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SQRE4T15B ENGINE MECHANICAL

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شرکت دیجیتال خودرو سامانه (مسئولیت محدود)
اولین سامانه دیجیتال تعمیرکاران خودرو در ایران

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GENERAL INFORMATION

Overview

Description

SQRE4T15B engine has the following features:

- DVVT
- Water cooled vertical
- In-line DOHC with 4 cylinders
- Four valves per cylinder
- Aluminum cylinder head
- Cast iron cylinder block
- Turbocharged water-cooled

Operation

- SQRE4T15B engine adopts design of vertical, in-line 4-cylinder, water-cooled, 4-stroke, 4 valves per cylinder, DOHC, turbocharged water-cooled, VVT and electronic controlled sequential multiport fuel injection. Engine adopts individual ignition.
- SQRE4T15B engine adopts a cast iron cylinder block. Aluminum oil pan is fixed to aluminum frame with bolts. And aluminum cylinder head is fixed to the cylinder block with bolts. Camshaft is installed in cylinder head. Camshaft is driven by timing chain, so the power output from crankshaft passes through crankshaft sprocket, thus the camshaft works together with valve lifter to open and close valve. Piston assembly is an aluminum piston with cast iron connecting rod, and connecting rod is made of powder metallurgy material. This engine has characteristics of reliable structure and excellent performance.

Specifications

Engine Specifications

Item	Specifications
Engine Type	Vertical, in-line 4-cylinder, water-cooled, 4-stroke, DOHC, turbocharged water-cooled
Engine Model	SQRE4T15B
Valve Number Per Cylinder	4
Cylinder Diameter (mm)	77
Piston Stroke (mm)	80.5
Displacement (ml)	1498
Compression Ratio	9.5:1
Ignition Type	Individual ignition
Ignition Sequence	1 - 3 - 4 - 2
Rated Power (kW)	108
Max. Torque (N·m)	210
Max. Torque Speed (r/min)	1750 - 4000
Rated Power Speed (r/min)	5500
Min. Fuel Consumption Rate (g/kW·h)	275
Fuel Octane Number (Not Less Than)	Unleaded gasoline, octane number 92
Oil Grade	SM SAE-5W-30 (for winter and summer) SM SAM-5W-40 (for winter) SM SAE-10W-40 (for summer)
Oil Capacity (L)	4.7 ± 0.2
Starting Type	Electrical starting
Cooling Type	Forced circulation type antifreeze cooling
Lubrication Type	Compound type (pressure, splash lubrication)

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Item	Specifications	
Cylinder Compression Pressure (bar) (180 - 250) r/min	7 - 10	
Oil Pressure (bar)	Idling speed (700 ± 50 r/min)	Not less than 0.7
	High speed (2000 r/min)	Not less than 2.5

Engine Mechanical Specifications

Item			Specifications
Camshaft	Cam height	Intake cam (mm)	37.07 - 37.31
		Exhaust cam (mm)	36.94 - 37.18
	Camshaft diameter (it is same for intake and exhaust camshafts) (mm)	1st journal	33.934 - 33.95
		2nd ~ 5th journal	23.947 - 23.96
	Camshaft axial clearance	Intake cam (mm)	0.15 - 0.2
		Exhaust cam (mm)	0.15 - 0.2
Cylinder Head	Lower surface flatness (mm)		0.04
	Overall height (mm)		141.05
	Surface grinding limit		Never grind
Valve	Valve head margin thickness	Intake valve (mm)	0.68 - 1.1
		Exhaust valve (mm)	0.48 - 0.9
	Valve stem diameter	Intake valve (mm)	5.98 ± 0.008
		Exhaust valve (mm)	5.96 ± 0.008
	Valve face sealing width	Intake valve (mm)	1.154
		Exhaust valve (mm)	1.307
	Clearance between valve stem and guide	Intake valve (mm)	0.012 - 0.043
		Exhaust valve (mm)	0.032 - 0.063
	Angle between conical surfaces of valve face	Intake valve	90°
		Exhaust valve	90°
	Height	Intake valve (mm)	107.75 - 108.25
		Exhaust valve (mm)	106.07 - 106.57
Valve Spring	Free height (mm)		47.8
	Operating preload (N)/operating height (mm)		229 - 251/41
Valve Guide	Inner diameter (mm)		6 - 6.015
	Depression depth (mm)		18.5 ± 0.3
Piston	Piston skirt diameter (mm)		76.955 - 76.907
	Piston pin hole diameter (mm)		18.004 - 18.009
Piston Ring	Piston ring side clearance (mm)	First ring	0.02 - 0.065
		Second ring	0.02 - 0.06
	Piston ring end gap (mm)	First ring	0.2 - 0.3
		Second ring	0.3 - 0.5
Piston Pin	Diameter (mm)		17.995 - 18
	Length (mm)		45/0/-0.3
Crankshaft	Crankshaft main journal	Diameter (mm)	Standard value: 50 Limit value: 49.979
		Coaxially (mm)	0.05
		Cylindricity (mm)	0.007
		Roundness (mm)	0.004
	Connecting rod journal	Diameter (mm)	Standard value: 50 Limit value: 49.984
		Parallelism to main journal (mm)	0.008

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Item		Specifications
Cylinder Block	Overall height (mm)	274.9
	Bore roundness/straightness (mm)	0.008/0.01
	Upper surface flatness (mm)	0.04
	Surface grinding limit	Never grind
Connecting Rod	Connecting rod big end hole axial clearance (mm)	0.15 - 0.40
	Connecting rod bearing shell radial clearance (mm)	0.026 - 0.075

Engine Torque Specifications

Description	Torque (N·m)
Ignition Coil Fixing Bolt	8 ± 1
Idler Pulley Fixing Bolt	47 + 5
Tensioner Fixing Bolt	47 + 5
Cylinder Head Cover Fixing Bolt	1st step: 3 + 2 2nd step: 8 + 3
Crankshaft Pulley Fixing Bolt	1st step: 100 ± 10 2nd step: 120° ± 10°
Crankshaft Timing Hole Fixing Bolt	40 + 5
Hydraulic Tensioner Fixing Bolt	9 + 3
Movable Guide Rail Fixing Bolt	12 + 2
Fixing Guide Rail Fixing Bolt	9 + 3
Upper Guide Rail Fixing Bolt	9 + 3
Phaser Fixing Bolt	115 + 5
Camshaft Bearing Cap Fixing Bolt	1st step: 9.5 ± 1.5 2nd step: 9.5 ± 1.5
Cylinder Head Fixing Bolt	1st step: 40 ± 5 2nd step: 90° ± 5° 90° ± 5°
Variable Timing Control Solenoid Valve	6 + 2
Camshaft Position Sensor Fixing Bolt	8 + 3
Lifting Eye Fixing Bolt	20 + 5
Coupling Bolt Between Rear Mounting Upper Body and Rear Mounting Lower Body	80 ± 8
Coupling Bolt Between Rear Mounting Upper Body and Transmission	80 ± 8
Coupling Bolt Between Rear Mounting Lower Body and Sub Frame	105 ± 10
Coupling Bolt Between Left Mounting Cushion and Body	60 ± 6
Coupling Bolt Between Left Mounting Bracket and Transmission	80 ± 8
Coupling Bolt Between Right Mounting Cushion and Engine	80 ± 8
Coupling Bolt Between Right Mounting Cushion and Body	60 ± 6
Knock Sensor Fixing Bolt	20 ± 5
Oil Pump Movable Guide Rail Fixing Bolt	12 + 2
Oil Deflector Fixing Bolt	8 + 3
Crankshaft Frame Fixing Bolt	27 + 3
Crankshaft Main Bearing Fixing Bolt (Frame)	1st step: 45 ± 5 180° ± 10°
Connecting Rod Bearing Cap Fixing Bolt	1st step: 15 + 3 2nd step: 60° ± 2°

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Lubrication Areas During Engine Assembly

Lubrication Area	Note
Valve Guide Bottom Hole	SM 10W - 40
Intake Valve Retainer Bottom Hole	SM 10W - 40
Exhaust Valve Retainer Bottom Hole	SM 10W - 40
Cylinder Head OCV Valve Opening	SM 10W - 40
Check Valve	SM 10W - 40
Valve Stem Part	SM 10W - 40
Valve Oil Seal Lip	SM 10W - 40
Valve Lifter Circumcircle and Lifter Hole	SM 10W - 40
Camshaft Journal and Bearing Seat Hole	SM 10W - 40
Cam Surface	SM 10W - 40
Camshaft Phaser Assembly Front Control Valve	SM 10W - 40
Rocker Arm Roller	SM 10W - 40
Timing System	SM 10W - 40
Cylinder Bore	SM 10W - 40
Main Bearing Cap Bolt	SM 10W - 40
Connecting Rod Bearing Shell and Connecting Rod Journal	SM 10W - 40
Main Bearing Shell and Crankshaft Main Journal	SM 10W - 40
Piston Pin Circumcircle Surface	SM 10W - 40
Crankshaft Front and Rear Oil Seal Journal and Oil Seal Lip	SM 10W - 40
Piston Ring Groove	SM 10W - 40
Cylinder Bore Inner Wall	SM 10W - 40
Crankshaft Front and Rear Oil Seal External Circular Surface	SM 10W - 40
Strainer O-ring	SM 10W - 40
Oil Pump Inlet	SM 10W - 40
Oil Filter Module Oil Inlet on Cylinder Block	SM 10W - 40
Oil Filter O-ring	SM 10W - 40
Dipstick Tube O-ring	SM 10W - 40

Areas with Seal Gum Applied During Engine Assembly

Area with Seal Gum Applied	Seal Gum
Coolant Temperature Sensor	Loctite 243
Bowl Plug	Loctite 11747
"T" Position of Junction Area Between Timing Chain Cover and Cylinder	Loctite 5900H
Timing Chain Cover	Loctite 5900H
Upper Guide Rail Bolt	Loctite 243
Cylinder Block Plug	Loctite 577
Cylinder Block Frame Assembly	Loctite 518/5182
Deflector Mounting Bolt Thread	Loctite 243
Oil Pump Mounting Bolt Thread	Loctite 243
Oil Pan Installation Surface Frame	Loctite 5900H
Oil Pressure Switch Thread	Loctite 577

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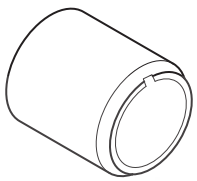
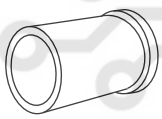
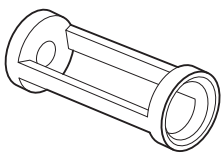
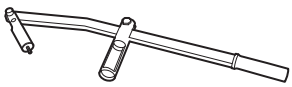
Non-reusable Part

Non-reusable Part	
Valve Oil Seal	Replace it
Cylinder Head Bolt and Gasket	Replace it
Cylinder Gasket	Replace it
Crankshaft Rear Oil Seal	Replace it
Crankshaft Front Oil Seal	Replace it
Connecting Rod Bearing Cap Fixing Bolt	Replace it
Flywheel Fixing Bolt (MT + CVT)	Replace it
Main Bearing Cap Fixing Bolt (Frame)	Replace it
O-ring (Installation Surface Between Frame and Cylinder Block)	Replace it

Tools

Special Tools

Crankshaft Front Oil Seal Guide Tool	Part No.: CH-20007	 049
Crankshaft Front Oil Seal Installer	Part No.: CH-20008	 067
Valve Spring Compression Adapter	Part No.:CH-20018-B	 050
Valve Spring Compressor	Part No.: CH-20017-A	 028

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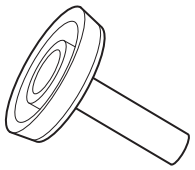
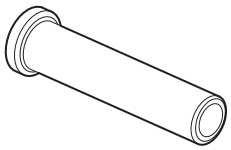
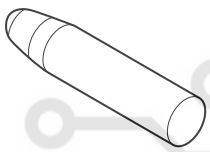
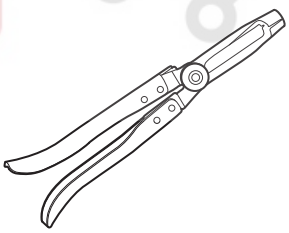
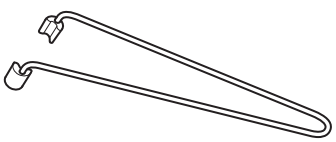
Crankshaft Rear Oil Seal Installer	Part No.: CH-20006	 031
Valve Oil Seal Installer	Part No.: CH-20011-A	 034
Valve Oil Seal Guide Sleeve	Part No.: CH-20012	 035
Valve Oil Seal Remover	Part No.: CH-20013-A	 037
Valve Cotter Installer	Part No.: CH-20017-A	 029

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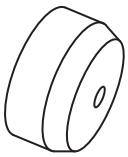
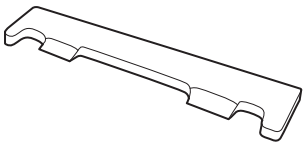
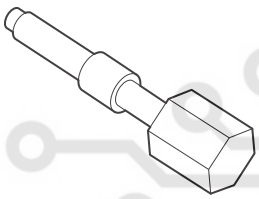
Crankshaft Rear Oil Seal Installer	Part No.: CH-20005-A	 070
Camshaft Timing Tool	Part No.: CH-20010	 033
Crankshaft Timing Tool	Part No.: CH-20089	 027

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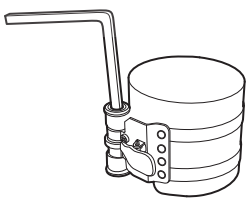
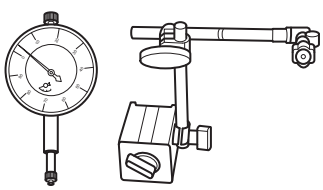
General Tools

Piston Installer	-	 039
Dial Indicator and Magnetic Holder	-	 023

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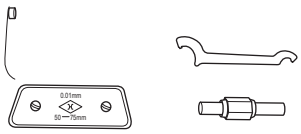
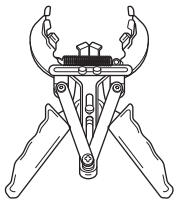
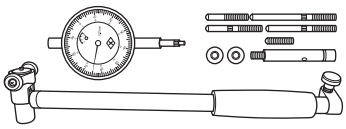
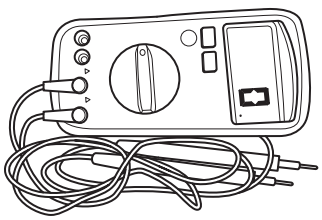
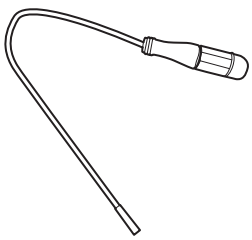
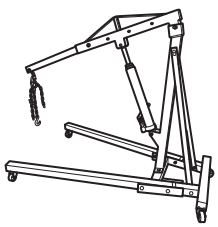
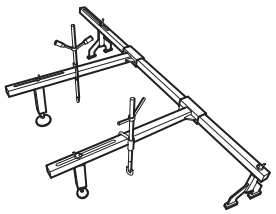
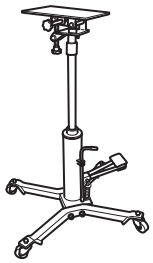
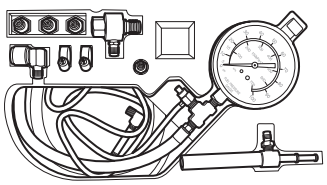
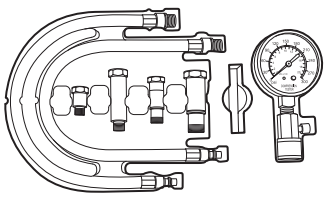
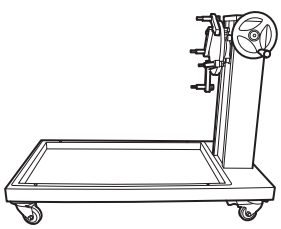
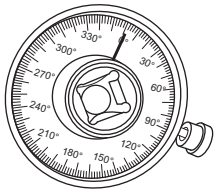
Outer Diameter Micrometer	-	
Vernier Caliper	-	
Inner Diameter Micrometer	-	
Precision Straightedge	-	
Feeler Gauge	-	

Piston Ring Remover	Part No.: CH-20080	 066
Cylinder Gauge	-	 065
Digital Multimeter	-	 002
Flexional Magnetic Rod	Part No.: CH-20053	 042
Engine Hoist	-	 043

Engine Equalizer	Part No.: CH-30040	 026
Transmission Carrier	-	 005
Fuel System Pressure Tester	-	 048
Cylinder Pressure Gauge	-	 044
Engine Service Platform	-	 057

Angle Gauge	-	 091

DIAGNOSIS & TESTING

Diagnosis Content

Problem Symptoms Table

Hint:

Use symptoms table below to help determine cause of problem. Check each suspected area in sequence. Repair, replace or adjust faulty components as necessary.

Symptom	Suspected Area
Valve mechanism noise	Engine oil (oil level high or low, oil lean or rich)
	Cam
	Valve spring seat (excessive runout)
	Valve (excessive clearance between valve and guide)
Connecting rod noise	Engine oil (low pressure)
	Engine oil (lean)
	Connecting rod bearing cap (loose fixing bolt)
	Connecting rod (misaligned)
	Connecting rod bearing shell (excessive radial clearance)
	Connecting rod journal (out-of roundness)
Main bearing noise	Engine oil (low pressure)
	Engine oil (lean)
	Main bearing shell (excessive clearance)
	Crankshaft axial clearance (excessive)
	Crankshaft journal (out-of roundness or worn)
	Flywheel or clutch (loose)
Oil loss or spark plug blockage	Piston ring (worn, scratched or damaged)
	Piston ring groove (carbon deposited)
	Valve oil seal (worn or damaged)
	Valve (excessive clearance between valve and guide)
Engine power loss	Spark plug (dirty, burnt or incorrect clearance)
	Electric fuel pump assembly
	Ignition coil
	Valve timing (incorrect)
	Cylinder head (leaked)
	Valve (burnt, deformation or excessive clearance)
	Cylinder pressure (low)
	Fuel system (dirty)
	Exhaust system (blocked)
Water in engine	Cylinder gasket (leakage)
	Cylinder liner (cracked)
	Drive through water
	Oil filter module (internal leakage)

Inspection

1. Check the coolant.
2. Check the engine oil.
3. Check the battery.
4. Check the air filter element.
   (a) Remove the air filter element.

(b) Visually check that there is no dirt, blockage or damage in the air filter element.
Hint:
- If there is any dirt or blockage in air filter element, clean it with compressed air.
- If any dirt or blockage remains, even after cleaning air filter element with compressed air, replace it.

5. Check the spark plug.
6. Test the cylinder compression pressure.

- Cylinder pressure is the main index to judge engine operation and also can be used to definitely judge whether some system of engine operates well or not. Therefore, it is necessary to perform cylinder pressure measurement when servicing engine.
- Ensure battery is fully charged and engine starter is in good operating condition. Otherwise, indicated compression pressure used for diagnosis may be invalid.

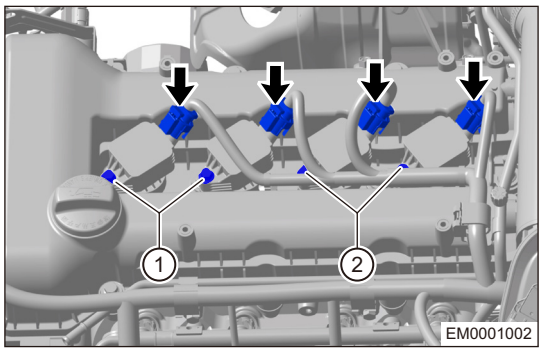
Caution:
- Recommended compression pressure is only used as a guide for diagnosing engine malfunction.
- Never determine cause of low pressure by disassembling engine unless there are some malfunctions.

Measurement procedures:

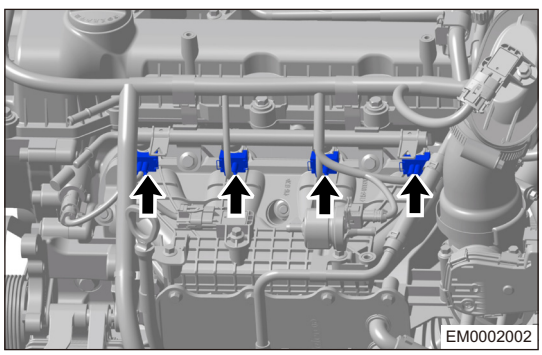
Caution:
- Use a cylinder pressure gauge with accurate reading and reset it to zero, or it will influence accuracy of reading.

(a) Turn off all electrical equipment and the ignition switch.
(b) Remove the engine trim cover.
(c) Remove the ignition coil.
- Disconnect the ignition coil connectors (arrow).
- Remove 4 fixing bolts (1) and (2) from ignition coil, and remove 4 ignition coils.

Tightening torque
8 ± 1 N·m

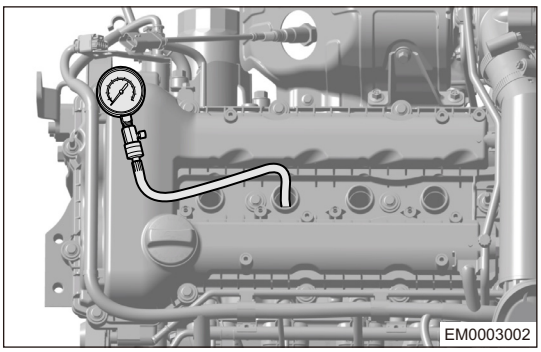


(d) Disconnect all injector connectors (arrow).



(e) Remove spark plug in each cylinder

(f) Slowly screw the cylinder pressure gauge connector vertically into the spark plug mounting hole. Do not tighten it excessively to prevent difficult removal.



(g) With transmission in P/N position (for CVT models) or neutral position (for MT models), depress accelerator pedal fully, then start engine and keep it racing for 3 to 5 seconds; record the measured pressure value.

(h) Press the bleeder button of cylinder pressure gauge to reset it to zero. Use same method to repeat this test three times and then calculate average value.
Cylinder pressure value is within 7 - 10 bar (180 - 250 r/min).
Caution:
- DO NOT screw the cylinder pressure gauge excessively to prevent difficult removal.
- During measurement, do not turn ignition switch to "START" for more than 10 seconds. Otherwise, engine may be damaged.
- Ensure battery is fully charged when cranking engine. Correct cylinder pressure can be measured only when engine is running at 180 - 250 r/min.
- Use same method to measure pressure of other cylinders.

Cylinder pressure value judgment:
Correct cylinder pressure
- Standard cylinder pressure value is 7 - 10 bar (180 - 250 r/min). The value will drop slightly with usage of engine, but lowest value cannot be below 7 bar and pressure difference between each cylinder should not be above 3 bar.
- If engine cylinder pressure is lower than standard value, it indicates that cylinder pressure is insufficient. Add a small amount of engine oil to cylinder through spark plug hole and perform measurement again.
- If pressure increases after adding oil, piston ring or cylinder bore may be worn or damaged.
- If pressure remains low, the valve may be stuck or damaged, or there may be air leakage in cylinder head gasket.

(i) Install the spark plug.
Caution:
- Be sure to check spark plugs, and apply a proper amount of lubricant to spark plug mounting threads before installing spark plugs. During installation, do not put spark plugs directly through mounting holes, as high dropping may cause the side electrode to deform, thus reducing the gap. Spark jump may affect the engine operation. Installation torque: 20 ± 3 N·m.

(j) Connect all injector connectors.

(k) Install the ignition coil.

7. Test cylinder head gasket for leakage.

Cylinder head gasket leakage may be present between adjacent cylinder and water jacket or from an oil passage to the external of engine.
- Possible trouble symptoms caused by cylinder head gasket leakage between adjacent cylinders are as follows:
  Engine power loss.
  Engine stall.
  Low fuel economy.

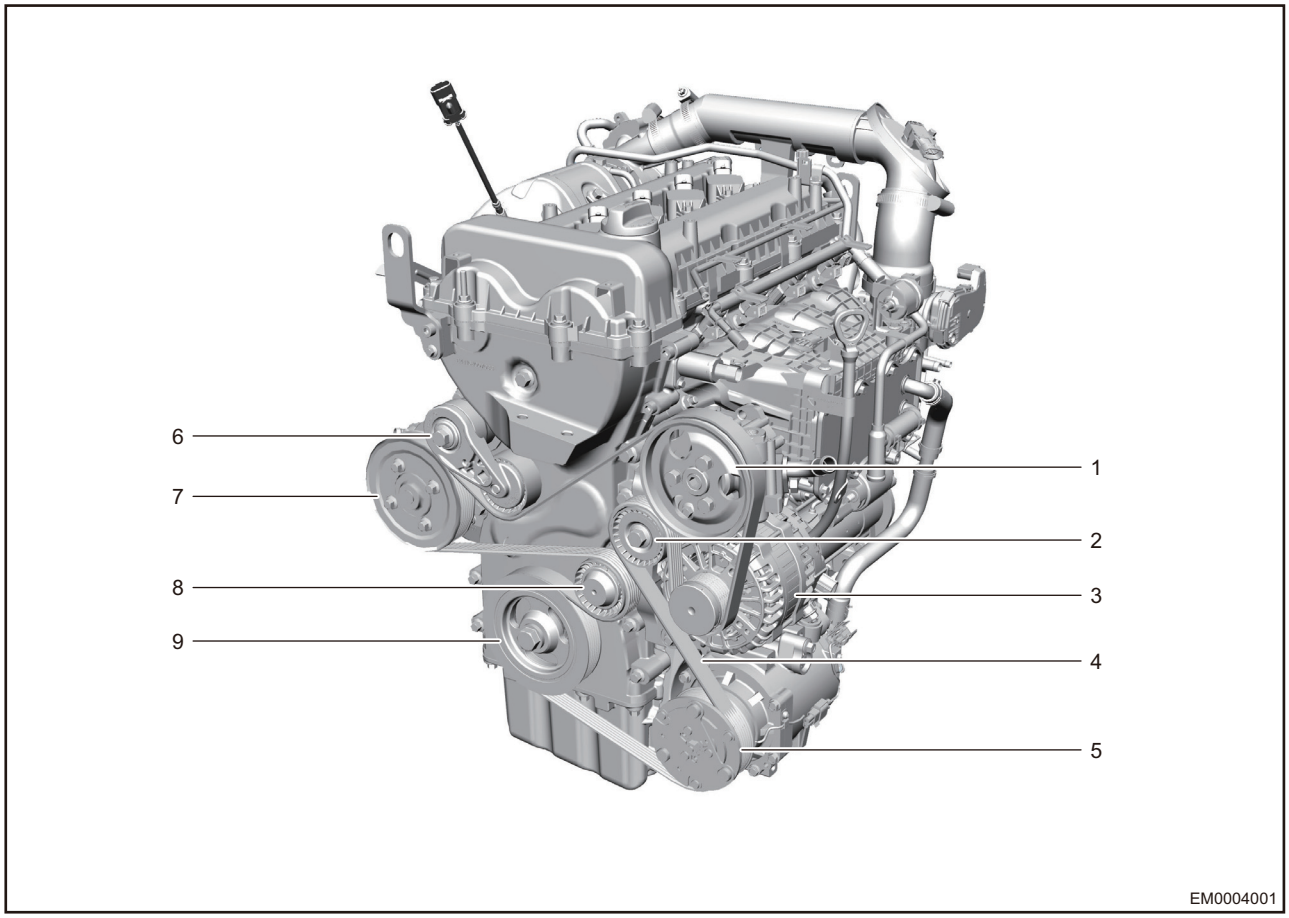
- Possible trouble symptoms caused by cylinder head gasket leakage between cylinder and adjacent water jacket are as follows:
  Engine overheats.
  Coolant loss.
  Excessive steam (white smoke) emitted from exhaust system.
  Coolant foaming.

