SECTION 1

ENGINE

SECTION 1A

ENGINE GENERAL INFORMATION

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SECTION 1B1

M162 ENGINE MECHANICAL

CAUTION: 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.

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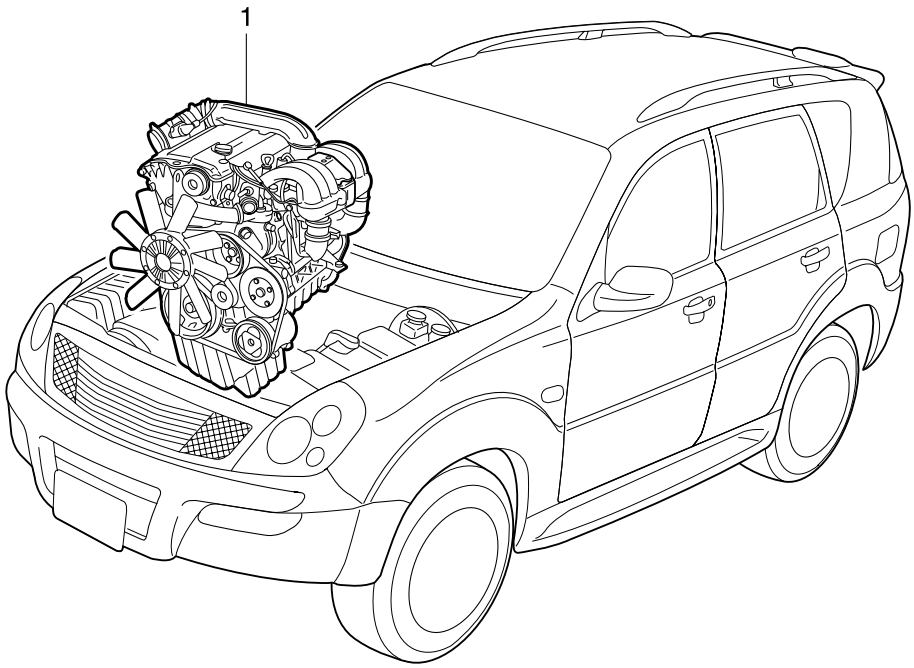
REPAIR INSTRUCTIONS

ON-VEHICLE SERVICE

ENGINE ASSEMBLY



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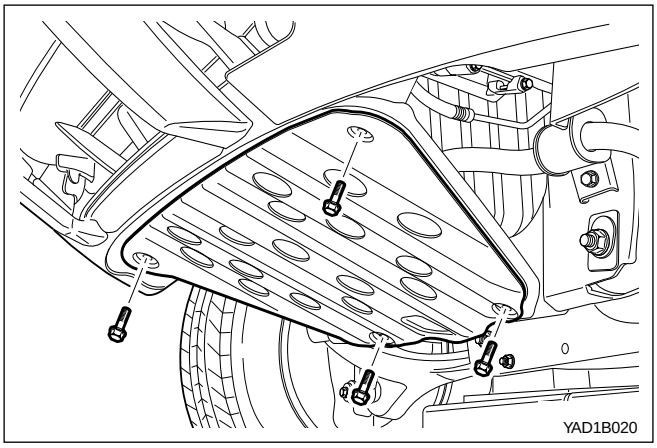
1 Engine Assembly

Tools Required

000 589 10 99 01 Torque Wrench
000 589 40 37 00 Hose Clamp
112 589 00 72 00 Oil Extractor

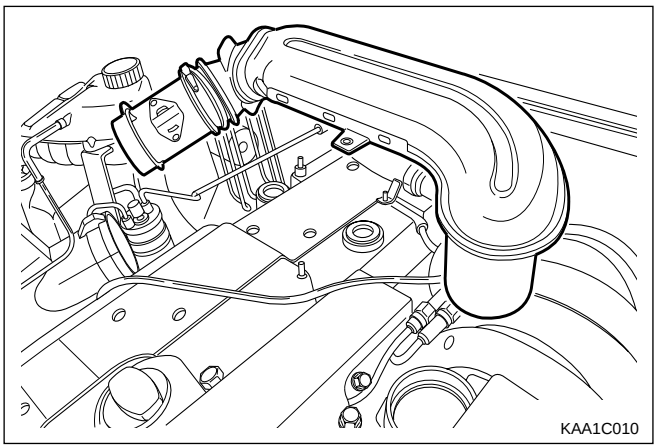

YAD1B020

Removal & Installation Procedure

1. Disconnect the negative terminal of battery.
2. Remove the hood.
3. Remove the under cover.

Installation Notice

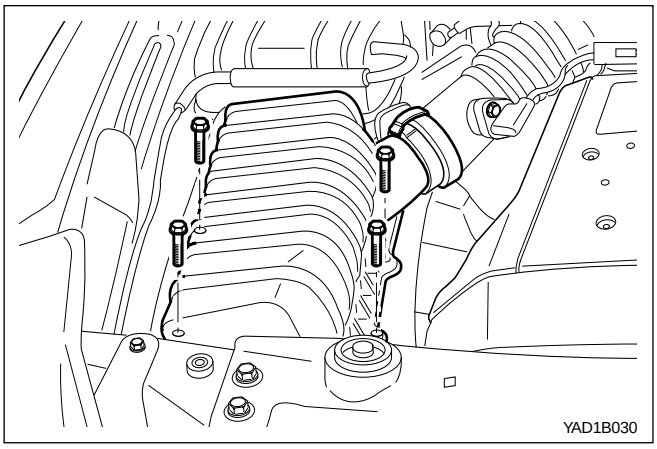
Tightening Torque	28 - 47 N•m (21 - 35 lb-ft)


KAA1C010

4. Disconnect the Hot Film Air Mass (HFM) sensor connector.
5. Disconnect the HFM sensor from the air filter housing.
6. Remove the intake air duct mounting nuts.

Installation Notice

Tightening Torque	9 - 11 N•m (80 - 97 lb-in)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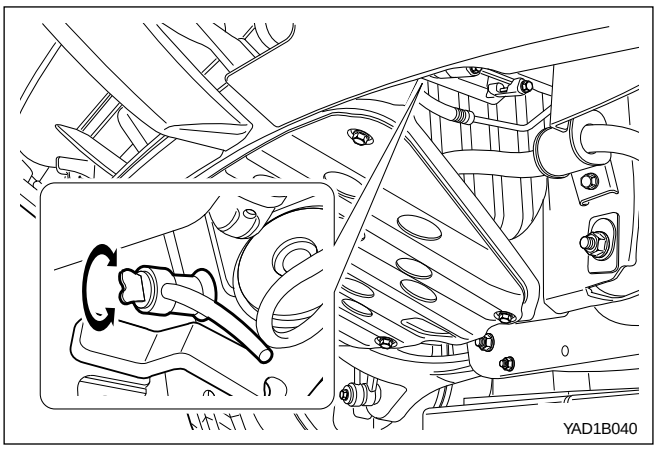
7. Remove the air cleaner cover. Remove the mounting bolts and air cleaner housing and element assembly.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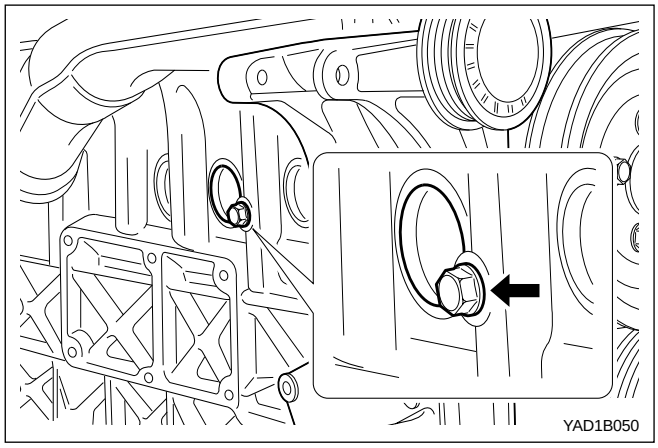
8. Loosen the radiator drain cock and drain the coolant.

   Notice: Open the coolant reservoir cap.

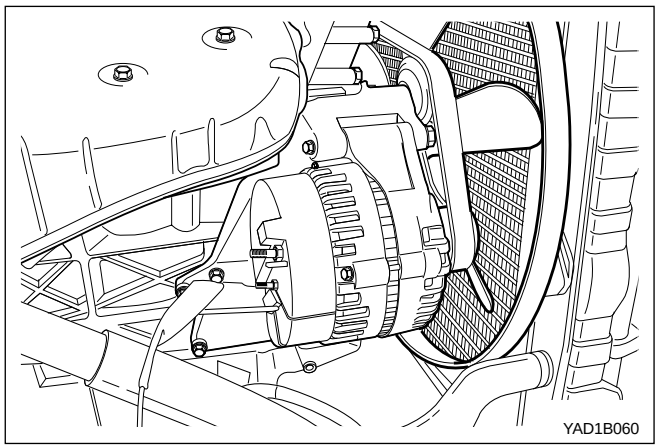


9. Loosen the cylinder block drain plug and then drain the coolant completely.

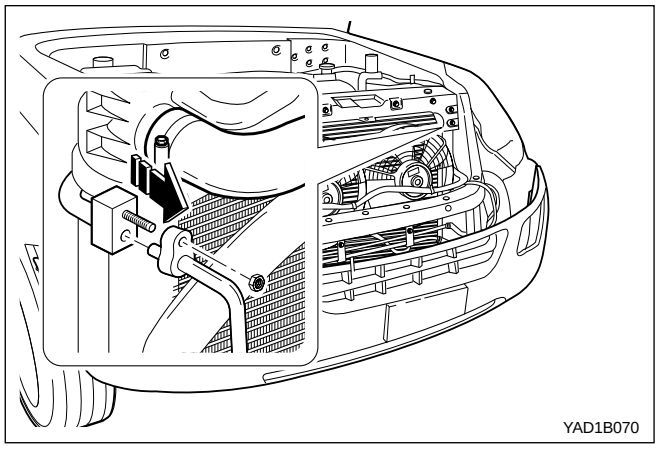
Installation Notice

Tightening Torque	30 N•m (22 lb-ft)

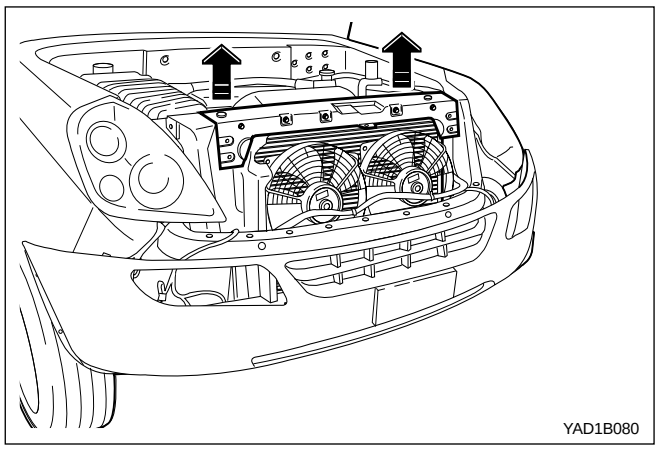
Replace the seal before installation of the drain plug.



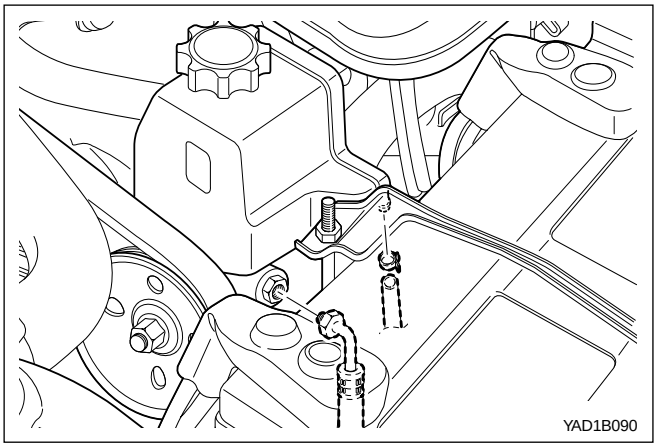
10. Remove the cooling fan shroud. Refer to *Section 1D, Engine Cooling.*



11. Disconnect the each hose from radiator.



12. Remove the upper mounting bolts of radiator and then remove the radiator.

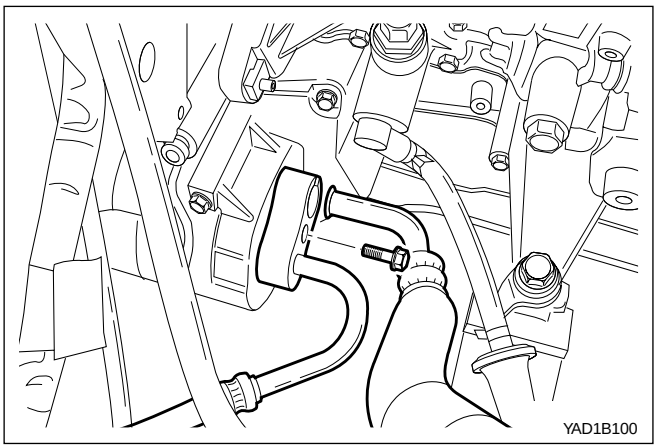


13. Remove the hydraulic pipe of power steering.

Installation Notice

Tightening Torque	40 - 50 N•m (30 - 37 lb-ft)

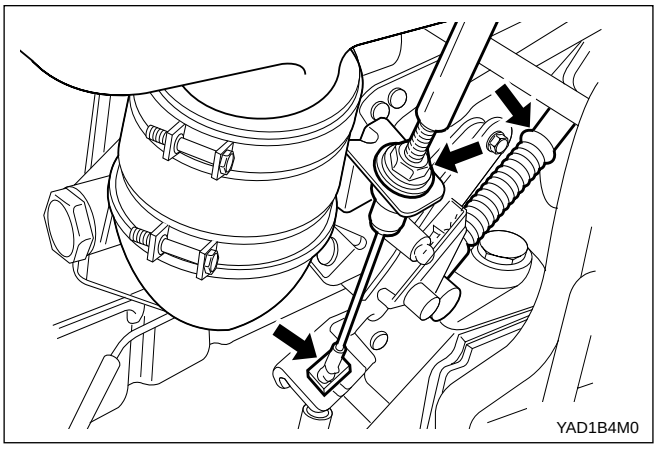
Completely drain the oil.



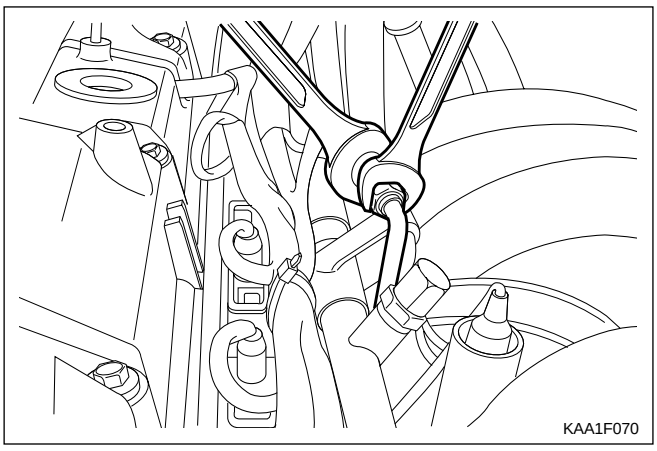
14. Discharge the refrigerant from A/C system, and disconnect the discharge pipe and suction pipe from the compressor. Refer to *Section 7B, Manual Control Heating, Ventilation, and Air Conditioning System.*

Installation Notice

Tightening Torque	20 - 30 N•m (15 - 22 lb-ft)



15. Remove the acceleration control cable and automatic transmission pressure cable.

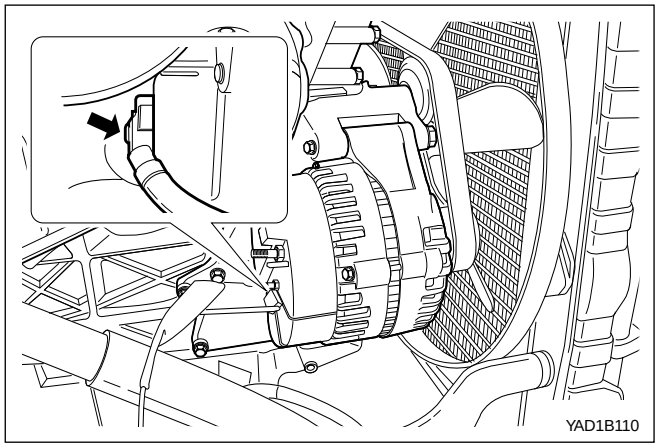


16. Remove the fuel feed and return line.

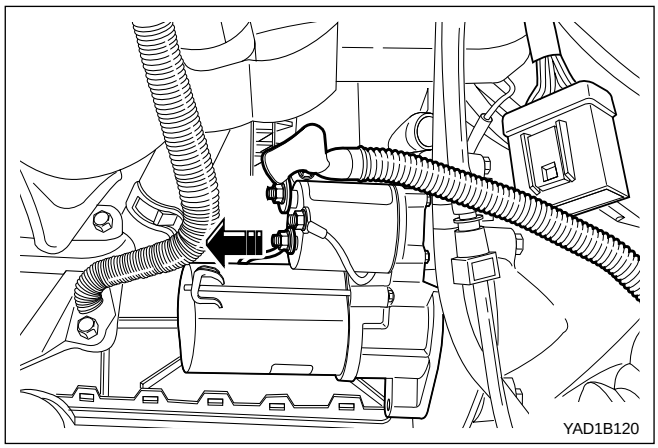
Installation Notice

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

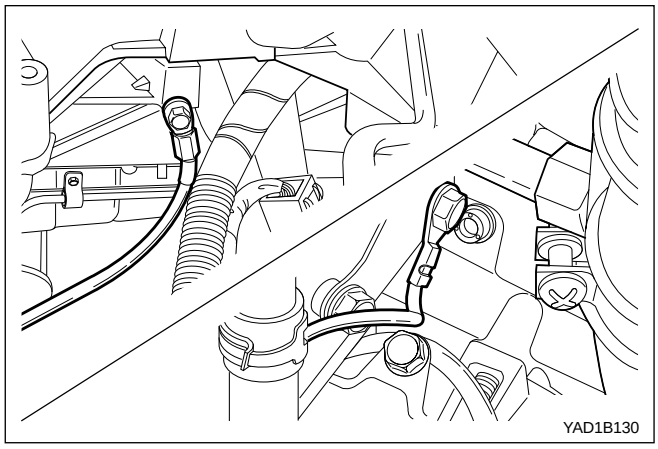
Before removing the fuel lines, release the pressure in the fuel system.



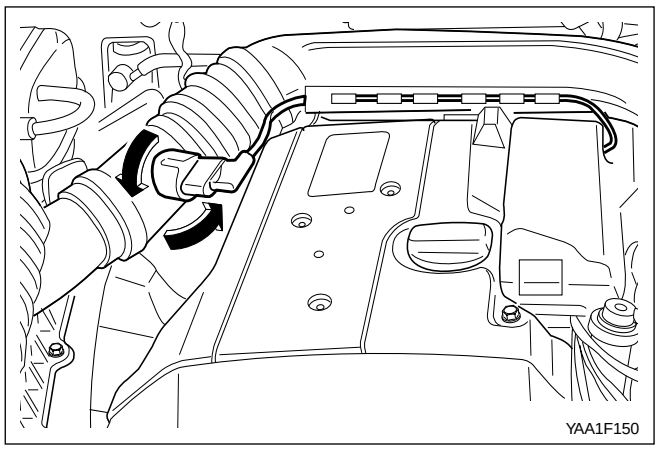
17. Disconnect the terminals from the generator.



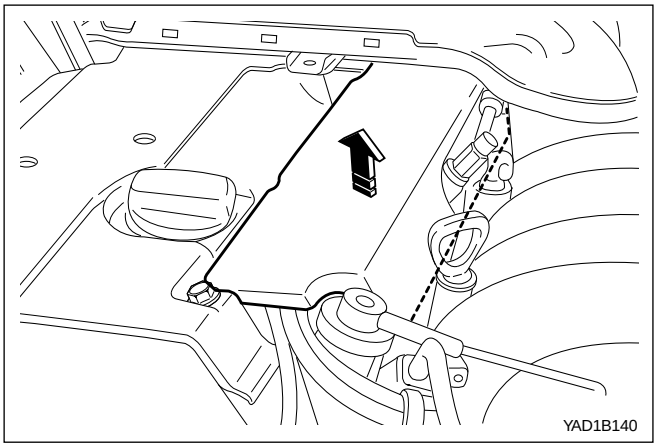
18. Disconnect the terminal from starter motor and remove the starter motor.
19. Disconnect the engine main harness ground.



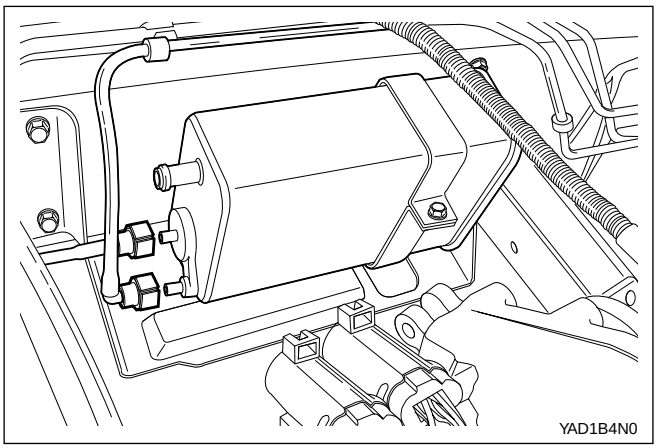
20. Disconnect the engine ground wire.



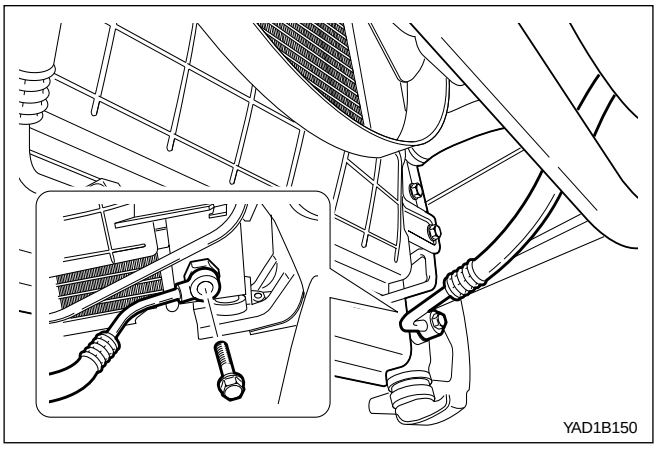
21. Disconnect following sensors connector.
    - Coolant temperature sensor.
    - 2 knock sensors.
    - Camshaft and crankshaft sensors.



22. After removing the ignition coil cover, disconnect the ignition coil connector.
23. Remove the harness cover and disconnect the 6 injection valve connectors. Disconnect the main harness.



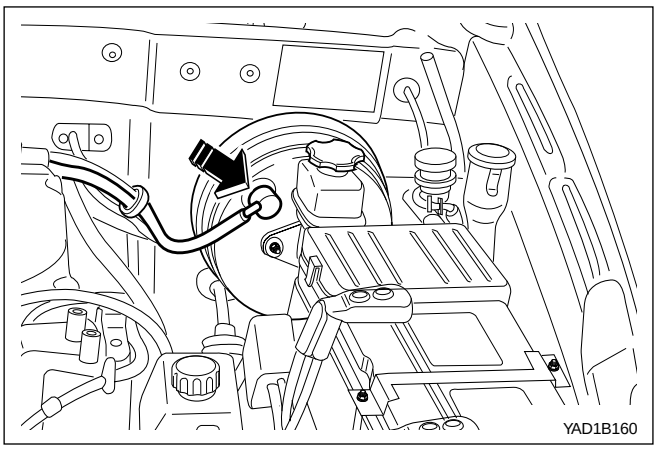
24. Separate the hose toward engine from canister purge solenoid valve.



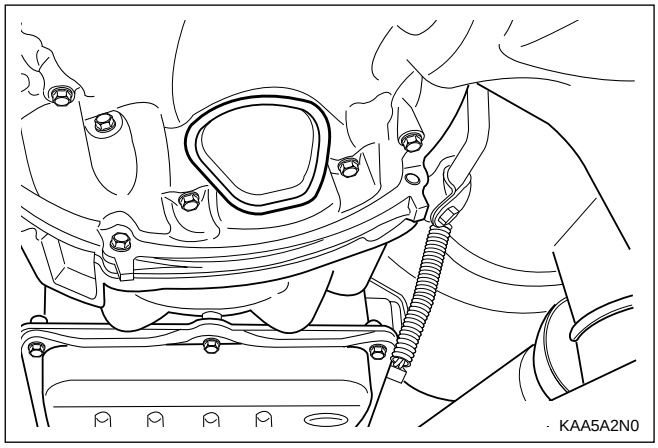
25. Remove the automatic transmission oil cooler line.

Installation Notice

Tightening Torque	25 - 35 N•m (18 - 26 lb-ft)



26. Separate the vacuum hose for brake booster.
27. Separate the other vacuum hoses.

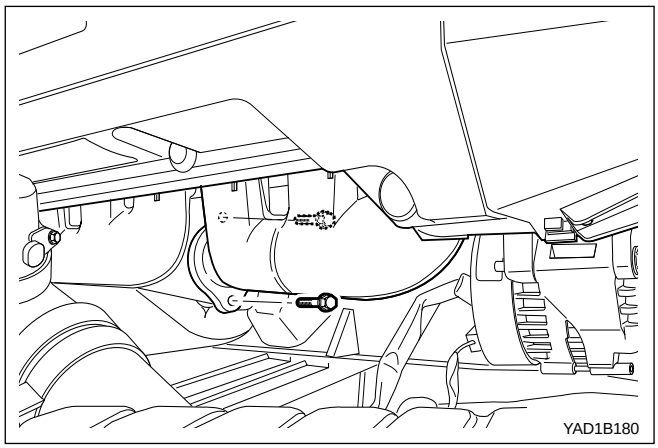


28. Remove the service hole cover in the engine block.
29. Put the alignment mark for installation, and remove the six mounting bolts for torque converter from drive plate through the service hole by rotating the engine and remove the torque converter.

Installation Notice

Tightening Torque	42 N•m (31 lb-ft)

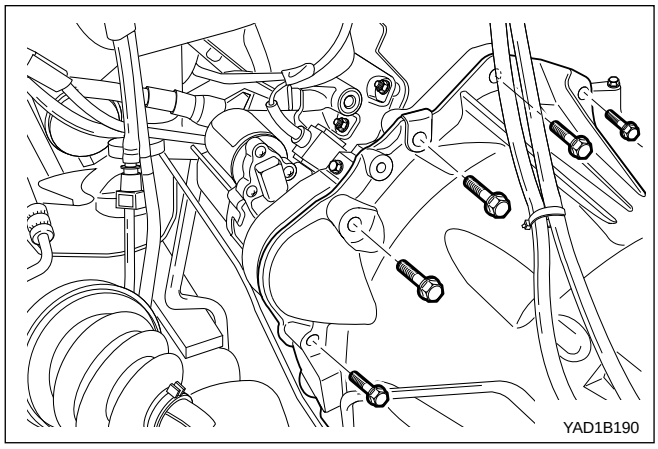
- Screw the six bolts mounting the torque converter through the service hole by using a mirror and rotating the engine.



30. Remove the exhaust manifold and exhaust pipe.

Installation Notice

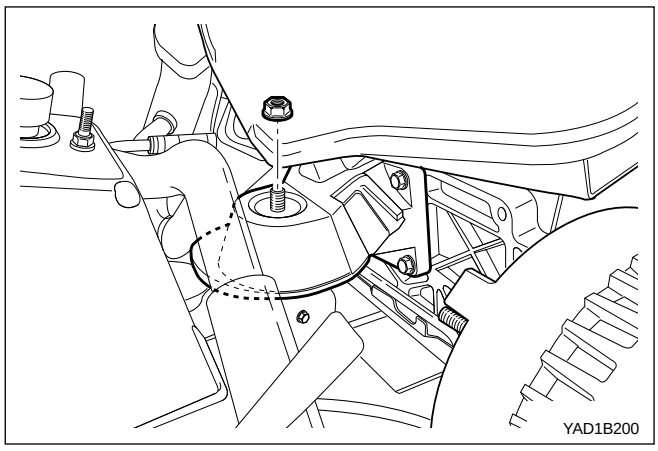
Tightening Torque	30 N•m (22 lb-ft)



31. Remove the transmission mounting bolts and separate the transmission from the engine.

Installation Notice

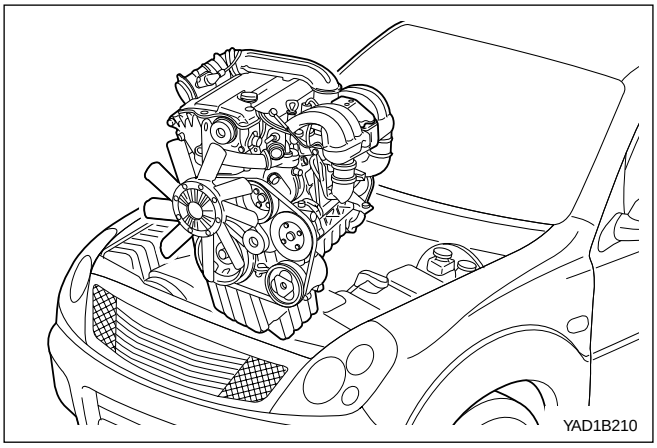
Tightening Torque	54 - 68 N•m (40 - 50 lb-ft)



32. Install a chain to the bracket of engine, by using a hoist or crane.
33. Remove the engine mounting bracket nuts.

Installation Notice

Tightening Torque	Upper : 70 N•m (52 lb-ft)
	Lower : 38 N•m (28 lb-ft)

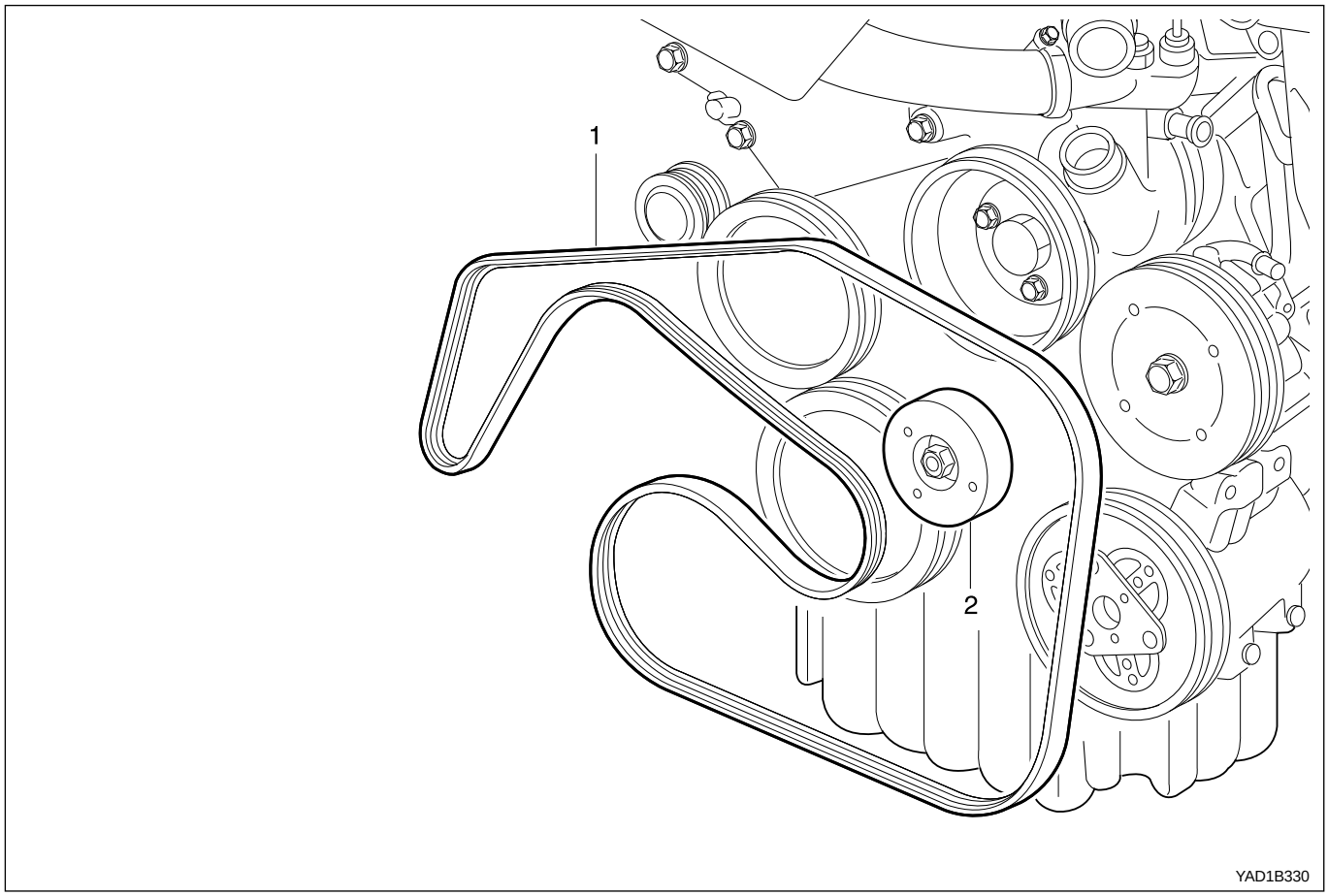


34. Carefully separate the engine assembly from the vehicle.
35. Installation should follow the removal procedure in the reverse order.

POLY V-BELT AND TENSIONING DEVICE

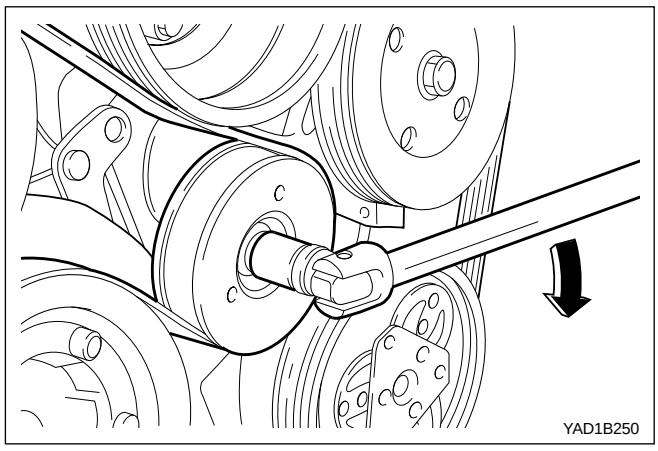
POLY V - BELT

Preceding Work : Removal of cooling fan



1 Poly V-belt

2 Belt Tensioning Pulley



Removal & Installation Procedure

1. Release the belt tension by turning the belt tensioning pulley nut clockwise.

   Installation Notice

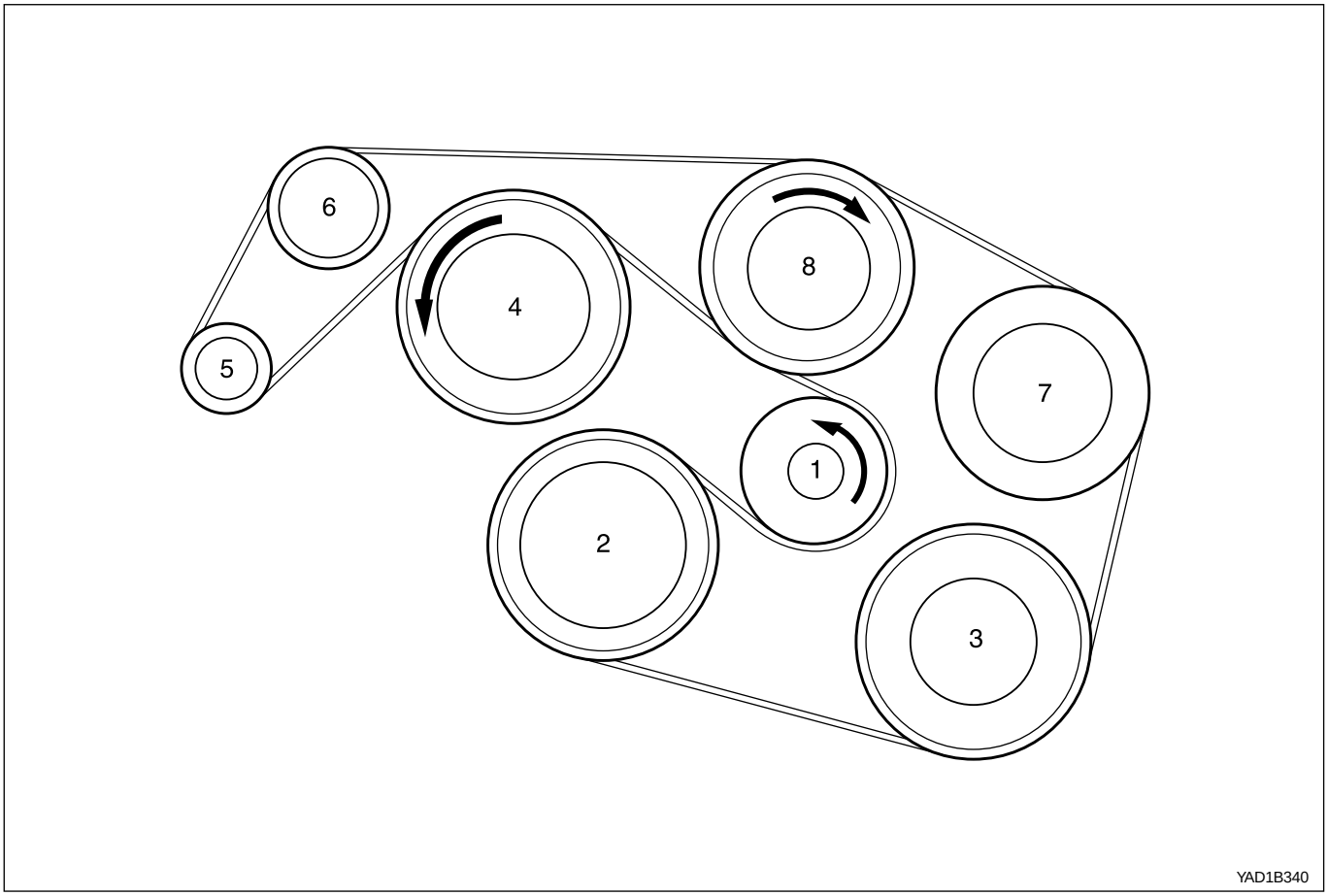
Tightening Torque	40.5 - 49.5 N•m (29.9 - 36.5 lb-ft)

2. Remove the poly v-belt.

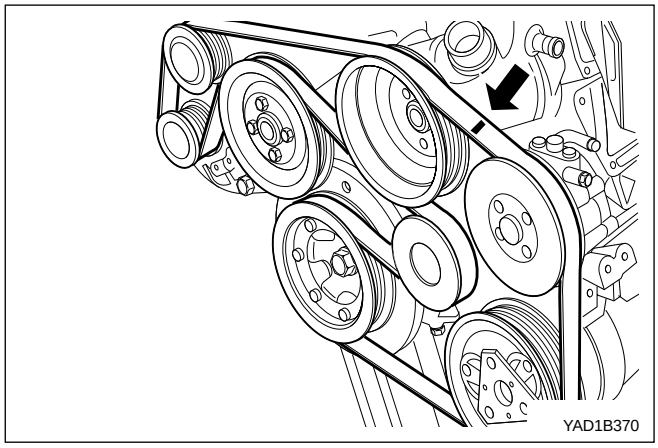
   Notice: Check the belt for damage and tensioning pulley bearing point for wear and replace them if necessary.

3. Install the belt by turning the nut of tensioning pulley clockwise.

Poly V-Belt Arrangement



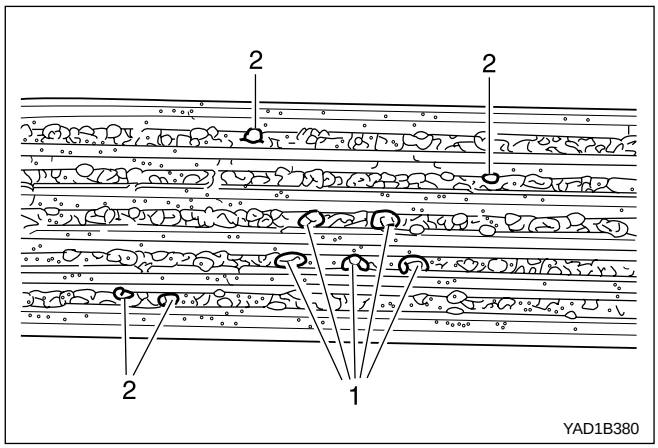
1 Belt Tensioning Pulley
2 Crankshaft Belt Pulley
3 A/C Compressor Pulley
4 Cooling Fan Pulley
5 Generator Pulley
6 Idler
7 Power Steering Pump Pulley
8 Cooling Fan and Water Pump Pulley


YAD1B370

POLY V - BELT INSPECTION

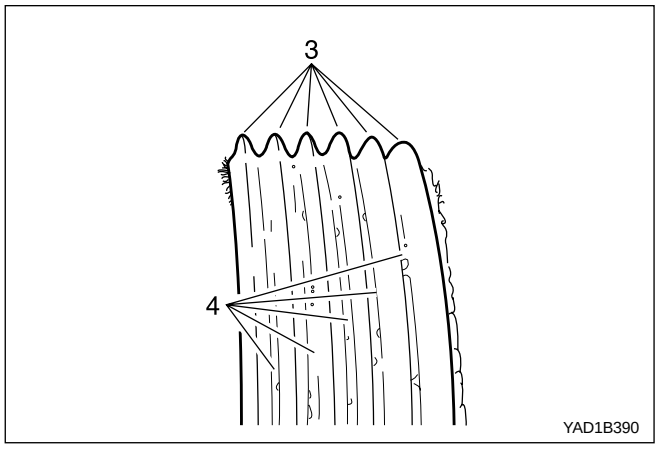
- Make marks on the belt with chalk.
- Rotate the engine and check the belt for damage.

Notice: If one of the following types of damages is found, replace the belt.



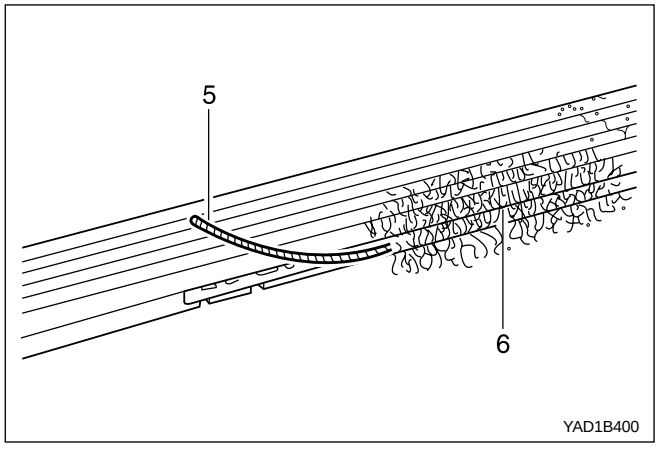
YAD1B380

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



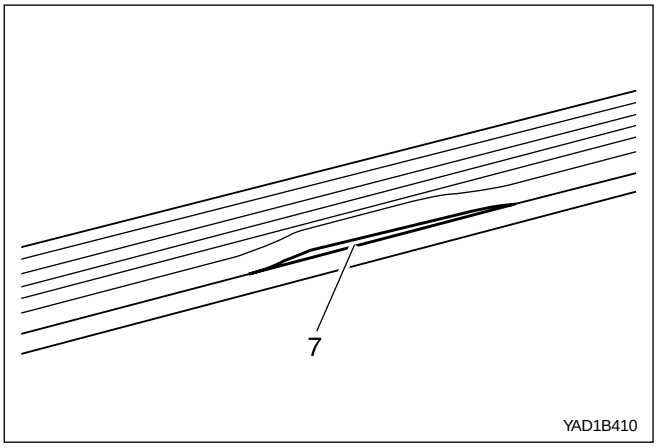
YAD1B390

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

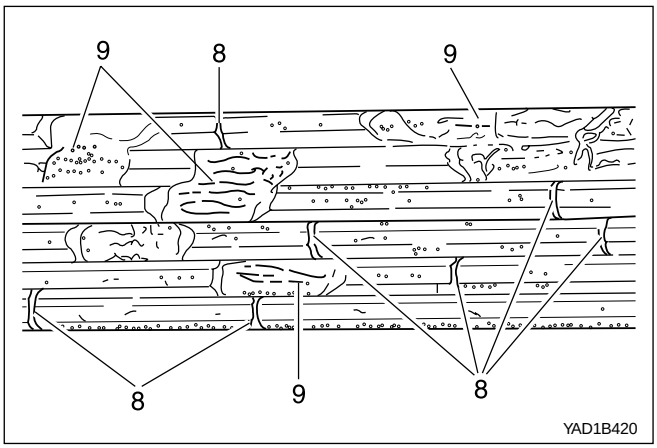


YAD1B400

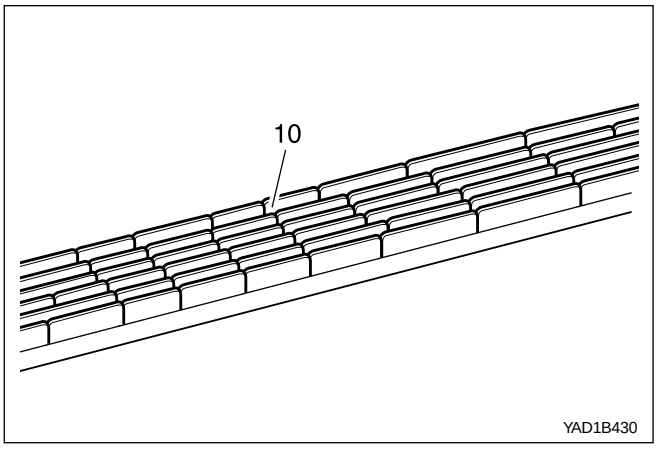
5. Cord torn out at the side.
6. Outer cords frayed.



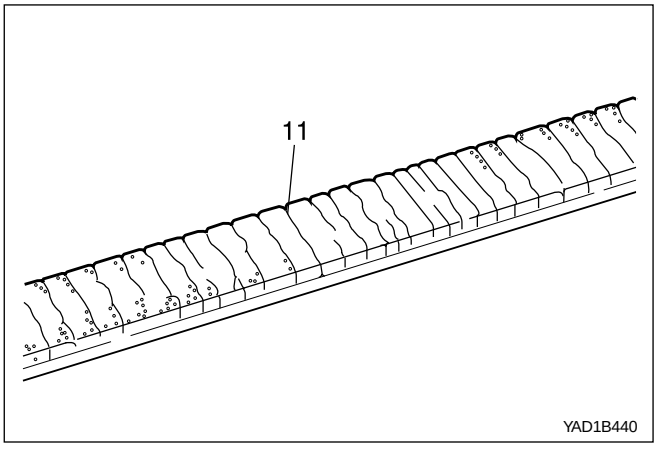
7. Rib detached from the base of belt.



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



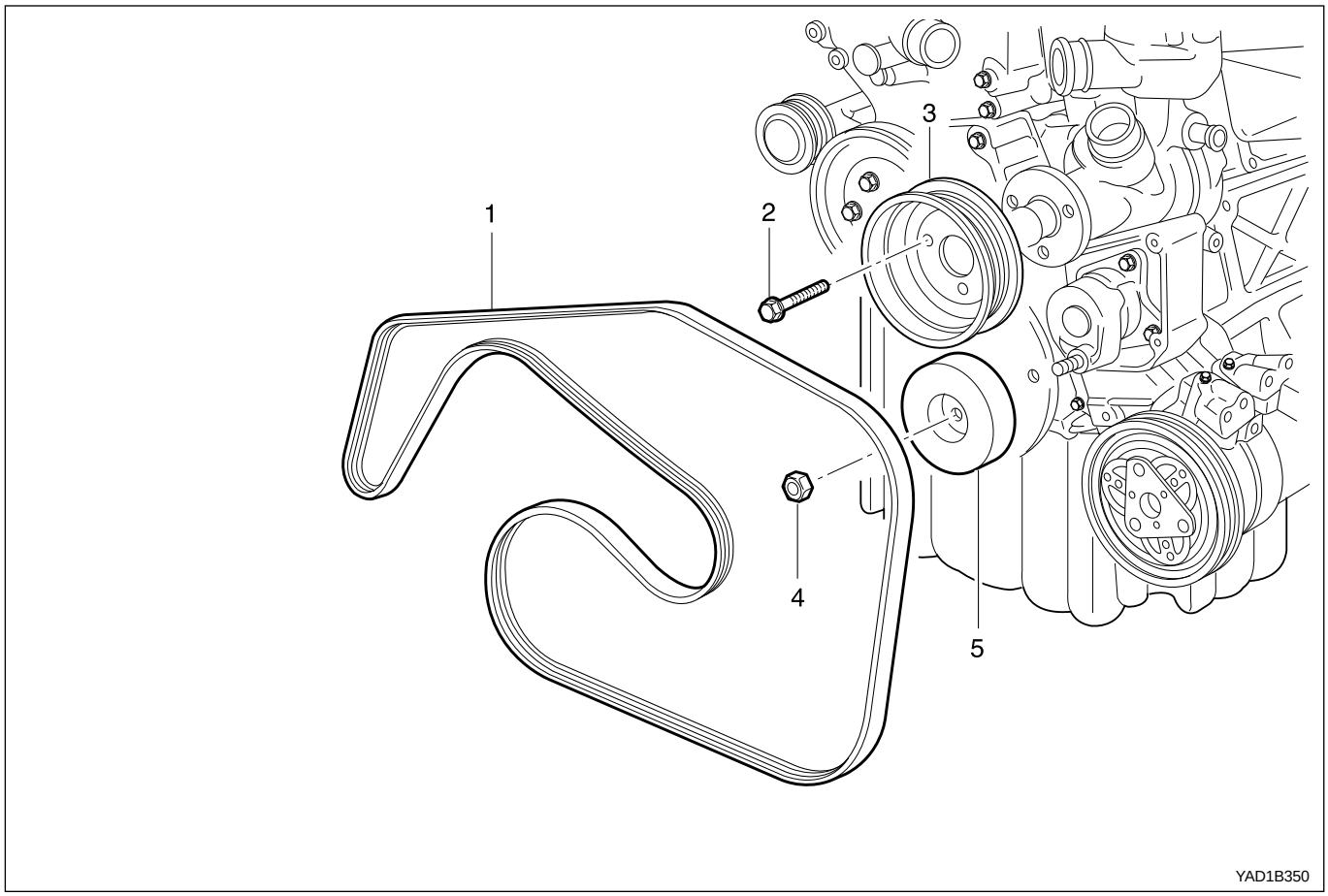
10. Splits across several ribs.



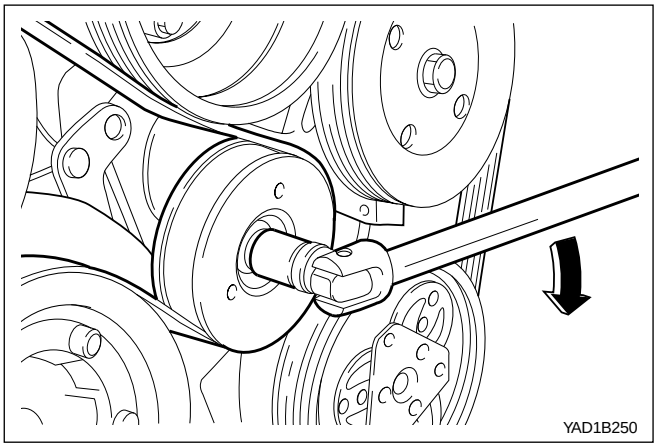
11. Splits across the back of the belt.

TENSIONING DEVICE

Preceding Work : Removal of poly v-belt



1 Belt (L = 2245)
2 Bolt Combi (M8 x 14, 3 pieces) + Washer
..... 22.5-27.5 N•m (16.6-20.3 lb-ft)
3 Water Pump Pulley
4 Nut
5 Belt Tensioning Pulley

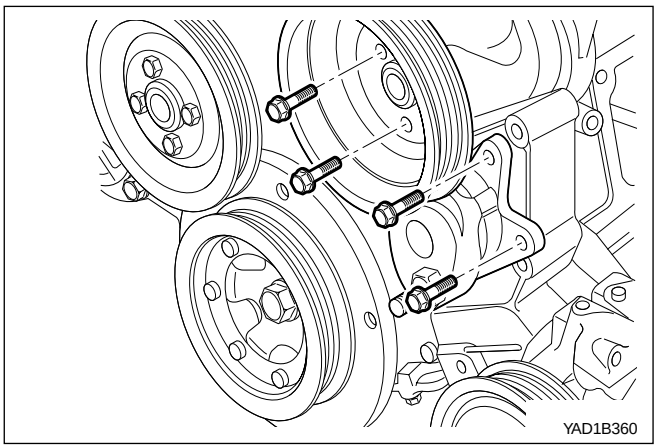


Removal & Installation Procedure

1. Remove the poly v-belt.
2. Remove the tensioning pulley by turning its mounting nut counter clockwise as shown in figure.

Installation Notice

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



3. Remove the bolts and remove the water pump pulley.

Installation Notice

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

4. Remove the mounting bolts(M8 x 30, 3 pieces) at the tensioning device, and remove the tensioning device.

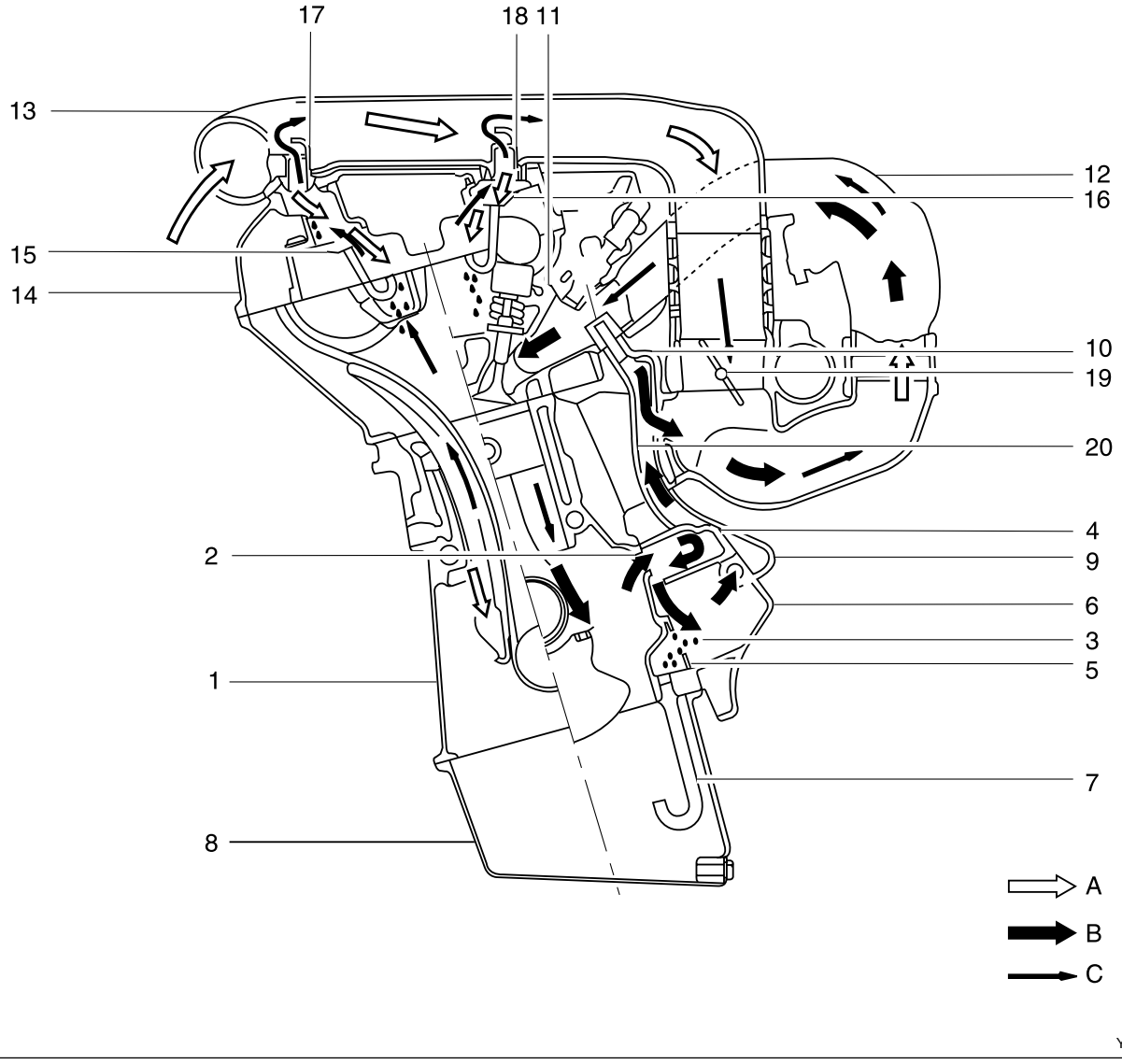
Installation Notice

Tightening Torque	26 - 32 N•m (19 - 24 lb-ft)

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

CRANK CASE AND CYLINDER HEAD

CRANKCASE VENTILATION SYSTEM



1 Crankcase
2 Air Admission Port in Crankcase
3 Oil Drain Port
4 Filter
5 Gasket
6 A/C Bracket
7 Oil Drain Pipe
8 Oil Pan
9 Air Admission Line
10 Vent Line
11 Restriction Hole (Diameter = 2 mm)
12 Intake Manifold
13 Intake Air Duct (Cross Pipe)
14 Cylinder Head Cover
15 Oil Separator
16 Oil Separator
17 Air Admission and Vent Connection
18 Air Admission and Vent Connection
19 Throttle Valve
20 Vent Line

A Fresh Air
B Blowby Gas in Partial Load
C Blowby Gas in Full Load

Operation at Idling and Mid-Load

- It show that the throttle valve (19) is closed or very partially opened and the vacuum pressure in intake manifold is high.

  The blowby gas in the crankcase in partial load flows into the intake manifold through the vent line (20) after passing the air conditioner bracket (6) and the filter (4). The air reentered into the intake manifold will be dilluted on the flow through the restriction hole (11) in the vent line (10).

  The circulated engine oil is separated at the air conditioner bracket (6) and then returns into the oil pan through the drain pipe (7).

  The vacuum pressure generated at the crankcase sucks fresh air from intake air line(13) through the air admission and vent connection (17, 18).

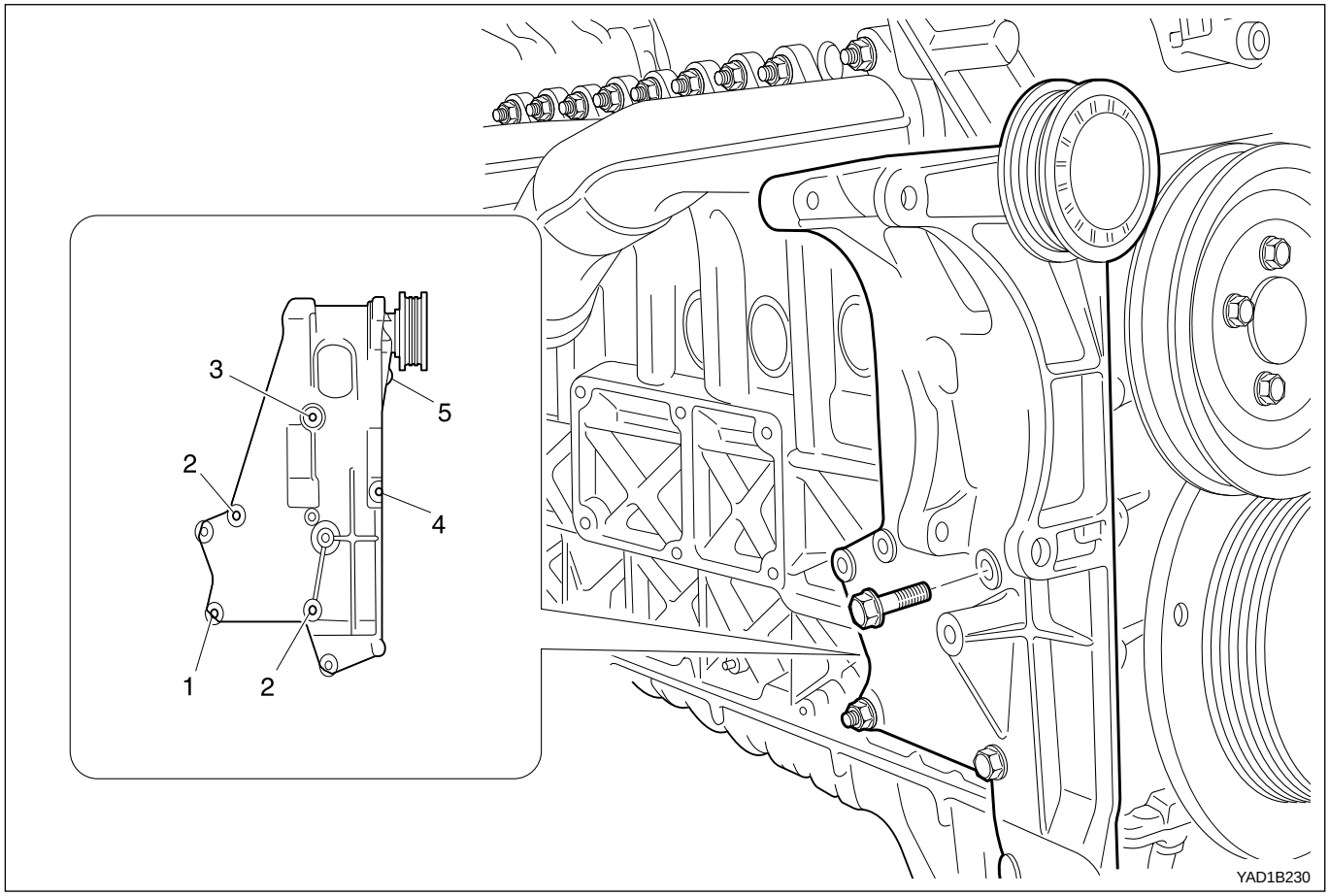
  The fresh air prevents engine oil from being contaminated and the air admission and vent connection (17, 18) is designed to control the rapid pressure changes in intake air line (13).

Operation at Full-Load

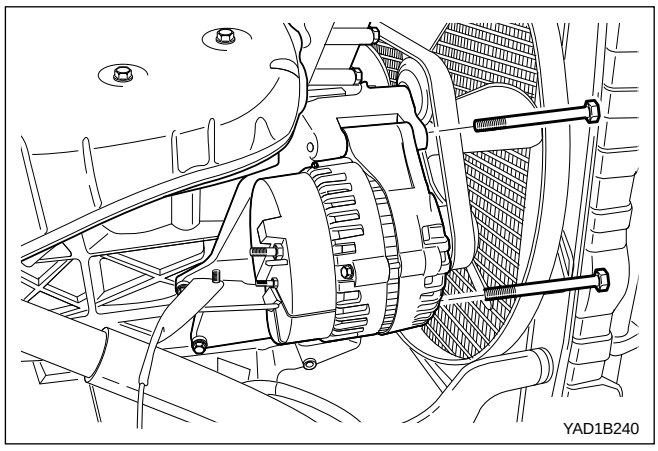
- The throttle valve (19) is fully opened.

  All the blowby gases flow into the intake air duct (13) after passing through the oil separator (15,16) of the cylinder head cover (14) when fully loaded. This dilluted air will be supplied to the combustion chamber through the intake manifold (12).

GENERATOR



1 Nut (M8) .....22.5-27.5 N•m (16.5-20.5 lb-ft)
2 Bolt (M8 x 30, 3 pieces)
.....22.5-27.5 N•m (16.5-20.5 lb-ft)
3 Bolt (M8 x 40, 1 piece)
.....22.5-27.5 N•m (16.5-20.5 lb-ft)
4 Bolt (M8 x 70, 1 piece)
.....22.5-27.5 N•m (16.5-20.5 lb-ft)
5 Bolt (M8 x 75, 1 piece)
.....22.5-27.5 N•m (16.5-20.5 lb-ft)



Removal & Installation Procedure

1. Remove the drive belt.
2. Remove the generator.
3. Unscrew the generator carrier bolts and remove the carrier.

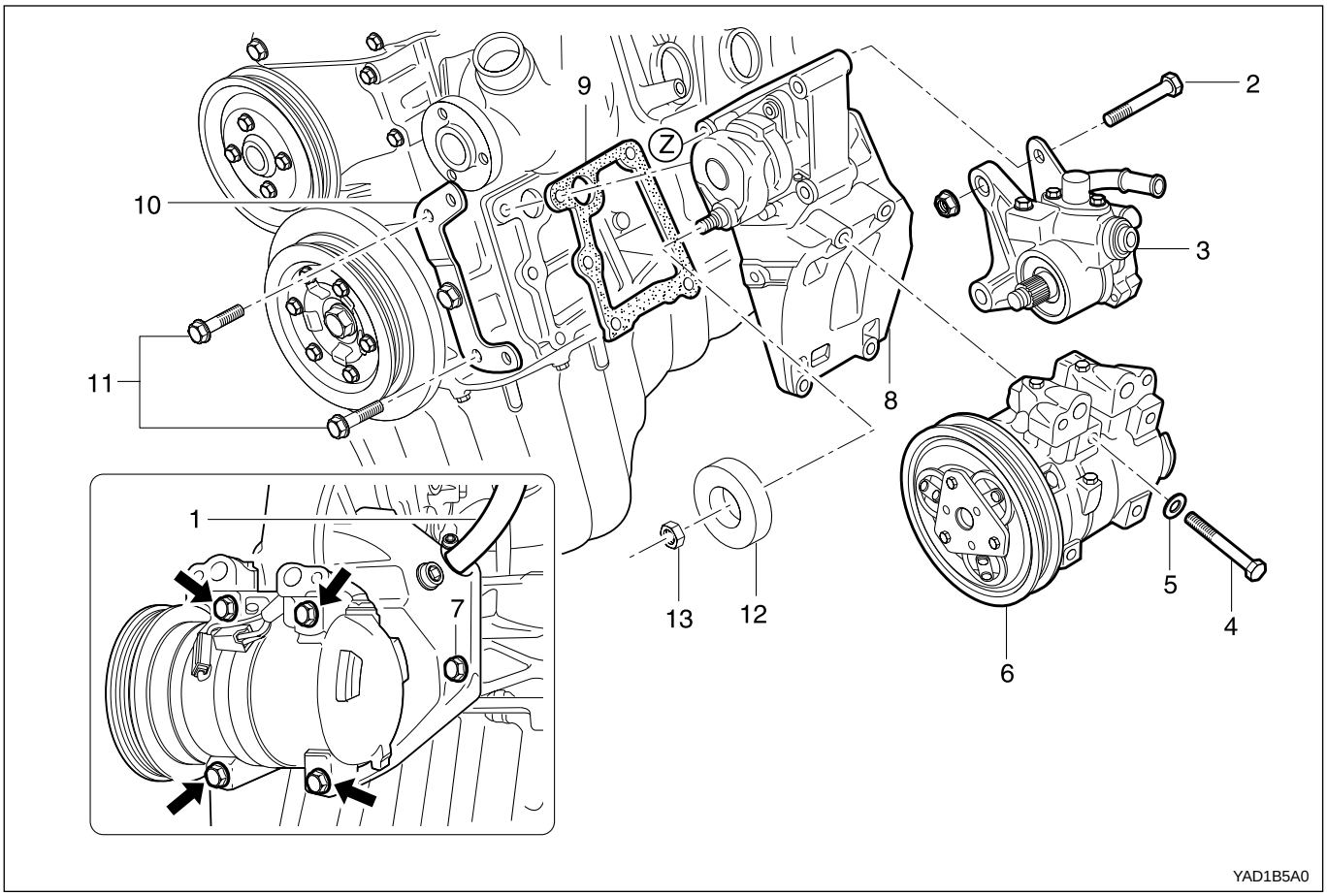
Installation Notice

Tightening Torque	25 N•m (18 lb-ft)

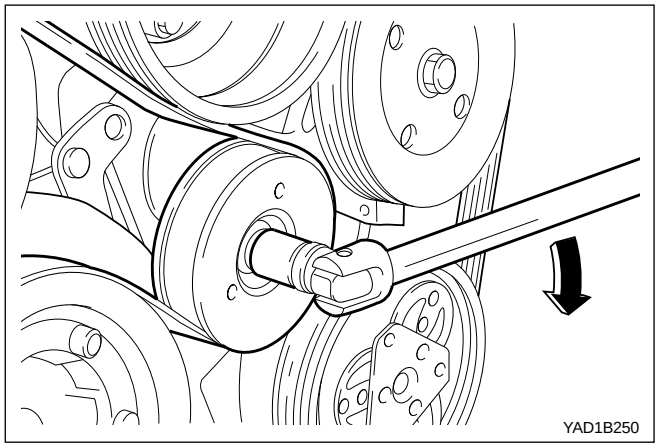
4. Installation should follow the removal procedure in the reverse order.

POWER STEERING PUMP AND A/C BRACKET

Preceding Work : Removal of cooling fan and shroud



1 Vent Hose
2 Bolt (M8 x 91, 2 pieces)
..... 22.5-27.5 N•m (16.5-20.5 lb-ft)
3 Power Steering Pump
4 Bolt (M8 x 105, 4 pieces)
..... 22.5-27.5 N•m (16.5-20.5 lb-ft)
5 Washer
6 A/C Compressor
7 Bolt (M8 x 40, 3 pieces, M8 x 95, 2 pieces)
..... 22.5-27.5 N•m (16.5-20.5 lb-ft)
8 A/C Bracket
9 Gasket..... Replace
10 Bracket
11 Bolt (M8 x 22, 2 pieces)
..... 22.5-27.5 N•m (16.5-20.5 lb-ft)
12 Tensioning Pulley
13 Nut ..... 40.5-49.5 N•m (29.9-36.5 lb-ft)


YAD1B250

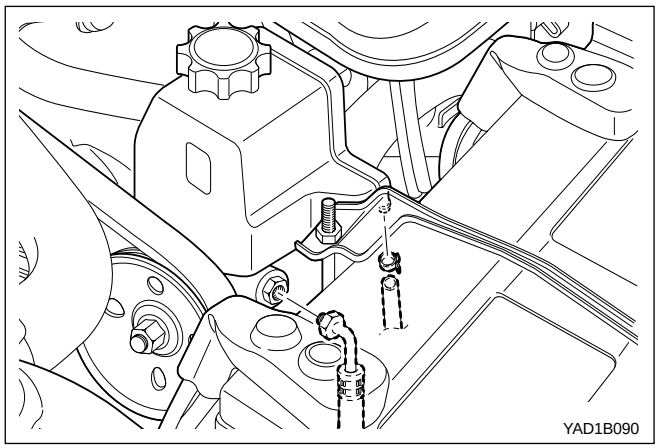
Removal & Installation Procedure

1. Remove the belt tensioning pulley.

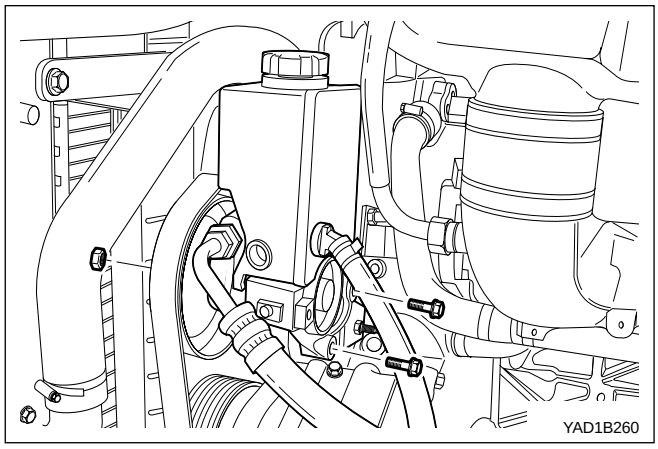
   Installation Notice

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

   Pull the tensioning pulley clockwise as shown in the figure.


YAD1B090

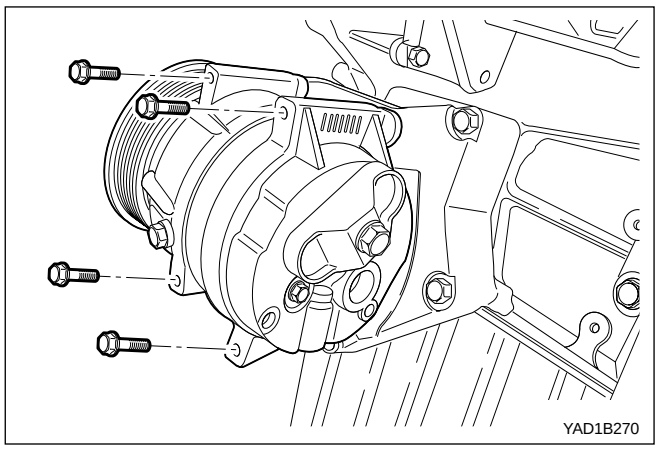
2. Disconnect the hydraulic pipe of the power steering pump and drain the oil.


YAD1B260

3. Unscrew the bolts and remove the steering pump.

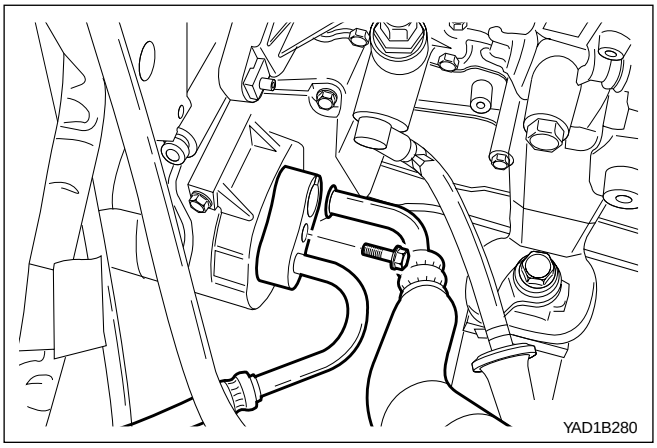
   Installation Notice

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


YAD1B270

4. Remove the compressor after disconnecting the wiring connector and refrigerant pipe of A/C compressor.

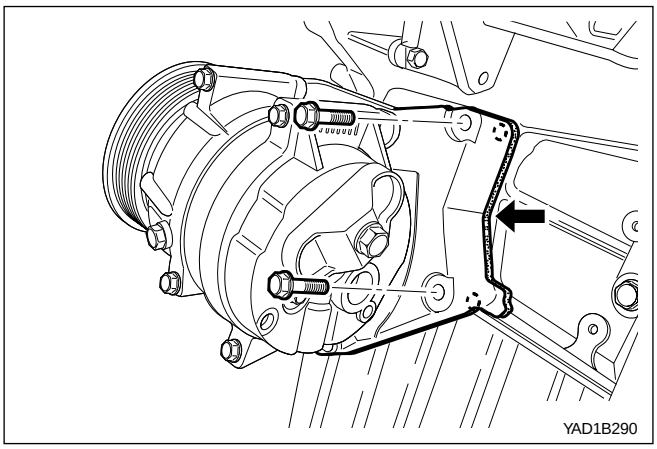
   Notice: Discharge all the refrigerant before removing the pipes.



5. Disconnect the vent hose from the A/C bracket.

Installation Notice

Tightening Torque	20 - 30 N•m (15 - 22 lb-ft)



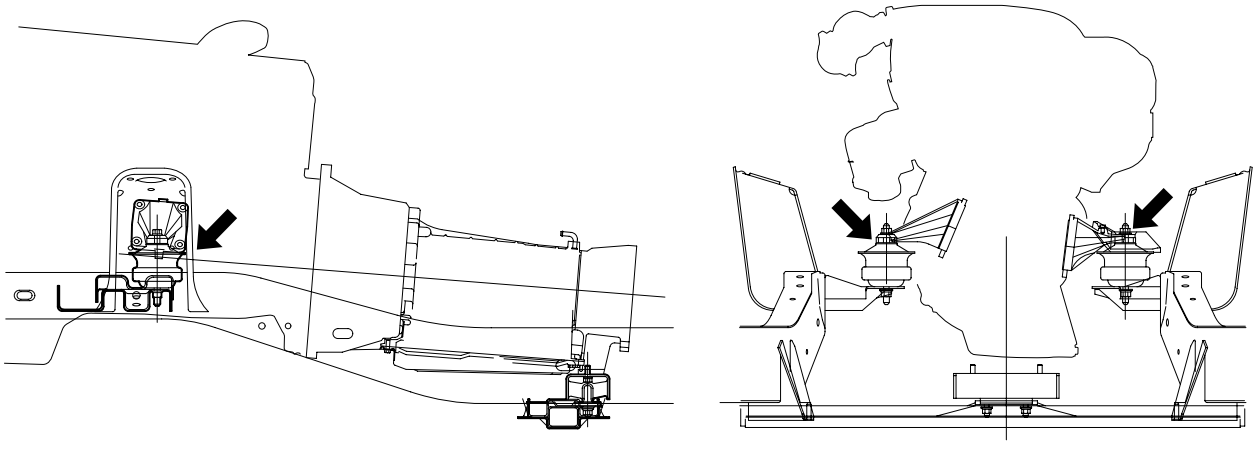
6. Unscrew all the mounting bolts and remove the A/C bracket and the gasket.

Installation Notice

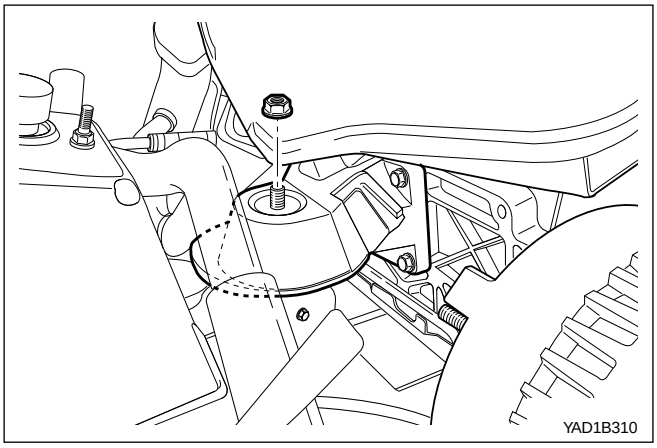
TighteningTorque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

7. Clean the sealing surface.
8. Replace the gasket with new one.
9. Installation should follow the removal procedure in the reverse order.
10. Check the oil leakage by operating the engine after installation.

ENGINE MOUNT



YAD1B300

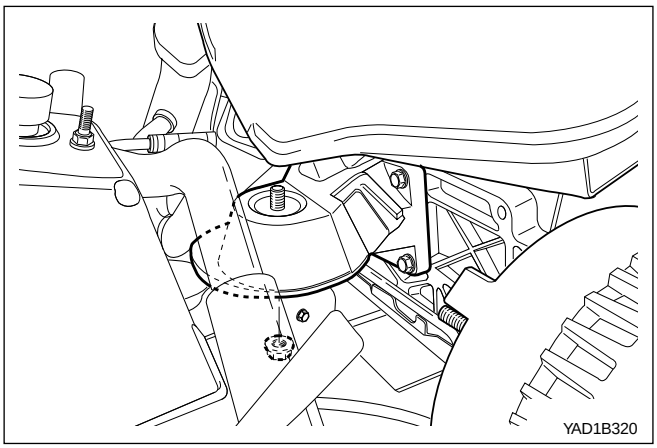


Removal and Installation Procedure

1. Unscrew the upper engine mounting nut.

   Installation Notice

Tightening Torque	70 N•m (52 lb-ft)



2. Unscrew the lower engine mounting nut.

   Installation Notice

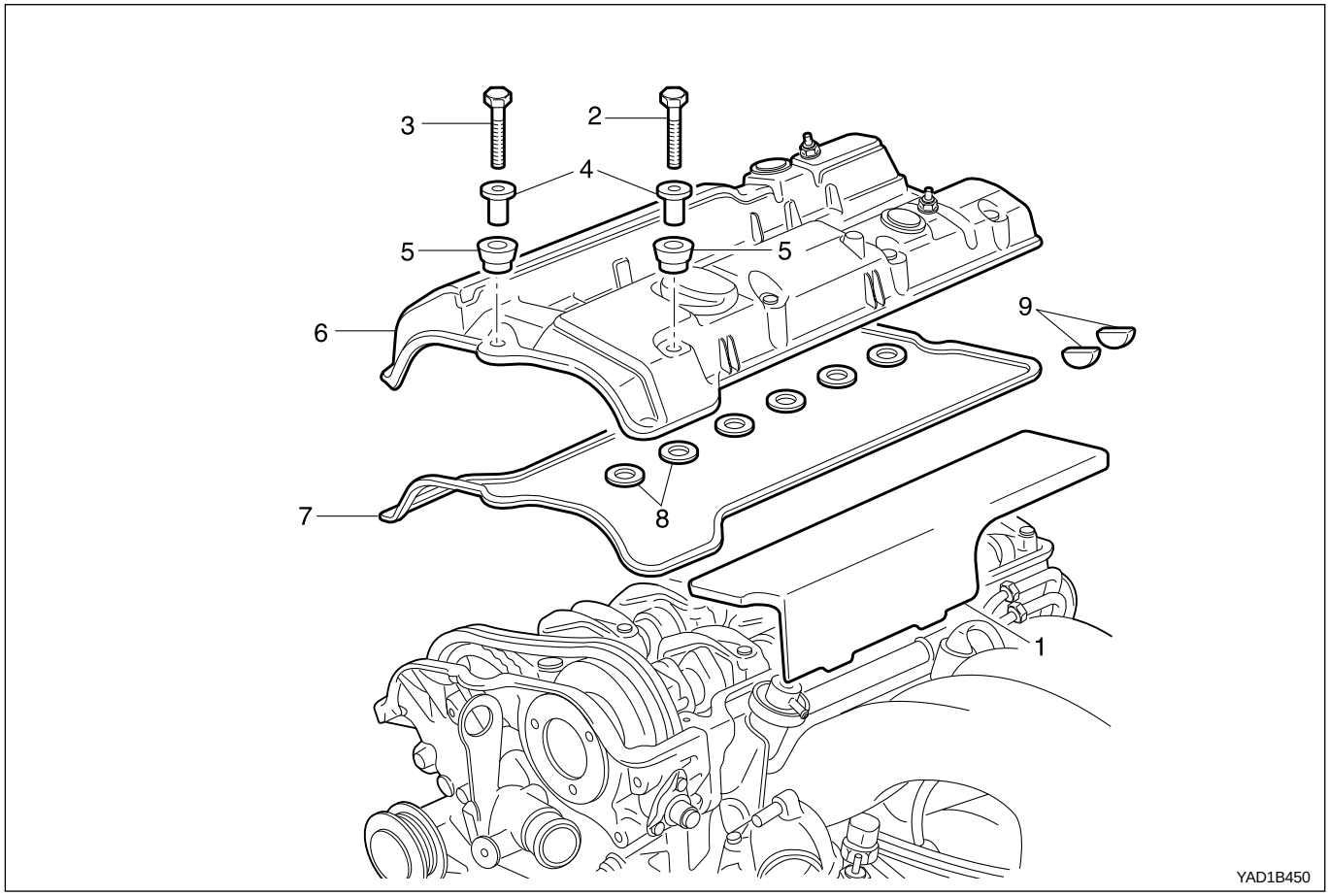
Tightening Torque	38 N•m (28 lb-ft)

3. Remove the hydraulic engine mounting insulator.

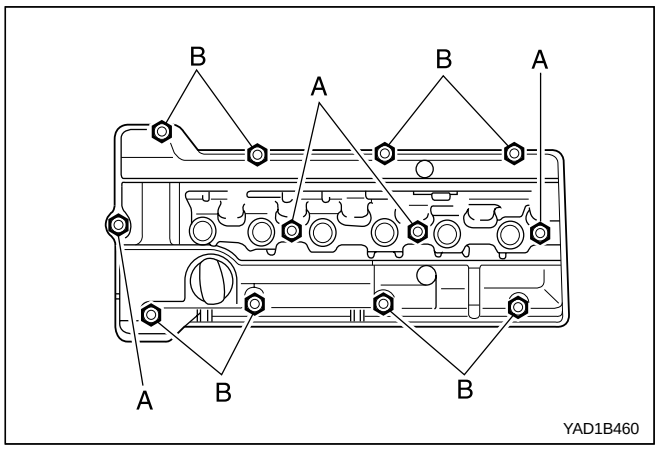
   Notice: If the insulator is spotted with oil, replace the hydraulic insulator asseambly.

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

CYLINDER HEAD COVER

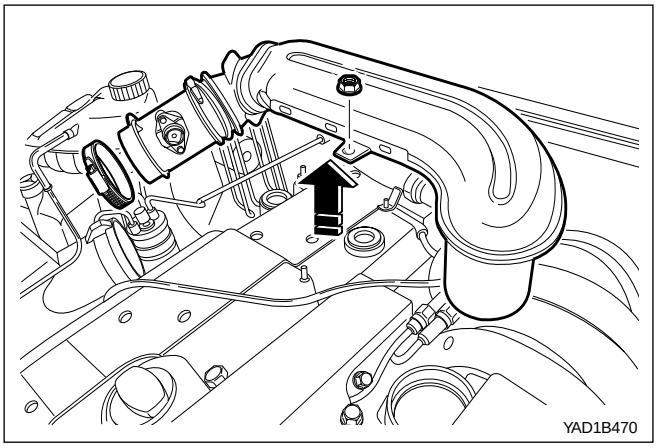


1 Ignition Cable Dust Cover
2 Bolt (M6 x 65, 8 pieces)
..... 9-11 N•m (80-97 lb-in)
3 Bolt (M6 x 50, 4 pieces)
..... 9-11 N•m (80-97 lb-in)
4 Spacer Sleeve
5 Thrust Piece
6 Cylinder Head Cover
7 Gasket..... Replace
8 Spart Plug Hole Seal ..... Replace
9 Camshaft Seal ..... Replace



Composition of The Cylinder Head Cover Bolts

A. M6 x 50, 4 Pieces - Bolts + Washers
B. M6 x 65, 8 Pieces - Bolts + Washers

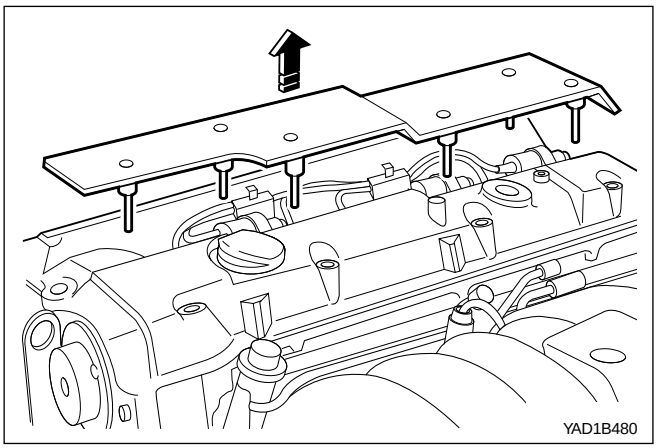


Removal & Installation Procedure

1. Remove the intake air duct.

Installation Notice

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

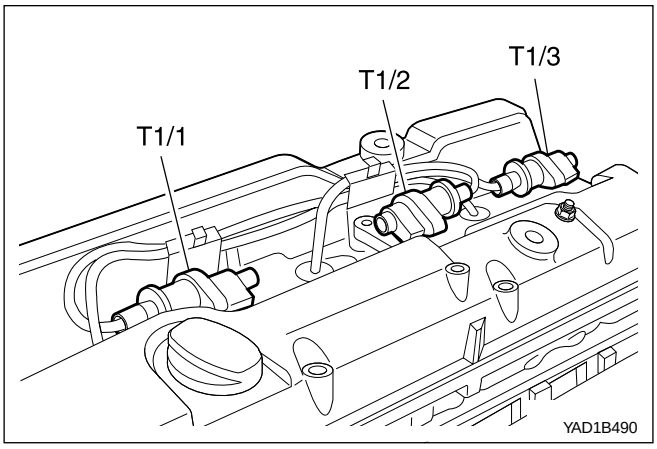


2. Remove the spark plug cover.

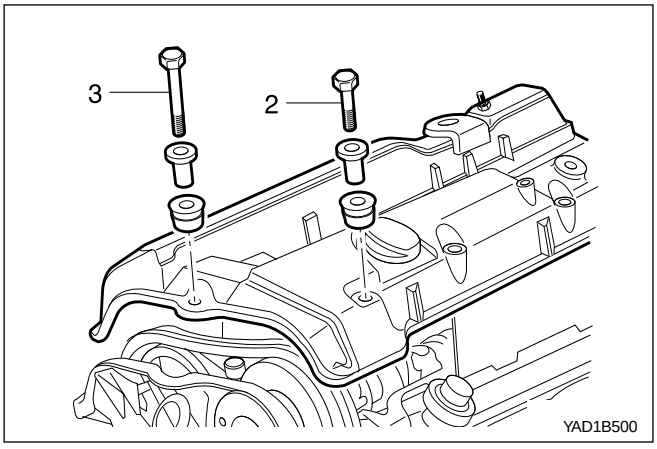
Installation Notice

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

Unscrew the seven (M6 x 60) bolts and remove the spark plug cover.



3. Remove the spark plug connector and ignition cable.



4. Unscrew all the bolts (2,3) and remove the head cover and the gasket.

Installation Notice

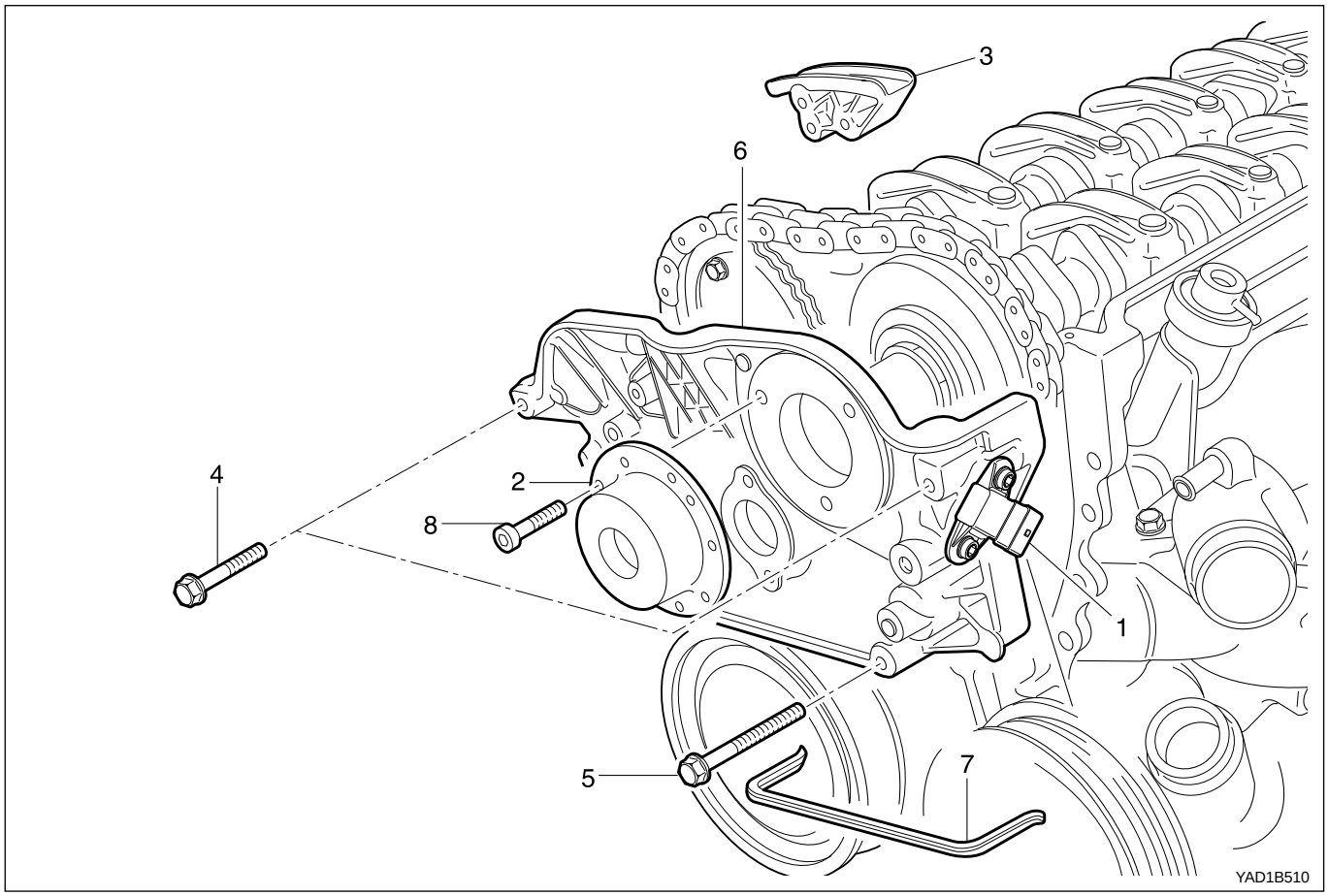
Tightening Torque	9 - 11 N•m (80 - 97 lb-in)

Replace the gasket with a new one if necessary.

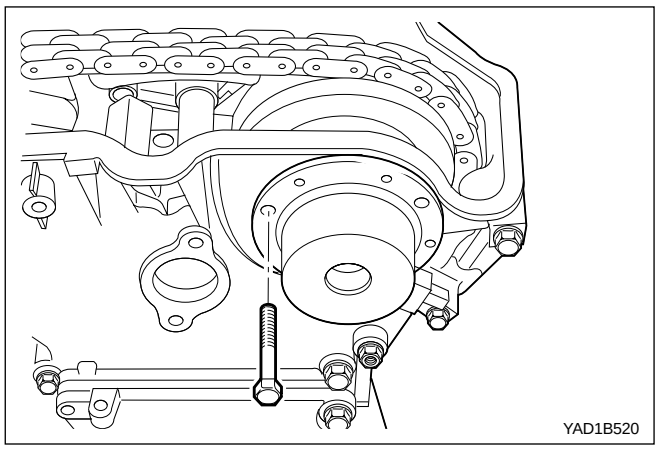
5. Installation should follow the removal procedure in the reverse order.
6. Check for oil leaks by operating the engine.

CYLINDER HEAD FRONT COVER

Preceding Work : Removal of cylinder head cover
Removal of coolant connection fitting



1 Camshaft Position Sensor
2 Camshaft Actuator
3 Upper Guide Rail
4 Bolt (M6 x 60, 3 pieces)
..... 22.5-27.5 N•m (16.6-20.3 lb-ft)
5 Bolt (M8 x 80, 3 pieces)
..... 22.5-27.5 N•m (16.6-20.3 lb-ft)
6 Front Cover
7 Rubber Gasket ..... Replace
8 Bolt (M6 x 16, 3 pieces)
..... 9-11 N•m (80-97 lb-in)

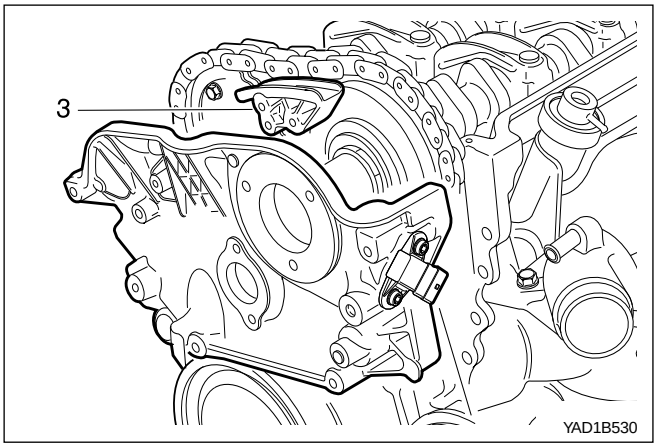


Removal & Installation Procedure

1. Remove the camshaft actuator.

Installation Notice

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



2. Remove the cylinder head front cover (6).

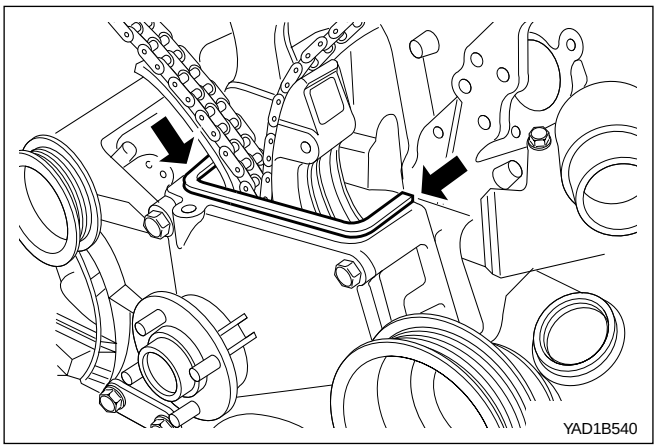
   Installation Notice

Tightening Torque	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 upper guide rail pin and the guide rail (3).

   Notice: Install it while the chain tensioner is loose.



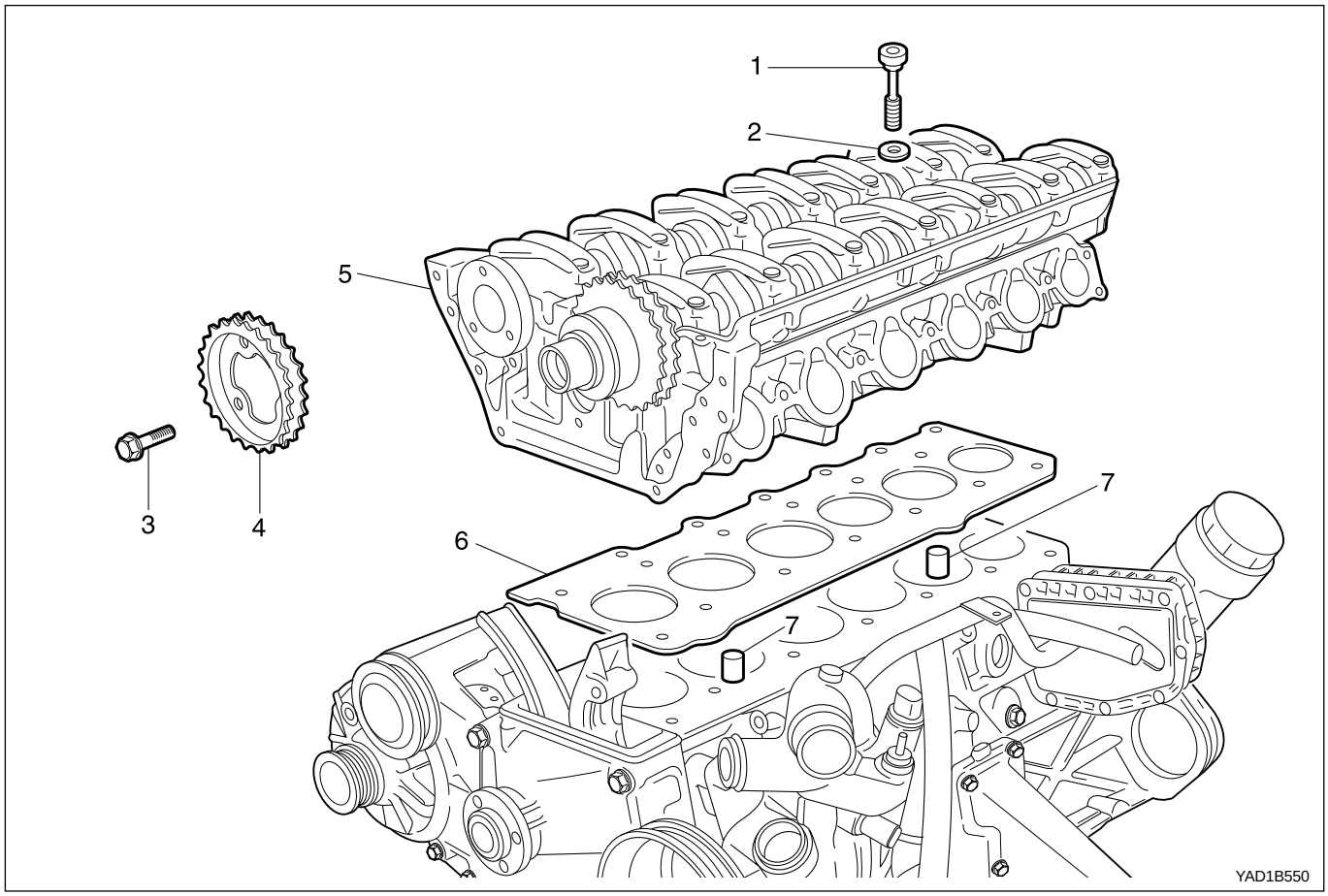
4. Remove the gasket (arrow).

   Notice: Replace the gasket with new one and apply the sealant.

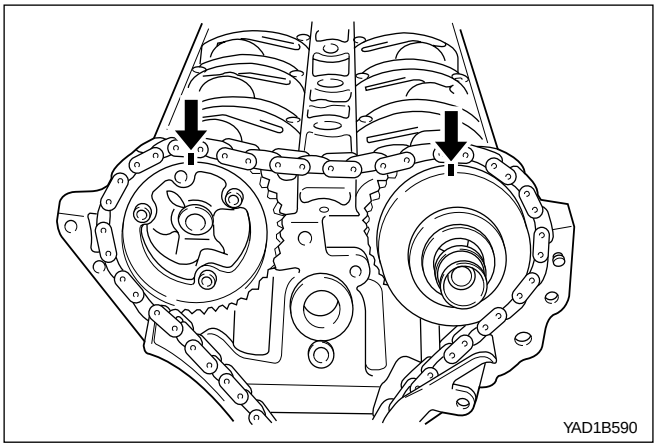
5. Installation should follow the removal procedure in the reverse order.

CYLINDER HEAD

Preceding Work : Removal of cylinder head cover
Removal of cylinder head front cover
Removal of upper intake manifold



1 Cylinder Head Bolt (14 pieces)
..... 1st step 55 N•m (141 lb-ft)
2nd step 90°
3rd step 90°
2 Washers (14 pieces)
3 Flange Bolts (3 pieces)
..... 1st step 18-22 N•m (13-16 lb-ft)
2nd step 90°±5°
4 Exhaust Camshaft Sprocket
5 Cylinder Head
6 Gasket ..... Replace
7 Dowel Sleeve


YAD1B590

Tools Required

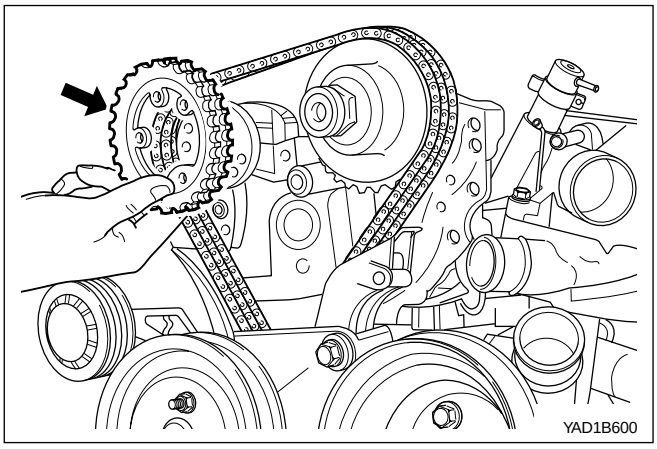
116 589 01 34 00 Threaded Pin
116 589 20 33 00 Sliding Hammer
617 589 00 10 00 Allen Wrench Socket

Removal & Installation Procedure

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

   Notice: Rotate the crankshaft in the normal engine direction.

2. Put the alignment marks (arrows) on the timing chain and camshaft sprocket.
3. Drain the coolant from the crankcase.

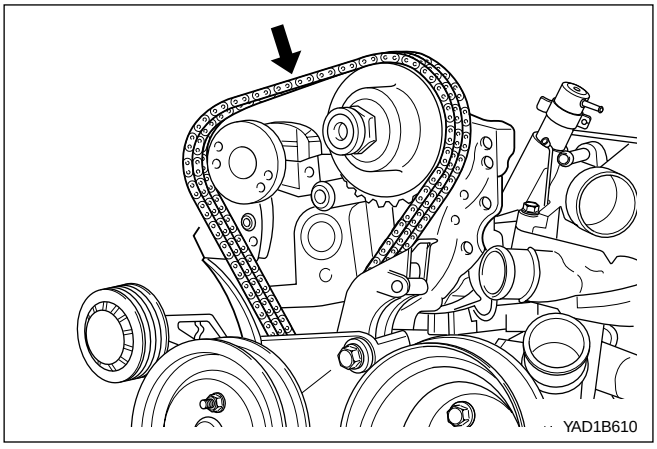

YAD1B600

4. Remove the three flange bolts in the exhaust camshaft sprocket.

   Installation Notice

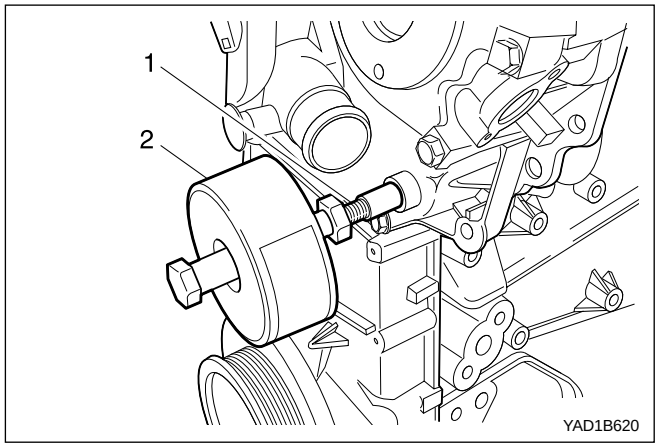
Tightening Torque	1st step: 18 - 22 N•m (13 - 16 lb-ft)
	2nd step: 90° ± 5°

   Do not reuse the removed bolts.

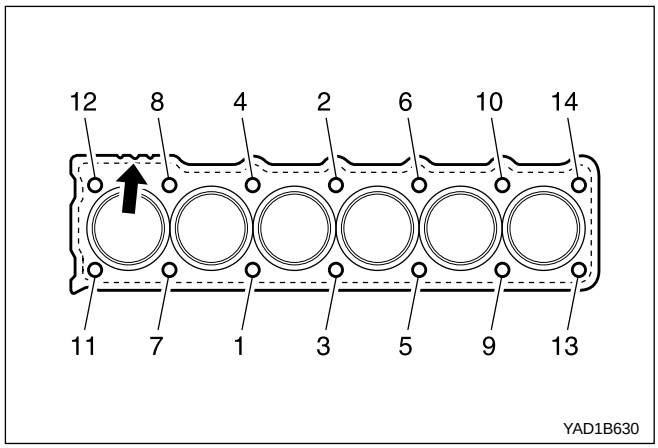

YAD1B610

5. Separate the chain from the camshaft sprockrt.

   Notice: Be careful not to drop the chain into the timing case.



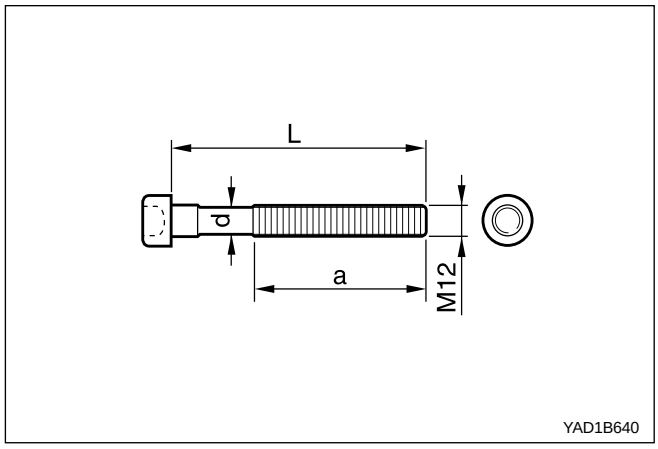
6. Remove the guide rail fixing pin from the cylinder head using the threaded pin 116 589 01 34 00 (1) and sliding hammer 116 589 20 33 00 (2).



7. Remove the cylinder head bolts in numerical order using allen wrench socket 617 589 00 10 00.

Installation Notice

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



8. Check the length of the cylinder head bolt.

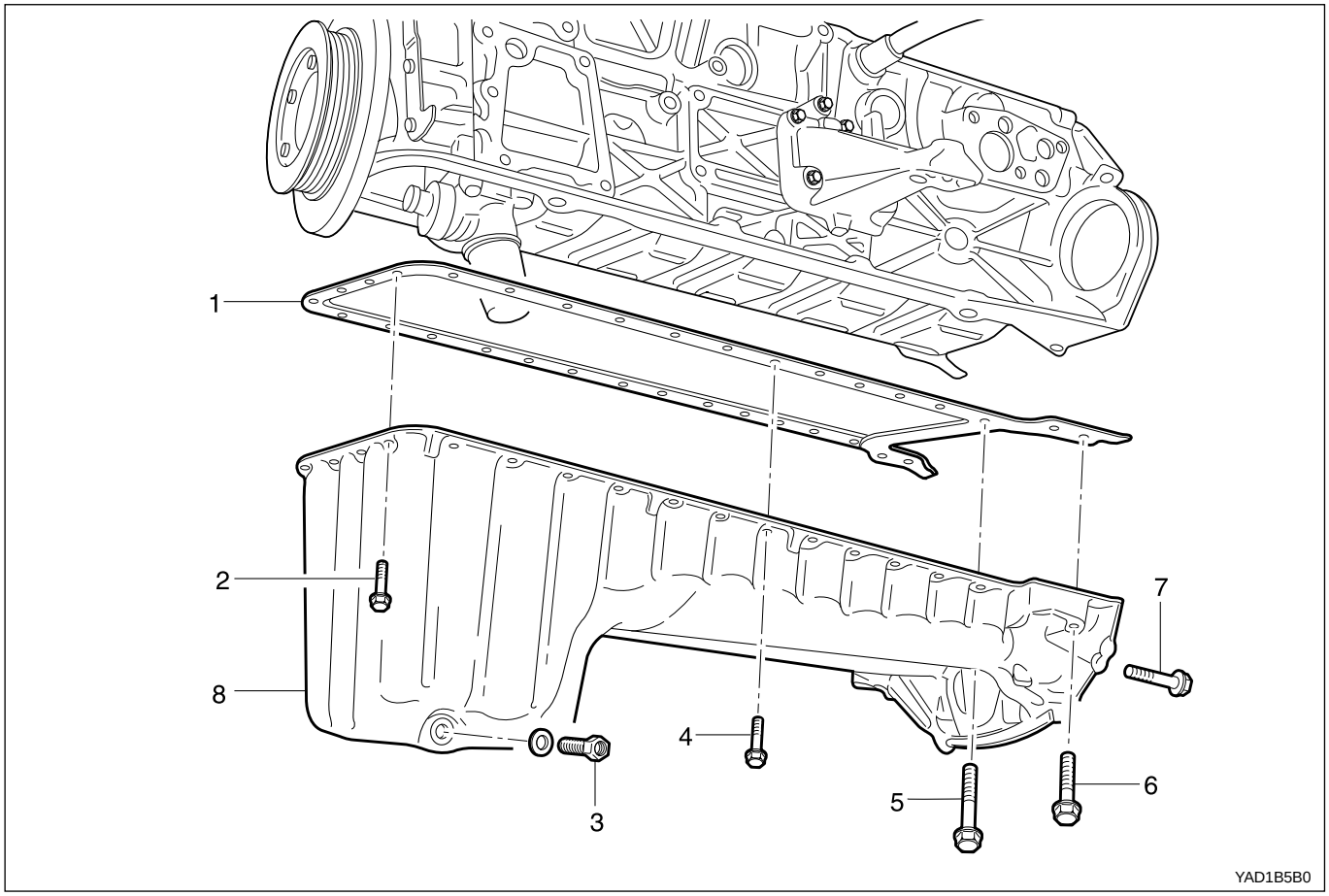
Installation Notice

Length (L)	New 160 ± 0.8 mm
	Max. 162 ± 0.7 mm

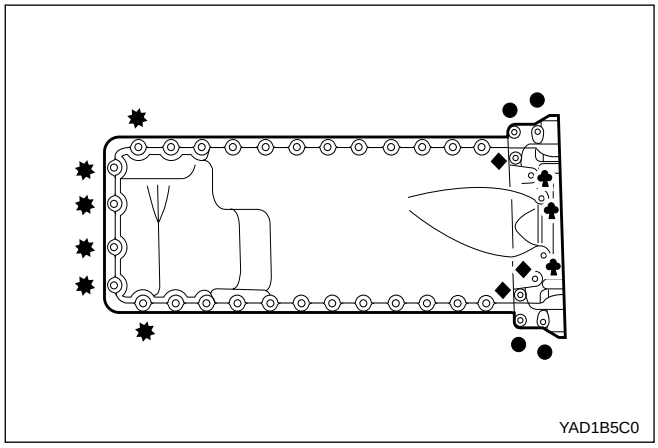
- Replace the bolt if the measured length exceed the max. length.
- Apply the oil to the thread surface of bolt.

9. Carefully remove the cylinder head and check the mating surface.
10. Installation should follow the removal procedure in the reverse order.

OIL PAN



1 Gasket..... Replace
2 Bolt (M6 x 22, 6 pieces)
.....9-11 N•m (80-97 lb-in)
3 Drain Plug .....22.5-27.5 N•m (16.6-20.3 lb-ft)
4 Bolt (M6 x 20, 22 pieces)
.....9-11 N•m (80-97 lb-in)
5 Bolt (M6 x 85, 3 pieces)
.....9-11 N•m (80-97 lb-in)
6 Bolt (M8 x 40, 4 pieces)
.....22.5-27.5 N•m (16.6-20.3 lb-ft)
7 Bolt (M10) ..... 40 N•m (30 lb-ft)
8 Oil Pan



● M8 X 40, 4 pieces
♣ M6 X 85, 3 pieces
◆ M6 X 35, 3 pieces
✸ M6 X 22, 6 pieces
Others M6 X 20, 28 pieces

Removal & Installation Procedure

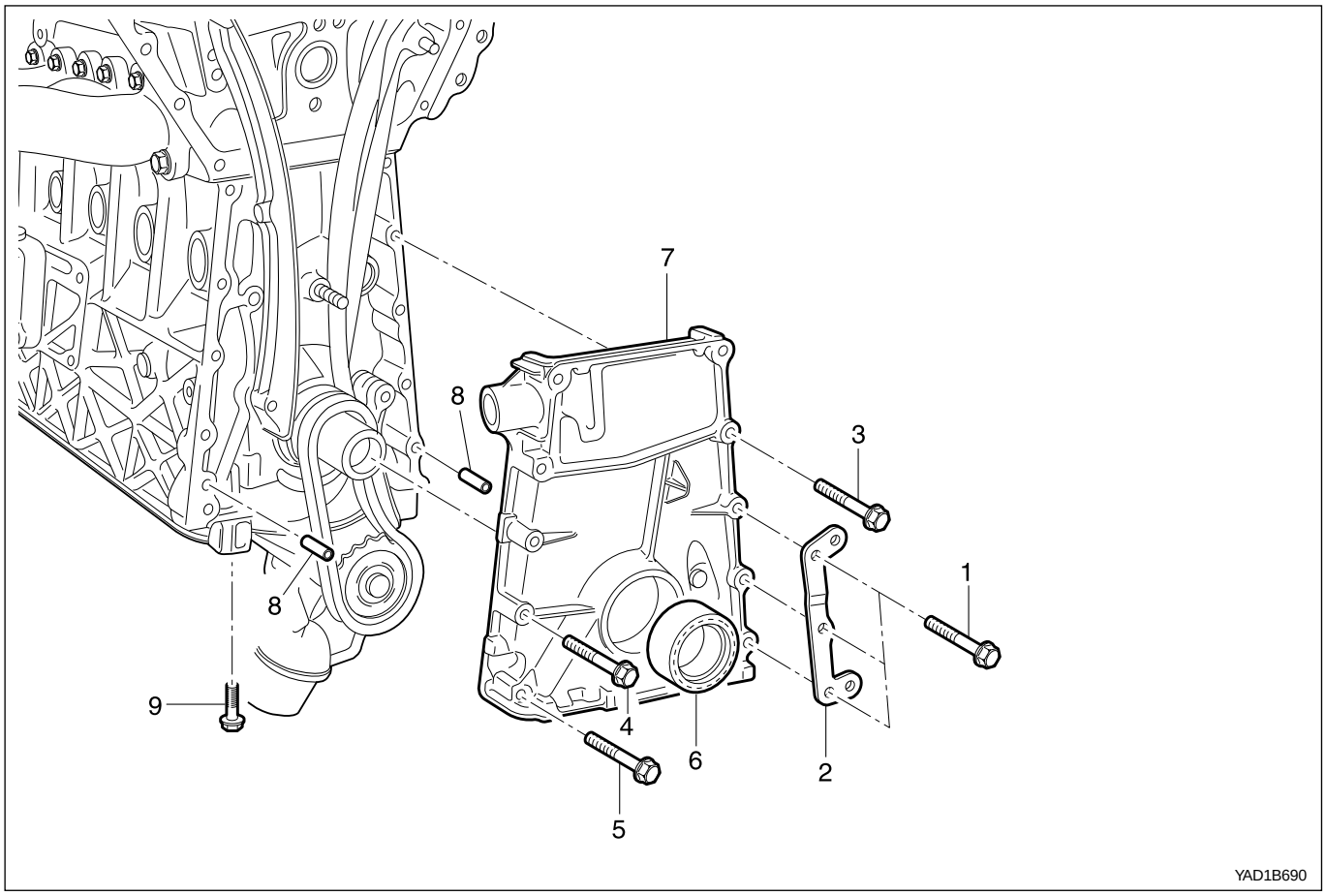
1. Remove the drain plug and drain the oil completely.
2. Unscrew the bolts and remove the oil pan and gasket.

   Notice: Arrange the bolts according to each size.

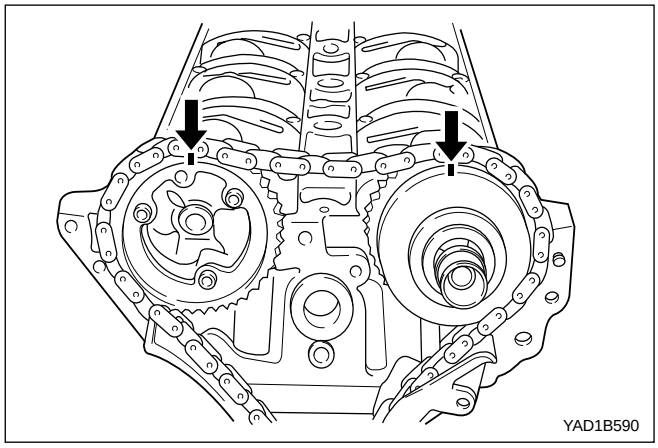
3. Clean the inside of oil pan and sealing surface, then apply the sealant.
4. Replace the gasket with new one.
5. Install the oil pan with gasket, and tighten each bolt in specified torque.
6. Check for oil leaks while running the engine.

TIMING GEAR CASE COVER

Preceding Work : Removal of cylinder head front cover
Removal of generator bracket
Removal of tensioning device
Removal of belt pulley and vibration damper



1 Bolt (M8 x 60, 3 pieces)
..... 22.5-27.5 N•m (16.6-20.3 lb-ft)
2 A/C Bracket
3 Bolt (M8 x 65, 3 pieces)
..... 22.5-27.5 N•m (16.6-20.3 lb-ft)
4 Bolt (M8 x 40, 1 piece)
..... 22.5-27.5 N•m (16.6-20.3 lb-ft)
5 Bolt (M8 x 60, 1 piece)
..... 22.5-27.5 N•m (16.6-20.3 lb-ft)
6 Seal
7 Timing Gear Case Cover
8 Roll Pin
9 Bolt (M6 x 22, 6 pieces)
..... 9-11 N•m (80-97 lb-in)

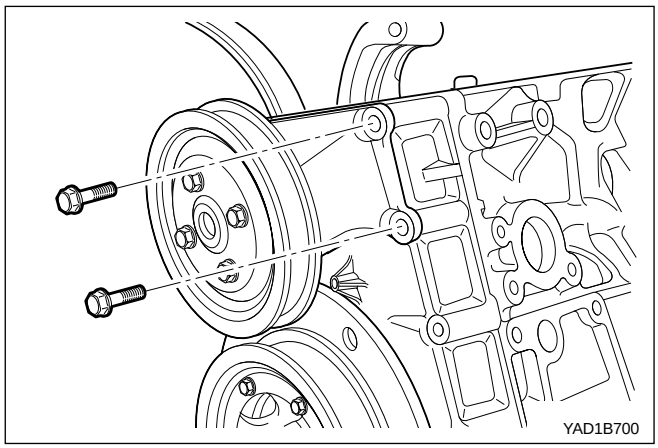


Removal & Installation Procedure

1. Put the alignment marks (arrows) on the timing chain and camshaft sprocket.
2. Unscrew the A/C bracket bolts (1) and remove the bracket.

Installation Notice

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



3. Remove the cooling fan and the viscous clutch. Unscrew the three bolts from the cooling fan bracket and remove the bracket.

Installation Notice

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

4. Remove the timing gear case cover after unscrewing the bolts (3) and (4) from the timing gear case cover and the bolt (9) from the oil pan.

   Notice: Be careful not to damage the oil pan gasket.

Installation Notice

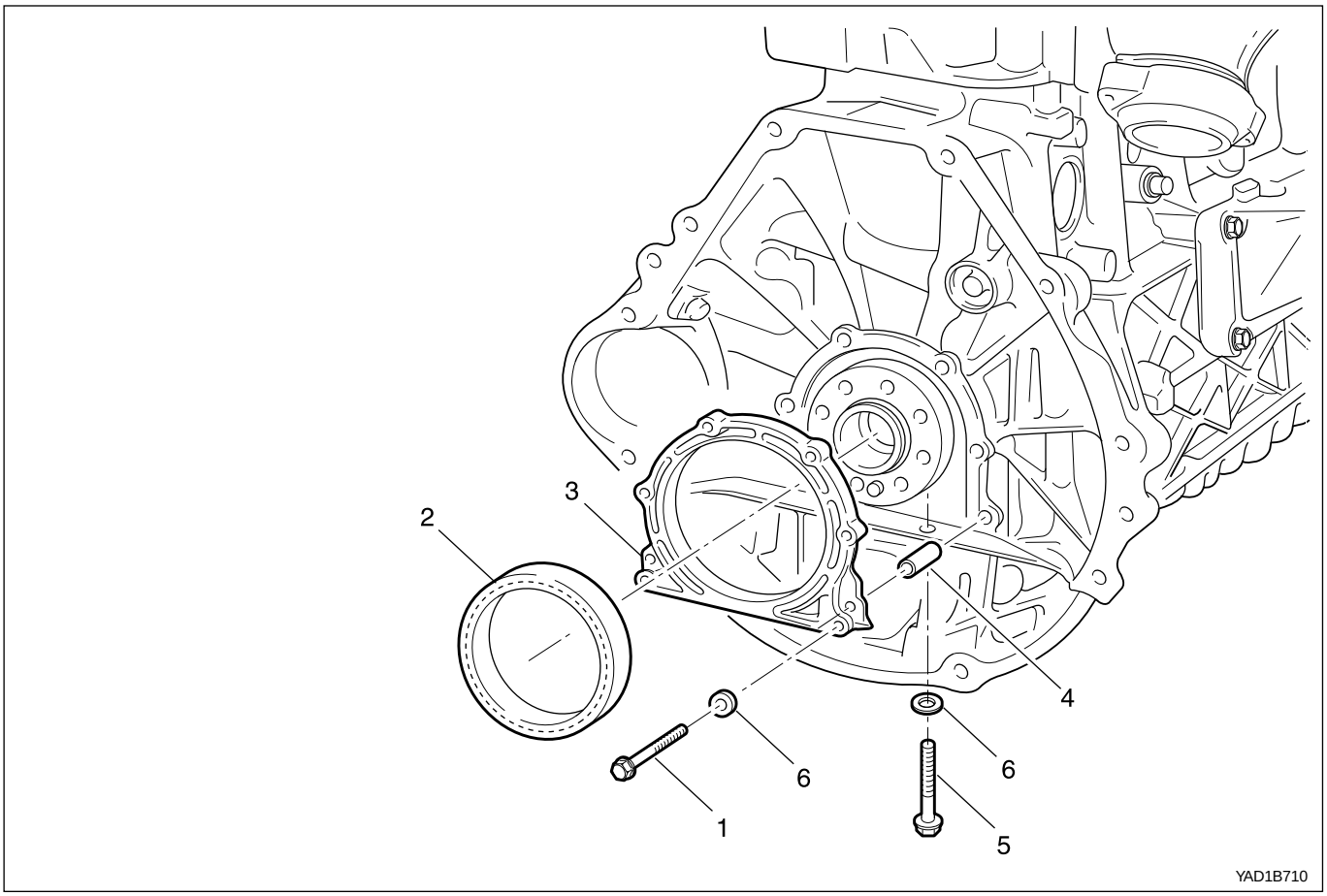
Tightening Torque	Bolt (3, 4) : 22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)
	Bolt (9) : 9 - 11 N•m (80 - 97 lb-in)

- Apply the sealant after cleaning the timing gear case cover surface.
- Be careful not to stain the oil chamber of chain tensioner with the sealant.

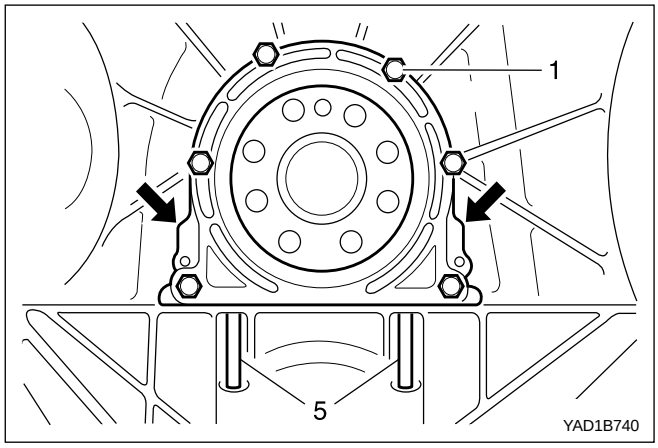
5. Installation should follow the removal procedure in the reverse order.
6. Warm up the engine and check for oil leaks.

CRANKSHAFT SEALING REAR COVER

Preceding Work : Removal of the automatic transmission drive plate



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



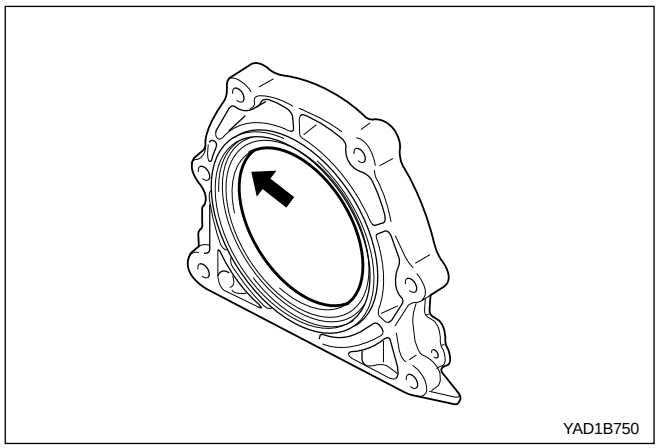
Tools Required

601 589 03 43 00 Crankshaft Rear Seal Installer

Removal & Installation Procedure

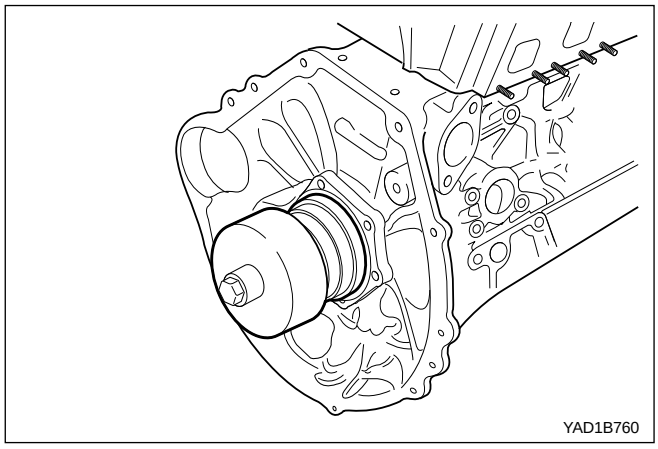
1. Unscrew the bolts (1) and (5) and remove the closing cover by pulling the rear cover lug (arrows).

   Notice: Be careful not to damage the oil pan gasket.

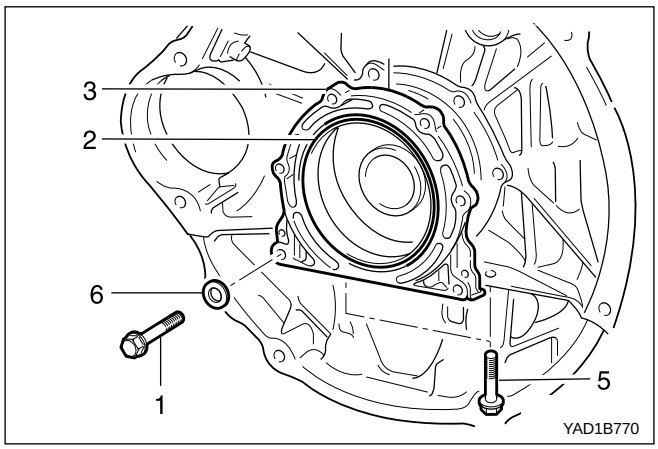


2. Clean the sealing surface of the crankcase and the rear sealing cover.
3. Check the radial shaft seal and replace it if necessary.
4. Apply the Loctite 573 to the rear cover sealing surface.
5. Apply the engine oil to the dust lip of the radial shaft seal.

   Notice: Do not use the grease.



6. Install the crankshaft rear radial seal and the crankshaft sealing rear cover, using crankshaft rear seal installer 601 589 03 43 00.



7. Install the crankshaft sealing rear cover mounting bolts and remove the crankshaft rear seal installer 601 589 03 43 00.

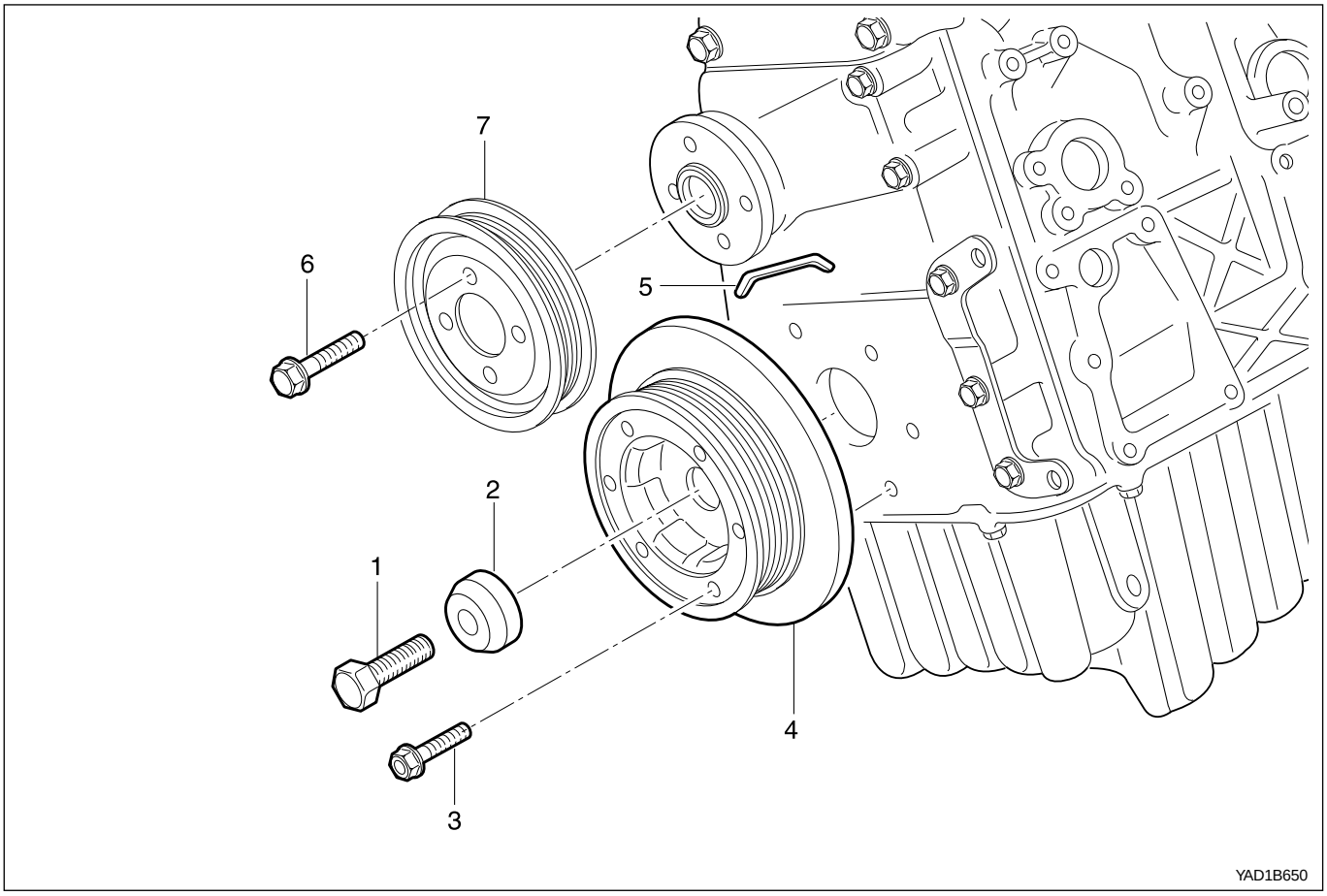
Installation Notice

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

CRANKSHAFT ASSEMBLY

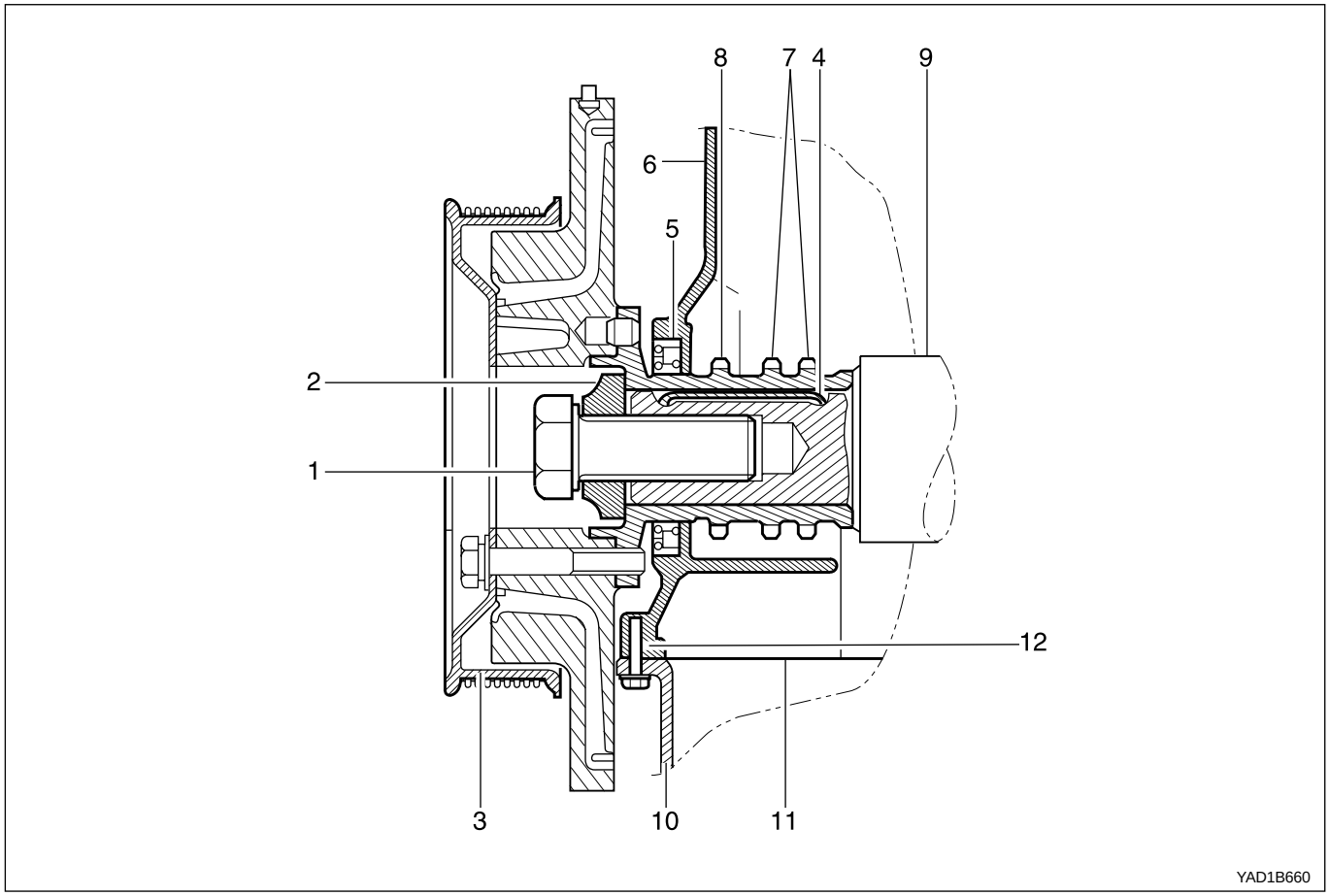
BELT PULLEY AND VIBRATION DAMPER

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



1 Center Bolt (M18 x 50)
..... 1st step 180- 220 N•m (133-162 lb-ft)
..... 2nd step 90°+10°
2 Vibration Damper Disk
3 Bolt (M6 x 20, 6 pieces)
..... 7.7-9.5 N•m (68.1-84.1 lb-in)
4 Vibration Damper Assembly
5 Woodruff Key
6 Bolt (M6 x 12, 4 pieces)
..... 9-11 N•m (80-97 lb-in)
7 Cooling Fan Pulley

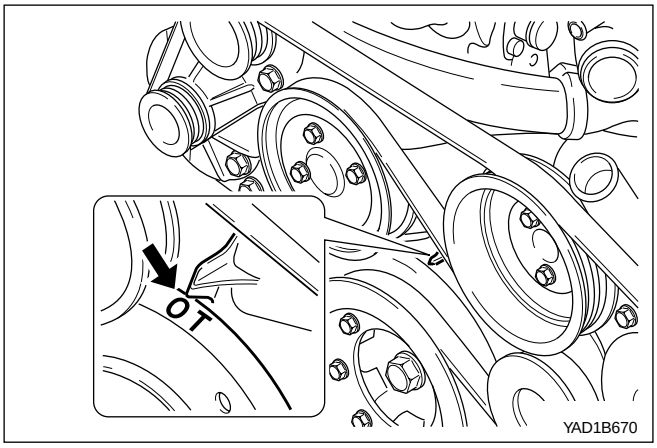
Components



1 Center Bolt (M18 x 50)
2 Vibration Damper Disk
3 Vibration Damper and Pulley Assembly
4 Woodruff 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 Runout	0.6 mm

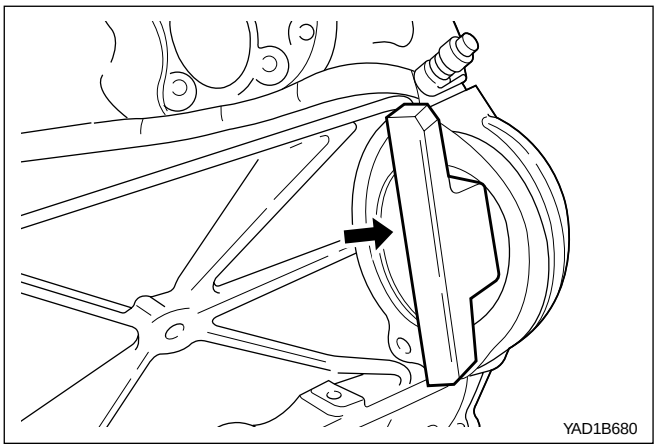


Tools Required

602 589 00 40 00 Engine Lock

Removal & Installation Procedure

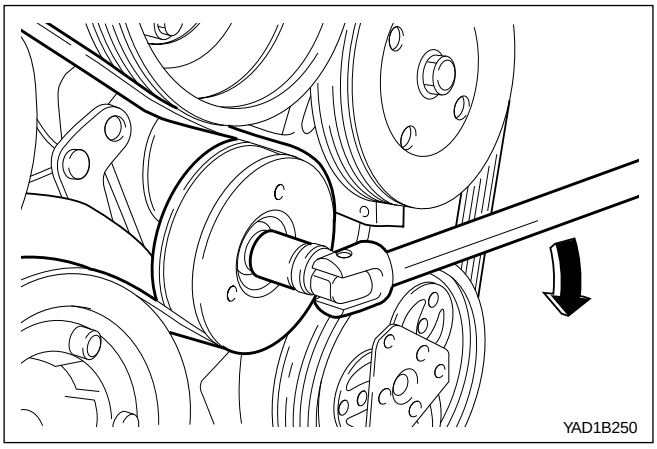
1. Adjust the piston of number 1 cylinder to the TDC.



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

Installation Notice

Tightening Torque	1st step: 180 - 220 N•m (133 - 162 lb-ft)
	2nd step: 90° + 10°

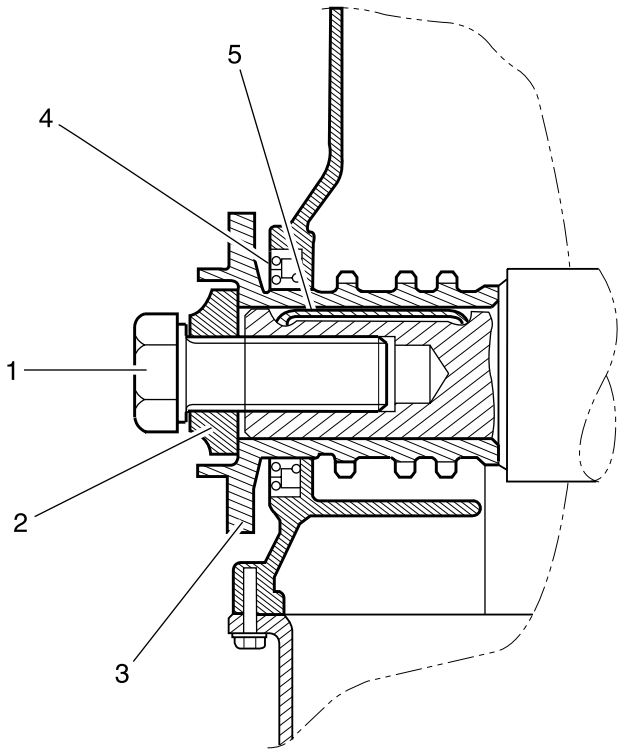


4. Remove the vibration damper assembly using the puller.
5. Installation should follow the removal procedure in the reverse order.

Notice: If possible, don't separate the vibration damper and the pulley.

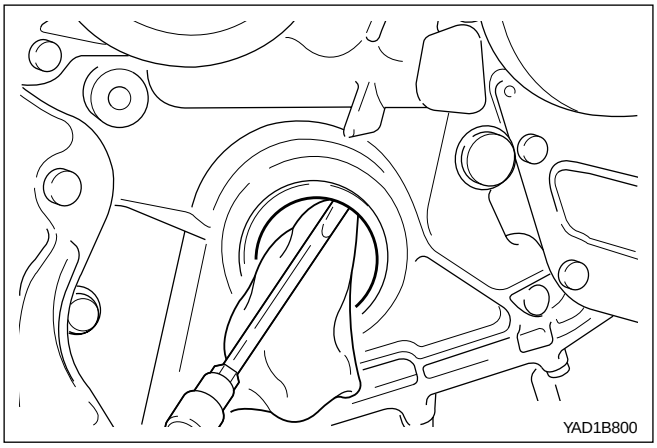
CRANKSHAFT FRONT RADIAL SEAL

Preceding Work : Removal of belt pulley and vibration damper



YAD1B780

1 Center Bolt (M18 x 50)
..... 1st step 180- 220 N•m (133-162 lb-ft)
2nd step 90°+10°
2 Center Bolt Washer
3 Sleeve (Special Tool)
4 Crankshaft Front Seal
5 Key



Tools Required

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 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.

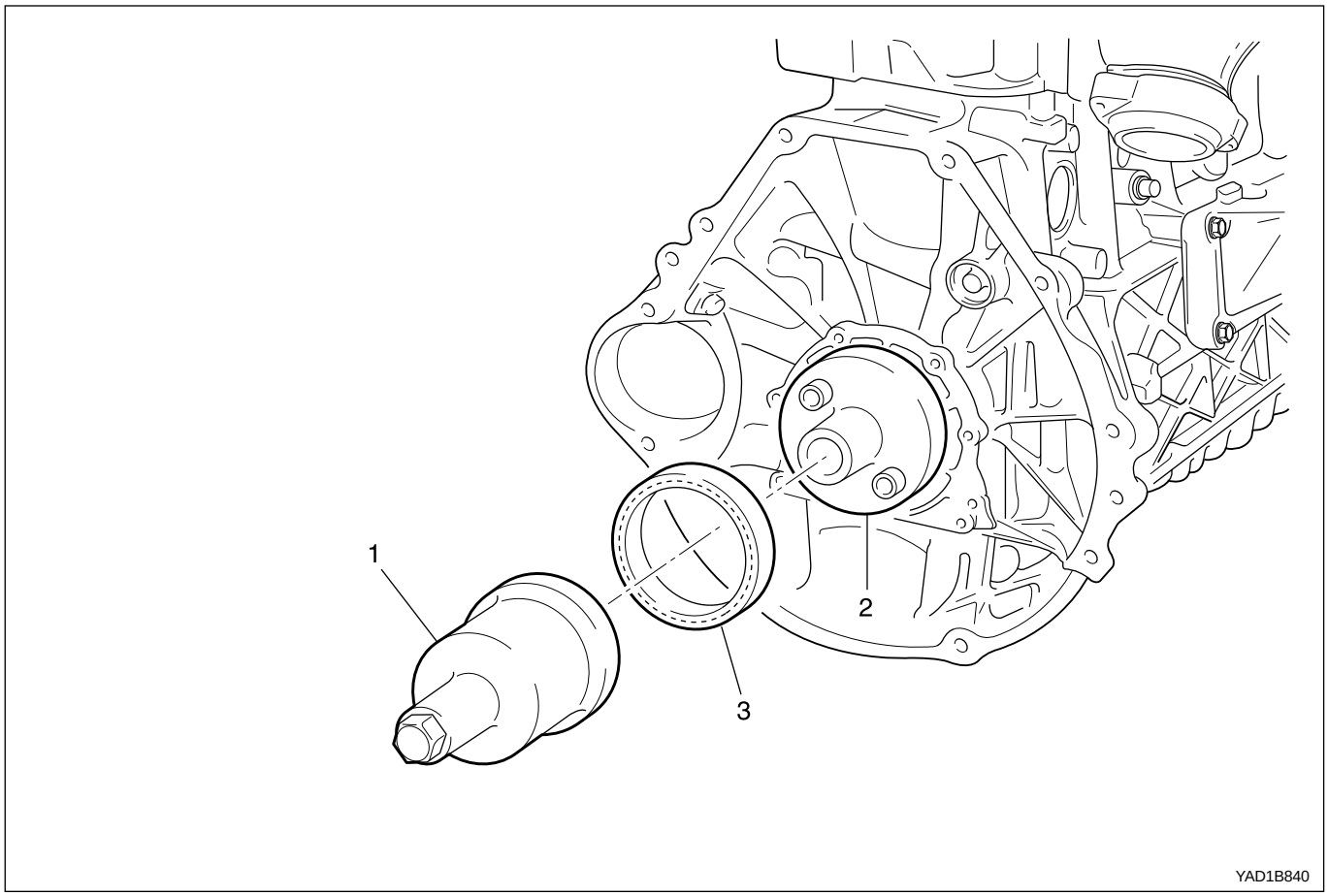
   Installation Notice

Tightening Torque	1st step: 180 - 220 N•m (133 - 162 lb-ft)
	2nd step: 90° + 10°

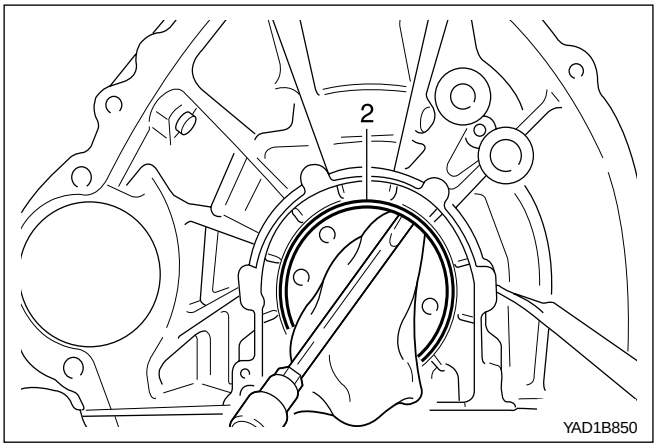
5. Remove the crankshaft front seal installer 601 589 03 14 00, and install the belt pulley and the vibration damper.
6. Check for leaks while operating the engine.

CRANKSHAFT REAR RADIAL SEAL

Preceding Work : Removal of flywheel or drive plate



1 Special Tool
2 Special Tool
3 Crankshaft Rear Seal



Tools Required

601 589 03 43 00 Crankshaft Rear Seal Installer

Replacement Proceudre

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.

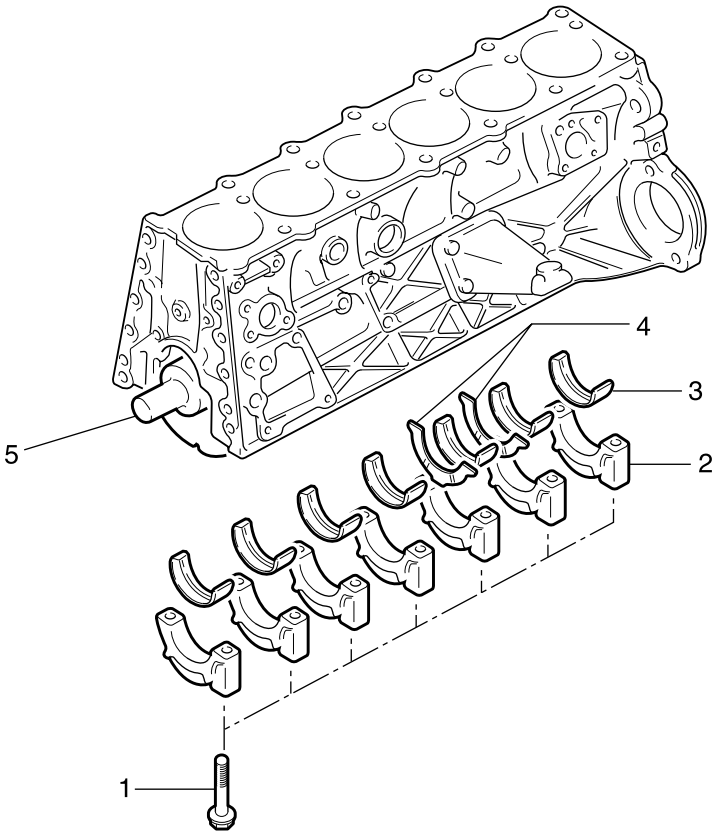
2. Install the crankshaft rear seal installer 601 589 03 43 00 (2) to the crankshaft.
3. Apply the engine oil on the crankshaft rear seal installer 601 589 03 43 00 (2).

   Notice: Do not use the grease.

4. Install the radial seal on the inner parts assembler.
5. Press in the crankshaft rear seal installer 601 589 03 43 00 (1) until the radial seal is stopped.
6. Check for leaks while operating the engine.

CRANKSHAFT

Preceding Work : Removal of engine assembly
Removal of timing gear case cover
Removal of cylinder head
Removal of crankshaft sealing rear cover
Removal of oil pan
Removal of oil pump
Removal of baffle plate



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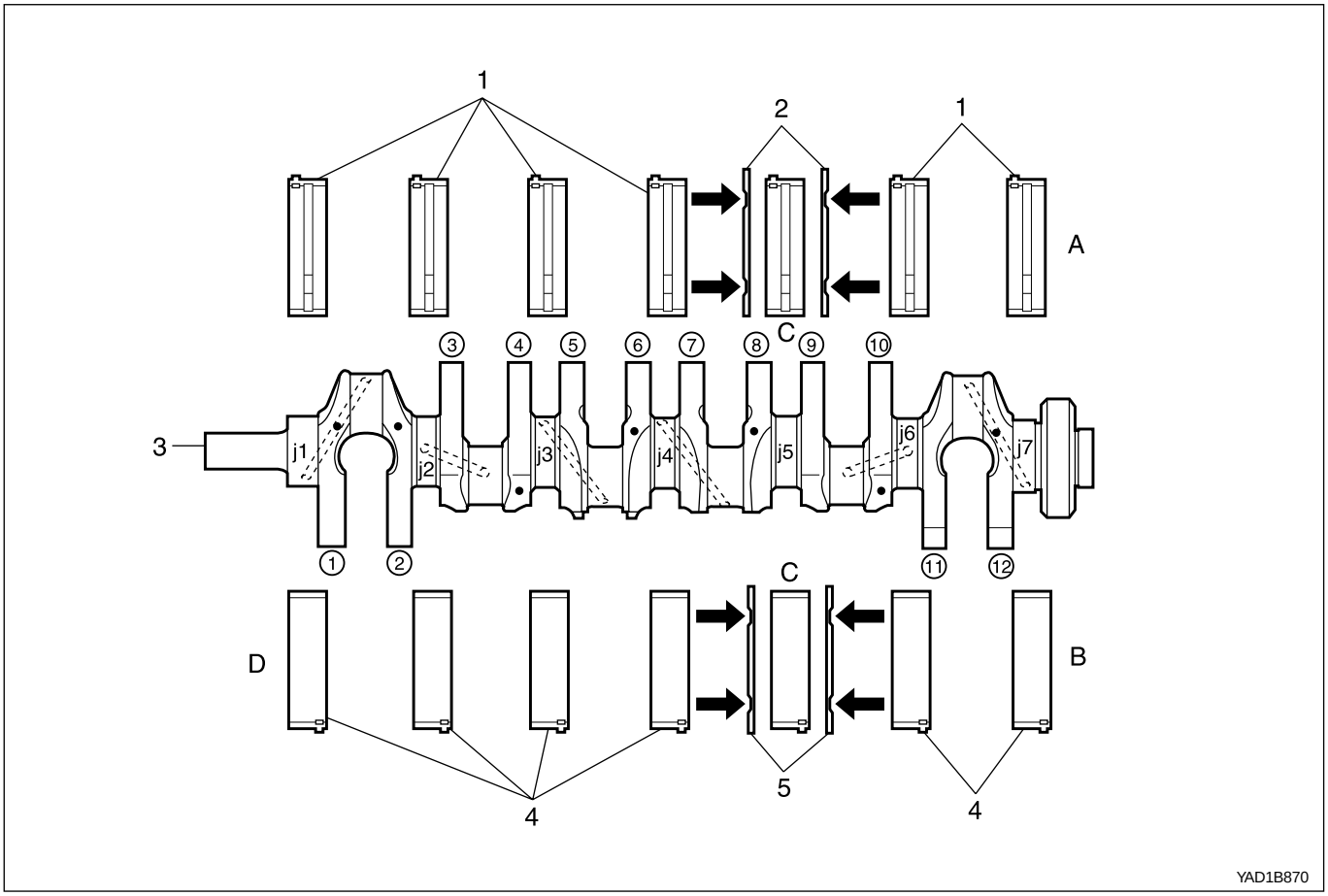
1 Crankshaft Bearing Cap Bolt
(M8 x 55, 14 pieces)
..... 1st step 50- 60 N•m (37-44 lb-ft)
2nd step 90°+5°
2 Crankshaft Bearing Cap
3 Crankshaft Lower Main Bearing
4 Crankshaft Lower Thrust Bearing
5 Crankshaft

Arrangement of the Thrust Bearing and the Main Bearing



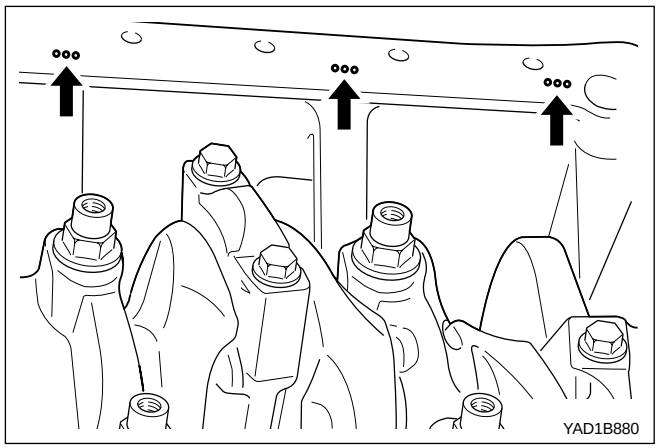
1 Upper Main Bearing
2 Upper Thrust Bearing
3 Crankshaft
4 Lower Main Bearing
5 Lower Thrust Bearing

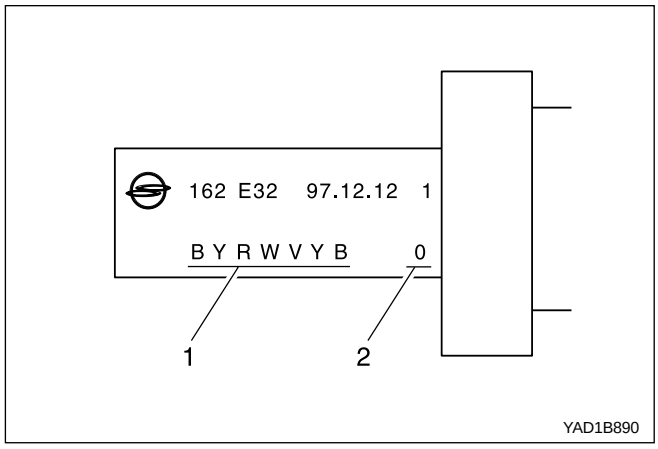
A Crankcase Side
B Bearing Cap Side (Oil Pan Side)
C Axial Fit Bearing (Number 5 Bearing Point)
D Radial Bearing

① - ⑫ Weight Balance/Color Marking Point
j1 - j7 Journal Main Bearing #1 - #7
● Color Dot Marking

The color dot marking are put on the ①, ②, ④, ⑥, ⑧, ⑩, ⑫ 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.

Punching Mark	Bearing Color Selected
●	Blue
●●	Yellow
●●●	Red

2. Crankshaft Bearing Cap Side

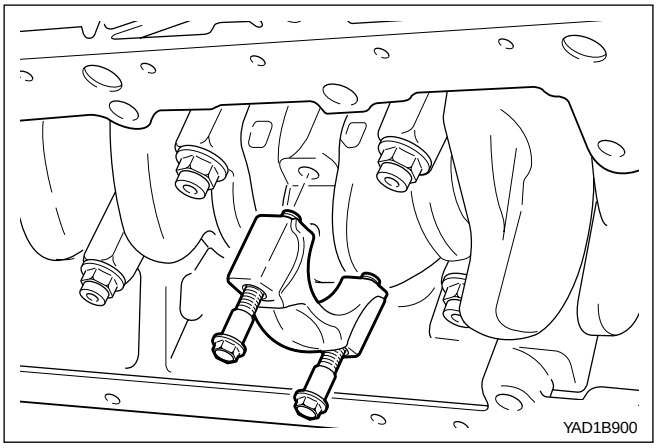
   Select the crankshaft main bearing according to the marking letter on the crankshaft main journal when repaired.

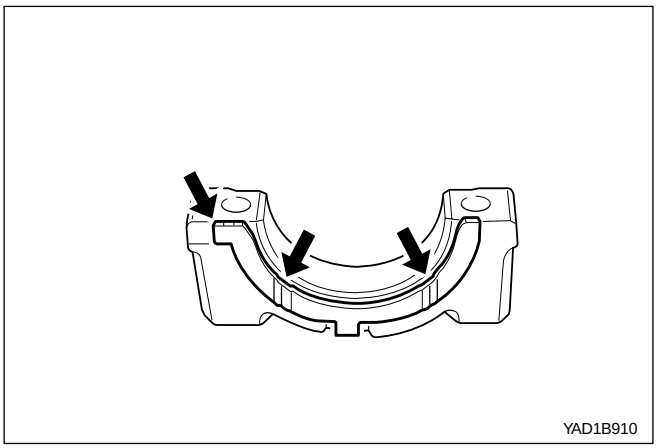
Marking Letter	Bearing Color Selected
B	Blue
Y	Yellow
R	Red
W	White
V	Violet

Service Data

Unit : mm

Crankshaft Standard and Repair Size	Crankshaft Bearing Journal Diameter	Thrust Washer Thickness	Crankshaft Journal Width at fit bearing	Connecting Rod Bearing Journal Diameter	Connecting Rod Bearing Journal Width
Standard size	57.950 - 57.965	2.15 or 2.20	24.50 - 24.533	47.94 - 47.96	27.958 - 28.042
1st repair size	57.700 - 57.715	2.25 or 2.35 or 2.40	-	47.75	-
2nd repair size	57.450 - 57.465			47.50	
3rd repair size	57.200 - 57.215			47.25	
4th repair size	56.950 - 56.965			47.00	


YAD1B900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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

Removal & Installation Procedure

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

   Installation Notice

Tightening Torque	1st step: 40 + 5 N•m (30 + 3.7 lb-ft)
	2nd step: 90° + 10°

   - 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.

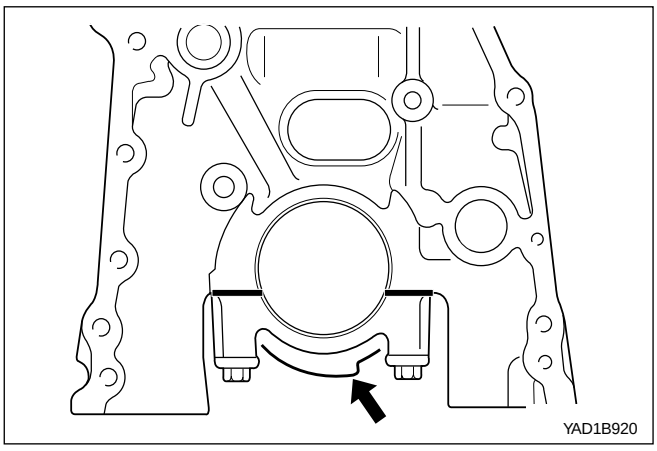
2. Unscrew the crankshaft bearing cap bolts and separate the upper and lower bearing shells and thrust washers.

   Installation Notice

Tightening Torque	1st step: 50 - 60 N•m (37 - 44 lb-ft)
	2nd step: 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 thickness. Select the proper washer when repaired.

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.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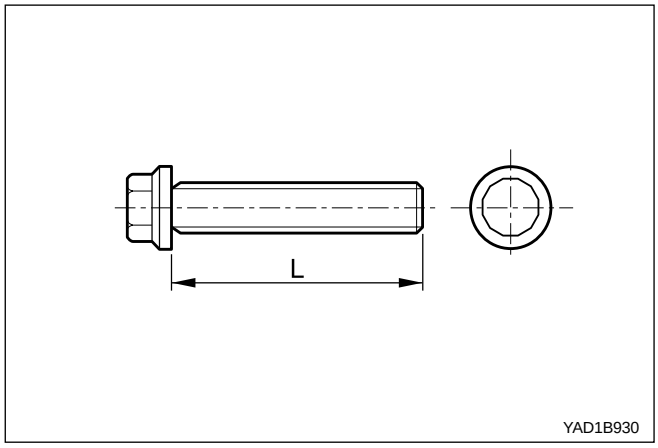
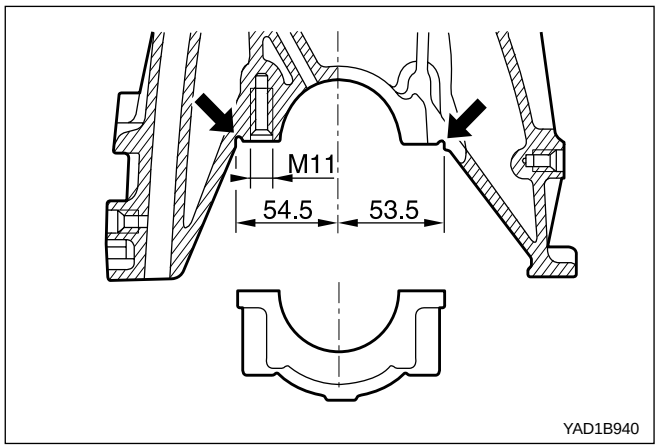
Notice:

- 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.

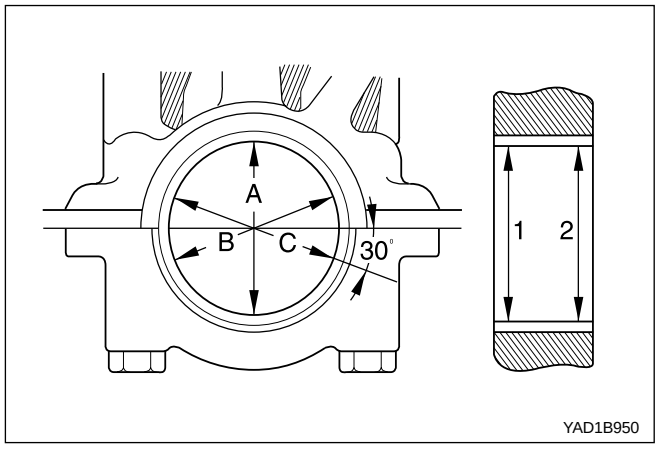


Inspection

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



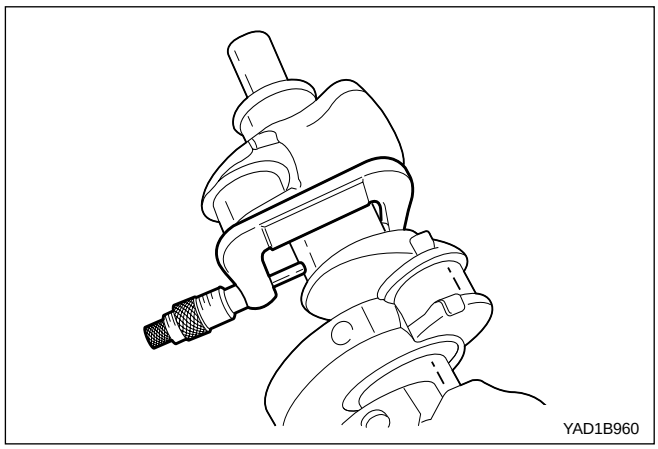
2. Make sure the crankshaft bearing cap is properly seated on the cylinder block (arrows).



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', then the 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.

Service Data Standard (Crankshaft Main Bearing Gap)

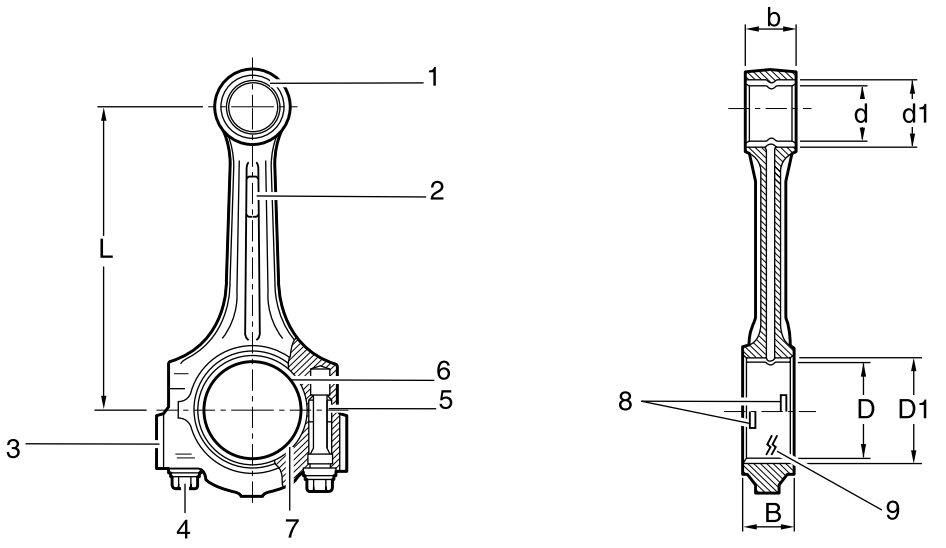
Item	Measuring Position	Gap (mm)
Main Bearing Journal (NO. 1, 5, 7)	Radial	Static condition :0.015 - 0.039 Dynamic condition: 0.031 - 0.051 (Consider the expansion 0.011 - 0.016)
	Axial	0.010 - 0.254
Main Bearing Journal (NO. 3, 4, 6)	Radial	Static condition :0.011 - 0.039 Dynamic condition: 0.031 - 0.051 (Consider the expansion 0.015 - 0.022)
	Axial	0.010 - 0.254

(Connecting Rod Bearing Gap)

Item	Measuring Position	Gap (mm)
Connecting Rod Bearing	Radial	0.030 - 0.050

CONNECTING ROD

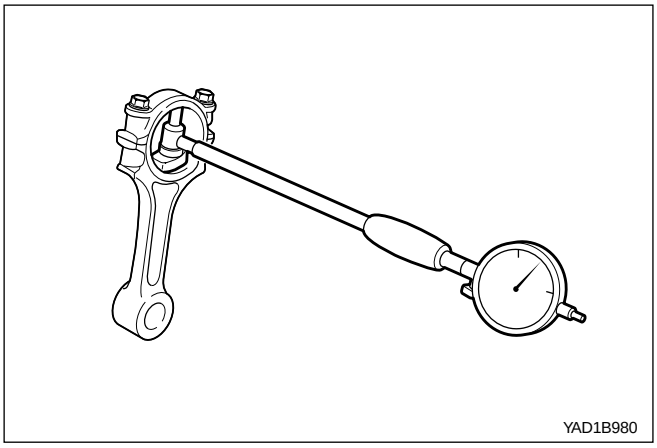
Preceding Work : Removal of piston



1 Connecting Rod Bushing
2 Oil Gallery
3 Balance Weight
4 Connecting Rod Bolt (M9 x 52, 12 pieces)
..... 1st step 40+5 N•m (30+3.7 lb-ft)
2nd step 90°+10°
5 Fit Sleeve
6 Upper Connecting Rod Bearing
7 Lower Connecting Rod Bearing
8 BearingShell Lug
9 Marking [Indication(//) or Numbers]

Service Data Standard

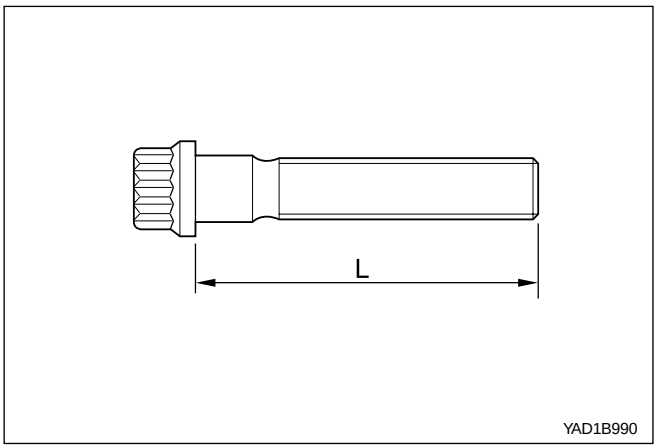
Distance (L) from The Connecting Rod Bearing Bore Center to The Bushing Bore Center	145 ± 0.05 mm
Width of The Connecting Rod (B) at Bearing Bore	21.940 - 22.000 mm
Width of The Connecting Rod (b) at Bushing Bore	21.940 - 22.000 mm
Basic Bore at The Bearing Shell (D1)	51.600 - 51.614 mm
Basic Bore at The Bushing (d1)	24.500 - 24.571 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 Twist of Connecting Rod Bearing Bore to Connecting Rod Bushing Bore	0.15 mm
Permissible Deviation of Axial Paralleism of Connecting Rod Bearing Bore to Connecting Rod Bushing Core	0.07 mm
Permissible Deviation of Connecting Rod Bearing Bore from Concentricity	0.01 mm
Permissible Difference of Each Connecting Rod in Weight	0.4 g


YAD1B980

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.

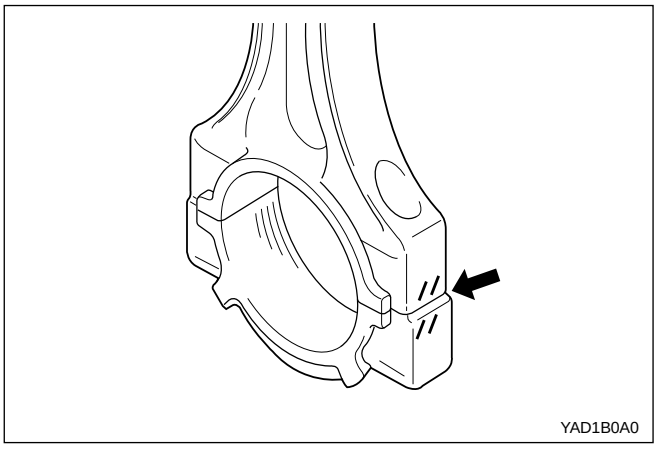


YAD1B990

2. Check connecting rod bolts.

Length When New (L)	51.7 - 52 mm
Max. Length (L)	52.9 mm
Tightening Torque	1st step: 40 + 5 N•m (30 + 3.7 lb-ft)
	2nd step: 90°+10°

   Notice: If the length exceeds max. length, replace it.


YAD1B0A0

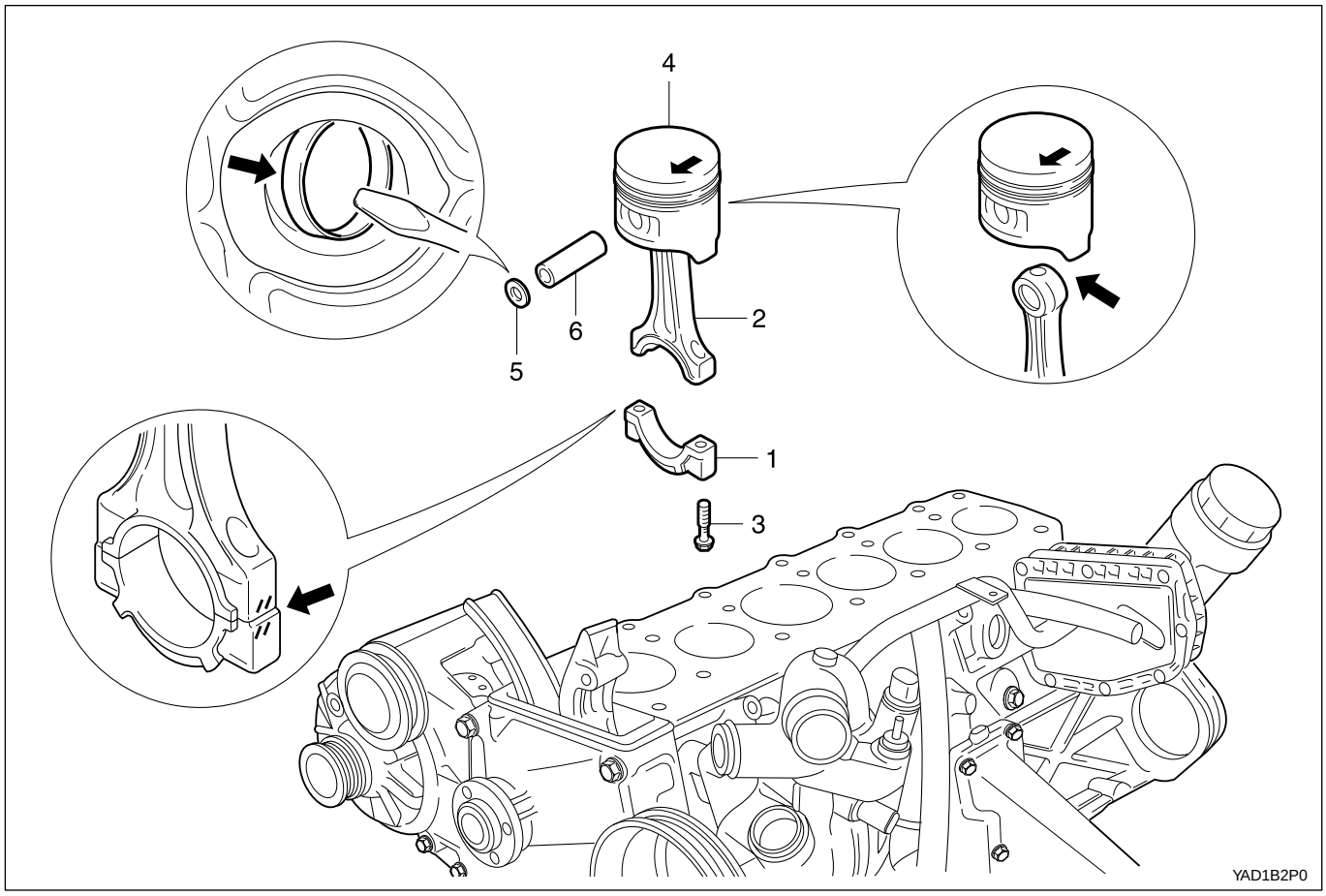
3. Check the assembly mark(indication//or number: arrow) of the connecting rods and the bearing cap when installing.

   Notice:

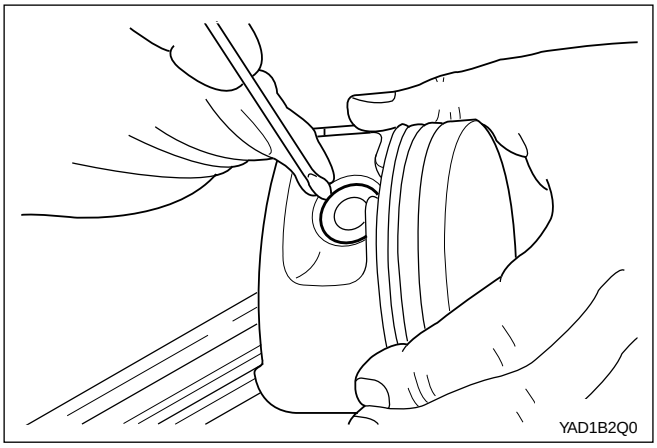
   - Make sure it doesn't exceed over 4g with other connecting rods when replacing the connecting rods.
   - Check if the connecting rod and the bearing cap are accurately seated on the groove when replacing the bearing.

PISTON

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 Bearing Cap Bolt
(M9 x 52, 12 pieces)
..... 1st step 40+5 N•m (30+3.7 lb-ft)
2nd step 90°+10°
4 Piston
5 Snap Ring
6 Piston Pin



Removal Procedure

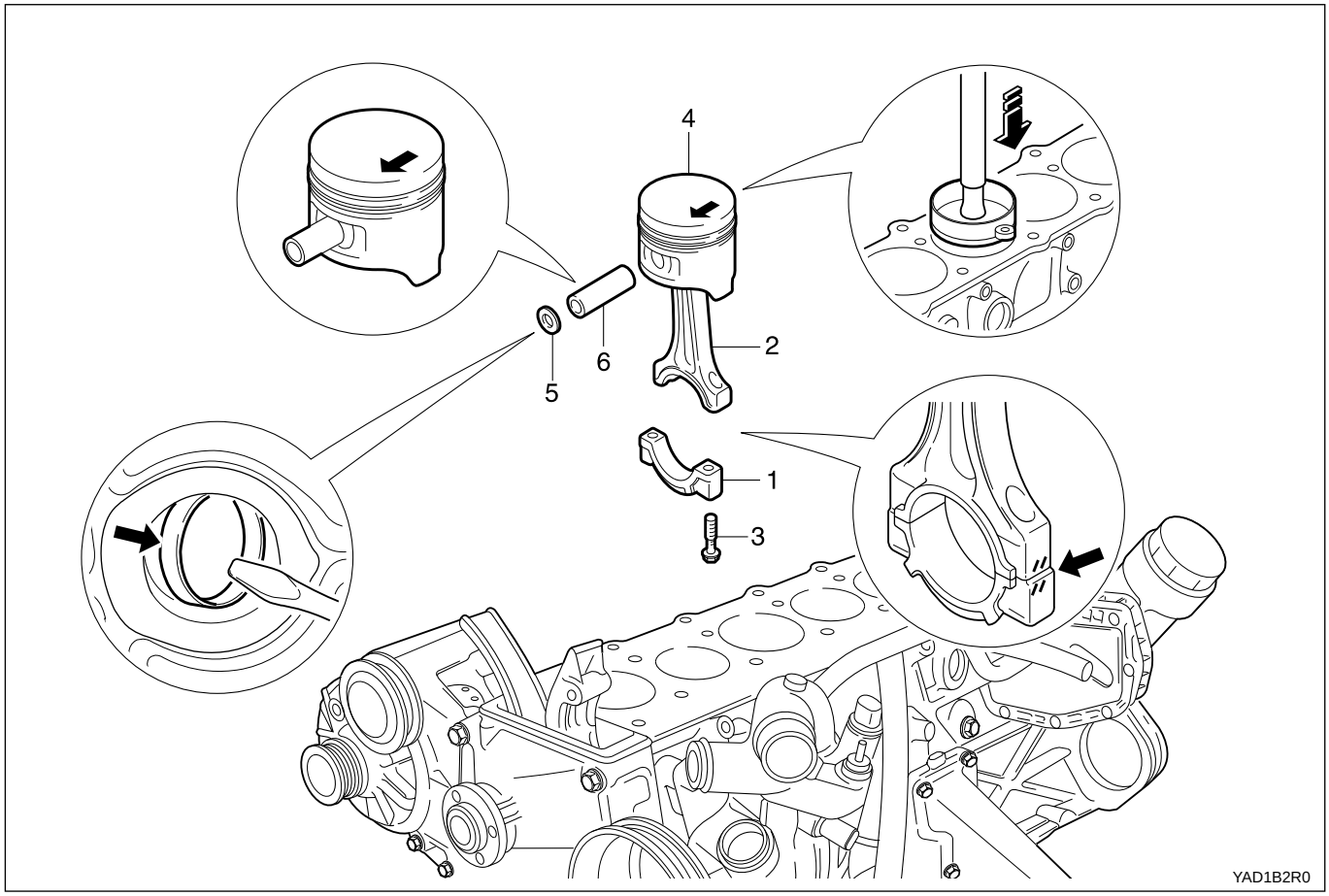
1. Unscrew the connecting rod bearing cap bolt (3) and remove the cap.
2. Remove the connecting rod and the piston upward.

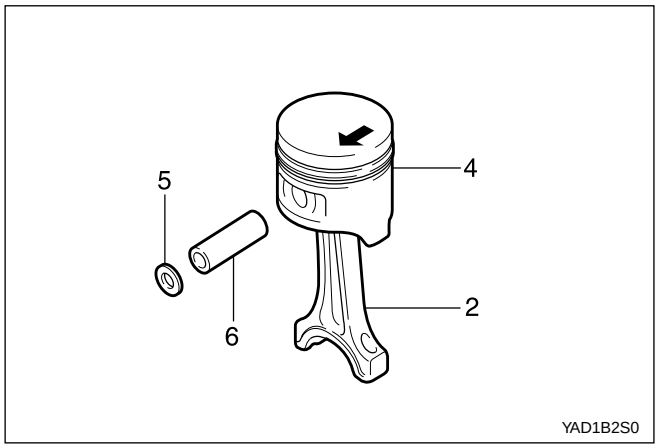
   Notice: Make sure that the bearing cap and shell are not changed each other.

3. Remove the snap ring (5) and pull out the piston 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

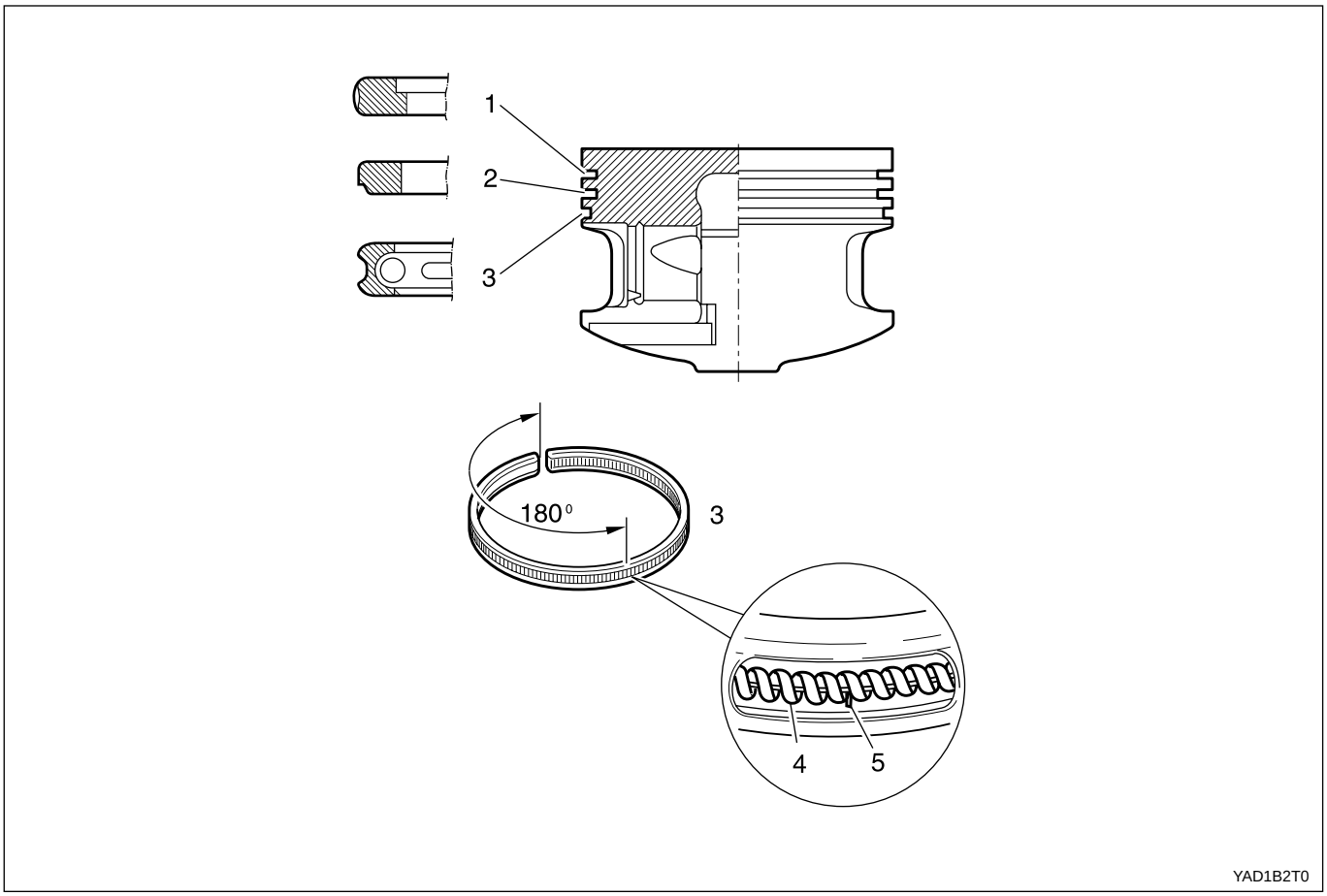
Tightening Torque	1st step: 40 + 5 N•m (30 + 3.7 lb-ft)
	2nd step: 90° + 10°

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.

PISTON RING

Preceding Work : Removal of piston



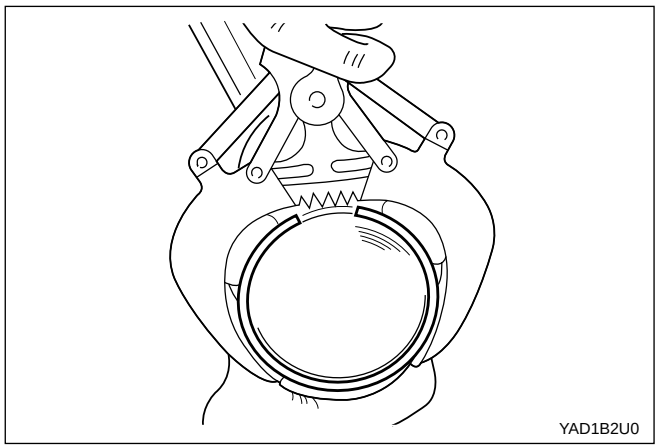
1 Piston Compression Ring
2 Piston Compression Ring
3 Piston Oil Ring
4 Coil Spring and Control Ring
5 Hook Spring

Replacement Procedure

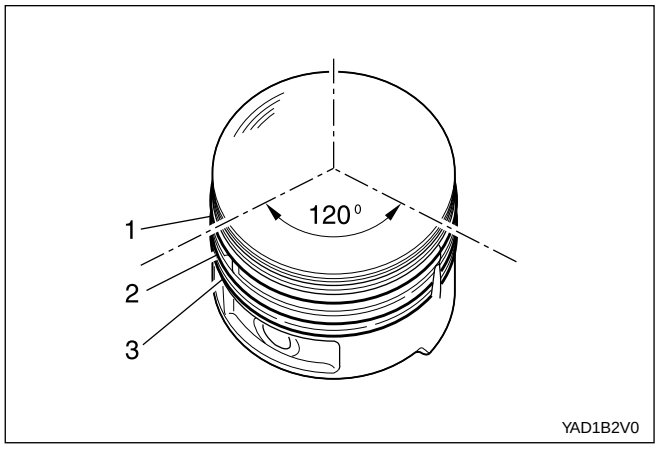
1. Measure the piston ring's gap.

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 0.015 - 0.050 mm
	Groove 2 0.020 - 0.040 mm
	Groove 3 0.010 - 0.045 mm

Notice: If out of specification, replace the piston ring.


YAD1B2U0

2. Remove the piston ring with a pliers.



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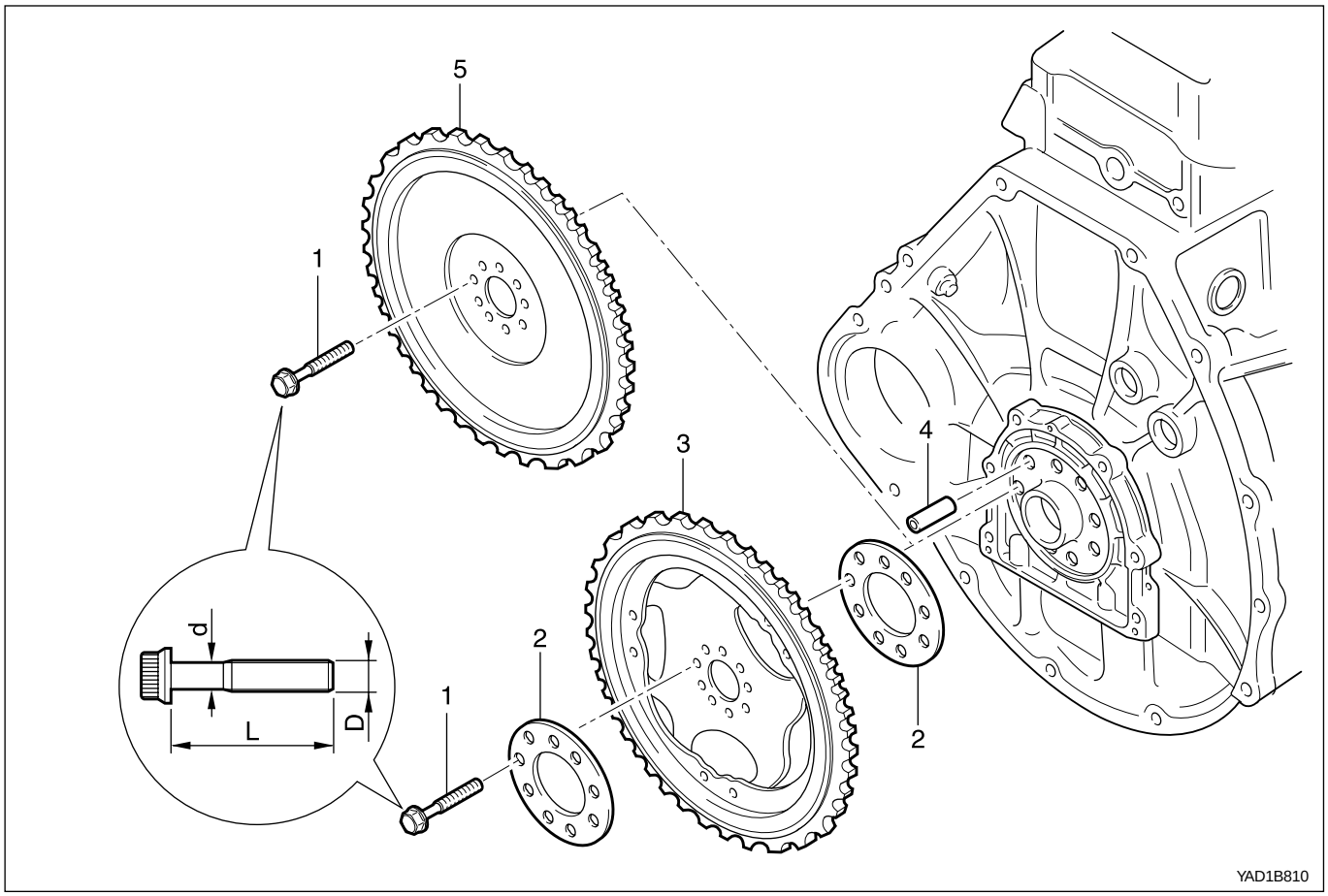
3. For installation, position the piston ring to be the 'TOP' mark on the piston ring upward and arrange the piston ring ends to be 120° apart.
4. Adjust the hook spring joint in the oil ring 180° away from the ring end.

FLYWHEEL / DRIVEN PLATE

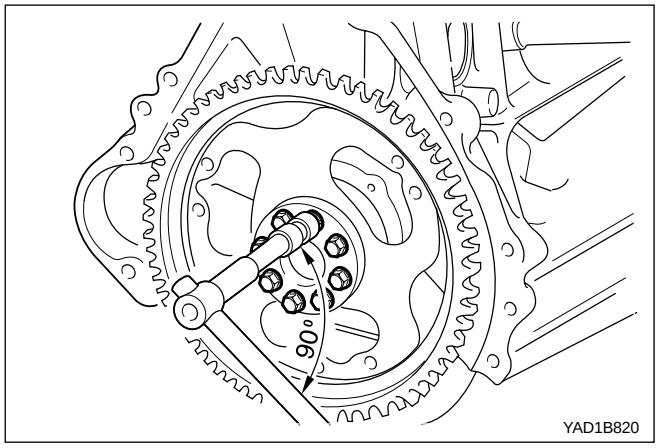
Preceding Work : Removal of manual or automatic transmission



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 Driven Plate (A/T)
4 Dowel Pin
5 Flywheel (M/T)

Service Data Standard (Stretch Bolt)

Nominal Size	D	-	M x 1.5
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 + 3.7 lb-ft), 2nd step 90° + 10°		



Removal & Installation Procedure

1. Unscrew the flywheel mounting bolt.

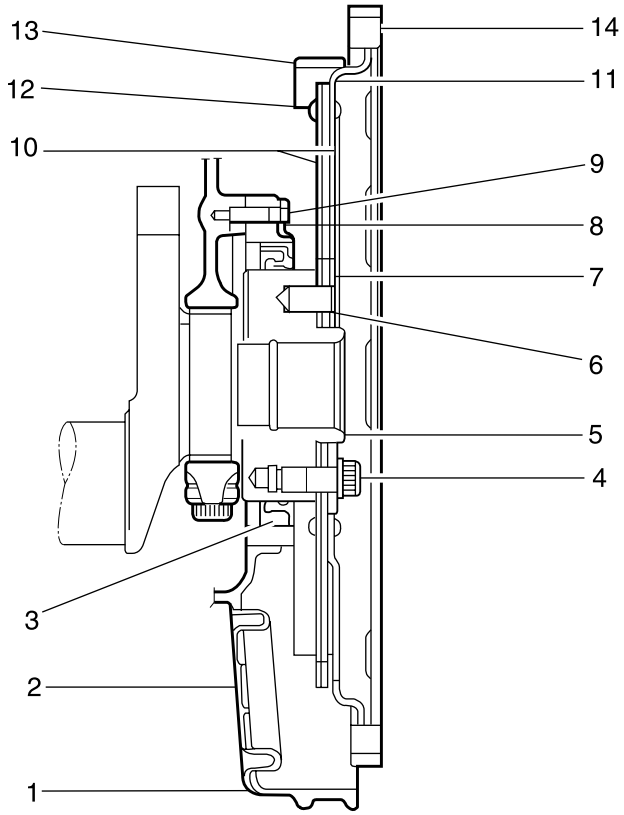
   Installation Notice

Tightening Torque	1st step: 40 + 5 N•m (30 + 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 8.0 mm.
   - For the stretch 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 automatic transmission vehicle.
3. Installation should follow the removal procedure in the reverse order.

Sectional View

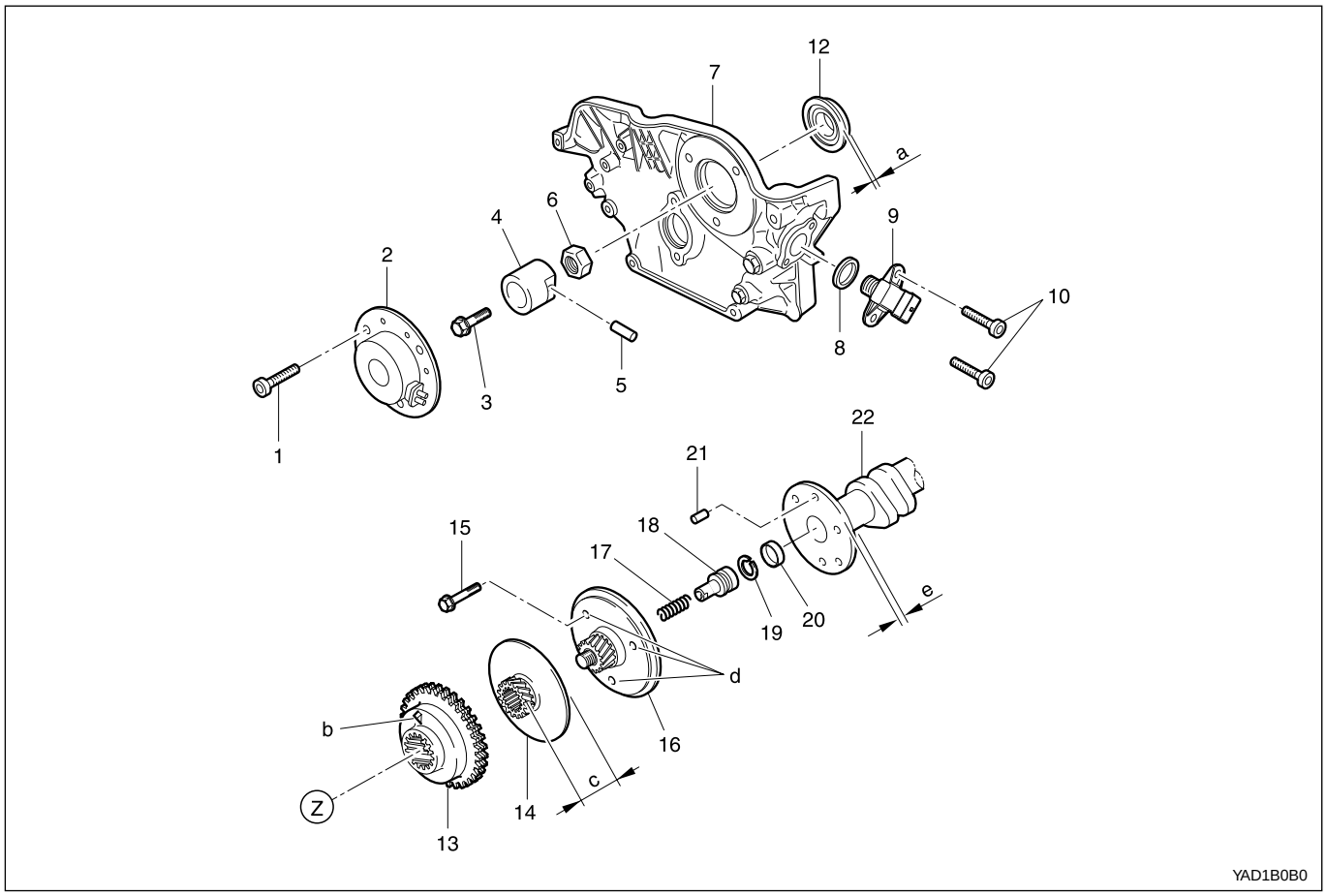


1 Oil Pan
2 Cover
3 Crankshaft Front Seal
4 Flywheel Mounting Bolt
5 Crankshaft
6 Dowel Pin
7 Washer (thickness = 3.5 mm)
8 Washer
9 Bolt
10 Front Drive Plate
11 Rear Drive Plate
12 Rivet
13 Segment
14 Ring Gear

TIMING DEVICE AND VALVE

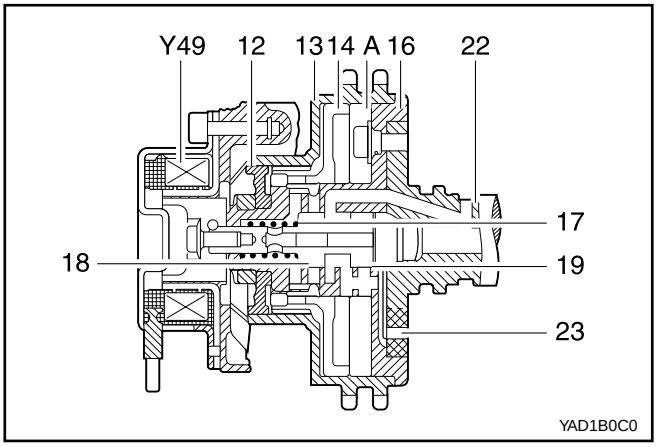
CAMSHAFT ADJUSTER

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



1 Bolt (M6 x 16, 3 pieces) ..... 9-11 N•m (80-97 lb-in)
2 Camshaft Actuator (2 Pin Connector)
3 Bolt ..... 35 N•m (26 lb-ft)
4 Armature
5 Roll Pin
6 Nut (M20 x 1.5) ..... 60-70 N•m (44-52 lb-ft)
7 Front Cover
8 Seal
9 Camshaft Position Sensor
10 Bolt (M6 x 16, 2 pieces) .....9-11 N•m (80-97 lb-in)
11 -
12 Seal Cover
13 Camshaft Sprocket and Position Indicator (b)
14 Adjuster Piston
15 Flange Bolt (M7 x 13, 3 pieces) .....1st step 18-22 N•m (13-16 lb-ft)
2nd step 90° ± 5°
16 Flange Shaft
17 Compression Spring
18 Control Piston
19 Circlip
20 Oil Gallery
21 Pin
22 Intake Camshaft

"Retarded" Position



12 Seal Cover
13 Camshaft Sprocket
14 Adjust Piston (Stops Towards The Front)
16 Flange Shaft
17 Compression Spring
18 Control Piston (Stops Towards The Rear)
19 Circlip
22 Intake Camshaft
23 Oil Outlet Drilling

A Working Chamber (Oil Pressure)
Y49 Electromagnetic Actuator (Not Functioning)

Functions

When the engine is running, the camshaft rotates the intake camshaft hydrauically/mechanically relative to the camshaft sprocket by 34° crankangle to the 'advanced' position and back to the 'retarded' position.

The camshaft adjuster is actuated electromechanically by the ECU. The positioning time of approx. 1 second is dependent on the engine oil pressure at the camshaft adjuster and on the oil viscosity and oil temperature, respectively. The position indicator (b) on the camshaft sprocket (13) provides the camshaft rotational speed to the position sensor (9) as an input parameter for the engine ignition control unit.

1. Ignition suitch OFF ('retarded')

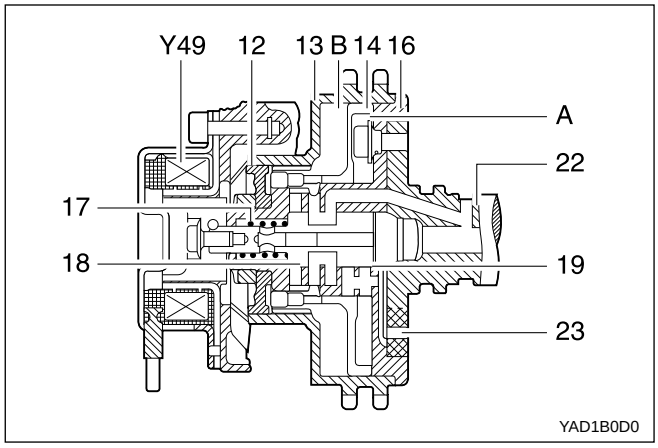
   The compression spring (17) pushes the control piston (18) against the circlip (19). The engine oil pressure in the camshaft is eliminated.

2. From 0 to 1000 - 2000 rpm ('retarded')

   The torque of the internally helically toothed camshaft sprocket (13) acting in the direction of rotation of the engine pushes the externally helically toothed positioning piston(14) against the cover(12) as a result of the screw action. Consequently, the likewise internally helically toothed positioning piston (14) holds the externally helically toothed flanged shaft (16) together with the bolted-on camshaft (22) in the 'retarded position'. The compressing spring (17) pushes the control piston(18) against the circlip (19). The engine oil flows through 2 oblique drillings in the camshaft flange and in the flanged shaft (16) in to the working chamber (A) and holds the positioning piston (14) additionally in the 'retarded' position with the available engine oil pressure.

   Leak oil flows off over control and positioning piston surface, through the control piston drilling and 2 drillings (23) in the camshaft flange.

“Advanced” Position



12 Seal Cover
13 Camshaft Sprocket
14 Adjust Piston (Stops Towards The Front)
16 Flange Shaft
17 Compression Spring
18 Control Piston (Stops Towards The Rear)
19 Circlip
22 Intake Camshaft
23 Oil Outlet Drilling

A Working Chamber (Oil Pressure)
Y49 Electromagnetic Actuator (Not Functioning)

3. From 1000 - 2000 to 4000 rpm (‘advanced’)

The control piston (18) is pulled forward as far as the stop in the flanged shaft (16) by the actuator (Y49) against the force of the compression spring (17).

The control piston (18) closes the oil feed to the working chamber ‘A’ and at the same time allows oil to flow to the working chamber ‘B’ through 2 drillings each in the flanged shaft (16) and adjusting piston (14). The engine oil pressure moves the adjusting piston (14) as for as the stop on the flanged shaft (16). As a result of the axial movement of the flanged shaft (16) is turned into the ‘advanced’ position. The turning action is achieved as a result of the effect of the helical teeth on the camshaft sprocket (13), positioning piston (14) and flanged shaft (16). The engine oil in working chamber ‘A’ flows off, assisted by the pushing action of the adjusting piston (14), over the flanged shaft (16) and through 2 drillings (23) in the camshaft flange.

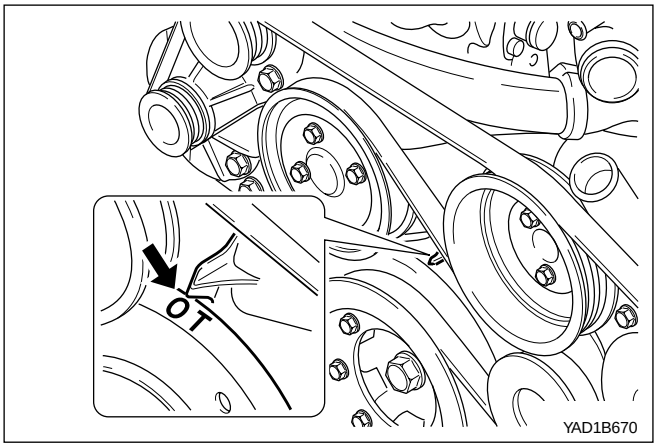
4. From 4000 rpm (‘retarded’)

The electromagnetic actuator (Y49) is not actuated and allows the control piston to move. The compression spring (17) pushes the control piston (18) against the circlip (19). The oil feed to the working chamber ‘B’ is closed off and oil is able to flow to working chamber ‘A’ along 2 drillings in the flanged shaft (16). As a result of the engine oil pressure, the control piston (18) is moved as far as the cover (12).

This axial movement of the adjusting piston (14) rotates the camshaft (22) bolted to the flanged shaft (16) in to the ‘retarded’ position.

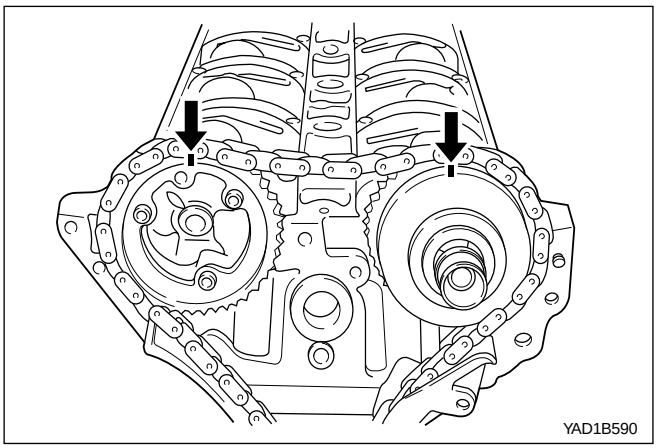
The rotational movement is a result of the screw effect of the helical teeth on the camshaft sprocket (13), positioning piston (14) and flanged shaft (16). The engine oil in the working chamber (B) flows off, assisted by the pushing action of the adjusting piston (14), through 2 drillings each in the adjusting piston (14), flanged shaft (16) and control piston (18) through the control piston (18) and 2 drillings in the camshaft flange (23).

Leak oil flows off over the control and adjusting piston surfaces through the control piston drilling and 2 drillings in the camshaft flange (23).

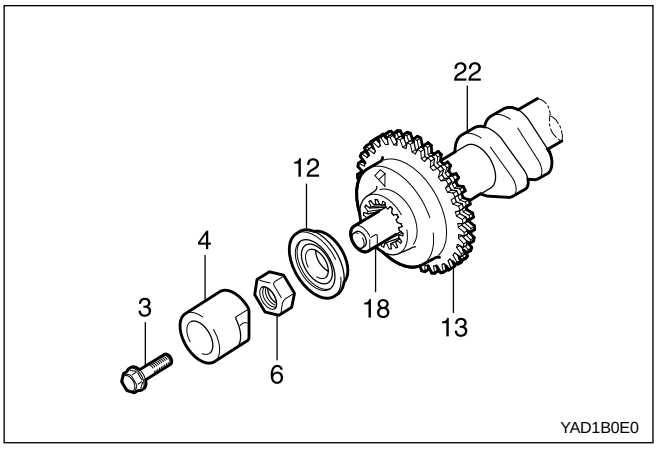


Removal & Installation Procedure

1. Turn the crankshaft to the direction of engine rotation and position the no.1 cylinder piston at TDC which the camshaft is positioned at OT.



2. Remove the cylinder head front cover. Refer to “Cylinder Head Front Cover” in this section.
3. Paint the alignment marks (arrows) on the intake and exhaust camshaft sprocket and the timing chain.



3 Bolt
4 Amarture
6 Nut (M20 x 1.5)
12 Seal Cover
13 Camshaft Sprocket
18 Control Piston
22 Intake Camshaft

4. Unscrew the bolt (3) from the armature (4) and remove the armature.

Installation Notice

Tightening Torque	35 N•m (26 lb-ft)

5. Unscrew the nut (6) and remove the ring and seal cover (11).

Installation Notice

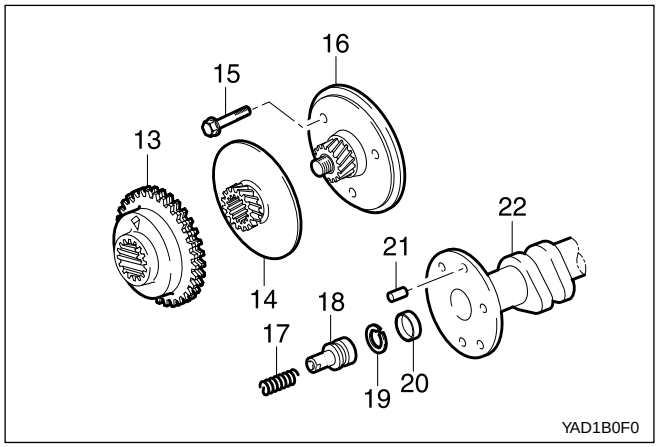
Tightening Torque	60 - 70 N•m (44 - 52 lb-ft)

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

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 always replace with new one.



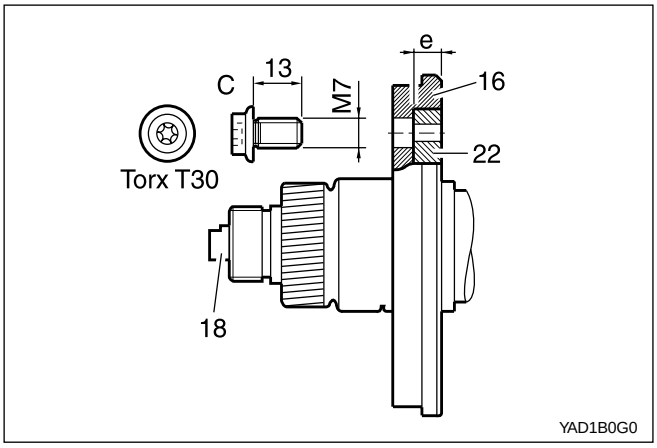
7. Remove the camshaft sprocket (13) and adjust piston (14), and remove the flange shaft (16) from the intake camshaft (22) after removing the bolt (15).

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 always replace with new one.

