SQRE4T15/SQRE4T15B ENGINE MECHANICAL

GENERAL INFORMATION

Description

SQRE4T15/E4T15B engine has the following features:

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

Operation

SQRE4T15/SQRE4T15B engine adopts design of vertical, in-line 4-cylinder, water-cooled, 4-stroke, 4 valves per cylinder, DOHC, turbocharged intercooler, VVT and electronic controlled sequential multiport fuel injection. Engine adopts individual ignition.

SQRE4T15/SQRE4T15B engine adopts a cast iron cylinder block. Aluminum oil pan is fixed to the bottom of cylinder block 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. This engine has characteristics of reliable construction and excellent performance.

Specifications

SQRE4T15 Engine Specifications

Item	Specifications
Type	Vertical, in-line 4-cylinder, water-cooled, 4-stroke, DOHC, turbocharged intercooler
Model	SQRE4T15
Valve Number Per Cylinder	4
Cylinder Diameter (mm)	77
Piston Stroke (mm)	80.5
Working Volume (ml)	1498
Compression Ratio	9.5:1
Combustion Chamber Type	Pentroof type
Ignition Type	Individual
Ignition Sequence	1 - 3 - 4 - 2
Rated Power (kW)	112
Max. Torque (N·m)	205
Max. Torque Speed (r/min)	2000 - 4000
Max. Permissible Speed (r/min)	6000

Item	Specifications	
Min. Fuel Consumption Rate (g/kW·h)	260	
Fuel Octane Number (Not Less Than)	Unleaded gasoline, octane number 92	
Oil Octane Number	In summer	SAE 10W - 40 (SM grade or higher)
	In winter	SAE 5W - 40 (SM grade or higher)
Oil Capacity (L)	4.7 ± 0.2	
Crankshaft Rotation Direction	Counterclockwise (viewed from end surface of engine flywheel)	
Starting Type	Electrical starting	
Cooling Type	Forced circulation type antifreeze cooling	
Lubrication Type	Compound type (pressure, splash lubrication)	
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
Starting Performance	With atmospheric temperature at -30°C, engine can start smoothly within 8 seconds without taking special measures. Starting test can be performed 3 times consecutively. If it fails to start once, perform starting again after 3 minutes.	

SQRE4T15B Engine Specifications

Item	Specifications
Type	Vertical, in-line 4-cylinder, water-cooled, 4-stroke, DOHC, turbocharged water-cooled
Model	SQRE4T15B
Valve Number Per Cylinder	4
Cylinder Diameter (mm)	77
Piston Stroke (mm)	80.5
Working Volume (ml)	1498
Compression Ratio	9.5:1
Combustion Chamber Type	Pentroof type
Ignition Type	Individual
Ignition Sequence	1 - 3 - 4 - 2
Rated Power (kW)	108
Max. Torque (N·m)	210
Max. Torque Speed (r/min)	1750 - 4000
Max. Permissible Speed (r/min)	6000
Min. Fuel Consumption Rate (g/kW·h)	275

Item	Specifications	
Fuel Octane Number (Not Less Than)	Unleaded gasoline, octane number 92	
Oil Octane Number	In summer	SAE 10W - 40 (SM grade or higher)
	In winter	SAE 5W - 40 (SM grade or higher)
Oil Capacity (L)	4.7 ± 0.2	
Crankshaft Rotation Direction	Counterclockwise (viewed from end surface of engine flywheel)	
Starting Type	Electrical starting	
Cooling Type	Forced circulation type antifreeze cooling	
Lubrication Type	Compound type (pressure, splash lubrication)	
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
Starting Performance	With atmospheric temperature at -30°C, engine can start smoothly within 8 seconds without taking special measures. Starting test can be performed 3 times consecutively. If it fails to start once, perform starting again after 3 minutes.	

SQRE4T15 Engine Mechanical Specifications

Item			Specifications
Camshaft	Cam height	Intake cam (mm)	37.07 ~ 37.31
		Exhaust cam	36.94 ~ 37.18
	Camshaft journal (it is the 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	0.15 ~ 0.2
Cylinder Head	Lower surface flatness (mm)		0.04
	Overall height (mm)		141.05
	Surface grinding limit		Never grind

Item			Specifications
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 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)		16 ± 0.3
Piston	Piston skirt diameter (mm)		76.947 ~ 76.907
	Piston pin hole diameter (mm)		18.010 ~ 18.025
Piston Ring	Piston ring side clearance (mm)	First ring	0.035 - 0.085
		Second ring	0.035 - 0.075
	Piston ring end gap (mm)	First ring	0.2 - 0.35
		Second ring	0.4 - 0.6
Piston Pin	Diameter (mm)		17.992 ~ 17.997
	Length (mm)		45/0/-0.3
Crankshaft	Crankshaft main journal	Diameter (mm)	Standard value: 50 Limit value: 49.979
		Coaxially (mm)	0.04
		Cylindricity (mm)	0.007
		Roundness (mm)	0.004
	Connecting rod journal	Diameter (mm)	Standard value: 46 Limit value: 45.979
		Parallelism to main journal (mm)	0.008

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 - 0.062

SQRE4T15B Engine Mechanical Specifications

Item			Specifications
Camshaft	Cam height	Intake cam (mm)	37.07 ~ 37.31
		Exhaust cam (mm)	36.94 ~ 37.18
	Camshaft journal (it is the 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 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)		16 ± 0.3

Item			Specifications
Piston	Piston skirt diameter (mm)		76.947 ~ 76.907
	Piston pin hole diameter (mm)		18.010 ~ 18.025
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 Ring	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: 46 Limit value: 45.984
		Parallelism to main journal (mm)	0.008
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)
Coupling Bolt Between Steering Pump and Fixing Bracket	25 ± 4
Idler Pulley Assembly Fixing Bolt	40 ± 5
Tensioner Fixing Bolt	40 ± 5
Camshaft Bearing Cap Fixing Bolt	1st step: 9.5 ± 1.5 2nd step: 9.5 ± 1.5
Camshaft Phaser Fixing Bolt	105 + 5
Variable Timing Control Valve Fixing Bolt	6 + 2
Cylinder Head Fixing Bolt	1st step: 40 ± 5 2nd step: 90 ± 5° 3rd step: 90 ± 5°

Description	Torque (N·m)
Lifting Eye Tightening Bolt	20 + 5
Oil Pump Fixing Bolt	20 + 5
Timing Chain Movable Guide Rail Fixing Bolt	12 + 2
Timing Chain Fixing Guide Rail Fixing Bolt	9 + 3
Timing Chain Upper Guide Rail Fixing Bolt	9 + 3
Oil Pump Drive Chain Movable Guide Rail Fixing Bolt	12 + 2
Oil Pump Sprocket Fixing Bolt	20 + 5
Timing Chain Cover Fixing Bolt	M8 × 40 - 10.9: 30 + 5 M10 × 45: 40 + 5 M10 × 80: 40 + 5
Hydraulic Tensioner Fixing Bolt	9 + 3
Frame Assembly (Crankshaft Main Bearing Cap) Fixing Bolt	1st step: 45 ± 5 2nd step: 180°
Frame Assembly Fixing Bolt	27+3
Connecting Rod Bearing Cap Fixing Bolt	1st step: 15 + 3 2nd step: 60 ± 5°
Crankshaft Pulley Fixing Bolt	1st step: 100 ± 10 2nd step: 120 ± 10°
Flywheel Fixing Bolt	Inner hexagon bolt: 1st step: 35 ± 5 2nd step: 30 ± 5° Hexagon flange bolt: 1st step: 35 ± 5 2nd step: 45 ± 5°
Cylinder Block Plug	10 + 5
Timing Locating Plug	40 + 5
Oil Deflector Fixing Bolt	8 + 3
Oil Level Gauge Guide - Frame	8 + 3
Oil Level Gauge Guide - Intake Manifold	8 + 3
Timing Chain Upper Cover Fixing Bolt	8 + 3
Crankshaft Pulley Fixing Bolt	105 - 115
Timing Chain Lower Cover Fixing Bolt	8 + 3
Timing Belt Tensioner Fixing Bolt	20 + 5
Camshaft Phaser Plug	30 ± 5
Camshaft Phaser Plug Fixing Bolt	120 ± 6
Worm Clamp	3.5 ± 0.5
Camshaft Position Sensor Fixing Bolt	10 ± 2
Fixing Bolt Between Coolant Pipe Assembly and Cylinder Block	20 ± 5
Discharge Steel Pipe Fixing Bolt	8 ± 3
Cylinder Head Cover Fixing Bolt	1st step: 3 + 2 2nd step: 8 + 3

Description	Torque (N·m)
Rocker Arm Shaft Fixing Bolt	1st step: 15 ± 1.5 2nd step: 30 ± 1.5
1st Bearing Cap Fixing Bolt	9.5 ± 1
Coupling Bolt Between Discharge Steel Pipe and Cylinder Head	9 ± 1
Cylinder Head Fixing Bolt	1st step: 25 ± 1.5 2nd step: 40 ± 3 3rd step: 60 ± 5° 4th step: 60 ± 5°
Flywheel Fixing Bolt	1st step: 30 ± 2 2nd step: 45 ± 5°
Coupling Bolt Between Left Mounting Cushion Assembly and Left Mounting Bracket	80 ± 5
Coupling Nut Between Left Mounting Cushion Assembly and Left Mounting Bracket	80 ± 5
Fixing Bolt Between Left Mounting Cushion Assembly and Body	60 ± 5
Coupling Bolt Between Left Mounting Bracket and Transmission	80 ± 5
Coupling Nut Between Right Mounting Cushion Assembly and Engine	80 ± 5
Fixing Bolt Between Right Mounting Cushion Assembly and Body	60 ± 5
Coupling Bolt Between Rear Mounting Upper Body and Lower Body	105 ± 10
Coupling Bolt Between Rear Mounting Lower Body and Sub Frame	150 ± 10
Coupling Bolt Between Rear Mounting Upper Body and Transmission	80 ± 5

Lubrication Areas during Engine Assembly

Lubrication Area	Note
Piston Pin	SM 10W - 40
Piston Ring	SM 10W - 40
Piston	SM 10W - 40
Cylinder Bore	SM 10W - 40
Crankshaft Thrust Washer (Oil Groove Side)	SM 10W - 40
Crankshaft Thrust Washer (Oil Groove Side)	SM 10W - 40
Connecting Rod Bearing Cap Bolt Head and Thread	SM 10W - 40
Connecting Rod Bearing Shell and Crankshaft Connecting Rod Journal	SM 10W - 40
Main Bearing Cap Bolt Head	SM 10W - 40

Lubrication Area	Note
Crankshaft Front Oil Seal Lip and Crankshaft Oil Seal Journal	SM 10W - 40
Crankshaft Rear Oil Seal Lip and Crankshaft Oil Seal Journal	SM 10W - 40
Valve Guide Hole	SM 10W - 40
Valve Stem	SM 10W - 40
Camshaft Cam and Journal	SM 10W - 40
Valve Rocker Arm Head	SM 10W - 40
Valve Small End, Valve Rocker Arm Head	SM 10W - 40
Valve Seat Hole (Cylinder Head Assembly)	SM 10W - 40
Valve Guide or Guide Bottom Hole (Cylinder Head)	SM 10W - 40
Camshaft Oil Seal Lip and Camshaft Journal	SM 10W - 40
Oil Filter Gasket Surface	SM 10W - 40

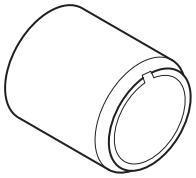
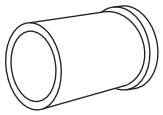
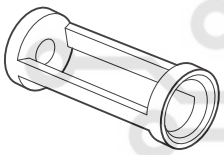
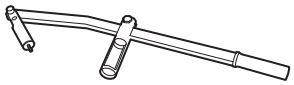
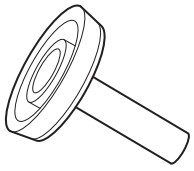
All engine lubricants should be 5W-40 (for winter)/10W-40 (for summer) SM grade or higher.

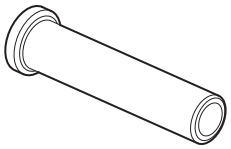
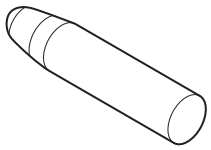
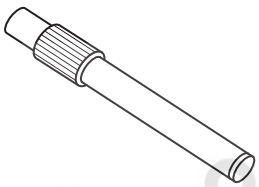
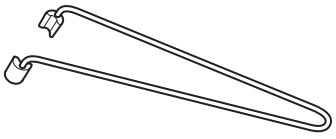
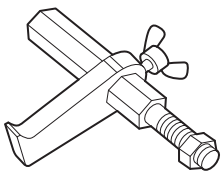
Areas with Seal Gum Applied during Engine Assembly

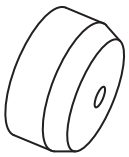
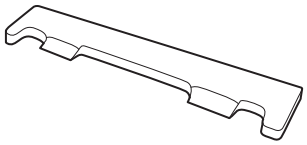
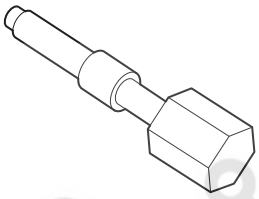
Area with Seal Gum Applied	Seal Gum Type
Timing Chain Cover	Loctite 5900H
Oil Pressure Switch	Loctite 243
Intake and Exhaust Manifold Studs	Loctite 271
Flywheel Bolt	Pre-applied seal gum
Cylinder Head Cover Gasket and Bolt	Loctite 5910
Coolant Temperature Sensor	Loctite 243
Stud	Loctite 2422
Bowl Plug	Loctite 11747
"T" Position of Junction Area Between Timing Chain Cover and Cylinder Head	Loctite 5900H
Upper Guide Rail Bolt	Loctite 243
Cylinder Block Bowl Plug	Loctite 11747
Cylinder Block Plug	Loctite 577
Cylinder Block Frame Assembly	Loctite 518/5182
Deflector Mounting Bolt Thread	Loctite 243
Collector 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

Tools

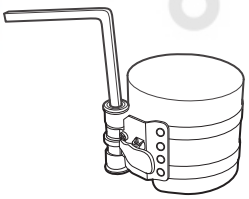
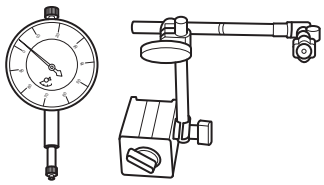
Special Tools

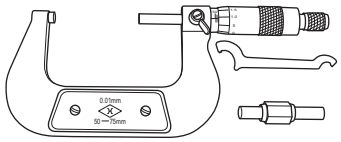
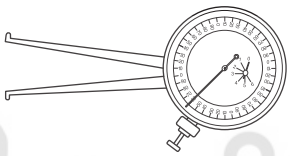
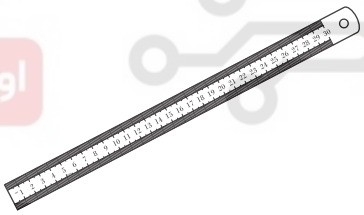
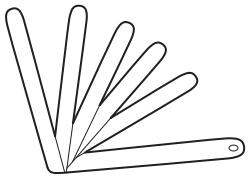
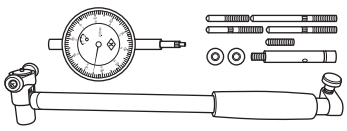
Crankshaft Front Oil Seal Guide Tool	 RCH0000049
Crankshaft Front Oil Seal Installer	 RCH0000067
Valve Spring Compression Adapter	 RCH0000050
Valve Spring Compressor	 RCH0000028
Crankshaft Rear Oil Seal Installer	 RCH0000031

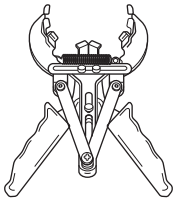
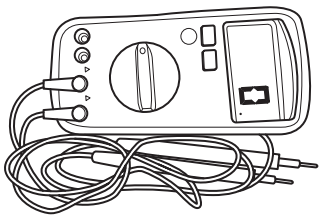
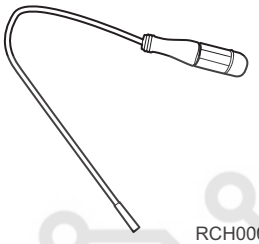
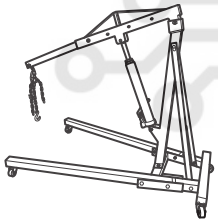
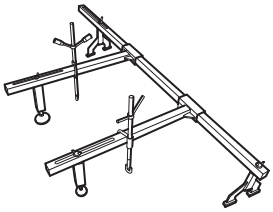
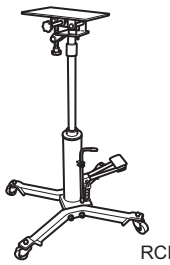
Valve Oil Seal Installer	 RCH0000034
Valve Oil Seal Guide Sleeve	 RCH0000035
Driven Disc Assembly, Clutch Cover Assembly, Guide Special Tool	 RCH0000018
Valve Oil Seal Remover	 RCH0000037
Valve Cotter Installer	 RCH0000029
Flywheel Holding Tool	 RCH0000040

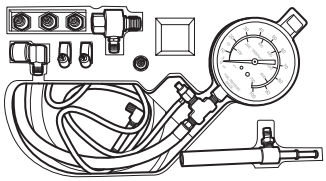
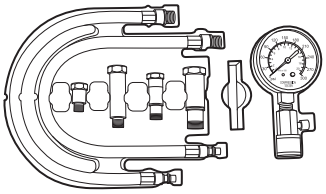
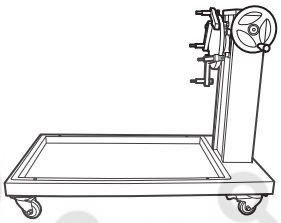
Crankshaft Rear Oil Seal Installer	 RCH0000070
Camshaft Timing Tool	 RCH0000033
Crankshaft Timing Tool	 RCH0000027

General Tools

Piston Installer	 RCH0000039
Dial Indicator and Magnetic Holder	 RCH0000023

Outer Diameter Micrometer	 RCH0000064
Vernier Caliper	 RCH0000019
Inner Diameter Micrometer	 RCH0000069
Precision Straightedge	 RCH0000063
Feeler Gauge	 RCH0000060
Cylinder Gauge	 RCH0000065

Piston Ring Remover	 RCH0000066
Digital Multimeter	 RCH0000002
Flexional Magnetic Rod	 RCH0000042
Engine Hoist	 RCH0000043
Engine Equalizer	 RCH0000026
Transmission Carrier	 RCH0000005

Fuel System Pressure Tester	 RCH0000048
Cylinder Pressure Gauge	 RCH0000044
Engine Service Platform	 RCH0000057

DIAGNOSIS & TESTING

Problem Symptoms Table

Engine Problem Symptoms Table

Symptom	Suspected Area	See page
Valve mechanism noise	Engine oil (oil level high or low, oil lean or rich)	22-10
	Cam	-
	Valve spring seat (excessive runout)	10-55
	Valve (excessive clearance between valve and guide)	10-57
Connecting rod noise	Engine oil (low pressure)	22-10
	Engine oil (lean)	22-10
	Connecting rod bearing cap (loose fixing nut)	10-106
	Connecting rod (misaligned)	10-106
	Connecting rod bearing shell (excessive radial clearance)	10-96
	Connecting rod journal (out-of roundness)	10-96
Main bearing noise	Engine oil (low pressure)	22-10
	Engine oil (lean)	22-10
	Main bearing shell (excessive clearance)	10-96
	Crankshaft axial clearance (excessive)	10-96
	Crankshaft journal (out-of roundness or worn)	10-96
	Flywheel or clutch (loose)	-
Oil loss or spark plug blockage	Piston ring (worn, scratched or damaged)	10-90
	Piston ring groove (carbon deposited)	10-96
	Valve oil seal (worn or damaged)	10-55
	Valve (excessive clearance between valve and guide)	10-57

Symptom	Suspected Area	See page
Engine power loss	Spark plug (dirty, burnt or incorrect clearance)	24-11
	Electric fuel pump assembly	12-15
	Ignition coil	24-9
	Valve timing (wrong)	-
	Cylinder head (leakage)	10-52
	Valve (burnt, deformation or excessive clearance)	-
	Cylinder pressure (low)	-
	Fuel system (dirty)	-
	Exhaust system (blocked)	-

Inspection

1. Check the coolant (See page 20-13).
2. Check the engine oil (See page 22-8).
3. Check the battery (See page 28-7).
4. Check the air filter element.
   a. Remove the air filter element (See page 16-12).
   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 plugs (See page 24-11).
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 the 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

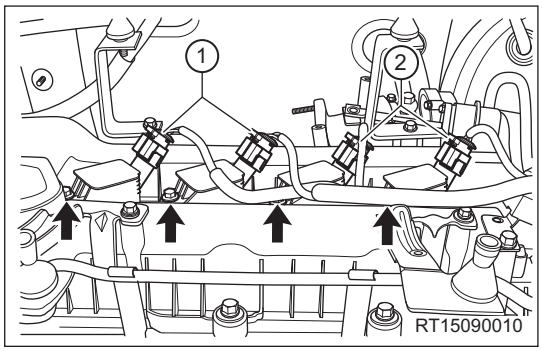
- Use a cylinder pressure gauge with accurate reading and reset it to zero, or it will influence accuracy of reading.

a. Turn off all electrical equipment and the engine switch.

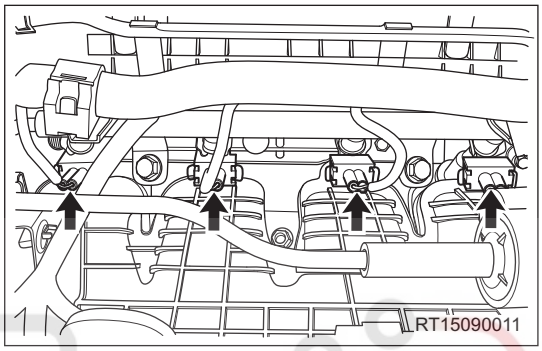
b. Remove the engine cover.

c. Remove the ignition coils.

- Disconnect ignition coil connectors (1) and (2).
- Remove 4 fixing bolts (arrow) from ignition coils, and remove 4 ignition coils.
  (Tightening torque: 8 + 3 N·m)

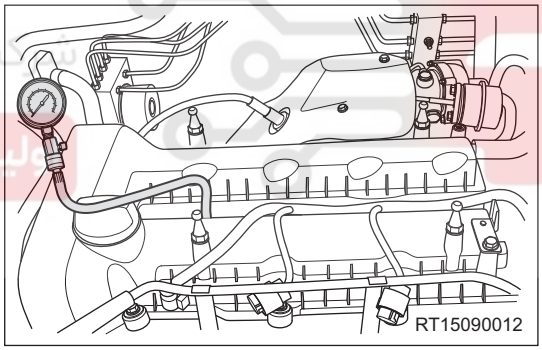


d. Disconnect all injector connectors (arrow).



e. Remove the spark plugs (See page 24-11).

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



g. With transmission in neutral position, depress accelerator pedal fully, then start engine and keep it racing for 3 to 5 seconds; record the measured pressure value.

h. Press 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.
   Value for cylinder pressure is 7 - 10 bar (180 - 250 r/min).

CAUTION

- DO NOT tighten 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 value for cylinder pressure is 7 - 10 bar (180 - 250 r/min). The value will drop as engine uses, but lowest value cannot be below 9 bar and pressure difference between each cylinder should not be above 3 bar.
- If cylinder pressure is lower than standard value, it indicates that cylinder pressure is insufficient, add a small amount of engine oil 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 not properly installed, or there may be air leakage in cylinder head gasket.

i. Install the spark plugs (See page 24-11).

CAUTION

- Always check spark plug before installation. Apply a proper amount of lubricant to spark plugs before installation. DO NOT place spark plugs into installation holes when installing spark plugs, as dropping will cause deformation of side electrode, thus causing gap become small and spark jumping will influence engine operation. Installation torque: 20 N·m.

j. Connect all injector connectors.

k. Install the ignition coils (See page 24-9).

7. Test the cylinder head gasket.

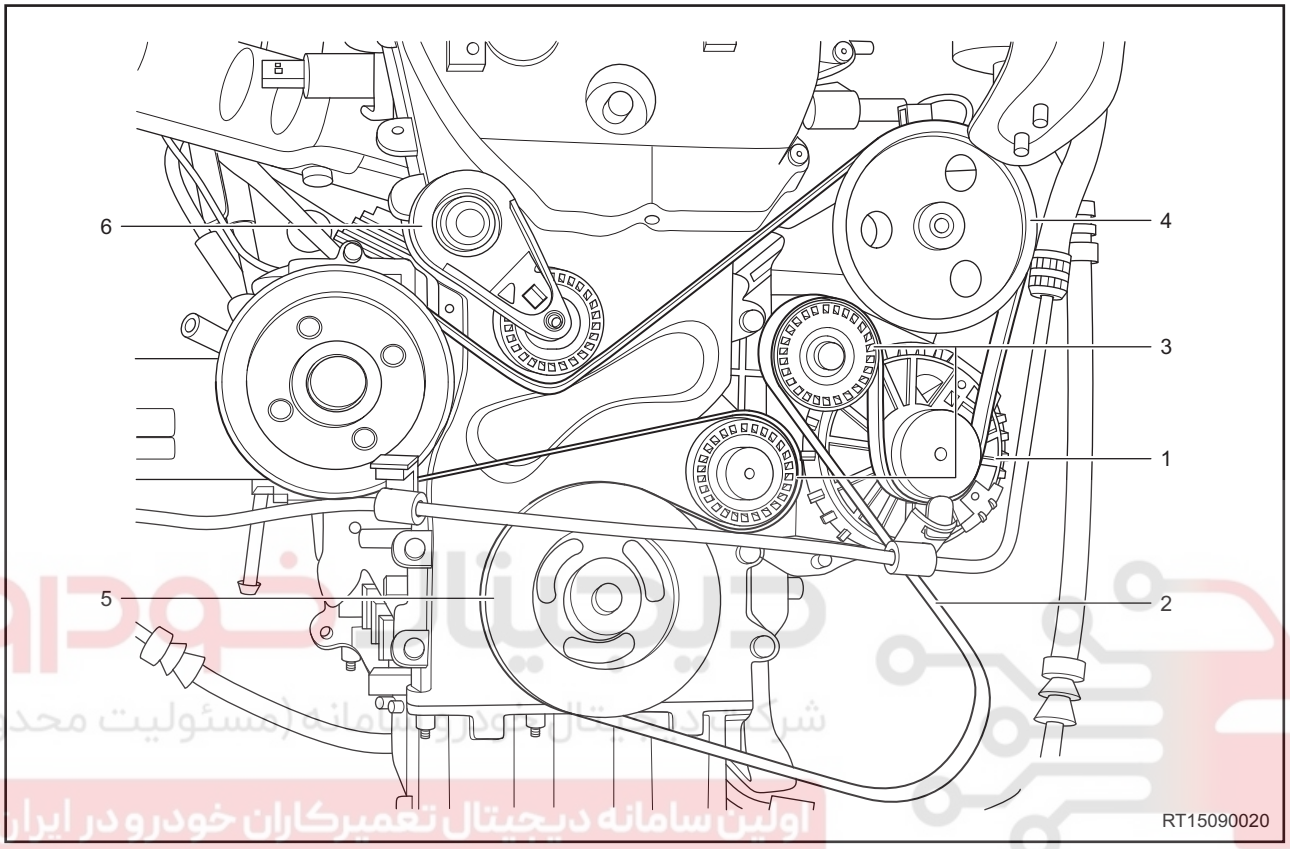
   Cylinder head gasket leakage may be present between adjacent cylinders, between cylinder and adjacent water jacket or from an oil passage to the external of engine.

   - 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 (overheating).
     - Coolant loss.
     - Excessive steam (white smoke) emitted from exhaust system.
     - Coolant foaming.

ON-VEHICLE SERVICE

Accessory Pulley (HPS)

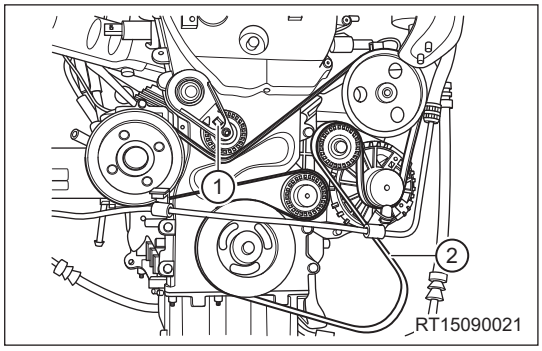
Description



1 - Alternator Assembly	2 - Accessory Drive Belt
3 - Idler Pulley Assembly	4 - Power Steering Pump Assembly
5 - Crankshaft Pulley	6 - Tensioner Assembly

Removal

1. Turn off all electrical equipment and the engine switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Raise vehicle to a proper height.
5. Remove the accessory drive belt.
   a. Insert head of ratchet wrench into tensioner pin hole (1), and raise it upward in direction of arrow as shown in illustration, then remove accessory drive belt assembly (2).



CAUTION

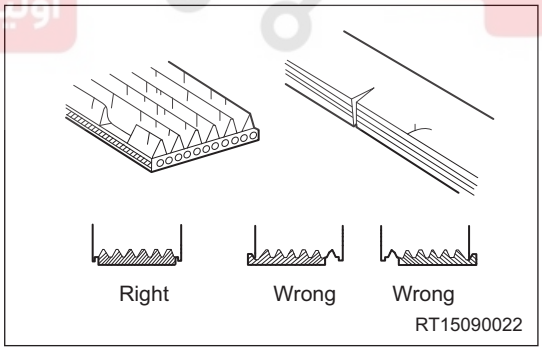
- Prevent hand from contacting belt tensioner when raising it upward.

Inspection

1. Check belt surface for pilling, oiliness and deterioration, etc. If any of these defects is found, replace accessory drive belt immediately.
2. 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:

- Cracks on rib side of ribbed belt are considered acceptable. If ribbed belt has chunks missing from ribs, it should be replaced.
- After installing ribbed 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

Installation is in the reverse order of removal.

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 disconnected parts.

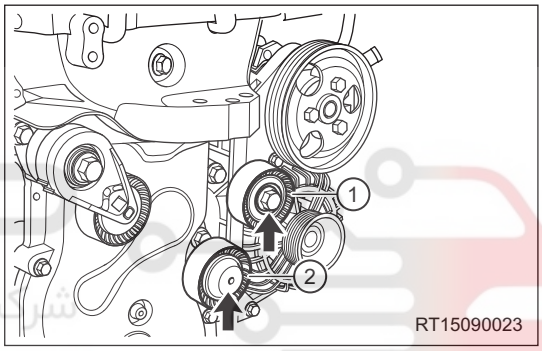
Idler Pulley Assembly

Removal

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 engine switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Remove the engine right lower protector.
5. Loosen the accessory drive belt (See page 10-22).
6. Remove the idler pulley assembly.
   a. Remove fixing bolt (arrow) from idler pulley (1).
      (Tightening torque: 40 + 5 N·m)
   b. Remove the idler pulley (1).
   c. Use a tool to pry off external protective cap (arrow) from idler pulley (2) and remove fixing bolt.
      (Tightening torque: 40 + 5 N·m)
   d. Remove the idler pulley (2).



