ENGINE

CONTENTS

ENGINE ASSEMBLY

1111

TABLE OF CONTENTS

1. DESCRIPTION AND OPERATION

▶ Cleanliness and Care

An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in the ten-thousanths of an inch. When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of enigne oil should be applied to friction areas during assembly, to protect and lubricate the surfaces on initial operation. Proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.

Whenever valve train components are removed for service, they should be kept in order. They should be installed in the same locations, and with the same mating surfaces, as when they were removed.

Battery cables should be disconnected before any major work is performed on the engine. Failure to disconnect cables may result in damage to wire harness or other electrical parts.

▶ On-engine Service

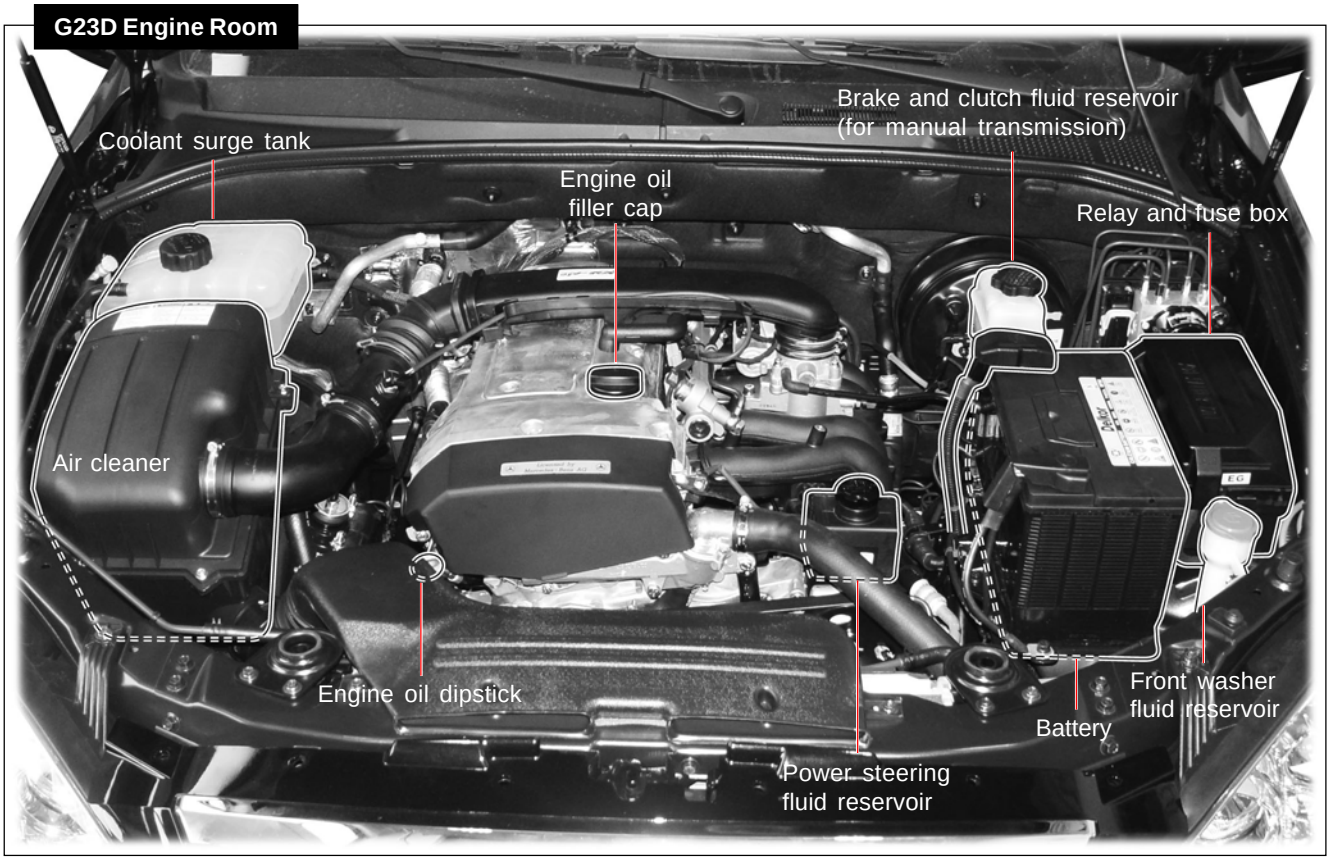
NOTICE

- **Disconnect the negative battery cable before removing or installing any electrical unit, or when a tool or equipment could easily come in contact with exposed electrical terminals. Disconnecting this cable will help prevent personal injury and damage to the vehicle. The ignition must also be in LOCK unless otherwise noted.**

NOTICE

- **Any time the air cleaner is removed, the intake opening should be covered. This will protect against accidental entrance of foreign material, which could follow the intake passage into the cylinder and cause extensive damage when the engine is started.**

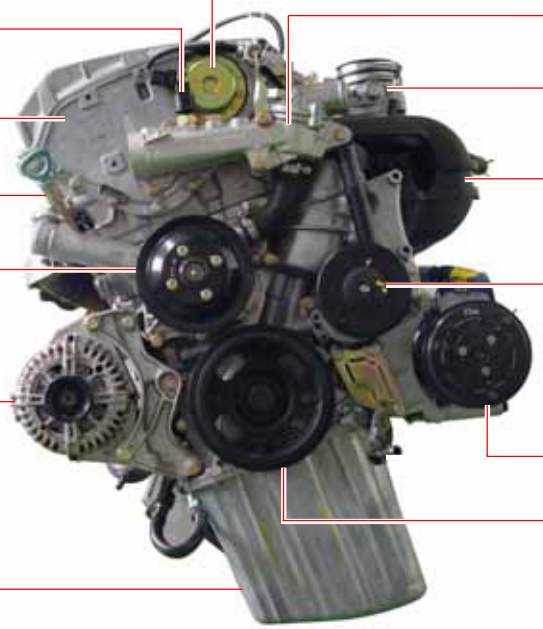
G23D Engine Room



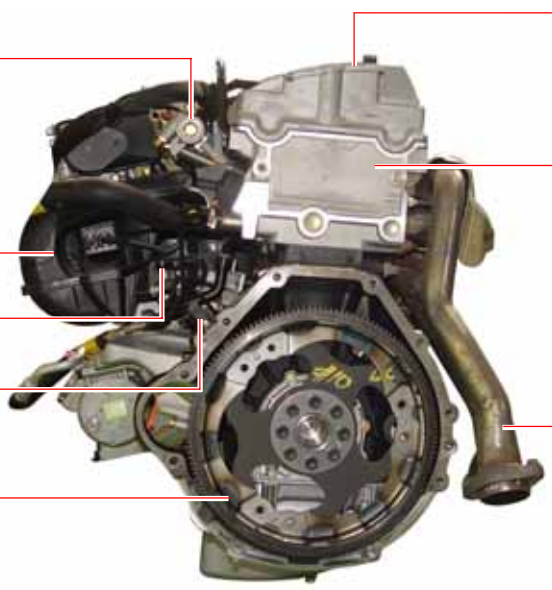
CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

2. G23D ENGINE ASSEMBLY

Front View

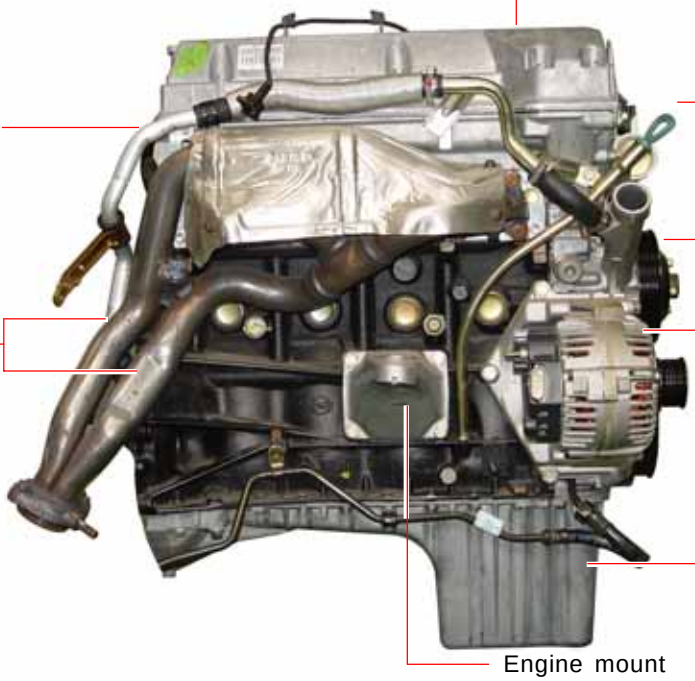


Rear View



LH Side View

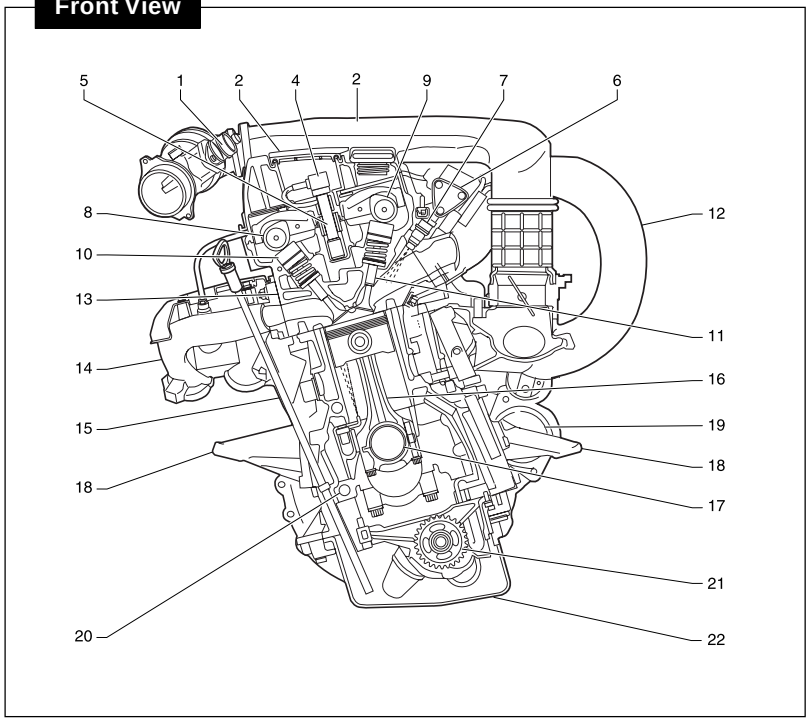
RH Side View



CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

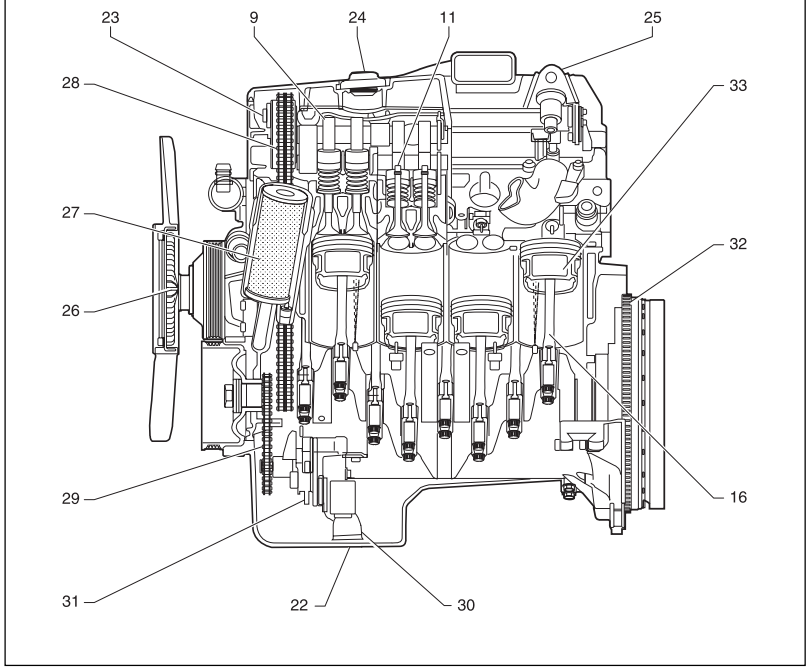
▶ G23D Engine Structure

Front View



1. Intake Air Temperature Sensor
2. Intake Air Duct
3. Cylinder Head Cover
4. Ignition Coil
5. Spark Plug Connector
6. Fuel Distributor
7. Injector
8. Exhaust Camshaft
9. Intake Camshaft
10. Valve Tappet
11. Intake Valve
12. Intake Manifold
13. Cylinder Head
14. Exhaust Manifold
15. Dipstick Guide Tube and Gauge
16. Connecting Rod
17. Crankshaft
18. Engine Mounting Bracket
19. Starter
20. Crankcase
21. Oil Pump Sprocket
22. Oil Pan

Side View



23. Camshaft Adjuster
24. Oil Filler Cap
25. Engine Hanger Bracket
26. Cooling Fan and Viscous Clutch
27. Oil Filter
28. Timing Chain
29. Oil Pump Drive Chain
30. Oil Strainer
31. Oil Pump
32. Ring Gear and Flywheel of Drive Plate
33. Piston

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

3. DIAGNOSTIC INFORMATION AND PROCEDURE

▶ Oil Leak Diagnosis

Most fluid oil leaks are easily located and repaired by visually finding the leak and replacing or repairing the necessary parts. On some occasions a fluid leak may be difficult to locate or repair. The following procedures may help you in locating and repairing most leaks.

Finding the Leak

1. Identify the fluid. Determine whether it is engine oil, automatic transmission fluid, power steering fluid, etc.
2. Identify where the fluid is leaking from.
   2.1 After running the vehicle at normal operating temperature, park the vehicle over a large sheet of paper.
   2.2 Wait a few minutes.
   2.3 You should be able to find the approximate location of the leak by the drippings on the paper.
3. Visually check around the suspected component. Check around all the gasket mating surfaces for leaks. A mirror is useful for finding leaks in areas that are hard to reach.
4. If the leak still cannot be found, it may be necessary to clean the suspected area with a degreaser, steam or spray solvent.
   4.1 Clean the area well.
   4.2 Dry the area.
   4.3 Operate the vehicle for several miles at normal operating temperature and varying speeds.
   4.4 After operating the vehicle, visually check the suspected component.
   4.5 If you still cannot locate the leak, try using the powder or black light and dye method.

Powder Method

1. Clean the suspected area.
2. Apply an aerosol-type powder (such as foot powder) to the suspected area.
3. Operate the vehicle under normal operating conditoins.
4. Visually inspect the suspected component. You should be able to trace the leak path over the white powder surface to the source.

Black Light and Dye Method

A dye and light kit is available for finding leaks, Refer to the manufacturer's directions when using the kit.

1. Pour the specified amount of dye into the engine oil fill tube.
2. Operate the vehicle normal operating conditions as directed in the kit.
3. Direct the light toward the suspected area. The dyed fluid will appear as a yellow path leading to the source.

Repairing the Leak

Once the origin of the leak has been pinpointed and traced back to its source, the cause of the leak must be determined in order for it to be repaired properly. If a gasket is replaced, but the sealing flange is bent, the new gasket will not repair the leak. The bent flange must be repaired also. Before attempting to repair a leak, check for the following conditions and correct them as they may cause a leak.

Gaskets

- The fluid level/pressure is too high.
- The crankcase ventilation system is malfunctioning.
- The fasteners are tightened improperly or the threads are dirty or damaged.
- The flanges or the sealing surface is warped.
- There are scratches, burrs or other damage to the sealing surface.
- The gasket is damaged or worn.
- There is cracking or porosity of the component.
- An improper seal was used (where applicable).

Seals

- The fluid level/pressure is too high.
- The crankcase ventilation system is malfunctioning.
- The seal bore is damaged (scratched, burred or nicked).
- The seal is damaged or worn.
- Improper installation is evident.
- There are cracks in the components.
- The shaft surface is scratched, nicked or damaged.
- A loose or worn bearing is causing excess seal wear.

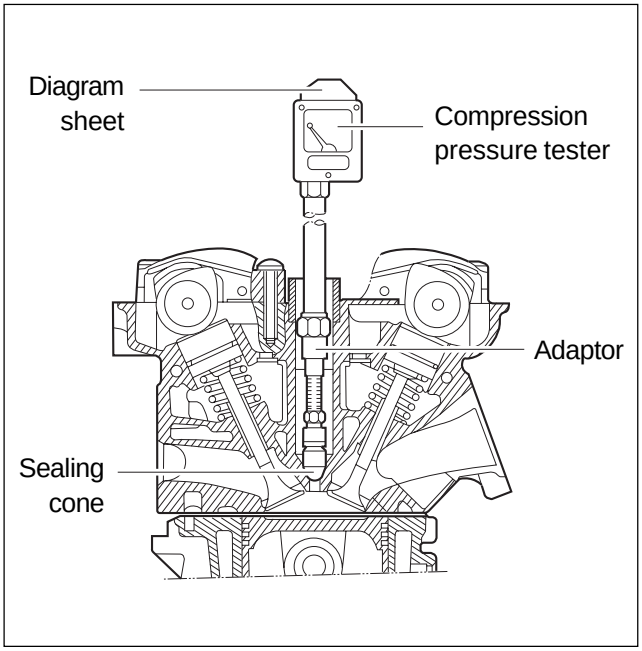
▶ Compression Pressure Test

Standard Service Data

Application	G23D Engine
Compression Ratio	10.4 : 1
Normal Engine Temperature	←
Normal Compression Pressure	Min. 11 bar, Max. 15 bar
Permissible Pressure Difference Between Individual Cylinders	←

Tools Required

A9912 0012B (001 589 76 21 00) Compression Pressure Tester



Measuring Procedure

1. Warm the engine up to normal operating temperature.
2. Remove the spark plugs using the spark plug wrench.
3. Place the diagram sheet to compression pressure tester A9912 0012B (001 589 76 21 00).
4. Connect the adaptor to compression pressure tester A9912 0012B (001 589 76 21 00) and install it into the spark plug hole.
5. Crank the engine approx. eight revolutions by using the start motor.
6. Compare the measurements of compression pressure tester A9912 0012B (001 589 76 21 00) with the specifications.
7. Measure the compression pressure of the other cylinders in the same way.
8. If measured value is not within the specifications, perform the cylinder pressure leakage test.

NOTICE

- **Discharge the combustion residues in the cylinders before testing the compression pressure.**
- **Apply the parking brake before cranking the engine.**

▶ Cylinder Pressure LeakageTest

Permissible Pressure Leakage

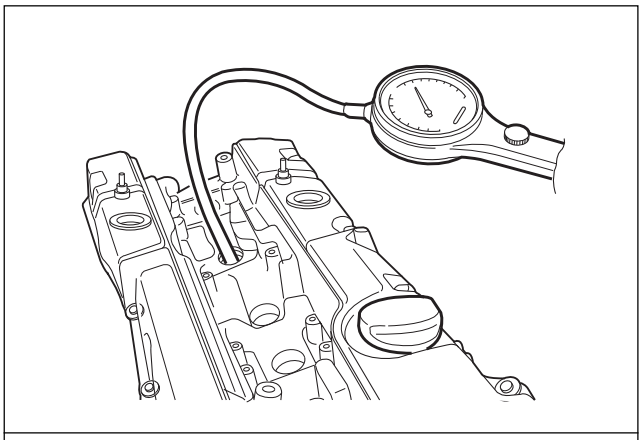
At Whole Engine	Max. 25 %
At Valve and Cylinder Head Gasket	Max. 10 %
At Piston and Piston Ring	Max. 20 %

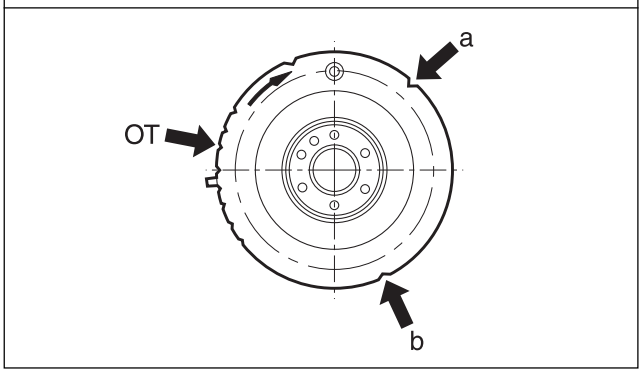
Cylinder Number

OT (TDC)	UT (BDC 180 °)
1, 4	2, 3

Universal Tool

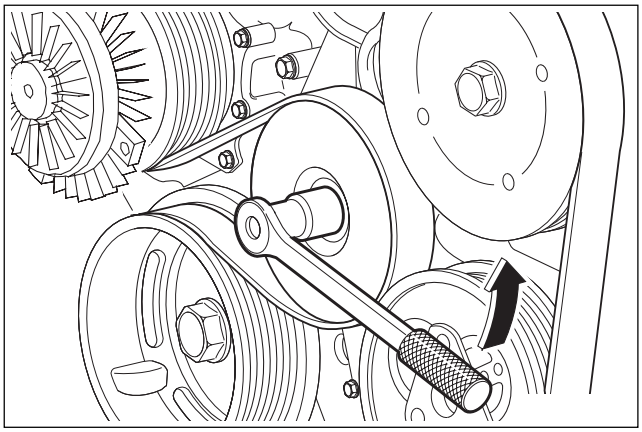
Cylinder Pressure Leakage Tester	Bosch, EFAW210A Sun, CLT 228





Leakage Test

1. Warm the engine up to normal operating temperature.
2. Disconnect the negative battery cable.
3. Remove the spark plugs.
4. Check the coolant level by opening the coolant reservoir cap and replenish if insufficient.
5. Open the engine oil filler cap.
6. Connect the tester to air pressure line and adjust the scale of tester.
7. Install the connecting hose to spark plug hole.
8. Position the piston of No.1 cylinder at TDC by rotating the crankshaft.
9. Connect the connecting hose to tester and measure the leakage volume after blowing up 5 bar of compressed air.



NOTICE

- **Measure the leakage volume in the completely opening condition of throttle valve by pulling the acceleration cable.**

10. Perform the pressure test according to the firing order.

NOTICE

- **Firing Order: 1 - 3 - 4 - 2**

11. Compare the leakage pressure with the specifications.

4. GENERAL DIAGNOSIS

Condition		Probable Cause	Correction
Hard starting (With normal cranking)	Malfunction of immobilizer system	• Faulty immoblilzer system	• Check (Antenna, Immobilizer transponder) • Replace (Antenna, Immobilizer transponder)
	Malfunction of ignition system	• Faulty fuse	• Replace the fuse.
		• Faulty spark plug.	• Clean, adjust the plug gap or replace.
		• Electric leakage at the high tension cable.	• Replace the cable.
		• Poor connection of the high tension cable or lead wires.	• Replace the cable or wires.
		• Faulty ignition coil.	• Replace the ignition coil.
	Malfunction of fuel system	• Empty of fuel in the fuel tank.	• Feed the fuel.
		• Dirty or clogged fuel filter.	• Replace the filter.
		• Clogged fuel pipe.	• Clean the fuel pipe.
		• Malfunction of the fuel pump.	• Replace the fuel pump.
		• Malfunction of the fuel injector.	• Replace the injector.
		• The foreign material in the fuel tank.	• Clean the fuel tank.
	Decline of compression pressure	• Poor tightening spark plug.	• Tighten to the specified torque. Compression
		• Cracked cylinder head gasket.	• Replace the gasket.
		• Inadequate the valve clearance.	• Adjust the clearance.
		• Leakage of the valve clearance.	• Repair the valve.
		• Interference of the valve stem.	• Replace the valve or the valve guide.
		• Low elasticity or damage of the valve spring.	• Replace the valve spring.
		• Abnormal interference of pistons and cylinders.	• Replace the piston ring.
		• Excessive wear of pistons, rings, or cylinders.	• Replace the ring or the piston and boring or replace the cylinder.
	Others	• Broken timing belt.	• Replace the belt.
		• Loosening, damage or leakage of the vacuum hose.	• Connect the hose correctly or replace it.
		• Leakage of intake system.	• Replace intake system.
Lack of engine power	Decline of compression pressure	• Refer to above in this page.	• Refer to above in this page.
	Malfunction of ignition system	• Faulty spark plug.	• Adjust or replace the spark plug.
		• Electric leakage or poor connection of the high tension cable.	• Connect the cable correctly or replace it.

▶ General Diagnosis (Cont'd)

Condition		Probable Cause	Correction
Lack of engine power	Malfunction of fuel system	• Clogged fuel pipe.	• Clean the pipe.
		• Clogged or contaminated fuel filter.	• Replace the filter.
	Others	• Clogged exhaust system.	• Check and repair the system.
		• Clogged or contaminated air cleaner element.	• Clean or replace the air cleaner element.
		• Leak of the intake manifold gasket.	• Replace the gasket.
		• Dragging brakes.	• Repair or replace the brakes.
Rough engine idling	Decline of compression pressure	• Refer to "Page 1A-7".	• Refer to "Page 1A-7".
	Malfunction of fuel system	• Clogged fuel pipe.	• Clean the pipe.
		• Clogged or contaminated fuel filter.	• Replace the filter.
		• Malfunction of the fuel pressure regulator.	• Replace the regulator.
	Malfunction of ignition system	• Malfunction of the spark plug.	• Adjust or replace the spark plug.
		• Electric leakage or poor connection of the high tension cable.	• Connect the cable correctly or replace it.
		• Malfunction of the ignition coil.	• Replace the ignition coil.
	Others	• Clogged or contaminated air cleaner element.	• Clean or replace the air cleaner element.
		• Leak of the intake manifold gasket.	• Replace the gasket.
		• Poor connection or damage or leakage of the vacuum hose.	• Connect the hose correctly or replace it.
Engine hesitate (Upon pressing accelerating pedal, the engine makes delayed response This situation is remarkable when cruising or starting.)	Decline of compression pressure	• Refer to "Page 1A-7".	• Refer to "Page 1A-7".
	Malfunction of ignition system	• Poor spark plug or Poor adjustment of the plug gap.	• Replace the plug or adjust the gap.
		• Electric leakage or poor connection of the high tension cable.	• Connect the cable correctly or replace it.
	Improper ignition timing	• Improper Ignition Timing	• Adjust the timing chain and check the dwell time control.
	Others	• Malfunction of the air cleaner system.	• Clean or replace the air cleaner system.
		• Leak of the intake manifold gasket.	• Replace the gasket.

▶ General Diagnosis (Cont'd)

Condition		Probable Cause	Correction
Engine surging (Engine power makes fluctuation in a fixed speed and speed changes without operating the accelerating pedal.)	Decline of compression pressure	• Refer to "Page 1A-7".	• Refer to "Page 1A-7".
	Malfunction of fuel system	• Clogged fuel pipe.	• Clean the pipe.
		• Clogged or contaminated fuel filter.	• Replace the filter.
		• Malfunction of the fuel pressure regulator.	• Replace the fuel pressure regulator.
	Malfunction of ignition system	• Malfunction of the spark plug.	• Adjust or replace the spark plug.
		• Electric leakage or poor connection of the high tension cable.	• Connect the cable correctly or replace it.
		• Poor ignition timing.	• Adjust the ignition timing.
	Improper ignition timing	• Improper Ignition Timing	• Adjust the timing chain and check the dwell time control.
	Others	• Leak of the intake manifold gasket.	• Clean or replace the gasket.
		• Leakage of the vacuum hose.	• Connect the hose correctly or replace it.
Excessive detonation (According to the opening range of Malfunction of metallic is made with abnormal explosion)	Overtheated engine	• Refer to "Overheat" in this page.	• Refer to "Overheat" in this page.
	Malfunction of ignition system	• Abnormal spark plug.	• Replace the spark plug.
		• Electric leakage or poor connection of the high tension cable.	• Connect the cable correctly or replace it.
	Malfunction of fuel system	• Clogged or contaminated fuel filter and fuel pipe.	• Clean or replace the fuel filter and the fuel pipe.
	Improper ignition timing	• Improper Ignition Timing	• Adjust the timing chain and check the dwell time control.
	Others	• Leak of the intake manifold gasket.	• Replace the gasket.
		• Excessive carbon deposit due to abnormal combustion.	• Remove the carbon.
Overheat	Malfunction of cooling system	• Lack of coolant.	• Refill coolant.
		• Malfunction of the thermostat.	• Replace the thermostat.
		• Malfunction of the cooling fan.	• Check or replace the cooling fan.
		• Poor water pump performance.	• Replace the pump.
		• Clogged or leaky radiator.	• Clean, repair or replace the radiator.
	Malfunction of lubrication system	• Poor engine oil.	• Replace engine oil with the specified one.
		• Blocking oil filter or strainer.	• Clean or repair the oil filter or the strainer.
		• Lack of engine oil.	• Refill oil.
		• Poor oil pump performance.	• Replace or repair the pump.
	Other	• Leakage of oil	• Repair.
		• Damaged cylinder head gasket.	• Replace the gasket.

▶ General Diagnosis (Cont'd)

Condition		Probable Cause	Correction
Poor fuel consumption	Decline of compression pressure	• Refer to "Page 1A-7".	• Refer to "Page 1A-7".
	Malfunction of fuel system	• Leakage of the fuel tank or the fuel pipe.	• Repair or replace the fuel tank or the fuel pipe
	Malfunction of ignition system	• Abnormal spark plug (Excessive carbon deposit, inadequate gap, burnt electrode).	• Replace the plug.
		• Electric leakage or poor connection of the high tension cable.	• Connect the cable normally or replace it.
	Malfunction of cooling system	• Malfunction of the thermostat.	• Repair the thermostat.
	Others	• Improperly installed valve.	• Repair or replace the valve.
		• Low pressure of tires.	• Adjust the pressure of tires.
Excessive consumption of engine oil	Leakage of engine oil	• Loosened oil drain plug.	• Tighten the plug.
		• Loosened oil pan bolt.	• Tighten the bolt. Engine Oil
		• Loosened oil filter.	• Tighten the filter.
		• Loosened oil pressure switch.	• Tighten the switch.
		• Leakage of camshaft front oil seal.	• Replace the seal.
		• Leakage of crankshaft front oil seal.	• Replace the seal.
		• Leakage at the cylinder head cover gasket.	• Replace the gasket.
		• Damage of the cylinder head gasket.	• Replace the gasket.
	Oil mixing in combustion chamber	• Stuck piston ring.	• Remove carbon and replace the ring.
		• Worn piston or cylinder.	• Replace the piston or the cylinder.
		• Worn piston ring or ring groove.	• Replace the piston or ring.
		• Inadequate position of the piston ring cutting part.	• Adjust the position.
		• Abrasion or damage of the valve system.	• Replace the valve system.
Low oil pressure	Malfunction of lubrication system	• Inadequate oil viscosity.	• Replace with the specified one.
		• Loosening of the oil pressure switch.	• Tighten the switch.
		• Lack of engine oil.	• Refill oil.
		• Blocking oil strainer.	• Clean the strainer.
		• Lowered function of the oil pump.	• Replace the pump.
		• Abrasion or damage of the oil pump relief valve.	• Replace the valve.

▶ General Diagnosis (Cont'd)

Condition		Probable Cause	Correction
Engine noise	Valve noise	• Inadequate valve clearance	• Adjust the valve clearance.
		• Abrasion of valve stem or guide.	• Replace the valve stem or the guide.
		• Weak valve spring.	• Replace the spring.
	Piston, ring, cylinder noise	• Abrasion of the piston, the ring or the cylinder.	• Boring the cylinder or replace the piston, the ring or the cylinder.
	Connecting rod noise	• Abrasion of the connecting rod bearing.	• Replace the bearing.
		• Loosened the connecting rod nut.	• Tighten to the specified torque
	Crankshaft noise	• Abrasion of the crankshaft bearing.	• Replace the bearing.
		• Abrasion of the crankshaft journal.	• Grind or replace the crankshaft journal.
		• Loosened bearing cap bolt.	• Tighten to the specified torque.
		• Excessive clearance of the crankshaft thrust bearing.	• Adjust or replace.

5. SPECIFICATIONS

▶ Engine Specifications

Application			G23D Engine	Remarks
Engine Model			M161.970	
Displacement			2295 cc	
Cylinder (Bore x Stroke)			90.9 x 88.4 mm	
Fuel Injection / Ignition System			MSE 3.53D	
Compression Ratio			10.4 : 1	
Number of Cylinders			4	
Camshaft Valve Arrangement			DOHC	
Camshaft Drive Type			Chain-Driven	
Max. Output			150 ps / 5500 rpm	
Max. Torque			214 Nm / 3500 ~ 4000 rpm	
Firing Order			1 - 3 - 4 - 2	
Ignition Type			Distributor less double ignition	
Ignition Timing			BTDC 6° ± 2°	
Valve Timing	Intake	Open/Close	ATDC 13.15° / ABDC 13.57°	
	Exhaust	Open/Close	BBDC 16.58° / BTDC 17.05°	
Valve Clearance Adjustment			←	
Idle Speed			750 ± 50 rpm	
Fuel Injection Pressure			3.2 - 4.2 kg/cm²	
Oil Capacity			7.5 ℓ (When shipping: 7.9 ℓ)	
Lubrication Type			Forced by gear pump	
Oil Filter Type			Full flow with paper filter	
Fuel			Unleaded gasoline	

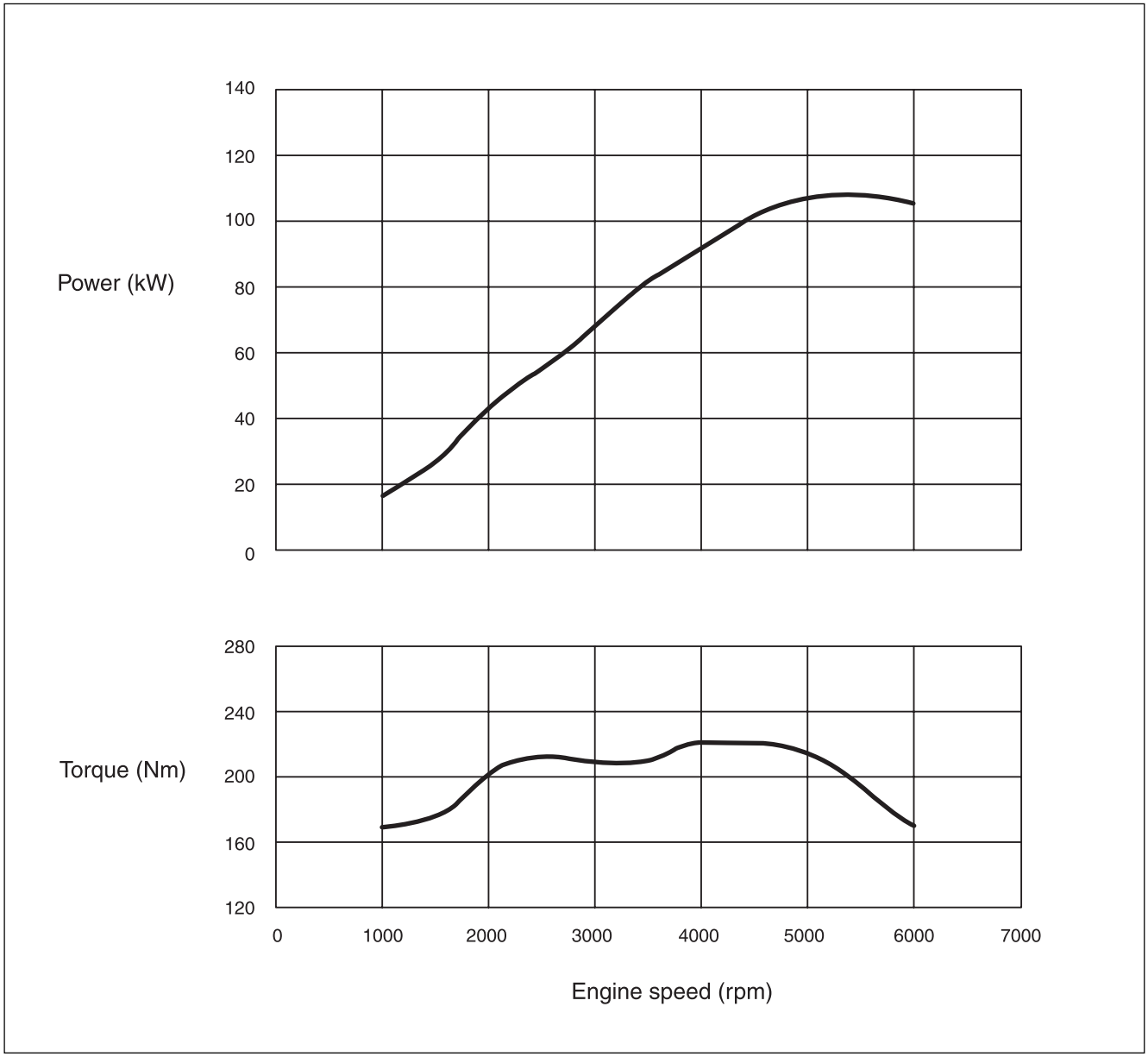
MSE : Engine Control Module

3.53D : 4 Cylinder Version

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Performance Curve

G23D Engine



6. SPECIAL TOOLS AND EQUIPMENT

▶ Special Tools Table

Name and Part Number
A99120012B (001 589 76 21 00) Compression Pressure Tester 

ENGINE MECHANICAL

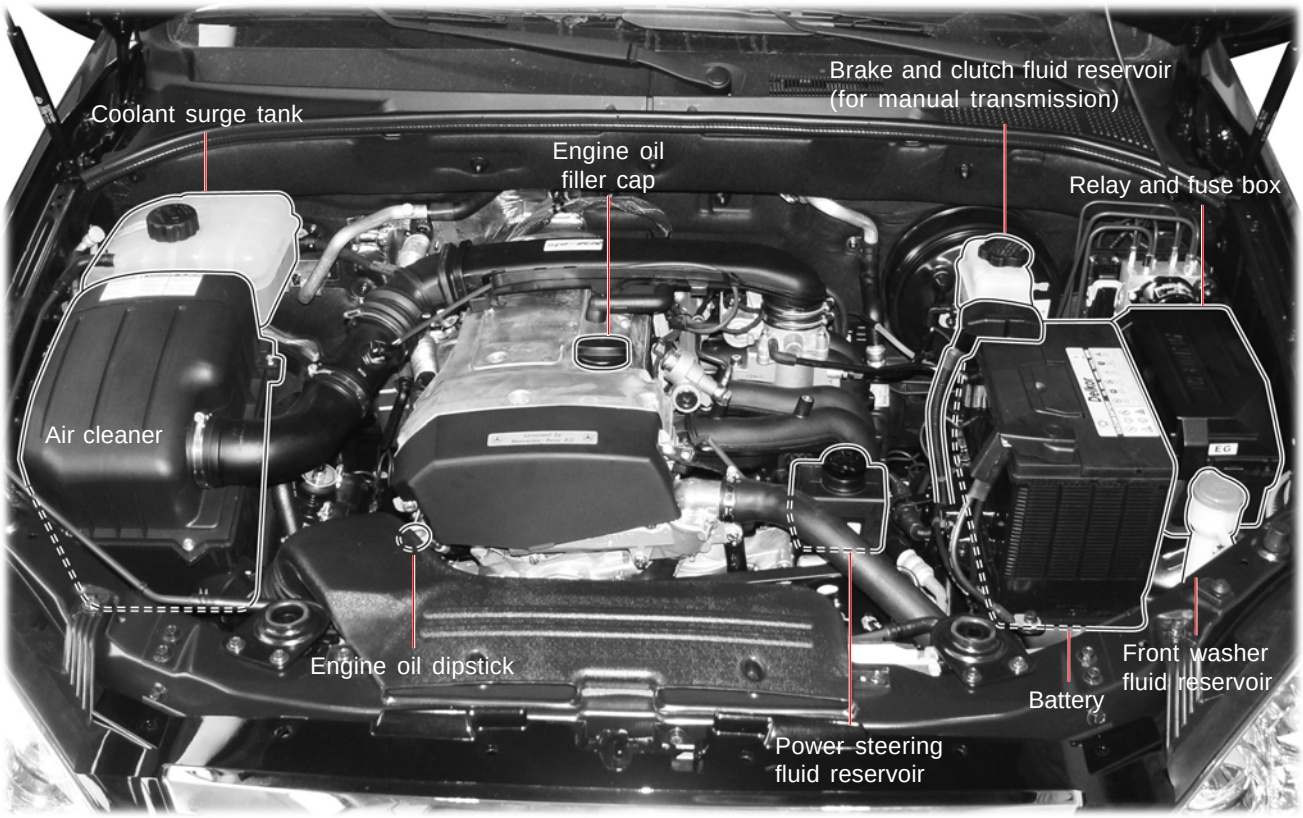
1112

TABLE OF CONTENTS

1. MAINTENANCE AND REPAIR

▶ ON-Vehicle Service

Engine Room



Removal & Installation Procedue

1. Disconnect the negative terminal of battery.
2. Remove the hinge mounting bolt of the hood and separate the uppper clamp of the hood shock absorber to remove the hood.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

3. Remove the under cover.

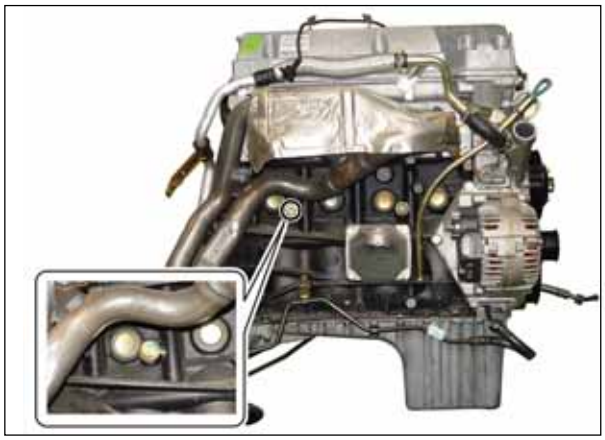
Installation Notice

Tightening Torque	28 - 47 N•m (21 - 35 lb-ft)

4. Loosen the radiator drain cock and drain the coolant.

NOTICE
- **Open the coolant reservoir cap.**

5. Loosen the cylinder block drain plug and then drain the coolant completely.



Installation Notice

Tightening Torque	30 N•m (22 lb-ft)

NOTICE
- **Replace the seal before installation of the drain plug.**

6. Remove the front duct from the vehicle.

7. Disconnect the coupling of Intake Air Temperature Sensor.

8. Remove the bleeder hose and the mounting bolt of the IAT sensor duct to remove the air center duct from the engine compartment.

LH Clamp Mounting Section

RH Clamp Mounting Section

Bleeder Hose

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

9. Remove the clamp of the Center duct and remove the IAT sensor duct from the air cleaner housing.

NOTICE

- **Observe the installation direction of the Center duct.**

10. Separate the reservoir tank from the vehicle by removing the mounting bolt.

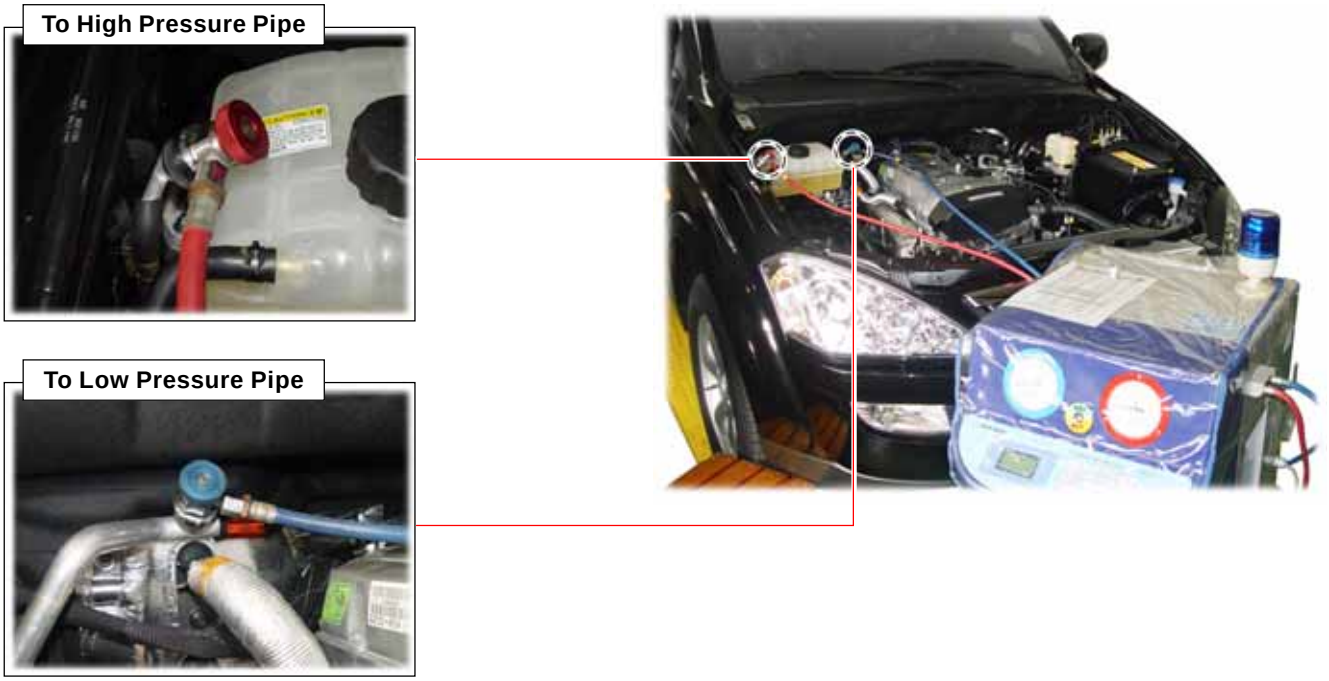
NOTICE

- **Be careful not to spill the remaning coolant on the vehicle or body.**

11. Remove the air cleaner cover. Remove the mounting bolts and air cleaner housing and element assembly.

12. Remove the radiator and PWM electric fans. For more information, refer to "Engine Cooling" section.

13. Drain the A/C refrigerant using the refrigerant collector.



14. Disconnect the upper and the lower hoses of the radiator.

NOTICE

- **Be careful not to spill the coolant when disconnecting the radiator hose.**

15. Disconnect the oil cooler pipe of the automatic transmission.

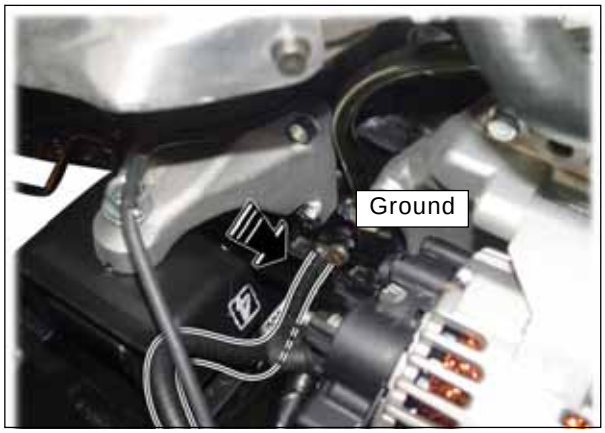
NOTICE

- **Be careful for the oil leakage and collect it using designated collector.**
- **Be careful not to spill the oil on other parts.**

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

16. Disconnect the parts connected to the engine from the engine compartment.

A. Disconnect the terminals and the ground terminal from the generator.



B. Disconnect the ground terminal to the intake manifold.

C. Disconnect the vacuum hose and the purge control hose to the intake manifold.

D. Disconnect the inlet and outlet heater hoses and main connector.

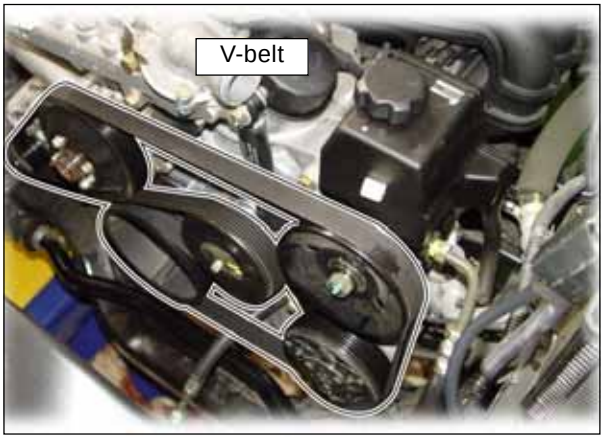
E. Remove the fuel feed and return line.

NOTICE

- **Before removing the fuel lines, release the pressure in the fuel system.**

Tightening Torque	21 - 25 N•m (15 - 18 lb-ft)

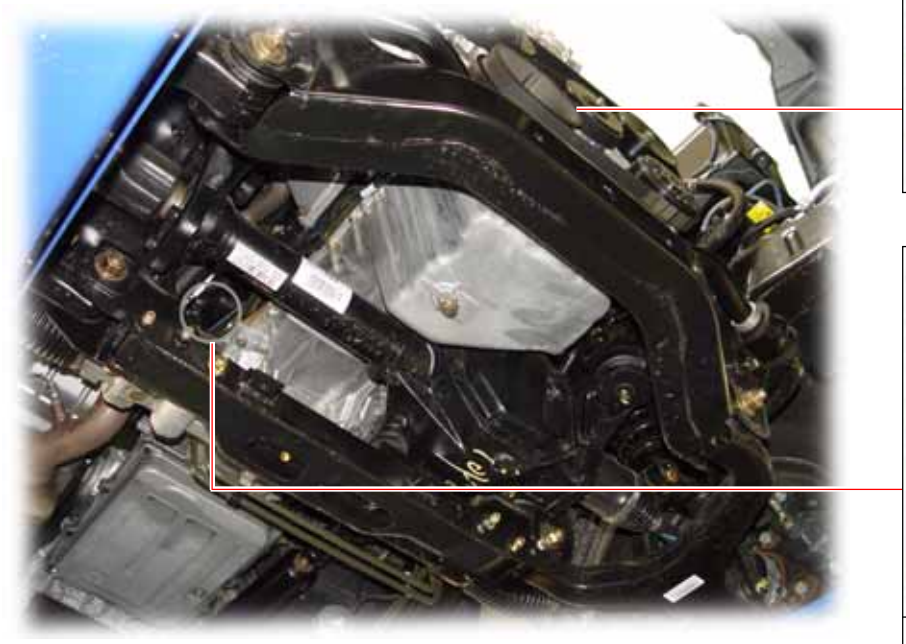
F. Remove the V-belt and the power steering pump assembly from the engine.

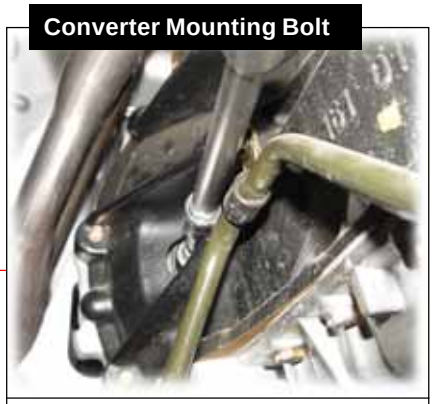


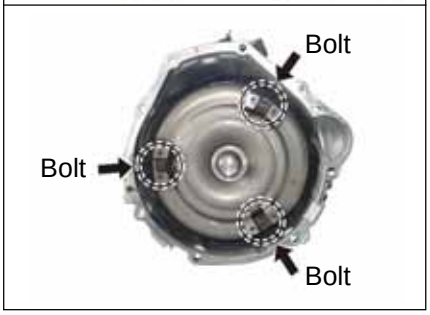
G. Discharge the refrigerant from A/C system, and disconnect the discharge pipe and suction pipe from the compressor.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

17. By rotating the crankshaft from the front of engine, remove the 6 torque converter mounting bolts from the engine ring gear plate.



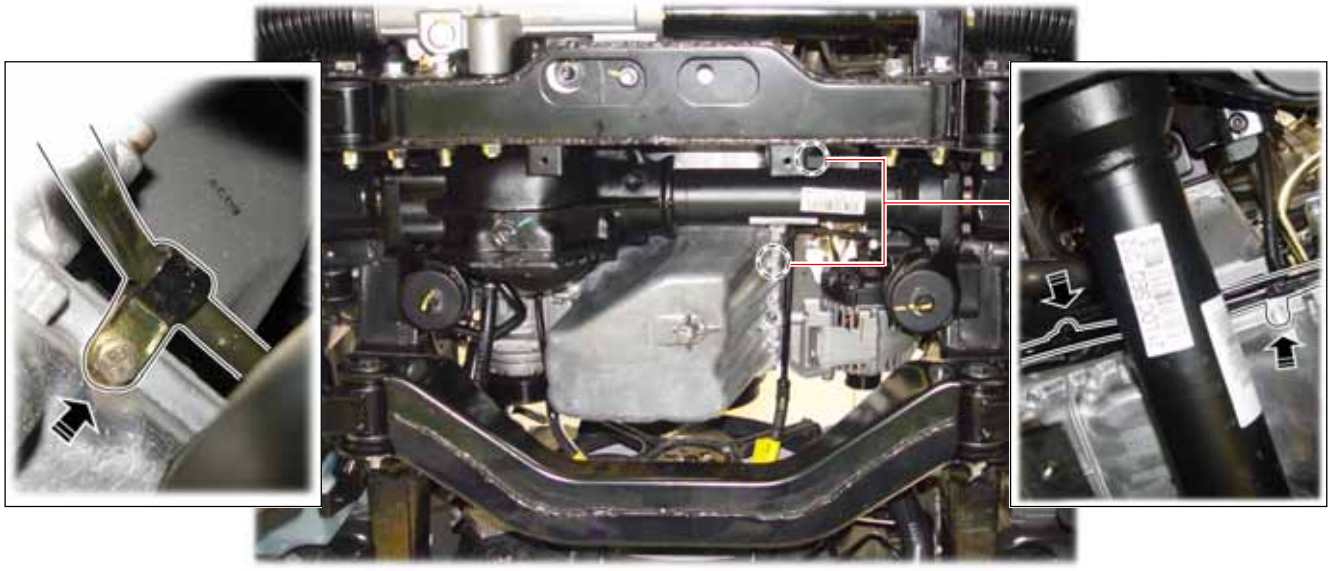




Tightening Torque	42 N•m (31 lb-ft)

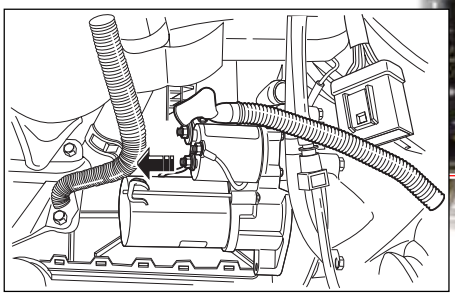
18. Remove the automatic transmission oil cooler line retaining bolts from the automatic transmission side and oil pan side.

    Remove the automatic transmission oil cooler line retaining bolts from engine side and oil pan side.



19. Remove the automatic transmission.

A. Disconnect the terminals from starter motor and remove the starter motor.



B. Remove the exhaust manifold and exhaust pipe.

Installation Notice

Tightening Torque
30 N•m (22 lb-ft)

20. Connect the chain to the engine bracket and unscrew the mounting bolts and nuts (LH/RH) from the engine mounting.

A. Fix the chain to the rear mounting bracket of the engine.

B. Remove the engine front cover and fix the chain to the front mounting bracket of the engine.

RH Mounting Nut

Tightening Torque	70 N•m (52 lb-ft)

C. Remove the RH mounting nut of the engine.

D. Remove the LH mounting nut of the engine.

LH Mounting Bolt

Tightening Torque	70 N•m (52 lb-ft)

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

21. Carefully separate the engine assembly from the vehicle.
22. Installation should follow the removal procedure in the reverse order.

Engine Assembly

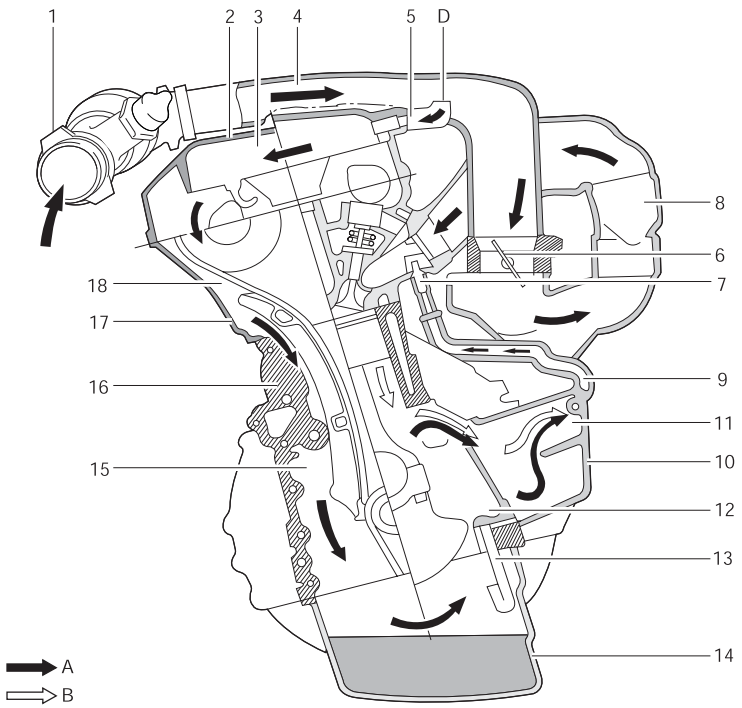
Upper (front) view

RH view

LH view

2. CRANKCASE VENTILATION SYSTEM

▶ Operation at Idling and Mid- Load



1. Intake Air Temperature Sensor
2. Cylinder Head Cover
3. Oil Spearation Chamber (Full-Load or Over Mid-Load)
4. Intake Air Duct (Cross Pipe)
5. Vent Line (Full-Load or Over Mid-Load)
6. Throttle Valve
7. Restrictor, Diameter 1.1mm (Mid-Load at Idling)
8. Intake Manifold
9. Vent Line (Mid-Load at Idling)
10. Air Conditioner Bracket
11. Oil Separation Chamber (Mid-Load at Idling)
12. Crank Chamber
13. Oil Return Pipe
14. Oil Pan
15. Timing Gear Case Cover
16. Crankcase
17. Chain Housing

A. Fresh Air
B. Blow-By Gas
D. Vent Connection

Operation at Idling and Mid- Load

- The throttle valve (6) is closed or very partially opened, and the vacuum pressure in intake manifold is high.

  The blow-by gas and the fresh air that is additionally supplied through the vent connection (D) in the crank-case in partial load gets supplied to the combustion chamber from the crank chamber (12) through the oil separation chamber (11), air-conditioner bracket (10), vent line (9), and restrictor (7) mounted to the cylinder head.

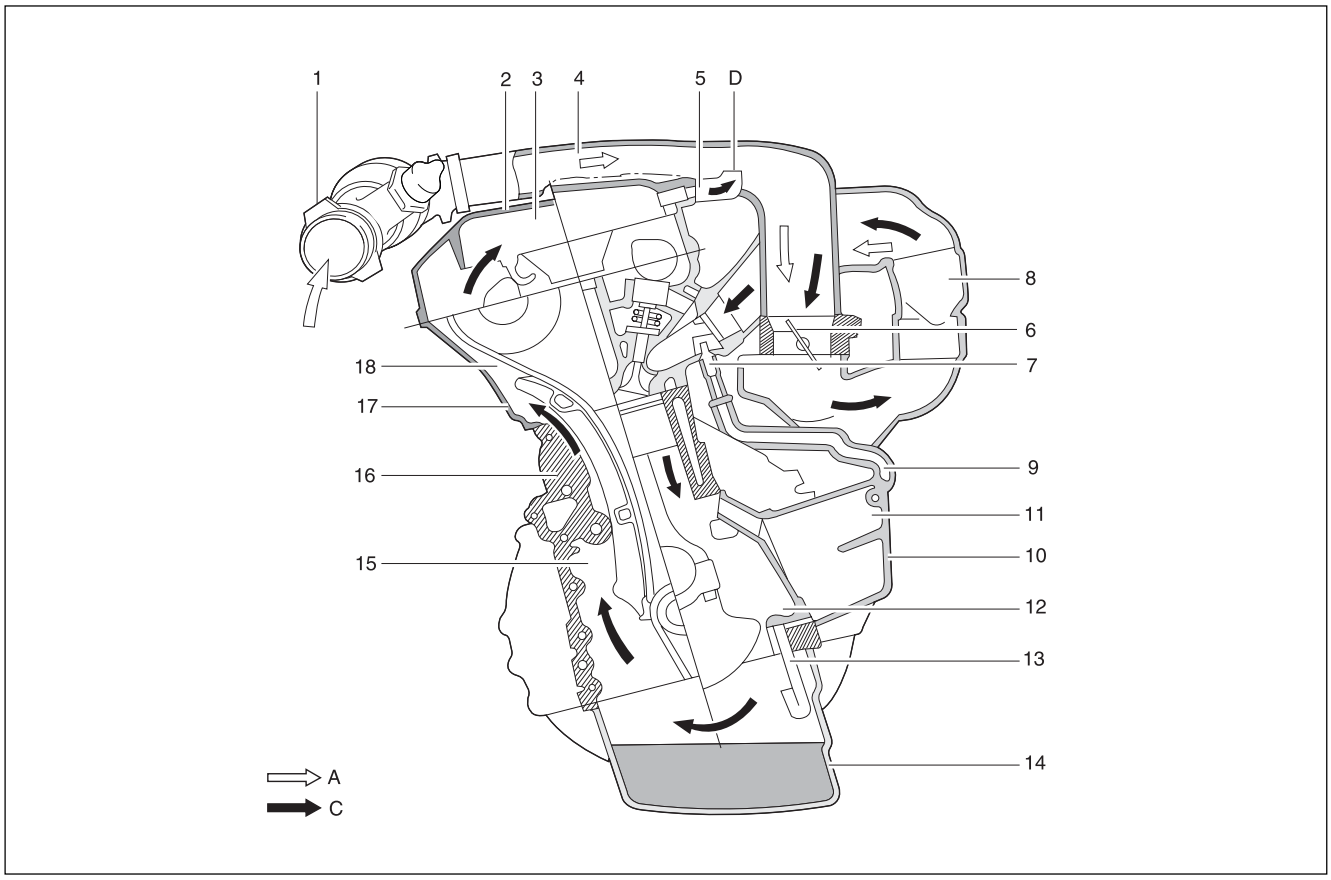
  The circulated engine oil returns to the oil pan through the oil return pipe (13) at the bottom of oil separation chamber (11).

  The fresh air gets supplied to the crank chamber (12) through the Intake Air Temperature Sensor (1), intake air duct (4), vent line (5), oil separation chamber (3), chain housing (17), and the timing gear case cover (15).

  The additional supply of the fresh air is needed to prevent from forming the residues of the engine oil.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Operation When Full- Load at Partial Load



1. Intake Air Temperature Sensor
2. Cylinder Head Cover
3. Oil Spearation Chamber (Full-Load or Over Mid-Load)
4. Intake Air Duct (Cross Pipe)
5. Vent Line (Full-Load or Over Mid-Load)
6. Throttle Valve
7. Restrictor, Diameter 1.1mm (Mid-Load at Idling)
8. Intake Manifold
9. Vent Line (Mid-Load at Idling)
10. Air Conditioner Bracket
11. Oil Separation Chamber (Mid-Load at Idling)
12. Crank Chamber
13. Oil Return Pipe
14. Oil Pan
15. Timing Gear Case Cover
16. Crankcase
17. Chain Housing

A. Fresh Air
C. Blow-By Gas
D. Vent Connection

Operation When Full- Load at Partial Load

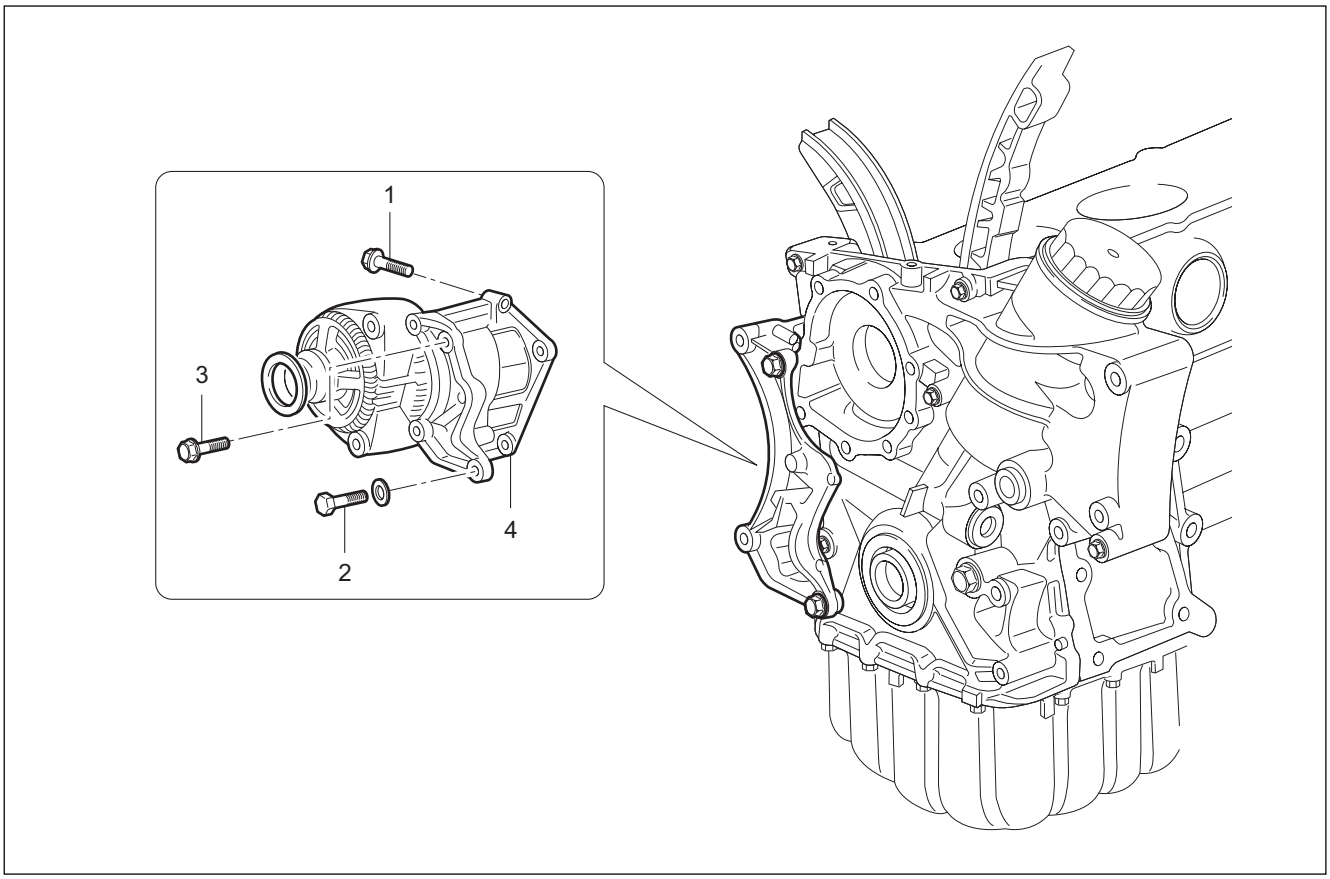
- The throttle valve (6) is partially opened or fully opened.

  The air flows very rapidly through the vent line (5) s connection (D) and the intake air duct when full load at partial load.

  Consequently, most of the low-by gases are supplied to the combustion chamber through the timing gear case cover (15), chain housing (17), oil separation chamber (3), vent line (5), throttle valve (6), and intake manifold (8).

3. REMOVAL AND INSTALLATION IN GROUPS

▶ Alternator



1. Bolt (M8 X 40, 3 pieces)
   ..... 22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)
2. Bolt (M8 X 70, 2 pieces)
   ..... 22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)
3. Bolt (M8 X 85, 1 piece)
   ..... 22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)
4. Alternator Bracket

Removal & Installation Procedure

1. Disconnect the negative battery cable.
2. Remove the drive belt.
3. Remove the alternator.
4. Unscrew the alternator carrier bolts and remove the carrier.

NOTICE

- **Apply 3 Nm of torque when mounting the bolt (1) ; apply 25 Nm of torque when mounting the bolts (2), and (3) ; and then tighten the bolt (1) with 25 Nm of torque.**

5. Installation should follow the removal procedure in the reverse order.

Installation Notice

Tightening Torque	70 N•m (52 lb-ft)

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Engine Mount

Removal & Installation Procedure

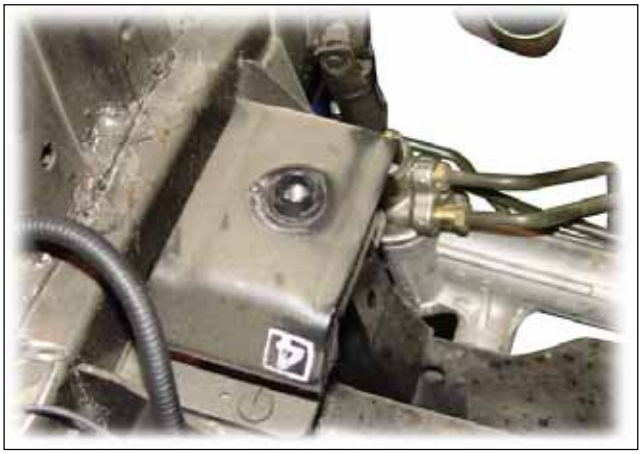
1. Unscrew the upper engine mount nut or bolt and remove the engine.

Tightening Torque	70 N•m (52 lb-ft)

Tightening Torque	70 N•m (52 lb-ft)

2. Unscrew the lower nuts.

Tightening Torque	38 N•m (28 lb-ft)

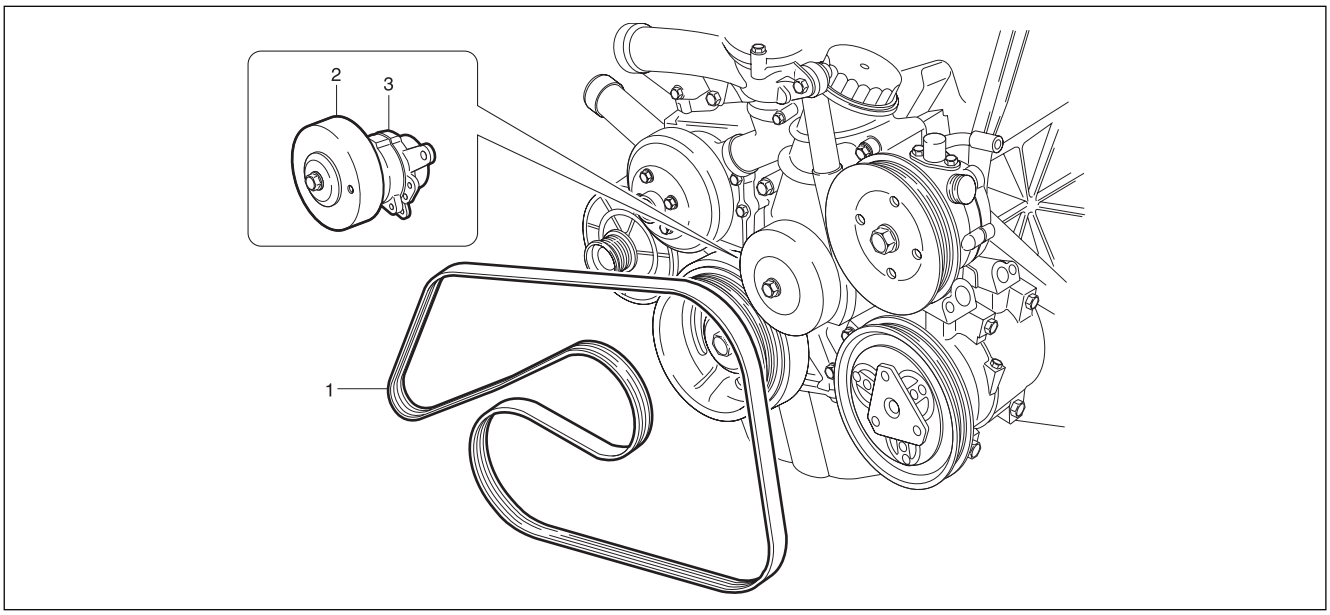


Tightening Torque	38 N•m (28 lb-ft)

3. Remove the hydraulic engine mounting insulator.
4. Installation should follow the removal procedure in the reverse order.

▶Poly V - Belt

※ **Preceding Work:** Removal of cooling fan



1. Poly V-Belt (2,155 mm)
2. Belt Tensioning Pulley
3. Belt Tensioner

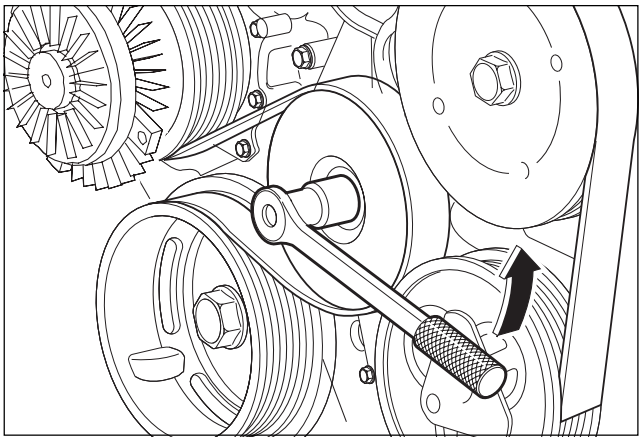
Removal & Installation Procedure

1. Release the belt tension by turning the stud on the cap with 12 sided wrench or spanner counterclock-wise.
2. Remove the poly v-belt.