ON-VEHICLE SERVICE

Accessory Pulley

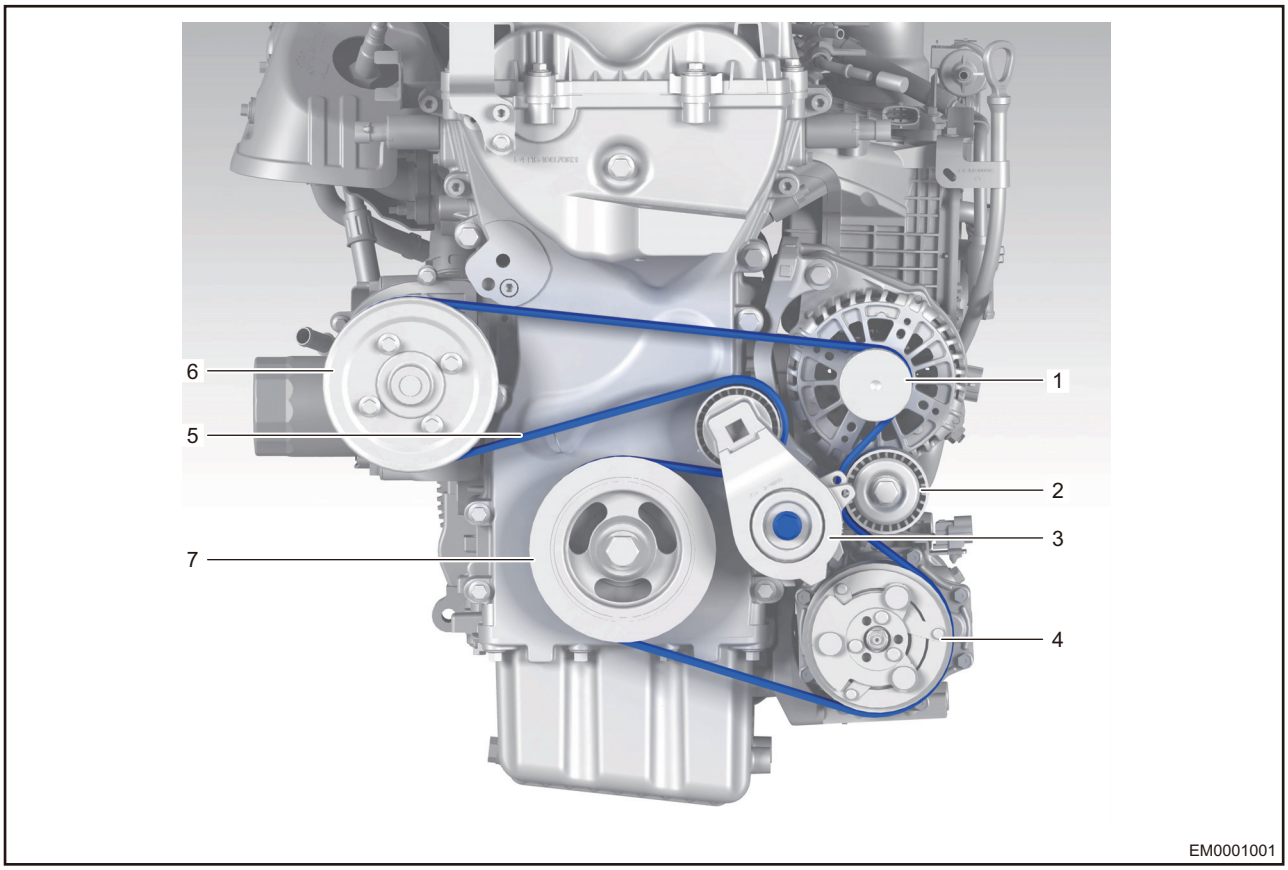
Description

For MT Models



1 - Power Steering Pump Pulley	2 - Upper Idler Pulley
3 - Alternator	4 - Accessory Drive Belt
5 - A/C Compressor Pulley	6 - Belt Tensioner Assembly
7 - Water Pump Pulley	8 - Lower Idler Pulley
9 - Crankshaft Pulley	

For CVT Models

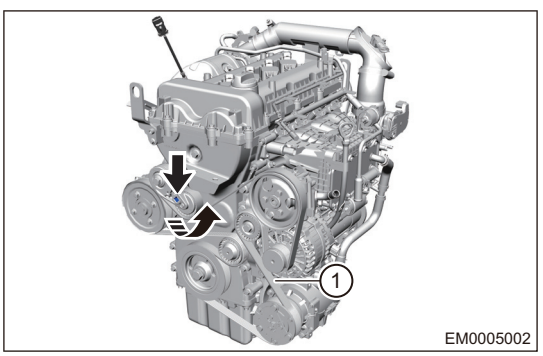


1 - Alternator Assembly	2 - Idler Pulley Assembly
3 - Tensioner Assembly	4 - Compressor Assembly
5 - Accessory Drive Belt	6 - Water Pump Pulley
7 - Crankshaft Pulley	

Removal

1. Turn off all electrical equipment and the ignition switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Remove the accessory drive belt (for MT models).
   (a) Insert tip of ratchet rod into tensioner pin hole (arrow) and pull it upward in direction of arrow as shown in illustration, then remove accessory drive belt assembly (1).

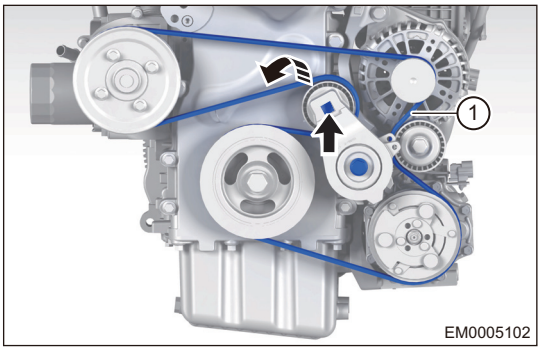
   Caution:
   - Prevent hand from contacting belt tensioner when raising it upward.



5. Remove the accessory drive belt (for CVT models).

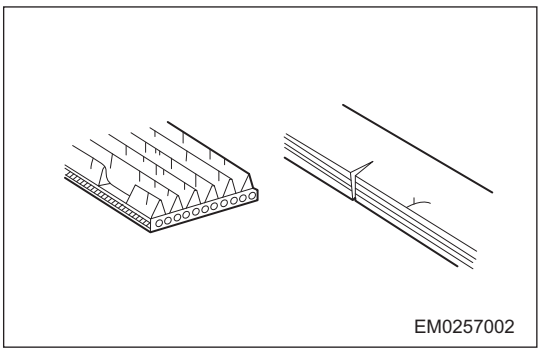
   (a) Insert tip of ratchet rod into tensioner pin hole (arrow) and pull it downward in direction of arrow as shown in illustration, then remove accessory drive belt assembly (1).

   Caution:
   - Prevent hand from contacting belt tensioner when raising it upward.



Inspection

1. Visually check accessory drive belt for excessive wear and cords for wear, etc. If any of these defects is found, replace accessory drive belt.



Hint:
- If accessory drive belt has chunks missing from ribs, it should be replaced.
- After installing accessory drive belt, check that it fits properly in the ribbed grooves. Check that belt has not slipped out of grooves on bottom of the crankshaft pulley by hand.

Installation

Warning/Caution/Hint

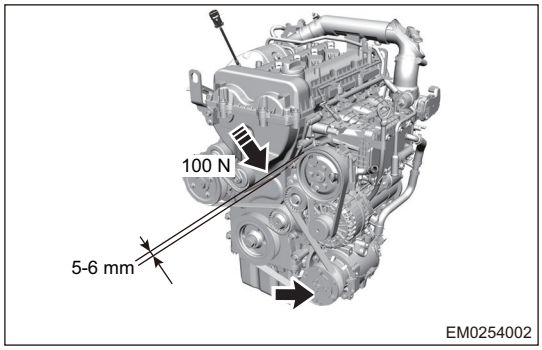
Caution:
- Before installation, remove the dirt from accessory drive belt.
- Rotate crankshaft after installation, make sure that accessory drive belt is installed in place and does not contact with other separate parts.

1. Installation is in the reverse order of removal.

Adjustment

1. Check the accessory drive belt tension.
   (a) Rotate crankshaft pulley 2 turns, so that belt tension between each pulley is even.

(b) Apply 100 N of force to center part of the belt between power steering pump pulley and tensioner pulley with your thumb. Check that displacement of belt is within 5 - 6 mm. If displacement is too large or too small, adjust, check or repair.



Idler Pulley Assembly

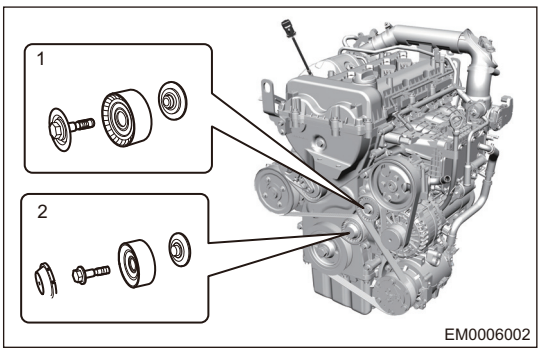
Removal

Warning/Caution/Hint

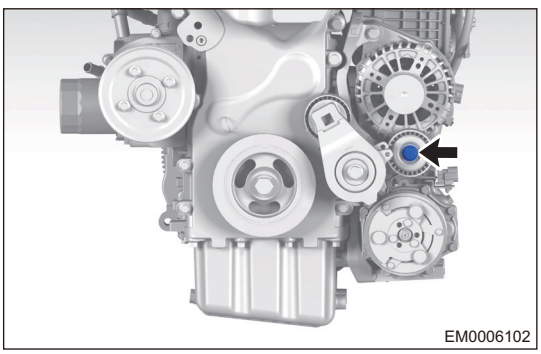
Caution:

- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the ignition switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Remove the accessory drive belt.
5. Remove the idler pulley assembly (for MT models).
   (a) Remove fixing bolt from upper idler pulley assembly (1), and remove upper idler pulley and washer.
   Tightening torque
   47 + 5 N·m



   (b) Remove protector from lower idler pulley assembly (2).
   (c) Remove fixing bolt from lower idler pulley assembly, and remove lower idler pulley and washer.
6. Remove the idler pulley assembly (for CVT models).
   (a) Remove fixing bolt (arrow) from idler pulley assembly.
   Tightening torque
   47 + 5 N·m



   (b) Remove the idler pulley assembly.

Inspection

1. Rotate idler pulley by hands and check if rotation is smooth and if abnormal noise occurs.
2. Wiggle idler pulley in axial and radial directions to check bearing for looseness.
3. Check if there is damage on idler pulley assembly operating surface.

Installation

Warning/Caution/Hint

Caution:

- After installation, turn crankshaft to run accessory drive belt several circles, and check if crankshaft turns smoothly and belt runs well. If it does not turn smoothly, reinstall accessory drive belt.
- Make sure to correctly install accessory drive belt, and it does not interfere with other components.

1. Installation is in the reverse order of removal.

Tensioner Assembly

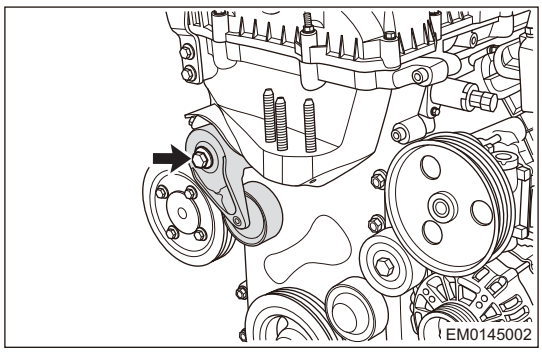
Removal

Warning/Caution/Hint

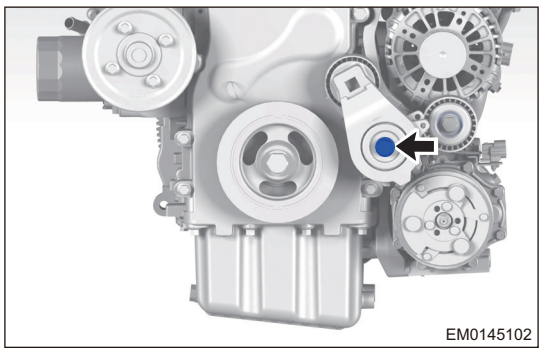
Caution:

- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the ignition switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Remove the accessory drive belt.
5. Remove the tensioner assembly (for MT models).
   (a) Remove the tensioner assembly fixing bolt (arrow).
   Tightening torque
   47 + 5 N·m



   (b) Remove the tensioner assembly.
6. Remove the tensioner assembly (for CVT models).
   (a) Remove the tensioner assembly fixing bolt (arrow).
   Tightening torque
   47 + 5 N·m



   (b) Remove the tensioner assembly.

Inspection

1. Rotate tensioner pulley assembly by hands and check if rotation is smooth and if abnormal noise occurs.
2. Wiggle tensioner pulley assembly in axial and radial directions to check for looseness.
3. Check if there is damage on tensioner pulley operating surface.

Installation

Warning/Caution/Hint

Caution:

- After installation, turn crankshaft to run accessory drive belt several circles, and check if crankshaft turns smoothly and belt runs well. If it does not turn smoothly, reinstall accessory drive belt.
- Make sure to correctly install accessory drive belt, and it does not interfere with other components.

1. Installation is in the reverse order of removal.

Cylinder Head Cover

Removal

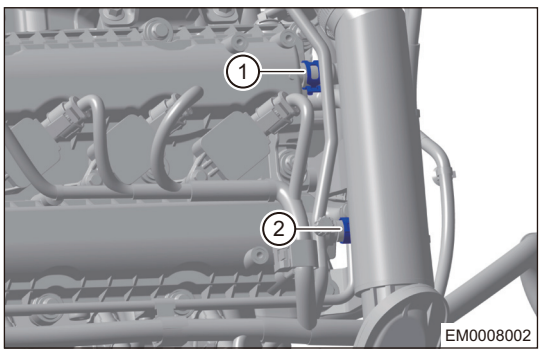
Warning/Caution/Hint

Caution:

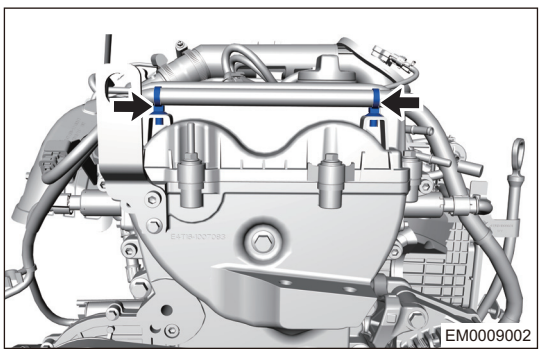
- Blow dirt and debris away from surface of cylinder head cover with compressed air.
- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the ignition switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Remove the ignition coil (See page 07-14).
5. Drain the coolant (See page 29-9).
6. Remove the turbocharger water outlet pipe set (See page 11-10).
7. Remove the discharge steel pipe (See page 12-24).
8. Remove the cylinder head cover.

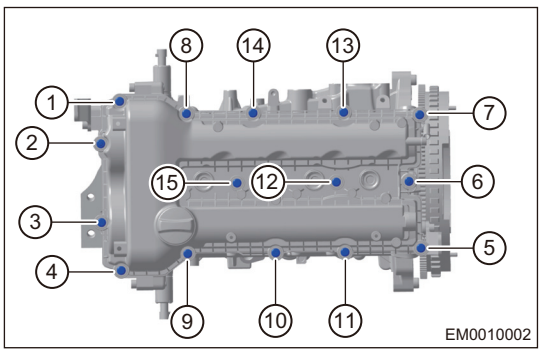
(a) Loosen clamping ring (2) and elastic clamp (1), disconnect connection between crankcase ventilation hose and cylinder head cover.



(b) Remove engine wire harness fixing clips (arrow) from cylinder head cover.

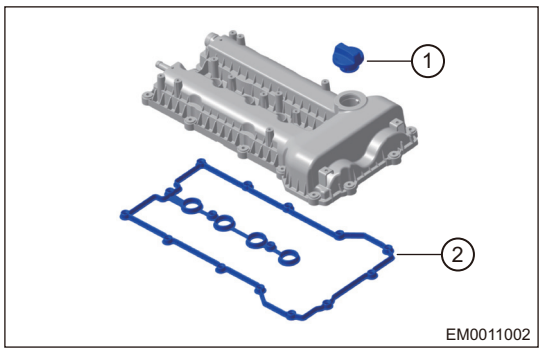


(c) Remove 15 cylinder head cover fixing bolts in order shown in illustration.



(d) Remove the cylinder head cover assembly.

(e) Remove fuel filler cap (1) and cylinder head cover gasket (2) from cylinder head cover assembly.



Installation

Warning/Caution/Hint

Caution:

- Remove oil and seal gum on cylinder head cover and cylinder head before installation.
- Check if gasket is damaged or loses elasticity, if so, replace it.

1. Install the cylinder head cover assembly.

(a) As shown in illustration, apply seal gum to "T" position of junction area between timing chain cover and cylinder head.

Seal Gum

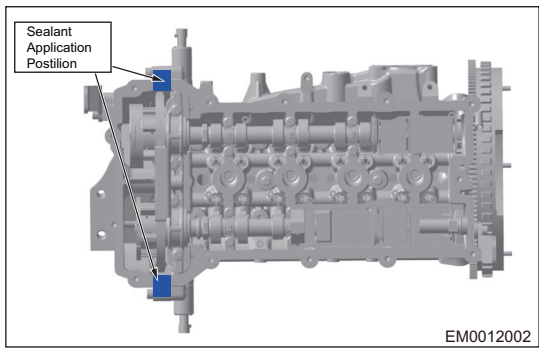
Loctite 5900H

Hint:

- Pay attention that seal gum should not be applied too thick, to prevent excessive seal gum entering into inside of engine when press fitting the cylinder head cover.
- Install cylinder head cover assembly 15 minutes elapse after applying seal gum.

Diameter of seal gum line:

2.5 - 5 mm



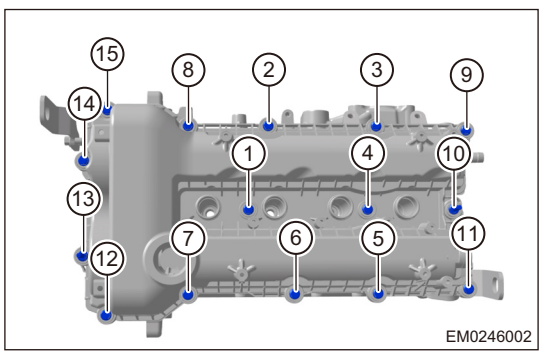
(b) Install cylinder head cover and manually install bolts to 1 to 2 threads.

(c) Tighten 15 cylinder head cover fixing bolts in order shown in illustration.

Tightening torque

1st step: 3 + 2 N·m

2nd step: 8 + 3 N·m



2. Other installation procedures are in the reverse order of removal.

Crankshaft Front Oil Seal

Removal

Warning/Caution/Hint

Caution:

- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the ignition switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Remove the accessory drive belt.
5. Remove the crankshaft front oil seal assembly.

(a) Remove fixing bolt (arrow) from crankshaft pulley.

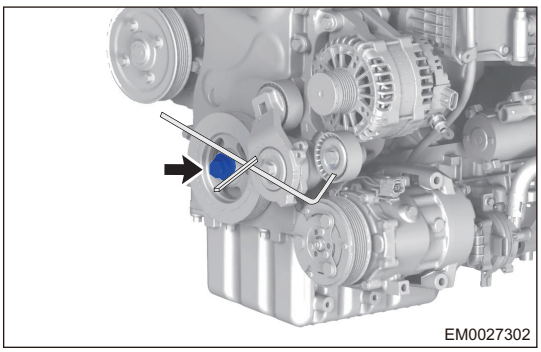
Tightening torque

1st step: 100 ± 10 N·m

2nd step: 120° ± 10°

Hint:

Use a rigid iron rod with proper right-angle bending, and insert the bent part into clearance on lower part of alternator bracket, use another right-angle iron rod as a fulcrum while inserting it into the crankcase pulley groove to lock crankshaft pulley and remove bolts at the same time.

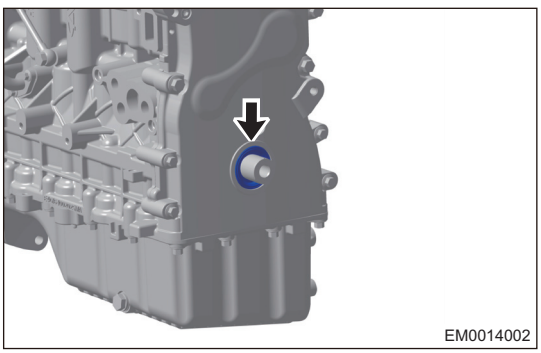


(b) Remove the crankshaft pulley.

(c) Using a flat tip screwdriver wrapped with tape, pry out the crankshaft front oil seal (arrow).

Hint:

Be careful not to scratch junction surface, when removing crankshaft front oil seal.



Installation

Warning/Caution/Hint

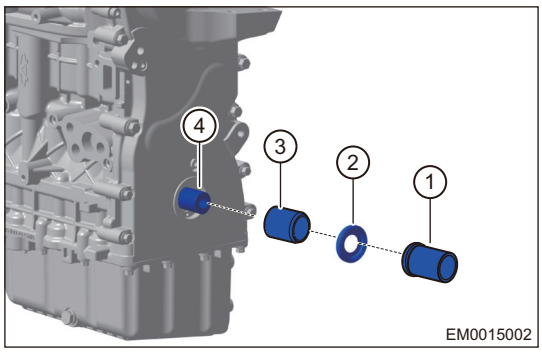
Caution:

- Apply a coat of engine oil to the crankshaft front oil seal guide tool before installing a new oil seal.
- Remove dirt on junction surface and apply a coat of engine oil to junction surface and oil seal lip (except the oil seal with surface applied wax) before assembly.
- Be sure to prevent the lip of crankshaft front oil seal from being scratched during installation. If it is damaged, replace it immediately.

1. Install the crankshaft front oil seal.

(a) Install crankshaft front oil seal guide tool (3) to crankshaft (4).

(b) Install new oil seal (2) to crankshaft front oil seal guide tool, then install new oil seal evenly and fully into oil seal retainer with a crankshaft front oil seal installer (1).



Caution:

- Make sure oil seal surface is 0 to 1 mm lower than end surface of timing chain cover oil seal hole.
- Make sure that the oil seal lip is not damaged during assembly.
- After installing oil seal, distance between oil seal surface and end surface of oil seal hole on timing chain cover should be not more than 0.3 mm, and trimming of oil seal outer retainer rubber are not allowed.

(c) Other installation procedures are in the reverse order of removal.

Flywheel

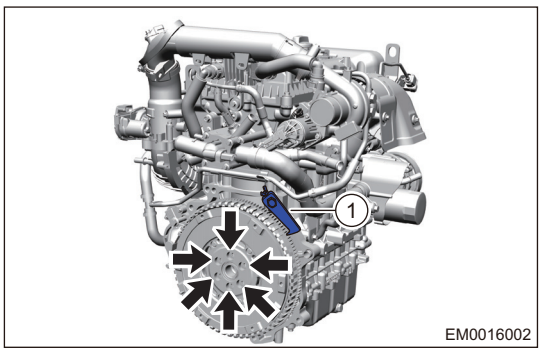
Removal

Warning/Caution/Hint

Caution:

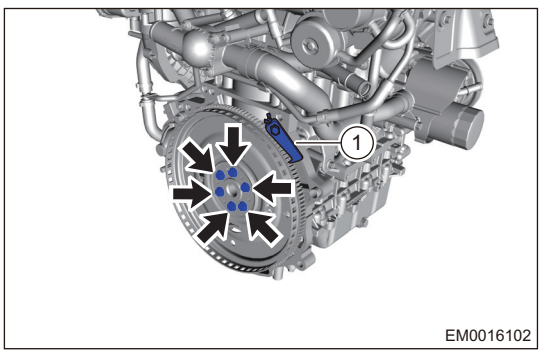
- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the ignition switch.
2. Disconnect the negative battery cable.
3. Remove the transmission assembly (See page 18-111).
4. Remove the flywheel assembly (for MT models).
   (a) Install flywheel holding tool (1) to lock flywheel.



   (b) Remove 6 fixing bolts from flywheel assembly, and remove flywheel assembly.
   Warning:
   - Pay attention to personal safety during operation.
   - DO NOT remove all fixing bolts without any auxiliary measures.

   Caution:
   - Flywheel fixing bolts must be disposed after removal. Never reuse them.
5. Remove the flywheel assembly (for CVT models).
   (a) Install flywheel holding tool (1) to lock flywheel.



   (b) Remove 6 fixing bolts from flywheel assembly, and remove flywheel assembly.
   Warning:
   - Pay attention to personal safety during operation.
   - DO NOT remove all fixing bolts without any auxiliary measures.

   Caution:
   - Flywheel fixing bolts must be disposed after removal. Never reuse them.

Inspection

1. Check if crankshaft position signal gear is distorted or deformed. If damaged, replace flywheel. Clean signal gear before installation.
2. Check if starter driven gear ring is worn. If excessively worn, replace flywheel.

Installation

Warning/Caution/Hint

Warning:

- Never reuse flywheel fixing bolts after removal.

Caution:

- Six bolt holes on the flywheel have asymmetrical positions. During installation, pay attention to that flywheel fixing bolts are aligned with crankshaft bolt holes.

1. Install the flywheel (for MT models).

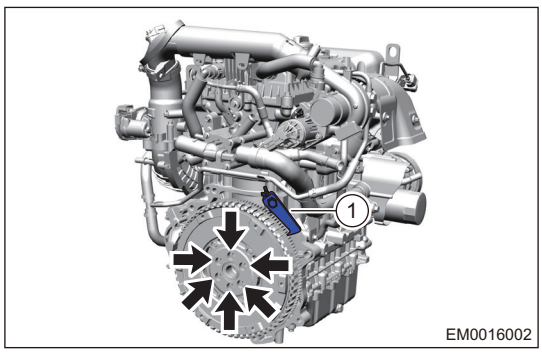
   Caution:

   - Lightly push flywheel after alignment during assembly. Do not tap flywheel with a hammer.
   - Replace flywheel fixing bolts with new ones.

   (a) When installing flywheel assembly, pretighten fixing bolts (arrow), and install flywheel holding tool (1), then tighten each flywheel bolt diagonally in order.

   ★
   Non-reusable Part

   Tightening torque
   1st step: 35 N·m
   2nd step: 35°



2. Install the flywheel (for CVT models).

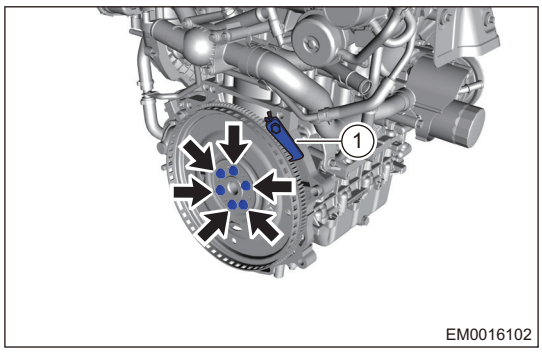
   Caution:

   - Lightly push flywheel after alignment during assembly. Do not tap flywheel with a hammer.
   - Replace flywheel fixing bolts with new ones.

   (a) When installing flywheel assembly, pretighten fixing bolts (arrow), and install flywheel holding tool (1), then tighten each flywheel bolt diagonally in order.

   ★
   Non-reusable Part

   Tightening torque
   1st step: 90 N·m



Crankshaft Rear Oil Seal

Removal

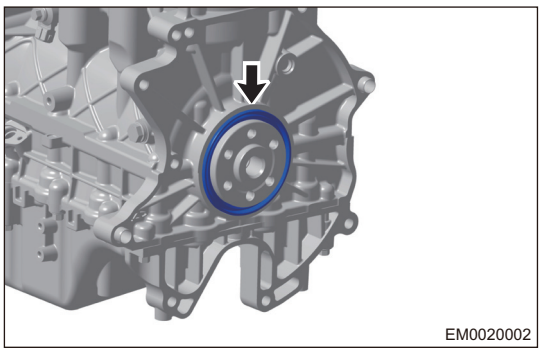
Warning/Caution/Hint

Caution:

- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the ignition switch.
2. Disconnect the negative battery cable.
3. Remove the transmission assembly (See page 18-111).
4. Remove the flywheel assembly.
5. Remove the crankshaft rear oil seal.
   (a) Using a screwdriver with the tip wrapped with tape, remove crankshaft rear oil seal (arrow).

   Caution:
   - Be careful not to scratch cylinder block, when removing oil seal.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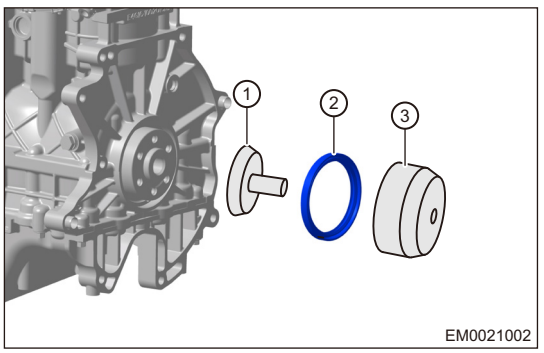
Installation

Warning/Caution/Hint

Caution:

- Be sure to clean dirt around oil seal retainer and on inside wall before installation.
- Check oil seal for damage before installation. If there is any damage, replace it.
- Be sure to prevent the lip of crankshaft rear oil seal from being scratched during installation.
- Be careful not to damage oil seal retainer during installation.

