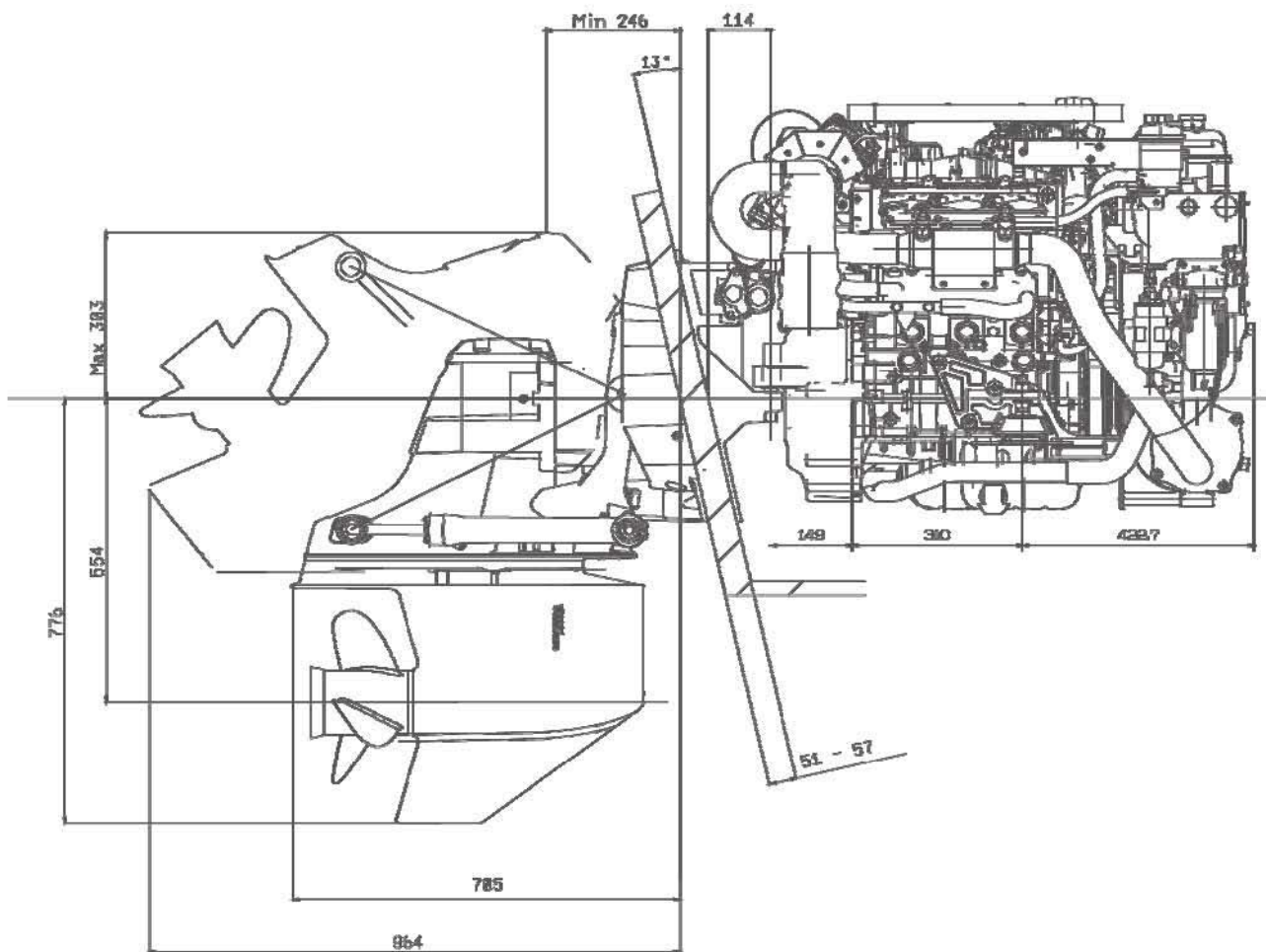




powering **marine** safety

WORKSHOP MANUAL for **S2 Engine Series**



Applicable to S270S, S270P, S270J model

Engine Mechanical System

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General Information

Specifications

Description		Specifications	Limit
General			
Type		V-type, DOHC	
Number of cylinders		6	
Bore		84.0mm (3.3071in)	
Stroke		89.0mm (3.5039in)	
Total displacement		2,959cc	
Compression ratio		17.3± 0.5 : 1	
Firing order		1-2-3-4-5-6	
Valve timing			
Intake valve	Opens (BTDC)	BTDC 13°	
	Closes (ATDC)	ABDC 34°	
Exhaust valve	Opens (BTDC)	BBDC 55°	
	Closes (ATDC)	ATDC 15°	
Cylinder head			
Flatness of cylinder head gasket surface		0.05mm (0.0020in) 0.03mm (0.0012in) -100mm x 100mm 0.01mm (0.004in) -20mm x 20mm	
Flatness of manifold gasket surface	Intake	0.016mm (0.0006in) 0.013mm (0.0005in) -25mm x25mm	
	Exhaust	0.016mm (0.0006in) 0.013mm (0.0005in) -25mm x25mm	
Camshaft			
Cam height Journal outer diameter	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 ~ 24.960 mm (0.9822 ~0.9827 in)
		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)	

Description		Specifications	Limit
Valve			
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 width	Intake	1.39 ~ 1.43mm (0.0547 ~ 0.0563 in)	
	Exhaust	1.39 ~ 1.47mm (0.0547 ~ 0.0563 in)	
Piston			
Piston outer diameter		83.926 ~83.956mm (3.3042 ~ 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)	

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		31.004~31.011mm (1.2206 ~1.2209in)	
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		0.029~0.062mm (0.0011 ~ 0.0023in)	
Side clearance between connecting rod and piston		0.007~0.024mm (0.0003~0.009in)	
Crankshaft			
Main journal outer diameter		75.982 ~76.000mm (2.9914 ~ 2.9921in)	
Pin journal outer diameter		63.482 ~63.500mm (2.4992 ~ 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)		7.7L (8.13 US qt, 6.99 Imp qt)	When replacing a short engine or a block assembly
Oil quantity (Excluding oil filter)		6.2L (6.55US qt, 5.63 Imp qt)	When replacing an oil pan only
Oil quantity (Drain and refill including oil filter)		7.2L (7.60 US qt, 6.53 Imp qt)	

Description		Specifications	Limit
Oil quality	ACEA	C3	Service oil quality should confirm to ACEA or API classification
	API	Above CH-4	
	SAE	15W-40	-15°C above
		10W-30	-20°C ~ 40°C
		5W-30	-25°C ~ 40°C
	0W-30	10°C below	
Oil pressure (at idle)		0.8kg/cm ² (7.85kPa, 1.14psi)	
Cooling system			
Cooling method		Forced circulation with sea water pump	
Coolant quantity		9.8~11.5L (10.35~12.15US qt, 8.89~10.44Imp qt)	
Thermostat	Type	Wax pellet type	
	Opening temperature	88±2°C(186.0~194.0°F) (Lift : 0.35mm(0.0138in.))	
	Full opening temperature	100°C (212°F) (Lift : 10mm(0.3939in) or more)	
Turbocharger			
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	117.6~137.2	12.0~14.0	86.79~101.3
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 position sensor mounting	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
Cylinder head bolt	56.8 + 88°~92° +118°~122°	5.8 + 88°~92° +118°~122°	41.95 + 88°~92° +118°~122°

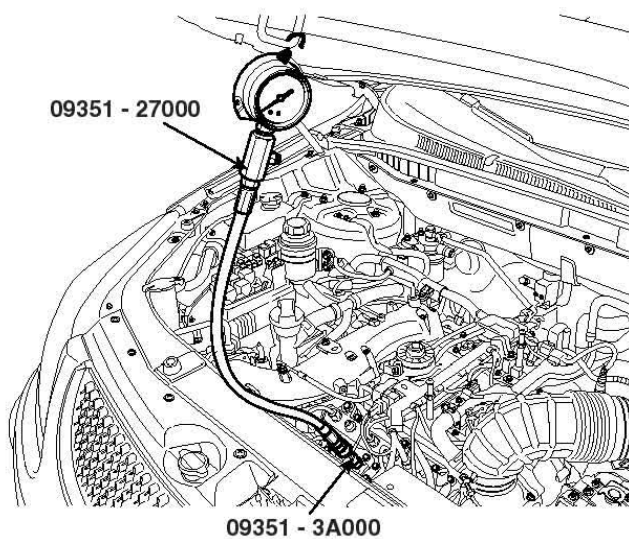
Item	N.m	Kgf.m	Lb.ft
Cooling system			
Water pump pulley bolt	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Water pump bolt	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Thermostat housing	19.6 ~ 26.5	2.0 ~ 2.7	14.5 ~ 19.5
Water outlet duct bolts	9.8 ~ 11.8	1.0 ~ 1.2	7.2 ~ 8.7
Lubrication system			
Oil pump assembly	19.6 ~ 26.5	2.0 ~ 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 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(09351-27000, 09351-3A000) 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) through 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 :

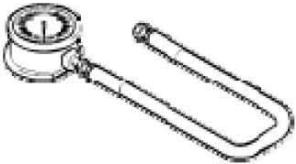
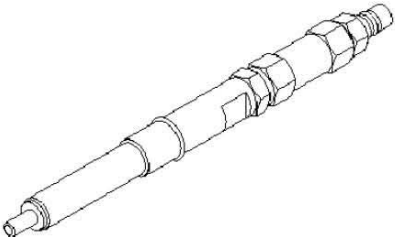
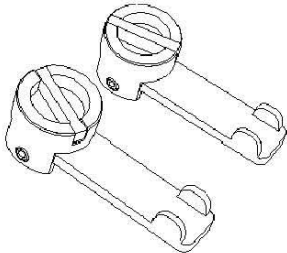
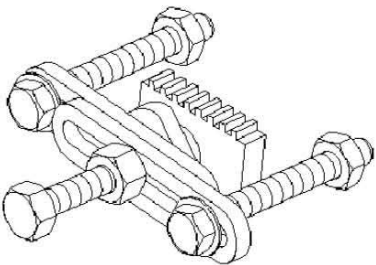
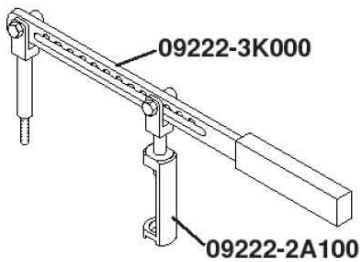
2,255.52kPa (23.0kg/cm², 327.14psi)


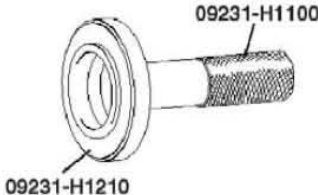
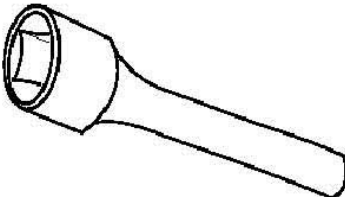
5) If the cylinder compression in 1 or more cylinders is low, pour a small amount of engine oil into the cylinder through the spark plug hole and repeat step 1) through 3) for cylinders with low compression.

- 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)

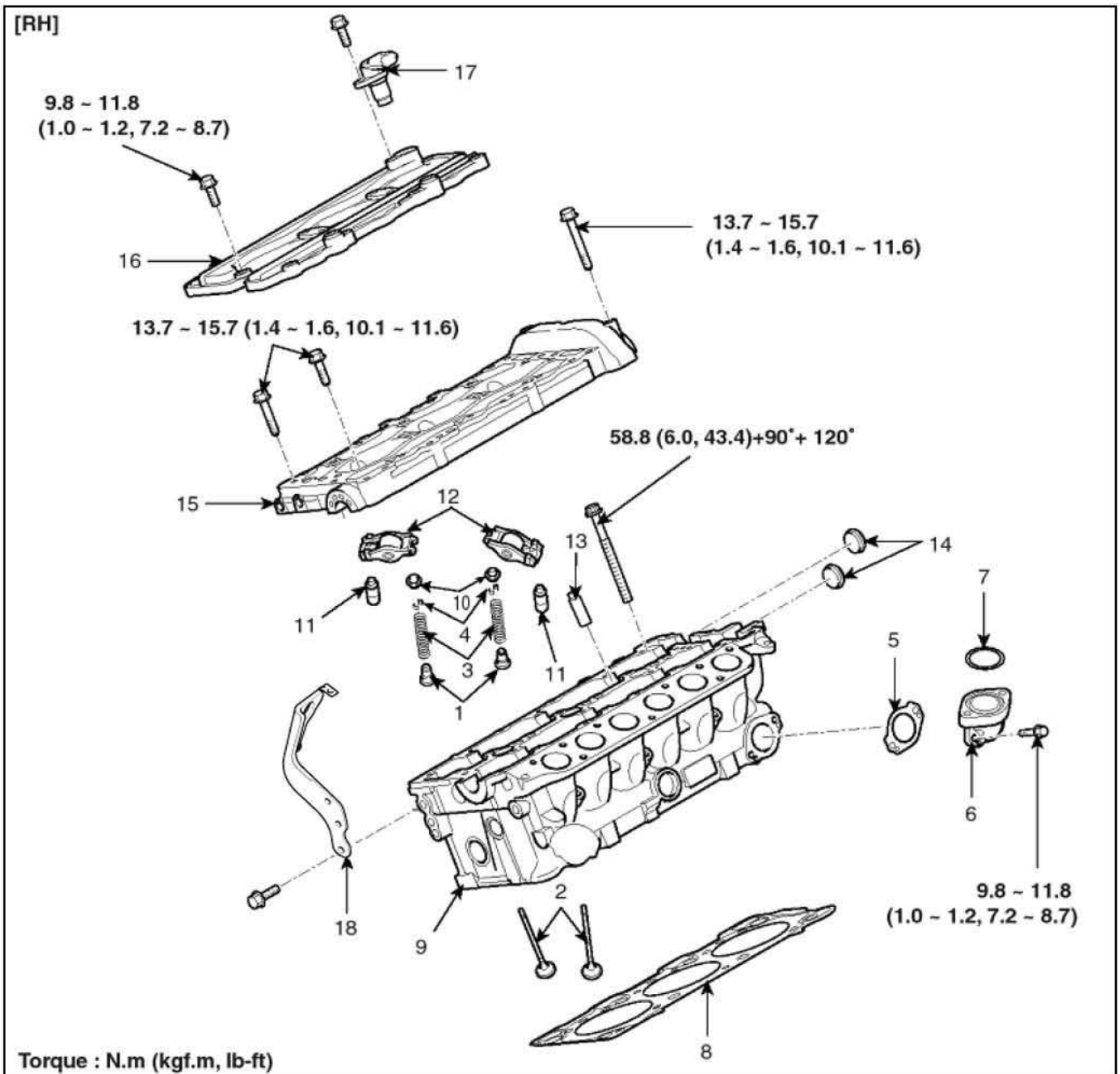
Special Service Tools

Tool (Number and name)	Illustration	Use
Compression gauge (09351-27000)		Checking engine compression pressure
Compression gauge adapter (09351-3A000)		Checking engine compression pressure
Camshaft locking tool (09231-3A000)		Fixation of timing chain and camshaft sprocket
Flywheel stopper (09231-2A100)		Removal and installation of crankshaft pulley bolt.
Valve spring compressor (09222-3K000) Valve spring compressor adaptor 09222-2A100		Removal and installation of intake/exhaust

<p>Valve stem oil seal installer (09222-2A000)</p>		<p>Installation of valve stem oil seals</p>
<p>Crankshaft rear oil seal installer (09231-H1210) Handle (09231-H1100)</p>		<p>Installation of crankshaft rear oil seal</p>
<p>Glow plug installer</p>		<p>Removal and installation of Glow plug</p>

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

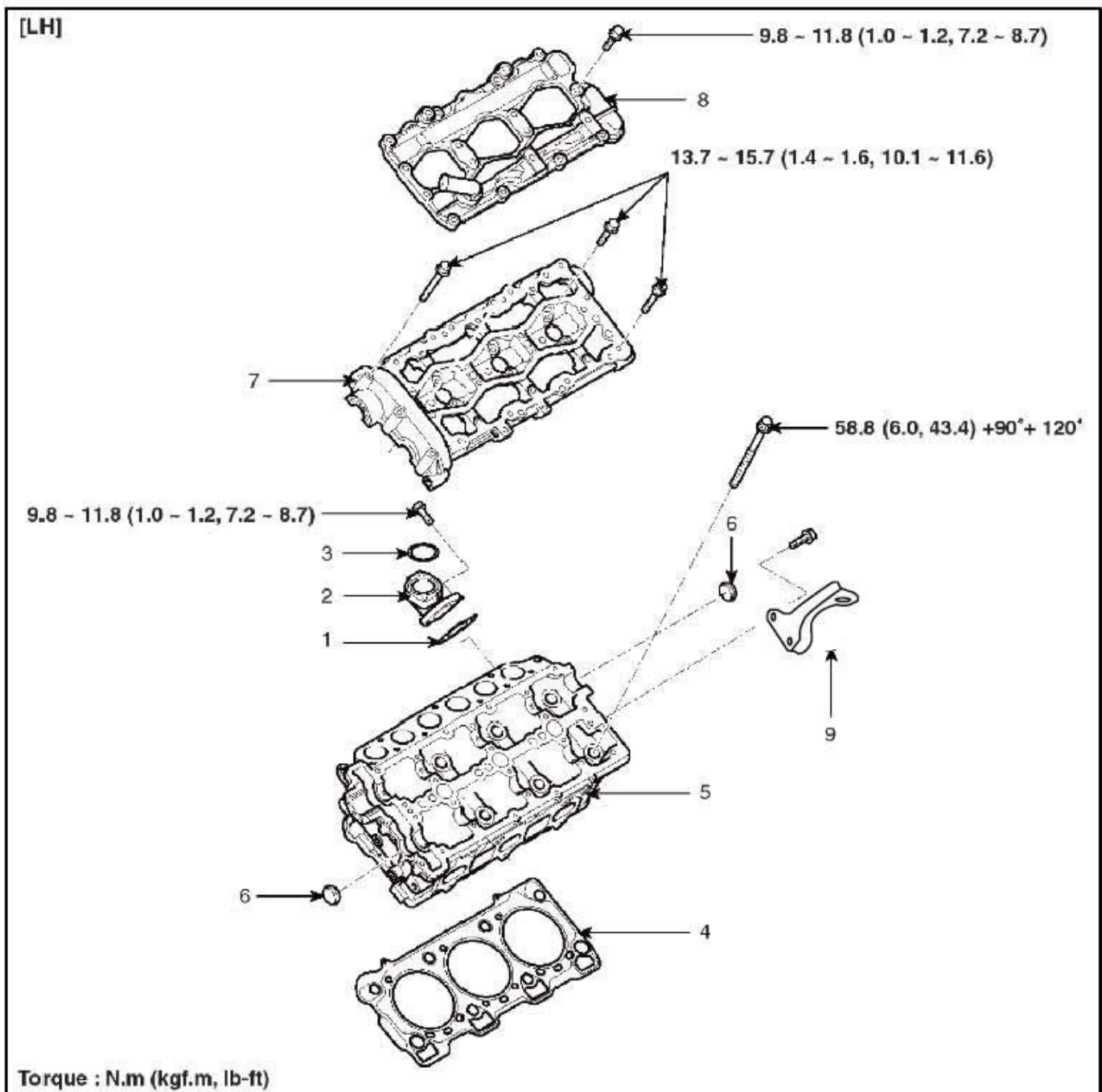
16. Cylinder head cover

17. Camshaft position sensor(CMP)

18. Engine hanger



Components

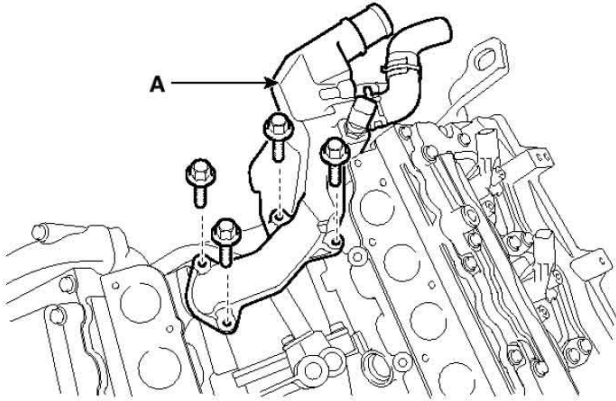


1. Water outlet fitting gasket
2. Water outlet fitting
3. Water outlet fitting O-ring
4. Cylinder head gasket
5. Cylinder head

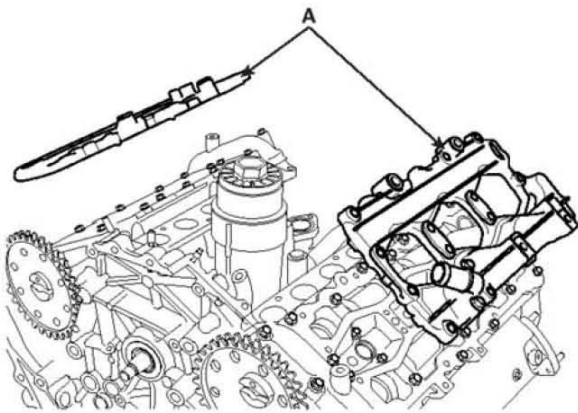
6. Sealing cap
7. Camshaft bearing ladder
8. Cylinder head cover
9. Engine hanger

Removal

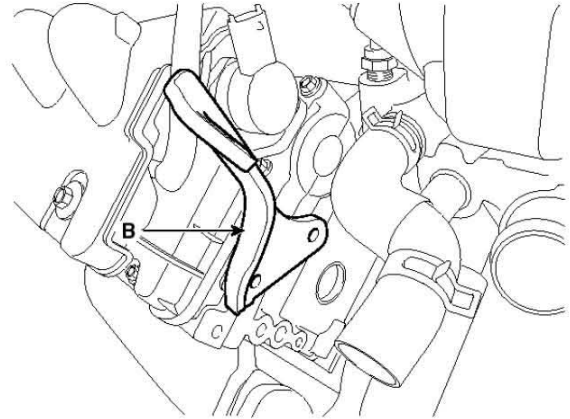
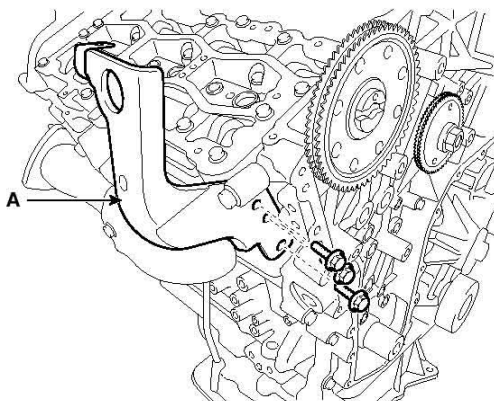
1. Remove the drive belt.
2. Remove the timing chain.
3. Remove the intake and exhaust manifold.
4. Remove the high pressure pipe, the injectors and the delivery pipe.
5. Remove the glow plug wiring.
6. Remove the water outlet duct (A).



7. Remove the cylinder head cover (A).



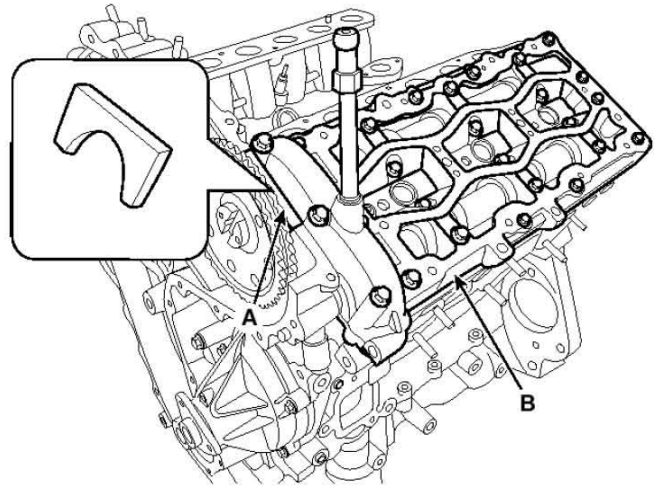
8. Remove the front engine hanger (A) and rear engine hanger (B).



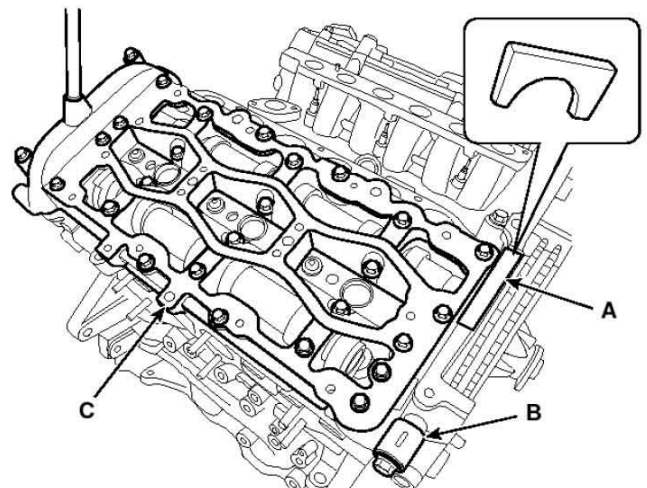
9. Remove the camshaft bearing ladder.

[LH]

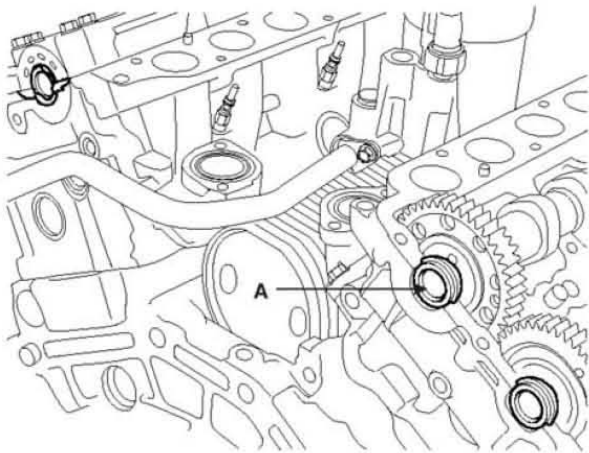
- 1) Remove the LH upper head seal (A).
- 2) Remove the LH camshaft bearing ladder (B).

**[RH]**

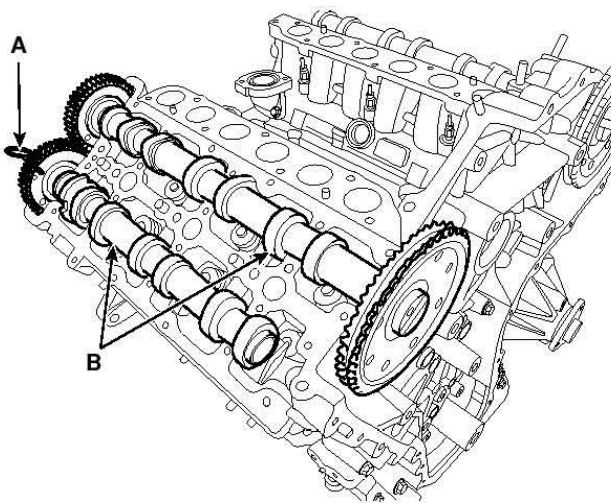
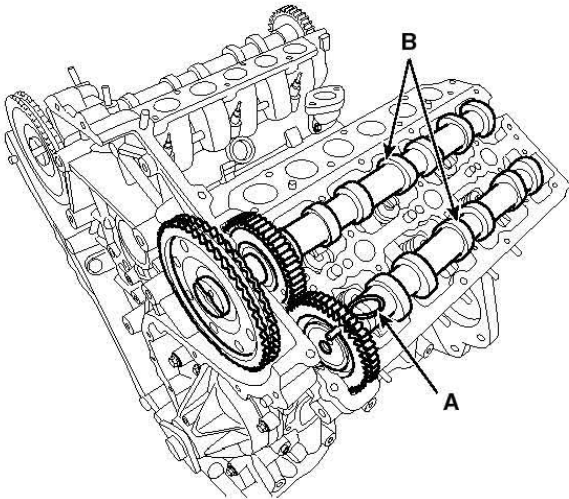
- 1) Remove the RH upper head seal (A).
- 2) Remove the timing chain case bracket (B).
- 3) Remove the RH camshaft bearing ladder (C).



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

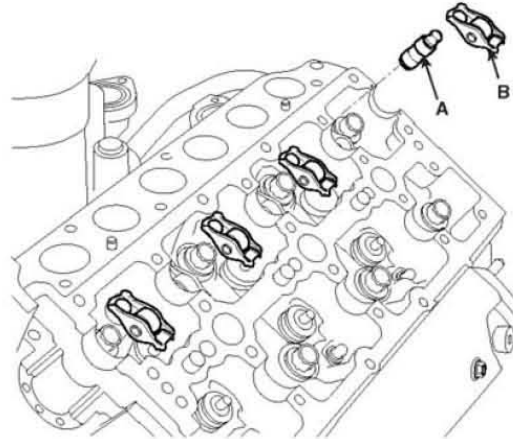


11. Insert the stopper pin (A) into the LH/RH exhaust camshaft scissors gear, and then remove the camshafts (B).



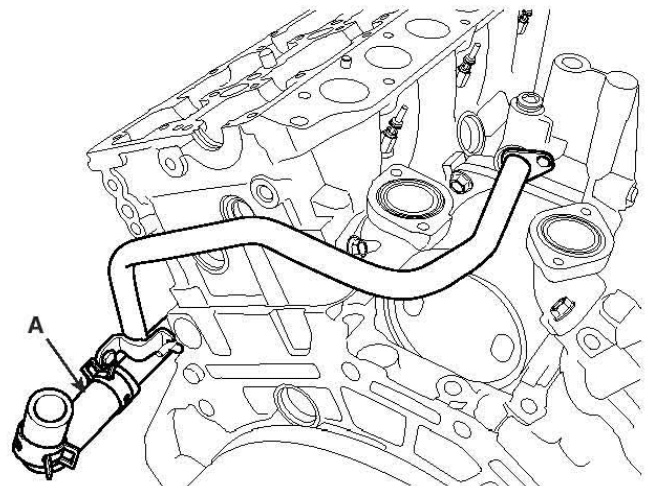
distorted. In this case, assemble a pin on the exhaust camshaft with the main gear and scissors gear aligned and then install the camshaft.

