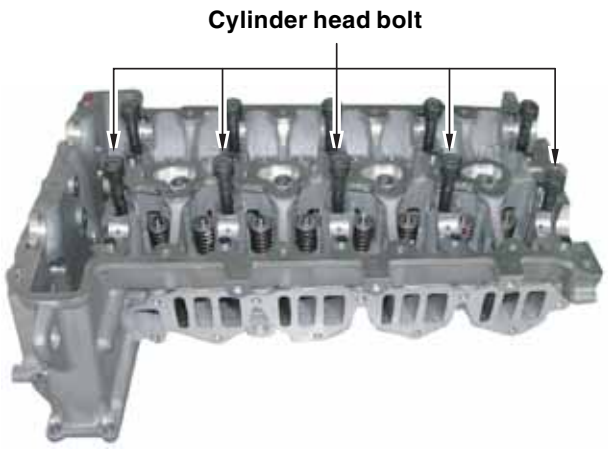
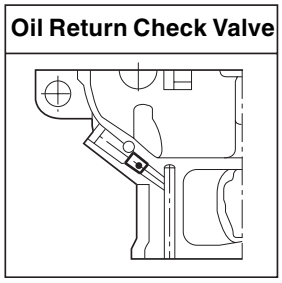
CYLINDER HEAD/CYLINDER BLOCK

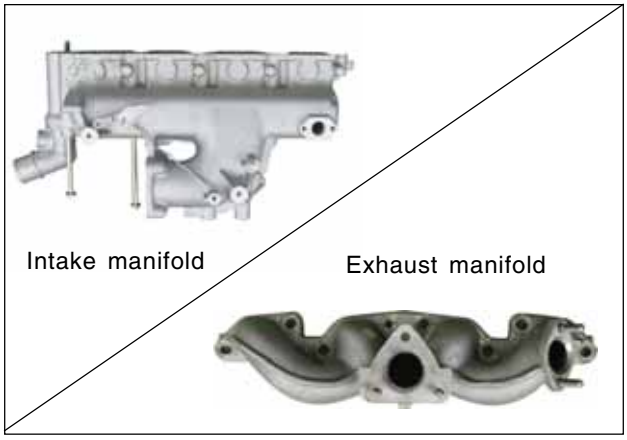
CYLINDER HEAD





▶ System Characteristics

1. 4-valve DOHC valve mechanism
2. Swirl and tangential port
3. 4-bolt type cylinder head bolt
4. Water jacket integrated casting
5. Integrated chain housing and cylinder head
6. Oil gallery: drilled and sealing with cap and screw plug



CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

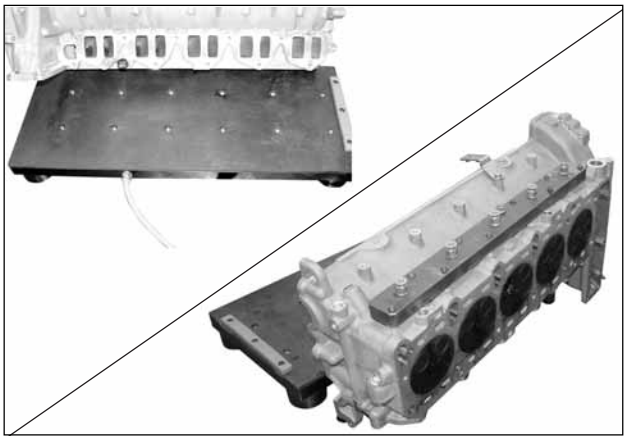
▶ Cylinder Head Pressure Leakage Test

※ **Preceding Works:**

1. Removal of cylinders
2. Removal of intake and exhaust manifold
3. Removal of valves

Test Procedures

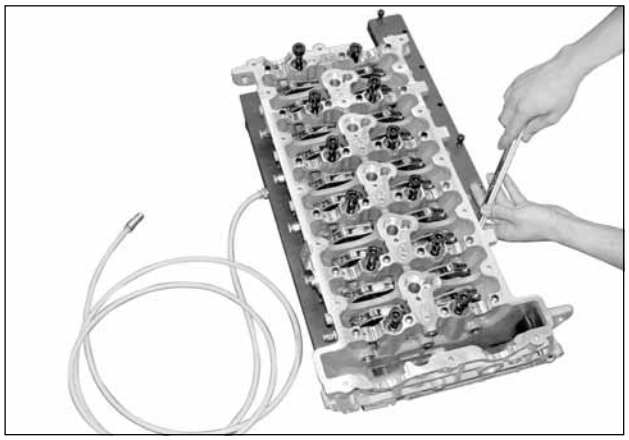
1. Place the pressure plate on a flat-bed work bench.



2. Install the cylinder head on the pressure plate.

Tightening torque	60 Nm

3. Immerse the cylinder head with the pressure plate into warm water (approx. 60°C) and pressurize with compressed air to 2 bar.



NOTICE

- **Examine the cylinder head for air bubbling. If the air bubbles are seen, replace the cylinder head.**

▶ Cylinder Head Mating Surface Check

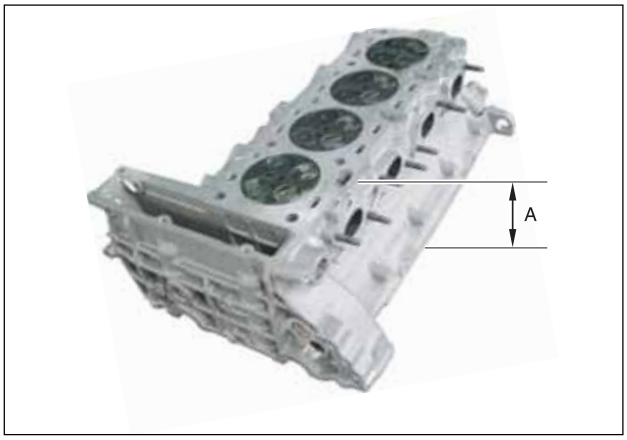
Specifications

Height “A” (cylinder head parting surface - cylinder head cover parting surface)		140.9 ~ 141.1 mm
Minimum height after machining		140.9 mm
Flatness	In longitudinal direction	0.075 mm
	In transverse direction	0.075 mm
Permissible variation of parallelism of top parting surface to bottom in longitudinal direction		within 0.1 mm
Peak-to-valley height		0.004 mm
Valve recess “a”	Intake valve	0.74 ~ 0.86 mm
	Exhaust valve	-0.15 ~ 0.15 mm

Measurement

1. Measure the cylinder head height “A”.

Limit	Over 140.9 mm

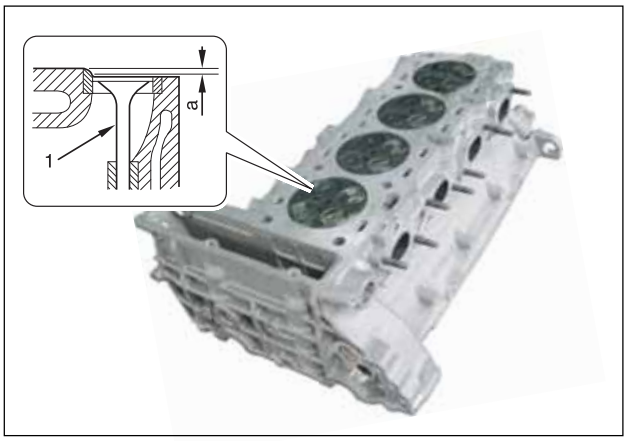


NOTICE

- **If the height is less than the limit, the cylinder head must be replaced.**

2. Insert the valves into the valve guides and measure the recesses.

Valve recess “a”	Intake Valve 0.74 ~ 0.86
	Exhaust Valve -0.15 ~ 0.15



NOTICE

- **If the measured value is out of the specified range, machine the valve seat as much as necessary until the specified value is achieved.**