1. Install the crankshaft rear oil seal.
   (a) Apply engine lubricant to crankshaft oil seal outer retainer and lip.
   Hint:
   Oil seal with surface applied with wax cannot be applied.
   (b) Install guide tool (1) to crankshaft.



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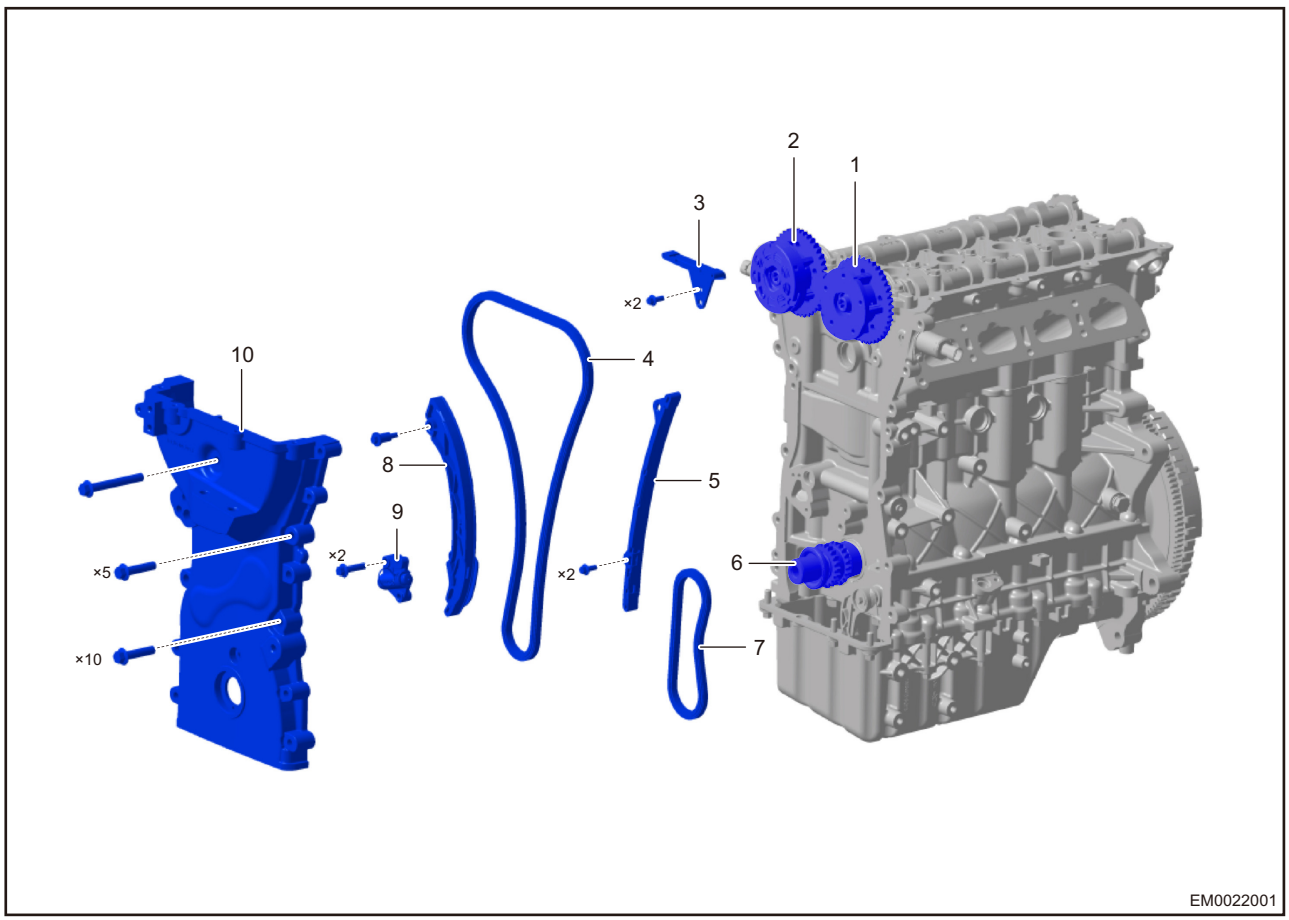
(c) Install new oil seal (2) to crankshaft rear oil seal guide tool, then install new oil seal evenly and fully into oil seal retainer with a crankshaft rear oil seal installer (3).

Caution:

- Oil seal surface lowering 0 - 1 mm than rear end surface of cylinder block mounting seat hole is enough.
- Make sure that the oil seal lip is not damaged during assembly.
- After installing oil seal, distance between oil seal surface and rear end surface of cylinder block oil seal mounting seat hole should be not more than 0.5 mm, and trimming of oil seal outer retainer rubber are not allowed.

Engine Timing Chain

Description



1 - Intake Phaser Assembly	2 - Exhaust Phaser Assembly
3 - Upper Fixing Guide Rail	4 - Engine Timing Chain
5 - Fixing Guide Rail	6 - Crankshaft Assembly
7 - Oil Pump Drive Chain	8 - Movable Guide Rail
9 - Tensioner Assembly	10 - Timing Chain Cover

Removal

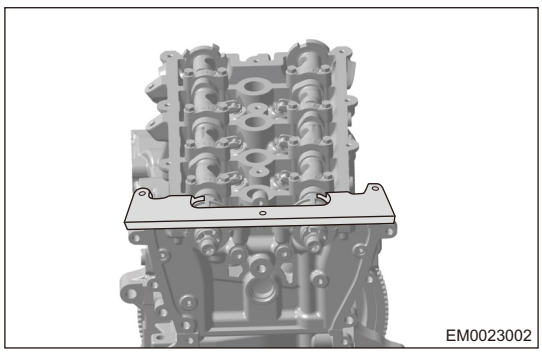
Warning/Caution/Hint

Caution:

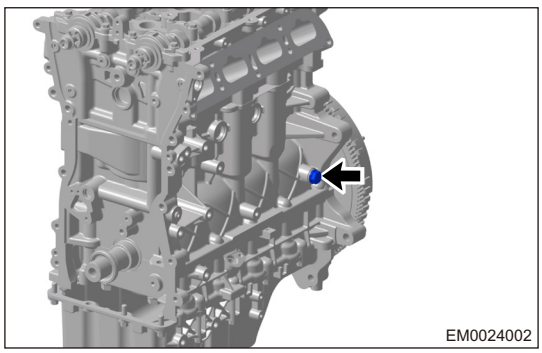
- Blow dirt and debris away from surface of cylinder head cover with compressed air.
- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the ignition switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Remove the ignition coil.
5. Remove the cylinder head cover.
6. Remove the accessory drive belt.
7. Remove the idler pulley assembly.
8. Remove the tensioner assembly.
9. Remove the crankshaft pulley.

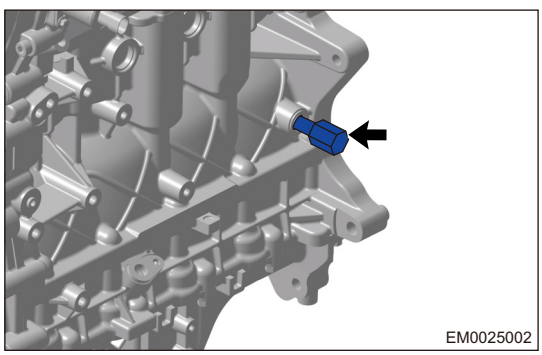
10. Remove the water pump pulley.
11. Use an engine equalizer to hang engine assembly.
    Hint:
    Use engine equalizer to hang lifting eye of engine when supporting the engine oil pan with jack. Avoid engine tilting to right side for easy removal of engine right mounting cushion assembly.
12. Remove the engine right mounting cushion assembly.
13. Install the camshaft timing tool.
    (a) Place camshaft timing positioning special tool on the back of cylinder head upper plane, rotate intake and exhaust camshafts separately in order to clamp the special tool into slots on rear end of both camshafts.


EM0023002

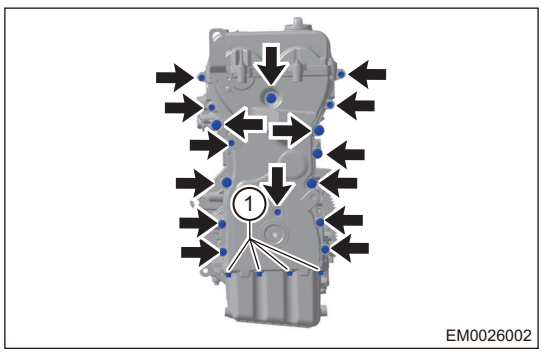
    (b) Remove starter assembly.
    (c) Remove crankshaft timing tool installation hole fixing bolt (arrow) from engine block.
    Tightening torque
    40 + 5 N·m


EM0024002

    (d) Install crankshaft timing positioning pin to cylinder block through thread hole on intake side of cylinder block, and insert front end of positioning pin into positioning hole of crankshaft balancer (each cylinder piston should be in the same plane).
    Caution:
    - It takes patience to perform this operation and pay more attention to avoid damage to crankshaft.


EM0025002

14. Remove the engine timing chain cover.
    (a) Remove 4 fixing bolts (1) between engine timing chain cover and oil pan assembly.
    Tightening torque
    20 + 5 N·m



EM0026002

(b) Remove fixing bolts (arrow) from timing chain cover.

Tightening torque

M8 x 45 (6): 20 + 5 N·m
M8 x 40 - 10.9 (4): 30 + 5 N·m
M10 x 45 (5): 40 + 5 N·m
M10 x 80 (1): 40 + 5 N·m

(c) Remove the timing chain cover.

Caution:

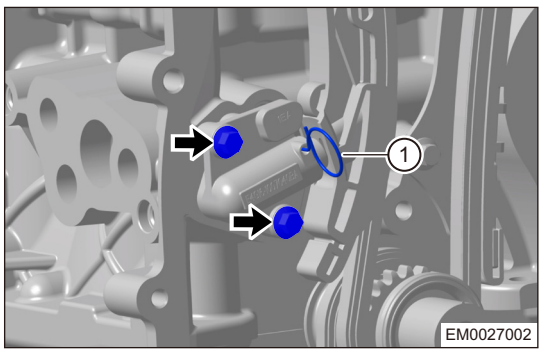
- Remove oil and seal gum with a special tool.
- Carefully observe timing chain cover for cracks or oil leakage. If exists, replace timing chain cover assembly.

15. Remove the timing chain.

(a) Push movable guide rail to keep tensioner plunger at maximum compression position, and insert plunger snap pin (1) to stick tensioner plunger.

Caution:

- Since tensioner plunger has large elastic force, never remove tensioner assembly fixing bolts when plunger snap pin is not installed, to prevent plunger from popping out suddenly and cause accidental injuries.



(b) Remove 2 fixing bolts (arrow) and tensioner assembly.

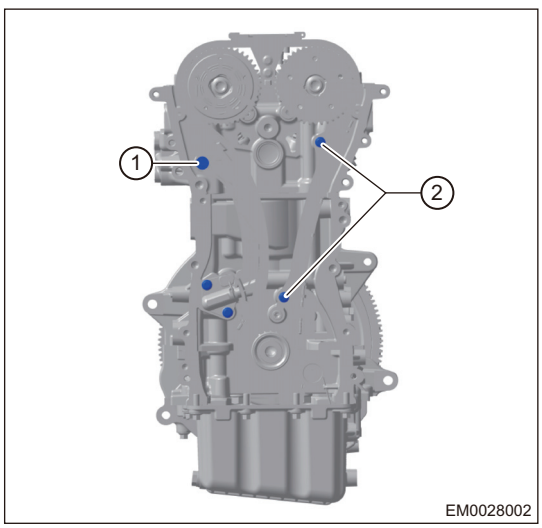
Tightening torque

9 + 3 N·m

(c) Remove movable guide rail fixing bolt (1), and remove movable guide rail assembly.

Tightening torque

12 + 2 N·m



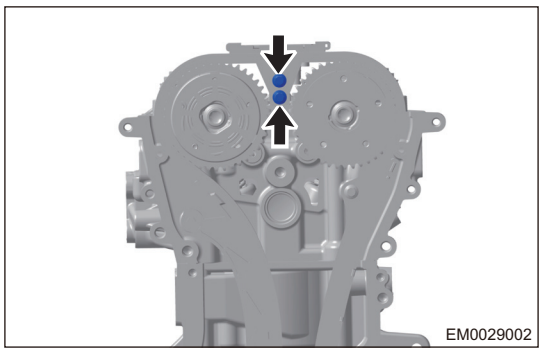
(d) Remove 2 fixing guide rail fixing bolts (2), and remove fixing guide rail assembly.

Tightening torque

9 + 3 N·m

(e) Remove 2 upper guide rail fixing bolts (arrow), and remove upper guide rail assembly.

Tightening torque
9 + 3 N·m



(f) Remove the engine timing chain assembly.

Caution:

- Mark front side and back side of chain with a marking pen after removing chain, so as to keep same direction during installation. Long time movement in one direction of timing chain will cause wear difference between two sides of chain, so it is necessary to remove and install the chain in same direction.

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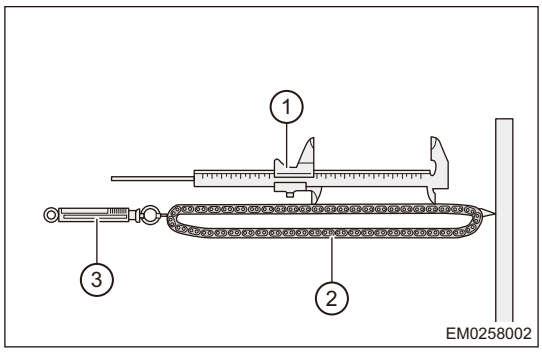
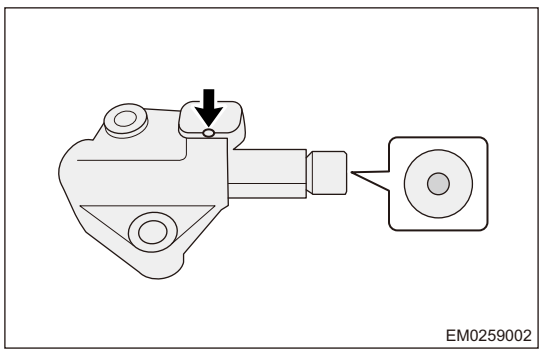
Inspection

1. Check the timing chain.
   (a) Carefully check timing chain for serious wear or cracks. If exists, replace timing chain assembly.
   (b) Pull chain with a force of 147 N, and select 15 chain links to measure with a vernier caliper. Maximum elongation is 120.84 mm.

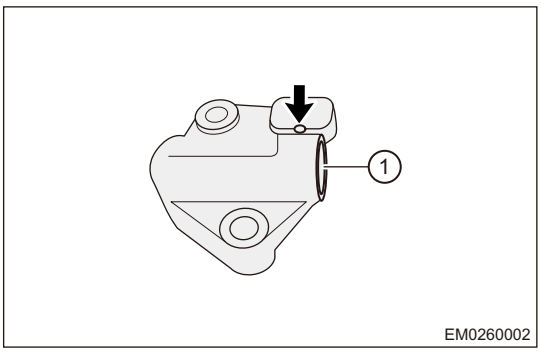
   Hint:
   Measure at any three positions, and average the measurements. If the value is larger than the maximum elongation, replace timing chain assembly.
   If it is not as specified, replace timing chain assembly.



2. Check the tensioner.
   (a) Press piston by hand and release it, and spring should have abundant elastic force without sticking. If sticking exists, replace tensioner assembly.
   (b) Plug the two hold-down pin holes (arrow) with figures, and blow air to piston hole, there should have no any air leakage. If leakage exists, replace tensioner assembly.



(c) Remove check valve, piston, spring, plug hold-down pin hole (arrow) with figures, and blow air to housing (1) with mouth, there should have no air to pass, and air should pass during inspiration, otherwise, replace hydraulic tensioner.



3. Check the movable guide rail.
   (a) Measure depth of movable guide rail with a vernier caliper.
   Hint:
   If wear limit is more than 2 mm, replace movable guide rail assembly.

Installation

07

Warning/Caution/Hint

Caution:

- Apply seal gum to edge of engine timing chain cover, and apply seal gum to inside of timing chain cover mounting bolt hole.

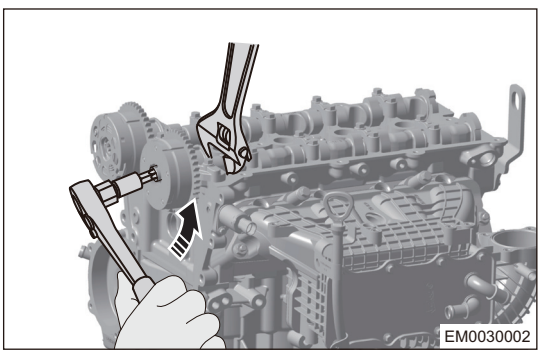
  Seal Gum

  Loctite 5900H

1. Install the timing chain.
   (a) Use a proper wrench to hold intake camshaft and loosen fixing bolt from intake phaser assembly.

   Tightening torque

   115 + 5 N·m



   (b) Loosening method for exhaust phaser fixing bolt is the same as that of intake phaser fixing bolt.
   Hint:
   It is only necessary to loosen intake and exhaust phaser fixing bolts without removing phaser.
   (c) Apply seal gum to 2 - 3 threads of two upper guide rail assembly bolts, and screw them into camshaft 1st bearing cap.
   Hint:
   Do not tighten the bolts.

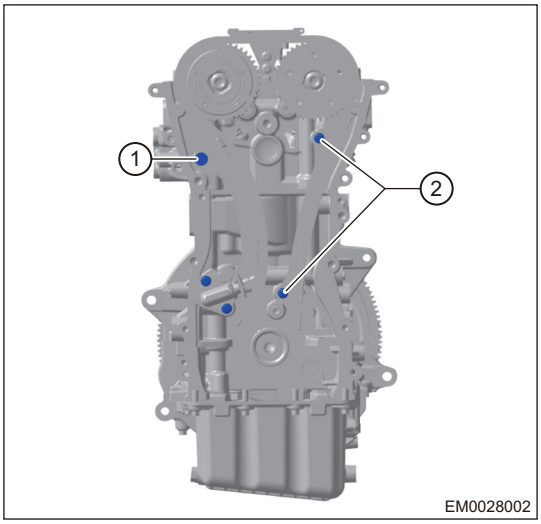
   Seal Gum

   Loctite 243
   (d) Install the timing chain assembly.
   Caution:
   - Ensure to install according to marks on timing chain correctly.
   - Ensure to hang timing chain to intake and exhaust phasers and crankshaft sprocket. Make sure that timing chain and upper guide rail are in level.

(e) Install fixing guide rail and tighten 2 bolts (2).

Tightening torque

9 + 3 N·m



(f) Install movable guide rail and tighten bolt (1).

Tightening torque

12 + 2 N·m

Caution:

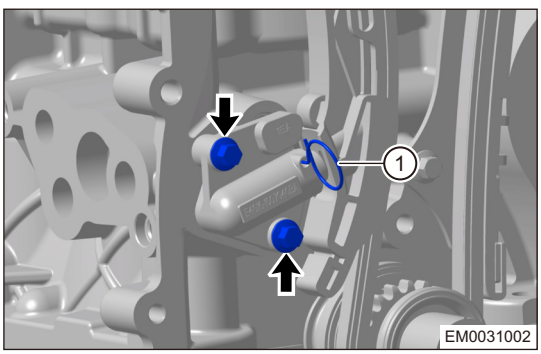
- Check if movable guide rail can rotate smoothly around the bolt after tightening movable guide rail fixing bolt, if not, check bolt and movable guide rail assembly.

(g) Install the tensioner assembly.

(1) Install tensioner assembly, and tighten 2 fixing bolts (arrow).

Tightening torque

9 + 3 N·m



(2) Push movable guide rail to chock against tensioner plunger, then remove hold-down pin (1).

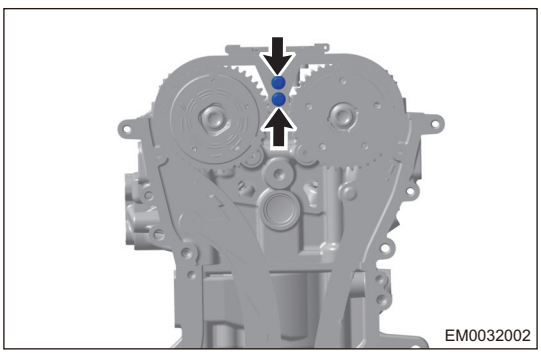
Caution:

- Make sure to keep tensioner assembly clean during installation. Otherwise, poor lubrication will cause abnormal engine noise and damage to timing chain and guide rail.
- Check if chain is in tension status.
- Check if chain is pressed in the fixing guide rail and movable guide rail, and engages normally with crankshaft sprocket, intake and exhaust phasers.
- Check that contact areas between chain and upper guide rail are in level without any looseness.

(h) Tighten 2 upper guide rail fixing bolts (arrow).

Tightening torque

9 + 3 N·m



(i) Tighten intake and exhaust phaser assembly fixing bolts.

Tightening torque

115 + 5 N·m

Warning:

- Tighten exhaust phaser fixing bolt first, and then tighten intake phaser fixing bolt. Failure to tighten in order may cause "tooth jump" phenomenon in timing chain.

(j) Remove crankshaft timing tool and camshaft timing tool, then rotate crankshaft clockwise 2 turns at least, to check if timing system can operate normally.

Caution:

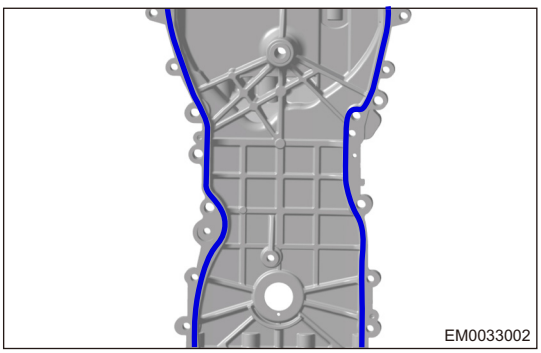
- Never rotate crankshaft counterclockwise.

2. Install the timing chain cover.

(a) Apply seal gum to edge of engine timing chain cover, and apply seal gum to inside of timing chain cover mounting bolt hole.

Seal Gum

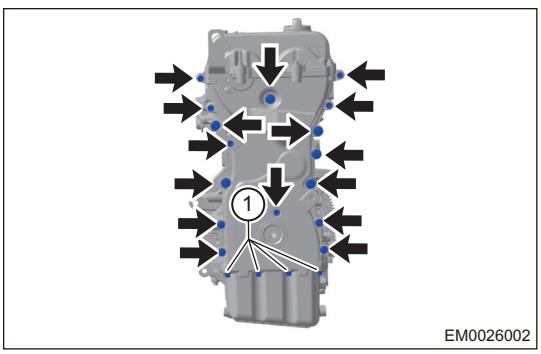
Loctite 5900H



(b) Install and tighten timing chain cover fixing bolts (arrow).

Tightening torque

M8 x 45 (6): 20 + 5 N·m
M8 x 40 - 10.9 (4): 30 + 5 N·m
M10 x 45 (5): 40 + 5 N·m
M10 x 80 (1): 40 + 5 N·m



(c) Install 4 fixing bolts (1) between timing chain cover and oil pan.

Tightening torque

20 + 5 N·m

Caution:

- Apply seal gum to oil pan before installing timing chain cover, and apply seal gum to inside of mounting bolt hole.

Seal gum:

Loctite 5900H

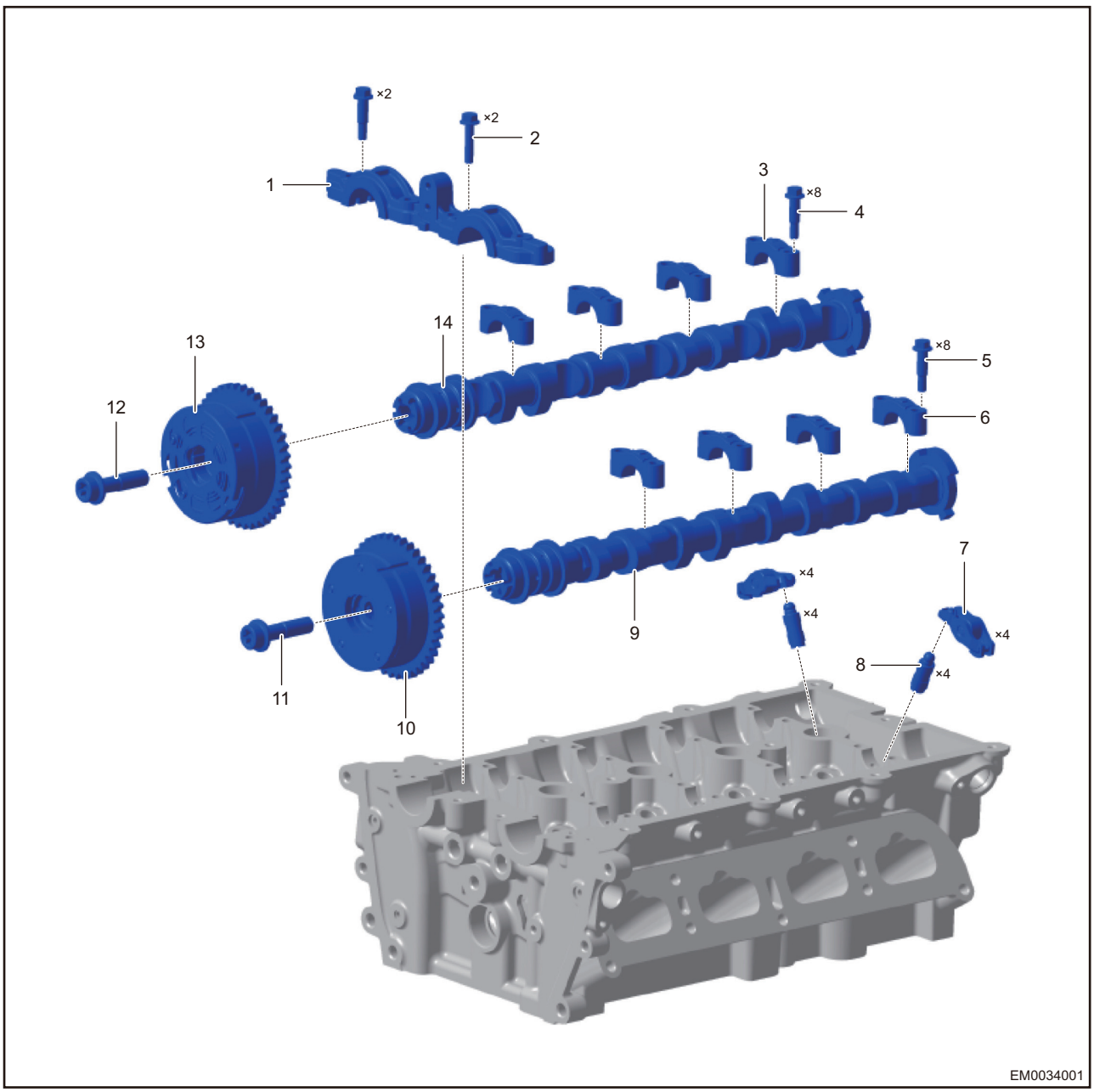
Diameter of seal gum line:

1.5 - 3 mm

3. Other installation procedures are in the reverse order of removal.

Camshaft & Rocker Arm

Description



1 - 1st Bearing Cap	2 - 1st Bearing Cap Fixing Bolt
3 - Exhaust Camshaft Bearing Cap	4 - Exhaust Camshaft Bearing Cap Fixing Bolt
5 - Intake Camshaft Bearing Cap Fixing Bolt	6 - Intake Camshaft Bearing Cap
7 - Rocker Arm	8 - Hydraulic Lifter
9 - Intake Camshaft Assembly	10 - Intake Phaser Assembly
11 - Intake Phaser Fixing Bolt	12 - Exhaust Phaser Fixing Bolt
13 - Exhaust Phaser Assembly	14 - Exhaust Camshaft Assembly

Removal

Warning/Caution/Hint

Caution:

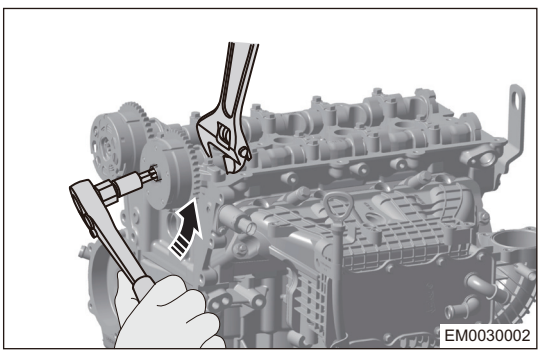
- Blow dirt and debris away from surface of cylinder head cover with compressed air.
- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the ignition switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Remove the ignition coil.
5. Remove the cylinder head cover assembly.
6. Remove the accessory drive belt.
7. Remove the tensioner assembly.
8. Remove the idler pulley assembly.
9. Remove the water pump pulley.
10. Remove the timing chain cover.
11. Remove the timing chain assembly.
12. Remove intake and exhaust phaser assemblies.