8. Installation should follow the removal procedure in the reverse order.
9. Adjust the camshaft timing.



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

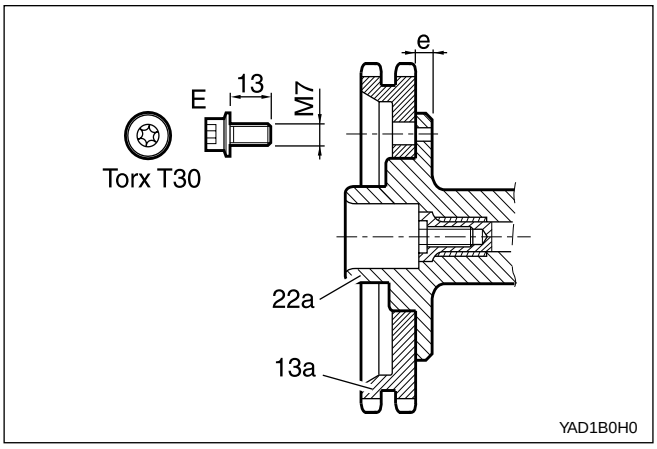
CAMSHAFT SPROCKET BOLT

Intake Flange Shaft Bolt

Installation Notice

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

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

Exhaust Camshaft Sprocket Bolt

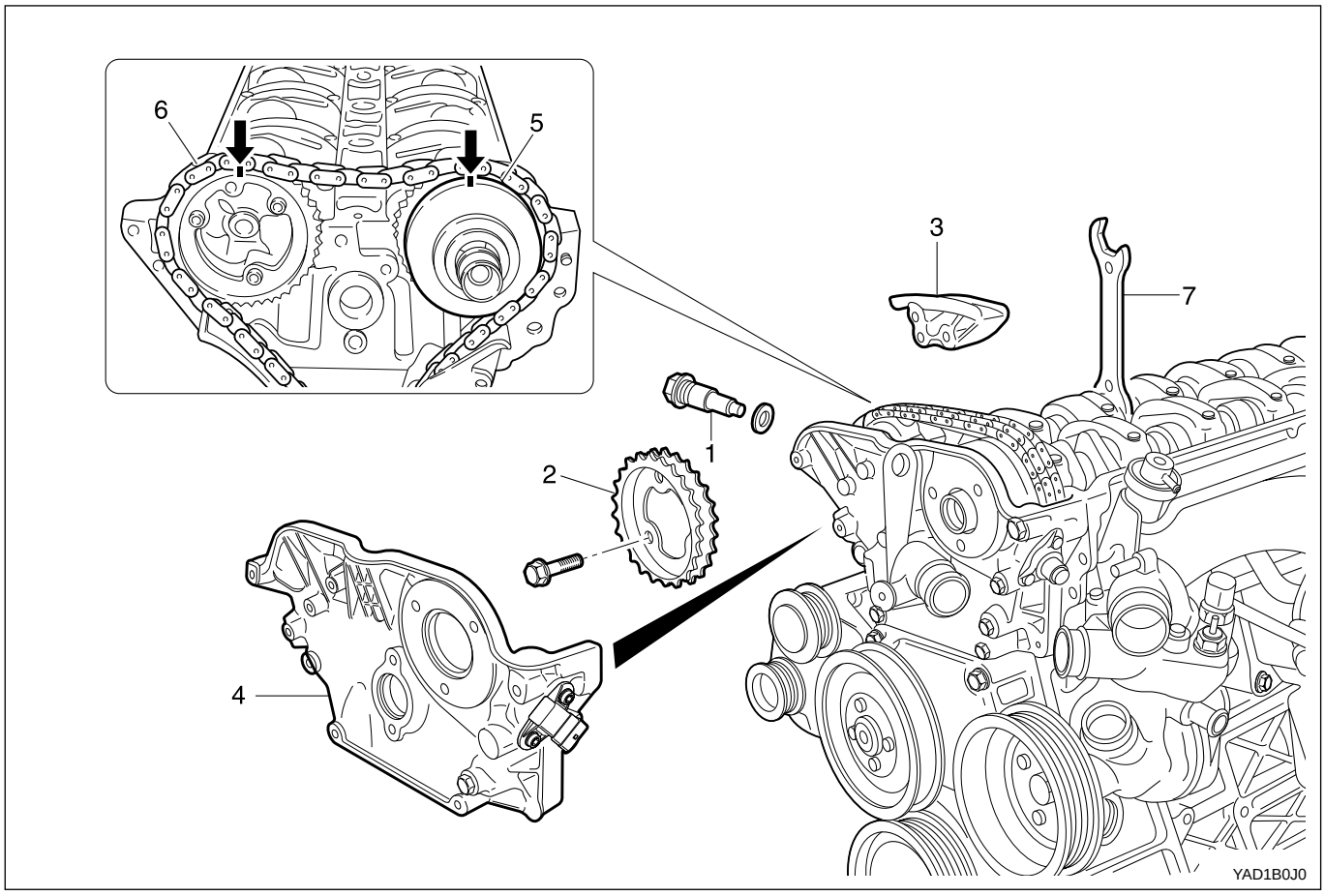
Installation Notice

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

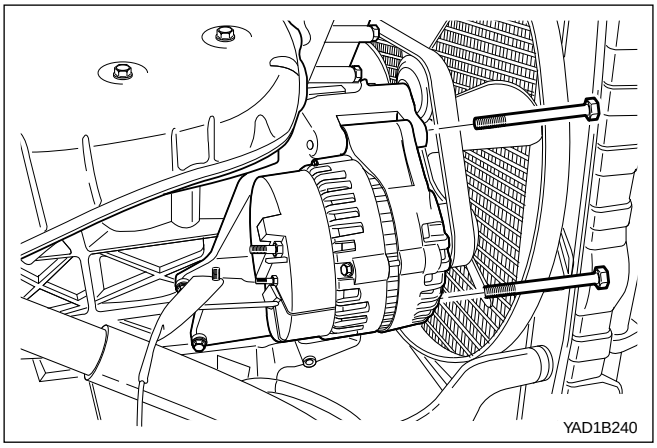
The sprocket bolts are designed to be used only once, so always replace with new one.

CAMSHAFT

Preceding Work : Removal of cylinder head cover
Removal of cylinder head front cover
Removal of coolant connection fitting



1 Chain Tensioner Assembly
..... 72-88 N•m (53-65 lb-ft)
2 Exhaust Camshaft Sprocket
3 Upper Guide Rail
4 Cylinder Head Front Cover
5 Intake Camshaft Sprocket
6 Chain
7 Wrench

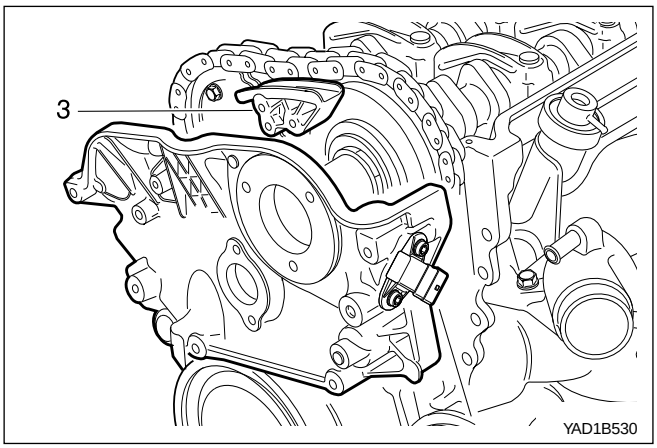


Tools Required

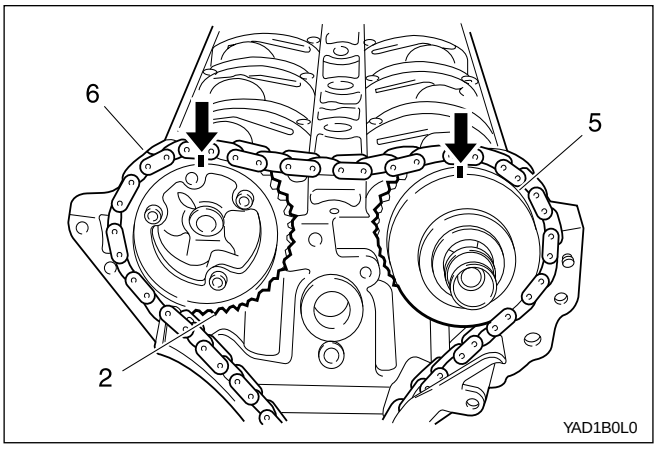
DW 110-120 Holding Pin

Removal Procedure

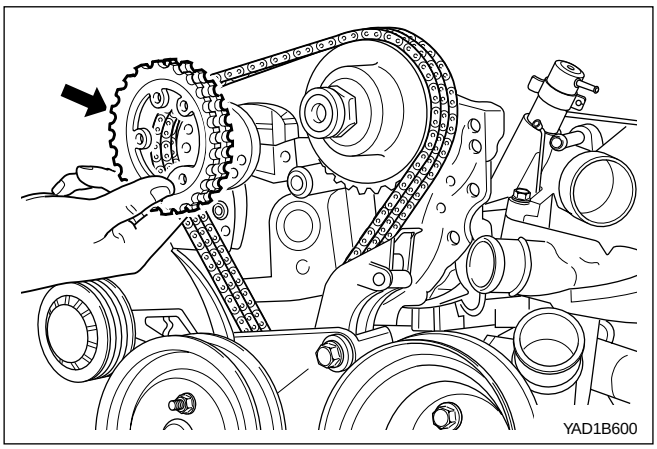
1. Turn the crankshaft and position the No. 1 cylinder piston at BTDC 30°.
2. Remove the generator.
3. Remove the chain tensioner. Refer to “Chain Tensioner” in this section.



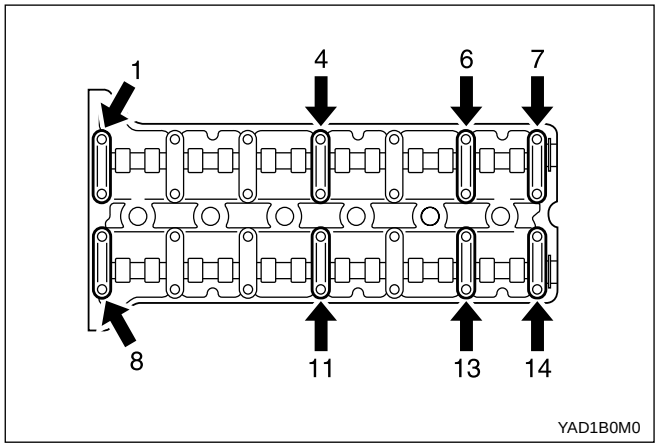
4. Remove the cylinder head front cover and the upper guide rail.



5. Put the alignment marks (arrows) on the camshaft sprocket (2, 5) and the timing chain (6).



6. Unscrew the exhaust camshaft sprocket bolt and remove the sprocket.
7. Separate the chain from the intake camshaft sprocket and put the chain not to be dropped into timing case.



8. Unscrew the intake side bolts (8, 11, 13, 14) and the exhaust side bolts (1, 4, 6, 7).
9. Loosen the remaining bolts and unscrew the intake and exhaust side camshaft bearing cap bolts.

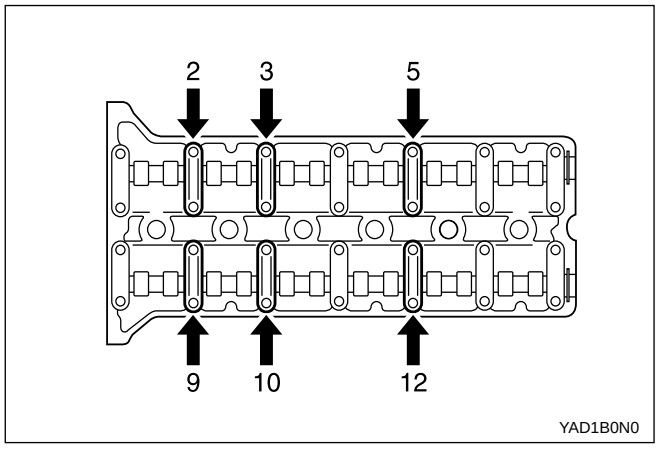
   Notice: Number the camshaft bearing cap bolts when removing them, so that they don't get mixed up.

10. Remove the intake and exhaust camshafts.

Installation Procedure

1. Turn the crankshaft and position the No. 1 cylinder piston at BTDC 30°.

   Notice: Turn the crankshaft in the direction of engine rotation.

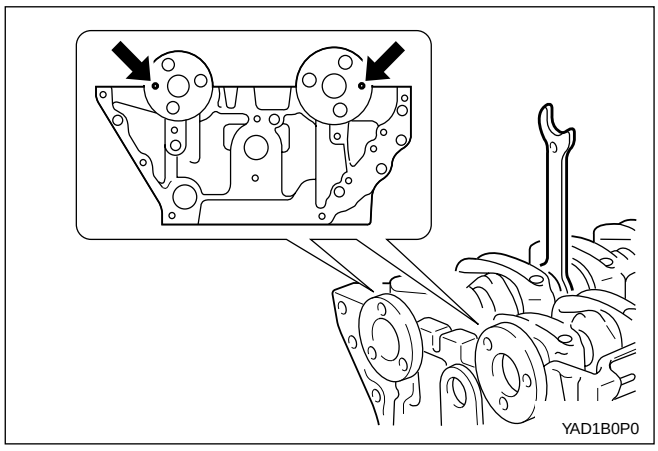


2. Install the exhaust camshaft bearing caps (2, 3, 5) and the intake camshaft bearing caps (9, 10, 12). Tighten the bolts with specified torque and install the remaining bearing caps.

   Installation Notice

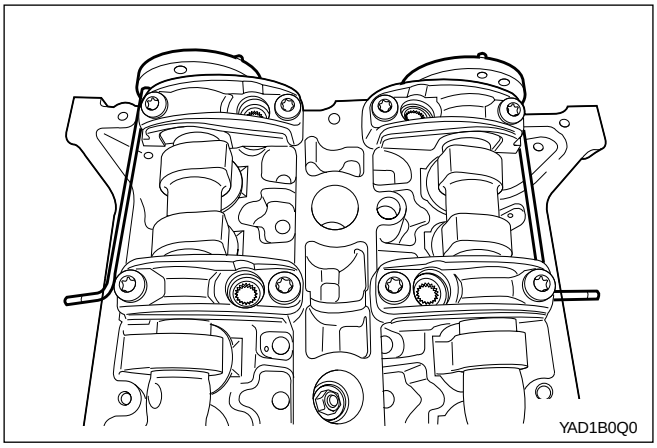
Tightening Torque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

   Install the bearing caps according to the numbers on the bearing caps.

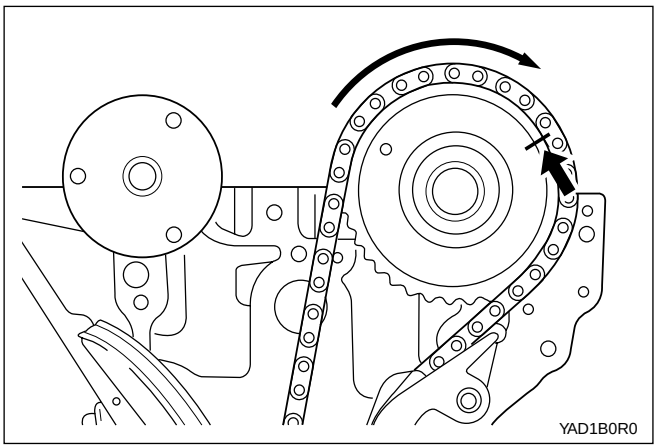


3. Turn the camshaft using the wrench so that the intake camshaft adjustment hole lines up with the cylinder head upper side (3 o'clock direction at the intake, 9 o'clock direction at the exhaust).

   Notice: Turn the crankshaft and adjust it to OT so that No. 1 cylinder's piston would be at TDC.



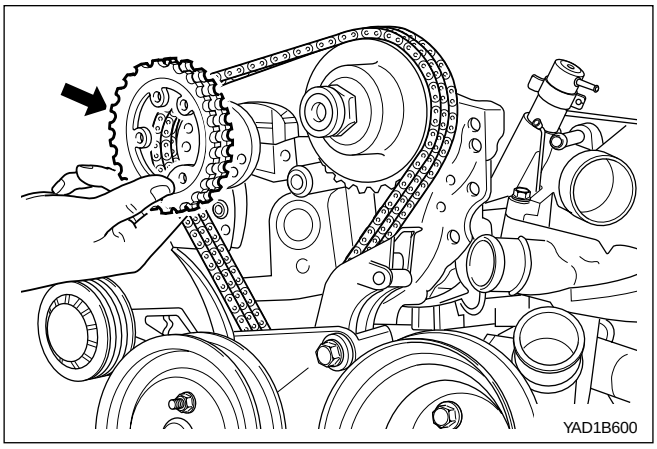
4. Align the holes on intake and exhaust camshaft to the hole on cylinder head. Insert the holding pin DW 110-120 into the holes.



5. Turn the intake camshaft adjuster to the direction of camshaft rotation by hard until it stops and then install the chain.

Notice:

- Make sure that the camshaft sprocket and timing chain are aligned with marks.
- Intake camshaft adjuster should be in retarded position.

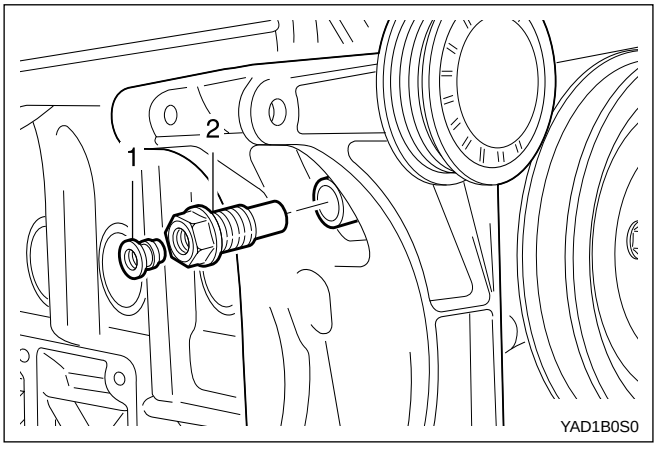


6. Install the chain on the exhaust sprocket and tighten the sprocket bolts.

Installation Notice

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

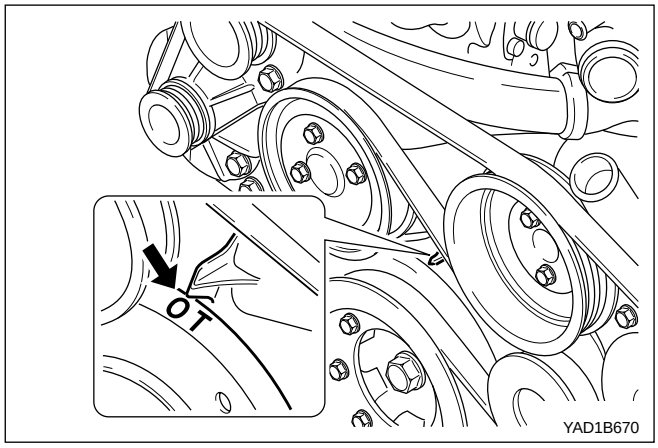
- Make sure that the camshaft sprocket and timing chain are aligned with marks.
- Replace the sprocket bolt with new one.



7. Install the chain tensioner screw plug (1) and chain tensioner assembly (2) and tighten it as specified.

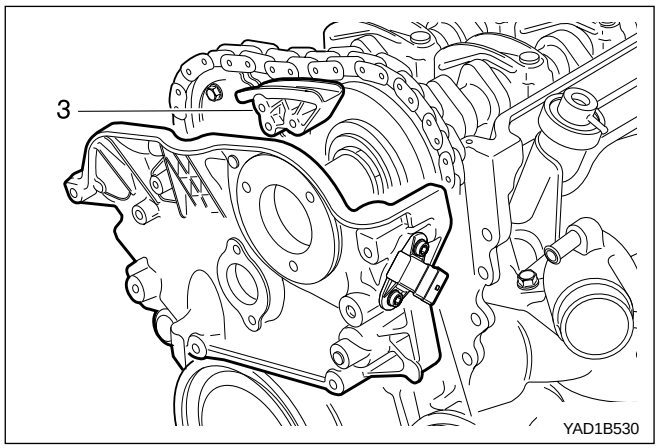
Installation Notice

Tightening Torque	(1) : 40 N•m (30 lb-ft)
	(2) : 72 - 88 N•m (53 - 65 lb-ft)



8. Rotate the crankshaft 2 revolutions and check followings:
   - TDC of no. 1 cylinder : OT
   - Alignment between camshaft adjustment hole and cylinder head surface.
   - Alignments between timing chain and sprocket marks.

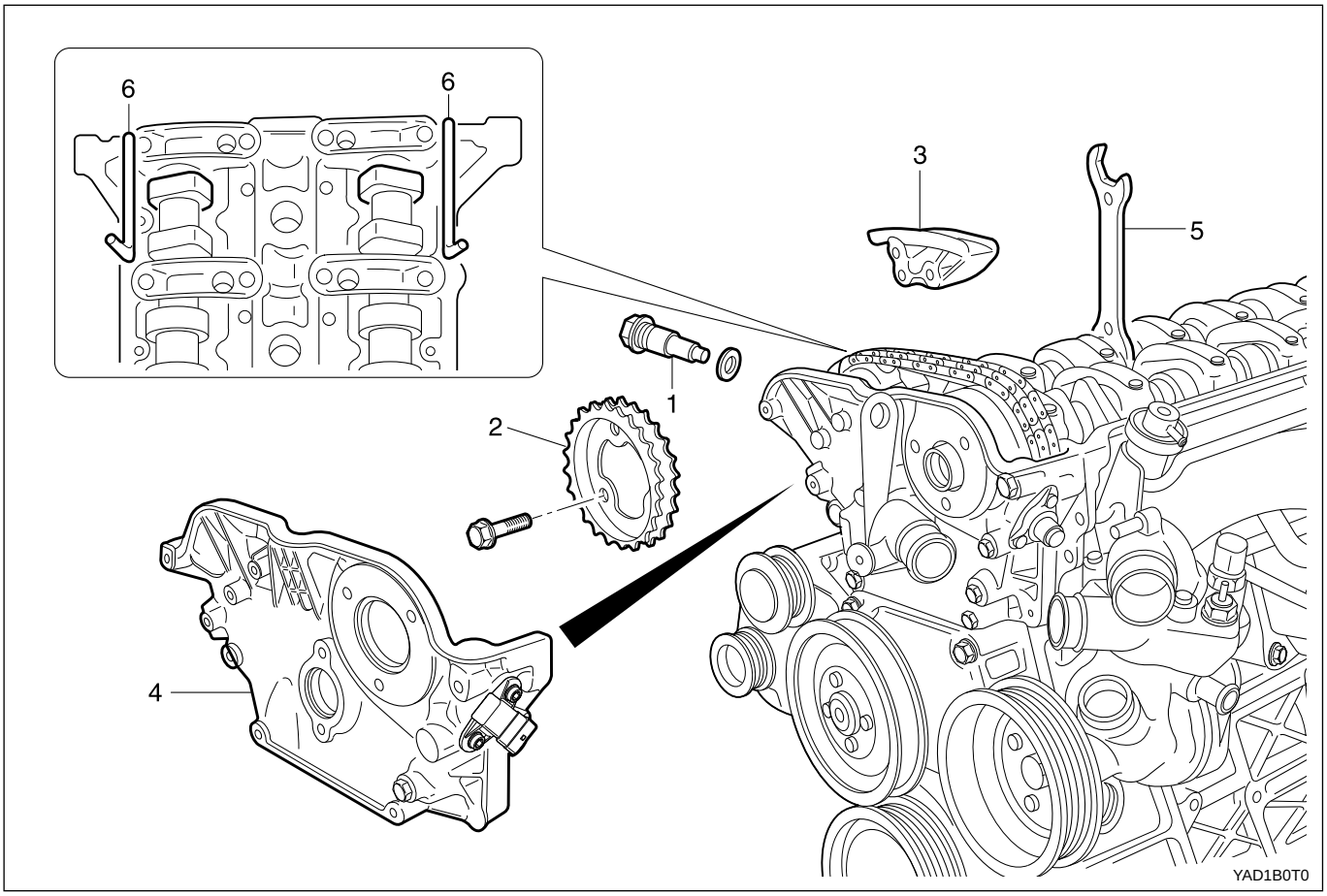
   Notice:
   - Turn the crankshaft in the direction of engine rotation.
   - Read just if not aligned.



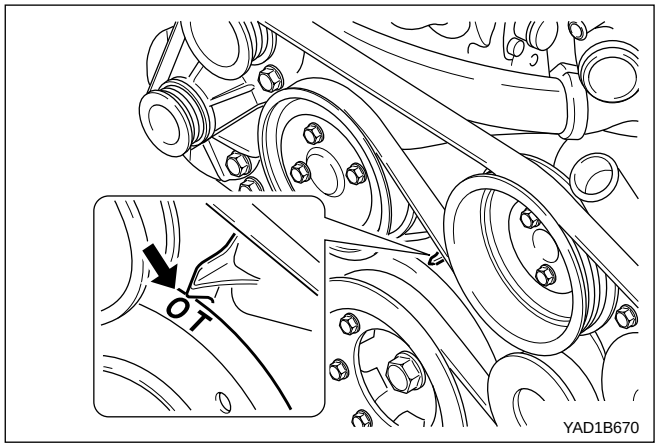
9. Install the upper guide rail and cylinder head front cover.
10. Install the generator.

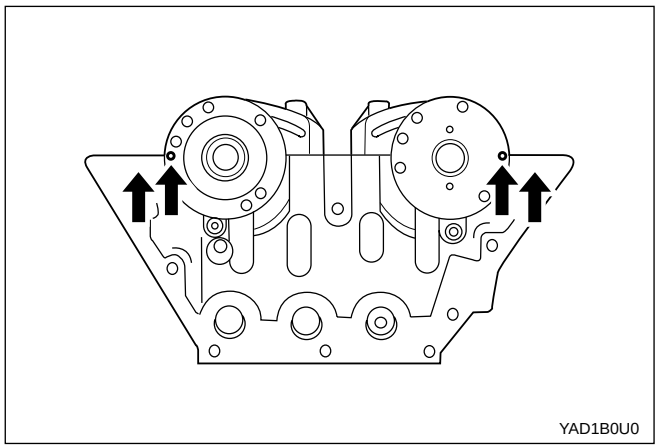
CAMSHAFT TIMING POSITION

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



1 Chain Tensioner Assembly
2 Exhaust Camshaft Sprocket
3 Upper Guide Rail
4 Cylinder Head Front Cover
5 Wrench
6 Holding Pin DW 110-120





Tools Required

DW 110-120 Holding Pin

Inspection

1. Position the No.1 cylinder piston to TDC (OT) by turning the crankshaft.

   Notice: When the OT mark on vibration damper is aligned with timing gear case cover, the intake and exhaust cam of cylinder will make the slope to the center and will face up. In this way, the adjustment hole of the intake and exhaust camshaft will match in line with the cylinder head upper end, at 3 o'clock, and 9 o'clock direction each other.

2. Check the timing as below procedure;
   - Check if the camshaft adjustment hole is positioned to 3 o'clock direction at the intake side and to 9 o'clock direction at the exhaust side, respectively and align with the cylinder head mating surface.
   - At this condition, check if the OT mark on vibration damper aligns with the marker on the timing gear case.

Adjustment Procedure

1. Position the No.1 cylinder to BTDC 30° .
2. Remove the chain tensioner.
3. Remove the exhaust camshaft sprocket.
4. Align the intake and exhaust camshaft flange hole with the cylinder head upper surface.
   - Intake Side : 3 o'clock direction
   - Exhaust Side : 9 o'clock direction
5. Align the holes on intake and exhaust camshaft to the hole on cylinder head. Insert the holding pin DW 110-120 into the hole.
6. Secure the intake and exhaust camshaft.
7. Position the piston of No.1 cylinder at TDC (OT) by turning the crankshaft.
8. Turn the camshaft adjuster of the intake camshaft to the left as much as possible (cam adjuster 'retarded' position).
9. Install the chain to the intake camshaft sprocket.

   Notice: Timing chain must be placed on the guide rail in gear case cover.

10. Install the chain to the exhaust camshaft sprocket and install it to the camshaft.

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.

11. Install the chain tensioner.

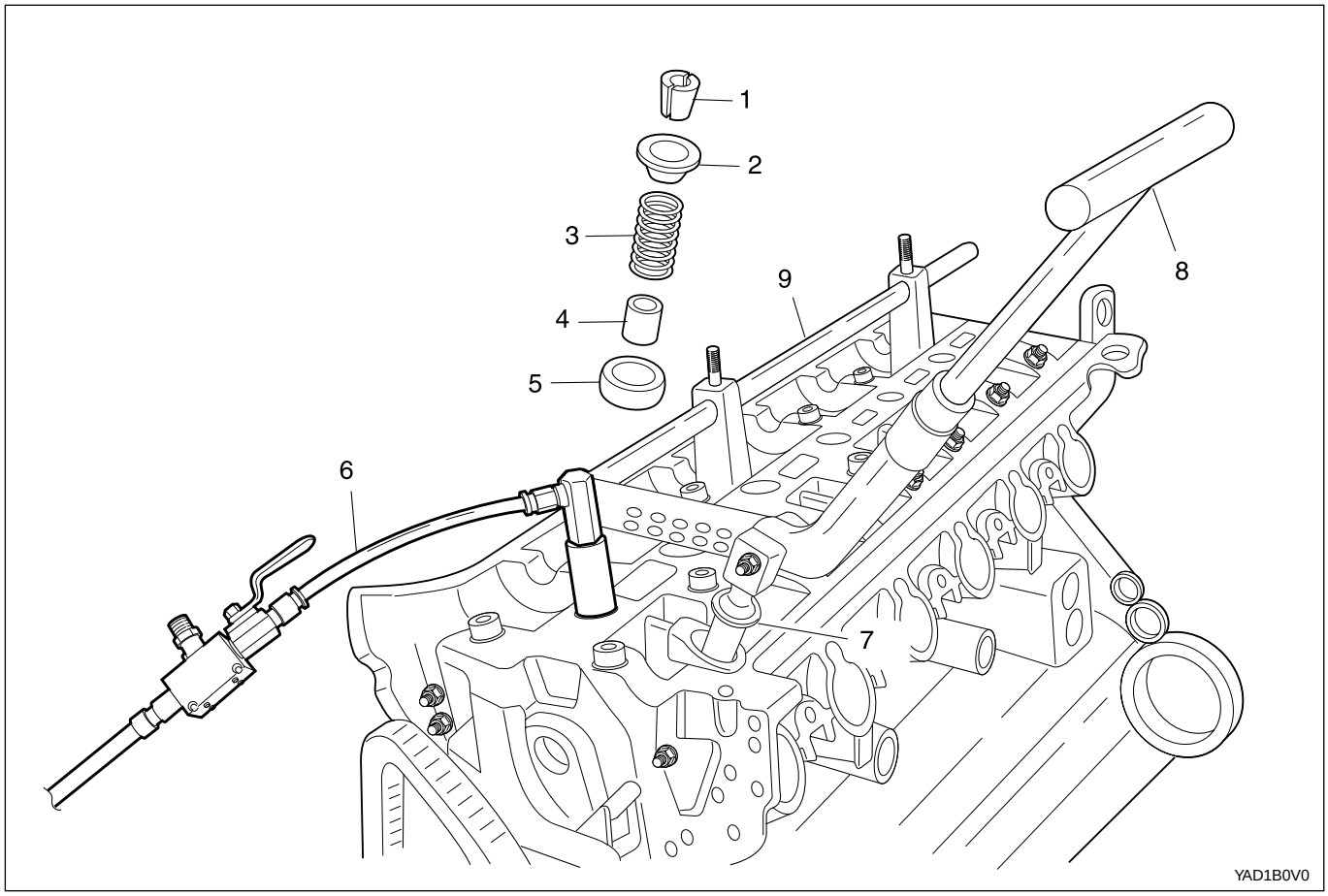
Installation Notice

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

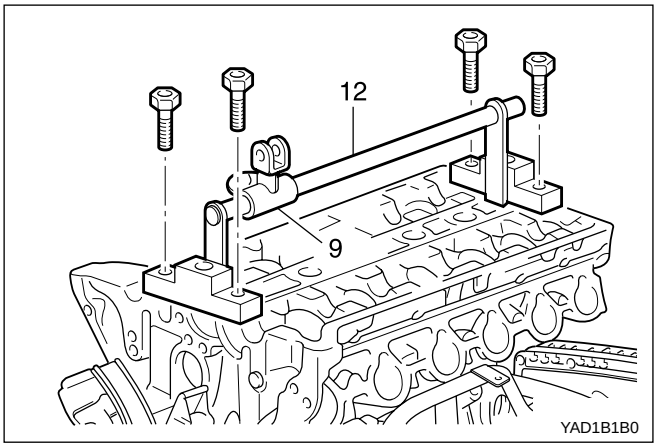
12. Check the camshaft timing.

VALVE SPRING

Preceding Work : Removal of camshaft
Removal of spark plug



1	Valve Cotter	6	Connecting Hose DW 110-090
2	Upper Retainer	7	Thrust Piece 111 589 25 63 00
3	Valve Spring ..... Check, Replace if necessary	8	Lever Pusher 111 589 18 61 00
4	Valve Stem Seal	9	Supporting Bar 111 589 01 59 00
5	Lower Retainer		



Tools Required

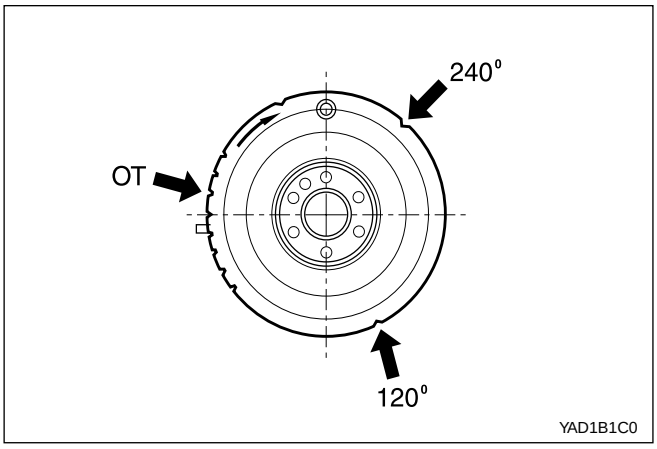
111 589 01 59 00	Supporting Bar
111 589 18 61 00	Lever Pusher
111 589 25 63 00	Thrust Piece
602 589 00 40 00	Engine Lock
DW 110-090	Connecting Hose
DW 110-100	Valve Tappet Remover

Removal & Installation Procedure

1. Place the supporting bar 111 589 01 59 00 (12) 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)

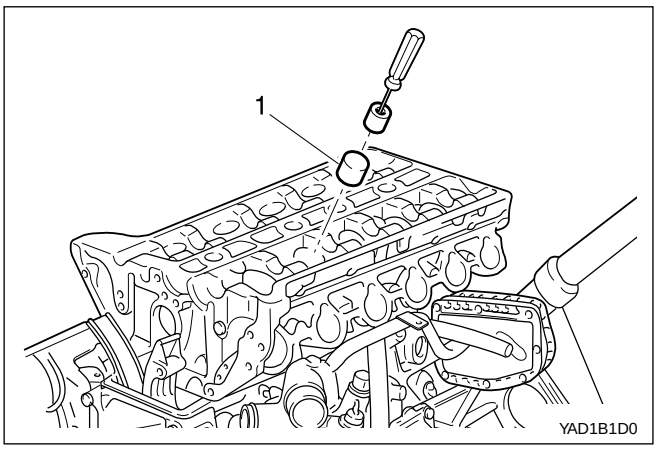


2. Turn the crankshaft to position the each cylinder piston at TDC.

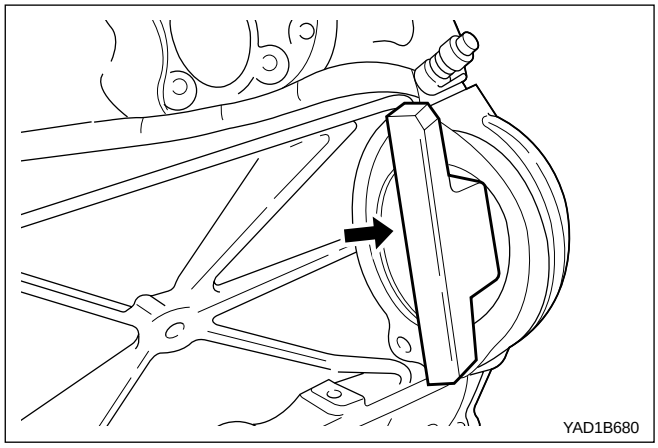
Mark on The Vibration Damper	Cylinder
OT	1, 6
120°	2, 5
240°	3, 4

Notice:

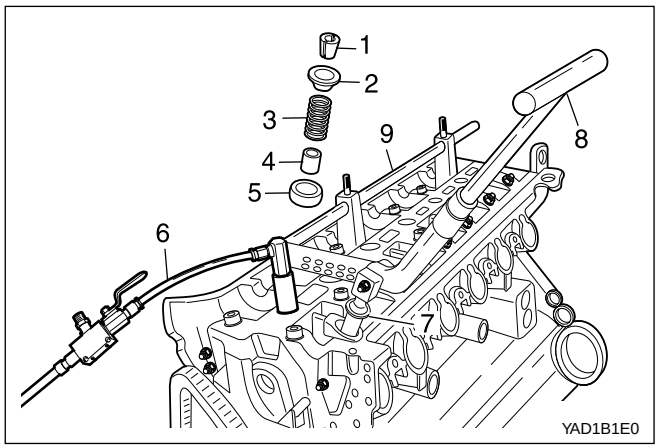
- Remove the valve spring only at TDC.
- Always rotate the crankshaft by holding the chain to prevent from timing chain damage and tangling, and for smooth rotation.



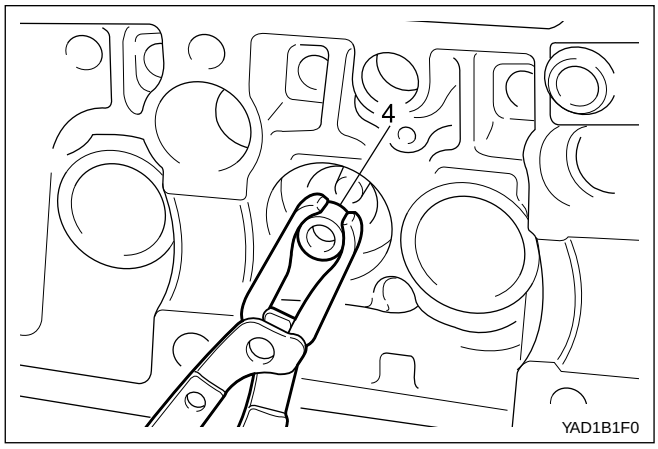
3. Remove the valve tappet (1) using the valve tappet remover DW 110-100.
4. Install the connecting hose DW 110-090 to the spark plug hole.



5. Install the engine lock to the ring gear to prevent the crankshaft from rotating.
6. Blow up with compressed air.



7. Install the lever pusher 111 589 18 61 00 (8) and the thrust piece 111 589 25 63 00 (7).
8. Mount the thrust piece 111 589 25 03 00 (7) vertically to the valve spring retainer (2).
9. Press the valve spring (3) by using the lever pusher 111 589 18 61 00 (8).
10. Remove the valve cotter (1) using the pincette.
11. Remove the upper retainer (2) and the valve spring (3).



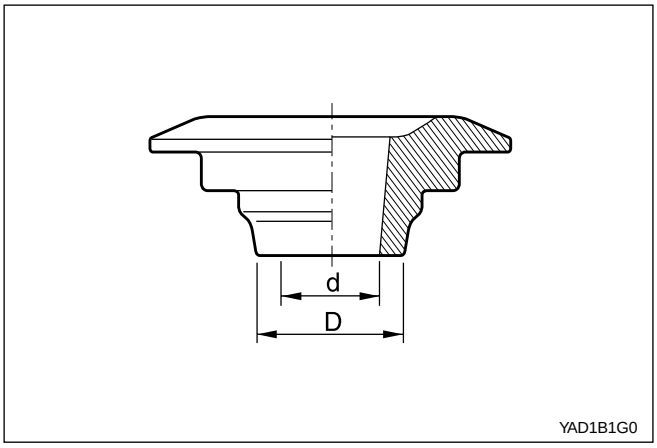
12. Remove the valve stem seal (4).

    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.

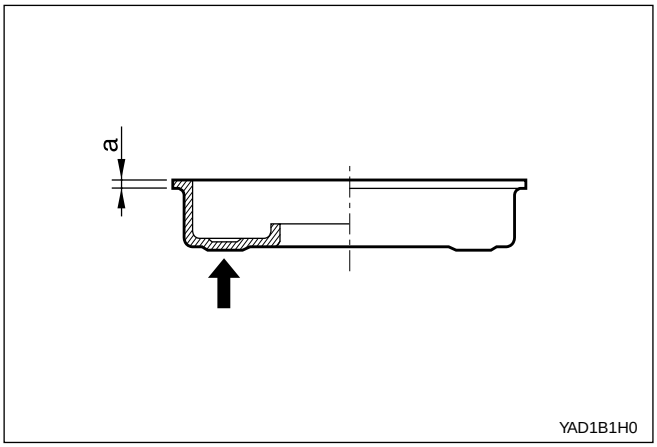
14. Installation should follow the removal procedure in the reverse order.



Test (Upper and Lower Valve Tappet and Valve Cotter)

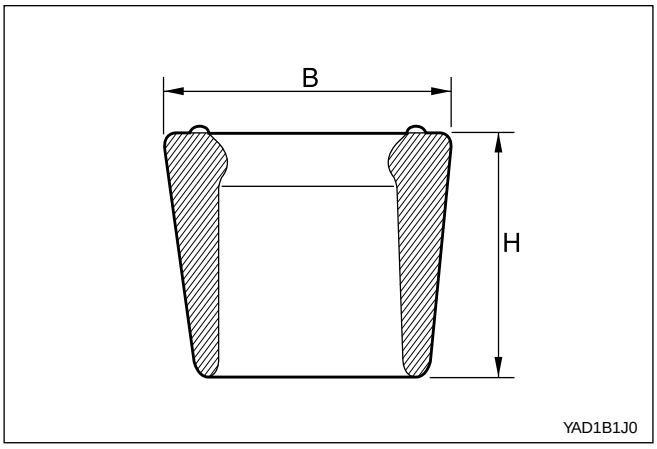
- Upper Valve Spring Retainer

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



- Lower Valve Spring Retainer

Thickness (mm)	(a)	0.8 - 1.0

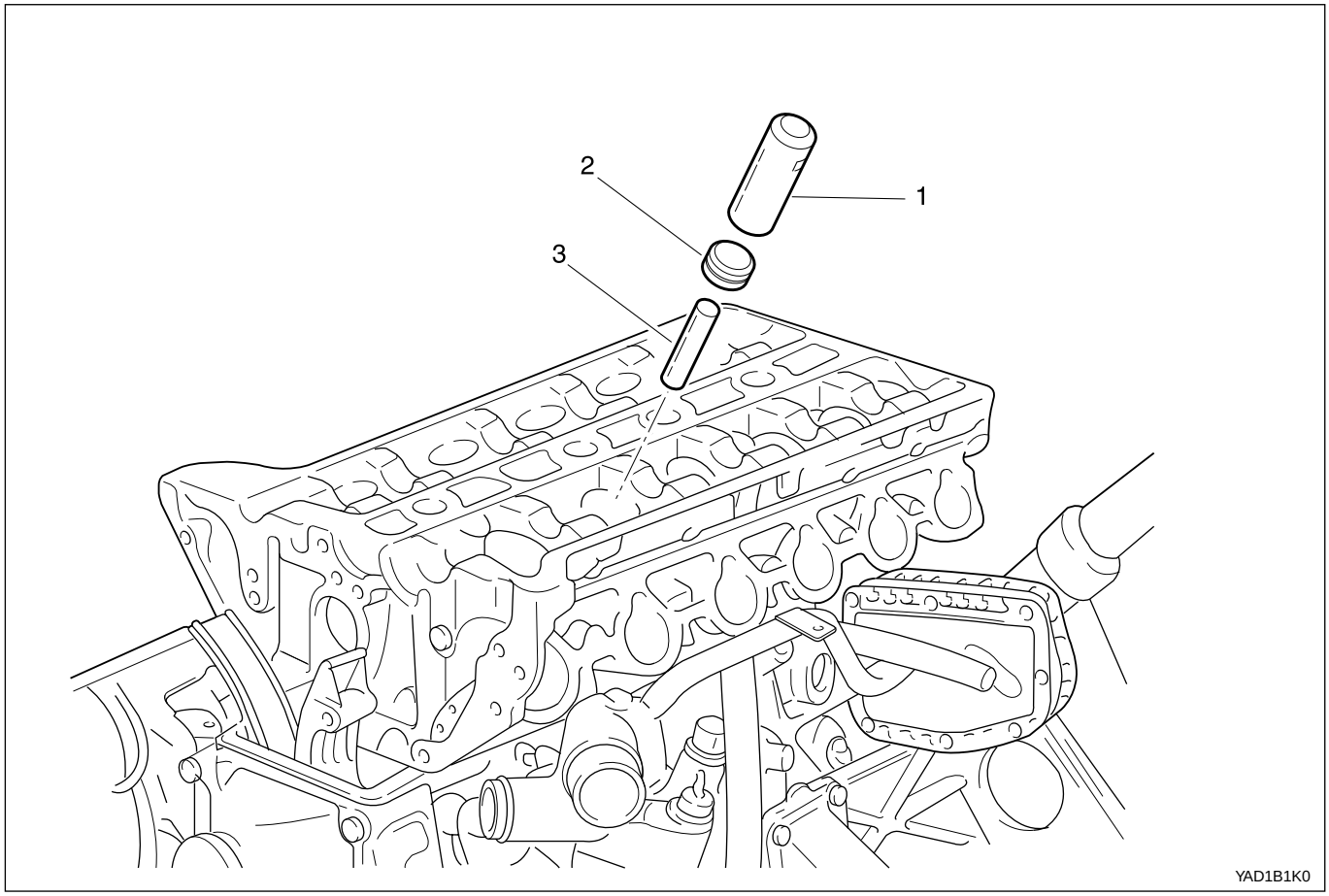


- Valve Cotter

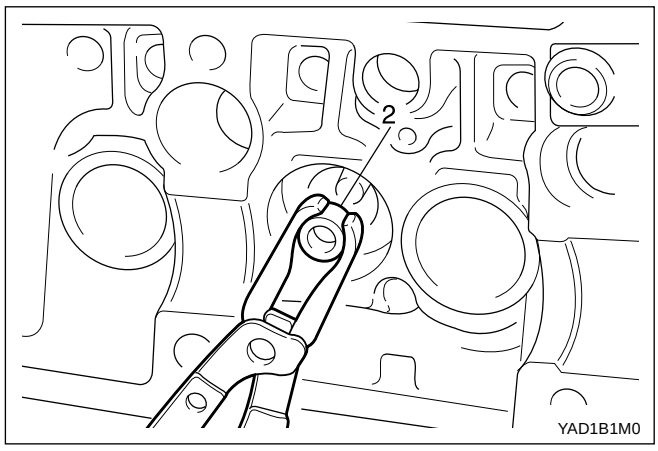
Size (mm)	(B)	9.0
	(H)	9.2 - 9.8

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

119 589 00 43 00 Drift

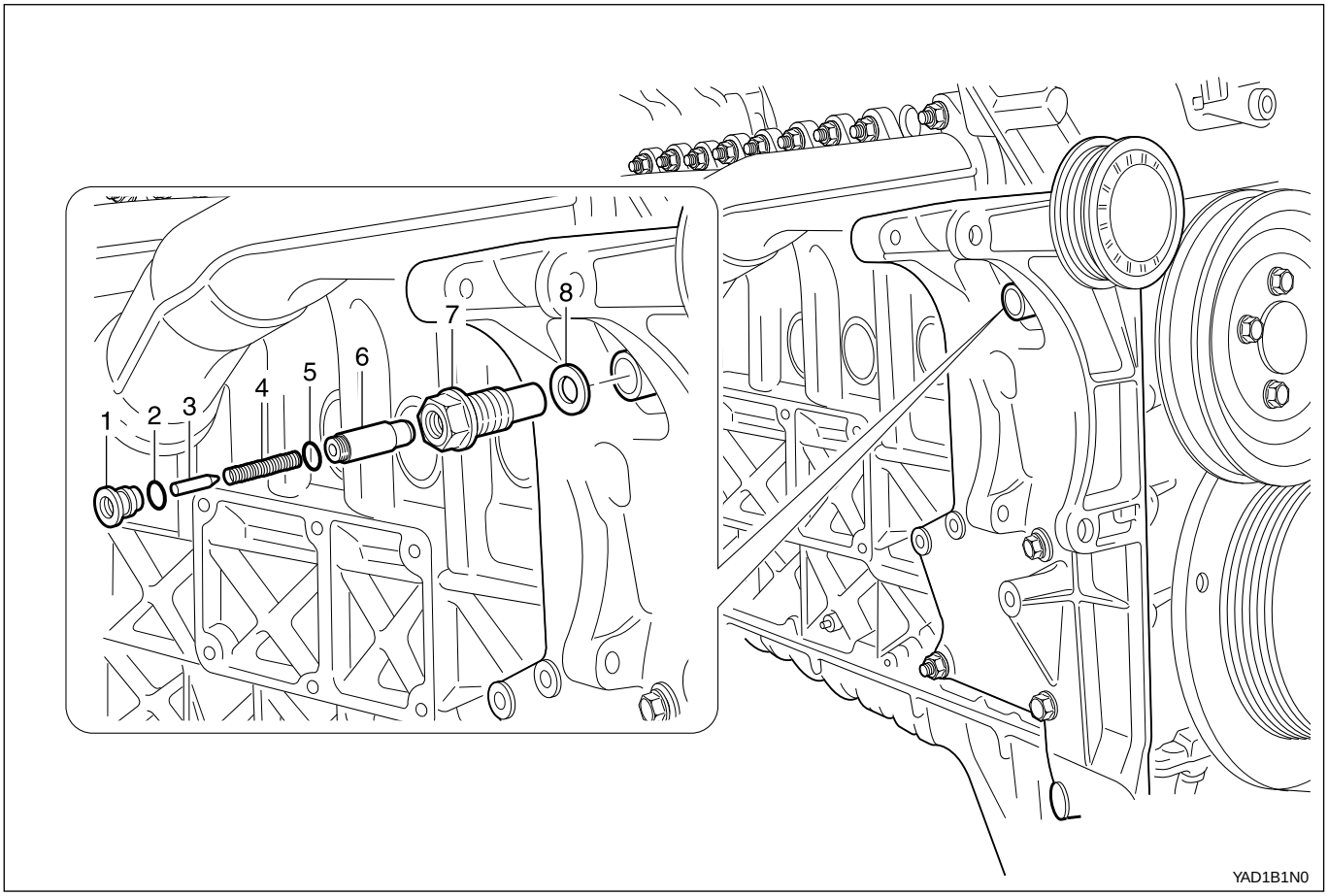
Replacement Procedure

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

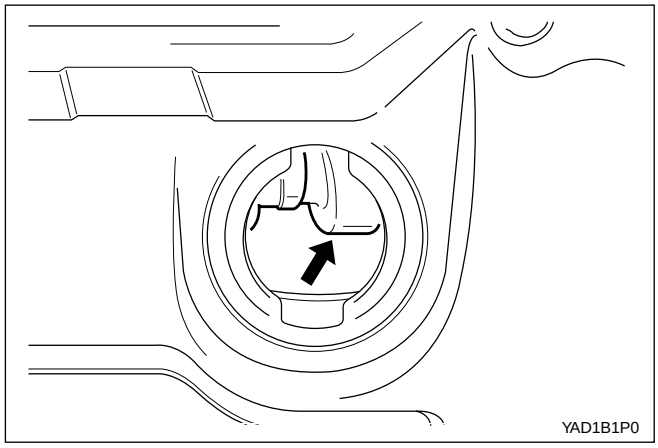
   Notice: Check the valve stem seal for damage and replace if necessary.

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 119 589 00 43 00.

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



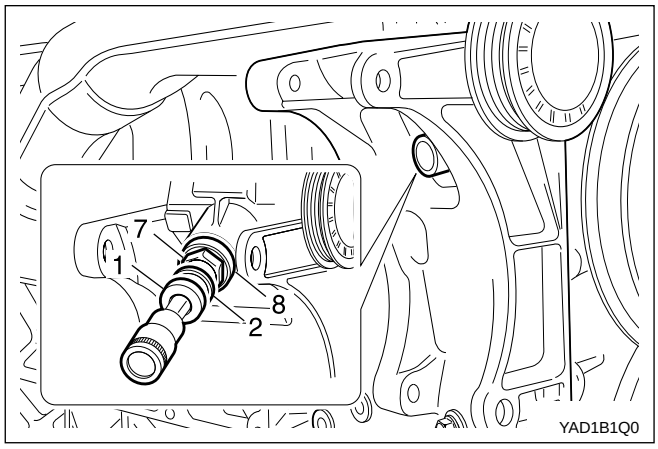
Removal Procedure

1. Position the No.1 cylinder to TDC (OT).

   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.

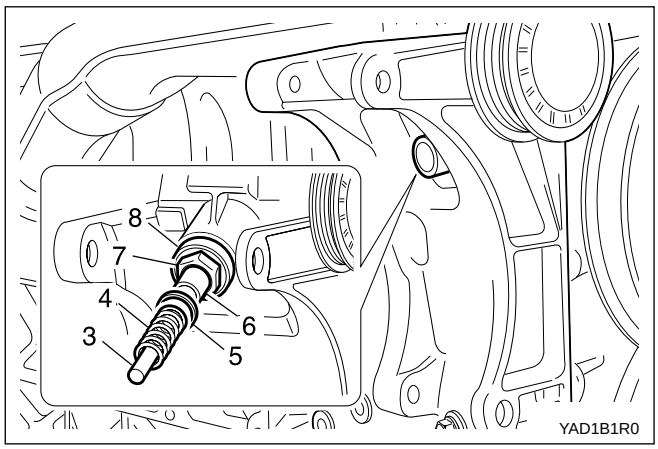
   Notice: In case that the tension is reduced by unscrewing the screw plug, reinstall after completely removing the chain tensioner. If the chain tensioner is tightened again without completely reducing its tension, then the detent spring doesn't return to the original position and the tension gets exceeded.



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.

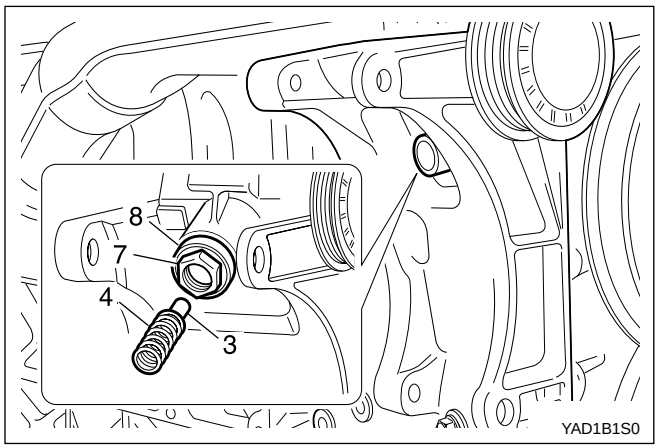


5. Carefully remove the filler pin (3), compression spring (4), snap ring (5), and the thrust pin (6).
6. Remove the chain tensioner housing (7) and the seal (8).

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.

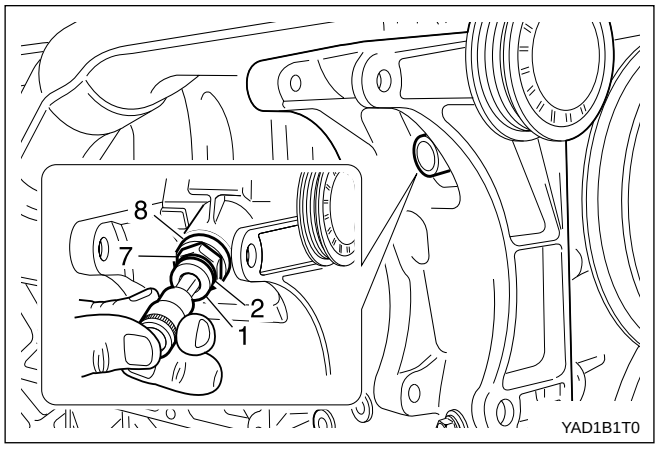


2. Install the chain tensioner housing (7), thrust pin (6), snap ring (5), and the seal (8).

   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.



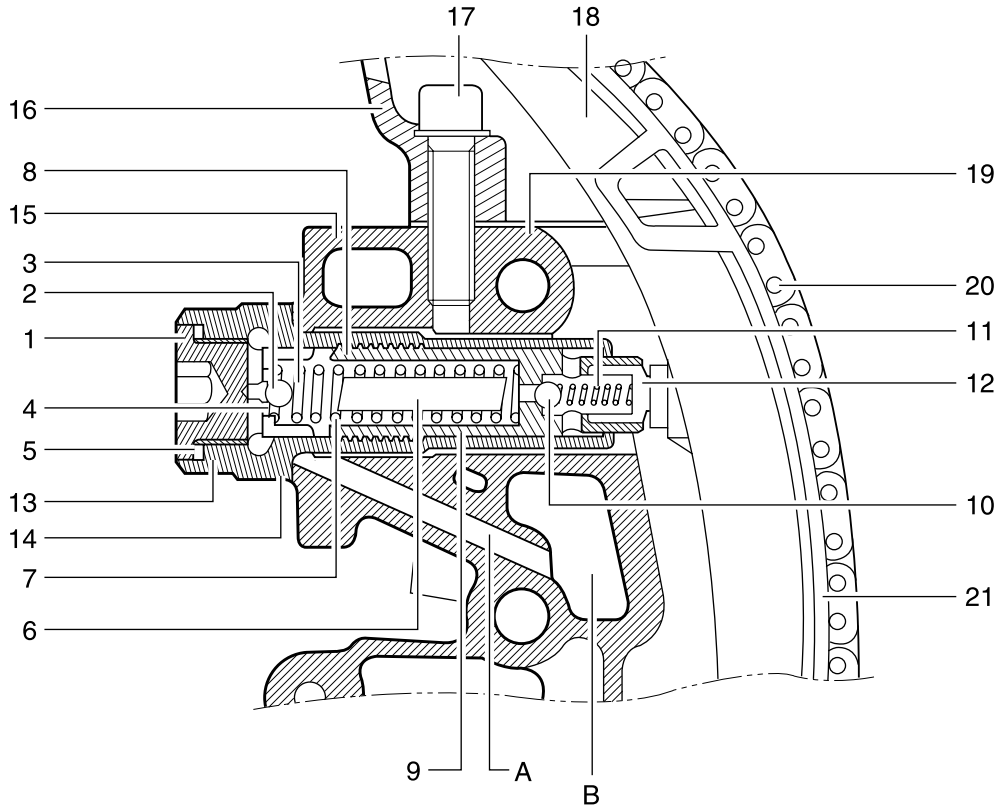
4. Lightly apply the grease to the seal (2) and install the screw plug (1).

   Installation Notice

Tightening Torque	40 N•m (30 lb-ft)

5. Check for leaks by operating the engine.

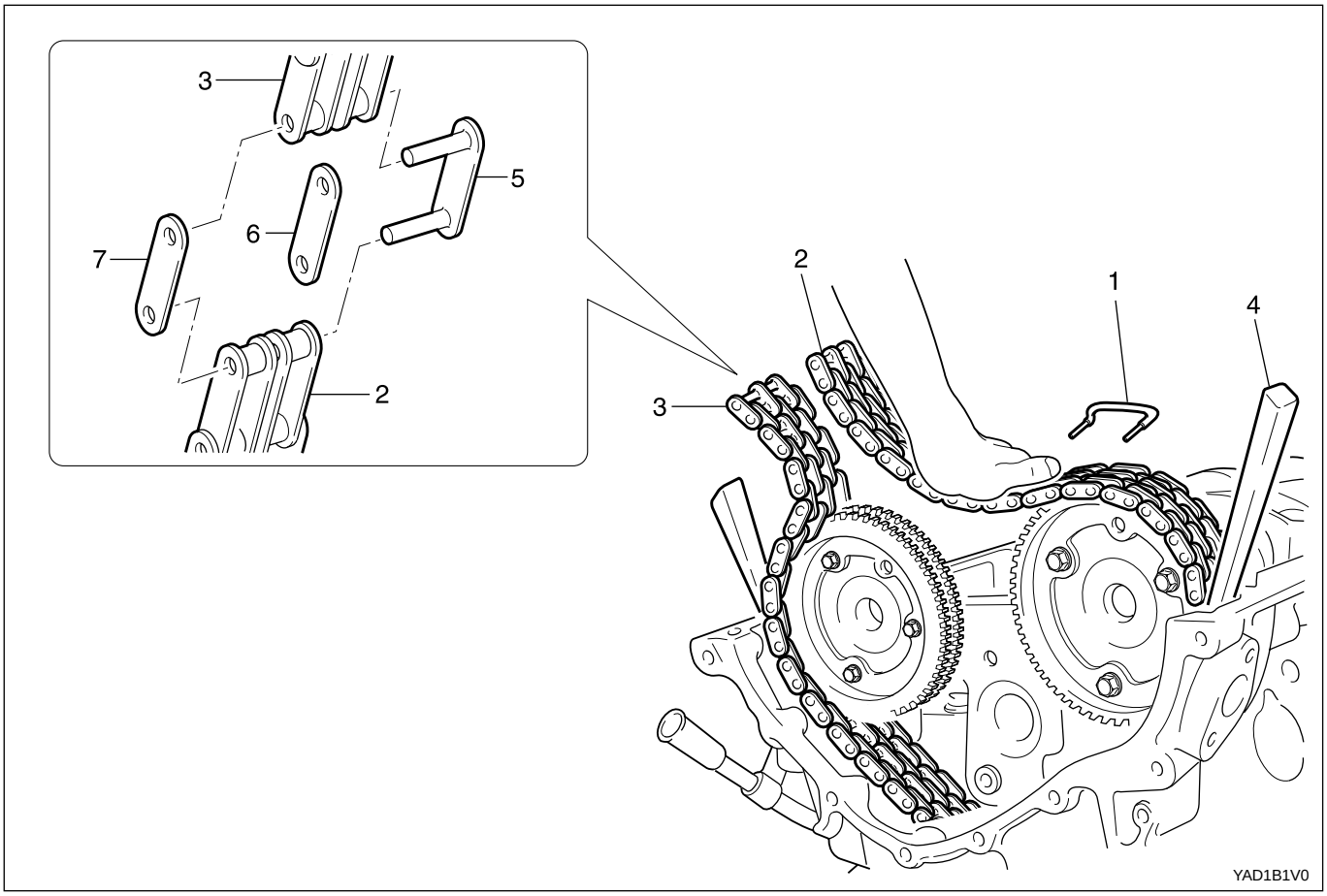
Sectional View



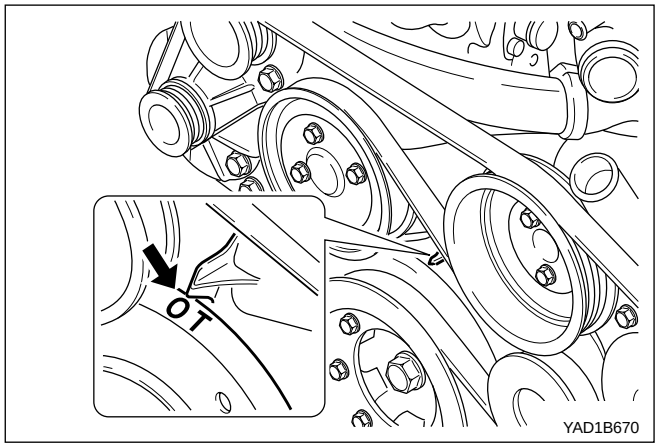
1 Screw Plug
2 Ball (Nonreturn Valve)
3 Compression Spring
4 Ball Guide
5 Seal (Aluminum)
6 Filler Pin
7 Compression Spring
8 Snap Ring
9 Thrust Pin
10 Ball (Nonreturn Valve)
11 Compression Spring
12 Thrust Piece
13 Chain Tensioner Housing
14 Seal
15 Timing Gear Case Cover
16 Cylinder Head
17 Bolt / 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

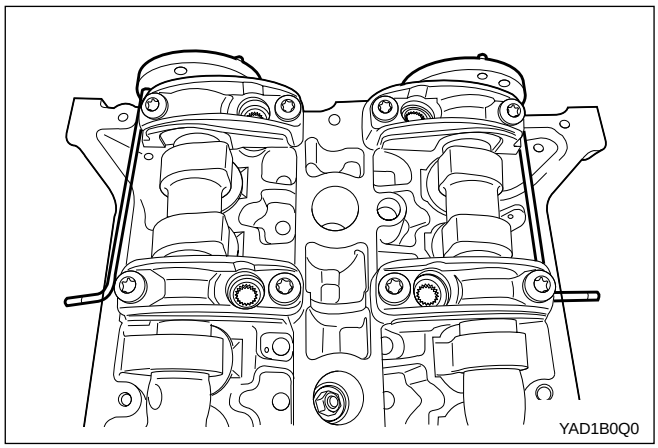


Tools Required

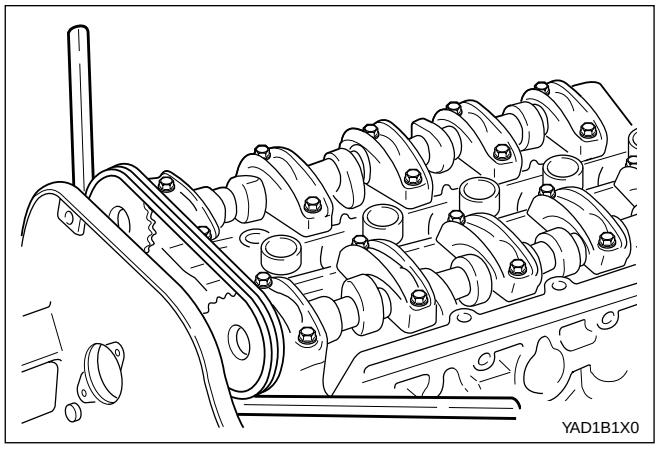
000 589 58 43 00	Chain Assembly
DW 110-120	Holding Pin

Replacement Procedure

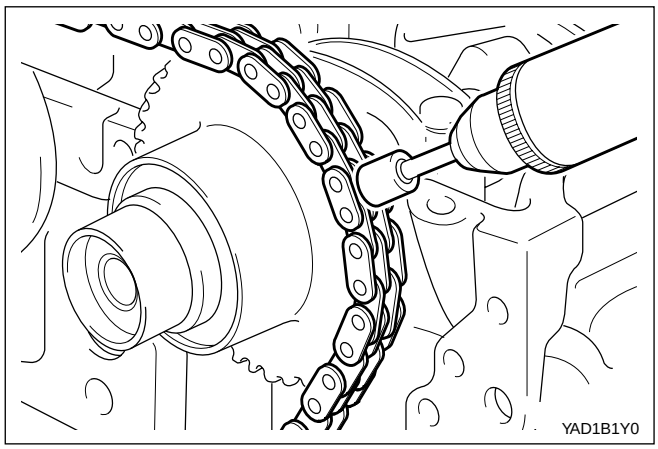
1. Position the No.1 cylinder to TDC (OT).



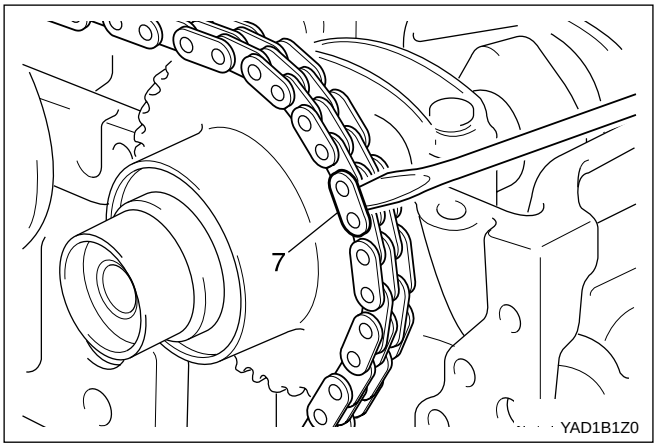
2. Insert the holding pin DW 110-120 to the intake and exhaust camshaft flange not to rotate camshaft.
3. Remove the chain tensioner.



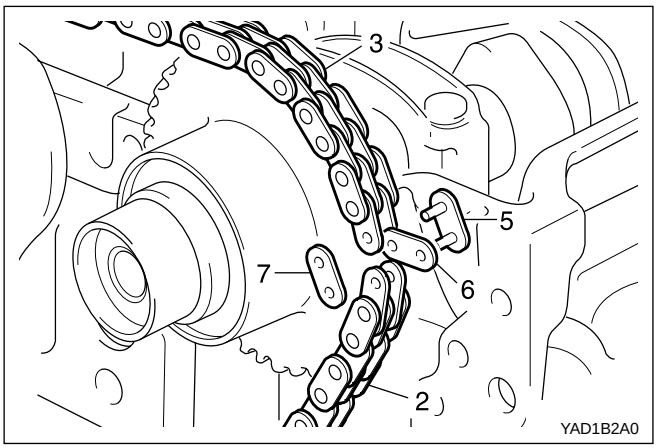
4. Mount the wedges to both sides of the camshaft sprocket as shown in the figure.



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

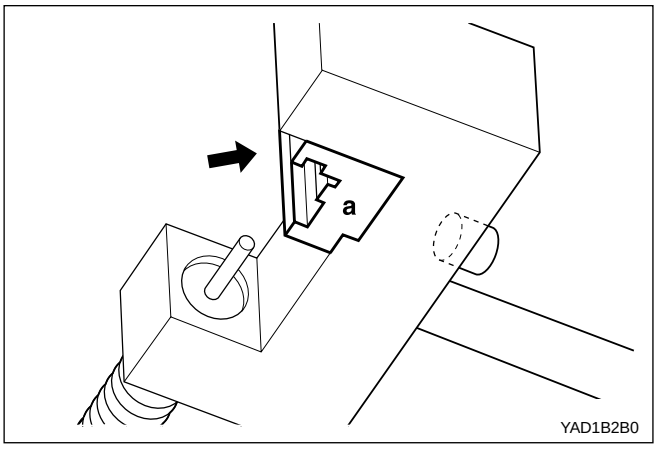


6. Remove the outer plate (7) with the screw driver and remove the link.

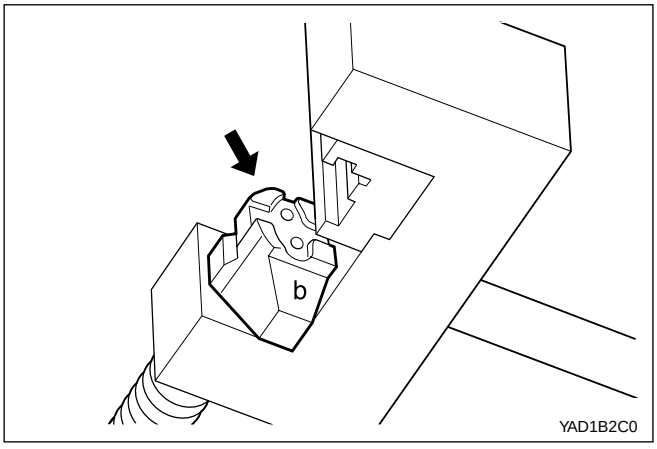


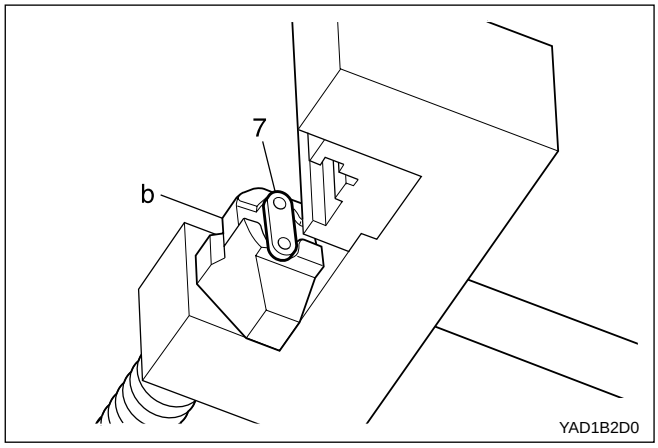
7. Connect the new timing chain (2) to the used timing chain (3) with the link (5), center plate (6, thickness 1.6 mm), and the outer plate (7).
8. Rotate the crankshaft in the direction if engine revolution by pressing the new timing chain against the exhaust camshaft sprocket to prevent it to be tangled.

   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).

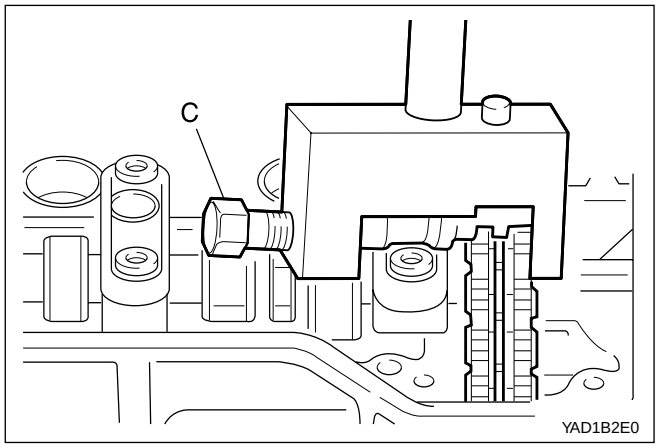


11. Install the jaw (a) and the thrust piece (b) to the assembly tool as shown in the figures.

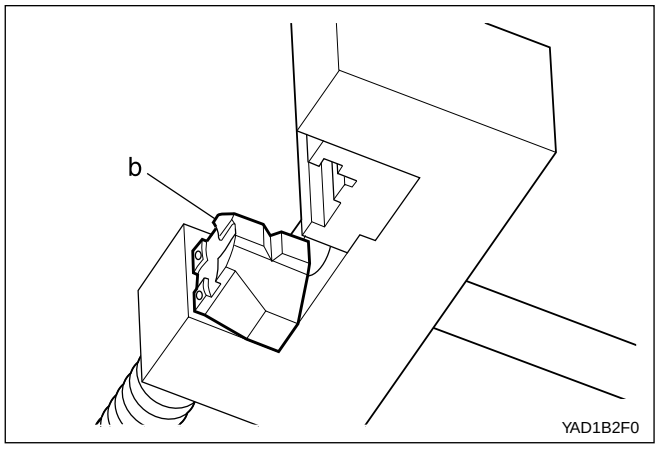




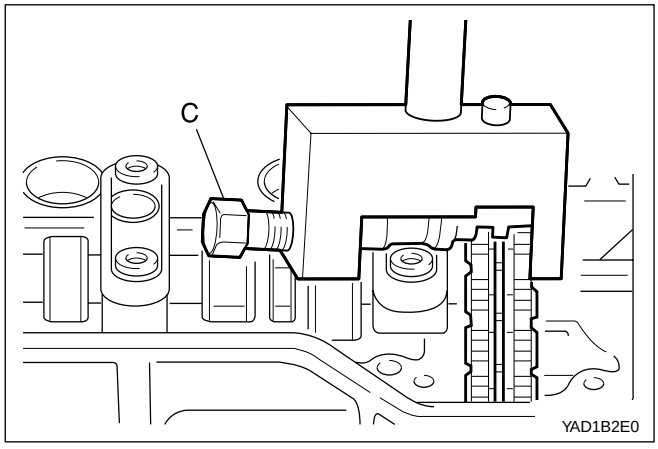
12. Place the outer plate (7, thickness 1.2 mm) inside the thrust piece (b).



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

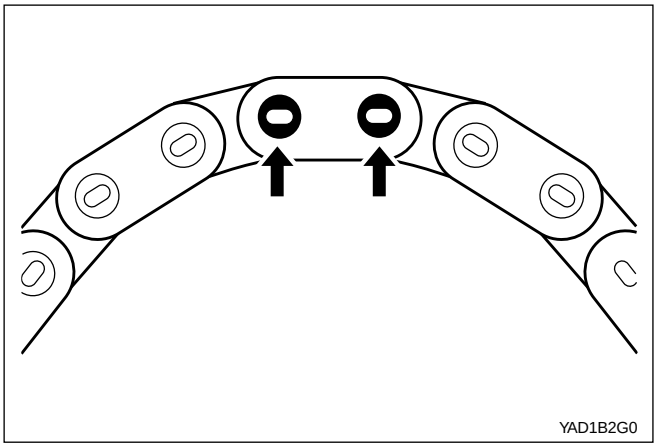


15. Replace the thrust piece (b) as shown in the figure.



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

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.

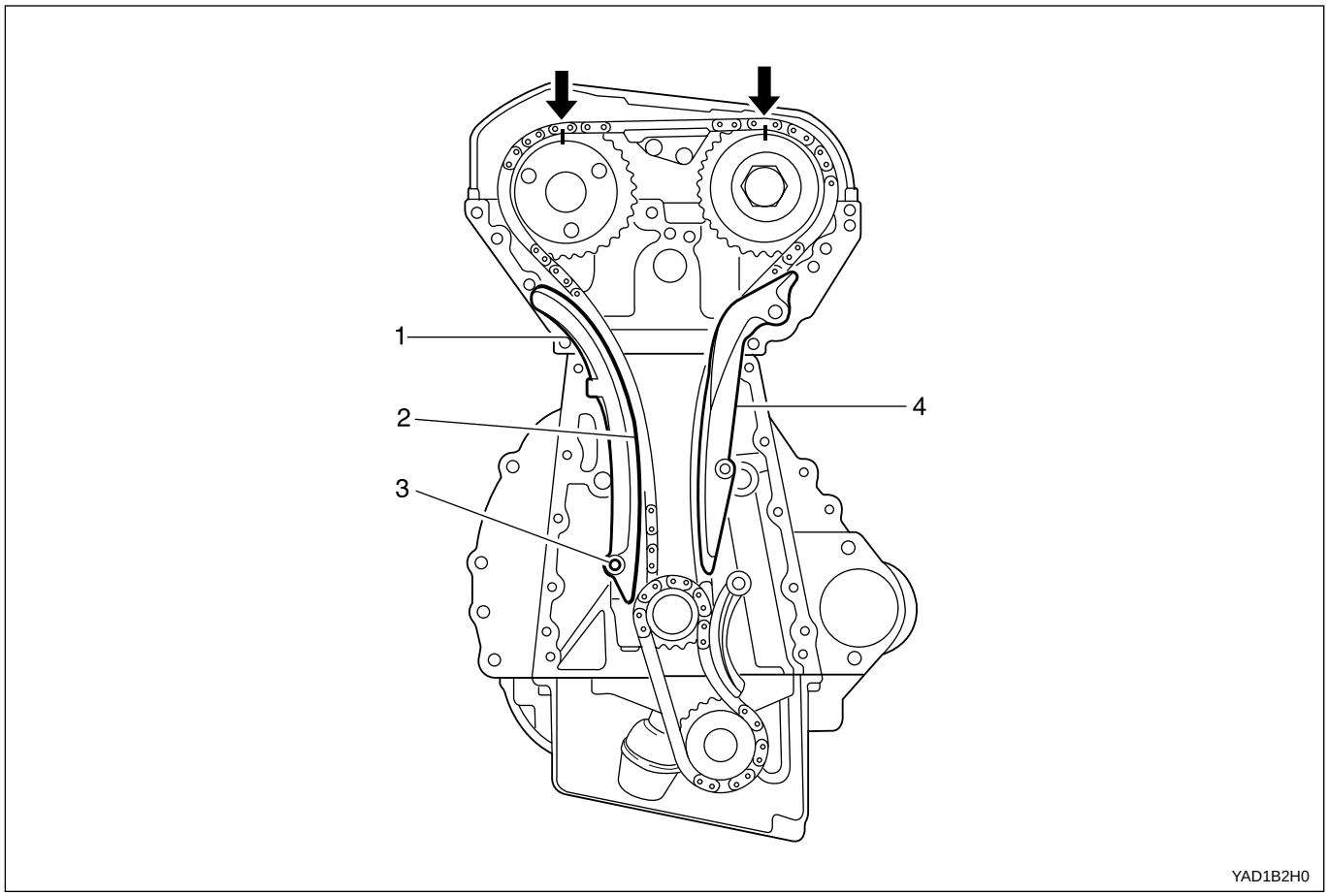
Installation Notice

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 timing gear case cover



1 Tensioning Rail
2 Plastic Guide
3 Tensioning Rail Pin
4 Guide Rail

Removal & Installation Procedure

1. Put the assembly mark at the camshaft sprocket and the timing chain with the paint (arrow).
2. Remove the exhaust camshaft sprocket.
3. Remove the tensioning rail (1) from the tensioning rail pin (3).

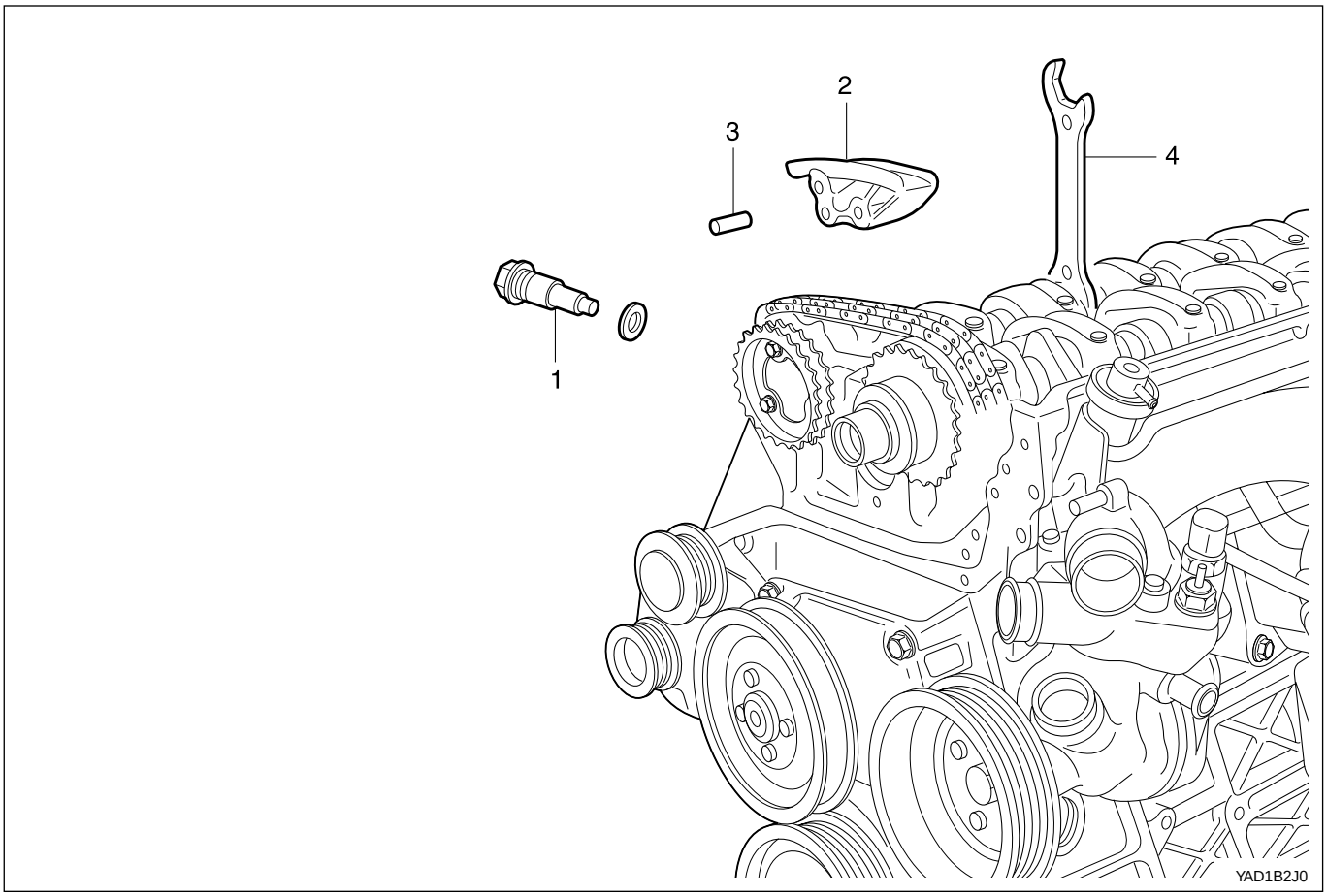
   Notice:

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

4. Installation should follow the removal procedure in the reverse order.
5. Check the camshaft timing position.

CYLINDER HEAD GUIDE RAIL

Preceding Work : Removal of cylinder head cover



1 Chain Tensioner
2 Upper Guide Rail
3 Upper Guide Rail Pin
4 Wrench (Special Tool)

Removal & Installation Procedure

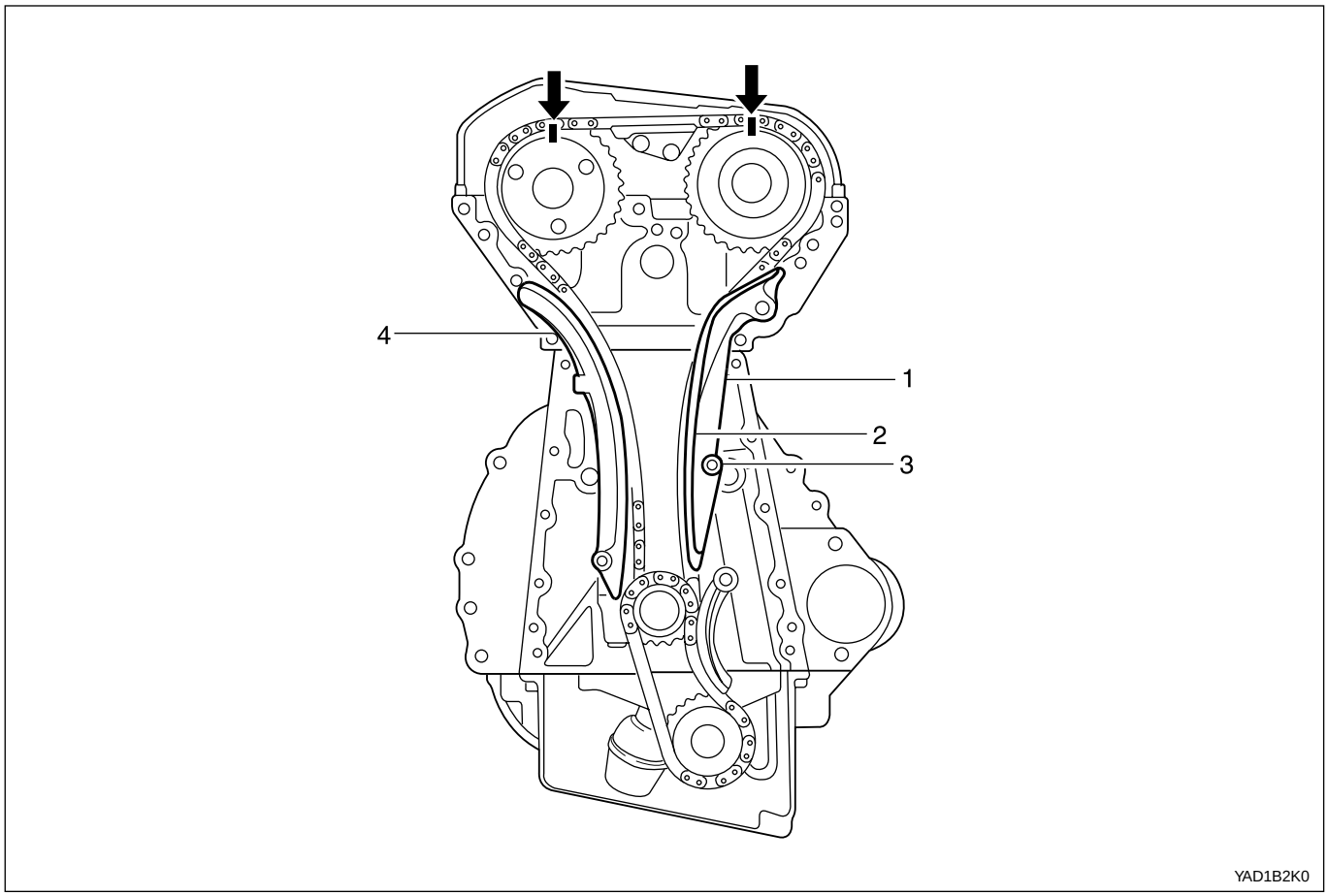
1. Remove the chain tensioner (1).
2. Turn the exhaust camshaft to the camshaft rotating direction using the wrench (4) and loosen the timing chain at upper guide rail (2).
3. Pull out the upper guide rail pin from the guide rail (2).
4. Turn the exhaust camshaft to the opposite direction of rotation using the wrench.
5. Check for damages at the upper sliding rail and replace it if necessary. Install the upper guide rail pin.
6. 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)

CRANKCASE GUIDE RAIL

Preceding Work : Removal of timing gear case cover



1 Guide Rail
2 Plastic Guide
3 Guide Rail Pin
4 Tensioning Rail

Removal & Installation Procedure

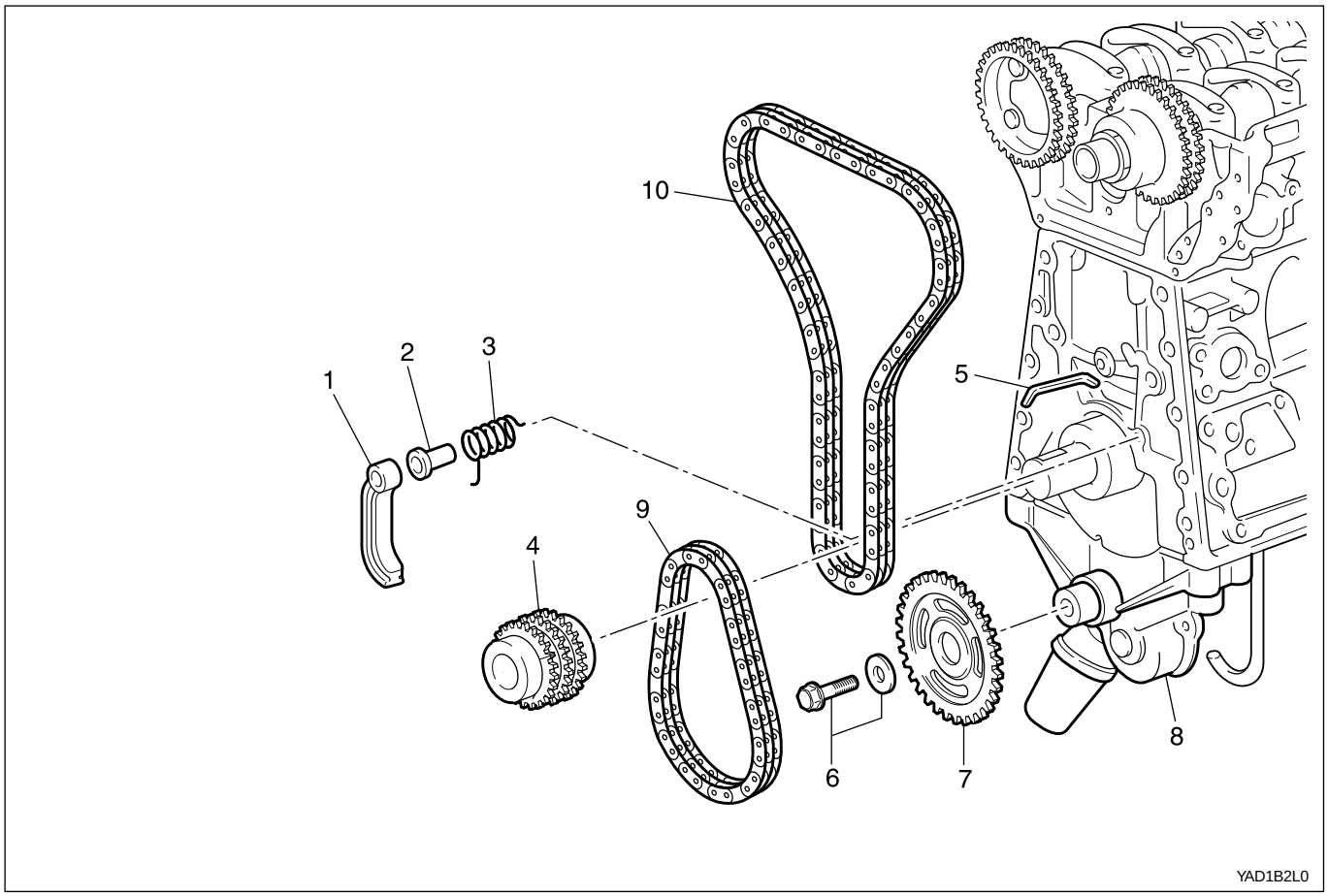
1. Put the assembly mark at the camshaft sprocket and the timing chain with the paint (arrow).
2. Remove the exhaust camshaft sprocket.
3. Remove the guide rail (1) from the guide rail pin (3).

   Notice:

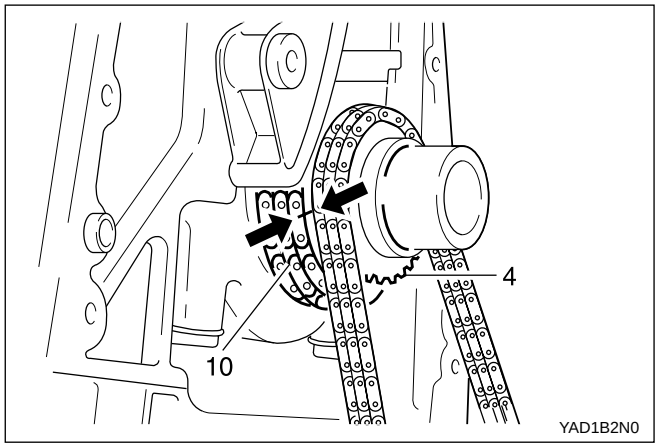
   - Replace the plastic guide (2) if damaged.
   - Connect the plastic guide (2) and the guide rail (1) by aligning them accurately when installing.
4. Installation should follow the removal procedure in the reverse order.
5. Check the camshaft timing position.

CRANKSHAFT SPROCKET

Preceding Work : Removal of oil pan
Removal of tensioning rail
Removal of crankcase 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

615 589 01 33 00 Crankshaft Sprocker Puller

Removal & Installation Procedure

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

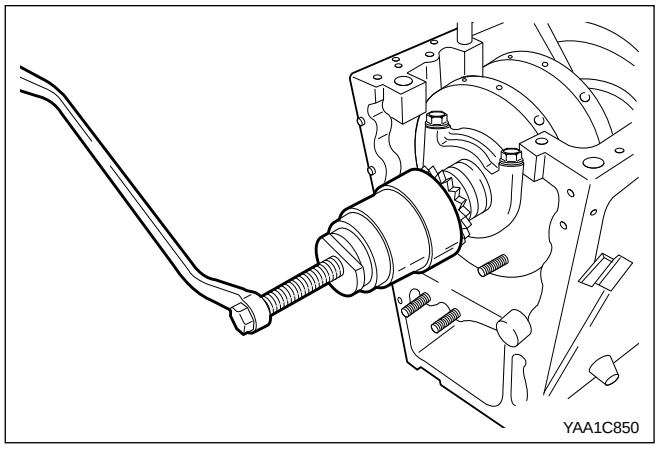
   Notice: Align the assembly marks on cranshaft sprocket and timing chain. Also, align the assembly marks on camshaft sprocket and timing chain when installing.

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 (2), and the oil pump chain spring (3).



5. Remove the crankshaft sprocket (4) using the crankshaft sprocket puller 615 589 01 33 00.

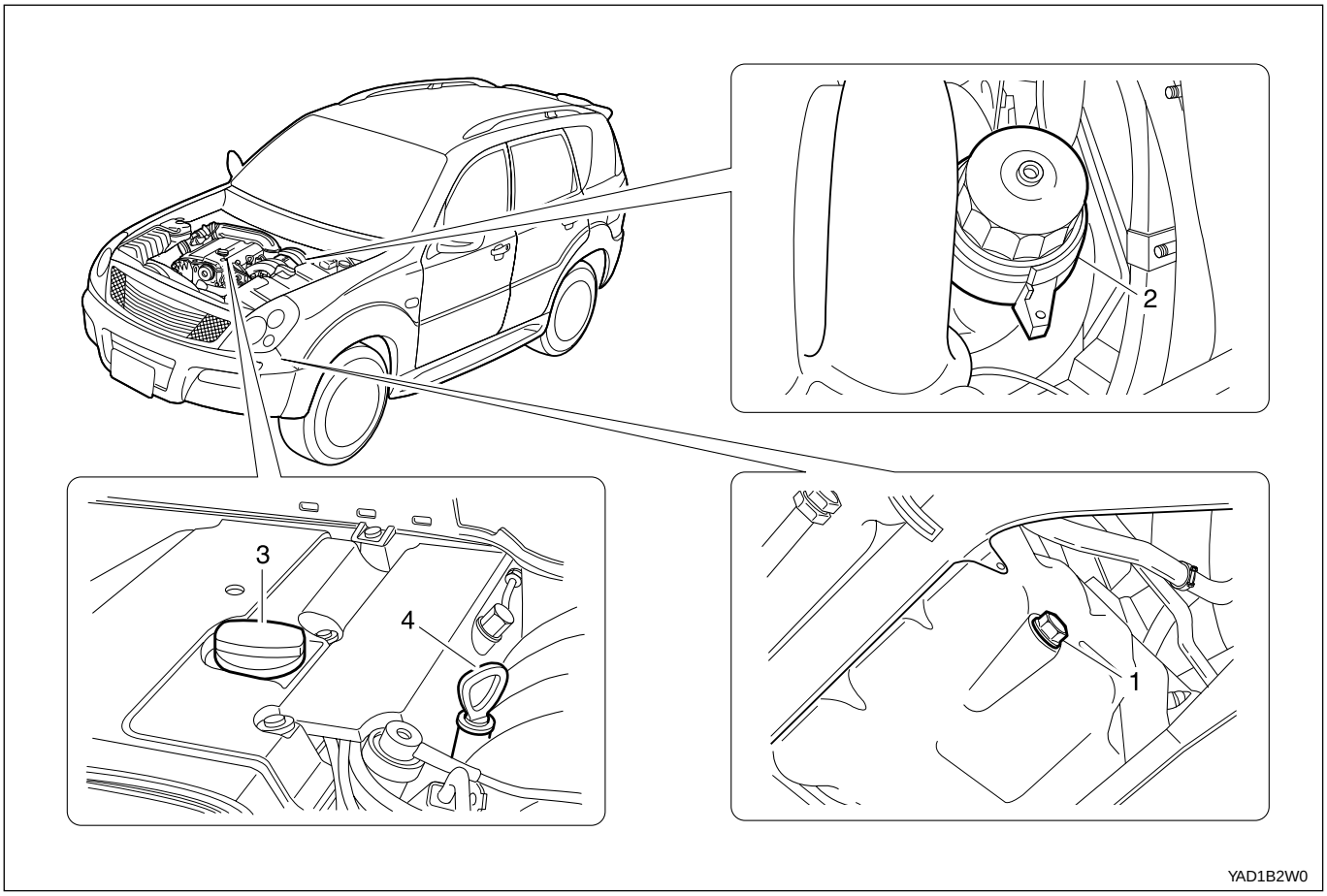
   Notice:

   - 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.

LUBRICATION SYSTEM

ENGINE OIL SPECIFICATION

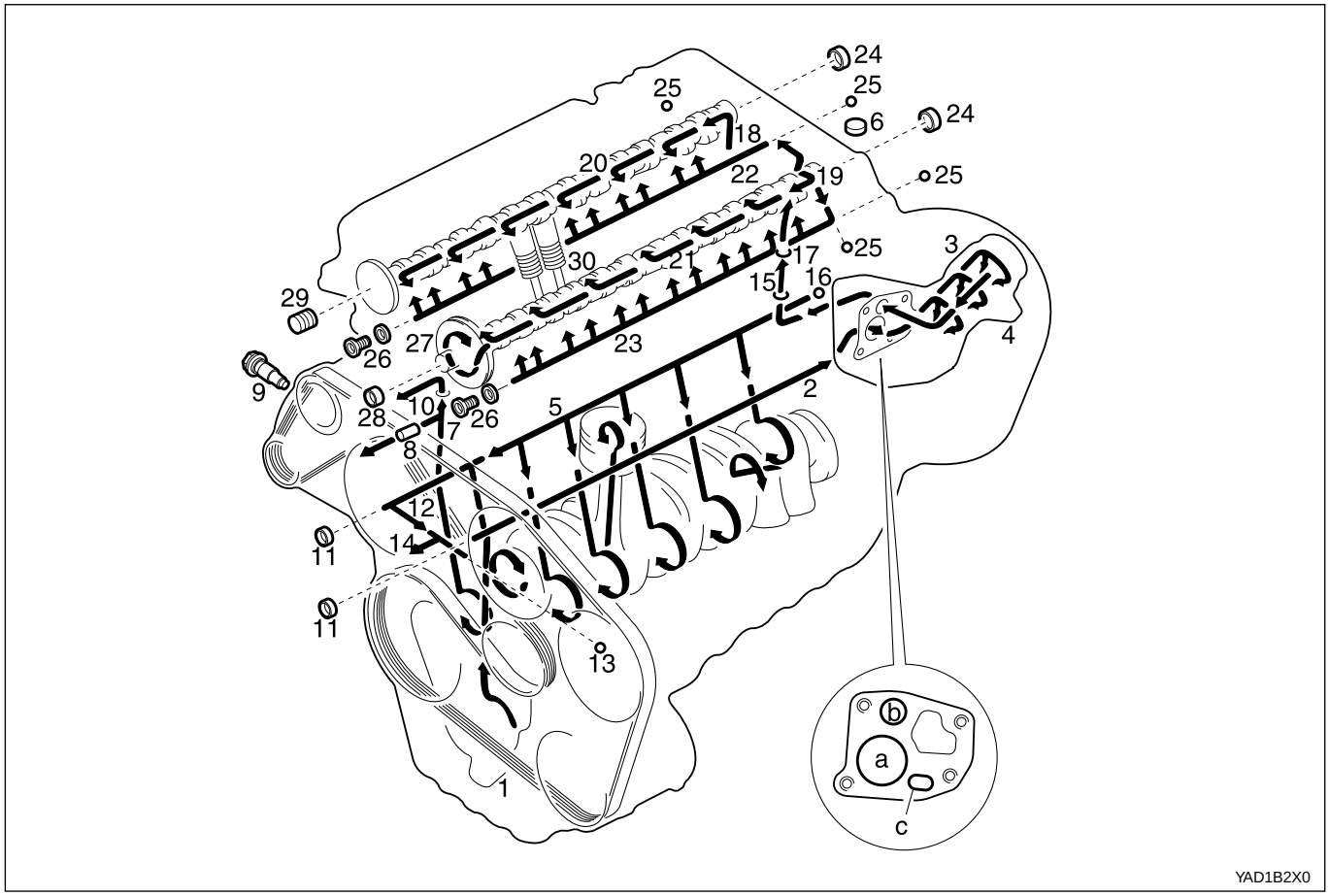


1 Drain Plug ..... 25 N•m (18 lb-ft)
2 Oil Filter
3 Engine Oil Filler Cap
4 Dipstick Gauge

Specifications

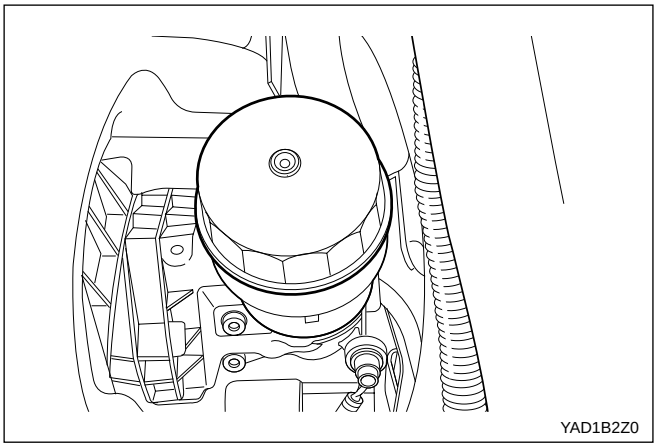
Application	Descrition
Capacity	Min : 6.7 L, Max : 8.2 L
Quality	• API SH or above grade
	• ACEA : A2 or A3
	• Approved oil by MB Sheet 229.1
Viscosity	• Approved oil by MB Sheet 224.1
Replacemant	• Initial at 1000-1500 km, Replace every 15000 km

OIL CIRCULATION



1 Oil Pump
2 Oil Gallery (to oil filter)
3 Oil Filter
4 Oil Pressure Switch
5 Main Oil Gallery
6 Cylinder Head Closing Cover
7 Oil Gallery (At Chain Tensioner)
8 Oil Non-return Valve
9 Chain Tensioner
10 Vent (Chain Tensioner)
11 Front Closing Cover (ϕ 17 mm)
12 Oil Gallery (Perpendicular to The Shaft)
13 Ball (ϕ 6 mm)
14 Oil Spray Nozzle (Timing Chain)
15 Oil Gallery (At Cylinder Head)
16 Ball (ϕ 15mm)
17 Oil Restriction Inner (ϕ 4mm)
18 Oil Supply (To Exhaust Camshaft)
19 Oil Supply (To Intake Camshaft)
20 Oil Supply (To Exhaust Camshaft Bearing)
21 Oil Supply (To Intake Camshaft Bearing)
22 Oil Gallery (Oil Supply to Exhaust Valve Tappet)
23 Oil Gallery (Oil Supply to Intake Valve Tappet)
24 Camshaft Closing Cover
25 Ball (ϕ 8 mm)
26 Screw Plug
27 Camshaft Adjuster
28 Front Closing Cover (Intake Camshaft)
29 Front Treaded Bushing (Exhaust Camshaft)
30 Valve tappet

a Oil Gallery (From Oil Pump to Oil Filter)
b Main Oil Gallery
c Oil Return Line (Oil Returns to the Oil Pan when Replacing the Filter Element)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ENGINE OIL AND OIL FILTER ELEMENT

Tools Required

103 589 02 09 00 Oil Filter Remover

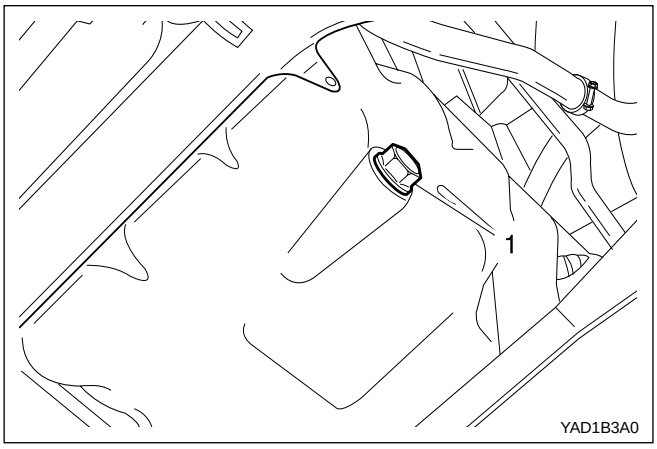
Replacement Procedure

1. Install the oil filter remover 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 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.



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4. Remove the drain plug (1) 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.

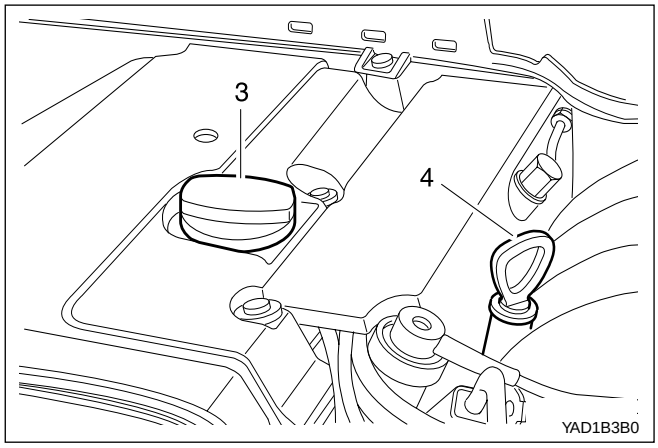
6. Replace the O-ring in the oil filter cover with new one.

   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 103 589 02 09 00, and then completely tighten it.

   Installation Notice

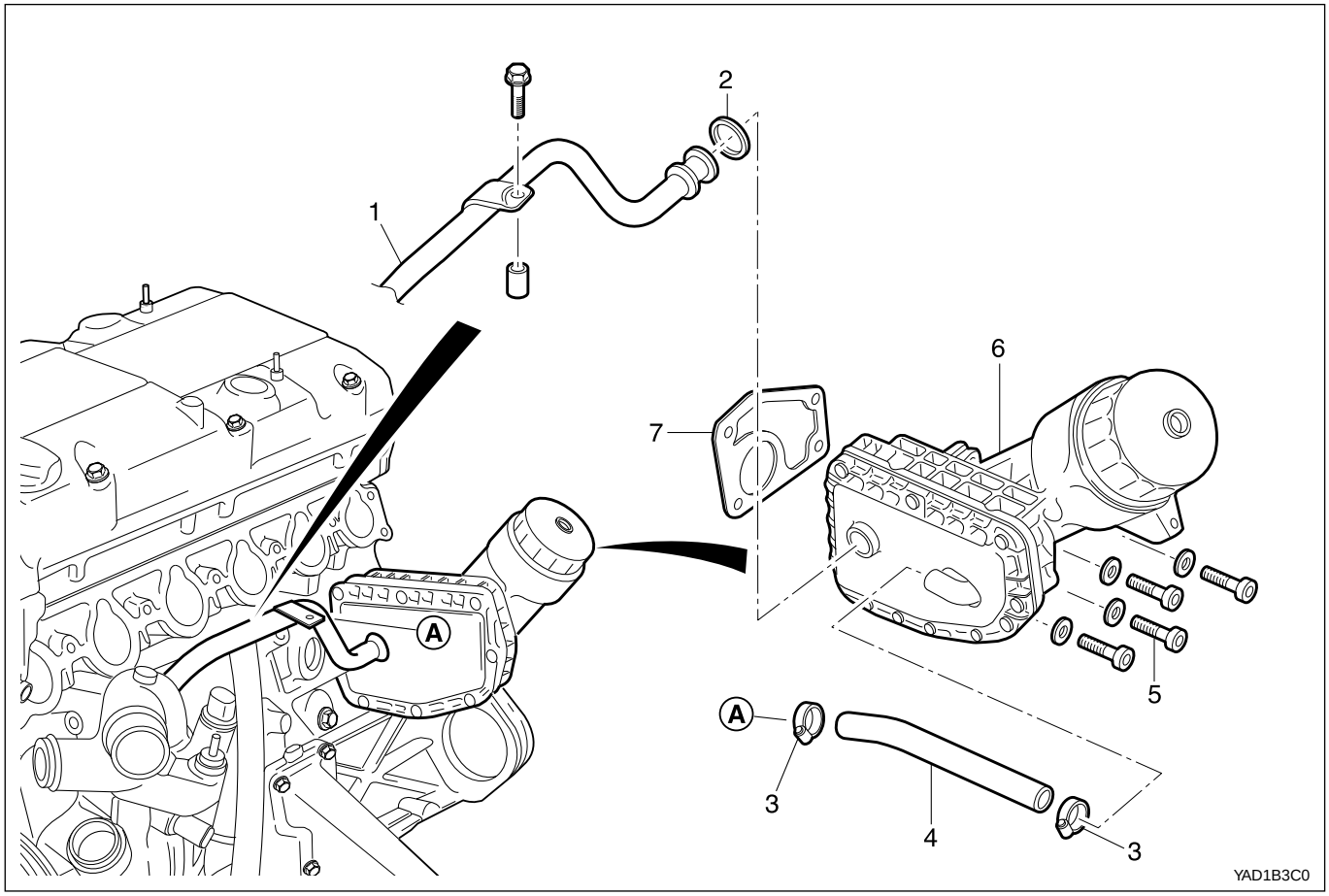
Tightening Torque	25 N•m (18 lb-ft)



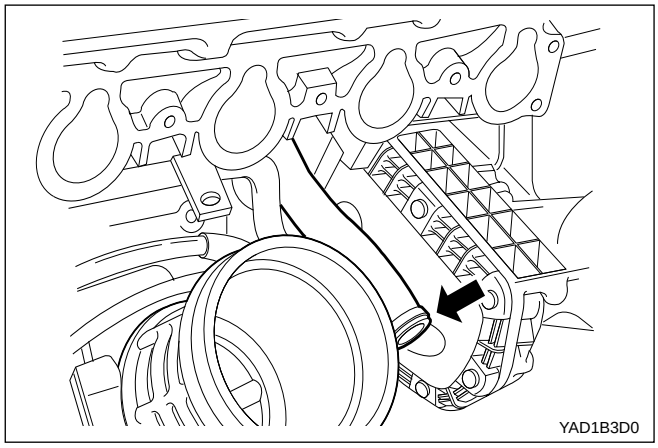
9. Fill up engine oil through the engine oil filler opening (3).
10. Check for oil leaks at normal engine temperature after starting the engine.
11. Stop the engine and wait 5 minutes.
    Check the oil level and fill up as specified if necessary.

OIL FILTER

Preceding Work : Removal of starter motor
Removal of upper intake manifold



1 Coolant Line
2 O-ring ..... Replace
3 Clip
4 Hose
5 Bolt..... 22.5-27.5 N•m (16.6-20.3 lb-ft)
6 Oil Filter
7 Gasket ..... Replace



Removal & Installation Procedure

1. Drain the coolant from the crankcase.
2. Remove the each coolant line and hose.
3. Remove the oil filter bolt and then remove the oil filter.

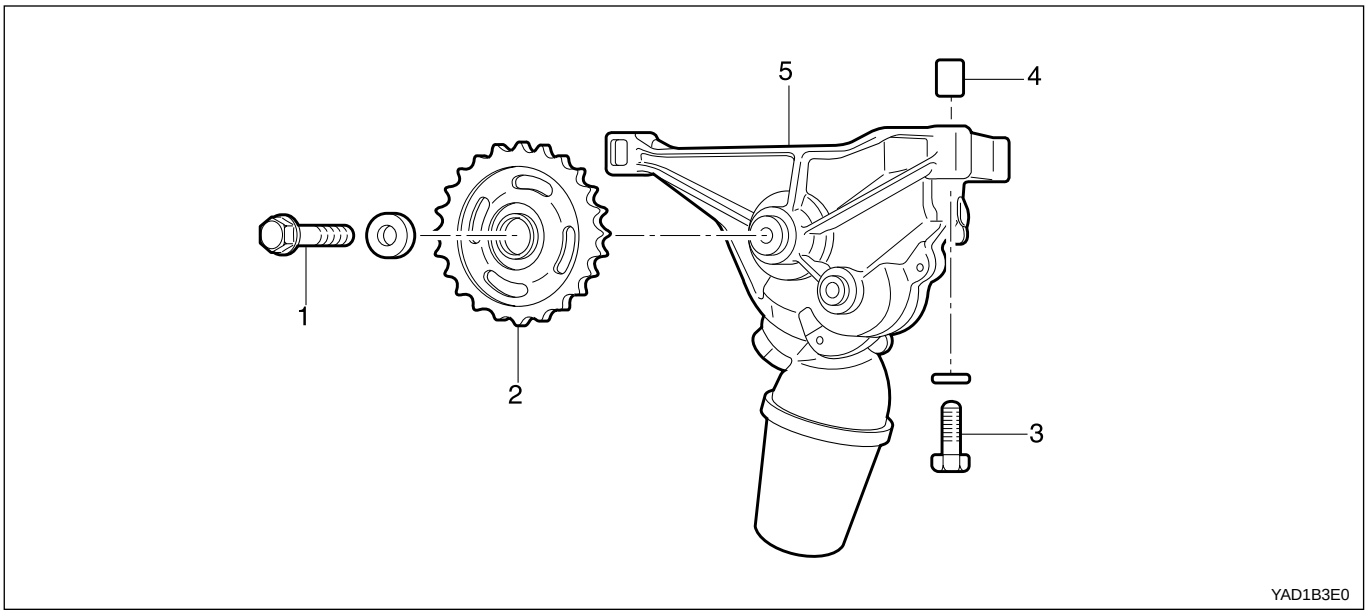
   Installation Notice

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

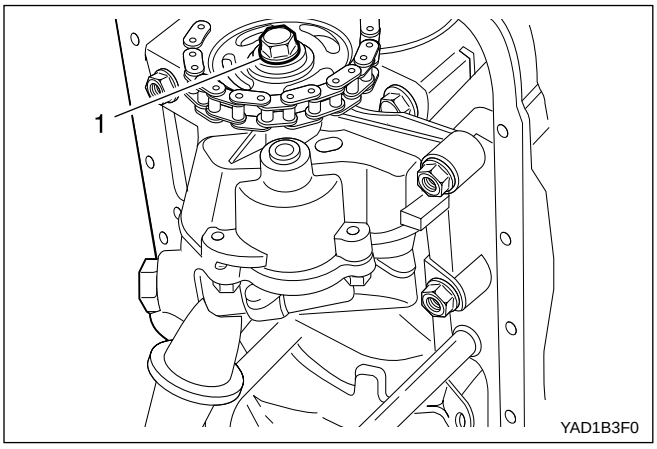
   Replace the oil filter gasket.
4. Installation should follow the removal procedure in the reverse order.
5. Check engine oil level.
6. Run the engine at idle and check the engine for leaks.

OIL PUMP

Preceding Work : Removal of oil pan



1 Bolt (M8 x 20, 1 piece)
..... 29-35 N•m (21-26 lb-ft)
2 Sprocket (Oil Pump Drive)
3 Bolt (M8 x 35, 3 pieces)
..... 22.5-27.5 N•m(16.6-20.3 lb-ft)
4 Spring Pin
5 Oil Pump



Removal & Installation Procedure

1. Remove the bolt (1) from the oil pump drive sprocket (2) and separate the gear and the oil pump drive chain.

   Installation Notice

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

2. Unscrew the oil pump mounting bolts (3).

   Installation Notice

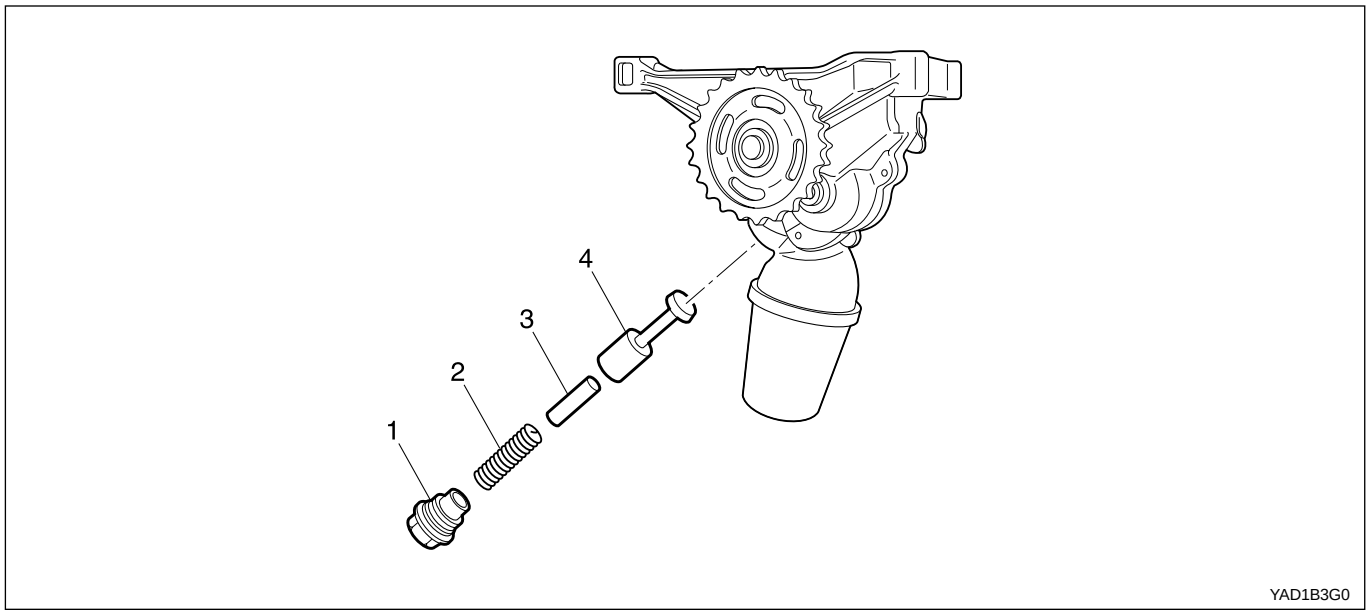
Tightening Torque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

   Tighten the baffle plate and the oil pump with the two bolts in right side first, and then tighten the other bolt.

3. Remove the oil pump and oil strainer assembly.
4. Replace the strainer in oil pump if necessary.
5. Installation should follow the removal procedure in the reverse order.

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

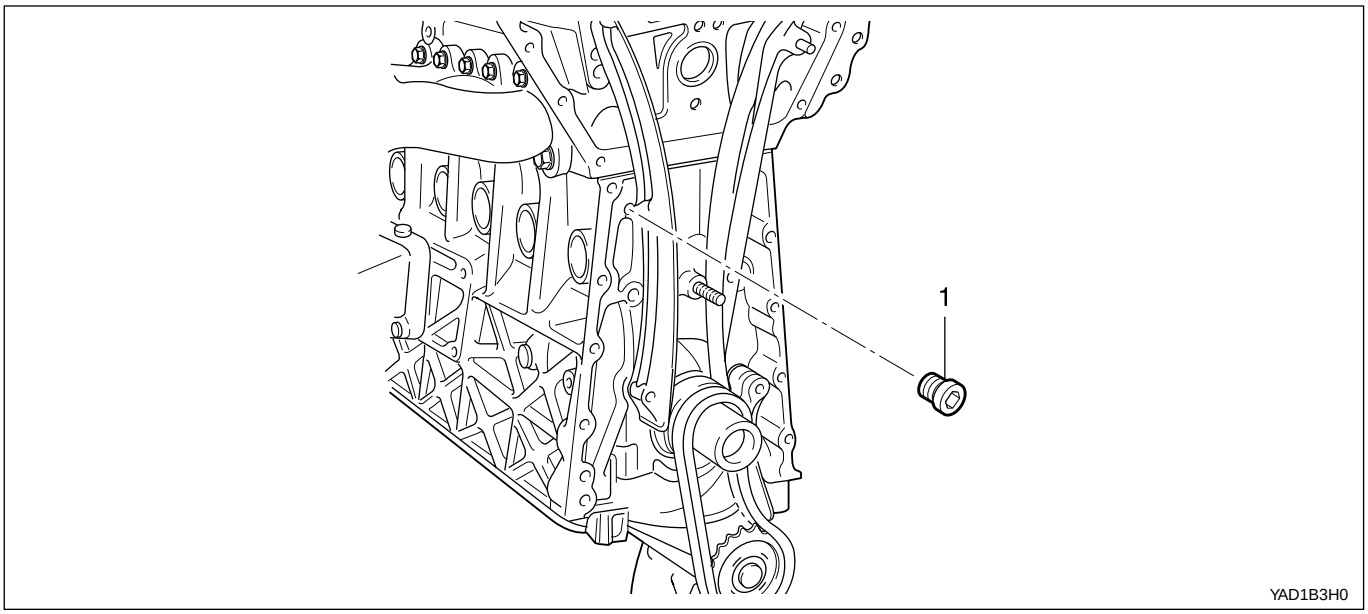
Tightening Torque	50 N•m (37 lb-ft)

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.

OIL NON-RETURN VALVE

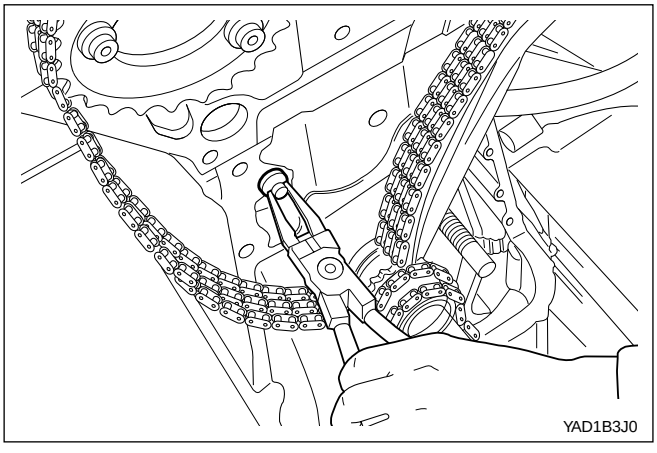
Preceding Work : Removal of timing gear case cover



1 Oil Non-return Valve

Functions

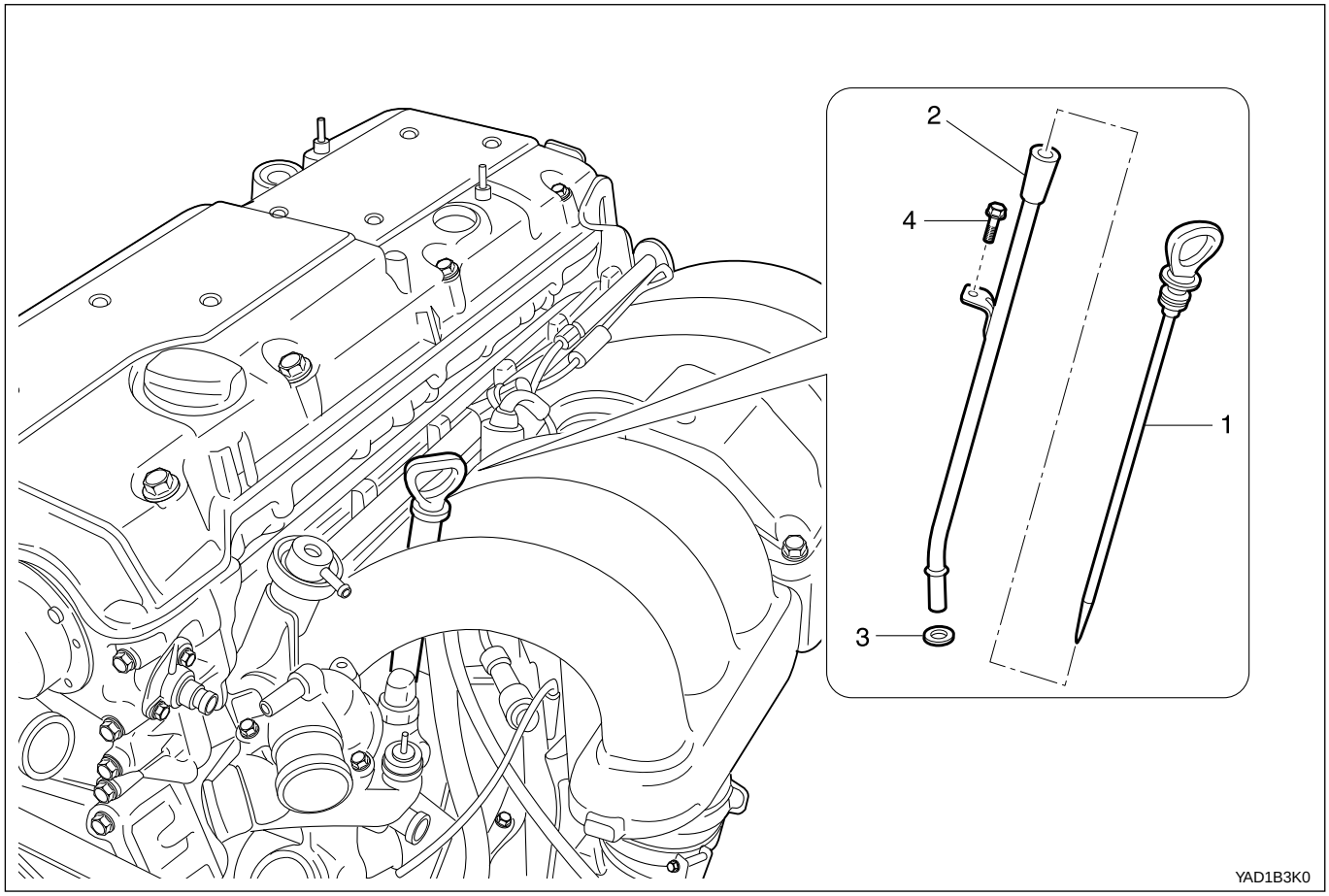
The non-return valve prevents the oil in the chain tensioner from drying up. In other words, it stops oil-returning in order to prevent the oil in the chain tensioner from getting dry. As a result, the chain tensioner can be activated with oil in itself.



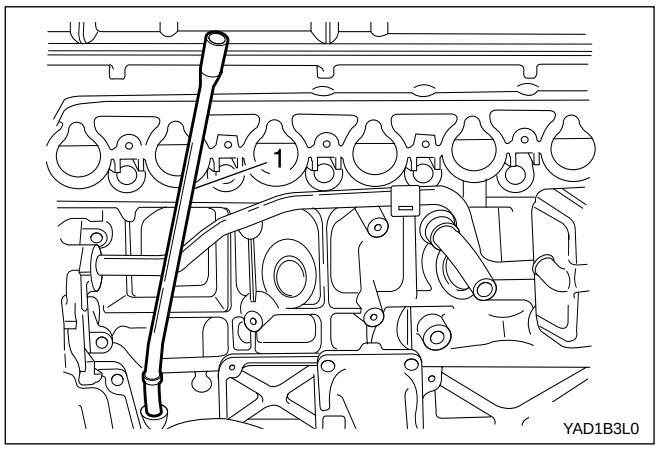
Replacement Procedure

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 12, 1 piece) ....9-11 N•m (80-97 lb-in)



Removal & Installation Procedure

1. Pull out the oil dipstick level gauge (1).
2. Remove the bolt (4) in the upper intake manifold and remove the oil dipstick guide tube.

Installation Notice

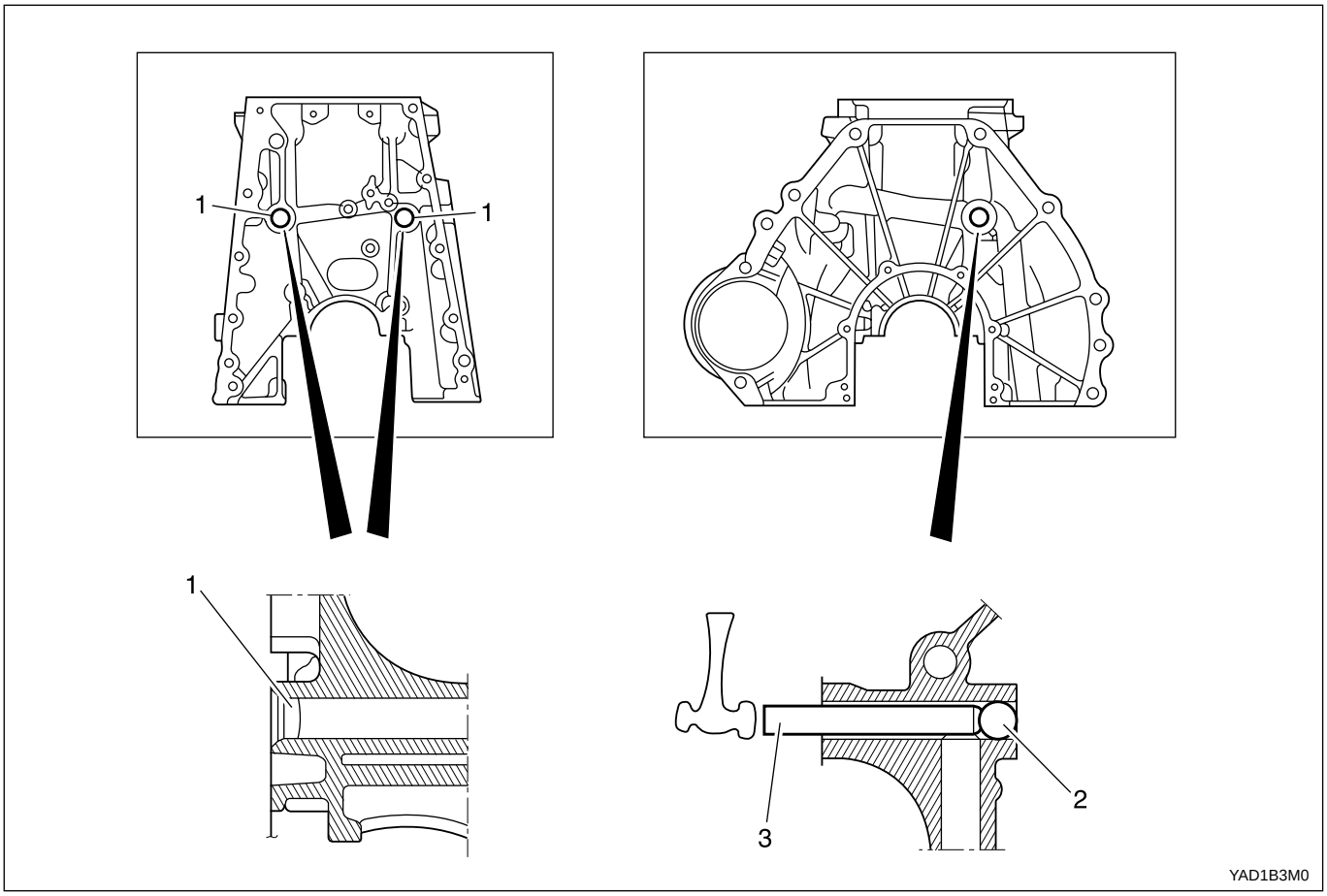
Tightening Torque	9 - 11 N•m (80 - 97 lb-in)

3. Install new O-ring to the dipstick guide tube.
4. Installation should follow the removal procedure in the reverse order.
5. Check for leaks by starting the engine.

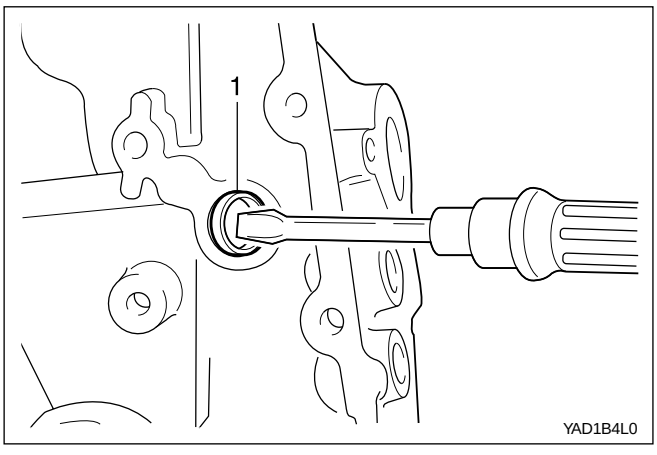
UNIT REPAIR

OIL GALLERY IN CRANKCASE

Preceding Work : Removal of crankshaft
Removal of oil spray nozzle

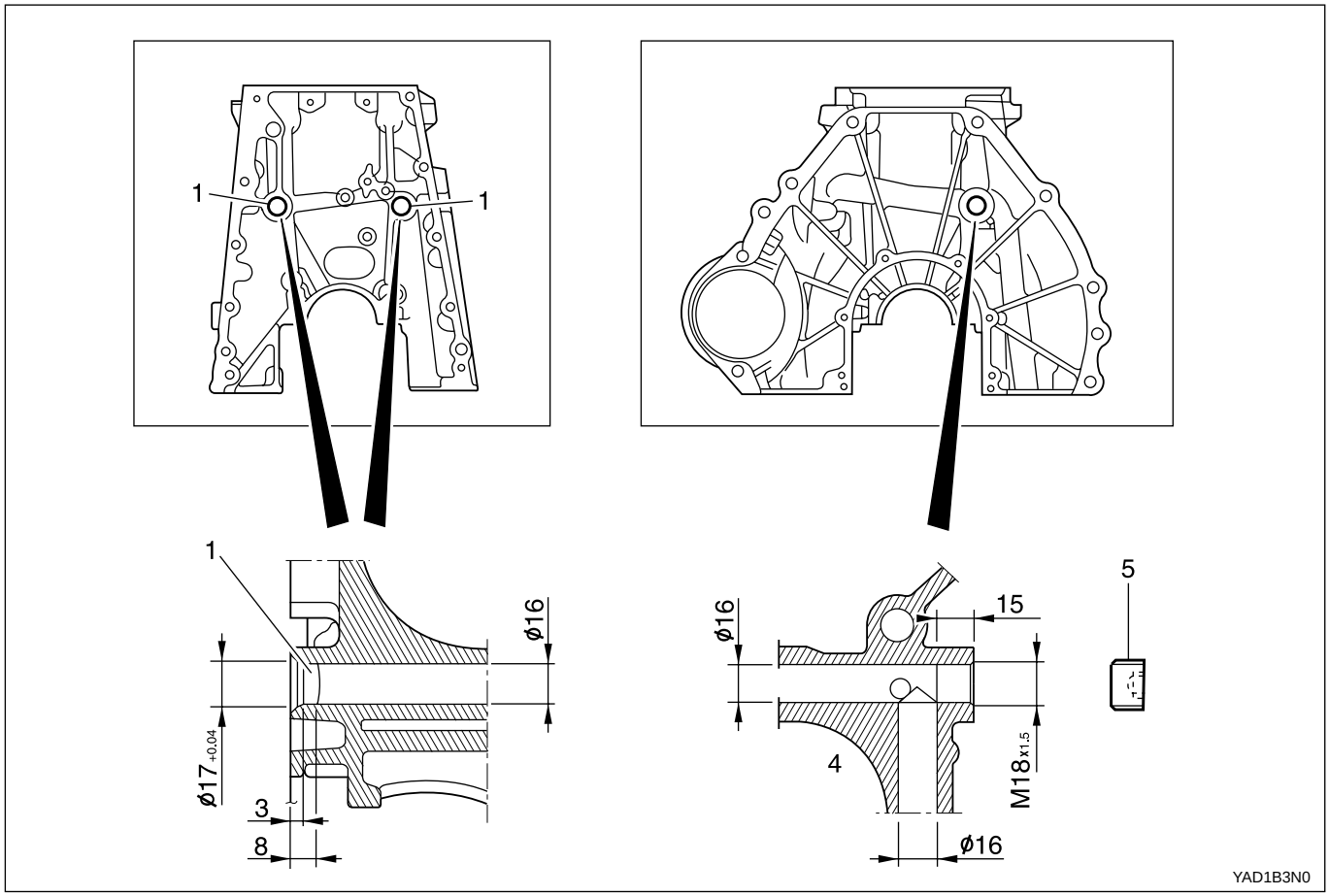


1 Plug
2 Steel Ball
3 Round Bar ..... ϕ 11 x 750 mm



Cleaning Procedure

1. Remove the plug (1) with a screwdriver.
2. Using a round bar (3) and hammer, remove the steel ball (2).
3. Using the compressed air, blow into the oil galleries and clean it off.



1 Plug ..... Replace
2 -
3 -
4 Main Oil Gallery
5 Screw Plug

Tools Required

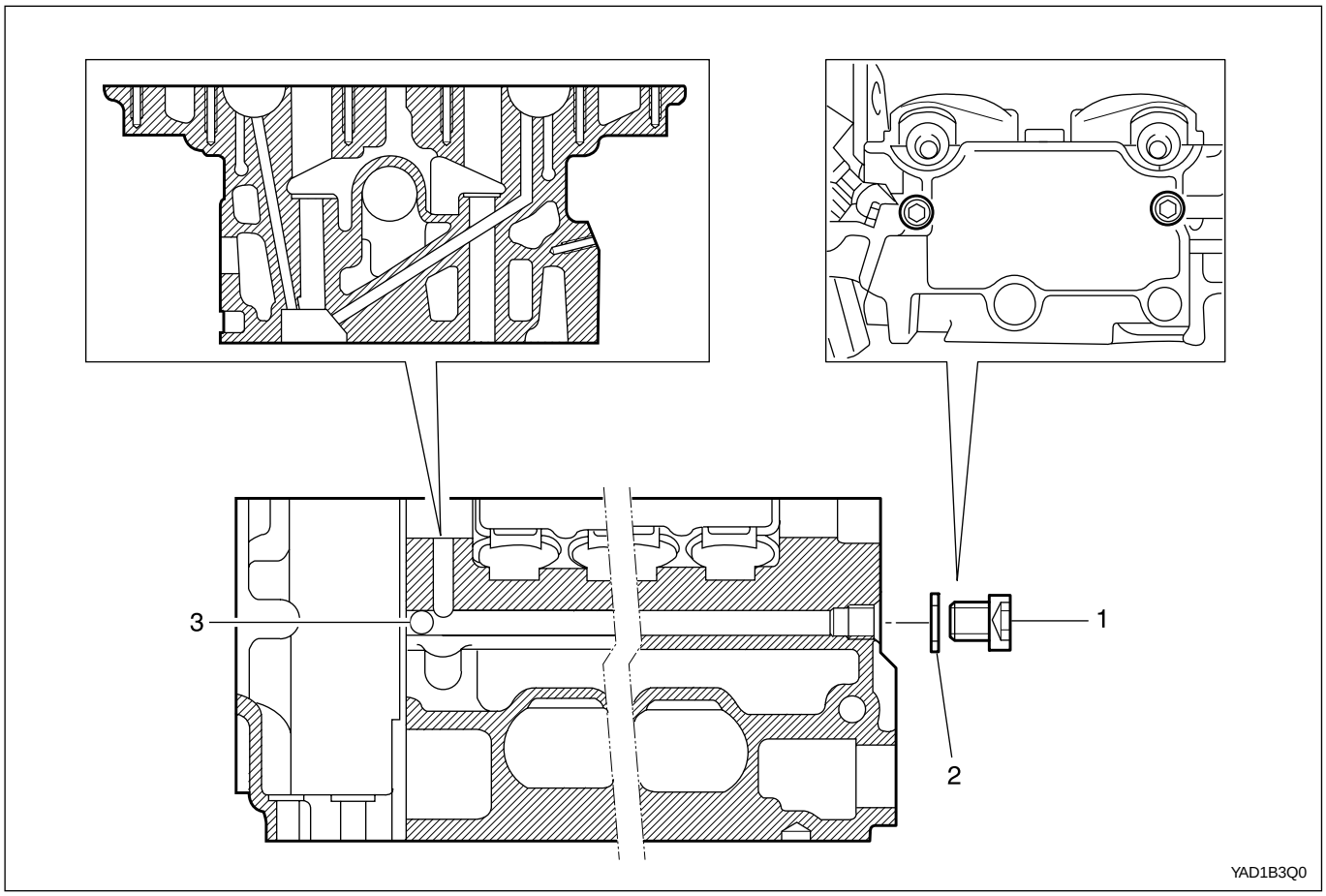
102 589 12 15 00 Drift

Sealing Procedure

1. Enlarge the end of main oil gallery (4) to be diameter of 16mm, depth of 15mm.
2. Using an M16 x 1.5 thread (tap), make the thread at the end of main oil gallery (4).
3. Throughly clean the oil gallery with compressed air and tighten the screw plug (M16 x 1.5) after applying sealing bond on it.
4. Apply Loctite 270 on new plug and tighten to the hole until the drift 102 589 12 15 00 is stopped after inserting new plug into the drift.

OIL GALLERY IN CYLINDER HEAD

Preceding Work : Removal of cylinder head
Removal of camshaft
Removal of tappet



1 Screw Plug ..... 15 N•m (11 lb-ft)
2 Seal
3 Steel Ball (ϕ8mm)

Cleaning Procedure

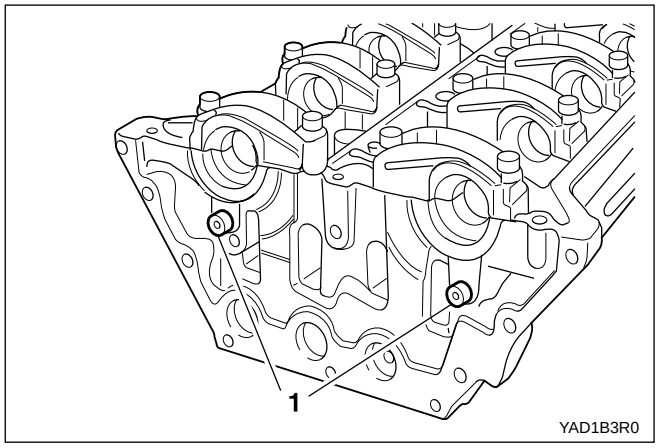
1. Remove the screw plug (1) and the seal (2).

   Installation Notice

Tightening Torque	15 N•m (11 lb-ft)

   Replace the seal with new one.

2. Clean the oil gallery using the compressed air.

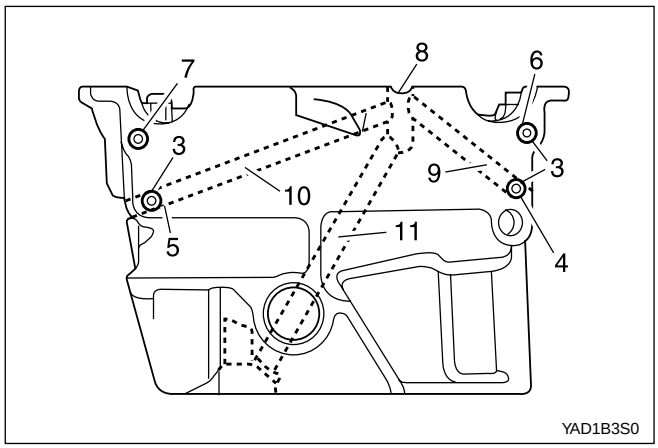


Sealing Procedure

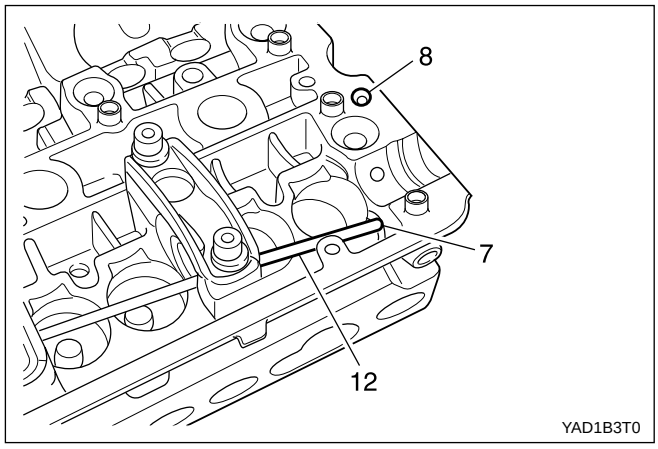
1. Remove the screw plug (1) and the seal.

Installation Notice

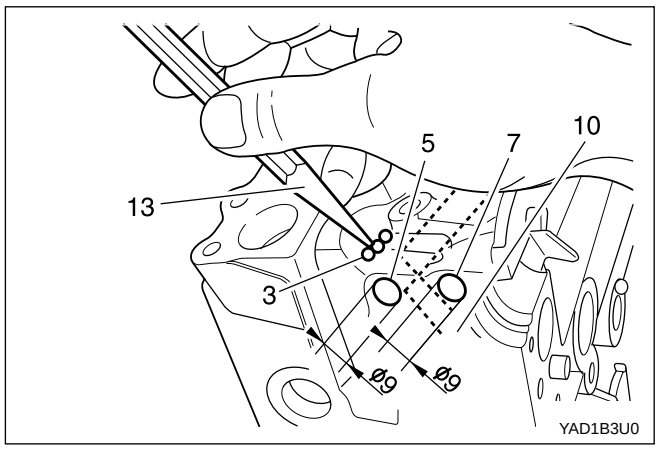
Tightening Torque	15 N•m (11 lb-ft)



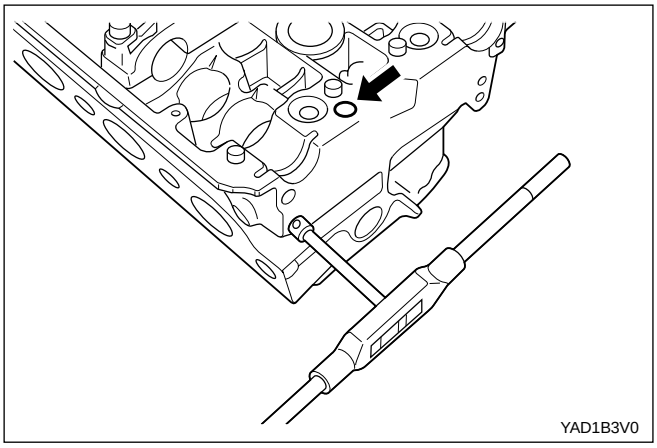
2. Remove the steel ball from the oil gallery (4), (5), (6) and (7) using the round bar (12, ϕ6 x 700 mm).



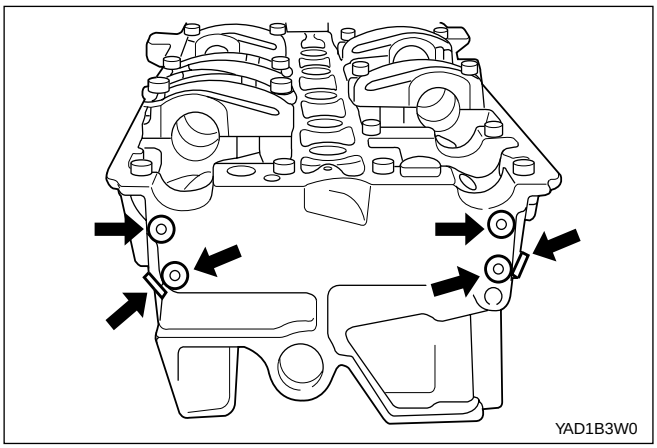
3. Remove the plug (8) using the screw driver.



4. Enlarge the oil gallery at the rear of the cylinder head to be diameter 9mm, depth 8mm.
5. Tap in the steel ball (3) from the side to the oil gallery using the punch (13).
6. Pull out the steel ball (3) using the round bar (12).
7. Enlarge the oil gallery to be diameter 9mm, depth 8 mm.



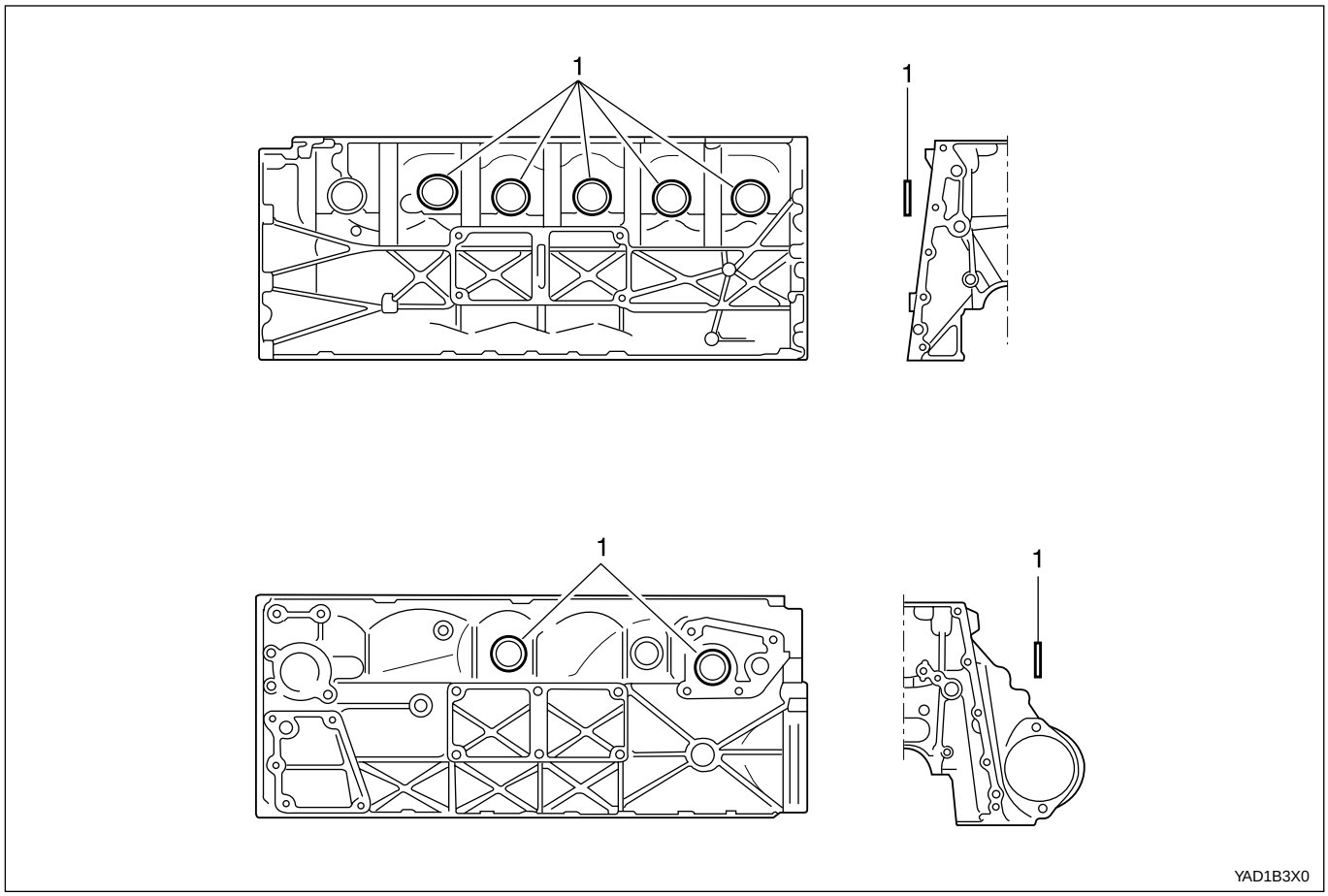
8. Make a screw hole at the oil gallery using M10 x 1 thread.
9. All the oil gallery should be cleaned with the compressed air.
10. Apply the Loctite 270 to new plug and press in using a suitable drift (arrow).



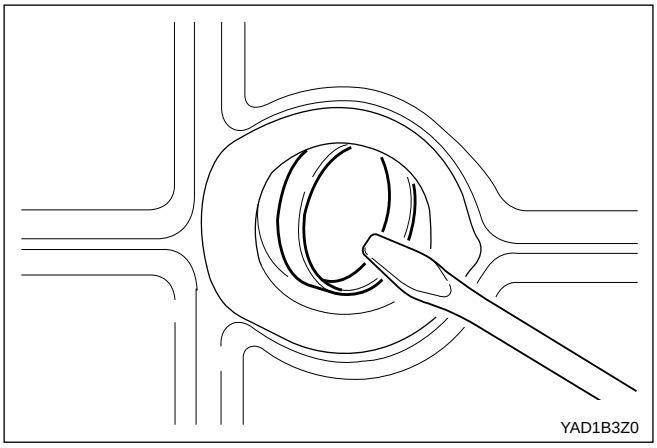
11. Tighten the screw plug with the seal (arrow).

CORE PLUGS IN CRANKCASE

Preceding Work : Draining of the coolant



1 Core Plug ..... Replace

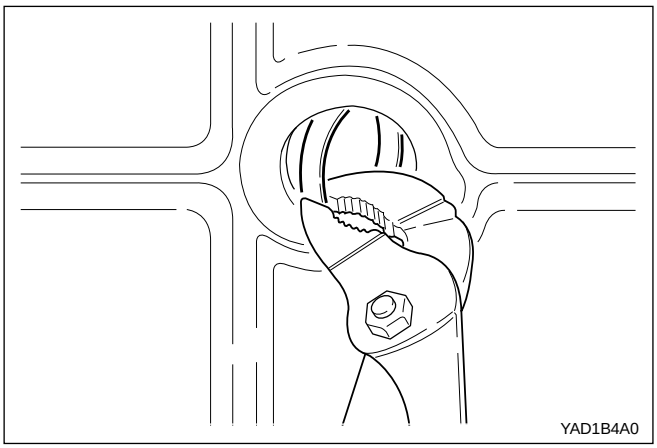

YAD1B3Z0

Tools Required

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.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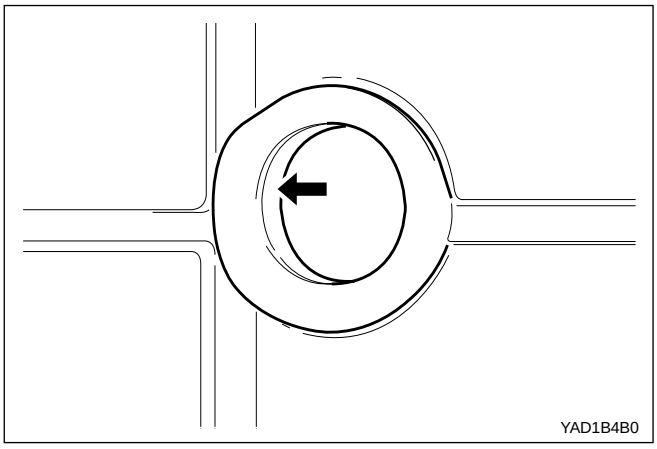
3. Pull out the plug carefully using a pliers.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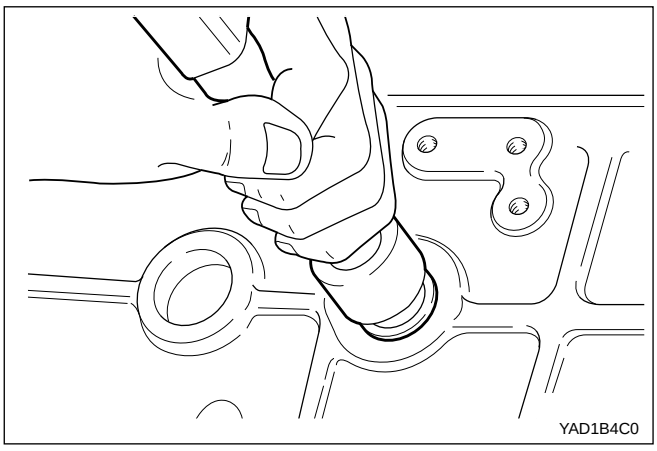
4. Clean the sealing surface and apply Loctite 241.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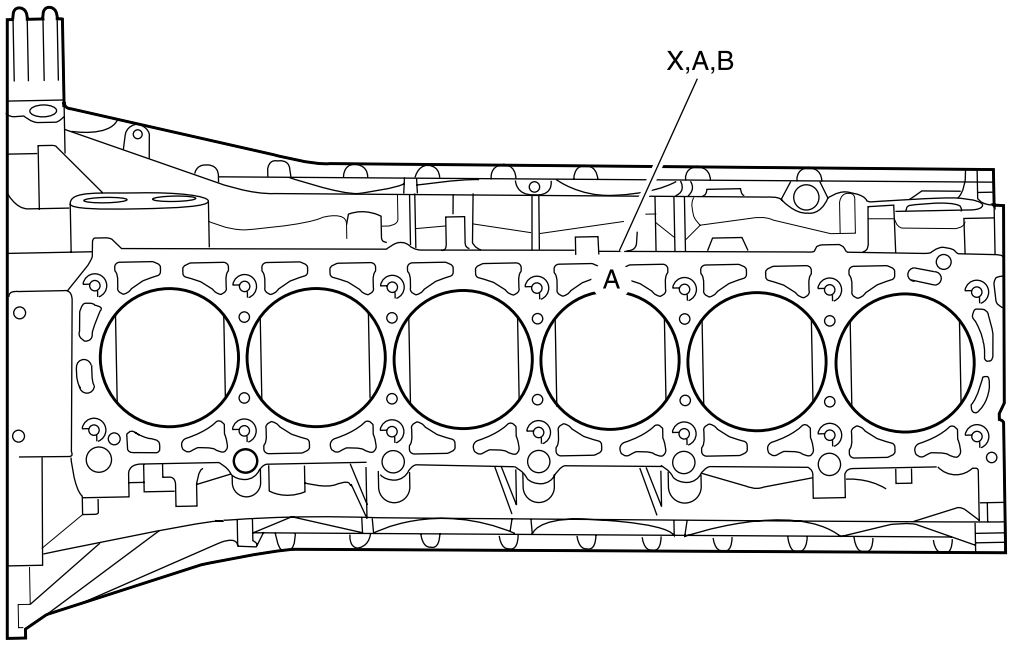
5. Press in new plug using a drift 102 589 00 15 00.

   Notice: Wait for about 45 minutes before filling the coolant so that the Loctite hardens.

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

CYLINDER BORE



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Group Code Letter and Cylinder Bore Size

Group Code Letter of Cylinder	Piston Type to be Used	Cylinder Bore Size (mm)
A	A or X	ϕ89.900 - ϕ90.906
X	A, X or B	ϕ89.906 - ϕ89.912
B	X or B	ϕ89.912 - ϕ89.918
X + 5	X + 5	ϕ89.950 - ϕ89.968
X + 10	X + 10	ϕ90.000 - ϕ90.018

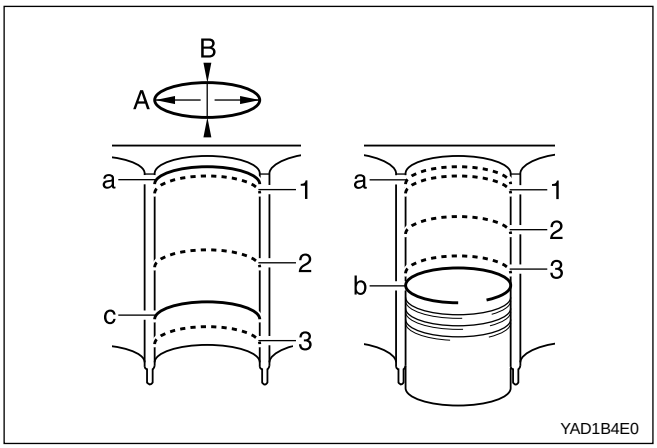
Repair Size

Type	Group Code Letter[1)]	Cylinder Bore Size (mm)
Standard Size ϕ89.9	A	ϕ89.900 - ϕ90.906
	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

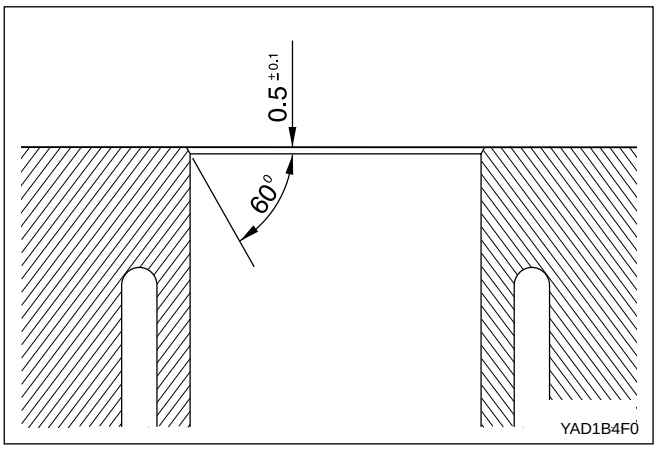
Wear Limit in Longitudinal and Transverse Direction		0.1 mm
Permissible Deviation of Cylinder Out-of-round	When new	0.007 mm
	Wear limit	0.05 mm
Permissible Deviation of Rectangular Cylinder Height (Except Chamfered Area)		0.05 mm
Basic Peak-to-valley Height After Final Honing and Brushing		0.003 - 0.006 mm
Chamfer Angle		60°
Honing Angle		50° ± 10°



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

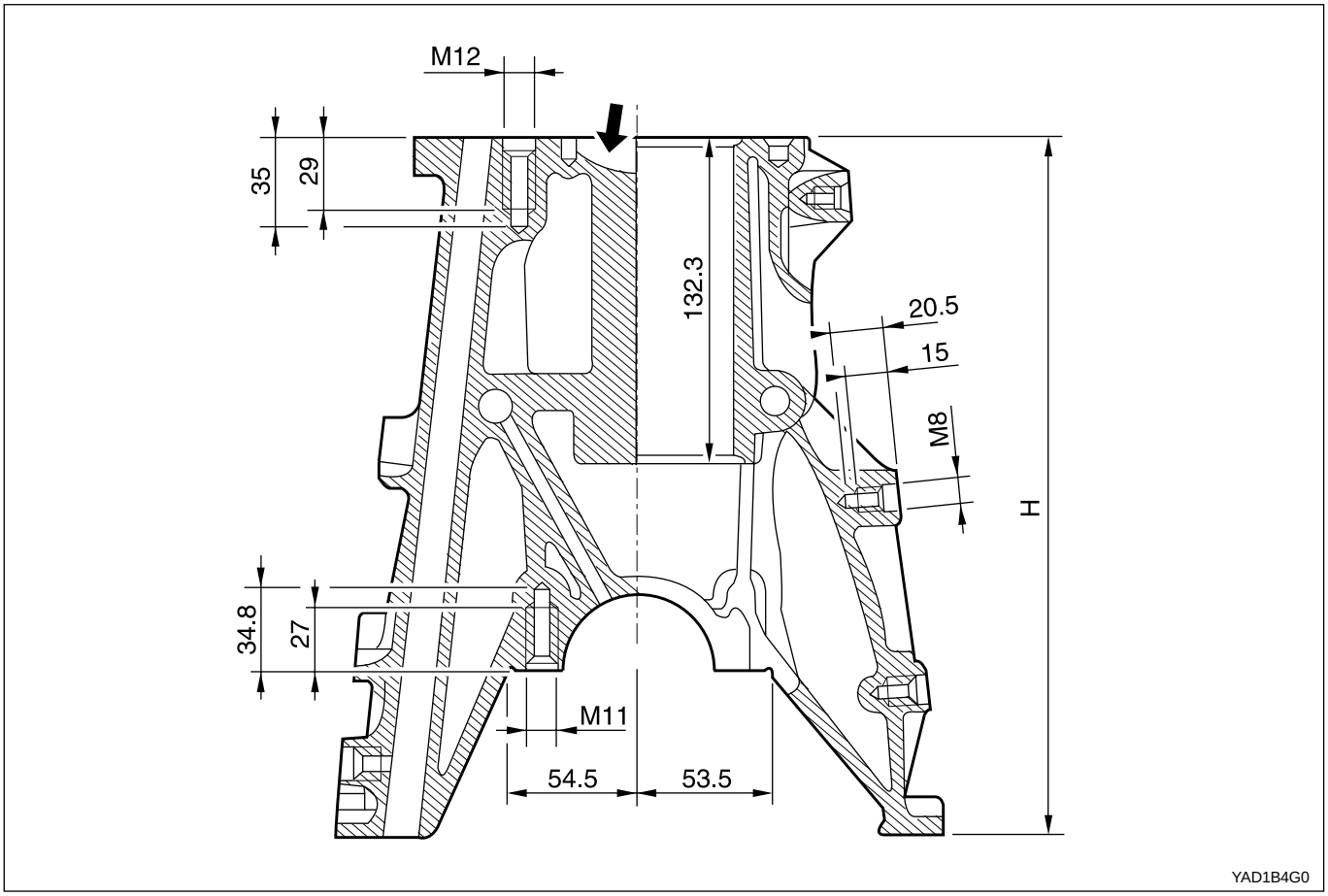
Measurement of Cylinder Bore

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).



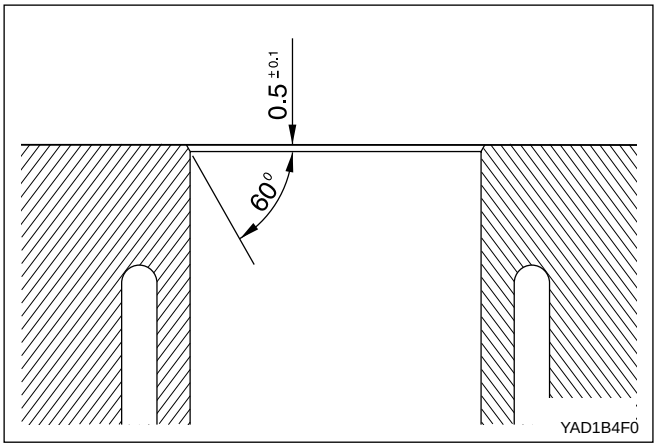
Chamfer Angle

CRANKCASE MATING SURFACE



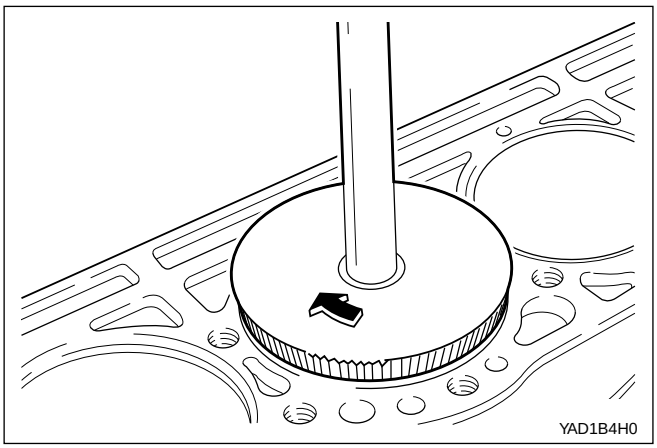
Service Data Standard

Height of The Crankcase “H” (When new)		282.25 - 282.35 mm
Minimum Height After Milling		281.95 mm
Flatness	Crankcase Upper Mating Surface	0.03 mm
	Crankcase Lower Mating Surface	0.04 mm
Permissible Deviation of Parallelism of The Upper to Lower Mating Surface	Axial Direction	0.1 mm
	Transverse Direction	0.05 mm
Peak-to-valley Height	Crankcase Upper Mating Surface	0.005 - 0.020 mm
	Crankcase Lower Mating Surface	0.025 mm



Chamfering Procedure

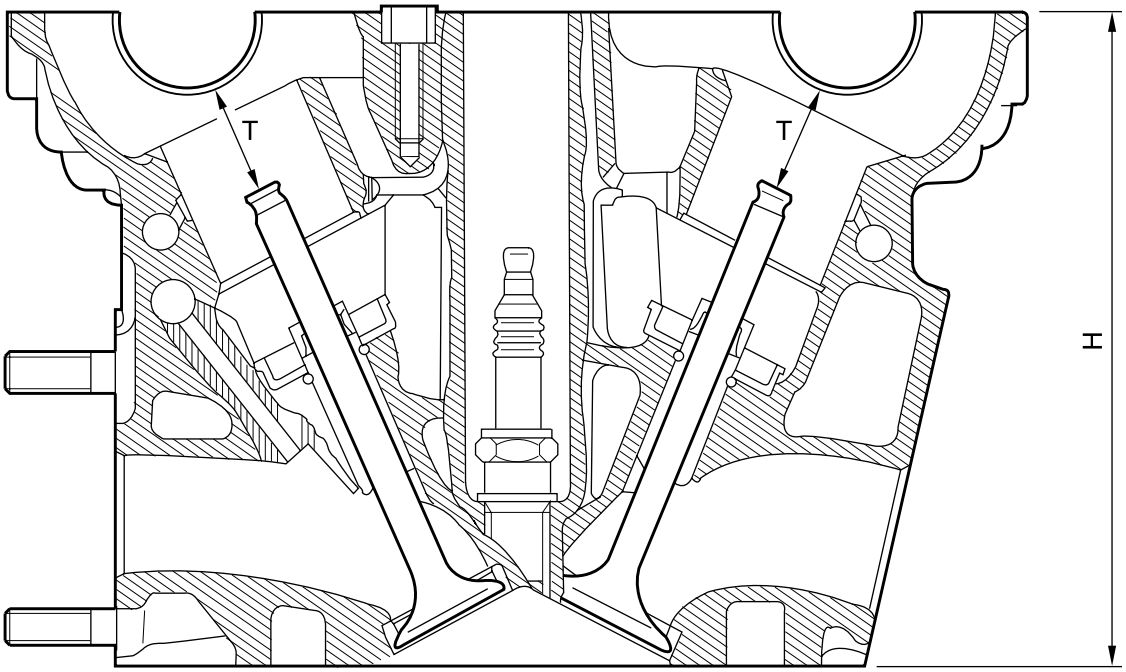
1. Chamfer angle : 60°



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

CYLINDER HEAD MATING SURFACE

Preceding Work : Removal of valves



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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 0.4mm for the milling of the mating surface of crankcase and cylinder head.

Measurement of Mating Surface

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

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

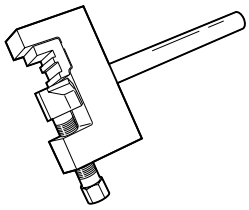
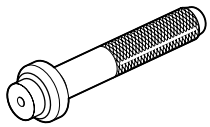
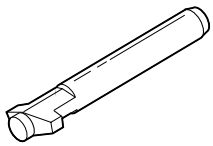
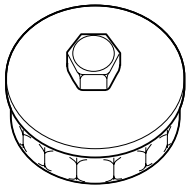
Application		N•m	Lb-Ft	Lb-In
A/C Bracket Bolt		22.5 - 27.5	16.6 - 20.3	-
Armature Bolt in Camshaft Actuator		35	26	-
Belt Tensioning Pulley Nut		40.5 - 49.5	29.9 - 36.5	-
Camshaft Actuator Bolt		9 - 11	-	80 - 97
Camshaft Adjuster Mounting Nut		60 - 70	44 - 52	-
Camshaft Bearing Cap Bolt		22.5 - 27.5	16.6 - 20.3	-
Chain Tensioner Assembly		72 - 88	53 - 65	-
Chain Tensioner Screw Plug		40	30	-
Connecting Rod Bearing Cap Bolt		40 + 5 90° + 10°	30 + 3.7 90° + 10°	-
Cooling Fan Bracket Bolt		22.5 - 27.5	16.6 - 20.3	-
Crankshaft Bearing Cap Bolt		50 - 60 90° + 5°	37 - 44 90° + 5°	-
Crankshaft Sealing Rear Cover Mounting Bolt		9 - 11	-	80 - 97
Cylinder Block Drain Plug		30	22	-
Cylinder Head Bolt		55 + 90 ° + 90 °	41 + 90 ° + 90 °	-
Cylinder Head Cover Bolt		9 - 11	-	80 - 97
Cylinder Head Front Cover Bolt		22.5 - 27.5	16.6 - 20.3	-
Engine Mounting Bracket Nut		70	52	-
Exhaust Camshaft Sprocker Bolt		18 - 22 90° ± 5°	13 - 16 90° ± 5°	-
Exhaust Manifold and Pipe		30	22	-
Flywheel Mounting Bolt		45 + 5 90° + 10°	33 + 3.7 90° + 10°	-
Fuel Feed and Return Hose to Fuel Rail		21 - 25	15 - 18	-
Generator Carrier Bolt		25	18	-
Intake Air Duct Nut		9 - 11	-	80 - 97
Intake Flange Shaft Bolt		18 - 22 90° ± 5°	13 - 16 90° ± 5°	-
Lower Engine Mounting Nut		38	28	-
Oil Dipstick Guide Tube Bolt		9 - 11	-	80 - 97
Oil Drain Plug		22.5 - 27.5	16.6 - 20.3	-
Oil Filter Bolt		22.5 - 27.5	16.6 - 20.3	-
Oil Filter Cover		25	18	-
Oil Gallery Screw Plug in Cylinder Head		15	11	-
Oil Pan Bolt	M10	40	30	-
	M8	22.5 - 27.5	16.6 - 20.3	-
	M6	9 - 11	-	80 -97

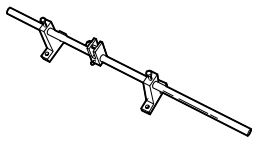
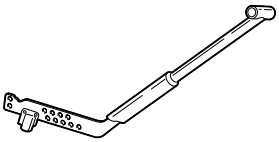
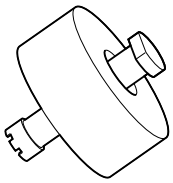
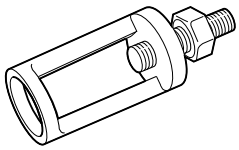
FASTENER TIGHTENING SPECIFICATIONS (Cont'd)

Application		N•m	Lb-Ft	Lb-In
Oil Pressure Relief Valve Screw Plug		50	37	-
Oil Pump Drive Sprocket Bolt		29 - 35	21 - 26	-
Oil Pump Mounting Bolt		22.5 - 27.5	16.6 - 20.3	-
Oil Pump Sprocket Bolt		29 - 35	21 - 26	-
Spark Plug Cover Bolt		9 - 11	-	80 - 97
Steering Pump Bolt		22.5 - 27.5	16.6 - 20.3	-
Tensioning Device Bolt		26 - 32	19 - 24	-
Timing Gear Case Cover Bolt	M8	22.5 - 27.5	16.6 - 20.3	-
	M6	9 - 11	-	80 - 97
Torque Converter Mounting Bolt		42	31	-
Transmission Mounting Nut		54 - 68	40 - 50	-
Under Cover		28 - 47	21 - 35	-
Upper Engine Mounting Nut		70	52	-
Vibration Damper Center Bolt		180 - 220 90° + 10°	133 - 162 90° + 10°	-
Water Pump Pulley Bolt		22.5 - 27.5	16.6 - 20.3	-

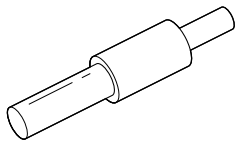
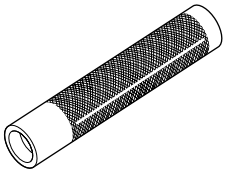
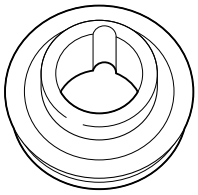
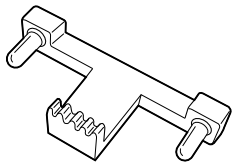
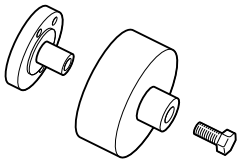
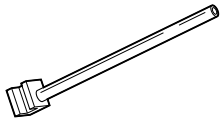
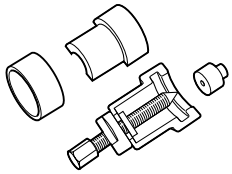
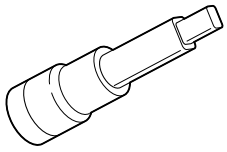
SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS TABLE

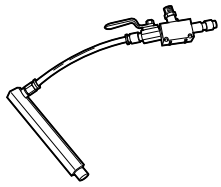
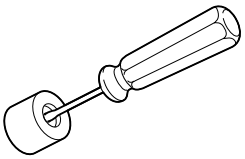
 YAD1B1W0	**000 589 58 43 00** **Chain Assembly**
 YAD1B3Y0	**102 589 00 15 00** **Drift**
 YAD1B3P0	**102 589 12 15 00** **Drift**
 YAD1B2Y0	**103 589 02 09 00** **Oil Filter Remover**

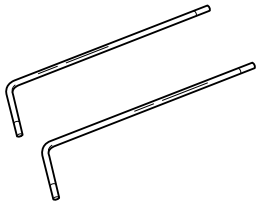
 YAD1B0W0	**111 589 01 59 00** **Supporting Bar**
 YAD1B0X0	**111 589 18 61 00** **Lever Pusher**
 YAD1B580	**111 589 20 33 00** **Sliding Hammer**
 YAD1B0Y0	**111 589 25 63 00** **Thrust Piece**

SPECIAL TOOLS TABLE (Cont'd)

 YAD1B570	**116 589 01 34 00** **Threaded Pin**
 YAD1B1L0	**119 589 00 43 00** **Drift**
 YAD1B790	**601 589 03 14 00** **Crankshaft Front Seal Installer**
 YAD1B720	**602 589 00 40 00** **Engine Lock**
 YAD1B730	**601 589 03 43 00** **Crankshaft Rear Seal Installer**
 YAD1B4K0	**603 589 00 40 00** **Fan Clutch Holder**
 YAD1B2M0	**615 589 01 33 00** **Crankshaft Sprocket Puller**
 YAD1B560	**617 589 00 10 00** **AllenWrench Socket**

SPECIAL TOOLS TABLE (Cont'd)

 YAD1B0Z0	**DW110-090** **Connecting Hose**
 YAD1B1A0	**DW110-100** **Valve Tappet Remover**

 YAD1B0K0	**DW110-120** **Holding Pin**

SECTION 1B2

M161 ENGINE MECHANICAL

CAUTION: 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 other-wise noted.

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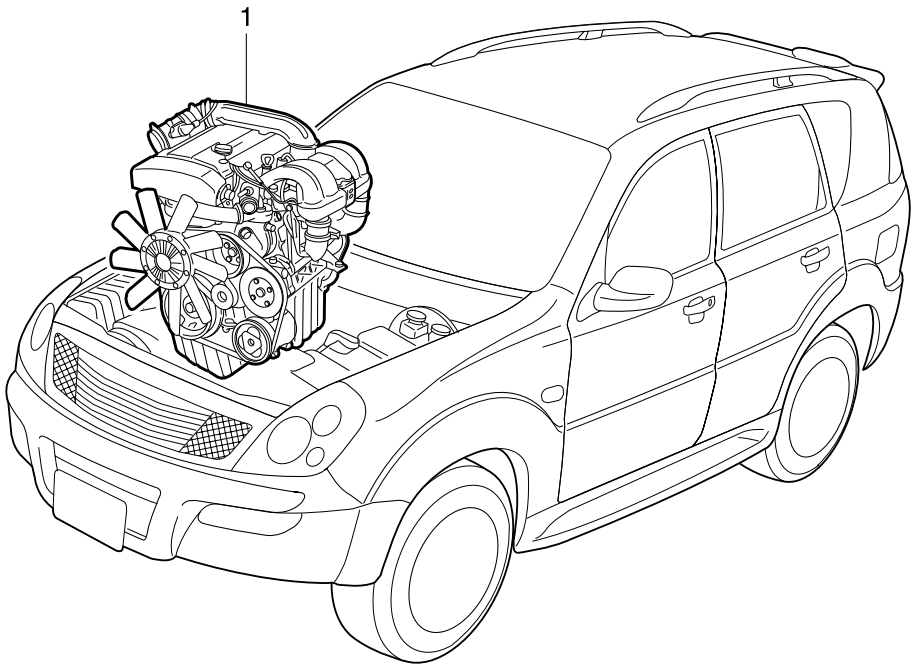
MAINTENANCE AND REPAIR

ON-VEHICLE SERVICE

ENGINE ASSEMBLY



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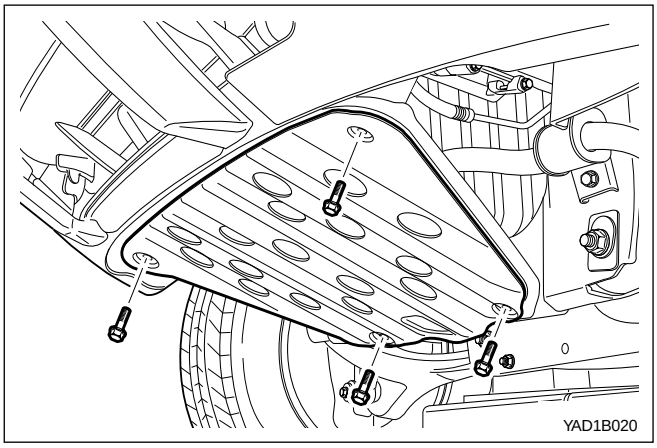
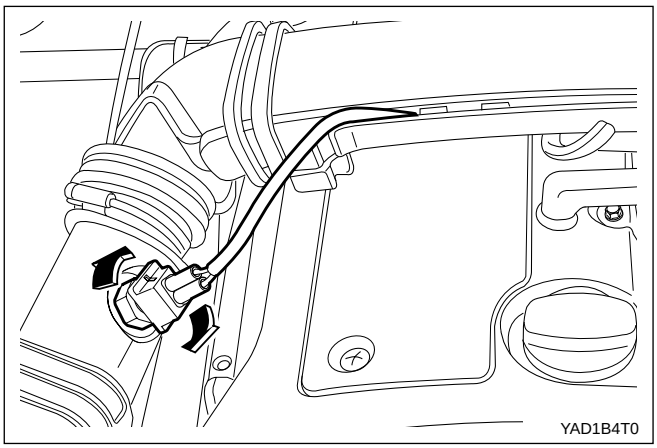


Removal & Installation Procedure

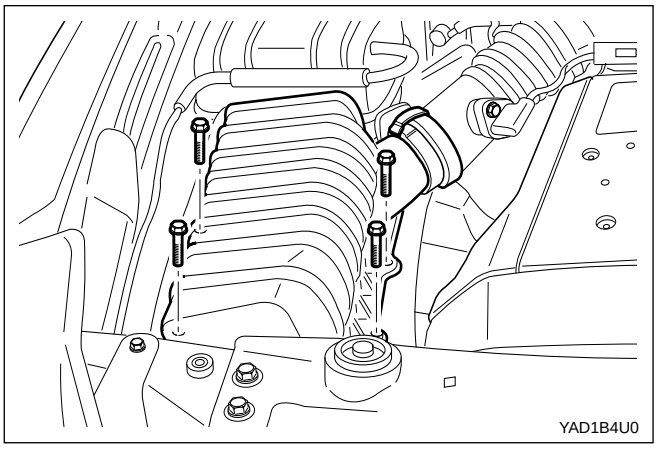
1. Disconnect the negative terminal of battery.
2. Remove the hood.
3. Remove the under cover.

Installation Notice

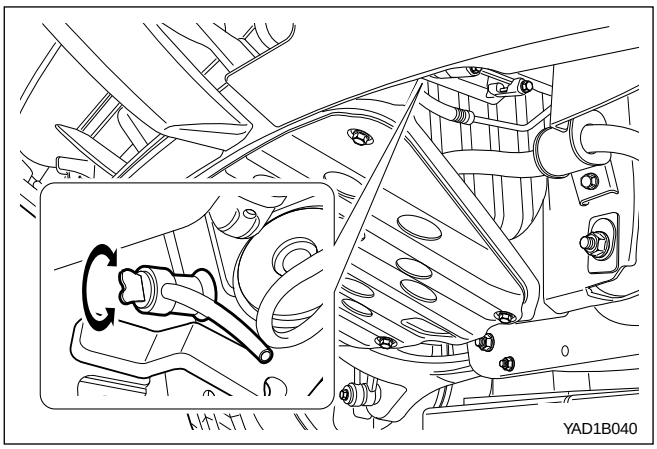
Tightening Torque	28 - 47 N•m (21 - 35 lb-ft)



4. Disconnect the coupling of HFM sensor and remove the air cleaner cross pipe.

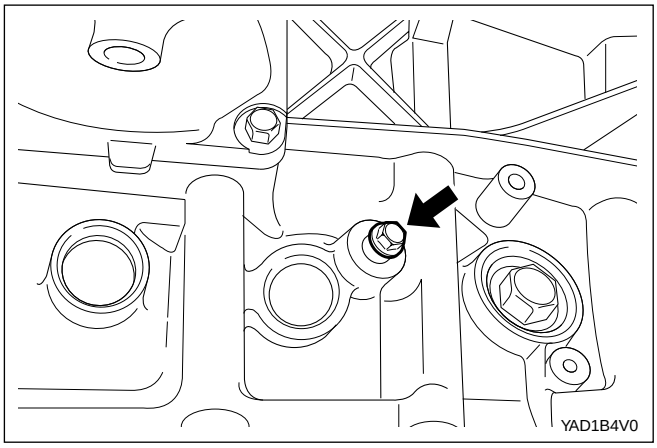


5. Remove the air cleaner cover. Remove the mounting bolts and air cleaner housing and element assembly.



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

   Notice: Open the coolant reservoir cap.

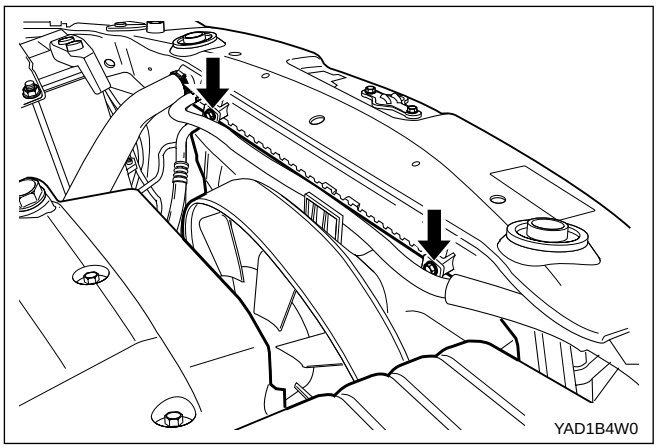


7. Loosen the cylinder block drain plug and then drain the coolant completely.

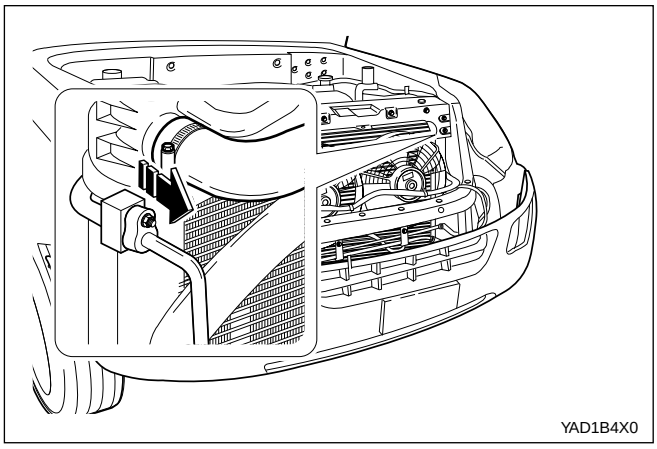
Installation Notice

Tightening Torque	5 N•m (26 lb-ft)

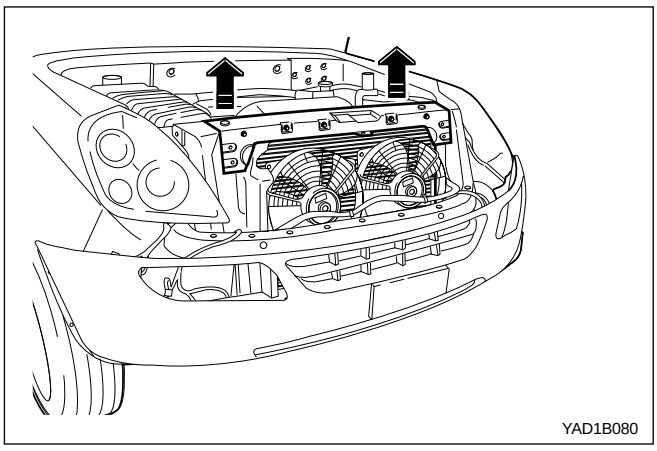
Notice: Replace the seal before installation of the drain plug.



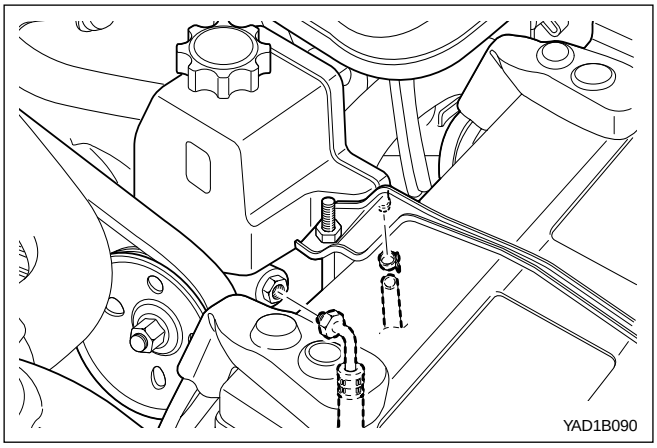
8. Remove the cooling fan shroud. Refer to *Section 1D2, Engine Cooling.*



9. Disconnect the each hose from radiator.

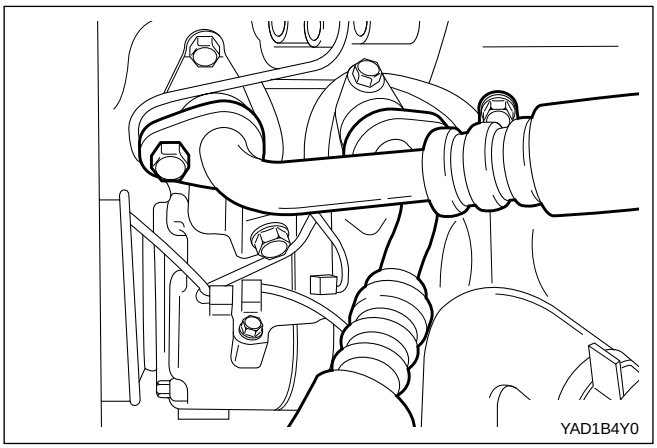


10. Remove the upper mounting bolts of radiator and then remove the radiator.

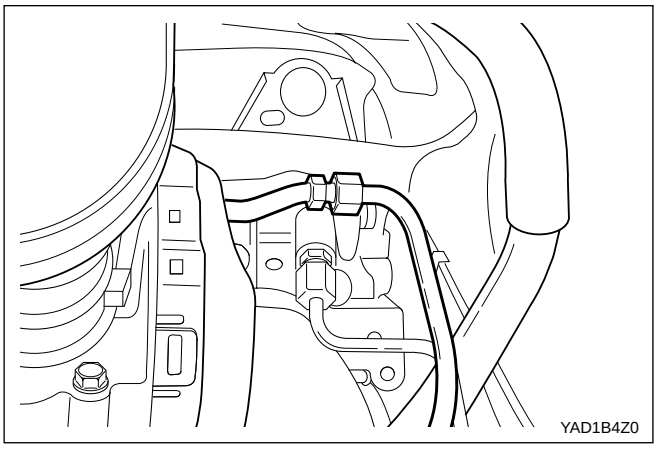


11. Remove the hydraulic pipe of power steering.

    Notice: Completely drain the oil.



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

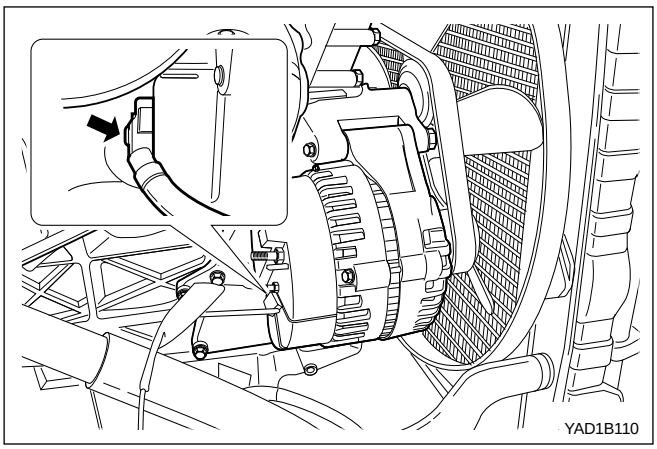


13. Remove the fuel feed and return line.

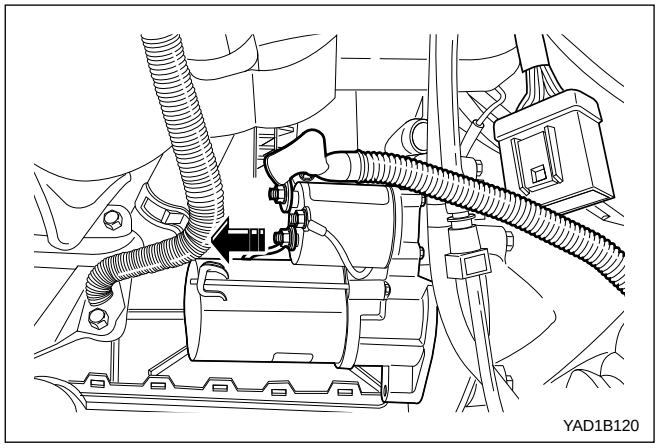
    Notice: Before removing the fuel lines, release the pressure in the fuel system.

    Installation Notice

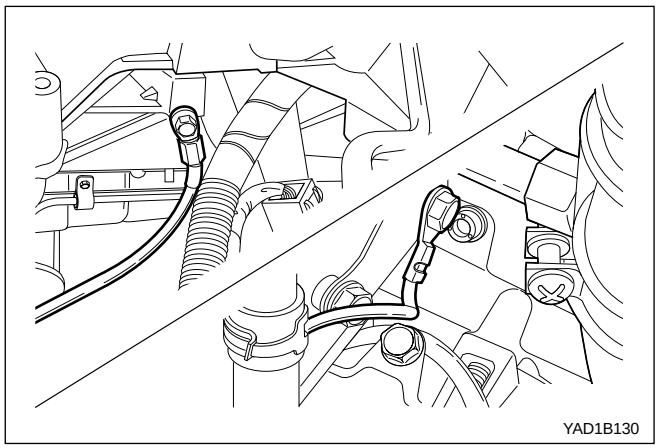
Tightening Torque	21 - 25 N•m (15 - 18 lb-ft)



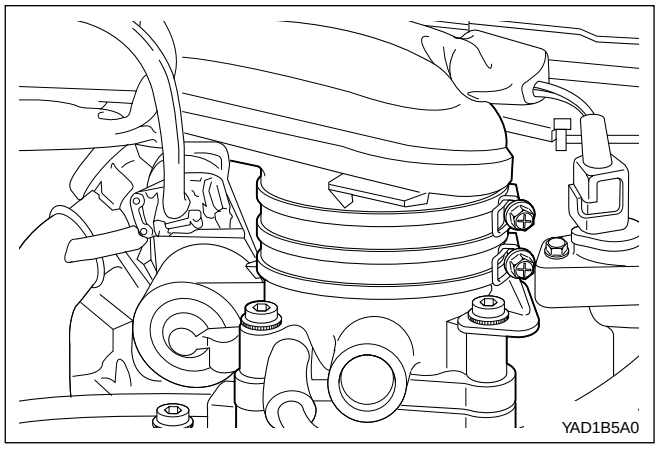
14. Disconnect the terminals from the generator.


YAD1B120

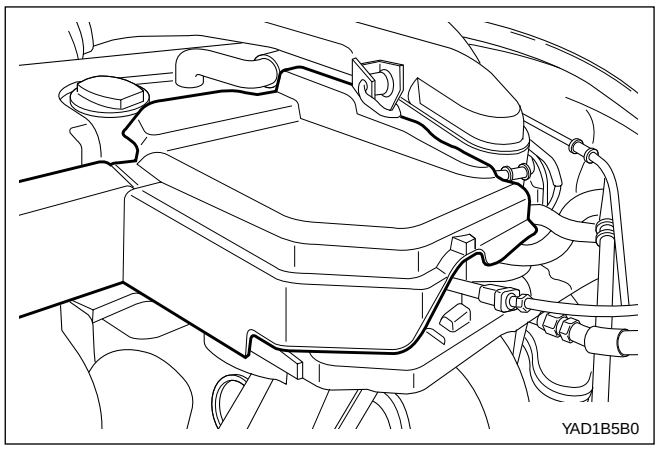
15. Disconnect the terminals from starter motor and remove the starter motor.
16. Disconnect the engine main harness ground.


YAD1B130

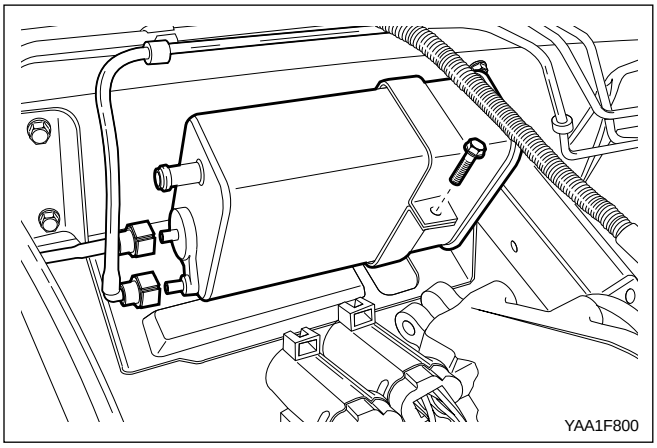
17. Disconnect the engine ground wire.


YAD1B5A0

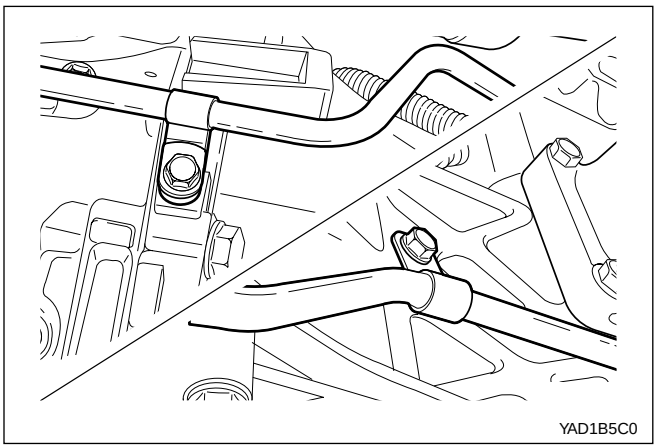
18. Disconnect following sensors connector.
    - HFM sensor.
    - Coolant temperature sensor.
    - Knock sensor.
    - Camshaft and crankshaft sensors.


YAD1B5B0

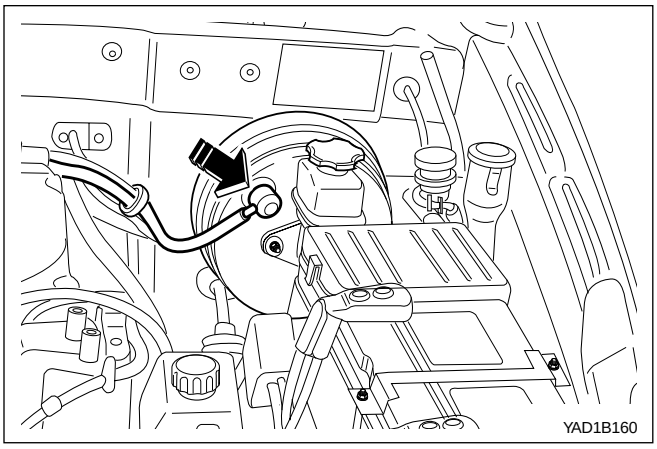
19. After removing the ignition coil cover, disconnect the ignition coil connector.
20. Remove the harness cover and disconnect the 4 injection valve connectors. Disconnect the main harness.



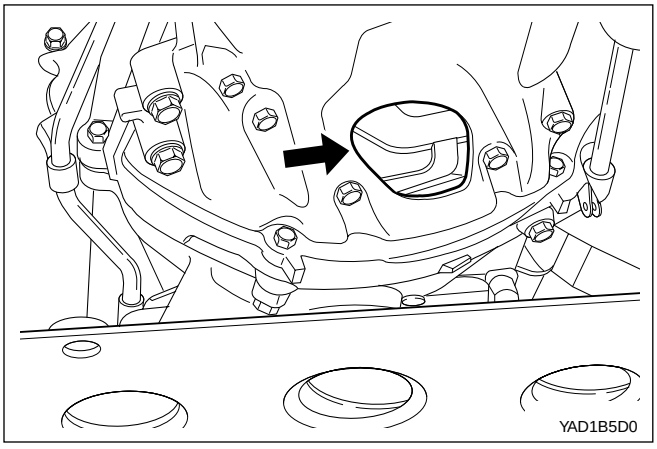
21. Separate the hose toward engine from canister purge solenoid valve and canister. Refer to *Section 1F2, Engine Control.*



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



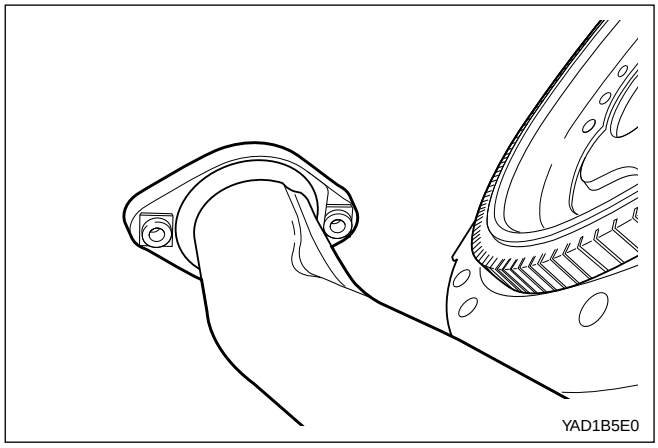
24. Separate the vacuum hose for brake booster.
25. Separate the other vacuum hoses.



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

Installation Notice

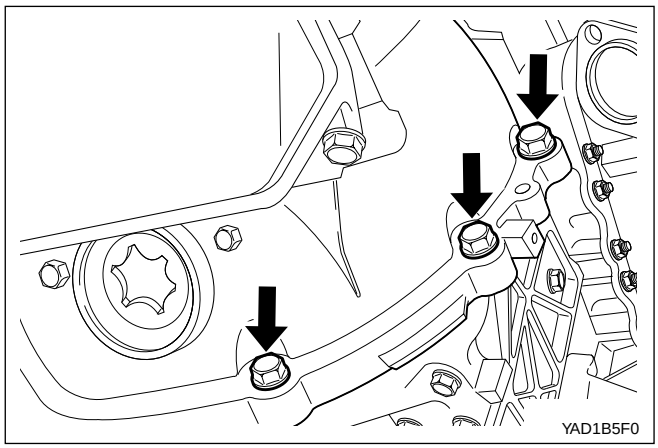
Tightening Torque	42 N•m (31 lb-ft)



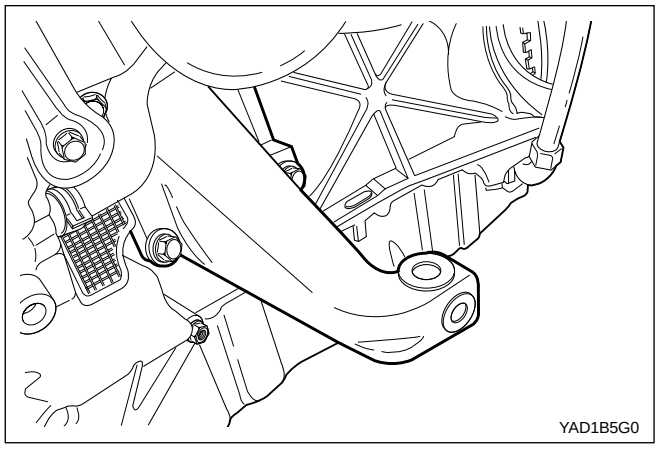
27. Remove the exhaust manifold and exhaust pipe.

Installation Notice

Tightening Torque	30 N•m (22 lb-ft)



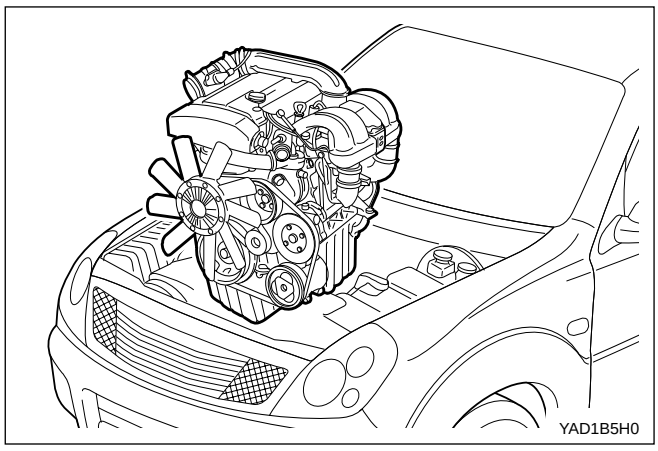
28. Remove the transmission. Refer to Section 5A, Automatic Transmission.



29. Install a chain to the bracket of engine, by using a hoist or crane.
30. Remove the engine mount nuts.

Installation Notice

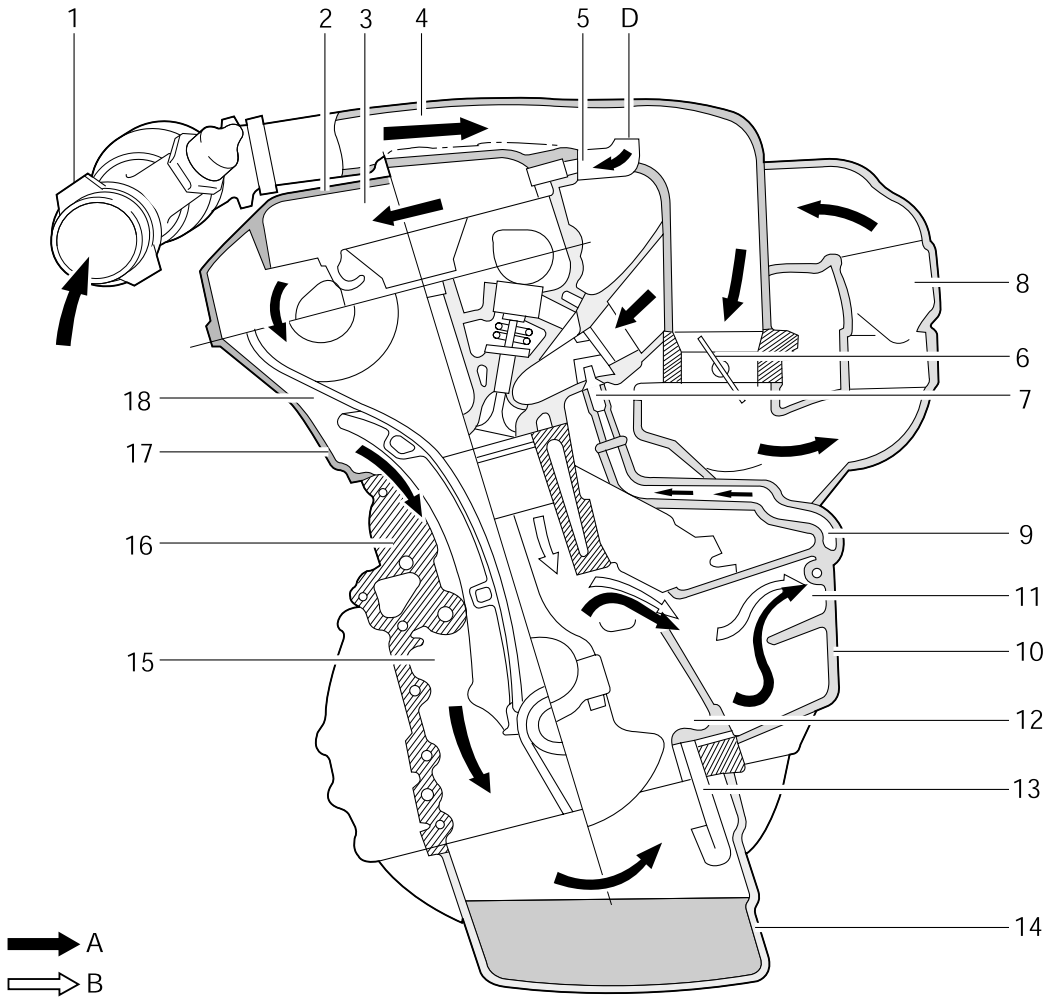
Tightening Torque	70 N•m (52 lb-ft)



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

CRANKCASE VENTILATION SYSTEM

Operation at Idling and Mid- Load



1 HFM 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.

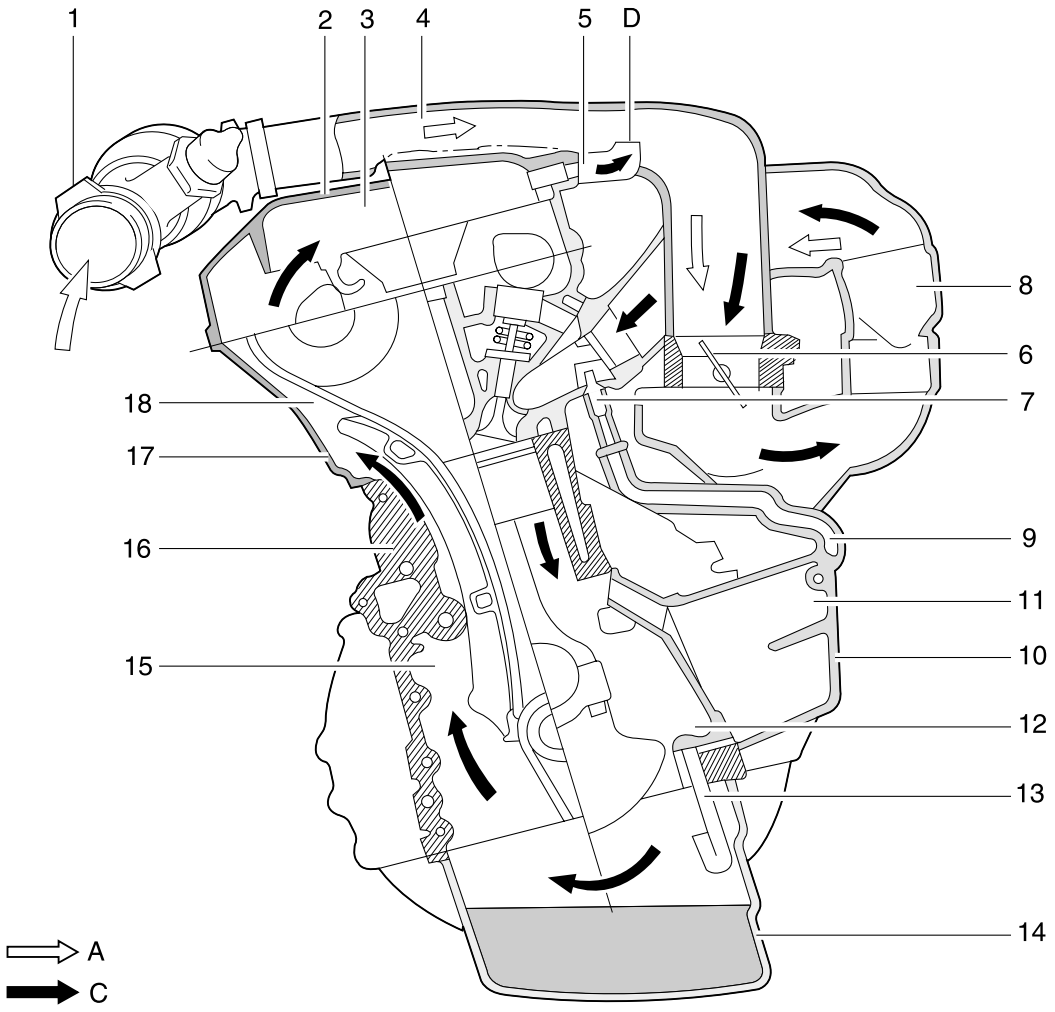
  The blow-by gas and the fresh air that is additionally supplied through the vent connection (D) in the crank-case in partial load gets supplied to the combustion chamber from the crank chamber (12) through the oil separation chamber (11), air-conditioner bracket (10), vent line (9), and restrictor (7)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

Operation When Full- Load at Partial Load



1 HFM 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

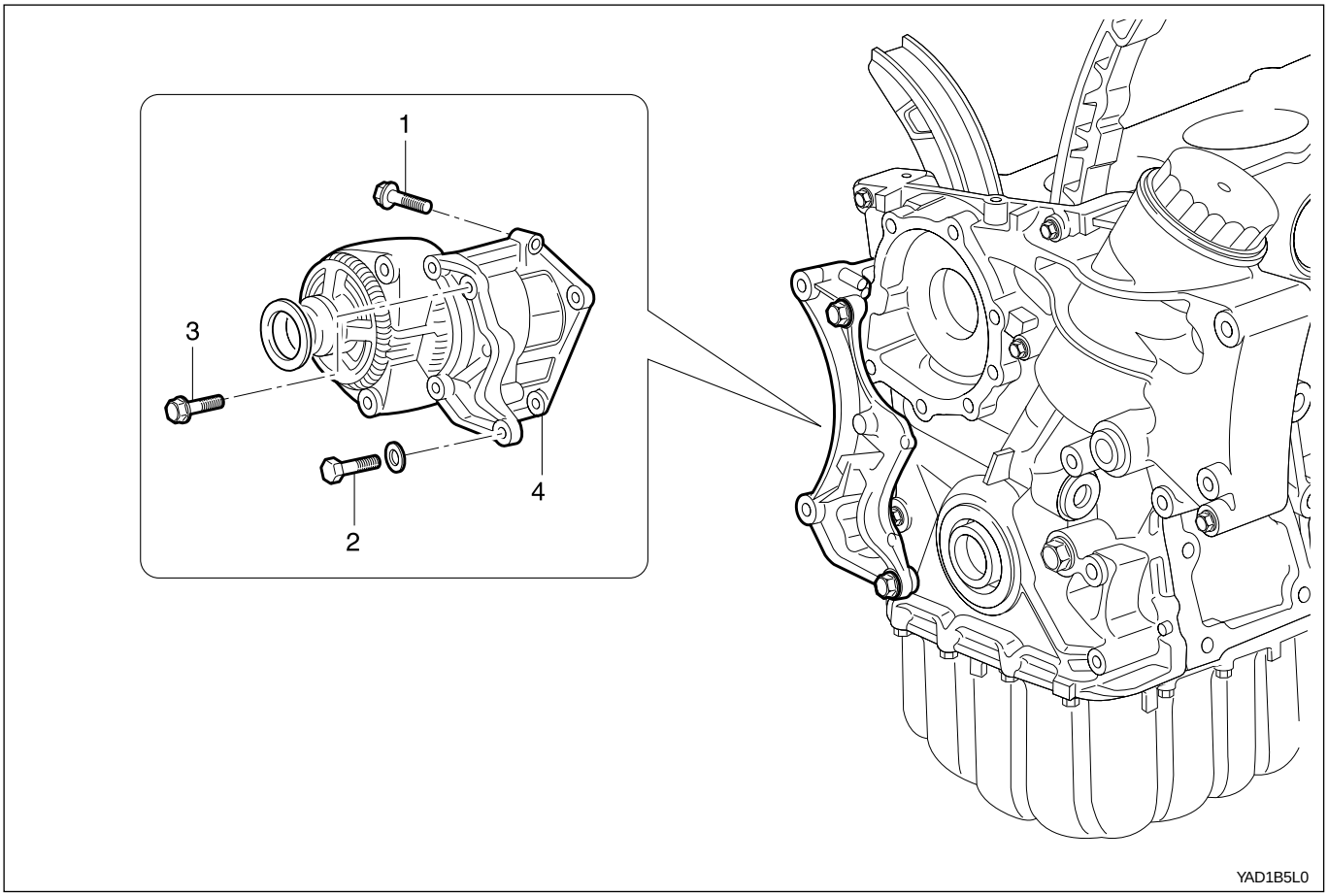
Operation When Full- Load at Partial Load

- 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).

GENERATOR



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 Generator Bracket

Removal & Installation Procedure

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

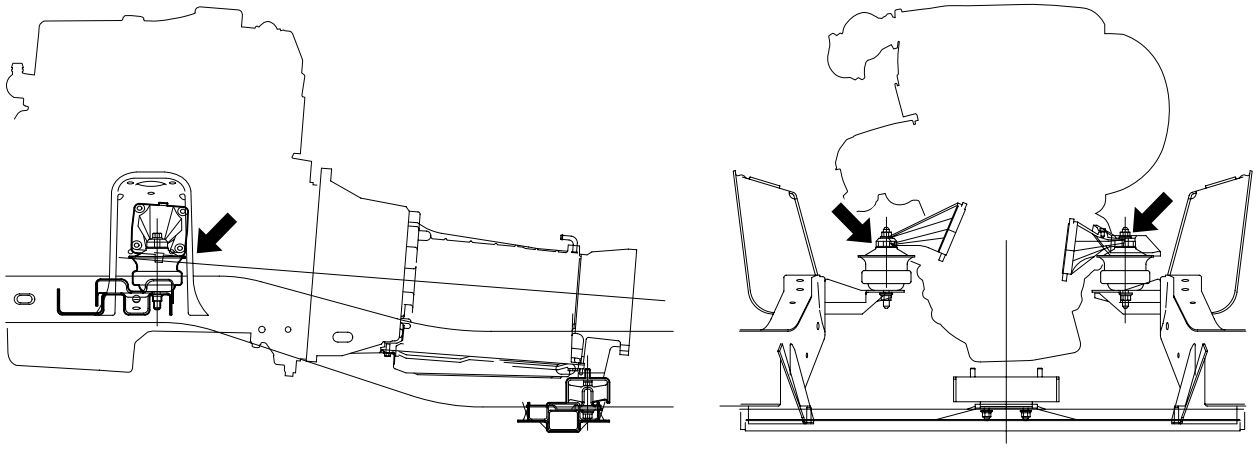
Installation Notice

Tightening Torque	70 N•m (52 lb-ft)

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.