12. 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.

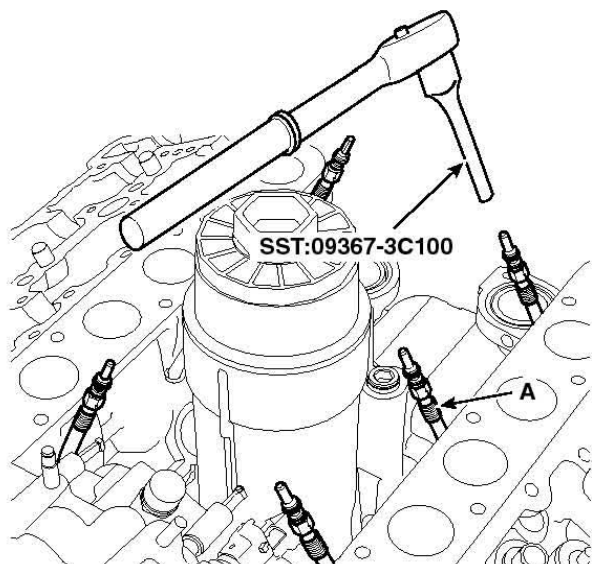
13. Remove the HLA (hydraulic lash adjuster)(A) and the cam follower assembly(B).



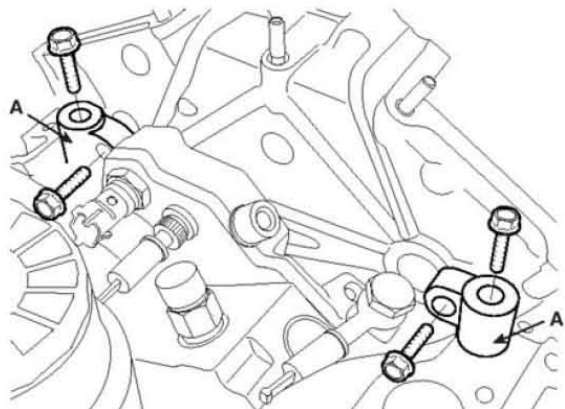
14. Use the SST (09367-3C100), remove the glow plugs (A).

NOTICE

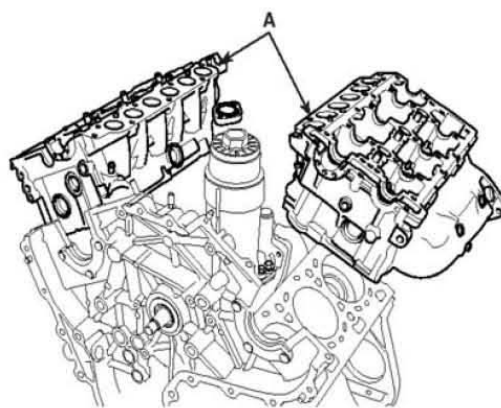
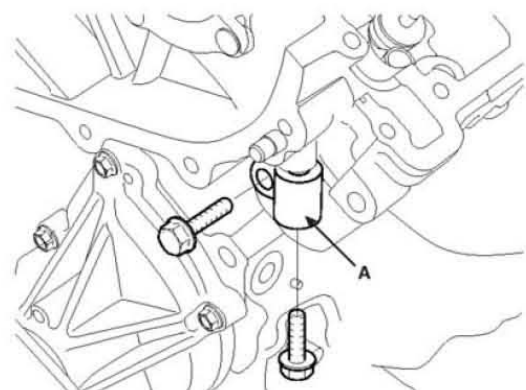
If the exhaust camshaft is removed when the stopper pin is not installed on the scissors gear of the exhaust camshaft, the main gear and scissors gear are



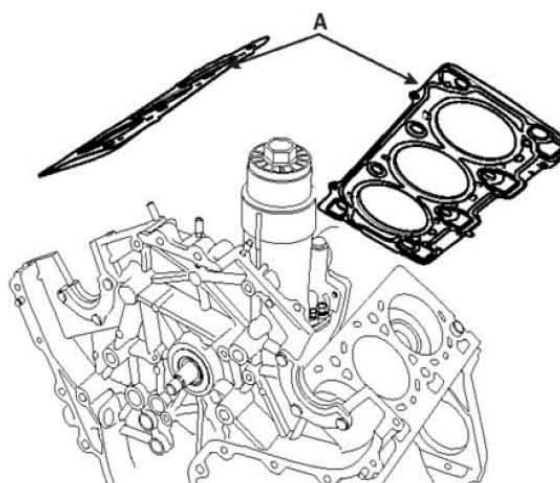
15. Remove the timing chain case bracket(A).



16. Remove the cylinder head bolts.



18. Remove the cylinder head gasket(A)



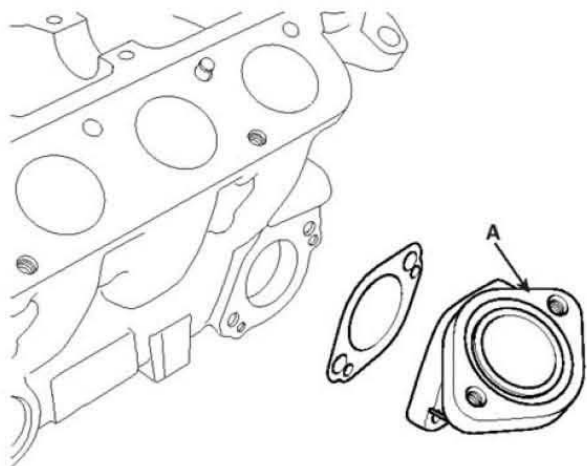
NOTICE

Do not reuse the cylinder head bolts more than twice.

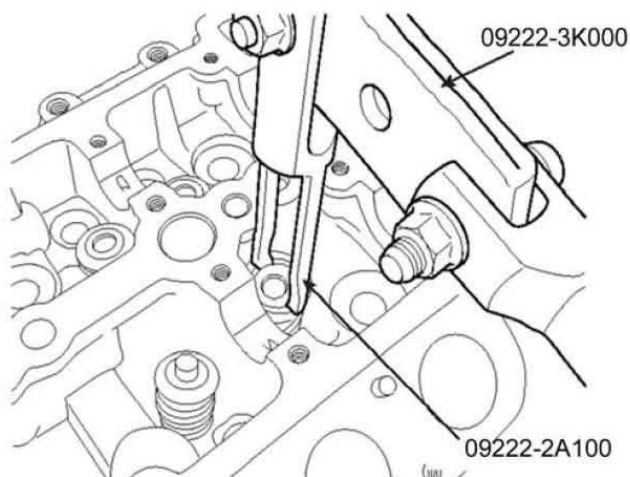
17. Remove the cylinder head quietly in order not to damage the gasket with the bottom part of the end.

Disassembly

1. Remove the water outlet fitting (A)



2. Using the SST (09222-2A100, 09222-3K000), compress the spring and remove the retainer locks.



3. Remove the valve, valve spring and spring retainer.

Reassembly

 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.

1. Install the valves.

- 1) Using the SST (09222-2A000)(A), push in a new stem oil seal.

 NOTICE

- Do not reuse old valve stem oil seals.
- Incorrect installation of the seal could result in 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.

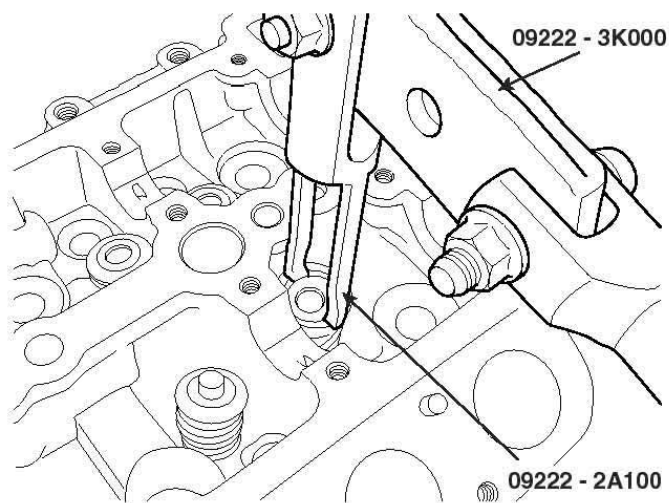
- 2) Install the valve, valve spring and spring retainer.

 NOTICE

- Apply engine oil on the valves when installing.

- 3) Using the SST (09222-2A100, 09222-3K000), 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.

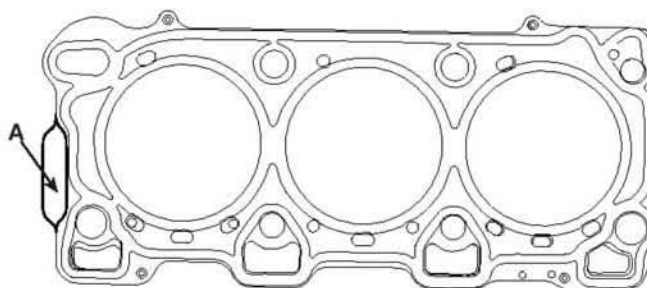
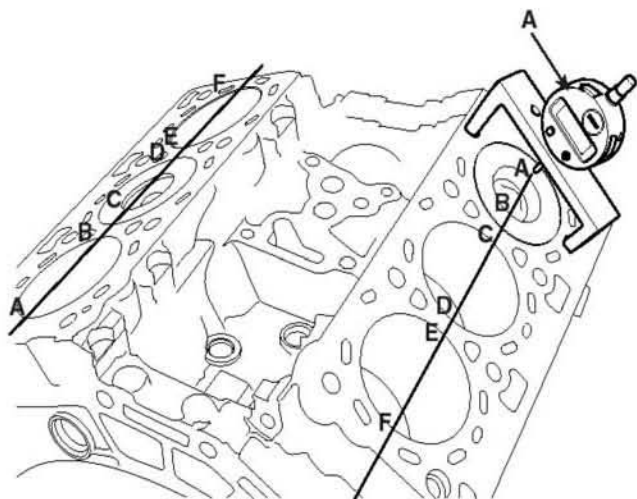
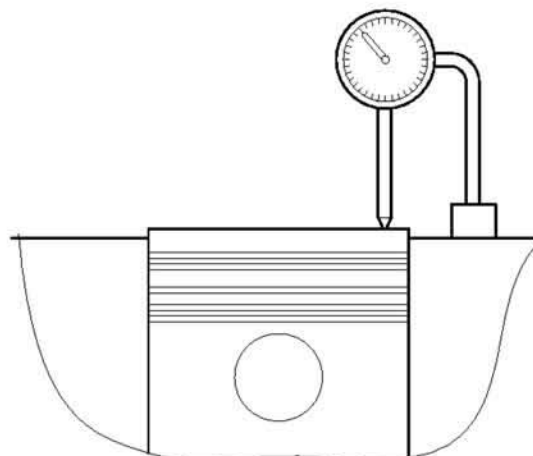
2. Install the water outlet fitting (A).

Tightening torque :

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

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.



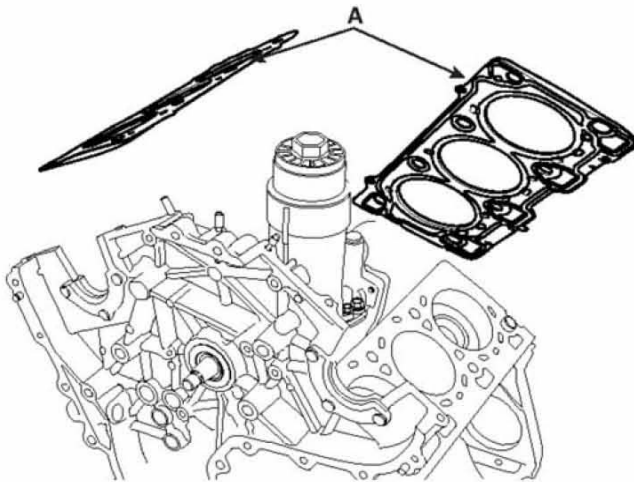
Grade (A)		A	B	C
Average of piston protrusion		0.310 ~ 0.410mm (0.0122 ~ 0.0161 in)	0.410 ~ 0.510mm (0.0161 ~ 0.0201 in)	0.510 ~ 0.610mm (0.0201 ~ 0.0240in)
Limit of each rank extant		0.460mm (0.181in)	0.560 mm (0.220in)	-
Gasket thickness(compressed)		1.1 ± 0.04 mm (0.0433±0.0016in)	1.2 ± 0.04mm (0.0472±0.0016in)	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



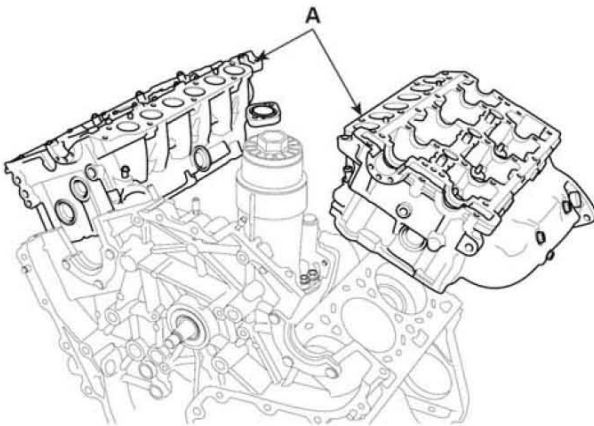
- 3) Install the LH gasket so that the identification mark (A) faces toward the timing chain side.
 - 4) Install the RH gasket so that the identification mark (A) faces toward the transaxle side.
3. Install the cylinder head gasket (A) on the cylinder block

 **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: 56.8~60.8N.m (5.8~6.2kgf.m, 41.9~44.8lb-ft)

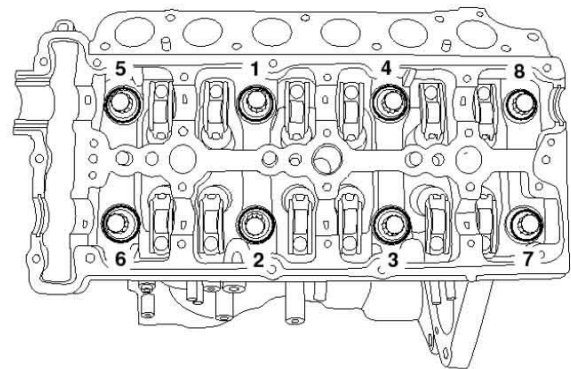
2nd step: $88\sim92^{\circ}\pm 2^{\circ}$

3rd step: $118\sim122^{\circ}\pm 2^{\circ}$

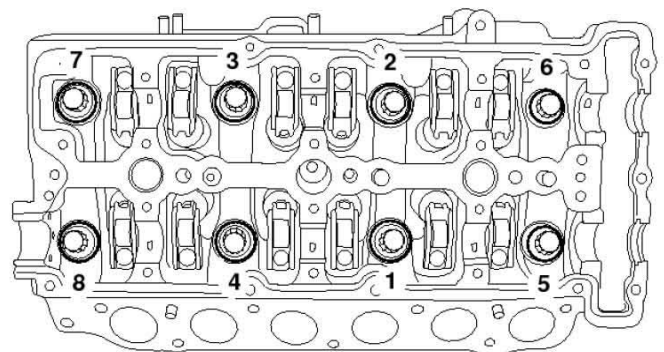
 **NOTICE**

Do not reuse the cylinder head bolts more than twice.

[LH]



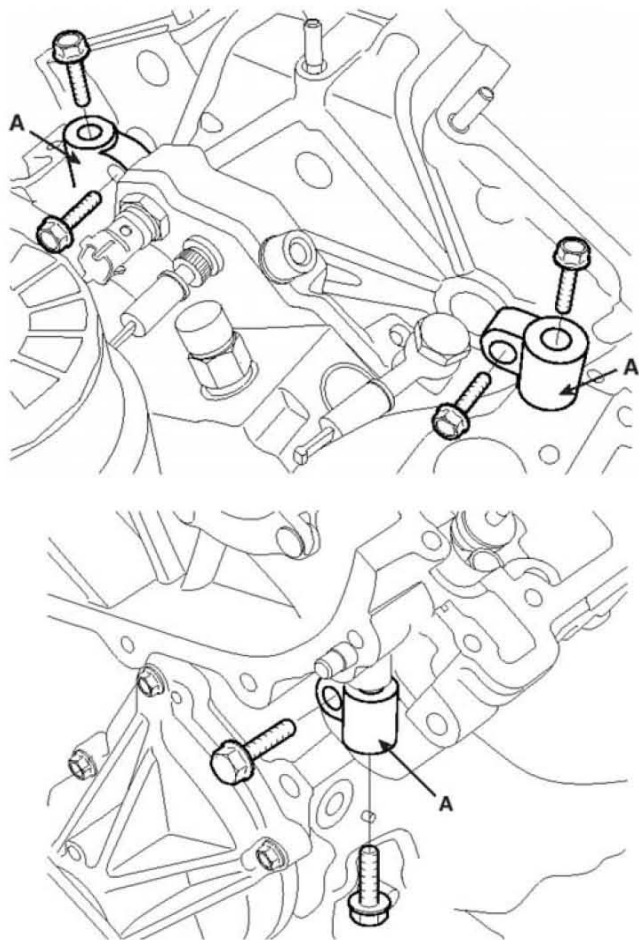
[RH]



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:

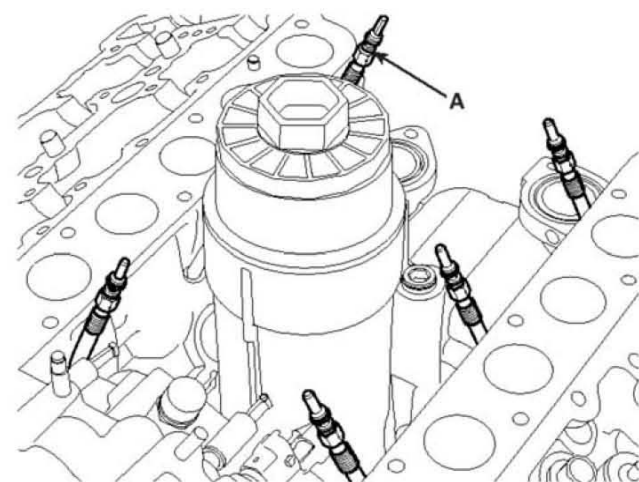
19.6 ~ 25.5Nm (2.0 ~ 2.6kgf.m, 14.5 ~ 18.8lb-ft)



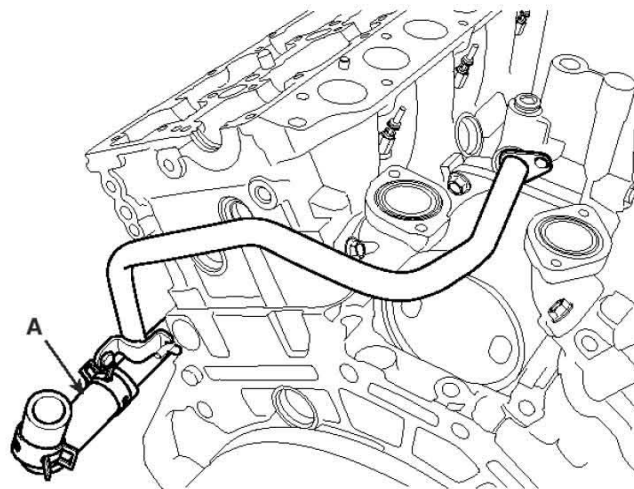
7. Tighten the glow plugs (A).

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.

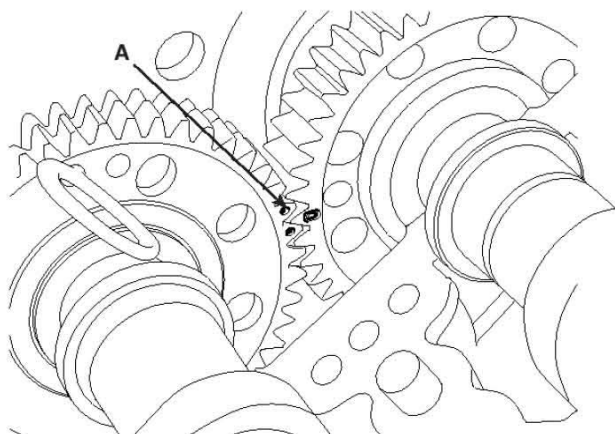
Camshaft end play Standard:

0.05 ~ 0.15mm (0.0020 ~ 0.0059in)



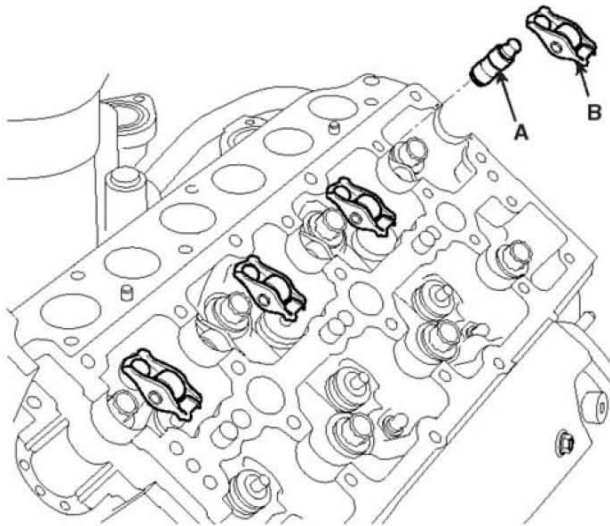
CAUTION

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.

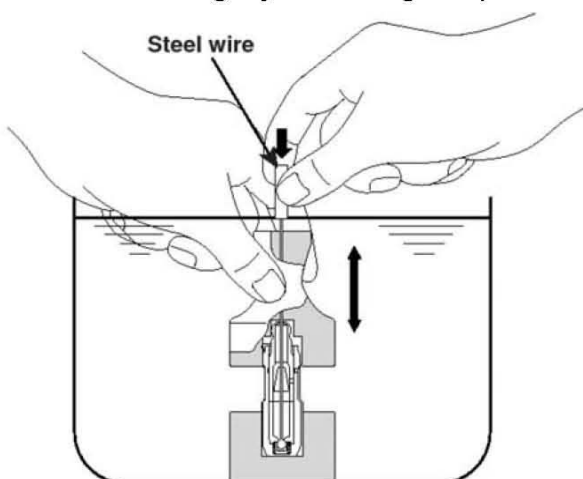
11. After applying oil, install the HLA (hydraulic lash adjuster) (A) and the cam follower assembly (B).



- 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 one in accordance with the air bent procedure.

NOTICE

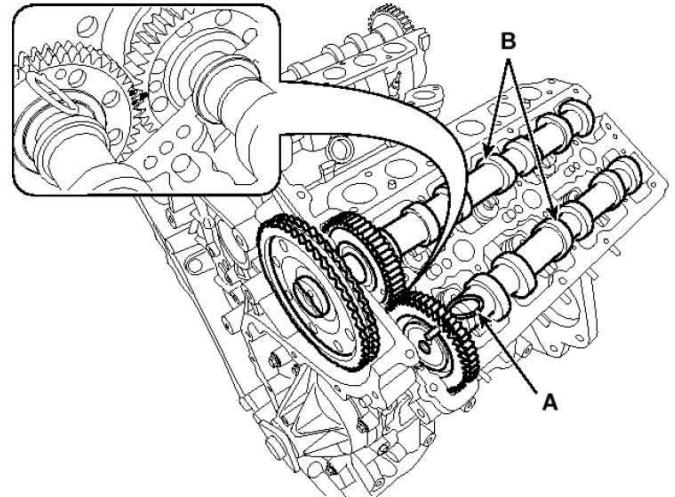
Stroke the HLA in oil 4~5 times by pushing its cap while pushing the ball down slightly by hard steel wire.
(Take care not to severely push hard steel wire down since the ball weighs just several grams.)



12. Wipe out oil on the upper surface of the cylinder head.
13. Install the LH/RH camshaft (B) with stopper pin (A) is assembled on the exhaust camshaft with the main gear and scissors gear aligned.

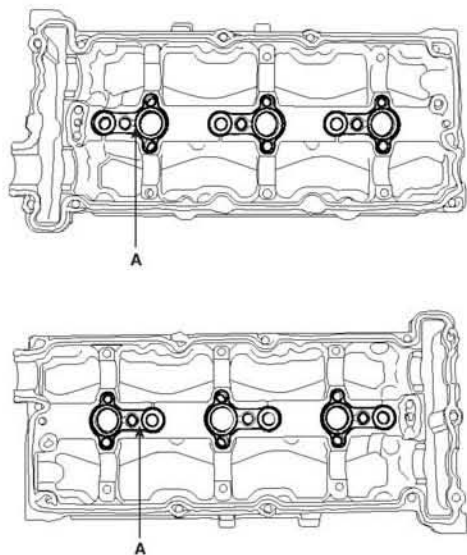
CAUTION

- **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.**

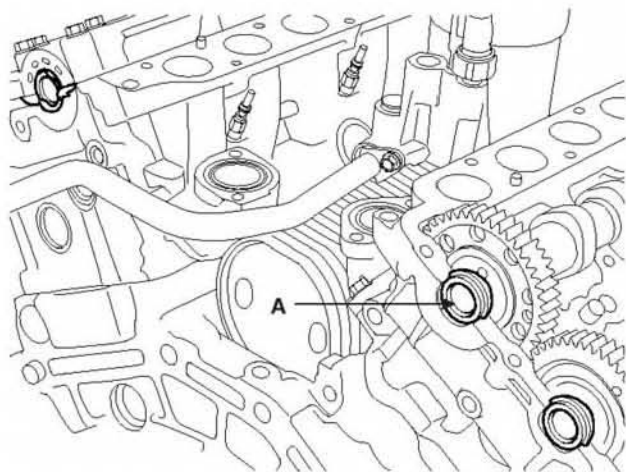


14. Press the exhaust camshafts, take out the pin from their sprockets.
15. Put the ladder gaskets (A) on the camshaft bearing ladder and apply sealant. Also apply some oil on the contacting surface with the camshafts.

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.



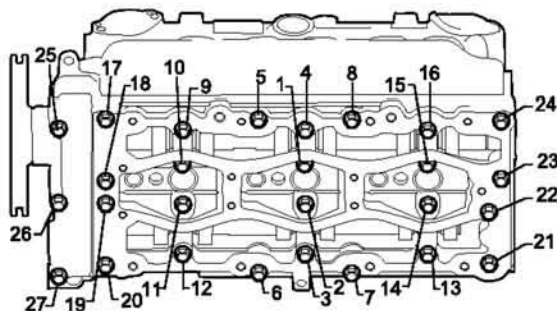
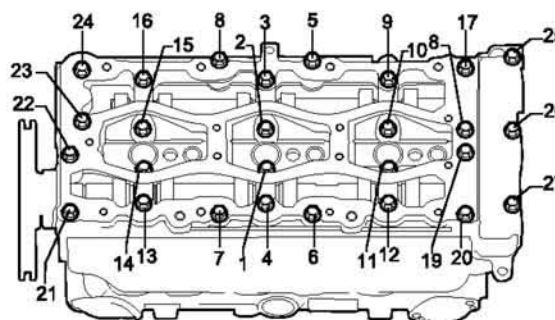
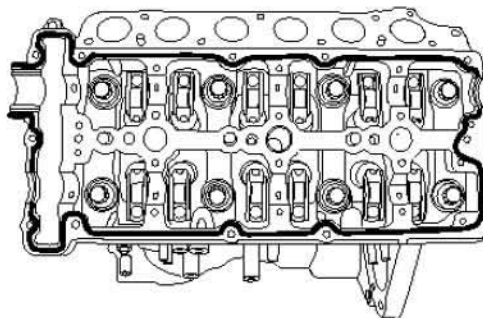
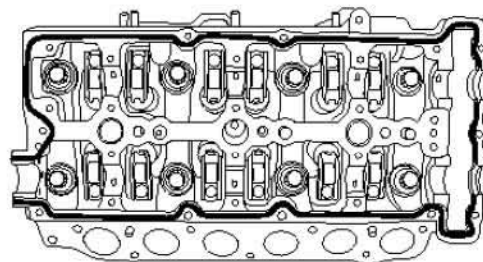
16. Install the sealing caps (A) with applying sealant (LOCTITE 5902/5900 or equivalent) on the grooves (4 places) at the circumference.



17. Install the camshaft bearing ladder (A) with the sequence and the torque below.
 - 1) Apply sealant to the surface of LH/RH cylinder head as following illustration.
 - 2) Tighten the bolts with the sequence and the torque below.

Tightening Torque:

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

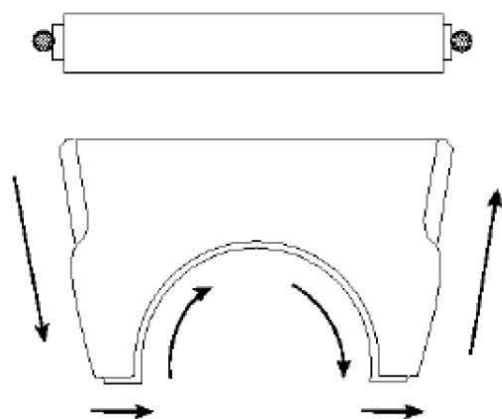


- 3) Apply sealant to the upper head seal as following illustration.