(a) Use a proper wrench to hold intake camshaft, and remove fixing bolt from intake phaser assembly in direction of arrow.

Tightening torque

115 + 5 N·m



(b) Removal method for exhaust phaser assembly is the same as that of intake phaser assembly.

13. Remove intake and exhaust camshafts.

(a) Remove intake and exhaust camshaft bearing cap fixing bolts in order shown in illustration.

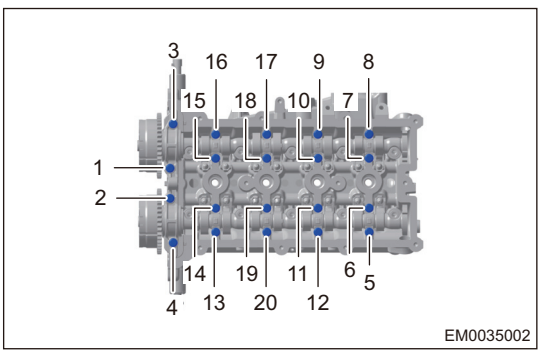
Hint:

During removal, loosen fixing bolts in order shown in illustration first, and then remove bolts thoroughly in order.

Tightening torque

1st step: 9.5 ± 1.5 N·m

2nd step: 9.5 ± 1.5 N·m

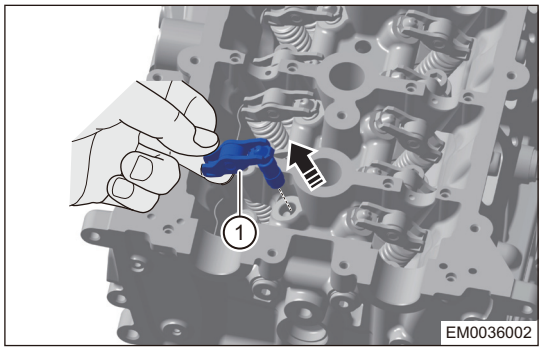


(b) Remove intake and exhaust camshaft bearing caps.

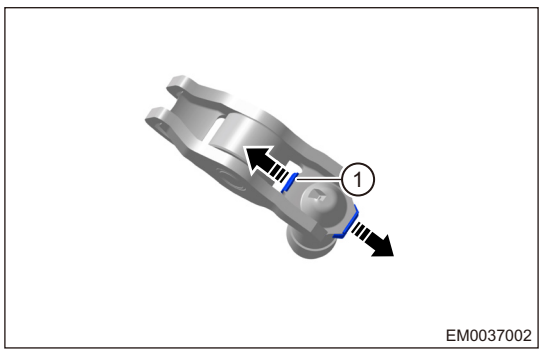
(c) Remove intake and exhaust camshaft assemblies.

14. Remove rocker arm and hydraulic lifter.

(a) Remove rocker arm and hydraulic lifter set (1) in direction of arrow.



(b) Remove elastic clip (1) and separate rocker arm and hydraulic lifter in direction of arrow as shown in illustration.



07

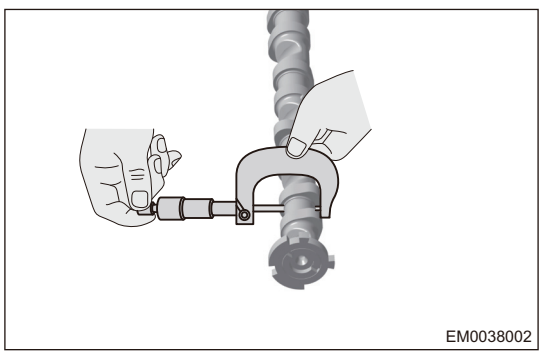
Inspection

1. Check the camshaft.

(a) Check the appearance.

- Check if there are scratches on camshaft surface. If there are scratches, replace camshaft.
- Check if there are leaking holes and cracks on camshaft bearing caps. If there are leaking holes or cracks, replace camshaft.

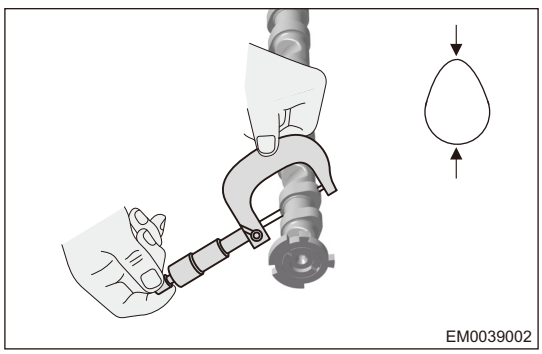
(b) Check the camshaft journal diameter.
Measure camshaft journal diameter with a micrometer.



Measurement Item	Specification (mm)
1st Journal Diameter (Same for Intake and Exhaust)	33.934 - 33.95
2nd ~ 5th Journal Diameter (Same for Intake and Exhaust)	23.947 - 23.96

If camshaft journal diameter is not within specified range, replace intake/exhaust camshaft assembly.

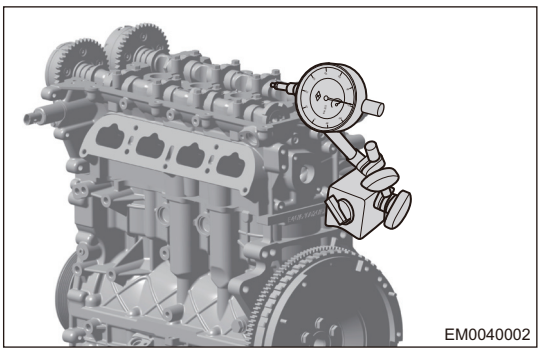
(c) Check the cam height.
Measure highest point of cam with a micrometer.



Measurement Item	Specification (mm)
Cam Height (Highest)	Intake: 37.07 - 37.31
	Exhaust: 36.94 - 37.18

If cam height is not within specified range, replace intake/exhaust camshaft assembly.

(d) Check the camshaft axial clearance.
- Reinstall intake and exhaust camshaft assemblies.
- Keep dial indicator plunger contact with front end of camshaft, and reset dial indicator to zero.
- Push camshaft forward and backward lightly (do not rotate camshaft), then read value on dial indicator.


EM0040002

Measurement Item	Specification (mm)
Intake Camshaft Axial Clearance	0.15 - 0.20
Exhaust Camshaft Axial Clearance	0.15 - 0.20

If camshaft axial clearance is not within specified range, replace intake/exhaust camshaft assembly.

2. Check the hydraulic lifter.
(a) Check if end surface and cylindrical operating surface of hydraulic lifter are normal.
(b) Check if hydraulic lifter slides properly in cylinder head guide hole.
(c) Check each hydraulic lifter for weakness. If exists, remove and soak it in 15W-30 oil for 24 hours, then press the hydraulic lifter plunger. If plunger can be pressed obviously, it indicates that lifter is weak, replace hydraulic lifter.

07

Installation

Warning/Caution/Hint

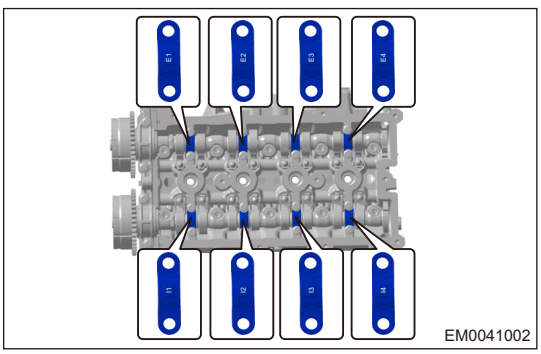
Caution:
- Adjust timing and adjust 4 pistons to same level before installing camshaft.
- When installing intake and exhaust phaser assemblies, tighten bolts on exhaust side first, and then tighten bolts on intake side.

1. Install the camshaft.
(a) Clean intake and exhaust camshafts and camshaft bearing caps.
(b) Apply engine oil to camshaft cam surface. Apply a proper amount of engine oil to camshaft bearing hole.
(c) Install intake, exhaust camshaft assemblies and intake and exhaust camshaft bearing caps.

Caution:
- Install according to marks on bearing cap.

I
Intake camshaft bearing cap

E
Exhaust camshaft bearing cap



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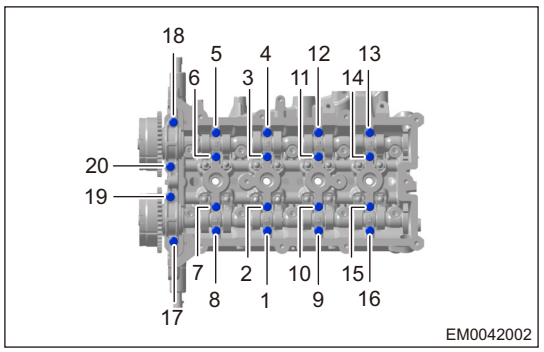
(d) Install intake and exhaust camshaft fixing bolts by hand.

(e) Tighten intake and exhaust camshaft bearing cap fixing bolts in order shown in illustration.

Tightening torque

1st step: 9.5 ± 1.5 N·m

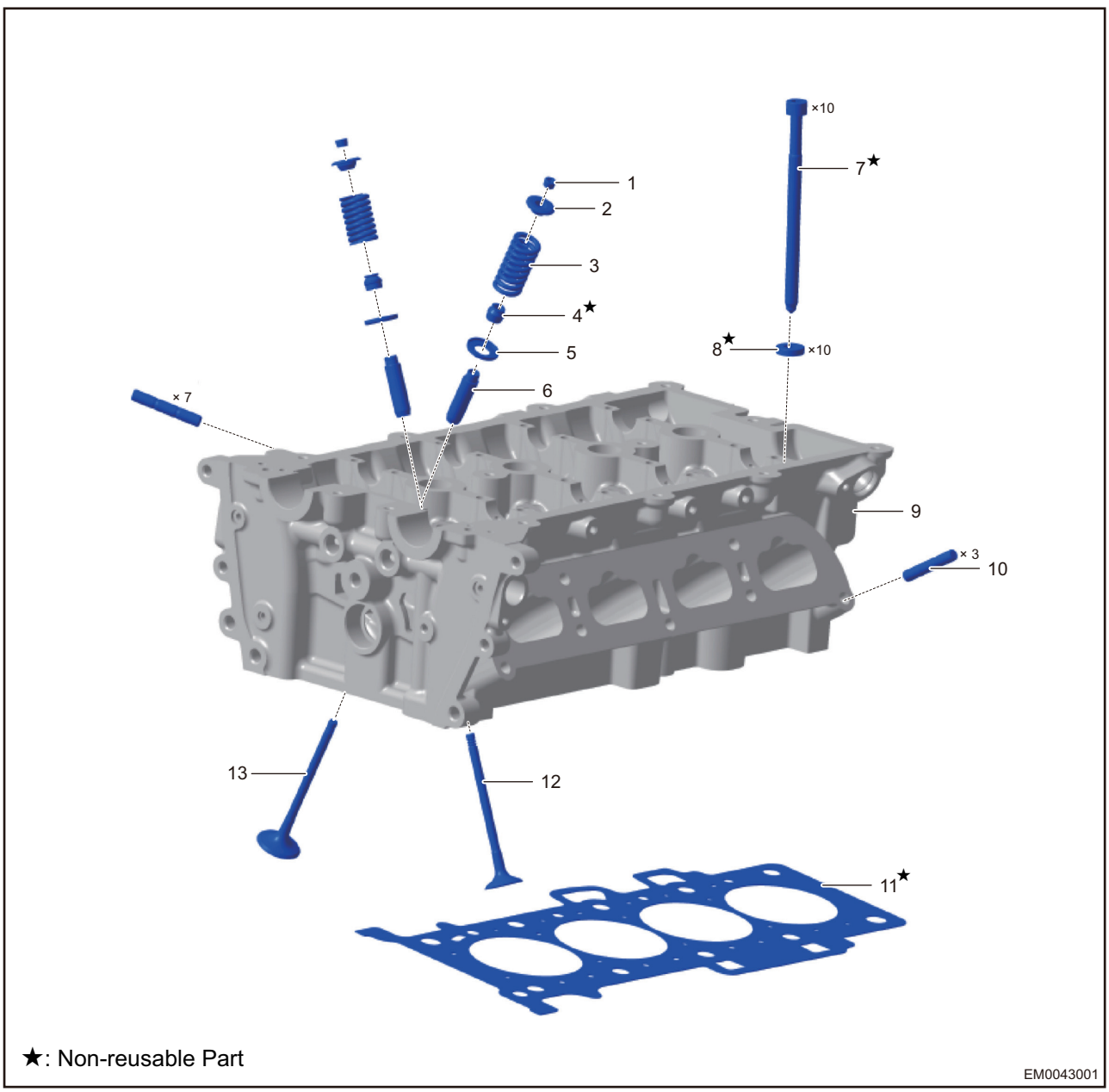
2nd step: 9.5 ± 1.5 N·m



2. Other installation procedures are in the reverse order of removal.

Cylinder Head

Description

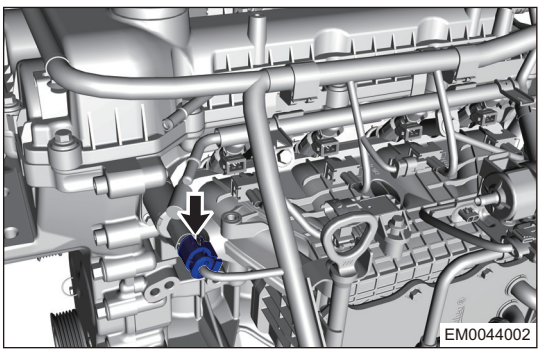


1 - Valve Cotter	2 - Valve Spring Upper Seat
3 - Valve Spring	4 - Valve Oil Seal
5 - Valve Spring Lower Seat	6 - Valve Guide
7 - Cylinder Head Fixing Bolt	8 - Cylinder Head Fixing Bolt Washer
9 - Cylinder Head	10 - Stud
11 - Cylinder Head Gasket	12 - Intake Valve
13 - Exhaust Valve	★ - Non-reusable Parts

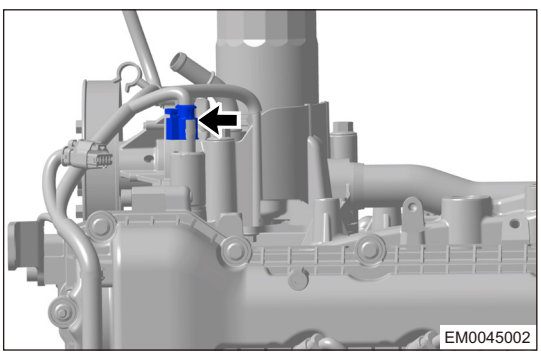
Removal

1. Fuel System Pressure Release
2. Turn off all electrical equipment and the ignition switch.
3. Disconnect the negative battery cable.
4. Drain the engine oil.
5. Drain the coolant.
6. Disconnect the wire harness connector.

(a) Disconnect the intake variable timing control valve connector (arrow).



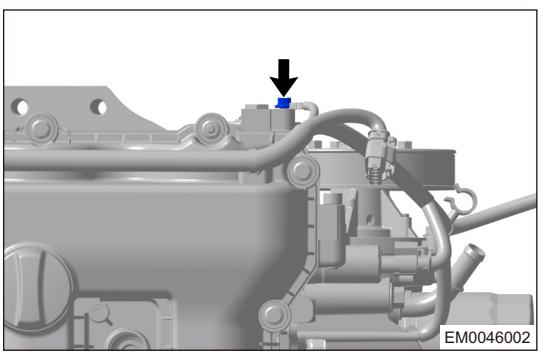
(b) Disconnect the exhaust variable timing control valve connector (arrow).



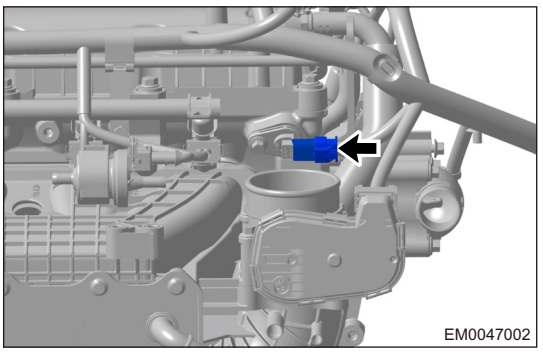
(c) Remove the engine wire harness ground wire fixing bolt (arrow).

Tightening torque

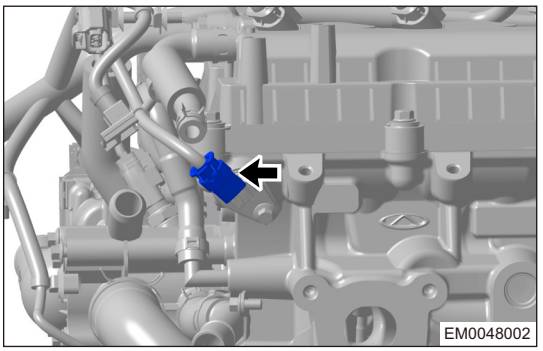
7 ± 1 N·m



(d) Disconnect the intake camshaft position sensor connector (arrow).



(e) Disconnect the exhaust camshaft position sensor connector (arrow).



7. Remove the air filter assembly.
8. Remove the battery assembly.
9. Remove the battery tray.
10. Remove the ignition coil (See page 14-7).
11. Remove the spark plug (See page 14-10).
12. Remove the fuel rail injector assembly (See page 06-400).
13. Remove the engine discharge steel pipe assembly.
14. Remove the intake manifold assembly (See page 10-20).
15. Remove the thermostat seat (See page 12-22).
16. Remove the turbocharger assembly (See page 11-10).
17. Remove the accessory drive belt.
18. Remove the idler pulley assembly (See page 07-22).
19. Remove the tensioner assembly (See page 07-23).
20. Remove the water pump pulley.
21. Remove the cylinder head cover assembly (See page 07-24).
22. Use an engine equalizer to hang engine assembly.
    Hint:
    Use an engine equalizer to hang engine assembly. while supporting engine oil pan with a jack. Avoid engine tilting to right side.
23. Remove the engine timing chain (See page 07-32).
24. Remove camshaft and rocker arm.
25. Remove the engine equalizer.
26. Remove the cylinder head assembly.

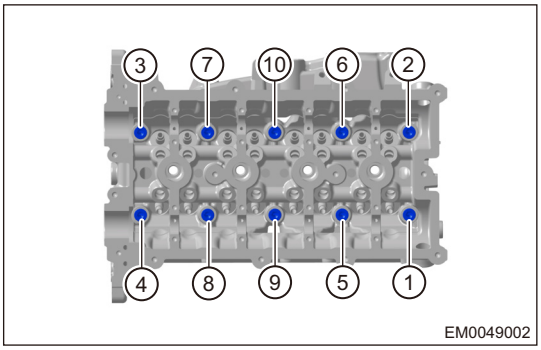
(a) Remove 10 cylinder head assembly fixing bolts in order shown in illustration.

Tightening torque

1st step: 40 ± 5 N·m
2nd step: 90° + 5°
3rd step: 90° ± 5°

Caution:

- Removal and installation with engine at high temperature may cause cylinder head to deform, so perform operations at normal temperature.
- Failure to remove cylinder head fixing bolts in order may cause cylinder head deformation.
- Make scraping marks on removed bolts and gasket, and they cannot be reused.

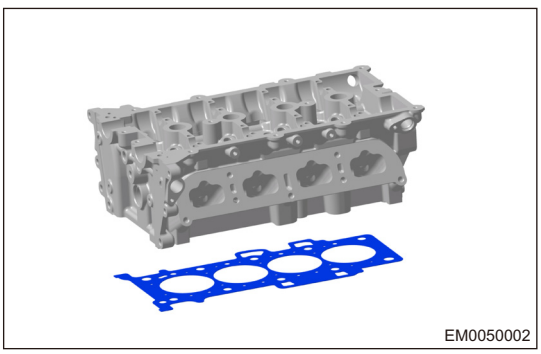


EM0049002

(b) Remove cylinder head and cylinder head gasket.

Caution:

- DO NOT reuse the removed cylinder head gasket, and it is necessary to replace it with new one. Be careful not to lose cylinder head mounting dowel pin during removal.


EM0050002

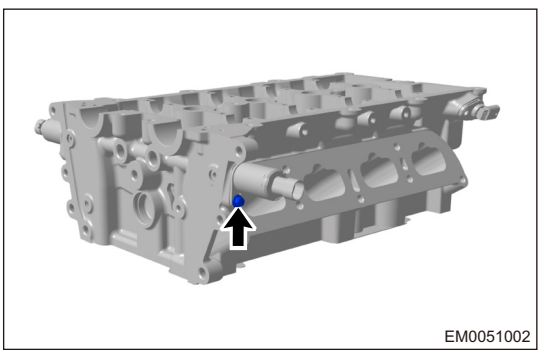
Disassembly

1. Disassemble the cylinder head.

(a) Remove intake variable timing control valve fixing bolt (arrow), and remove intake variable timing control valve assembly.

Tightening torque

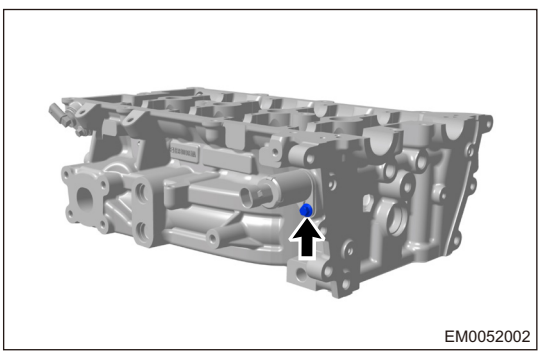
6 + 2 N·m


EM0051002

(b) Remove exhaust variable timing control valve fixing bolt (arrow), and remove exhaust variable timing control valve assembly.

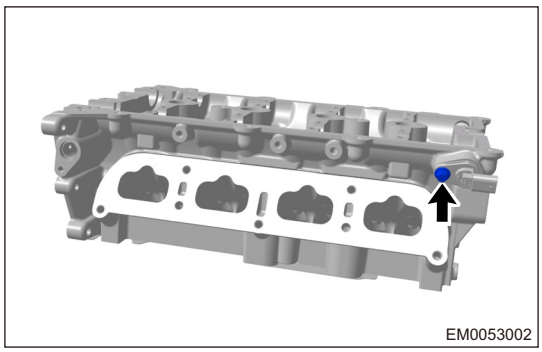
Tightening torque

6 + 2 N·m


EM0052002

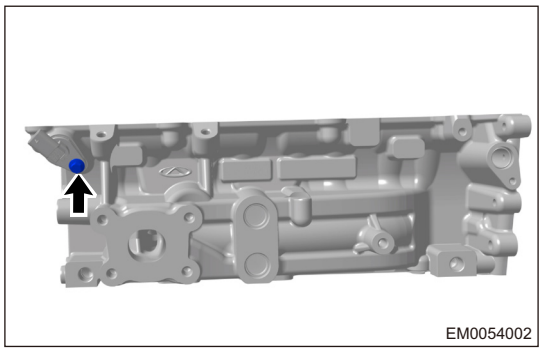
(c) Remove intake camshaft position sensor fixing bolt (arrow), and remove sensor assembly.

Tightening torque
8 + 3 N·m


EM0053002

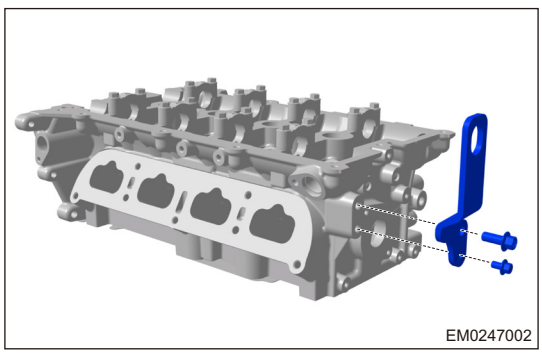
(d) Remove exhaust camshaft position sensor fixing bolt (arrow), and remove sensor assembly.

Tightening torque
8 + 3 N·m

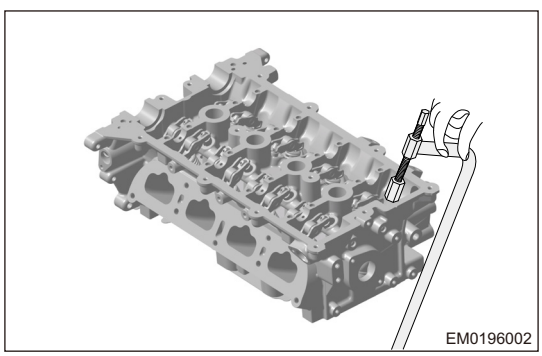

EM0054002

(e) Remove 2 rear lifting eye fixing bolts.

Tightening torque
20 + 5 N·m

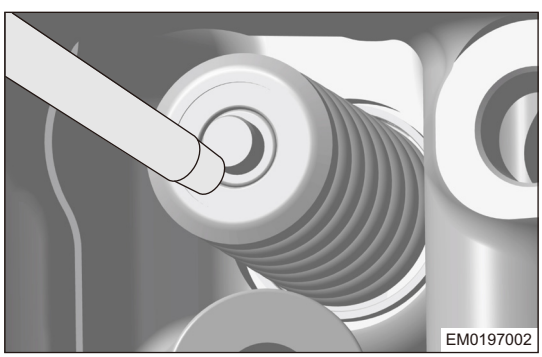

EM0247002

(f) Using a valve spring compressor, compress valve spring to a position so that valve cotter can be removed.

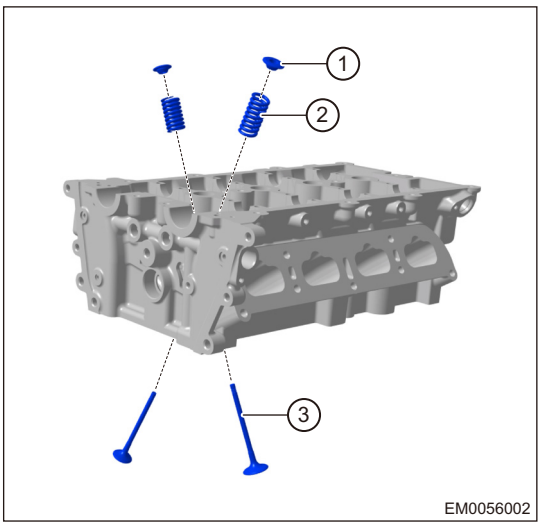

EM0196002

(g) Using a magnetic rod, remove valve cotter.

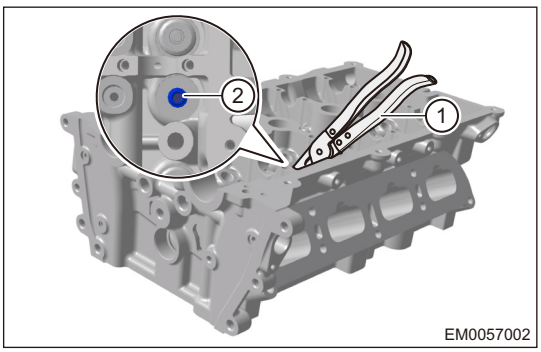
Caution:
- Due to the valve cotter is small, please operate carefully when removing it to avoid loss.


EM0197002

(h) Remove valve spring upper seat (1), valve spring (2) and intake and exhaust valve (3) from cylinder head.



(i) Using a valve oil seal remover (1), remove the valve oil seal (2).



(j) Using a magnetic rod, remove valve spring lower seat.