ENGINE MOUNT



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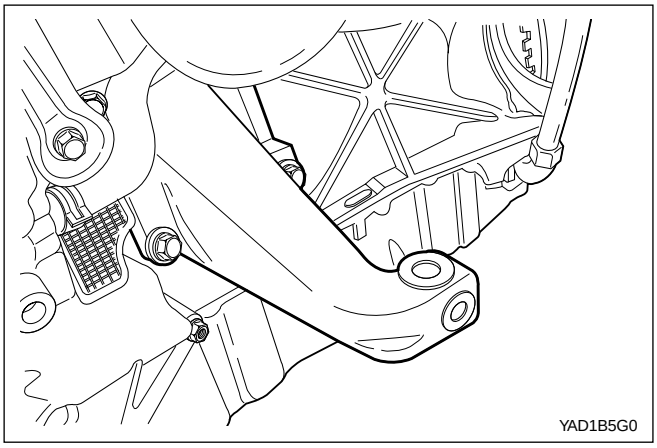
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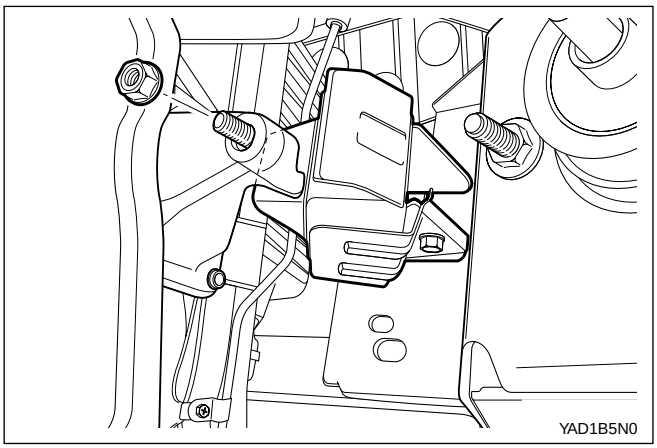
Removal & Installation Procedure

1. Unscrew the upper engine mount nuts and remove the engine.

Installation Notice

Tightening Torque	70 N•m (52 lb-ft)


YAD1B5N0

2. Unscrew the lower nuts.

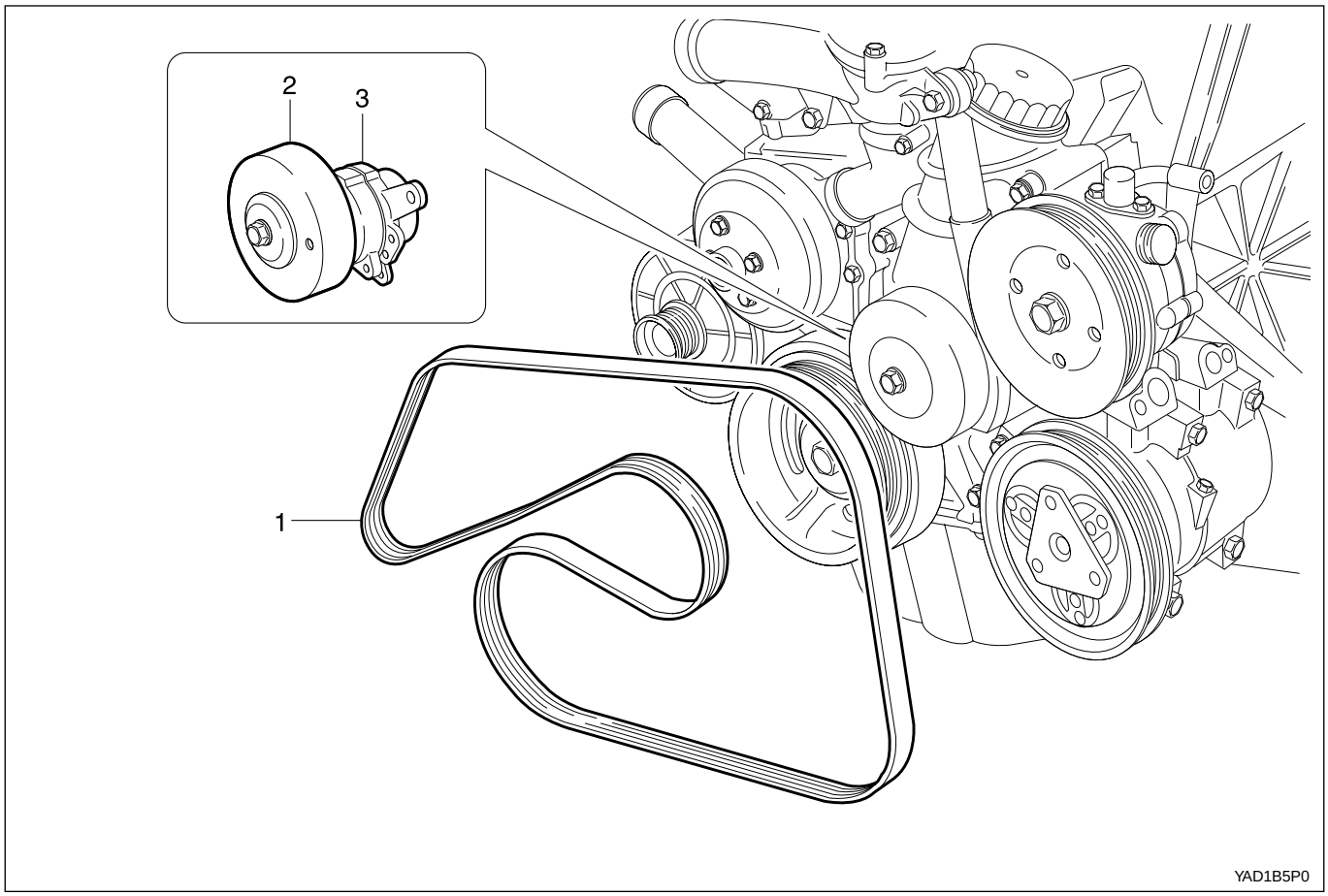
Installation Notice

Tightening Torque	38 N•m (28 lb-ft)

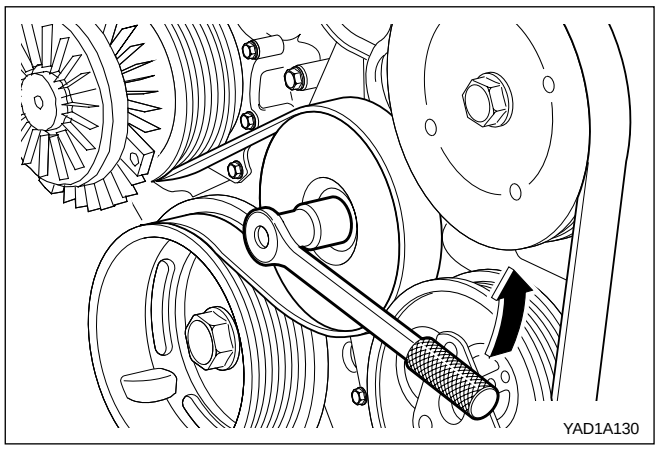
3. Remove the hydraulic engine mounting insulator.
4. Installation should follow the removal procedure in the reverse order.

POLY V - BELT

Preceding Work: Removal of cooling fan



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



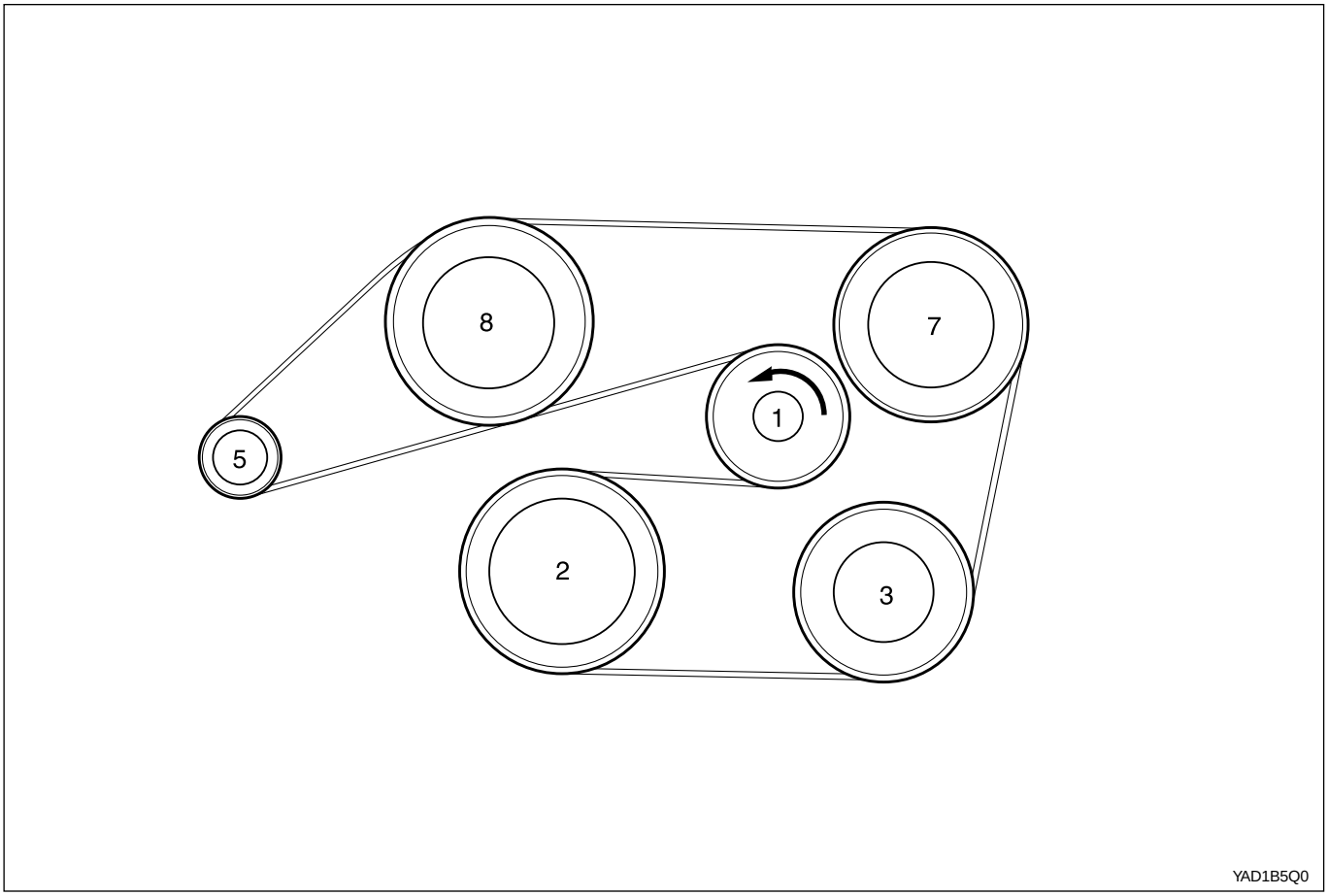
Removal & Installation Procedure

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.

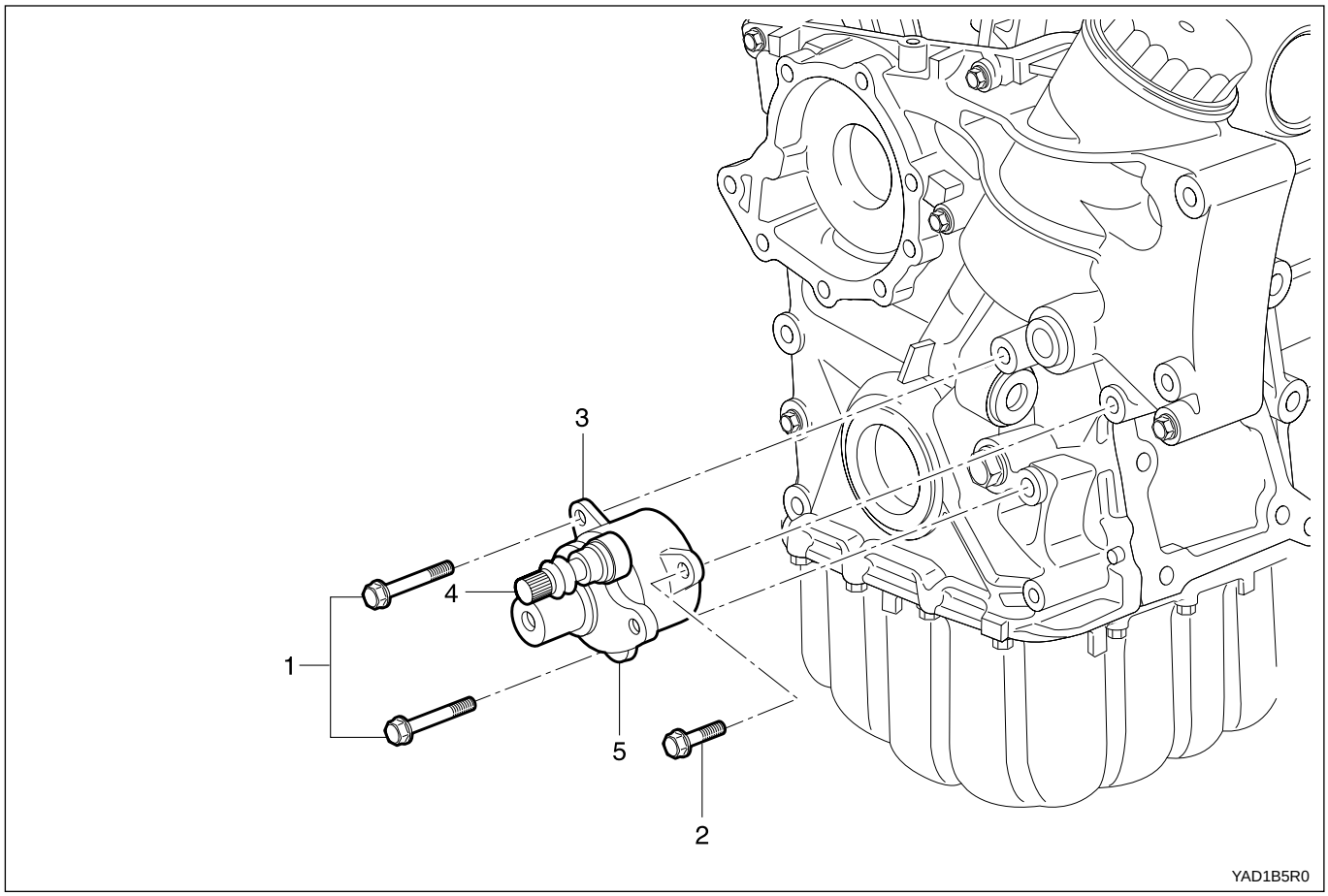
Poly V - Belt Arrangement



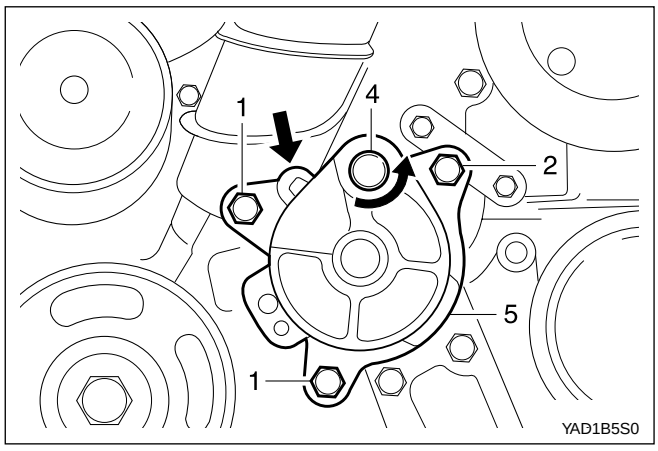
1 Belt Tensioning Pulley
2 Crankshaft Belt Pulley
3 A/C Compressor Pulley
5 Generator Pulley
7 Power Steering Pump Pulley
8 Water Pump Pulley

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

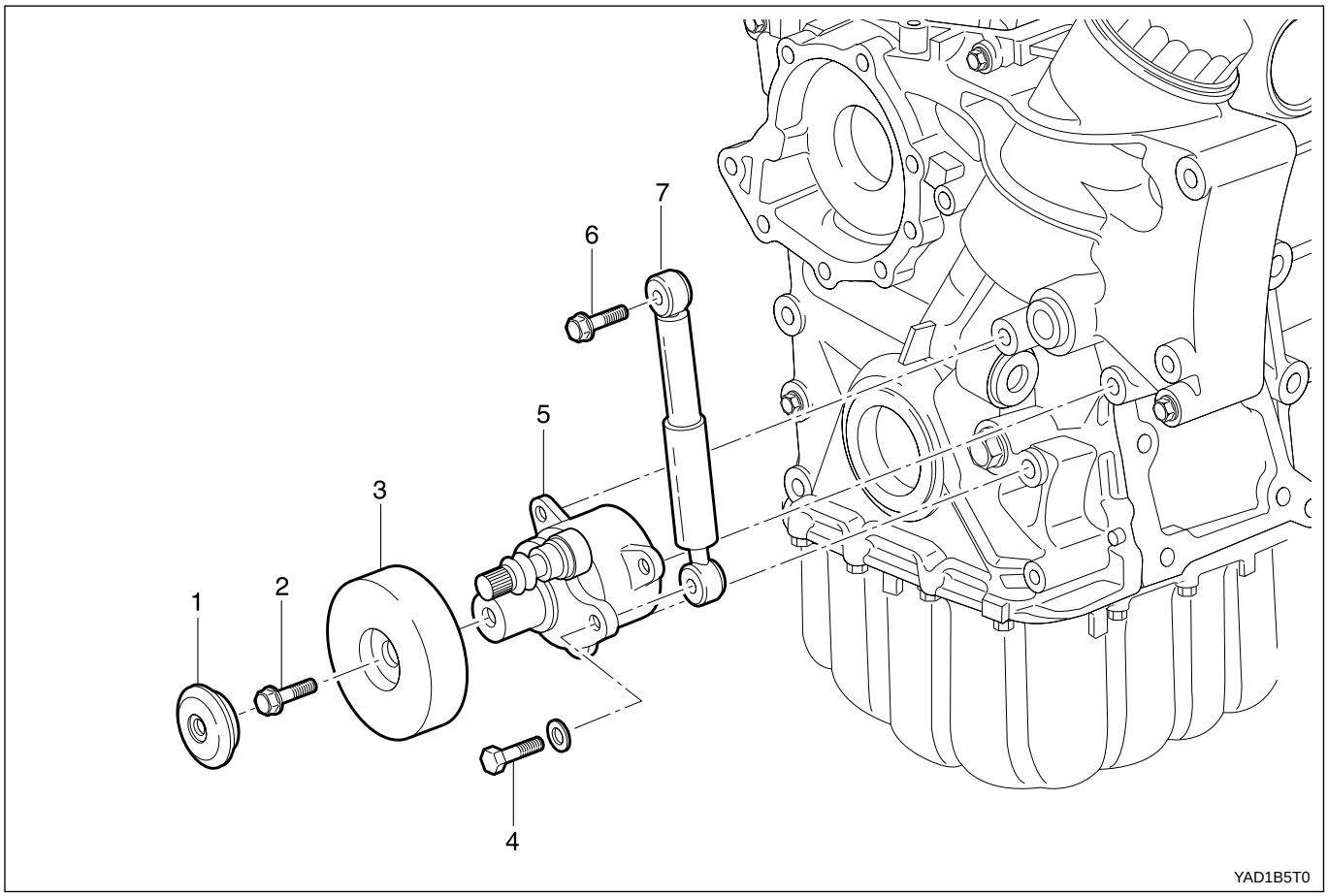
1. Turn the stud bolt to counterclockwise.
2. Insert the pin (111 589 01 15 00) into the hole in tensioning arm.
3. Unscrew the bolts (1, 2) and remove the tensioning device.

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).

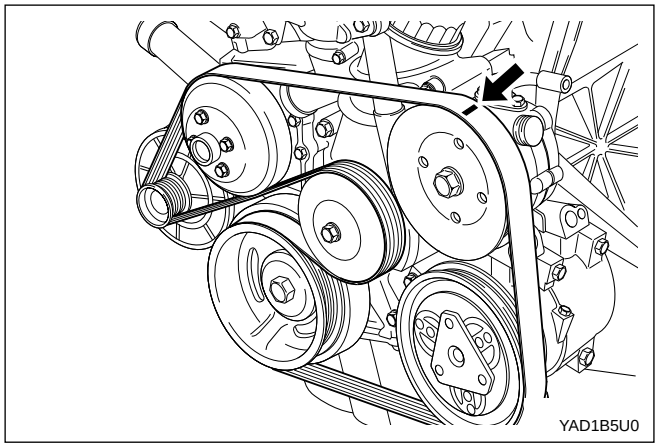
Installation Notice

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

3. Unscrew the bolts (4,6) and remove the shock absorber (7).

Installation Notice

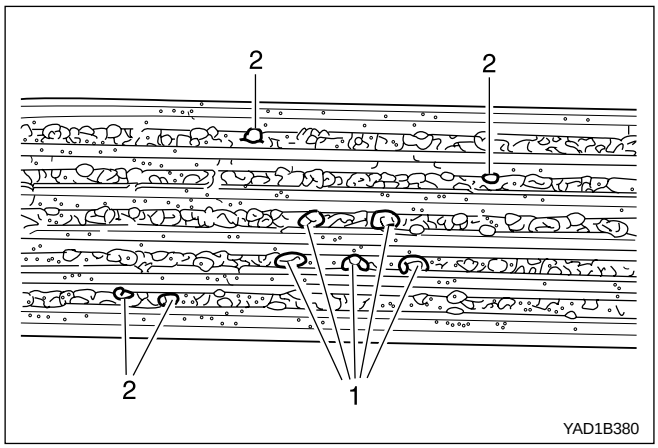
Tightening Torque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)


YAD1B5U0

POLY V - BELT INSPECTION

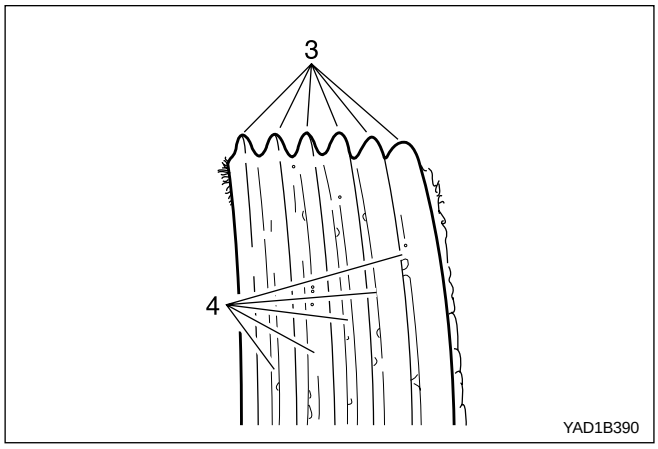
- Make marks on the belt with chalk.
- Rotate the engine and check the belt for damage.

  Notice: If one of the following types of damages is found, replace the belt.



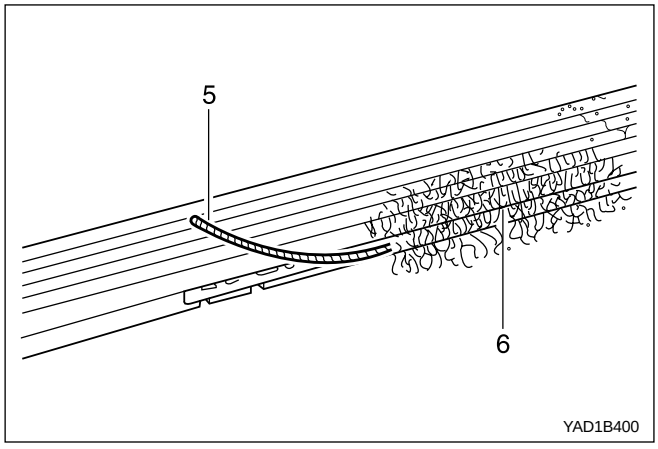
YAD1B380

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



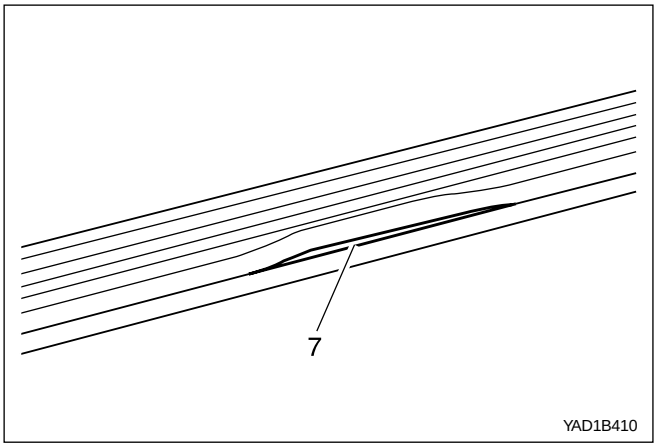
YAD1B390

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

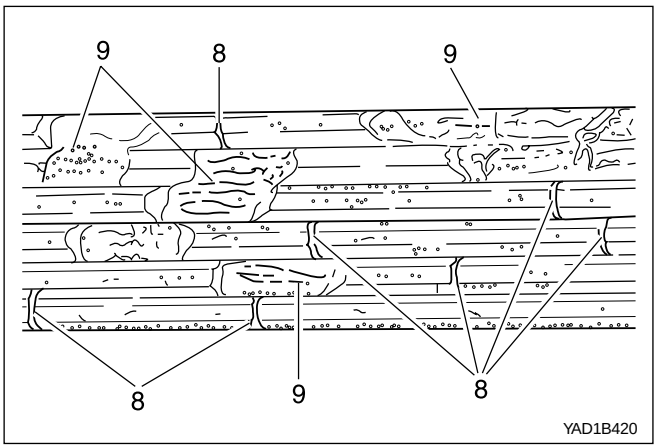


YAD1B400

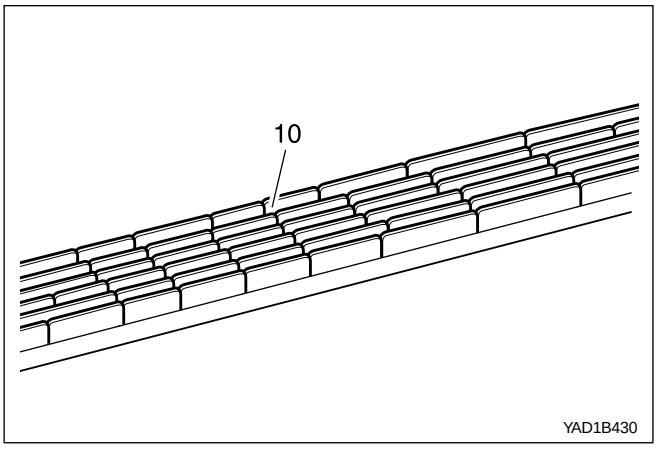
5. Cord torn out at the side.
6. Outer cords frayed.



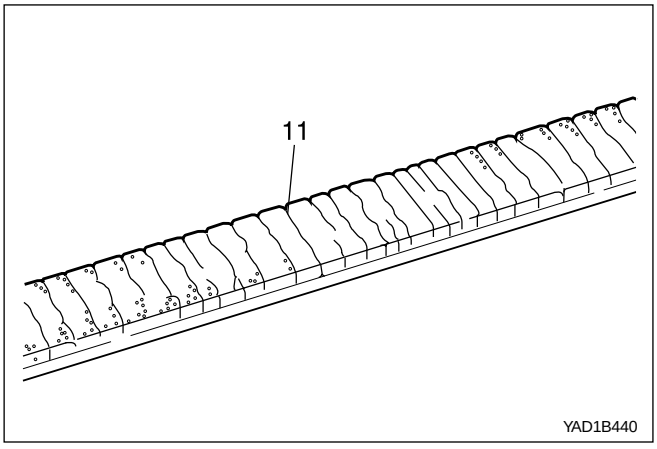
7. Rib detached from the base of belt.



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

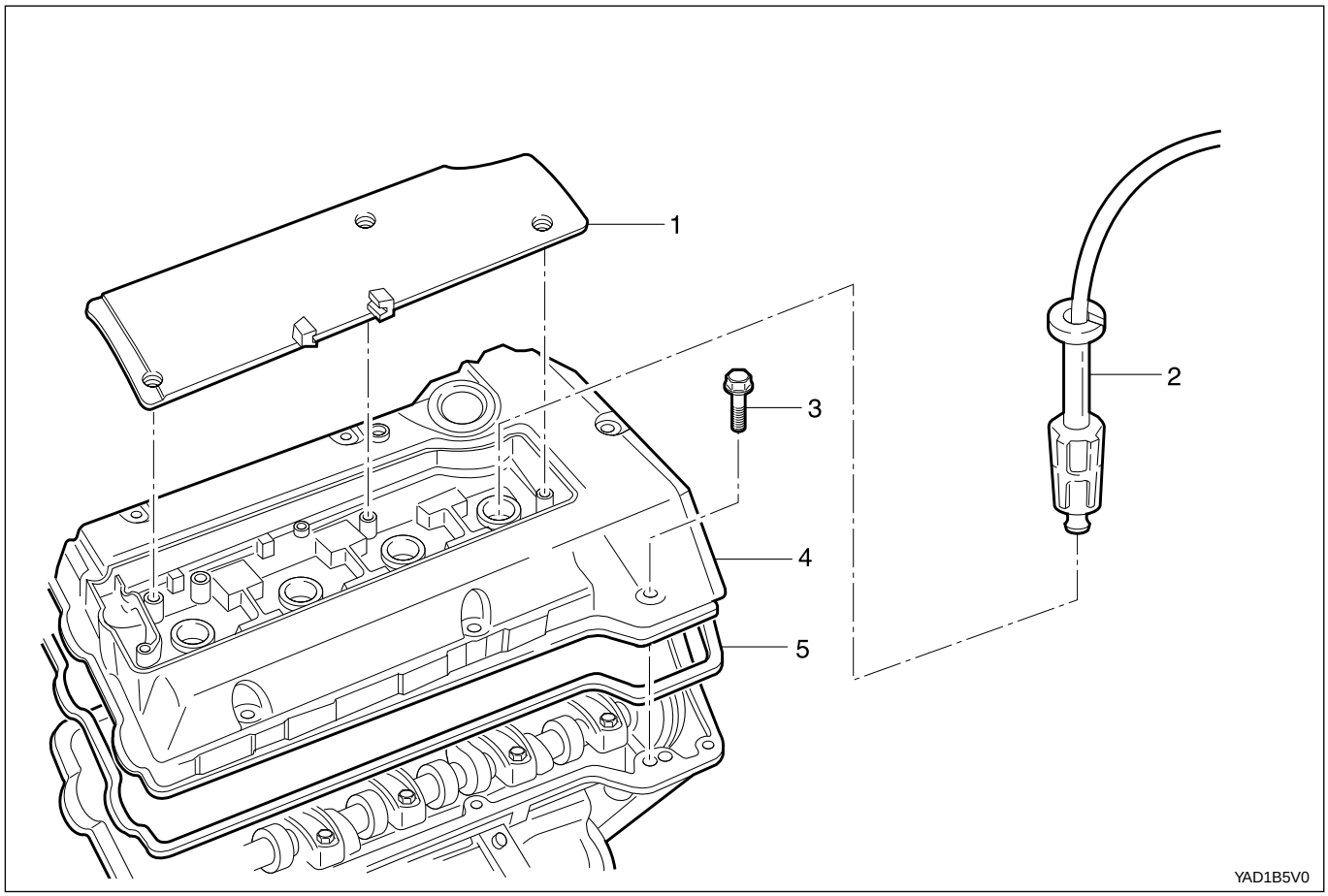


10. Splits across several ribs.

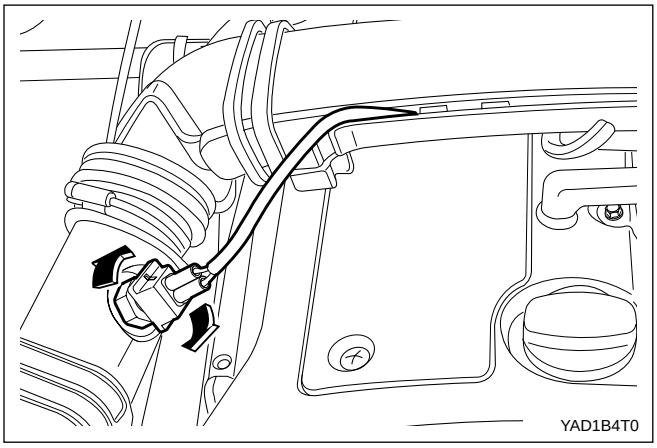


11. Splits across the back of the belt.

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

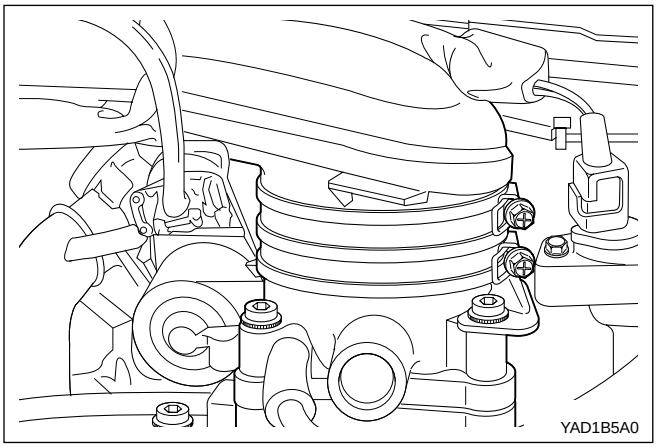


Removal & Installation Procedure

1. Remove the intake air duct.

Installation Notice

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

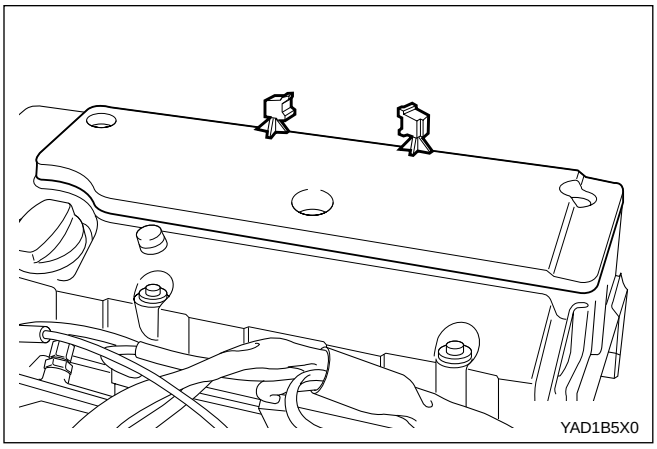


2. Remove the spark plug cover.

Installation Notice

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

Notice: Release 3 screws from the spark plug cover and remove the cover for M161 Engine coil.

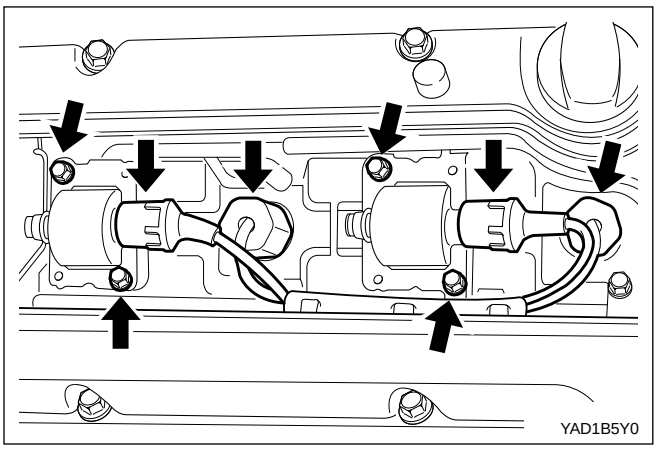


3. Remove the spark plug connector and ignition cable.
4. Unscrew the bolts (3) and remove the head cover and the gasket.

Installation Notice

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

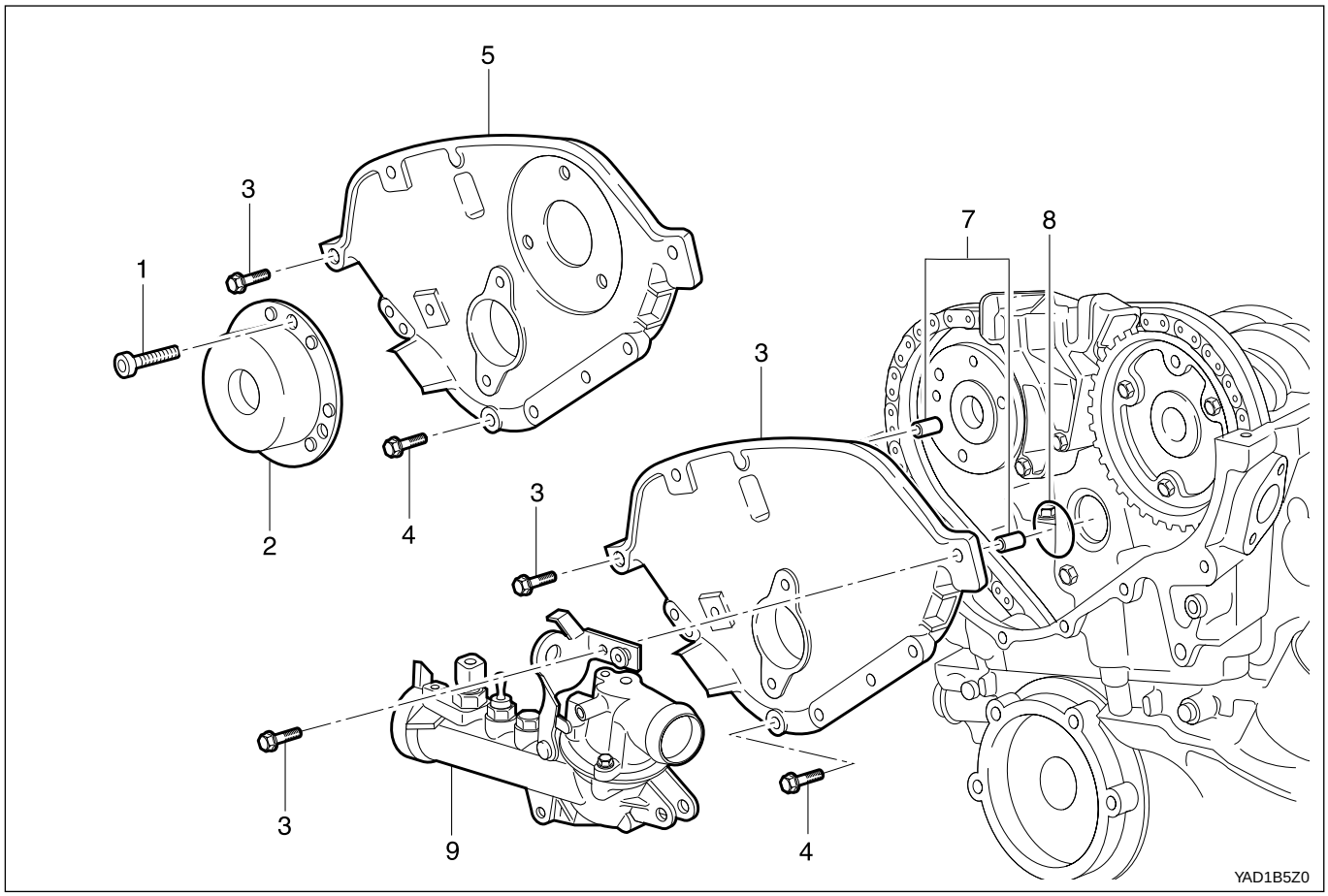
Notice: Replace the gasket with a new one if necessary.



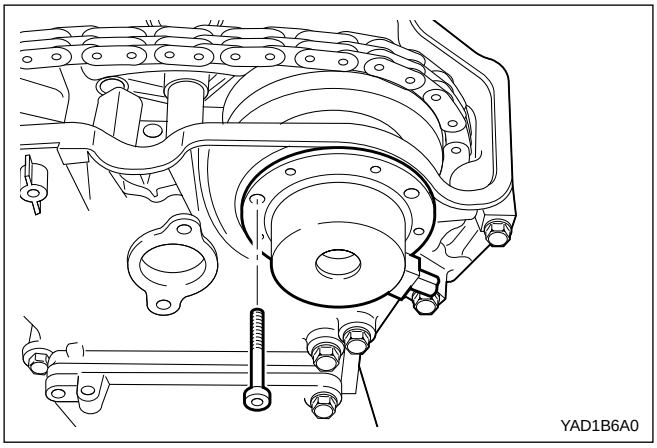
5. Installation should follow the removal procedure in the reverse order.
6. Check for oil leaks by operating the engine.

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 (E23 : M161.973)
6 Front Cover (E20 : M161.943)
7 Sleeve
8 O-Ring ..... Replace
9 Thermostat Housing.

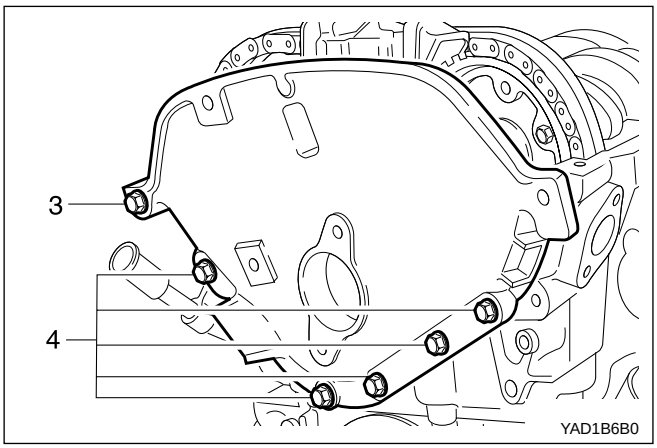


Removal & Installation Procedure

1. Disconnect the camshaft adjuster connector and remove the camshaft adjuster (E23 engine only).

Installation Notice

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



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 (4)	9 - 11 N•m (80 - 97 lb-in)

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

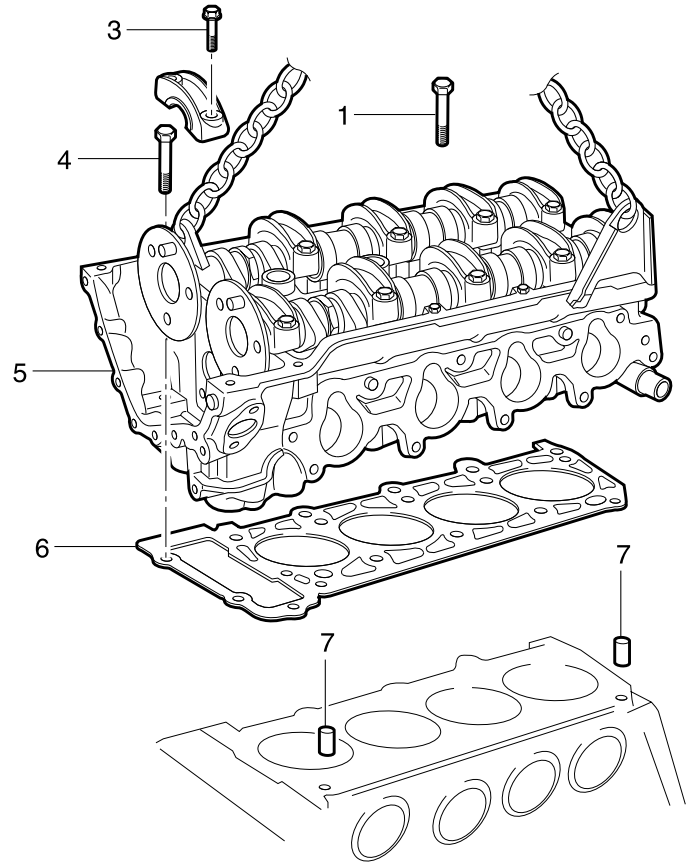
3. Remove the O-Ring.

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

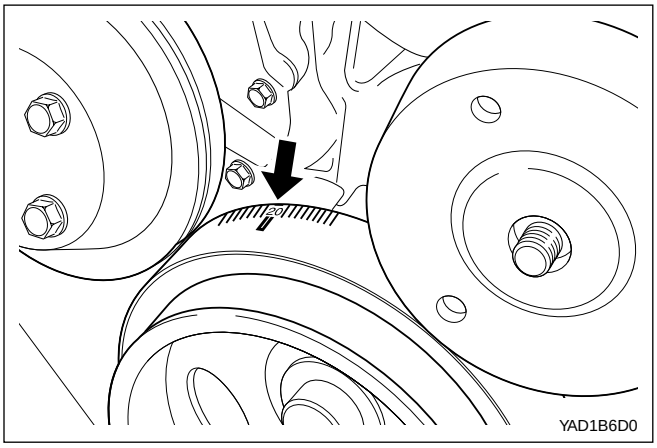
4. Installation should follow the removal procedure in the reverse order.

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

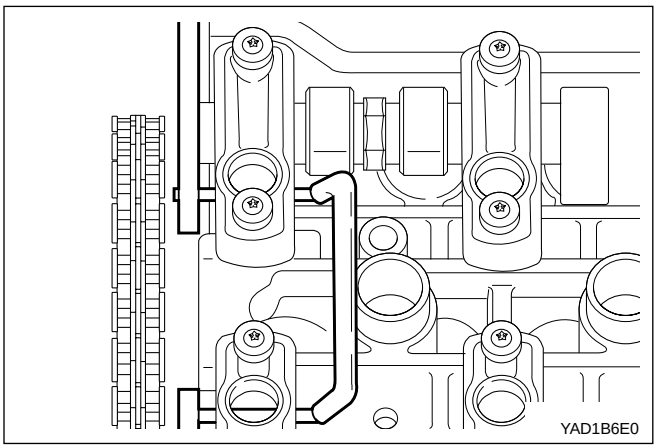


Tools Required

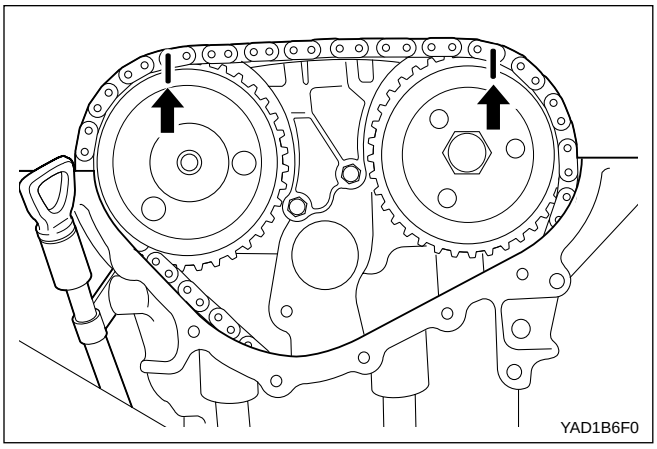
617 589 00 10 00 Allen Wrench Socket
116 589 20 33 00 Sliding Hammer
116 589 01 34 00 Threaded Pin
111 589 03 15 00 Holding Pin

Removal & Installation Procedure

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



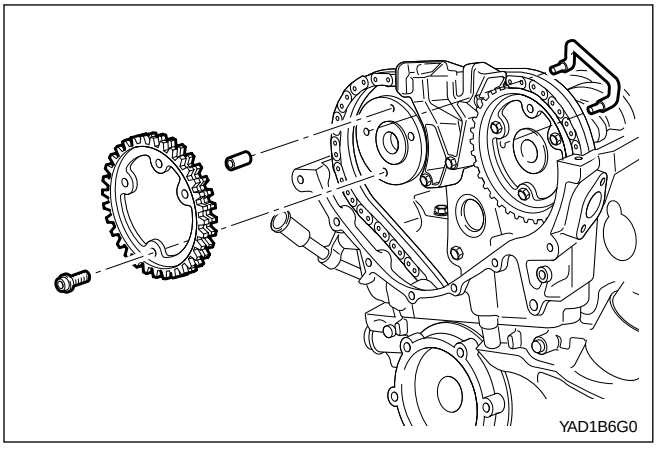
2. Put the holding pin 111 589 03 15 00 into the camshaft bearing cap (number 1, 6).



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)

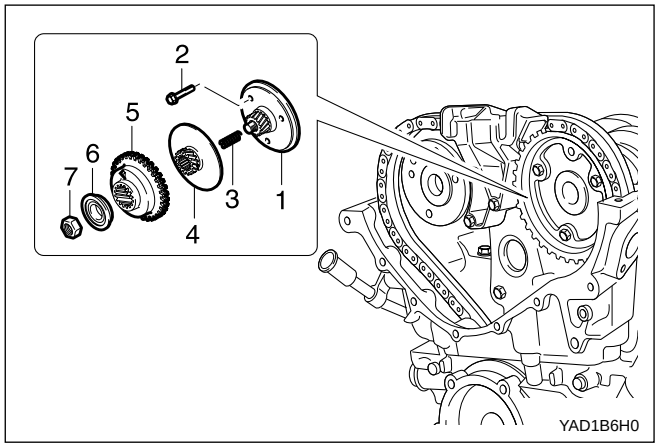


5. Remove the exhaust camshaft sprocket.

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.



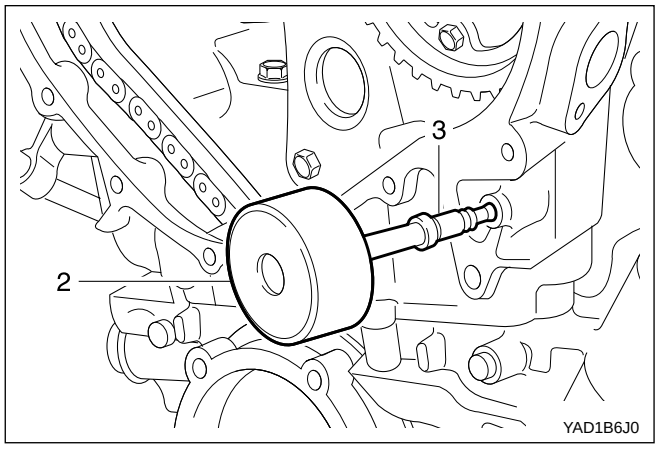
6. Remove the intake camshaft sprocket (E20 engine).
7. Remove the camshaft adjuster (E23, M161.970 engine).

Installation Notice (Flange Bolt)

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

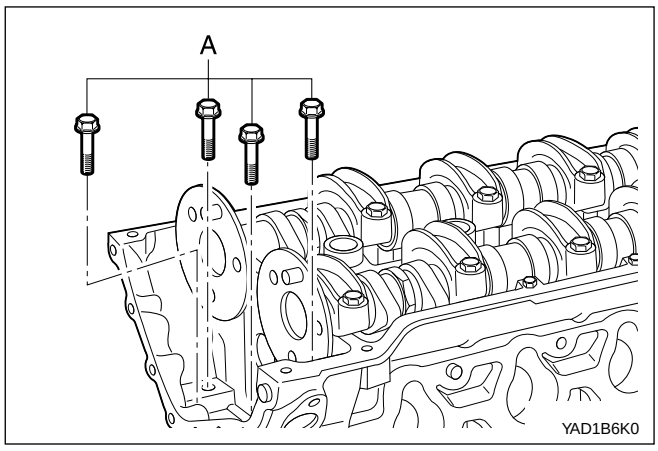
Notice: The flange bolt is designed to be used only once, so always replace with new one.

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



8. Remove the guide rail pin using the sliding hammer 116 589 20 33 00 (02) and the threaded pin 116 589 01 34 00 (03).

Notice: Apply the sealant on guide rail pin when installation.

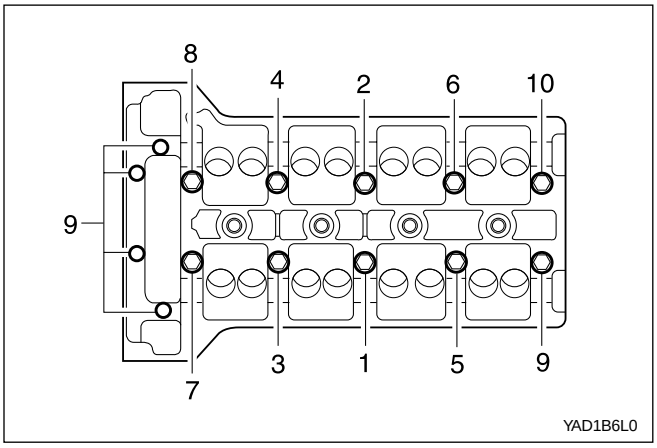


9. Unscrew the bolts (A).

Installation Notice

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

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



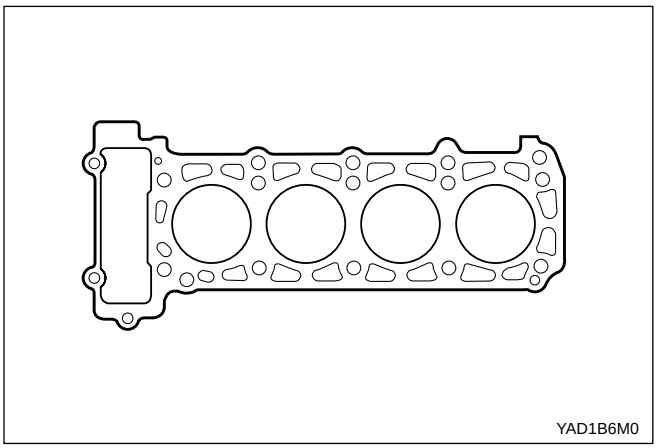
10. Remove the cylinder head bolts in the reverse order of the numerics (No.10 → No.1) using allen wrench socket 617 589 00 10 00.

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.

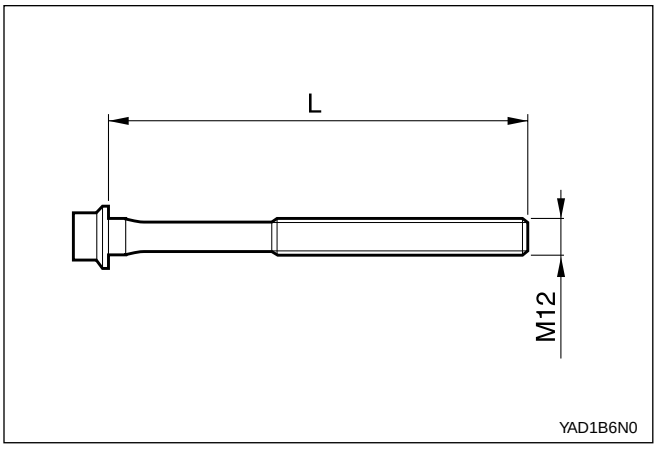


11. Remove the No. 1 bearing cap of the exhaust camshaft.

Installation Notice

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

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



15. Check the length of the cylinder head bolt.

Installation Notice

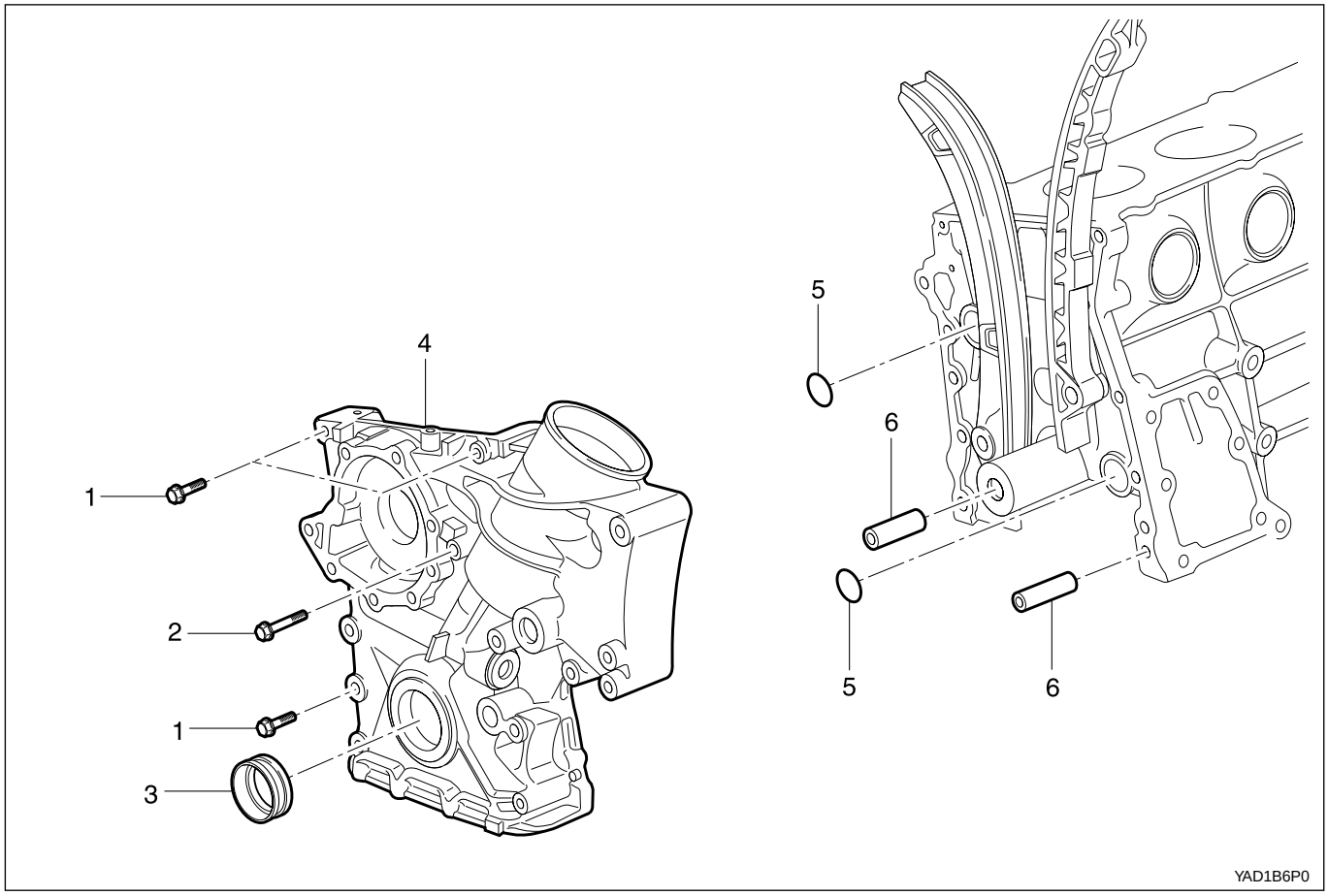
Length (L)	When New 100 mm
	Max. Length 105 mm

Notice: Replace the bolt if the measured length exceed the max. length.

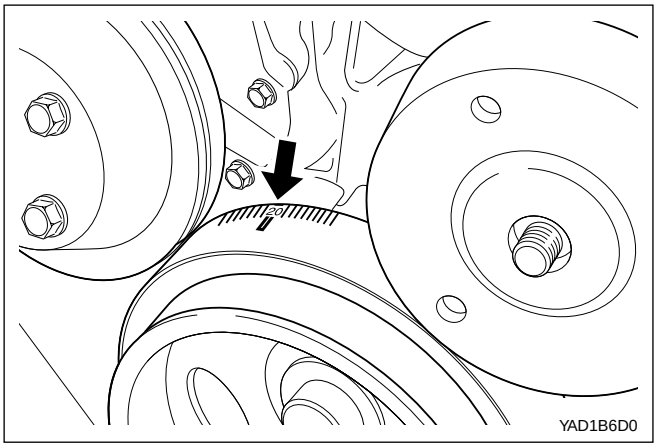
16. Installation should follow the removal procedure in the reverse order.

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.



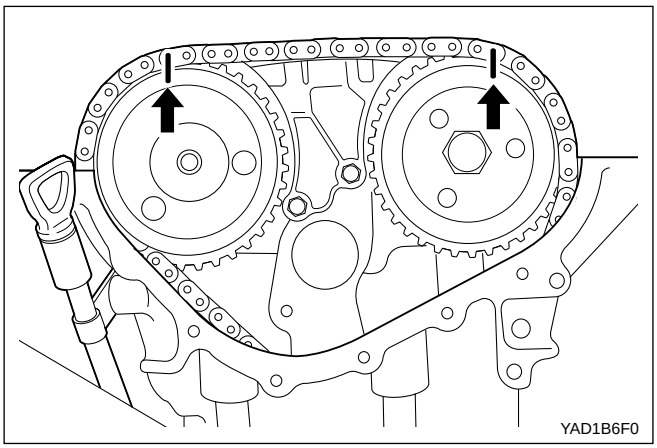
Tools Required

116 589 20 33 00 Sliding Hammer

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

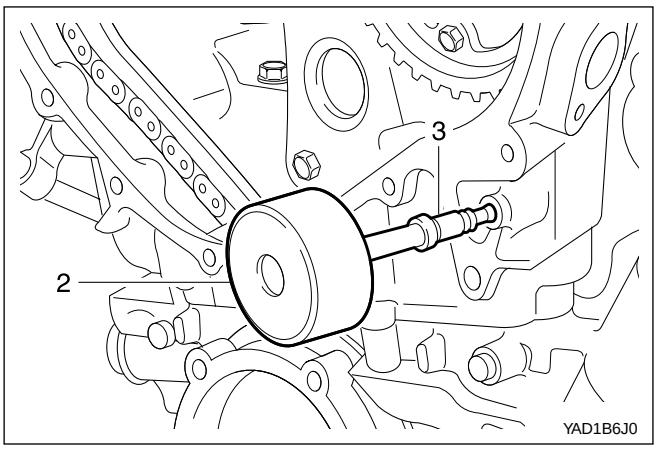
Tightening Torque	72 - 88 N•m (53 - 65 lb-ft)

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

Installation Notice

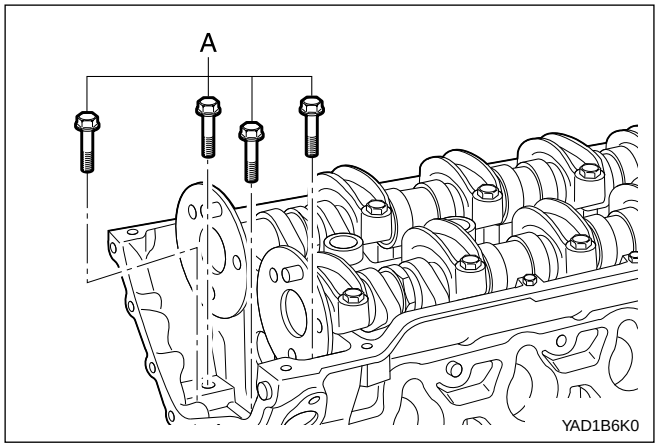
Tightening Torque	1st step: 18 - 22 N•m (13 - 16 lb-ft)
	2nd step: 60° ± 5°

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 116 589 20 33 00 (02) and the threaded pin 116 589 01 34 00 (03).

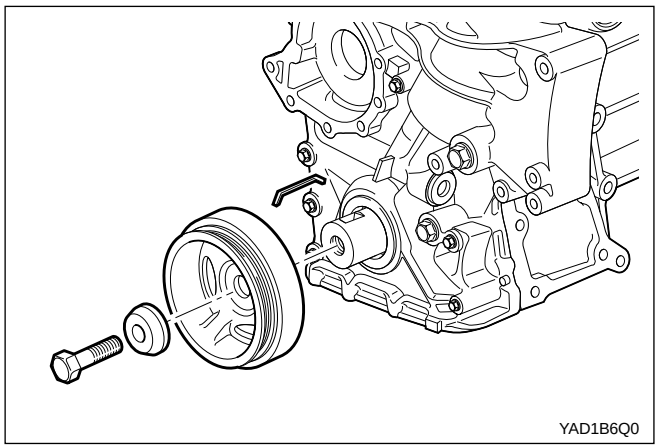
Notice: Apply the sealant on guide rail pin when installation.



8. Unscrew the bolts (A).

Installation Notice

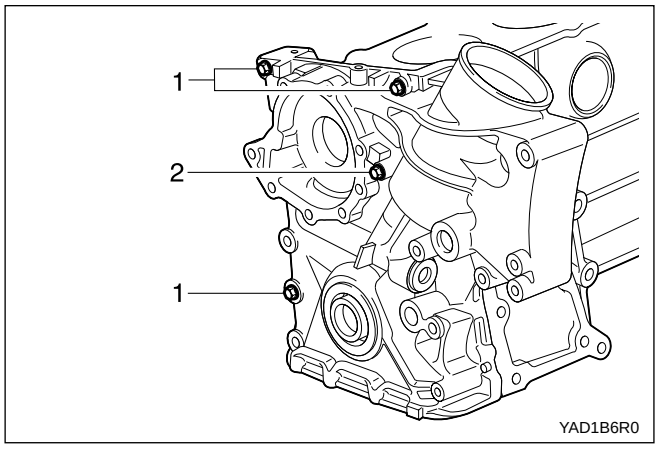
Tightening Torque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)



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.

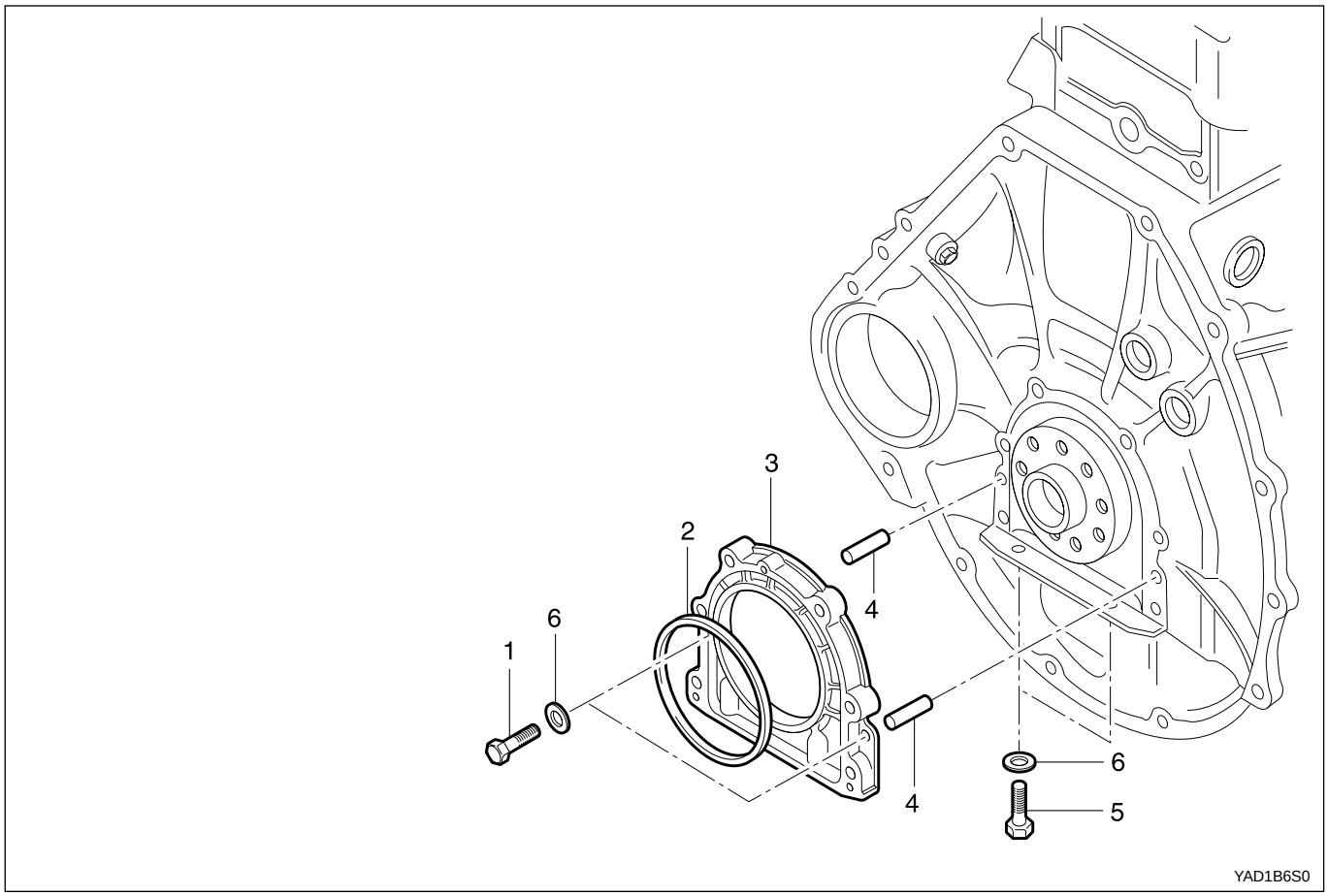
12. Clean the timing gear case cover and crankcase sealing surface.
13. Replace the O-ring with new one and apply the sealant on the sealing surface.

Notice: Be careful not to stain the oil chamber of chain tensioner with the sealant.

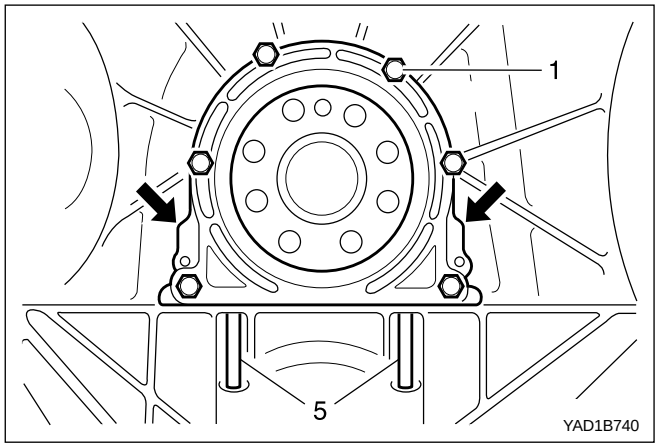
14. Installation should follow the removal precedure in the reverse order.
15. Warm up the engine and check for oil leaks.

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



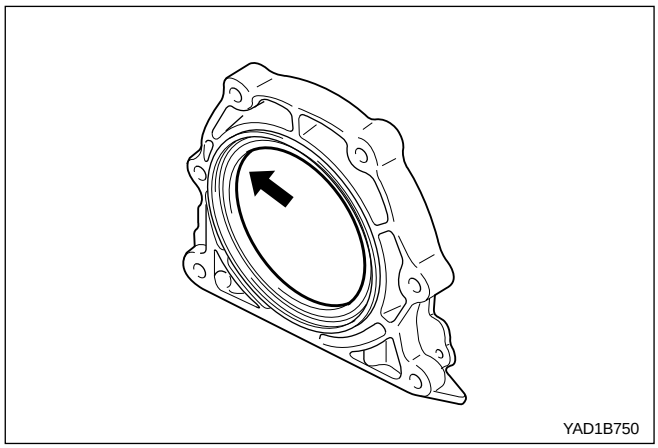
Tools Required

601 589 03 43 00 Crankshaft Rear Seal Installer

Removal & Installation Procedure

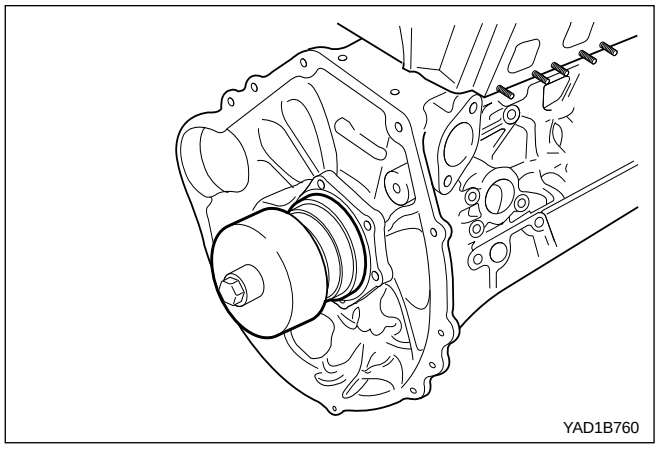
1. Unscrew the bolts (1) and (5) and remove the closing cover by pulling the rear cover lug (arrows).

   Notice: Be careful not to damage the oil pan gasket.

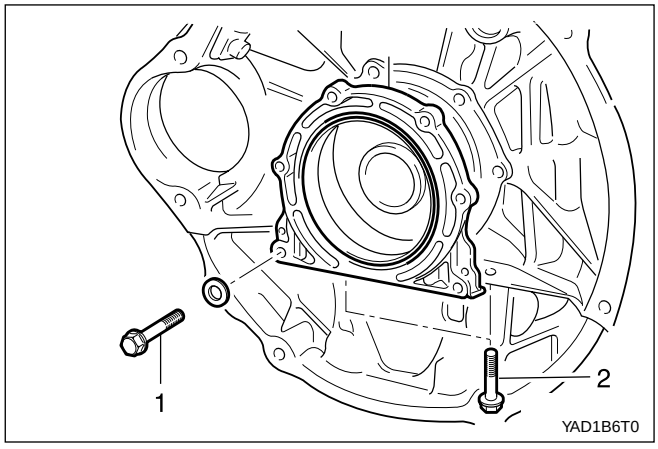


2. Clean the sealing surface of the crankcase and the rear sealing cover.
3. Check the radial shaft seal and replace it if necessary.
4. Apply the Loctite 573 to the rear cover sealing surface.
5. Apply the engine oil to the dust lip of the radial shaft seal.

   Notice: Do not use the grease.



6. Install the crankshaft rear radial seal and the crankshaft sealing rear cover, using crankshaft rear seal installer 601 589 03 43 00.



7. Install the crankshaft sealing rear cover mounting bolts and remove the crankshaft rear seal installer 601 589 03 43 00.

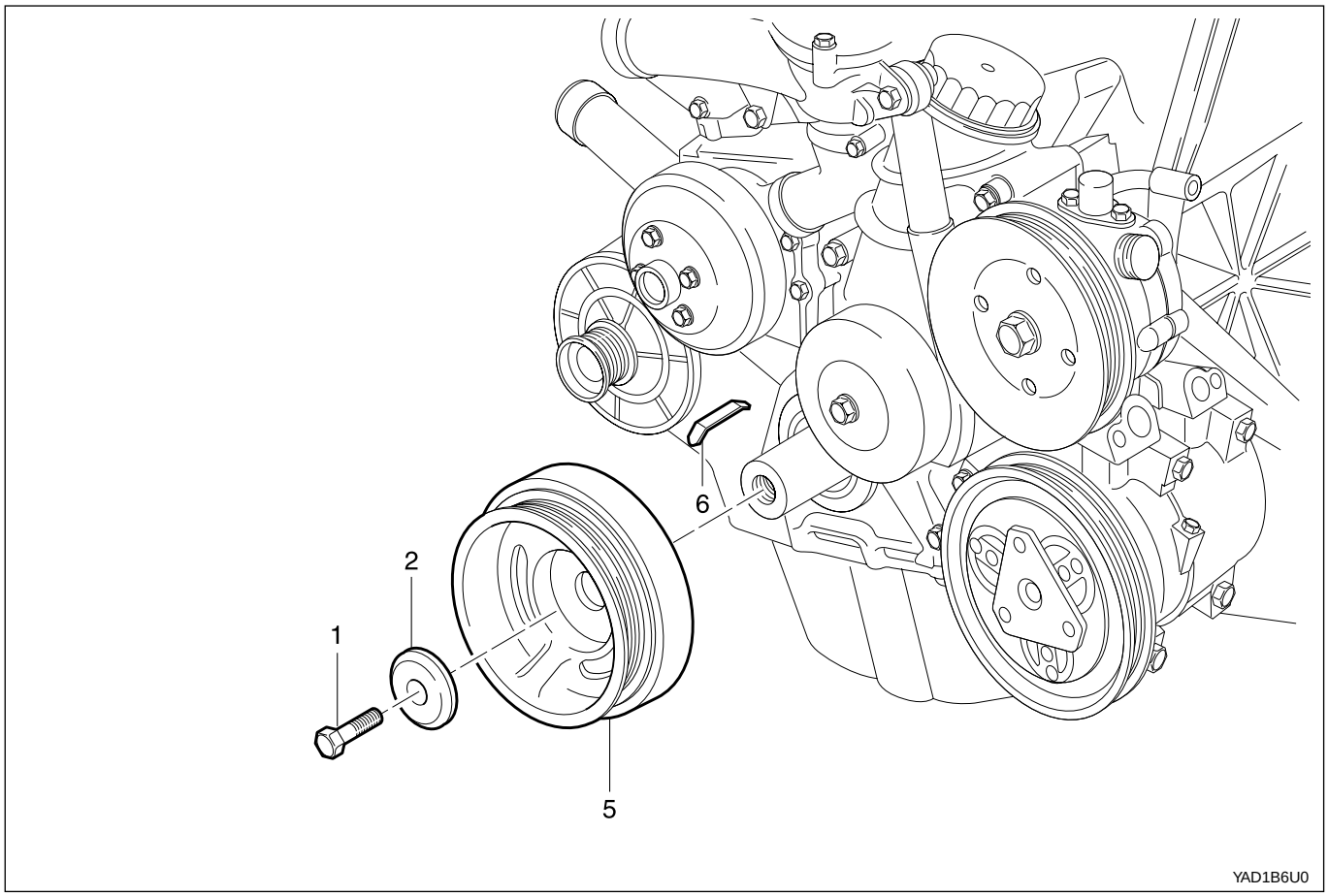
   Installation Notice

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

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

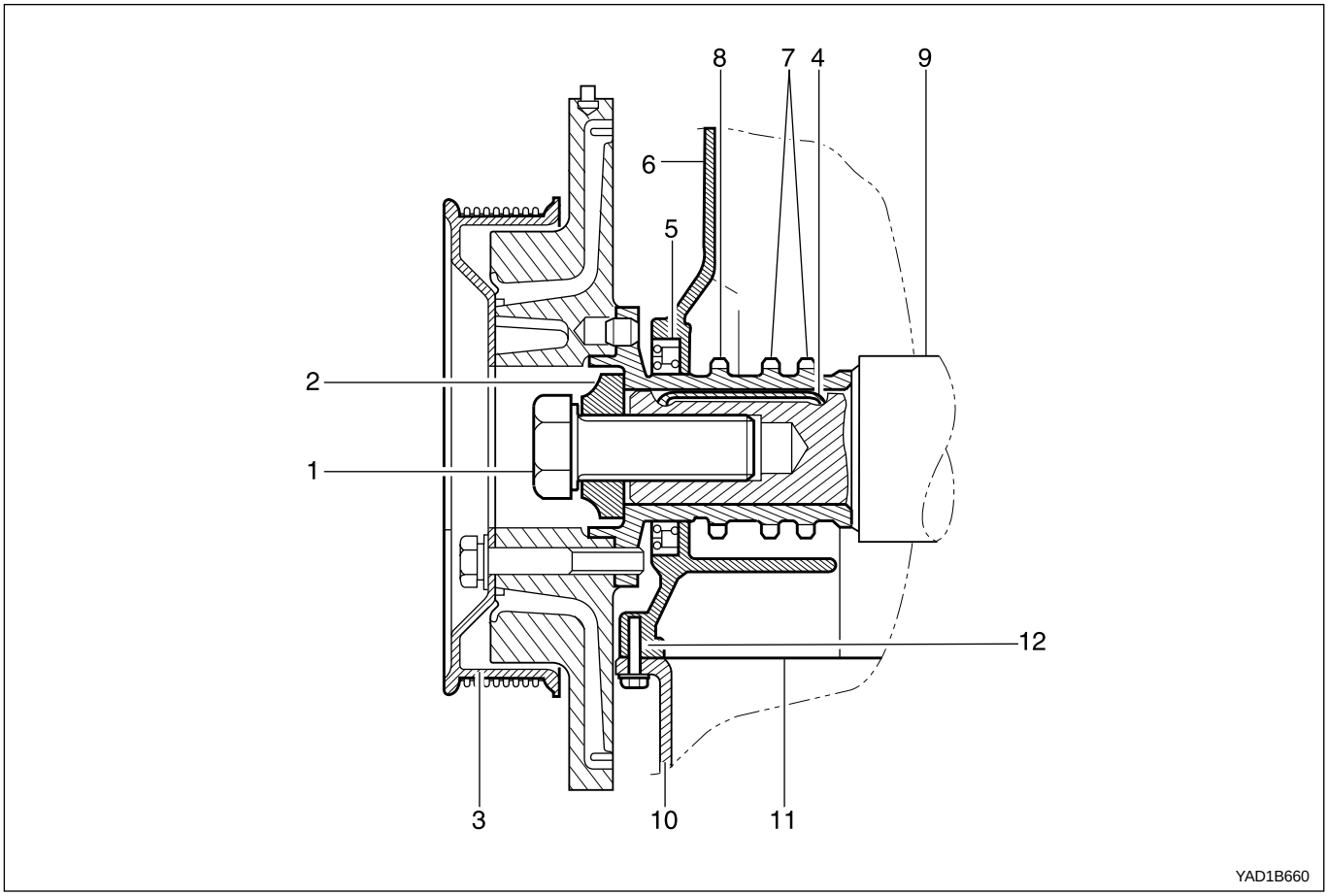
BELT PULLEY AND VIBRATION DAMPER

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



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

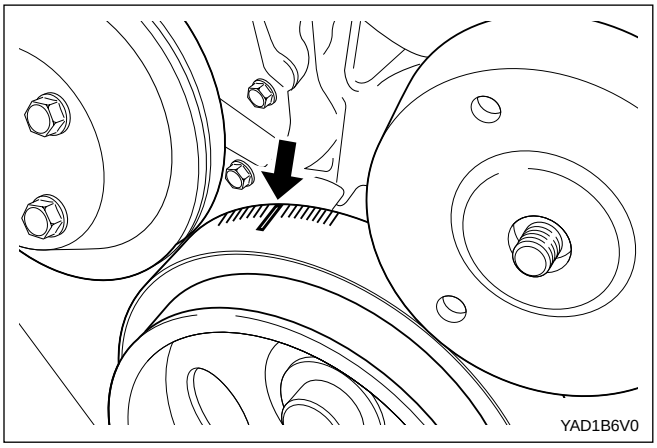
Components



1 Center Bolt (M18 x 50)
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

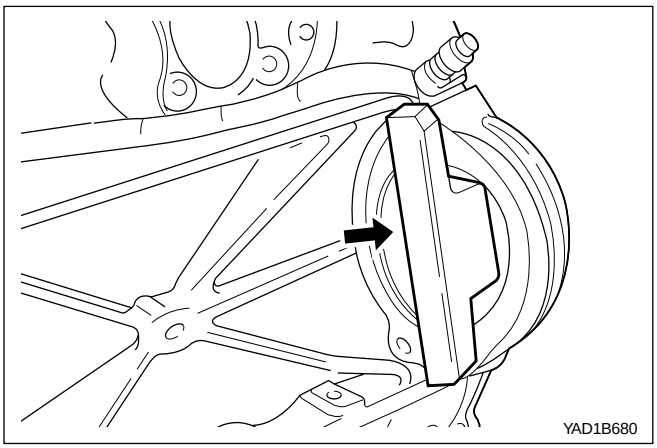


Tools Required

602 589 00 40 00 Engine Lock

Removal & Installation Procedure

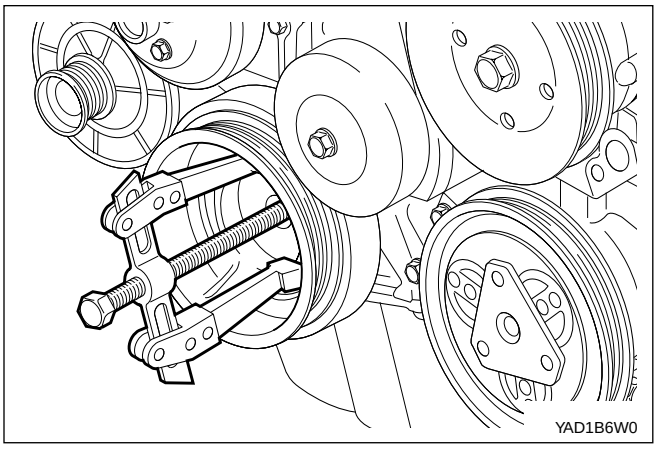
1. Adjust the piston of number 1 cylinder to the TDC.



2. Remove the start motor and install the engine lock 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°

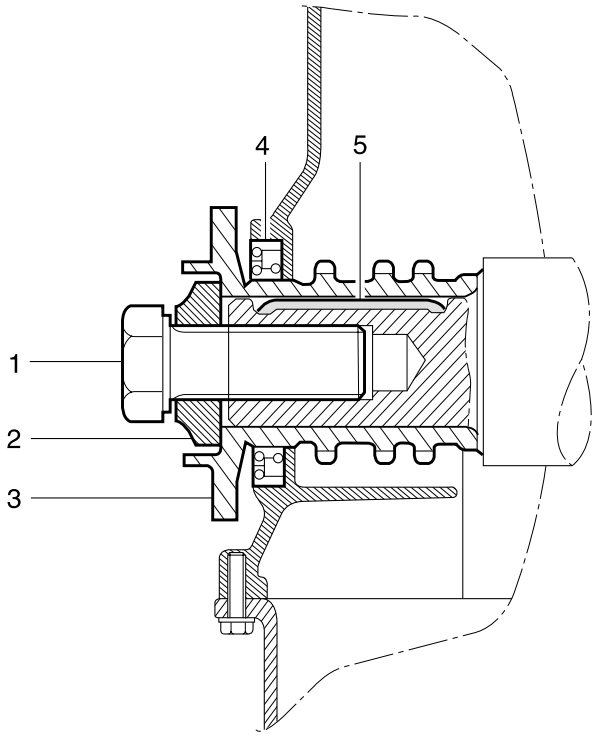


4. Remove the vibration damper assembly using the puller.
5. Installation should follow the removal procedure in the reverse order.

Notice: If possible, don't separate the vibration damper and the pulley.

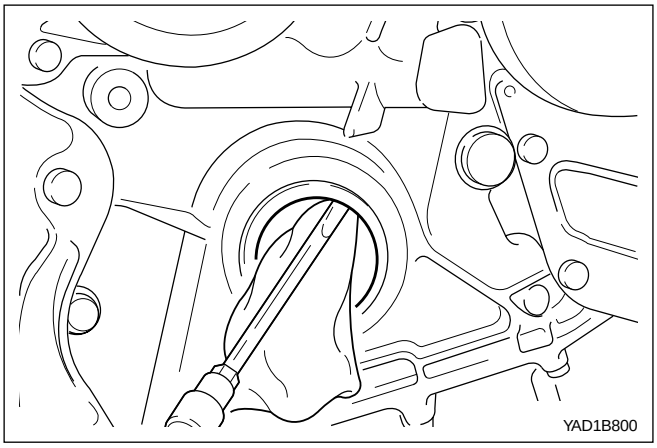
CRANKSHAFT FRONT RADIAL SEAL

Preceding Work: Removal of belt pulley and vibration damper



YAD1B6X0

1 Center Bolt (M18 x 50)
..... 1st step 200 + 20 45 N•m (148 +15 lb-ft)
2nd step 90 ° + 10 °
2 Center Bolt Washer
3 Crankshaft Front Seal Installer
4 Crankshaft Front Seal
5 Key



Tools Required

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 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.

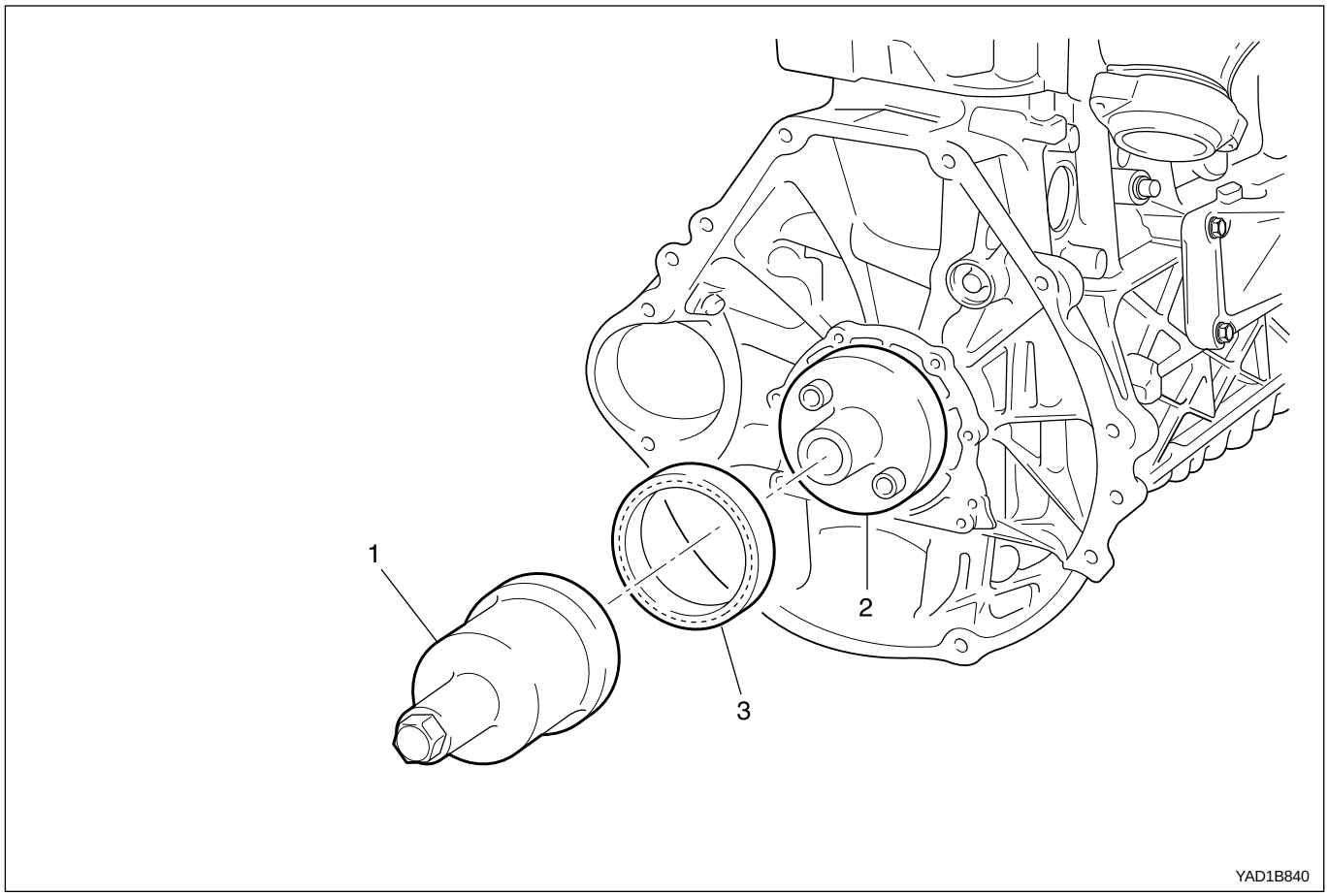
   Installation Notice

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

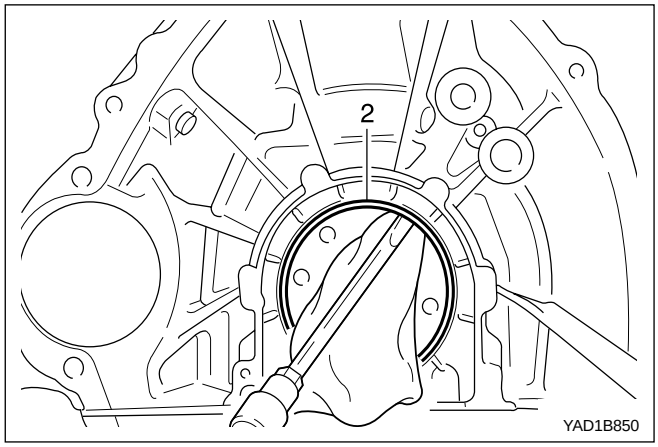
5. Remove the crankshaft front seal installer 601 589 03 14 00, and install the belt pulley and the vibration damper.
6. Check for leaks while operating the engine.

CRANKSHAFT REAR RADIAL SEAL

Preceding Work: Removal of flywheel or drive plate



1 Special Tool
2 Special Tool
3 Crankshaft Rear Seal



Tools Required

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.

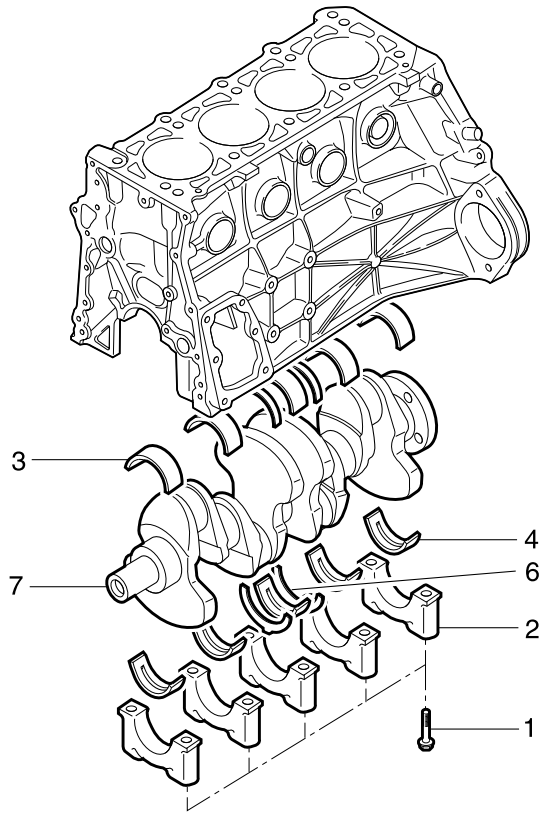
2. Install the special tool (2) to the crankshaft.
3. Apply the engine oil on the special tool (2).

   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

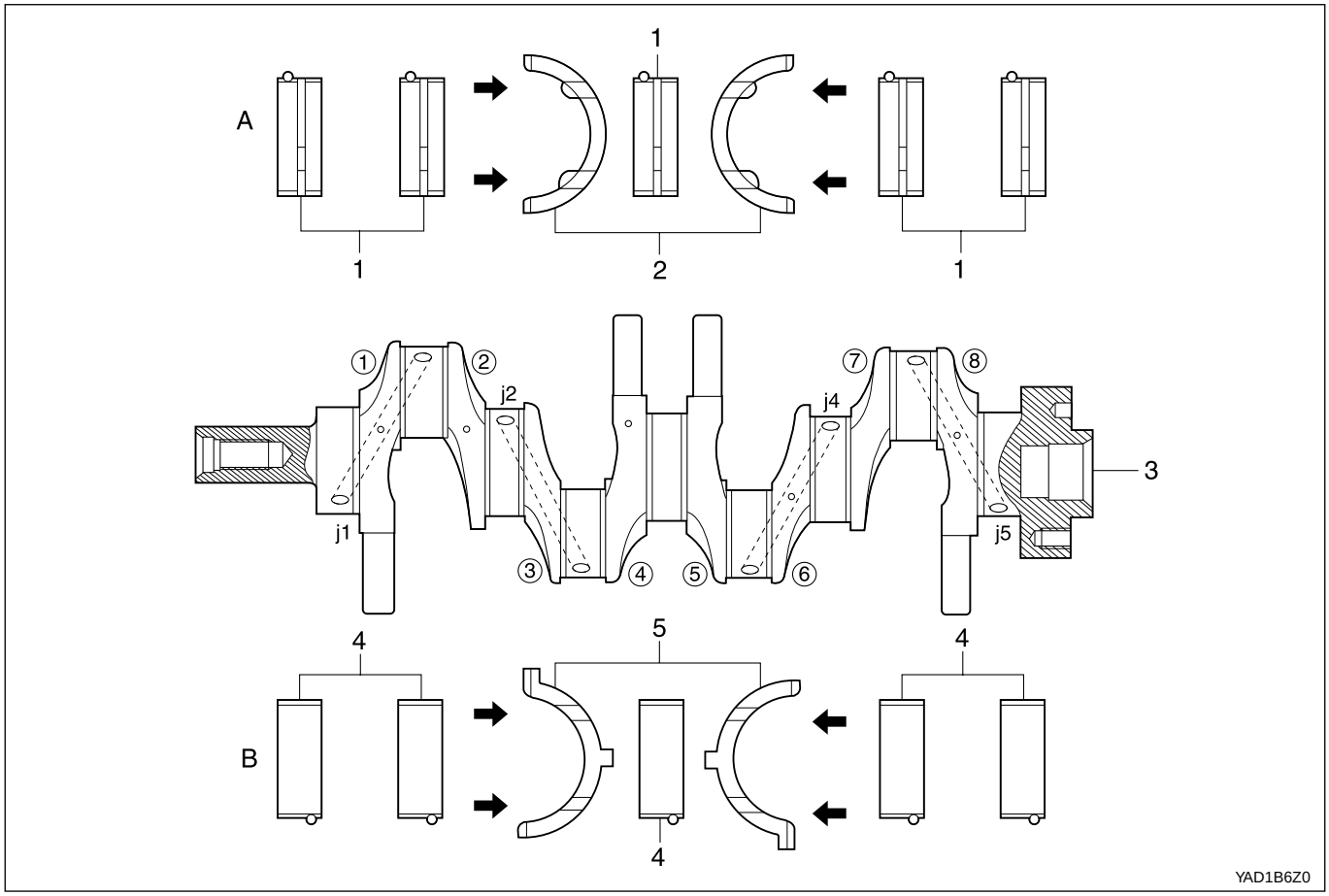
Preceding Work: Removal of engine
Removal of cylinder head
Removal of timing gear case cover
Removal of crankcase sealing rear cover
Removal of oil pan
Removal of baffle plate
Removal of oil pump



YAD1B6Y0

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
8 Crankshaft.

Arrangement of the Thrust Bearing and the Main Bearing



YAD1B6Z0

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)

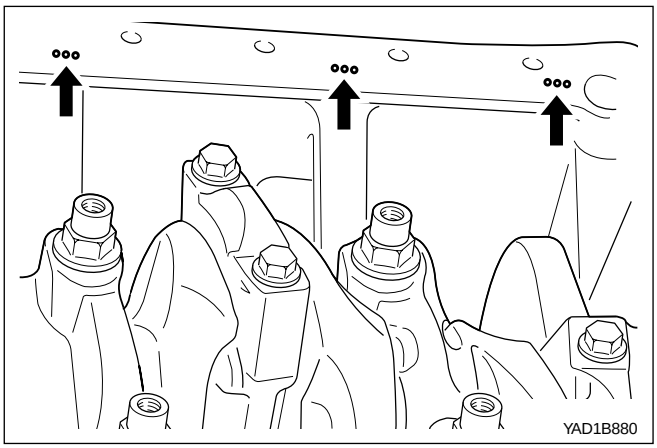
(1) - (8) Weight Balance/Color Marking Point

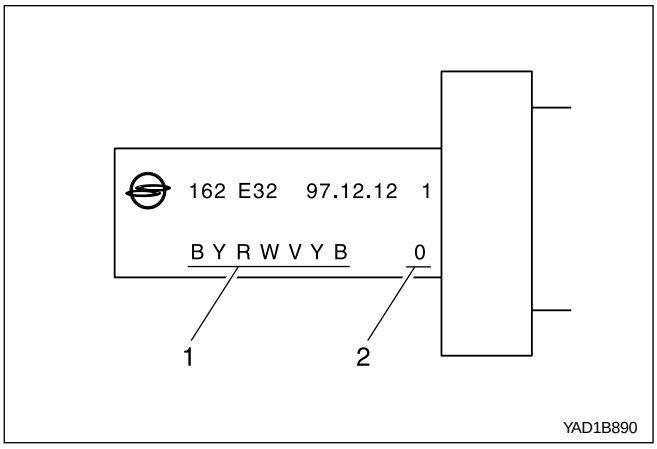
j1 - j5 Journal Main Bearing #1 - #5

- 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

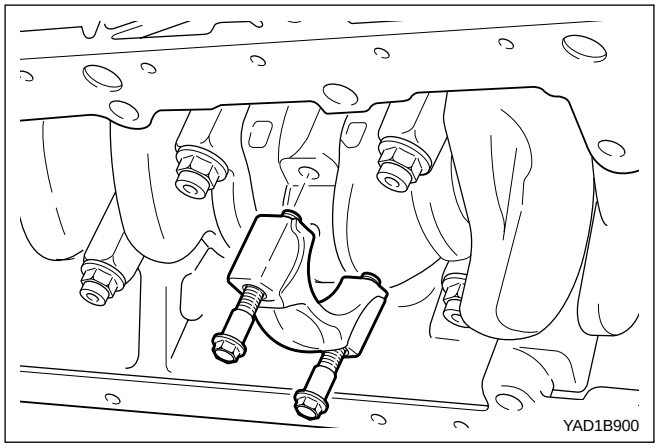
2. Crankshaft Bearing Cap Side

   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	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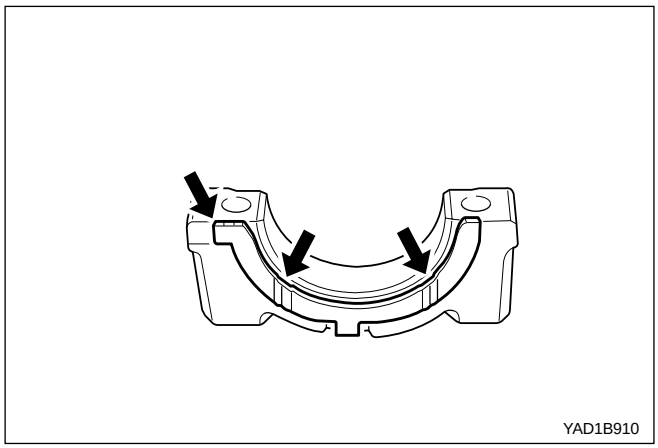

YAD1B910

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

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°

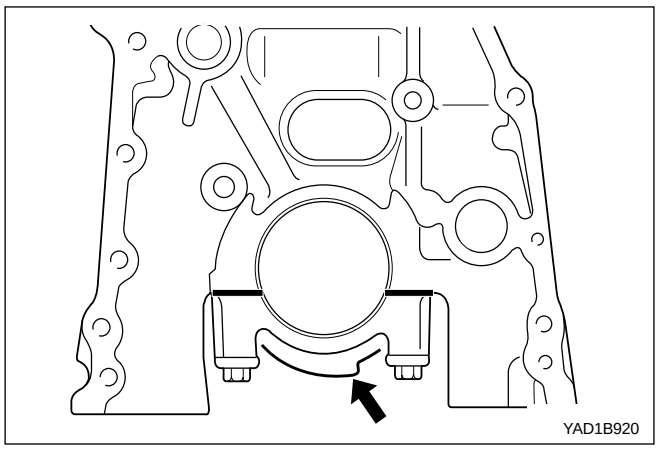
   - Make sure that the upper and lower bearing shells do not change each other.
   - Coat the bearing shell with engine oil.
   - Install the bearing cap according to the consecutive number.

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

   Installation Notice

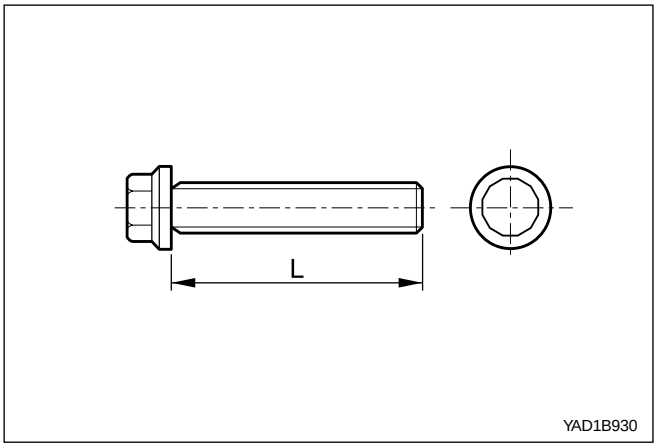
Tightening Torque	55 N•m (41 lb-ft)+ 90°

   - 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 thickness. Select the proper washer when repaired.
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.


YAD1B920

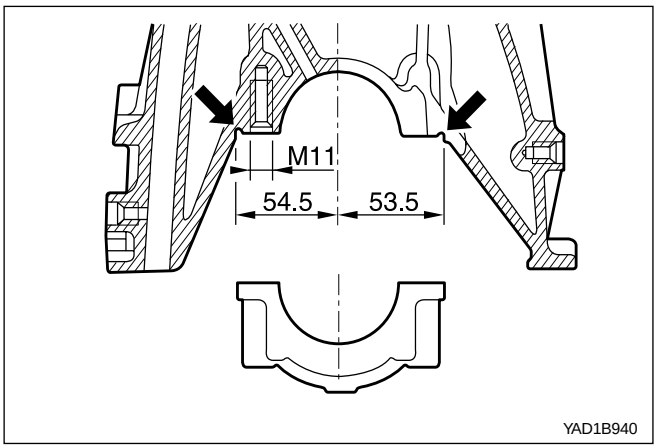
Notice:

- 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.

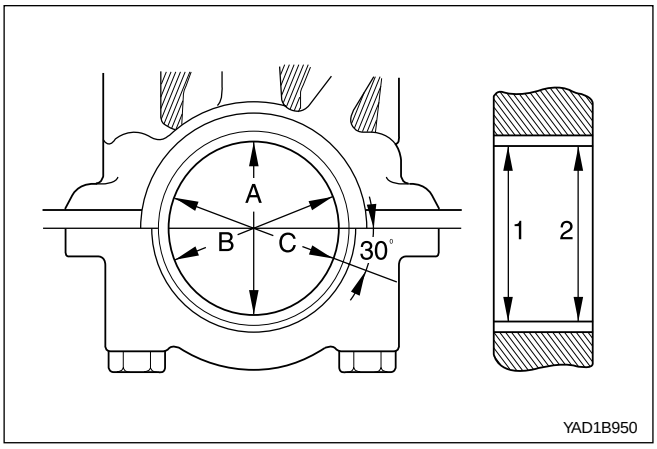


Inspection

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



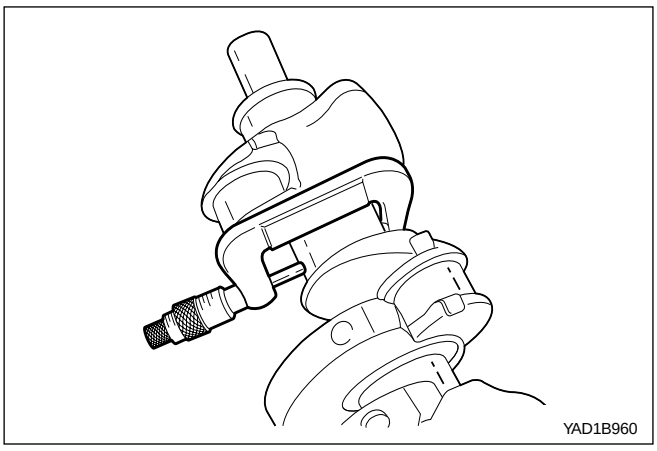
2. Make sure the crankshaft bearing cap is properly seated on the cylinder block (arrows).



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.

Service Data Standard (Crankshaft Main Bearing Gap)

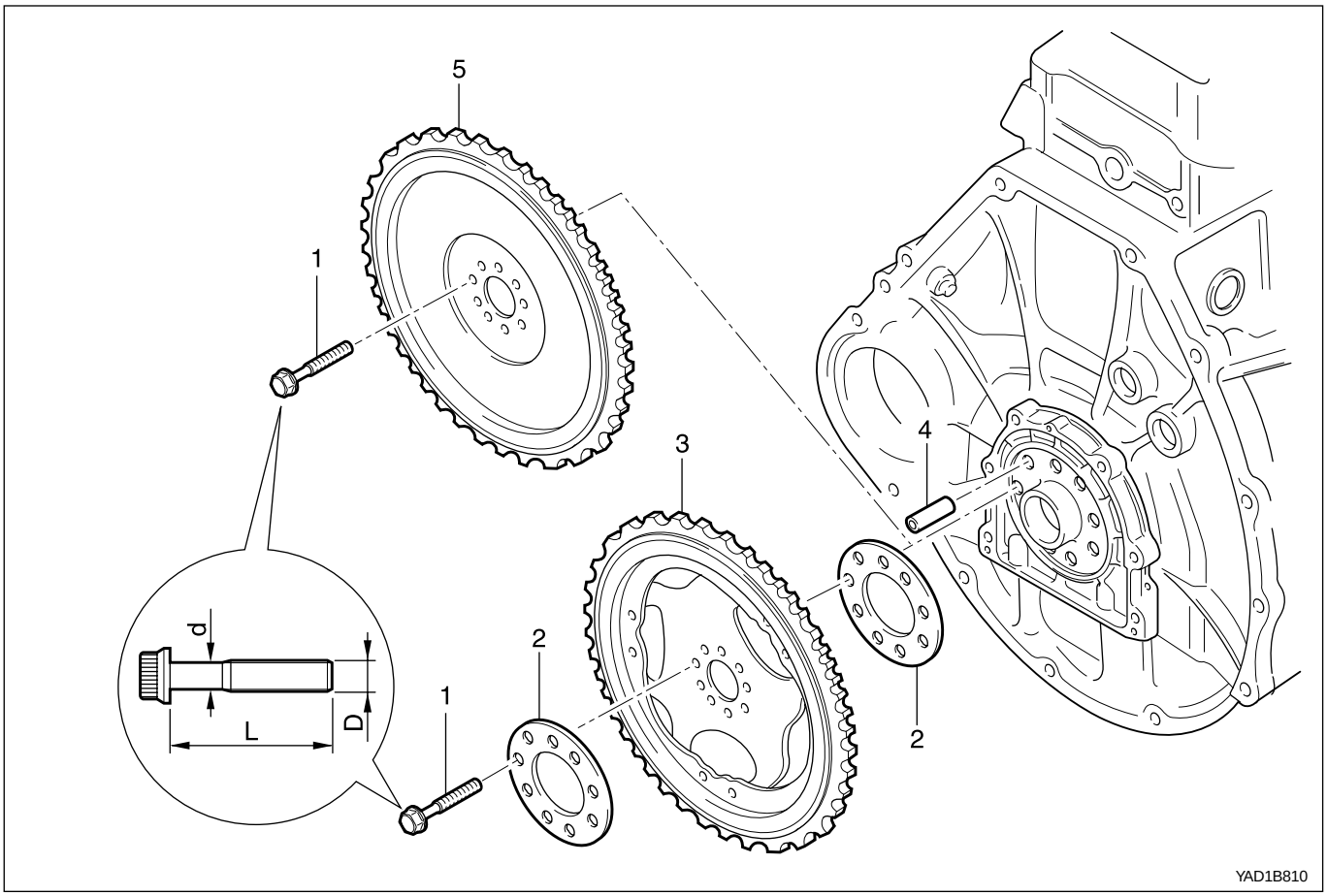
Item	Measuring Position	Gap (mm)
Main Bearing Journal (NO.1,5,7)	Radial	Static condition : 0.015 - 0.039 Dynamic condition : 0.031 - 0.051 (Consider the expansion 0.011 - 0.016)
	Axial	0.010 - 0254

(Connecting Rod Bearing Gap)

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

FLYWHEEL / DRIVEN 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 Driven Plate (A/T)
4 Dowel Pin
5 Flywheel (M/T)

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.

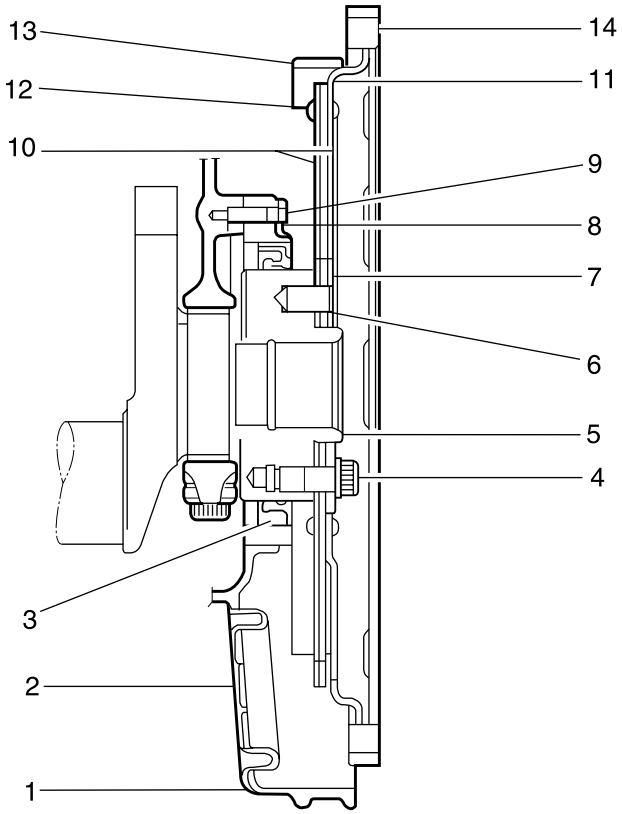
   Installation Notice

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.

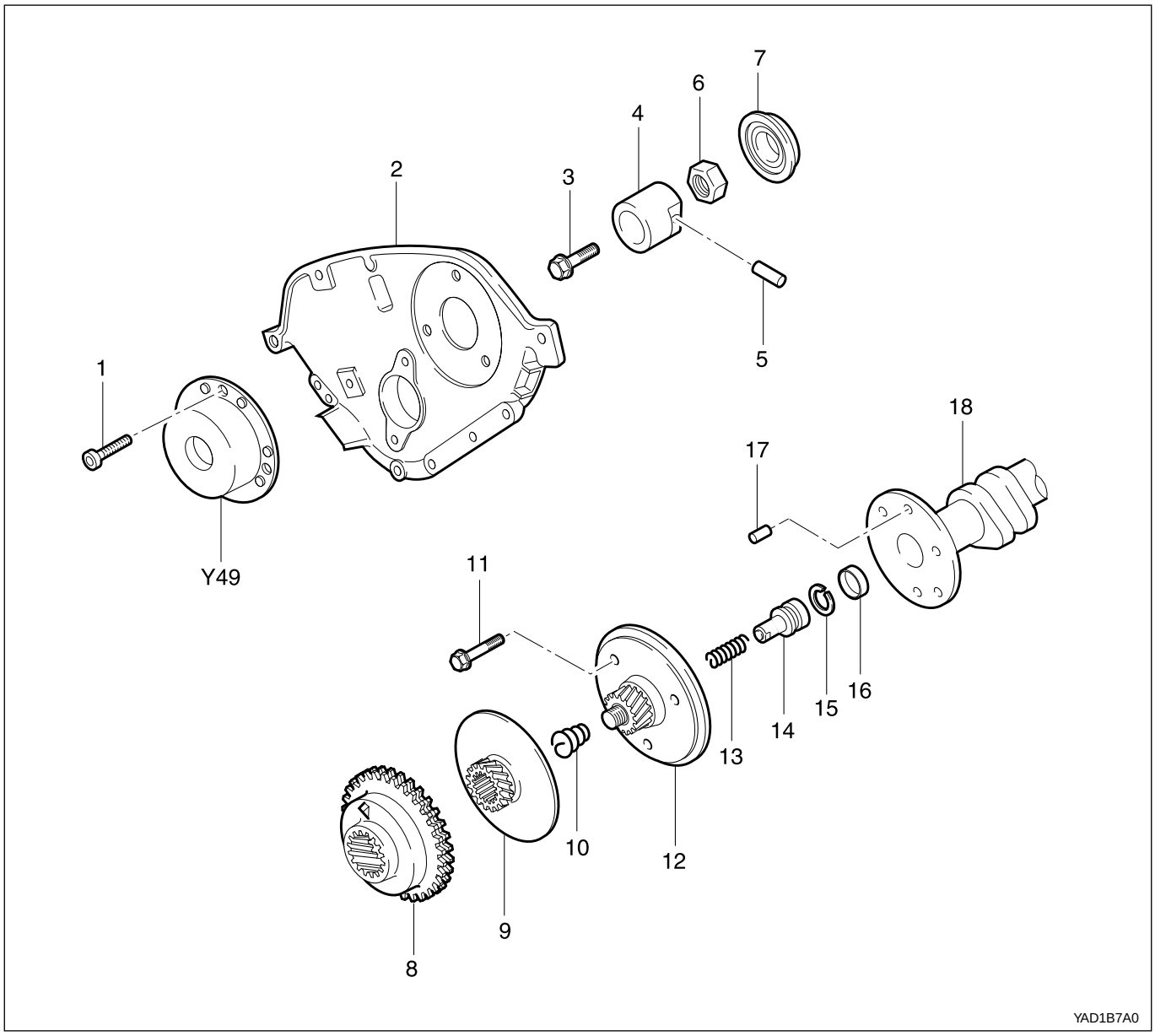
2. Remove the flywheel for manual transmission vehicles, or the driven plate (3), and plate (2) for Auto transmission vehicle.
3. Installation should follow the removal procedure in the reverse order.

Sectional View

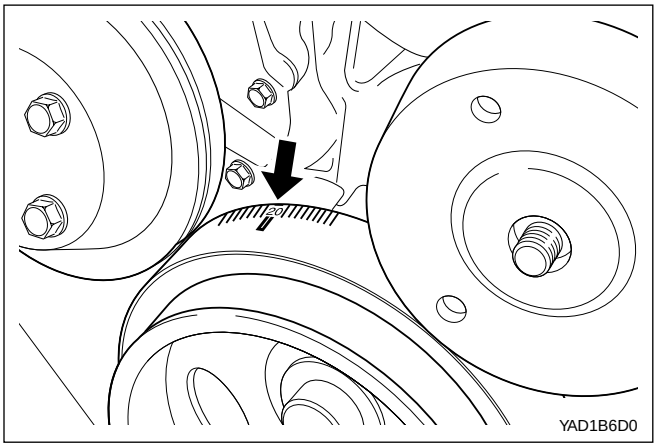


1 OilPan
2 Cover
3 Radial Seal
4 Bolt
5 Crankshaft
6 Dowel Pin
7 Washer (Thickness : 3.5 mm)
8 Washer
9 Bolt
10 Front Drive Plate
11 Rear Drive Plate
12 Rivet
13 Segment
14 Ring Gear

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)

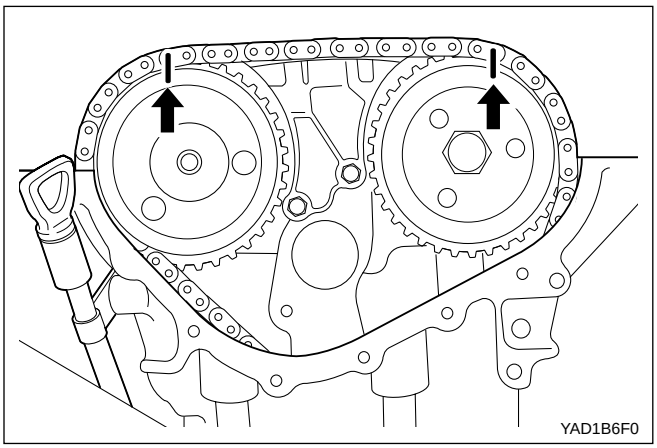


Removal & Installation Procedure

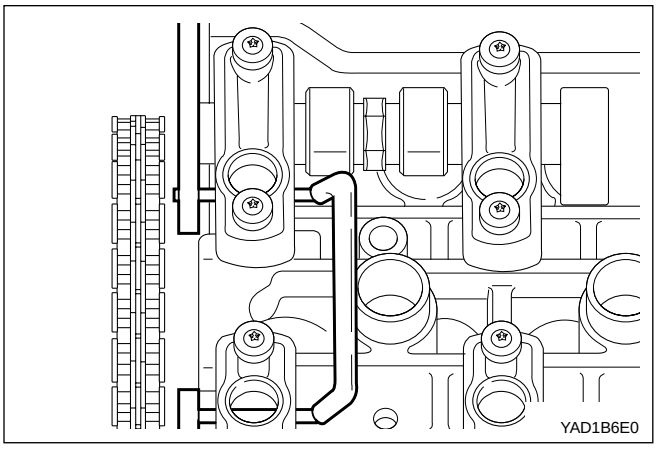
1. Turn the crankshaft and position the no.1 cylinder piston at ATDC 20 ° .

   Notice: Turn the crankshaft in the direction of engine rotation.

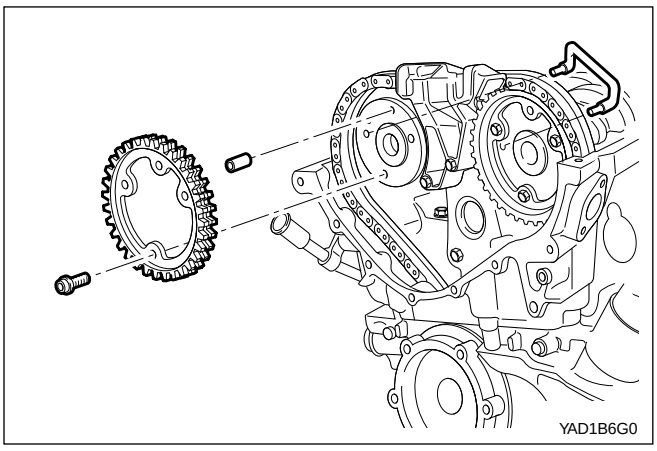
2. Remove the cylinder head front cover.



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



4. Insert the holding pin 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.

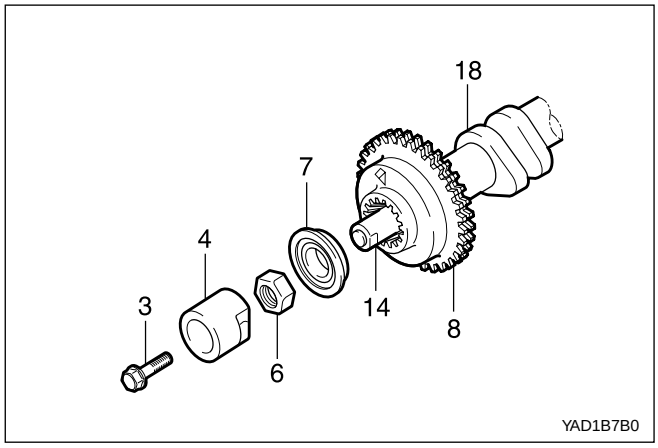


6. Unscrew the exhaust sprocket bolt and remove the exhaust camshaft sprocket.

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)

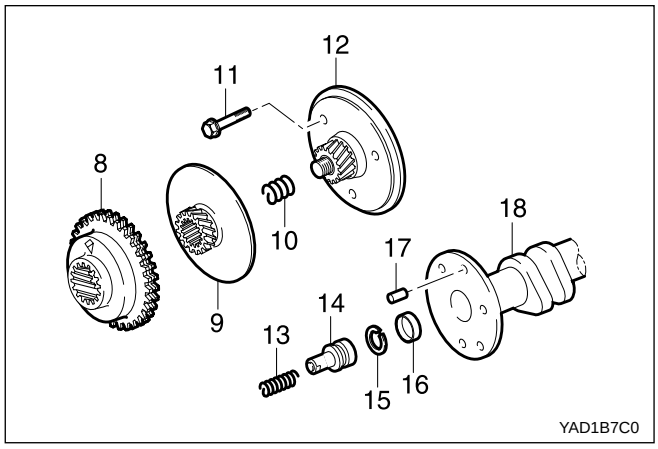
8. Unscrew the nut (6) and remove the seal cover (7).

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.



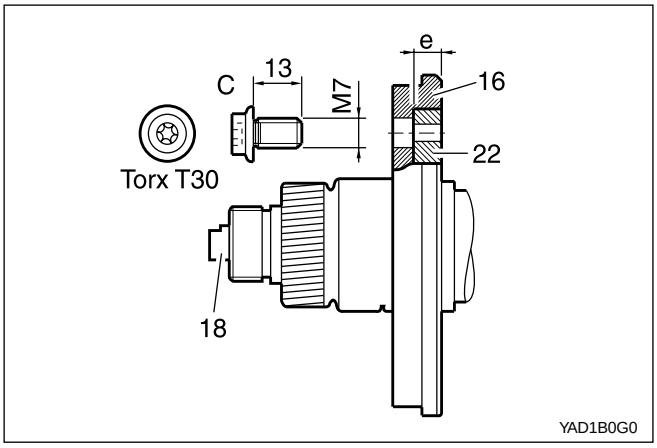
10. Remove the adjuster piston (9) and conical spring (10) from intake camshaft sprocket.
11. Unscrew the bolt (11) and remove the flange shaft.

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.



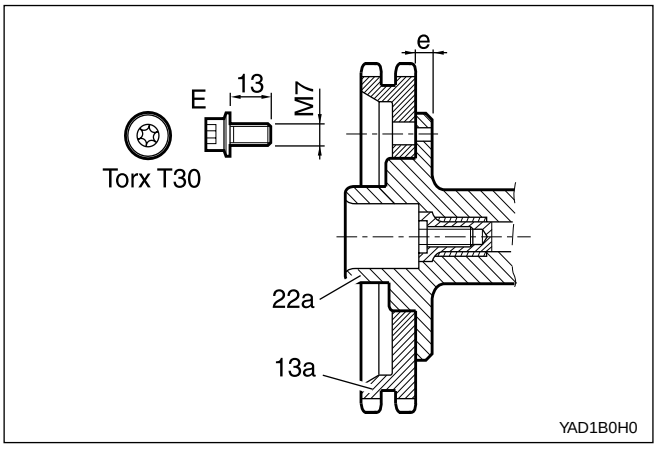
CAMSHAFT SPROCKET BOLT

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

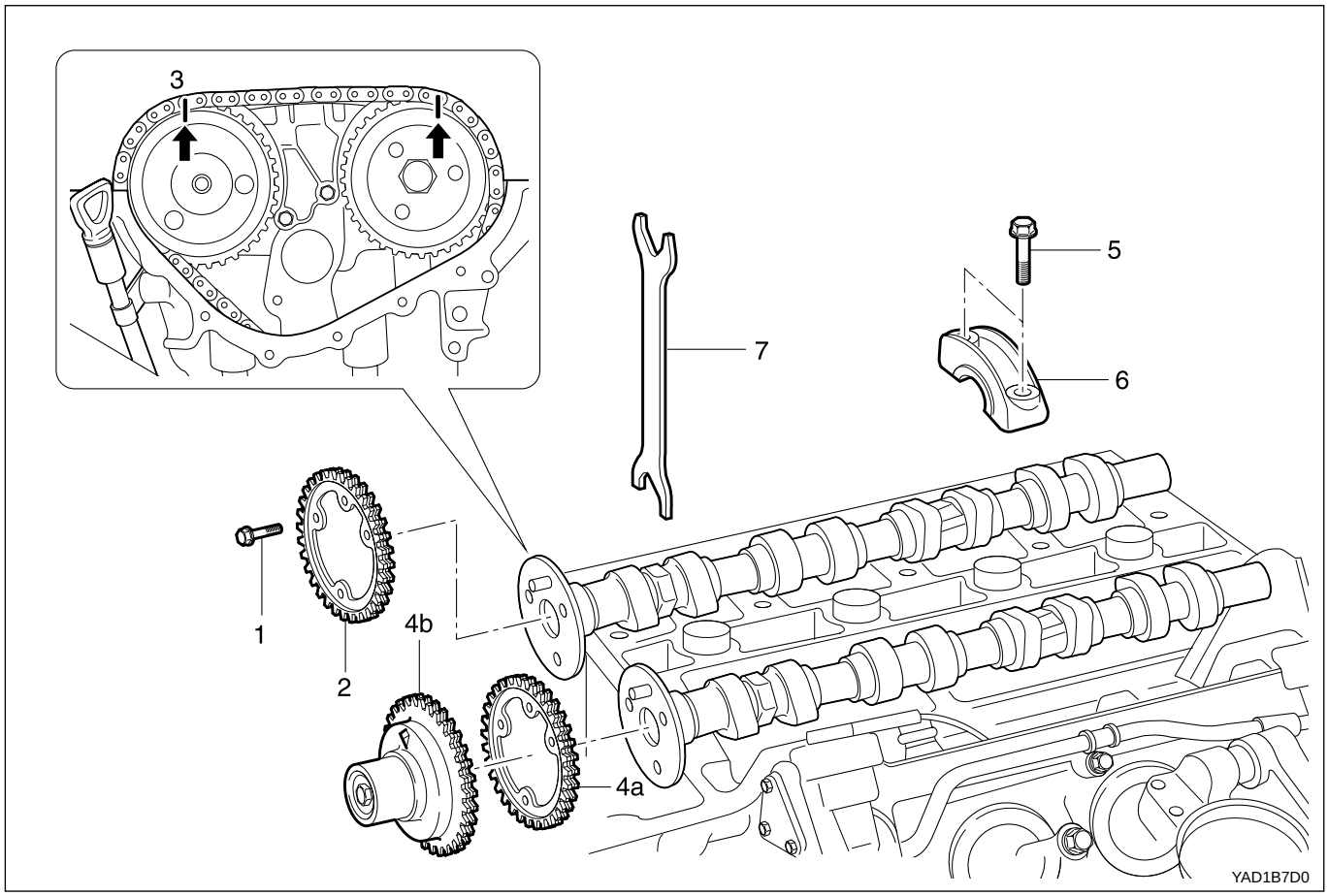
Tightening Torque	1st step: 18 - 22 N•m (13 - 16 lb-ft)
	2nd step: 60° ± 5°

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

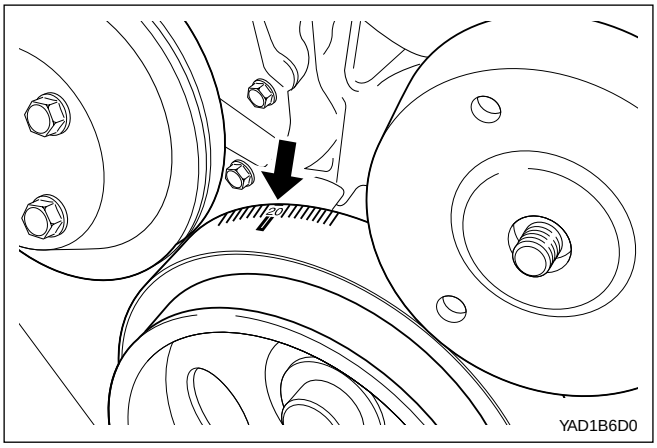
E. M7 x 13 Collar Bolt Torx-T30
e. 6.8 mm
13a. Camshaft Sprocket
22a. Exhaust Camshaft

CAMSHAFT

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

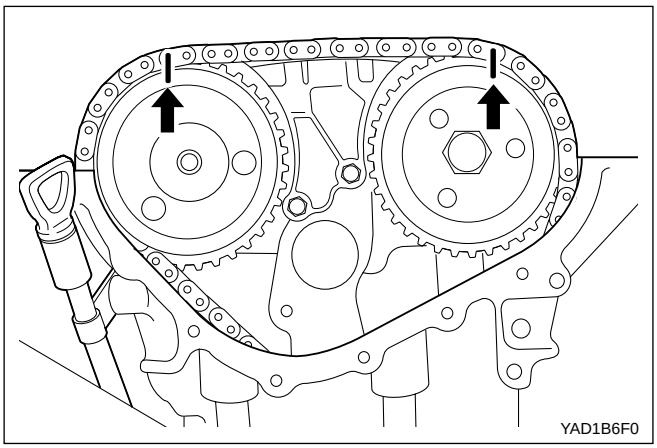


1 Bolt (M7 X 13, 3 pieces)
..... 1st Step 18 - 22 NSm (13 - 16 lb-ft)
2nd Step 60 ° ± 5 ° Rotation Added
2 Exhaust Camshaft Sprocket
3 Timing Chain
4a Intake Camshaft Spocket (E20)
4b Camshaft Adjuster and Camshaft Sprocket (E23)
5 Bearing Cap Bolt (20 pieces)
..... 22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)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



Removal & Installation Procedure

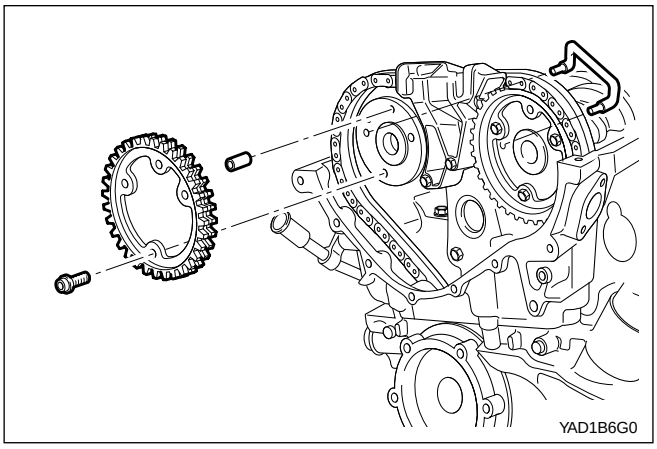
1. Turn the crankshaft and position the no.1 cylinder piston at ATDC 20 ° .



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)



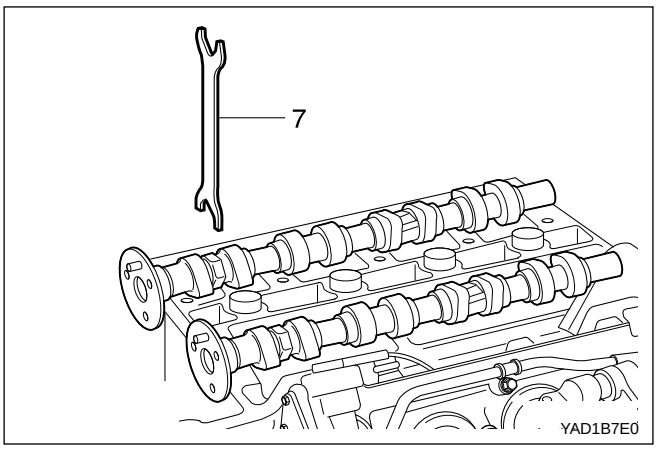
4. Remove the exhaust camshaft sprocket.

Installation Notice

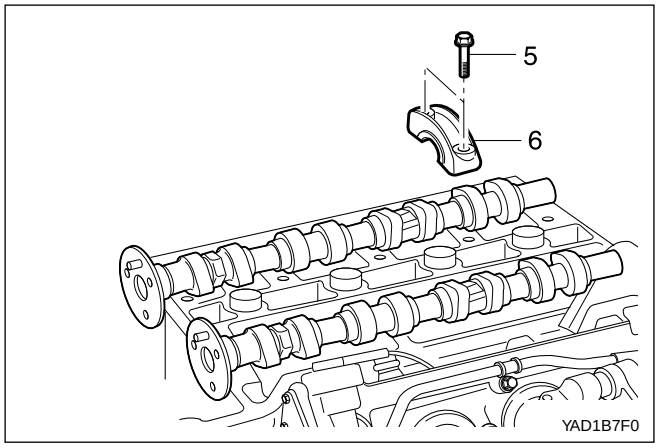
Tightening Torque	1st step: 18 - 22 N•m (13 - 16 lb-ft)
	2nd step: 60° ± 5°

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

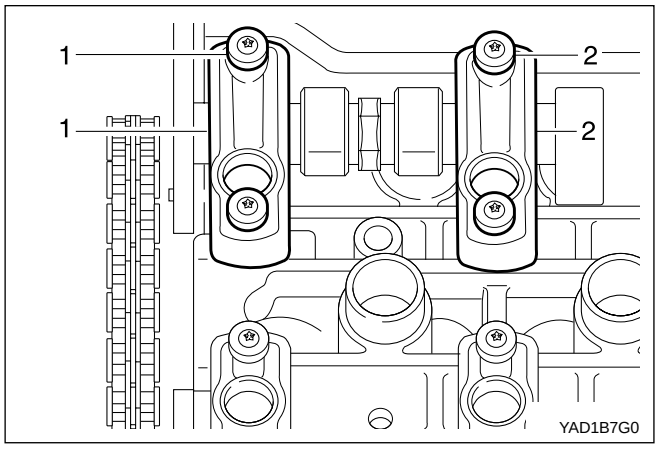
Tightening Torque	60 - 70 N•m (44 - 52 lb-ft)

   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:

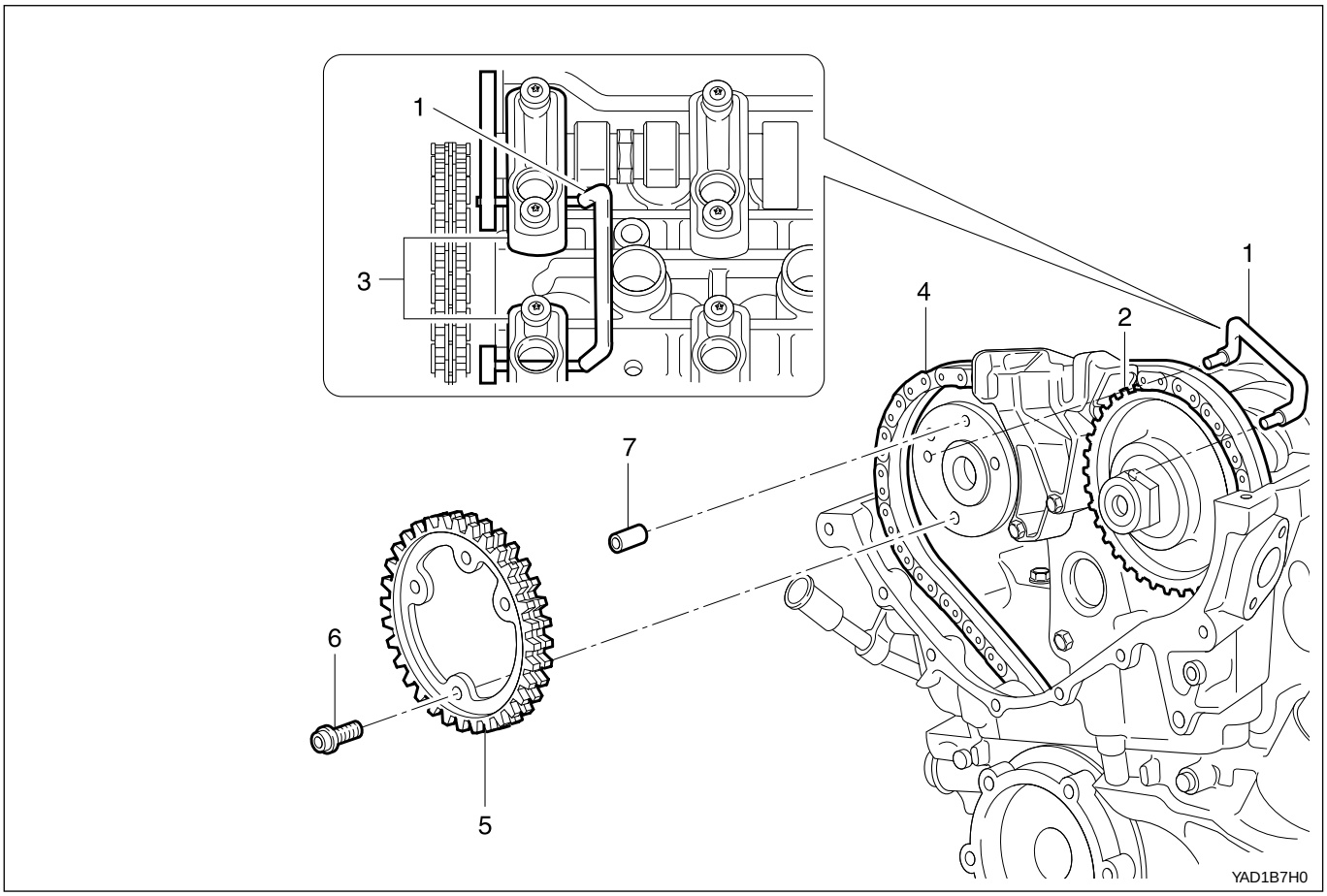
   - Base circle of cam should cantact with the valve tappet.
   - Install the camshaft bearing caps according to the numbers on the cylinder head cast and bearing cap.



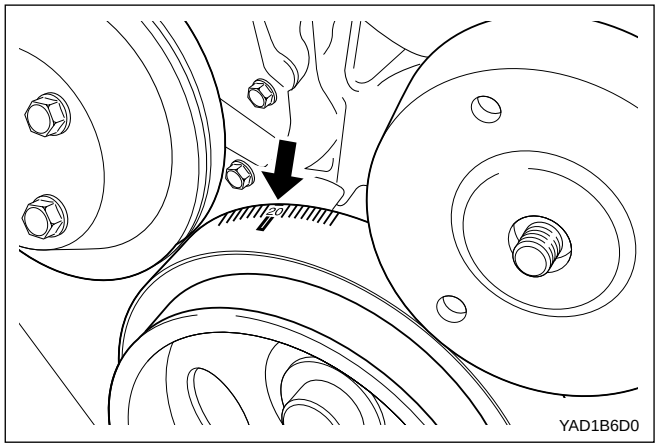
10. Check the camshaft timing position.

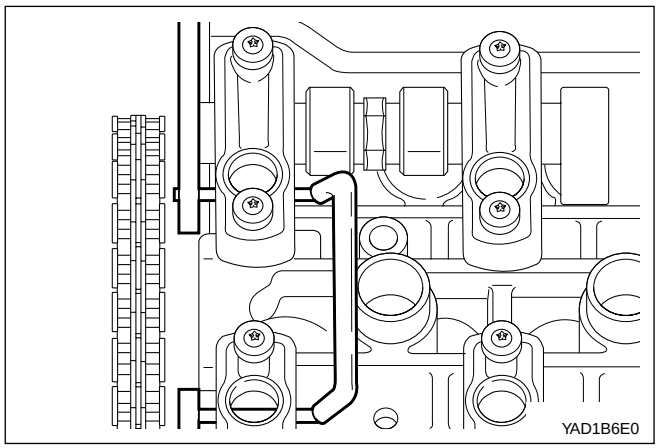
CAMSHAFT TIMING POSITION

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



1 Holding Pin 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)
..... 1ststep 18 - 22 NSm (13 - 16 lb-ft)
2nd step 60 ° ± 5 ° rotation added
7 StratePin





Tools Required

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 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 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.

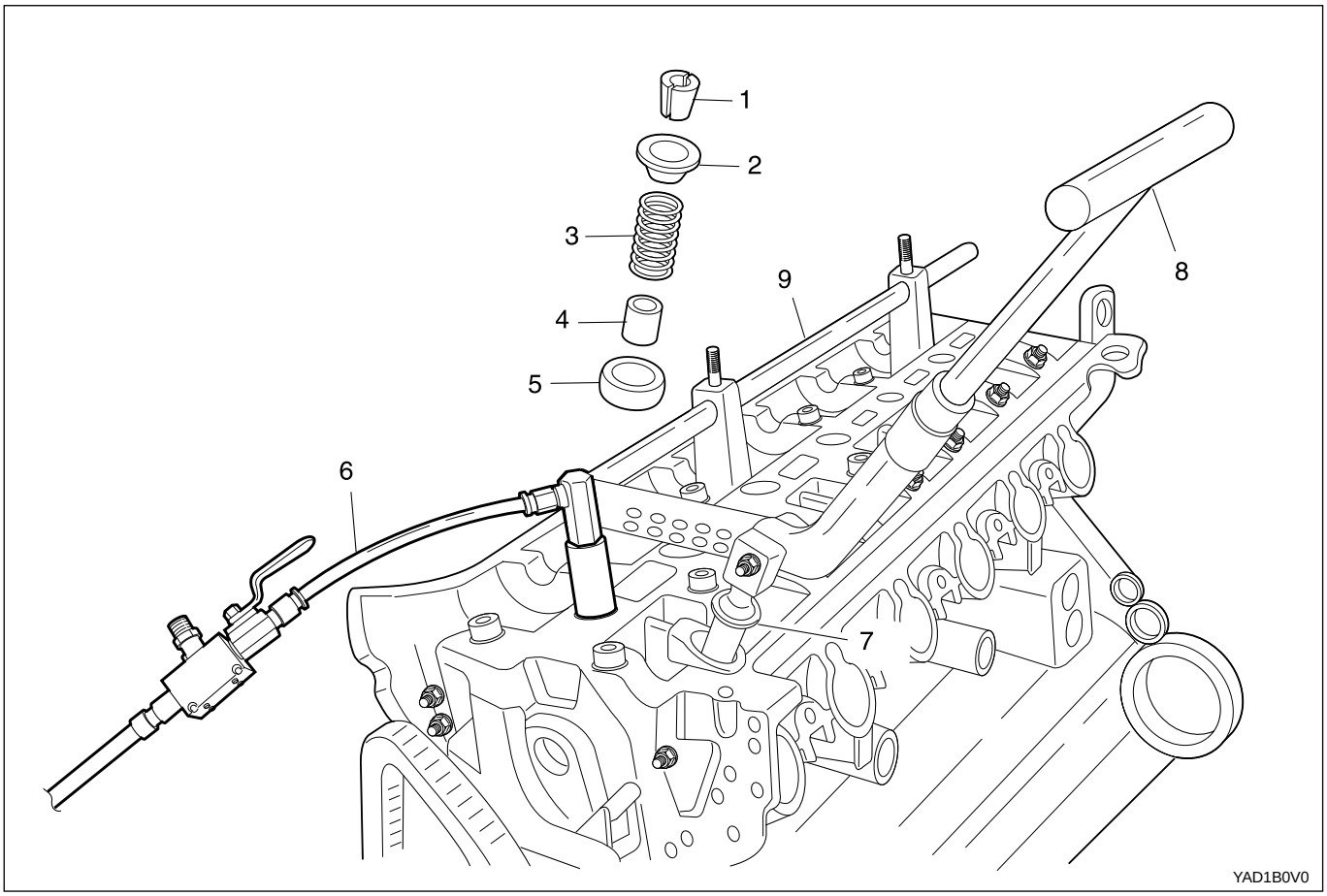
   Installation Notice

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.

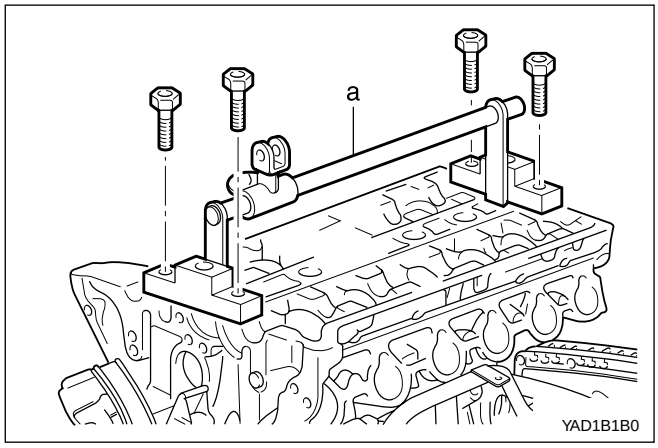
VALVE SPRING

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

a Lever Pusher 111 589 18 61 00
b Thrust Piece 111 589 25 63 00
c Connecting Hose DW 110 - 090
d Supporting Bar 111 589 01 59 00



Tools Required

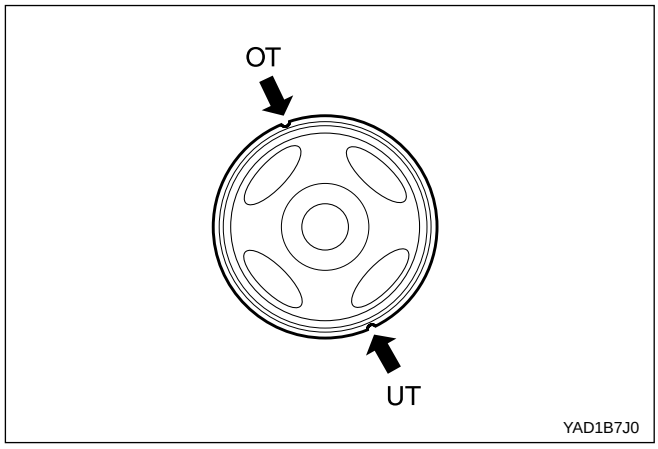
111 589 01 59 00	Supporting Bar
111 589 18 61 00	Lever Pusher
111 589 25 63 00	Thrust Piece
602 589 00 40 00	Engine Lock
DW110 - 090	Connecting Hose
DW110 - 100	Valve Tappet Remover

Removal & Installation Procedure

1. Place the supporting bar 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)

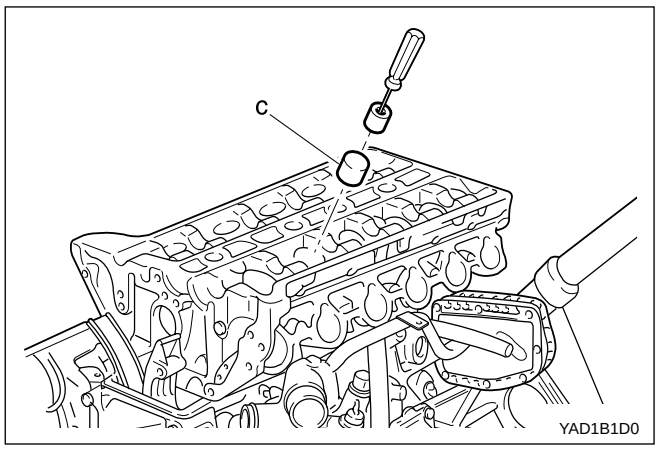


2. Turn the crankshaft to position the each cylinder piston at TDC.

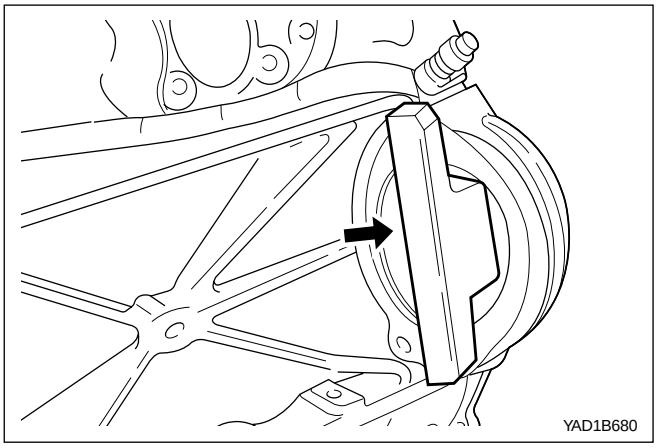
Tightening Torque	1st step: 18 - 22 N•m (13 - 16 lb-ft)
	2nd step: 90° ± 5°

Notice:

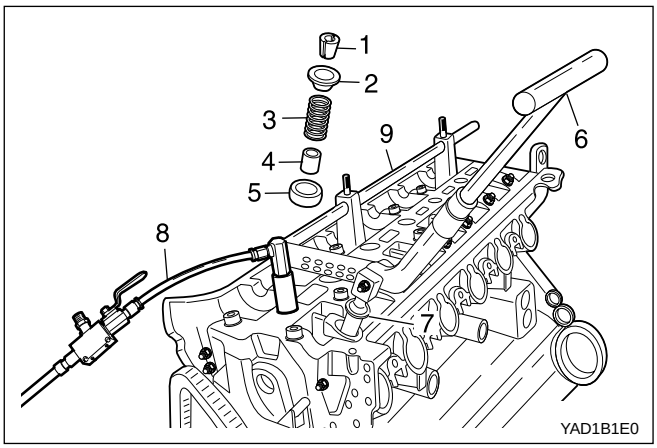
- Remove the valve spring only at TDC.
- Always rotate the crankshaft by holding the chain to prevent from timing chain damage and tangling, and for smooth rotation.



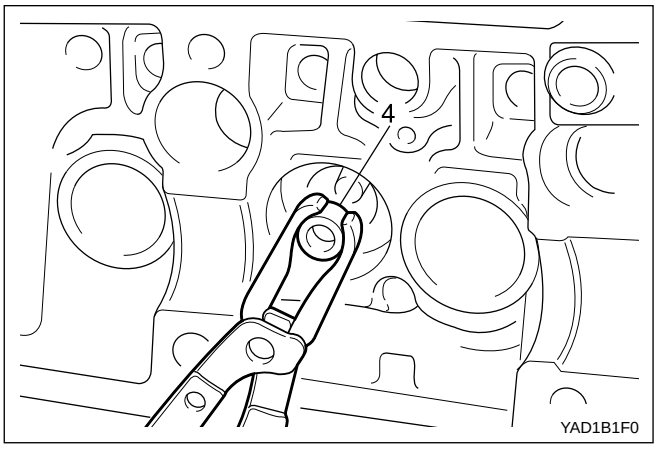
3. Remove the valve tappet using the valve tappet remover DW110 - 100.
4. Install the connecting hose DW110 - 090 (c) to the spark plug hole.



5. Install the engine lock 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 111 589 01 59 00 (d) and the lever pusher 111 589 18 61 00 (a).
8. Mount the thrust piece 111 589 25 63 00 (b) vertically to the valve spring retainer (2).
9. Press the valve spring (3) by using the lever pusher 111589 18 61 00 (a).
10. Remove the valve cotter (1) using the pincette.
11. Remove the upper retainer (2) and the valve spring (3).



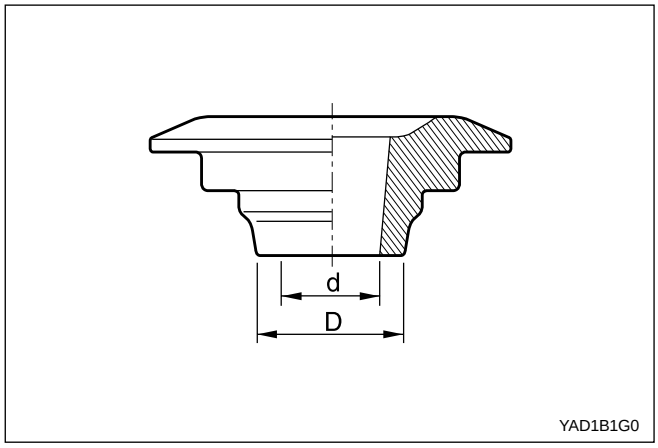
12. Remove the valve stem seal (4) and replace if necessary.

    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.

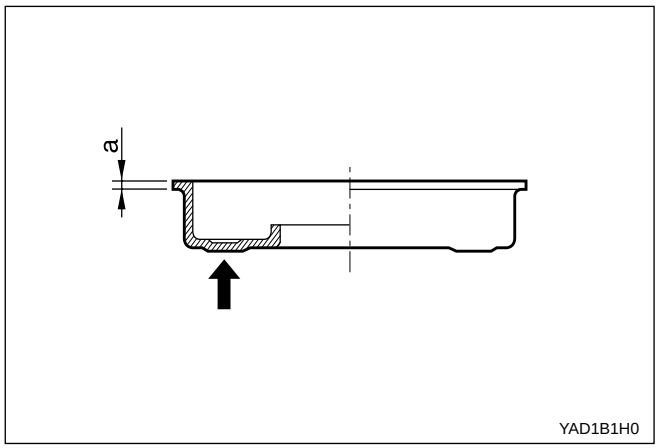
14. Installation should follow the removal procedure in the reverse order.



Test (Upper and Lower Valve Tappet and Valve Cotter)

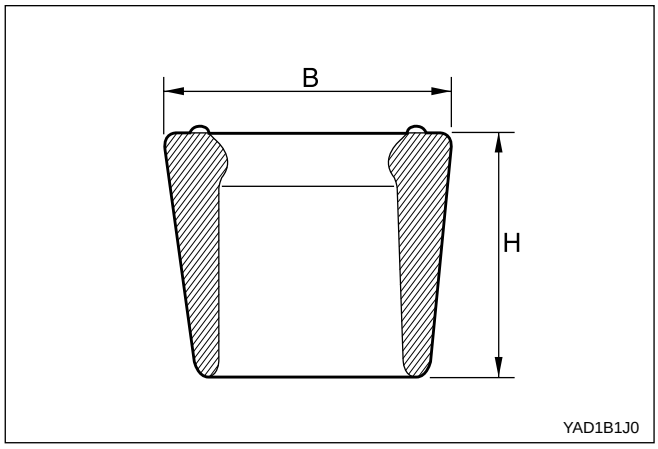
- Upper Valve Spring Retainer

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



- Lower Valve Spring Retainer

Size (mm)	(a)	0.8 - 1.0

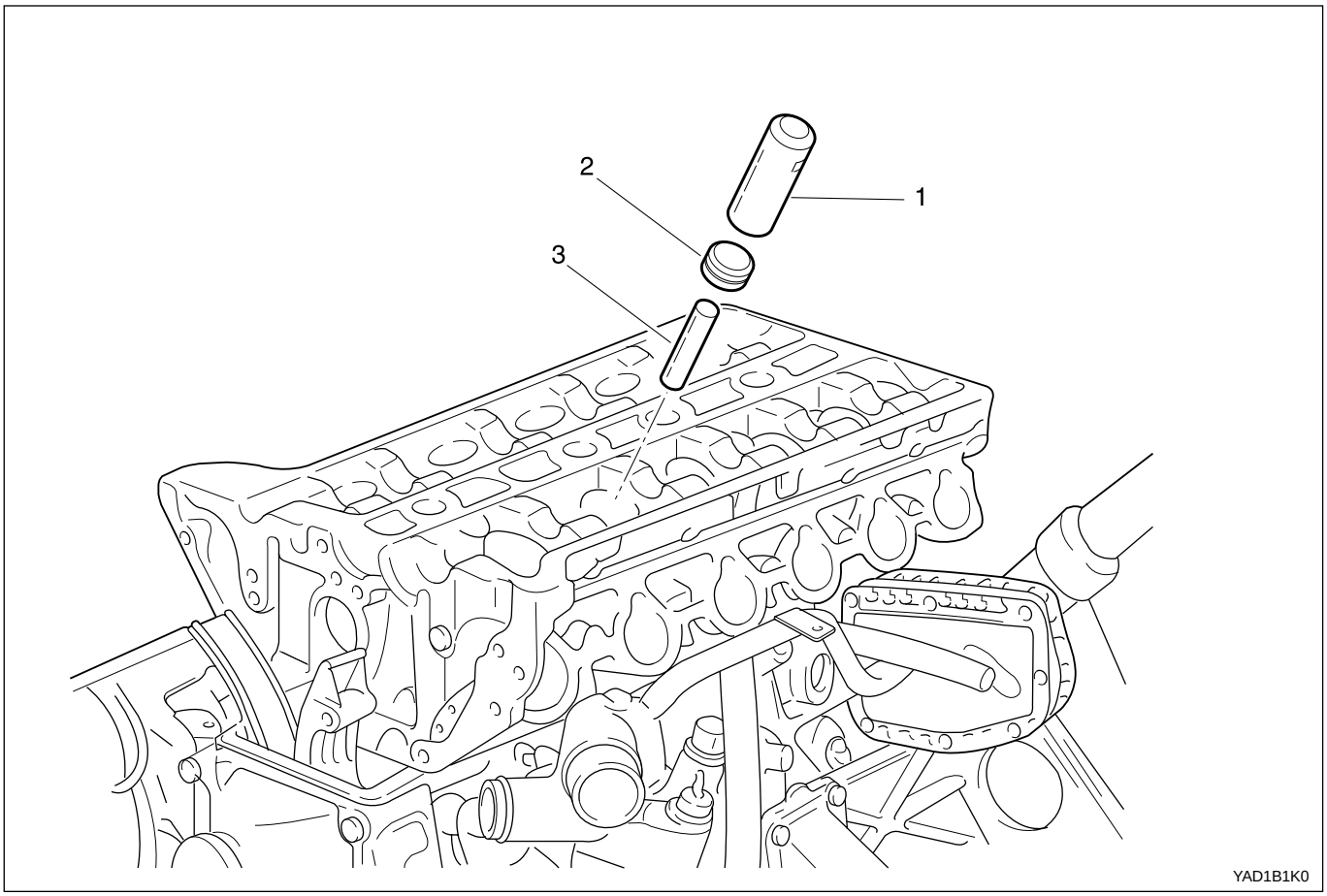


- Valve Cotter

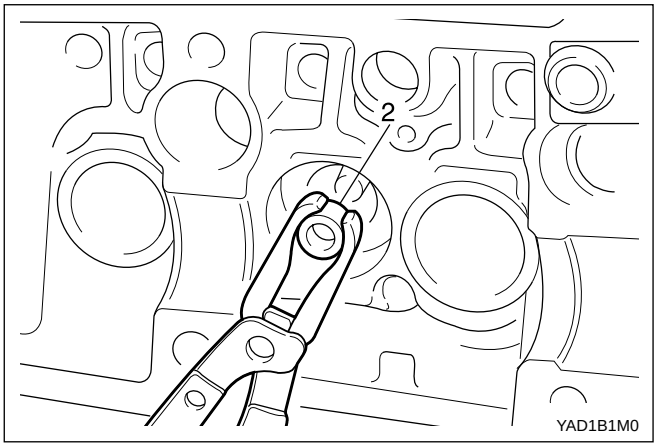
Size (mm)	(B)	9.0
	(H)	9.2 - 9.8

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

119 589 00 43 00 Drift

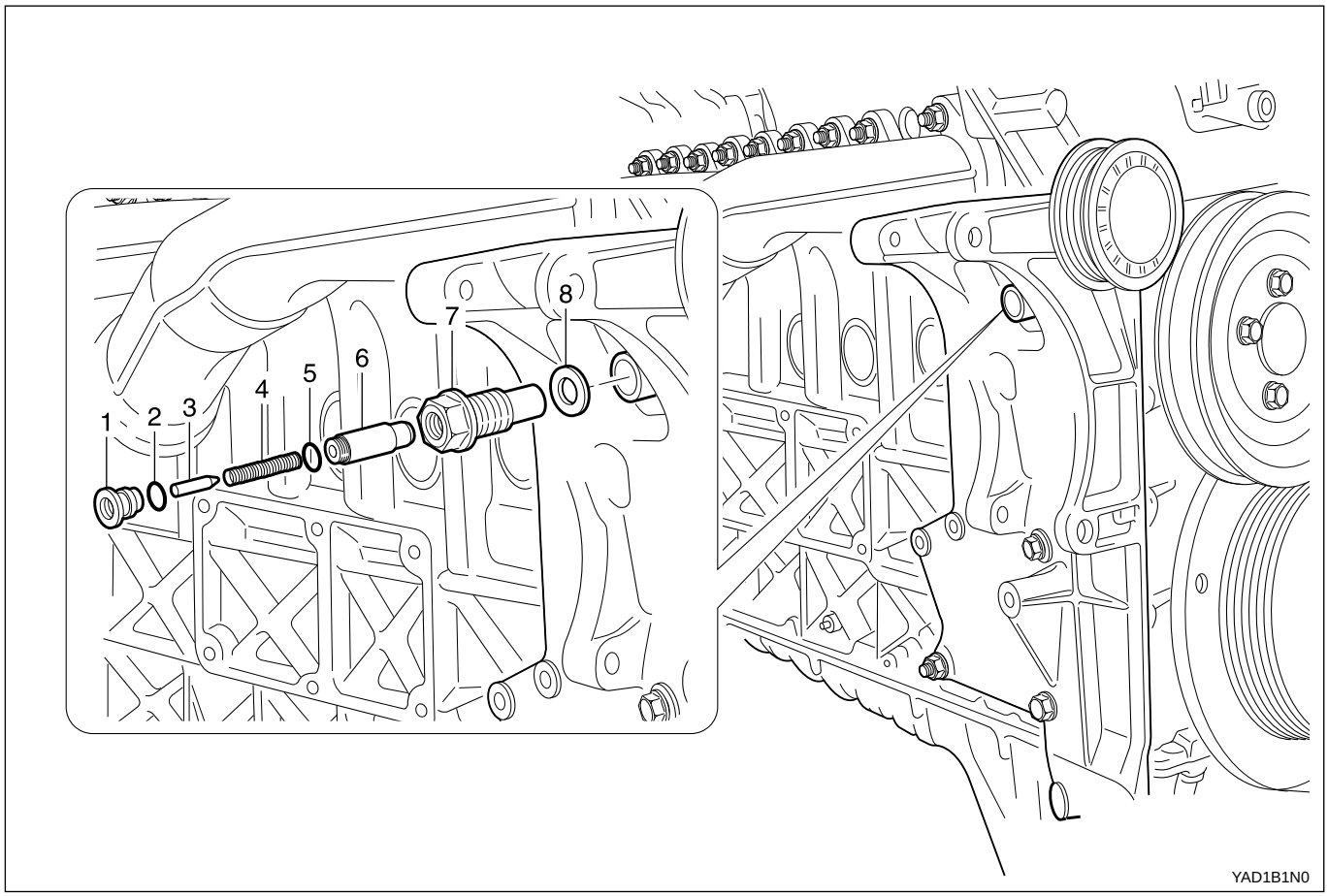
Replacement Procedure

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

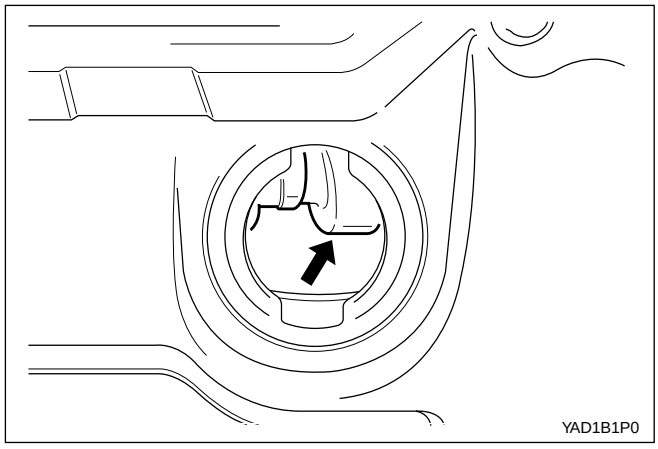
   Notice: Check the valve stem seal for damage and replace if necessary.

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 119 589 00 43 00.

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



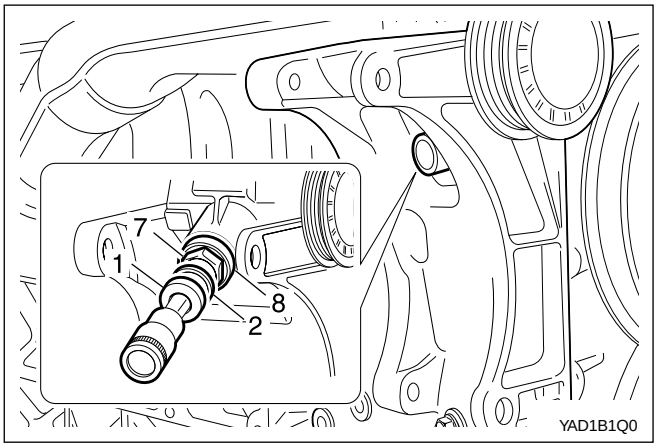
Removal Procedure

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.

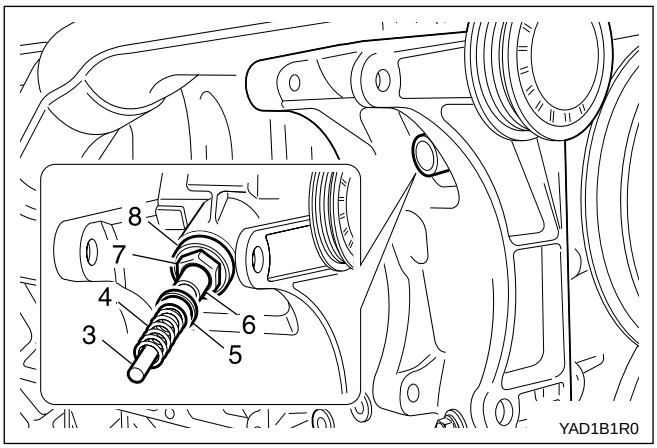


4. Carefully unscrew the screw plug (1), and remove the seal (2).

   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).

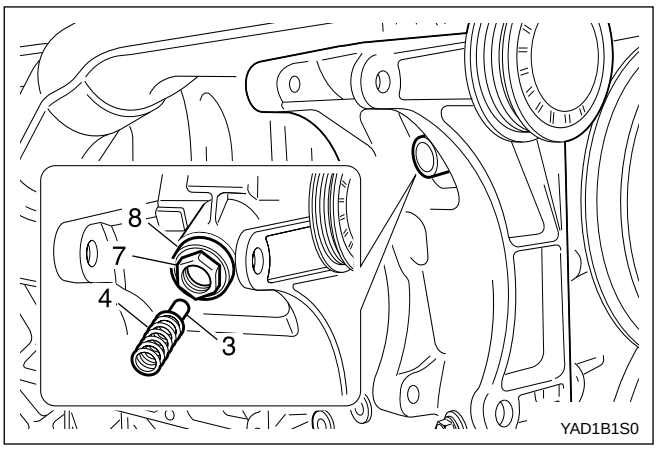


6. Remove the chain tensioner housing (7) and the seal (8).

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.

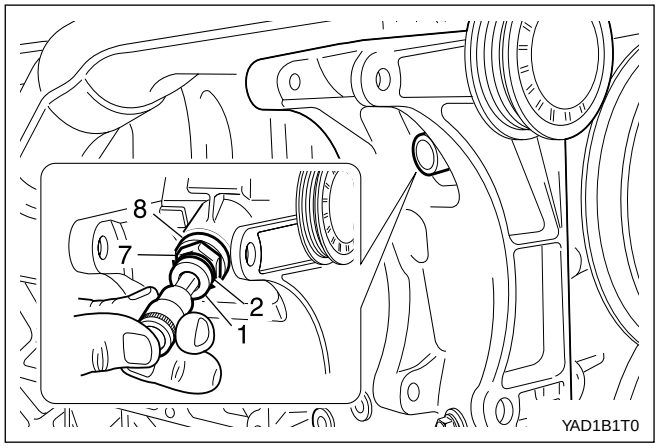


2. Install the chain tensioner housing (7), thrust pin (6), snap ring (5), and the seal (8).

   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.



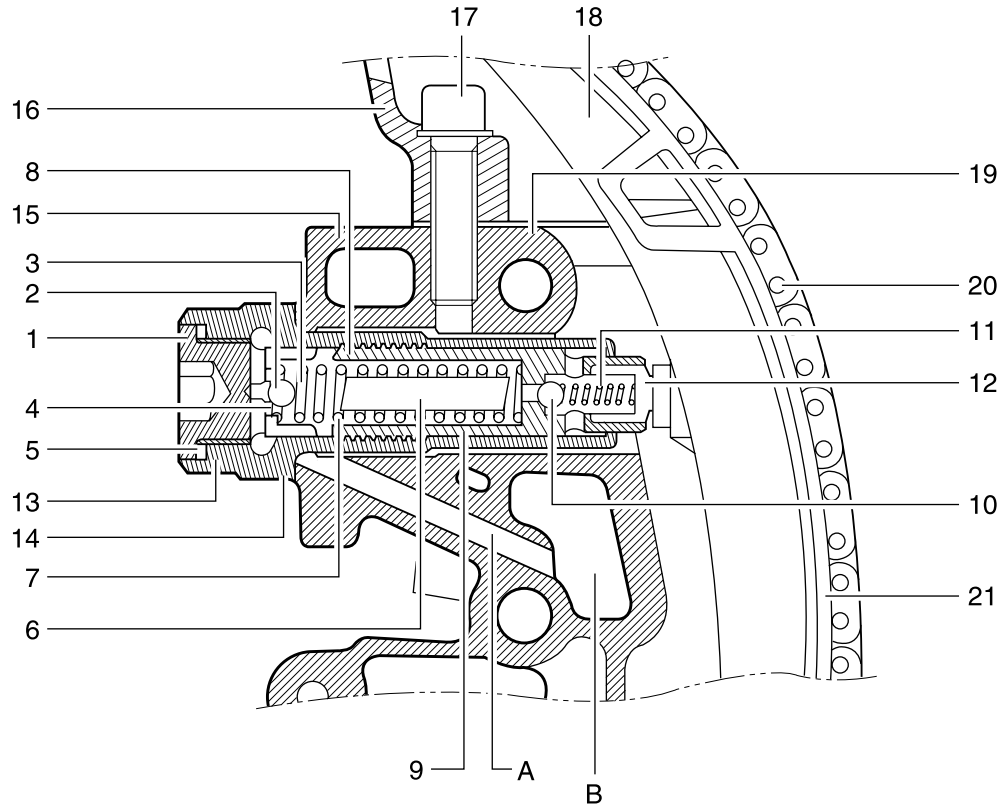
4. Lightly apply the grease to the seal (2) and install the screw plug (1).

   Installation Notice

Tightening Torque	40 N•m (30 lb-ft)

5. Check for leaks by operating the engine.

Sectional View

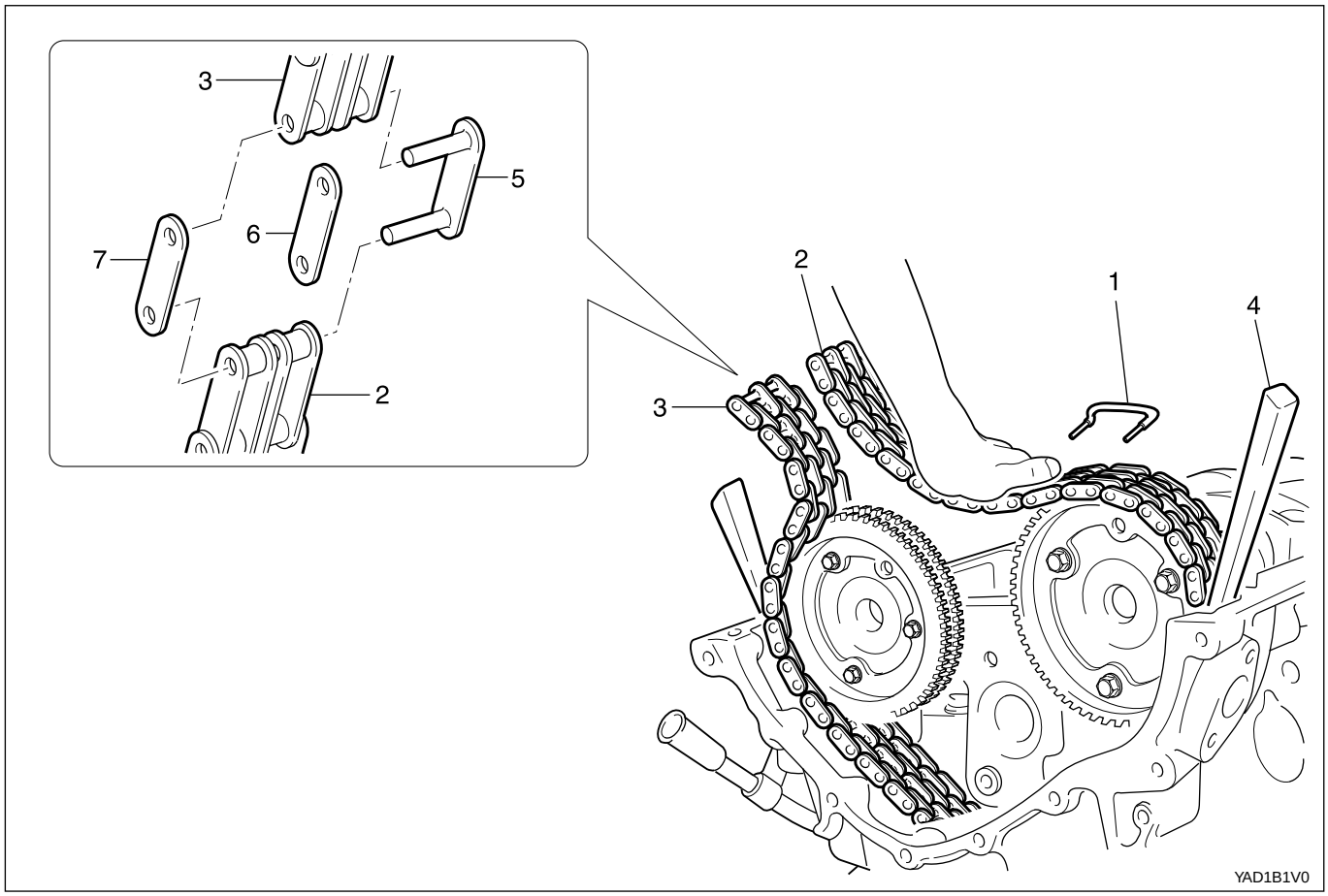


1 Screw Plug
2 Ball (Nonreturn Valve)
3 Compression Spring
4 Ball Guide
5 Seal (Aluminum)
6 Filler Pin
7 Compression Spring
8 Snap Ring
9 Thrust Pin
10 Ball (Nonreturn Valve)
11 Compression Spring
12 Thrust Piece
13 Chain Tensioner Housing
14 Seal
15 Timing Gear Case Cover
16 Cylinder Head
17 Bolt /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

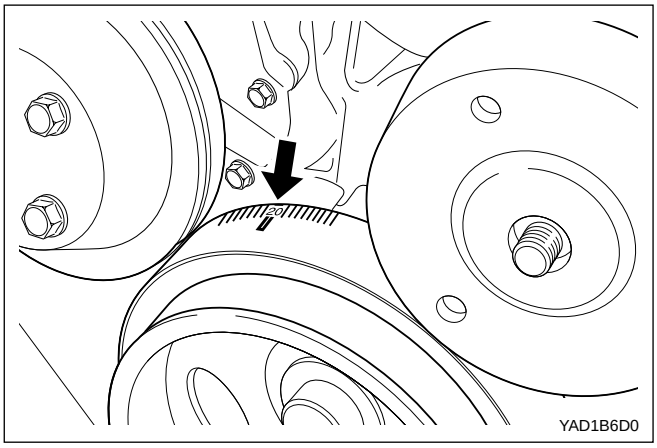
A Oil Supply Hole
B Chain Tensioner Oil Storage Hole

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



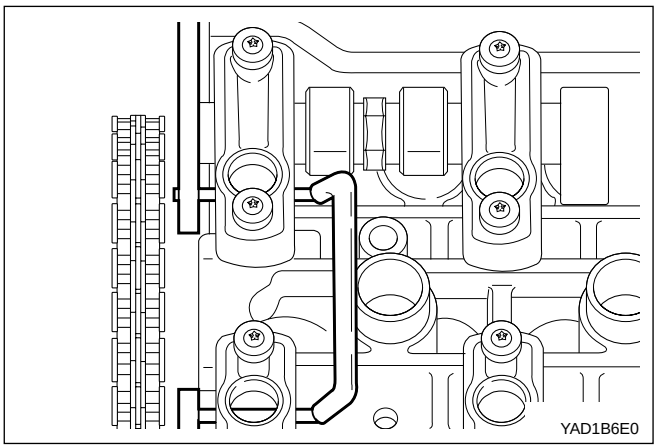
Tools Required

000 589 58 43 00 Chain Assembly

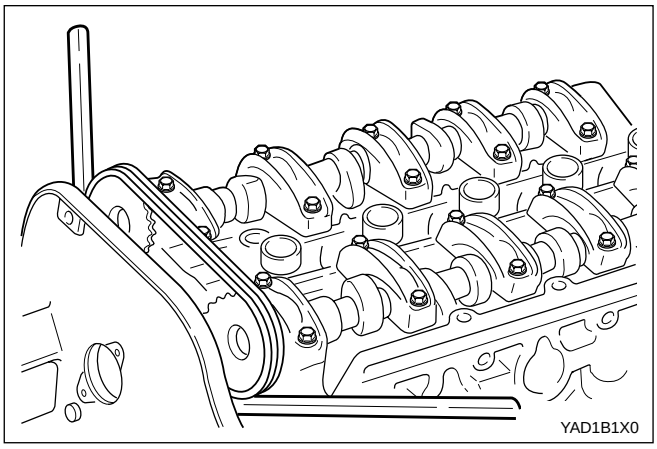
111 589 03 15 00 Holding Pin

Replacement Procedure

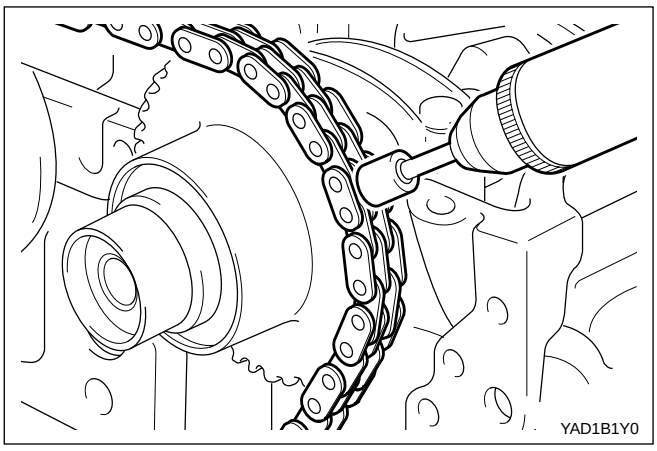
1. Position the NO.1 cylinder to ATDC 20 ° .



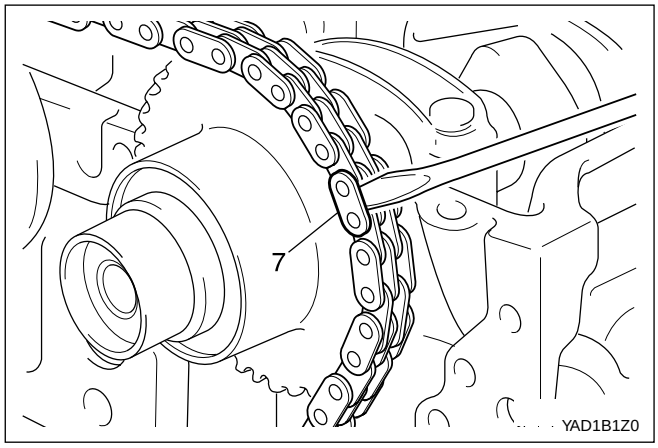
2. Insert the holding pin 111 589 03 15 00 to the intake and exhaust camshaft flange not to rotate camshaft.
3. Remove the chain tensioner.



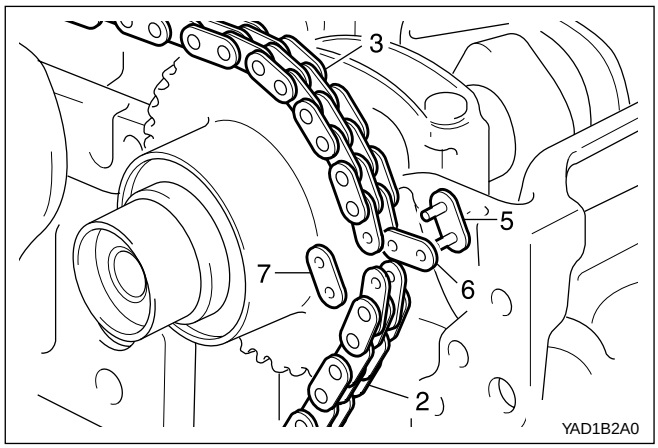
4. Mount the wedges to both sides of the camshaft sprocket as shown in the figure.



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



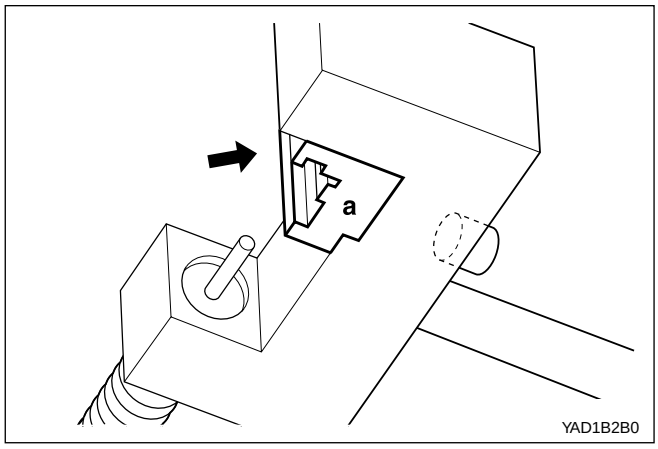
6. Remove the outer plate (7) with the screw driver and remove the link (5).

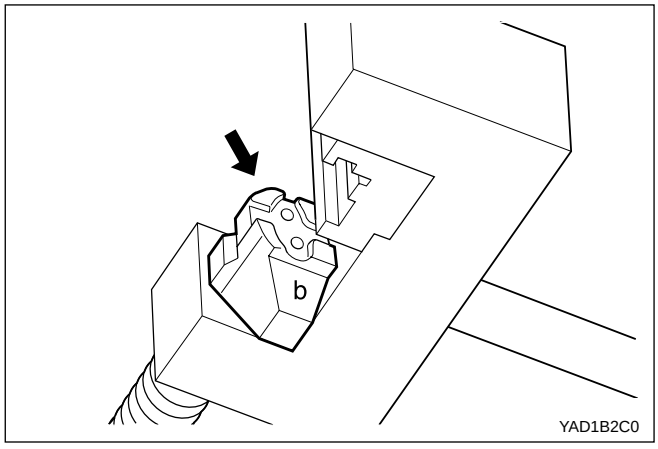


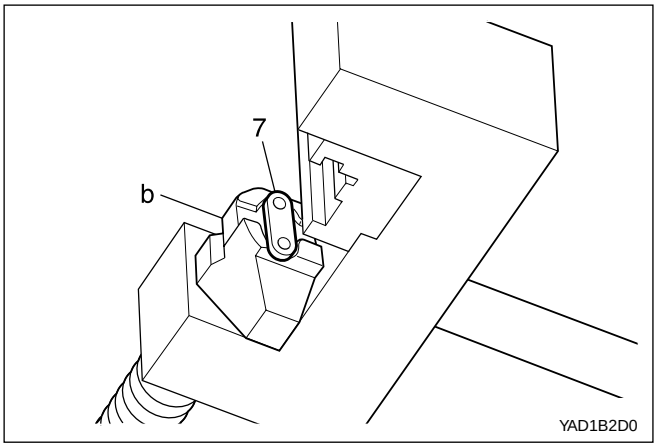
7. Connect the new timing chain (2) to the used timing chain (3) with the link (5), center plate (6, thickness 1.6 mm), and the outer plate (7).
8. Rotate the crankshaft in the direction if engine revolution by pressing the new timing chain against the exhaust camshaft sprocket to prevent it to be tangled.

   Notice: Be sure to remove the wedge before cranking the engine.

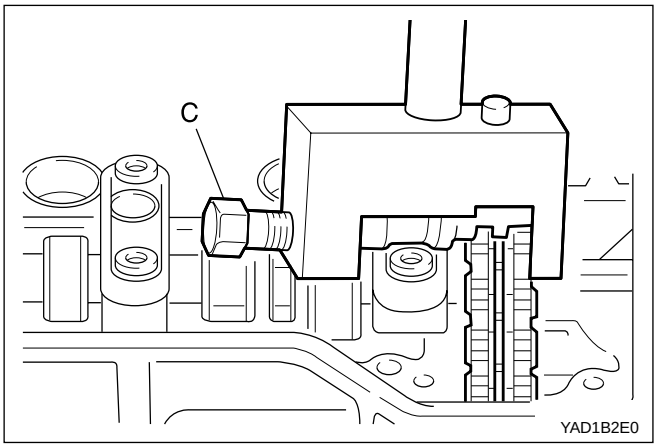
9. Take out the used timing chain out from the chain housing.
10. Connect both separators of the new timing chain with the link (5) and the center plate (6).
11. Install the jaw (a) and the thrust piece (b) to the assembly tool as shown in the figures.



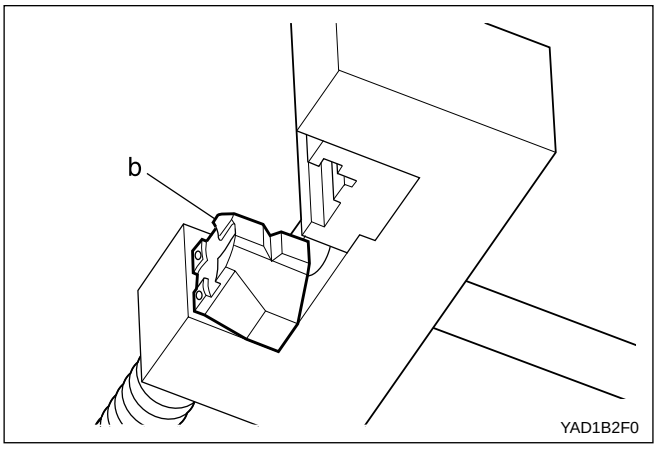




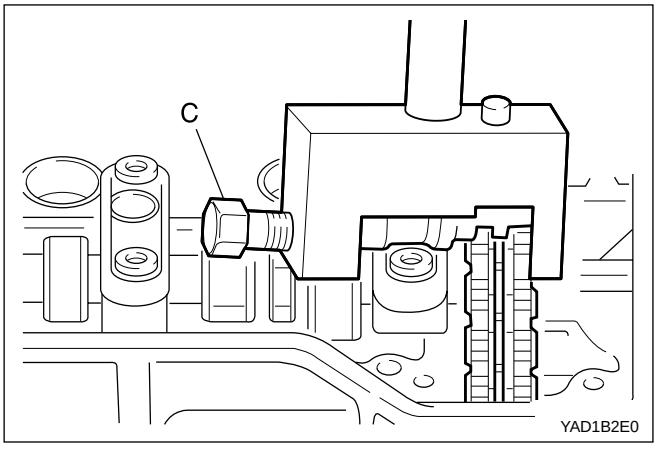
12. Place the outer plate (7, thickness 1.2 mm) inside the thrust piece (b).



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



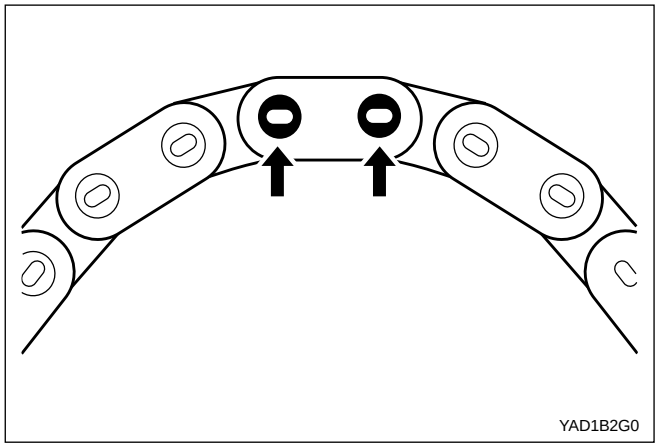
15. Replace the thrust piece (b) as shown in the figure.



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

Installation Notice

Tightening Torque	30 N•m (22 lb-ft)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17. Rivet the link pin.
    Check the condition and it again if necessary.
18. Install the chain tensioner.

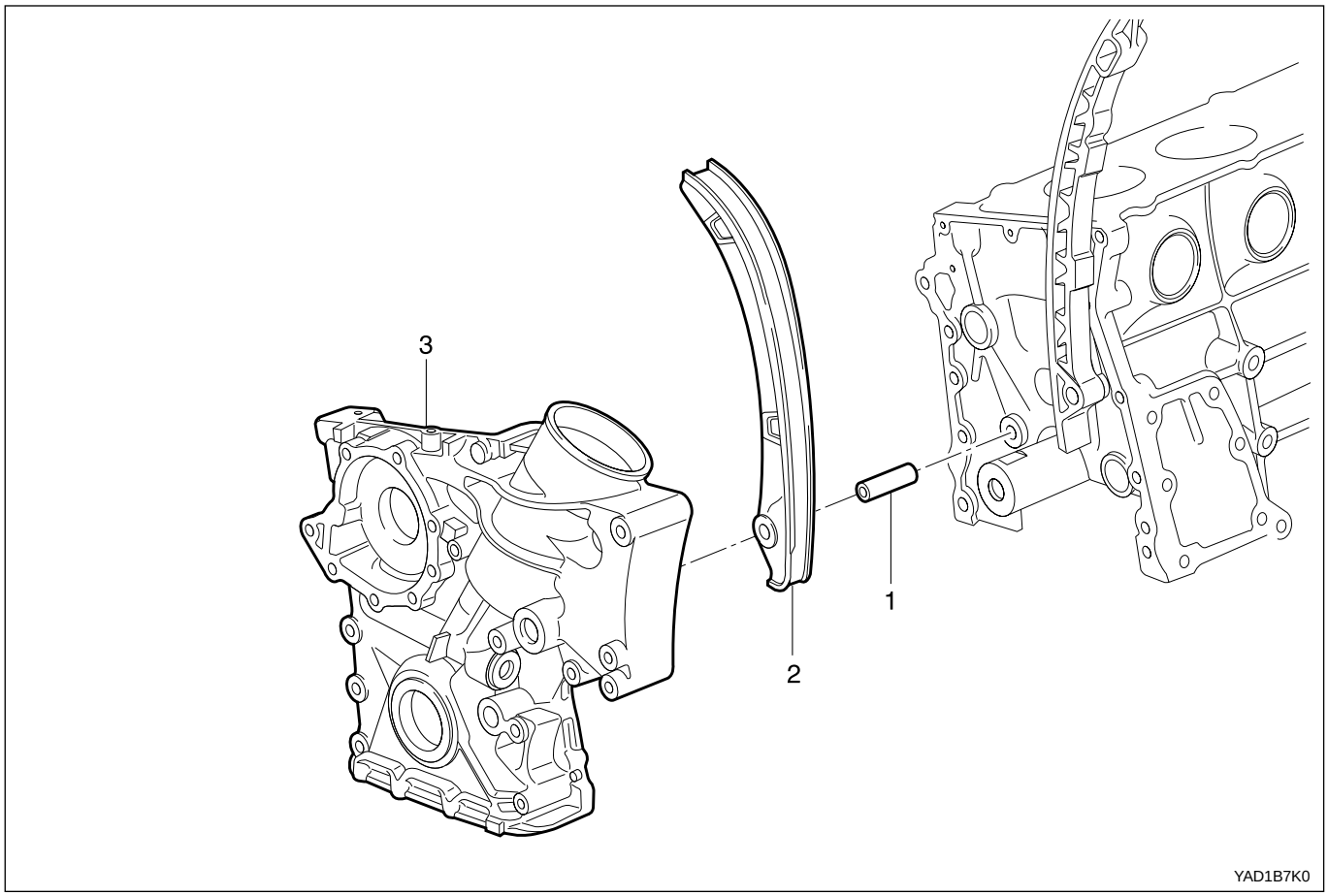
Installation Notice

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).

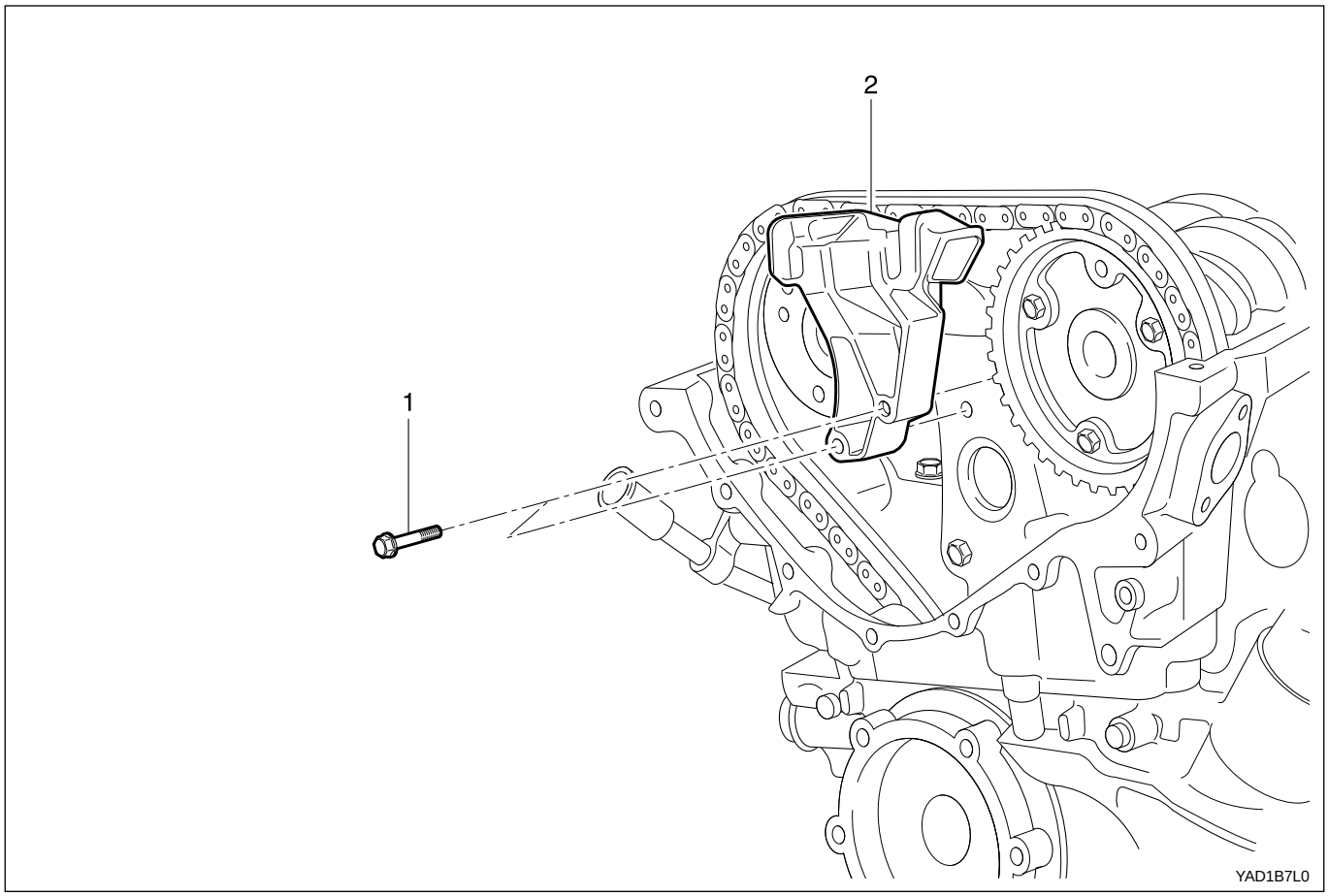
   Notice:

   - 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.

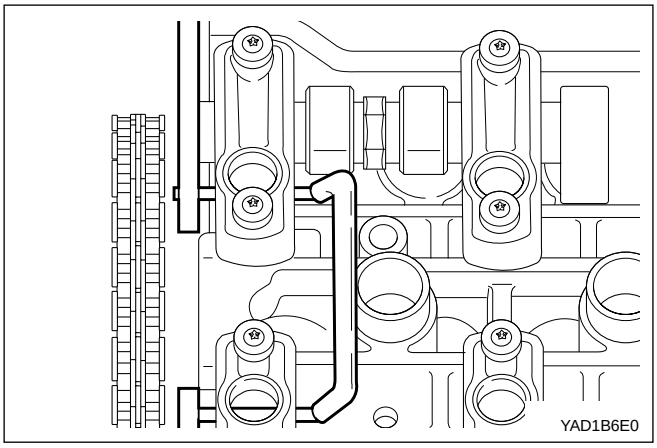
CYLINDER HEAD GUIDE RAIL

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

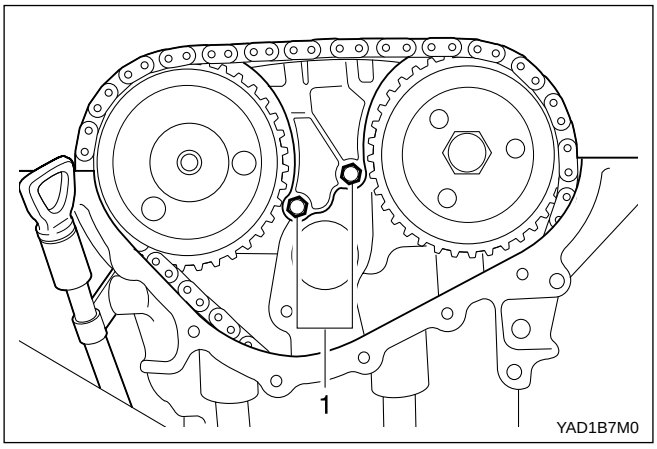
111 589 03 15 00 Holding Pin

Removal & Installation Procedure

1. Position the number 1 cylinder to ATDC 20 ° guide rail.
2. Install the holding pin 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.

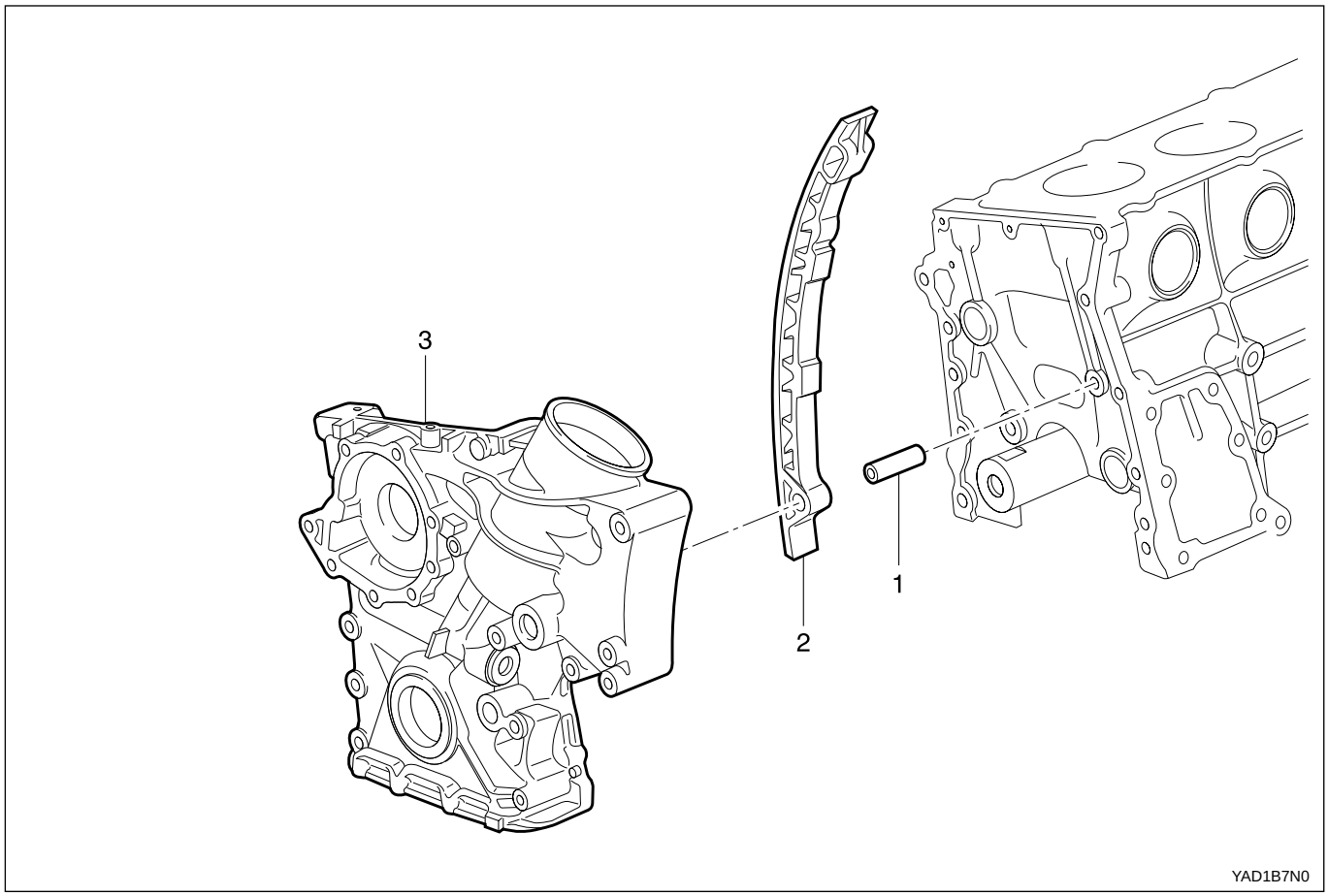
Installation Notice

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

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).

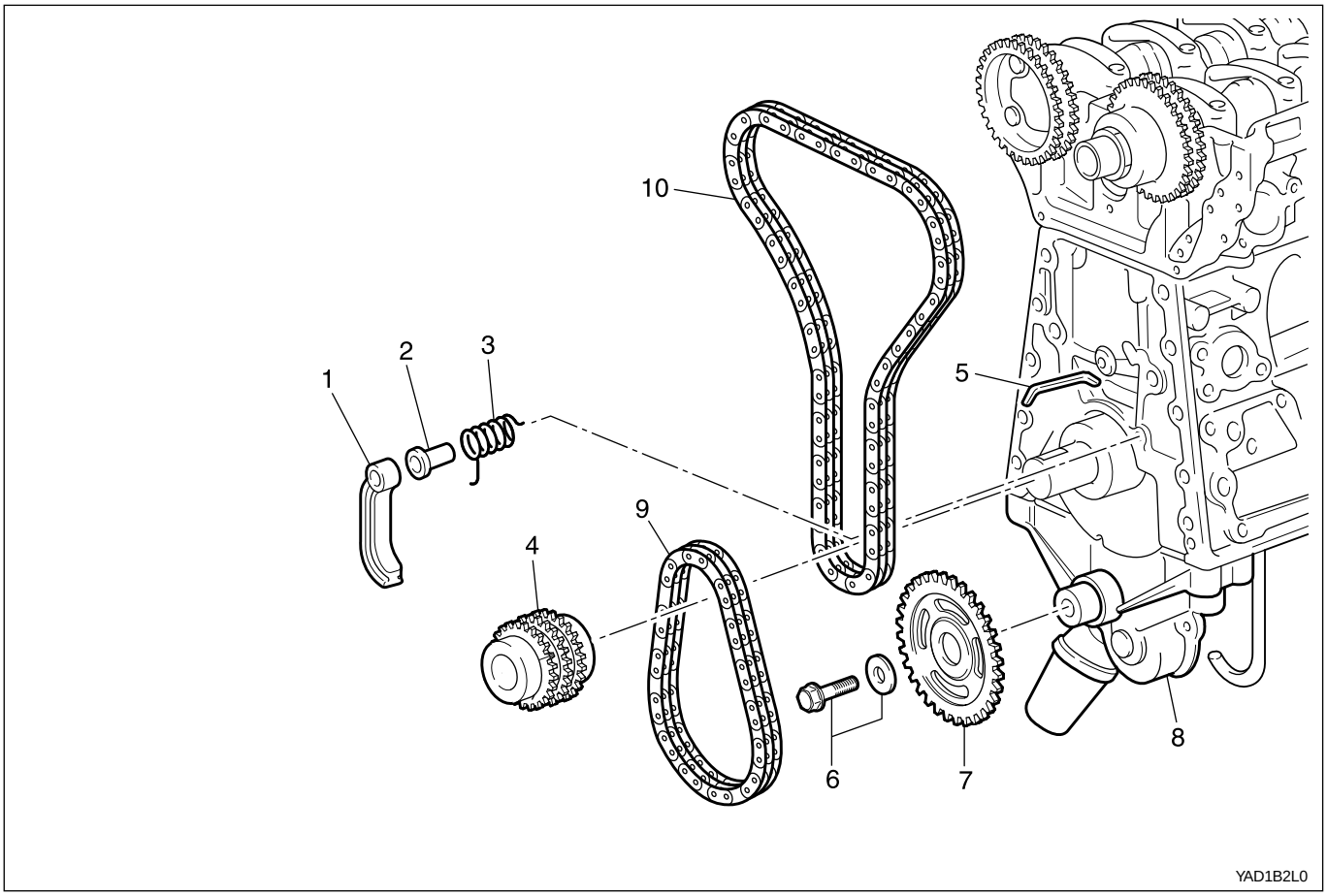
   Notice:

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

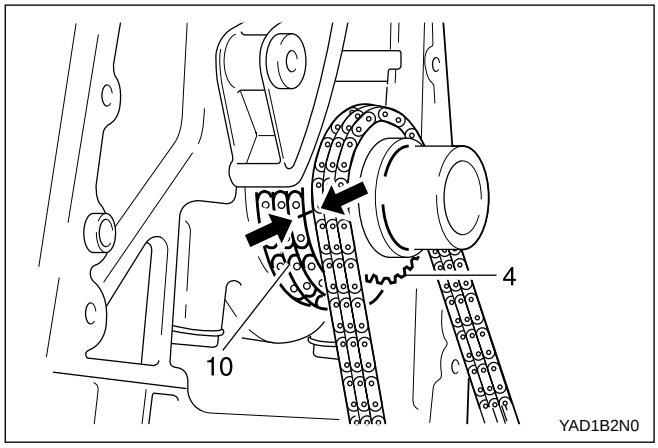
3. Installation should follow the removal procedure in the reverse order.

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

615 589 01 33 00 Crankshaft Sprocket Puller

Removal & Installation Procedure

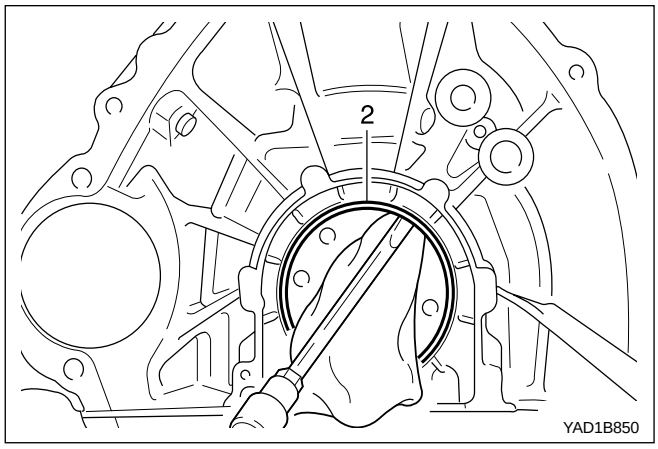
1. Put the assembly mark at the crankshaft sprocket (4) and the timing chain (10) with the paint (arrow).

   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 615 589 01 33 00.

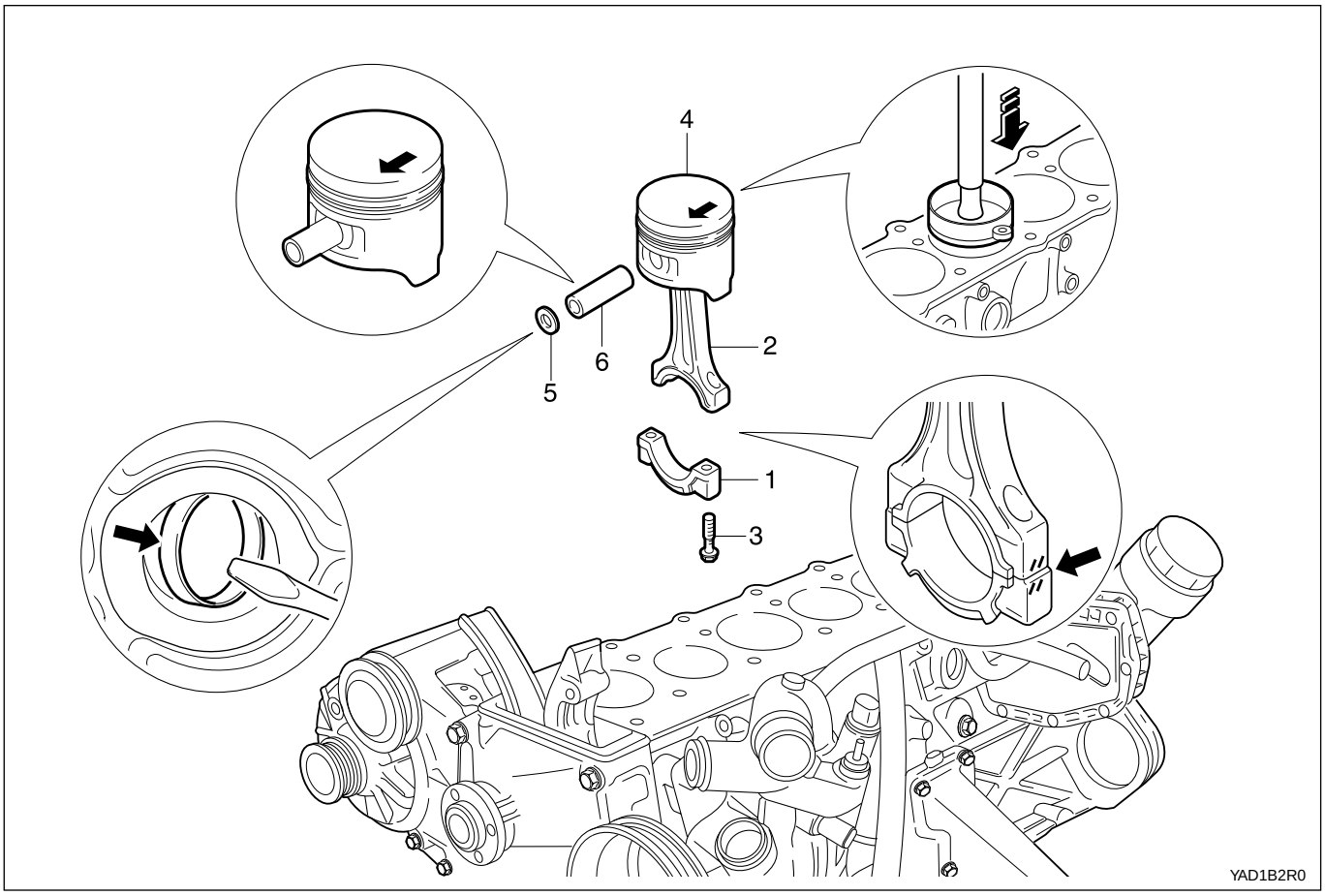
   Notice:

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

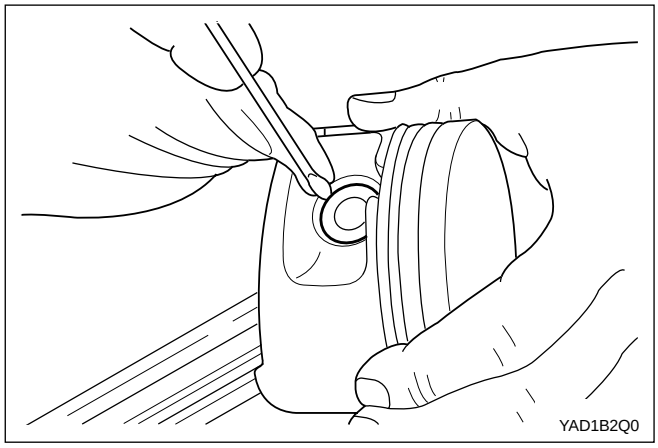
6. Installation should follow the removal procedure in the reverse order.

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

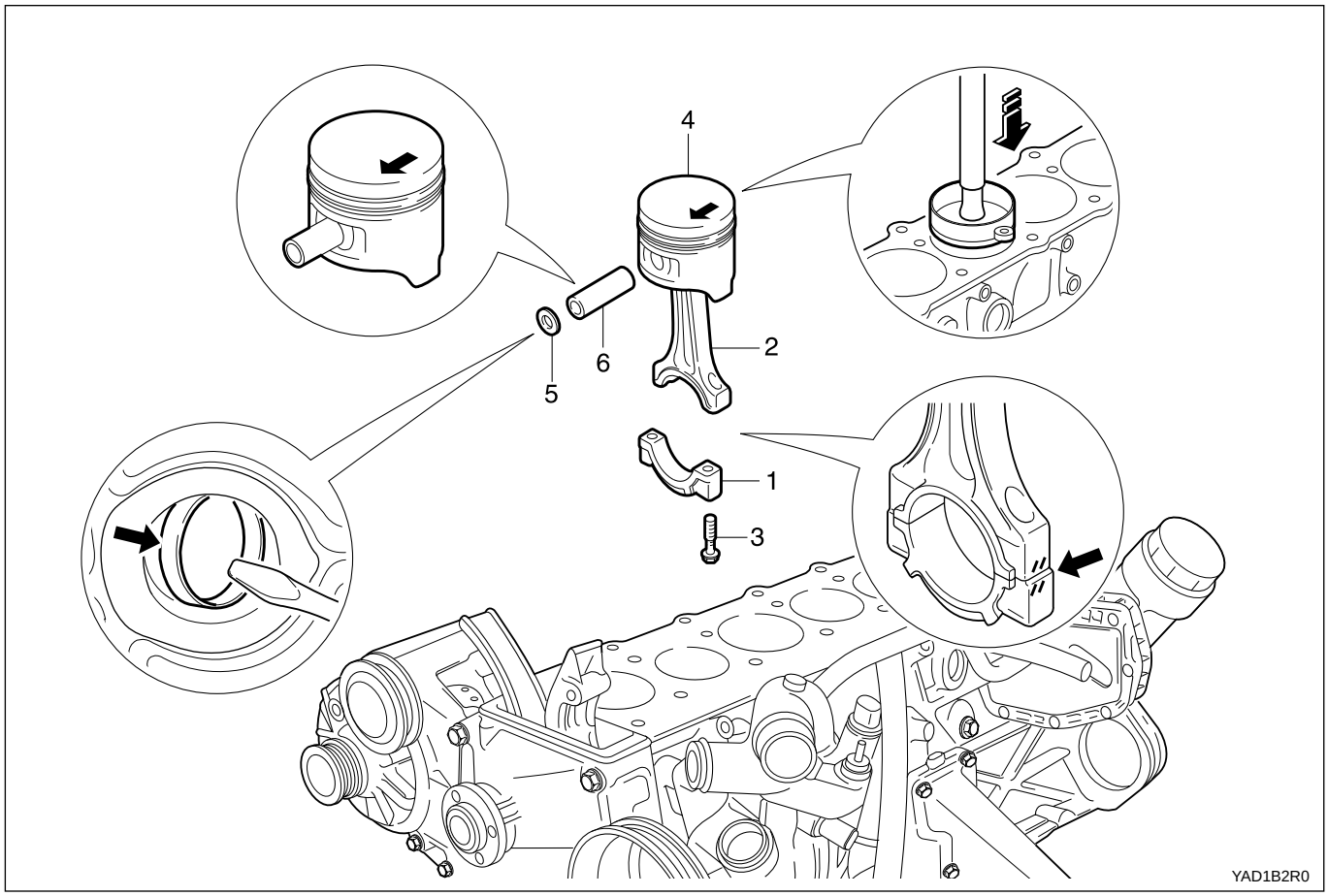
1. Unscrew the connecting rod bolt (3) and remove the cap.
2. Remove the connecting rod and the piston upward.