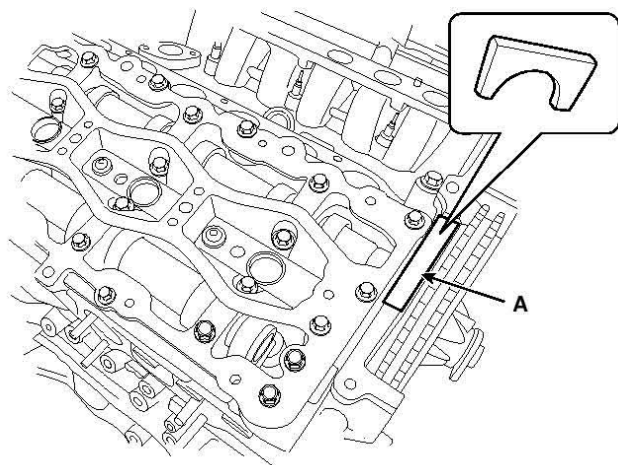
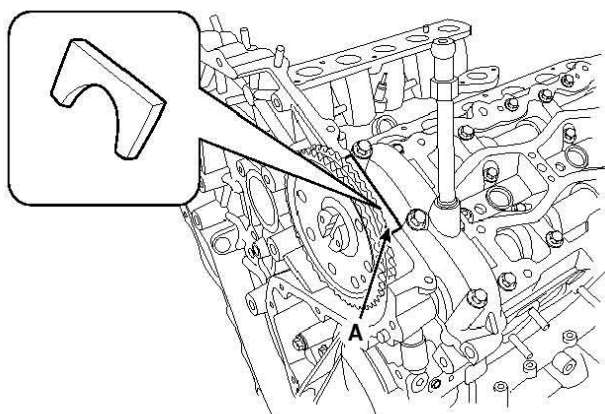
Sealant : LOCTITE 5900H, TH1217H

Bead Width : ϕ 2.5mm

specified torque below.



4) Install the LH/RH upper head seal (A).



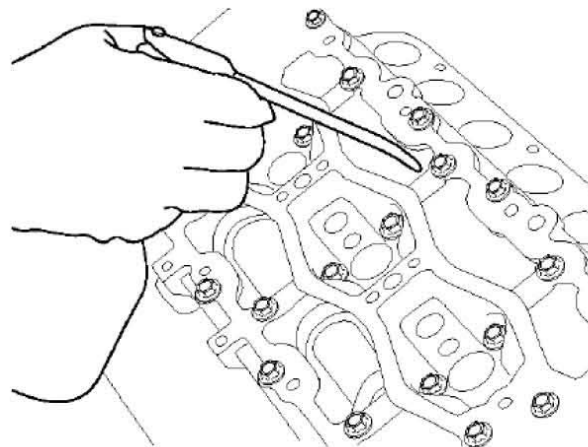
NOTICE

Reassemble the upper head seal within 5 minutes after applying.

5) Install the timing chain case bracket (A). Tighten the vertical-direction bolt slightly first and then the horizontal-direction ones and the vertical-direction one with the

Tightening torque :

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

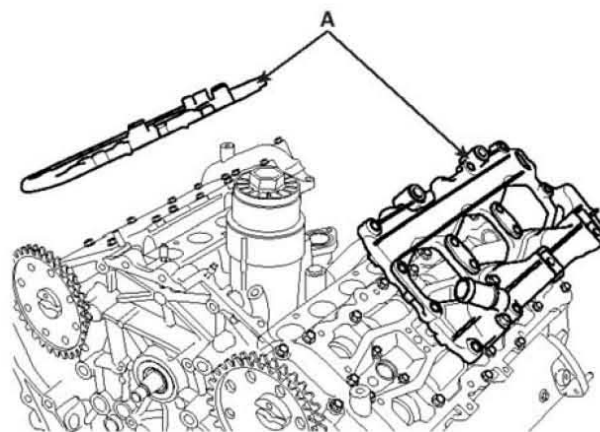


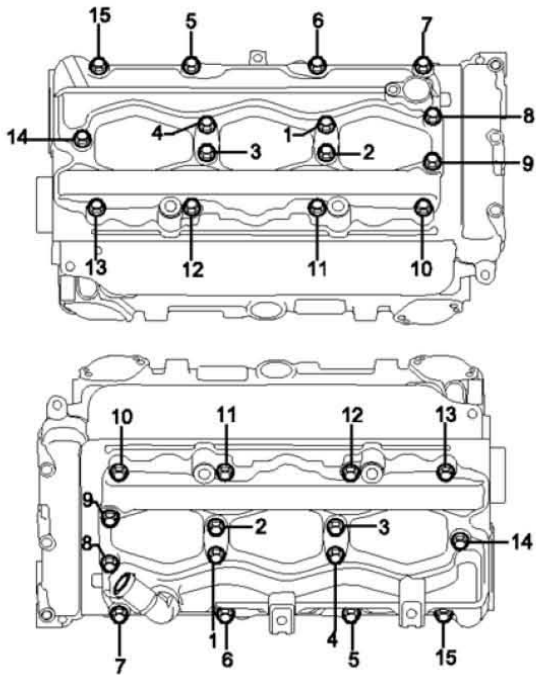
18. Apply oil on the camshafts sufficiently.

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)

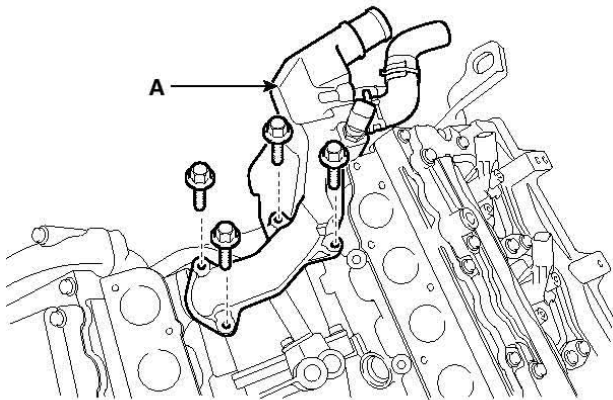




20. Install the water outlet duct (A).

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.

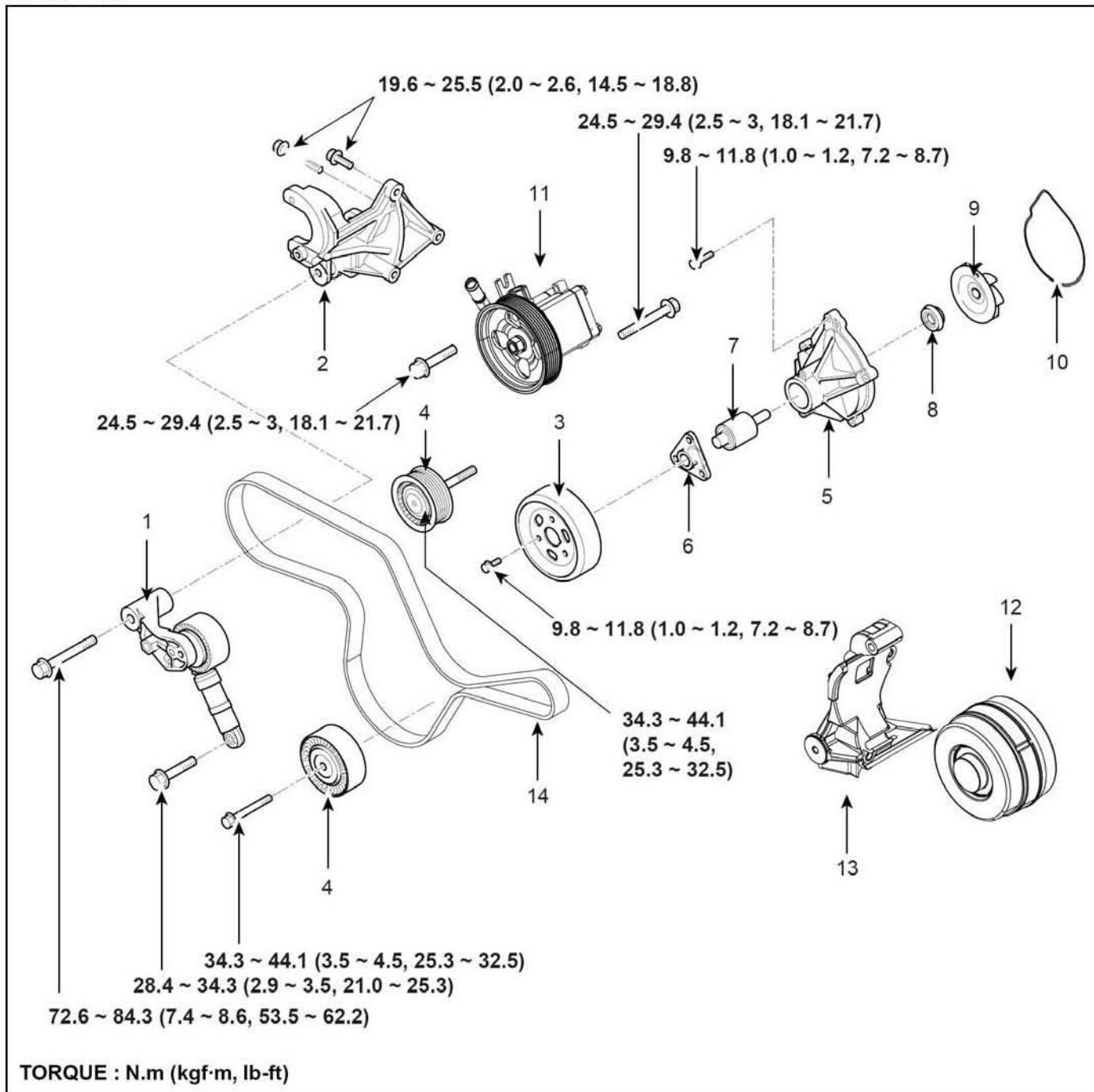
24. Install the timing chain.

25. Install the drive belt.

Timing System

Components

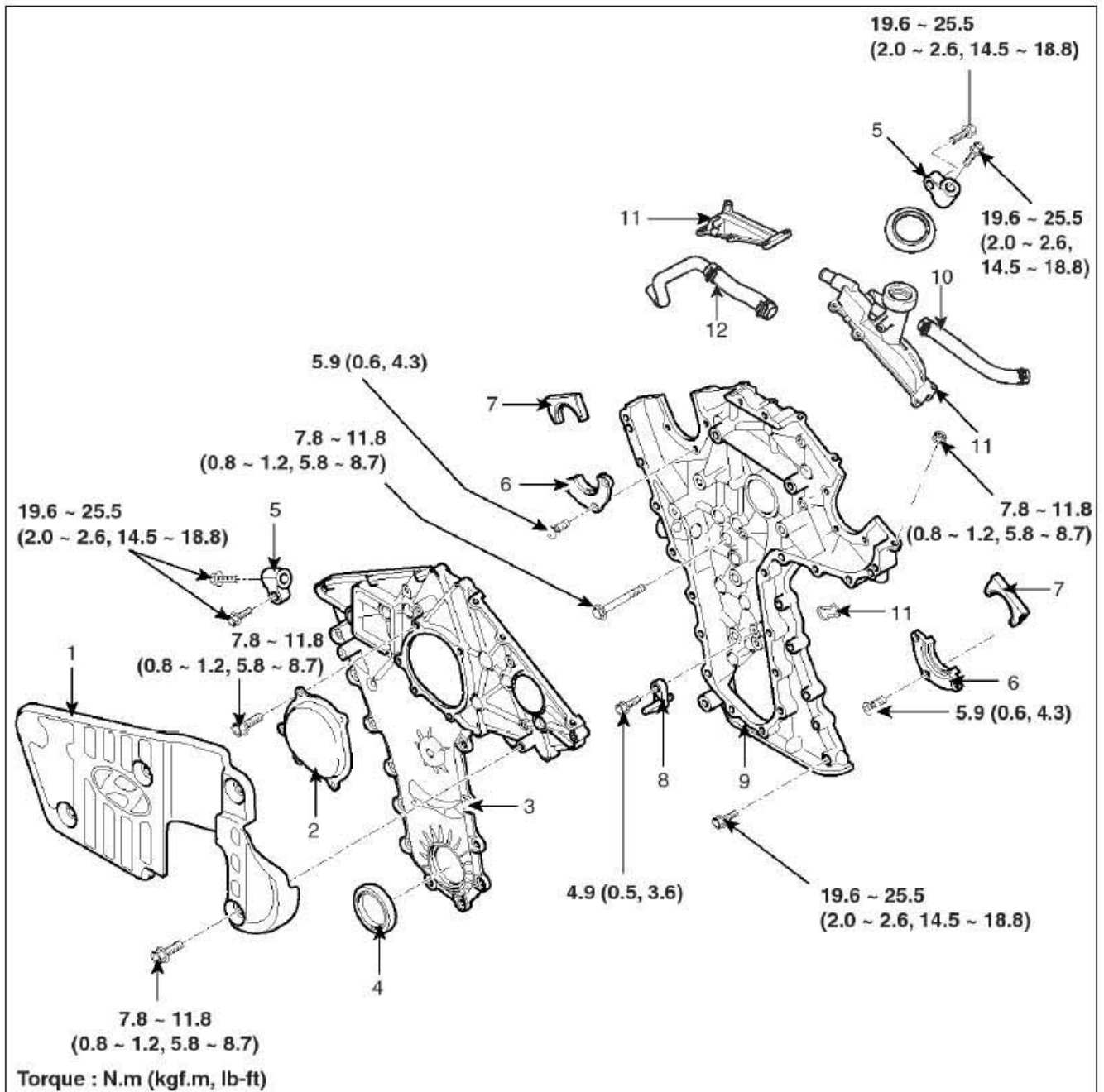
Timing Chain



- 1. Tensioner assembly
- 2. Bracket-tensioner
- 3. Water pump pulley
- 4. Stay-tensioner bracket
- 5. Water pump

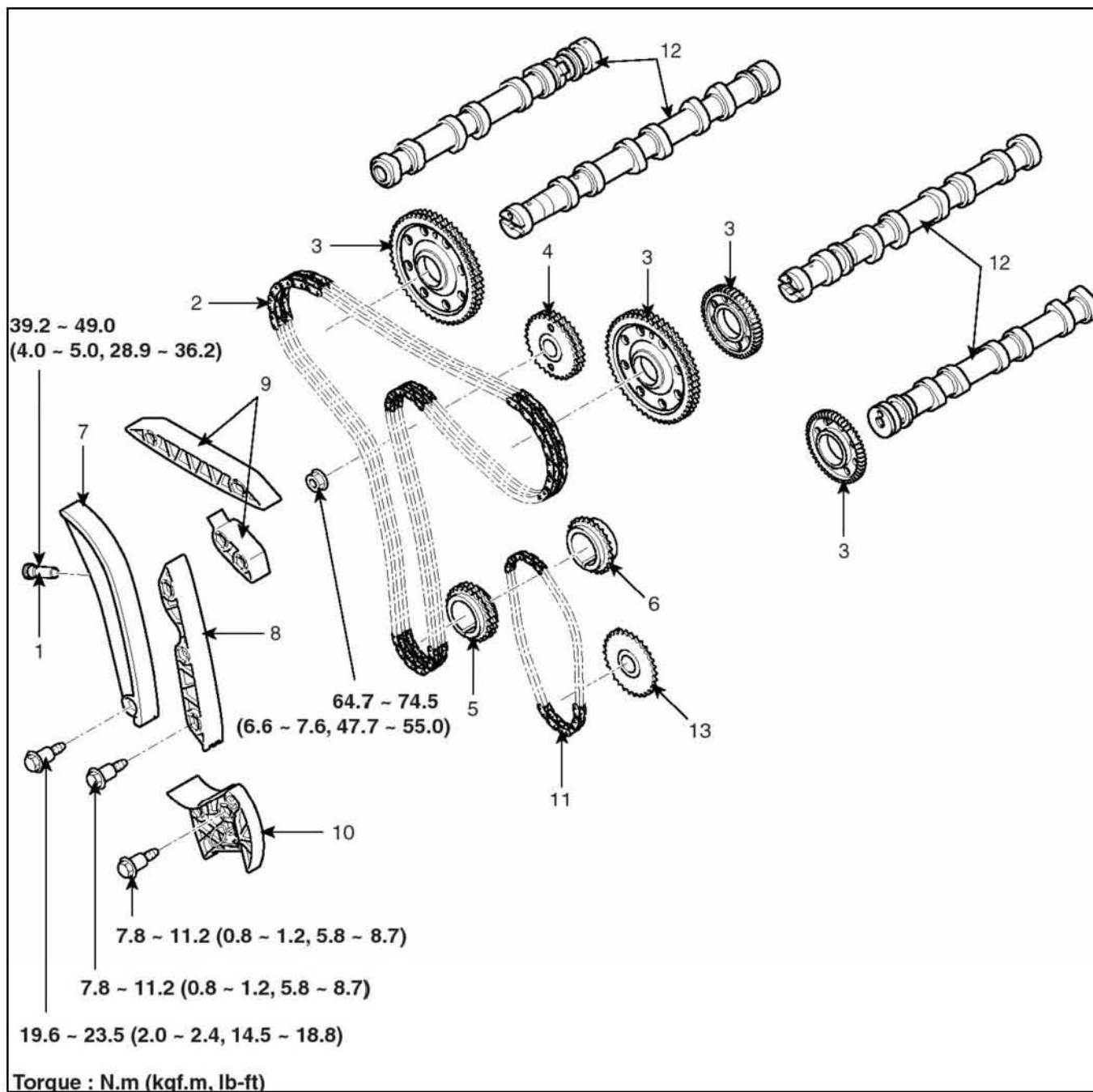
- 6. Water pump pulley flange
- 7. Water pump bearing
- 8. Seat unit
- 9. Water pump impeller
- 10. Water pump gasket

- 11. P/S oil pump
- 12. Alternator
- 13. Bracket-alternator
- 14. Drive belt



- | | | |
|-----------------------------|--------------------|--------------------|
| 1. Front cover | 6. Lower head seal | 11. Chain case cap |
| 2. High pressure pump cover | 7. Upper head seal | 12. Inlet hose |
| 3. Chain front cover | 8. Chain oil jet | |
| 4. Front oil seal | 9. Chain case | |
| 5. Chain case bracket | 10. Inlet hose | |

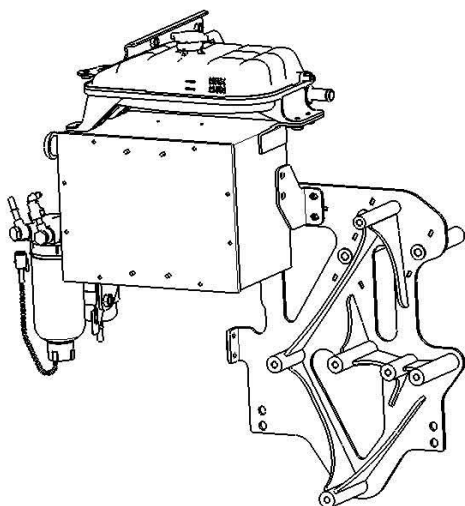




- | | | |
|--------------------------------|------------------------------|-----------------------------|
| 1. Hydraulic tensioner | 6. Oil pump sprocket | 11. Oil pump chain |
| 2. Timing chain | 7. Tensioner lever | 12. Camshaft |
| 3. Camshaft sprocket | 8. Lower chain guide | 13. Oil pump drive sprocket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

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)

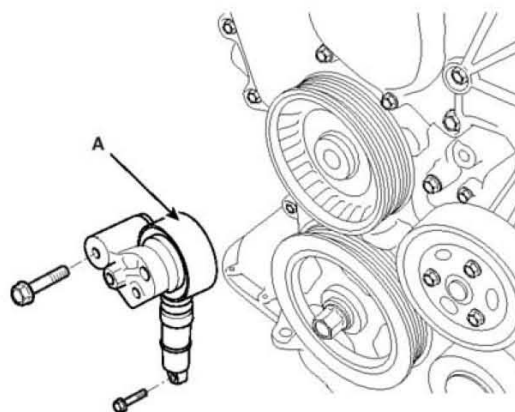
Engine Timing System

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.

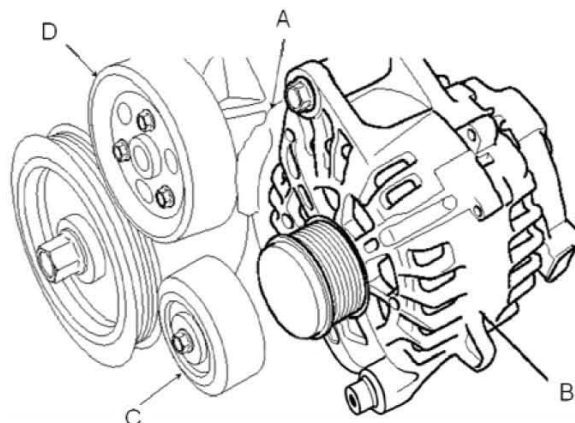
**NOTICE**

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.

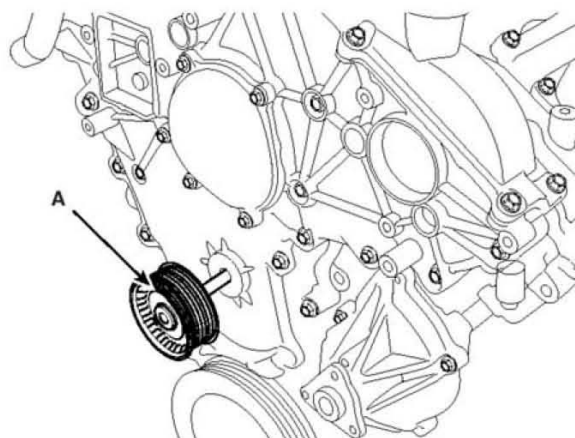
2. Remove the drive belt tensioner (A).



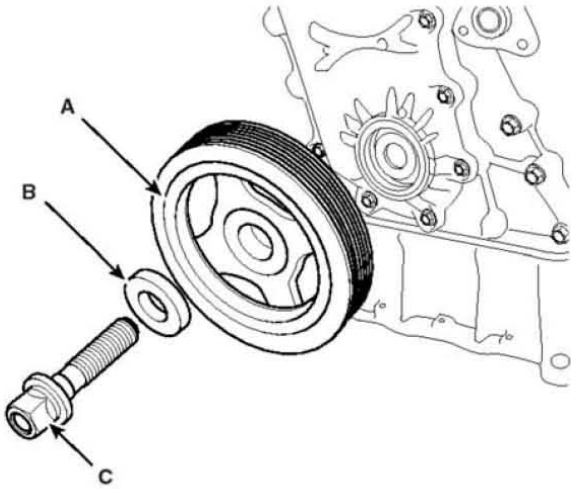
3. Remove the power steering bracket.
4. Remove the water pump pulley (D).
5. Remove the drive belt idler (C).
6. Remove the alternator (B) with its bracket (A).



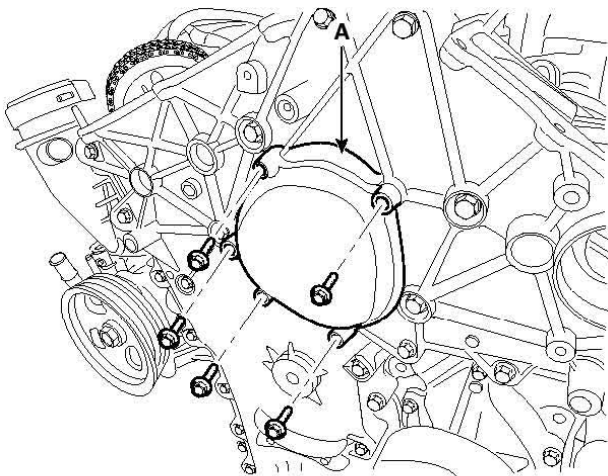
7. Remove the engine hanger.
8. Remove the water pump pulley bolt.
9. Remove the water pump pulley (A).



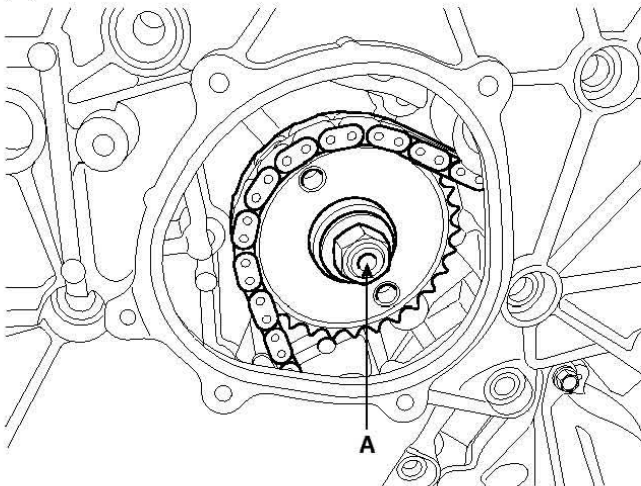
10. Remove the crankshaft pulley (A) with its washer (B) and mounting bolt (C).



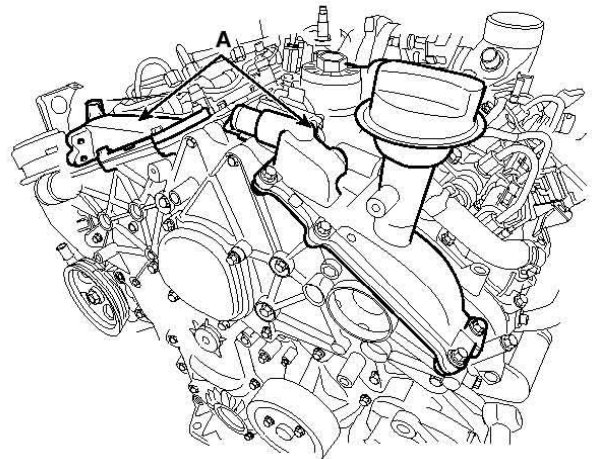
11. Remove the high pressure pump cover (A).



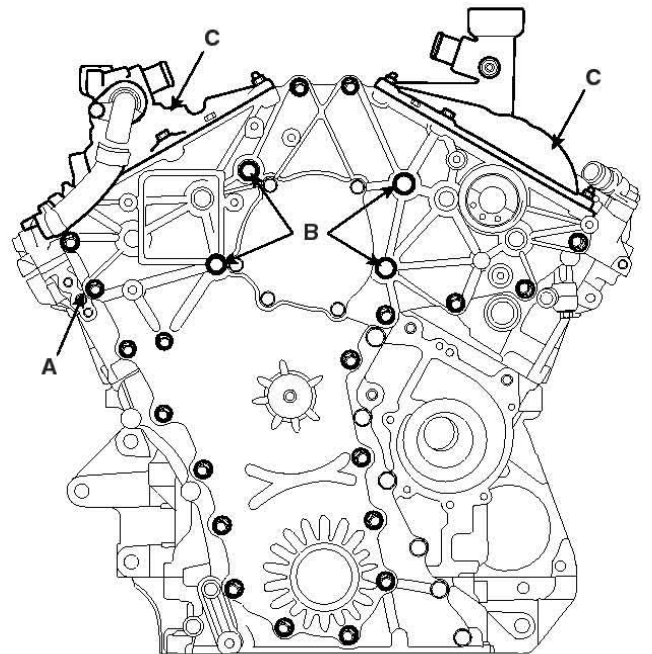
12. Remove the high pressure pump sprocket mounting nut (A).



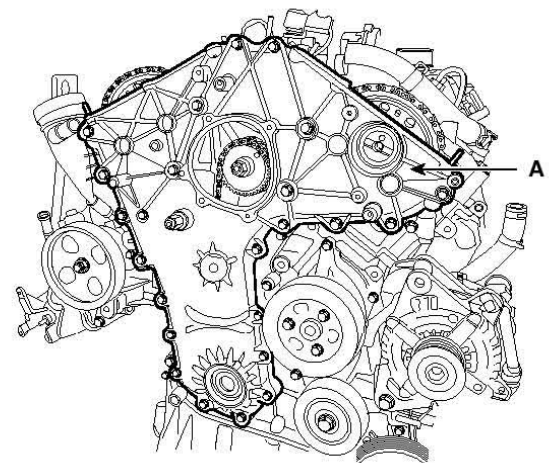
13. Remove the chain cap (A).



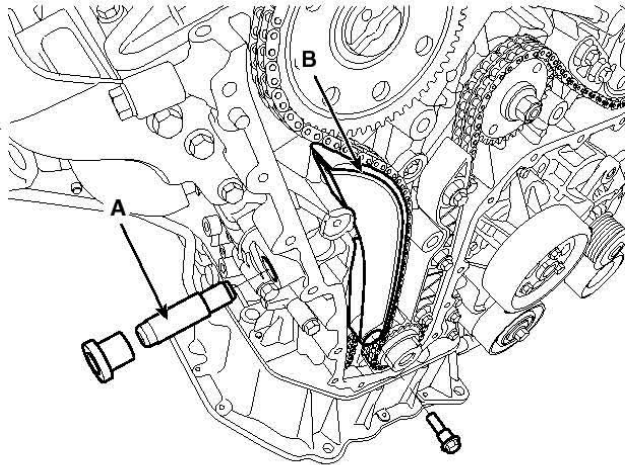
14. Remove the chain caps (C) and loosen the front chain cover mounting bolts (A-20EA, B-4EA).



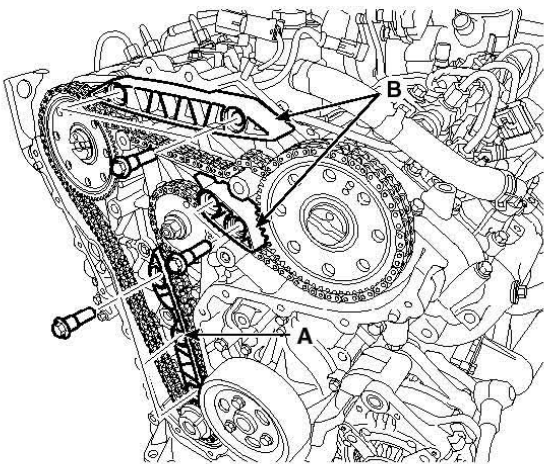
15. Remove the front chain cover (A).



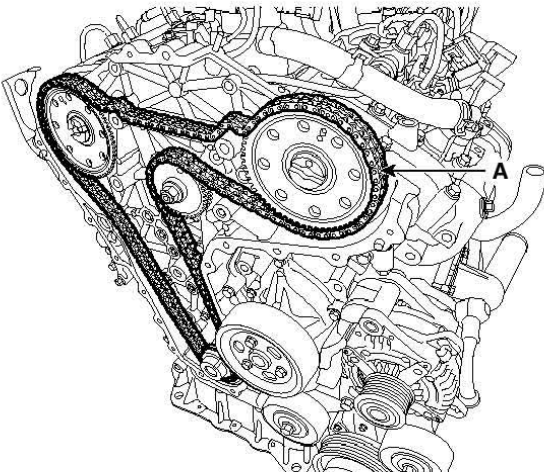
16. Remove the hydraulic tensioner (A) and tensioner lever (B).