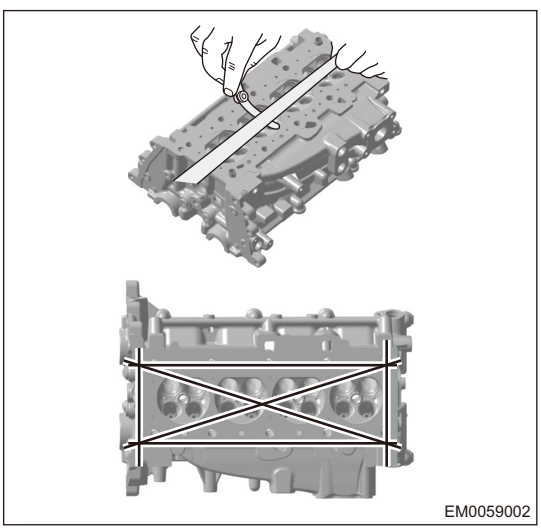
Inspection

1. Check the cylinder head assembly.
   (a) Check the appearance.
   - Check if there are scratches on camshaft bearing journals.
   - Remove carbon deposits inside valve guides with cleaner.
   - Make sure valve stem can move and rotate freely in its mounting hole.

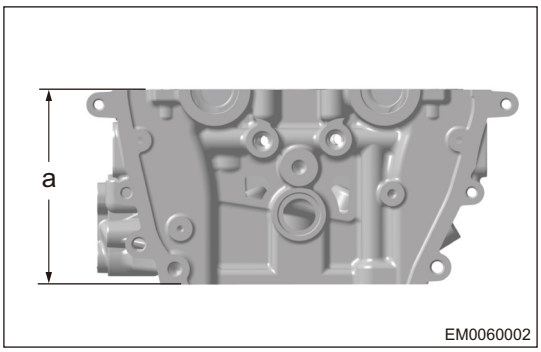
   (b) Check the cylinder head flatness.
   Using a precision straightedge and feeler gauge, check cylinder head flatness.

Measurement Item	Specification (mm)	Limit Value (mm)
Cylinder Head Flatness	0.04	0.04

If cylinder head flatness is not within specified range, replace cylinder head assembly.



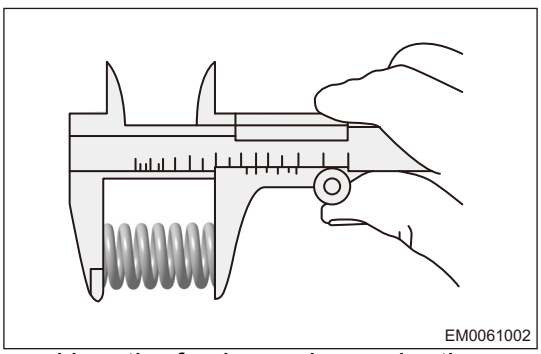
(c) Check the cylinder head height.
Using a precision straightedge, measure cylinder head height.



Measurement Item	Specification (mm)
Cylinder Head Height	141.05

If cylinder head height is not within specified range, replace cylinder head assembly.

2. Check the valve spring.



Using a vernier caliper, measure free length of valve spring and length of valve spring under the pre-pressure of 229 - 251 N.

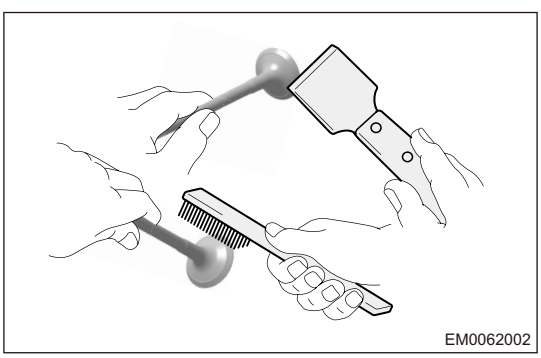
Measurement Item	Specification (mm)
Valve Spring Free Length	47.8
Valve Spring Length Under Pre-pressure of 229 - 251 N	41

If valve spring length is not within specified range, replace valve spring.

3. Check the valve.

(a) Clean the valve.

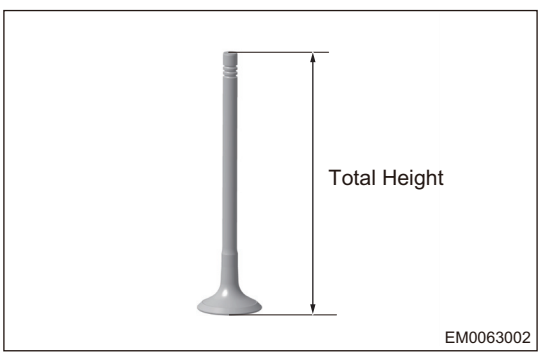
- Using a scraper, remove carbon deposited on valve head.
- Using a wire brush, clean the valve thoroughly.



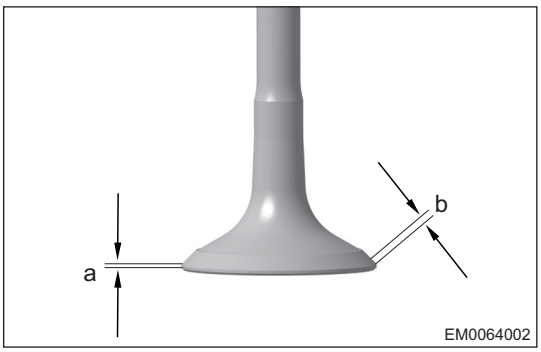
(b) Check the valve height.
Using a micrometer, measure the valve height.

Measurement Item	Specification (mm)
Intake Valve Height	107.75 - 108.25
Exhaust Valve Height	106.07 - 106.57

If valve height is less than specified value, replace valve.



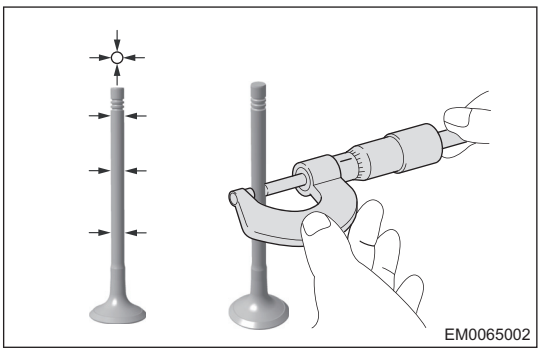
(c) Check the valve head.
- Measure margin thickness (a) of valve head.
- Measure width (b) of valve face.



Measurement Item	Specification (mm)
Intake Valve Head Margin Thickness	0.68 - 1.1
Exhaust Valve Head Margin Thickness	0.48 - 0.9
Intake Valve Face Width	1.154
Exhaust Valve Face Width	1.307

If valve head margin thickness and face width are not within specified range, replace valve.

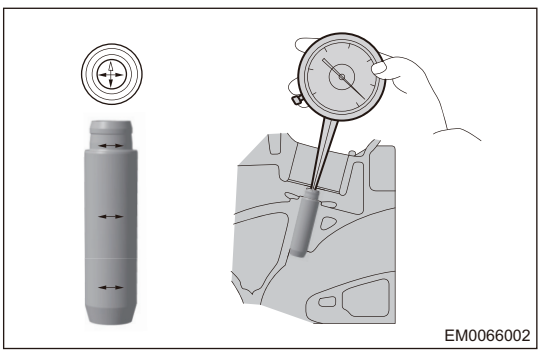
(d) Check the valve stem diameter.
Using a micrometer, measure the valve stem diameter.



Measurement Item	Specification (mm)
Intake Valve Stem Diameter	5.98 ± 0.008
Exhaust Valve Stem Diameter	5.96 ± 0.008

If valve stem diameter is not within specified range, check clearance between valve stem and valve guide.

(e) Check clearance between valve stem and valve guide.
Using a caliper gauge, measure inner diameter of valve guide.



Measurement Item	Specification (mm)
Valve Guide Inner Diameter	6.0 - 6.015

- Clearance between valve stem and valve guide = Valve guide inner diameter - Valve stem diameter

Measurement Item	Specification (mm)
Clearance Between Intake Valve and Valve Guide	0.012 - 0.043
Clearance Between Exhaust Valve and Valve Guide	0.032 - 0.063

If clearance between valve and valve guide is not within specified range, replace valve or valve guide.

Assembly

Warning/Caution/Hint

Caution:

- Soak valve oil seal in oil for several minutes before installing valve oil seal.
- Check if valve spring lower seat is installed properly before installing valve spring.

Hint:

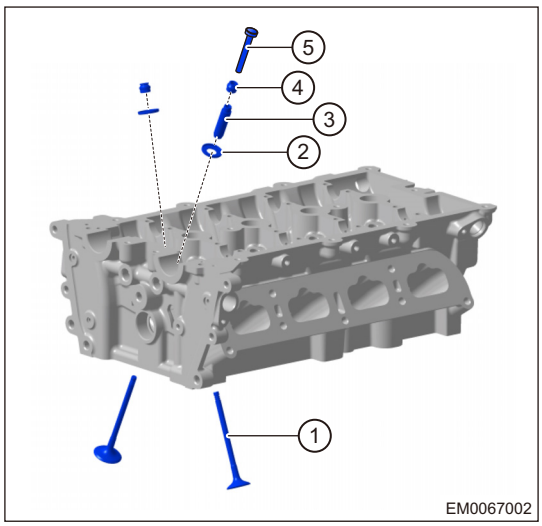
Clean all components to be assembled thoroughly before assembly.

1. Assemble the cylinder head.

(a) Install valve (1) into cylinder head.

Hint:

- Distinguish intake valves and exhaust valves during installation. Diameter of intake valve head is larger than that of exhaust valve head.
- Apply engine oil to valve stem end, when assembling valve.



(b) Install new valve spring lower seat (2) if necessary.

Caution:

- Bottom plane of valve spring lower seat should contact with cylinder head with flange facing upward.

(c) Install the valve oil seal.

Hint:

Apply engine oil to valve oil seal lip, when assembling valve oil seal.

(1) Install valve oil seal guide sleeve (3) to valve.

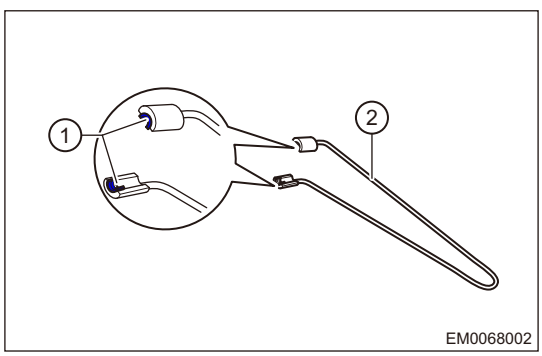
(2) Install valve oil seal (4) to valve oil seal guide sleeve.

(3) Press valve oil seal installer (5) lightly by hand to install valve oil seal (4) in place.

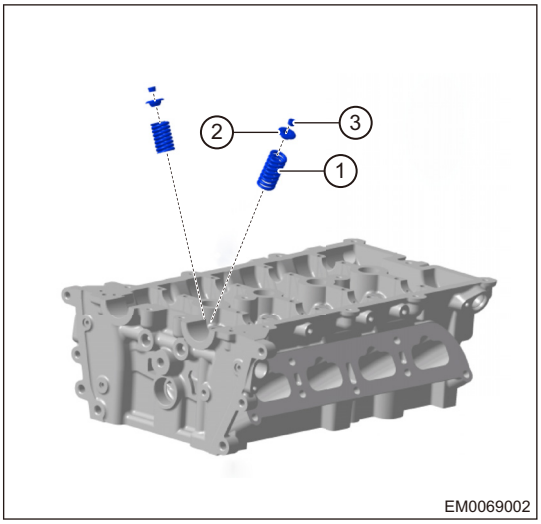
Caution:

- Check valve spring lower seat and valve oil seal for wrong installation, neglected installation and over installation.

(d) Install valve cotter (1) to valve cotter installer (2).



(e) Install valve spring (1) and valve spring upper seat (2). Using a valve spring compressor, compress valve spring to a position so that valve cotter can be installed. Using a valve cotter installer, install valve cotter (3) in place.



(f) Tap tip of valve stem lightly with a rubber hammer to make sure valve cotter is installed in place after assembly.

07

Installation

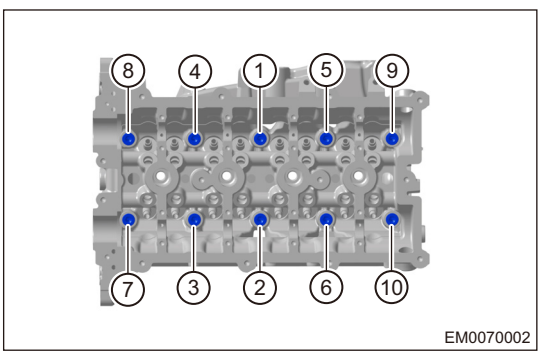
Warning/Caution/Hint

Caution:

- DO NOT damage or lose dowel pin on cylinder block.
- Remove residual seal gum and oil on cylinder head and cylinder block.
- Replace the cylinder head gasket.
- Check that cylinder head gasket is neat and clean without any chips and scratches, and the side stamped with part number faces upward.
- Install cylinder head gasket to flat surface of cylinder block with a dowel pin.
- Clean junction surface between cylinder head and combustion chamber, and remove any accumulated oil at bottom of cylinder block thread hole.
- During installation, piston should not be located at the top dead center, in order to prevent it from being impacted by opening valve, when installing the camshaft.
- Replace cylinder head fixing bolt and washer, and make scraping marks on removed bolt.
- Install the cylinder head bolt washer with chamfering surface facing upward and flat side facing cylinder head.

1. Tighten cylinder head fixing bolts in order from (1) to (10) shown in illustration:

(a) Tighten bolts in place by hands.



(b) Tighten cylinder head fixing bolts according to following procedures:

(1) 1st step: Tighten bolts to 40 ± 5 N·m in order from (1) to (10) shown in illustration.

(2) 2nd step: Rotate bolts clockwise by 90 ± 5° in tightening order.

(3) 3rd step: Rotate bolts clockwise by 90 ± 5° in tightening order again.

Caution:

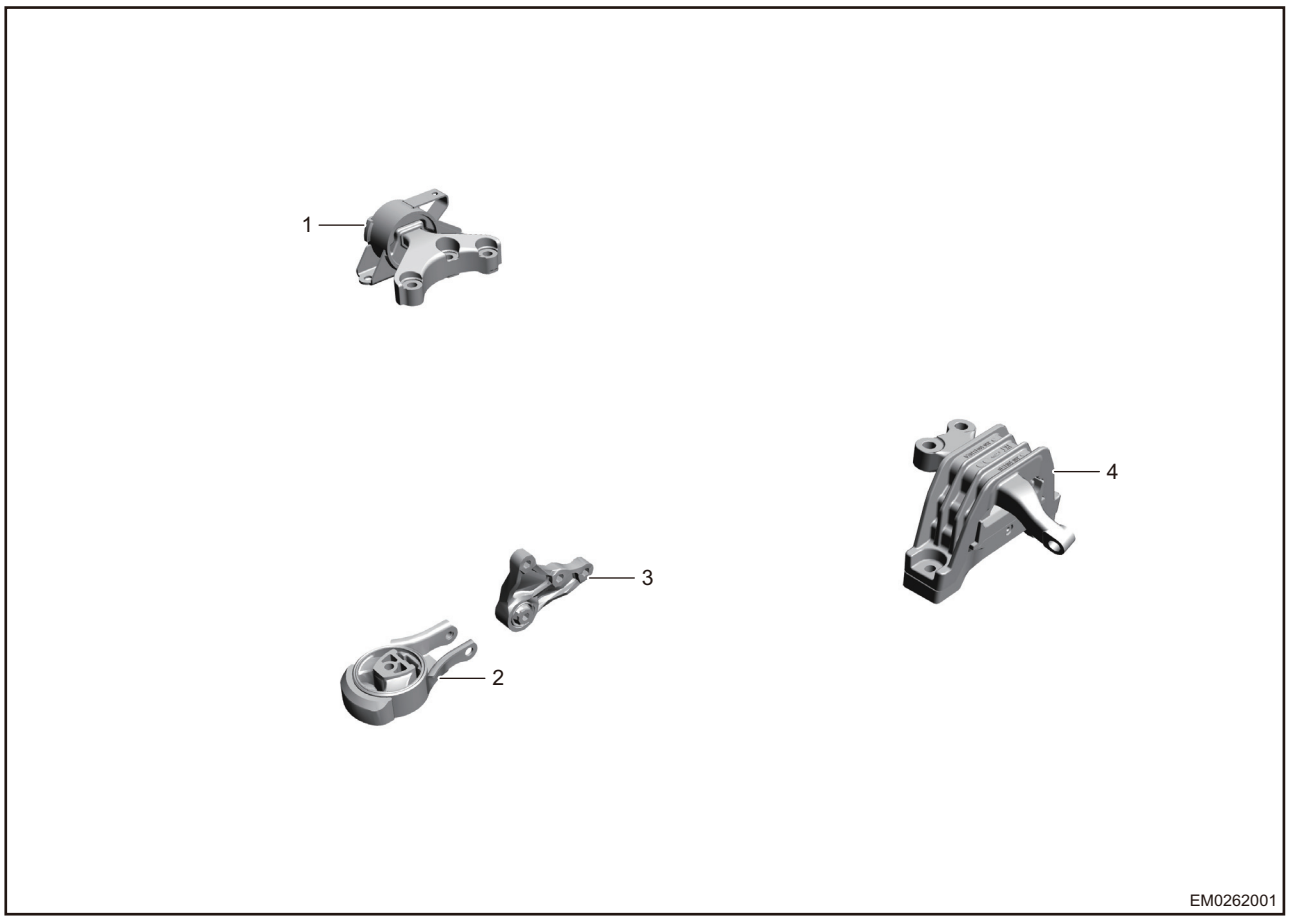
- Check cylinder head fixing bolts before installation. If damaged, replace them immediately.

- Be sure to tighten cylinder head bolts strictly according to operating procedures above, to achieve the technology standard for vehicle usage.

2. Other installation procedures are in the reverse order of removal.

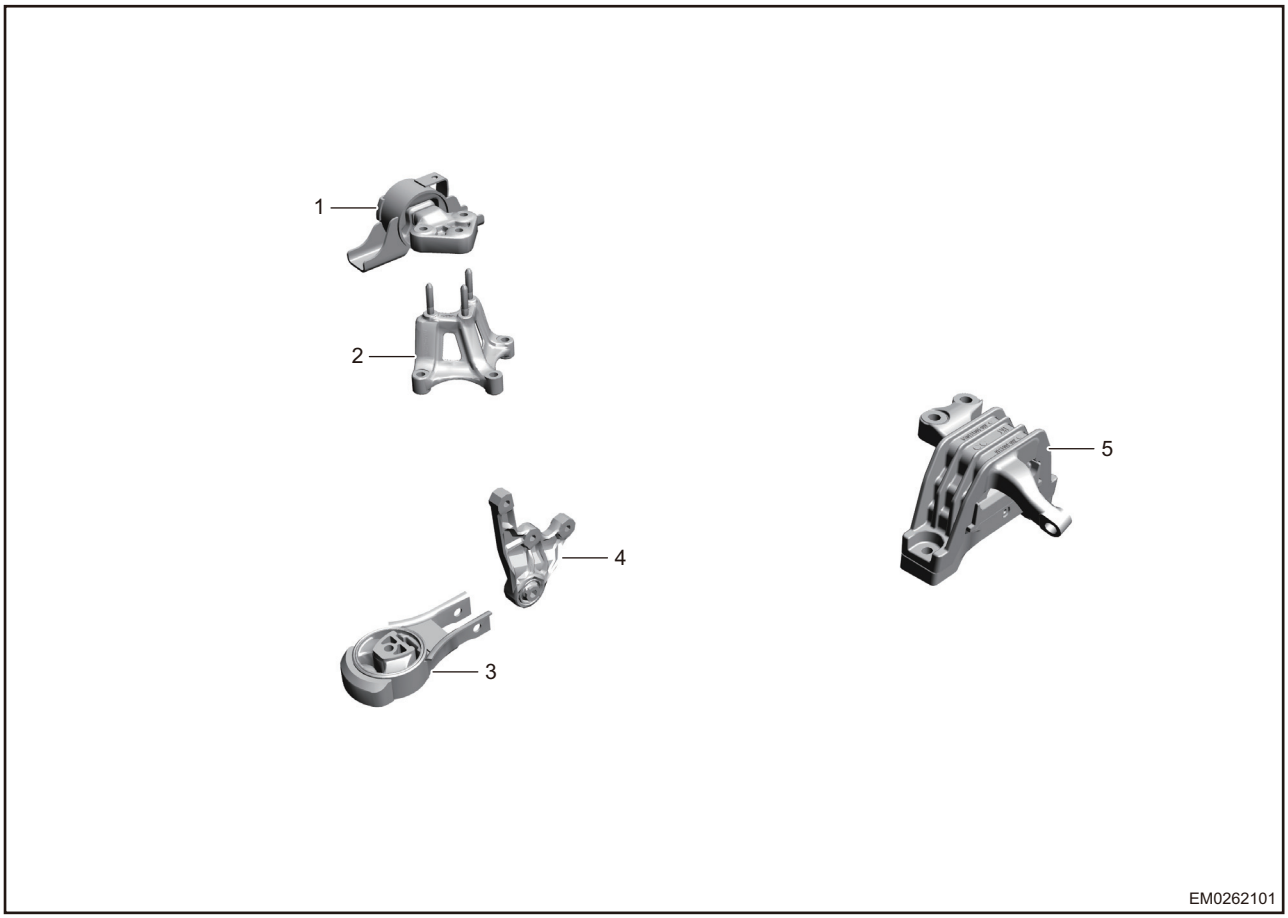
Engine Mounting Assembly

For CVT Models



1 - Left Mounting Cushion	2 - Rear Mounting Lower Body
3 - Rear Mounting Upper Body	4 - Right Mounting Cushion

For MT Models



1 - Left Mounting Cushion	2 - Left Mounting Bracket
3 - Rear Mounting Lower Body	4 - Rear Mounting Upper Body
5 - Right Mounting Cushion	

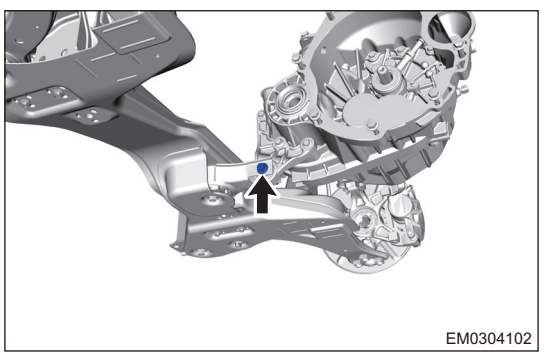
Removal & Installation - Rear Mounting Assembly (for MT Models)

Warning/Caution/Hint

Caution:

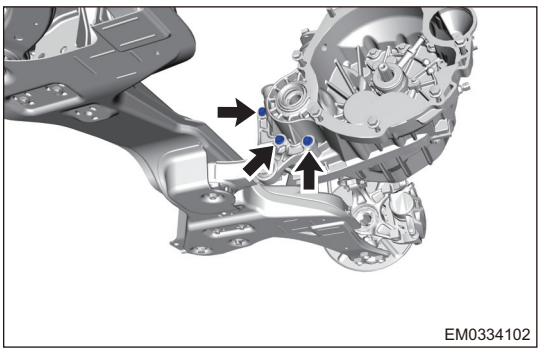
- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the ignition switch.
2. Disconnect the negative battery cable.
3. Remove the rear mounting upper body.
   (a) Remove coupling bolt (arrow) between rear mounting upper body and lower body.
   Tightening torque
   80 ± 8 N·m



(b) Remove 3 coupling bolts (arrow) between rear mounting upper body and transmission.

Tightening torque
80 ± 8 N·m

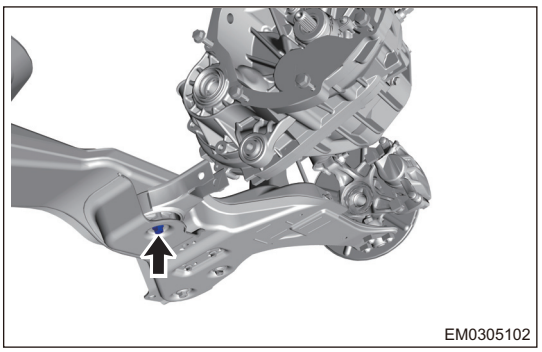

EM0334102

(c) Remove the rear mounting upper body.

4. Remove the rear mounting lower body.

(a) Remove coupling bolt (arrow) between rear mounting lower body and sub frame.

Tightening torque
105 ± 10 N·m


EM0305102

(b) Remove the rear mounting lower body.

Removal & Installation - Rear Mounting Assembly (for CVT Models)

Warning/Caution/Hint

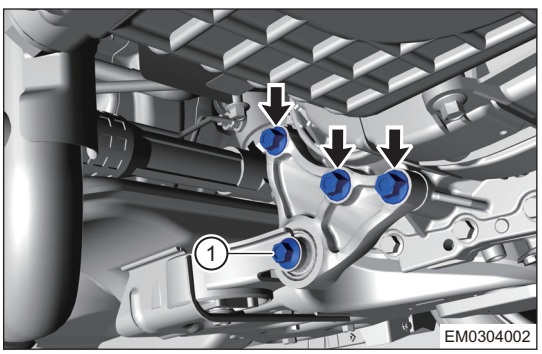
Caution:

- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the ignition switch.
2. Disconnect the negative battery cable.
3. Remove the rear mounting upper body.

(a) Remove coupling bolt (1) between rear mounting upper body and lower body.

Tightening torque
80 ± 8 N·m



EM0304002

(b) Remove 3 coupling bolts (arrow) between rear mounting upper body and transmission.

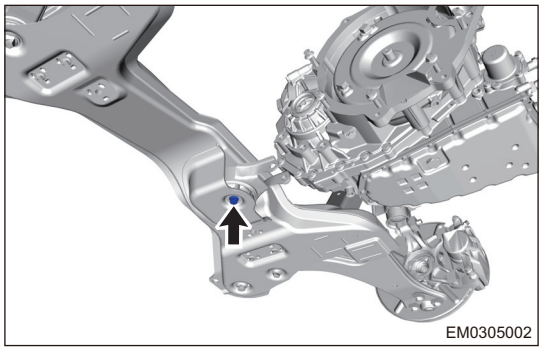
Tightening torque
80 ± 8 N·m

(c) Remove the rear mounting upper body.

4. Remove the rear mounting lower body.

   (a) Remove coupling bolt (arrow) between rear mounting lower body and sub frame.

   Tightening torque
   105 ± 10 N·m


EM0305002

   (b) Remove the rear mounting lower body.

Installation

1. Installation is in the reverse order of removal.

   Caution:
   - Pre-tighten 2 or 3 threads manually first during assembly of bolts and nuts, then pre-tighten and tighten it to specified torque with a tool.

Removal & Installation - Left Mounting Assembly (for MT Models)

Warning/Caution/Hint

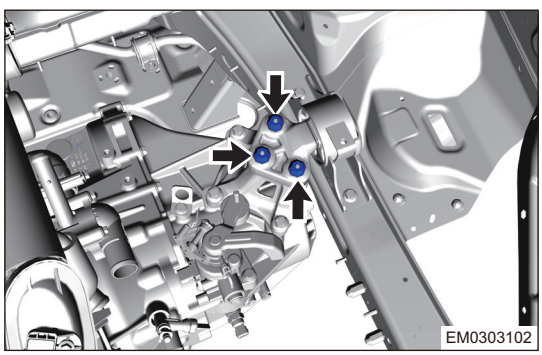
Caution:

- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the ignition switch.
2. Disconnect the negative battery cable.
3. Remove the air filter assembly.
4. Remove the battery assembly.
5. Remove the battery tray.
6. Use an engine equalizer to hang engine assembly.
7. Remove the left mounting cushion assembly.

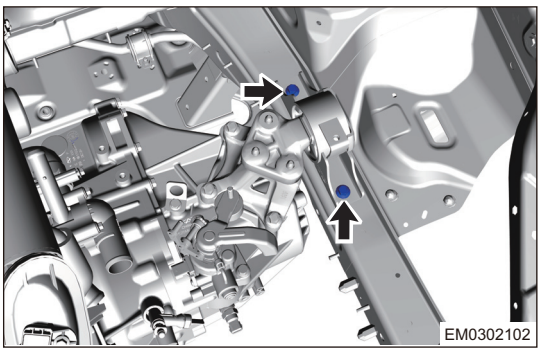
   (a) Remove 3 fixing nuts (arrow) between left mounting cushion assembly and left mounting bracket.

   Tightening torque
   60 ± 6 N·m


EM0303102

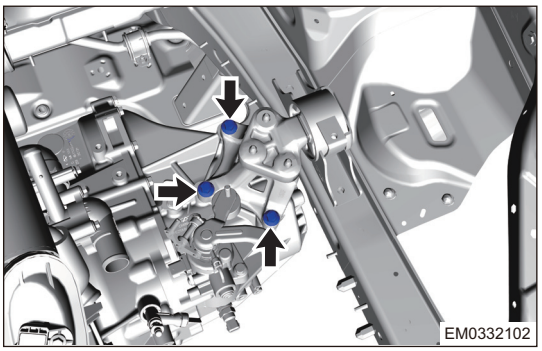
(b) Remove 2 fixing bolts (arrow) between left mounting cushion assembly and body side rail.