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

Installation is in the reverse order of removal.

CAUTION

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

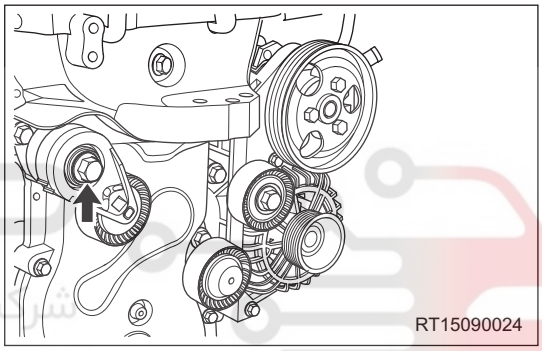
Tensioner Assembly

Removal

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 engine switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Remove the engine right lower protector.
5. Loosen the accessory drive belt (See page 10-22).
6. Remove the tensioner assembly.
   a. Remove the tensioner fixing bolt (arrow).
      (Tightening torque: 40 + 5 N·m)



   b. Remove the tensioner assembly.

Inspection

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

Installation

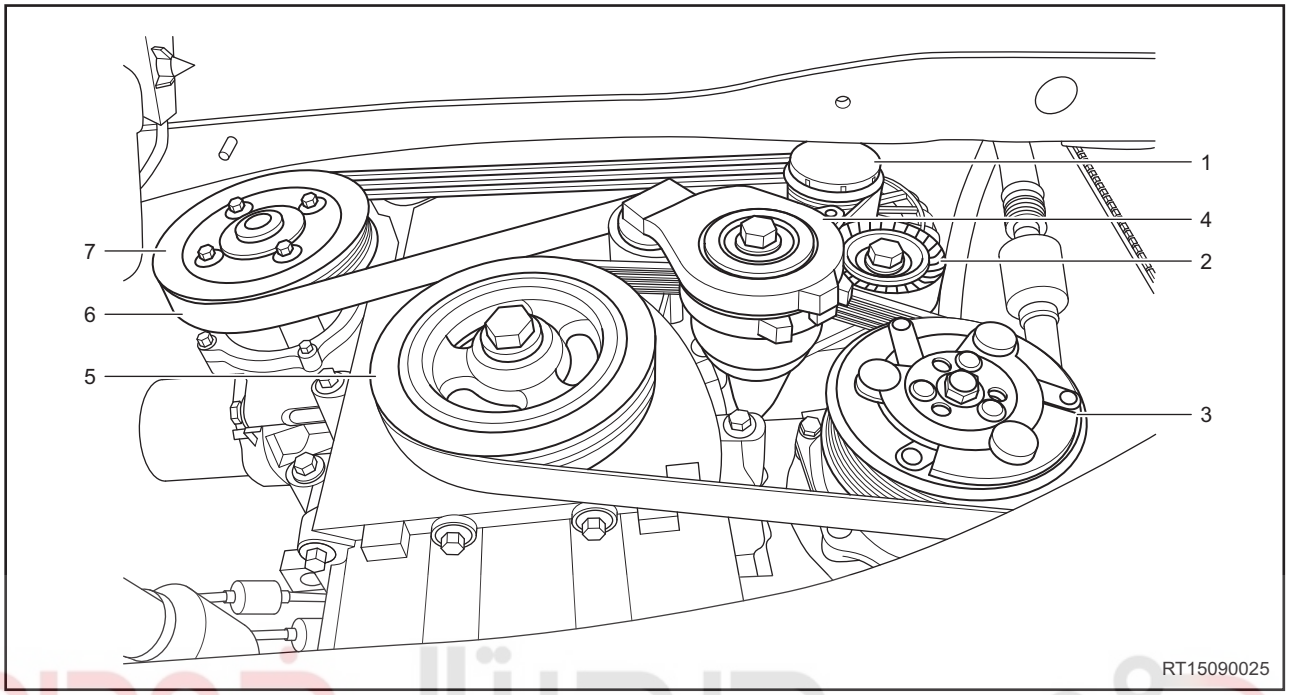
Installation is in the reverse order of removal.

CAUTION

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

Accessory Pulley (EPS)

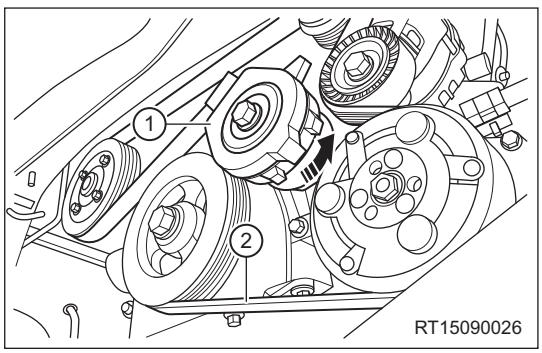
Description



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

Removal

1. Turn off all electrical equipment and the engine switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Raise vehicle to a proper height.
5. Remove the accessory drive belt.
   a. Insert head of ratchet wrench into tensioner pin hole (1), and raise it upward in direction of arrow as shown in illustration, then remove accessory drive belt assembly (2).



CAUTION

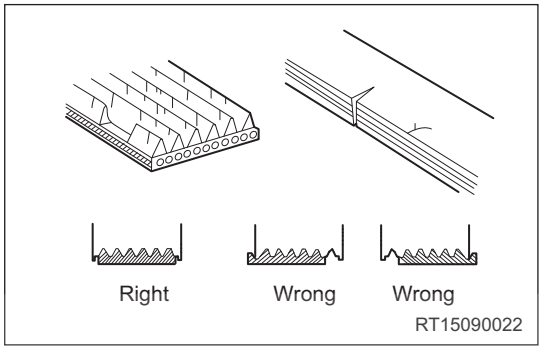
- Prevent hand from contacting belt tensioner when raising it upward.

Inspection

1. Check belt surface for pilling, oiliness and deterioration, etc. If any of these defects is found, replace accessory drive belt immediately.
2. 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:

- Cracks on rib side of ribbed belt are considered acceptable. If ribbed belt has chunks missing from ribs, it should be replaced.
- After installing ribbed 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

Installation is in the reverse order of removal.

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 disconnected parts.

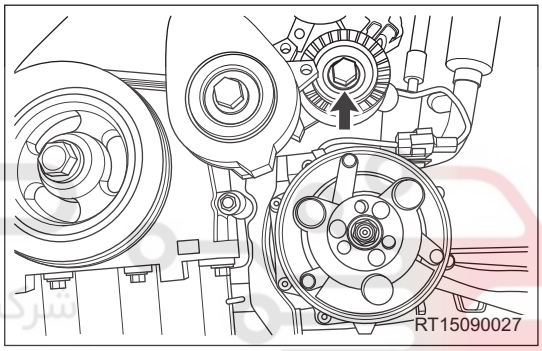
Idler Pulley Assembly

Removal

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 engine switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Remove the engine right lower protector.
5. Loosen the accessory drive belt (See page 10-26).
6. Remove the idler pulley assembly.
   a. Remove fixing bolt (arrow) from idler pulley.
      (Tightening torque: 40 + 5 N·m)



   b. Remove the idler pulley.

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

Installation is in the reverse order of removal.

CAUTION

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

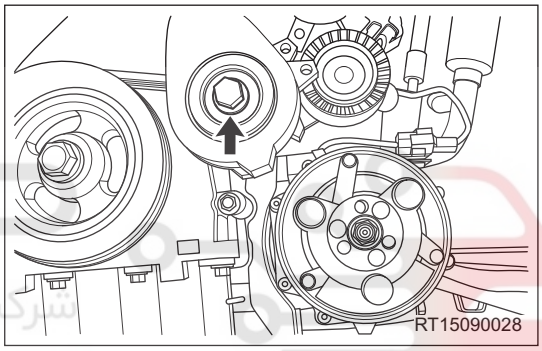
Tensioner Assembly

Removal

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 engine switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Remove the engine right lower protector.
5. Loosen the accessory drive belt (See page 10-26).
6. Remove the tensioner assembly.
   a. Remove the tensioner fixing bolt (arrow).
      (Tightening torque: 40 + 5 N·m)



   b. Remove the tensioner assembly.

Inspection

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

Installation

Installation is in the reverse order of removal.

CAUTION

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

Cylinder Head Cover

Removal

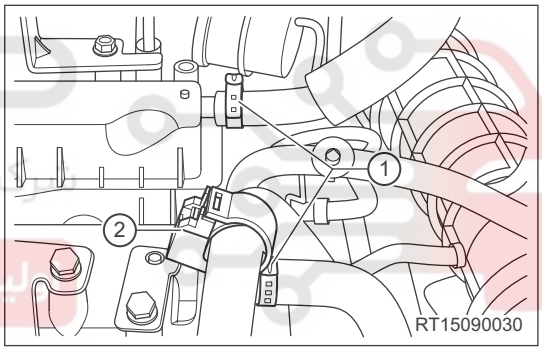
CAUTION

- 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 engine switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Blow dirt and debris away from upper surface of cylinder head cover with compressed air.
5. Remove the ignition coils (See page 24-9).
6. Remove the turbocharger outlet pipe set (1.5 TCI + DCT) (See page 18-20).
7. Remove the discharge steel pipe assembly (1.5 TCI + DCT) (See page 20-28).
8. Remove the cylinder head cover.

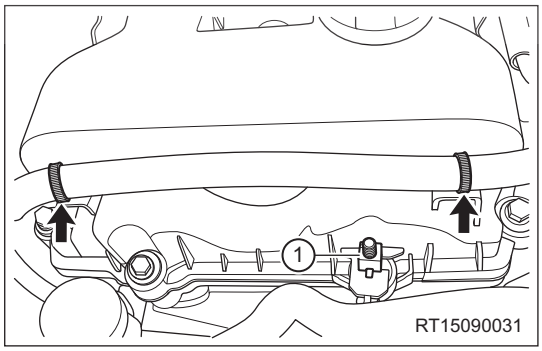
a. Loosen clamping rings (1) and disconnect connection between crankcase ventilation hose and cylinder head cover.

b. Disconnect the engine wire harness fixing clip (2).

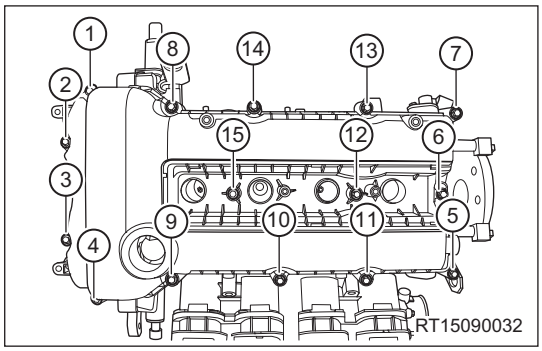


c. Remove 2 engine wire harness fixing clips (arrow).

d. Remove the inlet pipe fixing clip (1).

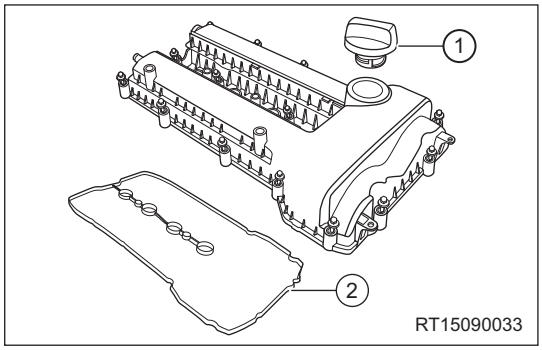


e. Remove 15 cylinder head cover fixing bolts in order shown in illustration.



f. Remove the cylinder head cover assembly.

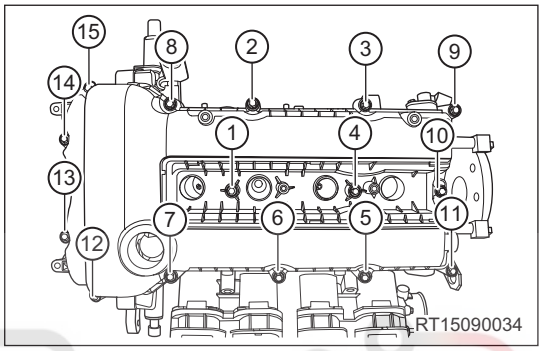
9. Remove fuel filler cap (1) and cylinder head cover gasket (2) from cylinder head cover.



Installation

1. Tighten 15 cylinder head cover fixing bolts in order shown in illustration.

   (Tightening torque: tighten to 3 + 2 N·m; retighten to 8 + 3 N·m)



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

Crankshaft Front Oil Seal

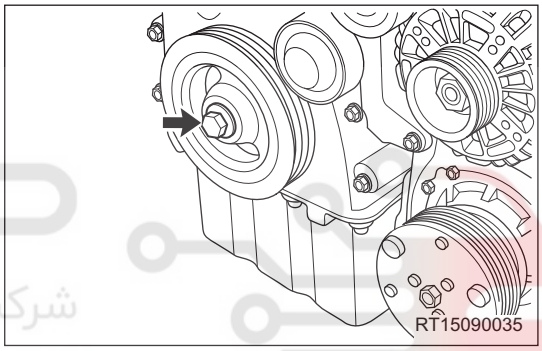
Removal

CAUTION

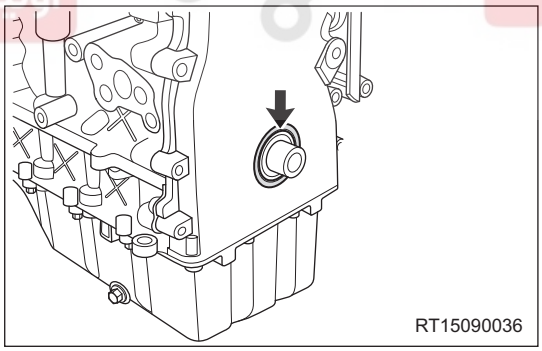
- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the engine switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Remove the engine right lower protector assembly.
5. Remove the accessory drive belt (See page 10-26).
6. Remove the crankshaft front oil seal assembly.
   a. Remove crankshaft pulley fixing bolt (arrow).
      (Tightening torque: 1st step: tighten to 100 ± 10 N·m; 2nd step: rotate by 120° ± 10°)

HINT:
Switch the gear position (for 6MT model) to 5th or switch the gear position (for DCT model) to "D" and depress brake pedal by other technician, thus locking crankshaft via mechanical drive device and loosening crankshaft pulley fixing bolt.



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



CAUTION

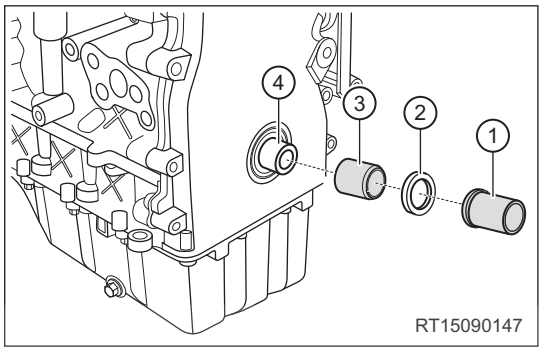
- Be careful to remove crankshaft front oil seal to avoid damaging oil seal retainer and crankshaft surface.

Installation

CAUTION

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

1. Install crankshaft front oil seal guide tool (3) to crankshaft (4).
2. Install new oil seal (2) to crankshaft front oil seal guide tool, then install new oil seal fully into oil seal retainer with a crankshaft front oil seal installer (1).



CAUTION

- Oil seal surface should be 0 - 1 mm lower than timing chain cover oil seal hole end surface.

Other installation procedures are in the reverse order of removal.

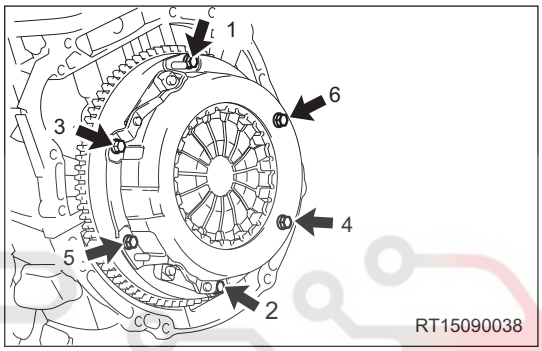
Flywheel (1.5 TCI + 6MT)

Removal

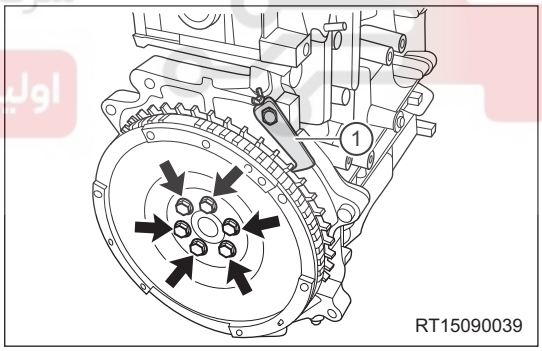
CAUTION

- 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 engine switch.
2. Disconnect the negative battery cable.
3. Remove the transmission assembly (1.5 TCI + 6MT) (See page 29-27).
4. Remove the clutch assembly.
   a. Remove 6 fixing bolts from clutch pressure plate in order shown in illustration, and remove clutch disc.
   (Tightening torque: 23 ± 2 N·m)



5. Remove the flywheel assembly.
   a. Install flywheel locking special tool (1) to lock flywheel.
   b. Remove 6 fixing bolts from flywheel assembly, and remove flywheel assembly.
   (Tightening torque: 1st step: 35 ± 5 N·m; 2nd step: 45 ± 5°)



WARNING

- Pay attention to personal safety during operation.
- Do not remove all fixing bolts without any auxiliary measures.

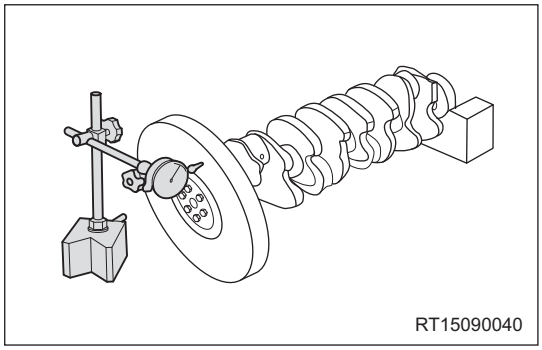
CAUTION

- 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 the flywheel. Clean signal gear before installation.
2. Check if starter drive gear ring is worn. If excessively worn, replace the flywheel.
3. Check contact surface of clutch lining. If contact surface is damaged or over worn, replace flywheel with a new one.
4. Use a dial indicator to measure runout of flywheel end surface. If measured value exceeds limit value, replace flywheel with a new one.

   Limit value for end surface runout: 0.2 mm.


RT15090040

Installation

WARNING

- Never reuse flywheel fixing bolts after removal.
- Make sure to use new bolts with seal gum applied, before installing flywheel fixing bolts.

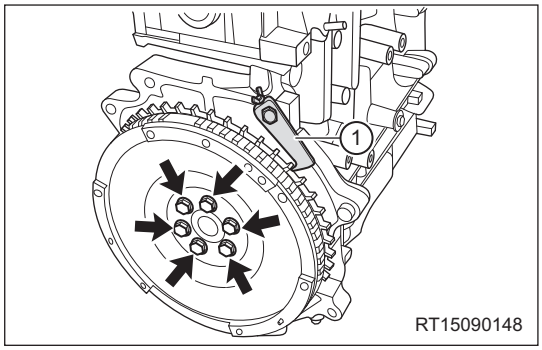
CAUTION

- Six bolt holes on the flywheel have asymmetrical positions. There is matchmark hole on flywheel. When cylinder 1 of engine is at top dead center, the matchmark hole is located at right above position and flywheel fixing bolts are aligned with bolt holes of crankshaft.

Installation procedures are in the reverse order of removal, and pay attention to the followings:

1. Flywheel installation hole is in clearance fit with crankshaft positioning journal, lightly push flywheel onto the journal after alignment during assembly. Do not tap flywheel with a hammer.
2. Replace flywheel fixing bolts with new ones and preapply seal gum to the bolt threads.
3. Pretighten flywheel fixing bolts (arrow), and install flywheel locking special tool (1), then tighten 6 flywheel fixing bolts.

   (Tightening torque: 1st step: 35 ± 5 N·m; 2nd step: 45 ± 5°)



RT15090148

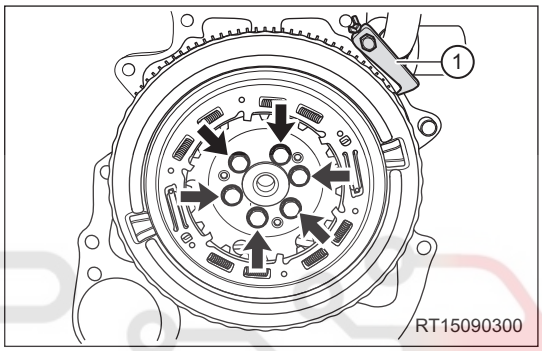
Flywheel (1.5 TCI + DCT)

Removal

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 engine switch.
2. Disconnect the negative battery cable.
3. Remove the transmission assembly (1.5 TCI + DCT) (See page 31-115).
4. Remove the flywheel assembly.
   a. Install flywheel locking special tool (1) to lock flywheel.
   b. Remove 6 fixing bolts from flywheel assembly, and remove flywheel assembly.
      (Tightening torque: 1st step: 35 ± 5 N·m; 2nd step: 45 ± 5°)



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 the flywheel. Clean signal gear before installation.
2. Check if starter drive gear ring is worn. If excessively worn, replace the flywheel.
3. Check contact surface of clutch lining. If contact surface is damaged or over worn, replace flywheel with a new one.

Installation

⚠ WARNING

- Never reuse flywheel fixing bolts after removal.
- Make sure to use new bolts with seal gum applied, before installing flywheel fixing bolts.

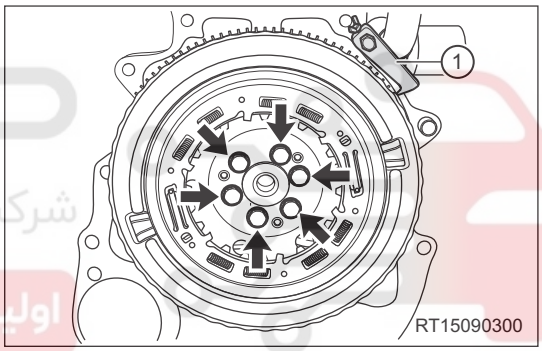
CAUTION

- Six bolt holes on the flywheel have asymmetrical positions. There is matchmark hole on flywheel. When cylinder 1 of engine is at top dead center, the matchmark hole is located at right above position and flywheel fixing bolts are aligned with bolt holes of crankshaft.

Installation procedures are in the reverse order of removal, and pay attention to the followings:

1. Flywheel installation hole is in clearance fit with crankshaft positioning journal, lightly push flywheel onto the journal after alignment during assembly. Do not tap flywheel with a hammer.
2. Replace flywheel fixing bolts with new ones and preapply seal gum to the bolt threads.
3. Pretighten flywheel fixing bolts (arrow), and install flywheel locking special tool (1), then tighten 6 flywheel fixing bolts.

   (Tightening torque: 1st step: 35 ± 5 N·m; 2nd step: 45 ± 5°)



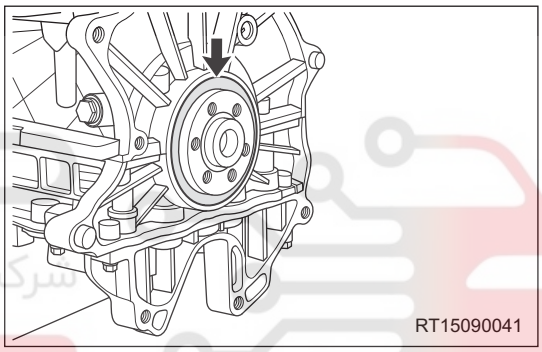
Crankshaft Rear Oil Seal

Removal

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 engine switch.
2. Disconnect the negative battery cable.
3. Remove the transmission assembly (for 1.5 TCI + 6MT, See page 29-27) (for 1.5 TCI + DCT, See page 31-115).
4. Remove the clutch assembly (for 1.5 TCI + 6MT, See page 32-15).
5. Remove the flywheel (for 1.5 TCI + 6MT, See page 10-34) (for 1.5 TCI + DCT, See page 10-36).
6. 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 damage surrounding parts and oil seal retainer, when removing oil seal.

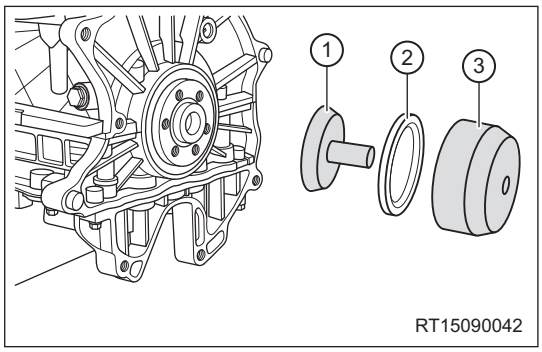
Installation

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. Apply engine oil to crankshaft oil seal retainer and crankshaft rear oil seal lip.

2. Install crankshaft rear oil seal guide tool (1) to crankshaft.
3. Install new oil seal (2) to crankshaft rear oil seal guide tool, then install new oil seal fully into oil seal retainer with a crankshaft rear oil seal installer (3).



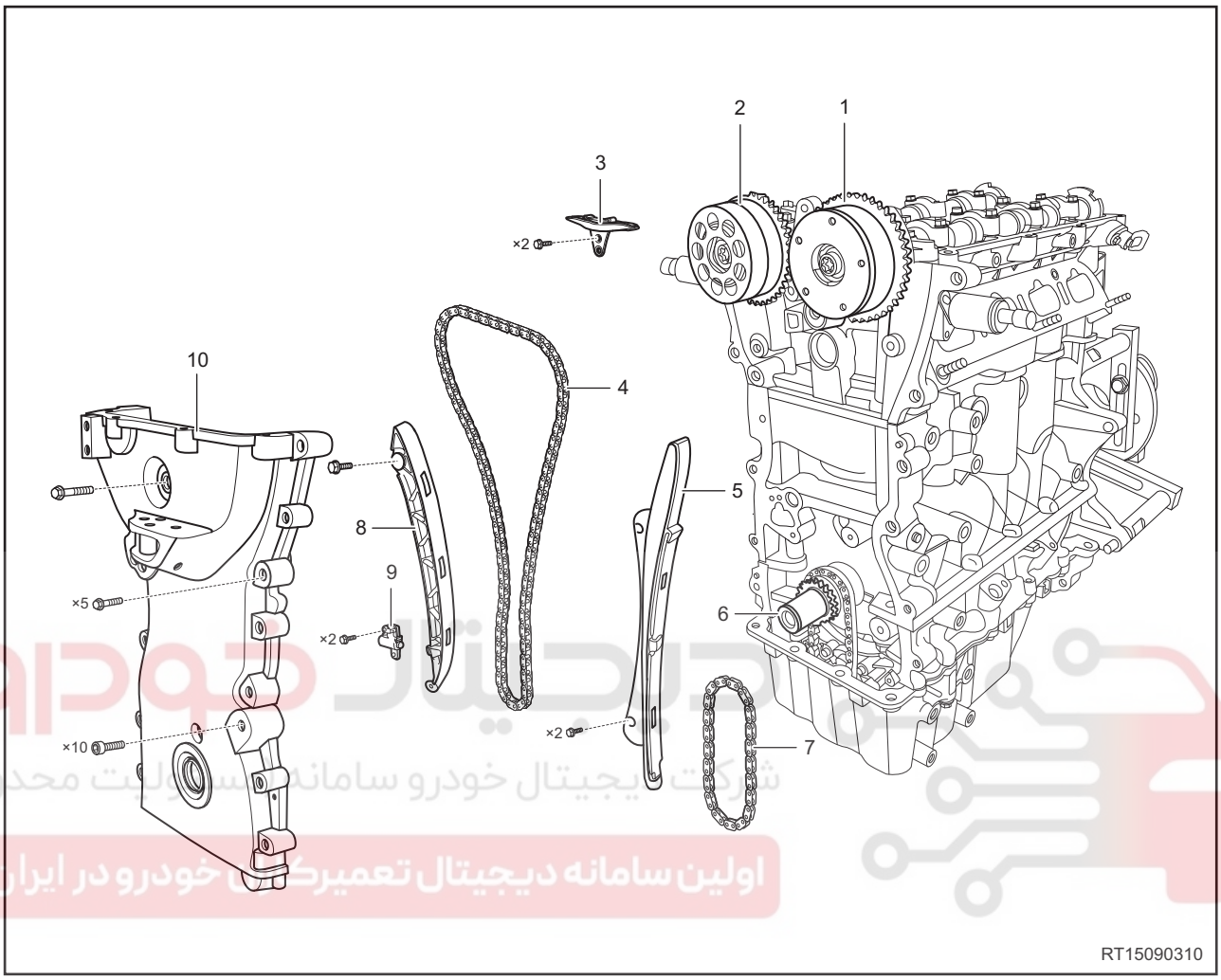
CAUTION

- Ensure to install crankshaft rear oil seal. Or it may cause oil leakage from engine.
- Tilting by 5° or more, cracks or burr of oil seal outer retainer are not allowed during oil seal pressing.

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

Engine Timing Chain

Description



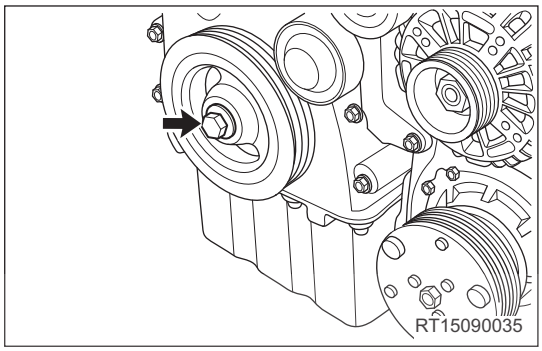
1 - Intake Camshaft Phaser Assembly	2 - Exhaust Camshaft Phaser Assembly
3 - Upper Fixing Guide Rail	4 - Engine Timing Chain
5 - Fixing Guide Rail	6 - Crankshaft Assembly
7 - Oil Pump Drive Chain	8 - Movable Guide Rail
9 - Tensioner Assembly	10 - Timing Chain Cover

Removal

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 engine switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Remove the ignition coils (See page 24-9).
5. Remove the cylinder head cover (See page 10-30).
6. Remove the engine right lower protector.
7. Remove the accessory drive belt (See page 10-26).
8. Remove the idler pulley assembly (See page 10-28).
9. Remove the tensioner assembly (See page 10-29).
10. Remove the crankshaft pulley.
    a. Remove the crankshaft pulley fixing bolt (arrow).
    (Tightening torque: 1st step: tighten to 100 ± 10 N·m; 2nd step: rotate by 120° ± 10°)

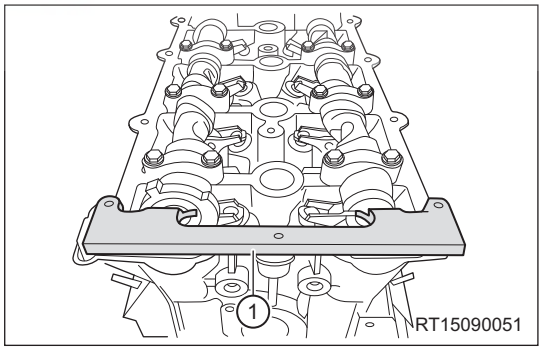


HINT:
Switch the gear position (for 6MT model) to 5th or switch the gear position (for DCT model) to "D" and depress brake pedal by other technician, thus locking crankshaft via mechanical drive device and loosening crankshaft pulley fixing bolt.