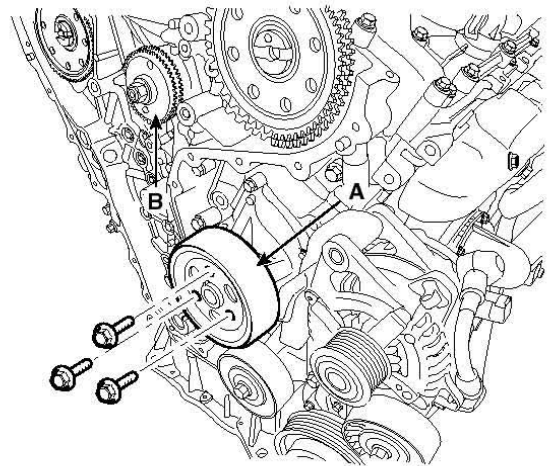
17. Remove the chain guide (A), tensioner lever (B).



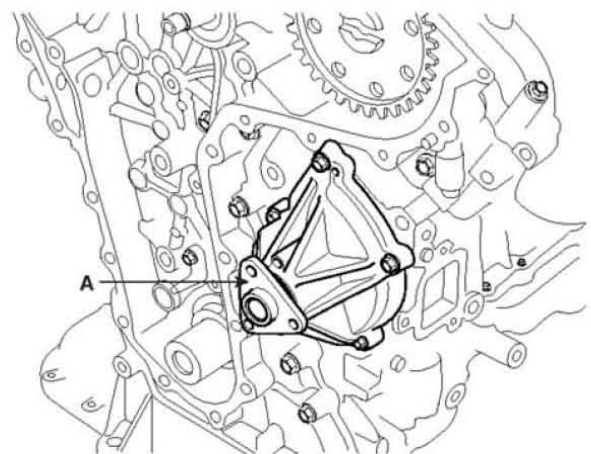
18. Remove the timing chain (A).



19. Remove the water pump pulley (A), high pressure fuel pump sprocket (B).

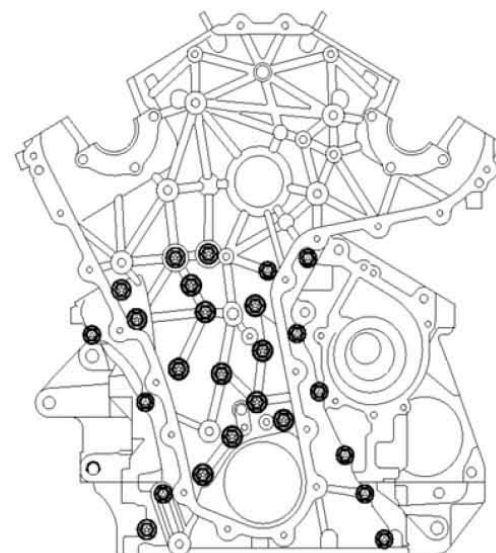


20. Remove the water pump(A) with its gasket.

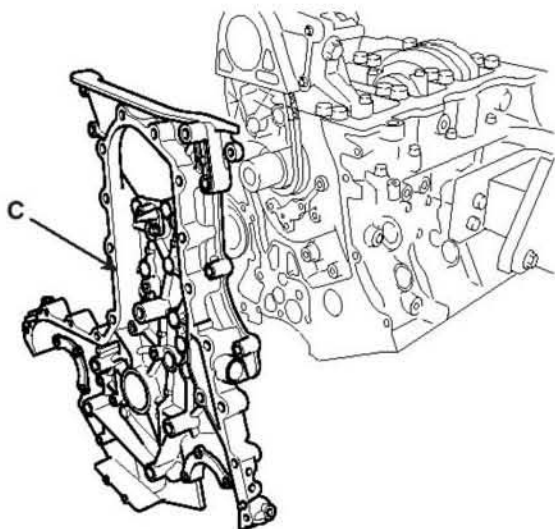


21. Remove the high pressure pump.

22. Remove the chain case mounting bolts.

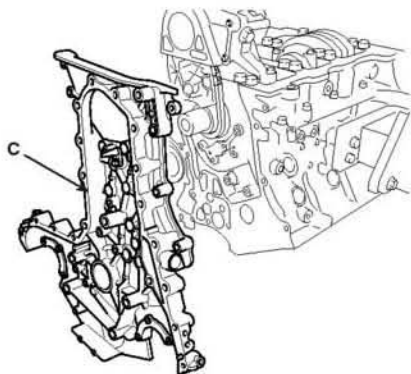


23. Remove the chain case assembly(C).



Installation

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

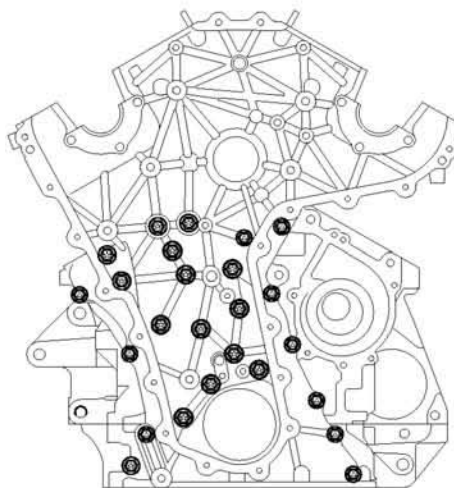


2. Tighten the chain case mounting bolts with the specified torque.

Tightening Torque:

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

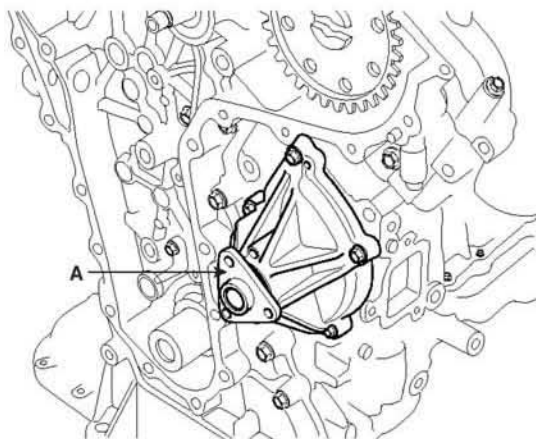
19.6 ~ 25.5Nm (2.0 ~ 2.6kgf.m, 14.5 ~ 18.8lb-ft) - 8×35(▲)



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 (09231-3A000).

9. Install the chain guide (F) and the tensioner lever (G).

Tightening Torque:

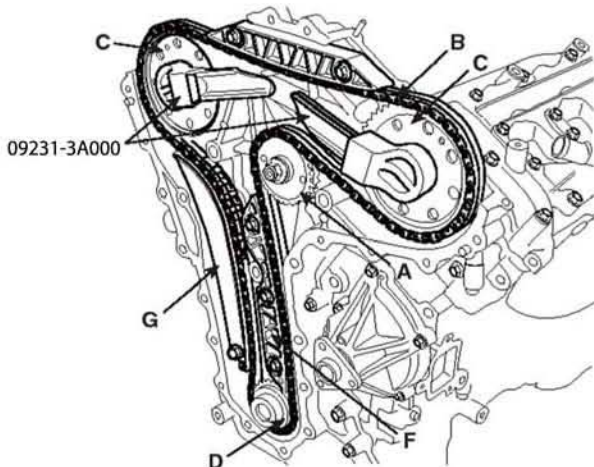
7.8 ~ 11.8Nm (0.8 ~ 1.2kgf.m, 5.8 ~ 8.7lb-ft) - chain guide

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

tensioner lever

NOTICE

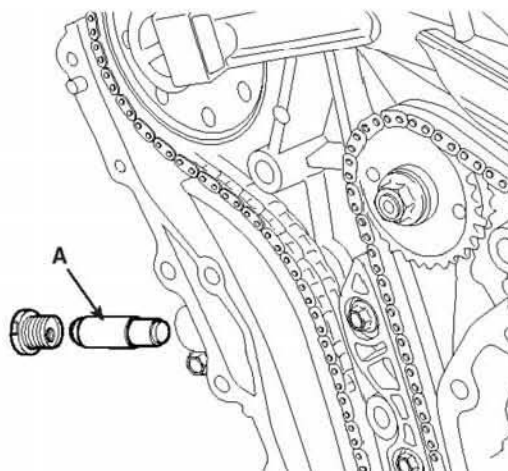
If you have difficulty in installing of the lower chain guide, turn the drive plate or move the SST a little bit.



10. Install the hydraulic tensioner (A).

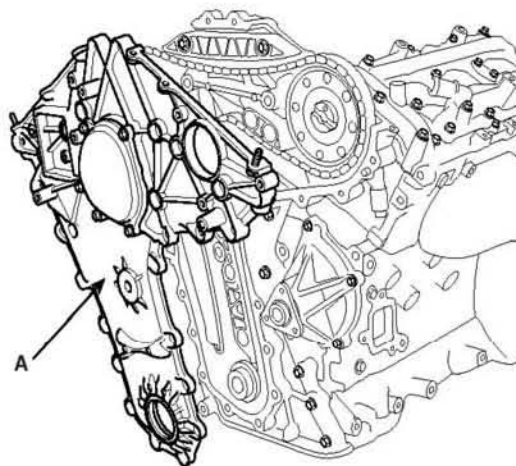
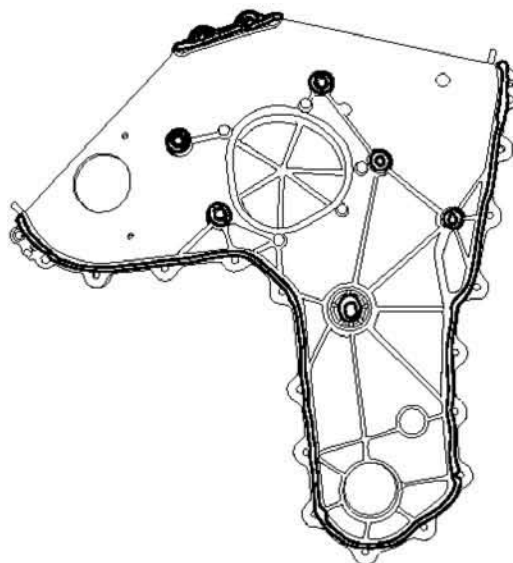
Tightening Torque:

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 (09351-3A000).

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



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

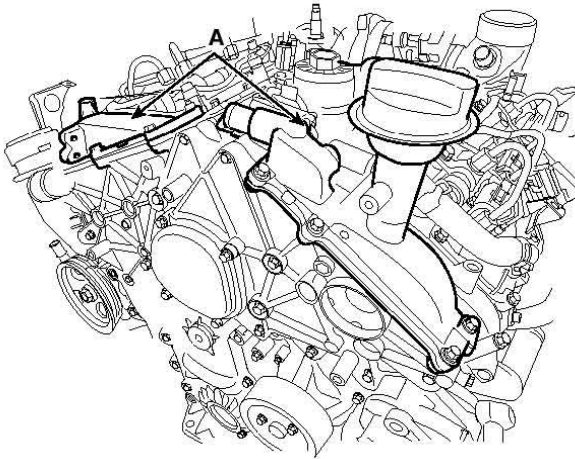
14. Applying sealant on the groove of the chain caps(C), install the caps within fifteen minutes.

Tightening Torque:

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

NOTICE

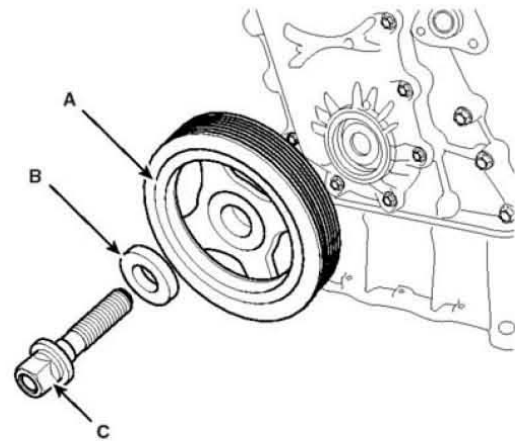
Install it after removing sealant from the camshaft bearing ladders.



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

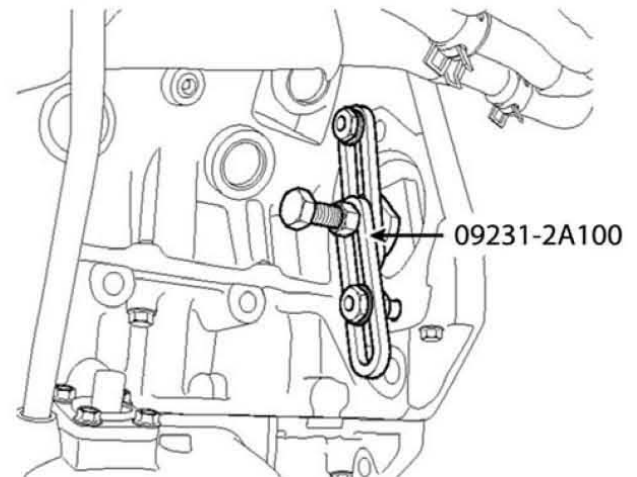
Tightening Torque:

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



NOTICE

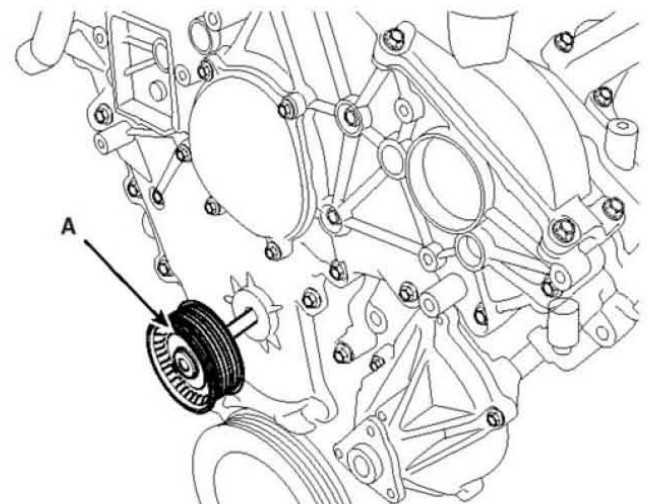
After removing the starter and installing the SST (09231-2A100), tighten the crankshaft bolt.



16. Install the drive belt idler (A).

Tightening Torque:

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



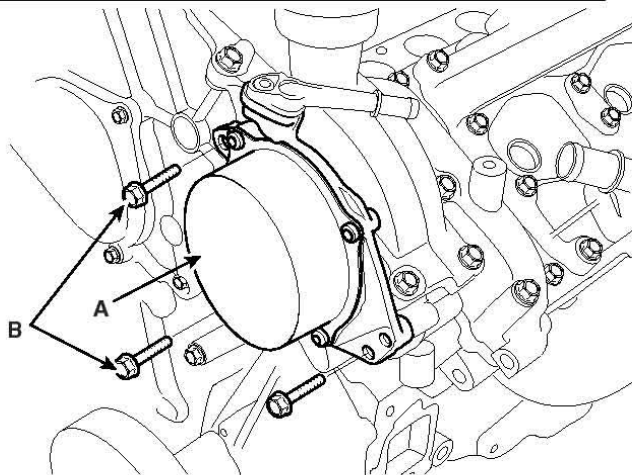
17. Install the water pump (A).

 **NOTICE**

- When reassembling, check if the O-ring is damaged and apply sealant.
- Align the nod of the pump.
- The two bolts (B) of the three mounting ones should be sealed with the LOCTITE.

Tightening Torque:

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



18. Install the engine support bracket (A).

Tightening Torque:

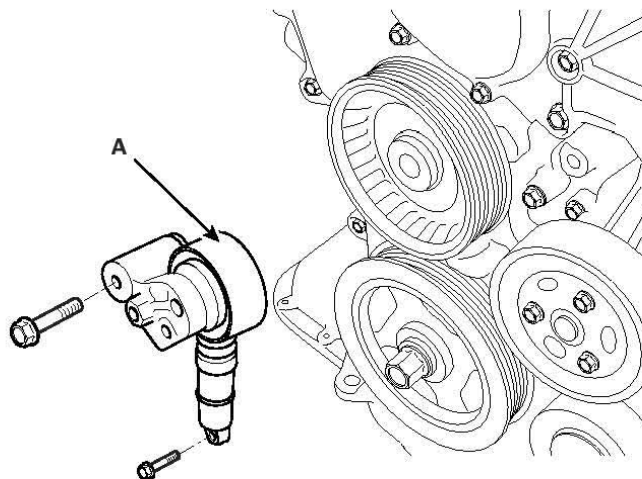
42.2 ~ 53.9Nm (4.3 ~ 5.5kgf.m, 31.1 ~ 39.8lb-ft)

19. 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



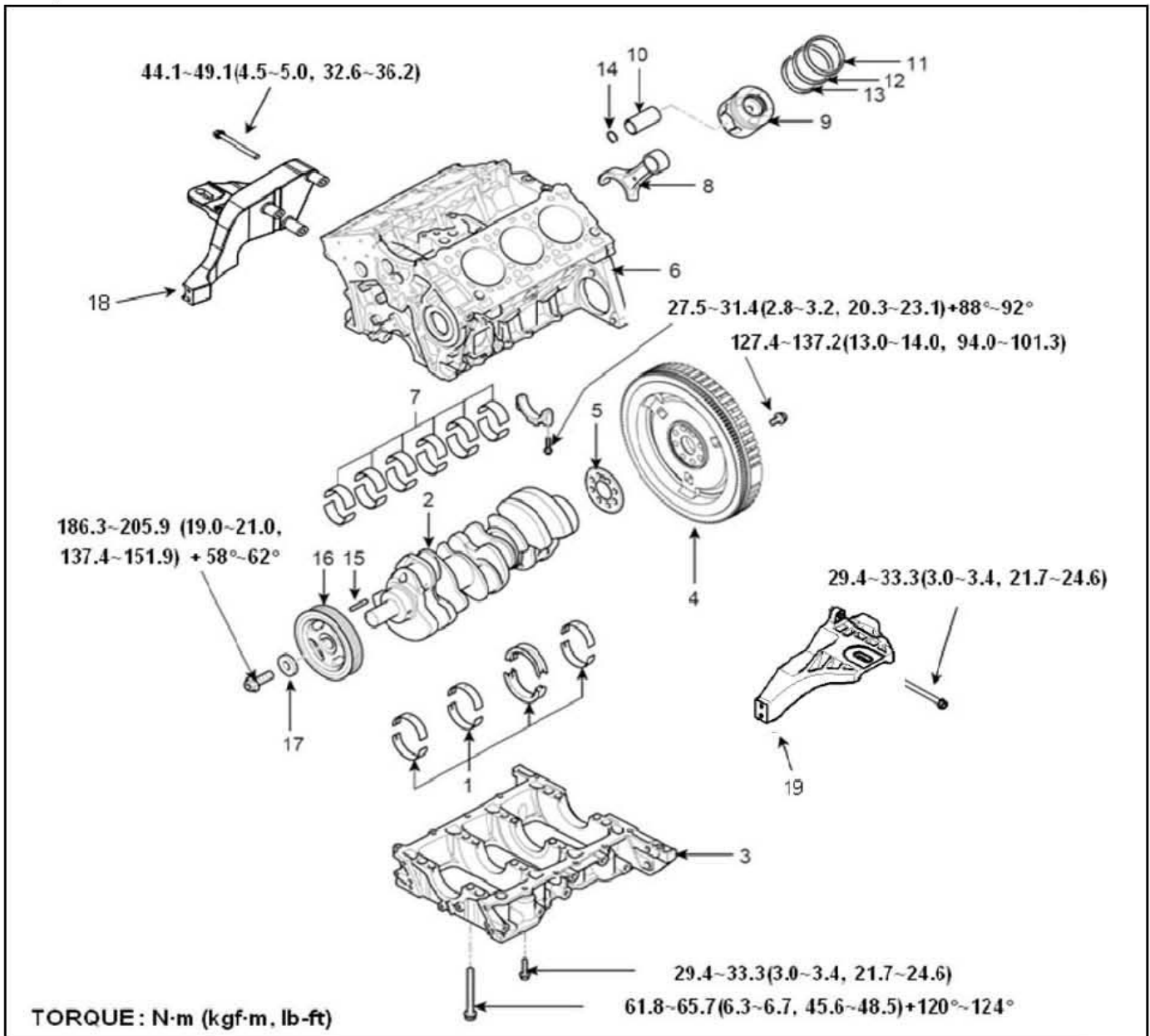
20. Compressing the tensioner with a wrench in a left hand by turning it clockwise, put on the belt lastly with the water pump side idler.

 **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 block

Components



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

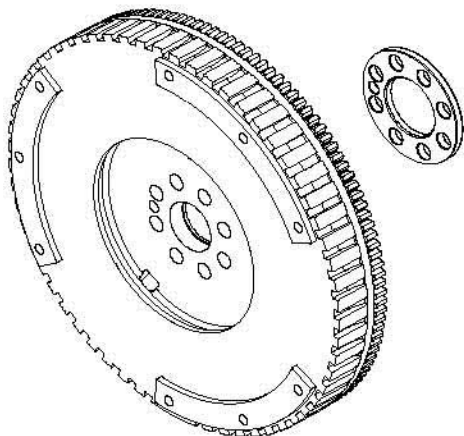
- Keep the connecting rod and the cap with its bearings together.
- Arrange the piston and connecting rod assemblies in the correct order.

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.

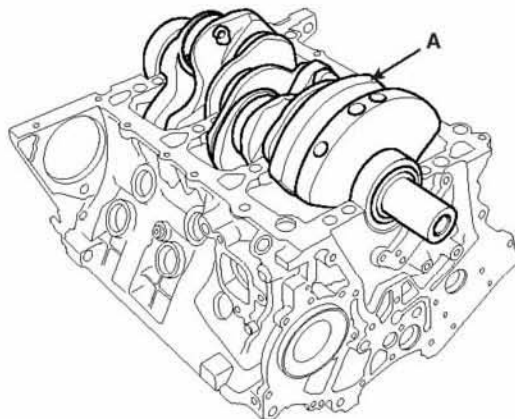
5. Remove the flywheel and flywheel adapter



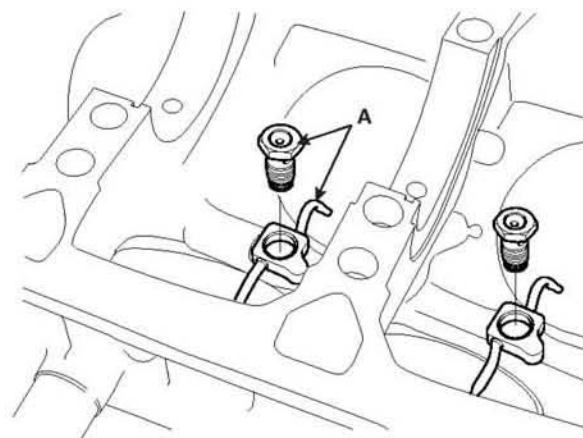
6. Remove the bedplate
7. Lift the crankshaft (A) out of the block, being careful not to damage journals.

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 clearance (mm(in)) (reference value)
A	A	Red	0.029~0.052(0.0011~0.0020)
	B	Red	0.035~0.058(0.0013~0.0023)
	C	Yellow	0.033~0.056(0.0012~0.0022)
B	A	Red	0.035~0.058(0.0013~0.0023)
	B	Yellow	0.033~0.056(0.0012~0.0022)
	C	Yellow	0.039~0.062(0.0015~0.0024)
C	A	Yellow	0.033~0.056(0.0012~0.0022)
	B	Yellow	0.039~0.062(0.0015~0.0024)
	C	Blue	0.037~0.060(0.0014~0.0023)

- 10) If the plastic gauge shows the clearance is still incorrect,

try the larger or smaller bearing. Recheck the oil clearance.

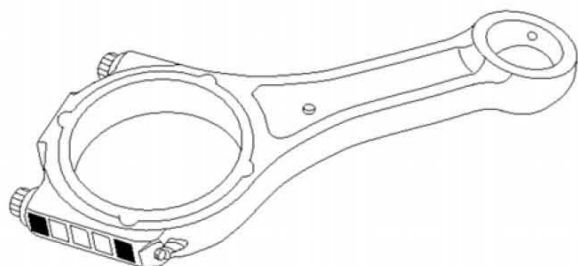
NOTICE

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	66.500~66.506mm (2.6181 ~2.6183in)
B	66.506~66.512mm (2.6183 ~2.6186in)
C	66.512~66.518 (2.6186 ~2.6188in)

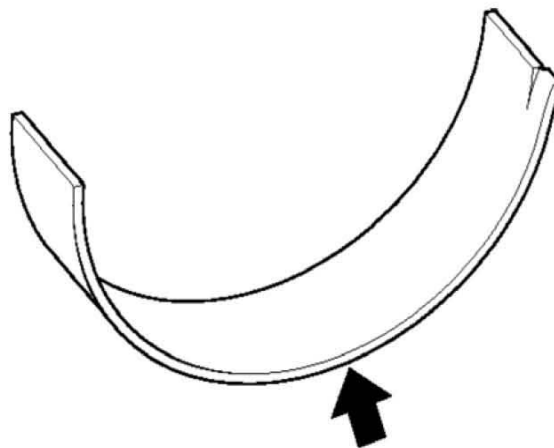
Crankshaft pin journal mark location



Discrimination of Crankshaft Pin Journal

Mark	Crankshaft pin journal outer diameter
A	63.494~63.500mm (2.4998 ~2.500 in)
B	66.488~66.494mm (2.4995 ~2.4998in)
C	66.482~66.488 (2.4993 ~2.4995in)

Connecting Rod Bearing Mark Location



Discrimination of Connecting Rod Upper Bearing

Color	Connecting rod upper bearing thickness
Blue	1.491~1.507mm (0.0587~0.0589 in)
Yellow	1.488~1.495mm (0.0585~0.0588in)
Red	1.475~1.487mm (0.0580~0.0583in)

Discrimination of Connecting Rod Lower Bearing

Color	Connecting rod lower bearing thickness
-	1.458~1.489mm (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:

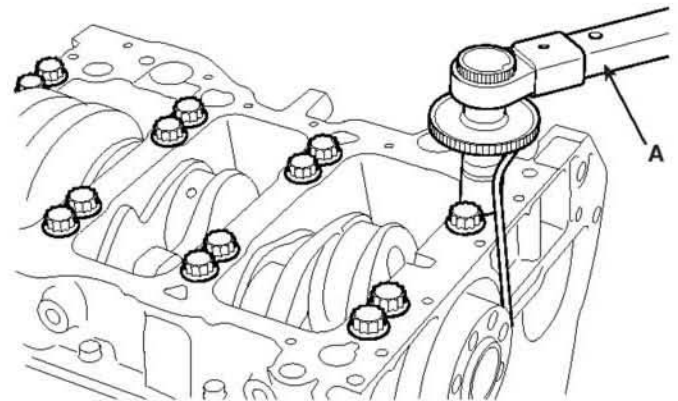
29.4 ~ 33.3Nm (3.0 ~ 3.4kgf.m, 21.7 ~ 24.6lb-ft)

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

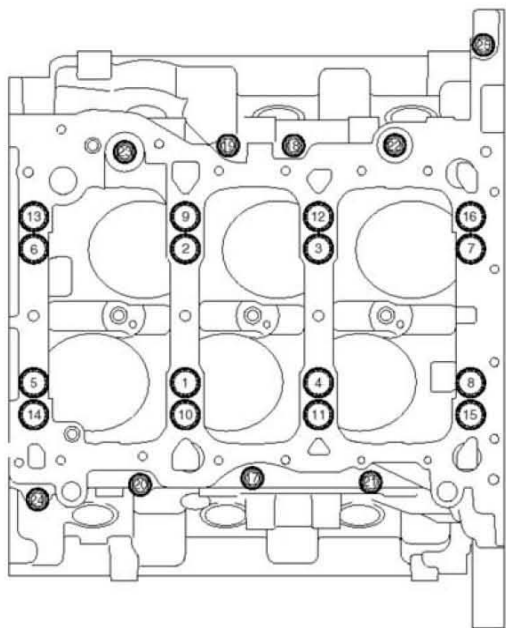


7) Loosen the bolts No. 18, 20 and 21.

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**

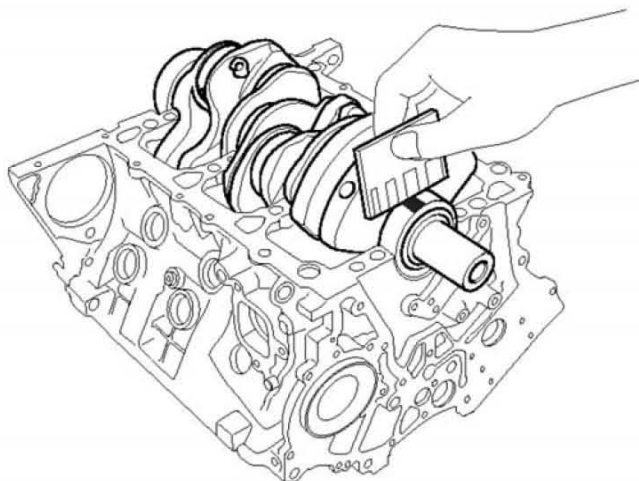
Do not rotate the crankshaft.

- 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.