Cylinder Head

▶ Disassembly

※ **Preceding Works:**

1. Disconnect the negative battery cable.
2. Apply the parking brake and place the chocks under the tires. (transmission “N” position)

1. Remove the EGR pipe.

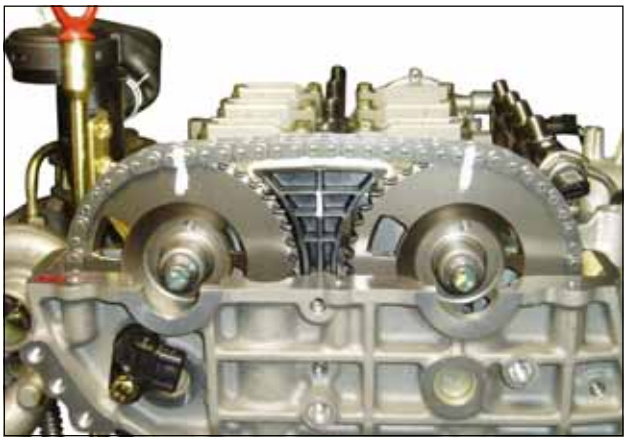
2. Disconnect the injector fuel lines, connector and preglow plug connector. Remove the cylinder head cover.

CAUTION

- **Cover the openings of fuel line with the protective caps.**

3. Rotate the crankshaft pulley to align the OT marks.
   1) Align the mark (notch) on sprocket for cylinder No.1 (exhaust) and for cylinder No.6 (intake). (align the cylinder No.1 OT)

4. Mark on the timing chain, intake camshaft sprocket and exhaust camshaft sprocket for timing setting during installation.



5. Remove the chain tensioner after removing the EGR pipe and oil dipstick.

6. Remove the high pressure pump and mark on the high pressure pump sprocket.

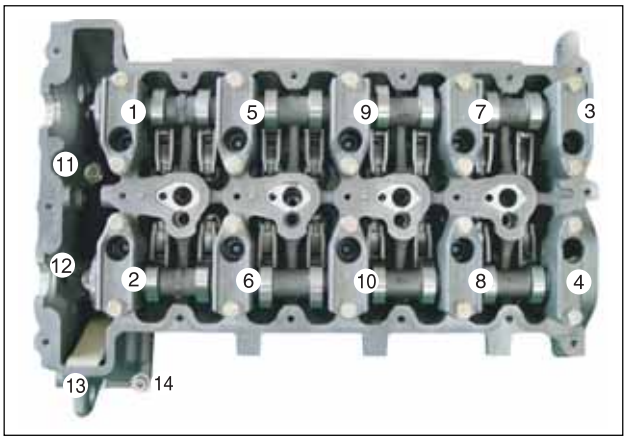
7. Remove the camshaft position sensor.

8. Hold the camshafts and remove the intake camshaft sprocket and exhaust camshaft sprocket.

9. Remove the upper guide rail with a sliding hammer.

10. Remove the oil cooler and the intake manifold.

11. Remove the cylinder head bolts according to the numerical sequence.
    1) M8 x 25: 2EA
    2) M8 x 50: 2EA
    3) M12 x 177: 9EA
    4) M12 x 158: 1EA (vacuum pump side)

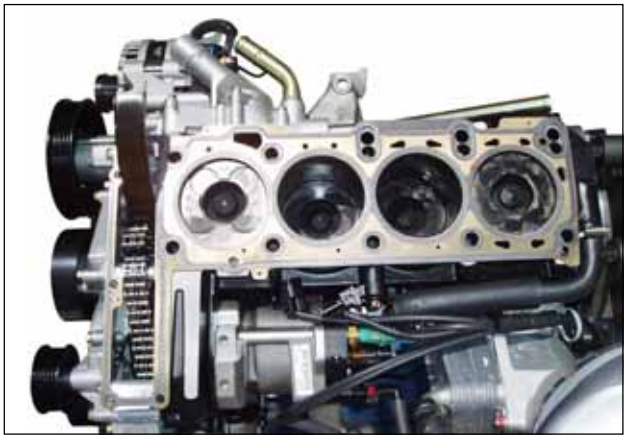


CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

12. Remove the cylinder head.

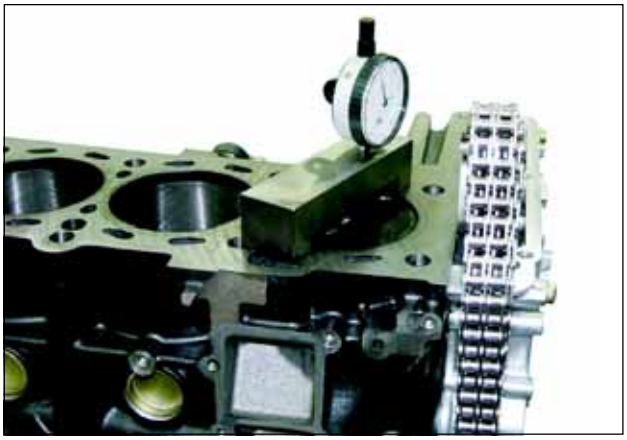
CAUTION

- **Inspect the cylinder head mating surface.**
- **Store the removed injectors and glow plugs so that they will not be damaged.**
- **If there is a sign of oil leakage on the cylinder head gasket, replace it with new one.**



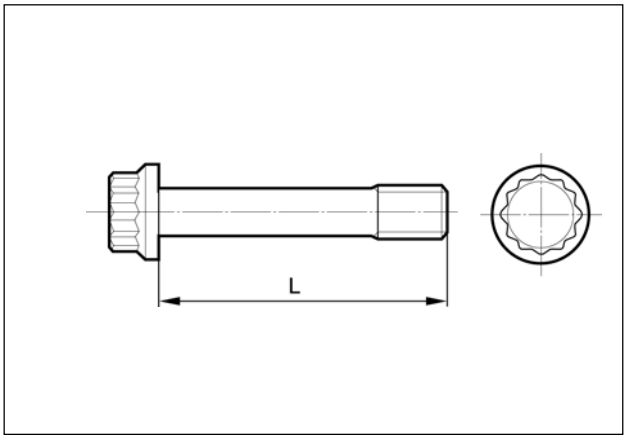
13. Measure the piston protrusion from the mating surface.

Standard	0.765 ~ 1.055 mm



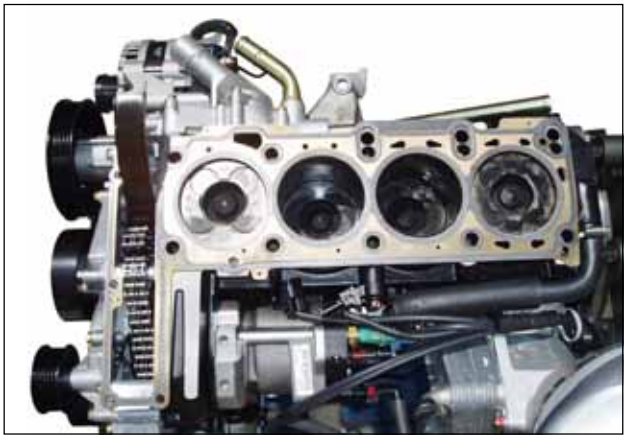
▶ Reassembly

1. Measure the length of cylinder head bolts.
   1) If the maximum length is exceeded by 2 mm, replace the cylinder head bolt.