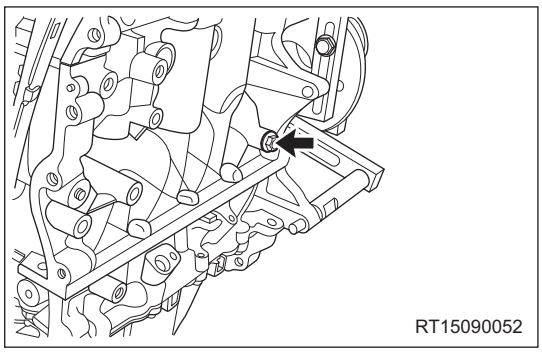
11. Remove the water pump pulley (See page 20-33).
12. Use an engine equalizer to hang engine assembly.

HINT:
Use engine equalizer to hang the lifting eye of engine when supporting the engine oil pan with jack. Avoid engine tilting to right side for removal of engine right mounting cushion assembly.

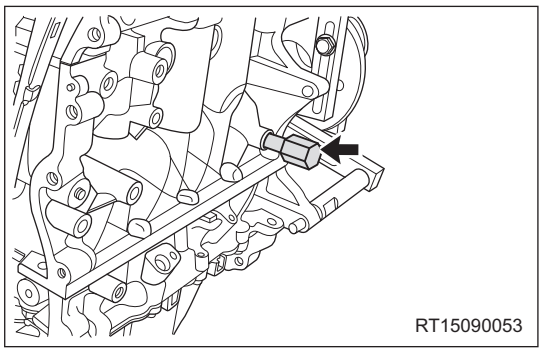
13. Remove the engine right mounting cushion assembly (See page 10-78).
14. Install the camshaft timing tool.
    a. Install camshaft timing tool (1) and tighten fixing bolts to lock intake and exhaust camshafts.



    b. Remove the starter assembly (See page 26-9).
    c. Remove crankshaft timing tool installation hole fixing bolt (arrow) from engine cylinder block.
    (Tightening torque: 40 ± 5 N·m)



d. Carefully screw into crankshaft timing tool (arrow) until crankshaft is stuck completely.



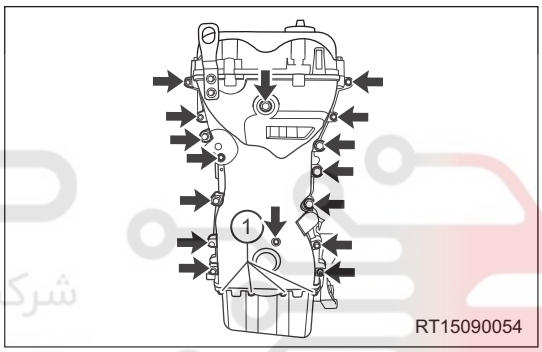
CAUTION

- It takes patience to perform this operation and pay more attention to avoid damage to crankshaft.
- Pistons of four cylinders are in same level when crankshaft timing is correct.

15. Remove the engine timing chain cover.

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

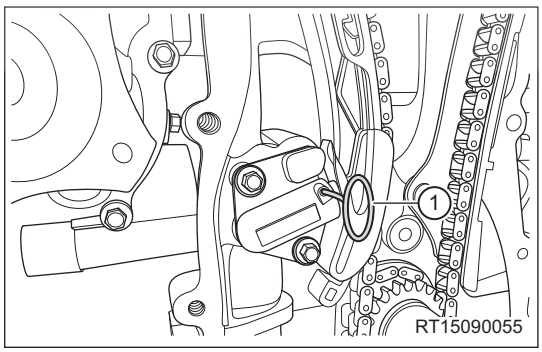
b. Remove the engine timing chain cover fixing bolts (arrow).



c. Remove the engine timing chain cover.

16. Remove the engine timing chain.

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



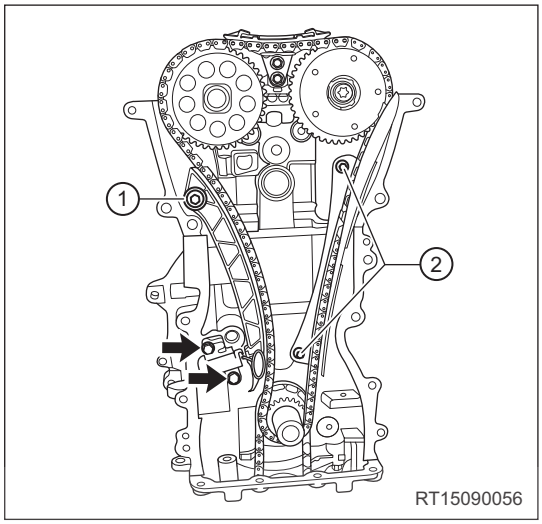
CAUTION

- Since tensioner plunger has large elastic force, never remove tensioner assembly fixing bolts when plunger spring pin is not installed. And prevent plunger from popping out suddenly.

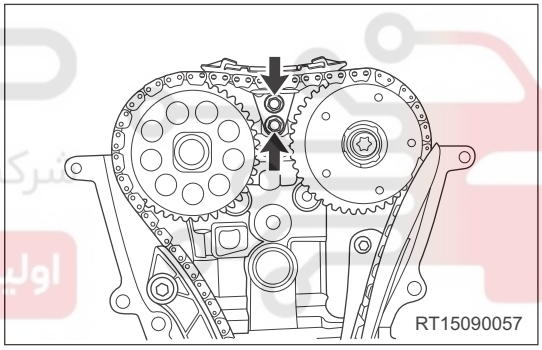
b. Remove 2 tensioner fixing bolts (arrow), and remove tensioner assembly.
(Tightening torque: 9 + 3 N·m)

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

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



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



CAUTION

- Long time movement in one direction of timing chain will cause difference between two sides of chain, so it is necessary to remove and install the chain in same direction.

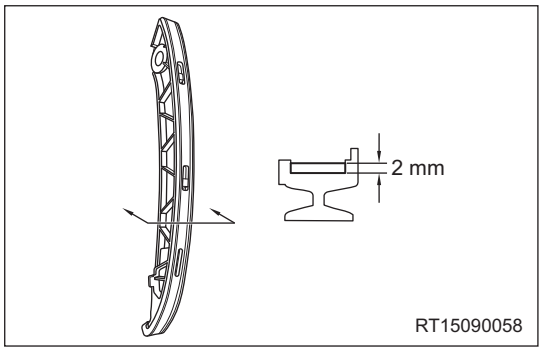
f. Remove the engine timing chain assembly.

CAUTION

- Mark front side and back side of chain with a marking pen after removing chain, so that keep same direction during installation.

Inspection

1. Check the timing chain.
   a. Carefully check the timing chain. Service life for timing chain and engine is the same. Reuse it if there is no serious wear or cracks on surface.
   b. If timing chain needs to be replaced, replace sprocket and guide rail together.
2. Check engine timing chain movable guide rail, and measure movable guide rail depth with a vernier caliper.
   Wear limit: 2 mm.

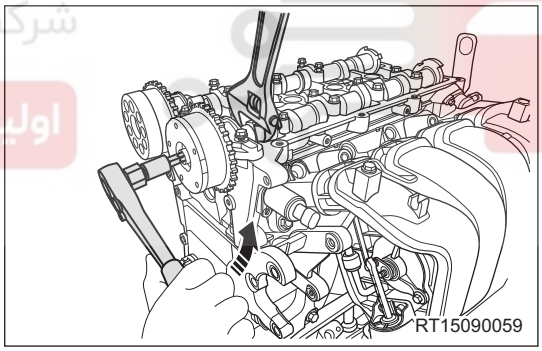


Installation

CAUTION

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

1. Use a proper wrench to hold intake camshaft and loosen fixing bolt from intake camshaft phaser assembly.

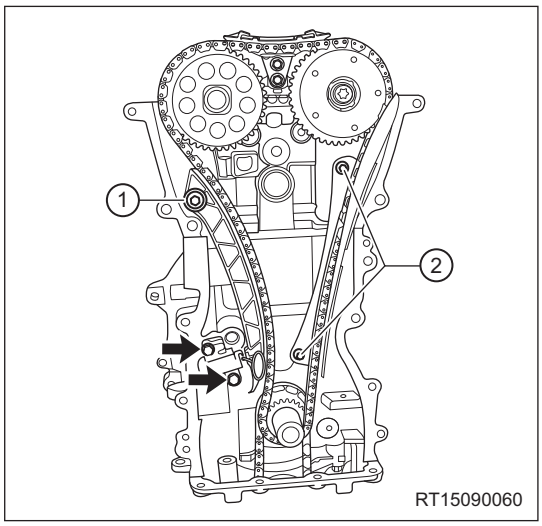


2. Loosening method for exhaust camshaft phaser fixing bolt is the same as that of intake camshaft phaser fixing bolt.
3. Install the timing chain upper guide rail assembly.
4. Install the timing chain assembly.

CAUTION

- Ensure to perform installation 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 upper guide rail is in level.

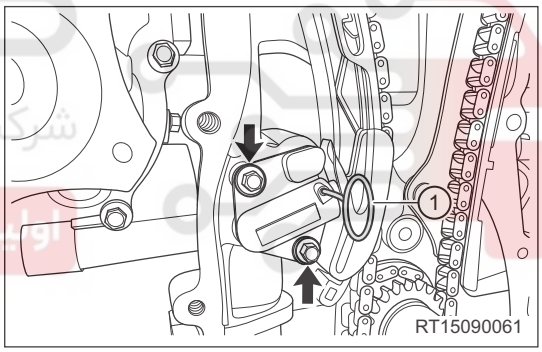
5. Install engine timing chain fixing guide rail and tighten 2 bolts (2).
   (Tightening torque: 9 + 3 N·m)
6. Install engine timing chain movable guide rail and tighten bolt (1).
   (Tightening torque: 12 + 2 N·m)



CAUTION

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

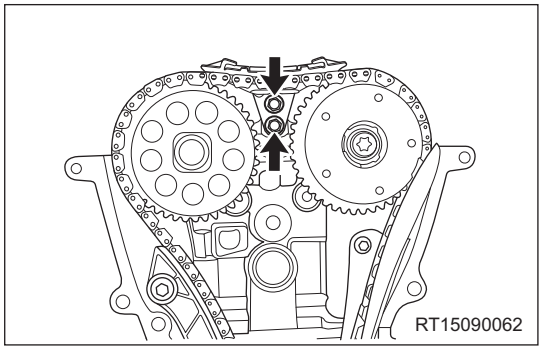
7. Install the tensioner assembly.
   a. Install tensioner assembly and tighten 2 fixing bolts (arrow).
      (Tightening torque: 9 + 3 N·m)
   b. Push movable guide rail to chock against tensioner plunger, then remove spring pin (1).



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.
- Confirm that there is no looseness between the timing chain and intake/exhaust phaser and the crankshaft sprocket, and always keep upper guide rail in level.

8. Tighten 2 upper guide rail fixing bolts (arrow).
   (Tightening torque: 9 + 3 N·m)

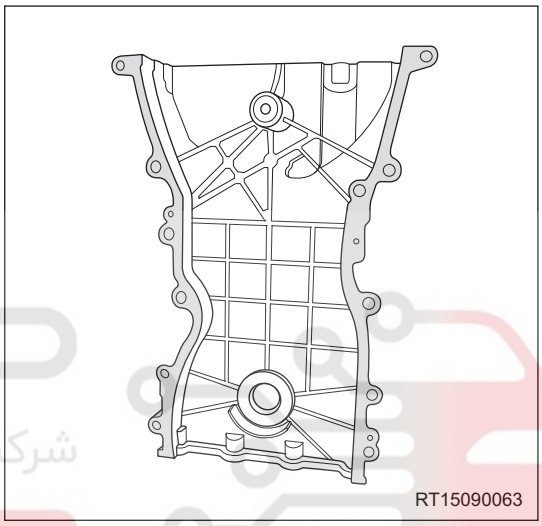


9. Tighten the exhaust camshaft phaser assembly fixing bolt.
   (Tightening torque: 105 + 5 N·m)
10. Tighten the intake camshaft phaser assembly fixing bolt.
    (Tightening torque: 105 + 5 N·m)
11. Remove crankshaft timing tool and camshaft timing tool, then rotate crankshaft clockwise 2 turns at least, to check if timing system can operate normally.

CAUTION

- Never rotate crankshaft counterclockwise.

12. Install the engine timing chain cover assembly.
    a. Apply seal gum to edge of engine timing chain cover, and apply seal gum to inside of timing chain cover mounting bolt hole.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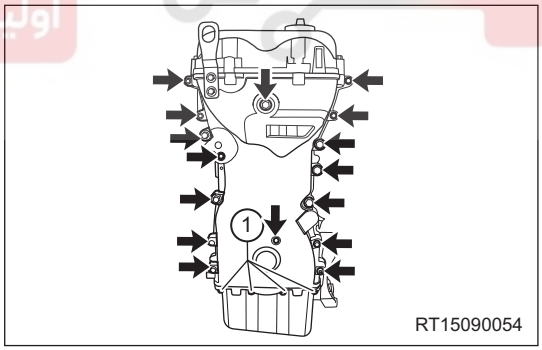
    b. Install and tighten timing chain cover fixing bolts (arrow).
       (Tightening torque for 6 hexagon flange bolts (5 M10 X 45) (1 M10 X 80): 40 + 5 N·m; tightening torque for 4 hexagon flange bolts: (M8 X 40 - 10.9): 30 + 5 N·m; tightening torque for 6 inner hexagon bolts: (M8 X 45): 20 + 5 N·m).
    c. Install 4 coupling bolts (1) between engine timing chain cover and oil pan.
       (Tightening torque: 20 ± 5 N·m)



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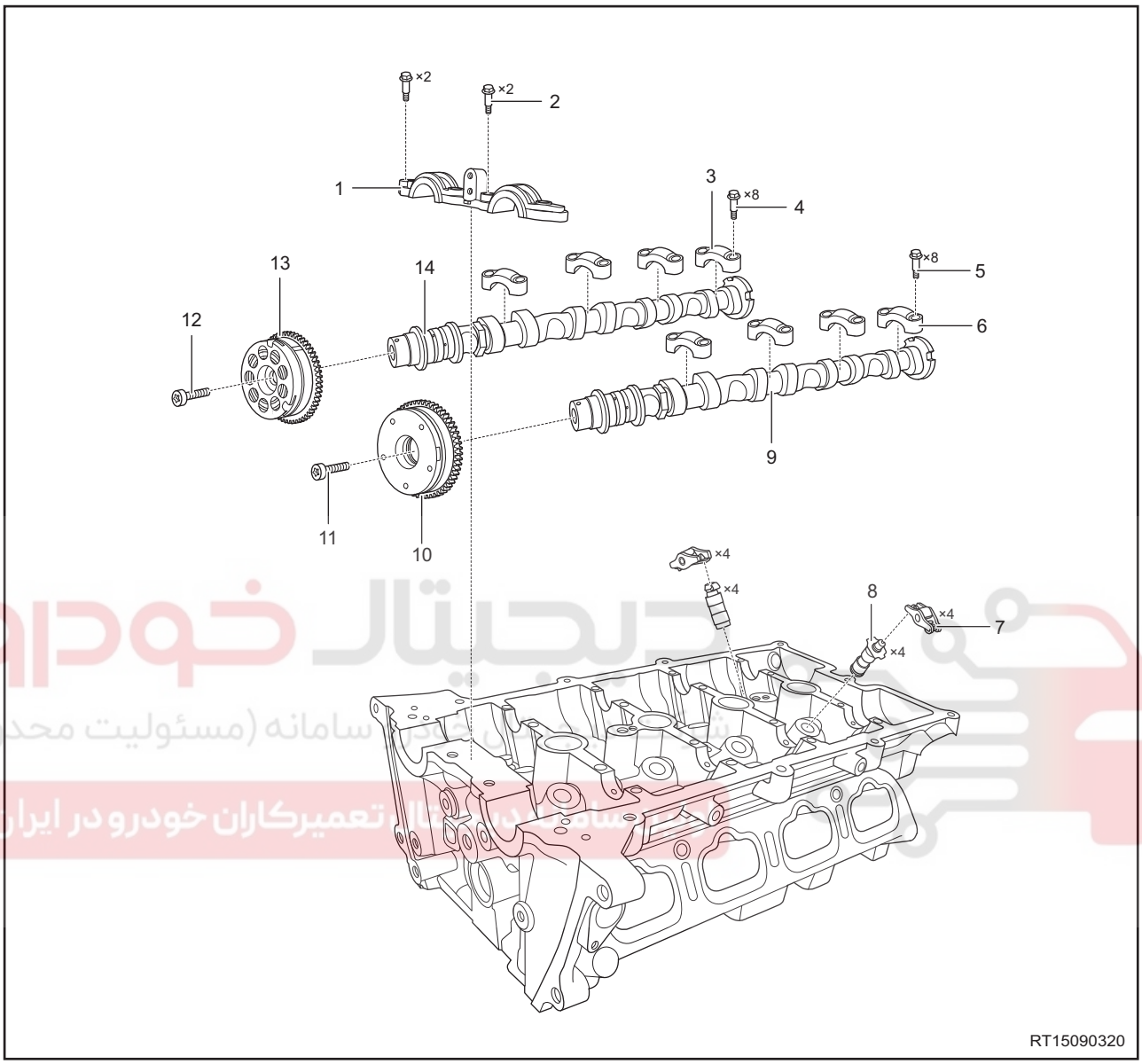
13. Other installation procedures are in the reverse order of removal.

Camshaft and Rocker Arm

Description



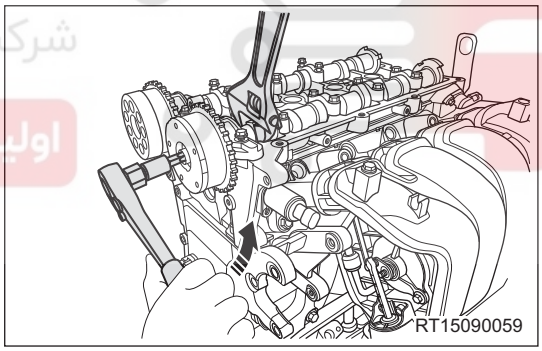
1 - 1st Bearing Cap	2 - 1st Bearing Cap Fixing Bolt
3 - Exhaust Camshaft Bearing Cap	4 - Exhaust Camshaft Bearing Cap Fixing Bolt
5 - Intake Camshaft Bearing Cap Fixing Bolt	6 - Intake Camshaft Bearing Cap
7 - Rocker Arm	8 - Hydraulic Lifter
9 - Intake Camshaft Assembly	10 - Intake Camshaft Phaser Assembly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

Removal

CAUTION

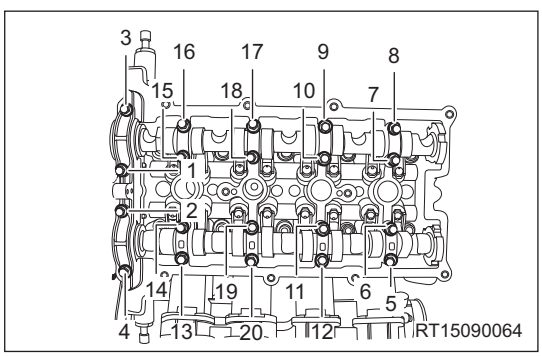
- Blow dirt and debris away from surface of cylinder head cover with compressed air.
- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the engine switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Remove the ignition coils (See page 24-9).
5. Remove the cylinder head cover assembly (See page 10-30).
6. Remove the engine right lower protector.
7. Remove the accessory drive belt (See page 10-26).
8. Remove the tensioner assembly (See page 10-29).
9. Remove the idler pulley assembly (See page 10-28).
10. Remove the water pump pulley (See page 20-33).
11. Remove the timing chain cover (See page 10-40).
12. Remove the timing chain assembly (See page 10-40).
13. Remove intake and exhaust camshaft phaser assemblies.
    a. Use a proper wrench to hold intake camshaft and remove fixing bolt from intake camshaft phaser assembly in direction of arrow.



    b. Removal method for exhaust camshaft phaser assembly is the same as that of intake camshaft phaser assembly.
14. Remove intake and exhaust camshafts.
    a. Remove intake and exhaust camshaft bearing cap fixing bolts in order shown in illustration.

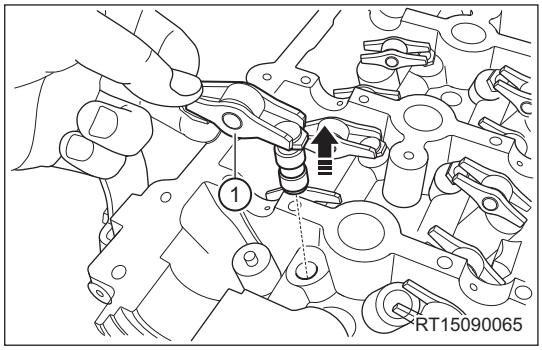
    HINT:
    Loosen fixing bolts in order shown in illustration during removal.



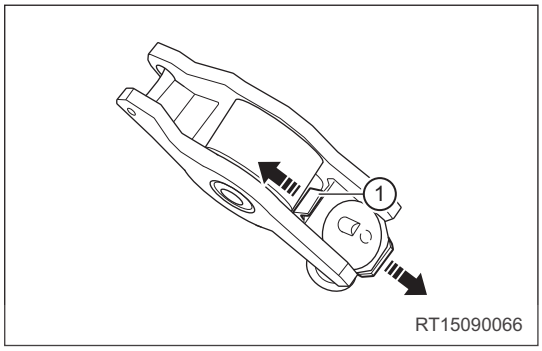
    b. Remove intake and exhaust camshaft bearing caps.
    c. Remove intake and exhaust camshafts.

15.Remove rocker arm and hydraulic lifter.

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



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



Inspection

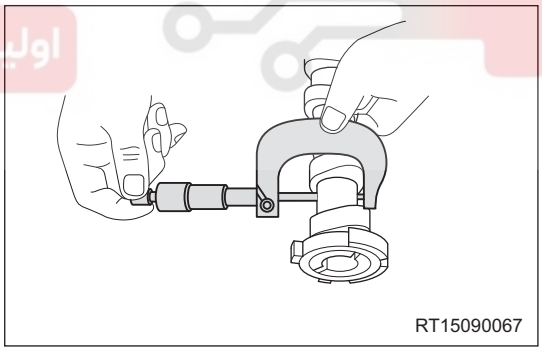
1. Check the camshaft.

a. Check the appearance.

- Check if there are scratches on camshaft bearings and cam surfaces. If so, replace camshaft.
- Check if there are leaking holes and cracks in camshaft bearing caps. If so, replace camshaft.

b. Check the camshaft journal diameter.

Measure camshaft journal diameter with a micrometer.

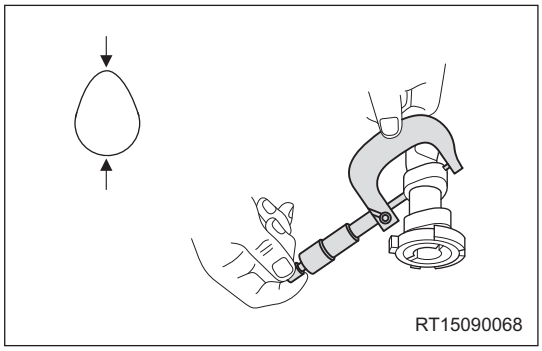


Measurement Item	Specification (mm)
1st Journal Diameter (Same for Intake and Exhaust)	33.934 ~ 33.95
2nd ~ 5th Journal Diameter (Same for Intake and Exhaust)	23.947 ~ 23.96

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

c. Check the cam height.

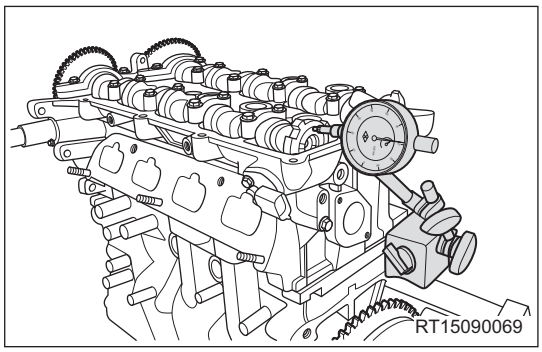
Measure peak height of cam lobe with a micrometer.



Measurement Item	Specification (mm)
Cam Height (Peak)	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.



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

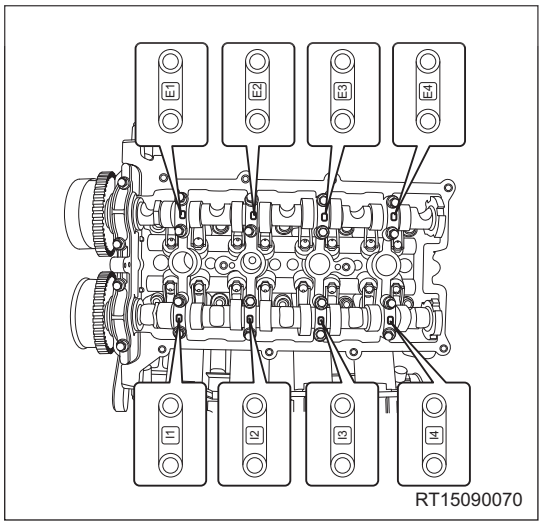
If camshaft axial clearance is not within specified range, replace intake/exhaust camshaft assembly.

Installation

CAUTION

- Adjust timing and adjust 4 pistons to same level before installing camshaft.
- Install exhaust camshaft phaser assembly and tighten bolts by hand, then check if exhaust camshaft phaser can rotate smoothly and normally, if not, remove and check exhaust camshaft phaser and bolts. Install intake camshaft phaser assembly in same way, first tighten bolts on exhaust side, then tighten bolts on intake side.

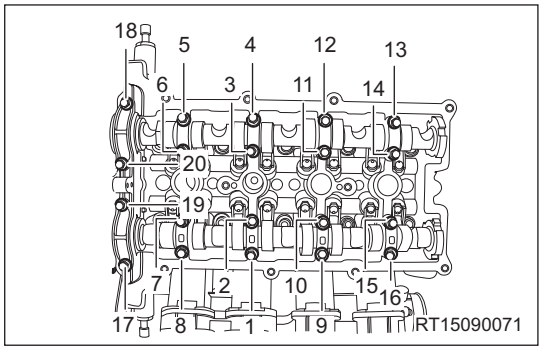
1. Clean intake, exhaust camshafts and camshaft bearing caps.
2. Apply engine oil to camshaft cam surface. Apply a proper amount of engine oil to camshaft bearing hole.
3. Install intake, exhaust camshaft assemblies and intake, exhaust camshaft bearing caps.



CAUTION

- Install camshaft bearing caps according to its marks.