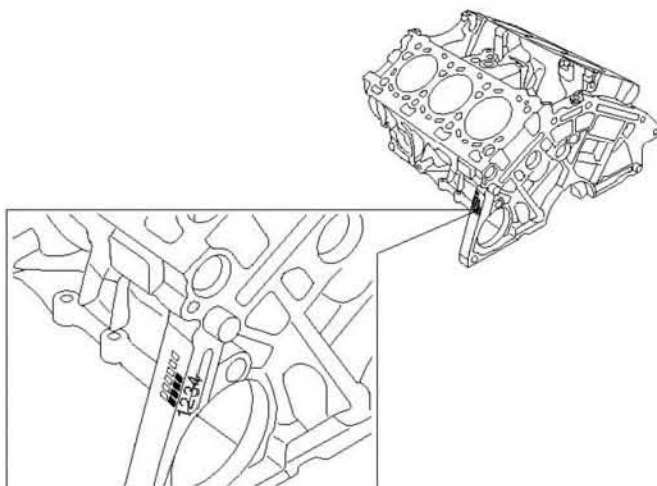
 **NOTICE**

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.

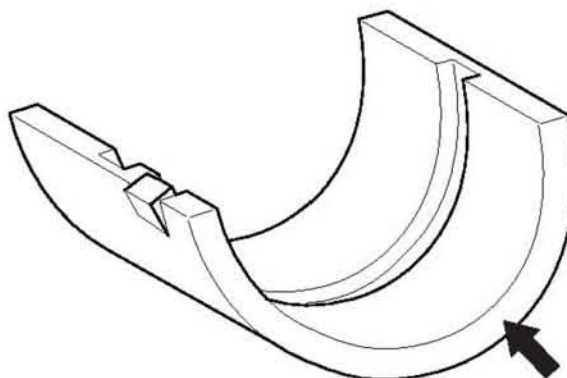
 **CAUTION**

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



Crankshaft Main Bearing Mark Location

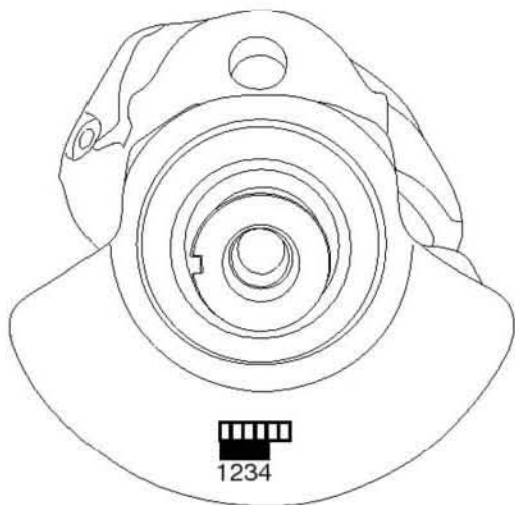


Mark	Cylinder block journal bore inner diameter
A	80.000~80.006mm (3.1496 ~3.1498in)
B	80.006~80.012mm (3.1498 ~3.1501in)
C	80.012~80.018mm (3.1501 ~3.1503in)

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)

Crankshaft Main Journal Mark Location



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

Crankshaft Main Bearing Selection Table

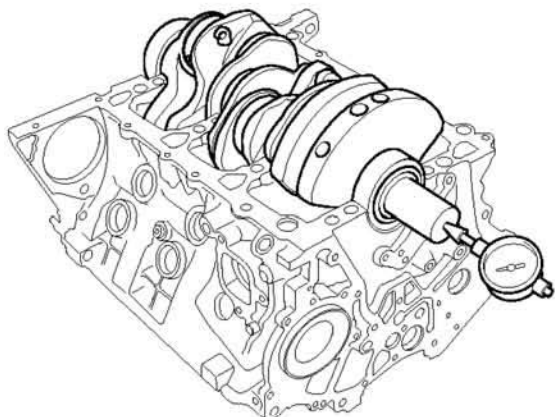
Crankshaft main bearing		Crankshaft bore mark		
		A	B	C
Crankshaft main journal mark	A	Green	Yellow	-
	B	Yellow	-	Blue
	C	-	Blue	Red

Mark	Crankshaft main journal outer diameter
A	75.994~76.000mm (2.9919 ~2.9921in)
B	75.998~75.994mm (2.9916 ~2.9919in)
C	80.012~80.018mm (3.1500 ~3.1503in)

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.

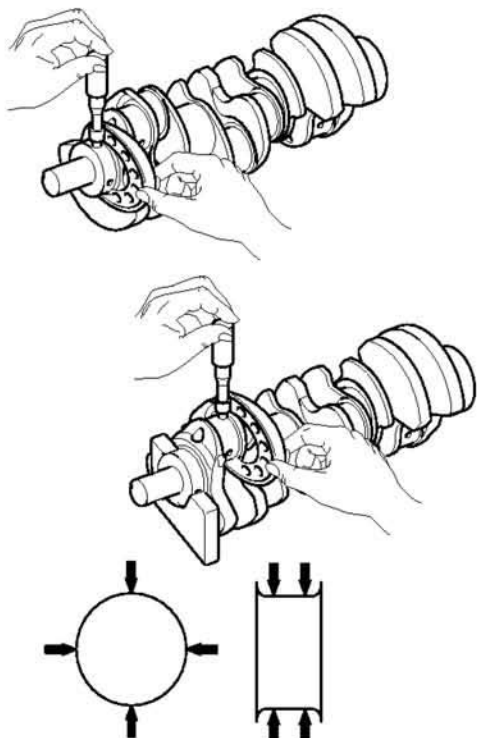
Using a micrometer, measure the diameter of each main journal and pin journal.

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.

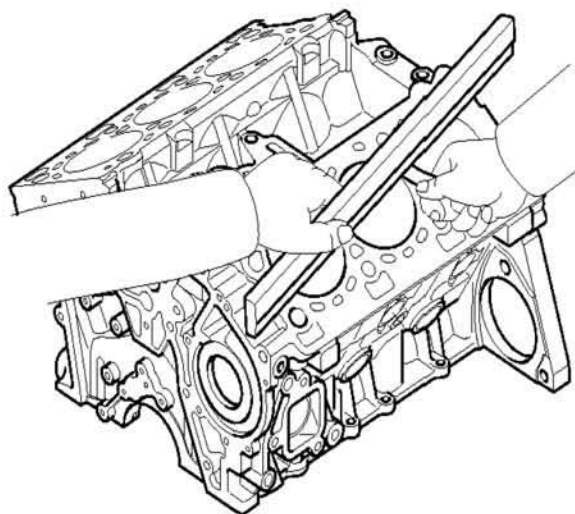
Flatness of cylinder block gasket surface

Less than 0.05mm (0.0020in)

Less than 0.042mm (0.0017in) for width

Less than 0.096mm (0.0038in) for length

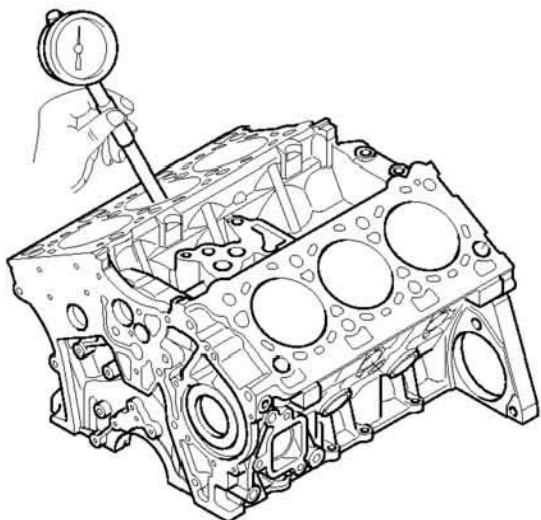
Less than 0.012mm (0.0005in) for 50mm × 50mm



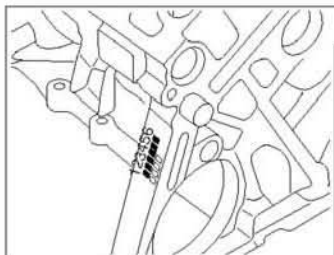
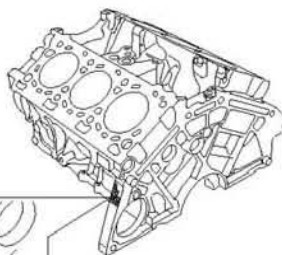
4. Inspect the cylinder bore. Visually check the cylinder for vertical scratch. If deep scratch is present, replace the cylinder block.
5. Inspect the cylinder bore diameter. Using a cylinder bore gauge, measure the cylinder bore diameter at position in a thrust and an axial direction.

Standard diameter:

84.000 ~ 84.030mm (3.3071 ~ 3.3083in)



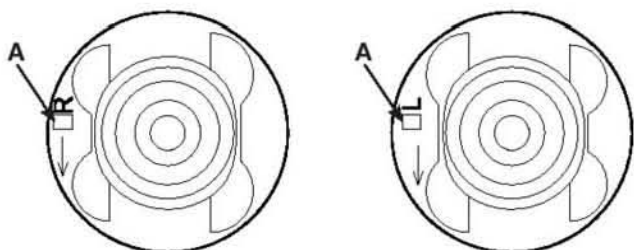
6. Check the cylinder bore size code on the cylinder block side face.



Discrimination of Cylinder Bore Size

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

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



Discrimination of Piston Outer Diameter

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

8. Select the piston related to cylinder bore class.

Piston-to-cylinder clearance:

0.064 ~ 0.084mm (0.0025 ~ 0.0033in)

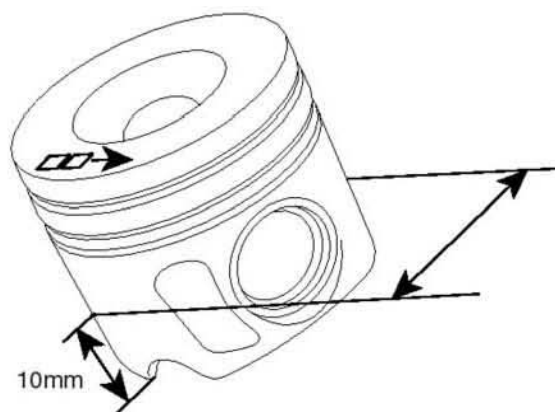
Cylinder Boring

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

- Clean the piston.
 - Using a gasket scraper, remove carbon from the piston top.
 - Using a groove cleaning tool or a broken ring, clean the piston ring grooves.
 - Using a brush with solvent, thoroughly clean the piston.

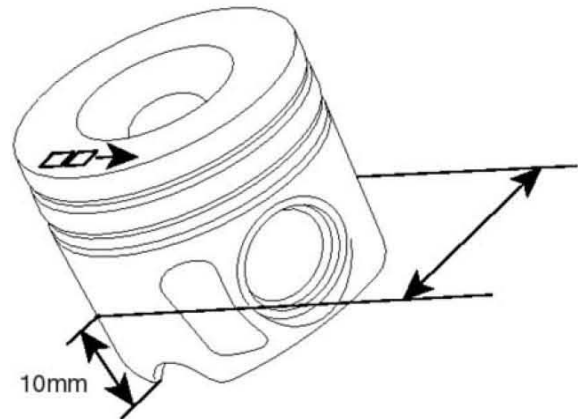
NOTICE

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)

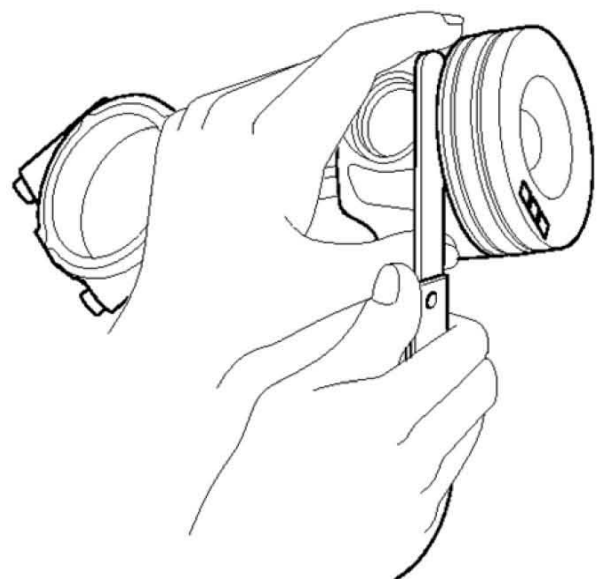
4. Inspect the piston ring side clearance. Using a feeler gauge, measure the clearance between new piston ring and the wall of ring groove.

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.)

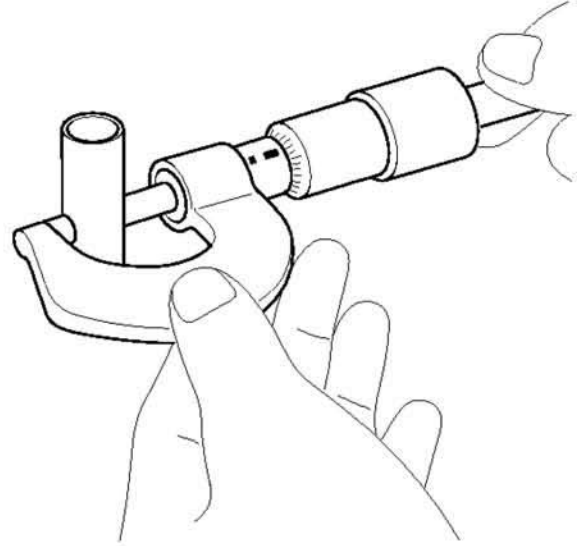
Oil ring: 0.25 ~ 0.50mm (0.0098 ~ 0.0197in.)

Piston Pins

1. Measure the outer diameter of piston pin.

Piston pin diameter:

30.994 ~ 31.000mm (1.2202 ~ 1.2205in)



2. Measure the piston pin-to-piston clearance.

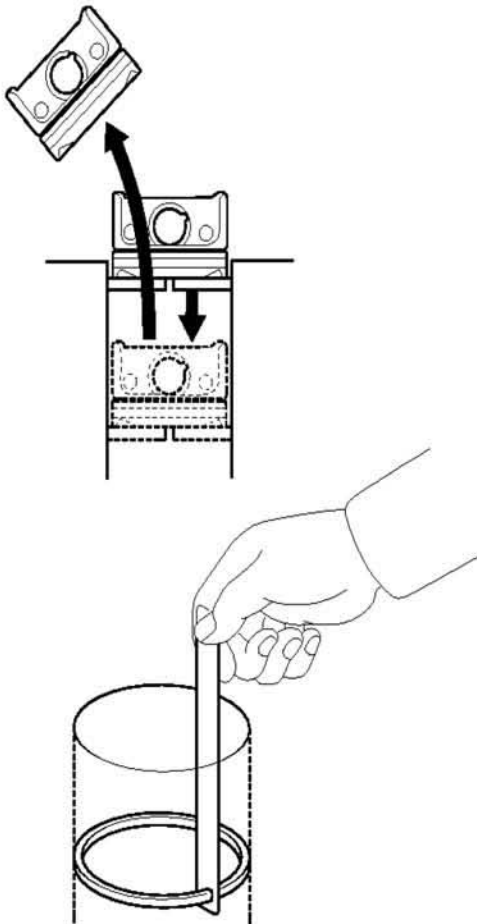
Piston pin-to-piston clearance:

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)



Reassembly

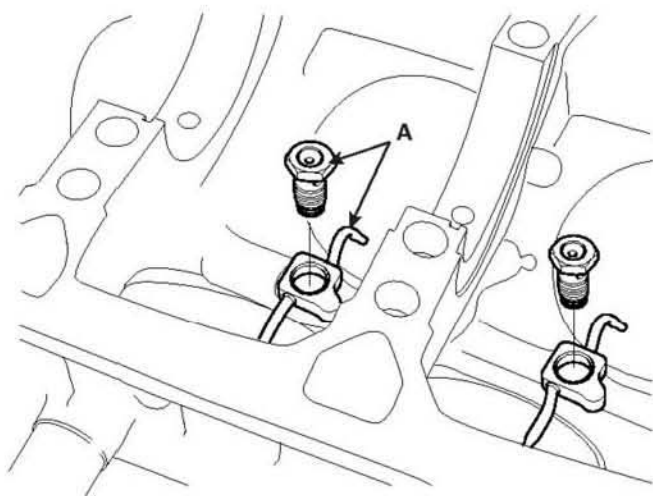
 NOTICE

- 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.

1. Install the oil jet (A).

Tightening Torque:

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

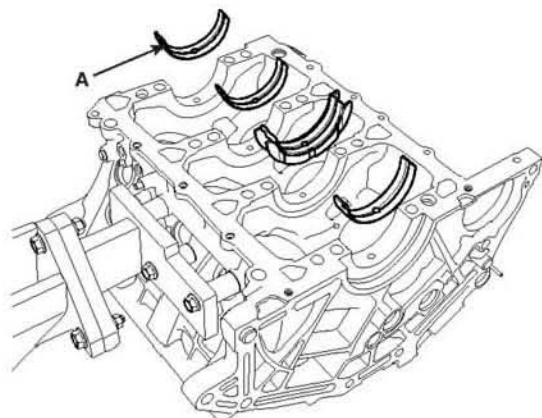


2. Install the crankshaft main bearings(A).

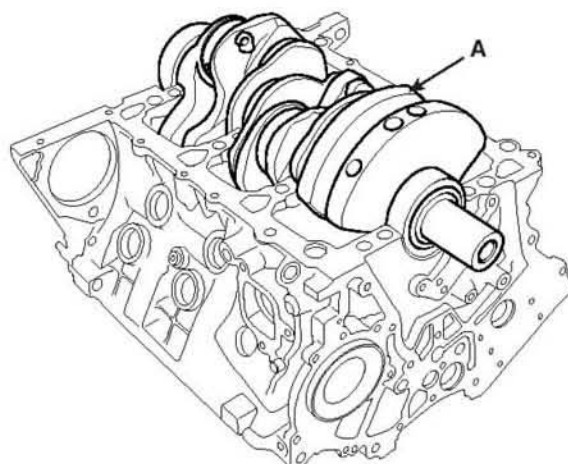
 NOTICE

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

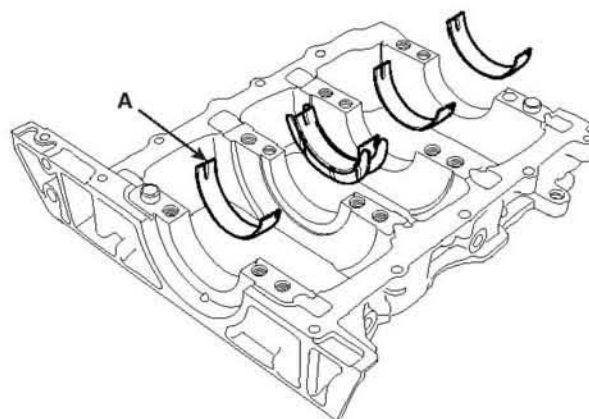
1) Aligning the bearing claw with the groove of the cylinder block, push in the four upper bearings (A). Apply oil on the bearings at this moment.



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



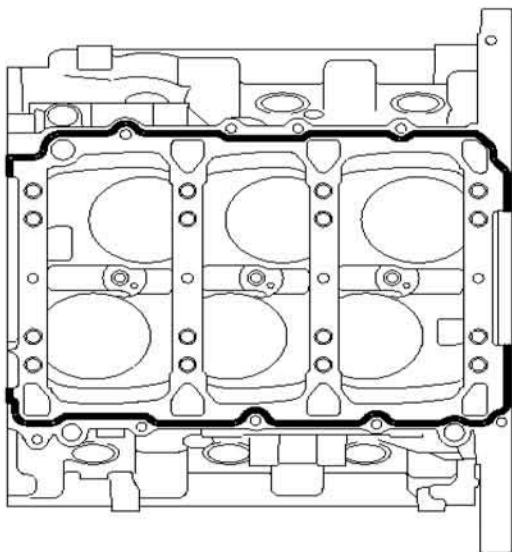
4. Aligning the bearing claw with the groove of the bedplate, push in the four lower bearings (A). Apply oil on the bearings at this moment.



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:

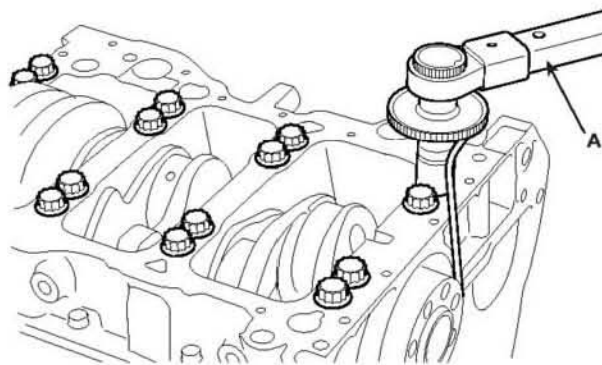
29.4 ~ 33.3Nm (3.0 ~ 3.4kgf.m, 21.7 ~ 24.6lb-ft)

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

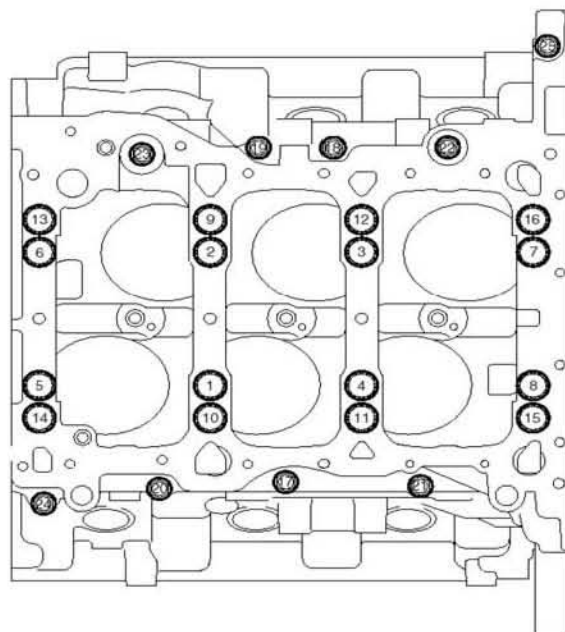


3) Loosen the bolts No. 18, 20 and 21.

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

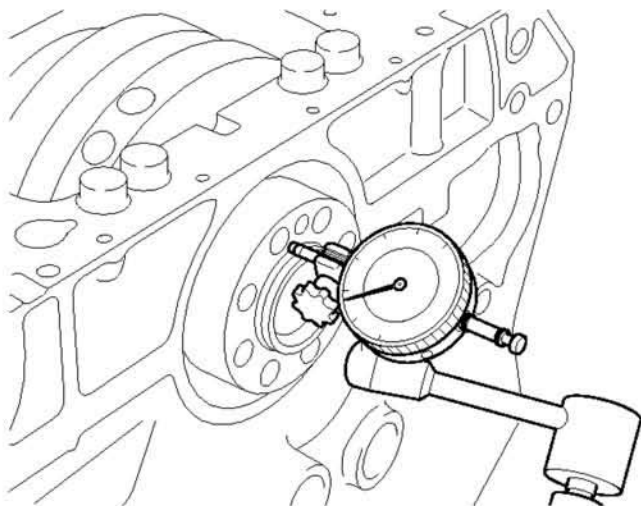


5) Check that the crankshaft rotates smoothly.

7. Check the crankshaft end play, using a dial indicator.

Endplay

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

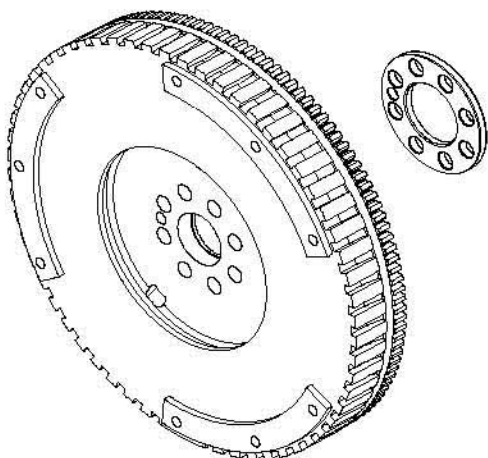


8. Using the SST (09231-H1210, 09231-H1100) and a plastic hammer, tap in a new oil seal (A) until SST surface is flush with the cylinder block. At this time, the depth of the oil seal (A) from the cylinder block surface is 0.8mm (0.032in).

9. Install the flywheel and flywheel adapter

Tightening Torque:

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

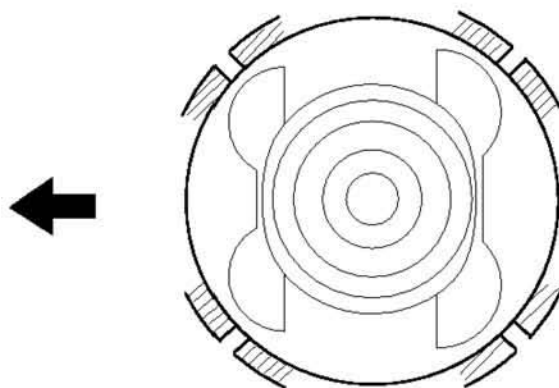


10. Install the piston rings.

- 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

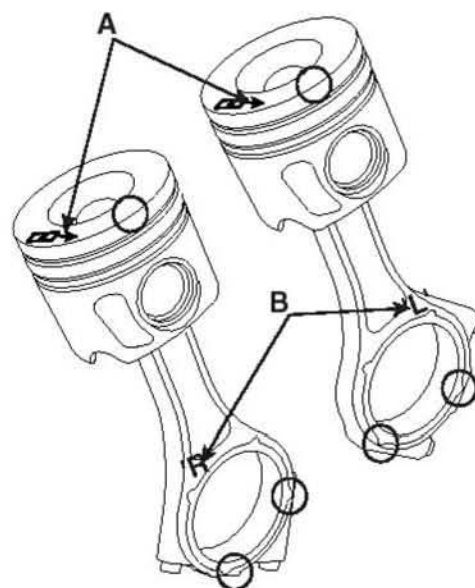
with 180° to that of coil spring and 90° to hat of No.1 ring.


- 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 hole 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.



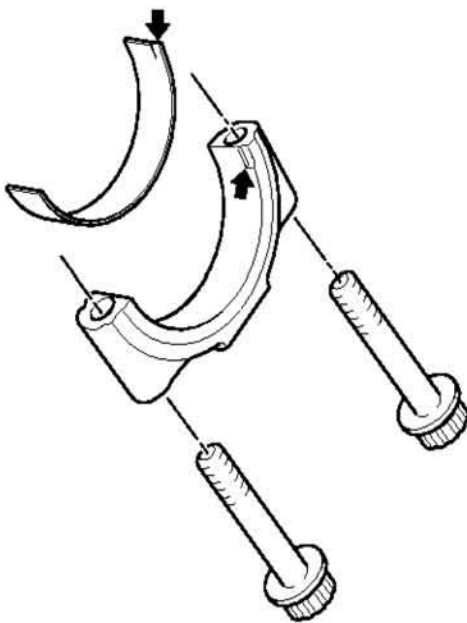
 **NOTICE**

Marking the parts at the 'o' 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.



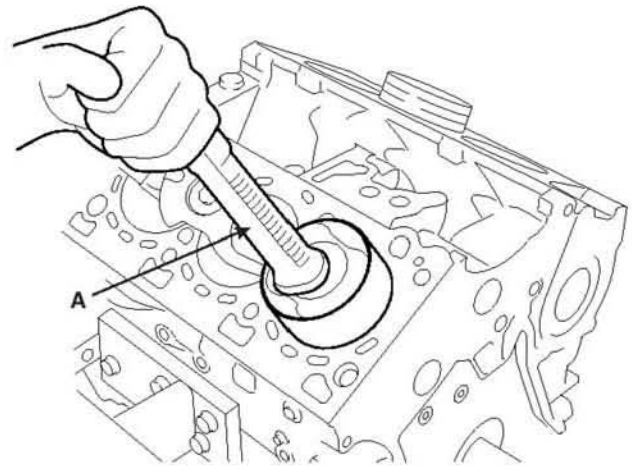
13. Install the piston and connecting rod assembly.