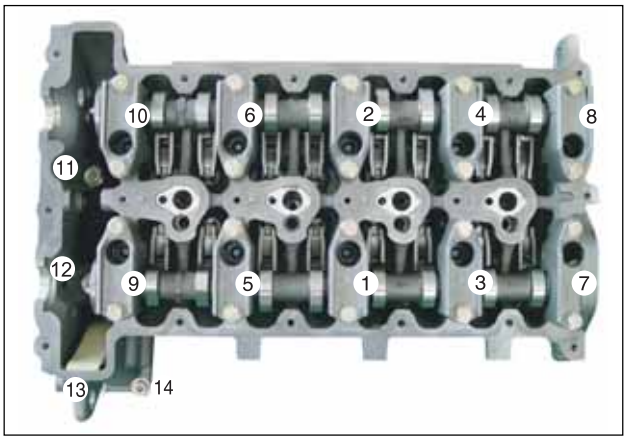
2. Install the cylinder head with the steel gasket.

NOTICE
- **Make sure to place the "TOP" mark upward.**



3. Tighten the cylinder head bolts to specified torque and torque angle.

Tightening torque	Step 1: 20 ± 2.0 Nm
	Step 2: 85 ± 5.0 Nm
	Step 3: 360° (120° x 3) + 10°



NOTICE
- **Apply the oil on the bolt thread when installing.**
- **Always insert new washer first.**
- **The bolts at vacuum pump side are shorter than others.**

4. Pull the timing chain over the cylinder head and install the upper guide rail.

NOTICE
- **Make sure that the convex surface of upper guide rail faces to front side**
- **Be careful not to alter the timing point of high pressure pump.**

5. Install the intake and exhaust camshaft sprockets and the timing chain.

Tightening torque	25 Nm + 90°

NOTICE

- **If the sprocket bolt is stretched over 0.9 mm, replace it with new one.**
- **Always install the intake camshaft sprocket first.**

1) Make sure that the upper guide rail is installed with proper direction.

2) Make sure that the timing chain is securely seated on the guide rails.

NOTICE

- **Make sure that the markings on camshaft sprocket and timing chain are aligned.**

6. Install the chain tensioner.

Tightening torque	65 ± 5.0 Nm

NOTICE

- **Make sure that the EGR steel gasket is properly installed.**

7. Rotate the crankshaft pulley two revolutions and ensure that the OT mark on the crankshaft pulley and the OT mark on the camshaft pulley are aligned.

NOTICE

- **If the markings are not aligned, reinstall the cylinder head.**

8. Install the cylinder head cover and the high pressure pump housing.

NOTICE

- **Apply the sealant on the bolt threads when installing the high pressure pump.**

9. Remove the protective caps from the injector and install the new fuel supply pipes.

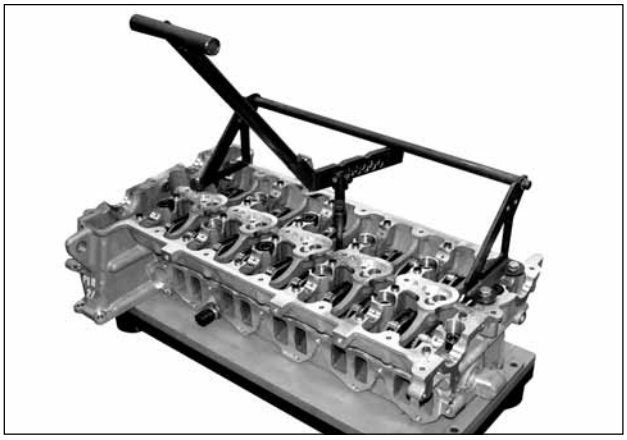
NOTICE

- **The fuel pipes are not reusable to keep the cleanness and parts damage.**

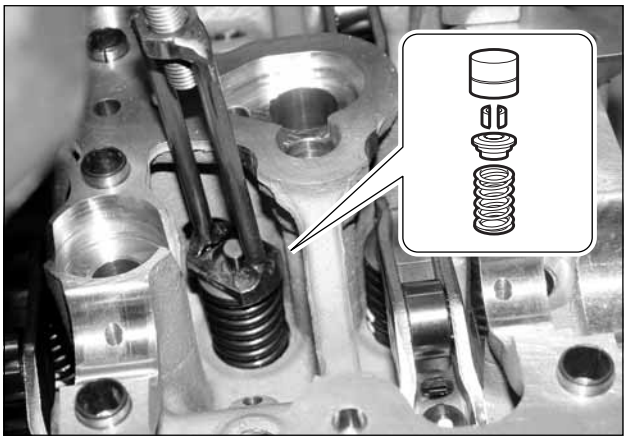
Intake/Exhaust-Removal/Installation

1. Remove the cylinder head assembly.

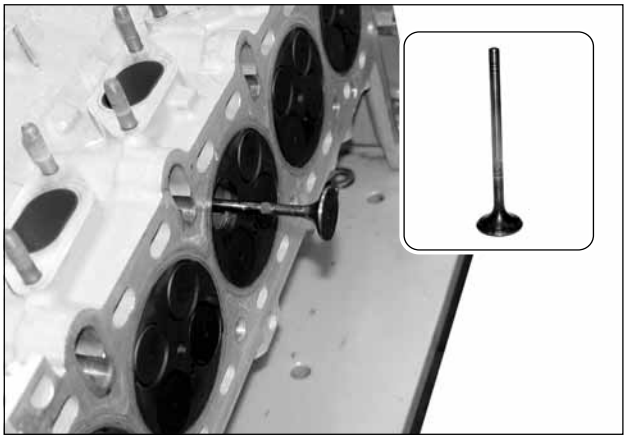
2. Install the removed cylinder head on the assembly board (special tool) and set the supporting bar and lever (special tool) on the cylinder head.



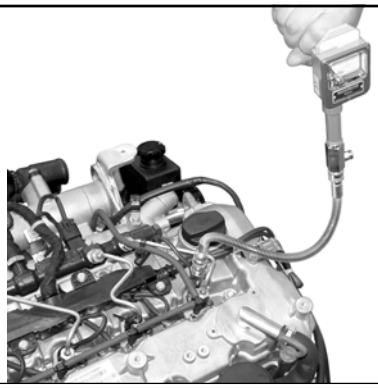
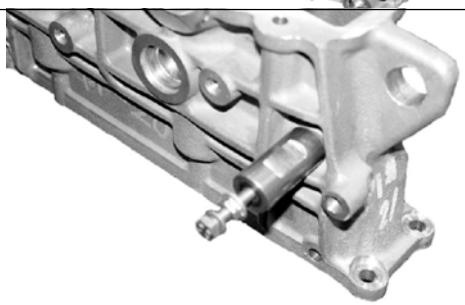
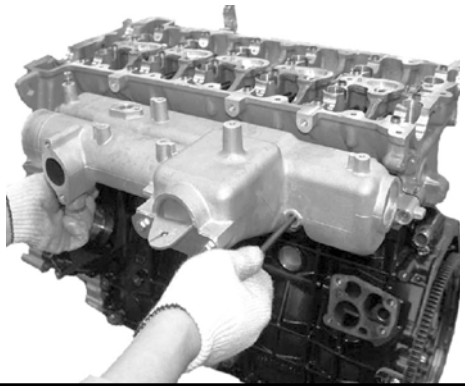
3. Push the valve spring seat down with the lever and remove the valve cotter, valve seat and valve spring.