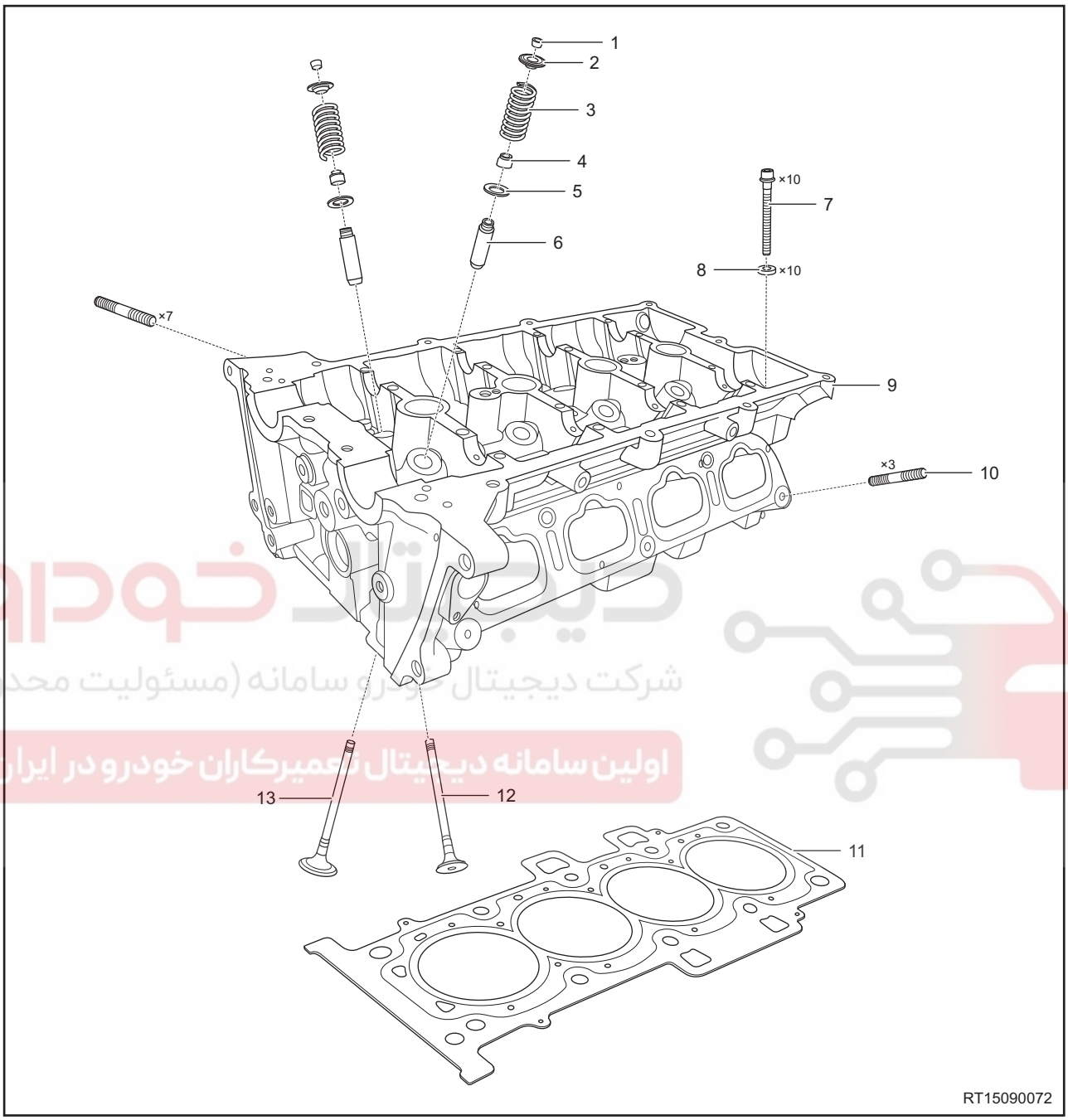
4. Install camshaft bearing cap fixing bolts by hand.
5. Tighten intake and exhaust camshaft bearing cap fixing bolts in order shown in illustration.
   (Tightening torque: 1st step: tighten to 9.5 ± 1.5 N·m; 2nd step: retighten to 9.5 ± 1.5 N·m)



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

Cylinder Head (1.5 TCI + 6MT)

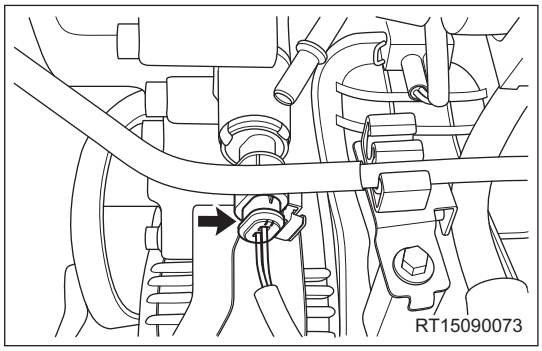
Description



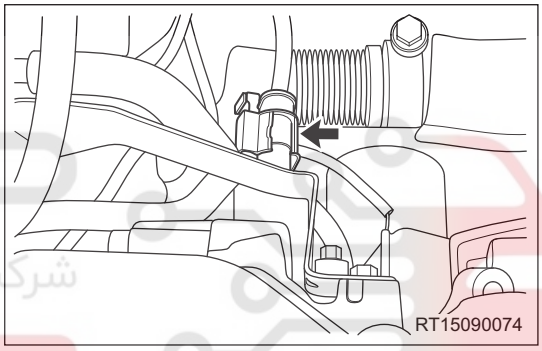
1 - Valve Cotter	2 - Valve Spring Upper Seat
3 - Valve Spring	4 - Valve Oil Seal
5 - Valve Spring Lower Seat	6 - Valve Guide
7 - Cylinder Head Fixing Bolt	8 - Cylinder Head Fixing Bolt Washer
9 - Cylinder Head	10 - Stud
11 - Cylinder Head Gasket	12 - Intake Valve
13 - Exhaust Valve	

Removal

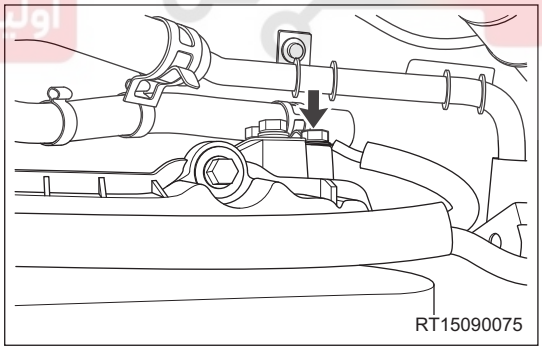
1. Release the fuel system pressure (See page 12-10).
2. Turn off all electrical equipment and the engine switch.
3. Disconnect the negative battery cable.
4. Drain the engine oil (See page 22-10).
5. Drain the coolant (See page 20-14).
6. Disconnect the wire harness connectors.
   a. Disconnect the intake camshaft variable timing control valve connector (arrow).



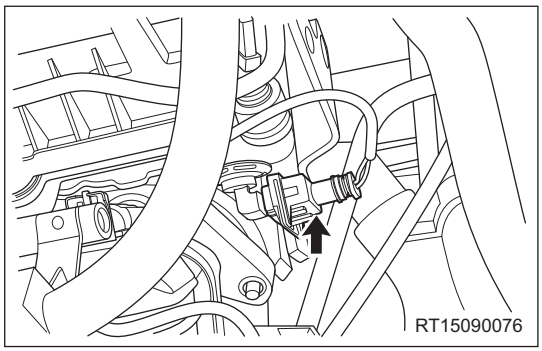
   b. Disconnect the exhaust camshaft variable timing control valve connector (arrow).



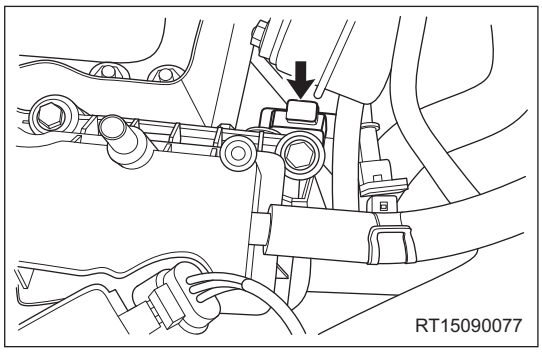
   c. Remove the engine wire harness ground wire fixing bolt (arrow).
   (Tightening torque: 7 ± 1 N·m)



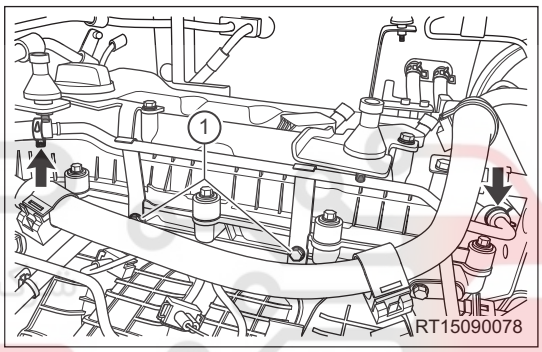
   d. Disconnect the intake camshaft position sensor connector (arrow).



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



7. Remove the air filter assembly (See page 16-13).
8. Remove the battery assembly (See page 28-7).
9. Remove the battery tray bracket (See page 28-9).
10. Remove the ignition coils (See page 24-9).
11. Remove the spark plugs (See page 24-11).
12. Remove the fuel rail injector assembly (See page 12-26).
13. Remove the engine discharge steel pipe assembly.
    a. Remove 2 fixing bolts (1) from engine discharge steel pipe.
       (Tightening torque: 7 ± 1 N·m)
    b. Loosen elastic clamp (arrow) and disconnect connection between engine discharge hose and discharge steel pipe.



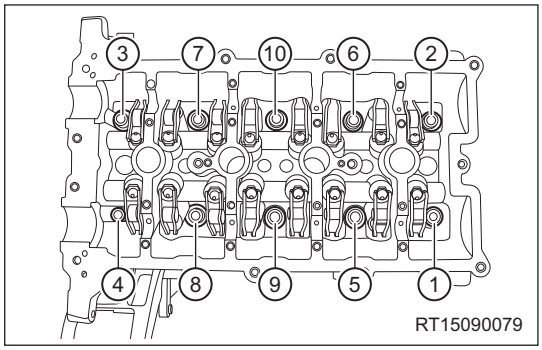
14. Remove the intake manifold assembly (See page 16-28).
15. Remove the thermostat seat (See page 20-24).
16. Remove the exhaust manifold (See page 18-11).
17. Remove the accessory drive belt (See page 10-22).
18. Remove the idler pulley assembly (See page 10-28).
19. Remove the tensioner assembly (See page 10-29).
20. Remove the water pump pulley (See page 20-33).
21. Remove the cylinder head cover assembly (See page 10-30).
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 10-40).
24. Remove camshaft and rocker arm (See page 10-47).
25. Remove the engine equalizer.

26.Remove the cylinder head assembly.

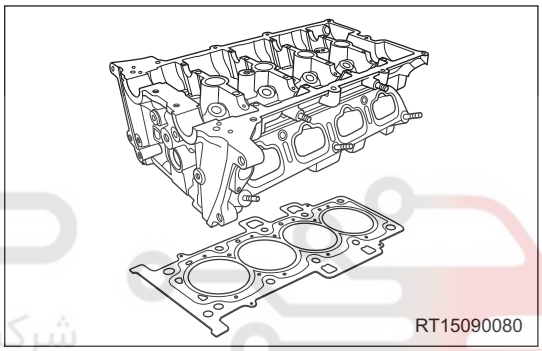
a. Remove 10 cylinder head assembly fixing bolts in order shown in illustration.



CAUTION

- Failure to remove cylinder head fixing bolts in order may cause cylinder head deformation.

b. Remove cylinder head and its gasket.

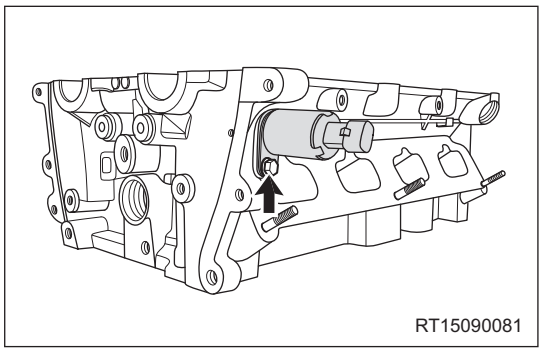


CAUTION

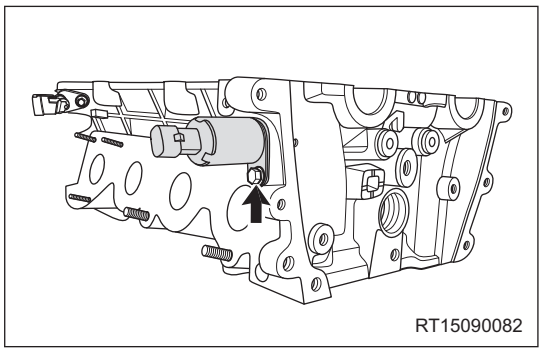
- DO NOT reuse the removed cylinder head gasket, and it is necessary to replace it with new one. Be careful not to lose cylinder head mounting dowel pin during removal.

Disassembly

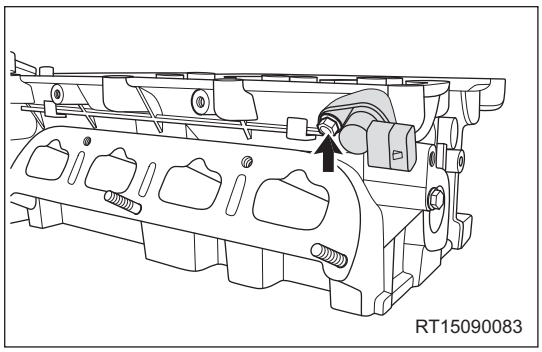
1. Remove intake camshaft variable timing control valve fixing bolt (arrow), and remove intake camshaft variable timing control valve.
   (Tightening torque: 6 + 2 N·m)



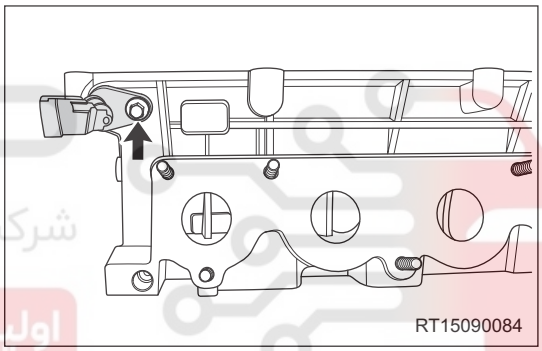
2. Remove exhaust camshaft variable timing control valve fixing bolt (arrow), and remove exhaust camshaft variable timing control valve.
   (Tightening torque: 6 + 2 N·m)


RT15090082

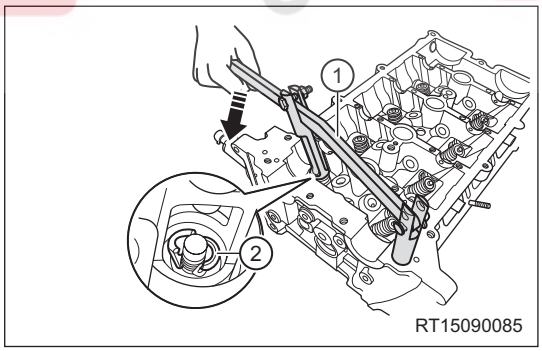
3. Remove the intake camshaft position sensor fixing bolt (arrow).
   (Tightening torque: 8 ± 1 N·m)


RT15090083

4. Remove the exhaust camshaft position sensor fixing bolt (arrow).
   (Tightening torque: 8 ± 1 N·m)

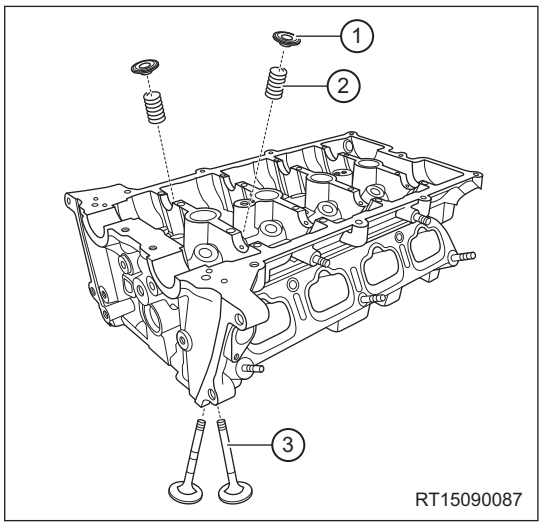

RT15090084

5. Use valve spring compressor (1) to compress valve spring, and use flexional magnetic rod to remove valve cotter (2).

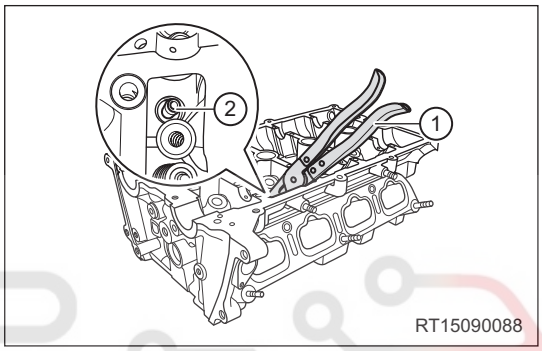


RT15090085

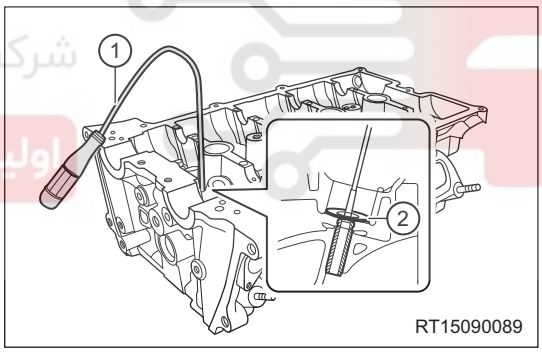
6. Remove valve spring upper seat (1), valve spring (2) and valve (3) from cylinder head.



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



8. Using a flexional magnetic rod (1), remove valve spring lower seat (2).



Inspection

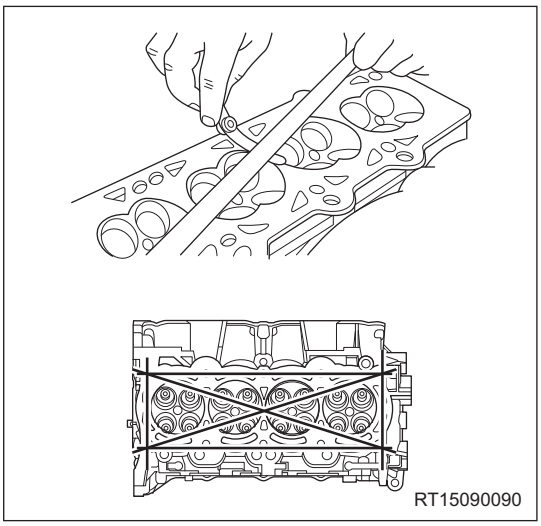
1. Check the cylinder head.
   a. Check the appearance.
      - Check if there are scratches on camshaft bearing journals.
      - Remove carbon deposits and varnish inside valve guides with valve guide cleaner.
      - Make sure valve stem can move and rotate freely.

b. Check the cylinder head flatness.

Using a precision straightedge and feeler gauge, check cylinder head flatness. Cylinder head flatness must be within 0.04 mm.

Measurement Item	Specification (mm)
Cylinder Head Flatness	0.04

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

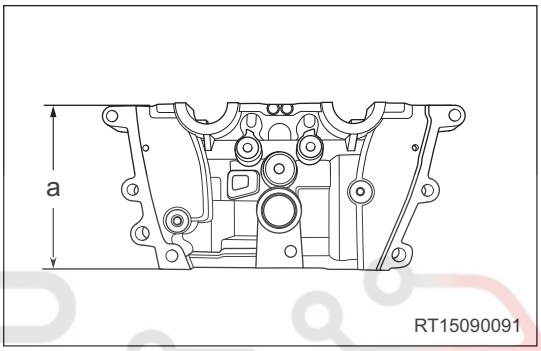


c. Check the cylinder head height.

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.



10

CAUTION

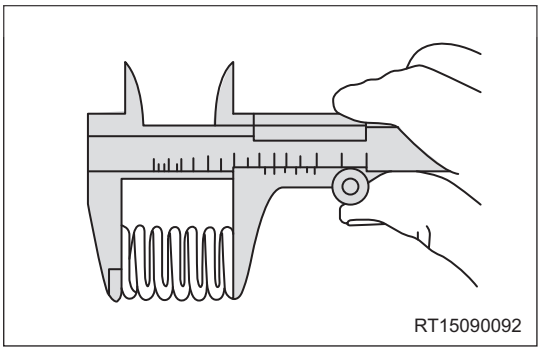
- Valve, oil seal, spring, seat, cotter, hydraulic lifter and crankshaft should be equipped completely when replacing cylinder head.

2. Check the valve spring.

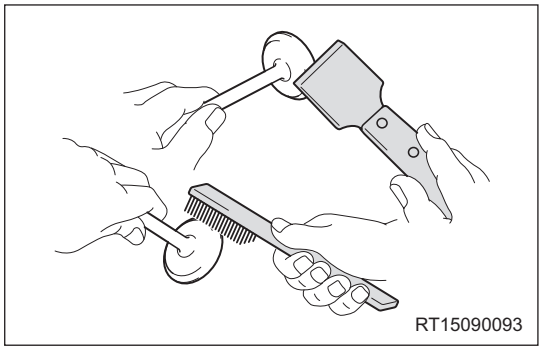
Using a vernier caliper, measure free length of valve spring and length of valve spring under the pre-pressure of 229 ~ 251 N.

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

If free length of valve spring and length under pre-pressure are not within specified range, replace valve spring.

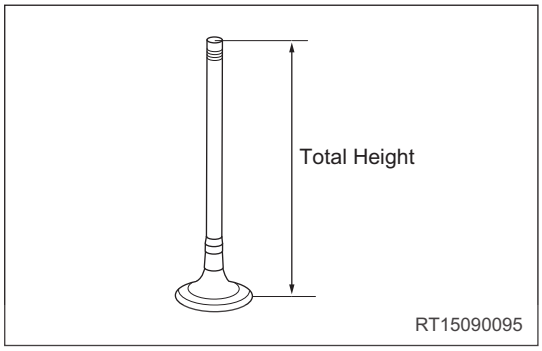


3. Check the valve.
   a. Clean the valve.
      - Using a scraper, Remove carbon deposited on valve head.
      - Using a wire brush, clean the valve thoroughly.



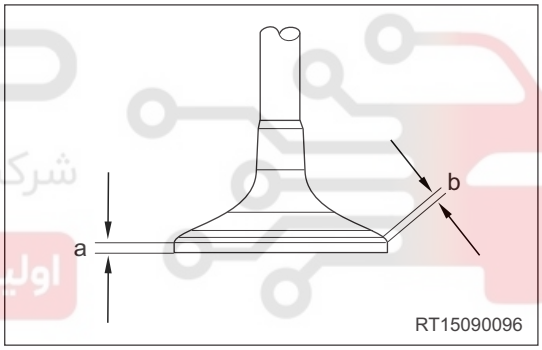
   b. Check the valve height.
      Using a vernier caliper, measure the valve height.

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



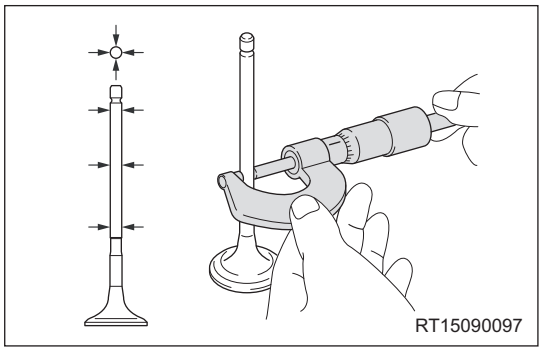
      If valve height is less than specified value, replace valve.
   c. Check the valve head.
      - Measure thickness (a) of valve head.
      - Check if contact area of valve surface is even, if valve face is in center of valve inclined plane and measure valve width (b).

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



      If valve head 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.

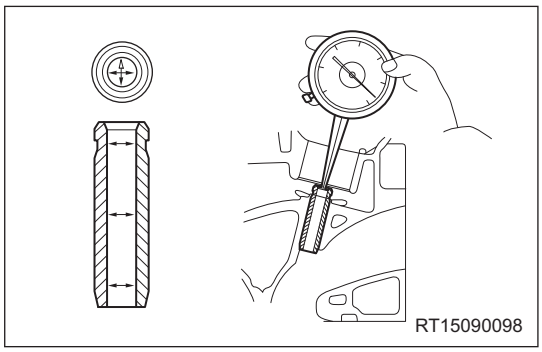
Measurement Item	Specification (mm)
Intake Valve Stem Diameter	5.98 ± 0.008
Exhaust Valve Stem Diameter	5.96 ± 0.008



      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.

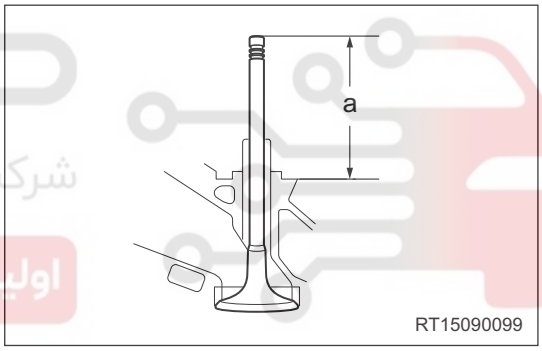
Measurement Item	Specification (mm)
Clearance Between Intake Valve Stem and Valve Guide	0.012 ~ 0.043
Clearance Between Exhaust Valve Stem and Valve Guide	0.032 ~ 0.063

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

10

4. Check the valve stem protrusion length.

a. Using a vernier caliper, measure distance (valve stem protrusion length) between valve stem end surface and valve spring seat end surface.



Measurement Item	Specification (mm)
Valve Stem Protrusion Length	47.5
Exhaust Valve Stem Protrusion Length	47.5

If valve stem protrusion is not within specified range, replace valve.

Assembly

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. Install valve (1) into cylinder head.

   HINT:

   - Distinguish intake valve and exhaust valve during installation.
   - Apply a coat of engine oil to valve stem end, when assembling valve.

2. Install new valve spring lower seat (2) if necessary.
3. Install the valve oil seal.

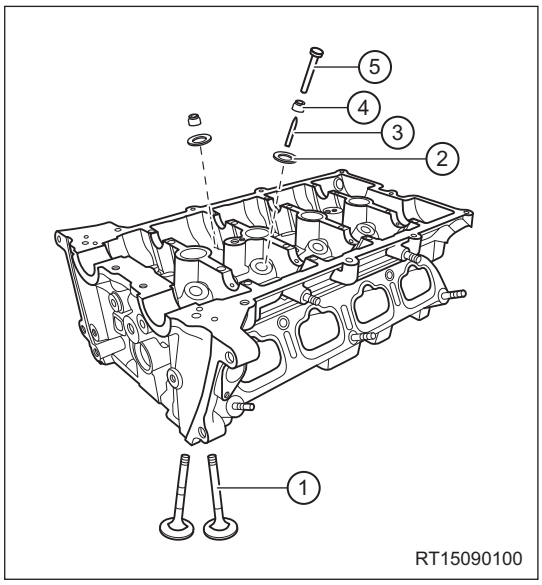
   HINT:

   Apply a coat of engine oil to installation surface of valve oil seal, when assembling valve oil seal.

   a. Install valve oil seal guide (3) to valve stem.

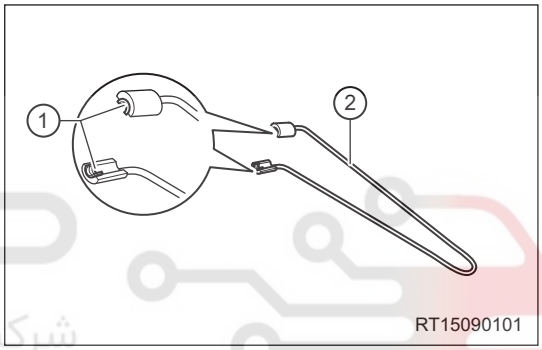
   b. Install valve oil seal (4) to valve oil seal guide sleeve.

   c. Tap valve oil seal installer (5) lightly with a rubber hammer to install valve oil seal in place.



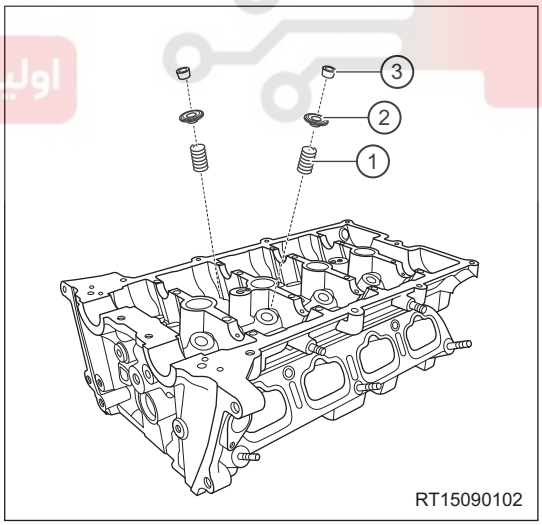
RT15090100

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



RT15090101

5. Install valve spring (1) and valve spring upper seat (2).
6. Using a valve spring compressor, compress valve spring and install valve cotter (3) in place.



RT15090102

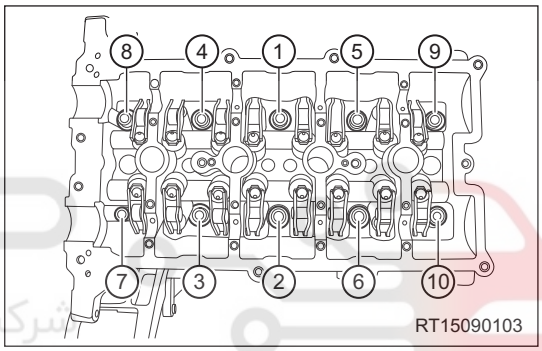
7. Tap tip of valve stem lightly with a rubber hammer to make sure valve cotter is installed in place after assembly.

Installation

CAUTION

- 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 with stamped part number facing upward.
- Install cylinder head gasket to flat surface of cylinder block with a dowel pin.
- Clean junction surface between cylinder head and combustion chamber, top flat surface and threaded hole of cylinder block. There should be no accumulated oil at the 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 camshaft.
- 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. Apply a small amount of engine oil to bolt head and root.
   b. Install bolts and tighten them in place by hands.
   c. Tighten cylinder head fixing bolts according to following procedures:
      - 1st step: Tighten bolts to 40 ± 5 N·m in sequence from (1) to (10) shown in illustration.
      - 2nd step: Rotate bolts clockwise by 90° ± 5° in tightening sequence.
      - 3rd step: Rotate bolts clockwise by 90° ± 5° in tightening sequence again.



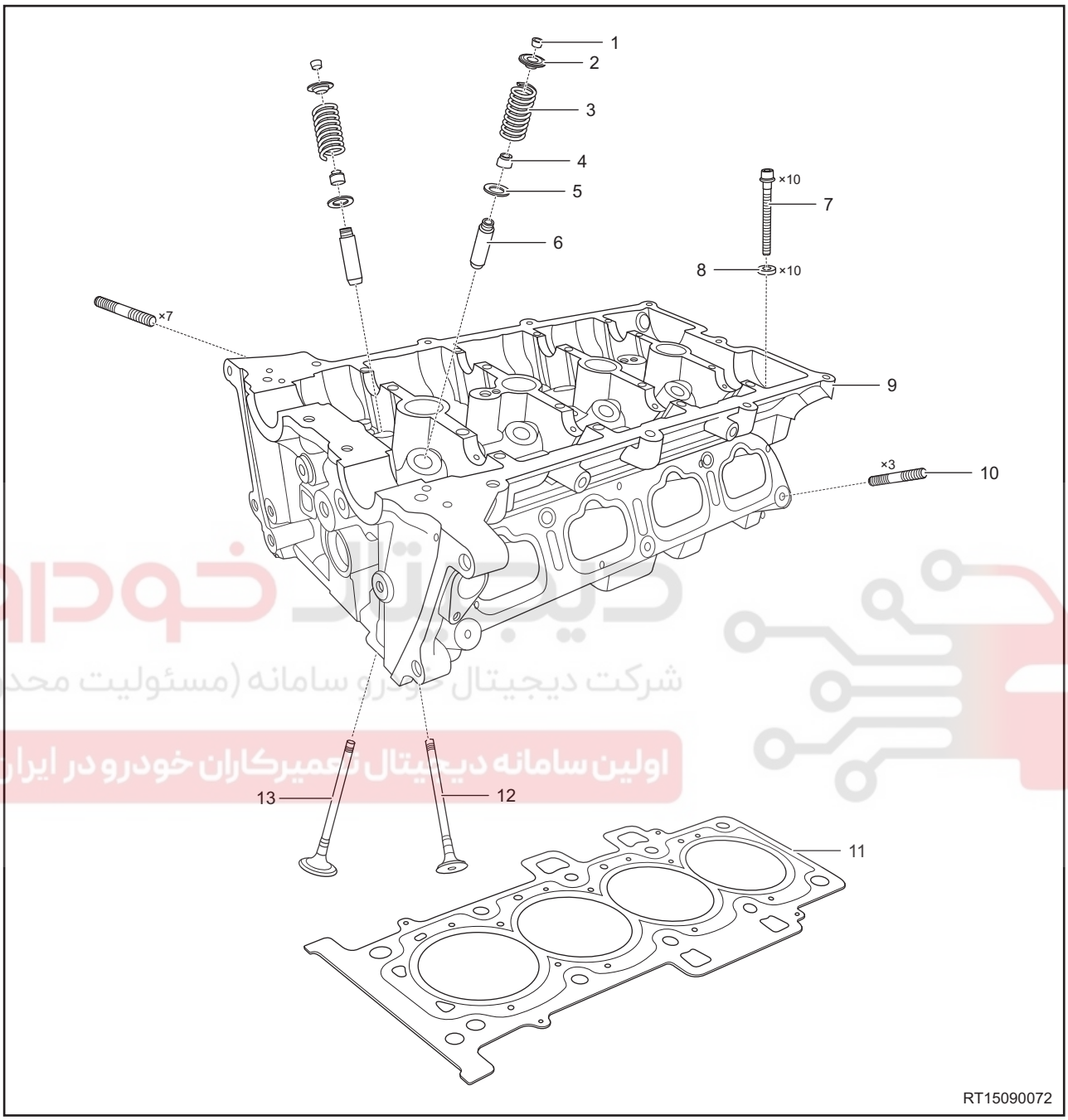
CAUTION

- 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.