Tightening torque
60 ± 6 N·m



(c) Remove 3 fixing bolts (arrow) between left mounting bracket and transmission.

Tightening torque
80 ± 8 N·m



07

Removal & Installation - Left Mounting Assembly (for CVT Models)

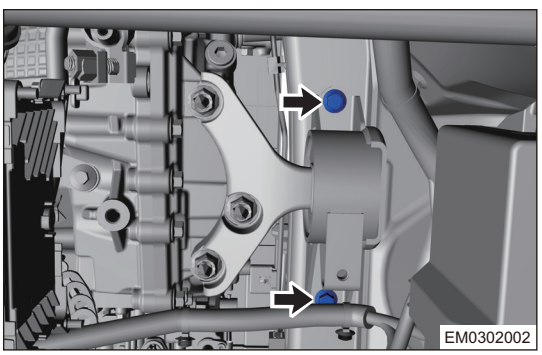
Warning/Caution/Hint
Caution:

- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the ignition switch.
2. Disconnect the negative battery cable.
3. Remove the air filter assembly.
4. Remove the battery assembly.
5. Remove the battery tray.
6. Use an engine equalizer to hang engine assembly.
7. Remove the left mounting cushion assembly.

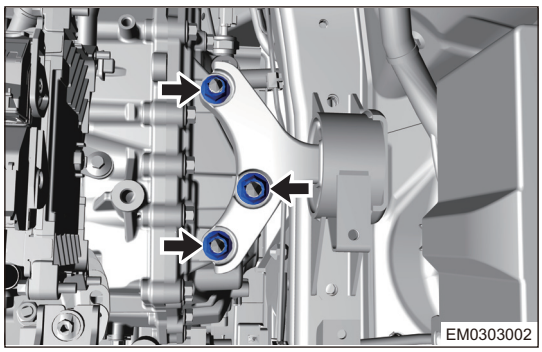
(a) Remove 2 fixing bolts (arrow) between left mounting cushion assembly and body side rail.

Tightening torque
60 ± 6 N·m



(b) Remove 3 fixing nuts (arrow) between left mounting cushion assembly and transmission.

Tightening torque
80 ± 8 N·m



(c) Remove the left mounting cushion assembly.

Installation

1. Installation is in the reverse order of removal.

Removal & Installation - Right Mounting Assembly (for MT Models)

Warning/Caution/Hint

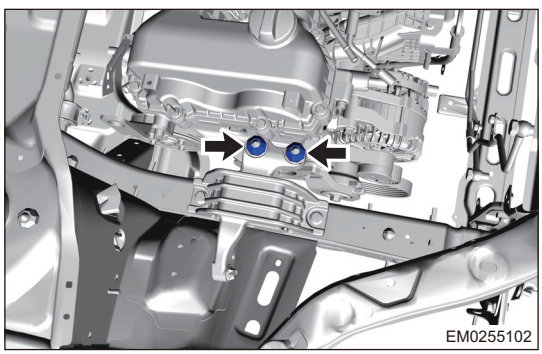
Caution:

- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the ignition switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Move away the expansion tank assembly.
5. Use an engine equalizer to hang engine assembly.
6. Remove the engine right mounting cushion assembly.

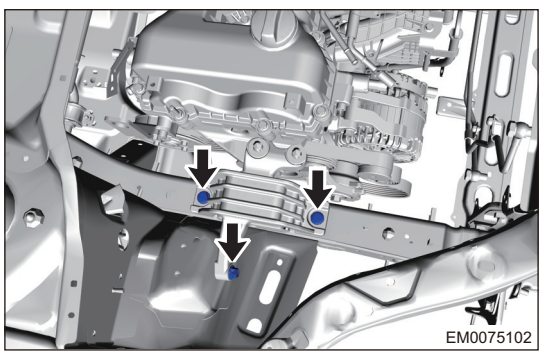
(a) Remove 2 fixing nuts (arrow) between right mounting cushion assembly and engine.

Tightening torque
80 ± 8 N·m



(b) Remove 3 coupling bolts (arrow) between right mounting cushion assembly and body.

Tightening torque
60 ± 6 N·m



(c) Remove the engine right mounting cushion assembly.

Removal & Installation - Right Mounting Assembly (for CVT Models)

Warning/Caution/Hint

Caution:

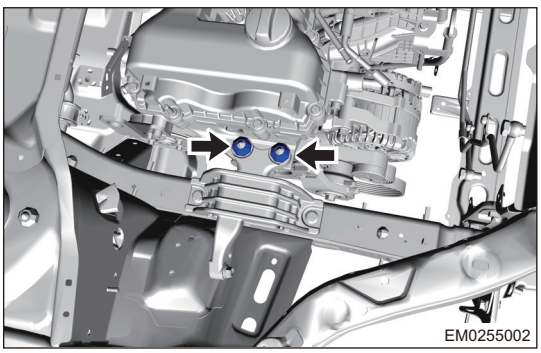
- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the ignition switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Move away the expansion tank assembly.
5. Use an engine equalizer to hang engine assembly.
6. Remove the engine right mounting cushion assembly.

(a) Remove 2 fixing nuts (arrow) between right mounting cushion assembly and engine.

Tightening torque

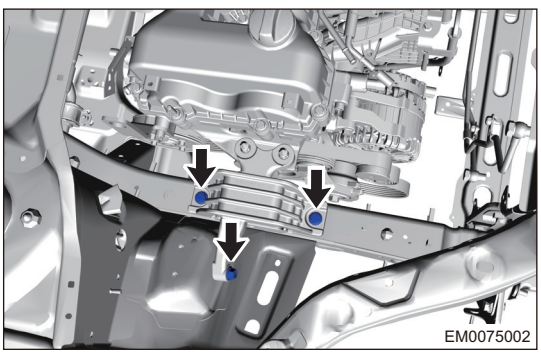
80 ± 8 N·m



(b) Remove 3 coupling bolts (arrow) between right mounting cushion assembly and body.

Tightening torque

60 ± 6 N·m



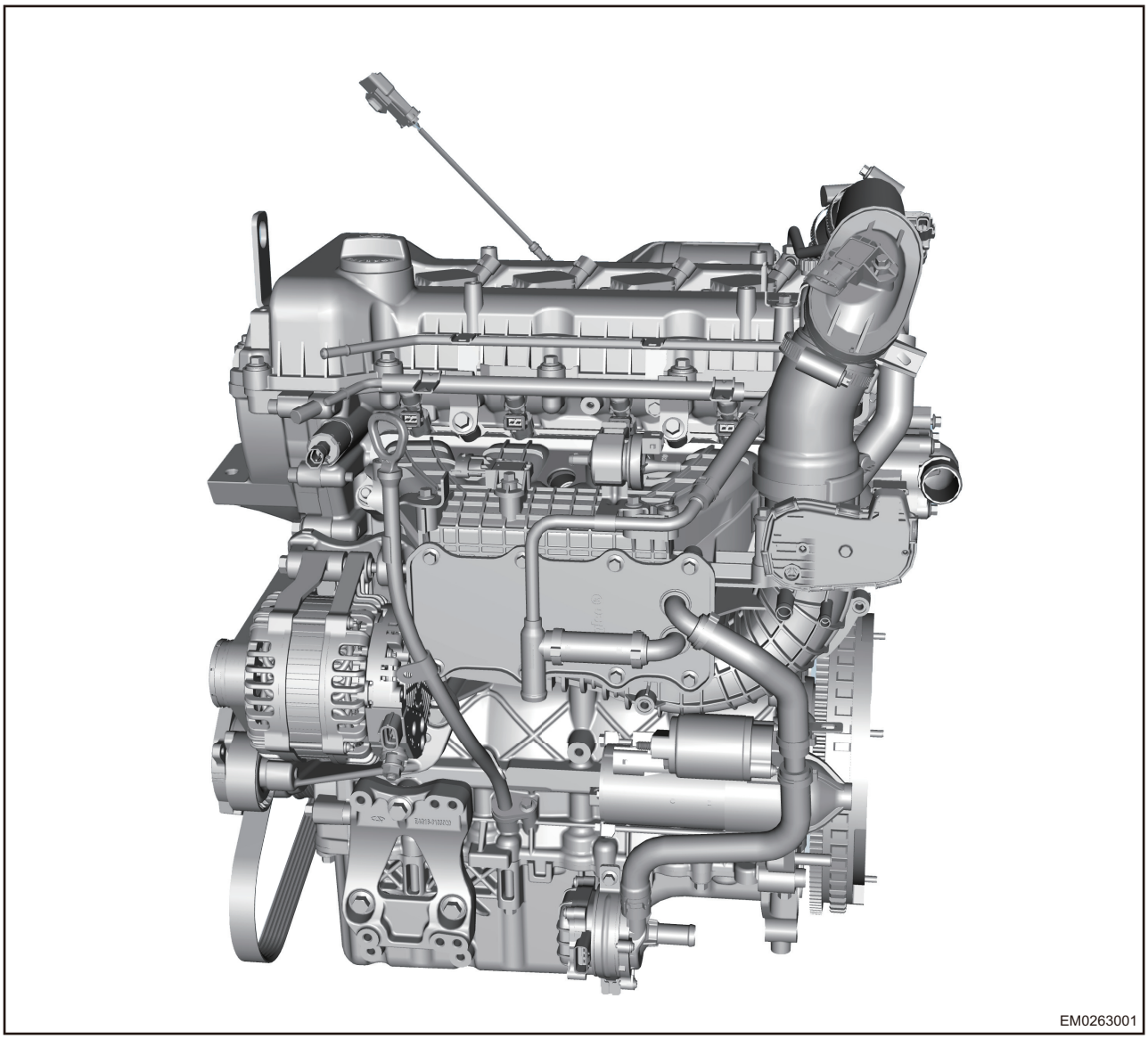
(c) Remove the engine right mounting cushion assembly.

Installation

1. Installation is in the reverse order of removal.

Engine Assembly

Description



Removal

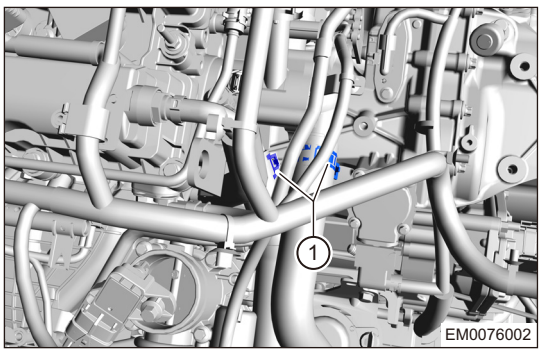
Warning/Caution/Hint

Caution:

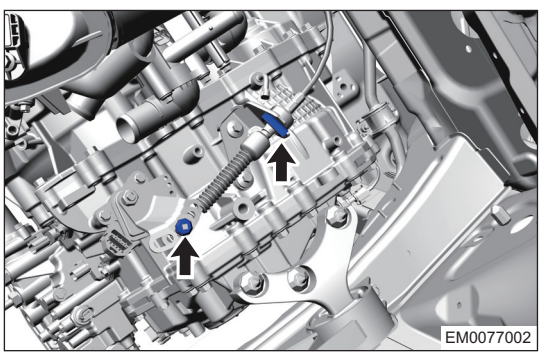
- Remove engine and transmission as an assembly.
- Install protector to prevent body from being scratched.
- Plug inlet port of intake pipe to prevent foreign matter from entering after removing intake system components. Or the foreign matter will block cylinder intake passage when starting to seriously damage the engine.

1. Remove the engine trim cover.
2. Release the fuel system pressure.
3. Turn off all electrical equipment and the ignition switch.
4. Remove the battery assembly.
5. Remove the battery tray.

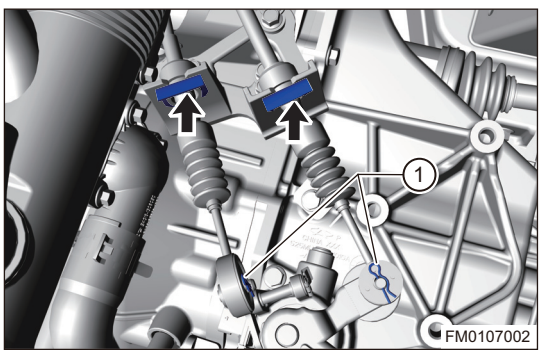
6. Remove the air filter assembly (See page 10-8).
7. Remove the intake manifold assembly (See page 10-20).
8. Remove the turbocharger assembly (See page 11-10).
9. Remove the precatalytic converter assembly (See page 11-16).
10. Drain the engine oil.
11. Drain the transmission oil (See page 17-16).
12. Drain the coolant.
13. Recover the refrigerant.
14. Disconnect engine inlet and outlet hoses.
    (a) Loosen elastic clamps (1) and disconnect connections between engine inlet and outlet hoses and thermostat seat.



15. Disconnect connection between shift cable and transmission (for CVT models).
    (a) Loosen shift cable fixing clip, and remove fixing bolt between shift cable and gear switch.

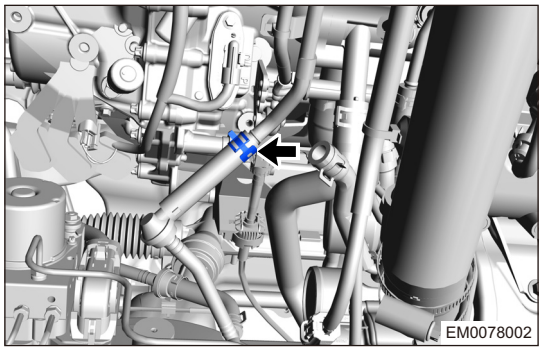


    (b) Detach shift cable damper from bracket limit hole.
    (c) Move shift cable to one side.
16. Disconnect connection between shift cable and transmission (for MT models).
    (a) Remove gear select and shift cable pins (1) separately, and remove gear select and shift cable joints from transmission rocker arm.

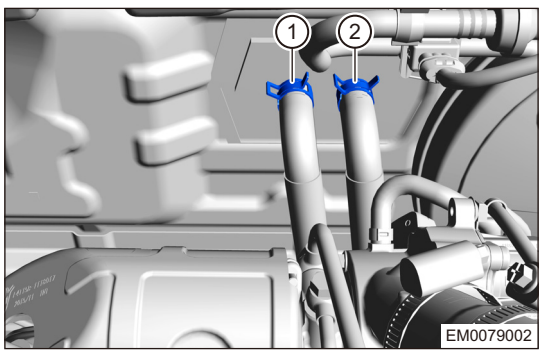


    (b) Remove gear select and shift cable fixing clips (arrow), and detach gear select and shift cable dampers from flexible shaft bracket limit hole. Then move cables to one side.

17. Disconnect the vacuum pipe.
    (a) Loosen elastic clamp (arrow) and disconnect connection between brake vacuum hose and brake vacuum steel pipe.

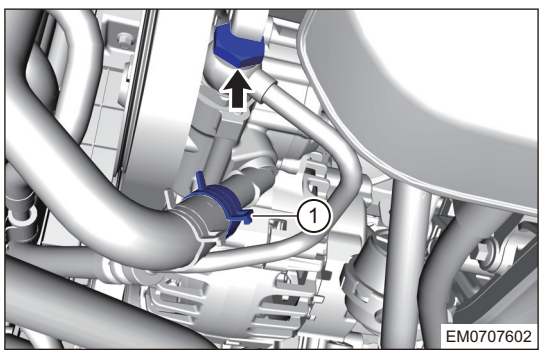


18. Disconnect connection between hose and heater core.
    (a) Loosen elastic clamp (1) and disconnect connection between heater core inlet hose and heater core.



    (b) Loosen elastic clamp (2) and disconnect connection between heater core outlet hose and heater core.
19. Remove the front exhaust pipe assembly.
20. Move away the canister solenoid valve intake pipe.
21. Disconnect coupling jonint between inlet pipe III and fuel rail injector assembly.
22. Remove the expansion tank assembly.
23. Disconnect the steering pump line (for MT models).
    (a) Remove high pressure fluid pipe hollow bolt (arrow), and move away steering pump line from steering pump.

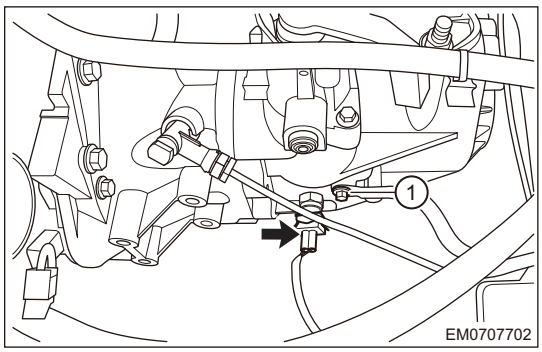
    Tightening torque
    45 ± 5 N·m



24. Disconnect back-up light switch connector and move away ground wire (for MT models).
    (a) Disconnect the back-up light switch connector (arrow).

(b) Remove transmission ground wire fixing bolt (1) and move away transmission ground wire.

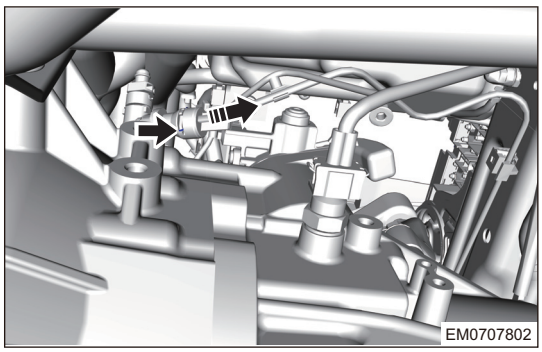
Tightening torque
15 ± 2 N·m



25. Disconnect the clutch inlet pipe (for MT models).

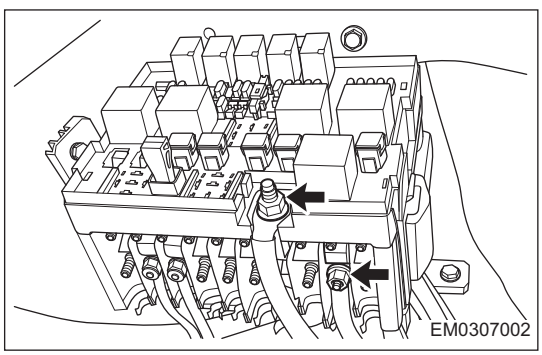
(a) Disconnect clutch pipe clip (arrow), and move away clutch pipe in direction of arrow as shown in illustration.

Tightening torque
15 ± 2 N·m



26. Disconnect the following wire harnesses.

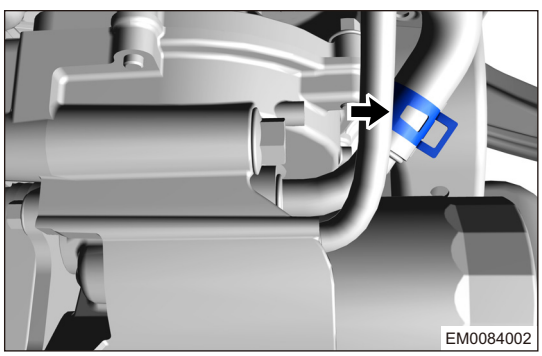
(a) Open the fuse and relay box cover, and remove battery wire harness fixing nuts (arrow), then disconnect connection between battery wire harness and engine compartment fuse and relay box.



(b) Remove engine compartment fuse and relay box, and disconnect engine wire harness connector from engine compartment fuse and relay box.

27. Remove the front wheel.
28. Remove the drive shaft.
29. Remove A/C compressor high and low pressure pipes.
30. Disconnect the water supply pipe.

(a) Loosen elastic clamp (arrow) and disconnect connection between expansion tank water supply pipe and oil filter module assembly.



31. Use an engine equalizer to hang engine assembly.
32. Remove the rear mounting assembly.

33. Remove the left mounting assembly.
34. Remove the right mounting assembly.
35. Check that engine assembly is separated with external components.
36. Hang out engine assembly from engine compartment.
37. Remove engine wire harness and battery wire harness from engine.
38. Separate engine assembly and transmission assembly.
39. Install engine assembly to engine service platform.

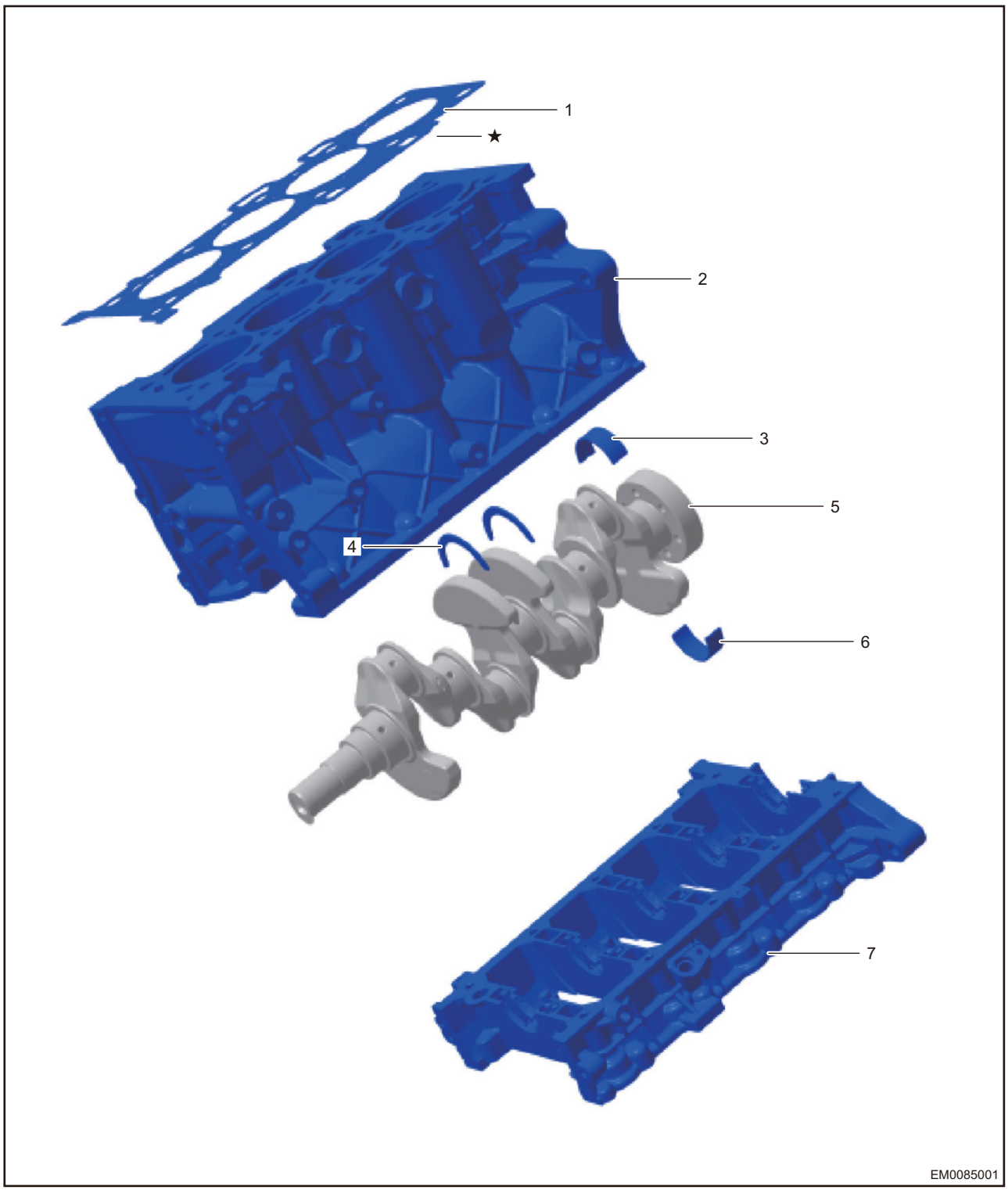
Installation

1. Installation is in the reverse order of removal.

CYLINDER BLOCK UNIT REPAIR

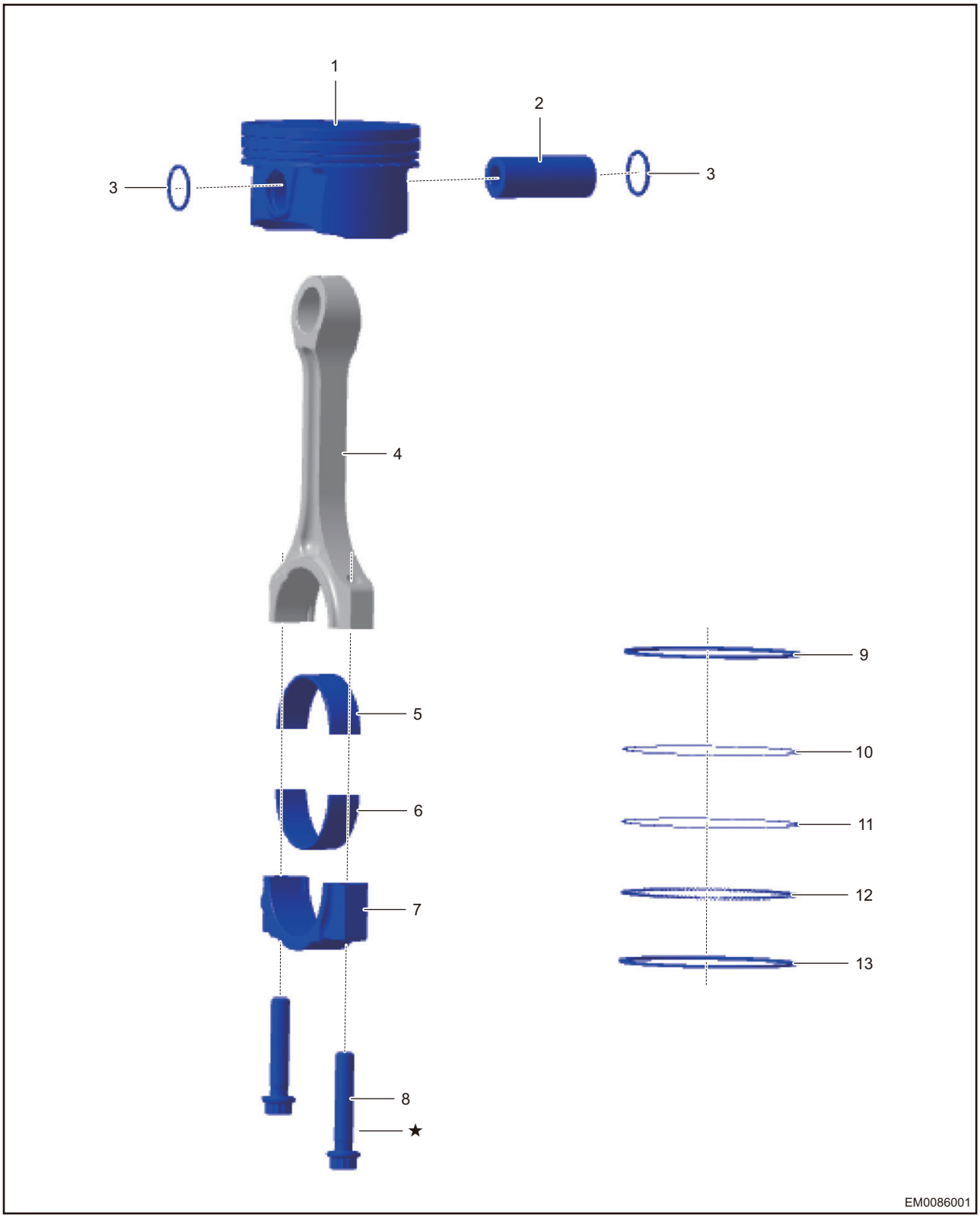
Engine Block

Description



1 - Cylinder Head Gasket	2 - Cylinder Block
3 - Crankshaft Main Bearing Upper Shell	4 - Thrust Washer
5 - Crankshaft	6 - Crankshaft Main Bearing Lower Shell
7 - Cylinder Block Frame Assembly	★ - Non-reusable Parts

Description

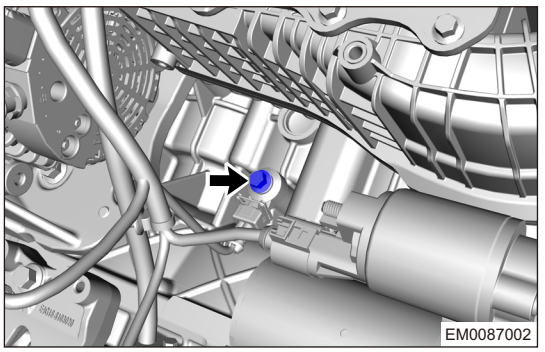


1 - Piston	2 -Piston Pin (Full-floating)
3 - Elastic Circlip	4 - Connecting Rod Body
5 - Connecting Rod Bearing Upper Shell	6 - Connecting Rod Bearing Lower Shell
7 - Connecting Rod Bearing Cap	8 - Connecting Rod Bearing Cap Fixing Bolt
9 - First Compression Ring	10 - Second Compression Ring

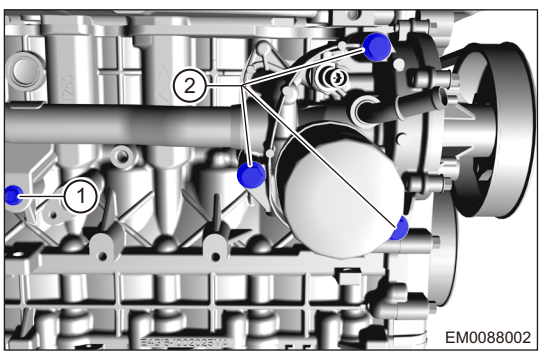
11 - Upper Rail	12 - Expander
13 - Lower Rail	★ - Non-reusable Parts

Disassembly

1. Remove the accessory drive belt.
2. Remove the idler pulley assembly.
3. Remove the tensioner assembly.
4. Remove the thermostat assembly (See page 12-20).
5. Remove the thermostat seat assembly (See page 12-22).
6. Remove the knock sensor.
   (a) Remove knock sensor fixing bolt (arrow), and remove knock sensor.
   Tightening torque
   20 ± 5 N·m

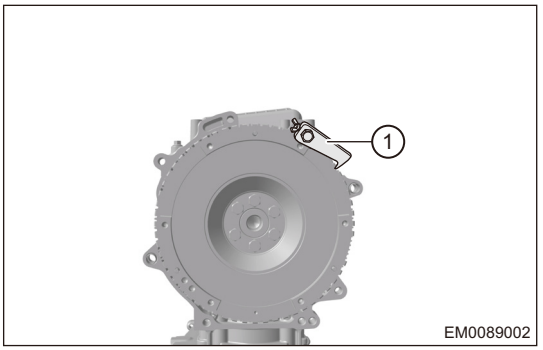


7. Remove the power steering pump (See page 29-14).
8. Remove alternator assembly and mounting bracket (See page 16-14).
9. Remove A/C compressor assembly and mounting bracket.
10. Remove the engine discharge pipe (See page 12-18).
11. Remove the oil filter module.
    (a) Remove fixing bolt (1) from cooling pipe assembly I.
    Tightening torque
    20 + 5 N·m

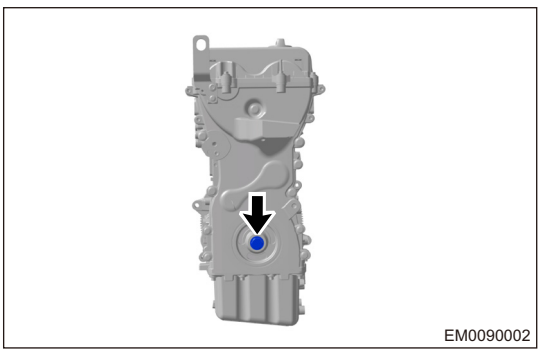


    (b) Remove 3 fixing bolts (2) from oil filter module.
    Tightening torque
    40 + 5 N·m
    Caution:
    - There will be residual coolant inside engine during removal and installation, if your skin contacts coolant directly, clean it with water immediately. If it is serious, please go to hospital.
    - Prolonged and repeated contact with engine oil will be harmful to your skin. If engine oil spills on your skin, wash it off immediately with water. In addition, the used engine oil contains potentially harmful contaminants, which may cause skin cancer. Therefore, always take proper skin protection measures when performing vehicle service.
    - There will be coolant residue inside engine. Coolant should be handled according to local environmental regulations.