 **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:

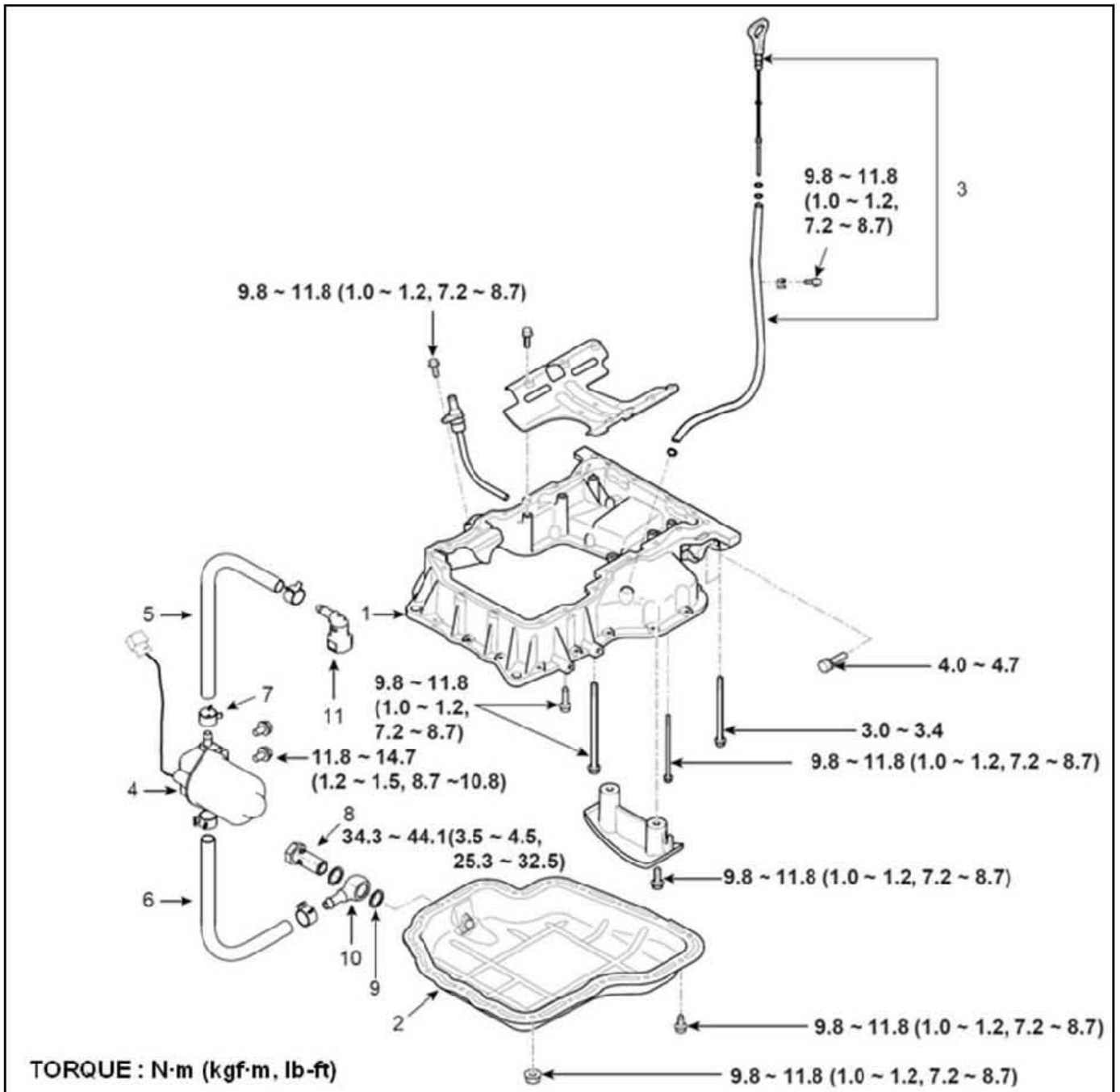
27.5 ~ 31.4Nm (2.8 ~ 3.2kgf.m, 20.3 ~ 23.1lb-ft) + 88°~92°

 **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

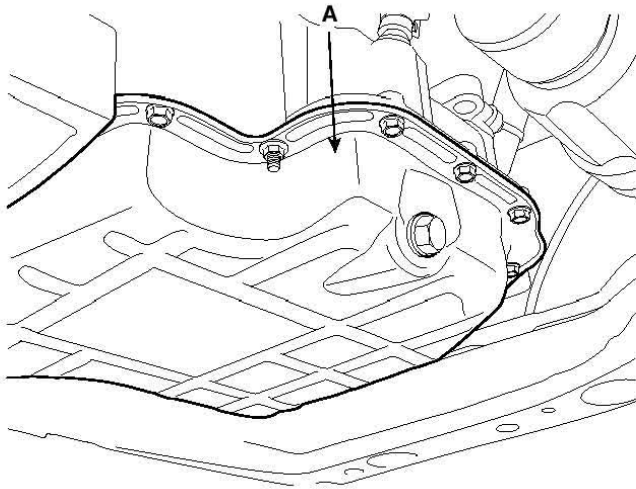


- | | | |
|-----------------------------|--------------------|-------------------|
| 1. Upper oil pan | 5. Hose-oil outlet | 9. Washer – Plain |
| 2. Lower oil pan | 6. Hose-oil inlet | 10. Joint- i |
| 3. Oil level gauge assembly | 7. Ear Clamp | 11. Q-connector |
| 4. Oil extraction pump | 8. Bolt-i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

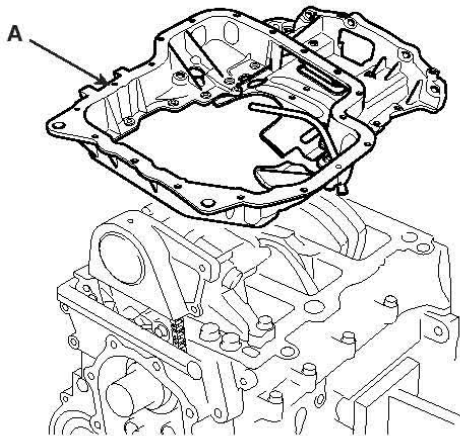


Removal

1. Remove the lower oil pan (A).

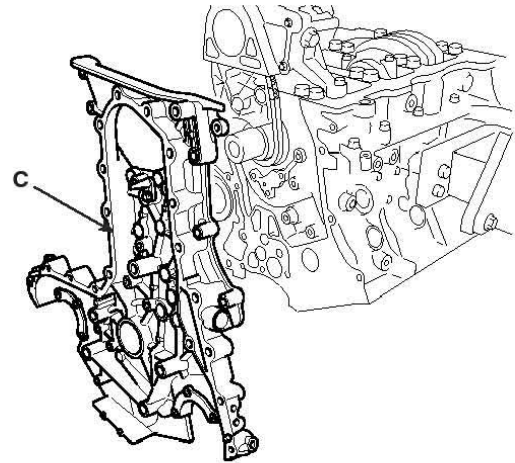
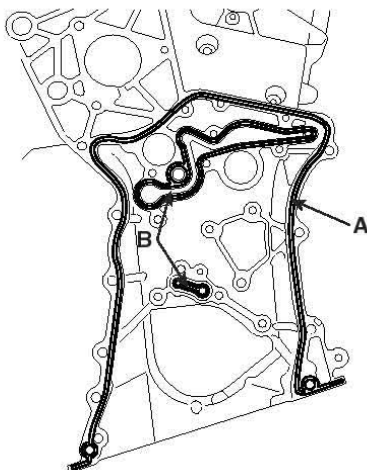


2. Remove the upper oil pan (A).



Installation

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.



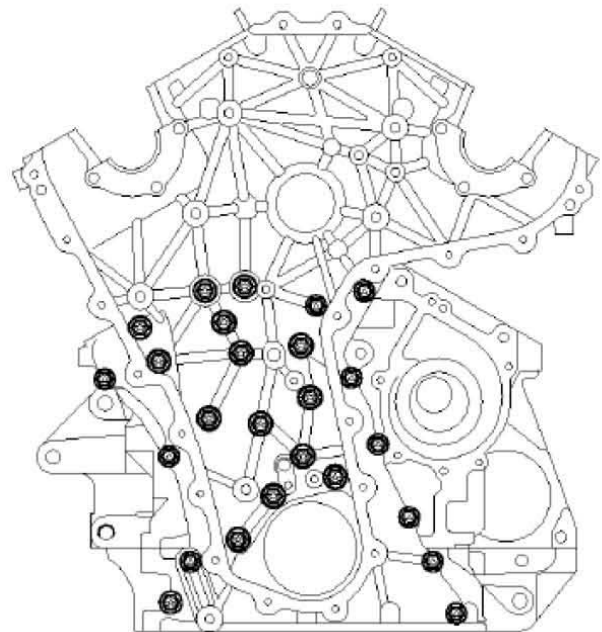
3. Tighten the mounting bolts of the chain case with the specified torque below.

Tightening torque :

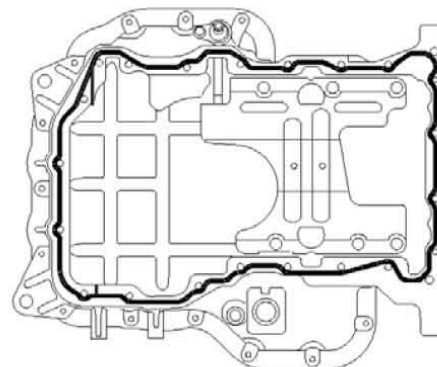
7.8 ~ 11.8Nm (0.8 ~ 1.2kgf.m, 5.8 ~ 8.7lb-ft) - 6×16(★)

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.

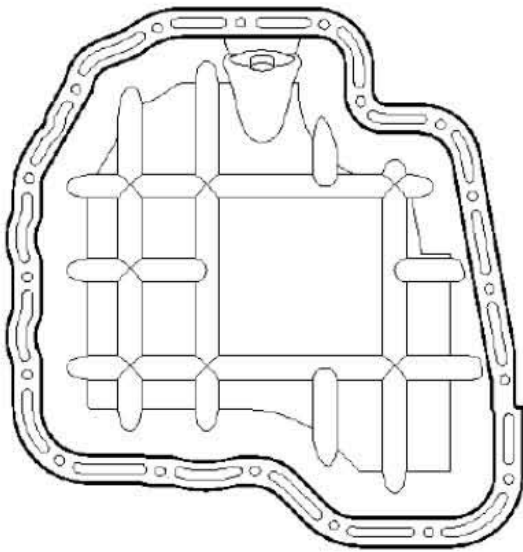


Liquid gasket: LOCTITE 5900 or equivalent

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



Liquid gasket: LOCTITE 5900 or equivalent

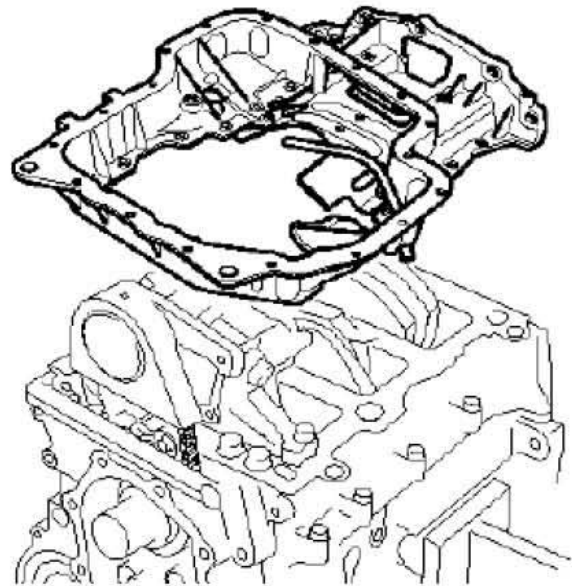
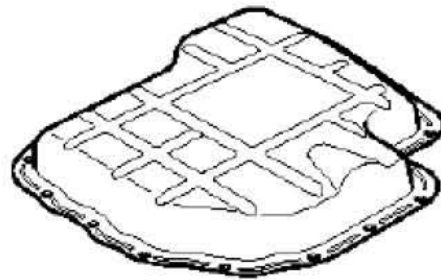
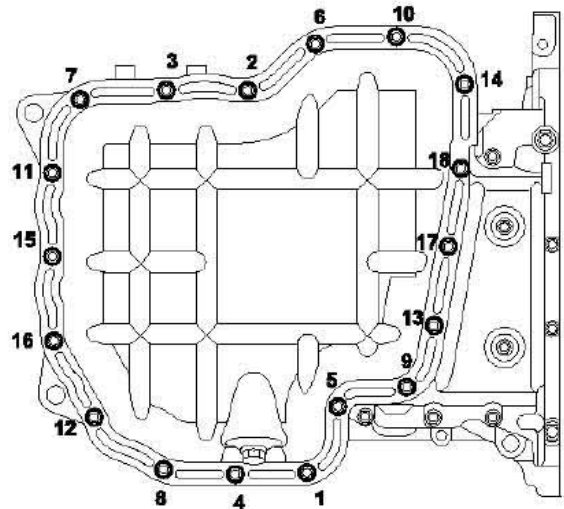
NOTICE

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

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

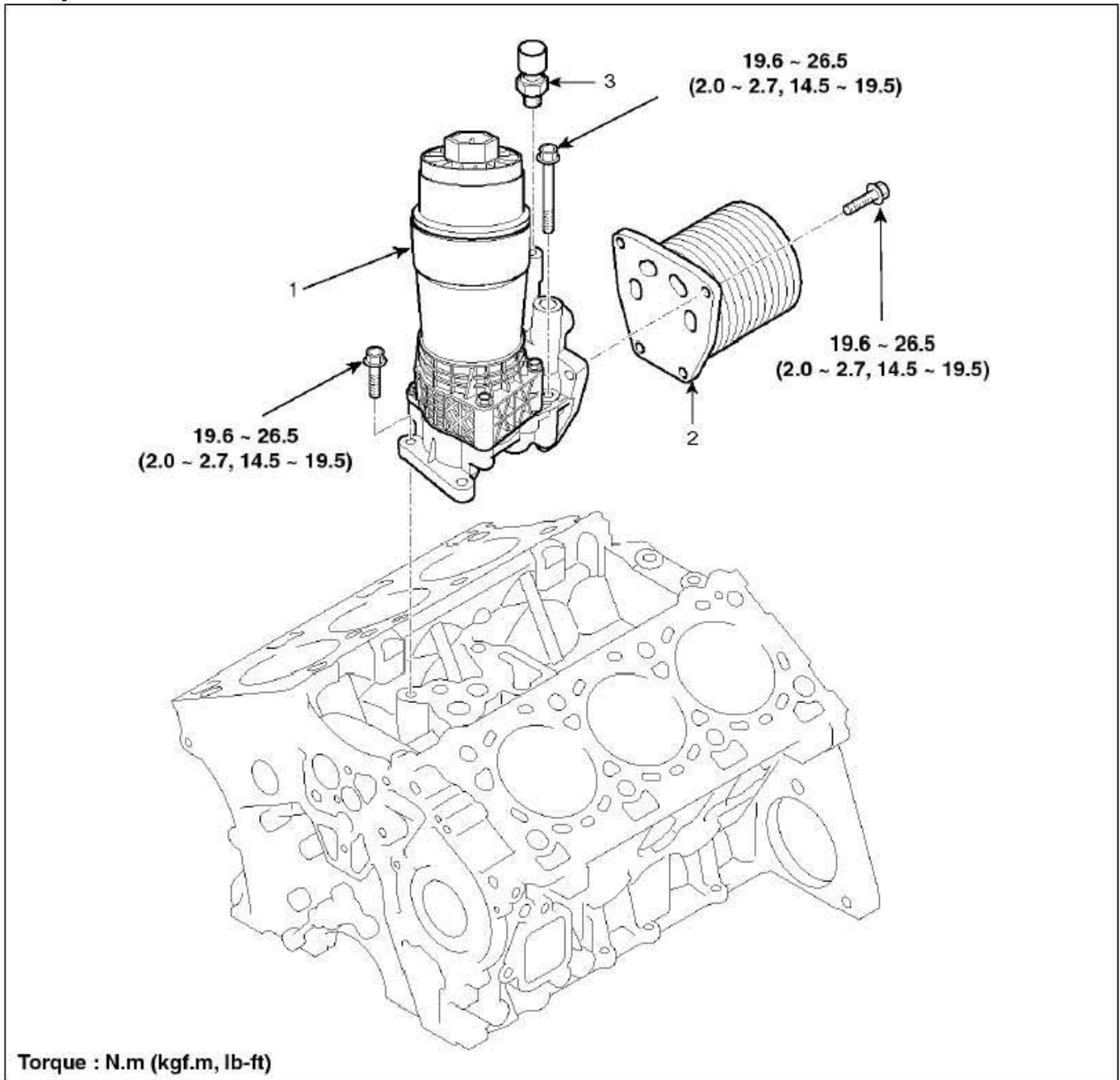
Tightening torque :

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



Oil Cooler

Components



1. Oil filter assembly
2. Oil cooler assembly

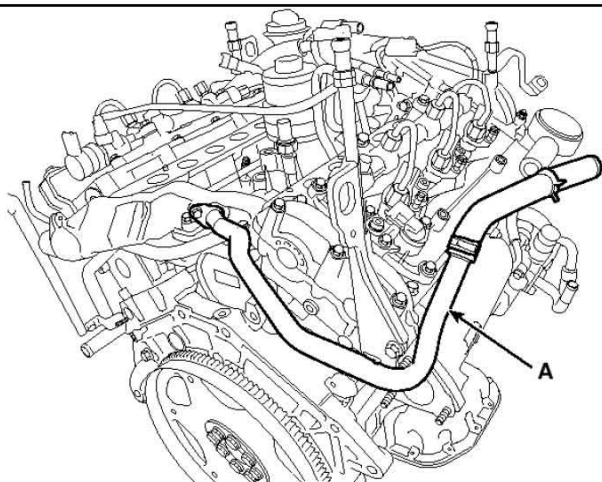
3. Oil pressure sensor

Removal and Installation

1. Remove the intake manifold. (Refer to Intake and exhaust system in this group)
2. Remove the EGR pipe & hose assembly (A).

Tightening torque :

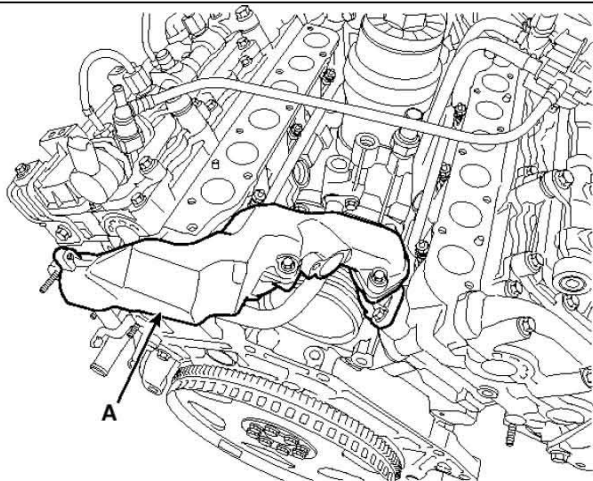
9.8 ~ 11.8N.m (1.0 ~ 1.2kgf.m, 7.2 ~ 8.7lb-ft)



3. Remove the water outlet duct (A).

Tightening torque :

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



4. Remove the water pipe and hose assembly (A).

Tightening torque :

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

5. Remove the oil filter & cooler assembly (A).

Tightening torque :

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

6. Installation is reverse order of removal.

 **NOTICE**

Check if there are rubber pickings between the oil filter and the block or the oil cooler. If so, apply

engine oil.

Engine Oil**Inspection**

1. Check the engine oil quality. Check the oil deterioration, entry of water, discoloring or 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.

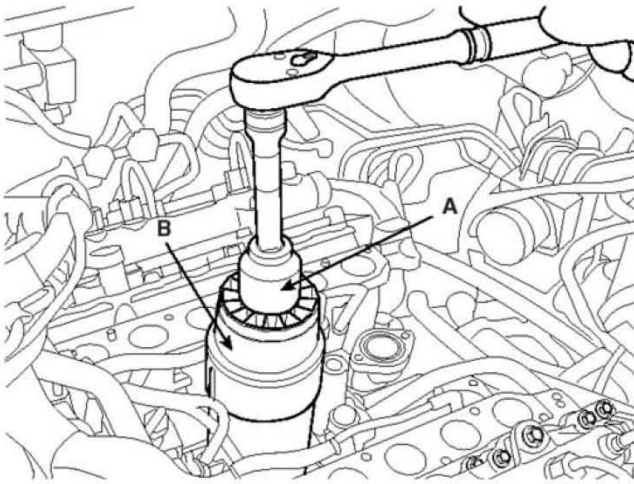
Replacement**Oil and Filter**

 **CAUTION**

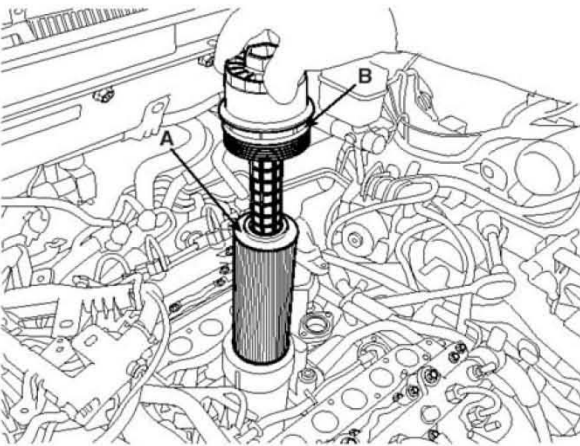
- **Prolonged and repeated contact with mineral oil will result in the removal of natural fats from the skin, leading to dryness, irritation and dermatitis. In addition, used engine oil contains potentially harmful contaminants which may cause skin cancer.**
- **Exercise CAUTION in order to minimize 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, 6.42Imp qts)

When replacing oil pan only:

5.8L (6.13US qt, 5.10Imp qts)

Drain and refill including oil filter:

6.8L (7.19US qt, 6.00Imp qts)



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.

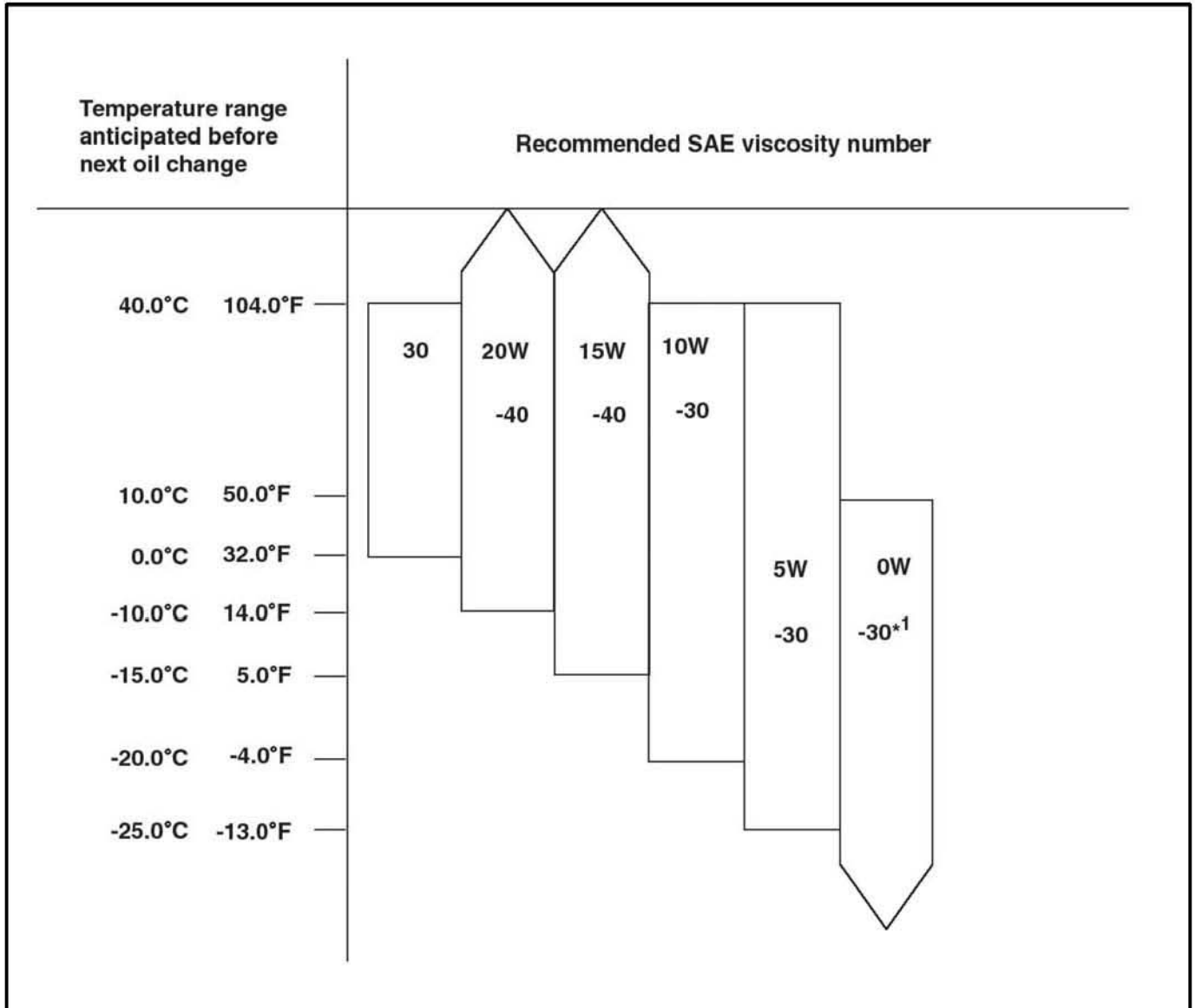
8. Recheck the engine oil level

Inspection**Selection of Engine Oil**

Recommended API classification: CH-4 OR ABOVE

Recommended ACEA classification: B4 OR ABOVE

Recommended SAE classification:

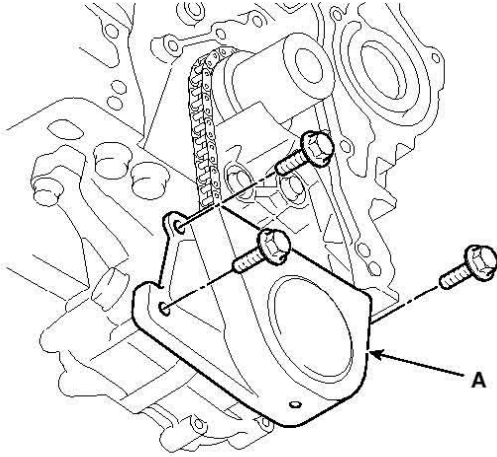
**NOTICE**

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

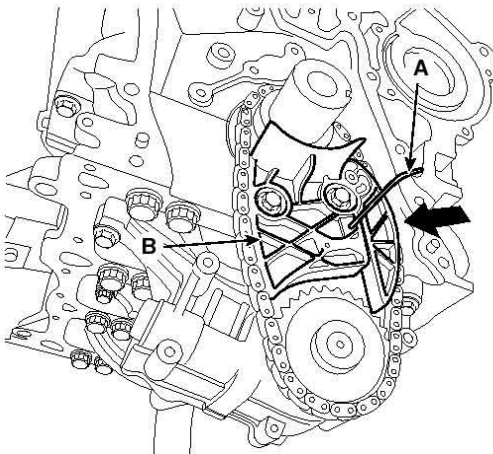
1. Satisfy the requirement of the API or ACEA classification.
2. Have proper SAE grade number for expected ambient temperature range.
3. Lubricants that do not have both an SAE grade number and API service classification on the container should not be used.

Oil Pump**Removal**

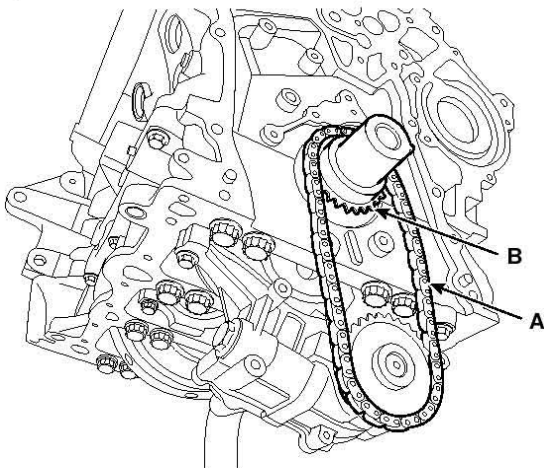
1. Remove the timing chain and chain case assembly
(Refer to Timing system in this group)
2. Remove the baffle plate (A).



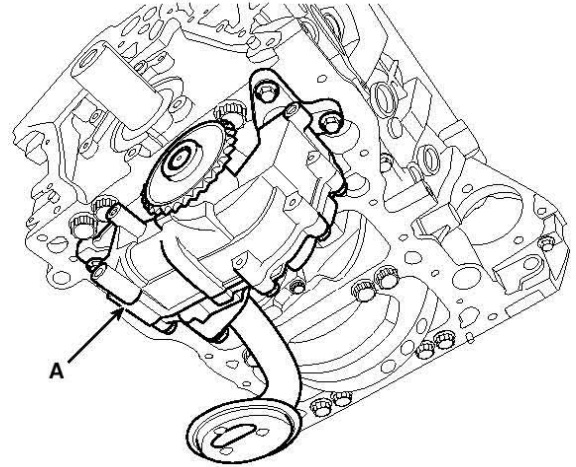
3. Compress the tensioner arrow direction for insert the stopper pin (A) into the tensioner hole, and then remove the oil pump chain tensioner (B).



4. Remove the oil pump chain (A) and crankshaft sprocket (B).



5. Remove the oil pump assembly (A).

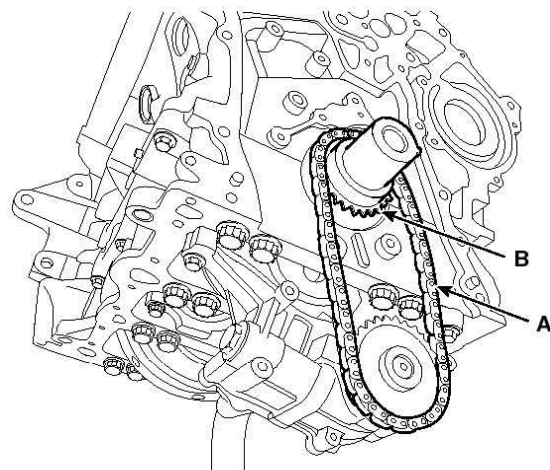
**Installation**

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

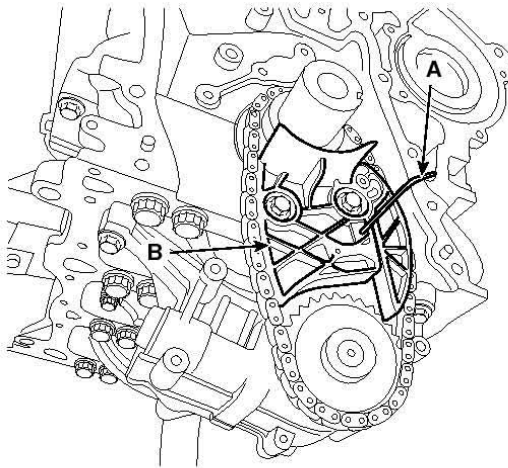
3. Check if the oil pump works properly.
4. With the cylinder block, bed plate, crankshaft piston assembly, connecting rod assembly and the oil pump assembly installed, insert the crankshaft sprocket (B) in the crankshaft, aligning the No.1 piston at the BDC (Bottom Dead Center).
5. Install the oil pump chain (A).