4. Remove the valves from the cylinder head.



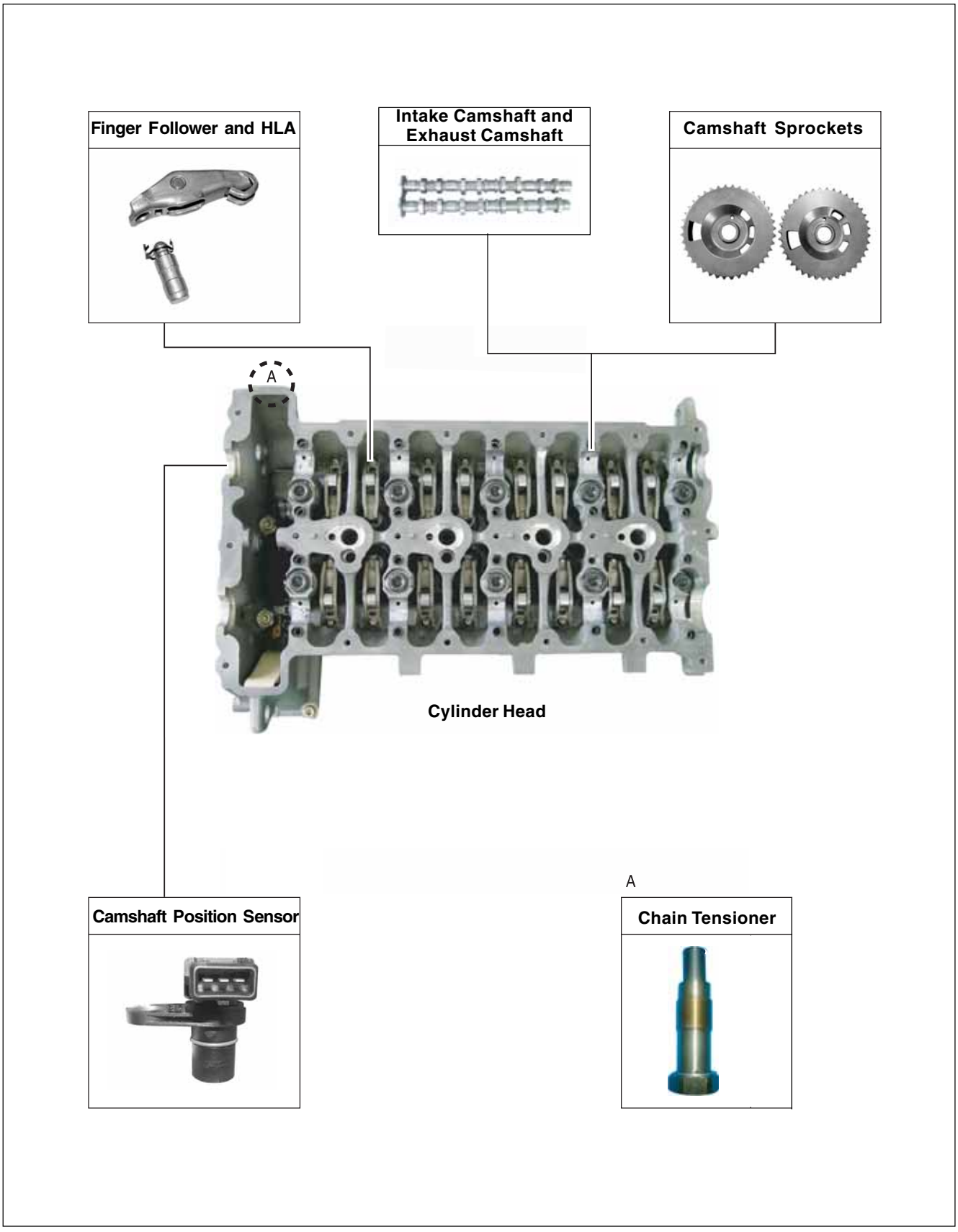
▶ Special Tools and Equipment

Name and Part Number	Application
Y99220092B Compression pressure measuring adapter and gauge 	
Y99220082B Supporting bar and lever 	
Y99220162B Guide pin extractor 	
Y99220112B Intake manifold guide pin  	

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

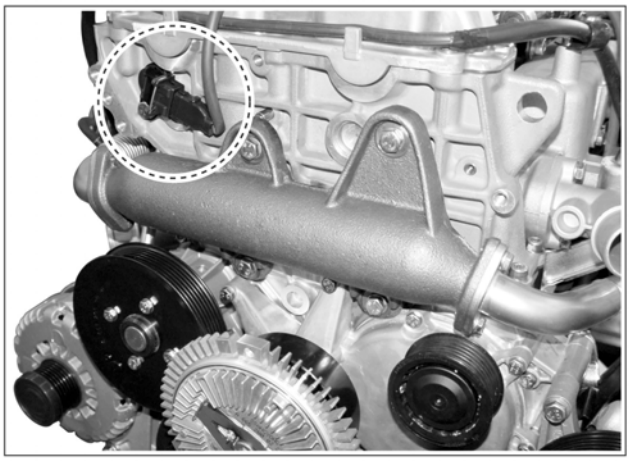
CAMSHAFT ASSEMBLY

※ **Preceding Work:** Removal of cylinder head cover

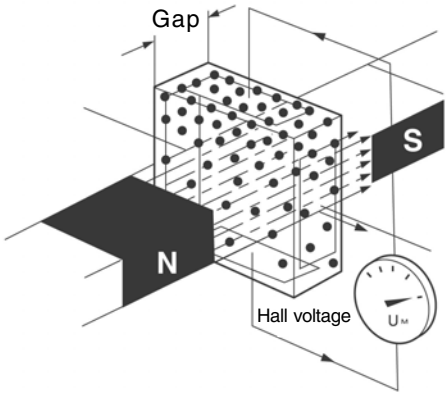


CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Camshaft Position Sensor



<Location of Camshaft Position Sensor>



<Operation Principle of Hall Sensor>

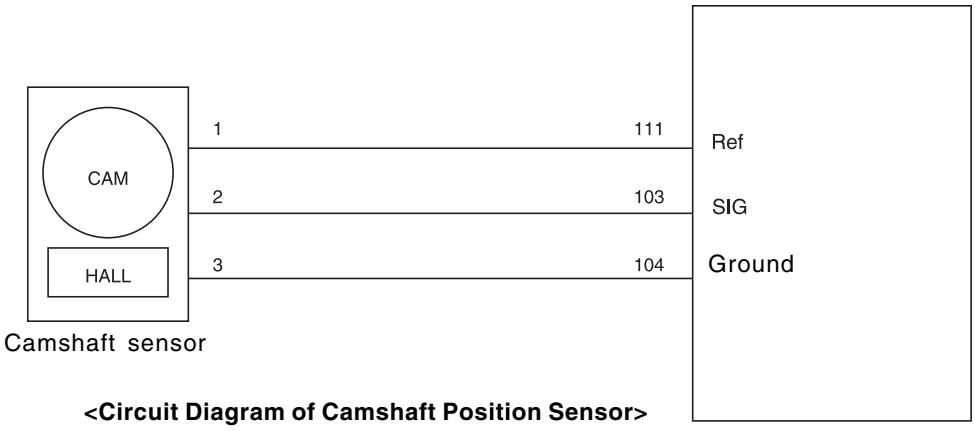
The camshaft position sensor uses hall-effect to set the camshaft position and metallic-magnetic-material sensor end is attached on the camshaft and then rotates with it. If sensor protrusion passes camshaft position sensor's semi-conductor wafer, magnetic field changes direction of electron on the semi-conductor wafer to the current flow direction that passes through wafer from the right angle. When operation power is supplied from camshaft position sensor, camshaft hall sensor generates signal voltage. The signal voltage will be 0V if protrusion and camshaft position sensor are near and 5 V if apart.