NOTICE

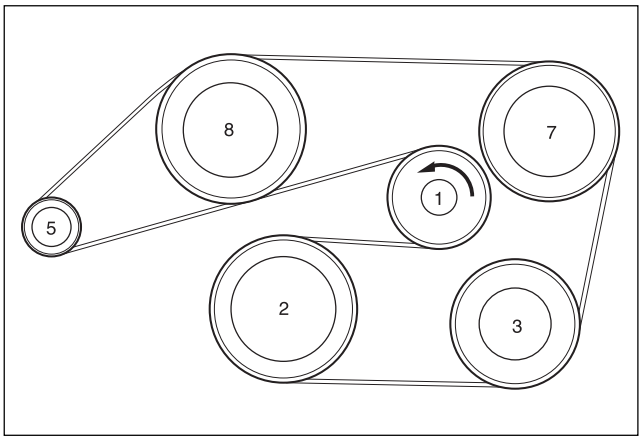
- **Check the belt for damage and tensioning pulley bearing point for wear and replace them if necessary.**

3. Install the belt after prying the tensioning pulley.



Poly V - Belt Arrangement

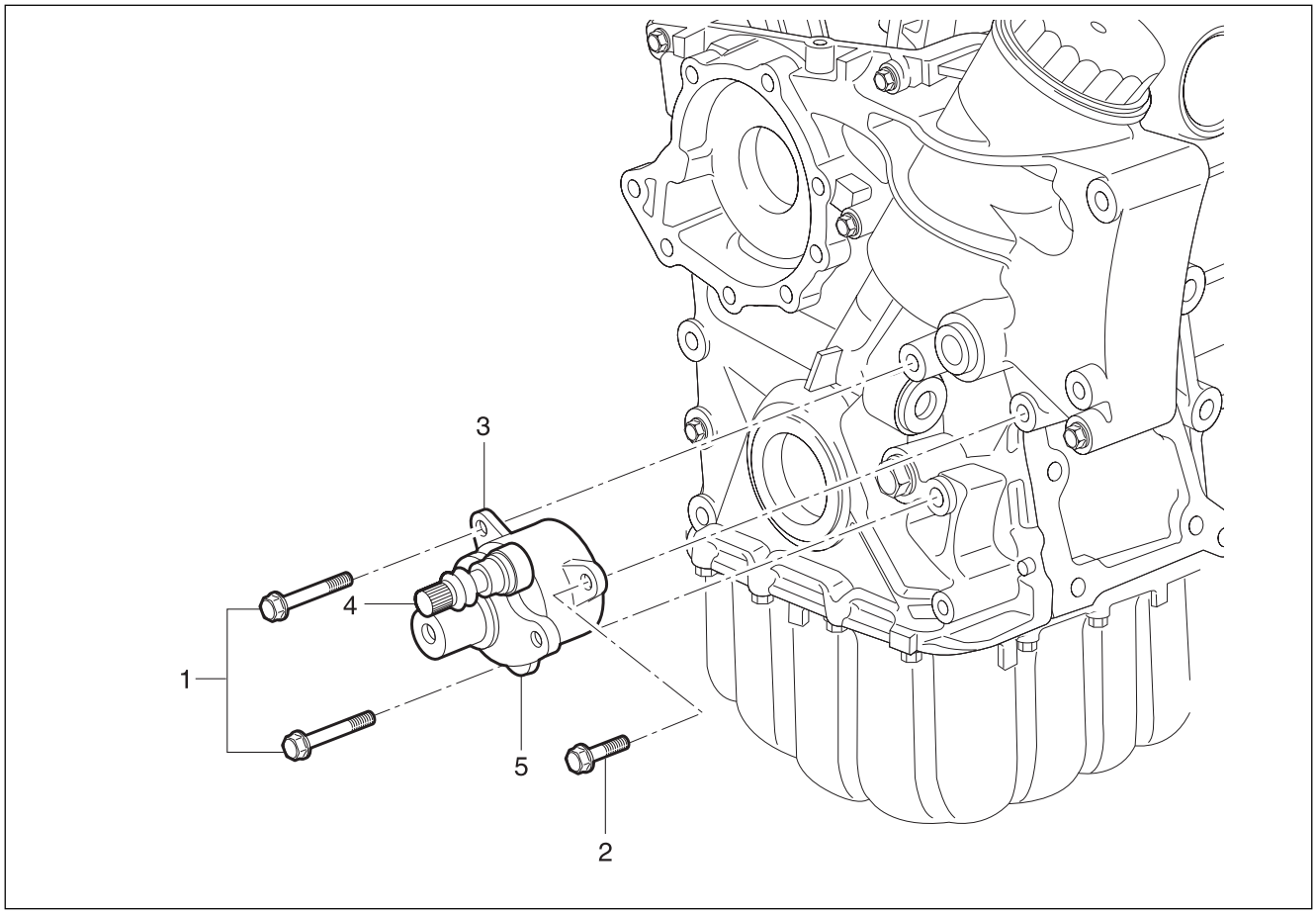
1. Belt Tensioning Pulley
2. Crankshaft Pulley
3. A/C Compressor Pulley
5. Generator Pulley
7. Power Steering Pump Pulley
8. Water Pump Pulley



CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Tensioning Device

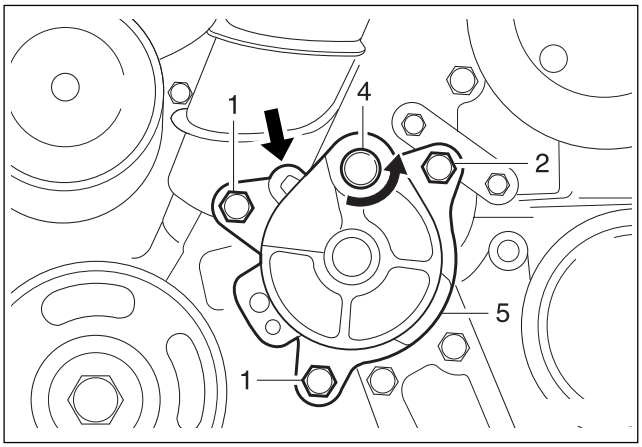
※ **Preceding Work:** Removal of tensioning device shock absorber



1. Bolt (M8 x 75, 2 pieces) + Washer ..... 22.5 - 27.5 N•m (16.6 - 0.3 lb-ft)
2. Bolt (M8 x 25, 1 pieces) + Washer ..... 22.5 - 27.5 N•m (16.6 - 0.3 lb-ft)
3. Tensioning Device
4. Stud bolt
5. Tensioning Arm

Removal & Installation Procedure

1. Turn the stud bolt to counterclockwise.
2. Insert the pin into the hole in tensioning arm.
3. Unscrew the bolts (1, 2) and remove the tensioning device.

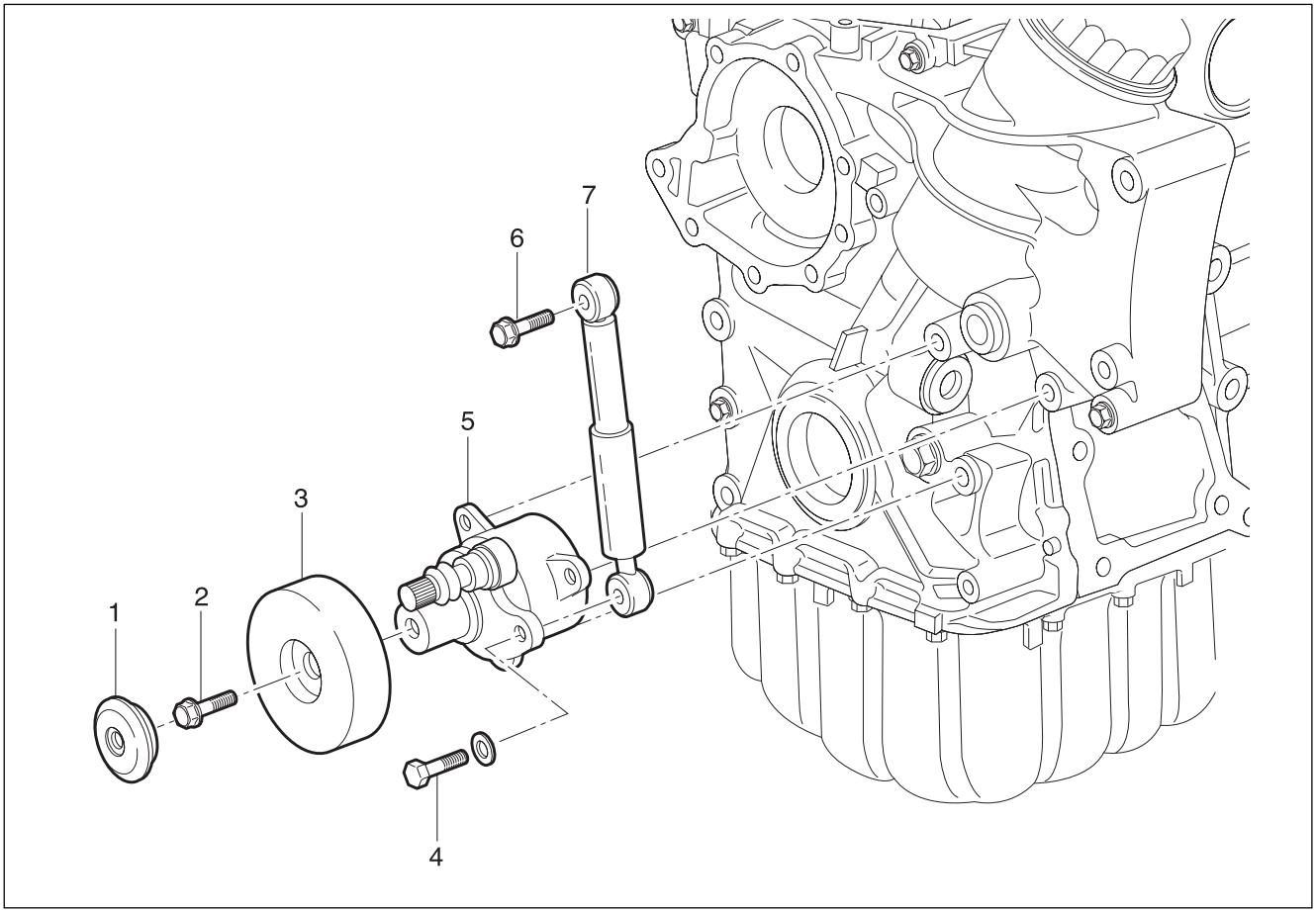


Installation Notice

Tightening Torque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

4. Installation should follow the removal procedure in the reverse order.

▶ Tensioning Device Shock Absorber



1. End Cover
2. Bolt ..... 40.5 - 9.5 N•m (29.9 - 6.5 lb-ft)
3. Tensioning Pulley
4. Bolt (M8 X 25) + Washer
   ..... 22.5 - 7.5 N•m (16.6 - 0.3 lb-ft)
5. Tensioning Device
6. Bolt (M8 X 35) + Washer
   ..... 22.5 - 7.5 N•m (16.6 - 0.3 lb-ft)
7. Shock Absorber

Removal & Installation Procedure

1. Remove the end cover (1).
2. Remove the bolt (2) and remove the tensioning pulley (3).
3. Unscrew the bolts (4,6) and remove the shock absorber (7).

Installation Notice

Tightening Torque	40.5 - 49.5 N•m (29.9 - 36.5 lb-ft)

Installation Notice

Tightening Torque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

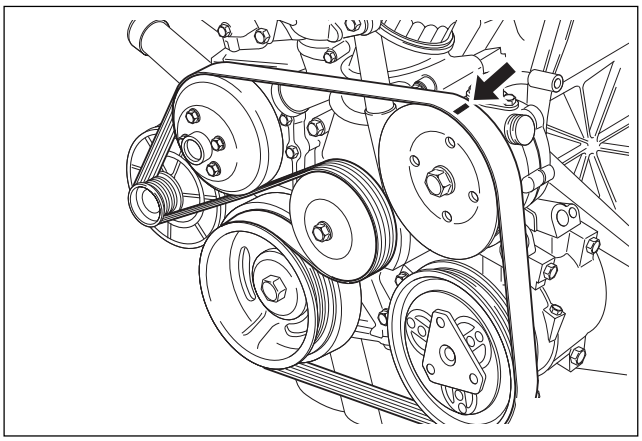
CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Poly V - Belt Inspection

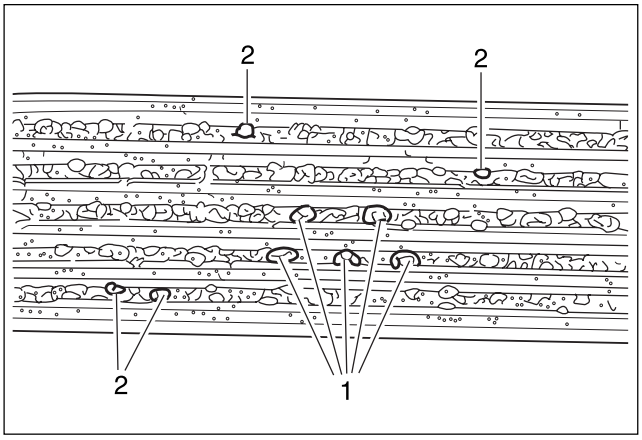
- Make marks on the belt with chalk.
- Rotate the engine and check the belt for damage.

NOTICE

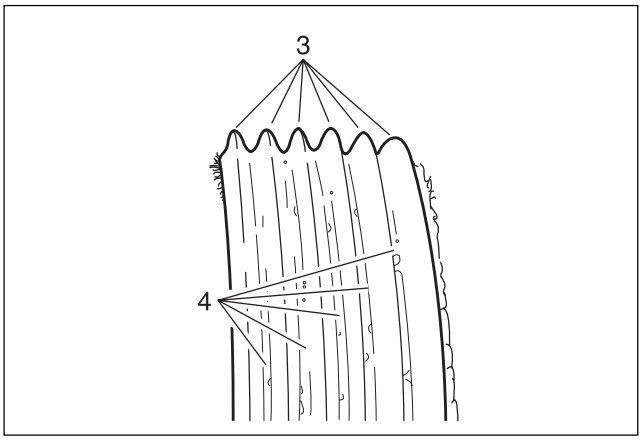
- **If one of the following types of damages is found, replace the belt.**



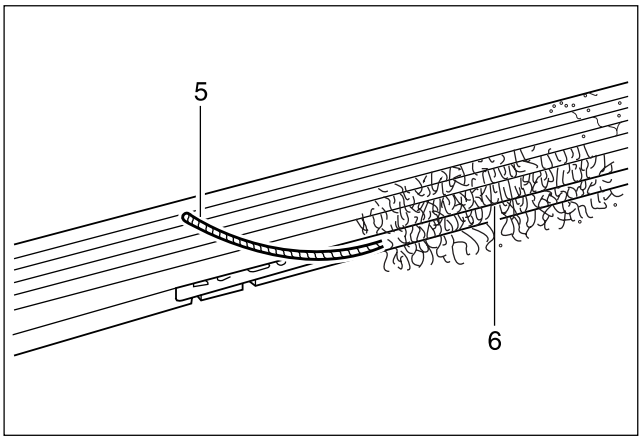
1. Rubber lumps in the base of rib.
2. Dirt or grit ingrained.



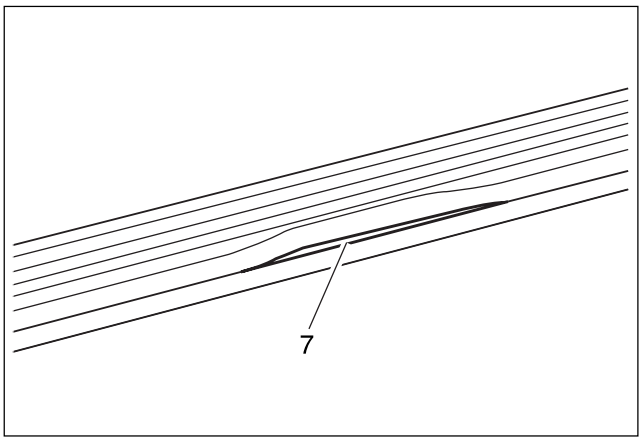
3. Pointed rib.
4. Belt cord visible in the base of rib.



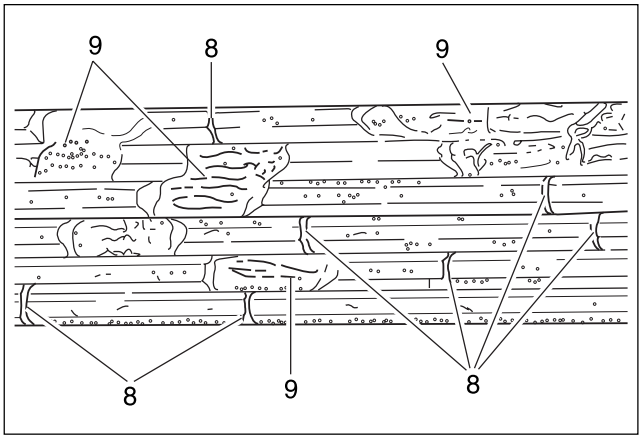
5. Cord torn out at the side.
6. Outer cords frayed.



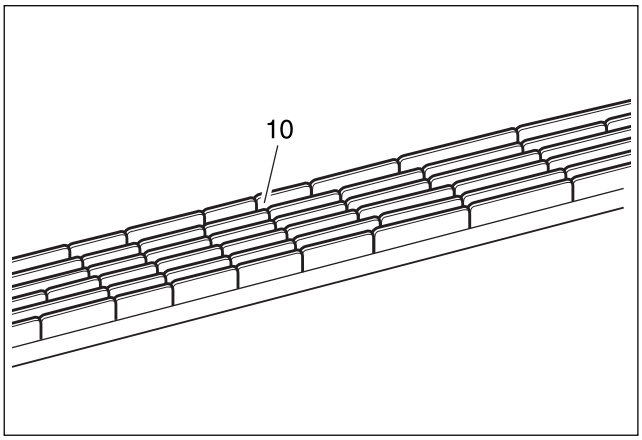
7. Rib detached from the base of belt.



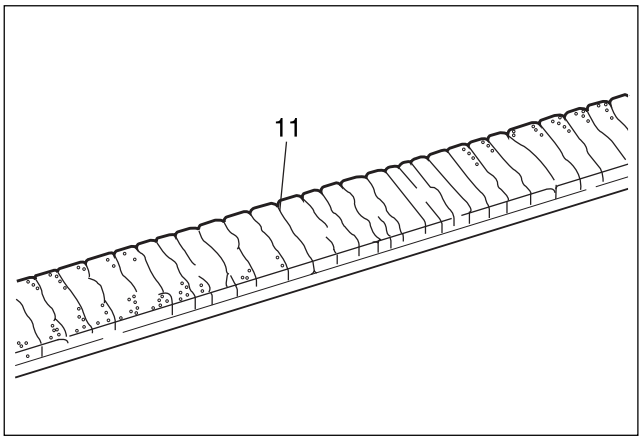
8. Splits across the rib.
9. Sections of rib torn out.



10. Splits across several ribs.

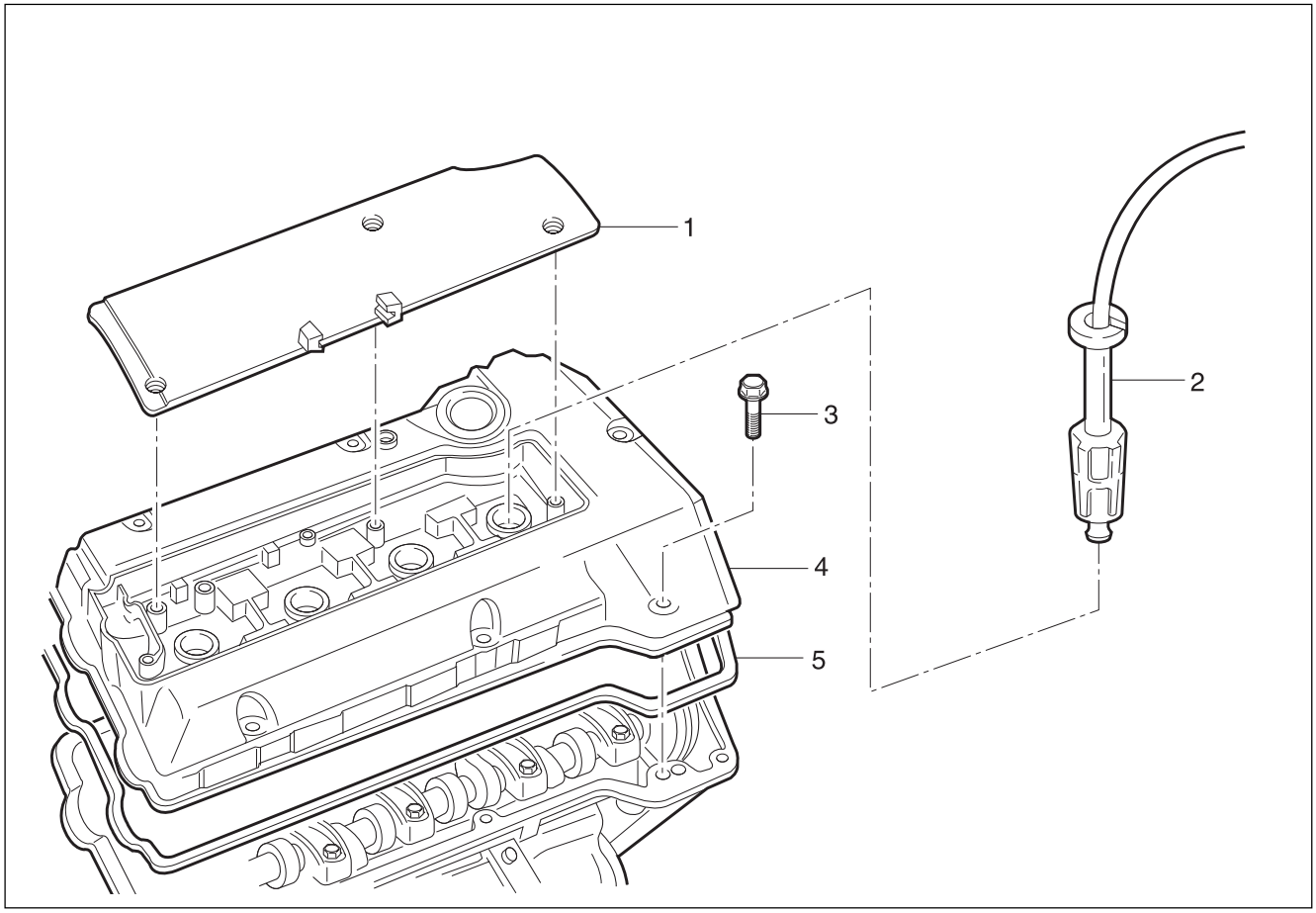


11. Splits across the back of the belt.



CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

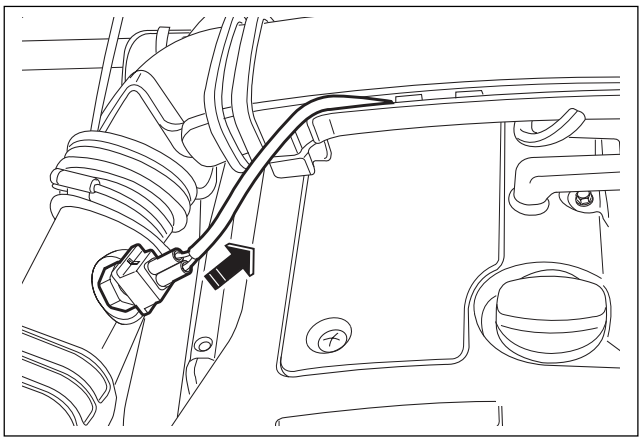
▶ Cylinder Head Cover



1. Spark Plug Cover
2. Spark Plug Connector
3. Bolt (M6 X 45 : 4 pieces, M6 X 60 : 6 pieces)
   ..... 9 - 11 N•m (80 - 97 lb-in)
4. Cylinder Head Cover
5. Gasket .....Replace

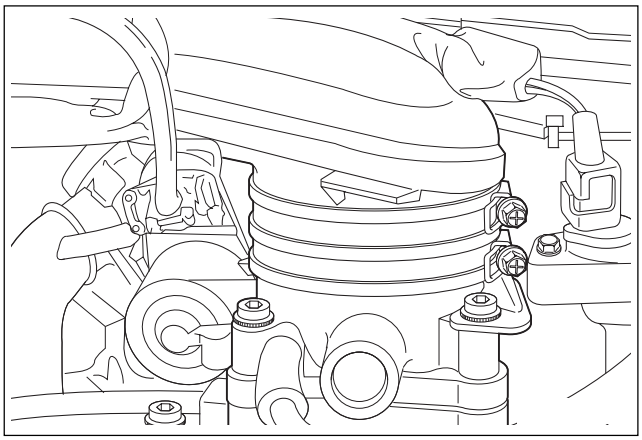
Removal & Installation Procedure

1. Remove the intake air duct.



Installation Notice

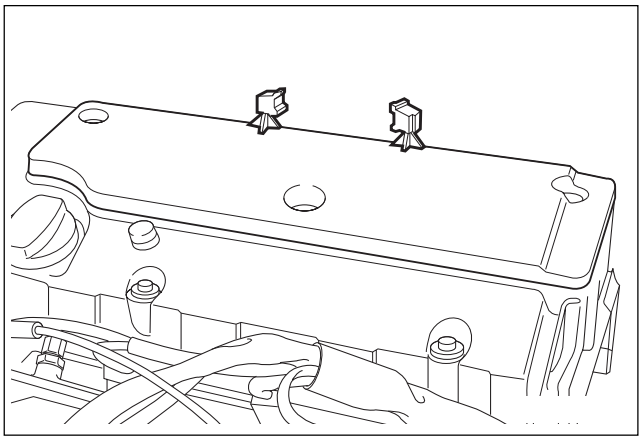
Tightening Torque	9 - 11 N•m (80 - 97 lb-in)



2. Remove the spark plug cover.

Installation Notice

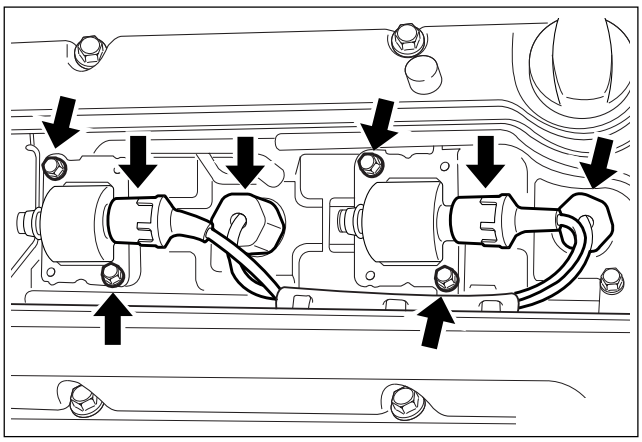
Tightening Torque	9 - 11 N•m (80 - 97 lb-in)



NOTICE

- **Release 3 screws from the spark plug cover and remove the cover for G23D Engine coil.**

3. Remove the spark plug connector and ignition cable.
4. Unscrew the bolts (3) and remove the head cover and the gasket.



Installation Notice

Tightening Torque	9 - 11 N•m (80 - 97 lb-in)

NOTICE

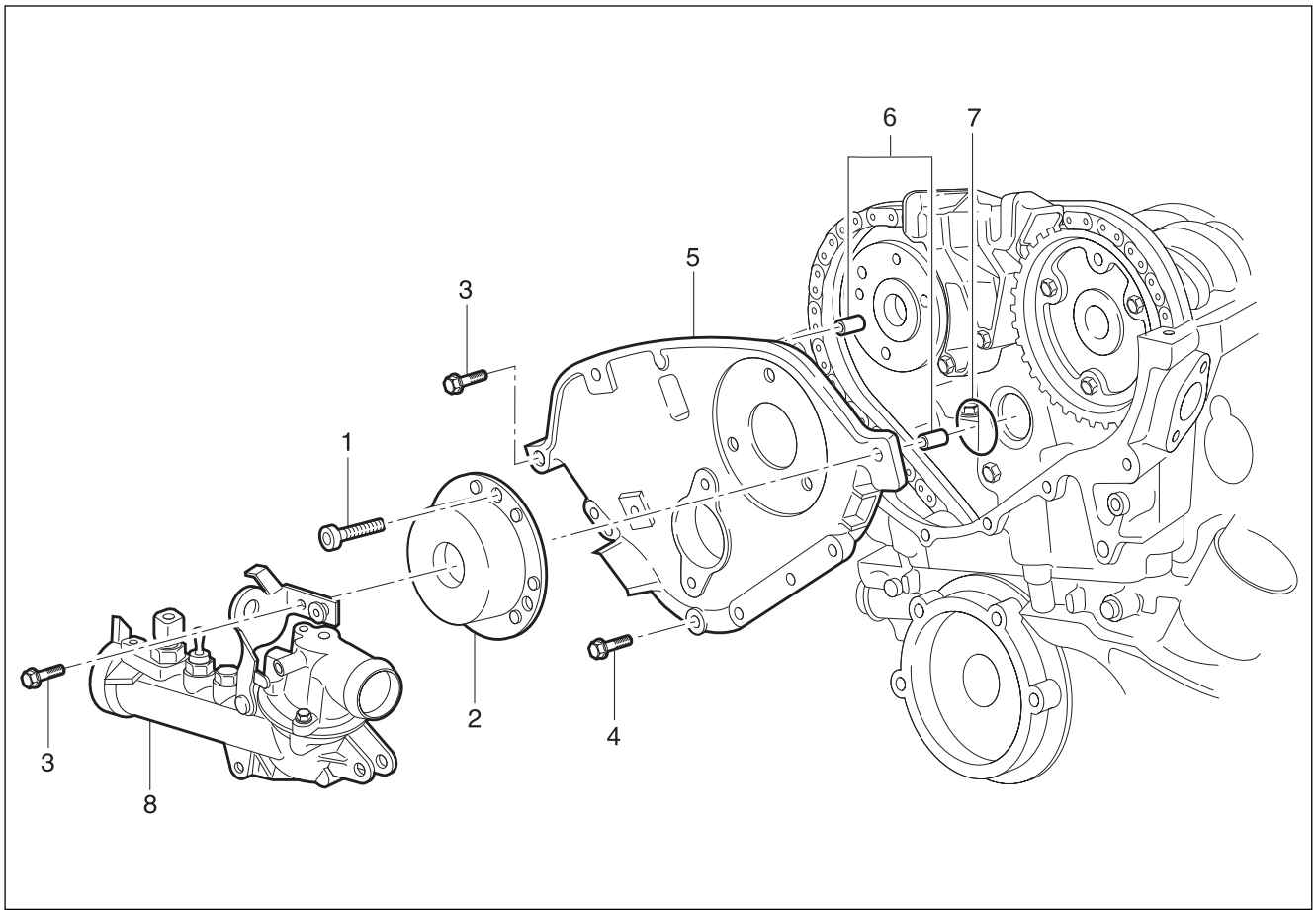
- **Replace the gasket with a new one if necessary.**

5. Installation should follow the removal procedure in the reverse order.
6. Check for oil leaks by operating the engine.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Cylinder Head Front Cover

※ **Preceding Work:** Removal of cylinder head cover
Removal of thermostat housing assembly
Removal of engine hanger bracket



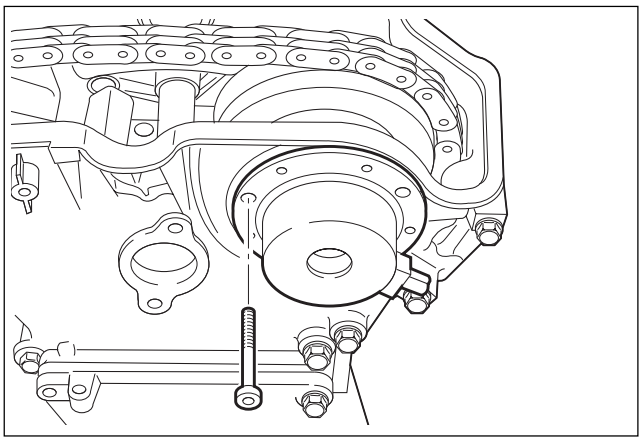
1. Bolt (M6 X 16, 3 pieces)
..... 9 - 11 N•m (80 - 97 lb-in)
2. Camshaft Adjuster
3. Bolt (M8 X 35, 2 pieces)
..... 22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)
4. Bolt (M6 X 22, 6 pieces)
..... 9 - 11 N•m (80 - 97 lb-in)
5. Front Cover (E20 : G23D.943)
6. Sleeve
7. O-Ring .....Replace
8. Thermostat Housing.

Removal & Installation Procedure

1. Disconnect the camshaft adjuster connector and remove the camshaft adjuster.

Installation Notice

Tightening Torque	9 - 11 N•m (80 - 97 lb-in)

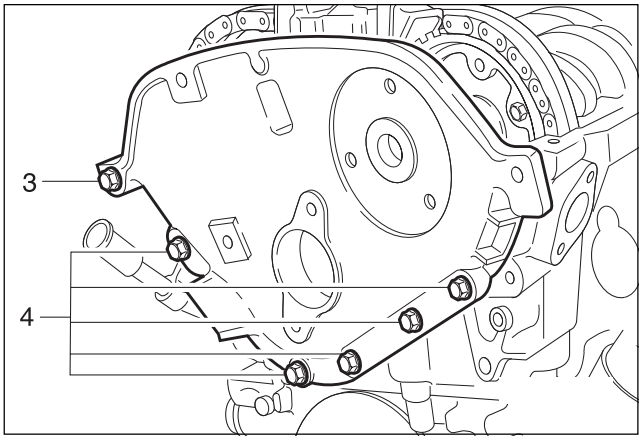


2. Remove the cylinder head front cover.

Installation Notice

Tightening Torque (3)	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)
Tightening Torque (3)	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

Apply the sealant at the mating surface of the cylinder head and the front cover.



3. Remove the O-Ring.

NOTICE

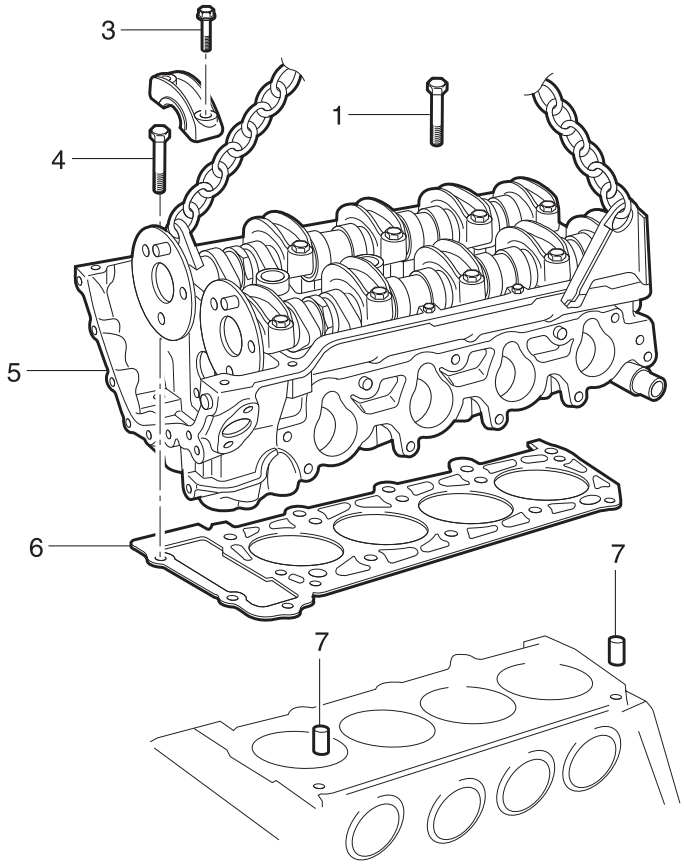
- **Replace the O-ring with new one and apply the sealant.**

4. Installation should follow the removal procedure in the reverse order.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Cylinder Head

※ **Preceding Work:** Removal of cylinder head cover
Removal of cylinder head front cover
Removal of intake manifold
Removal of cylinder head lower line (intake manifold side)



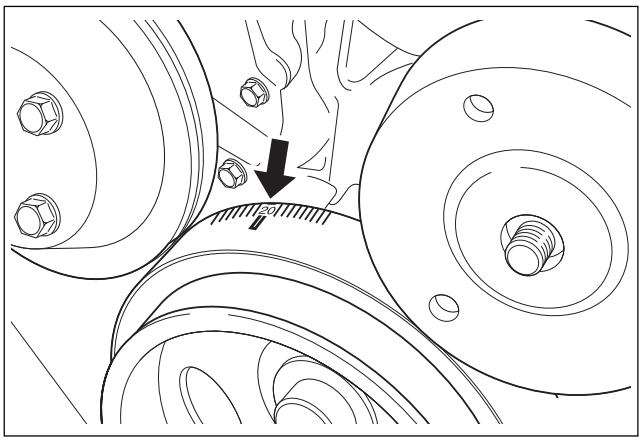
1. Cylinder Head Bolt (M12 X 100, 10 pieces)
..... 1ststep 55 N•m (41 lb-ft)
..... 2nd step 90 °rotation added
..... 3rd step 90 °rotation added
3. Bolt (M8 X 35, 4 pieces)
..... 22.5 - 27.5 N•m (16.6 - 0.3 lb-ft)
4. Camshaft Bearing cap
5. Cylinder Head
6. Gasket ..... Replace
7. Dowel Sleeve ..... Note

Tools Required

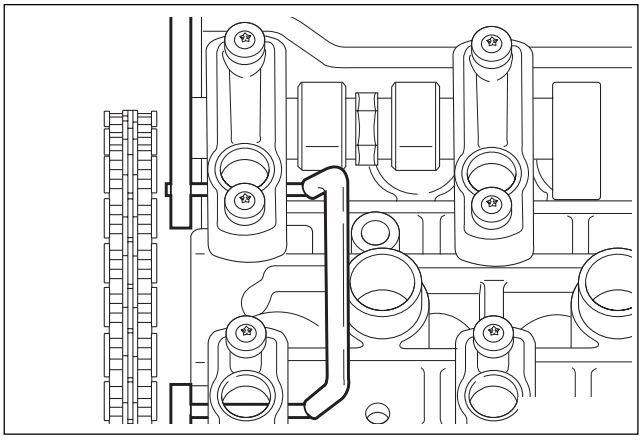
A9912 0080B (617 589 00 10 00) Allen Wrench Socket
A9913 0080B (116 589 20 33 00) Sliding Hammer
A9913 0061B (116 589 01 34 00) Threaded Pin

Removal & Installation Procedure

1. Rotate the crankshaft so that the piston of number 1 cylinder is at ATDC 20.



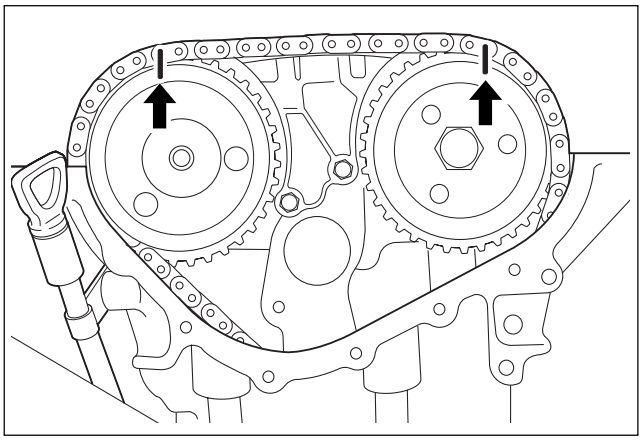
2. Put the holding pin A9913 0052B (111 589 03 15 00) into the cam-shaft bearing cap.



3. Put the alignment marks (arrows) on the timing chain and camshaft sprocket.
4. Remove the chain tensioner.

Installation Notice

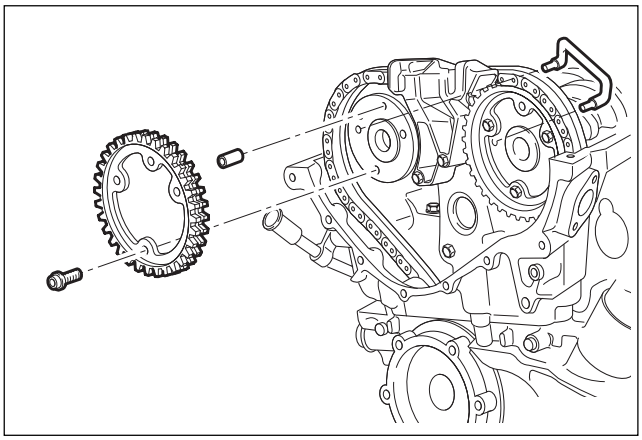
Tightening Torque	72 - 88 N•m (53 - 65 lb-ft)



5. Remove the exhaust camshaft sprocket.

Installation Notice

Tightening Torque	1st step: 18 - 22 N•m (13 - 16 lb-ft)
	2nd step: 60° ± 5°

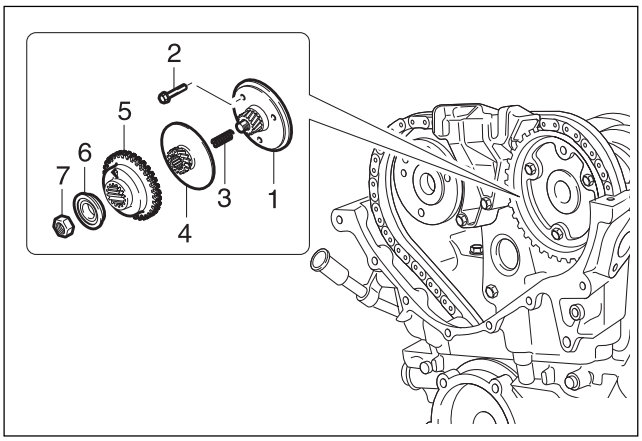


NOTICE

- **The flange bolt is designed to be used only once, so always replace with new one.**

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

6. Remove the camshaft adjuster.



Installation Notice (Flange Bolt)

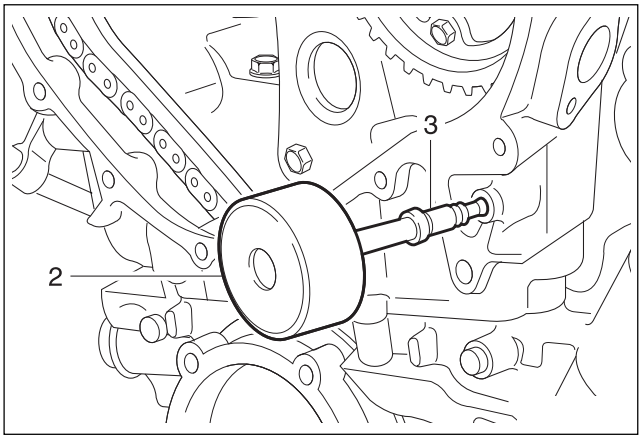
Tightening Torque	1st step: 18 - 22 N•m (13 - 16 lb-ft)
	2nd step: 60° ± 5°

NOTICE

- **The flange bolt is designed to be used only once, so always replace with new one.**

1. Flange Shaft
2. Flange Bolt
3. Compression Spring
4. Adjust Piston
5. Camshaft Sprocket
6. Seal Cover
7. Nut

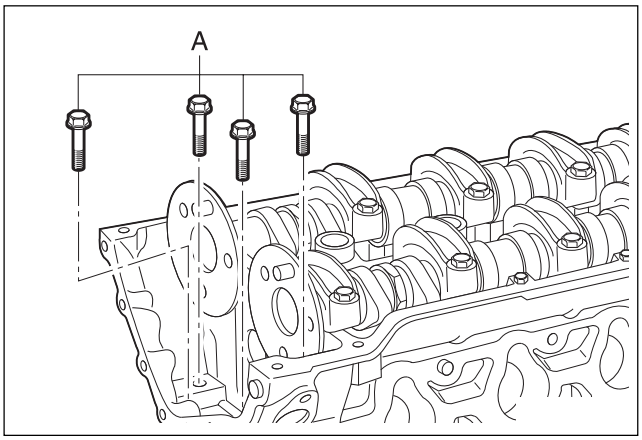
7. Remove the guide rail pin using the sliding hammer A9913 0080B (116 589 20 33 00) (02) and the threaded pin A9913 0061B (116 589 01 34 00) (03).



NOTICE

- **Apply the sealant on guide rail pin when installation.**

8. Unscrew the bolts (A).

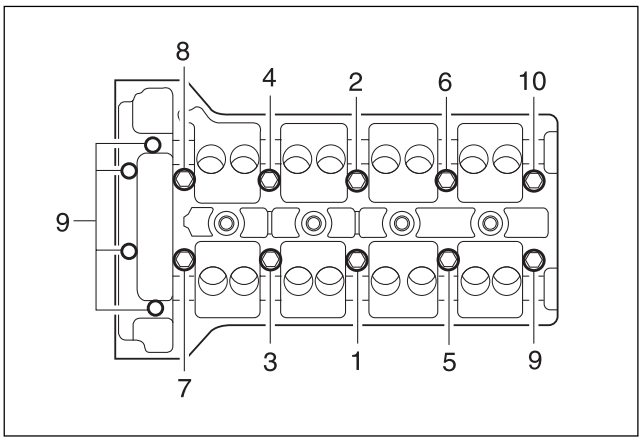


Installation Notice

Tightening Torque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

Bolt (A) : (M8 X 35, 4 pieces)

9. Remove the cylinder head bolts in the reverse order of the numerics (No.10 → No.1) using allen wrench socket A9912 0080B (617 589 00 10 00).



Installation Notice

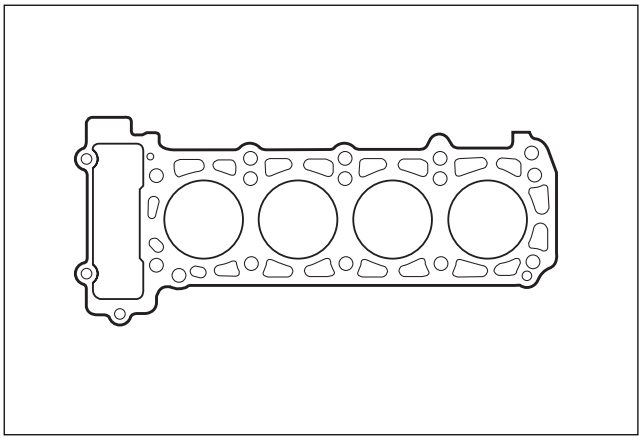
Tighten the bolts as numerical order with specified torque (No.1 → No.10).

Tightening Torque	1st step: 55 N•m(41 lb-ft)
	2nd step: +90°
	3rd step: +90°

NOTICE

- **Operate during engine cooling.**

10. Remove the No. 1 bearing cap of the exhaust camshaft.

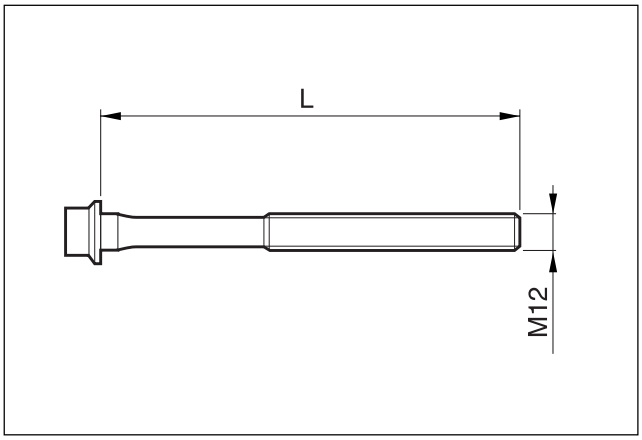


Installation Notice

Tightening Torque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

11. Carefully remove the cylinder head.
12. Check the cylinder head mating surface and clean the crankcase head bolt mounting hole.
13. Replace the cylinder head gasket with new one.

14. Check the length of the cylinder head bolt.



Installation Notice

Length (L)	When New 100 mm
	Max. Length 105 mm

NOTICE

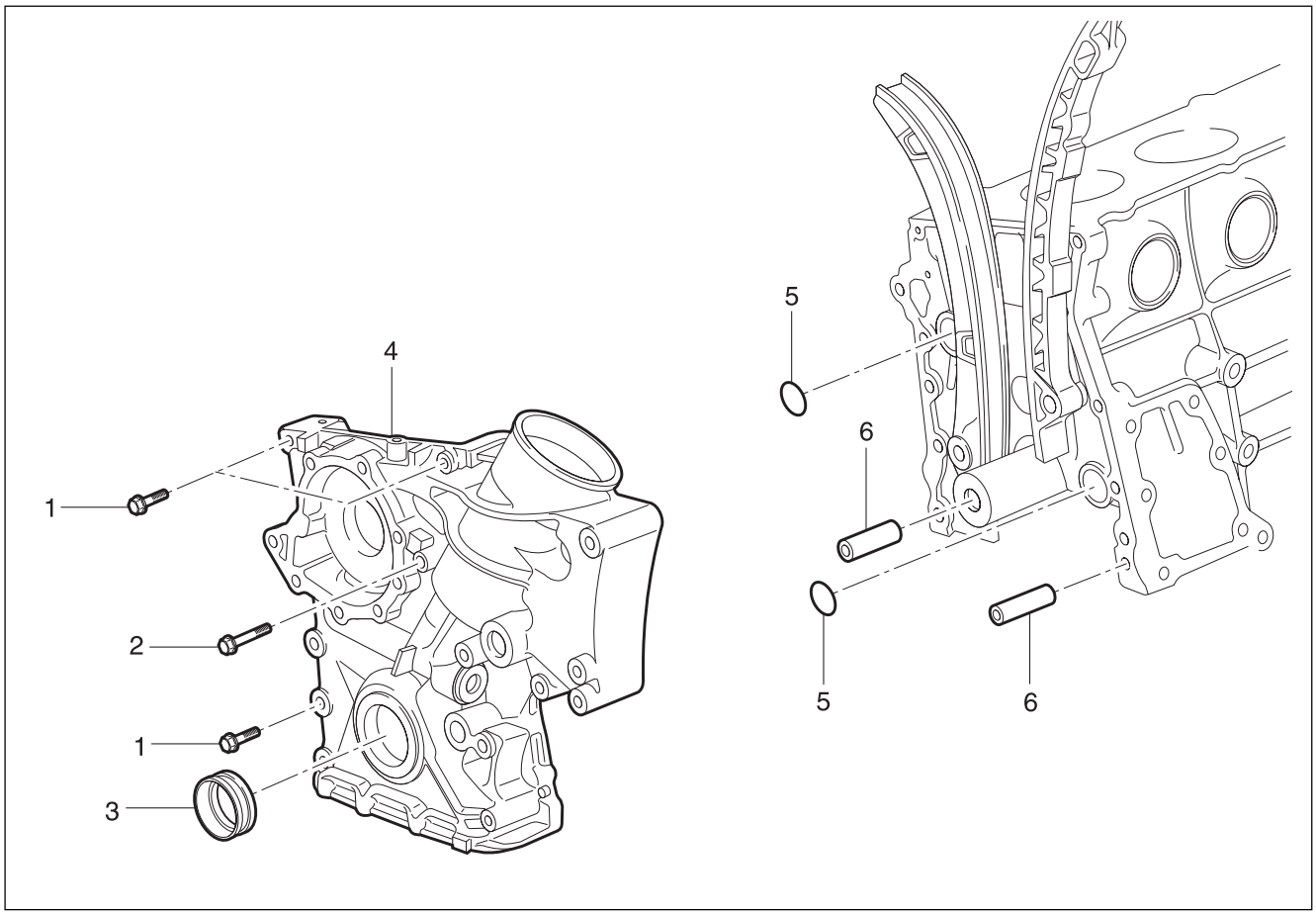
- **Replace the bolt if the measured length exceed the max. length.**

15. Installation should follow the removal procedure in the reverse order.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Timing Gear Case Cover

※ **Preceding Work:** Removal of viscous clutch
Removal of cylinder head front cover
Removal of tensioning device
Removal of water pump
Removal of oil filter element
Removal of oil pan
Removal of generator bracket



1. Bolt (M8 X 60, 3 pieces)
..... 22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)
2. Bolt (M8 X 75, 1 piece)
..... 22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)
3. Seal
4. Timing Gear Case Cover
5. O-Ring
6. Sleeve.

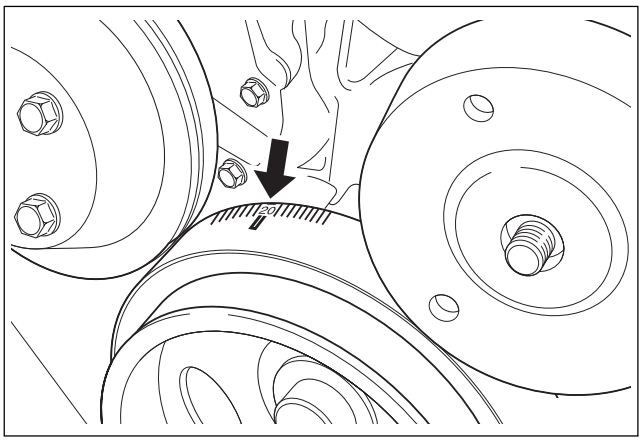
Tools Required

A9913 0080B (116 589 20 33 00) Sliding Hammer

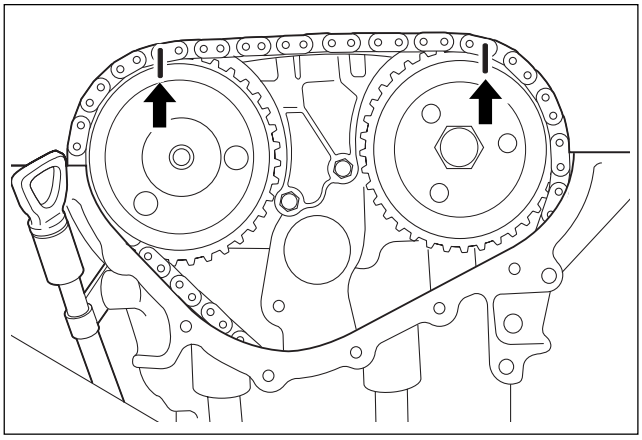
A9913 0061B (116 589 01 34 00) Threaded Pin

Removal & Installation Procedure

1. Remove the power steering belt pulley and A/C compressor bracket.
2. Remove the oil line from power steering pump.
3. Rotate the crankshaft so that the piston of number, cylinder is at ATDC 20 °.



4. Put the alignment marks (arrows) on the timing chain and camshaft sprocket.
5. Remove the chain tensioner.



Installation Notice

Tightening Torque	72 - 88 N•m (53 - 65 lb-ft)

6. Remove the intake and exhaust camshaft sprocket (remove the camshaft adjuster assembly in E23 engine).

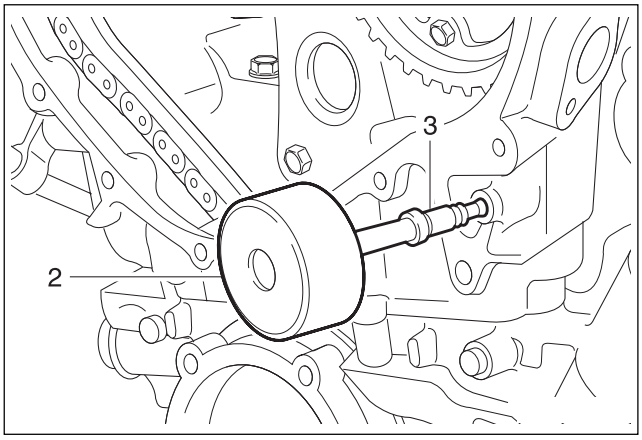
Installation Notice

Tightening Torque	1st step: 18 - 22 N•m (13 - 16 lb-ft)
	2nd step: 60° ± 5°

NOTICE

- **The flange bolt is designed to be used only once, so always replace with new one.**

7. Remove the guide rail pin using the sliding hammer A9913 0080B (116 589 20 33 00) (02) and the threaded pin A9913 0061B (116 589 01 34 00) (03).

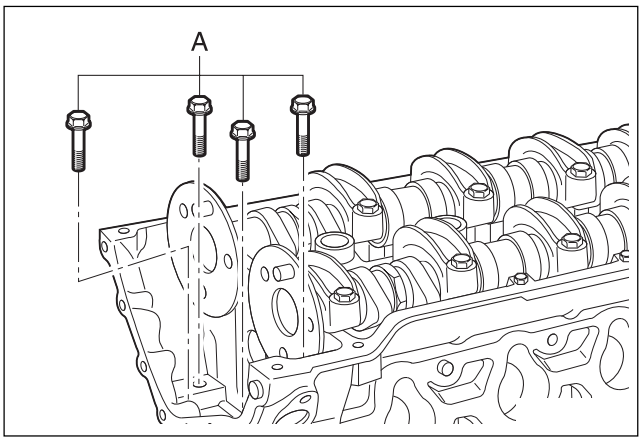


NOTICE

- **Apply the sealant on guide rail pin when installation.**

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

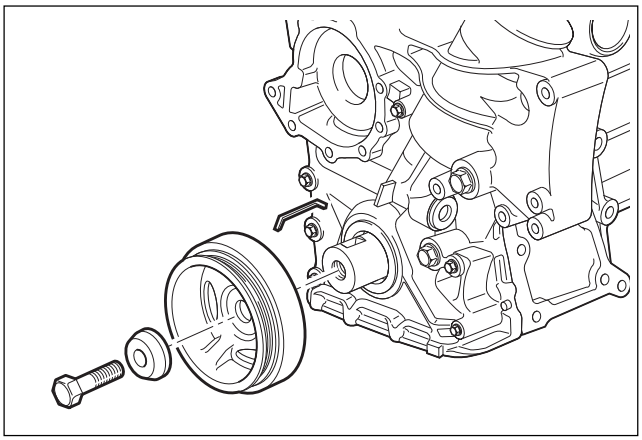
8. Unscrew the bolts (A).



Installation Notice

Tightening Torque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

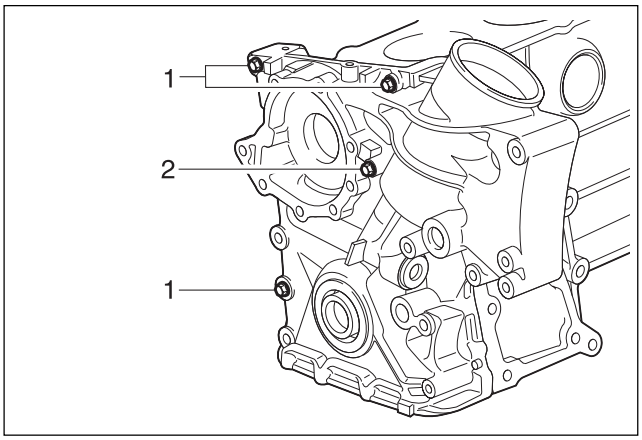
9. Remove the belt pulley and vibration damper.



Installation Notice (Center Bolt)

Tightening Torque	1st step: 200 + 20 N•m (148 + 15 lb-ft)
	2nd step: 90° ± 10°

10. Unscrew the bolts (1, 2) on timing gear case cover and remove the timing gear case cover.



Installation Notice

Tightening Torque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

NOTICE

- **Be careful not to damage the cylinder head gas-ket.**

11. Remove the radial shaft seal.

NOTICE

- **Installation note replace the seal with new one.**

12. Clean the timing gear case cover and crankcase sealing surface.
13. Replace the O-ring with new one and apply the sealant on the sealing surface.

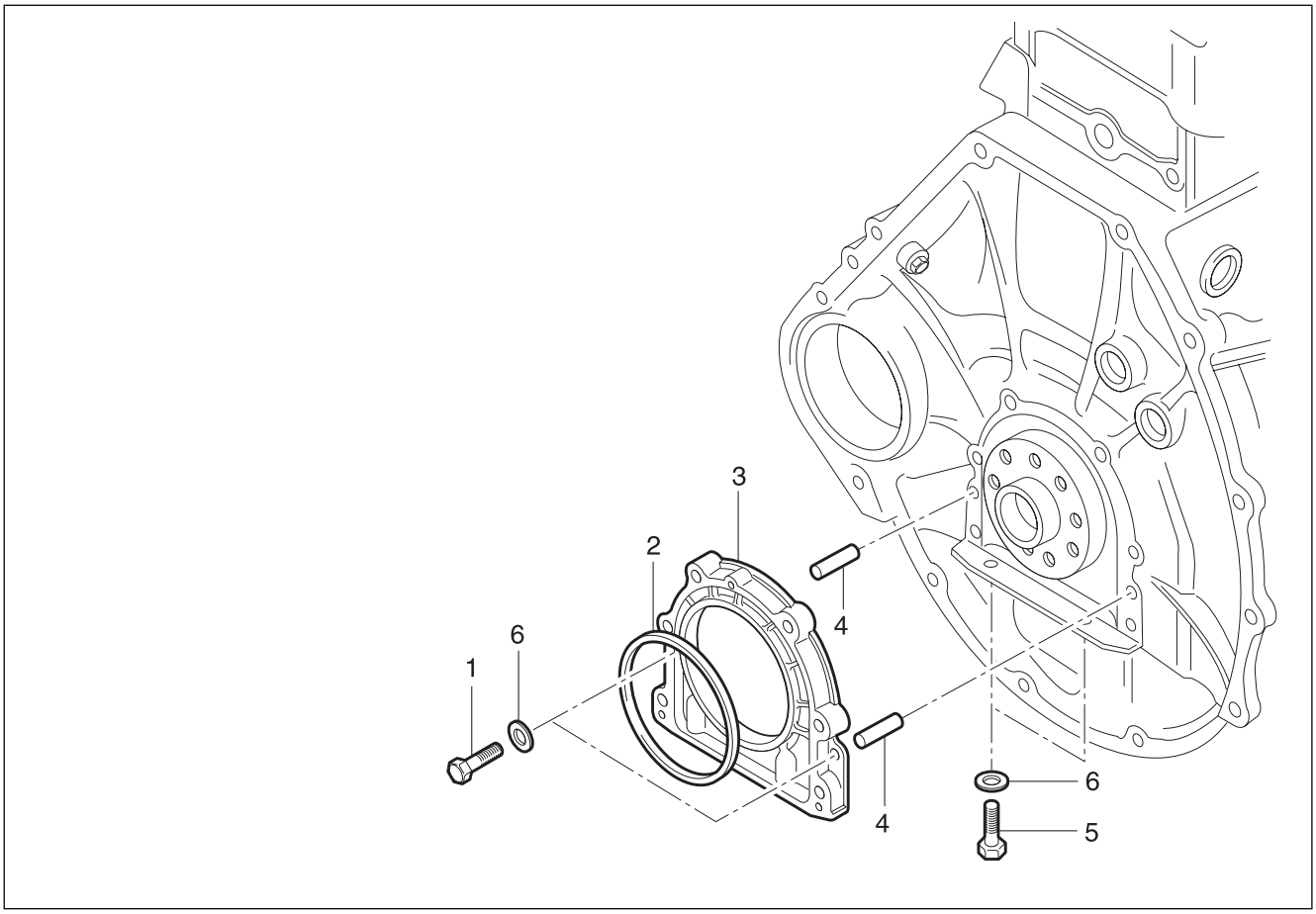
NOTICE

- **Be careful not to stain the oil chamber of chain tensioner with the sealant.**

14. Installation should follow the removal precedure in the reverse order.
15. Warm up the engine and check for oil leaks.

▶ Crankshaft Sealing Rear Cover

※ **Preceding Work:** Removal of the automatic transmission drive plate or flywheel



1. Bolt (M6 x 20, 6 pieces)
   ..... 9 - 11 N•m (80 - 97 lb-in)
2. Radial Shaft Seal
3. Rear Cover
4. Sleeve
5. Bolt (M6 x 85, 2 pieces)
   ..... 9 - 11 N•m (80 - 97 lb-in)
6. Washer

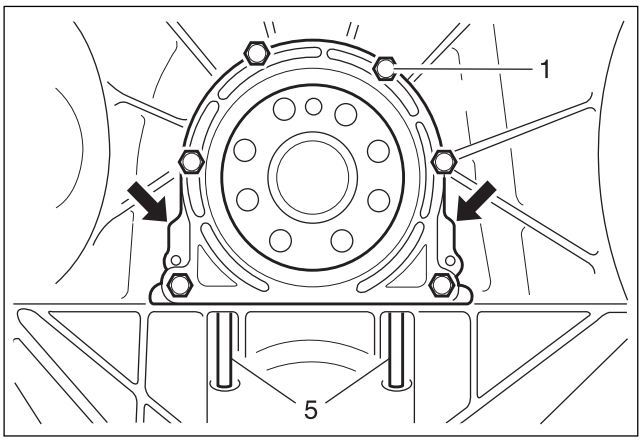
CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

Tools Required

W9911 0020B (601 589 03 43 00) Crankshaft Rear Seal Installer

Removal & Installation Procedure

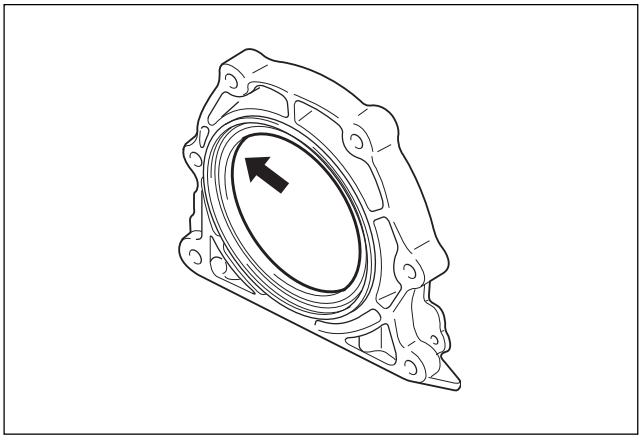
1. Unscrew the bolts (1) and (5) and remove the closing cover by pulling the rear cover lug (arrows).



NOTICE

- **Be careful not to damage the oil pan gasket.**

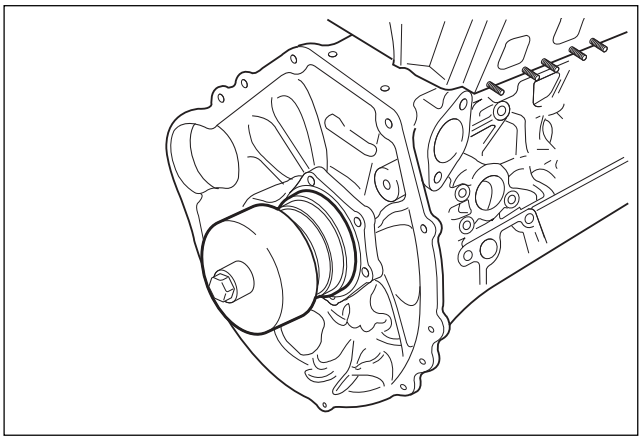
2. Clean the sealing surface of the crankcase and the rear sealing cover.
3. Check the radial shaft seal and replace it if necessary.
4. Apply the Loctite 573 to the rear cover sealing surface.
5. Apply the engine oil to the dust lip of the radial shaft seal.



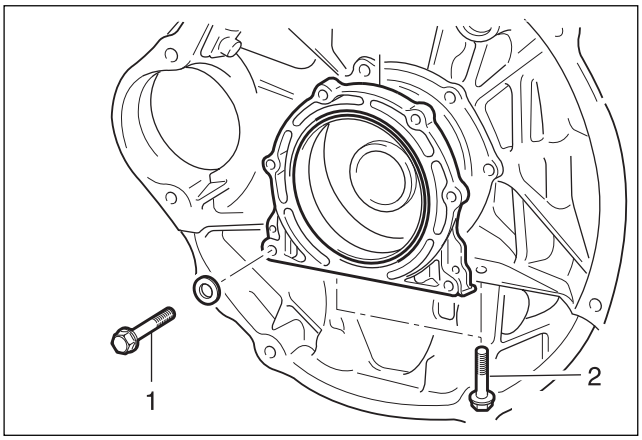
NOTICE

- **Do not use the grease.**

6. Install the crankshaft rear radial seal and the crankshaft sealing rear cover, using crankshaft rear seal installer W9911 0020B (601 589 03 43 00).



7. Install the crankshaft sealing rear cover mounting bolts and remove the crankshaft rear seal installer W9911 0020B (601 589 03 43 00).



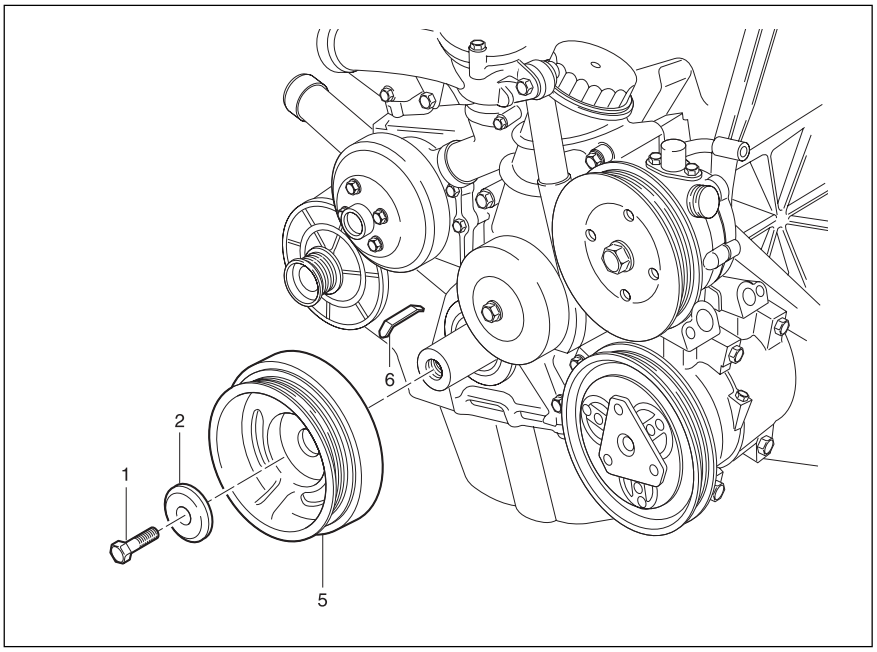
Installation Notice

Tightening Torque	9 - 11 N•m (80 - 97 lb-in)

8. Installation should follow the removal procedure in the reverse order.

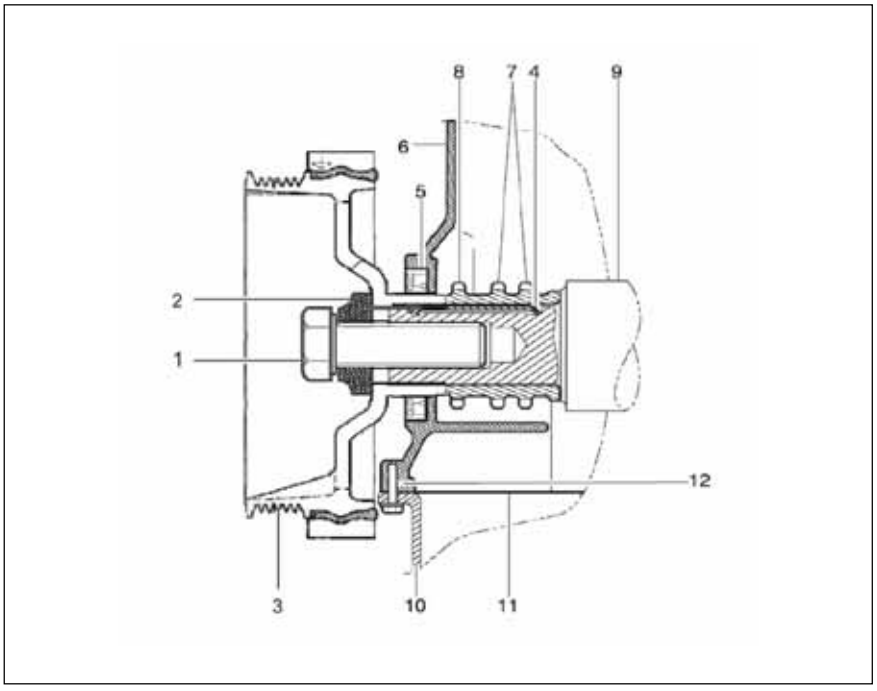
▶ Belt Pulley and Vibration Damper

※ **Preceding Work:** Removal of cooling fan and viscous clutch
Removal of fan shroud
Removal of drive belt



1. Center Bolt
   1st step 200+20 N•m
   (148 + 15 lb-ft)
   2nd step 90 °+ 10 °rotation added
2. Center bolt washer
5. Vibration Damper Assembly
6. Key

▶ Components



1. Center Bolt (M18 x 55)
2. Center Bolt Washer
3. Vibration Damper and Pulley Assembly
4. Key
5. Crankshaft Front Seal
6. Timing Gear Case Cover
7. Crankshaft Sprocket (Camshaft Driven)
8. Crankshaft Sprocket (Oil Pump Driven)
9. Crankshaft
10. Oil Pan
11. Oil Pan Gasket
12. Oil Pan Mounting Bolt (M6 x 22)

Service Data Standard

Permissble Deviation of The Vibration Damper	Radial Runout	0.6 mm
	Axial Ruout	0.6 mm

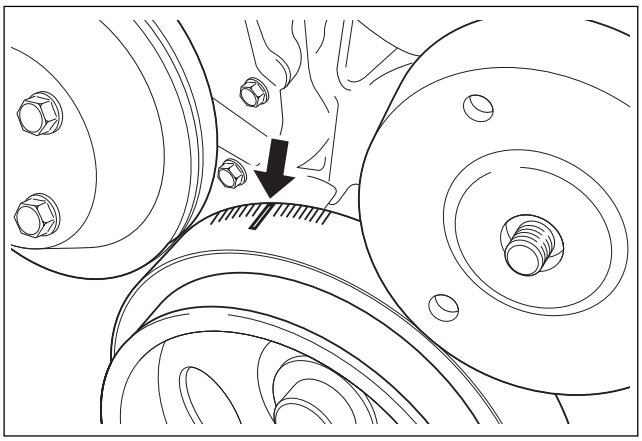
CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

Tools Required

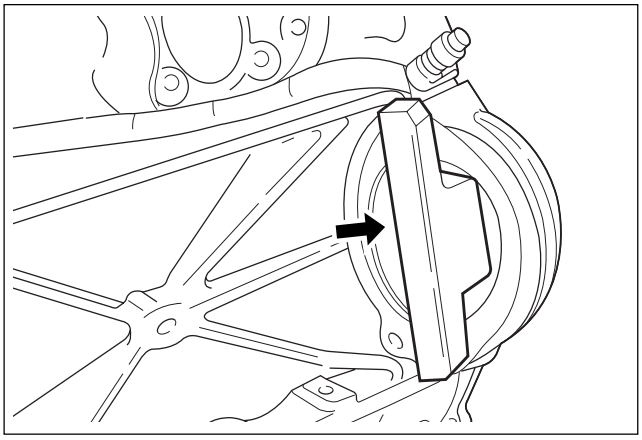
A9910 0150B (602 589 00 40 00) Engine Lock

Removal & Installation Procedure

1. Adjust the piston of number 1 cylinder to the TDC.



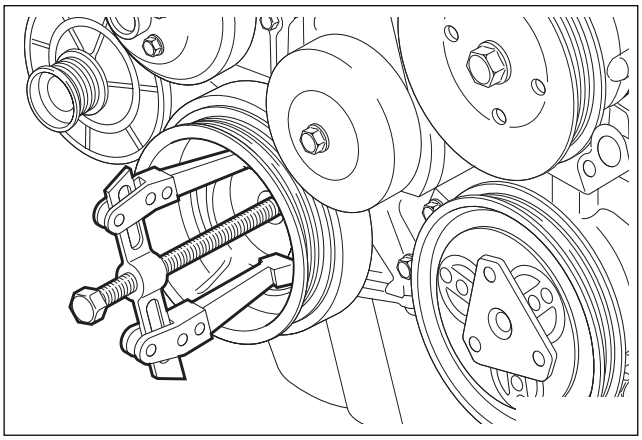
2. Remove the start motor and install the engine lock A9910 0150B (602 589 00 40 00) to the flywheel ring gear.
3. Remove the vibration damper center bolt.



Installation Notice

Tightening Torque	1st step: 200 + 20 N•m (148 + 15 lb-ft)
	2nd step: 90° ± 10°

4. Remove the vibration damper assembly using the puller.
5. Installation should follow the removal procedure in the reverse order.



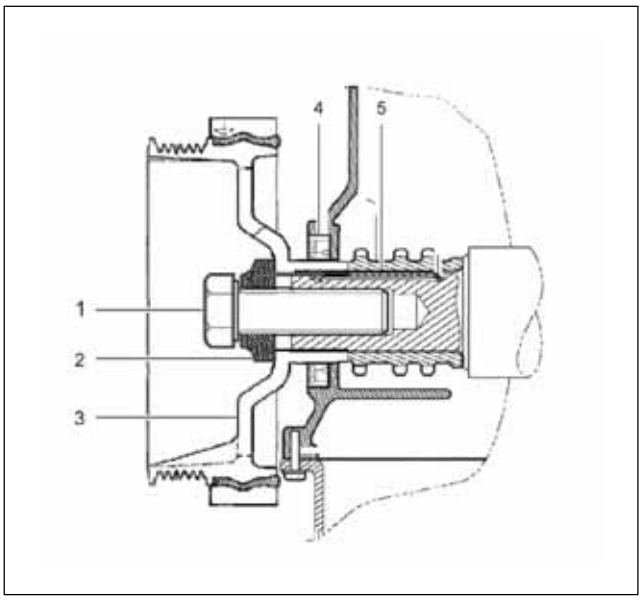
NOTICE

- **If possible, don't separate the vibration damper and the pulley.**

▶ Crankshaft Front Radial Seal

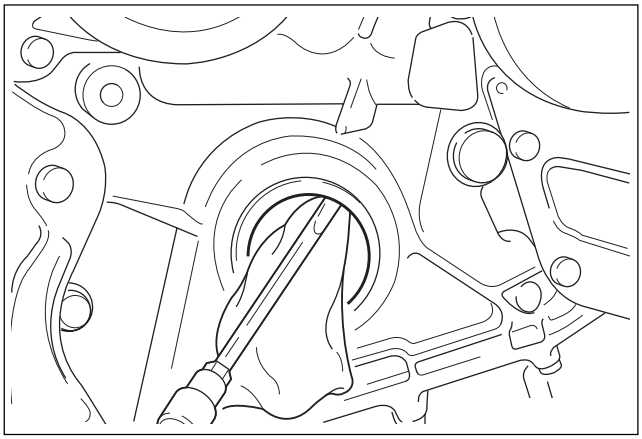
※ **Preceding Work:** Removal of belt pulley and vibration damper

1. Center Bolt (M18 x 55)
   ..... 1st step 200 + 20 45 N•m (148 +15 lb-ft)
   ..... 2nd step 90 ° + 10 °
2. Center Bolt Washer
3. Vibration Damper Assembly
4. Crankshaft Front Seal
5. Key



Tools Required

A9911 0060B (601 589 03 14 00) Crankshaft Front Seal Installer



Replacement Procedure

1. Remove the radial seal with a screw driver.

NOTICE

- **Use a clean cloth not to damage the radial seal mounting hole and the crankshaft.**

2. Coat the radial sealing lip with engine oil.
3. Using the crankshaft front seal installer A9911 0060B (601 589 03 14 00), assemble the radial seal.
4. Align the sleeve groove and the woodruff key and tighten the center bolt until the center bolt and the damper disk stop in the movement.