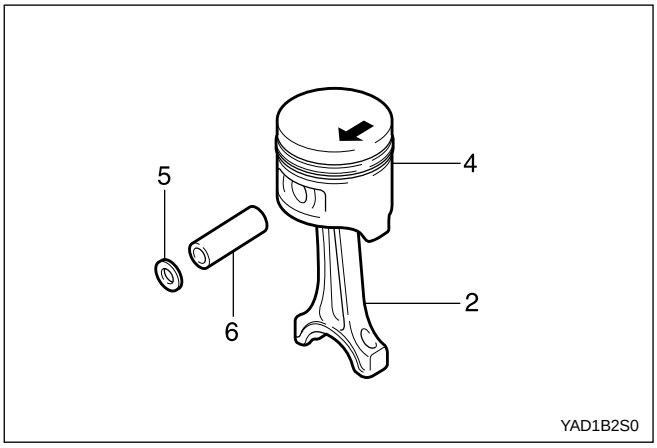
   Notice: Make sure that the bearing cap and shell are not changed each other.

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

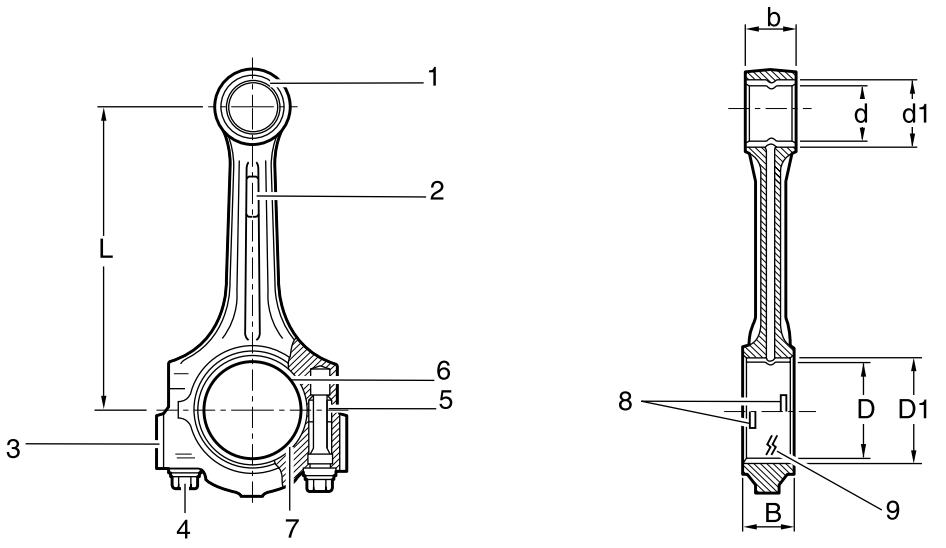
Tightening Torque	1st step : 40 N•m (30 lb-ft)
	2nd step : 90 °

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

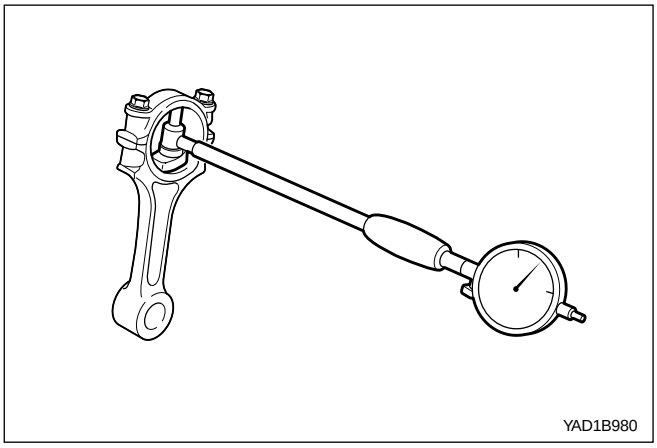
Preceding Work: Removal of piston



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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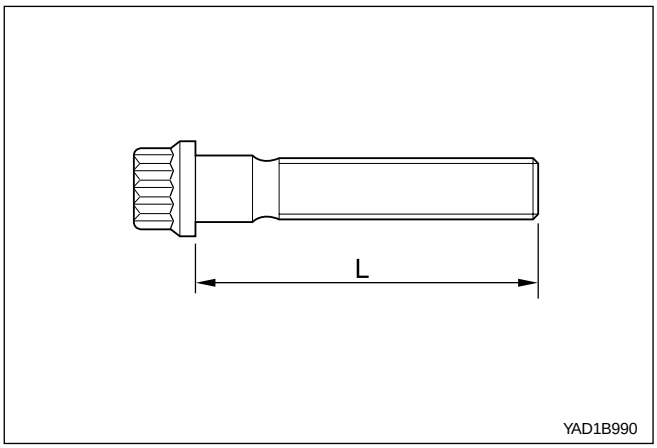
Inspection

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.

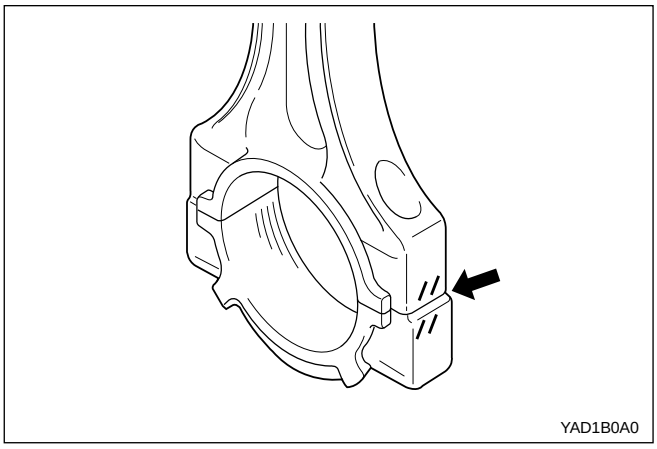


YAD1B990

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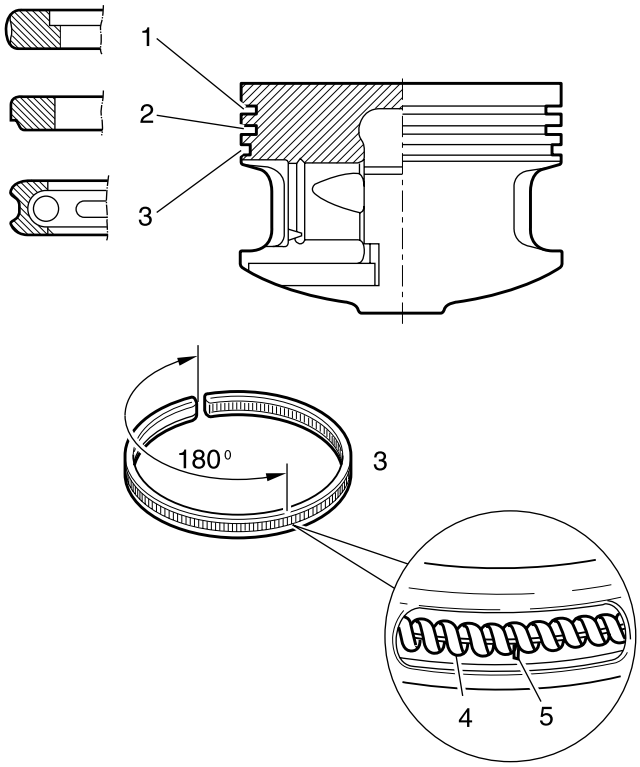
3. Check the assembly mark (indication//or number:arrow) of the connecting rods and the bearing cap when installing.

   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



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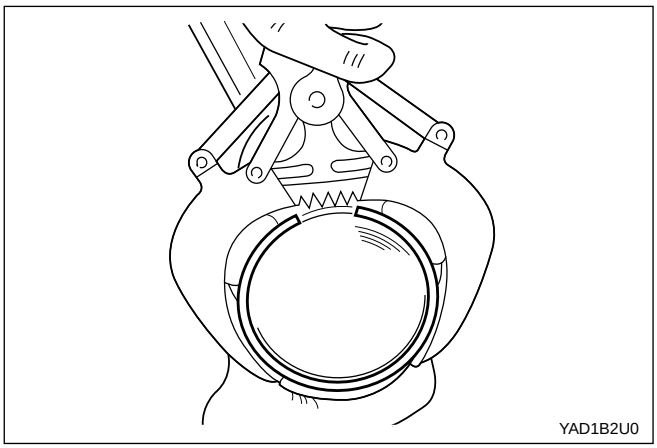
1 Piston Compression Ring (Top Ring)
2 Piston Compression Ring (2nd Ring)
3 Piston Oil Ring
4 -
5 Spacer
6 SideRail

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.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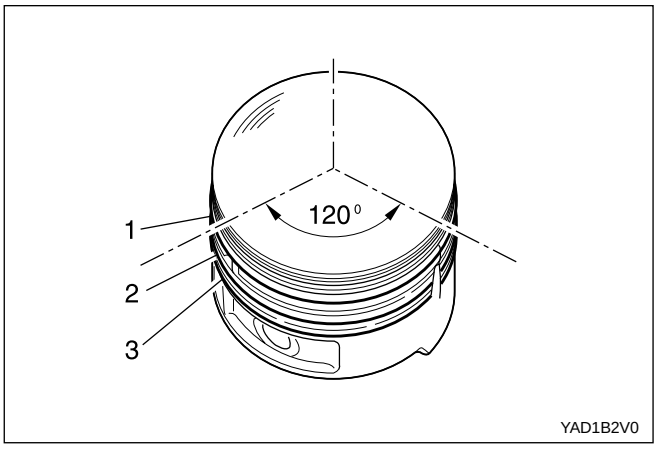
2. Remove the piston ring with a pliers.



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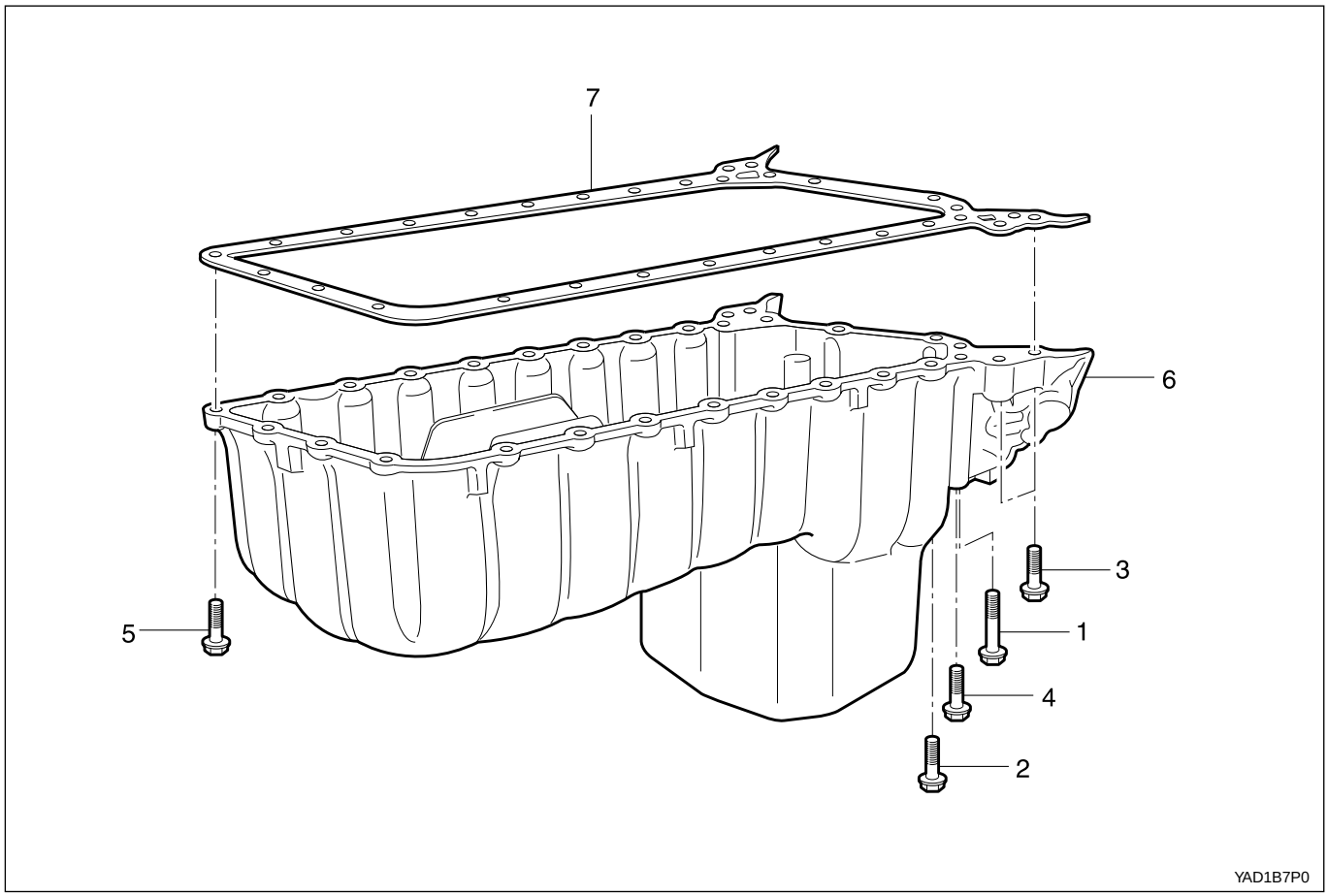
3. For installation, position the piston ring to be the 'TOP' mark on the piston ring upward and arrange the piston ring ends to be 120 ° part.
4. Adjust the hook spring joint in the oil ring 180 ° way from the ring end.

OIL PAN



1 Bolt
2 Bolt
3 Bolt
4 Bolt
5 Bolt
6 OilPan
7 Gasket

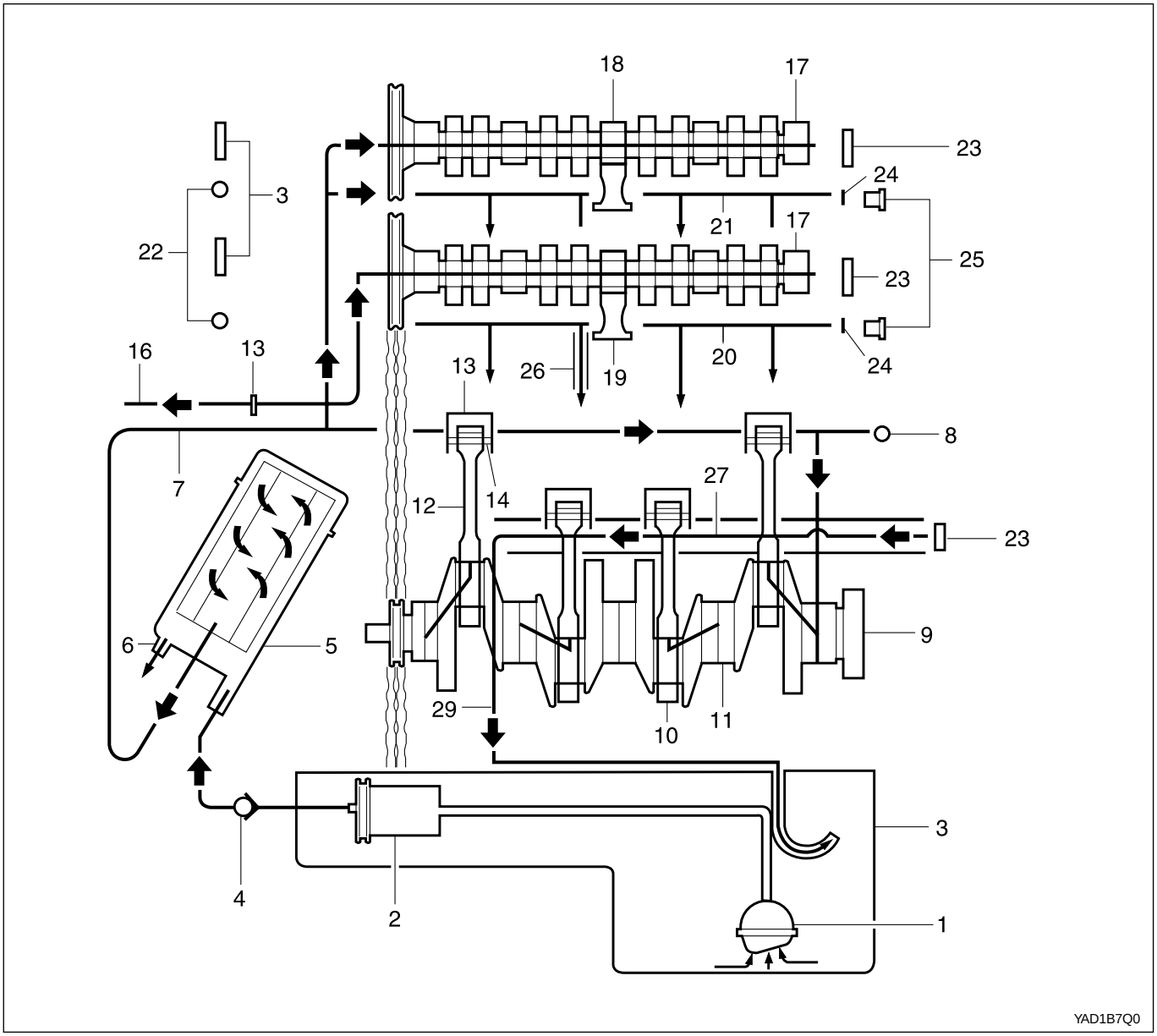
Removal & Installation Procedure

1. Remove the drain plug and drain the oil completely.
2. Unscrew the bolts and remove the oil pan and gasket.

   Notice: Arrange the bolts according to each size.

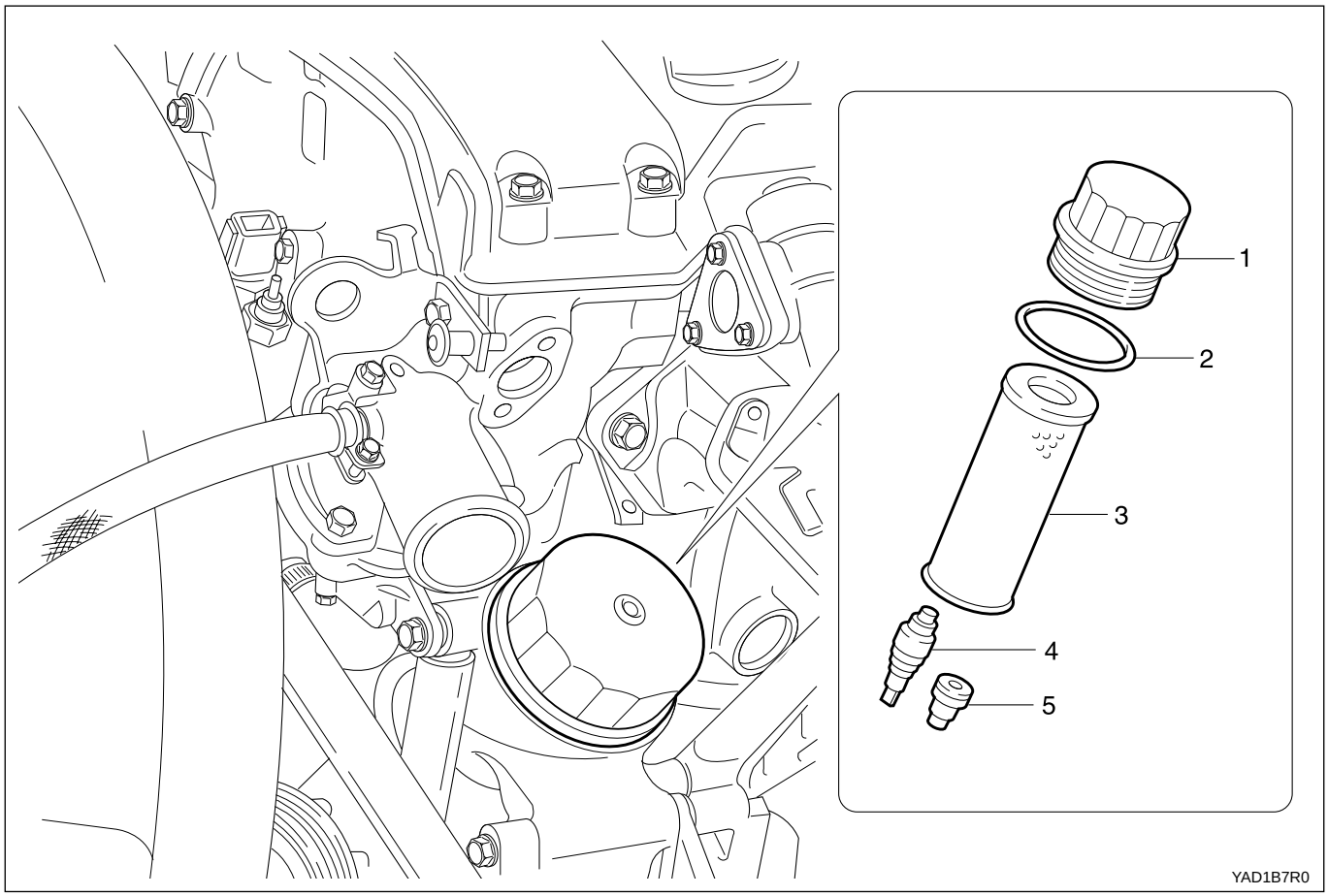
3. Clean the inside of oil pan and sealing surface, then apply the sealant.
4. Replace the gasket with new one.
5. Install the oil pan with gasket, and tighten each bolt in specified torque.
6. Check for oil leaks while running the engine.

Oil Circulation

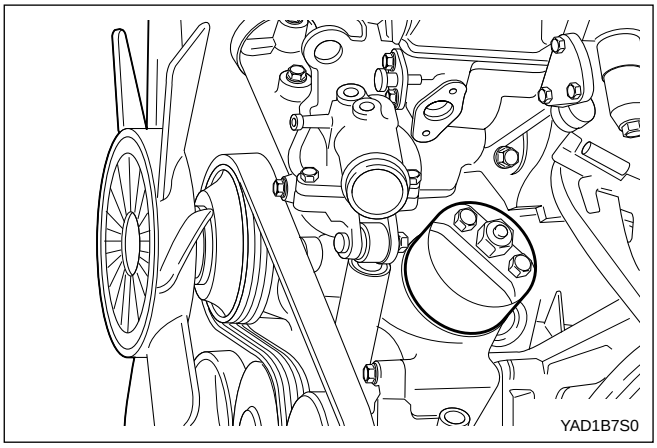


1 Oil Strainer
2 Oil Pump
3 Oil Pan
4 Oil Non-Return Valve
5 Oil Filter
6 Oil Filter Bypass Valve
7 Main Oil Gallery
8 Closing Ball (ϕ 15 mm)
9 Crankshaft
10 Connecting Rod Bearing
11 Crankshaft Bearing
12 Connecting Rod
13 Piston
14 Oil Spray (Piston Crown Area)
15 Non-Return Valve (Crankcase)
16 Oil 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

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

103 589 02 09 00 Oil Filter Remover

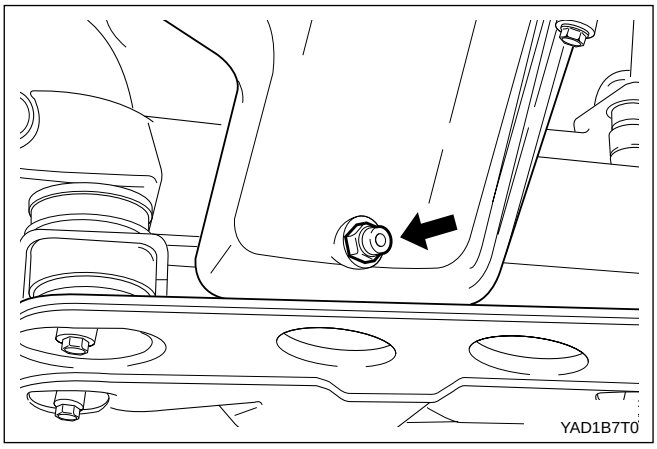
Replacement Procedure

1. Install the oil filter remover 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 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 103 589 02 09 00, and then completely tighten it.

   Installation Notice

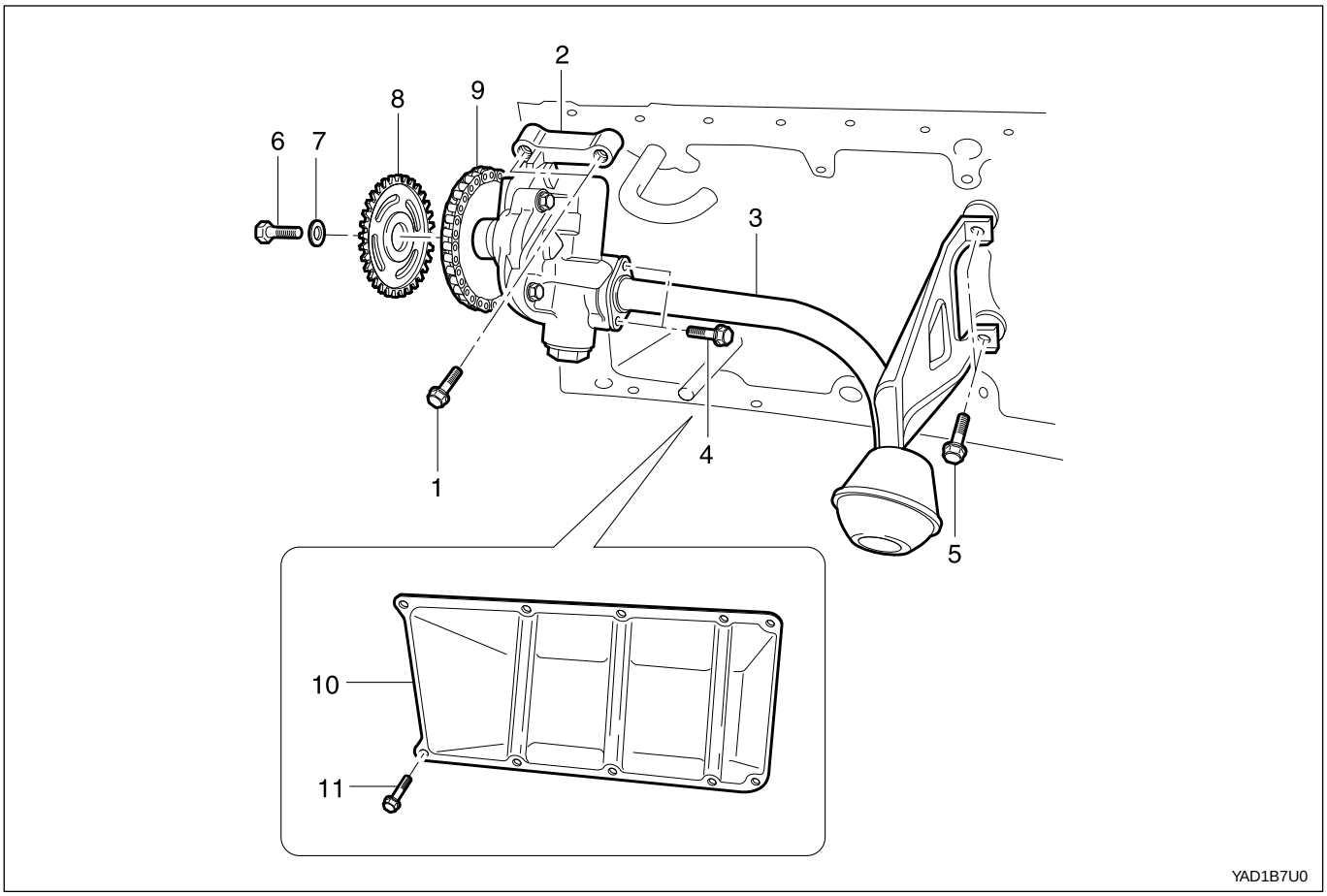
Tightening Torque	25 N•m (18 lb-ft)

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.

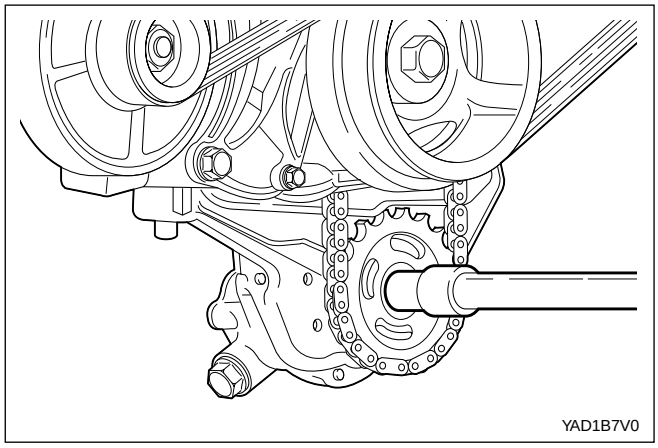
    Check the oil level and fill up as specified if necessary.

OIL PUMP

Preceding Work: Removal of oil pan



1 Bolt (M8 X 35, 3 piece)
..... 22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)
2 OilPump
3 Oil Strainer Assembly
4 Bolt (M6 X 20, 2 pieces)
..... 9 - 11 N•m (80 - 97 lb-in)
(In E23 Engine, These Bolts are Combined with Baffle Plate)
5 Bolt (M6 X 12, 2 pieces)
..... 9 - 11 N•m (80 - 97 lb-in)
6 Bolt (M8 X 20, 1 pieces)
..... 29 - 35 N•m (21 - 26 lb-ft)
7 Washer
8 Sprocket (Oil Pump Drive)
9 Chain (Oil Pump Drive)
10 Plate-Baffle
11 Bolt (M6 X 12, 6 pieces)
..... 9 - 11 N•m (80 - 97 lb-in)
(E23 Engine Only : Baffle Plate Mounting Bolt)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Removal & Installation Procedure

1. Unscrew the bolt (6) from the oil pump drive sprocket and separate the oil pump drive chain.

   Installation Notice

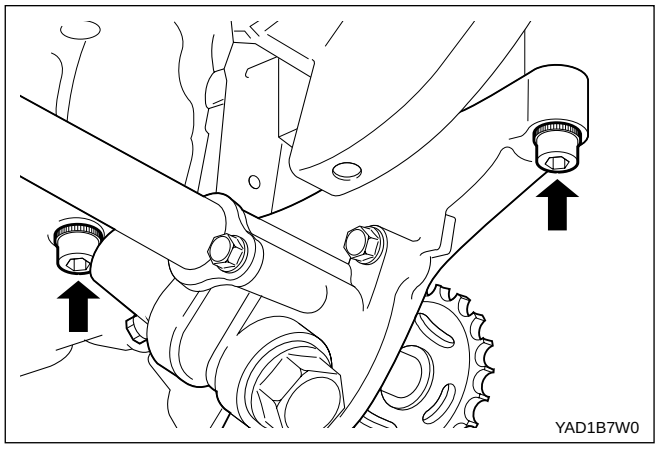
Tightening Torque	25 - 39 N•m (21 - 26 lb-ft)

2. Unscrew the bolts (4,5) and remove the oil strainer assembly (3).

   Installation Notice

Tightening Torque	Bolt (4):	9 - 11 N•m (80 - 97 lb-ft)
	Bolt (5):	9 - 11 N•m (80 - 97 lb-ft)

   Insert the steel gasket into the oil pump and bolt (4) mounting surface.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3. Unscrew the six bolts (11) and remove the baffle plate.

   Installation Notice

Tightening Torque	70 N•m (52 lb-ft)

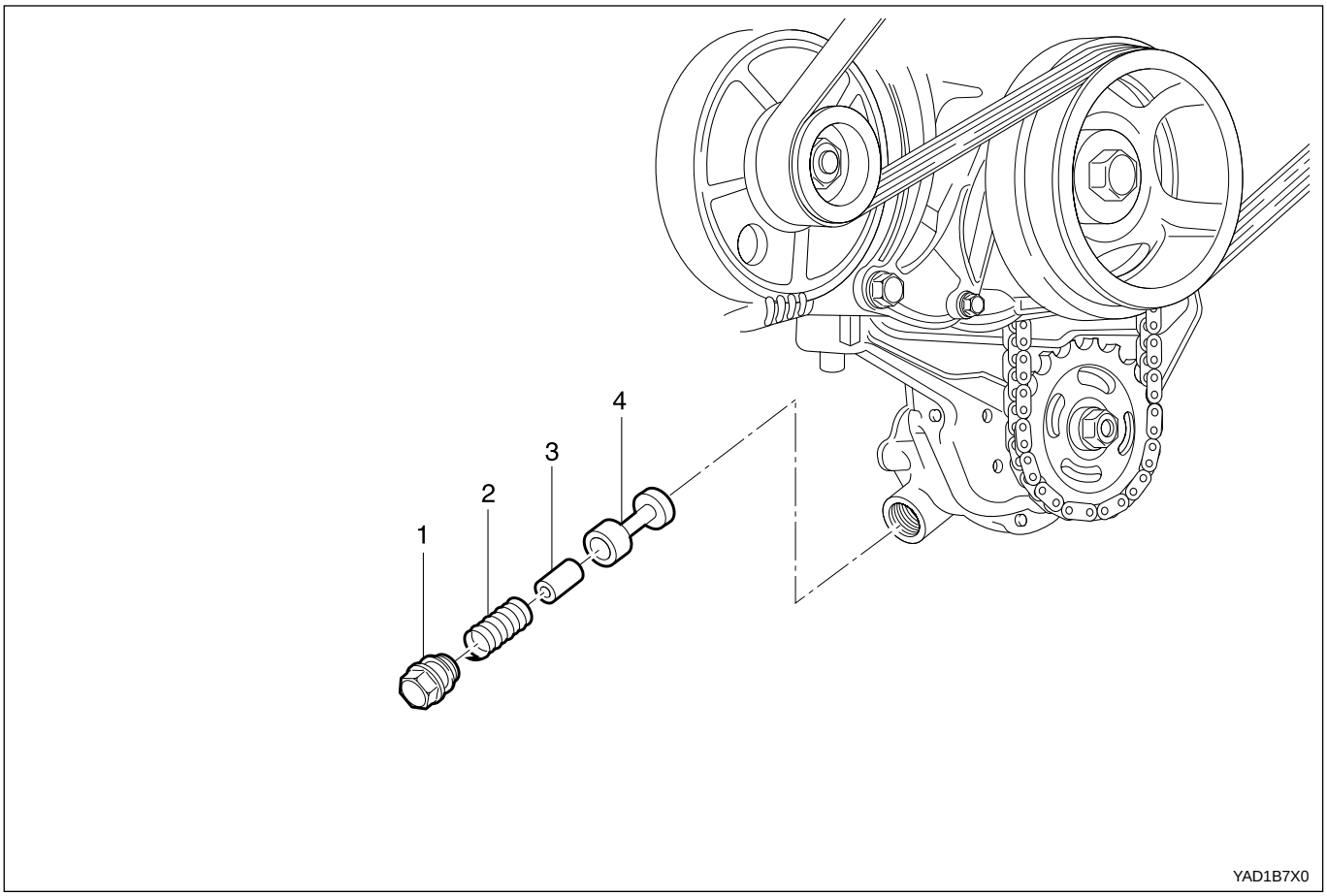
4. Unscrew the three bolt (1) and remove the oil pump.

   Installation Notice

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

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

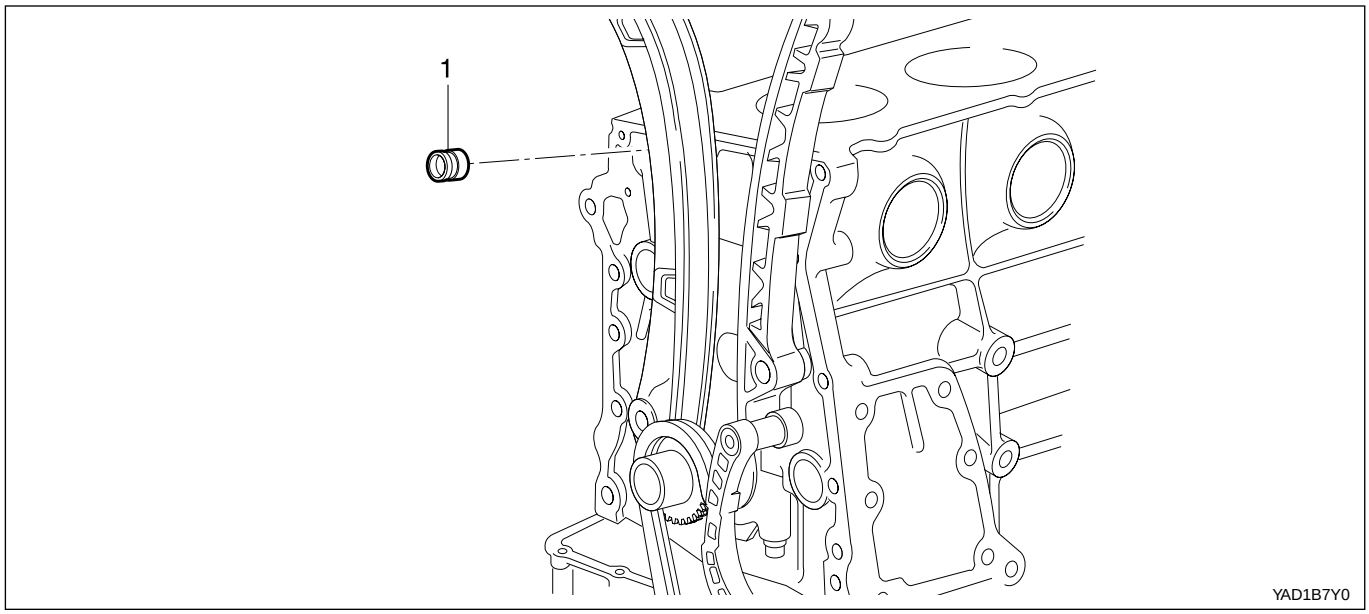
Tightening Torque	50 N•m (37 lb-ft)

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.

OIL NON-RETURN VALVE

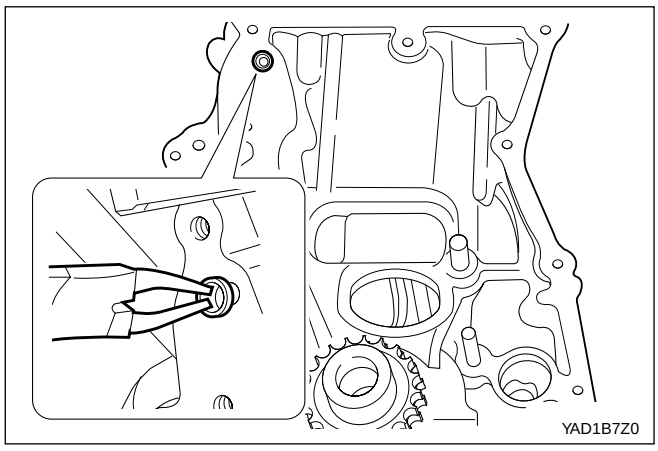
Preceding Work: Removal of timing gear case cover



1 Oil Non-return Valve

Functions

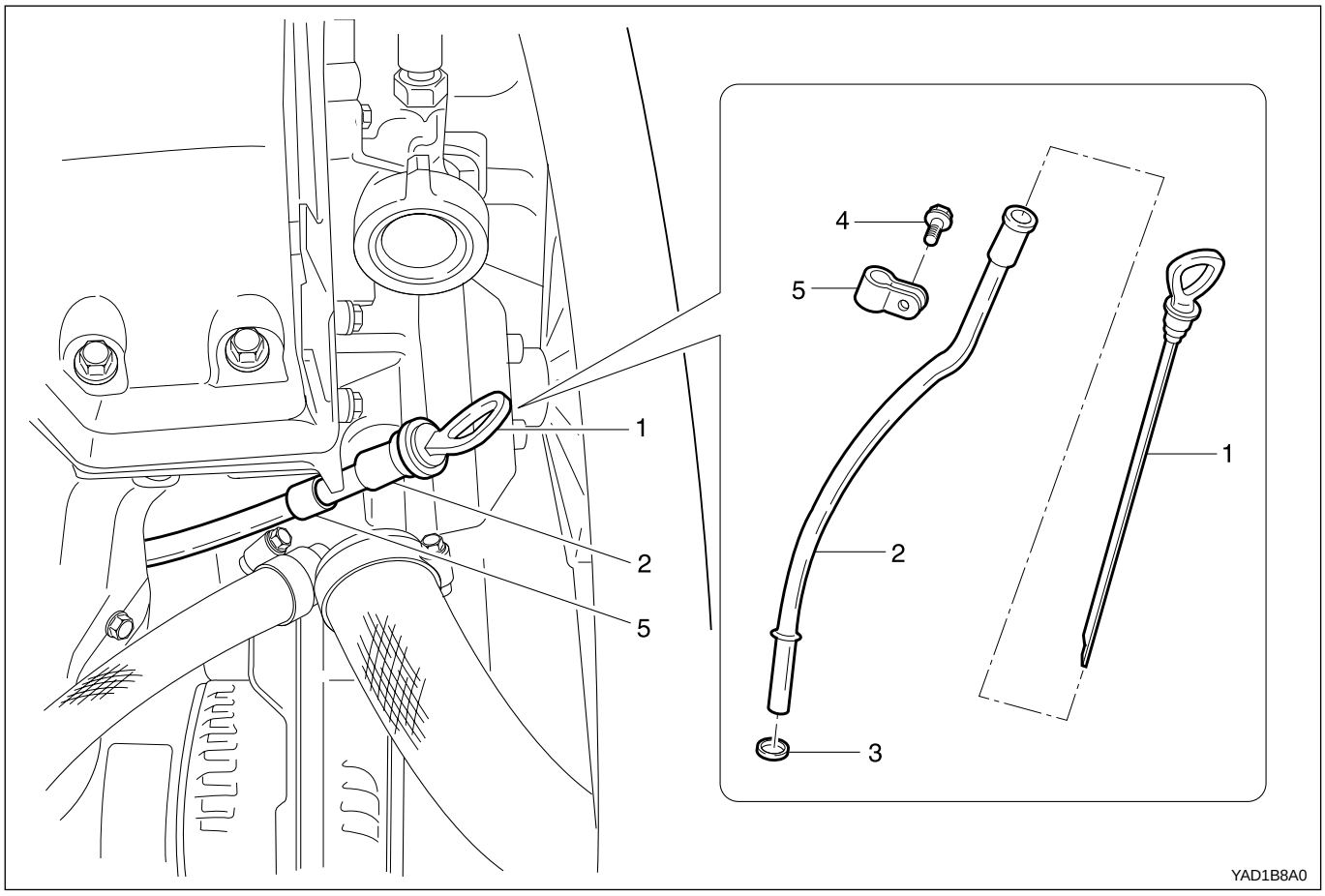
The non-return valve prevents the oil in the chain tensioner from drying up. In other words, it stops oil-returning in order to prevent the oil in the chain tensioner from getting dry. As a result, the chain tensioner can be activated with oil in itself.



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-ft)

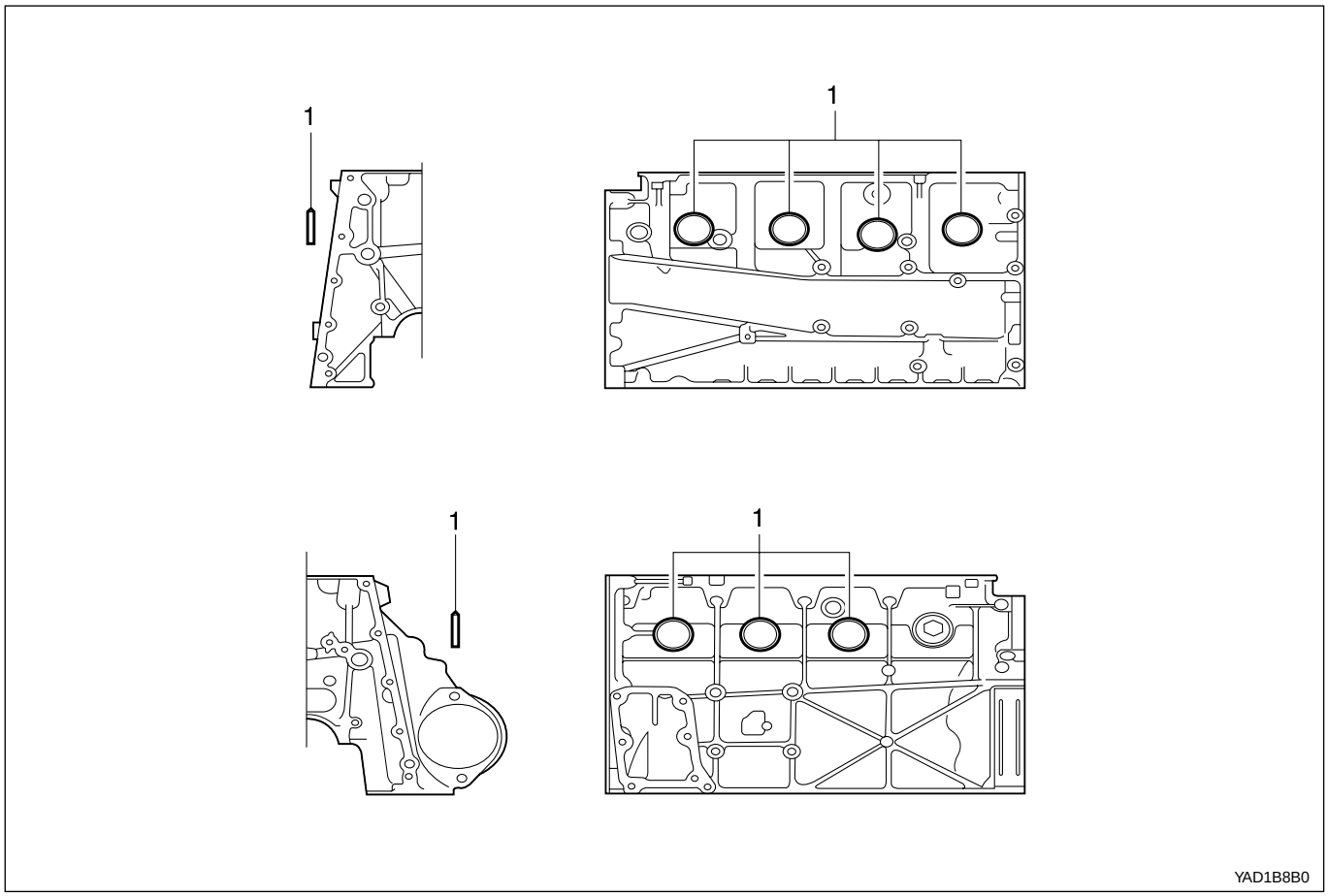
It is very hard to remove the oil dipstick guide tube without special tool. If it is not necessary, do not remove the guide tube.

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

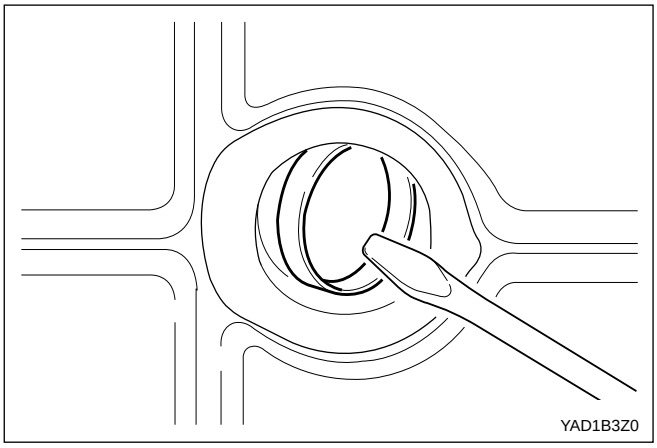
UNIT REPAIR

CORE PLUGS IN CRANKCASE

Preceding Work: Draining of the coolant



1 Core Plug ..... Replace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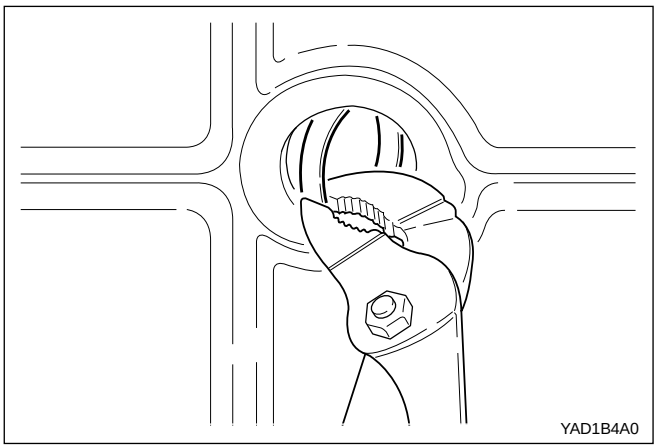
Tools Required

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.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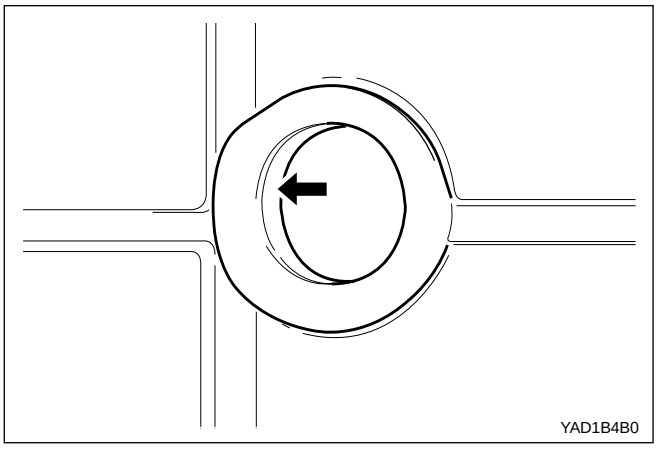
3. Pull out the plug carefully using a pliers.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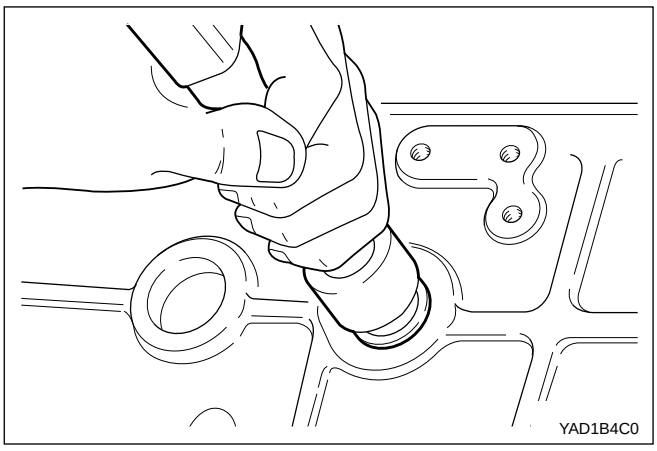
4. Clean the sealing surface and apply Loctite 241.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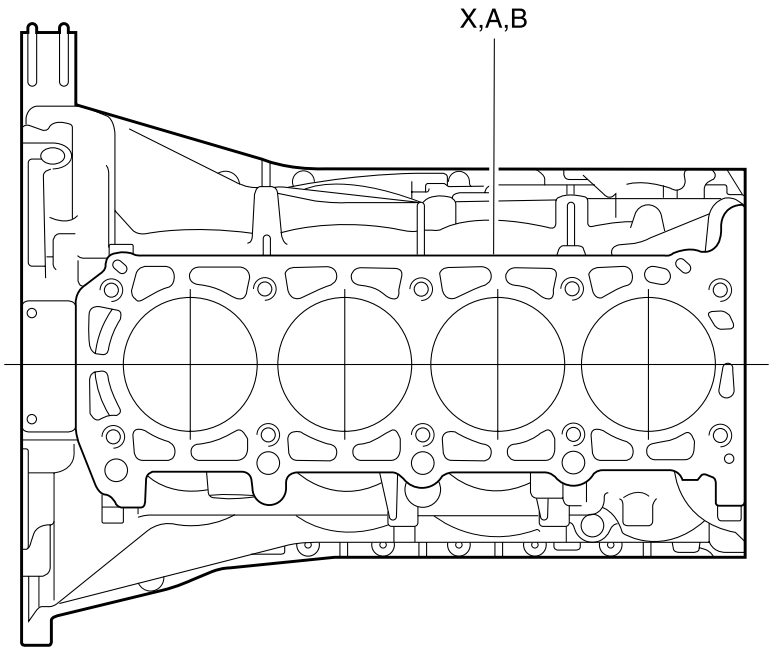
5. Press in new plug using a drift.

   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.

CYLINDER BORE



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Group Code Letter and Cylinder Bore Size

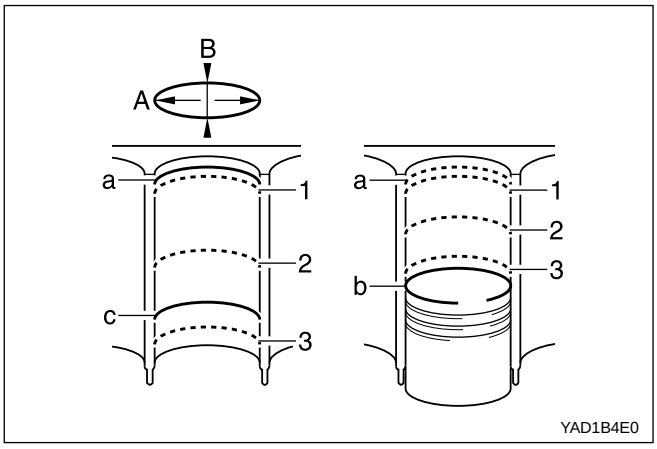
Engine	Group Code Letter of Cylinder	Piston Type to be Used	Cylinder Bore Size (mm)
E23	A	A or X	ϕ 90.906 - ϕ 90.912
	X	A, X or B	ϕ 90.906 - ϕ 90.912
	B	X or B	ϕ 90.912 - ϕ 90.918
	X + 5	X + 5	ϕ 90.950 - ϕ 90.968
	X + 10	X + 10	ϕ 91.000 - ϕ 91.018

Group Code Letter Cylinder	Group Code Letter 1)	Cylinder Bore Size (mm)
Standard Size ∅ 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

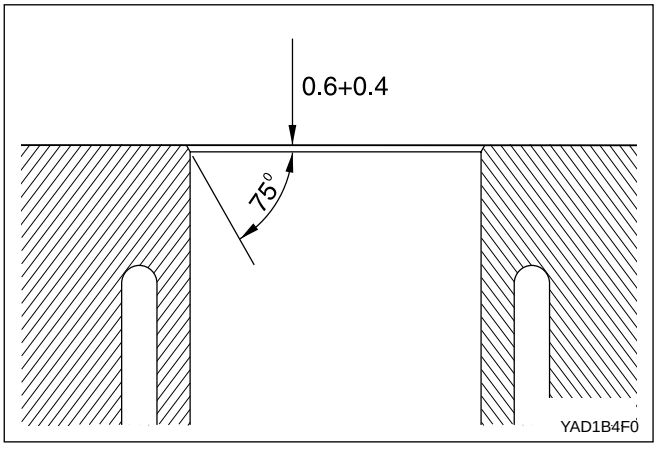
A. Axial Direction

B. Transverse Direction

a. Location of the No.1 Piston Ring at TDC

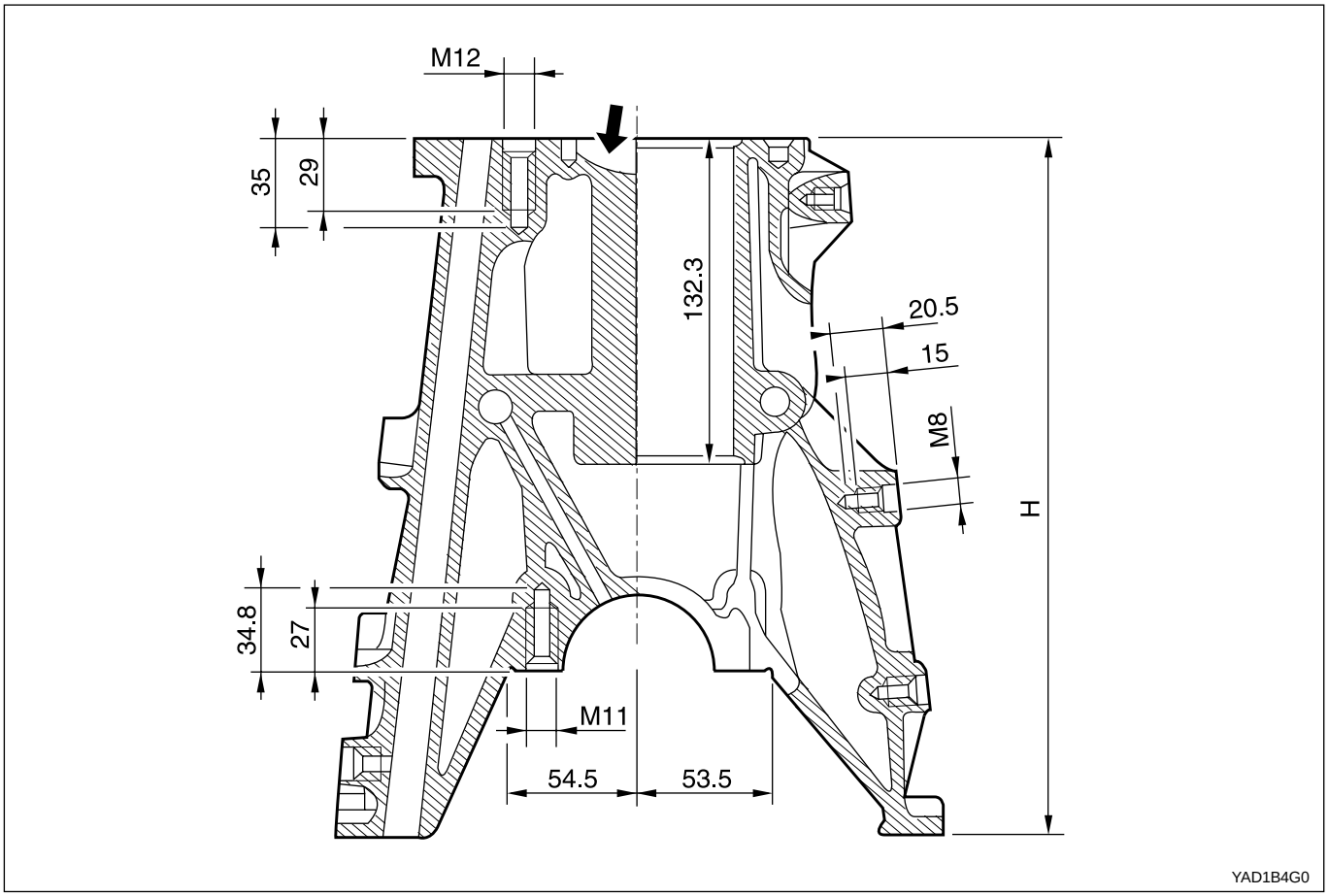
b. Location of the Piston BDC

c. Location of the Oil Ring at BDC



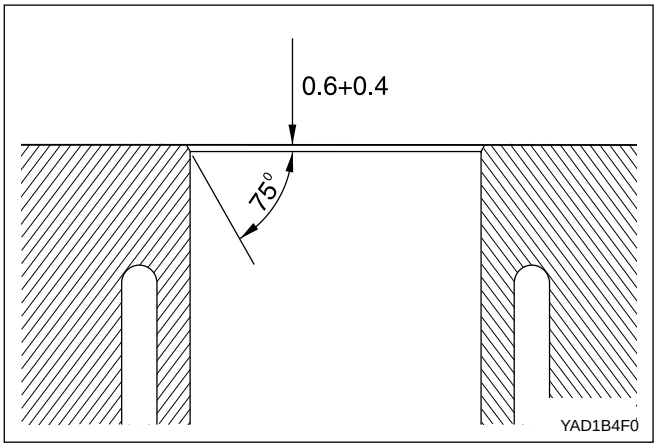
Chamfer Angle

CRANKCASE MATING SURFACE



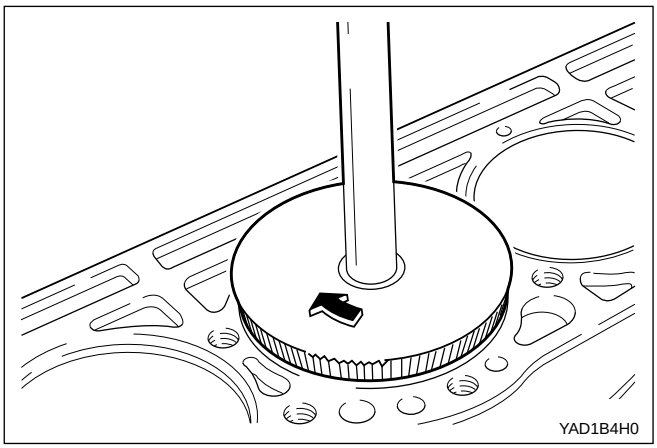
Service Data Standard

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

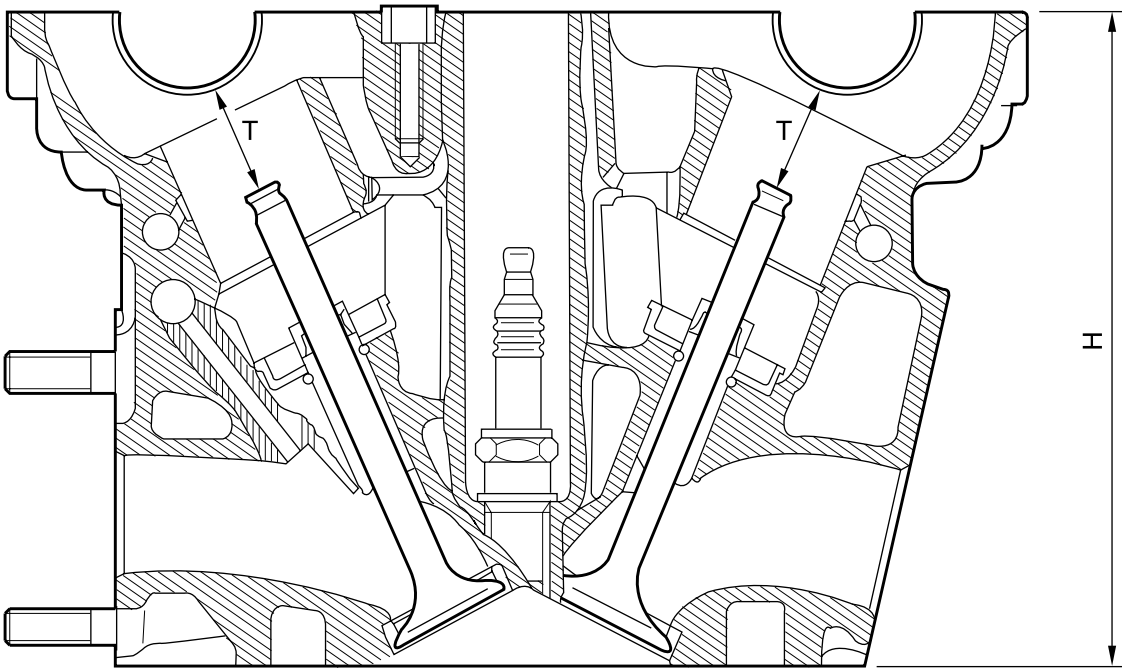
1. Chamfer angle : 75 °



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

CYLINDER HEAD MATING SURFACE

Preceding Work: Removal of valves



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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

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

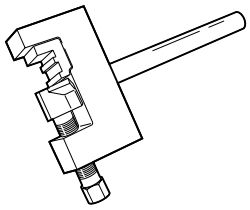
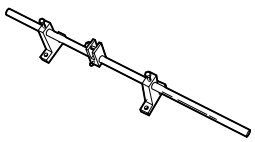
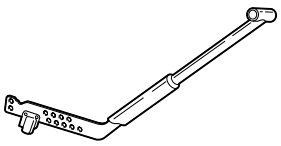
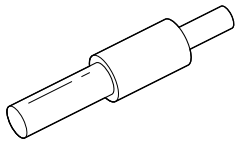
Application		N•m	Lb-Ft	Lb-In
Fuel Feed and Return Line		21 - 25	15 - 18	-
Exhaust Manifold and Pipe		30	22	-
Engine Mounting Nuts		70	52	-
Generator Carrier Bolts		25	18	-
Tensioning Pulley Bolt		40.5 - 49.5	29.9 - 36.5	-
Steering Pump Bolts		22.5 - 27.5	16.6 - 20.3	-
A/C Braket Bolts		22.5 - 27.5	16.6 - 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	-

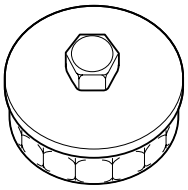
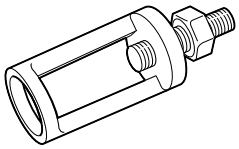
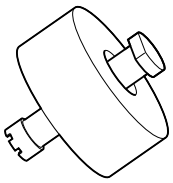
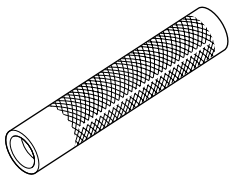
FASTENER TIGHTENING SPECIFICATIONS (Cont'd)

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	-

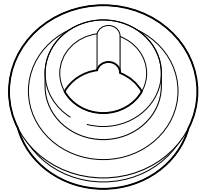
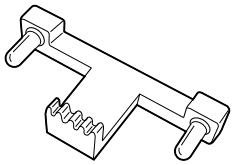
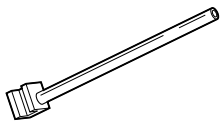
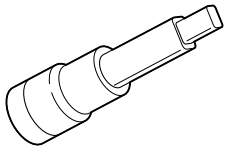
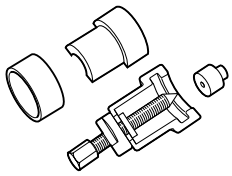
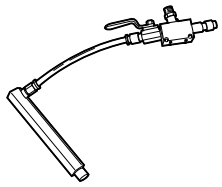
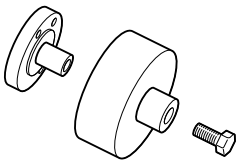
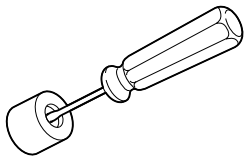
SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS TABLE

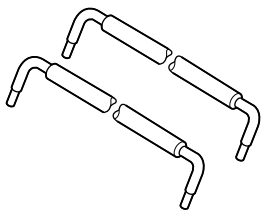
 YAD1B1W0	**000 589 58 43 00** **Chain Assembly**
 YAD1B0W0	**111 589 01 59 00** **Supporting Bar**
 YAD1B0X0	**111 589 18 61 00** **Lever Pusher**
 YAD1B570	**116 589 01 34 00** **Threaded Pin**

 YAD1B2Y0	**103 589 02 09 00** **Oil Filter Remover**
 YAD1B0Y0	**111 589 25 63 00** **Thrust Piece**
 YAD1B580	**116 589 20 33 00** **Sliding Hammer**
 YAD1B1L0	**119 589 00 43 00** **Drift**

Special Tools Table (Cont'd)

 YAD1B790	**601 589 03 14 00 Crankshaft Front Seal Installer**	 YAD1B720	**602 589 00 40 00 Engine Lock**
 YAD1B4K0	**603 589 00 40 00 Fan Clutch Holder**	 YAD1B560	**617 589 00 10 00 Allen Wrench Socket**
 YAD1B2M0	**615 589 01 33 00 Crankshaft Sprocket Puller**	 YAD1B0Z0	**DW110 - 090 Connecting Hose**
 YAD1B730	**601 589 03 43 00 Crankshaft Rear Seal Installer**	 YAD1B1A0	**DW110 - 100 Valve Tappet Remover**

Special Tools Table (Cont'd)

 YAD1B4R0	**111 589 03 15 00** **Holding Pin**

SECTION 1B3

DIESEL ENGINE MECHANICAL

CAUTION: 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.

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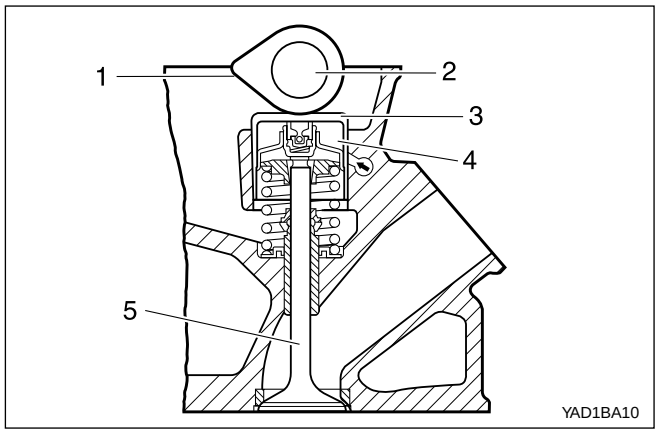
DESCRIPTION AND OPERATION

VALVE DEVICE

Operation

The diesel engines have valves with bucket tappets and automatic valve clearance adjustment. This eliminates the need to re-set the valve clearance.

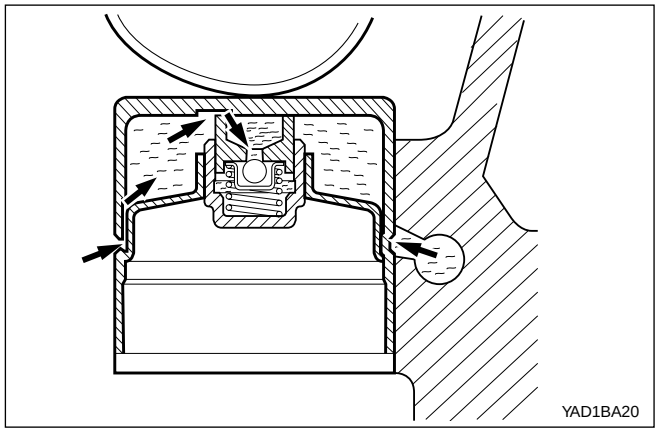
The compact design of the valve timing gear from the cam through the bucket tappet to the valve contributes to weight savings, to low drag power and also to increased rigidity. Oil is supplide to the bucket tappets through oil bores in the cylinder head.



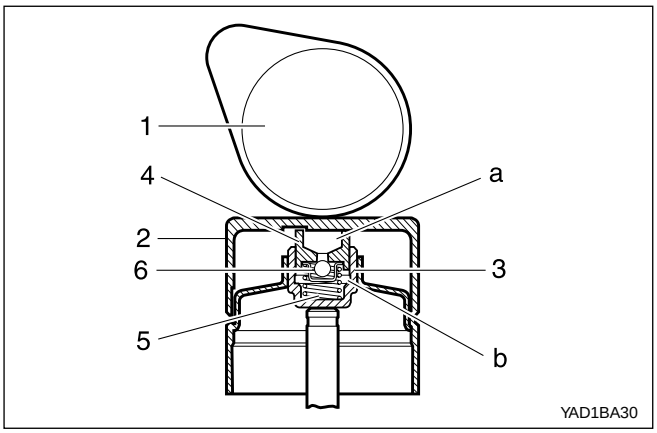
1 Cam
2 Camshaft
3 Tappet
4 Oil
5 Valve

The maintenance-free hydraulic valve clearance adjusting elements automatically compensates the valve clearance resulting from thermal expansion and wear.

This produces a quiet-running valve train.



Function



1 Cam
2 Tappet
3 Guide Sleeve
4 Thrust Piece
5 Pressure Spring
6 Ball Valve
a Supply Chamber
b Working Chamber

The hydraulic valve clearance adjusting elements are installed in the bucket tappets and operate the valves directly through the thrust pins and guide sleeves.

When the engine is running and a load is applied on the element by cam tip, the element cam go down fully. The oil displaced from the working chamber flows via the annular gap (clearance between guide sleeve and thrust pin) to the supply chamber.

As soon as the cam lobe rotates upwards from the tappet (2), the load on the guide sleeve (3) is relieved.

The spring (5) pushes the thrust pin (4) up until the tappet is resting against the cam (1). The vacuum produced in the working chamber (b) as a result of the upward movement of the guide sleeve opens the ball valve (6) and oil flows out of the supply chamber (a) into the working chamber (b).

The ball valve closes when the cam presses against the tappet and thus applies pressure on the thrust pin.

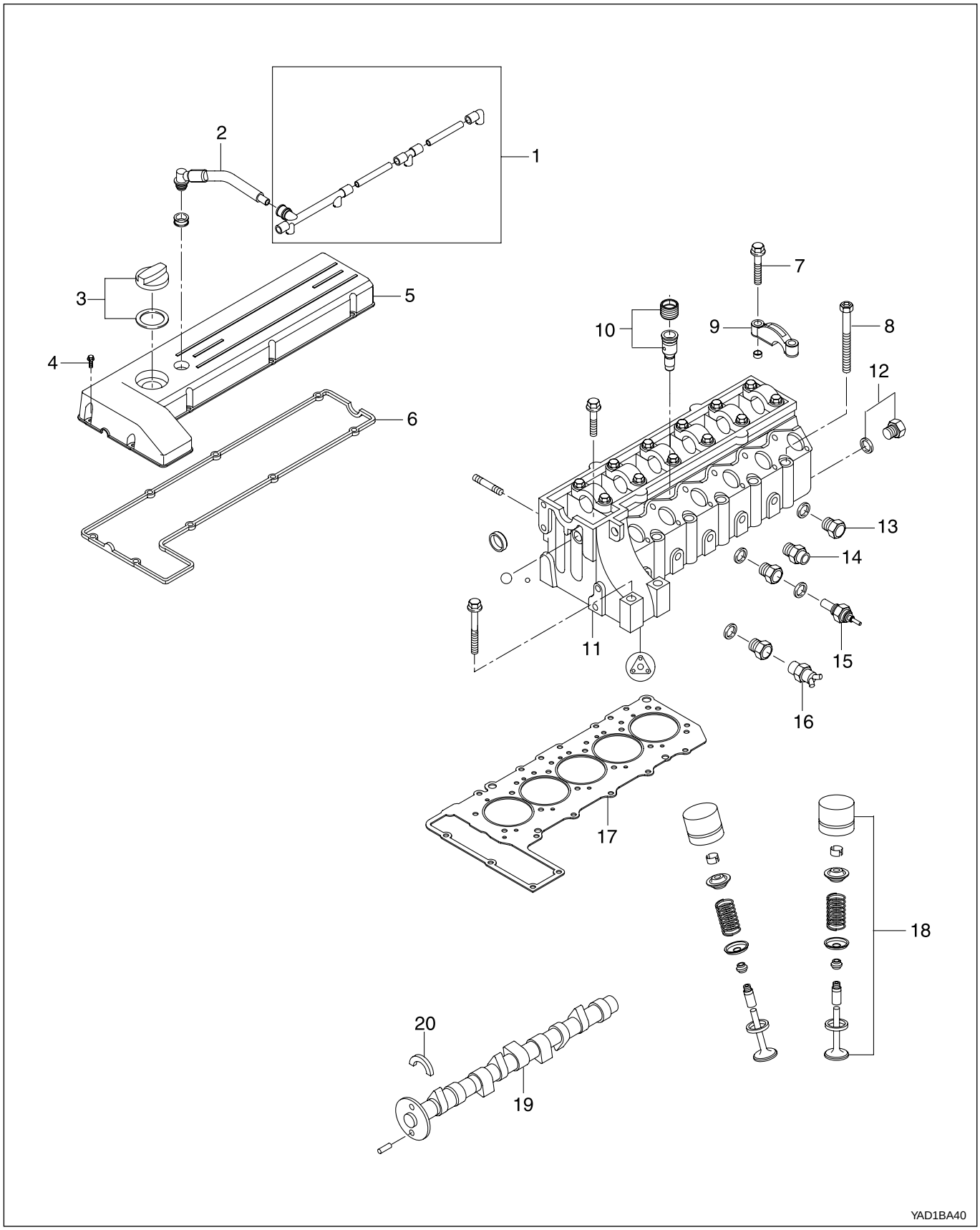
The oil in the working chamber acts as a “hydraulic rigid connection” when the engine is running and the relevant valve is opened. The oil required for this purpose is supplied to the elements along a longitudinal passage in the cylinder head. From here, the oil flows through a bore to the relevant adjustment element.

The oil to the supply chamber flows via the groove provided in the base of the tappet.

BLANK

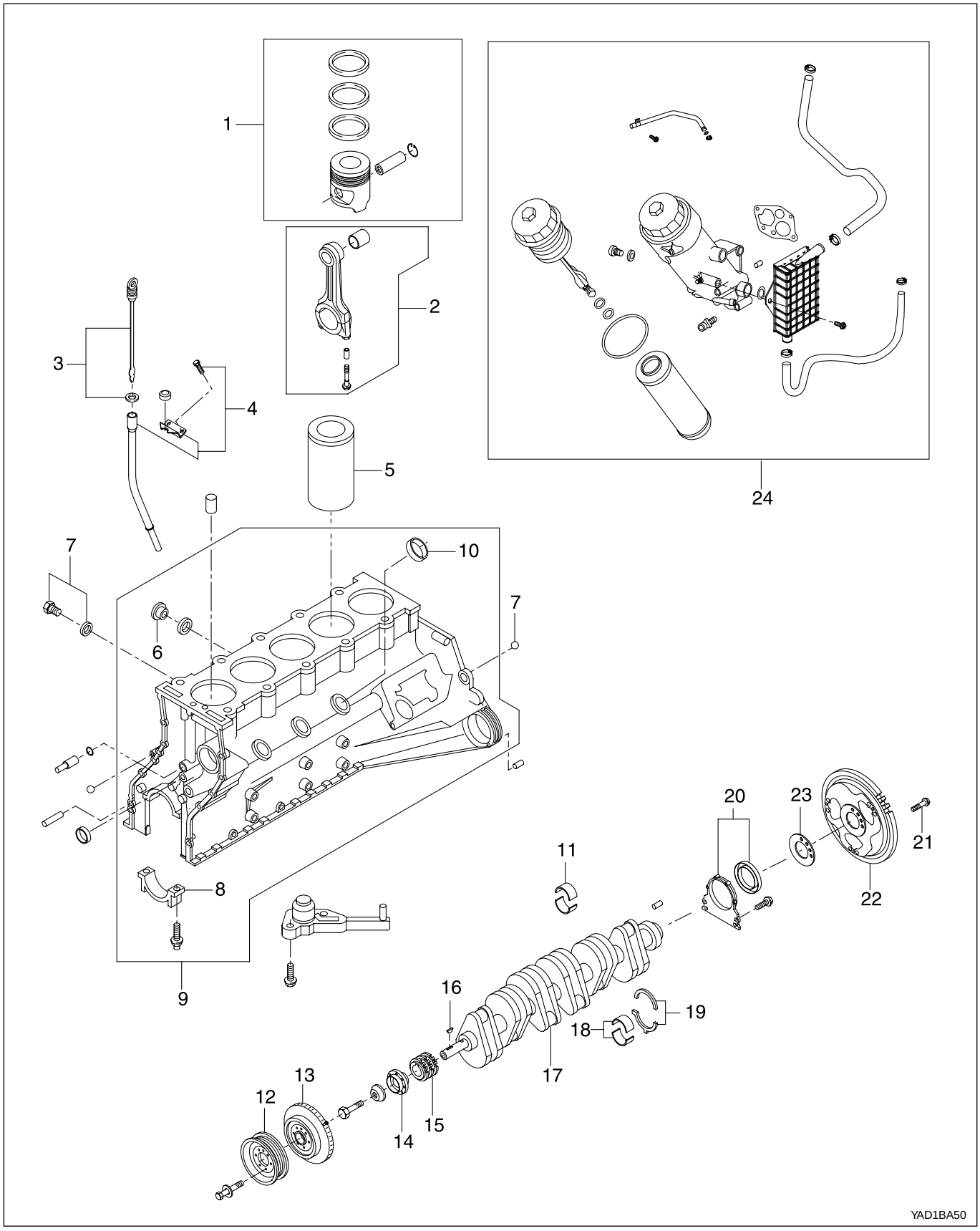
COMPONENT LOCATOR

CYLINDER HEAD



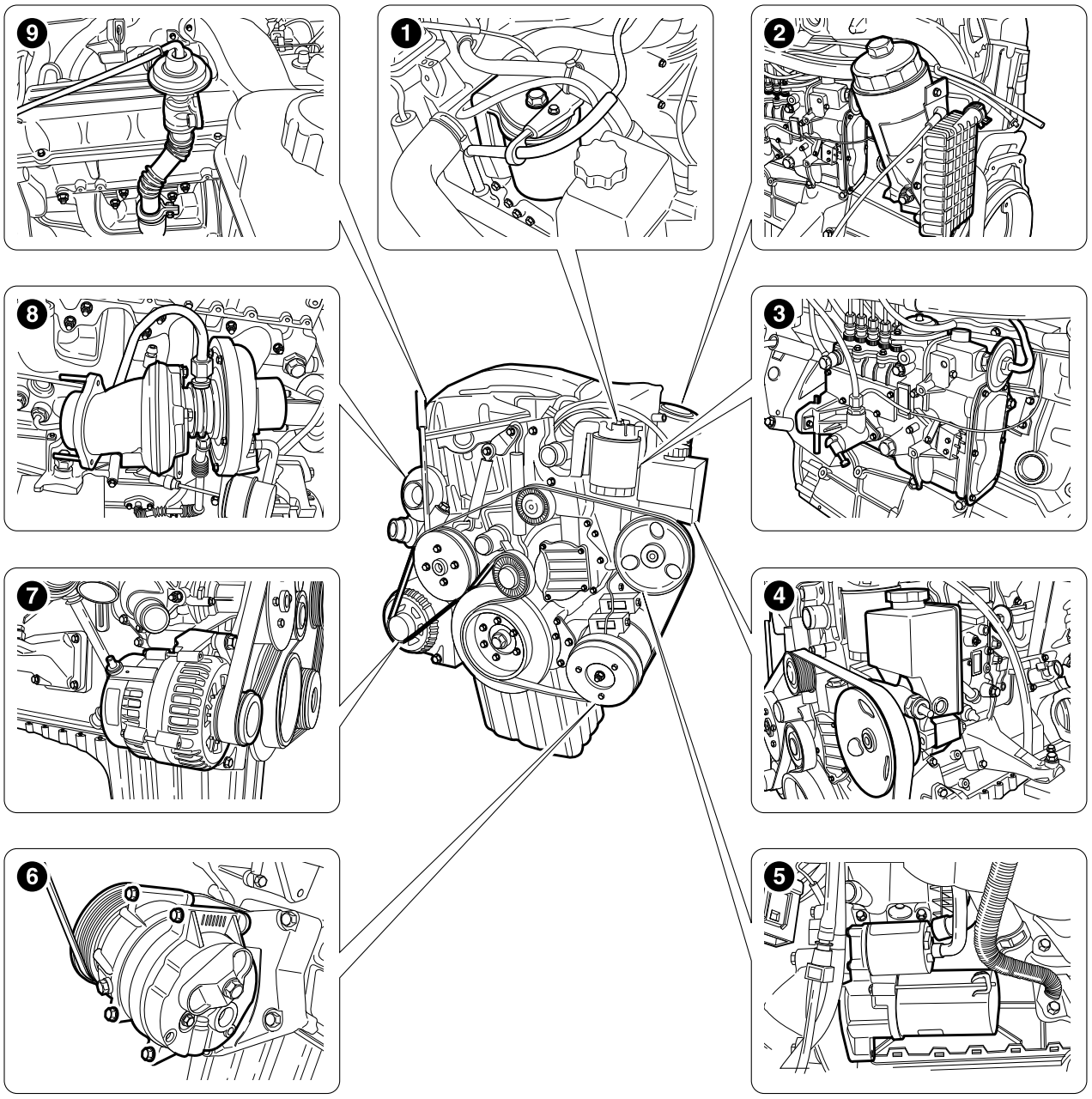
1 Blow By Gas Return Hose
2 Blow By Gas Return Pipe
3 Oil Filler Cap
4 Bolt
5 Cylinder Head Cover
6 Cylinder Head Cover Gasket
7 Camshaft Cap Bolt
8 Cylinder Head Bolt
9 Camshaft Bearing Cap
10 Pre Chamber Assembly
11 Cylinder Head
12 Plug
13 Plug
14 Connector
15 Engine Coolant Temperature Sensor
16 Thermo Valve
17 Cylinder Head Gasket
18 Valve Assembly
19 Camshaft
20 Camshaft Adjust Key

CYLINDER BLOCK



1 Piston & Piston Ring Assembly
2 Connection Rod Assembly
3 Oil Dipstick Gauge
4 Oil Dipstick Gauge Bracket
5 Cylinder Liner
6 Plug
7 Screw & Seal Ring
8 Crankshaft Bearing Cap
9 Cylinder Block
10 Plug
11 Crankshaft Journal Bearing
12 Crankshaft Pulley
13 Vibration Damper
14 Hub
15 Crankshaft Sprocket
16 Key
17 Crankshaft
18 Crankshaft Journal Bearing
19 Crankshaft Thrust Bearing
20 Crankshaft Sealing Cover
21 Bolt
22 Flywheel
23 Plate
24 Oil Pump Assembly

ENGINE COMPONENT

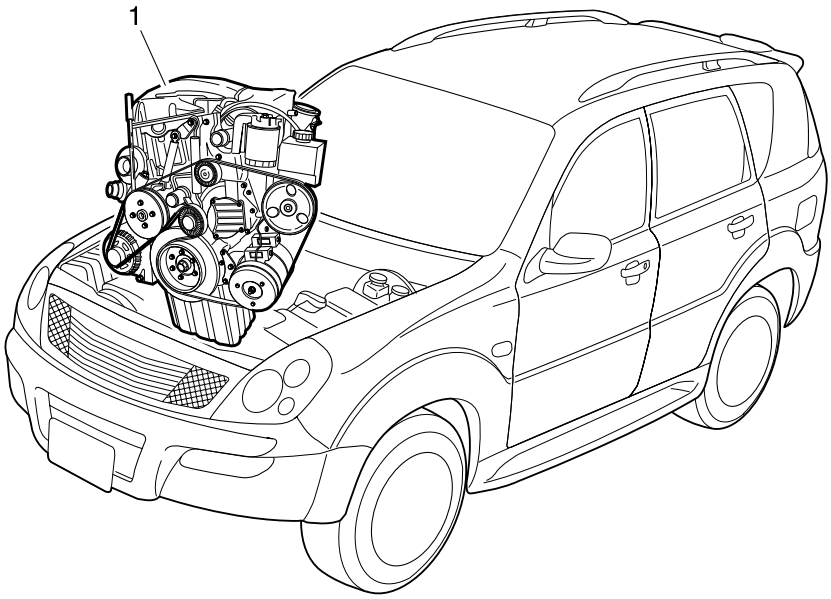


1 Fuel Filter Assembly
2 Oil Filter Assembly
3 Injection Pump Assembly
4 Power Steering Pump Assembly
5 Starter Assembly
6 A/C Compressor Assembly
7 Generator Assembly
8 Turbo Charger Assembly
9 EGR Valve Assembly

REPAIR INSTRUCTIONS

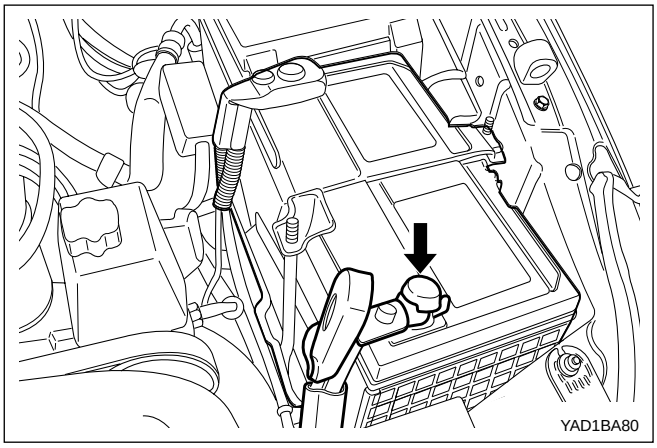
ON-VEHICLE SERVICE

ENGINE ASSEMBLY



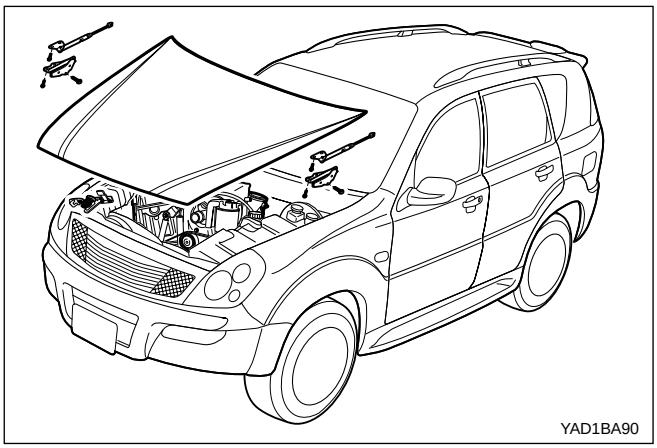
YAD1BA70

1. Engine Assembly

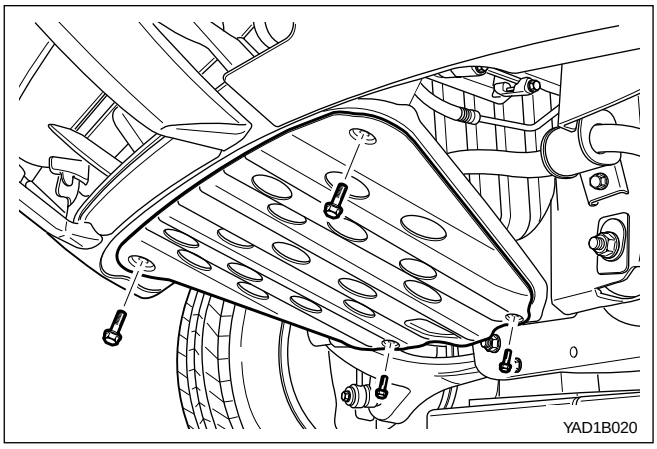

YAD1BA80

Removal Procedure

1. Disconnect the negative battery cable.


YAD1BA90

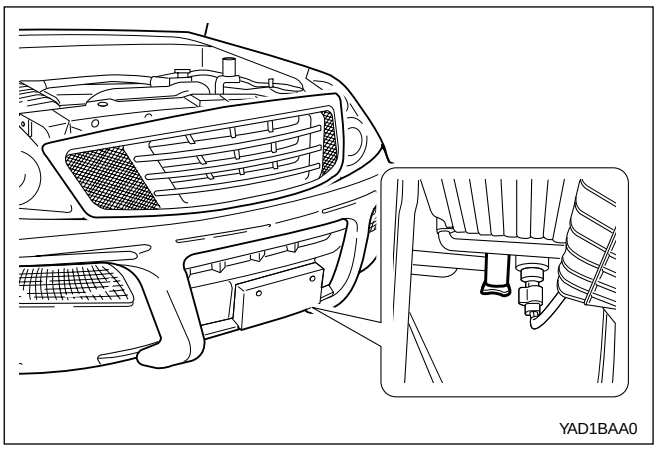
2. Remove the hood.


YAD1B020

3. Remove the skid plate.

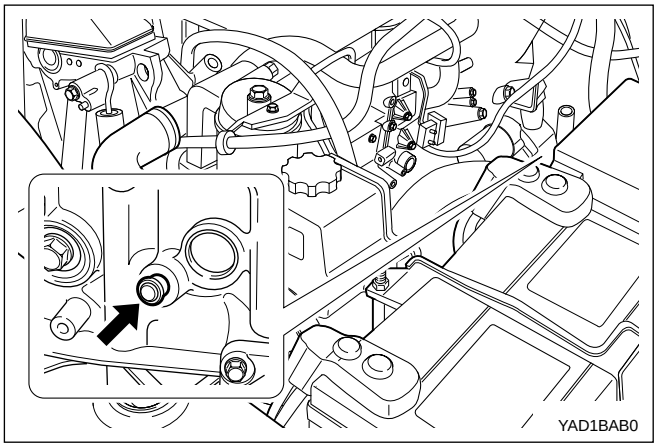
Installation Notice

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


YAD1BAA0

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

Notice: Open the coolant reservoir tank cap.

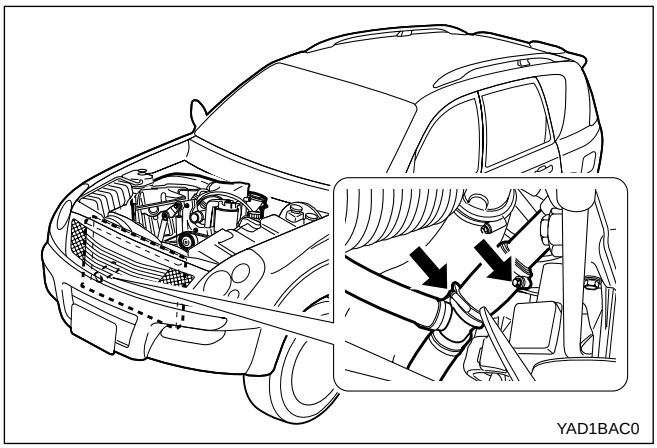


5. Remove the drain plug and seal from the cylinder block and drain the coolant completely.

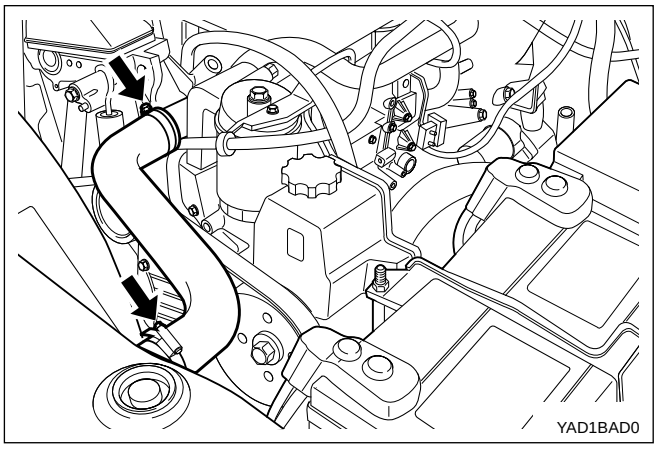
Installation Notice

Tightening Torque	30 N•m (22 lb-ft)

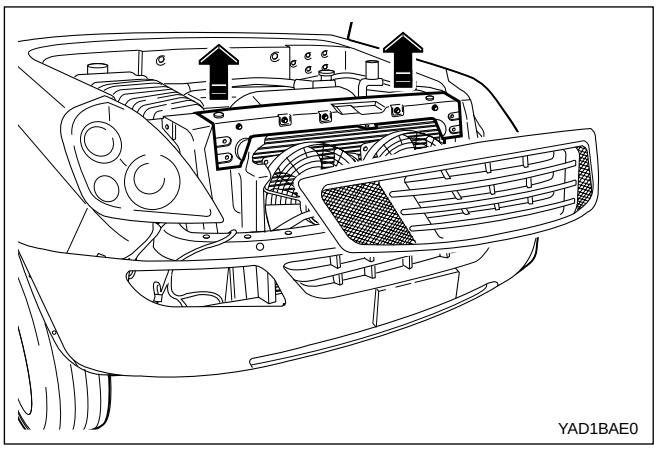
After draining, replace the seal and reinstall the drain plug.



6. Disconnect the lower coolant hose from the radiator.



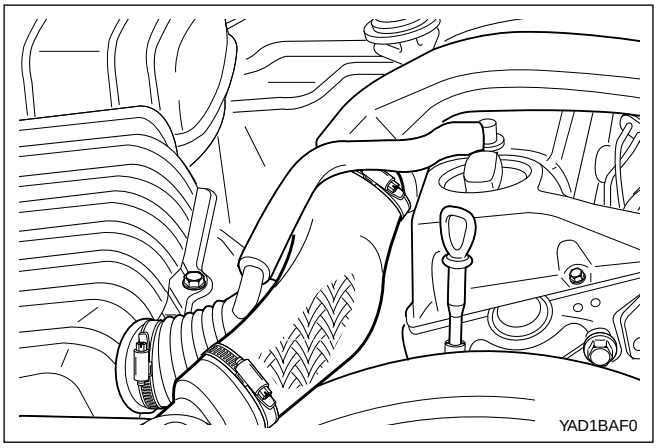
7. Disconnect the upper coolant hose from the radiator.



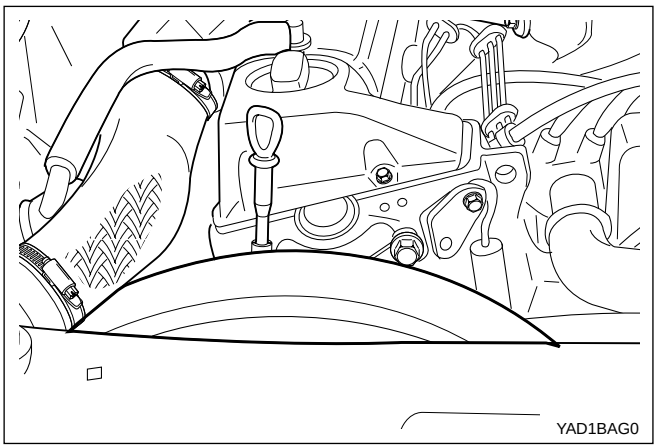
8. Remove the radiator grille mounting screws and radiator grille.
9. Remove the front end upper member mounting blots and front end upper.

Installation Notice

Tightening Torque	30 - 40 N•m (22 - 30 lb-ft)



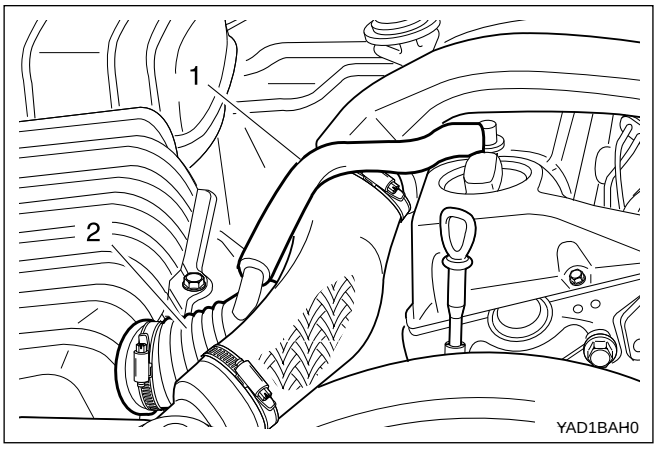
10. Remove the hoses (air intake to intercooler, intercooler to intake duct).



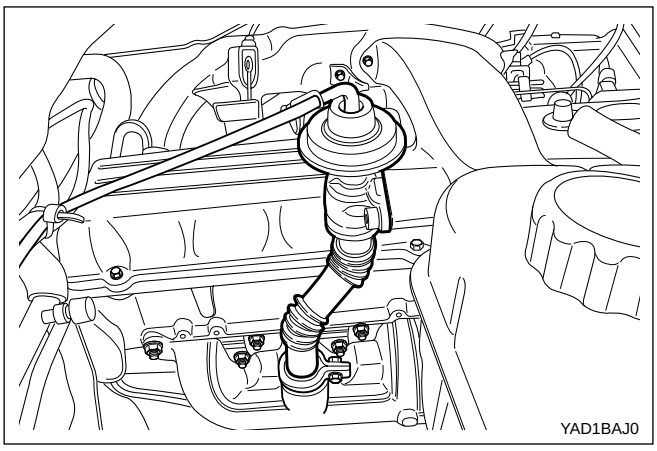
11. Loosen the cooling fan shroud bolts and remove the cooling fan shroud.

Installation Notice

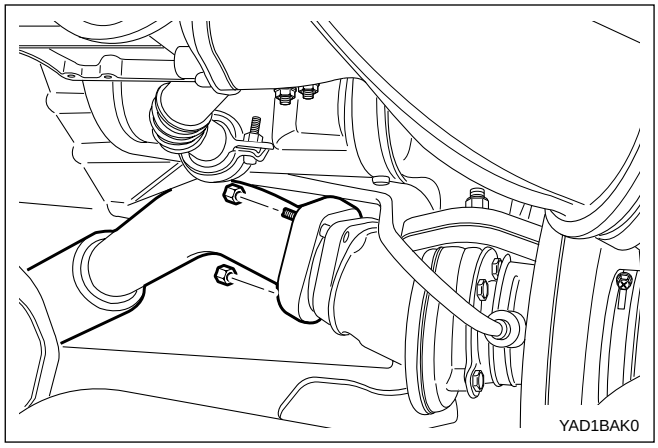
Tightening Torque	3 - 7 N•m (27 - 62 lb-in)



12. Remove the air cleaner to turbo charger hose(2) with blow by hose(1).



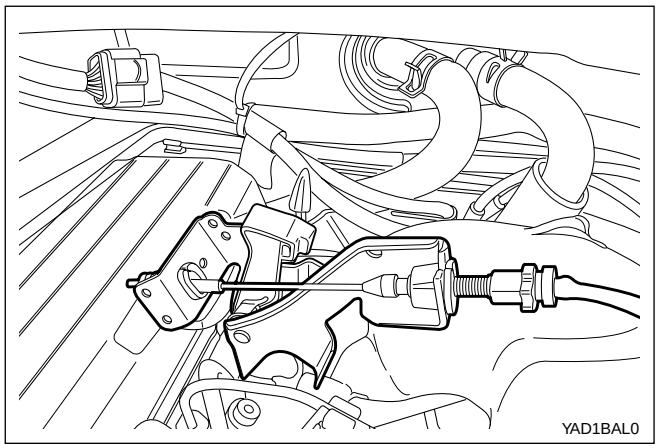
13. Disconnect the exhaust gas recirculation (EGR) valve hose and necessary hoses and pipes.



14. Remove the turbo charge to exhaust pipe bolts and separate the exhaust pipe flange from the turbo charger.

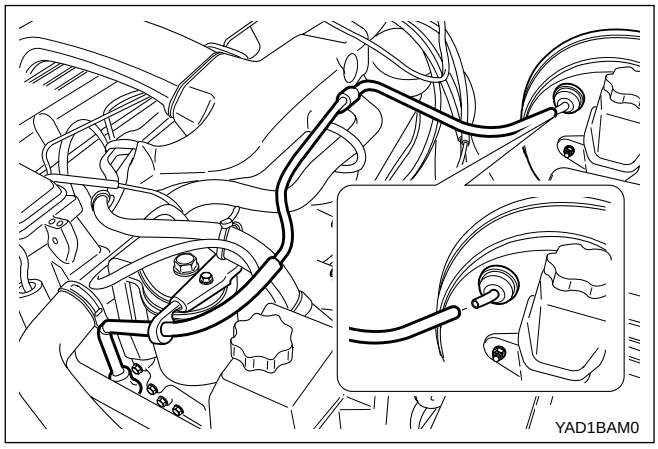
Installation Notice

Tightening Torque	30 N•m (22 lb-ft)

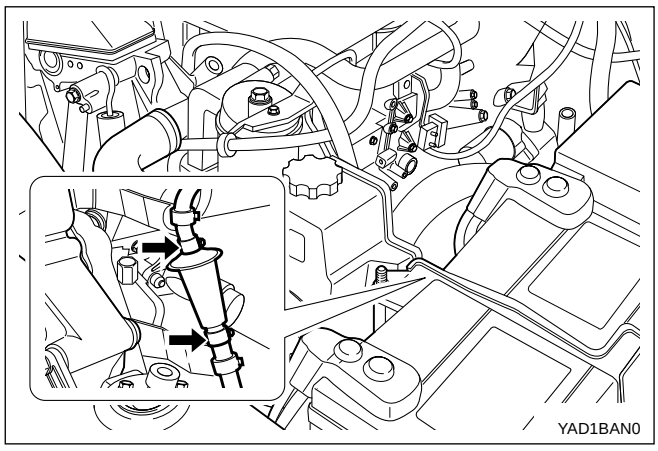


15. Disconnect the accelerator cable from the control linkage.

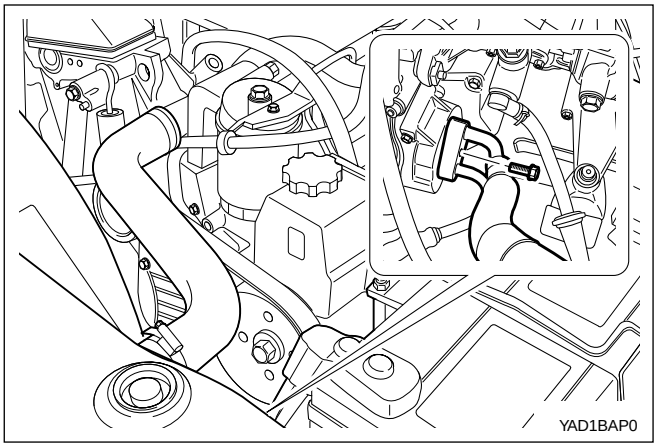
Notice: After installation of accelerator cable, check the engine idling and operation condition.



16. Disconnect the brake booster hose from vacuum pump.

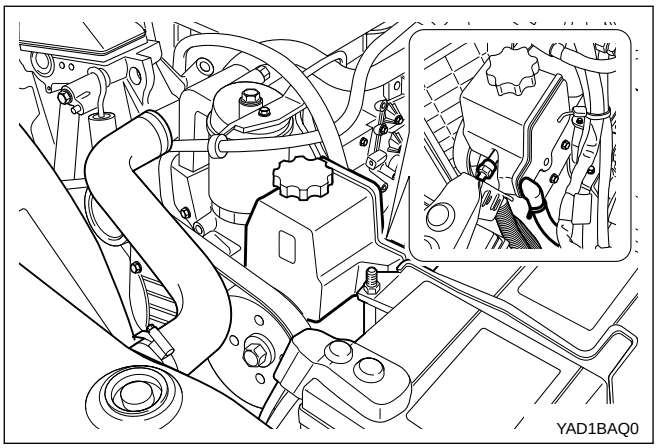


17. Disconnect the fuel feed line with prefilter from the feed pump on injection pump.



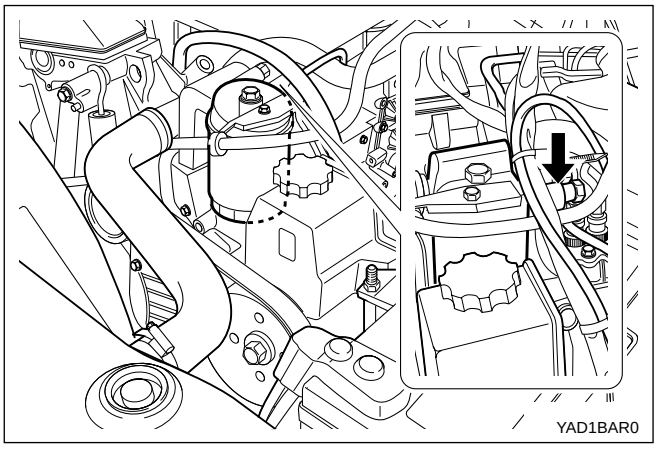
18. Remove the A/C compressor IN/OUT pipes.

    Notice: Evacuate the refrigerant before removal.

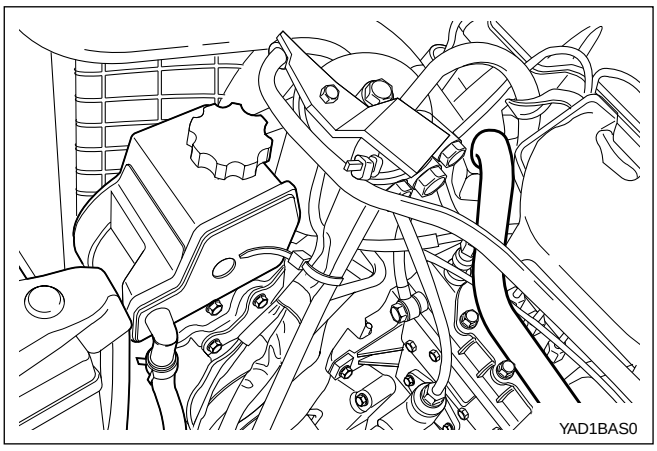


19. Remove the power steering pump lines.

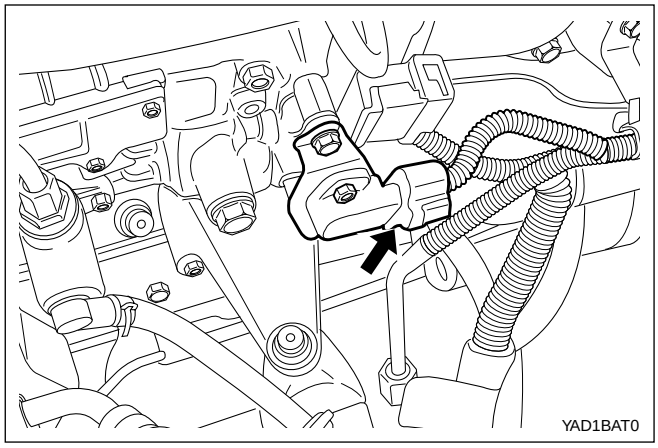
    Notice: Completely drain the fluid.



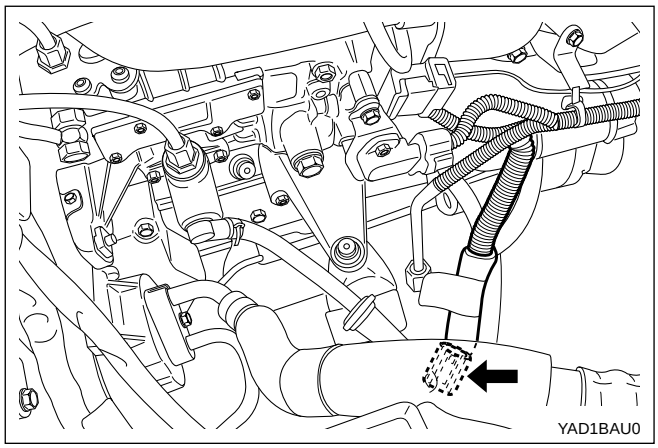
20. Remove the fuel lines from the fuel filter and cover the filter with plug.



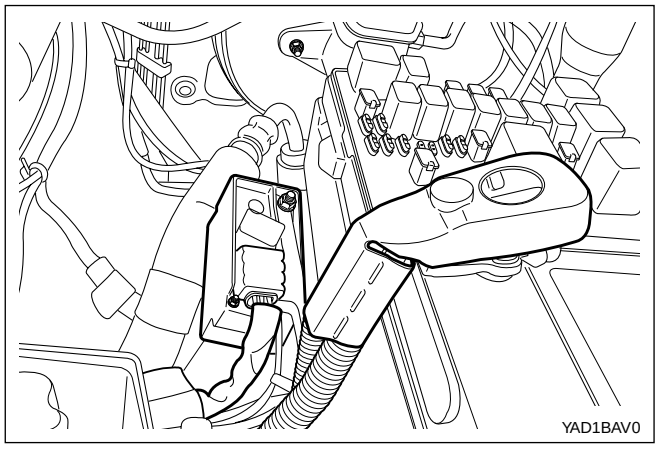
21. Disconnect the coolant hose from the water inlet.



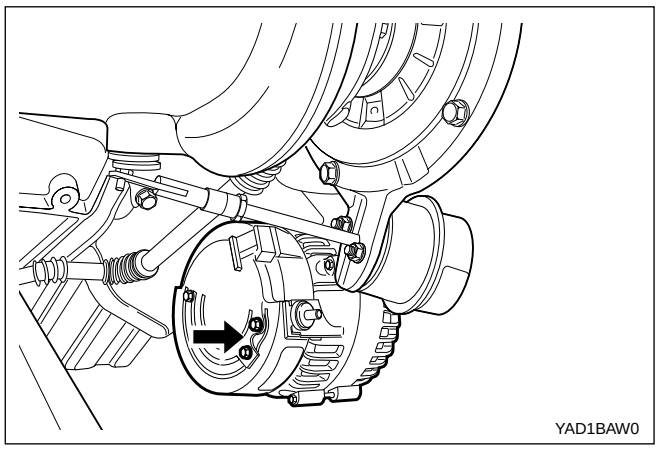
22. Disconnect the injection timing relay connector from injection pump.



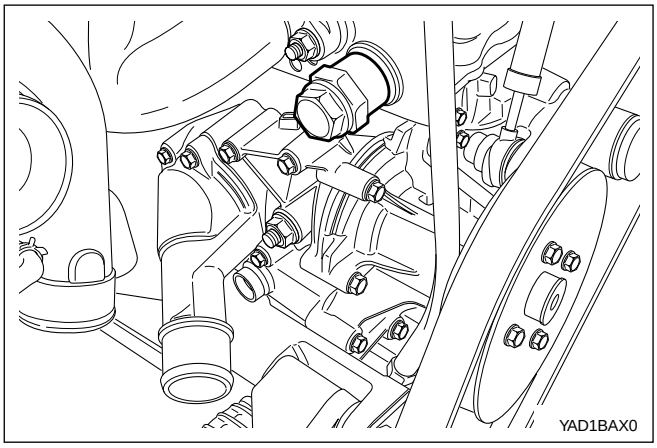
23. Disconnect the starter motor wires and necessary connectors.



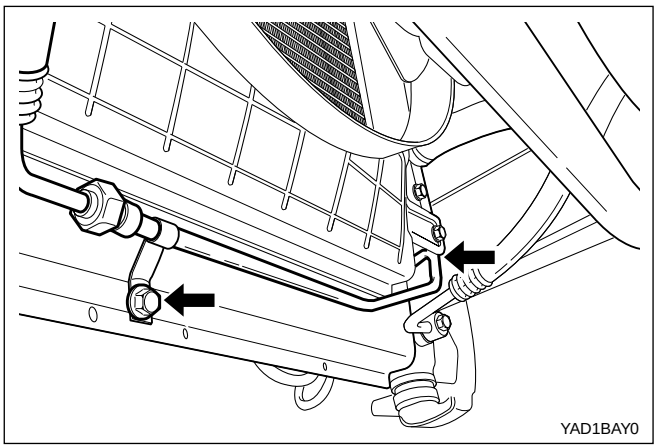
24. Disconnect the preheating time relay cable and glow plug cable.



25. Disconnect the ground cable.
26. Disconnect the generator wires.



27. Disconnect the engine coolant temperature sensor connector.

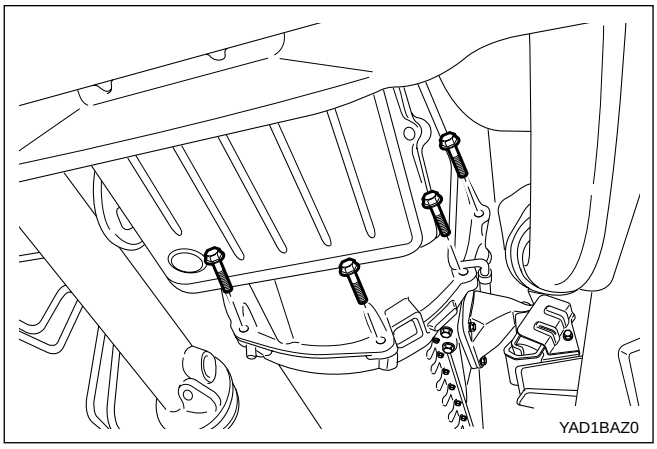


28. Remove the automatic transmission oil cooler lines.

Installation Notice

Tightening Torque	25 - 35 N•m (18 - 26 lb-ft)

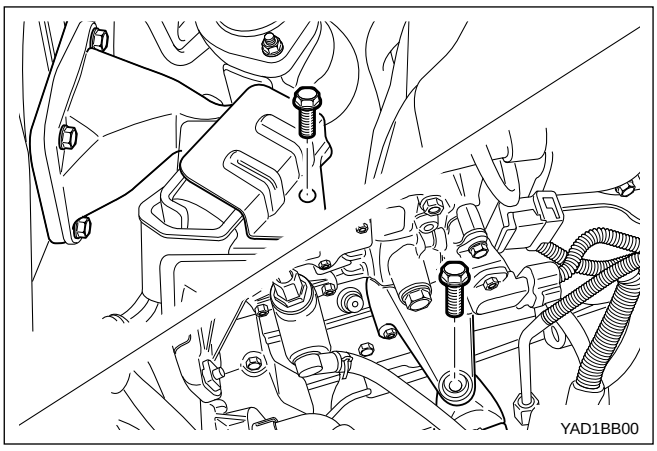
Use the new washer before installation of oil cooler lines.



29. Remove the transmission mounting bolts and separate the transmission from the engine.

Installation Notice

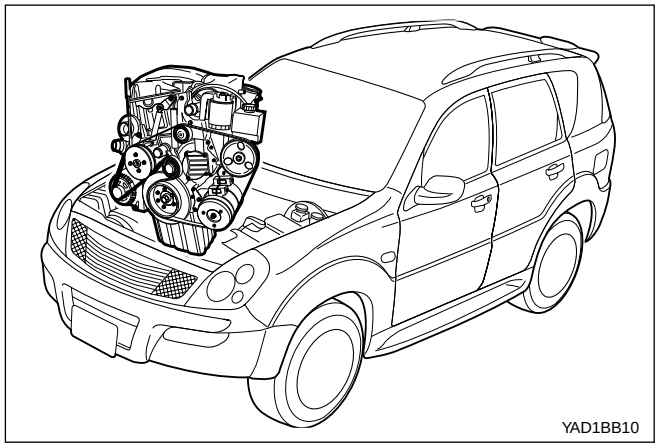
Tightening Torque	54 - 68 N•m (40 - 50 lb-ft)



30. Remove the engine mounting bracket bolts.

Installation Notice

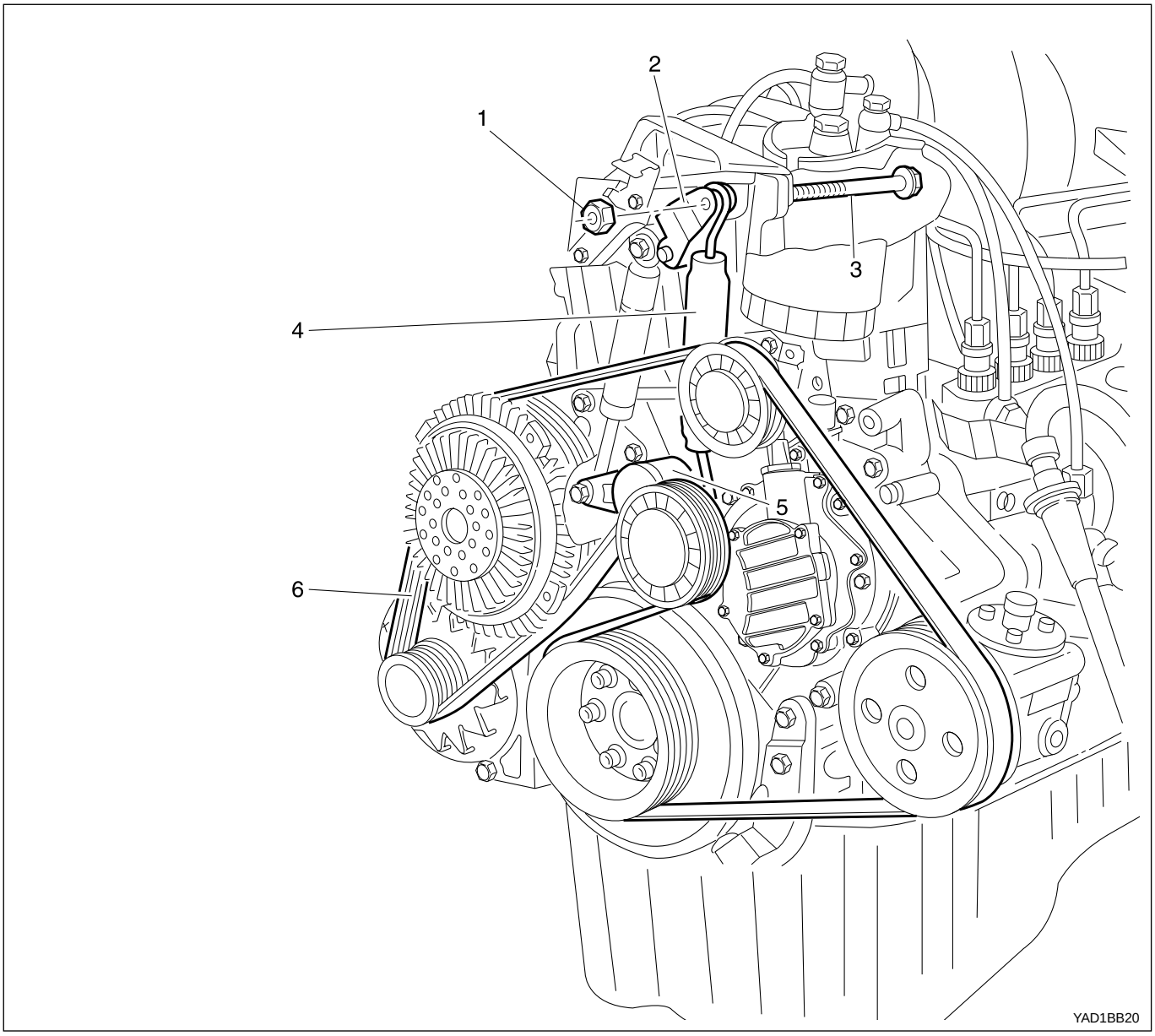
Tightening Torque	50 - 75 N•m (37 - 55 lb-ft)


YAD1BB10

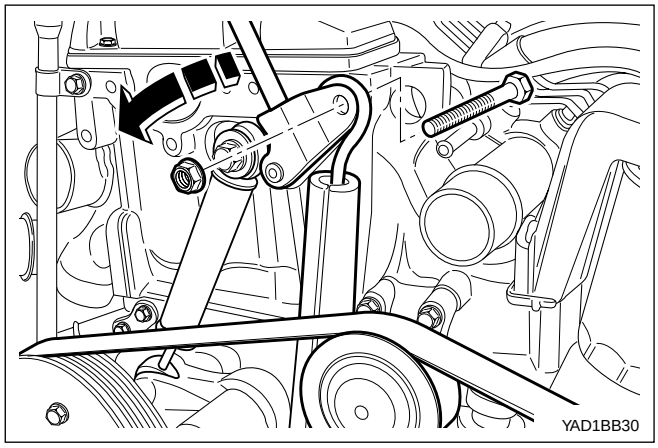
31. Remove the engine assembly from the vehicle by using a hoistor crane.
32. Installation should follow the removal procedure in the reverse order.

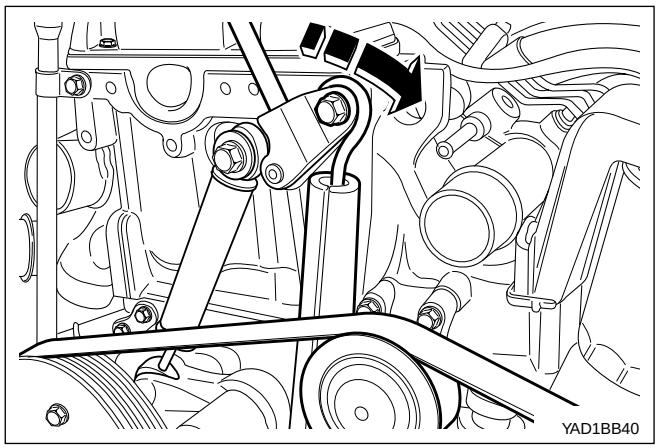
POLY V-BELT AND TENSIONING DEVICE

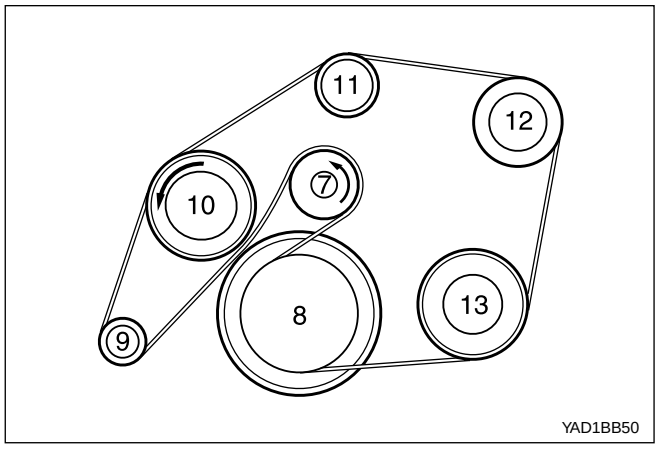
POLY V-BELT



1 Nut ..... 21 N•m (15 lb-ft)
2 Tensioning Lever
3 Bolt
4 Spring
5 Tensioning Lever
6 Poly V-Belt







7 Tensioning Pulley
8 Crankshaft
9 Generator
10 Water Pump
11 Guide Pulley
12 Power Steering Pump
13 A/C Compressor

Removal & Installation Procedure

1. Remove the tensioning lever nut (1).

   Installation Notice

Tightening Torque	21 N•m (15 lb-ft)

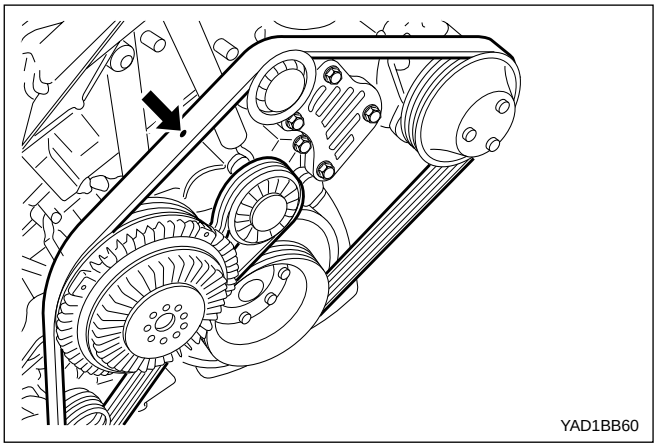
2. Push the tensioning lever in direction of arrow with a rod (ϕ 12, 180 mm) and pull out the bolt to the rear.

3. Push back the tensioning lever (arrow direction) to release the spring tension and remove the belt.

4. Install the poly V-belt beginning at the tensioning pulley (7).

Length of Belt

Length (L)	With Air Conditioner	2,100 mm
	Without Air Conditioner	2,040 mm

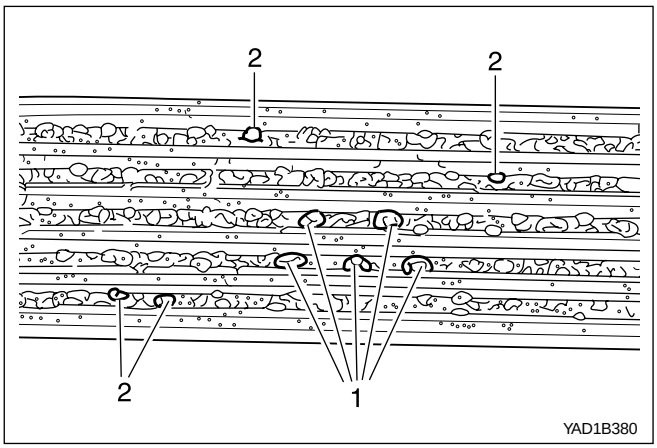

YAD1BB60

Poly V-Belt Inspection

Inspection Procedure

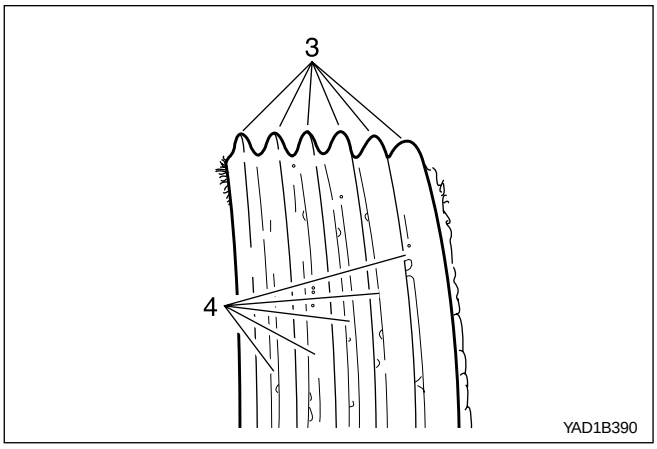
- Mark poly V-belt at a clearly visible point with chalk.
- Rotate the engine and check the belt.

  Notice: If one of the following types of damage is found, replace the belt.



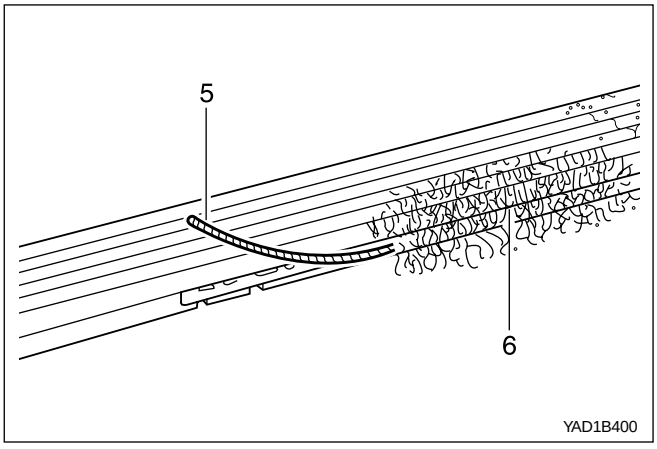
YAD1B380

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



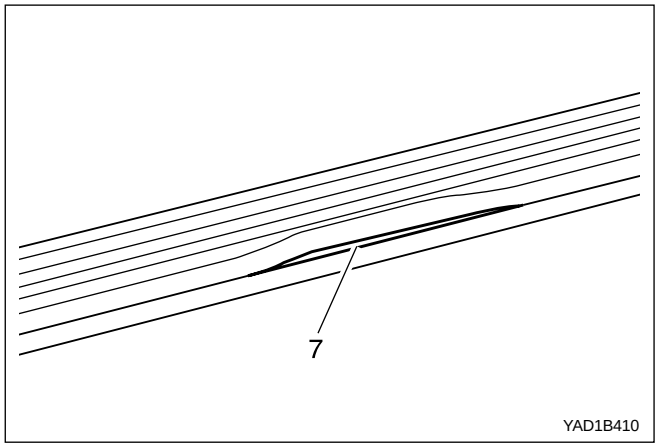
YAD1B390

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

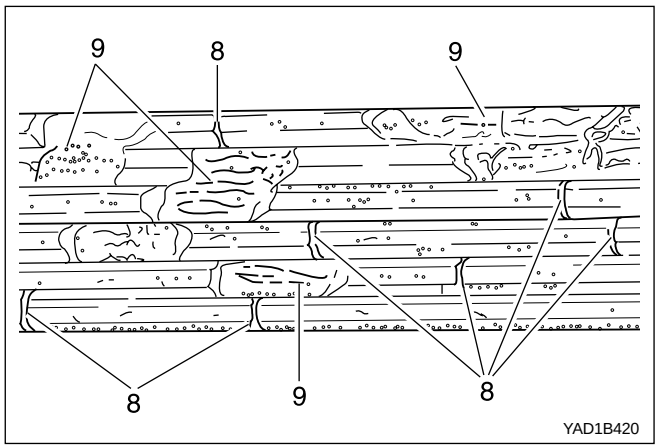


YAD1B400

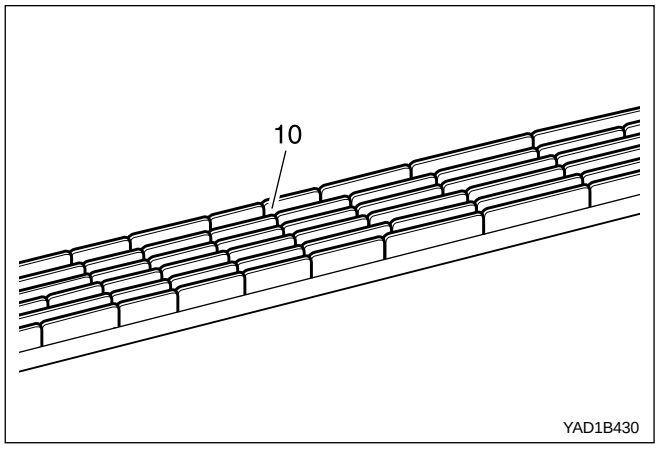
5. Cord torn out at the side.
6. Outer cords frayed.



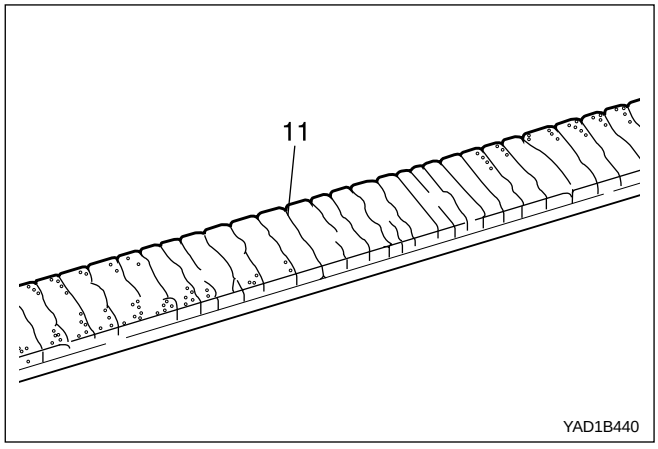
7. Belt detached from the base of rip.



8. Splits across the rips.
9. Sections of rip torn out.



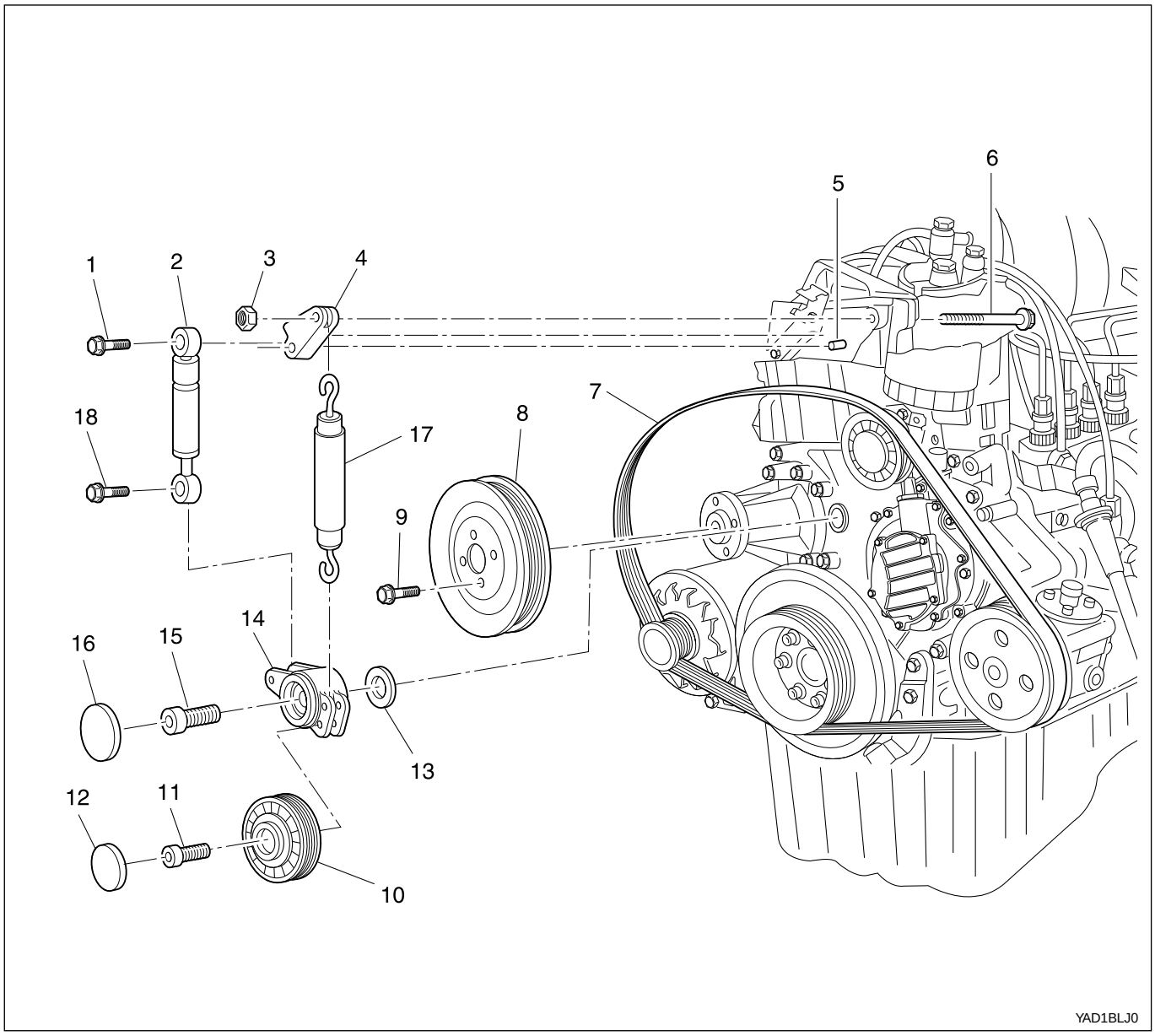
10. Splits across several rips.



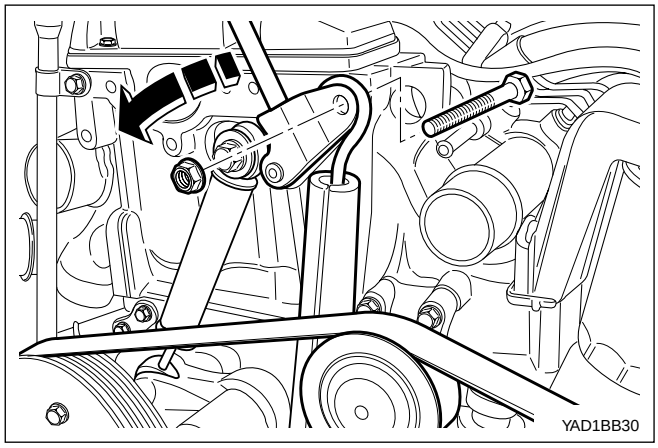
11. Splits across the back.

TENSIONING DEVICE

Preceding Work: Removal of cooling fan



1 Bolt ..... 21 N•m (15 lb-ft)
2 Damper
3 Nut ..... 21 N•m (15 lb-ft)
4 Tensioning Lever
5 Guide Rail Pin
6 Bolt
7 Poly V-Belt
8 Belt Pulley
9 Bolt ..... 10 N•m (89 lb-in)
10 Tensioning Pulley
11 Socket Bolt ..... 29 N•m (21 lb-ft)
12 Closing Cover
13 Washer
14 Tensioning Lever
15 Fit Bolt ..... 100 N•m (74 lb-ft)
16 Closing Cover
17 Spring
18 Bolt ..... 20 N•m (15 lb-ft)



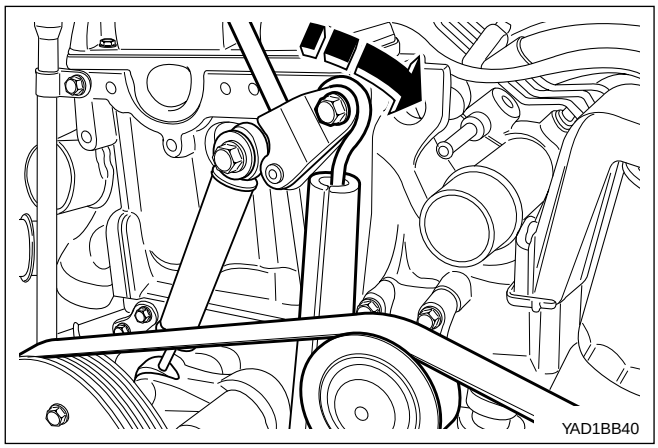
Removal & Installation Procedure

1. Remove the tensioning lever nut.

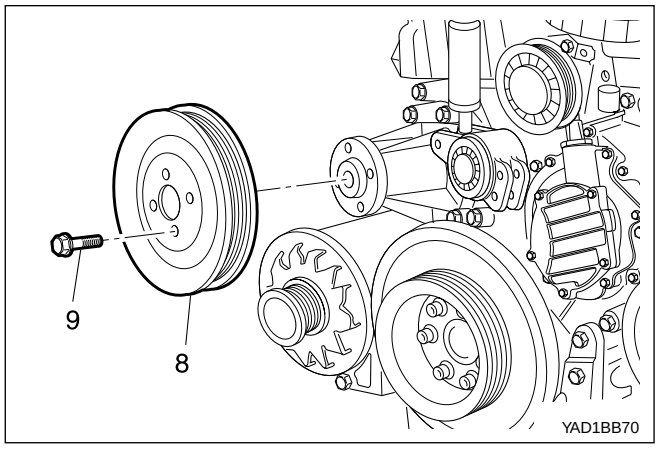
   Installation Notice

Tightening Torque	21 N•m (15 lb-ft)

2. Push the tensioning lever in direction of arrow with a rod (ϕ 12, 180 mm) and push out the bolt to the rear.



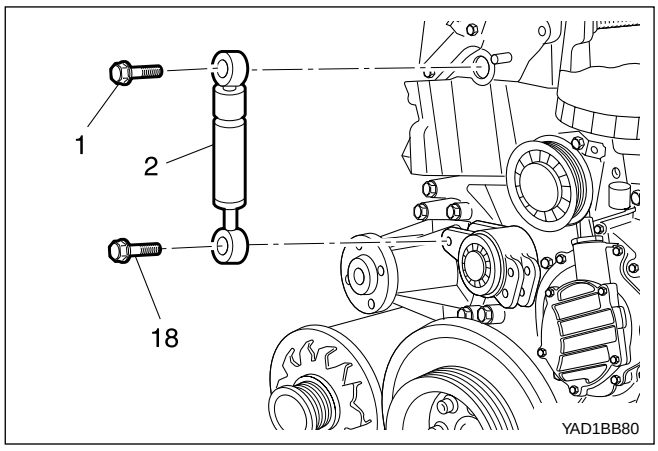
3. Push back the tensioning lever to release the spring tension and remove the belt.



4. Remove the bolt (9) and then remove the belt pulley (8).

   Installation Notice

Tightening Torque	10 N•m (89 lb-in)

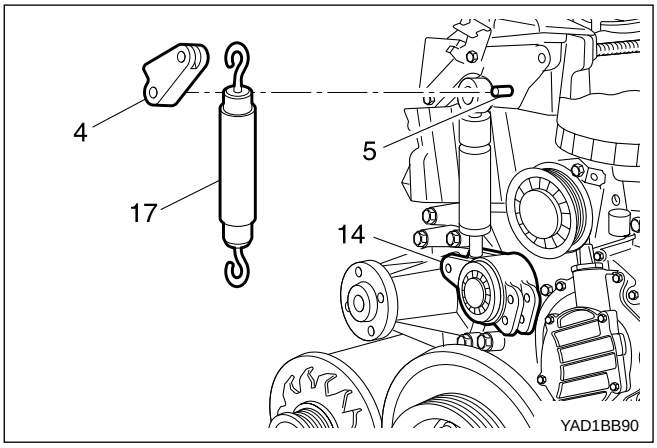


5. Remove the bolt (1, 18) and take off the damper (2).

   Installation Notice

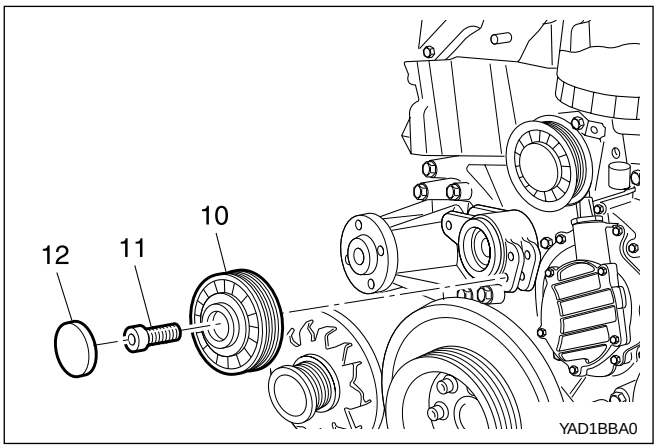
Tightening Torque	bolt (1) : 21 N•m (15 lb-ft)
	bolt (18): 20 N•m (15 lb-ft)

Pay attention to installation position of the damper.



6. Pull off the tensioning lever (4) from guide rail pin.
7. Remove the spring (17).

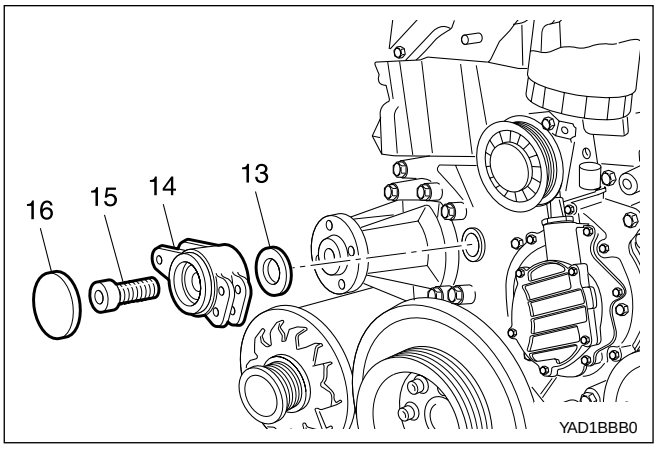
   Notice: Insert spring (17) with color coding (blue/violet) facing up.



8. Pry off the closing cover (12) and remove the socket bolt (11) and then remove the tensioning pulley (10).

   Installation Notice

Tightening Torque	29 N•m (21 lb-ft)



9. Pry off the closing cover (16) and remove the fit bolt (15).

   Installation Notice

Tightening Torque	100 N•m (74 lb-ft)

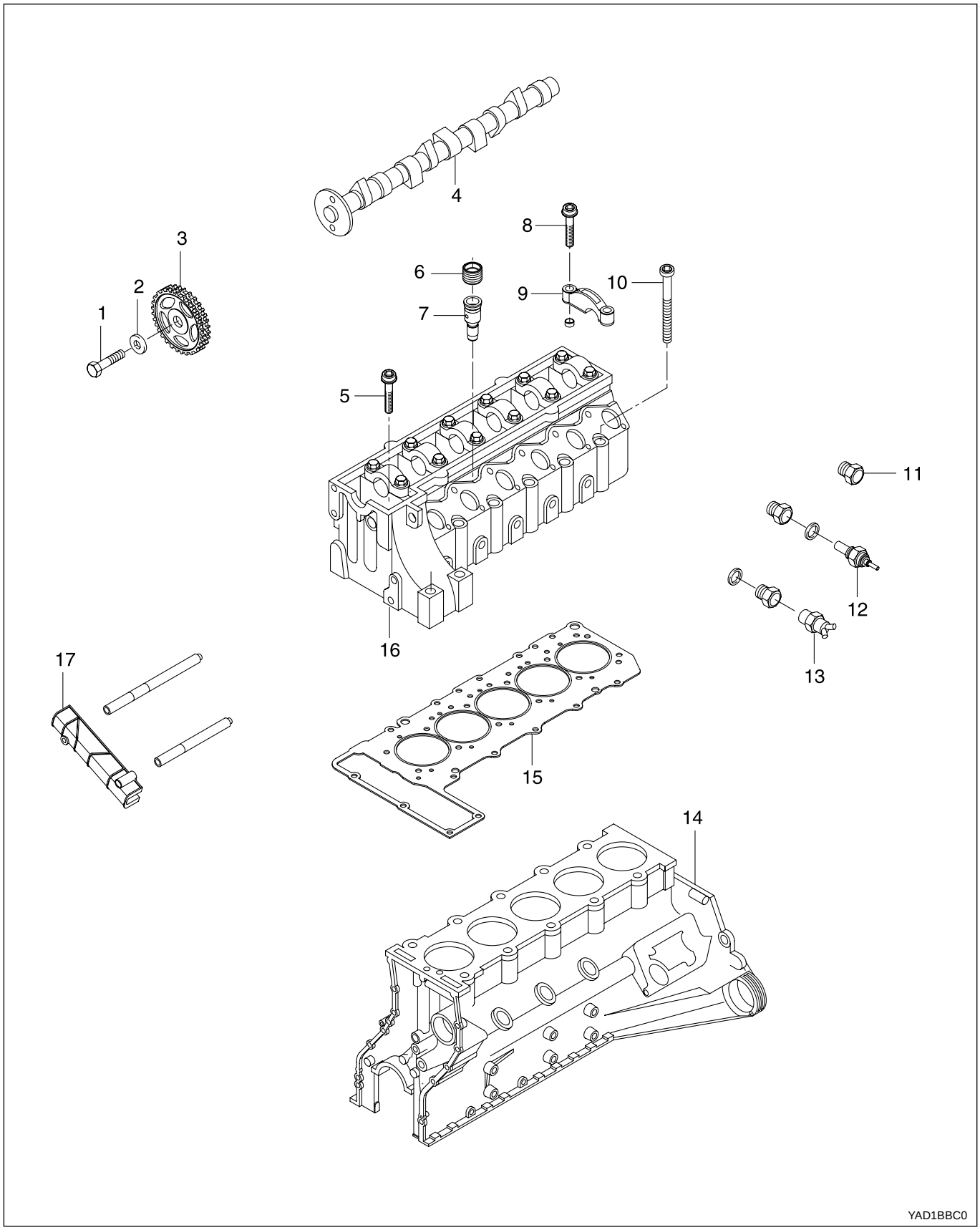
   Apply loctite on thread of fit bolt.

10. Remove the tensioning lever (14) and washer (13).
11. Clean thread in the timing case cover and fit bolt.

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

CRANKCASE AND CYLINDER HEAD

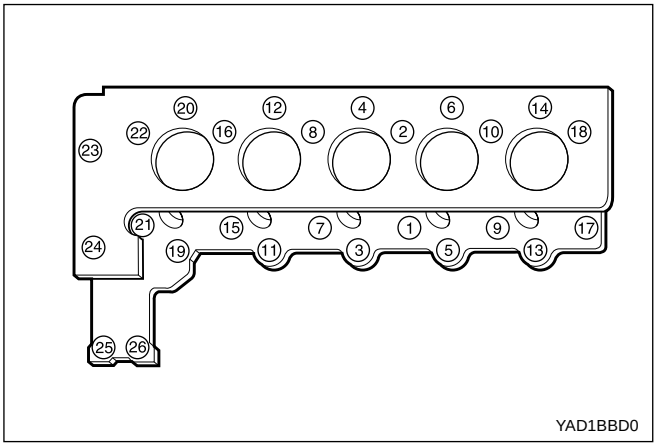
CYLINDER HEAD



1 Bolt..... 25 N•m (18 lb-ft)+90°
2 Washer
3 Camshaft Drive Sproket ..... Relace
4 Camshaft
5 Bolt..... 10 N•m (89 lb-in)
6 Threaded Ring ..... 130 N•m (96 lb-ft)
7 Prechamber
8 Bolt..... 25 N•m (18 lb-ft)
9 Camshaft Bearing Cap
10 Cylinder Head Bolt ..... See Table
11 Plug
12 Engine Coolant Temperature
13 Thermo Valve Sensor
14 Cylinder Block
15 Gasket..... Replace
16 Cylinder Head
17 Sliding Rail

Cylinder Head Bolt Tightening Torque

Cylinder Head Bolts (12-sided socket head) (Engine cold)	1st Step	10 N•m (89 lb-in)
	2nd Step	35 N•m (26 lb-ft)
	3rd Step	180°
M8 Cylinder Head Bolts		25 N•m (18 lb-ft)



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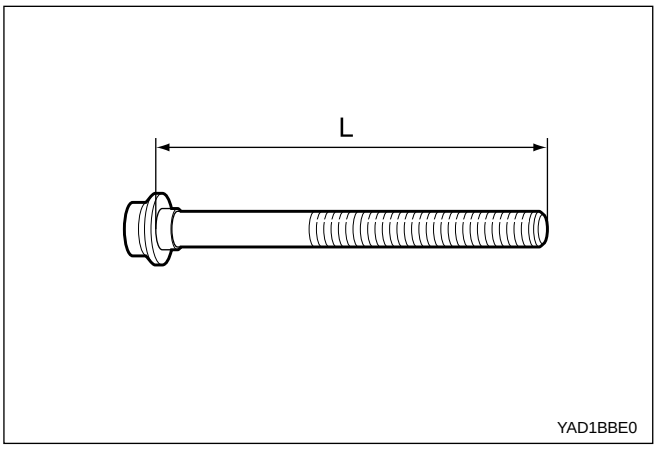
Tightening Sequence for Cylinder Head Bolts



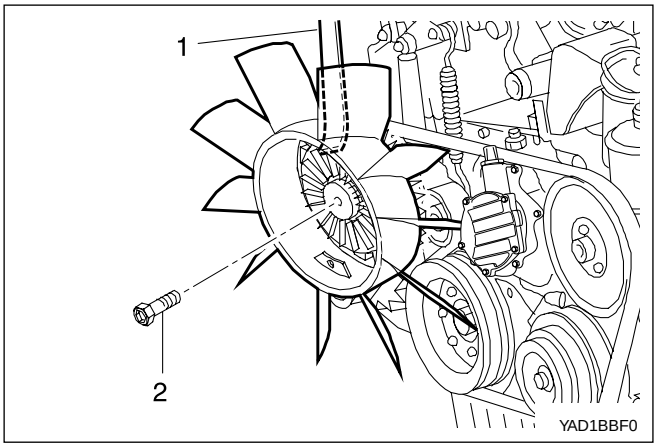
YAD1BBE0

Notice: The cylinder head may only be removed when the engine has cooled down. The cylinder head is removed together with the exhaust manifold. As the cylinder head bolts undergo a permanent tightening. They require to be replaced if they exceed the maximum lengthes indicated in the table.

Thread Dia.	Length(L) When New	Max. Length(L)
M10	80 mm	82 mm
M10	102 mm	104 mm
M10	115 mm	117 mm

The twelve-sided socket head bolts are tightened with each stages of torque and torque angle.

It is not necessary to retighten the cylinder head bolts at the 1000~1500 km inspection or after 1000~1500 km of repairs.

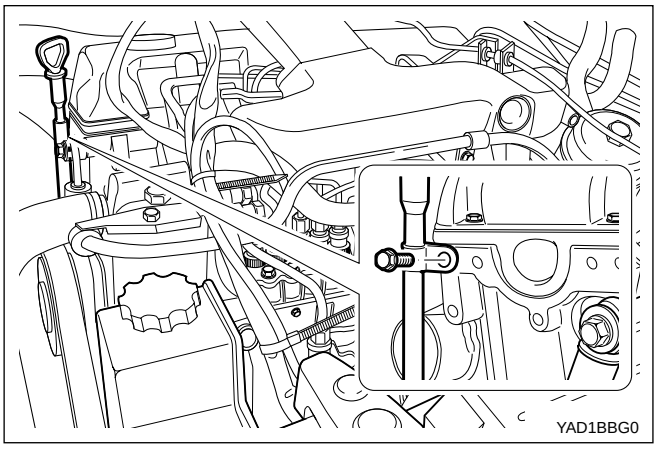


Tools Required

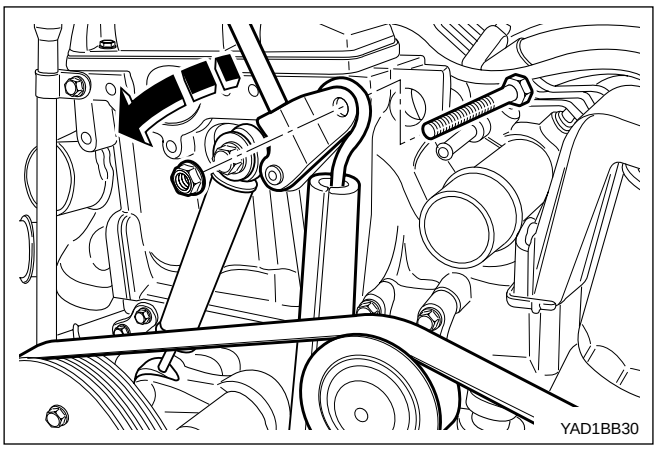
116 589 02 34 00	Threaded Pin
116 589 03 07 00	T Type Socket Wrench
116 589 20 33 00	Sliding Hammer
602 589 00 40 00	Engine Lock
603 589 00 40 00	Counter Holder

Removal Procedure

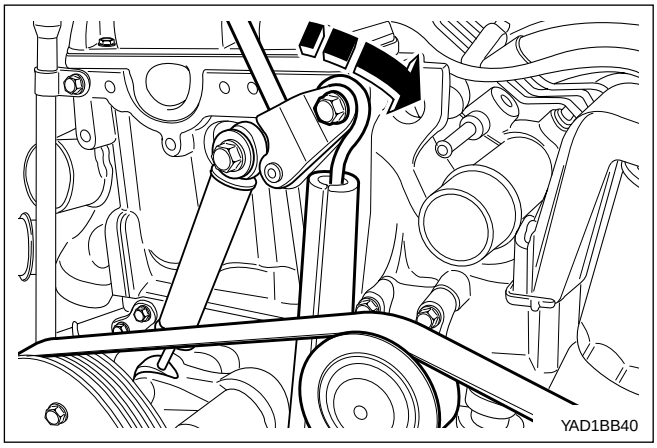
1. Completely drain the coolant from the radiator and cylinder block.
2. Remove the cooling fan shroud.
3. Hold the fan with counter holder 603 589 00 40 00 and remove the bolt and then remove the cooling fan.



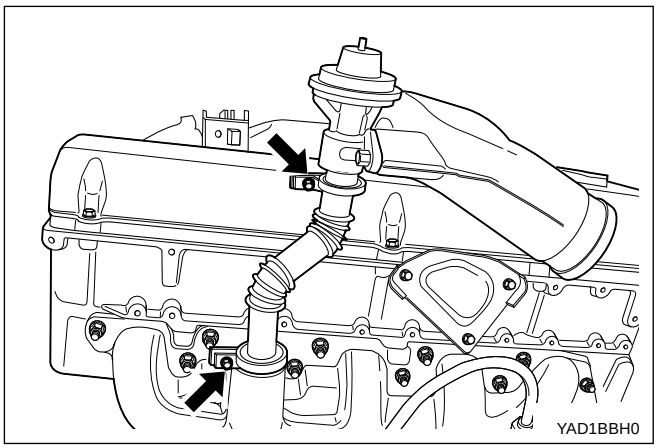
4. Remove the bracket oil dipstick tube.



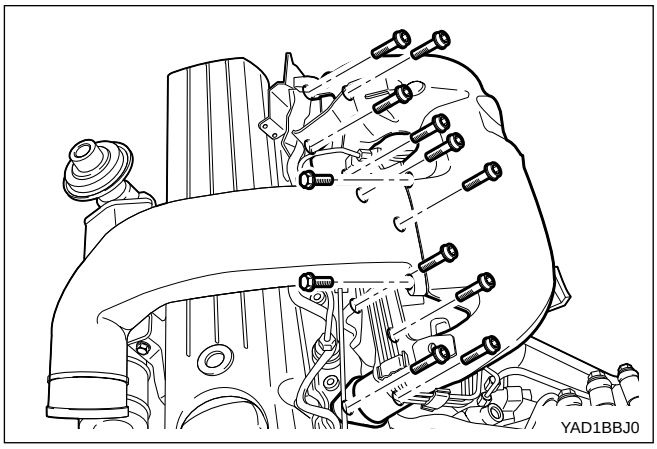
5. Remove the tensioning lever nut.
6. Remove the nut on the tensioning lever and insert the rod(ϕ 18, 180 mm). By pushing the rod to the arrow direction, pull back the bolt.



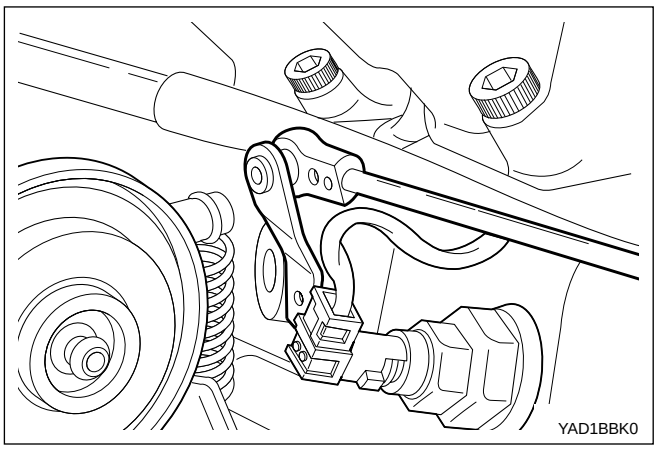
7. Push the tensioning lever to the opposite direction to release the spring tension and remove the poly V-belt.



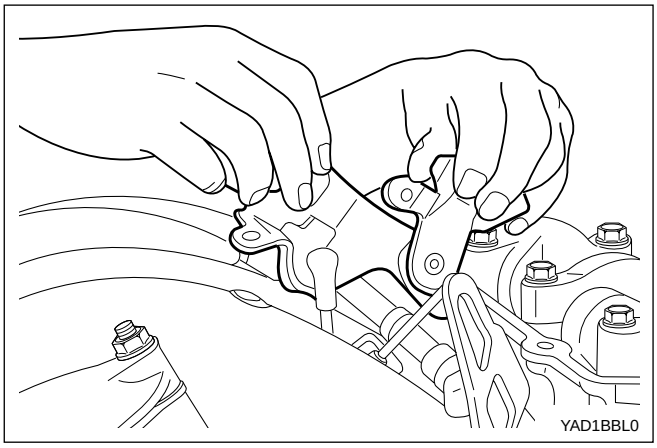
8. Unscrew the EGR pipe mounting bolts onto the exhaust manifold.
9. Remove the duct bracket from the cylinder head.



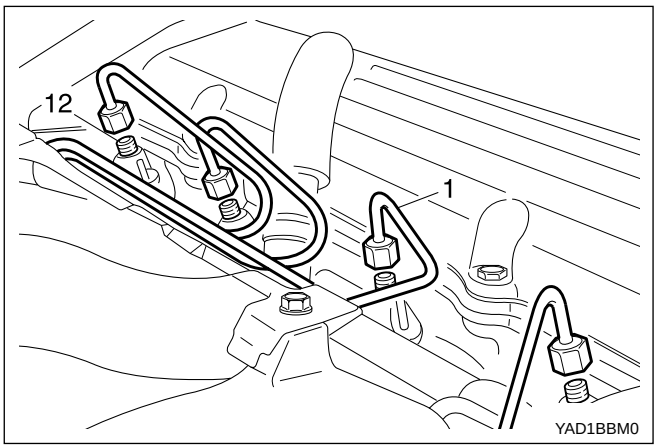
10. Unscrew the intake duct mounting bolts onto the intake manifold.



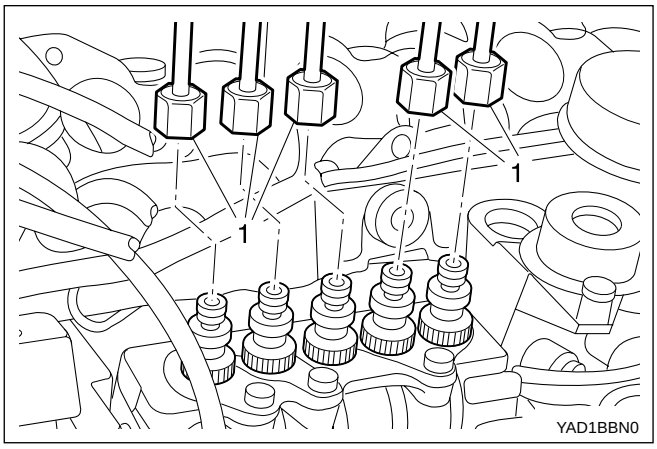
11. Separate the connecting rod from the control lever.



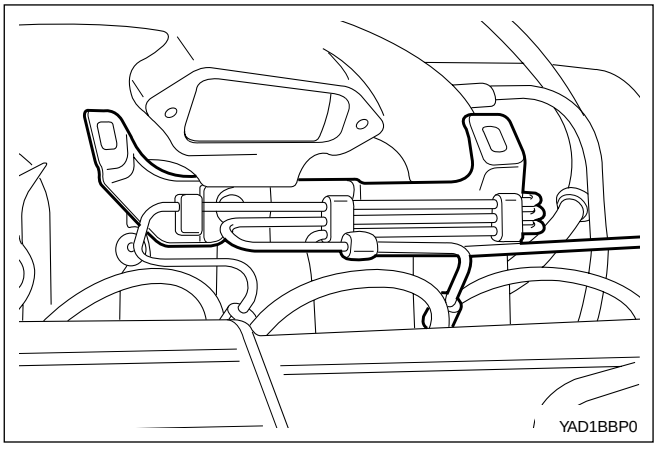
12. Pull out the accelerator control linkage.



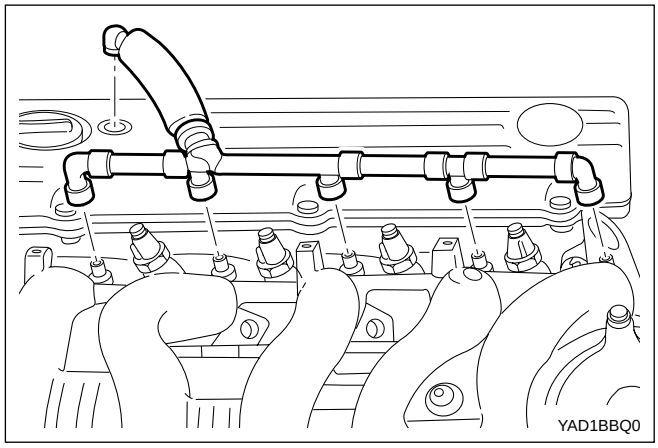
13. Remove the fuel injection line (1) from the fuel injection nozzle (12).



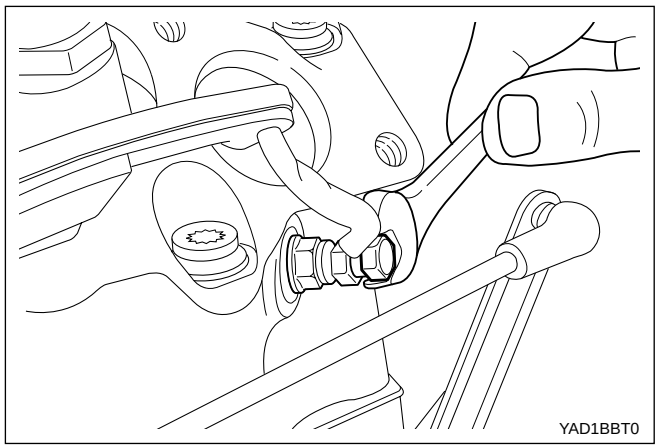
14. Remove the fuel injection line from the fuel injection pump.



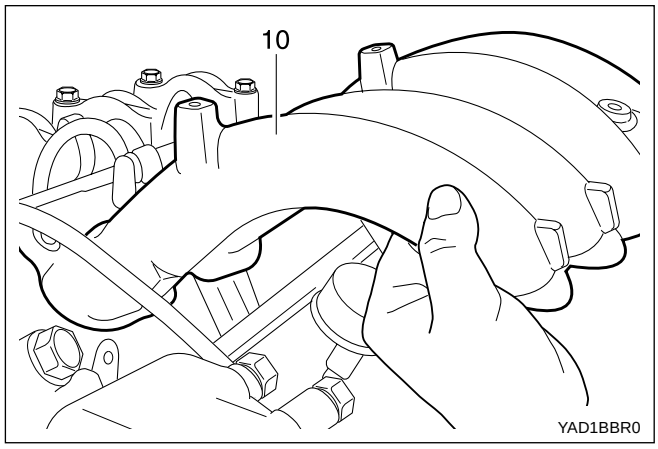
15. Remove the bracket mounting bolts and then remove the fuel injection line (1).



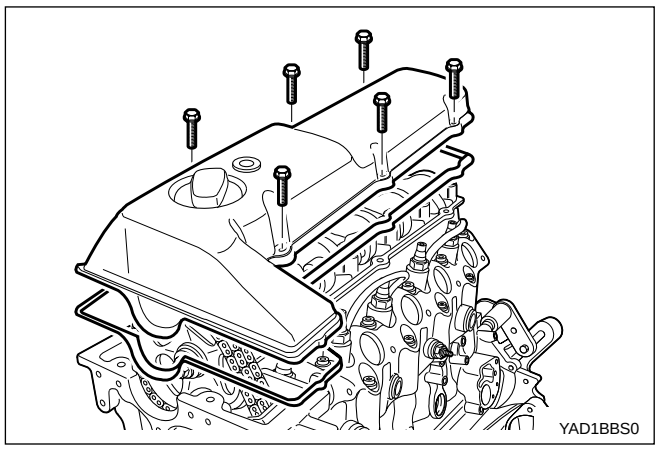
16. Disconnect the blow by hose from the cylinder head cover.



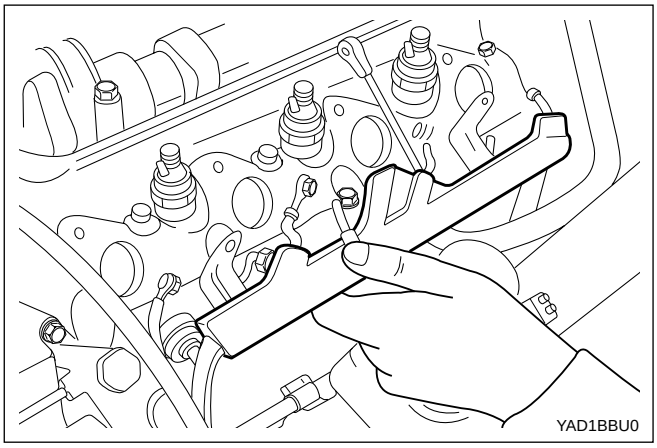
17. Disconnect the glow plug cables.



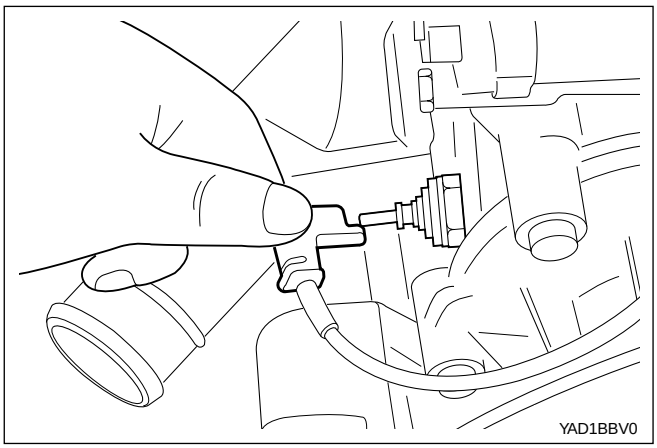
18. Remove the intake manifold (10) and gasket.



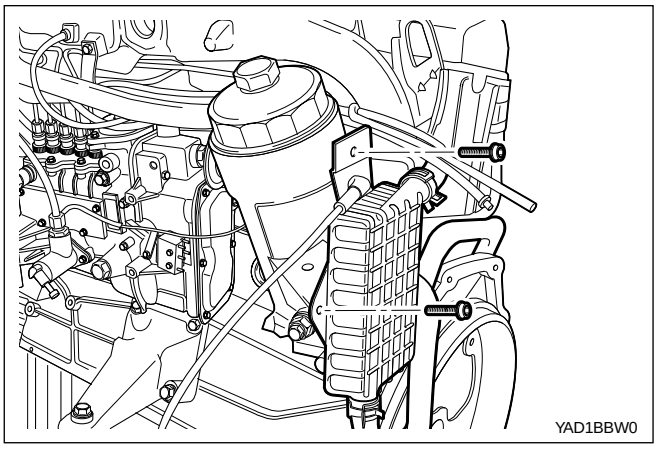
19. Remove the cylinder head cover and gasket.



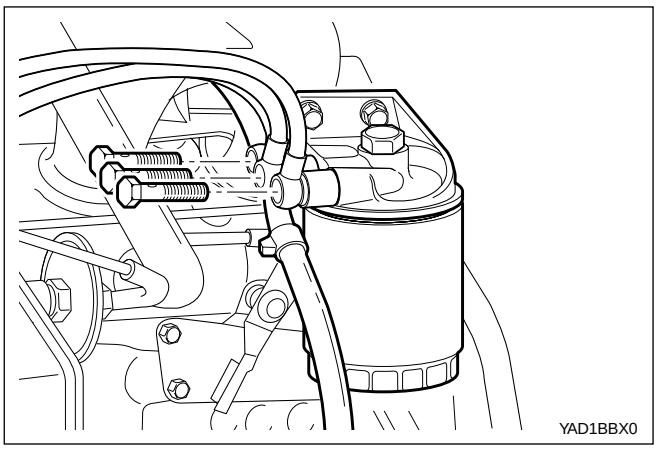
20. Remove the cable channel.



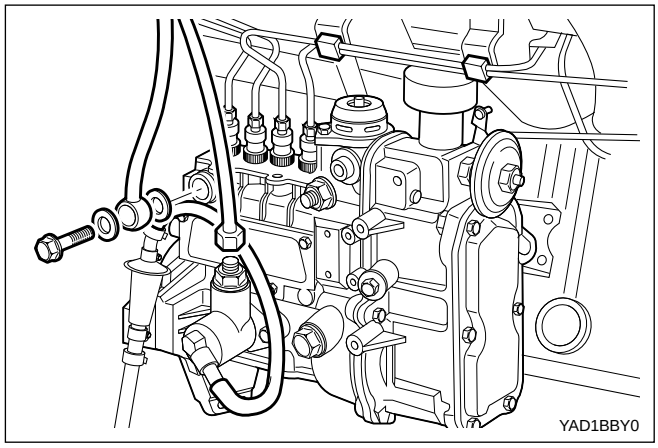
21. Disconnect the cables from the glow plug sensor and engine coolant temperature sensor.



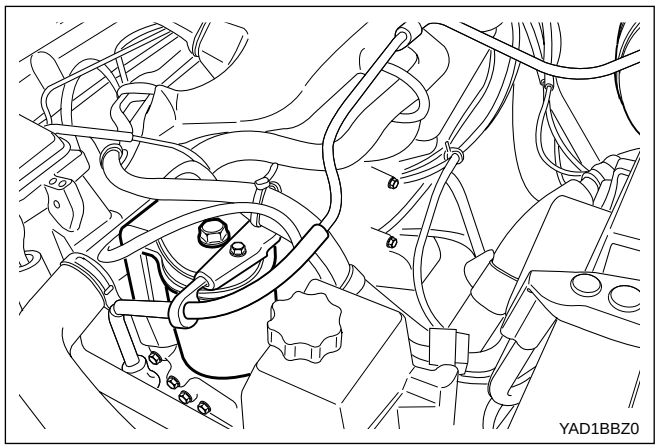
22. Remove the heater pipe bracket from the oil filter.
23. Pry off the clamp and push the heater feed pipe forward and then pull out the pipe.



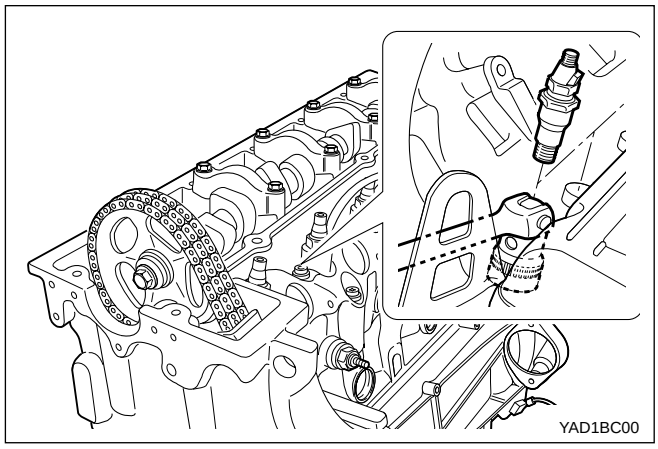
24. Disconnect the fuel lines from the fuel filter.



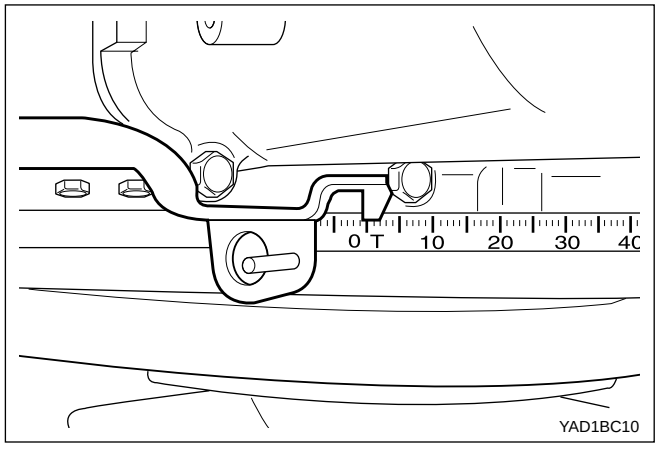
25. Disconnect the fuel lines from the injection pump.



26. Remove the fuel filter.

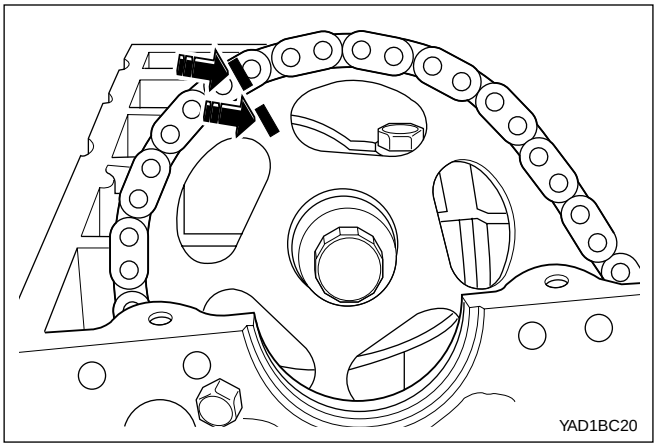


27. Remove the fuel injection nozzle and nozzle washer.

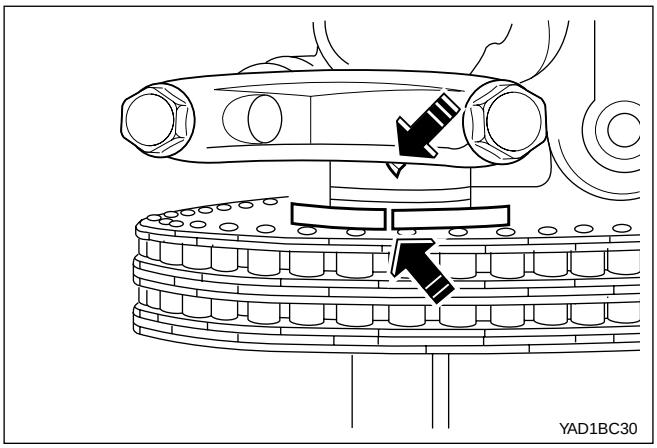


28. Rotate the crankshaft and set the no.1 cylinder at TDC.

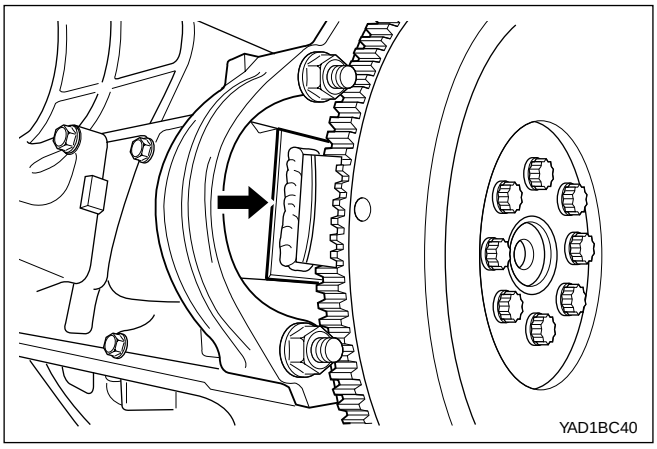
    Notice: Do not rotate the crankshaft to the opposite direction of engine revolution.



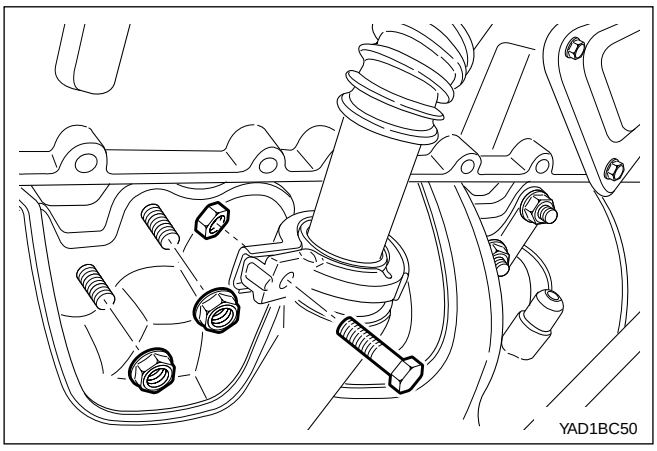
29. Place alignment marks on the camshaft gear and timing chain.



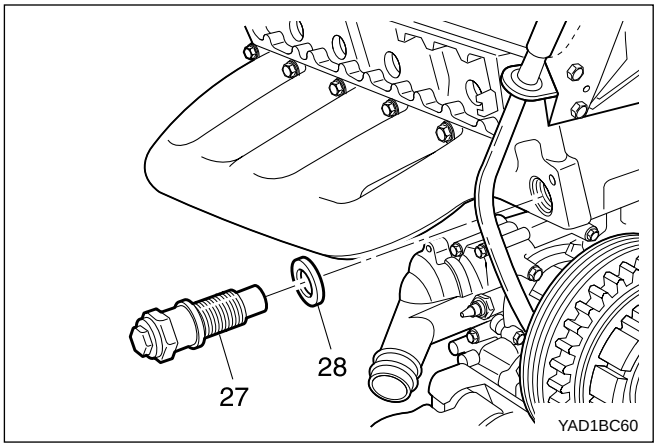
30. Ensure that the camshaft and the bearing cap marking are aligned.



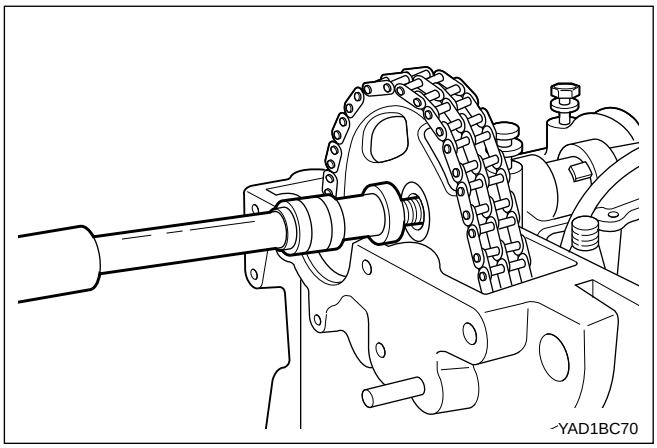
31. Remove the starter motor and install the engine lock 602 589 00 40 00 onto the flywheel ring gear.



32. Remove the exhaust manifold and exhaust pipe.



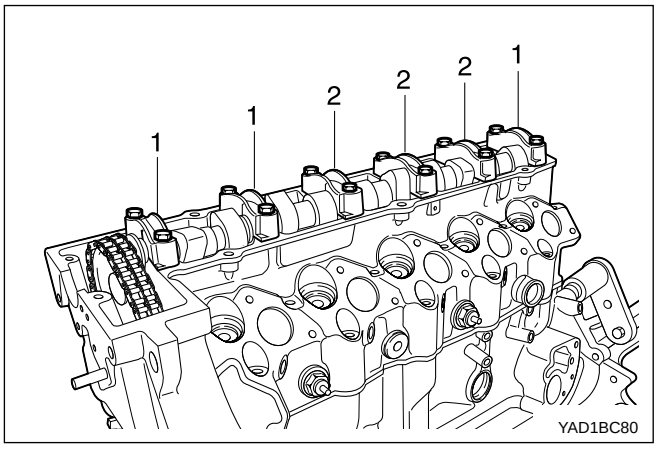
33. Remove the chain tensioner and seal.



34. Remove the bolt and separate the drive sprocket.

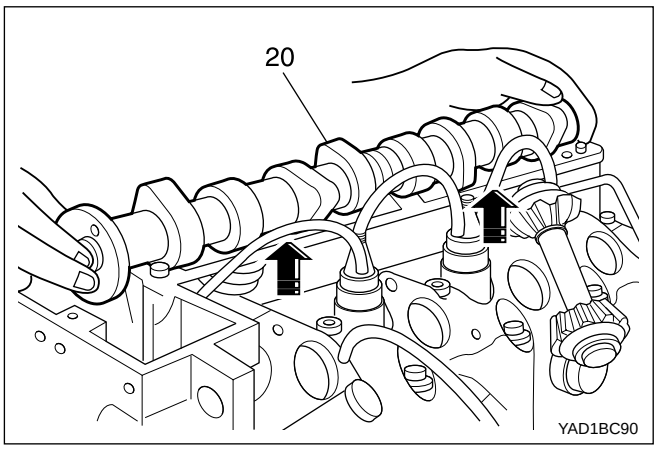
    Notice: During removal, be careful not to drop the sprocket and chain into the timing case.

    Carefully pull off the chain and then pull out the sprocket.



35. Remove the camshaft bearing cap bolts according to the numerical sequence.

    Notice: Remove the No.1 bolts first and then remove the No. 2 bolts. Do not remove the bolts at a time completely but remove them step by step evenly or camshaft can be seriously damaged.

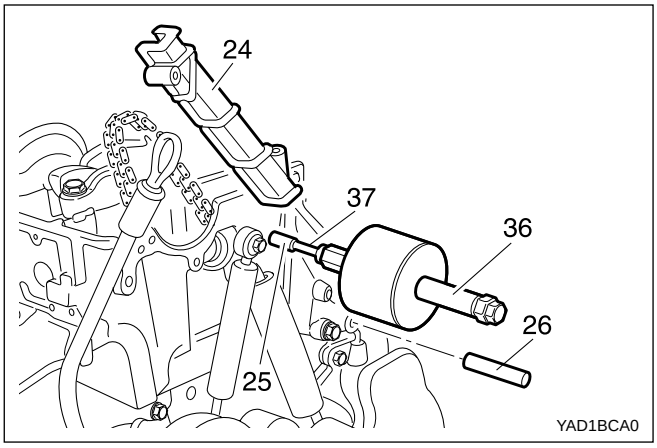


36. Remove the bearing caps and then pull out the camshaft(20) upward.

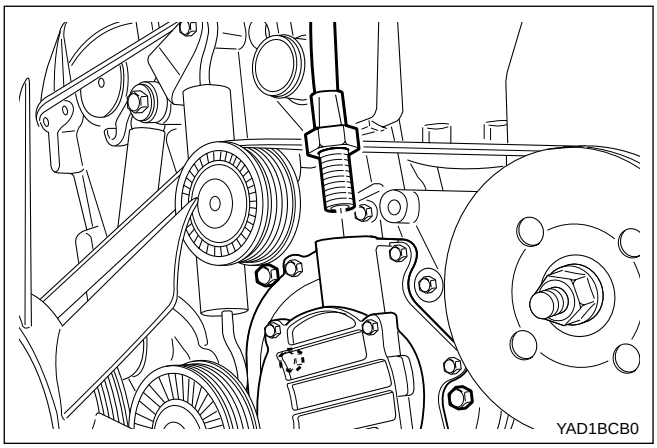
    Notice: Be careful not to miss the locking washer.

37. Remove the locking washer.

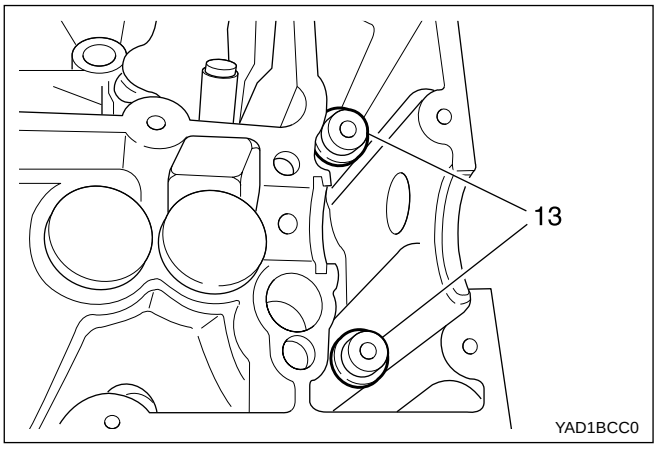
    Notice: Check the locking washer and replace if necessary.



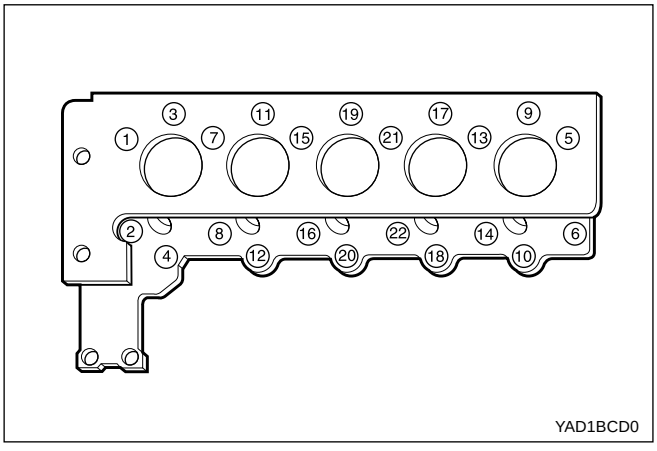
38. Using the sliding hammer 116 589 20 33 00 (36) and the threaded pin 116 589 02 34 00 (37), pull out the sliding rail pins (25, 26) and remove the sliding rail (24).



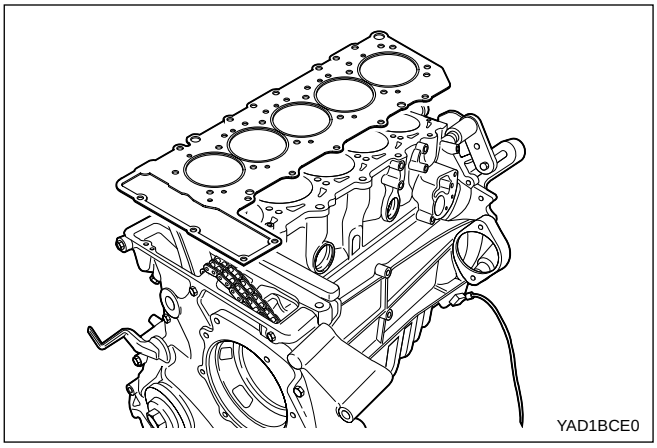
39. Remove the vacuum line from the vacuum pump.
40. Disconnect the vacuum pipe from thermo valve.



41. Remove the socket bolts (13) of the chain box using the T type socket wrench 116 589 03 07 00.

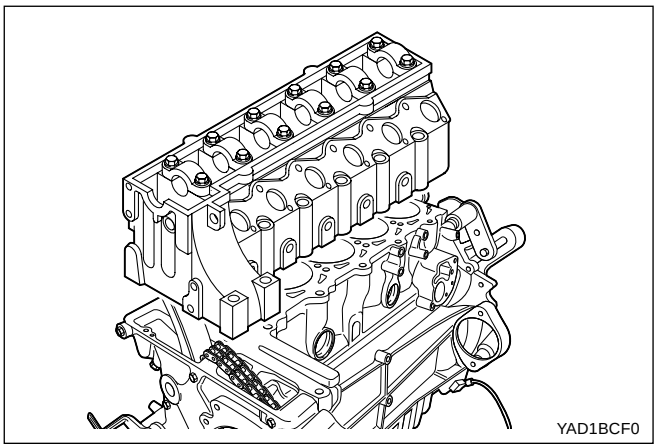


42. Remove the cylinder head bolts in numerical sequence.
43. Remove the cylinder head and gasket.


YAD1BCE0

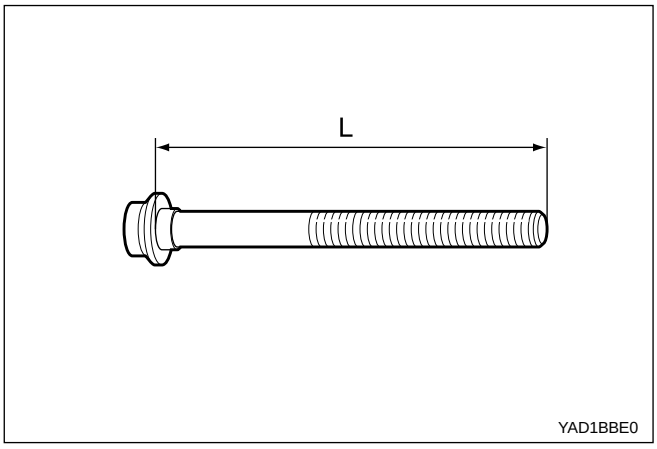
Installation Procedure

1. Replace the cylinder head gasket.


YAD1BCF0

2. Install the cylinder head onto the crankcase.

   Notice: Align the cylinder head holes with the guide pins.

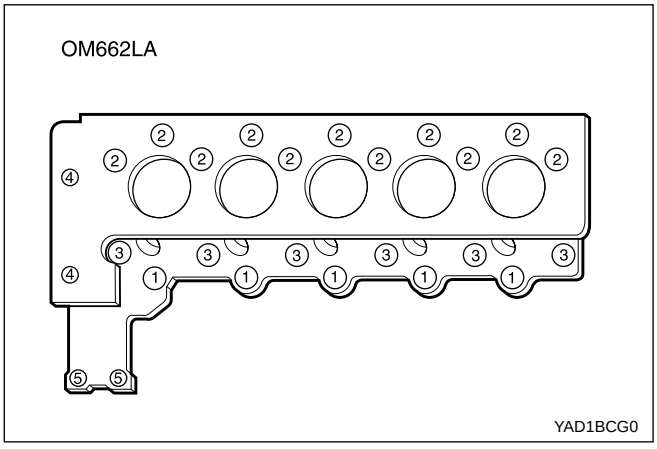


YAD1BBE0

3. Measure the length(L) of cylinder head bolts.

   Notice: If the max. length is exceeded, replace the bolts.

Thread Dia.	Length (L) when New	Max. Limit(L)
M10	80 mm	82 mm
M10	102 mm	104 mm
M10	115 mm	117 mm



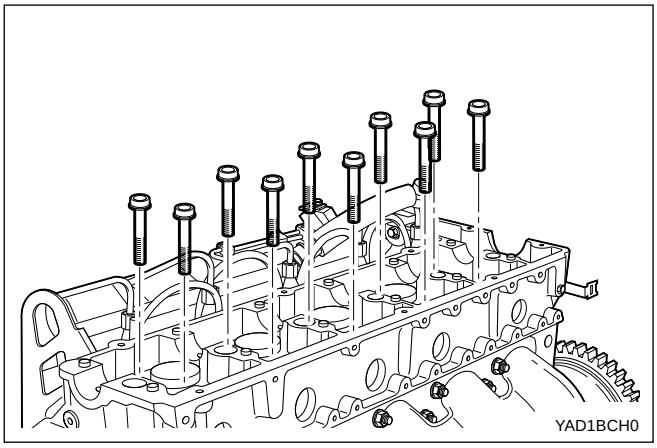
YAD1BCG0

4. Coat the head contact surface of bolts and thread with oil and insert them as shown.

   - **Cylinder head bolts arrangement**

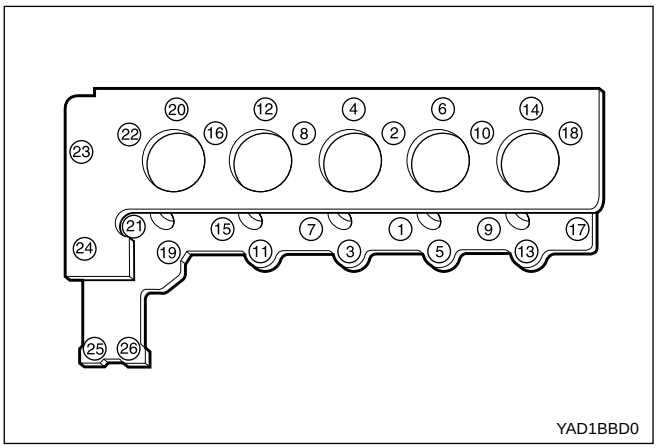
     Bore

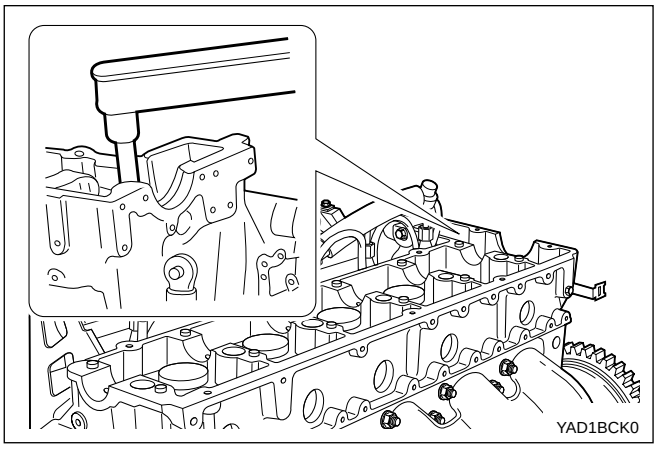
     1 ..... M10 × 80
     2 ..... M10 × 102
     3 ..... M10 × 115
     4 ..... M 8 × 50
     5 ..... M 8 × 80



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

Tightening Torque	1st Step	10 N•m (89 lb-in)
	2nd Step	35 N•m (26 lb-ft)
	Torque Angle	90°
	Wait for	10 minutes
	Torque Angle	90°

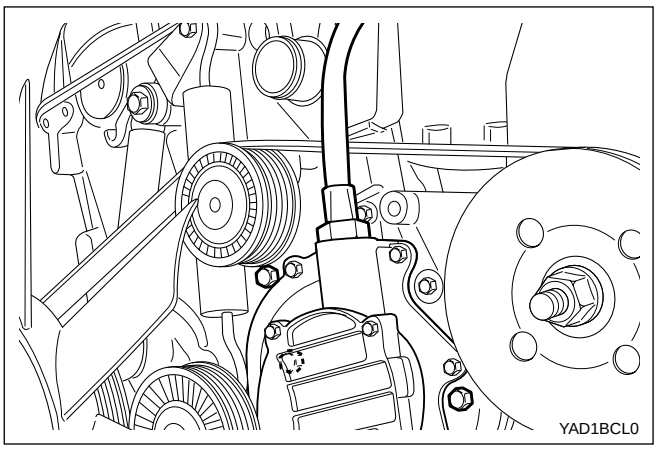




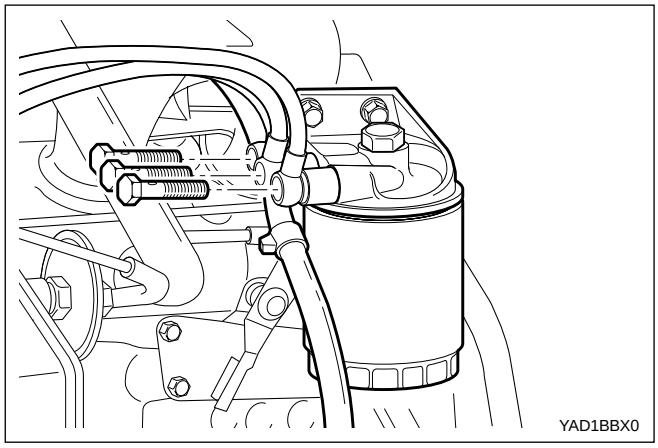
6. Install the socket bolts in the chain box using the T type socket wrench 116 589 03 07 00.

Installation Notice

Tightening Torque	25 N•m (18 lb-ft)



7. Connect the vacuum pipe to the thermo valve.
8. Connect the vacuum lines to the vacuum pump.

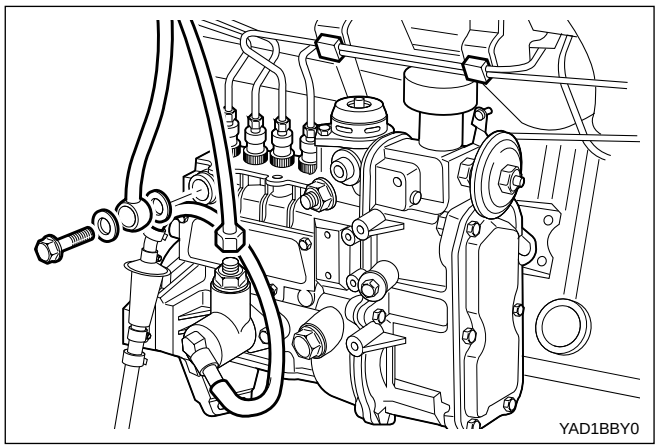


9. Install the fuel filter and connect the pipe.

Installation Notice

Tightening Torque	25 N•m (18 lb-ft)

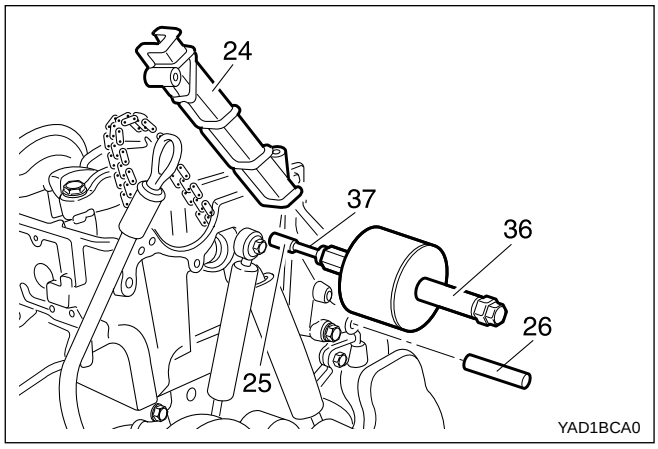
Be careful not to be confused the connections and hoses.



10. Connect the fuel line to the injection pump.

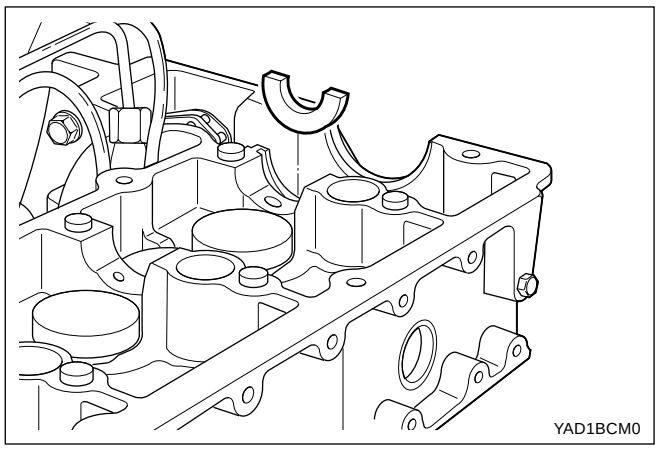
Installation Notice

Tightening Torque	13 N•m (10 lb-ft)

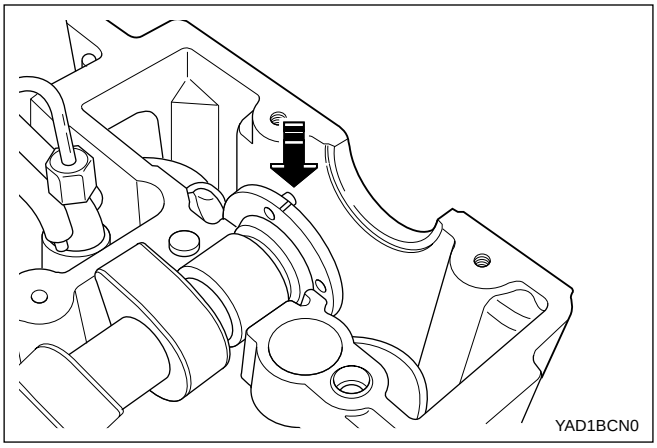


11. Install the sliding rail (24) and insert the sliding rail pins (25, 26) using the sliding hammer 116 589 20 33 00 (36) and threaded pin 116 589 02 34 00 (37).

Notice: Apply sealing compound on the each collar of the sliding rail pins.



12. Insert the locking washer.
13. Inspect the valve tappet and check that the tappet moves smoothly.

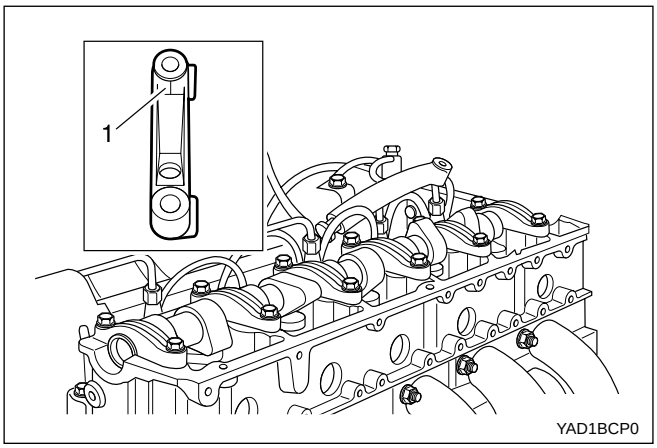

YAD1BCN0

14. Coat the camshaft with oil and install the camshaft on the cylinder head to be TDC mark(arrow) upward.
15. Measure the axial end play of the camshaft.

Installation Notice

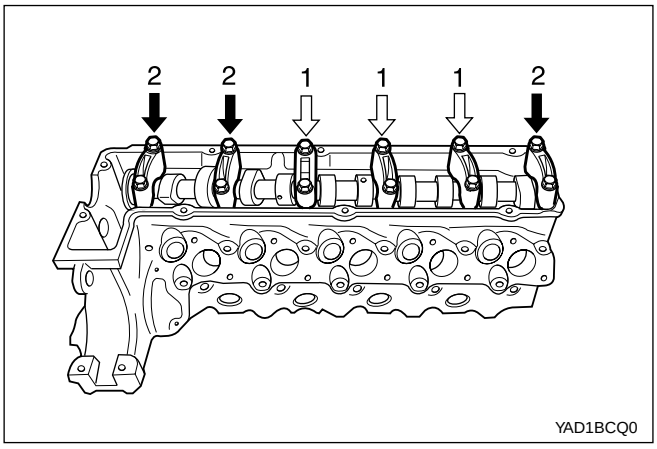
End Play	0.06 ~ 0.21 mm

If out of standard, adjust it with the proper thickness of locking washer.



YAD1BCP0

16. Install the bearing caps on the camshaft according to the number on the caps.



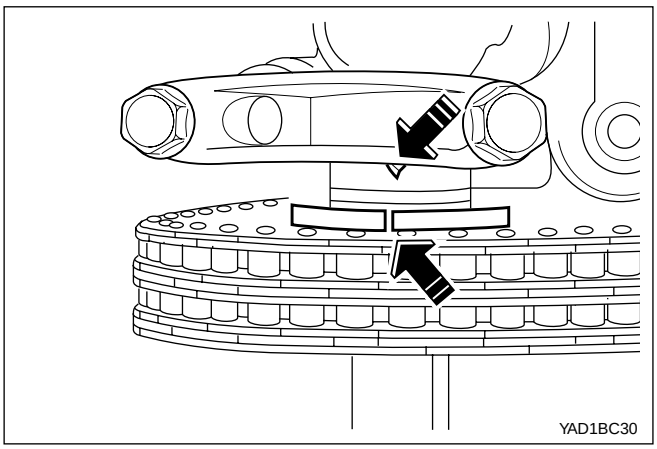
YAD1BCQ0

17. Tighten the bearing cap bolts according to the numerical sequence.

Installation Notice

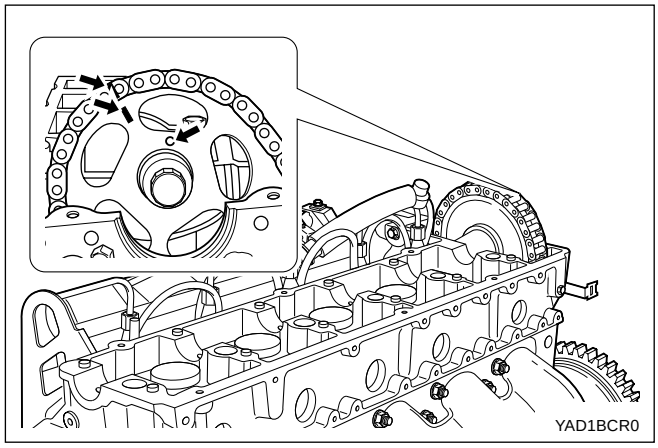
Tightening Torque	25 N•m (18 lb-ft)

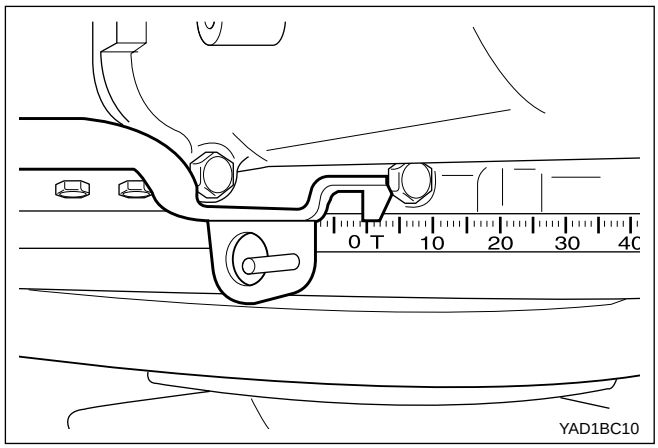
Tighten the No. 1 bolts (light arrow) first and then tighten the No. 2 bolts (dark arrow) stage by stage.


YAD1BC30

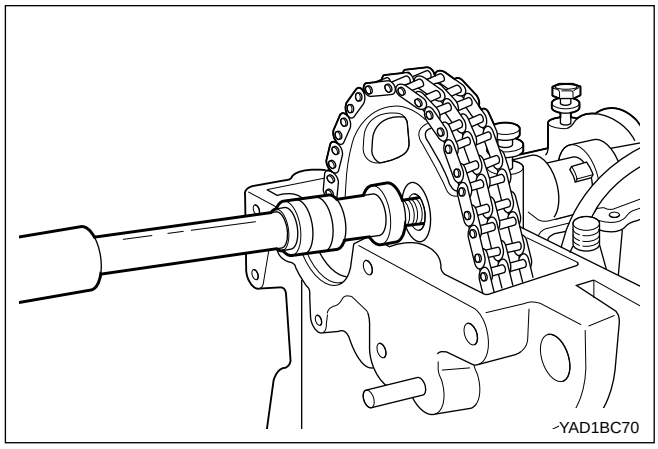
18. Position the camshaft on marking and install the camshaft sprocket.

Notice: Align the alignment marks on the chain and sprocket.





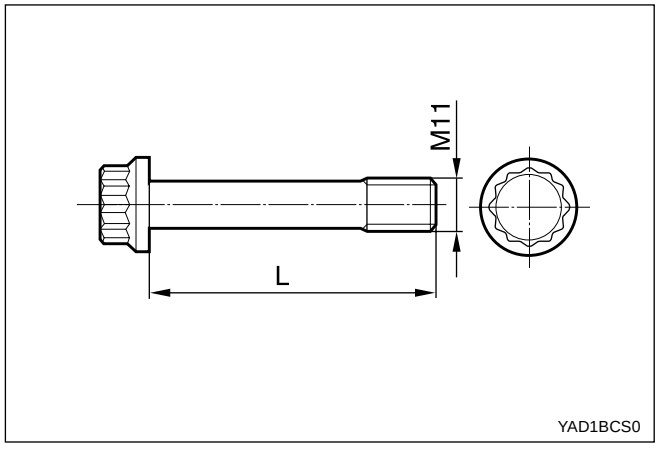
19. Check the TDC position of the crankshaft.



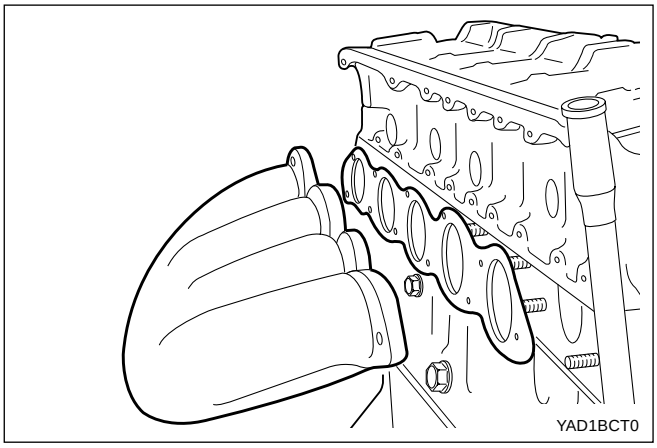
20. Install the camshaft sprocket bolt.

Installation Notice

Tightening Torque	1st Step	25 N•m (18 lb-ft)
	2nd Step	90°



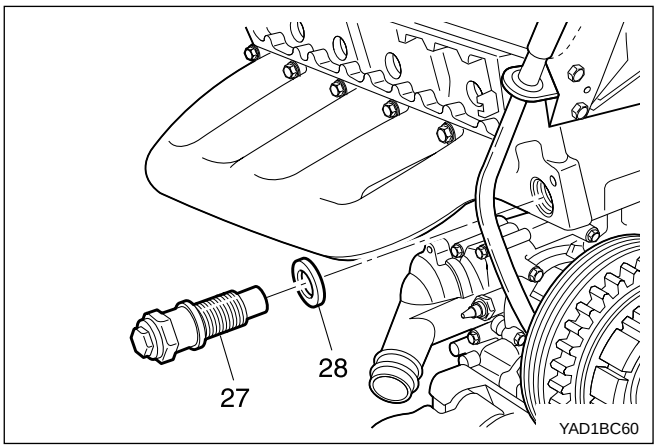
Notice: Measure the max. length ‘L’ and replace the bolt if it exceeds 53.6 mm.



21. Install the exhaust manifold and gasket.

Installation Notice

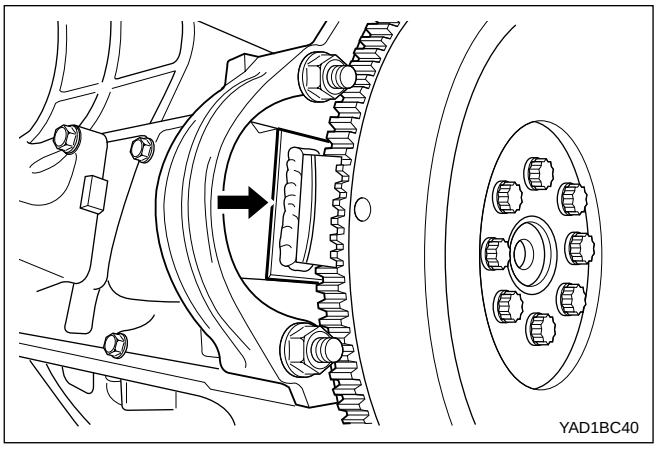
Tightening Torque	25 N•m (18 lb-ft)



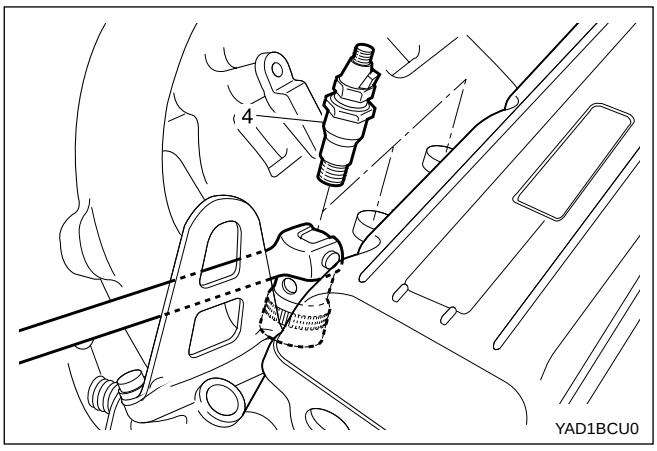
22. Replace the seal and then install the chain tensioner.