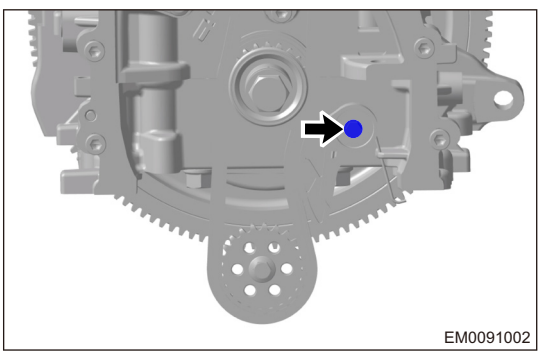
12. Remove the crankshaft pulley.
    (a) Install flywheel special tool (1) to lock flywheel as shown in illustration.



    (b) Remove fixing bolt (arrow) from crankshaft pulley.
    Tightening torque
    1st step: 100 ± 10 N·m
    2nd step: 120 ° ± 10°

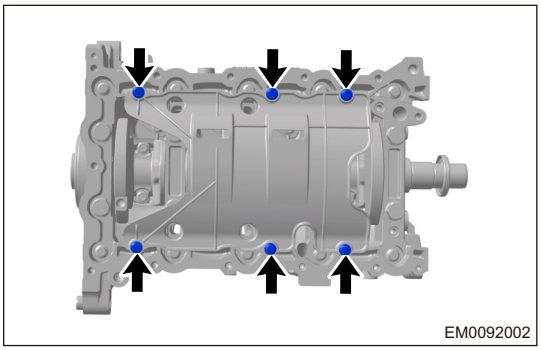


    (c) Remove the crankshaft pulley.
13. Remove the crankshaft front oil seal (See page 07-26).
14. Remove the flywheel assembly (See page 07-28).
15. Remove the crankshaft rear oil seal (See page 07-30).
16. Remove the cylinder head cover assembly (See page 07-24).
17. Remove the oil pan assembly (See page 13-16).
18. Remove the timing chain (See page 07-32).
19. Remove intake and exhaust camshaft assemblies.
20. Remove the cylinder head assembly (See page 07-43).
21. Remove the oil strainer assembly.
22. Remove the oil pump assembly (See page 13-19).
23. Remove the oil pump chain.
    (a) Remove oil pump movable guide rail fixing bolt (arrow), and remove movable guide rail.
    Tightening torque
    12 + 2 N·m

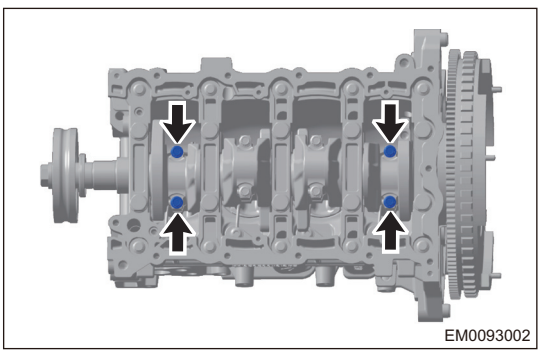


    (b) Remove the oil pump chain.

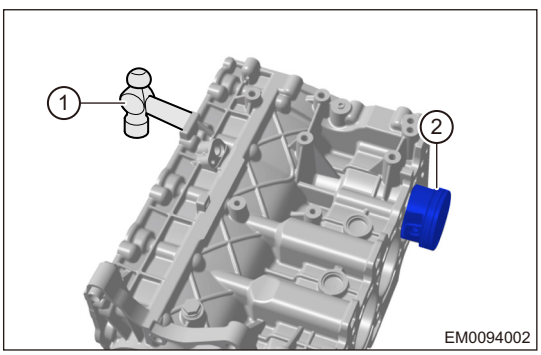
24. Remove the oil deflector assembly.
    (a) Remove 6 oil deflector fixing bolts (arrow).
    Tightening torque
    8 + 3 N·m


EM0092002

    (b) Remove the oil deflector assembly.
25. Remove the piston connecting rod assembly.
    (a) Using a ridge reamer or equivalent, remove all the carbon deposit from top of cylinder.
    (b) Turn crankshaft, so that pistons of cylinders 1 and 4 are at bottom dead center, remove fixing bolts (arrow) from connecting rod bearing caps of cylinders 1 and 4, and remove connecting rod bearing caps of cylinders 1 and 4.


EM0093002

    (c) Using a hammer handle (1), push out piston connecting rod assembly (2) of cylinders 1 and 4 from cylinder block.

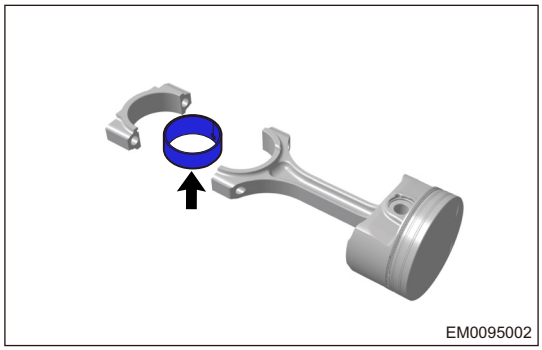


EM0094002

    (d) Removal procedures for piston connecting rod assembly of cylinders 2 and 3 are the same as above.
    Caution:
    - Please operate carefully when pushing out piston, to avoid cylinder liner damage.
    - Mark the removed piston connecting rod assemblies, so as to distinguish them.
    - Connecting rod bolts and connecting rod bolt holes must correspond one to one without exchange.
    - Replace with new bolts during assembly.

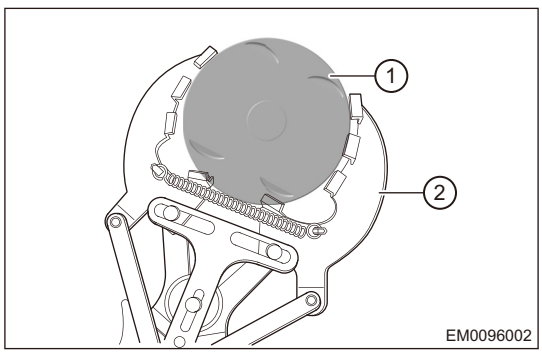
26. Remove the connecting rod bearing shell.

(a) Remove the connecting rod bearing shell (arrow).
Hint:
Arrange removed parts in correct order.



27. Remove the piston rings.

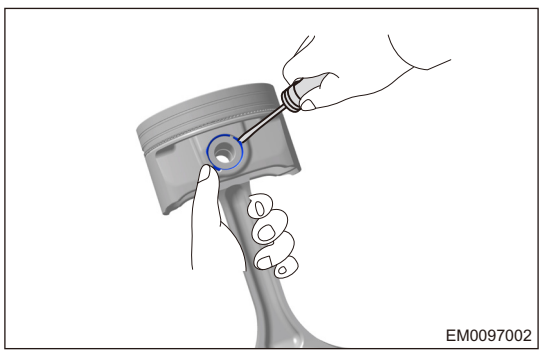
(a) Using a piston ring remover (1), remove 2 compression rings (2).
Caution:
- Before removing piston ring, check piston ring side clearance. If it is necessary to be reused, be sure to mark piston ring position.



(b) Remove oil ring rail and expander by hands.

28. Separate piston and connecting rod.

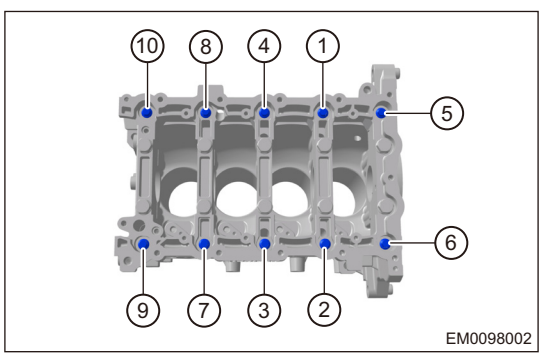
(a) Using a flat tip screwdriver, pry out elastic circlips at both sides of piston pin carefully from the notch. Carefully pry out elastic circlips on both ends of piston pin.
Caution:
- Elastic circlip has a large tensile force. Be careful during removal to prevent personal injury.



(b) Remove the piston pin assembly.

29. Remove the crankshaft.

(a) Evenly loosen and remove crankshaft frame fixing bolts in order shown in illustration.
Tightening torque
27 + 3 N·m



(b) Evenly loosen and remove crankshaft main bearing cap fixing bolts in order shown in illustration.

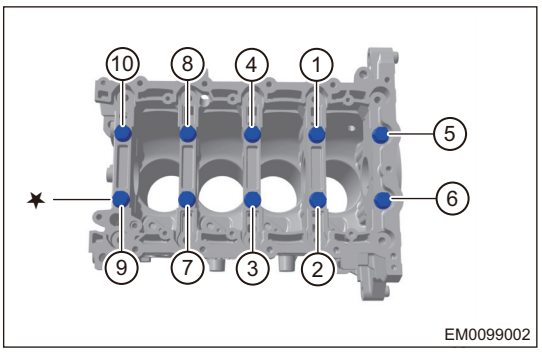
Tightening torque

1st step: 45 ± 5 N·m

2nd step: 180° ± 10°

★

Non-reusable Part



(c) Remove the crankshaft frame assembly.

Hint:

If it is difficult to remove crankshaft frame due to seal gum, lightly tap it with a rubber hammer to loosen it. Be sure not to damage surrounding components.

(d) Remove the crankshaft assembly.

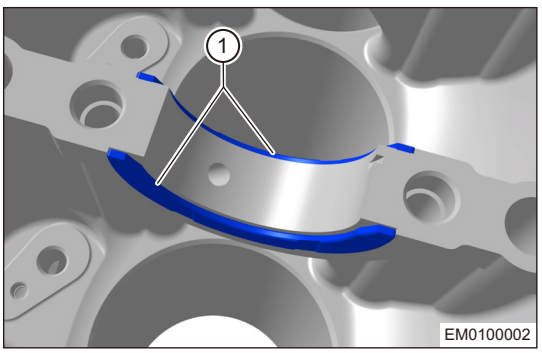
Caution:

- Take care when removing crankshaft, as it is heavy. If necessary, ask other operators to assist. Avoid scratching contact surfaces between crankshaft and bearing shell.

07

30. Remove the thrust washers.

(a) Remove crankshaft thrust washers (1) from cylinder block.

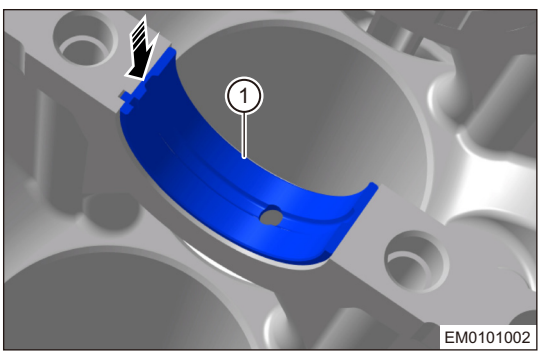


31. Remove the crankshaft main bearing shell.

(a) Push out crankshaft main bearing upper shell (1) slightly in direction of arrow to remove it.

Hint:

- Remove other crankshaft main bearing upper shells from cylinder block in the same way.
- Pay attention to the notch position. Push out bearing shell carefully as shown in illustration. It is difficult to push out bearing shell and parts may be damaged if pushing in opposite direction.

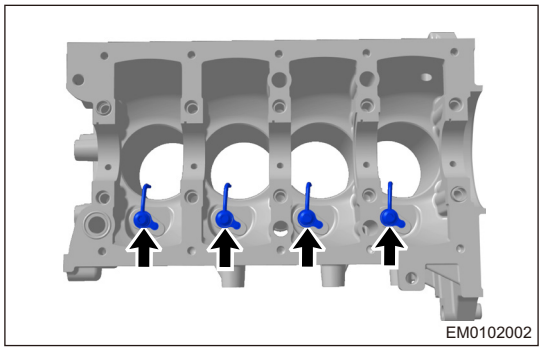


(b) Remove crankshaft main bearing lower shell from crankshaft frame in the same way.

32. Remove the piston cooling nozzles.

(a) Remove piston cooling nozzle fixing bolts (arrow), and remove piston cooling nozzles from cylinder block.

Tightening torque
20 + 5 N·m


EM0102002

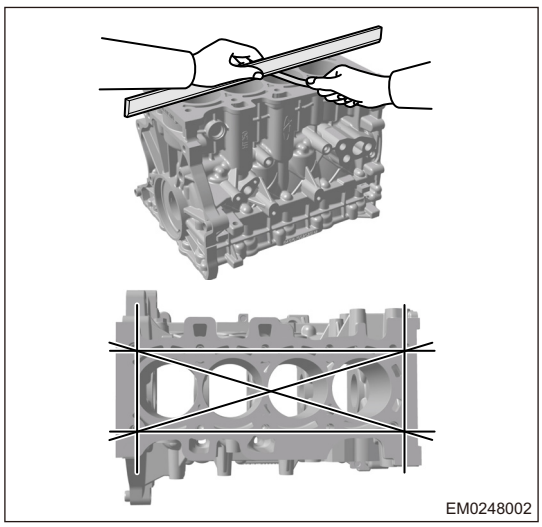
Inspection

1. Check the cylinder block.
   - Clean engine block thoroughly and check all hole passages for leakage.
   - Check cylinder liner for cracks.
   - Check cylinder block for cracks.

   Caution:
   - DO NOT wash cylinder at high temperature; otherwise, cylinder liner will stick out beyond cylinder block.
2. Check the cylinder block upper surface flatness.
   (a) Clean the cylinder block upper surface.
   (b) Using precision straightedge and feeler gauge, measure cylinder block upper surface flatness.

Measurement Item	Specification (mm)	Limit Value (mm)
Cylinder Block Upper Surface Flatness	0.04	0.1

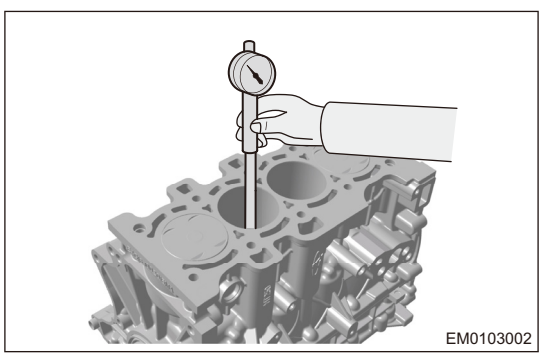
Never grind the cylinder block upper surface. If cylinder block upper surface flatness exceeds limit, replace cylinder block.


EM0248002

3. Check cylinder diameter and piston clearance.
   (a) Using a cylinder gauge, measure cylinder diameter and calculate piston clearance.

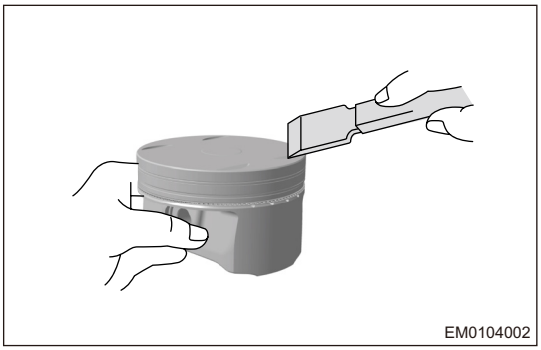
Measurement Item	Specification (mm)	Limit Value (mm)
Cylinder Diameter	77	77.105
Clearance Between Piston and Cylinder	0.04	0.115

If cylinder diameter exceeds the limit, replace cylinder block. If clearance between piston and cylinder exceeds specified value, check cylinder diameter and piston diameter, and replace if necessary.

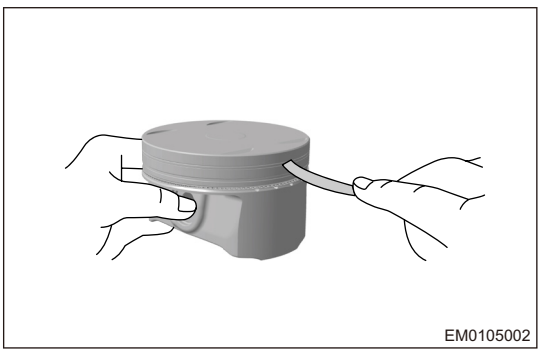

EM0103002

4. Check the piston.

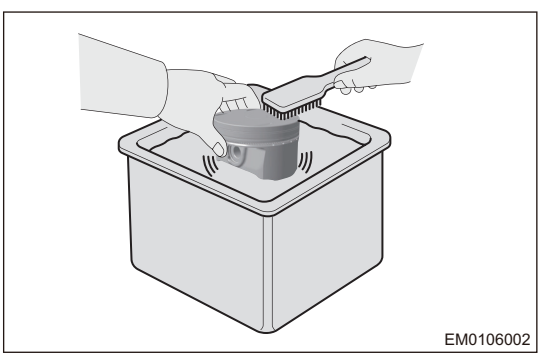
(a) Using a scraper, remove carbon deposits on piston top.


EM0104002

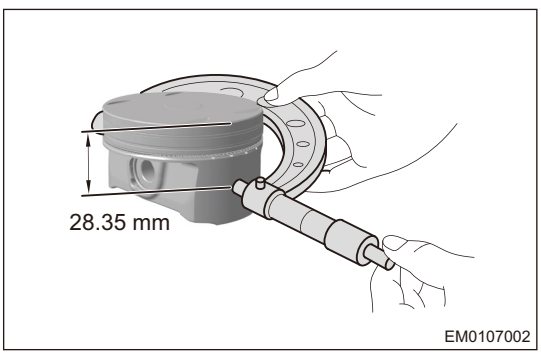
(b) Using a piston ring, remove carbon deposits from piston ring grooves.


EM0105002

(c) Using a brush and solvent, thoroughly clean piston.
Caution:
- DO NOT use a wire brush to clean.


EM0106002

(d) Measure piston diameter with a micrometer at a position, that is 41 mm from piston top in vertical direction of piston pin.



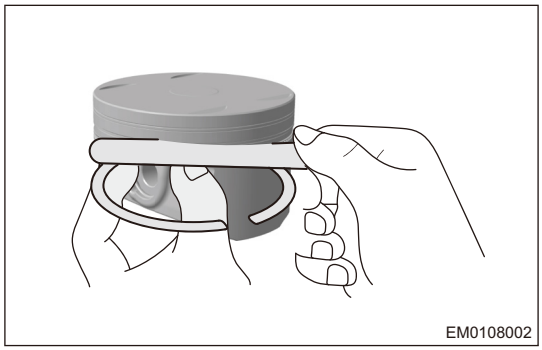
EM0107002

Measurement Item	Specification (mm)
Piston Diameter	76.955 - 76.965

If piston diameter is not within specified range, replace the piston connecting rod assembly.

5. Check clearance between piston ring and ring groove side.

   (a) Using a feeler gauge, measure clearance between new piston ring and ring groove side.


EM0108002

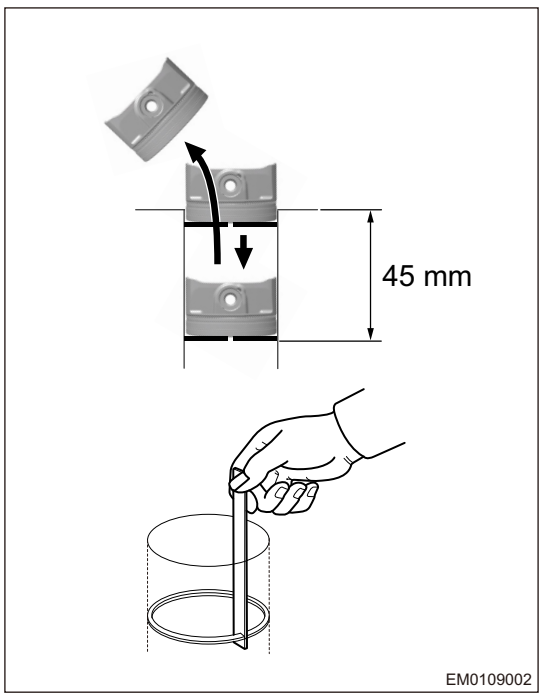
Measurement Item	Specification (mm)	Limit Value (mm)
First Compression Ring Groove Side Clearance	0.02 - 0.065	0.13
Second Compression Ring Groove Side Clearance	0.02 - 0.06	0.12

   If piston ring side clearance exceeds specified range, replace piston ring and piston assembly.

6. Check the piston ring end gap.

   (a) Using a piston, push piston ring from top of cylinder to a position, that is 45 mm from bottom of cylinder bore. Keep the piston ring level.

   (b) Measure at the specified position, which has the minimum piston ring wear with a feeler gauge.



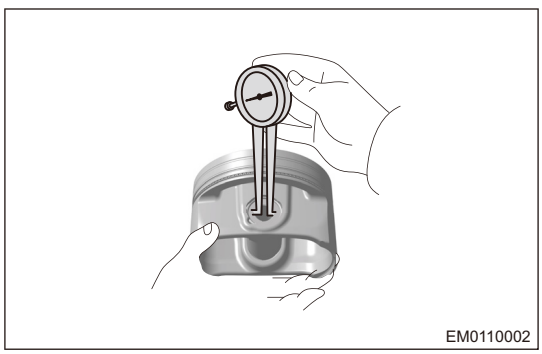
EM0109002

Measurement Item		Specification (mm)
Piston Ring End Gap	First ring	0.2 - 0.3
	Second ring	0.3 - 0.5

   If piston ring end gap is not within specified range, replace piston ring with a new set.
   If end gap is still not within specified range after replacement, replace cylinder block assembly.

7. Check the piston pin.

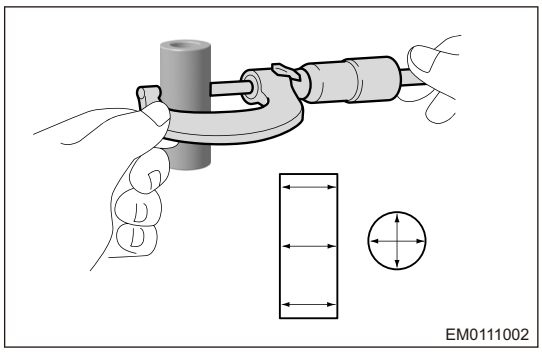
   (a) Using a feeler gauge, measure diameter of piston pin hole.


EM0110002

Measurement Item	Specification (mm)
Piston Pin Hole Diameter	18.004 - 18.009

   If piston pin hole diameter is not within specified range, replace piston.

(b) Using an outer diameter micrometer, measure diameter of piston pin.

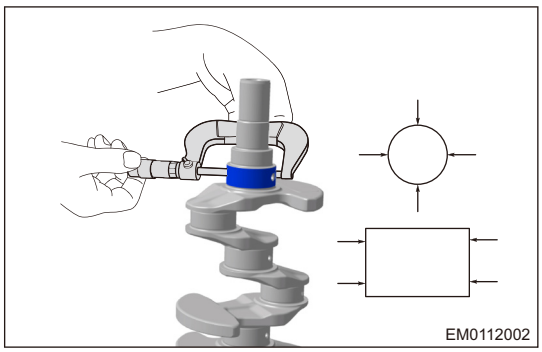


Measurement Item	Specification (mm)
Piston Pin Diameter	17.995 - 18

If piston pin diameter is not within specified range, replace piston pin.

8. Check the crankshaft main journal diameter.

(a) Measure crankshaft main journal diameter with an outer diameter micrometer, and measure again after rotating the crankshaft 90°.



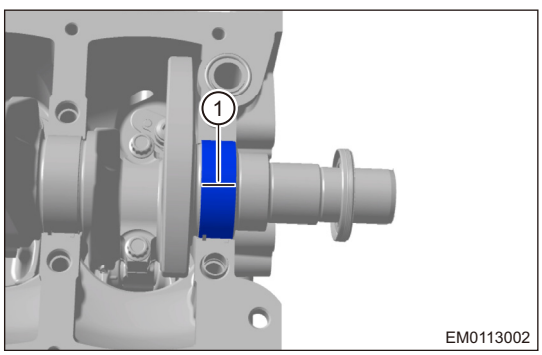
Measurement Item	Specification (mm)	Limit Value (mm)
Crankshaft Main Journal Diameter	50	49.984
Taper and Out-of-roundness	0	0.008

If crankshaft main journal diameter is not within specified range, replace main bearing shells with new ones and check matching clearance of crankshaft main bearing.
If matching clearance of main bearing is still not within specified range after replacing with new main bearing shells, replace crankshaft.

9. Check matching clearance of crankshaft main bearing.

(a) Clean crankshaft main journals and main bearing shells.

(b) Install the crankshaft. Place feeler gauge (1) on crankshaft main journal, parallel to crankshaft center axis and as wide as distance covered by main bearing cap.