ECU can recognize that the No. 1 cylinder is under compression stroke by using this voltage signal (hall voltage).

The rotating speed of camshaft is half of the crankshaft and controls engine's intake and exhaust valves. By installing sensor on the camshaft, can recognize specific cylinder's status, compression stroke or exhaust stroke, by using camshaft position when the piston is moving toward TDC (OT). Especially when started first, it is difficult to calculate the stroke of a specific cylinder with only crankshaft position sensor.

Accordingly, camshaft position sensor is necessary to identify the cylinders correctly during initial starting. However, when engine is started, ECU learns every cylinder of the engine with crankshaft position sensor signals so can run the engine even though the camshaft position sensor is defective during engine running.

Pulse generation	Cam angle ± 6°
Sensor air gap	0.45 ~ 1.80 mm
Tightening torque	10 ~ 14 Nm
Operating temperature	- 40 ~ 130°C



<Circuit Diagram of Camshaft Position Sensor>

Disassembly

※ **Preceding Works:**

1. Disconnect the negative battery cable.
2. Apply the parking brake and place the chocks under the tires. (transmission “N” position)

1. Remove the EGR pipe.

2. Disconnect the injector fuel lines, connector and preglow plug connector. Remove the cylinder head cover.

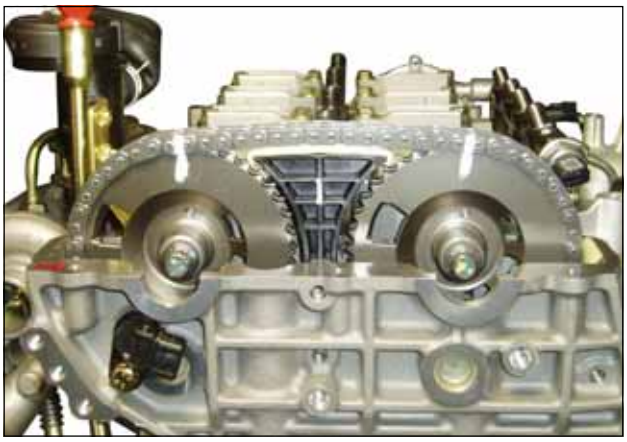
CAUTION

- **Cover the openings of fuel line with the protective caps.**

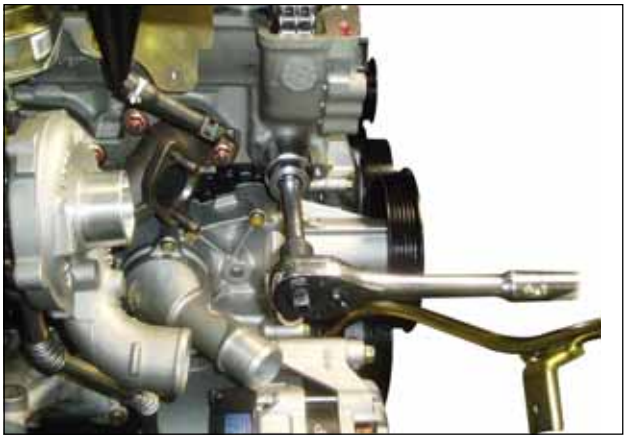
3. Rotate the crankshaft pulley to align the OT marks.
   1) Align the mark (notch) on sprocket for cylinder No.1 (exhaust) and for cylinder No.6 (intake). (align the cylinder No.1 OT)

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

4. Mark on the timing chain, intake camshaft sprocket and exhaust camshaft sprocket for timing setting during installation.



5. Remove the chain tensioner after removing the EGR pipe and oil dipstick.



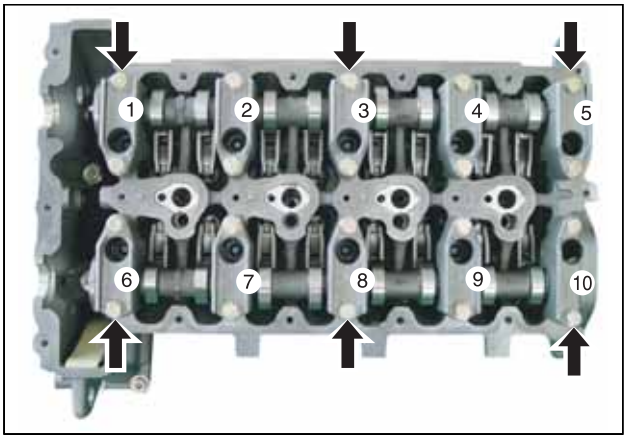
6. Remove the high pressure pump and mark on the high pressure pump sprocket.

7. Remove the camshaft position sensor.

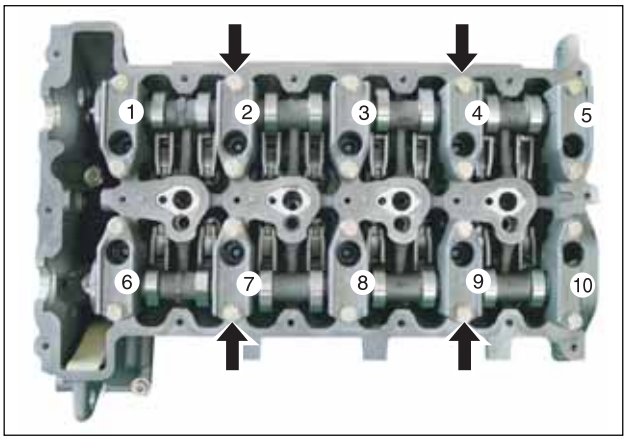
8. Hold the camshafts and remove the intake camshaft sprocket and exhaust camshaft sprocket.

9. Remove the camshaft bearing cap bolts so that the tightening force can be relieved evenly.
   1) Exhaust: #1, #3, #5
   2) Intake: #6, #8, #10

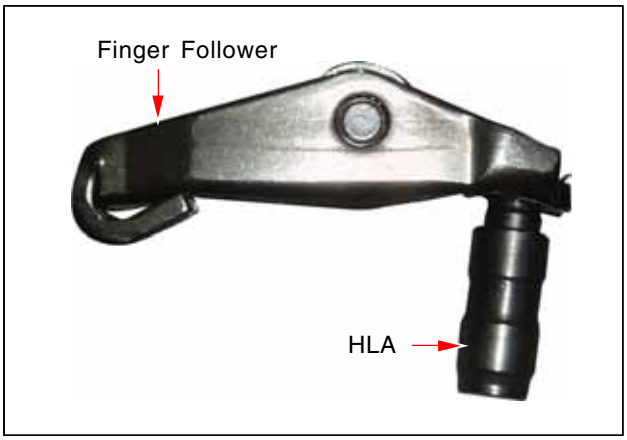
   However, there is no specific removal sequence.