6. Install the oil pump chain tensioner (B) and remove the stopper pin (A) from the tensioner.

Tightening torque :

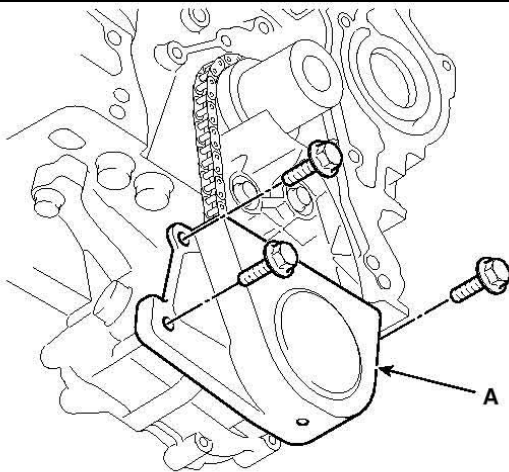
7.8 ~ 11.8N.m (0.8 ~ 1.2kgf.m, 5.8 ~ 8.7lb-ft)



7. Install the baffle plate (A).

Tightening torque :

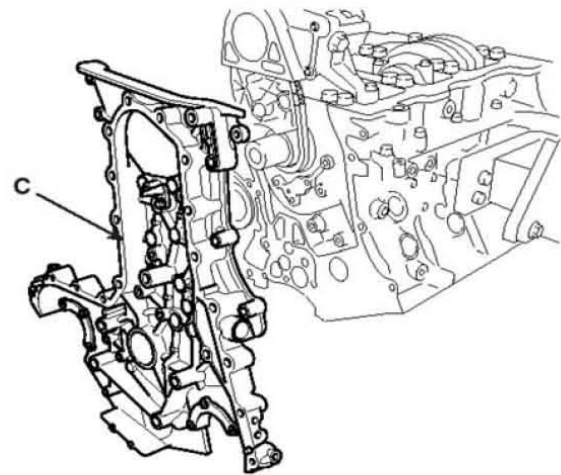
9.8 ~ 11.8N.m (1.0 ~ 1.2kgf.m, 7.2 ~ 8.7lb-ft)



8. Install the timing chain case and timing chain. (Refer to Timing system in this group)

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.



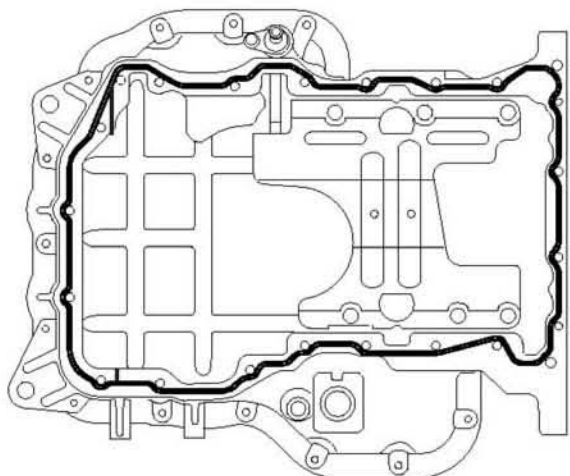
3. Tighten the mounting bolts of the chain case with the specified torque below.

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 5902 or equivalent

NOTICE

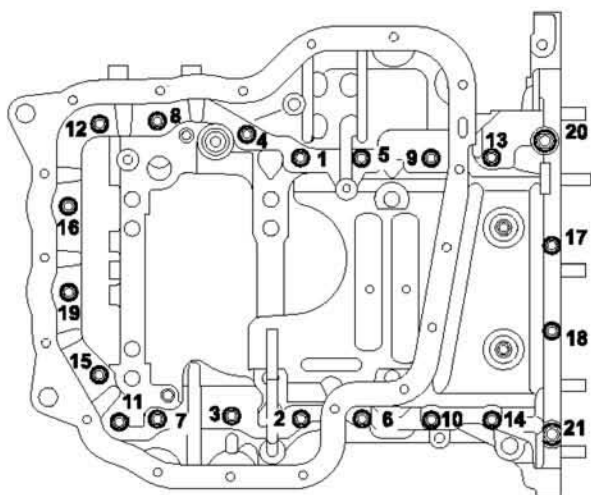
- Apply sealant cautiously to prevent sealant from coming in the oil pan during installation.
- After applying sealant, assemble the oil pan in fifteen minutes.

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

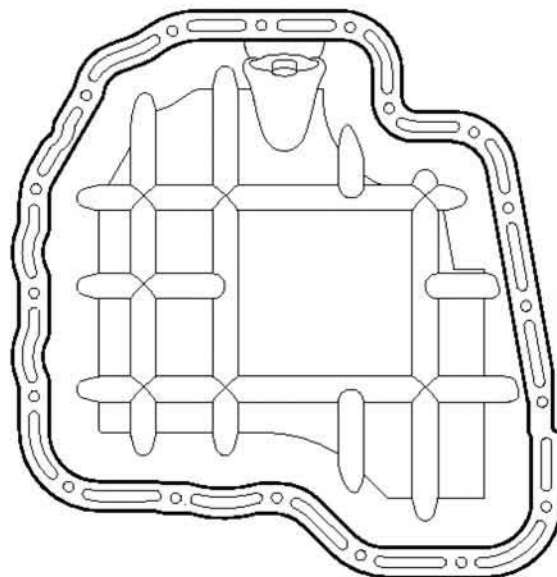
Tightening Torque:

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 5902 or equivalent

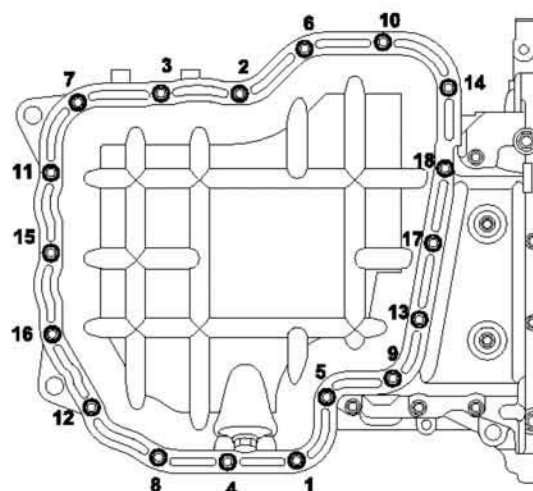
NOTICE

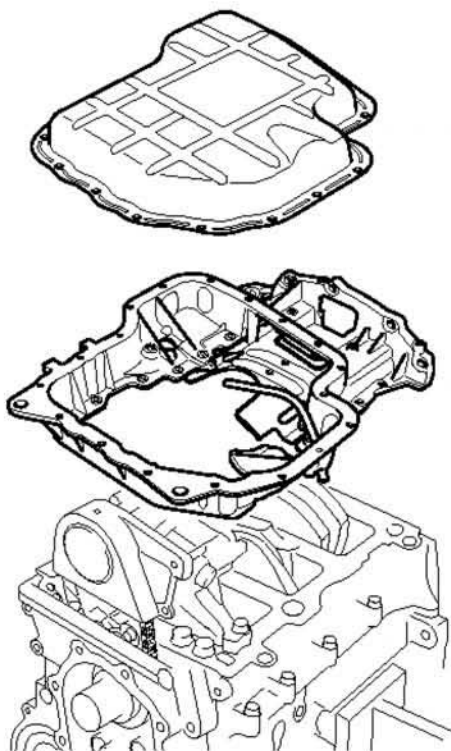
- Apply sealant cautiously to prevent sealant from coming in the oil pan during installation.
- After applying sealant, assemble the oil pan in fifteen minutes.

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)





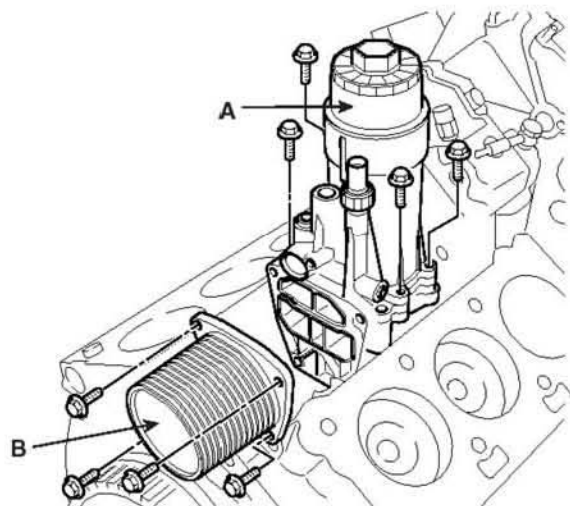
4. Install the water outlet duct and then the intake and exhaust system.

Oil Filter and Cooler Assembly

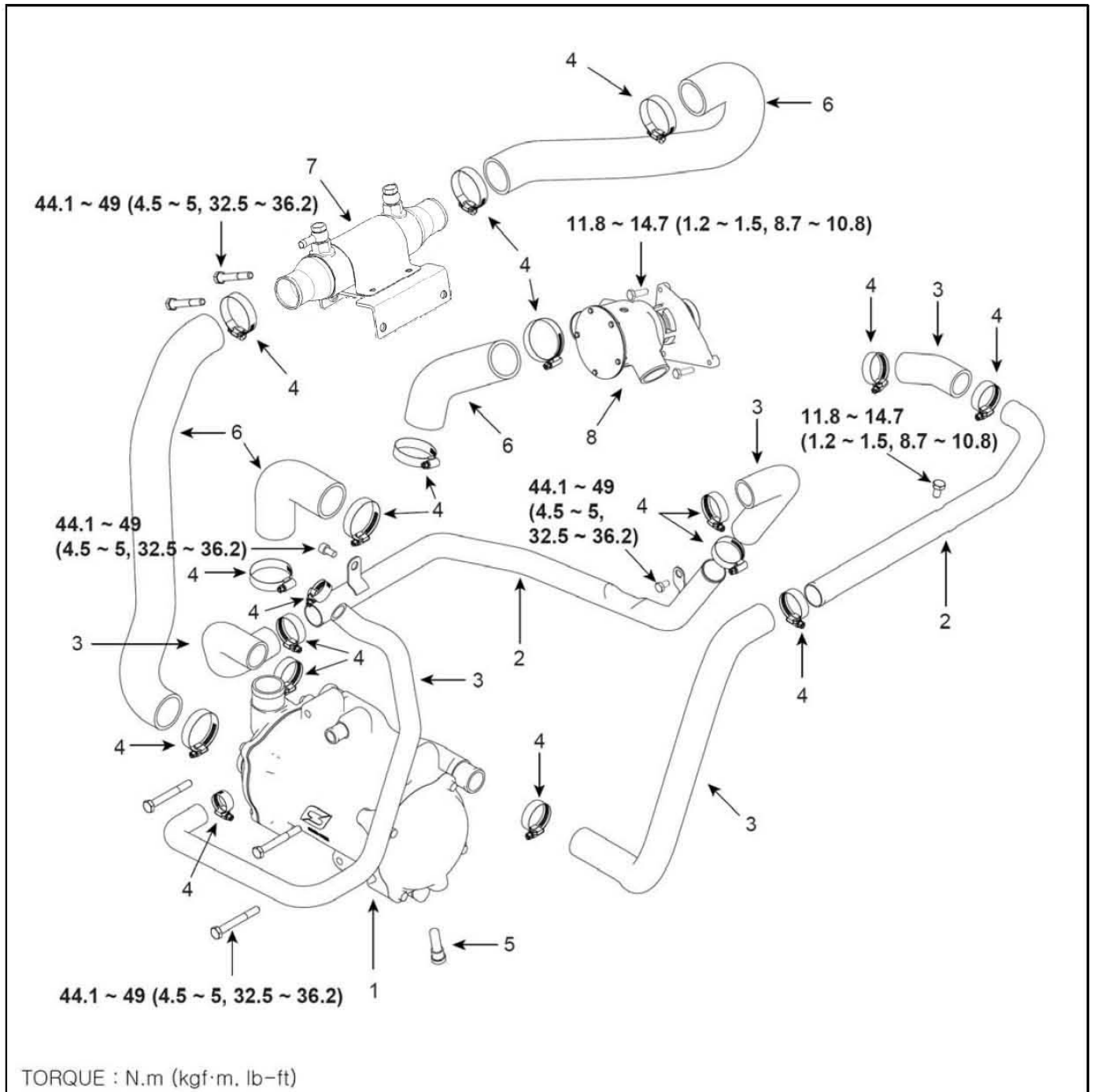
1. Assemble the oil cooler (B) to the oil filter (A).
2. Install the oil filter and cooler assembly to the cylinder block.
3. Check if there is rubber packing between the oil filter and the block or the oil cooler. If so, apply Engine oil.

Tightening Torque:

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



Cooling system
Components



1. Heat exchanger assembly

5. Anode

2. Coolant pipe

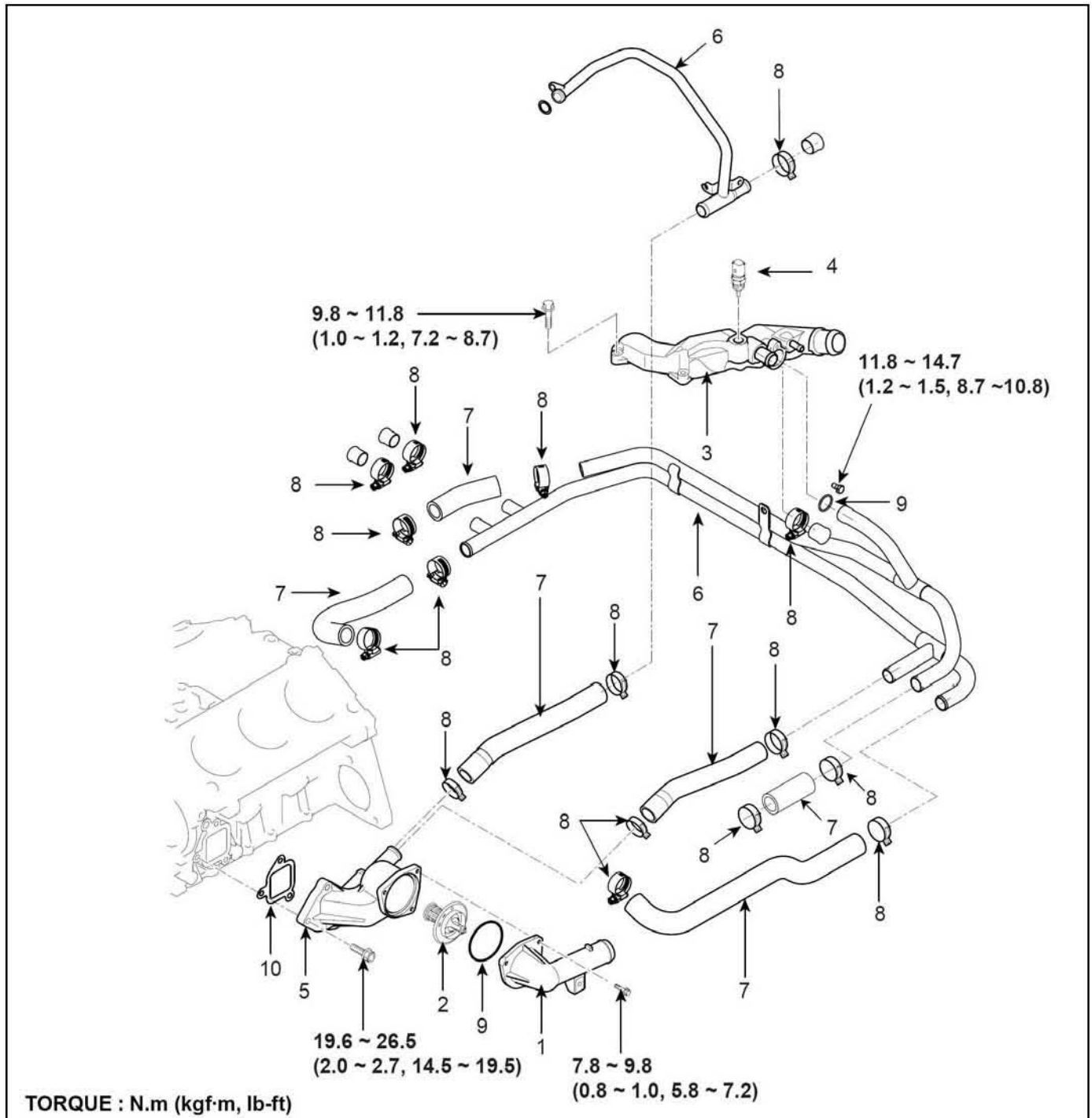
6. Raw water hose

3. Coolant hose

7. Oil cooler assembly

4. Clamp

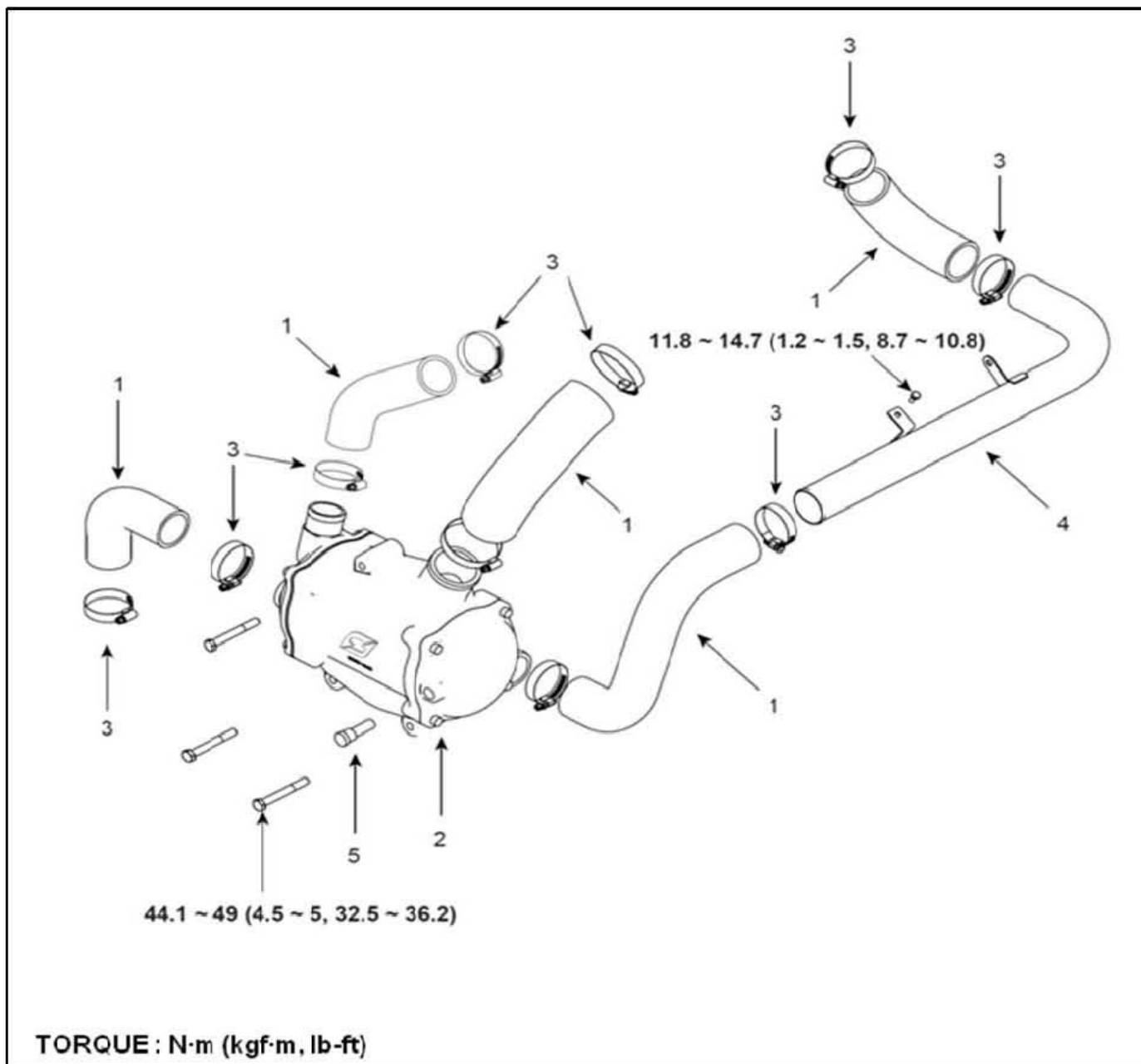
8. Sea water pump



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

Intercooler

Component



1. Intercooler hose

4. Intercooler pipe

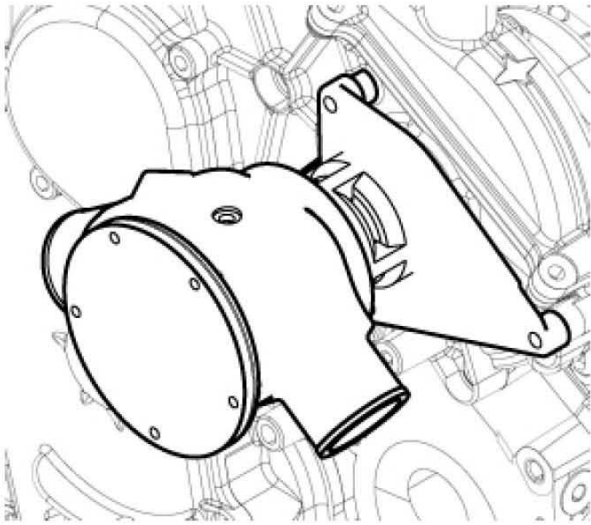
2. Intercooler assembly

5. Anode

3. Clamp



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.

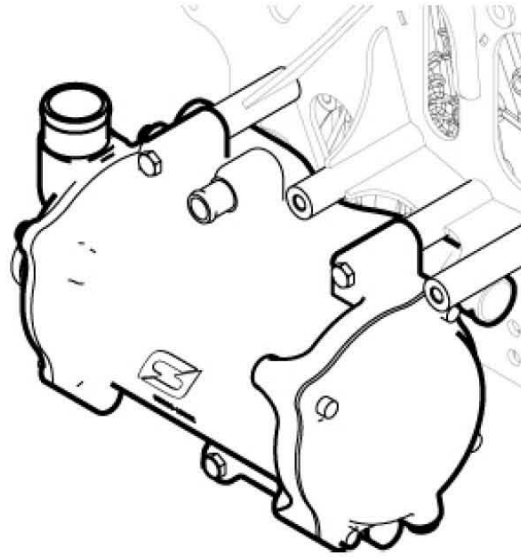
8. Reassemble aligning axis of impeller shaft and engine cam.
9. Apply lubricant O-rings on inserting parts and cover and assembly.

! 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.

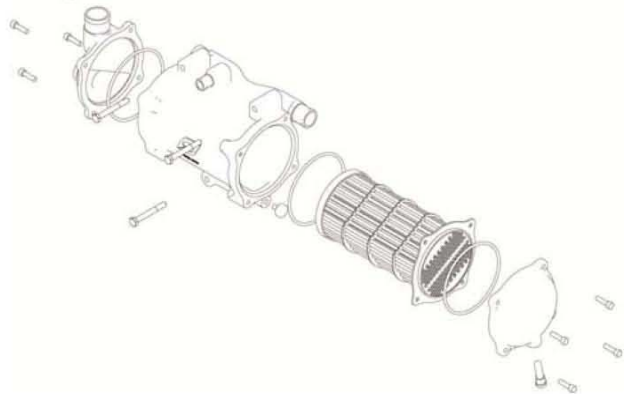
Heat Exchanger



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 disassemble 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)

Water Pump

1. Drain engine coolant

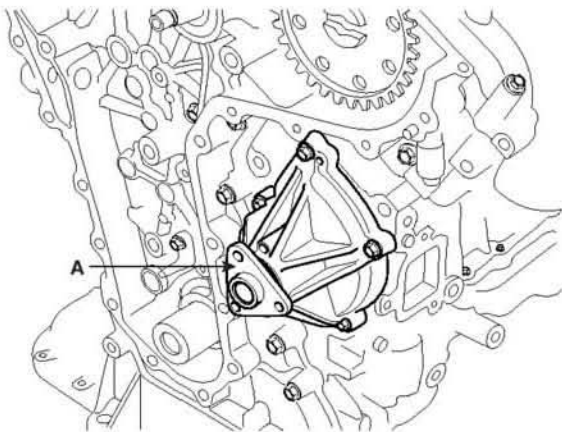
⊗ WARNING

The system is under high pressure when the engine is hot. To avoid danger, 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.

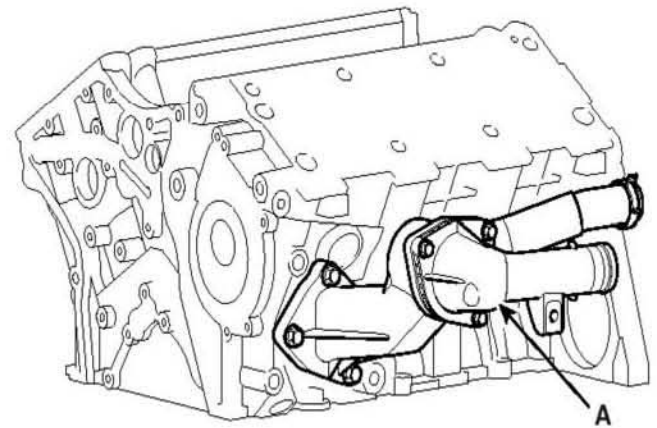
Thermostat**📖 NOTICE**

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)



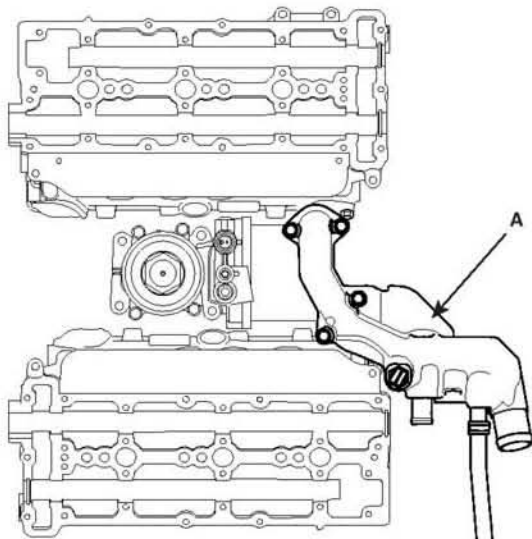
3. Installation is in the reverse order of removal. Water Outlet Duct and Fitting

Water outlet and fitting

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

Tightening torque:

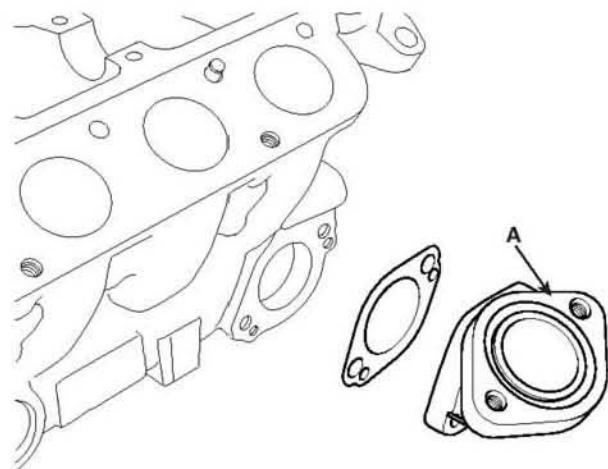
9.8 ~ 11.8Nm (1.0 ~ 1.2kgf.m, 7.2 ~ 8.7lb-ft)



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.

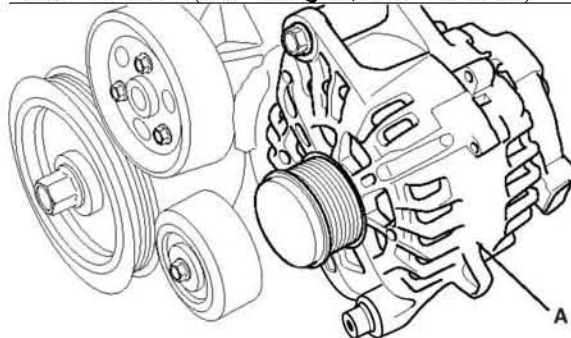
⊗ WARNING

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

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

Tightening torque:

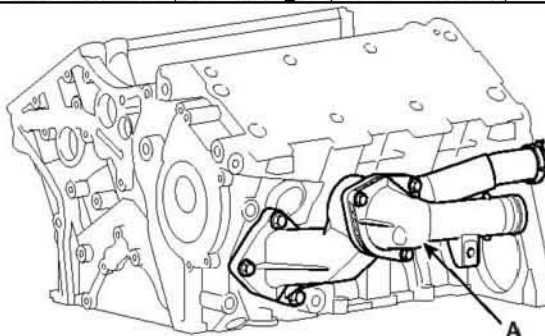
29.4 ~ 41.2Nm (3.0 ~ 4.2kgf.m, 21.7 ~ 30.4lb-ft)



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.

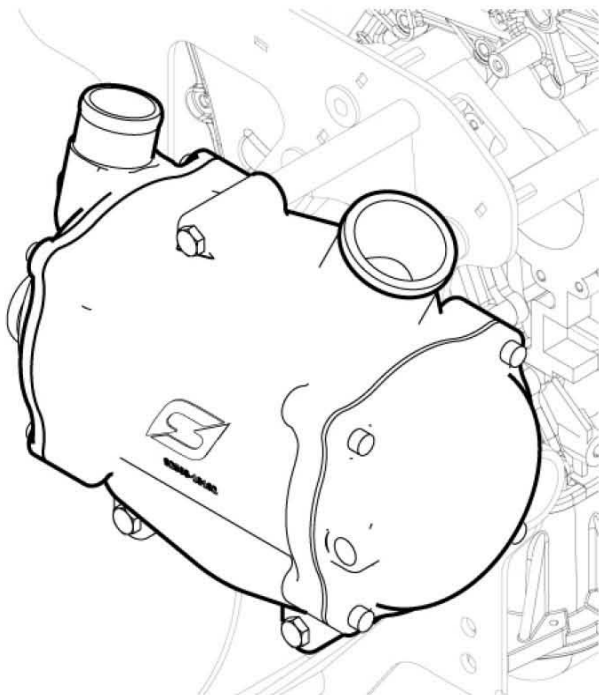
Check Engine Coolant Level at Reservoir

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

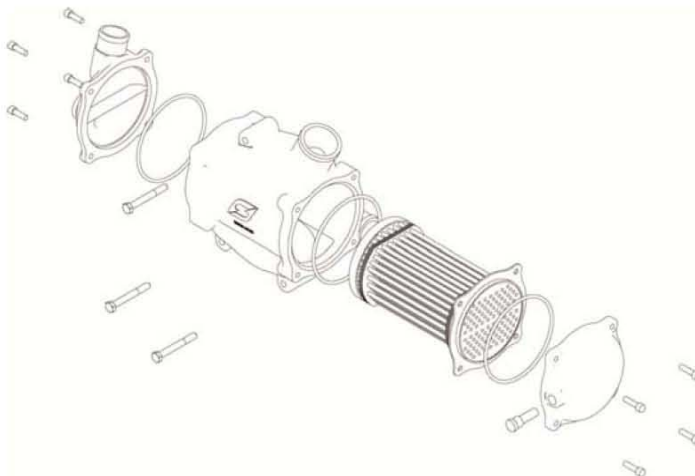
1. Wait until engine is cool, and then carefully remove the cap.
2. Check if there is any excessive deposit of rust or scale around the cap.
3. If excessive dirty, clean the cooling system and replace coolant.
4. Reinstall the cap.

