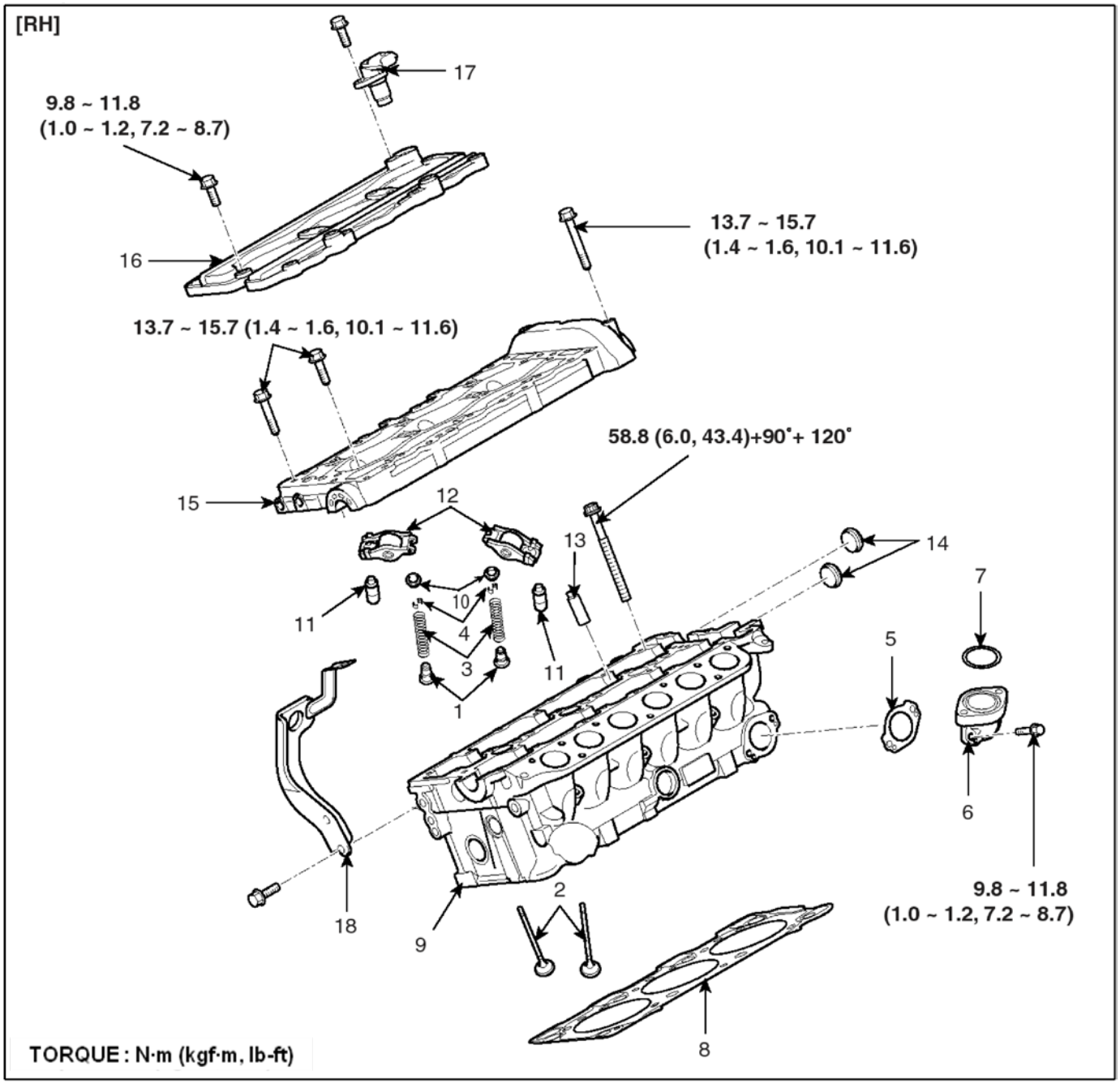
25. Compressing the tensioner with a wrench in a left hand by turning it clockwise, put on the belt lastly with the water pump side idler.

✍ NOTICE

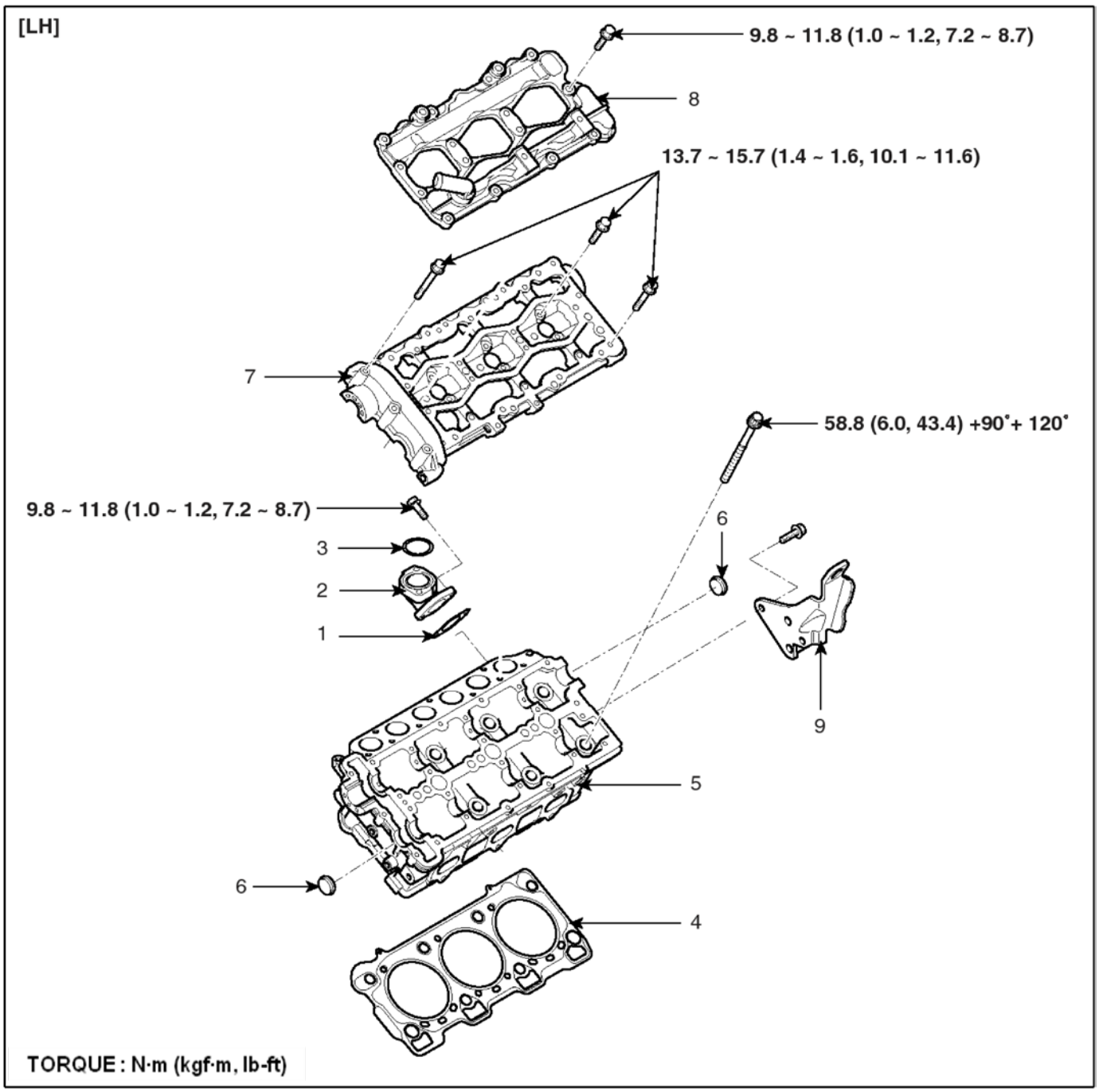
Conform to what is described above because tension of the belt in this engine is higher than ones of other engines for preventing a slip.

Cylinder Head Assembly

Components



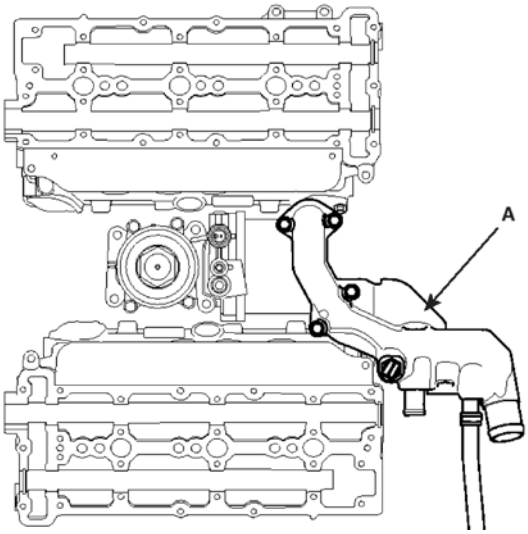
1. Valve stem seal
2. Valve
3. Valve spring
4. Valve spring retainer lock
5. Water outlet fitting gasket
6. Water outlet fitting
7. Water outlet fitting O-ring
8. Cylinder head gasket
9. Cylinder head
10. Valve spring upper retainer
11. Hydraulic lash adjuster (HLA)
12. Cam follower
13. Valve guide
14. Sealing cap
15. Camshaft bearing ladder
16. Cylinder head cover
17. Camshaft position sensor (CMP)
18. Engine hanger



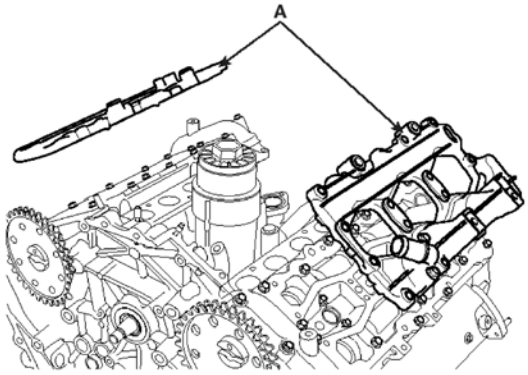
1. Water outlet fitting gasket
2. Water outlet fitting
3. Water outlet fitting O-ring
4. Cylinder head gasket
5. Cylinder head
6. Sealing cap
7. Camshaft bearing ladder
8. Cylinder head cover
9. Engine hanger

Removal

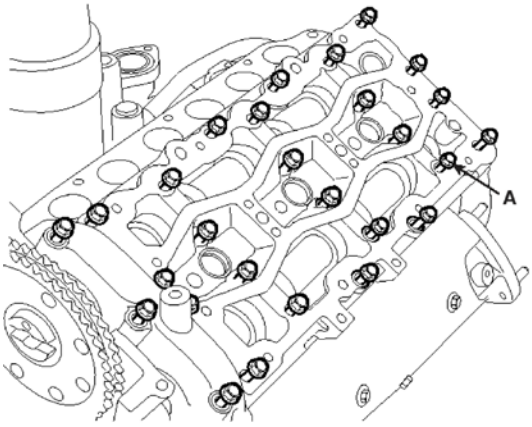
1. Remove the drive belt.
2. Remove the timing chain.
3. Remove the intake and exhaust manifold.
4. Remove the high pressure pipe, the injectors and the delivery pipe.
5. Remove the glow plug wiring.
6. Remove the water outlet duct (A).



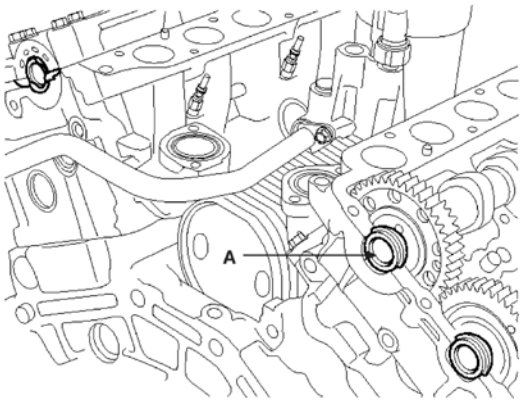
7. Remove the cylinder head cover(A).



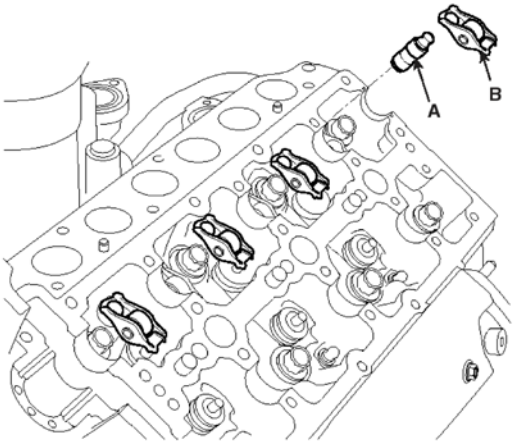
8. Remove the camshaft bearing ladder (A).



9. Remove the sealing cap (A) from the cylinder head assembly.

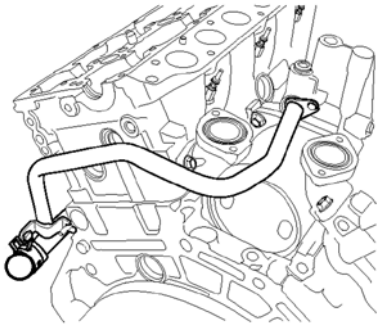


10.Remove the camshafts.
11. Remove the HLA (hydraulic lash adjuster) (A) and the cam follower assembly (B).

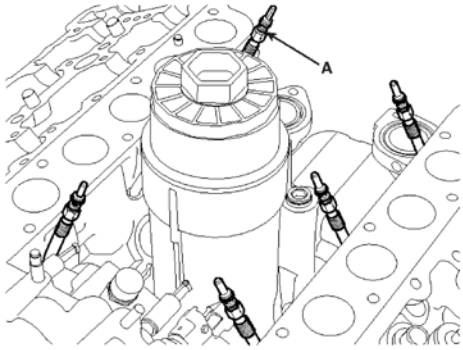


1) After you removing it, HLA shall be held upright so that oil in it should not spill and be assured that dust does not adhere to it.

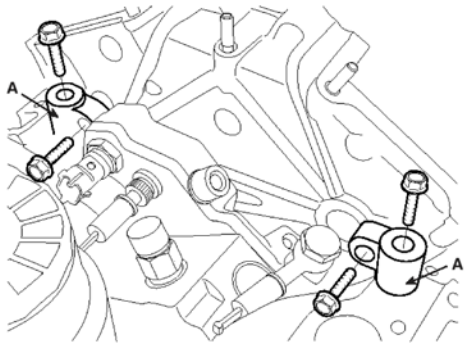
12. Remove the water pipe.

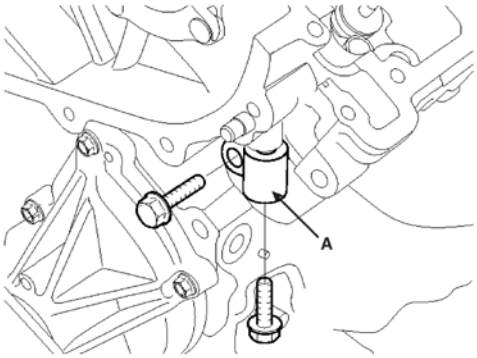


13. Remove the glow plugs (A).



14.Remove the timing chain case bracket(A).



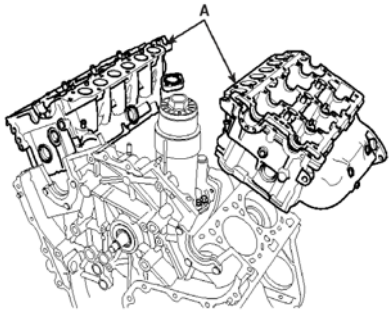


15.Remove the cylinder head bolts.

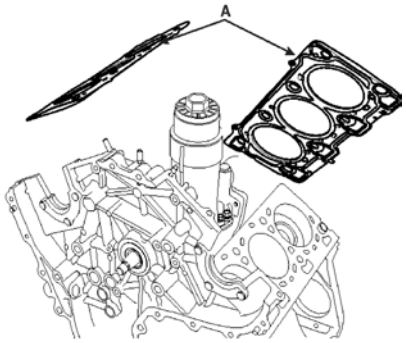
✍NOTICE

Do not reuse the cylinder head bolts more than twice.

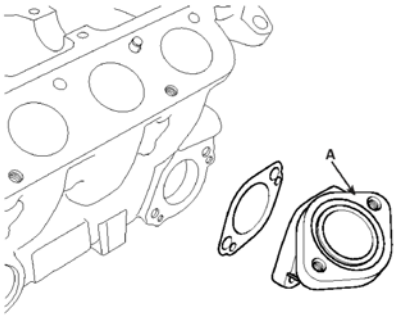
16. Remove the cylinder head quietly in order not to damage the gasket with the bottom part of the end.



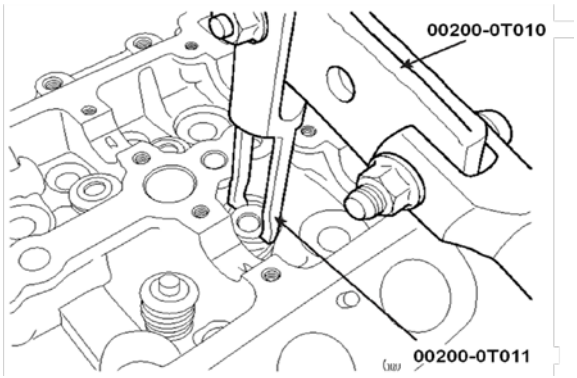
17.Remove the cylinder head gasket(A)



18. Remove the water outlet fitting(A)



19. Using the SST (00200-0T011, 00200-0T010), compress the spring and remove the retainer locks



20. Remove the valve, valve spring and spring retainer

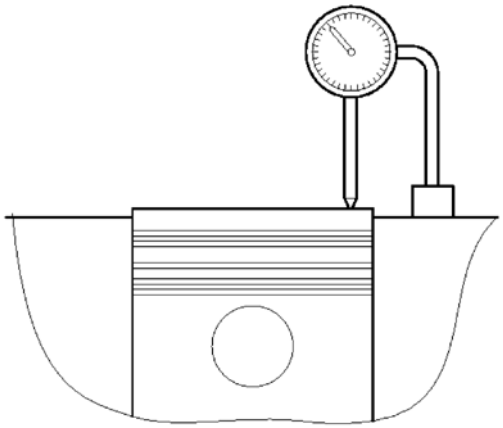
Installation

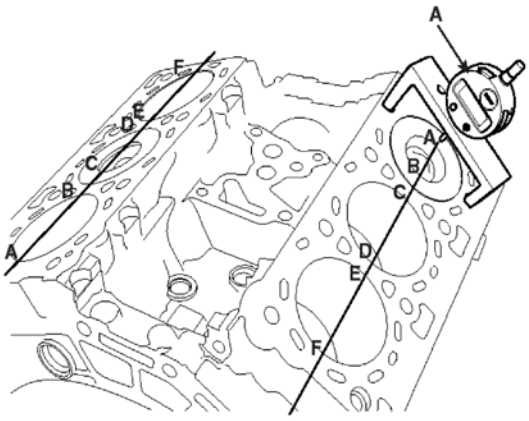
1. Clean the cylinder head and the cylinder block surfaces contacting with their gaskets.

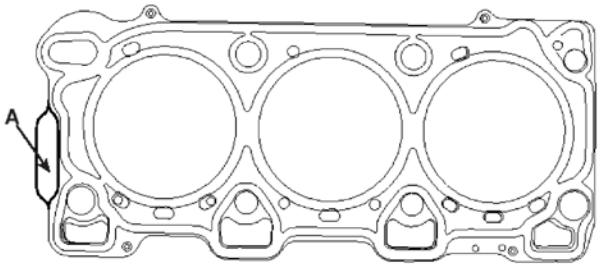
2. Select the cylinder head gasket.

1) Measure the piston protrusion from the upper cylinder block face on the twelve places (A ~ F) for each bank) at TDC (top dead center).

2) Select the gasket in the table below using the average value of the six piston protrusions. If an average value of a piston is over than the each rank limit, use one rank thicker gasket than the specified one in the table below.





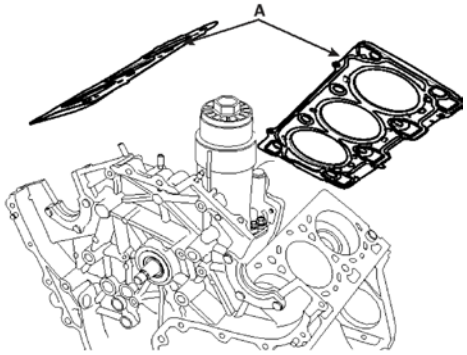


Grade(A)		A	B	C
Average of piston protrusion		0.310 ~ 0.410mm (0.0122~0.0161in.)	0.410 ~ 0.510mm (0.0161~0.0201in.)	0.510 ~ 0.610mm (0.0201~0.0240in.)
Limit of each rank extant		0.460mm(0.181in.)	0.560mm(0.220in.)	-
Gasket thickness(compressed)		1.1 ± 0.04mm (0.0433±0.0016in.)	1.2 ± 0.04mm (0.0472±0.0016in.)	1.3 ± 0.04mm (0.0512±0.0016in.)
Part No.	Left bank	22311 - 3A010	22311 - 3A000	22311 - 3A020
	Right bank	22312 - 3A010	22312 - 3A000	22312 - 3A020

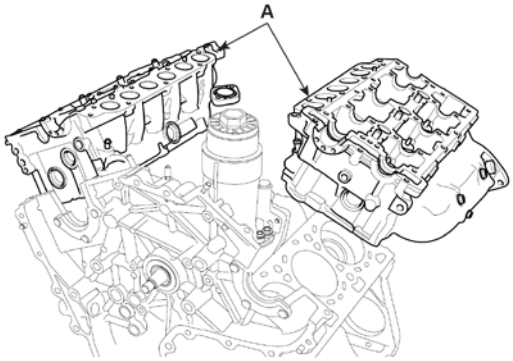
3) Install the LH gasket so that the identification mark (A) faces toward the timing chain side.
4) Install the RH gasket so that the identification mark (A) faces toward the transaxle side.
3. Install the cylinder head gasket (A) on the cylinder block

NOTICE

Be careful of the installation direction.



4. Place the cylinder head quietly in order not to damage the gasket with the bottom part of the end.



CAUTION

Put on a lid on the intake port or the water outlet fitting in order for some materials such as bolts not to get inside

5. Install the cylinder head bolts.
1) Tighten the eight cylinder head bolts on each bank, in several passes, in the sequence shown.

Tightening Torque:

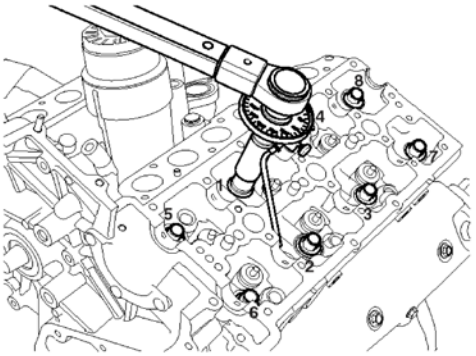
1st step: 58.8N.m (6.0kgf.m, 43.4lbf-ft)

2nd step: 90°± 2°

3rd step: 120°± 2°

NOTICE

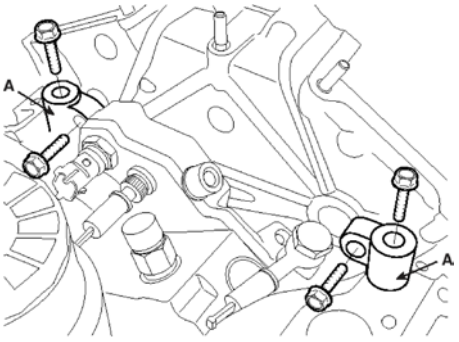
Do not reuse the cylinder head bolts more than twice.

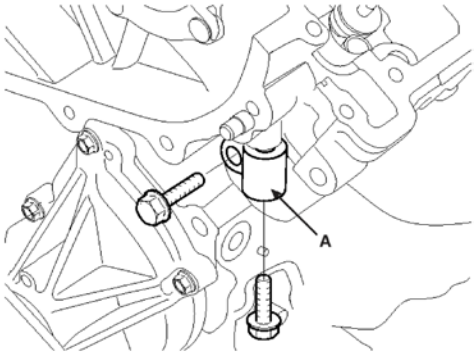


6. Install the timing chain case bracket (A). Tighten the vertical-direction bolts slightly first and then the horizontal-direction ones and the vertical-direction ones with the specified torque below.

Tightening Torque:

19.6 ~ 25.5Nm (2.0 ~ 2.6kgf.m, 14.5 ~ 18.8lb-ft)

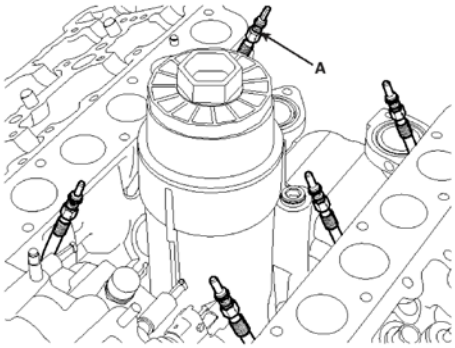




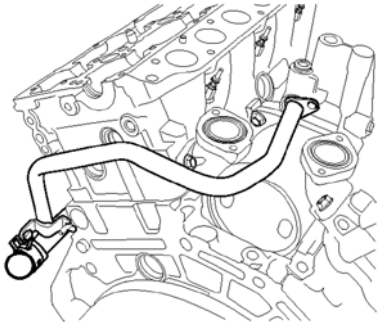
7. Tighten the glow plugs (A).

Tightening Torque:

7.8 ~ 10.8Nm (0.8 ~ 1.1kgf.m, 5.8 ~ 8.0lb-ft)



8. Install the water pipe and hose assembly(A).



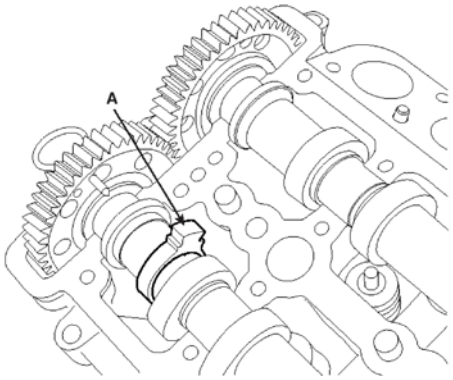
9. Install the camshafts and measure the end play.

Camshaft end play Standard:

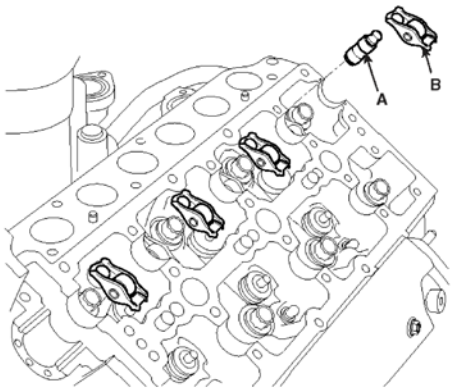
0.05 ~ 0.15mm (0.0020 ~ 0.0059in)

◉ CAUTION

When installing the RH exhaust camshaft, always check the location of TDC (top dead center) mark on the shaft.



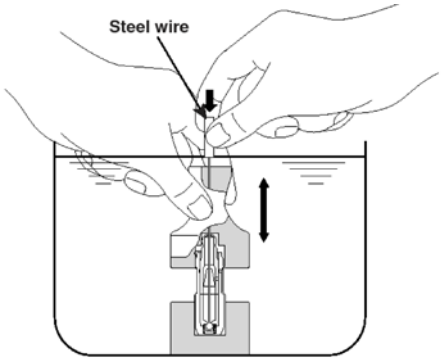
10. After measuring the end play, remove the camshafts.
11. After applying oil, install the HLA (hydraulic lash adjuster) (A) and the cam follower assembly (B).



1) Until installing, HLA shall be held upright so that oil in it should not spill and be assured that dust does not adhere to it.
2) HLA shall be inserted tenderly to the cylinder head not to spill oil from it. In case of spilling, air bent shall be done in accordance with the air bent procedure.

✍ NOTICE

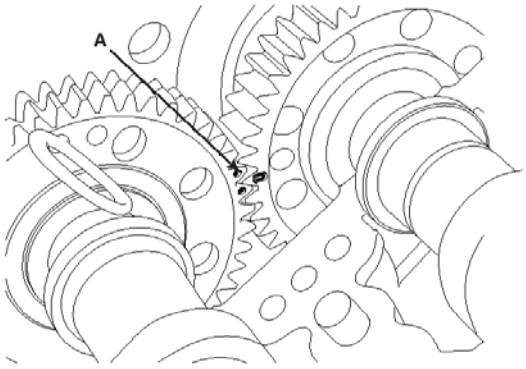
Stroke the HLA in oil 4~5 times by pushing its cap while pushing the ball down slightly by hard steel wire. (Take care not to severely push hard steel wire down since the ball weighs just several grams.)



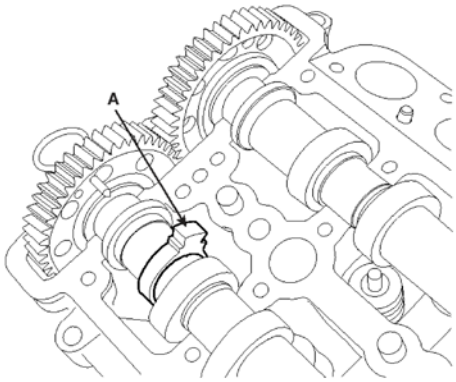
12. Wipe out oil on the upper surface of the cylinder head.
13. Install the camshafts.

◉ CAUTION

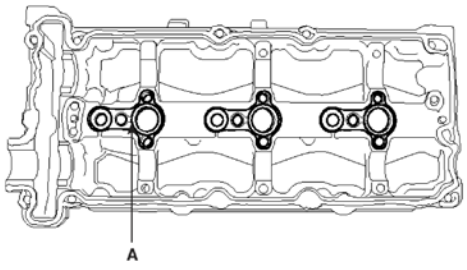
• *Align the marks (A) on the sprockets.*

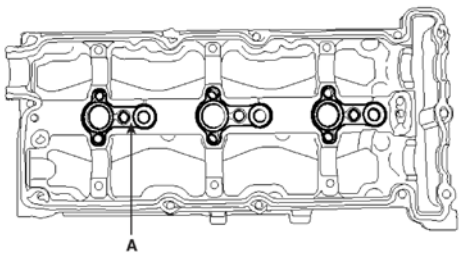


• *When installing the RH exhaust camshaft always check the location of TDC(top dead center) mark on the shaft.*

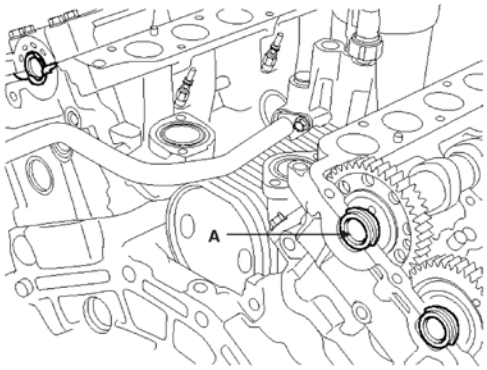


14. pressing the exhaust camshafts, take out the pin from their sprockets.
15. Put the ladder gaskets (A) on the camshaft bearing ladder and apply sealant. Also apply some oil on the contacting surface with the camshafts.





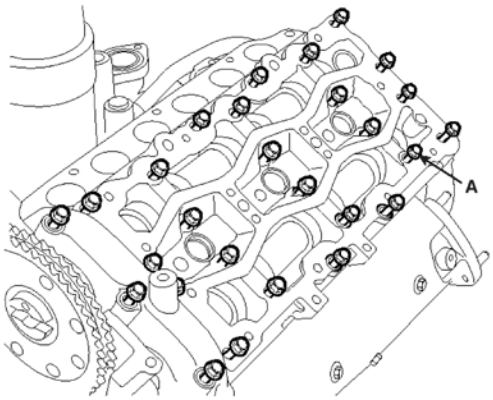
16. Install the sealing caps (A) with applying sealant LOCTITE 5902/5900 or equivalent) on the grooves (4 places) at the circumference.

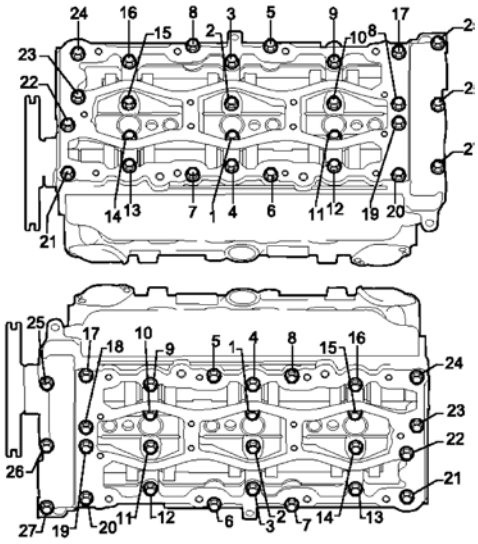


17. Install the camshaft bearing ladder (A) with the sequence and the torque below.

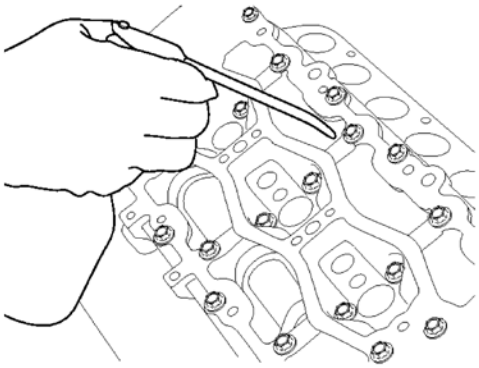
Tightening Torque:

13.7 ~ 15.7Nm (1.4 ~ 1.6kgf.m, 10.1 ~ 11.6lb-ft)





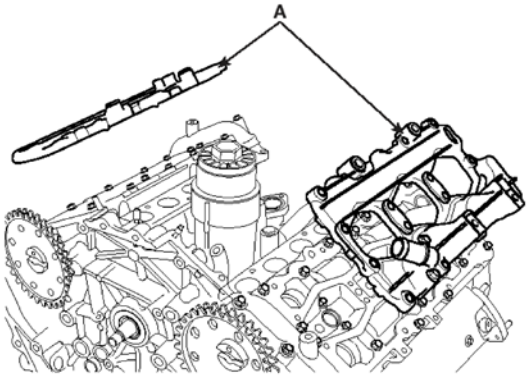
18. Apply oil on the camshafts sufficiently.

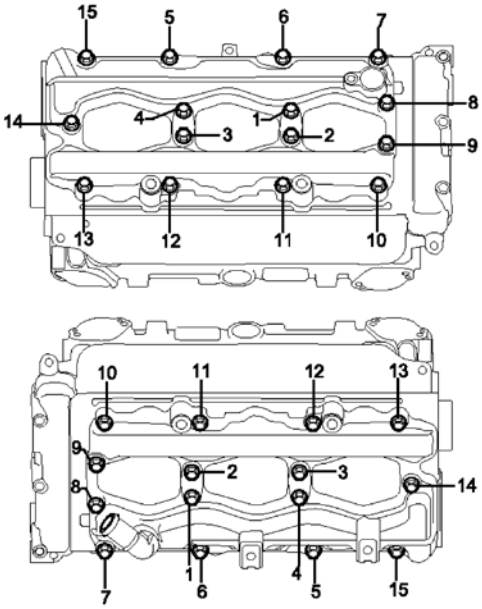


19. Install the cylinder head cover (A) with the sequence and the torque below.

Tightening Torque:

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





20. Install the water outlet duct (A).

Tightening torque

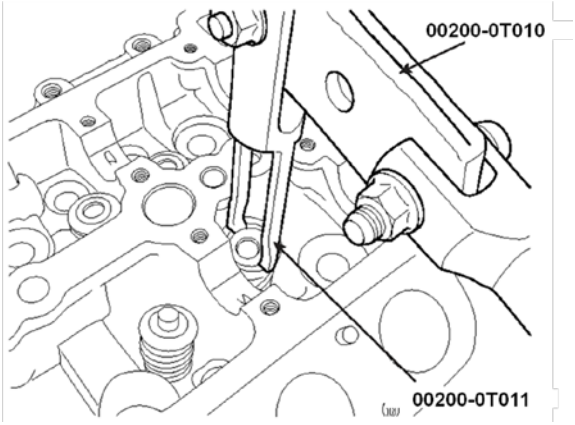
9.8 ~ 11.8Nm (1.0 ~ 1.2kgf.m, 7.2 ~ 8.7lb-ft)

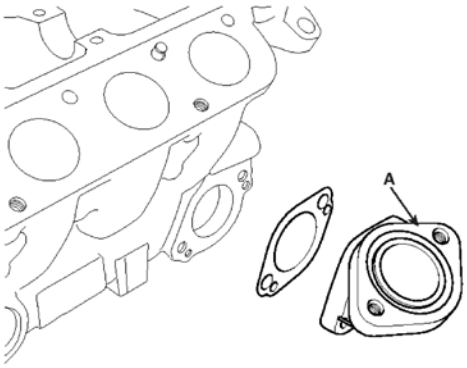
21. Install the glow plug wiring.
22. Install the delivery pipe, the injectors and the high pressure pipe.
23. Install the intake and exhaust manifold.
24. Install the timing chain.
25. Install the drive belt.

✍ NOTICE

- *Thoroughly clean all parts to be assembled.*
- *Before installing the parts, apply fresh engine oil to all sliding and rotating surface.*
- *Replace oil seals with new ones.*

26. Install the valves.
1) Using the SST (00200-0T008) (A), push in a new tem oil seal.





✍ NOTICE

• *Do not reuse old valve stem oil seals.*

• *Incorrect installation of the seal could result n oil leakage through the valve guides.*

• *Apply engine oil on a valve stem seal surface contacting with a valve guide or a valve guide outer surface before installing a valve stem seal.*

2) Install the valve, valve spring and spring retainer.

✍ NOTICE

Apply engine oil on the valves when installing.

3) Using the SST (00200-0T011, 00200-0T010), compress the spring and install the retainer locks. After installing the valves, ensure that the retainer locks are correctly in place before releasing the valve spring compressor.

4) Lightly tap the end of each valve stem two or three times with the wooden handle of a hammer to ensure proper seating of the valve and retainer lock.

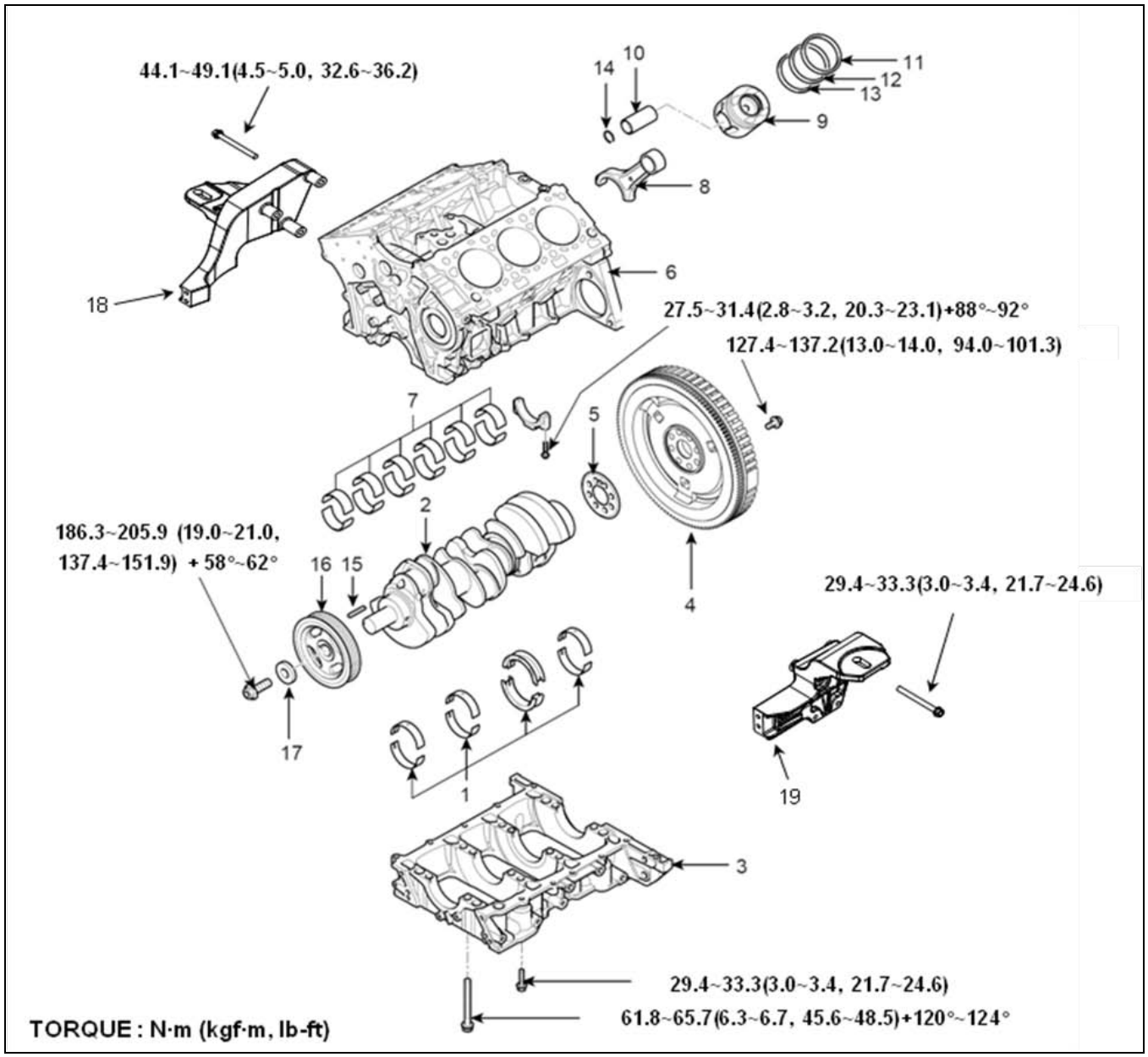
27. Install the water outlet fitting (A).