   3) Do not remove the bolts at a time completely. Remove them step by step evenly or camshaft can be seriously damaged.
   4) Remove the exhaust camshafts and then remove the intake camshaft.
      - Exhaust: #2, #4
      - Intake: #7, #9



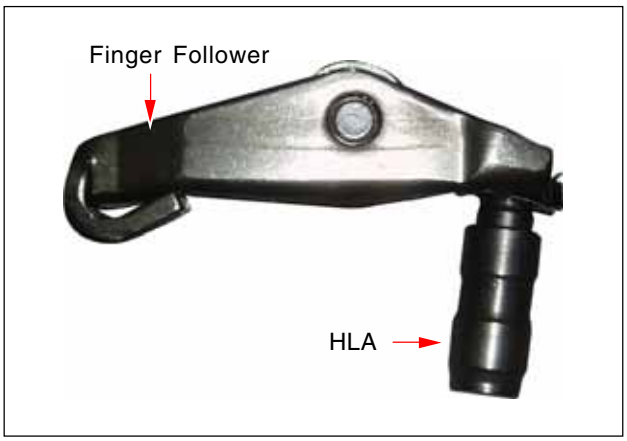
10. Remove the finger follower and the HLA device.



CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

Reassembly

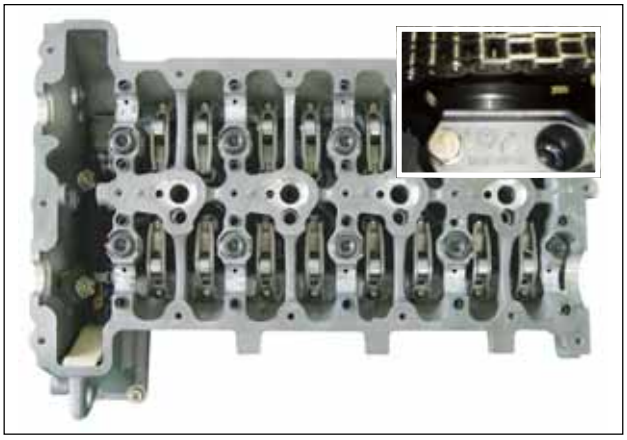
1. Install the HLA device and finger follower. Check the HLA device with the diagnosis procedures before installation.



NOTICE

- **Perform the air bleeding process if it has been stored for a extended period of time.**
- **Make sure that it is properly installed on the locating pin.**

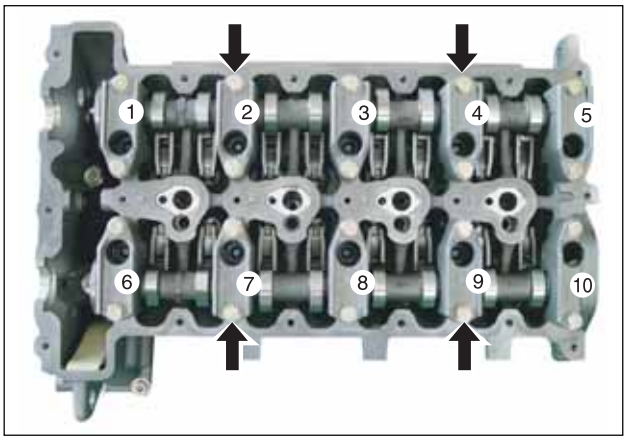
2. Place the bearing cap with the OT marks on both camshafts facing upward.



NOTICE

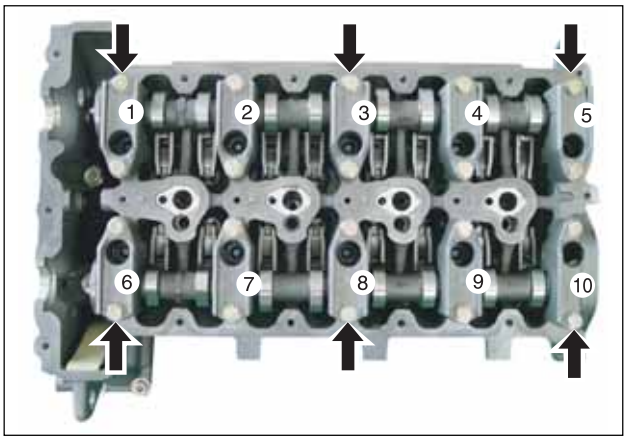
- **Apply the sealant on the cap (#12) for the vacuum pump when installing.**
  Part number: 661 989 56 A0 (DB2210)
- **Apply the oil on the bearing journals before installation.**

3. Tighten the camshaft bearing cap bolts.
   1) Intake: #7, #9
   2) Exhaust: #2, #4



   3) Intake: #6, #8, #10
   4) Exhaust: #1, #3, #5

Tightening torque	25 Nm



NOTICE

- **Check the finger follower positions and align if needed.**

4. Install the intake and exhaust camshaft sprockets and the timing chain.

Tightening torque	25 Nm + 90°

NOTICE

- **If the sprocket bolt is stretched over 0.9 mm, replace it with new one.**
- **Always install the intake camshaft sprocket first.**

1) Make sure that the upper guide rail is installed with proper direction.

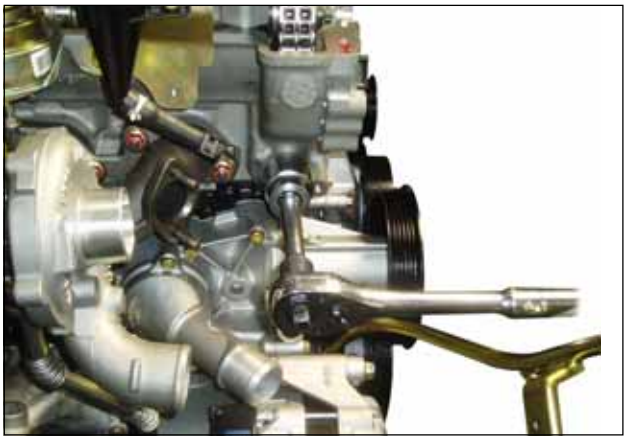
2) Make sure that the timing chain is securely seated on the guide rails.

NOTICE

- **Make sure that the markings on camshaft sprocket and timing chain are aligned.**

5. Install the chain tensioner.

Tightening torque	65 ± 5.0 Nm



NOTICE

- **Make sure that the EGR steel gasket is properly installed.**

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

6. Rotate the crankshaft pulley two revolutions and ensure that the OT mark on the crankshaft pulley and the OT mark on the camshaft pulley are aligned.

NOTICE

- **If the markings are not aligned, reinstall the cylinder head.**

7. Install the cylinder head cover and the high pressure pump housing.

NOTICE

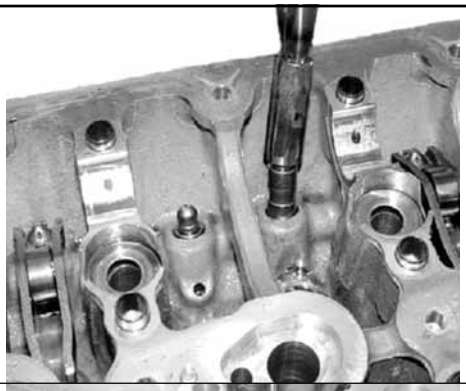
- **Apply the sealant on the bolt threads when installing the high pressure pump.**