Cylinder Head (1.5 TCI + DCT)

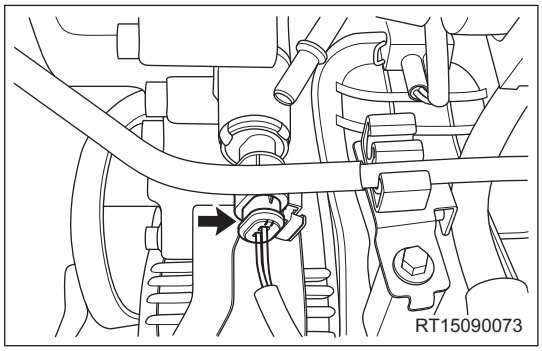
Description



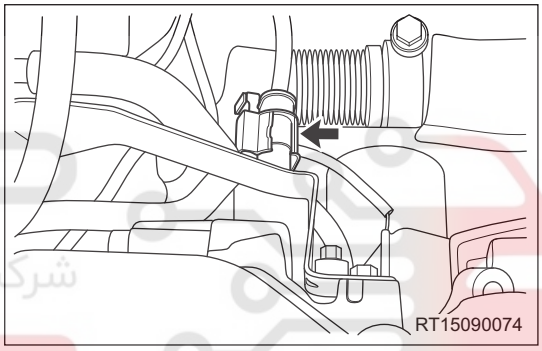
1 - Valve Cotter	2 - Valve Spring Upper Seat
3 - Valve Spring	4 - Valve Oil Seal
5 - Valve Spring Lower Seat	6 - Valve Guide
7 - Cylinder Head Fixing Bolt	8 - Cylinder Head Fixing Bolt Washer
9 - Cylinder Head	10 - Stud
11 - Cylinder Head Gasket	12 - Intake Valve
13 - Exhaust Valve	

Removal

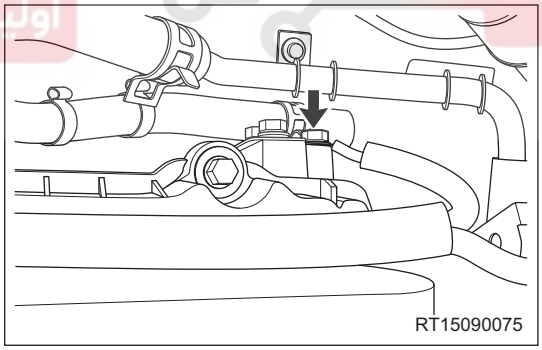
1. Release the fuel system pressure (See page 12-10).
2. Turn off all electrical equipment and the engine switch.
3. Disconnect the negative battery cable.
4. Drain the engine oil (See page 22-10).
5. Drain the coolant (See page 20-14).
6. Disconnect the wire harness connectors.
   a. Disconnect the intake camshaft variable timing control valve connector (arrow).



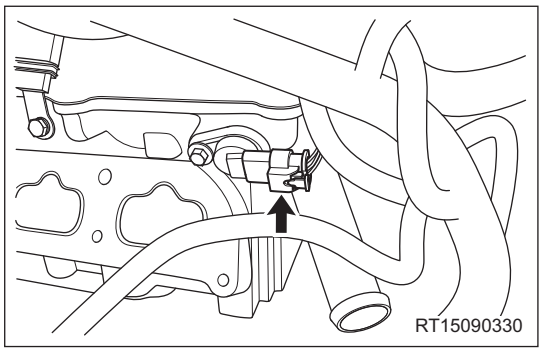
   b. Disconnect the exhaust camshaft variable timing control valve connector (arrow).



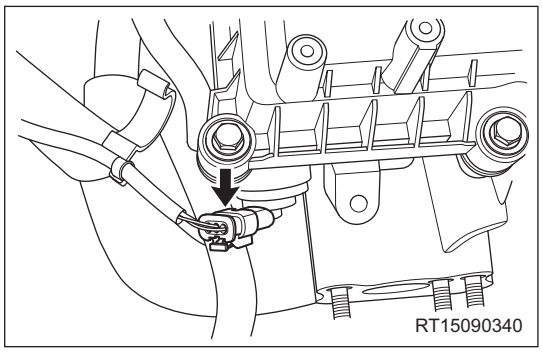
   c. Remove the engine wire harness ground wire fixing bolt (arrow).
   (Tightening torque: 7 ± 1 N·m)



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



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



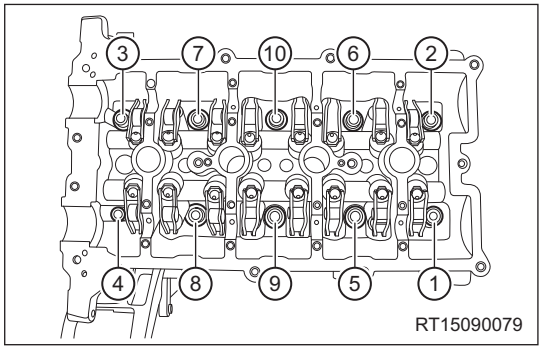
7. Remove the air filter assembly (See page 16-13).
8. Remove the battery assembly (See page 28-7).
9. Remove the battery tray bracket (See page 28-9).
10. Remove the ignition coils (See page 24-9).
11. Remove the spark plugs (See page 24-11).
12. Remove the fuel rail injector assembly (See page 12-26).
13. Remove the engine discharge steel pipe assembly (See page 20-28).
14. Remove the intake manifold assembly (See page 16-31).
15. Remove the thermostat seat (See page 20-26).
16. Remove the turbocharger assembly (See page 18-20).
17. Remove the accessory drive belt (See page 10-26).
18. Remove the idler pulley assembly (See page 10-28).
19. Remove the tensioner assembly (See page 10-29).
20. Remove the water pump pulley (See page 20-33).
21. Remove the cylinder head cover assembly (See page 10-30).
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 10-40).
24. Remove camshaft and rocker arm (See page 10-47).
25. Remove the engine equalizer.
26. Remove the cylinder head assembly.

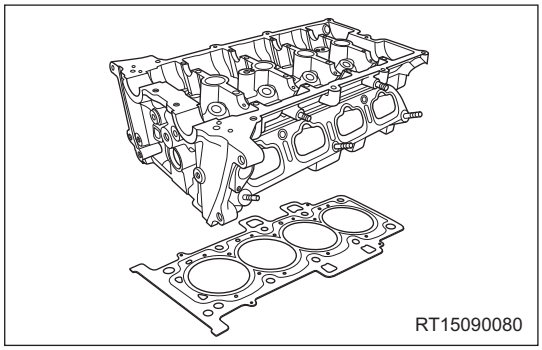
a. Remove 10 cylinder head assembly fixing bolts in order shown in illustration.



CAUTION

- Failure to remove cylinder head fixing bolts in order may cause cylinder head deformation.

b. Remove cylinder head and its gasket.

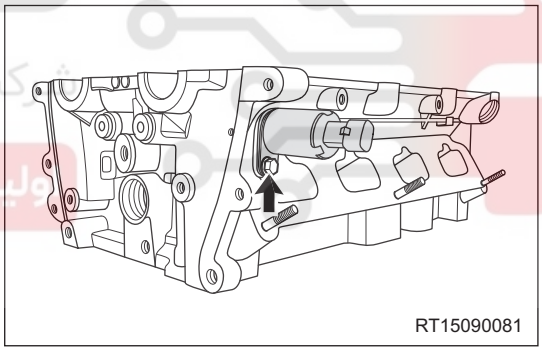

RT15090080

CAUTION

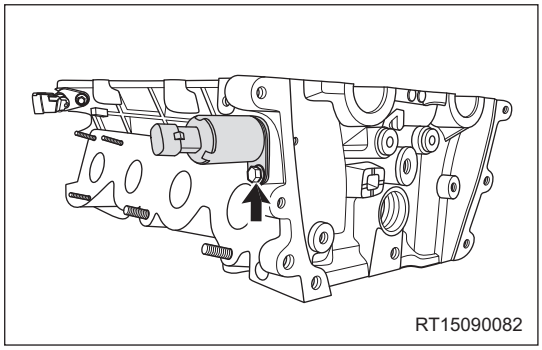
- DO NOT reuse the removed cylinder head gasket, and it is necessary to replace it with new one. Be careful not to lose cylinder head mounting dowel pin during removal.

Disassembly

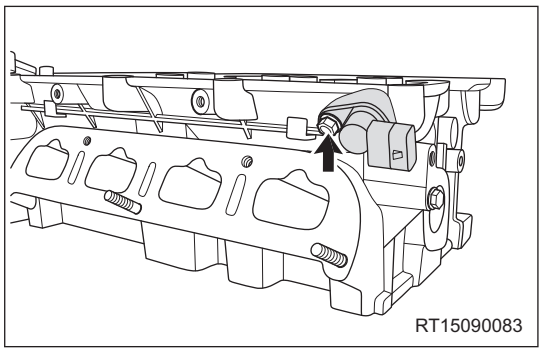
1. Remove intake camshaft variable timing control valve fixing bolt (arrow), and remove intake camshaft variable timing control valve.
   (Tightening torque: 6 + 2 N·m)


RT15090081

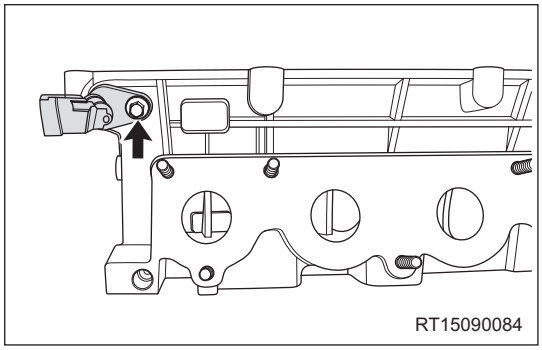
2. Remove exhaust camshaft variable timing control valve fixing bolt (arrow), and remove exhaust camshaft variable timing control valve.
   (Tightening torque: 6 + 2 N·m)


RT15090082

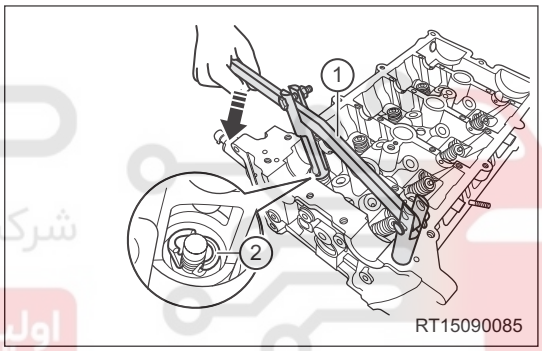
3. Remove the intake camshaft position sensor fixing bolt (arrow).
   (Tightening torque: 8 + 3 N·m)


RT15090083

4. Remove the exhaust camshaft position sensor fixing bolt (arrow).
   (Tightening torque: 8 + 3 N·m)

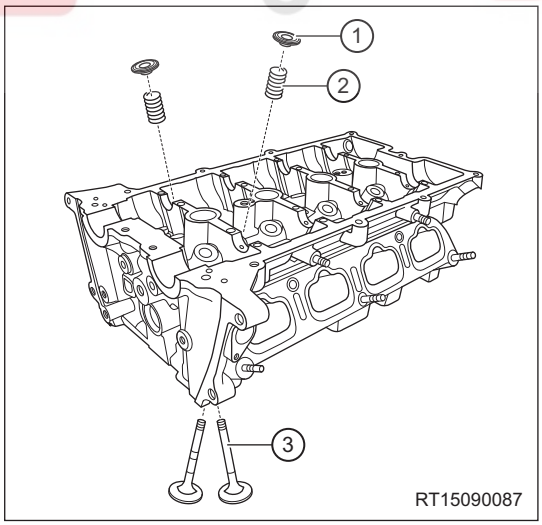

RT15090084

5. Use valve spring compressor (1) to compress valve spring, and use flexional magnetic rod to remove valve cotter (2).



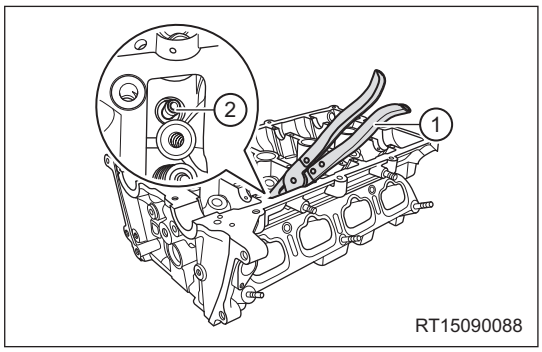
RT15090085

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

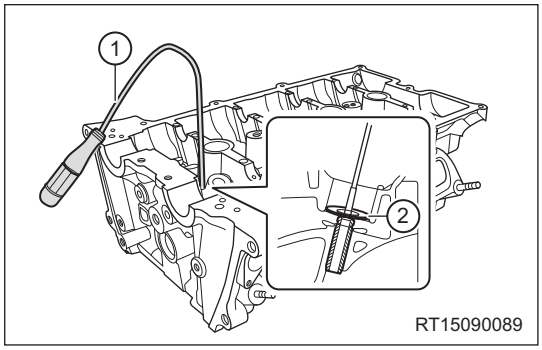


RT15090087

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



8. Using a flexional magnetic rod (1), remove valve spring lower seat (2).

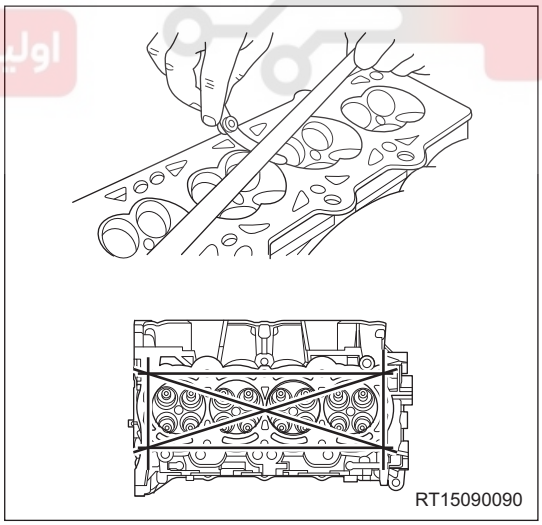


10 Inspection

1. Check the cylinder head.
   a. Check the appearance.
      - Check if there are scratches on camshaft bearing journals.
      - Remove carbon deposits and varnish inside valve guides with valve guide cleaner.
      - Make sure valve stem can move and rotate freely.
   b. Check the cylinder head flatness.
      Using a precision straightedge and feeler gauge, check cylinder head flatness. Cylinder head flatness must be within 0.04 mm.

Measurement Item	Specification (mm)
Cylinder Head Flatness	0.04

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

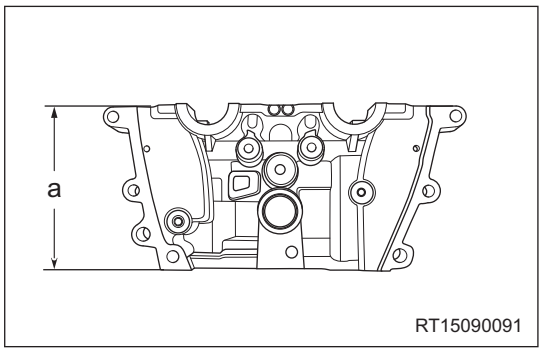


c. Check the cylinder head height.

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.



CAUTION

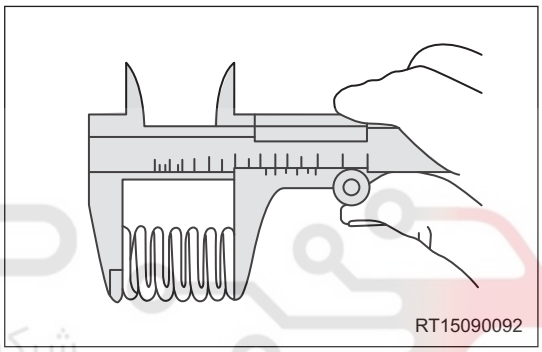
- Valve, oil seal, spring, seat, cotter, hydraulic lifter and crankshaft should be equipped completely when replacing cylinder head.

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 (229 ~ 251 N)	41

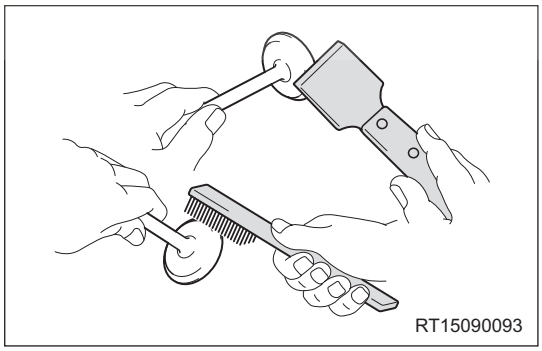
If valve spring length is not within specified range, replace valve spring.



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.

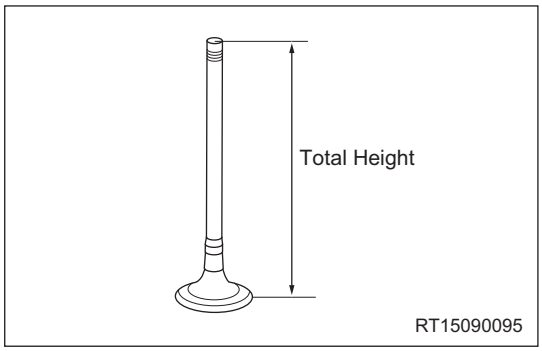


b. Check the valve height.

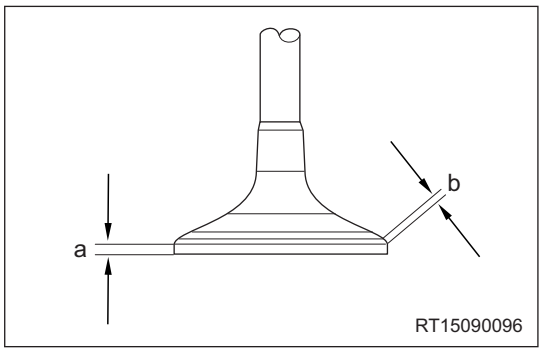
Using a vernier caliper, measure the valve height.

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

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



c. Check the valve head.
- Measure thickness (a) of valve head.
- Check if contact area of valve surface is even, if valve face is in center of valve inclined plane and measure valve width (b).

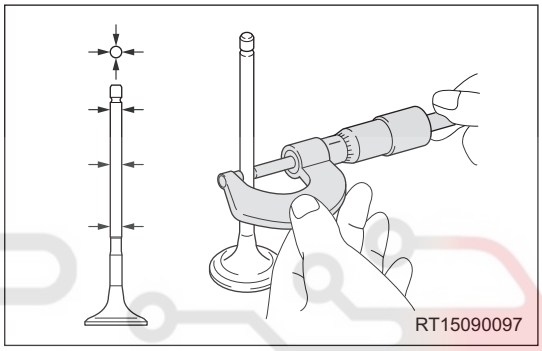


Measurement Item	Specification (mm)
Intake Valve Head Thickness	0.68 ~ 1.1
Exhaust Valve Head Thickness	0.48 ~ 0.9
Intake Valve Face Width	1.154
Exhaust Valve Face Width	1.307

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

d. Check the valve stem diameter.

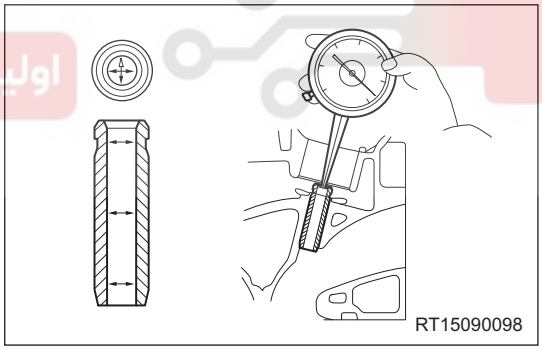
Using a micrometer, measure the valve stem diameter.



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.



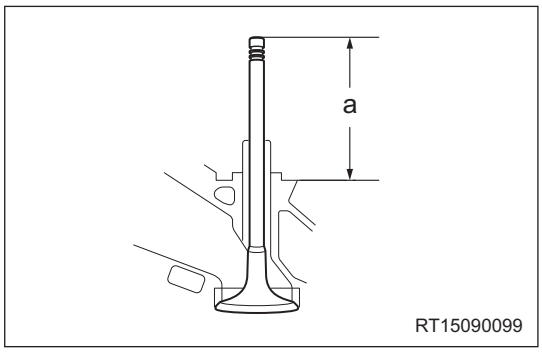
Measurement Item	Specification (mm)
Valve Guide Inner Diameter	6.0 ~ 6.015

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

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

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

4. Check the valve stem protrusion length.
   a. Using a vernier caliper, measure distance (valve stem protrusion length) between valve stem end surface and valve spring seat end surface.



Measurement Item	Specification (mm)
Valve Stem Protrusion Length	47.5
Exhaust Valve Stem Protrusion Length	47.5

If valve stem protrusion is not within specified range, replace valve.

Assembly

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. Install valve (1) into cylinder head.

   HINT:

   - Distinguish intake valve and exhaust valve during installation.
   - Apply a coat of engine oil to valve stem end, when assembling valve.

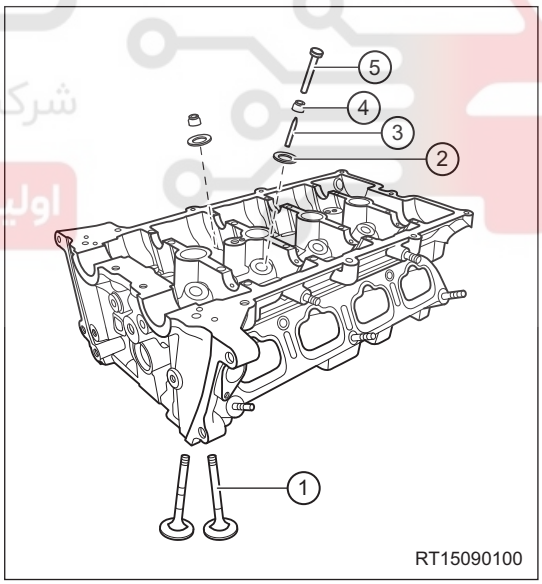
2. Install new valve spring lower seat (2) if necessary.
3. Install the valve oil seal.

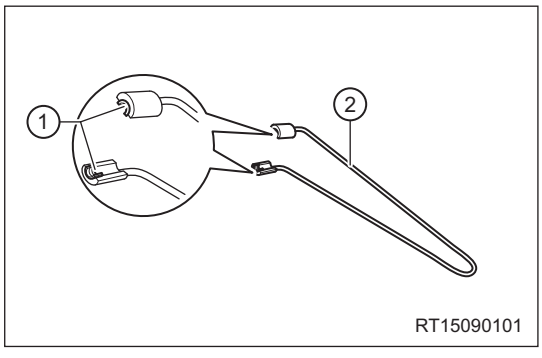
   HINT:

   Apply a coat of engine oil to installation surface of valve oil seal, when assembling valve oil seal.

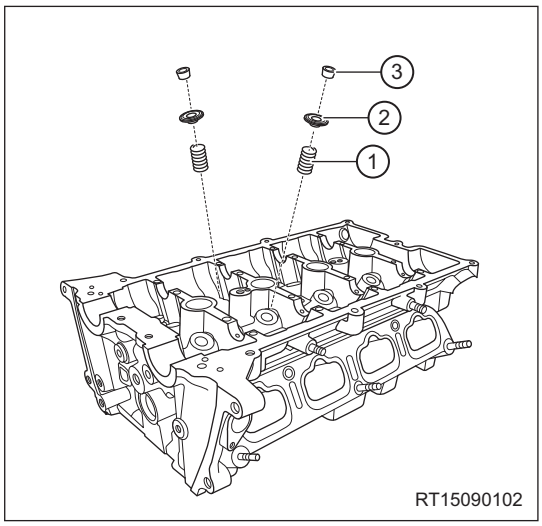
   a. Install valve oil seal guide (3) to valve stem.
   b. Install valve oil seal (4) to valve oil seal guide sleeve.
   c. Tap valve oil seal installer (5) lightly with a rubber hammer to install valve oil seal in place.

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





5. Install valve spring (1) and valve spring upper seat (2).
6. Using a valve spring compressor, compress valve spring and install valve cotter (3) in place.



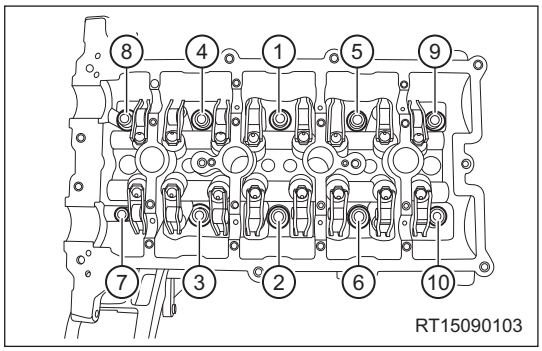
7. Tap tip of valve stem lightly with a rubber hammer to make sure valve cotter is installed in place after assembly.

Installation

CAUTION

- 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 with stamped part number facing upward.
- Install cylinder head gasket to flat surface of cylinder block with a dowel pin.
- Clean junction surface between cylinder head and combustion chamber, top flat surface and threaded hole of cylinder block. There should be no accumulated oil at the 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 camshaft.
- 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. Apply a small amount of engine oil to bolt head and root.
   b. Install bolts and tighten them in place by hands.
   c. Tighten cylinder head fixing bolts according to following procedures:
      - 1st step: Tighten bolts to 40 ± 5 N·m in sequence from (1) to (10) shown in illustration.
      - 2nd step: Rotate bolts clockwise by 90° ± 5° in tightening sequence.
      - 3rd step: Rotate bolts clockwise by 90° ± 5° in tightening sequence 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.

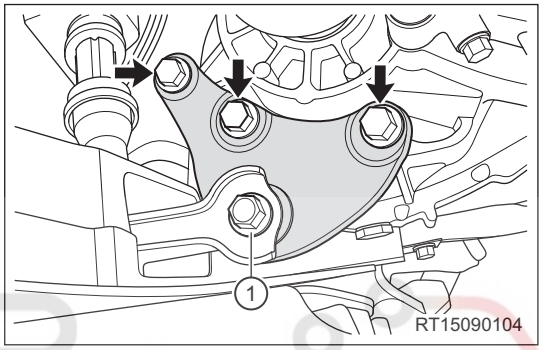
Engine Mounting Assembly (1.5 TCI + 6MT)

Removal & Installation - Rear Mounting Assembly

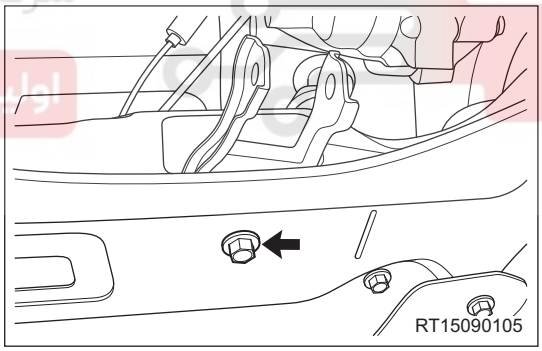
CAUTION

- 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 engine 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: 105 ± 10 N·m)
   b. Remove coupling bolts (arrow) between rear mounting upper body and transmission.
      (Tightening torque: 80 ± 5 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: 150 ± 10 N·m)



   b. Remove the rear mounting lower body.

Installation is in the reverse order of removal.

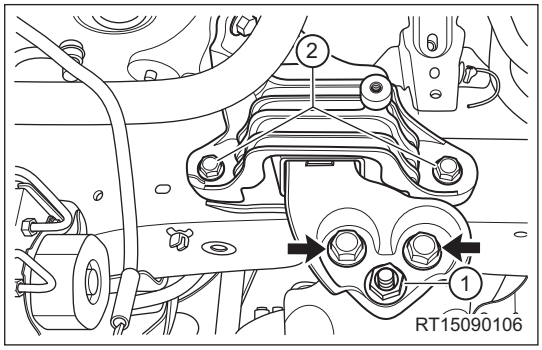
Removal & Installation - Left Mounting Assembly

CAUTION

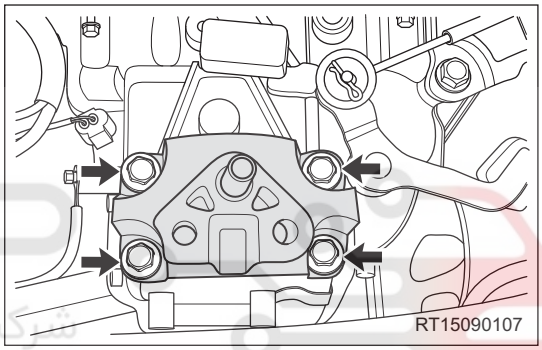
- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the engine switch.
2. Disconnect the negative battery cable.
3. Use an engine equalizer to hang engine assembly.

4. Remove the air filter assembly (See page 16-13).
5. Remove the battery assembly (See page 28-7).
6. Remove the battery tray bracket (See page 28-9).
7. Remove the left mounting cushion assembly.
   a. Remove 2 coupling bolts (arrow) and 1 coupling nut (1) between left mounting cushion assembly and left mounting bracket.
      (Tightening torque: 80 ± 5 N·m)
   b. Remove 3 fixing bolts (2) between left mounting cushion assembly and body.
      (Tightening torque: 60 ± 5 N·m)



   c. Remove the left mounting cushion assembly.
8. Remove the left mounting bracket.
   a. Remove 4 fixing bolts (arrow) between left mounting bracket and transmission.
      (Tightening torque: 80 ± 5 N·m)



   b. Remove the left mounting bracket.

Installation is in the reverse order of removal.