Tightening Torque:

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

Cylinder block

Components



1. Main bearing
2. Crankshaft assembly
3. Bed plate
4. Flywheel sub assembly
5. Flywheel adapter
6. Cylinder Block
7. Bearing pare set - Connecting rod
8. Connecting rod
9. Piston
10. Piston pin
11. No. 1 piston ring
12. No. 2 piston ring
13. Oil ring
14. Snap ring
15. Crankshaft key
16. Damper pulley
17. Washer
18. Engine supt brkt, RH
19. Engine supt brkt, LH

Removal

1. Remove the connecting rod caps.

✍ NOTICE

Mark the connecting rod caps to be able to reassemble in the original position and direction.

2. Remove the piston and connecting rod assembly.
1) Using a ridge reamer, remove all the carbon from the top of the cylinder.
2) Push the piston, connecting rod assembly and upper bearing out of the cylinder block.✍ NOTICE

• *Keep the connecting rod and the cap with its bearings together.*

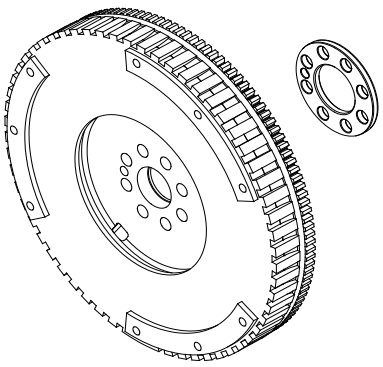
• *Arrange the piston and connecting rod assemblies in the correct order.*

3. Remove the piston and connecting rod assembly.
Using a press machine, remove the piston pin from the piston.
4. Remove the piston rings.

✍ NOTICE

Arrange the piston rings in its order, having an eye to the 'Y' mark on the ring which tells you it is the upper side.

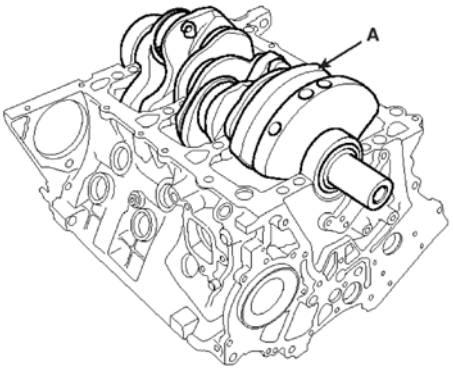
5. Remove the flywheel and flywheel adapter



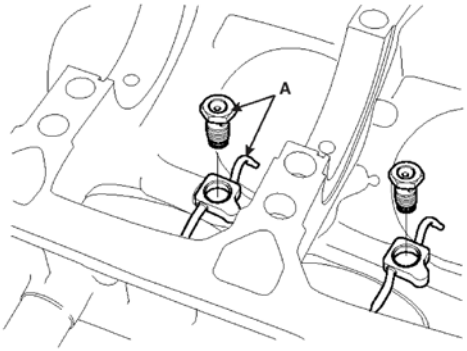
6. Remove the bedplate
7. Lift the crankshaft (A) out of the block, being careful not to damage journals.

✍ NOTICE

Arrange the main bearings and thrust bearings in the correct order.



8. Remove the oil jet(A).



Inspection

Connecting Rod

1. Check the connecting rod bearing oil clearance.
1) Check the marks on the connecting rod and rod cap for accurate reassembling.
2) Loosen the two connecting rod cap bolts.
3) Remove the connecting rod cap and the lower bearing.
4) Clean up the crankshaft pin journal and its
5) Put on the plastic gauge along the axis direction of the crankshaft.
6) Reassemble the lower bearings and the connecting rod caps and tighten the bolts with the specified torque below.

Tightening Torque:

27.5 ~ 31.4Nm (2.8 ~ 3.2kgf.m, 20.3 ~ 23.1lb-ft) + 88˚~92˚

NOTICE

• *Do not rotate the crankshaft.*

• *Do not reuse the connecting rod cap bolts.*

7) Remove the connecting rod cap again.
8) Measure the plastic gauge at its widest point.
9) If the measurement from the plastic gauge is out of the specification, change the bearings with new ones of the same identification color. Recheck the oil clearance.

CAUTION

Do not file, shim, or scrape the bearings or the caps to adjust the clearance.

Standard oil clearance:

Crankshaft pin outer diameter identification mark	Connecting rod big end inner diameter identification mark	Assembling classification of upper bearings(identification mark)	Oil cleareance(mm(in.))(reference value)
A	A	Red	0.024~0.050(0.0009~0.0020)
	B	Red	0.030~0.056(0.0012~0.0022)
	C	Yellow	0.026~0.052(0.0010~0.0020)
B	A	Red	0.030~0.056(0.0012~0.0022)
	B	Yellow	0.026~0.052(0.0010~0.0020)
	C	Yellow	0.032~0.058(0.0013~0.0023)
C	A	Yellow	0.026~0.052(0.0010~0.0020)
	B	Yellow	0.032~0.058(0.0013~0.0023)
	C	Blue	0.028~0.054(0.0011~0.0021)

10) If the plastic gauge shows the clearance is still incorrect, try the larger or smaller bearing. Recheck the oil clearance.

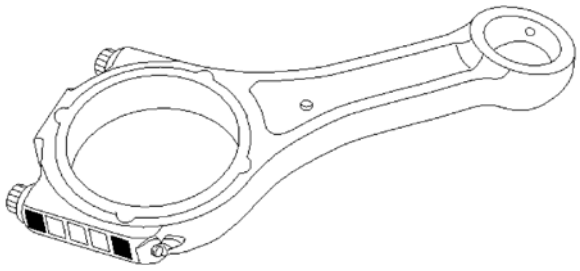
NOTICE

If the proper clearance still cannot be obtained after using the appropriate larger or smaller bearings, replace the crankshaft and restart measuring

CAUTION

If the marks are indecipherable because of an accumulation of dirt or dust, do not scrub them with a wire brush or scraper. Clean them only with solvent or detergent.

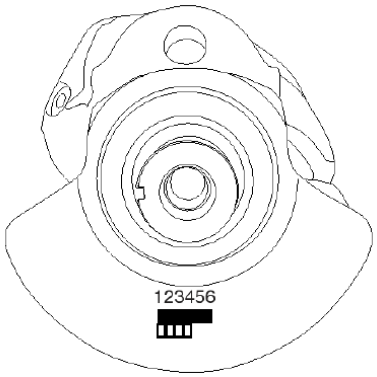
Connecting rod mark location



Discrimination Of Connecting Rod

Mark	Connecting rod big-end inner diameter
A	66.500 ~ 66.506 mm(2.6181~2.6183 in.)
B	66.506 ~ 66.512 mm(2.6183~2.6186 in.)
C	66.512 ~ 66.518 mm(2.6186~2.6188 in.)

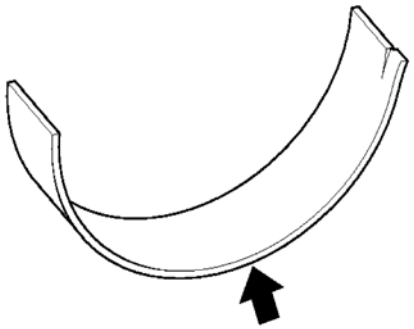
Crankshaft pin journal mark location



Discrimination Of Crankshaft Pin Journal

Mark	Crankshaft pin journal outer diameter
A	63.494 ~ 63.500 mm(2.4998~2.5000 in.)
B	63.488 ~ 63.494 mm(2.4995~2.4998 in.)
C	63.482 ~ 63.488 mm(2.4993~2.4995 in.)

Connecting Rod Bearing Mark Location



Discrimination Of Connecting Rod Upper Bearing

Color	Connecting rod upper bearing thickness
Blue	1.497 ~ 1.507mm (0.0589 ~ 0.0593in.)
Yellow	1.487 ~ 1.497mm (0.0585 ~ 0.0589in.)
Red	1.477 ~ 1.487mm (0.0581 ~ 0.0585in.)

Discrimination of connecting rod lower bearing

Color	Connecting rod lower bearing thickness
-	1.485 ~ 1.489mm (0.0585 ~ 0.0586in.)

11) Select the suitable bearing by using the selection table below.

Connecting Rod Bearing Selection Table

Connecting rod bearing		Connecting rod mark		
		A	B	C
Crankshaft pin journal mark	A	Red	Red	Yellow
	B	Red	Yellow	Yellow
	C	Yellow	Yellow	Blue

2. Check the connecting rods.

1) When reinstalling, make sure that cylinder numbers put on the connecting rod and cap at disassembly match. When a new connecting rod is installed, make sure that the notches for holding the bearing in place are on the same side.

2) Replace the connecting rod if it is damaged on the thrust faces at either end. Also if step wear or a severely rough surface of the inside diameter of the small end is apparent, the rod must be replaced as well.

3) Using a connecting rod aligning tool, check the rod for bend and twist. If the measured value is close to the repair limit, correct the rod by a press. Any connecting rod that has been severely bent or distorted should be replaced.

Crankshaft

1. Check the crankshaft bearing oil clearance.
1) To check main bearing-to-journal oil clearance, remove the bed plate and lower bearings.
2) Clean each main journal and lower bearing with a clean shop towel.
3) Place one strip of plastic gauge across each main journal.
4) Reinstall the lower bearings and bed plate, and then tighten the bolts.

✍ **NOTICE**

• *Reinstall the lower bearings and bed plate, and then tighten the bolts.*

• *If the bed plate bolts are damaged or deformed, replace them with new ones.*

5) Tighten the No.18, 20, 21 bolts in its number order (18→20→21) with the specified torque.

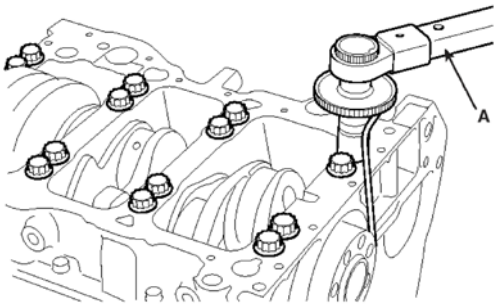
Tightening Torque:

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

6) Tighten the No.1~16 bolts in two steps with the specified torque and angle below.

Tightening Torque:

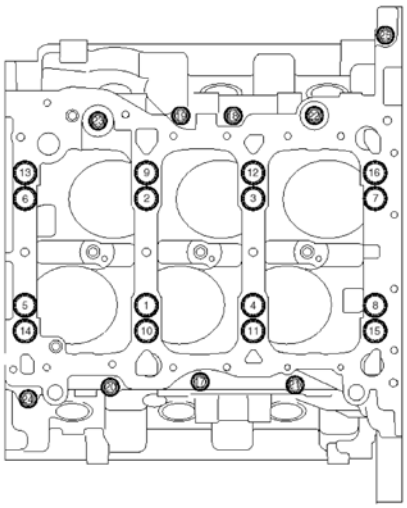
61.8 ~ 65.7Nm (6.3 ~ 6.7kgf.m, 45.6 ~ 48.5lb-ft) – 1st step 120° ~ 124° - 2nd step



7) Loosen the bolts No. 18, 20 and 21.
8) Tighten the No.17~25 bolts with the specified torque below.

Tightening Torque:

29.4 ~ 33.3Nm (3.0 ~ 3.4kgf.m, 21.7 ~ 24.6lb-ft) – 1st step



✍ **NOTICE**

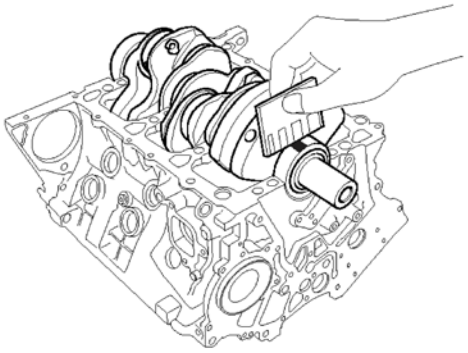
Do not rotate the crankshaft.

9) Remove the bed plate and lower bearing again, and measure the widest part of the plastic gauge.

Standard oil clearance:

0.030 ~ 0.048mm (0.0012 ~ 0.0019in)

10) If the plastic gauge measurement is too wide or too narrow, remove the bearings and then install new bearings with the same color mark. Recheck the oil clearance.



◉ CAUTION

Do not file, shim, or scrape the bearings or the caps to adjust clearance.

11) If the plastic gauge shows the clearance is still incorrect, try the larger or smaller bearing. Recheck the oil clearance.

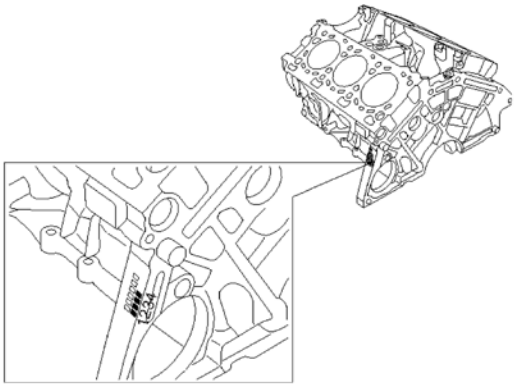
✍ NOTICE

If the proper clearance cannot be obtained by using the appropriate larger or smaller bearings, replace the crankshaft and start the measurement from the first.

◉ CAUTION

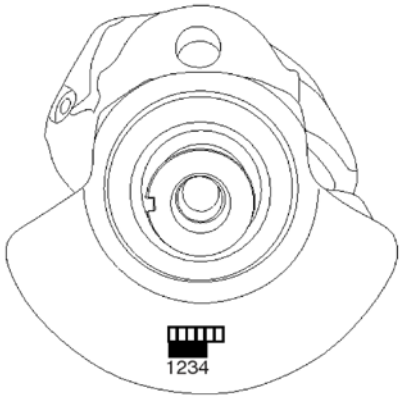
If the marks are indecipherable because of an accumulation of dirt and dust, do not scrub them with a wire brush or scraper. Clean them only with solvent or detergent. Crankshaft Journal Bore Mark Location

Crankshaft Journal Bore Mark Location



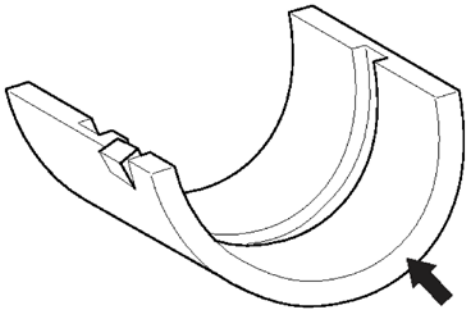
Mark	Cylinder block journal bore inner diameter
A	80.000 ~ 80.006 mm(3.1496~3.1498 in.)
B	80.006 ~ 80.012 mm(3.1498~3.1501 in.)
C	80.012 ~ 80.018 mm(3.1501~3.1503 in.)

Crankshaft Main Journal Mark Location



Mark	Crankshaft main journal outer diameter
A	75.994 ~ 76.000 mm(2.9919~2.9921 in.)
B	75.988 ~ 75.994 mm(2.9916~2.9919 in.)
C	75.982 ~ 75.988 mm(2.9914~2.9916 in.)

Crankshaft Main Bearing Mark Location



Discrimination Of Crankshaft Main Bearing

Color	Crankshaft bearing thickness
Red	1.994 ~ 1.997mm (0.0785 ~ 0.0786in.)
Blue	1.991 ~ 1.994mm (0.0784 ~ 0.0785in.)
-	1.988 ~ 1.991mm (0.0783 ~ 0.0784in.)
Yellow	1.985 ~ 1.988mm (0.0781 ~ 0.0783in.)
Green	1.982 ~ 1.985mm (0.0780 ~ 0.0781in.)

12) Select the suitable bearing by using the selection table below.

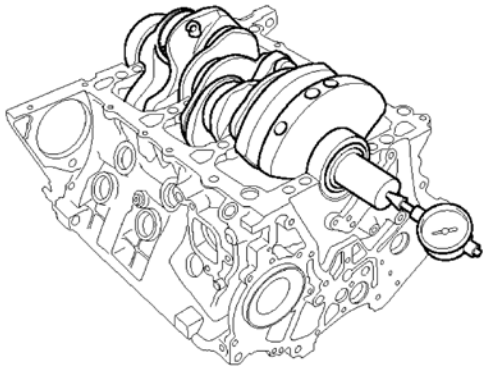
Crankshaft Main Bearing Selection Table

Crankshaft main bearing		Crankshaft bore mark		
		A	B	C
Crankshaft main journal mark	A	Green	Yellow	-
	B	Yellow	-	Blue
	C	-	Blue	Red

2. Check the crankshaft end play. Using a dial indicator measure the clearance while prying the crankshaft back and forth.

End play

Standard: 0.1 ~ 0.3mm (0.0039 ~ 0.118in)



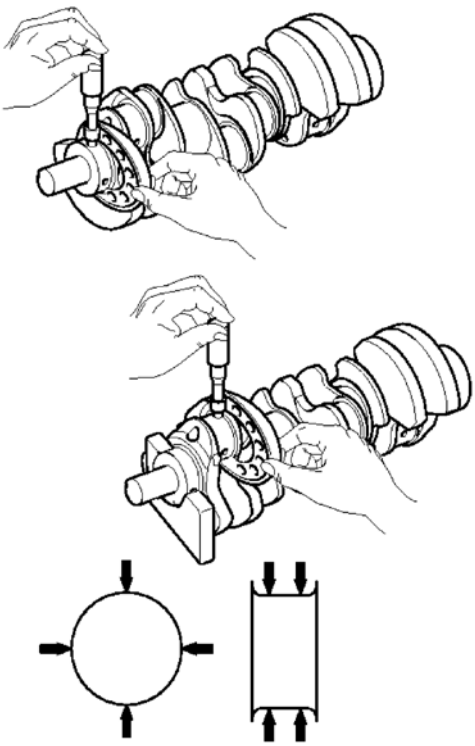
3. Inspect the crankshaft main journals and pin journals. Using a micrometer, measure the diameter of each main journal and pin journal.

Main journal diameter:

75.982 ~ 76.000mm (2.9914 ~ 2.9921in)

Pin journal diameter:

63.482 ~ 63.500mm (2.4993 ~ 2.5000in)



Cylinder Block

1. Remove the gasket material. Using a gasket scraper, remove all the gasket material from the top surface of the cylinder block.
2. Clean the cylinder block Using a soft brush and solvent, thoroughly clean the cylinder block.
3. Inspect the top surface of cylinder block for flatness. Using a precision straight edge and feeler gauge measure the surface contacting the cylinder head gasket for war page.

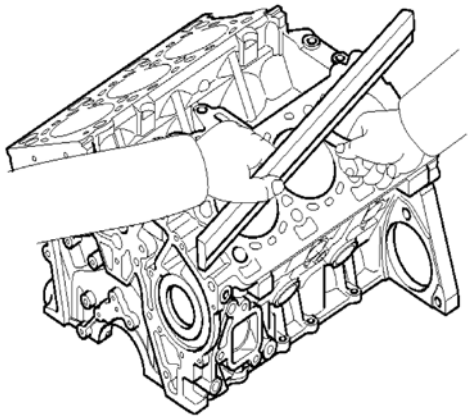
Flatness of cylinder block gasket surface

Less than 0.05mm (0.0020in)

Less than 0.042mm (0.0017in) for width

Less than 0.096mm (0.0038in) for length

Less than 0.012mm (0.0005in) for 50mm × 50mm

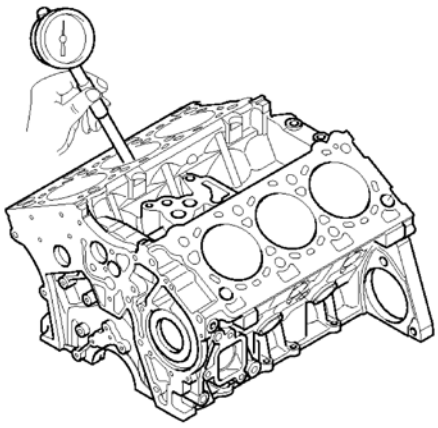


4. Inspect the cylinder bore. Visually check the cylinder for vertical scratch. If deep scratch is present, replace the cylinder block.

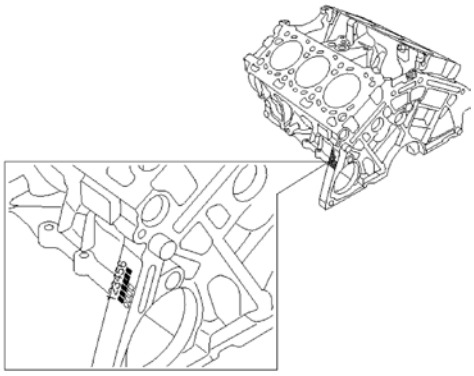
5. Inspect the cylinder bore diameter. Using a cylinder bore gauge, measure the cylinder bore diameter at position in a thrust and an axial direction.

Standard diameter:

84.000 ~ 84.030mm (3.3071 ~ 3.3083in)



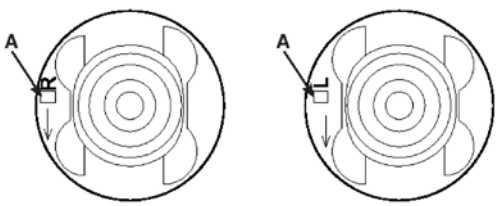
6. Check the cylinder bore size code on the cylinder block side face.



Discrimination Of Cylinder Bore Size

Mark	Cylinder bore inner diameter
A	84.000 ~ 84.010 mm(3.3071~3.3075 in.)
B	84.010 ~ 84.020 mm(3.3075~3.3079 in.)
C	84.020 ~ 84.030 mm(3.3079~3.3083 in.)

7. Check the piston size mark(A) on the piston top face.



Discrimination Of Piston Outer Diameter

Mark	Piston outer diameter
A	83.926 ~ 83.936 mm(3.3042~3.3046 in.)
B	83.936 ~ 83.946 mm(3.3046~3.3050 in.)
C	83.946 ~ 83.956 mm(3.3050~3.3053 in.)

8. Select the piston related to cylinder bore class.

Piston-to-cylinder clearance:

0.064 ~ 0.084mm (0.0025 ~ 0.0033in)

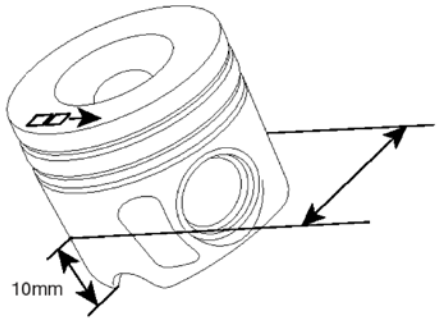
Cylinder Boring

1. Oversize pistons should be selected according to the largest cylinder bore.

NOTICE

The size mark of piston is stamped on the top surface of the piston.

2. Measure the outer diameter of the piston to be used. The standard measurement of the piston outer diameter is taken 10mm (0.39in) height from bottom land of the piston.



3. According to the measured outer diameter, calculate the new bore size.

New bore size = piston O.D + 0.064 ~ 0.084mm (0.0025~ 0.0033in) (clearance between piston and cylinder) - 0.01mm (0.0004in) (honing margin.)

4. Bore each of the cylinders to the calculated size.

CAUTION

To prevent distortion that may result from temperature rise during honing, bore the cylinder holes in the firing order.

5. Hone the cylinders, finishing them to the proper dimension (piston outside diameter + gap with cylinder).

6. Check the clearance between the piston and cylinder

Piston-to-cylinder clearance:

0.064 ~ 0.084mm (0.0025 ~ 0.0033in)

NOTICE

When boring the cylinders, finish all of the cylinders to the same oversize. Do not bore only one cylinder to the oversize.

Piston and Piston Ring

1. Clean the piston.

1) Using a gasket scraper, remove carbon from the piston top.

2) Using a groove cleaning tool or a broken ring, clean the piston ring grooves.

3) Using a brush with solvent, thoroughly clean the piston.

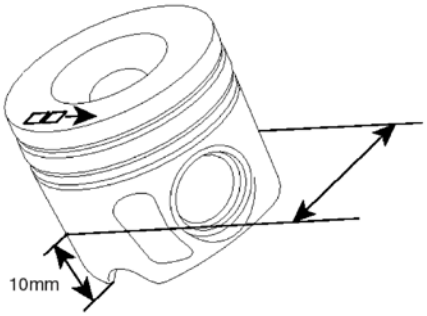
NOTICE

Do not use a wire brush.

2. The standard measurement of the piston outer diameter is taken 10mm (0.39in) height from bottom land of the piston.

Standard diameter:

83.926 ~ 83.956mm (3.3042 ~ 3.3053in)



3. Calculate the difference between the cylinders bore inner diameter and the piston outer diameter.

Piston-to-cylinder clearance:

0.064 ~ 0.084mm (0.0025 ~ 0.0033in)

4. Inspect the piston ring side clearance. Using a feeler gauge, measure the clearance between new piston ring and the wall of ring groove.

Piston ring side clearance

No.1: 0.102 ~ 0.146mm (0.0040 ~ 0.0057in.)

No.2: 0.08 ~ 0.12mm (0.0031 ~ 0.0047in.)

Oil ring: 0.03 ~ 0.07mm (0.0012 ~ 0.0028in.)

If the clearance is out of the specification above replace the piston.

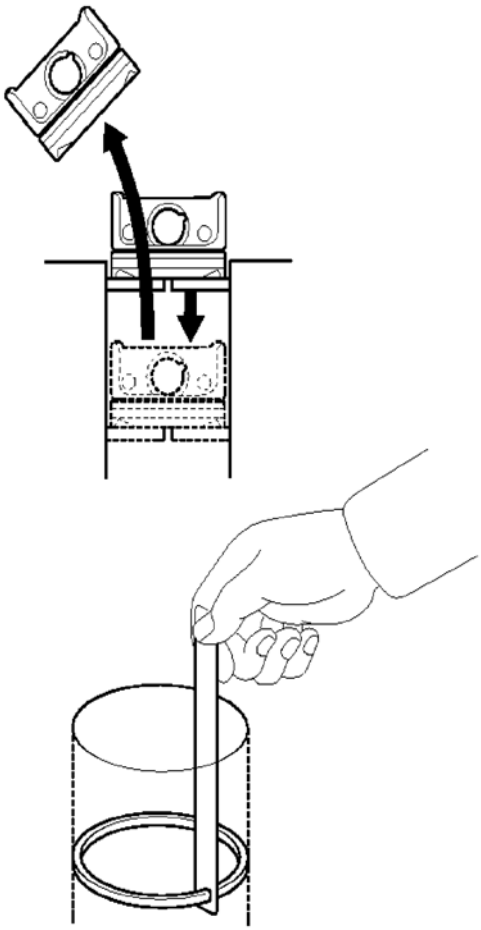
5. Inspect the piston ring end gap. To measure the piston ring end gap, insert a piston ring into the cylinder bore. Position the ring at right angles to the cylinder wall by gently pressing it down with a piston. Measure the gap with a feeler gauge. If the gap exceeds the service limit, replace the piston rings. If the gap is too large, recheck the Cylinder bore inner diameter. If the bore is over the service limit, the cylinder block must be re boring

Piston ring end gap

No.1: 0.20 ~ 0.35mm (0.0079 ~ 0.0138in.)

No.2: 0.40 ~ 0.60mm (0.0157 ~ 0.0236in.)

Oil ring: 0.25 ~ 0.50mm (0.0098 ~ 0.0197in.)

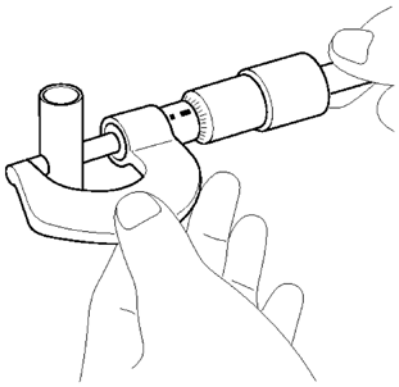


Piston Pins

Measure the outer diameter of piston pin.

Piston pin diameter:

30.994 ~ 31.000mm (1.2202 ~ 1.2205in)



Measure the piston pin-to-piston clearance.

Piston pin-to-piston clearance:

0.014 ~ 0.027mm (0.0006 ~ 0.0011in)

3. Check the difference between the piston pin outer diameter and the connecting rod small end inner diameter.

Piston pin-to-connecting rod interference:

0.020 ~ 0.037mm (0.0008 ~ 0.014in)

Installation

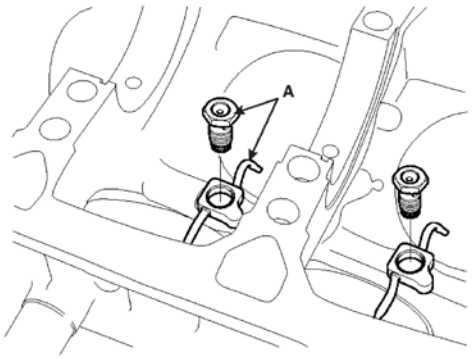
NOTICE

- *Thoroughly clean all parts to assemble.*
- *Before installing the parts, apply fresh engine oil to all sliding and rotating surfaces.*
- *Replace all gaskets, O-rings and oil seals with new parts.*

Install the oil jet(A).

Tightening Torque:

29.4 ~ 34.3Nm (3.0 ~ 3.5kgf.m, 21.7 ~ 25.3lb-ft)

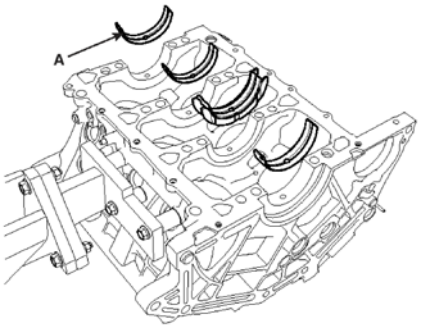


Install the crankshaft main bearings(A).

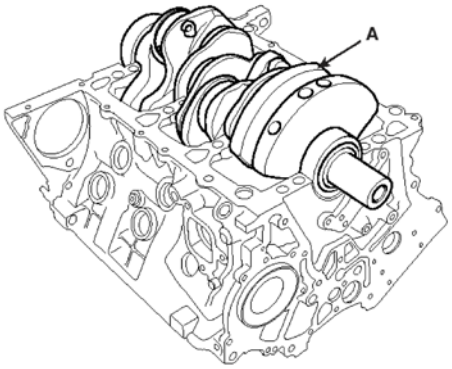
NOTICE

The upper bearings have the oil grooves of the oil holes; The lower ones do not.

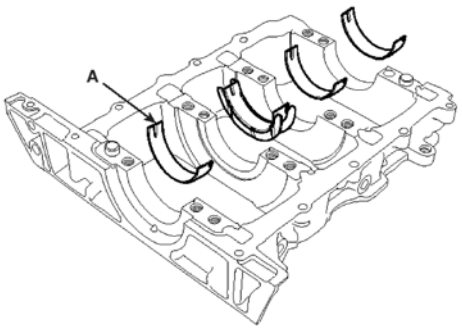
1) Aligning the bearing claw with the groove of the cylinder block, push in the four upper bearings (A). Apply oil on the bearings at this moment.



3. Place the crankshaft(A) on the cylinder block.



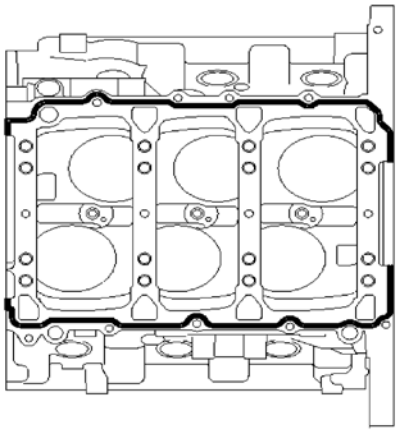
4. Aligning the bearing claw with the groove of the bedplate, push in the four lower bearings (A). Apply oil on the bearings at this moment.



5. Place the bed plate on the cylinder block.

NOTICE

- *Standard liquid gasket: LOCTITE 5902*
- *Check that the mating surfaces are clean and dry before applying liquid gasket.*
- *Apply liquid gasket in a 3mm wide bead without stopping.*
- *Assemble the bedplate in fifteen minutes after applying liquid gasket.*
- *After assembly, wipe out flowed-off sealant to front face and rear crankshaft oil seal housing.*



6. Install the bedplate bolts.

✍ NOTICE

• The bedplate bolts are tightened in several progressive steps.

• If any of the bedplate bolts are broken or deformed, it must be replaced.

1) Tighten the No.18, 20, 21 bolts in its number order (18→20→21) with the specified torque.

Tightening Torque:

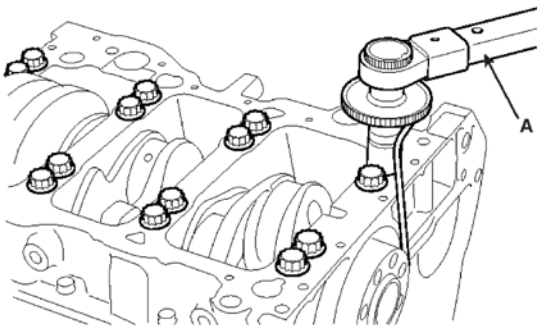
29.4 ~ 33.3Nm (3.0 ~ 3.4kgf.m, 21.7 ~ 24.6lb-ft)

2) Tighten the No.1~16 bolts in two steps with the specified torque and angle below.

Do not reuse the No.1 ~ 16 bolts.

Tightening Torque:

61.8 ~ 65.7Nm (6.3 ~ 6.7kgf.m, 45.6 ~ 48.5lb-ft) - 1st step 120° ~ 124° - 2nd step

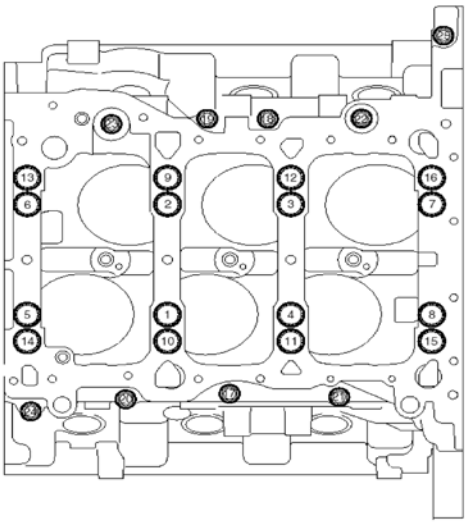


3) Loosen the bolts No. 18, 20 and 21.

4) Tighten the No.17~25 bolts with the specified torque below.

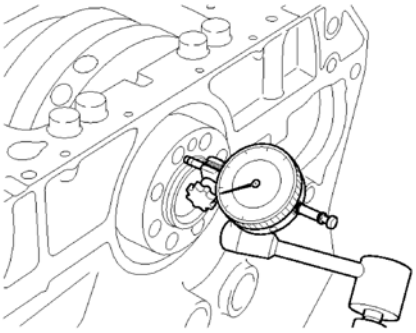
Tightening Torque:

29.4 ~ 33.3Nm (3.0 ~ 3.4kgf.m, 21.7 ~ 24.6lb-ft) - 1st step



5) Check that the crankshaft rotates smoothly.

7. Check the crankshaft end play, using a dial indicator End play Standard: 0.1 ~ 0.3mm (0.0039 ~ 0.118in)

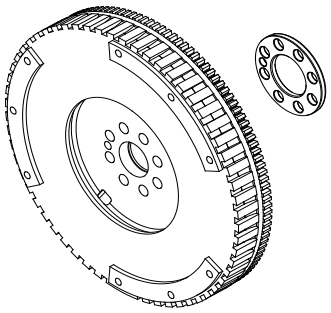


8. Using the SST (00200-0T013, 00200-0T012) and a plastic hammer, tap in a new oil seal (A) until SST surface is flush with the cylinder block. At this time, the depth of the oil seal (A) from the cylinder block surface is 0.8mm (0.032in).

9. Install the flywheel and flywheel adapter

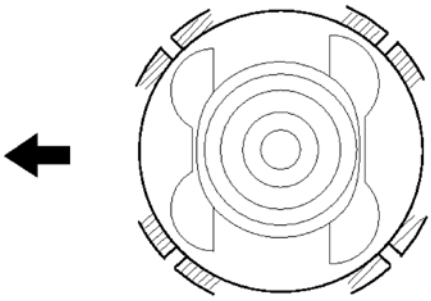
Tightening Torque:

127.4 ~ 137.2Nm (13.0 ~ 14.0kgf.m, 94.0 ~ 101.3lb-ft)

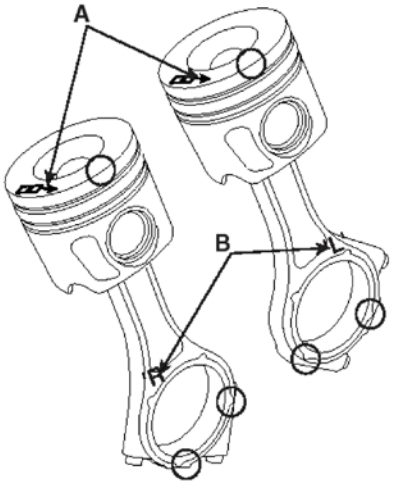


10. Install the piston rings.

1) No.1 and No.2 piston rings - assemble the rings with the 'Y' marks on the edge of the rings facing the cylinder head side. One end gap is placed at 180˚ opposite position with the other.
2) Oil ring - the end gap of the oil ring should be located with 180˚ to that of coil spring and 90˚ to hat of No.1 ring.
3) Check that the oil ring assembly (oil ring and coil Spring) can be turned smoothly toward any (clockwise or counter-clockwise) direction.
4) Position the piston rings so that the ring ends are as shown below.



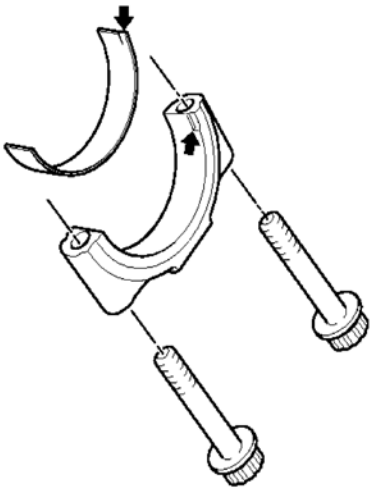
11. Assemble the piston and connecting rod.
1) Set the snap ring in one side of piston pin hole.
2) Apply sufficient engine oil or non-water-soluble press oil to outer surface of the piston, inner surface of piston pin hole and small end bore of the connecting rod before inserting the piston pin.
3) Insert the piston pin into the piston pin hose and the small end bore of connecting rod after setting the piston front marks (A) and the RH/LH marks (B) of the connecting rod facing to the timing chain.



✍ NOTICE

Marking the parts at the '○' points in the picture above makes the reassembly work much easier for its direction.

4) Set the snap ring in the other side after inserting the piston pin.
12. Install the connecting rod bearings.
1) Align the bearing claw with the groove of the connecting rod cap.

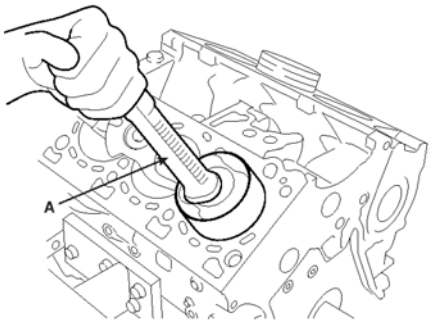


13.Install the piston and connecting rod assembly.

✍ NOTICE

Before installing the piston, apply a coat of engine oil to the ring grooves and cylinder bores.

1) Remove the connecting rod caps, and slip short sections of rubber hose over the threaded ends of the connecting rod bolts.
2) Install a ring compressor, check that the rings are securely in place, position the piston in the cylinder, and tap it in using the wooden handle (A) of a hammer.