8. Remove the protective caps from the injector and install the new fuel supply pipes.

NOTICE

- **The fuel pipes are not reusable to keep the cleanness and parts damage.**

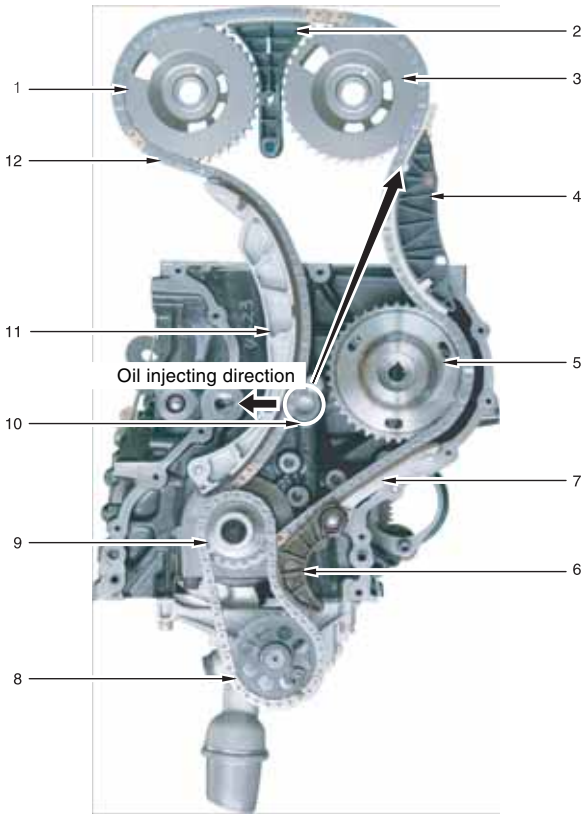
▶ Special Tools and Equipment

Name and Part Number	Application
Y99220152B HLA remover 	
Y99220142B Stem seal installer 	

TIMING CHAIN ASSEMBLY

▶ Chain Drive System

System Layout

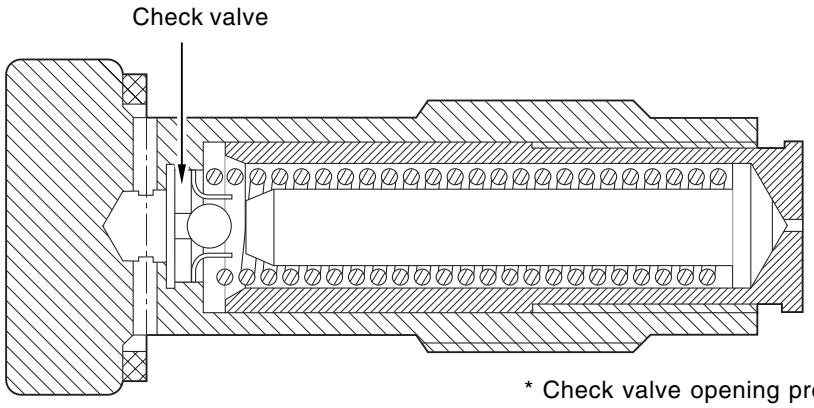


1. Exhaust camshaft sprocket
2. Upper guide rail
3. Intake camshaft sprocket
4. Clamping guide rail
5. HP pump sprocket
6. Lower guide rail
7. Oil pump tensioner
8. Oil pump sprocket
9. Crankshaft sprocket
10. Oil nozzle
11. Tensioner guide rail
12. Chain tensioner

Chain

1. Chain type: Double Bush
2. Pitch: 9.525 mm
3. Load limits: 19,000 N
4. No. of links: 148 EA
5. Overall length: 1409.7 mm
6. Replace when the chain is extended by 0.5 % from overall length (Replace if extended by over 7.0485 mm)

Chain Tensioner



* Check valve opening pressure: 0.2 ~ 0.5 bar

The major function of tensioner is optimizing the movement of chain drive system by using spring constant and oil pressure in the tensioner.

The tensioner performs function of adjusting chain tension to be always tight, not loose, while engine running. By doing so, can reduce wears of each guide rail and sprocket.

Tightening torque	65 ± 5.0 Nm (Installed on the cylinder head)

Guide Rail

Guide rail is used to optimize the movement of chain drive system like tensioner.

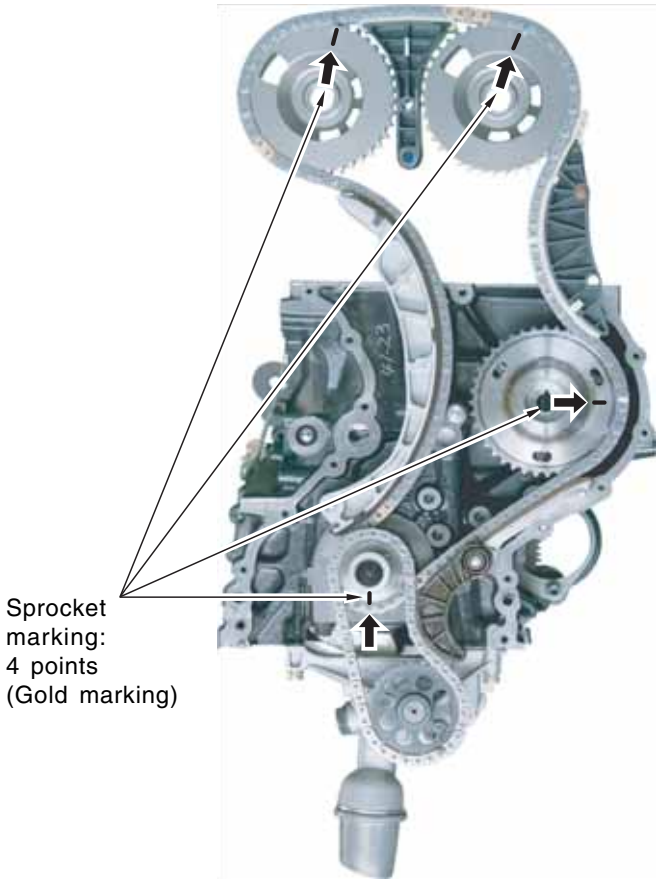
Guide rail can prevent chain slap when chain is extended and reduce chain wears.

Guide rail is needed especially when the distance between the sprockets are too long.

The material is plastic.

1. Location of guide rail
   1) Tensioner guide rail: Between crankshaft sprocket and exhaust camshaft sprocket
   2) Upper guide rail: Between exhaust camshaft sprocket and intake camshaft sprocket
   3) Clamping guide rail: Between intake camshaft sprocket and HP pump sprocket
   4) Lower guide rail: Between HP pump sprocket and crankshaft sprocket

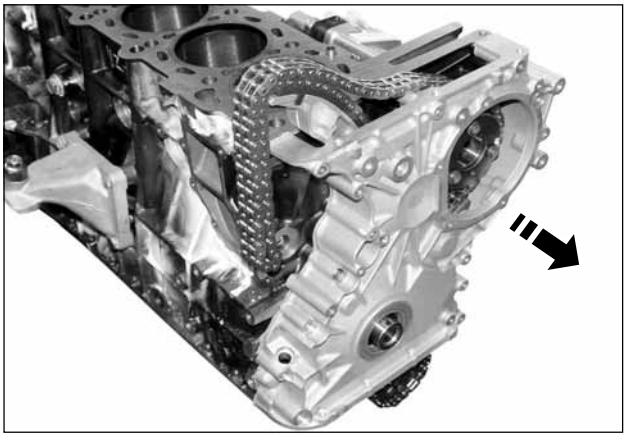
Timing Setting



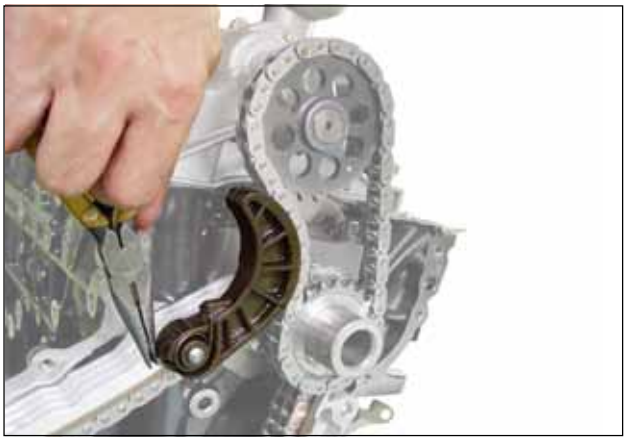
1. Check marking links on the chain (Gold marking)
2. Locate a point with two continuous marking links and align it to a marking on crankshaft sprocket (△)
3. Align respective marking link to each camshaft sprocket (intake and exhaust) marking (△)
4. Align another marking link to HP pump sprocket marking (△)