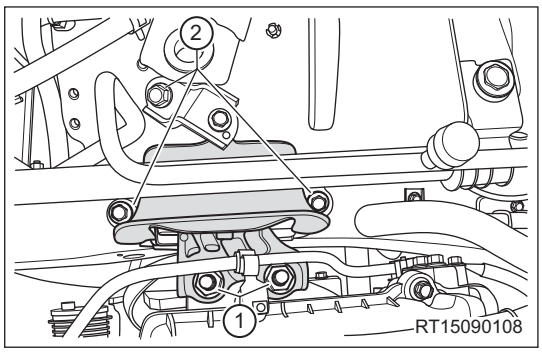
Removal & Installation - Right Mounting Assembly

CAUTION

- Install protector to prevent body from being scratched.

1. Turn off all electrical equipment and the engine switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Drain the coolant (See page 20-14).
5. Remove the expansion tank assembly (See page 20-18).
6. Use an engine equalizer to hang engine assembly.

7. Remove the engine right mounting cushion assembly.
   a. Remove 2 fixing nuts (1) between right mounting cushion assembly and engine.
      (Tightening torque: 80 ± 5 N·m)
   b. Remove 3 fixing bolts (2) between right mounting cushion assembly and body.
      (Tightening torque: 60 ± 5 N·m)



   c. Remove the engine right mounting cushion assembly.

Installation is in the reverse order of removal.

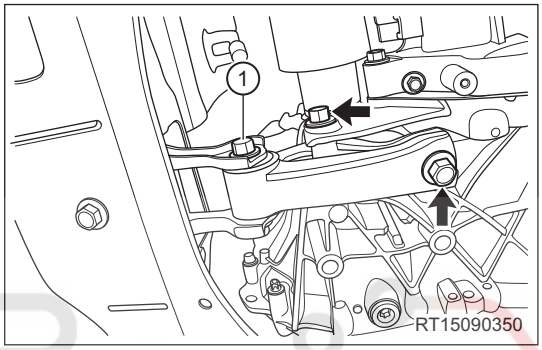
Engine Mounting Assembly (1.5 TCI + DCT)

Removal & Installation - Rear Mounting Assembly

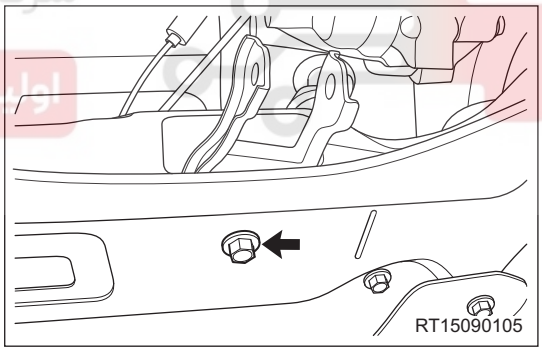
CAUTION

- 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 engine 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: 105 ± 10 N·m)
   b. Remove coupling bolts (arrow) between rear mounting upper body and transmission.
      (Tightening torque: 80 ± 5 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: 150 ± 10 N·m)



   b. Remove the rear mounting lower body.

Installation is in the reverse order of removal.

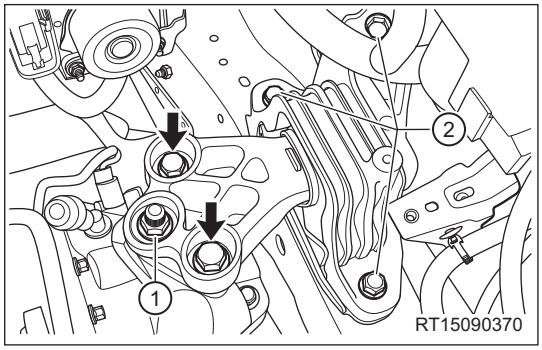
Removal & Installation - Left Mounting Assembly

CAUTION

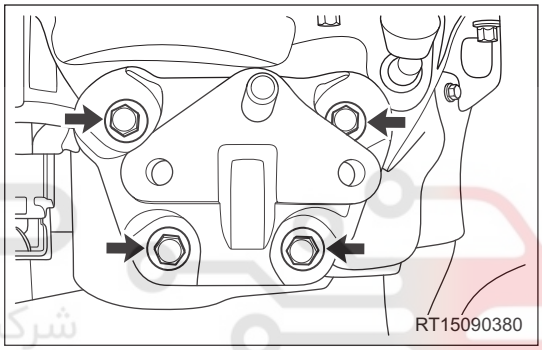
- Be sure to wear necessary safety equipment to prevent accidents when repairing.
- Try to prevent body paint surface from being scratched during removal and installation.

1. Turn off all electrical equipment and the engine switch.
2. Disconnect the negative battery cable.
3. Use an engine equalizer to hang engine assembly.

4. Remove the air filter assembly (See page 16-13).
5. Remove the battery assembly (See page 28-7).
6. Remove the battery tray bracket (See page 28-9).
7. Remove the left mounting cushion assembly.
   a. Remove 2 coupling bolts (arrow) and 1 coupling nut (1) between left mounting cushion assembly and left mounting bracket.
      (Tightening torque: 80 ± 5 N·m)
   b. Remove 3 fixing bolts (2) between left mounting cushion assembly and body.
      (Tightening torque: 70 ± 5 N·m)



   c. Remove the left mounting cushion assembly.
8. Remove the left mounting bracket.
   a. Remove 4 fixing bolts (arrow) between left mounting bracket and transmission.
      (Tightening torque: 60 ± 5 N·m)



   b. Remove the left mounting bracket.

Installation is in the reverse order of removal.

10

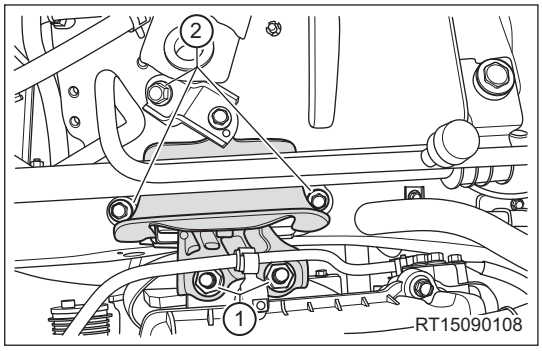
Removal & Installation - Right Mounting Assembly

CAUTION

- Install protector to prevent body from being scratched.

1. Turn off all electrical equipment and the engine switch.
2. Disconnect the negative battery cable.
3. Remove the engine trim cover.
4. Drain the coolant (See page 20-14).
5. Remove the expansion tank assembly (See page 20-18).
6. Use an engine equalizer to hang engine assembly.

7. Remove the engine right mounting cushion assembly.
   a. Remove 2 fixing nuts (1) between right mounting cushion assembly and engine.
      (Tightening torque: 80 ± 5 N·m)
   b. Remove 3 fixing bolts (2) between right mounting cushion assembly and body.
      (Tightening torque: 70 ± 5 N·m)



   c. Remove the engine right mounting cushion assembly.

Installation is in the reverse order of removal.

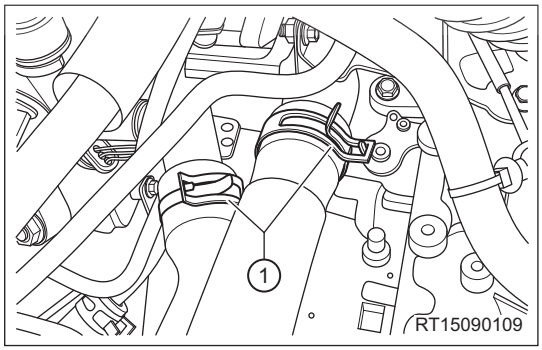
Engine Assembly (1.5 TCI + 6MT)

Removal

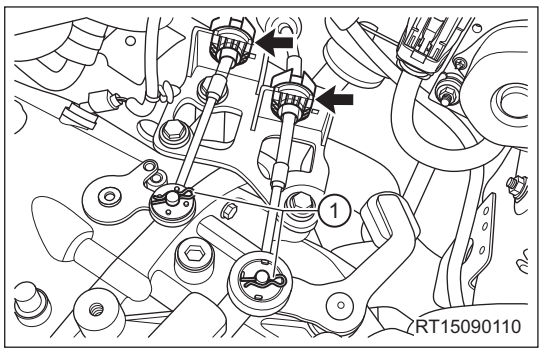
CAUTION

- 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 being entered after removing air filter and engine trim cover. 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 (See page 12-10).
3. Turn off all electrical equipment and the engine switch.
4. Remove the battery assembly (See page 28-7).
5. Remove the battery tray bracket (See page 28-9).
6. Remove the air filter assembly (See page 16-13).
7. Remove the intake manifold assembly (See page 16-28).
8. Remove the turbocharger assembly (See page 18-16).
9. Remove the precatalytic converter assembly (See page 18-31).
10. Drain the engine oil (See page 22-10).
11. Drain the transmission oil (See page 29-20).
12. Drain the coolant (See page 20-14).
13. Drain the steering fluid (hydraulic power configuration) (See page 42-7).
14. Recover the refrigerant (See page 44-88).
15. Disconnect connection between engine inlet and outlet hoses.
    a. Loosen elastic clamps (1) and disconnect connection between engine inlet, outlet hoses and thermostat seat.

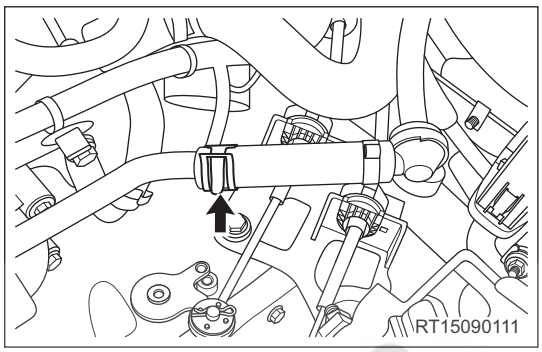


16. Move away gear select and shift cables.
    a. Remove fixing lock pin (1) between the gear select and shift cables and the transmission gear select and shift rocker arms, and disconnect connection.
    b. Detach gear select and shift cable dampers (arrow) from soft shaft bracket limit hole.

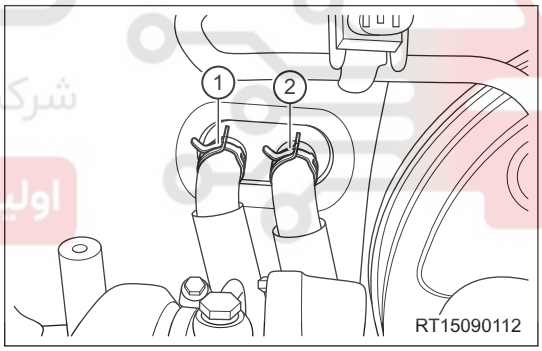


    c. Move away gear select and shift cables.

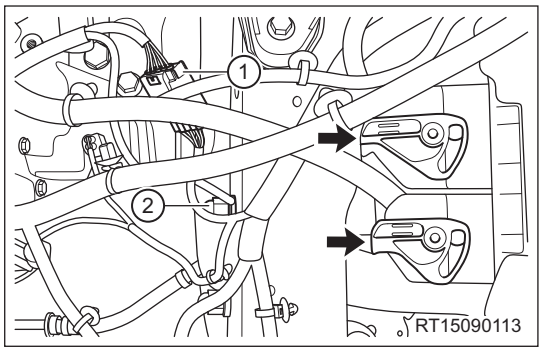
17. Loosen elastic clamp (arrow) and disconnect connection between brake vacuum hose and brake vacuum steel pipe.



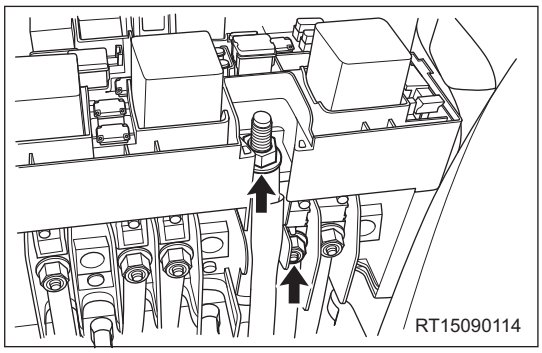
18. Disconnect connection between hose and heater core.
    a. Loosen elastic clamp (1) and disconnect connection between heater inlet hose and heater core.
    b. Loosen elastic clamp (2) and disconnect connection between heater outlet hose and heater core.



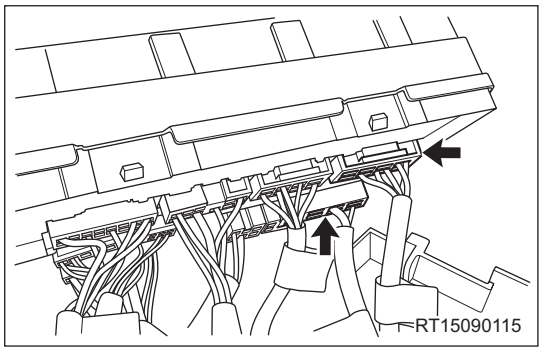
19. Remove the expansion tank assembly (See page 20-18).
20. Disconnect the following wire harness connectors.
    a. Disconnect the ECU connectors (arrow).
    b. Disconnect connector (1) between engine wire harness and engine compartment wire harness.
    c. Remove the ground wire fixing nut (2).
    (Tightening torque: 40 ± 5 N·m)



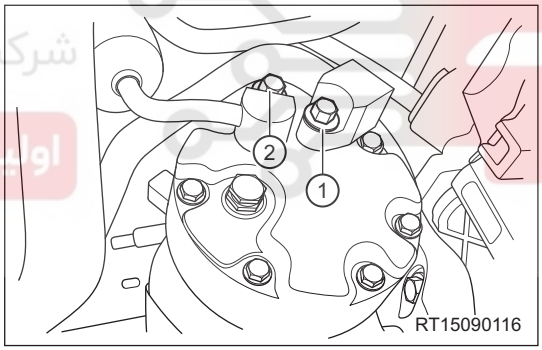
d. Open engine compartment fuse and relay box cover and remove battery wire harness fixing nuts (arrow), then disconnect connection between battery wire harness and engine compartment fuse and relay box.
(Tightening torque: 7 ± 1 N·m)



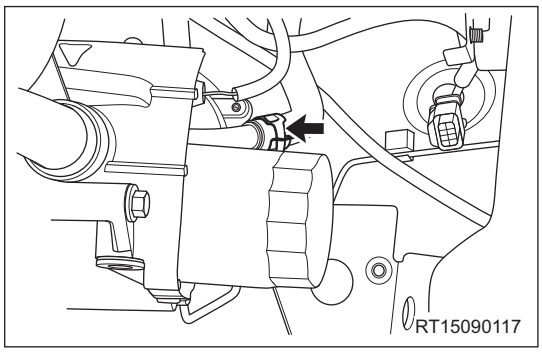
e. Remove engine compartment fuse and relay box, disconnect A and B connectors (arrow), and remove A and B connector wire harnesses from engine compartment fuse and relay box.



21. Remove the front wheel (See page 37-7).
22. Remove the drive shaft (See page 33-5).
23. Remove the vacuum pump assembly.
24. Remove A/C compressor high and low pressure pipes.
    a. Remove coupling bolt (1) between low pressure pipe and A/C compressor assembly, and disconnect low pressure pipe.
    (Tightening torque: 25 ± 4 N·m)
    b. Remove coupling bolt (2) between high pressure pipe and A/C compressor assembly, and disconnect high pressure pipe.
    (Tightening torque: 25 ± 4 N·m)



25. Loosen elastic clamp (arrow) and disconnect connection between expansion tank outlet pipe and oil filter module assembly.



26. Use an engine equalizer to hang engine assembly.
27. Remove the rear mounting assembly (See page 10-74).
28. Remove the left mounting assembly (See page 10-74).
29. Remove the right mounting assembly (See page 10-75).
30. Check that engine assembly is separated with external components.

31.Hang engine assembly from engine compartment.

32.Remove electronic injector wire harness and battery wire harness from engine.

33.Separate connection between engine assembly and transmission assembly.

34.Remove clutch assembly from engine assembly (See page 32-15).

35.Install engine assembly to engine service platform.

Installation

Installation is in the reverse order of removal.

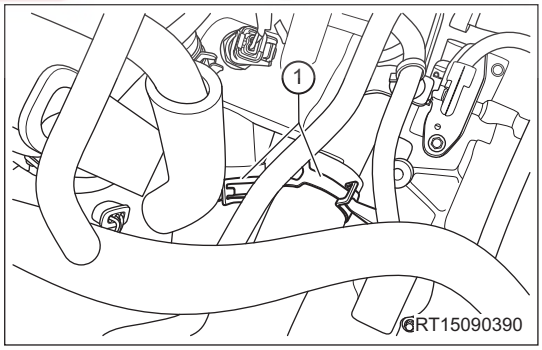
Engine Assembly (1.5 TCI + DCT)

Removal

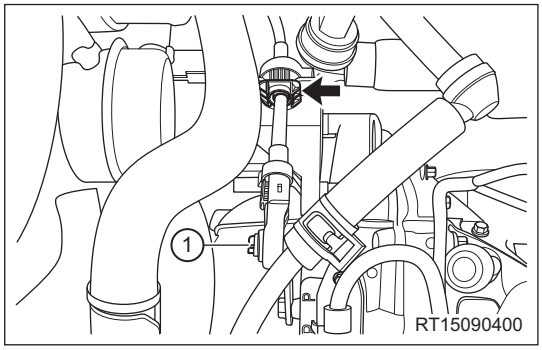
CAUTION

- 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 being entered after removing air filter and engine trim cover. 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 (See page 12-10).
3. Turn off all electrical equipment and the engine switch.
4. Remove the battery assembly (See page 28-7).
5. Remove the battery tray bracket (See page 28-9).
6. Remove the air filter assembly (See page 16-13).
7. Remove the intake manifold assembly (See page 16-31).
8. Remove the turbocharger assembly (See page 18-20).
9. Remove the precatalytic converter assembly (See page 18-31).
10. Drain the engine oil (See page 22-10).
11. Drain the transmission oil (See page 29-20).
12. Drain the coolant (See page 20-14).
13. Recover the refrigerant (See page 44-88).
14. Disconnect connection between engine inlet and outlet hoses.
    a. Loosen elastic clamps (1) and disconnect connection between engine inlet, outlet hoses and thermostat seat.

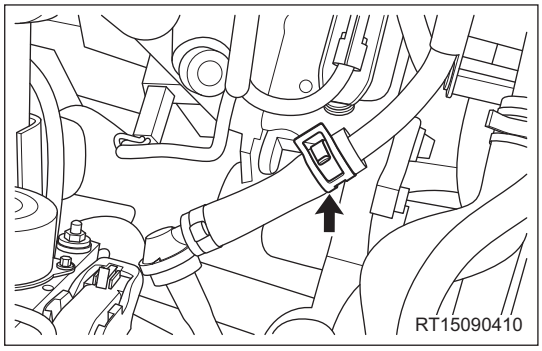


15. Move away gear select and shift cables.
    a. Use a proper tool to loosen fixing lock pin (1) between gear shift cable and transmission gear shift rocker arms, and disconnect connection.
    b. Detach gear shift cable damper (arrow) from soft shaft bracket limit hole.

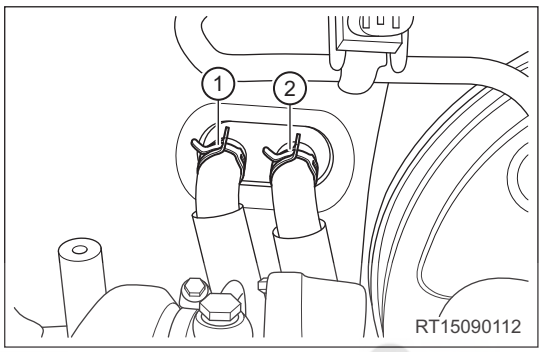


c. Move away the gear shift cable.

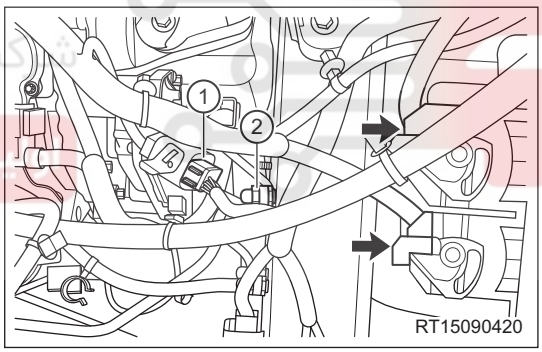
16. Loosen elastic clamp (arrow) and disconnect connection between brake vacuum hose and brake vacuum steel pipe.



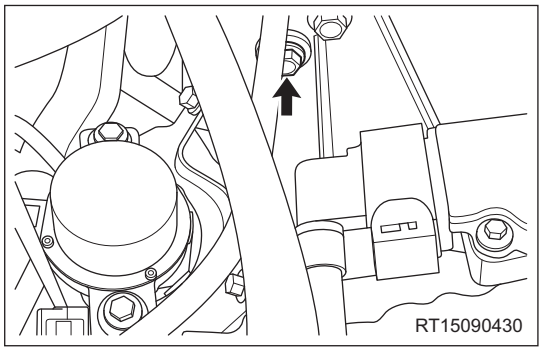
17. Disconnect connection between hose and heater core.
    a. Loosen elastic clamp (1) and disconnect connection between heater inlet hose and heater core.
    b. Loosen elastic clamp (2) and disconnect connection between heater outlet hose and heater core.



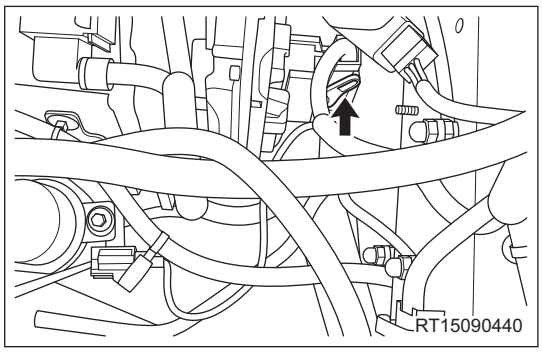
18. Remove the expansion tank assembly (See page 20-18).
19. Disconnect the following wire harness connectors.
    a. Disconnect the ECU connectors (arrow).
    b. Disconnect connector (1) between engine wire harness and engine compartment wire harness.
    c. Remove the ground wire fixing nut (2).
    (Tightening torque: 40 ± 5 N·m)



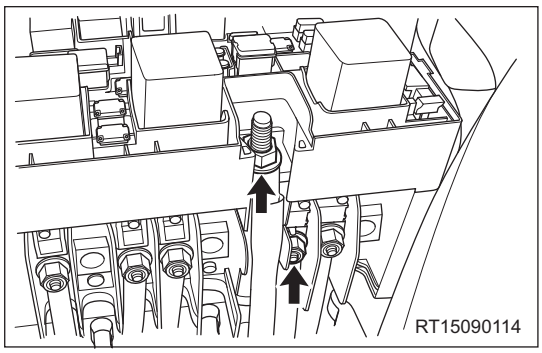
    d. Remove fixing bolt (arrow) from ground wire on transmission assembly.
    (Tightening torque: 45 ± 5 N·m)



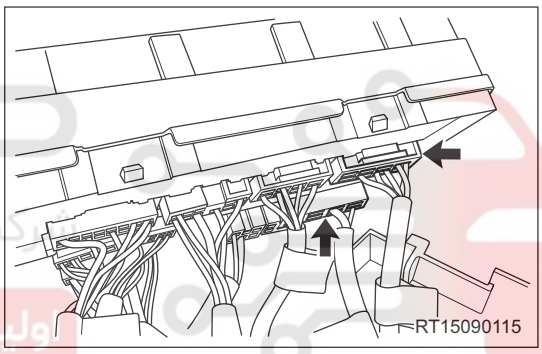
e. Disconnect the transmission controller connector (arrow).



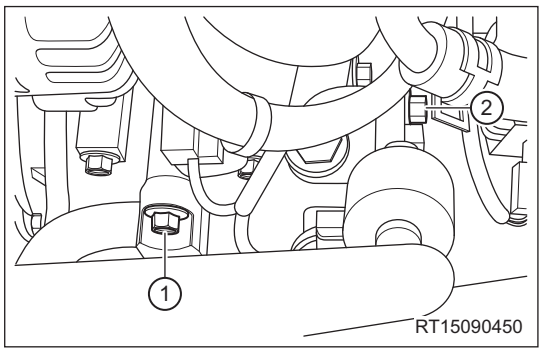
f. Open engine compartment fuse and relay box cover and remove battery wire harness fixing nuts (arrow), then disconnect connection between battery wire harness and engine compartment fuse and relay box.
(Tightening torque: 7 ± 1 N·m)



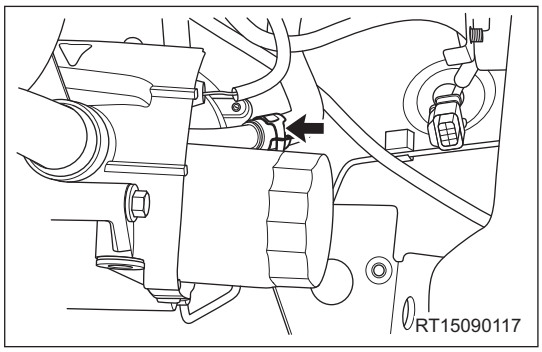
g. Remove engine compartment fuse and relay box, disconnect A and B connectors (arrow), and remove A and B connector wire harnesses from engine compartment fuse and relay box.



20. Remove the front wheel (See page 37-7).
21. Remove the drive shaft (See page 33-5).
22. Remove the vacuum pump assembly.
23. Remove A/C compressor high and low pressure pipes.
    a. Remove coupling bolt (1) between low pressure pipe and A/C compressor assembly, and disconnect low pressure pipe.
    (Tightening torque: 25 ± 4 N·m)
    b. Remove coupling bolt (2) between high pressure pipe and A/C compressor assembly, and disconnect high pressure pipe.
    (Tightening torque: 25 ± 4 N·m)



24. Loosen elastic clamp (arrow) and disconnect connection between expansion tank outlet pipe and oil filter module assembly.



25. Use an engine equalizer to hang engine assembly.
26. Remove the rear mounting assembly (See page 10-74).
27. Remove the left mounting assembly (See page 10-74).
28. Remove the right mounting assembly (See page 10-75).
29. Check that engine assembly is separated with external components.
30. Hang engine assembly from engine compartment.
31. Remove electronic injector wire harness and battery wire harness from engine.
32. Separate connection between engine assembly and transmission assembly.
33. Remove flywheel assembly from engine assembly (See page 10-36).
34. Install engine assembly to engine service platform.

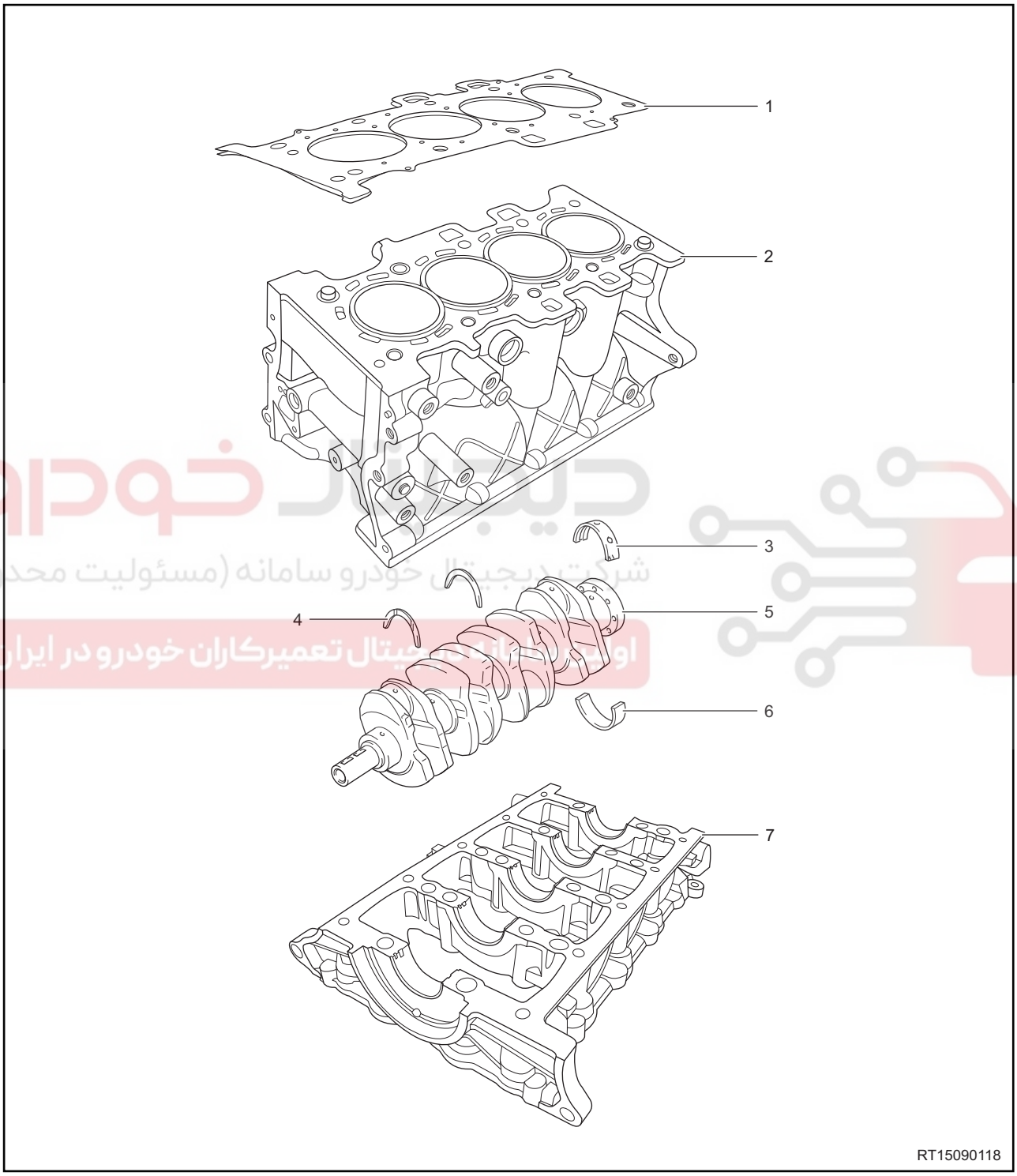
Installation

Installation is in the reverse order of removal.