3) Stop pushing after the rings go into the cylinder, and check the connecting rod-to-crank journal alignment before pushing the piston into place again. Be careful for the oil jets not to be damaged by the connecting rods in this step.
4) Apply engine oil to the bolt threads. Install the rod caps with bearings, and tighten the bolts

Tightening Torque:
27.5 ~ 31.4Nm (2.8 ~ 3.2kgf.m, 20.3 ~ 23.1lb-ft) + 88°~92°

NOTICE

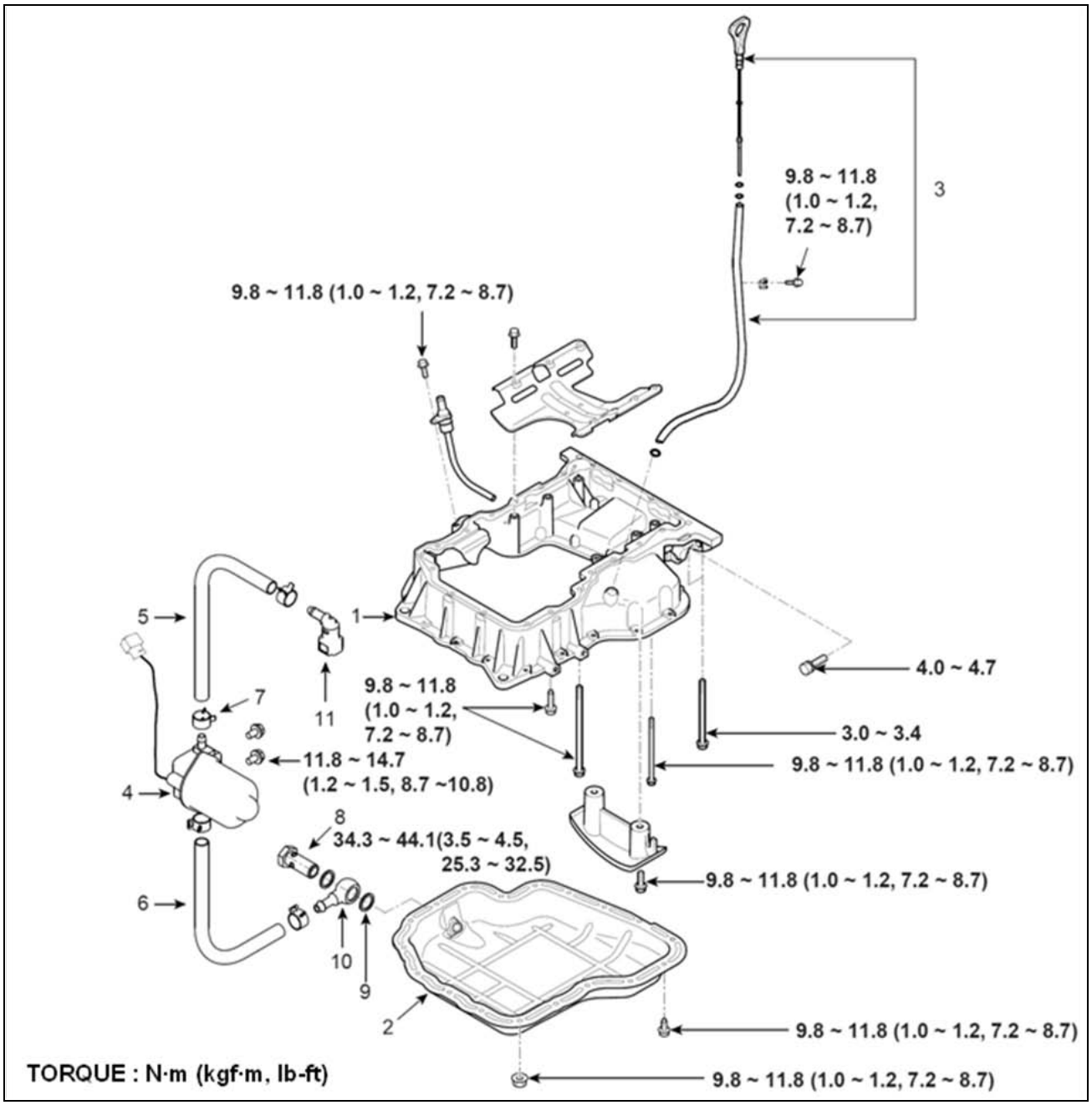
• Maintain downward force on the ring compressor to prevent the rings from expending before entering the cylinder bore.

• Installing order: No.1 and No.4 cylinders → No.3 and No.6 cylinders → No.2 and No.5 cylinders

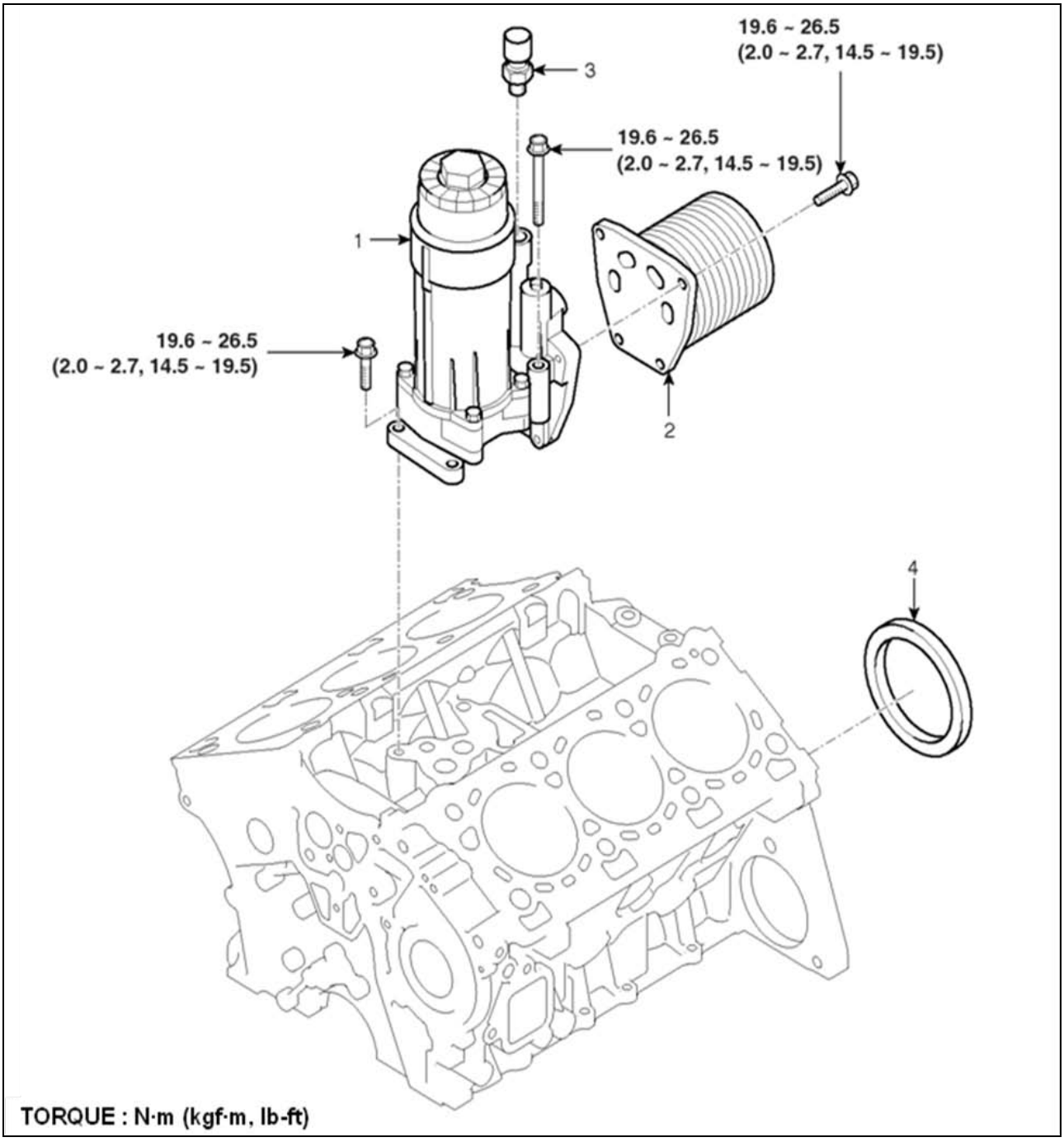
• When installing the pistons in the order above and having a difficulty in pushing some pistons, rotating the crankshaft may make the installation easier.

Lubrication System

Components

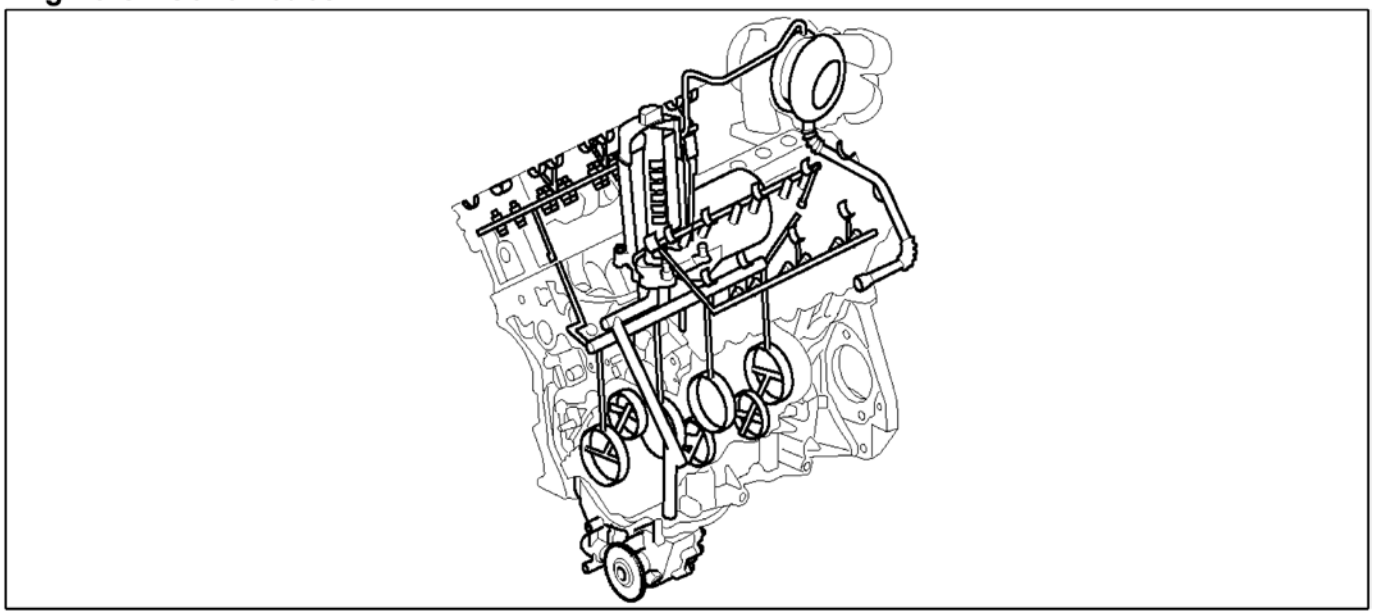


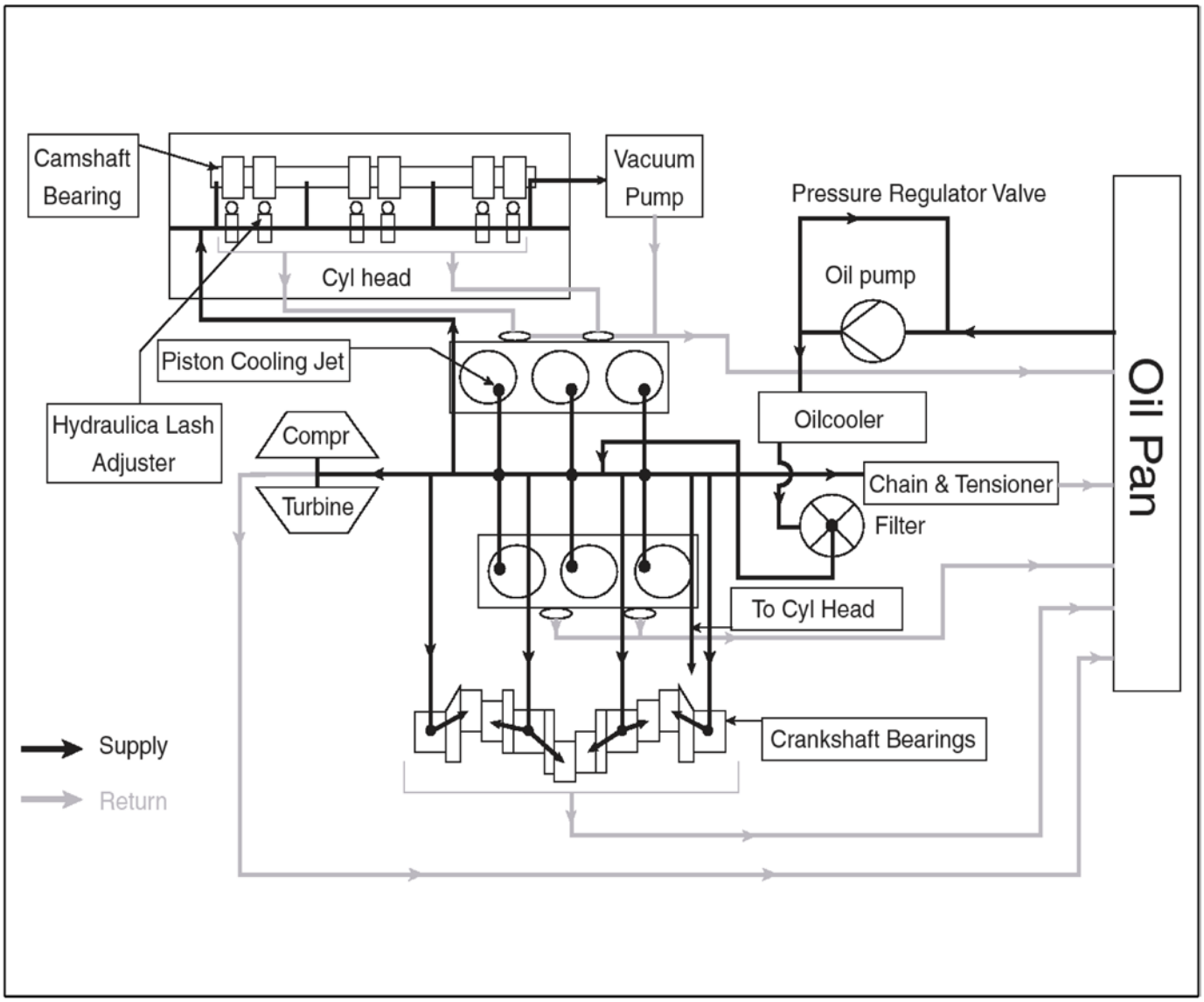
1. Upper oil pan
2. Lower oil pan
3. Oil level gauge assembly
4. Oil extraction pump
5. Hose - oil outlet
6. Hose - oil inlet
7. Ear Clamp
8. Bolt - I
9. Washer - Plain
10. Joint - I
11. Q-connector



1. Oil filter assembly
2. Oil cooler assembly
3. Oil pressure sensor
4. Rear oil seal

Engine Oil Schemetics





Replacement

Oil and Filter

◉ **CAUTION**

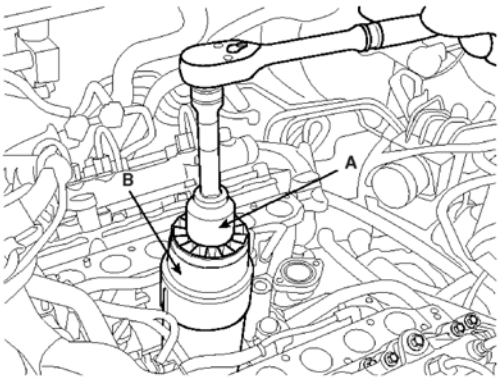
• Prolonged and repeated contact with mineral oil will result in the removal of natural fats from the skin, leading to dryness, irritation and dermatitis. In addition, used engine oil contains potentially harmful contaminants which may cause skin cancer.

• Exercise CAUTION in order to minimize the length and frequency of contact of your skin to used oil. Wear protective clothing and gloves. Wash your skin thoroughly with soap and water, or use water-less hand cleaner, to remove any used engine oil. Do not use gasoline, thinners, or solvents.

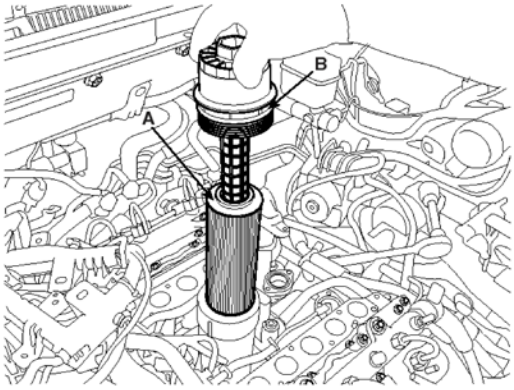
• In order to preserve the environment, used oil and used oil filter must be disposed of only at designated disposal sites.

1. Remove the oil filter cap.

1) Using a wrench (32mm or equivalent), loosen the oil filter cap slowly. Be careful not to drop engine oil because the oil filter paper is removed with its cap at this moment.



2. Remove the oil filter paper (A) and its O-ring (B) from its cap



1) Remove the filter paper assembly (A).

2) Replace the filter paper assembly and O-ring (B) with new ones and do not reuse the O-ring removed.

3. Assemble the oil filter cap with the filter fixed.

Tightening Torque:

24.5Nm (2.5kgf.m, 18.1lb-ft)

4. Opening the oil filler cap and removing the oil pan drain plug, drain engine oil thoroughly.

5. Reassemble the drain plug with a new gasket. Do not reuse the gasket removed.

Tightening Torque:

34.3 ~ 44.1Nm (3.5 ~ 4.5kgf.m, 25.3 ~ 32.5lb-ft)

6. Fill new engine oil through the oil filler pipe.

[Capacity]

When replacing a short engine or a block assembly:

7.3L (7.71US qt, 6.42lmp qts)

When replacing oil pan only:

5.8L (6.13US qt, 5.10lmp qts)

Drain and refill including oil filter:

6.8L (7.19US qt, 6.00lmp qt)

◉ **CAUTION**

• Fill a half oil of the total amount first and do the rest again after about one minute later,

• Do not fill oil over the 'F' line, checking the level with the oil level gauge.

7. Start engine and check for oil leaks.

8. Recheck the engine oil level

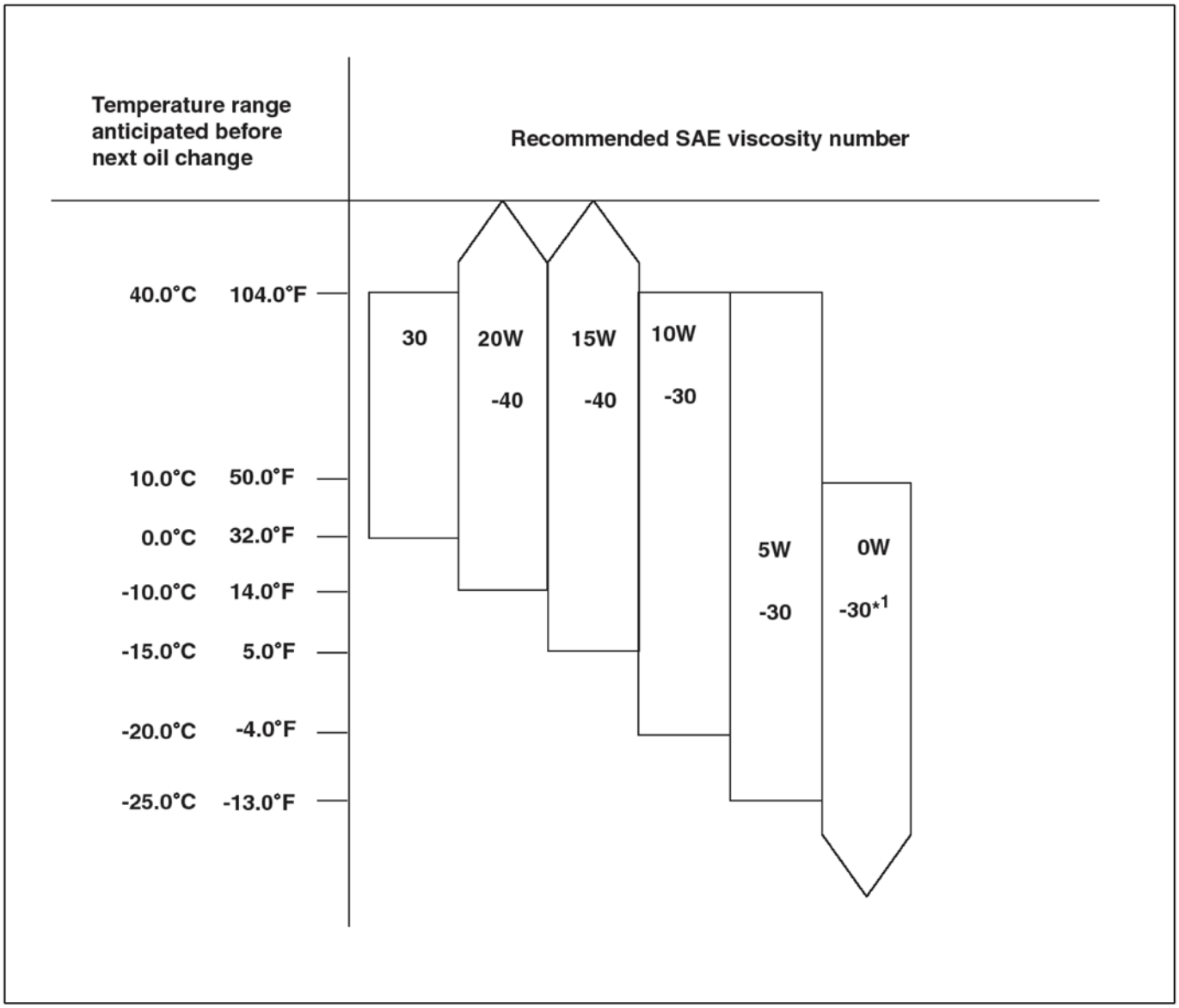
Inspection

Selection Of Engine Oil

Recommended API classification : CH-4 OR ABOVE

Recommended ACEA classification : B4 OR ABOVE

Recommended SAE viscosity grades :



NOTICE

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

1. Satisfy the requirement of the API or ACEA classification.

2. Have proper SAE grade number for expected ambient temperature range

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

Engine Oil

1. Check the engine oil quality. Check the oil deterioration, entry of water, discoloring of thinning. If the quality is visibly poor, replace the oil.
2. Check the engine oil level.

After warming up the engine and then 5 minutes after the engine stop, oil level should be between the “L” and “F” marks in the dipstick. If low, check for leakage and add oil up to the “F” mark.

✍ **NOTICE**

Do not fill with engine oil above the “F” mark.

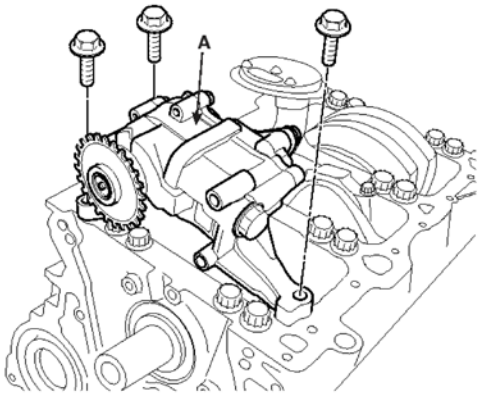
Installation

Oil Pump

1. Before installing the oil pump and screen assembly on the bed plate, check if the O-ring is seated properly and not damaged.
2. Install the oil pump and screen assembly with the specified torque.

Tightening Torque:

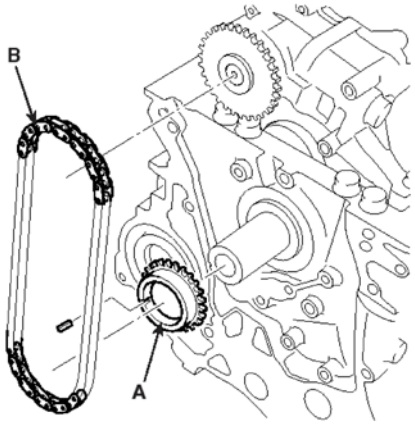
19.6 ~ 26.5Nm (2.0 ~ 2.7kgf.m, 14.5 ~ 19.5lb-ft)



3. Check if the oil pump works properly.
4. With the cylinder block, bed plate, crankshaft piston assembly, connecting rod assembly and the oil pump assembly installed, insert the crankshaft sprocket(A) in the crankshaft, aligning the No.1 piston at the BDC(bottom dead center).
5. Install the oil pump chain (B) and the oil pump chain tensioner and remove the pin from the tensioner.

Tightening Torque:

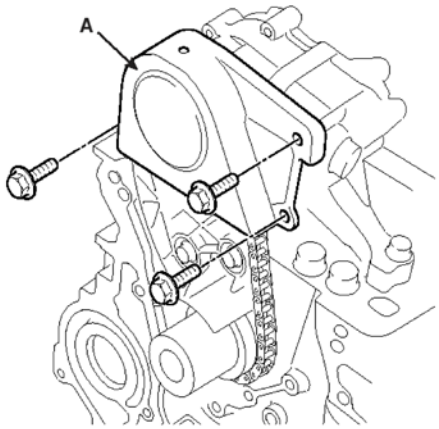
7.8 ~ 11.8Nm (0.8 ~ 1.2kgf.m, 5.8 ~ 8.7lb-ft)



6. Install the baffle plate (A).

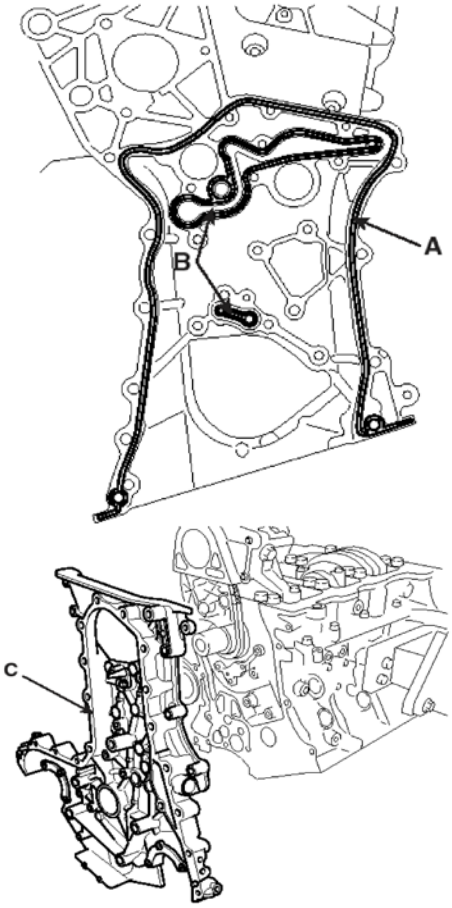
Tightening Torque:

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



Oil Pan

1. Install the oil pump.
2. After applying sealant (A) on the groove and checking if the O-rings are seated securely, Install the timing chain case assembly(C) in fifteen minutes.

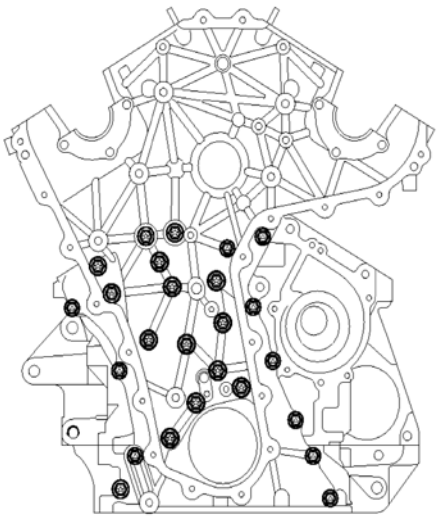


3. Tighten the mounting bolts of the chain case with the specified torque below.

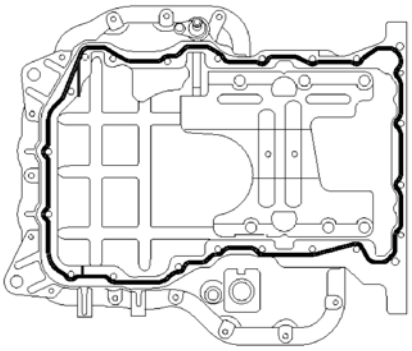
Tightening Torque:

7.8 ~ 11.8Nm (0.8 ~ 1.2kgf.m, 5.8 ~ 8.7lb-ft) - 6×16(★)

19.6 ~ 25.5Nm (2.0 ~ 2.6kgf.m, 14.5 ~ 18.8lb-ft) - 8×35(▲)



4. Apply liquid gasket on the upper oil pan assembly shown as below.



Liquid gasket: LOCTITE 5900 or equivalent

NOTICE

• Apply sealant cautiously to prevent sealant from coming in the oil pan during installation.

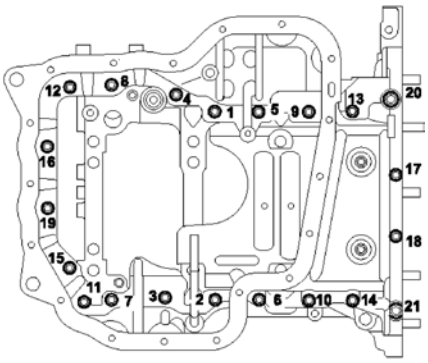
• After applying sealant, assemble the oil pan in fifteen minutes.

5. Tighten the mounting bolts with the order and the specified torque below.

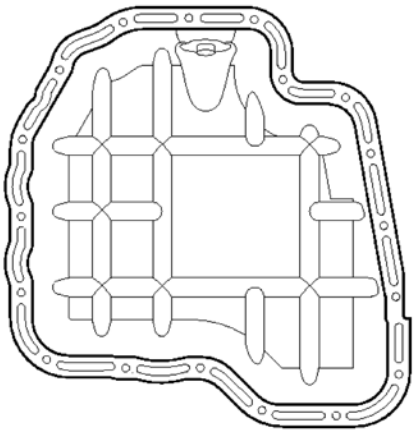
Tightening Torque:

9.8 ~ 11.8Nm (1.0 ~ 1.2kgf.m, 7.2 ~ 8.7lb-ft) - all bolts except 20, 21

29.4 ~ 33.3Nm (3.0 ~ 3.4kgf.m, 21.7 ~ 24.6lb-ft) - 20, 21 Bolts



6. Apply liquid gasket on the lower oil pan assembly shown as below.



Liquid gasket: LOCTITE 5900 or equivalent

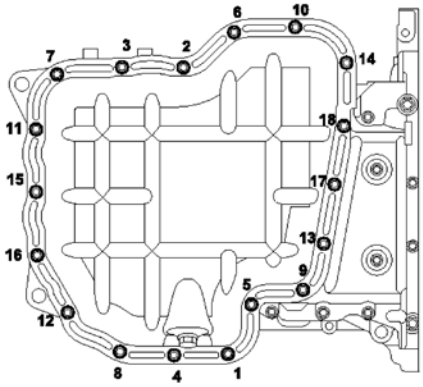
✍ NOTICE

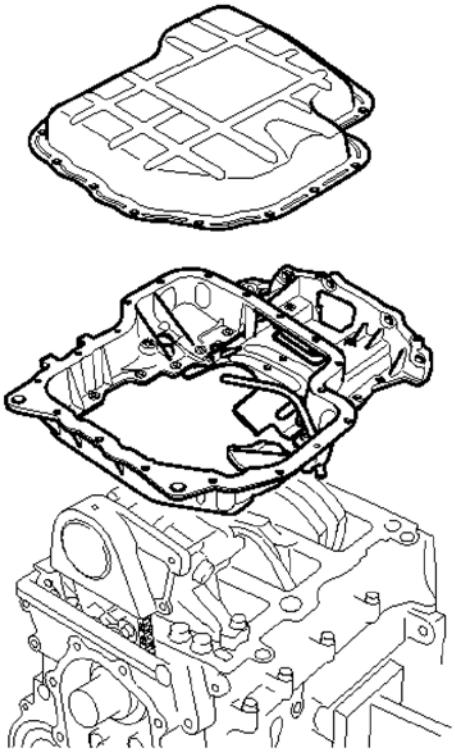
- *Apply sealant cautiously to prevent sealant from coming in the oil pan during installation.*
- *After applying sealant, assemble the oil pan in fifteen minutes.*

7. Tighten the mounting bolts with the order and the specified torque below.

Tightening Torque:

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



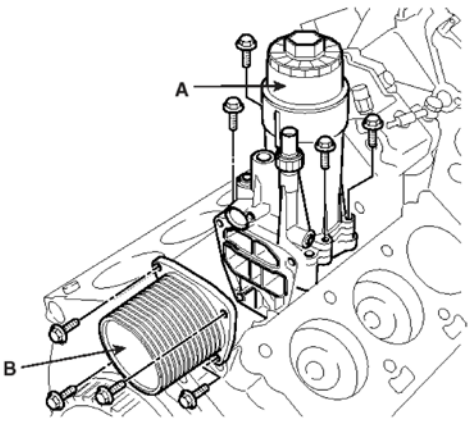


Oil Filter And Cooler Assembly

1. Assemble the oil cooler (B) to the oil filter (A).
2. Install the oil filter and cooler assembly to the cylinder block.
3. Check if there is rubber packing between the oil filter and the block or the oil cooler. If so, apply Engine oil.

Tightening Torque:

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

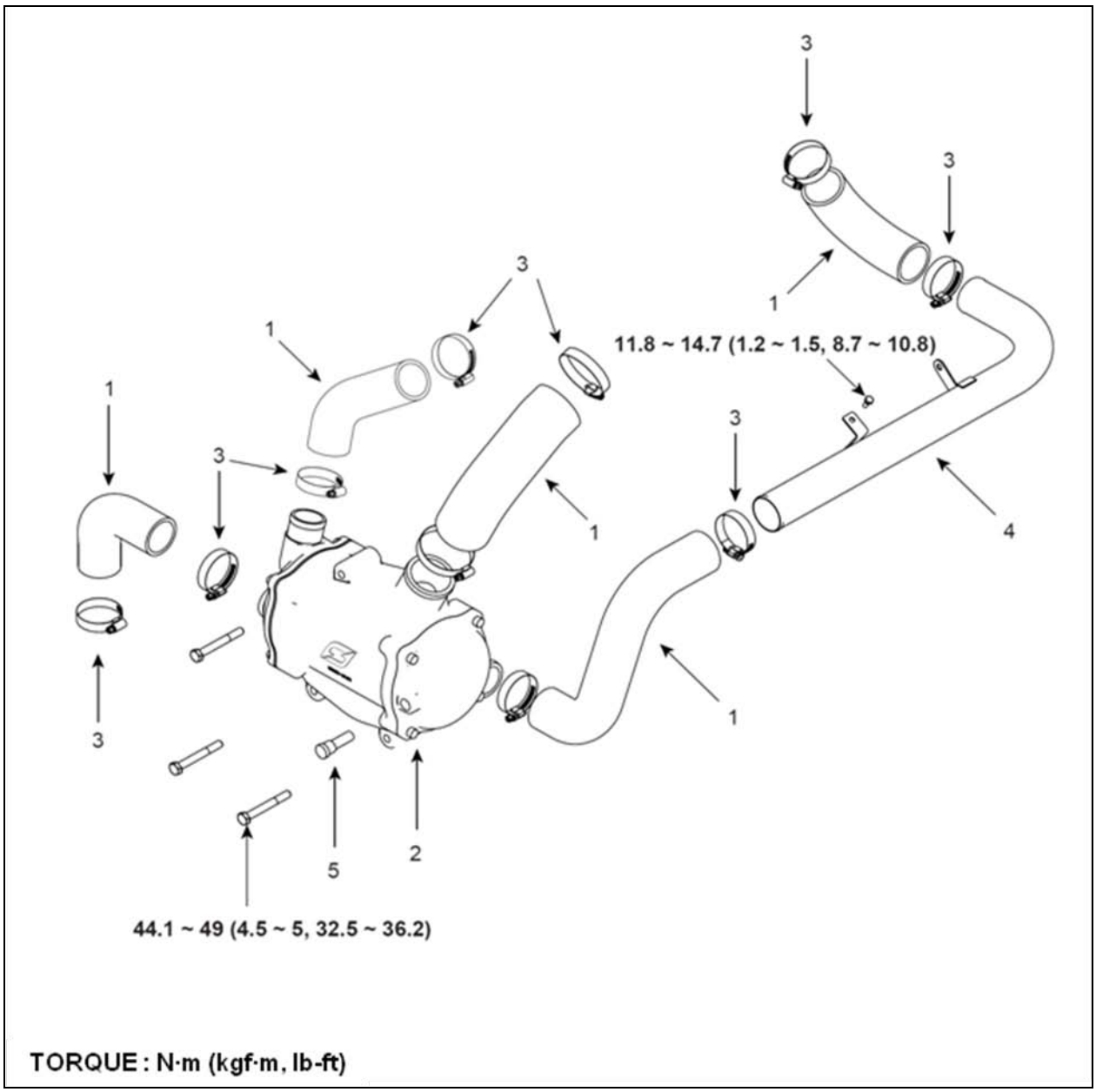


4. Install the water outlet duct and then the intake and exhaust system.

Intake and Exhaust System

Inter-cooler

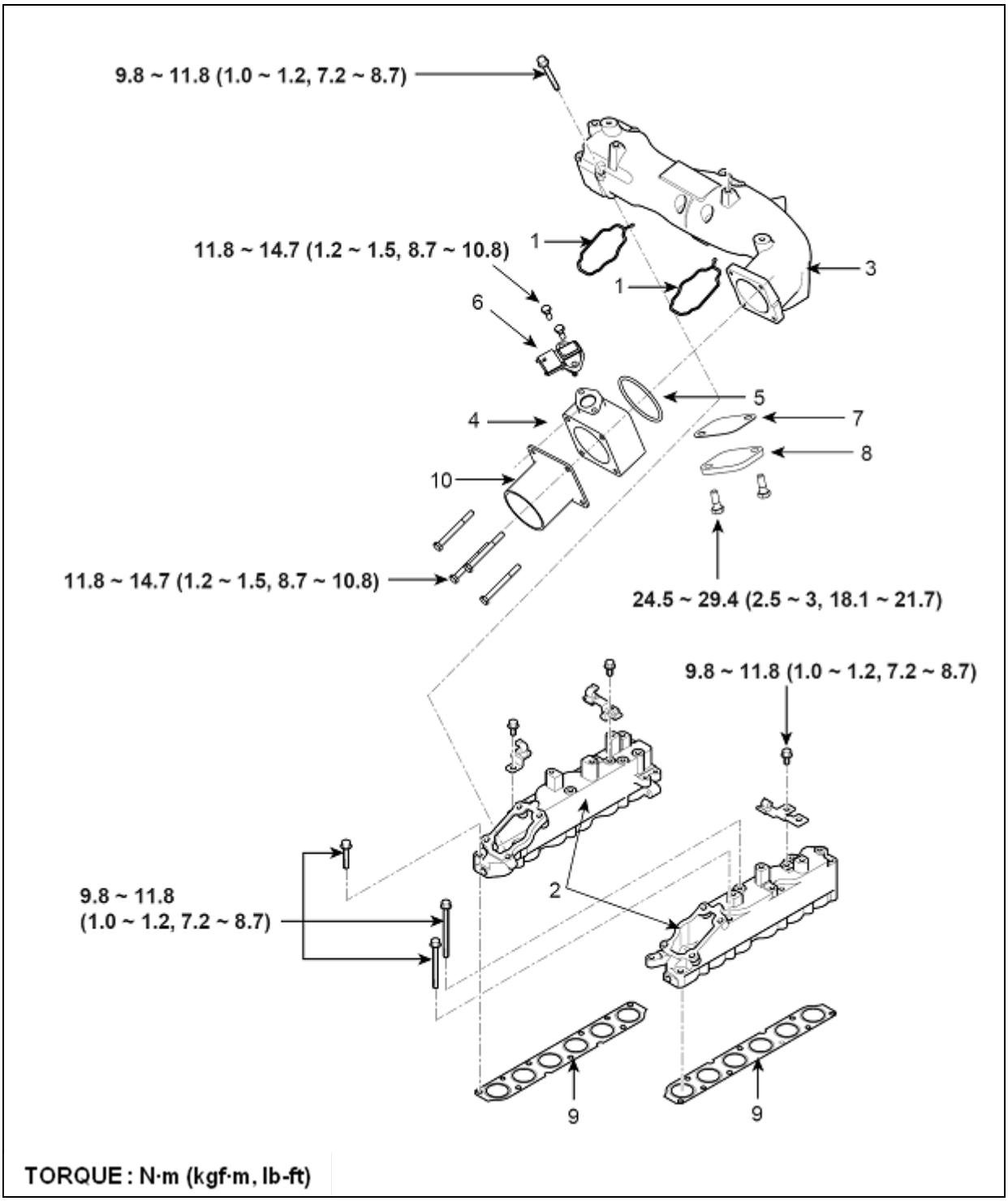
Component



1. Intercooler hose
2. Intercooler assembly
3. Clamp
4. Intercooler pipe
5. Anode

Intake Manifold

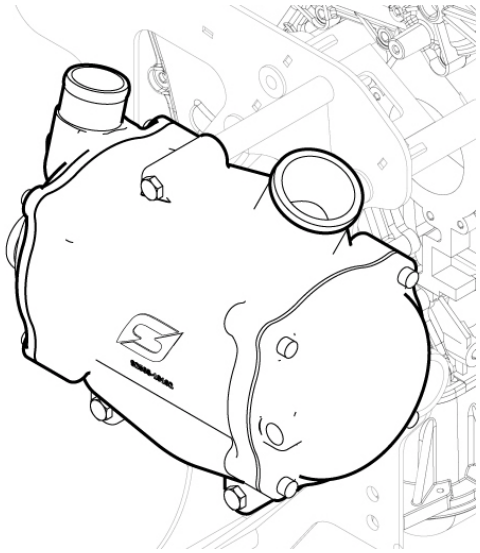
Components



1. Gasket – Rubber, Upper
2. Manifold assembly – Inlet lower
3. Manifold assembly – Inlet Upper
4. Adaptor – Boost pressure sensor
5. O - Ring
6. Boost Pressure sensor
7. Gasket - Pipe
8. Bracket – Intake manifold
9. Gasket – Intake manifold
10. Adapter

Removal

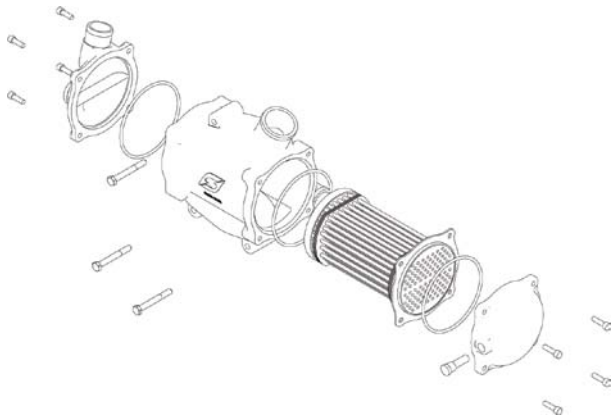
Intercooler



1. Open the drain plug and drain seawater inside the intercooler.
2. Remove all clamps on intercooler and hoses.
3. Unscrew three bolts fixing intercooler.

Tightening Torque:

44.1 ~ 49.0Nm (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.
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.

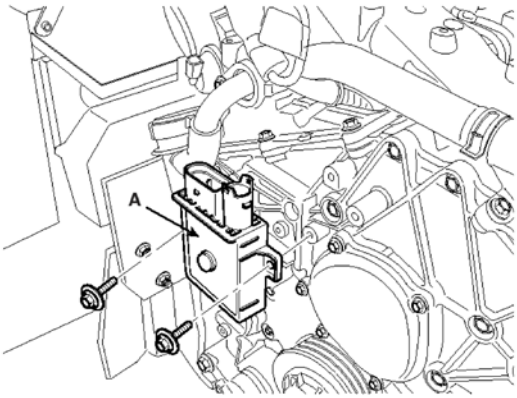
◉ CAUTION

Take CAUTION avoid intercooler fin damage.