Installation Notice

Tightening Torque	80 N•m (59 lb-ft)



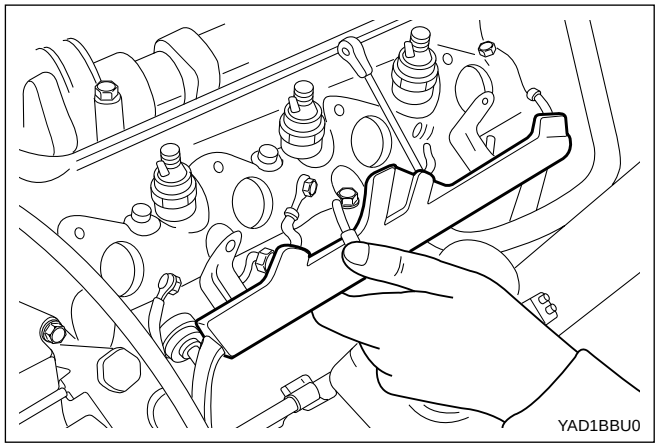
23. Remove the engine lock 602 589 00 40 00.



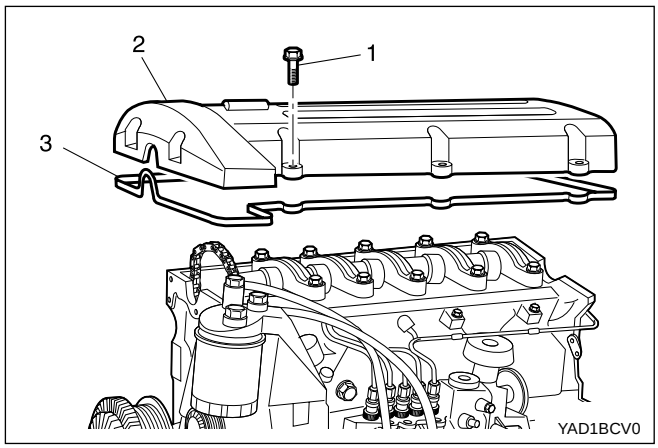
24. Insert the nozzle washer into the hole to face round part downward.
25. Install the fuel injection nozzle.

Installation Notice

Tightening Torque	40 N•m (30 lb-ft)



26. Connect the fuel hose.
27. Install the cable channel and connect the cables to glow plugs.

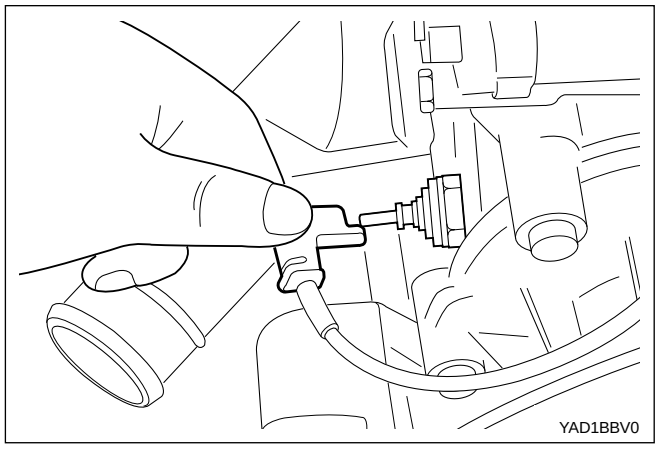


28. Replace the gasket and install the cylinder head cover.

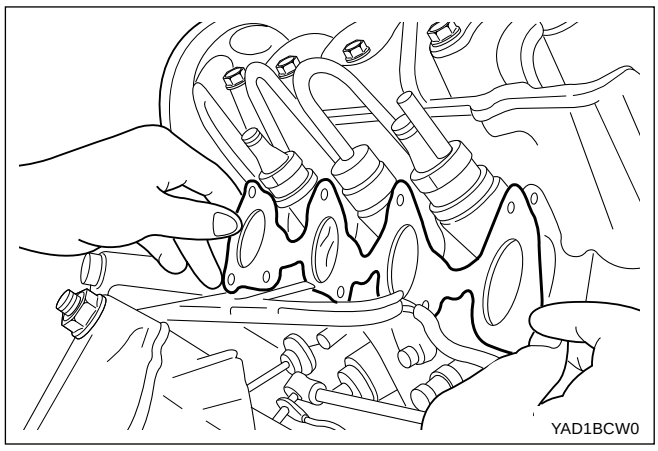
Installation Notice

Tightening Torque	10 N•m (89 lb-in)

29. Install the blow-by hose.



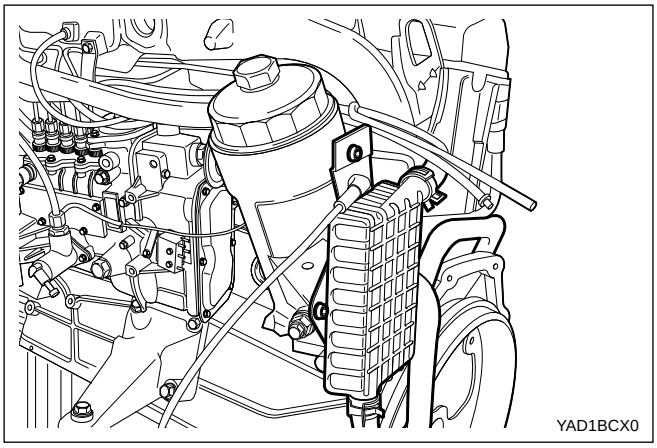
30. Connect the wires to the engine coolant temperature sensor and the glow plug sensor.



31. Replace the intake manifold gasket.
32. Install the intake manifold.

Installation Notice

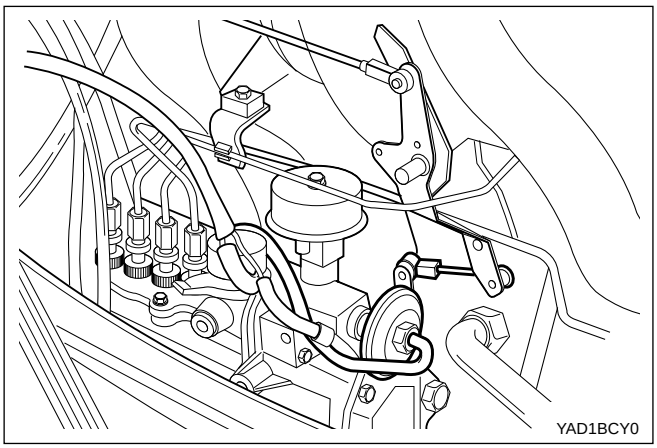
Tightening Torque	25 N•m (18 lb-ft)


YAD1BCX0

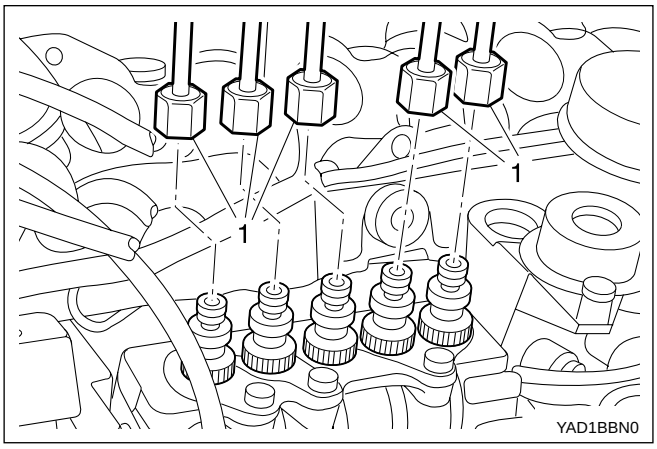
33. Replace the O-ring of heater feed pipe and install it to the cylinder head.

    Notice: For installation, clean the hole.

34. Install the bracket of heater feed pipe to the oil filter.


YAD1BCY0

35. Install the fuel pipe and the accelerator control linkage.



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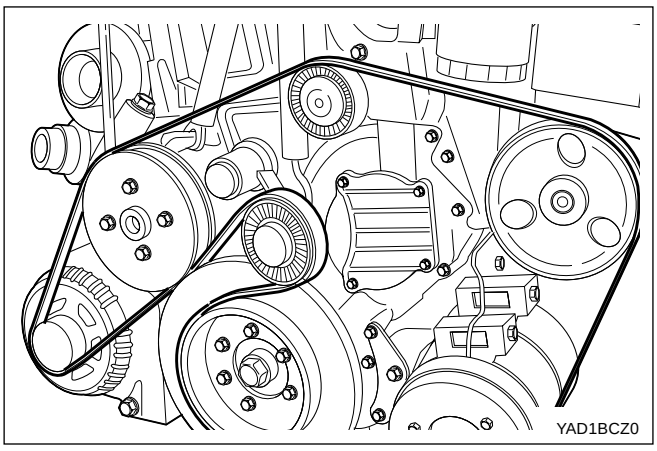
36. Connect the fuel lines to the injection nozzles and to the injection pump.

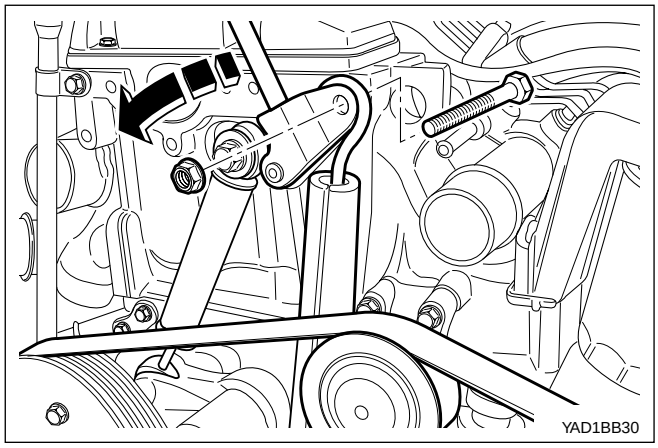
    Installation Notice

Tightening Torque	18 N•m (13 lb-ft)


YAD1BCZ0

37. Install the poly V-belt.

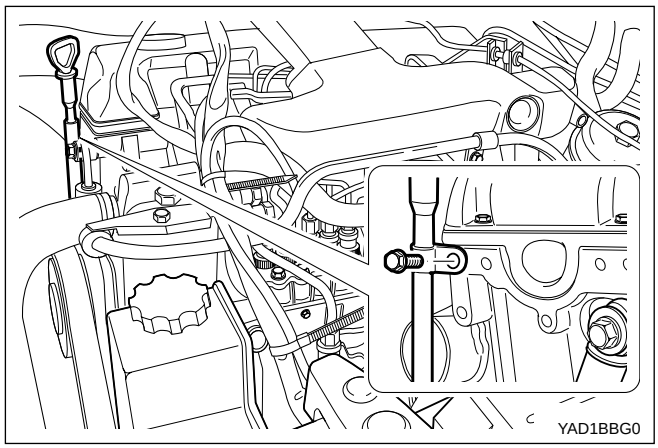
    Notice: Be careful not to contaminate the belt.



38. By inserting a rod into the tensioning lever upper hole and pulling the rod, install the bolt and then tighten the nut.

Installation Notice

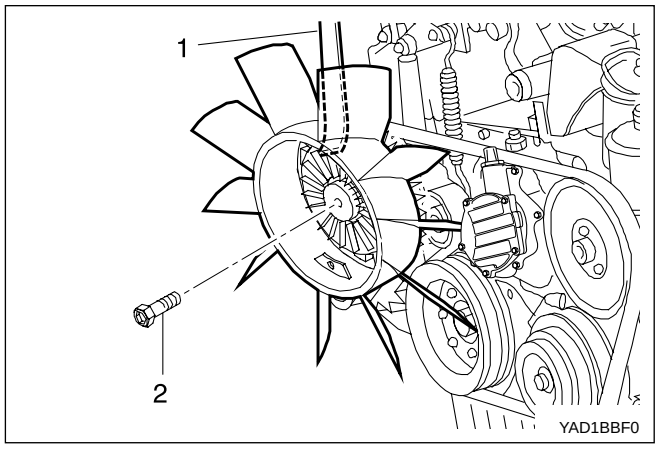
Tightening Torque	21 N•m (15 lb-ft)



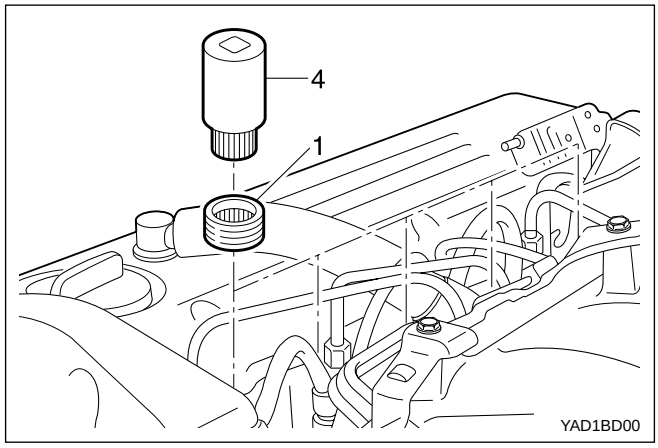
39. Install the oil dipstick tube bracket.

Installation Notice

Tightening Torque	10 N•m (89 lb-in)



40. Hold the cooling fan with the counter holder 603 589 00 40 00 and tighten the bolt.



PRECHAMBER

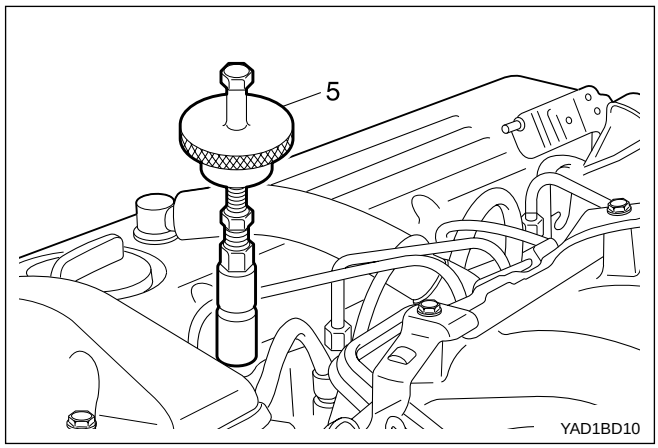
Preceding work: Removal of glow plug
Removal of fuel injection nozzle

Tools Required

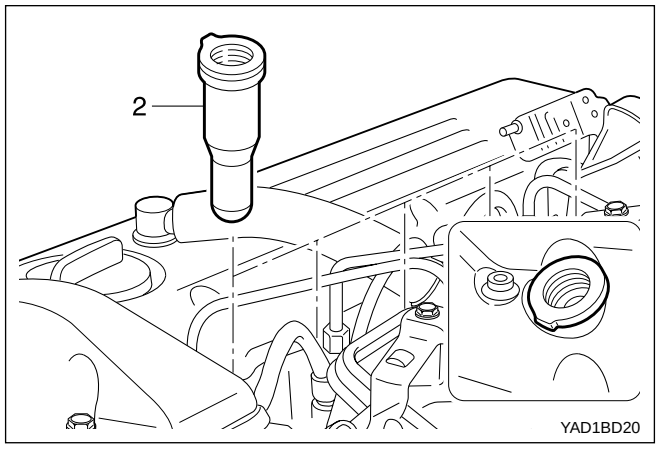
603 589 00 09 00 Serration Wrench
667 589 03 63 00 Sliding Hammer

Removal Procedure

1. Using the serration wrench 603 589 00 09 00 (4), remove the threaded ring (1).

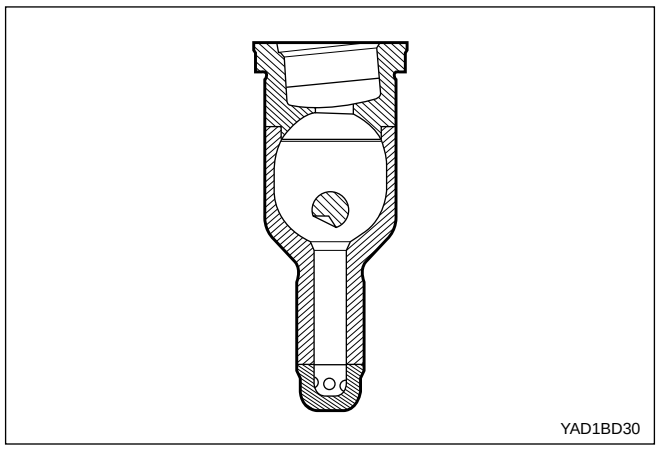


2. Install the sliding hammer 667 589 03 63 00 (5) into the prechamber.



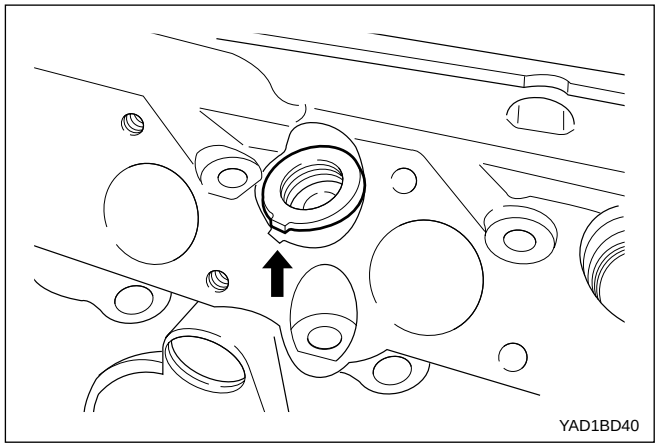
3. Remove the perchamber (2).

   Notice: After removing the prechamber, cover over the bores with clean rag.



4. Inspect the prechamber.

   Notice: If the prechamber seats in the cylinder head are leaking or if the prechambers are replaced, the sealing surfaces in the cylinder head must be remachined.



Installation Procedure

Notice: In case the prechambers are reused, inspect the prechambers thoroughly, if the ball pin by heat and fire is broken, it can not be used.

1. Clean the sealing surface of the prechamber.
2. Insert the prechamber into the cylinder head at the same time aligning the cam on the collar of the prechambers with the slots in the cylinder head.

Installation Notice

Thickness of Spacer Ring	0.3, 0.6, 1.0 mm

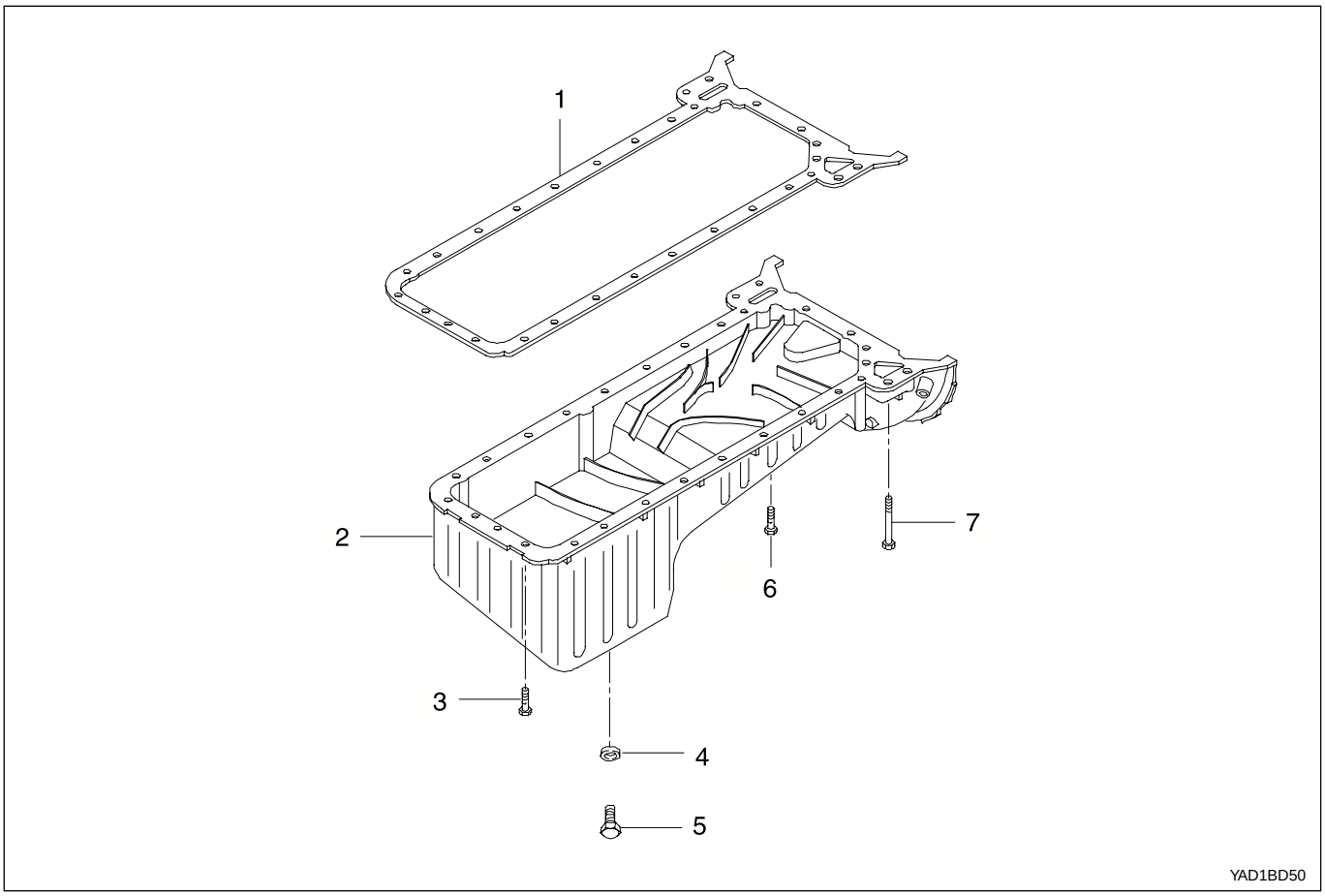
If the spacer rings are fitted to the prechambers, the spacer rings should be replaced with rings of the same thickness.

3. Coat the threaded ring with oil and assemble the ring by using the serration wrench 603 589 00 09 00.

Installation Notice

Tightening Torque	130 N•m (96 lb-ft)

OIL PAN

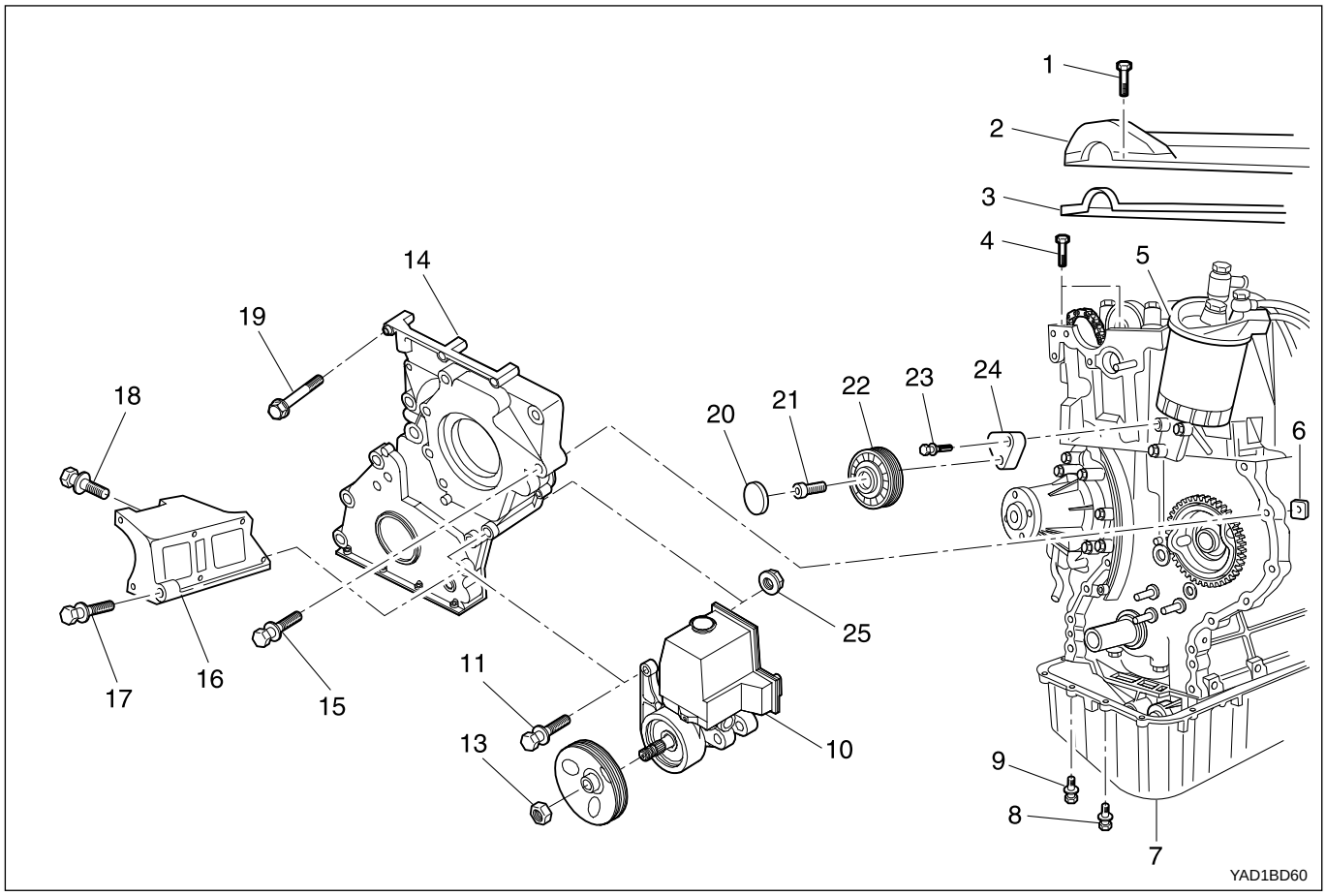


1	Gasket	Replace	
2	Oil Pan		
3	Bolt	10 N•m (89 lb-in)	
4	Washer	Replace	
5	Drain Plug	25 N•m (18 lb-ft)	
6	Bolt	10 N•m (89 lb-in)	
7	Bolt	25 N•m (18 lb-ft)	

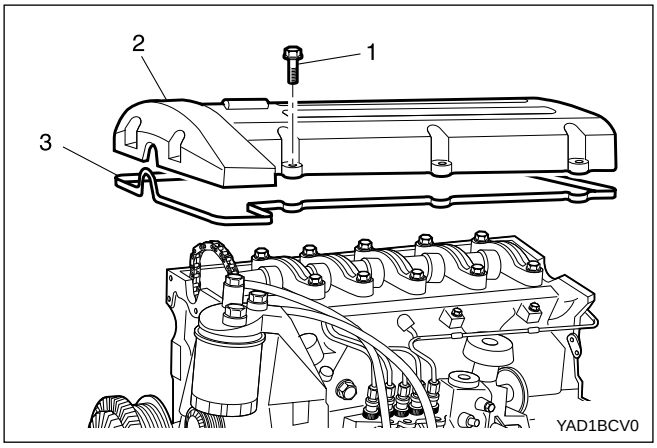
Notice: Replace the washer seal with new one.

TIMING CASE COVER

Preceding Work : Removal of the cooling fan
Removal of the V-belt tensioning device
Removal of the vibration damper and hub
Removal of the generator



1 Bolt ..... 10 N•m (89 lb-in)
2 Cylinder Head Cover
3 Gasket ..... Replace
4 Socket Bolt ..... 25 N•m (18 lb-ft)
5 Fuel Filter
6 Square Nut
7 Oil Pan
8 Socket Bolt ..... 10 N•m (89 lb-in)
9 Bolt ..... M6 : 10 N•m (89 lb-in)
..... M8 : 23 N•m (17 lb-ft)
10 Power Steering Pump
11 Bolt
12 Belt Pulley
13 Bolt ..... 32 N•m (24 lb-ft)
14 Timing Case Cover
15 Bolt ..... 23 N•m (17 lb-ft)
16 Generator Bracket
17 Bolt ..... 45 N•m (33 lb-ft)
18 Bolt ..... 25 N•m (18 lb-ft)
19 Bolt ..... 10 N•m (89 lb-in)
20 Closing Cover
21 Socket Bolt ..... 23 N•m (17 lb-ft)
22 Guide Pulley
23 Bolt ..... 9 N•m (80 lb-in)
24 Guide Pulley Bracket
25 Nut ..... 23N•m (17 lb-ft)

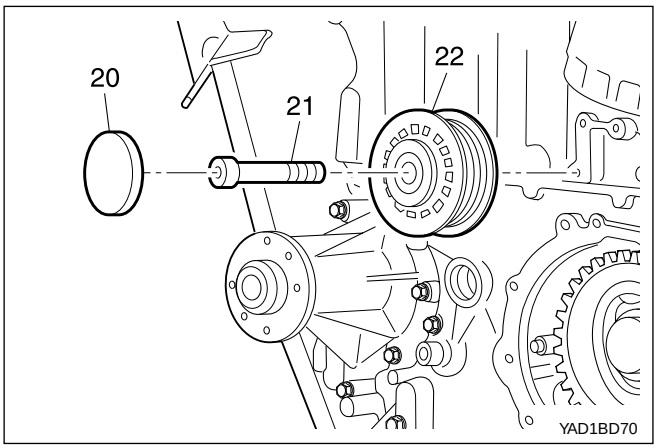


Tools Required

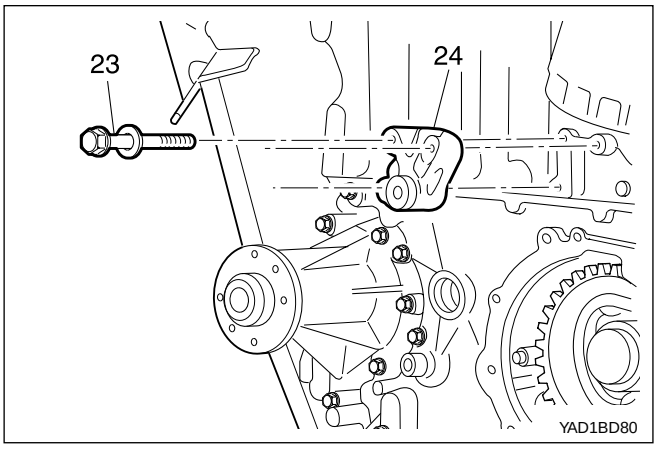
116 589 03 07 00 T Type Socket Wrench

Removal Procedure

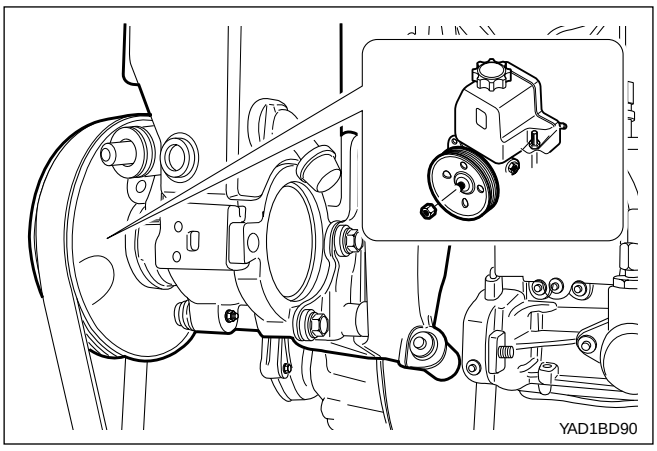
1. Remove the fan clutch and cooling fan belt pulley.
2. Drain the engine oil completely.
3. Remove the crankshaft pulley.
4. Loosen the bolt (1) and then remove the cylinder head cover (2) and gasket.
5. Remove the vacuum pump.



6. Detach the closing cover (20). Remove the bolts (21) and then remove the guide pulley (22).



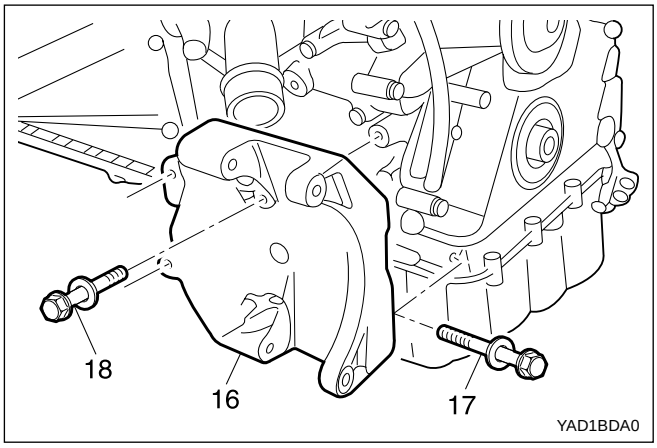
7. Remove the guide pulley bracket (24).



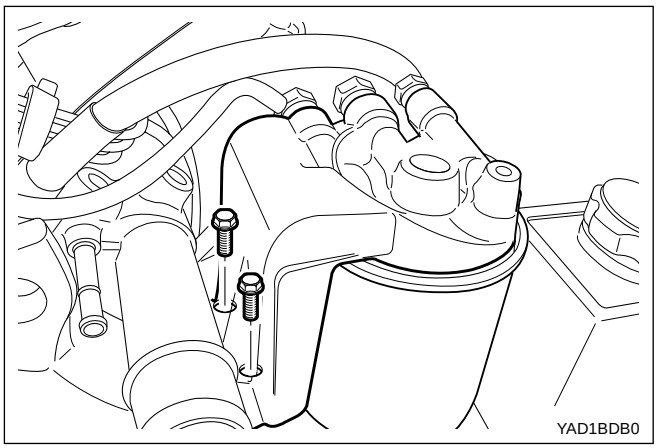
8. Disconnect the pipes of power steering pump and remove the belt pulley.

   Notice: Be careful not to lose the key.

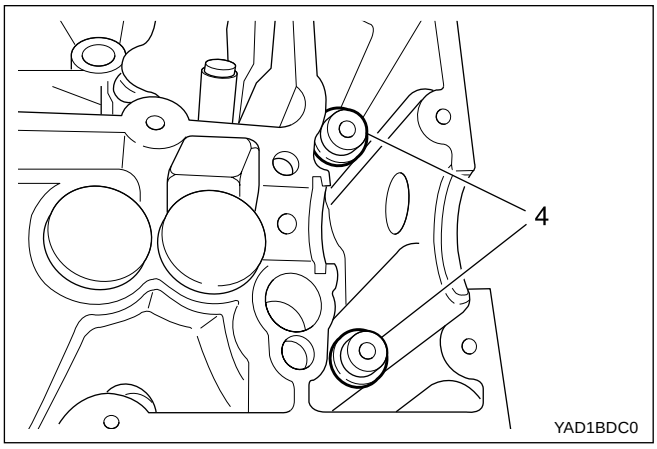
9. Remove the nut and pull out the bolt and then remove the power steering pump.



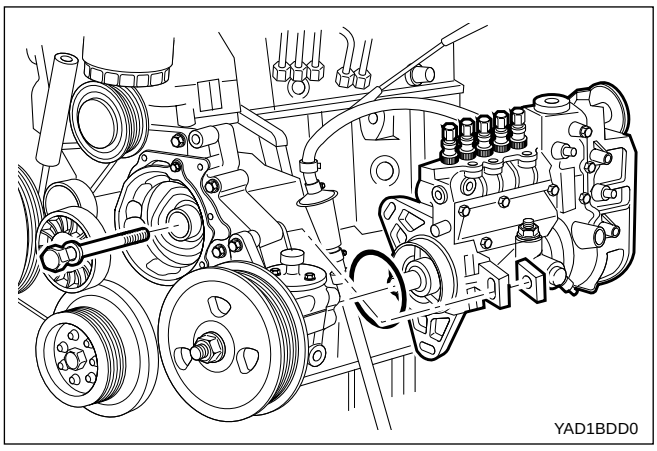
10. Remove the generator bracket (16).



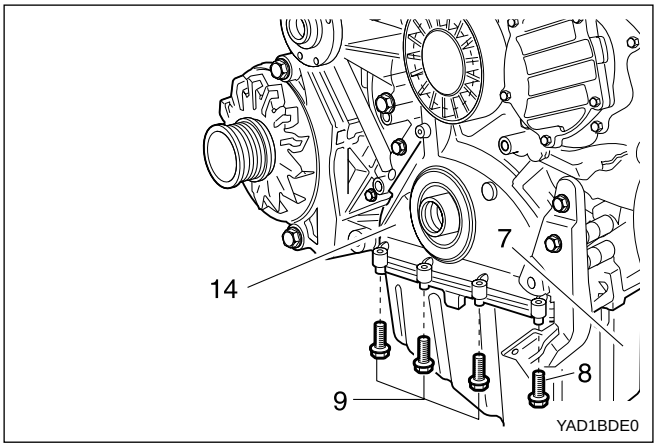
11. Remove the fuel filter.



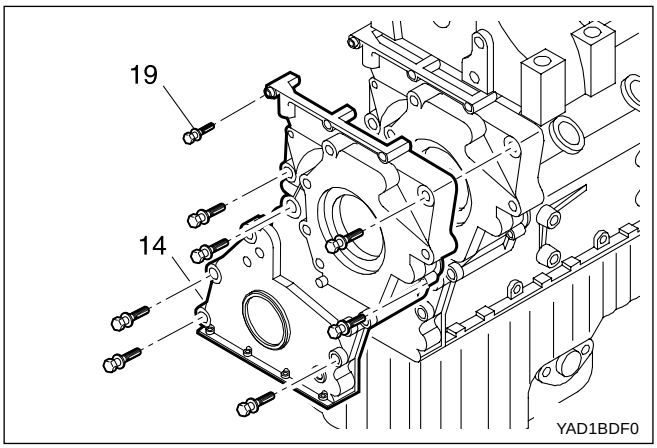
12. Remove the camshaft.
13. Remove the socket bolts (4) in the chain box using the socket wrench 115 589 03 07 00.



14. Remove the injection pump. Refer to *Section 1F3 Diesel Engine Control.*



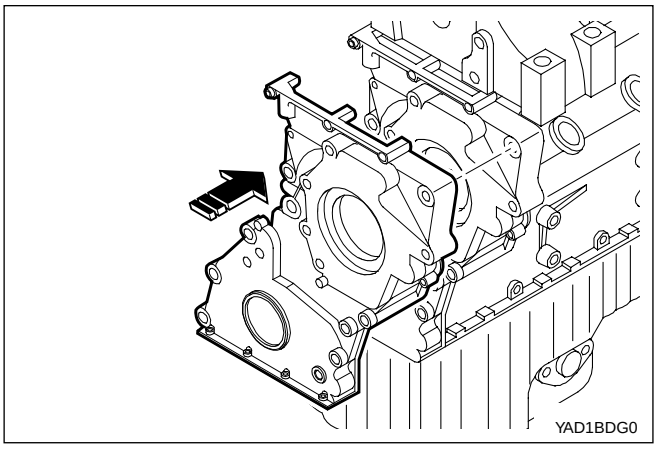
15. Remove the oil pan bolts (8, 9) in the area of the timing case cover (14).
16. Slightly loosen the remaining oil pan bolts.



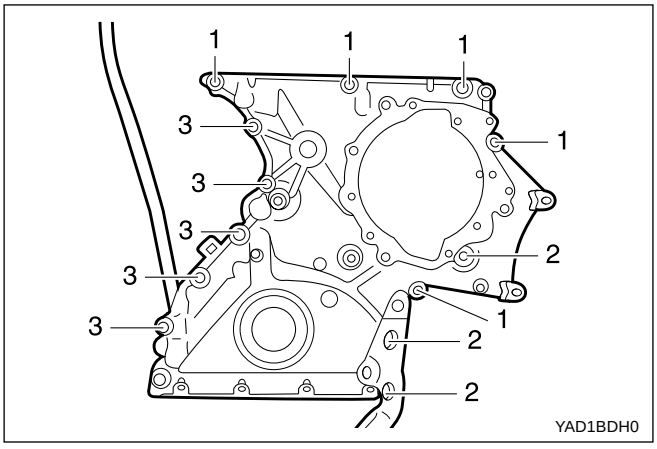
17. Remove the timing case cover (19) bolts and then remove the timing case cover (14).

    Notice: Be careful not to damage the cylinder head gasket or oil pan gasket.

Installation Procedure



1. Thoroughly clean the sealing surface and apply sealant.



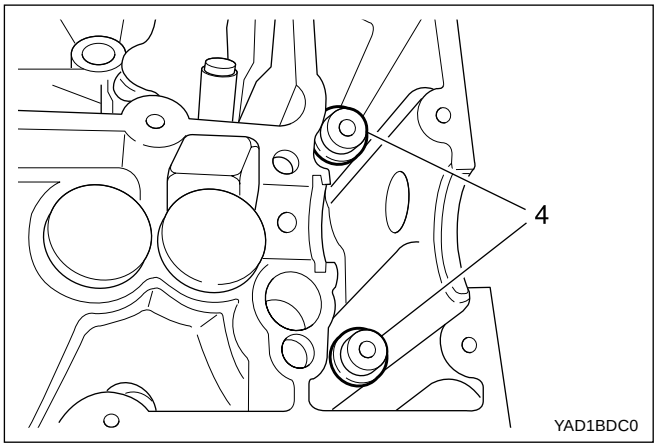
2. Install the timing case cover.

   Installation Notice

Tightening Torque	10 N•m (89 lb-in)

   Bolts arrangement

   1. M6 x 60
   2. M6 x 70
   3. M6 x 40



3. Tighten the socket bolts in the chain box.

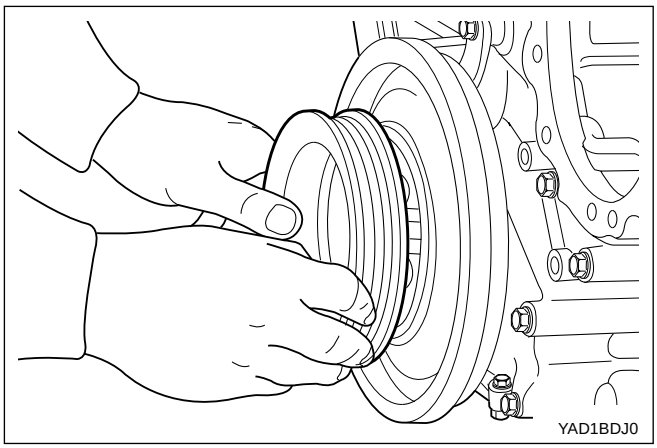
Installation Notice

Tightening Torque	25 N•m (18 lb-ft)

4. Tighten the oil pan bolts.

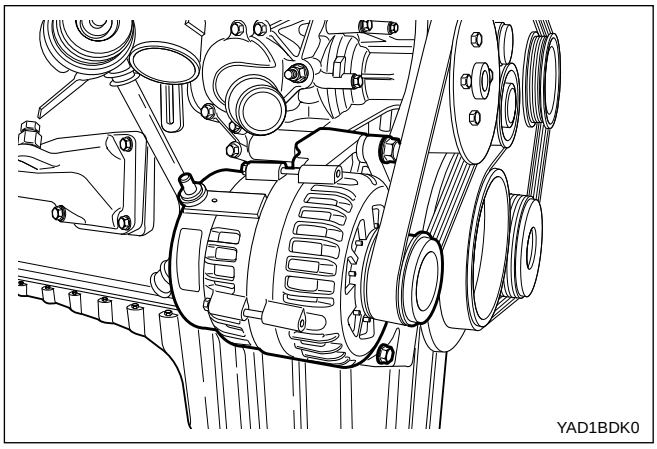
Installation Notice

Tightening Torque	Socket Bolt	10 N•m (89 lb-in)
	M6 Bolt	10 N•m (89 lb-in)
	M8 Bolt	25 N•m (18 lb-ft)



5. Install the flange, vibration damper and crankshaft belt pulley.

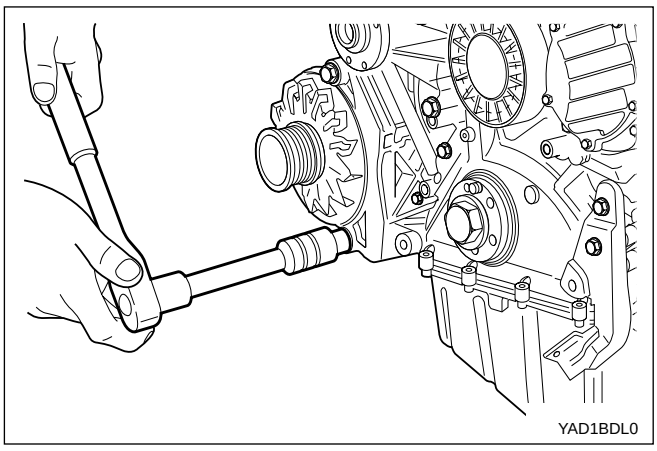
Notice: Replace front radial seal if necessary.



6. Install the generator bracket.

Installation Notice

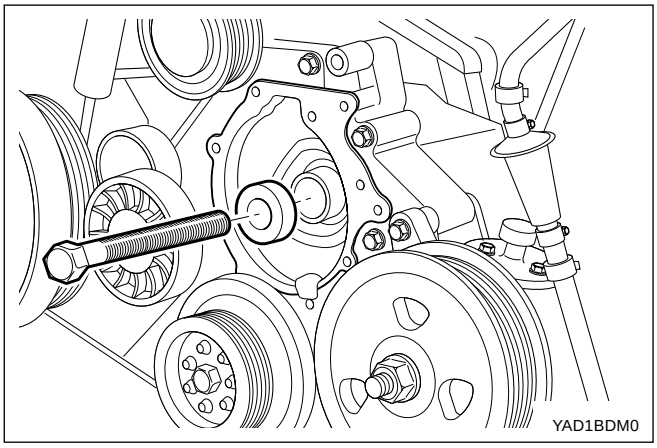
Tightening Torque	Front	25 N•m (18 lb-ft)
	Side	25 N•m (18 lb-ft)



7. Install the generator.

Installation Notice

Tightening Torque	Upper	25 N•m (18 lb-ft)
	Lower	45 N•m (33 lb-ft)


YAD1BDM0

8. Install the cylinder head cover.

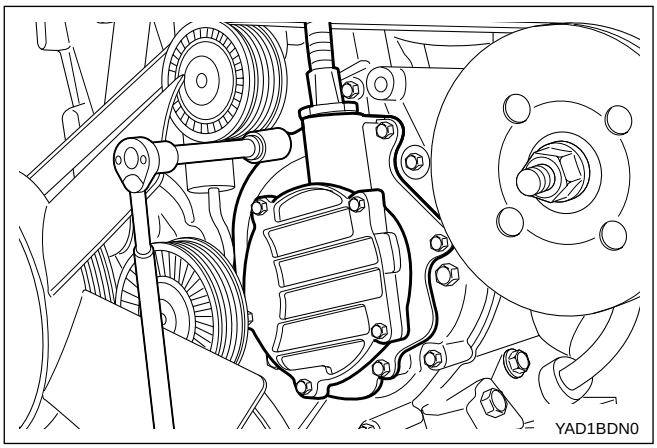
Installation Notice

Tightening Torque	10 N•m (89 lb-in)

9. Tighten the injection pump mounting bolts.

Installation Notice

Tightening Torque	23 N•m (17 lb-ft)


YAD1BDN0

10. Install the fuel filter.

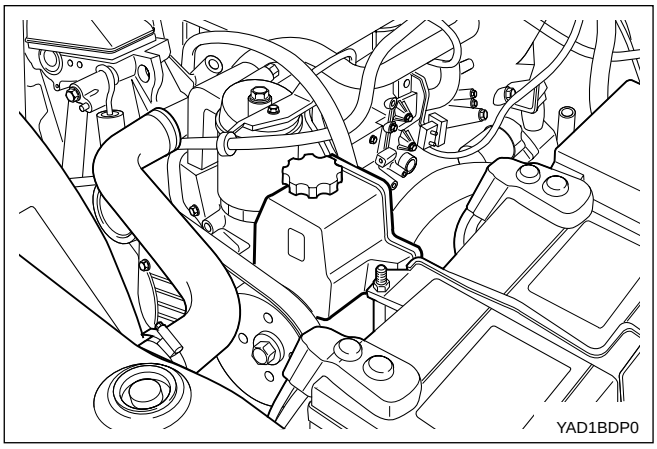
Installation Notice

Tightening Torque	25 N•m (18 lb-ft)

11. Install the vacuum pump.

Installation Notice

Tightening Torque	10 N•m (89 lb-in)


YAD1BDP0

12. Install the power steering pump.

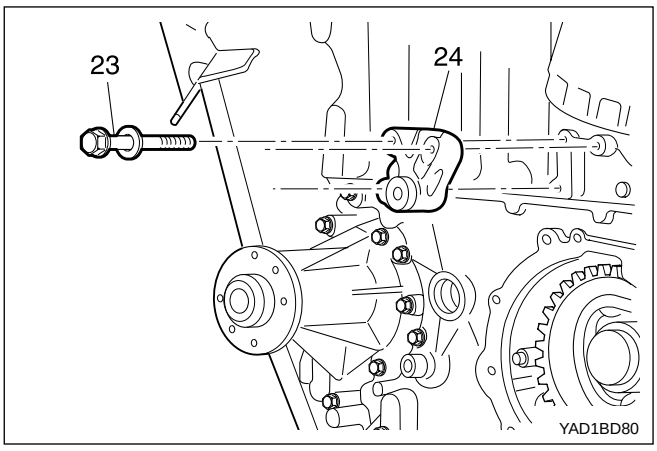
Installation Notice

Tightening Torque	23 N•m (17 lb-ft)

13. Install the power steering pump pulley.

Installation Notice

Tightening Torque	32 N•m (24 lb-ft)

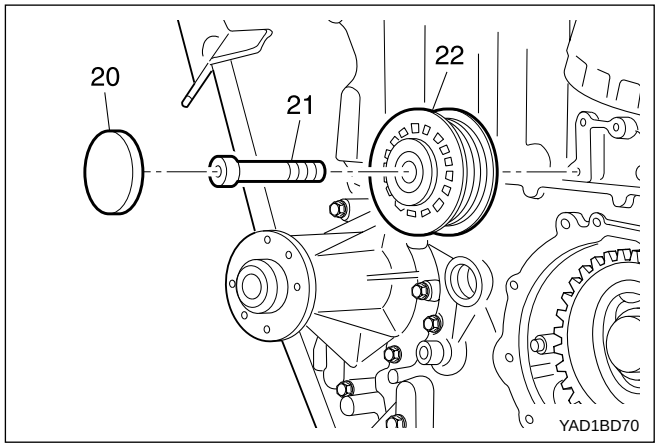


YAD1BD80

14. Install the guide pulley bracket.

Installation Notice

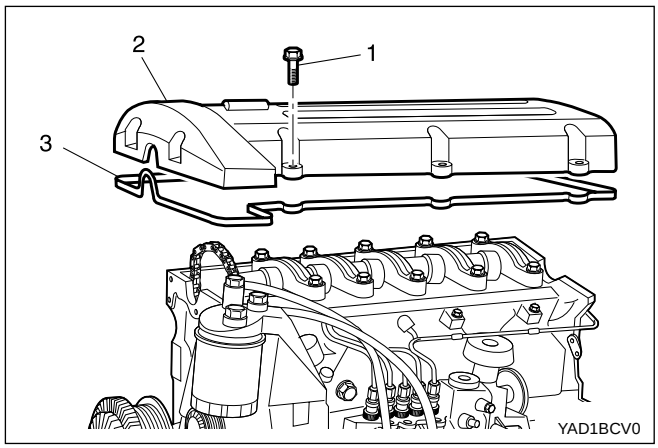
Tightening Torque	9 N•m (80 lb-in)



15. Install the guide pulley (22) and fit the closing cover (20).

Installation Notice

Tightening Torque	23 N•m (17 lb-ft)



16. Replace the gasket (3) and install the cylinder head cover (2).

Installation Notice

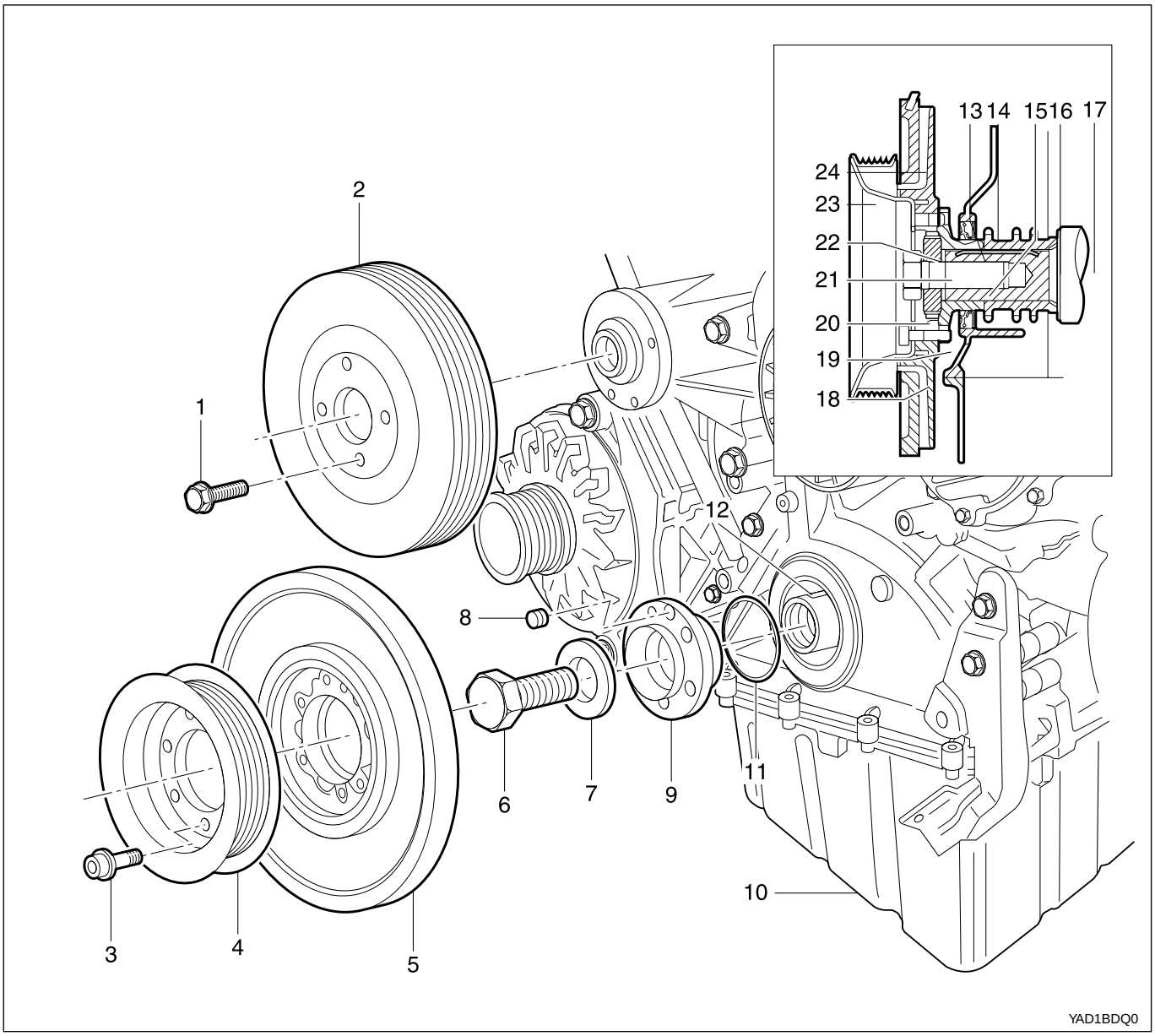
Tightening Torque	10 N•m (89 lb-in)

17. Install the cooling fan belt pulley and fan clutch.
18. Install the belt tensioning device and then install the belt.
19. Install the cooling fan.
20. Fill the engine oil and check oil leaks by running the engine.

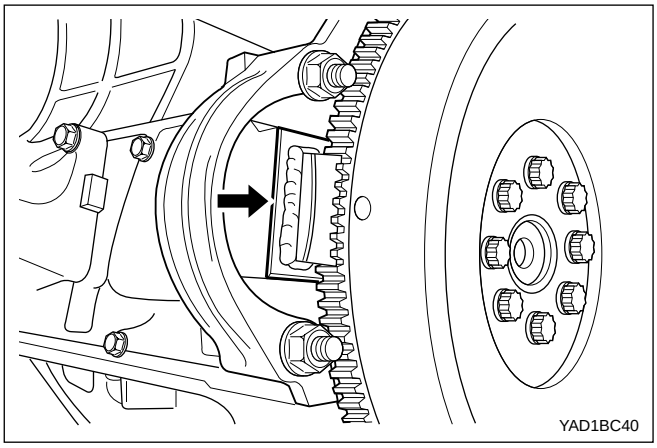
CRANKSHAFT ASSEMBLY

VIBRATION DAMPER AND HUB

Preceding Work: Removal of the cooling fan
Removal of poly V-belt



1 Bolt ..... 10 N•m (89 lb-in)
2 Cooling Fan Belt Pulley
3 Socket Bolt ..... 23 N•m (17 lb-ft)
4 Crankshaft Belt Pulley
5 Vibration Damper
6 Bolt ..... 200 N•m (148 lb-ft)+ 90°
7 Washer
8 Straight Pin
9 Hub
10 Oil Pan
11 Radial Seal
12 Key
13 Radial Seal
14 Timing Gear Case Cover
15 Key
16 Crankshaft Sprocket
17 Crankshaft
18 Socket Bolt ..... 23 N•m (17 lb-ft)
19 Washer
20 Bolt ..... 20 N•m (148 lb-ft)+ 90°
21 Hub
22 Straight Pin
23 Crankshaft Velt Pulley
24 Vibration Damper



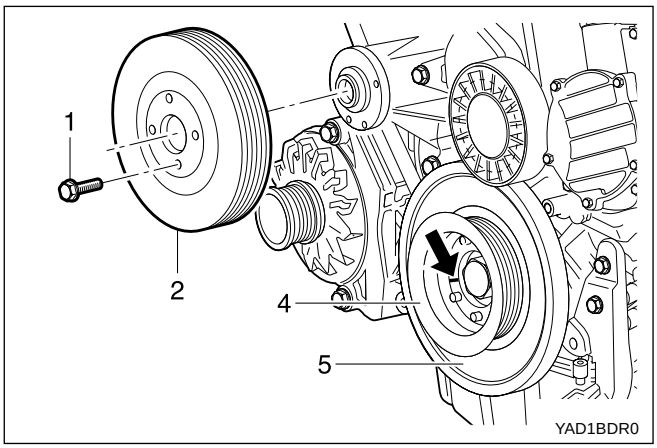
Tools Required

103 589 00 33 00 Puller
601 589 03 14 00 Sleeve
602 589 00 40 00 Engine Lock

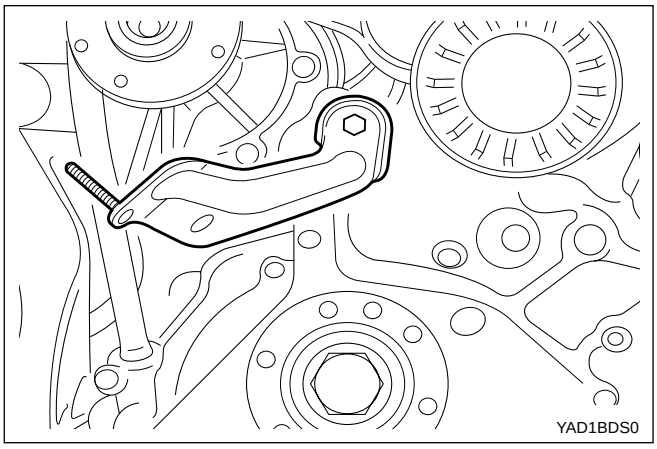
Removal Procedure

1. Remove the starter motor and install the engine lock 602 589 00 40 00 into the flywheel ring gear.
2. Remove the poly V-belt.
3. Remove the cooling fan.

   Notice: Keep the fan in vertical position.

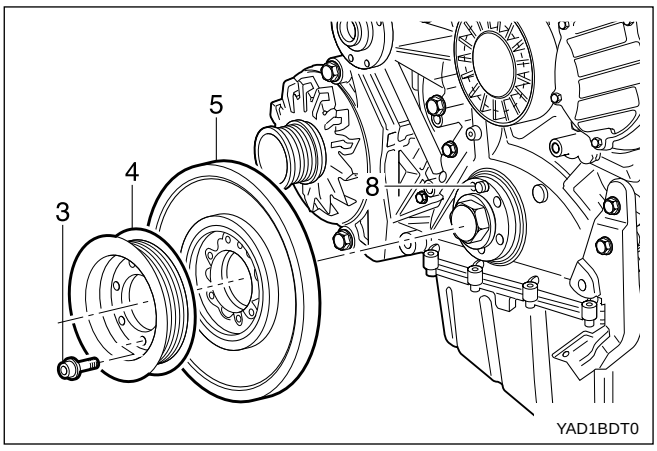


4. Remove the cooling fan belt pulley (2).
5. Place alignment marks (arrow) on the vibration damper (5) and crankshaft belt pulley (4).

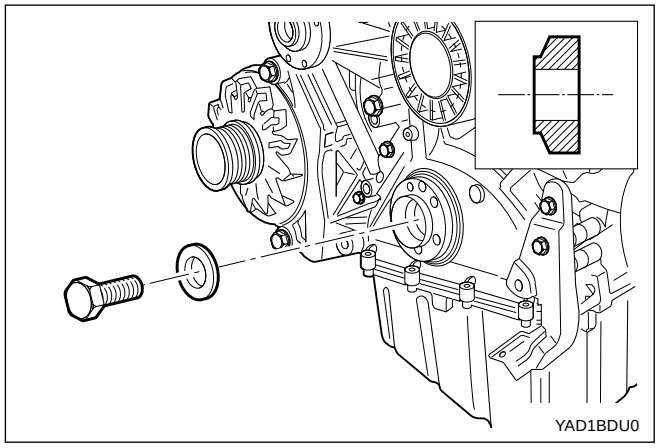


6. Remove the timing sensor bracket.

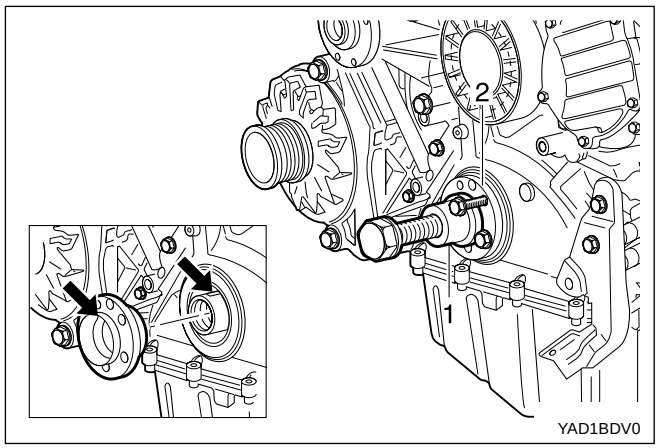
   Notice: Remove if necessary.



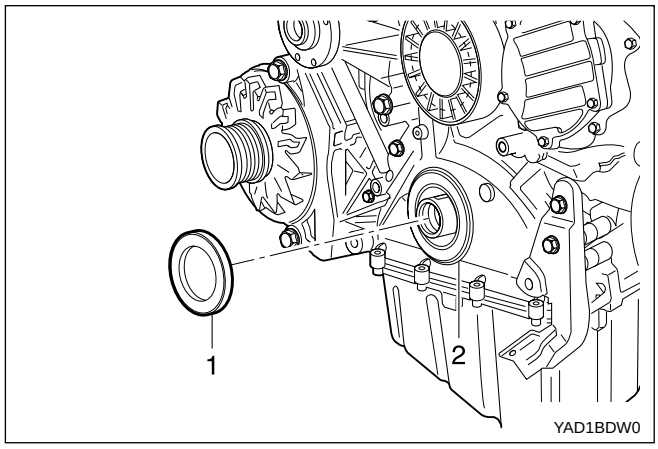
7. Remove the socket bolts (3) and then remove the belt pulley (4) and vibration damper (5).



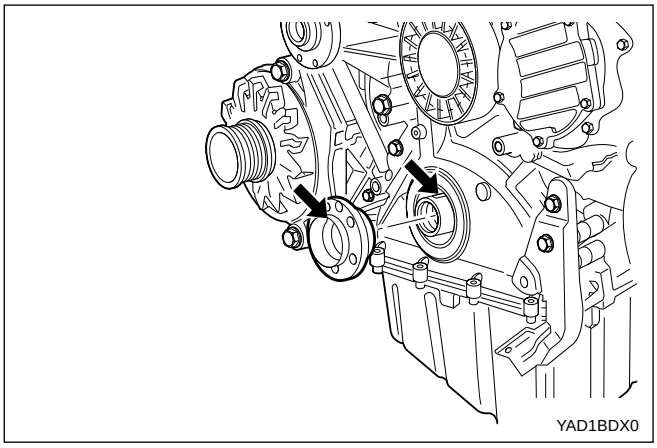
8. Remove the washer and bolt.



9. Remove the hub by using a puller 103 589 00 33 00.



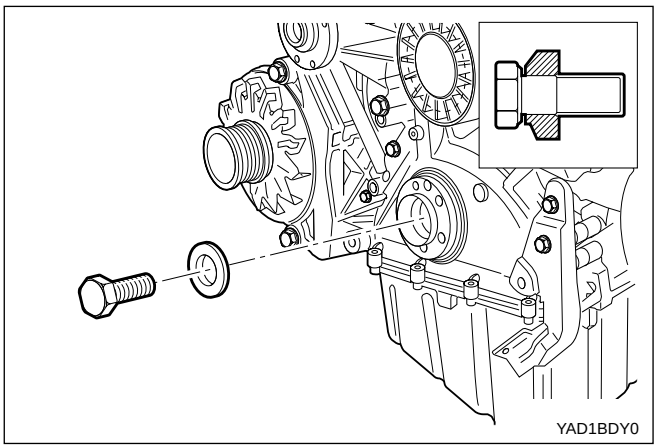
10. Pull out the radial seal (1) and be careful not to damage the sealing surface of timing case cover.



Installation Procedure

1. Install the hub.

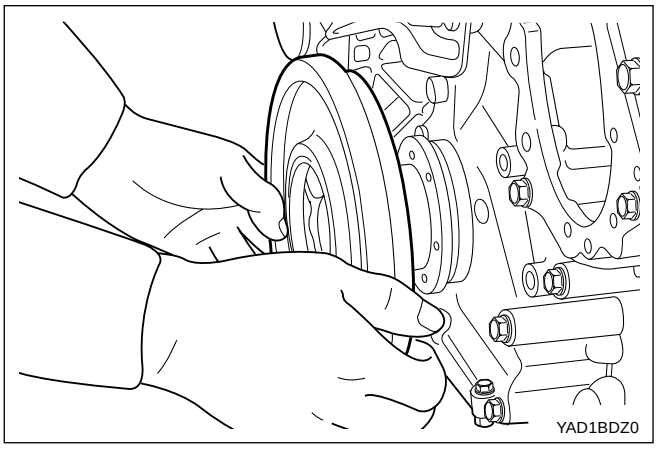
   Notice: Exactly align the woodruff key and the groove of hub (arrow).



2. Install the washer and tighten the bolt.

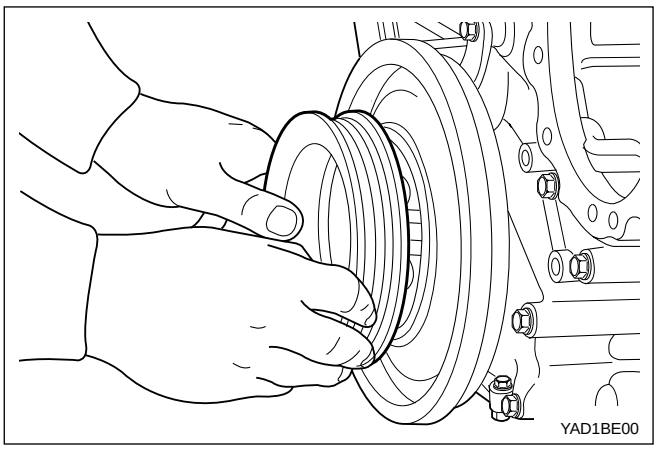
   Installation Notice

Tightening Torque	200 N•m (148 lb-ft)+ 90°



3. Install the vibration damper.

   Notice: Exactly align and insert onto the straight pin.

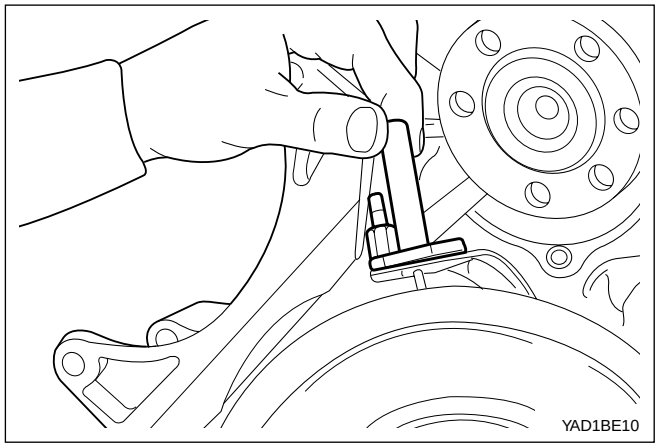


4. Install the crankshaft belt pulley.

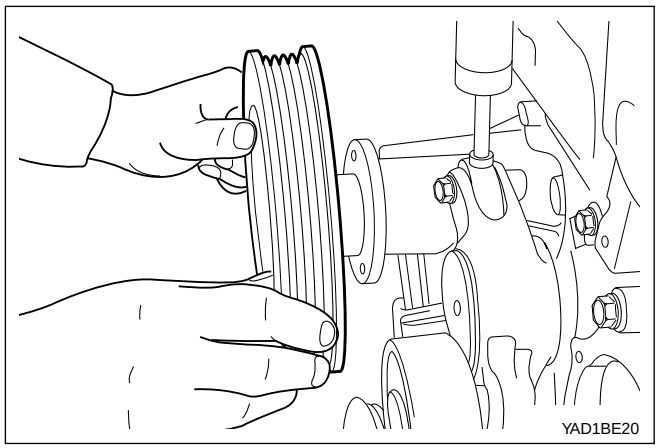
   Installation Notice

Tightening Torque	23 N•m (17 lb-ft)

   Align the alignment marks.



5. Install the timing sensor bracket.
   Refer to “TDC Setting” in this section.

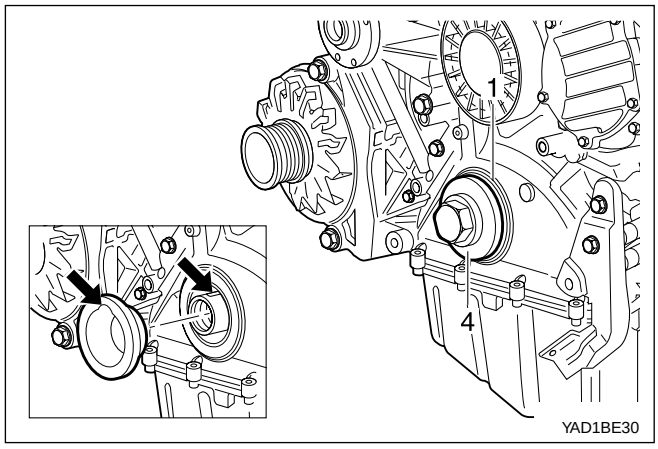


6. Install the cooling fan pulley.

   Installation Notice

Tightening Torque	10 N•m (89 lb-in)

7. Install the cooling fan.
8. Install the fan belt.
9. Remove the engine lock 602 589 00 40 00.

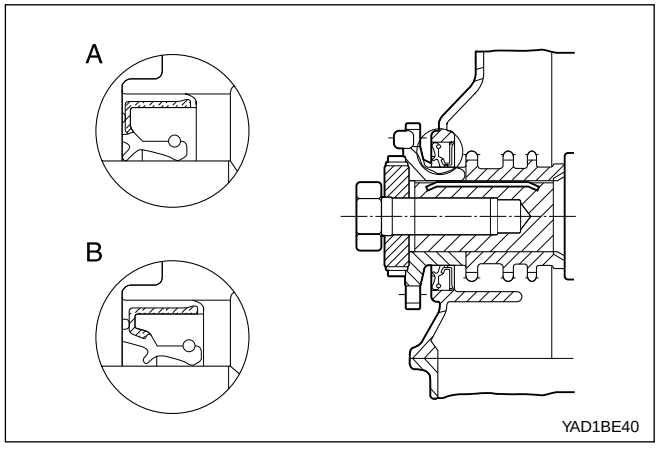


10. Throughly clean the mounting bore of the radial seal.
11. Coat a little oil on the sealing lip of new radial (1) and contact surface.

    Notice: Don’t use grease.

12. Install the radisl seal (1) by using a sleeve 601 589 03 14 00 (4).

    Notice: Align the groove of sleeve and woodruff key (arrow).

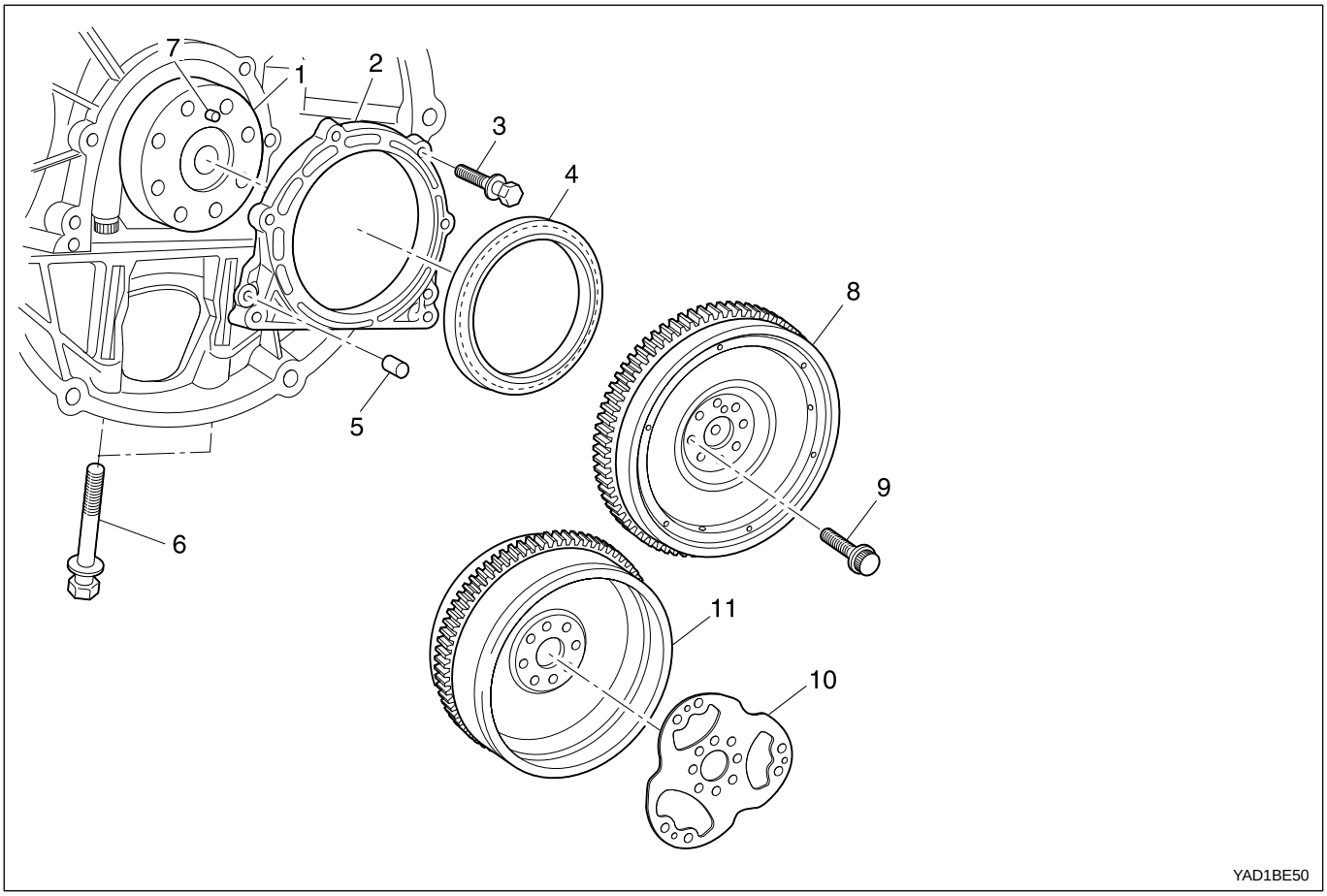


Notice: The sealing lip of the repair radial seal is offset to the inside by 2 mm to ensure that is does not run in any groove which the standard radial seal may have left on the crankshaft flange.

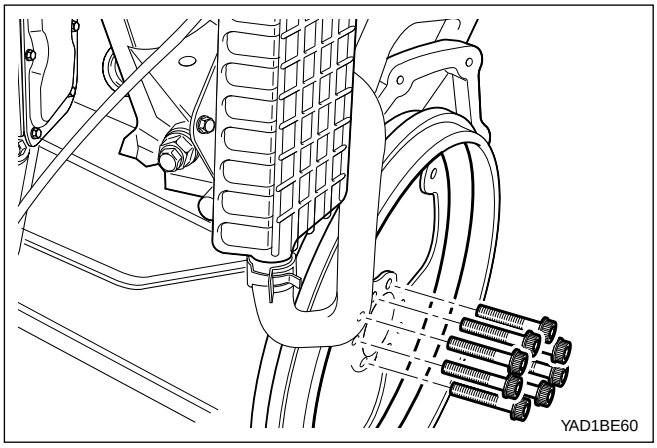
A Standard Radial Seal
B Repair Radial Seal

FLYWHEEL AND CRANKSHAFT END COVER

Preceding Work: Removal of the transmission
Removal of the clutch



1 Crankshaft Flange
2 End Clver ..... Clean Loctite 573
3 Bolt..... 10 N•m (89 lb-in) Loctite 573
4 Radial Seal..... Replace
5 Dowel Sleeve
6 Bolt..... 10 N•m (89 lb-in) Loctite 573
7 Straight Pin
8 Flywheel (Manual Transmission)
9 12-Sided Stretch Bolt
..... Check, 45 N•m (33 lb-ft)+ 90°
10 Drive Plate (Automatic Transmission)
11 Flywheel (Automatic Transmission)


YAD1BE60

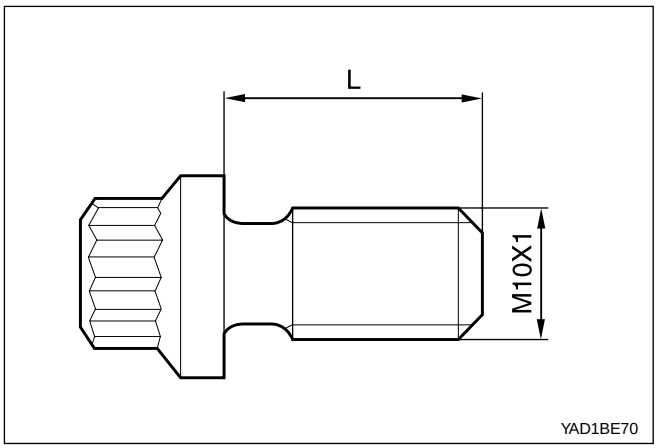
Tools Required

601 589 03 43 00 Oil Seal Assembler
602 589 00 40 00 Engine Lock

Removal Procedure

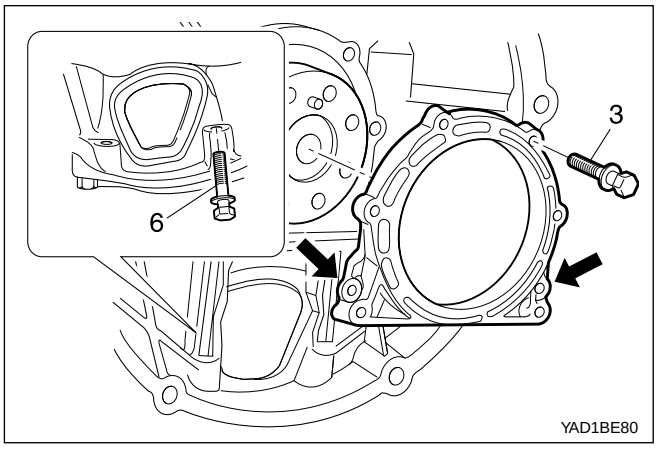
1. Install the engine lock 602 589 00 40 00.
2. Remove the 12-sided stretch bolts.

   Notice: Remove the flywheel and drive plate, if equipped with automatic transmission.



YAD1BE70

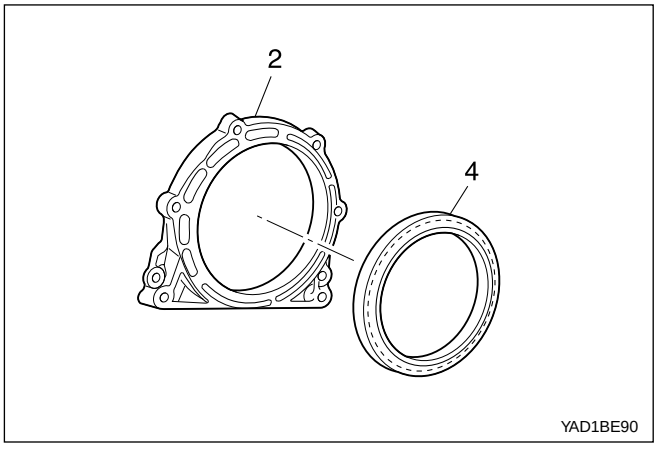
Notice: If the length 'L'of bolts exceeds 22.5 mm, replace the bolts.



YAD1BE80

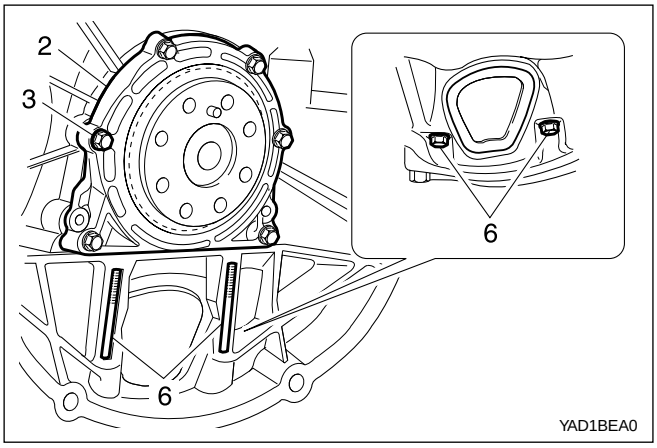
3. Remove the bolts (3. 6) from end cover, by pulling out the lug (arrow), remove the cover.

   Notice: Be careful not to damage the oil pan gasket.



YAD1BE90

4. Remove the radial seal (4) with care not to damage the sealing surface.



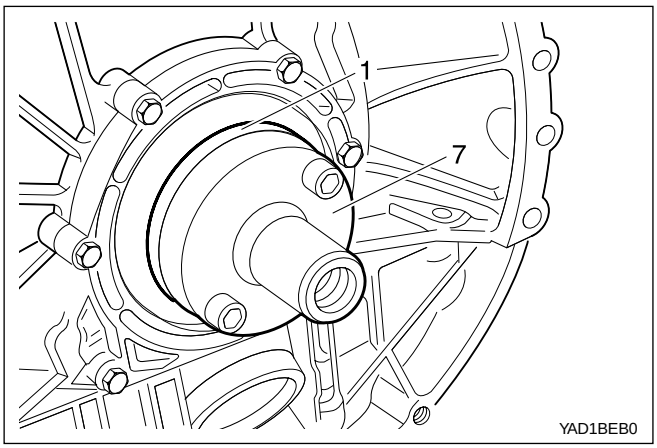
Installation Procedure

1. Throughly clean the sealing surface of end cover and apply Loctite 573.
2. Clean the groove of radial seal.
3. Apply Loctite 573 on the bolts and install the end cover.

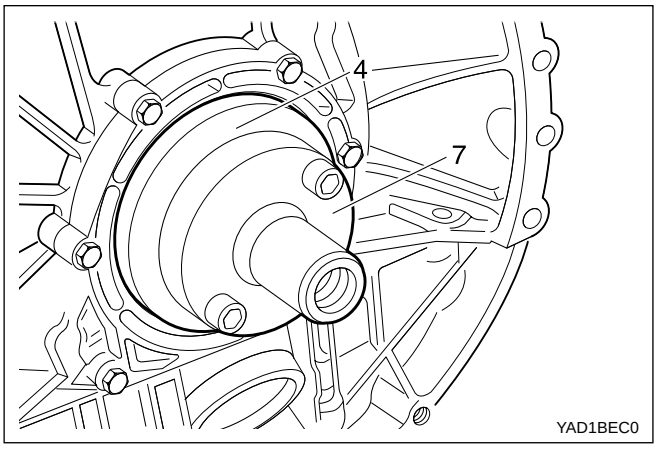
Installation Notice

Tightening Torque	10 N•m (89 lb-in)

Be careful not to damage the oil pan gasket.



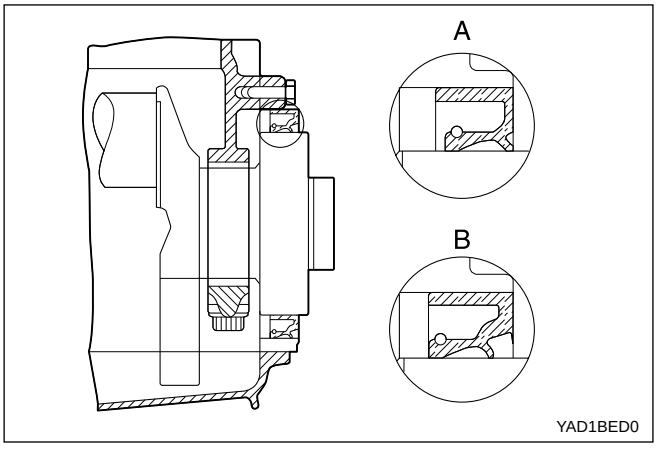
4. Install the inner oil seal assembler 601 589 03 43 00 to the crankshaft flange.



5. Coat a little oil on the sealing lip of new radial seal and contacting surface.

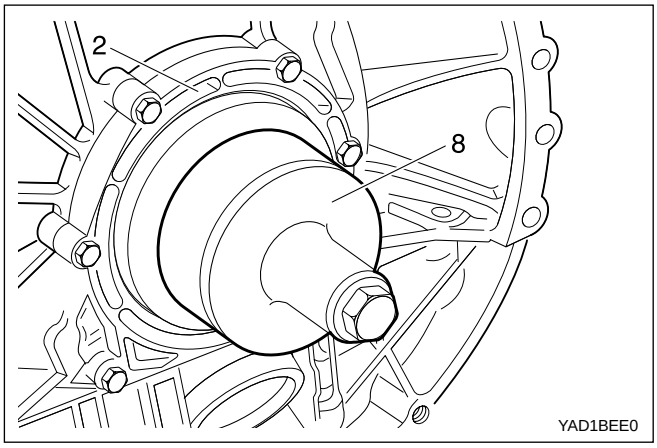
   Notice: Don't use grease.

6. Insert the new radial seal (4) on to the oil seal assembler 601 589 03 43 00 (7).



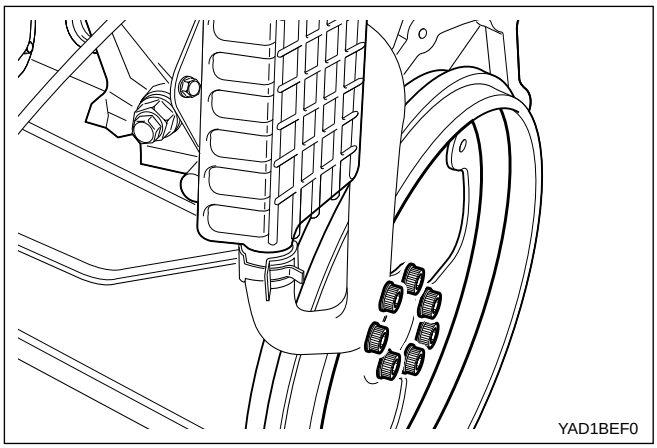
Notice: The sealing lip of the repair radial seal is offset to the inside by 3 mm to ensure that is does not run in any groove which the standard radial seal may have left on the crankshaft flange.

A Standard Radial Seal
B Repair Radial Seal



7. Install the outer oil seal assembler 601 589 03 43 00 on the seal and by tightening the bolts, press the radial seal into the end cover as far as the stop.

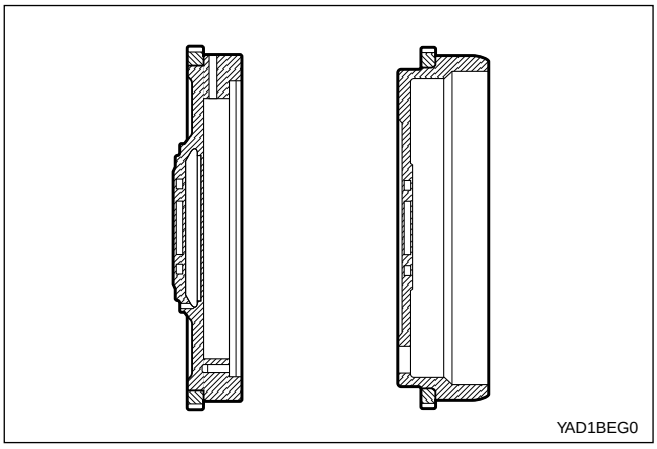
   Notice: The seal must be positioned exactly at right angles in the end cover to ensure that it provide a proper seal.



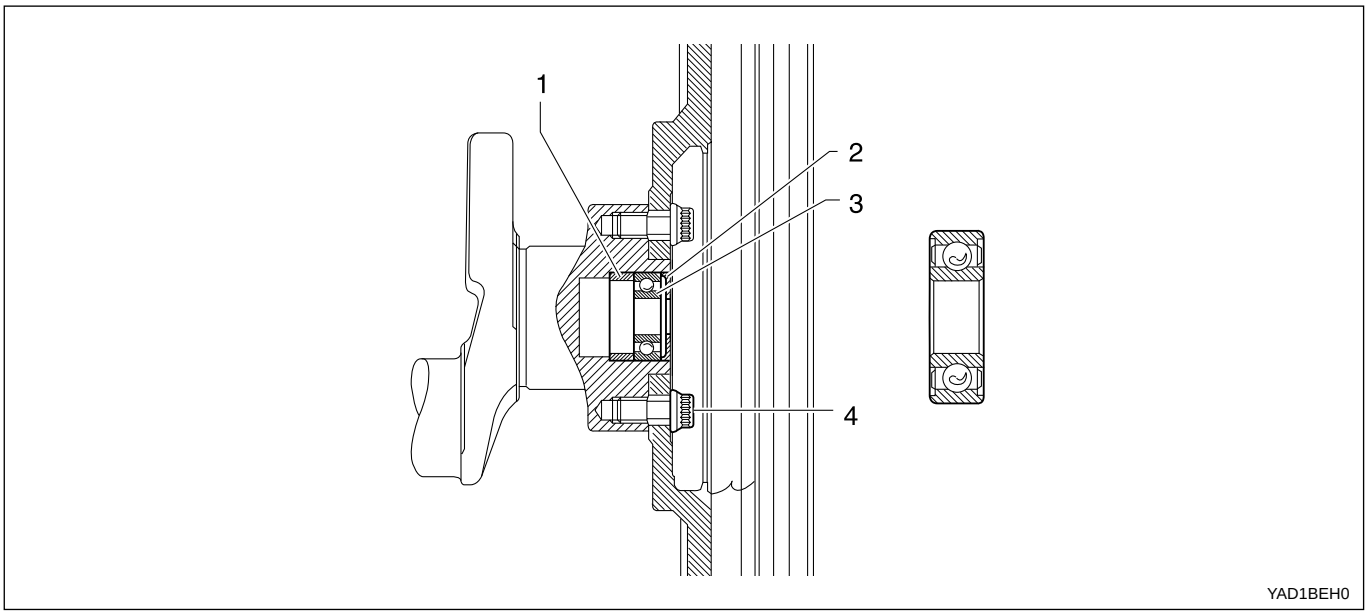
8. Install the flywheel.

   Installation Notice

Tightening Torque	45 N•m (33 lb-ft)+ 90°



CRANKSHAFT BALL BEARING

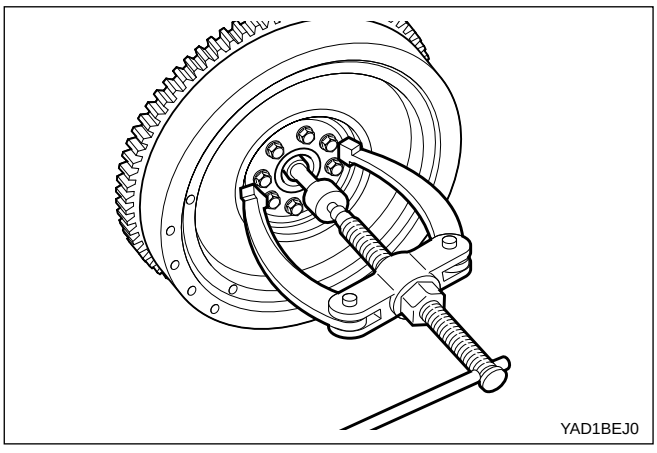


1 Spacer
2 Cover ..... Replace
3 Ball Bearing
4 Bolt ..... 45 N•m (33 lb-ft)+ 90°

Notice: Manual transmission only.

Tools Required

000 589 25 33 00 Internal Extractor
000 589 33 33 00 Counter Support

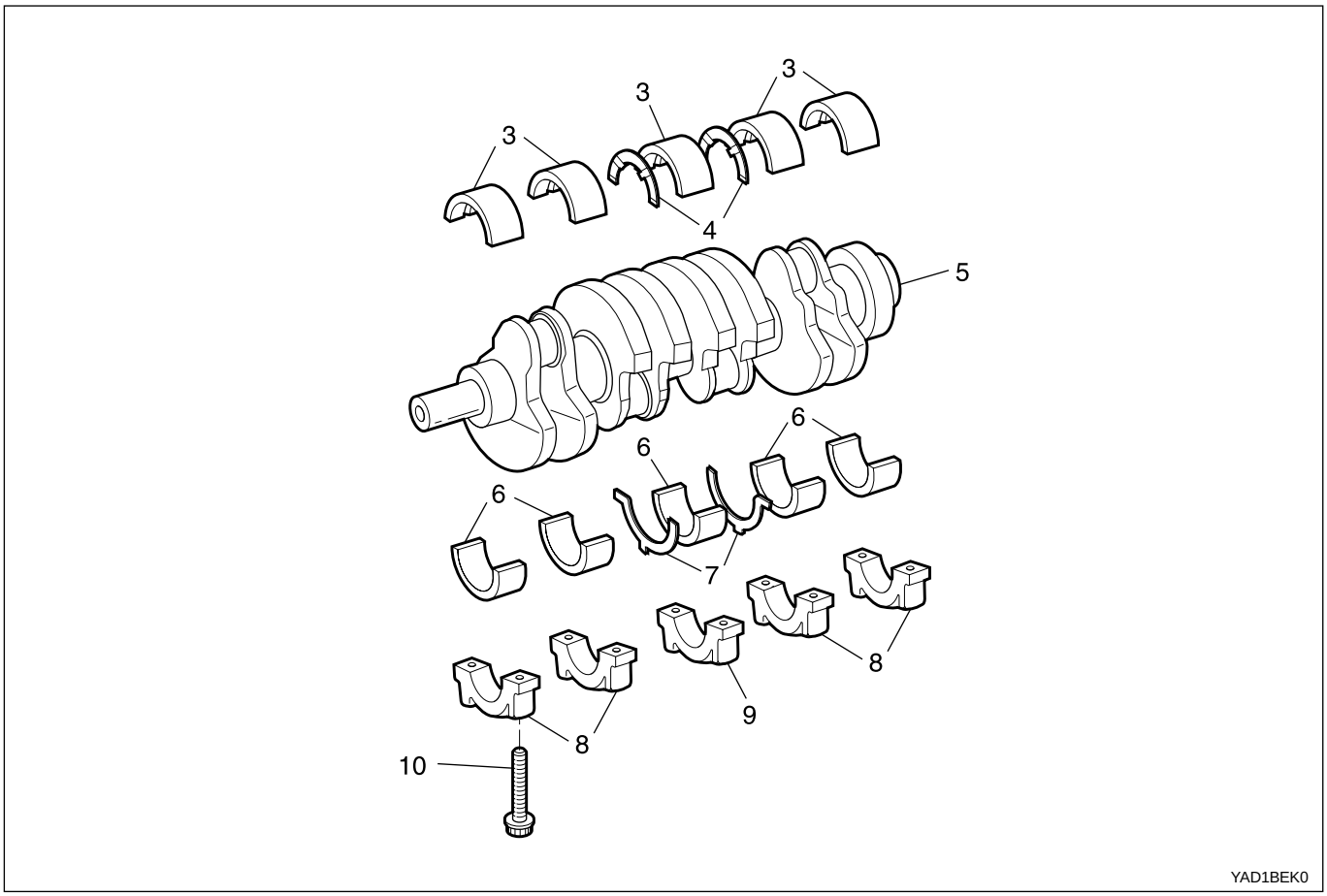


Removal & Installation Procedure

1. Remove the manual transmission.
2. Using a internal extractor 000 589 25 33 00 and counter support 000 589 33 33 00, pull out the locking ring and ball bearing together.
3. Apply Loctite 241 on the new ball bearing and then insert the ball bearing to be stopped at the spacer ring by using a proper mandrel.

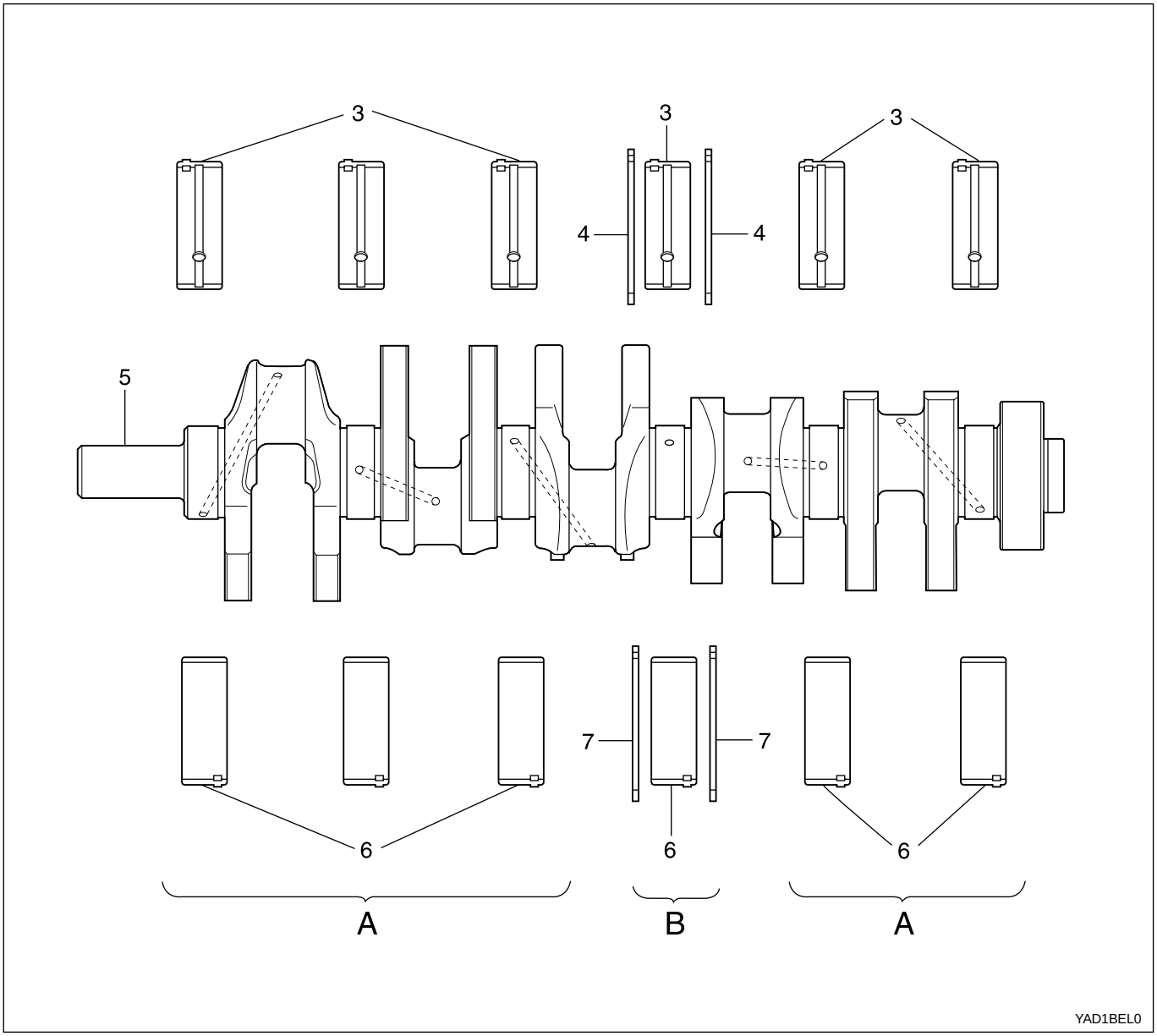
CRANKSHAFT

Preceding Work: Removal of the end cover
Removal of the piston
Removal of the crankshaft sprocket



3 Crankshaft Main Bearing Shells (Upper)
4 Trust Bearings (Upper)
5 Crankshaft
6 Crankshaft Main Bearing Shells (Lower)
7 Thrust Bearings (Lower)
8 Crankshaft Bearing Cap
9 Crankshaft Bearing Cap (Fit Bearing)
10 12-sided Stretch Bolts .... 55 N•m (41 lb-ft)+ 90°

Thrust Washer and Bearing Arrangement



3 Crankshaft Main Bearing Shells (Upper)
4 Thrust Bearings (Upper)
5 Crankshaft
6 Crankshaft Main Bearing Shells (Lower)
7 Thrust Bearings (Lower)

A Radial Bearings
B Radial and Axial Bearings (Thrust Bearing)

Notice: The gaps between the bearing shell and bore and between the bearing shell and journal are different each other. Refer to service data.

Crankshaft Standard and Repair Sizes

	Crankshaft bearing journal diameter	Thrust bearing journal width	Thrust bearing journal diameter
Standard size	50.950 - 57.965	24.500 - 24.533	47.950 - 47.965
		24.600 - 24.633	
Repair size 1	57.500 - 57.715	24.700 - 24.733	47.700 - 47.715
Repair size 2	57.450 - 57.465	24.900 - 24.933	47.450 - 47.650
Repair size 3	57.200 - 57.215	25.000 - 25.033	47.200 - 47.215
Repair size 4	56.950 - 56.965	-	46.950 - 46.965

Bearing Clearances

		Crankshaft bearing	Thrust bearing
Radial clearances	New	0.027 - 0.051 mm	0.026 - 0.068 mm
	Limit	Max. 0.070 mm	Max. 0.080 mm
Axial clearances	New	0.100 - 0.254 mm	-
	Limit	Max. 0.300 mm	-

Matching Fit Bearing Journal Width to Thrust Bearings

Fit bearing journal width	Thrust bearings thickness
24.500 - 24.533 mm	2.15 mm
24.600 - 24.633 mm	2.20 mm
24.700 - 24.733 mm	2.25 mm
24.900 - 24.933 mm	2.35 mm
25.000 - 25.033 mm	2.40 mm

Notice:

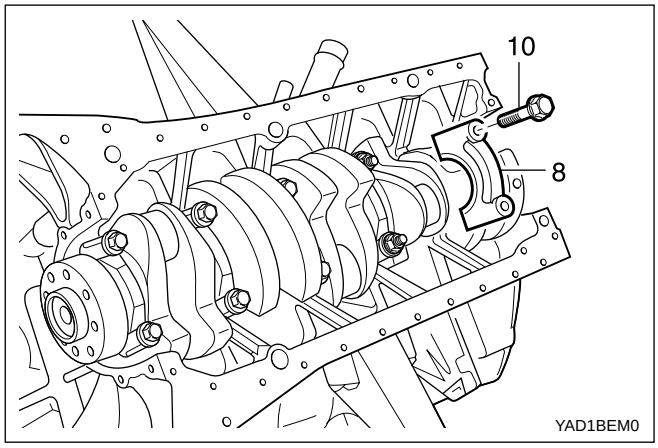
- Measure crankshaft axial clearance and adjust with proper thrust Bearing.
- The same thickness of washer must be installed on both sides of the fit bearing.

Matching Crankshaft Bearing Shells to Basic Bearing Bore in Crankshaft

Marking of basic bearing bore in lower parting surface	Color code of relevant crankshaft bearing shell
1 punch mark or blue	Blue or white-blue
2 punch marks or yellow	Yellow or white-yellow
3 punch marks or red	Red or white-red

Matching Crankshaft Bearing Shells to Basic Bearing Journal of Crankshaft

Marking of bearing journals on crank webs	Color code of relevant crankshaft bearing shell
Blue or white-blue	Blue or white-blue
Yellow or white-blue	Yellow or white-yellow
Red or white-blue	Red or white-red



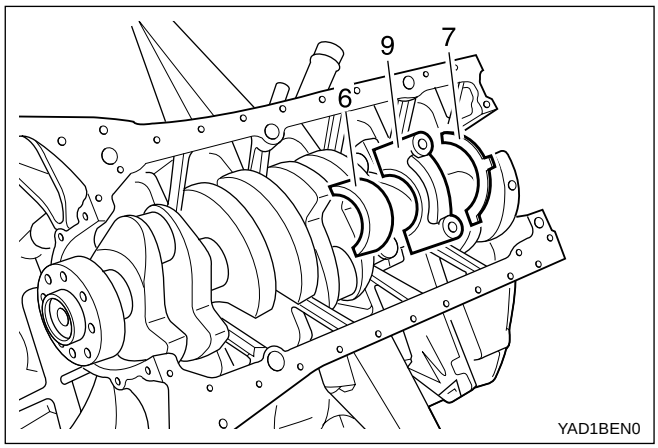
Tools required

001 589 53 21 00 Dial Gauge
363 589 02 21 00 Dial Gauge Holder
366 589 00 21 05 Extension

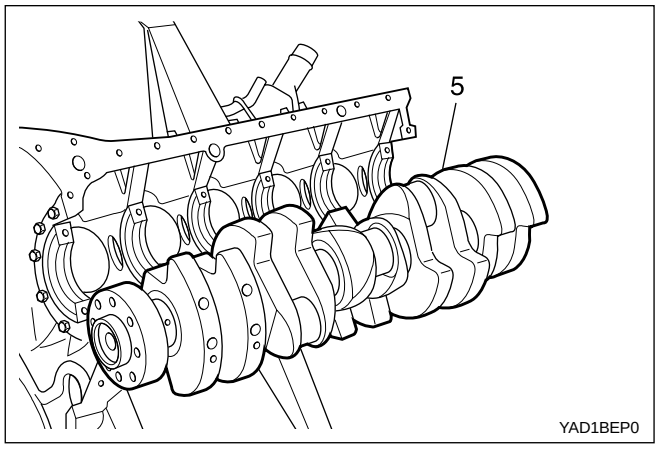
Removal & Installation Procedure

1. Remove the bearing cab bolt.
2. Remove the bearing caps (8).

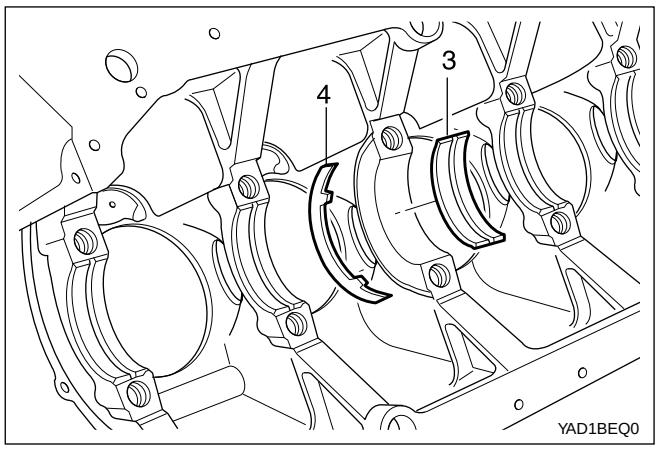
   Notice: The crankshaft bearing caps are marked with stamped numbers. Remove the bearing cap from the vibration damper side.



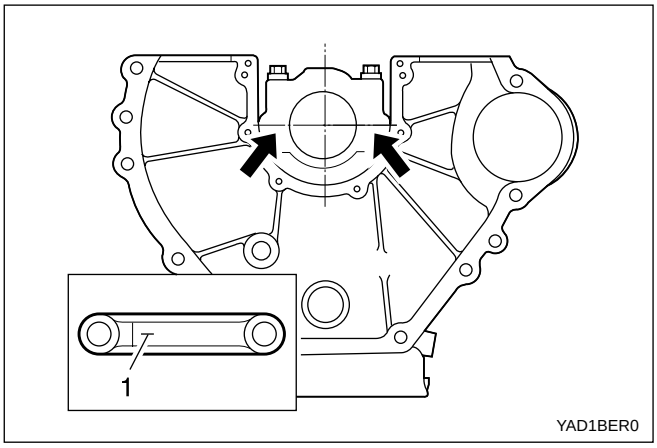
3. Remove the crankshaft bearing caps (9) and lower thrust bearings (7).
4. Remove the lower bearing shell (6) from the bearing cap (9).



5. Remove the crankshaft (5).



6. Remove the upper thrust bearings (4).
7. Remove the upper bearing shells (3) from crankcase.



8. Thoroughly clean the oil gallery.
9. Select a proper new bearing shells with reference to table.
10. Coat the new bearing shells with oil and insert into the crankcase and into the crankshaft bearing caps.

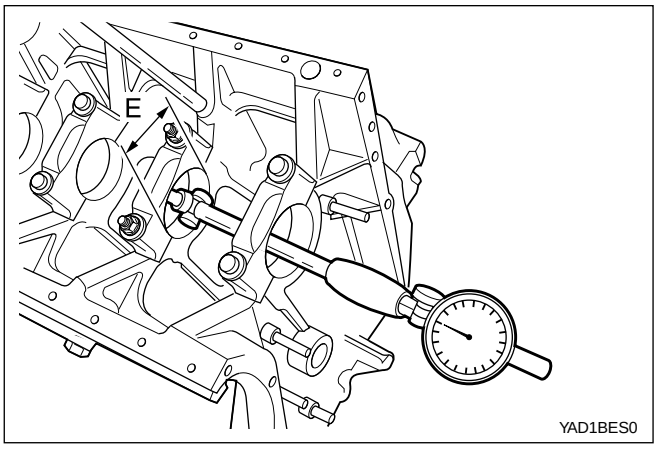
    Notice: Do not mix up upper and lower crankshaft bearing shells.

11. Install the bearing caps according to marking and tighten the 12-sided stretch bolts.

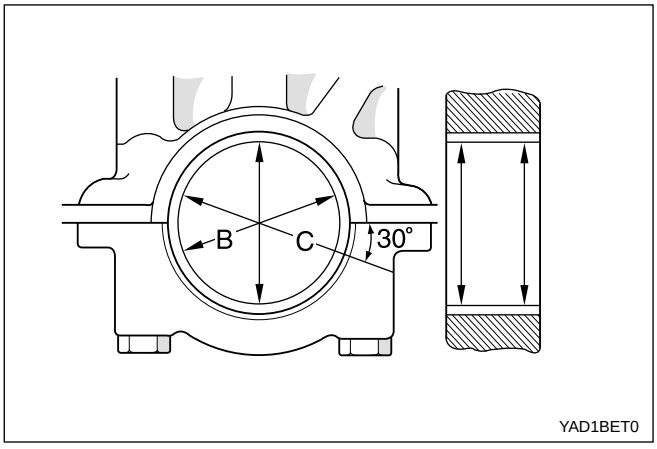
    Installation Notice

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

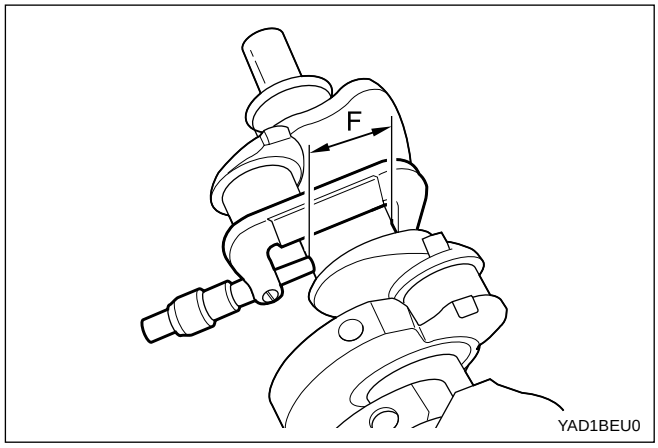
    No. 1 is vibration damper side.



12. Measure crankshaft bearing diameters (E) using the dial gauge 001 589 53 21 00 and extension 366 589 00 21 05.

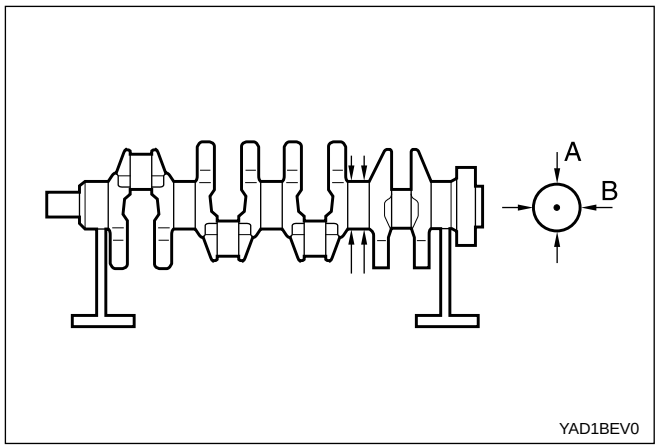


13. Measure at 3 points (A, B and C) and if the average value of B and C is less than A's value, the average value of B and C is the mean value and if more than A's value, A's value is the mean value.



14. Measure crankshaft bearing journal diameter (F).

    Notice: When measured in A and B, the runout should not exceed 0.010 mm.

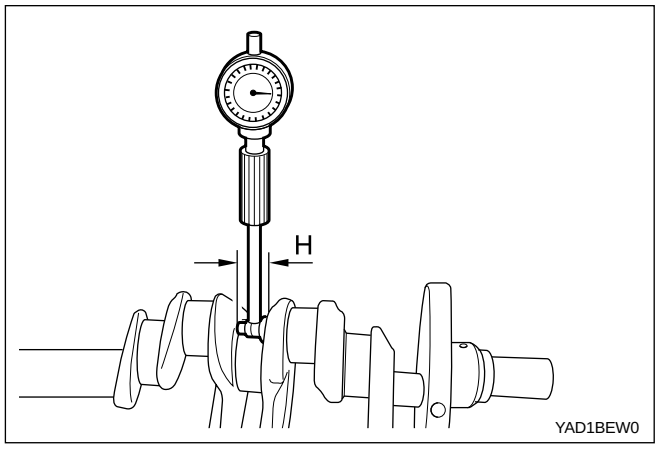


15. Measure radial clearance of crankshaft bearing (G).

Clearance 'G'	0.027 - 0.051 mm

    Notice: If 'G' is out of standard, replace the bearing shells and adjust the radial clearance of crankshaft bearing.

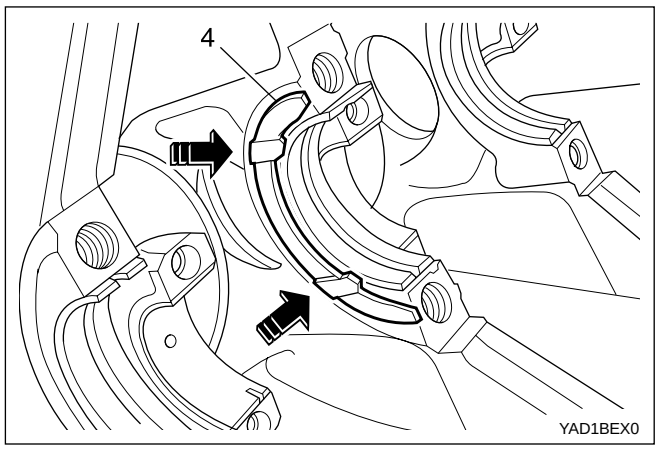
    Example) Measured value 'E' = 57.700 mm
    Measured value 'F' = 57.659 mm
    Clearance 'G' = 0.041 mm



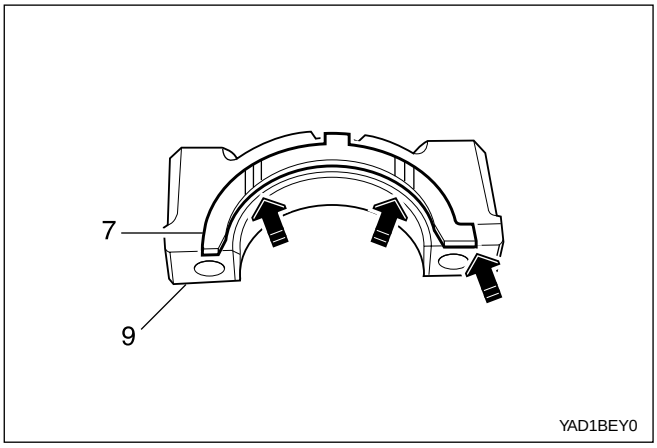
16. Remove the crankshaft bearing cap.

17. Measure width of thrust bearing journal (H) and adjust with proper thrust bearings (see table).

    Notice: The same thickness of thrust washers should be installed on both sides of the thrust bearing.

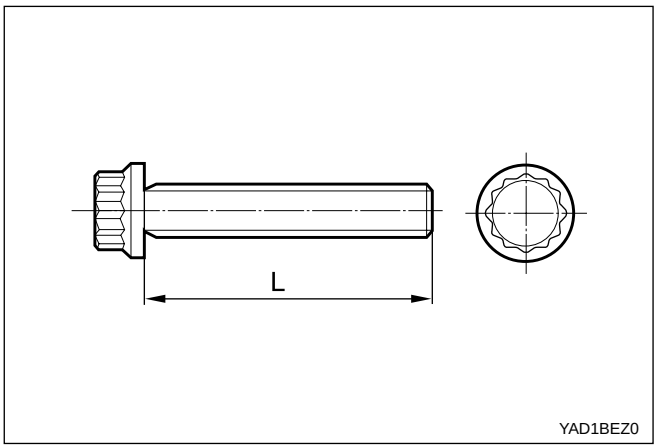


18. Coat the upper thrust bearing (4) with oil and insert into the crankcase so that the oil grooves are facing the crank webs (arrow).

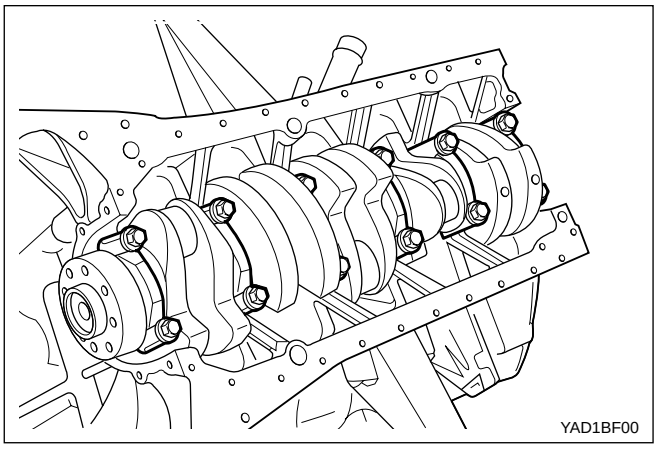


19. Coat the lower thrust bearing (7) with oil and insert into the crankshaft bearing cap so that the oil grooves are facing the crank webs (arrow).

    Notice: The retaining lugs should be positioned in the grooves (arrow).



Notice: If the max. length of bolts (L) exceed 63.8 mm, replace them.

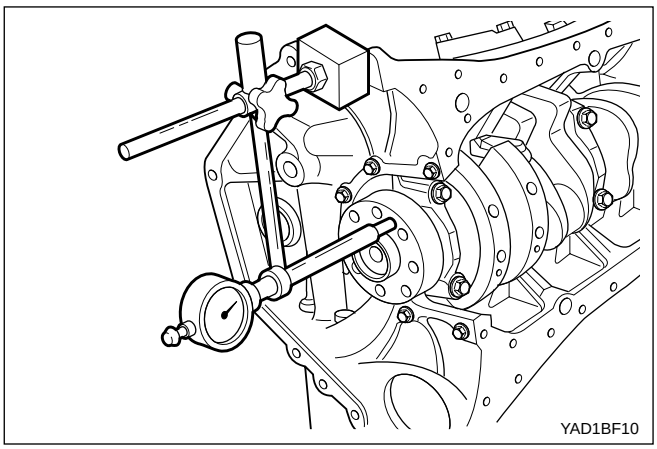


20. Coat the new crankshaft with engine oil and place it on the crankcase.
21. Install the crankshaft bearing caps according to marking and tighten the bolts.

    Installation Notice

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

    Install from No. 1 cap.

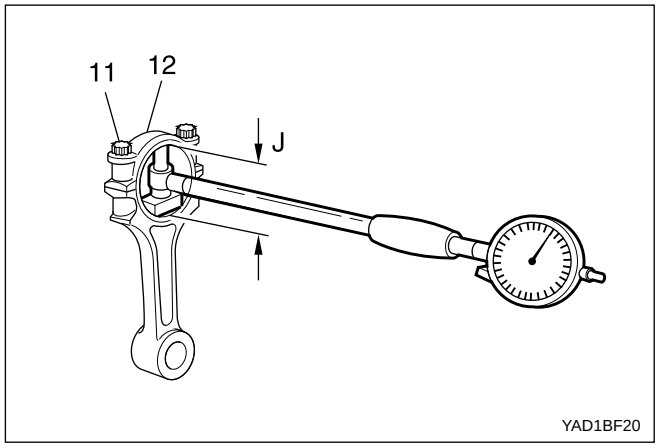


22. Rotate the crankshaft with hand and check whether it rotates smoothly.
23. Measure crankshaft bearing axial clearance using dial gauge 001 589 53 21 00 and dial gauge holder 363 589 02 21 00.

Clearance	0.100 - 0.245 mm

    Notice: If the clearance is out of standard, adjust the axial clearance of crankshaft bearing by replacing the thrust washers.

    Notice: The same thickness of thrust washers should be installed on both sides of the thrust bearing.

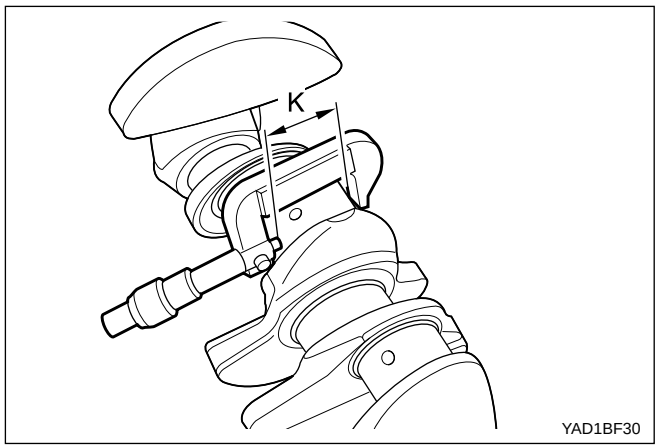


24. Insert the new connecting rod bearing shells into the connecting rod and connecting rod bearing cap and tighten the 12-sided stretch bolts (11).

Installation Notice

Tightening Torque	35 N•m (26 lb-ft)+ 90°

25. Measure inner diameter of connecting rod bearing.



26. Measure connecting rod bearing journal diameter (K).

Notice: Refer to measurement of the crankshaft bearing journal diameter.

27. Measure the radial clearance (L) of the connecting rod bearing.

Example) Measured value 'J' = 47.700 mm
Measured value 'K' = 47.653 mm
Clearance 'L' = 0.047 mm

Radial Clearance 'L'	0.026 - 0.068 mm

Notice: If the clearance is out of standard, adjust the radial clearance of connecting rod bearing by replacing the connecting rod bearing shells.

28. Remove the connecting rod bearing cap.
29. Install the piston.
30. Rotate the crankshaft by hand and check whether it rotates smoothly.
31. If the bearings are damaged,
    - replace the oil presser relief valve.
    - clean the oil pump and oil filter housing carefully and replace the hose if necessary.

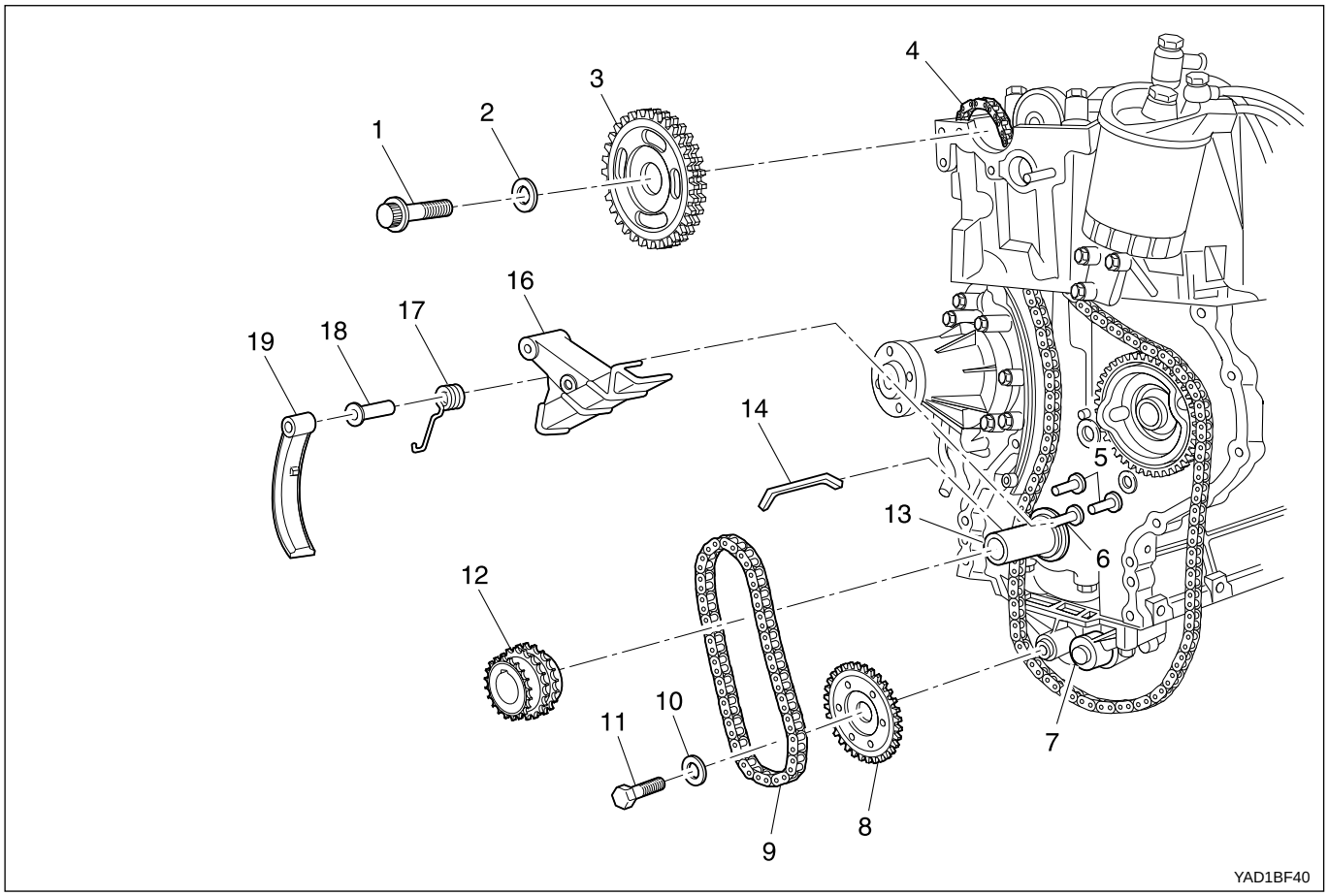
Notice: After assembling the engine, check the camshaft timing, adjust the start of fuel injection and check the TDC sensor bracket setting.

32. Fill oil and run the engine and then check the oil pressure and oil level.

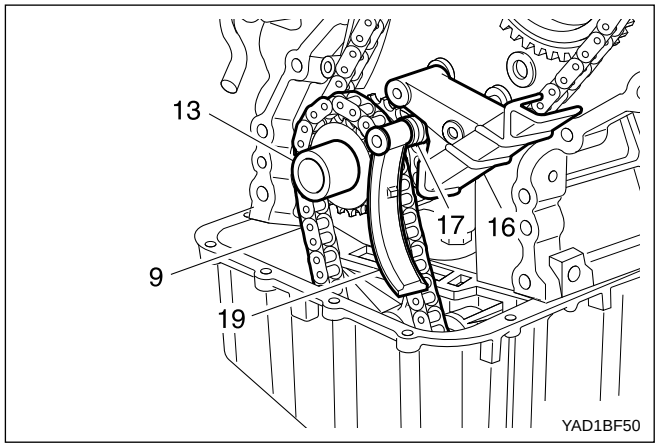
Notice: Install the original oil filter element and then change the engine oil and oil filter element after 1,000 - 1,500 km.

CRANKSHAFT SPROCKET

Preceding Work: Removal of oil pan
Removal of timing case cover



1 12-Sided Stretch Bolt (M11) ..... Check, 25 N•m (18 lb-ft)+ 90°
2 Washer
3 Camshaft Sprocket
4 Timing Chain
5 Bearing Pin
6 Bearing Pin
7 Oil Pump
8 Oil Pump Sprocket
9 Oil Pump Chain
10 Washer
11 Bolt ..... 25 N•m (18 lb-ft)
12 Crankshaft Sprocket
13 Crankshaft
14 Key
16 Guide Rail
17 Spring
18 Bushing
19 Tensioning Lever



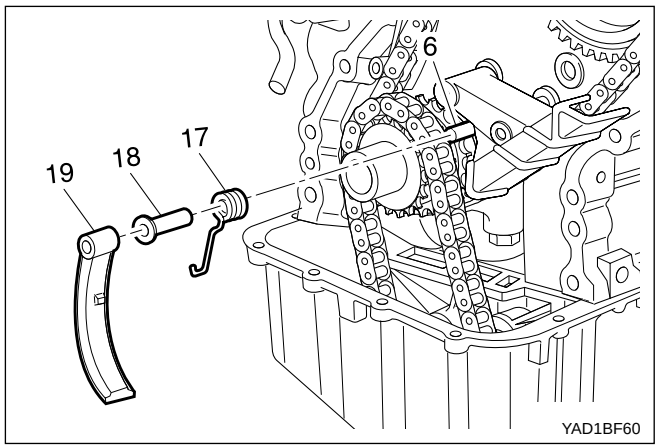
Special Tools

102 589 05 33 00 Puller

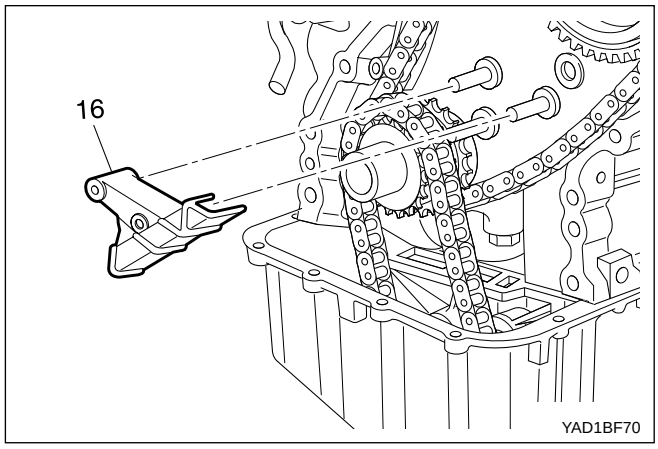
116 589 07 15 00 Drift

Removal Procedure

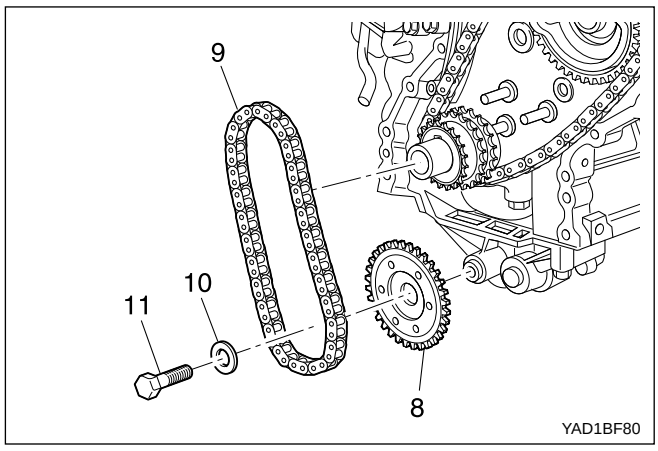
1. Pull out the tensioning lever (19) together with the spring (17) and guide rail (16) far enough until the tensioning lever has passed the oil pump chain (9) and is resting against the crankshaft (13).



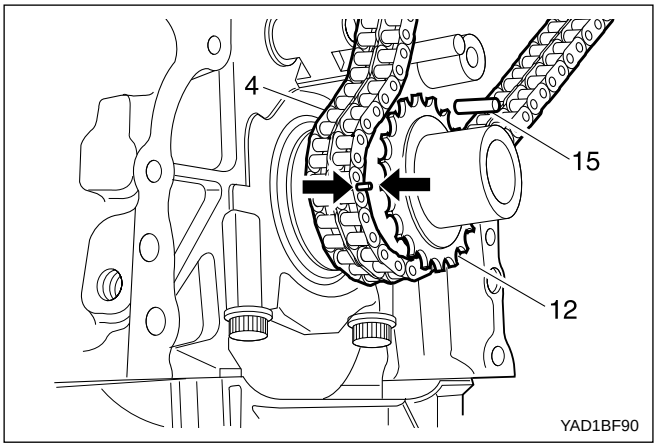
2. Pull out tensioning lever (19), spring (17) and bushing (18) from the bearing pin (6).



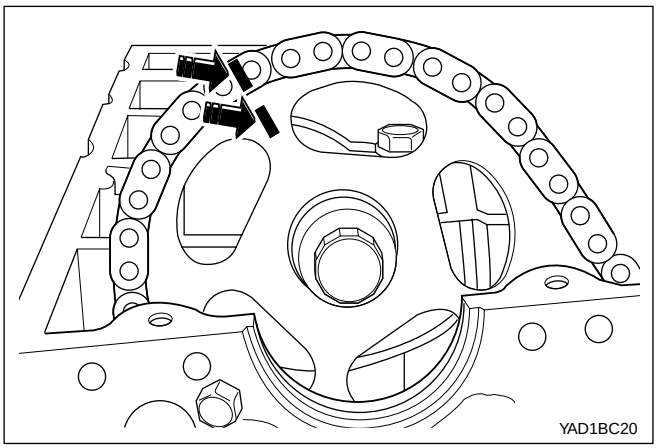
3. Pull out the guide rail (16).



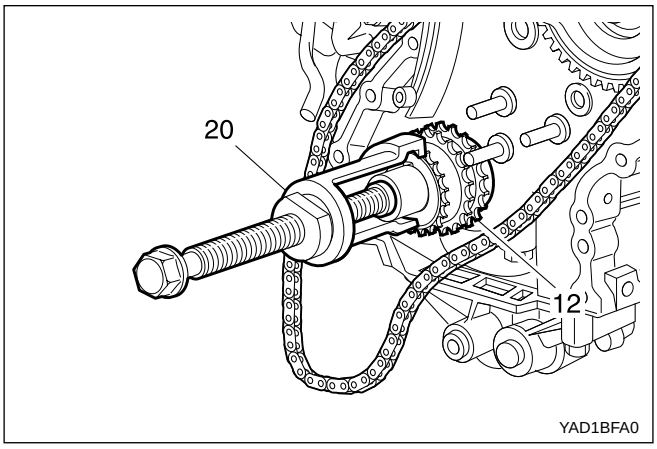
4. Remove the bolt(11) and then remove the washer (10), oil pump chain (9) and sprocket (8).



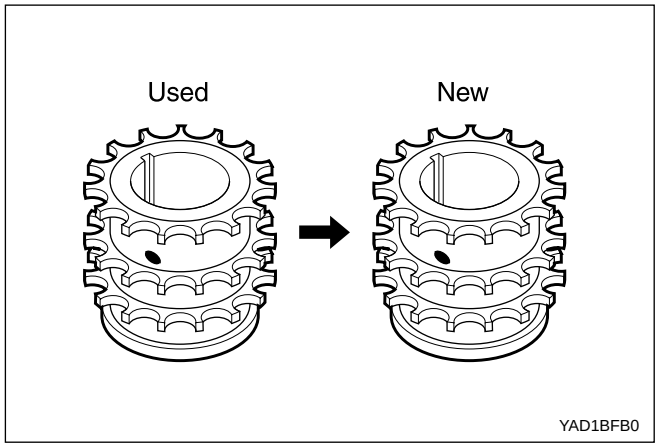
5. Place alignment marks (arrow) on the timing chain (4) and crankshaft sprocket (12).
6. Remove the woodruff key (15).



7. Place alignment marks (arrow) on the timing chain (4) and camshaft sprocket (3).
8. Remove the chain tensioner.
9. Remove the bolt (1) and then remove the washer (2) and camshaft sprocket (3).



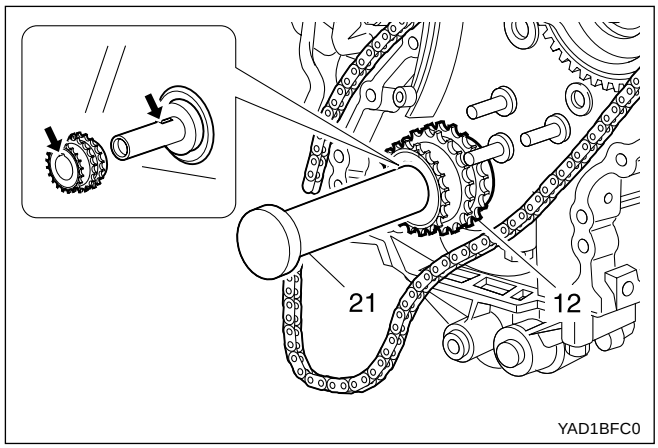
10. Remove the crankshaft sprocket (12) by using a puller 102 589 05 33 00 (20).



Installation Procedure

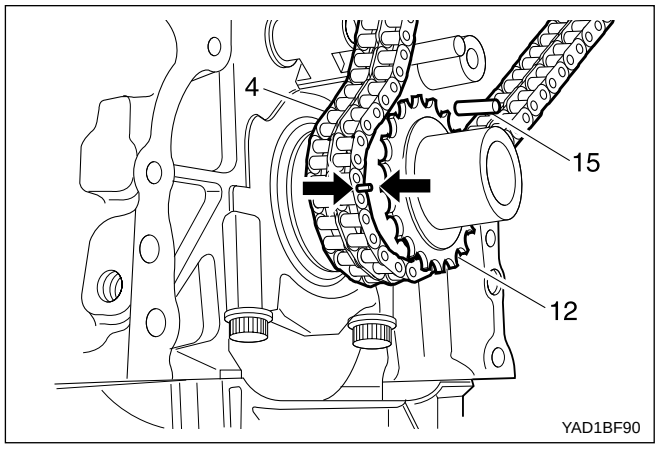
1. Put the same alignment mark on the new crankshaft sprocket as in the old sprocket.

   Notice: Check the timing chain, camshaft sprocket, injection pump timing sprocket, oil pump chain and oil pump sprocket for wear and replace if necessary.



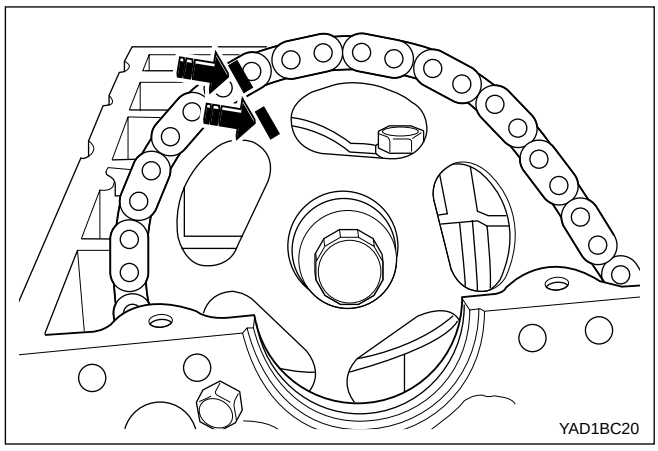
2. Install the new crankshaft sprocket (12) by using a drift 116 589 07 15 00 (21).

   Notice: Align the groove of sprocket and woodruff key (arrow) exactly.



3. Fit the timing chain (4) on the crankshaft sprocket (12).

   Notice: Align the alignment marks (arrow) on the chain and sprocket.

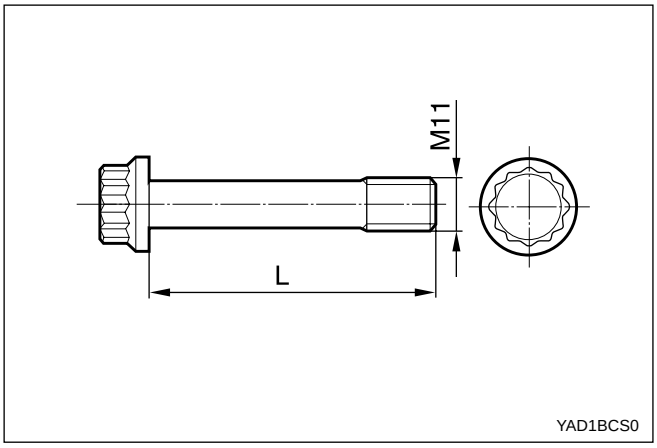


4. Install the camshaft sprocket (3).

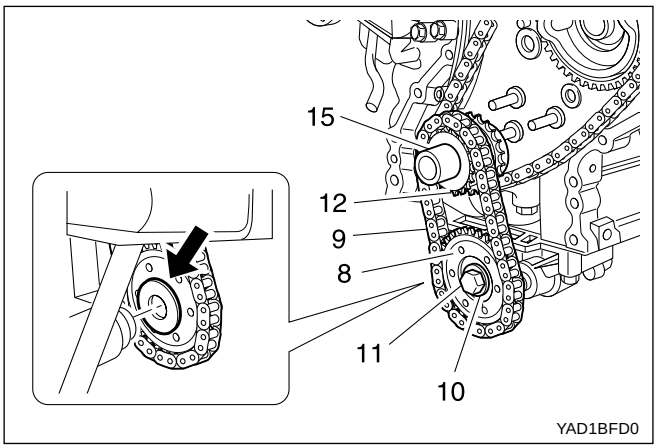
   Installation Notice

Tightening Torque	25 N•m (18 lb-ft)+ 90°

   Pay attention on the alignment marks and dowel pin (arrow).



Notice: If the max. length 'L' of the stretch bolt exceeds 53.6 mm, replace it.



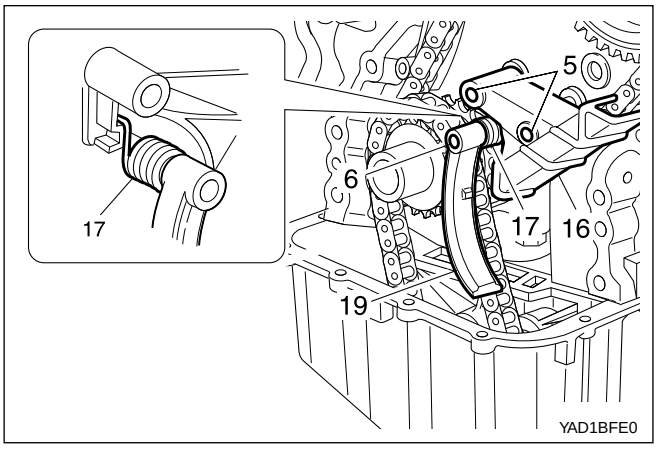
5. Fit the oil pump chain (9) on the crankshaft sprocket (12) and insert the oil pump sprocket (8) into the oil pump chain and then install it on the oil pump.

   Installation Notice

Tightening Torque	25 N•m (18 lb-ft)

   The curved side of the oil pump sprocket should face the oil pump.

6. Insert the woodruff key (15).

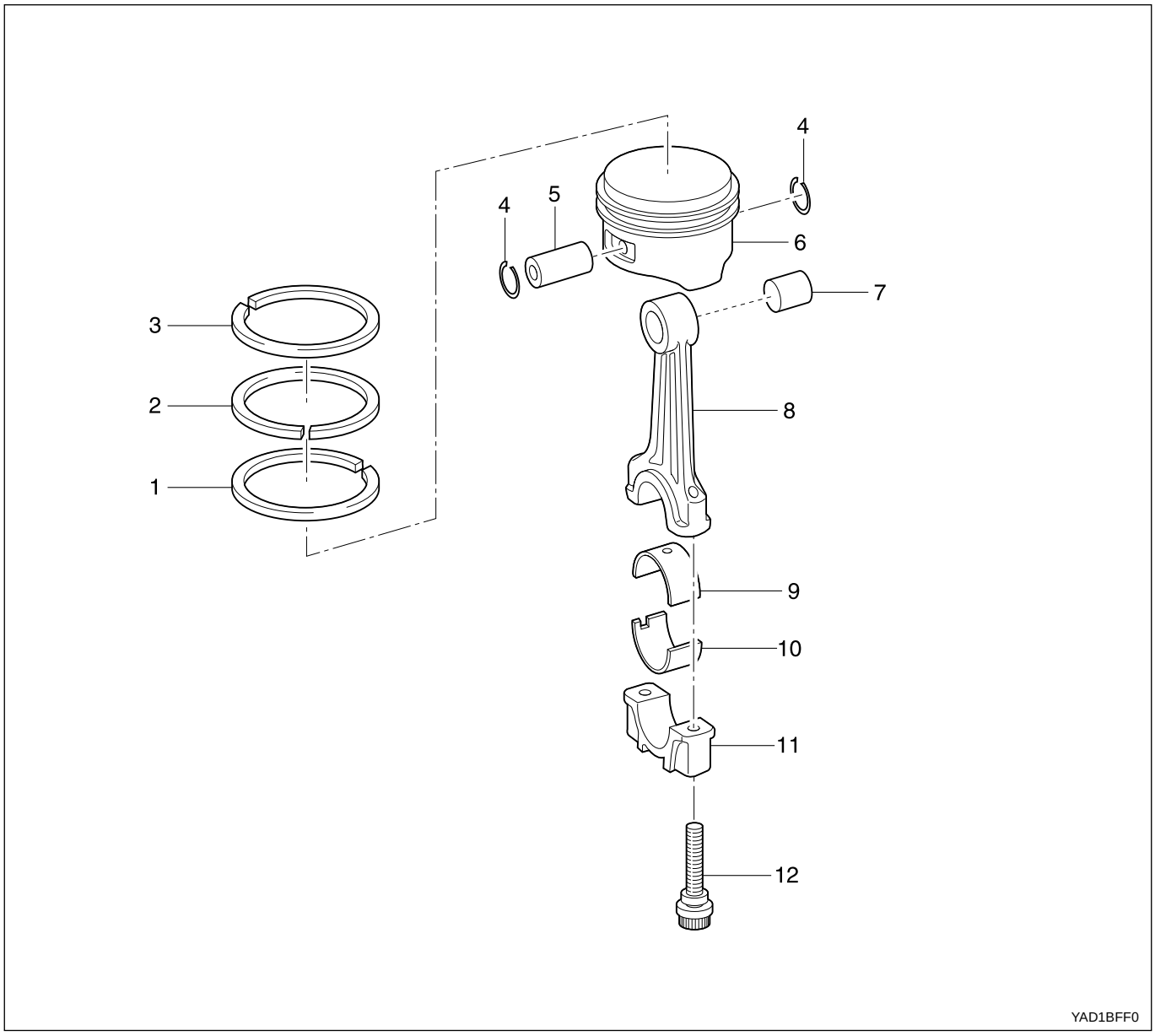


7. Install the guide rail (16). Attach the spring (17) to guide rail and to tensioning lever together onto the bearing pins (5, 6).

   Notice: Ensure that the spring is correctly located in the guide rail (arrow).

PISTON

Preceding Work: Removal of the cylinder head
Removal of the oil pump



1 Oil Ring
2 2nd Ring
3 Top Ring
4 Snap Ring ..... Replace
5 Piston Pin
6 Piston
7 Connecting Rod Bushing .....Check
8 Connecting Rod
9 Connecting Rod Upper Bearing Shell
10 Connecting Rod Lower Bearing Shell
11 Connecting Rod Bearing Cap
12 Connecting Rod Bolt ..... 35 N•m (26 lb-ft)+ 90°

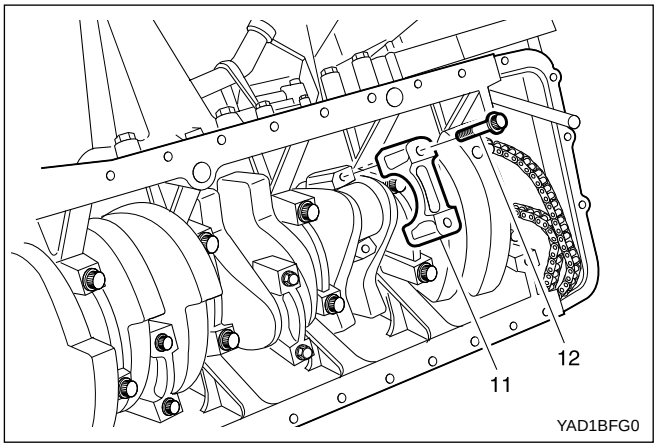
Notice: There are two kinds of connecting rods (for machining) and they are different in weight approx. 15g. When replacing the connecting rod, measure its weight and ensure that a engine has the same weight of connecting rods. If not, there would be a unbalancing of engine.

Service Data

Piston clearance	Max. 0.12 mm
Piston crown protrusion in TDC position	0.735 - 0.965 mm
Connecting rod bushing diameter	26.012 - 26.018 mm

Connecting Rod Bolt Dimensions

Thread	M9 x 1
Stretch shaft (C) diameter (new)	7.4 mm
Minimum stretch shaft diameter (C)	7.1 mm
Length (L) (new)	52 mm

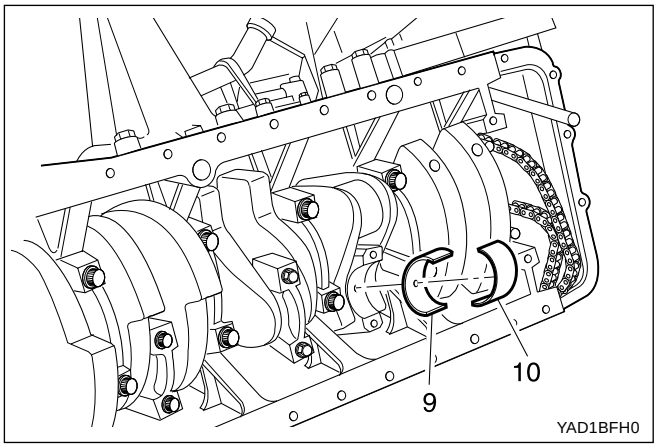


Tools Required

000 589 04 14 00 Tensoning Strap
001 589 53 21 00 Dial Gauge
363 589 02 21 00 Dial Gauge Holder

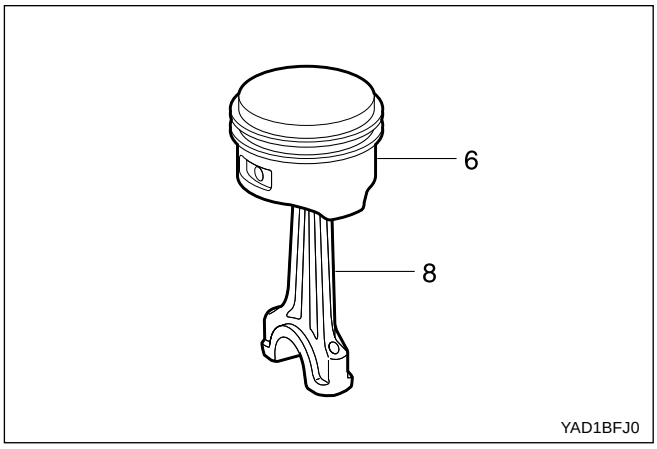
Removal Procedure

1. Remove combustion residues from the cylinder bores.
2. Remove the connecting rod bolts (12) and then remove the connecting rod bearing caps (11).

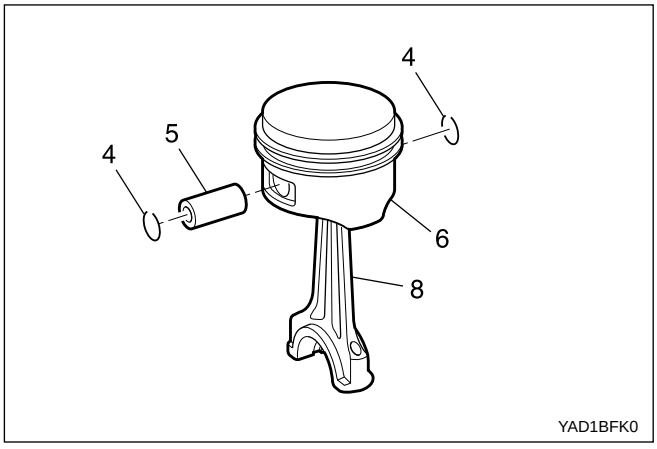


3. Remove the connecting rod bearing shells (9, 10).

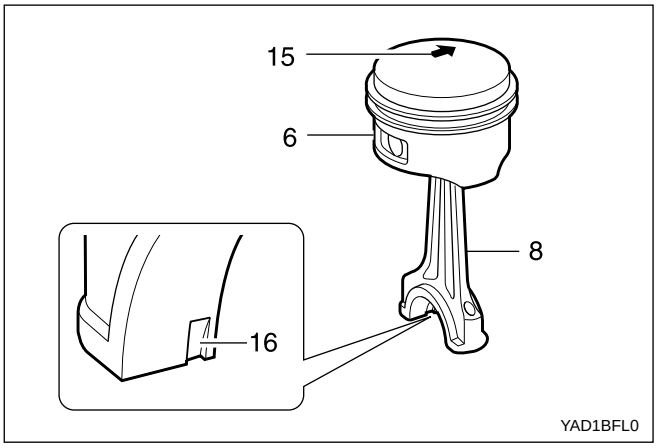
   Notice: Be careful not mix the bearing caps and shells each other.



4. Remove the piston (6) and connecting rod (8).

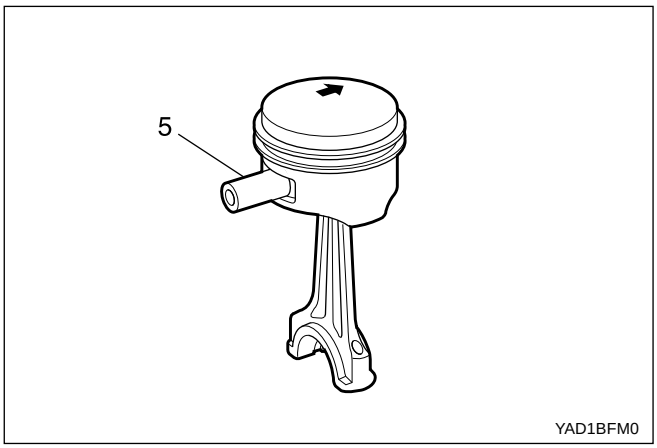


5. Remove the snap ring (4) and pull out the piston pin (5).
6. Separate the piston and connecting rod.



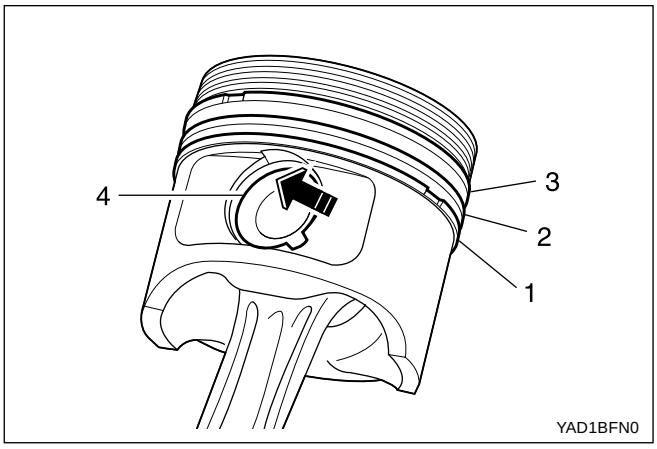
Installation Procedure

1. Fit the piston onto the connecting rod so that the arrow (15) and the locking slot (16) are facing in direction of the vehicle.

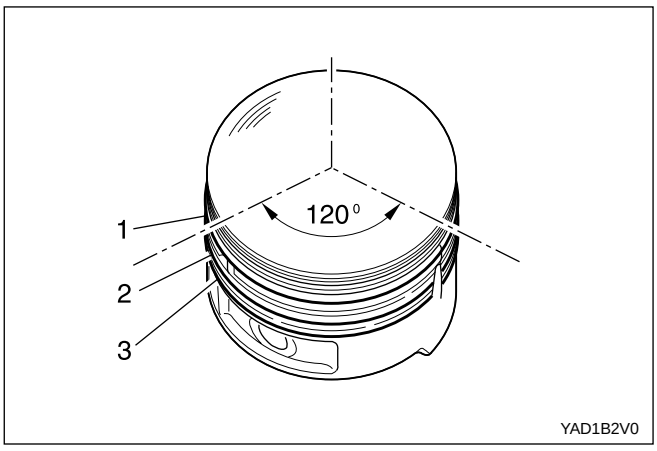


2. Coat the piston pin (15) with engine oil and insert it by hand.

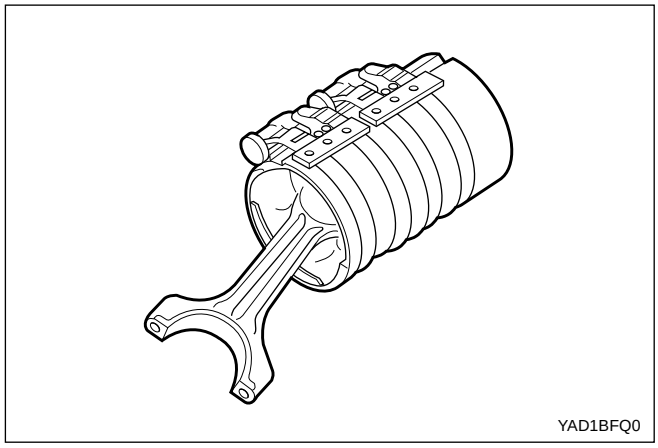
   Notice: Do not heat up the piston.



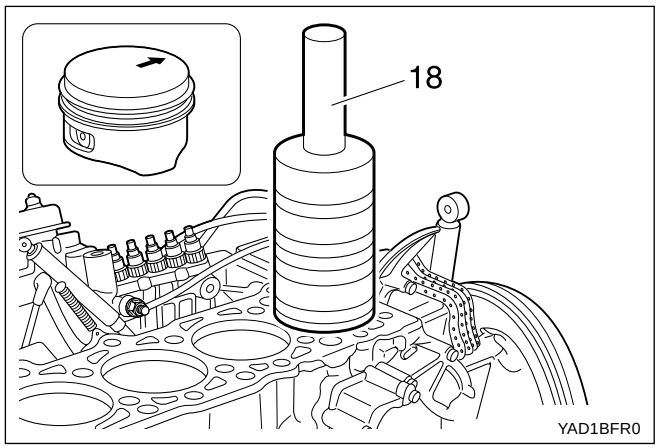
3. Install the new snap ring (4) into the grooves (arrow).
4. Check the piston rings (1, 2, 3) and replace them if necessary.



5. Install and arrange the piston rings to be evenly 120° from each ends gap.


YAD1BFQ0

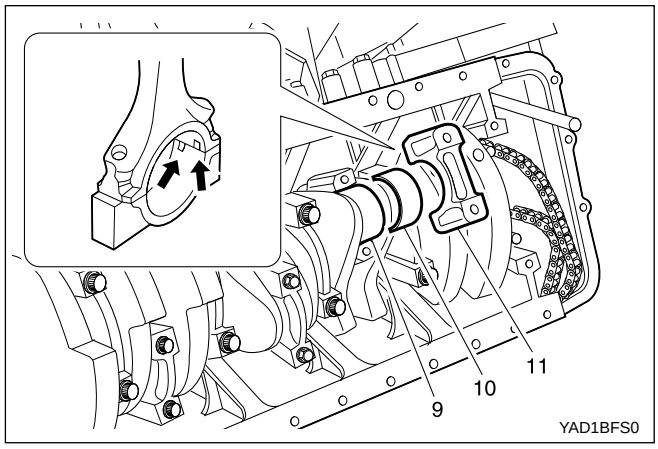
6. Coat the cylinder bore, connecting rod bearing journal, connecting rod bearing shell and piston with oil.
7. Compress the piston rings with a tensioning strap 000 589 04 14 00.



YAD1BFR0

8. Insert the piston assembly into the cylinder with a wooden stick (18).

   Notice: The arrow on the piston crown must point toward the front of vehicle.



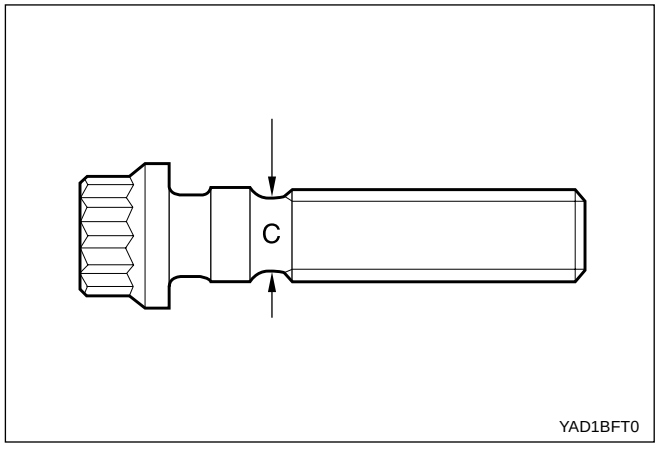
YAD1BFS0

9. Insert the connecting rod bearing shells (9, 10).

   Notice: Be careful of the difference in upper and lower bearing shells and not to be changed.

10. Position the connecting rod bearings caps.

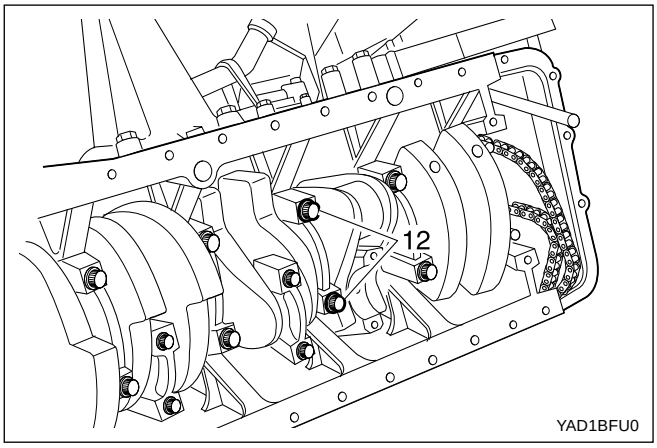
    Notice: Position so that the retaining lugs are on the same side of the connecting rod bearing (arrow).



YAD1BFT0

11. Measure stretch shaft diameter (C) of the connecting rod bolts.

Limit 'C'	7.1 mm

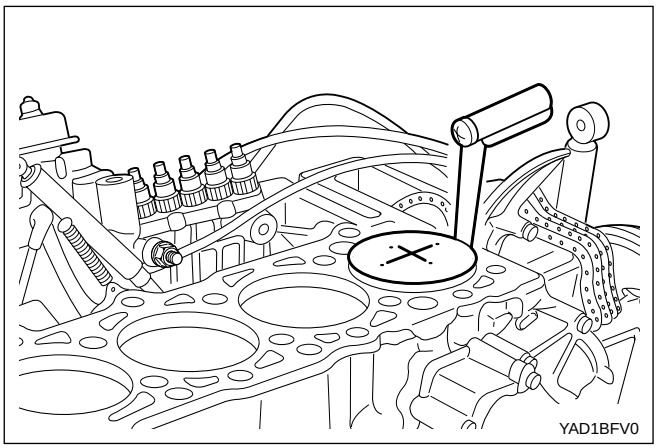


12. Coat the bolts (12) with oil and then tighten the bolts.

Installation Notice

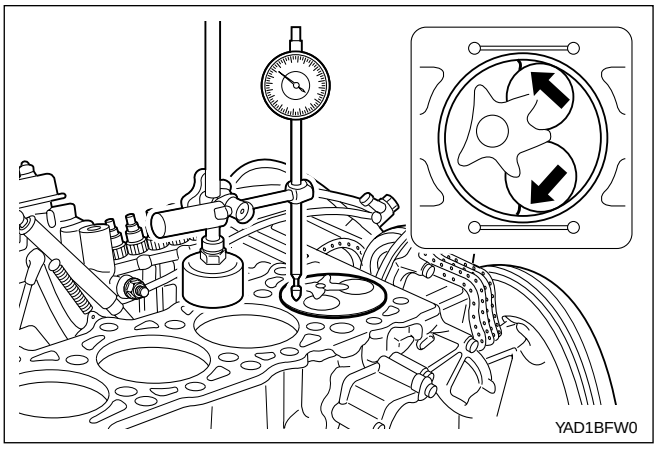
Tightening Torque	35 N•m (26 lb-ft)+ 90°

13. Rotate the crankshaft and check axial clearance between the connecting rod and crankshaft.



14. Measure clearance between the piston crown and cylinder.

Standard	Max. 0.12 mm



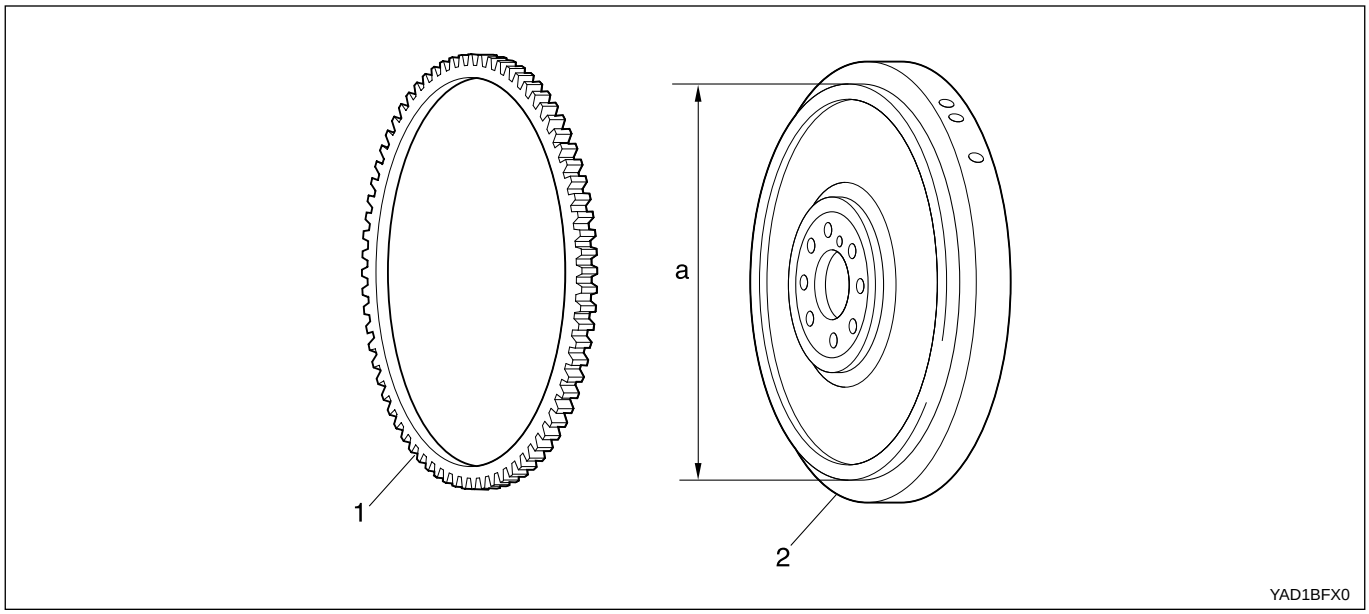
15. Position the piston at TDC and measure the distance between the piston crown and the crankcase surface using dial gauge 001 589 00 53 21 and dial gauge holder 363 589 02 21 00.

Standard	Max. 0.965 mm

Notice: Measure at points marked.

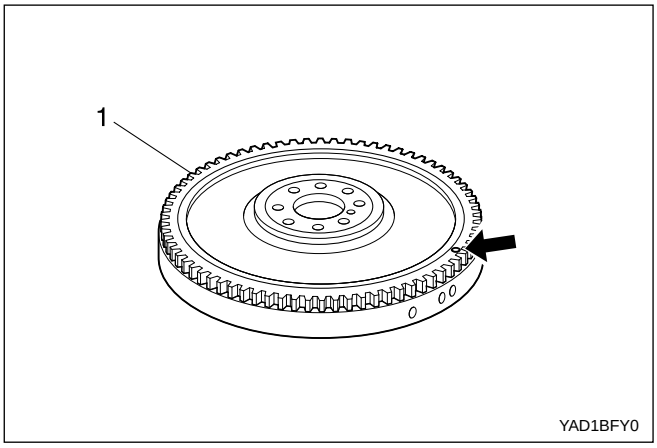
FLYWHEEL RING GEAR

Preceding Work: Removal of flywheel



1 Ring Gear
2 Flywheel

a Centering Collar Diameter



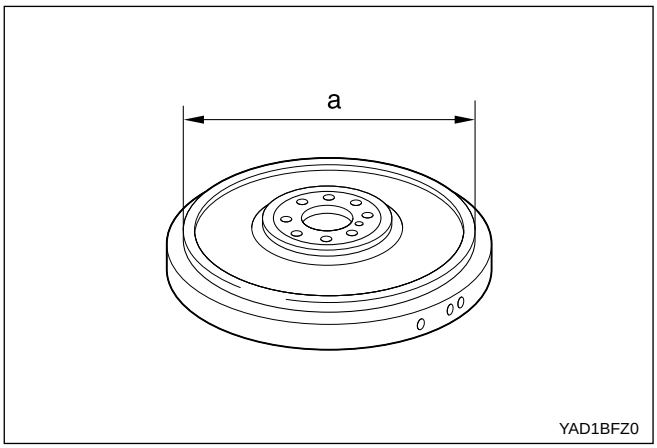
Tools Required

001 589 53 21 00 Dial Gauge

363 589 02 21 00 Dial Gauge Holder

Replacement Procedure

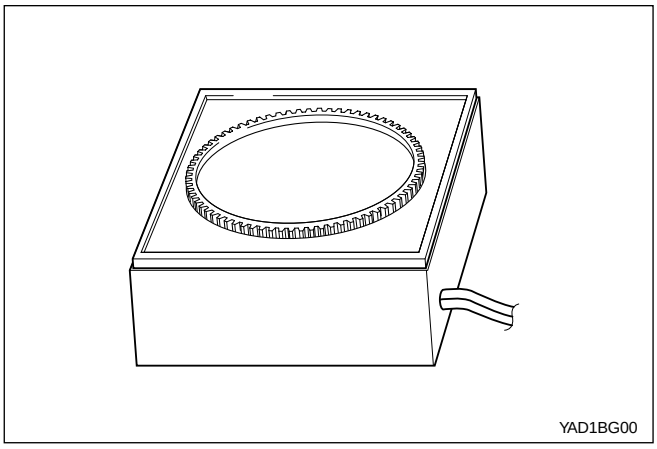
1. Drill a hole into the ring gear (1) (arrow) and snap with a chisel.
2. Thoroughly clean the collar surfaces of ring gear.



3. Measure diameter (a) of centering collar.

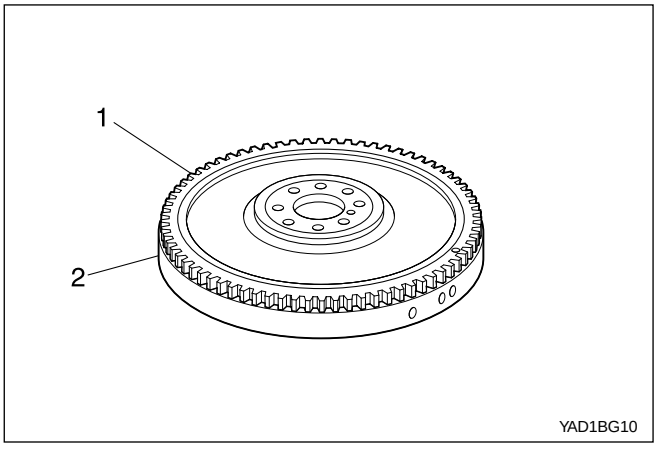
Diameter ‘a’	275 + 0.5 mm

Notice: If out of standard, replace the flywheel.

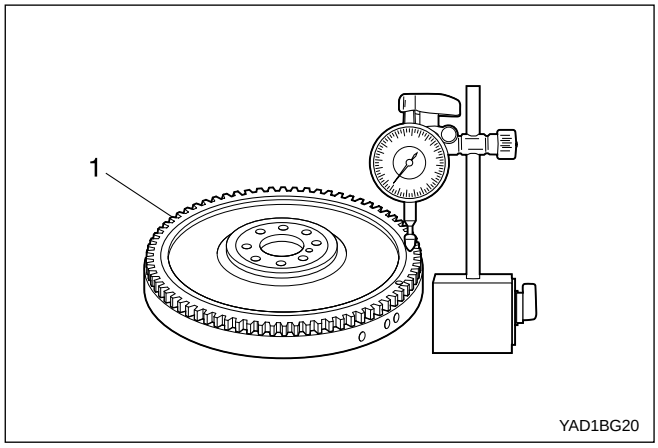


4. Heat up the new ring gear up to 220°C (428°F) by using a heating device.

Notice: Use temperature measuring chalk.



5. Install the new ring gear (1) onto the flywheel (2) by using a drift.



6. Measure axial runout of ring gear (1) on a surface plate using dial gauge 001 589 53 21 00 and dial gauge holder 363 589 02 21 00.

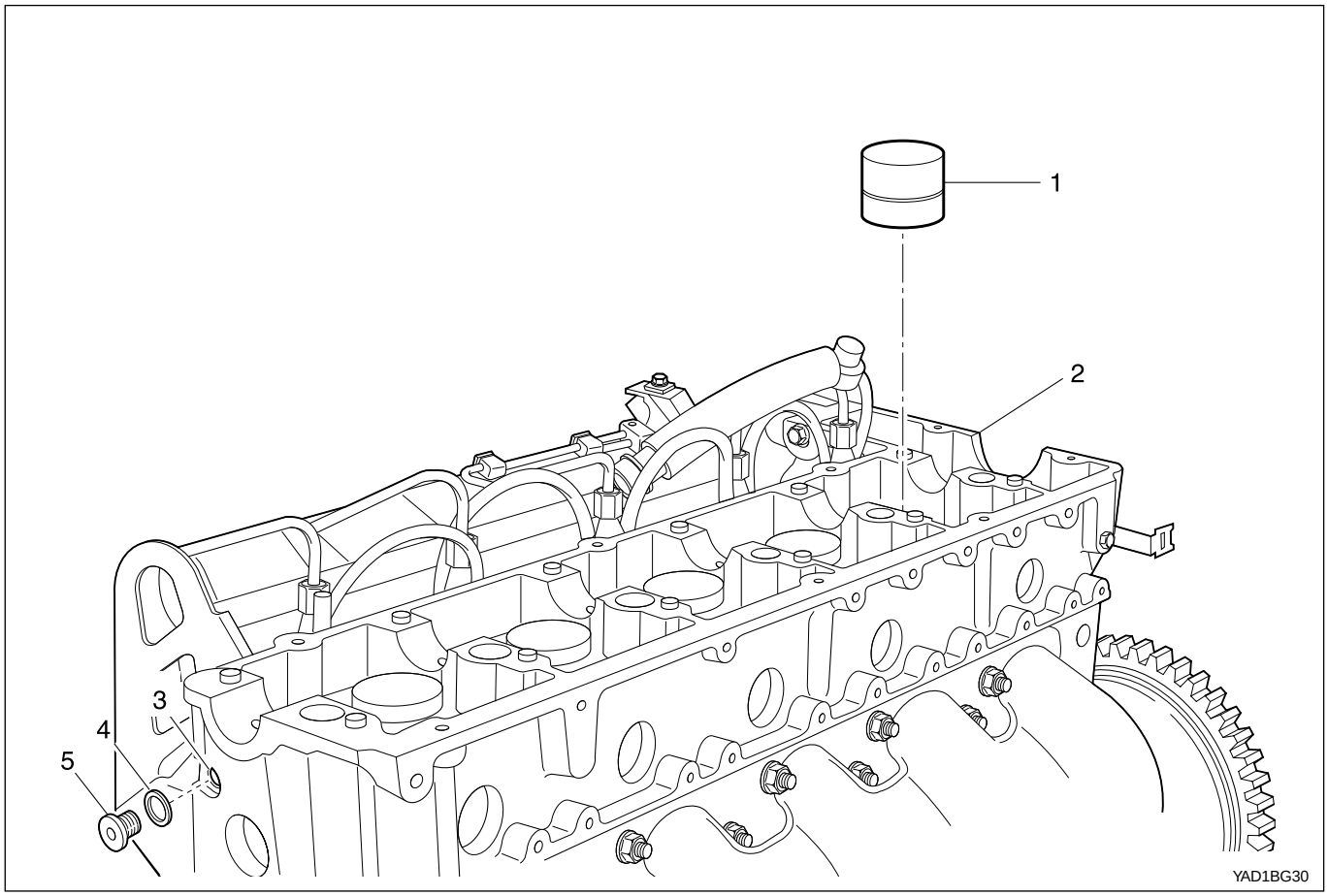
Limit	Max. 0.4 mm

Notice: For correct measurement, put the flywheel on the flat measuring board.

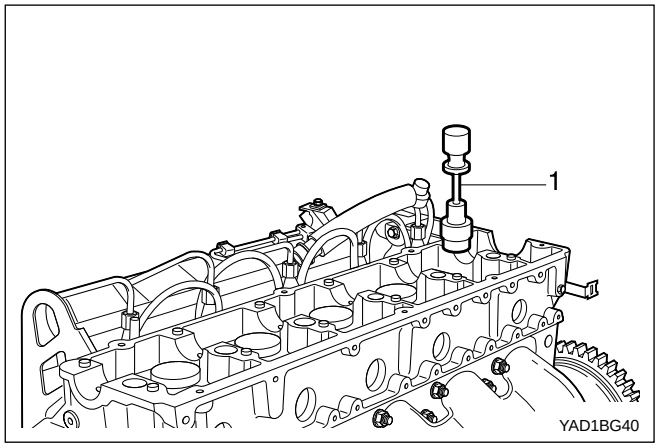
TIMING DEVICE AND VALVE

VALVE TAPPETS

Preceding Work: Removal of camshaft



1 Valve Tappet
2 Cylinder Head
3 Oil Gallery
4 Seal ..... Replace
5 Screw Plug

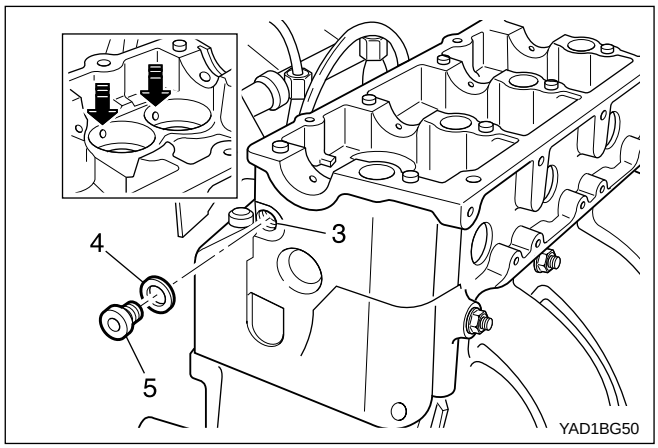


Tools Required

102 589 03 40 00 Magnetic Bar

Replacement Procedure

1. Pull out the valve tappet (1) using magnetic bar 102 589 03 40 00.

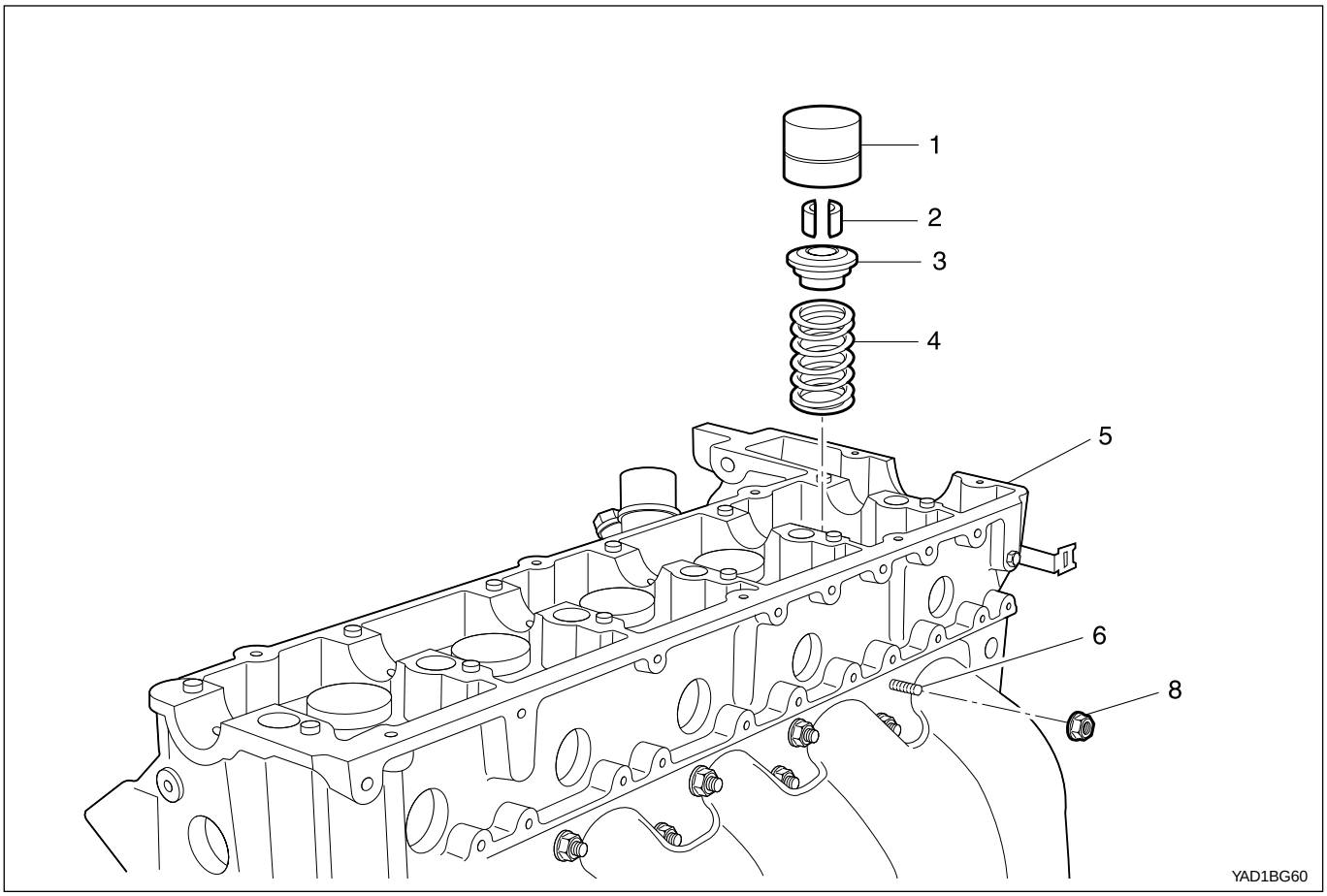


2. Remove the plug (5) and blow compressed air into the oil gallery (3). At this time, check that the outlet bores (arrow) at the seat of the valve tappet are clear.
3. Replace the seal (4) and tighten the plug (5).
4. Insert the new valve tappet.

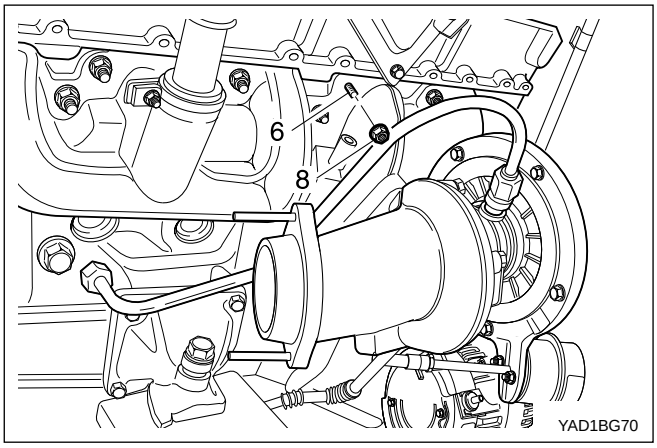
   Notice: Coat the valve tappet with oil.

VALVE SPRINGS (CYLINDER HEAD REMOVED)

Proceding Work: Remove of cylinder head



1 Valve Tappet
2 Valve Cotters
3 Spring Retainer
4 Valve Spring ..... Check, replace if necessary
5 Cylinder Head
6 Stud Bolt ..... 12 N•m (106 lb-in)
7 Nut ..... Replace, 25 N•m(18 lb-ft)



Tools Required

102 589 03 40 00 Magnetic Bar
116 589 06 63 00 Magnetic Finger
601 589 01 59 00 Assembling Board
601 589 02 59 00 Supporting Bridge
667 589 00 31 00 Press Lever

Removal & Installation Procedure

1. Remove the nuts (8) uniformly and then remove the washer (7), exhaust manifold (9) and gasket.

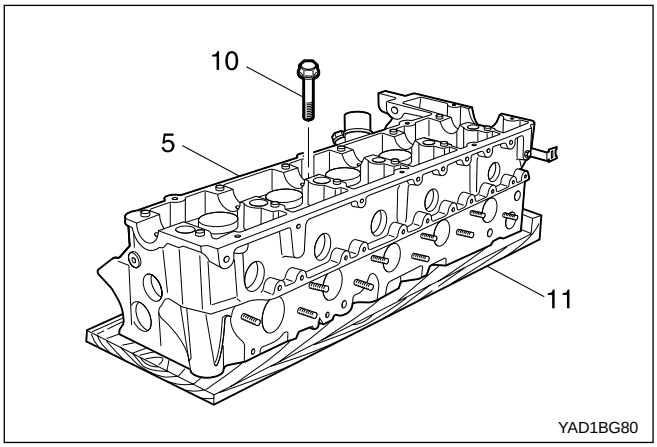
Installation Notice

Check the stud bolt (6) for damage and replace if necessary.

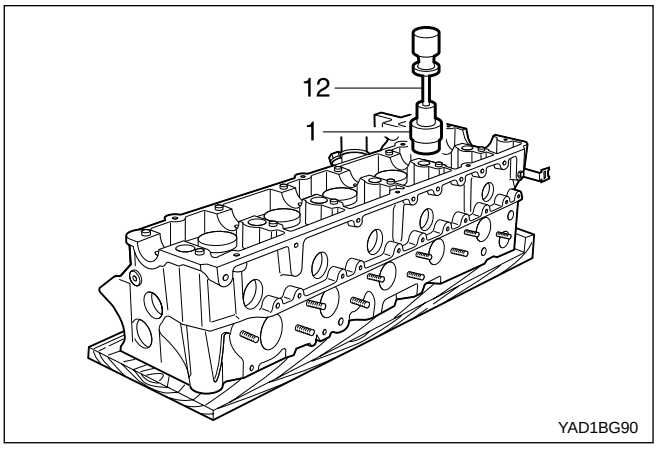
Tightening Torque	12 N•m (106 lb-in)

Replace the gasket and tighten the nuts (8).

Tightening Torque	25 N•m (18 lb-ft)

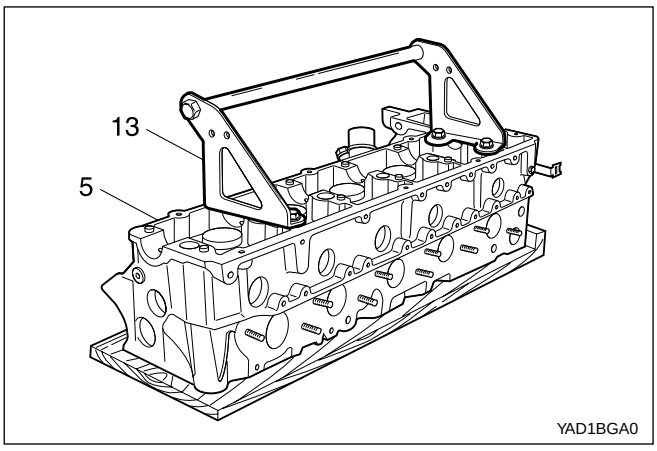


2. Install the assembling board 601 589 01 59 00 (11) to the cylinder head with 4 cylinder head blots (10).

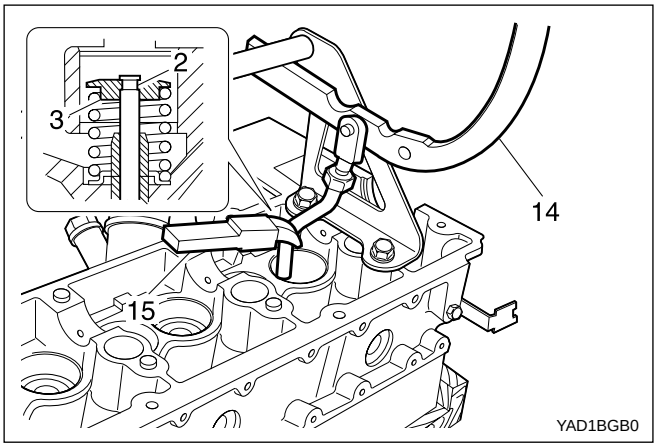


3. Pull out the valve tappet (1) with magnetic bar 102 589 03 40 00 (12).

Notice: Place the valve tappets upside down (open end upward).

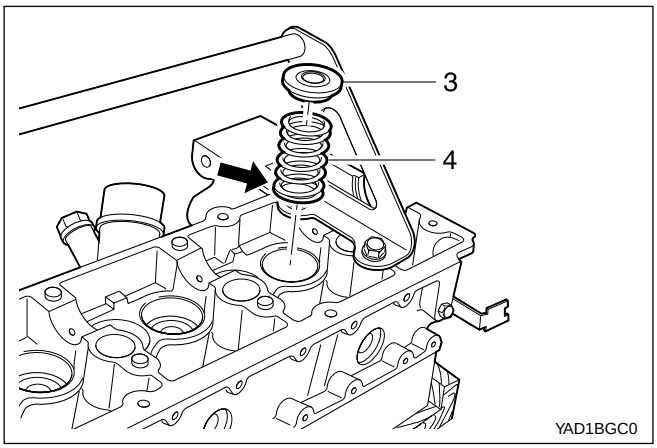


4. Install the supporting bridge 601 589 02 59 00 (13) on the cylinder head (5).



5. Using the press lever 667 589 00 31 00 (14), press the spring retainer downward and remove the valve cotters (2) with magnetic finger 116 589 06 63 00 (15).

   Notice: Be careful not to damage guide bore of the valve tappet.



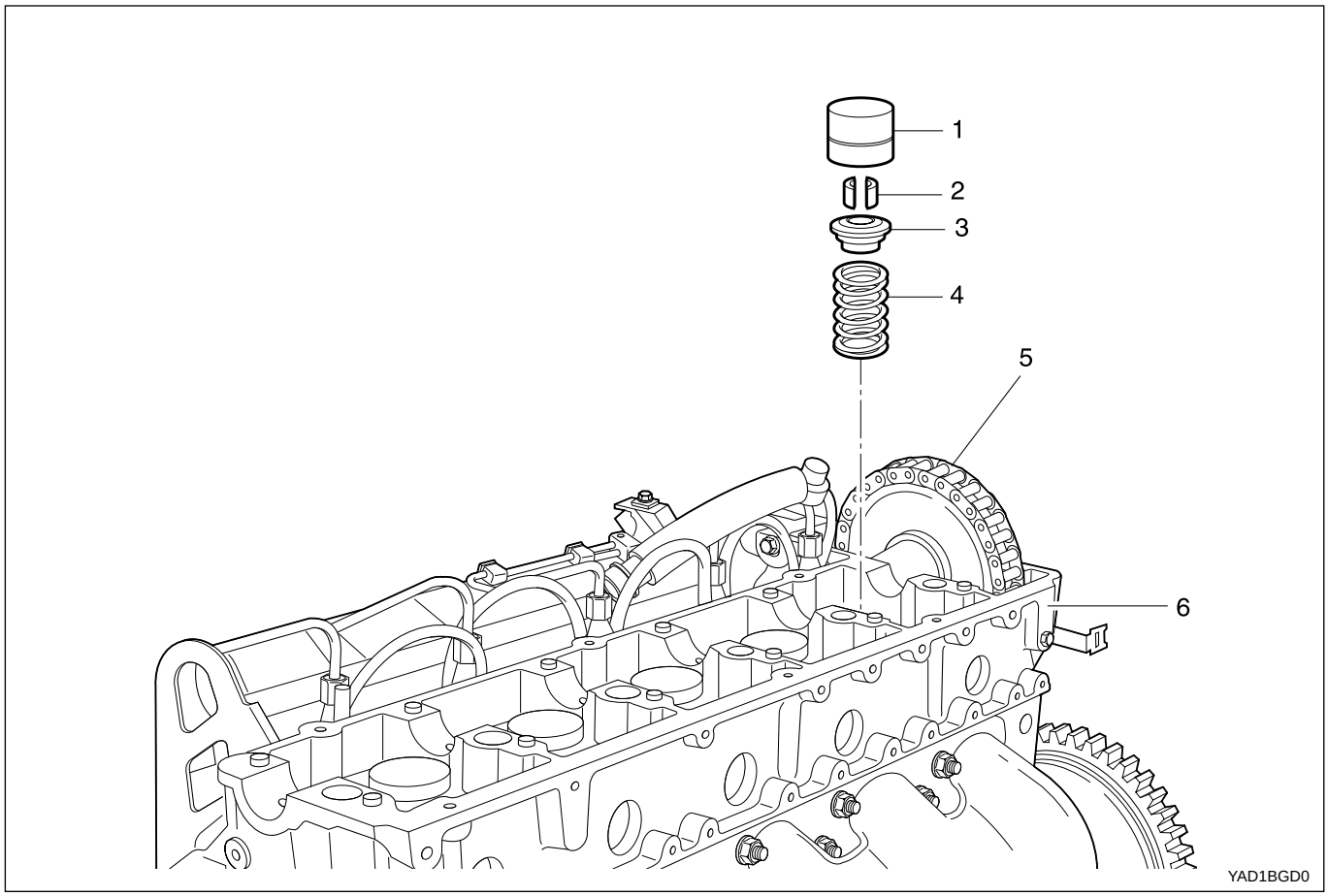
6. Remove the spring retainer (3) and spring (4).

   Notice: Install the valve spring with the color coding (arrow) facing down.

7. Check the valve spring and replace if necessary.
8. Installation should follow the removal procedure in the reverse order.

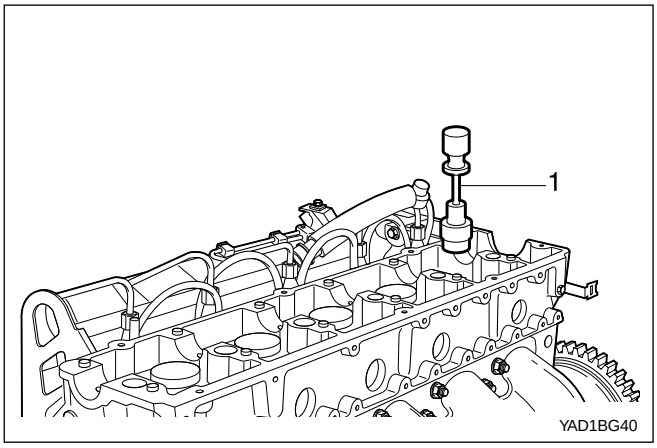
VALVE SPRINGS (CYLINDER HEAD INSTALLED)

Preceding Work: Removal of camshaft



1 Valve Tappet
2 Valve Cotters
3 Spring Retainer
4 Valve Spring ..... Check, replace if necessary
5 Timing Chain
6 Cylinder Head

Notice: Remove the valve springs only when the piston is at TDC.



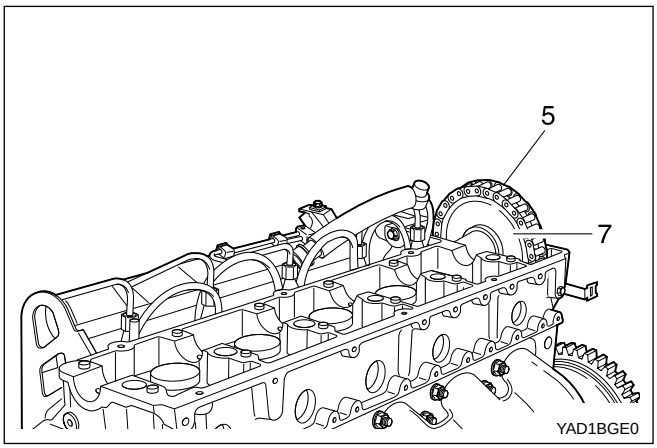
Tools Required

102 589 03 40 00 Magnetic Bar
116 589 06 63 00 Magnetic Finger
603 589 01 40 00 Holding Wheel
667 589 00 31 00 Press Lever
667 589 02 63 00 Supproting Bar

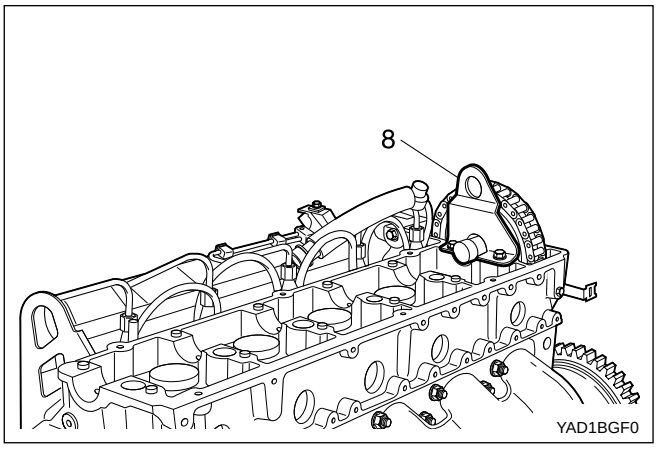
Removal & Installation Procedure

1. Remove the valve tappet (1) with magentic bar 102 589 03 40 00.

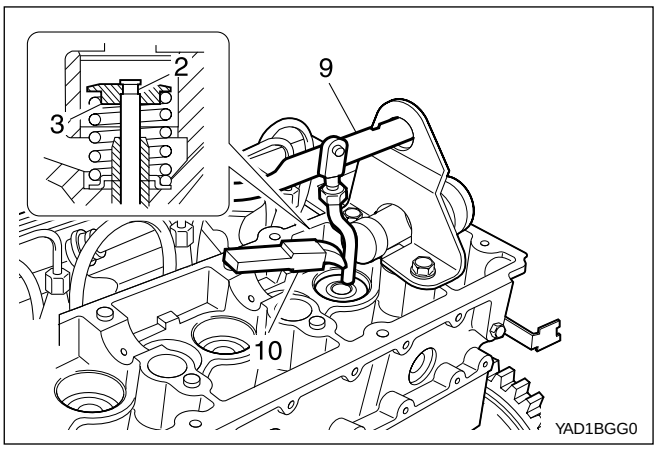
   Notice: Place the valve tappets upside down (open end upward).



2. Install the holding wheel 603 589 01 40 00 (7) into the timing chain of camshaft sprocket piston.
3. Position the piston of relevant cylinder at TDC.

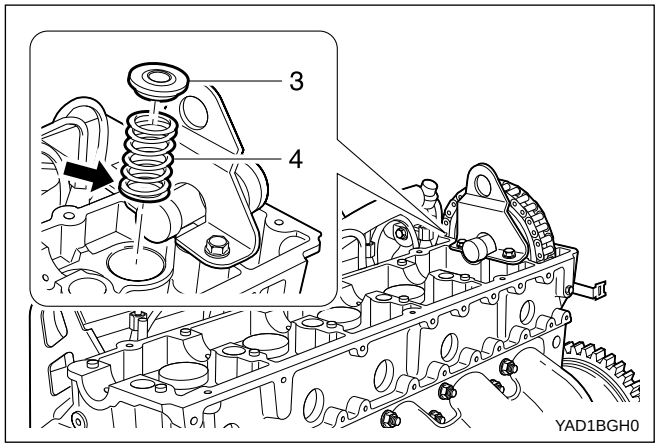


4. Install the supporting bar 667 589 02 63 00 (8).

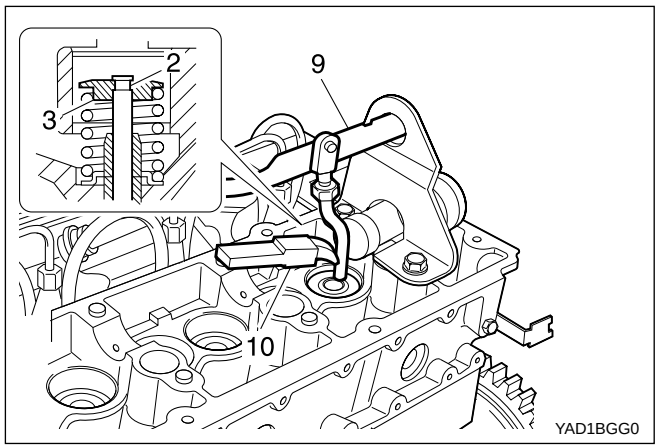


5. Using the press lever 667 589 00 31 00 (9), press the spring retainer (3) downward and remove the valve cotters (2) with magnetic finger 116 589 06 63 00 (10).

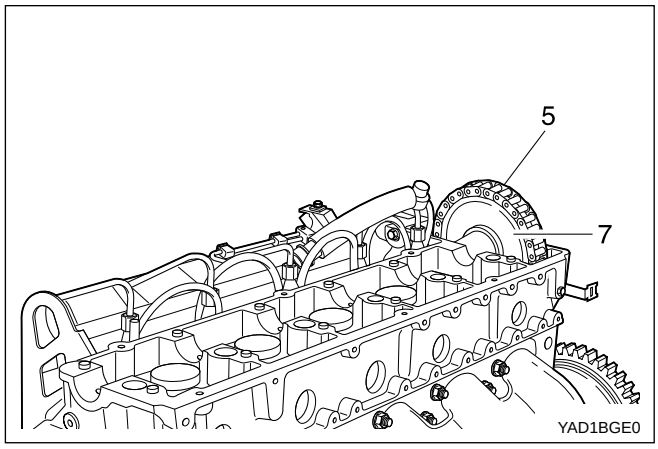
   Notice: Be careful not to damage guide bore of the valve tappet.



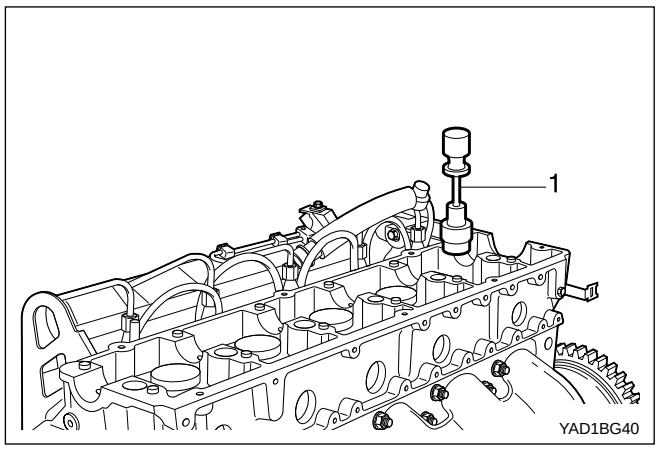
6. Remove the spring retainer (3) and spring (4).
7. Check the valve spring and replace if necessary.
8. Insert valve spring (4) with the color coding (arrow) facing down and insert valve spring Retainer (3).



9. By press the spring retainer (3) with press lever 667 589 00 31 00 (9), install the valve cotters with magnetic finger 116 589 06 63 00 (10).



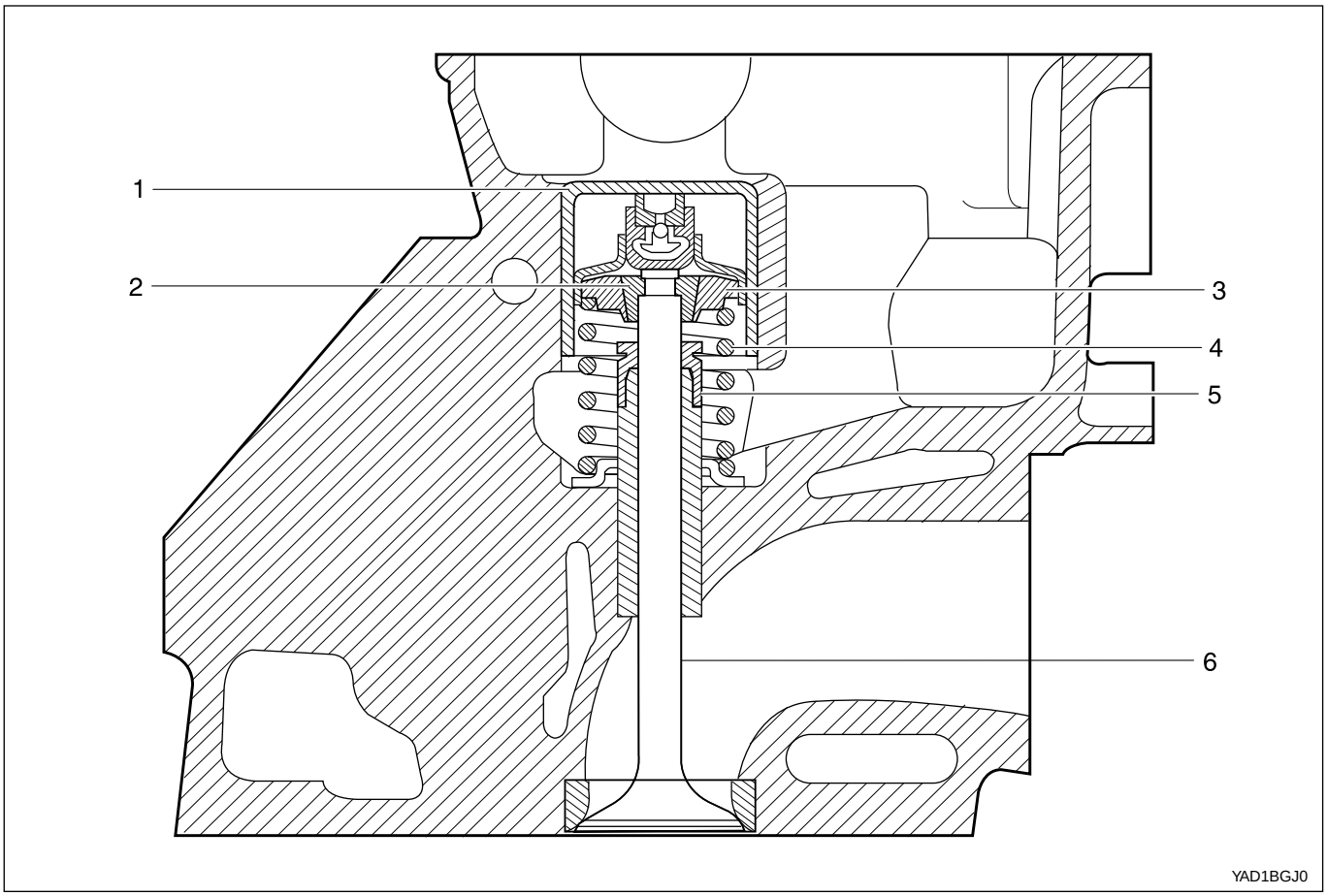
10. Remove the supporting bar 667 589 02 63 00.
11. Remove the holding wheel 603 589 01 40 00 (7) from the timing chain (5).



13. Coat the valve tappet with oil and install it with magnetic bar 102 589 03 40 00.

VALVE STEM SEALS

Preceding Work: Removal of camshaft.

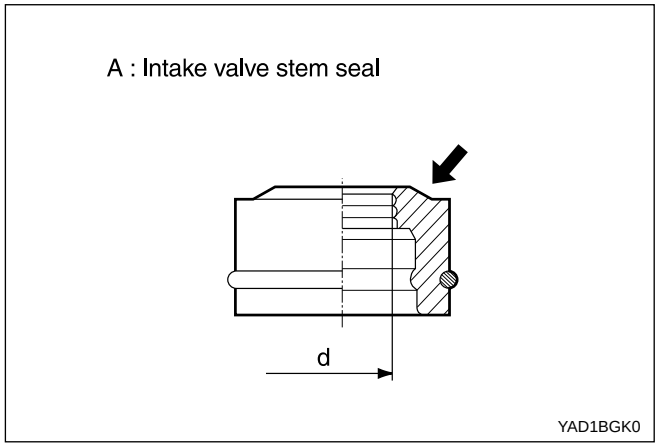


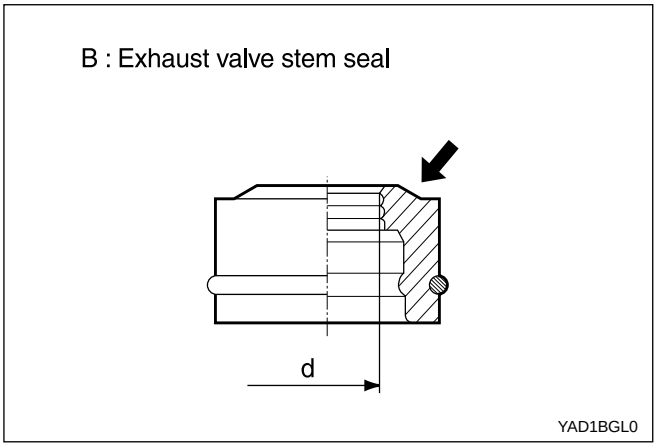
1 Valve Tappet
2 Valve Cotters
3 Spring Retainer
4 Valve Spring ..... Check, replace if necessary
5 Valve Stem Seal
6 Valve

Notice: Remove the valve stem seals when the pistion is positioned at TDC.

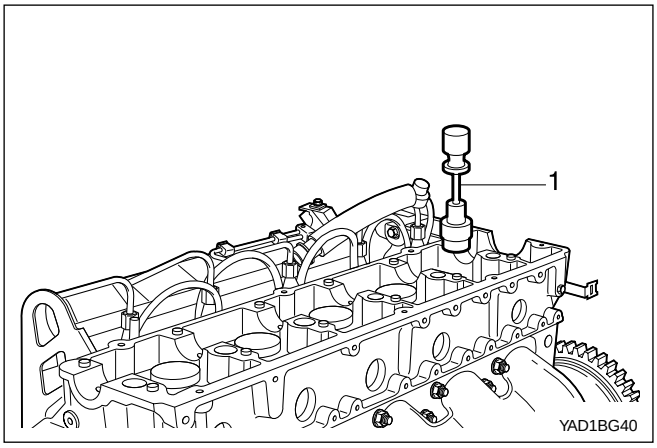
Tools Required

102 589 03 40 00 Magnetic Bar
104 589 00 37 00 Pliers
116 589 06 63 00 Magnetic Finger
601 589 02 43 00 Drift
603 589 01 40 00 Holding Wheel
667 589 00 31 00 Press Lever
667 589 02 63 00 Supporting Bar





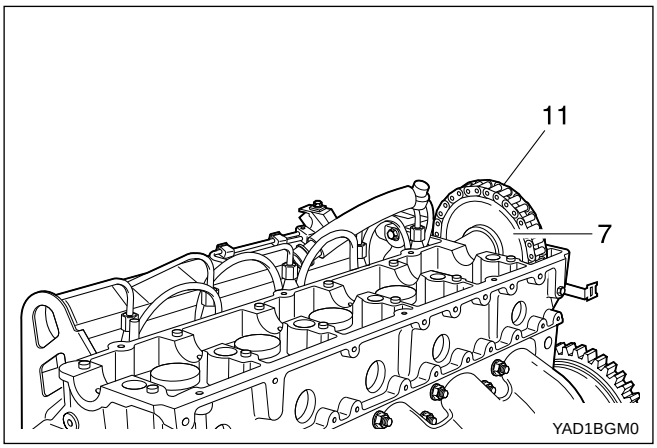
	Intake valve stem seal	Exhaust valve stem seal
Chamfer	Offset	All round
Inner diameter ‘d’	7.3mm	8.2 mm
Color	Brown	Green
Wire ring	Black	Yellow



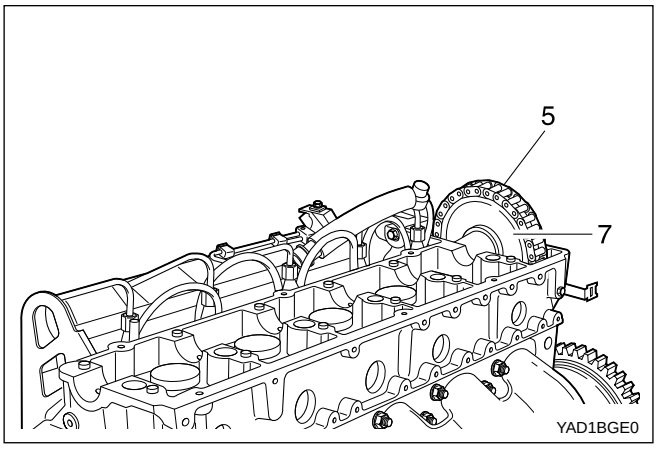
Replacement Procedure

1. Remove the valve tappet (1) with magnetic bar 102 589 03 40 00.

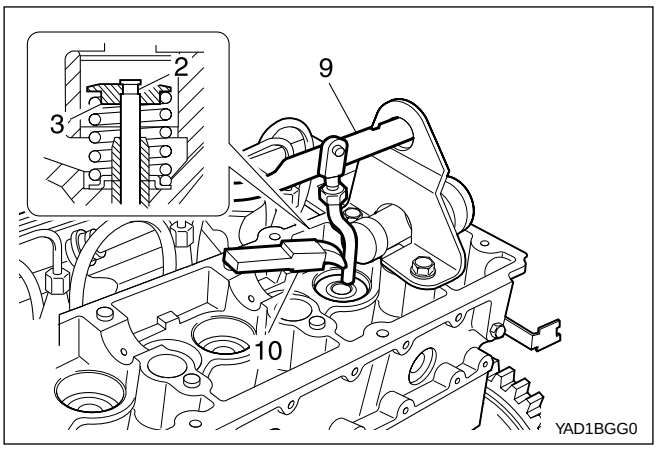
   Notice: Place the valve tappets upside down (open end upward).



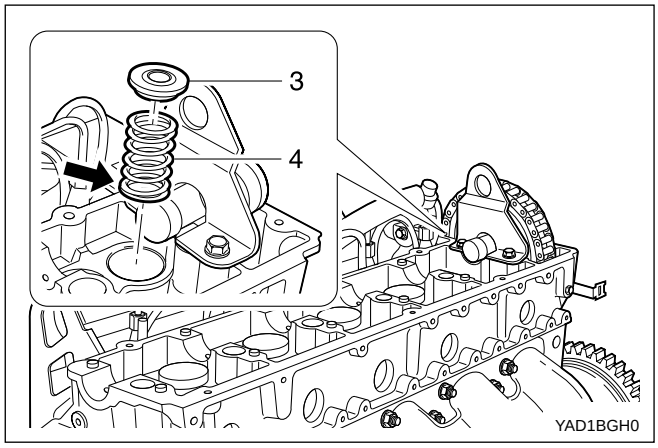
2. Install the holding wheel 603 589 01 40 00 (7) into the timing chain (11).
3. Position the piston of relevant cylinder at TDC.



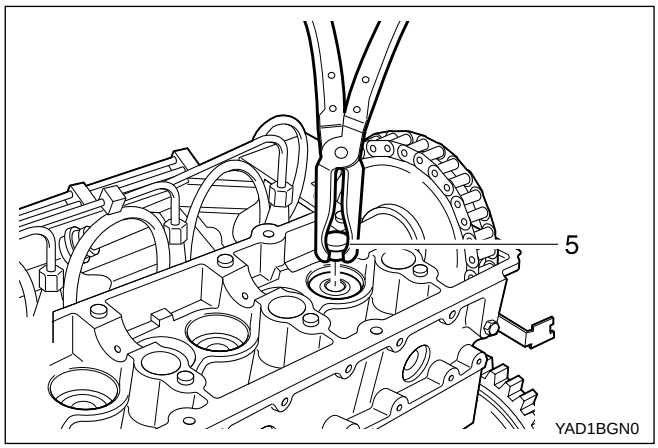
4. Install the supporting bar 667 589 02 63 00 (8).