CYLINDER BLOCK UNIT REPAIR

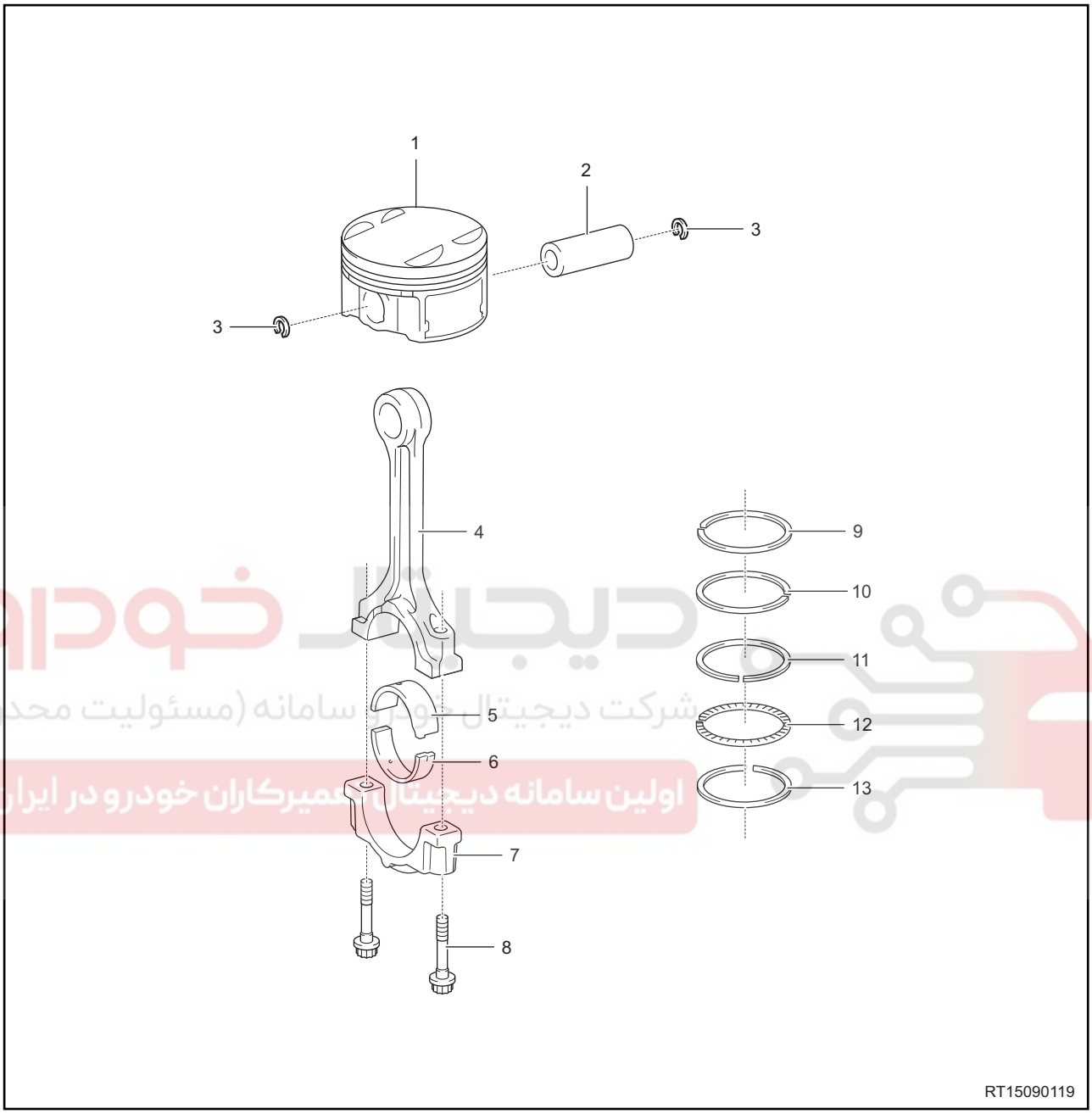
Cylinder Block

Description



1 - Cylinder Head Gasket	2 - Cylinder Block
3 - Crankshaft Main Bearing Upper Shell	4 - Thrust Washer

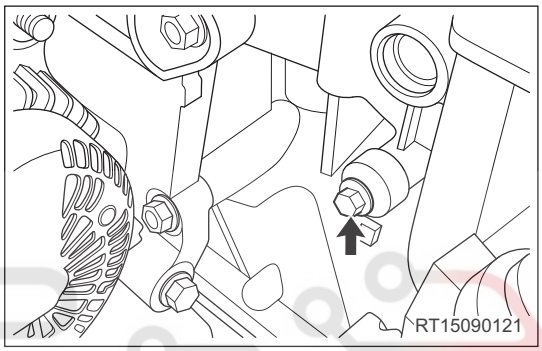
5 - Crankshaft	6 - Crankshaft Main Bearing Lower Shell
7 - Cylinder Block Frame Assembly	



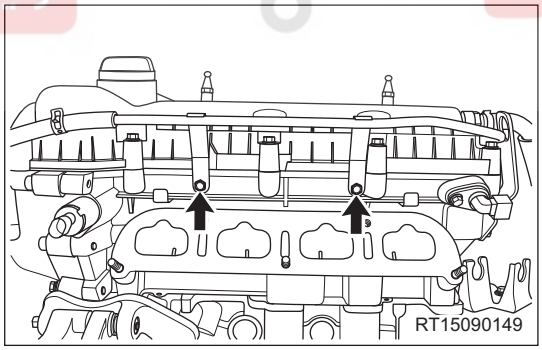
1 - Piston	2 - Piston Pin (Semi-floating)
3 - Elastic Circlip	4 - Connecting Rod Assembly
5 - Connecting Rod Bearing Upper Shell	6 - Connecting Rod Bearing Lower Shell
7 - Connecting Rod Bearing Cap	8 - Connecting Rod Bearing Cap Fixing Bolt
9 - First Compression Ring	10 - Second Compression Ring
11 - Upper Rail	12 - Expander
13 - Lower Rail	

Disassembly

1. Remove engine assembly and install engine to engine service platform.
2. Remove the accessory drive belt (See page 10-22).
3. Remove the idler pulley assembly (See page 10-24).
4. Remove the tensioner assembly (See page 10-29).
5. Remove electrical water pump assembly, bracket and water pipe (for 1.5 TCI + 6MT, See page 18-27) (for 1.5 TCI + DCT, See page 18-29).
6. Remove the thermostat assembly (for 1.5 TCI + 6MT, See page 20-20) (for 1.5 TCI + DCT, See page 20-22).
7. Remove the thermostat seat assembly (for 1.5 TCI + 6MT, See page 20-24) (for 1.5 TCI + DCT, See page 20-26).
8. Remove the exhaust manifold assembly (for 1.5 TCI + 6MT, See page 18-11).
9. Remove the knock sensor (1.5 TCI + 6MT) (1.5 TCI + DCT).
   a. Remove knock sensor fixing bolt (arrow), and remove knock sensor.
      (Tightening torque: 20 ± 5 N·m)

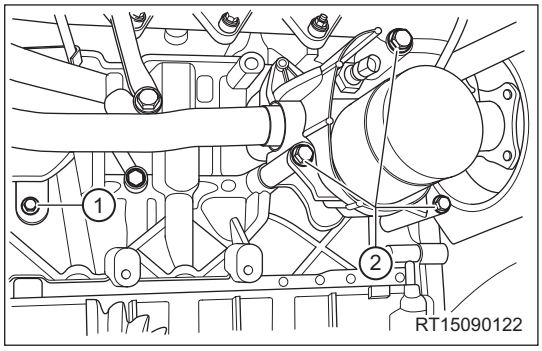


10. Remove alternator assembly and mounting bracket (See page 28-10).
11. Remove A/C compressor assembly and mounting bracket (for 1.5 TCI + 6MT, See page 44-119) (for 1.5 TCI+ DCT, See page 44-119).
12. Remove the engine discharge steel pipe (1.5 TCI + 6MT).
    a. Remove 2 fixing bolts from engine discharge steel pipe.
       (Tightening torque: 7 ± 1 N·m)

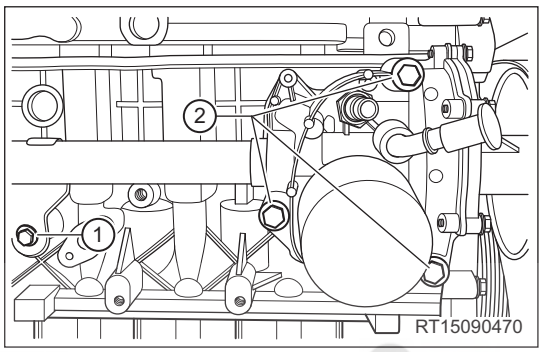


    b. Remove the engine discharge steel pipe.
13. Remove the engine discharge steel pipe (for 1.5 TCI + DCT, See page 20-28).
14. Remove the ignition coils (See page 24-9).

15. Remove the oil filter module (1.5 TCI + 6MT).
    a. Remove fixing bolt (1) from coolant 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)



16. Remove the oil filter module (1.5 TCI + DCT).
    a. Remove fixing bolt (1) from coolant 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)



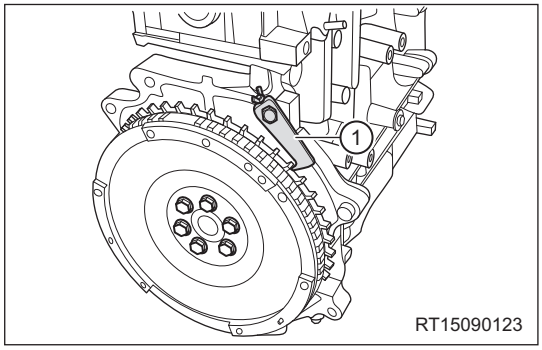
CAUTION

- There will be residual coolant inside engine when removing and installing, 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, used engine oil contains potentially harmful contaminants, which may cause skin cancer. Therefore, always take proper skin protection measures when servicing vehicle.

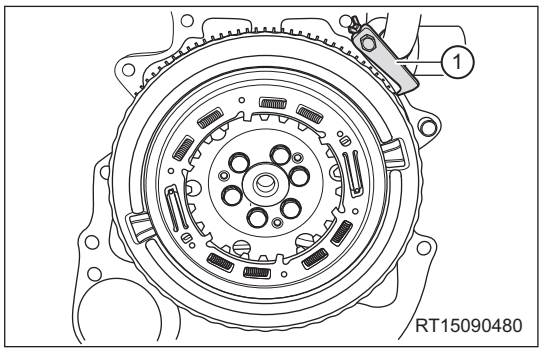
ENVIRONMENTAL PROTECTION

- There will be coolant residue inside engine. Coolant should be handled according to local environmental regulations.

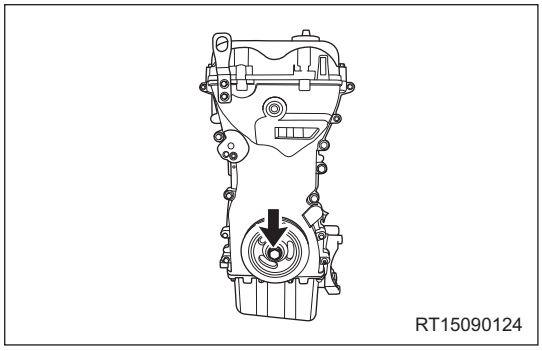
17. Remove the crankshaft pulley.
    a. Install flywheel special tool (1) to lock flywheel as shown in illustration (1.5 TCI + 6MT).



b. Install flywheel special tool (1) to lock flywheel as shown in illustration (1.5 TCI + DCT).



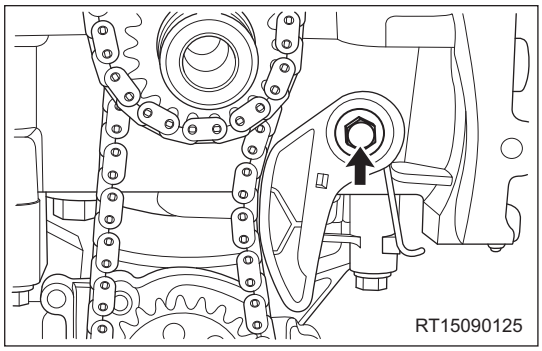
c. Remove the crankshaft pulley fixing bolt (arrow).
(Tightening torque: 1st step: tighten to 100 ± 10 N·m; 2nd step: rotate by 120° ± 10°)



d. Remove the crankshaft pulley.

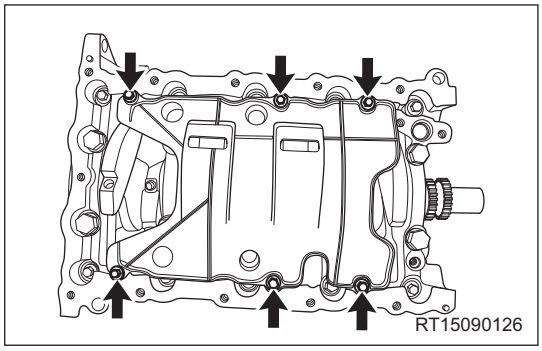
18. Remove the crankshaft front oil seal (See page 10-32).
19. Remove the flywheel assembly (for 1.5 TCI + 6MT, See page 10-34) (for 1.5 TCI + DCT, See page 10-36).
20. Remove the crankshaft rear oil seal (See page 10-38).
21. Remove the cylinder head cover assembly (See page 10-30).
22. Remove the oil pan assembly (See page 22-18).
23. Remove the engine timing chain (See page 10-40).
24. Remove intake and exhaust camshaft assemblies.
25. Remove the cylinder head assembly (for 1.5 TCI + 6MT, See page 10-52) (for 1.5 TCI + DCT, See page 10-63).
26. Remove the strainer assembly (See page 22-20).
27. Remove the oil pump assembly (See page 22-21).
28. Remove the oil pump drive chain.

a. Remove fixing bolt (arrow) from oil pump drive chain movable guide rail, and remove movable guide rail.
(Tightening torque: 12 + 2 N·m)

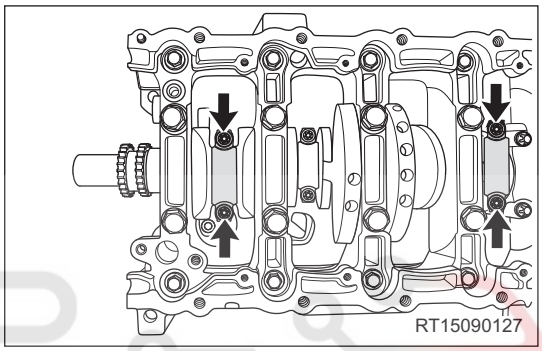


b. Remove the oil pump drive chain.

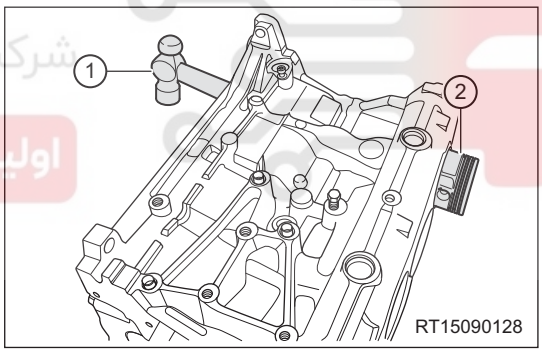
29. Remove the oil deflector assembly.
    a. Remove 6 oil deflector fixing bolts (arrow).
    (Tightening torque: 8 + 3 N·m)



    b. Remove the oil deflector assembly.
30. 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 on flywheel side, 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.



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



    d. Removal procedures for piston connecting rod assembly of cylinders 2 and 3 are the same as above.

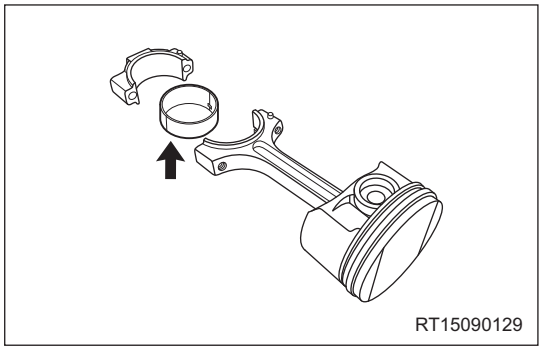
CAUTION

- Be careful during removal to avoid damaging cylinder liner.

31.Remove the connecting rod bearing.

a. Remove the connecting rod bearing shell (arrow).

HINT:
Arrange removed parts in correct order.

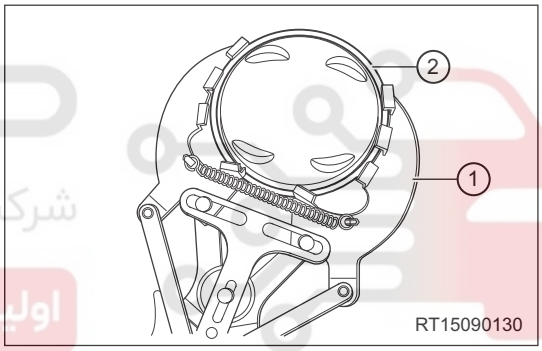

RT15090129

CAUTION

- Be careful not to scratch cylinder wall during operation.
- Attach a label with corresponding number to each piston connecting rod assembly to prevent incorrect installation.

32.Remove the piston rings.

a. Using a piston ring remover (1), remove 2 compression rings (2).



RT15090130

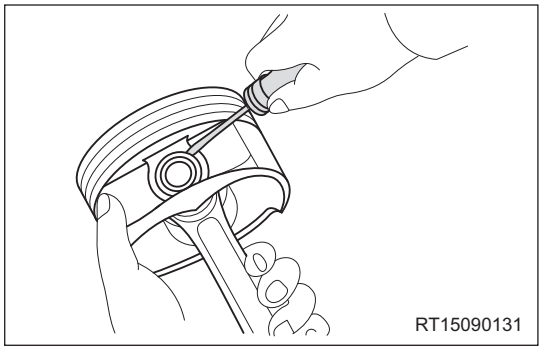
CAUTION

- Before removing piston ring, check piston ring side clearance. If it is necessary to be reused, be sure to mark the piston ring position.

b. Remove oil ring rail and expander by hands.

33.Separate piston and connecting rod.

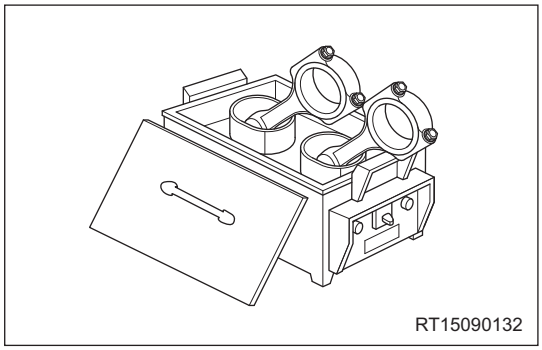
a. Using a flat tip screwdriver, remove piston pin snap rings from both ends of piston pin.


RT15090131

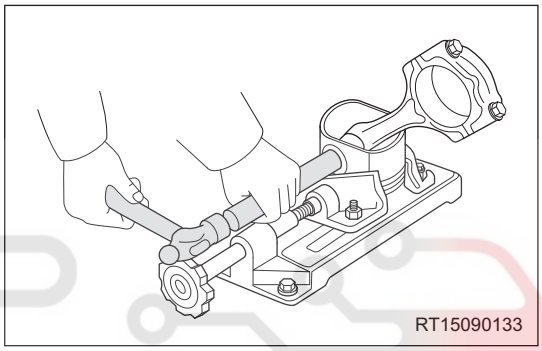
CAUTION

- Piston pin snap ring has a large tensile force. Be careful during removal to prevent personal injury.

b. Gradually heat pistons to 80°C - 90°C.

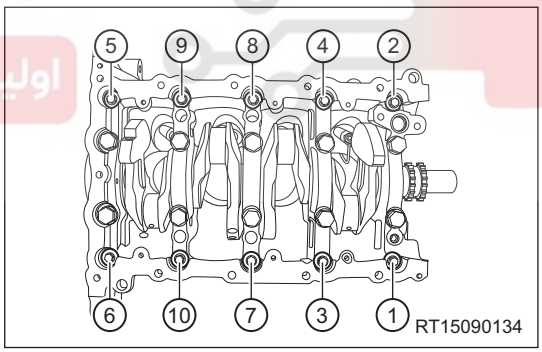

RT15090132

c. Gently tap out piston pin and remove connecting rod with a rubber hammer and a brass bar.


RT15090133

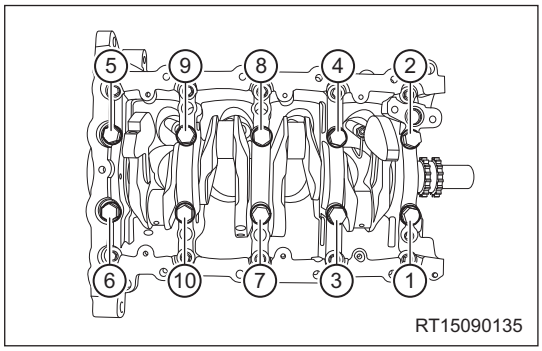
34. Remove the crankshaft.

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



RT15090134

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



RT15090135

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.

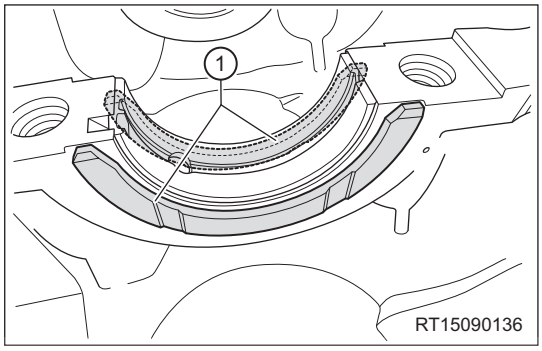
d. Remove the crankshaft assembly.

CAUTION

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

35. Remove the crankshaft thrust washers.

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

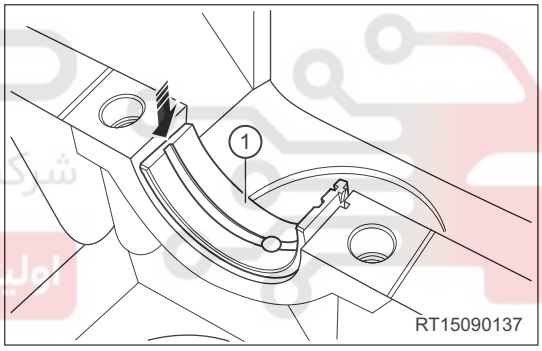


36. Remove the crankshaft main bearing shell.

a. Slightly push crankshaft main bearing upper shell (1) in direction of arrow and remove it carefully.

HINT:

- Remove other crankshaft main bearing upper shell from cylinder block in the same way.
- Pay attention to 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 pushes in opposite direction.

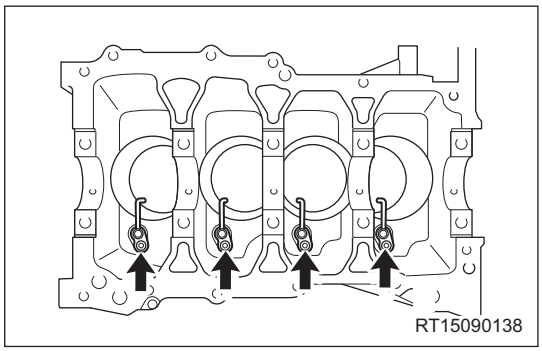


b. Remove crankshaft main bearing lower shell from crankshaft frame in the same way.

37. Remove the piston cooling nozzle.

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

(Tightening torque: 20 + 5 N·m)



Inspection

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

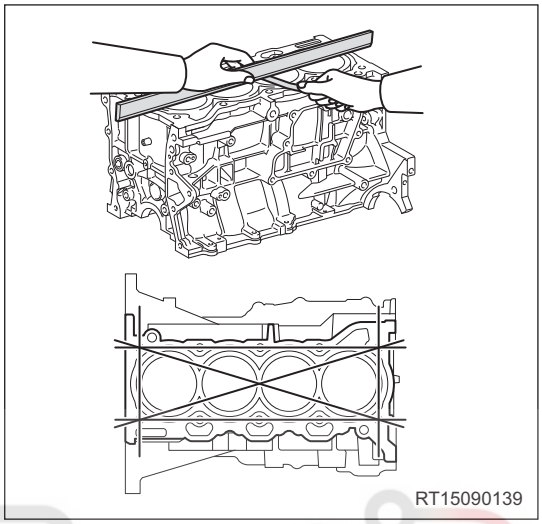
CAUTION

- 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)
Cylinder Block Upper Surface Flatness	0.04

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



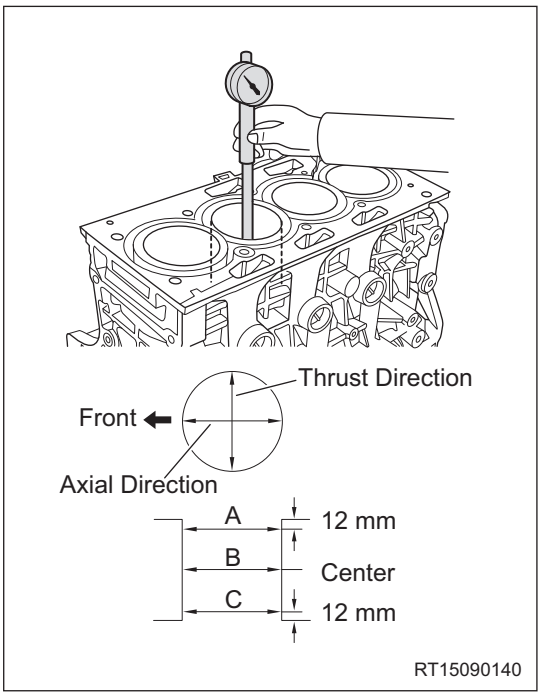
3. Check the cylinder.
   a. Roundness and cylindricity calculation method for cylinder (for general measurement):
   Thrust direction: perpendicular to axis of crankshaft; axial direction: parallel with axis of crankshaft.
   - Cylindricity calculation method
     Cylindricity is half of diameter difference measured in the same direction.
     Cylindricity in thrust direction = (maximum bore diameter measured at B and C in thrust direction - minimum bore diameter measured at B and C in thrust direction)/2
     Cylindricity in axial direction = (maximum bore diameter measured at A, B and C in axial direction - minimum bore diameter measured at A, B and C in axial direction)/2
     Compare maximum value measured at 2 directions with standard cylinder cylindricity.
   - Roundness calculation method
     Roundness error is half of diameter difference measured at the same section.
     Roundness of section A = (maximum bore diameter measured in thrust direction and axial direction at point A - minimum bore diameter measured in thrust direction and axial direction at point A)/2
     Roundness of section B = (maximum bore diameter measured in thrust direction and axial direction at point B - minimum bore diameter measured in thrust direction and axial direction at point B)/2
     Roundness of section C = (maximum bore diameter measured in thrust direction and axial direction at point C - minimum bore diameter measured in thrust direction and axial direction at point C)/2
     Compare maximum value measured at A, B and C with standard cylinder roundness.

b. Check cylindricity of cylinder.

Using a cylinder gauge, measure cylinder bore at positions A, B and C in thrust and axial directions.

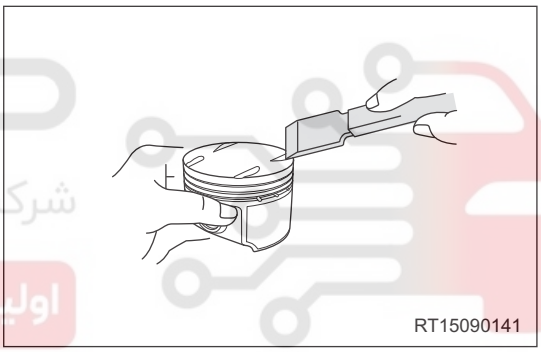
Measurement Item	Specification (mm)
Cylinder Cylindricity	0.01
Cylinder Roundness	0.008

If average bore value measured at positions A, B and C exceeds specified value, replace cylinder block.

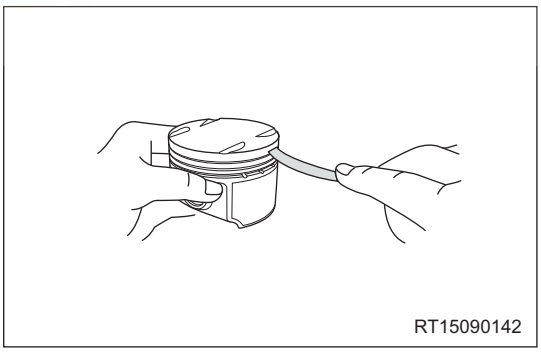


4. Check the piston.

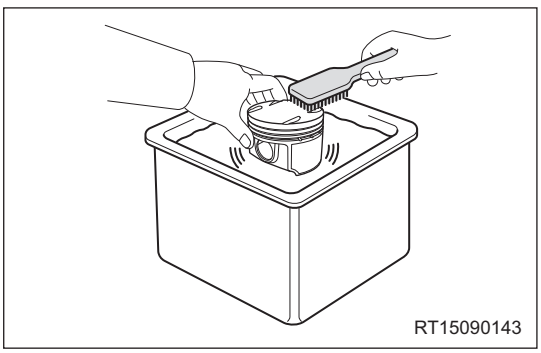
a. Using a scraper, remove carbon deposits on piston top.



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



c. Using a brush and solvent, thoroughly clean piston.

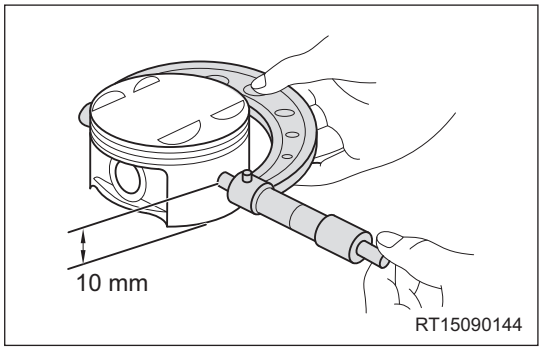


CAUTION

- DO NOT use a wire brush to clean.

d. Measure piston diameter with a micrometer at position, that is 10 mm below piston skirt in vertical direction of piston pin.

(1.5 TCI + 6MT)



Measurement Item	Specification (mm)
Piston Diameter	76.907 ~ 76.947

(1.5 TCI + DCT)

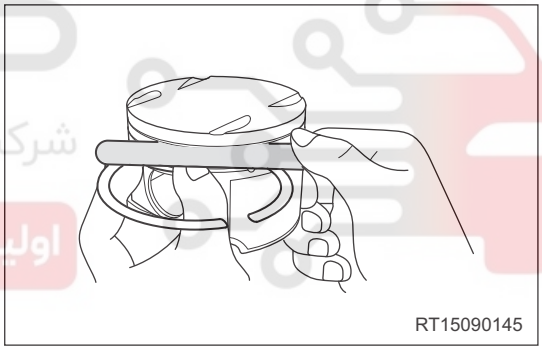
Measurement Item	Specification (mm)
Piston Diameter	76.955 ~ 76.965

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

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

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

(1.5 TCI + 6MT)



Measurement Item	Specification (mm)
First Compression Ring Groove Side Clearance	0.035 ~ 0.085
Second Compression Ring Groove Side Clearance	0.035 ~ 0.075

(1.5 TCI + DCT)

Measurement Item	Specification (mm)
First Compression Ring Groove Side Clearance	0.02 ~ 0.065
Second Compression Ring Groove Side Clearance	0.02 ~ 0.06

If piston ring groove side clearance is not within 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 block to a position, that is 45 mm from bottom of cylinder bore.
   b. Using a feeler gauge, measure end gap.