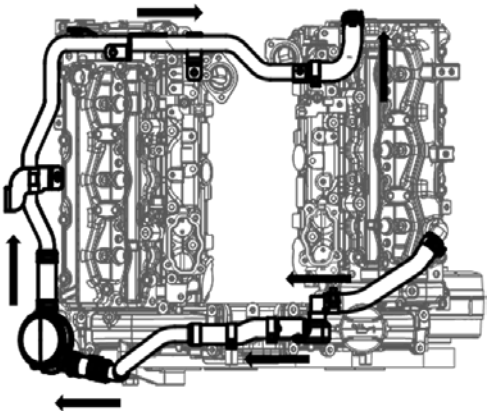
10. Clean housing and intercooler and heat exchanger into housing.
11. Install new O-ring.
12. Check the direction of end cap on both sides for assembly.
13. Install new anode.

Intake Manifold

1. Remove the inlet upper manifold assembly.
2. Remove the glow control unit(A).



3. Remove the CMP sensor.
4. Remove the fuel feed and return hose or pipe.
5. Remove the high pressure fuel pipe(rail to rail).
6. Remove the oil level gauge.
7. Remove the engine hanger.
8. Remove the high pressure fuel pipe(rail to pump).
9. Remove the common rail system.
10. Remove the high pressure fuel pipe (rail to injector).
11. Remove the injector packing.
12. Remove the injectors. (Refer to Injector in FL Group).
13. Remove the blow-by gas recirculation system such as the oil separator pipes and hoses.



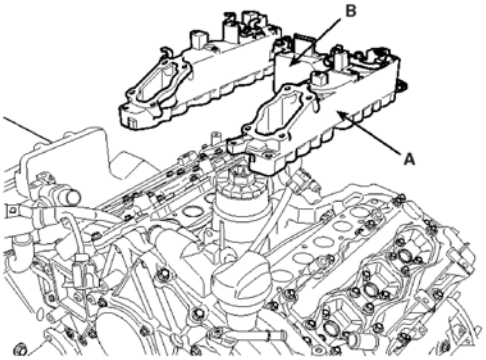
14. Remove the inlet lower manifold assembly(A).

◉ **CAUTION**

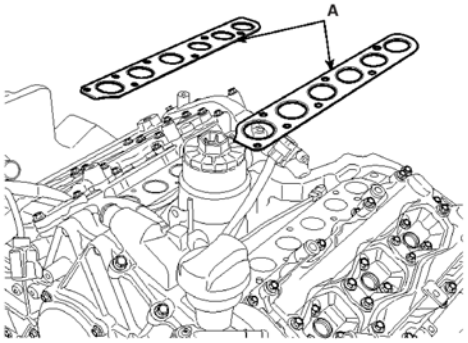
The inlet lower manifold assembly (A) is the assembly including the swirl control actuator (B).

Do NOT disassemble the swirl control actuator from the inlet lower manifold.

Disassembly and reassembly may change the setting specification of the two link shafts which are connected between the inlet lower manifold and the swirl control actuator.

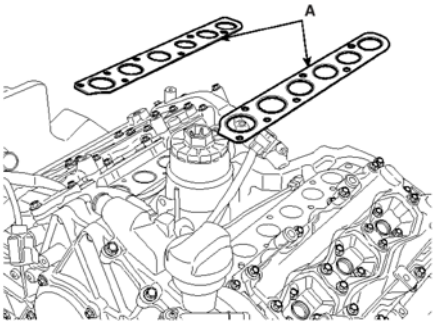


17. Remove the inlet manifold gaskets(A).



Installation

1. Install the inlet manifold gaskets(A).



2. Install the inlet lower manifold assembly(A).

◉ **CAUTION**

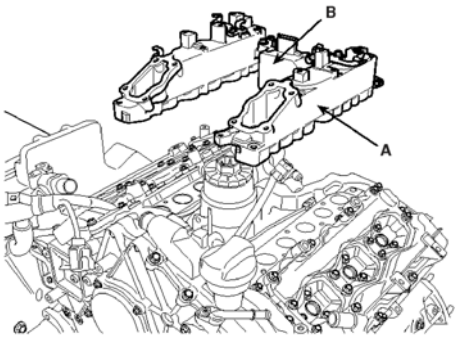
The inlet lower manifold assembly (A) is the assembly including the swirl control actuator (B).

If you have already disassembled the swirl control actuator from the inlet lower manifold, you should throw them away and install a new inlet lower manifold assembly including the swirl control actuator.

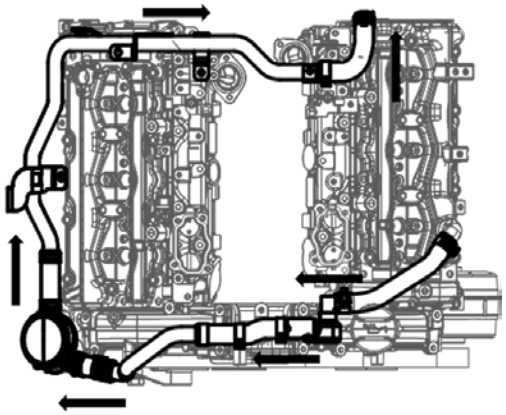
Disassembly and reassembly may change the setting specification of the two link shafts which are connected between the inlet lower manifold and the swirl control actuator.

Tightening Torque:

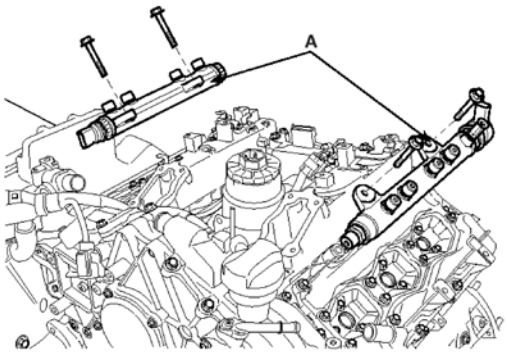
9.8 ~ 11.8Nm (1.0 ~ 1.2kgf.m, 7.2 ~ 8.7lb-ft)



3. Install the blow-by gas recirculation system such as the oil separator pipes and hoses.



4. Tighten the common rail (A) slightly for the installation of the high pressure pipes.



5. Install the injectors with inserting the packing. (Refer to Injector in FL Group).
6. Check if the packing are seated well.
7. Install the high pressure fuel pipe (rail to injector).
8. Tighten the common rail with the specific torque.
9. Install the high pressure fuel pipe (rail to pump).

Tightening Torque:

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

10. Install the engine hanger.

Tightening Torque:

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

11. Install the high pressure fuel pipe(rail to rail).
12. Install the fuel feed and return hose or pipe

Tightening Torque:

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

13. Install the CMP sensor.

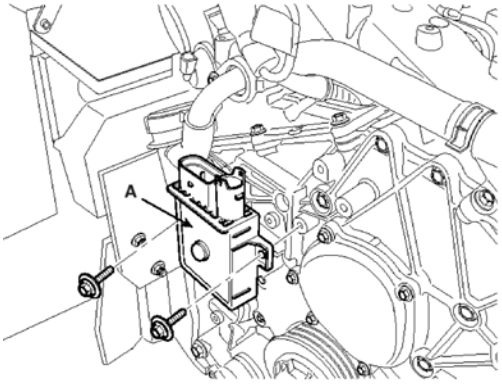
Tightening Torque:

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

14. Install the glow control unit(A).

Tightening Torque:

6.9 ~ 10.8Nm (0.7 ~ 1.1kgf.m, 5.1 ~ 8.0lb-ft)



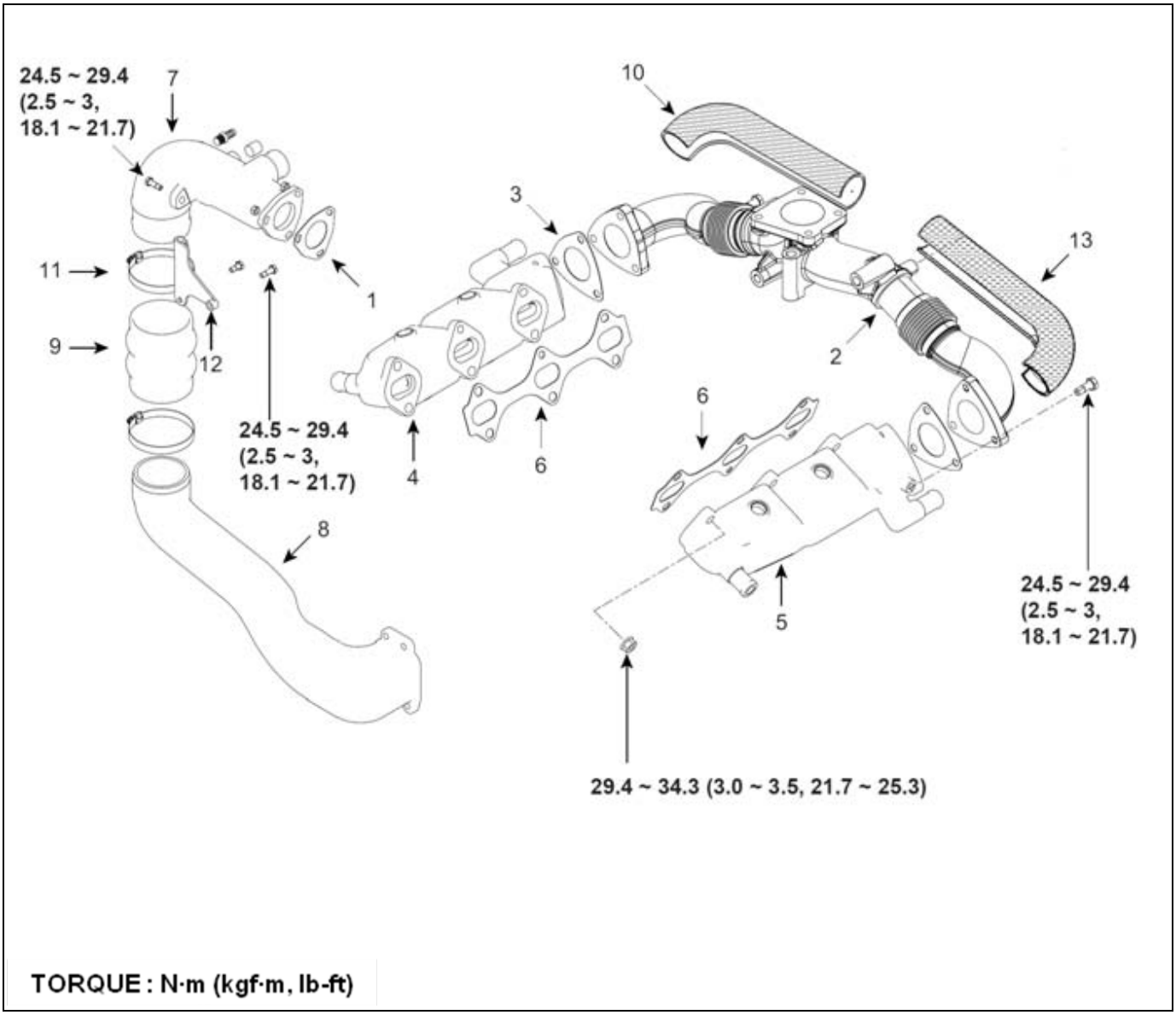
15. After seating the inlet manifold gasket, install the inlet upper manifold assembly.

Tightening Torque:

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

Exhaust Manifold

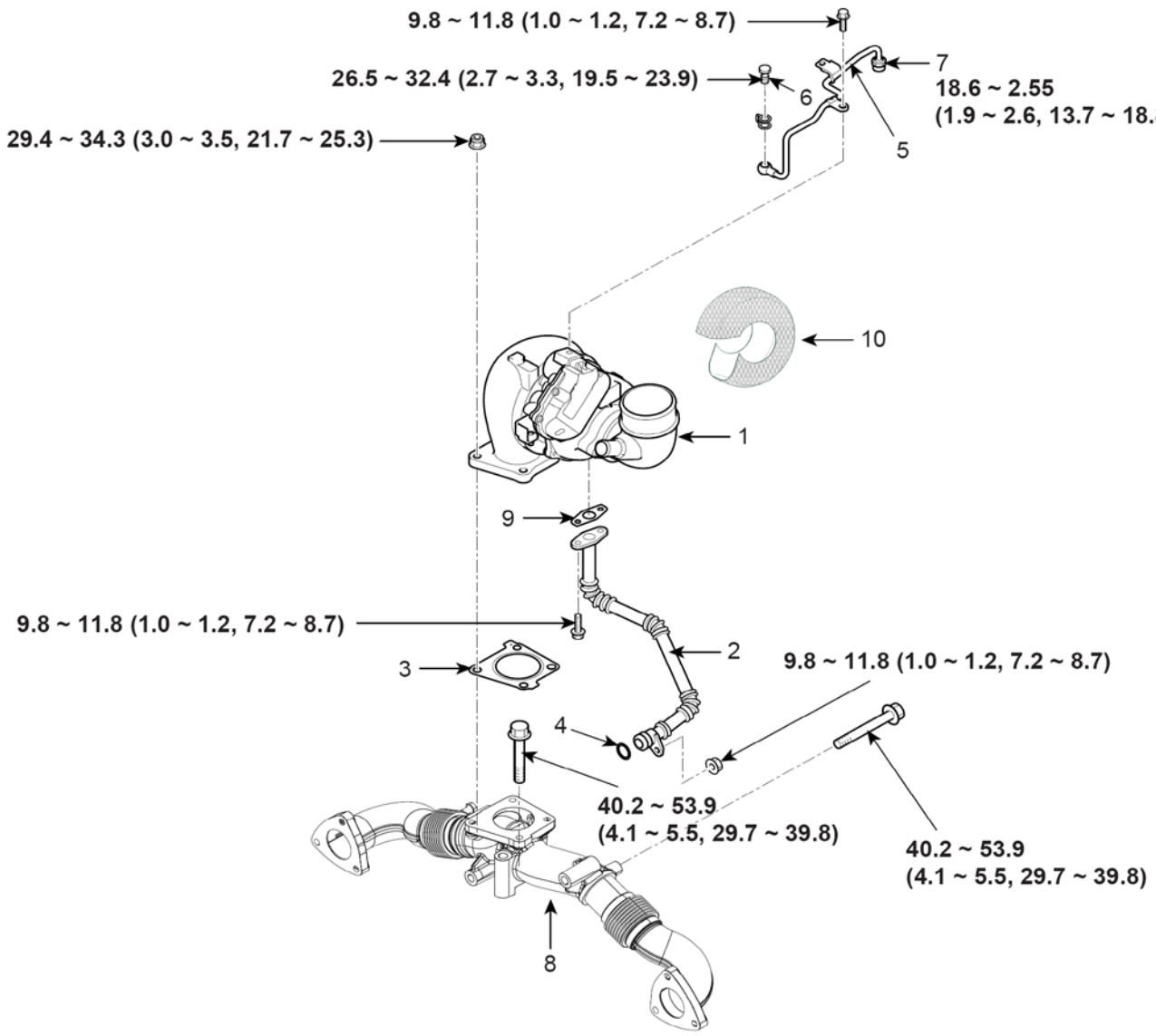
Component



1. Gasket-Turbocharger outlet
2. Exhaust pipe
3. Gasket-Exhaust pipe
4. Exhaust manifold (LH)
5. Exhaust manifold (RH)
6. Gasket-Exhaust manifold
7. Exhaust elbow
8. Exhaust pipe
9. Bellows
10. Heat protector-Ex. pipe (RH)
11. Clamp- Bellows
12. Bracket-Exhaust elbow
13. Heat Protector-Ex. pipe (LH)

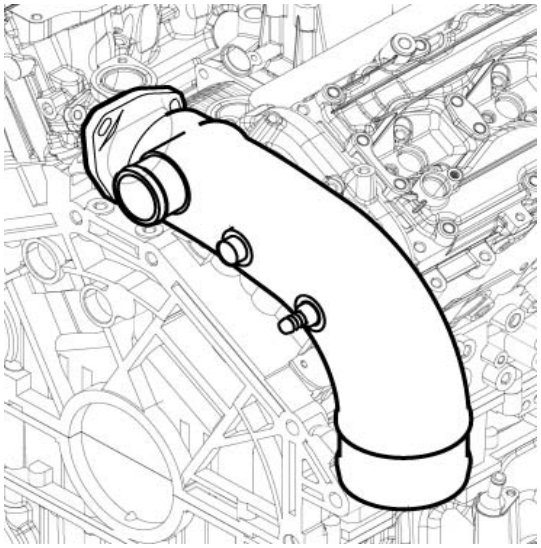
Turbocharger (TC)

Component



1. Turbo charger
2. Pipe-oil return
3. Gasket
4. O-Ring
5. Pipe-Oil feed
6. I-bolt joint
7. Nut- Oil feed pipe
8. Exhaust pipe
9. Gasket-T/C oil drain
10. Heat protector – T/C

Removal



1. Stop the engine completely and remove exhaust elbow.
2. It is essential that elbow has completely cooled off.

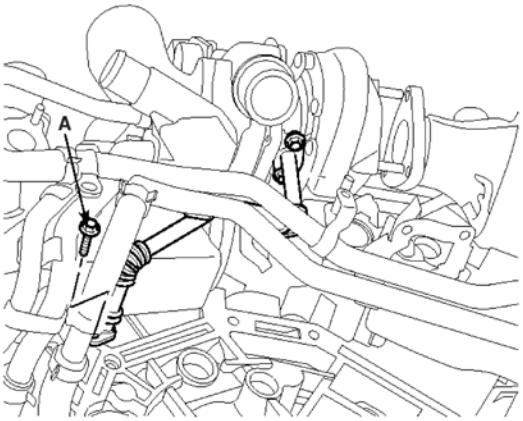
◉ CAUTION

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.
7. Remove the oil return pipe bolts(A).

Tightening Torque:

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



8. Remove the oil feed pipe and the blow-by hose(C).

Tightening Torque:

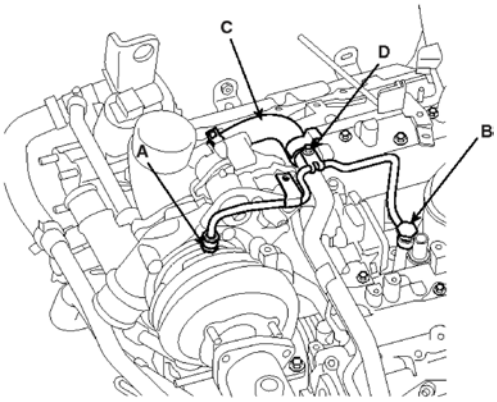
18.6 ~ 25.5Nm (1.9 ~ 2.6kgf.m, 13.7 ~ 18.8lb-ft) – oil feed pipe nut (A)

26.5 ~ 32.4Nm (2.7 ~ 3.3kgf.m, 19.5 ~ 23.9lb-ft) – oil feed pipe eye bolt (B)

9.8 ~ 11.8Nm (1.0 ~ 1.2kgf.m, 7.2 ~ 8.7lb-ft) - oil feed pipe mounting bolt (D)

☢ WARNING

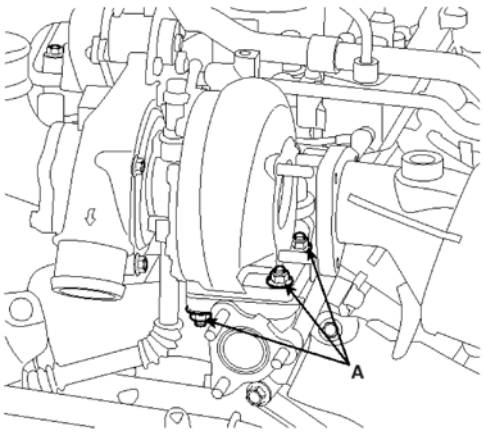
When install the turbocharger oil feed pipe eye-bolt, always use a new gasket.



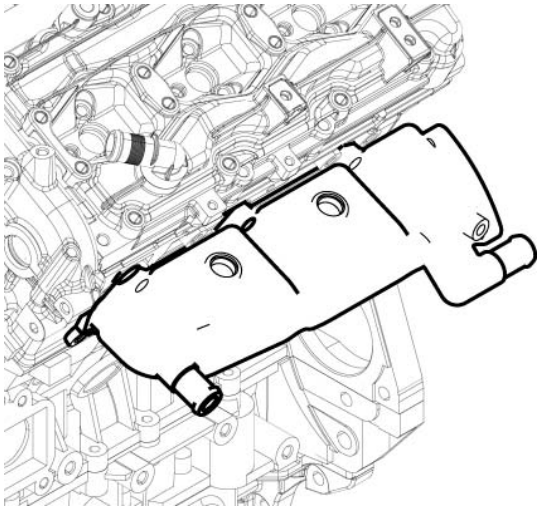
9. After removing the rest turbocharger mounting nuts (A), take off the turbocharger by lifting up.

Tightening Torque:

29.4 ~ 34.3Nm (3.0 ~ 3.5kgf.m, 21.7 ~ 25.3lb-ft)



10. Cool off the engine and remove manifold
.



- **CAUTION**

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

12. Installation is in the reverse order of removal.

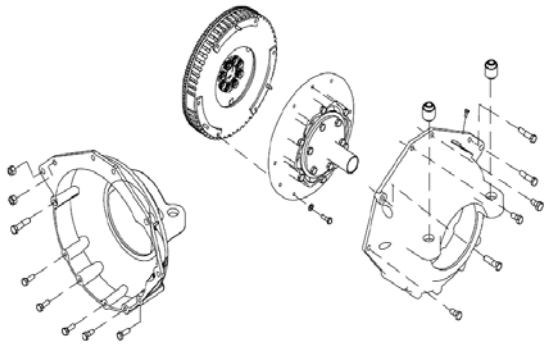
13. Check to see possible engine coolant and exhaust emission leakage after manifold reassembly.

Coupling System

NOTICE

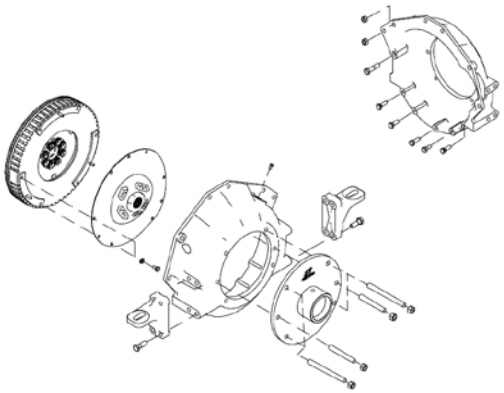
Use locking compound LOCTITE 242 on threads.

Stern Drive



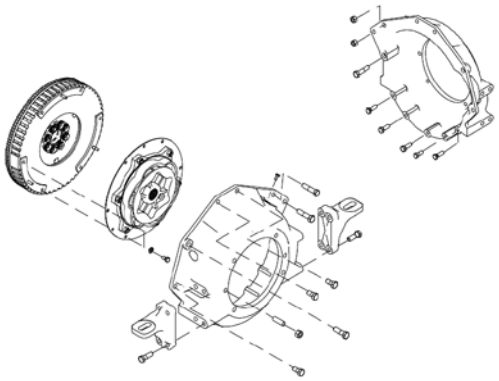
1. Loosen 13 bolts
2. Loosen 2 nuts, Remove housing.
3. Loosen 6 bolts, Remove coupling

WaterJet



1. Loosen 12 bolts.
2. Loosen 2 nuts, Remove housing
3. Loosen 6 bolts, Remove coupling.

Shaft Drive



1. Loosen 12 bolts
2. Loosen 2 nuts, Remove housing.
3. 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

Items		Specification
Alternator	Rate voltage	12 V, 150A
	Speed in use	1,000 ~ 18,000 rpm
	Voltage regulator	IC Regulator built-in type
	Regulator setting voltage	14.55 ± 0.2 V
	Temperature compensation	-7 ± 3 mV / °C
Battery	Type	80-33 FL
	Cold cranking amperage [at -18°C(-0.4°F)]	850 A
	Reserve capacity	182 min
	Specific gravity [at 20°C(68°F)]	1.280 ± 0.01

Starting system

Items			Specification
Starter	Rated voltage		12V, 2.2kW
	No. of pinion teeth		10
	No-load characteristics	Voltage	11V
		Ampere	130A, MAX
		Speed	3,600 rpm, MIN

Preheating system

Items		Specification
Glow plug	Nominal voltage	4.3~4.5V
	Initial current at 11V	less than 27.0A
	Operating current after 5 sec.	less than 9.0A
	Operating current after 60 sec.	less than 8.0A
	Time to 1000℃	less than 3 seconds
	Resistance(at 18~22℃)	410±110mΩ

Troubleshooting

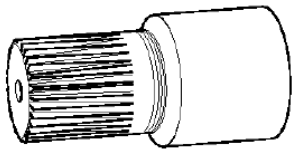
Charging system

Symptom	Suspect area	Remedy
Charging warning indicator does not light with ignition switch "ON" and engine off.	Fuse blown	Check fuses
	Light burned out	Replace light
	Wiring connection loose	Tighten loose connection
	Electronic voltage regulator	Replace voltage regulator
Charging warning indicator does not go out with engine running. (Battery requires frequent recharging)	Drive belt loose or worn	Adjust belt tension or replace belt
	Battery cable loose, corroded or worn	Inspect cable connection, repair or replace cable
	Fuse blown	Check fuses
	Electronic voltage regulator or alternator	Replace voltage regulator or alternator
	Wiring	Repair or replace wiring
Overcharge	Electronic voltage regulator	Replace voltage regulator
	Voltage sensing wire	Repair or replace wiring
Discharge	Drive belt loose or worn	Adjust belt tension or replace belt
	Wiring connection loose or short circuit	Inspect wiring connection, repair or replace wiring
	Fuse blown	Check fuses
	Electronic voltage regulator or alternator	Replace voltage regulator or alternator
	Poor grounding	Inspect ground or repair
	Worn battery	Replace battery

Starting system

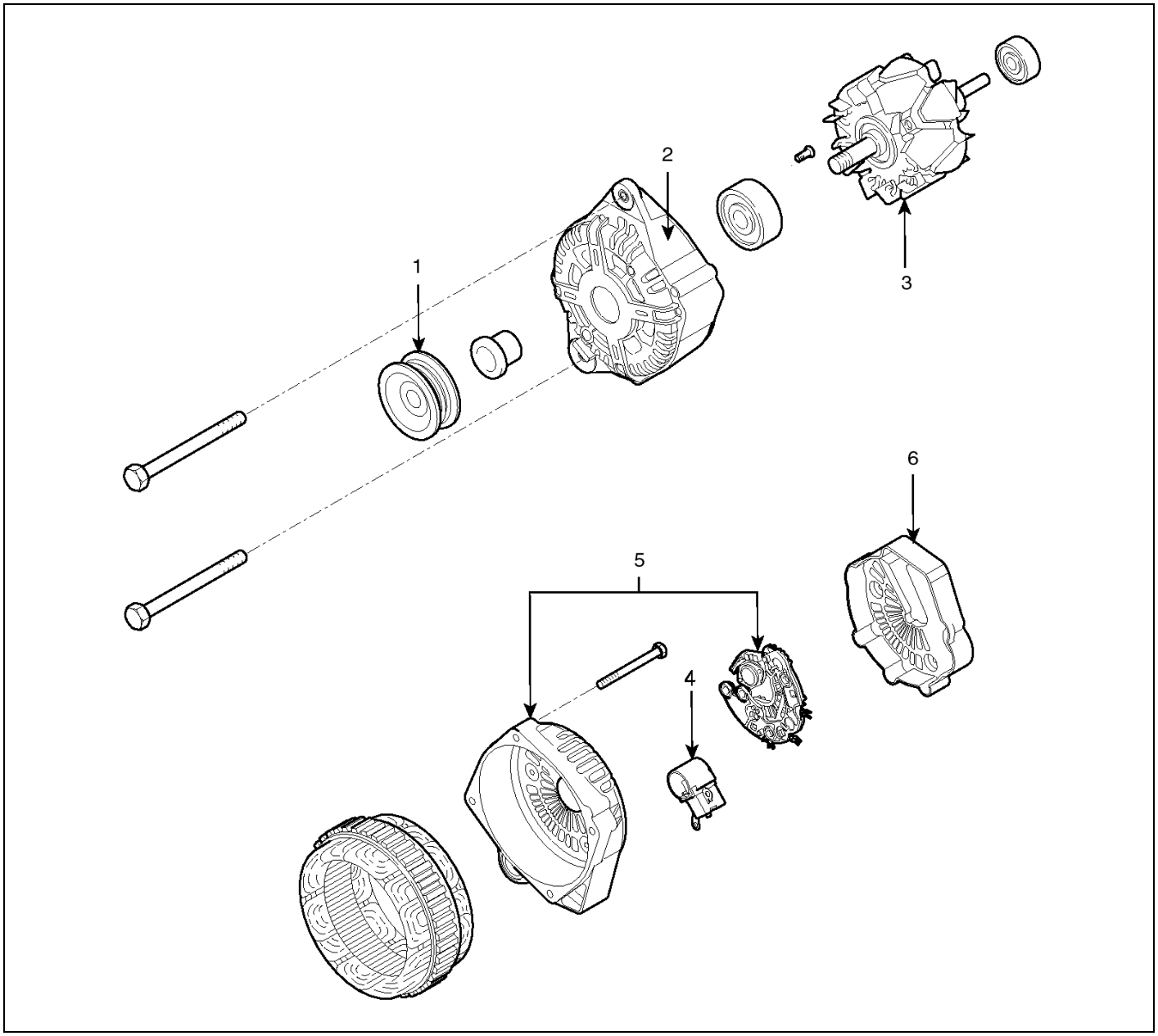
Symptom	Suspect area	Remedy
Engine will not crank	Battery charge low	Charge or replace battery
	Battery cables loose, corroded or worn out	Repair or replace cables
	Transaxle range switch (Vehicle with automatic transaxle only)	Refer to TR group-automatic transaxle
	Fuse blown	Replace fuse
	Starter motor faulty	Replace
	Ignition switch faulty	Replace
Engine cranks slowly	Battery charge low	Charge or replace battery
	Battery cables loose, corroded or worn out	Repair or replace cables
	Starter motor faulty	Replace
Starter keeps running	Starter motor	Replace
	Ignition switch	Replace
Starter spins but engine will not crank	Short in wiring	Repair wiring
	Pinion gear teeth broken or starter motor	Replace
	Ring gear teeth broken	Replace fly wheel 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

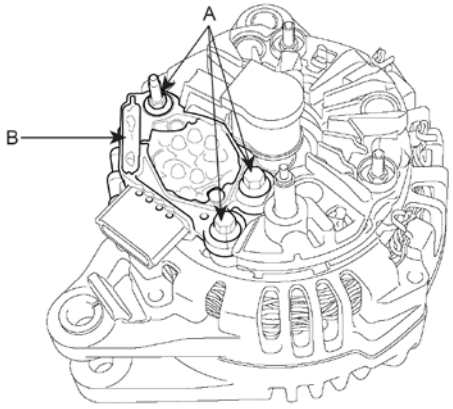
Alternator



1. Overrunning Alternator Pulley(OAP)
2. Front housing complete
3. Rotor assembly
4. Regulator
5. Rectifier assembly
6. Cover

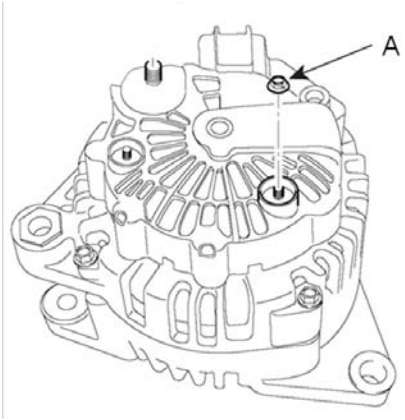
Replacement

1. Remove from the (-) terminal of the battery
2. Remove from the (+) terminal of the battery
3. After pressing the auto-tensioner with a wrench remove the drive belt
4. Remove the tow alternator mounting bolts. 3.0 ~ 4.2 kgf·m
5. Installation is in the reverse order of removal.

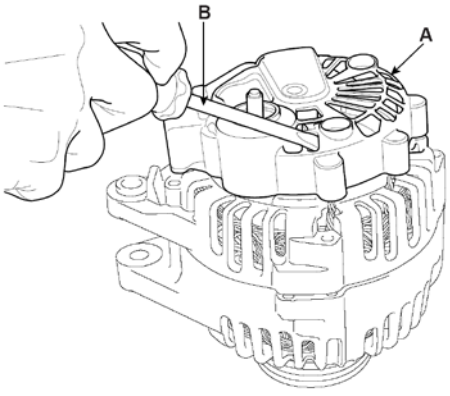


Disassembly

1. Remove the rear cover nut(A)

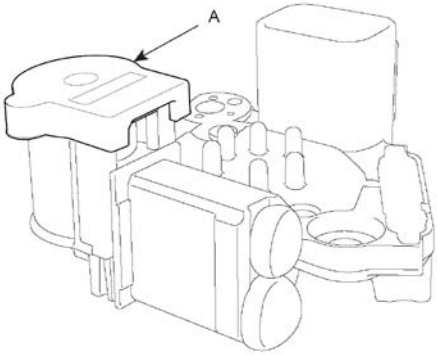


2. Remove the alternator cover(A) using a screw Drive(B)

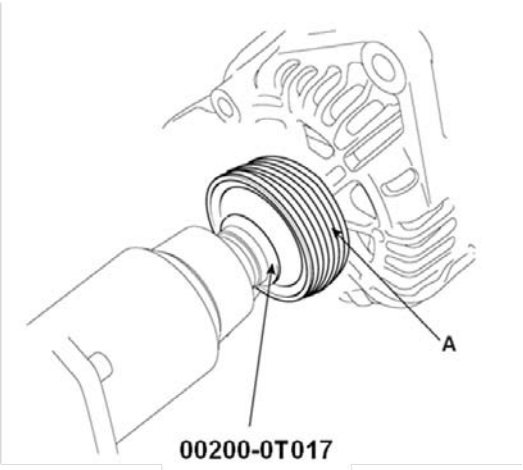


3. Loosen the mounting bolts (A) and disconnect the brush holder assembly(B)

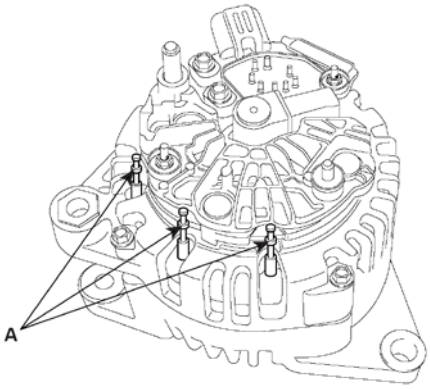
4. Remove the slip ring guide(A)



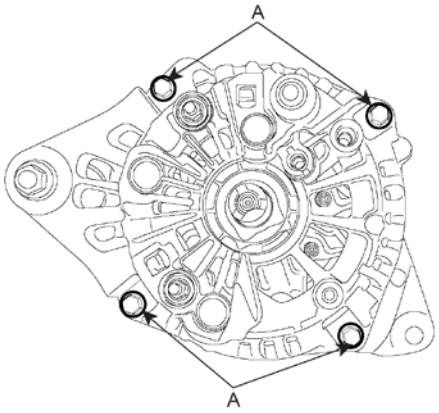
5. Remove the pulley(A) using the SST(00200-0T017)



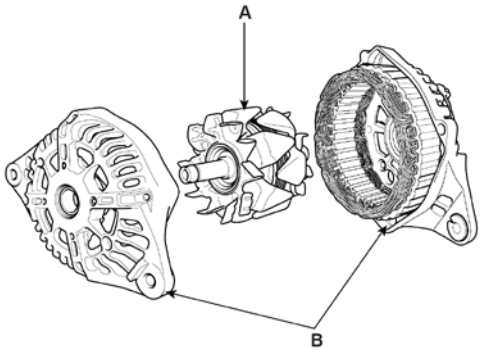
6. Unsolder the 3 stator leads(A)



7. Loosen the 4 through bolts(A)



8. Disconnect the rotor(A) and cover(B)

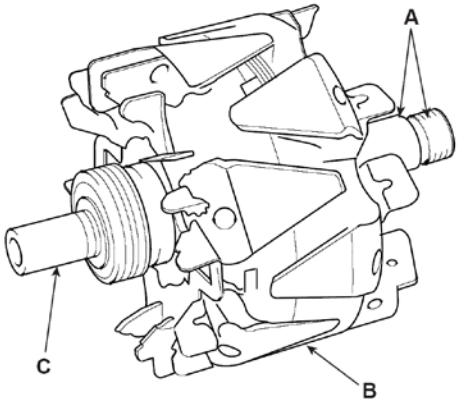


9. Reassembly is the reverse order of disassembly

Inspection

Rotor

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

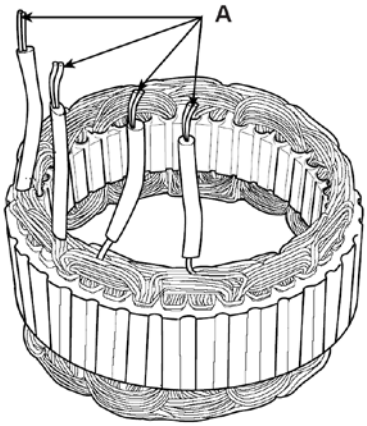


2. Check that there is no continuity between the Slip rings and the rotor(B) or rotor shaft(C)

3. If the rotor fails either continuity check, replace the alternator

Stator

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



2. Check that there is no continuity between each lead and the coil core

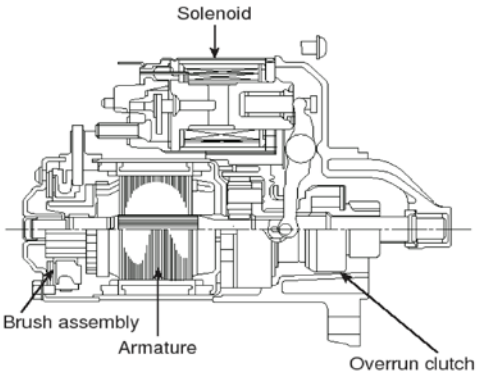
3. If the coil fails either continuity check, replace the alternator

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.

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.

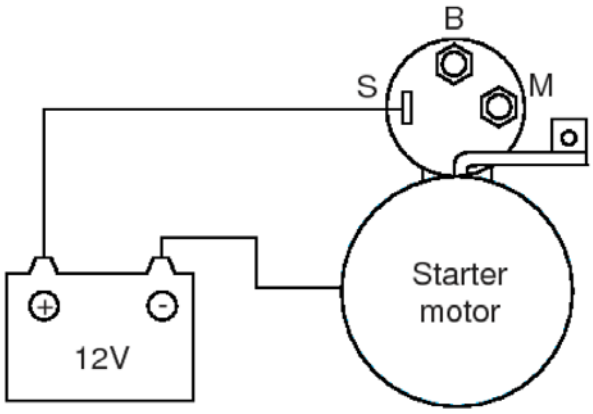
If the starter still does not crank the engine, remove the starter, and repair or replace as necessary.

4. 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.

Stator 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.

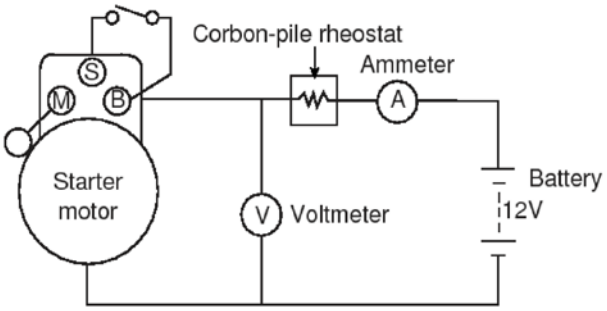
If the pinion does not move, replace the solenoid.

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 a fully-charged 12-volt battery to starter motor as follows.
2. Connect a test ammeter (100-ampere scale) and carbon pile rheostats shown is the illustration.
3. Connect a voltmeter (15-volt scale) across starter motor.