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.

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.	<ul style="list-style-type: none"> •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 gasket or bolts		Check the tightening of the water pump mounting bolts	Retighten the mounting bolts.
	From outer surface of water pump		Check damage of gaskets or inflow of dust.	Replace the gasket and clean dust off.
			Check the material or any cracks of the water pump.	Poor material. If any crack found, replace the water pump.
Noise	<ul style="list-style-type: none"> •From bearings •From mechanical seals •Impeller interference 	Inspection with stethoscope	After starting the engine, check noise with a stethoscope.	<ul style="list-style-type: none"> •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.	<ul style="list-style-type: none"> •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	<ul style="list-style-type: none"> •Damaged impeller •Loosened impeller 	Loosened impeller	•Corrosion of the impeller wing	<ul style="list-style-type: none"> •Check engine coolant. •Poor coolant quality/ Maintenance check.
			•Impeller separation from the shaft	•Replace the water pump.

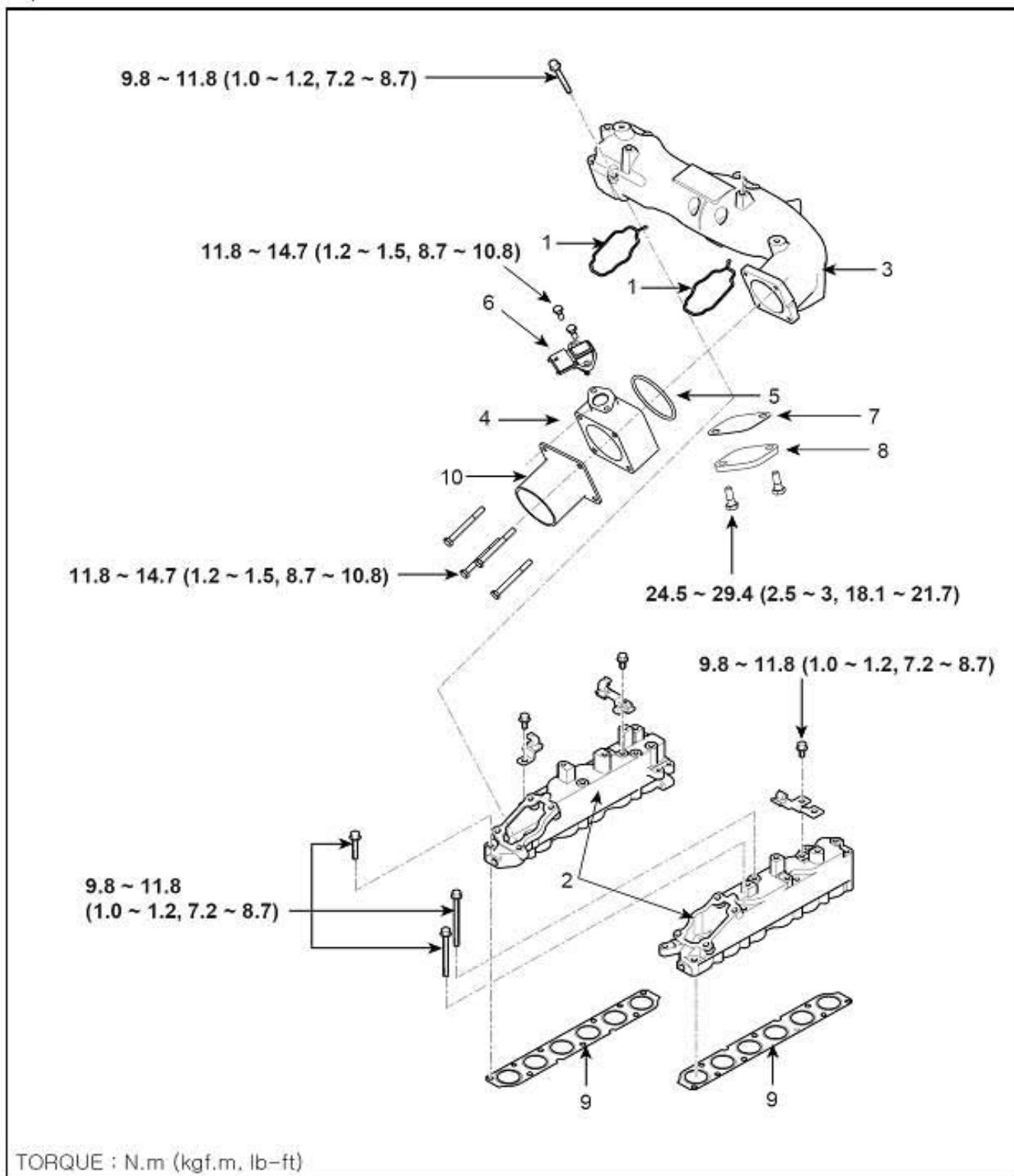
Thermostat

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	<ul style="list-style-type: none"> ·Low heater performance (cool air blown-out) ·Thermogauge indicates 'LOW' 	Visually check after removing the radiator cap	Insufficient coolant or leakage.	After refilling coolant recheck.
		GDS check & starting engine	<ul style="list-style-type: none"> ·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. 	<ul style="list-style-type: none"> ·Check the engine coolant sensor, wiring and connectors. ·Replace the component
		Remove the thermostat and inspect	<ul style="list-style-type: none"> ·Check if there are dusts or chips in the thermostat valve. ·Check adherence of the thermostat. 	<ul style="list-style-type: none"> ·Clean the thermostat valve and reuse the thermostat. ·Replace the thermostat, if it doesn't work properly
Heated excessively	<ul style="list-style-type: none"> ·Engine overheated ·Thermogauge indicates "HI" 	Visually check after removing the heat exchanger or cap.	<ul style="list-style-type: none"> ·Insufficient coolant or leakage. ※ Be careful when removing a heat-exchanger or cap of the overheated engine. ·Check leaks. 	<ul style="list-style-type: none"> ·After refilling coolant recheck. ·Check the cylinder head gaskets for damage and the tightening torque of the mounting bolts.
		GDS check & Starting engine	<ul style="list-style-type: none"> ·Check DTCs. ·Check the fan motor performance as temperature varies. ·Check coolant in a heat exchanger ·Check the water pump adherence or impeller damaged 	<ul style="list-style-type: none"> ·Check the engine coolant sensor, wiring and connectors. ·Replace the water pump, if it doesn't work properly

Intake and Exhaust System

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

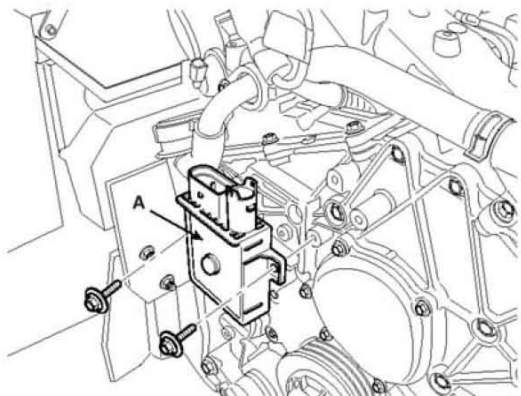
9. Gasket-Intake manifold

10. Adapter

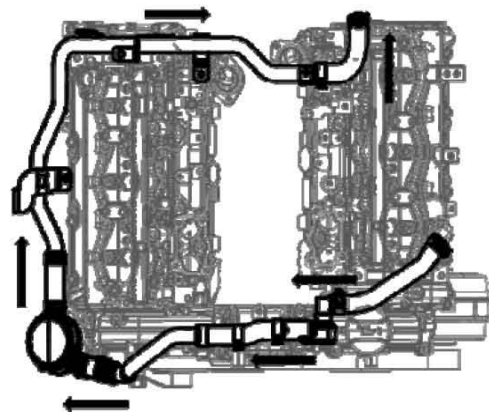


Intake Manifold

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



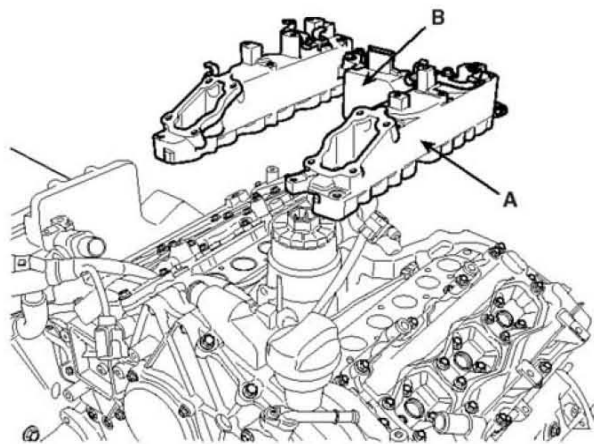
3. Remove the CMP sensor.
4. Remove the fuel feed and return hose or pipe.
5. Remove the high pressure fuel pipe (rail to rail).
6. Remove the oil level gauge.
7. Remove the engine hanger.
8. Remove the high pressure fuel pipe (rail to pump).
9. Remove the common rail system.
10. Remove the high pressure 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.



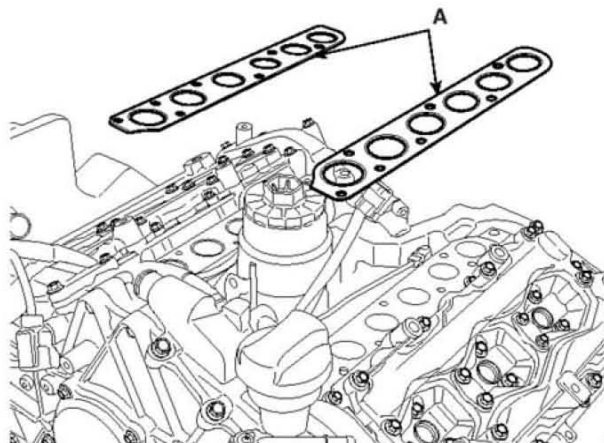
14. Remove the inlet lower manifold assembly (A).

 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.

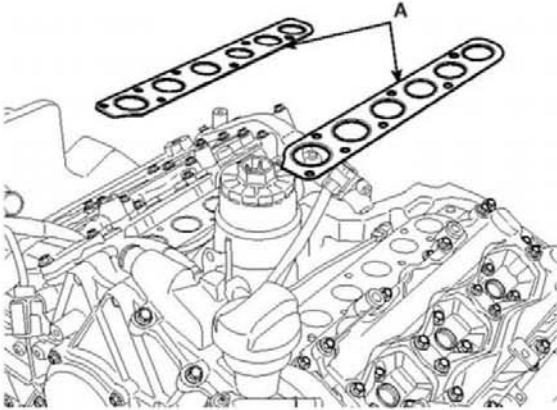


15. Remove the inlet manifold gaskets (A).



Installation

1. Install the inlet manifold gaskets (A).



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



CAUTION

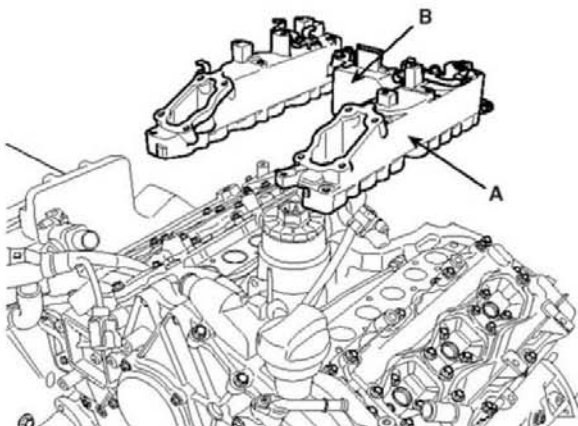
The inlet lower manifold assembly (A) is the assembly including the swirl control actuator (B).

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.

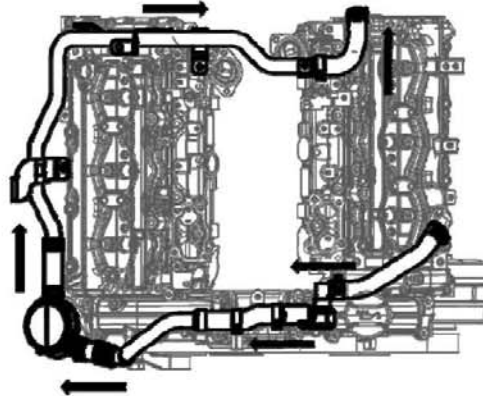
Disassembly and reassembly may change the setting specification of the two link shafts which are connected between the inlet lower manifold and the swirl control actuator.

Tightening Torque:

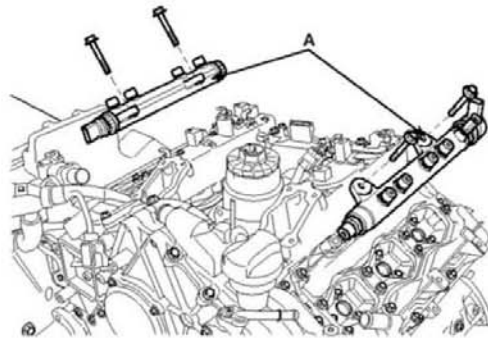
9.8 ~ 11.8Nm (1.0 ~ 1.2kgf.m, 7.2 ~ 8.7lb-ft)



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:

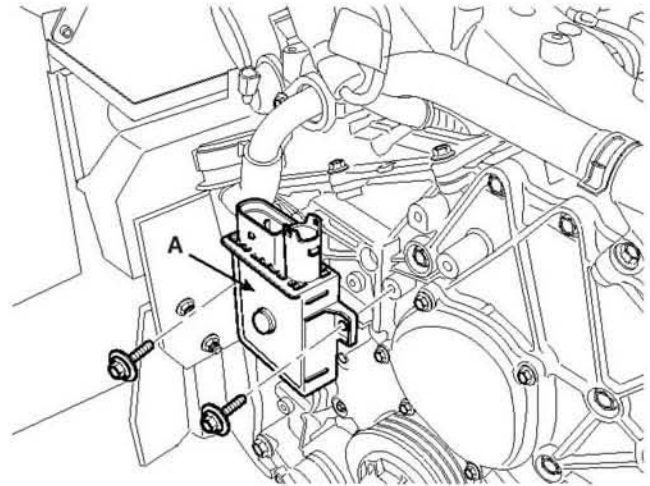
9.8 ~ 11.8Nm (1.0 ~ 1.2kgf.m, 7.2 ~ 8.7lb-ft)

14. Install the glow control unit (A).

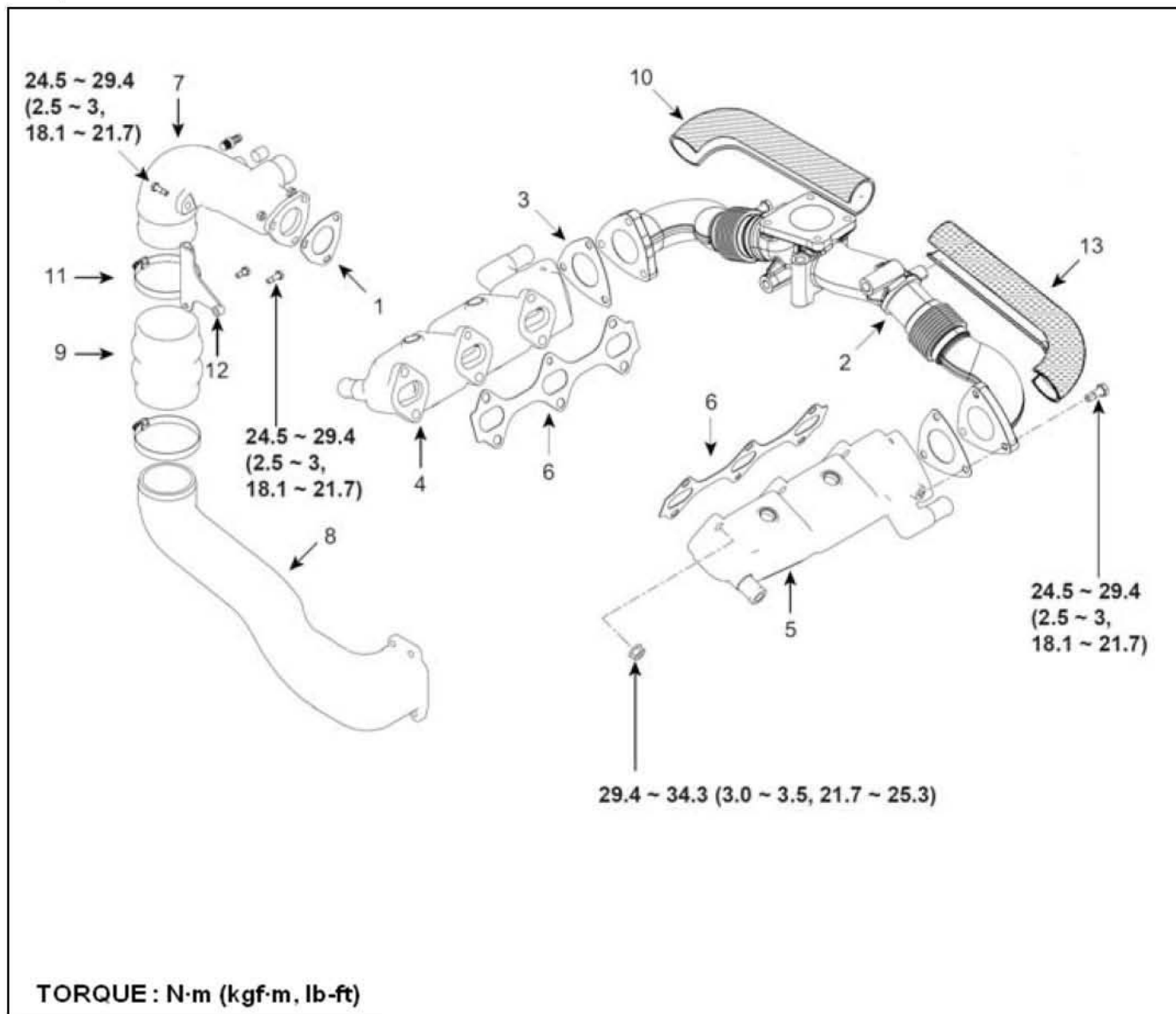
Tightening Torque:

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.



Exhaust Manifold Component



1. Gasket-Turbocharger outlet

6. Gasket-Exhaust manifold

11. Clamp- Bellows

2. Exhaust pipe

7. Exhaust elbow

12. Bracket-Exhaust elbow

3. Gasket-Exhaust pipe

8. Exhaust pipe

13. Heat Protector-Ex. pipe (LH)

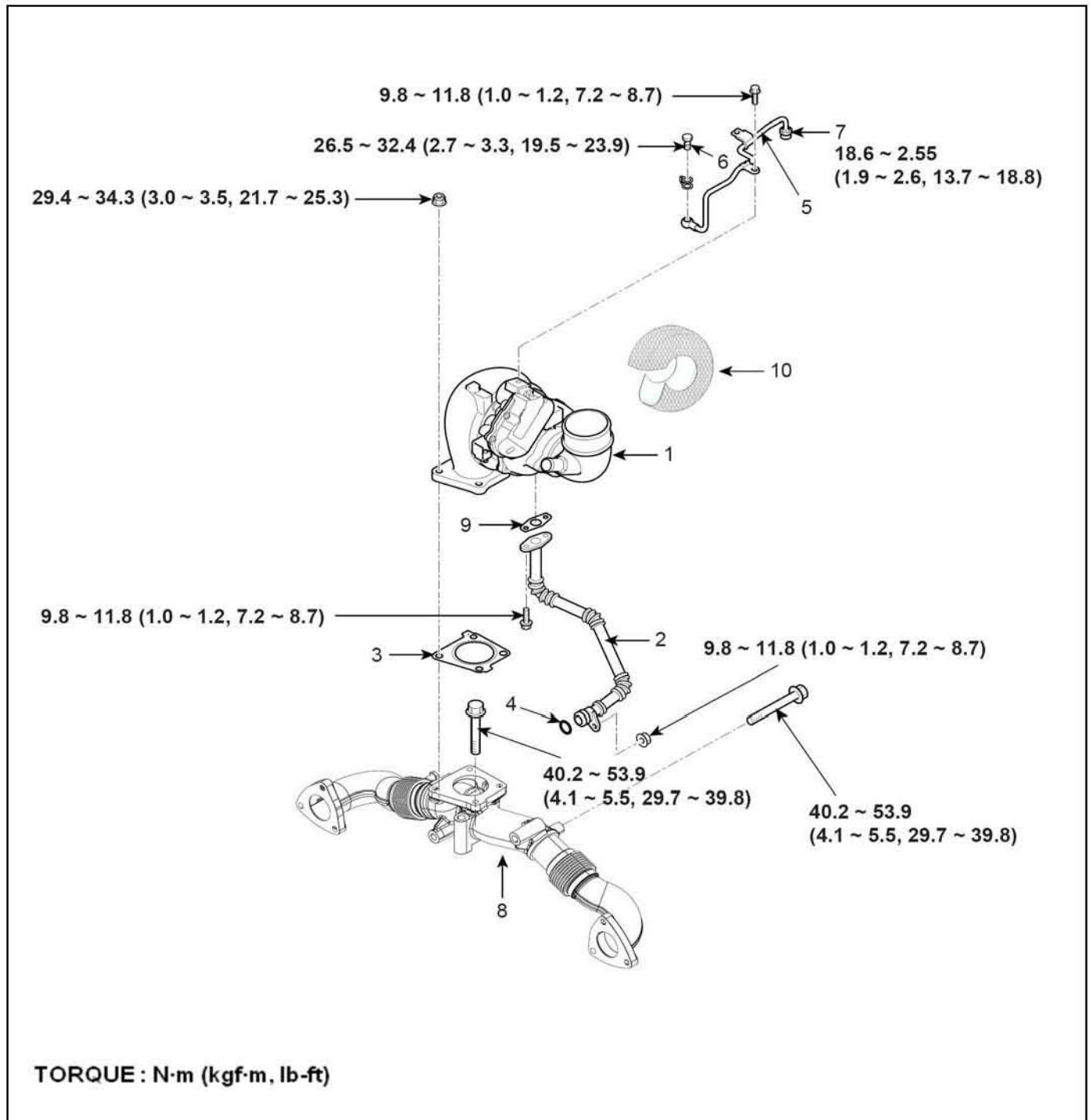
4. Exhaust manifold (LH)

9. Bellows

5. Exhaust manifold (RH)

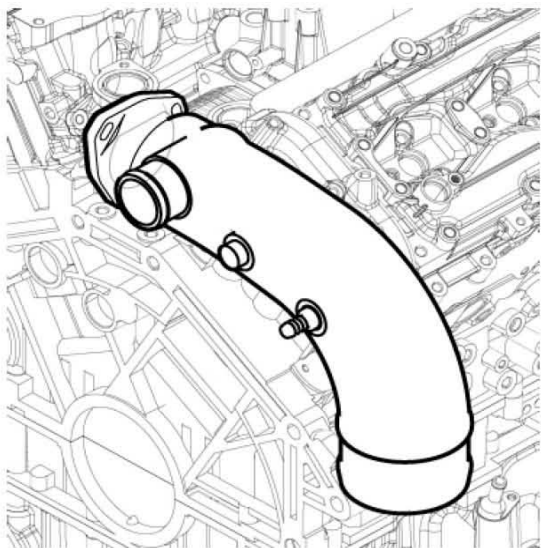
10. Heat protector-Ex. pipe (RH)

Turbocharger (TC)
Component



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

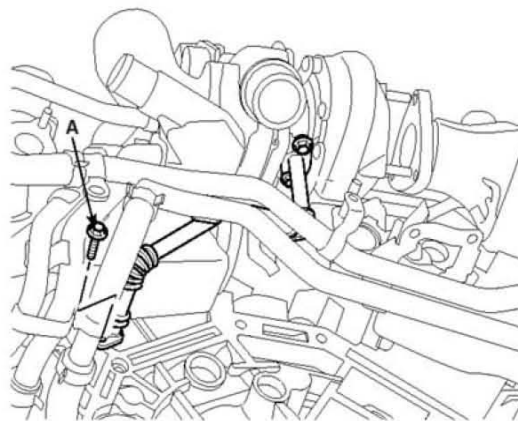
CAUTION

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:

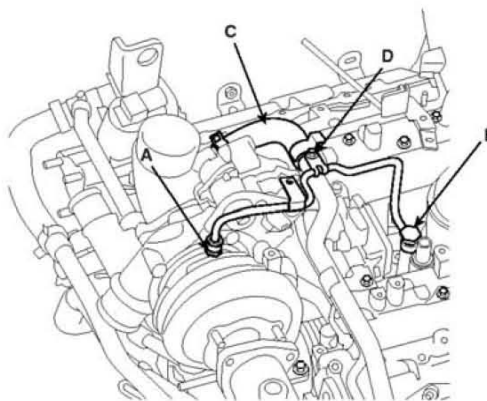
18.6 ~ 25.5Nm (1.9 ~ 2.6kgf.m, 13.7 ~ 18.8lb-ft) – oil feed pipe nut (A)

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

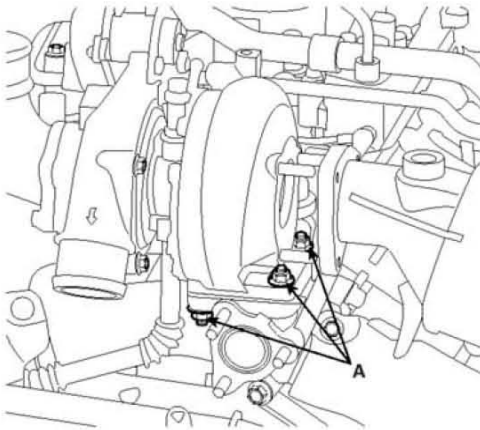
When install the turbocharger oil feed pipe eye bolt, always use a new gasket.



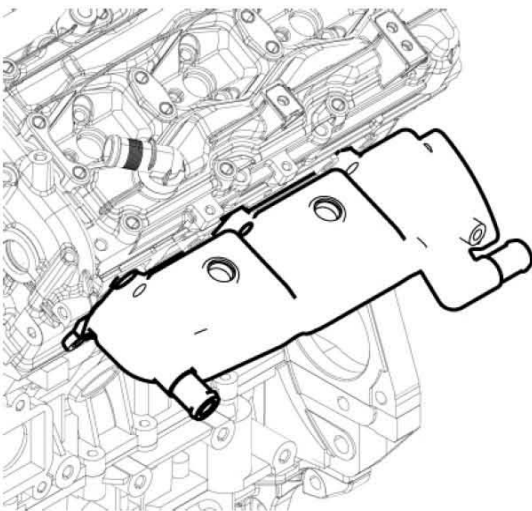
9. After removing the rest turbocharger mounting nuts (A), take off the turbocharger by lifting up.

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.

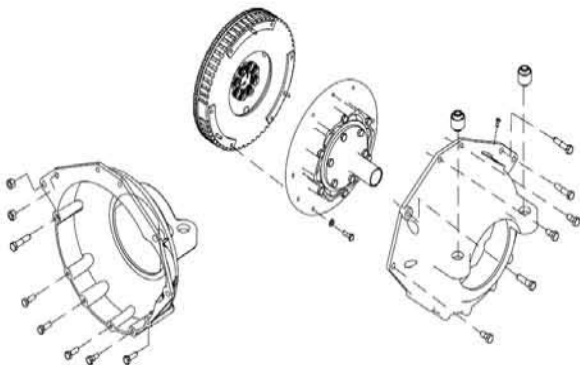
12. Installation is in the reverse order of removal.
13. Check to see possible engine coolant and exhaust emission leakage after manifold reassembly.

Coupling System

NOTICE

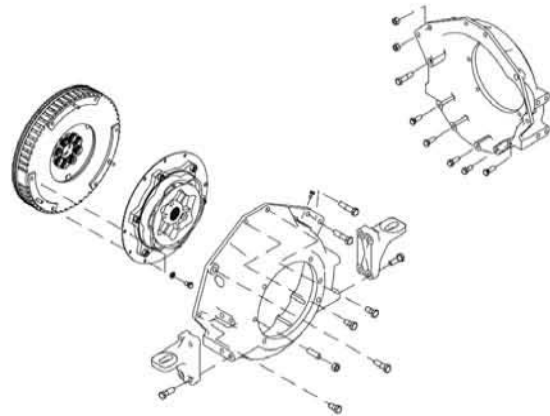
Use locking compound LOCTITE 242 on threads.

Stem Drive



1. Loosen 13 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.

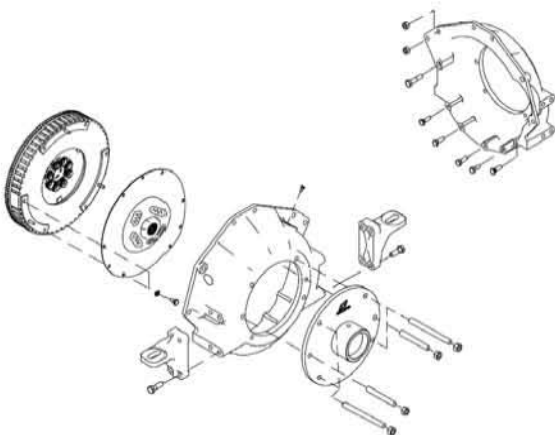
Tightening Torque:

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)

WaterJet



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



powering **marine** safety

WORKSHOP MANUAL for BUKH SEASALL MARINE ENGINE **S2** ENGINE SERIES



powering **marine** safety

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