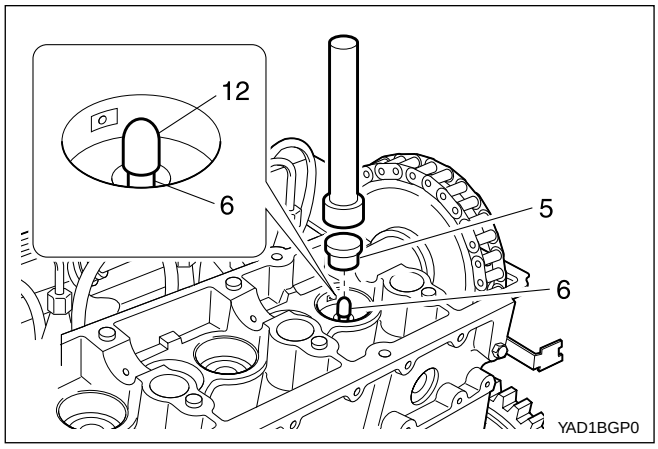
5. Using press lever 667 589 00 31 00 (9), press the spring retainer (3) downward and remove the valve collets with magnetic finger 116 589 06 63 00 (10).



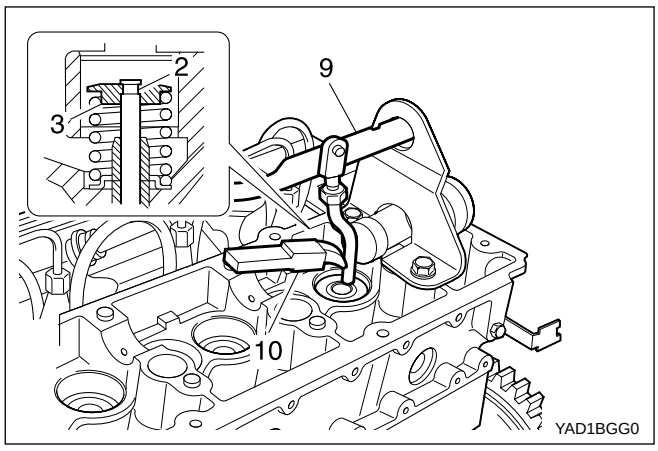
6. Remove the spring retainer (3) and valve spring (4).



7. Remove the valve stem seal with pliers 104 589 00 37 00 (5).



8. Insert the cap (12) onto the valve (6) and install the new valve stem seal (5) with drift 601 589 02 43 00 and then remover the cap.

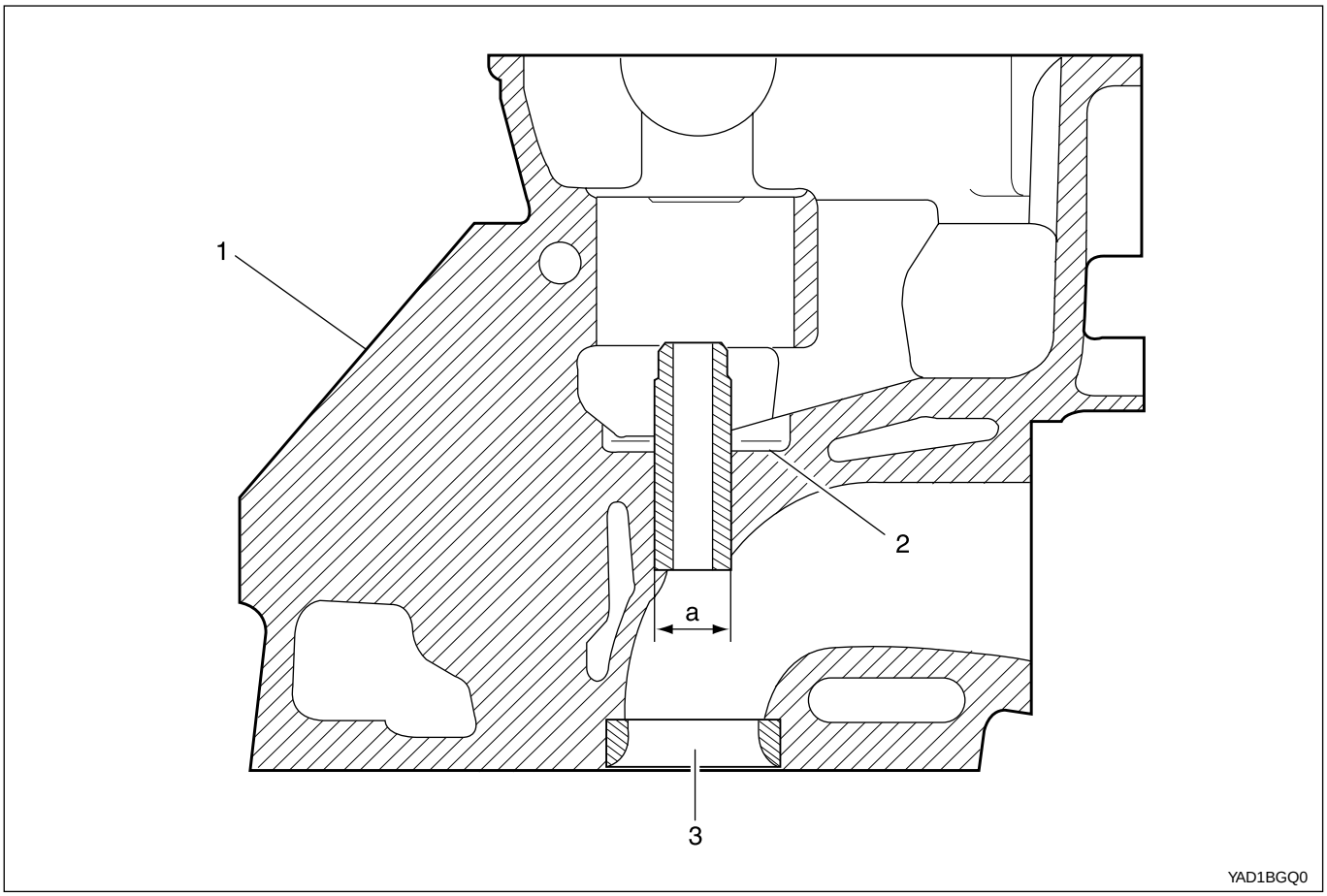


9. By pressing the spring seat with press lever 667 589 00 31 00 (9), install the valve cotters (2) with magnetic finger 116 589 06 63 00 (10).

   Notice: Be careful not to damage guide bore of the valve tappet.

VALVE GUIDES

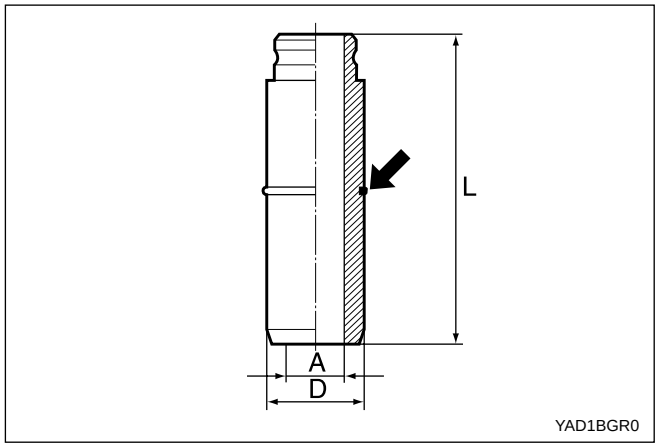
Preceding Work: Removal of cylinder head
Removal of valve spring
Removal of valve



1 Cylinder Head
2 Valve Guide
3 Valve Seat Ring
a Basic Bore Diameter

Service Data

	Item	Outer Diameter ' D '	Color Code	Basic Bore Diameter 'a'	Overlap 'D' - 'a'	Valve Guide Inner Diameter' A '	Length ' L'
Intake	Repair size 1	14.251	Red	14.200 - 14.211	0.029 - 0.051	8.000 - 8.030	39.5
	Repair size 2	14.440 - 14.451	White	14.400 - 14.411			
Exaust	Repair size 1	14.240 - 14.251	Red	14.200 - 14.211	0.029 - 0.051	9.000 - 9.050	37.7
	Repair size 2	14.440 - 14.451	White	14.400 - 14.411			



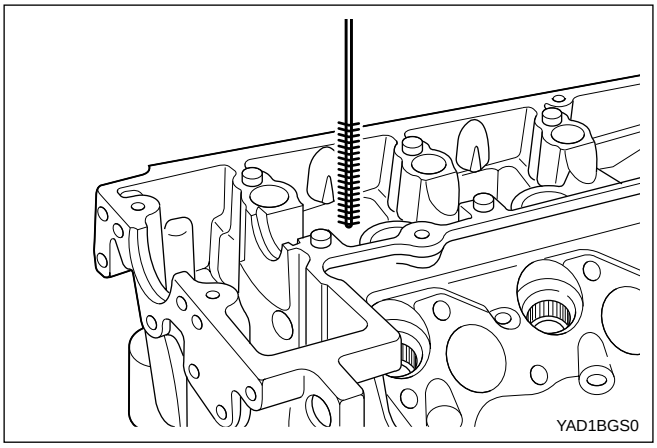
Notice: Measure center (arrow) of the valve guide and if the inner diameter 'A' exceeds standard value, replace the guide.

Tools Required

000 589 10 53 00	Reamer (for Exhaust)
000 589 10 68 00	Cylinder Brush
000 589 21 53 00	Reamer (for Intake)
102 589 00 23 00	GO / NO GO Gauge (for Intake)
103 589 02 15 00	Drift (for Exhaust)
103 589 03 15 00	Drift (for Intake)
115 589 34 63 00	Mounting Device
117 589 03 23 00	GO / NO GO Gauge (for Exhaust)
346 589 00 63 00	Super Cooling Box
601 589 05 15 00	Drift (for Intake)
601 589 06 15 00	Drift (for Exhaust)

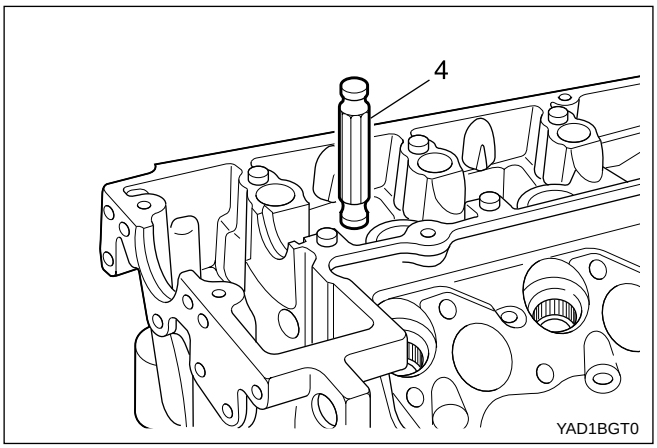
Matching Valve Seat - Broaching Tools - Guide Sleeves

Valve Seat	Broaching Tool No.	Guide Sleeve Tool No.	Guide Sleeve Side
Intake	115 589 00 53 00 (14.2 mm)	102 589 00 63 00	B
Exhaust		102 589 08 63 00	B
Intake	115 589 01 53 00 (14.4 mm)	601 589 15 63 00	A
Exhaust			B

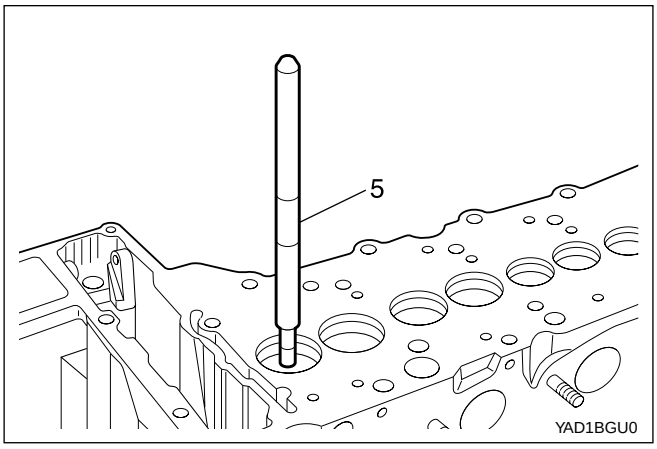


Checking

1. Thoroughly clean the valve guide bore using a cylinder brush 000 589 10 68 00.



2. Insert the GO/NO GO gauge (Intake: 102 589 00 23 00, Exhaust: 117 589 03 23 00) into the valve guide bore. If the NO GO side is inserted fully, replace the valve guide (Intake 8 mm, Exhaust 9mm).

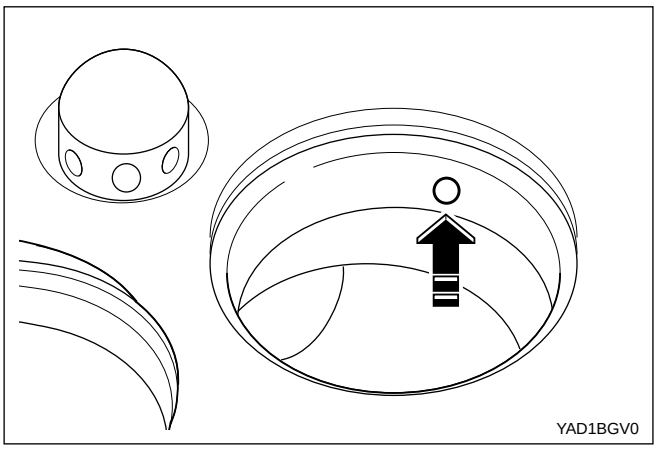


Replacement Procedure

1. Drive out the valve guide (2) by using a drift (Intake: 103 589 03 15 00, Exhaust: 103 589 02 15 00) (5).

   Notice: The valve guide must be driven out upward of the cylinder head.

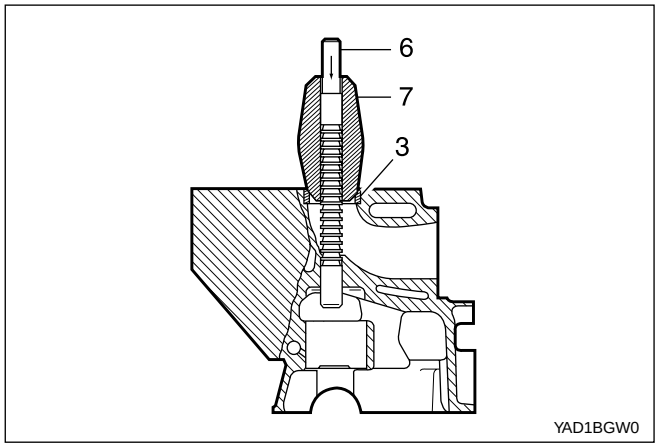
2. Thoroughly clean the basic bore by using a cylinder brush 000 589 10 68 00.
3. Check the basic bore in cylinder head for scoring marks and ream to next repair size if necessary.



4. Reaming basic bore in cylinder head (repair size).
   - Thoroughly remove carbon deposits in cylinder head.

     Notice: Particularly remove the insides of the valve seat rings.

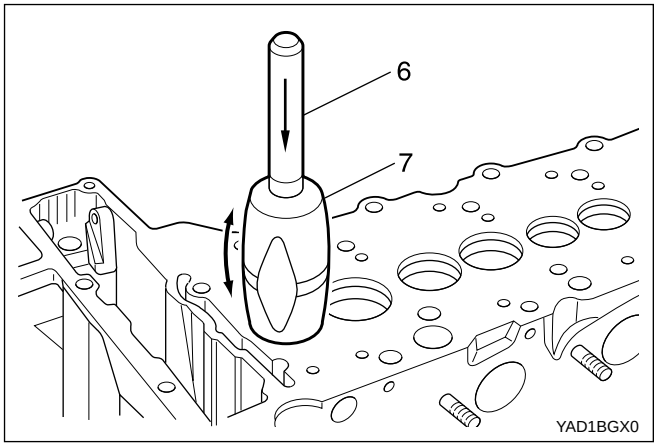
   - Remove the elevation (arrow) of intake valve seat rings.



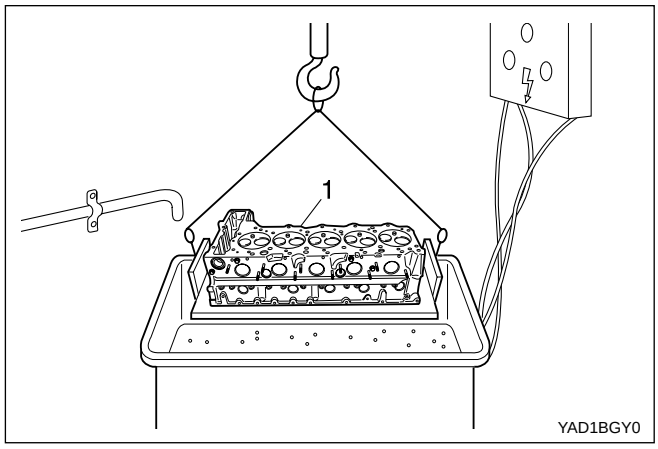
- Select correct broaching tool and guide sleeve (refer to the table).

  Notice: Before broaching work, the broaching tool must be cleared of swarf with a stiff plastic brush.

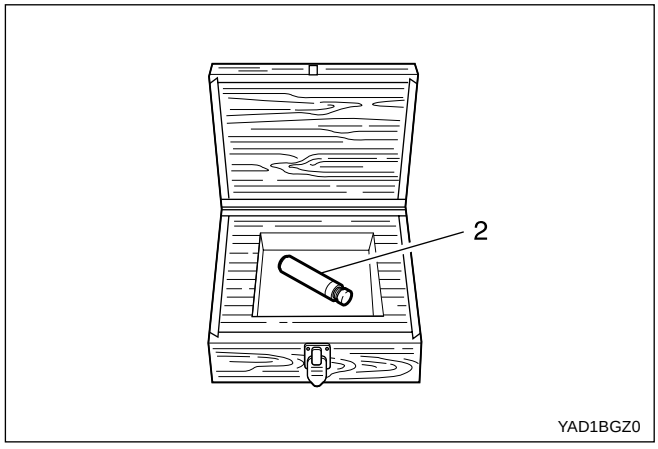
- Lubricate the basic bore, guide sleeve and broaching tool with petroleum.
- Push broaching tool (6) in broaching direction (arrow) into the guide sleeve (7) far enough so that the first cut of the broaching tool is positioned in the basic bore when guide sleeve is fitted onto the valve seat ring (3).



- Center the guide sleeve (7) in the valve seat ring (3) by turning.
- Knock through the broaching tool (6) with a plastic hammer (approx. 25 g) and aluminum drift.

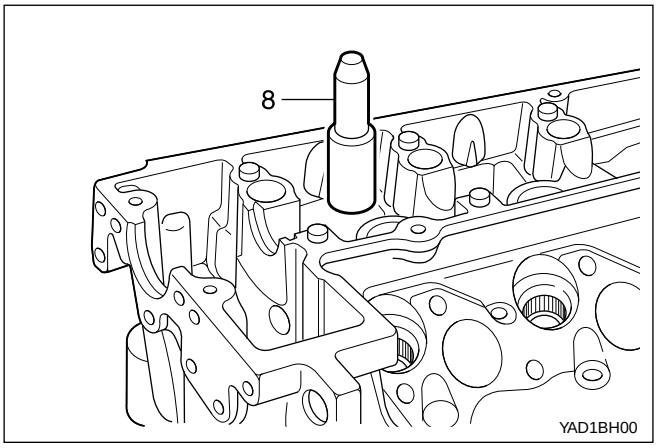


5. Heat the cylinder head (1) in a wear tank to approx. 80°C (176°F) with mounting device 115 589 34 63 00.



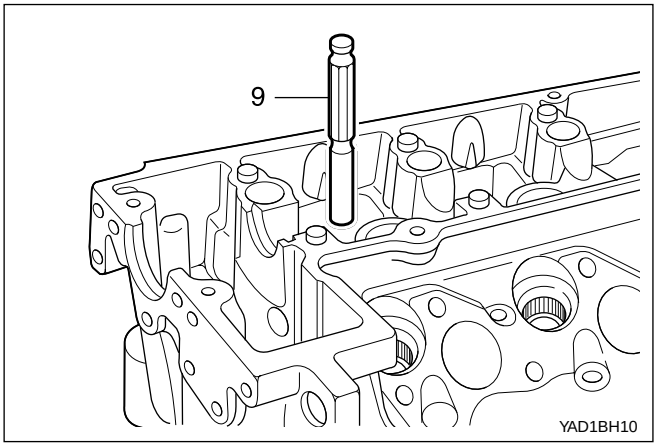
6. Cool down the new valve guide (2) into the super cooling box 346 589 00 63 00 with liquid nitrogen.

   Notice: Do not touch the cooled valve guide by hand.



7. Drive in new valve guide with drift (Intake: 601 589 05 15 00, Exhaust: 601 589 06 15 00) (8) until the wire ring makes contact.

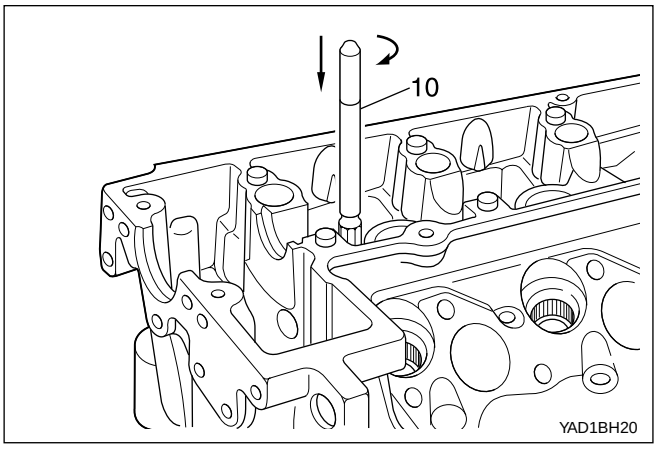
   Notice: The valve guide must be driven in from the cylinder head cover.



8. Check the valve guide bore with GO / NO GO gauge (Intake: 102 589 00 23 00, Exhaust: 117 589 03 23 00) (9).

   The GO side (marked '0') should just still drop. If the GO side cannot be inserted, the bore of valve guide should be reamed.

   Notice: Perform the check only on cooled down cylinder head.

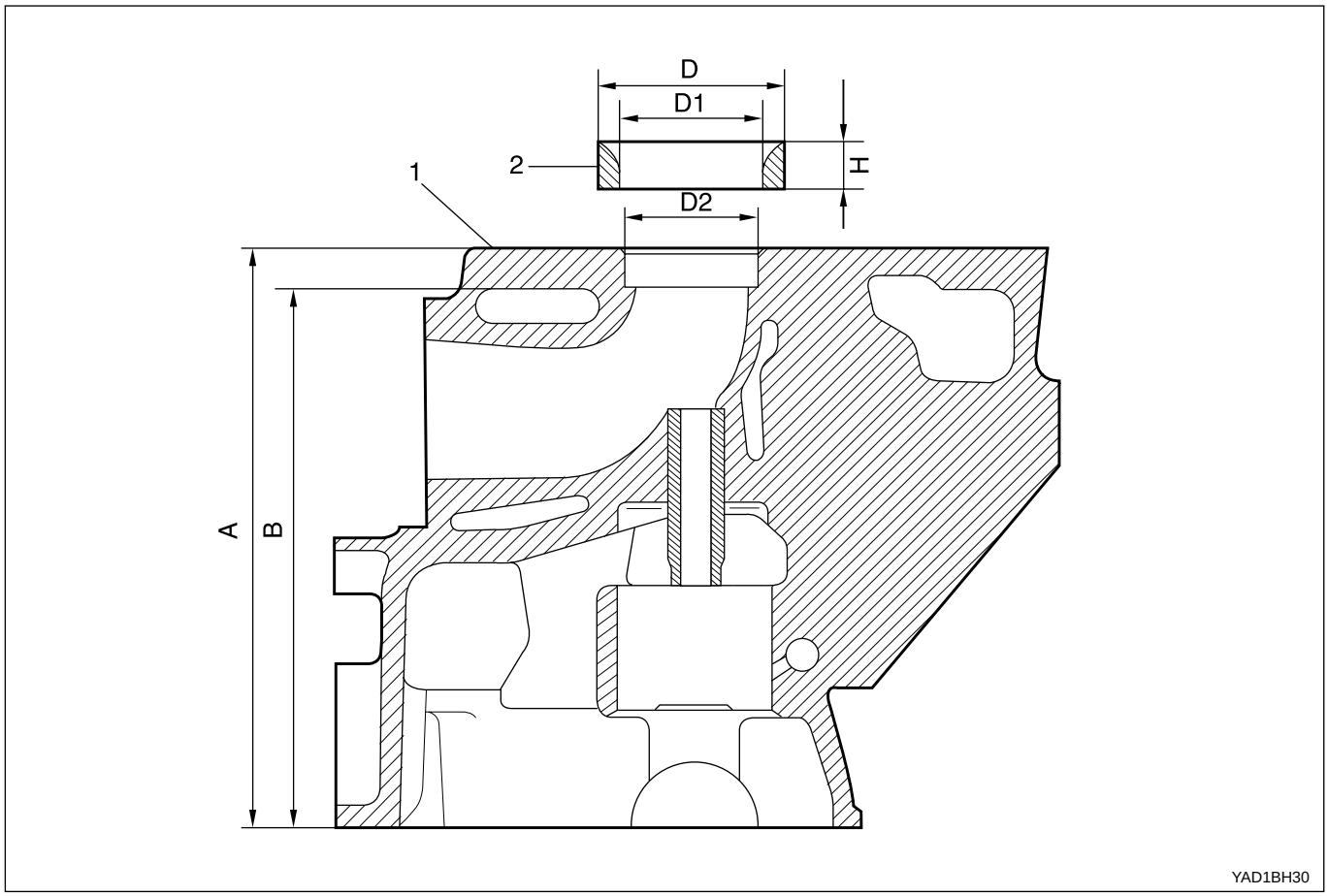


9. If necessary, ream the valve guide bore evenly with a reamer (Intake: 000 589 21 53 00, Exhaust: 000 589 10 53 00) (10).

   Notice: Never turn the reamer against the direction of rotation.

VALVE SEAT RINGS

Preceding Work: Removal of valve
Checking of valve guide, replace if necessary
Removal of prechamber



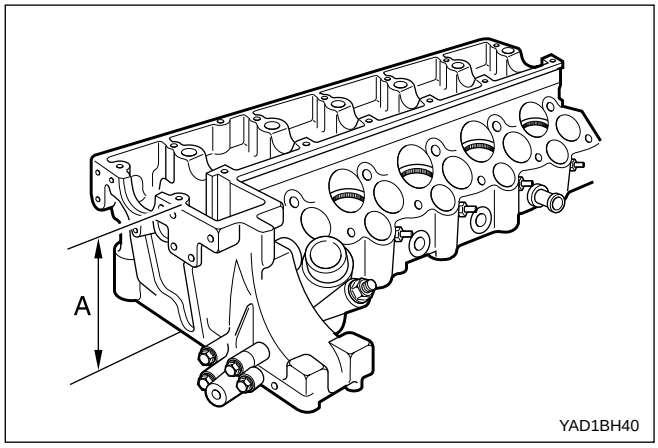
1 Cylinder Head
2 Valve Seat Ring
A Height (Cylinder Head Upper / Lower Surface)
B Height (Cylinder Head Cover Surface / Seat of Valve Seat Ring)
D Valve Seat Ring Outer Diameter
D1 Valve Seat Ring Inner Diameter
D2 Basic Bore Diameter
H Height of Valve Seat Ring

Service Data

Item	Intake	Exhaust
D2	40.000 - 40.016 mm	37.000 - 37.016 mm
D	40.084 - 40.100 mm	37.084 - 37.100 mm
D1	33.400 - 33.600 mm	30.400 - 30.600 mm
H	6.955 - 7.045 mm	6.955 - 7.045 mm
Overlap U=D-D2	0.068 - 0.100 mm	0.068 - 0.100 mm
B	133.4 mm	133.4 mm
A	142.5 mm	142.5 mm

Commercial Tools

Cylinder Head Clamping Device	Hunger D-8000 München 70 Type Ventilknecht K2000 Order No. 221 00 100
Valve Seat Turning Tool	Hunger D-8000 München 70 Type VDS 1A Order No. 236 03 308
Ring Seat Turning Tool	Hunger D-8000 München 70 Type RDS 1 Order No. 219 00 100
Pneumatic Removal / Installation Device (Drift : 8 mm, 9 mm, 14 mm)	Hunger D-8000 München 70 Type PVM 1
Tensioning Head	Hunger D-8000 München 70 Order No. 250 15 250
Cutting Tool for Recessing Grooves	Hunger D-8000 München 70 Order No. 217 93 601
Test Set for Valves	Hunger D-8000 München 70 Order No. 216 69 210
Internal Dial Gauge (Range : 25 - 60 mm)	Mahr D-7300 Esslingen Order No. 844
External Micrometer (Range : 25 - 60 mm)	Mahr D-7300 Esslingen Order No. 40 S
Electrically Heated Water Tank	Otto Dürr D-7123 Sachsenherm - Ochsenbach



Tools Required

115 589 34 63 00 Mounting Device

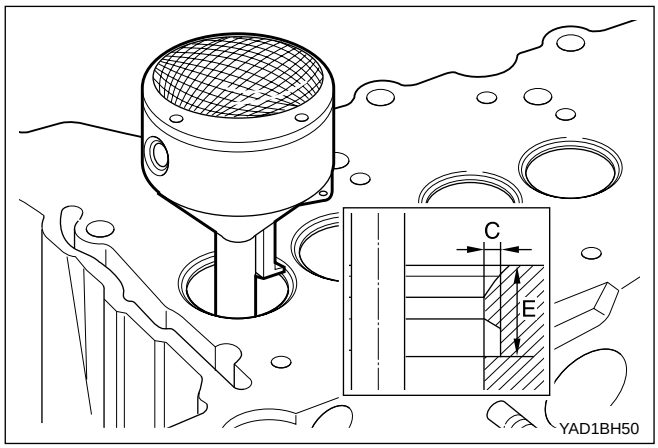
345 589 00 63 00 Super Cooling Box

Removal Procedure

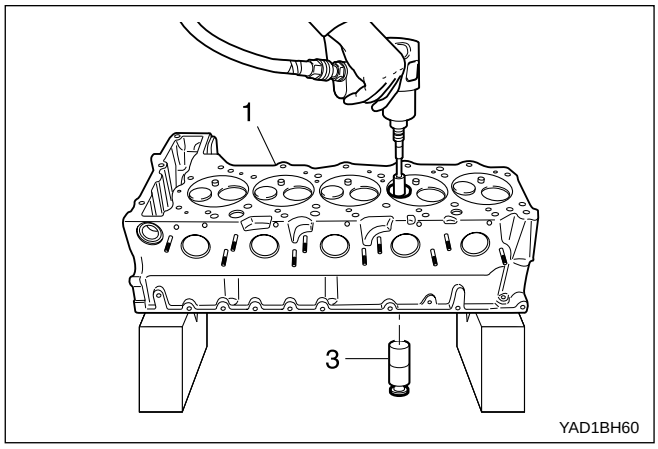
1. Measure dimension ‘A’.

Limit	142.5 mm

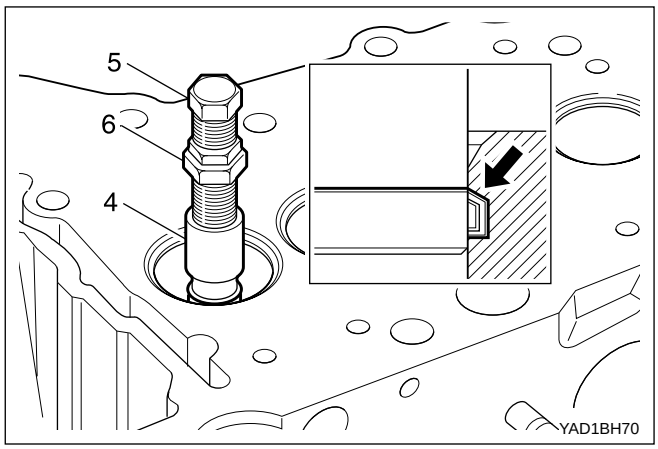
2. Clamp the cylinder head with clamping device.



3. Cut groove into the valve seat ring so that dimension ‘C’ is approx. 2 mm and dimension ‘E’ is approx. 6 mm.



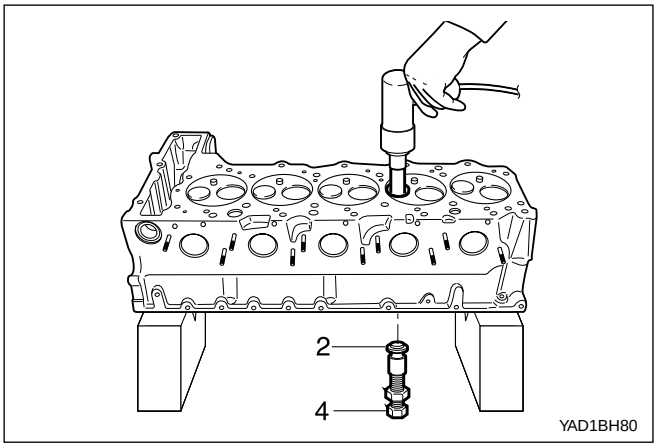
4. Remove the cylinder head from the clamping device and place it onto wooden blocks.
5. Remove the valve guide (3) by using a drift (Intake: 8 mm, Exhaust: 9 mm).



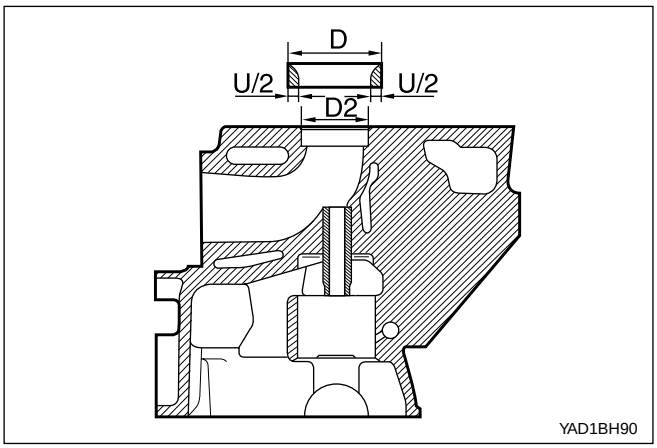
6. Insert the tensioning head (4) and extracted wedges(arrow) by turning the bolt (5).

   Notice: Carefully tighten the bolt (5) otherwise the valve seat ring in the cylinder head will be excessively tensioned.

7. Lock the bolt (5) with nut (6).



8. Turn over the cylinder head.
9. Remove the tensioning head (4) and valve seat ring (2) with drift (14 mm) and removal tool.
10. Clean the basic bore of valve seat ring.

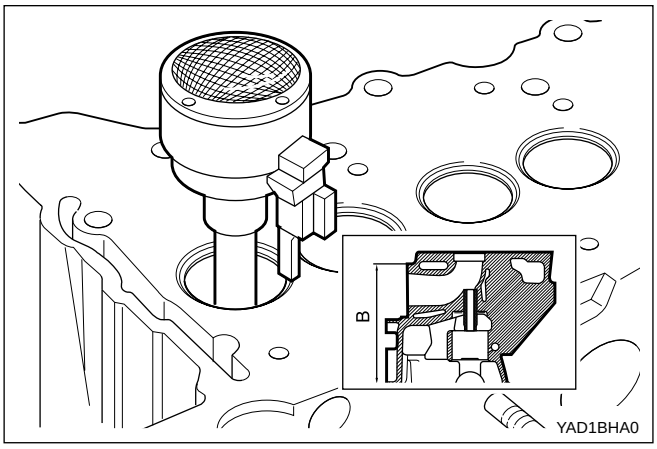


11. Measure the basic bore diameter (D2) and outer diameter (D) of the new valve seat ring (standard size).
12. Calculate the overlap value 'U' (D - D2).

Overlap Valve 'U'	0.068 - 0.100 mm

Example) Measured value D = 37.100 mm
Measured value D2 = 37.010 mm
Overlap value 'U' = 0.090 mm

If overlap value 'U' is out of standard, machine the basic bore for the valve seat ring.



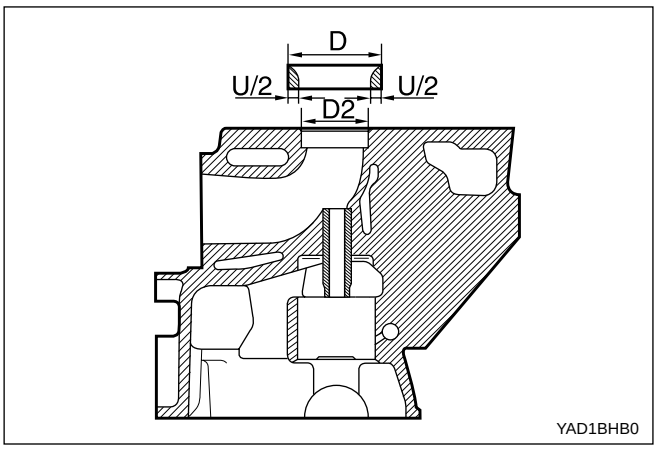
13. Clamp the cylinder head with clamping device.
14. Machining basic bore for valve seat ring (repair size).

Notice: Maintain minimum value of 'B'.

- Machine the basic bore.

Limit

Max. D2	Intake	40.516 mm
	Exhaust	37.516 mm
Min. B		133.4 mm

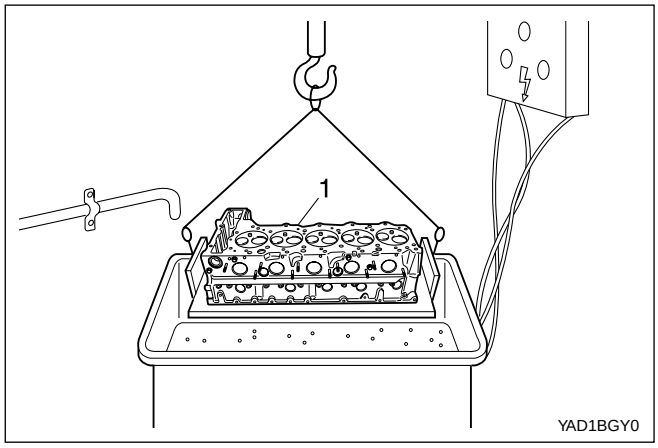


- Measure machined basic bore and outer diameter 'D' of valve seat ring (repair size).
- Measure the overlap 'U'

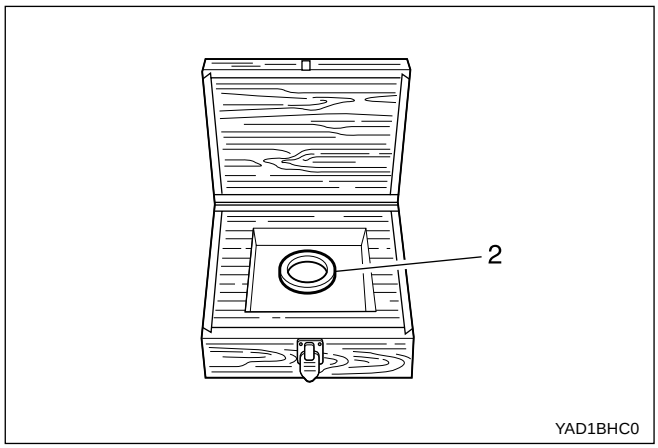
Overlap 'U' (D - D2)	0.068 - 0.100 mm

Example) Measured value D = 37.600 mm
Measured value D2 = 37.480 mm
Overlap U = 0.120 mm

The basic diameter D2 must be machined by 0.020 mm in order to get the required overlap value.

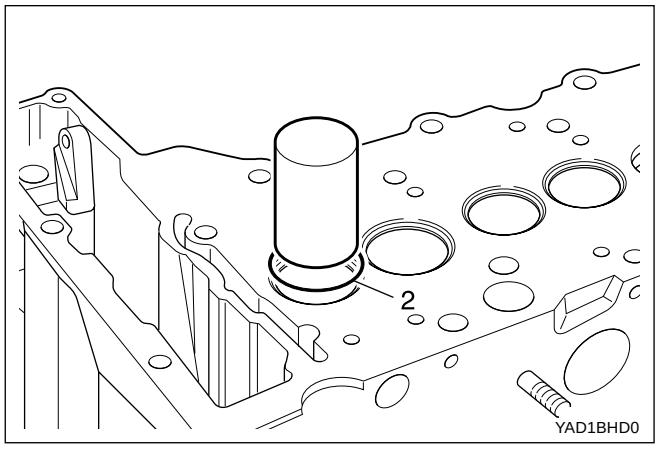


15. Hang the cylinder head (1) to the lifting device and heat in a water tank to approx. 80°C(176°F) with mounting device 115 589 34 63 00.

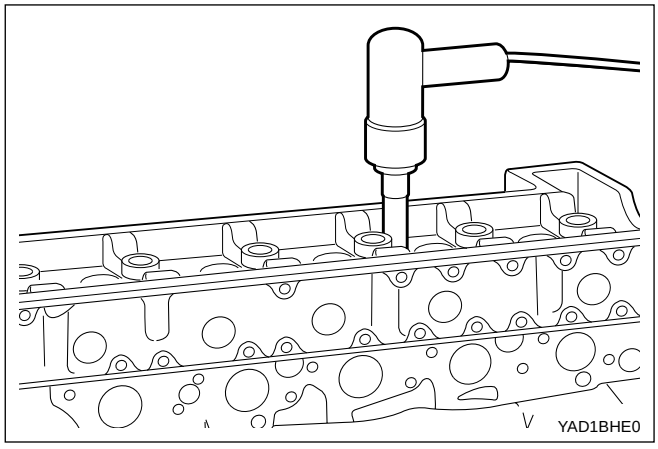


16. Cool down new valve seat ring (2) into the cooling box 345 589 00 63 00 with liquid nitrogen.

    Notice: Do not touch the cooled valve seat rings with hand.



17. Drive in new valve seat ring (2) with a proper wooden drift.



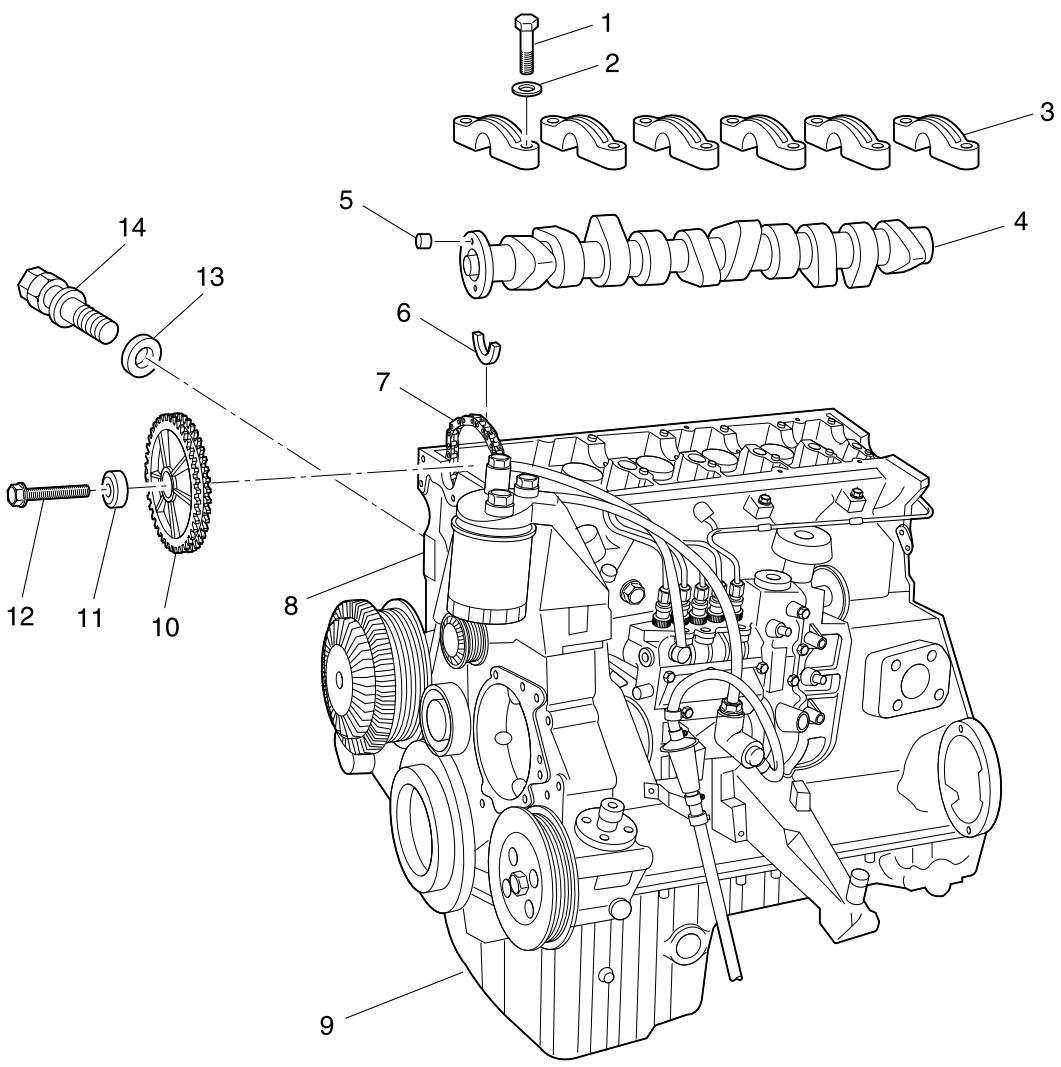
18. Install the valve guide (3) with a proper drift (Intake: 8 mm, Exhaust: 9 mm) and assembling tool.

    Notice: The valve guide must be driven in from the cylinder head cover.

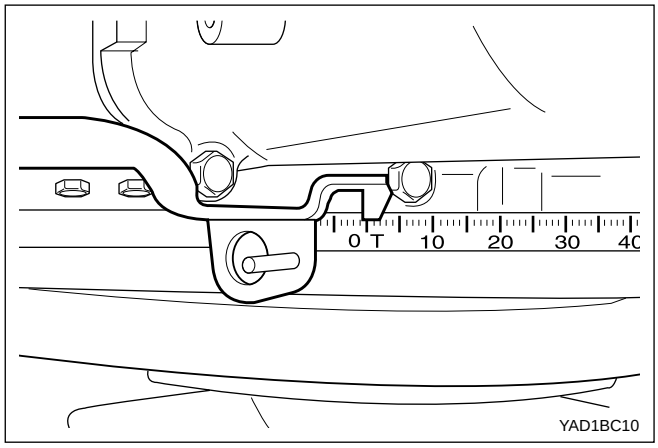
19. Machine the valve seats.

CAMSHAFT

Preceding Work: Removal of cylinder head cover



1 Bolt ..... 25 N•m (18 lb-ft)
2 Washer
3 Camshaft Bearing Cap
4 Camshaft
5 Dowel Pin
6 Locking Washer
7 Timing Chain
8 Cylinder Head
9 Oil Pan
10 Camshaft Sprocket
11 Washer
12 12-Sided Bolt (M11)
..... Check, 25 N•m (18 lb-ft)+ 90°
13 Gasket ..... Replace
14 Chain Tensioner ..... 80 N•m (59 lb-ft)



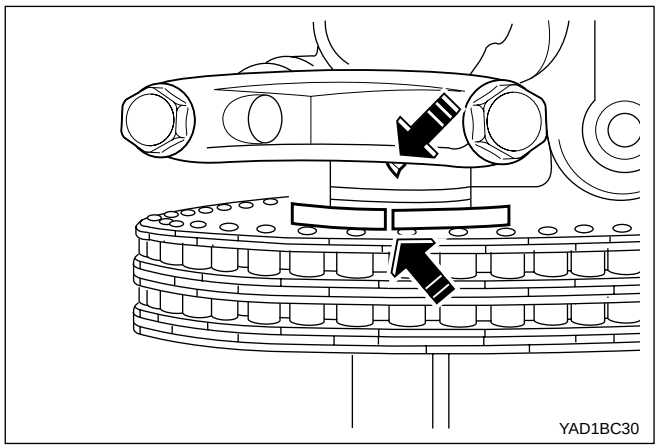
Tools Required

602 589 00 40 00 Engine Lock

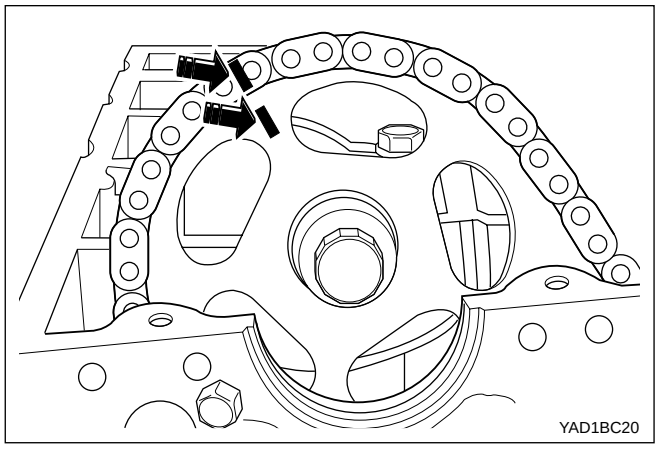
Removal Procedure

1. Rotate the crankshaft and position the piston of No.1 cylinder at TDC.

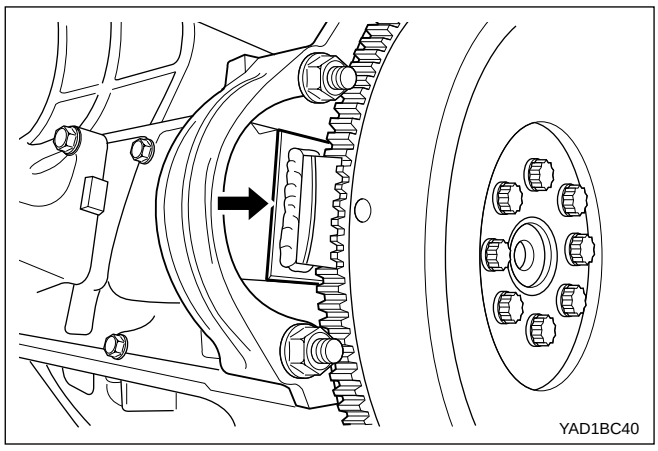
   Notice: Do not rotate the crankshaft in the opposite direction of engine rotation.



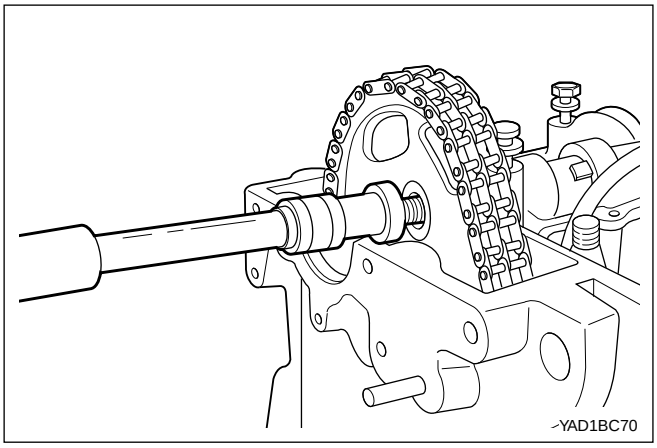
In this position, the markings of the camshaft/ camshaft bearing cap (arrow) must be aligned.



2. Place alignment marks on the camshaft sprocket and timing chain.

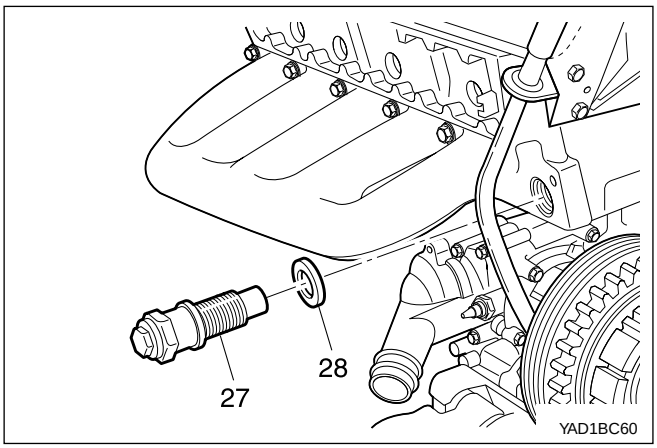


3. Remove the starter motor and install the engine lock 602 589 00 40 00.

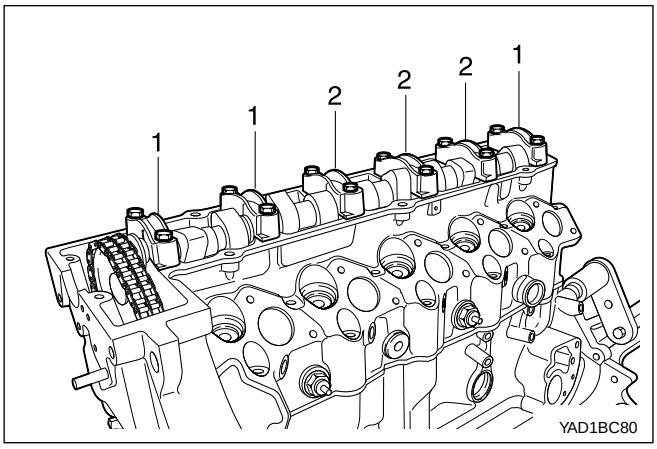


4. Remove the bolt and then remove the camshaft sprocket.

   Notice: During removal, be careful not to drop the sprocket with chain. Remove the chain carefully and then pull out the sprocket.

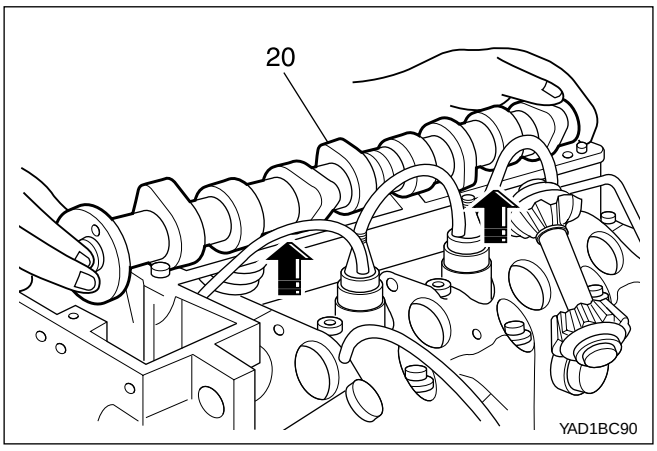


5. Remove the chain tensioner.



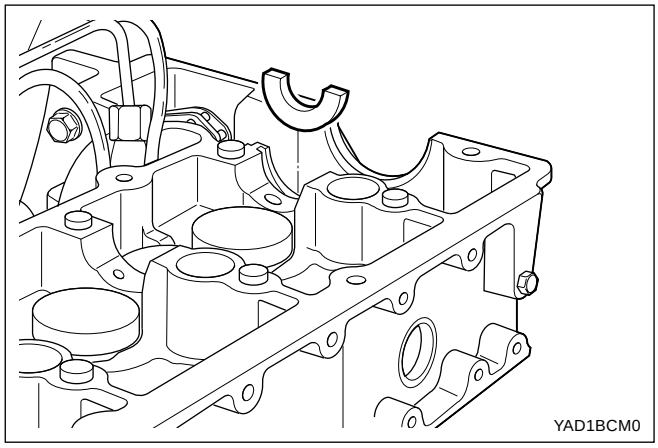
6. Remove the camshaft bearing cap bolts according to the removal order.

   Notice: Remove the camshaft bearing cap bolts of 1 first and then remove the bolts of 2 one revolution in stages until the counter-pressure is released. In order to avoid damaging the camshaft, it is essential to adhere to the removal order for the camshaft bearing caps.



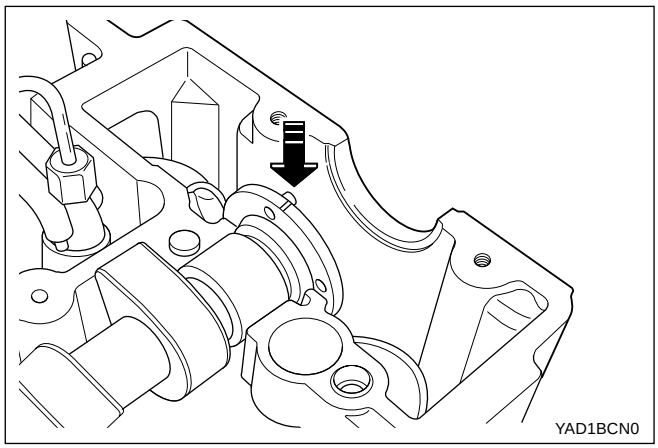
7. Remove the camshaft bearing cap.
8. Pull off the camshaft.

   Notice: Be careful not to miss front locking washer.


YAD1BCM0

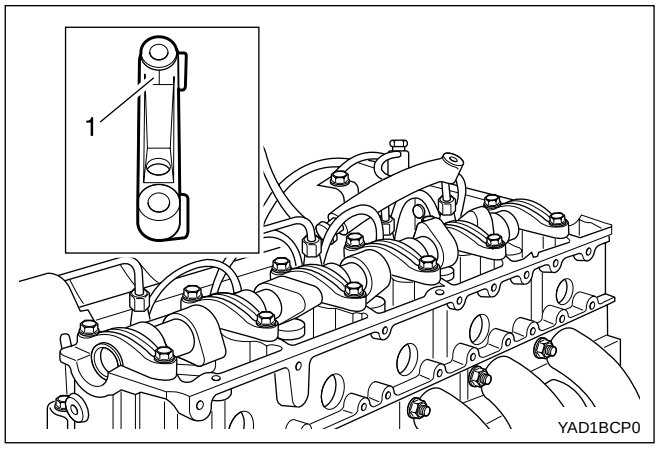
9. Pull out the locking washer.

   Notice: Check the condition of locking washer and replace if necessary.


YAD1BCN0

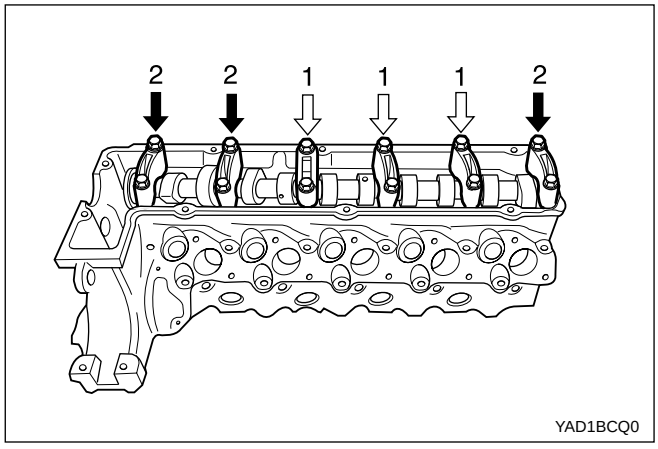
Installation Procedure

1. Insert the locking washer.
2. Check the valve tappet and ensure that tappet moves smoothly.
3. Coat the camshaft with oil and install the camshaft onto the cylinder head so that the TDC marking (arrow) is positioned upward vertically.



YAD1BCP0

4. Install the camshaft bearing caps according to markings(1, 2, 3 etc.).



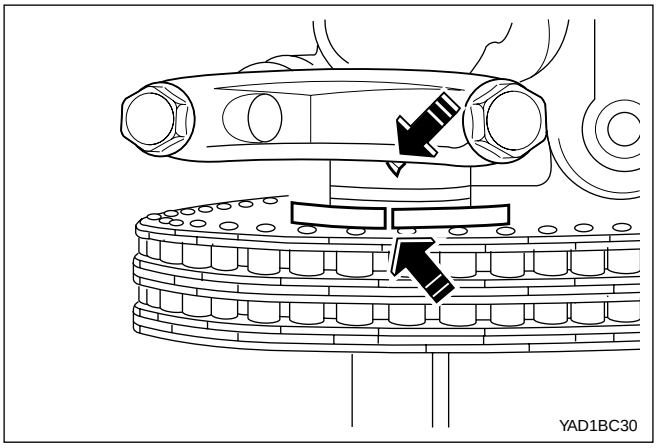
YAD1BCQ0

5. Tighten the camshaft bearing cap bolts acccording to installation order.

   Installation Notice

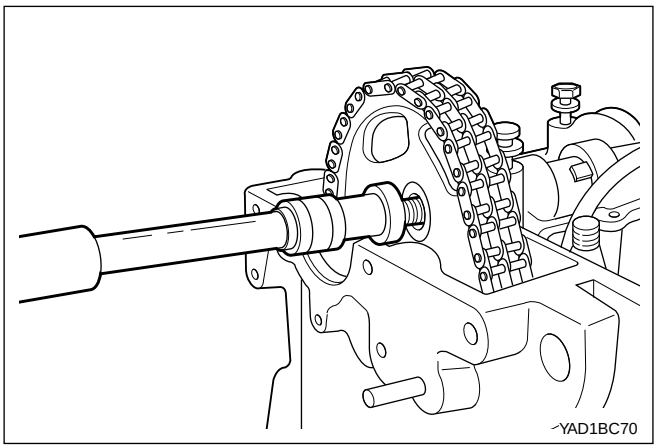
Tightening Torque	25 N•m (18 lb-ft)+ 90°

   Tighten the No. 1 bolts (light arrow) by one revolution in stages first and then tighten the No. 2 bolts (dark arrow).



6. Install the camshaft sprocket to be aligned the markings of the camshaft / camshaft bearing cap (arrow).

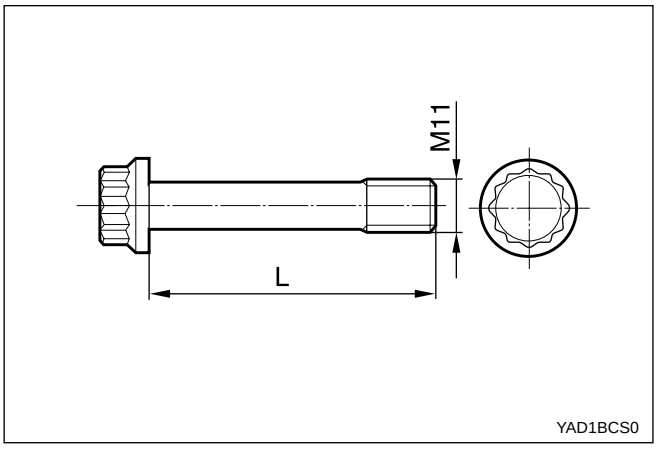
   Notice: Align the alignment marks on the timing chain and sprocket.



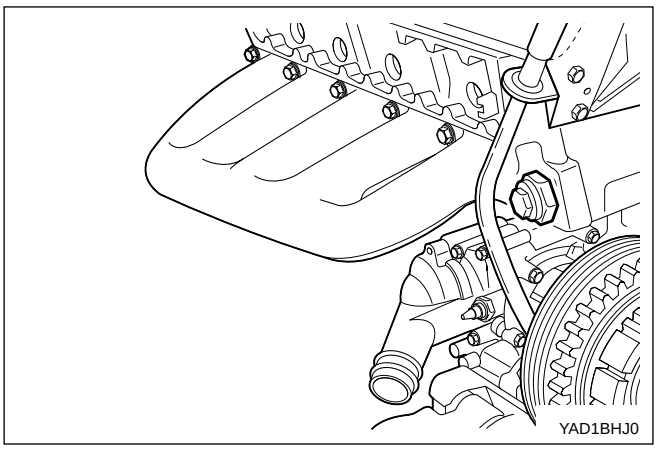
7. Tighten the camshaft sprocket bolt.

   Installation Notice

Tightening Torque	25 N•m (18 lb-ft)+ 90°



Notice: If max. length 'L' of the 12-sided bolt exceeds 53.6mm, replace it.



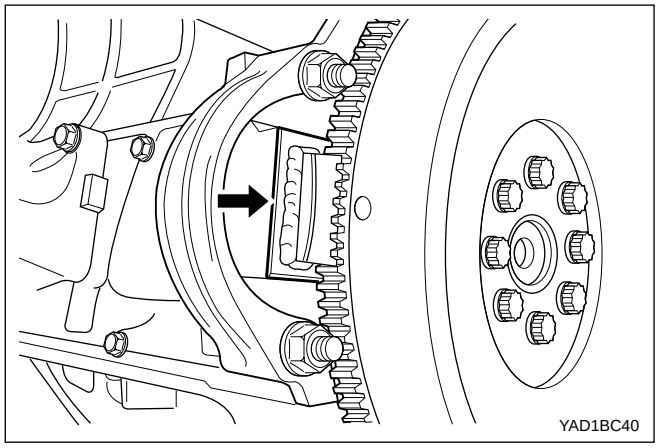
8. Install the chain tensioner.

   Installation Notice

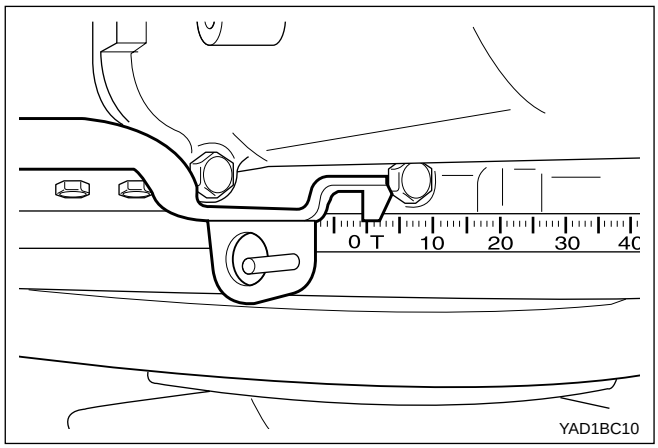
Tightening Torque	80 N•m (59 lb-ft)

   Replace the seal.

   Before installation, by pumping in the oil approx. 10 times, fill the oil.



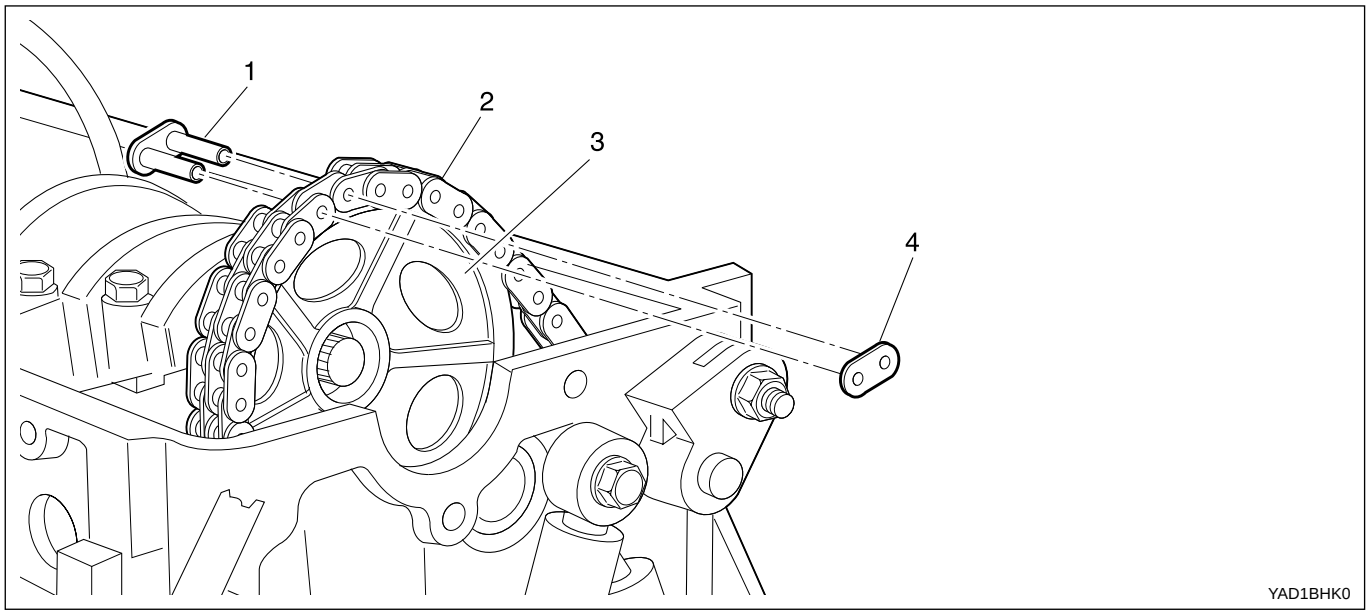
9. Remove the engine lock 602 589 00 40 00.



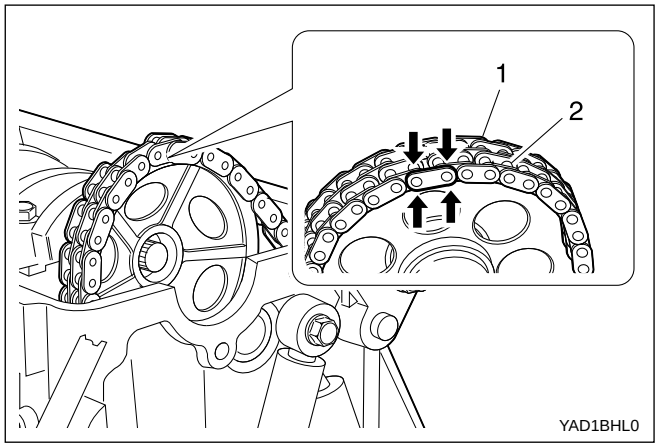
10. Check the TDC marking of OT on the crankshaft.

TIMING CHAIN

Preceding Work: Removal of glow plug
Removal of chain tensioner
Removal of cooling fan
Removal of cylinder head cover



1 Chain Link
2 Timing Chain
3 Camshaft Sprocket
4 Outer Plate

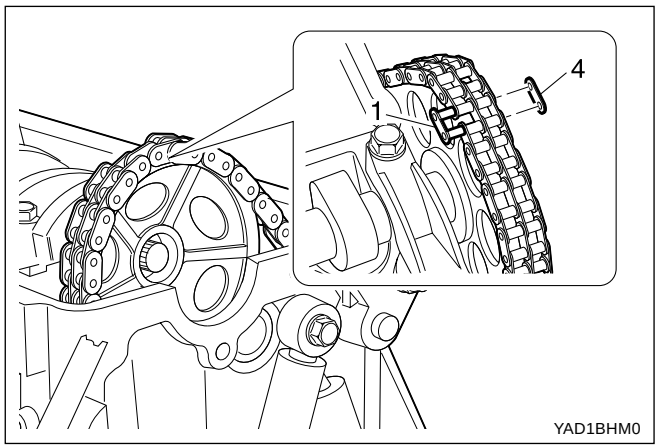


Tools Required

000 589 58 43 00 Chain Assembling Device

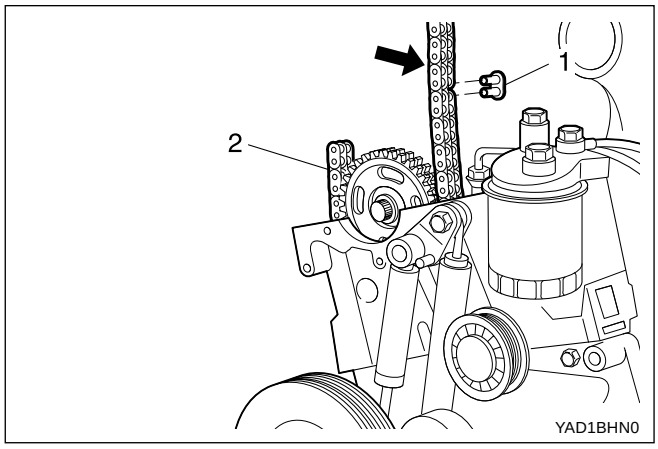
Replacement Procedure

1. Cover over the chain box with cleaning rag and grind off both chain pins (arrow) at a chain link (1) of the timing chain.

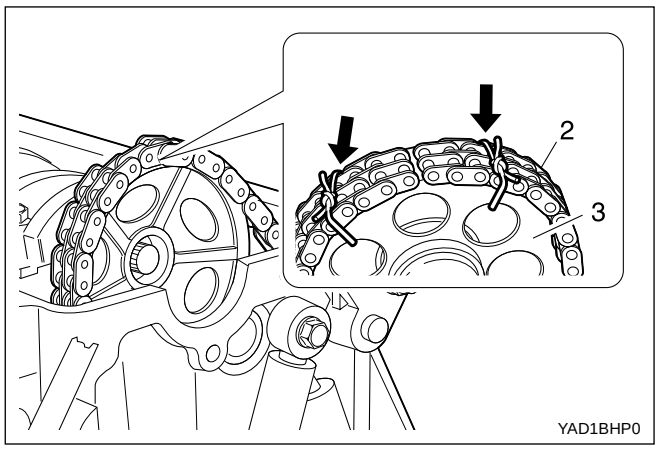


2. Remove the outer plate (4) and chain link (1).

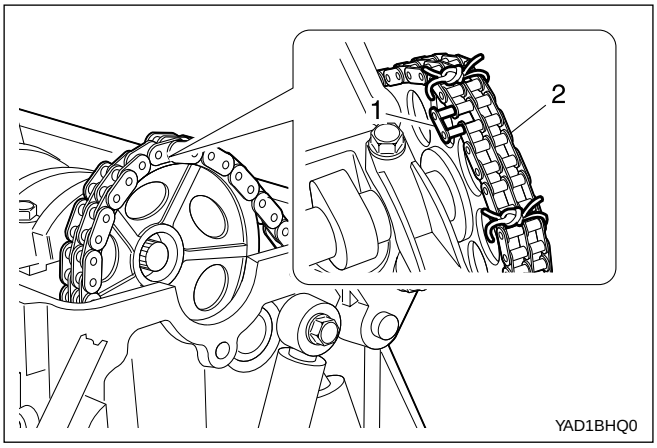
   Notice: Ensure that the ends of the timing chain do not drop into the chain box.



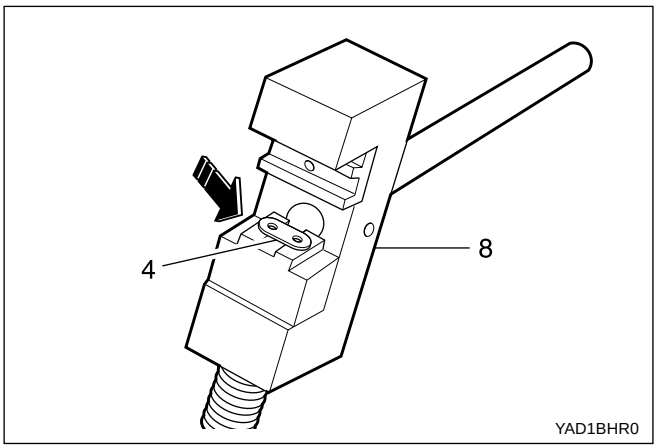
3. Loosen the chain tension with approx. 4 turns.
4. Connect the new timing chain (arrow) with chain link (1) to the old timing chain (2).



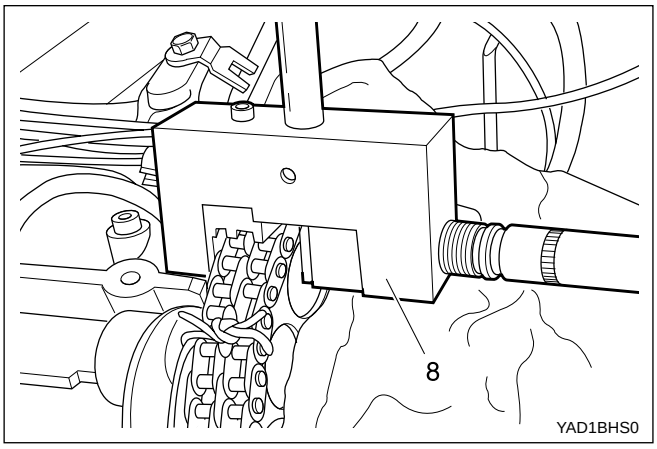
5. By rotating the crankshaft in the of engine rotation, pull out the old timing chain with installing the new timing chain.
6. Remove the old timing chain and hold the ends of the new timing chain to camshaft sprocket (3) with wire (arrow).



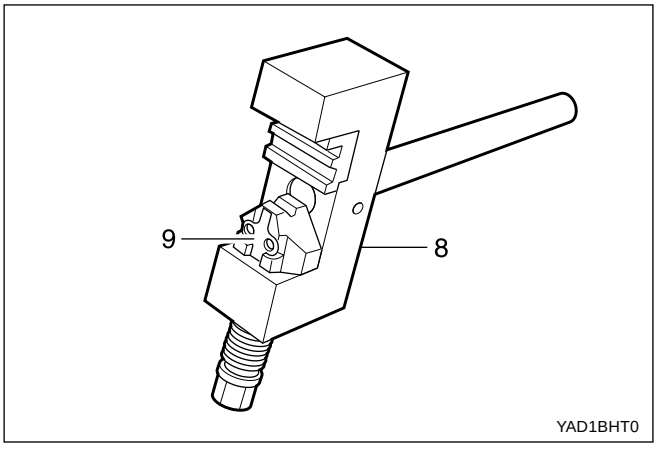
7. Insert the new chain link (1) to connect the chain.



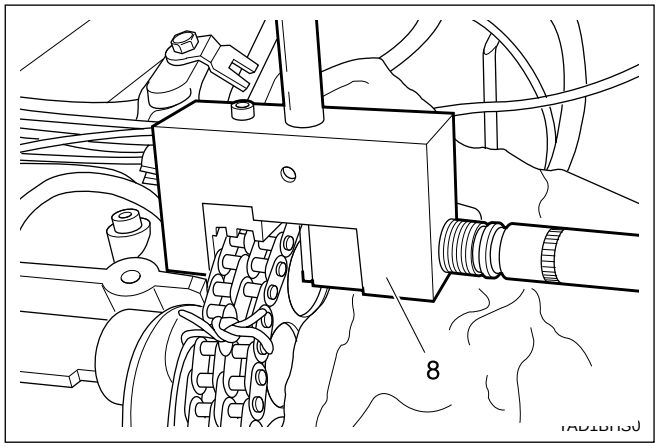
8. Insert the new outer plate (4) into the chain assembling device 000 589 58 43 00 tool (8) and then the outer plate will be held by a magnet.



9. Place the chain assembling device 000 589 58 43 00 (8) onto the chain link and press the outer plate on as far as the stop.

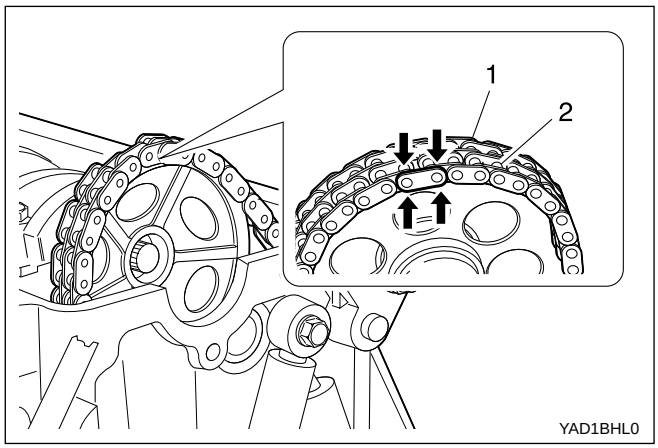


10. Switch over the die (9) of the chain assembling device 000 589 58 43 00 (8).

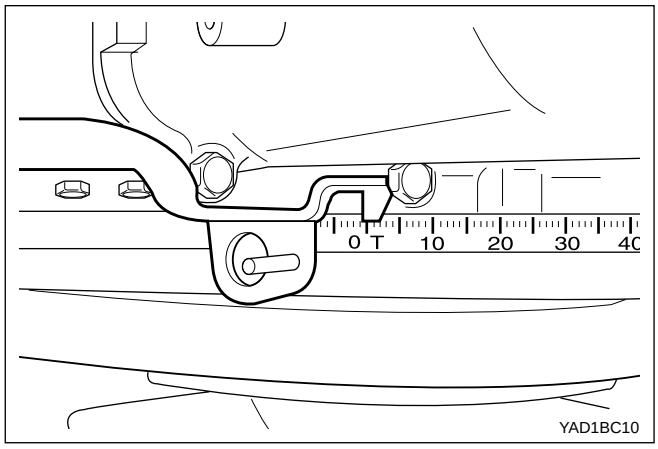


11. Place the fitting tool (8) onto the chain link and rivet the chain pins one by one.

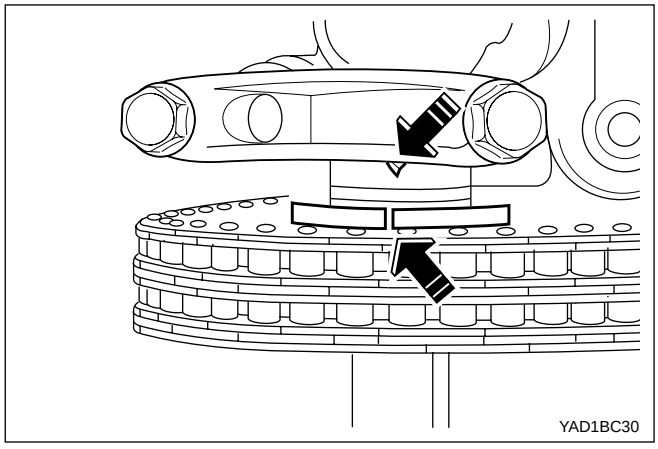
Tightening Torque	35 - 40 N•m (20 - 30 lb-ft)



12. Check the riveting of chain pins and re-rivet if necessary.
13. Remove the wire.

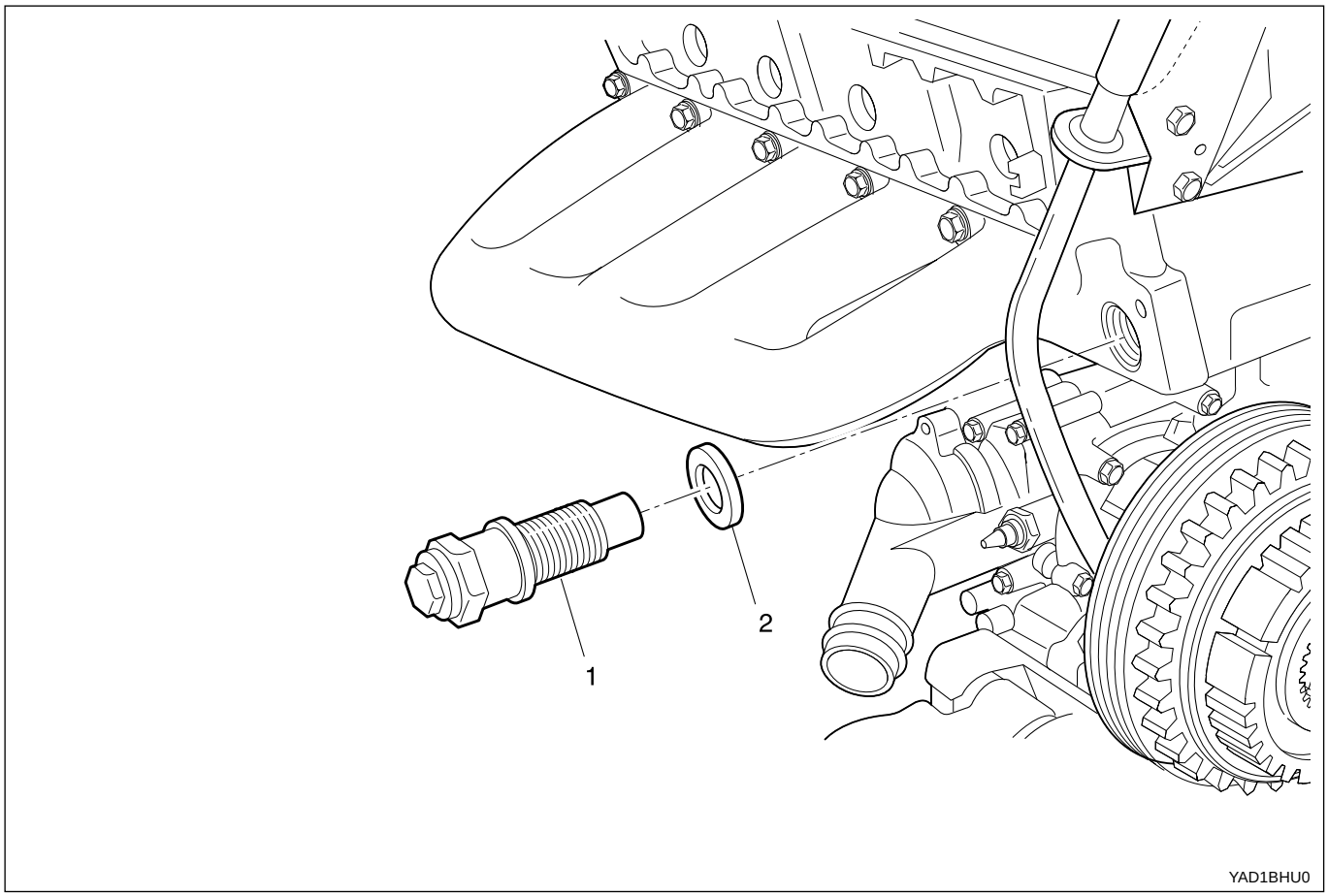


14. Position the no.1 cylinder at TDC.



Notice: In this position, the marking on camshaft / camshaft bearing cap (arrow) must also be aligned. If the markings are not aligned, the timing chain must be re-set and the injection pump timing has to be set.

CHAIN TENSIONER

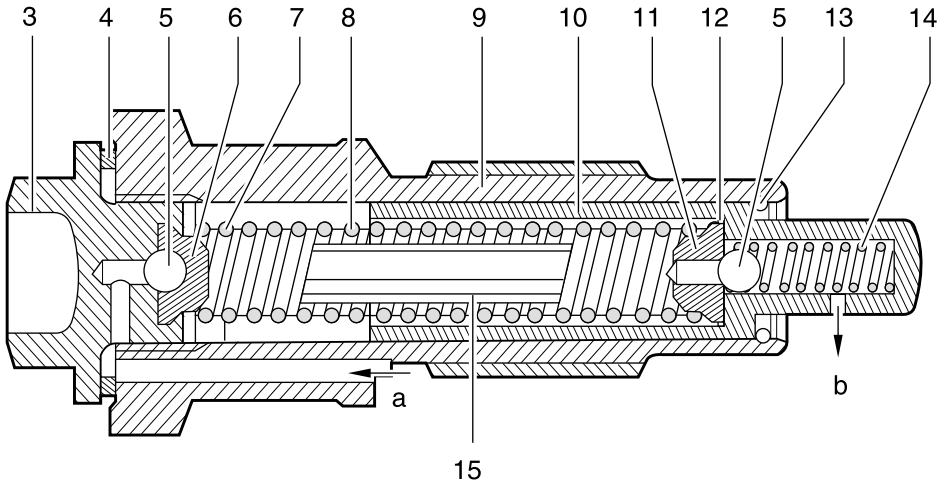


1 Chain Tensioner ..... 80 N•m (59 lb-ft)
2 Seal ..... Replace

Notice: Always install the chain tensioner to be filled with oil.

Place the chain tensioner in engine oil up to over the collar on the hexagon head with the thrust pin facing up. Slowly push down the thrust pin as far as the stop 7~10 times with the aid of a press or a column drill.

Faulty chain tensioners should be replaced completely.



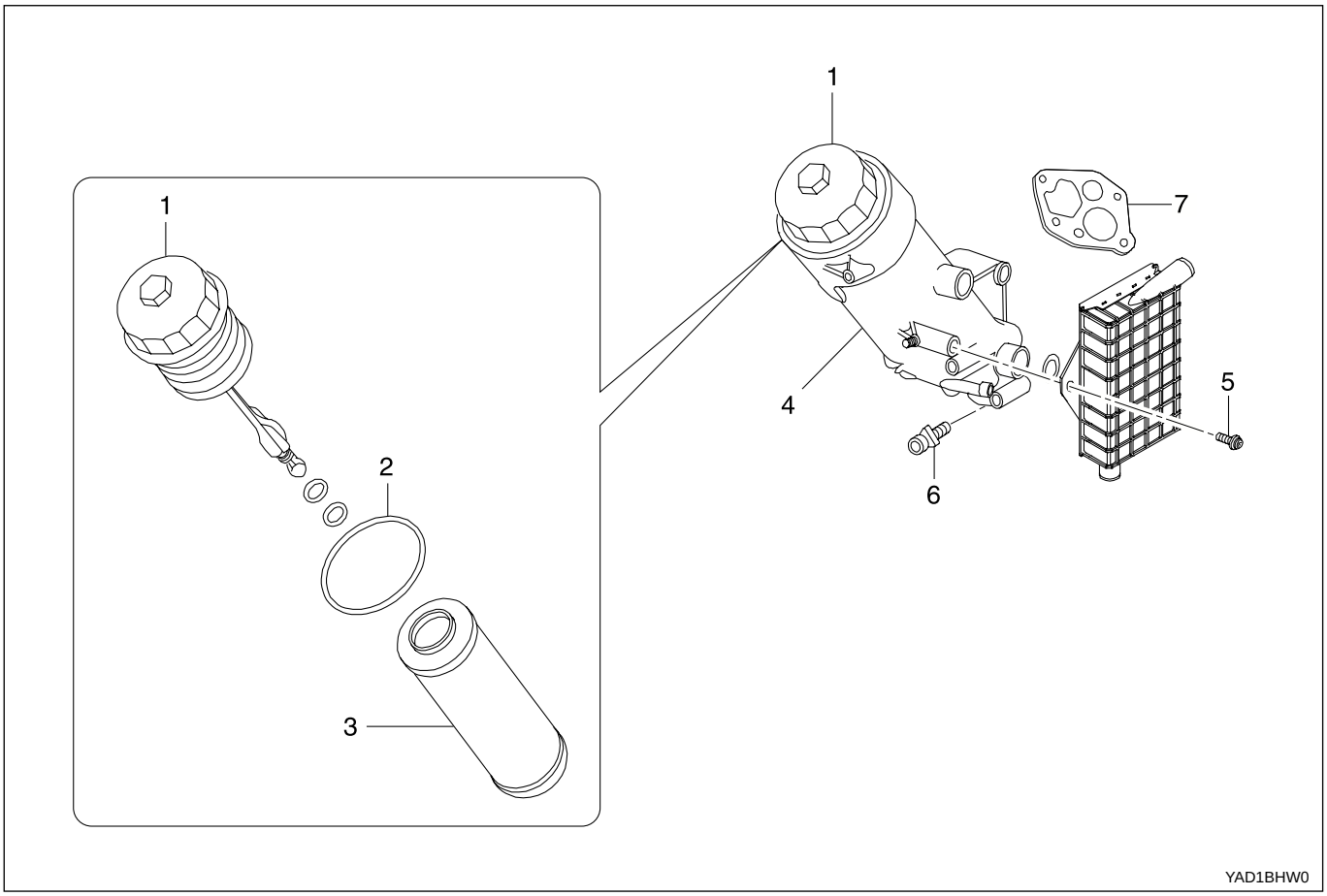
YAD1BHV0

3 Screw Plug
4 Aluminum Gasket
5 Ball
6 Ball Guide
7 Compression Spring
8 Compression Spring
9 Housing
10 Thrust Pin
11 Valve Disc
12 O-Ring
13 Snap Ring
14 Compression Spring
15 Filler

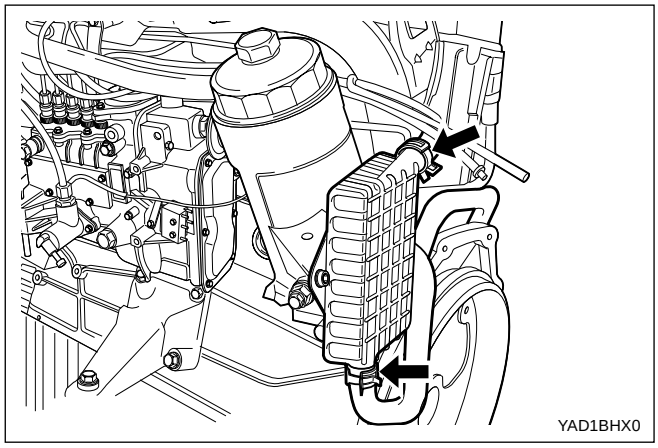
a Feed Bore from Cylinder Head
b To Oil Pan

LUBRICATION SYSTEM

OIL FILTER

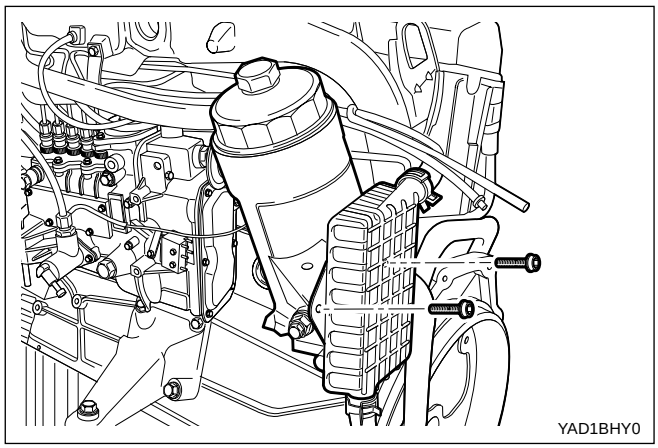


1 Housing Cap ..... 25 N•m (18 lb-ft)
2 O-Ring ..... Replace
3 Oil Filter ..... Element replace if necessary
4 Oil Filter Housing
5 Bolt ..... 25 N•m (18 lb-ft)
6 Oil Pressure Switch
7 Gasket



Removal & Installation Procedure

1. Disconnect the oil cooler inlet and outlet hoses.



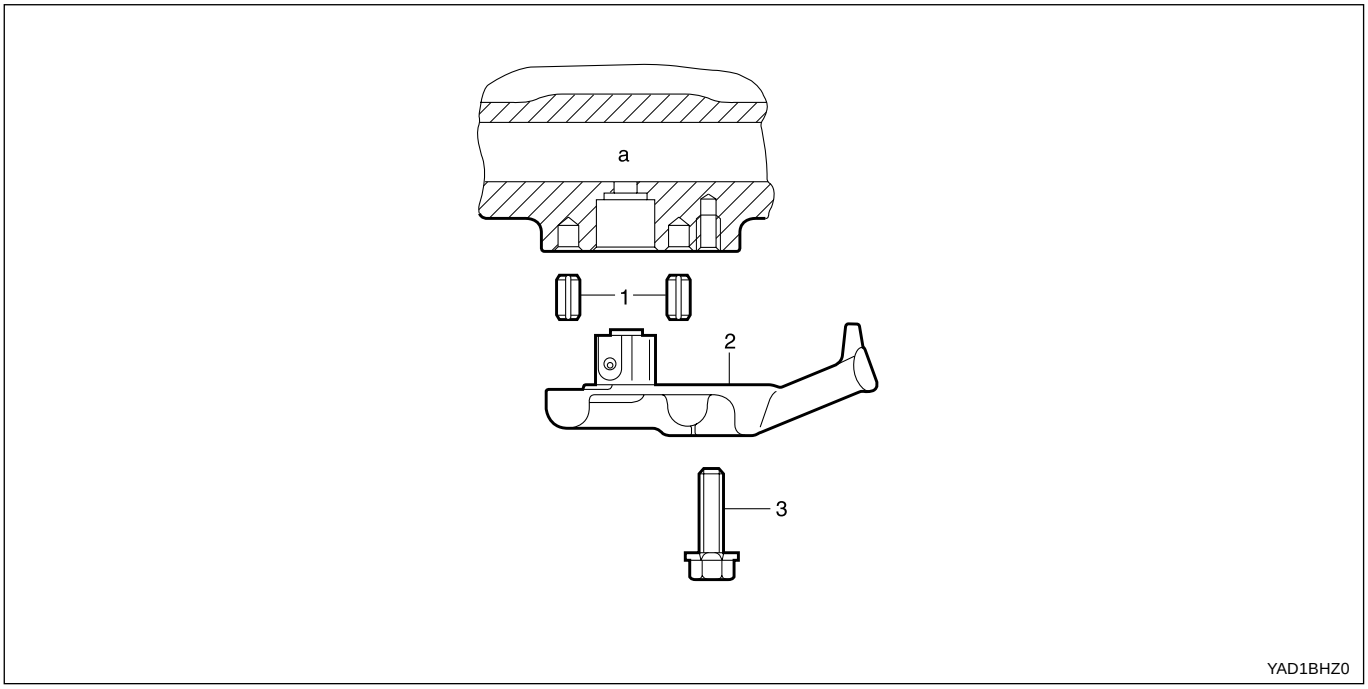
2. Remove the oil pressure switch line.
3. Remove the oil filter housing bolts and oil filter housing.

Installation Notice

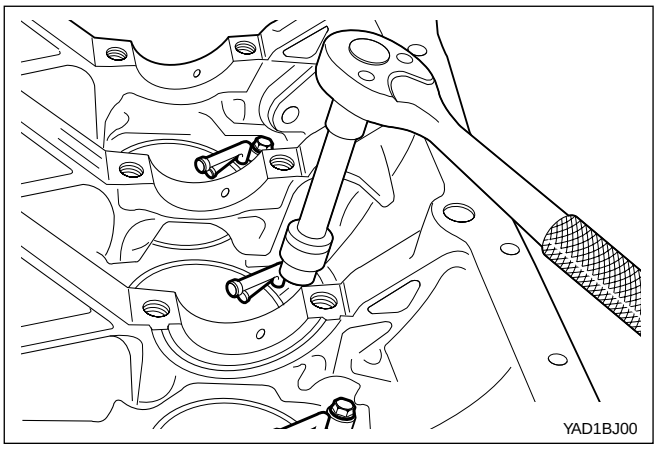
Tightening Torque	25 N•m (18 lb-ft)

4. Clean the sealing surface.
5. Installation should follow the removal procedure in the reverse order.

OIL SPRAY NOZZLE



1 Fitting Sleeve
2 Oil Spray Nozzle
3 Combination Bolt ..... 10 N•m (89 lb-in)
a Oil Duct



Removal & Installation Procedure

1. Remove oil pan or crankshaft.
2. Loose the bolt and then remove the nozzle.

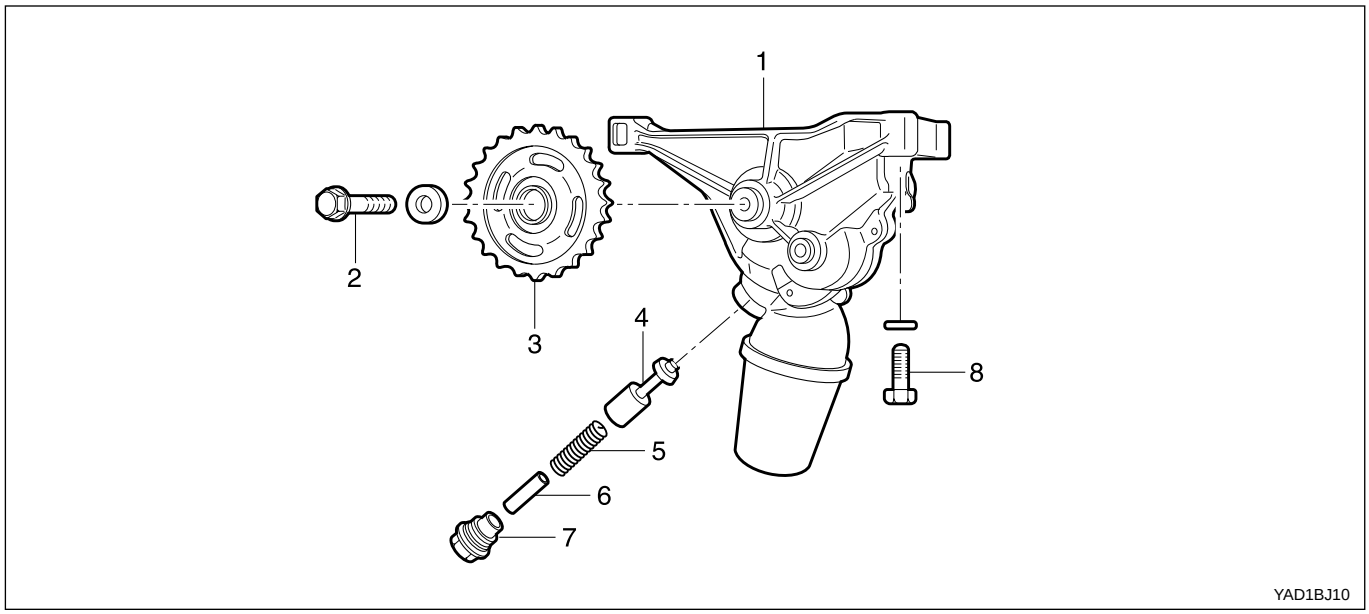
Installation Notice

Tightening Torque	10 N•m (89 lb-in)

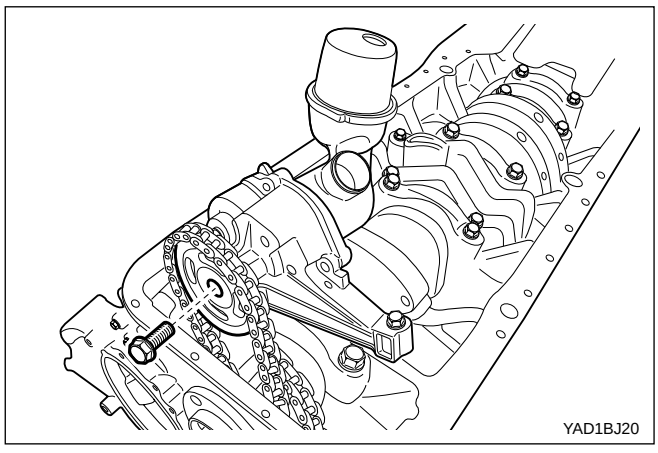
3. Installation should follow the removal procedure in the reverse order.

OIL PUMP

Preceding Work: Removal of oil pan



1 Oil Pump
2 Bolt ..... 25 N•m (18 lb-ft)
3 Sprocket
4 Poston
5 Pressure Spring
6 Guide Pin
7 Screw Plug ..... 50 N•m (37 lb-ft)
8 Bolt ..... 25 N•m (18 lb-ft)

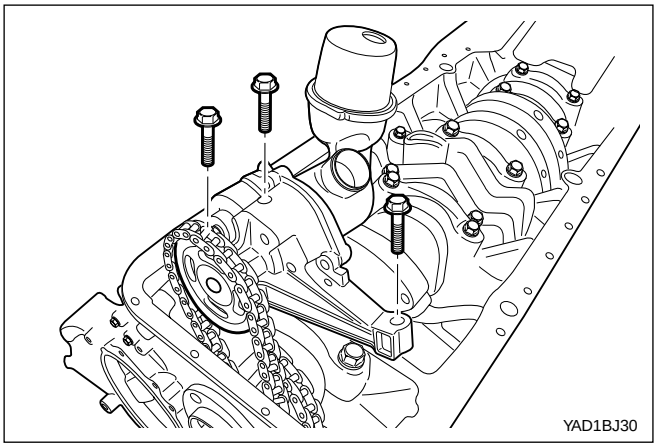


Removal & Installation Procedure

1. Removae the bolt from the oil pump drive sprocket and separate the gear and the oil pump drive chain.

Installation Notice

Tightening Torque	25 N•m (18 lb-ft)



2. Remove the oil pump mounting bolts and oil pump.

Installation Notice

Tightening Torque	25 N•m (18 lb-ft)

3. Unscrew the screw plug and remove the relief valve.

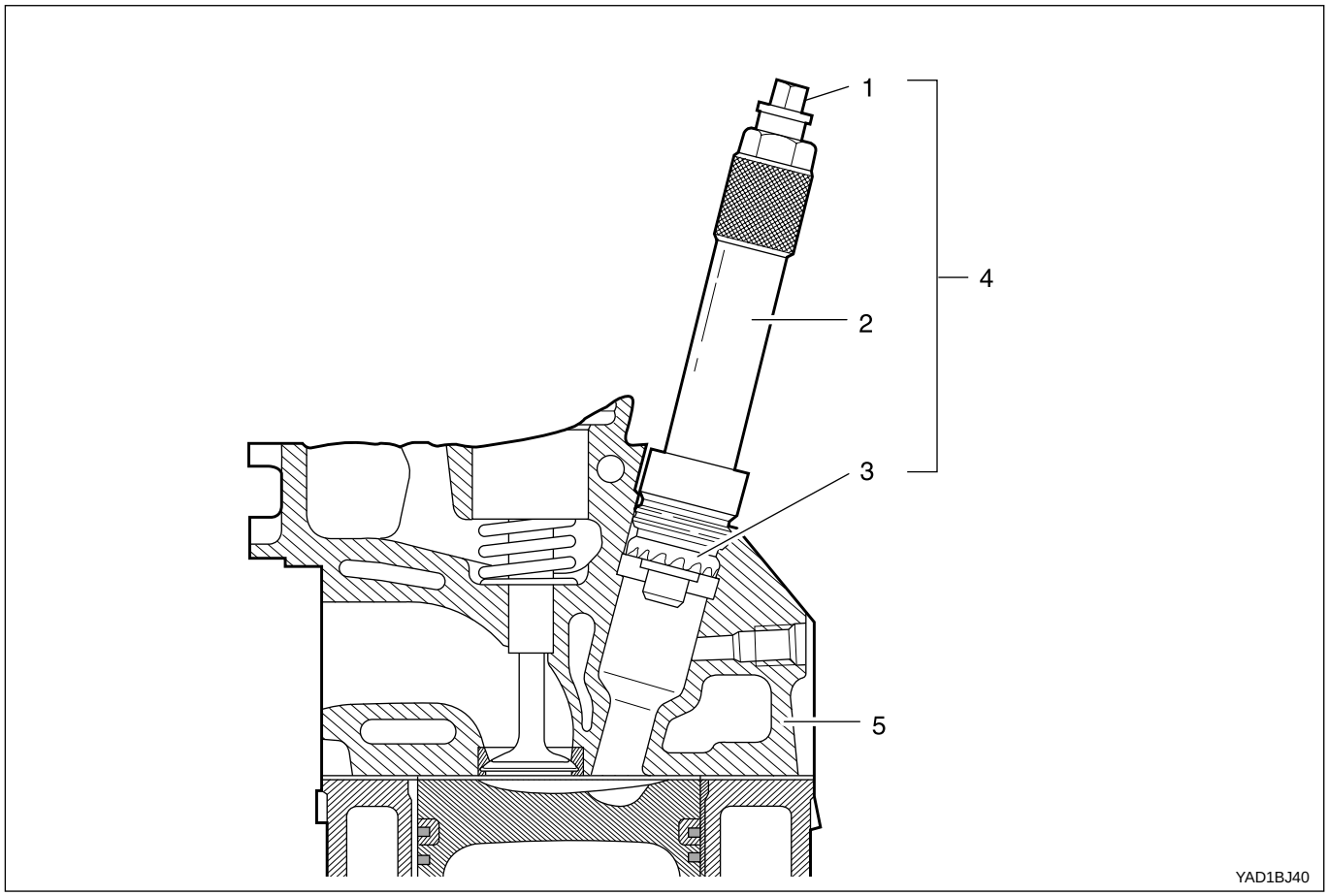
Installation Notice

Tightening Torque	50 N•m (37 lb-ft)

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

UNIT REPAIR

MILLING OF PRECHAMBER SEALING SURFACE



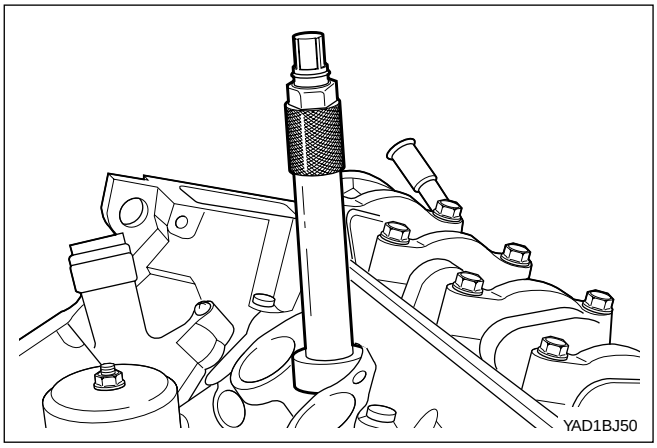
1 Drift
2 Sleeve
3 Milling Cutter
4 Counter Sink (Special Tool - 601 589 00 66 00)
5 Cylinder Head

Notice: The prechamber sealing surface may only be remachined once with the cylinder head fitted. It is essential to adhere to the specified projection ‘C’ of the prechamber of 7.6 - 8.1mm.

This ensures that the required clearance exists between prechamber and piston crown with the piston in TDC. For this reason, spacer rings should be inserted on remachined sealing surfaces.

Thickness of spacers	0.3, 0.6, 1.0 mm

If a spacer ring is already fitted, or a marking is made on the cylinder head, the cylinder head must be removed and size ‘C’ measured if further remachining is necessary on a prechamber sealing surface.



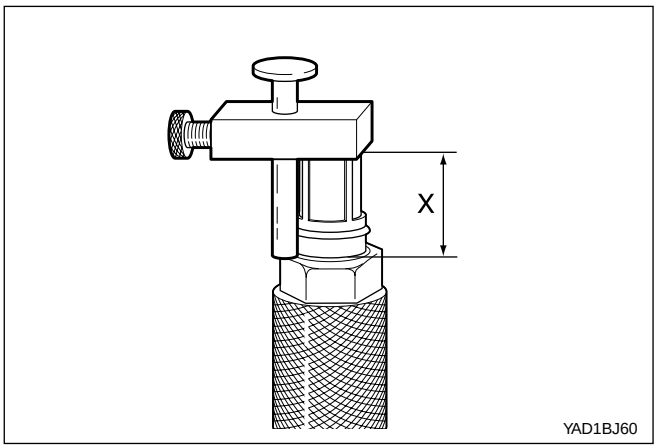
Tools Required

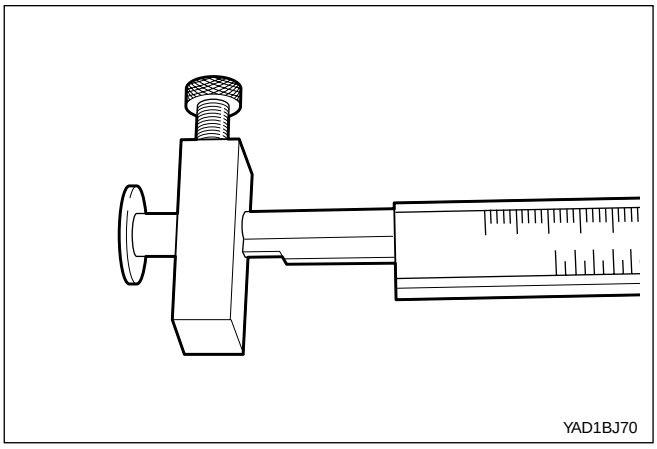
601 589 00 66 00 Counter Sink

607 589 00 23 00 Height Gauge

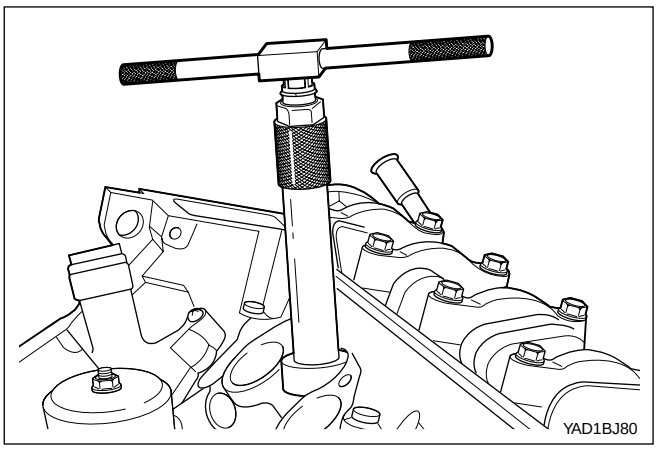
Milling of the Prechamber Sealing Surface

1. Remove the injection nozzle.
2. Remove the prechamber.
3. Cover the prechamber bore to avoid any chips dropping into the combustion chamber.
4. Remove the protective sleeve from the counter sink 601 589 00 60 00 and rotate the counter sink 601 589 00 60 00 into the prechamber bore to be machined as far as the stop.
5. Maintain size ‘X’ from the top edge of mandrel to the top edge of the sleeve with the height gauge 667 589 00 23 00.





6. Measure the ‘X’ by using a vernier caliper.



7. Mount the turning tool onto the counter sink 601 589 00 60 00 and rotate to the right approx. 5 revolutions by applying slight pressure.

8. Remeasure size ‘X’ and compare it with the first measurement and determine the thickness of spacer ring.

Ex

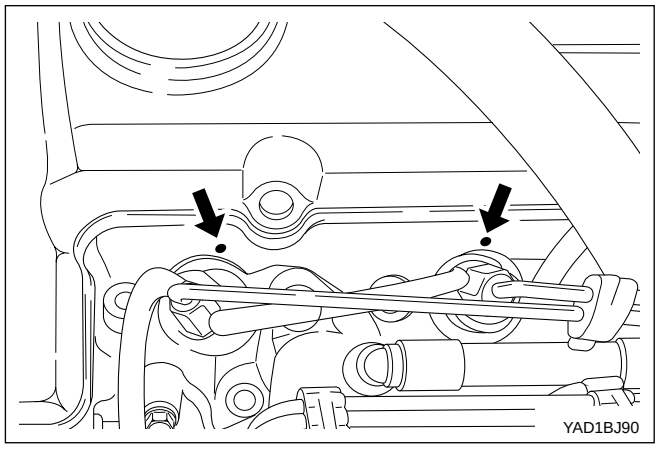
Size before machining	25.7 mm
Size after machining	25.5 mm

The spacer ring should be selected so that it is at least 0.1 mm and not more than 0.3 mm thicker than the measured on the sealing surface. In this example, the necessary thickness of spacer ring should be within 0.3 ~ 0.5 mm and the thickness of spacer ring to be installed is 0.3 mm.

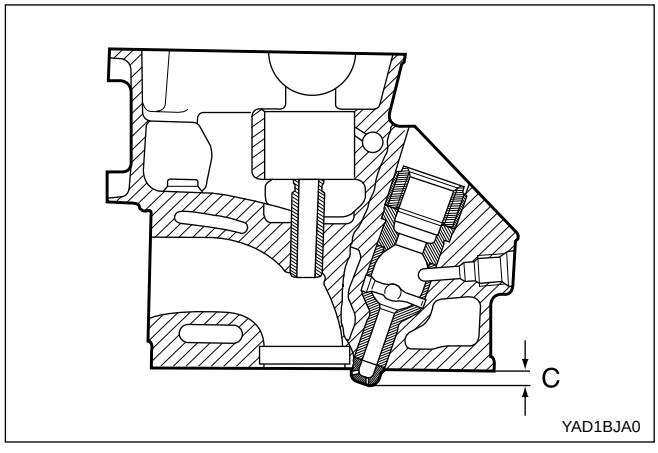
9. Remove the counter sink 601 589 00 60 00 and clean the chips.

Notice: If the sealing surface is not completely flat, remachine the sealing surface.

10. Remove rag from the prechamber bore and crank the engine with starter motor to threw out any chips which may have got into the combustion chamber.
11. Insert the proper spacer ring into the prechamber sealing surface.



12. Punch a mark on the cylinder head above the prechamber sealing surface which has been machined.



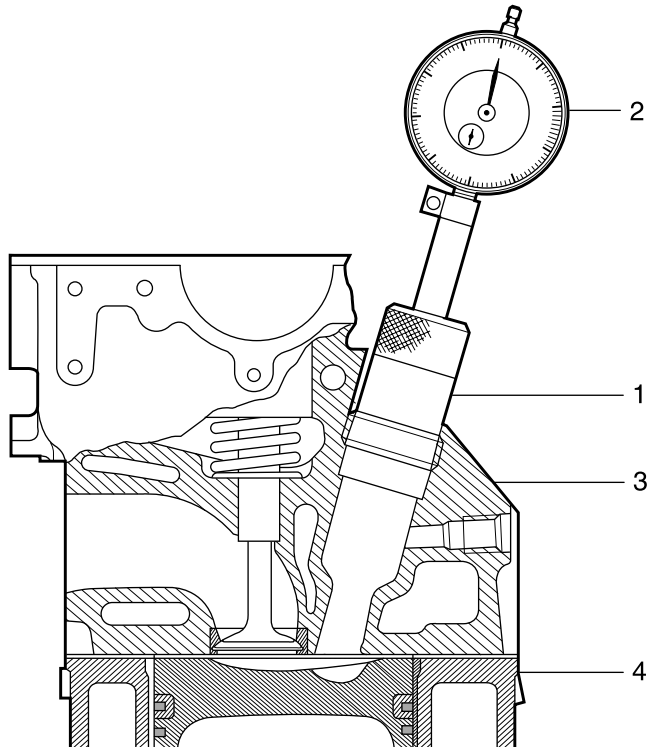
13. Install the prechambers.

Notice: If the cylinder head is removed, the projection ‘C’ is measured in place of size ‘X’ and the appropriate size of spacer ring selected.

Normal Projection (C)	7.6 - 8.1 mm

TDC (TDC SENSOR BRACKET) SETTING

Preceding Work: Removal of No.1 cylinder prechamber



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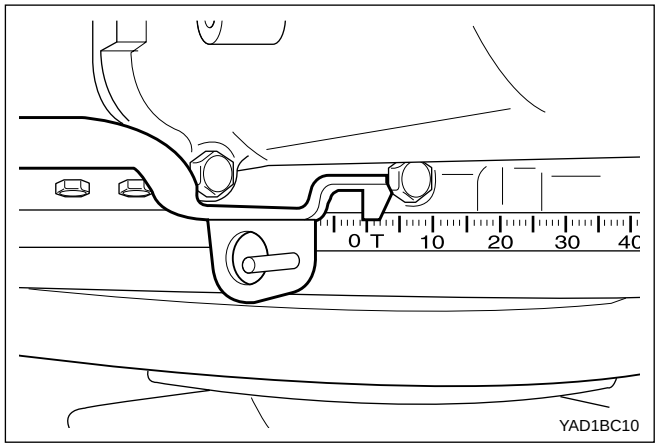
1 Measuring Device
2 Dial Gauge
3 Cylinder Head
4 Piston ..... Set at TDC

Notice:

The TDC sensor bracket must be adjusted in case of followings.

- When replacing the TDC sensor bracket.
- When replacing the crankshaft, the hub or the vibration damper.
- When replacing or installing the timing case cover.
- After engine overhauling.

* If the cylinder head is removed, the measuring pin of the dial gauge can be positioned on the piston crown. This is done by placing the magnetic dial holder on the mating surface of the crankcase.

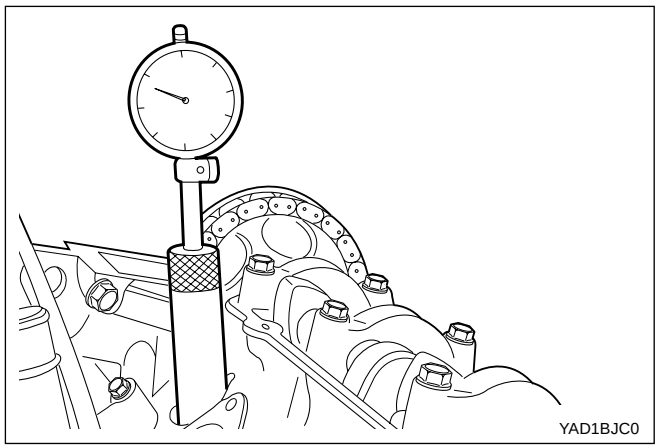


Tools Required

001 589 32 21 00 Dial Gauge
601 589 07 21 00 Measuring Device
667 589 01 21 00 Fixing Device

Setting (With Cylinder Head Installed)

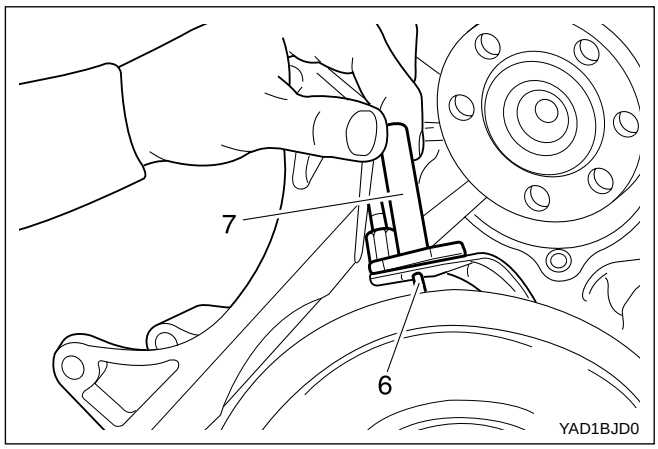
1. Remove the prechamber of No. 1 cylinder.
2. Position the piston of No.1 cylinder at BTDC 10°.



3. Install the measuring device 601 589 07 21 00 into the prechamber bore and position the dial gauge 001 589 53 21 00 with a preload of 5mm.
4. Slowly rotate the crankshaft in the direction of engine rotation until the large pointer on the dial gauge 001 589 53 21 00 stops (TDC position).

   Notice: The position of TDC is when the large pointer on the dial gauge is stopped before moving back.

5. Remove the reinstall the measuring device and position the dial gauge 001 589 53 21 00 scale at '0'.
6. Slowly rotate the crankshaft in the direction of engine rotation until the dial gauge 001 589 53 21 00 has moved back (counterclockwise) by 3.65 mm.



7. Insert fixing device into the sensor bracket.

   Notice: The pin (6) on the vibration damper must engage into the slot of the fixing device 667 589 01 21 00 (7).

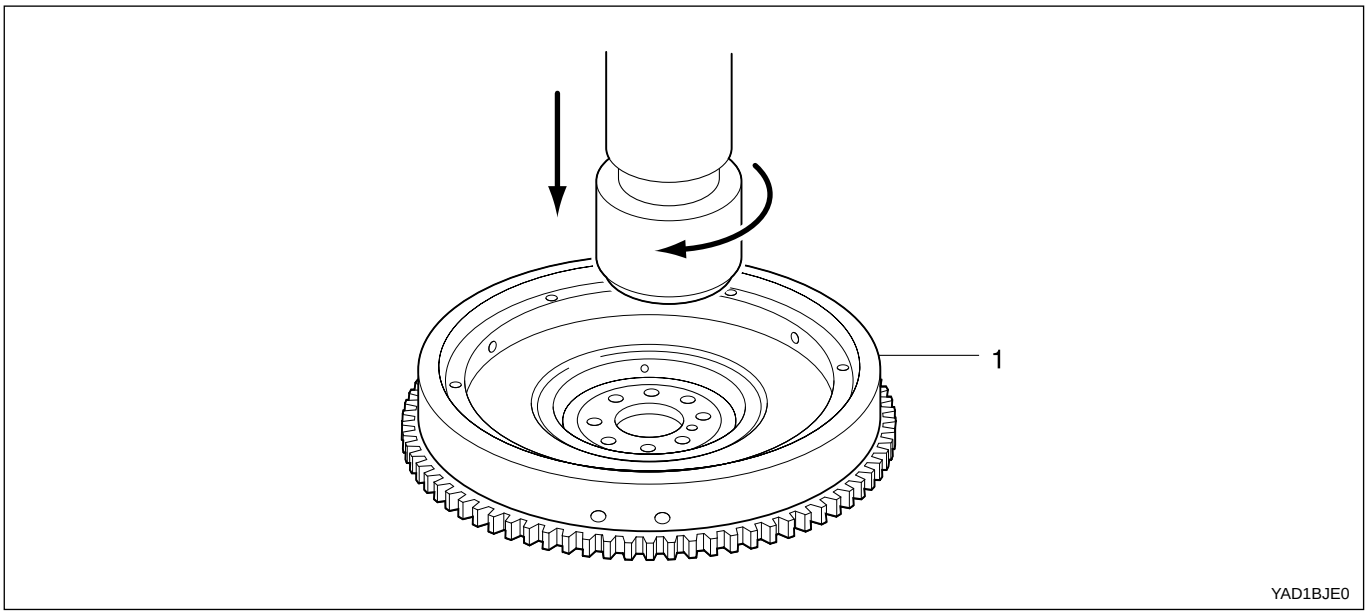
8. If the pin does not engage, adjust the setting of the sensor bracket by removing and tightening of the sensor bracket bolts.

   Installation Notice

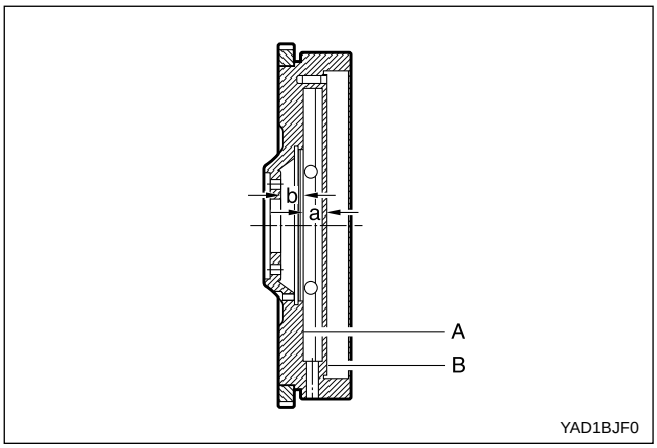
Tightening Torque	10 N•m (89 lb-in)

   The timing mark on the damper must be positioned at ATDC 20°.

MACHINING OF FLYWHEEL



1 Flywheel



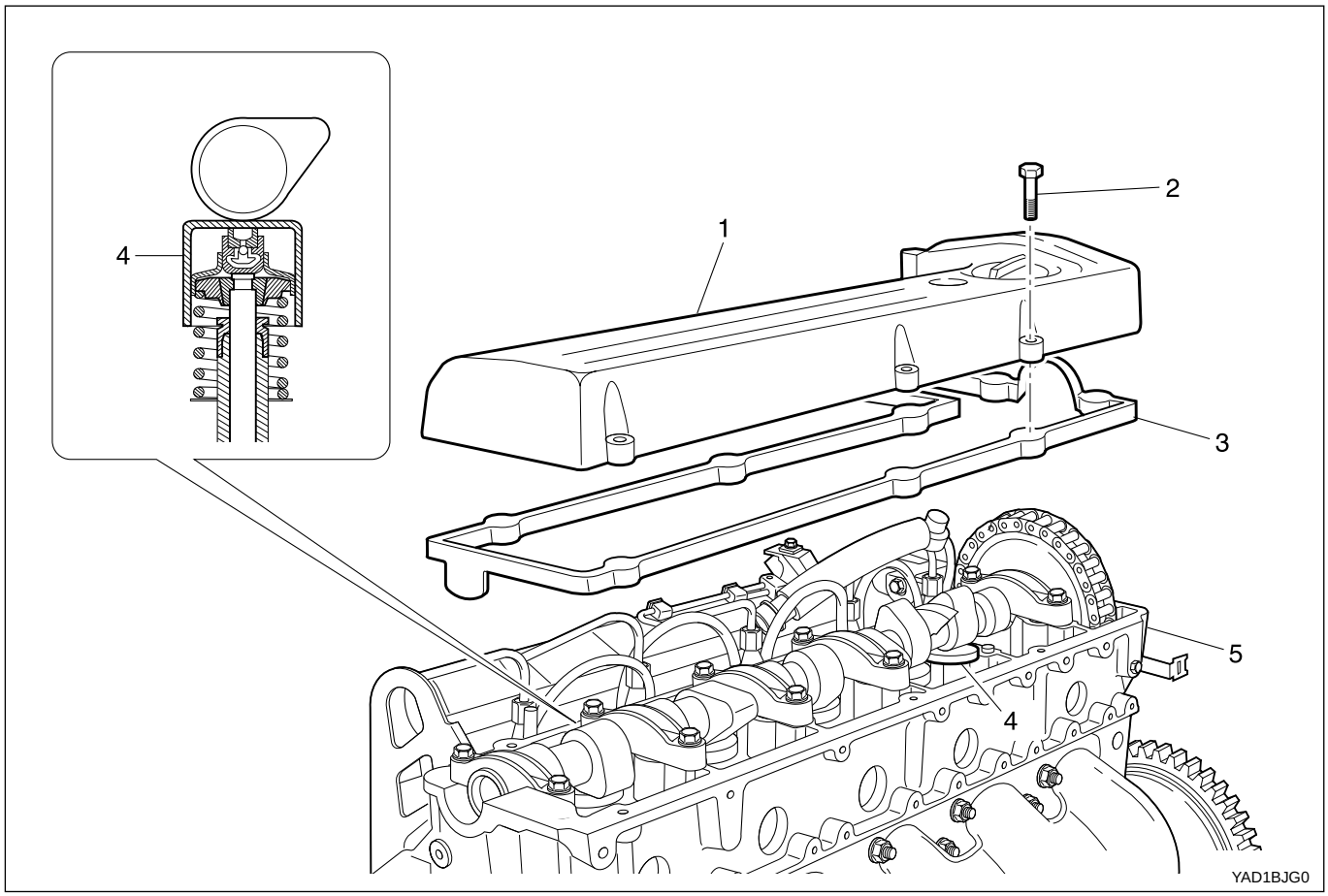
Machining of Flywheel

Notice: Flywheels which have scorch marks, scoring or cracks in the clutch surface should be machined by grinding or precision-turning. If the scores or cracks are severe than permissible specifications, replace the flywheel.

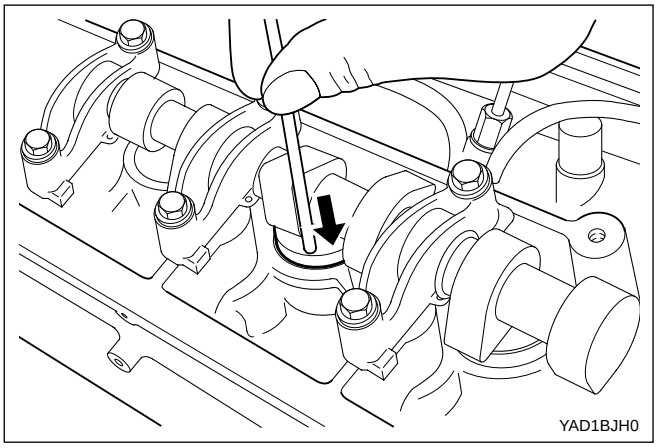
Distance ‘a’	19.3 - 19.5 mm	
Distance ‘b’	New	16.6 mm
	Repair up to	15.6 mm
Max. axial runout		0.05 mm

- When machining the clutch surface ‘A’, the mounting surface (B) for the clutch pressure plate should also be machined in accordance with ‘A’ to keep the distance ‘a’.
- Do not machine under ‘b’ value.
- When machining, fix the flywheel exactly not to exceed the standard runout.

HYDRAULIC VALVE CLEARANCE COMPENSATION ELEMENT CHECK



1 Cylinder Head Cover
2 Bolt.....10 N•m (89 lb-in)
3 Gasket..... Replace
4 Valve Tappet
5 Cylinder Head



Checking

Notice: The noise which continues short time during short travel (frequent starting of the engine) or engine starting after a long time storage is normal operating conditions. So, it does not need to be repaired. Determine the malfunctions in valve clearance compensation device with noise through following tests. If defective, replace as respectively.

1. Run the engine at more than 3000rpm for approx. 4 minutes.
2. Stop the engine. After 5minutes, check the engine oil level and adjust if necessary.
3. Remove the cylinder head cover.
4. Check the valve tappets at TDC position of each cylinders.
5. Using a drift, lightly press the valve tappet and measure clearance between the cam and valve tappet.

   Notice: If the clearance exceeds 0.4mm, replace the valve tappet.

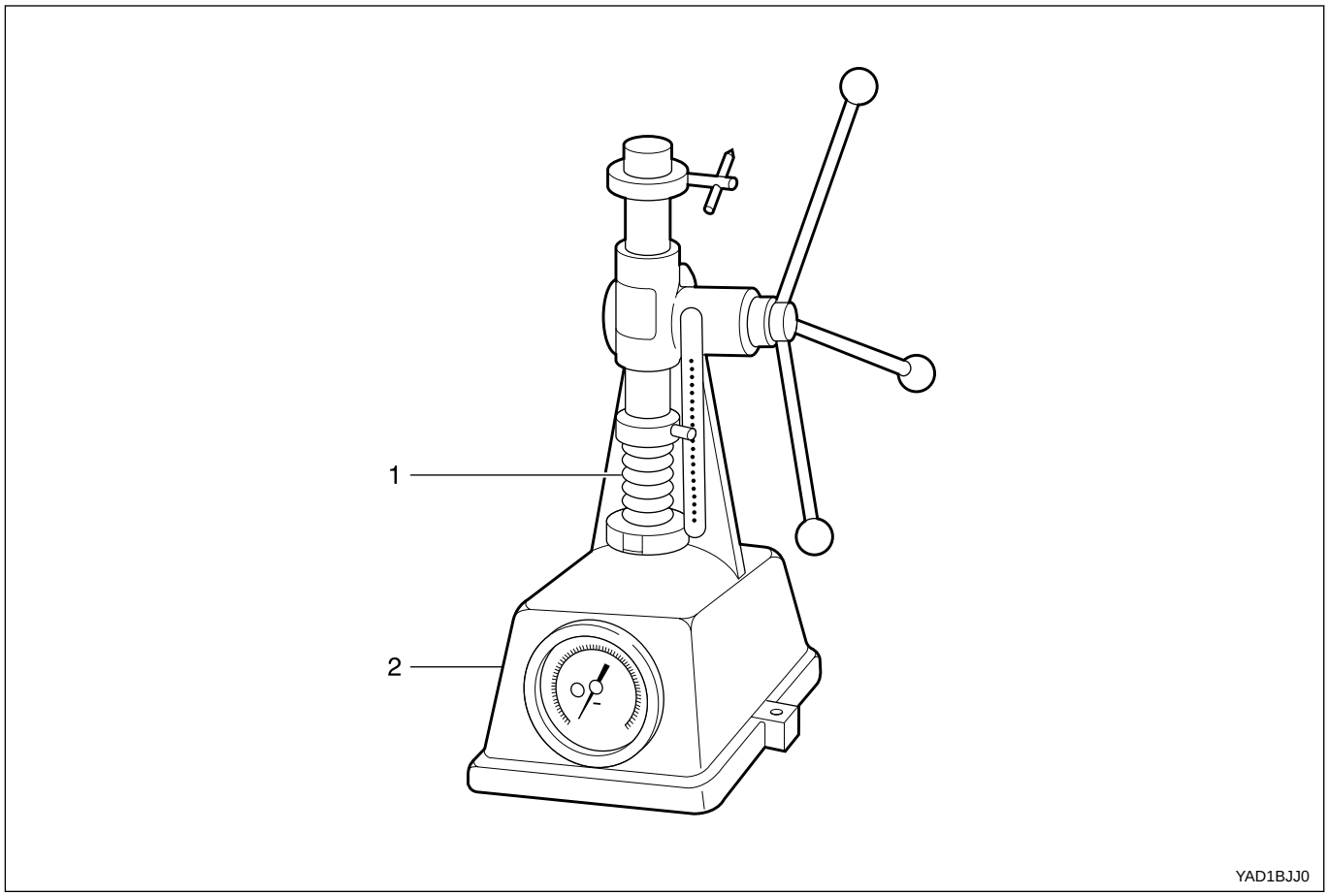
6. If a valve tappet moves down too far in comparison to the others, replace the valve tappet.
7. Rotate the engine and check the remaining valve tappets.

   Notice:

   - Unnecessary rotation of the engine will damage the valve tappets.
   - Do not rotate the engine by using the camshaft sprocket bolt or to the opposite direction of the engine rotation.

VALVE SPRINGS CHECK

Preceding Work : Removal of valve spring



1 Valve Spring

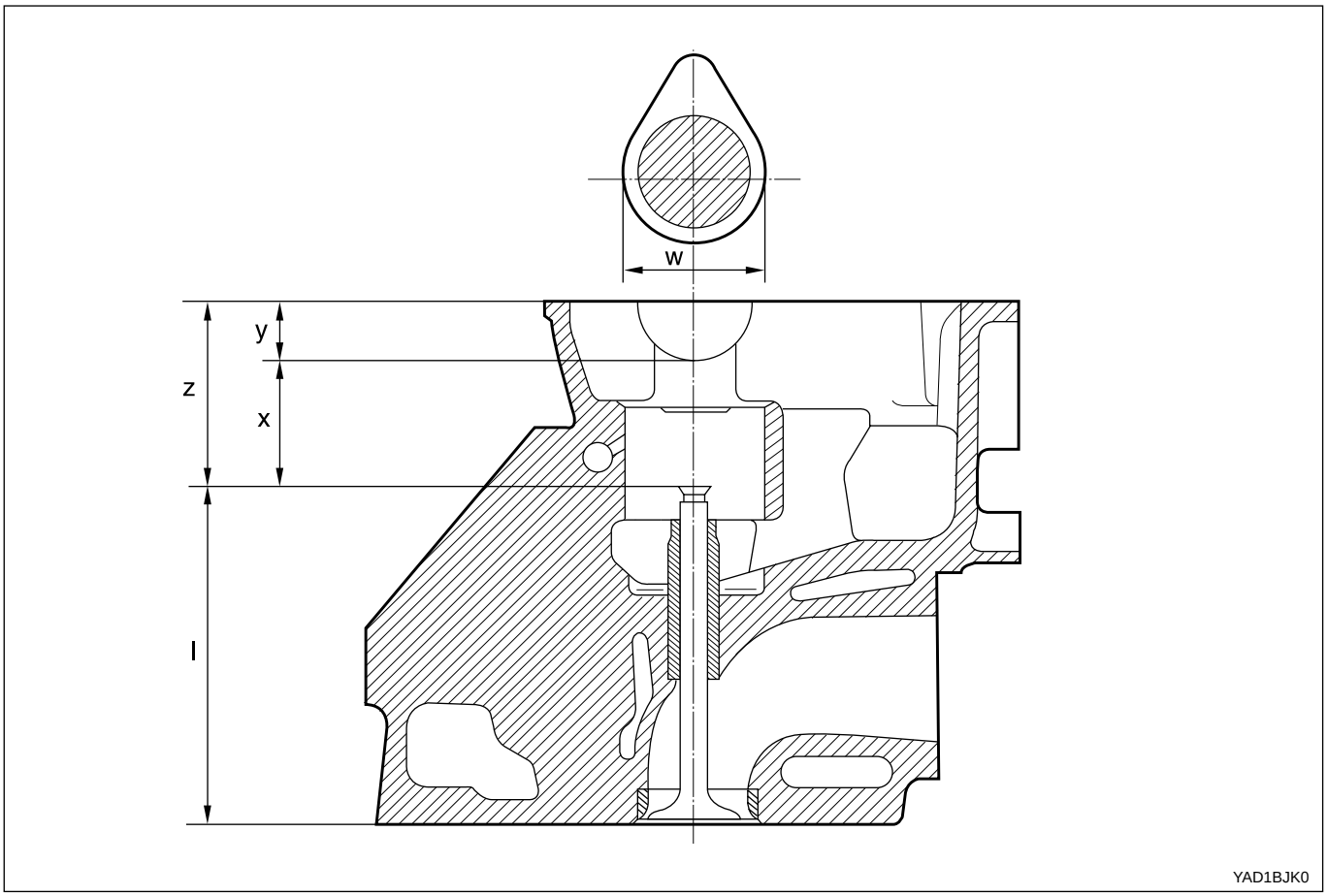
2 Spring Scale

Service Data

Outer diameter	Wire diameter	Free length	At preloaded		
			Length	Tension (new)	Limit
33.1 mm	4.20 mm	50.0 mm	27 mm	680 - 740 N	612 N

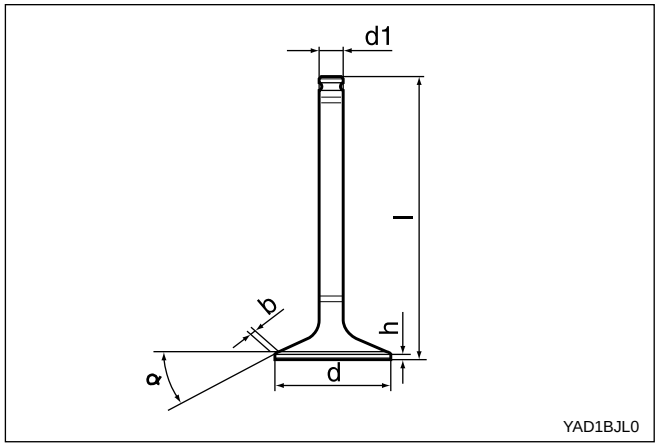
CHECK AND MACHINING OF VALVES

Preceding Works: Removal of cylinder head
Removal of the vale spring
Removal of the valve

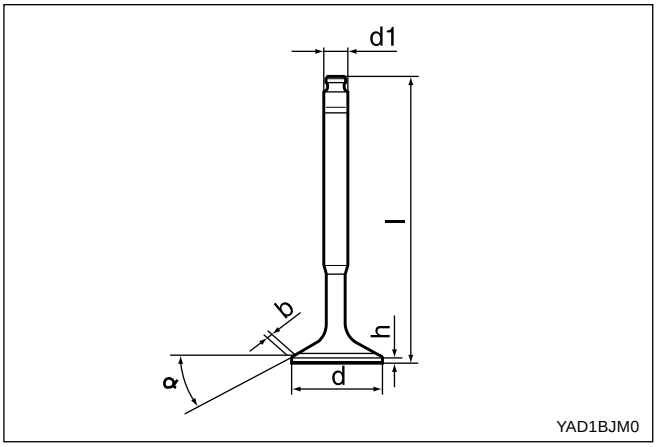


l Valve Length
w Camshaft Cam Basic Diameter
x Distance (Camshaft Basic Bore - Valve Stem)
y Half Camshaft Basic Bore Diameter
z Distance (Cylinder Head Cover Parting Surface - Valve Stem)

Intake Valve



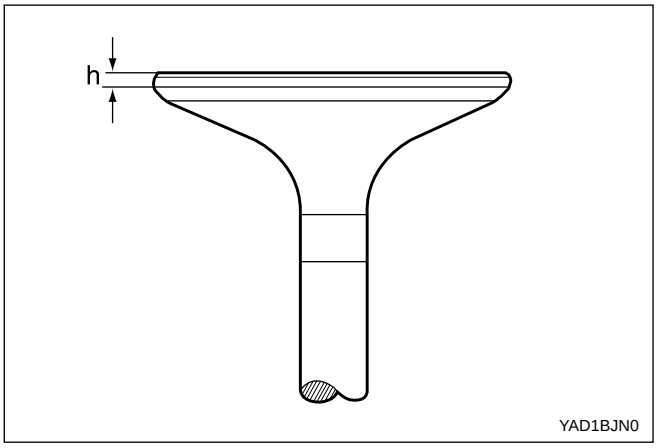
Exhaust Valve



Item		Intake Valve	Exhaust Valve
Valve Disc Diameter ‘d’		37.90 - 38.10 mm	34.90 - 35.10 mm
Valve Disc Height ‘h’		1.7 mm	1.7 mm
Setting Angle “α” o r Machining the Valve		45°	45°
Valve Stem Diameter ‘d1’		7.955 - 7.970 mm	9.945 - 8.960 mm
Valve Length ‘I’	Standard	106.20 - 106.60 mm	106.20 - 106.60 mm
	Repair	105.30 - 105.70	105.30 - 105.70 mm
Max. Permissible Runout at Valve Stem and Valve Seat		0.03 mm	0.03 mm

Matching Valves

	Camshaft Cam Basic Dia. W = 38.0 ± 0.2 mm	Camshaft Cam Basic Dia. W = 36.6 ± 0.2 mm	Valve to be used
Size (x)	19.5 - 20.3 mm	19.5 - 20.1 mm	Use machined valve, if needed new repair valve I = 105.5 ± 0.2 mm
Size (x)	20.4 - 21.4 mm	20.2 - 21.2 mm	Reuse valve
Size (x)	21.4 - 21.97 mm	21.2 - 21.97 mm	Use standard size valve I = 106.4 ± 0.2 mm



Tools Required

001 589 32 21 00 Dial Gauge

Commercial Tool

Valve corn grinding machine

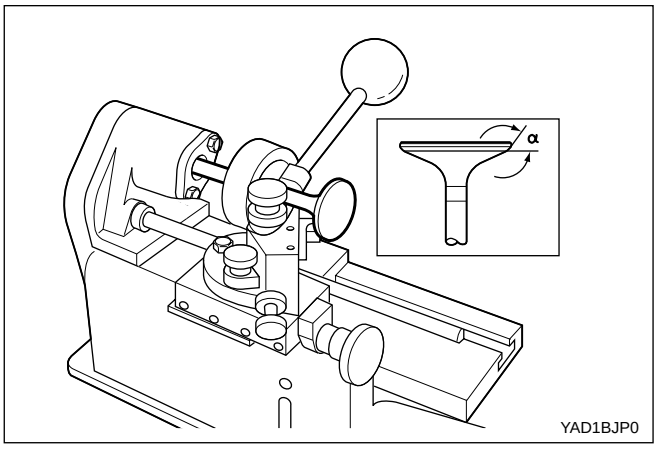
Checking and Machining Procedure

1. Clean the valves and do visual check.

   Notice: Valves with wobbled valve disc, with worn or scored valve stem should be replaced.

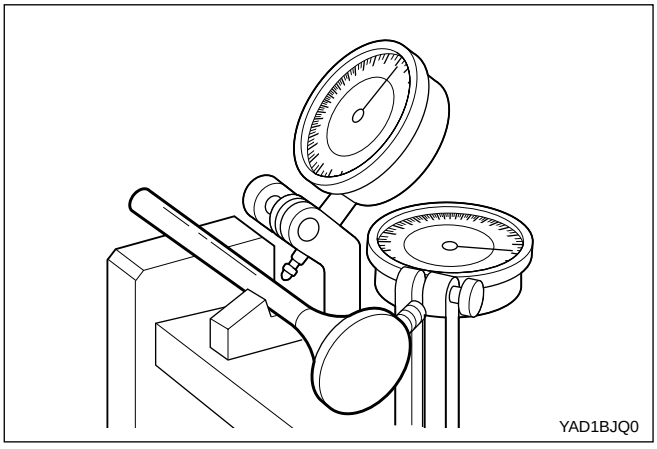
2. Measure valve disc height ‘h’.

Service data	Intake	1.7 ± 0.15 mm
	Exhaust	1.7 ± 0.15 mm



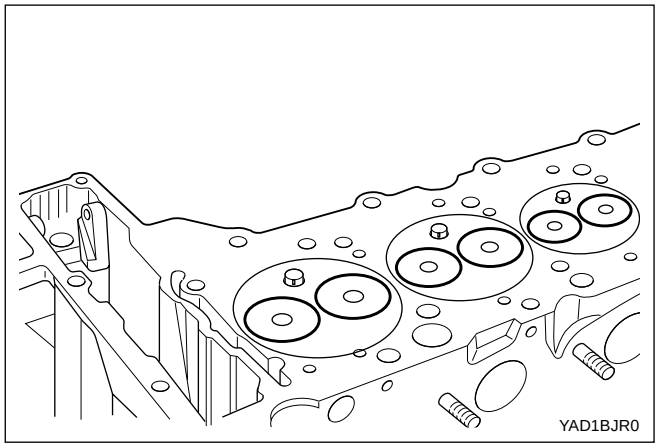
3. Machine the valve.

   Notice: Pay attention to setting angle ‘α’ .

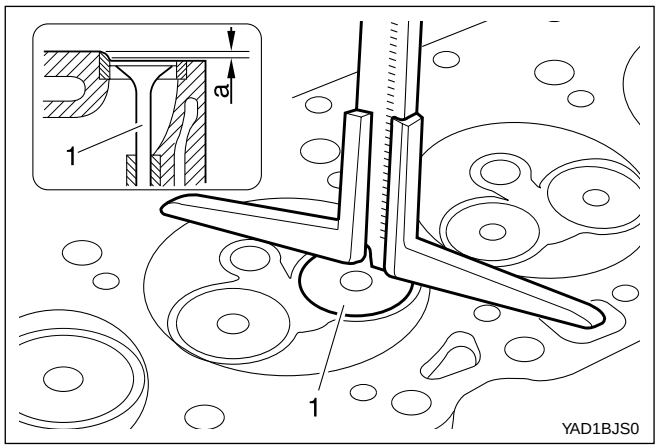


4. Measure radial runout between valve stem and valve seat with a dial gauge 001 589 32 21 00.

Limit	Max. 0.03 mm



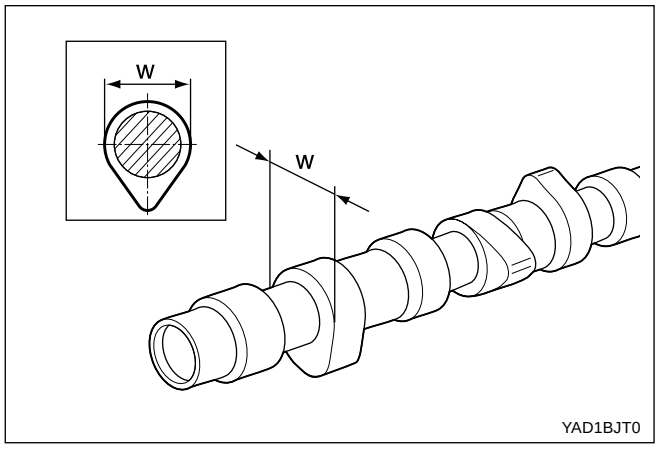
5. Clean the vales, valve seats and valve guides.
6. Coat the valve stem with oil and insert it into valve guide.



7. Insert the valves (1) into the valve guides according to marking.
8. Measure amount by which the valve arrears ‘a’.

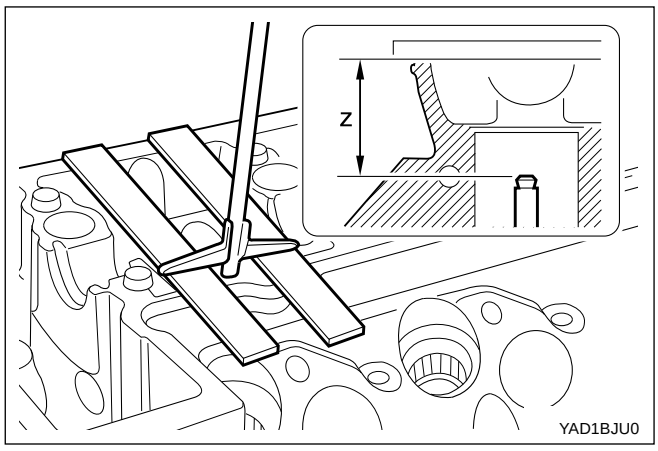
Arrears ‘a’	0.1 - 0.7 mm

Notice: If out of standard, replace the valve seat ring.



9. Measure camshaft cam basic diameter (w).

Diameter ‘w’	38 ± 0.2 mm or 37.6 ± 0.2 mm



10. Measure distance ‘z’ (cylinder head cover parting surface - valve stem).

11. The distance ‘x’ (camshaft basic bore - valve stem).

    ‘x’ = ‘z’ - ‘y’.

    Determine the valve to use according to this measurement (See ‘matching valves’)

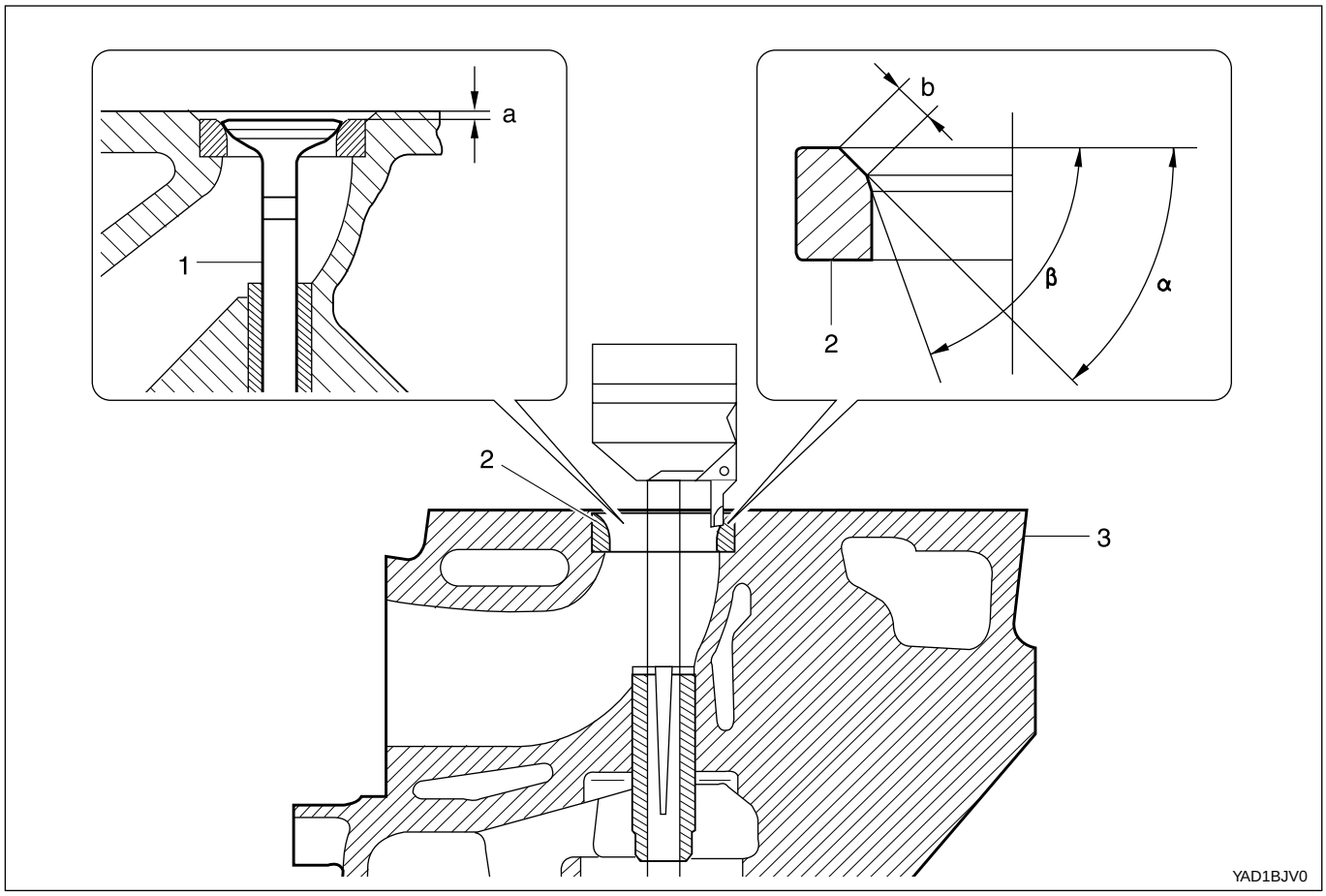
    Example) Measured value ‘w’ = 38.2 mm
    Measured value ‘z’= 36.5 mm
    Value ‘y’ = 15.5 mm

    ‘x’ = 36.5 - 15.5 = 21.0 mm

    In this case according to ‘Matching valves’ table, the installed valve may be used.

MACHINING OF VALVE SEAT

Preceding Work: Removal of prechamber
Removal and inspection of valve, replace if necessary
Inspection of valve guide, replace if necessary



1 Valve
2 Valve Seat Ring
3 Cylinder Head
4 Valve Guide

a Valve Arreare
b Valve Seat Width
α Valve Seat Angle
β Valve Seat Free Angle

Service Data

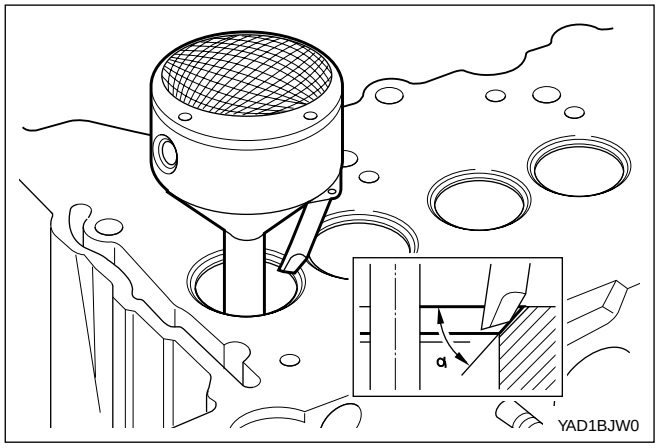
Item		Intake	Exhaust
Valve Arrears 'a'		0.1 - 0.7 mm	0.1 - 0.7 mm
Valve Seat Width 'b'		1.2 - 1.7 mm	1.5 - 2.0 mm
Valve Seat Angle 'α'		45°	45°
Valve Seat Free Angle 'β'		65°	65°
Permissible Radial Runout		0.03 mm	0.03 mm
Valve Length 'I'	Standard	106.20 - 106.60 mm	106.20 - 106.60 mm
	Repair	105.30 - 105.70 mm	105.30 - 105.70 mm

Matching Valves

	Camshaft Cam Basic Dia. w = 38.0 ± 0.2 mm	**Camshaft Cam Basic Dia. w = 37.6 ± 0.2 mm**	**Valve to be Used**
Size (x)	19.5 - 20.3 mm	19.5 - 20.1 mm	Use machined valve, if needed use pair valve 1 = 105.5 ± 0.2 mm
Size (x)	20.4 - 21.4 mm	20.2 - 21.2 mm	Reuse valve
Size (x)	21.4 - 21.97 mm	21.2 - 21.97 mm	Use standard size valve I = 106.4 ± 0.2 mm

Commercial Tools

Cylinder Head Clamping Devie	Hunger D-8000 München 70 Type Ventilknecht K2000 Order No. 221 00 100
Valve Seat Turning Tool	Hunger D-8000 München 70 Type VDS 1A Order No. 236 03 308
Test Sat for Valves	Hunger D-8000 München 70 Order No. 217 93 601

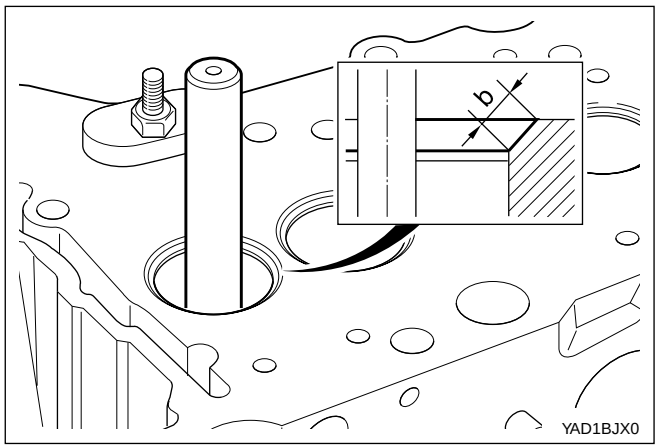


Machining Procedure

Valve machining is required :

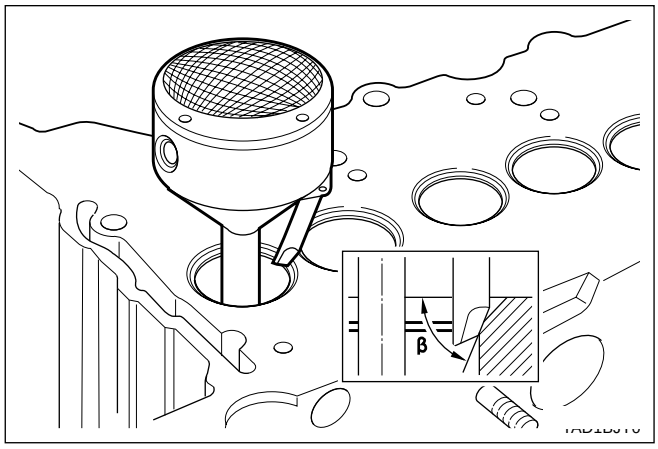
- When the valve is leaking.
- When replacing the valve.
- When replacing the valve guide.
- When replacing the valve seat or valve seatring.

1. Machine the valve seat (α=45°).

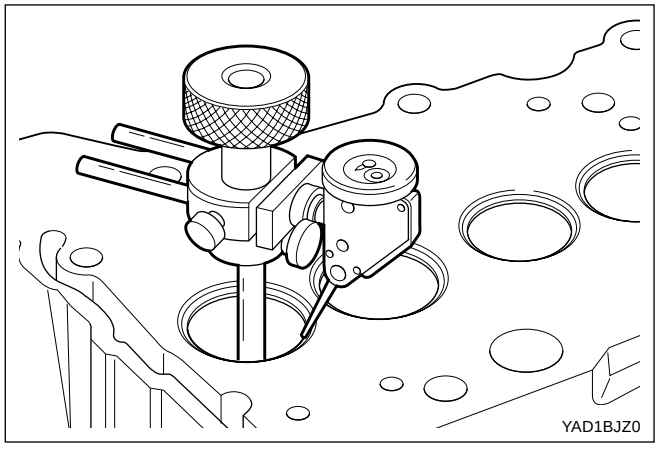


2. Measure valve seat width ‘b’.

Valve seat width ‘b’	Intake	1.2 - 1.7 mm
	Exhaust	1.5 - 2.0 mm

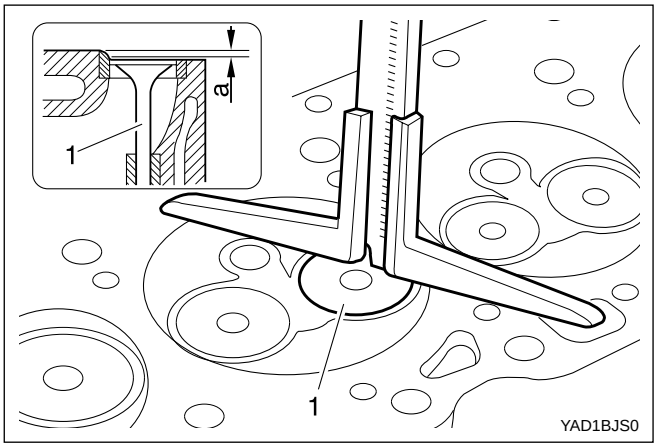


3. If the specification is exceeded, the valve seat width has to be corrected at the lower free angle of ‘β’ =65°.



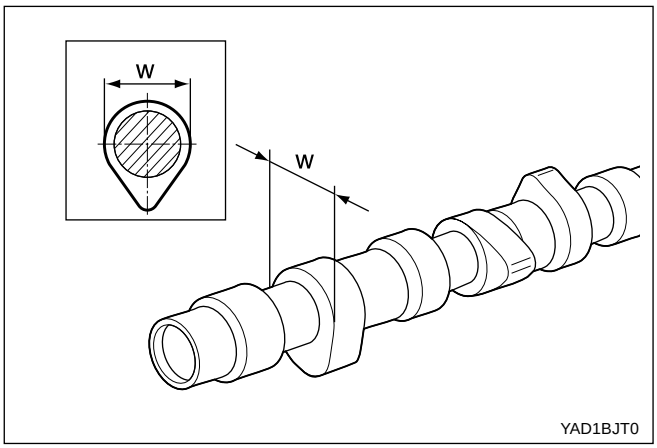
4. Measure radial runout.

Runout	Max. 0.03 mm



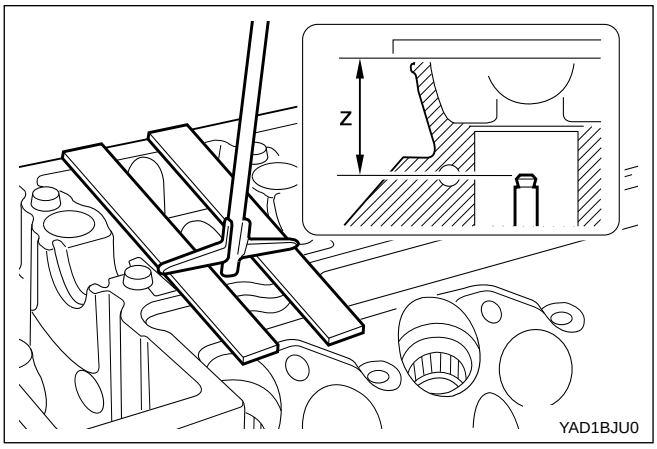
5. Insert the valve (1) into the valve guide according to marking and measure amount by which the valve arrears ‘a’.

Arrears ‘a’	0.1 - 0.7 mm

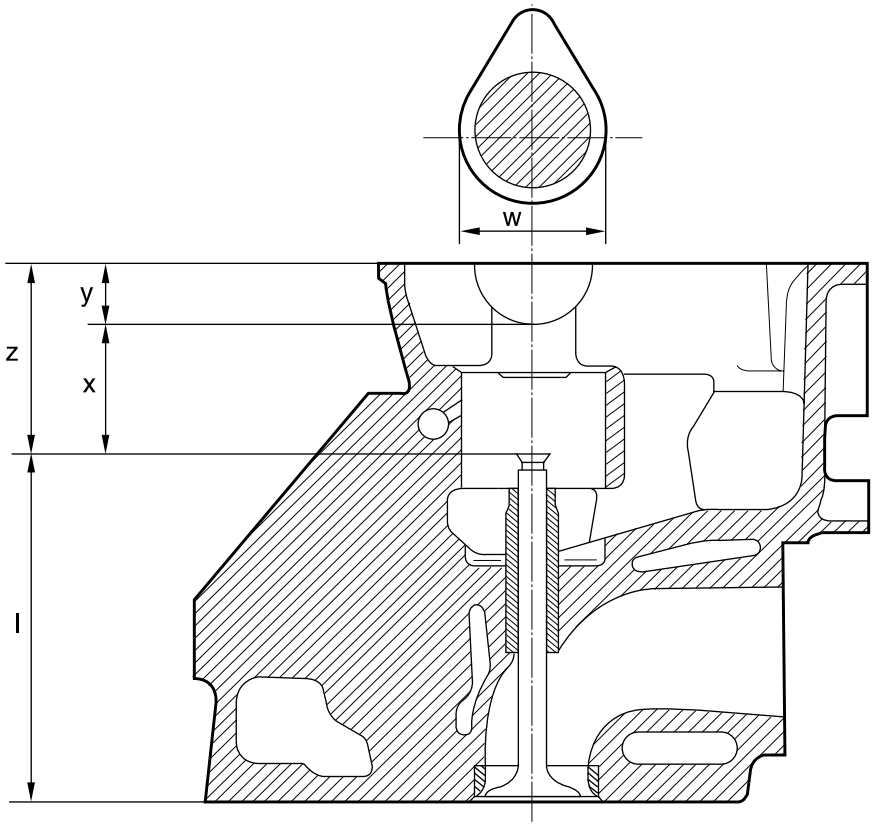


6. Measure camshaft cam basic circle diameter (w).

Diameter ‘w’	38 ± 0.2 mm or 37.6 ± 0.2 mm



7. Measure distance ‘z’ (cylinder head cover parting surface - valve stem).



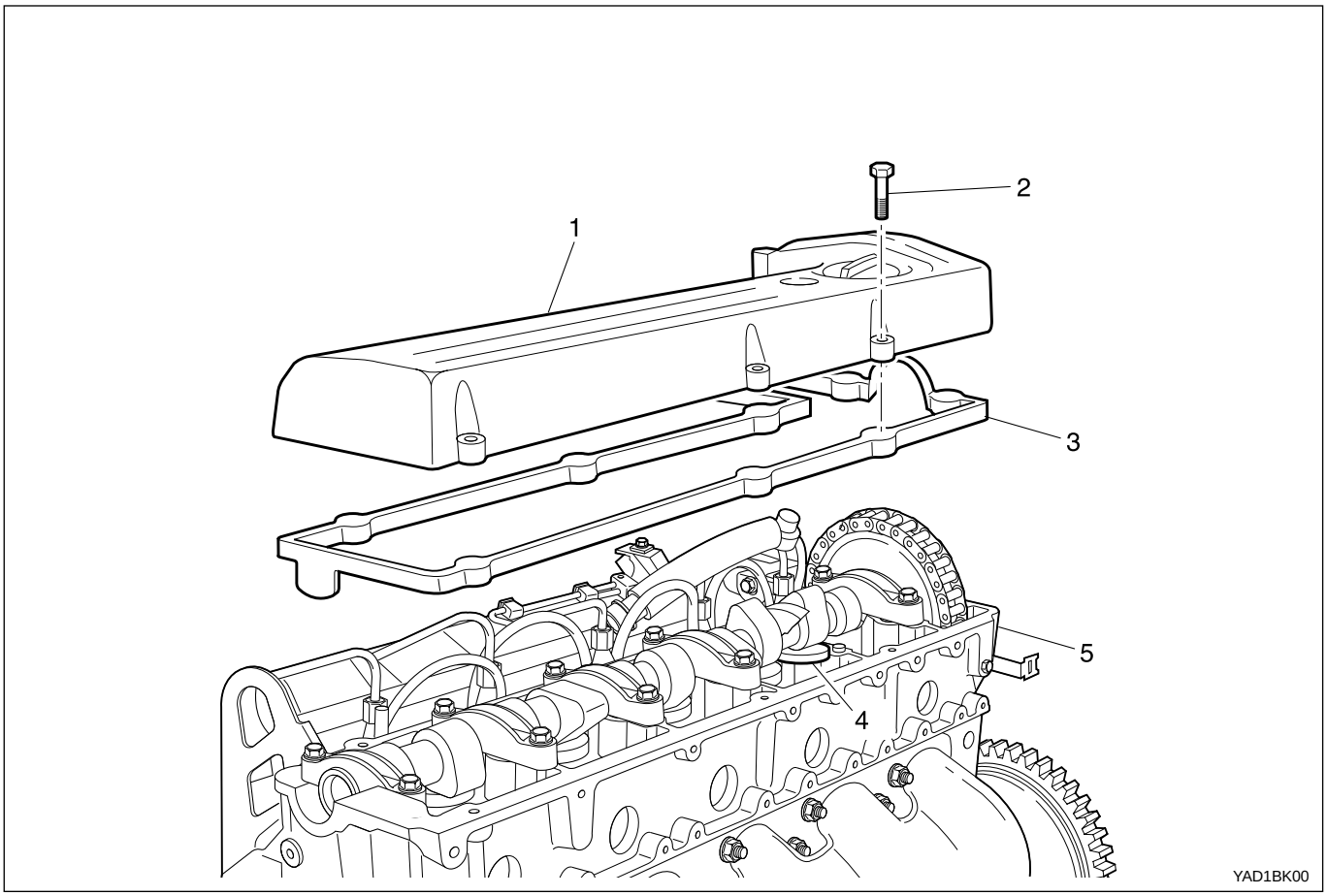
YAD1BJK0

l Length of Valve
w Camshaft Cam Basic Circle Diameter
x Distance (Camshaft Basic Bore - Valve Stem)
y Half Camshaft Basic Bore Diameter
z Distance (CylinderHead Cover Parting Surface - Valve Stem)

8. Measure ‘x’ (Camshaft basic bore - valve stem).
   ‘x’ = ‘z’ - ‘y’
9. Determine the valve to be used.
   (See ‘Matching valves’)
   Example) Measured value ‘w’ = 38.2 mm
   Measured value ‘z’ = 36.5 mm
   Value ‘y’ = 15.5 mm
   ‘x’ = 36.5 - 15.5 = 21.0 mm
   In the case of a camshaft cam basic circle diameter ‘w’ = 38.2 mm and a distance ‘x’ = 21.0 mm, the installed valve may be used.

CAMSHAFT TIMING TEST

Preceding Work: Removal of glow plug

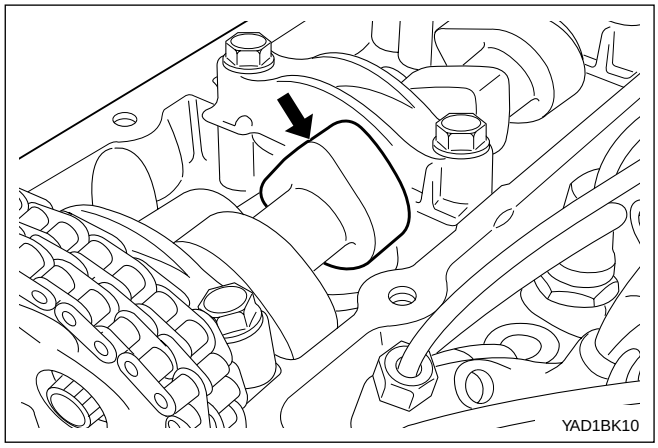


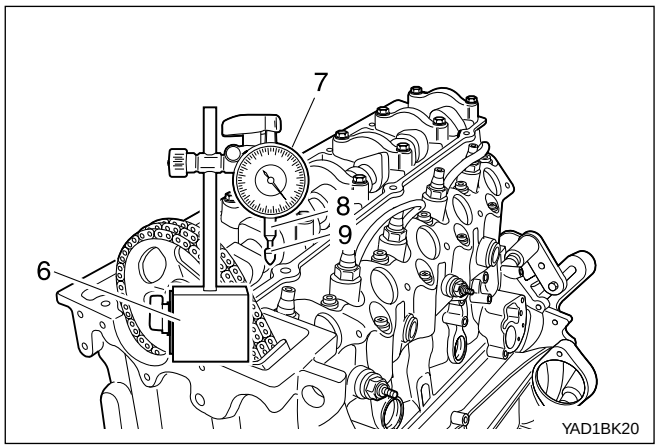
1 Cylinder Head Cover
2 Bolt.....10 N•m (89 lb-in)
3 Gasket..... Replace
4 Valve Tappet
5 Cylinder Head

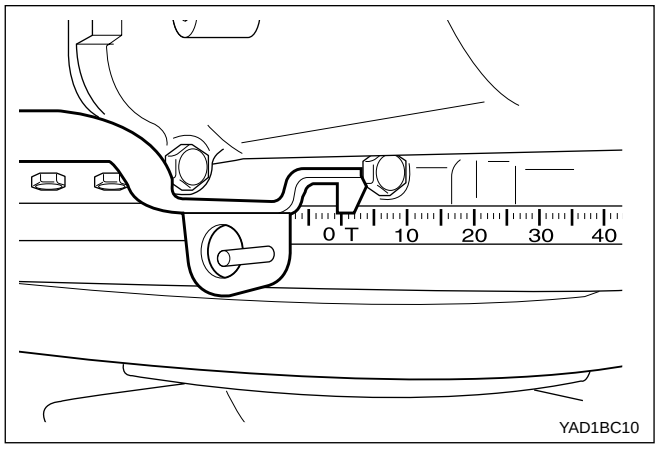
Timing

Condition of camshaft	Intake valve		Exhaust valve	
	Open	Close	Open	Close
New	ATDC 11.33°	ABDC 17°	BBDC 28°	BTDC 15.25°
After approx. 20,000km	ATDC 12°	ABDC 18°	BBDC 27°	BTDC 14°

*At 2mm of valve lifting stroke.







Tools Required

001 589 53 21 00 Dial Gauge
363 589 02 21 00 Dial Gauge Holder
366 589 00 21 05 Extension

Measurement Procedure

1. Remove the cylinder head cover.
2. Rotate the engine in the direction of engine rotation until the intake valve of no. 1 cylinder is completely closed. The cam lobe faces up (arrow).

   Notice: Do not rotate the engine at the bolt of the crankshaft sprocket. Do not rotate the engine in the opposite direction of engine rotation. If do, this will cause serious measuring errors.

3. Install the dial gauge holder 363 589 02 21 00 and dial gauge 001 589 53 21 00 (7) with the extension 366 589 00 21 05 (8) to the cylinder head and position the tracer pin (9) onto the valve tappet (intake valve of cylinder no.1) with a preload of min. 3mm.

   Notice: The tracer pin should be positioned exactly vertical.

4. Set the dial gauge to ‘0’.
5. Rotate the engine further in direction of rotation until the dial gauge has moved back by 2 mm (valve lift) to 1mm.
6. Check the timing.

New	ATDC 11.33°
After approx.	ATDC 12°

   Notice: If timing is out of standard, the camshaft should be checked for wear and the timing chain for stretch. If a difference of more than 4° exists, the timing chain should be replaced.

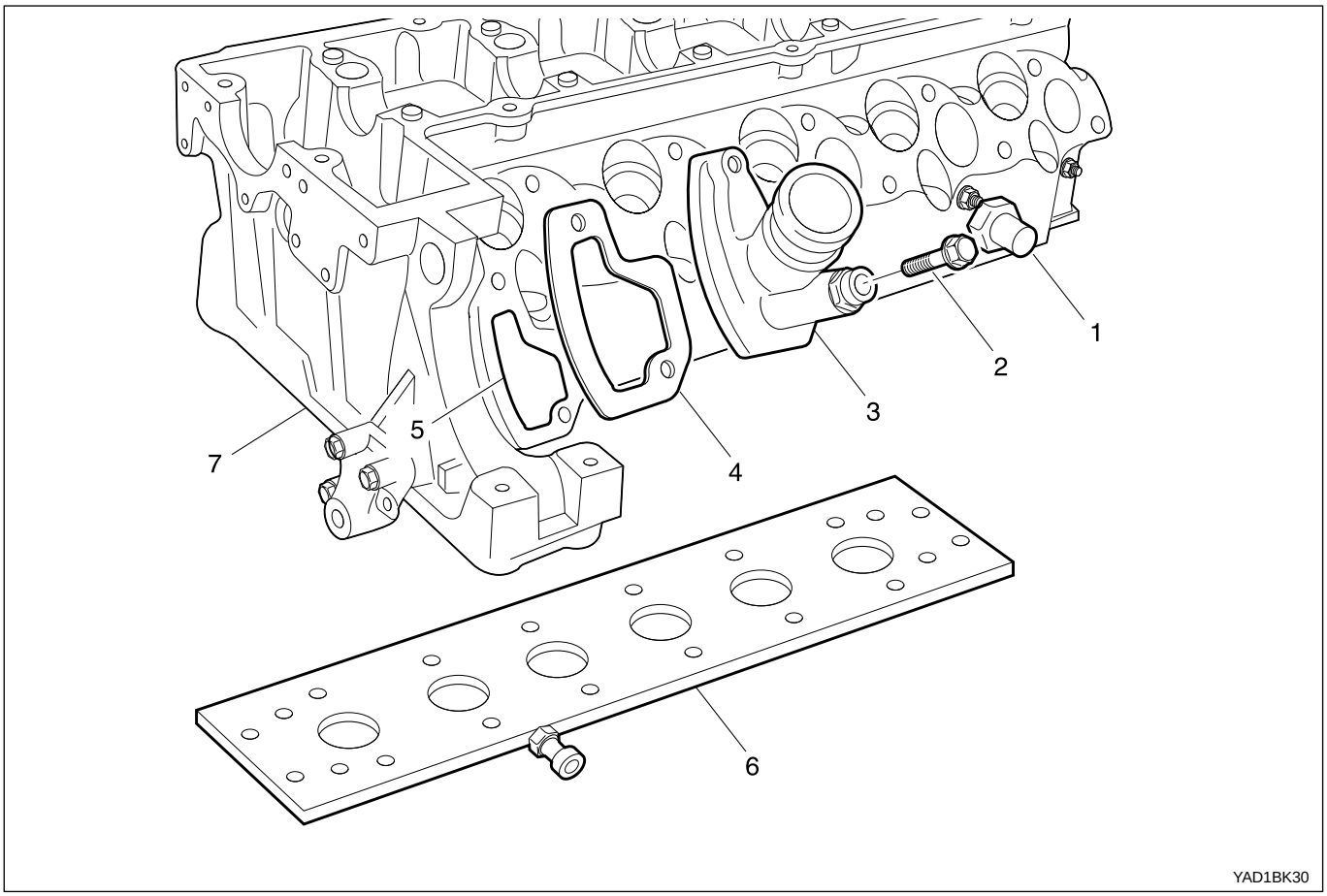
7. Replace the gasket and install the cylinder head cover.

   Installation Notice

Tightening Torque	10 N•m (89 lb-in)

CYLINDER HEAD PRESSURE LEAKAGE TEST

Preceding Work: Removal of the cylinder head
Removal of the exhaust manifold
Removal of the valve



1 Feed Pipe
2 Bolt
3 Return Connection
4 Gasket ..... Replace
5 Coolant Gallery ..... Sealing
6 Pressure Measuring Plate ..... Completely tight to the cylinder head
7 Cylinder Head .....
Immerse with pressure measuring plate into warm water of approx. 60°C (140°F) and pressurize with compressed air of 2 bar.

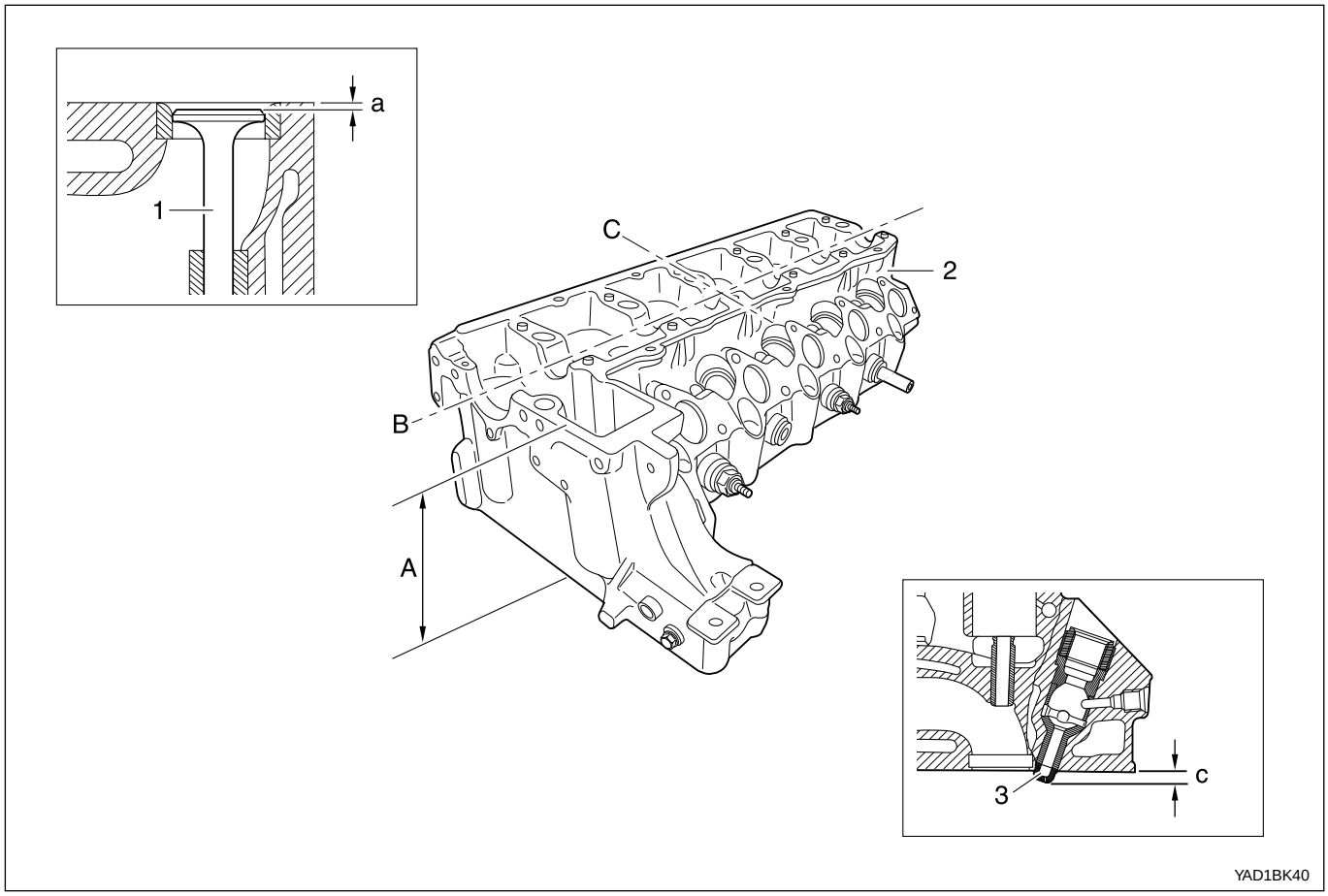
Notice: If air bubbles are seen, replace the cylinder head.

Tools Required

115 589 34 63 00 Mounting Device
601 589 00 25 00 Pressure Testing Device

FACING CYLINDER HEAD MATING SURFACE

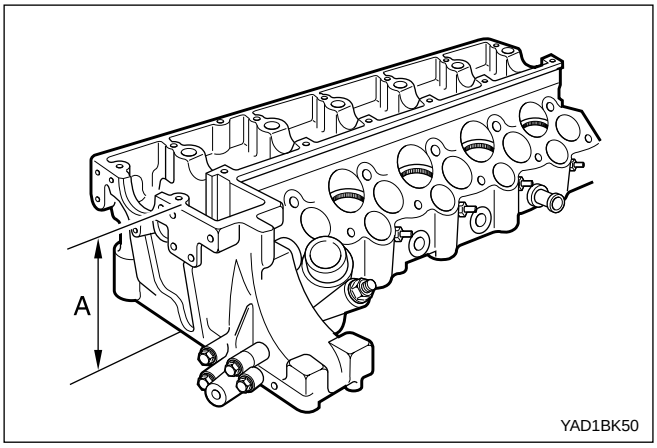
Preceding Work: Removal of prechamber
Cylinder head pressure leakage test



1 Valve
2 Cylinder Head
3 Prechamber
A Height of Cylinder Head
B Longitudinal Direction
C Transverse Direction
a Valve Arrears
b Prechamber Protrusion

Service Data

Height 'A' (Cylinder Head Surface - Cylinder Head Cover Surface)		142.9 - 143.1 mm
Minimum Height After Machining		142.5 mm
Permissible Unevenness of Parting Surface	In Longitudinal Direction	0.08 mm
	In Transverse Direction	0.0 mm
Permissible Variation of Parallelism (Longitud. direction)		Max. 0.1 mm
Peak-to-Valley Height		0.0017 mm
Valve Arrears 'a'	Intake Valve	0.1 - 0.7 mm
	Exhaust Valve	0.1 - 0.7 mm
Prechamber Protrusion 'c'		7.6 - 8.1 mm

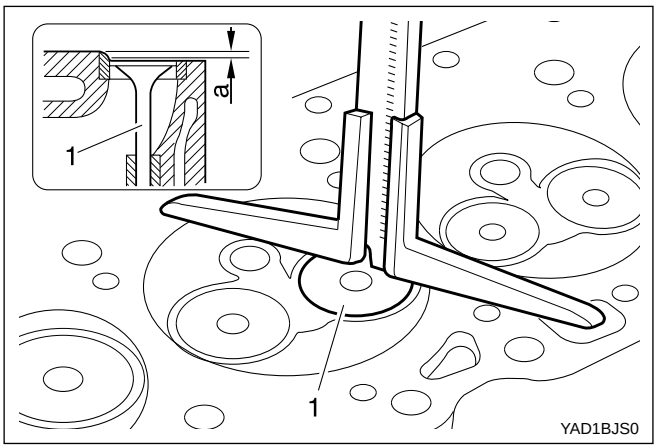


Measurement Procedure

1. Measure height ‘A’.

Limit	142.5 mm

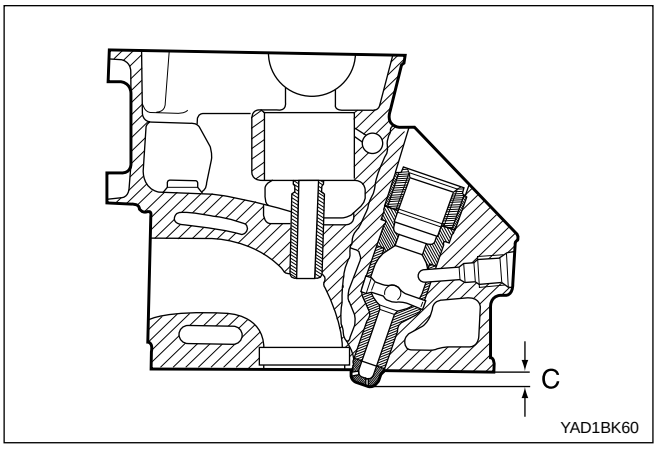
Notice: If the height is less than 142.5 mm, replace the cylinder head.



2. Insert the valve (1) and measure valve arrears ‘a’.

Valve Arrears ‘a’	0.1 - 0.7 mm

Notice: If out of standard, machine the valve seat.



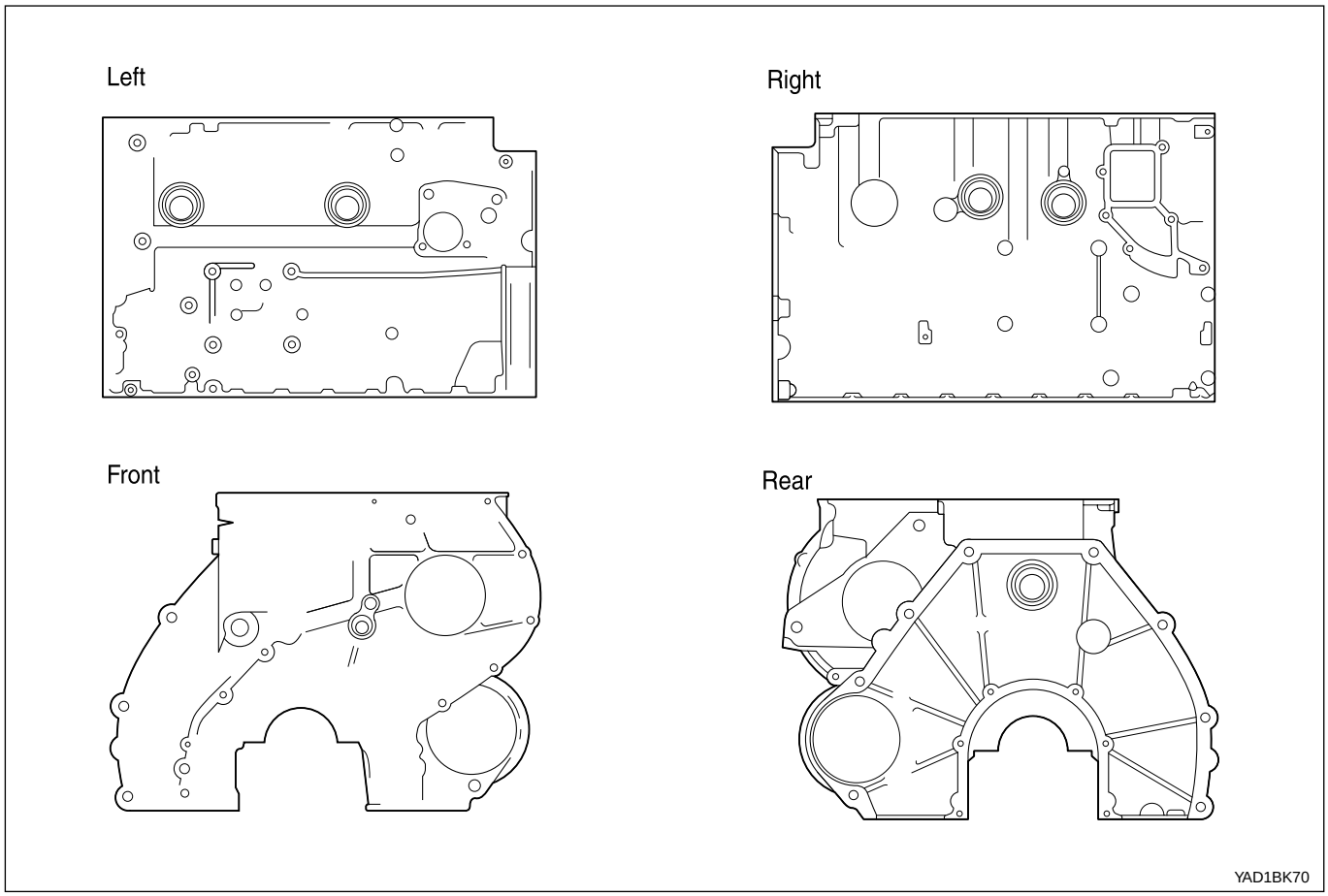
3. Install the prechamber and measure protrusion ‘c’

Protrusion ‘c’	7.6 - 8.1 mm

4. Assemble the engine and check the valve timing.

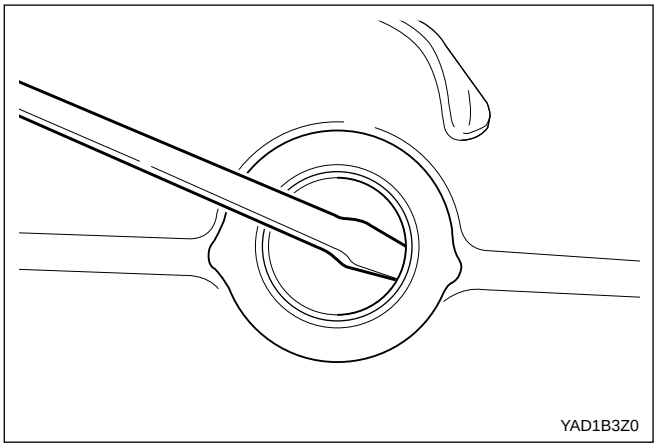
REPLACEMENT OF CRANKCASE CORE PLUG

Core Plug



Service Data

Left	ϕ 34 mm
	3 EA
Right	ϕ 34 mm
	3 EA
Front	ϕ 17 mm
	1 EA
Rear	ϕ 34 mm
	1 EA


YAD1B3Z0

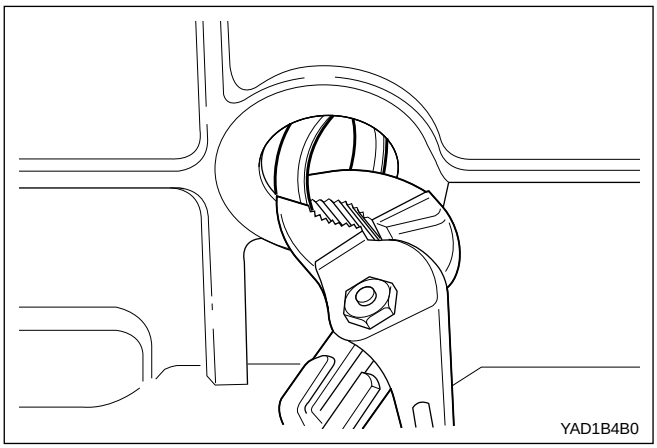
Tools Required

102 589 00 15 00 Drift

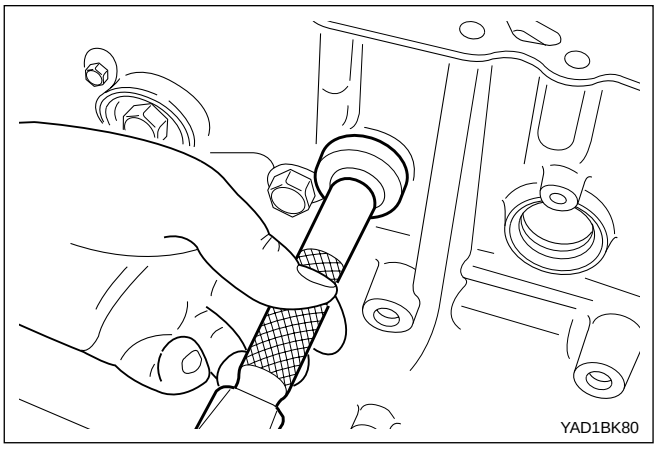
102 589 12 15 00 Drift

Replacement Procedure

1. Completely drain the coolant.
2. Remove any parts which impede access.
   (Example : transmission, injection pump)
3. Place the screwdriver to the deepdrawn edge of the core plug and pull forward and then rotate 90°.


YAD1B4B0

4. Pull out the core plug with pliers.

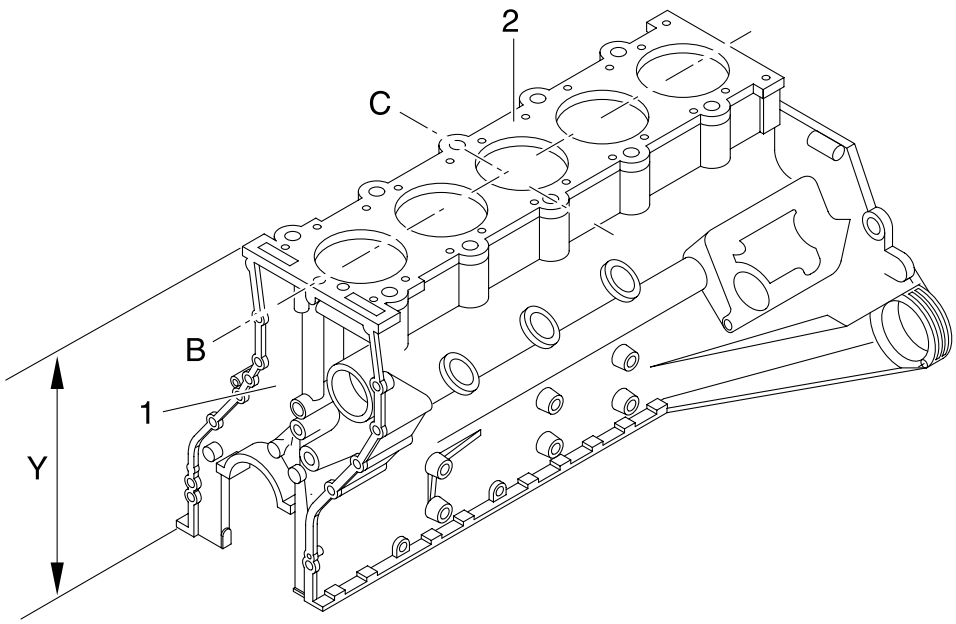

YAD1BK80

5. Thoroughly clean the sealing surface and apply Loctite 241.
6. Install the new core plug by using a drift.
7. Install the removed parts and fill the coolant.

   Notice: The adhesive must be allowed to harden for about 45 minutes before filling of coolant.

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

FACING CRANKCASE CONTACTING SURFACE



YAD1BK90

1 Crankcase
2 Crankcase Contacting Surface

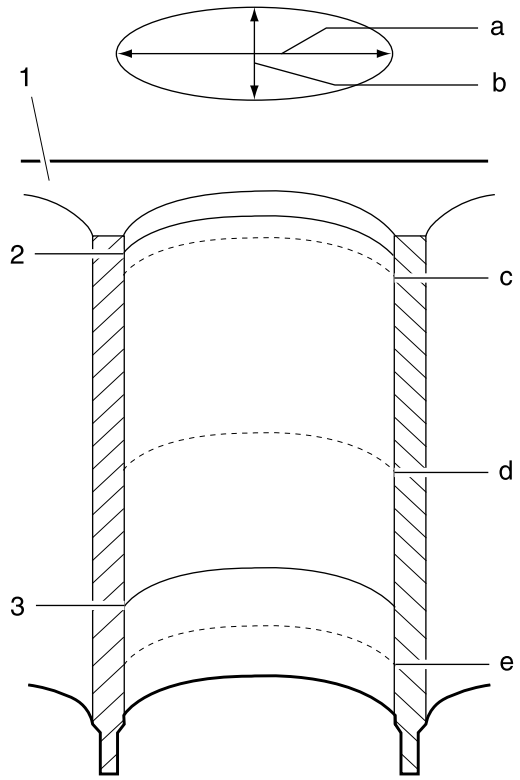
B Longitudinal Direction
C Transverse Direction

Y Height (crankcase upper surface - crankcase lower surface)

Service Data

Height 'Y'		Min. 299.62 mm
Permissible unevenness of contacting surface	In longitudinal direction (B)	0.06 mm
	In transverse direction (C)	0.06 mm
Permissible roughness upper contacting surface		0.0006 - 0.0016 mm
Permissible variation of parallelism of crankcase upper surface to lower surface in longitudinal direction		0.05 mm
Piston protrusion at TDC to crankcase upper surface	Max.	0.965 mm
	Min.	0.735 mm

CYLINDER BORE MEASUREMENT



YAD1BKA0

1 Crankcase Contacting Surface
2 TDC of 1 st Piston Ring
3 BDC of Ring

a Longitudinal Direction
b Transverse Direction
c,d,e Measuring Point

Service Data

Standard size	Code letter 'A'	89.000 - 89.006 mm
	Code letter 'X'	89.006 - 89.012 mm
	Code letter 'B'	89.012 - 89.018 mm
Wear limit in direction of travel and in transverse direction		Max. 0.20 mm
Permissible deviation of cylinder shape	When new	0.01 mm
	Wear limit	0.05 mm
Honing angle		50° ± 10°

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

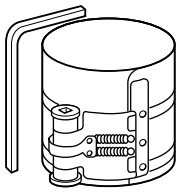
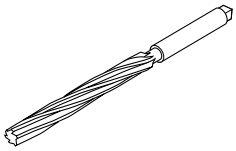
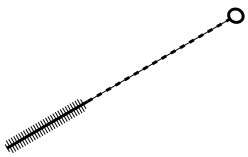
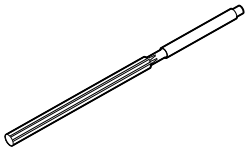
Application		N•m	Lb-Ft	Lb-In
12-Sided Stretch Bolt (Flywheel)		45 + 90°	33 + 90°	-
Camshaft Bearing Cap Bolt		25	18	-
Camshaft Sprocket Bolt		25 + 90°	18 + 90°	-
Chain Tensioner		80	59	-
Connecting Rod Bearing Cap Bolt		35 + 90°	26+ 90°	-
Cooling Fan Belt Pulley Bolt		10	-	89
Cooling Fan Shroud Bolt		3 - 7	-	27 - 62
Crankshaft Bearing Cap Bolt		55 + 90°	41 + 90°	-
Crankshaft Belt Pulley Bolt		23	17	-
Cylinder Head Bolt	1st Step	10	-	89
	2nd Step	35	26	-
	Torque Angel	90°	90°	-
	Wait For	10 min	10 min	-
	Torque Angel	90°	90°	-
Cylinder Head Cover Bolt		10	-	89
Damper Bolt		21	15	-
Drain Plug (Cylinder Head)		30	22	-
End Cover Bolt		10	-	89
Engine Mounting Bolt		50 - 75	37 - 55	-
Exhaust Manifold Nut		25	18	-
Fuel Filter Pipe Bolt		25	18	-
Fuel Line (to Injection Pump)		13	10	-
Fuel Pipe (to Injection Nozzle)		18	13	-
Fuel Pipe (to Injection Pump)		18	13	-
Generator Bracket Bolt		25	18	-
Generator Mounting Bolt	Upper	25	18	-
	Lower	45	33	-
Guide Pulley Bolt		23	17	-
Guide Pulley Bracket Bolt		9	-	80
Hub Bolt		200 + 90°	148 + 90°	-
Idle Pulley Bolt		23	17	-
Injection Nozzle		40	30	-
Injection Pump Mounting Bolt		23	17	-
Intake Manifold Nut		25	18	-
Oil Dipstick Tube Bracket Bolt		10	-	89
Oil Filter Housing Bolt		25	18	-
Oil Filter Housing Cap		25	18	-

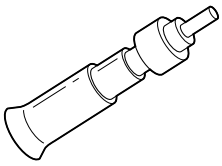
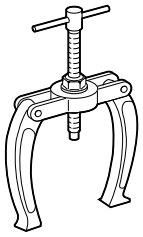
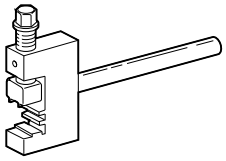
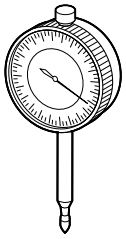
FASTENER TIGHTENING SPECIFICATIONS (Cont'd)

Application		N•m	Lb-Ft	Lb-In
Oil Pan Bolt	Socket Bolt	10	-	89
	M6	10	-	89
	M8	25	18	-
Oil Pan Drain Plug		25	18	-
Oil Pump Mounting Bolt		25	18	-
Oil Pump Sprocket Bolt		25	18	-
Oil Pump Screw Plug		50	37	-
Oil Spray Nozzle Bolt		10	-	89
Power Steering Dump Pulley Bolt		32	24	-
Prechamber Threaded Ring		130	96	-
Skid Plate Bolt		28 - 47	21 - 35	-
Socket Bolt		25	18	-
Stud Bolt		12	-	106
TDC Sensor Bracket Bolt		10	-	89
Tensioning Lever Nut		21	15	-
Tensioning Pulley Bolt		29	21	-
Timing Case Cover Bolt		10	-	89
Transmission Mounting Bolt		54 - 68	40 - 50	-
Turbo Charger to Exhaust Pipe Bolt		30	22	-
Vacuum Pump Mounting Bolt		10	-	89

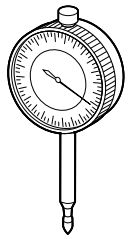
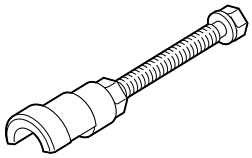
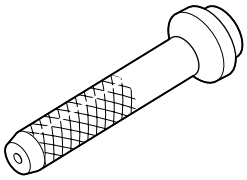
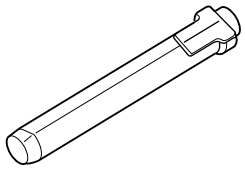
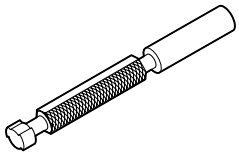
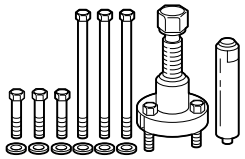
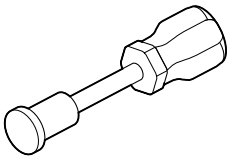
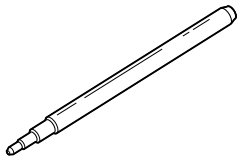
SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS TABLE

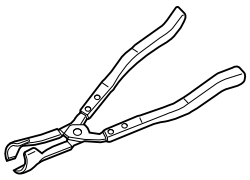
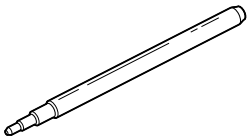
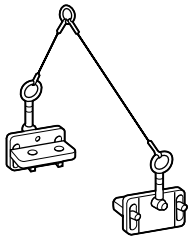
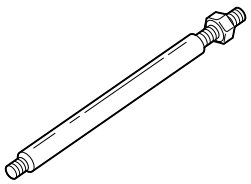
 YAD1BKW0	**000 589 04 14 00 Tensioning Strap**
 YAD1BLC0	**000 589 10 53 00 Reamer (for Exhaust)**
 YAD1BL60	**000 589 10 68 00 Cylinder Brush**
 YAD1BLD0	**000 589 21 53 00 Reamer (for Intake)**

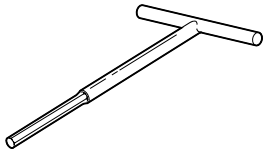
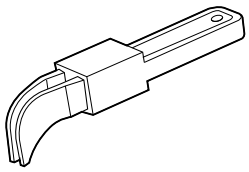
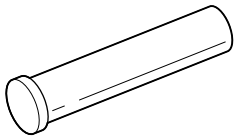
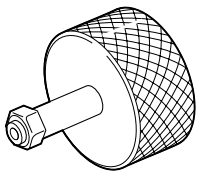
 YAD1BKS0	**000 589 25 33 00 Internal Extractor**
 YAD1BKR0	**000 589 33 33 00 Counter Support**
 YAD1B1W0	**000 589 58 43 00 Chain Assembling Device**
 YAD1BLG0	**001 589 32 21 00 Dial Gauge**

SPECIAL TOOLS TABLE (Cont'd)

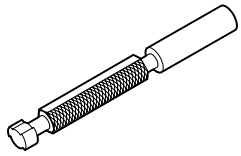
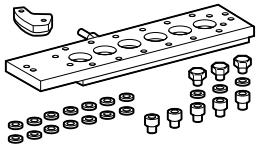
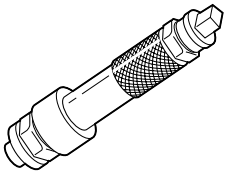
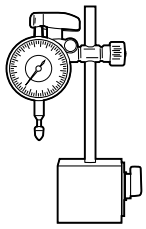
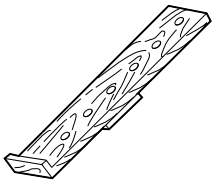
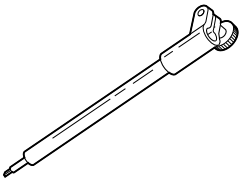
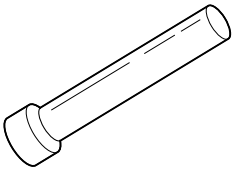
 YAD1BKJ0	**001 589 53 21 00 Dial Gauge**	 YAD1BKU0	**102 589 05 33 00 Puller**
 YAD1B3Y0	**102 589 00 15 00 (ϕ 34) Drift**	 YAD1B1A0	**102 589 12 15 00 (ϕ 17) Drift**
 YAD1BLF0	**102 589 00 23 00 Go/No Go Gauge (for Intake)**	 YAD1BKM0	**103 589 00 33 00 Puller**
 YAD1BKX0	**102 589 03 40 00 Magnetic Bar**	 YAD1BL80	**103 589 02 15 00 Drift (for Exhaust)**

SPECIAL TOOLS TABLE (Cont'd)

 YAD1BL40	**104 589 00 37 00** **Pliers**
 YAD1BL70	**105 589 03 15 00** **Drift (for Intake)**
 YAD1BKG0	**115 589 34 63 00** **Mounting Device**
 YAD1BLH0	**116 589 02 34 00** **Thread Bolt**

 YAD1BKF0	**116 589 03 07 00** **T Type Socket Wrench**
 YAD1BL10	**116 589 06 63 00** **Magnetic Finger**
 YAD1BKV0	**116 589 07 15 00** **Drift**
 YAD1B580	**116 589 20 33 00** **Sliding Hammer**

SPECIAL TOOLS TABLE (Cont'd)

 YAD1BLE0	**117 589 03 23 00** **Go/No Go Gauge** **(for Exhaust)**	 YAD1BKH0	**601 589 00 25 00** **Pressure Testing Device**
YAD1BL90	**346 589 00 63 00** **Super Cooling Box**	 YAD1BKD0	**601 589 00 66 00** **Counter Sink**
 YAD1BKQ0	**363 589 02 21 00** **Dial Gauge Holder**	 YAD1BKY0	**601 589 01 59 00** **Assembling Board**
 YAD1BKP0	**366 589 00 21 05** **Extension**	 YAD1BL50	**601 589 02 43 00** **Drift**

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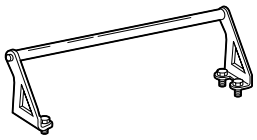
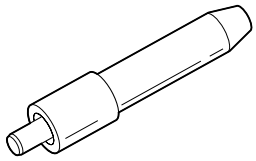
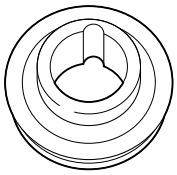
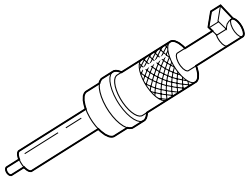
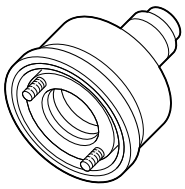
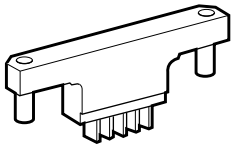
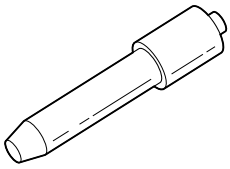
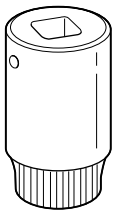
 YAD1BKZ0	**601 589 02 59 00 Supporting Bridge**	 YAD1BLB0	**601 589 06 15 00 Drift (for Exhaust)**
 YAD1B790	**601 589 03 14 00 Sleeve**	 YAD1BKK0	**601 589 07 21 00 Measuring Device**
 YAD1BKN0	**601 589 03 43 00 Oil Seal Assembler**	 YAD1B720	**602 589 00 40 00 Engine Lock**
 YAD1BLA0	**601 589 05 15 00 Drift (for Intake)**	 YAD1BKB0	**603 589 00 09 00 Serration Wrench**

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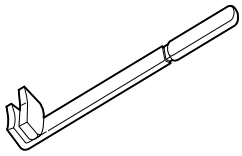
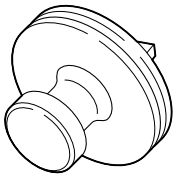
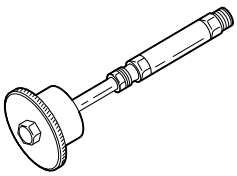
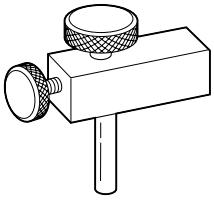
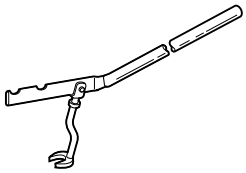
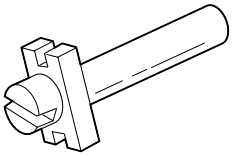
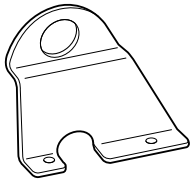
 YAD1B4K0	**603 589 00 40 00** **Counter Holder**
 YAD1BL20	**603 589 01 40 00** **Holding Wheel**
 YAD1BKC0	**657 589 03 63 00** **Sliding Hammer**
 YAD1BKE0	**667 589 00 23 00** **Height Gauge**

 YAD1BL00	**667 589 00 31 00** **Press Lever**
 YAD1BKL0	**667 589 01 21 00** **Fixing Device**
 YAD1BL30	**667 589 02 63 00** **Supporting Bar**

SECTION 1D

ENGINE COOLING

CAUTION: 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.

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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).

ELECTRIC COOLING FAN

Caution: 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.

Caution: 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

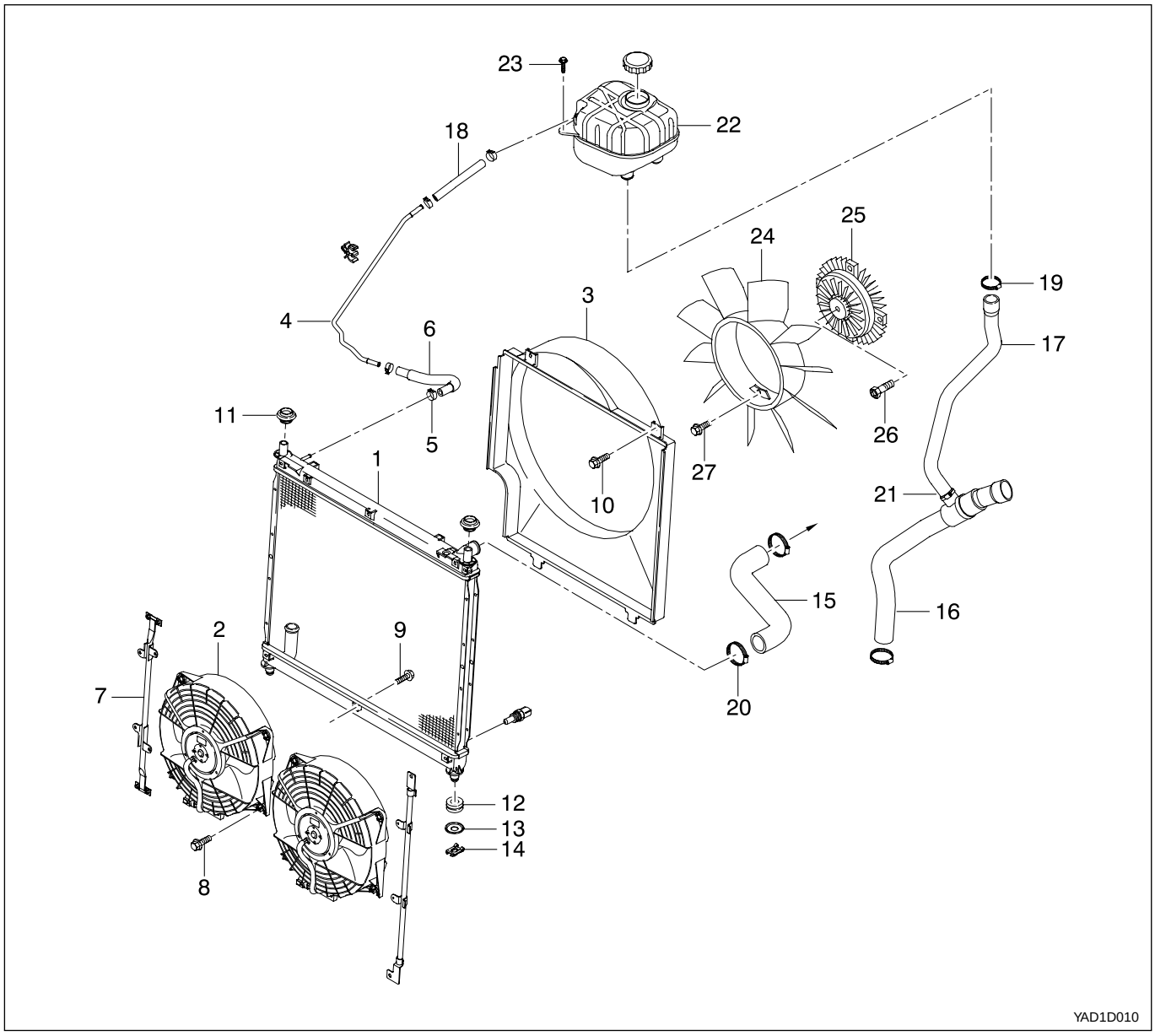
The Engine Coolant Temperature (ECT) sensor uses a temperature to control the signal voltage to the Engine Control Module (ECM).