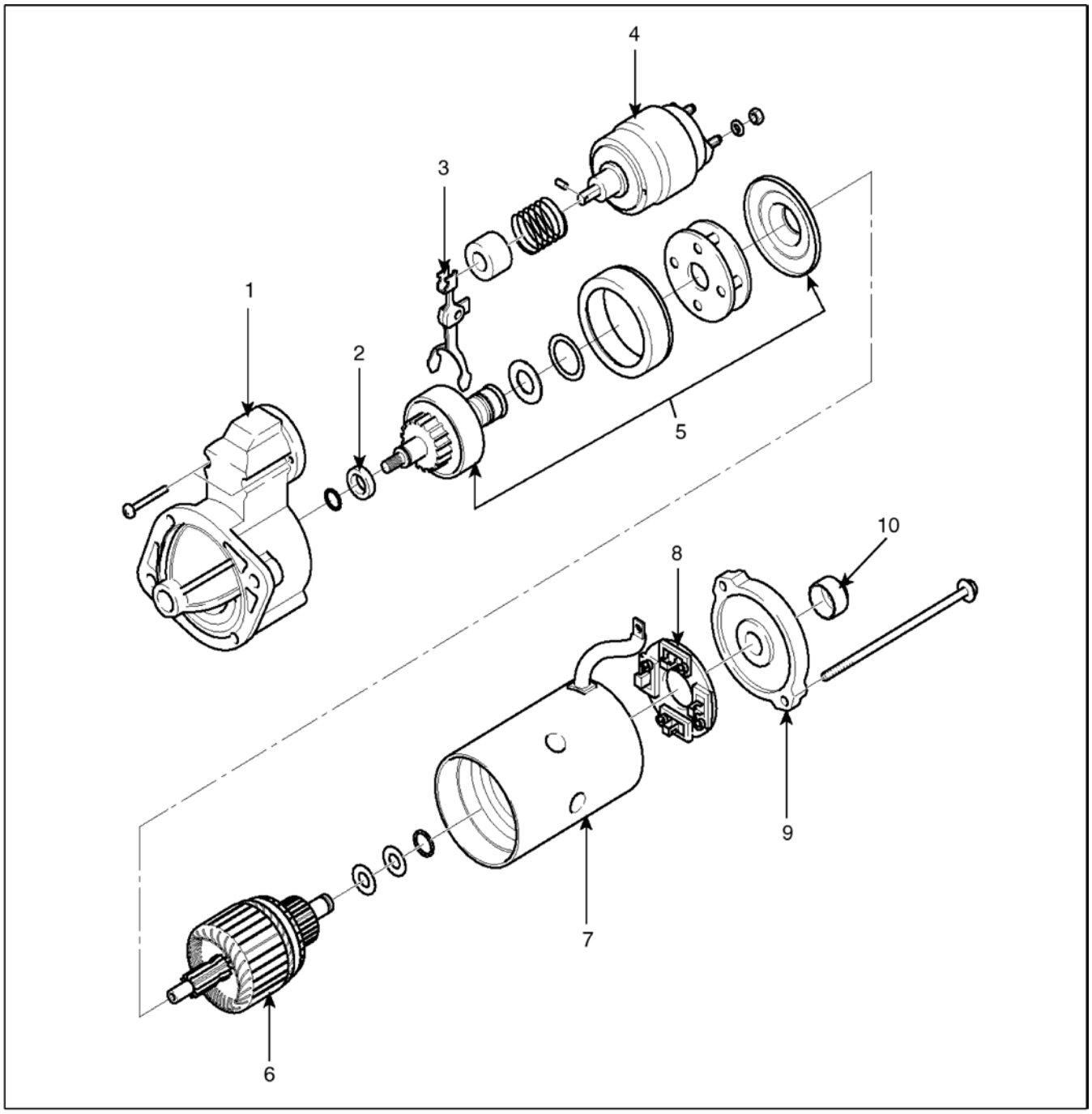


4. Rotate carbon pile to the off position.
5. Connect the battery cable from battery's negative post to the starter motor body.
6. Adjust until battery voltage shown on the voltmeter reads 11volts.
7. Confirm that the maximum amperage is within the specifications and that the starter motor turns smoothly and freely.

Current : 130A max

Speed : 3,600 rpm

Components

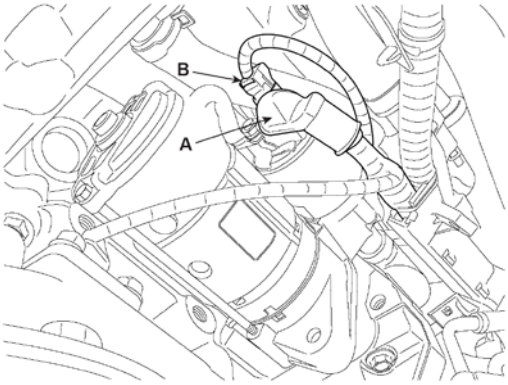


SENEE9001L

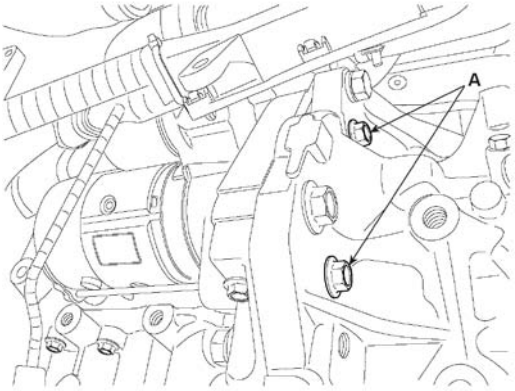
1. Front bracket
2. Spaceer
3. Lever
4. Magnetic switch
5. Overrunning clutch
6. Amature assembly
7. York assembly
8. Brush holder assembly
9. Rear bracket
10. Cover

Replacement

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



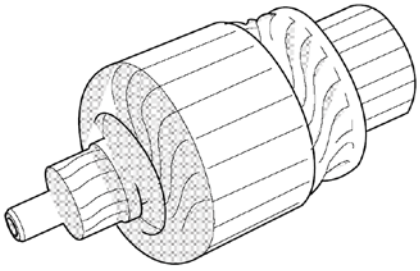
2. Remove the starter by loosening the starter mounting bolts(A).



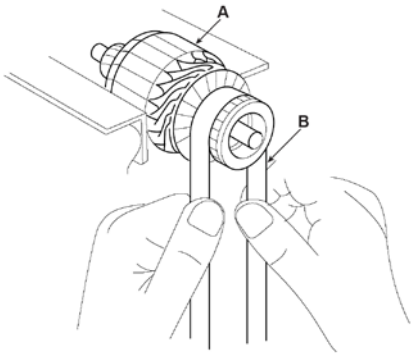
3. Installation is in the reverse order of remove

Amature

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.

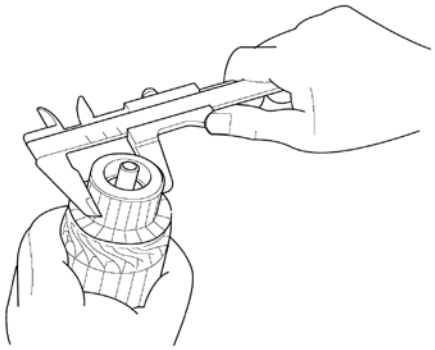


4. Check the commutator(A) surface. If the surface is dirty or burnt, resurface with emery cloth or a lathe within the following specifications, or recondition with #500 or #600 sandpaper(B).



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

Standard (New) : 30.0 mm (1.1811 in)
Service limit : 29.2 mm (1.1496 in)

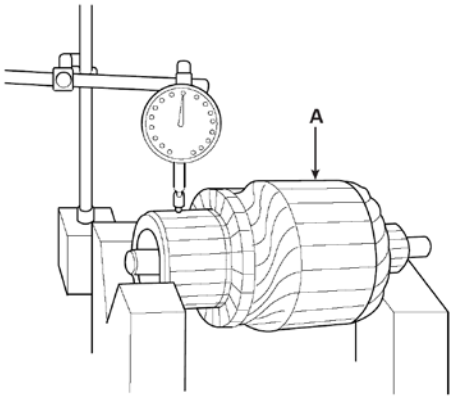


6. Measure the commutator(A) runout.

• If the commutator runout 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) : 0.02mm (0.0008in.) max
Service limit : 0.05mm (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 (0.0197 in.)
Limit : 0.2mm (0.0079 in.)

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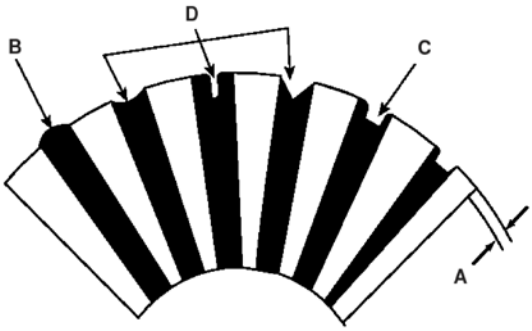
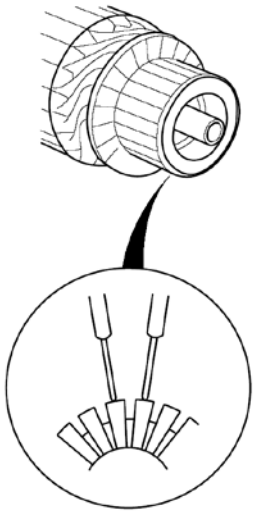
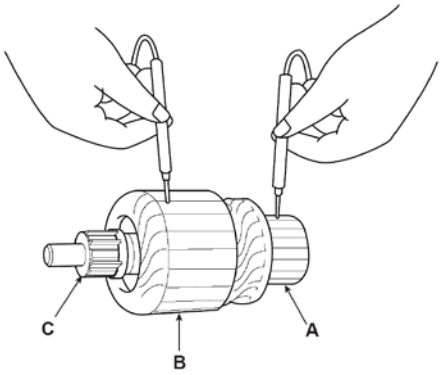
8. Check for continuity between the segments of the commutator. If an open circuit exists between any segments, replace the armature.



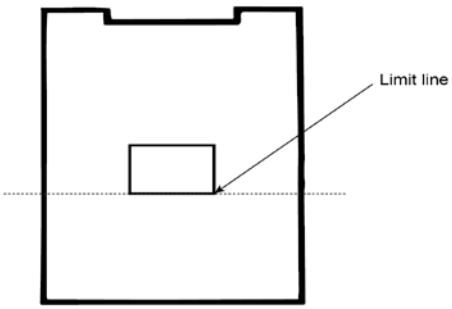


9. Check with an ohmmeter that no continuity exists between the commutator(A) and armature coil core(B), and between the commutator and armature shaft(C). If continuity exists, replace the armature.



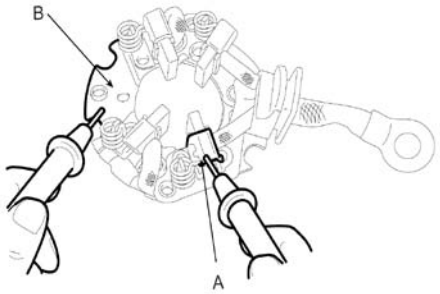
Inspect starter brush

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



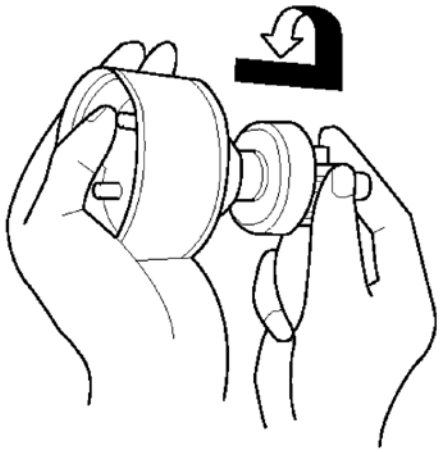
Starter Brush Holder

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 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.



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.

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 sol-vent will wash lubrication from the clutch.

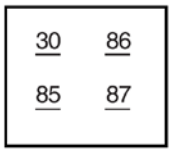
3. The drive unit may be cleaned with a brush moistened with cleaning solvent and wiped dry with a cloth.

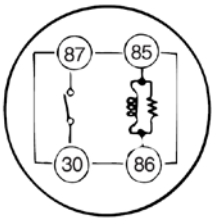
Starter Relay

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.





5. If there is no continuity, replace the starter relay.
6. install the ECU box cover

Preheating System

General Description

Preheating on Diesel engine improves cold starting with glow plug which heat combustion chamber. Preheating before starting improves cold starting, preheating after starting reduces to generate white smog. GCU(Glow plug Control Unit) is installed on the upper side of timing chain cover and is operated by 12V power supply. GCU receives sensors data such as 1)engine coolant temperature, 2)engine rpm, 3)fuel injection amount from ECM via CAN communication in order to control glow plug. GCU controls 1)glow plug operation with PWM, 2)compensates voltage when low voltage 3)controls not to flow over current on glow plug 4) retrieves DTC after diagnosing each glow plug corresponding to engine condition.

ISS(Instant Starting System) operated by 4.4Voltage which is slim and enhanced heating performance, is newly adopted on S engine. GCU emerges battery voltage to glow plug directly for 1~2sec. at IG key ON. After that, GCU controls glow plug operating voltage with PWM corresponding to engine condition. ISS glow plug is increased to 1000℃ within 2~3sec. so that starting performance is reached as same level as gasoline. In addition, it is realized that consumption of electricity is optimized by PWM control.

Inspection

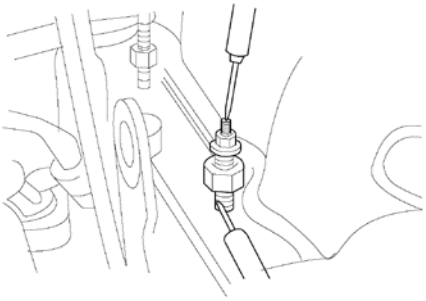
Conditions before inspection :

Battery voltage : 12V

Cooling water temperature : Below 30℃ (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 temperature20°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.

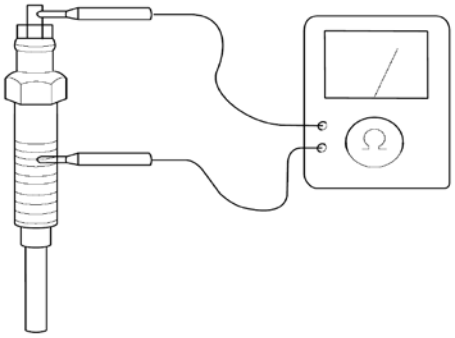


Glow Plug

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.



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℃(1562˚F), where the air-fuel mixture evaporizes 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.

Cold Resistance

The measured values are valid for 4 minutes at nominal voltage or for 10 minutes at 980℃(1796℉) pre-oxidized glow plugs

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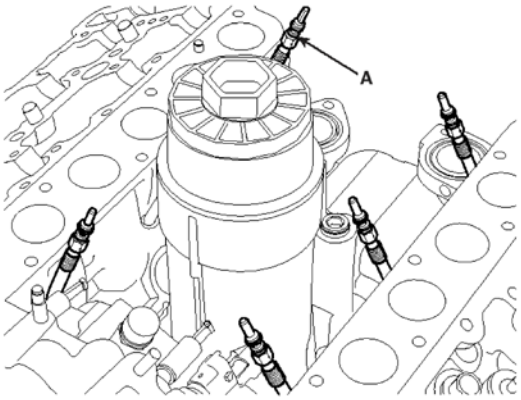
Glow plug resistance at 18~22℃(64.4~71.6℉) : 410±110mΩ

Removal

1. Remove the inlet lower and upper manifold assembly.(Refer to Intake manifold in this Group)
2. Remove the glow plugs (A).



Inspection

The specified electrical data below are related to the nominal voltage and to an ambient temperature of 22.5~23.5℃(72.5~74.3˚F) on new glow plugs.

Current Consumption

Initial current at 11V : less than 27.0A

Operating current after 5 sec : less than 9.0A

Operating current after 60 sec : less than 8.0A

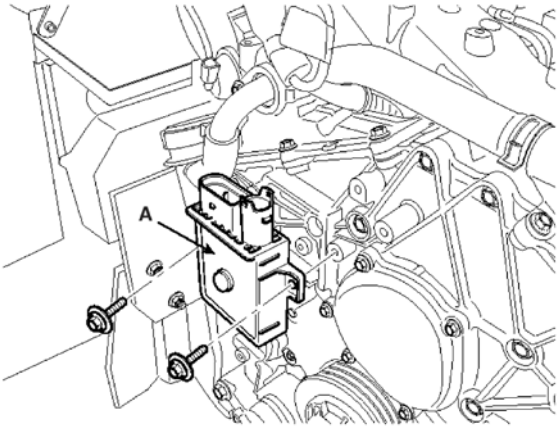
Glow Control Unit

Removal

1. Remove the main bracket.
2. Remove the glow plug control unit(A).

Tightening torque **:**

6.9 ~ 10.8Nm (0.7 ~ 1.1kgf.m, 5.1 ~ 8.0lb-ft)



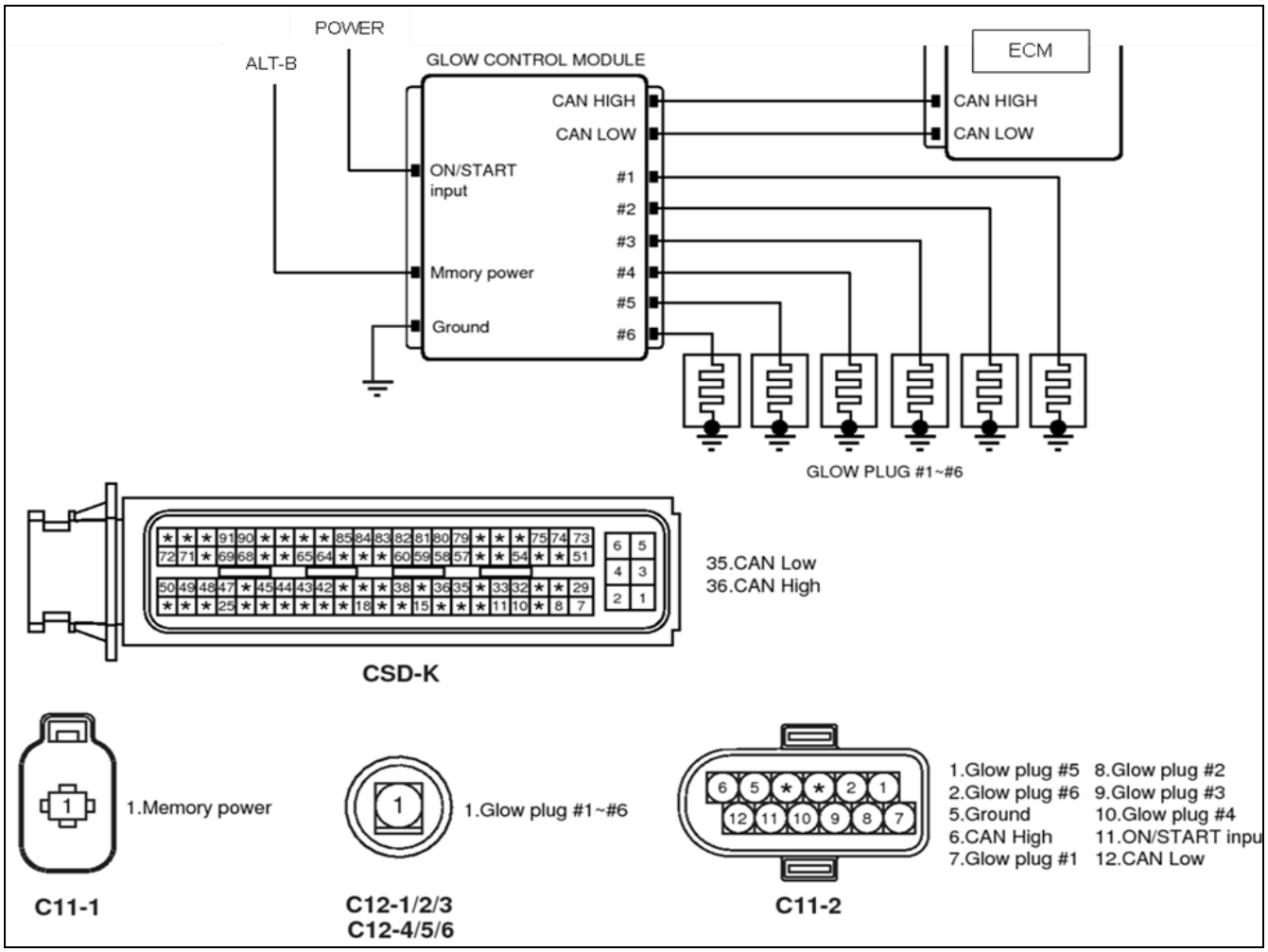
[Preheating time before starting]

Coolant Temp.	Operating time	Coolant Temp.	Operating time	Coolant Temp.	Operating time	Coolant Temp.	Operating time	Coolant Temp.	Operating time
- 25 ℃	21 sec.	- 20 ℃	18 sec.	- 10 ℃	8 sec.	5 ℃	2 sec.	15 ℃	1.5 sec.

[Preheating time after starting]

Coolant Temp.	Operating time	Coolant Temp.	Operating time	Coolant Temp.	Operating time	Coolant Temp.	Operating time	Coolant Temp.	Operating time
- 25 ℃	300 sec.	- 20 ℃	300 sec.	- 10 ℃	300 sec.	60 ℃	300 sec.	90 ℃	0 sec.

Schematic diagram



Fuel System

General

Diesel Control System

Fuel Delivery System

DTC(Diagnosis Trouble Code)

General Information

Specification

Fuel Delivery System

Items	Specification	
Fuel injection System	Type	Common rail direct injection(CRDI)
Fuel Return System	Type	Return type
Fuel Pressure	Max. Pressure	1,600 bar
Fuel Filter	Type	High pressure type (Built in engine room)
High Pressure Fuel Pump	Type	Mechanical, Plunger pumping type
	Driven by	Timing chain
Low Pressure Fuel Pump	Type	Electrical
	Driven by	Electric motor

Sensor

Boost Pressure Sensor (BPS)

① Type : Piezo-resistive pressure sensor type

②Specification

Pressure (kPa)	Output Voltage (V)
32.5	0.5
70.0	1.02 ~ 1.17
140.0	2.13 ~ 2.28
210.0	3.25 ~ 3.40
270.0	4.20 ~ 4.35
284.0	4.5

Engine Coolant Temperature Sensor(ECTS)

① Type : Thermistor type

② Specification

Temperature [℃(°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

Intake Air Temperature Sensor(IAT,Built in Air Filter)

① Type : Thermistor type

② Specification

Temperature [℃(°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

Camshaft Position Sensor(CMPS)

① Type : Hall effect type

② Specification

Level	Output Pulse (V)
High	5
Low	0

Item	Specification
Air Gap (mm)	0.5 ~ 1.5

Crankshaft Position Sensor(CKPS)

① Type : Magnetic field sensitive type

② Specification

Items	Specification
Coil Resistance (Ω)	774 ~ 946 [20℃(68°F)]
Air Gap (mm)	0.5 ~ 1.5

Rail Pressure Sensor (RPS)

① Type : Piezo-resistive pressure sensor type

② Specification

Condition	Rail pressure (bar)	Output Voltage (V)
Idle	200 ~ 300	0.9 ~ 1.2
3,000 rpm	450 ~ 650	1.5 ~ 1.9

Fuel Temperature sensor(FTS)

① Type : Thermistor type

② Specification

Temperature [℃(°F)]	Resistance(kΩ)
-10(14)	8.64 ~ 10.15
20(68)	2.35 ~ 2.65
80(176)	0.31 ~ 0.33
120(248)	0.11 ~ 0.12

Accelerator Position Sensor(APS)

① Type : Potentiometer type

② Specification

Pedal Position	Output Voltage(V) [Vref = 5.0V]	
	APS1	APS2
Released	0.7 ~ 0.8	0.275 ~ 0.475
Fully depressed	3.8 ~ 4.4	1.75 ~ 2.35

Water sensor

① Specification

Item	Specification
Warning Level (cc)	53 ~ 63

Actuators

Injector

① Type : Piezo injector

② Specification

Items	Specification
Component Resistance(kΩ)	150 ~ 250 [20℃(68°F)]
Operating Voltage (V)	100 ~ 200

Fuel Pressure Regulator Valve

① Specification

Item	Specification
Coil Resistance (Ω)	2.9 ~ 3.15Ω [20℃(68°F)]

Rail Pressure Regulator Valve

① Specification

Items	Specification
Coil Resistance (Ω)	3.42 ~ 3.78Ω [20℃(68°F)]
Operating Current (A)	0 ~ 1.7

Electric VGT Control Actuator

① Type : DC motor driven

Tightening Torques

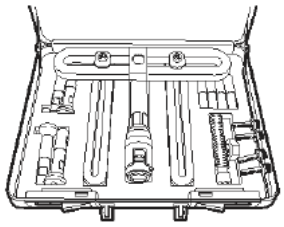
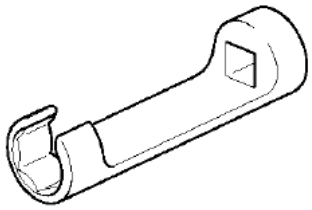
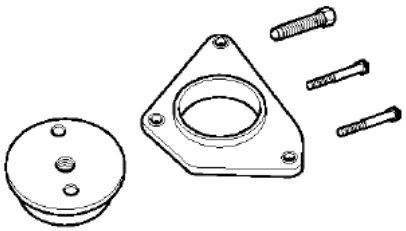
Engine Control System

Item	N·m	Kgf·m	lb-ft
Boost pressure sensor installation bolts	6.9~10.8	0.7~1.1	5.1~8.0
Engine coolant temperature sensor installation	39.2~54.0	4.0~5.5	28.9~39.8
Camshaft position sensor installation bolt	9.8~11.8	1.0~1.2	7.2~8.7
Crankshaft position sensor installation bolt	9.8~11.8	1.0~1.2	7.2~8.7
Glow control module installation bolt	6.9~10.8	0.7~1.1	5.1~8.0
Glow plug installation bolt	7.8~10.8	0.8~1.1	5.8~8.0

Fuel Delivery System

Item	N·m	Kgf·m	lb-ft
Low pressure fuel pump installation bolts	39.2~44.1	4.0~4.5	28.9~32.5
Injector clamp installation bolts	24.5~26.5	2.5~2.7	18.1~19.5
High pressure fuel pump installation bolts	24.5~34.3	2.5~3.5	18.1~25.3
Common rail[Bank1] installation bolts	19.6~26.5	2.0~2.7	14.5~19.5
Common rail[Bank2] installation bolts	19.6~26.5	2.0~2.7	14.5~19.5
High pressure fuel pipe installation nut(High pressure fuel pump ↔ Common rail)	24.5~28.4	2.5~2.9	18.1~21.0
Delivery pipe installation bolts	8.8~11.8	0.9~1.2	6.5~8.7

Special Service Tools

Tool (Number and name)	Illustration	Application
00200-0T014 Injector Remover		Removing the injector
00200-0T015 Torque Wrench Socket (17mm)		Installing the high pressure fuel pipe
00200-0T016 High Pressure Fuel Pump Remover		Removing the high pressure fuel pump

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

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

3. Environment

Problem frequency	□ Constant □ Sometimes_____ □ Once only □ Other_____
Weather	□ Fine □ Cloudy □ Rainy □ Snowy □ Other_____
Temperature	□ Approx _____℃/°F □ Other_____
Place	□ Sea □ Lake □ Other_____
Engine operation	□ Starting □ Just after starting □ Idling □ Driving □ Constant speed □ Deceleration □ Other_____

4. MIL /DTC/Alarm

MIL(Malfunction Indicator Lamp)	□ ON □ Sometimes lights up □ OFF □Other_____
Alarm	□ON □ Sometimes □ OFF □Other_____
DTC	□DTC NO(_____)
Freeze Frame Date	

Basic Inspection Procedure

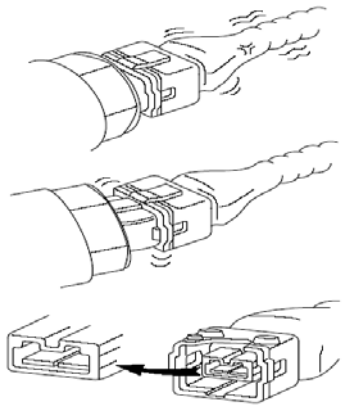
The measured resistance at high temperature after vehicle running may be high or low. So all resistance must be measured at ambient temperature (20℃, 68℉), unless stated otherwise.

✍ **NOTICE**

The measured resistance in except for ambient temperature (20℃, 68℉) is reference value.
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 engine 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.

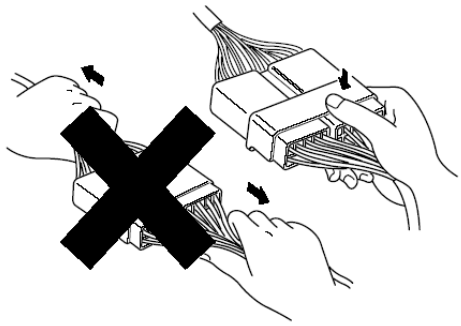
● Simulating Electrical Load.

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

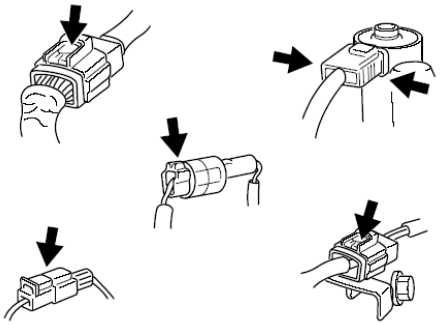
Connector Inspection Procedure

1. Handling of Connector

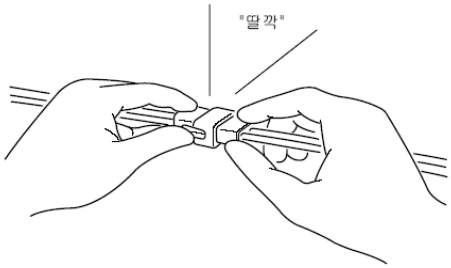
a. Never pull on the wiring harness when disconnecting connectors.



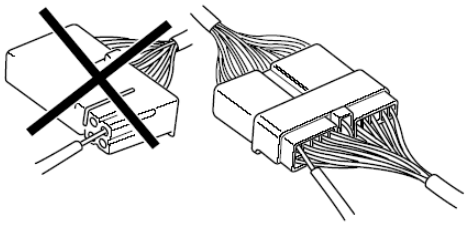
b. When removing the connector with a lock, press or pull locking lever.



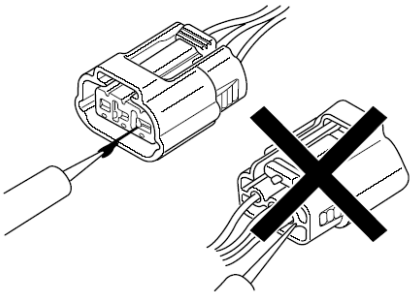
c. Listen for a click when locking connectors. This sound indicates that they are securely locked



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



✍ **NOTICE**

• *Use a fine wire to prevent damage to the terminal.*

• *Do not damage the terminal when inserting the tester lead.*

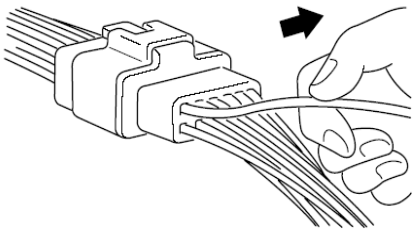
2. Checking Point for Connector

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

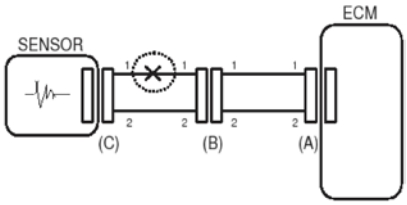
1. Procedures for Open Circuit

• 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

✍ **NOTICE**

When measuring for resistance, lightly shake the wire harness above and below or from side to side.

Specification (Resistance)

1Ω or less → Normal Circuit

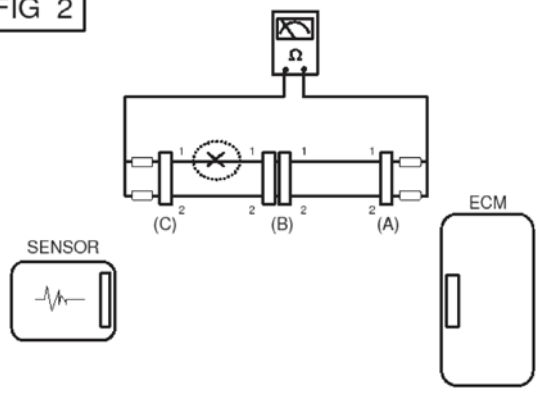
1㏁ or Higher → Open Circuit

---

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

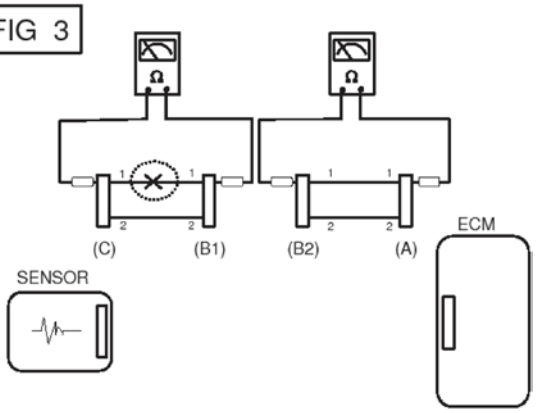
In [FIG.2.] the measured resistance of line 1 and 2 is higher than 1㏁ and below 1 Ω respectively. Specifically the open circuit is line 1 (Line 2 is normal). To find exact break point, check sub line of line 1 as described in next step.

FIG 2



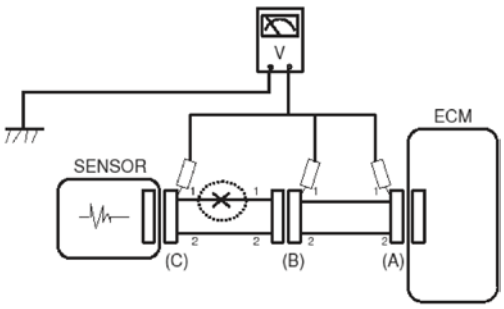
b. Disconnect connector (B), and measure for resistance between connector (C) and (B1) and between (B2) and (A) as shown in [FIG. 3].
In this case the measured resistance between connector (C) and (B1) is higher than 1㏁ and the open circuit is between terminal 1 of connector (C) and terminal 1 of connector (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).

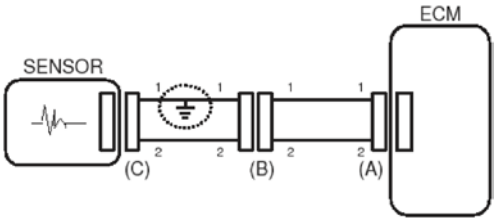
FIG 4



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)

✍ **NOTICE**

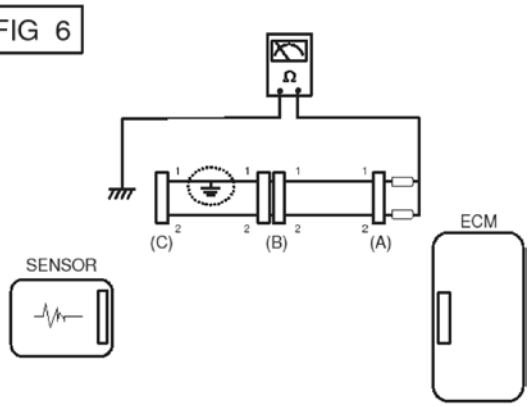
Lightly shake the wire harness above and below, or from side to side when measuring the resistance.

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

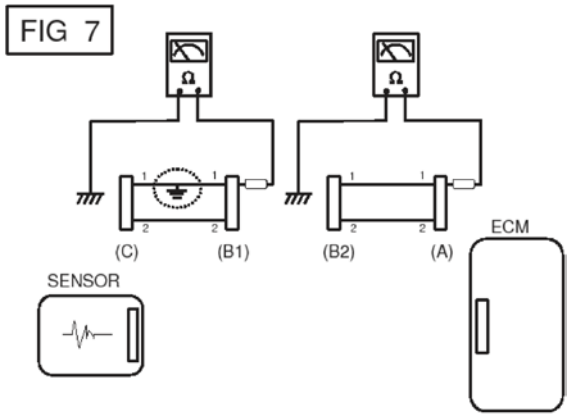
FIG 6



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



Actuation test

Items	Test Condition
MIL(ENGINE CHECK)	ACTUATION TEST/ IG ON /ENGINE RUN
FUEL PUMP RELAY	ACTUATION TEST/ IG ON /ENGINE RUN
ELECTRIC VGT CONTROL ACTUATOR	ACTUATION TEST/ IG ON /ENGINE RUN
FUEL PRESSURE REGULATOR VALVE(HP PUMP SIDE)	ACTUATION TEST/ IG ON /ENGINE RUN
RAIL PRESSURE REGURATOR VALVE(COMMON RAIL SIDE)	ACTUATION TEST/ IG ON /ENGINE RUN

SYMPTOM TROUBLESHOOTING GUIDE TABLE

(SYMPTOM 1) ENGINE DOES NOT START

- 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
- 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

- 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)
- 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

- 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
- 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

Engine 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 sand 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.

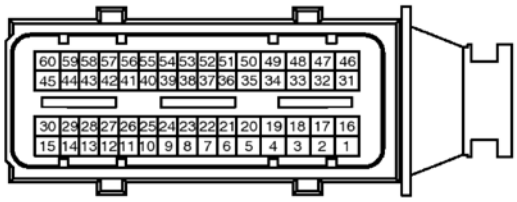
Component Location

1. ECU Box
2. Coolant Expansion Tank
3. Engine Oil Cap
4. Engine Oil Filter
5. E-VGT & Cooler
6. Air Filter
7. Engine Oil Gauge
8. Acceleration Lever Sensor
9. Seawater Pump
10. Intercooler
11. Heat Exchanger
12. Alternator

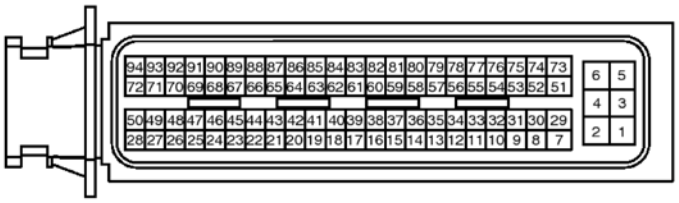
1. E-VGT Heat Protector
2. Exhaust Elbow
3. Bell Housing (Sterndrive Model)
4. Drive Coupler (Sterndrive Model)
5. Engine Oil Exchange Button
6. Engine Emergency Stop Button
7. P/STRG Oil Reservoir Tank(Sterndrive Model)
8. Shift Plate (Sterndrive Model)
9. Main Fuel Filter with Water Detection Sensor
10. T/M Oil Cooler or P/STRG Oil Cooler
11. Cabin Heater Connector
12. BPS & IATS

ECM(ENGINE CONTROL MODULE)

1. ECM Harness connector

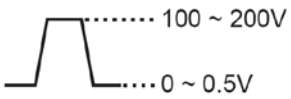
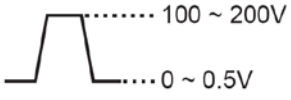


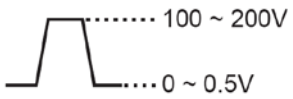
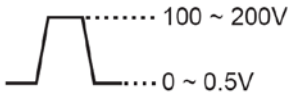
CONNECTOR(CSD-A)



CONNECTOR(CSD-K)

2. ECM Terminal Function

Connector **[CSD-A]**				
Pin	Description	Condition	Type	Level
1	Injector (Cylinder #2) [Low]control output	Engine run	DC	
2	Injector (Cylinder #4) [Low] control output			
3	Injector (Cylinder #6) [Low] control output			
4	Fuel Pressure Regulator Valve control output	Engine run	PWM (120~200Hz)	
5	Rail Pressure Regulator Valve control output	Engine run	PWM (1kHz)	
7	Intake Air Temperature Sensor (IATS) #2 signal input	Idle	Analog	0.5 ~ 4.5V
10	Fuel Temperature Sensor (FTS) signal input	IG ON	Analog	0.5 ~ 4.5V
16	Injector (Cylinder #2) [High] control output	Engine run	DC	
17	Injector (Cylinder #4) [High] control output			
18	Injector (Cylinder #6) [High] control output			
20	Electric VGT Control Actuator control output	IG ON	PWM (250Hz)	 Engine running duty: 20~80
21	Sensor ground	Always	DC	0 ~ 0.5V
22	Engine Coolant Temperature Sensor(ECTS) signal input	Idle	Analog	0.5 ~ 4.5V
23	Sensor ground	Always	DC	0 ~ 0.5V
26	Sensor power (+5V)	IG ON	DC	4.9 ~ 5.1V
27	Sensor power (+5V)	IG ON	DC	4.9 ~ 5.1V
28	Camshaft Position Sensor(CMPS) signal input	Engine Run	Pulse	High : 4.8 ~5.2V Low : Max 1.0V
29	Sensor ground	Always	DC	0 ~ 0.5V

31	Injector (Cylinder #1) [High] control output	Engine Run	DC	
32	Injector (Cylinder #3) [High] control output			
33	Injector (Cylinder #5) [High] control output			
39	Sensor ground	Always	DC	0 ~ 0.5V
40	Rail Pressure Sensor(RPS) signal input	Engine Run	Analog	0.5 ~ 4.5V
41	Boost Pressure Sensor(BPS) signal input	Engine Run	Analog	1.0 ~ 4.4V
43	Crankshaft Position Sensor (CKPS) [-] signal input	Engine Run	SINE wave	Vp_p: Min 1.0V
46	Injector (Cylinder #1) [Low] control output	Engine Run	DC	
47	Injector (Cylinder #3) [Low] control output			
48	Injector (Cylinder #5) [Low] control output			
49	Motor [+] control output	Engine Run	PWM	
50	Motor [-] control output			
51	Sensor power (+5V)	IG ON	DC	4.9 ~ 5.1V
52	Position Sensor signal input	Idle	DC	0.5 ~ 4.5V
54	Sensor power (+5V)	IG ON	DC	4.9 ~ 5.1V
55	Sensor ground	Always	DC	0 ~ 0.5V
56	Sensor ground	Always	DC	0 ~ 0.5V
57	Sensor shield			
58	Crankshaft Position Sensor (CKPS) [+] signal input	Engine Run	SINE Wave	Vp_p: Min.0V
Connector (CSD-K)				
1, 2	Power ground	Always	DC	0 ~ 0.5V
3	Battery power	IG ON	DC	Battery Voltage
4	Power ground	Always	DC	0 ~ 0.5V
5	Battery power	IG ON	DC	Battery Voltage
6	Battery power	IG ON	DC	Battery Voltage
18	Key power	IG ON	DC	Battery Voltage
35	CAN [Low]	RECESSIVE	DC	2.0 ~ 3.0V
		DOMINANT		0.5 ~ 2.25V
36	CAN [High]	RECESSIVE	DC	2.0 ~ 3.0V
		DOMINANT		2.75 ~ 4.5V
38	Intake Air Temperature Sensor (IATS) #1 signal input	Idle	Analog	0.5 ~ 4.5V
42	Sensor Power (+5V)	IG ON	DC	4.9 ~ 5.1V
47	Engine speed signal output	Engine Run	Pulse (4-pulse)	
49	Main Relay control output	OFF/ ON	DC	Battery Voltage Max 1.0 V

57	Accelerator Position Sensor (APS) #1 signal input	ON	DC	0.7 ~ 0.8V
		Idle		3.8 ~ 4.4V
58	Accelerator Position Sensor (APS) #2 signal input	WOT	DC	0.275 ~ 0.475V
		Idle		1.75 ~ 2.35V
60	Sensor power (+5V)	IG ON	DC	4.9 ~ 5.1V
68	Fuel Pump Relay control output	OFF / ON	DC	Battery Voltage / Max 1.0 V
72	Diagnosis Data Line (K-Line)	When transmitting	Pulse	High: Min. V batt x 80%
				Low: Max. V batt x 20%
		When receiving		High: Min. V batt× 70%
				Low: Max. V batt× 30%
79	Sensor ground	Always	DC	0 ~ 0.5V
80	Sensor ground	Always	DC	0 ~ 0.5V
81	Sensor ground	Always	DC	0 ~ 0.5V
82	Sensor power (+5V)	IG ON	DC	4.9 ~ 5.1V
90	EVGT feedback signal input	IG ON	PWM	Engine running duty: 20~8
91	Malfunction Indicator Lamp (MIL) Control output	OFF	DC	Battery Voltage
		ON		Max 1.0 V

ECM Replacement

1. Turn ignition switch OFF and disconnect the negative (-) battery cable. .
2. Remove the cover of the ECM & relay box
3. Disconnect the ECM connector
4. Install a new ECM.