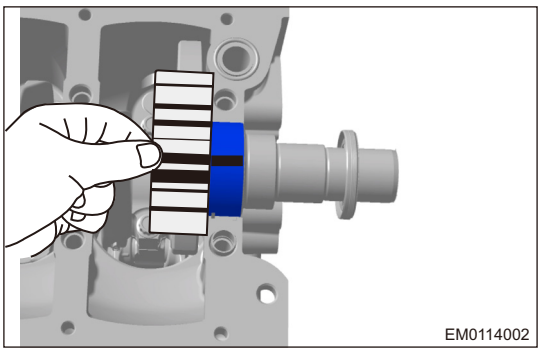


(c) Install crankshaft frame assembly and tighten main bearing cap fixing bolts to specified torque in order.

Tightening torque

1st step: 45 ± 5 N·m
2nd step: 180° ± 10°

(d) Remove the crankshaft frame assembly. Using a feeler gauge, measure widest part of compressed feeler gauge. Measured value is matching clearance of crankshaft main bearing.


EM0114002

Measurement Item	Specification (mm)
Matching Clearance of Crankshaft Main Bearing	0.023 - 0.075

If matching clearance of crankshaft main bearing is not within specified range, install new main bearing shells. Replace crankshaft assembly if necessary.

Caution:

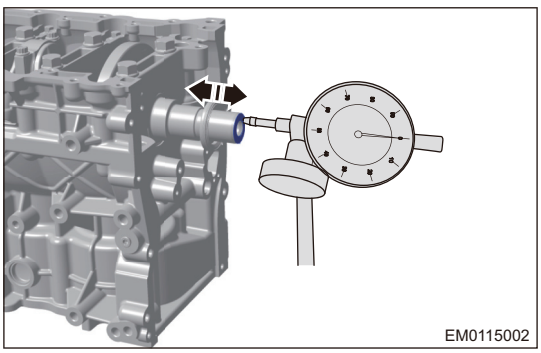
- Replace bearing shells in pairs.

10. Check the crankshaft axial clearance.
    (a) Clean crankshaft main journals and main bearing shells.
    (b) Install crankshaft frame and tighten main bearing cap fixing bolts to specified torque in order.

Tightening torque

1st step: 45 ± 5 N·m
2nd step: 180° ± 10°

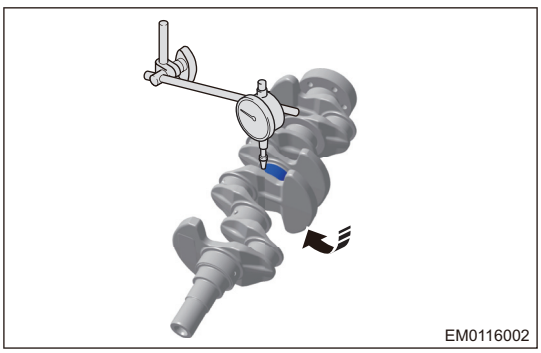
(c) Using a flat tip screwdriver, pry crank position left and right, and read value on dial indicator.


EM0115002

Measurement Item	Specification (mm)	Limit Value (mm)
Crankshaft Axial Clearance	0.07 - 0.265	0.295

If crankshaft axial clearance is not within specified range, replace the thrust washers as a set.

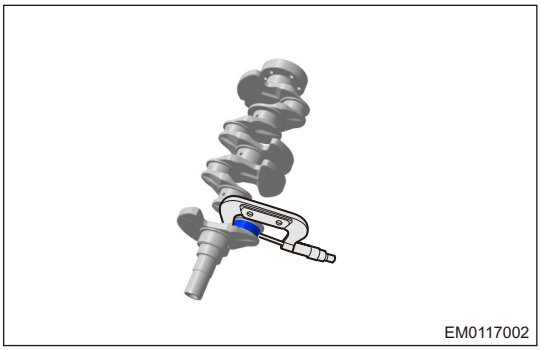
11. Check the crankshaft main journal coaxiality.
    (a) Install crankshaft onto tester and keep it level as shown in illustration.
    (b) Rotate crankshaft slowly and read maximum change value from dial indicator. (Readings on dial indicator)/2 is the coaxiality of crankshaft main journal.


EM0116002

Measurement Item	Specification (mm)	Limit Value (mm)
Crankshaft Main Journal Coaxiality	0	0.05

If crankshaft main journal coaxiality is not within specified range, replace crankshaft assembly.

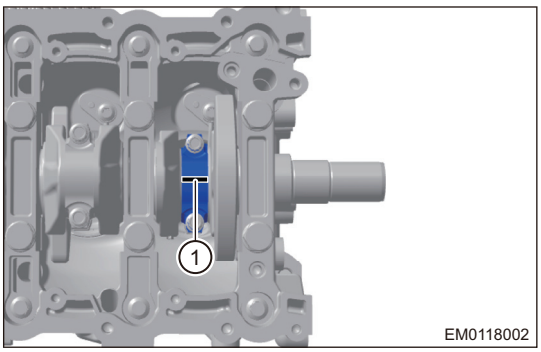
12. Check diameter of crankshaft connecting rod journal.
    (a) Using an outer diameter micrometer, measure diameter of crankshaft connecting rod journal.


EM0117002

Measurement Item	Specification (mm)	Limit Value (mm)
Crankshaft Connecting Rod Journal Diameter	46	45.984

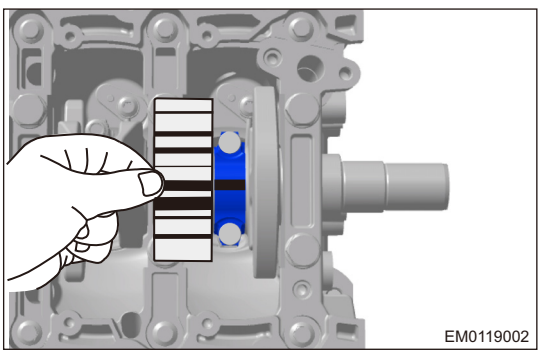
If connecting rod journal diameter is not within specified range, replace connecting rod bearing shells with new ones, and check radial clearance of connecting rod bearing shell.
If radial clearance of connecting rod bearing shell is still not within specified range after replacement, replace crankshaft.

13. Check radial clearance of crankshaft connecting rod bearing shell.
    (a) Clean connecting rod journals and connecting rod bearing shells.
    (b) Place a feeler gauge (1) on connecting rod journal as shown in illustration.



EM0118002

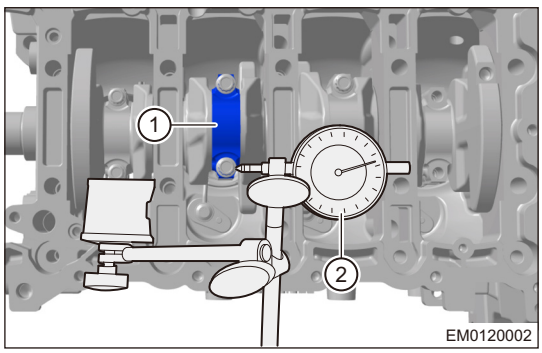
    (c) Install connecting rod bearing caps, and tighten connecting rod bearing cap fixing bolts to specified torque.
    Tightening torque
    1st step: 15 + 3 N·m;
    2nd step: 60° ± 2°
    Caution:
    • DO NOT turn crankshaft during installation.
    (d) Remove the connecting rod bearing cap.
    (e) Using gauge scale of feeler gauge, measure the widest part of compressed feeler gauge to obtain radial clearance of connecting rod bearing shell as shown in illustration.


EM0119002

Measurement Item	Specification (mm)
Connecting Rod Bearing Shell Radial Clearance	0.026 - 0.075

If radial clearance of connecting rod bearing shell is not within specified range, replace connecting rod bearing shells. Replace crankshaft assembly if necessary.

14. Check axial clearance of connecting rod.
    (a) Install connecting rod bearing caps, and tighten connecting rod bearing cap fixing bolts to specified torque.
    Tightening torque
    1st step: 15 + 3 N·m;
    2nd step: 60° ± 2°
    (b) Install a dial indicator (2) with its plunger contacting the side of connecting rod cap (1).
    (c) Reset dial of dial indicator to zero.
    (d) Push connecting rod cap forward and backward (do not move crankshaft forward and backward) and read value on dial indicator.

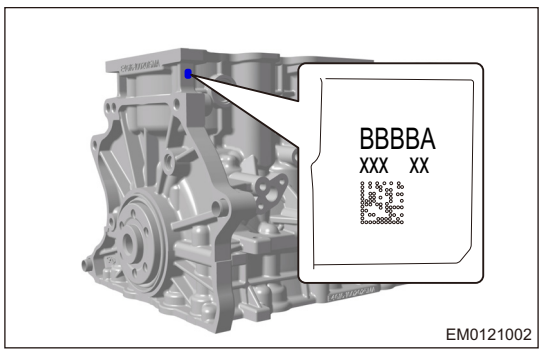


Measurement Item	Specification (mm)
Connecting Rod Axial Clearance	0.15 - 0.40

If axial clearance of connecting rod is not within specified range, replace piston connecting rod assembly. Replace crankshaft assembly if necessary.

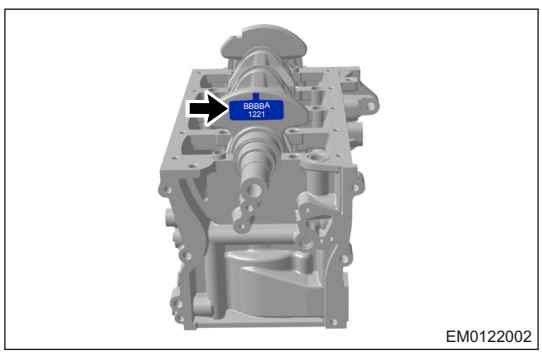
Selection of Main Bearing Shell

1. Selection of crankshaft main bearing upper shell
    (a) Related letter marks are available on cylinder block (consisting of A and B). Such as "BBBBA" in illustration, each letter from left to right is for one type of crankshaft main bearing first journal, and so on; fifth letter "A" is for upper shell type of crankshaft main bearing fifth journal.



Name	Type	Letter Mark
Crankshaft Main Bearing Upper Shell	Red shell	A
	Blue shell	B

2. Selection of crankshaft main bearing lower shell
    (a) Related marks are available on first balancer at front end of crankshaft (consisting of A and B). Such as "BBBBA" on first balancer at front end of crankshaft shown in illustration, first letter "B" is for first journal of crankshaft main bearing lower shell, and so on; fifth letter "A" is for fifth journal of crankshaft main bearing lower shell.



Name	Type	Letter Mark
Crankshaft Main Bearing Lower Shell	Red shell	A
	Blue shell	B

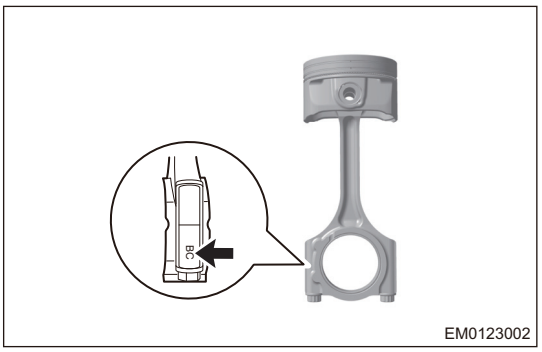
3. Precautions for crankshaft main bearing shell assembly:
    Caution:
    - There is a shell groove and oil hole on the main bearing upper shell, and oil hole should be aligned with that on the engine block, but the main bearing lower shell has no oil hole.

- Apply a coat of engine oil to inner surface of main bearing shell before installation. Back side of bearing shell should be clean without any oil or foreign matter during assembly, and make sure that back side and inner surface are clean.

Selection of Connecting Rod Bearing Shell

1. Selection of connecting rod bearing upper shell
   (a) Connecting rod bearing upper shells are divided into red shell and blue shell. Related marks are available on connecting rod bearing shell cap. Select related connecting rod bearing shell according to marks.
   (b) As shown in illustration, among mark "BC" on connecting rod, "B" indicates blue shell.

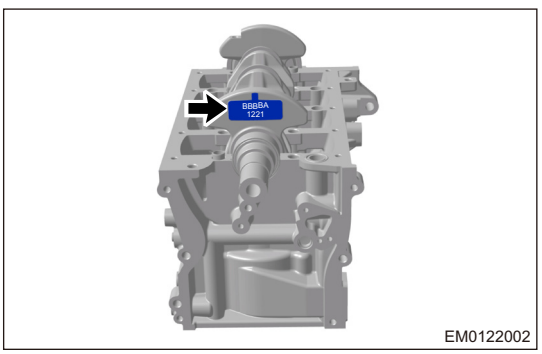
Name	Type	Letter Mark
Connecting Rod Bearing Upper Shell	Red shell	A
	Blue shell	B



EM0123002

2. Selection of connecting rod bearing lower shell
   (a) Related digital marks are available on first balancer at front end of crankshaft (consisting of 1 and 2). Such as "1221" on first balancer at front end of crankshaft shown in illustration, first digit "1" is for lower shell type of cylinder 1 piston connecting rod bearing, and so on; fourth digit "1" is for lower shell type of cylinder 4 piston connecting rod bearing.

Name	Type	Digital Mark
Connecting Rod Bearing Lower Shell	Red shell	1
	Blue shell	2



EM0122002

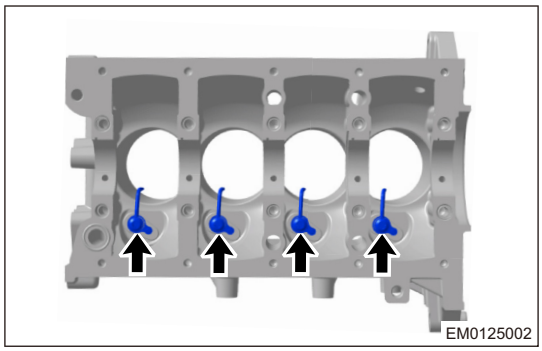
3. Precautions for connecting rod bearing shell assembly:
   Caution:
   - Connecting rod upper and lower bearing shells without oil grooves are universal, but one of the connecting rod bearing shells has an oil hole.
   - It is necessary to use a set of connecting rod bearing shells that are provided by the same manufacturer on the same engine.
   - Apply a coat of engine oil to inner surface of connecting rod bearing shell before installation. Back side of bearing shell should be clean without any oil or foreign matter during assembly, and make sure that back side and inner surface are clean.

Assembly

1. Install the piston cooling nozzles.

   (a) Install piston cooling nozzles and tighten fixing bolts (arrow).

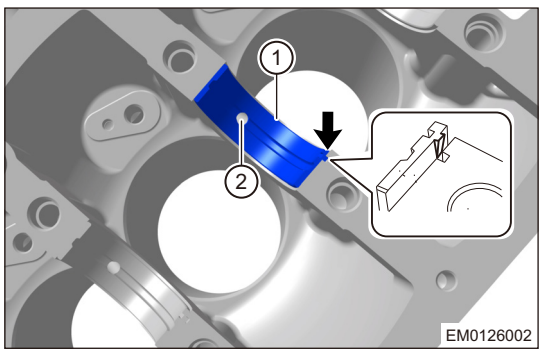
   Tightening torque
   20 + 5 N·m


EM0125002

2. Install the crankshaft main bearing shells.

   (a) Carefully install crankshaft main bearing upper shell (1) in direction of arrow, and notch of each main bearing upper shell should be aligned with cylinder block. Oil passage hole (2) on crankshaft main bearing upper shell should be aligned with passage hole on cylinder block after installation.

   Caution:
   - Apply a coat of engine oil to inner surface of the main bearing shell before installation.

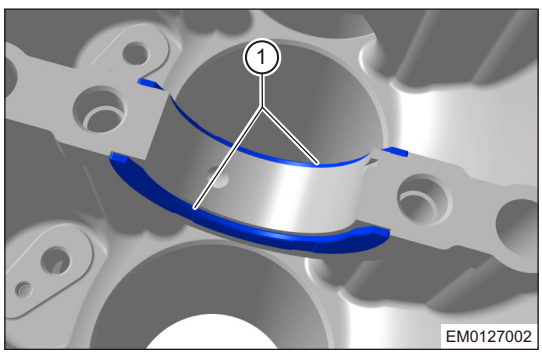


EM0126002

   (b) Install crankshaft main bearing lower shell to crankshaft frame in the same way.

3. Install the thrust washers.

   (a) Clean thrust washers and cylinder block inner wall before installation.
   (b) Apply engine oil to thrust washers.
   (c) There are 2 thrust washers on the cylinder, which are installed on the front and rear thrust surfaces of 3rd main bearing seat respectively.
   (d) As shown in illustration, the side of crankshaft thrust washers (1) without groove should face cylinder block side while the other side with groove should face crankshaft side.



EM0127002

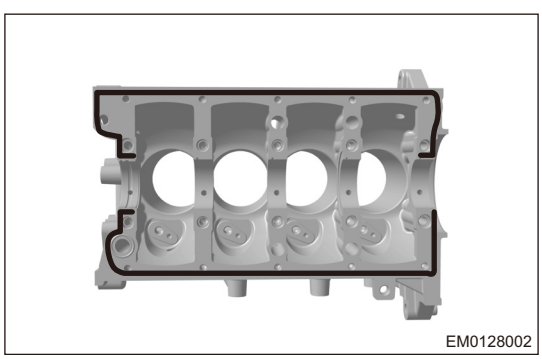
4. Install the crankshaft.

   (a) Apply seal gum to installation surface of crankshaft frame before installation.

   Seal gum
   Loctite 518/5182

   Diameter of seal gum line:
   1.5 - 3 mm

   Caution:
   - DO NOT apply seal gum to bearing shell when applying seal gum.


EM0128002

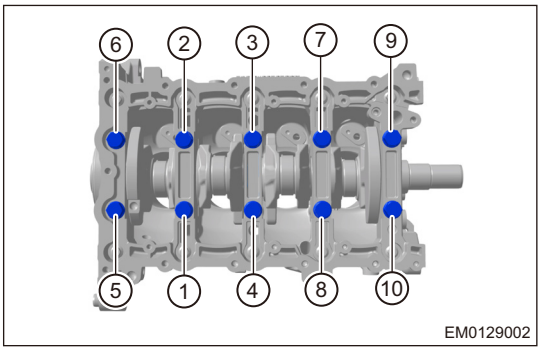
- Seal gum should not be applied too thick. Avoid seal gum entering bearing shell installation area due to compression.

(b) Place crankshaft on cylinder block carefully.

(c) Install crankshaft main bearing cap fixing bolts in place by hands, and then tighten 10 crankshaft main bearing cap fixing bolts in order shown in illustration.

Tightening torque

1st step: 45 ± 5 N·m
2nd step: 180° ± 10°



EM0129002

(d) Evenly tighten 10 crankshaft frame fixing bolts in order shown in illustration.

Tightening torque

27 + 3 N·m

5. Assemble piston and piston connecting rod.

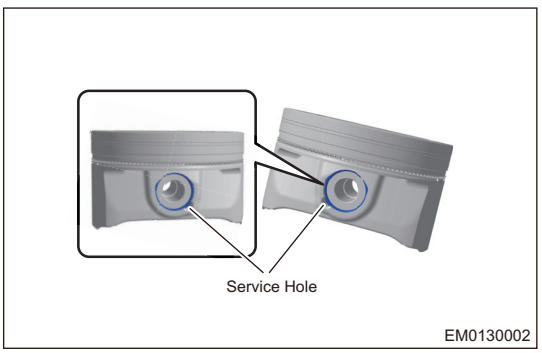
Caution:

- Apply clean engine oil to outer surface of piston pin and inner surface of piston hole before assembly.

(a) Using a small screwdriver, install new elastic circlip to one end of piston pin hole.

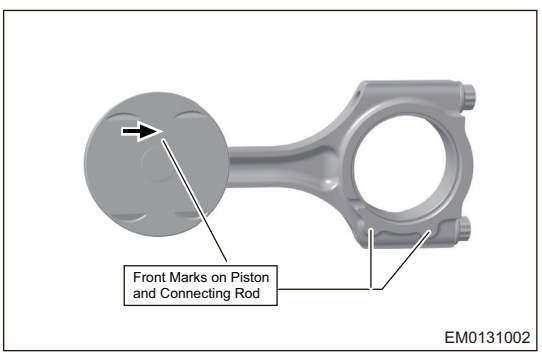
Warning:

- Relative angle between elastic circlip opening and removed notch is 180° ± 40°.



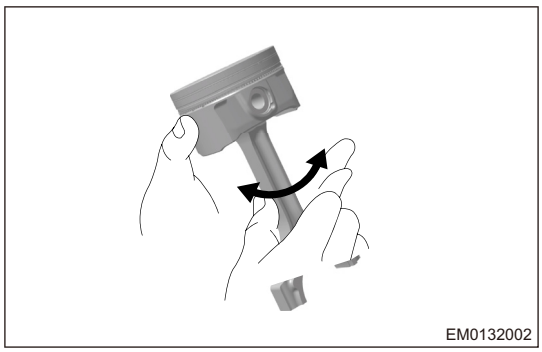
EM0130002

(b) Align front marks on piston and connecting rod, push piston pin with thumb until it contacts with elastic circlip.



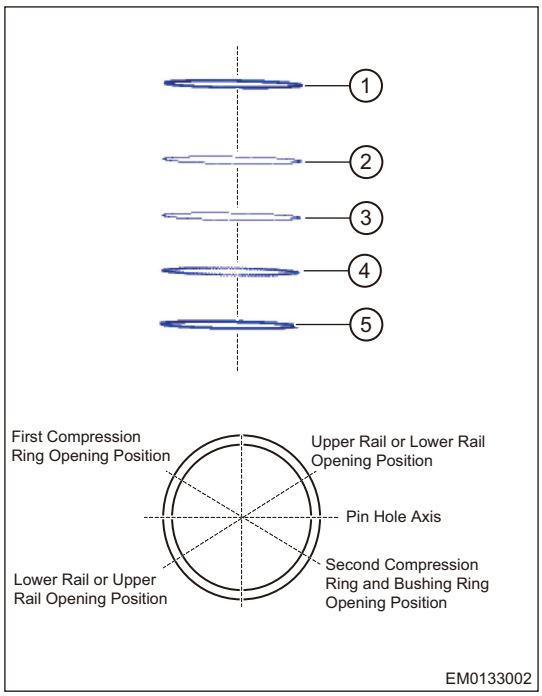
EM0131002

(c) Install elastic circlip to the other end of piston pin hole, and check for free rotation between piston and connecting rod assembly.



6. Install the piston rings.

(a) Apply a small amount of engine oil to piston ring groove and piston. Pay attention that the sides with words of first compression ring (1) and second compression ring (2) should face upward.



(b) Oil ring is steel band combination oil ring and composed of upper rail (3), lower rail (5) and expander (4). When installing the oil ring, first install the expander into oil groove, then install upper and lower rails with opening staggered by 90° from the expander closed gap, and the upper and lower rails at 180°. Then install the second compression ring, and install the first compression ring finally with two compression rings staggered by 90° from upper rail opening. The piston ring should rotate in the ring groove freely without any stuck condition.

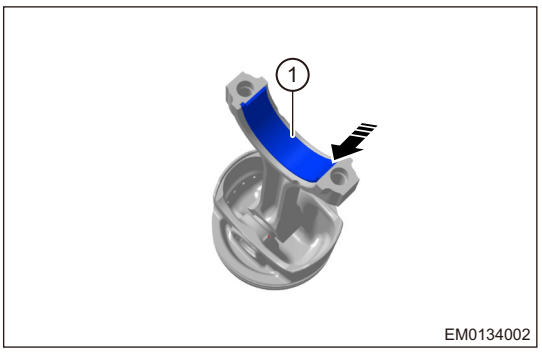
(c) Rotate piston ring several turns after addling engine oil to piston ring groove, and note that the position of ring notch should be the same with that described above; clean crankshaft connecting rod journal and cylinder with a non-woven fabric cloth.

7. Install the connecting rod bearing shells.

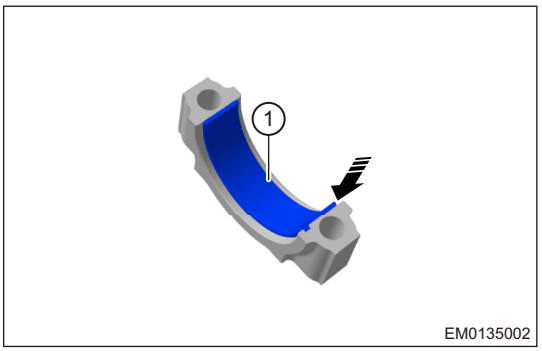
Caution:

- Apply a coat of engine oil to inner surface of connecting rod bearing shell before installation.
- Back side of connecting rod bearing shell should be clean without any foreign matter during assembly.

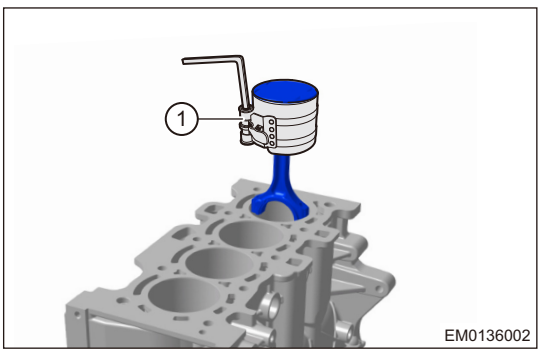
(a) Carefully install the connecting rod bearing upper shell (1) in direction of arrow, and keep notch of each connecting rod bearing upper shell face the cutout of connecting rod bearing.



(b) Carefully install connecting rod bearing lower shell (1) in direction of arrow, and keep notch of each connecting rod bearing lower shell face the cutout of connecting rod bearing cap.

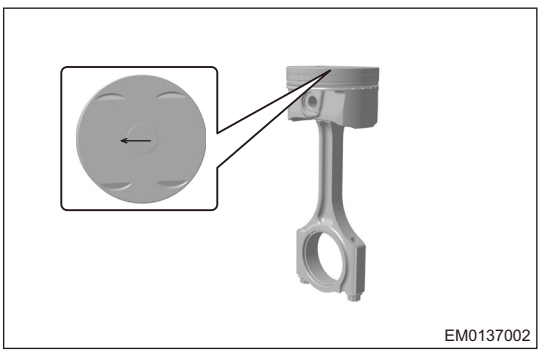


8. Install the piston connecting rod assembly.
   (a) Rotate crankshaft to top dead center of cylinder 1 and cylinder 4.
   (b) Apply a coat of engine oil to piston surface and cylinder inner wall.
   (c) As shown in illustration, install piston connecting rod assembly to cylinder with piston installer (1).



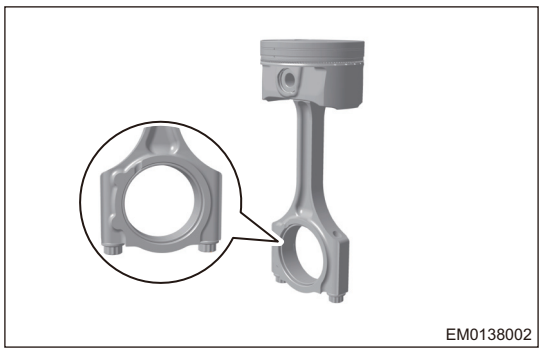
Caution:

- Pay attention to front marks on piston and connecting rod during assembly, without being reversed.



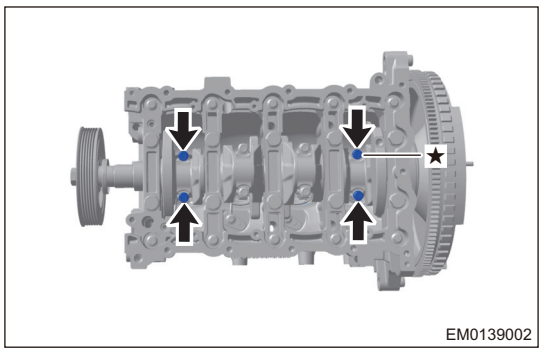
9. Install the connecting rod bearing cap.

Hint:
Protrusion points on connecting rod and connecting rod bearing cap are in same side.


EM0138002

(a) Install connecting rod bearing caps in place, and screw connecting rod bearing cap fixing bolts (arrow) by hands, then tighten connecting rod bearing cap fixing bolts in 2 steps with a torque wrench.

Tightening torque
1st step: 5 + 3 N·m
2nd step: 60° ± 5°


EM0139002

Caution:
- Apply a small amount of engine lubricant to connecting rods, connecting rod bearing caps and thread joint surfaces.

10. Other assembly is in the reverse order of disassembly.