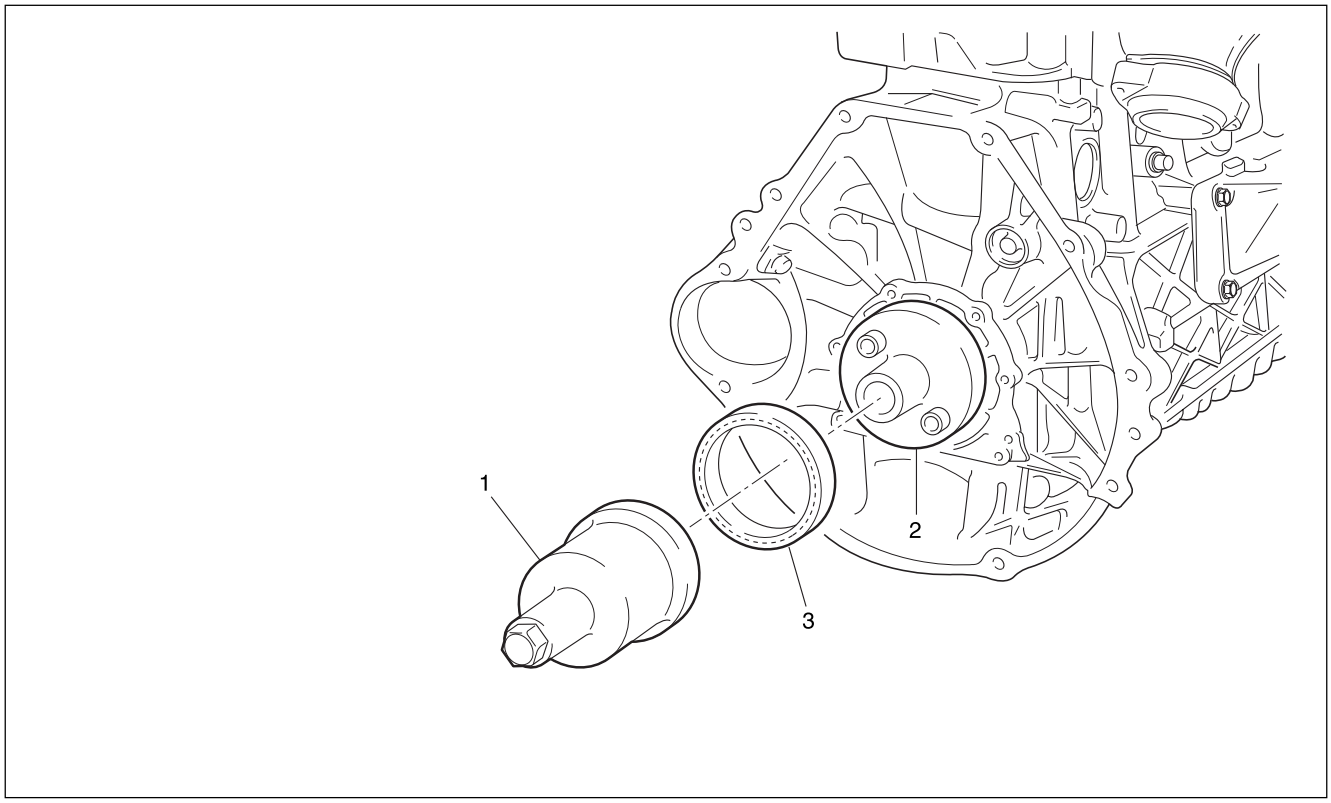
Installation Notice

Tightening Torque	1st step: 200 + 20 N•m (148 + 15 lb-ft)
	2nd step: 90° ± 10°

5. Remove the crankshaft front seal installer A9911 0060B (601 589 03 14 00), and install the belt pulley and the vibration damper.
6. Check for leaks while operating the engine.

▶ Crankshaft Rear Radial Seal

※ **Preceding Work:** Removal of flywheel or drive plate



1. Special Tool
2. Special Tool
3. Crankshaft Rear Seal

Tools Required

W9911 0020B (601 589 03 43 00) Crankshaft Rear Seal Installer

Replacement Procedure

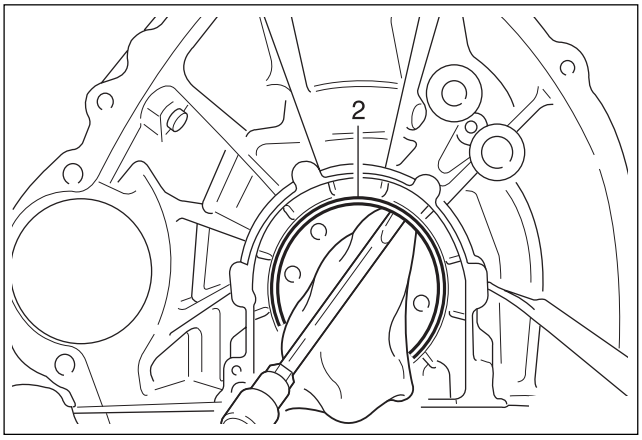
1. Remove the radial seal with a screw driver.

NOTICE
- **Use a clean cloth not to damage the radial seal mounting hole and the crankshaft.**

2. Install the special tool (2) to the crankshaft.
3. Apply the engine oil on the special tool (2).

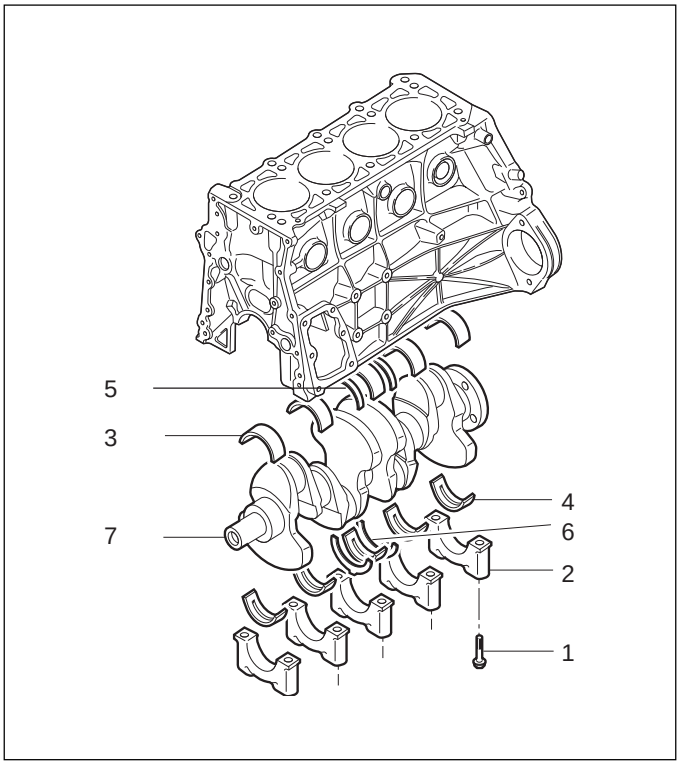
NOTICE
- **Do not use the grease.**

4. Install the radial seal on the inner parts assembler.
5. Press in the special tool (1) until the radial seal is stopped.
6. Check for leaks while operating the engine..



▶ Crankshaft

※ **Preceding Work:** Removal of engine
Removal of cylinder head
Removal of timing gear case cover
Removal of crankcase sealing rear cover
Removal of oil pan
Removal of baffle plate
Removal of oil pump



1. Bearing Cap Bolt (M8 X 55 - 10 pieces)
   ..... 1ststep 55 N•m (41 lb-ft)
   ..... 2nd step 90 °rotation added
2. Bearing Cap
3. Upper Main Bearing
4. Lower Main Bearing
5. Upper Thrust Bearing
6. Lower Thrust Bearing
7. Crankshaft.

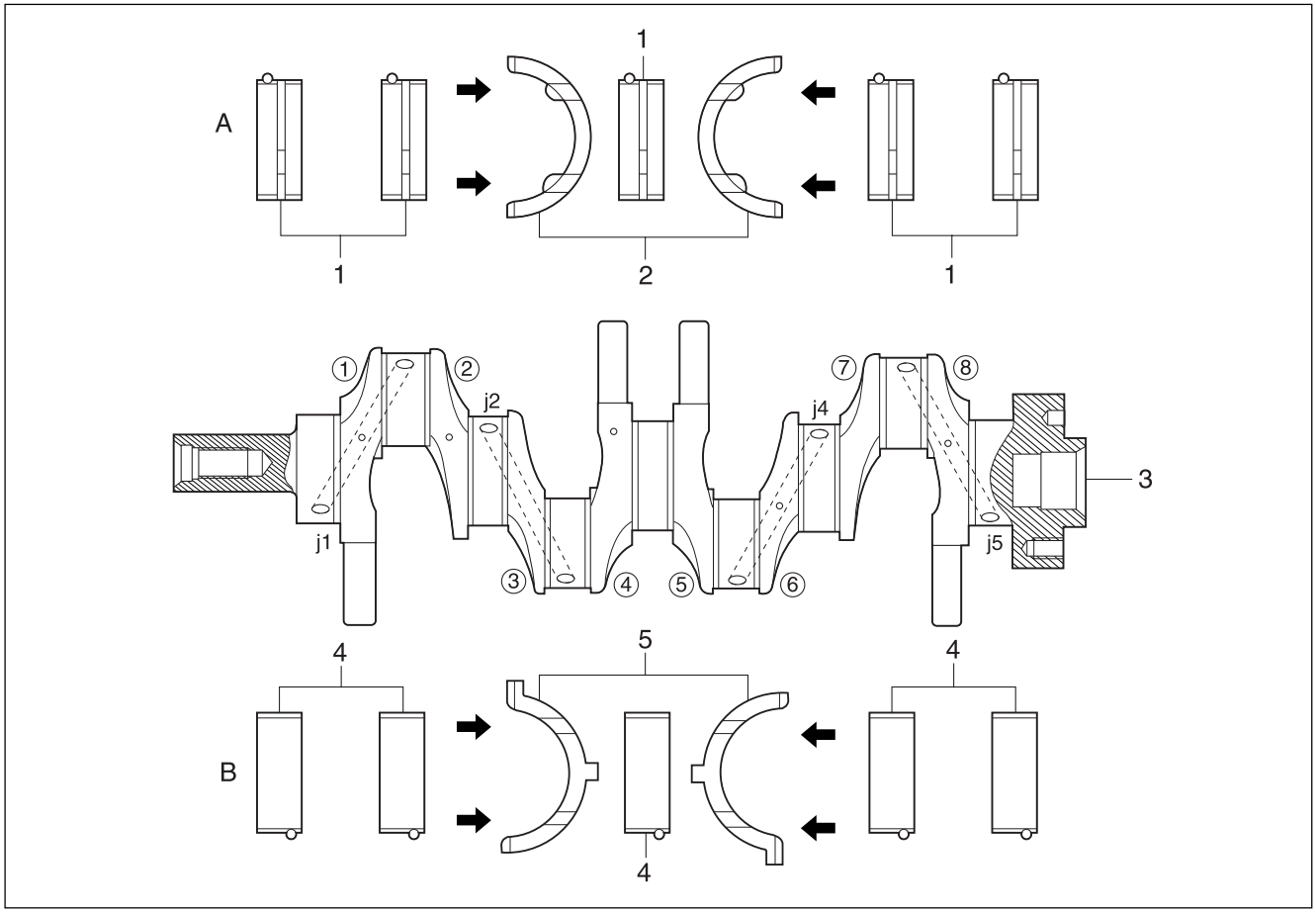
Service Data Standard (Crankshaft Main Bearing Gap)

Item	Measuring Position	Gap (mm)
Main Bearing Journal (NO.1,5,7)	Radial	Static condition : 0.015 - 0.039 Dynamic condition : 0.031 - 0.051 (Consider the expansion 0.011 - 0.016)
	Axial	0.010 - 0254

(Connecting Rod Bearing Gap)

Item	Item	Gap (mm)
Connection Rod Bearing	Radial	0.020 - 0.065

▶ Arrangement of the Thrust Bearing and the Main Bearing



1. Upper Main Bearing
2. Upper Thrust Bearing
3. Crankshaft
4. Lower Main Bearing
5. Lower Thrust Bearing

A. Crankcase Side
B. Bearing Cap Side (Oil Pan Side)

(1) - (8) Weight Balance/Color Marking Point
j1 - j5 Journal Main Bearing #1 - #5

- Color Dot Marking

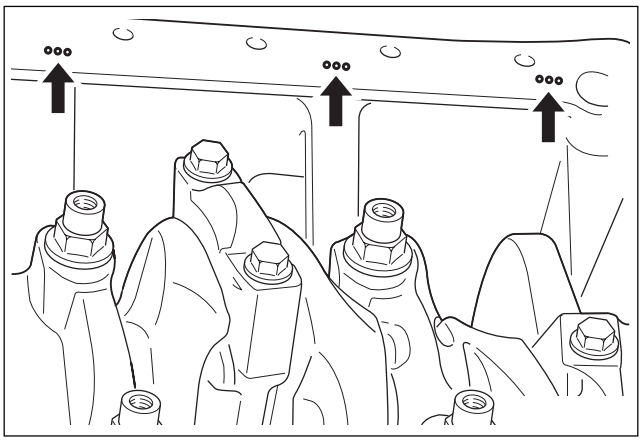
The color dot marking are put on the (1), (2), (4), (6), (8), and it indicates the diameter of crankshaft journal by color as below.

Color Dot Marking	Crankshaft Journal Diameter (mm)
Blue	57.960 - 57.965
Yellow	57.955 - 57.960
Red	57.950 - 57.955
White	57.945 - 57.950
Violet	57.940 - 57.945

Selection of Crankshaft Main Bearing

1. Crankcase Side

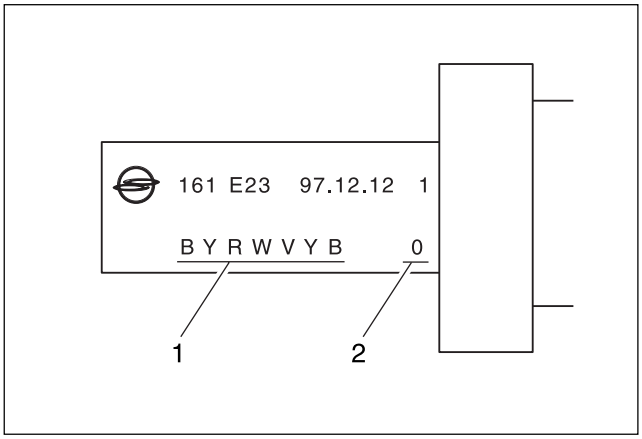
   There are seven punching marks on the mating surface to oil pan. This mark is correspondent to the bearing distinguished by color. Select the relevant bearing according to the punching mark when repaired.



Purching Mark	Bearing Color Selected
B	Blue
Y	Yellow
R	Red

2. Crankshaft Bearing Cap Side

   Select the crankshaft main bearing according to the marking letter on the crank shaft main journal when repaired.



Marking Letter	Bearing Color Selected
B	Blue
Y	Yellow
R	Red
W	White
V	Violet

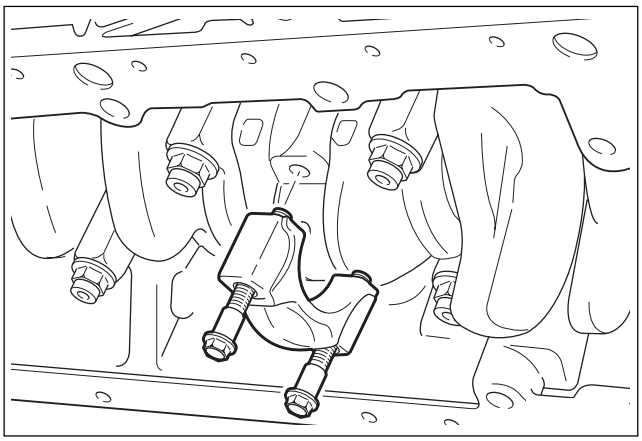
Service Data

Crankshaft Standard and Repair Size	Crankshaft Bearing Journal Diameter	Crankshaft Bearing Diameter	Crankshaft Journal Width at fit bearing	Connecting Rod Bearing Journal Diameter	Connecting Rod Bearing Journal Width
Standard size	57.940 - 57.965	58	24.50 - 24.533	47.935 - 47.965	27.958 - 28.042
1st repair size	57.705 - 57.715	-	-	47.700 - 47.715	-
2nd repair size	57.450 - 57.465			47.450 - 47.465	
3rd repair size	57.205 - 57.215			47.200 - 4.215	
4th repair size	56.955 - 56.965			46.950 - 46.965	

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

Removal & Installation Procedure

1. Unscrew the connecting rod bearing cap bolt and remove the bearing cap.

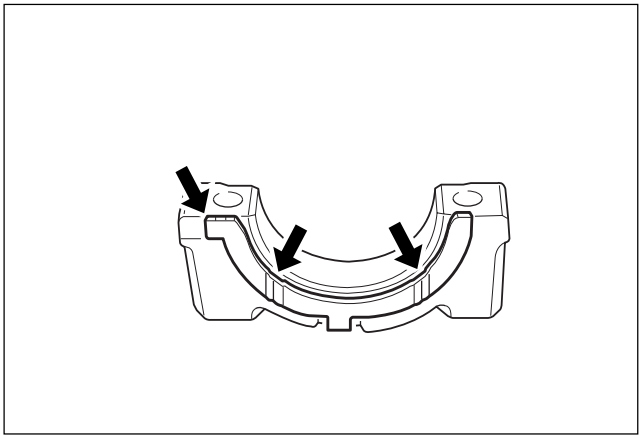


Installation Notice

Tightening Torque	40 N•m (30 lb-ft) + 90°

- Make sure that the upper and lower bearing shells do not change each other.
- Coat the bearing shell with engine oil.
- Install the bearing cap according to the consecutive number.

2. Unscrew the crankshaft bearing cap bolts and separate the upper and lower bearing shells and thrust washers.



Installation Notice

Tightening Torque	55 N•m (41 lb-ft)+ 90°

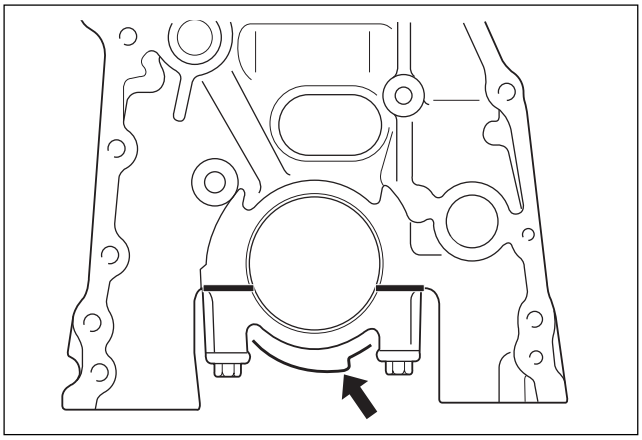
- Remove the bearing cap from front (pulley side) to rear.
- Make sure that the upper and lower bearing shells do not change each other and coat with engine oil.
- The oil grooves (arrows) in the thrust washers must face outward and insert the thrust bearing into the bearing cap.
- There are five kinds of thrust washers by thick-ness. Select the proper washer when repaired.

Part No. : 601 030 00 62 2.15 mm
Part No. : 601 030 01 62 2.20 mm
Part No. : 601 030 02 62 2.25 mm
Part No. : 601 030 03 62 2.30 mm
Part No. : 601 030 04 62 2.40 mm

3. Remove the crankshaft.
4. Installation should follow the removal procedure in the reverse order.
5. After completion of the installation, check for the rotating condition of the crankshaft.

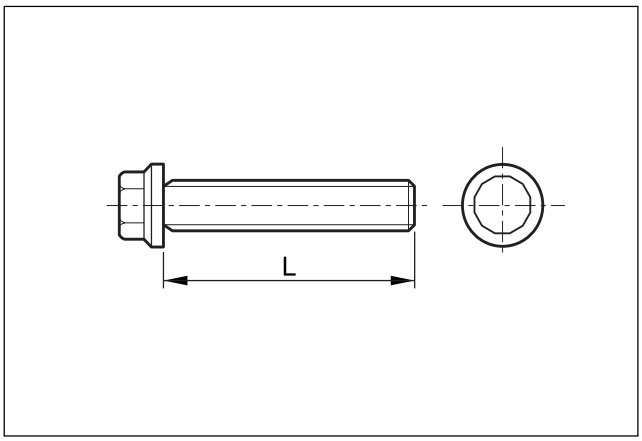
NOTICE

- **Make sure the crankshaft bearing cap properly seated in place in the crankcase side. When perfectly installed, the projected part (arrow) locates in the left side (intake manifold side).**
- **Assemble so that the projected part of the cap and crankcase face the same direction.**

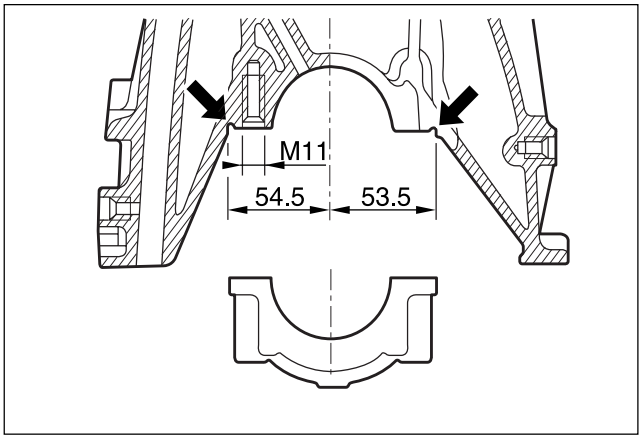


Inspection

1. If the length 'L' of the crankshaft bearing cap bolt exceeds 63.8 mm, replace it.



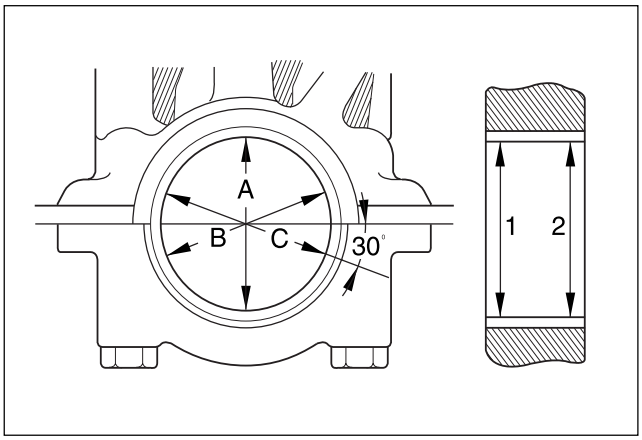
2. Make sure the crankshaft bearing cap is properly seated on the cylinder block (arrows).



3. Measure and record the inner diameter of the crankshaft bearing.

NOTICE

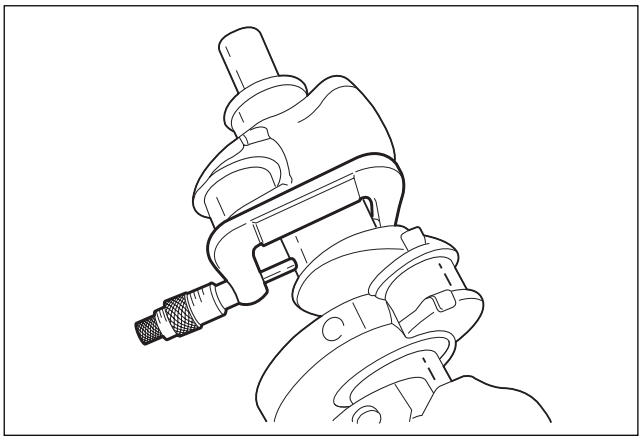
- **Measure at 2 points (1, 2).**
- **Measure 'A', 'B' and 'C' as shown. If average value of 'B' and 'C' is less than value 'A', then the average value of 'B' and 'C' is actual average value. If average value of 'B' and 'C' is more than value 'A' is actual average value.**



4. Measure and record the diameter of the crankshaft bearing journal.

NOTICE

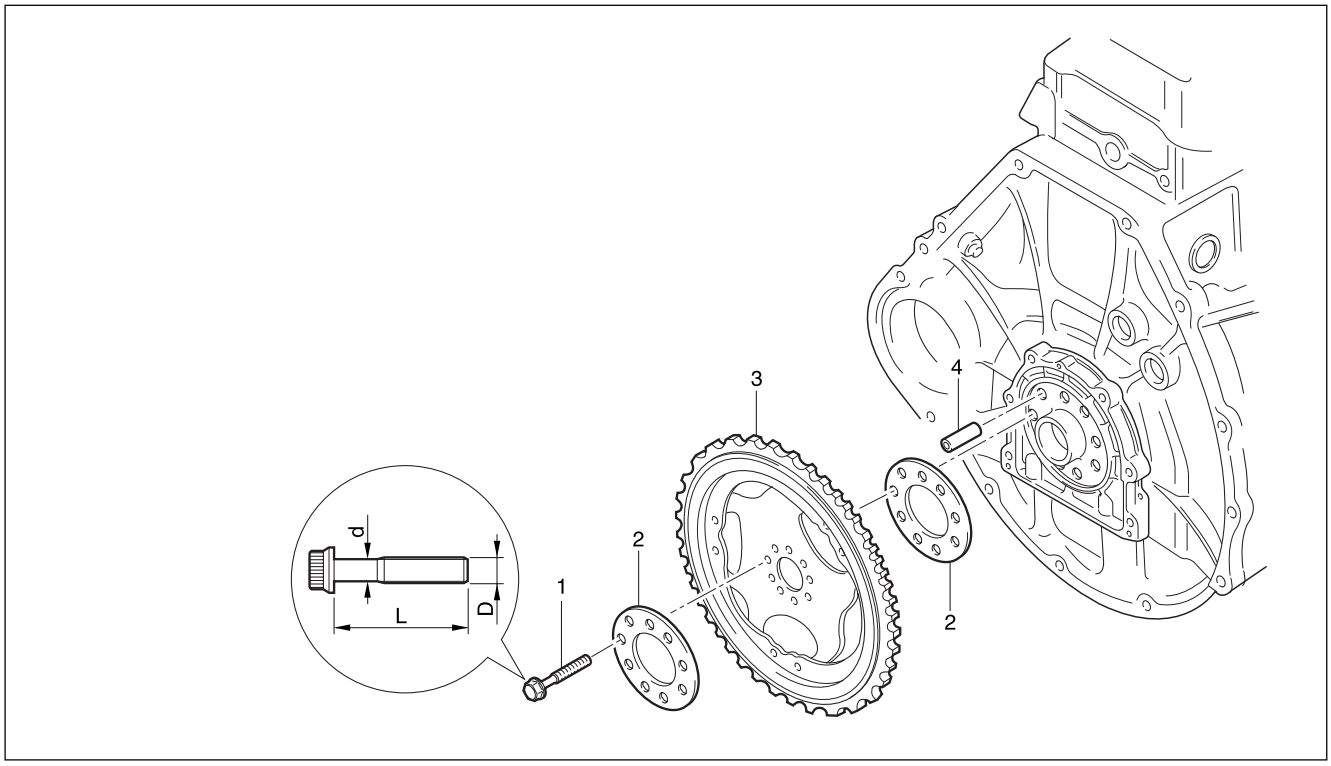
- **Record the mean value when measured at 3 points (A,B,C).**
- **Measure the inner diameter of bearing and the diameter of journal and if it is out of the standard data, replace the bearing shell.**



CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Flywheel / Drive Plate

※ **Preceding Work:** Removal of manual or automatic transmission



1. Flywheel Mounting Bolt (M10 x 22, 8 pieces)
   ..... 1st step 45 + 5 N•m (33 + 3.7 lb-ft)
   2nd step 90 ° + 10 °
2. Plate
3. Drive Plate (A/T)
4. Dowel Pin

Service Data Standard (Stretch Bolt)

Normal Size	D	-	M x 15
Stretch Side Diameter	d	When New	8.5 - 0.2 mm
		Min. Diameter	8.0 mm
Bolt Length	L	When New	21.8 - 22.2 mm
Tightening Torque	1st step 45 + 5 N•m (33 + 37 lb-ft), 2nd step 90° + 10°		

Removal & Installation Procedure

1. Unscrew the flywheel mounting bolt.

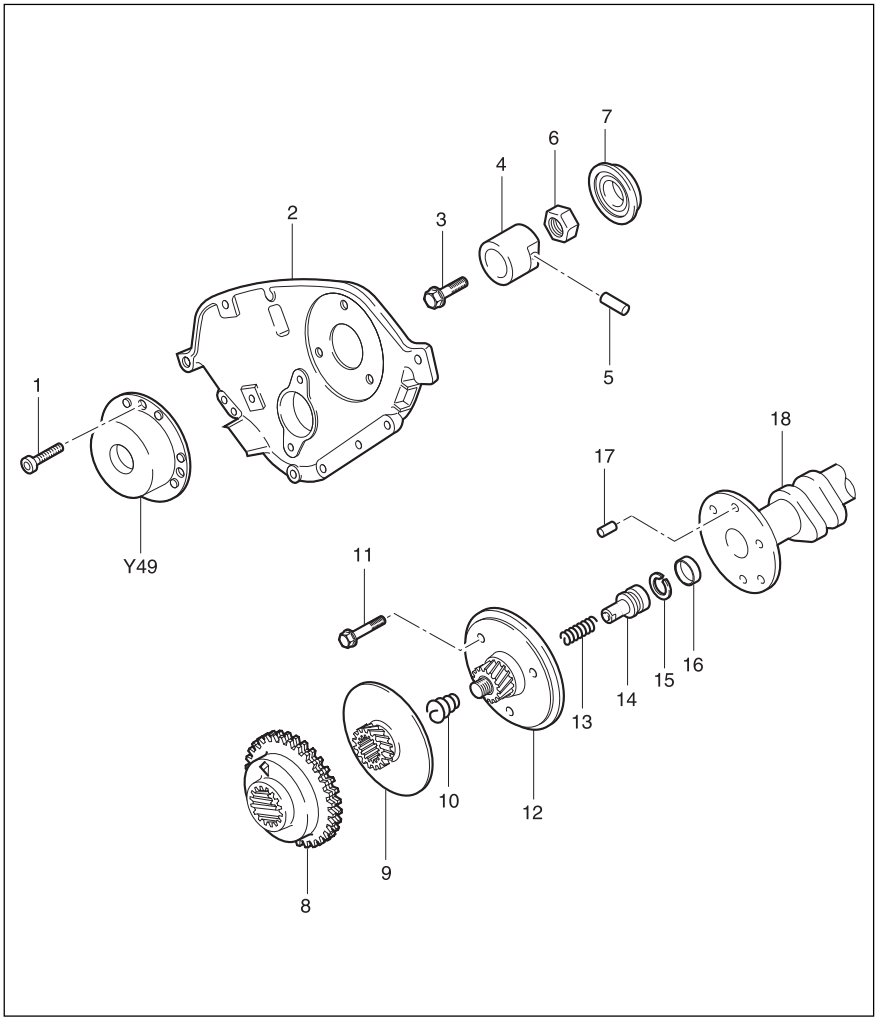
Installation Notice

Tightening Torque	1st step: 45 + 5 N•m (33 + 3.7 lb-ft)
	2nd step: 90° ± 10°

- Replace the bolt when the stretch side diameter (d) of the flywheel mounting bolt is less than 8.0mm.
- For the flywheel mounting bolt tightening, keep the socket wrench and Tommy-bar to be 90 °and tighten as specified.

2. Remove the flywheel for manual transmission vehicles, or the driven plate (3), and plate (2) for Auto transmission vehicle.
3. Installation should follow the removal procedure in the reverse order.

▶ Camshaft Adjuster



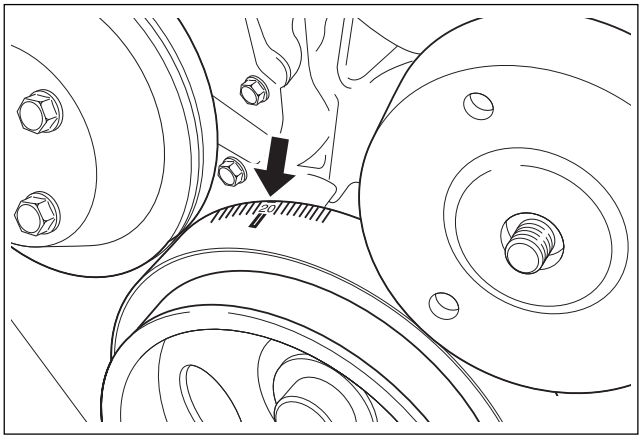
1. Bolt (M6 X 16, 3 pieces)
   9 - 11 N•m (80 - 97 lb-in)
2. Cylinder Head Front Cover
3. Bolt
   35 N•m (26 lb-ft)
4. Armature
5. RollPin
6. Nut (M20 X 1.5)
   60 - 70 N•m (44 - 52 lb-ft)
7. Seal Cover
8. Camshaft Sprocket
9. Adjust Piston
10. Conical Spring
11. Flange Bolt (M7 X 13, 3 pieces)
    1stStep 18 - 22 N•m
    (13 - 16 lb-ft)
    2nd Step 60 ° ± 5 °Rotation
    Added
12. Flange Shaft
13. Compression Spring
14. Control Piston
15. Circlip
16. Oil Gallery
17. Straight Pin
18. Intake Camshaft
    Y49 Magnetic Actuator
    (2 - Pin Connector)

Removal & Installation Procedure

1. Turn the crankshaft and position the no.1 cylinder piston at ATDC 20 °.

NOTICE

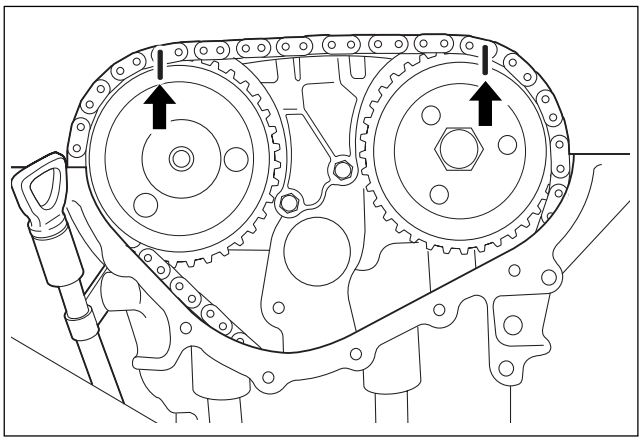
- **Turn the crankshaft in the direction of engine rotation.**



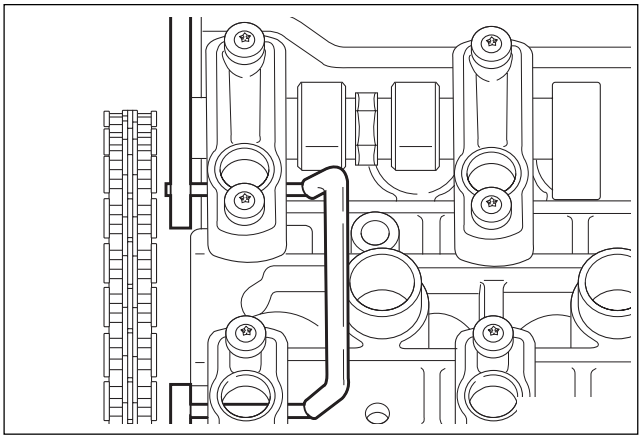
2. Remove the cylinder head front cover.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

3. Put the alignment marks (arrows) on the camshaft sprocket and the timing chain.



4. Insert the holding pin A9913 0052B (111 589 03 15 00) into the no.1 and no.6 bearing cap hole on camshaft to secure intake and exhaust camshaft.
5. Remove the chain tensioner.



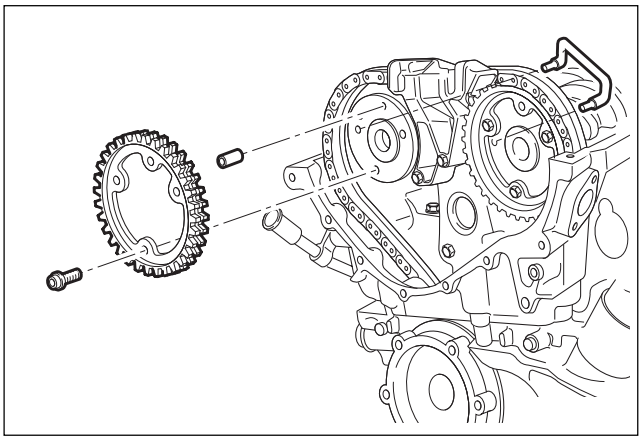
6. Unscrew the exhaust sprocket bolt and remove the exhaust camshaft sprocket.

Installation Notice

Tightening Torque	1st step: 18 - 22 N•m (13 - 16 lb-ft)
	2nd step: 60° ± 5°

NOTICE

- **The flange bolt is designed to be used only once, so always replace with new one.**



7. Unscrew the bolt (3) from the armature (4) and re ove the roll pin, and remove the armature.

Installation Notice

Tightening Torque	35 N•m (26 lb-ft)

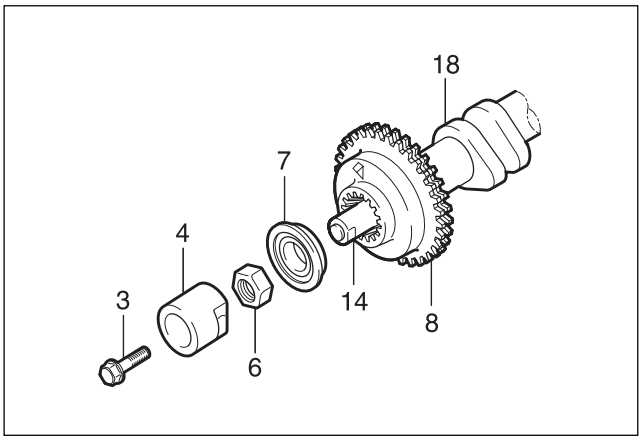
8. Unscrew the nut (6) and remove the seal cover (7).

Installation Notice

Tightening Torque	60 - 70 N•m (44 - 52 lb-ft)

NOTICE

- **Put the locking slot of nut toward armarture.**



9. Take off the timing chain from intake camshaft sprocket.

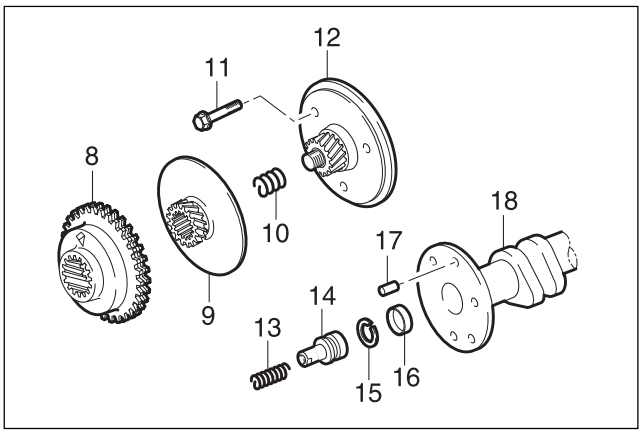
10. Remove the adjuster piston (9) and conical spring (10) from intake camshaft sprocket.
11. Unscrew the bolt (11) and remove the flange shaft.

Installation Notice

Tightening Torque	1st step: 18 - 22 N•m (13 - 16 lb-ft)
	2nd step: 60° ± 5°

NOTICE

- **The flange bolt is designed to be used only once, so always replace with new one.**



12. Installation should follow the removal procedure in the reverse order.
13. Check and adjust the camshaft timing.

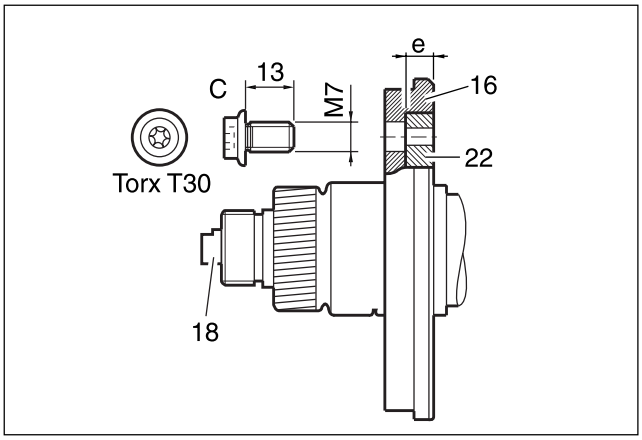
Camshaft Sprocket Bolt

Intake Flange Shaft Bolt

Tightening Torque	1st step: 18 - 22 N•m (13 - 16 lb-ft)
	2nd step: 60° ± 5°

NOTICE

- **The sprocket bolts are designed to be used only once, so always replace with new one.**



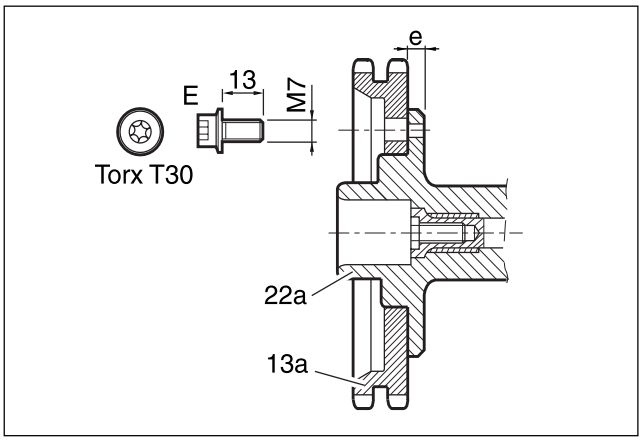
C. M7 x 13 Collar Bolt Torx-T30
e. 6.8 mm
16. Flange Shaft
18. Control Piston
22. Intake Camshaft

Exhaust Camshaft Sprocket Bolt

Tightening Torque	1st step: 18 - 22 N•m (13 - 16 lb-ft)
	2nd step: 60° ± 5°

NOTICE

- **The sprocket bolts are designed to be used only once, so always replace with new one.**

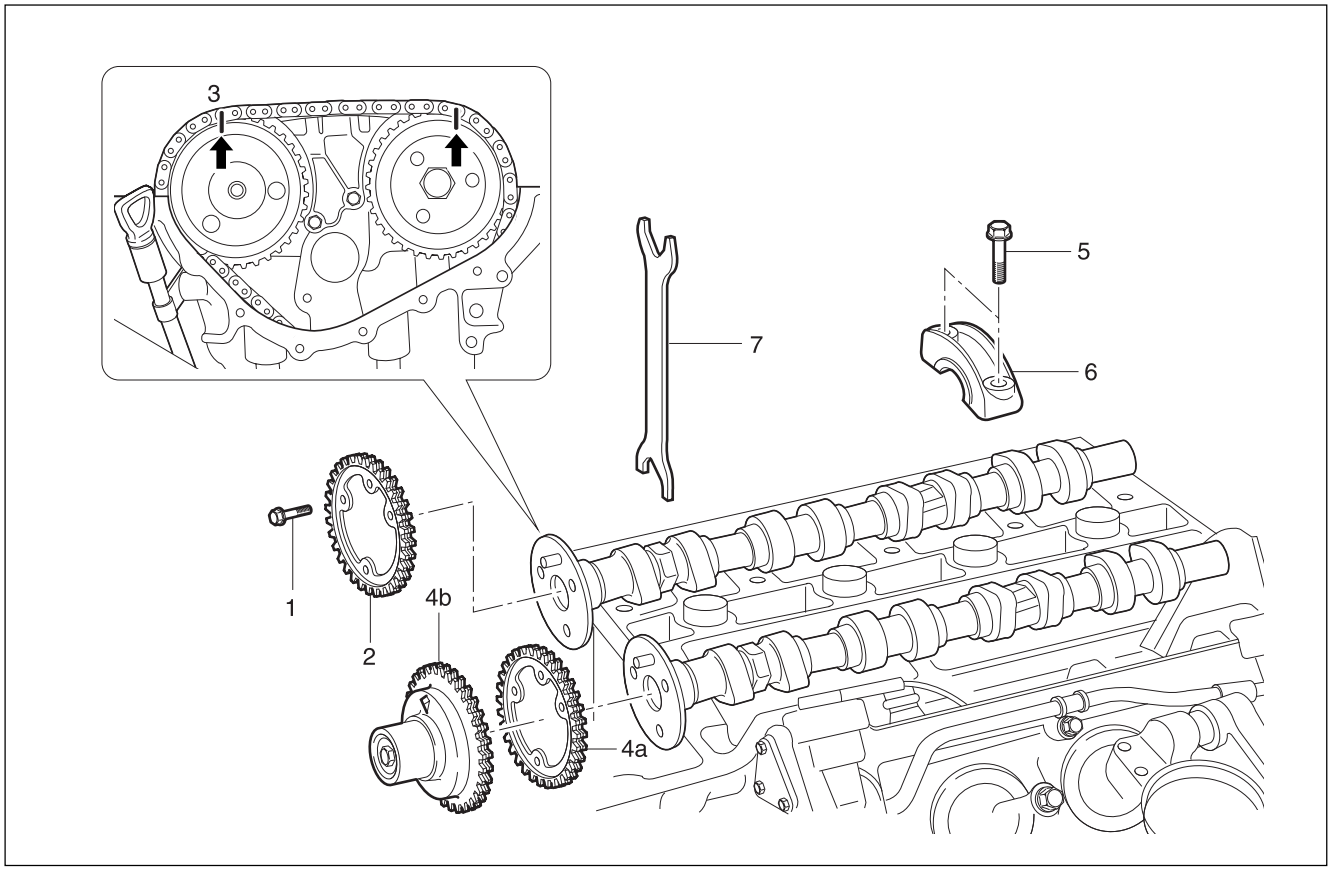


E. M7 x 13 Collar Bolt Torx-T30
e. 6.8 mm
13a. Camshaft Sprocket
22a. Exhaust Camshaft

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Camshaft

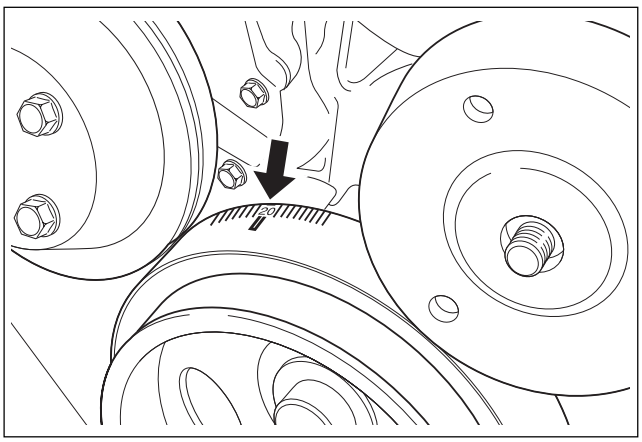
※ **Preceding Work:** Removal of cylinder head cover
Removal of camshaft adjust actuator and cylinder head front cover



1. Bolt (M7 X 13, 3 pieces)
   ..... 1st Step 18 - 22 NSm (13 - 16 lb-ft)
   ..... 2nd Step 60 ° ± 5 ° Rotation Added
2. Exhaust Camshaft Sprocket
3. Timing Chain
   4a. Intake Camshaft Spocket (E20)
   4b. Camshaft Adjuster and Camshaft Sprocket (E23)
5. Bearing Cap Bolt (20 pieces)
   ..... 22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)
6. Camshaft Bearing Cap
7. Wrench

Removal & Installation Procedure

1. Turn the crankshaft and position the no.1 cylinder piston at ATDC 20 °.
2. Put the alignment marks (arrows) on the camshaft sprocket and the timing chain.
3. Remove the chain tensioner.



Installation Notice

Tightening Torque	Screw Plug	40 N•m (30 lb-ft)
	Tensioner Assembly	72 - 88 N•m (53 - 65 lb-ft)

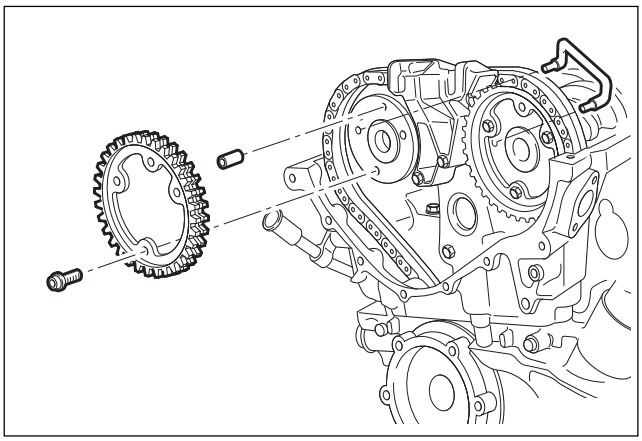
CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

4. Remove the exhaust camshaft sprocket.

Installation Notice

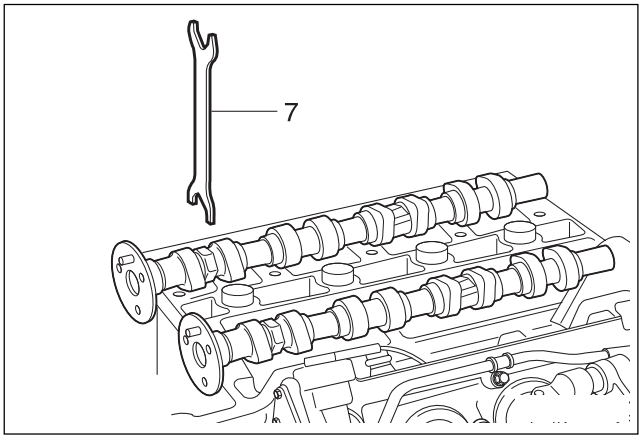
Tightening Torque	1st step: 18 - 22 N•m (13 - 16 lb-ft)
	2nd step: 60° ± 5°

NOTICE
- **The sprocket bolt is designed to be used only once, so always replace with new one.**



5. Take off the timing chain from intake camshaft sprocket, and secure it not to fall down into the timing gear case.

6. Using the wrench (7), turn the camshaft until there is no resistence in camshaft bearing area.

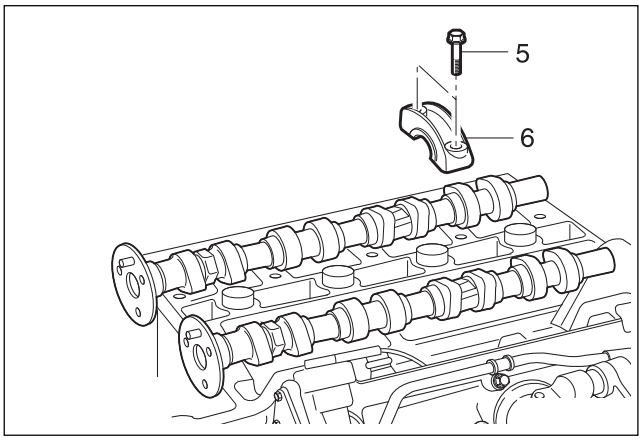


7. Remove the bearing cap, and remove the intake and the exhaust camshaft.

Installation Notice

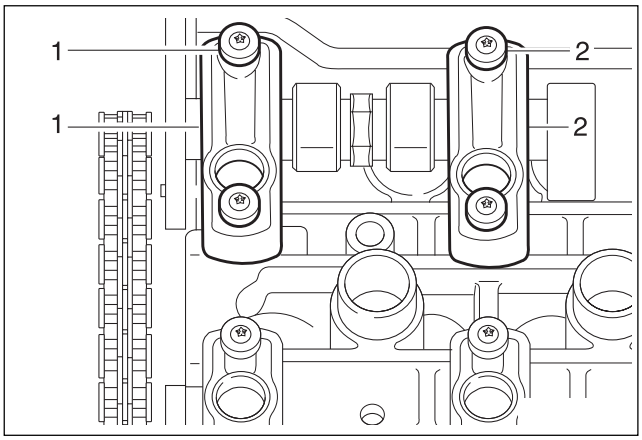
Tightening Torque	60 - 70 N•m (44 - 52 lb-ft)

NOTICE
- **Check the numbers on the bearing cap not to be mixed up.**



8. Apply the engine oil on the valve tappet and camshaft bearing.
9. Installation should follow the removal procedure in the reverse order.

NOTICE
- **Base circle of cam should cantact with the valve tappet.**
- **Install the camshaft bearing caps according to the numbers on the cylinder head cast and bearing cap.**

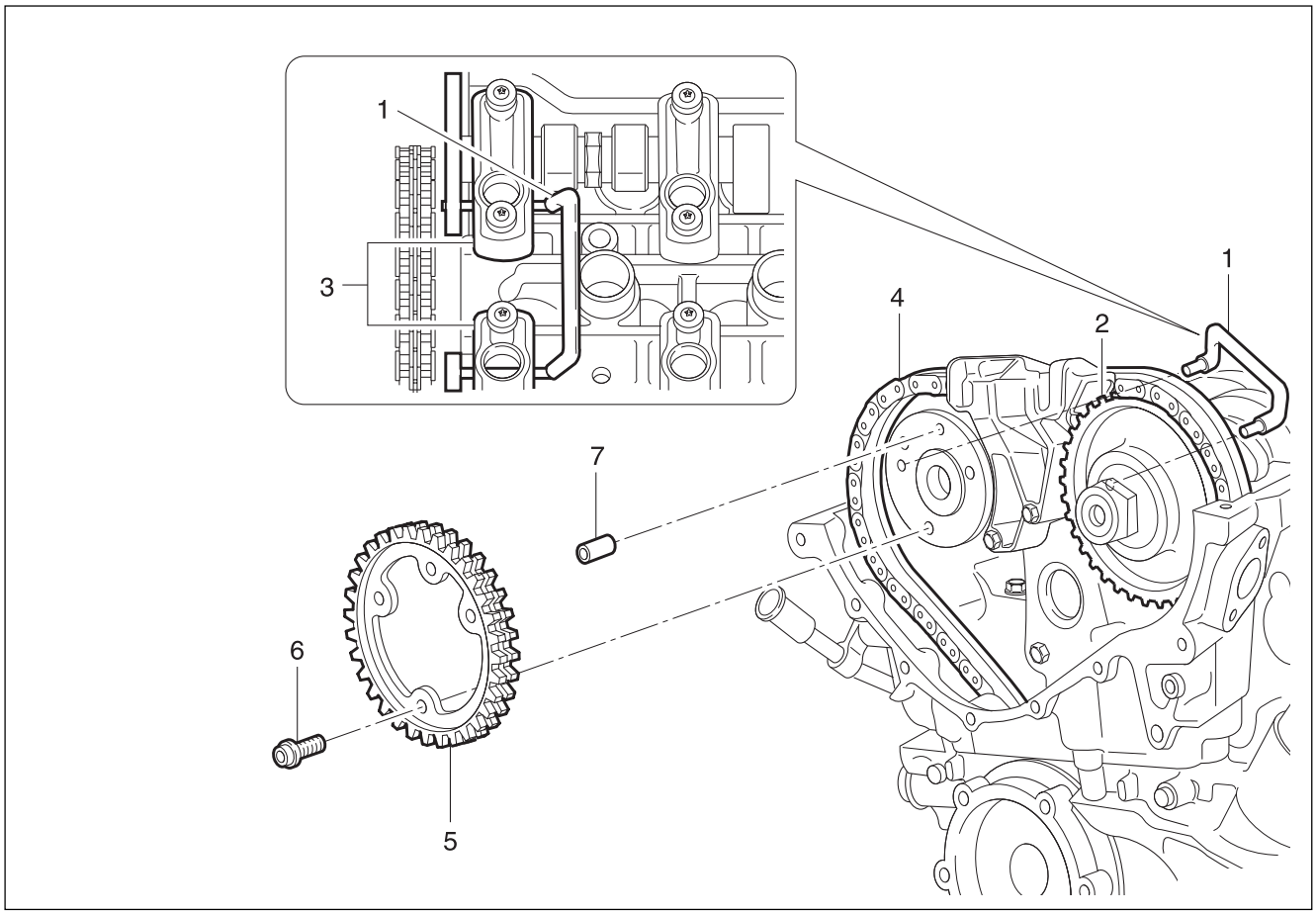


10. Check the camshaft timing position.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Camshaft Timing Position

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



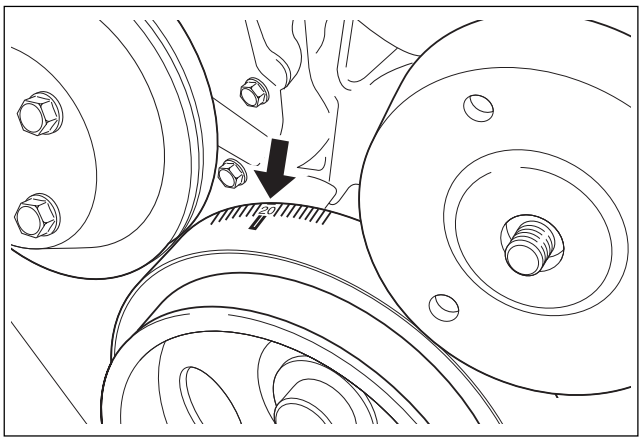
1. Holding Pin A9913 0052B (111 589 03 15 00)
2. Intake Camshaft Sprocket
3. Camshaft Bearing Cap
4. Timing Chain
5. Exhaust Camshaft Sprocket
6. Bolt (M7 X 13, 3 pieces)
   ..... 1st step 18 - 22 NSm (13 - 16 lb-ft)
   .....2nd step 60 ° ± 5 °rotation added
7. StratePin

Tools Required

A9913 0052B (111 589 03 15 00) Holding Pin

Inspection Procedure

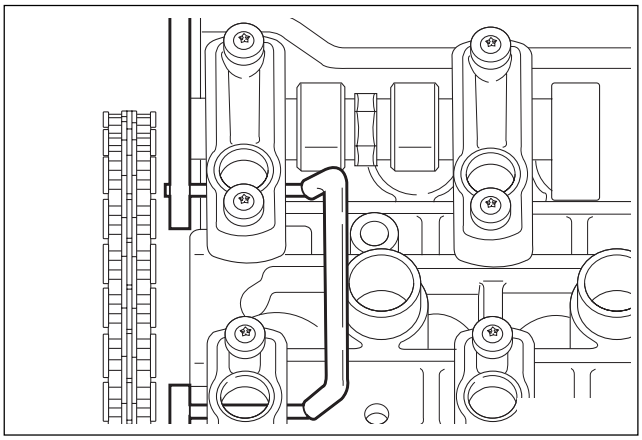
1. Position the NO.1 cylinder piston to ATDC 20 °by turning the crankshaft.



NOTICE

- **When the ATDC 20 °mark on vibration damper is aligned with timing gear case cover, the intake and ex-haust cam of cylinder will make the slope to the center and will face up. In this way, the insert hole in NO.1 and NO.4 camshaft bearing cap will match in line with the flange hole for camshaft sprocket.**

2. Check the timing as below procedure;
   - Check if the holding pin A9913 0052B (111 589 03 15 00) can be inserted into the NO.1 and NO.4 bearing cap hole.
   - At this condition, check if the ATDC 20 °mark on vibration damper aligns with the marker on the timing gear case.



Adjustment Procedure

1. Position the NO.1 cylinder to ATDC 20 °.
2. Remove the chain tensioner.
3. Remove the exhaust camshaft sprocket.
4. Adjust the timing position with inserting the holding pin A9913 0052B (111 589 03 15 00) into the NO.1 and NO.4 camshaft bearing cap hole and flange hole while rotating the camshaft by using wrench.
5. Install the chain to the intake camshaft sprocket.
6. Install the chain to the exhaust camshaft sprocket and tighten the bolt.

Installation Notice

Tightening Torque	1st step: 18 - 22 N•m (13 - 16 lb-ft)
	2nd step: 90° ± 5°

The sprocket bolt is designed to be used only once, so replace with new one.

7. Install the chain tensioner.

Installation Notice

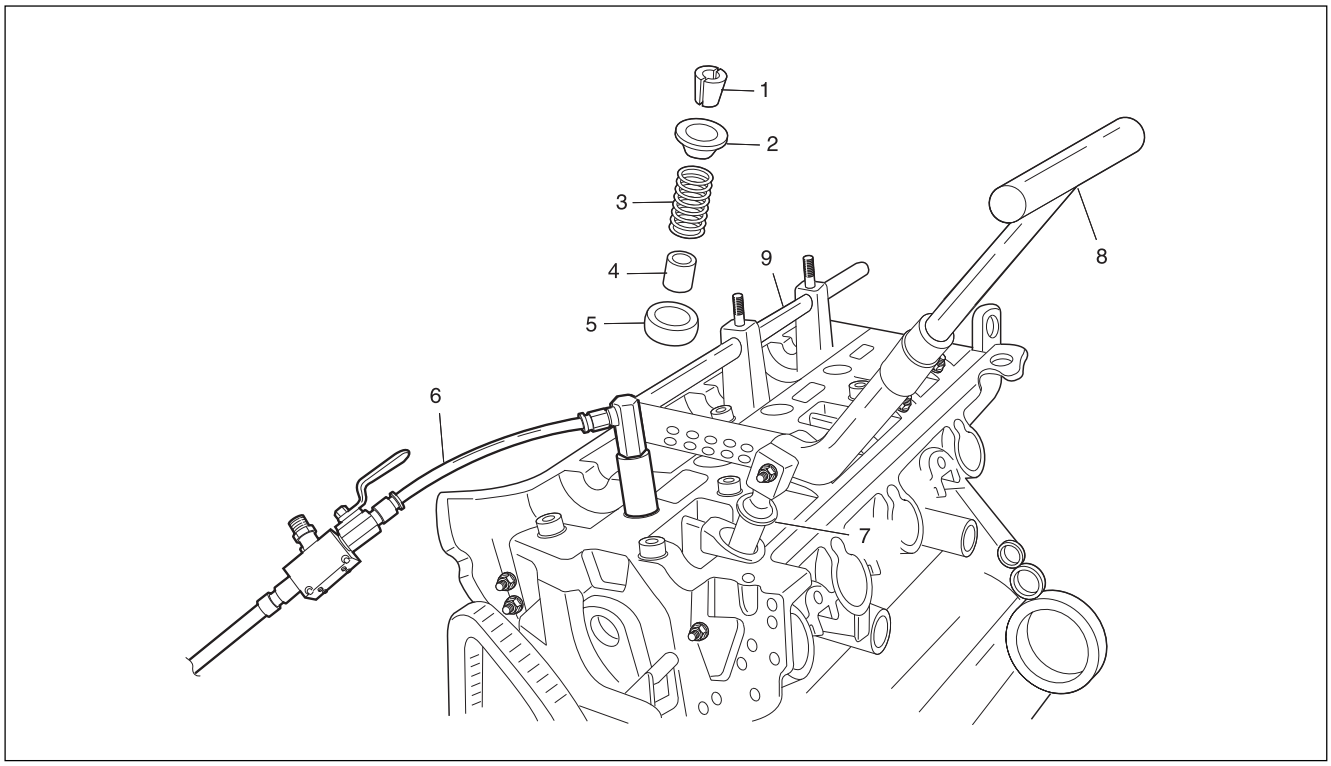
Tightening Torque	Screw Plug	40 N•m (30 lb-ft)
	Tensioner Assembly	72 - 88 N•m (53 - 65 lb-ft)

8. Check the camshaft timing.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Valve Spring

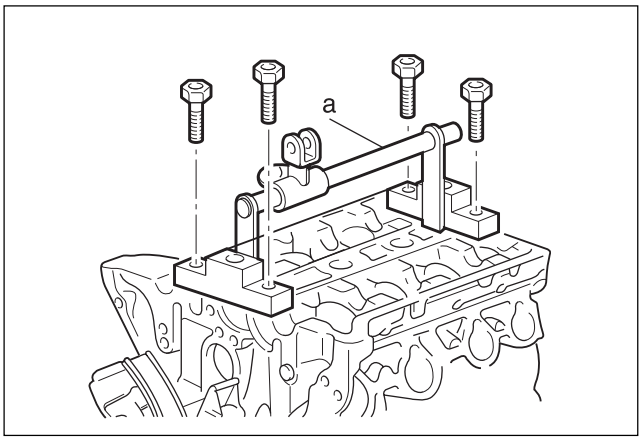
※ **Preceding Work:** Removal of camshaft
Removal of spark plug



1. Valve Cotter
2. Valve Spring Retainer
3. Valve Spring
4. Valve Stem Seal
5. Lower Retainer
6. Connecting Hose A9912 0012B (DW110 - 090)
7. Thrust Piece A9917 0121B (111 589 25 63 00)
8. Lever Pusher A9917 0111B (111 589 18 61 00)
9. Supporting Bar A9917 0101B (111 589 01 59 00)

Tools Required

A9917 0101B (111 589 01 59 00) Supporting Bar
A9917 0111B (111 589 18 61 00) Lever Pusher
A9917 0121B (111 589 25 63 00) Thrust Piece
A9910 0150B (602 589 00 40 00) Engine Lock
A9912 0012B (DW110 - 090) Connecting Hose



Removal & Installation Procedure

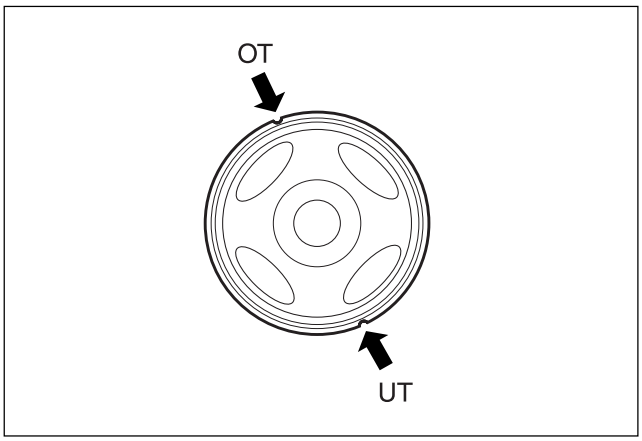
1. Place the supporting bar A9917 0101B (111 589 01 59 00) (a) at the camshaft bearing cap and tighten them with the bearing cap bolt.

Installation Notice

Tightening Torque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

2. Turn the crankshaft to position the each cylinder piston at TDC.

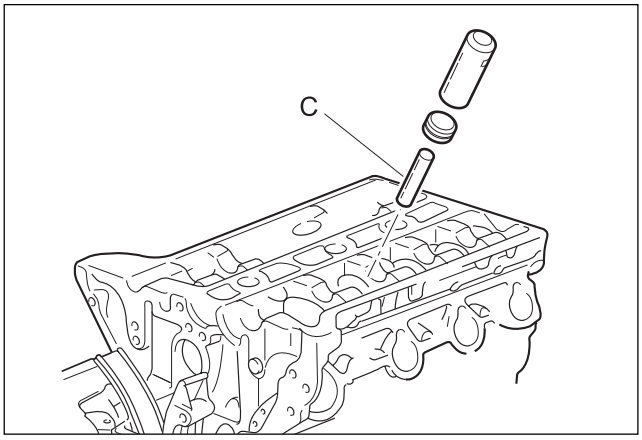
Tightening Torque	1st step: 18 - 22 N•m (13 - 16 lb-ft)
	2nd step: 90° ± 5°



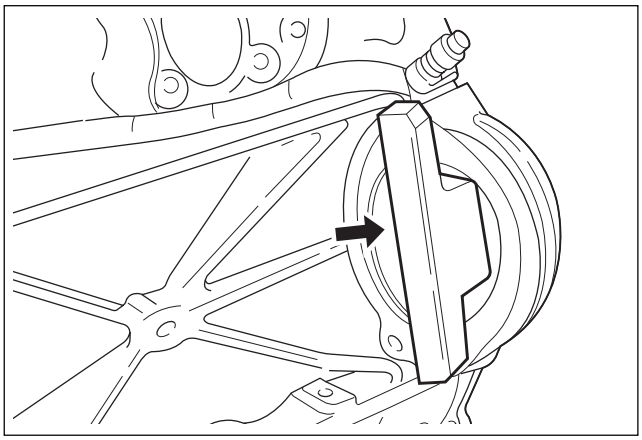
NOTICE

- **Remove the valve spring only at TDC.**
- **Always rotate the crankshaft by holding the chain to prevent from timing chain damage and tangling, and for smooth rotation.**

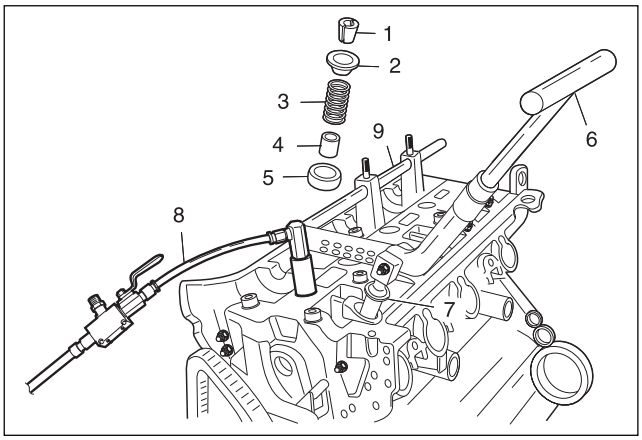
3. Remove the valve tappet using the valve tappet remover.
4. Install the connecting hose A9912 0012B (DW110 - 090) (c) to the spark plug hole.



5. Install the engine lock A9910 0150B (602 589 00 40 00) to the ring gear to prevent the crankshaft from rotating.
6. Blow up with compressed air.



7. Install the supporting bar A9917 0101B (111 589 01 59 00) (d) and the lever pusher A9917 0111B (111 589 18 61 00) (a).
8. Mount the thrust piece A9917 0121B (111 589 25 63 00) (b) vertically to the valve spring retainer (2).
9. Press the valve spring (3) by using the lever pusher A9917 0111B (111 589 18 61 00) (a).
10. Remove the valve cotter (1) using the pincette.
11. Remove the upper retainer (2) and the valve spring (3).



CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

12. Remove the valve stem seal (4) and replace if necessary.

NOTICE

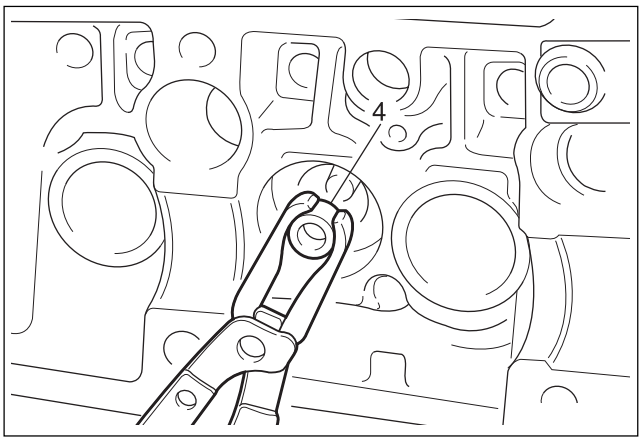
- **Check the valve stem seal for damage and replace if necessary.**

13. Remove the lower retainer (5).

NOTICE

- **Check the retainer for damages and replace with a new one if necessary.**

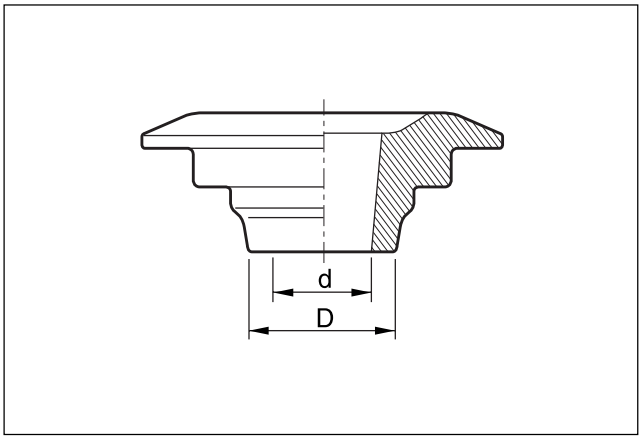
14. Installation should follow the removal procedure in the reverse order.