ECM Problem Inspection Procedure

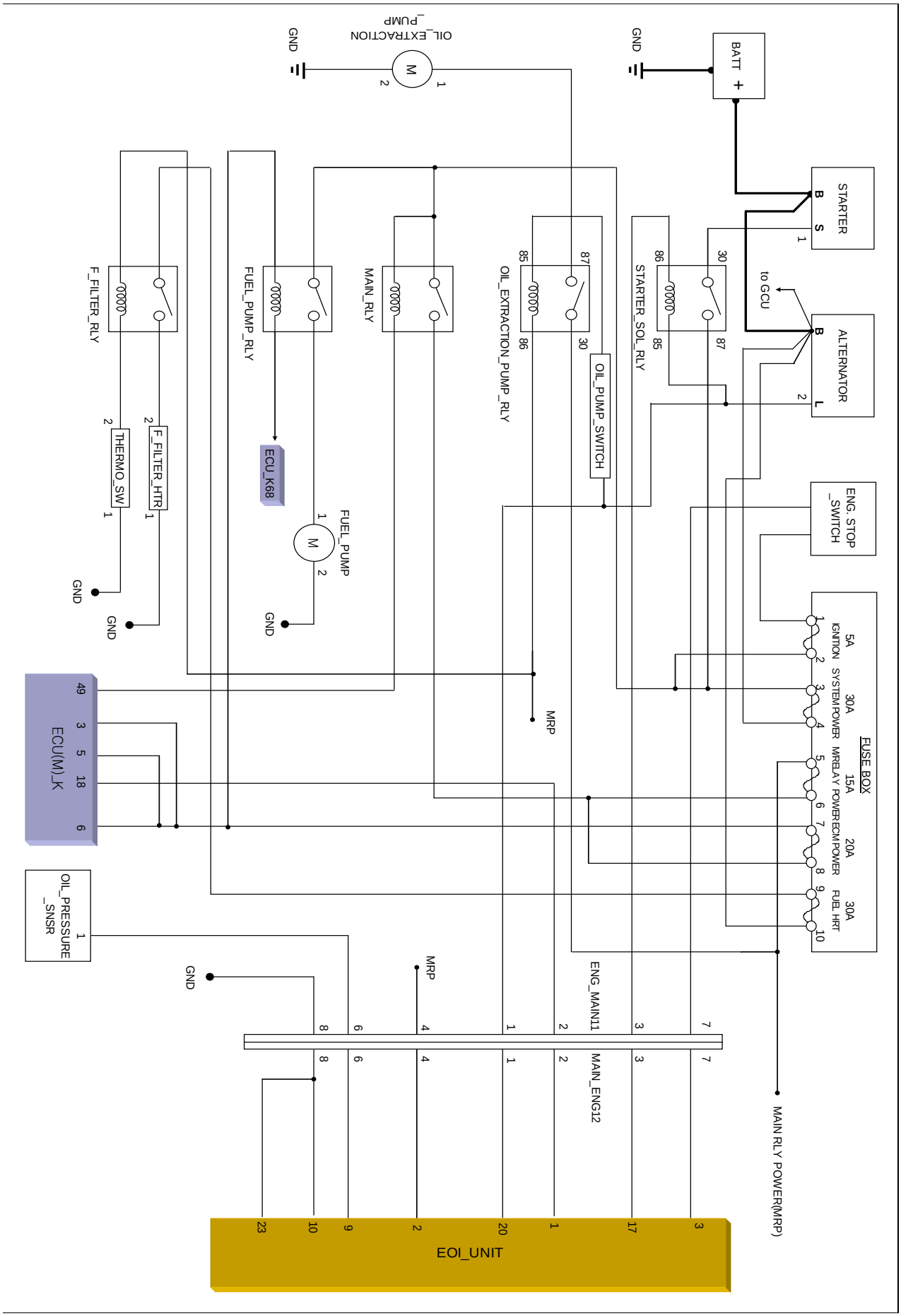
1. TEST ECM GROUND CIRCUIT: Measure resistance between ECM and chassis ground using the backside of ECM harness connector as ECM side check point. If the problem is found, repair it.

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 pressure. If the problem is found, repair it.

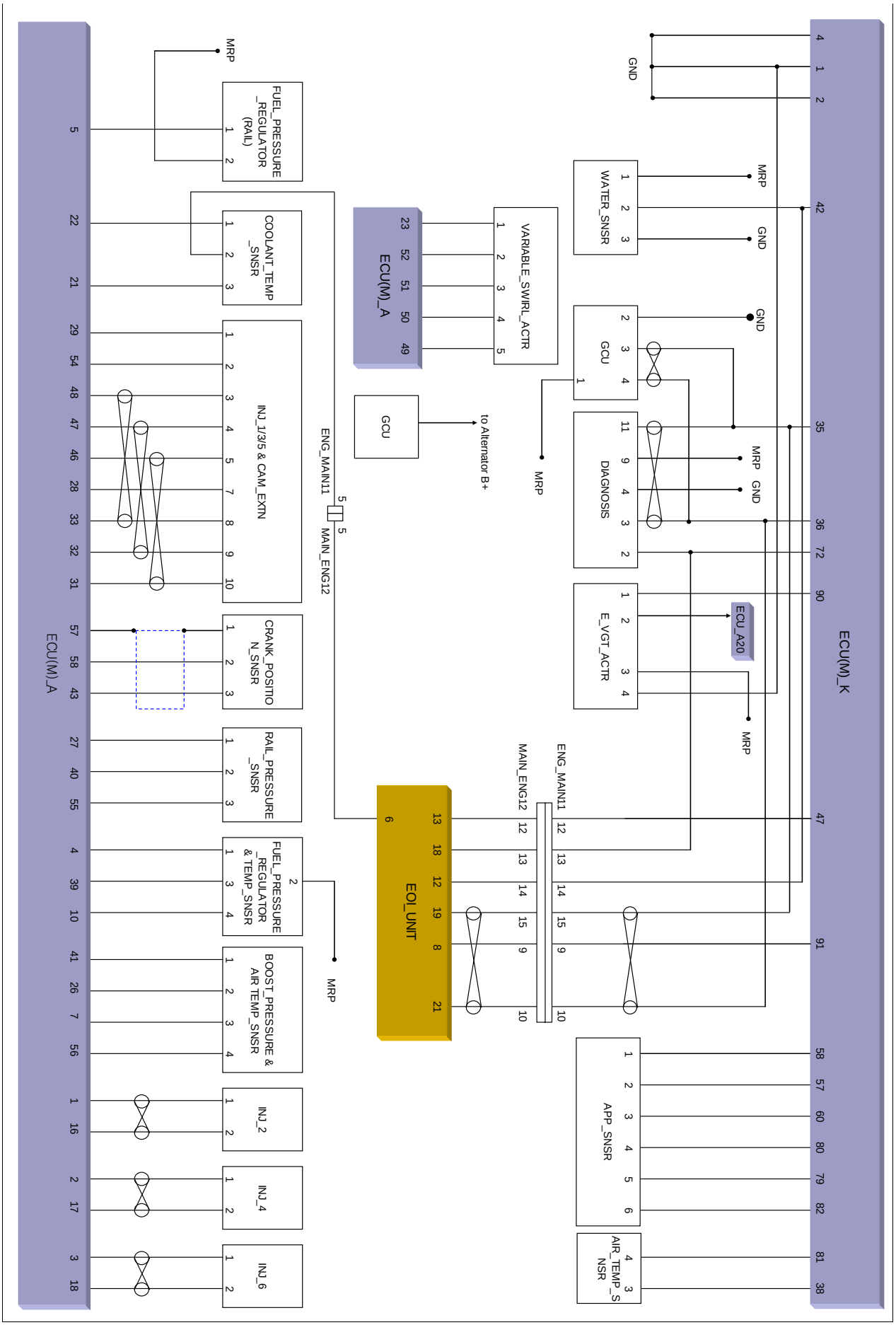
3. If problem is not found in Step 1 and 2, the ECM could be faulty. If so, replace the ECM with a new one, and then check the engine again. If the engine operates normally then the problem was likely with the ECM.

4. RE-TEST THE ORIGINAL ECM : Install the original ECM (may be broken) into a known-good engine and check the engine. 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 – 1



ECM Circuit Diagram – 2

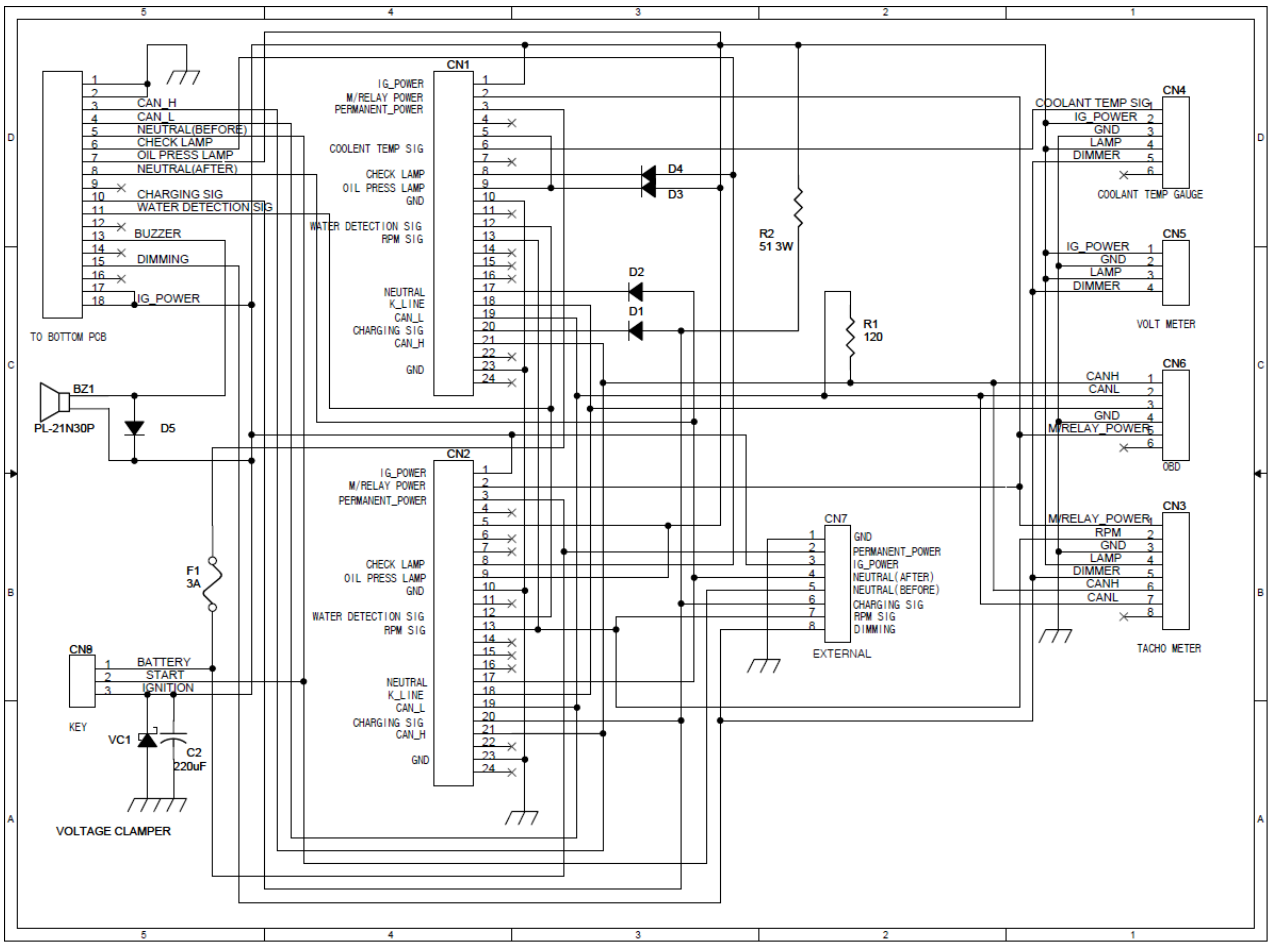


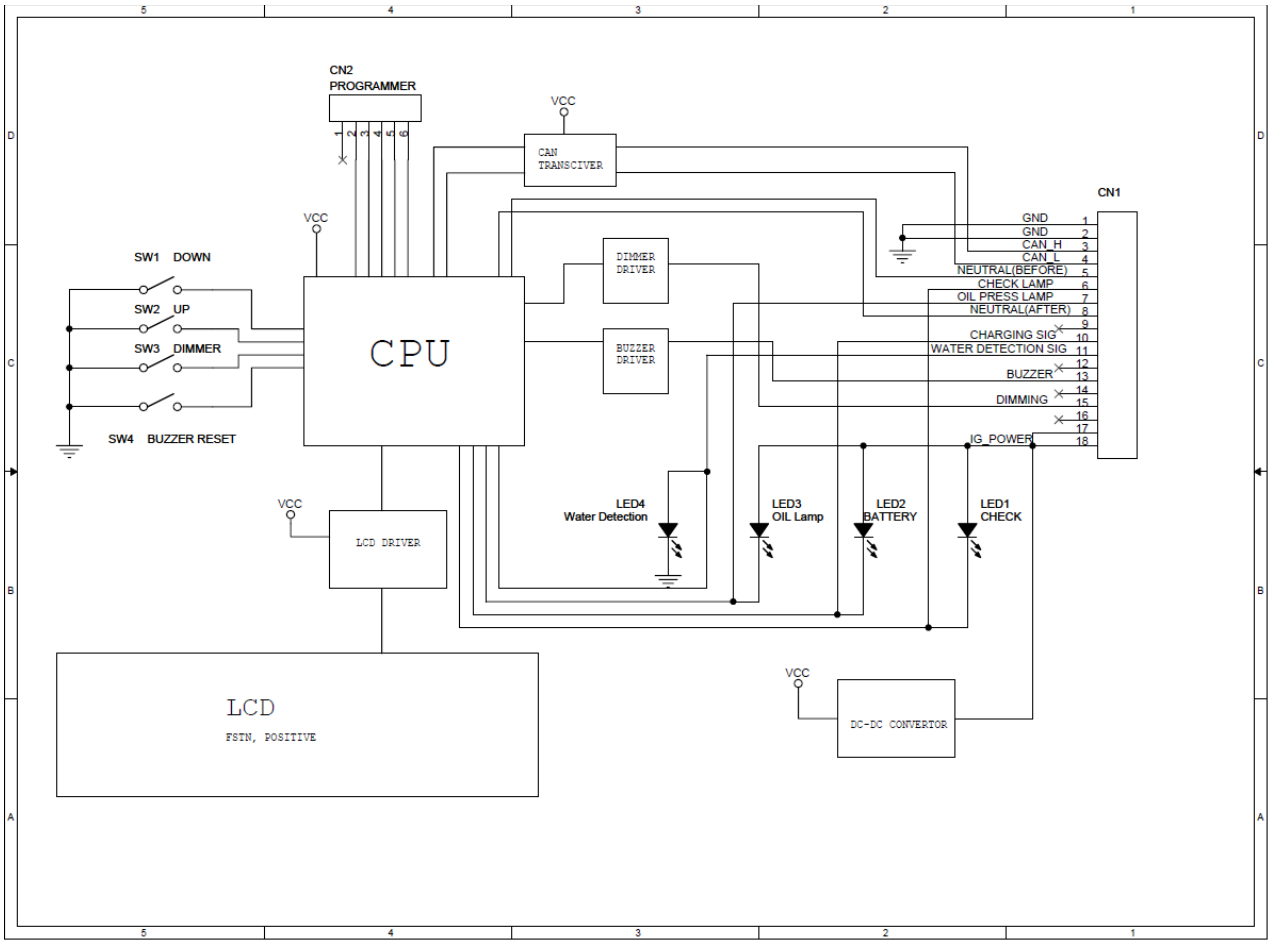
ECM Circuit Diagram – 3

Connector **[ECU-A]**	
Pin	Description
1	Injector (Cylinder #2) [Low]control output
2	Injector (Cylinder #4) [Low] control output
3	Injector (Cylinder #6) [Low] control output
4	Fuel Pressure Regulator Valve control output
5	Rail Pressure Regulator Valve control output
7	Intake Air Temperature Sensor (IATS) #2 signal input
10	Fuel Temperature Sensor (FTS) signal input
16	Injector (Cylinder #2) [High] control output
17	Injector (Cylinder #4) [High] control output
18	Injector (Cylinder #6) [High] control output
20	Electric VGT Control Actuator control output
21	Sensor ground
22	Engine Coolant Temperature Sensor(ECTS) signal input
23	Sensor ground
26,27	Sensor power (+5V)
28	Camshaft Position Sensor(CMPS) signal input
29	Sensor ground
31	Injector (Cylinder #1) [High] control output
32	Injector (Cylinder #3) [High] control output
33	Injector (Cylinder #5) [High] control output
39	Sensor ground
40	Rail Pressure Sensor(RPS) signal input
41	Boost Pressure Sensor(BPS) signal input
43	Crankshaft Position Sensor (CKPS) [-] signal input
46	Injector (Cylinder #1) [Low] control output
47	Injector (Cylinder #3) [Low] control output
48	Injector (Cylinder #5) [Low] control output
49	VSA motor [+] control output
50	VSA motor [-] control output
51	Sensor power (+5V)
52	Position Sensor signal input
54	Sensor power (+5V)
55	Sensor ground
56	Sensor ground
57	Sensor shield
58	Crankshaft Position Sensor (CKPS) [+] signal input

Connector **[ECU-K]**	
Pin	Description
1,2	Power ground
3	Battery power
4	Power ground
5	Battery power
6	Battery power
18	Key power
35	CAN [Low]
36	CAN [High]
38	Intake Air Temperature Sensor (IATS) #1 signal input
42	Sensor Power (+5V)
47	Engine speed signal output
49	Main Relay control output
57	Accelerator Position Sensor (APS) #1 signal input
58	Accelerator Position Sensor (APS) #2 signal input
60	Sensor power (+5V)
68	Fuel Pump Relay control output
72	Diagnosis Data Line (K-Line)
79	Sensor ground
80,81	Sensor ground
82	Sensor power (+5V)
90	Feedback signal input
91	Malfunction Indicator Lamp (MIL) Control output

EOI (Engine Operating Indicator System)Circuit Diagram - 1





EOI (Engine Operating Indicator System)Circuit Diagram - 2

Connector view of EOI rear side

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

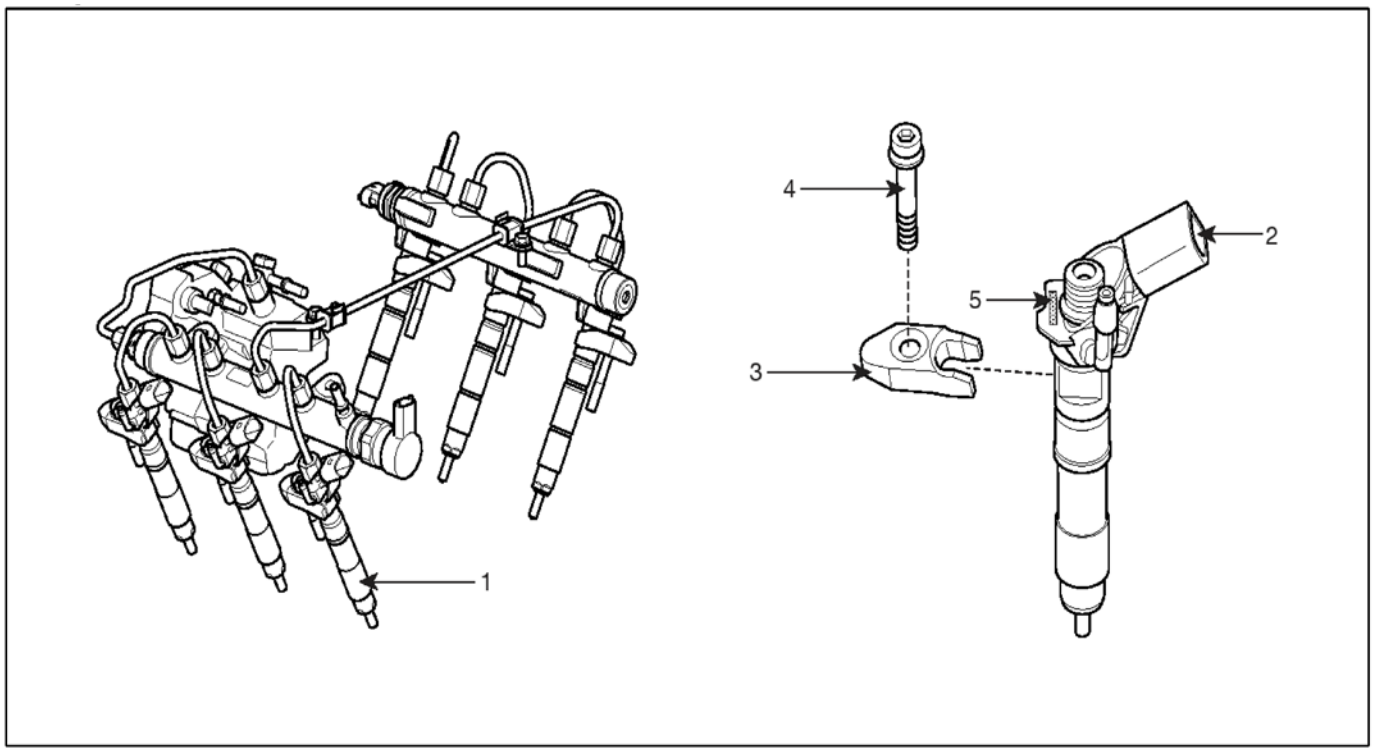
Description

☢ WARNING

As the Piezo-Injector operates under maximum DC 200V, there may be a risk of an electric shock caused by shorted control line etc. So when repairing the injector or its wiring, disconnect the battery negative (-) terminal from the battery and wait for about 30 seconds.

Components

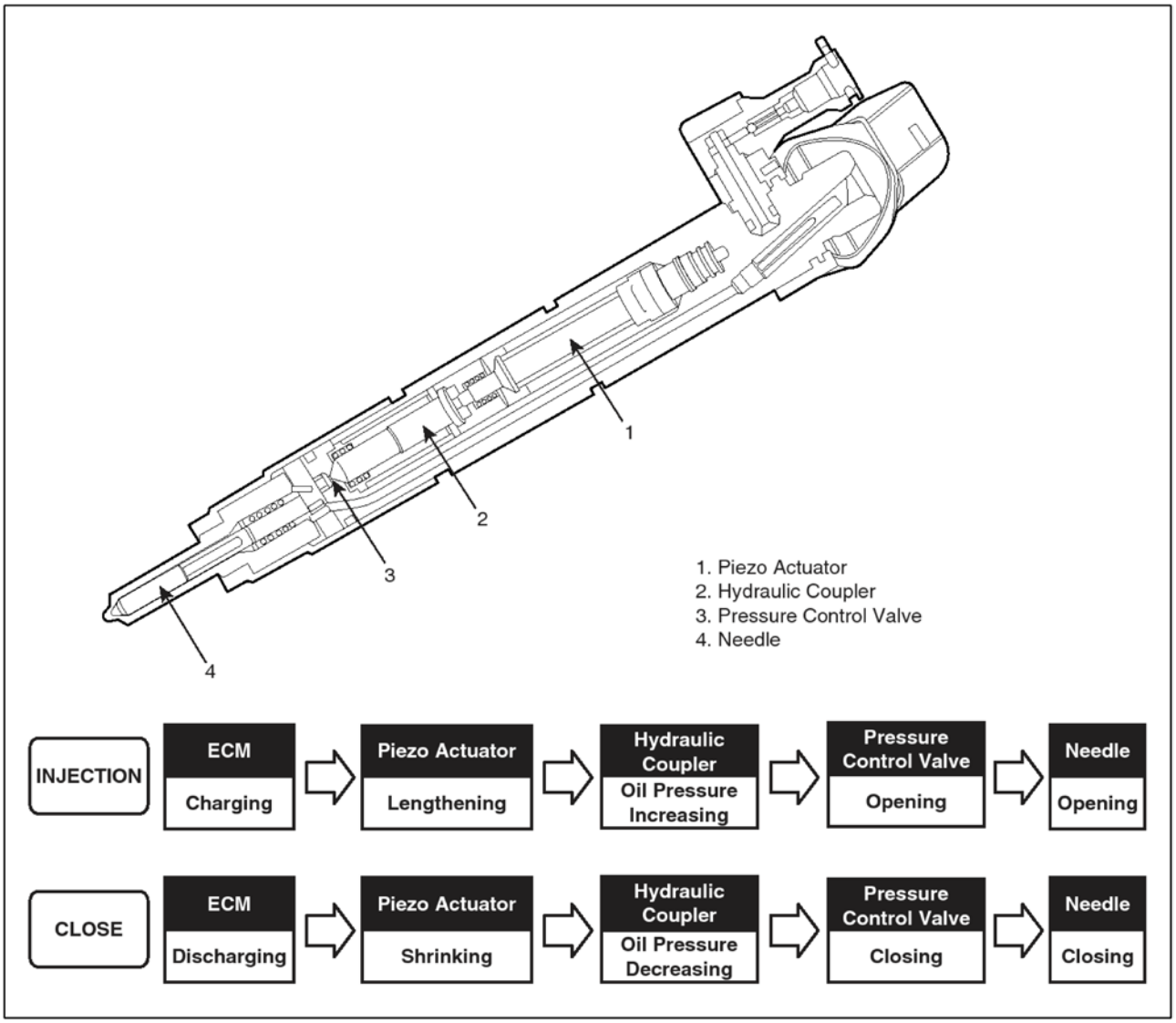
The injectors are installed on the cylinder head and inject the compressed fuel stored in common rail into each cylinder by ECM control signal. This consists of the piezo actuator, the hydraulic coupler which amplifies output of the piezo actuator, the pressure control valve which moves the needle, the needle which opens or closes the injection hole of the injector, the fuel inlet nipple, and the fuel return nipple



SENFL9159L

1. Injector
2. Connector
3. Clamp
4. Clamp Mounting Bolt
5. Injector Specific Data (7 digits)

Operation Principle

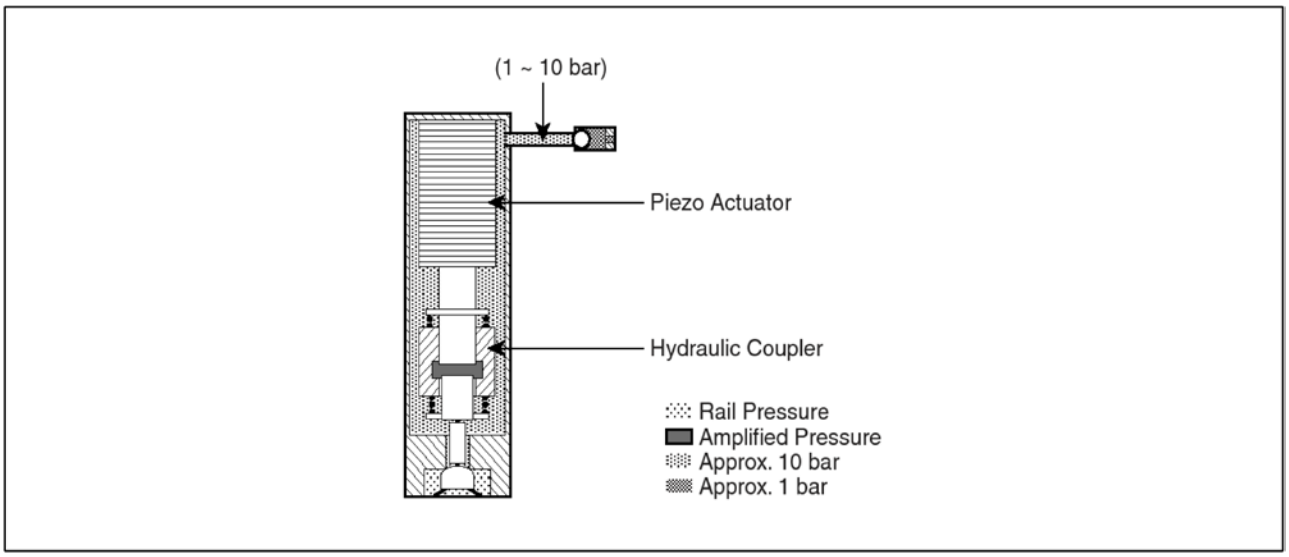


PIEZO ACTUATOR

The Piezo Actuator is made up of several floors of cylindrical piezo-ceramic (height: approximately 90㎛). This lengthens by from 1.5% through 2.0% of its length if voltage is applied (Piezoelectric Converse Effect) and this length is “Stroke”. The number and the cross section of the ceramic are proportional to the actuator’s stroke and output respectively.

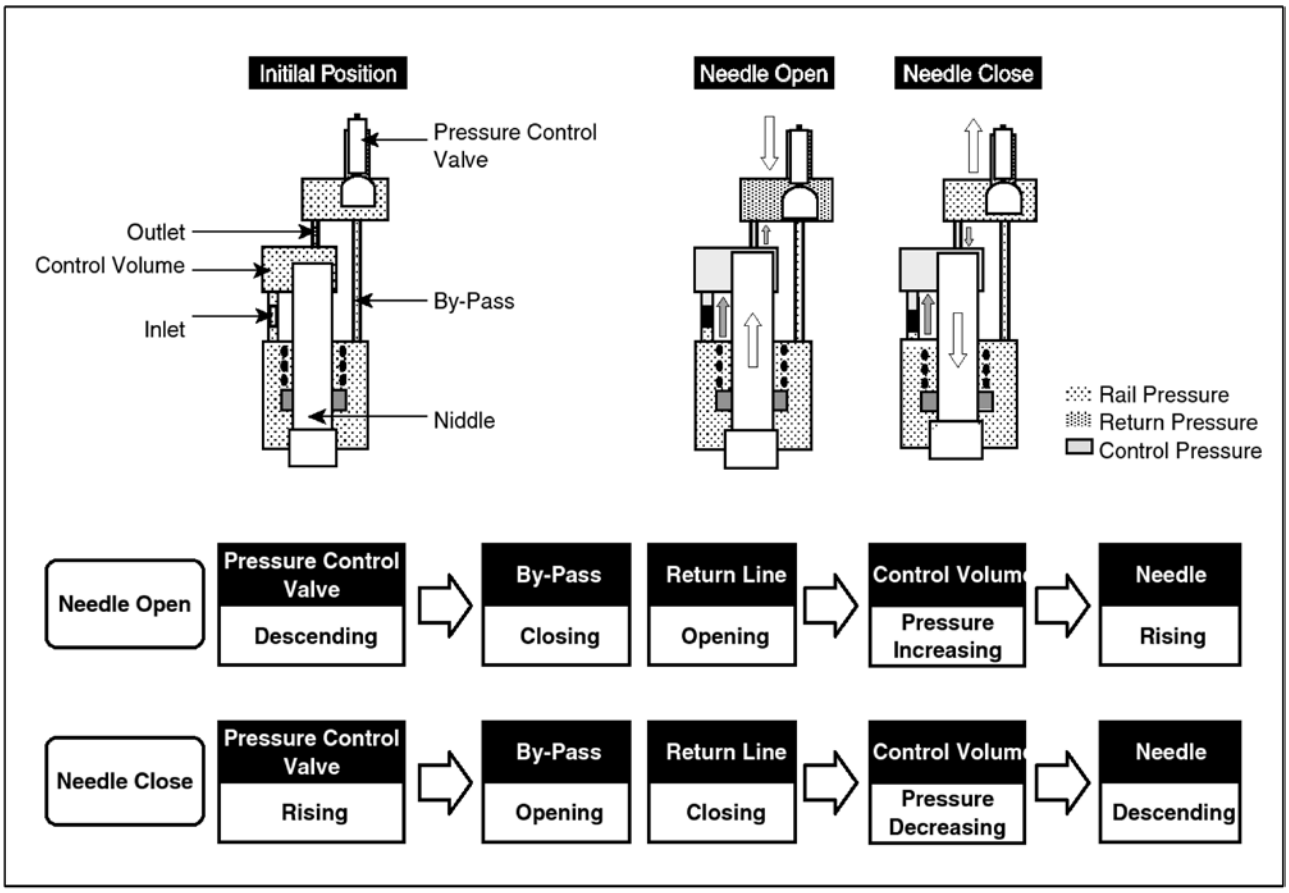
HYDRAULIC COUPLER

. The hydraulic coupler is located under the piezo actuator and amplifies the actuator’s output by the cross section ratio of the upper and the lower pistons. At this time, the actuator’s stroke is lengthened. The hydraulic oil is the fuel and the oil pressure to operate the hydraulic coupler normally is from 1 through 10 bar.



PRESSURE CONTROL VALVE

The Pressure Control Valve is located under the hydraulic coupler and controls the needle by amplified actuator's output.



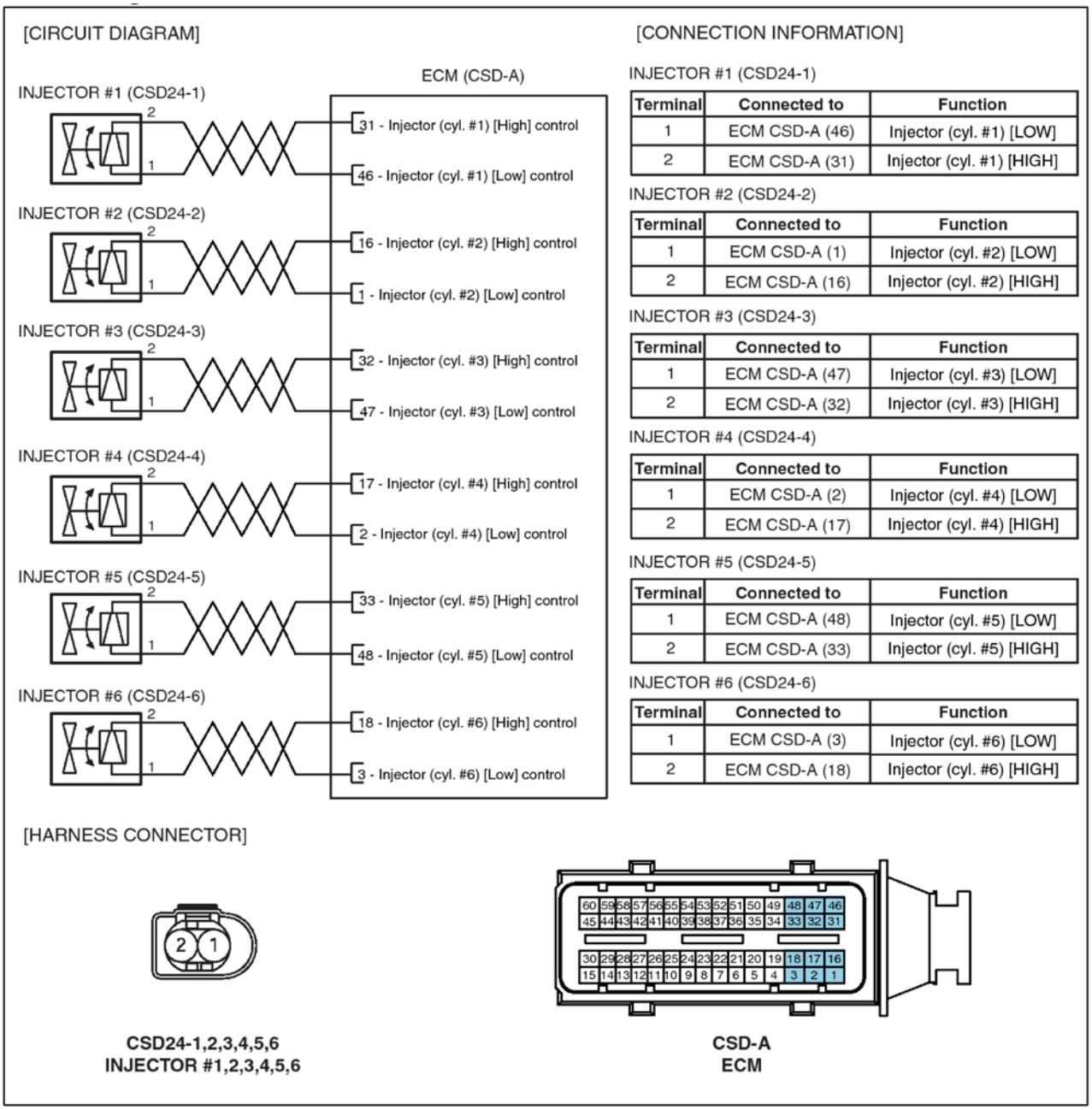
NEEDLE

The needle is located under the pressure control valve and finally opens or closes the injection hole.

Specification

Items	Specification
Component Resistance (kΩ)	150 ~ 250 [20℃(68°F)]
Operation Voltage (V)	100 ~ 200

Circuit Diagram



[CONNECTION INFORMATION]

INJECTOR #1 (CSD24-1)

Terminal	Connected to	Function
1	ECM CSD-A (46)	Injector (cyl. #1) [LOW]
2	ECM CSD-A (31)	Injector (cyl. #1) [HIGH]

INJECTOR #2 (CSD24-2)

Terminal	Connected to	Function
1	ECM CSD-A (1)	Injector (cyl. #2) [LOW]
2	ECM CSD-A (16)	Injector (cyl. #2) [HIGH]

INJECTOR #3 (CSD24-3)

Terminal	Connected to	Function
1	ECM CSD-A (47)	Injector (cyl. #3) [LOW]
2	ECM CSD-A (32)	Injector (cyl. #3) [HIGH]

INJECTOR #4 (CSD24-4)

Terminal	Connected to	Function
1	ECM CSD-A (2)	Injector (cyl. #4) [LOW]
2	ECM CSD-A (17)	Injector (cyl. #4) [HIGH]

INJECTOR #5 (CSD24-5)

Terminal	Connected to	Function
1	ECM CSD-A (48)	Injector (cyl. #5) [LOW]
2	ECM CSD-A (33)	Injector (cyl. #5) [HIGH]

INJECTOR #6 (CSD24-6)

Terminal	Connected to	Function
1	ECM CSD-A (3)	Injector (cyl. #6) [LOW]
2	ECM CSD-A (18)	Injector (cyl. #6) [HIGH]

Removal

☢ WARNING

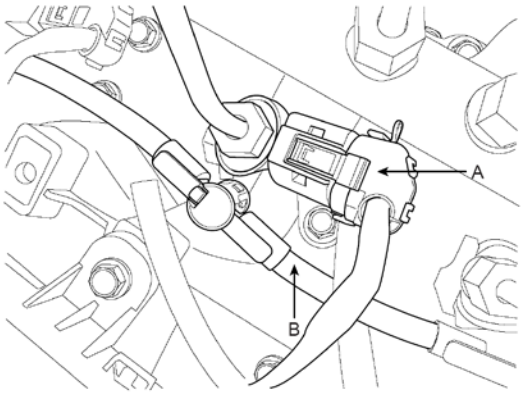
• As the Piezo-Injector operates under maximum DC 200V, there may be a risk of an electric shock caused by shorted control line etc. So when repairing the injector or its wiring, disconnect the battery negative (-) terminal from the battery and wait for about 30 seconds.

◉ 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

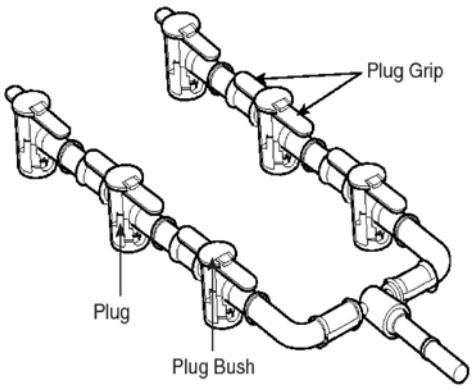
2. Disconnect the injector connector (A).



3. Disconnect the injector return line (B).

✍ NOTICE

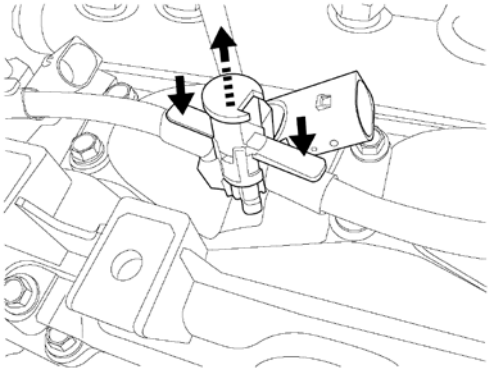
Before connecting the injector return line or after disconnecting the injector return line, check that the plug bush was completely raised from the plug. Otherwise fuel will leak around the injector's nipple because of broken plug..