COOLANT TEMPERATURE GAUGE

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

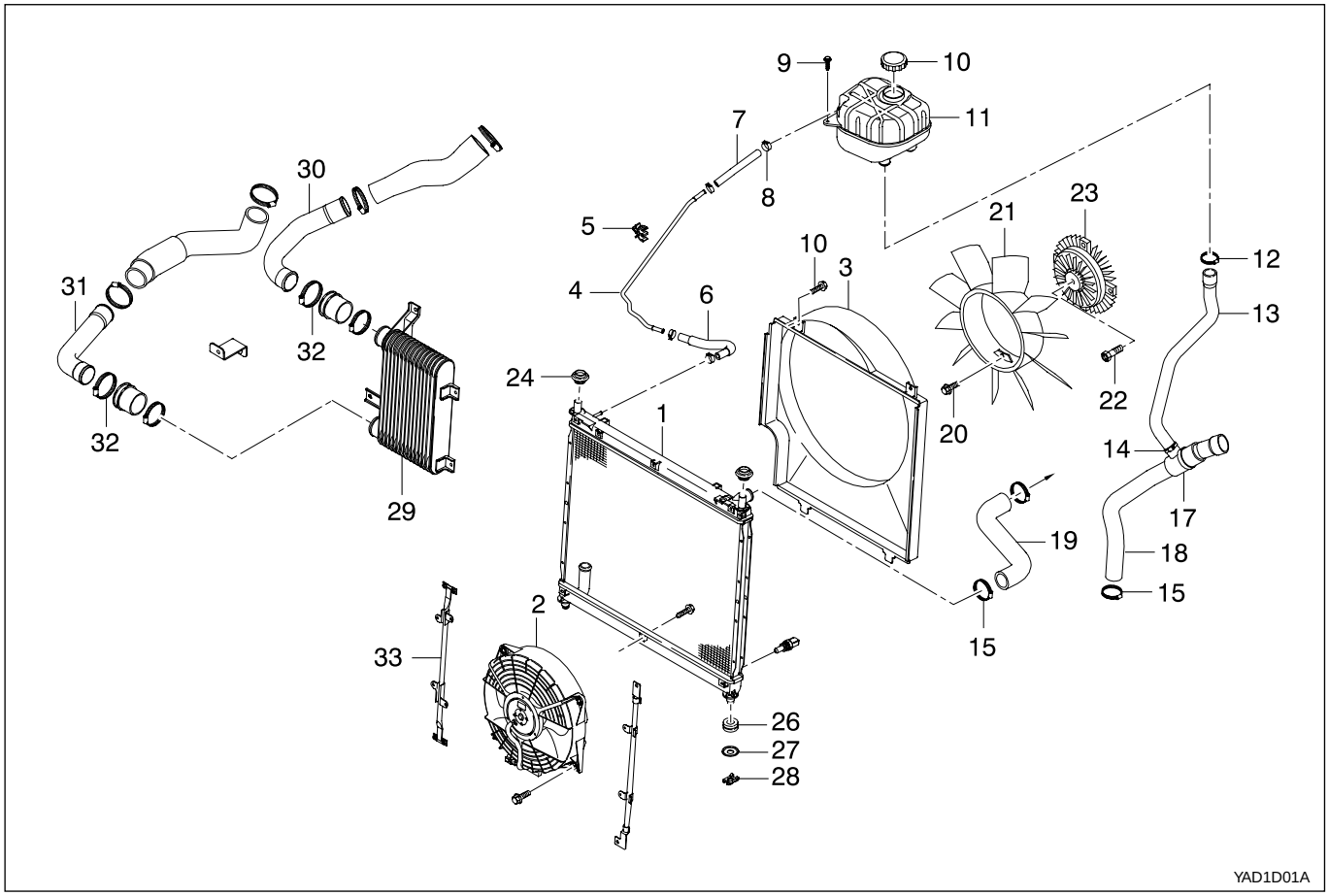
COMPONENT LOCATOR

GASOLINE ENGINE



1 Radiator
2 Electric Fan
3 Shroud
4 Deaeration Tube
5 Clamp
6 Deaeration Hose (Radiator)
7 Electric Fan Mounting Bracket
8 Bolt (M6, 8 pieces)
9 Bolt (M6, 4 pieces)
10 Bolt (M6, 4 pieces)
11 Upper Radiator Insulator
12 Lower Radiator Insulator
13 Plate
14 Clip
15 Inlet Hose
16 Outlet Hose
17 3 way Hose
18 Deaeration Hose (Reserver Tank)
19 Clamp
20 Clamp
21 Make Up Hose Holder
22 Reserver Tank
23 Bolt (M6, 2 piece)
24 Cooling Fan
25 Viscous Clutch
26 Bolt (M6, 1 piece)
27 Bolt (M6, 3 piece)

DIESEL ENGINE



1 Radiator
2 Electric Fan
3 Shroud
4 Deaeration Tube
5 Clip
6 Deaeration Hose (Radiator)
7 Deaeration Hose (Reserver Tank)
8 Clip
9 Bolt (M6, 2 pieces)
10 Reserver Cap
11 Reserver Tank
12 Clamp
13 3 way Hose
14 Clamp
15 Clamp
16 -
17 Connector
18 Outlet Hose
19 Intlet Hose
20 Bolt
21 Cooling Fan
22 Bolt
23 Viscous Clutch
24 Upper Radiator Insulator
25 Bolt
26 Lower Radiator Insulator
27 Plate
28 Clip
29 Intercooler
30 Intercooler Outlet Duct
31 Intercooler Inlet Duct
32 Clamp
33 Electric Fan Mounting Bracket

DIAGNOSTIC INFORMATION AND PROCEDURE

COOLING SYSTEM DIAGNOSIS

Engine Overheats

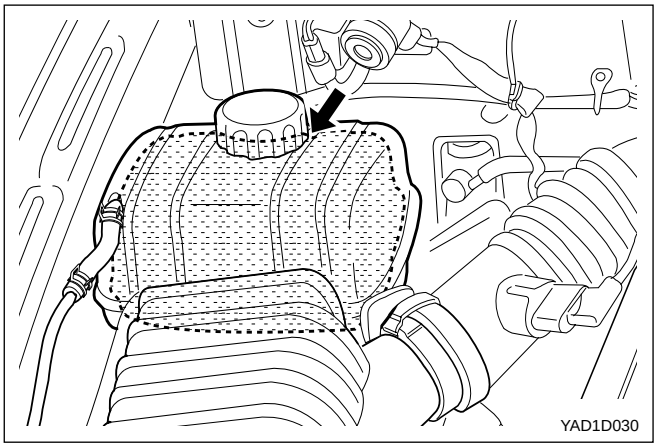
Checks	Action
Check for a loss of the coolant	Add the coolant.
Check for a weak coolant solution.	Confirm that the coolant solution is a 50/50 mixture of ethylene glycol and water.
Check the front of the radiator for any dirt, any leaves, or any insects.	Clean the front of the radiator.
Check for leakage 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.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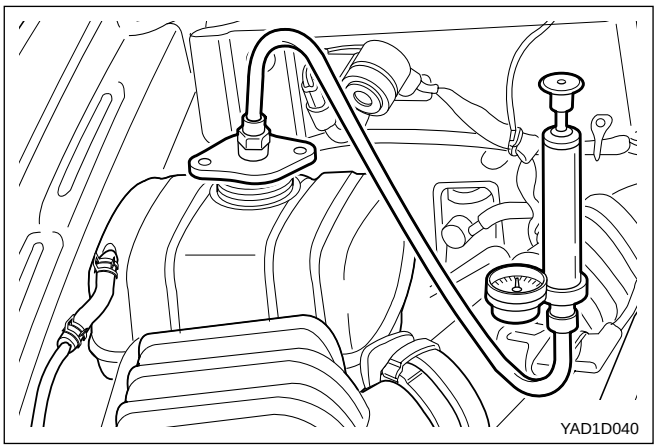
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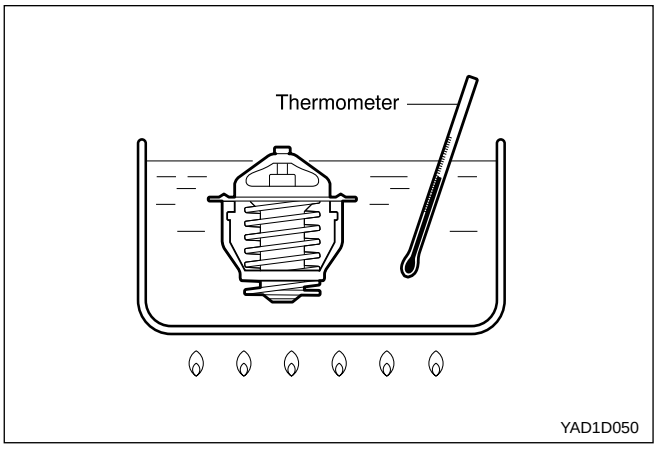


YAD1D050

SYSTEM LEAKAGE TEST

Tools Required

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.

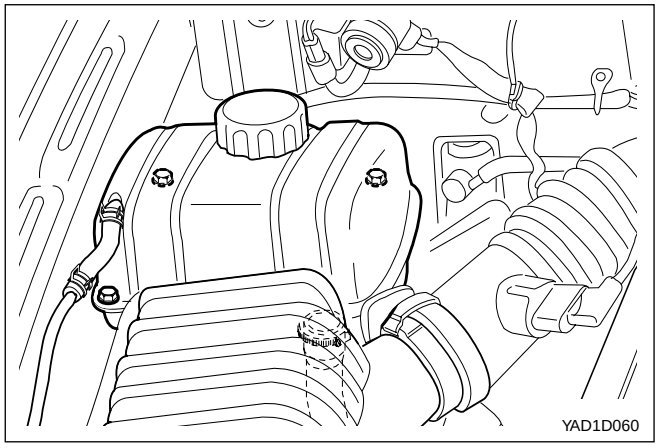
3. Connect the leakage tester 124 589 15 21 00 to the reservoir filler cap and apply 1.4 bar of pressure.
4. If the pressure on the tester drops, check leakage at the all coolant hoses and pipes and each connections. Replace or retighten if necessary.

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.

REPAIR INSTRUCTIONS



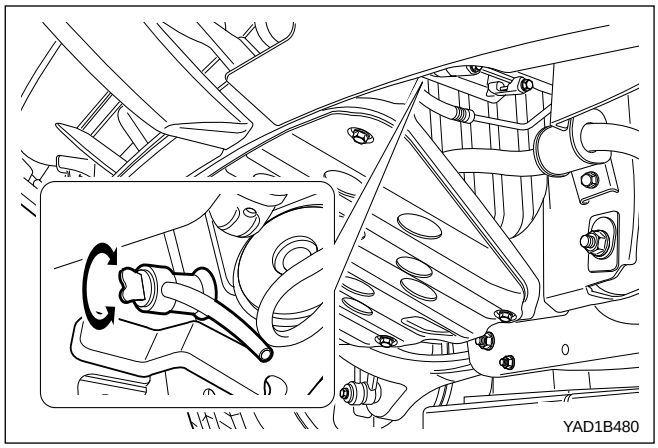
ON-VEHICLE SERVICE

COOLANT DRAIN AND FILL UP

Draining & Filling up Procedure (Gasoline Engine)

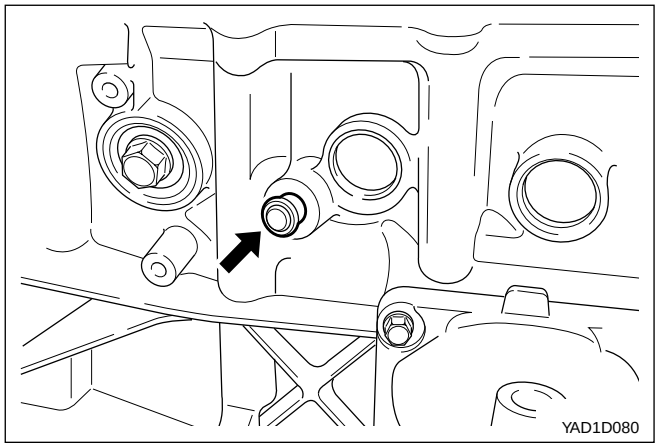
1. Loosen the cap a little and release pressure and remove the cap.

   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:

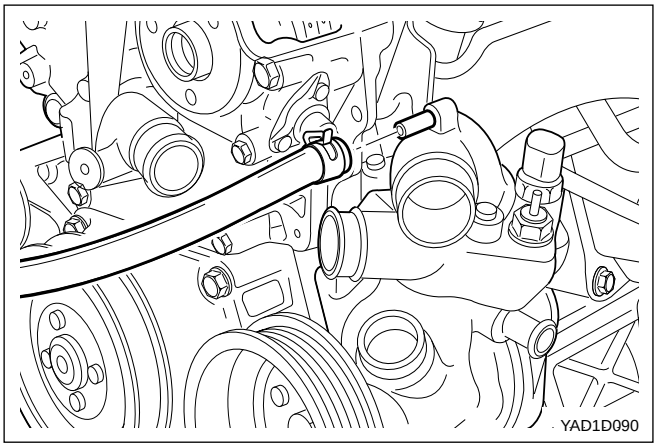
   - Just loosen the drain plug to drain the coolant and do not remove the plug completely.
   - Collect coolant by using proper container.

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

   Installation Notice

Tightening Torque	30 N•m (22 lb-ft)

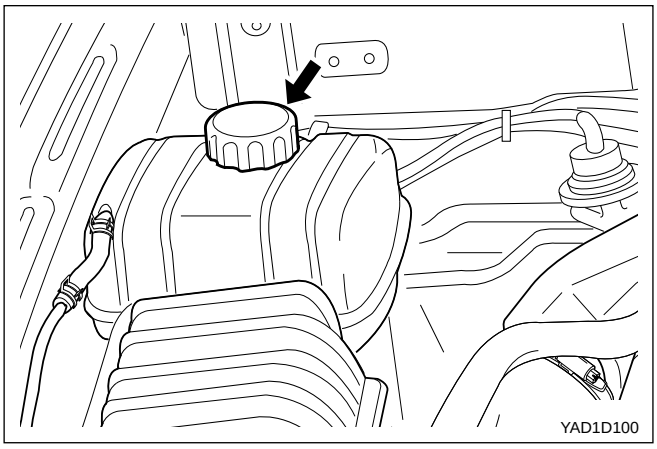
5. Tighten the radiator lower drain cock.


YAD1D090

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.

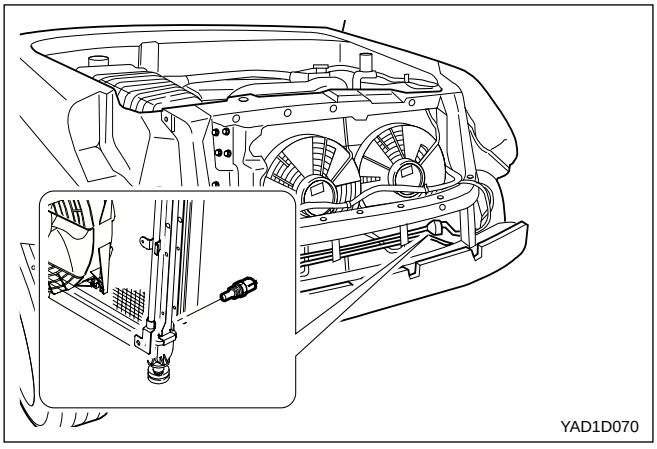
8. Insert the de-aeration hose and completely tighten the clamp.
9. Check the coolant level in the coolant reservoir tank.
10. Warm up (until thermostat is opened) the engine and recheck the coolant level in the reservoir tank and fill up the coolant if necessary.


YAD1D100

Draining & Filling up Procedure (Diesel Engine)

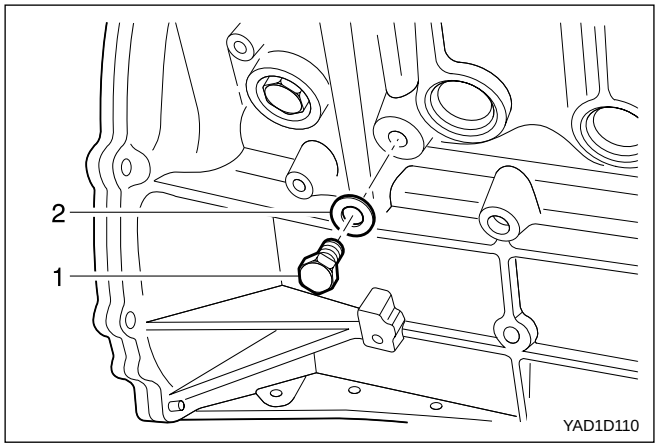
1. Loosen the pressure cap of reservoir by 1 notch and remove pressure and then loosen the cap.

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


YAD1D070

2. Open the drain plug and drain the coolant.

   Notice: Collect the coolant by using a proper container.



3. Remove the drain plug (1) and seal (2) of cylinder block and drain the coolant.
4. Replace the seal to new one and tighten the drain plug.

   Installation Notice

Tightening Torque	30 N•m (22 lb-ft)

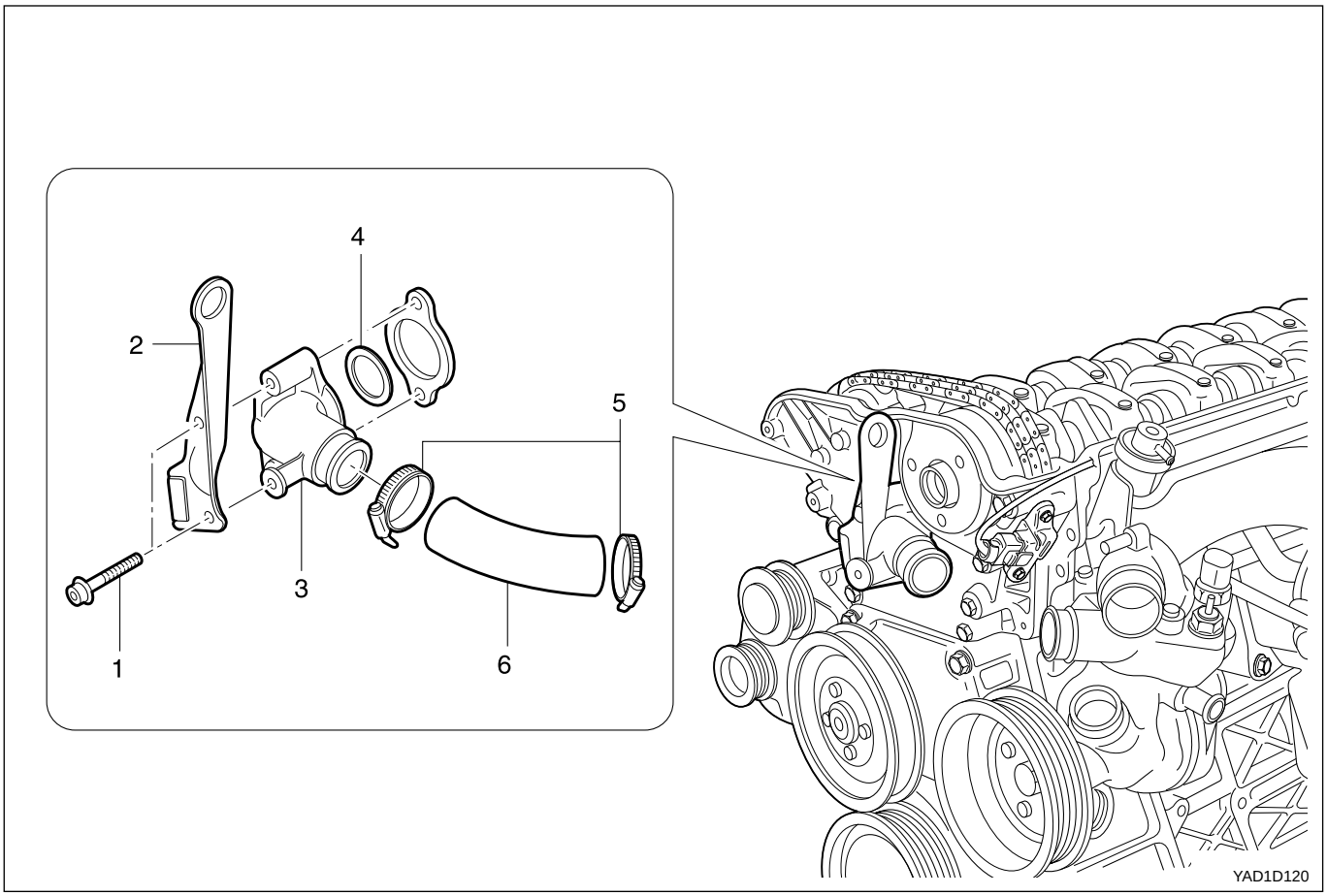
5. Tighten the drain plug of the lower radiator.
6. Fill the coolant through coolant reservoir-tank.

   Notice: Match the anti-freeze and the water ratio to 50 : 50.

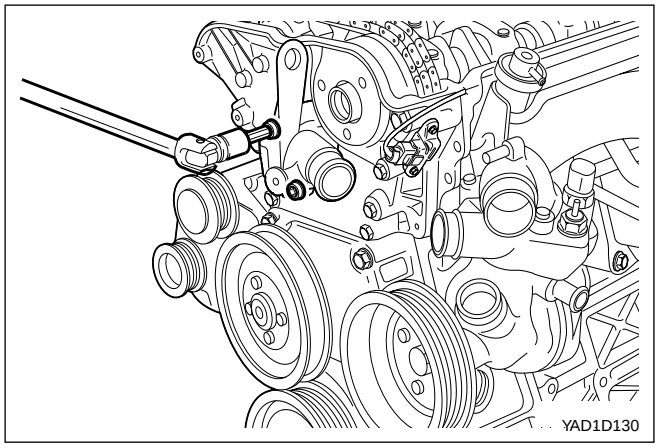
7. Warm up (until thermostat is opened) the engine and recheck the coolant level in the reservoir tank and fill up the coolant if necessary.

COOLANT CONNECTION FITTING (M162 ENGINE)

Preceding Work : Removal of cooling fan shroud



1 Bolt (M8 X 100, 2 pieces)..... 22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)
2 Engine Hanger Bracket
3 Coolant Outlet Port
4 O-ring
5 Hose Mounting Clamp
6 Hose



Removal & Installation Procedure

1. Drain coolant from the radiator.
2. Remove the hose mounting clamp (5) and disconnect the coolant hose (6).
3. Remove the two bolts (1), the engine hanger bracket (2) and coolant outlet port (3).

   Installation Notice

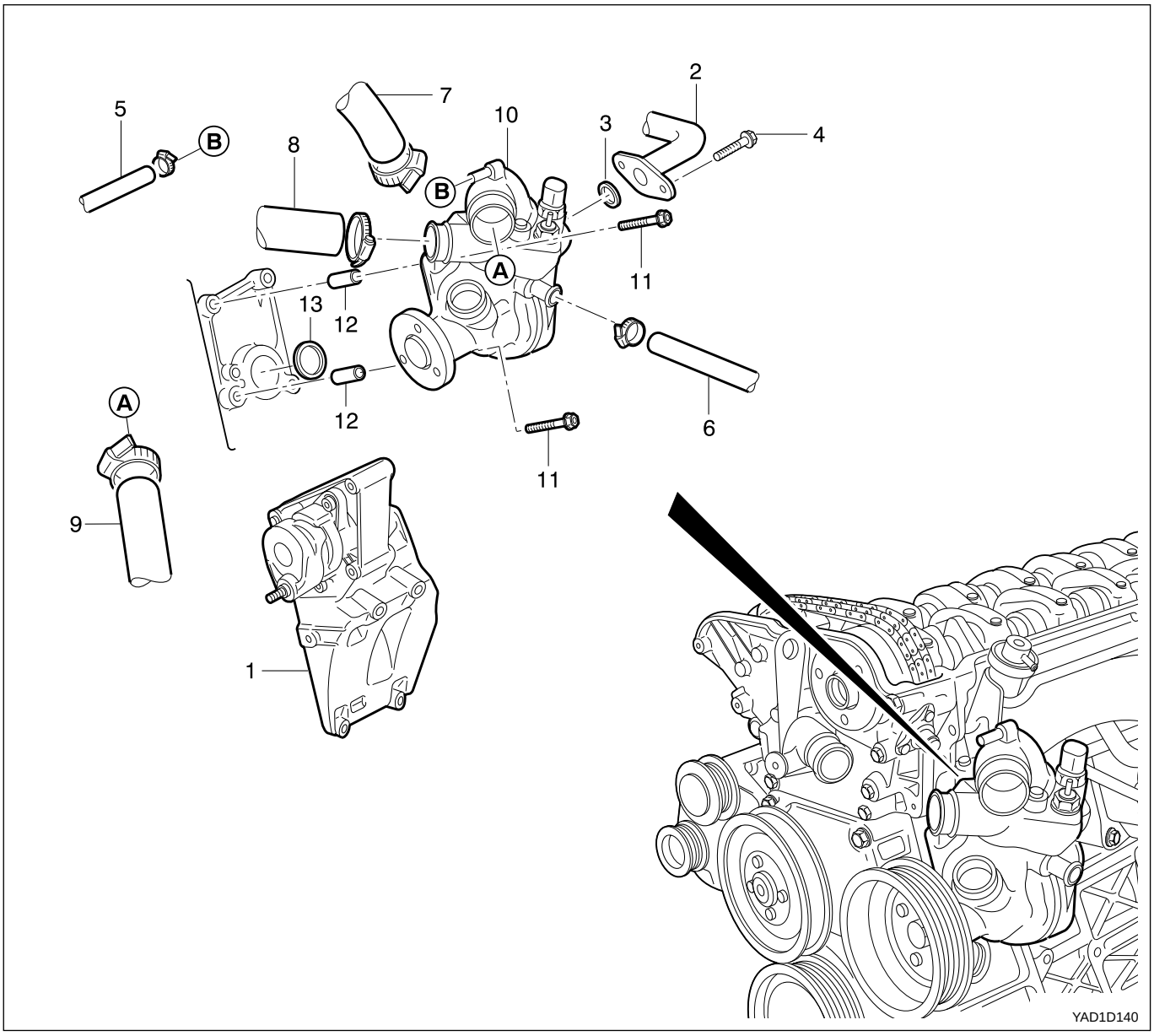
Tightening Torque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

   Replace the O-ring with new one.

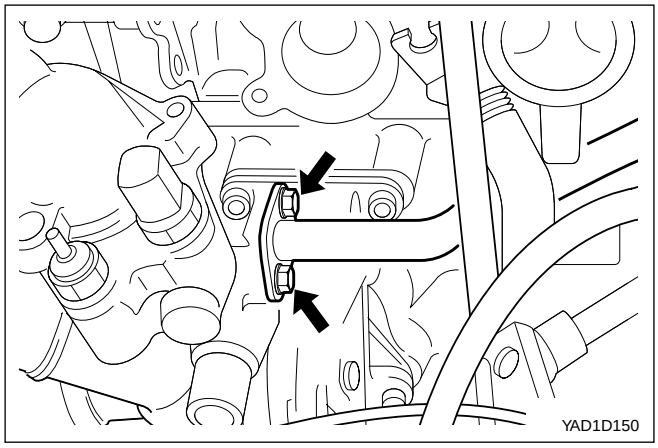
4. Installation should follow the removal procedure in the reverse order.
5. Fill up the coolant as specified.
6. Check the leaks in the cooling system.

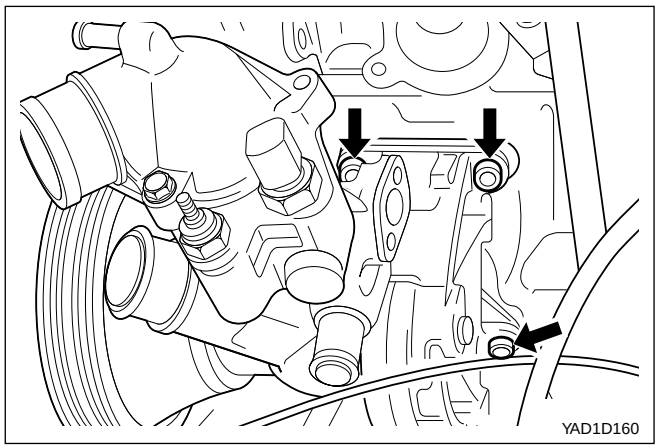
WATER PUMP (M162 ENGINE)

Preceding Work : Removal of V-belt
Removal of air admission housing



1 Air Admission Housing
2 Oil Cooler Pipe Line
3 Seal ..... Replace
4 Bolt..... 9 - 11 N•m (80 - 97 lb-in)
5 Coolant Hose
6 Coolant Hose
7 Outlet Coolant Hose
8 Coolant Hose
9 Inlet Coolant Hose
10 Water Pump
11 Bolt..... 22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)
12 Dowel Sleeve
13 Seal ..... Replace





Removal & Installation Procedure

1. Drain the coolant.
2. Disconnect the water pump wire connector.
3. Loosen the hose clip and disconnect all hoses from the water pump
4. Remove the coolant line bolts (4) and then remove the coolant line (2).

Installation Notice

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

Replace the seal (3).

5. Remove the mounting bolts (11) and carefully pull out water pump (10).

Installation Notice

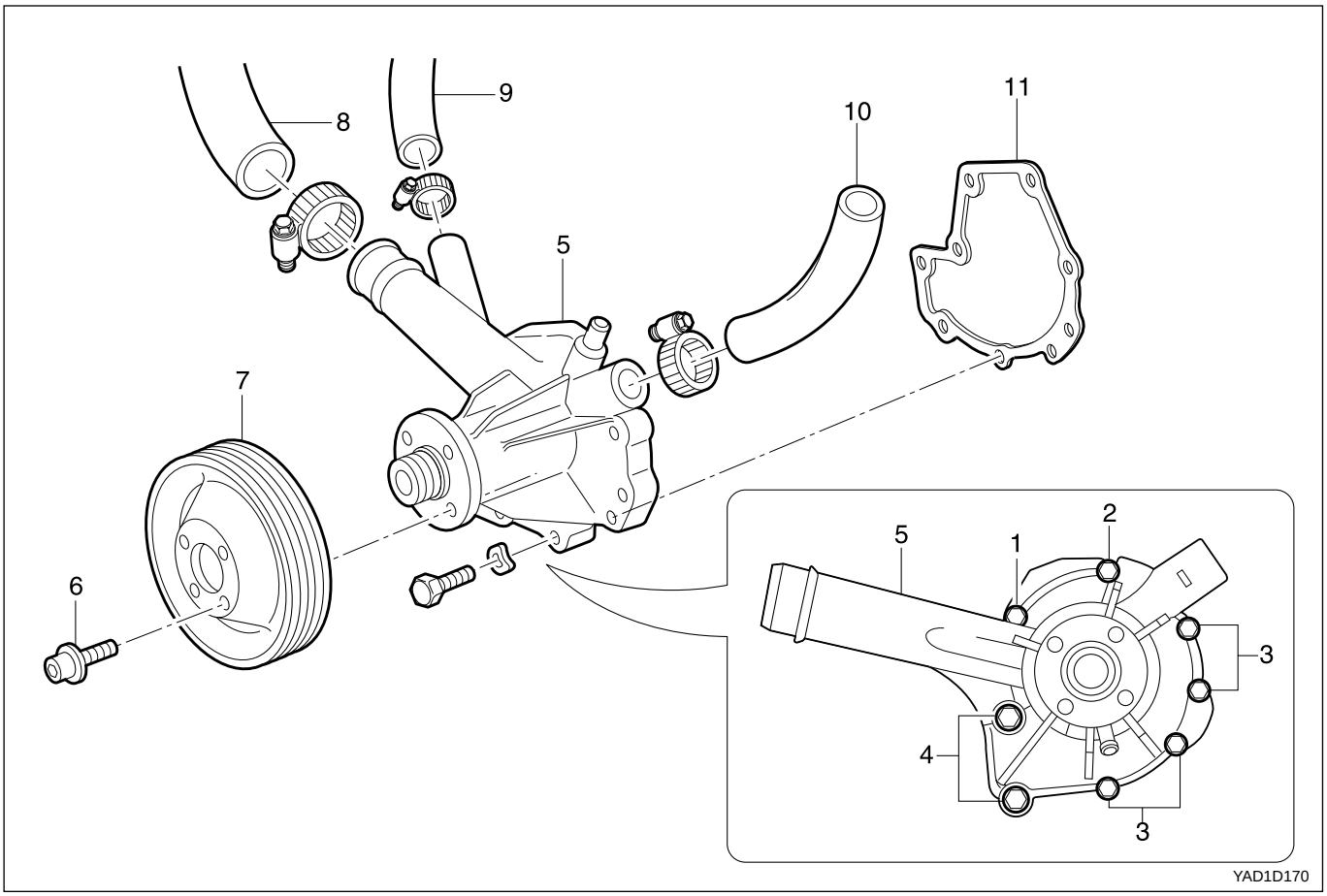
Tightening Torque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

Replace the seal (13).

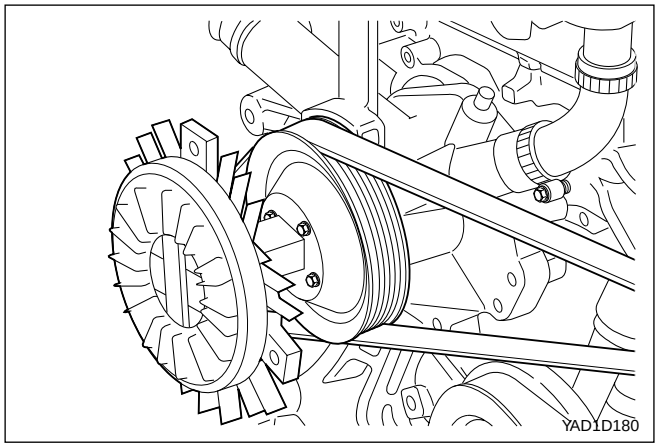
6. Installation should follow the removal procedure in the reverse order.
7. Fill up coolant.
8. Do coolant system leakage test.

WATER PUMP (M161 ENGINE)

Preceding Work : Removal of viscous clutch



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



Tools Required

603 589 00 40 00 Fan Clutch Holder

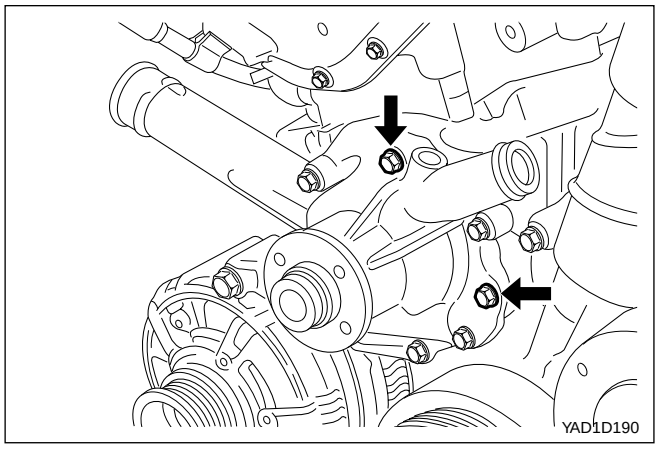
Removal & Installation Procedure

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 N•m (80 - 97 lb-in)

   Hold the pulley with fan clutch holder 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 N•m (80 - 97 lb-in)
	(4)	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

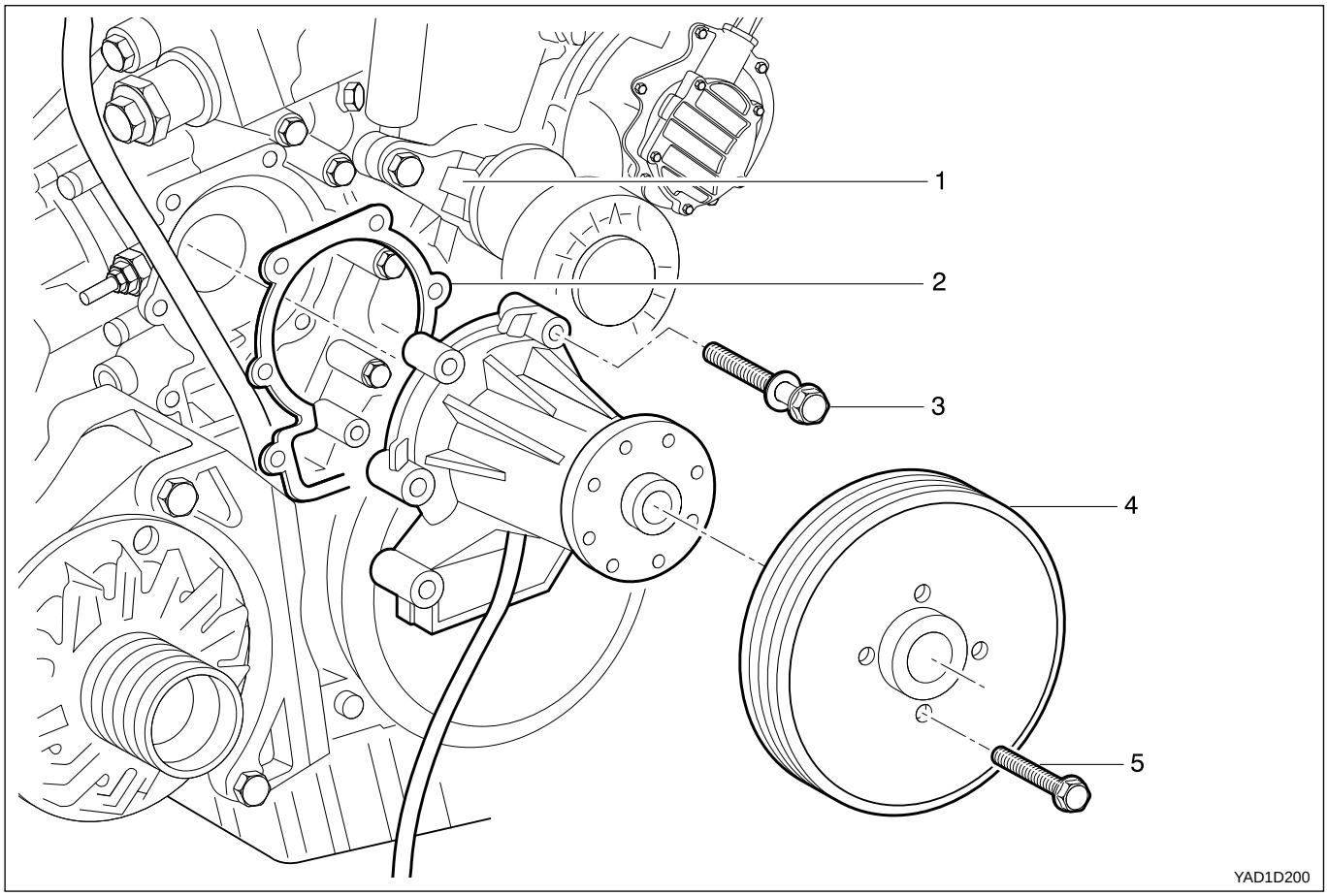
6. Clean the sealing surface.
7. Replace the gasket with new one.

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

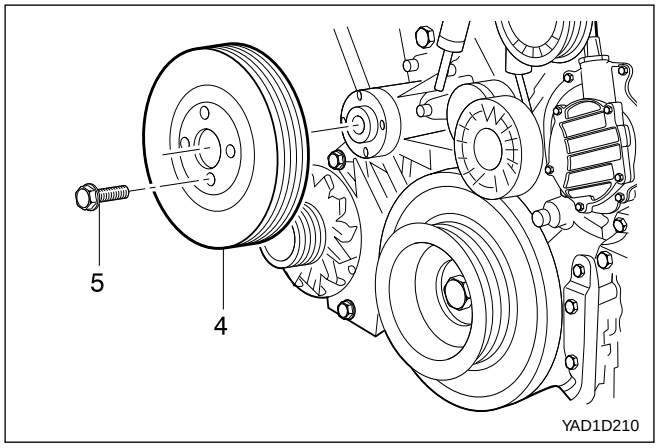
8. Installation should follow the removal procedure in the reverse order.
9. Check for leaks by starting the engine.

WATER PUMP (DIESEL ENGINE)

Preceding Work : Removal of cooling fan
Removal of V-belt



1 Tensioning Lever
2 Gasket ..... Replace
3 Bolt..... 9 - 11 N•m (80 - 97 lb-in)
4 Water Pump Pulley
5 Bolt..... 9 - 11 N•m (80 - 97 lb-in)
6 Water Pump

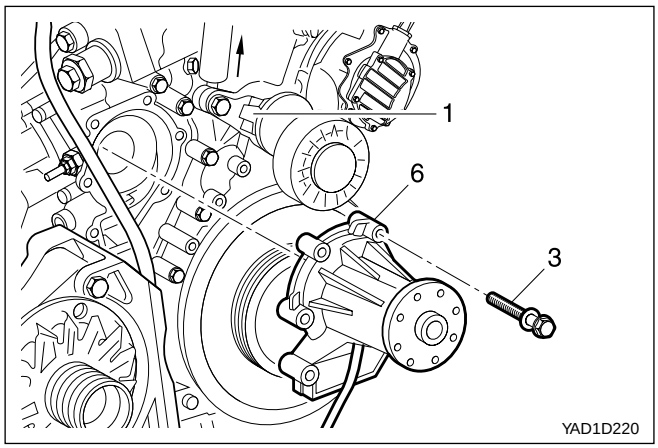


Removal & Installation Procedure

1. Loose the bolts (5) and remove the pulley (4).

   Installation Notice

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



2. Loose the bolts (3).

   Installation Notice

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

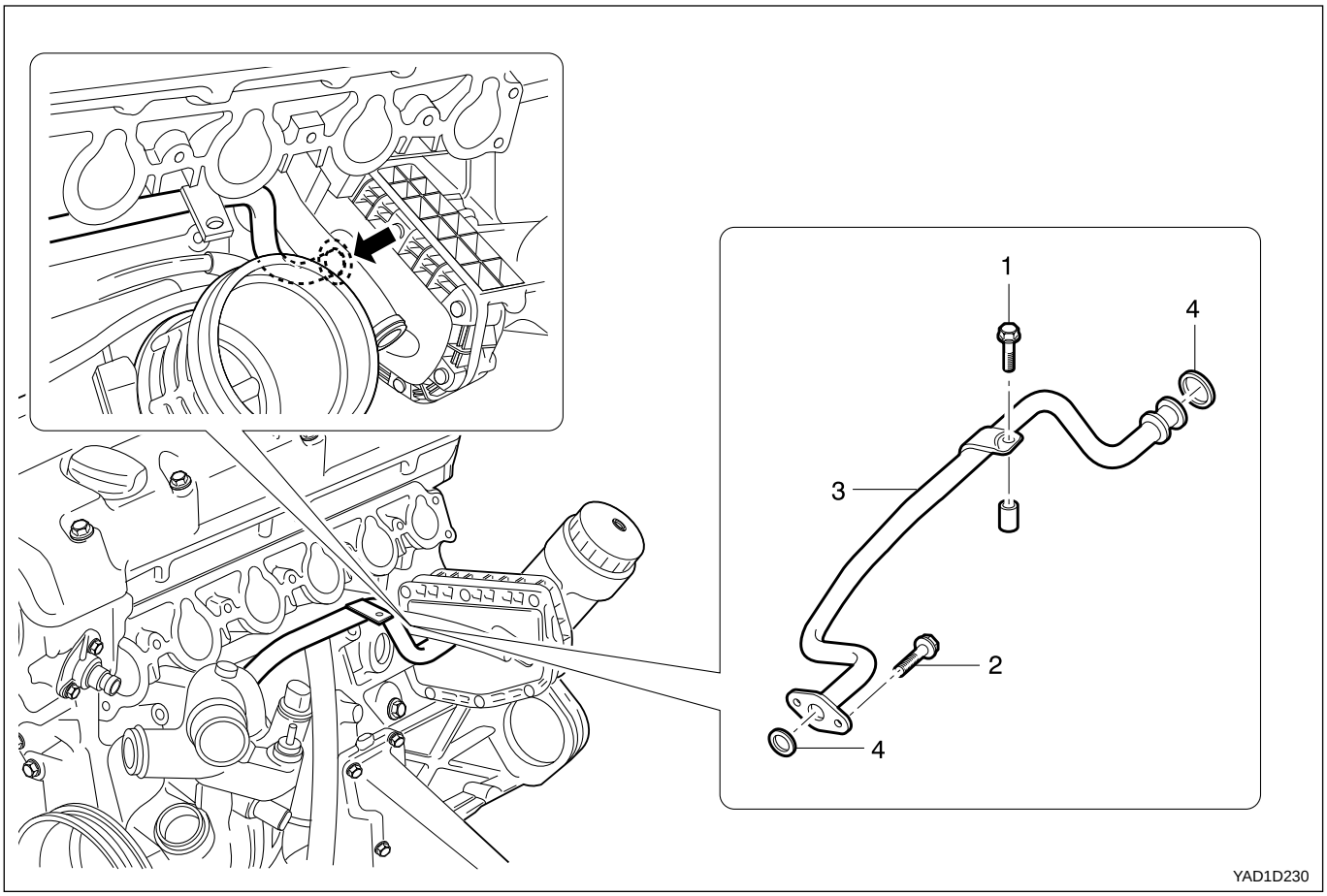
3. Pull the tensioning lever (1) to the arrow direction.
4. Remove the water pump (6).

   Notice: Clean gasket residues on the sealing surface of water pump and replace the gasket.

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

OIL COOLER PIPE LINE (M162 ENGINE)

Preceding Work : Removal of upper intake manifold



1 Bolt (M6 X 35, 1 piece)
..... 9 - 11 N•m (80 - 97 lb-in)
2 Bolt (M6 X 16, 2 pieces)
..... 9 - 11 N•m (80 - 97 lb-in)
3 Oil Cooler Pipe Line
4 O-ring ..... Replace

Removal & Installation Procedure

1. Drain the coolant.
2. Unscrew the bolts (1, 2) and remove the oil cooler pipe line (3).

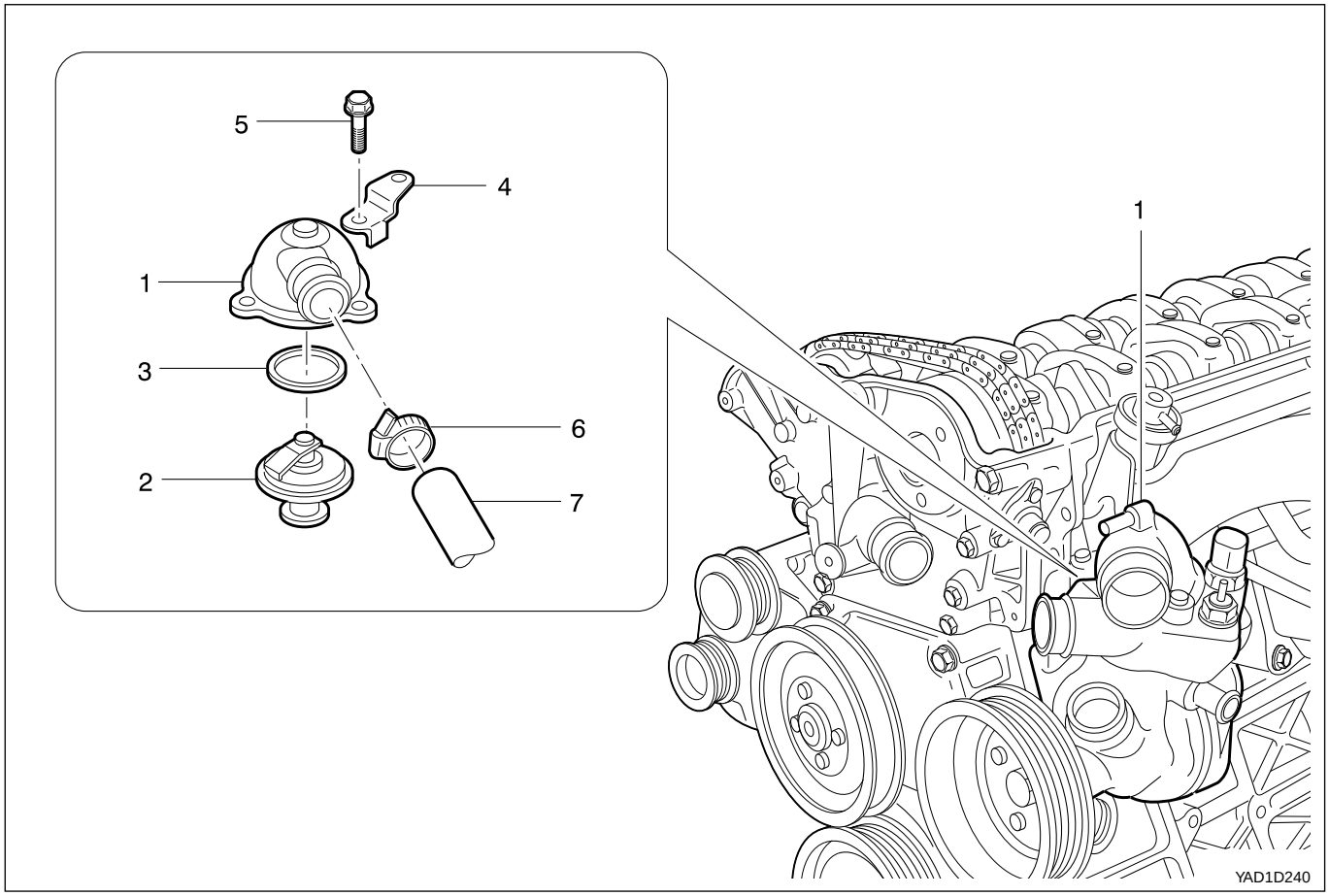
Installation Notice

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

Replace the O-ring with new one.

3. Installation should follow the removal procedure in the reverse order.
4. Fill up the coolant as specified.
5. Check the leaks in the cooling system.

THERMOSTAT (M162 ENGINE)



1 Thermostat Cover
2 Thermostat
3 O-ring
4 Thermostat Cover Bracket
5 Bolt (M6 X 25, 3 pieces)
..... 9 - 11 N•m (80 - 97 lb-in)
6 Hose Mounting Clamp
7 Heater Hose

Removal & Installation Procedure

1. Drain the coolant from the radiator.
2. Loosen the hose mounting clamp (6) and remove the heater hose (7).
3. Unscrew the three bolts (5) and remove the thermostat cover bracket, thermostat cover and the thermostat in order.

Installation Notice

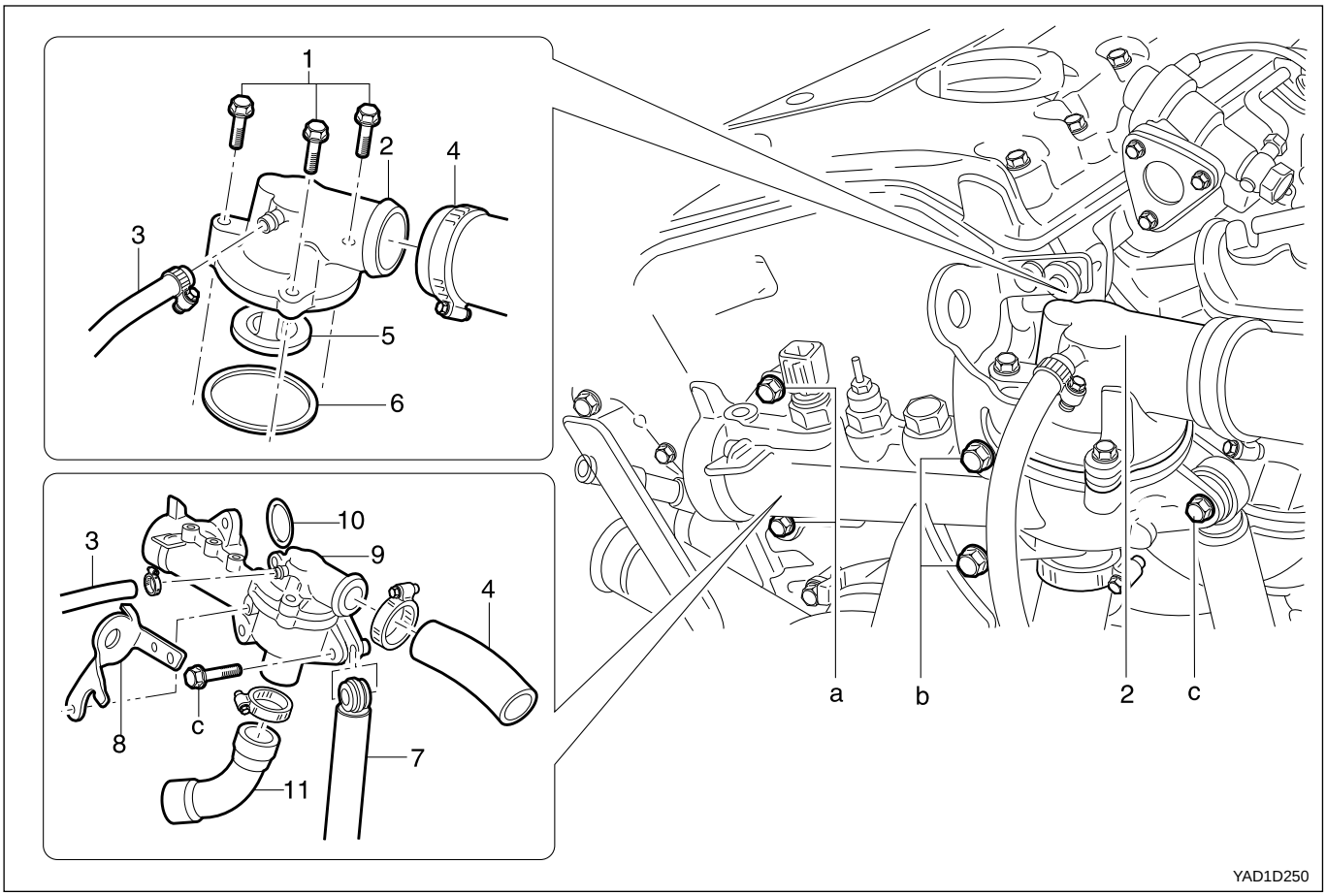
Tightening Torque	9 - 11 N•m (80 - 97 lb-in)

Do not separate the thermostat cover and thermostat.

4. Replace the O-ring if necessary.
5. Check the leakage in the cooling system.

THERMOSTAT AND THERMOSTAT HOUSING ASSEMBLY (M161 ENGINE)

Preceding Work : Removal of viscous clutch



1 Bolt (M6 X 25, 3 pieces)
..... 9 - 11 N•m (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
8 Engine Hanger Bracket
9 Thermostat Housing Assembly
10 O-ring
11 Coolant Bypass Hose

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

   Installation Notice

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

   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).

   Installation Notice

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

7. Unscrew the bolts (a, b) and remove the engine hanger bracket and thermostat housing.

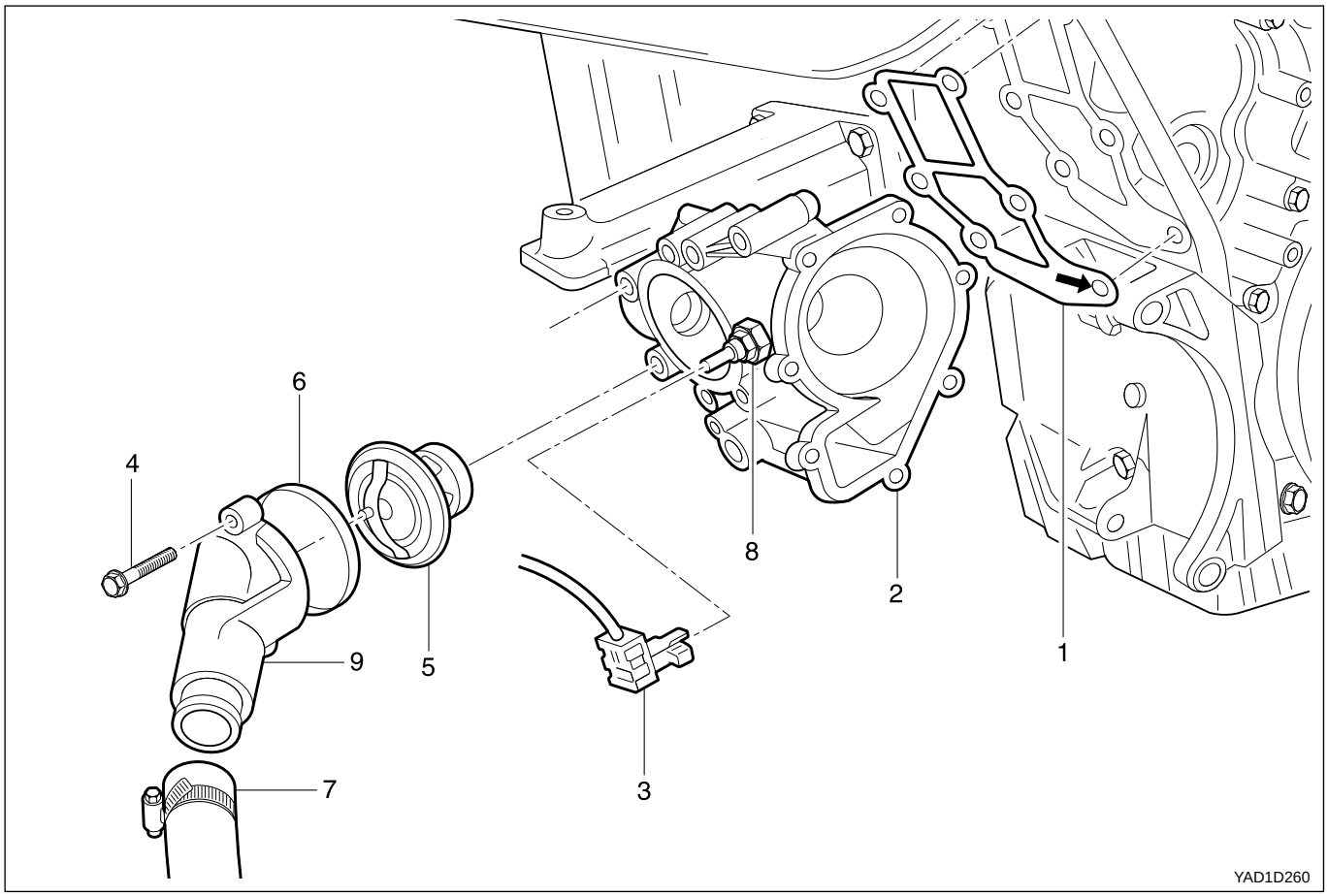
   Installation Notice

Tightening Torque	(a)	9 - 11 N•m (80 - 97 lb-in)
	(b)	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

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.

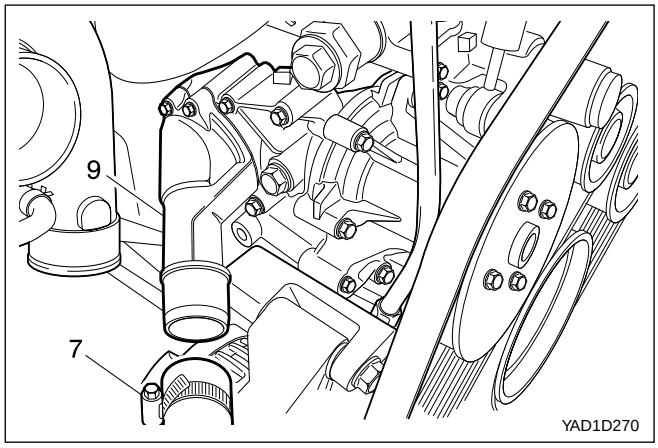
THERMOSTAT AND WATER PUMP HOUSING (DIESEL ENGINE)

Preceding Work : Removal of coolant pump
Removal of thermostat
Removal of alternator



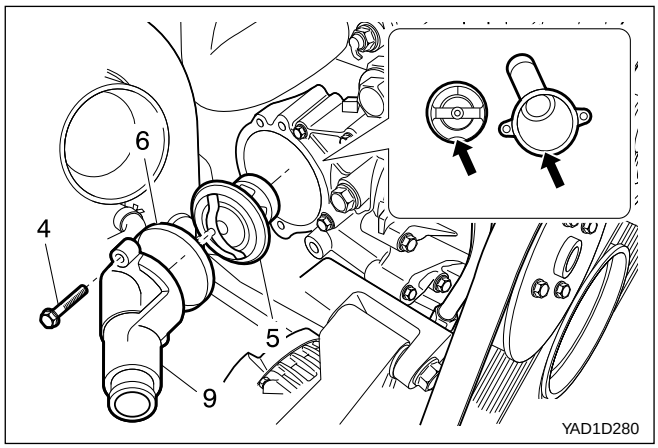
1 Gasket ..... Replace
2 Water Pump Housing
3 Connector
4 Bolt..... 9 - 11 N•m (80 - 97 lb-in)
5 Thermostat
6 Seal ..... Replace
7 Coolant Hose
8 Coolant Temperature Guage
9 Thermostat Housing Cover

Notice: The bolt on the arrow should be installed last.



Removal & Installation Procedure

1. Drain the coolant completely.
2. Disconnect the coolant hose (7) from the thermostat housing cover (9).



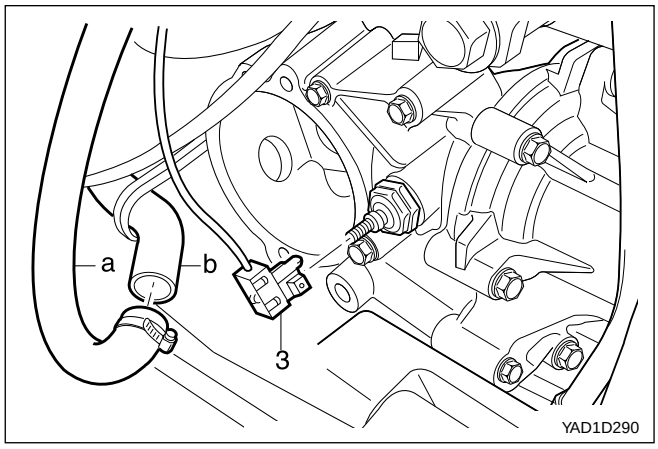
3. Remove the bolts (4) and then remove the thermostat (5) and housing cover (9).

   Installation Notice

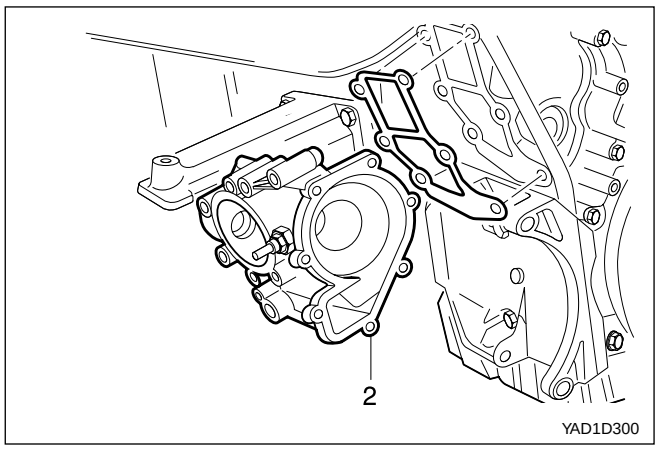
   Align the groove on thermostat and the housing cover rib (arrow).

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

   Replace the seal (6).



4. Disconnect the coolant temperature guage connector (3).
5. Separate the coolant hose (a) and return pipe (b).



6. Remove the water pump housing bolts.

   Installation Notice

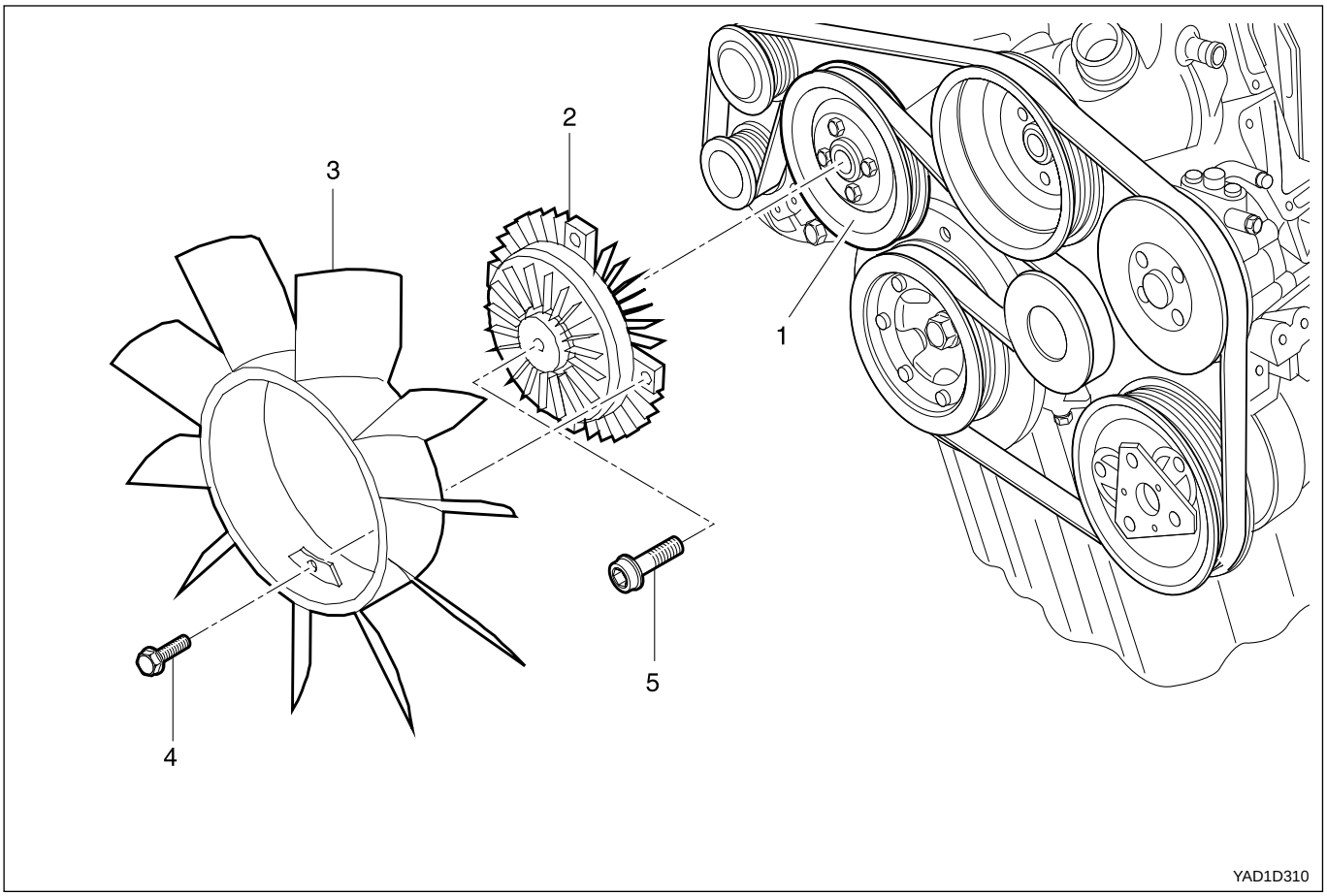
Tightening Torque	9 - 11 N•m (80 - 97 lb-in)

   Clean gasket residues on the sealing surface of water pump and replace the gasket.

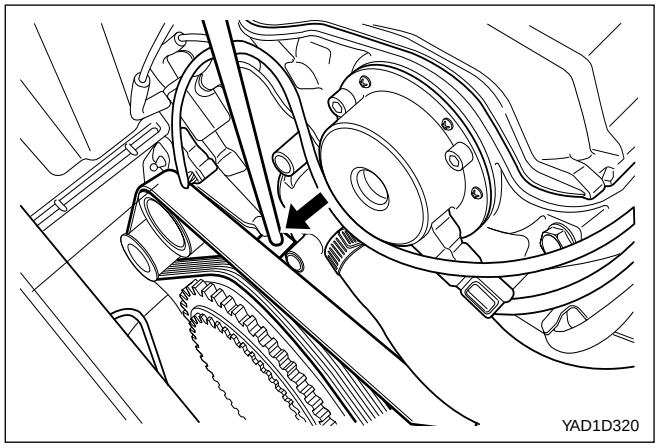
7. Remove he water pump housing (2).
8. Installation should follow the removal procedure in the reverse order.

COOLING FAN AND VISCOUS CLUTCH (M162 ENGINE)

Preceding Work : Removal of cooling fan shroud



1 Cooling Fan Pulley
2 Viscous Clutch
3 Cooling Fan
4 Bolt (M6 X 12, 4 pieces)
..... 9 - 11 N•m (80 - 97 lb-in)
5 Bolt (M10 X 45, 1 piece)
..... 40.5 - 49.5 N•m (29.8 - 36.5 lb-ft)


YAD1D320

Tools Required

603 589 00 40 00 Fan Clutch Holder

Removal & Installation Procedure

1. Remove the engine hanger bracket bolts.

   Installation Notice

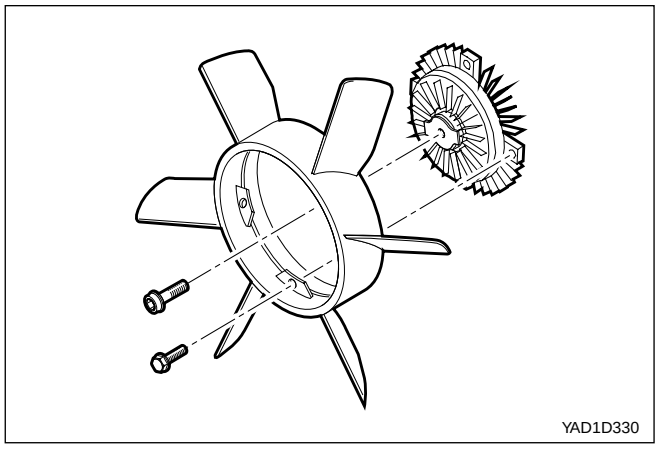
Tightening Torque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

2. Remove the engine hanger bracket.
3. Remove the cooling fan bolts.

   Installation Notice

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

4. Hold the cooling fan pulley using the fan clutch holder 603 589 00 40 00.


YAD1D330

5. Remove the viscous clutch mounting bolts and viscous clutch.

   Installation Notice

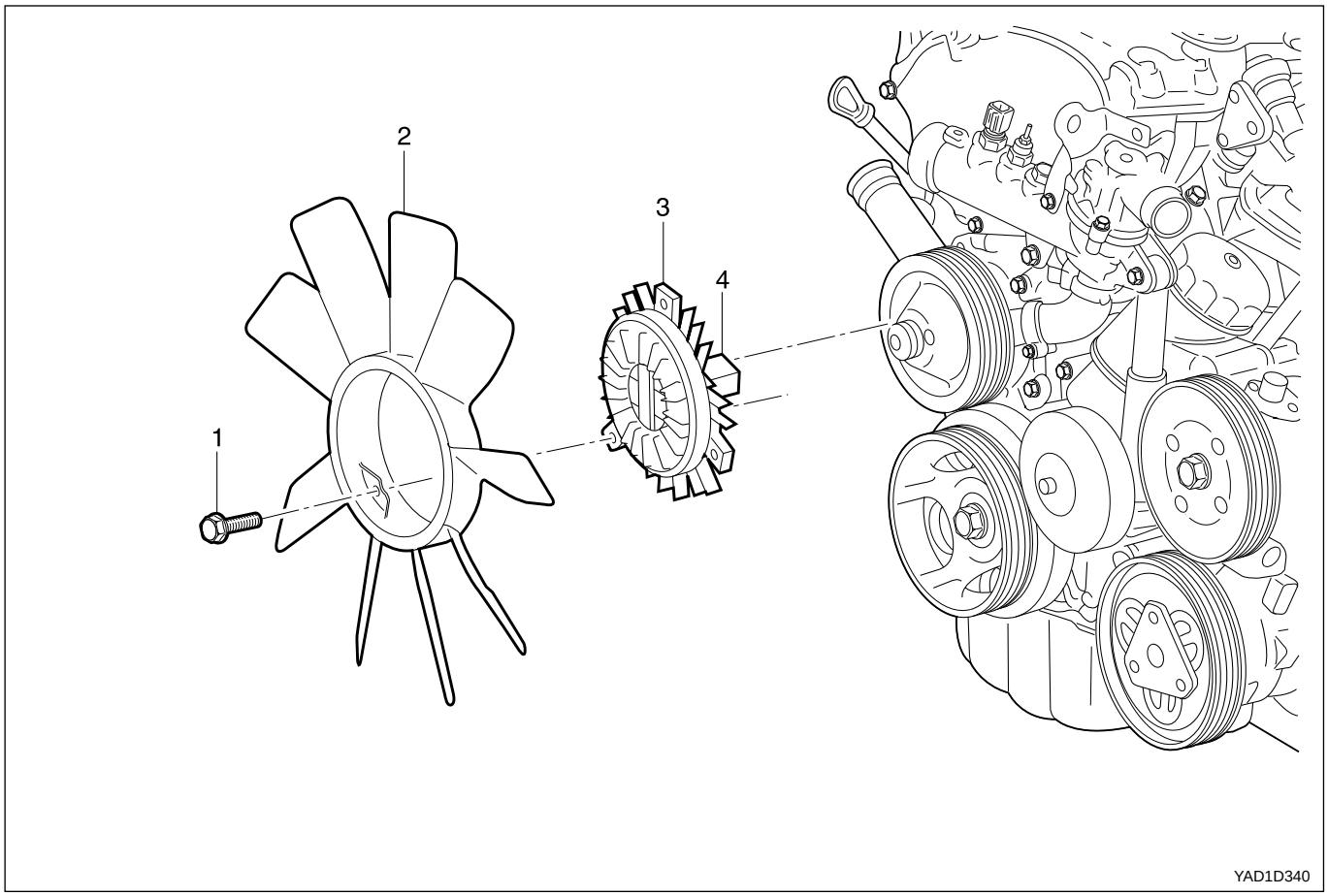
Tightening Torque	40.5 - 49.5 N•m (29.8 - 36.5 lb-ft)

   Important: There are two chambers in the viscous clutch. Be sure to make the viscous clutch stand on the ground not to flow silicone oil into another chamber in the viscous clutch. Do not lay down the clutch.

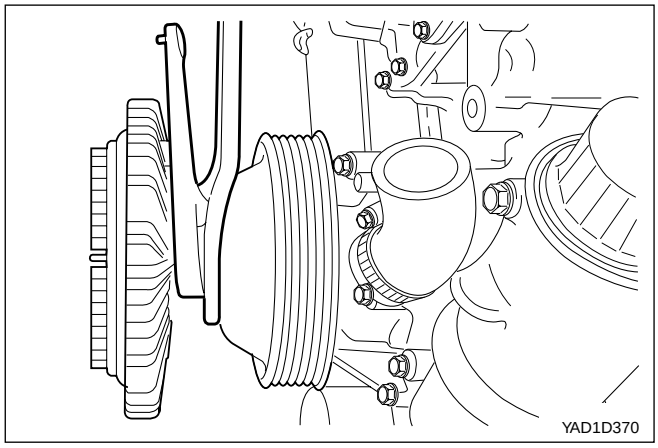
6. Installation should follow the removal procedure in the reverse order.

COOLING FAN AND VISCOUS CLUTCH (M161 ENGINE)

Preceding Work : Removal of cooling fan shroud



1 Bolt (M6 X 14, 3 piece)
..... 9 - 11 N•m (80 - 97 lb-in)
2 Cooling Fan
3 Viscous Clutch
4 Union Nut (Left Threaded Screw)
..... 40.5 - 49.5 N•m (29.8 - 36.5 lb-ft)



Tools Required

111 589 02 01 00 Open End Wrench

111 589 00 40 00 Holder

Removal & Installation Procedure

1. Install the holder 111 589 00 40 00 to the bolt at the pulley as shown in the right figure to hold the pulley.
2. Remove the viscous clutch using an open end wrench 111 589 02 01 00.

   Installation Notice

Tightening Torque	40.5 - 49.5 N•m (29.8 - 36.5 lb-ft)

   The union nut is left threaded screw.

3. Remove the 3 bolts (1) from the viscous clutch and remove the cooling fan and the viscous clutch.

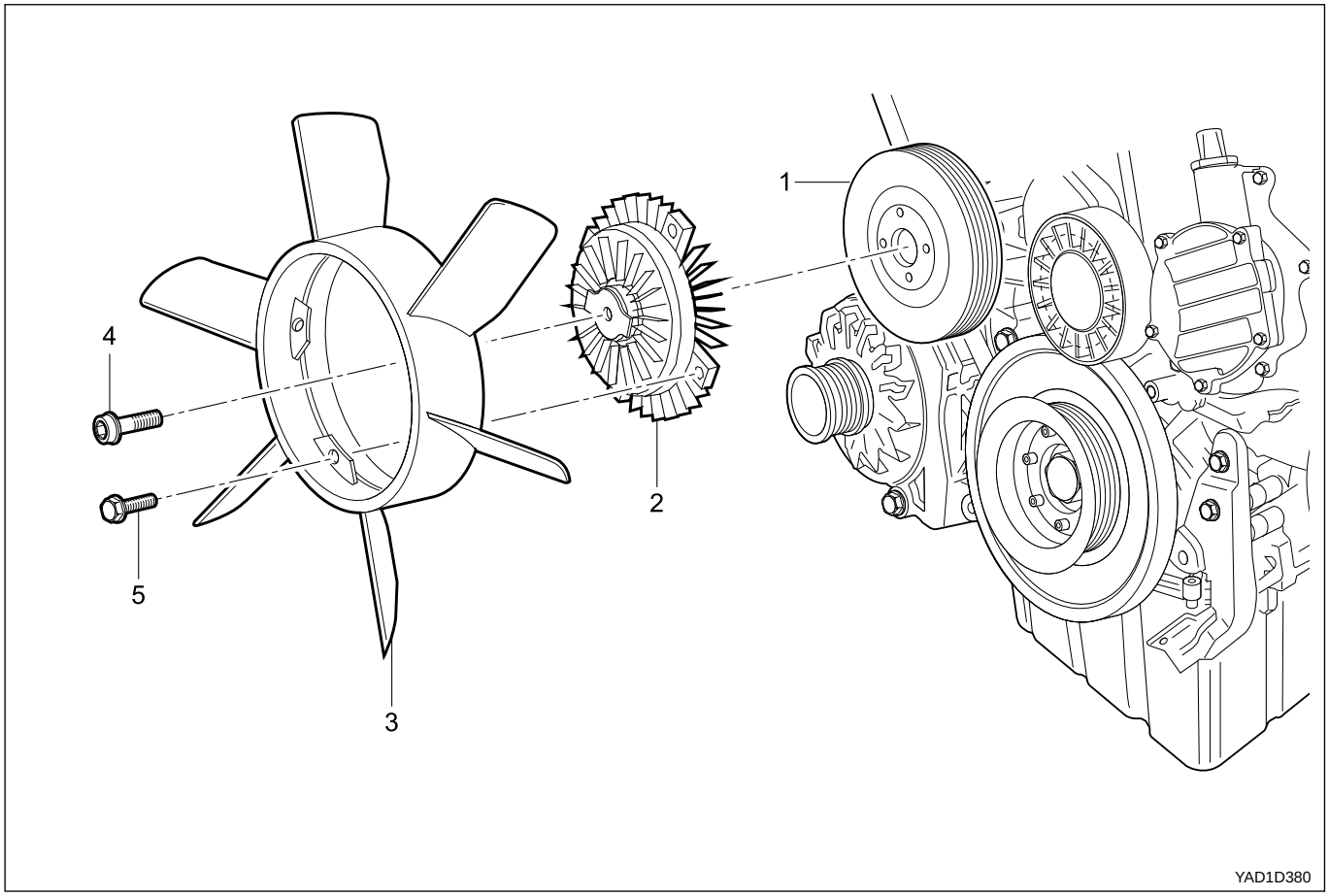
   Installation Notice

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

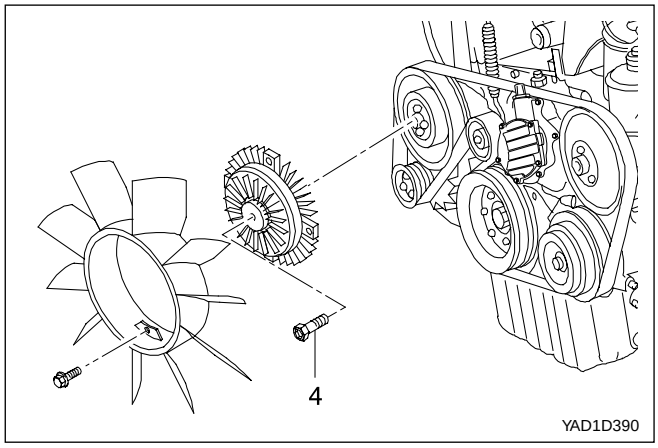
   You may change the procedure (2) and (3) if necessary.

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

COOLING FAN AND VISCOUS CLUTCH (DIESEL ENGINE)



1 Cooling Fan Pulley
2 Viscous Clutch
3 Cooling Fan
4 Bolt..... 40.5 - 49.5 N•m (29.8 - 36.5 lb-ft)
5 Bolt..... 9 - 11 N•m (80 - 97 lb-in)



Tools Required

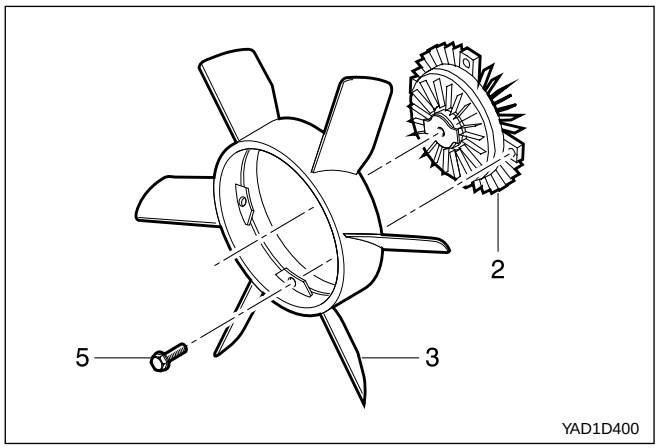
603 589 00 40 00 Fan Clutch Holder

Removal & Installation Procedure

1. Hold the cooling fan pulley with fan clutch holder 603 589 00 40 00 and remove the bolt (4).

   Installation Notice

Tightening Torque	40.5 - 49.5 N•m (29.8 - 36.5 lb-ft)



2. Remove the socket bolt (5) and then remove the cooling fan (3) and viscous clutch (2).

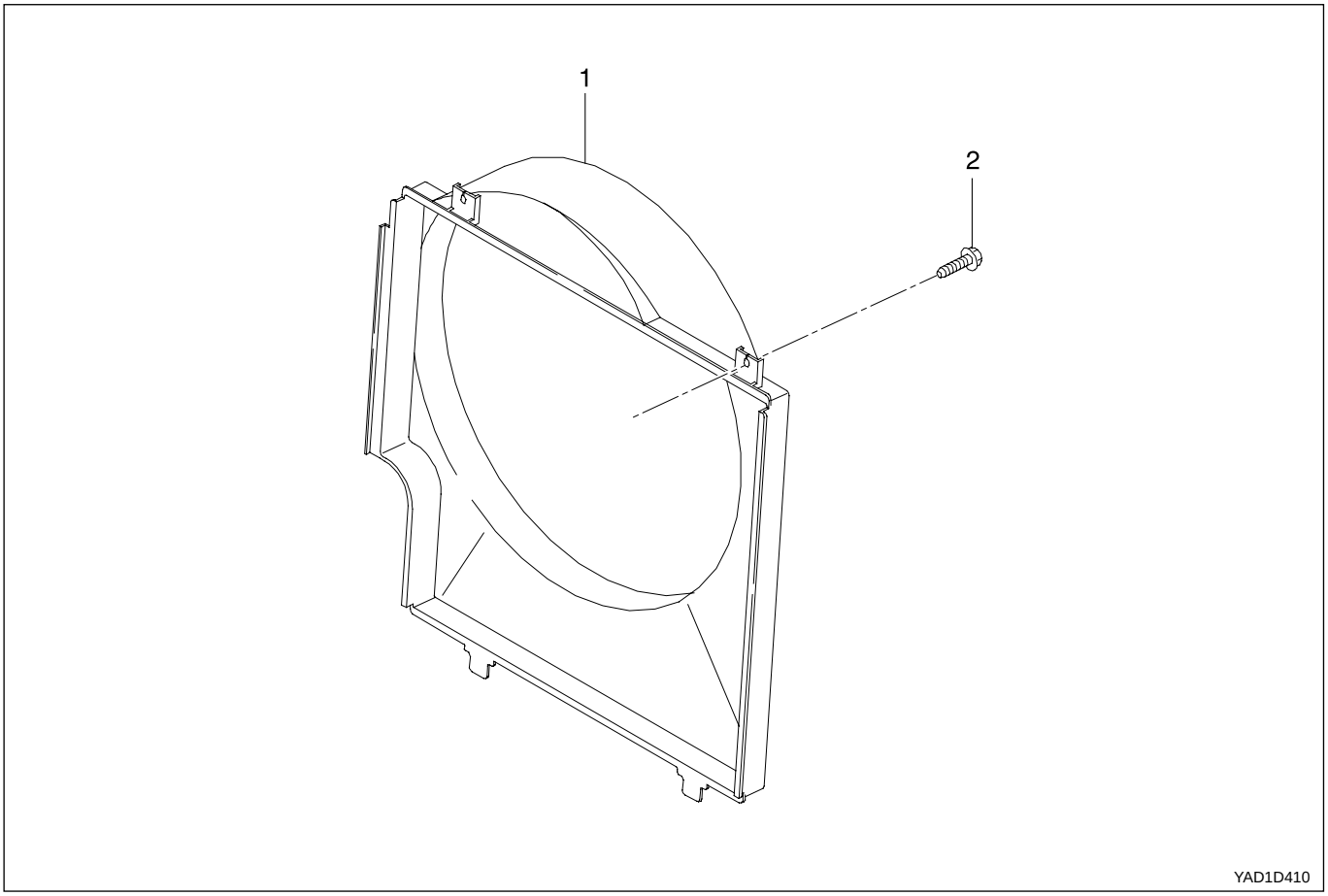
   Installation Notice

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

   Keep the viscous clutch vertically.

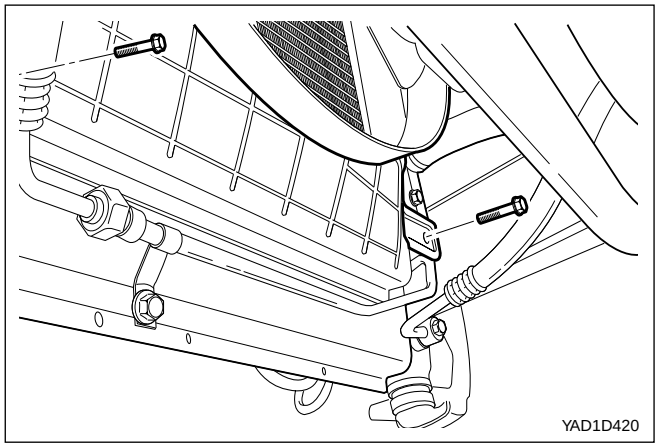
3. Installation should follow the removal procedure in the reverse order.

COOLING FAN SHROUD (GASOLINE ENGINE)



1 Fan Shroud Assembly

2 Bolt..... 3 - 7 N•m (27 - 62 lb-in)



Removal & Installation Procedure

1. Pull out the 2 clips (1) from the fan shroud assembly.
2. Remove the lower fan shroud (2).

   Notice: For installation, exactly align the lower fan shroud pin into the hole of the fan shroud assembly (4) and insert the clips.

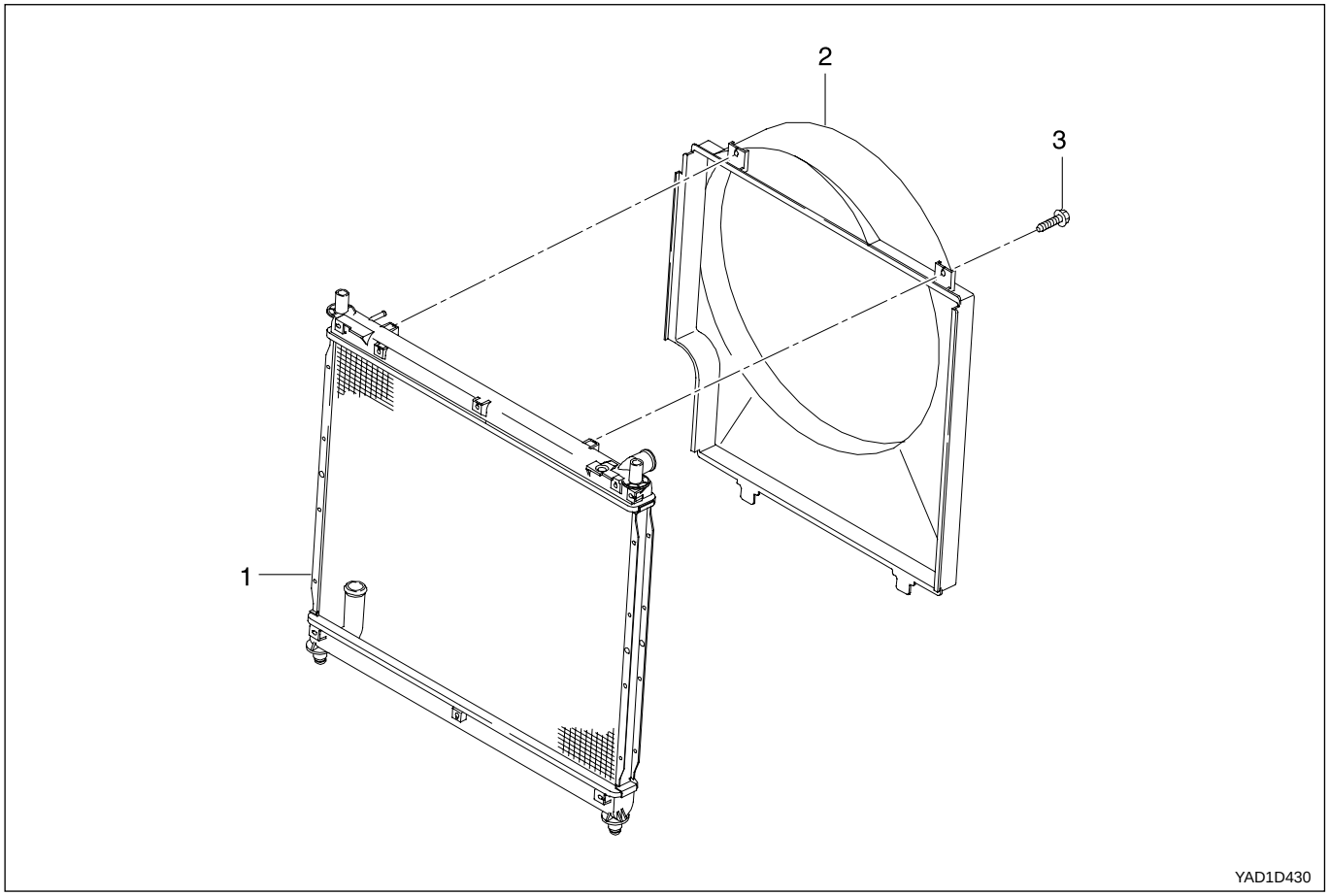
3. Remove the bolts (3) and then remove the cooling fan shroud assembly (4).

   Installation Notice

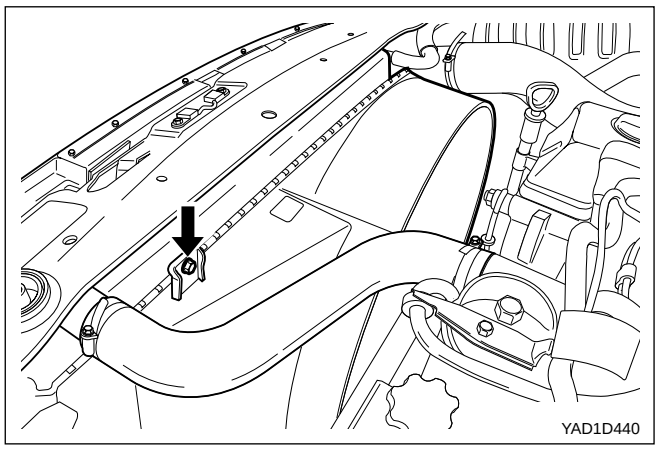
Tightening Torque	3 - 7 N•m (27 - 62 lb-in)

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

COOLING FAN SHROUD (DIESEL ENGINE)



1 Radiator
2 Cooling Fan Shroud
3 Bolt ..... 3 - 7 N•m (27 - 62 lb-in)



Removal & Installation Procedure

Cooling Fan Shroud

1. Remove the radiator deaeration hose and tube.
2. Remove the bolt (3) and then remove the cooling fan shroud (2).

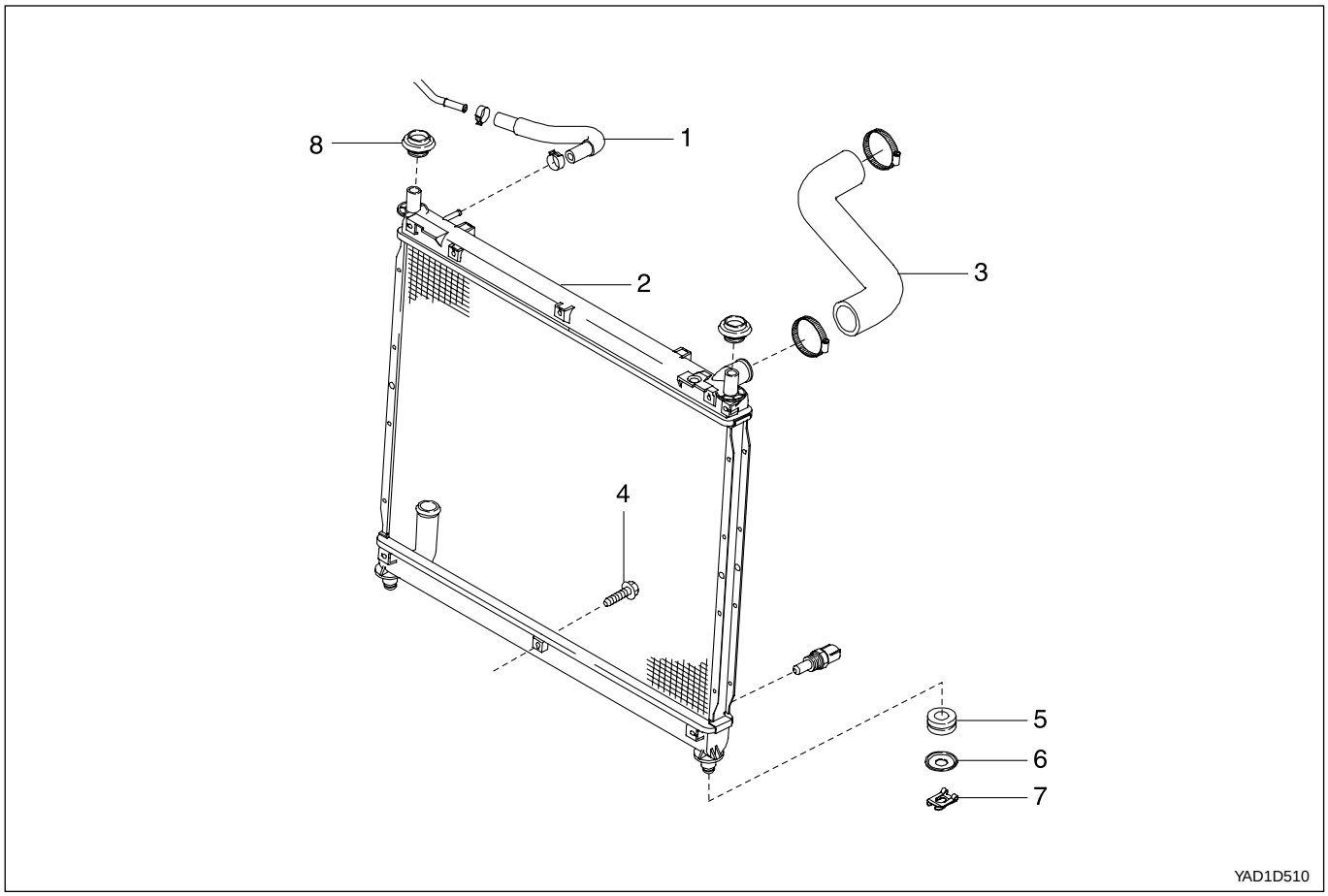
Installation Notice

Tightening Torque	3 - 7 N•m (27 - 62 lb-in)

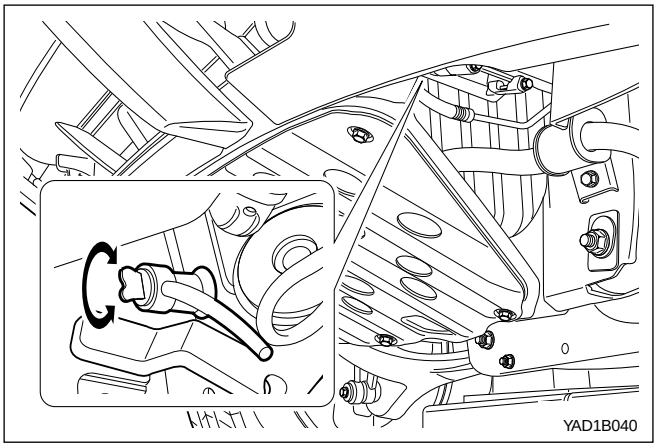
3. Installation should follow the removal procedure in the reverse order.

RADIATOR (GASOLINE ENGINE)

Preceding Work : Removal of cooling fan shroud

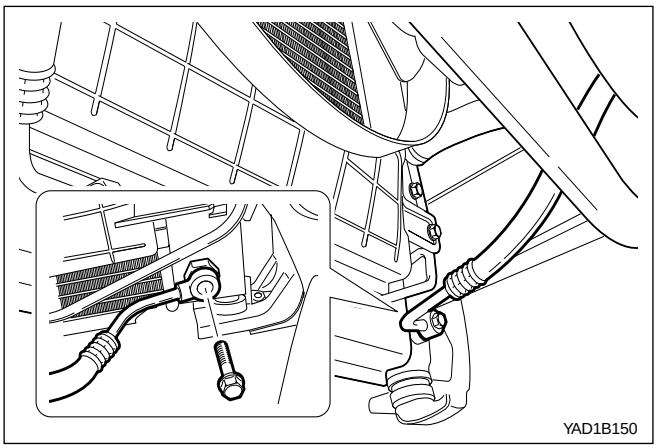


1 Deaeration Hose
2 Radiator
3 Inlet Hose
4 Bolt
5 Lower Radiator Insulator
6 Plate
7 Clip
8 Upper Radiator Insulator


YAD1B040

Removal & Installation Procedure

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


YAD1B150

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

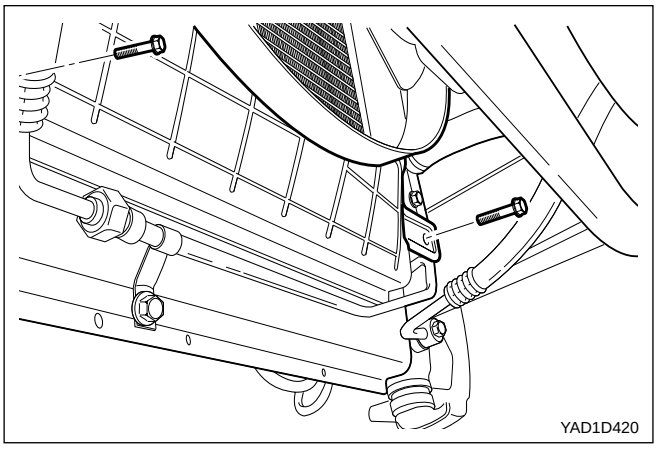
Installation Notice

Tightening Torque	25 - 35 N•m (18 - 26 lb-ft)

4. Remove the mounting bolt (9) from the automatic transmission oil cooler pipe (5) and then disconnect the cooler pipe (5).

Installation Notice

Tightening Torque	3 - 7 N•m (27 - 62 lb-in)

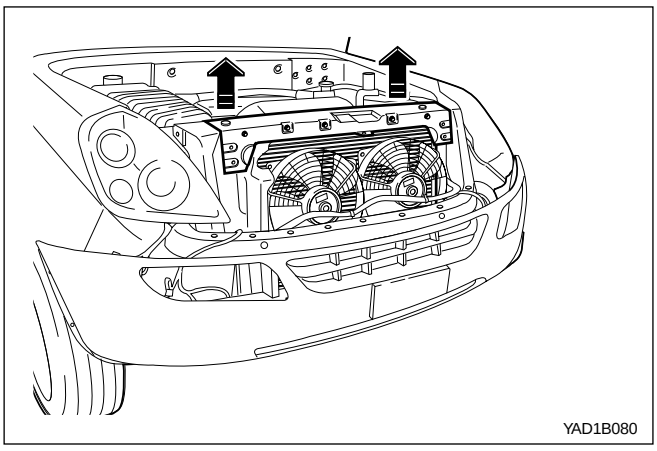

YAD1D420

5. Remove the cooling fan shroud bolts and cooling fan shroud.

Installation Notice

Tightening Torque	3 - 7 N•m (27 - 62 lb-in)

6. Remove the radiator grille mounting screw and radiator grille.


YAD1B080

7. Remove the front and upper member mounting bolts and front end upper member.

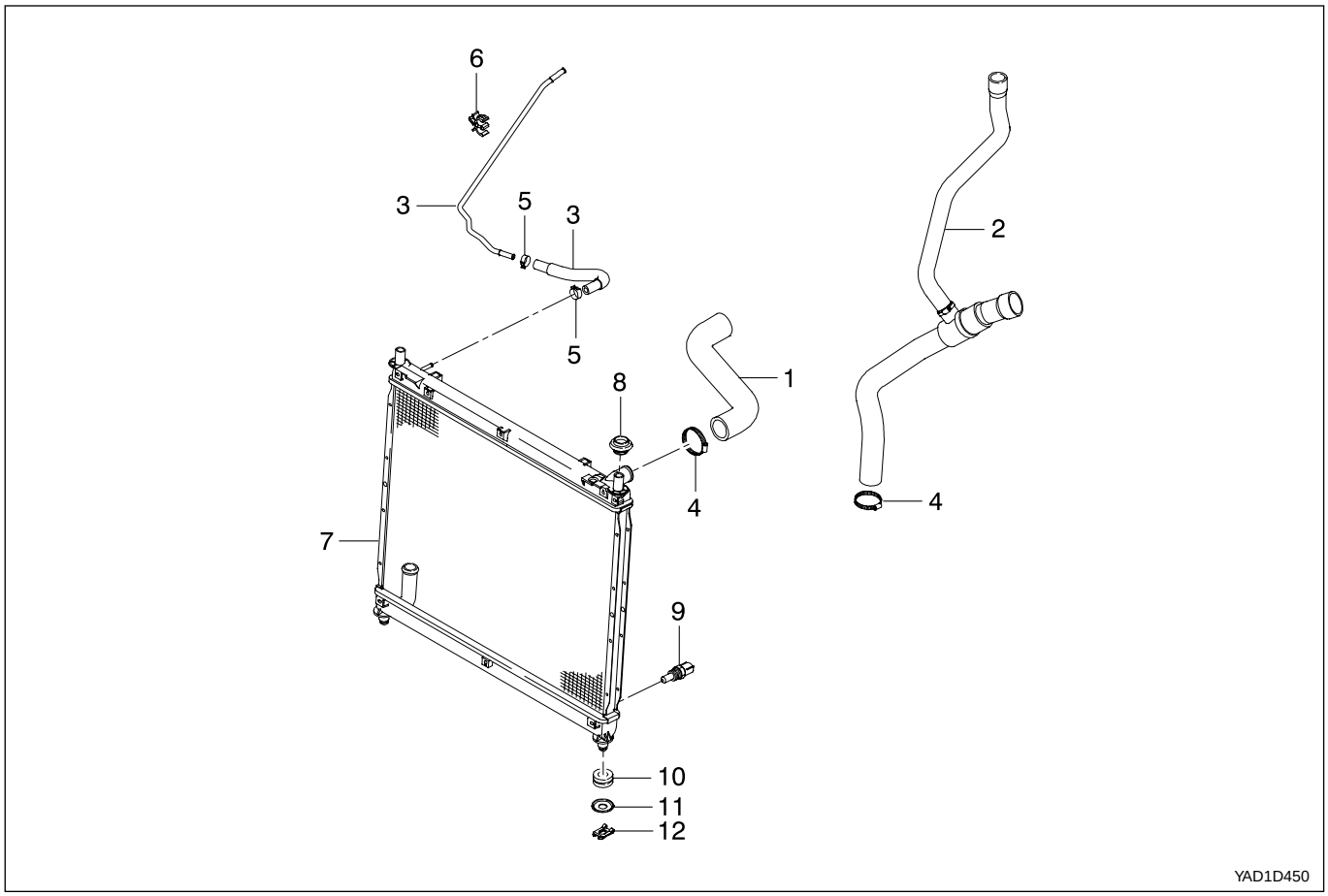
Installation Notice

Tightening Torque	30 - 40 N•m (22 -30 lb-ft)

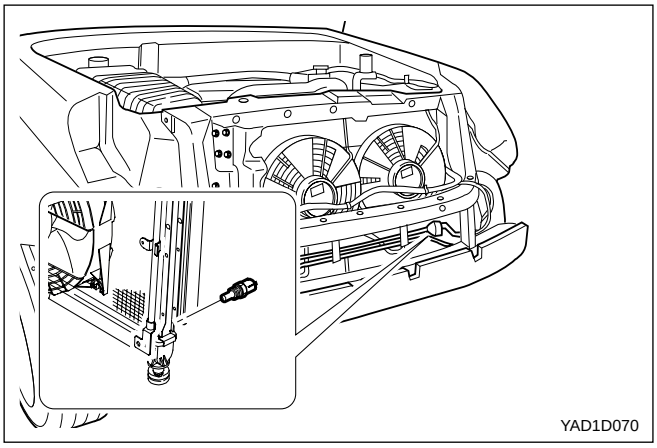
8. Remove the radiator
9. Check the radiator pin for crack, damage, leakage and bending and replace it if necessary.
10. Installation should follow the removal procedure in the reverse order.
11. Check for leakage in the cooling system.

RADIATOR (DIESEL ENGINE)

Preceding : Removal of cooling fan shroud

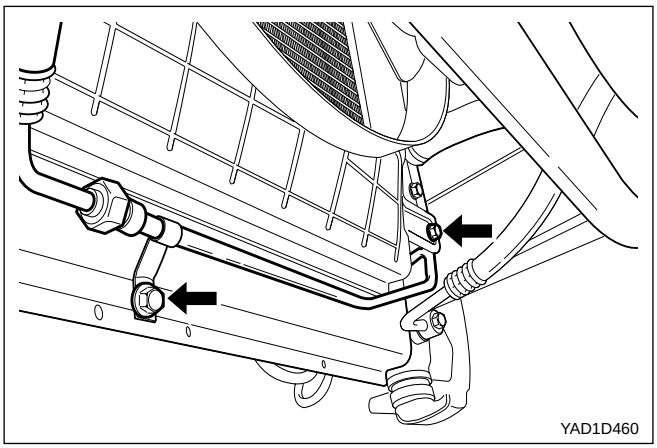


1 Radiator Inlet Hose
2 Radiator Outlet Hose
3 Radiator Deaeration Tube & Hose
4 Clamp
5 Spring Clamp
6 Clip
7 Radiator
8 Upper Insulator
9 Coolant Thermo Switch
10 Lower Insulator
11 Lower Radiator Mounting Plate
12 Clip


YAD1D070

Removal & Installation Procedure

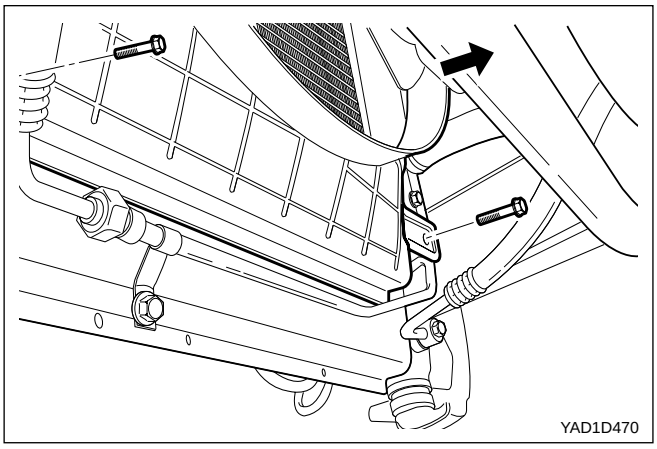
1. Drain coolant from the radiator.
2. Remove the coolant thermoswich connector from radiator.
3. Remove the each coolant hose.


YAD1D460

4. Remove the automatic transmission oil cooler hose and cooling line.

Installation Notice

Tightening Torque	25 - 35 N•m (18 - 26 lb-ft)

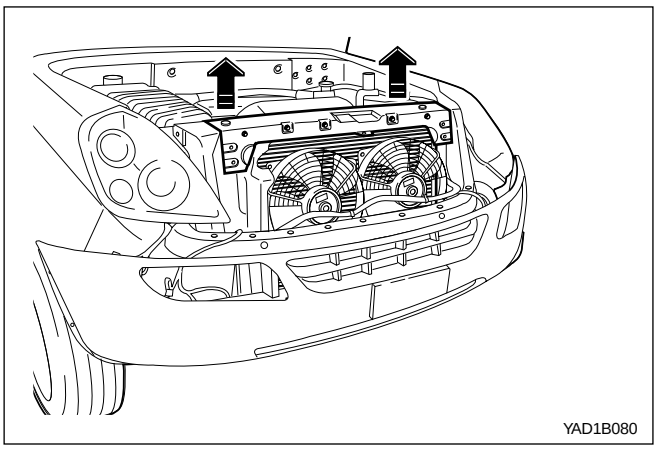

YAD1D470

5. Remove the cooling fan shroud bolts and cooling fan shroud.

Installation Notice

Tightening Torque	3 - 7 N•m (27 - 62 lb-in)

6. Remove the radiator grille mounting screw and radiator grille.


YAD1B080

7. Remove the front and upper member mounting bolts and front end upper member.

Installation Notice

Tightening Torque	30 - 40 N•m (22 - 30 lb-ft)

8. Remove the radiator.
9. Check the radiator pin for crack, damage, leakage and bending and replace it if necessary.
10. Installation should follow the removal procedure in the reverse order.
11. Check for leakage in the cooling system.

SPECIFICATION

GENERAL SPECIFICATIONS

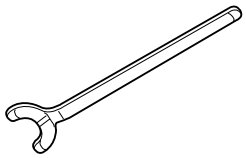
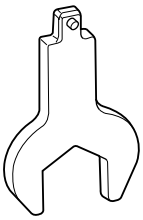
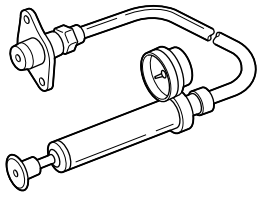
Application		Unit	Gasoline Engine	Diesel Engine
Cooling System	Type	-	Water Cooling Forced Circulation	←
Coolant	Capacity	L	11.3	11.0
Thermostat	Type	-	Wax Pellet Type	←
	Initial Opening Temp.	°C (°F)	82 (180)	←
	Fully Opening Temp.	°C (°F)	95 (203)	←
	Fully Closing Temp.	°C (°F)	80 (176)	←
	Stroke	mm	7	←
Cooling Fan	Type	-	Electric Cooling Fan	←
	Blades	-	5	←
	Diameter	mm	320	←
	Low Speed ON Temp.	°C (°F)	95 (203)	88 (190)
	Low Speed OFF Temp.	°C (°F)	90 (194)	85 (185)
	High Speed ON Temp.	°C (°F)	105 (221)	92 (198)
	High Speed OFF Temp.	°C (°F)	100 (212)	89 (192)
	High Speed ON Temp. (By A/C Pres-	kPa (psi)	269.8 (1860)	←
Coolant Reservoir	sure)	kPa (psi)	118 - 147 (17.1 - 21.3)	←
	Pressure Valve Opening Pressure	kPa (psi)	9.8 (1.4)	←
Water Pump	Vacuum Valve Opening Pressure	-	Turbo Centrifugal	←
	Type	mm	65	←
	Impeller Diameter	-	8	←
Radiator	Impeller Blades	-	Cross-flow	Down-flow
	Type	mm	701	←
	Core Width	mm	372	←
	Core Height	mm	18	←
	Core Thickness	Kcal/h	45,000	←
Coolant Temperature Gauge	Minimum Radiation Capability	Ω	185.2	←
	Resistance (at 50 °C (122° F))	Ω	47.4	←
	Resistance (at 80 °C (176° F))	Ω	28.2	←
Engine Coolant Temperature Sensor	Resistance (at 105 °C (221° F))	K Ω	3.33 - 37.8	←
	Resistance (at 20 °C (68° F)) 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		N•m	Lb-Ft	Lb-In
Automatic Transmission Oil Cooler Pipe		20	15	-
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
Engine Hanger Bracket and Coolant Outlet Port Bolt (M162 Engine)		22.5 - 27.5	16.6 - 20.3	-
Oil Cooler Pipe Line Bolt (M161 Engine)		9 - 11	-	80 - 97
Radiator Mounting Bracket Bolt		3 - 7	-	27 - 62
Tensioning Device Shock Absorber Bolt (M161 Engine)		22.5 - 27.5	16.6 - 20.3	-
Thermostat Cover Bolt (Diesel Engine)		9 - 11	-	80 - 97
Thermostat Cover Bolt (M161 Engine)		9 - 11	-	80 - 97
Thermostat Cover Bracket Bolt (M162 Engine)		9 - 11	-	80 - 97
Thermostat Housing Bolt (M161 Engine)	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 (Diesel Engine)		9 - 11	-	80 - 97
Water Pump Housing Bolt (M161 Engine)	M6	9 - 11	-	80 - 97
	M8	22.5 - 27.5	16.6 - 20.3	-
Water Pump Mounting Bolt (Diesel Engine)		9 - 11	-	80 - 97
Water Pump Mounting Bolt (M162 Engine)		22.5 - 27.5	16.6 - 20.3	-
Water Pump Pulley Bolt (Diesel Engine)		9 - 11	-	80 - 97
Water Pump Pulley Bolt (M161 Engine)		9 - 11	-	80 - 97

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS TABLE

 YAD1D350	**111 589 00 40 00** **Holder**
 YAD1D360	**111 589 02 01 00** **Open End Wrench**
 YAD1D020	**124 589 15 21 00** **Leakage Tester**
KAA1C2D0	**603 589 00 40 00** **Fan Clutch Holder**

SECTION 1E

ENGINE ELECTRICAL

CAUTION: 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.

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DESCRIPTION AND OPERATION

BATTERY

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 re-charging 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.

   Notice: 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.

Caution: 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.

Caution: Do not attach the cable directly to the negative 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.

GENERATOR

Generators are equipped with internal regulators. Unlike three-wire generators, the generator 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.

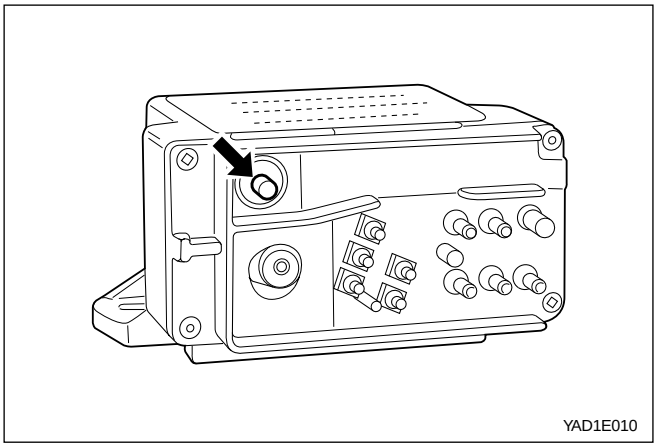
DIAGNOSTIC INFORMATION AND PROCEDURE

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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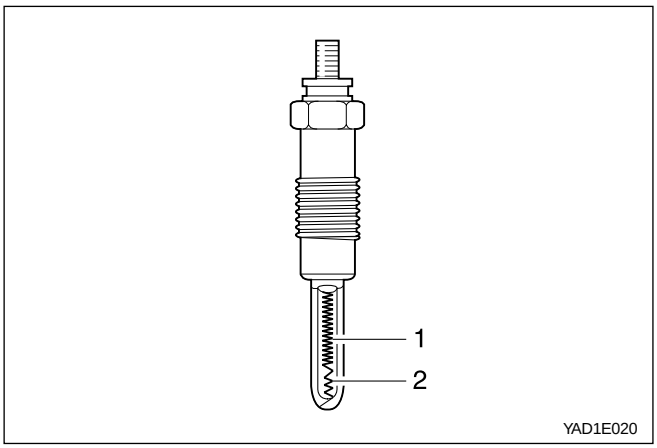

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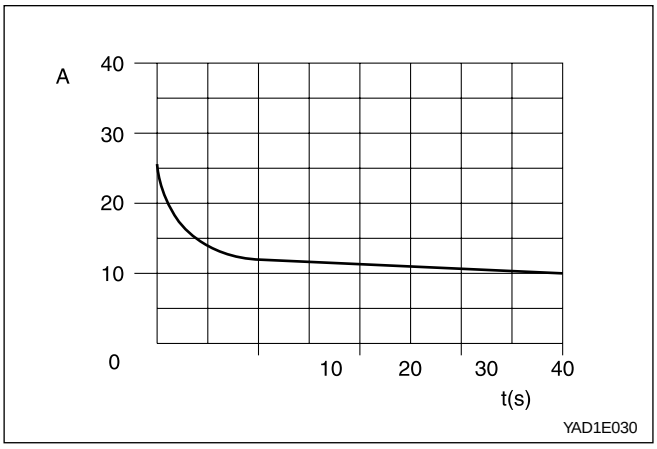

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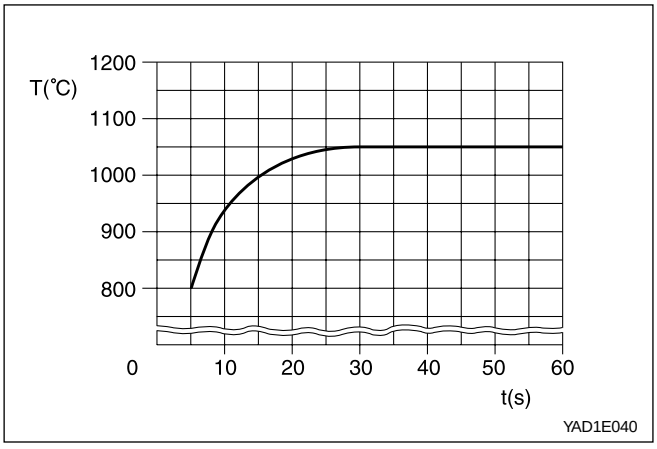

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PREHEATING SYSTEM (DIESEL ENGINE)

General information

The preheating system consists of control relay, coolant temperature sensor and glow plugs.

1. Preheating time - control relay.

   Control relay functions as followings :

   - Switching of preheating current.
   - Indication of preheating finish.
   - Control of preheating sequence.
   - Indication of fault.

2. Coolant temperature sensor.

   Coolant temperature sensor senses coolant's temperature and signals it to the preheating relay continuously.

3. Glow plug

   The glow plug parts are housing with M12 ´ 1.25 thread and heating pin in housing. It is connected in a parallel circuit with the specified voltage of 11.5 V.

   The heating element has a heating coil and a control coil and they are connected in series.

4. Current and temperature of glow plug

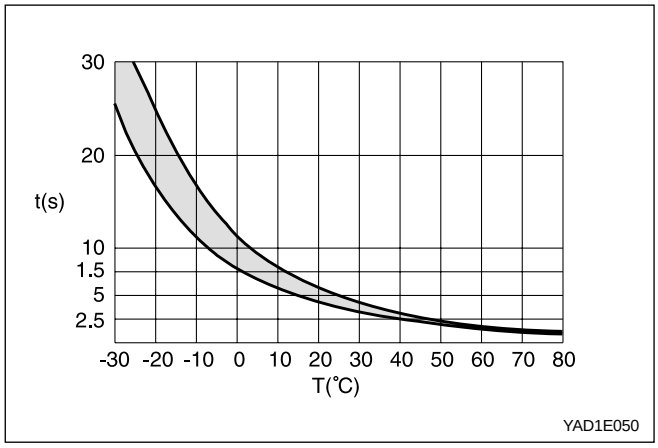
   - Current of glow plug

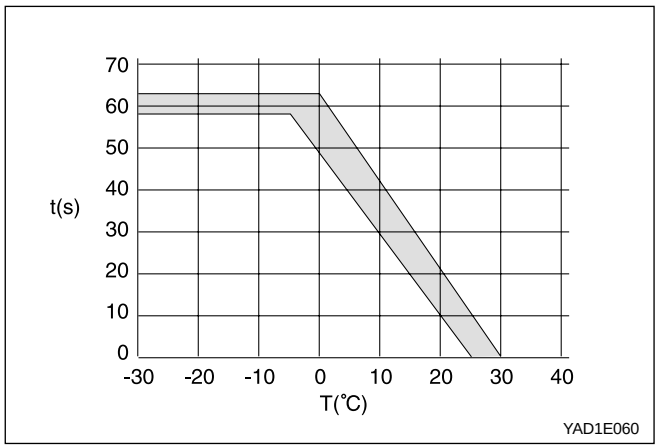
     While the preheating system operates, current of about 30 A flows in each glow plug and temperature of heating coil rises very fast.

     Due to the rise of temperature, the resistance of control coil increases therefore the current is controlled to about 8 - 15A and that protects the glow plug from overheating.

   - Temperature of glow plug

     The temperature of the glow plug reaches up to 900 °C (1,652 °F) after about 9 seconds and up to 1,050 °C (1,922 °F) after 30 seconds.





Preheating System Operation

1. Preheating before start.

   Preheating time is different by coolant temperature and it is on until the glow indicator light goes off.

2. Preheating after start.

   Preheating continues for max. 60 seconds to rise in characteristic of warming-up on engine after starting too.

3. Monitoring on glow plug.

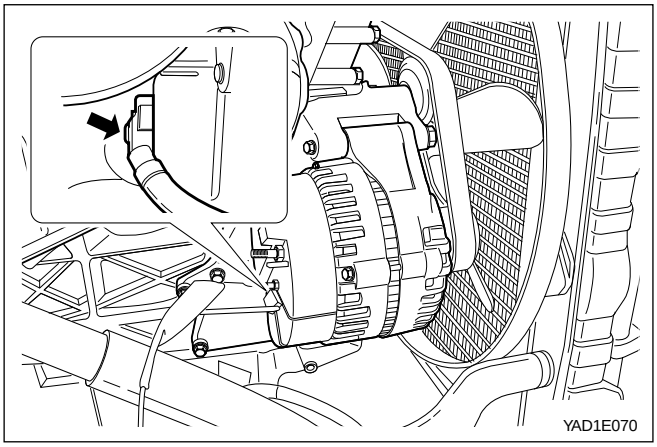
   Glow plugs are monitored by low current by the micro processor in control relay respectively while running the engine.

   If glow indicator comes on after starting for about one minute, it indicates one or several plugs are faulty.

	Problem	Possible Cause
1	Glow indicator does not come on in preheating time and comes on after starting the engine.	One or several glow are faulty
2	Glow indicator does not come on while preheating and after starting engine.	Faulty glow indicator Faulty circuit of glow indicator Faulty control relay
3	Glow indicator does not come on and engine's starting is difficult or does not start at all.	Circuits short in one or several glow plugs Faulty preheating circuits Faulty control relay
4	Glow indicator comes on after starting for about one minute.	One or several glow plugs are faulty
5	Glow indicator comes on constantly.	Faulty circuit of glow indicator Faulty control relay
6	Preheating time until glow indicator goes off is too short/long.	Faulty coolant temperature sensor Faulty control relay Short/Open circuit in wire.

REPAIR INSTRUCTIONS

ON-VEHICLE SERVICE



GENERATOR (GASOLINE ENGINE)

Preceding Work : Removal of the polly V-belt

Removal & Installation Procedure

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

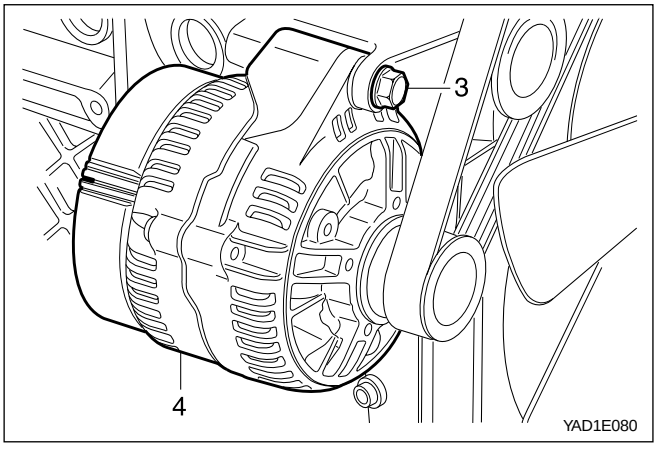
Installation Notice

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

3. Unscrew the nut and disconnect the terminal (2).

Installation Notice

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

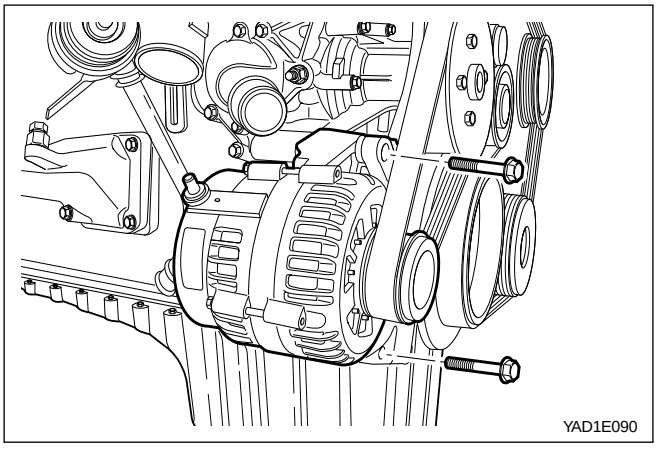


4. Unscrew the combination bolt (3).

Installation Notice

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

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



GENERATOR (DIESEL ENGINE)

Preceding Work: Removal of the polly V-belt

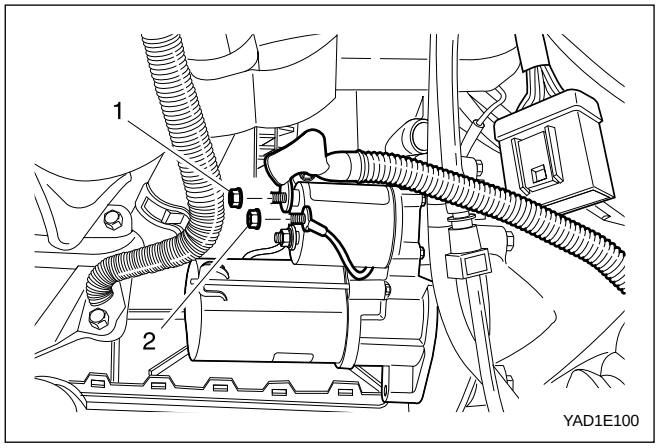
Removal & Installation Procedure

1. Disconnect the negative battery terminal.
2. Disconnect the plug connection.
3. Unscrew the bolts and take out the generator.

Installation Notice

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

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



STARTER

Removal & Installation Procedure

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

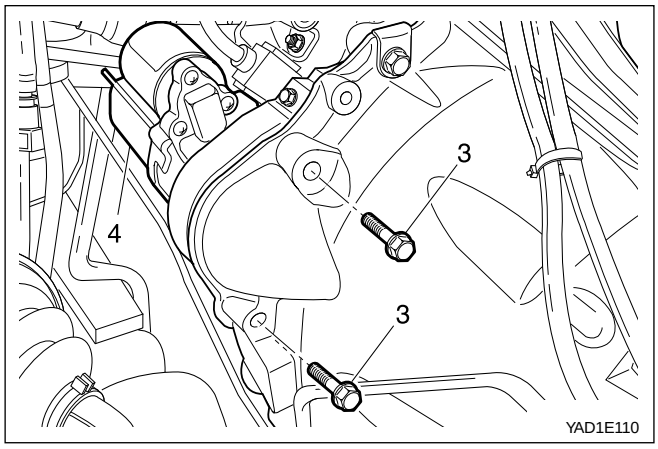
Installation Notice

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)

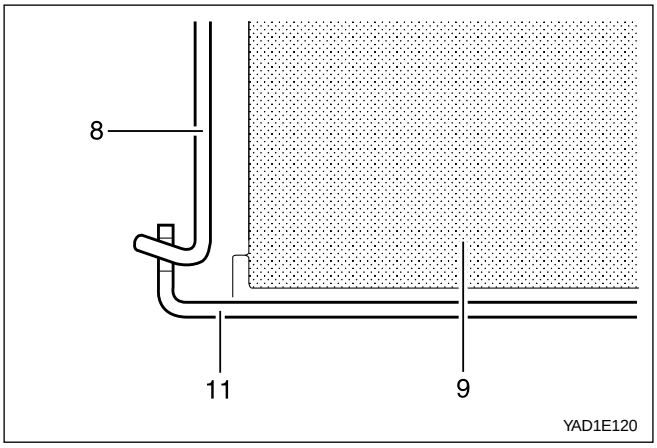


4. Unscrew the mounting bolts (3) of starter.

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.

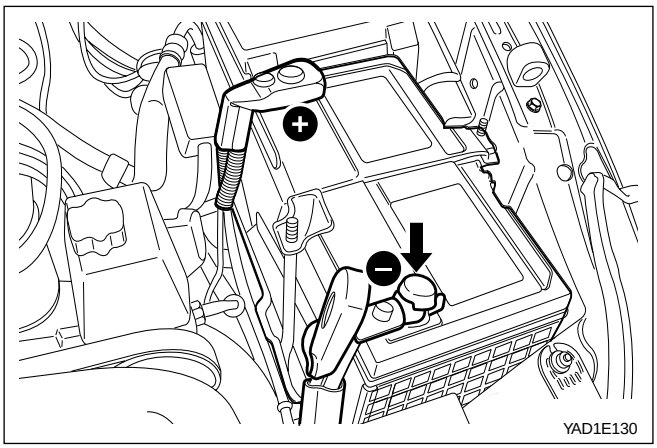


BATTERY

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

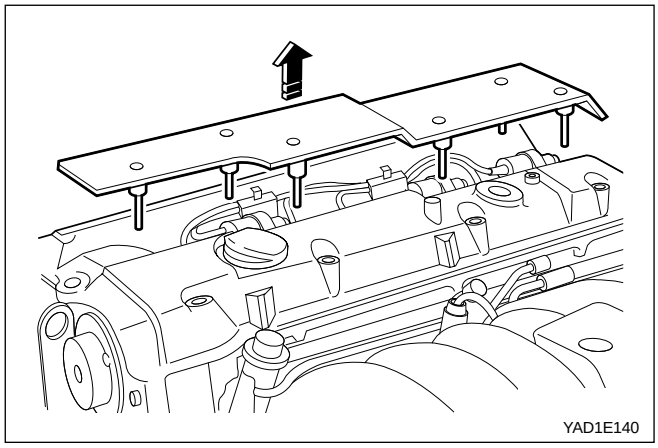
Tightening Torque	12 - 18 N•m (9 - 13 lb-ft)

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.


YAD1E140

SPARK PLUG AND IGNITION COIL (GASOLINE ENGINE)

Preceding Work : Removal of intake air duct

Tools Required

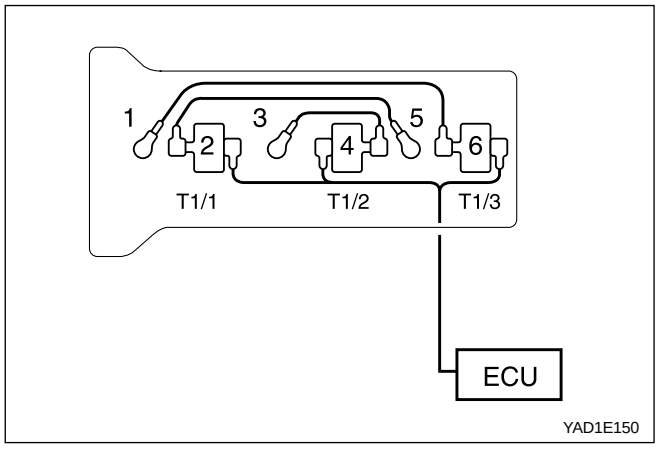
120 589 02 09 00 Spark Plug Wrench

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)



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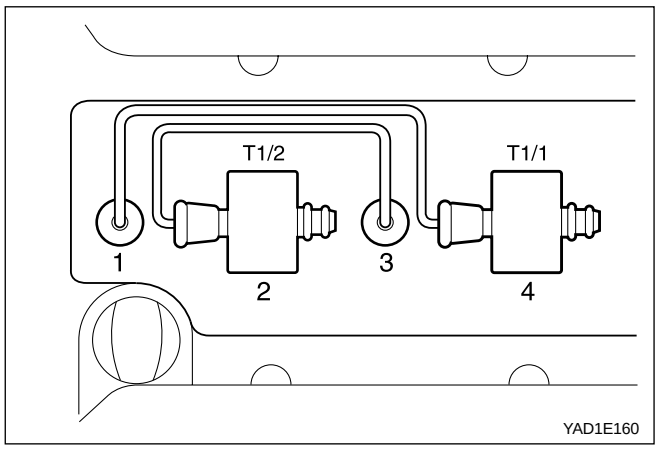


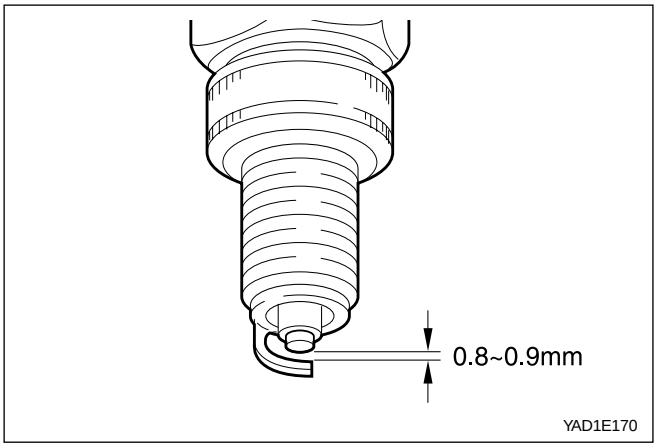
YAD1E160

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.
  - M162 ENGINE
    T 1/1 : Cylinder 2 and 5
    T 1/2 : Cylinder 3 and 4
    T 1/3 : Cylinder 1 and 6
  - M161 ENGINE
    T 1/1 : Cylinder 1 and 4
    T 1/2 : Cylinder 2 and 3

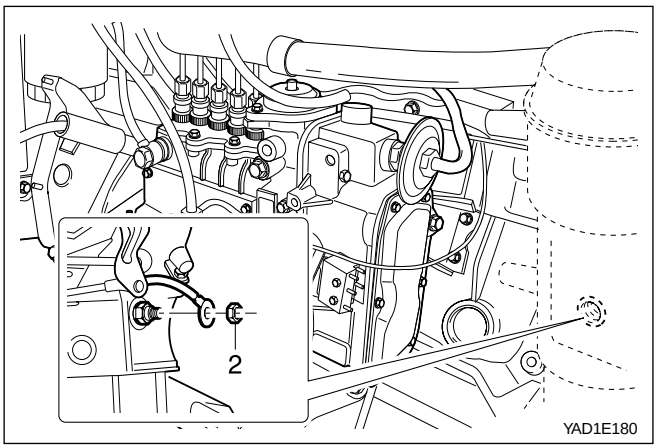


5. Remove the spark plug using the spark plug wrench 120 589 02 09 00.

Installation Notice

Tightening Torque	25 - 30 N•m (15 - 22 lb-ft)
Clearance	0.8 + 0.1 mm

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



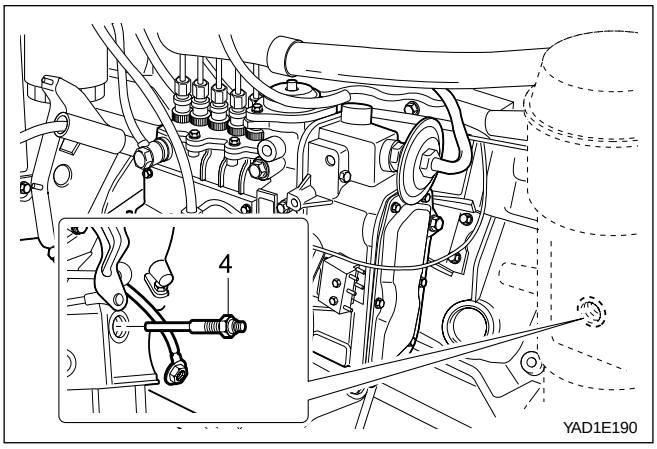
GLOW PLUG (DIESEL ENGINE)

Removal & Installation Procedure

1. Disconnect the negative battery cable.
2. Remove the nut (2).

Installation Notice

Tightening Torque	4 N•m (35 lb-in)



3. Remove the glow plug (4).

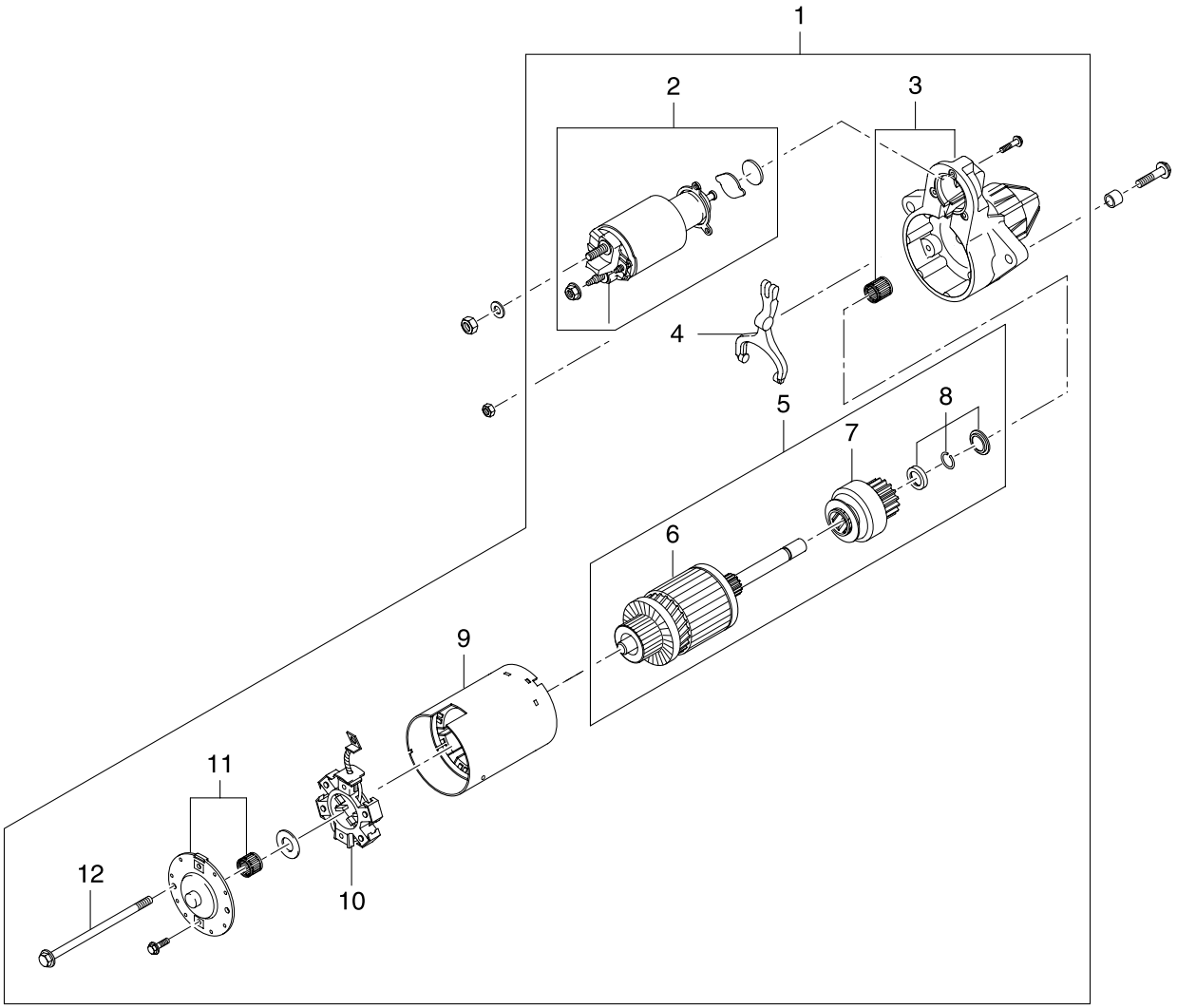
Installation Notice

Tightening Torque	20 N•m (15 lb-ft)

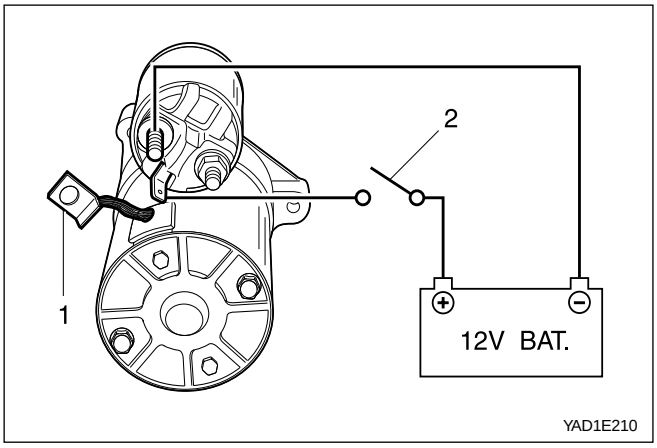
4. Installation should follow the removal procedure in the reverse order.

UNIT REPAIR

STARTER



1 Starter Motor Assembly
2 Starter Solenoid Assembly
3 Starter Housing
4 Shift Lever
5 Armature Set
6 Armature
7 Pinion Gear Assembly
8 Ring Set
9 Field Frame Assembly
10 Brush Holder Assembly
11 Contact End Frame Assembly
12 Starter Through – Bolts

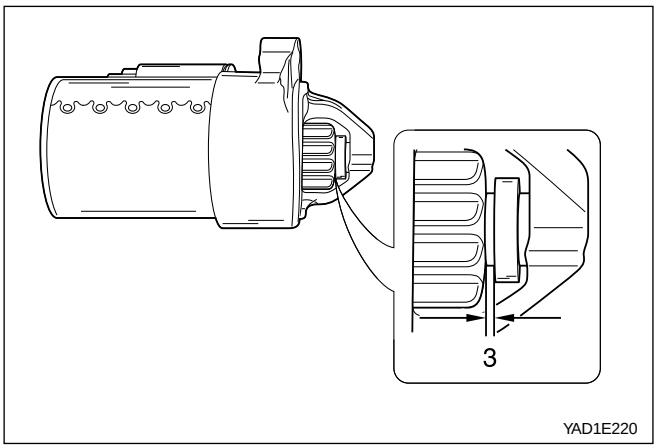


YAD1E210

Inspection/Measurement (Before the Overhaul)

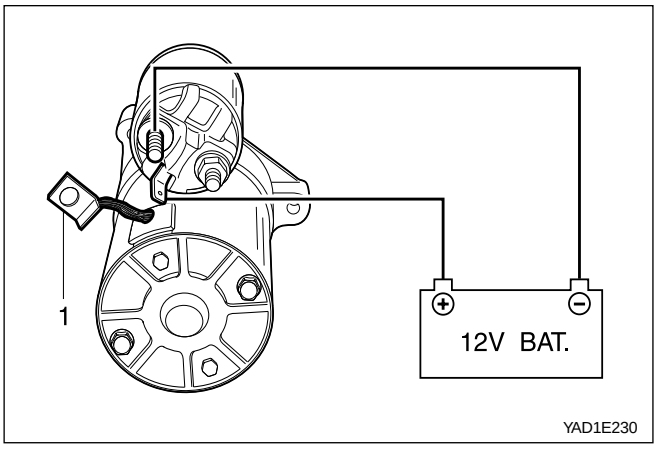
1. Remove the starter. Refer to “Starter” in this section.
2. Pinion clearance inspection.
   - Disconnect the starter motor terminal M (1).
   - Connect the 12-volt battery lead to the starter motor terminals M and S.

   Notice: Complete the testing in a minimum amount of time to prevent overheating and damaging the solenoid. (in 10 seconds)



YAD1E220

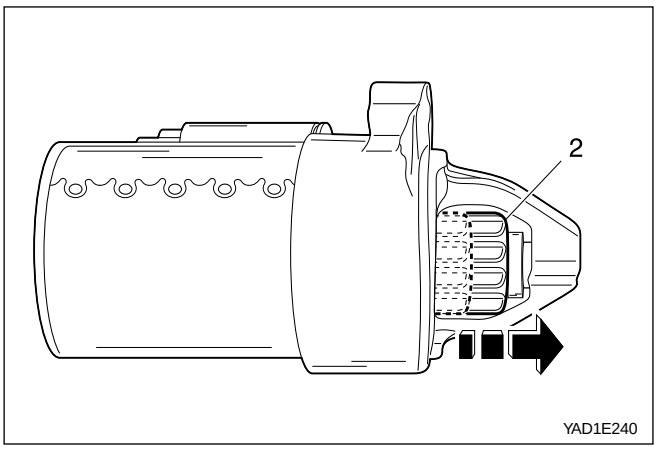
   - Switch on to move the pinion gear (2).
   - Now check the clearance between the pinion and the stopper with the filler gauge (3).
   - If the clearance does not fall within the limits, check for improper installation and replace all wom parts.



YAD1E230

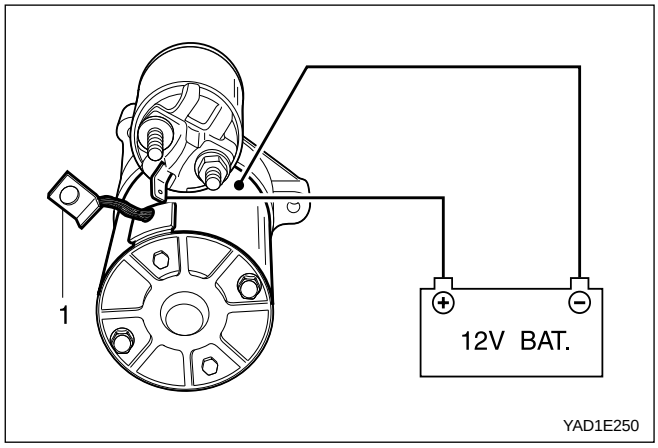
3. Magnetic switch pull-in test.
   - Disconnect the starter motor terminal M (1).
   - Connect the 12-volt battery lead to the starter motor terminals M and S.

   Notice: Complete the testing in a minimum amount of time to prevent overheating and damaging the solenoid. (in 10 seconds)



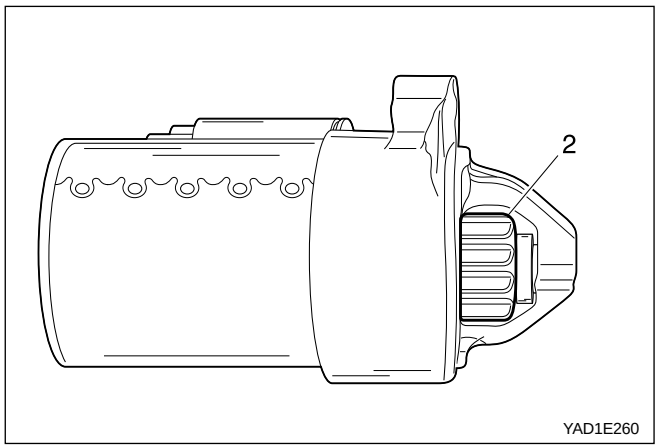
YAD1E240

   - Inspect the pinion gear’s moving to the outside (2).
   - If the pinion gear does not move outside, replace the magnetic switch.

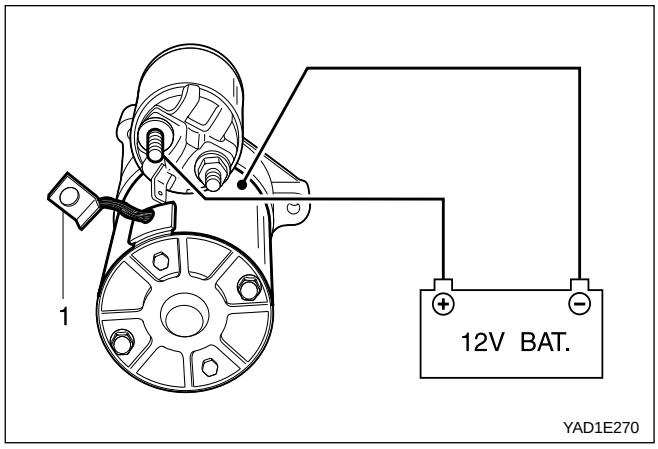


4. Solenoid hold-in test.
   - Disconnect the starter motor terminal M (1).
   - Connect the 12-volt battery lead to the starter motor terminal S and body.

   Notice : Complete the testing in a minimum amount of time to prevent overheating and damaging the solenoid.

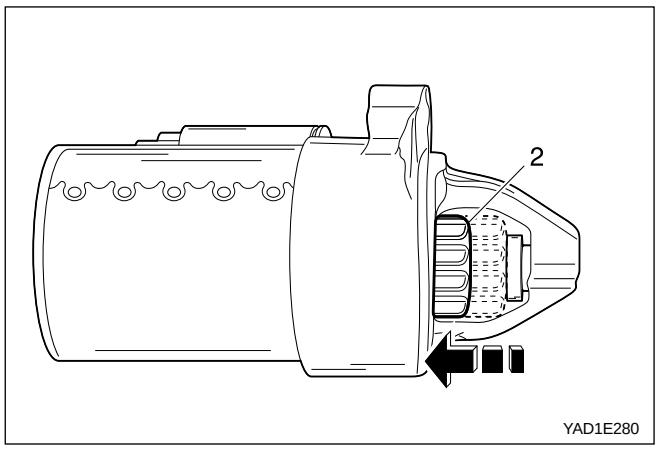


- Check the pinion gear's moving to the outside (2).
- If the pinion gear move to the inside, the circuit is open. Replace the magnetic switch.

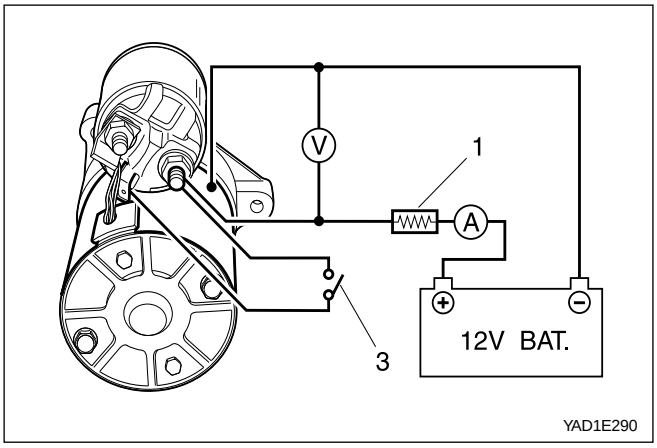


5. Solenoid return test.
   - Disconnect the starter motor terminal M (1).
   - Connect the 12-volt battery lead to the starter motor terminal S and body.

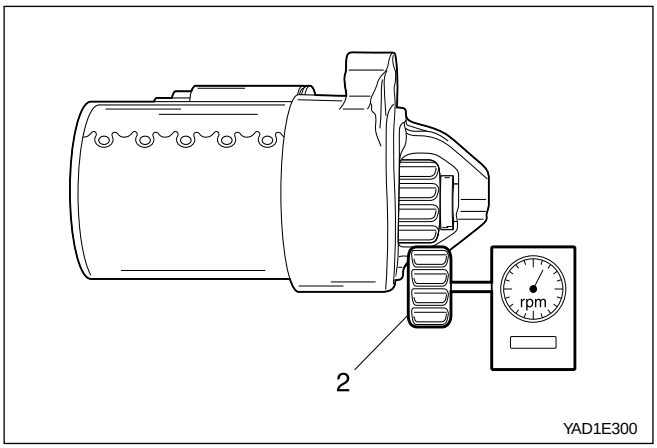
   Notice: Complete the testing in a minimum amount of time to prevent overheating and damaging the solenoid.



- Check the returning speed of pinion gear (2). If the returning speed is fast, the operation is normal.
- Replace the solenoid if the operation is abnormal.



5. No-road test.
   - Connect the 12-volt battery lead to the starter circuit.
   - Connect the current and the voltage (1).
   - Install the starter motor rpm gage (2).
   - Start the starter motor with the switch on (3).
   - Measure the speed of pinion gear and the current.
   - If the measurement satisfy the limit, the starter motor is normal.

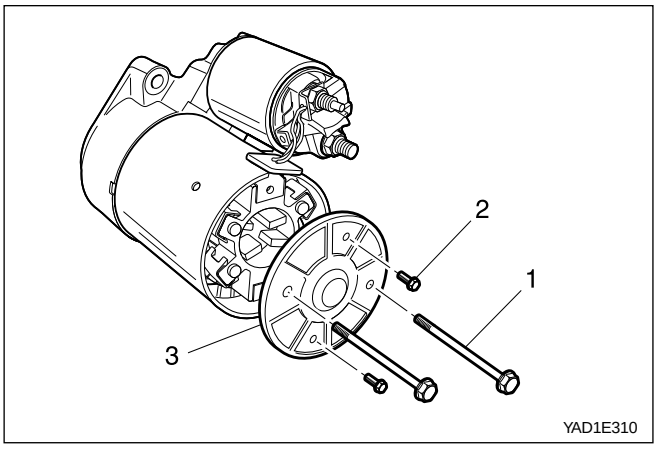


Desciption	Limit
The speed of pinion gear	Minimum : 2,000 rpm
Condition : Voltage/ Current	Maximum : 9V / 150A

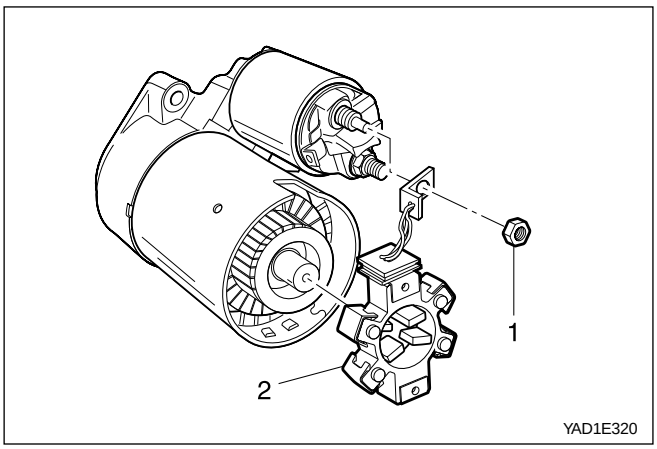
- Replace the starter motor if necessary.

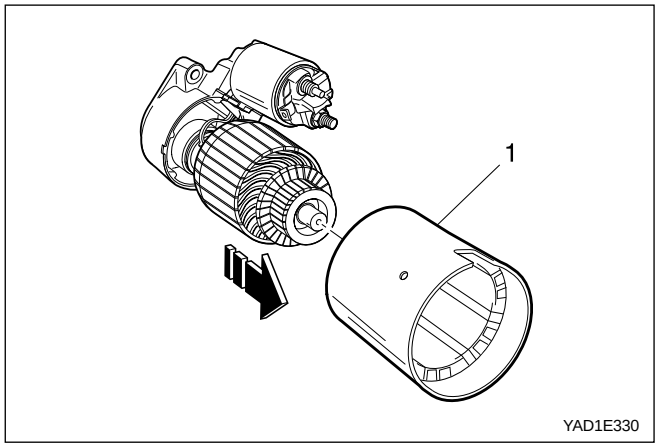
Disassembly Procedure

1. Remove the starter contact end frame.
   - Remove the through-bolts (1).
   - Remove the contact end frame bolts (2).
   - Remove the frame with the spacer (3).

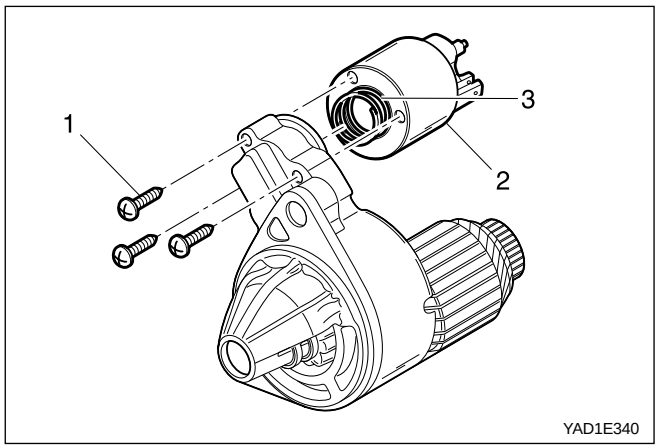


2. Remove the brush holder assembly.
   - Remove the starter motor terminal M nut (1).
   - Remove the brush holder assembly (2).

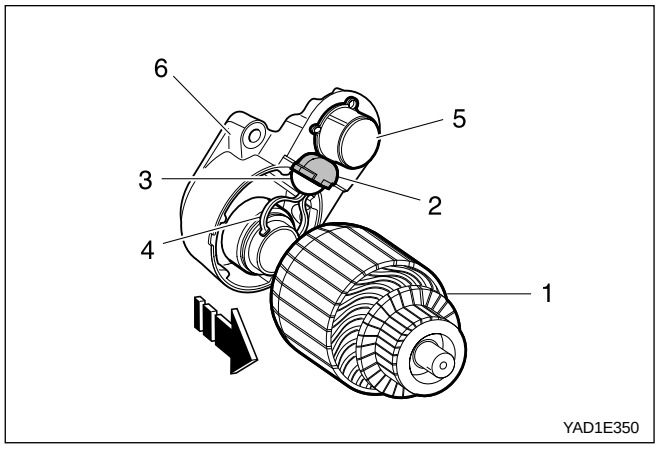




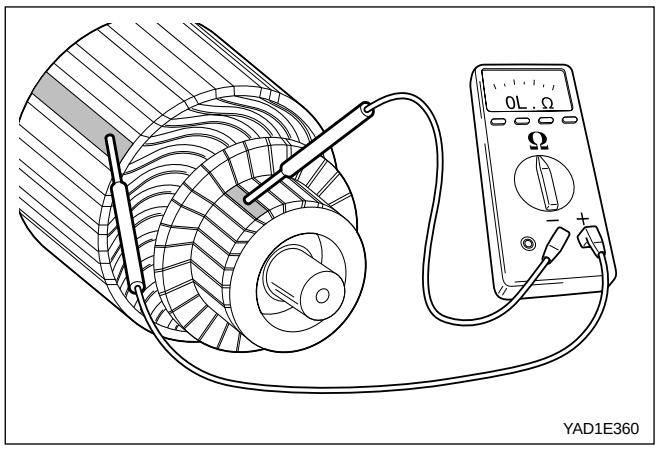
3. Remove the field frame assembly from the armature set (1).



4. Remove the solenoid assembly.
   - Remove the solenoid screws (1).
   - Remove the magnetic switch (2).
   - Remove the spring (3).

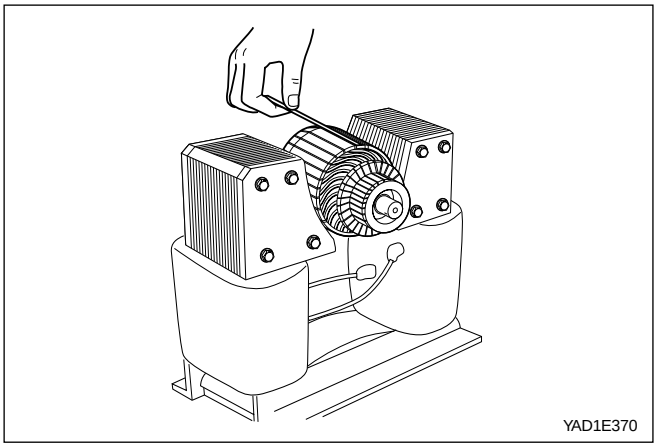


5. Remove the armature set and solenoid from the starter housing.
   - Remove the armature set (1).
   - Remove the rubber sealer (2).
   - Remove the shift lever plate (3).
   - Remove the shift lever (4).
   - Remove the solenoid (5).
   - Remove the gasket (6).

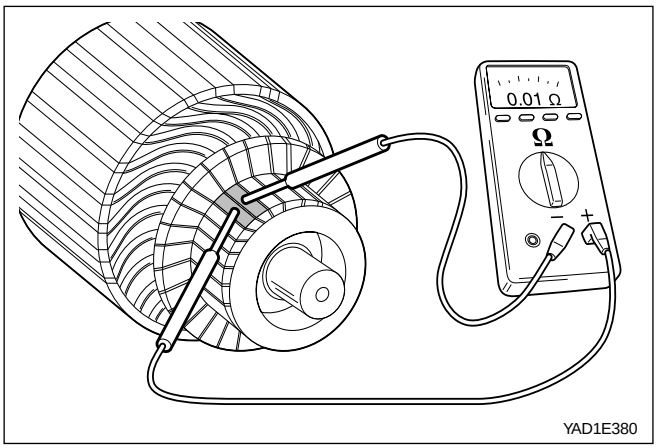


Inspection / Measurement (After the Overhaul)

1. Ground test for armature coil.
   - Inspect the insulation between commutator and armature coil using the voltmeter.
   - Replace the armature assembly if necessary.

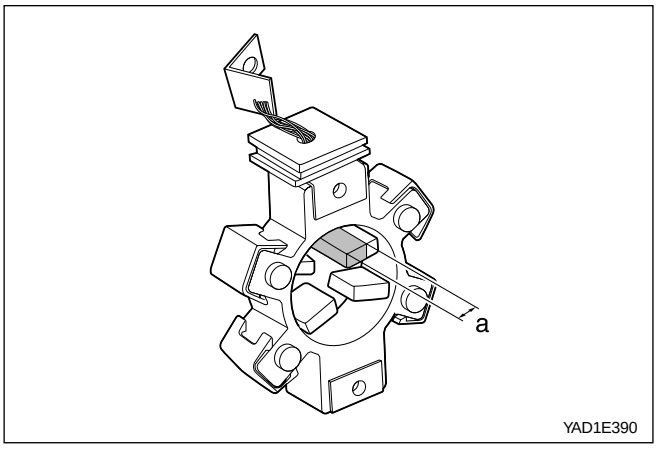

YAD1E370

2. Short circuit test for armature coil.
   - If test equipment is available, check the armature for short circuit by placing it on a growler, and holding back a saw blade over the armature core while the armature is rotated. If the saw blade vibrates, replace the armature.



YAD1E380

3. Open circuit test for armature coil.
   - Check the continuity between the commutator bars using multimeter.
   - Replace the armature assembly if necessary.

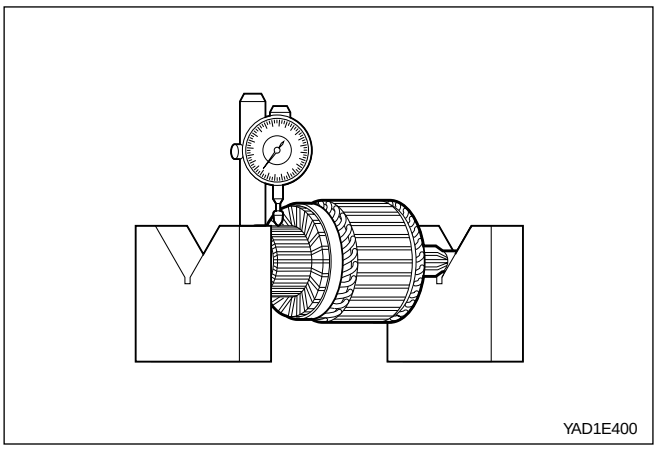


YAD1E390

4. Inspect the brushes wear.
   - Inspect the brushes, the pop-out springs and the brush holder for wear and damage, Replace the brushes, if necessary.

   a. Brushes wear limit.

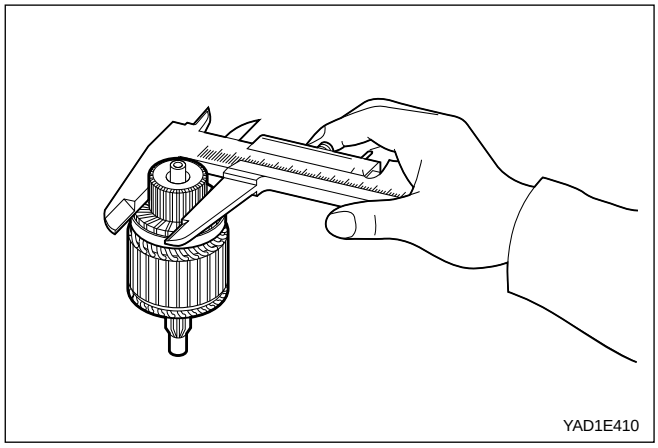
Desciption	Standard	Limit
Brushes wea	11.3 - 11.5 mm (0.445 - 0.453 in)	7.0 - 7.25 mm (0.275 - 0.285 in)


YAD1E400

Inspection the Commutator Bar

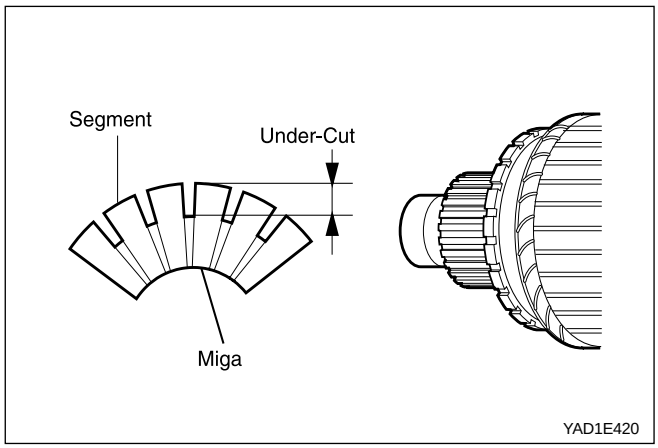
1. Inspect the wear length using the dial indicator after placing the armature coil on the two “V” block.

Application	Standard (mm)	Limit (mm)
Wear	0.05	0.1


YAD1E410

2. Measure the outside diameter of the commutator bar.

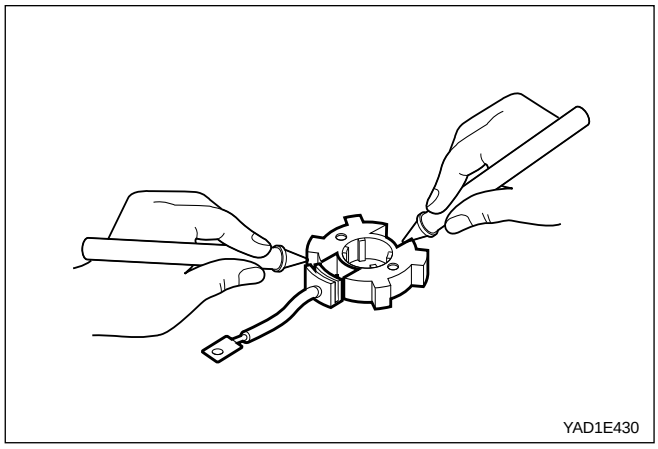
Application	Standard (mm)	Limit (mm)
O.D.	29.4	28.4



YAD1E420

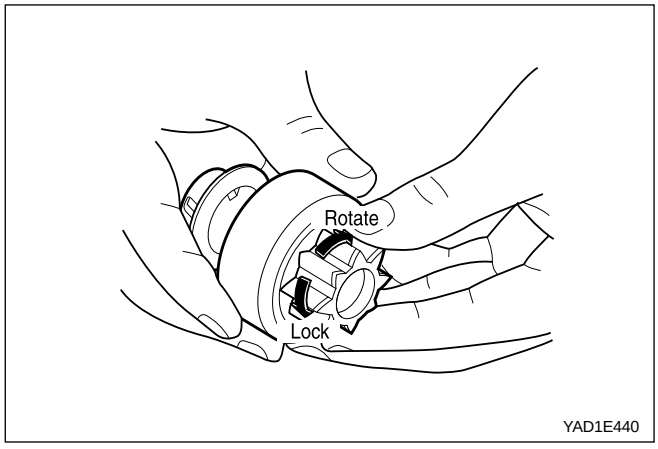
3. Check the under-cut depth between segments.

Application	Standard (mm)	Limit (mm)
Under-cut depth	0.5	0.2


YAD1E430

Brush Holder

Inspect the continuity between the brush holder plate and (+) brush holder. If the current does not send, it's normal.

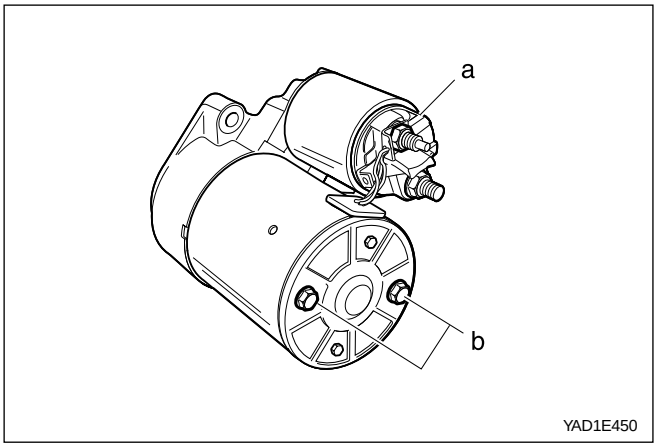


YAD1E440

Overrunning Clutch

1. Rotate the pinion grabbing the clutch housing. The driving pinion must rotate softly at one direction and must not rotate at opposite direction. If the driving pinion rotates at opposite direction, replace the overrunning clutch assembly.
2. Check the wear and damage of the pinion and replace the pinion as needed. If the pinion gets damaged, inspect the wear and damage of the ring gear.
3. Front and rear bracket bushing

   Check the wear and damage of the bushing and replace the front and rear bracket as needed.



Assembly Procedure

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

   For installing the lever to the starter housing, install it according to its proper direction.

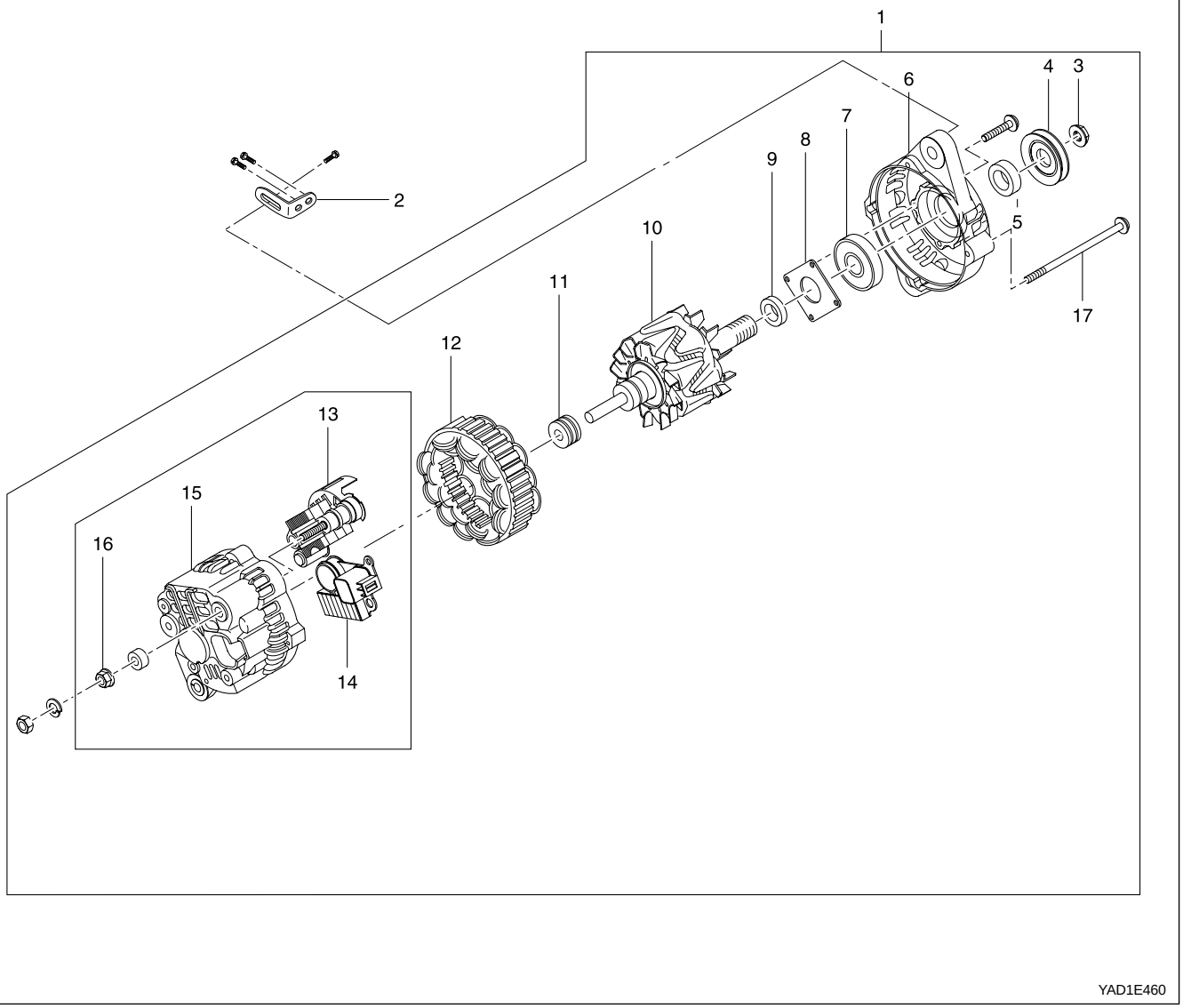
   (The lever should be installed to the hole of the starter housing at one direction.)

2. Tighten nuts/bolts as specified torque.

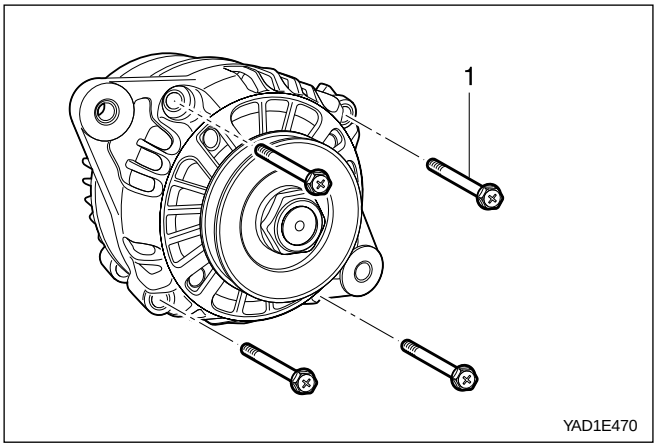
   a. Starter M terminal nut

   b. Starter pass-through bolt

GENERATOR (MANDO TYPE)

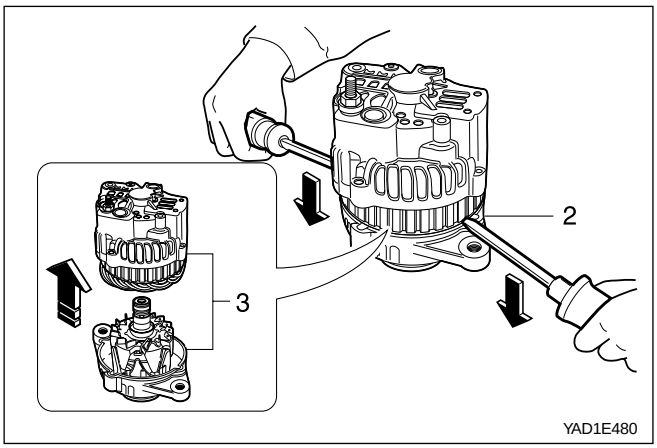


1 Generator Assembly
2 Generator Shackle
3 Generator Drive End Nut
4 Generator Pully
5 Generator Collar (Large)
6 Generator Front Bracket
7 Front Bearing
8 Bearing Spot Plate
9 Generator Collar (Small)
10 Generator Rotor Assembly
11 Rear Bearing
12 Generator Stator Assembly
13 Rectifier Assembly
14 Voltage Regulator / Brush Holder Assembly
15 Generator Rear Bracket
16 Battery Positive Terminal Nut
17 Through Bolt

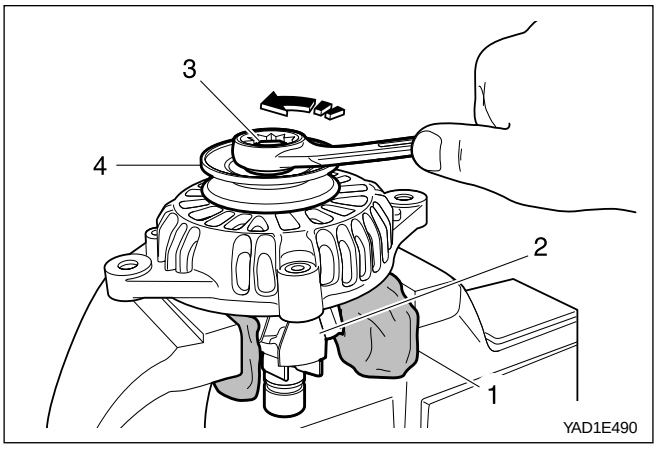


Disassembly Procedure

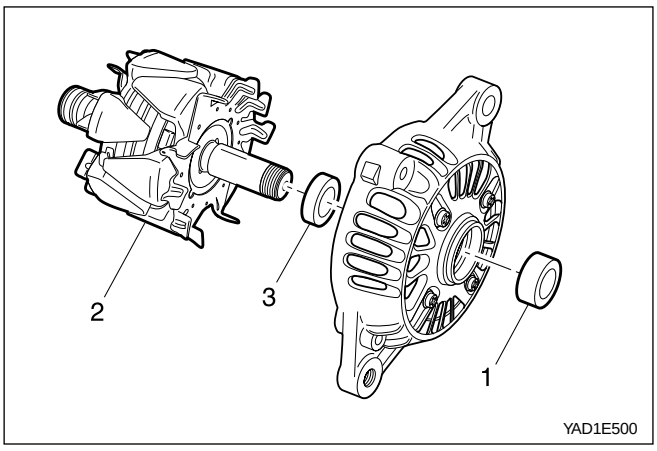
1. Remove the generator. Refer to “Generator” in this section.
2. Remove the front bracket and rear bracket.
   - Remove the through-bolts (1).



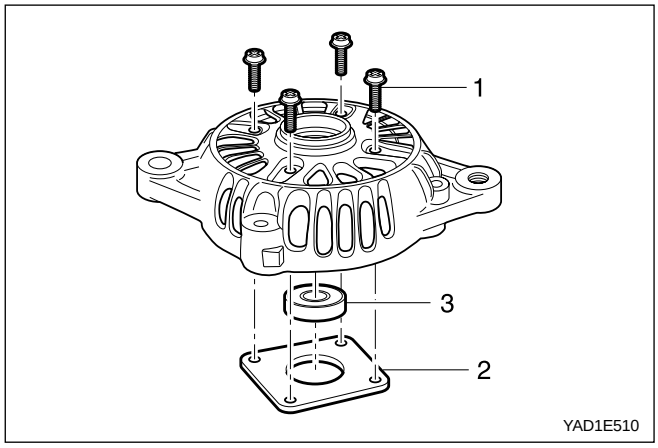
   - Pry front bracket downwards using a screwdriver (2).
   - Separate the front bracket and rear bracket (3).



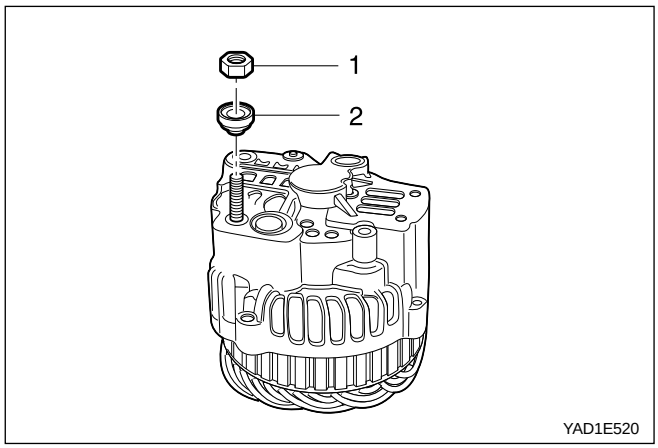
3. Remove the pulley and rotor assembly from the front bracket.
   - Cover the rotor with the cloth (1).
   - Place the pulley upwards and vice the rotor (2).
   - Remove the pulley nut (3).
   - Remove the pulley (4).



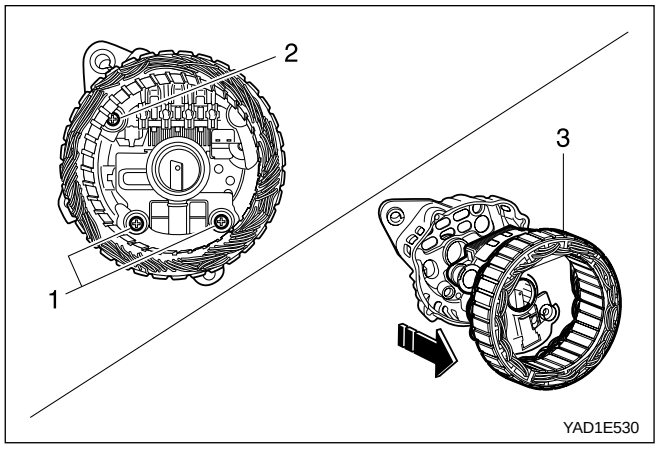
4. Remove the front bracket, rotor and collar.
   - Remove the collar (large) (1).
   - Remove the rotor from the front bracket (2).
   - Remove the collar (small) from the rotor shaft (3).



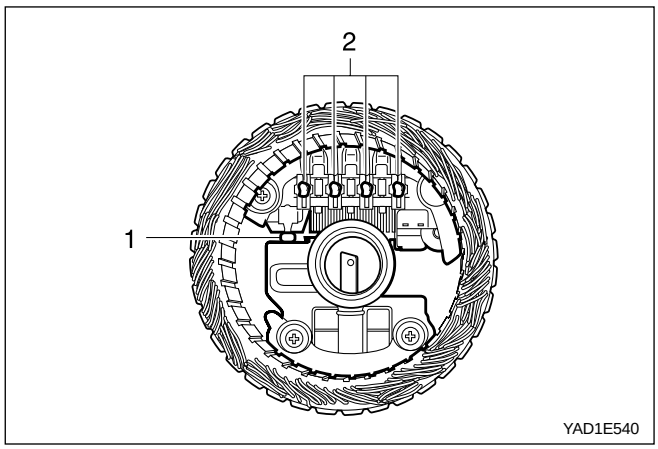
5. Remove the front bearing.
   - Remove the support plate screws (1).
   - Remove the plate (2).
   - Remove the front bearing using the press (3).



6. Remove the battery positive terminal nut from the rear bracket.
   - Remove the battery position terminal nut (1).
   - Remove the washer (2).

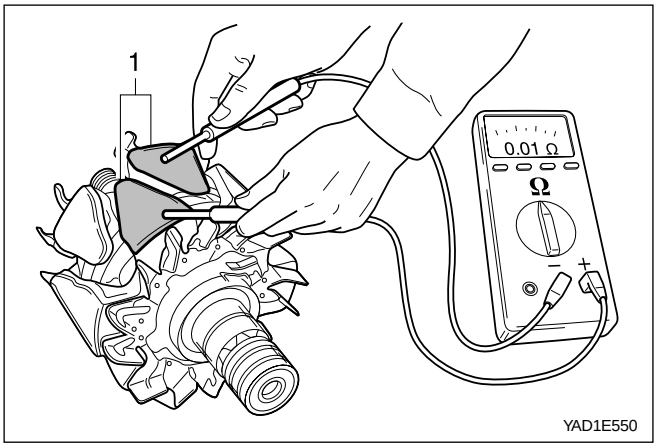


7. Remove the stator assembly from the rear bracket.
   - Remove the rectifier screw (1).
   - Remove the brush holder and regulator assembly screw (2).
   - Remove the stator assembly with the rectifier / brush holder / regulator (3).



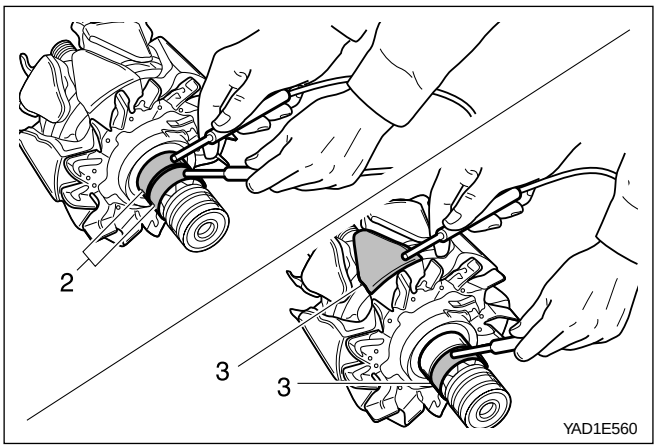
8. Remove the rectifier / brush holder / regulator from the stator.
   - Remove the rectifier / brush holder / regulator connections (1).
   - Remove the stator and rectifier connections (2).

   Notice: If the stator connections are welded, melt the lead. Avoid overheating as it can damage the diodes.



Inspection / Measurement

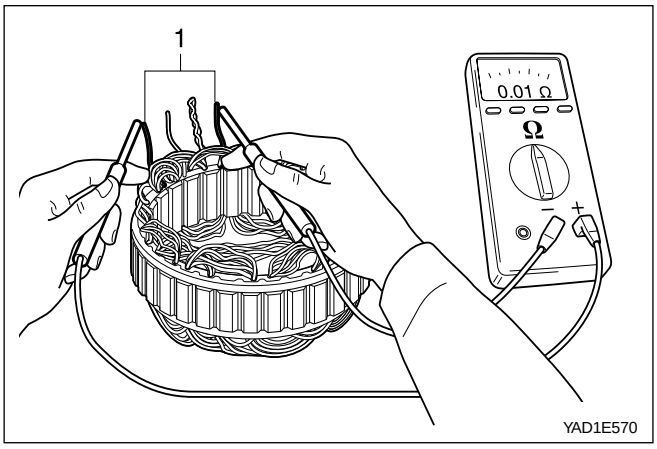
1. Inspect the rotor assembly.
   - Test the rotor for an open circuit by using the ohmmeter (1). Replace the rotor if necessary.



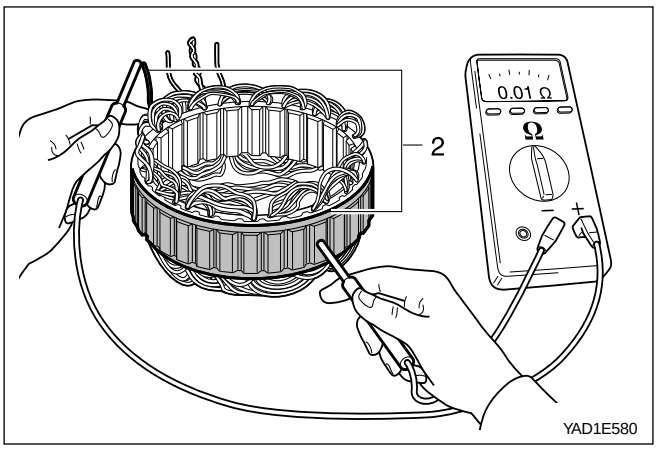
   - Test the rotor for open or short circuit (2).

Desciption	Limit
The measured resistance	2.9 Ω

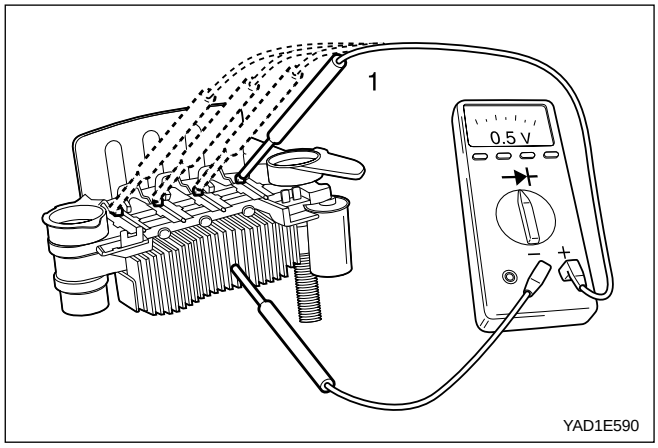
   - Replace the rotor if necessary.
   - Test the rotor for open or ground circuit by using the ohmmeter (3). Replace the rotor if necessary.



2. Inspect the stator.
   - Test the stator for an open circuit by using the ohmmeter (1). Replace the stator if necessary.

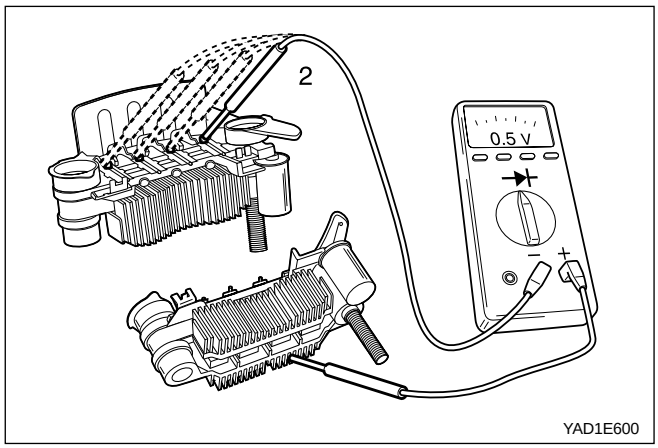


   - Test the stator for open or ground circuit by using the ohmmeter (2). Replace the starter if necessary.



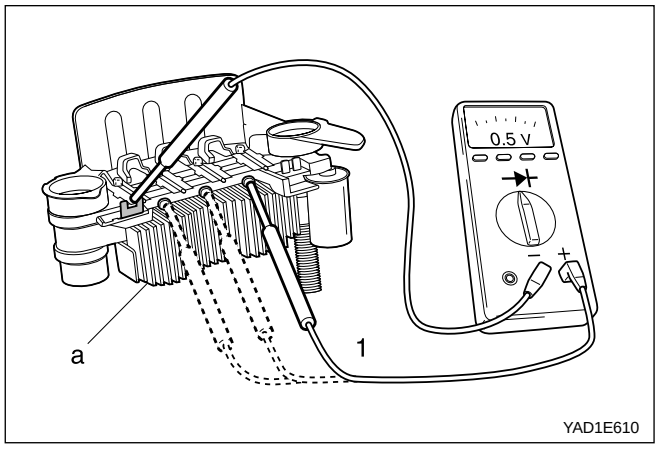
3. Inspect the rectifier.
   - Positive rectifier test :

     Inspect the open circuit for stator coil lead terminals using the ohmmeter (1). Replace the rectifier if necessary.

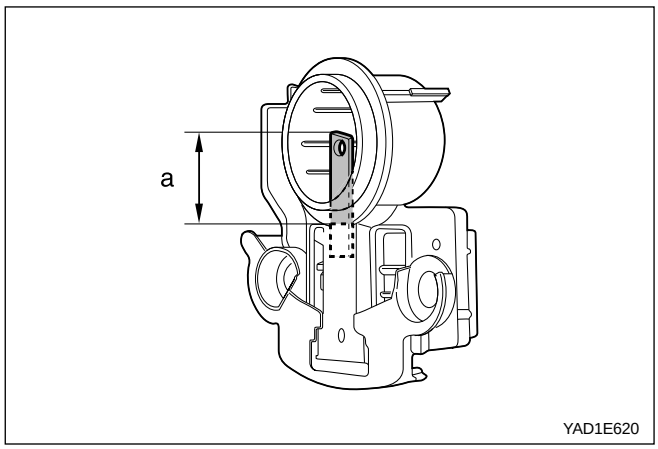


   - Negative rectifier test:

     Inspect the open circuit for stator coil lead terminals using the ohmmeter (2). Replace the rectifier if necessary.

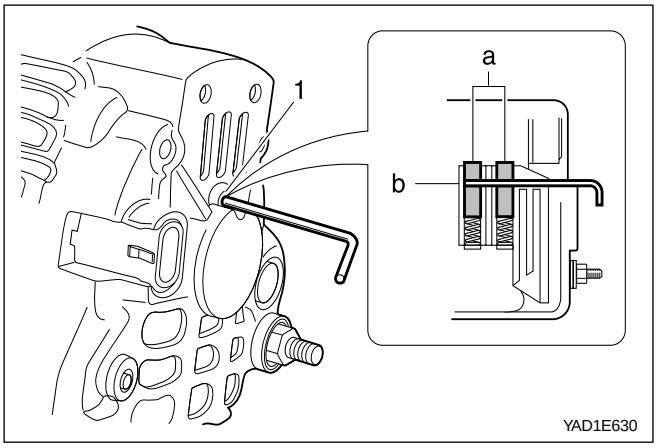


4. Inspect trio diodes.
   - Inspect the open circuit for trio diodes using the ohmmeter (1).
   - Replace the heat sink if necessary (a).



5. Inspect the brush wear.
   - If the brush wear exceeds the specified valve (a), replace the brush.

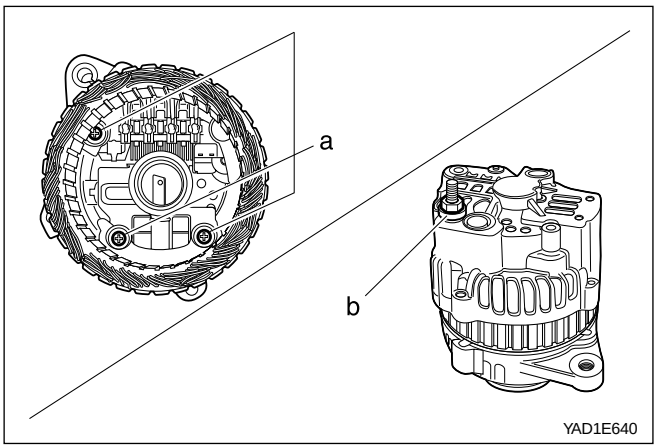
Application	Standard	Limit
Brushes wear	18.5 (0.73)	13.5 (0.53)



Assembly Procedure

1. Install in the reverse order of removal.
   - Assemble the stator assembly into the rear bracket and rotor assembly.

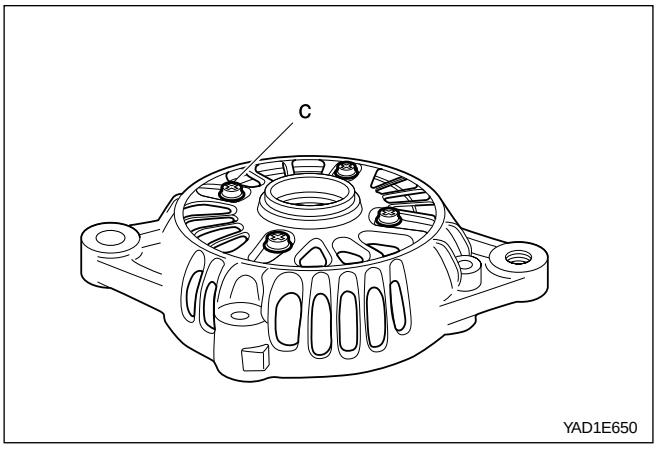
   a. Brushes.
   b. Hole.



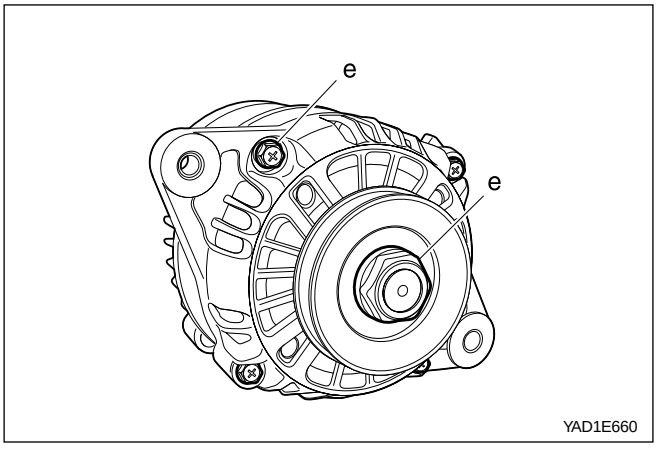
2. Install the bolts / nuts / screws.

   Tighten

   - Tighten the brush holder / regulator / rectifier screws to 9 - 12 N•m (80 - 106 Ib-in) (a).
   - Tighten the battery positive terminal nut to 4 - 7 N•m (35 - 62 Ib-in) (b).



   - Tighten the front bearing spot plate screws to 6 - 8N•m (53 - 71 Ib-in) (c).



   - Tighten the generator pulley nut to 80 - 110 N•m (59 - 81 Ib-ft) (d).
   - Tighten the through-bolts to 4 - 6 N•m (35 - 53 Ib-in)

SPECIFICATIONS

GENERAL SPECIFICATIONS

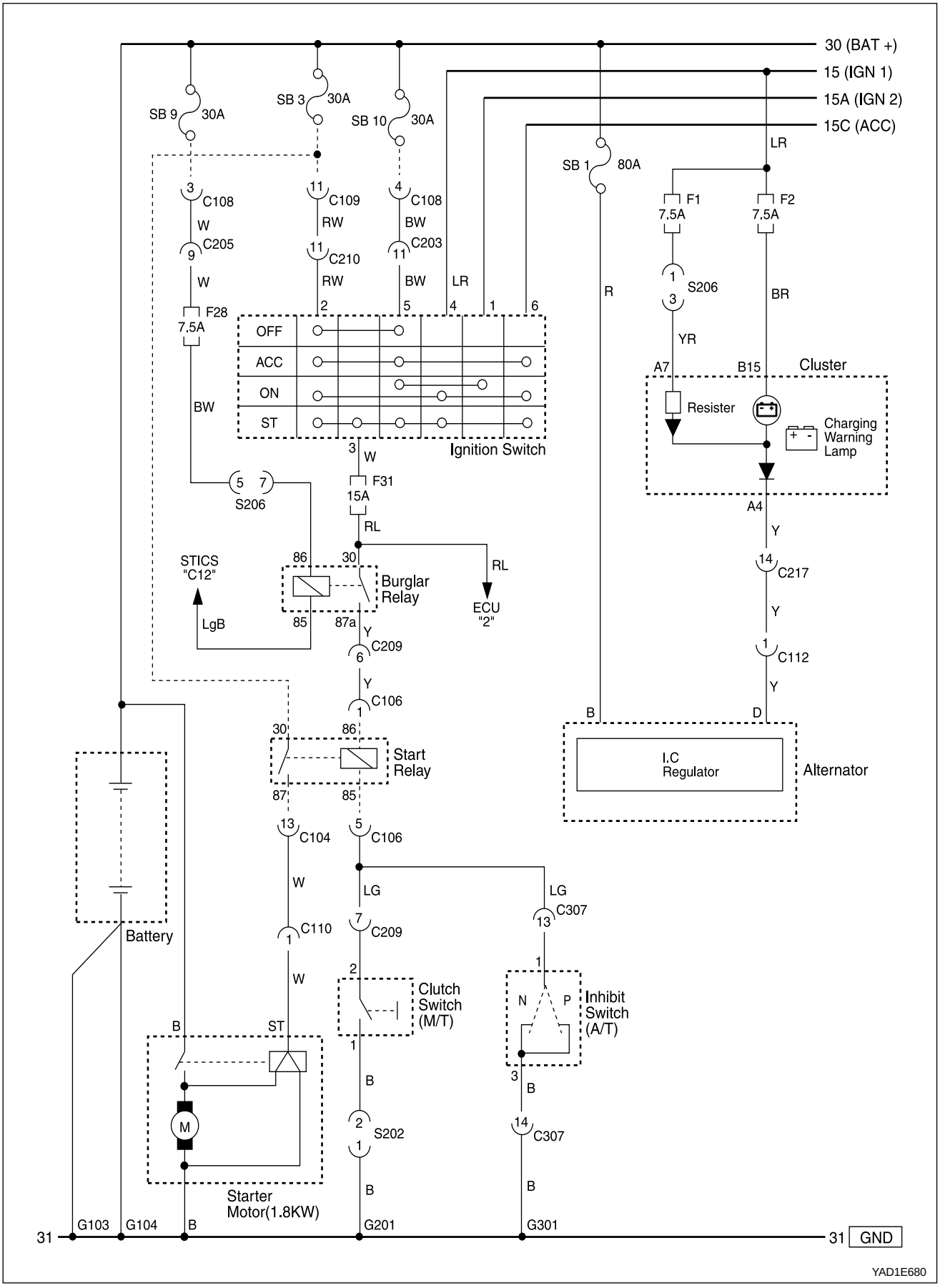
Application			Unit	Gasoline Engine	Diesel Engine
Starter	Type		-	PG170S	WP220
	Output Power		Kw	1.8	2.2
	No Load Test @ 12 volts		A	98	160
	Drive Pinion Speed at No Load		rpm	2,600	4500
	Drive Pinion Speed at Load		rpm/A	1,087/380	1700/430
	Brush Length		mm	16.1	18
	Armature Diameter		mm	54.1	55
	Armature Run-out		mm	0.08	0.1
	Segment Groove Depth		mm	19.6	21.7
Generator	Type		-	SG135	CS128D
	Output Voltage / Current		V/A	14/115	14/90
	Regulator Type		-	HYBRID	←
	Regulating Voltage		V	14.7	14.6
	Brush	Length	mm	18.5	12.5
		Quantity	-	2	2
		Abrasion Limit	mm	13.5	7
Battery	Type		-	MF	MF
	Capacity		AH	75	90
	Reserve Capacity		RC	130	160
Ignition Coil	Type		-	DIS	-
	Primary Coil Resistance		Ω	0.3 - 0.9	-
	Secondary Coil Resistance		KΩ	6 - 8.5	-
Spark Plug	Type		-	WR8DC	-
	Clearance		-	0.8 - 0.9	-
High Tension Cable	Resistance		KΩ/m	1.9	-
Glow Plug	Type		-	-	
	Used Voltage		-	-	11.5
	Circuit Connection		-	-	Parallel
	Preheating Time		sec	-	60 - 90

FASTENER TIGHTENING SPECIFICATIONS

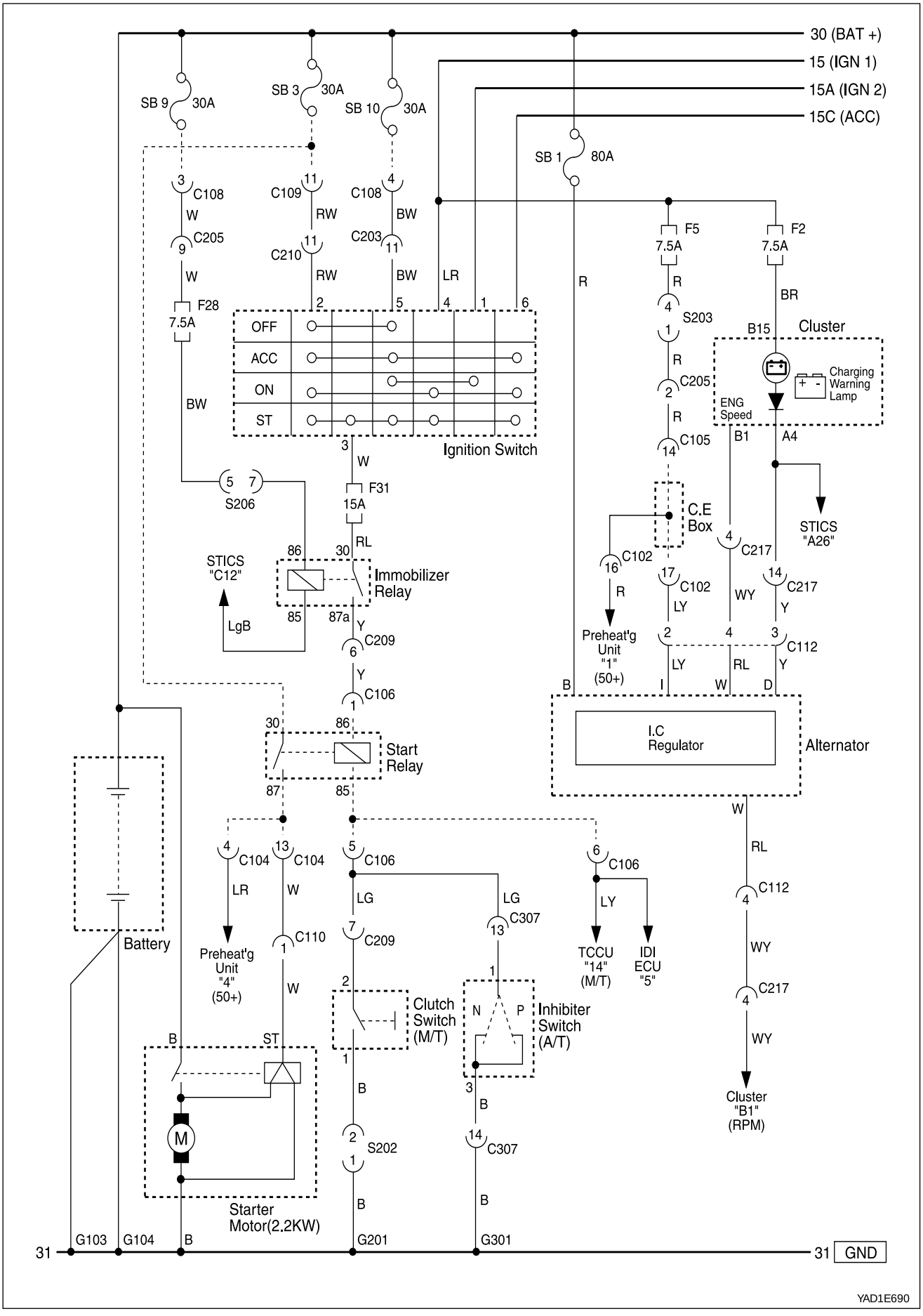
Application	N•m	Lb-Ft	Lb-In
Batter Cable Nut	12 - 18	9 - 13	-
Battery Cable Nut on Starter	12 - 15	9 - 11	-
Batter Mounting Bracket Nut	12 - 18	9 - 13	-
Engine Electric Wire Nut on Starter	6 - 7	-	53 - 62
Generator Combination Bolt	42 - 50	31 - 37	-
Generator Terminal B+ Nut	14 - 18	10 - 13	-
Generator Terminal D+ Nut	4 - 5	-	35 - 44
Glow Plug	20	15	-
Glow Plug Nut	4	-	35
Ignition Cable Cover Bolt	9 - 11	-	80 - 97
Ignition Coil Bolt	9 - 11	-	80 - 97
Spark Plug	25 - 30	15 - 22	-
Starter Mounting Bolt	35 - 48	26 - 35	-

SCHEMATIC AND ROUTING DIAGRAMS

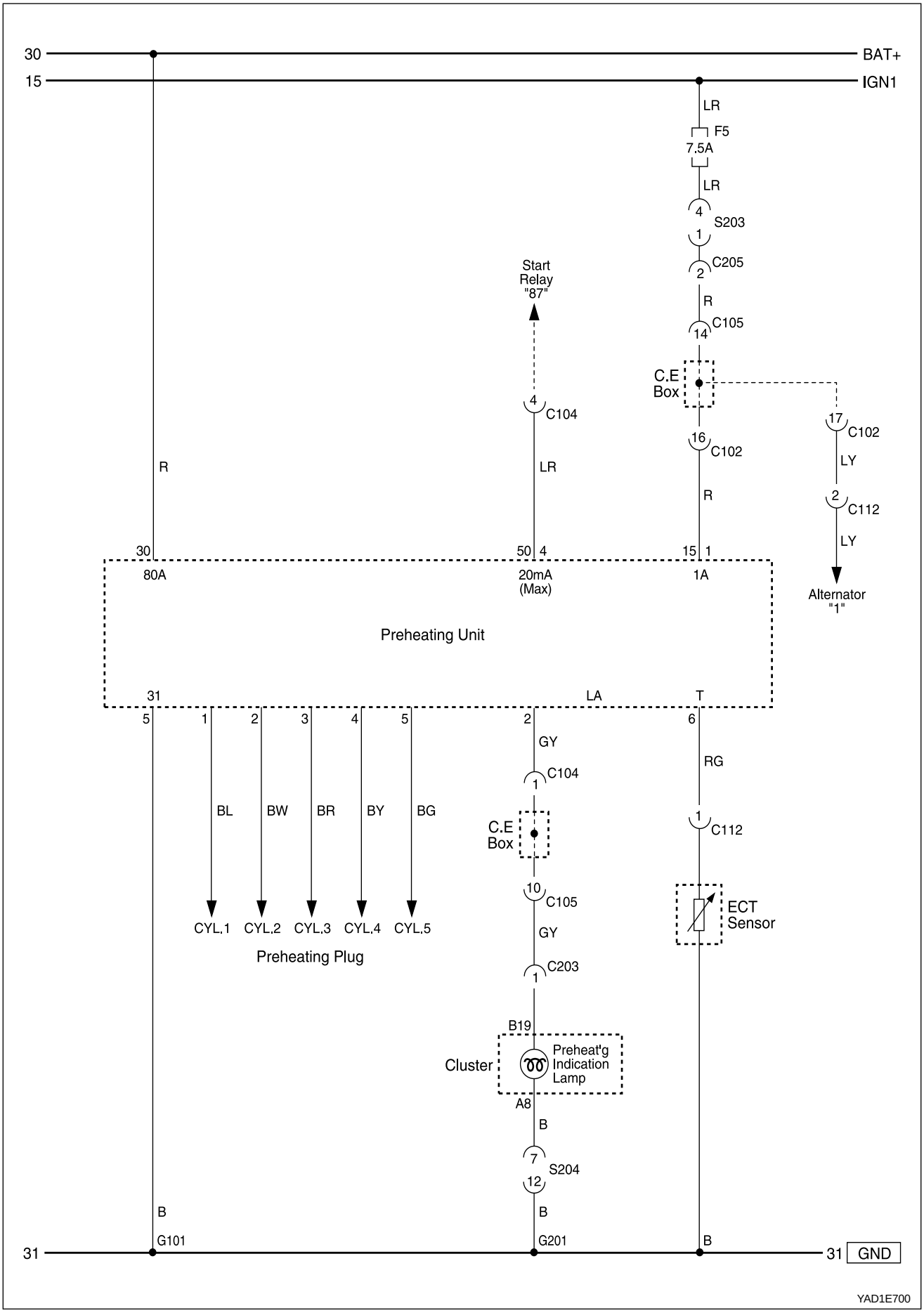
STARTING AND CHARGING SYSTEM (GASOLINE ENGINE)



STARTING AND CHARGING SYSTEM (DIESEL ENGINE)

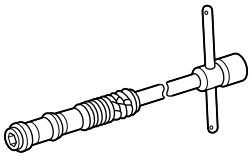


PREHEATING SYSTEM (DESEL ENGINE)



SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS TABLE

 YAD1E670	**120 589 02 09 00** **Spark Plug Wrench**

SECTION 1F1

M162 ENGINE CONTROLS

CAUTION: Disconnect the negative battery cabl e beforer emoving or i nstalling 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 other-wise noted.

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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 (if available)	☐ Normal ☐ Malfunction code(s) (code) ☐ 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

DIAGNOSTIC INFORMATION AND PROCEDURE

FAILURE CODE DIAGNOSIS

CLEARING FAILURE CODES

Notice: To prevent Engine Control Module(ECM) damage, the key must be OFF when disconnecting or reconnecting the power to the ECM (for example battery cable, ECM pigtail connector, ECM fuse, jumper cables, etc.)

Parameters listed in the table may not be exactly the same as your reading due to the type of instrument or other factors. If a failure code is displayed during the “TROUBLE CODE” in scan tool check mode, check the circuit for the code listed in the table below. For details of each code, turn to the page referred to under the “See Page” for the re-spective “Failure Code” in the below table.

Failure codes should be cleared after repairs have been completed.