Removal and Installation

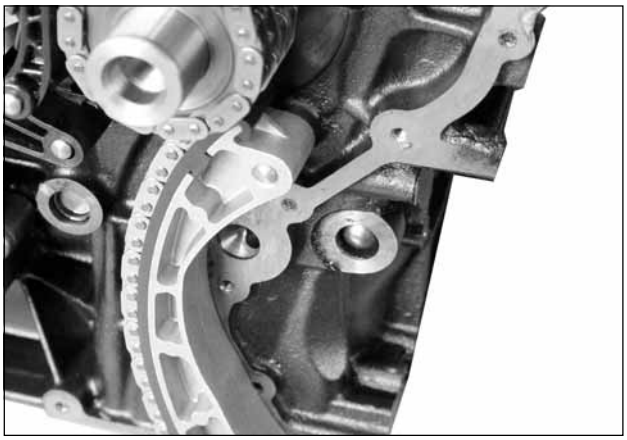
1. Remove the cylinder head assembly.
2. Remove the oil pan.
3. Remove the chain guide rail with a sliding hammer.
4. Remove the chain cover.



5. Remove the oil pump drive chain.
6. Remove the upper guide rail while pushing the retaining spring with a screwdriver.
7. Remove the lower guide rail.
8. Remove the oil pump drive chain.



9. Remove the tensioner guide rail.
10. Remove the timing chain.
11. Install in the reverse order of removal.

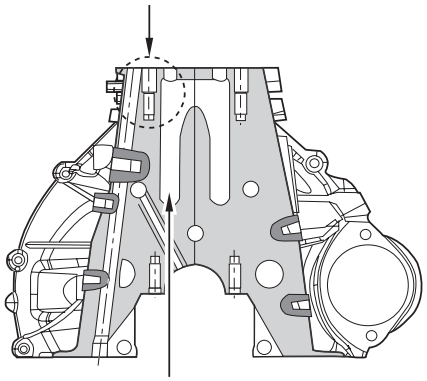


NOTICE

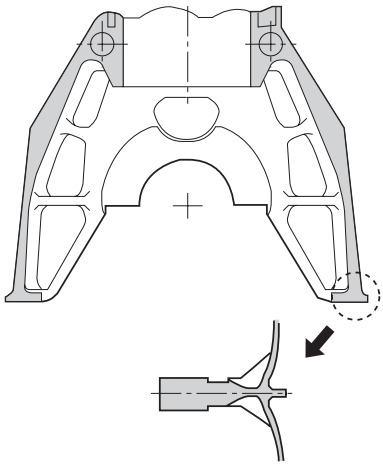
- **Thoroughly clean the removed components before installing.**

CYLINDER BLOCK

Deep head bolt thread to prevent the deformation at cylinder bore surfaces



Water jacket design to increase the cooling efficiency



Cambering type skirt to reduce the noise

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ System Characteristics

1. Rib design by considering strength against engine vibrations and weight
2. Cambering type skirt design on case housing wall to reduce the engine noise
3. Water jacket design to increase the cooling efficiency of cylinder bore bridge
4. Deep head bolt thread to prevent the deformation at cylinder bore surfaces
5. Reinforcement of strength
   1) Main bearing housing / Main bearing cap
   2) Extended main bearing cap bolt
6. Reducing the noise, vibration and harshness (NVH)
   1) Minimize the vibration by adding external ribs
   2) Adding the ribs around oil pan mating surface

▶ Knock Sensor

Two knock sensors are located on the cylinder block (intake manifold side).

To detect engine vibration under abnormal combustion, knock sensor has piezoelectric element fixed on the vibration plate and this vibration plate is fixed on the base. If happens knocking, pistons or connecting rods vibrate and occurs heavy sounds that hit metal. Knock sensor is used to detect those knockings caused by abnormal combustions. It controls idling stabilities and turns on the engine warning light when detects injector damages. And also controls pilot injection very precisely during MAP learning.

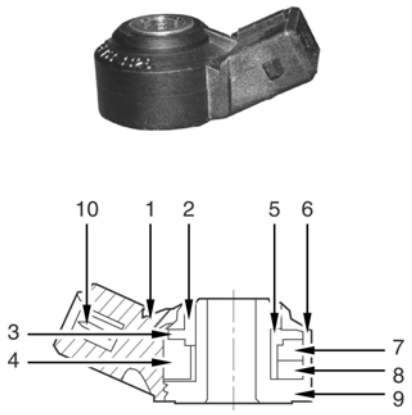
When knock sensor is defective, engine ECU corrects injection timing based on MAP values like engine speed, intake air volume and coolant temperature.

※ Before checking the knock sensor unit, be sure to check the tightening torque of the sensor and connector connecting conditions.

Insulating resistance	Min. 1 MΩ
Resonance frequency	25 kHz
Operating temperature	- 40 ~ 150°C
Output voltage	26 ± 8 mV/g (at 5 kHz)
	22 ~ 37 mV/g (3 ~ 10 kHz)
	22 ~ 57 mV/g (10 ~ 20 kHz)
Tightening torque	20 ± 5 Nm

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

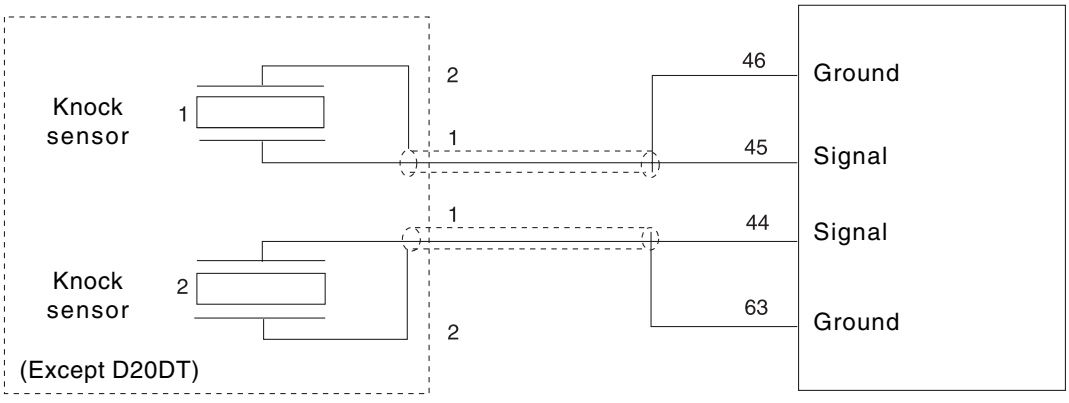
<Location of Knock Sensor>



1. Sensor housing
2. Nut
3. Disc spring
4. Weight
5. Insulation disc
6. Upper contact plate
7. Piezo element
8. Lower contact plate
9. Body
10. Terminal

NOTICE

- **The knock sensor should be tightened with the specified tightening torque. Otherwise, the engine output may be decreased and the "ENGINE CHECK" warning lamp may come on. The internal resistance of the sensor is approx. 4.7 kW.**



<Circuit Diagram of Knock Sensor>

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	