✍ **NOTICE**

[DISCONNECTION-INJECTOR RETURN LINE]

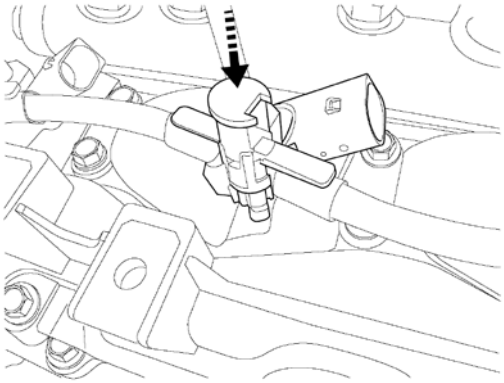
1. Pull the plug bush upward with the plug grip pressed.



2. Seize the return line on both sides of the plug, and then disconnect the plug upward from the injector nipple

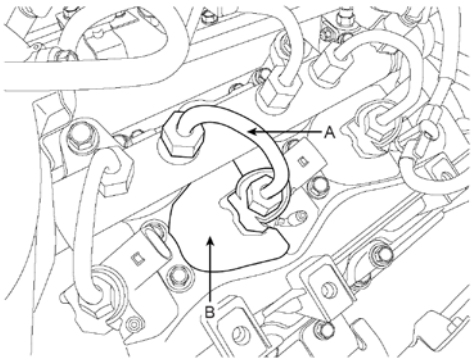
[CONNECTION-INJECTOR RETURN LINE]

1. With the plug bush fully raised, vertically install the plug to the injector nipple until "Click" sound generates.



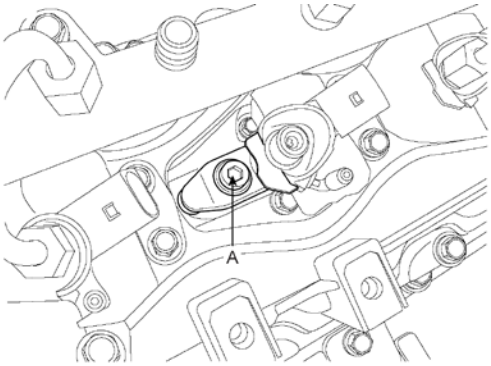
2. Press the plug bush downward until "Click" sound generates.

4. Disconnect the high pressure fuel pipe (A).



5. Remove the injector pad (B).

6. Unscrew the injector clamp bolt (A), and then remove 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**

1. When installing the high pressure fuel pipe, apply the specified tightening torques with the special service tool [SST No.: 00200-0T015].

2. When installing the high pressure fuel pipe connecting the common rail and injector, follow the below procedure.

- Injector clamp installation bolt: 24.5 ~ 26.5 N·m (2.5 ~ 2.7 kgf·m, 18.1 ~ 19.5 lbf·ft)

- High pressure fuel pipe installation nut: 24.5 ~ 28.4 N·m (2.5 ~ 2.9 kgf·m, 18.1 ~ 21.0 lbf·ft)

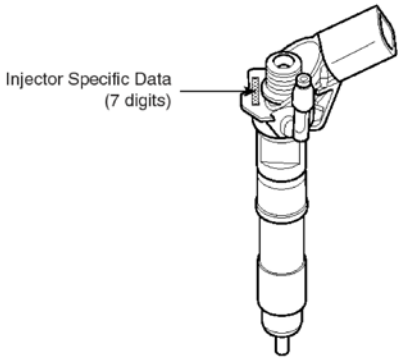
◉ **CAUTION**

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
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

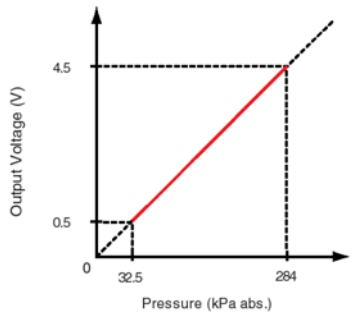
Function And Operation Principle.

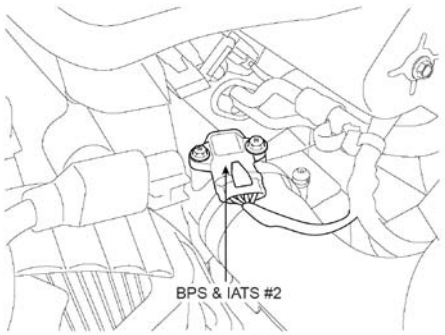
The Boost Pressure Sensor (BPS) is installed on the intercooler assembly and measures the pressure of the compressed air in turbocharger. By using this signal, the ECM controls the Variable Geometry Turbocharger (VGT).

Specification

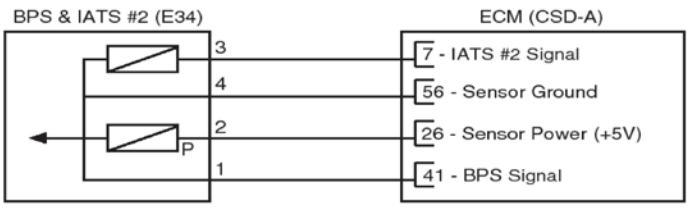
Pressure (Kpa)	Output Voltage (V)
32.5	0.5
70	1.02 ~ 1.17
140	2.13 ~ 2.28
210	3.25 ~ 3.40
270	4.20 ~ 4.35
284	4.5

Temperature [℃(°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





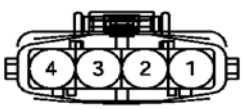
[CIRCUIT DIAGRAM]



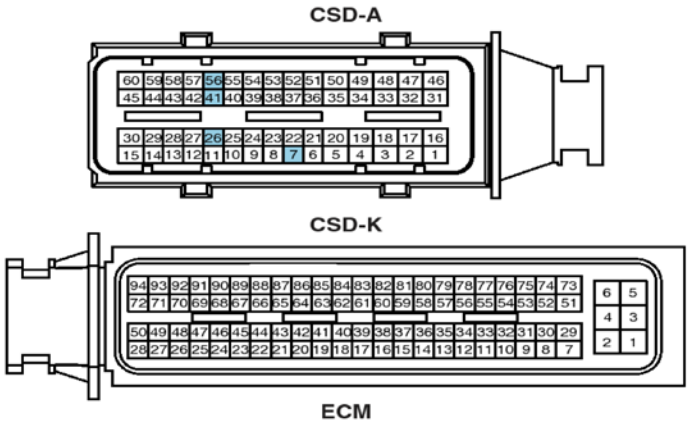
[CONNECTION INFORMATION]

Terminal	Connected to	Function
1	ECM CSD-A (41)	BPS Signal
2	ECM CSD-A (26)	Sensor Power (+5V)
3	ECM CSD-A (7)	IATS #2 Signal
4	ECM CSD-A (56)	Sensor Ground

[HARNESS CONNECTOR]

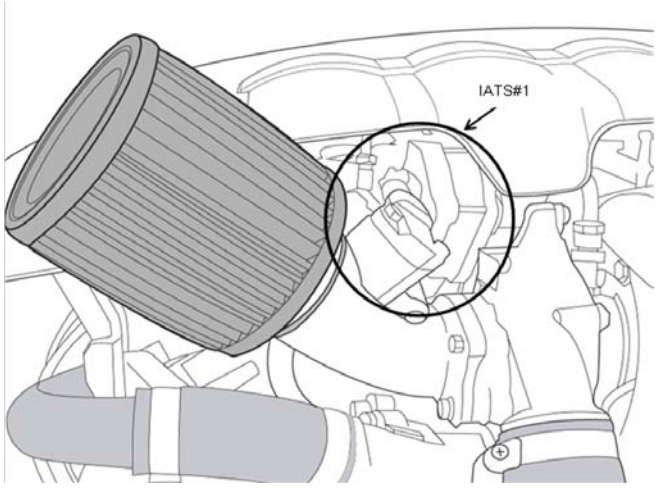


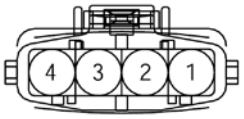
E34
BPS & IATS #2

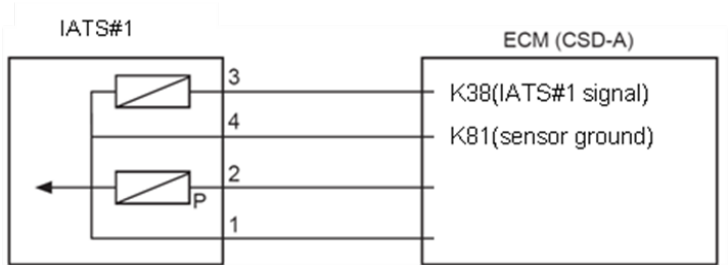


Intake Air Temperature Sensor (IATS#1)

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.





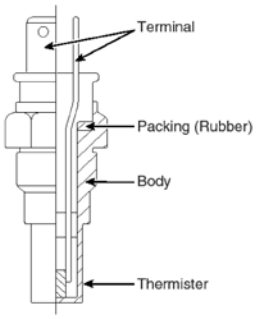


Engine Coolant Temperature Sensor (ECTS)

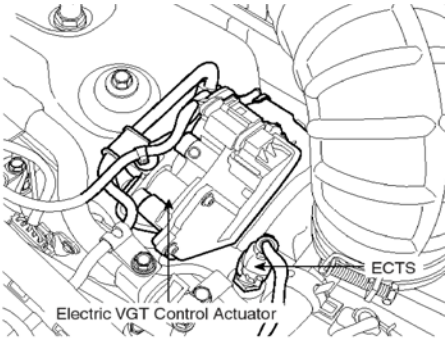
Function And Operation Principle

The Engine Coolant Temperature Sensor (ECTS) is located in the engine coolant passage of the cylinder for detecting the engine coolant temperature. The ECTS uses a thermistor which resistance is in inverse proportion to the temperature (NTC: Negative Temperature Coefficient). During cold engine operation, the ECM adjusts the injection amount and the timing by using this ECTS output signal to avoid engine stalling and improve drivability

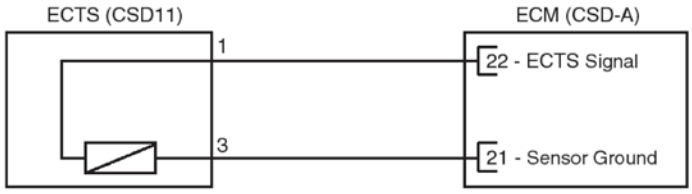
Specification



Temperature [℃(℉)]	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



[CIRCUIT DIAGRAM]



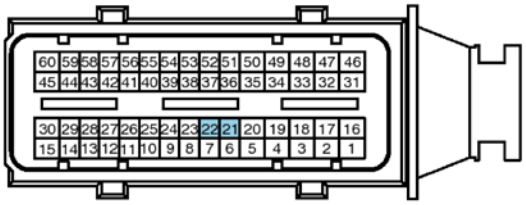
[CONNECTION INFORMATION]

Terminal	Connected to	Function
1	ECM CSD-A (22)	ECTS Signal
2	-	-
3	ECM CSD-A (21)	Sensor Ground

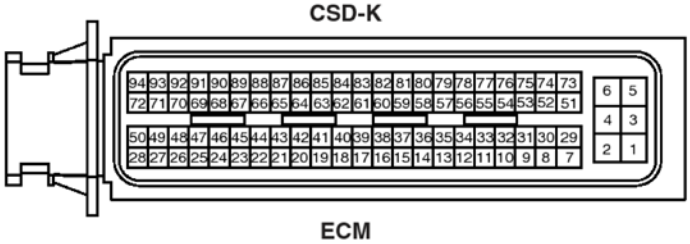
[HARNESS CONNECTOR]

CSD11
ECTS

CSD-A



CSD-K



ECM

Component Inspection

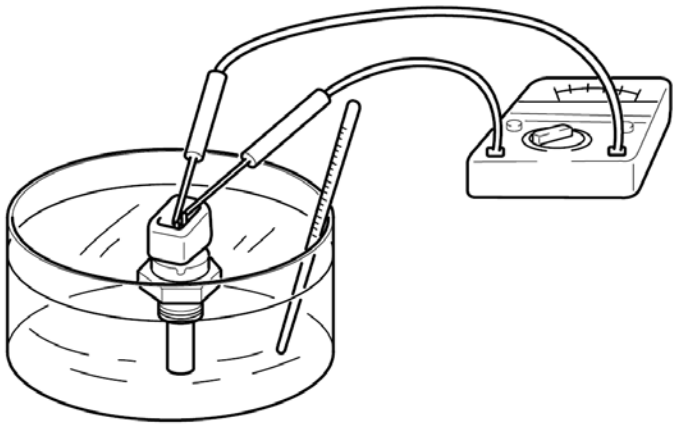
1. Turn ignition switch OFF.

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)

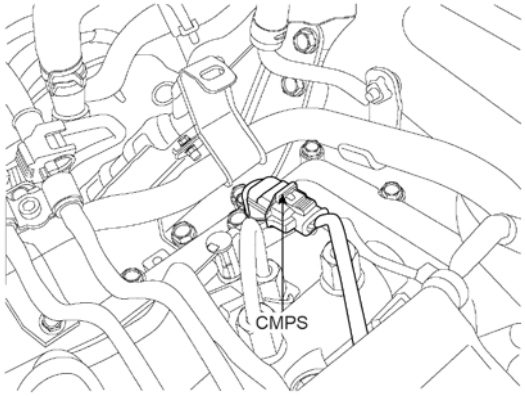
Function And Operation Principle

.The Camshaft Position Sensor (CMPS) is installed on the cylinder head cover and detects the camshaft position. This is a hall sensor and has a hall-effect IC which output voltage changes when magnetic field is made on the IC with current flow It is related with Crankshaft Position Sensor (CKPS) and
detects the piston position of the each cylinder which the CKPS can't detect. By using this signal, the ECM perceives the position of each cylinder and controls sequential injection.

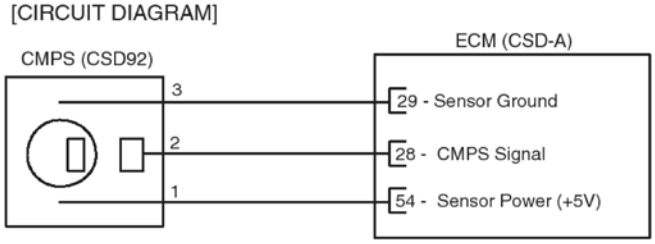
Specification

Level	Output Voltage (V)
High	5
Low	0

Item	Specification
Air gap (mm)	0.5 ~ 1.5



[CIRCUIT DIAGRAM]

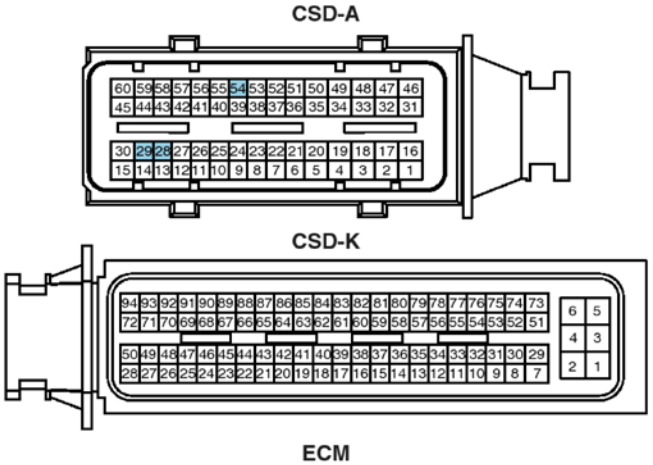


[CONNECTION INFORMATION]

Terminal	Connected to	Function
1	ECM CSD-A (54)	Sensor Power (+5V)
2	ECM CSD-A (28)	CMPS Signal
3	ECM CSD-A (29)	Sensor Ground

[HARNESS CONNECTOR]

CSD92
CMPS



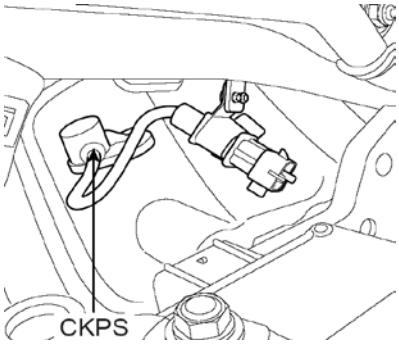
Crankshaft Position Sensor (CKPS)

Function And Operation Principle

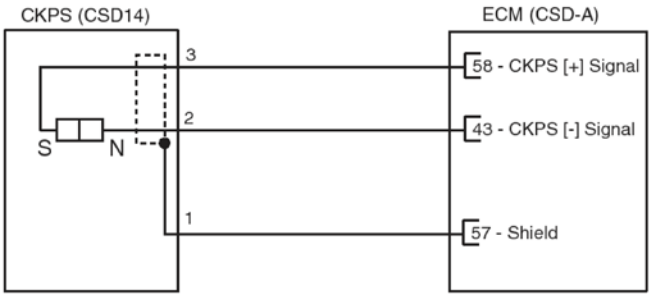
The Crankshaft Position Sensor (CKPS) is installed on the flywheel housing and detects the crankshaft position. By using this signal, the ECM can calculate the piston position of each cylinder and the engine speed for sequential injection.

Specification

Items	Specification
Coil Resistance (Ω)	774 ~ 946Ω [20℃(68°F)]
Air Gap (mm)	0.5 ~ 1.5



[CIRCUIT DIAGRAM]

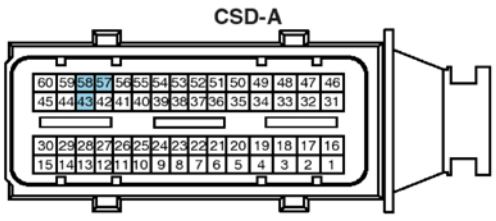


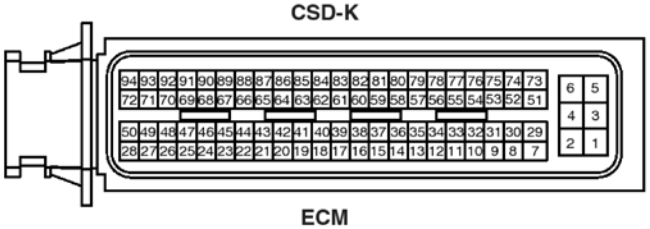
[CONNECTION INFORMATION]

Terminal	Connected to	Function
1	ECM CSD-A (57)	Sensor Shield
2	ECM CSD-A (43)	CKPS [-] Signal
3	ECM CSD-A (58)	CKPS [+] Signal

[HARNESS CONNECTOR]

CSD14
CKPS





ECM

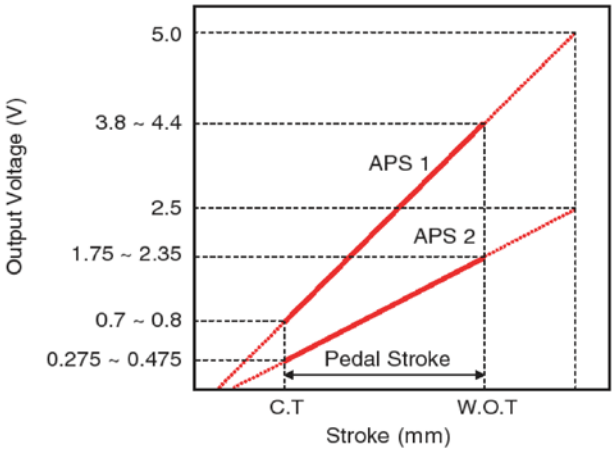
Accelerator Position Sensor (APS)

Function And Operation Principle

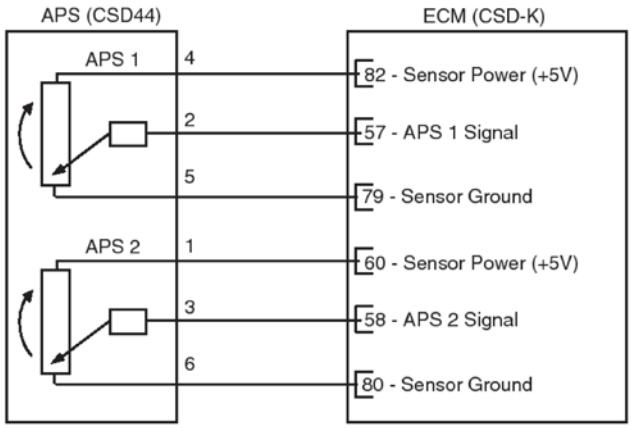
The Accelerator Pedal Position Sensor (APS) is installed on the accelerator pedal assembly and consists of the two potentiometers which have independent circuit (power, signal output, and ground) individually. This system makes the ECM recognize the driver's intention even if one sensor is broken. Also the ECM can diagnose the sensor by comparing the two sensor's signal..

Specification

Pedal Position	Output Voltage(V) [Vref = 5.0V]	
	APS1	APS2
Released	0.7 ~ 0.8	0.275 ~ 0.475
Fully depressed	3.8 ~ 4.4	1.75 ~ 2.35



[CIRCUIT DIAGRAM]



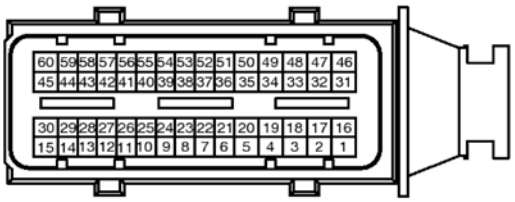
[CONNECTION INFORMATION]

Terminal	Connected to	Function
1	ECM CSD-K (60)	APS 2 Sensor Power (+5V)
2	ECM CSD-K (57)	APS 1 Signal
3	ECM CSD-K (58)	APS 2 Signal
4	ECM CSD-K (82)	APS 1 Sensor Power (+5V)
5	ECM CSD-K (79)	APS 1 Sensor Ground
6	ECM CSD-K (80)	APS 2 Sensor Ground

[HARNESS CONNECTOR]

CSD44
APS

CSD-A



CSD-K

ECM

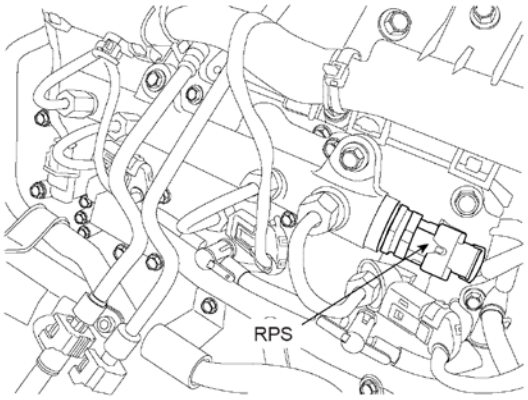
Rail Pressure Sensor (RPS)

Function And Operation Principle

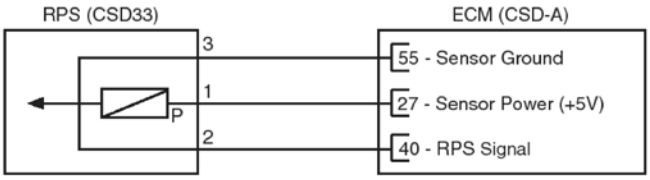
The Rail Pressure Sensor (RPS) is installed at the end of the common rail (bank 1) and measures the instantaneous fuel pressure in the common rail. The sensing element (semiconductor device) built in the sensor converts the pressure to voltage signal. By using this signal, the ECM can control correct injection amount and timing. And it adjusts the rail pressure with the rail pressure regulator valve if the target pressure and the actual pressure calculated by the RPS output signal are different.

Specification

Condition	Rail pressure (bar)	Output Voltage (V)
Idle	200 ~ 300	0.9 ~ 1.2
3,000 rpm	450 ~ 650	1.5 ~ 1.9



[CIRCUIT DIAGRAM]

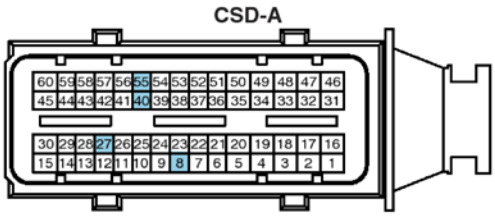


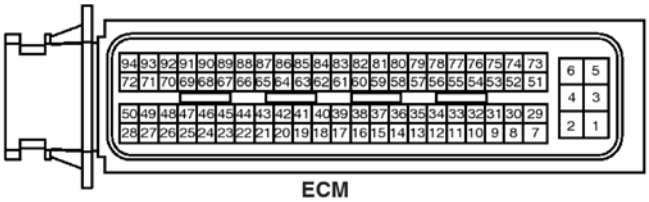
[CONNECTION INFORMATION]

Terminal	Connected to	Function
1	ECM CSD-A (27)	Sensor Power (+5V)
2	ECM CSD-A (40)	RPS Signal
3	ECM CSD-A (55)	Sensor Ground

[HARNESS CONNECTOR]

CSD33
RPS





Fuel Temperature Sensor (FTS)

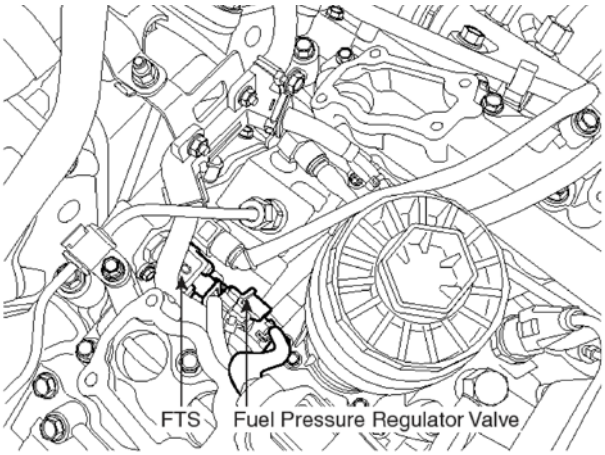
Function And Operation Principle

The Fuel Temperature Sensor (FTS) is installed on the high pressure fuel pump and measures the temperature of the fuel supplied from the fuel tank (via fuel filter). The FTS uses a thermistor which resistance is in inverse proportion to the temperature (NTC: Negative Temperature Coefficient). With this signal, the ECM can adjust the injection amount.

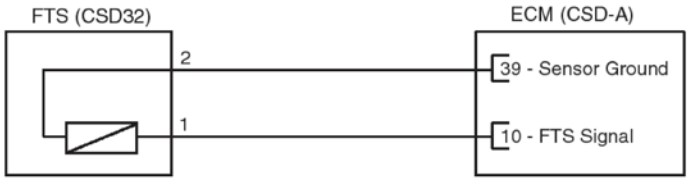
At high temperature, vapor-lock in fuel line or oil membrane destruction may appear. Especially oil membrane destruction deteriorates fuel's lubrication performance and it may damage the high pressure fuel pump and the injector.

Specification

Temperature [℃(°F)]	Resistance(kΩ)
-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]

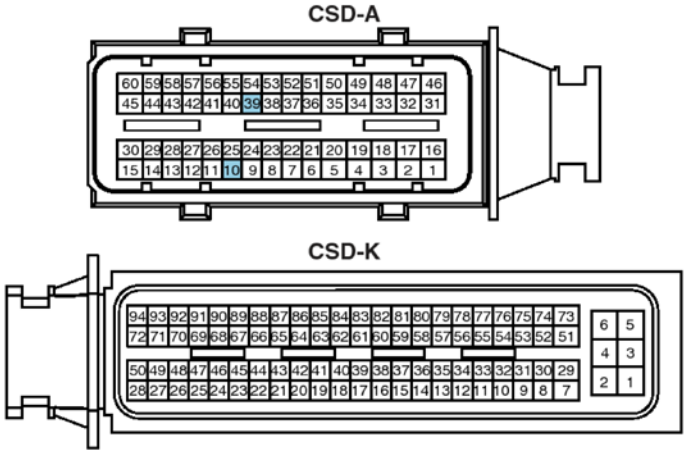


[CONNECTION INFORMATION]

Terminal	Connected to	Function
1	ECM CSD-A (10)	FTS Signal
2	ECM CSD-A (39)	Sensor Ground

[HARNESS CONNECTOR]

CSD32
FTS



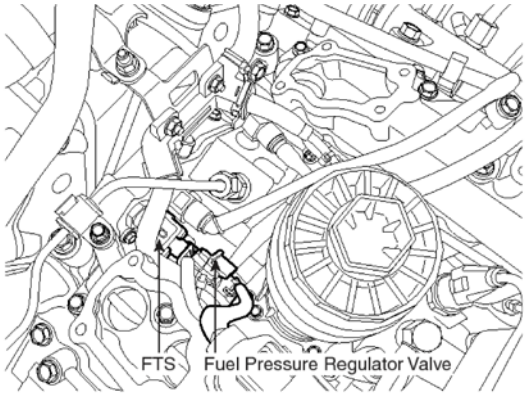
Fuel Pressure Control Valve (High pressure pump side)

Function And Operation Principle

The Fuel Pressure Regulator Valve and the Rail Pressure Regulator Valve are installed on high pressure pump and common rail (bank 2) 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

Item	Specification
Coil Resistance (Ω)	2.9 ~ 3.15Ω [20℃(68°F)]



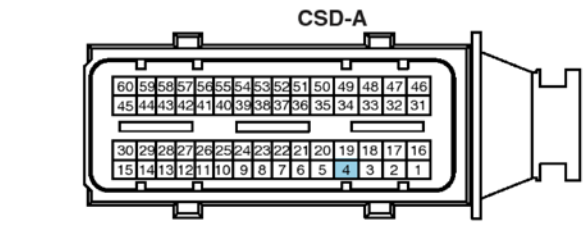
[CIRCUIT DIAGRAM]

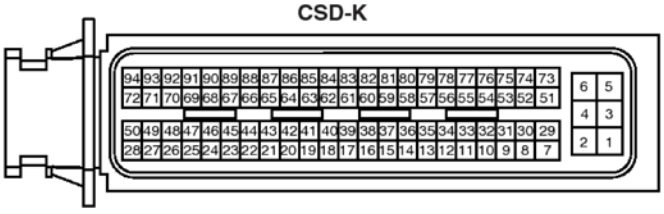
[CONNECTION INFORMATION]

Terminal	Connected to	Function
1	Main Relay	Power Supply (B+)
2	ECM CSD-A (4)	Valve Control

[HARNESS CONNECTOR]

CSD38
FUEL PRESSURE
REGULATOR VALVE





ECM

Rail Pressure Regulator Valve (rail side)

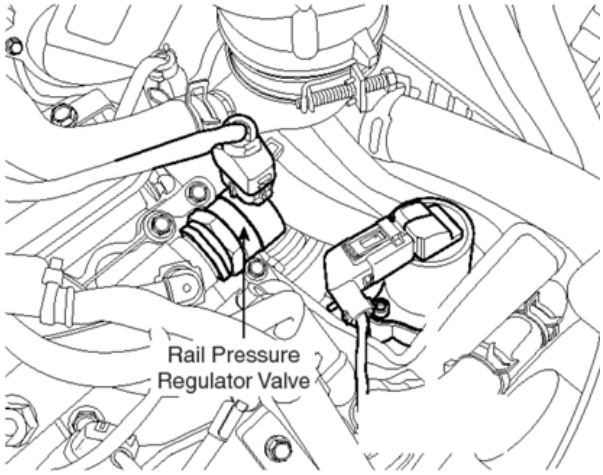
Function And Operation Principle

The Fuel Pressure Regulator Valve and the Rail Pressure Regulator Valve are installed on high pressure pump and common rail (bank 2) 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

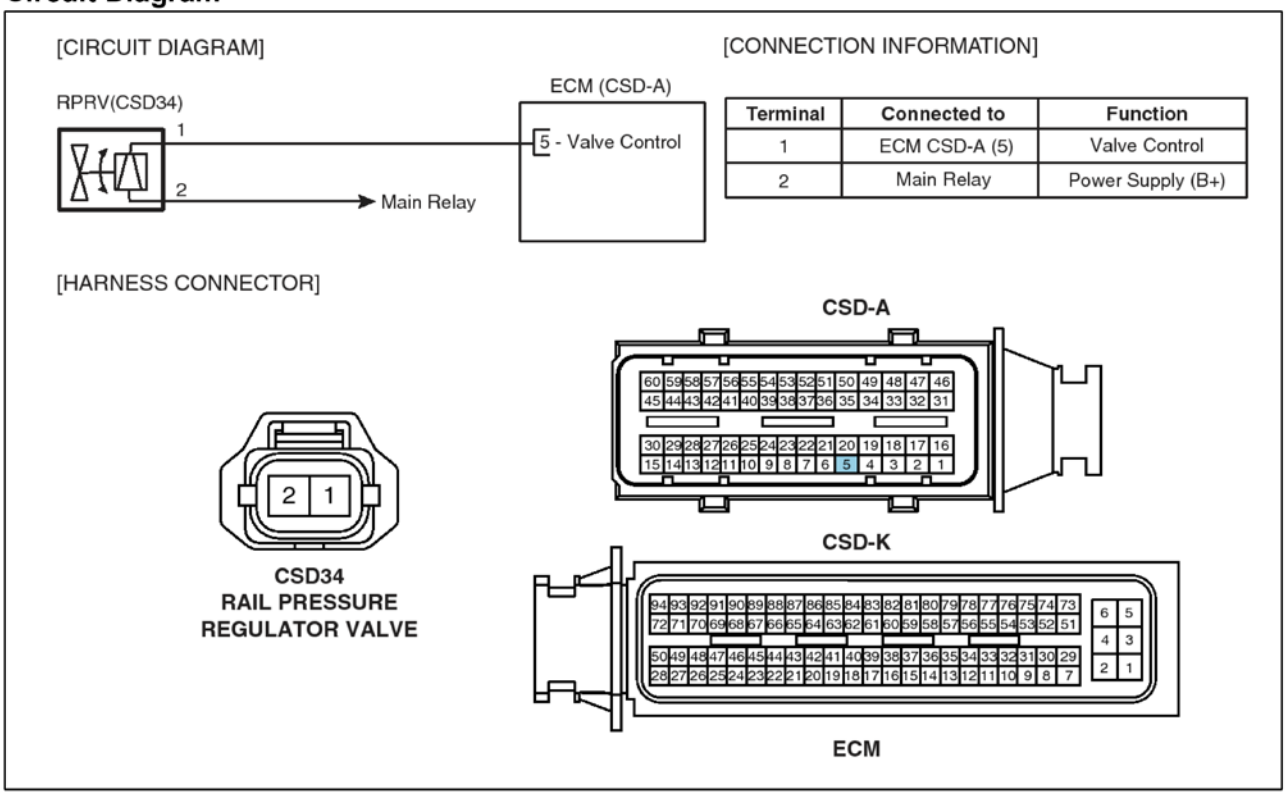
.

Specification

Items	Specification
Coil Resistance (Ω)	3.42 ~ 3.78Ω [20℃(68°F)]
Operating Current (A)	0 ~ 1.7



Circuit Diagram



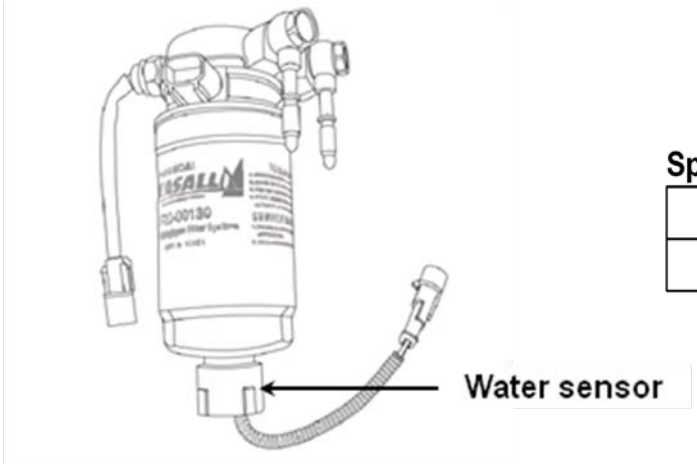
Water Sensor

Function And Operation Principle

The Water Sensor is installed on bottom end of fuel filter and detects presence of water in fuel. When the water amount reaches the predetermined level, the sensor sends the warning signal to the ECM.

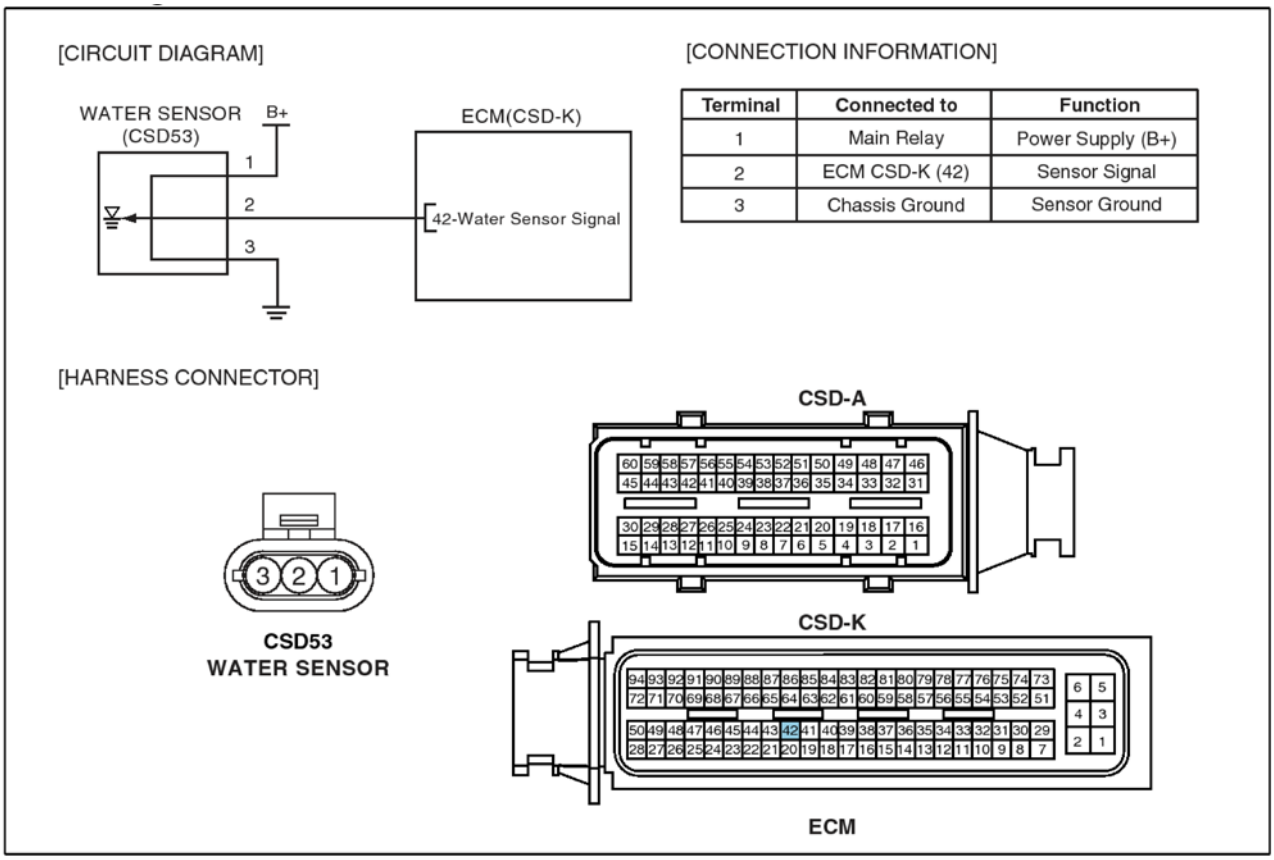
✍ NOTICE

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)	53 ~ 63



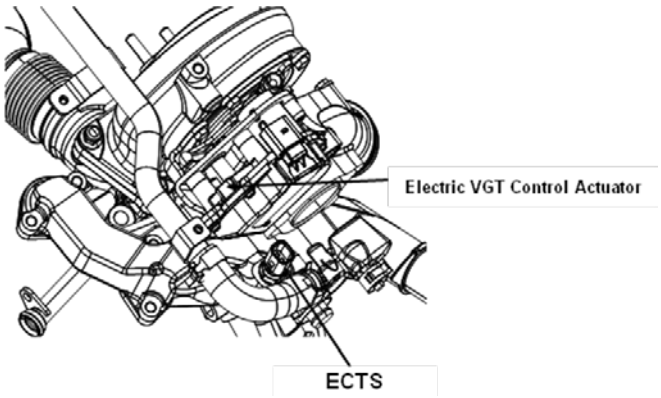
Electric VGT Control Actuator

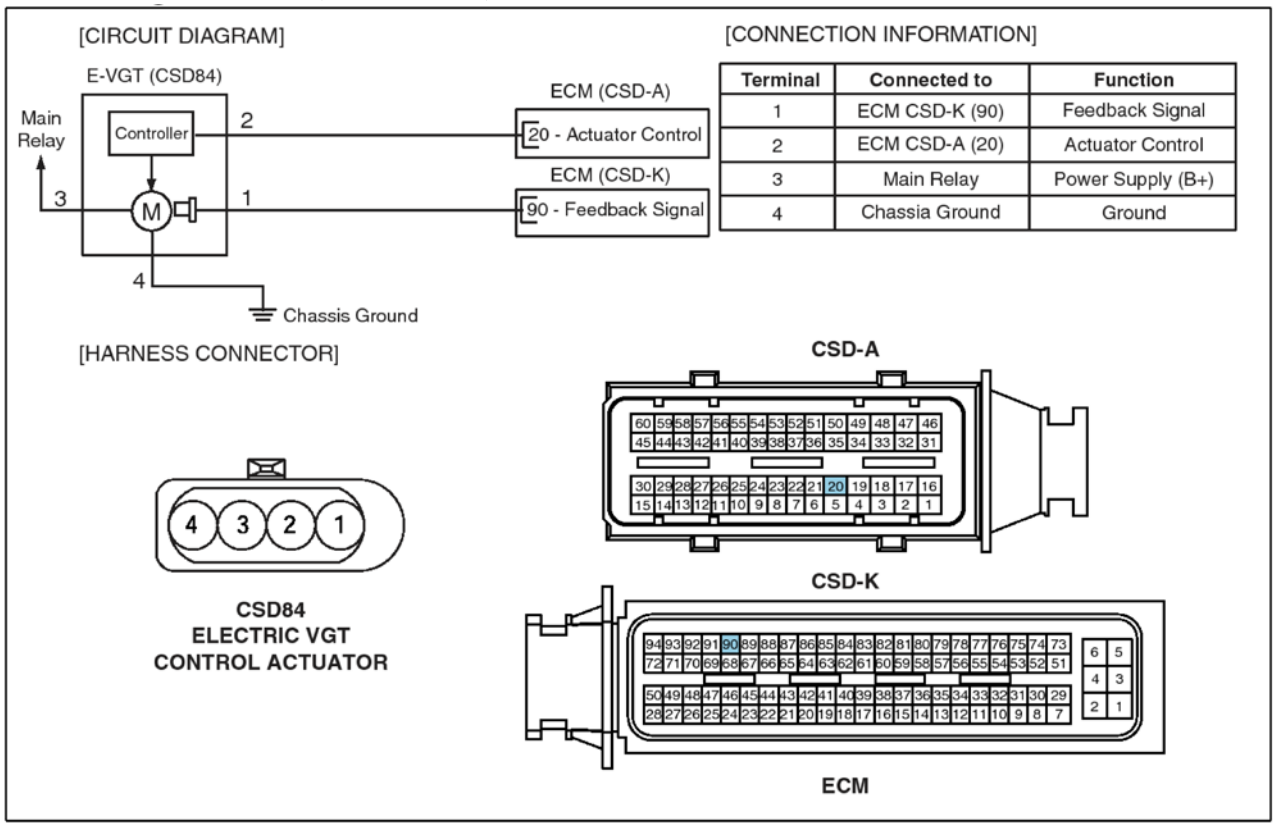
Function And Operation Principle

The Electric VGT Control Actuator is installed on the turbocharger. It operates the vain in the Variable Geometry Turbocharger (VGT) and regulates the compressed air amount by the ECM's PWM signal. This valve consists of a DC motor which actuates the vane, a 2-step gear which increases torque of the DC motor, a position sensor which detects status of the vane, an electric control unit which drives the DC motor, and a reset spring which resets the de-energized vane to its open position.