Test (Upper and Lower Valve Tappet and Valve Cotter)

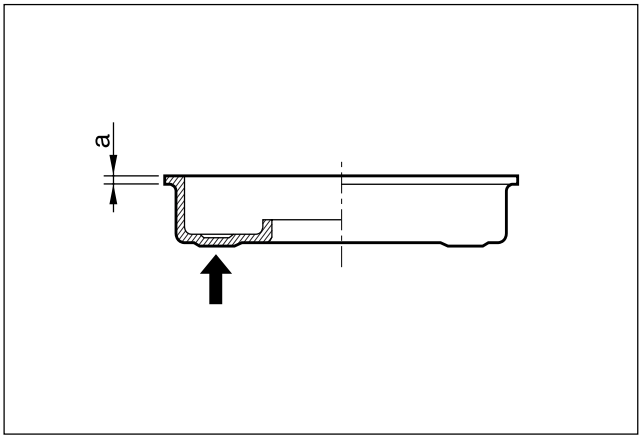
- Upper Valve Spring Retainer

Size (mm)	(d)	8.5
	(D)	12.3



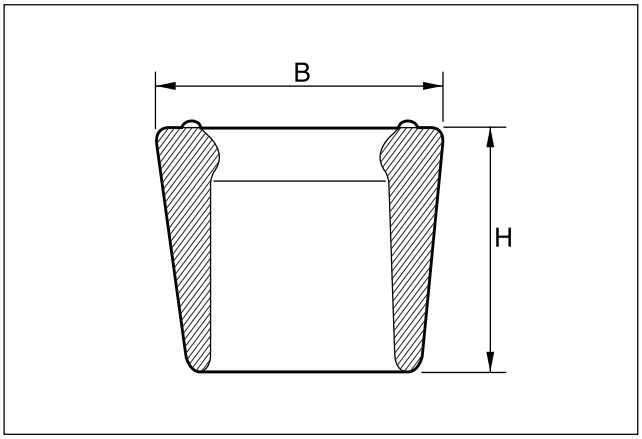
- Lower Valve Spring Retainer

Size (mm)	(a)	0.8 - 1.0



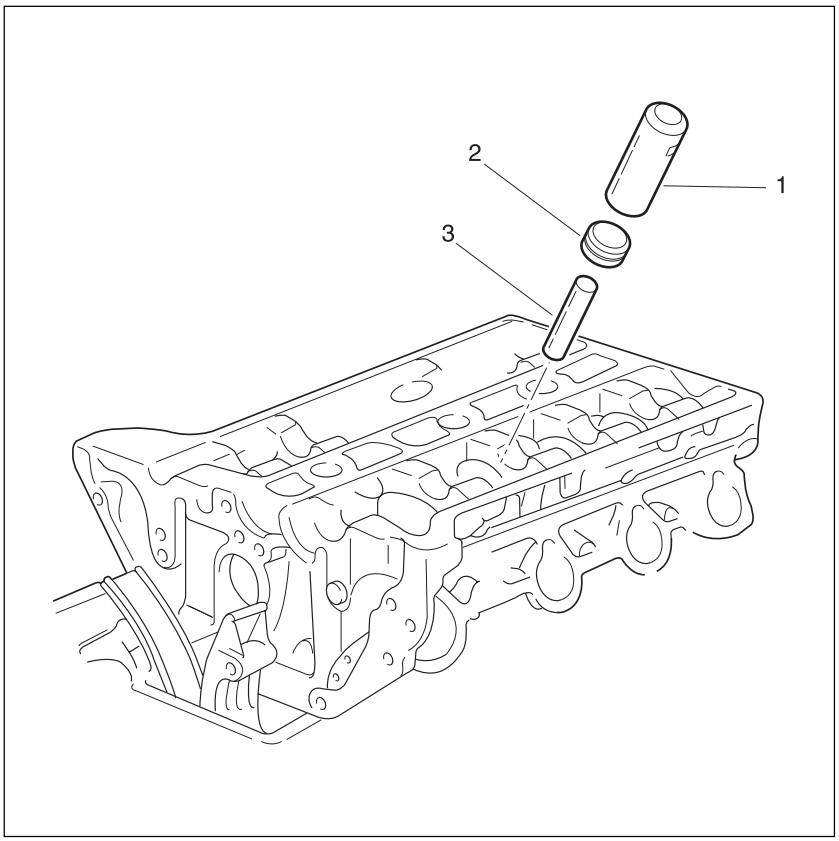
- Valve Cotter

Size (mm)	(B)	9.0
	(H)	9.2 - 9.8



▶ Valve Stem Seal

※ **Preceding Work:** Removal of valve spring



1. Drift 119 589 00 43 00
2. Valve Stem Seal
3. Protective Sleeve

Tools Required

A9917 0171B (119 589 00 43 00) Drift

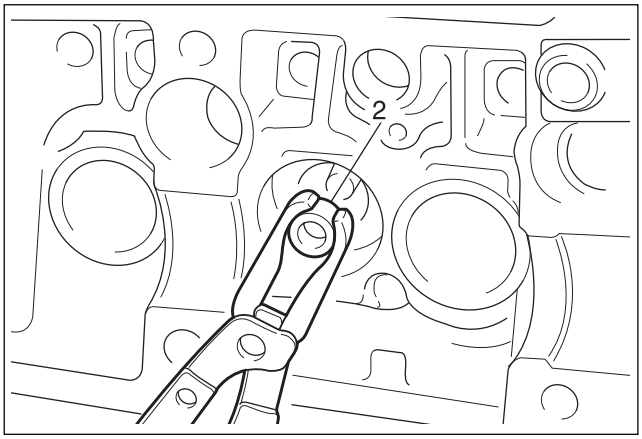
Replacement Procedure

1. Remove the valve stem seal (2) using the pliers.

NOTICE

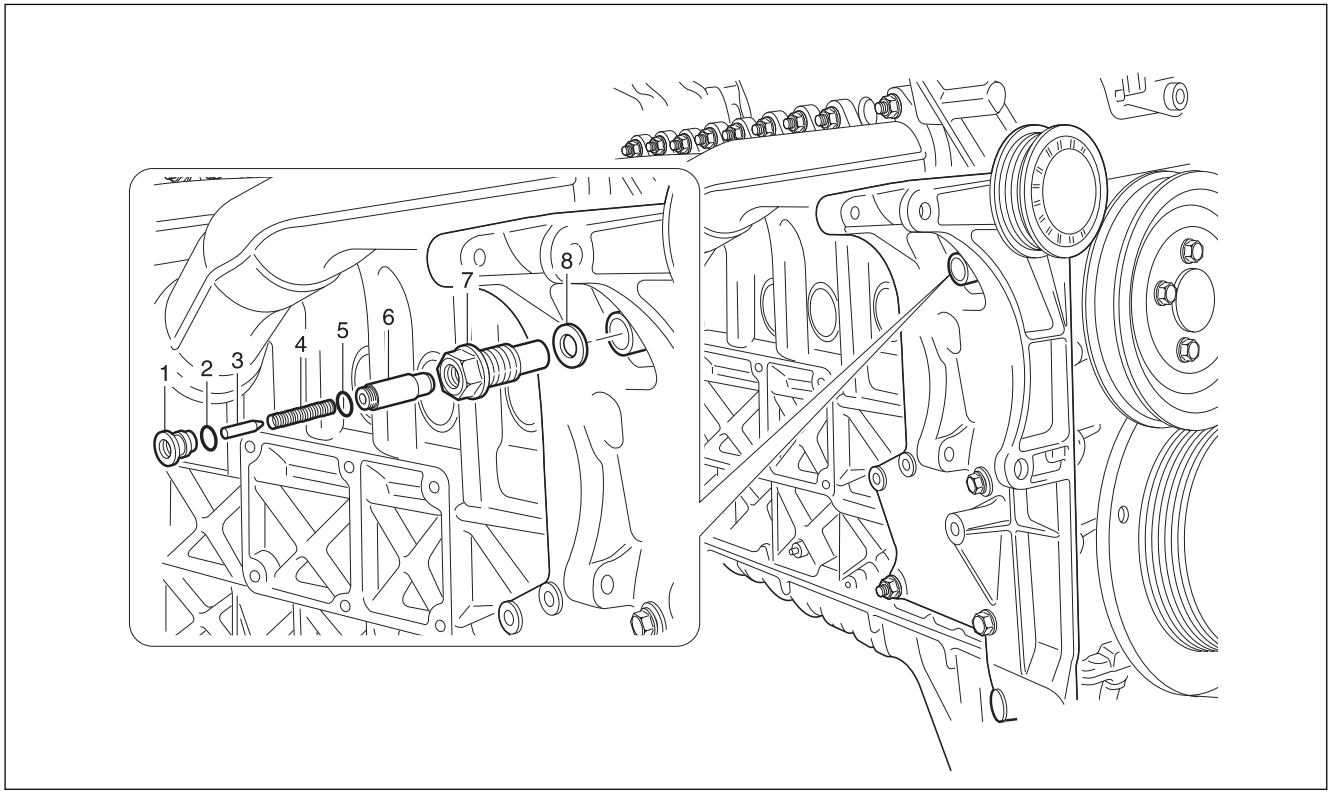
- **Check the valve stem seal for damage and replace if necessary.**

2. Coat the valve stem seal with oil and assemble it with the protective sleeve.
3. Insert the valve stem seal by pressing it with the drift A9917 0171B (119 589 00 43 00).



CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Chain Tensioner



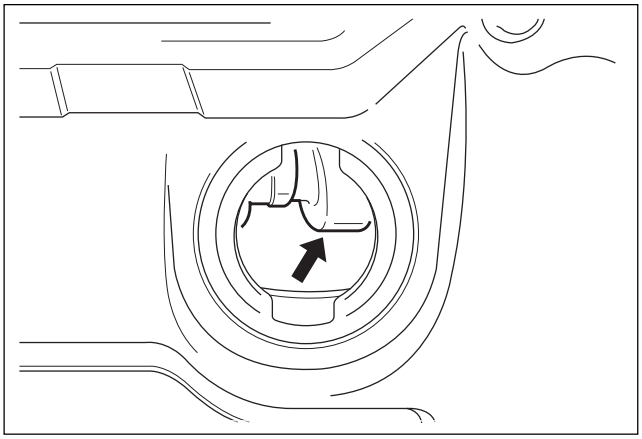
1. Screw Plug ..... 40 N•m (30 lb-ft)
2. Seal
3. Filler Pin
4. Compression Spring
5. Snap Ring
6. Thrust Pin
7. Chain Tensioner Housing
   ..... 72 - 88 N•m (53 - 65 lb-ft)
8. Seal

Removal Procedure

1. Position the number 1 cylinder to ATDC 20 °.

NOTICE

- **Remove the oil filler cap at adjustment position, and check whether the intake camshaft cam's lobe (arrow) stays in the upper side.**

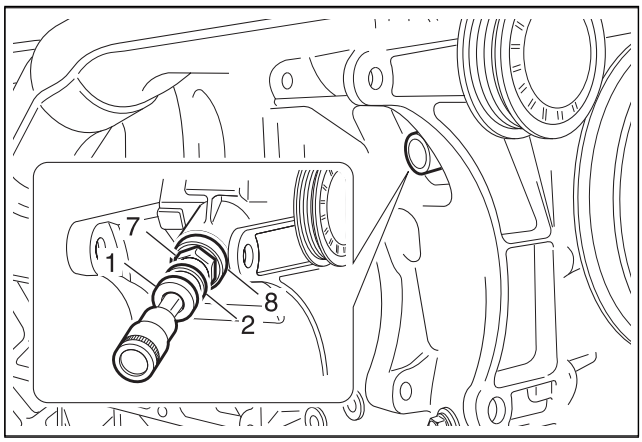


2. Cover the generator with a clean cloth.
3. Release the tension by unscrewing the screw plug once.

NOTICE

- **In case that the tension is reduced by unscrewing the screw plug, reinstall after completely removing the chain tensioner. If the chain tensioner is tightened again without completely reducing its tension, then the snap ring doesn't return to the original position and the tension gets exceeded.**

4. Carefully unscrew the screw plug (1), and remove the seal (2).

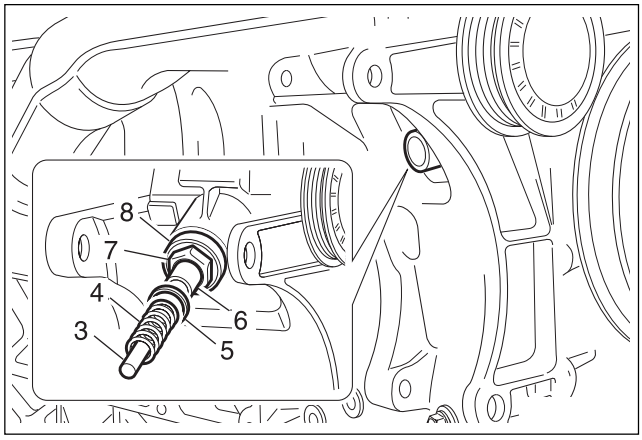


NOTICE

- **For the removal of screw plug, be careful that it can be jumped out due to the force of compression spring.**
- **Remove the screw plug only when the seal and compression spring are damaged.**

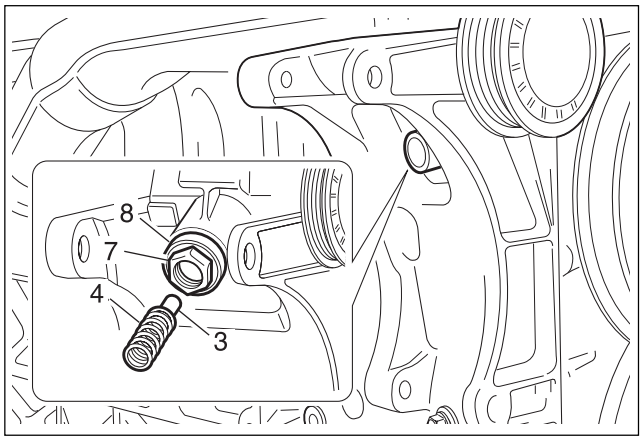
5. Carefully remove the filler pin (3), compression spring (4), snap ring (5), and the thrust pin (6).

6. Remove the chain tensioner housing (7) and the seal (8).



Installation Procedure

1. Connect the thrust pin (6) and the snap ring (5) to the chain tensioner housing (7).



NOTICE

- **When connecting the thrust pin, push in the thrust pin far enough so that it doesn't protrude at the chain tensioner housing.**

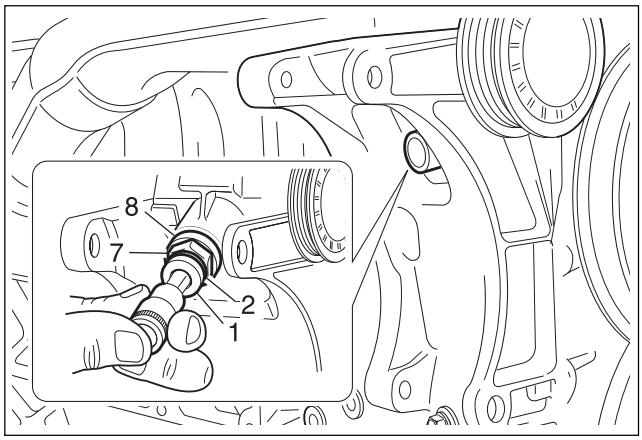
2. Install the chain tensioner housing (7), thrust pin (6), snap ring (5), and the seal (8).

Installation Notice

Tightening Torque	72 - 88 N•m (53 - 65 lb-ft)

3. Insert the compression spring (4) with the filler pin (3) into chain tensioner housing.

4. Lightly apply the grease to the seal (2) and install the screw plug (1).



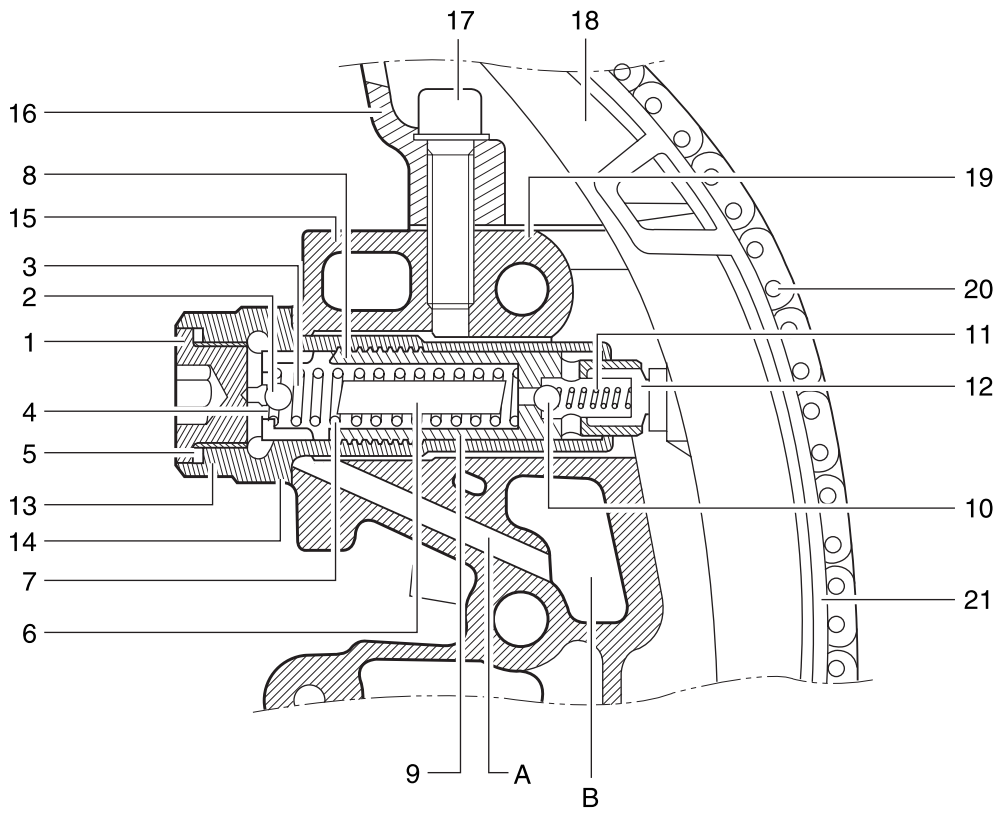
Installation Notice

Tightening Torque	40 N•m (30 lb-ft)

5. Check for leaks by operating the engine.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Sectional View

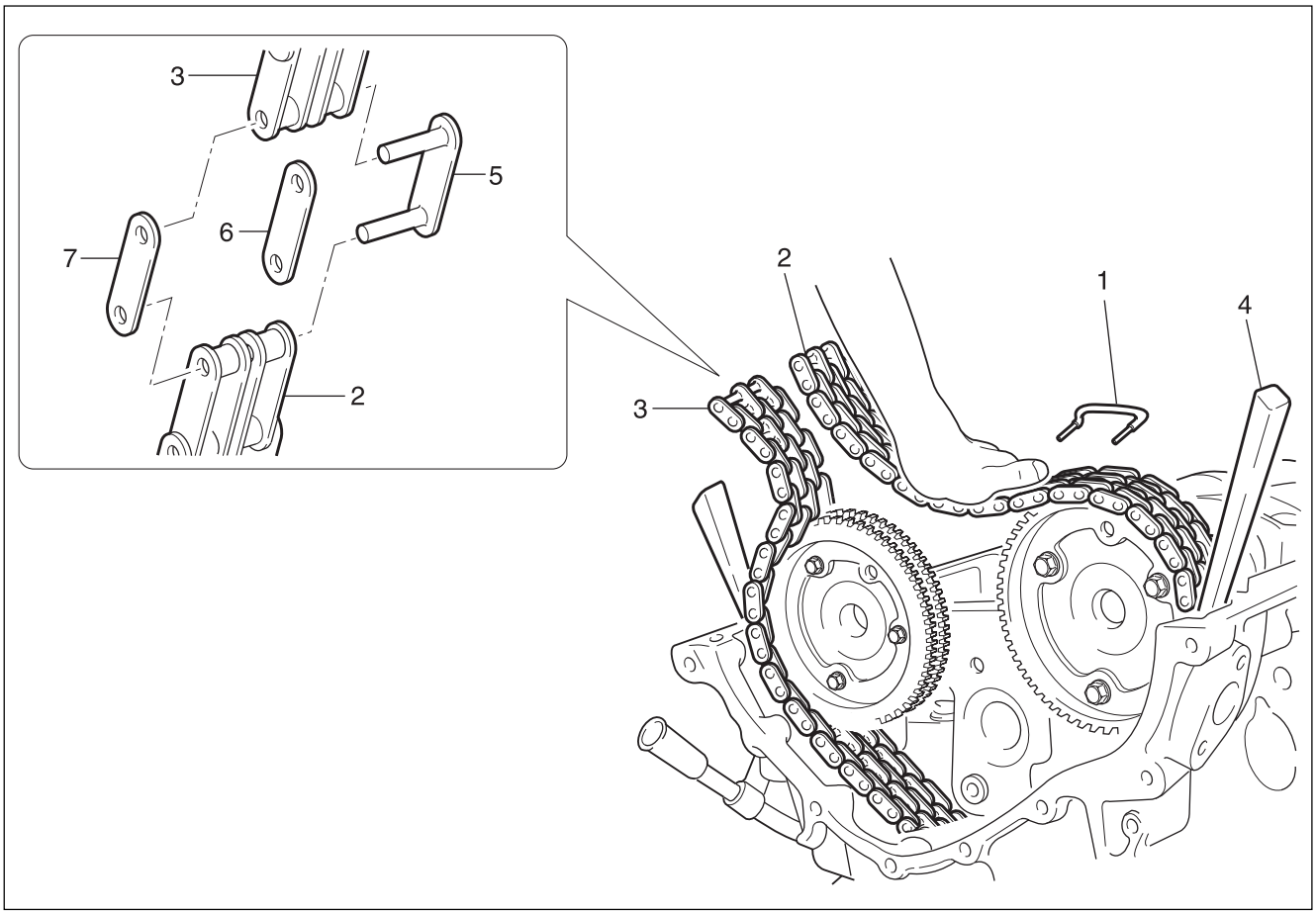


1. Screw Plug
2. Ball (Nonreturn Valve)
3. Compression Spring
4. Ball Guide
5. Seal (Aluminum)
6. Filler Pin
7. Compression Spring
8. Snap Ring
9. Thrust Pin
10. Ball (Nonreturn Valve)
11. Compression Spring
12. Thrust Piece
13. Chain Tensioner Housing
14. Seal
15. Timing Gear Case Cover
16. Cylinder Head
17. Bolt / Washer
18. Tensioning Rail
19. Cylinder Head Gasket
20. Timing Chain
21. Tensioning Rail Base (Sliding Surface)

A. Oil Supply Hole
B. Chain Tensioner Oil Storage Hole

▶ Timing Chain

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



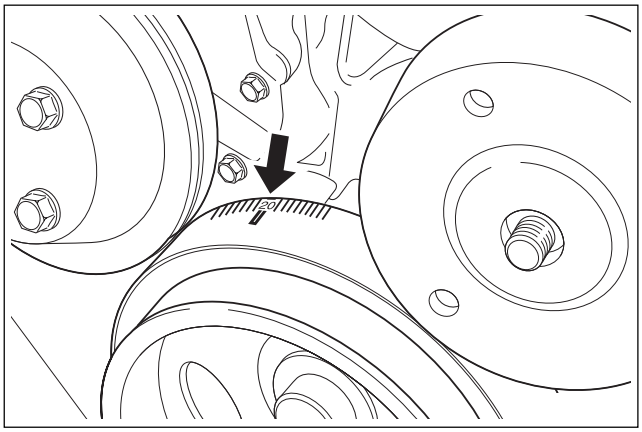
1. Pin
2. New Timing Chain
3. Timing Chain (Used)
4. Wedge
5. Link
6. Center Plate
7. Outer Plate

Tools Required

A9913 0010B (000 589 58 43 00) Chain Assembly
A9913 0052B (111 589 03 15 00) Holding Pin

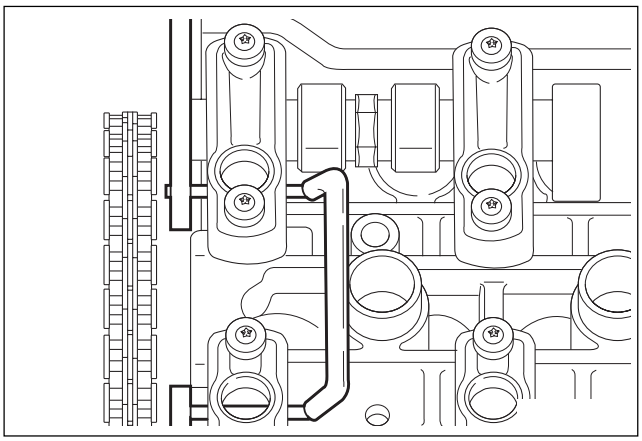
Replacement Procedure

1. Position the NO.1 cylinder to ATDC 20 °.

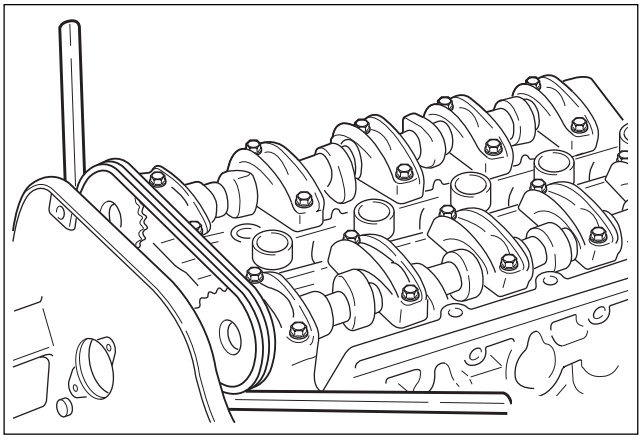


CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

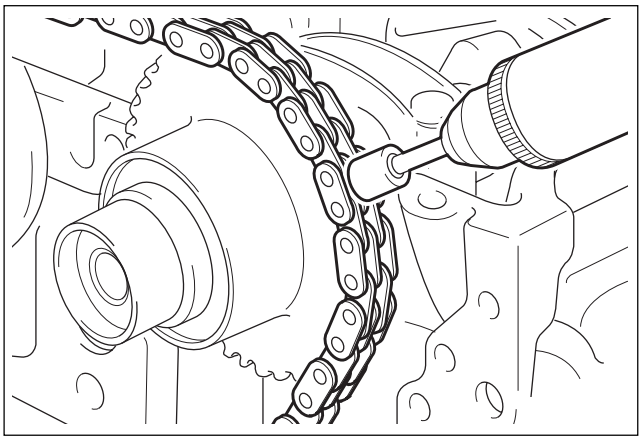
2. Insert the holding pin A9913 0052B (111 589 03 15 00) to the intake and exhaust camshaft flange not to rotate camshaft.
3. Remove the chain tensioner.



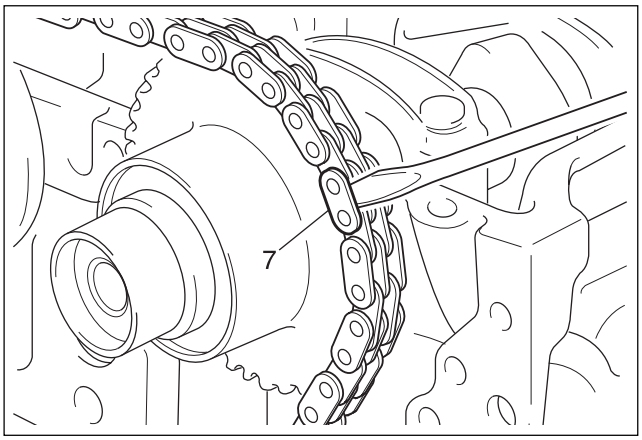
4. Mount the wedges to both sides of the camshaft sprocket as shown in the figure.



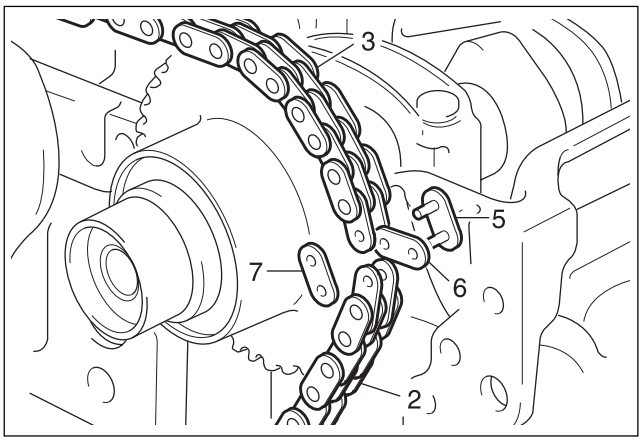
5. Cover the chain housing with a clean cloth, and grind off the timing chain pin from the intake camshaft sprocket with the grinder.



6. Remove the outer plate (7) with the screw driver and remove the link (5).



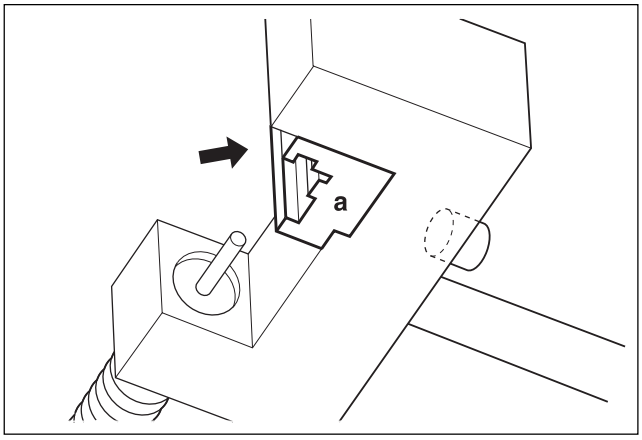
7. Connect the new timing chain (2) to the used timing chain (3) with the link (5), center plate (6, thickness 1.6 mm), and the outer plate (7).
8. Rotate the crankshaft in the direction if engine revolution by pressing the new timing chain against the exhaust camshaft sprocket to prevent it to be tangled.

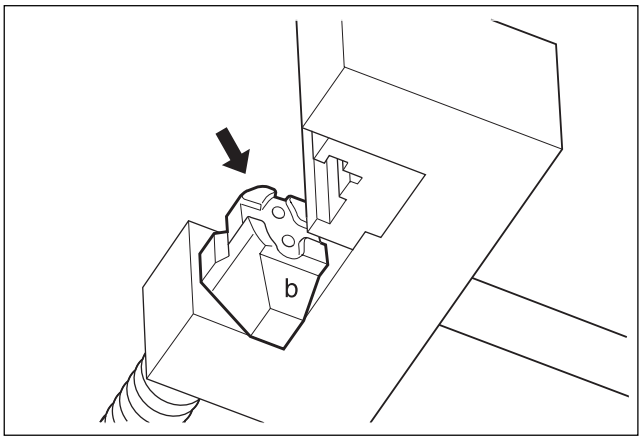


NOTICE

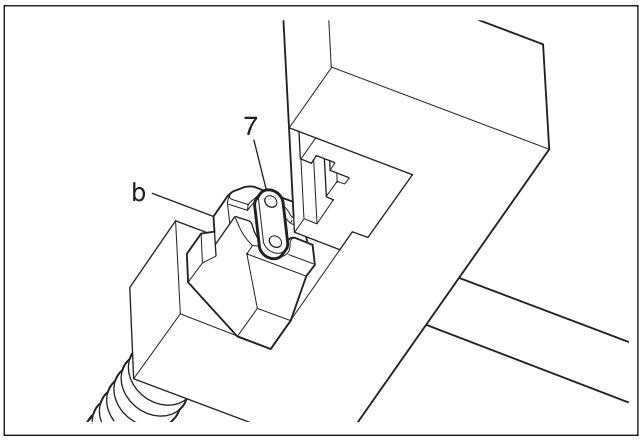
- **Be sure to remove the wedge before cranking the engine.**

9. Take out the used timing chain out from the chain housing.
10. Connect both separators of the new timing chain with the link (5) and the center plate (6).
11. Install the jaw (a) and the thrust piece (b) to the assembly tool as shown in the figures.



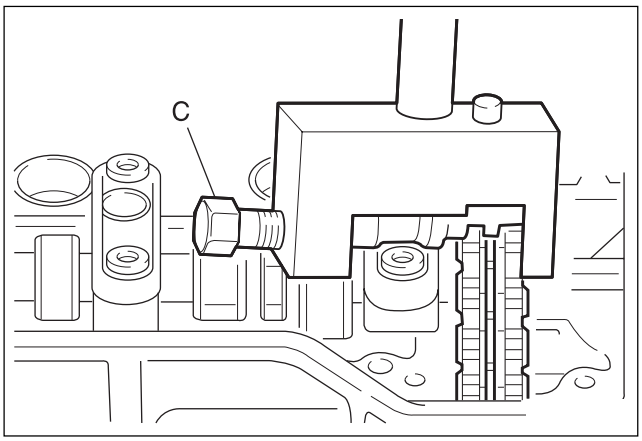


12. Place the outer plate (7, thickness 1.2 mm) inside the thrust piece (b).

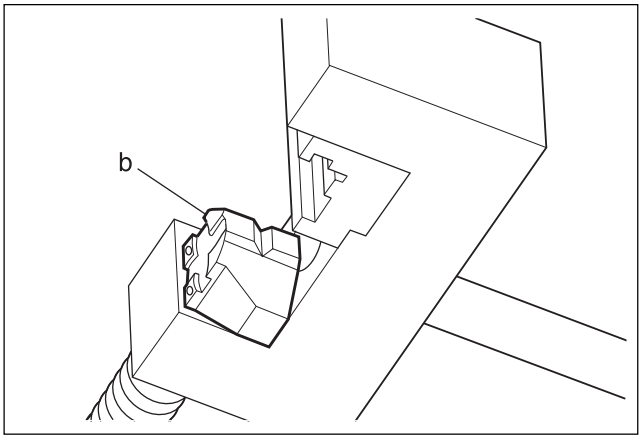


CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

13. Install the chain assembly A9913 0010B (000 589 58 43 00)above the link and tighten the spindle (c) until a block is felt.
14. Place the chain assembly A9913 0010B (000 589 58 43 00).



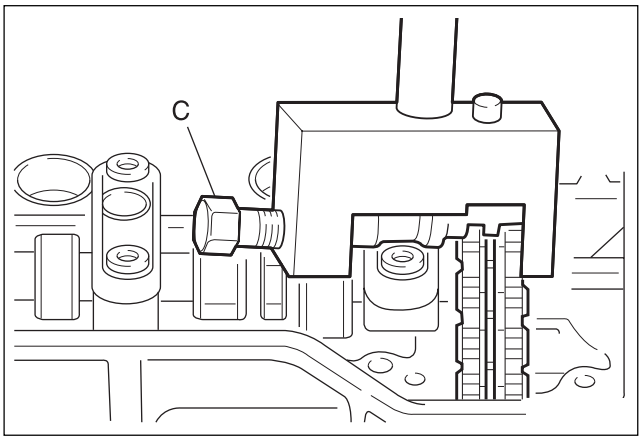
15. Replace the thrust piece (b) as shown in the figure.



16. Install the chain assembly A9913 0010B (000 589 58 43 00) to the link pin and tighten the spindle (c).

Installation Notice

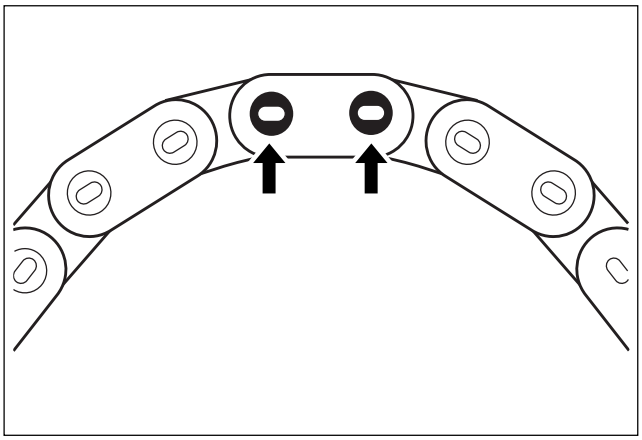
Tightening Torque	30 N•m (22 lb-ft)



17. Rivet the link pin.
    Check the condition and it again if necessary.
18. Install the chain tensioner.

Installation Notice

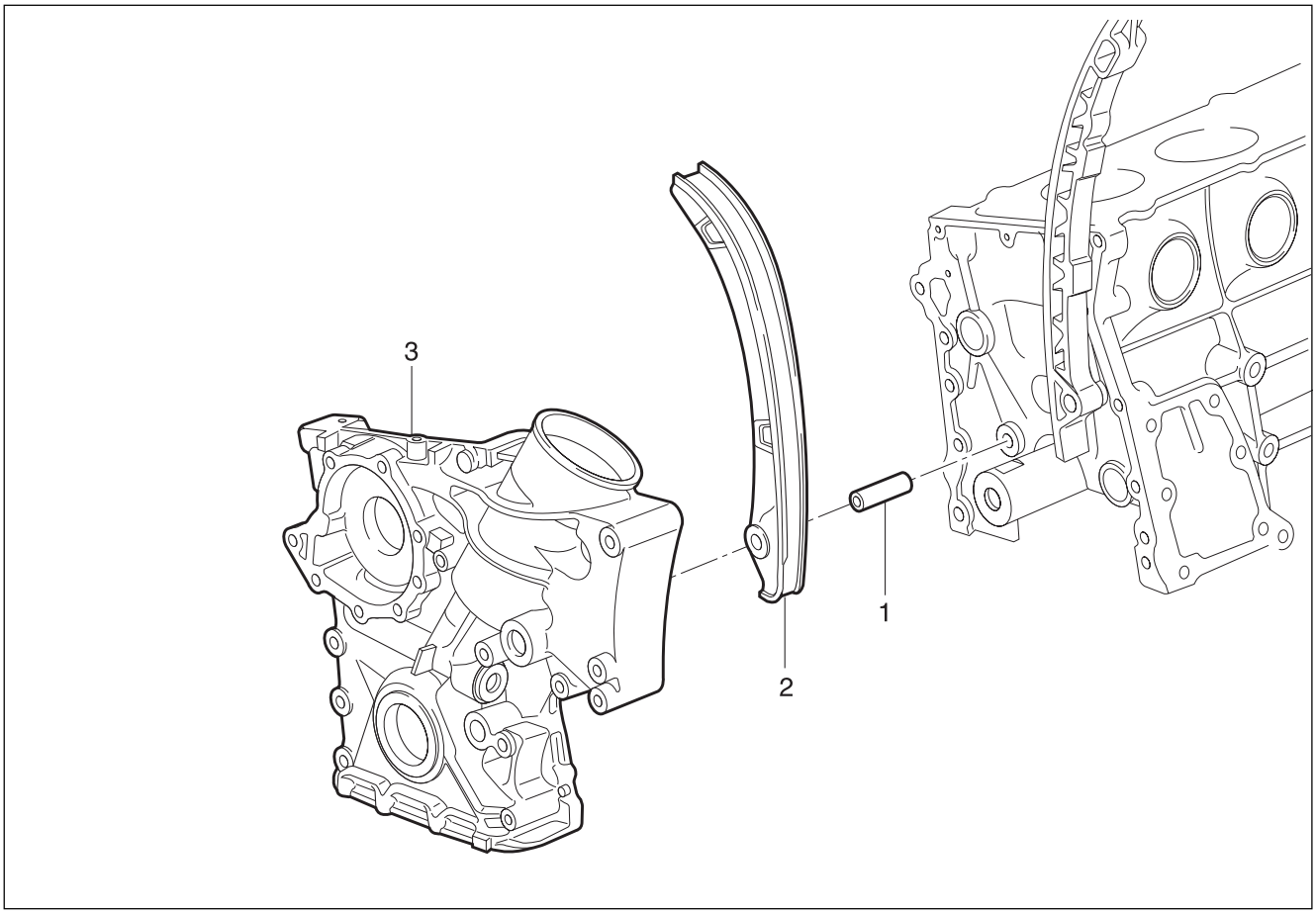
Tightening Torque	Screw Plug	40 N•m (30 lb-ft)
	Tensioner Assembly	72 - 88 N•m (53 - 65 lb-ft)



19. Check the camshaft timing position.

▶ Tensioning Rail

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



1. Sliding Rail Pin
2. Sliding Rail
3. Timing Gear Case Cover

Removal & Installation Procedure

1. Remove the timing gear case cover (3).

NOTICE
- **Be careful not to damage the gasket.**

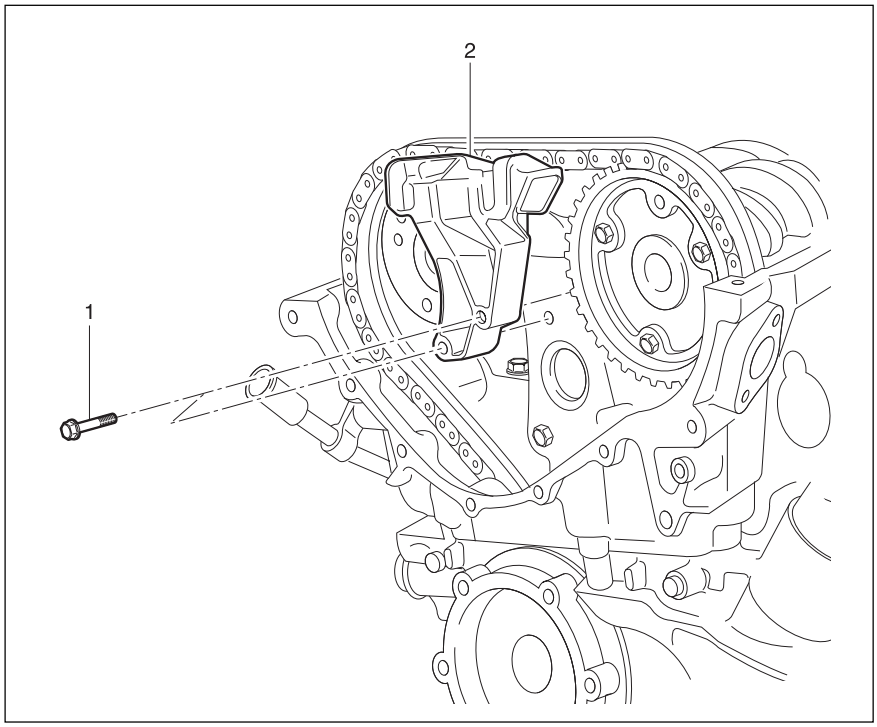
2. Remove the sliding rail (1) from the sliding rail pin (2).

NOTICE
- **Replace the plastic guide (2) if it is damaged.**
- **For installation, exactly align the plastic guide (2) with the sliding rail (1).**

3. Installation should follow the removal procedure in the reverse order.

▶ Cylinder Head Guide Rail

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



1. Bolt (M6 X 45, 2 pieces)
   9 - 11 N•m (80 - 97 lb-in)
2. Guide Rail

Tools Required

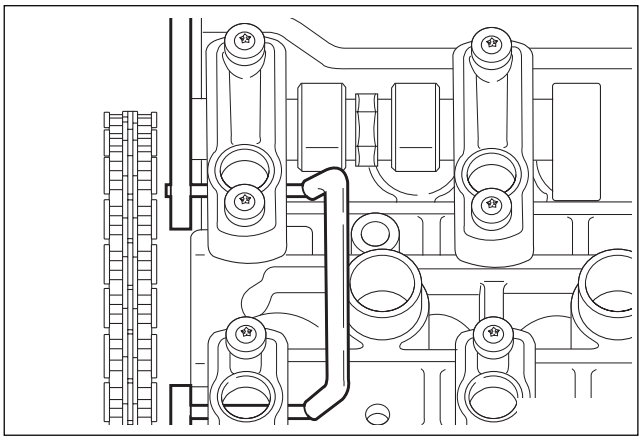
A9913 0052B (111 589 03 15 00) Holding Pin

Removal & Installation Procedure

1. Position the number 1 cylinder to ATDC 20 ° guide rail.
2. Install the holding pin A9913 0052B (111 589 03 15 00) into the no.1 and no.6 bearing cap hole.
3. Remove the chain tensioner.

Installation Notice

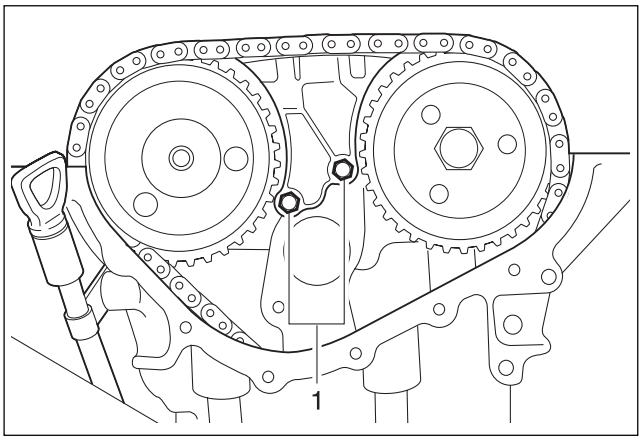
Tightening Torque	Screw Plug	40 N•m (30 lb-ft)
	Tensioner Assembly	72 - 88 N•m (53 - 65 lb-ft)



4. Unscrew the bolt (1) and remove the guide rail.

Installation Notice

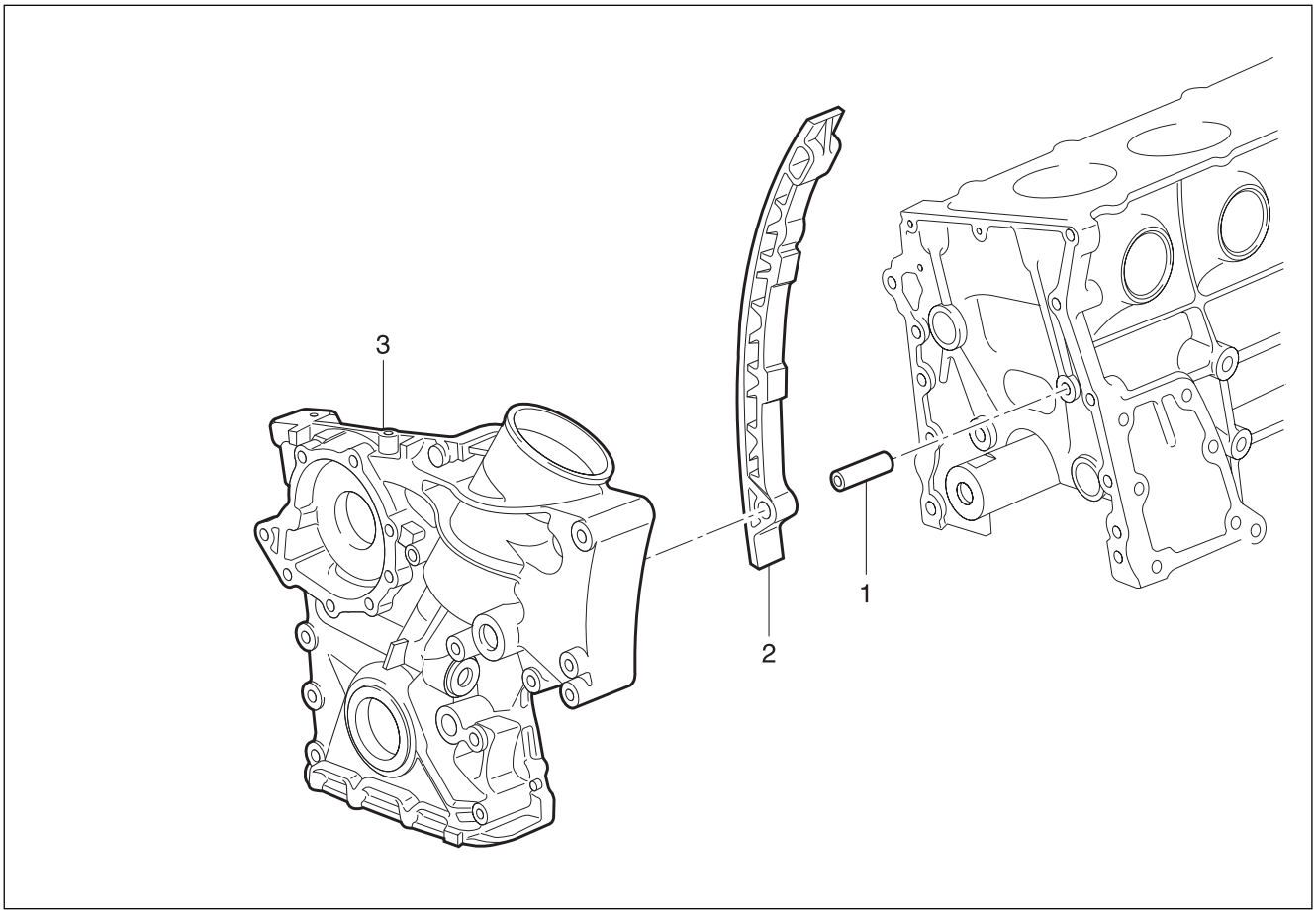
Tightening Torque	9 - 11 N•m (80 - 97 lb-in)



5. Installation should follow the removal procedure in the reverse order.

▶ Crankcase Guide Rail

※ **Preceding Work:** Removal of timing gear case cover



1. Guide Rail Pin
2. Guide Rail
3. Timing Gear Case Cover

Removal & Installation Procedure

1. Remove the timing gear case cover (3).

NOTICE
- **Be careful not to damage the gasket when removing / installing the timing gear case cover.**

2. Remove the guide rail (2) from the guide rail pin (1).

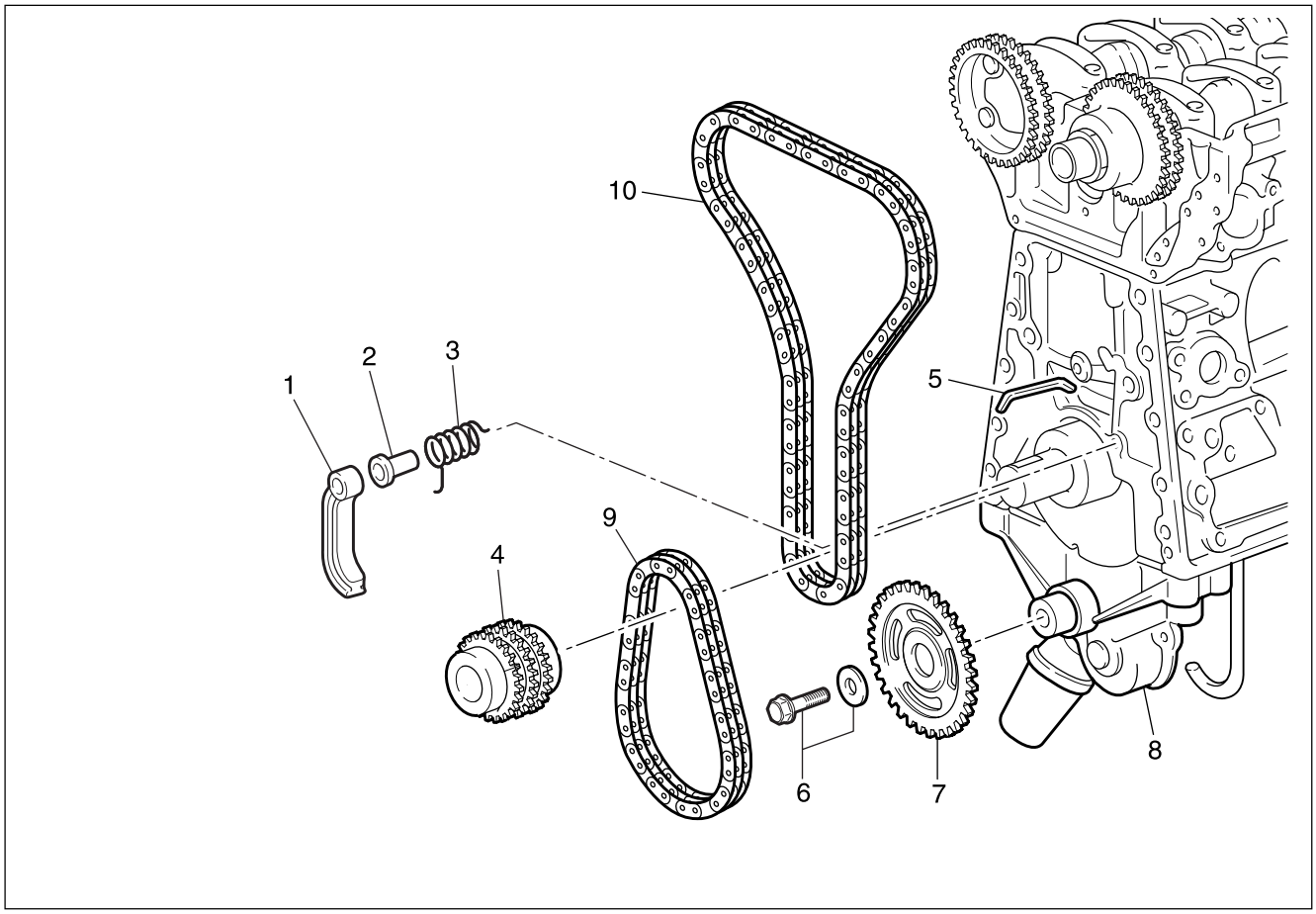
NOTICE
- **Replace the plastic guide (2) if damaged.**
- **Connect the plastic guide (2) and the guide rail (1) by aligning them accurately when installing.**

3. Installation should follow the removal procedure in the reverse order.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Crankshaft Sprocket

※ **Preceding Work:** Removal of oil pan
Removal of tensioning rail
Removal of crank case guide rail



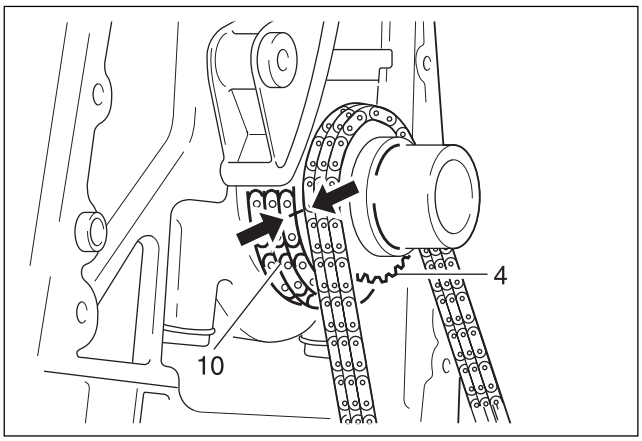
1. Oil Pump Chain Tensioner
2. Oil Pump Chain Bushing
3. Oil Pump Chain Spring
4. Crankshaft Sprocket
5. Key
6. Bolt (M8 x 20, 1 piece) / Washer
..... 29 - 35 N•m (21 - 26 lb-ft)
7. Oil Pump Sprocket
8. Oil Pump
9. Oil Pump Roller Chain
10. Timing Chain

Tools Required

W9911 0050B (615 589 01 33 00) Crankshaft Sprocket Puller

Removal & Installation Procedure

1. Put the assembly mark at the crankshaft sprocket (4) and the timing chain (10) with the paint (arrow).



NOTICE

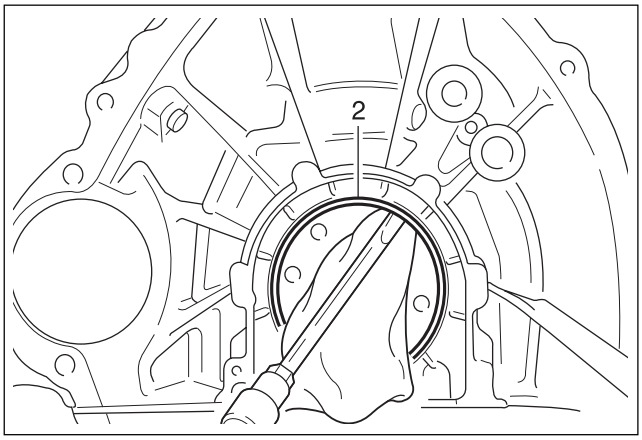
- **Align the assembly marks on crankshaft sprocket and timing chain. Also, align the assembly marks on camshaft sprocket and timing chain when installing.**

2. Unscrew the bolt (6) and remove the oil pump sprocket (7) from the oil pump.

Installation Notice

Tightening Torque	29 - 35 N•m (21 - 26 lb-ft)

3. Remove the oil pump roller chain (9).
4. Remove the oil pump chain tensioner (1), oil pump chain bushing (3), and the oil pump chain spring (2).
5. Remove the crankshaft sprocket (4) using crankshaft sprocketpuller W9911 0050B (615 589 01 33 00).



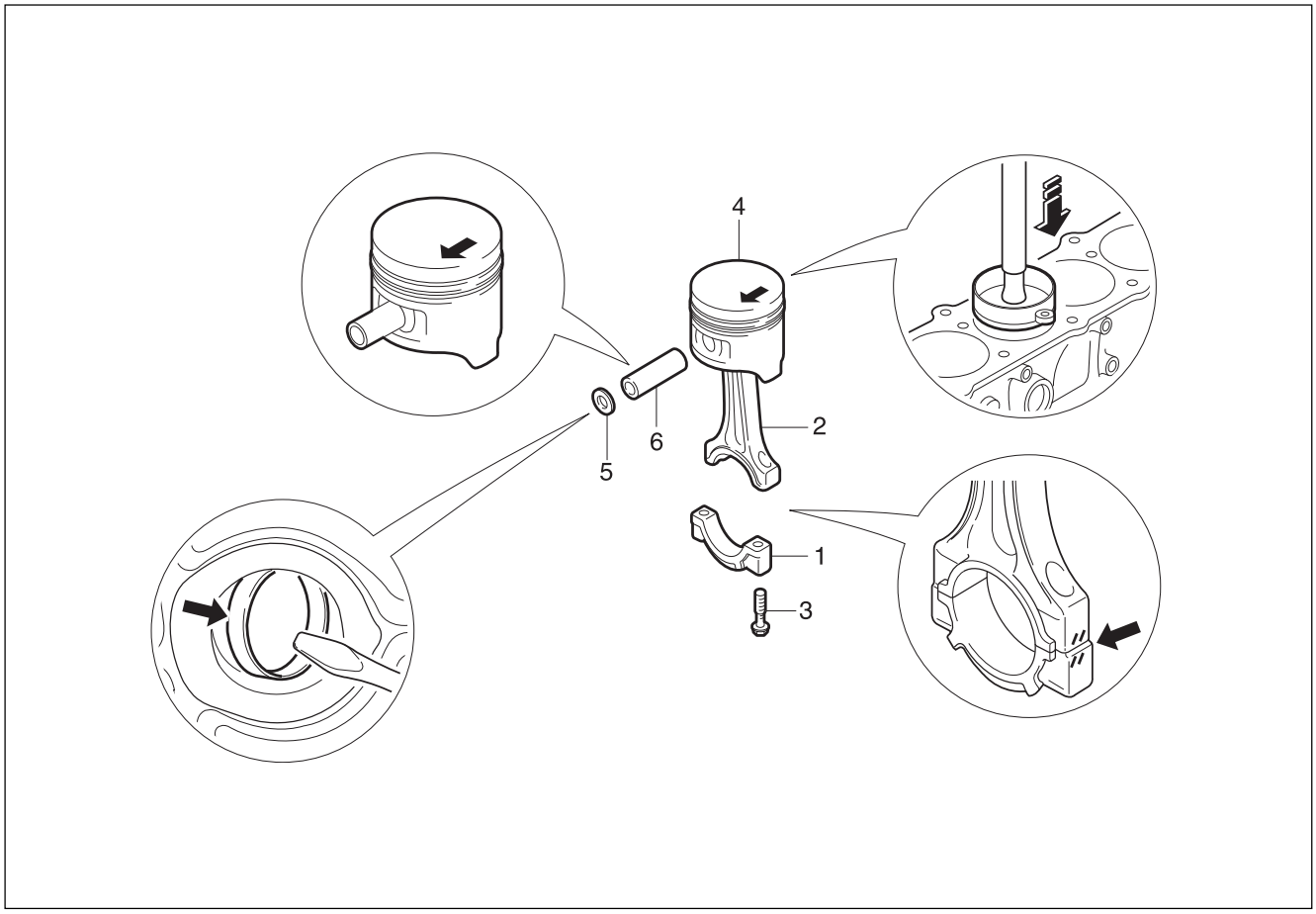
NOTICE

- **Make sure not to lose the crankshaft pulley key (5) when removing.**
- **Install the crankshaft sprocket (4) after warming it up.**

6. Installation should follow the removal procedure in the reverse order.

▶ Piston

※ **Preceding Work:** Removal of engine
Removal of cylinder head
Removal of oil pan
Removal of oil pump
Removal of baffle plate



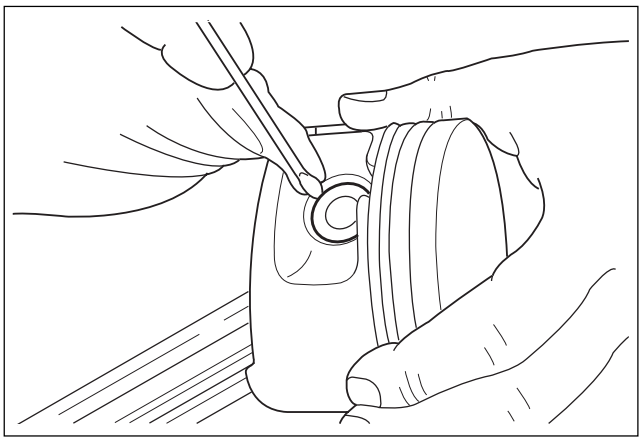
1. Connecting Rod Bearing Cap
2. Connecting Rod
3. Connecting Rod Bolt (M9 x 52, 8 pieces)
   ..... 1st step 40 N•m (30 lb-ft)
   ..... 2nd step 90 °
4. Piston
5. Snap Ring
6. Piston Pin

Removal Procedure

1. Unscrew the connecting rod bolt (3) and remove the cap.
2. Remove the connecting rod and the piston upward.

NOTICE

- **Make sure that the bearing cap and shell are not changed each other.**



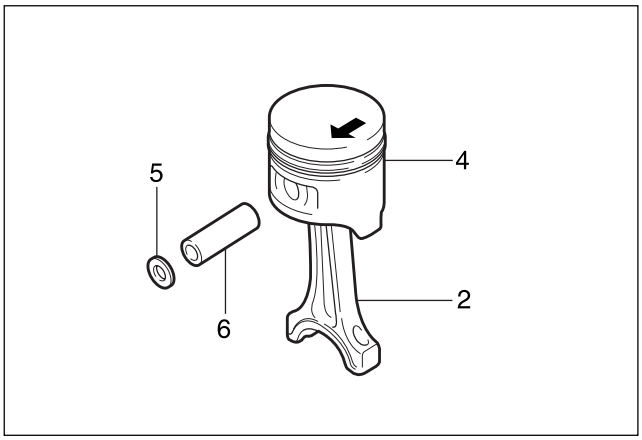
3. Removethe snapring (5)and pulloutthepiston pin (6).

NOTICE

- **Remove the snap ring using a clean cloth as shown in the right picture so that the piston, piston ring, and the snap ring don't get damaged.**

Installation Procedure

1. Check the piston ring gap and apply the engine oil to the piston pin and the connecting rod bushing.
2. Connect the piston and the connecting rod by pressing in the piston pin (6) and install the snap ring to the groove.
3. Clean the cylinder bore, connecting rod bearing journal, connecting rod bearing shell and the piston and coat them with engine oil.
4. Install the piston ring.
5. Install the piston so that the arrow on the piston head faces to the forward of the vehicle.
6. After aligning the connecting rod and the bearing cap mark (// or a number), tighten the bolts.



Installation Notice

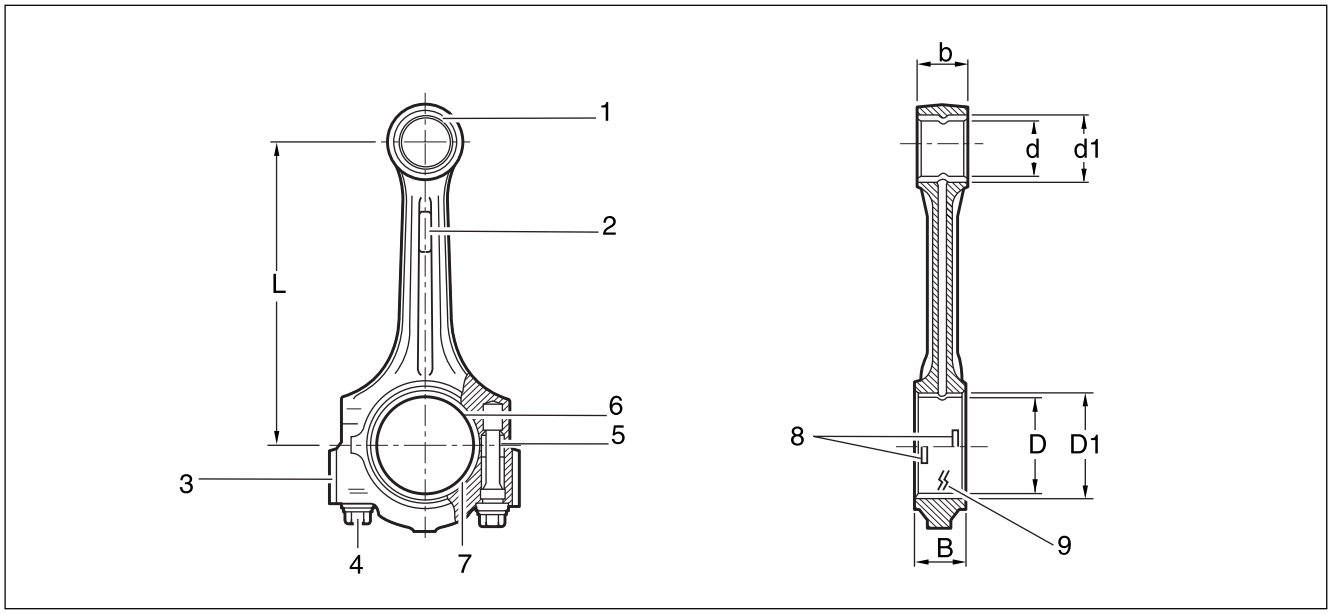
Tightening Torque	1st step: 40 N•m (30 lb-ft)
	2nd step: 90°

Apply the engine oil to the bearing cap upper and lower bearing shells.

7. Check if the crankshaft rotates without any trouble by rotating it.

▶ Connecting Rod

※ **Preceding Work:** Removal of piston



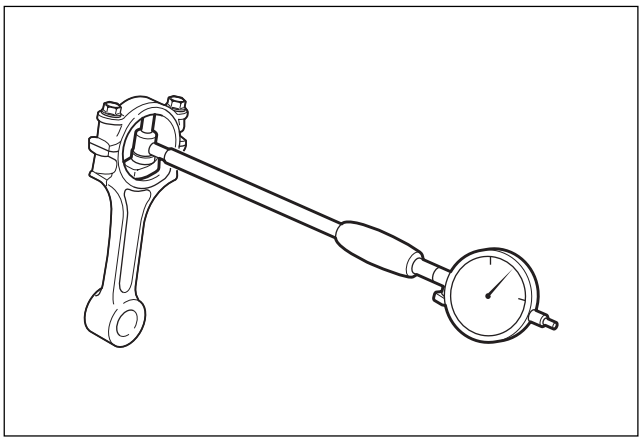
1. Connecting Rod Bushing
2. Oil Gallery
3. Balance Weight
4. Connecting Rod Bearing Cap Bolt
   (M9 x 52, 8 pieces)
   ..... 1ststep 40 N•m (30 lb-ft)
   ..... 2nd step 90 °
5. Fit Sleeve
6. Upper Connecting Rod Bearing
7. Lower Connecting Rod Bearing
8. Bearing Shell Lug
9. Marking [Indication (//) or Numbers]

Service Data Standard

Distance (L) from The Connecting Rod Bearing to Bushing Bore Center	149 ±0.05 mm
Width of The Connecting Rod (B) at Bearing Bore	21.940 - 22.000 mm
Width of The Connecting Rod (b) at Bushing Bore	21.940 - 22.000 mm
Basic Bore at The Bearing Shell (D1)	51.600 - 51.614 mm
Basic Bore at The Bushing (d1)	24.500 - 24.521 mm
Bushing Inner Diameter (d)	22.007 - 22.013 mm
Clearance Between The Piston Pin and The Bushing	0.007 - 0.018 mm
Peak-to-valley Height of Connecting Rod Bushing on Inside	0.005 mm
Permissible Wwist of Connecting Rod Bearing Bore to Connecting Rod Bushing Bore	0.1/100 mm
Permissible Deviation of Axial Paralleism of Connecting Rod Bearing Bore to Connecting Rod Bushing Bore	0.045/100 mm
Permissible Deviation of Axial Paralleism of Connecting Rod Bearing Bore from Concentricity	0.01 mm
Permissible Difference of Each Connecting Rod in Weight	0.4 g

Inspection

1. Measure the basic bore of the connecting rod bearing.

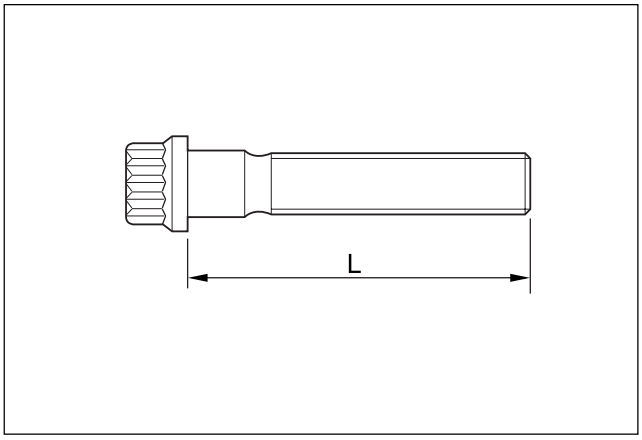


NOTICE

- **If the basic bore exceeds the value of 51.614 mm, replace the bearing or check the connecting rod.**

2. Check connecting rod bolts.

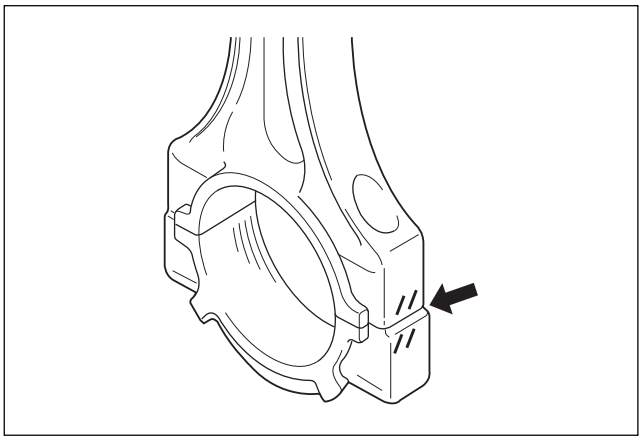
Length When New (L)	51.7 - 52 mm
Max. Length (L)	52.9 mm
Tightening Torque	1st step : 40 N•m (30 lb-ft)
	2nd step : 90°



NOTICE

- **If the length exceeds max. length, replace it.**

3. Check the assembly mark (indication//or number: arrow) of the connecting rods and the bearing cap when installing.

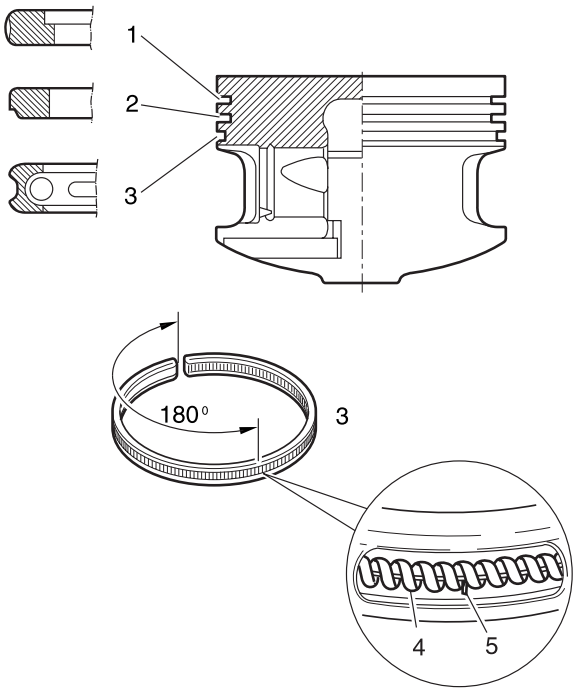


NOTICE

- **Make sure it doesn't exceed over 4g with other connecting rods when replacing the connecting rods.**
- **Check if the connecting rod and the bearing cap are accurately seated on the groove when replacing the bearing.**

▶ Piston Ring

※ **Preceding Work:** Removal of piston

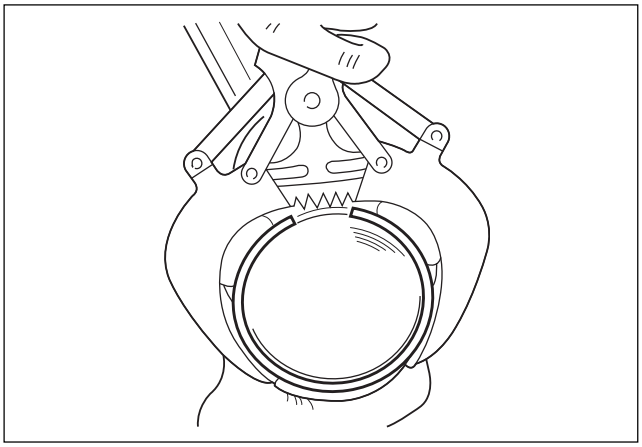


1. Piston Compression Ring (Top Ring)
2. Piston Compression Ring (2nd Ring)
3. Piston Oil Ring
4. Spring
5. Spacer
6. SideRail

Replacement Procedure

1. Measure the piston ring's gap.

End Gap of the Piston Ring	Groove 1 0.20 - 0.40 mm
	Groove 2 0.20 - 0.40 mm
	Groove 3 0.20 - 0.45 mm
Gap Between the Piston and the Piston Ring	Groove 1 0.028 - 0.060 mm
	Groove 2 0.010 - 0.045 mm
	Groove 3 0.010 - 0.045 mm

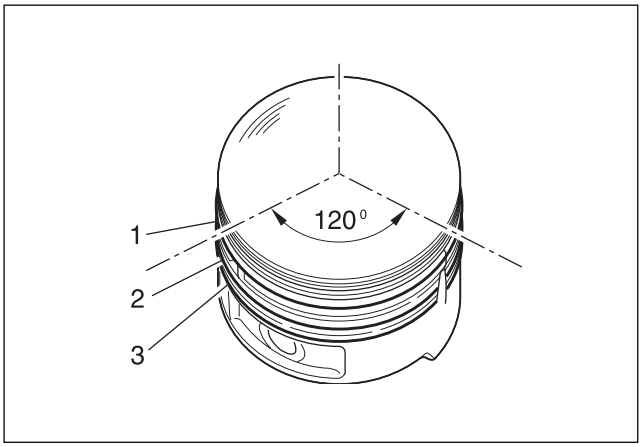


NOTICE

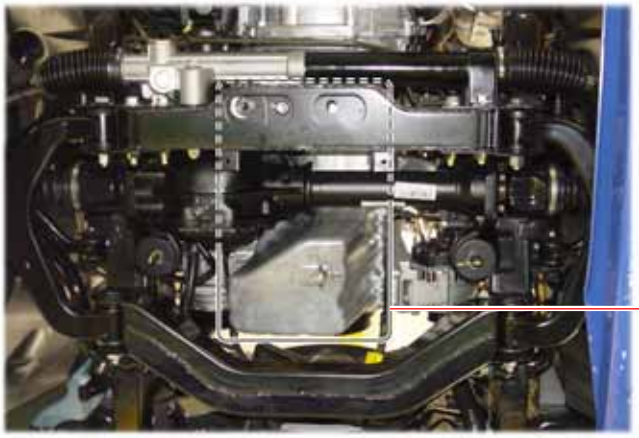
- **If out of specification, replace the piston ring.**

2. Remove the piston ring with a pliers.

3. For installation, position the piston ring to be the 'TOP' mark on the piston ring upward and arrange the piston ring ends to be 120 ° part.
4. Adjust the hook spring joint in the oil ring 180 ° way from the ring end.



▶ Oil Pan

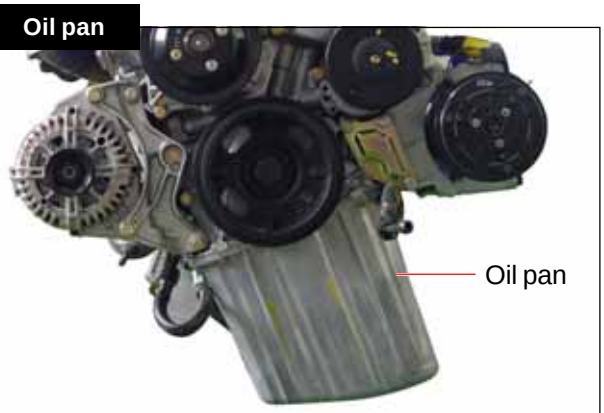


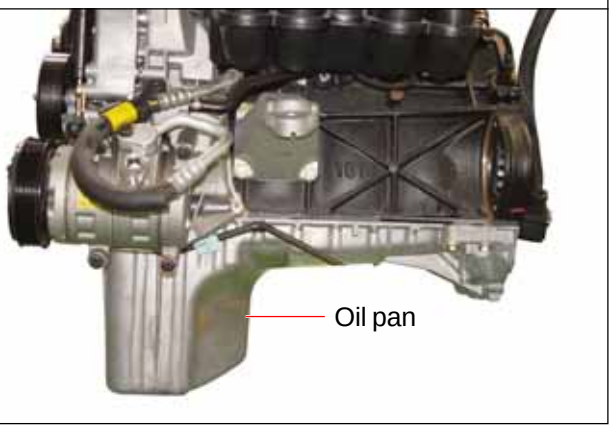
Oil pan assembly

Removal & Installation Procedure

1. Remove the drain plug and drain the oil completely.

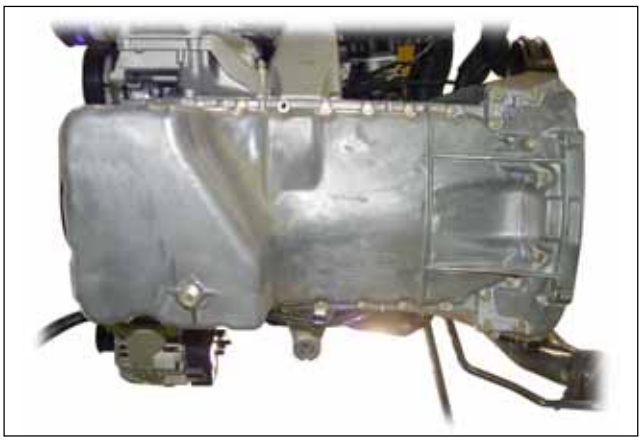
Oil pan





CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

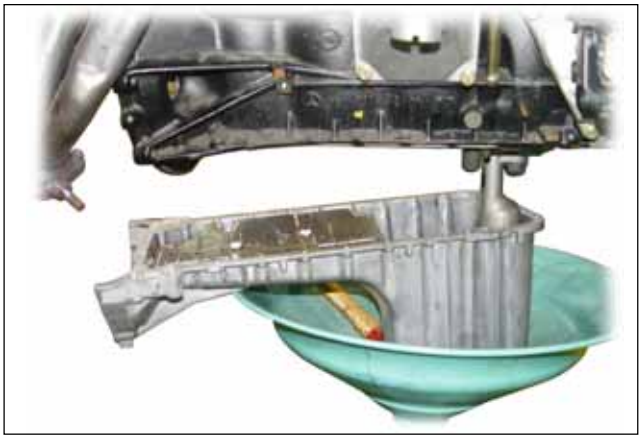
2. Unscrew the bolts and remove the oil pan and gasket.