(1.5 TCI + 6MT)

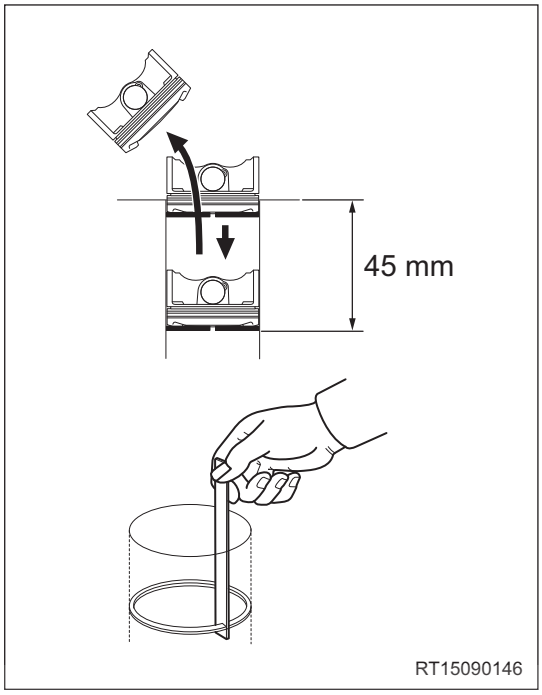
Measurement Item		Specification (mm)
Piston Ring End Gap	First ring	0.2 ~ 0.35
	Second ring	0.4 ~ 0.6

(1.5 TCI + DCT)

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 rings 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 caliper gauge, measure piston pin hole diameter.

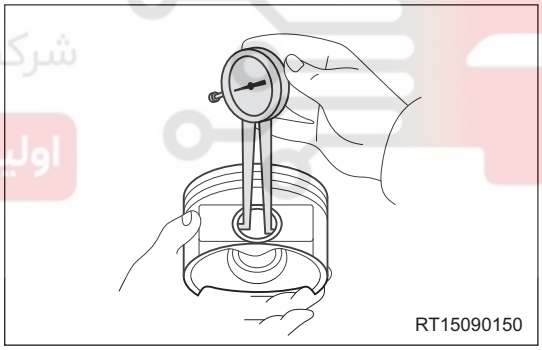
(1.5 TCI + 6MT)

Measurement Item	Specification (mm)
Piston Pin Hole Diameter	18.010 ~ 18.025

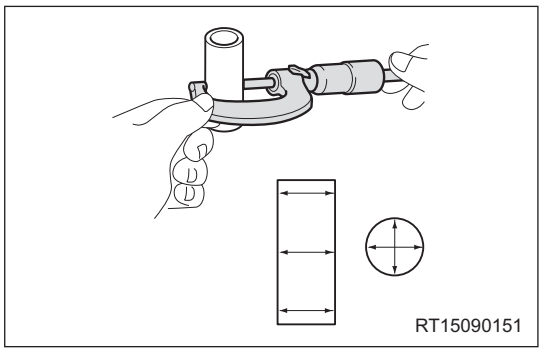
(1.5 TCI + DCT)

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. Measure piston pin diameter with an outer diameter micrometer.



(1.5 TCI + 6MT)

Measurement Item	Specification (mm)
Piston Pin Diameter	17.992 ~ 17.997

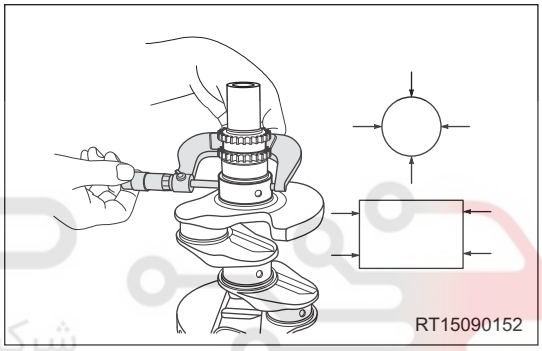
(1.5 TCI + DCT)

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

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

8. Check diameter of crankshaft main journal.

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



(1.5 TCI + 6MT)

Measurement Item	Specification (mm)	Limit Value (mm)
Crankshaft Main Journal Diameter	50	49.979

(1.5 TCI + DCT)

Measurement Item	Specification (mm)	Limit Value (mm)
Crankshaft Main Journal Diameter	50	49.984

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

If radial clearance of the main bearing shell is still not within specified range after replacement, replace the crankshaft.

b. Calculate crankshaft roundness and cylindricity with measured values.

Roundness and cylindricity calculation method (for general measurement):

- Measure the diameter twice on the same cross section, and roundness is half of difference between maximum and minimum values.

  Roundness = (maximum measured diameter - minimum measured diameter)/2

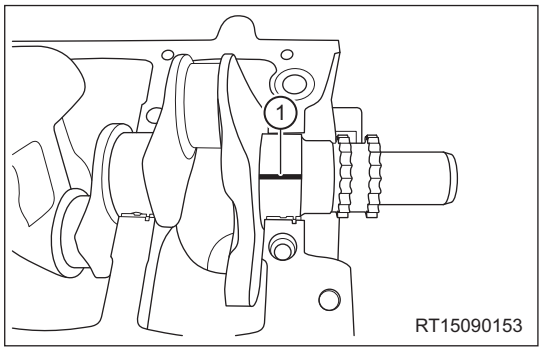
- Measure diameter twice in different directions on two cross sections separately to obtain four values. Cylindricity is half of difference between maximum and minimum values among four values.

  Cylindricity = (maximum measured diameter - minimum measured diameter)/2

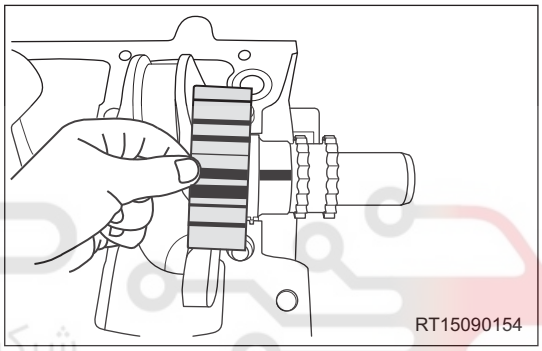
Measurement Item		Specification (mm)
Crankshaft main journal	Cylindricity	0.007
	Roundness	0.04

If roundness or cylindricity of crankshaft main journal exceeds specified value, replace crankshaft assembly.

9. Check the crankshaft radial clearance.
   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: pretighten to 45 ± 5 N·m in order; rotate by 180 ± 10° in order)
   d. Remove the crankshaft frame assembly. Using a feeler gauge, measure widest part of compressed feeler gauge. Measured value is crankshaft radial clearance.



10

Measurement Item	Specification (mm)
Crankshaft Radial Clearance	0.023 ~ 0.075

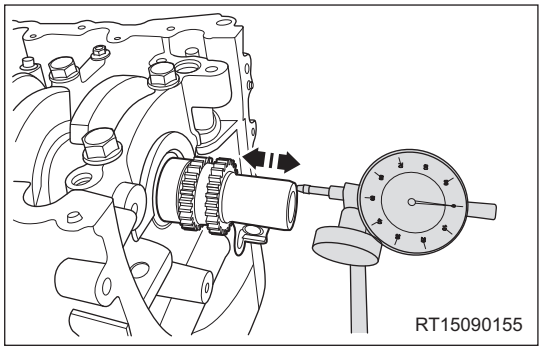
If crankshaft radial clearance exceeds specified range, install new main bearing shells. Replace crankshaft assembly if necessary.

Selection of main bearing shell (See page 10-105).

CAUTION

- Replace bearing shells in pairs.

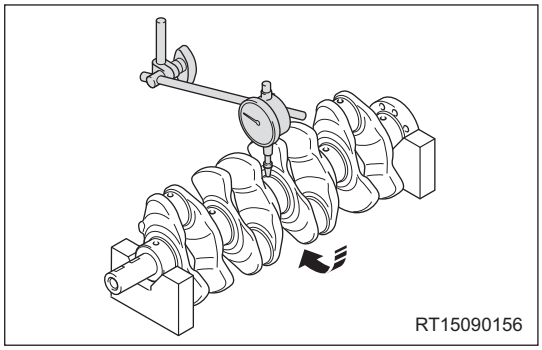
10. Check the crankshaft axial clearance.
   a. Clean crankshaft main journals and main bearing shells.
   b. Install crankshaft frame and tighten main bearing cap fixing bolts to specified torque in order.
   (Tightening torque: pretighten to 45 ± 5 N·m in order; rotate by 180 ± 10° in order)
   c. Push crankshaft forward and backward, then read value in dial indicator.



Measurement Item	Specification (mm)
Crankshaft Axial Clearance	0.07 ~ 0.265

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

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


RT15090156

(1.5 TCI + 6MT)

Measurement Item	Specification (mm)
Crankshaft Main Journal Coaxiality	0.04

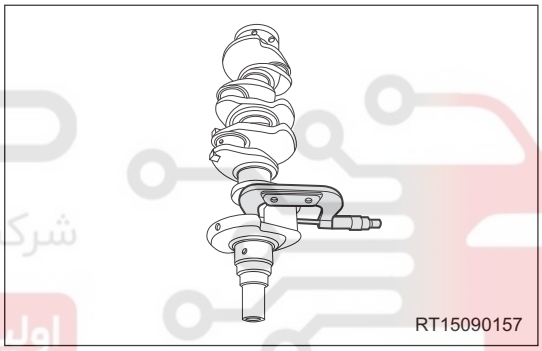
(1.5 TCI + DCT)

Measurement Item	Specification (mm)
Crankshaft Main Journal Coaxiality	0.05

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

12. Check diameter of crankshaft connecting rod journal.

Using an outer diameter micrometer, measure diameter of crankshaft connecting rod journal.


RT15090157

(1.5 TCI + 6MT)

Measurement Item	Specification (mm)	Limit Value (mm)
Crankshaft Connecting Rod Journal Diameter	46	45.979

(1.5 TCI + DCT)

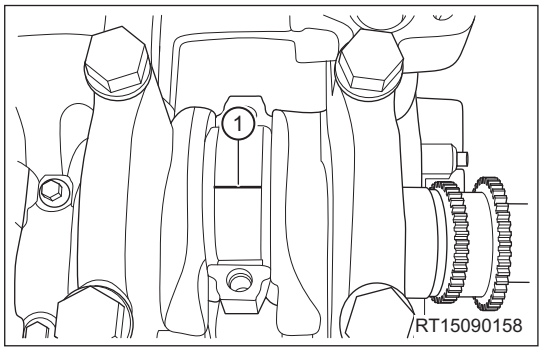
Measurement Item	Specification (mm)	Limit Value (mm)
Crankshaft Connecting Rod Journal Diameter	46	45.984

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.

If radial clearance of connecting rod bearing is still not within specified range after replacement, replace crankshaft.

For selection of connecting rod bearing shell, refer to 10-106.

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.

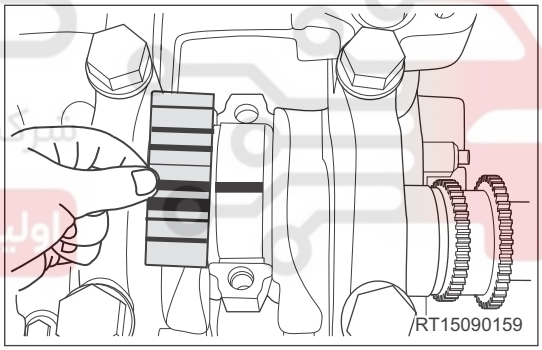


    c. Install connecting rod bearing caps, and tighten connecting rod bearing cap fixing bolts to specified torque.
    (Tightening torque: 1st step: 15 + 3 N·m; 2nd step: 60 + 5°)

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.
    (1.5 TCI + 6MT)



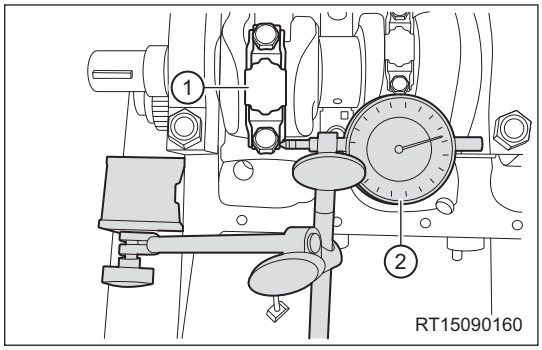
Measurement Item	Specification (mm)
Connecting Rod Bearing Shell Radial Clearance	0.026 ~ 0.062

(1.5 TCI + DCT)

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 the connecting rod bearing shell. Replace crankshaft assembly if necessary.

14. Check axial clearance of connecting rod big end hole.
    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 + 5°)
    b. Install a dial indicator (2) with its plunger contacting the side of connecting rod cap (1).
    c. Turn dial of dial indicator to reset it to zero.
    d. Push connecting rod forward and backward (do not move crankshaft forward and backward) and read value in dial indicator.

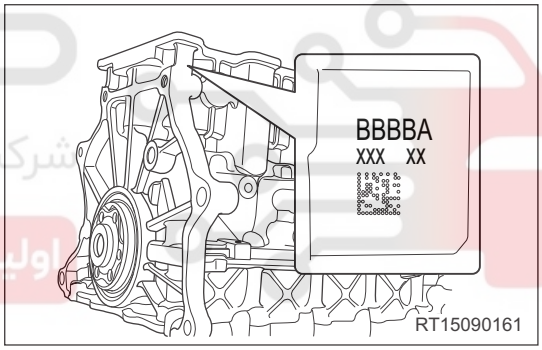


Measurement Item	Specification (mm)
Connecting Rod Big End Hole Axial Clearance	0.15 - 0.40

If axial clearance of connecting rod big end hole is not within specified range, replace piston connecting rod assembly.

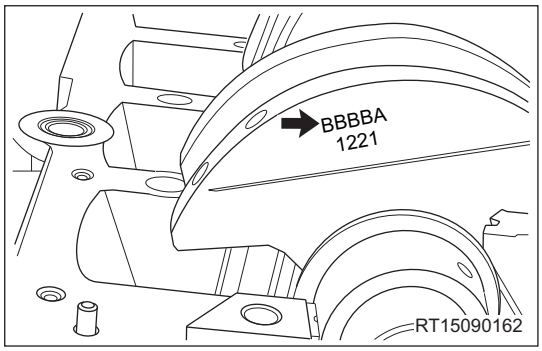
Selection of Main Bearing Shell

1. Selection of crankshaft main bearing upper shell
   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 upper shell. First letter "B" is for upper shell 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
   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:
   a. There is a oil groove and oil hole on main bearing upper shell, and oil hole should be aligned with that on cylinder block, but main bearing lower shell has no oil hole.

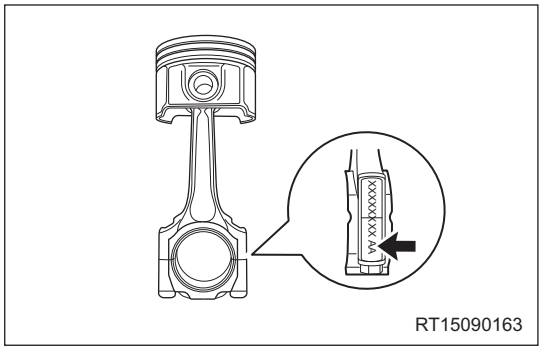
b. Apply a coat of engine oil to surface of main bearing shell before installation. Back side of bearing shell should be clean without any foreign matter during assembly.

Selection of Connecting Rod Bearing Shell

1. Selection of connecting rod bearing upper shell

   Connecting rod bearing upper shells are divided into red shell and blue shell. Related marks are available on connecting rod. Select related connecting rod bearing shell according to marks.

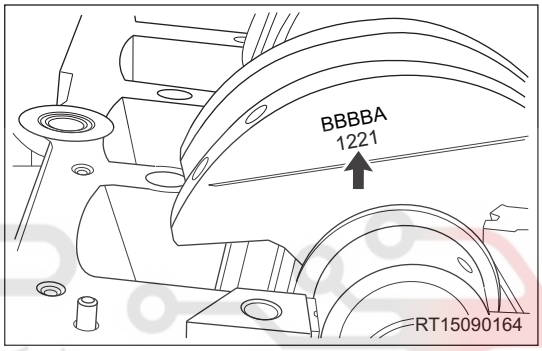
   As shown in illustration, among mark "130523 A" on connecting rod, "A" indicates red shell.



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

2. Selection of connecting rod bearing lower shell

   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.



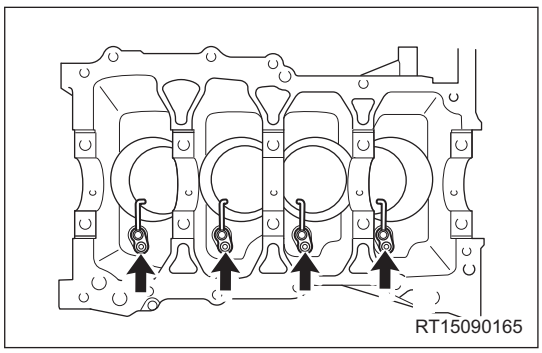
Name	Type	Letter Mark
Connecting Rod Bearing Lower Shell	Red shell	1
	Blue shell	2

3. Precautions for connecting rod bearing shell assembly:
   a. Connecting rod bearing upper and lower shells have no oil grooves, but connecting rod bearing shell has an oil hole.
   b. It is necessary to use a set of connecting rod bearing shells that are provided by the same manufacturer on the same engine.
   c. Apply a coat of engine oil to surface of connecting rod bearing shells before installation. Back side of bearing shell should be clean without any foreign matter during assembly.

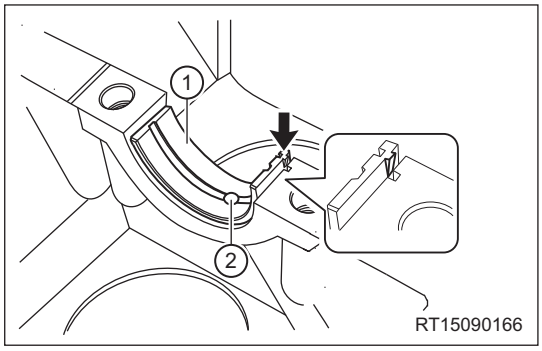
Assembly

1. Install the piston cooling nozzle.
   a. Install piston cooling nozzle and tighten fixing bolts (arrow).

      (Tightening torque: 20 + 5 N·m)



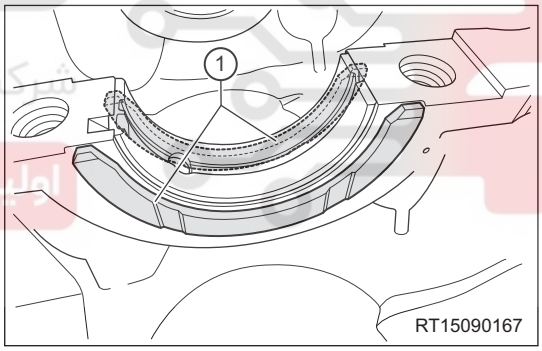
2. Install the crankshaft main bearing shells.
   a. Carefully install crankshaft main bearing upper shell (1) in direction of arrow, and notch of each main bearing upper shell should be aligned with cylinder block. Oil passage hole (2) on crankshaft main bearing upper shell should be aligned with passage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



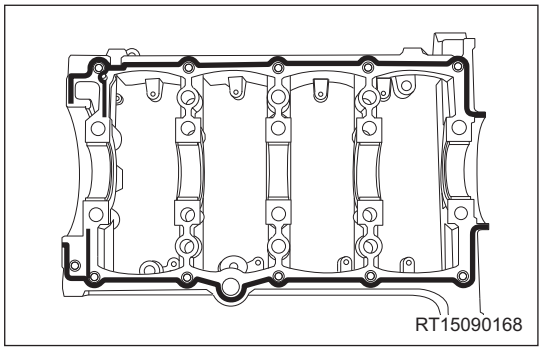
CAUTION

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

   b. Install crankshaft main bearing lower shell to crankshaft frame in the same way.
3. Install the crankshaft thrust washers.
   a. Clean crankshaft thrust washers and cylinder block inner wall before installation.
   b. Apply a coat of engine oil to crankshaft thrust washers.
   c. There are 2 crankshaft thrust washers on the cylinder, which are installed on the front and rear sides of thrust surface (both sides of 3rd bearing) respectively.
   d. As shown in illustration, the two grooves on one side of crankshaft thrust washers (1) face outward while the other side without groove is jointed with the cylinder block inner wall.



4. Install the crankshaft.
   a. Apply seal gum to installation surface of crankshaft frame before installation.

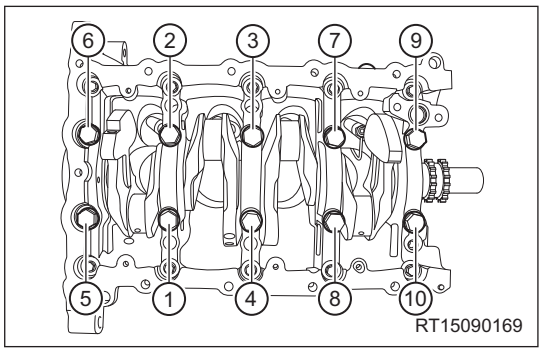


CAUTION

- DO NOT apply seal gum to bearing shell when applying seal gum.
- 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: tighten to 45 ± 5 N·m; 2nd step: rotate by 180 ± 10°)



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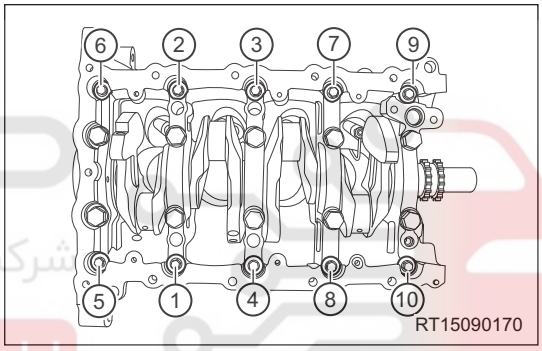
d. Evenly tighten 10 crankshaft frame fixing bolts in order shown in illustration.
(Tightening torque: 27 + 3 N·m)



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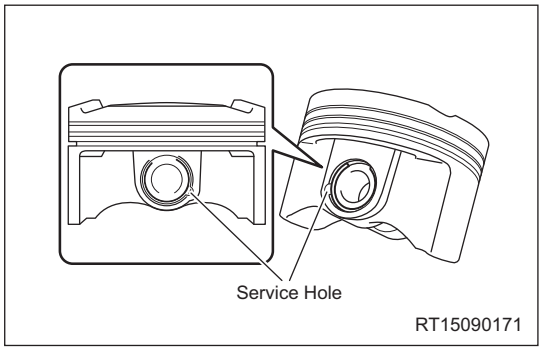
5. Assemble piston and piston connecting rod.

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 piston pin snap ring to one end of piston pin hole.



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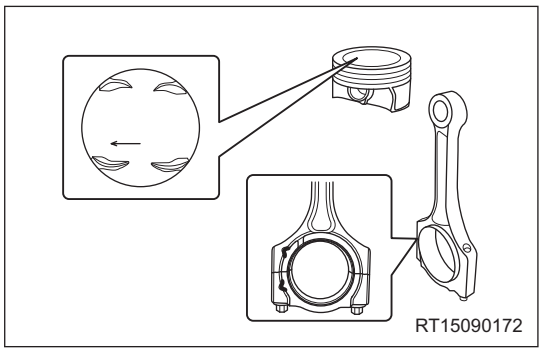
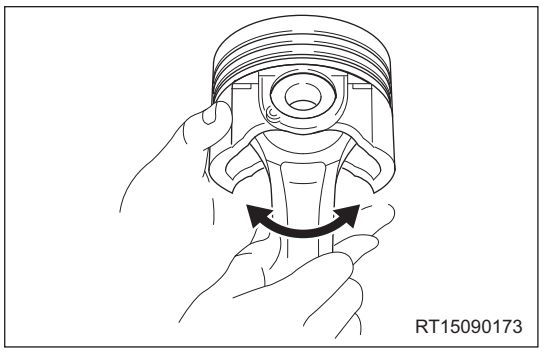
b. Gradually heat pistons to 80°C - 90°C.

c. Align front marks on piston and piston connecting rod, push piston pin with thumb until it contacts with snap ring pin hole.



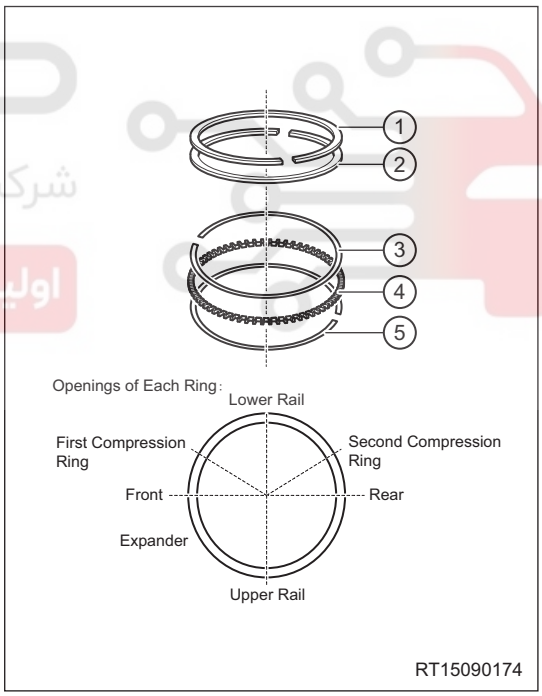
d. Install piston pin snap ring to the other end of piston pin hole, check if piston pin rotates smoothly after installation.



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) 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 two rails with two rails opening of steel band combination oil ring 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 120° from the upper rail opening. The piston ring should rotate in the ring groove freely without any stuck condition.



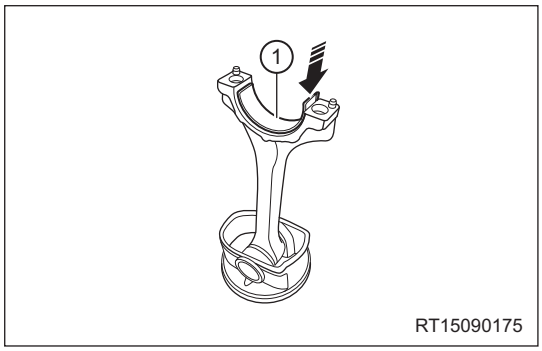
c. Rotate piston ring several turns after addling engine oil to piston ring groove, and note that the position of ring notch should be the same with that described above; clean crankshaft connecting rod journal and cylinder bore with a non-woven fabric cloth.

7. Install the connecting rod bearing shells.

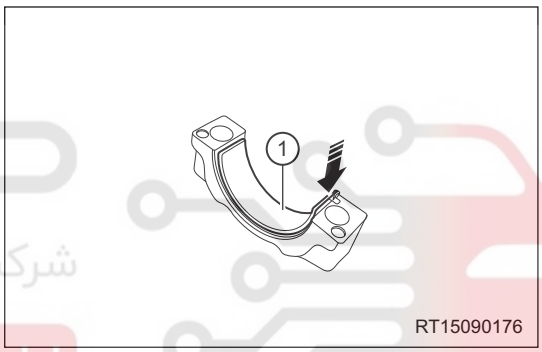
CAUTION

- 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 oil or foreign matter during assembly.

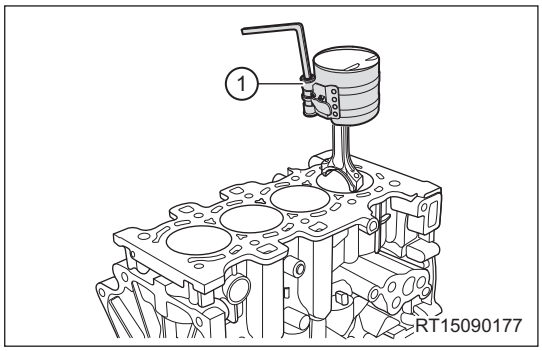
a. Carefully install connecting rod bearing upper shell (1) in direction of arrow, and keep the notch of each connecting rod bearing upper shell face the piston and connecting rod assembly.



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 groove opening of connecting rod bearing cap.

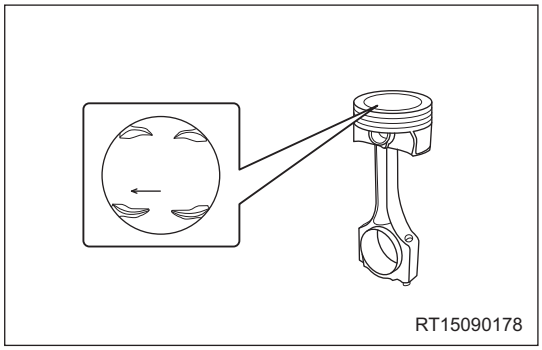


8. Install the piston connecting rod assembly.
   a. Rotate crankshaft to the top dead center of cylinder 1 and cylinder 4.
   b. Apply a coat of engine oil to piston surface and cylinder inner wall.
   c. As shown in illustration, install piston connecting rod assembly to cylinder with piston installer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



CAUTION

- Pay attention to front marks on piston and connecting rod during assembly, without being reversed.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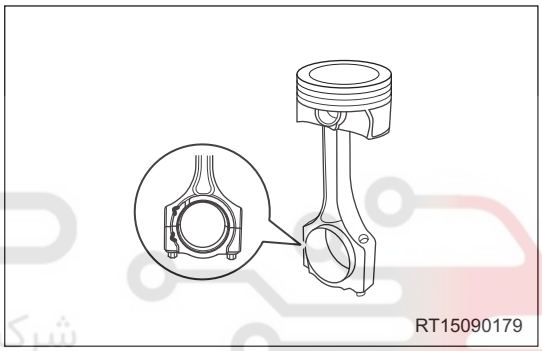
9. Install the connecting rod bearing cap.

HINT:
Protrusion points on connecting rod and connecting rod bearing cap are in same side.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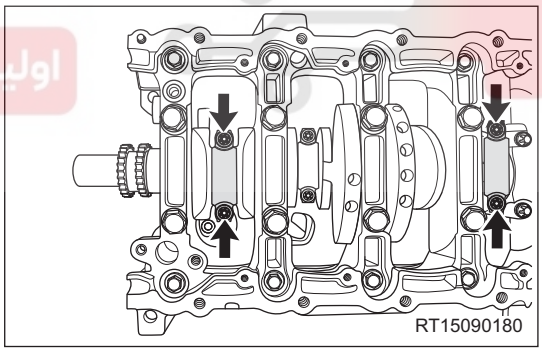
a. Install connecting rod bearing caps in place, and screw connecting rod bearing cap fixing bolts (arrow) by hands, then tighten connecting rod bearing cap fixing bolts in 2 steps with a torque wrench.

(Tightening torque: 1st step: tighten to 15 + 3 N·m; 2nd step: 60 + 5°)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CAUTION

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

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

- MEMO -