◉ **CAUTION**

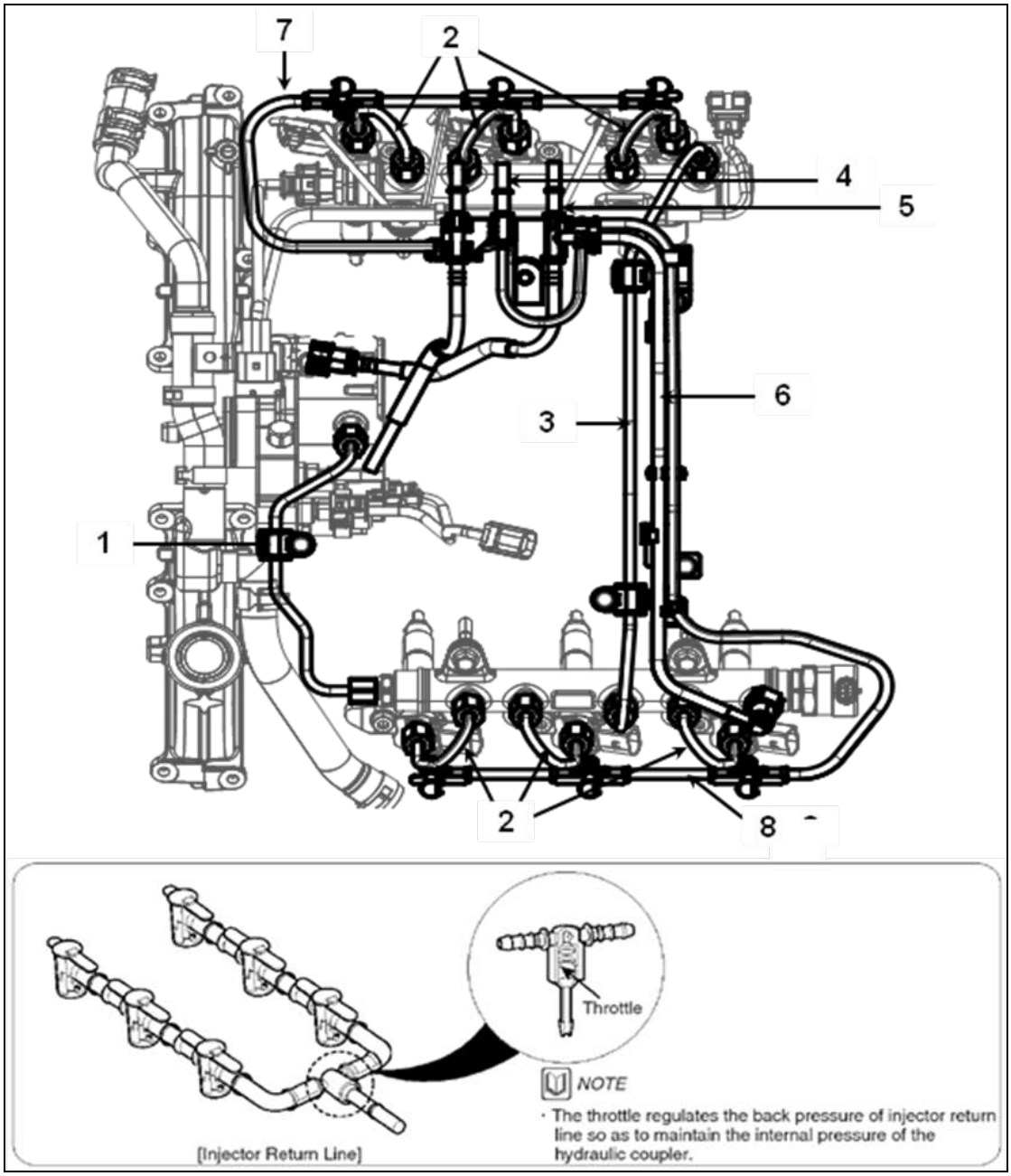
After replacing the Electric VGT Control Actuator, MUST perform the "COMPONENT CHANGE ROUTINE" procedure (Refer to "REPLACEMENT" procedure). Otherwise trouble related with engine performance or emission control may occur until ECM learning about the component is over.





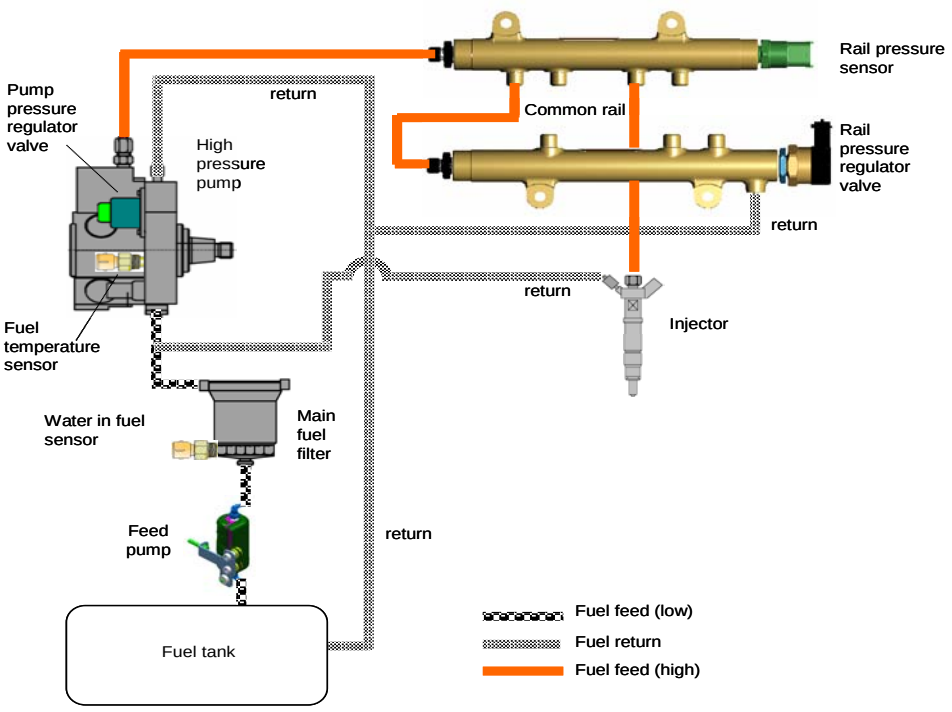
Fuel Delivery System

Fuel Line



1. High Pressure Fuel Pipe (High Pressure Fuel Pump ↔ Common Rail)
2. High Pressure Fuel Pipe (Common Rail ↔ Injector)
3. High Pressure Fuel Pipe (Common Rail ↔ Common Rail)
4. Fuel Feed Tube (Fuel Filter ↔ High Pressure Fuel Pump)
5. Fuel Return Tube (High Pressure Fuel Pump ↔ Fuel Tank)
6. Fuel Return Tube (Common Rail ↔ Fuel Tank)
7. Fuel Return Tube (Injector [Bank 1] ↔ Fuel Filter)
8. Fuel Return Tube (Injector [Bank 2] ↔ Fuel Filter)

Common Rail Fuel Injection System (CRDI)



Low Pressure Fuel Circuit

Low Pressure Fuel Pump

The low pressure fuel pump is either an electric fuel pump with pre-filter, or a gear-type fuel pump. The pump draws the fuel from the fuel tank and continually delivers the required quantity of fuel in the direction of the high pressure fuel pump (via fuel filter).

Fuel Filter

The fuel filter is located in between the low pressure fuel pump and the high pressure fuel pump and filters the fuel delivered from the fuel tank.

High Pressure Fuel Circuit

High Pressure Fuel Pump

The high pressure fuel pump compresses fuel up to 1,600 bar and delivers the compressed fuel to the common rail

Common Rail

The two common rails are installed on bank 1 and 2 and are connected with the high pressure fuel pump and the injectors by the high pressure fuel pipes. This rail stores the fuel compressed in the high pressure fuel pump. So that the two rails have same fuel pressure, the high pressure fuel pipe connects the two rails. The ECM controls the fuel pressure of the common rail by using the rail pressure sensor and the rail pressure regulator valve installed on the common rail (Bank 1) and (Bank 2) respectively.

Injector

The injector injects the high pressure fuel stored in the common rail into the cylinder by the ECM control signal.

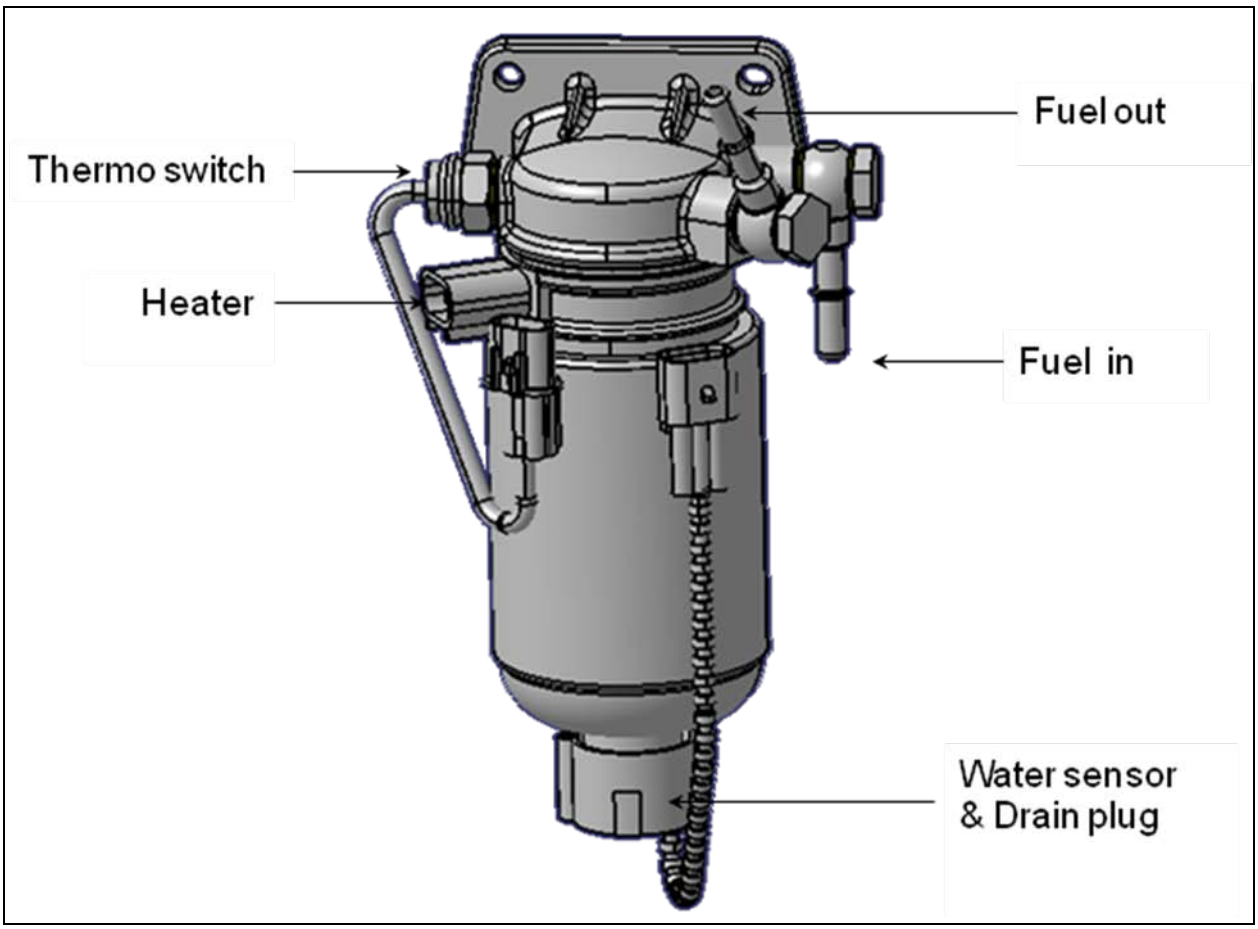
High Pressure Fuel Pump

The high pressure fuel pipe is a channel in high pressure fuel circuit consisting of the high pressure fuel pump, common rails, and injectors. It is a steel tube which can withstand high frequency generated when the fuel pressure reaches the maximum pressure or fuel injection stops.

The differences in length between the common rail and the individual injectors are compensated for by using slight or pronounced bends in the individual lengths of tubing. Nevertheless, the injection lines should be kept as short as possible.

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

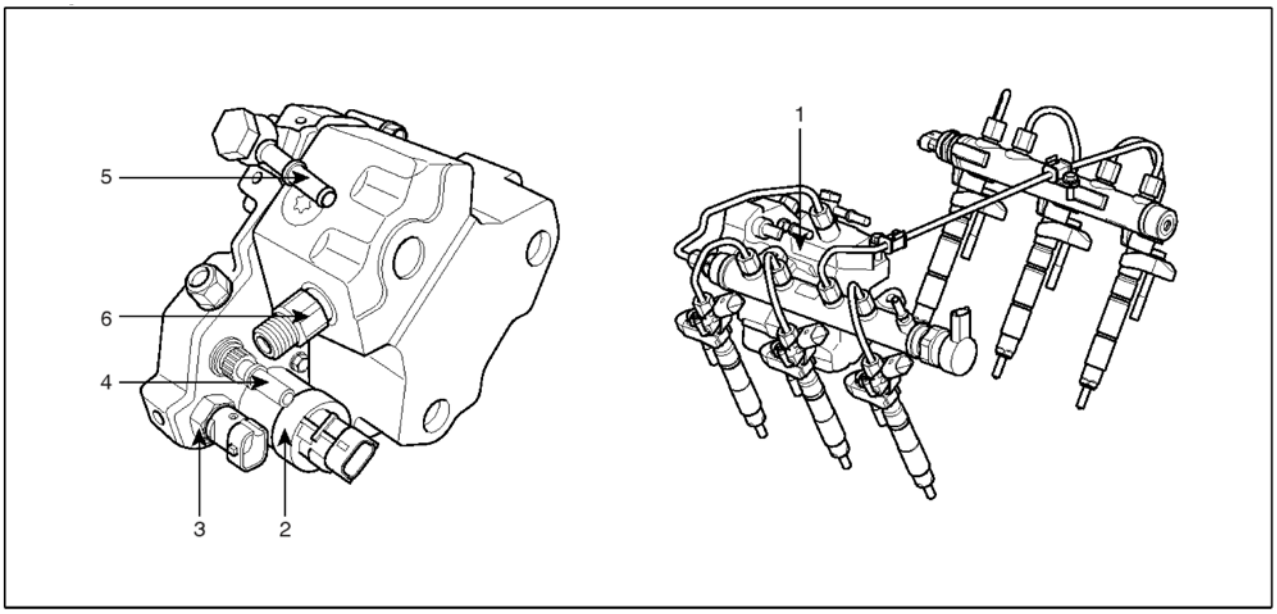
5. Unscrew the fuel filter bracket installation nuts and then remove the fuel filter from the engine. .

Installation

1. Installation is reverse of removal .

High Pressure Pump

Component



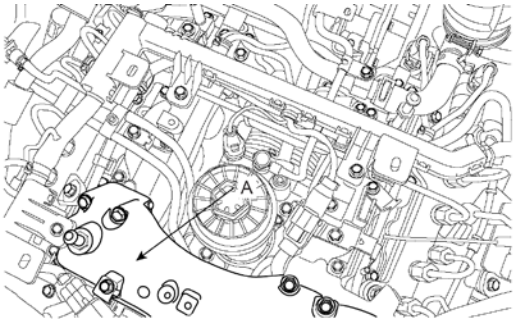
SENFL9157L

1. High Pressure Fuel Pump
2. Fuel Pressure Regulator Valve
3. Fuel Temperature Sensor (FTS)
4. Nipple - Fuel Inlet (↔ Fuel Filter)
5. Nipple - Fuel Return (↔ Fuel Tank)
6. Nipple - Fuel Outlet (↔ Common Rail)

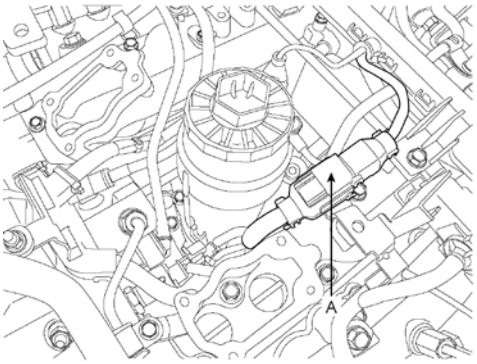
Removal

1. Turn ignition switch OFF and disconnect the negative (-) battery cable.
2. Remove the inlet upper manifold assembly (A).

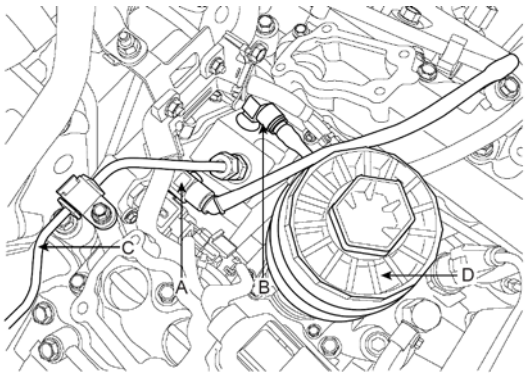
.



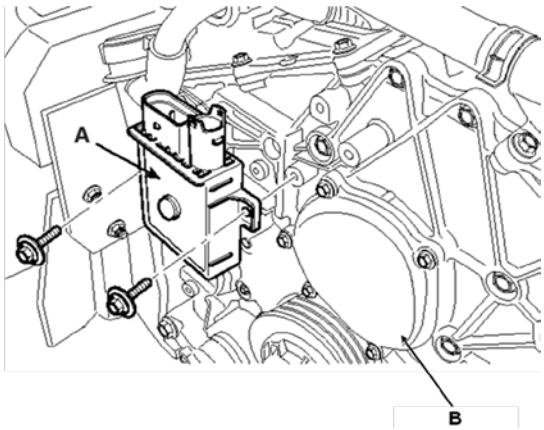
3. Disconnect the fuel pressure regulator valve & fuel temperature sensor connector (A). .



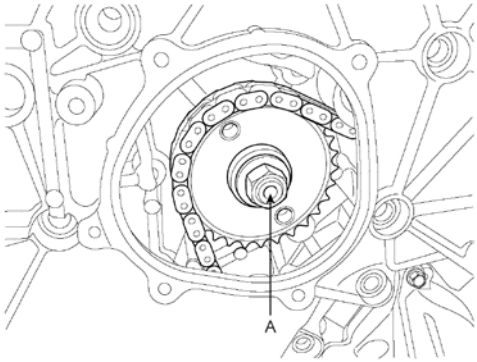
4. Disconnect the fuel inlet tube quick-connector (A) and the fuel return tube quick-connector (B).



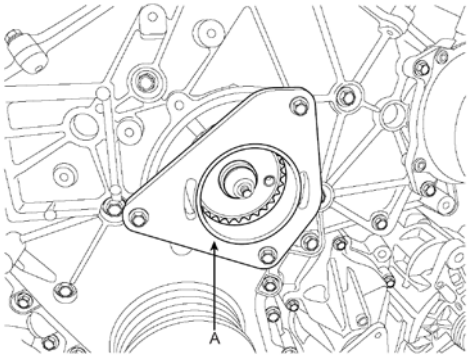
5. Remove the high pressure fuel pipe (C).
6. Remove the engine oil filter (D)
7. Unscrew the three high pressure fuel pump mounting bolts.
8. Remove the glow control module (A) .
9. Remove the service cover (B).



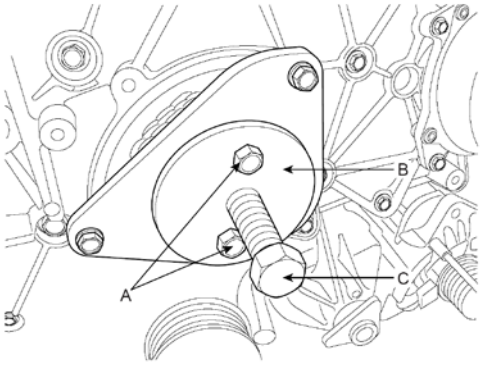
10. Remove the sprocket tightening nut (A).



11. Install the fixing plate (A) [SST No.: 00200-0T016] on the timing case. .



12. Install the supporter (B) [SST No.: 00200-0T016] on the sprocket with the bolts (A) [SST No.: 00200-0T016]. .



13. Push the pump shaft from the sprocket with rotating the main bolt (C) [SST No.: 00200-0T016] clockwise, and then remove the high pressure fuel pump from the engine. .

Installation

1 . Installation is reverse of removal.

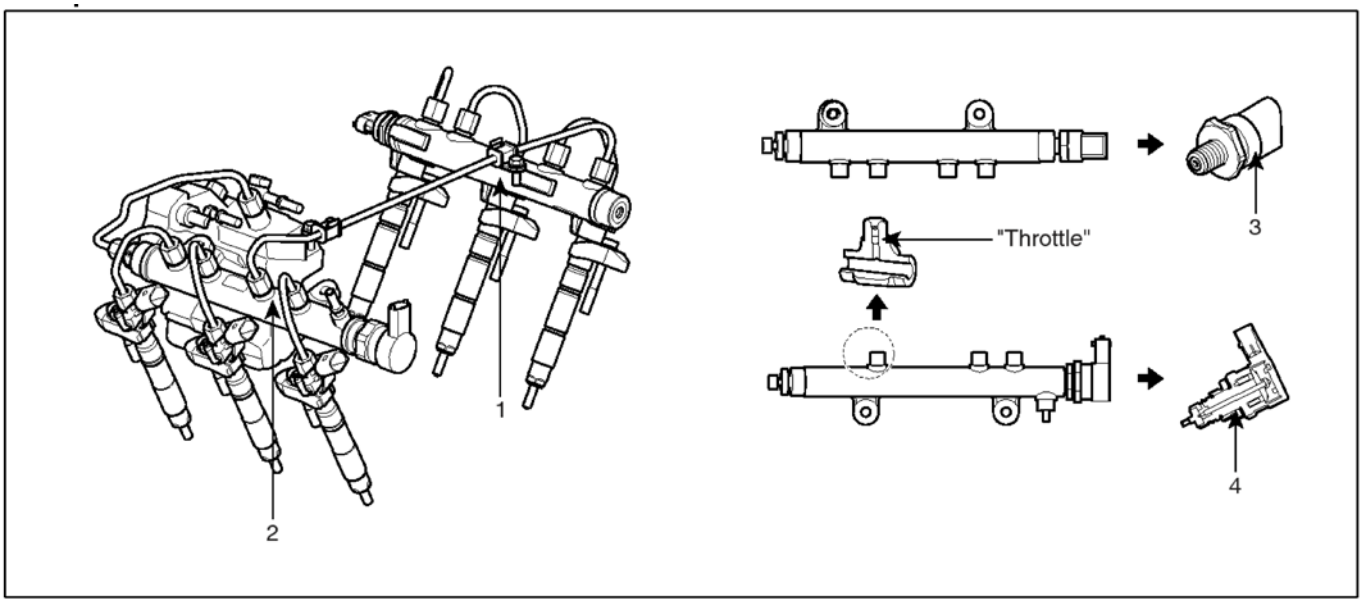
NOTICE

When installing the high pressure fuel pipe, apply the specified tightening torques with the special service tool [SST No.: 00200-0T015].

High pressure fuel pump installation bolts:
19.6 ~ 26.5 N.m (2.0 ~2.7 kgf.m, 14.5 ~ 19.5 lb-ft)
High pressure fuel pipe installation nut:
24.5 ~ 28.4 N.m (2.5 ~2.9 kgf.m, 18.1 ~ 21.0 lb-ft)

Common Rail

Component



SENFL7158L

1. Common Rail (Bank 1)
2. Common Rail (Bank 2)
3. Rail Pressure Sensor (RPS)
4. Rail Pressure Regulator Valve

Removal

WARNING

As the Piezo-Injector operates under maximum DC 200V, there may be a risk of an electric shock caused by shorted control line etc. So when repairing the injector or its wiring, disconnect the battery negative (-) terminal from the battery and wait for about 30 seconds.

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.

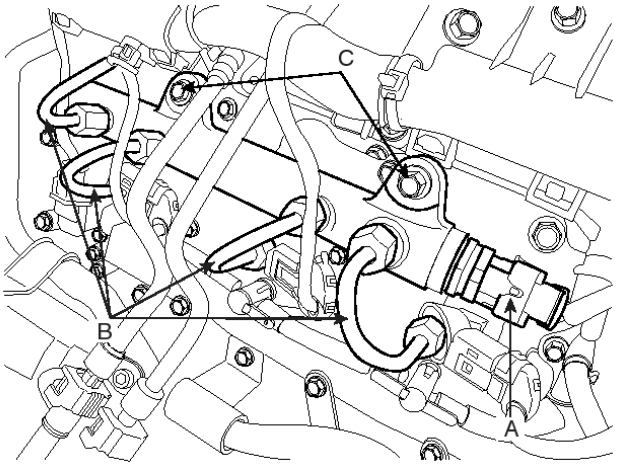
▪ *When installing High Pressure Fuel Pipe*

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

-Install the flange nut correctly.

[Common Rail (Bank 1)]

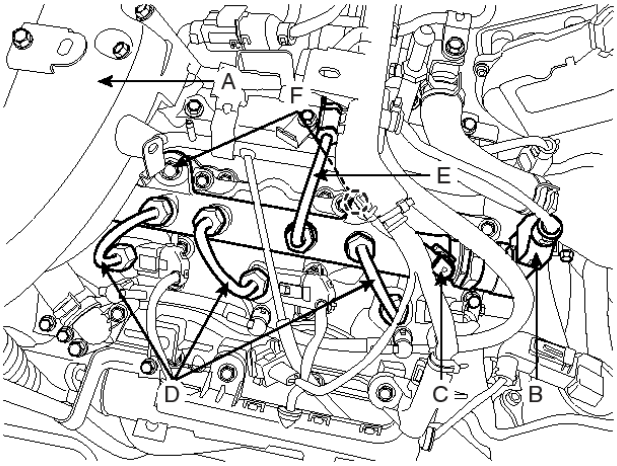
1. Turn ignition switch OFF and disconnect the negative (-) battery cable.
2. Disconnect the rail pressure sensor connector (A).



3. Remove the high pressure fuel pipes (B).
4. Unscrew the mounting bolts (C), and then remove the common rail from the engine.

[Common Rail (Bank 2)]

1. Turn ignition switch OFF and disconnect the negative (-) battery cable.
2. Remove the inlet upper manifold assembly (A).



3. Disconnect the rail pressure regulator valve connector (B).
4. Disconnect the fuel return tube quick-connector (C).
5. Remove the high pressure fuel pipes (D,E).
6. Unscrew the mounting bolts (F), and then remove the common rail from the engine.

Installation

1. Installation is reverse of removal.

✍ NOTICE

1.When installing the high pressure fuel pipe, apply the specified tightening torques with the special service tool [SST No.: 09314-3A000].

2.When installing the high pressure fuel pipe connecting the common rail and injector, follow the below procedure.

1) *Temporarily install the nut on common rail.*
2) *Temporarily install the nut on injector.*
3) *Install the injector side nut.*
4) *Install the common rail side nut.*

Common rail installation bolts:

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

High pressure fuel pipe installation nut:

24.5 ~ 28.4 N.m (2.5 ~ 2.9 kgf.m, 18.1 ~ 21.0 lb-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
69	P0606	ECM/PCM Processor

NO	P code	DESCRIPTION
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
104	P1653	After-Run Check Error
105	P1655	Tacho Output Fault

NO	P code	DESCRIPTION
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 CAUSE(S)
						FUEL CUT OFF	*RPM LIMITATION (Recreation / Commercial)	CHECK LAMP	BUZZER	DEFAULT		
VGT variable geometry turbocharger	P2263	Overheat, Overload, Learning Error, Feedbk Line Error	2500 ms	2500 ms	Engine Running		● & (3000 / 2400 rpm)	●	●		• Engine Warm Up • Vgt Actuator Duty - Fulload Load :25~35% - Idle : 80% • Boost Pressure - 2400~2550Hpa	• Overload, EVGT Cooling Circuit • VGT Actuator Adaption Error • VGT Actuator Performance Error
	P2563	Pw m Failure	2500 ms	2500 ms								
	P0048	Short Circuit Battery	1000 ms	1000 ms	Ig Key On		● & (3000 / 2400 rpm)	●	●			• VGT Actuator Circuit • VGT Actuator
	P0047	Short Circuit Ground	1000 ms	1000 ms								
		No Load	1000 ms	1000 ms								
	P0234	Negative Governor Deviation Below Limit	5000 ms	No Healing	Engine Running		● & (3000 / 2400 rpm)	●	●			• VGT Actuator Performance Error
	P0299	Positive Governor Deviation Above Limit	5000 ms									• Air Leakage Check • Intercooler • VGT Actuator Performance Error
GCU glow control unit	P0670	No Main Supply	1000 ms	1000 ms	Ig Key On							• GCU Circuit
	P0683	Can Message Error	1000 ms	1000 ms								• GCU • CAN Communication Error
	P0671~6	Glow Plug 1/…/6 Error Per Cyl	1000 ms	1000 ms								
APS1 accel.position sensor1	P2138	Plausibility With Aps2 Violated	240ms	100ms	Ig Key On		● & 1250 rpm fixed	●	●	0%	•|APS1-2*APS2| < 405mv	• APS1/2 Sensor Circuit • APS Sensor • ECM
	P2127	Voltage Above Low er Limit	2000 ms	1010 ms							• Idle(Lever Not Activated) Aps1 : 700~800Mv Aps2 : 275~475Mv • Full(Lever Full Activated) Aps1 : 3800~4400Mv Aps2 : 1750~2350Mv • Sensor Pow er 4700~5158Mv	
	P2123	Voltage Above Upper Limit	180 ms	100 ms								
	P0643	Supply Voltage Above Upper Limit	100 ms	100 ms								
	P0642	Supply Voltage Below Low er Limit	100 ms	100 ms								
APS2 accel.position sensor2	P2128	Voltage Above Upper Limit	180 ms	100 ms								
	P0653	Supply Voltage Above Upper Limit	100 ms	100 ms								
	P0652	Supply Voltage Below Low er Limit	100 ms	100 ms								
APS atmosphere pressure sensor	P0108	Voltage Above Upper Limit	800 ms	500 ms	Ig Key On					1000 hPa		• ECM
	P0107	Voltage Below Low er Limit	800 ms	500 ms								
BAT battery	P0563	Voltage Above Upper Limit	5000ms	100 ms	Ig Key On					7.9V	• above 2000 RPM 10.5V~14.5V	• Charging Circuit • Alternator • Battery
	P0562	Voltage Below Low er Limit	5000ms	100ms								

ITEMS	DTC	DESCRIPTION	DETECTION	HEALING	CONDITION	FAIL SAFETY					NORMAL VALUES	EXPECTATION CAUSE(S)
						FUEL CUT OFF	*RPM LIMITATION	CHECK LAMP	BUZZER	DEFAULT		
IQA injector quantity adjustment	P1670	Read Or Write Error	Promptly	Promptly	Ig Key On							• Iqa Code Input Error
	P1671	Ima Checksum Not Valid	Promptly	Promptly								
CMPS camshaft position sensor	P0340	No Camshaft Signal	CKPS 8 revolution	Promptly	Engine Running	● (at starting)	● & (3300 / 2700 rpm) (after starting)	●	●		• Signal Change / 2rev.	• CMPS Circuit • CMPS
	P0341	Wrong Camshaft Signal	Promptly	Promptly								
CKPS crankshaft position sensor	P0335	No Crankshaft Signal (Engine Running)	CMPS 4 revolution	Promptly	Engine Running	●		●	●		• 60-2 Tooth / 1rev.	• Ckps Circuit • Ckps • Target Wheel Check
	P0336	Wrong Crankshaft Signal (Restart)	Promptly	Promptly								
FTS fuel temperature sensor	P0183	Voltage Above Upper Limit	2000 ms	500 ms	Ig Key On					40℃		• FTS Circuit • FTS
	P0182	Voltage Below Lower Limit	2000 ms	500 ms								
Water detection in fuel	P2264	Water In Fuel Is Detected	4000 ms	Promptly	Engine Running		● & (3300 / 2700 rpm)	●	●			• Water In Fuel, Fuel Filter (Drain Out Water And Check The Fuel In Fuel Tank) • Warning Lamp Circuit • Water Detection Sensor Error
ECM H/W engine control module hardware	P0602	Communication - Spi	Promptly	No Healing	Engine Running	●						• ECM
		Recovery Locked										
		Recovery Suppresed										
		Recovery Visible										
		Tpu Monitoring										
		Watch Dog Monitoring										
		Ems Internal Processor Supervision Fault										
	P0606	Adc Error										
	P0605	Eeprom										
IATS induction air temperature sensor	P0098	Voltage Above Upper Limit	2000 ms	500 ms	IG ON					45℃		• IATS • IATS Circuit
	P0097	Voltage Below Lower Limit	2000 ms	500 ms								
EATS environment air temperature sensor	P0113	Voltage Above Upper Limit	1000 ms	500 ms	IG ON					25℃		• EATS • EATS Circuit
	P0112	Voltage Below Lower Limit	1000 ms	500 ms								

ITEMS	DTC	DESCRIPTION	DETECTION	HEALING	CONDITION	FAIL SAFETY					NORMAL VALUES	EXPECTATION CAUSE(S)
						FUEL CUT OFF	*RPM LIMITATION	CHECK LAMP	BUZZER	DEFAULT		
Cylinder1 injector	P0201	Open Load	Promptly	Promptly	Engine Running		● & (3000 / 2400 rpm)	●	●			• Injector Circuit • Injector
	P0261	Short Circuit Ground	Promptly	Promptly		●						
	P0262	Short Circuit Battery	Promptly	Promptly								
	P0263	Defect Resistance Cylinder1, Charging/Discharging Energy Error	Promptly	Promptly								
Cylinder2 injector	P0202	Open Load	Promptly	Promptly	Engine Running		● & (3000 / 2400 rpm)	●	●			• Injector Circuit • Injector
	P0264	Short Circuit Ground	Promptly	Promptly		●						
	P0265	Short Circuit Battery	Promptly	Promptly								
	P0266	Defect Resistance Cylinder2, Charging/Discharging Energy Error	Promptly	Promptly								
Cylinder3 injector	P0203	Open Load	Promptly	Promptly	Engine Running		● & (3000 / 2400 rpm)	●	●			• Injector Circuit • Injector
	P0267	Short Circuit Ground	Promptly	Promptly		●						
	P0268	Short Circuit Battery	Promptly	Promptly								
	P0269	Defect Resistance Cylinder3, Charging/Discharging Energy Error	Promptly	Promptly								
Cylinder4injector	P0204	Open Load	Promptly	Promptly	Engine Running		● & (3000 / 2400 rpm)	●	●			• Injector Circuit • Injector
	P0270	Short Circuit Ground	Promptly	Promptly		●						
	P0271	Short Circuit Battery	Promptly	Promptly								
	P0272	Defect Resistance Cylinder4, Charging/Discharging Energy Error	Promptly	Promptly								
Cylinder5 injector	P0205	Open Load	Promptly	Promptly	Engine Running		● & (3000 / 2400 rpm)	●	●			• Injector Circuit • Injector
	P0273	Short Circuit Ground	Promptly	Promptly		●						
	P0274	Short Circuit Battery	Promptly	Promptly								
	P0275	Defect Resistance Cylinder5, Charging/Discharging Energy Error	Promptly	Promptly								
Cylinder6 injector	P0206	Open Load	Promptly	Promptly	Engine Running		● & (3000 / 2400 rpm)	●	●			• Injector Circuit • Injector
	P0276	Short Circuit Ground	Promptly	Promptly		●						
	P0277	Short Circuit Battery	Promptly	Promptly								
	P0278	Defect Resistance Cylinder6, Charging/Discharging Energy Error	Promptly	Promptly								

ITEMS	DTC	DESCRIPTION	DETECTION	HEALING	CONDITION	FAIL SAFETY: FUEL CUT OFF	FAIL SAFETY: *RPM LIMITATION	FAIL SAFETY: CHECK LAMP	FAIL SAFETY: BUZZER	FAIL SAFETY: DEFAULT	NORMAL VALUES	EXPECTATION CAUSE(S)
injector Bank Error	P062D	Bank 1 Error	Promptly	Promptly	Engine Running	●		●	●			• Charging System (battery, alternator Check) • ECM
	P062E	Bank 2 Error	Promptly	Promptly								
Injector Circuit	P0611	Error Path For Short-Circuit Of Charging Switch Is Detected	Promptly	Promptly	Engine Running	●		●	●			• Injector Circuit • ECM
	P0200	Injector Circuit Error	Promptly	Promptly	Ig Key On							
Check engine lamp	P0650	Short Circuit Battery	2000ms	1000ms	Engine Running						• KEY ON & engine stop allways ON • after Engine Running ON if system Error hAPSen	• Lamp Circuit • EOI Circuit
		Short Circuit Ground	2000ms	1000ms								
		No Load	2000ms	1000ms								
Main relay	P0685	Main Relay Dose Not Open In Time	Promptly	Promptly	Engine Running							• 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		● & (3300 / 2700 rpm)	●	●	360bar	• Warm Up Idle rail pressure : 25 ± 5 Mpa	• PRS Circuit • PRS • APS 2 Power Supply Circuit • BPS Power Supply Circuit • ECM
	P0192	Voltage Below Lower Limit	200 ms	480 ms								
	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	No Healing	Engine Running		● & (3000 / 2400 rpm)	●	●		• Warm Up Idle rail pressure : 25 ± 5 Mpa PRV Duty : 25 ± 5% PPRV Duty : 40 ± 5%	• Fuel Filter • RPS Check • P-PRV , PRV Check(stuck)
	P0088	Maximum Negative Deviation Of Rail Pressure Exceeded	2000 ms									
	P1171	Minimum Rail Pressure Exceeded	400 ms			●						
	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℃		• ECTS Circuit • ECTS
	P0117	Voltage Below Lower Limit	2000 ms	480 ms			●					
	P0116	Dynamic Plausibility Error	on condition	on condition								
BPS boost pressure sensor	P0238	Voltage Above Upper Limit	2000 ms	1000 ms	Ig Key On		● & (3300 / 2700 rpm)	●	●	980hPa		• BPS Circuit • BPS • RPS Power Supply Circuit • APS 2 Power Supply Circuit • ECM
	P0237	Voltage Below Lower Limit	2000 ms	1000 ms								
	P0069	Not Plausible With Atmospheric Pressure Sensor	3000 ms	500 ms	Ig Key On / Afterrun							
	P0653	Supply Voltage Above Upper Limit	100 ms	100 ms	Ig Key On		● & (3300 / 2700 rpm)	●	●			
	P0652	Supply Voltage Below Lower Limit	100 ms	100 ms								

ITEMS	DTC	DESCRIPTION	DETECTION	HEALING	CONDITION	FAIL SAFETY					NORMAL VALUES	EXPECTATION CAUSE(S)
						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
P-PRV pump-pressure regulator valve	P0254	Short Circuit To Battery Of Metering Unit Output	220 ms	1000 ms	Ig Key On		● & (3000 / 2400 rpm)	●	●			• P-PRV Circuit • P-PRV
	P0253	Short Circuit To Ground Of Metering Unit Output	280 ms	No Healing		●						
		Open Load Of Metering Unit Output	220 ms	500 ms			● & (3000 / 2400 rpm)					
	P0252	Powerstage Error	220 ms	500 ms								
PRV pressure regulator valve	P0092	Short Circuit To Battery Of Pressure Control Valve Output	140 ms	No Healing	Ig Key On	●		●	●			• PRV Crcuit • PRV
	P0091	Short Circuit To Ground Of Pressure Control Valve Output	110 ms									
		Open Load Of Pressure Control Valve Output	140 ms									
	P0089	Powerstage Error	220 ms									
CAN controller area network	U0001	Bus Off In Can	190 ms	100 ms	Ig Key On							• CAN Communication Circuit • CAN Module Error(ECM-GCU)
	U0106	Error Path For Gpc1 Message Timeout Error	500 ms	500 ms								

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