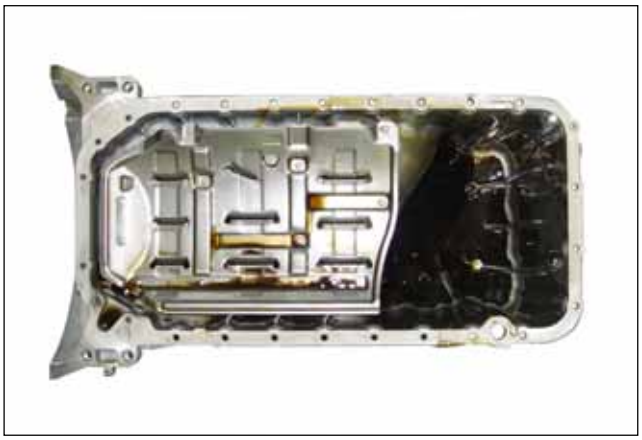
NOTICE

- **Arrange the bolts according to each size.**

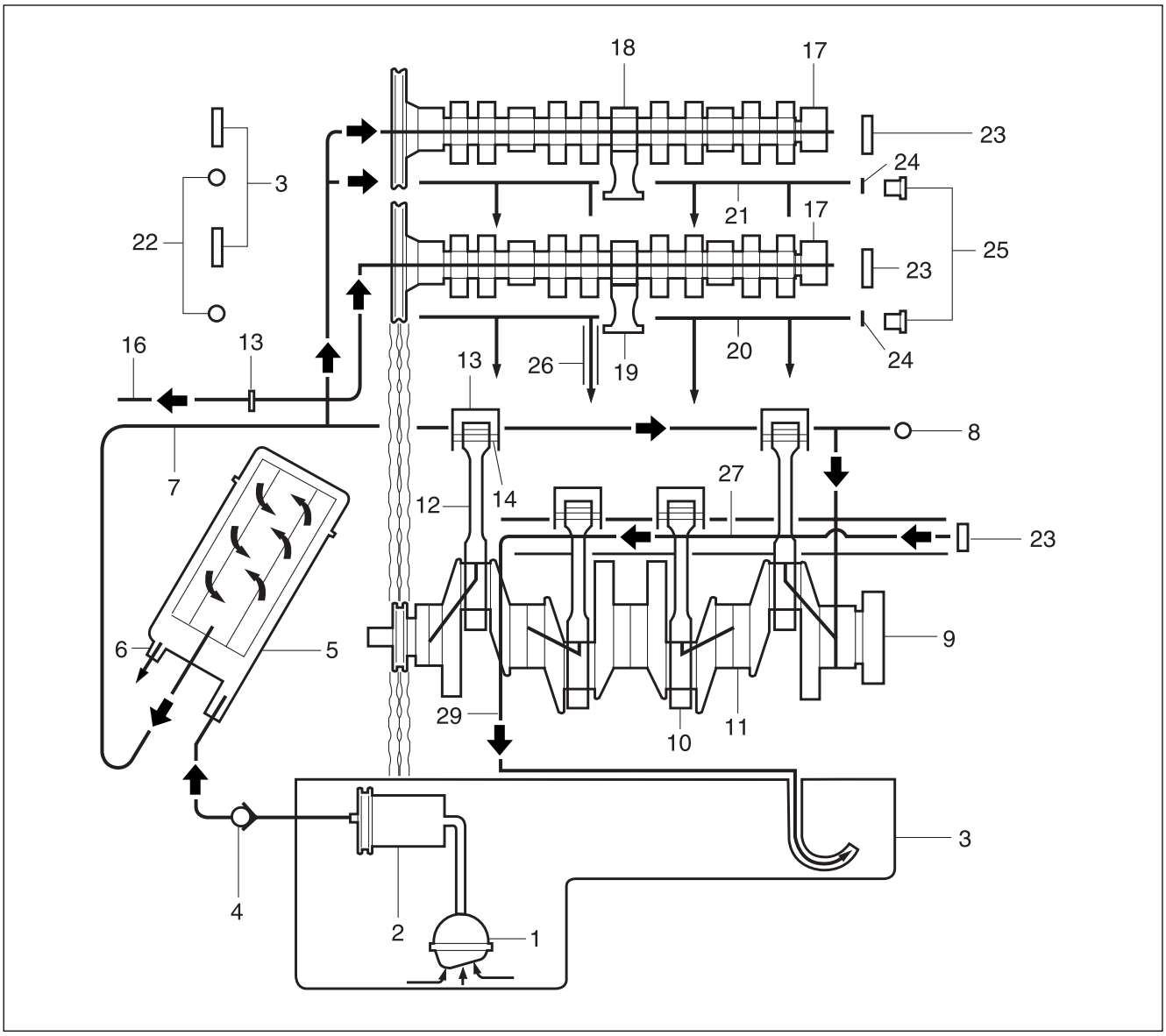
3. Clean the inside of oil pan and sealing surface, then apply the sealant.
4. Replace the gasket with new one.
5. Install the oil pan with gasket, and tighten each bolt in specified torque.



6. Check for oil leaks while running the engine.



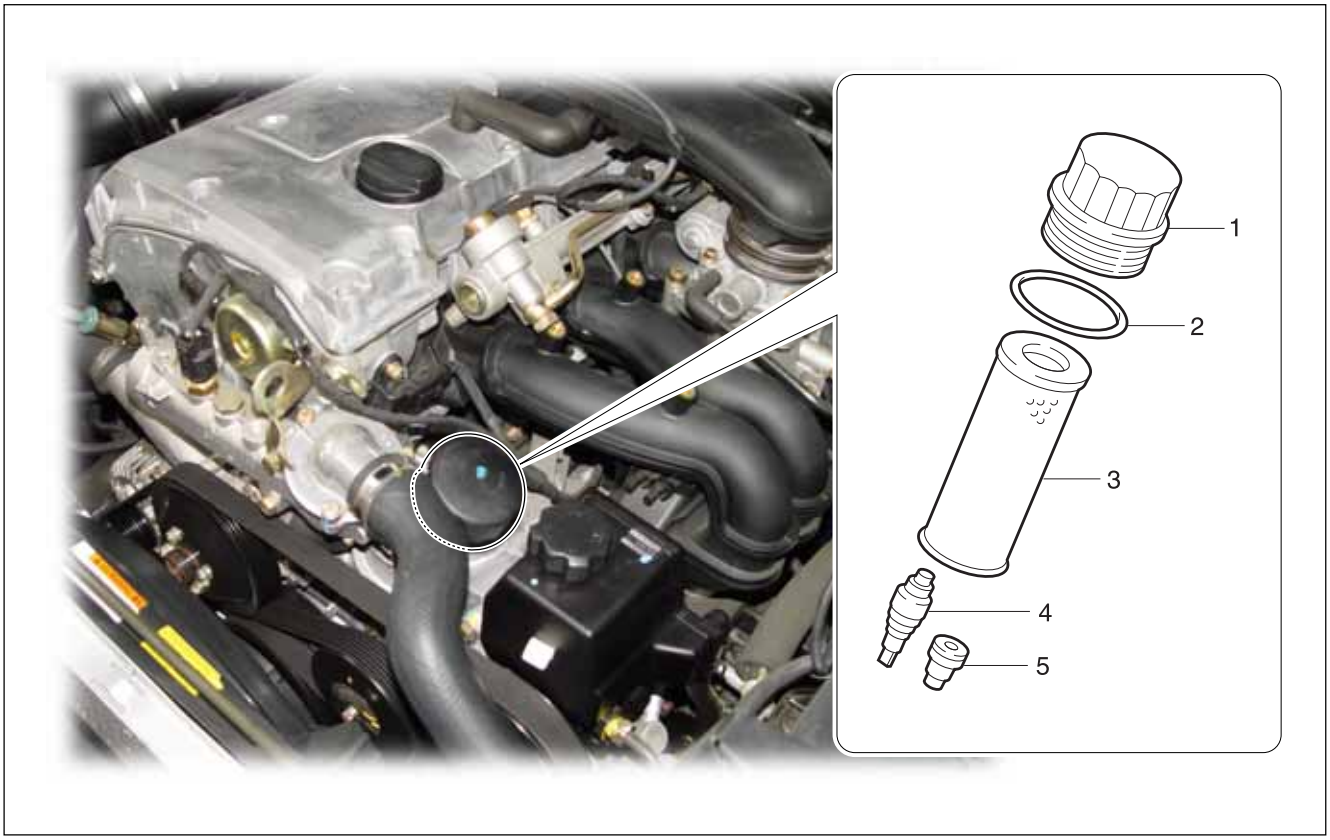
▶ Oil Circulation



1. Oil Strainer
2. Oil Pump
3. Oil Pan
4. Oil Non-Return Valve
5. Oil Filter
6. Oil Filter Bypass Valve
7. Main Oil Gallery
8. Closing Ball (ϕ 15 mm)
9. Crankshaft
10. Connecting Rod Bearing
11. Crankshaft Bearing
12. Connecting Rod
13. Piston
14. Oil Spray (Piston Crown Area)
15. Non-Return Valve (Crankcase)
16. Oil Supply (To Chain Tensioner)
17. Camshaft
18. Cam Bearing
19. Valve
20. Oil Gallery (Supply Oil to Intake Tappet)
21. Oil Gallery (Supply Oil to Exhaust Tappet)
22. Ball (ϕ 8 mm)
23. Camshaft Plug
24. Seal
25. Screw Plug
26. Oil Return Gallery (Cylinder Head and Crankcase)
27. Oil Return Gallery (Crankcase)
28. End Cover (ϕ 20 mm)
29. Oil Return Pipe

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Engine Oil and Oil Filter Element



1. Oil Filter Cover 25 N•m (18 lb-ft)
2. O-Ring Replace
3. Oil Filter Element
4. Oil Drain Plug
5. Oil Filter Bypass Valve

Tools Required

A9910 0050A (103 589 02 09 00) Oil Filter Remover

Replacement Procedure

1. Install the oil filter remover A9910 0050A (103 589 02 09 00) on the oil filter cover.

NOTICE

- **Make the screw cover removable by tightening the bolt at the side of the oil filter remover 103 589 02 09 00.**

2. Install the wrench to the upper bolt in the oil filter remover A9910 0050A (103 589 02 09 00) and remove the oil cover by turning it.
3. Remove the oil filter element.

NOTICE

- **Work with a cloth under the vehicle when removing the oil filter element to not drain the oil.**

4. Remove the drain plug and drain the engine oil.

NOTICE

- **Leave the oil filler cap open to ease the engine oil discharge.**

5. Tighten the engine oil drain plug after cleaning it.

Installation Notice

Tightening Torque	25 N•m (18 lb-ft)

Replace the seal washer with new one.

6. Replace the O-ring in the oil filter cover with new one.

NOTICE

- **Apply the engine oil to the O-ring.**

7. Insert new oil filter element into the oil filter housing.
8. Temporarily tighten the oil filter cover. Install the Oil filter remover A9910 0050A (103 589 02 09 00), and then completely tighten it.

Installation Notice

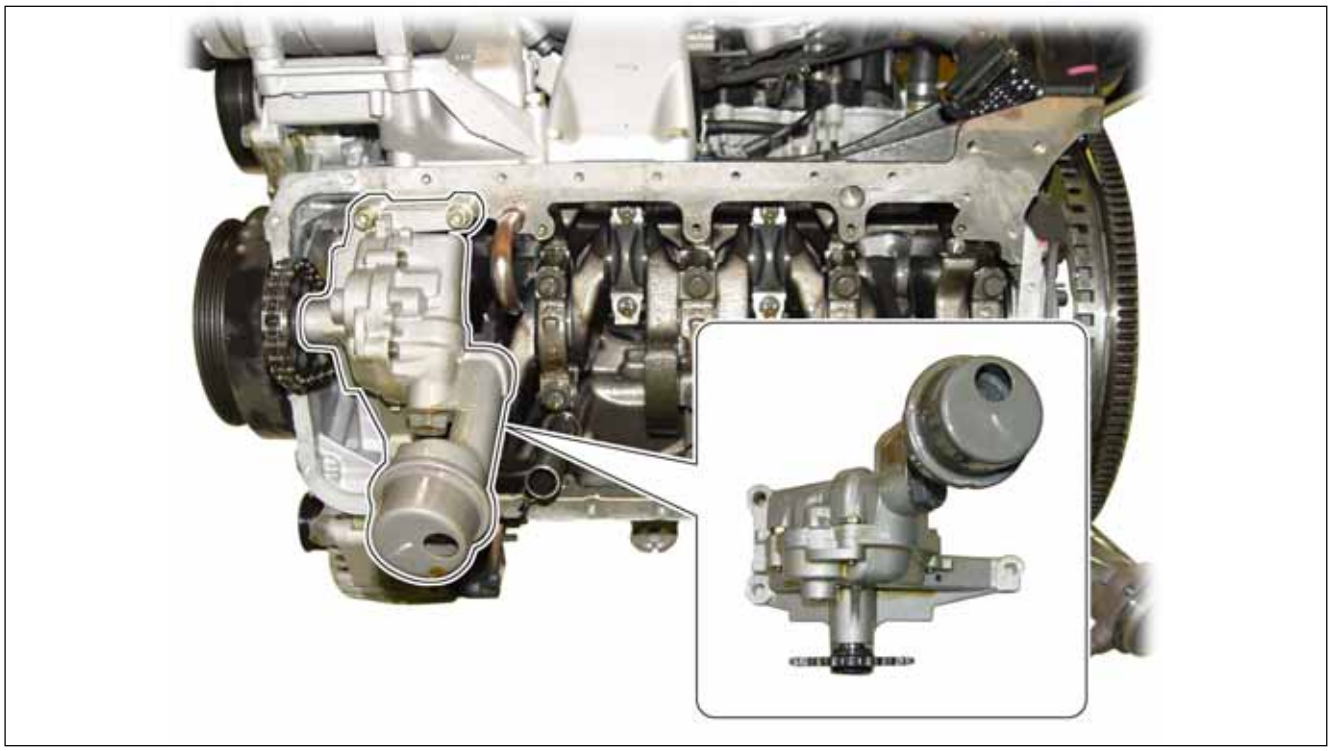
Tightening Torque	25 N•m (18 lb-ft)

9. Fill up engine oil through the engine oil filler opening (3).
10. Check for oil leaks at normal engine temperature after starting the engine.
11. Stop the engine and wait 5 minutes.

    Check the oil level and fill up as specified if necessary.

▶ Oil Pump

※ **Preceding Work:** Removal of oil pan



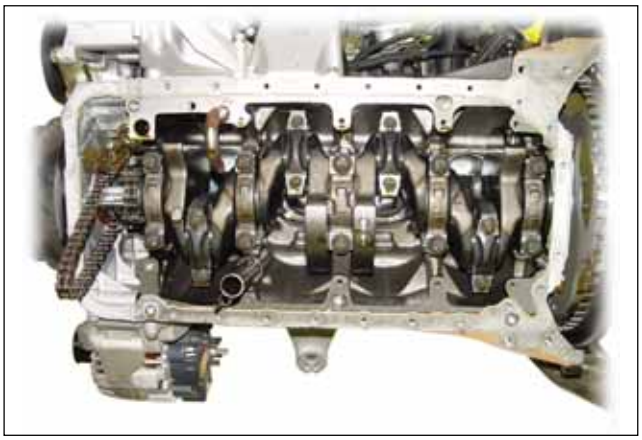
Removal & Installation Procedure

1. Unscrew the three bolt (1) and remove the oil pump.

Installation Notice

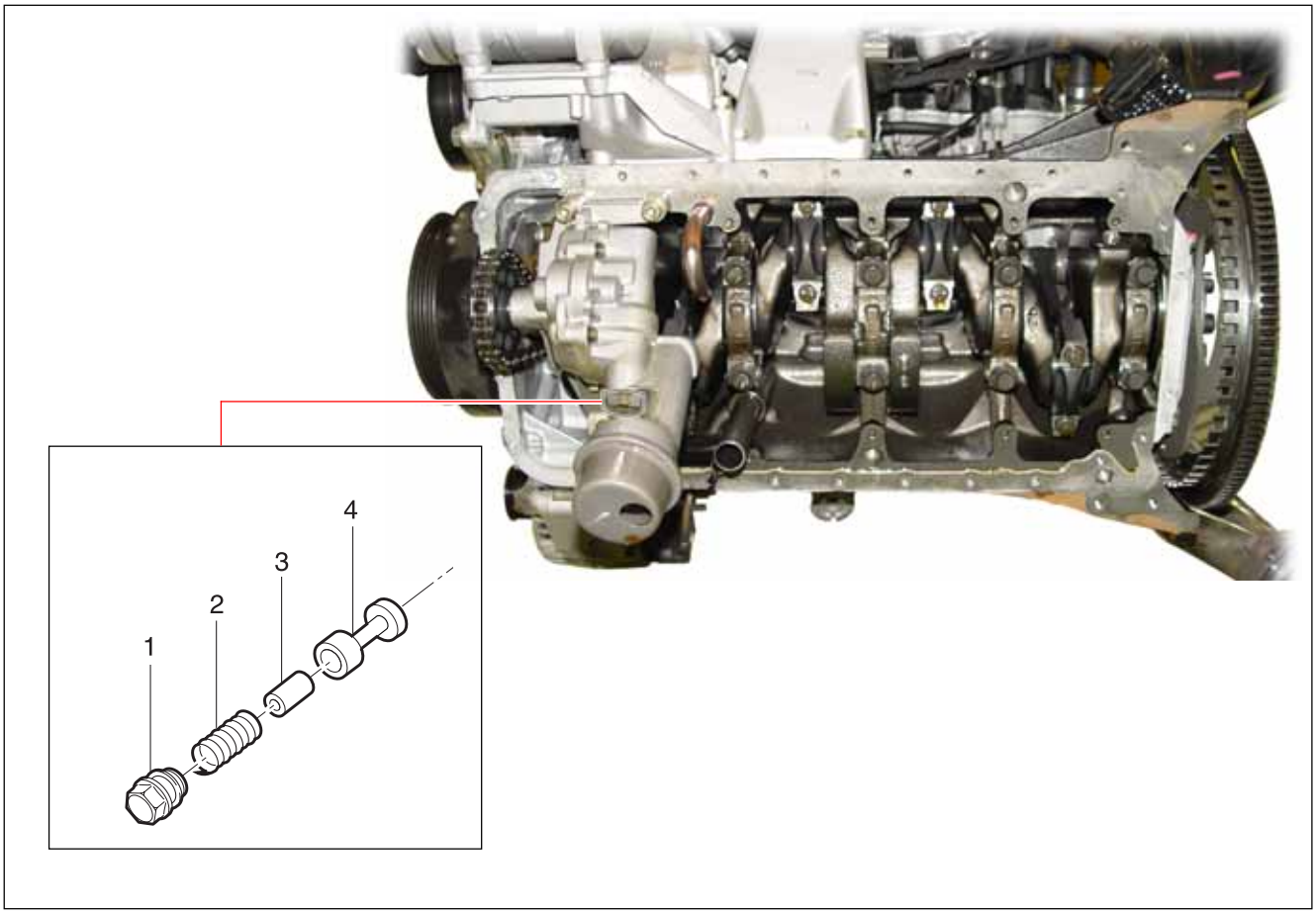
Tightening Torque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

2. Remove the oil pump from the cylinder block.



▶ Oil Pressure Relief Valve

※ **Preceding Work:** Removal of oil pan



1. Screw Plug ..... 50 N•m (37 lb-ft)
2. Compression Spring
3. Guide Pin
4. Piston

Removal & Installation Procedure

1. Remove the screw plug (1).

Installation Notice

Tightening Torque	50 N•m (37 lb-ft)

2. Remove the spring (2), guide pin (3) and the piston (4).
3. Installation should follow the removal procedure in the reverse order.

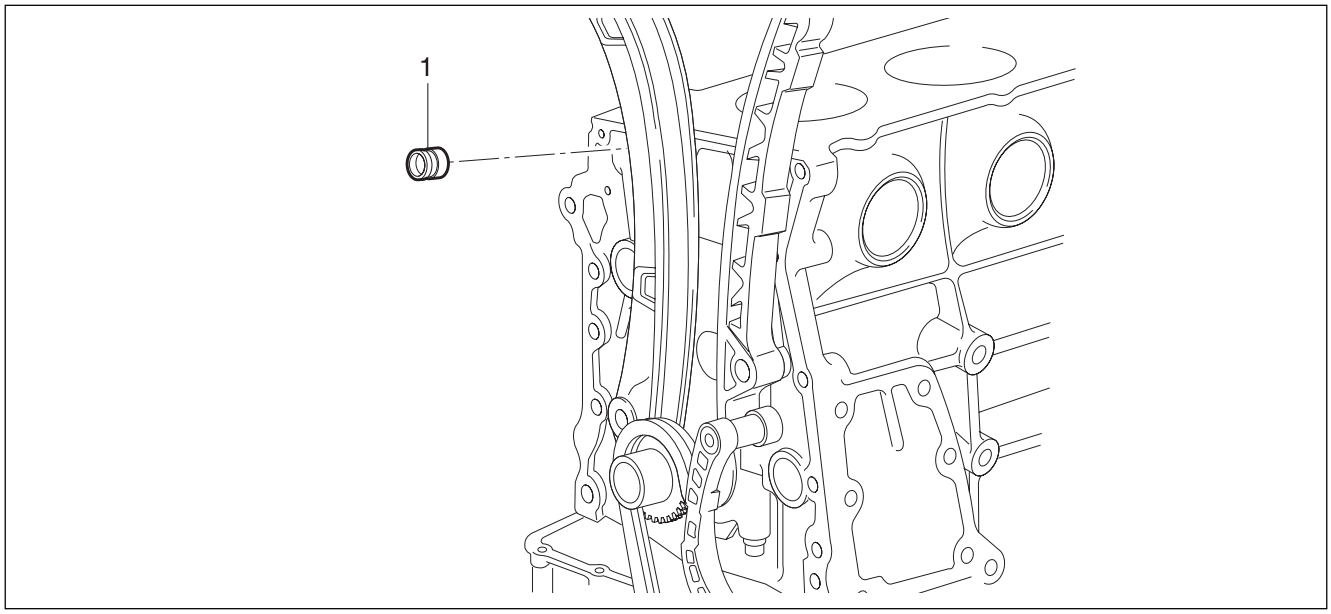
NOTICE

- **Don't use the seal for the screw plug.**

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Oil Non-Return Valve

※ **Preceding Work:** Removal of timing gear case cover



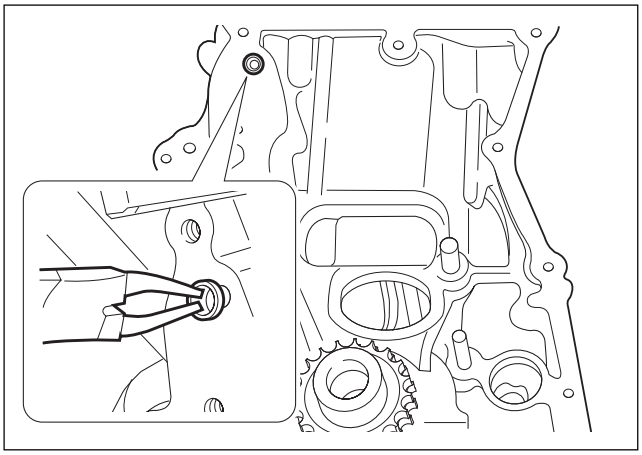
1. Oil Non-return Valve

Functions

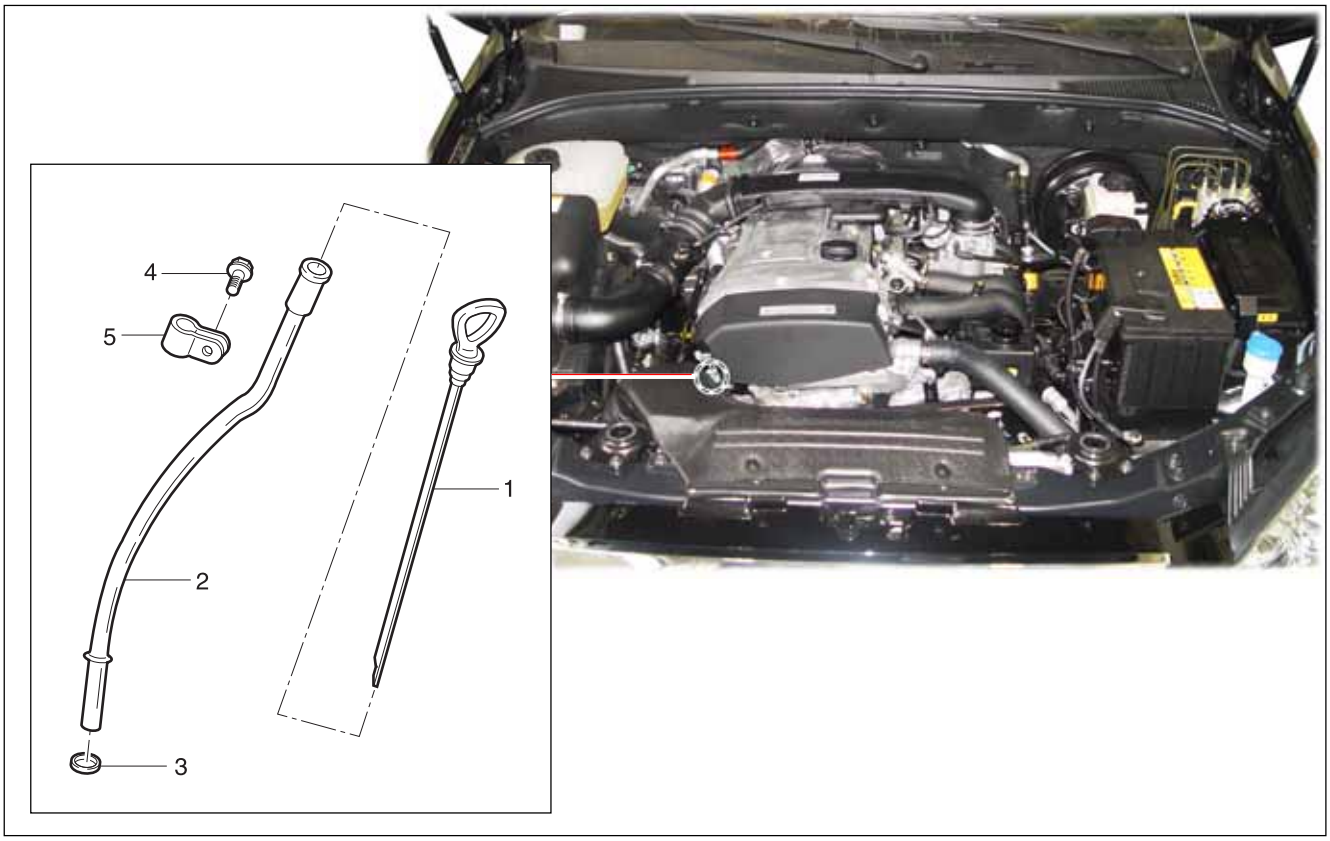
The non-return valve prevents the oil in the chain tensioner from drying up. In other words, it stops oil-returning in order to prevent the oil in the chain tensioner from getting dry. As a result, the chain tensioner can be activated with oil in itself.

Replacement Procedure

1. Remove the non-return valve using a pliers.
2. Insert new non-return valve with hand.



▶ Oil Dipstick Guide Tube



1. Oil Dipstick Level Gauge
2. Oil Dipstick Guide Tube
3. O-Ring
4. Bolt (M6 X 16, 1 piece)
   ..... 9 - 11 N•m (80 - 97 lb-in)
5. Clamp

Removal & Installation Procedure

1. Pull out the oil dipstick level gauge (1).
2. Unscrew the bolt (4) and remove the oil dipstick guide tube (2).

Installation Notice

Tightening Torque	9 - 11 N•m (80 - 97 lb-in)

It is very hard to remove the oil dipstick guide tube without special tool. If it is not necessary, do not remove the guide tube.

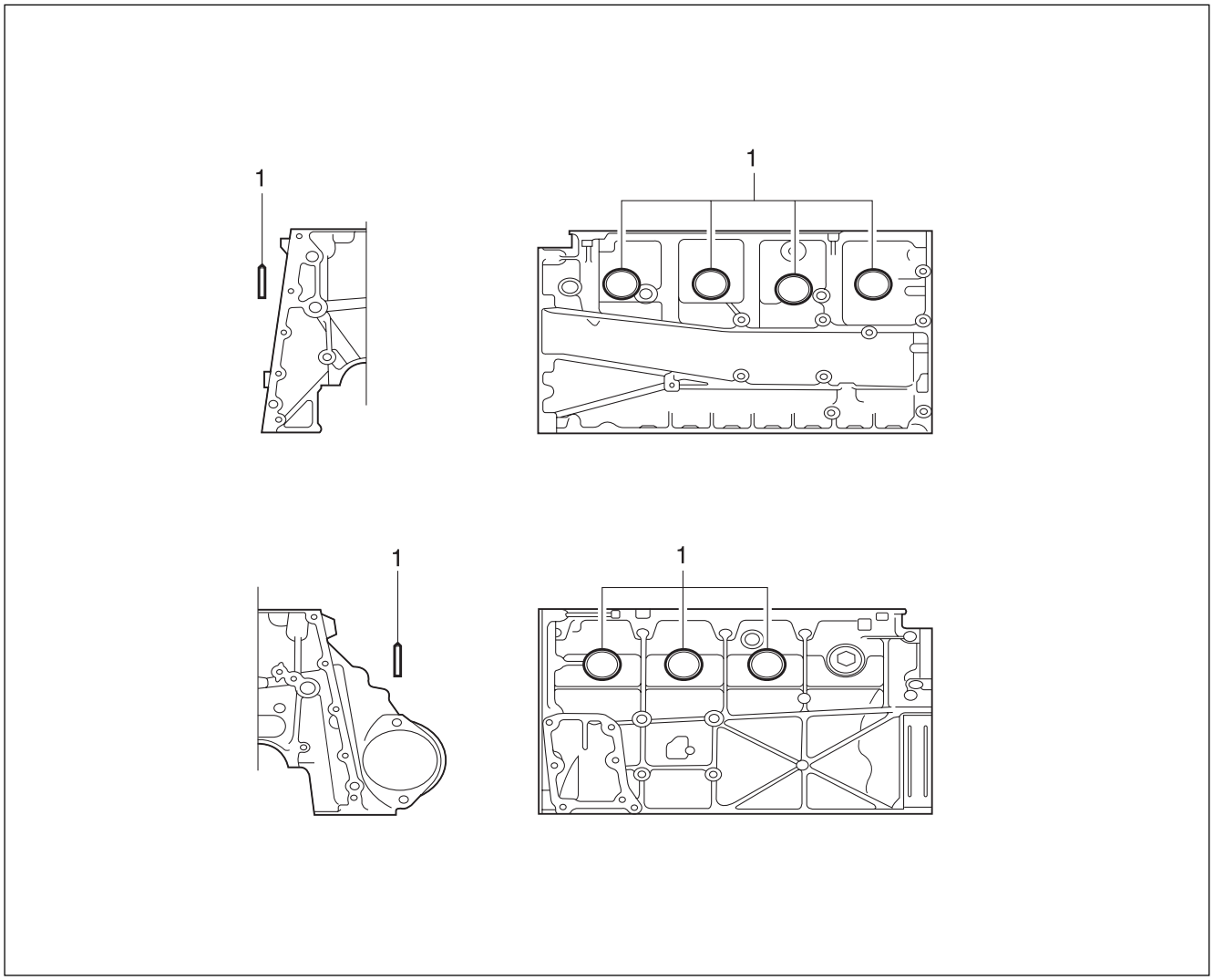
3. Installation should follow the removal procedure in the reverse order.
4. Check for leaks by starting the engine.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

4. UNIT REPAIR

▶ Core Plugs in Crankcase

※ **Preceding Work:** Draining of the coolant



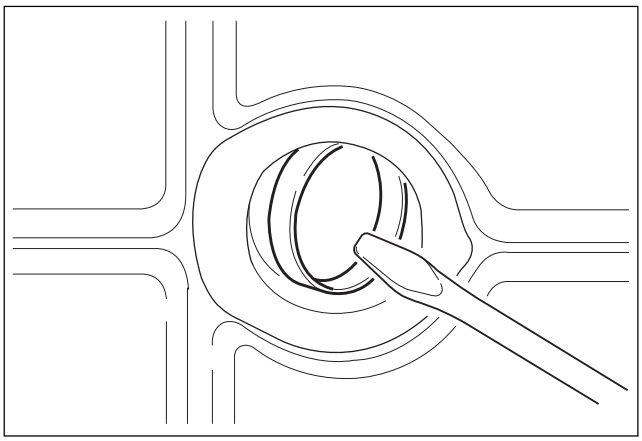
1. Core Plug ..... Replace

Tools Required

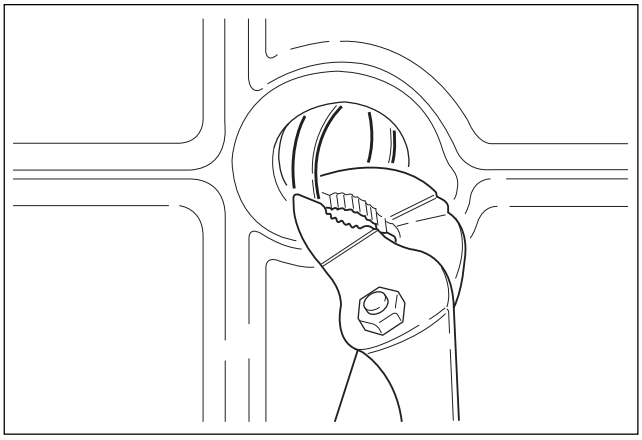
W9911 0010B (102 589 00 15 00) Drift

Replacement Procedure

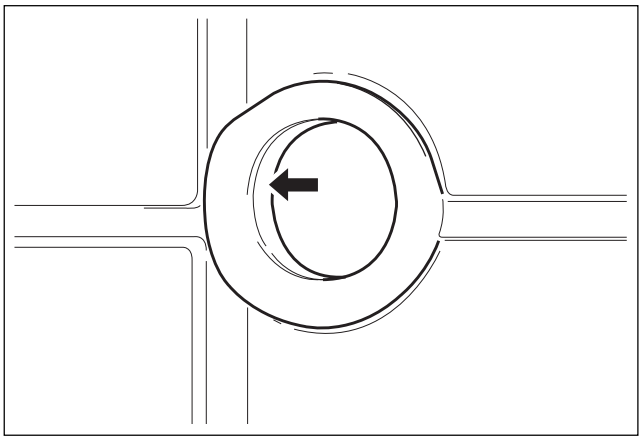
1. Remove the intake and exhaust manifolds.
2. Pull back the core plug until the end of one side comes out using the screw driver.



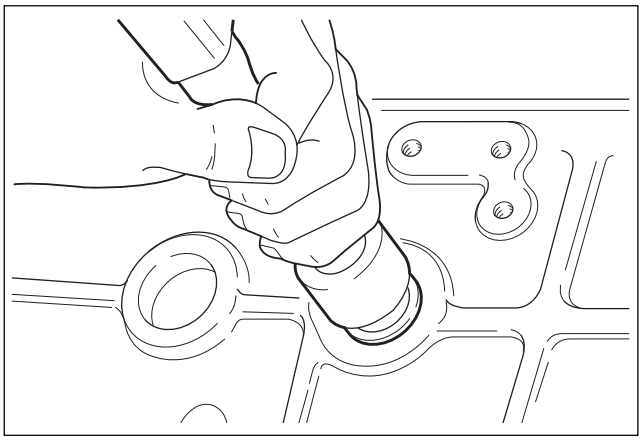
3. Pull out the plug carefully using a pliers.



4. Clean the sealing surface and apply Loctite 241.



5. Press in new plug using a drift.



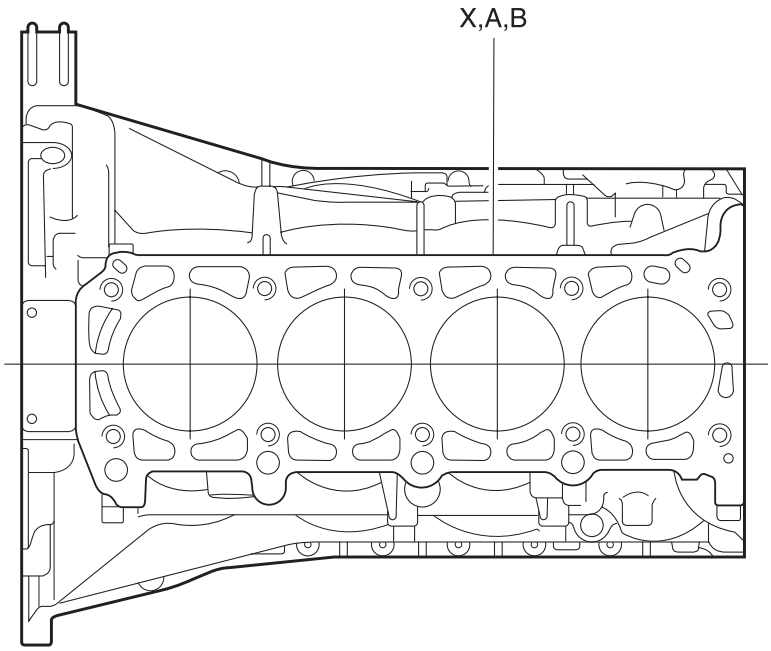
NOTICE

- **Wait for about 45 minutes before filling the coolant so that the Loctite 241 hardens.**

6. Warm up the engine and check the coolant for leaks.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Cylinder Bore



Group Code Letter and Cylinder Bore Size

Engine	Group Code Letter of Cylinder	Piston Type to be Used	Cylinder Bore Size (mm)
G23D	A	A or X	ϕ90.906 - ϕ90.912
	X	A, X or B	ϕ90.906 - ϕ90.912
	B	X or B	ϕ90.912 - ϕ90.918
	X + 5	X + 5	ϕ90.950 - ϕ90.968
	X + 10	X + 10	ϕ91.000 - ϕ91.018

Group Code Letter Cylinder	Group Code Letter [1]	Cylinder Bore Size (mm)
Standard Size ϕ 90.9	A	ϕ89.900 - ϕ89.906
	X	ϕ89.906 - ϕ89.912
	B	ϕ89.912 - ϕ89.918
1st Repair Size (Standard Size + 0.25)	A	ϕ90.150 - ϕ90.156
	X	ϕ89.156 - ϕ90.162
	B	ϕ90.162 - ϕ90.168
2nd Repair Size (Standard Size + 0.5)	A	ϕ90.400 - ϕ90.406
	X	ϕ90.406 - ϕ90.412
	B	ϕ90.412 - ϕ90.418

1) The group code letters are carved on the surface of the piston crown and in the mating surface of the crankcase.

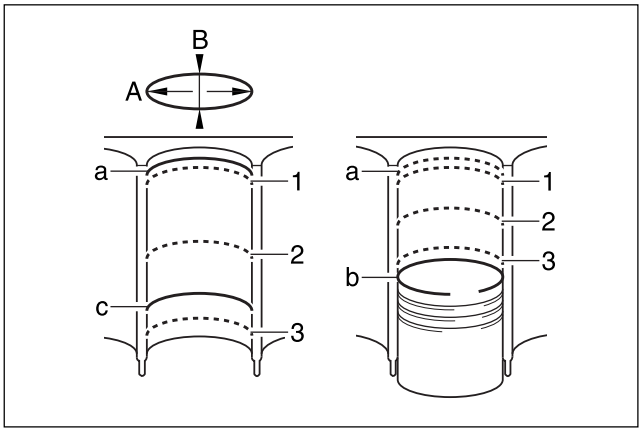
Service Data Standard

Wear Limit in Longitudinal and Transverse Direction		0.1 mm
Permissible Deviation of Cylinder Out-of-round	When new	0.007 mm
	Wear limit	0.05 mm
Permissible Deviation of Rectangular Cylinder Height (Except Chamfered Area)		0.05 mm
Basic Peak-to-valley Height After Final Honing and Brushing		0.003 - 0.006 mm
Chamfer Angle		75 °
Honing Angle		50 ° ± 10 °

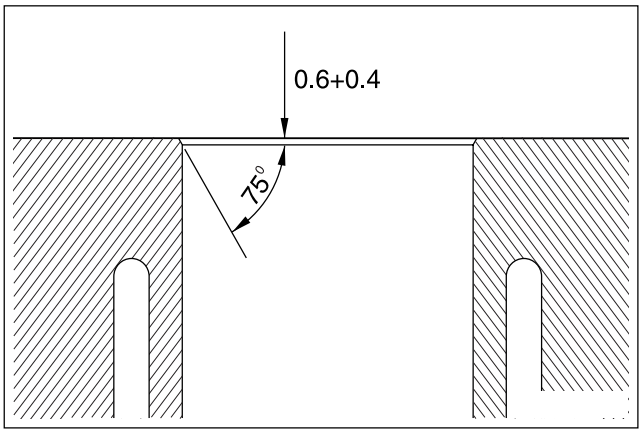
Measurement of Cylinder Bore

1. Clean the cylinder wall.
2. Using a internal diameter gauge, measure the bore size in axial and transverse direction at three points (1,2,3).

   1, 2, 3 Measuring Points
   - A. Axial Direction
   - B. Transverse Direction
   - a. Location of the No.1 Piston Ring at TDC
   - b. Location of the Piston BDC
   - c. Location of the Oil Ring at BDC

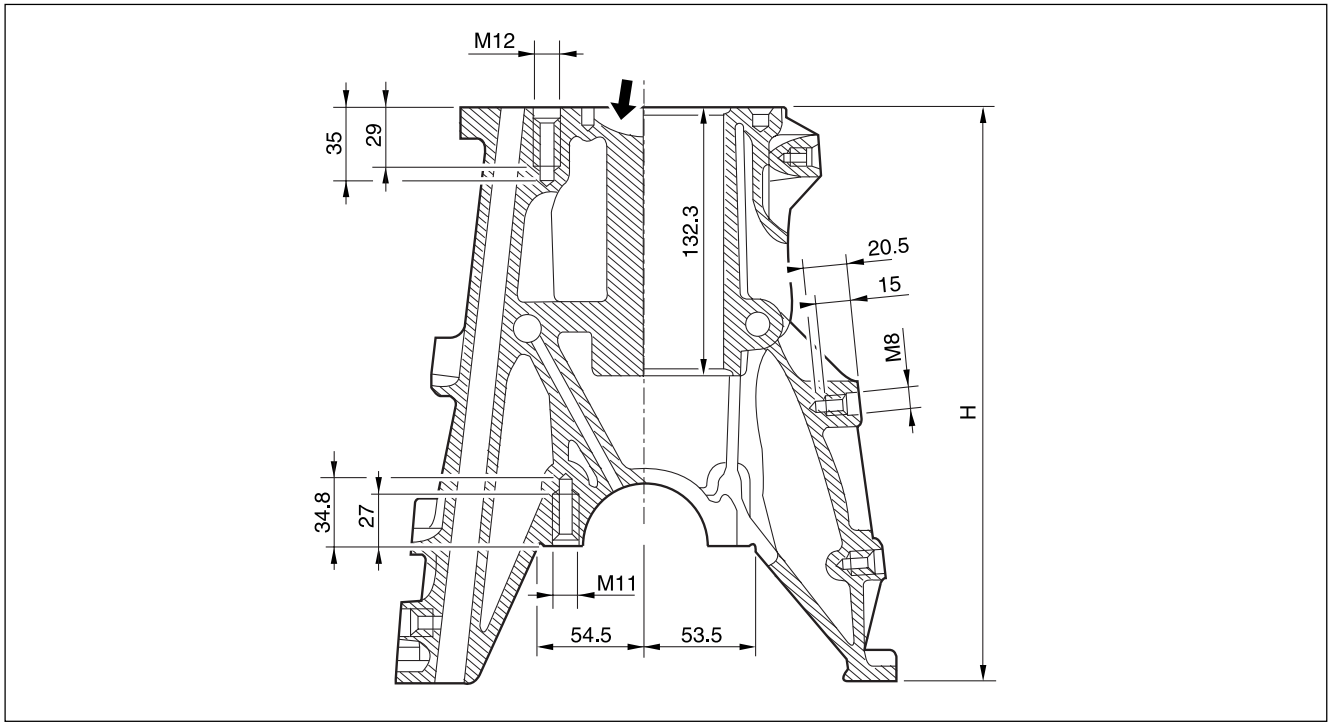


Chamfer Angle



CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Crankcase Mating Surface

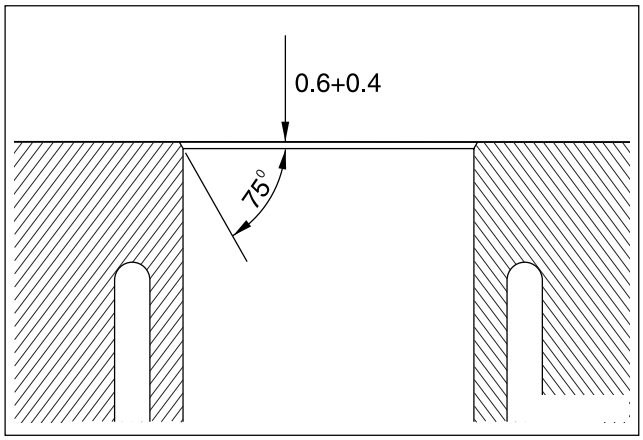


Service Data Standard

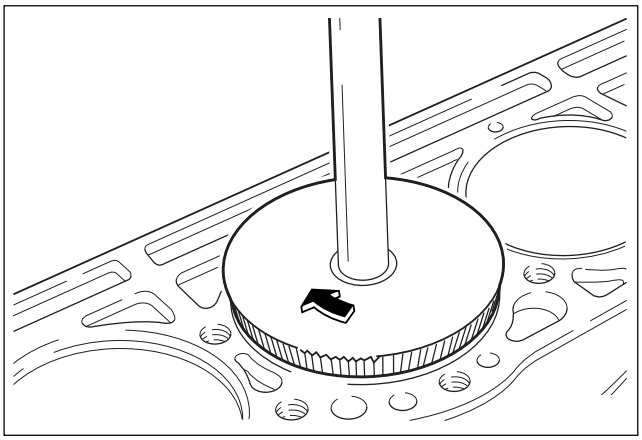
Height of The Crankcase 'H' (When new)		289.35 - 289.45 mm
Minimum Height After Milling		289.05 mm
Flatness	Crankcase Upper Mating Surface	0.03 mm
	Crankcase Lower Mating Surface	0.04 mm
Permissible Deviation of Parallelismof The Upper to Lower Mating Surface	Axial Direction	0.1 mm
	Transverse Direction	0.05 mm
Peak-to-valley Height	Crankcase Upper Mating Surface	0.012 - 0.009 mm
	Crankcase Lower Mating Surface	0.025 - 0.020 mm

Chamfering Procedure

1. Chamfer angle : 75 °



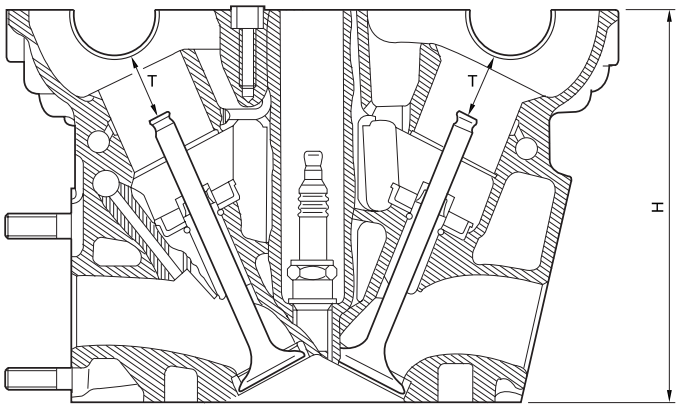
2. Polish the lower chamfered area evenly with a grinder after finishing the chamfering with a suitable tool (e.g., hand milling cutter).



CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Cylinder Head Mating Surface

※ **Preceding Work:** Removal of valves



Service Data Standard

Overall Height of Cylinder Head			135.9 - 136.0 mm
Minimum Height After Machining			135.5 mm
Flatness	Axial Direction		0.08 mm
	Transverse Direction		0.0 mm
Distance 'T' (Between Camshaft Bearing and Valve Stem)	Standard Size	Intake	24.21 - 24.75 mm
		Exhaust	22.21 - 22.75 mm
	Repair Size	Intake	23.96 - 24.51 mm
		Exhaust	21.96 - 22.51 mm

NOTICE

- **Do not exceed 0.4 mm for the milling of the mating surface of crankcase and cylinder head.**

Measurement of Mating Surfac

1. Measure the height (H) of the cylinder head (refer to Service data standard).
2. Check the mating surface of the cylinder head.
3. Mill the sharp edge of the combustion chamber.
4. Re-measure the height (H) of the cylinder head.
5. Seal the intake and exhaust valves.
6. Measure the dimension (T) between the camshaft bearing and the valve system *(refer to Service data standard).*
7. Mill the cylinder head valve seat *(refer to Service data standard).*

Universal Tool

Surface Grinding Machine	Sceledum, Type RTY Roaro Schio / Italy

5. SPECIFICATIONS

▶ Fastener Tightening Specifications

Application		N•m	Lb-Ft	Lb-In
Fuel Feed and Return Line		21 ~ 25	15 ~ 18	-
Exhaust Manifold and Pipe		30	22	-
Engine Mounting Nuts		70	52	-
Generator Carrier Bolts		25	18	-
Tensioning Pulley Bolt		40.5 ~ 49.5	29.9 ~ 36.5	-
Steering Pump Bolts		22.5 ~ 27.5	16.6 ~ 20.3	-
A/C Braket Bolts		22.5 ~ 27.5	16.6 ~ 20.3	-
Intake Air Duct Mounting Nuts		9 ~ 11	-	80 ~ 97
Spark Plug Cover Bolts		9 ~ 11	-	80 ~ 97
Cylinder Head Cover Bolts		9 ~ 11	-	80 ~ 97
Magnetic Assembly Bolt		9 ~ 11	-	80 ~ 97
Cylinder Head Front Cover Bolts	M8	22.5 ~ 27.5	16.6 ~ 20.3	-
	M6	9 ~ 11	-	80 ~ 97
Cylinder Head Bolts		55 +90° +90°	41 +90° +90°	- - 80 ~ 97
Timing Gear Case Cover Bolts		22.5 - 27.5	16.6 ~ 20.3	-
Crankshaft Sealing Rear Cover Mounting Bolts		9 ~ 11	-	-
Vibration Damper Center Bolts		200 + 20 +90° + 10°	148 + 15 +90° + 10°	- -
Flywheel Mounting Bolt		40 +90°	30 +90°	- -
Amarture Bolt in Flywheel		45 + 5	33 + 3.7	-
Camshaft Adjuster Flange Bolts		+90° + 10° 35	+90° + 10° 26	- -
Intake Flange Shaft Bolts		18 ~ 22 60° ± 5°	13 ~ 16 60° ± 5°	- -
Exhaust Camshaft Sprocket Bolts		18 ~ 22 60° ± 5°	13 ~ 16 60° ± 5°	- -
Intake Flange Shaft Bolts		18 ~ 22	13 ~ 16	-
Exhaust Camshaft Sprocket Bolts		60° ± 5°	60° ± 5°	-
Camshaft Bearing Cap Bolts		22.5 ~ 27.5	16.6 ~ 20.3	-
Chain Tensioner Screw Plug		40	30	-
Chain Tension Assembly		72 ~ 88	53 ~ 65	-
Oil Pump Sprocket Bolt		29 ~ 35	21 ~ 26	-
Tensioning Device Bolts		26 ~ 32	19 ~ 24	-
Water Pump Pulley		22.5 ~ 27.5	16.6 ~ 20.3	-
Upper Intake Manifold Bolt		22.5 ~ 27.5	16.6 ~ 20.3	-
Lower Intake Mainfold Bolt		22.5 ~ 27.5	16.6 ~ 20.3	-
Flange Bolt to Exhaust Mainfold		30	22	-

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

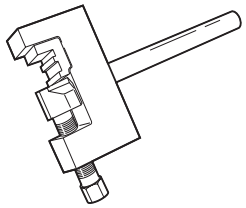
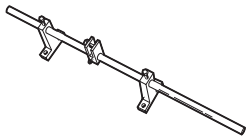
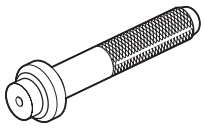
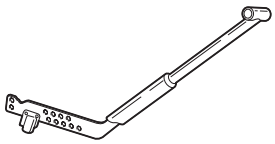
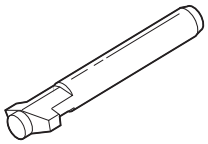
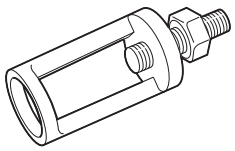
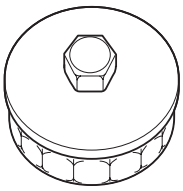
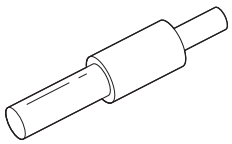
▶ Fastener Tightening Specifications (Cont'd)

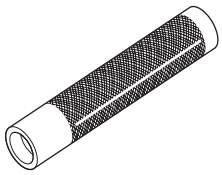
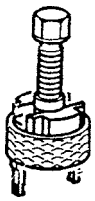
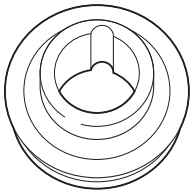
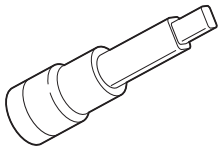
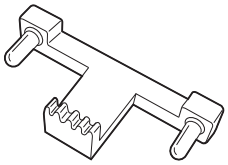
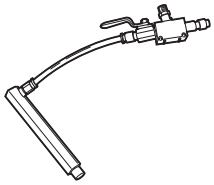
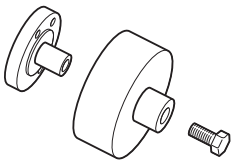
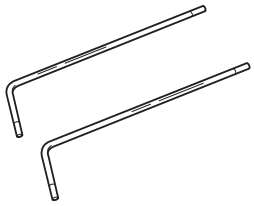
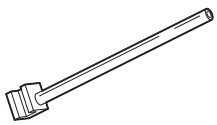
Application	N•m	Lb-Ft	Lb-In
Exhaust Mainfold Nut to Stud Bolt	26 ~ 34	19 ~ 25	-
Oil Drain Plug	25	18	-
Oil Filter Cover	25	18	-
Oil Filter Bolt	22.5 ~ 27.5	16.6 ~ 20.3	-
Oil Pump Drive Sprocket Bolt	29 ~ 35	21 ~ 26	-
Oil Pump Mounting Bolt	22.5 ~ 27.5	16.6 ~ 20.3	-
Oil Strainer Bracket Bolt	9 ~ 11	-	80 ~ 97
Oil Pressure Relief Valve Screw Plug	50	37	-
Oil Dipstick Guide Tube Bolt	9 ~ 11	-	80 ~ 97
Oil Gallery Screw Plug	15	11	-
Shock Absorber Bolts	22.5 ~ 27.5	16.6 ~ 20.3	-
Crankshaft Bearing Cap Bolts	55/+90°	41/+90°	-
Torque Converter Mounting Bracket Bolts	42	31	-

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

6. SPECIAL TOOLS AND EQUIPMENT

▶ Special Tools Table

Name and Part Number	Name and Part Number
A9913 0010B (000 589 58 43 00) Chain Assembly 	A9917 0101B (111 589 01 59 00) Supporting Bar 
W9911 0010B (102 589 00 15 00) Drift 	A9917 0111B (111 589 18 61 00) Lever Pusher 
A9911 0050B (102 589 12 15 00) Drift 	A9917 0121B (111 589 25 63 00) Thrust Piece 
A9910 0050A (103 589 02 09 00) Oil Filter Remover 	A9913 0061B (116 589 01 34 00) Threaded Pin 

Name and Part Number	Name and Part Number
A9917 0171B (119 589 00 43 00) Drift 	W9911 0050B (615 589 01 33 00) Crankshaft Sprocket Puller 
A9911 0060B (601 589 03 14 00) Crankshaft Front Seal Installer 	A9912 0080B (617 589 00 10 00) Allen Wrench Socket 
A9910 0150B (602 589 00 40 00) Engine Lock 	A9911 0012B (DW110-090) Connecting Hose 
W9911 0020B (601 589 03 43 00) Crankshaft Rear Seal Installer 	A9917 0012B (DW110-120) Holding Pin 
A9910 0150A (603 589 00 40 00) Fan Clutch Holder 	

ENGINE COOLING

1521

TABLE OF CONTENTS

NOTICE

- **Disconnect the negative battery cable before removing or installing any electrical unit or when a tool or equipment could easily come in contact with exposed electrical terminals. Disconnecting this cable will help prevent personal injury and damage to the vehicle. The ignition must also be in LOCK unless otherwise noted.**

1. DESCRIPTION AND OPERATION

▶ General Description

The cooling system maintains the engine temperature at an efficient level during all engine operating conditions. When the engine is cold, the cooling system cools the engine slowly or not at all. This slow cooling of the engine allows the engine to warm up quickly.

The cooling system includes a radiator and recovery subsystem, cooling fans, a thermostat and housing, a water pump, and a water pump drive belt. The timing belt drives the water pump.

All components must function properly for the cooling system to operation. The water pump draws the coolant from the radiator. The coolant then circulates through water jackets in the engine block, the intake manifold, and the cylinder head. When the coolant reaches the operating temperature of the thermostat, the thermostat opens. The coolant then goes back to the radiator where it cools.

This system directs some coolant through the hoses to the heat core. This provides for heating and defrosting. The coolant reservoir is connected to the radiator to recover the coolant displaced by expansion from the high temperatures. The coolant reservoir maintains the correct coolant level.

The cooling system for this vehicle has no radiator cap or filler neck. The coolant is added to the cooling system through the coolant reservoir.

▶ Radiator

This vehicle has a lightweight tube-and-fin aluminum radiator. Plastic tanks are mounted on the upper and the lower sides of the radiator core.

On vehicles equipped with automatic transaxles, the transaxle fluid cooler lines run through the radiator tank. A radiator drain plug is on this radiator.

To drain the cooling system, open the drain plug.

▶ Coolant Reservoir

The coolant reservoir is a transparent plastic reservoir, similar to the windshield washer reservoir.

The coolant reservoir is connected to the radiator by a hose and to the engine cooling system by another hose. As the vehicle is driven, the engine coolant heats and expands. The portion of the engine coolant displaced by this expansion flows from the radiator and the engine into the coolant reservoir. The air trapped in the radiator and the engine is degassed into the coolant reservoir.

When the engine stops, the engine coolant cools and contracts. The displaced engine coolant is then drawn back into the radiator and the engine. This keeps the radiator filled with the coolant to the desired level at all times and increases the cooling efficiency.

Maintain the coolant level between the MIN and MAX marks on the coolant reservoir when the system is cold.

▶ Water Pump

The belt-driven centrifugal water pump consists of an impeller, a drive shaft, and a belt pulley.

The impeller is supported by a completely sealed bearing.

The water pump is serviced as an assembly and, therefore, cannot be disassembled.

▶ Thermostat

A wax pellet-type thermostat controls the flow of the engine coolant through the engine cooling system. The thermostat is mounted in the thermostat housing to the front of the cylinder head.

The thermostat stops the flow of the engine coolant from the engine to the radiator to provide faster warm-up, and to regulate the coolant temperature. The thermostat remains closed while the engine coolant is cold, preventing circulation of the engine coolant through the radiator. At this point, the engine coolant is allowed to circulate only throughout the heater core to warm it quickly and evenly.

As the engine warms, the thermostat opens. This allows the engine coolant to flow through the radiator where the heat is dissipated. This opening and closing of the thermostat permits enough engine coolant to enter the radiator to keep the engine within proper engine temperature operating limits.

The wax pellet in the thermostat is hermetically sealed in a metal case. The wax element of the thermostat expands when it is heated and contracts when it is cooled.

As the vehicle is driven and the engine warms, the engine coolant temperature increases. When the engine coolant reaches a specified temperature, the wax pellet element in the thermostat expands and exerts pressure against the metal case, forcing the valve open. This allows the engine coolant to flow through the engine cooling system and cool the engine.

As the wax pellet cools, the contraction allows a spring to close the valve.

The thermostat begins to open at 82 °C (180 °F) and is fully open at 95 °C (203 °F). The thermostat closes at 80 °C (176 °F).

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Electric Cooling Fan

NOTICE

- **Keep hands, tools, and clothing away from the engine cooling fans to help prevent personal injury. This fan is electric and can turn on even when the engine is not running.**

NOTICE

- **If a fan blade is bent or damaged in any way, no attempt should be made to repair or reuse the damaged part. A bent or damaged fan assembly should always be replaced with a new one to prevent possible injury.**

The cooling fans are mounted behind the radiator in the engine compartment. The electric cooling fans increase the flow of air across the radiator fins and across the condenser on air conditioned (A/C)-equipped vehicles.

This helps to speed cooling when the vehicle is at idle or moving at low speeds.

All models have two fans. The main fan is 320 mm (12.6 inches) in diameter with seven blades to aid the airflow through the radiator and the condenser. An electric motor attached to the radiator support drives the fan. The auxiliary fan is 320 mm (12.6 inches) in diameter.

A/C Off or Non-AC Model

- The cooling fans are actuated by the engine control module (ECM) using a low-speed cooling fan relay, a high-speed cooling fan relay and a cooling fan motor relay.
- The ECM will turn the cooling fans on at low speed when the coolant temperature reaches 95 °C (203 °F) and at high speed when the coolant temperature reaches 105 °C (221 °F).
- The ECM will change the cooling fans from high peed to low speed at 100 °C (212 °F) and will turn the cooling fans off at 90 °C (194 °F).

A/C ON

- The ECM will turn the cooling fans on at low speed when the A/C system is on. The ECM will change to high speed when the high side A/C pressure reaches 1860 kPa (269.8 psi).
- The cooling fans will return to low speed when the high side A/C pressure reaches 1378 kPa (199.8 psi).

▶ Engine Coolant Temperature Sensor

The Engine Coolant Temperature (ECT) sensor uses a temperature to control the signal voltage to the Engine Control Module (ECM).

▶ Coolant Temperature Gauge

The coolant temperature gauge controls the instrument panel temperature indicator. The coolant temperature gauge is located with ECT sensor.

▶ PWM Electric Fan

Advantages and Disadvantages of the PWM Electric Fan

Advantages:

- Enhanced A/C performance: at low speed, at idling, driving in city
- Reduction of vibration/noise: fan activated by PWM only when necessary
- Reduction of engine consuming power (V/Fan driving force) by 4 Hp
- Cost saving

Disadvantage:

- Poor engine cooling perfomance at low and high rpm

▶ PWM (Pulse Width Modulation) Unit

It controls the time of the output voltage to control the fan motor speed independently.

Internal functions:

- Motor power shutting-off function when overcurrent is applied
- Adverse voltage prevention function
- Detection function for the motor lock
- Temperature detecting function: The electric fan operates at FULL speed to cool down the PWM unit when the interior temperature of PWM unit is over 120~150°C.
- Communication function when failing: The fail signal is transmitted to the ECU when the PWM unit is malfunctioning.
- Soft start function: The motor speed is gradually increased when the motor is initially operated.

▶ Shutting-off Condition of the A/C Compressor

Coolant temperature:

- When coolant temperature is below 20°C or over 115°C, engine speed is below 650 rpm or over 4500 rpm for 4 seconds after engine starting, abrupt acceleration and A/C refrigerant pressure sensor detecting the followings
- A/C compressor is turned off when the refrigerant pressure is below 2.0 kg/cm^2 and then is turned on when the refrigerant pressure is over 2.4 kg/cm^2.
- A/C compressor is turned off when the refrigerant pressure is over 30 kg/cm^2 and then is turned on when the refrigerant pressure is below 21.4 kg/cm^2.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

2. DTC FOR PWM ELECTRIC FAN

Related item	DTC	Trouble	Help	Engine CHECK warning lamp
Cooling fan system (PWM electric fan)	P0480	PWM electric fan - Short circuit to power supply	Condition - The cooling fan's output wiring has a short circuit to power supply. Actions 1.Inspect the circuit and the terminal of No. 39 ECU pin. 2.Inspect the power supply. 3.Inspect the cooling fan. 4.Check the ECU.	
		PWM electric fan - Open/ Short circuit to ground	Condition - The cooling fan's output wiring has a short circuit to power supply. Actions 1.Inspect the circuit and the terminal of No. 39 ECU pin. 2.Inspect the power supply. 3.Inspect the cooling fan. 4.Check the ECU.	
	P0483	PWM electric fan - Motor overloaded	Condition - The cooling fan's output wiring has a short circuit to power supply. Actions 1.Inspect the circuit and the terminal of No. 39 ECU pin. 2.Inspect the power supply. 3.Inspect the cooling fan. 4.Check the ECU.	
	P0484	PWM electric fan - Motor stalled	Condition - The cooling fan's output wiring has a short circuit to power supply. Actions 1.Inspect the circuit and the terminal of No. 39 ECU pin. 2.Inspect the power supply. 3.Inspect the cooling fan. 4.Check the ECU.	
	P0485	PWM electric fan - Short circuit	Condition - The cooling fan's output wiring has a short circuit to power supply. Actions 1.Inspect the circuit and the terminal of No. 39 ECU pin. 2.Inspect the power supply. 3.Inspect the cooling fan. 4.Check the ECU.	

3. DIAGNOSTIC INFORMATION AND PROCEDURE

▶ Cooling System Diagnosis

Engine Overheats

Checks	Action
Check for a loss of the coolant	Add the coolant.
Check for a weak coolant solution.	Confirm that the coolant solution is a 50/50 mixture of ethylene glycol and water.
Check the front of the radiator for any dirt, any leaves, or any insects.	Clean the front of the radiator.
Check for leakage from the hoses, the water pump, the heater, the thermostat housing, the radiator, the core plugs, or the head gasket.	Replace any damaged components.
Check for a faulty thermostat.	Replace a damaged thermostat.
Check for retarded ignition timing.	Perform an ECM code diagnosis. Confirm the integrity of the timing chain.
Check for an improperly operating electric cooling fan.	Replace the electric cooling fan.
Check for radiator hoses that are plugged or rotted.	Replace any damaged radiator hoses.
Check for a faulty water pump.	Replace a faulty water pump.
Check for a faulty coolant reservoir cap.	Replace a faulty coolant reservoir cap.
Check for a cylinder head or an engine block that is cracked or plugged.	Repair the damaged cylinder head or the damage engine block.

Loss of Coolant

Checks	Action
Check for a leak in the radiator.	Replace a damaged radiator.
Check for a leak in the following locations: • Coolant reservoir. • Hose.	Replace the following parts, as needed. • Coolant reservoir. • Hose.
Check for loose or damaged radiator hoses, heater hoses, and connections.	Reseat the hoses. Replace the hoses or the clamps.
Check for leaks in the water pump seal.	Replace the water pump seal.
Check for leaks in the water pump gasket.	Replace the water pump gasket.
Check for an improper cylinder head torque.	Tighten the cylinder head bolts to specifications. Replace the cylinder head gasket, if needed.
Check for leaks in the following locations: • Intake manifold. • Cylinder head gasket. • Cylinder block plug. • Heater core. • Radiator drain plug.	Repair or replace any components, as needed, to correct the leak.

Engine Fails to Reach Normal Operating Temperature or Cool Air from the Heater

Checks	Action
Check to determine if the thermostat is stuck open or is the wrong type of thermostat.	Install a new thermostat of the correct type and heat range.
Check the coolant level to determine if it is below the LOW mark on the coolant reservoir.	Add sufficient coolant to raise the fluid to the specified mark on the coolant reservoir.

▶ System Leakage Test

Tools Required

A9921 0012A (124 589 15 21 00) Leakage Tester

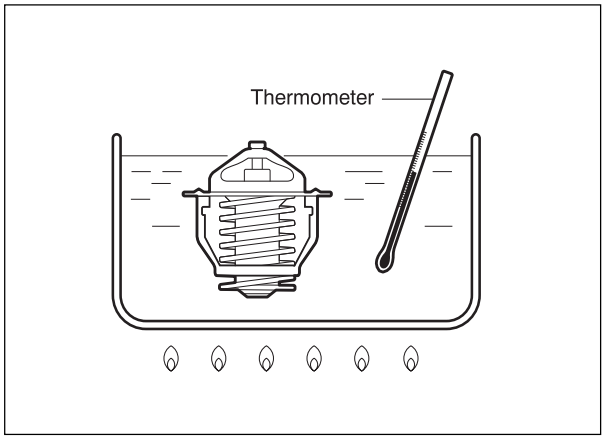
Test Procedure

1. Loosen the cap a little and release pressure and remove the cap.

> **NOTICE**
> - **For the risk of scalding, cap must not be opened unless the coolant temperature is below 90 °C (194 °F).**

2. Fill coolant up to upper edge (arrow) of reservoir.
3. Connect the leakage tester A9921 0012A (124 589 15 21 00) to the reservoir filler cap and apply 1.4 bar of pressure.
4. If the pressure on the tester drops, check leakage at the all coolant hoses and pipes and each connections. Replace or retighten if necessary.

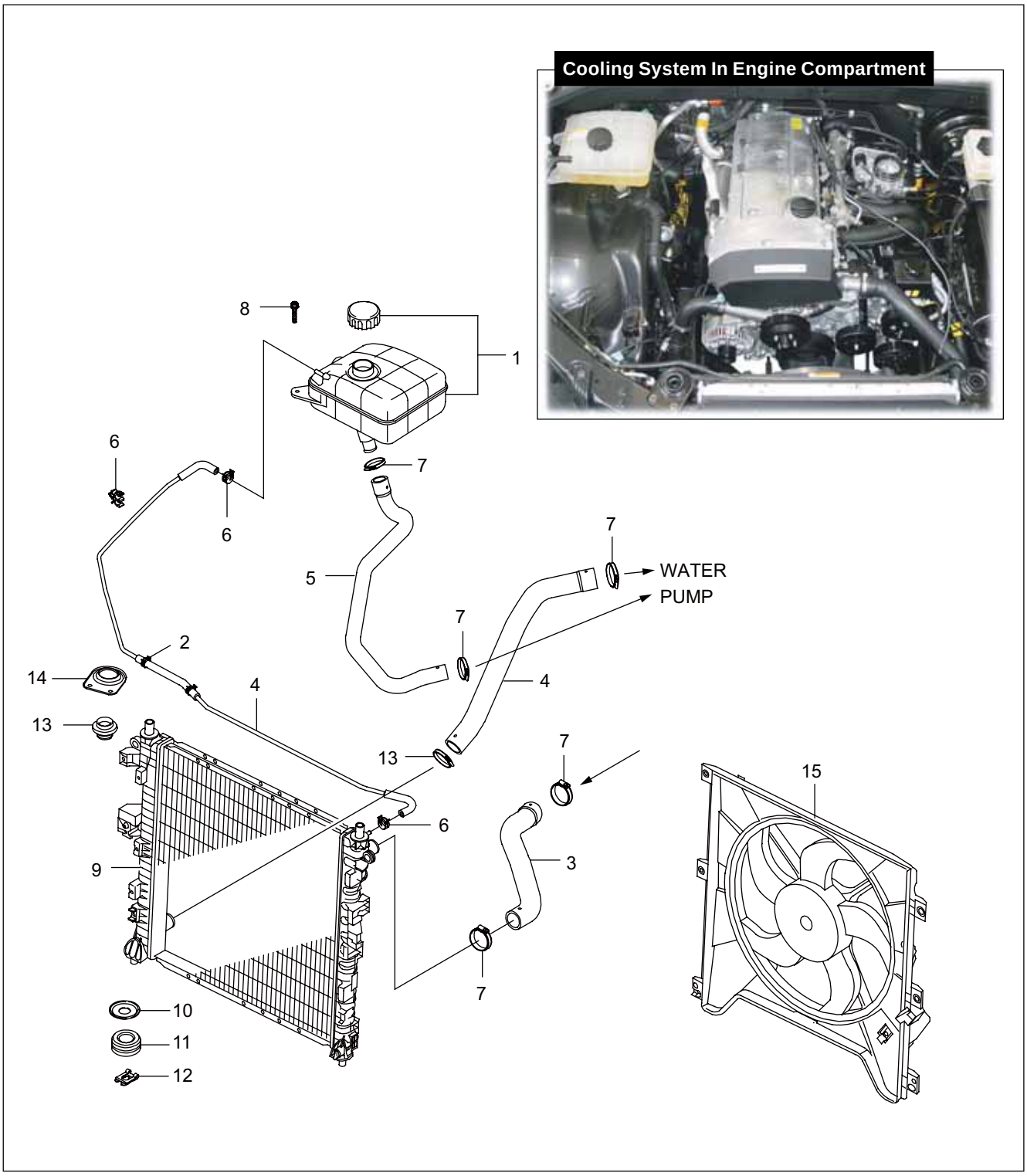
▶ Thermostat Test



Test Procedure

1. Remove the thermostat from the vehicle. Refer to “Thermostat” in this section.
2. Make sure the valve spring is tight when the thermostat is closed. If the spring is not tight, replace the thermostat.
3. Suspend the thermostat and a thermometer in a pan of 50/50 mixture of ethylene glycol and water. Do not let the thermostat or the thermometer rest on the bottom of the pan. The uneven concentration of heat on the bottom could result in inaccurate temperature measurements.
4. Heat the pan on a burner.
5. Use the thermometer to measure the temperature of the heated solution.
6. The thermostat should begin to open at 82°C (180°F) and it should be fully be fully open at 95°C (203°F). If it does not open at these temperatures, replace the thermostat.

4. COMPONENT LOCATOR



1. Reserver Tank
2. Deaeration Tube
3. Inlet Hose
4. Outlet Hose
5. 3 way Hose
6. Clamp
7. Clamp
8. Bolt (M6, 2 piece)
9. Radiator
10. Lower Radiator Insulator
11. Plate
12. Clip
13. Upper Radiator Insulator
14. Bracket
15. PWM Electric Fan

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

5. REPAIR INSTRUCTIONS ON-VEHICLE SERVICE

▶ Coolant Drain and Fill Up

Draining & Filling up Procedure

1. Loosen the cap a little and release pressure and remove the cap.

NOTICE
- **For the risk of scalding, the cap must not be opened unless the coolant temperature is below 90 °C (194 °F).**

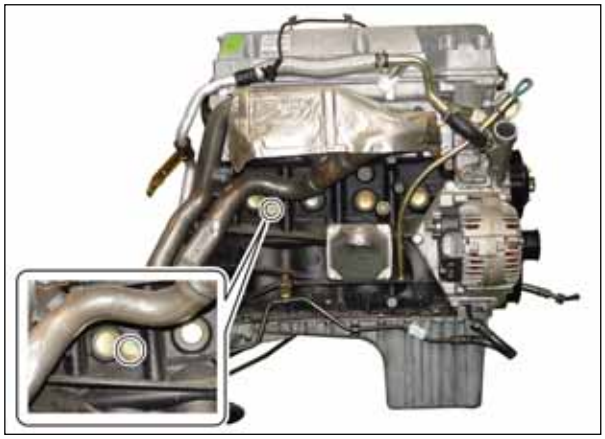
2. Loosen the radiator lower drain cock and drain the coolant.

NOTICE
- **Collect coolant by using a proper container.**

3. Drain the coolant from the crankcase by inserting a hose (dia. 14 mm) onto the drain bolt on the side of crankcase (exhaust manifold) and by loosening the plug.

NOTICE
- **Just loosen the drain plug to drain the coolant and do not remove the plug completely.**
- **Collect coolant by using proper container.**

4. After complete draining of the coolant, remove the hose connector to drain plug and reinstall the drain plug.



Installation Notice

Tightening torque	30 Nm (22 lb-ft)

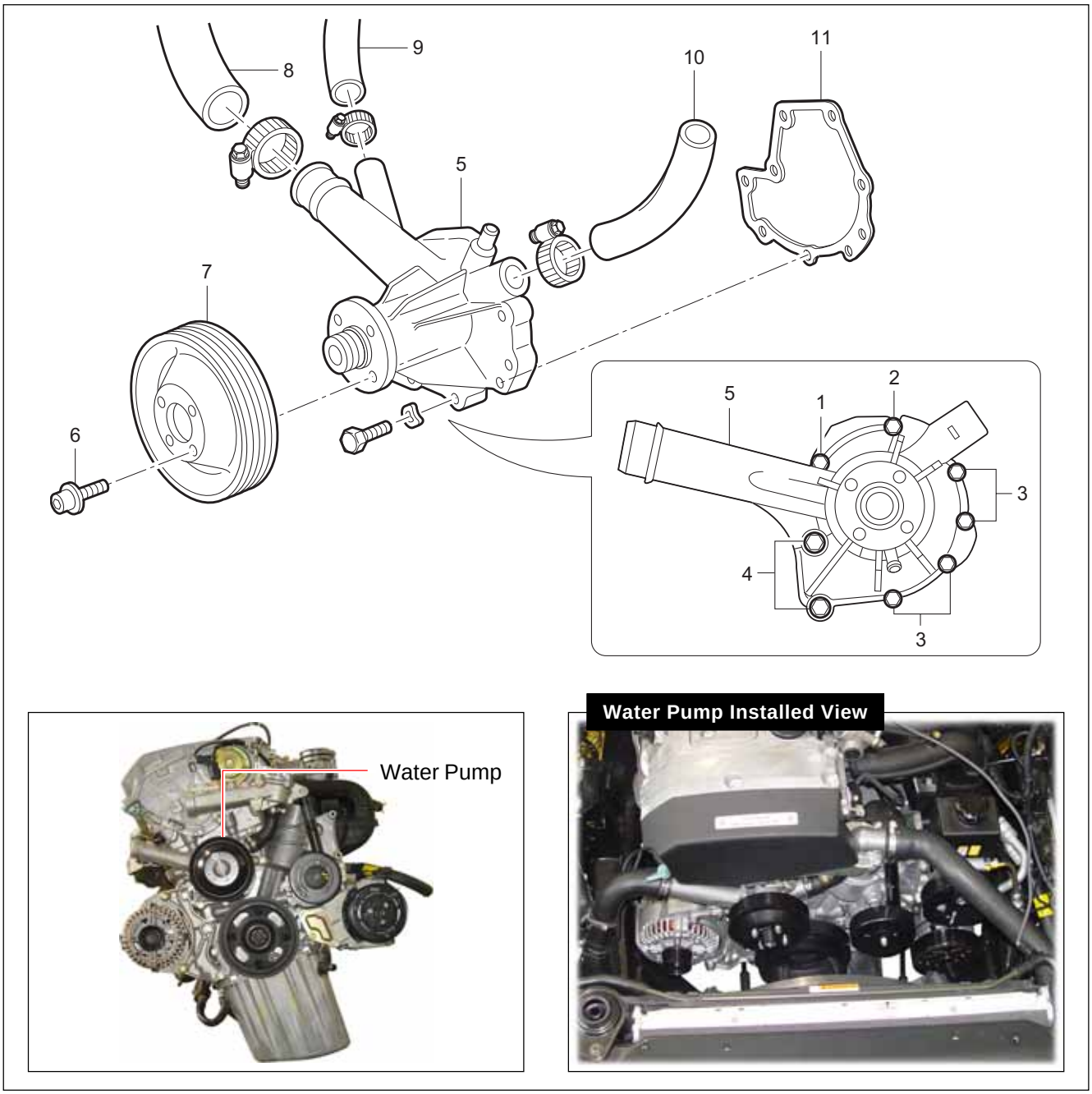
5. Tighten the radiator lower drain cock.
6. Remove the de-aeration hose clamp in the coolant pump and remove the de-aeration hose.
7. Fill up the coolant through the coolant reservoir tank.

NOTICE
- **Match the anti-freeze and the water ratio to 50 : 50.**
- **Supplement the coolant until the coolant overflows to the de-aeration hose.**

8. Insert the de-aeration hose and completely tighten the clamp.
9. Check the coolant level in the coolant reservoir tank.
10. Warm up (until thermostat is opened) the engine and recheck the coolant level in the reservoir tank and fill up the coolant if necessary.

▶ Water Pump

※ **Preceding Works:** Removal of viscous clutch



Water Pump Installed View

1. Bolt (M6 X 45, 1 pieces) ..... 9 - 11 Nm (80 - 97 lb-in)
2. Bolt (M6 X 95, 1 pieces) ..... 9 - 11 Nm (80 - 97 lb-in)
3. Bolt (M6 X 25, 4 pieces) ..... 9 - 11 Nm (80 - 97 lb-in)
4. Bolt (M6 X 85, 2 pieces) ..... 22.5 - 27.5 Nm (16.6 - 20.3 lb-ft)
5. Water Pump Housing
6. Bolt (M6 X 16, 4 pieces) ..... 9 - 11 Nm (80 - 97 lb-in)
7. Water Pump Pulley
8. Coolant Inlet Hose
9. Heater Hose
10. Coolant Bypass Hose
11. Gasket

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

Tools Required

A9910 0150A (603 589 00 40 00) Fan Clutch Holder

Removal & Installation Procedure

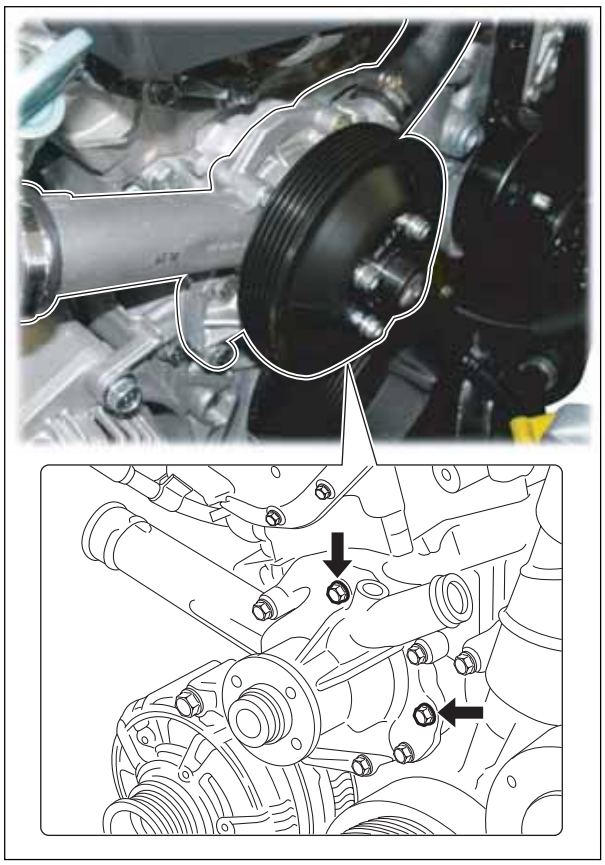
1. Drain the coolant.
2. Disconnect the coolant hoses (8, 9, 10).
3. Tak off the drive belt.
4. Unscrew the four bolts (6) from water pump pulley and remove the pulley (7).

Installation Notice

Tightening torque	9 - 11 Nm (80 - 97 lb-in)

Hold the pulley with fan clutch holder A9910 0150A (603 589 00 40 00) while removing the pulley.

5. Unscrew the bolts (1, 2, 3, 4) from water pump housing (5) and remove the water pump.



Installation Notice

Tightening torque	(1, 2, 3)	9 - 11 Nm (80 - 97 lb-in)
	(4)	22.5 - 27.5 Nm (16.6 - 20.3 lb-ft)

6. Clean the sealing surface.
7. Replace the gasket with new one.

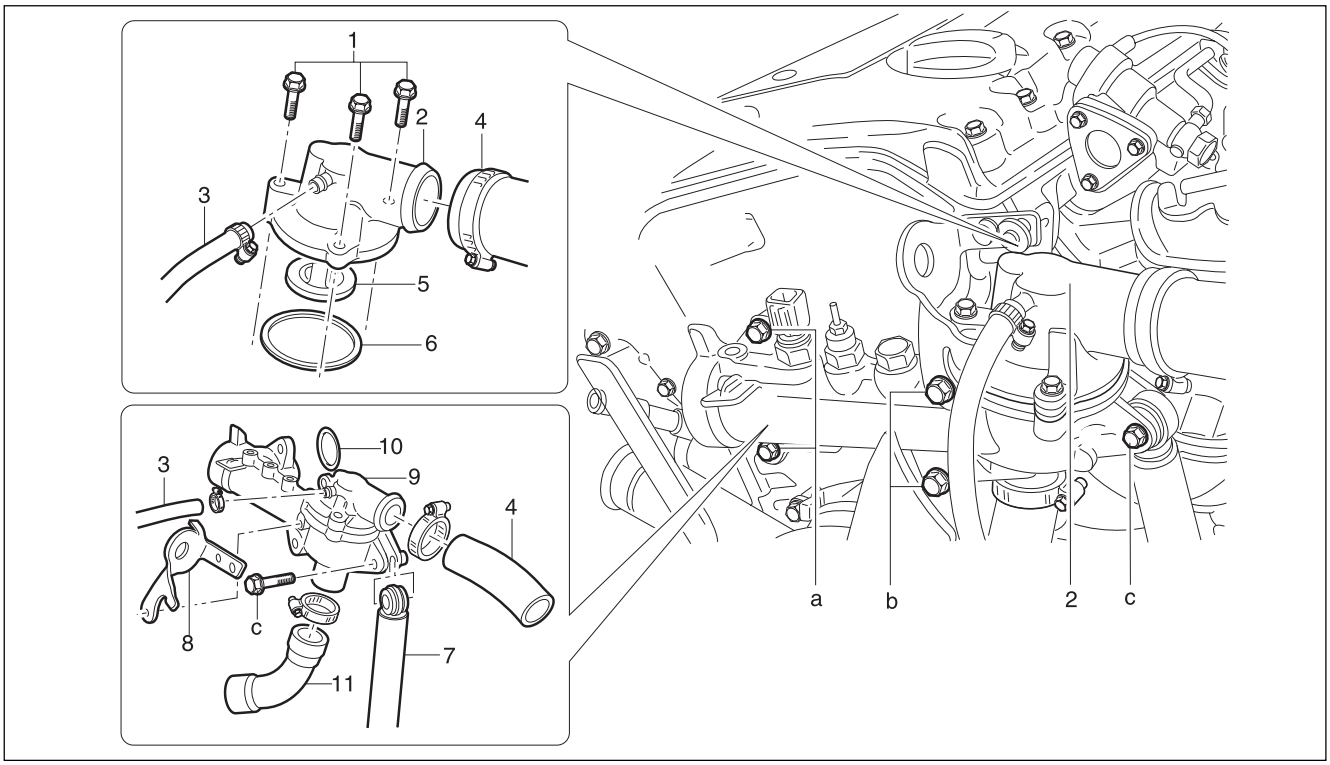
NOTICE

- **Apply the sealant when the sealing surface of water pump housing and coolant mounting area is clean.**

8. Installation should follow the removal procedure in the reverse order.
9. Check for leaks by starting the engine.

▶ Thermostat and Thermostat Housing Assembly

※ **Preceding Works:** Removal of viscous clutch



1. Bolt (M6 X 25, 3 pieces)
   ..... 9 - 11 Nm (80-97 lb-in)
2. Thermostat Cover
3. De-aeration Hose
4. Coolant Outlet Hose
5. Thermostat
6. O-ring
7. Tensioning Device Shock Absorber
   ..... 22.5 - 27.5 Nm (16.6-20.3 lb-in)
8. Engine Hanger Bracket
9. Thermostat Housing Assembly
10. O-ring
11. Coolant Bypass Hose

a. Bolt (M6 X 95, 2 pieces)
   ..... 9 -11 Nm (80 - 97 lb-in)
b. Bolt (M8 X 75, 2 pieces)
   ..... 22.5 - 27.5 Nm (16.6 - 20.3 lb-ft)
c. Bolt (M8 X 35, 1 piece)
   ..... 22.5 - 27.5 Nm (16.6 - 20.3 lb-ft)

Removal & Installation Procedure

1. Drain the coolant.
2. Remove the de-aeration hose (3), coolant outlet hose (4) and coolant bypass hose (11).
3. Disconnect the engine coolant temperature sensor connector and coolant temperature gauge connector.
4. Unscrew the three bolts (1) and remove the thermostat cover assembly from thermostat housing.

   Do not separate the thermostat cover and thermostat.
5. Replace the O-ring if necessary.
6. Unscrew the bolt (c) and pry off the tensioning device shock absorber (7).
7. Unscrew the bolts (a, b) and remove the engine hanger bracket and thermostat housing.
8. Replace the O-ring with new one.
9. Installation should follow the removal procedure in the reverse order.
10. Check for leaks in cooling system.

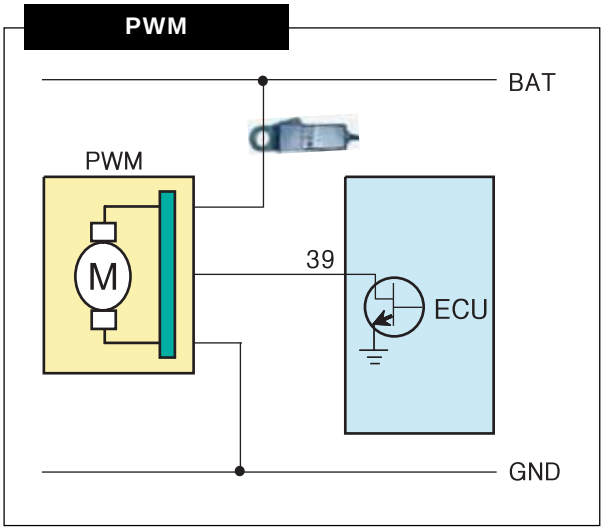
CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ PWM (Pulse Width Modulation) Electric Fan

Function

The PWM (Pulse Width Modulation) high capacity electric fan is installed instead of electric condenser fan to enhance the durability and controllability and reduce noise.

Mounting Location

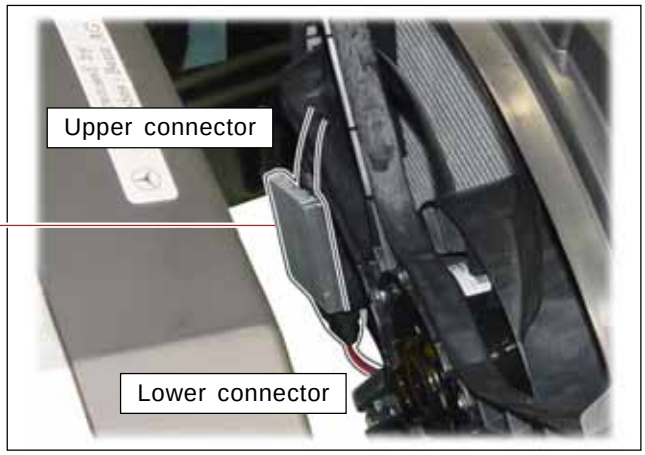


CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

PWM Controller Unit

※ **Preceding Works:** Disconnect the negative battery cable to prevent the abrupt operation of PWM electric fan.

1. Disconnect the PWM controller unit's connector.



2. Remove two mounting bolts and remove the PWM controller unit.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

PWM Electric Fan and Shroud Assembly

※ **Preceding Works:** Disconnect the negative battery cable or remove the key switch.

Mounting Location

1. Unscrew four mounting bolts to remove the front center undershield assembly.

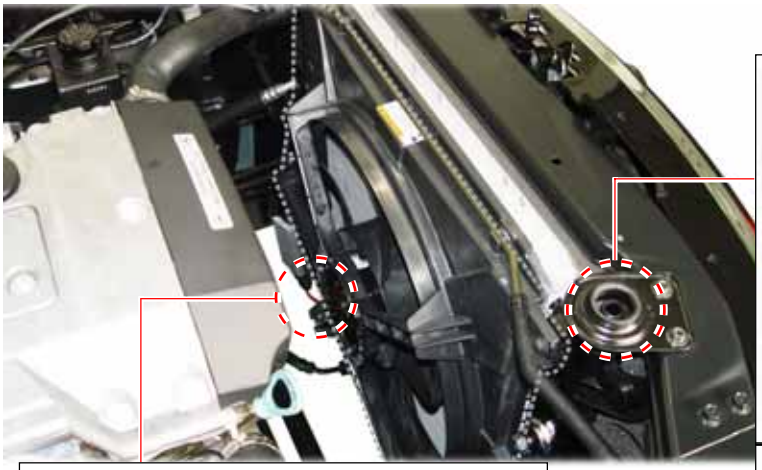
2. Remove the front air duct.

3. Disconnect the upper coolant hose of the radiator.

NOTICE

- **When disconnecting the coolant upper hose, be careful not to spill the coolant.**

3. Disconnect the upper connector of the PWM unit and unscrew the fan shroud mounting bolt.



Removal of the Fan Shroud Mounting Bolt

Disconnection of the PWM Unit Connector

4. Remove the PWM electric fan and the fan shroud from the vehicle with care.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Radiator Assembly

Removal & installation procedure

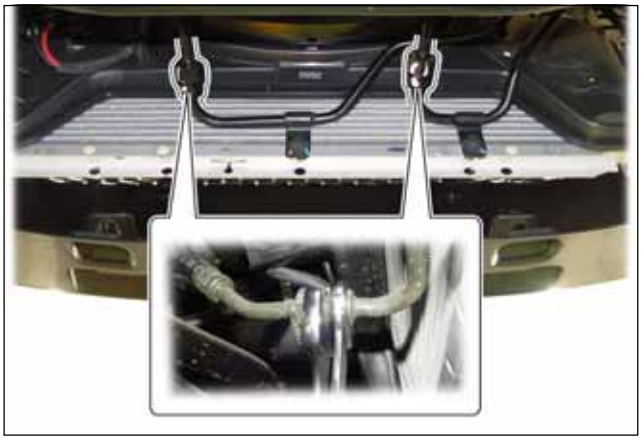
1. Drain the A/C refrigerant using the refrigerant collector.

2. Drain coolant from the radiator.
3. Remove the each coolant hoses.

4. Remove the upper and lower automatic transmission oil cooling pipes from radiator.

Installation Notice

Tightening torque	25 - 35 Nm (18 - 26 lb-ft)



5. Remove the mounting bolt from the automatic transmission oil cooler pipe and then disconnect the cooler pipe.

Installation Notice

Tightening torque	3 - 7 Nm (27 - 62 lb-in)

6. Disconnect the right and left mounting clips of the radiator.

7. Disconnect the upper coolant hose, the return hose and the lower coolant hose from the radiator.

Lower Hose

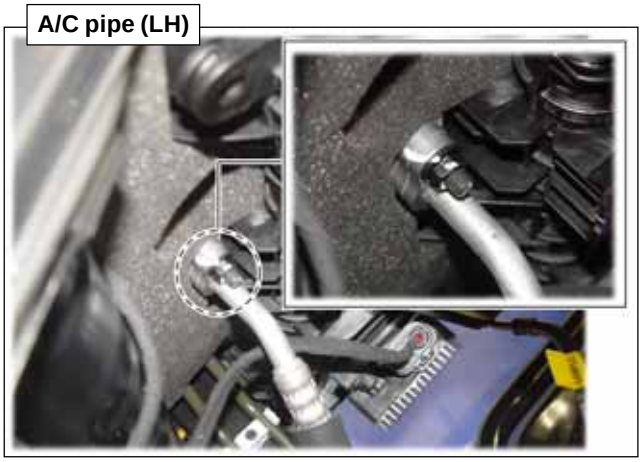
* Be careful of the coolant leaks.

Upper Hose and Return Hose

* Be careful of the coolant leaks.

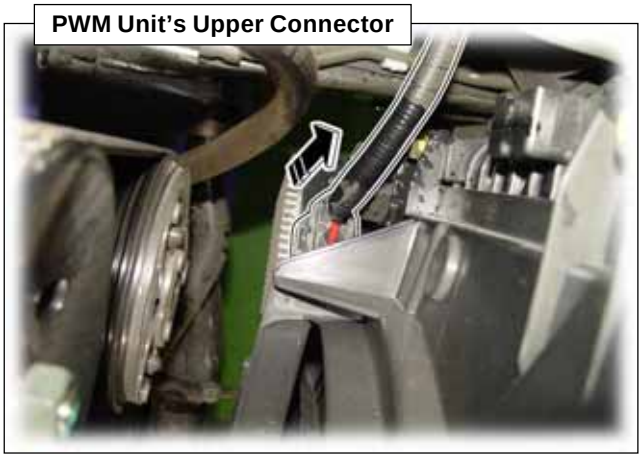
8. Disconnect the A/C pipe from the radiator.

A/C pipe (LH)



9. Disconnect the upper connector of the PWM unit.

PWM Unit's Upper Connector



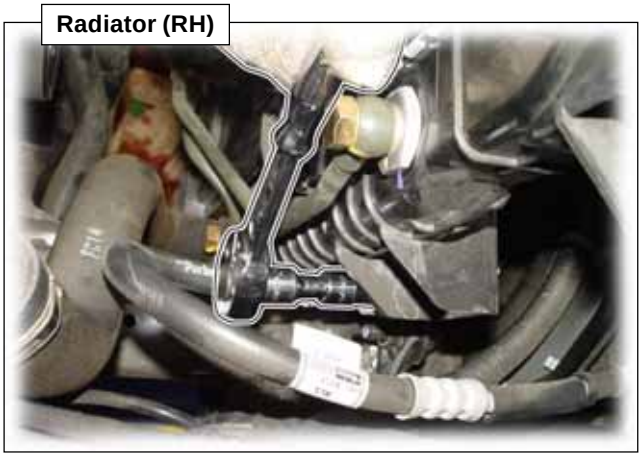
CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

10. Remove the upper mounting bracket of the radiator.

11. Unscrew the right and left mounting bolts of the radiator.

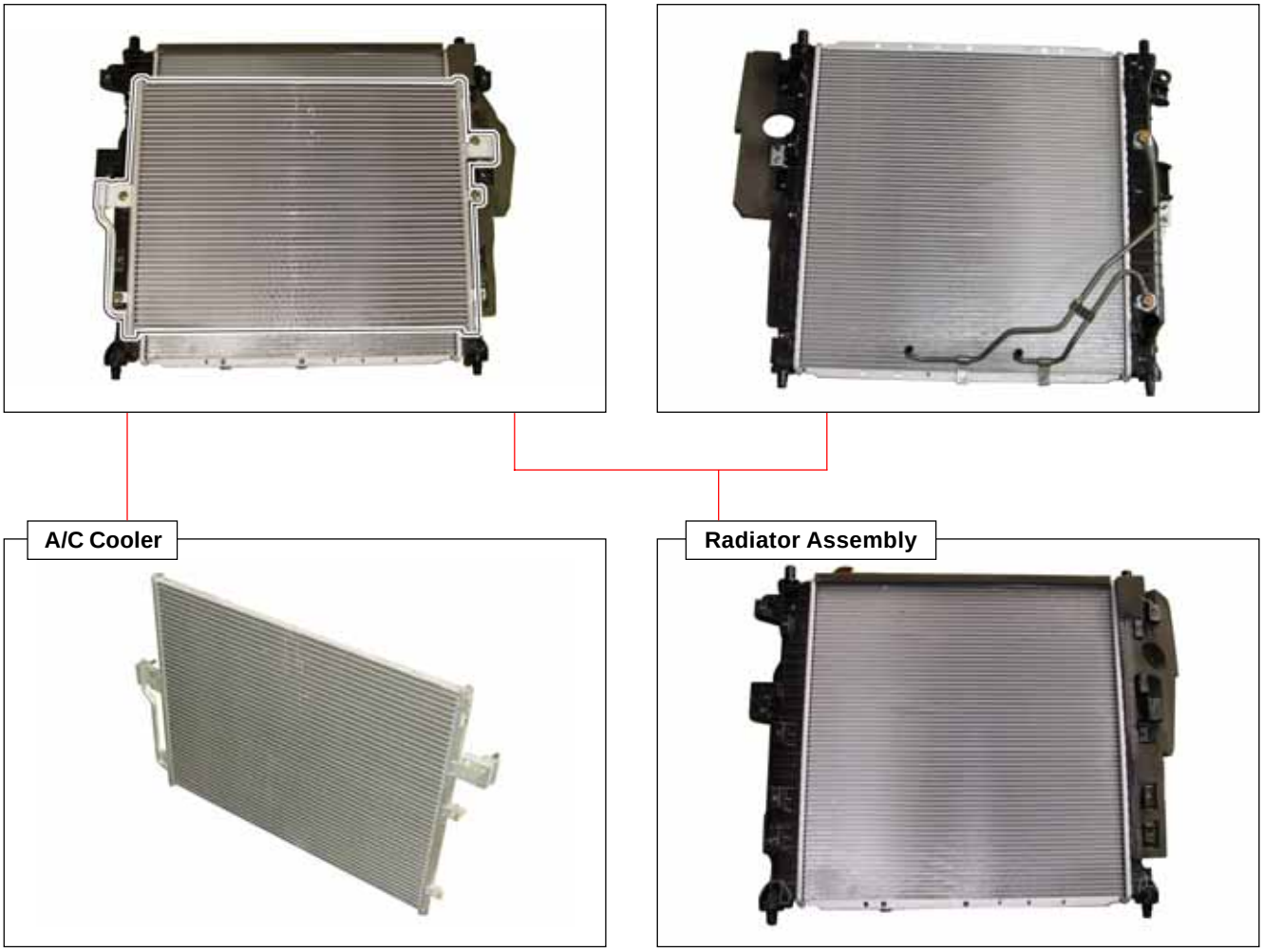
Radiator (LH)

Radiator (RH)



12. Remove the radiator assembly from the vehicle. (The front upper mounting can be removed before for easier removal.)

13. Remove the A/C cooler from the radiator assembly.



14. Install in the reverse order of removal.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

6. SPECIFICATION

▶ General Specifications

Application		Unit	Gasoline Engine
Cooling System	Type	-	Water Cooling Forced Circulation
Coolant	Capacity	L	11.3
Thermostat	Type	-	Wax Pellet Type
	Initial Opening Temp.	°C (°F)	82 (180)
	Fully Opening Temp.	°C (°F)	95 (203)
	Fully Closing Temp.	°C (°F)	80 (176)
	Stroke	mm	7
Cooling Fan	Type	-	PWM
	Blades	-	5
	Diameter	mm	320
	Low Speed ON Temp.	°C (°F)	95 (203)
	Low Speed OFF Temp.	°C (°F)	90 (194)
	High Speed ON Temp.	°C (°F)	105 (221)
	High Speed OFF Temp.	°C (°F)	100 (212)
	High Speed ON Temp. (By A/C Pressure)	kPa (psi)	269.8 (1860)
Coolaant Reservoir	Pressure Valve Opening Pressure	kPa (psi)	118 - 147 (17.1 - 21.3)
	Vacuum Valve Opening Pressure	kPa (psi)	9.8 (1.4)
Water Pump	Type	-	Turbo Centrifugal
	Impeller Diameter	mm	65
	Impeller Blades	-	8
Radiator	Type	-	Cross-flow
	Core Width	mm	701
	Core Height	mm	372
	Core Thickness	mm	18
Coolant Temperature Gauge	Minimum Radiation Capability	Kcal/h	45,000
	Resistance (at 50 °C (122°F))	Ω	185.2
	Resistance (at 80 °C (176°F))	Ω	47.4
	Resistance (at 105 °C (221°F))	Ω	28.2
Engine Coolant Temperature Sensor	Resistance (at 20 °C (68°F))	K Ω	3.33 - 37.8
	Resistance (at 80 °C (176°F))	K Ω	0.32 - 0.35
Anti-Freeze Agent	Type	-	ALUTEC-P78
	Mixture of Water and Good Quality Ethylene Glycol-Base Anti-Freeze	-	50 : 50

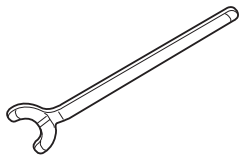
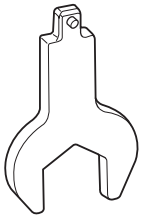
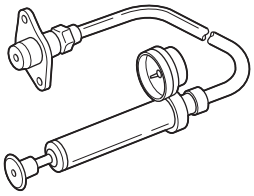
▶ Fastener Tightening Specifications

Application		Nm	Lb-Ft	Lb-In
Automatic Transmission Oil Cooler Pipe Mounting Bolt		3 - 7	-	27 - 62
Coolant Drain Plug		30	22	-
Cooling Fan Bolt		9 - 11	-	80 - 97
Cooling Fan Shroud Bolt		3 - 7	-	27 - 62
Oil Cooler Pipe Line Bolt		9 - 11	-	80 - 97
Radiator Mounting Bracket Bolt		3 - 7	-	27 - 62
Tensioning Device Shock Absorber Bolt		22.5 - 27.5	16.6 - 20.3	-
Thermostat Cover Bolt		9 - 11	-	80 - 97
Thermostat Housing Bolt	M6	9 - 11	-	80 - 97
	M8	22.5 - 27.5	16.6 - 20.3	-
Viscous Clutch Mounting Bolt		40.5 - 49.5	29.8 - 36.5	-
Water Pump Housing Bolt	M6	9 - 11	-	80 - 97
	M8	22.5 - 27.5	16.6 - 20.3	-
Water Pump Pulley Bolt		9 - 11	-	80 - 97

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

7. SPECIAL TOOLS AND EQUIPMENT

▶ Special Tools Table

Name and Part Number	Name and Part Number
A9910 0060A (111 589 00 40 00) Holder 	A9910 0070A (111 589 02 01 00) Open End Wrench 
A9921 0012A (124 589 15 21 00) Leakage Tester 	A9910 0150A (603 589 00 40 00) Fan Clutch Holder 

MEMO

ENGINE ELECTRICAL

1411

TABLE OF CONTENTS

1. DESCRIPTION AND OPERATION

▶ Battey

The sealed battery is standard on all cars. There are no vent plugs in the cover. The battery is completely sealed, except for two small vent holes in the sides.

These vent holes allow the small amount of gas produced in the battery to escape. The battery has the following advantages over conventional batteries:

- No water addition for the life of the battery.
- Overcharge protection. If too much voltage is applied to the battery, it will not accept as much current as a conventional battery. In a conventional battery, the excess voltage will still try to charge the battery, leading to gassing, which causes liquid loss.
- Not as liable to self-discharge as a conventional battery. This is particularly important when a battery is left standing for long periods of time.
- More power available in a lighter, smaller case.

The battery has three major functions in the electrical system. First, the battery provides a source of energy for cranking the engine. Second, the battery acts as a voltage stabilizer for the electrical system. Finally, the battery can, for a limited time, provide energy when the electrical demand exceeds the output of the generator.

▶ Ratings

A battery has two ratings: (1) a reserve capacity rating designated at 27 °C (80 °F), which is the time a fully charged battery will provide 25 amperes of current flow at or above 10.5 volts; (2) a cold cranking amp rating determined under testing at -18 °C (0 °F), which indicates the cranking load capacity.

Reserve Capacity

The reserve capacity (RC) is the maximum length of time it is possible to travel at night with the minimum electrical load and no generator output. Expressed in minutes, the RC rating is the time required for a fully charged battery, at a temperature of 27 °C (80 °F) and being discharged at a current of 25 amperes, to reach a terminal voltage of 10.5 volts.

Cold Cranking Amperage

The cold cranking amperage test is expressed at a battery temperature of -18 °C (0 °F). The current rating is the minimum amperage, which must be maintained by the battery for 30 seconds at the specified temperature, while meeting a minimum voltage requirement of 7.2 volts. This rating is a measure of cold cranking capacity.

The battery is not designed to last indefinitely. However, with proper care, the battery will provide many years of service. If the battery tests well, but fails to perform satisfactorily in service for no apparent reason, the following factors may point to the cause of the trouble:

- Vehicle accessories are left on overnight.
- Slow average driving speeds are used for short periods.
- The vehicle's electrical load is more than the generator output, particularly with the addition of aftermarket equipment.
- Defects in the charging system, such as electrical shorts, a slipping generator belt, a faulty generator, or a faulty voltage regulator.
- Battery abuse, including failure to keep the battery cable terminals clean and tight or a loose battery hold-down clamp.
- Mechanical problems in the electrical system, such as shorted or pinched wires.

▶ Charging Time Required

The time required to charge a battery will vary depending upon the following factors:

- **Size of Battery** — A Completely discharged large heavy-duty battery required more than twice the recharging time as a completely discharged small passenger car battery.
- **Temperature** — A longer time will be needed to charge any battery at -18 °C (0 °F) than at 27 °C (80 °F). When a fast charger is connected to a cold battery, the current accepted by the battery will be very low at first. The battery will accept a higher current rate as the battery warms.
- **Charger Capacity** — A charger which can supply only 5 amperes will require a much longer charging period than a charger that can supply 30 amperes or more.
- **State-of-Charge** — A completely discharged battery requires more than twice as much charge as a one-half charged battery. Because the electrolyte is nearly pure water and a poor conductor in a completely discharged battery, the current accepted by the battery is very low at first. Later, as the charging current causes the electrolyte acid content to increase, the charging current will likewise increase.

Charging a Completely Discharged Battery (Off the Vehicle)

Unless this procedure is properly followed, a perfectly good battery may be needlessly replaced. The following procedure should be used to recharge a completely discharged battery:

1. Measure the voltage at the battery terminals with an accurate voltmeter. If the reading is below 10 volts, the charge current will be very low, and it could take some time before the battery accepts the current in excess of a few milliamperes. Refer to "Charging Time Required" in this section, which focuses on the factors affecting both the charging time required. Such low current may not be detectable on ammeters available in the field.
2. Set the battery charger on the high setting.

IMPORTANT

- **Some chargers feature polarity protection circuitry, which prevents charger unless the charger leads are correctly connected to the battery terminals. A completely discharged battery may not have enough voltage to activate this circuitry, even though the leads are connected properly, making it appear that the battery will not accept charging current. Therefore, follow the specific charger manufacturer's instruction for by passing or overriding the circuitry so that the charger will turn on and charge a low-voltage battery.**

3. Continue to charge the battery until the charge current is measurable. Battery chargers vary in the amount of voltage and current provided. The time required for the battery to accept a measurable charger current at various voltages may be as follows:

Voltage	Hours
16.0 or more	Up to 4 hours
14.0 - 15.9	Up to 8 hours
13.9 or less	Up to 16 hours

- If the charge current is not measurable at the end of the above charging times, the battery should be replaced.
- If the charge current is measurable during the charging time, the battery is good, and charging should be completed in the normal manner.

IMPORTANT

- **It is important to remember that a completely discharged battery must be recharged for a sufficient number of ampere hours (AH) to restore the battery to a usable state.**

- If the charge current is still not measurable after using the charging time calculated by the above method, the battery should be replaced.

Jump Starting Procedure

1. Position the vehicle with the charged battery so that the jumper cables will reach from the charged battery to the battery that requires charging.
2. Turn off the ignition, all the lights, and all the electrical loads in both vehicles.
3. Leave the hazard flasher on if jump starting where there may be other traffic and any other lights needed for the work area.
4. Apply the parking brake firmly in both vehicles.

IMPORTANT

- **In order to avoid damaging the vehicle make sure the cables are not on or near pulleys, fans, or other parts that will move when the engine starts.**

5. Shift an automatic transmission to PARK.

NOTICE

- **In order to avoid injury, do not use cables that have loose or missing insulation.**

6. Clamp one end of the first jumper cable to the positive terminal on the booster battery. Make sure it does not touch any other metal parts.
7. Clamp the other end of the same cable to the positive terminal on the discharged battery. Never connect the other end to the negative terminal of the discharged battery.

NOTICE

- **Do not attach the cable directly to the neg-ative terminal of the discharged battery. Doing so could cause sparks and possible battery explosion.**

8. Clamp one end of the second cable to the negative terminal of the booster battery.
9. Make the final connection to a solid engine ground, such as the engine lift bracket at least 450 millimeters (18 inches) from the discharged battery.
10. Start the engine of the vehicle with the good battery. Run the engine at a moderate speed for several minutes.
11. Then start the engine of the vehicle with the discharged battery.
12. Remove the jumper cables by reversing the above sequence exactly, removing the negative cable from the vehicle with the discharged battery first. While removing each clamp, take care that it does not touch any other metal while the other end remains attached.

▶ Alternator

Alternators are equipped with internal regulators. Unlike three-wire generators, the alternator may be used with only two connections: battery positive and an “D+” terminal to the charge indicator lamp.

As with other charging systems, the charge indicator lamp lights when the ignition switch is turned to RUN, and goes out when the engine is running. If the charge idicator is on with the engine running, a charging system defect is indicated. This indicator light will glow at full brilliance for several kinds of defects as well as when the system voltage is too high or too low.

The regulator voltage setting varies with temperature and limits the system voltage by controlling rotor field current. Achieve correct average field current for proper system voltage control by varying the on-off time. At high speeds, the on-time may be 10 percent and the off-time 90 percent. At low speeds, with high electrical loads, the on-time may be 90 percent and the off-time 10 percent.

▶ Charging System

Generators use a new type of regulator that incorporates a diode trio. A Delta stator, a rectifier bridge, and a rotor with slip rings and brushes are electrically similar to earlier generators. A conventional pulley and fan are used. There is no test hole.

▶ Starter

Wound field starter motors have pole pieces, arranged around the armature, which are energized by wound field coils.

Enclosed shift lever cranking motors have the shift lever mechanism and the solenoid plunger enclosed in the drive housing, protecting them from exposure to dirt, icy conditions, and splashes. In the basic circuit, solenoid windings are energized when the switch is closed. The resulting plunger and shift lever movement causes the pinion to engage the engine flywheel ring gear. The solenoid main contacts close. Cranking then takes place.

When the engine starts, pinion overrun protects the armature from excessive speed until the switch is opened, at which time the return spring causes the pinion to disengage.

To prevent excessive overrun, the switch should be released immediately after the engine starts.

▶ Starting System

The engine electrical system includes the battery, the ignition, the starter, the generator, and all the related wiring.

Diagnostic tables will aid in troubleshooting system faults. When a fault is traced to a particular component, refer to that component section of the service manual.

The starting system circuit consists of the battery, the starter motor, the ignition switch, and all the related electrical wiring. All of these components are connected electrically.

2. DIAGNOSTIC INFORMATION AND PROCEDURE

▶ Ignition System

Condition	Probable Cause	Correction
No Crank	• Low battery voltage.	• Charging the battery or Replace the battery.
	• Battery cable is loose, corroded, or damaged.	• Repair or Replace the battery cable.
	• Faulty starter motor or starter motor circuit is open.	• Repair or Replace the starter motor/starter motor circuit.
	• Faulty ignition switch.	• Replace the ignition switch.
	• Ground short.	• Repair the ground short.
Crank OK, But Too Slow	• Low battery voltage.	• Charging the battery or Replace the battery.
	• Battery. • Battery cables are loose, corroded, or damaged.	• Repair or Replace the battery cable.
	• Faulty starter motor.	• Repair or Replace the starter motor.
Starter Motor Does Not Stop	• Faulty starter motor.	• Repair or Replace the starter motor.
	• Faulty ignition switch.	• Replace the ignition switch.
Starter Motor Running, But Not Cranking	• Broken the clutch pinion gear or faulty starter motor.	• Replace the starter motor.
	• Broken the flywheel ring gear.	• Replace the flywheel.
	• Connected circuit is open.	• Repair the open circuit.
Battery Discharge	• Loosen the generator drive belt.	• Adjust the belt tension or Replace the belt.
	• The circuit is open or a short.	• Repair the open or a short circuit.
	• Battery run down.	• Replace the battery.
	• Open ground circuit.	• Repair the open ground circuit.
Charging Indicator Lamp Does Not Work When the Ignition Switch ON (Engine Does Not Work)	• Charging indicator lamp is blown or fuse is blown.	• Repair or Replace the charging indicator lamp/fuse.
	• Faulty ignition switch.	• Replace the ignition switch.
	• Generator ground circuit is open or a short.	• Repair the circuit.
Charging Indicator Lamp Does Not Put Out Lights After Starting the Engine	• Battery cable is corroded or damaged.	• Repair or Replace the battery cable.
	• Loosen the generator drive belt.	• Adjust the belt tension or Replace the belt.
	• Faulty wiring harness.	• Repair the wiring harness.
Battery Over Charging	• Generator Voltage Regulator Faulty	• Replace Generator
	• Voltage detecfing wiring faulty	• Repair Wiring

▶ Ignition System (Cont'd)

Condition	Probable Cause	Correction
Hard Engine Starting	• Ignition coil faulty	• Replace ignition coil
	• Distributor (including optical sensor) faulty	• Replace distribator (or sensor)
	• Spark plug malfuntion	• Replace spark plug or adjust clearance
	• Ignition timing faulty (spark plug light is normal)	• Resetting valve timing
Unstable Engine Idling	• Spark plug malfunction	• Replace spark plug or adjust clearance
	• Ignition coil faulty	• Replace ignition coil
	• Ignition timing faulty	• Resetting valve timing
Enging Acceralation Malfunction	• Ignition timing faulty	• Resetting valve timing

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

3. GENERATOR REPAIR INSTRUCTIONS

▶ ON-Vehicle Service

Removal & Installation Procedure

1. Disconnect the negative battery terminal.
2. Unscrew the nut and disconnect the terminal.

Installation Notice

Tightening Torque	14 - 18 N•m (10 - 13 lb-ft)

3. Unscrew the nut and disconnect the terminal.

Installation Notice

Tightening Torque	4 - 5 N•m (35 - 44 lb-in)

4. Remove the fan belt.

5. Unscrew the combination bolt.

Installation Notice

Tightening Torque	42 - 50 N•m (31 - 37 lb-ft)

6. Remove the generator.
7. Installation should follow the removal procedure in the reverse order.

4. STARTER REPAIR INSTRUCTIONS

▶ ON-Vehicle Service

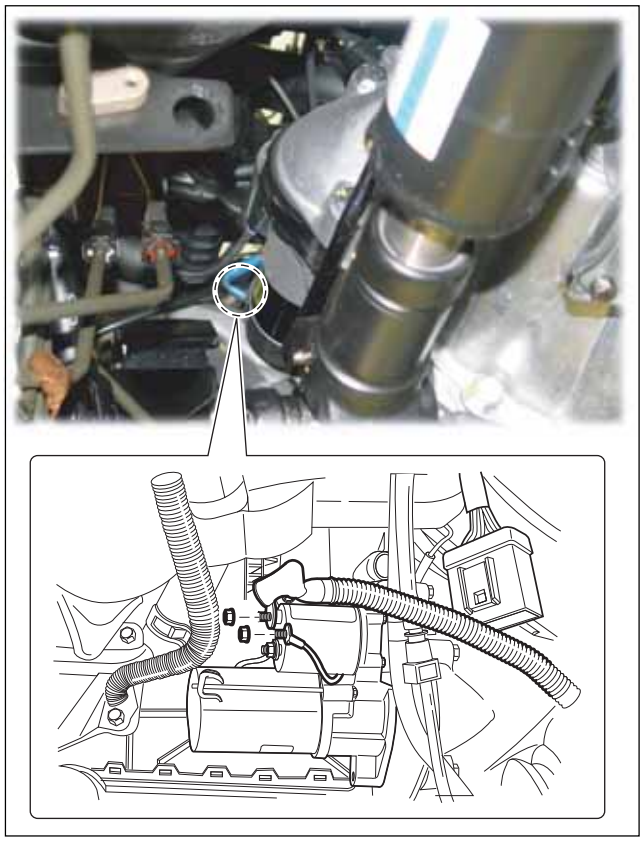
Removal & Installation Procedure

1. Disconnect the negative battery terminal.
2. Unscrew the nut and disconnect the battery cable(1).

Installation Notice

Tightening Torque	12 - 15 N•m (9 - 11 lb-ft)

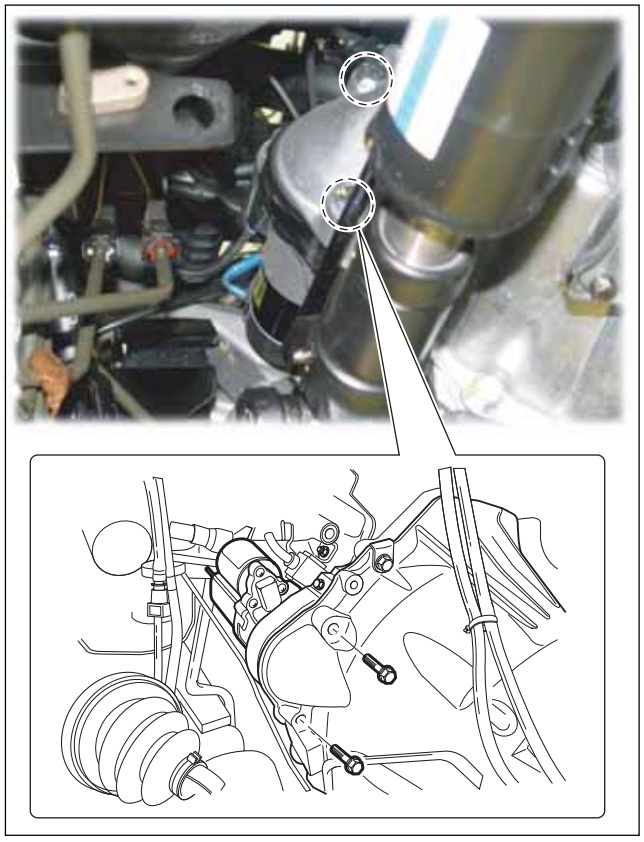
3. Unscrew the nut and disconnect the engine electric wire (2).



Installation Notice

Tightening Torque	6 - 7 N•m (53 - 62 lb-in)

4. Unscrew the mounting bolts (3) of starter.



Installation Notice

Tightening Torque	35 - 48 N•m (26 - 35 lb-ft)

5. Remove the starter.
6. Installation should follow the removal procedure in the reverse order.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

5. BATTERY REPAIR INSTRUCTIONS

▶ ON-Vehicle Service

Removal & Installation Procedure

NOTICE

- **Disconnect the negative battery cable first.**
- **Insert the clamp bolt (8) into the battery tray hole (11) from inside when installing.**

1. Disconnect the negative battery cable and then disconnect the positive battery cable.

Installation Notice

Tightening Torque	12 - 18 N•m (9 - 13 lb-ft)

2. Remove the nut from the battery clamp bolt that fasten the battery holddown bracket.

Installation Notice

Tightening Torque	15 N•m (11 lb-ft)

3. Remove the battery.
4. Installation should follow the removal procedure in the reverse order.

6. SPARK PLUG AND IGNITION COIL REPAIR INSTRUCTIONS

▶ ON-Vehicle Service

Replacement Procedure

1. Disconnect the negative battery cable.
2. Remove the ignition cable cover bolts and remove the ignition cable cover.

Installation Notice

Tightening Torque	9 - 11 N•m (80 - 97 lb-in)

3. Separate the ignition cable from the ignition coil and the spark plug.
4. Remove the two bolts (M6 X 25) from each ignition coil and remove the ignition coil.

Installation Notice

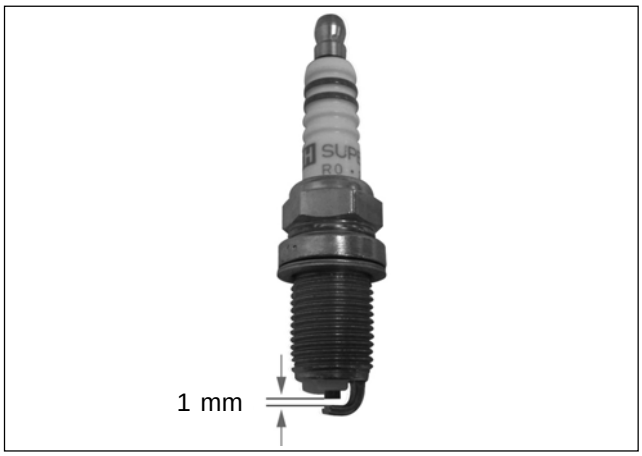
Tightening Torque	9 - 11 N•m (80 - 97 lb-in)

- Make sure that the ignition cables are correctly routed.
- Exactly install the ignition cable guide pin into the vehicle to be grounded.
- The ignition cables are located on the cylinder head cover. Each ignition coil provides the high voltage to two spark plugs simultaneously.

  T 1/1 : Cylinder 1 and 4

  T 1/2 : Cylinder 2 and 3

5. Remove the spark plug using the spark plug wrench.



Installation Notice

Tightening Torque	25 - 30 N•m (15 - 22 lb-ft)
Clearance	1 + 0.1 mm

6. Installation should follow the removal procedure in the reverse order.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

ENGINE CONTROL

1430

TABLE OF CONTENTS

NOTICE

- **Disconnect the negative battery cable before removing or installing any electrical unit or when a tool or equipment could easily come in contact with exposed electrical terminals. Disconnecting this cable will help prevent personal injury and damage to the vehicle. The ignition must also be in LOCK unless otherwise noted.**

1. ENGINE AND ECM PROBLEM CHECK REPORT

▶ Vehicle and Customer Information

Date Problem Occurred			
Customer Name		Vehicle Model	
Driver Name		VIN	
Purchase date		Engine Model	
License No.		Mileage	Km miles

▶ MIL Information

Condition of MIL	☐ Remains on	☐ Sometimes illuminates	☐ Does not illuminate
DTC inspection	☐ Normal	☐ Malfunction code(s) (code)	
(if available)	☐ **Freeze frame data ( )**		

▶ Problem Description

☐ Engine Does Not Start	☐ No cranking	☐ No initial combustion	☐ No complete combustion	
☐ Hard to Start	☐ Slow cranking ☐ Others			
☐ Poor Idling	☐ Incorrect first Idle	☐ Abnormal idle rpm	☐ High (rpm)	☐ Low (rpm)
	☐ Idling Unstable	☐ Others		
☐ Poor Driveability	☐ Hesitation	☐ Back fire	☐ Muffler explosion (after-burning)	
	☐ Surging	☐ Knocking	☐ Poor performance	☐ Other
☐ Engine Stall	☐ Soon after starting	☐ After accelerator pedal depressed		
	☐ After accelerator pedal released	☐ During A/C operation		
	☐ Shifting from N to D or D to N			
	☐ At full steering	☐ Others		
☐ Others				

▶ Condition when Problem Occurs

Problem Frequency	☐ Constant	☐ Intermittent (times per day/month)	☐ Once only	☐ Others	
Weather	☐ Fine	☐ Cloudy	☐ Rainy	☐ Snowy	☐ Various/Others
Ambient Temperature	☐ Hot	☐ Warm	☐ Cool	☐ Cold (approx.____°F/____°C)	
Place	☐ Highway	☐ Suburbs	☐ Inner City	☐ Uphill	☐ Downhill
	☐ Rough Road	☐ Others			
Engine Temperature	☐ Cold	☐ Warming Up	☐ Before warming up	☐ After warm-up	
	☐ Any temp.	☐ Others			
Engine Operation	☐ Starting	☐ Just after starting (min.)	☐ Idling	☐ Racing	☐ Driving
	☐ Constant speed	☐ Acceleration	☐ Deceleration		
	☐ A/C switch ON/OFF	☐ Other			

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

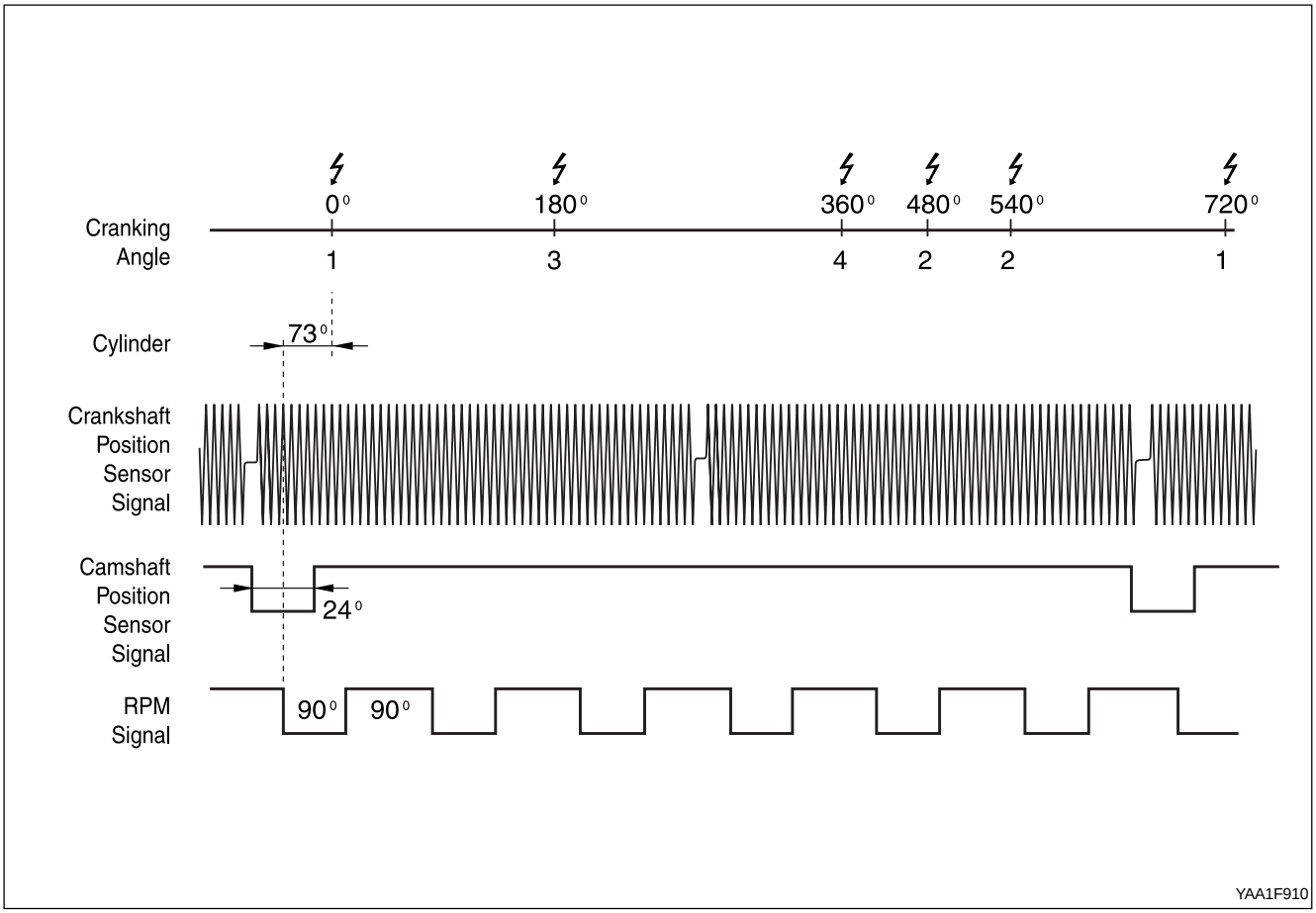
2. IGNITION SYSTEM

This ignition system does not use a conventional distributor and coil. It uses a crankshaft position sensor input to the Engine Control Module (ECM). The ECM then determines Electronic Spark Timing (EST) and triggers the electronic ignition system ignition coil.

This type of distributorless ignition system uses a "waste spark" method of spark distribution. Each cylinder is paired with the cylinder that is opposite it (2-3 or 1-4). The spark occurs simultaneously in the cylinder coming up on the compression stroke and in the cylinder coming up on the exhaust stroke. The cylinder on the exhaust stroke requires very little of the available energy to fire the spark plug. The remaining energy is available to the spark plug in the cylinder on the compression stroke.

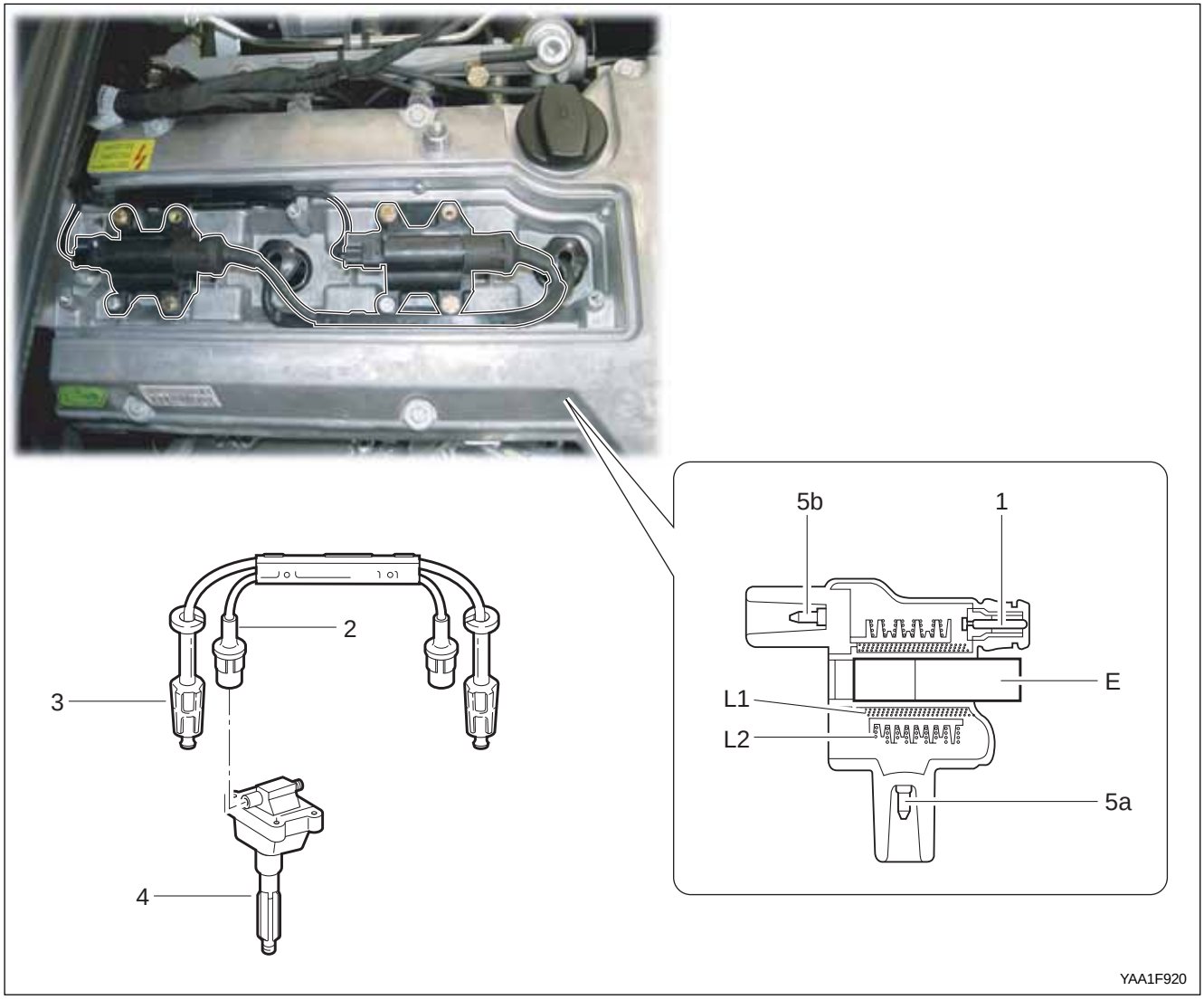
These systems use the EST signal from the ECM to control the EST. The ECM uses the following information:

- Engine load (mass air flow sensor).
- Engine temperature.
- Intake air temperature.
- Crankshaft position.
- Engine speed (rpm).



CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Ignition Coil



1. Control Cable Connection
2. Ignition Cable
3. Spark Plug Connector
4. Coupling Plug

5a, 5b. Secondary Voltage Connection

E. Iron Core

L1. Secondary Ignition Coil

L2. Primary Ignition Coil

The Electronic Ignition (EI) system ignition coil is located on the cylinder head cover. The double ended coils receive the signal for the Engine Control Module (ECM) which controls the spark advance.

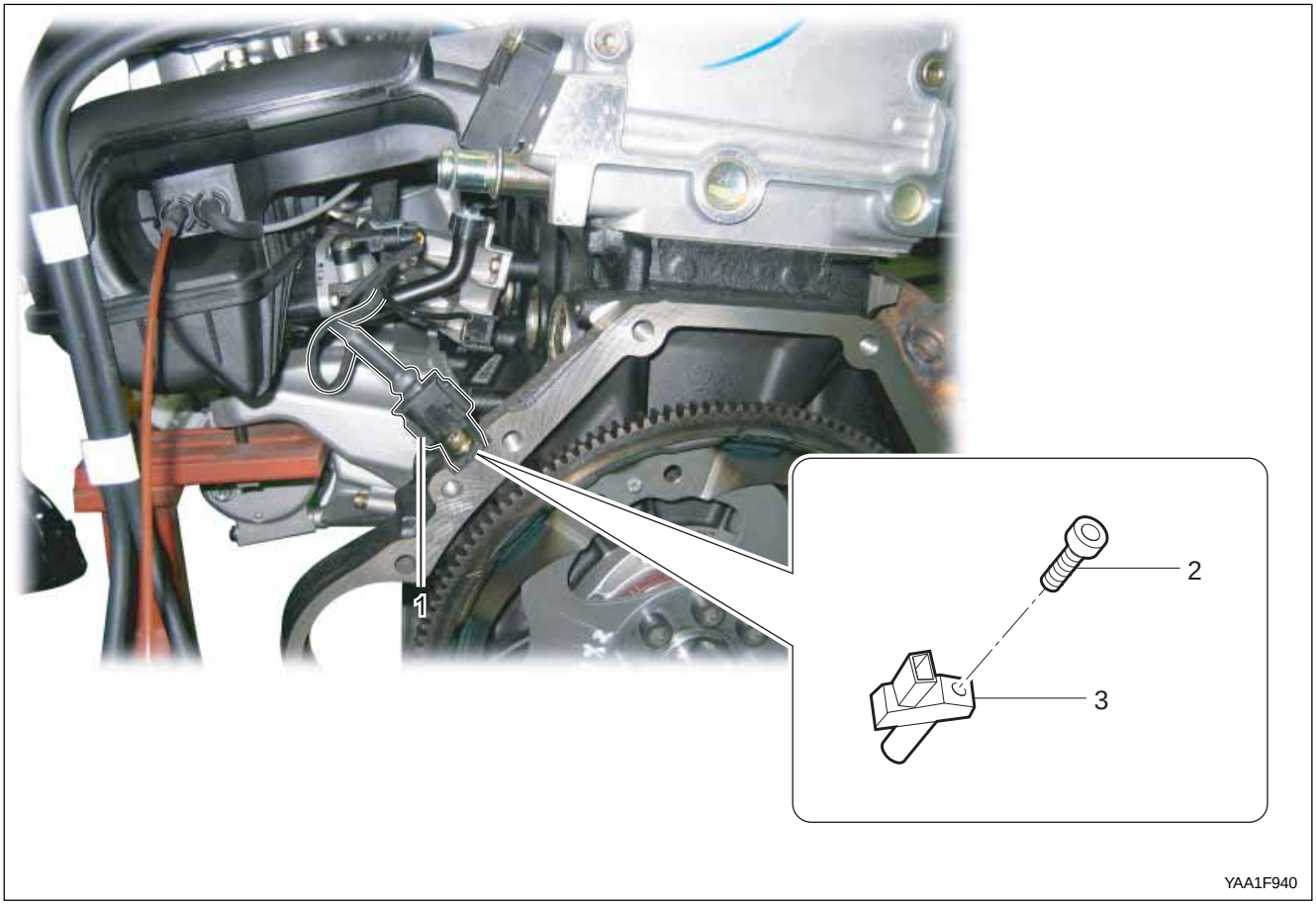
Each EI system ignition coil provides the high voltage to two spark plugs simultaneously;

T1/1: cylinder 1 and 4

T1/2: cylinder 2 and 3

The EI system ignition coil is not serviceable and must be replaced as an assembly.

3. CRANKSHAFT POSITION (CKP) SENSOR



1. Crankshaft Position Sensor Connector
2. Bolt
3. Crankshaft Position Sensor

This Electronic Ignition (EI) system uses inductive or pick up type magnetic Crankshaft Position (CKP) sensor. The CKP sensor is located in the opposite side of the crankshaft pulley and triggers the pick-up wheel teeth which is equipped 60-2 teeth with agap of 2 teeth at 360 degree spacing. This sensor protrudes through its mount to within 1.1 ± 0.14 mm.

The output of the sensor is a sinusoidal signal. Each tooth of the pick-up 60-2 wheel generates a positive half wave.

The Engine Control Module (ECM) uses this sensor signal to generate timed ignition and injection pulses that it sends to the ignition coils and to the fuel injectors.

Crankshaft Position Sensor Resistance Inspection

1. Disconnect the coupling “E” of ECM while the ignition switch is in “OFF” position.
2. Measure the resistance between the coupling terminal pin No. 99 and No. 100 using a multimeter.

Specified Value	1,050 ~ 1,400 Ω

NOTICE

- **Measure the insulator resistance of the CKP sensor if out of the specified value.**

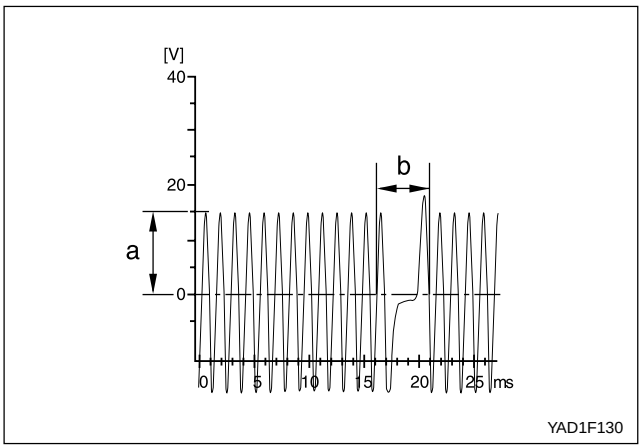
CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

Crankshaft Position Sensor Output Wave Inspection

1. Measure the output wave between the ECM terminals No. 99 and No. 100 using the scan tool or the oscilloscope while engine cranking (start motor activated).

NOTICE

- **Check the segment or crankshaft position sensor and air gap if cannot get the output wave as shown in the figure.**



a. Voltage
b. Identifying the No. 1-2 Missing Teeth

Crankshaft Position Sensor Insulator Resistance Inspection

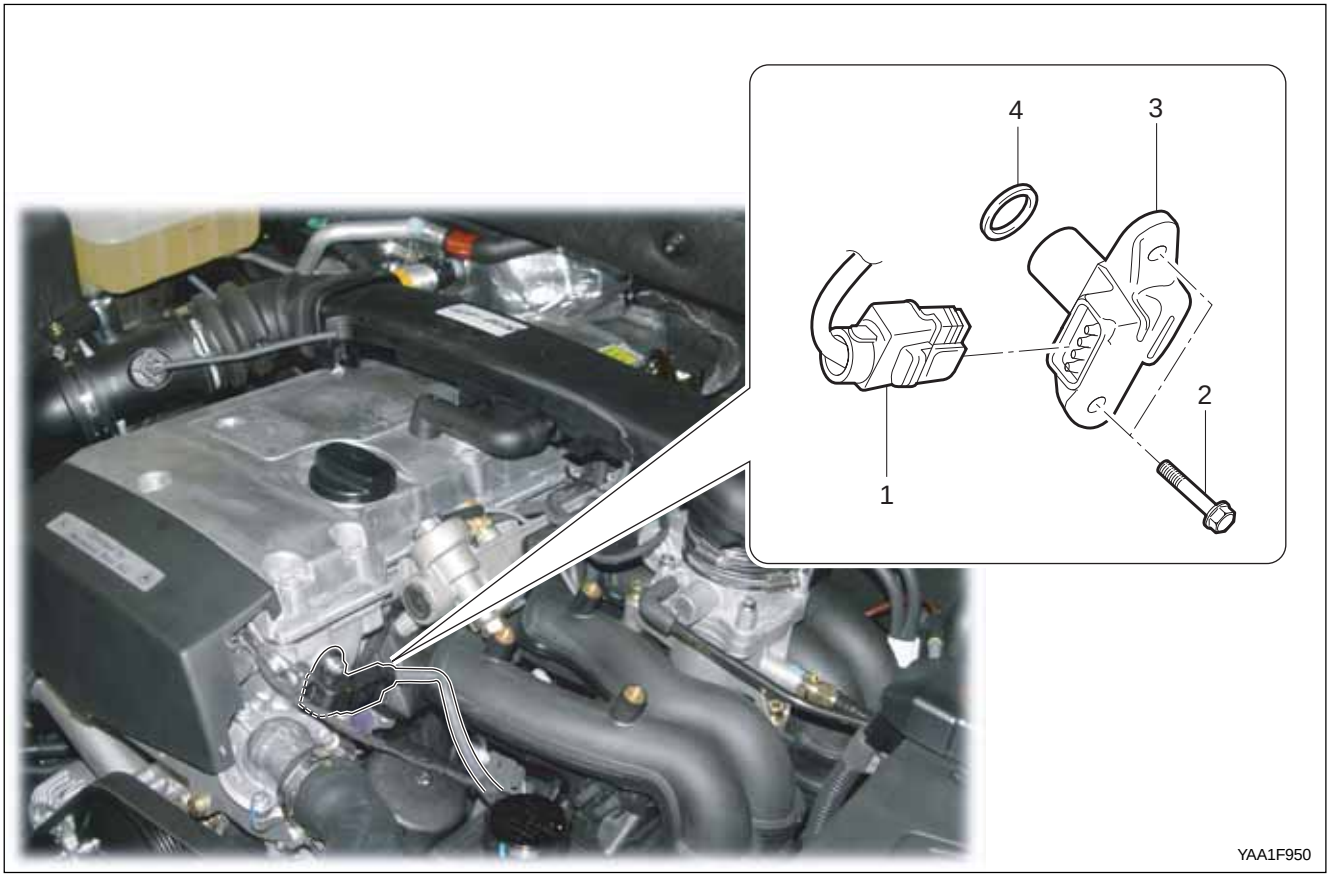
1. Disconnect the coupling from ECM while the ignition switch is in “OFF” position.
2. Measure the resistance between the coupling terminal pin No. 100 and No. 69 using a multimeter.

Specified Value	> 20 kΩ

NOTICE

- **Measure the check and ground terminal of the CKP sensor if out of the specified value.**

▶ Camshaft Position (CMP) Sensor



1. Camshaft Position Sensor Connector
2. Bolt
3. Camshaft Position Sensor
4. O-Ring

The Camshaft Position (CMP) sensor sends a CMP signal to the Engine Control Module (ECM). The ECM uses this signal as a “synchronized pulse” to trigger the injectors in the proper sequence. The ECM uses the CMP signal to indicate the position of the #1 piston during its power stroke. This allows the ECM to calculate true sequential fuel injection mode of operation.

Camshaft Position Sensor Signal Voltage Inspection

1. Measure the voltage between the ECM terminal No. 11 and No. 106 while the engine speed is at idle.

Specified Value	1.2 ~ 1.7 V

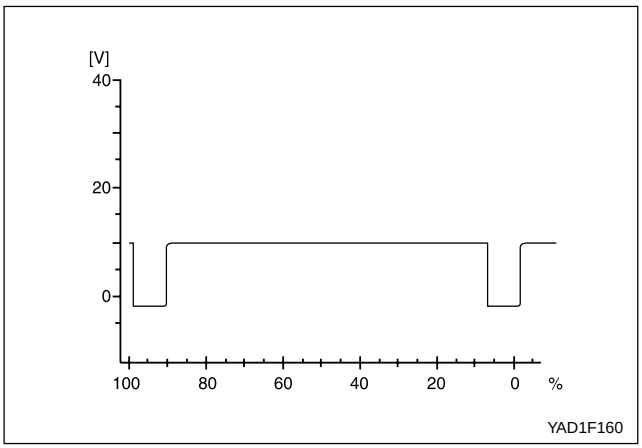
NOTICE

- **The signal voltage will be changed in the range of 1.2 ~ 1.7 V.**

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

Camshaft Position Sensor Output Wave Inspection

1. Measure the output wave between the ECM terminals No. 106 and No. 104 using the scan tool or the oscilloscope while engine speed is at idle.



NOTICE

- **Replace the CAM sensor if cannot get the output wave as shown in the figure.**

Camshaft Position Sensor Power Supply Inspection

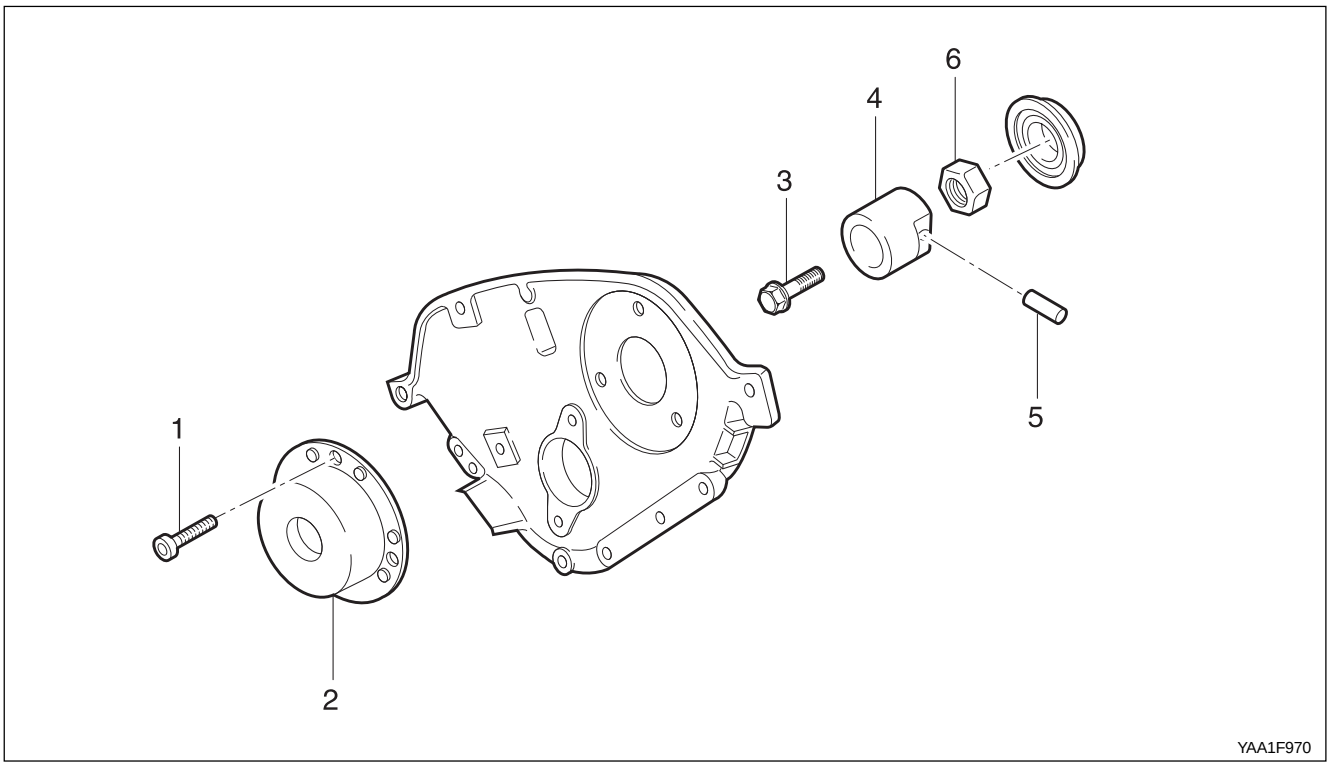
1. Disconnect the CMP sensor Connector.
2. Measure the voltage between the No. 3 and No. 1 pin of the CMP sensor connector while the ignition switch is in “ON” position.

Specified Value	11 ~ 14 V

NOTICE

- **If the measured value is not within the specified value, check the cable.**

▶ Camshaft Actuator



1. Bolt
2. Camshaft Actuator
3. Bolt
4. Armature
5. Roll Pin
6. Nut

When the engine is running, the camshaft actuator rotates the intake camshaft hydraulically and mechanically relative to the camshaft sprocket by 20° crank angle to the “advanced” position and back to the “retard” position.

The camshaft actuator is actuated electro-mechanically by the Engine Control Module (ECM).

The positioning time of apporx. 1 second is dependent on the engine oil pressure at the camshaft actuator and on the oil viscosity and oil temperature, respectively.

The camshaft indicator on the camshaft sprocket provides the camshaft rotational speed to the position sensor as an input parameter for the engine ignition control unit.

Operation Condition of Camshaft Actuator

Engine RPM	Camshaft Position	Effect
Engine stop	Retard	-
0 ~ 1,740 rpm	Retard	Idle speed is improved Blow-by gas is decreased Valve overlap is decreased
1,740 ~ 3,540 rpm	Advanced	Torque is increased Fuel loss is decreased NOx is decreased
Above 3,540 rpm	Retard	Engine overrun is prohibited

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

Camshaft Actuator Current Consumption Inspection

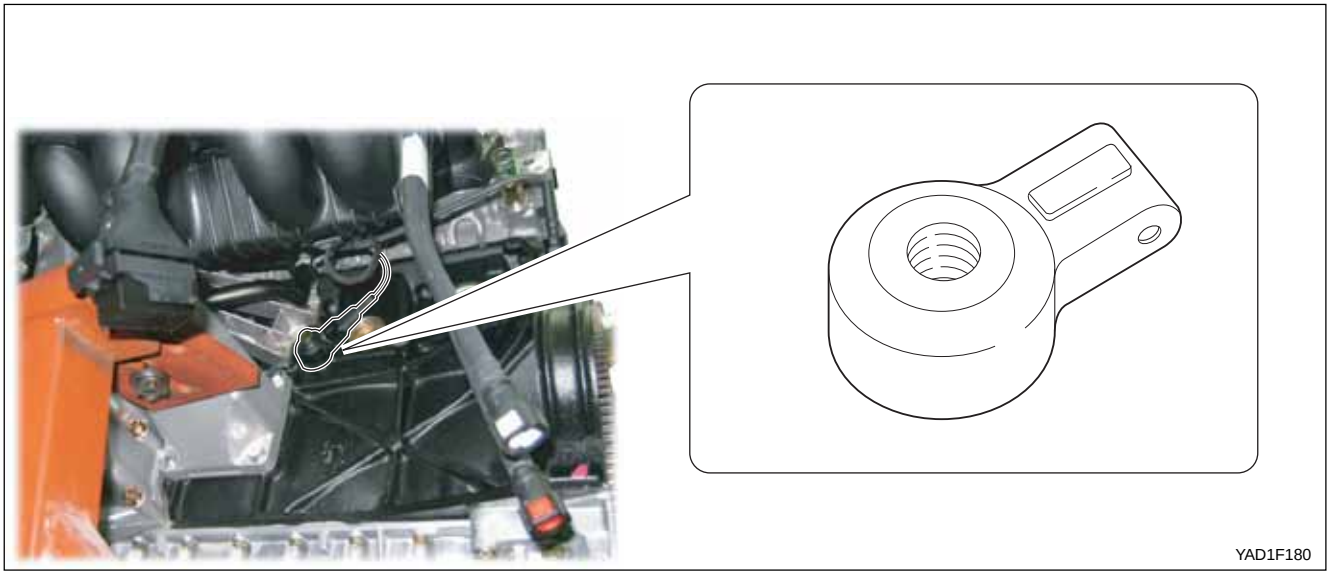
1. Run the engine to reach the coolant temperature above 70°C.
2. Increase the engine rpm up to 2000 rpm
3. Measure the current by contacting the terminal No. 1 or No. 2 of the camshaft actuator connector.

Specified Value	1 ~ 1.5 A

NOTICE

- **If the measured value is not within the specified value, check the cable.**

▶ Knock Sensor (KS)



The Knock Sensor (KS) detects abnormal knocking in the engine. The two KS are mounted in the engine block near the cylinders. The sensors produce an output voltage which increases with the severity of the knock. This signal is sent to the Engine Control Module (ECM) via a shielded cable. The ECM then adjusts the ignition timing to reduce the spark knock.

Knock Sensor Resistance Inspection

1. Disconnect the coupling from ECM while the ignition switch is in “OFF” position.
2. Measure the resistance between the coupling terminal pin No. 118 and No. 117 using a multimeter.

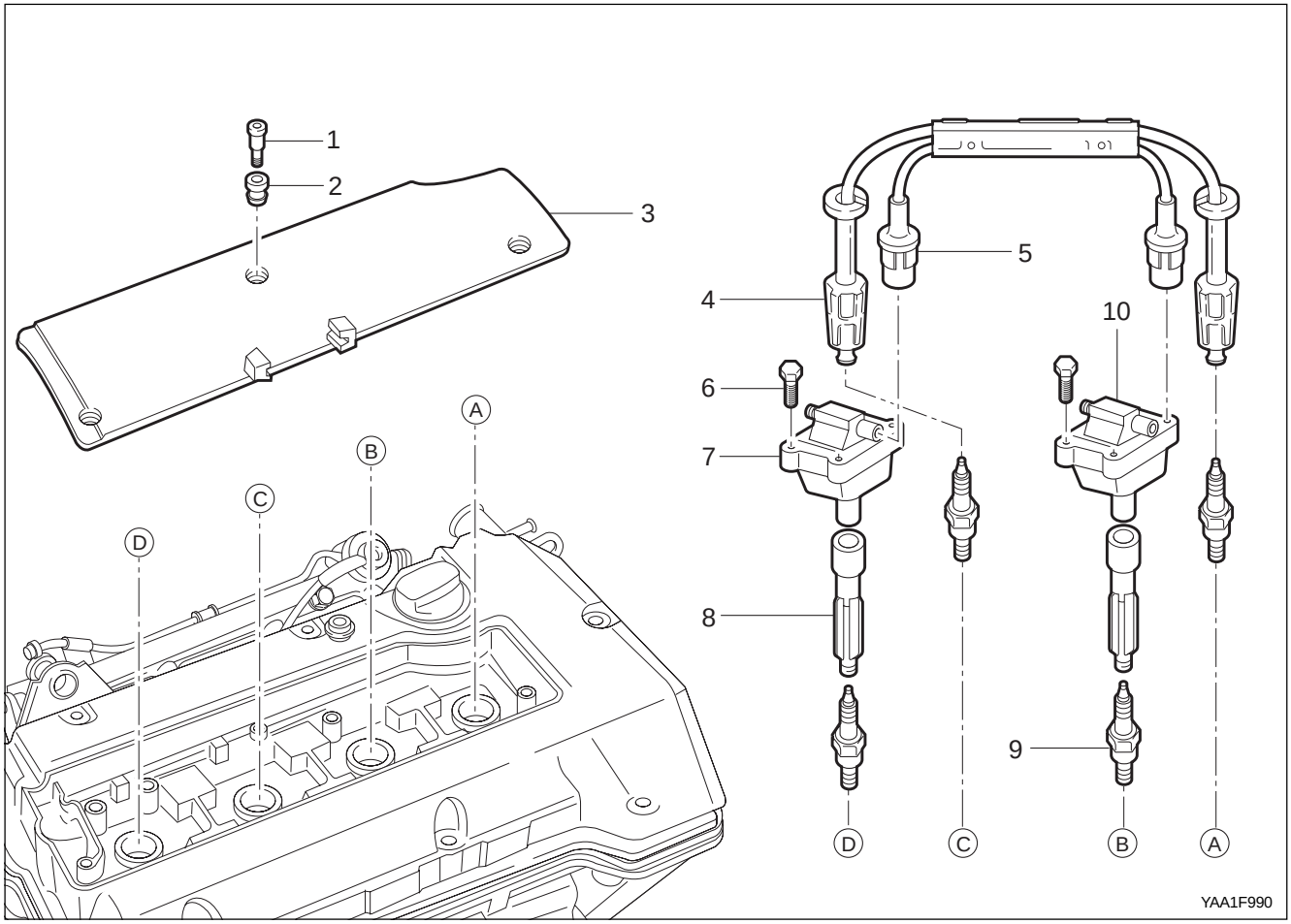
Specified Value	4.87 ± 0.75 MΩ

NOTICE

- **Replace the KS if the measured values is out of the specified values. Check the connector and wire connection between ECM and the KS if the measured values are normal.**

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Spark Plug



1. Screw
2. Adaptor
3. Ignition Coil Cable Cover
4. Spark Plug Connector
5. Ignition Coil Connector
6. Bolts
7. Ignition Coil (T 1/1)
8. Coupling Plug
9. Spark Plug
10. Ignition Coil (T 1/2)

Spark Plug Cable Resistance Inspection

1. Turn the ignition switch “OFF” position.
2. Disconnect the spark plug cables Refer to *Section 1E1, Engine electrical.*
3. Measure the spark plug resistance using a multimeter.

Specified Value	1.8 ~ 2.2 kΩ

NOTICE

- **Replace the spark plug cable if the measured values is out of the specified values.**

4. FUEL SYSTEM

The function of the fuel metering system is to deliver the correct amount of fuel to the engine under all operating conditions.

The fuel is delivered to the engine by the individual fuel injectors mounted into the intake manifold near each cylinder.

The main fuel control sensors are the manifold absolute pressure (MAP) sensor and the oxygen (O2) sensors.

The MAP sensor monitors the manifold absolute being drawn into the engine. An electrically heated element is mounted in the intake air stream, where it is cooled by the flow of incoming air.

The O_2 sensors are located in the exhaust pipe before catalytic converter. The O_2 sensors indicate to the ECM the amount of oxygen in the exhaust gas, and the ECM changes the air/fuel ratio to the engine by controlling the fuel injectors. The best air/fuel ratio to minimize exhaust emissions is 14.7 to 1, which allows the catalytic converter to operate most efficiently. Because of the constant measuring and adjusting of the air/fuel ratio, the fuel injection system is called a “closed loop” system.

The ECM uses voltage inputs from several sensors to determine how much fuel to provide to the engine. The fuel is delivered under one of several conditions, called “modes”.

▶ Starting Mode

When the ignition is turned ON, the ECM turns the fuel pump relay on for 1 second. The fuel pump then builds fuel pressure. The ECM also checks the Engine Coolant Temperature (ECT) sensor and the Throttle Position (TP) sensor and determines the proper air/fuel ratio for starting the engine. This ranges from1.5 to 1 at -36 °C (-33 °F) coolant temperature to 14.7 to 1 at 94 °C (201 °F) coolant temperature. The ECM controls the amount of fuel delivered in the starting mode by changing how long the fuel injector is turned on and off. This is done by ‘‘pulsing” the fuel injectors for very short times.

▶ Run Mode

The run mode has two conditions called ‘‘open loop” and ‘‘closed loop”.

▶ Open Loop

When the engine is first started and it is above 690 rpm, the system goes into “open loop” operation. In “open loop”, the ECM ignores the signal from the O_2 sensor and calculates the air/fuel ratio based on inputs from the ECT sensor and the MAP sensor. The ECM stays in “open loop” until the following conditions are met:

- The O_2 sensor has a varying voltage output, showing that it is hot enough to operate properly.
- The ECT sensor is above a specified temperature (22.5 °C).
- A specific amount of time has elapsed after starting the engine.

▶ Closed Loop

The specific values for the above conditions vary with different engines and are stored in the Electronically Erasable Programmable Read-Only Memory (EEPROM). When these conditions are met, the system goes into “closed loop” operation. In “closed loop”, the ECM calculates the air/fuel ratio (fuel injector on-time) based on the signals from the O_2 sensors. This allows the air/fuel ratio to stay very close to 14. 7 to 1.

▶ Acceleration Mode

The ECM responds to rapid changes in throttle position and airflow and provides extra fuel.

▶ Deceleration Mode

The ECM responds to changes in throttle position and airflow and reduces the amount of fuel. When deceleration is very fast, the ECM can cut off fuel completely for short periods of time.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Battery Voltage Correction Mode

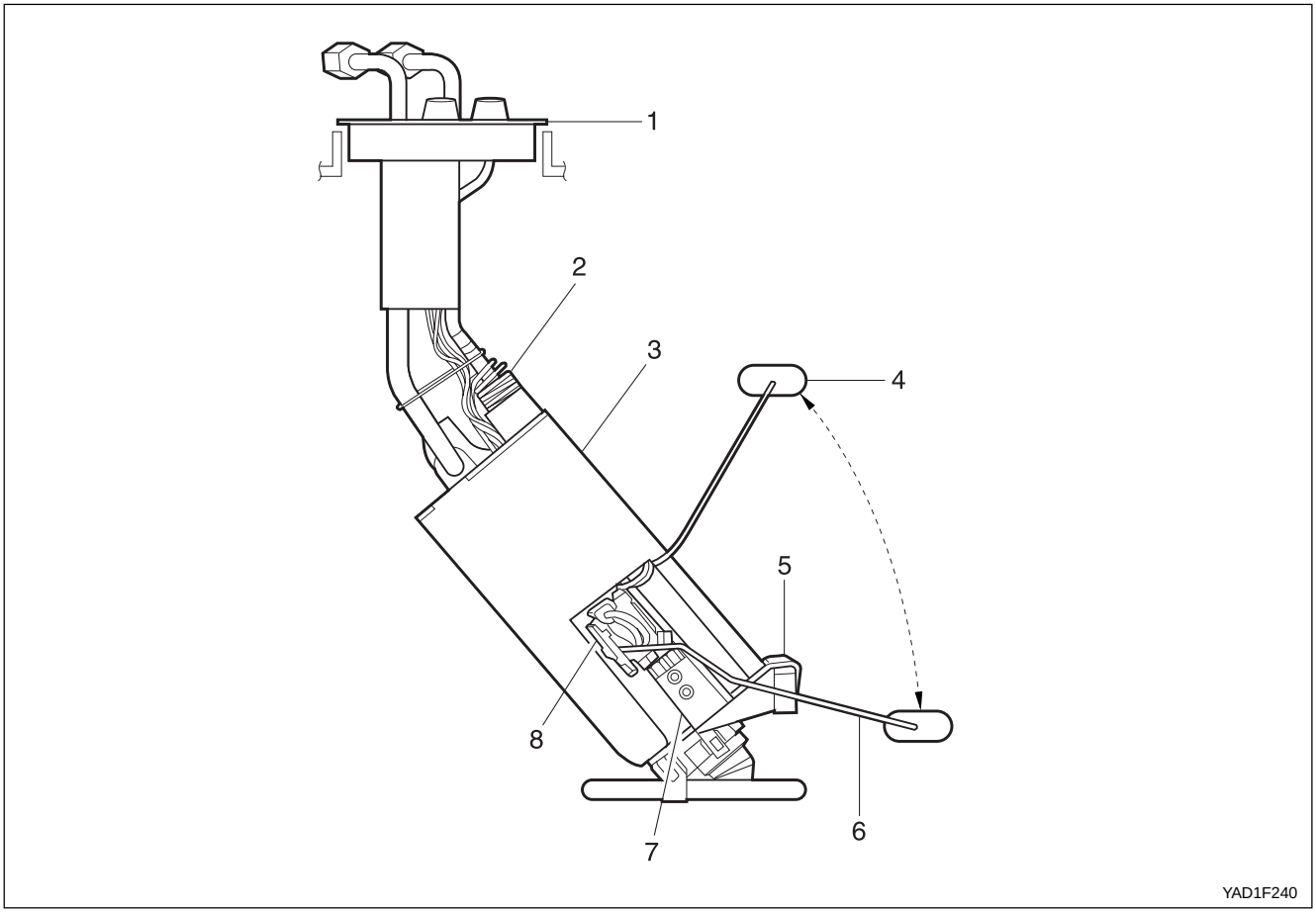
When battery voltage is low, the ECM can compensate for a weak spark delivered by the ignition module by using the following methods:

- Increasing the fuel injector pulse width.
- Increasing the idle speed rpm.
- Increasing the ignition dwell time.

▶ Fuel Cut-Off Mode

No fuel is delivered by the fuel injectors when the ignition is off. This prevents dieseling or engine run-on. Also, the fuel is not delivered if there are no reference pulses received from the CKP sensor. This prevents flooding.

▶ Fuel Pump



1. Flange and Harness Assembly
2. Spring
3. Fuel Pump
4. Float
5. Thermistor
6. Float Arm
7. Thermistor Housing
8. Resistor Card and Wiper

Requirements for Fuel Pump

Item	Specified Value	Item	Specified Value
System Pressure	3.8 bar	Minimum Delivery at 8V	30 Litre/ Hr
Maximum Pressure	6.5 bar (12 V)	Operating Voltage	8 ~ 13.5 V
Minimum Pressure	5.0 bar (12 V)	Maximum Allowable Current	7.5 A
Nominal Voltage	12 V	Ambient Temperature	-30 ~ +70° C
Minimum Amount of Fuel Supply	114 Liter/ Hr (12 V, 3.8 bar, -30 ~ +70° C)	Maximum Amount of Fuel Supply	165 Liter/ Hr (12 V, 3.8 bar, -30 ~ +70° C)

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

Fuel Pump Relay Inspection

Measure the voltage between the ECM terminal No. 33 and ground.

Ignition Switch : ON	0 V (for 1 ~ 2 sec.)
Cranking	0 V

Measure the Fuel Delivery from the Fuel Pump

1. Disconnect the return pipe from fuel distributor and insert the appropriate hose into it.
2. Place the hose end into the beaker with the minimum capacity of 1 Liter
3. Turn the ignition switch to “ON” position.
4. Connect the terminal No. 33 and No. 5 of ECM with a service wire.
5. Measure the fuel delivery from the fuel pump.

Specified Value	1 Liter/max. 35 sec.

NOTICE

- **Check the fuel filter and fuel line when the fuel delivery is not within specified value.**

Measure the Current Consumption of Fuel Pump

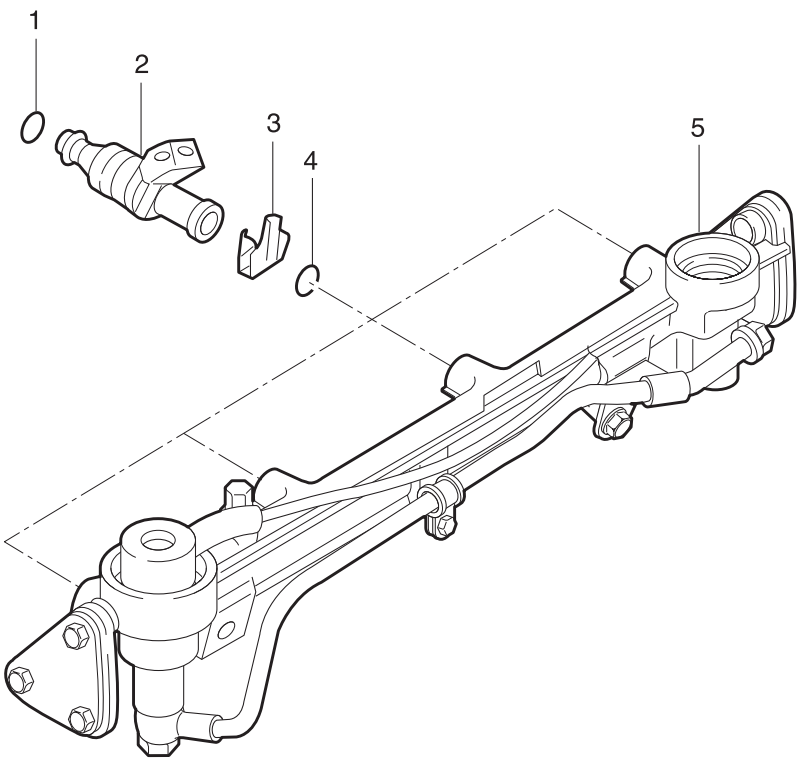
1. Remove the fuel pump relay from fuse and relay box in trunk, and turn the ignition switch to “ON” position.
2. Using a multimeter, measure the current consumption by connecting the terminal No. 30 and No. 87 of the fuel pump relay connector.

Specified Value	5 ~ 9 A

NOTICE

- **Replace the fuel pump relay if the measured value is over 9 A.**

▶ Fuel Injector



YAA1F0C0

1. O-Ring
2. Injector
3. Injector Bracket
4. O-Ring
5. Fuel Rail

The Multipoint Fuel Injection (MFI) assembly is a solenoid-operated device controlled by the Engine Control Module (ECM) that meters pressurized fuel to an each individual cylinder. The injector sprays the fuel, in precise quantities at a point in time determined by the ECM, directly towad the cylinder intake valve. ECM energizes the fuel injector solenoid to lift the needle valve and to flow the fuel through the orifice. This injector's discharge orificeis calibrated to meet the effective fuel atomization necessary for both ensuring the maximum homogeneity in the air-fuel mixture and holding the condensation along the walls of the intake tract to a minimum.

Fuel enters the top feed injector from above and flows through its vertical axis. The lower end extends into the intake valve. Fuel from the tip is directed at the intake valve, causing it to become further atomized and vaporized before entering the combustion chamber.

A fuel injector which is stuck partially open would cause a loss of fuel pressure after the engine is shut down. Also, an extended crank time would be noticed on some engines. Dieseling could also occur because some fuel could be delivered to the engine after the ignition is turned off.

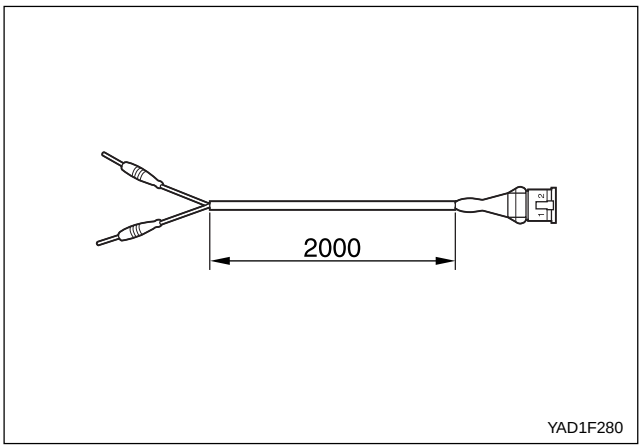
Injector Spray Pattern Check

1. Turn the ignition switch OFF.
2. Remove the fuel injector connectors.
3. Remove the fuel distributor and injector with a unit. At this time, do not remove the supply and return line.

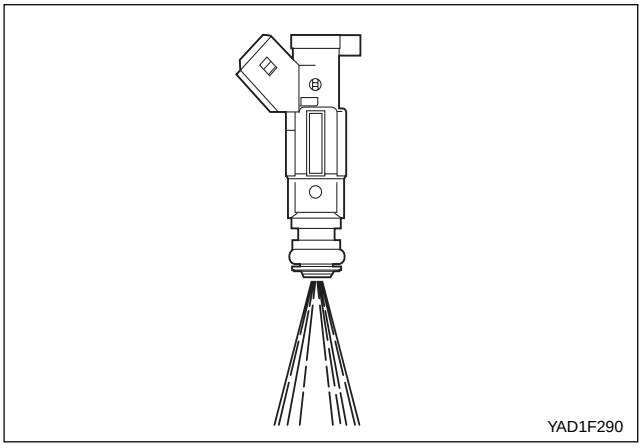
NOTICE

- **Prepare the beaker for taking the fuel.**

4. Connect the shop made cable to the inject or with a firing order.
5. Connect the other end of shop made cable to the positive battery cable and negative battery cable.
6. Turn the ignition switch ON.
7. Check the inject or for normal spray pattern as shown in the figure. Check inject or for leaks or later drop.



YAD1F280


YAD1F290

Injector Resistance Inspection

1. Turn the ignition switch OFF.
2. Remove the fuel injector connectors .
3. Meas ure the fuel injector coil resistance using a multimeter.

Specified Value	14 ~ 17 Ω

NOTICE

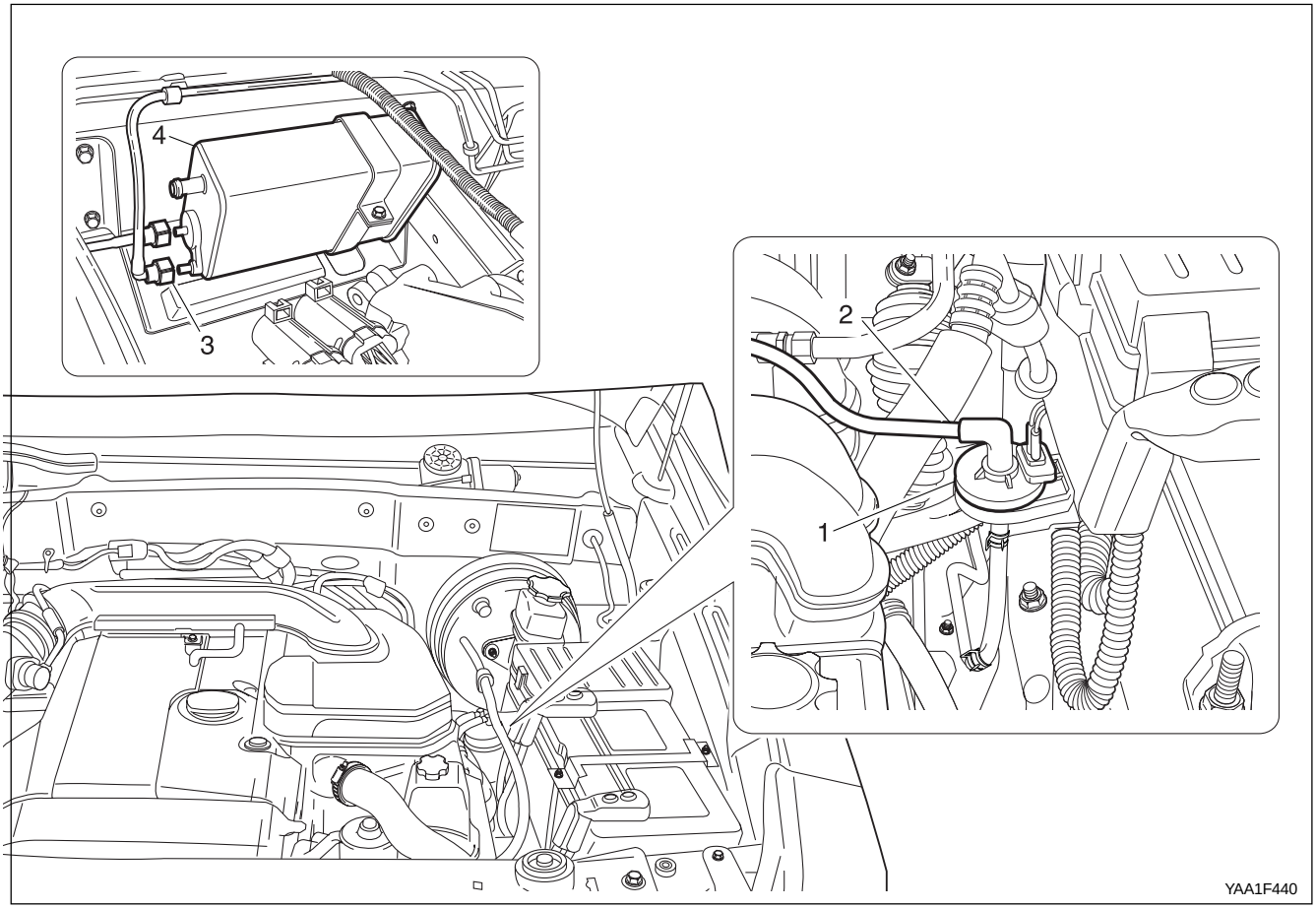
- **Replace the fuel injector if the measured value is out of the specified values. Check the connector and wire connection between the ECM and the injector if the measured values are normal.**

Injector Pulse Width Inspection

1. Turn the ignition switch OFF.
2. Install the scan tool.
3. Turn the ignition switch ON.
4. Monitor the “INJECTION TIME” with a scan tool.

Cranking	8.0 ms
Engine Idle	3 ~ 5 ms
Wide Open Throttle (WOT)	14 ms

▶ Purge Control Valve



1. Purge Control Valve
2. Line to Engine
3. Line to Canister
4. Canister

The fuel vaporization control system is installed to inhibit the fuel vaporized gas from discharging into the atmosphere. The fuel vaporized gas that is accumulated in the canister abstracts through the purge control valve purification during the engine combustion (except the decreasing mode) and coolant temperature of over 80 °C. For this reason, the Engine Control Module (ECM) transacts the engine speed, air inflow quantity, coolant temperature, and intake temperature.

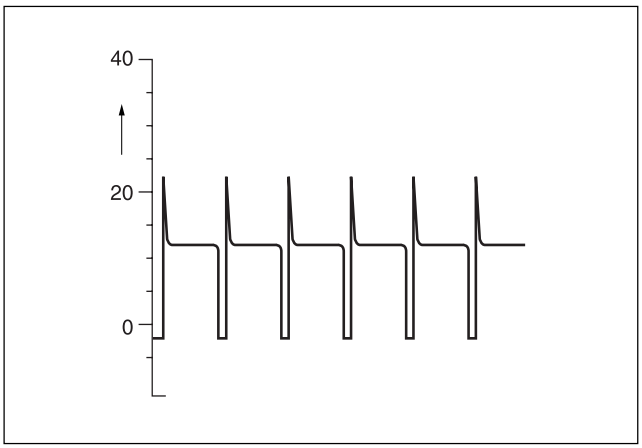
The purge control valve is activated by the ECM frequency according with the engine rotating speed to adjust the purification rate. The purification rate is determined by the continuous valve opening interval.

The purge control valve is activated by the ECM for the following conditions:

- Coolant temperature of over 80 °C
- Engine speed of over 1,000 rpm
- 2 minutes after starting
- When the fuel cut-off mode is not activated

Test

1. Maintain the normal temperature and idling state by operating the engine.
2. Connect the ECM terminal No. 11 and No. 34 and check for normal operation through the output waves using oscilloscope.



NOTICE

- **Test during purge control valve operation after the minimum of 1 minute after the engine turned on.**

3. Connect the ECM terminal No. 34 and No.10 and check for current consumption during the ignition switch ON.

Specified Value	0.3 ~ 0.5 A

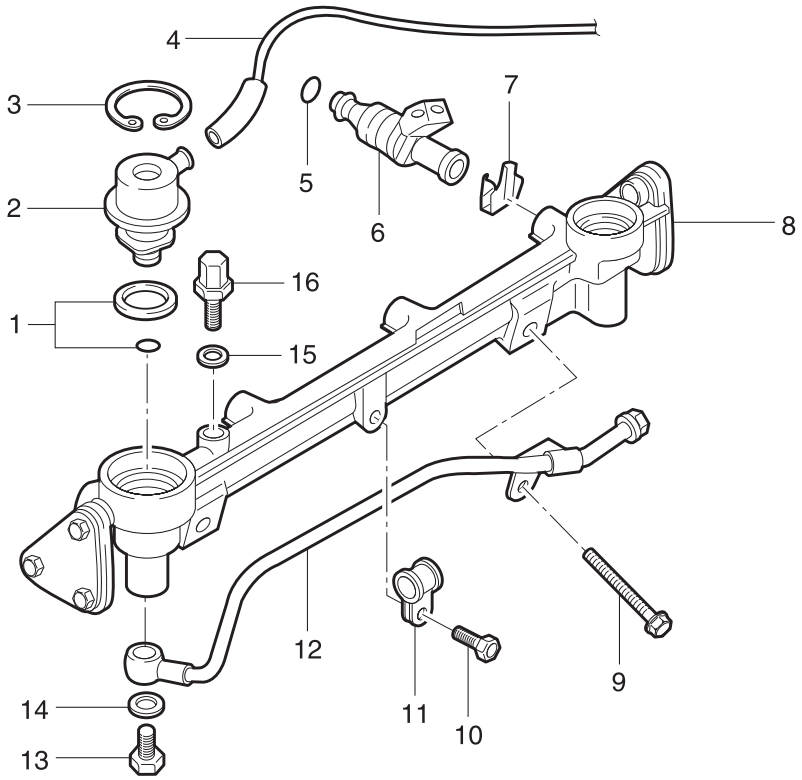
4. Remove the line to canister and measure the pressure with the vacuum pressure gauge.

Specified Value	> 500 mbar (after approx. 1 min.) purge control valve operates at this time

NOTICE

- **Test while at normal temperature and at idling state by operating the engine.**

▶ Fuel Rail



YAA1F0E0

1. O-Ring
2. Fuel Pressure Regulator
3. Circlip
4. Vacuum Hose
5. O-Ring
6. Injector
7. Injector Bracket
8. Fuel Rail
9. Combination Bolt
10. Bolt
11. Clamp
12. Fuel Return Line
13. Hollow Bolt
14. Seal Ring
15. Seal Ring
16. Fuel Pressure Test Connector

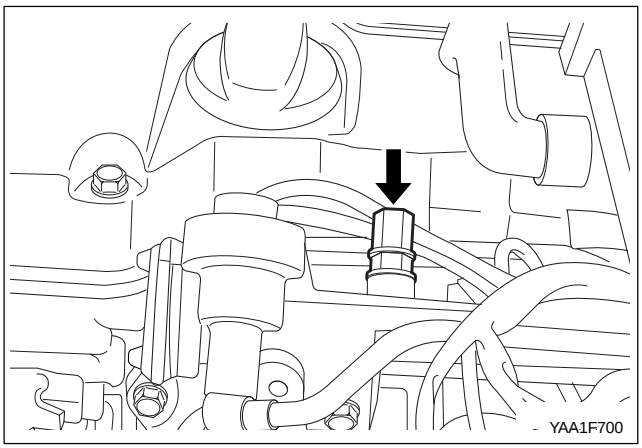
CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

Fuel Pressure Test

Tools Required

103 589 00 21 00 Fuel Pressure Gauge

1. Turn the ignition switch to “OFF” position.
2. Remove the fuel pressure test connector.
3. Connect the fuel pressure gauge to the fuel pressure test connector.
4. Test the fuel pressure at idling by operating the engine using the fuel pressure gauge 103 589 00 21 00.



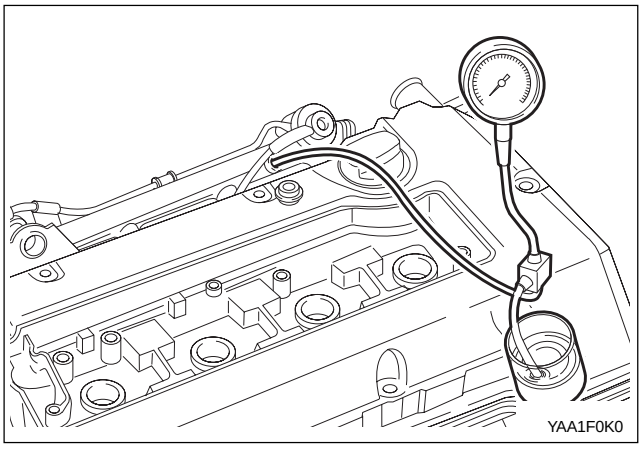
Vacuum Hose Connected (bar)	3.2 ~ 3.6
Vacuum Hose Disconnected (bar)	3.7 ~ 4.2

5. Replace the pressure regulator diaphragm if out of the specification.

Internal Leakage Test

1. Connect the fuel pressure gauge103 589 002100 to the fuel pressure test connector.
2. Stop the engine for approximately 30 minutes and then check the fuel pressure changes.

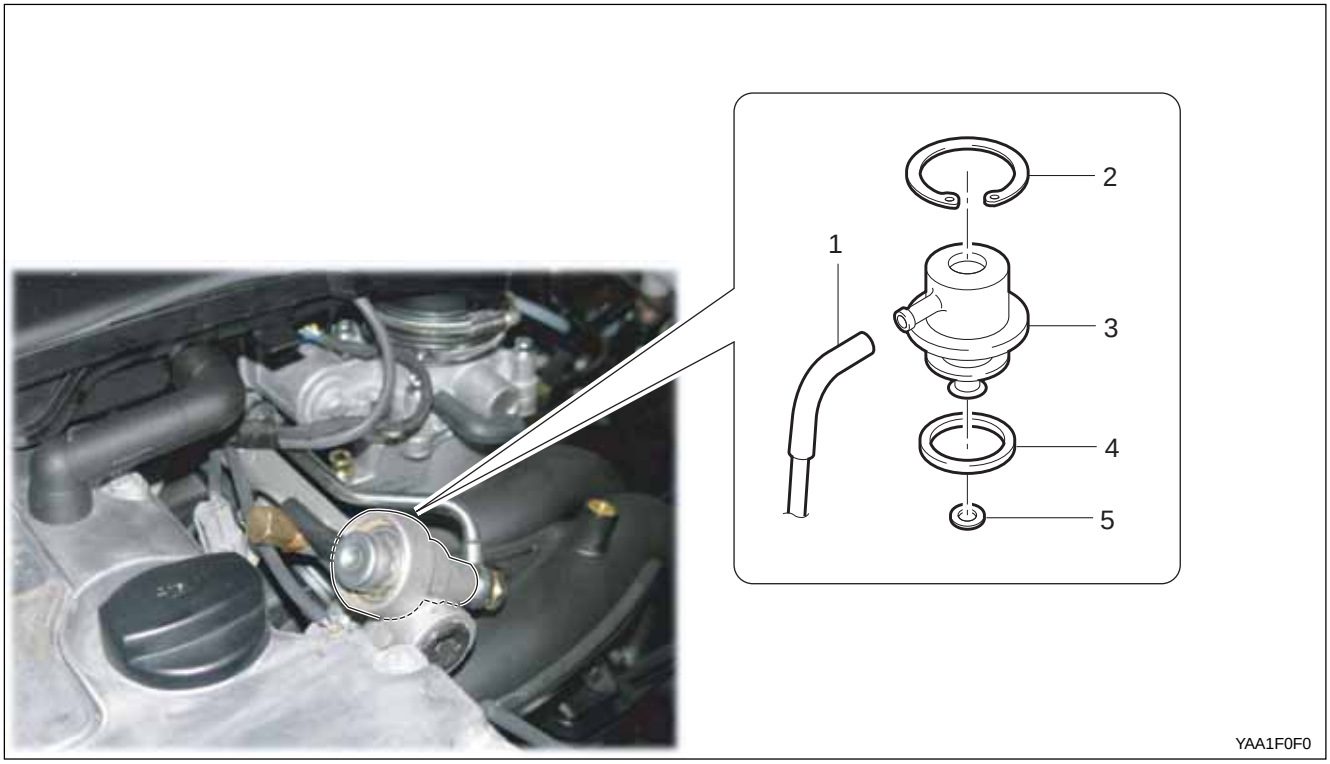
Pressure change	
Fuel pressure drops slowly	• Fuel leakage at the injector • Faulty fuel pressure regulator’s diaphragm and O-ring
Fuel pressure drops rapidly	• Faulty check valve in the fuel pump



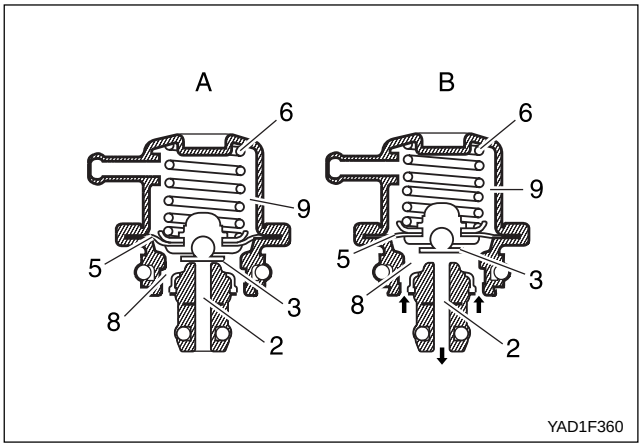
3. If there is no change in fuel pressure and maintain the following pressure over 30minutes, it is normal.

Fuel pressure (bar)	≥ 2.5

▶ Fuel Pressure Regulator



1. Vacuum Hose
2. Circlip
3. Fuel Pressure Regulator
4. O-Ring
5. O-Ring



2. Fuel return line
3. Valve
5. Diaphragm
6. Compression Spring
8. Fuel Chamber
9. Spring Chamber
A. Valves Closed
B. Valves Opened

Function of the Fuel Pressure Regulator

The fuel pressure regulator maintains the fuel pressure in the fuel line with the pressure of 3.2 bars to 3.8 bars according to the intake manifold pressure. This operating pressure cannot be changed, and the fuel injection volume will be only determined by the injection time. Over supplied fuel returns to the fuel tank through the return line.

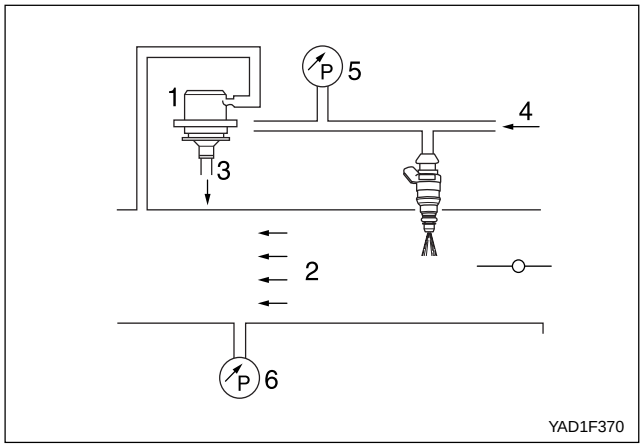
<Operating at full load>

There is no negative pressure applied to the spring chamber (9) during the full load, and it is separated from the fuel chamber (8) by the diaphragm (5).

When the fuel pressure goes up, the diaphragm forces the compression spring (6) in the direction of compression. At this moment, the valve (3) sticks to the diaphragm by the fuel pressure, and the fuel return line (2) opens. The fuel over supplied returns to the fuel tank through the return line.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

The pressure difference between the fuel pressure and the intake manifold is about 3.8 bars during the full load.

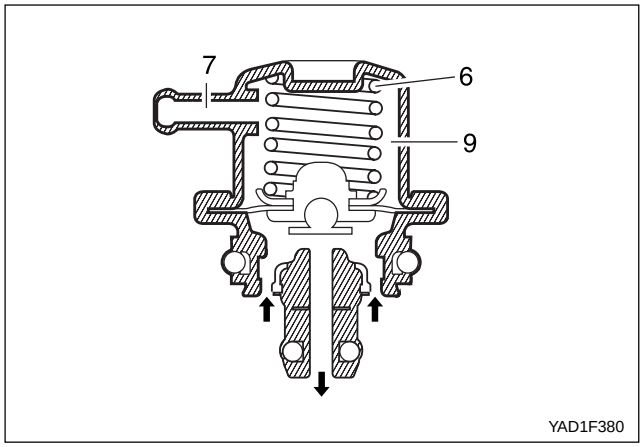


YAD1F370

1. Fuel Pressure Regulator
2. Intake Manifold
3. Fuel Return (to fuel tank)
4. Fuel Supply (from fuel pump)
5. Fuel Pressure (approx. 3.8 bars)
6. Intake Manifold Negative Pressure (0 bar)

<Operating at Idle and partial load>

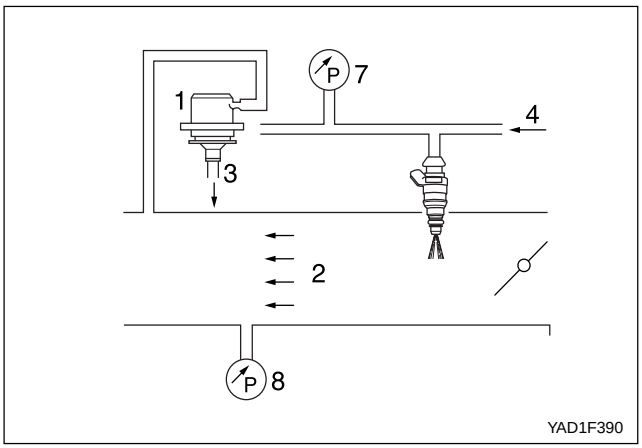
The spring chamber (9) is connected to the intake manifold with the vacuum hose at the intake pipe connection (7). The negative pressure generated in the intake manifold activates the diaphragm, and thus the fuel pressure gets reduced to the rate of the operating extent of the diaphragm by the intake manifold's negative pressure.



YAD1F380

Consequently, the fuel pressure in the fuel distributor changes by the intake manifold's negative pressure, and the injector's fuel pressure gets reduced independently to the throttle valve's position. Thus, the fuel injection volume can only be determined according to the injector's injecting duration.

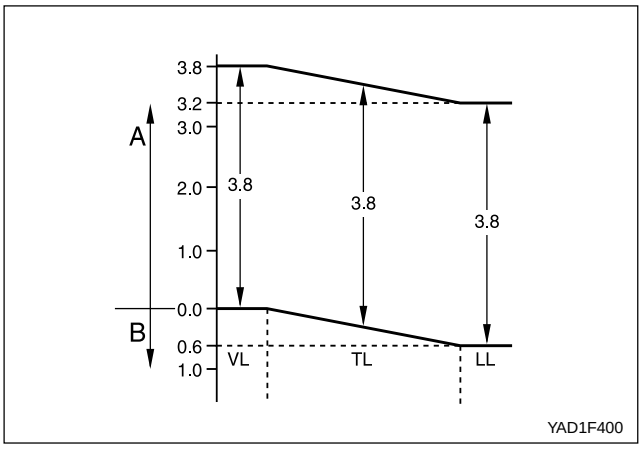
The pressure difference between the fuel pressure and the intake manifold is approx. 3.2 bars during idling.



YAD1F390

1. Fuel Pressure Regulator
2. Intake Manifold
3. Fuel Return (to fuel tank)
4. Fuel Supply (from fuel pump)
7. Fuel Pressure (approx. 3.2 bars)
8. Intake Manifold Negative Pressure (0.6 bars)

<Fuel Pressure Diagram>

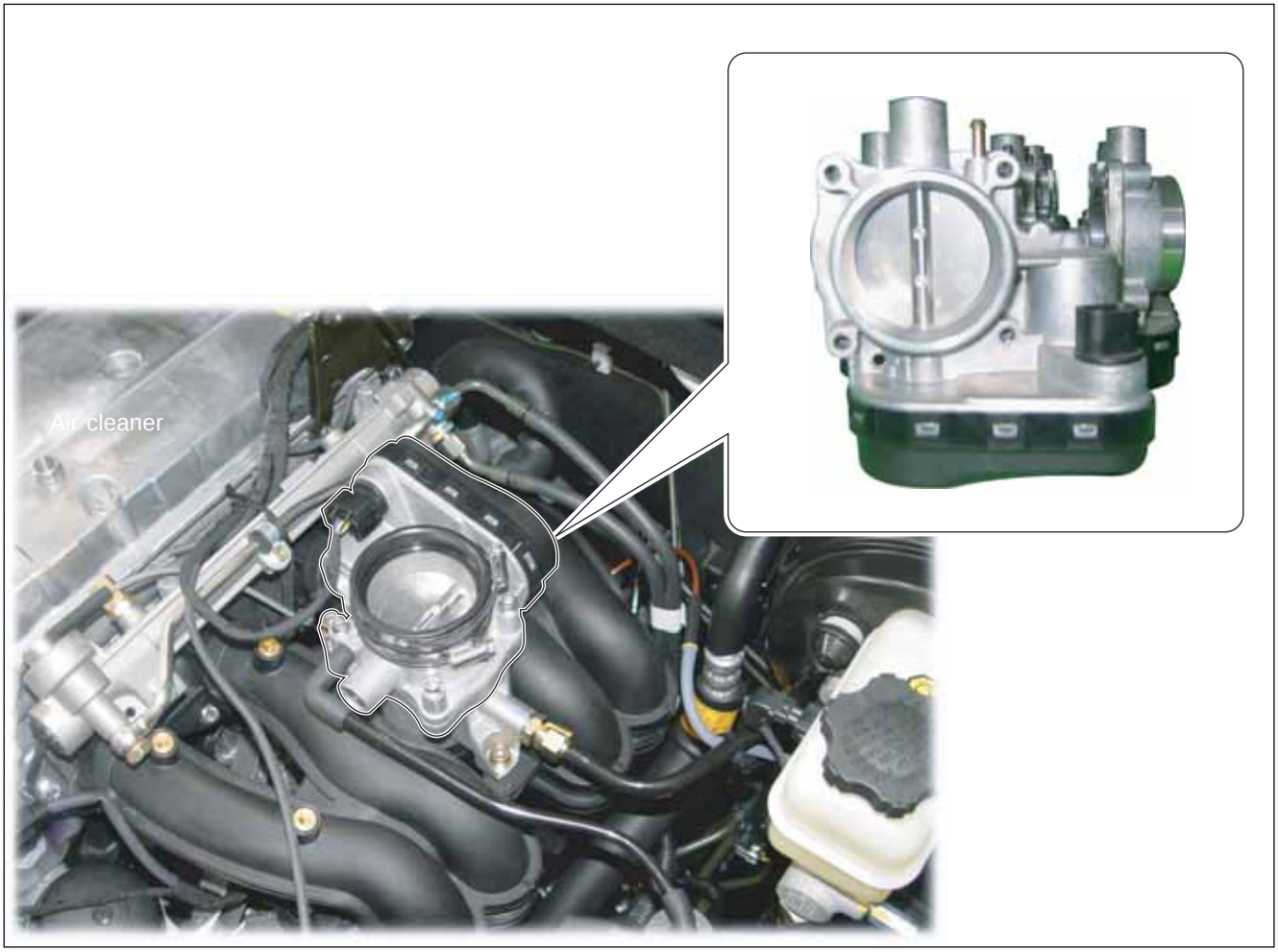


YAD1F400

A. Fuel pressure
B. Intake Manifold Negative Pressure
LL. Idling
TL. Partial load
VL. Full load

5. INDUCTION SYSTEM

▶ Throttle Valve Actuator



The throttle actuator is actuated by the Engine Control Module (ECM) according to the position of the accelerator pedal position.

It has two potentiometers which signal the position of the throttle valve to the ECM to enable it to recognize the various engine load states.

Consequently, the throttle valve opening is a constant 10-12 °approximately.

At no load, this produces an engine speed of about 1, 800 rpm.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

Ignition "Off"

In the de-energized states the throttle valve position is determined to be spring capsule.

Ignition "On"

When the ignition S/W on the servo motor in the throttle actuator is operated by the ECM. The throttle valve adopts a position in line with the coolant temperature.

Closed position

In the closed throttle position, the servo motor controls engine speed by operating the throttle valve further (greater mixture) or closing it further (reduced mixture), depending on coolant temperature and engine load. When this is done, the throttle valve can be closed further by the servo motor overcoming the force of the spring capsule (mechanical end stop). If the actuator is de-energized, the throttle valve is resting against the spring capsule.

Driving

When driving (part/full throttle), the servo motor controls the throttle valve in line with the various load states and according to the input signals from the pedal value sensor according to the input signals from the pedal value sensor according to the position of the accelerator pedal.

The function of the EA (electronic accelerator) in the ECM determines the opening angle of the throttle valve through the throttle actuator. Further functions are;

- Idle speed control
- Cruise control
- Reducing engine torque for ASR/ABS operation
- Electronic accelerator emergency running
- Storing faults
- Data transfer through CAN

Throttle Actuator Inspection

1. Turn the ignition switch to "ON" position.
2. Measure the TPS 1 signal volt age at the ECM pin No. 87 and TPS 2 signal volt age at the ECM pin No. 85.

	Pedal Position	Specified Value
TPS 1	Closed	0.3 ~ 0.9 v
	Opened	4.0 ~ 4.6 v
TPS 2	Closed	4.0 ~ 4.6 v
	Opened	0.3 ~ 0.9 v

Throttle Actuator DC Motor Inspection

1. Turn the ignition switch to "ON" position.
2. Measure the signal volt age between the ECM pin No. 67 and No. 68.

Application		Specified Value
Engine Status	Ignition "ON"	0.8 ~ 2.3 v
	Idling	1.0 ~ 2.5 v (Coolant temperature is over 70° C)

Throttle Actuator DC Motor Resistance

1. Turn the ignition switch to "OFF" position.
2. Measure the resistance between the ECM pin No. 67 and No. 68.

Specified Value	< 10 Ω

▶ Intake Air Temperature

The Intake Air Temperature (IAT) sensor is a thermistor, a resistor which changes value based on the temperature of theair entering the engine. Low temperature produces a high resistance, while high temperature causes a low resistance as the following table.

The ECM provides 5 volts to the IAT sensor through a resistor in the ECM and measures the change in voltage to determine the IAT. The voltage will be high when the manifold air is cold and low when the air is hot. The ECM knows the intake IAT by measuring the voltage.

The IAT sensor is also used to control spark timing when the manifold air is cold.

Temp. (°C)	R min.(Ω)	R nom. (Ω)	R max. (Ω)
-40	35140	39260	43762
-20	12660	13850	15120
0	5119	5499	5892
20	2290	2420	2551
40	1096	1166	1238
60	565	609	654
80	312	340	370
100	184	202	222
120	114	127	141
130	91	102	114

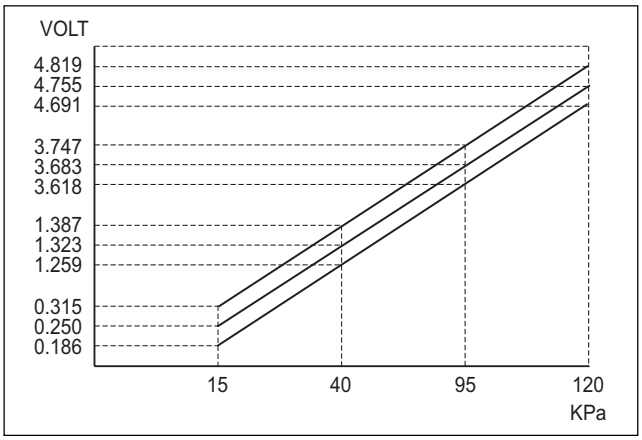
CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ MAP (Manifold Absolute Pressure) Sensor

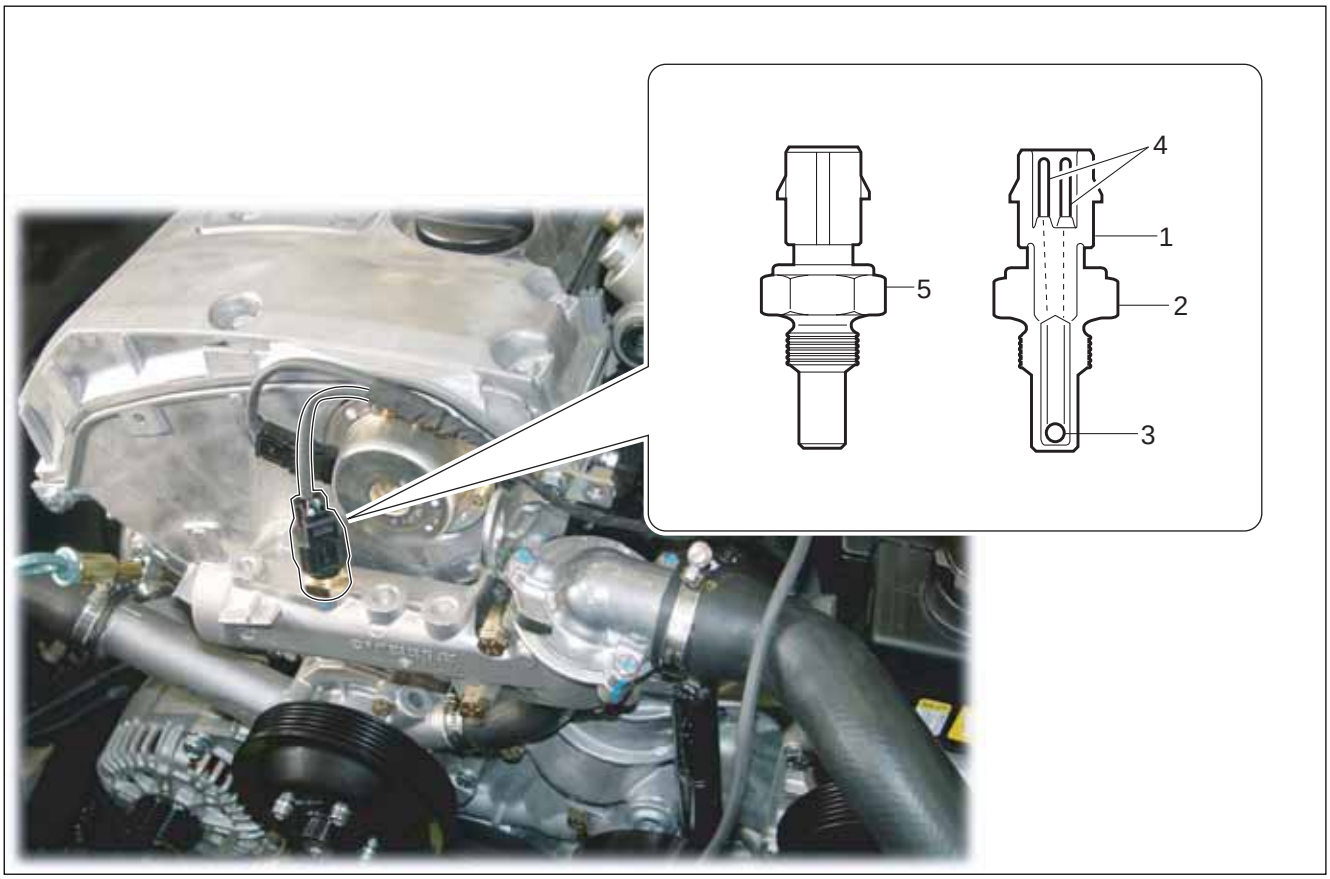
MAP sensor detects absolute pressure and supples information to the ECM.

Pressure	15 ~ 120 ± 1.5 KPa

Tightening Torque	6 - 10 N•m (4.43 - 7.38 lb-ft)



▶ Engine Coolant Temperature (ECT) Sensor



1. Artificial Resin Housing
2. Metal Housing
3. NTC (Negative Temperature Coefficient) Resistor
4. Connector
5. Engine Coolant Temperature Sensor

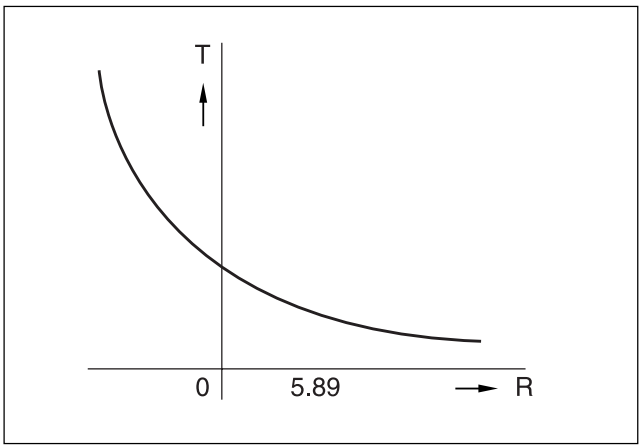
Engine Coolant Temperature (ECT) sensor detects coolant temperature and supplies information to the ECM. It is composed of metal housing with two NTC resistor, 4 pin connector. The ECM provides a 5 volt signal to the ECT sensor through a dropping resistor. When the engine is cold, the ECT sensor provides high resistance, which the ECM detects as a high signal voltage. As the engine warms up, the sensor resistance becomes lower, and the signal voltage drops. At normal engine operating temperature, the ECT signal will measure about 1.5 to 2.0 volts.

The ECM uses information about coolant temperature to make the necessary calculations for:

- Fuel delivery
- Ignition control
- Knock sensor system
- Idle speed
- Torque converter clutch application
- Canister purge
- Cooling fan operation
- Others

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

Temperature (°C)	Resistance (Ω)	Voltage (V)
-40	48,550	4.90
-30	27,000	4.82
-20	15,570	4.70
-10	9,450	4.52
0	5,890	4.43
10	3,790	3.96
20	2,500	3.57
30	1,692	3.14
40	1,170	2.70
50	826	2.26
60	594	1.86
70	434	1.51
80	322	1.22
90	243	0.98
100	185	0.78
110	143	0.63
120	111.6	0.50
130	88	0.40
140	71.2	0.33



Engine Coolant Temperature Sensor Inspection

1. Turn the ignition switch to “ON” position.
2. Measure the voltage between the ECM pin No. 78 and No. 79.

Temperature (°C)	Specified Value (V)
20	3.57
80	1.22
100	0.78

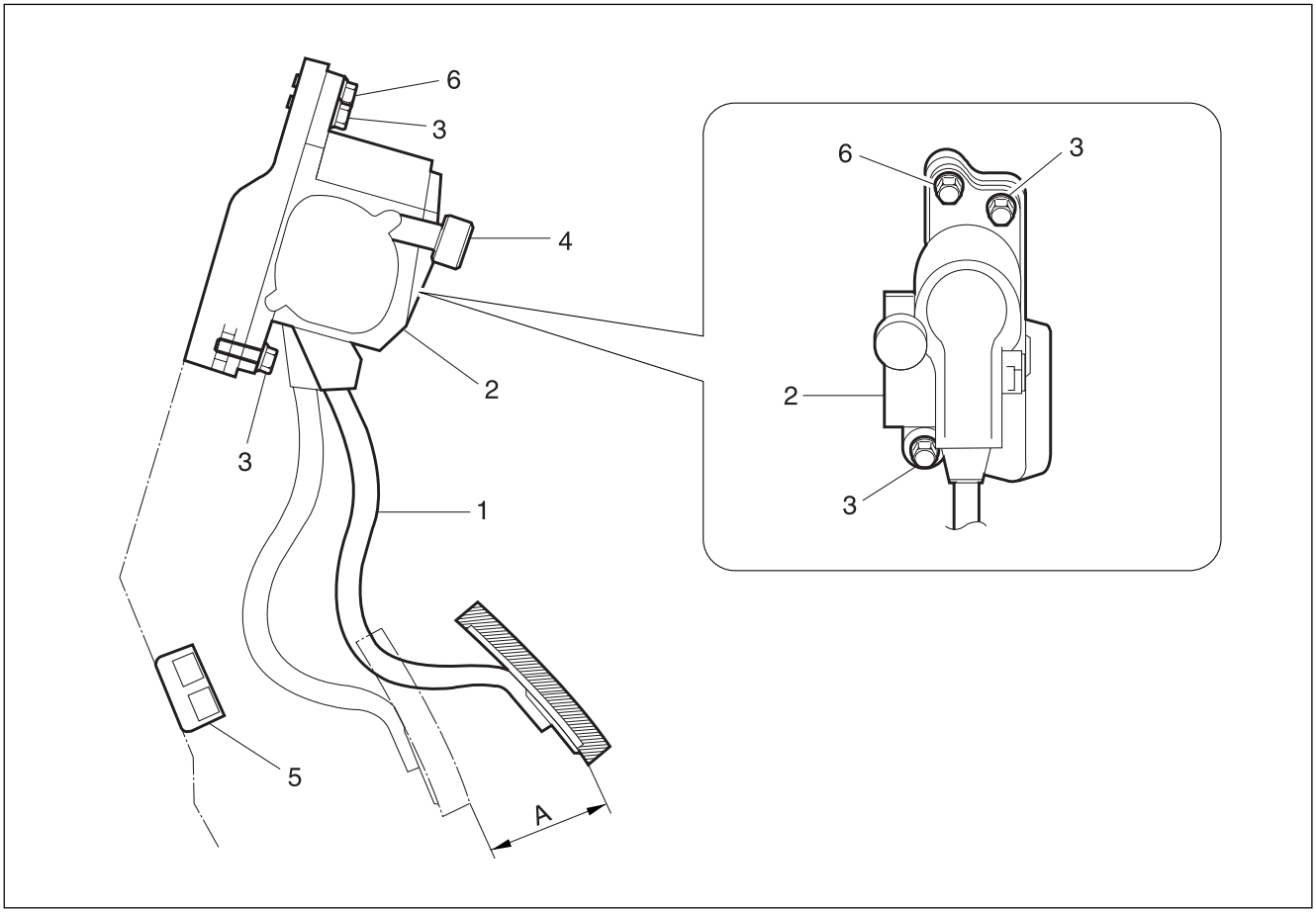
3. Turn the ignition switch to “OFF” position.
4. Disconnect the ECT sensor connector.
5. Turn the ignition switch to “ON” position.
6. Measure the resistance between the ECT sensor terminal pin No. 1 and No. 4.

Temperature (°C)	Specified Value (Ω)
20	2,500
80	322
100	185

NOTICE

- **Replace wiring and coolant temperature sensor if out of specified value.**

▶ Accelerator Pedal Module



1. Accelerator Pedal
2. Accelerator Pedal Sensor
3. Bolts
4. 6-Pin Connector
5. Kick-down Switch
6. Nut

The Acceleration Pedal Position (APP) sensor is mounted on the accelerator pedal assembly. The sensor is actually two individual APP sensors and one housing. This sensor works with theThrottle Position (TP) sensor to provide input to the Engine Control Module (ECM) regarding driver requested accelerator pedal and throttle angle at the throttle body.

When the APP sensor is defected:

When the APP 1 or APP 2 sensor is defected condition, the engineis still running at idle condition but, the accelerator pedal reaction is not response correctly and also, the engine rpm will be reacted to 4,000 rpm slowly. If the APP 1 sensor is out of order, the APP 2 sensor will be conducted with signal as adefault signal but, the throttle valve opening is limited 60% and delayed opening speed.

When the TP sensor or servo motor is defected:

When the TP 1, 2 sensor or servomotor is defected condition, the throttle valve will be closed to the spring capsule by spring force, at this condition, the throttle valve will open 10° ~ 20° and engine rpm will be controlled by ECM will opening (On/Off) time of injector. The engine rpm will be maintaining 900 rpm (at idle) to 1,800 according to the engine load.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

Acceleration Pedal Position Sensor 1 Inspection

1. Turn the ignition switch to “ON” position.
2. Measure the signal voltage between the ECM pin No. 47 and No. 31 while operating the accelerator pedal as following conditions.
   - Not depress the pedal (closed throttle position)
   - Fully depress the pedal (full throttle with kick down)

Condition of Throttle Valve	Specified Value (V)
Closed Throttle Valve	0.3 ~ 0.7
Fully Depressed Throttle Valve	4.3 ~ 4.8

NOTICE

- **If measured value is not within the specified value, check the pedal valve sensor and the supply voltage to APP 1 sensor.**

Acceleration Pedal Position Sensor 2 Inspection

1. Turn the ignition switch to “ON” position.
2. Measure the signal voltage between the ECM pin No. 48 and No. 50 while operating the accelerator pedal as following conditions.
   - Not depress the pedal (closed throttle position)
   - Fully depress the pedal (full throttle with kick down)

Condition of Throttle Valve	Specified Value (V)
Closed Throttle Valve	0.1 ~ 0.4
Fully Depressed Throttle Valve	2.1 ~ 2.5

NOTICE

- **If measured value is not within the specified value, check the pedal valve sensor and the supply voltage to APP sensor 2.**

5. EXHAUST SYSTEM

▶ Catalytic Converter

The purpose of the catalytic converter is to convert the three pollutants of carbon monoxide (CO), hydrocarbons (HC) and oxides of nitrogen (NOx) contained in the exhaust of gasoline engines, into the harmless compounds of water (H2O), carbon dioxide (CO2) and nitrogen (N2).

The catalytic converter contains acatalyst, a word coming from the Greek and which designates the element essential for catalyst which triggers chemical reactions without itself being consumed.

These catalysts in the 3-way catalytic converter are the rare metals platinum (Pt) and rhodium (Rh).

The catalytic converter consists essentially of three main elements. The exhaust gases flow through the catalytic converter and, in so doing, coming into contact with rare metals (Pt and Rh).

The following chemical reaction are produced.

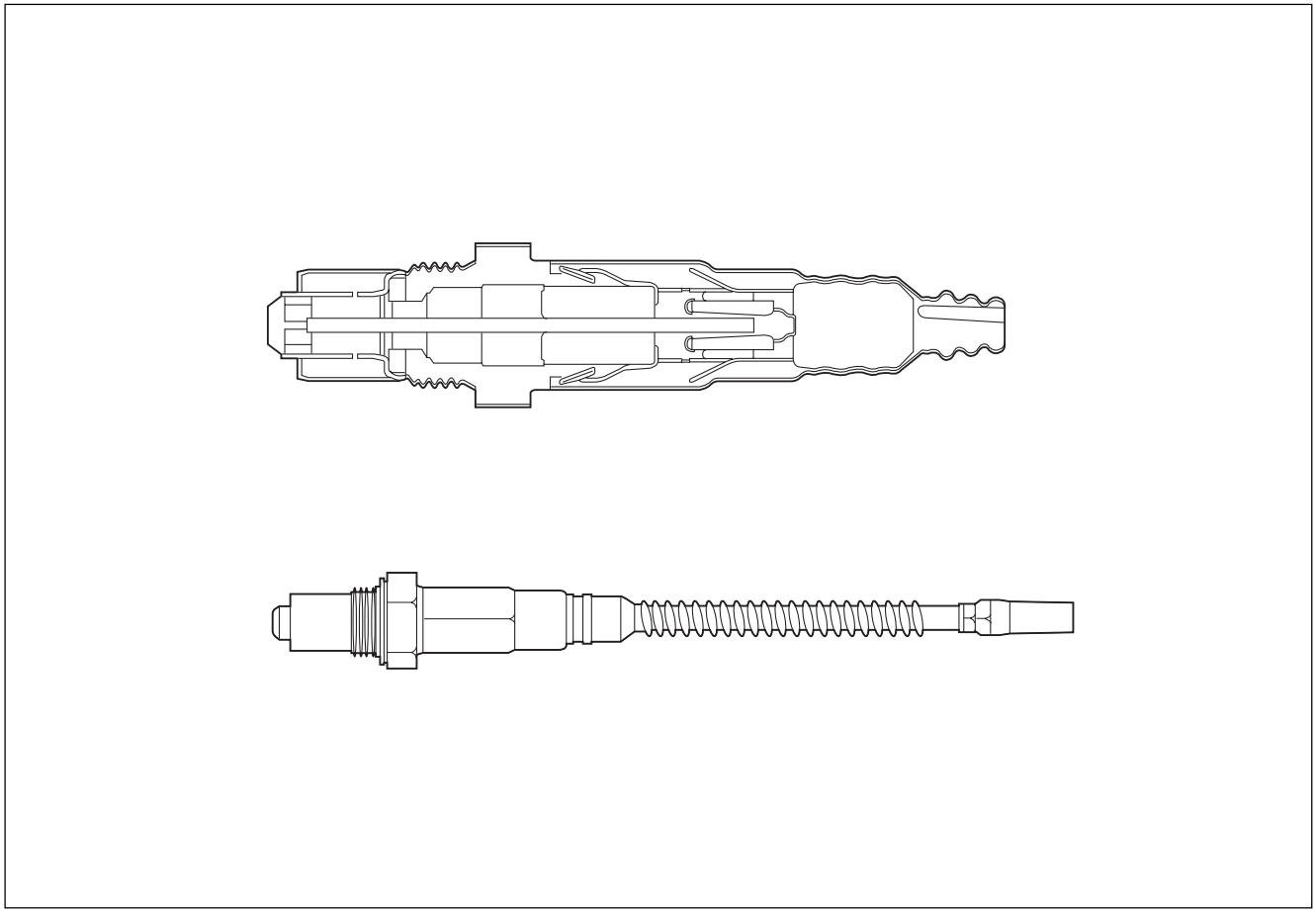
$CO + O_2 \rightarrow CO_2$

$HC + O_2 \rightarrow CO_2 + H_2O$

$NO_x \rightarrow N_2 + O_2$

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Oxygen Sensor



The oxygen sensor is unique amongthe engine control sensors because is acts like a battery and is able to generate its own low voltage signal. It is located the exhaust system and monitors the amount of oxygen in the exhaust stream and provides feedback to the Engine Control Module (ECM).

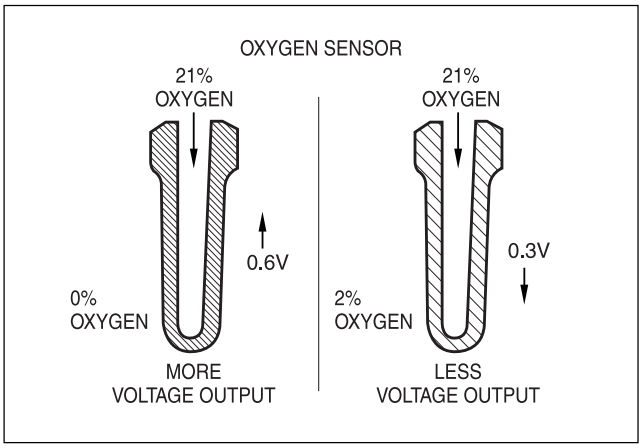
The electrically heated oxygen sensor warms up quickly and remains hot, even at idle when the exhaust manifold may cool down.

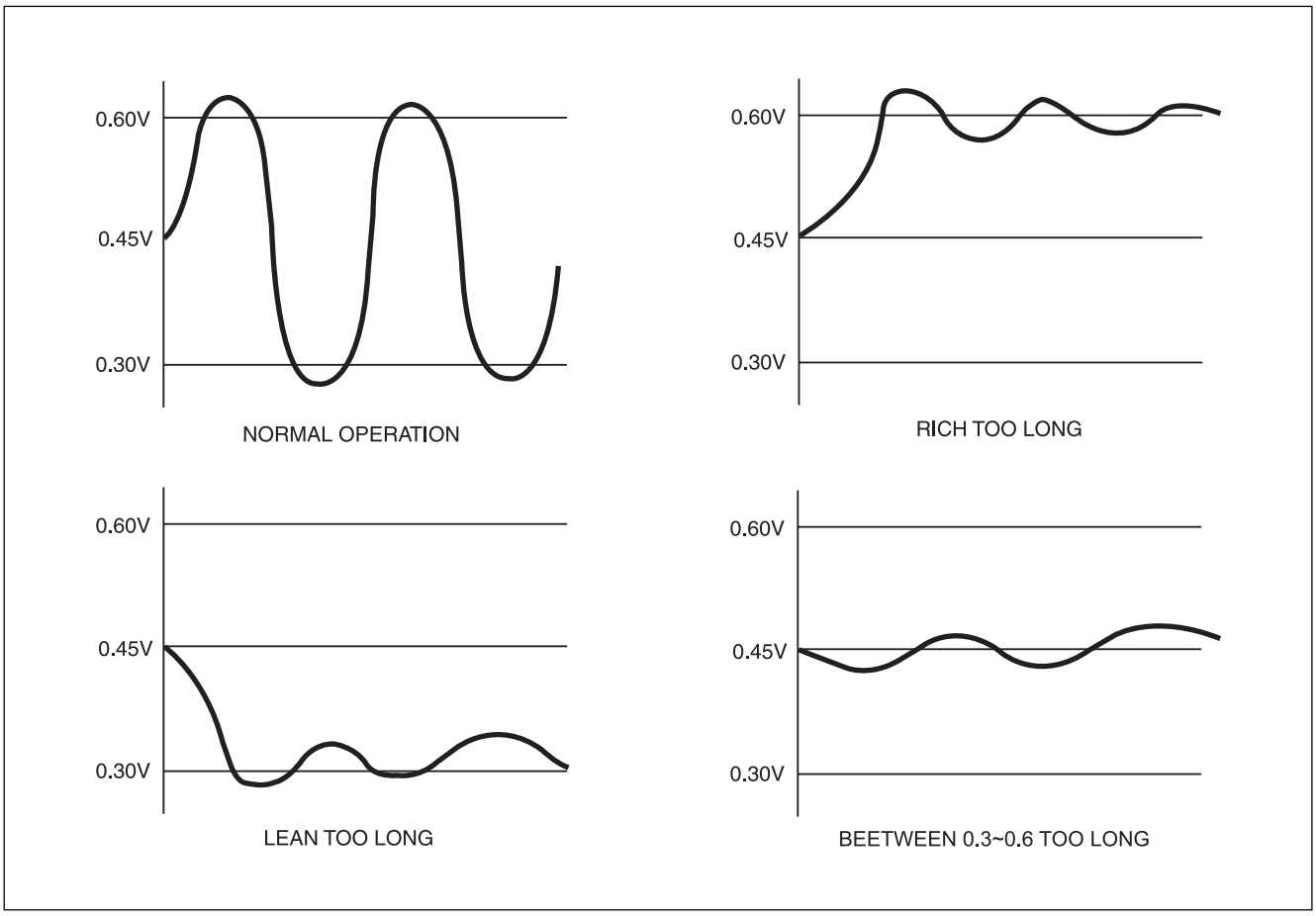
The ECM applies a reference voltage of 450 mv to the oxygen sensor, the ECM compares this reference voltage with the voltage generated by oxygen sensor. The amount of voltage the oxygen sensor generates is proportionate to the difference between the amount of oxygen in the outside air and the exhaust gases. The atmosphere contains about 21% oxygen. The exhaust from a rich air/fuel ratio contains almost no oxygen. With a large difference betweenthe amounts of oxygen containing the two surface, the sensor generates less voltage.

When the exhaust gas is rich (below 14.7:1), the voltage output is high, above 450 mv. When the exhaust gas is lean (above 14.7:1 air/fuel ratio), the sensor's voltage output is low, below 450 mv.

The ECM uses oxygen sensor information for:

- Open loop / closed loop criteria
- Ideal air / fuel ratio





CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

Oxygen Sensor Signal Voltage Inspection

1. Maintain the engine speed is at idle while the coolant temperature is over 80°C.
2. Measure the oxygen sensor signal voltage between the ECM terminal No. 16 and No. 17 (O_2 sensor No. 2: terminal No. 19 and 20).

Specified Value	0.2 ~ 1.0 V

NOTICE

- **If the measured value is not within the specified value, check the cable.**

Oxygen Sensor Heating Voltage Inspection

1. Maintain the engine speed is at idle while the coolant temperature is over 80 °C.
2. Measure the oxygen sensor signal voltage between the ECM terminal No. 11 and No. 9 (O_2 sensor No. 2: terminal No. 11 and 7).

Specified Value	11 ~ 14 V

NOTICE

- **If the measured value is not within the specified value, the possible cause may be in cable, oxygen sensor or ECM.**

Oxygen sensor Heating Current Consumption Inspection

1. Turn the ignition switch to “ON” position.
2. Measure the oxygen sensor heating current consumption between the ECM terminal No. 9 and No. 5 (O_2 sensor No. 2: terminal No. 7 and 5).

Specified Value	0.2 ~ 2.0 V

NOTICE

- **If the measured value is not within the specified value, the possible cause may be in cable, oxygen sensor or ECM.**

6. ENGINE CONTROL MODULE

The Engine Control Module (ECM), located inside the right side kick panel, is the control center of the fuel injection system. It constantly looks at the information fromvarious sensors and controls the systems that affect the vehicle's performance. Engine rpm and air mass are used to measure the air intake quantity resulting in fuel injection metering. The ECM also performs the diagnostic functions of the system. It can recognize operational problems, store failure code(s) which identify the problem areas to aid the technician in making repairs.

There are no serviceable parts in the ECM. The calibrations are stored in the ECM in the Programmable Read Only Memory (PROM).

The ECM supplies either 5 or 12 volts to power the sensors or switches. This is done through resistance in the ECM which are so high in value that a test light will not come ON when connected to the circuit. In some cases, even an ordinary shop voltmeter will not give and accurate reading because its resistance is too low. You must use a digital voltmeter with a 10 Mohm input impedance to get accurate voltage readings. The ECM controls output circuits such as the ignition coils, the fuel injectors, the fuel pump relay, the camshaft actuator, the canister purge valve, etc., by controlling the ground circuit.

7. MAINTENANCE AND REPAIR

ON-VEHICLE SERVICE

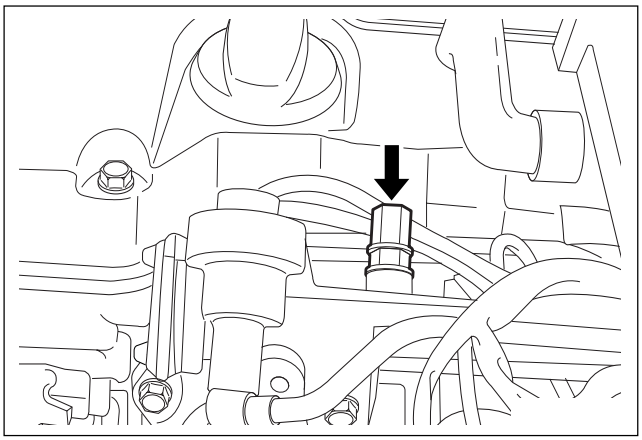
▶ Discharging The Pressure In Fuel System

Removal and Installation Procedure

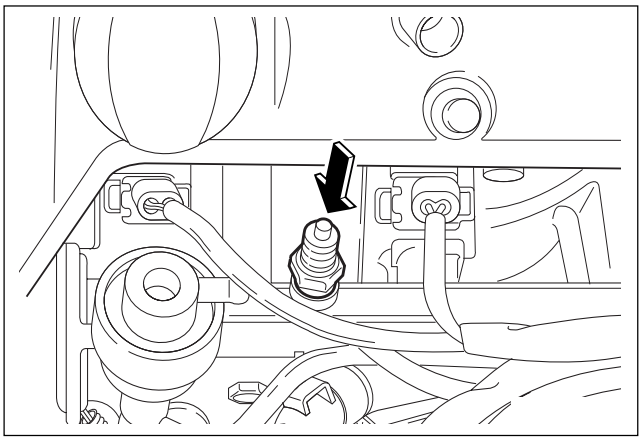
1. Remove the fuel pressure test connector.

   Installation Notice

Tightening Torque	22.5 N•m (18 lb-ft)



2. Remove the fuel pressure in fuel systemby pressing the service valve with a clean, pointy tool.



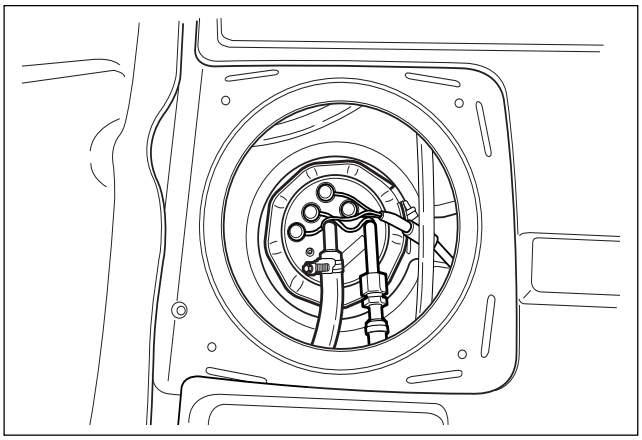
NOTICE
- **Place a cloth so that the fuel doesn't stain around.**

3. Installation should follow the removal procedure in the reverse order.

▶ Fuel Pump

Tools Required
661 589 00 46 00 Fuel Tank Cap Wrench

Removal and Installation Procedure



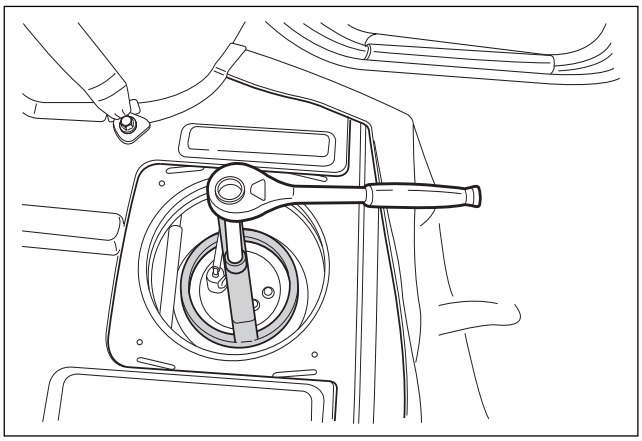
CAUTION
- **The fuel system is under pressure. To avoid fuel spillage and the risk of personal injury or fire, it is necessary to relieve the fuel system pressure before disconnecting the fuel lines.**

1. Relieve the fuel system pressure. Refer to "Discharging the Pressure in Fuel System" in this section.
2. Disconnect the negative battery cable.
3. Put aside the floor carpet to remove the fuel pump access cover.
4. Remove the fuel pump access cover.
5. Remove the fuel pump wiring connectors.
6. Disconnect the fuel supply and return pipes.
7. Remove the fuel pump locking cap band.

8. Using the fuel tank cap wrench 661 589 00 46 00, remove the locking cap.
9. Remove the pump from the fuel tank.

NOTICE

- **Check the condition of the seal and replace if necessary. Drain the fuel before removing the pump.**



10. Perform an operational check of the fuel pump.
11. Installation should follow the removal procedure in the reverse order.

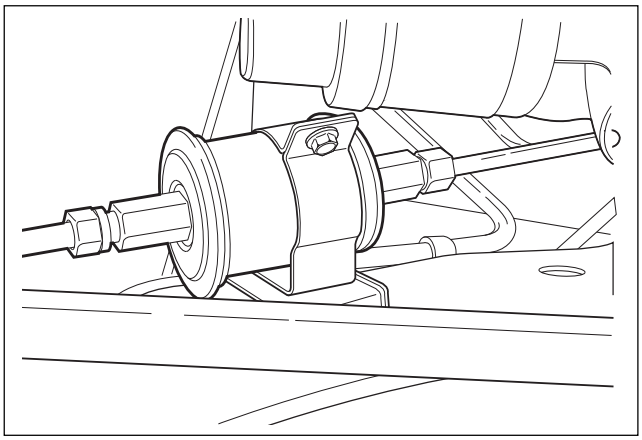
▶ Fuel Filter

Removal and Installation Procedure

1. Disconnect the negative battery cable.

NOTICE

- **The fuel system is under pressure. To avoid fuel spillage and the risk of personal injury or fire, it is necessary to relieve the fuel system pressure before disconnecting the fuel lines.**



2. Relieve the fuel system pressure. Refer to “Discharging the Pressure in Fuel System” in this sec-tion.
3. Disconnect the fuel lines from the fuel filter.

Installation Notice

Tightening Torque	28 N•m (21 lb-ft)

4. Remove the fuel filter mounting bracket bolt .

Installation Notice

Tightening Torque	6 N•m (53 lb-in)

NOTICE

- **Place the fuel pump pad. There may be acorrosion due to the contact between the fuel filter and the bracket.**

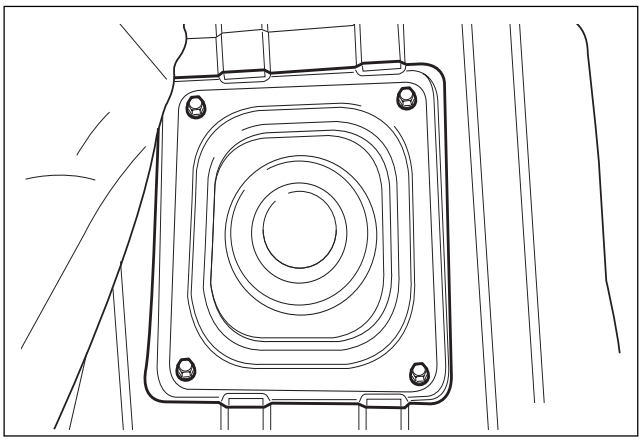
5. Remove the fuel filter.
6. Install the fuel filter.
7. Perform a leak test of the fuel filter.
8. Installation should follow the removal procedure in the reverse order.

▶ Fuel Tank

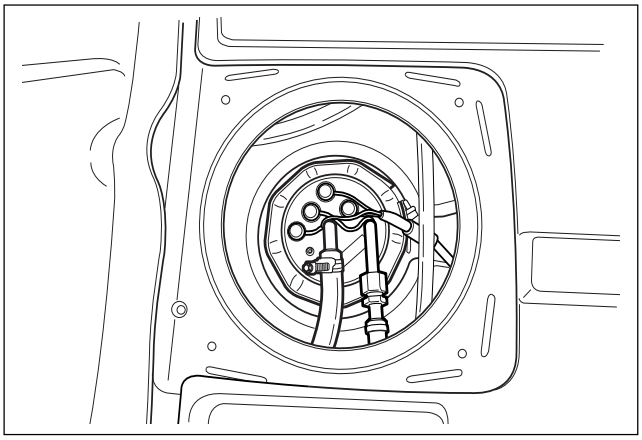
Removal and Installation Procedure

CAUTION

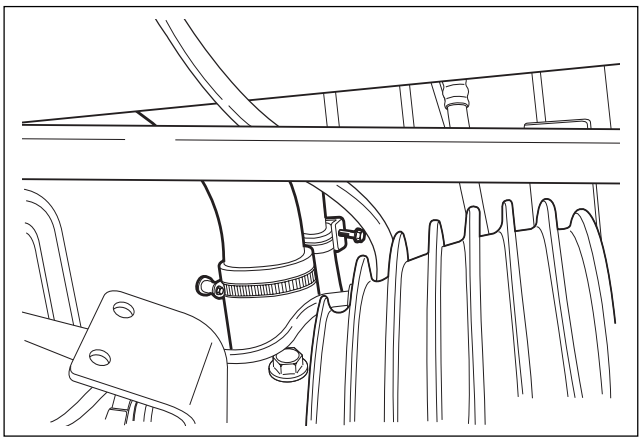
- **The fuel system is under pressure. To avoid fuel spillage and the risk of personal injury or fire, it is necessary to relieve the fuel system pressure before disconnecting the fuel lines.**



1. Relieve the fuel pressure. Refer to “Discharging the Pressure in Fuel System” in this section.
2. Disconnect the negative battery cable.
3. Drain the fuel tank.
4. Put aside the floor carpet to remove the fuel pump access cover.
5. Remove the fuel pump access cover.



6. Disconnect the return line.
7. Disconnect the supply line.
8. Disconnect the fuel tank-to-canister hose from the fuel tank.
9. Disconnect the fuel pump wiring connector.



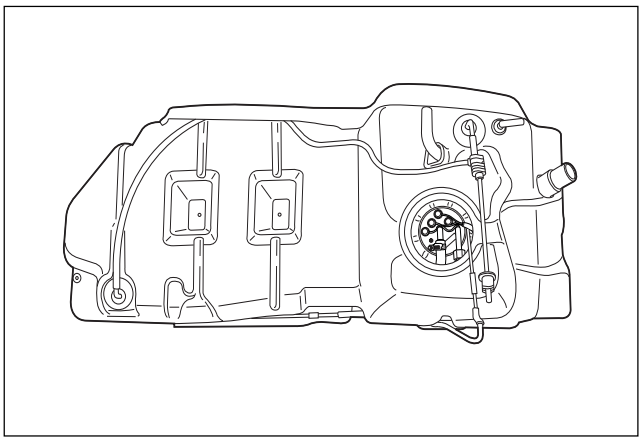
10. Disconnect thefuel filler hoseand air vent hosefrom the fuel tank.
11. Support the fuel tank.
12. Remove the fuel tank retaining nuts.

Installation Notice

Tightening Torque	38 N•m (28 lb-ft)

13. Carefully lower the fuel tank.

14. Turn the rollover valves counterclockwise at an angle of 90 degrees.
15. Turn the lock ring counterclockwise.
16. Remove and discard the gasket.
17. Installation should follow the removal procedure in the reverse order.



▶ Fuel Pressure Regulator

Removal and Installation Procedure

1. Disconnect the negative battery cable.
2. Remove the fuel pressure test connector.

Installation Notice

Tightening Torque	25 N•m (18 lb-ft)

NOTICE

- **The fuel system is under pressure. To avoid fuel spillage and the risk of personal injury or fire, it is necessary to relieve the fuel system pressure before disconnecting the fuel lines.**

3. Relieve the fuel pressure in fuel supply systemby pressing the service valve.

4. Disconnect the vacuum hose.
5. Disconnect the circlip and remove the fuel pressure regulator.
6. Apply the oil to O-ring lightly and then replace it.
7. Perform a leak test of the fuel pressure regulator with the engine off and the ignition on.
8. Installation should follow the removal procedure in the reverse order.

▶ Fuel Rail and Injectors

Removal and Installation Procedure

CAUTION

- **The fuel system is under pressure. To avoid fuel spillage and the risk of personal injury or fire, it is necessary to relieve the fuel system pressure before disconnecting the fuel lines.**

1. Discharge the fuel pressure from the fuel pressure test connector.
2. Disconnect the negative battery cable.
3. Disconnect the vacuumhose from the fuel pressure regulator.

4. Remove the cable guide.
5. Disconnect the IAT sensor connector.
6. Remove the intake air duct mounting bolts.

Installation Notice

Tightening Torque	9 N•m (80 lb-in)

7. Remove the intake air duct clamps.
8. Remove the intake air duct.

9. Remove the fuel return and supply line.

NOTICE

- **For removal, cover around parts with cloths not to be stained by fuel. In case of checking the injector only, do not remove the fuel return and supply line.**

Installation Notice

Tightening Torque	23 N•m (17 lb-ft)

10. Remove the six injector connectors.

11. Remove the two left and two right bolts and one center bolt of the fuel rail assembly from the intake manifold.

Installation Notice

Tightening Torque	25 N•m (18 lb-ft)

NOTICE

- **Before removal, the fuel rail assembly may be cleaned with a spray-type cleaner, following package instructions. Do not immerse the fuel rails in liquid cleaning solvent. Use care in removing the fuel rail assembly to prevent damage to the electrical connectors and injector spray tips. Prevent dirt and other contaminants from entering open lines and passages. Fittings should be capped and holes plugged during service.**

NOTICE

- **If an injector becomes separated from the rail and remains in the cylinder head, replace the injector O-ring seals and the retaining clip.**

12. Remove the injectors and the fuel rail carefully.
13. Remove the fuel injector retainer clips.
14. Remove the fuel injectors by pulling them down and out.
15. Discard the fuel injector O-rings.
16. Lubricate the new fuel injector O-rings with engine oil. Install the new O-rings on the fuel injectors.
17. Perform a leak check of the fuel rail and fuel injectors.
18. Installation should follow the removal procedure in the reverse order.

▶ Engine Coolant Temperature Sensor

Removal and Installation Procedure

1. Relieve the coolant system pressure.
2. Disconnect the negative battery cable.
3. Disconnect the engine coolant temperature sensor connector.

NOTICE

- **Take care when handling the engine coolant temperature sensor. Damage to the sensor will affect the proper operation of the fuel injection system.**

4. Remove the engine coolant temperature sensor from the pump hosing.

Installation Notice

Tightening Torque	30 N•m (22 lb-ft)

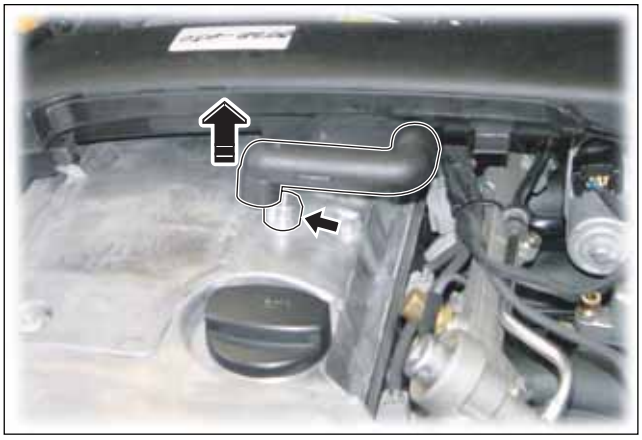
5. Installation should follow the removal procedure in the reverse order.

▶ Throttle Body (Integrated with the Actuator)

Removal and Installation Procedure

1. Disconnect the negative battery cable.
2. Disconnect the intake air temperature (IAT) sensor connector.
3. Remove the intake air duct clamps.

4. Remove the blow-by hose.
5. Remove the intake air duck.



6. Disconnect the throttle body electrical connector.
7. Remove the throttle body bolts.

Installation Notice

Tightening Torque	12 N•m (106 lb-in)

8. Remove the vacuum hose.

9. Remove the throttle body and discard the gasket.

NOTICE

- **Use care in cleaning old gasket material. Sharp tools may damage sealing surfaces.**

10. Installation should follow the removal procedure in the reverse order.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Intake Air Temperature Sensor

Removal and Installation Procedure

1. Disconnect the negative battery cable.
2. Disconnect the Intake Air Temperature sensor electrical connector.
3. Remove the IAT sensor.
4. Installation should follow the removal procedure in the reverse order.

Installation Notice

Tightening Torque	20 - 24 N•m (14.8 - 17.7 lb-ft)

▶ Knock Sensor

Removal and Installation Procedure

1. Disconnect the negative battery cable.
2. Disconnect the knock sensor electrical connector from the intake manifold bracket.
3. Remove the knock sensor mounting bolt from the knock sensor installed on the cylinder block.

Installation Notice

Tightening Torque	25 N•m (18 lb-ft)

4. Remove the knock sensor.
5. Installation should follow the removal procedure in the reverse order.

▶ Pedal Position Sensor

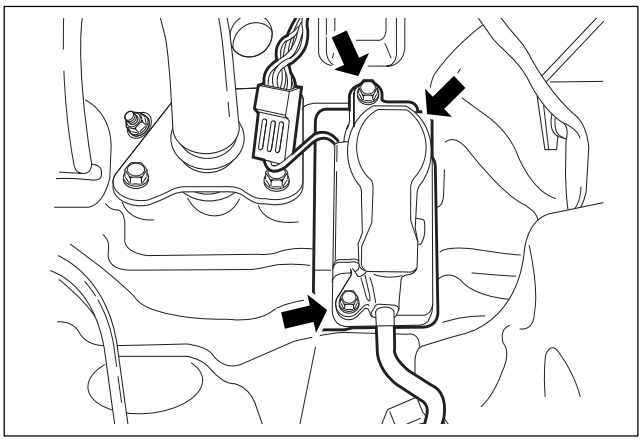
Removal and Installation Procedure

1. Disconnect the negative battery cable.
2. Disconnect the pedal position sensor connector.
3. Unscrew the bolts and nut.

Installation Notice

Tightening Torque	6 N•m (53 lb-in)

4. Remove the pedal and sensor assembly.
5. Installation should follow the removal procedure in the reverse order.



▶ Oxygen Sensor

Removal and Installation Procedure

1. Disconnect the negative battery cable.

NOTICE

- **The oxygen sensor uses a permanently attached pigtail and connector. This pigtail should not be removed from the oxygen sensor. Damage or removal of the pigtail or the connector could affect proper operation of the oxygen sensor. Do not drop the oxygen sensor.**

2. Disconnect the electrical connector.
3. Carefully remove the oxygen sensor from the exhaust pipe.

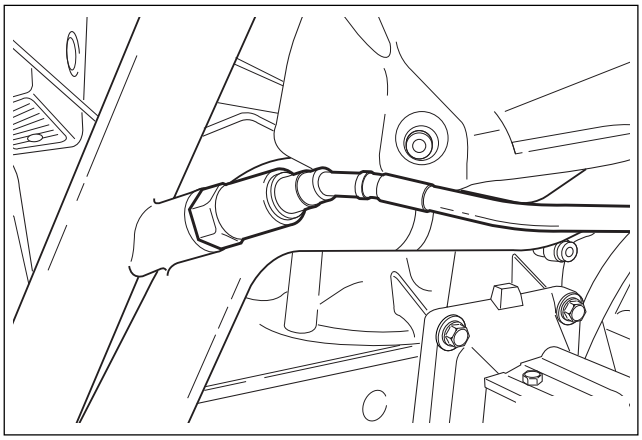
Installation Notice

Tightening Torque	55 N•m (41 lb-ft)

IMPORTANT

- **A special anti-seize compound is used on the oxygen sensor threads. This compound consists of aliquid graphiteand glass beads. The graphite will burn away, but the glass beads will remain, making the sensor easier to remove. New or serviced sensors will already have the compound applied to the threads. If a sensor is removed from any engine and is to be reinstalled, the threads must havean antiseize compound applied before reinstallation.**

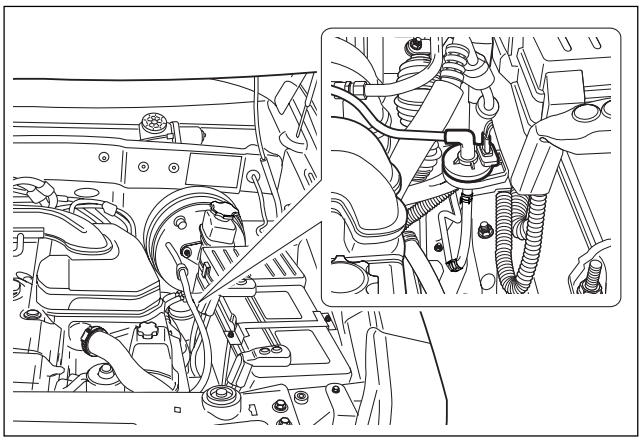
4. Coat the threads of the oxygen sensor with an anti-seize compound, if needed.
5. Installation should follow the removal procedure in the reverse order.



▶ Purge Control Valve

Removal and Installation Procedure

1. Disconnect the negative battery cable.
2. Disconnect the purge control valve connector.
3. Disconnect the throttle body-to-purge control valve hose from the purge control valve.
4. Disconnect the canister-to-purge control valve hose from the purge control valve.
5. Remove the purge control valve.
6. Installation should follow the removal provedure in the reverse order.



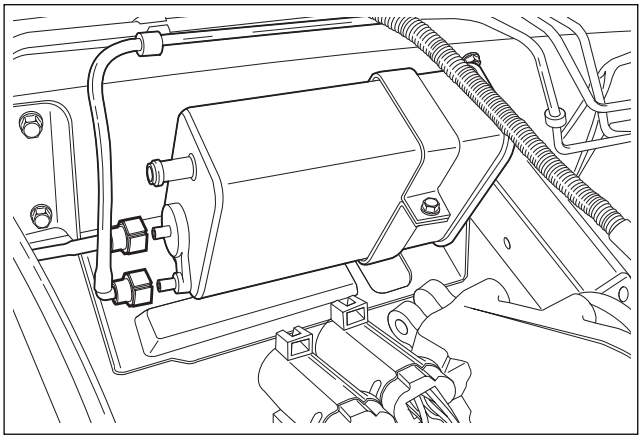
▶ Canister

Removal and Installation Procedure

NOTICE

- **Canister and vacuum hoses contain fuel vapors. Do not smoke in the area or permit an open flame.**

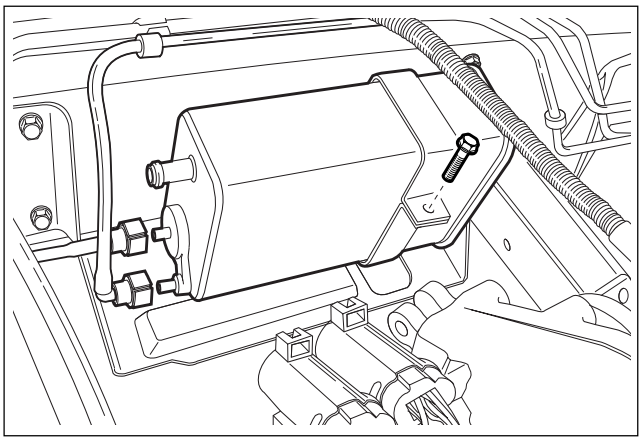
1. Disconnect the fuel tank-to-canister hose form the canister.
2. Disconnect the canister-to-purge control valve hose form the canister.



3. Remove the canister mounting bolts.

Installation Notice

Tightening Torque	6 N•m (53 lb-in)



4. Remove the canister.
5. Installation should follow the removal procedure in the reverse order.

▶ Camshaft Position Sensor

Removal and Installation Procedure

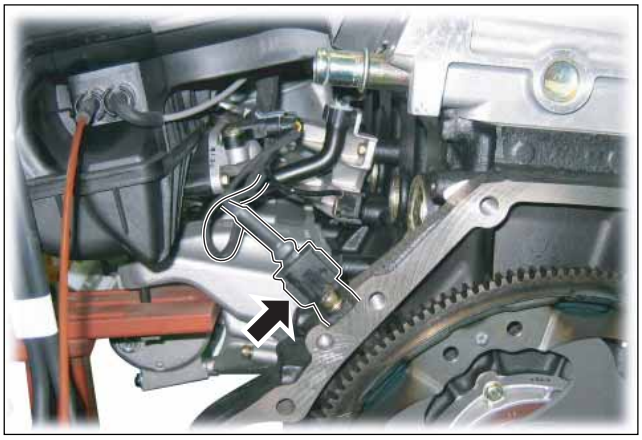
1. Disconnect the negative battery cable.
2. Disconnect the electrical connector from the camshaft position sensor.
3. Remove the camshaft position sensor retaining bolt.

Installation Notice

Tightening Torque	10 N•m (89 lb-in)

4. Check the O-ring for damage and replace it if necessary.
5. Installation should follow the removal procedure in the reverse order.

▶ Crankshaft Position Sensor



Removal and Installation Procedure

1. Disconnect the negative battery cable.
2. Disconnect the electrical connector at the crankshaft position sensor.
3. Remove the crankshaft position sensor retaining bolt.

Installation Notice

Tightening Torque	10 N•m (89 lb-in)

4. Installation should follow the removal procedure in the reverse order.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ Engine Control Module

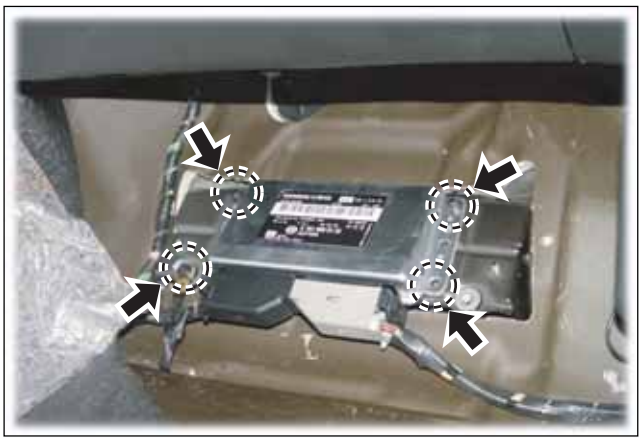
Removal and Installation Procedure

1. Disconnect the negative battery cable.
2. Remove the cowl side trim form passenger side.
3. Remove the securing nuts for the Engine Control Module (ECM) from the mounting bracket.

Installation Notice

Tightening Torque	10 N•m (89 lb-in)

4. Pull out the ECM from the bracket.
5. Disconnect the vehicle side coupling.
6. Installation should follow the removal procedure in the reverse order.



▶ MAP (Manifold Absolute Pressure) Sensor

Removal and Installation Procedure

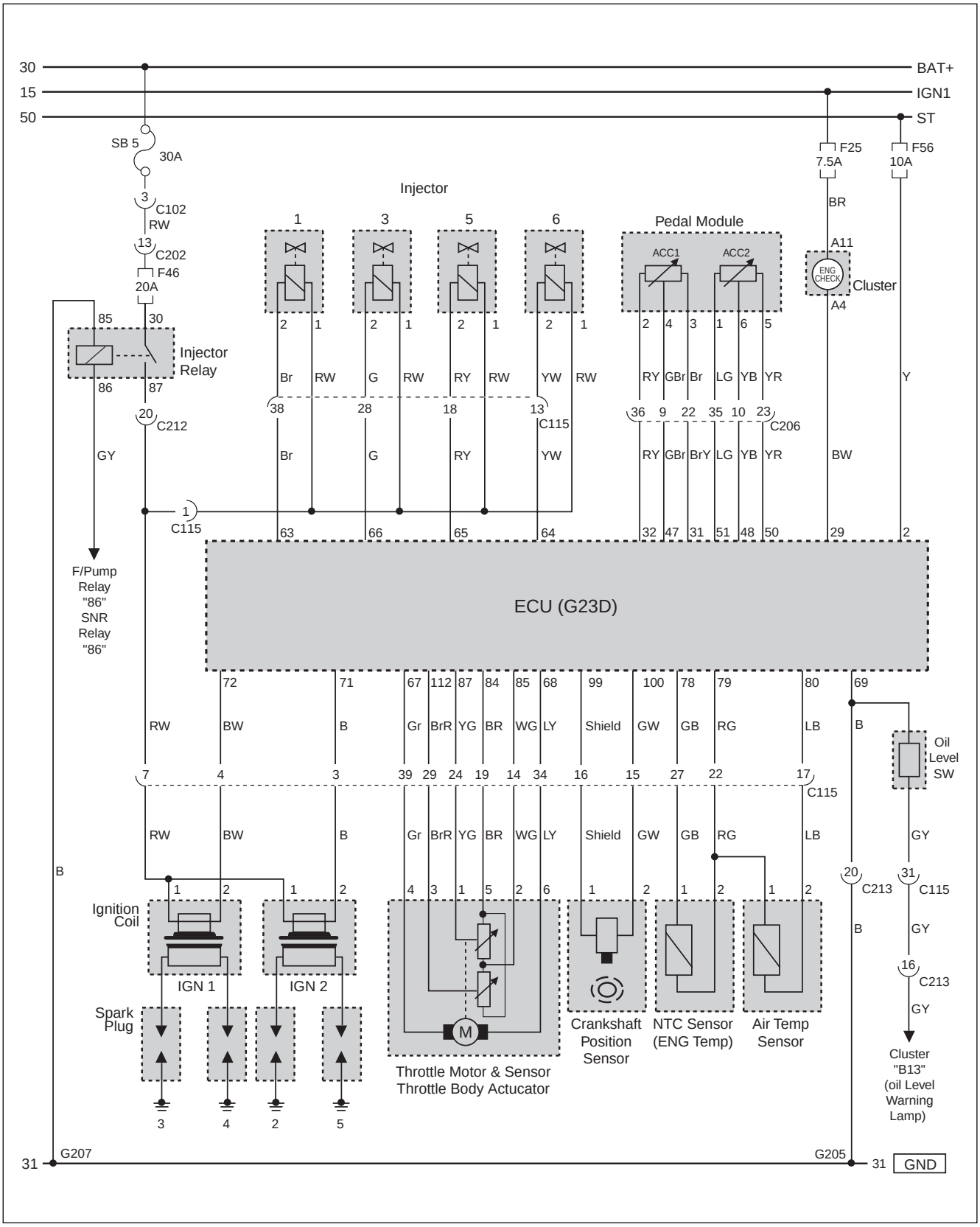
1. Disconnect the battery cable.
2. Disconnect the MAP sensor connector.
3. Remove the MAP sensor mounting bolt (6 mm).
4. Remove the MAP sensor.
5. Installation should follow the removal procedure in the reverse order.

Installation Notice

Tightening Torque	6 - 10 N•m (4.43 - 7.38 lb-ft)

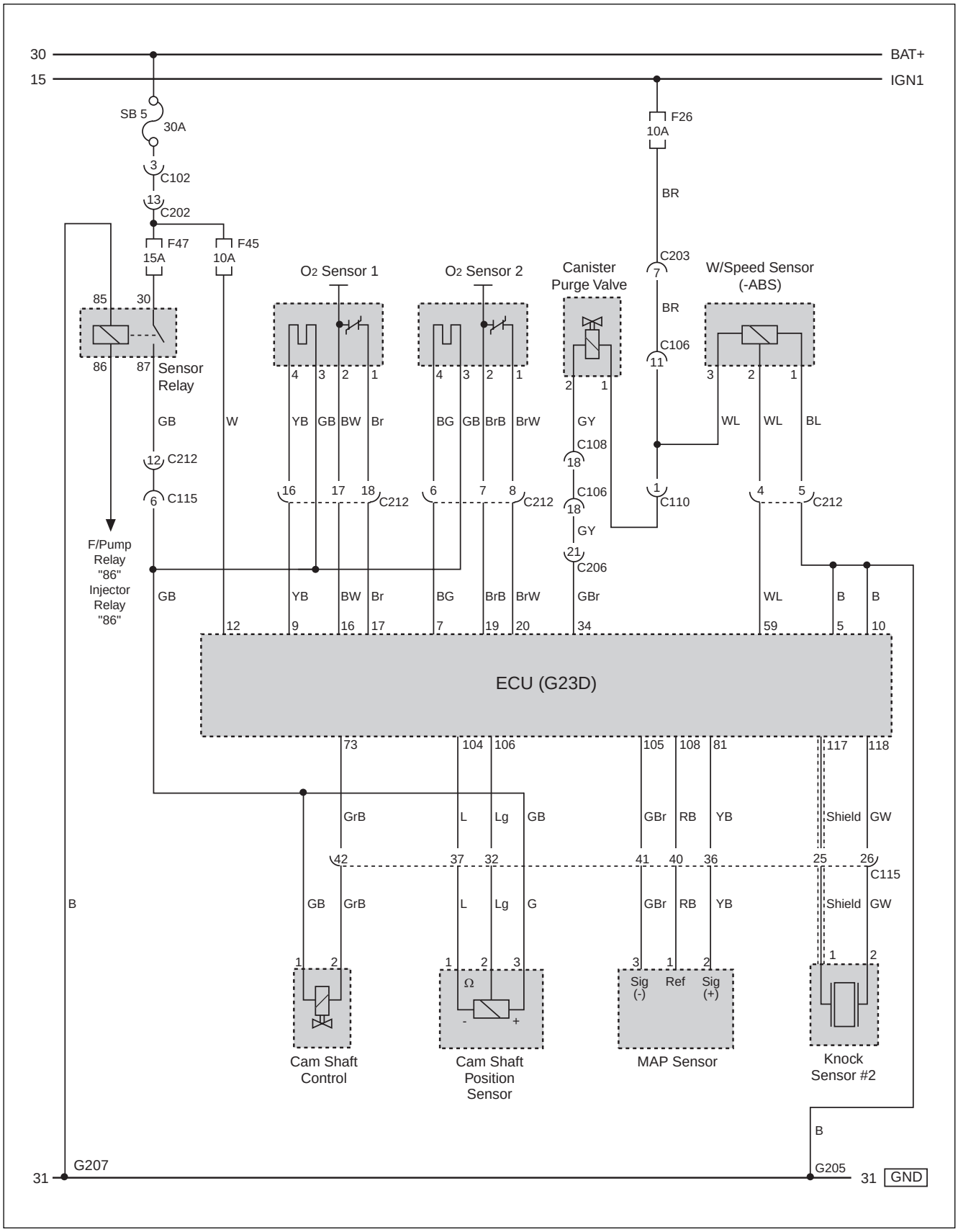
8. SCHEMATIC AND ROUTING DIAGRAMS

▶ IGN COIL, INJECTOR, PEDAL MODULE, THROTTLE SENSOR



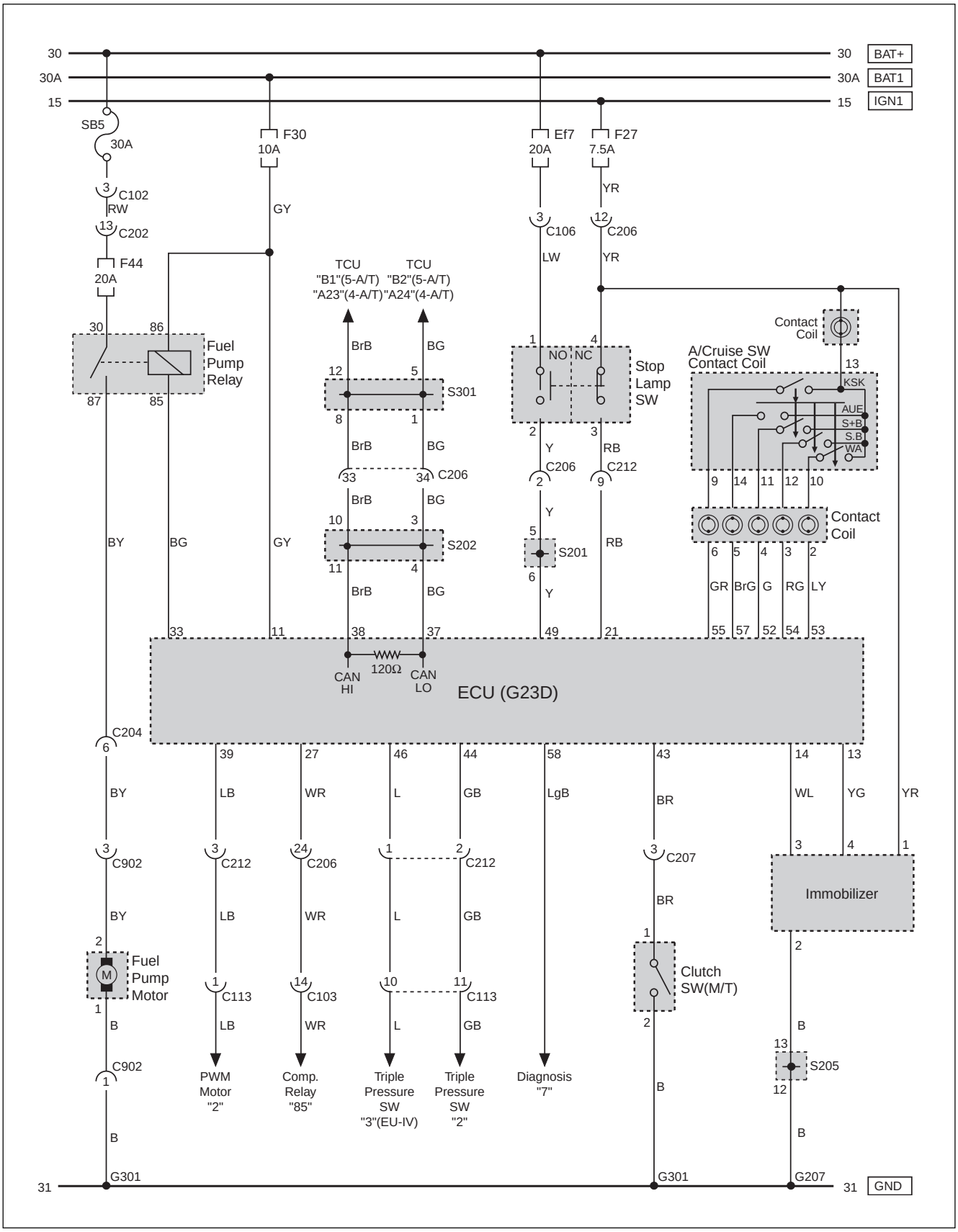
CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ O_2 SENSOR, CPS, KNOCK SENSOR, MAP SENSOR, CANISTER PURGE VALVE



CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

▶ STOP LAMP, CRUISE CONTROL SW, FUEL PUMP, IMMOBILIZER



CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

9. SPECIFICATIONS

▶ Engine Data Display Table

Parameter	Unit	Value
Engine Coolant Temp.	℃	greater than 95 °C after warm up
Intake Air Temp.	℃	-40 ~ 130 °C (varies with ambient temp. or engine mode)
Engine RPM	rpm	700 ± 50 (P/N), 600 ± 50 (D)
Regular RPM	rpm	700 ± 50 (P/N), 600 ± 50 (D)
Engine Load	%	18 ~ 25 %
MAP Sensor	kpa	15 ~ 120 kpa (Tolerance ± 1.5kpa)
Throttle Position Angle	°TA	0 °TA (up to 100 °TA at the wide open throttle)
Spark Advance	°CA	°CA (6 ~ 9 °CA)
Indicated Engine Torque	Nm	Varies with engine condition
Injection Time	ms	3 ~ 5 ms
Battery Voltage	V	13.5 ~ 14.1 V (engine running)
Front Axle Speed	Km/h	0 ~ 265 Km/h
Rear Axle Speed	Km/h	0 ~ 265 Km/h
Accel. Pedal Position 1	V	0.4 ~ 4.8 V
Accel. Pedal Position 2	V	0.2 ~ 2.4 V
Throttle Position 1	V	0.3 ~ 4.6 V
Throttle Position 2	V	0.3 ~ 4.6 V
Fuel Integrator		0.8 ~ 1.2
Oxygen Sensor	mv	100 ~ 900 mv
A/C S/W Condition	1=ON/0=OFF	-
Full Load State	1=ON/0=OFF	-
Shift Gear State (A/T)	1=ON/0=OFF	-
A/C Control State	1=ON/0=OFF	-
Clutch Switch (M/T)	1=ON/0=OFF	-
Cam Actuator State	1=ON/0=OFF	-
Knocking Control	1=ON/0=OFF	-
Protect Mission	1=ON/0=OFF	-
Purge Control Valve	1=ON/0=OFF	-
Lambda Function	1=ON/0=OFF	-
Catalyst Heating	1=ON/0=OFF	-
Overrun Fuel Cut	1=ON/0=OFF	-
Full Fuel Cut	1=ON/0=OFF	-
Brake Switch	1=ON/0=OFF	-
Cruise Control Status	1=ON/0=OFF	-

* Condition : Warmed up, idle, P/N or neutral

▶ Fastener Tightening Specifications

Application	N•m	Lb-Ft	Lb-In
Camshaft Position Sensor Retaining Bolts	10	-	89
Canister Mounting Bolts	6	-	53
Coolant Temperature Sensor	30	22	-
Crankshaft Position Sensor Retaining Bolt	10	-	89
Engine Control Module (ECM) Mounting Bracket Nuts	10	-	89
Fuel Filter Mounting Bracket Bolt	6	-	53
Fuel Filter Lines	28	21	-
Fuel Pressure Test Connector	25	18	-
Fuel Rail Assembly Bolts	25	18	-
Fuel Return And Supply Lines	23	17	-
Fuel Tank Retaining Nuts	38	28	-
Knock Sensor Mounting Bolt	25	18	-
Oxygen Sensor	55	41	-
Pedal Position Censor Mounting Bolts And Nut	6	-	53
Throttle Body Bolts	12	-	106

▶ Fuel System Specification

Use Only Unleaded Fuel Rated at 89 Octane or Higher

Fuel quality and additives contained in fuel have a significant effect on power output, drivability, and life of the engine.

Fuel with too low an octane number can cause engine knock.

CAUTION

- **Use of fuel with an octane number lower than 89 may damage engine and exhaust system.**

NOTICE

- **To prevent accidental use of leaded fuel, the nozzles for leaded fuel are larger, and will not fit the fuel filler neck of your vehicle.**

Do Not Use Methanol

Fuels containing methanol (wood alcohol) should not be used in vehicle.

This type of fuel can reduce vehicle performance and damage components of the fuel system.

CAUTION

- **Use of methanol may damage the fuel system.**

Vehicle Fueling from Drums or Storage Containers

For safety reasons (particularly when using noncommercial fueling systems) fuel containers, pumps and hoses must be properly earthed.

Static electricity build up can occur under certain atmospheric and fuel flow conditions if unearthed hoses, particularly plastic, are fitted to the fuel-dispensing pump.

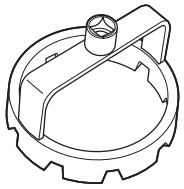
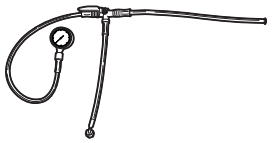
It is therefore recommended that earthed pumps with integrally earthed hoses be used, and that storage containers be properly earthed during all noncommercial fueling operations.

▶ Temperature Vs Resistance

℃	°F	ECT sensor	IAT sensor
		ohms (Ω)	
Temperature vs Resistance Values (Approximate)			
130	266	88	102
120	248	111.6	127
110	230	143	159
100	212	202	202
90	194	261	261
80	176	340	340
70	158	452	452
60	140	609	609
50	122	835	835
40	113	1166	1166
30	86	1662	1662
20	68	2420	2420
10	50	3604	3604
0	32	5499	5499
-10	14	8609	8609
-20	-4	13850	13850
-30	-22	22960	22960
-40	-40	39260	39260

10. SPECIAL TOOLS AND EQUIPMENT

▶ Special Tools Table

	**661 589 00 46 00Fuel Tank Cap Wrench**
	**103 589 00 21 00 Fuel Pressure Gauge**

INTAKE & EXHAUST

1712, 1722

TABLE OF CONTENTS

1. DESCRIPTION AND OPERATION

▶ Exhaust System

Notice: When you are inspecting or replacing exhaust system components, make sure there is adequate clearance from all points on the underbody to avoid possible overheating of the floor panel and possible damage to the passenger compartment insulation and trim materials.

Check the complete exhaust system and the nearby body areas and trunk lid for broken, damaged, missing or mispositioned parts, open seams, holes, loose connections, or other deterioration which could permit exhaust fumes to seep into the trunk may be an indication of a problem in one of these areas. Any defects should be corrected immediately.

▶ Muffler

Aside from the exhaust manifold connection, the exhaust system uses a flange and seal joint design rather than a slip joint coupling design with clamp and U-bolts. If hole, open seams, or any deterioration is discovered upon inspection of the front muffler and pipe assembly, the complete assembly should be replace, the complete assembly should be replaced. The same procedure is applicable to the rear muffler assembly.

Heat shields for the front and rear muffler assembly and catalytic converter protect the vehicle and the environment from the high temperatures that the exhaust system develops.

▶ Catalytic Converter (Gasoline Engine)

1. When jacking or lifting the vehicle from the body side rails, be certain that the lift pads do not contact the catalytic converter, as this could damage the catalytic converter.
2. Use of anything other than unleaded fuel will damage the catalyst in the catalytic converter.

The catalytic converter are emission-control devices added to the exhaust system to reduce pollutants from the exhaust pipes.

The oxidation catalyst is coated with a catalytic material containing platinum and palladium, which reduces levels of hydrocarbon (HC) and carbon monoxide (CO) from the exhaust gas. The three-way catalyst has coatings which contain platinum and rhodium, which additionally lower the levels of oxides of nitrogen (NOx).

Catalytic Converter Structure

The Catalytic converter of monolith type consists of 2 walled metal bodies which is made of Cordierite.

The principal element of converter consists of the materials like Alumina or oxidized Serume in order to apply to Ceramic Monolith.

Washer coat operates first, and catalytic metal elements (Pt, Pd, Rh) operates to washer coat next.

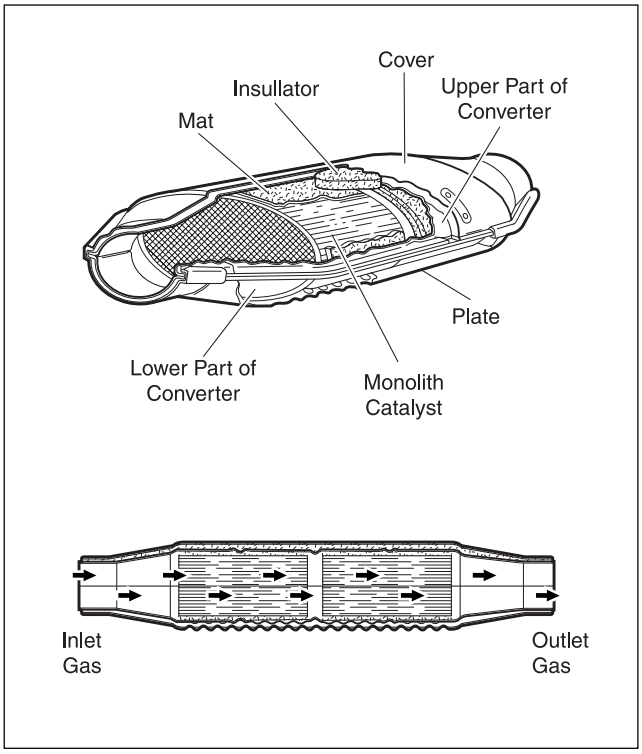
Monolith type is lighter than other types, easy to manufacture and quickly approaches to proper temperature.

Washer coat is used to make a contact surface with exhaust gas bigger by adhering closely to small holes of inner layer.

If a lead compound or phosphorus adheres to the surface and the temperature rises, its surface is decreased.

The total area of general monolith converter is about 45, 000~500,000ft^3. (10 times of a football field)

Generally Alumina (AL_2 O^3) is used as a raw material and its 7 phases of gamma, delta, theta have big areas and high stability for the temperature, and nowadays gamma Alumina is used usually.



CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

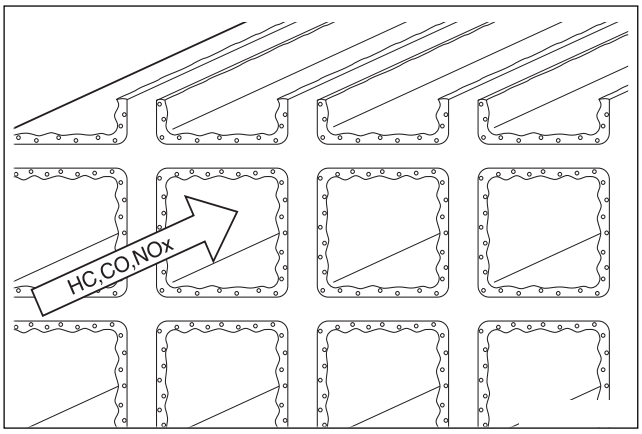
Catalytic Converter and Temperature

Catalytic converter has the normal function of purification at a range of the temperature.

Because it has a weak point of decreasing of the purification rate in the condition of continuous high temperature, it should keep the temperature range of 400 to 500°C for normal condition.

HC purification rate becomes better according to the increase of temperature in the normal range of temperature.

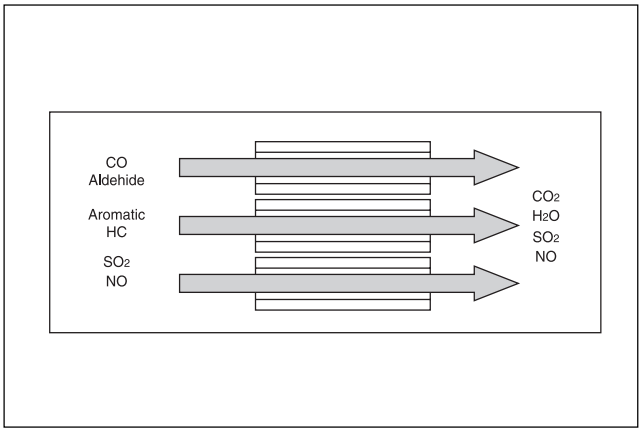
CO purification rate becomes the best near the temperature of 450°C, and NO_x does so near the temperature of 400 to 500°C.



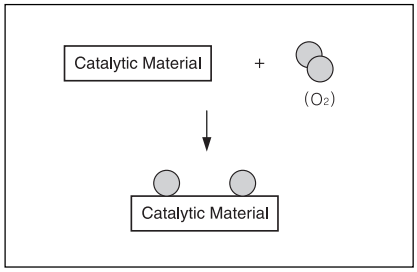
Purification of Catalytic Converter

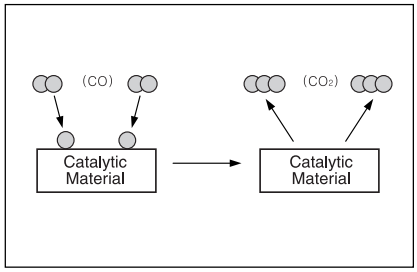
- Adhesion of soluble organic fraction (SOF) below 180°C
- Purification of soluble organic fraction (SOF) over 180°C

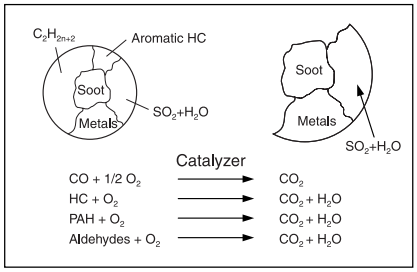
  Chemical reaction formula
  - $SOF(HC)+O_2 \rightarrow CO_2+H_2O$
  - $2CO+O_2 \rightarrow 2CO_2$
  - $2C_2H_6+7O_2 \rightarrow 4CO_2+6H_20$
- By catalytic action of two primary catalytic converter, oxidation occurs in order to decrease HC and CO.



- Oxygen adheres to catalytic material : below 180°C
- Catalytic material supplies each CO and HC with O_2 for their oxidation : above 180°C
- Catalytic material conversion process by DOC







Method for Reduction of NOx

NOx is generated a great deal in case that combustion temperature and excess air factor are high. EGR valve can decrease NOx (30 to 35% decrease) by making temperature of combustion chamber fall by means of exhaust gas re-circulation.

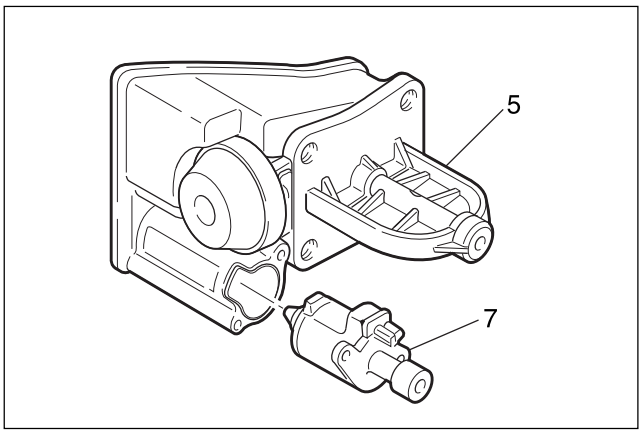
- EGR valve is installed on the diesel engine of Musso, Korando, Istana and Rexton.

  And micro switch is installed together to control EGR valve.
- The setting method of micro switch is identical with the existing one.

▶ Resonance Flap

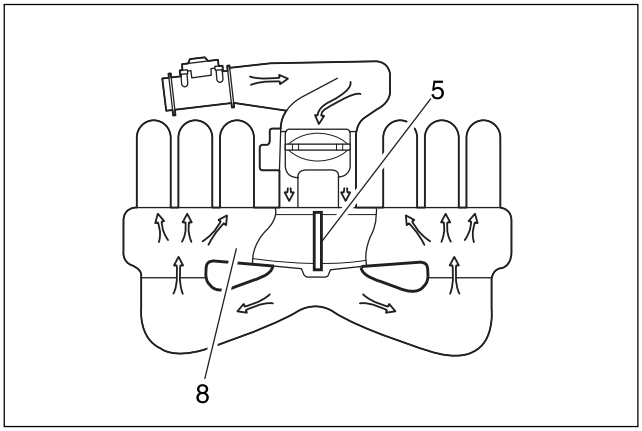
Function

A pneumatically actuated resonance flap (5) is located on the intake manifold, and will be opened and closed by load, which operates resonance flap according to engine and controlled by ECU and rpm.



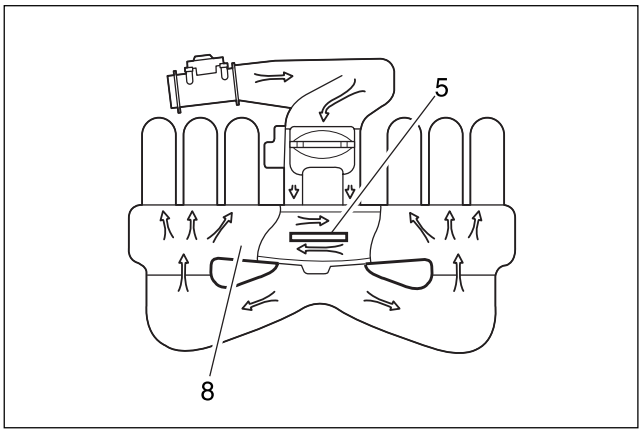
Resonance flap closed (at idle/partial load : less than 3,800/rpm)

The switch valve (7) will be adjusted by ECU and resonance falp will be colosed. By increasing air flow passage through dividing intaking air flow toward both air collection housing (8). This leads to a signficant increase in the torque in the lower speed range.



Resonance flap open (at full load : over 3, 800/rpm)

The switch valve (7) will not be adjusted by ECU and resonance falp (5) will be open. The collected air in the air collection housing (8) will not be divided and intaking air passage will be shorten.



CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

2. REPAIR INSTRUCTIONS ON-VEHICLE SERVICE

▶ Air Cleaner and Intake Air Duct

Installed View

Removal & Installation Procedure

1. Remove the LH/RH mounting bolts and clamps to remove the front duct.

2. Disconnect the intake temperature sensor connector.

3. Remove the blow-by gas hose and mounting clamp of the air center duct on the engine compartment.

RH Clamp Mounting Section

LH Clamp Mounting Section

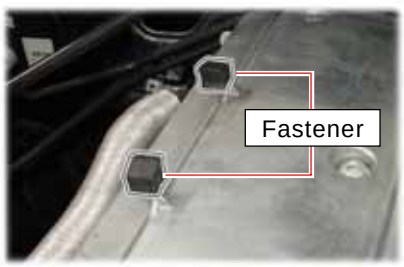
Bleeder Hose

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

4. Remove the center air duct.

NOTICE

- When removing the fasteners, check their correct location to install the fastener properly later on.



9. Remove the clamp of the HFM sensor and remove the HFM sensor from the air cleaner housing.

NOTICE

- **Observe the installation direction of the Center duct.**

10. Separate the reservoir tank from the vehicle by removing the mounting bolt.

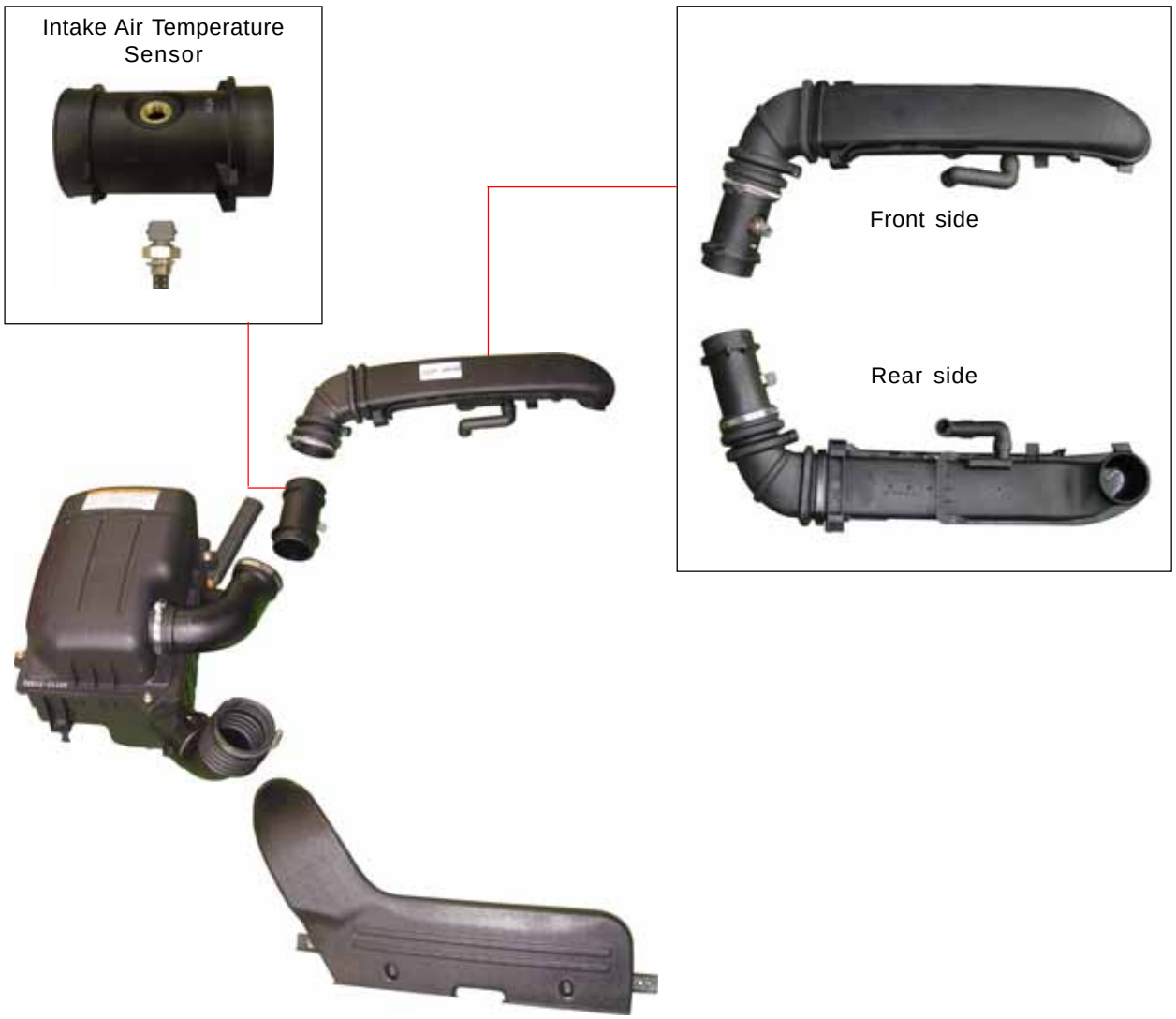
NOTICE

- **Be careful not to spill the remaning coolant on the vehicle or body.**

7. Remove the air cleaner cover. Remove the mounting bolts and air cleaner housing and element assembly.

8. Install in the reverse order of removal.

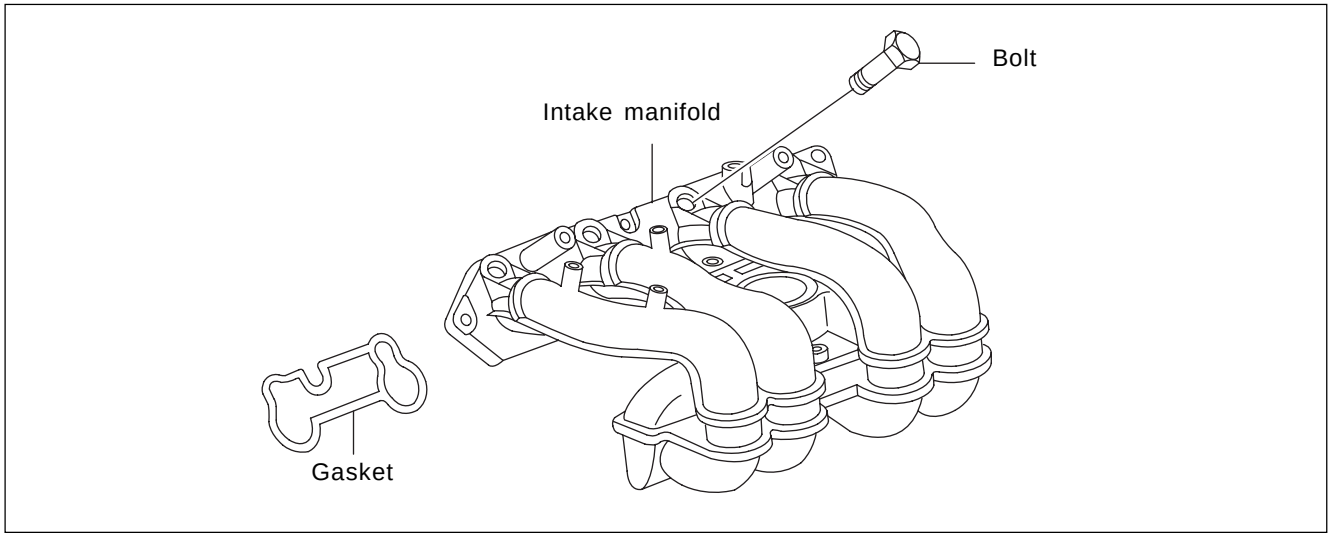
Structure of air cleaner



CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

3. INTAKE MANIFOLD

※ **Preceding Work:** Remove the fuel distributor and injection valve.



▶ Removal & Installation Procedue

1. Remove the air duct and the injector (refer to the "Inlet Air duct" section).

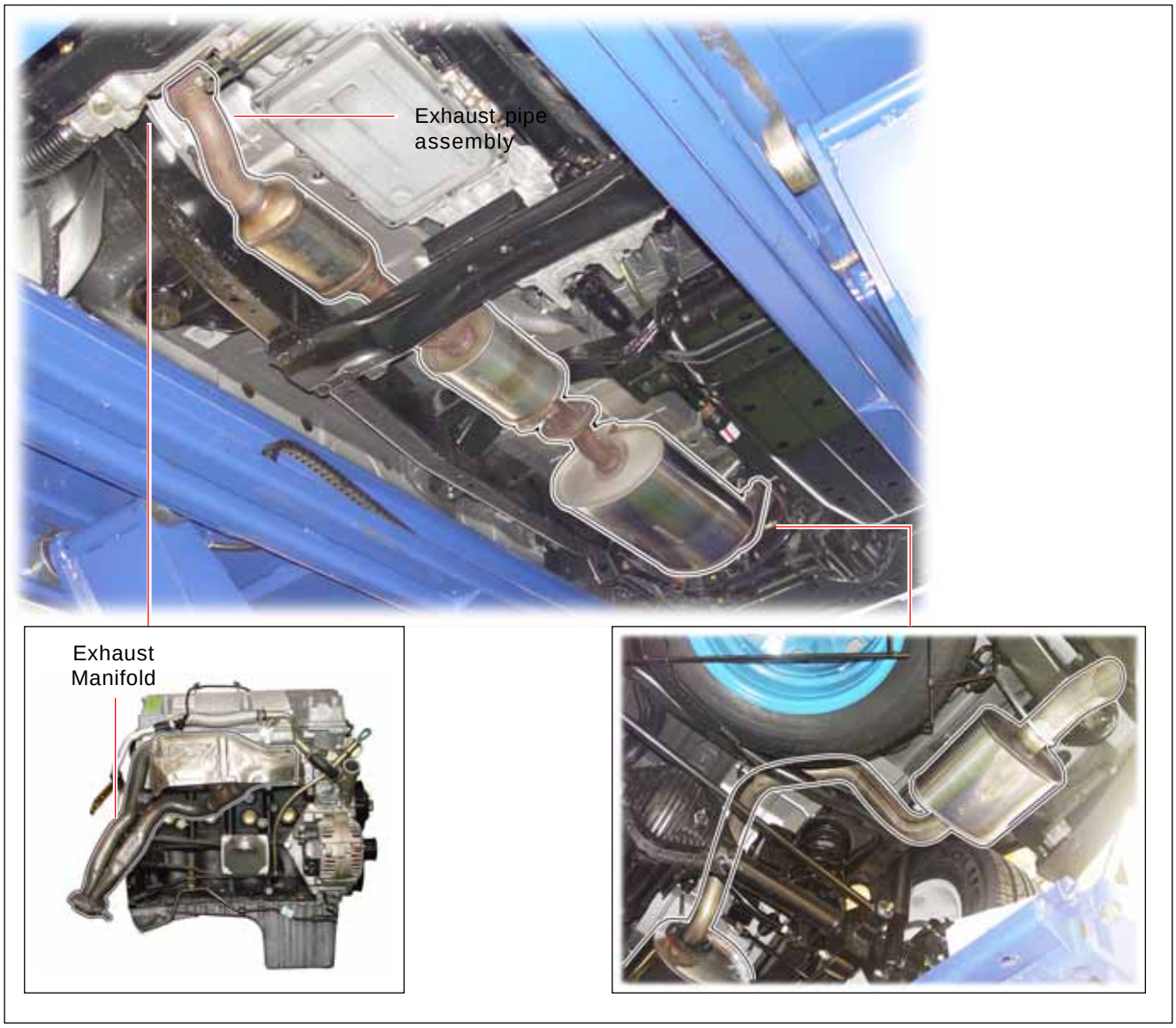
2. Disconnect the vacuum hose of the throttle valve actuator mounted on the intake manifold and remove the throttle valve actuator from the intake manifold.

3. Disconnect the MAP sensor connector from inside of the intake manifold.

4. Unscrew the intake manifold mounting nut and bolt from the engine to remove the intake manifold.

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

4. EXHAUST LINE & EXHAUST MANIFOLD



▶ Removal & Installation Procedue

1. Remove the air duct from the engine compartment (refer to the "Air duct" section).

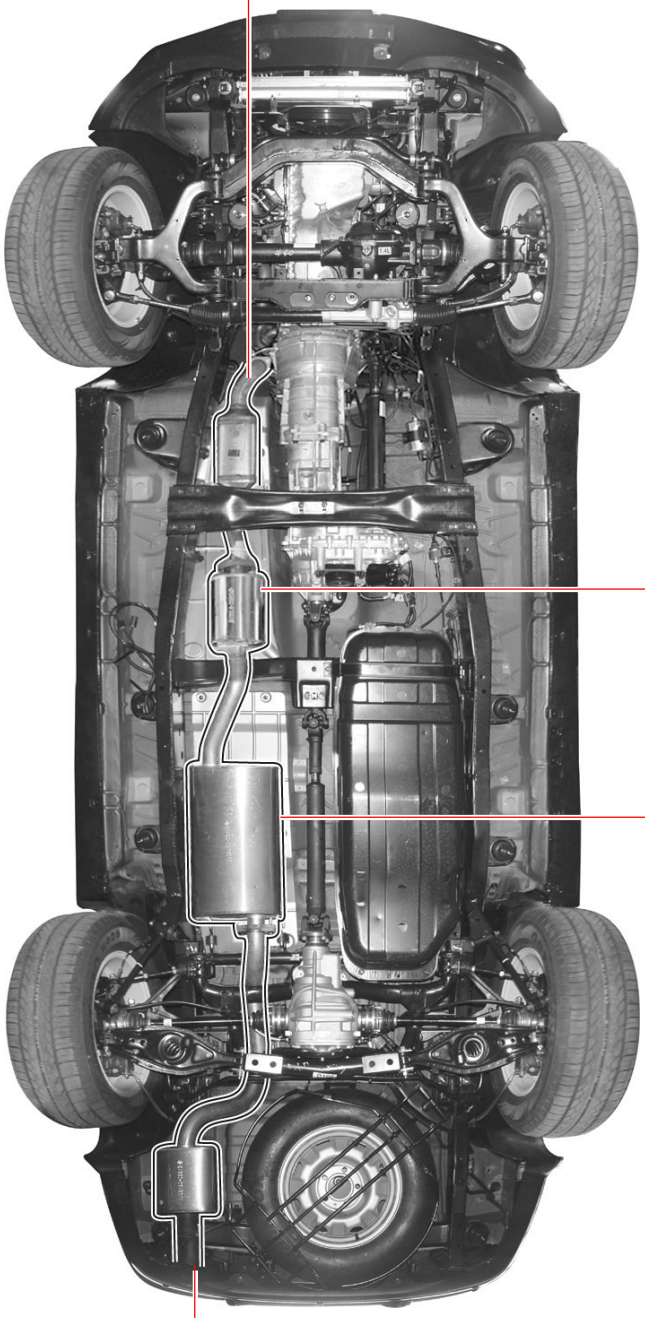
2. Disconnect the heater hose to the exhaust manifold.

3. Remove the two oxygen sensors from the exhaust pipe.

4. **Remove the mounting bolt of No. 1 exhaust pipe to the exhaust manifold.**

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	

5. Remove the upper mounting nut and mounting rubber of the exhaust pipe to remove the exhaust pipe assembly.



5. SPECIFICATIONS

▶ Fastener Tightening Specifications

Application	N•m	Lb-Ft	Lb-In
DOC to Muffler Nut	28 - 47	21 - 35	-
Exhaust Manifold to Front Exhaust Pipe Nut	15 - 28	11 - 21	-
Front Exhaust Pipe to DOC Nut	28 - 47	21 - 35	-
Front Exhaust Pipe to Muffler Nut	28 - 47	21 - 35	-
Intake Air Duct Mounting Bolt	22.5 - 27.5	16.6 - 20.3	-
Intake Manifold Mounting Bolt	22.5 - 27.5	16.6 - 20.3	-
Muffler to Tail Exhaust Pipe Nut	28 - 47	21 - 35	-
Resonance Flap Mounting Bolt	9 - 11	-	80 - 97

CHANGED BY	
EFFECTIVE DATE	
AFFECTED VIN	