FAILURE CODES TABLE

Failure Code	See Page	Description
00	1F1-56	Engine coolant temperature sensor low voltage
01	1F1-56	Engine coolant temperature sensor high voltage
02	1F1-56	Engine coolant temperature sensor plausibility
03	1F1-52	Intake air temperature sensor low voltage
04	1F1-52	Intake air temperature sensor high voltage
05	1F1-52	Intake air temperature sensor plausibility
06	1F1-56	Engine coolant temperature insufficient for closed loop fuel control
08	1F1-28	System voltage too low
09	1F1-52	Mass air flow sensor plausibility
10	1F1-52	Mass air flow sensor low voltage
11	1F1-52	Mass air flow sensor high voltage
17	1F1-13	Crankshaft position sensor signal failure (no engine revolution signal)
18	1F1-13	Crankshaft position sensor signal failure (rpm > max. value)
19	1F1-17	Camshaft position senosr signal : No.1 cylinder recognition failure
20	1F1-13	Crankshaft position sensor signal failure (gap recognition failure)
21	1F1-79	Transmission coding failure
23	1F1-77	CAN communication failure : ASR/MSR
24	1F1-77	CAN communication failure : ABS
25	1F1-82	Communication with transponder missing
26	1F1-77	CAN communication failure : TCU (A/T only)
27	1F1-78	CAN communication failure : TOD (E32 only)
29	1F1-78	CAN communication failure : ID 200h not plausible
30	1F1-78	CAN communication failure : ID 208h not plausible
31	1F1-78	CAN communication failure : communication initialization failure
32	1F1-68	Engine rpm output circuit short circuit to battery
33	1F1-68	Engine rpm output circuit short circuit to ground or open
34	1F1-33	Fuel pump relay short circuit to battery
35	1F1-33	Fuel pump relay short circuit to ground or open
40	1F1-41	Purge control valve short circuit to battery
41	1F1-41	Purge control valve short circuit to ground or open

FAILURE CODES TABLE (Cont'd)

Failure code	See Page	Description
44	1F1-62	Cooling fan (HI) relay short circuit to power
45	1F1-62	Cooling fan (HI) relay short circuit to ground or open
54	1F1-41	Purge control circuit malfunction
56	1F1-23	No.1 knock sensor signal failure
57	1F1-23	No.2 knock sensor signal failure
58	1F1-17	Camshaft position sensor signal : No.1 cylinder synchronization failure
59	1F1-78	CAN communication failure : MSR data transmission not plausible
60	1F1-78	CAN communication failure : ASR data transmission not plausible
62	1F1-61	Clutch switch defective
64	1F1-11	No ignition voltage output (No.1 ignition coil)
65	1F1-11	No ignition voltage output (No.2 ignition coil)
66	1F1-11	No ignition voltage output (No.3 ignition coil)
67	1F1-13	Crankshaft position sensor adaptation failure
68	1F1-25	Random/Multiple Misfire
71	1F1-29	Starter signal recognition failure
72	1F1-37	No.1 injector short circuit to battery
73	1F1-37	No.1 injector short circuit to ground or open
74	1F1-37	No.2 injector short circuit to battery
75	1F1-37	No.2 injector short circuit to ground or open
76	1F1-37	No.3 injector short circuit to battery
77	1F1-38	No.3 injector short circuit to ground or open
78	1F1-38	No.4 injector short circuit to battery
79	1F1-38	No.4 injector short circuit to ground or open
80	1F1-72	Oxygen sensor high voltage
81	1F1-73	Bank 1 system short term fuel trim adaptation below lean threshold
82	1F1-72	Oxygen sensor no activity detected
83	1F1-72	Oxygen sensor not lean after overrun fuel shut -off
84	1F1-72	Oxygen sensor slow response
85	1F1-72	Oxygen sensor heater failure
86	1F1-72	Oxygen sensor heater short circuit to battery
87	1F1-72	Oxygen sensor heater short circuit to ground or open
89	1F1-72	Oxygen sensor low voltage
93	1F1-73	Bank 1 system short term fuel trim adaptation above rich threshold
96	1F1-73	Bank 1 system short term fuel trim at rich stop
97	1F1-73	Bank 1 system short term fuel trim at lean stop
98	1F1-73	Bank 1 system idle adaptation failure (above rich threshold)
99	1F1-73	Bank 1 system idle adaptation failure (below lean threshold)
100	1F1-73	Bank 1 system learning control failure (rich, low load)
101	1F1-73	Bank 1 system learning control failure (lean, low load)
102	1F1-73	Bank 1 system learning control failure (rich, high load)

FAILURE CODES TABLE (Cont'd)

Failure code	See Page	Description
103	1F1-73	Bank 1 system learning control failure (lean, high load)
104	1F1-47	Throttle position sensor 1 low voltage
105	1F1-47	Throttle position sensor 1 high voltage
108	1F1-47	Throttle position sensor 2 low voltage
109	1F1-47	Throttle position sensor 2 high voltage
110	1F1-80	Throttle actuator learning data fault
116	1F1-47	Throttle actuator learning control failure
117	1F1-80	Exceed fuel -cut safety time
119	1F1-47	Throttle valve return spring failure
120	1F1-80	Cruise control interruption memory failure
121	1F1-47	Throttle actuator failure
122	1F1-59	Accelerator pedal position sensor signal failure
123	1F1-47	Different Mass air flow sensor signal with throttle position sensor
125	1F1-47	Both throttle position sensors failure
126	1F1-48	Throttle position sensor 1 not plausible with throttle position sensor 2
127	1F1-48	High permanent throttle signal
129	1F1-64	Cruise control "OFF" due to message counter failure
130	1F1-64	Vehicle speed signal failure
131	1F1-64	Vehicle speed signal failure
132	1F1-64	Cruise control lever failure
133	1F1-64	Cruise control acceleration failure
134	1F1-64	Cruise control deceleration failure
135	1F1-67	Stop lamp switch failure
136	1F1-79	ECU failure (RAM)
137	1F1-79	ECU failure (EPROM)
138	1F1-80	Call monitoring
139	1F1-80	Servo motor control output interruption memory failure
140	1F1-80	Servo motor open/short
141	1F1-82	Unprogramed ECU with immobilizer
142	1F1-79	Uncoded/unprogramed ECU
143	1F1-79	ECU failure (EEPROM/Flash-EPROM checksum failure)
144	1F1-79	ECU failure (coding ID checksum failure)
145	1F1-79	ECU failure (coding checksum failure)
146	1F1-79	ECU failure (programing checksum failure)
150	1F1-65	TCS input signal short circuit to battery
151	1F1-65	TCS input signal short circuit to ground or open
160	1F1-59	Accelerator pedal position sensor 1 low voltage
161	1F1-59	Accelerator pedal position sensor 1 high voltage
162	1F1-59	Accelerator pedal position sensor 2 low voltage
163	1F1-59	Accelerator pedal position sensor 2 high voltage
164	1F1-59	Accelerator pedal position sensor 1 not plausible with pedal position sensor 2

FAILURE CODES TABLE (Cont'd)

Failure code	See Page	Description
167	1F1-59	Both setpoint accelerator pedal position sensor defective
185	1F1-48	Mass air flow sensor and throttle position sensor failure
186	1F1-80	ECU failure (incompatible CPU)
187	1F1-80	ECU failure (CPUs communication failure)
188	1F1-80	ECU failure (CPU 2 configuration failure)
189	1F1-80	ECU failure (CPU 2 fault)
190	1F1-80	ECU failure (CPU run time failure between CPUs)
192	1F1-38	No.5 injector short circuit to battery
193	1F1-38	No.5 injector short circuit to ground or open
194	1F1-38	No.6 injector short circuit to battery
195	1F1-38	No.6 injector short circuit to ground or open
198	1F1-66	Resonance flap short circuit to battery
199	1F1-66	Resonance flap short circuit to ground or open
226	1F1-21	Camshaft actuator short circuit to battery
227	1F1-21	Camshaft actuator short circuit to ground or open
228	1F1-63	A/C compressor relay short circuit to battery
229	1F1-63	A/C compressor relay short circuit to ground or open
231	1F1-80	ECU failure (CPU 2 cruise control message counter failure)
232	1F1-80	Over decceleration limit (CPU 2)
233	1F1-80	Over acceleration limit (CPU 2)
234	1F1-80	Cruise control lever dual operation (CPU 2)
235	1F1-80	Cruise control lever safety terminal failure (CPU 2)
236	1F1-80	Unusual pedal position variation (CPU 2)
237	1F1-80	Unusual throttle position variation (CPU 2)
238	1F1-80	Unusual throttle controller monitor data comparison fault (CPU 2)
239	1F1-81	Unusual accelerator pedal position sensor comparison fault (CPU 2)
240	1F1-81	Throttle potentiometer comparision fault (CPU 2)
241	1F1-81	Unusual CPU communication (CPU 2)
242	1F1-81	Unusual CPU configuration (CPU 2)
243	1F1-81	A/D converter failure (CPU 2)
244	1F1-81	Accelerator pedal position sensor setpoint fault between CPU 1 and CPU 2
245	1F1-81	Position controller setpoint fault between CPU 1 and CPU 2
246	1F1-81	MSR setpoint fault between CPU 1 and CPU 2
247	1F1-81	Idle control setpoint fault between CPU 1 and CPU 2
248	1F1-81	A/D converteroverflow (CPU 2)
249	1F1-81	ROM f aul t (CPU 2)
250	1F1-81	RAM f aul t (CPU 2)
251	1F1-85	Cycle monitor fault (CPU 2)

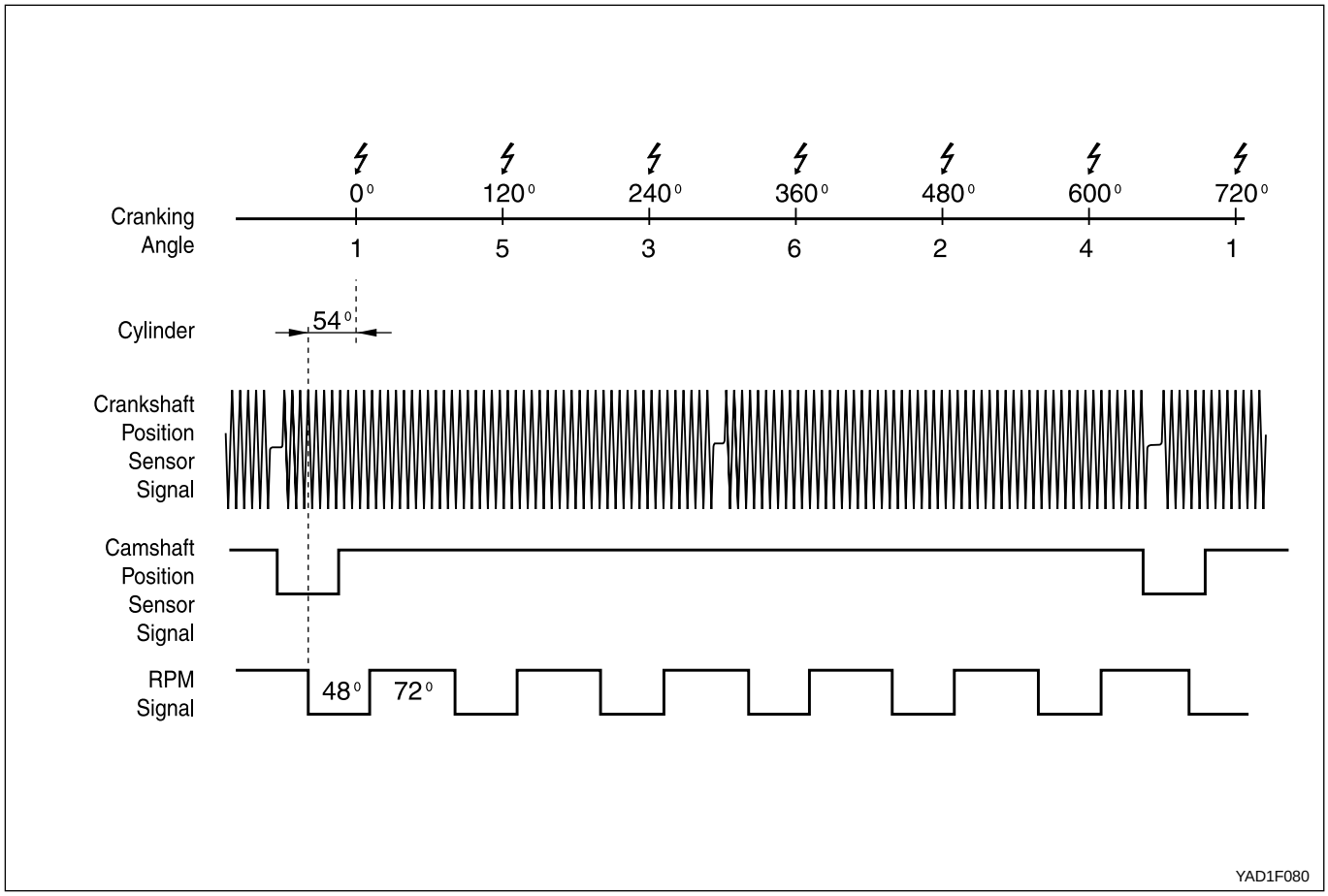
IGNITION SYSTEM

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 (1-6 or 2-5 or 3-4). The spark occurs simultaneously in the cylinder coming upon 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 tofire 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).



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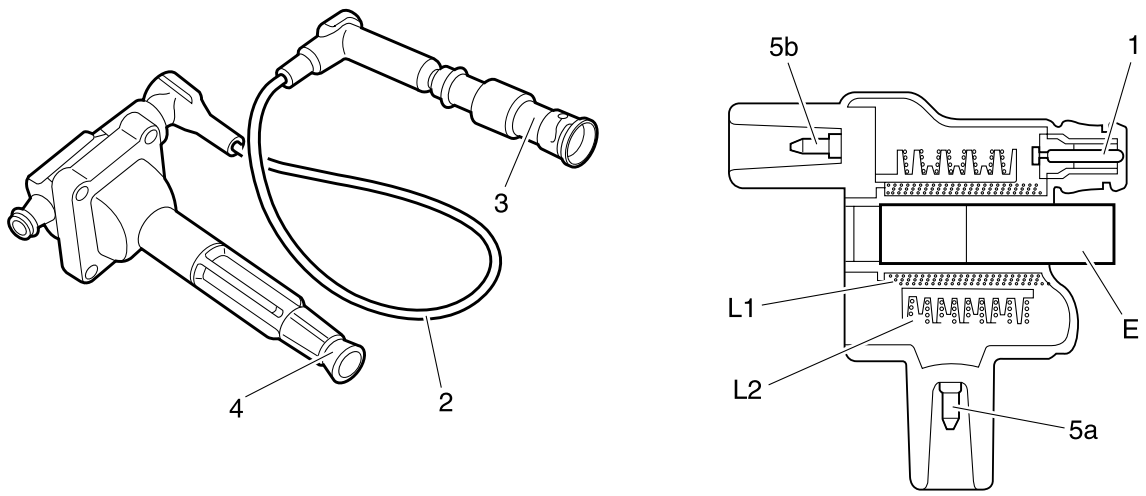
IGNITION COIL



YAD1F090

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.

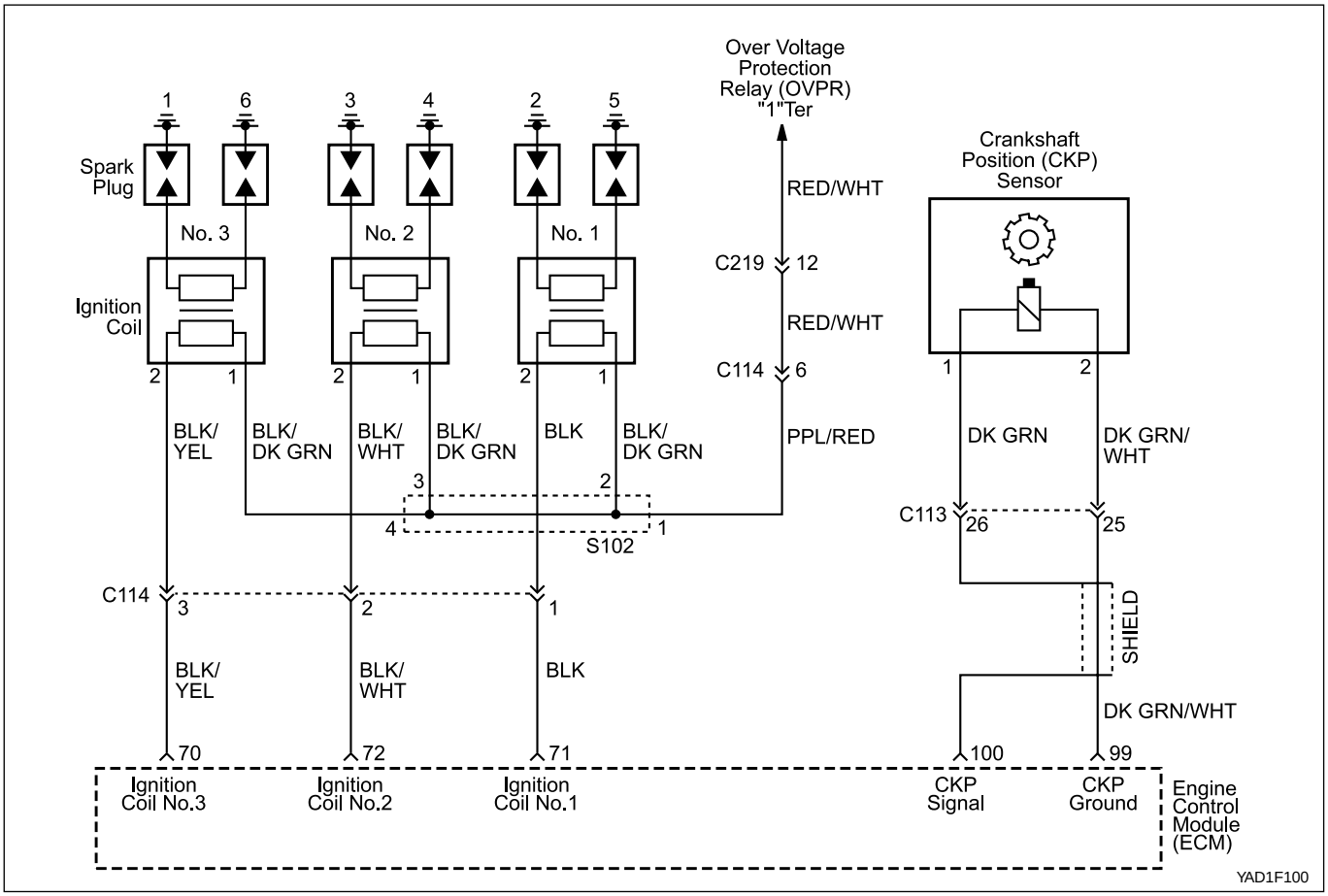
Each EI system ignition coil provides the high voltage to two spark plugs simultaneously;

T1/1: cylinder 2 and 5

T1/2: cylinder 3 and 4

T1/3: cylinder 1 and 6

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



Failure Code	Description	Trouble Area	Maintenance Hint
64	No ignition voltage output (No. 1 ignition coil)	Malfunction of ignition circuit Primary current values or secondary short circuit	• Inspection the ECM pin 70 (71 and72) about short circuit or open with bad contact • Inspection the power source to ignition • Inspection the power source to ignition coil • Inspection the ignition coil, high tension cords etc. • Inspection the spark plug (wet, cracks, wear, improper gap, burned electrodes, heavy deposit) • Inspection the ECM
65	No ignition voltage output (No. 2 ignition coil)		
66	No ignition voltage output (No. 3 ignition coil)		

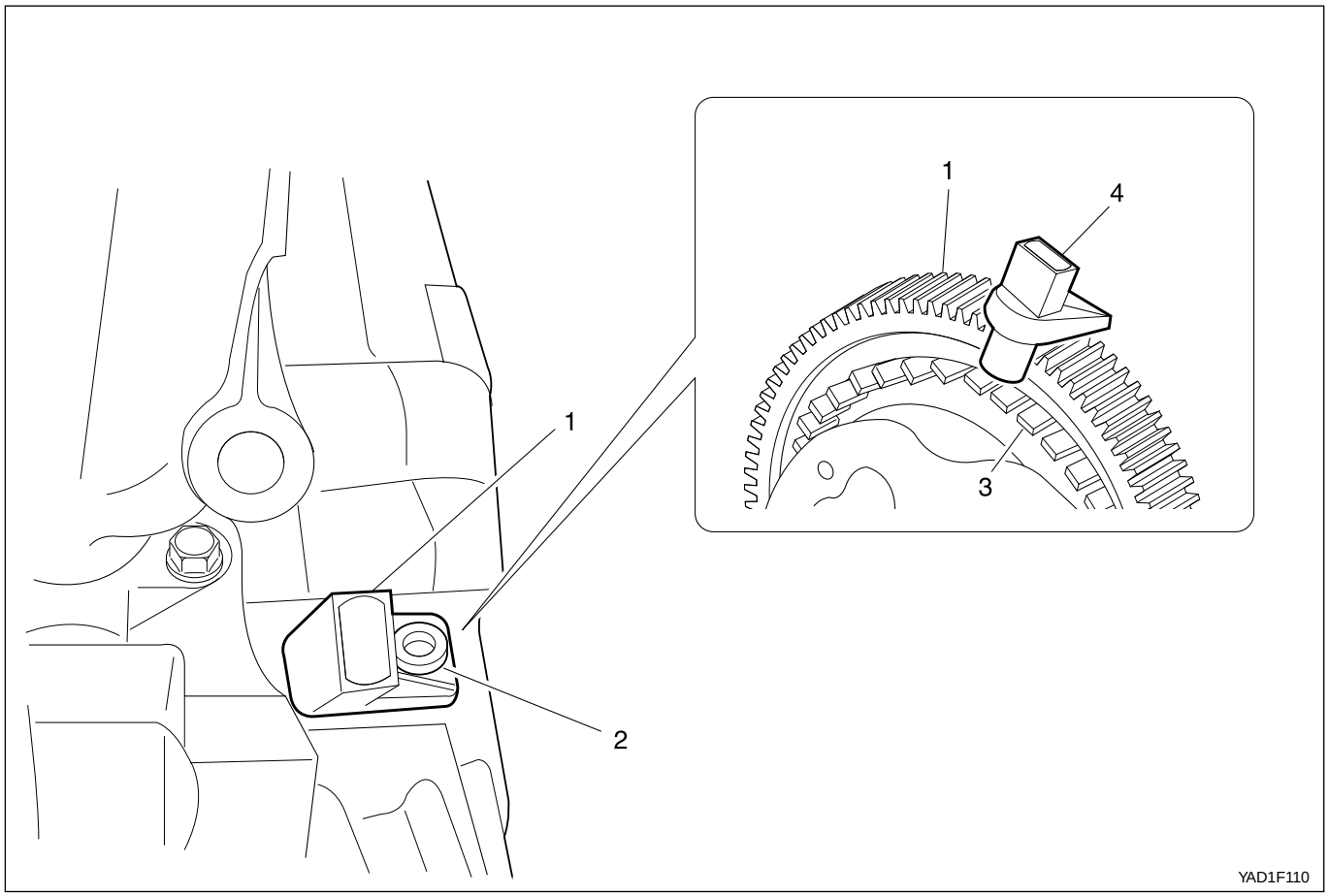
Circuit Description

The Electronic Ignition (EI) system uses a waste spark method of spark distribution. The Crankshaft Position (CKP) sensor sends reference pulses to the ECM. The ECM then triggers the EI system ignition coils. Once the ECM triggers the EI system ignition coils both of the connected spark plugs fire at the same time. One cylinder is on its compression stroke at the same time that the other is on the exhaust stroke, resulting in lower energy needed to fire the spark plugin the cylinder on its exhaust stroke.

This leaves there remainder of the high voltage to be used to fire the spark plug in the cylinder on its compression stroke.

Since the CKP sensor is in a fixed position, timing adjustments are not possible or needed.

CRANKSHAFT POSITION (CKP) SENSOR

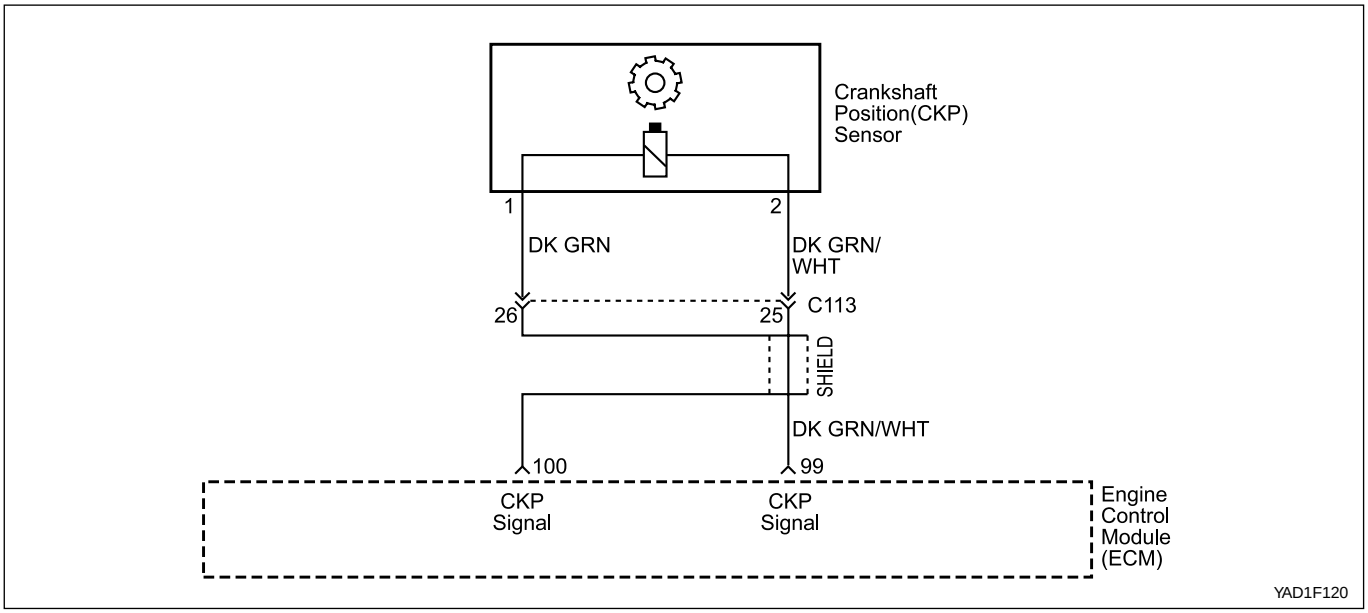


1 Crankshaft Position Sensor
2 Bolt
3 Segment
4 Flywheel

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 a gap of 2 teeth at 360 degree spacing. This sensor protrudes throughits 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.



Failure Code	Description	Trouble Area	Maintenance Hint
17	Crankshaft position sensor signal failure (no engine revolution signal)	Even through cam position recognition is normal, no crankshaft position signal recognition	• Monitoring the actual rpm through or scan tool • Inspection the ECM pin 100, 99 about short circuit with bad contact • Inspection the CKP sensor • Inspection the air gap between sensor and drive plate • Inspection the drive plate (teeth condition) • Inspection the ECM
18	Crankshaft position sensor signal failure (rpm > max. value)	When more than applicable revolution values or implausible to 60-2 teeth scan tool	
20	Crankshaft position sensor signal failure (gap recognition failure)	When implausible recognition of cam and crank angle signal or intermittent sensing the signal or error count of undetected gap.	
67	Crankshaft position sensor adaptation failure	When faulty crank angle sensor adaption	

Circuit Description

The 58X reference signal is produced by the CKP sensor. During one crankshaft revolution, 58 crankshaft pulses will be produced. The ECM uses the 58X reference signal to calculate engine rpm and CKP. The ECM constantly monitors the number of pulses on the 58X reference circuit and compares them to the number of Camshaft Position (CMP) signal pulses being received. If the ECM receives and incorrect number of pulses on the 58X reference circuit, this failure code will set.

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.

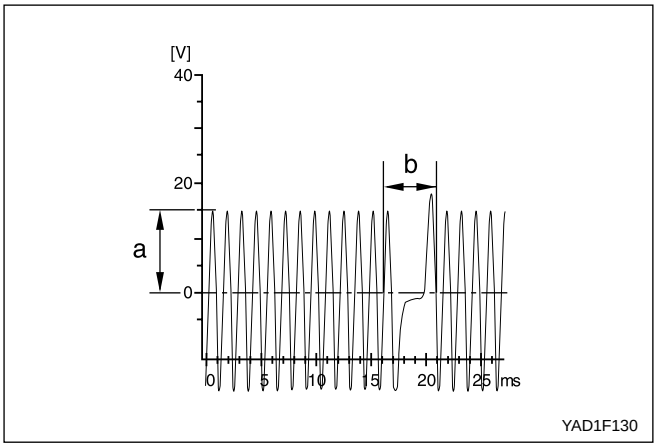
Specified Value	1,050 ~ 1,400 Ω

Notice: Measure the insulator resistance of the CKP sensor if out of the specified value.

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.



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.

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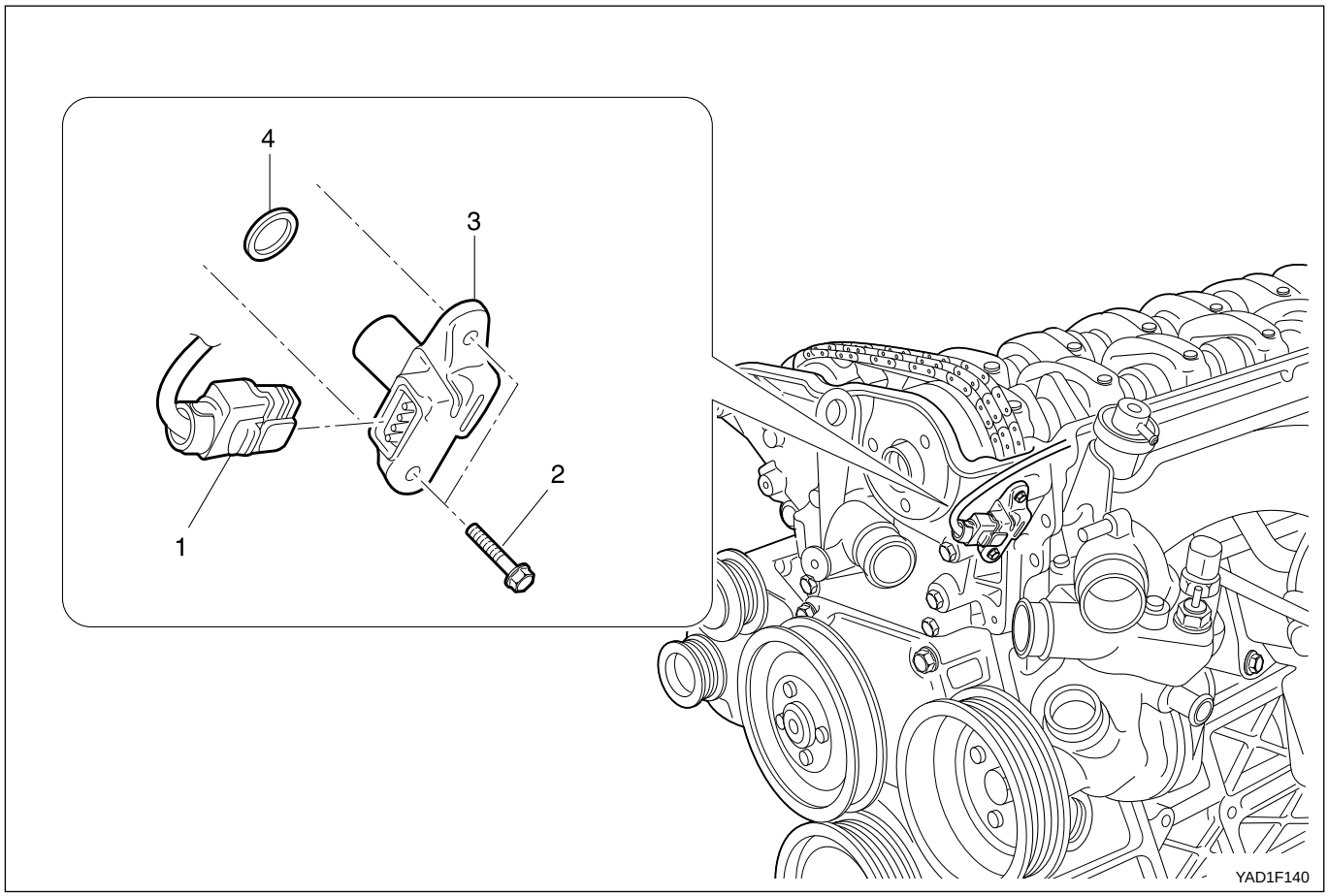
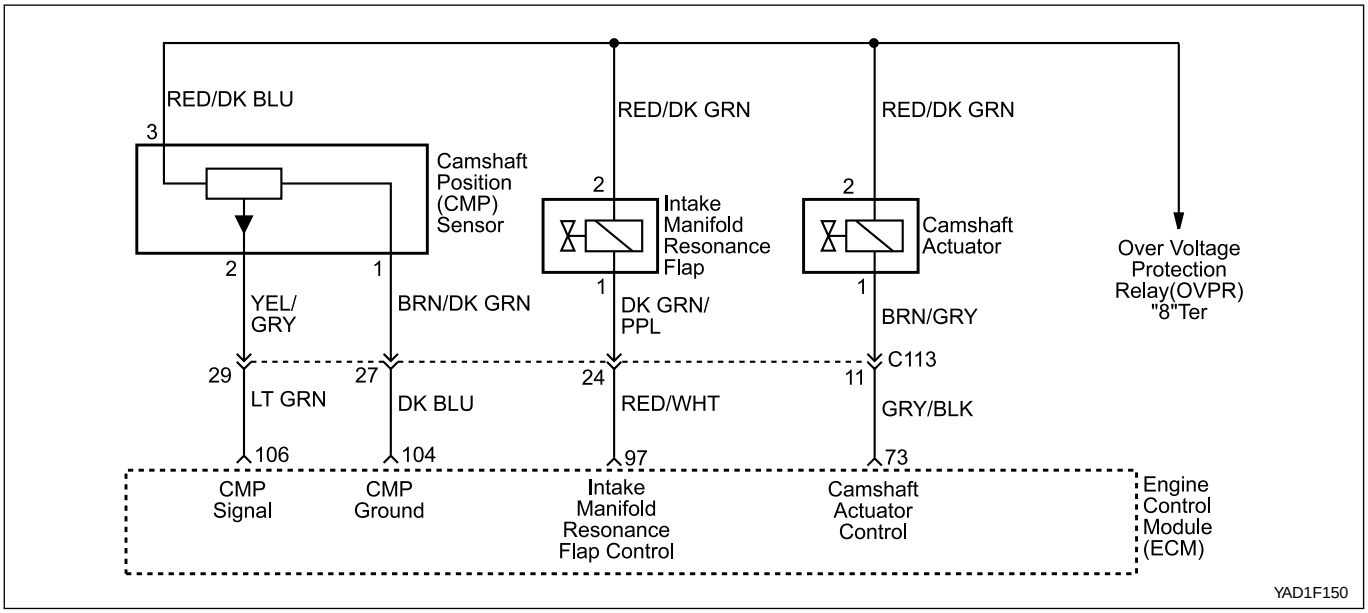
CAMSHAFT POSITION (CMP) SENSOR



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.



Failure Code	Description	Trouble Area	Maintenance Hint
19	Camshaft position sensor signal : No. 1 cylinder recognition failure	When no cam recognition signal during TN 24 counts more. (maintain the constant low or high level)	• Inspection the source voltage of CMP sensor • Inspection the ECM pin 106, 104 about short circuit or open with bad contact • Inspection the CMP sensor • Inspection the damage of sensor or sprocket • Inspection the ECM
58	Camshaft position sensor signal : No. 1 cylinder synchronization failure	When synchronization fault of cylinder 1 (TDC recognition)	

Circuit Description

The CMP sensor sends a cam position signal to the ECM. If the cam position signal is lost while the engine is running, the fuel injection system shifts to a calculated sequential fuel injection mode based on the last fuel injection pulse, and the engine continuous to run.

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.

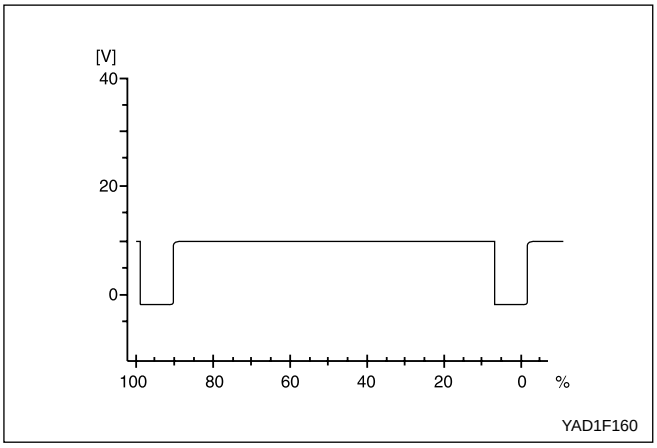
Specified Value	1.2 ~ 1.7 v

Notice: The signal voltage will be changed in the range of 1.2 ~ 1.7 v.

Camshaft Position Sensor Output Wave Inspection

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

   Notice: Replace the CAM sensor if cannot get the out-put wave as shown in the figure.



Camshaft Position Sensor Power Supply Inspection

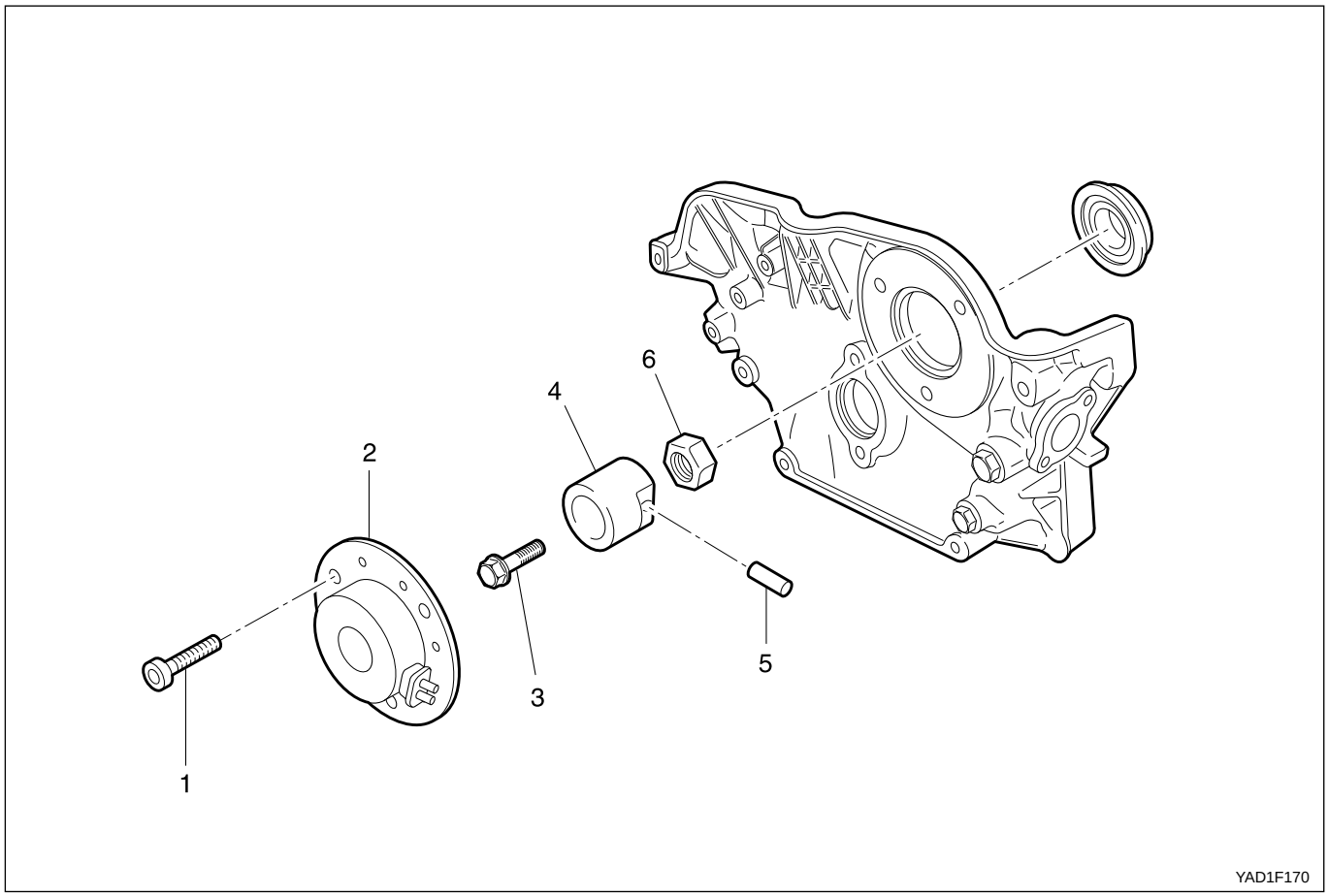
1. Disconnect the CMP sensor Connector.
2. Measure the voltage between the No. 1and No. 3 pin of the CMP sensor connector while the ignition switch is in “ON” position.

Specified Value	11 ~ 14 v

   Notice: If the measured value is not within the specified value, check the cable.

BLANK

CAMSHAFT ACTUATOR

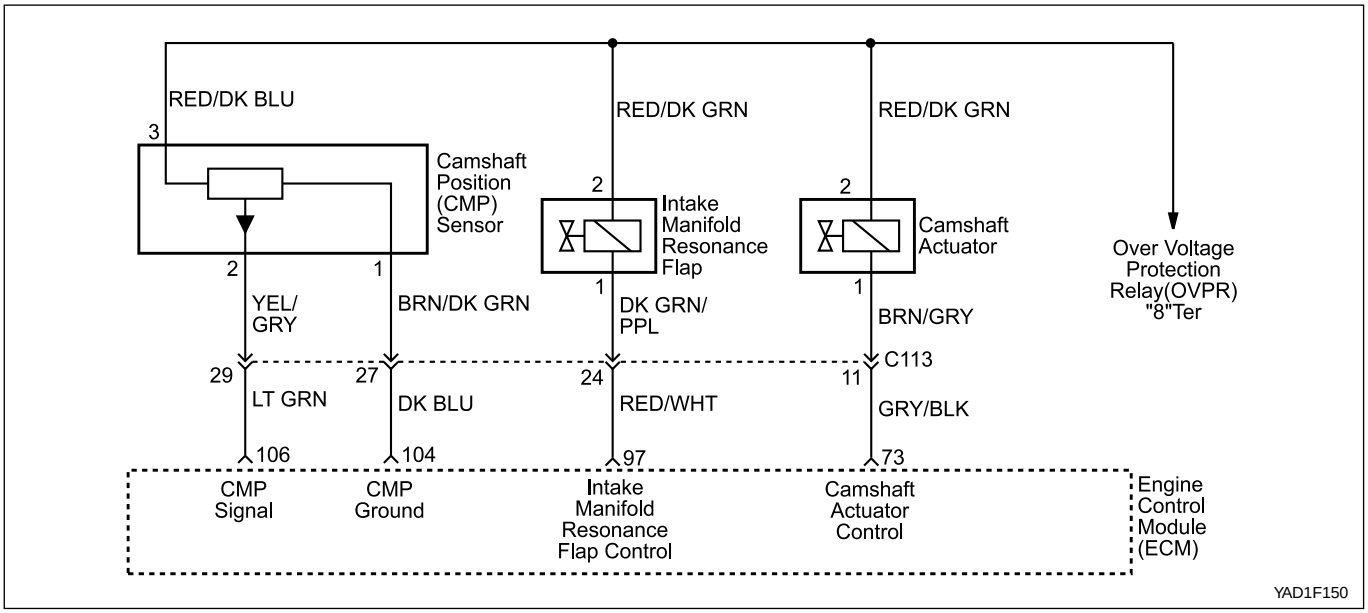


1 Bolt
2 Camshaft Actuator
3 Bolt
4 Armature
5 Roll Pin
6 Nut

When the engine is running, the camshaft actuator rotates the intake camshaft hydraulically and mechanically relative to the camshaft sprocket by 32° 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 ~ 1,500 rpm	Retard	Idle speed is improved Blow-by gas is decreased Valve overlap is decreased
1,500 ~ 4,300 rpm	Advanced	Torque is increased Fuel loss is decreased NOx is decreased
Above 4,300 rpm	Retard	Engine overrun is prohibited



Failure Code	Description	Trouble Area	Maintenance Hint
226	Camshaft actuator short circuit to battery	When malfunction of cam phasing control	• Monitoring the actual operational status through scan tool • Inspection the ECM pin 73 about short circuit or open • Inspection the power source short circuit or open to cam actuator • Inspection the magnet and hardware • Inspection the ECM
227	Camshaft actuator short circuit to ground or open		

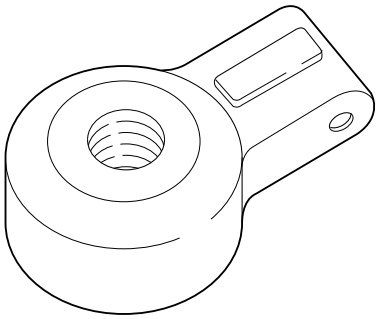
Camshaft Actuator Current Consumption Inspection

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 between the No. 1 and No. 2 pin of the camshaft actuator connector.

Specified Value	1 ~1.5 A

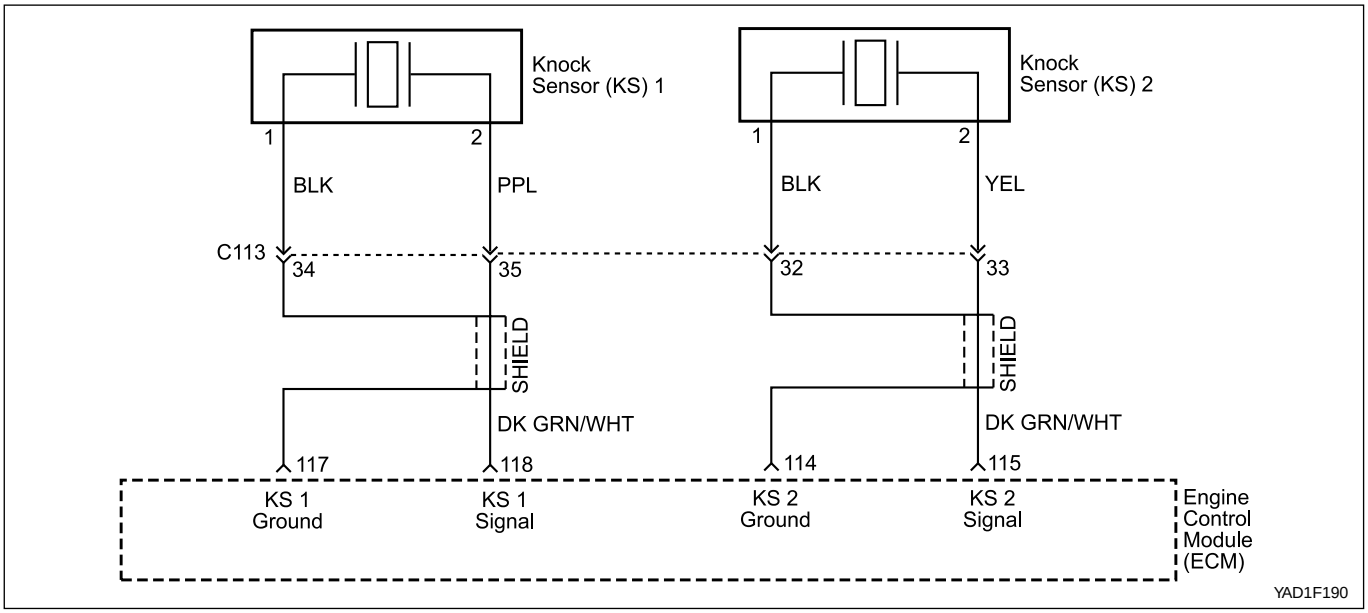
Notice: If the measured value is not within the specified value, check the cable.

KNOCK SENSOR (KS)



YAD1F180

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.



Failure Code	Description	Trouble Area	Maintenance Hint
56	No. 1 knock sensor signal failure	When recognition in more than control gain threshold at normal operational condition of other system during over 75 and 3,000 rpm running area (cylinder 1, 2, 3)	• Inspection the ECM pin 118, 117about short circuit or open with bad contact • Inspection the KS 1 malfunction • Inspection the ECM • Inspection the ECM pin 115, 114 about short circuit or open with bad contact • Inspection the KS 2 malfunction • Inspection the ECM
57	No. 2 knock sensor signal failure	When recognition in more than control gain threshold at normal operational condition of other system during over 75 and 3,000 rpm running area (cylinder 4, 5, 6)	

Circuit Description

The KS system is used to detect engine detonation, allowing the ECM to retard the ignition control spark timing based on the KS signal being received. The KS signal's amplitude and frequency depend upon the amount of knock being experienced. The ECM monitors the KS signal and can diagnose the KS sensor and circuitry.

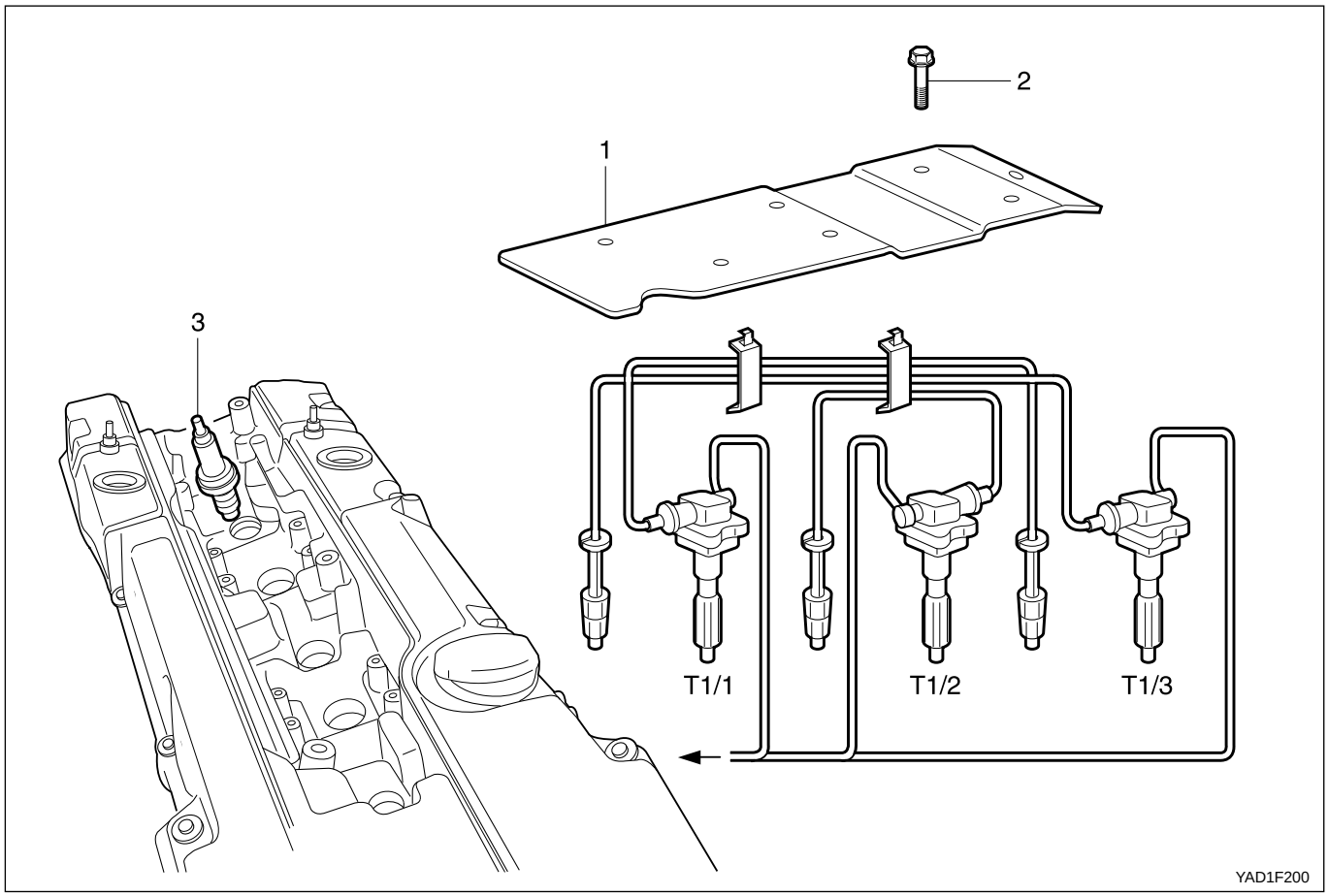
Knock Sensor Resistance Inspection

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 and terminal pin No. 115 and No. 114 using a multimeter.

Specified Value	>10 MΩ

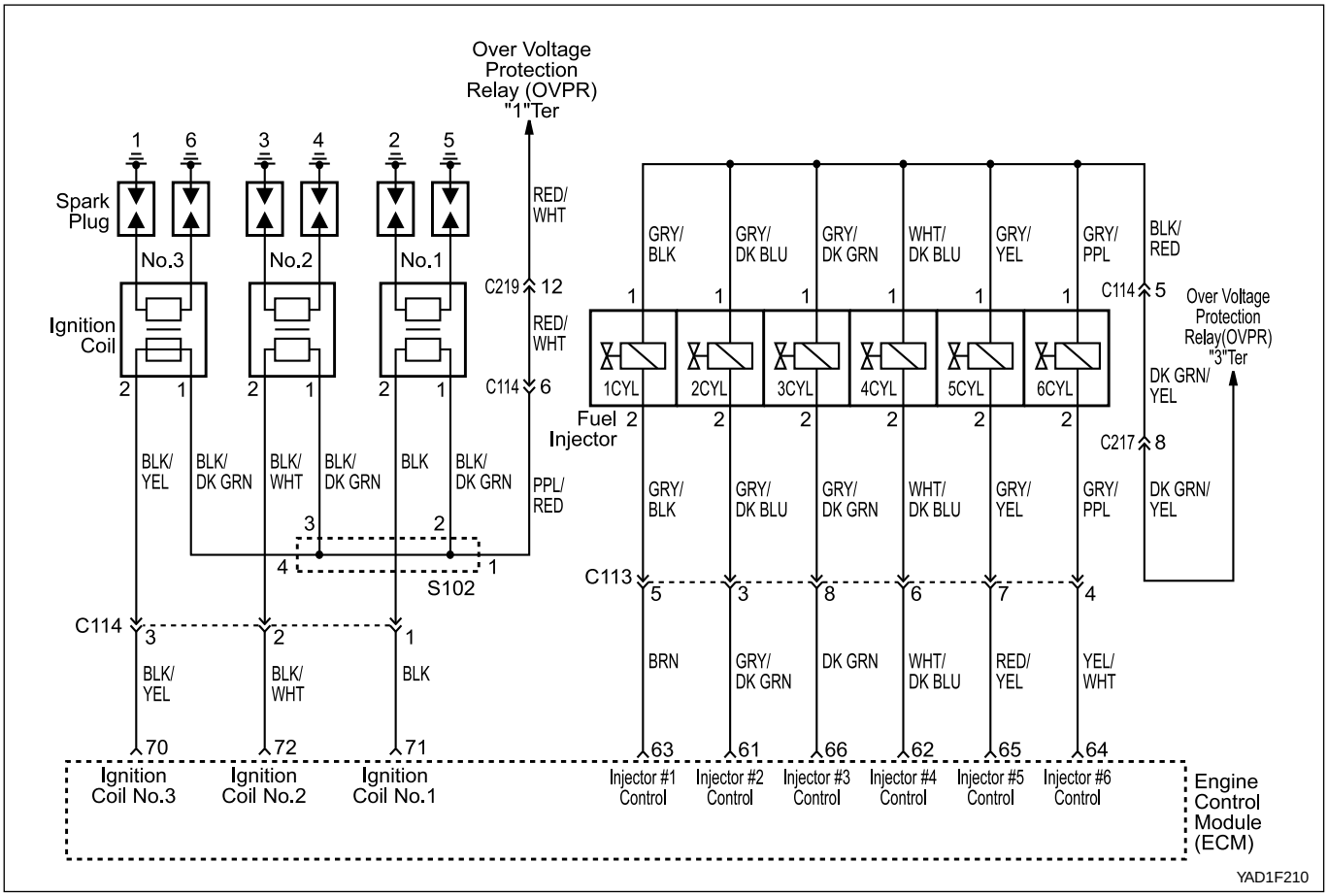
Notice: Replace the KS if the measured values is out of the specified values. Check the connector and wire connection between ECM and the KS if the measured values are normal.

SPARK PLUG



1 Ignition Coil Cable Cover
2 Bolt
3 Spark Plug

T 1/1 Ignition Coil Cylinder 2 and 5
T 1/2 Ignition Coil Cylinder 3 and 4
T 1/3 Ignition Coil Cylinder 1 and 6



Failure Code	Description	Trouble Area	Maintenance Hint
68	Random / Multiple Misfire	When detection misfire of multiple cylinder for source of over the emission threshold or catalyst damage	• Inspection the ignition system • Inspection the injection system • Inspection the fuel pressure • Inspection the compression pressure • Inspection the valve timing or clearance • Inspection the air flow sensor • Inspection the crankshaft position sensor and air gap • Inspection the engine wiring system • Inspection the Engine Control Module (ECM)

Circuit Description

The ECM monitors the crankshaft and camshaft positions to detect if the engine is misfiring. The ECM looks for a quick drop in crankshaft speed. Misfire multiple cylinder is monitored by engine roughness measuring. The actual roughness value is compared with the actual (emission and catalyst damage) threshold.

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.

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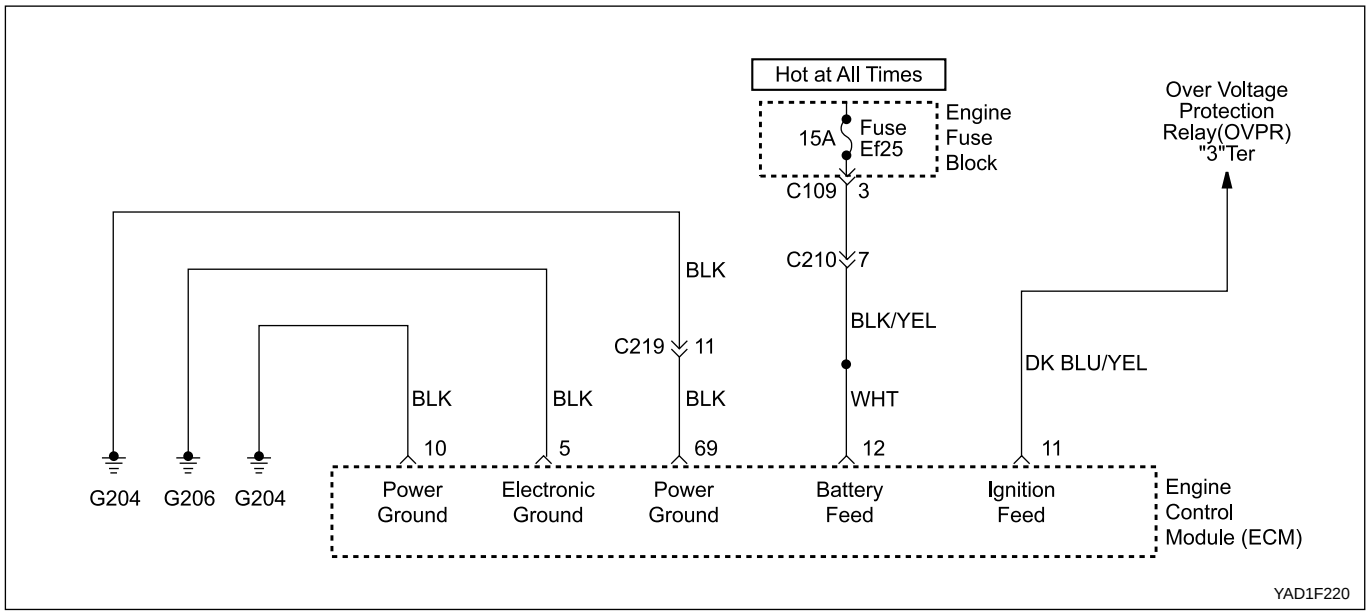
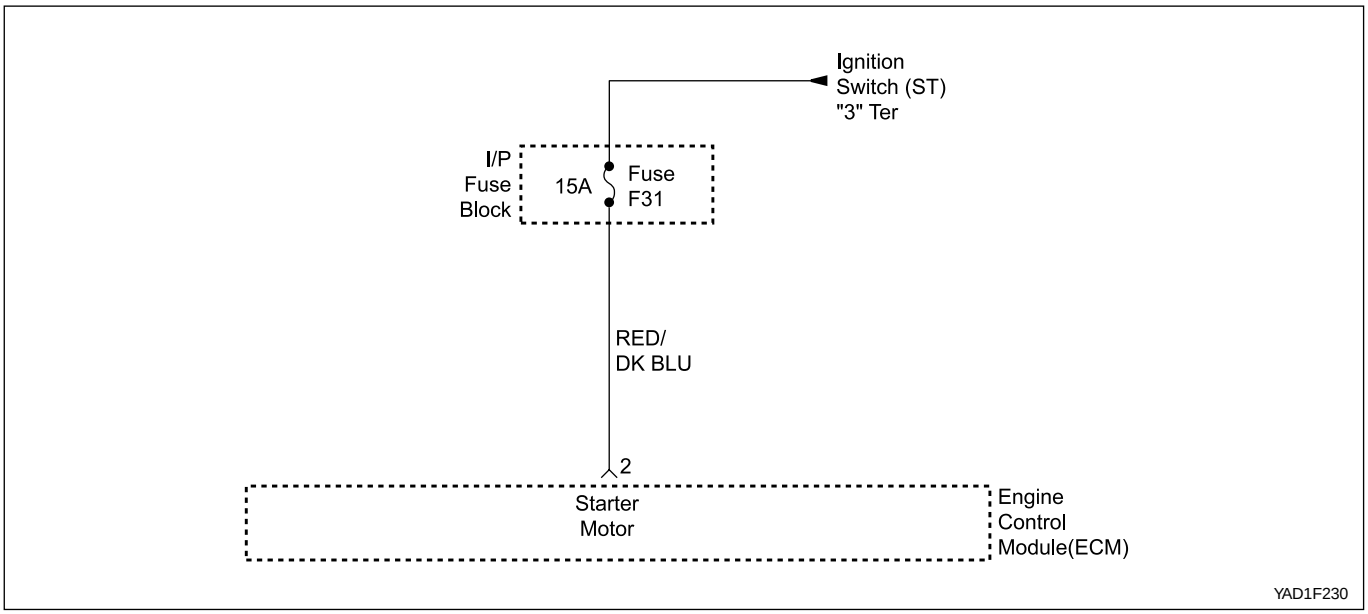
SYSTEM VOLTAGE



Failure Code	Description	Trouble Area	Maintenance Hint
08	System voltage too low	Malfunction in recognition of system source voltage. Less than minimum 8 volts in 2,000 rpm below, or less than 10 volts in 2,000 rpm above.	• Monitoring the actual battery voltages through the scan tool • Inspection the Engine Control Module (ECM) pin 12, 11, 10, 5 about short circuit or open with bad contact • Inspection the over voltage protection relay • Inspection the battery • Inspection ECM

IGNITION SWITCH



Failure Code	Description	Trouble Area	Maintenance Hint
71	Starter signal recognition failure	When not detection of starter signal	• Inspection the Engine Control Module (ECM) pin 2 circuit short or open with bad contact • Inspection ECM

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 Mass Air Flow (MAF) sensor and the oxygen (O2) sensors.

The MAF sensor monitors the mass flow of the air 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. Engine Control Module (ECM) modulates the flow of heating current to maintain the temperature differential between the heated film and the intake air at a constant level. The amount of heating current required to maintain the temperature thus provides an index for the mass air flow. This concept automatically compensates for variations in air density, as this is one of the factors that determines the amount of warmth that the surrounding air absorbs from the heated element. MAF sensor is located between the air filter and the throttle valve.

Under high fuel demands, the MAF sensor reads a high mass flow condition, such as wide open throttle. The ECM uses this information to enrich the mixture, thus increasing the fuel injector on—time, to provide the correct amount of fuel. When decelerating, the mass flow decreases. This mass flow change is sensed by the MAF sensor and read by the ECM, which then decreases the fuel injector on—time due to the low fuel demand conditions.

The O2 sensors are located in the exhaust pipe before catalytic converter. The O2 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 O2S and calculates the air/fuel ratio based on inputs from the ECT sensor and the MAF sensor. The ECM stays in “open loop” until the following conditions are met:

- The O2 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 O2 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.

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.

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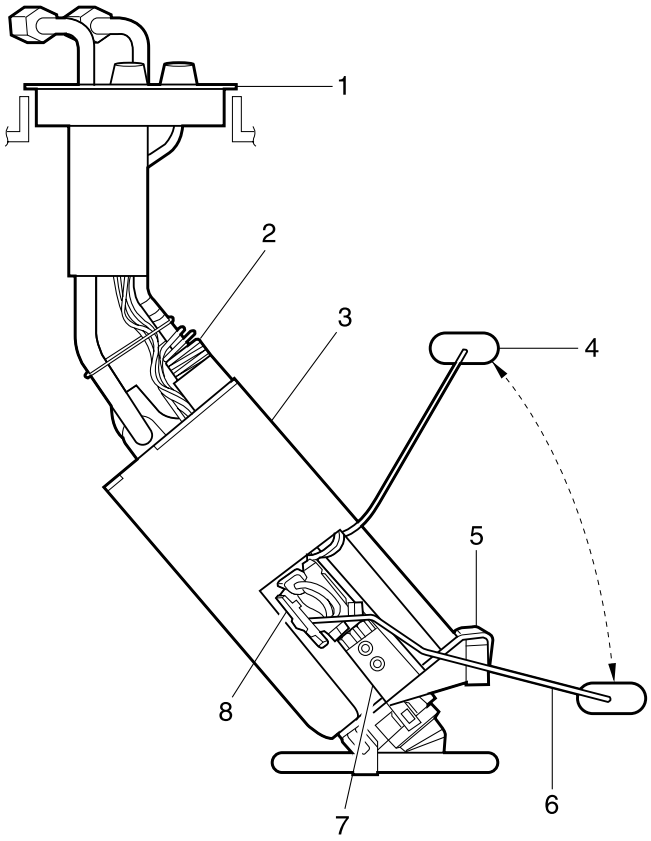
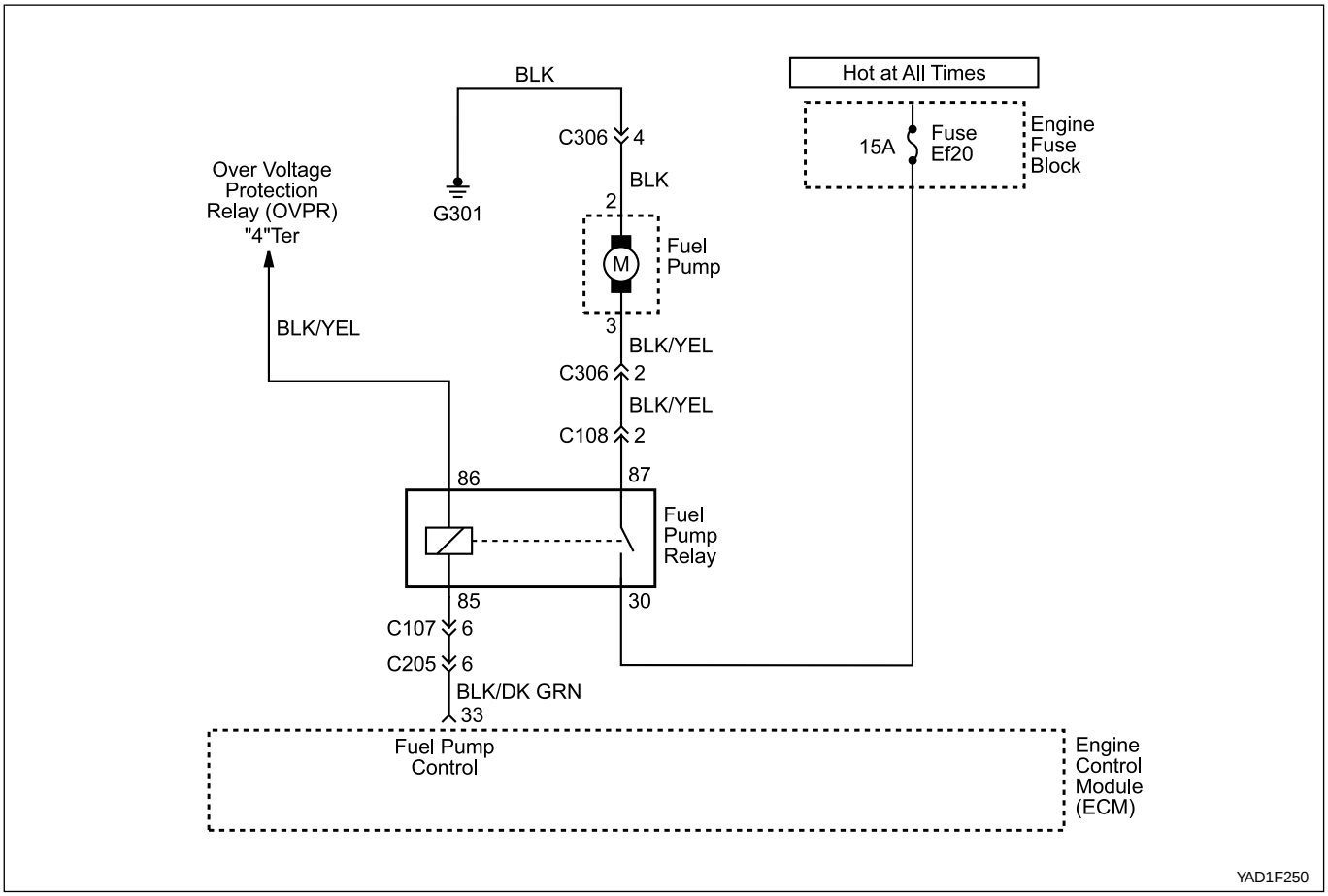
FUEL PUMP



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	8.5 bar (12 V)	Operating Voltage	8 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 (12V, 3.8 bar, -30 ~ +70 °C)



Failure Code	Description	Trouble Area	Maintenance Hint
34	Fuel pump relay short circuit to battery	When short circuit to power source	• Inspection the Engine Control Module (ECM) pin 33 about short circuit or open with bad contact • Inspection the fuel pump relay • Inspection the ECM
35	Fuel pump relay short circuit to ground or open	When short circuit to ground or open open with bad contact	

Circuit Description

When the ignition switch is turned ON, the ECMwill activate the pump relay and run the in-tank fuel pump. The fuel pump will operate as long as the engine is cranking or running and the ECMis receiving ignition reference pulses.

If there are no reference pulses, the ECM will shut off the fuel pump within 2 seconds after the ignition switch is turned ON, engine stopped or engine stalled.

Fuel Pump Relay Inspection

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

Ignition Switch : ON	0 V (for1 ~ 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.

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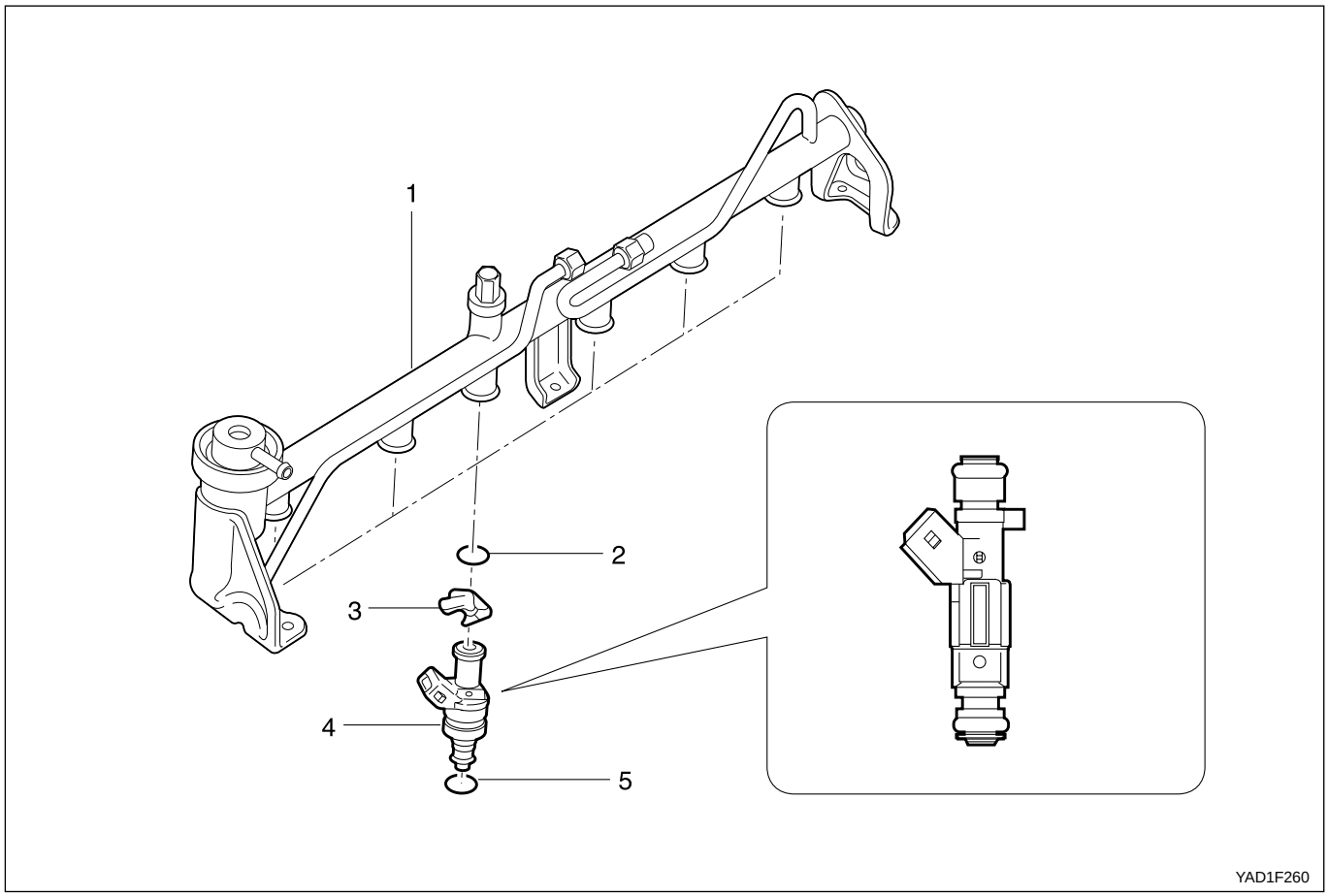
FUEL INJECTOR

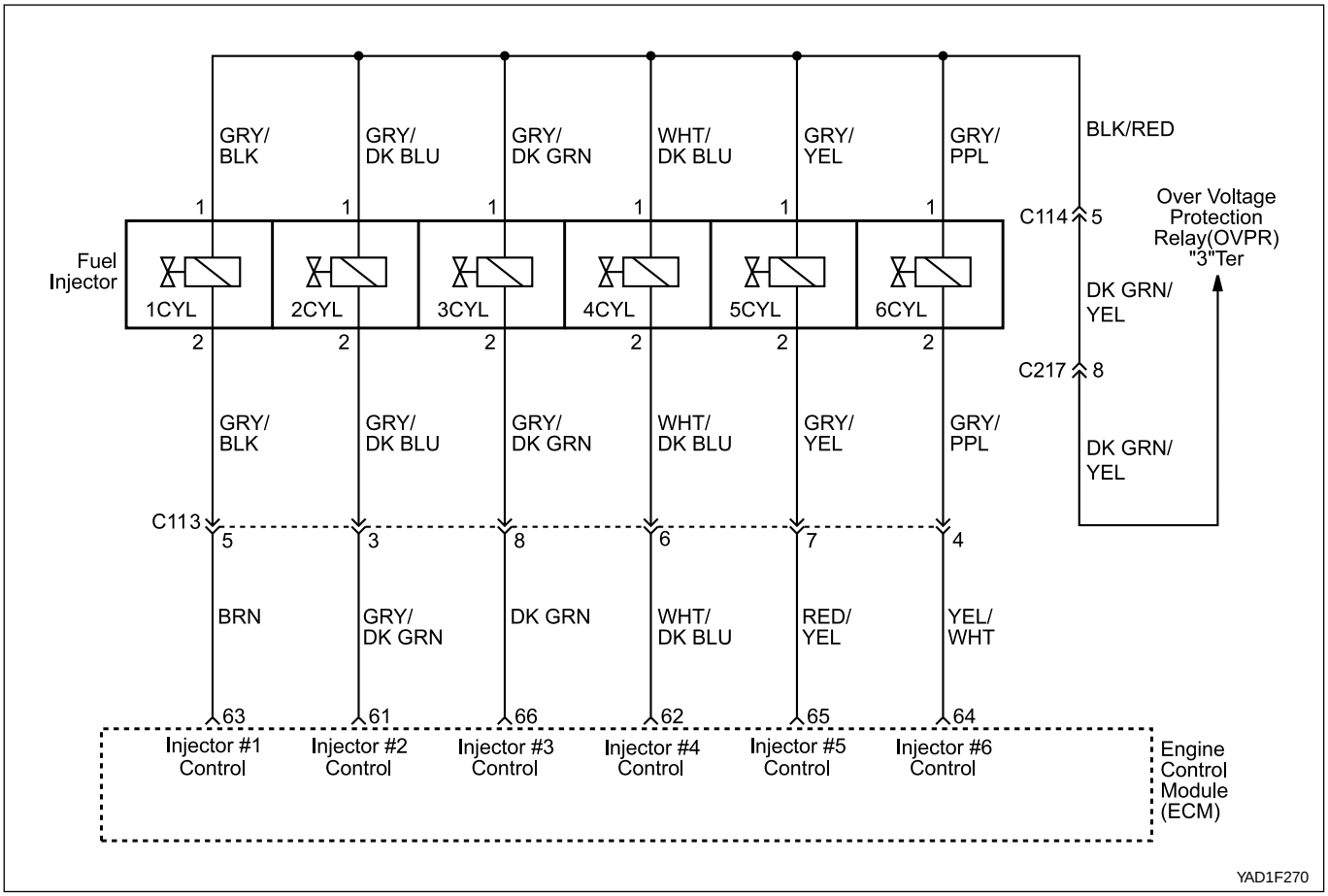


1 Fuel Rail
2 O-Ring
3 Injector Bracket
4 Injector
5 O-Ring

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 to ward 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 orifice is 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.

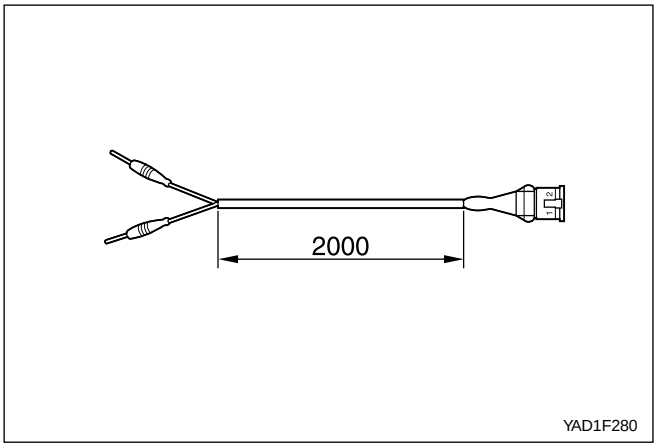
Fuel enters the top feed injector from above and flows through its vertical axis. The lower end extends into the intake valve. Fuel from the tip is directed at the intake valve, causing it to become further atomized and vaporized before entering the combustion chamber.

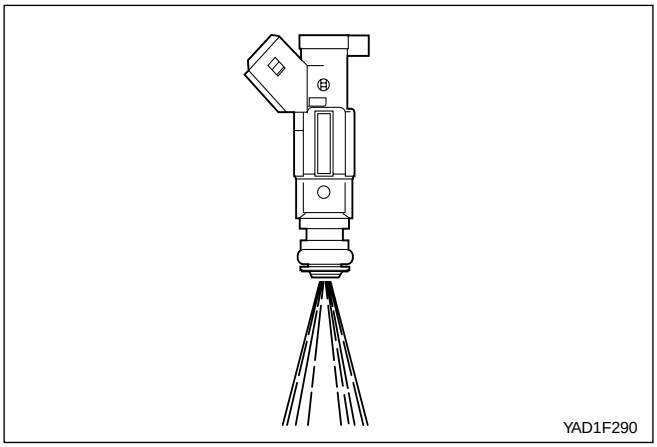
A fuel injector which is stuck partially open would cause a loss of fuel pressure after the engineis shut down. Also, an extended crank time would be noticed on some engines. Dieseling could also occur because some fuel could be delivered to the engine after the ignition is turned off.



Failure Code	Description	Trouble Area	Maintenance Hint
72	No. 1 injector short circuit to battery	When malfunction of injector circuit Injector #1 short circuit to power	• Inspection the power to injector #1 or bad contact • Inspection the injector • Inspection the ECM
73	No. 1 injector short circuit to ground or open	When malfunction of injector circuit Injector #1 short circuit to ground or open	• Inspection the ECM pin 63 about short circuit or open with bad contact • Inspection the injector • Inspection the ECM
74	No. 2 injector short circuit to battery	When malfunction of injector circuit Injector #2 short circuit to power	• Inspection the power to injector #2 or bad contact • Inspection the injector • Inspection the ECM
75	No. 2 injector short circuit to ground or open	When malfunction of injector circuit Injector #2 short circuit to ground or open	• Inspection the ECM pin 61 about short circuit or open with bad contact • Inspection the injector • Inspection the ECM
76	No. 3 injector short circuit to battery	When malfunction of injector circuit Injector #3 short circuit to power	• Inspection the power to injector #3 or bad contact • Inspection the injector • Inspection the ECM

Failure Code	Description	Trouble Area	Maintenance Hint
77	No. 3 injector short circuit to ground or open	When malfunction of injector circuit Injector #3 short circuit to ground or open	• Inspection the ECM pin 66 about short circuit or open with bad contact • Inspection the injector • Inspection the ECM
78	No. 4 injector short circuit to battery	When malfunction of injector circuit Injector #4 short circuit to power	• Inspection the power to injector #4 or bad contact • Inspection the injector • Inspection the ECM
79	No. 4 injector short circuit to ground or open	When malfunction of injector circuit Injector #4 short circuit to ground or open	• Inspection the ECM pin 62 about short circuit or open with bad contact • Inspection the injector • Inspection the ECM
192	No. 5 injector short circuit to battery	When malfunction of injector circuit Injector #5 short circuit to power	• Inspection the power to injector #5 or bad contact • Inspection the injector • Inspection the ECM
193	No. 5 injector short circuit to ground or open	When malfunction of injector circuit Injector #5 short circuit to ground or open	• Inspection the ECM pin 65 about short circuit or open with bad contact • Inspection the injector • Inspection the ECM
194	No. 6 injector short circuit to battery	When malfunction of injector circuit Injector #6 short circuit to power	• Inspection the power to injector #6 or bad contact • Inspection the injector • Inspection the ECM
195	No. 6 injector short circuit to ground or open	When malfunction of injector circuit Injector #6 short circuit to ground or open	• Inspection the ECM pin 64 about short circuit or open with bad contact • Inspection the injector • Inspection the ECM





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 injector 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 injector for normal spray pattern as shown in the figure. Check injector for leaks or later drop

Injector Resistance Inspection

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

Specified Value	14 ~ 17 Ω

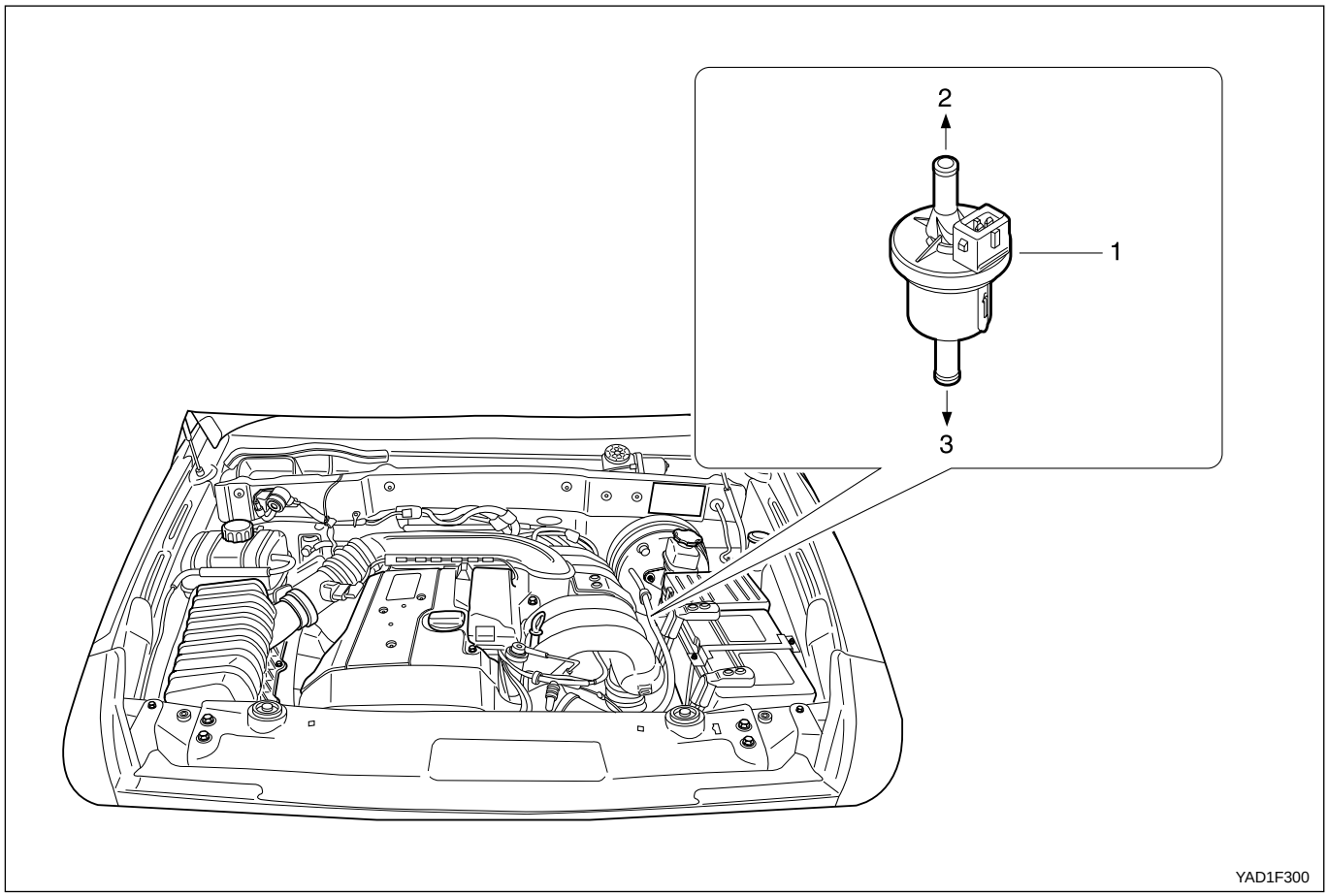
Notice: Replace the fuel injector if the measured value is out of the specified values. Check the connector and wire connection between the ECM and the injector if the measured values are normal.

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 Conister

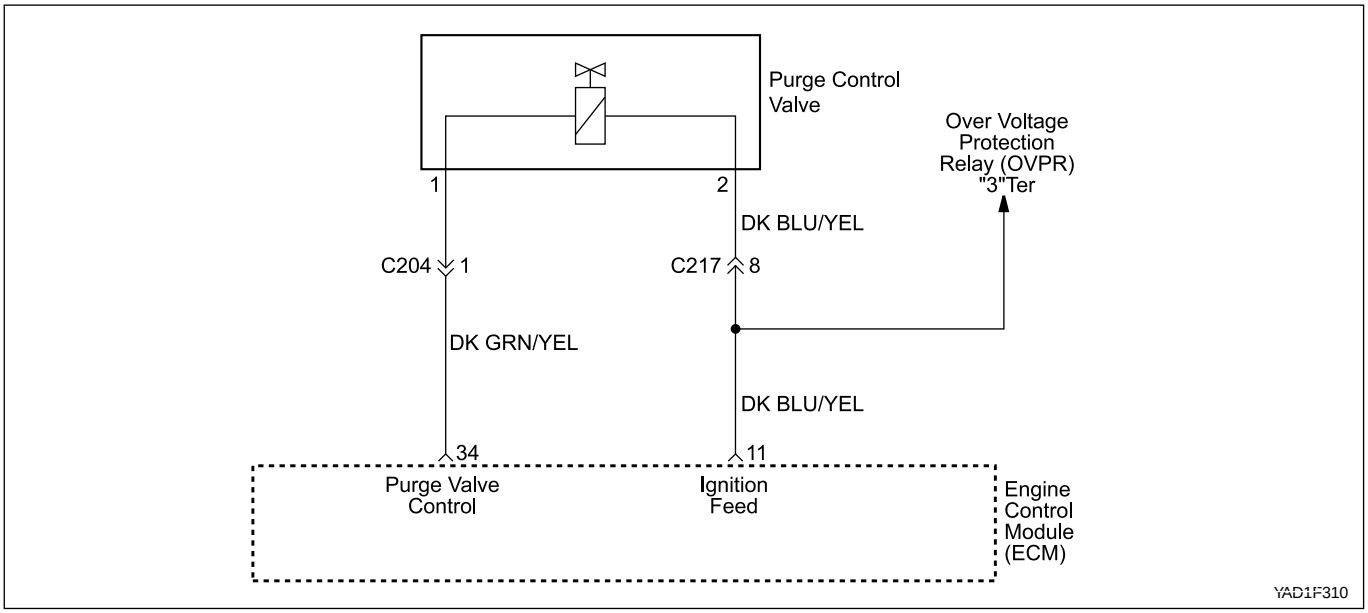
The fuel vaporization control system is in stalled to inhibit the fuel vaporized gas from discharging into the atmosphere.

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.

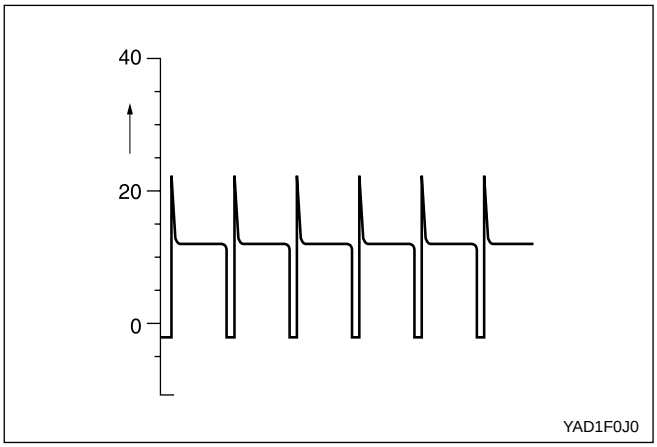
The purge control valve is activated by the ECM frequency according with the engine rotating speed to adjust the purification rate. The purification rate is determined by the continuous valve opening interval.

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



Failure Code	Description	Trouble Area	Maintenance Hint
40	Purge control valve short circuit to battery	When short circuit to power source	• Inspection the ECM pin 34 about short circuit or open with bad contact. • Inspection the source power of valve • Inspection the purge control solenoid vale • Inspection the ECM
41	Purge control valve short circuit to ground or open	When short circuit to ground or open circuit or open with bad contact	
54	Purge control circuit malfunction	When malfunction of purge control : not work vale	



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.

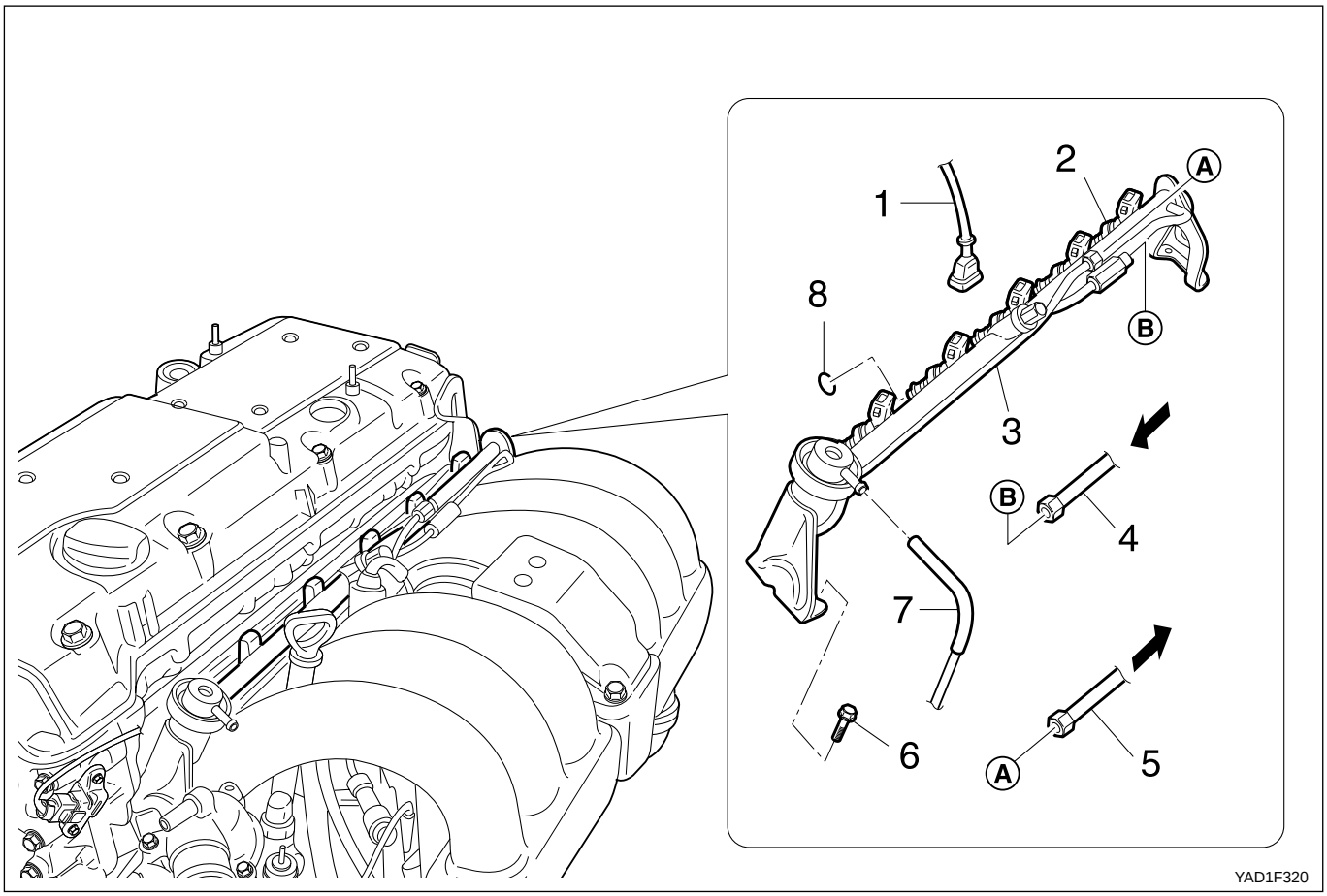
Specified Value	0.3 ~ 0.5 A

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

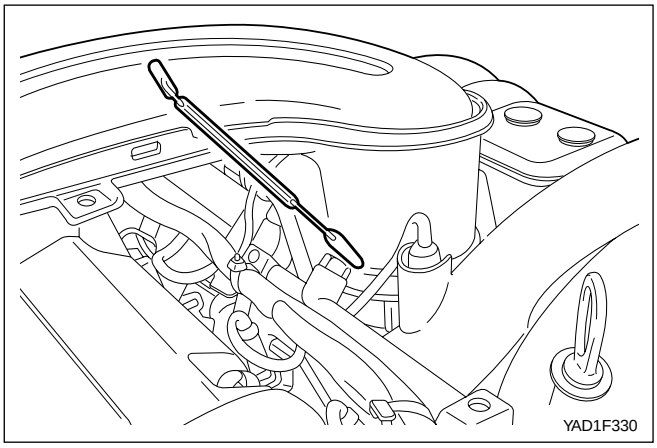
Specified Value	> 500 mbar (after approx. 1 min.) purge control valve operates at this time

Notice: Test while at normal temperature and at idling state by operating the engine.

FUEL RAIL



1 Injector Connector
2 Injector
3 Fuel Rail
4 Fuel Supply Line
5 Fuel Return Line
6 Bolt
7 Vacuum Hose
8 O-Ring



Fuel Pressure Test

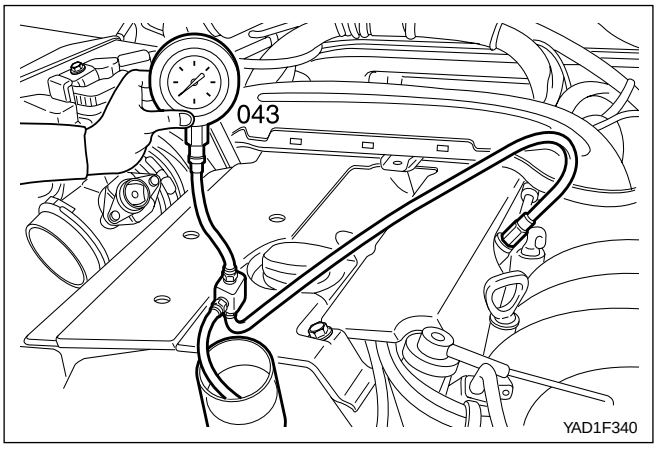
Tools Required

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

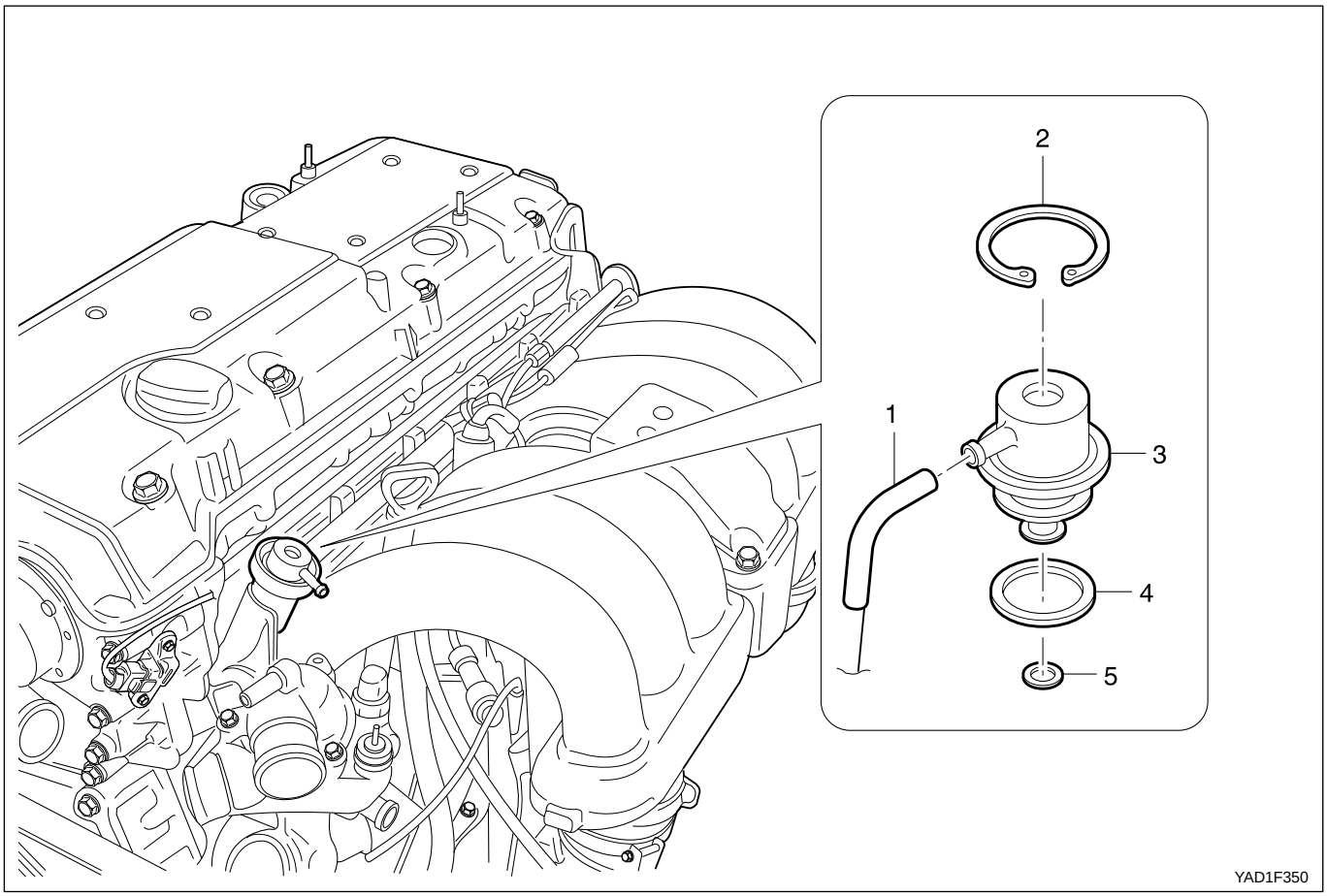
1. Connect thefuel pressure gauge 103 589 00 21 00 to the fuel pressure test connector.
2. Stop the engine for approximately 30 minutes and then check the fuel pressure changes.

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

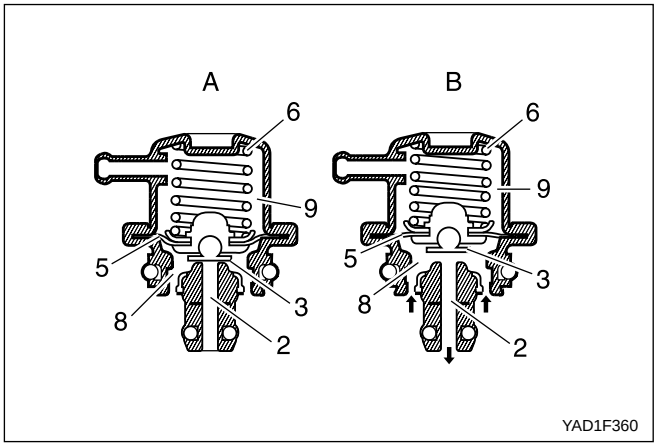
3. If there is no change in fuel pressure and maintain the following pressure over 30 minutes, it is normal.

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.

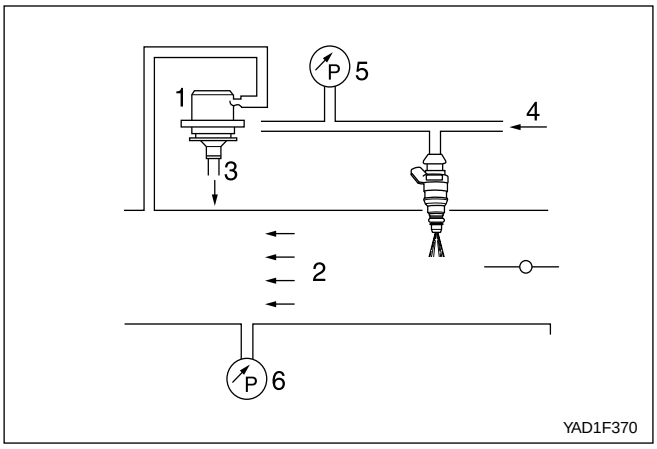
Over supplied fuel returns to the fuel tank through the return line.

<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.

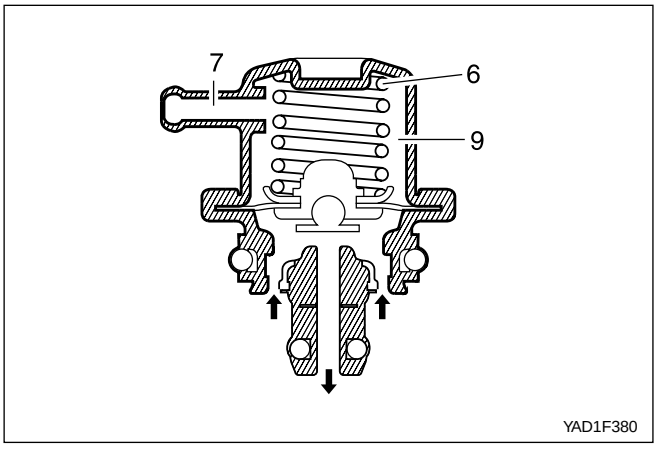
The pressure difference between the fuel pressure and the intake manifold is about 3.8 bars during the full load.



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)

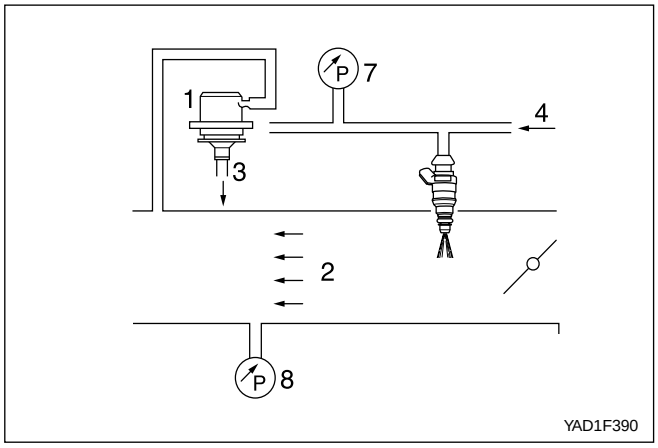
<Operating at Idle and partial load>

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.



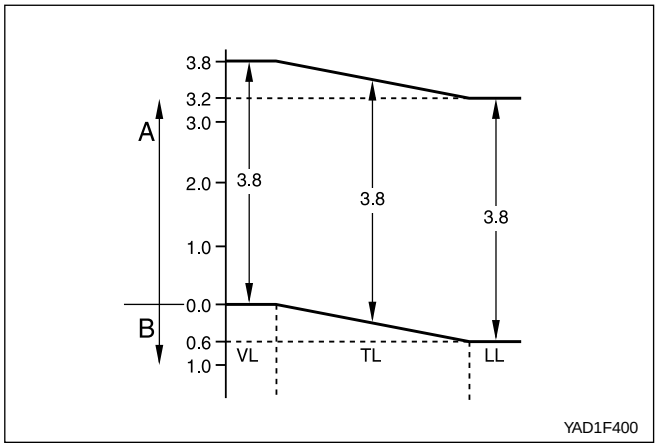
Consequently, the fuel pressure in the fuel distributor changes by the intake manifold's negative pressure, and the injector's fuel pressure gets reduced independently to the throttle valve's position. Thus, the fuel injection volume can only be determined according to the injector's injecting duration.

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



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)

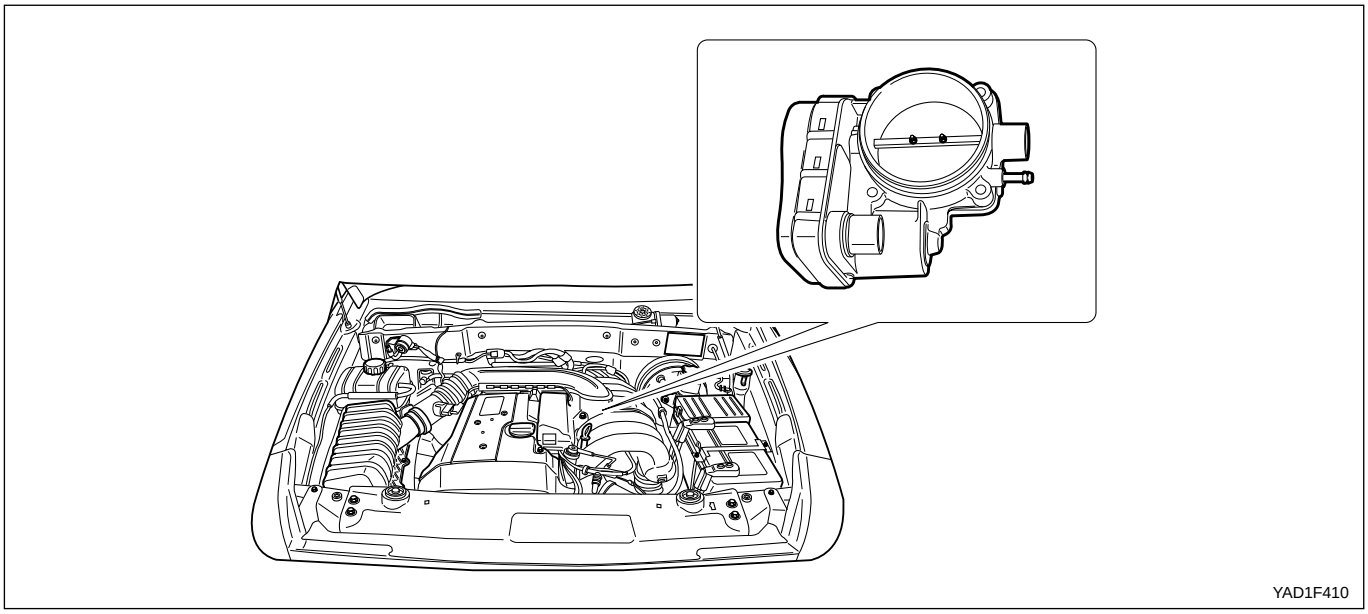
<Fuel Pressure Diagram>



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

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.

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 deenergized, the throttle valve is resting against the spring capsule.

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

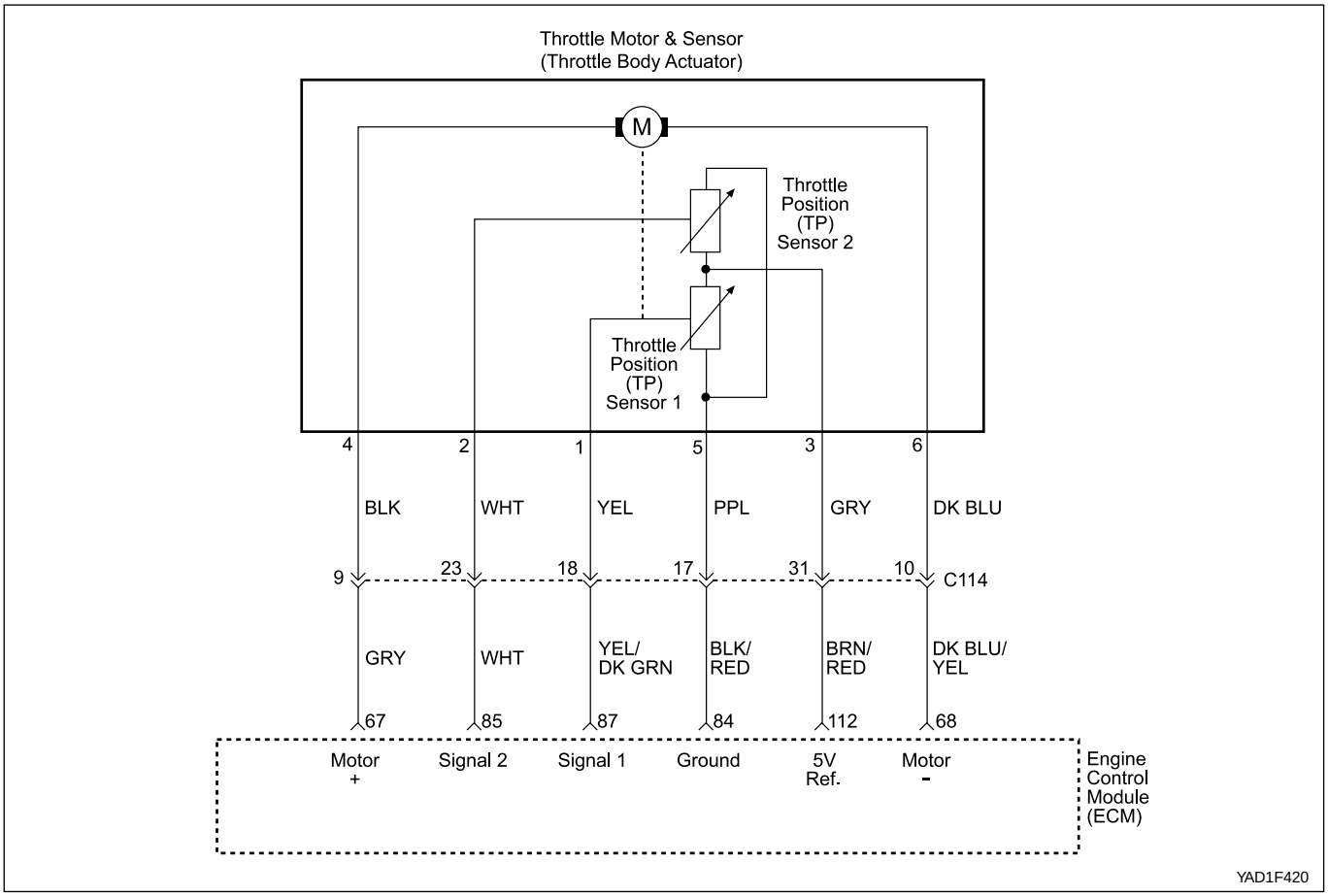
At no load, this produces an engine speed of about 1,800 rpm

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



Failure Code	Description	Trouble Area	Maintenance Hint
104	Throttle position sensor 1 low voltage	TPS 1 short circuit to ground or open	• Monitoring the actual values through • Inspection the ECM pin 84, 85, 87, 112, 67, 68 about short circuit or open with bad contact • Inspection the throttle valve actuator • Inspection the ECM
105	Throttle position sensor 1 high voltage	TPS 1 short circuit to power	
108	Throttle position sensor 2 low voltage	TPS 2 short circuit to ground or open	
109	Throttle position sensor 2 high voltage	TPS 2 short circuit to power	
116	Throttle actuator learning control failure	When actuator adaption fluctuation or not meet the condition scan tool	
119	Throttle valve return spring failure	When return spring defective of actuator with bad contact	
121	Throttle actuator failure	When supply voltage of the actuator short circuit to power Inspection the ECM	
123	Different mass air flow sensor signal with throttle position sensor	When shut down of output driver	
125	Both throttle position sensor failure	When defective of both potentiometers	

Failure Code	Description	Trouble Area	Maintenance Hint
126	Throttle position sensor 1 not plausible with Throttle position sensor 2	When difference between TPS 1 and TPS 2	• Monitoring the actual values through scan tool • Inspection the ECM pin 84, 85, 87, 112, 67, 68 about short circuit or open with bad contact • Inspection the throttle valve actuator • Inspection the ECM
127	High permanent throttle signal	When failure of wiring harness or actuator	
185	Mass air flow sensor and throttle position sensor failure	When difference between MAF and TPS signal	

Circuit Description

The ECM supplies a 5 volt reference signal and a ground to the TP sensor. The TP sensor sends a voltage signal back to the ECM relative to the throttle plate opening. The voltage signal will vary from approximately 0.3 ~ 0.9 volts at closed throttle, to over 4.0 ~ 4.6 volts at Wide Open Throttle (WOT).

The TP sensors serve for engine load control according to the drive pedal command. Load adjustments independent of the drive pedal command can be implemented; such functions are, for instance, idle control, speed control, drive slip control, load shock damping, and similar functions.

When the actuator current fails, the throttle valve is returned to emergency operating position by a spring. The throttle valve position, thereby the actuator drive position check back is provided by two potentiometers. The motor positions the throttle valve against the return spring force. Motor and return spring are two separate energy sources. Each of Them is able to position the throttle valve in emergency position alone. Throttle valve position check back and monitoring is provided by two actual value potentiometers connected to the engine control electronics.

Throttle Actuator Inspection

1. Turn the ignition switch to “ON” position.
2. Measure the TPS 1 signal voltage at the ECM pin No. 87 and TPS 2 signal voltage at the ECM pin No. 85.

	Pedal Position	Specified Value
TPS 1	Closed	0.3 ~ 0.9 v
	Opened	1 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 voltage 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)

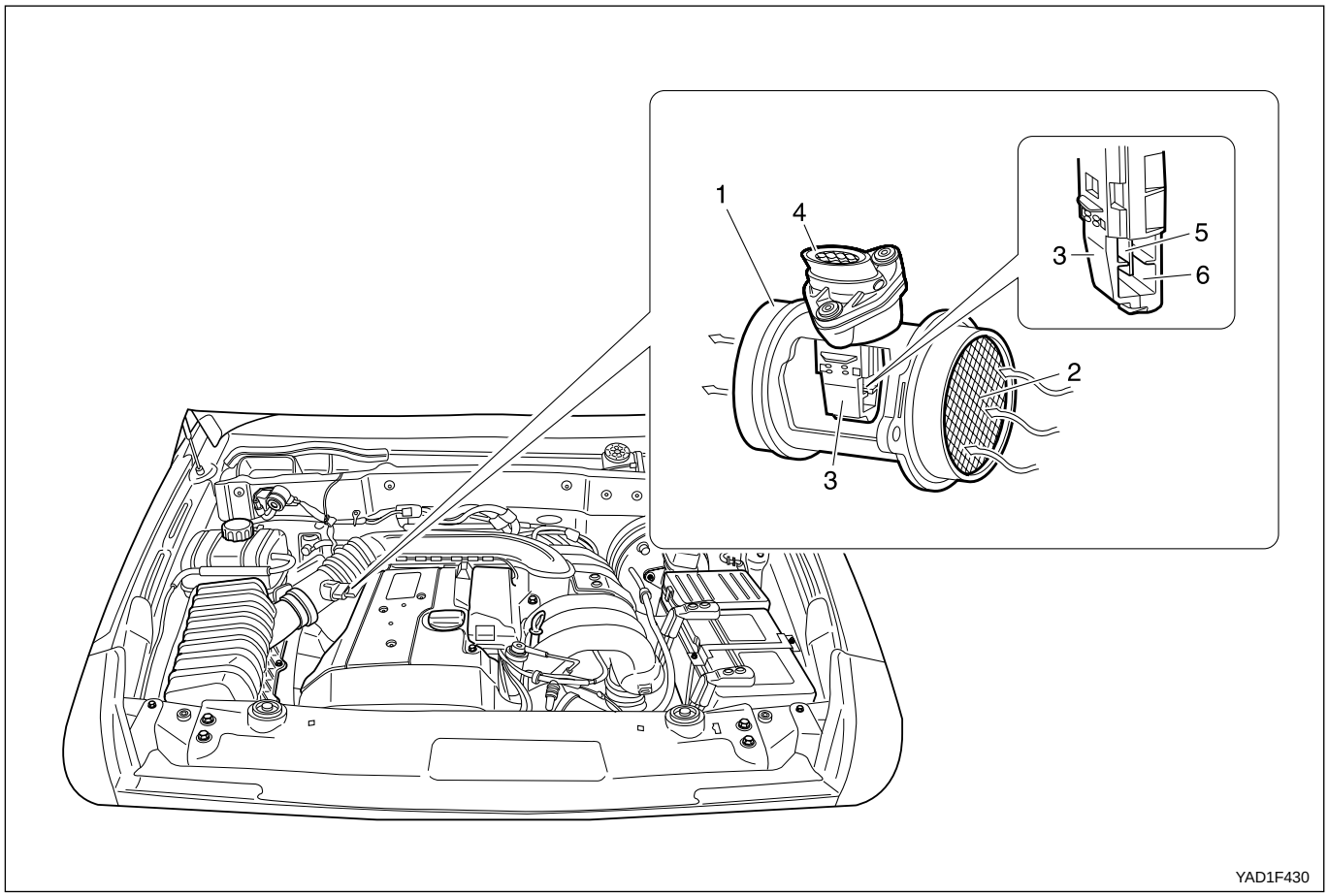
Throttle Actuator DC Motor Resistance

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

BLANK

HOT FILM AIR MASS (HFM) SENSOR



1 Housing
2 Protector Net
3 Electronic Housing
4 Connector
5 Hot Film Air Mass Sensor
6 Measuring Port

The Hot Film Air Mass (HFM) sensor with recognition of flow direction related to pulsating flow is designed for recording load on Engine Control Module (ECM) by measuring the output voltage proportional to the reference voltage of the ECM.

Mass Air Flow Sensor

Mass Air Flow (MAF) is a thermal flow meter whose sensor element with its temperature sensors and heating area is exposed to the MAF to be measured. A heating area located in the center of a thin membrane is controlled to an over-temperature by a heating resistor and a temperature sensor of this membrane. And the value of over-temperature depends on the temperature of the in-flowing air.

Two temperature sensors on upstream and downstream of the heating area show the same temperature without incoming flow. With incoming flow, upstream part is cooled down but downstream temperature retains its temperature more or less due to the air heated up in the heating area. This temperature difference in quantity and direction depends on the direction of the incoming flow.

ECM modulates the flow of heating current to maintain the temperature differential between the heated film and the intake air at a constant level. The amount of heating current required to maintain the temperature thus provides an index for the MAF. This concept automatically compensates for variations in air density, as this is one of the factors that determines the amount of warmth that the surrounding air absorbs from the heated element. MAF sensor is located between the air filter and the throttle valve.

Under high fuel demands, the MAF sensor reads a high mass flow condition, such as Wide Open Throttle (WOT). The ECM uses this information to enrich the mixture, thus increasing the fuel injector on-time, to provide the correct amount of fuel. When decelerating, the mass flow decreases. This mass flow change is sensed by the MAF sensor and read by the ECM, which then decreases the fuel injector on-time due to the low fuel demand conditions.

To facilitate the installation of the HFM in the intake passage, lubricating agents may be used. However, when lubricants are used care must be taken to ensure that they do not enter the flow passage and cannot be sucked in with the air flow.

The following tables show the relationship between MAF and output voltage.

Mass Air Flow (kg/h)	Voltage (V)	Mass Air Flow (kg/h)	Voltage (V)
0	0.95 ~ 1.05	250	3.51
10	1.28	370	3.93
15	1.41	480	4.23
30	1.71	640	4.56
60	2.16	800	4.82
120	2.76		

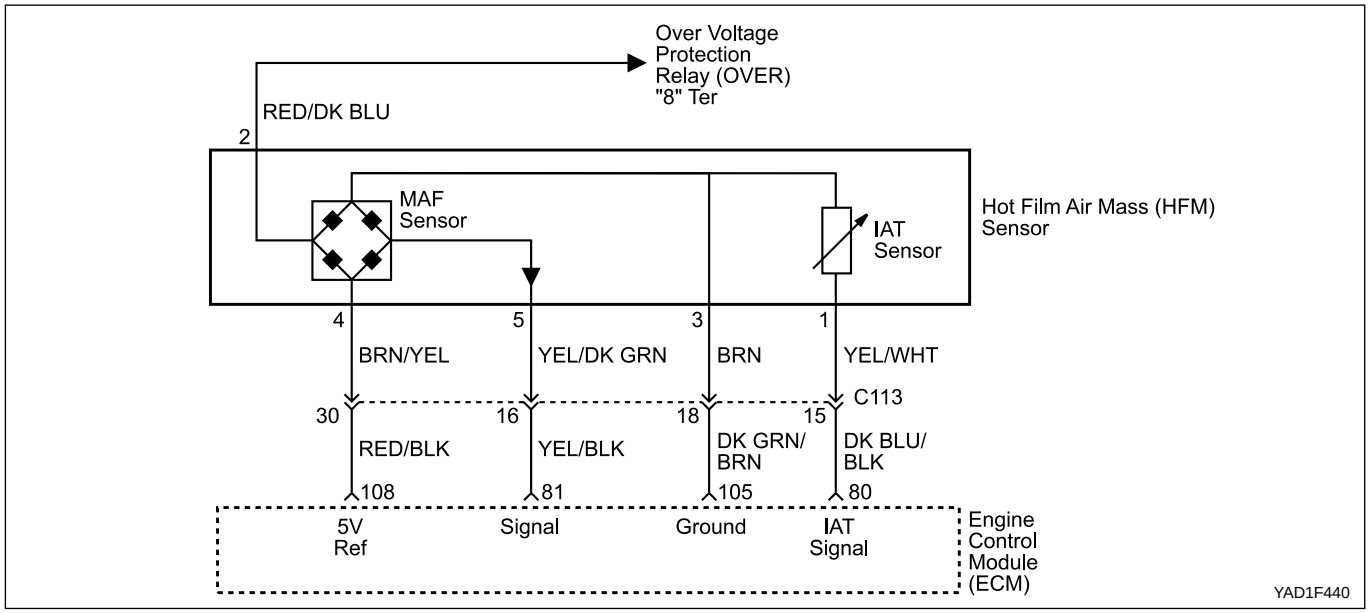
Intake Air Temperature

The Intake Air Temperature (IAT) sensor is a part of Hot Film Air Mass (HFM) sensor and is a thermistor, a resistor which changes value based on the temperature of the air 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	43760
-20	12660	13850	15120
0	5119	5499	5829
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



Failure Code	Description	Trouble Area	Maintenance Hint
03	Intake air temperature sensor low voltage	IAT sensor short circuit to ground or open	• Monitoring the actual air temperature through scan tool • Inspection the ECM pin 80, 79 about short circuit or open with bad contact • Inspection the IAT sensor (integrated in HFM sensor) • Inspection the ECM
04	Intake air temperature sensor high voltage	IAT sensor short circuit to power	
05	Intake air temperature sensor plausibility	Malfunction in recognition of IAT When functional problem	
09	Mass air flow sensor plausibility	Malfunction in recognition of MAF When air mass not plausible	• Monitoring the actual air mass flow through scan tool • Inspection the ECM pin 81, 105 about short circuit or open with bad contact • Inspection the MAF sensor (integrated 11 in HFM sensor) • Inspection the ECM
10	Mass air flow sensor low voltage	MAF sensor short circuit to ground or open	
11	Mass air flow sensor high voltage	MAF sensor short circuit to power	

Circuit Description

The heated element on the MAF is a platinum film resistor (heater). It is located on a ceramic plate together with the other elements in the bridge circuit. The temperature sensitive resistor (flow sensor) also included in the bridge. The separation of heater and flow sensor facilitates design of the control circuitry. Saw cuts are employed to ensure thermal decoupling between the heating element and the intake air temperature (IAT) sensor. The complete control circuitry is located on a single layer. The voltage at the heater provides the index for the mass air flow. The MAF's electronic circuitry then converts the voltage to a level suitable for processing in the ECM. This device does not need a burn off process to maintain its measuring precision over an extended period. In recognition of the fact that most deposits collect on the sensor element's leading edge, the essential thermal transfer elements are located downstream on the ceramic layer. The sensor element is also design to ensure that deposits will not influence the flow pattern around the sensor.

The IAT sensor uses a thermistor to control the signal voltage to the ECM. The ECM supplies 5 volt reference and a ground to the sensor. When the air is cold, the resistance is high; therefore the IAT signal voltage will be high. If the intake air is warm, resistance is low; therefore the IAT signal voltage will be low.

Mass Air Flow Sensor Input Voltage Inspection

1. Turn the ignition switch to “ON” position.
2. Measure the signal voltage between the ECM pin

Application		Specified Value
Engine Status	Ignition “ON”	0.9 ~ 1.1 V
	Idling	1.3 ~ 1.7 V (Coolant temperature is over 70 °C)

Notice: If the measured value is not within the specified value, the possible cause may be in cable or MAF sensor in itself. Perform the 5 volt power supply inspection procedures.

Mass Air Flow Sensor 5 volt Power Supply Inspection

1. Turn the ignition switch to “OFF” position.
2. Disconnect the HFM sensor connector.
3. Turn the ignition switch to “ON” position.
4. Measure the voltage between the ECM pin No. 108 and MAF sensor connecter terminal No. 3.

Specified Value	4.7 ~ 5.2 V

Notice: If the measured value is not within the specified value, the possible cause may be in cableor ECM coupling.

5. Measure the voltage between the ECM pin No. 105 and MAF sensor connecter terminal No. 4.

Specified Value	4.7 ~ 5.2 V

Notice: If the measured value is not within the specified value, the possible cause may be in cableor ECM coupling.

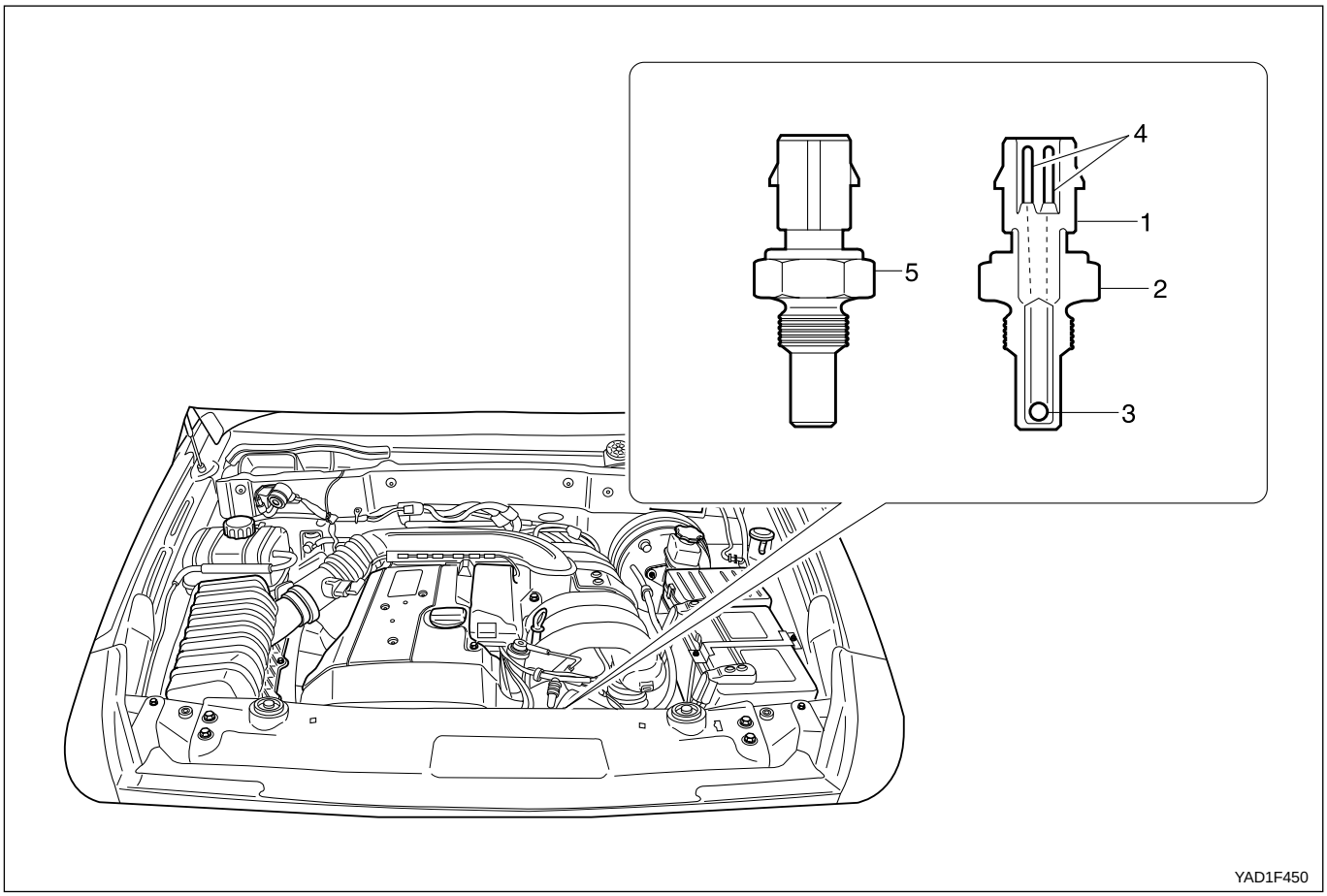
Mass Air Flow Sensor 12 volt Power Supply Inspection

1. Turn the ignition switch to “OFF” position.
2. Disconnect the HFM sensor connector.
3. Turn the ignition switch to “ON” position.
4. Measure the voltage between the ECM pin No. 105 and MAF sensor connecter terminal No. 2.

Specified Value	11 ~ 14 V

Notice: If the measured value is not within the specified value, the possible cause may be in cable or Over Voltage Protection Relay (OVPR).

ENGINE COOLANT TEMPERATURE (ECT) SENSOR



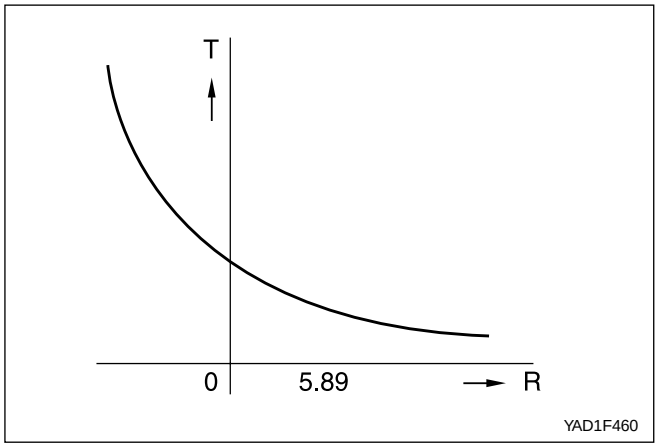
1 Artificial Resin Housing
2 Metal Housing
3 NTC (Negative Temperature Coefficient) Resistor
4 Connector
5 Engine Coolant Temperature Sensor

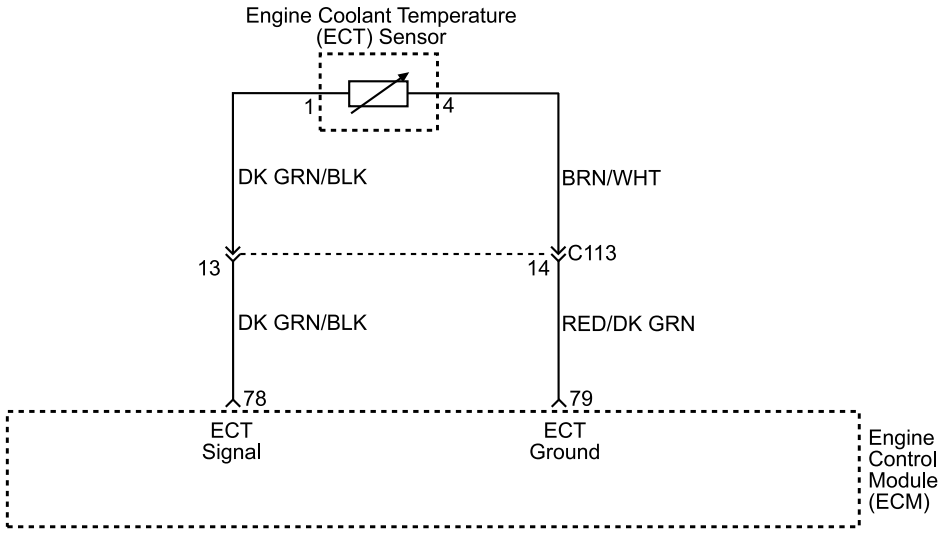
Engine Coolant Temperature (ECT) sensor detects coolant temperature and supplies information to the ECM. It is composed of metal housing with two NTC resistor, 4 pin connector. The ECM provides a 5 volt signal to the ECT sensor through a dropping resistor. When the engine is cold, the ECT sensor provides 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

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





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Failure Code	Description	Trouble Area	Maintenance Hint
00	Engine coolant temperature sensor low voltage	ECT sensor short circuit to ground or open	• Monitoring the actual coolant temperature through scan tool • Inspection the ECM pin 78, 79 about short circuit or open with bad contact • Inspection the ECT sensor • Inspection the ECM
01	Engine coolant temperature sensor high voltage	ECT sensor short circuit to power	
02	Engine coolant temperature sensor plausibility	Malfunction in recognition of ECT When drop to about 50 °C below after warm up	
06	Engine coolant temperature insufficient for closed loop fuel control	Malfunction in recognition of ECT When minimum temperature for lambda control after warm up	

Circuit Description

The ECT sensor uses a thermistor to control the signal voltage to the ECM. The ECM supplies a voltage on the signal circuit to the sensor. When the engine coolant is cold, the resistance is high; therefore the ECT signal voltage will be high

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.

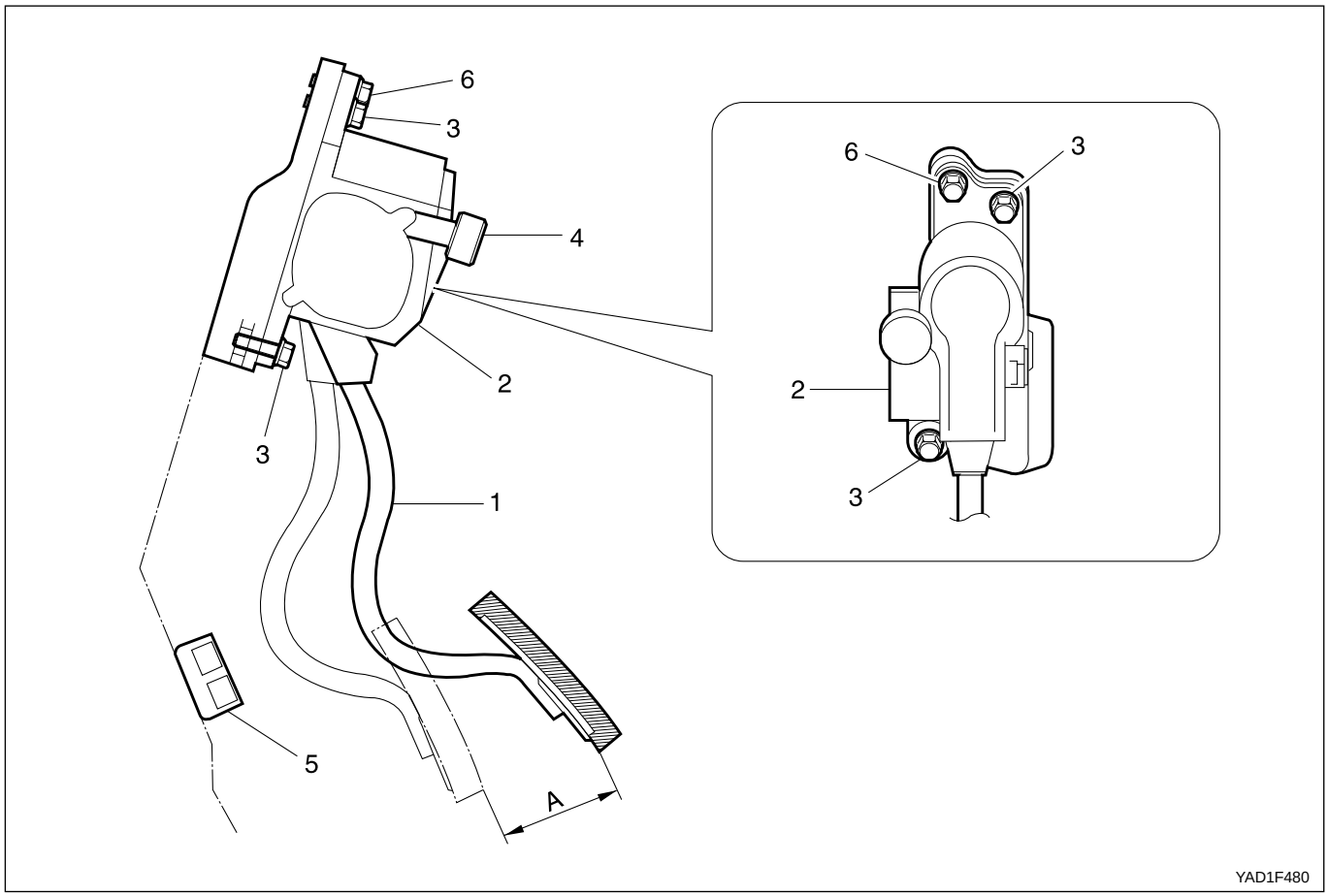
Temperature (°C)	Specified Value (V)
20	3.57
80	1.22
100	0.78

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

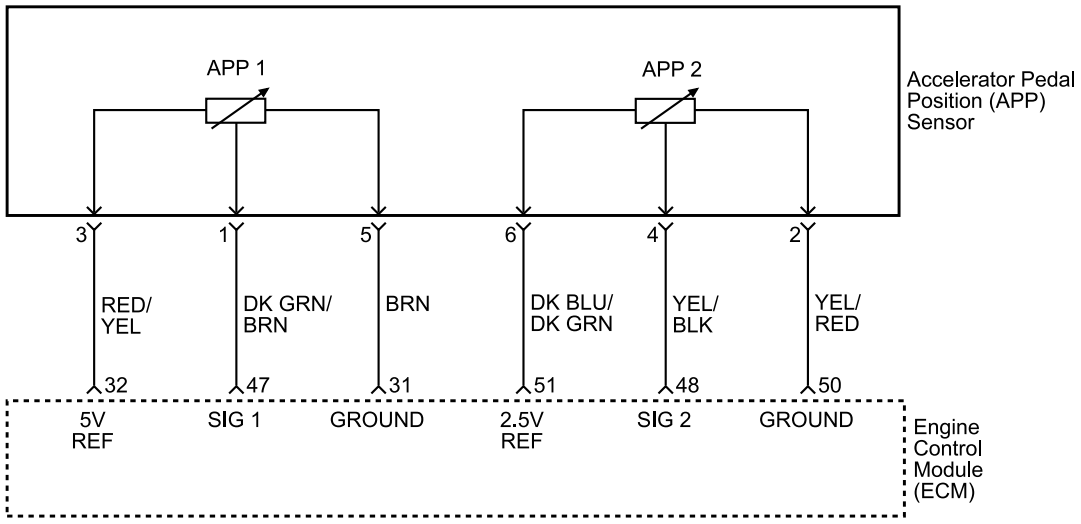
The Acceleration Pedal Position (APP) sensor is mounted on the accelerator pedal assembly. The sensor is actually two individual APP sensors and one housing. This sensor works with the Throttle Position (TP) sensor to provide input to the Engine Control Module (ECM) regarding driver requested accelerator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

When the APP sensor is defected:

When the APP1 or APP 2 sensor is defected condition, the engine is 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 a default 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 servo motor 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 with opening (On/Off) time of injector. The engine rpm will be maintaining 900 rpm (at idle) to 1,800 according to the engine load.



Failure Code	Description	Trouble Area	Maintenance Hint
122	Acceleration pedal position sensor signal failure	When malfunction of APP sensor	• Monitoring the actual values through scan tool • Inspection the ECM pin 31, 47, 32, 48, 59, 51 about short circuit or open with • Inspection the APP sensor • Inspection the ECM
160	Acceleration pedal position 1 sensor low voltage	APP 1 sensor short circuit to ground or open	
161	Acceleration pedal position sensor 1 high voltage	APP 1 sensor short circuit to power	
162	Acceleration pedal position sensor 2 low voltage	APP 2 sensor short circuit to ground or open	
163	Acceleration pedal position sensor 2 high voltage	APP 2 sensor short circuit to power bad contact	
164	Accelerator pedal position sensor 1 not plausible with accelerator pedal position sensor 2	When difference between APP 1 sensor and APP 2 sensor	
167	Both setpoint accelerator pedal position sensor defective	When defective of both APP sensor	

Circuit Description

The ECM supplies a 5 or 2.5 volt reference signal and a ground to the APP sensor 1or 2. The ECM calculates on these signal lines. The APP sensor output changes as the accelerator pedal is moved. The output of the APP 1and APP2 sensor are low, about 0.4 ~ 0.7 volts and 0.2 ~ 0.35 volts respectively at the closed throttle position. As pushing the accelerator pedal, the output increases so that the output voltages will be about 4.3 ~ 4.8 volts and 2.1 ~ 2.4 volts individually when accelerating fully with the kick down, at Wide Open Throttle (WOT).

Acceleration Pedal Position Sensor 1 Inspection

1. Turn the ignition switch to “ON” position.
2. Measure the signal voltage between the ECM pin No. 47andNo. 31while 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.

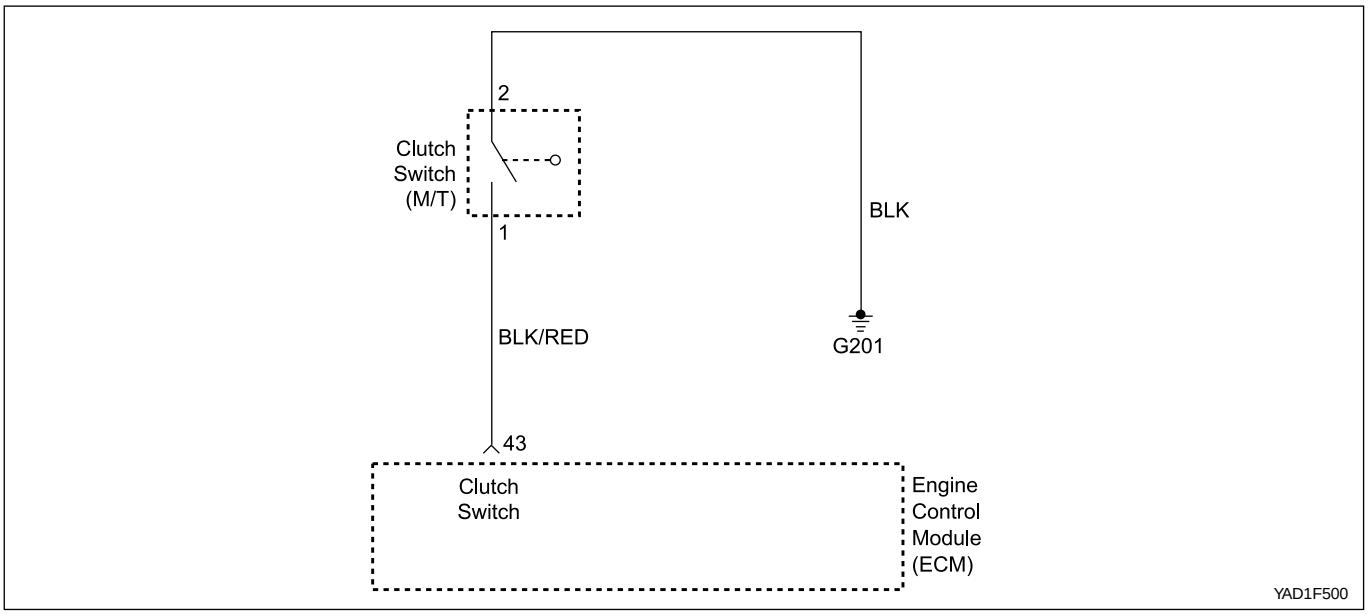
Acceleration Pedal Position Sensor 2 Inspection

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

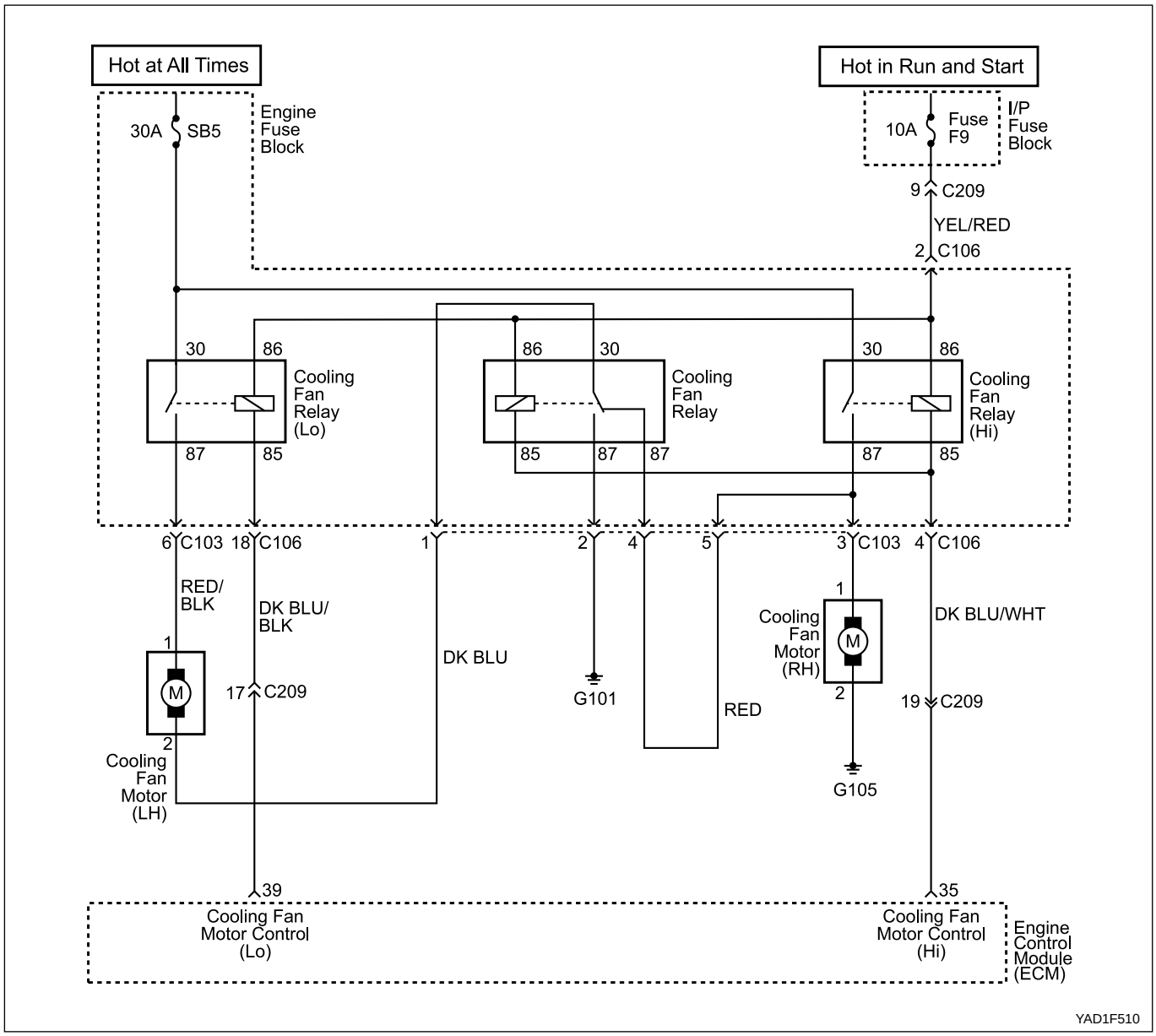
Notice: If measured value is not within the specified value, check the pedal valve sensor and the supply voltage to APP sensor 2.

CLUTCH SWITCH



Failure Code	Description	Trouble Area	Maintenance Hint
62	Clutch switch defective	When malfunction of clutch switch	• Inspection the Engine Control Module (ECM) pin 43 about shout circuit or open • Inspection the clutch switch • Inspection the ECM

COOLING FAN



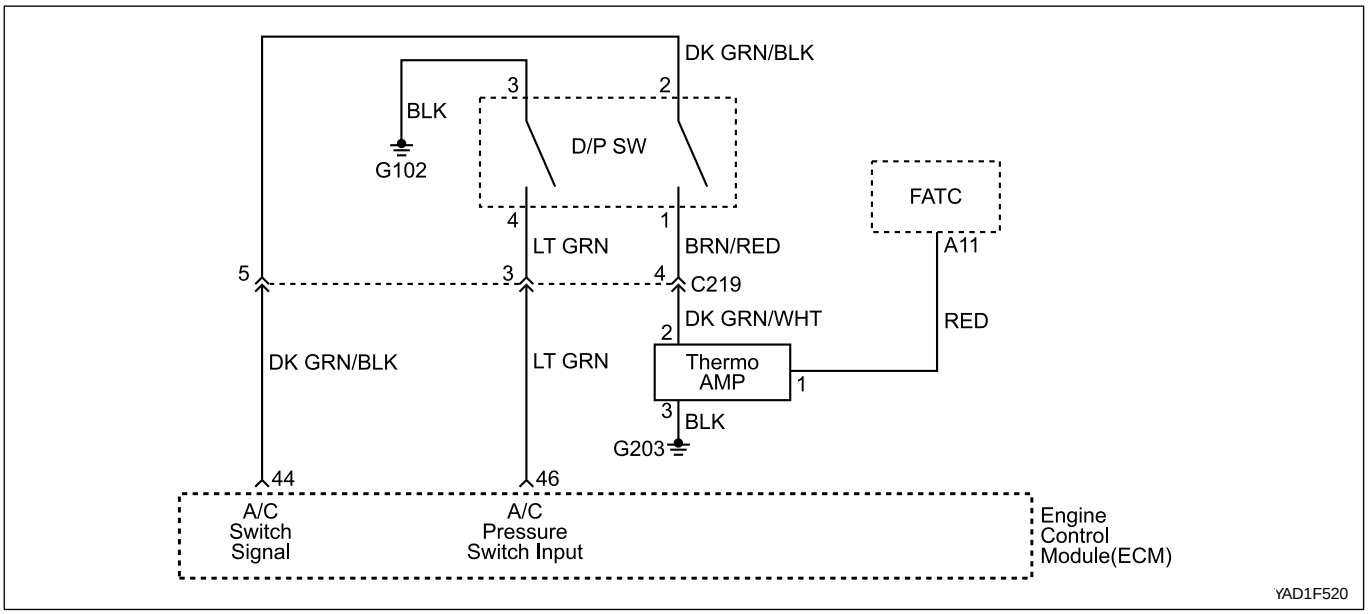
Failure Code	Description	Trouble Area	Maintenance Hint
44	Cooling fan (HI) relay short circuit to power	Cooling fan short circuit to power	• Inspection the Engine Control Module (ECM) pin 35 about short circuit or open with bad contact • Inspection the power source • Inspection the cooling fan • Inspection the ECM
45	Cooling fan (HI) relay short circuit to ground or open	Cooling fan short circuit to ground or open with bad contact	

Circuit Description

Ignition voltage is supplied directly to the cooling fan relay coil. The ECM controls the relay by grounding the control circuit. When the ECM is commanding a command ON, the voltage of the control circuit should be low (near 0 volt).

When the ECM is commanding the control circuit should be high (near battery voltage). If the fault detection circuit senses a voltage other than what is expected, the fault line status will change causing the fault code to set.

A/C COMPRESSOR RELAY

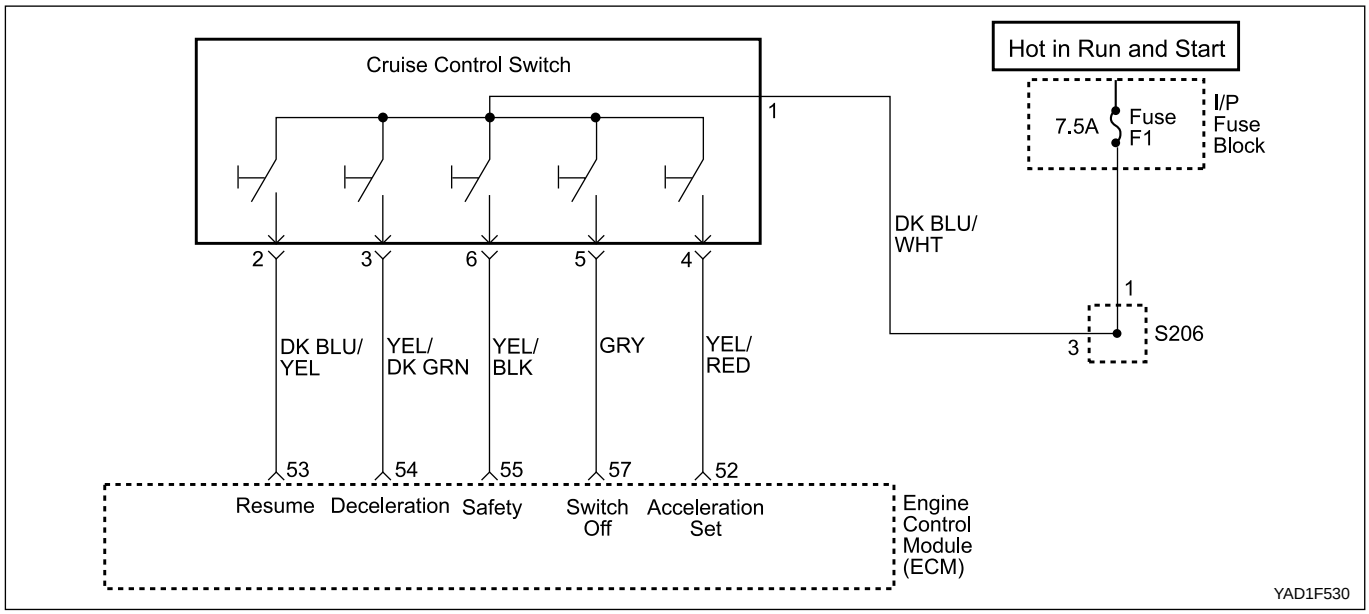


Failure Code	Description	Trouble Area	Maintenance Hint
228	A/C compressor relay short circuit to battery	When malfunction of A/C compressor control	• Monitoring the actual operation through scan tool • Inspection the Engine Control Module (ECM) pin 44 about short circuit or open with bad contact • Inspection the relay short circuit or open • Inspection the ECM
229	A/c compressor relay short circuit to ground or open		

Circuit Description

When the ECM detects that A/C has been requested, the ECM will activated the A/C clutch relay. When the relay has been activated, voltage should be present at both the A/C clutch relay and A/C switch circuit at ECM.

CRUISE CONTROL SWITCH

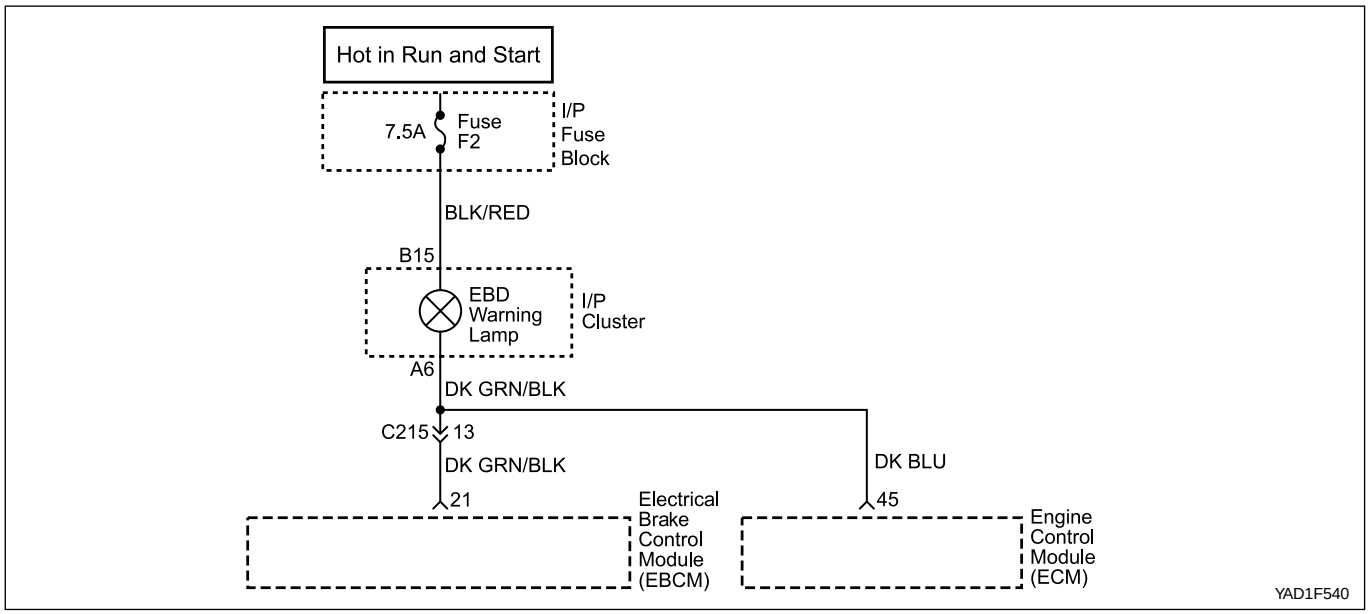


Failure Code	Description	Trouble Area	Maintenance Hint
129	Cruise control “OFF” due to message counter failure	Cruise control system message counter fault	• Monitoring the actual recognition status and vehicle speed signal through scan tool • Inspection the Engine Control Module (ECM) pin 52 53 54 55 57 about short circuit or open with bad contact • Inspection the CAN and ABS • Inspection the cruise control lever switch • Inspection the ECM
130	Vehicle speed signal failure	When malfunction of auto-cruise system Implausible condition of vehicle speed signal.	
131	Vehicle speed signal failure		
132	Cruise control lever failure	Cruise control lever defective	
133	Cruise control acceleration failure	Cruise control system Implausible condition of acceleration signal	
134	Cruise control deceleration failure	Cruise control system Implausible condition of deceleration signal	

Circuit Description

Cruise control is an automatic speed control system that maintain a desired driving speed without using the accelerator pedal. The vehicle speed must be greater than 40 km/h to engage cruise control.

TRACTION CONTROL SYSTEM (TCS)

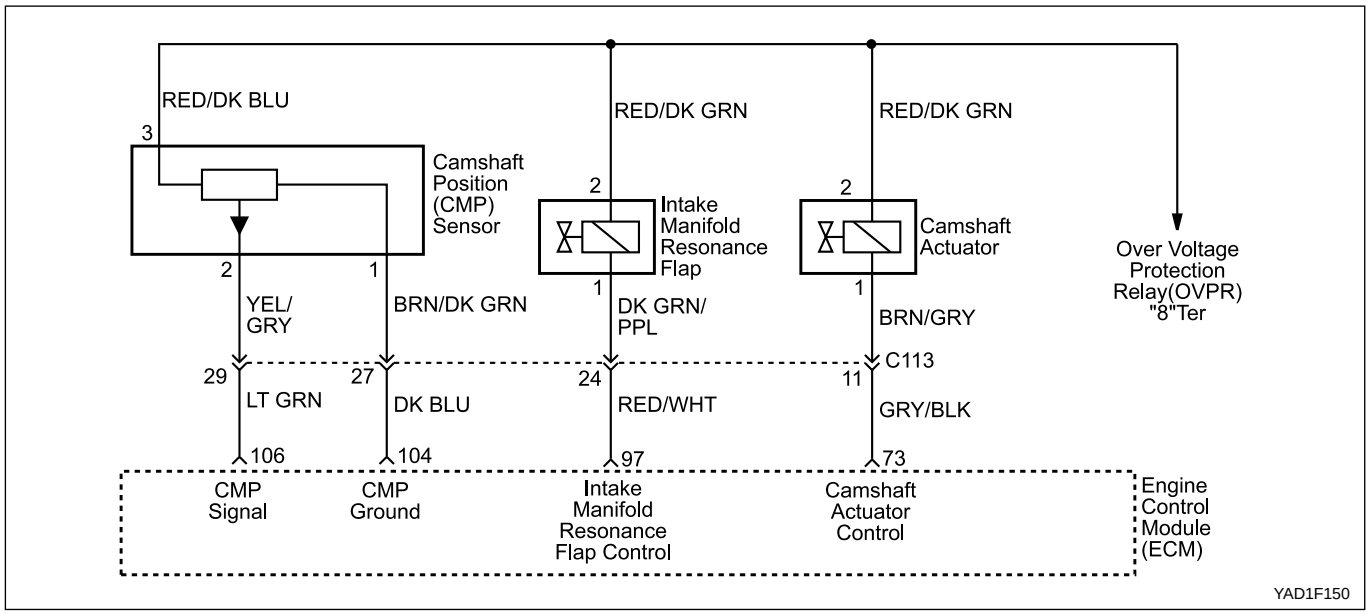


Failure Code	Description	Trouble Area	Maintenance Hint
150	TCS input signal short circuit to battery	TCS short circuit to power	• Inspection the Engine Control Module (ECM) pin 45 about short circuit or open with bad contact • Inspection the TCS lamp of I/P cluster. • Inspection the ECM
151	TCS input signal short circuit to ground or open	TCS short circuit to ground or open	

Circuit Description

Battery voltage is supplied to the TCS warning lamp with the ignition in ON and START. The warning lamp can be activated only by the Electrical Brake Control Module (EBCM) internally supplying ground to terminal 21. If the TCS input circuit is open or short, this failure code will be set.

RESONANCE FLAP



Failure Code	Description	Trouble Area	Maintenance Hint
198	Resonance flap short circuit to battery	Resonance flap short circuit to power	• Monitoring the actual operational status and vehicle speed signal through scan tool • Inspection the Engine Control Module (ECM) pin 97 about short circuit or open with bad contact • Inspection the power source short circuit or open to resonance flap • Inspection the resonance flap solenoid and hardware • Inspection the ECM
199	Resonance flap short circuit to ground or open	Resonance flap short circuit to ground or open	

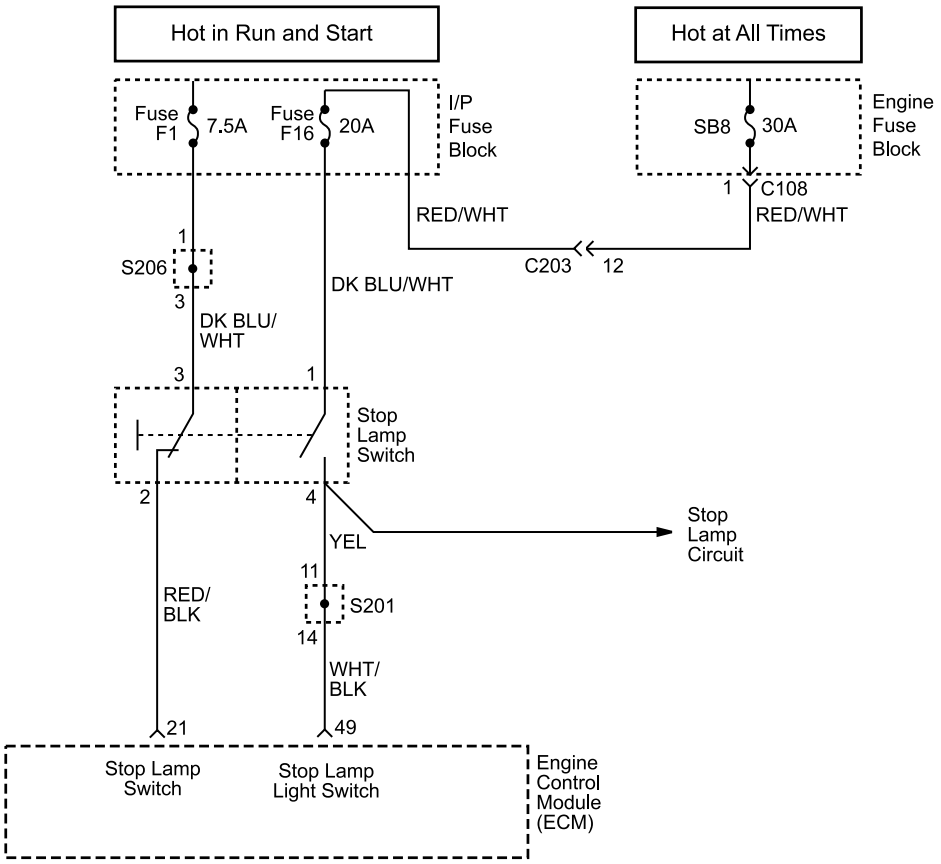
Circuit Description

A pneumatically actuated resonance flap is located on the intake manifold, and will be opened and closed by load, which operates resonance flap according to engine and controlled by ECM and rpm.

Resonance flap is closed at idle/partial load (less than 3,800/rpm). The switch valve will be adjusted by ECM and resonance flap will be closed. By increasing air flow passage through dividing intake air flow toward both air collection housing. This leads to a significant increase in the torque in the lower speed range.

Resonance flap is open at full load (over 3,800/rpm). The switch valve will not be adjusted by ECM and resonance flap will be open. The collected air in the air collection housing will not be divided and intake air passage will be shorten.

STOP LAMP SWITCH

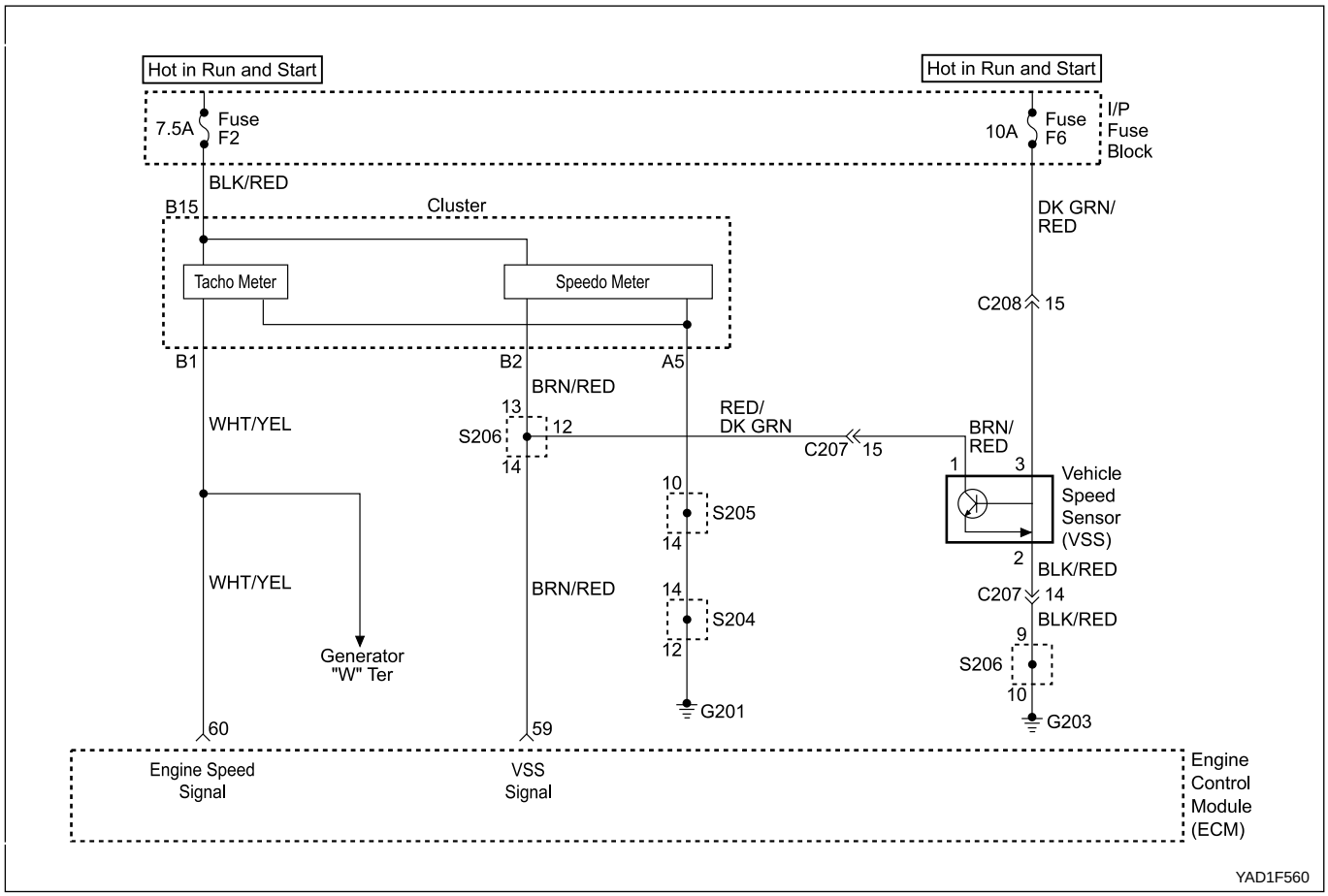


Failure Code	Description	Trouble Area	Maintenance Hint
135	Stop lamp switch failure	When malfunction of stop lamp switch - implausible condition of stop lamp signal input	• Monitoring the actual operational status and vehicle speed signal through scan tool • Inspection the Engine Control Module (ECM) pin 49 about short circuit or open with bad contact • Inspection the contact condition of stop lamp switch • Inspection the ECM

Circuit Description

The stop lamp switch is normally opened. When the ignition switch ON and brake ON, the battery voltage is supplied to the ECM. A scan tool should display ON when brake pedal is depressed and should read OFF with brake pedal released.

ENGINE RPM



Failure Code	Description	Trouble Area	Maintenance Hint
32	Engine rpm output circuit short circuit to battery	When short circuit to battery	• Inspection the cluster panel board circuit • Inspection the ECM • Monitoring the actual rpm in cluster • Inspection the Engine Control Module (ECM) pin 60 about short circuit or open
33	Engine rpm output circuit short circuit to ground or open	When short circuit to ground or open	

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 a catalyst, 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).

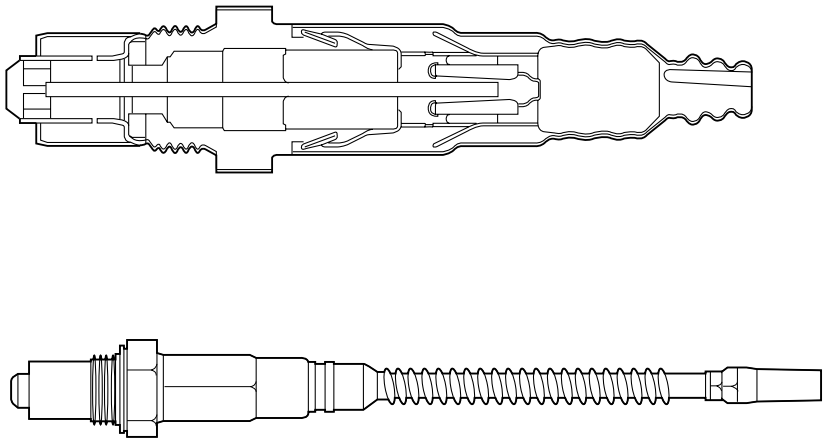
The following chemical reaction are produced.

$CO + O_2 \rightarrow CO_2$

$HC + O_2 \rightarrow CO_2 + H_2O$

$NO_x \rightarrow N_2 + O_2$

OXYGEN SENSOR



YAD1F570

The oxygen sensor is unique among the 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).

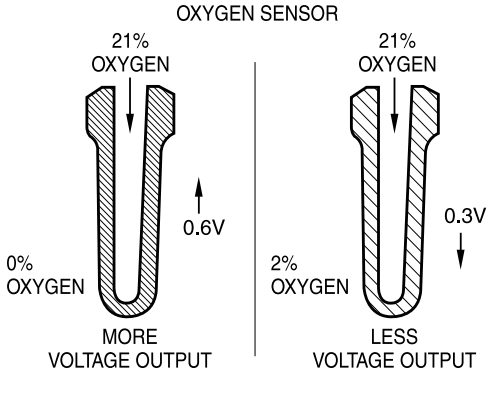
The electrically heated oxygen sensor warms up quickly and remains hot, even at idle when the exhaust manifold may cool down.

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 between the amounts of oxygen containing the two surface, the sensor generates less voltage.

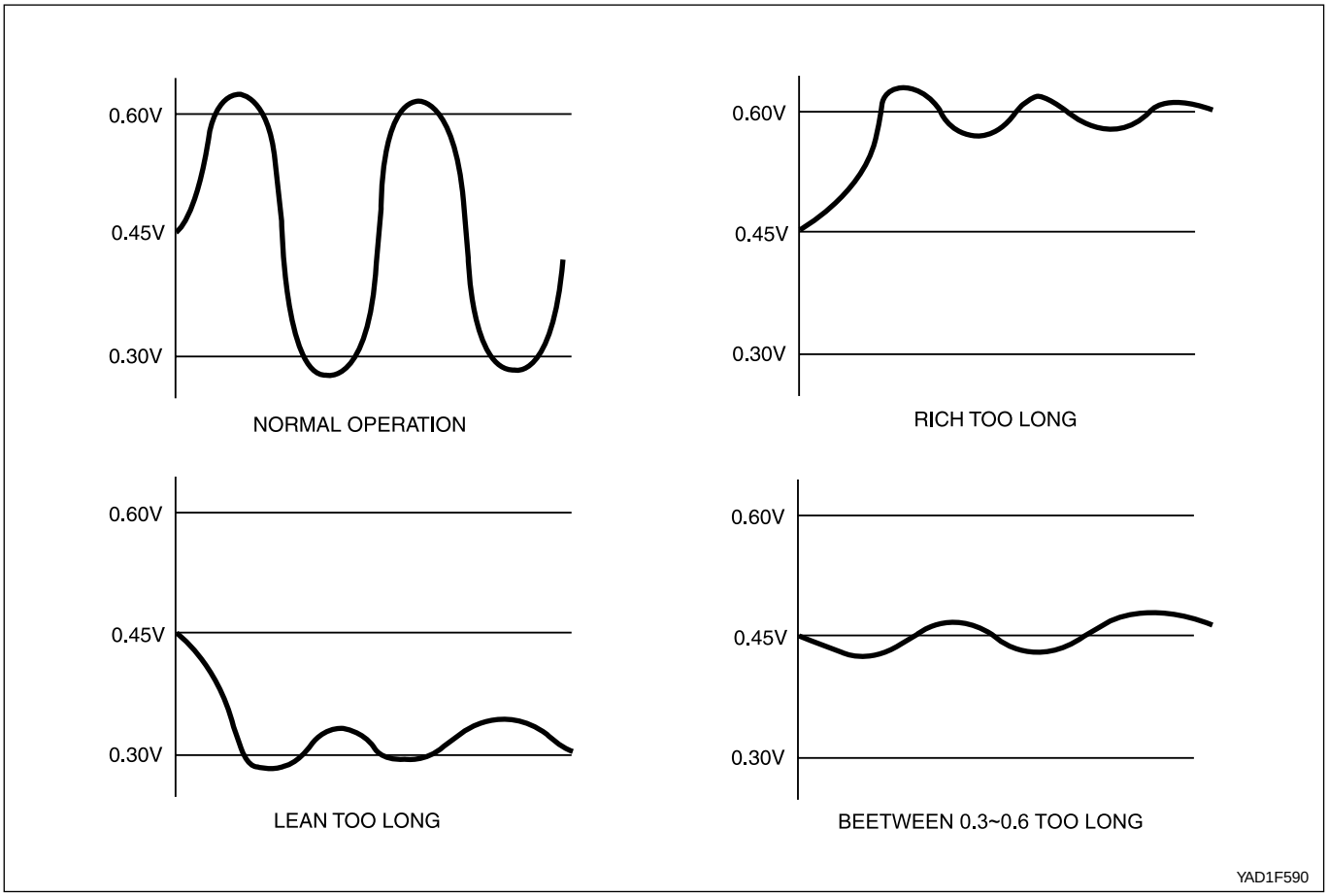
When the exhaust gas is rich (below 14.7:1), the voltage output is high, above450mv. When the exhaust gas is lean (above 14.7:1 air/fuel ratio), the sensor's voltage output is low, below 450 mv.

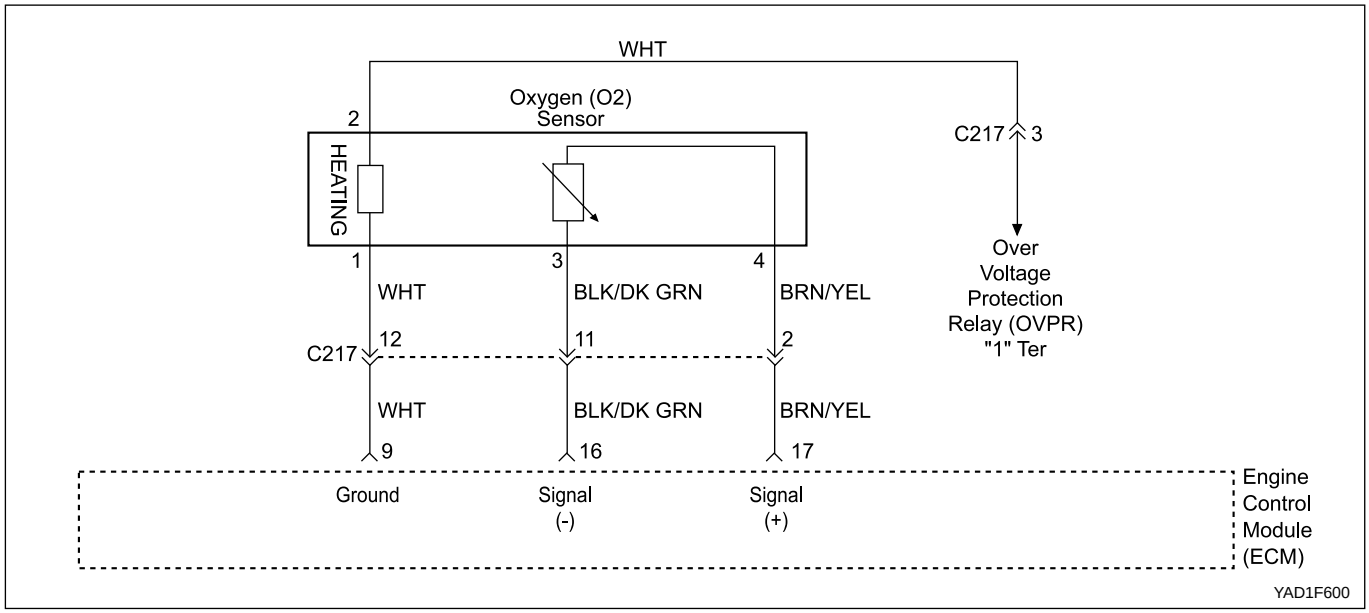
The ECM uses oxygen sensor information for:

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



YAD1F580


0.60V
0.45V
0.30V
NORMAL OPERATION
0.60V
0.45V
0.30V
RICH TOO LONG
0.60V
0.45V
0.30V
LEAN TOO LONG
0.60V
0.45V
0.30V
BEETWEEN 0.3~0.6 TOO LONG
YAD1F590



Failure Code	Description	Trouble Area	Maintenance Hint
80	Oxygen sensor high voltage	When recognition the output that more than nominal threshold, malfunction of sensing voltage.	• Monitoring the actual output signal through scan tool • Inspection the ECM pin 16, 17 about short circuit or open with bad contact • Inspection the oxygen sensor • Inspection the ECM
89	Oxygen sensor low voltage	When recognition the output that more than nominal threshold, malfunction of sensing voltage.	
82	Oxygen sensor no activity detected	When recognition the output that not active the sensor etc.	
83	Oxygen sensor not lean after overrun fuel shut-off	When recognition the output that no lean signal after overrun fuel shut-off	
84	Oxygen sensor slow response	When slow response of sensor signal	
85	Oxygen sensor heater failure	When recognition the heating circuit	• Monitoring the heating status through scan tool • Inspection the ECM pin 9 about short circuit or open with bad contact • Inspection the heating power source • Inspection the heating circuit of oxygen sensor • Inspection the ECM
86	Oxygen sensor heater short circuit to battery	When recognition the heating currents that more or less than set values (less than 0.2 A or more than 2 A)	
87	Oxygen sensor heater short circuit to ground or open	When recognition the heating voltages than less than set values (less than 2v)	

Failure Code	Description	Trouble Area	Maintenance Hint
81	Bank 1 system short term fuel trim adaptation below lean threshold	When recognition the value less than nominal control threshold, it means that when big deviation in control range of adaptation values through fuel and air mixture formation	• Inspection the intake air leakage • Inspection the injection quantities with injector block or leakage • Inspection the exhaust leakage • Inspection the ECM
93	Bank 1 system short term fuel trim adaptation above rich threshold	When recognition the value more than nominal control threshold, it means that when big deviation in control range of adaptation values through fuel and air mixture formation	
96	Bank 1 system short term fuel trim at rich stop	When recognition the short term fuel trim that more than nominal threshold	
97	Bank 1 system short term fuel trim at lean stop	When recognition the short term fuel trim that less than nominal threshold	
98	Bank 1 system idle adaptation failure (above rich threshold)	When recognition the long term fuel trim exceeds rich threshold	
99	Bank 1 system idle adaptation failure (below rich threshold)	When recognition the long term fuel trim exceeds lean threshold	
100	Bank 1 system learning control failure (rich, low load)	When recognition the long term fuel trim exceeds rich threshold	
101	Bank 1 system learning control failure (lean, low load)	When recognition the long term fuel trim exceeds lean threshold	
102	Bank 1 system learning control failure (rich, high load)	When recognition the long term fuel trim exceeds rich threshold	
103	Bank 1 system learning control failure (rich, low load)	When recognition the long term fuel trim exceeds lean threshold	

Circuit Description

In order to control emissions, a catalytic converter is used to covert harmful emissions into harmless water vapor and carbon dioxide. The ECM has the ability to monitor this process by using a oxygen sensor. The oxygen sensor produces and output signal which indicates the storage capacity of the catalyst. This in turn indicates the catalyst's ability to convert exhaust emission effectively. If the oxygen sensor pig tail wiring, connector, or terminal is damaged. Do not attempt to repair the wiring, connector, or terminals. In order for the sensor to function properly, it must have a clean air reference provided to it. This clean air reference is obtained by way of the oxygen sensor wire(s). Any attempt to repair the wires, connector, or terminal and degrade the oxygen sensor performance.

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.

Specified Value	2 ~ 1.0 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 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.

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

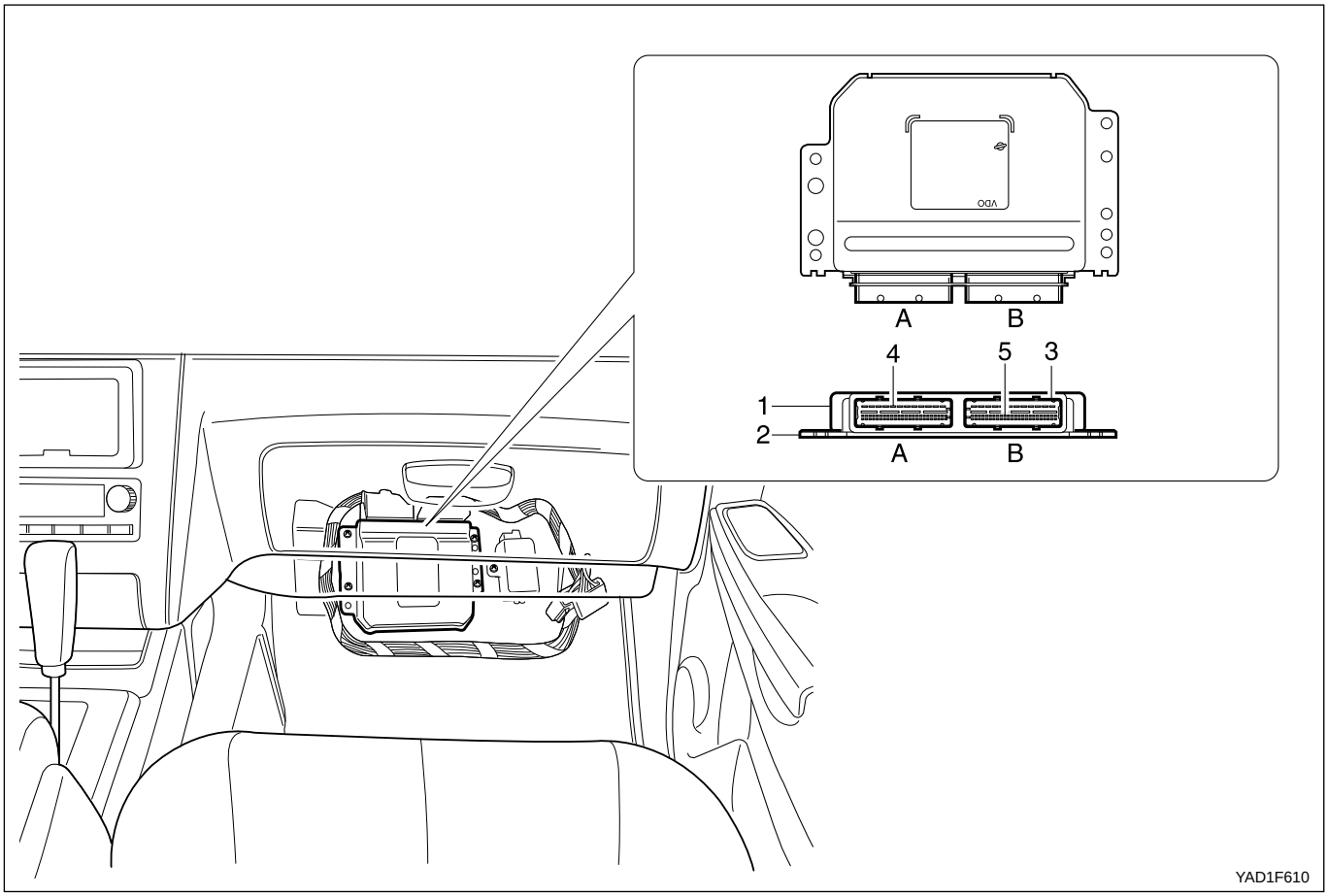
1. Turn the ignition switch to “ON” position.
2. Measure the oxygen sensor heating current consumption between the ECM terminal No. 9 and No. 5.

Specified Value	0.2 ~ 2.0 A

Notice: If the measured value is not within the specified value, the possible cause may be in cable, oxygen sensor or ECM

BLANK

ENGINE CONTROL MODULE



1 Cover
2 Plate
3 Connector
4 Flat Pin
Vehicle Side : No. 1-12
Engine Side : No. 61-72
5 Pin
Vehicle Side : No. 13-60
Engine Side : No. 73-120
A Vehicle Side Connector : Black
B Engine Side Connector : Gray

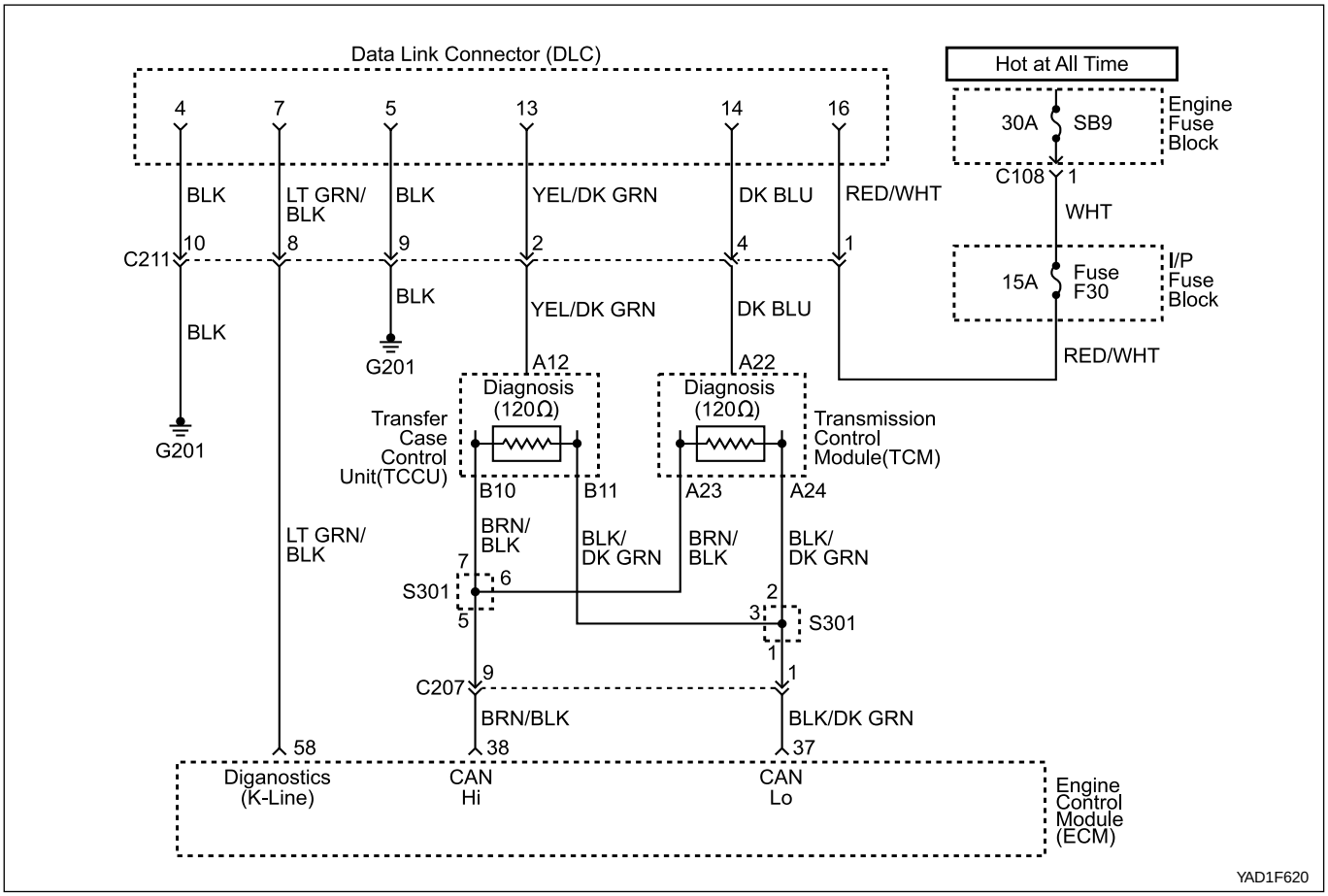
The Engine Control Module (ECM), located inside the right side kick panel, is the control center of the fuel injection system. It constantly looks at the information from various sensors and controls the systems that affect the vehicle's performance. Engine rpm and air mass are used to measure the air 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 intake manifold resonance flap, the camshaft actuator, the canister purge valve, etc., by controlling the ground circuit.

SERIAL DATA COMMUNICATION



Failure Code	Description	Trouble Area	Maintenance Hint
23	CAN communication failure: ASR/MSR	When CAN signal message missing or implausibility for ASR/MSR unit or not initialized condition	• Inspection the ASR unit with CAN connection • Inspection the Engine Control Module (ECM) pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
24	CAN communication failure: ABS	When CAN signal message missing or implausibility for ABS unit or not initialized condition	• Inspection the ABS unit with CAN connection • Inspection the ECM pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
26	CAN communication failure: TCU (A/T only)	When CAN signal message missing or implausibility for TCU unit or not initialized condition	• Inspection the TCM unit with CAN connection • Inspection the ECM pin 38, 37 about short circuit or open with bad contact • Inspection the ECM

Failure Code	Description	Trouble Area	Maintenance Hint
27	CAN communication failure: TOD (E32 only)	When CAN signal message missing or implausibility for TOD unit or not initialized condition	• Inspection the TOD unit with CAN connection • Inspection the ECM pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
29	CAN communication failure: ID 200h not plausible	When CAN signal message missing or implausibility for ABS/ABD unit or not initialized condition	• Inspection the ABS/ABD unit with CAN connection • Inspection the ECM pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
30	CAN communication failure: ID 208h not plausible	When CAN signal message missing or implausibility for ABS/ABD unit or not initialized condition	• Inspection the ABS/ABD unit with CAN connection • Inspection the ECM pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
31	CAN communication failure: communication initialization failure	When CAN signal message missing or implausibility for each unit (ABS, ASR, TCM, TOD etc.) or not initialized condition	• Inspection the each control unit with CAN connection • Inspection the ECM pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
59	CAN communication failure: MSR data transmission not plausible	When CAN signal message missing or implausibility for MSR unit or not initialized condition	• Inspection the MSR unit with CAN connection • Inspection the Engine Control Module (ECM) pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
60	CAN communication failure: ASR data transmission not plausible	When CAN signal message missing or implausibility for ASR unit or not initialized condition	• Inspection the ASR unit with CAN connection • Inspection the Engine Control Module (ECM) pin 38, 37 about short circuit or open with bad contact • Inspection the ECM

Circuit Description

The provision for communicating with the ECM is the Data Link Connector (DLC). It is located in the instrument panel fuse block. The DLC is used to connect the scan tool. Battery power and ground is supplied for the scan tool through the DLC. CAN line is used to communicate with the other module such as the Transmission Control Module (TCM) and Transfer Case Control Unit (TCCU).

Keyword 2000 Serial Data Communications

Each bit of information can have one of two lengths: long or short. This allows vehicle wiring to be reduced by transmitting and receiving multiple signals over a singles wire. The message carried on KWP 2000 data streams are also prioritized. If two messages attempt to establish communications on the data line at the same time, only the message with higher priority will must wait.

INTERNAL FAILURE

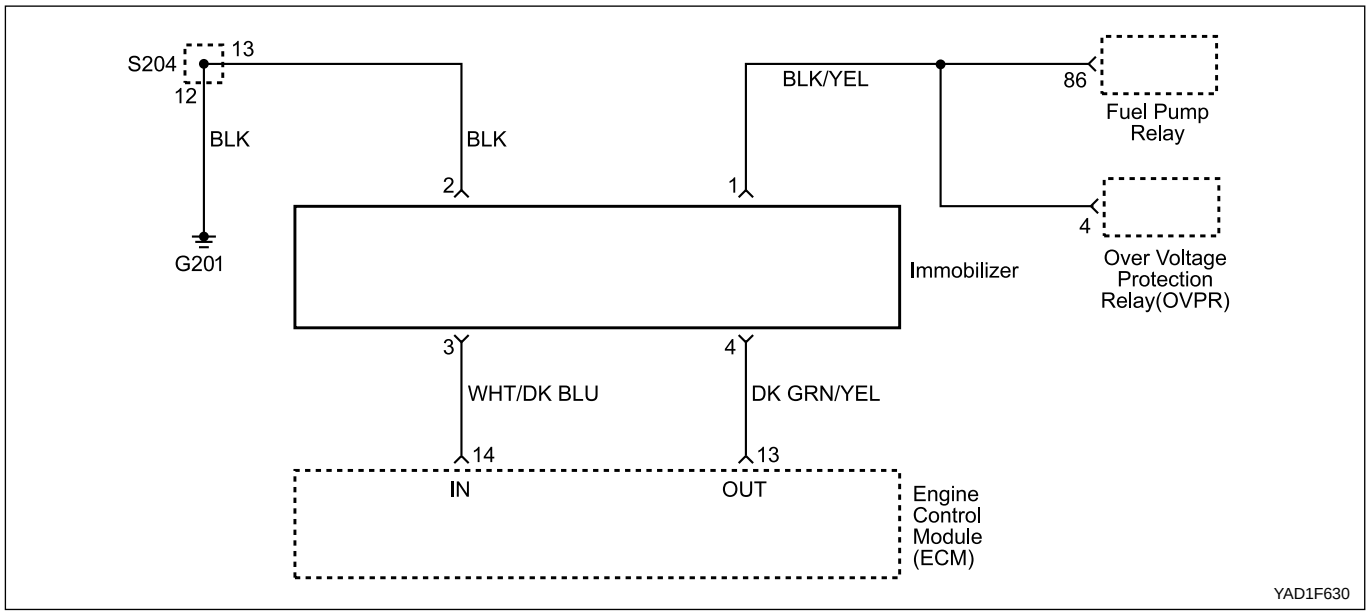
Failure Code	Description	Trouble Area	Maintenance Hint
21	Transmission coding failure	When faulty of variant coding of transmission	• Inspection the coding condition through scan tool • Inspection the Engine Control Module (ECM) • Inspection the CAN line • Inspection the TCM
136	ECM failure (RAM)	When malfunction of random access memory - ECM internal error	• Inspection the ECM
142	Uncoded/ unprogramed ECM	When malfunction of ECM coding-required ECM encoding	• Fulfill the ECM variant coding
137	ECM failure (EPROM)	When malfunction of ECM internal	• Inspection the ECM
143	ECM failure (EEPROM/ Flash - EPPOM checksum failure)		
144	ECM failure (coding ID checksum failure)		
145	ECM failure (coding checksum failure)		
146	ECM failure (programming checksum failure)		

ELECTRONIC THROTTLE CONTROLLER SAFETY MALFUNCTION

Failure Code	Description	Trouble Area	Maintenance Hint
110	Throttle actuator learning data fault	System internal failure	• Inspection the Engine Control Module (ECM)
117	Exceed fuel-cut safety time		
120	Cruise control interruption memory failure		
138	Call Monitoring		
139	Servo motor control output interruption memory failure		
140	Servo motor open/short		
186	ECM failure (incompatible CPU)		
187	ECM failure (CPUs communication failure)		
188	ECM failure (CPU 2 configuration failure)		
189	ECM failure (CPU 2 fault)		
190	ECM failure (CPU run time failure between CPUs)		
231	ECM failure (CPU 2 cruise control message counter failure)		
232	Over deceleration limit (CPU 2)		
233	Over acceleration limit (CPU 2)		
234	Cruise control lever dual operation (CPU 2)		
235	Cruise control lever safety terminal failure (CPU 2)		
236	Unusual pedal position variation (CPU 2)		
237	Unusual throttle position variation (CPU 2)		
238	Unusual throttle controller monitoring data comparison fault (CPU 2)		

Failure Code	Description	Trouble Area	Maintenance Hint
239	Unusual accelerator pedal position sensor comparison fault (CPU 2)	System internal failure	• Inspection the Engine Control Module
240	Throttle potentiometer comparison fault (CPU 2)		
241	Unusual CPU communication (CPU 2)		
242	Unusual CPU configuration (CPU 2)		
243	A/D converter failure (CPU 2)		
244	Accelerator pedal position sensor set-point fault between CPU 1 and CPU 2 (ECM)		
245	Position controller set-point fault between CPU 1 and CPU 2		
246	MSR setpoint fault between CPU 1 and CPU 2		
247	Idle control setpoint fault between CPU 1 and CPU 2		
248	A/D converter overflow (CPU 2)		
249	ROM fault (CPU 2)		
250	RAM fault (CPU 2)		
251	Cycle monitor fault (CPU 2)		

IMMOBILIZER



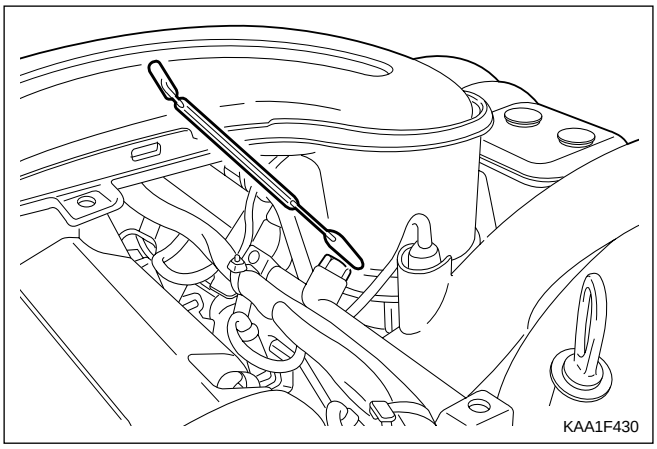
Failure Code	Description	Trouble Area	Maintenance Hint
25	Communication with transponder missing	When missing the transponder signal	• D Inspection the Engine Control Module (ECM) pin 13, 14 about short circuit or open with bad contact • Inspection the power source or ground short circuit or open of immobilizer unit • Inspection the transponder condition (broken etc.) • Inspection the ECM
141	Unprogramed ECM with immobilizer	When malfunction of immobilizer Required immobilizer encoding, no paired condition of immobilizer even through start trial	• Fulfill the immobilizer pairing

Circuit Description

Immobilizer is a device disabling vehicle ignition unless a specific key is used and designed to help prevent vehicle theft.

Immobilizer is comprised of two devices, a key with encoded transponder and ECM with the same encoding of the transponder. When a key is inserted into the hole to start vehicle and turned to ON, the ECM reads and decodes the transponder code and, if the same, starts the engine, it is called immobilizer. It means immobilizer system disables starting by stopping fuel supply if the code in the transponder does not match the code stored in ECM each other.

MAINTENANCE AND REPAIR


KAA1F430

ON-VEHICLE SERVICE

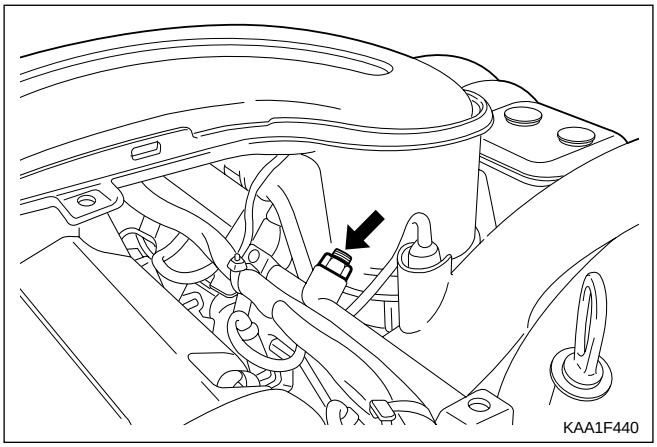
DISCHARGING THE PRESSURE IN FUEL SYSTEM

Removal and Installation Procedure

1. Remove the fuel pressure test connector.

   Installation Notice

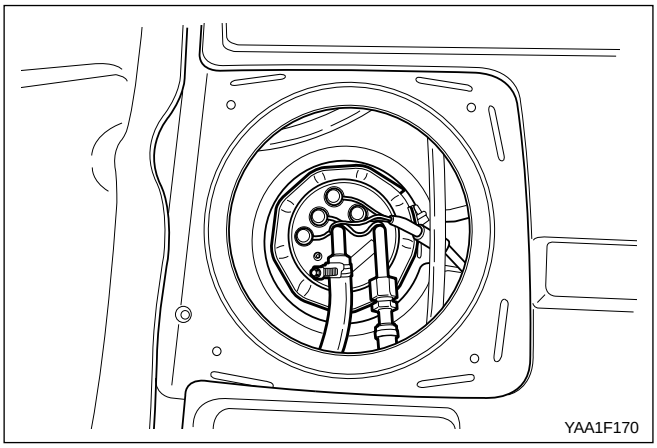
Tightening Torque	25 N•m (18 lb-ft)


KAA1F440

2. Remove the fuel pressure in fuel system by 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.


YAA1F170

FUEL PUMP

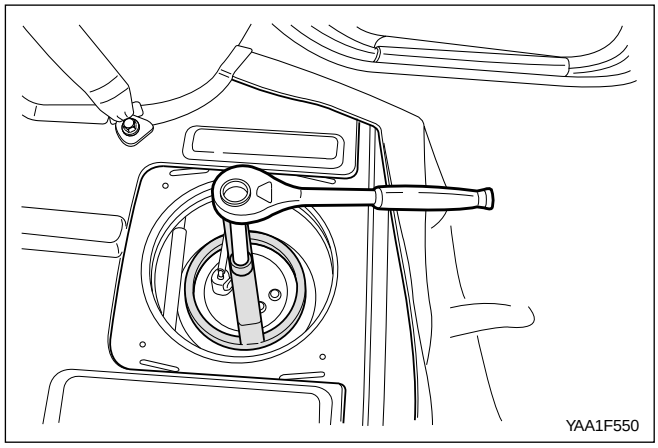
Tools Required

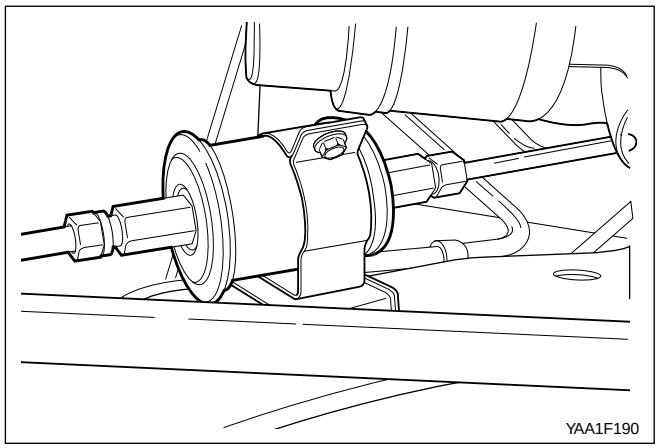
661 589 00 46 00 Fuel Tank Cap Wrench

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.


YAA1F550


YAA1F190

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.

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.

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

   Installation Notice

Tightening Torque	28 N•m (21 lb-ft)

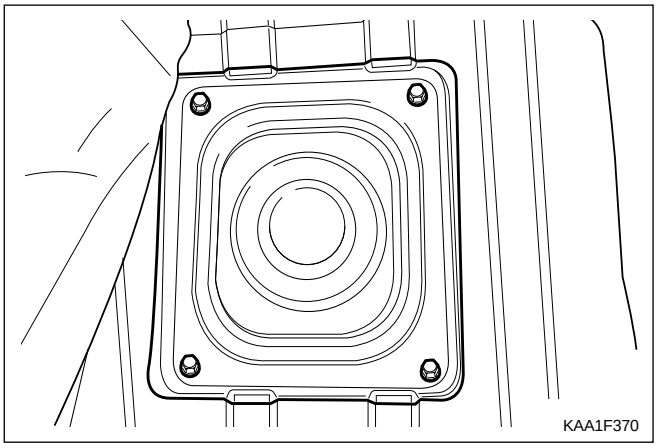
4. Remove the fuel filter mounting bracket bolt.

   Installation Notice

Tightening Torque	28 N•m (21 lb-ft)

   Notice: Place the fuel pump pad. There may be a corrosion 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.

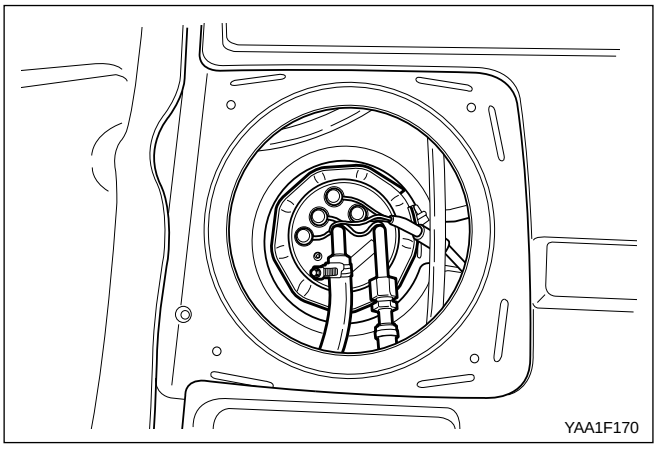

KAA1F370

FUEL TANK

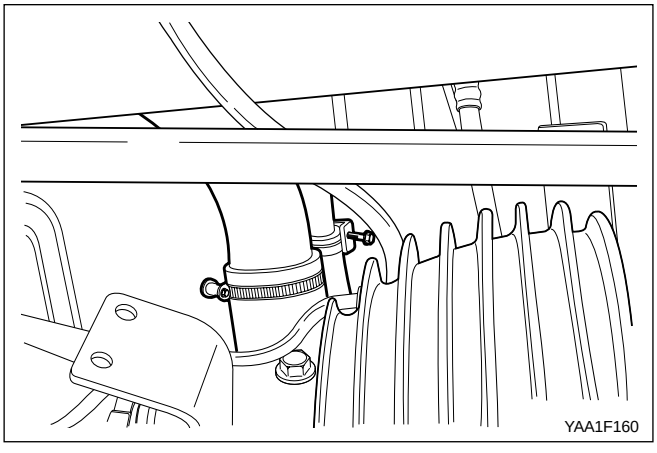
Removal and Installation Procedure

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.


YAA1F170

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.

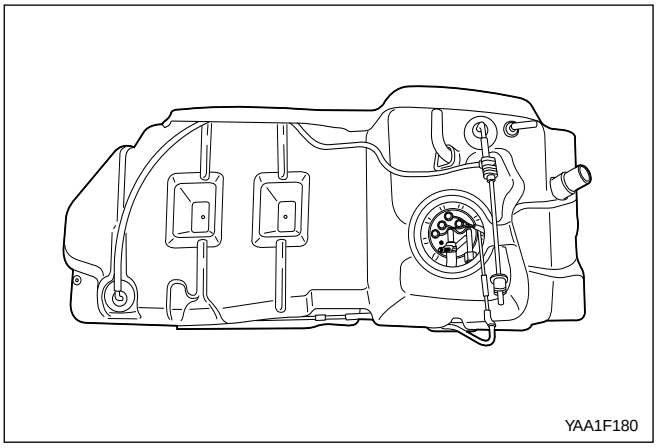

YAA1F160

10. Disconnect the fuel filler hose and air vent hose from the fuel tank.
11. Support the fuel tank.
12. Remove the fuel tank retaining nuts.

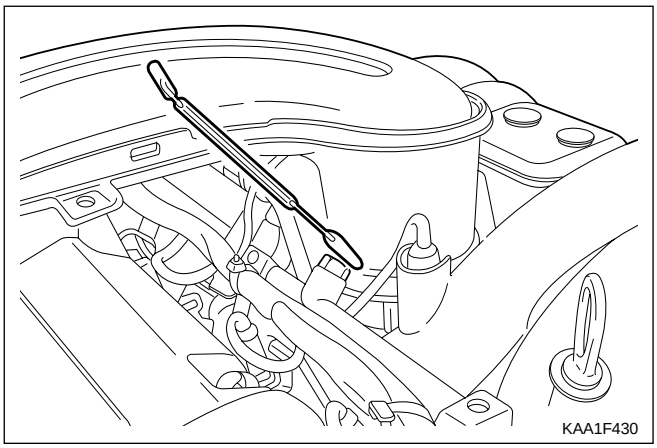
    Installation Notice

Tightening Torque	38 N•m (28 lb-ft)

13. Carefully lower the fuel tank.


YAA1F180

14. Turn the roll over 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.


KAA1F430

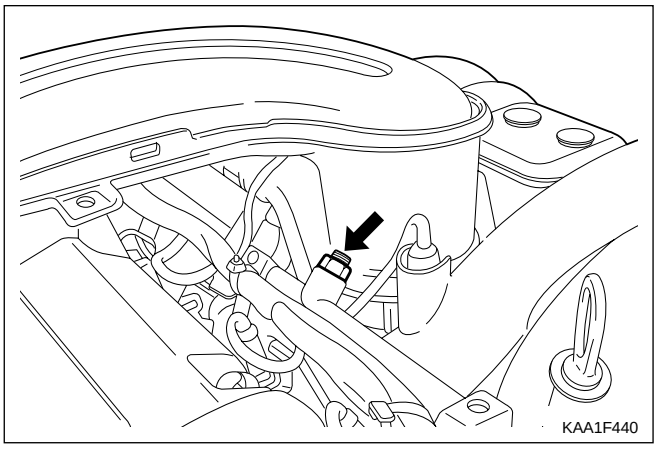
FUEL PRESSURE REGULATOR

Removal and Installation Procedure

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

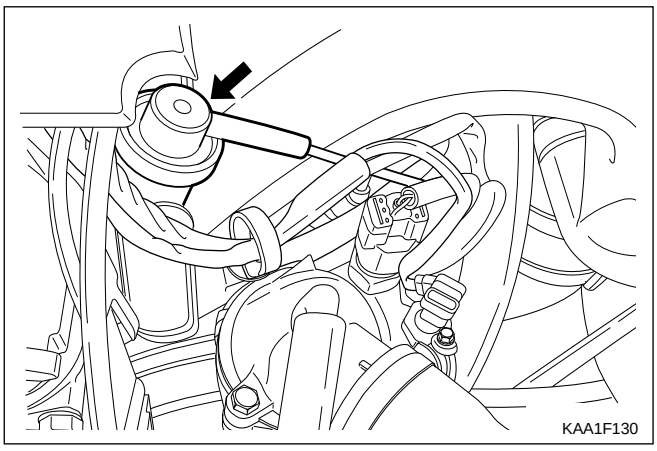
Installation Notice

Tightening Torque	25 N•m (18 lb-ft)

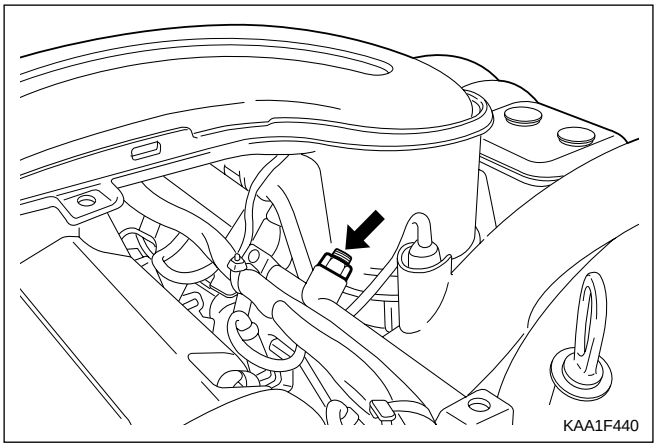

KAA1F440

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.

3. Relieve the fuel pressure in fuel supply system by pressing the service valve.


KAA1F130

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.

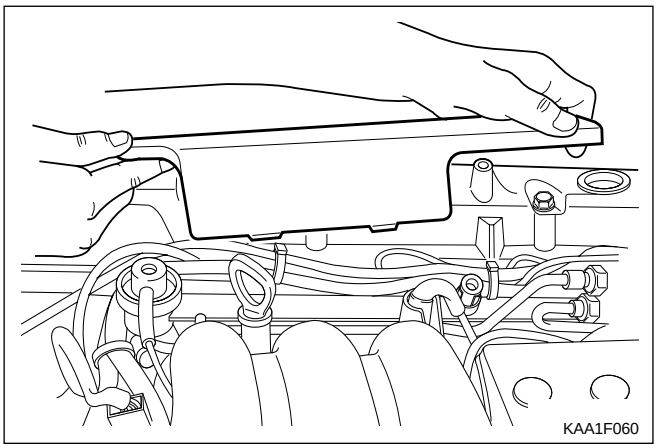

KAA1F440

FUEL RAIL AND INJECTORS

Removal and Installation Procedure

Caution: The fuel system is under pressure. To avoidfuel 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 vacuum hose from the fuel pressure regulator.

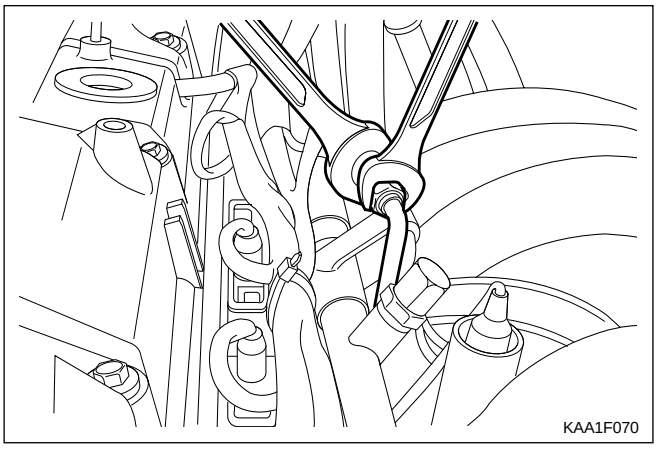

KAA1F060

4. Remove the cable guide.
5. Disconnect the Hot Film Air Mass (HFM) sensor connector.
6. Remove the intake air duct mounting bolts.

Installation Notice

Tightening Torque	9 N•m (80 lb-ft)

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


KAA1F070

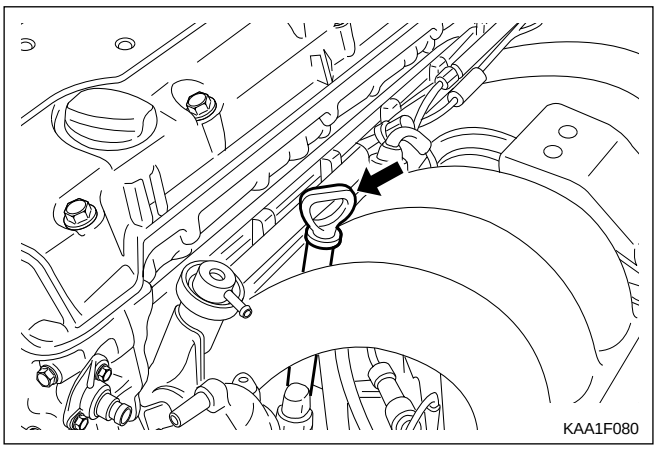
9. Remove the fuel return and supply line.

   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)

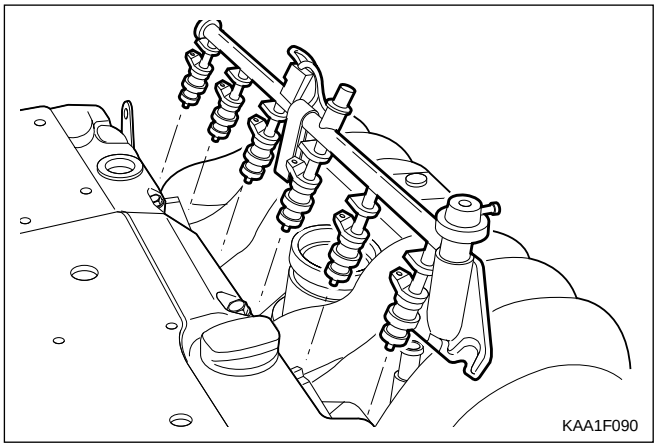
10. Remove the six injector connectors.


KAA1F080

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

Installation Notice

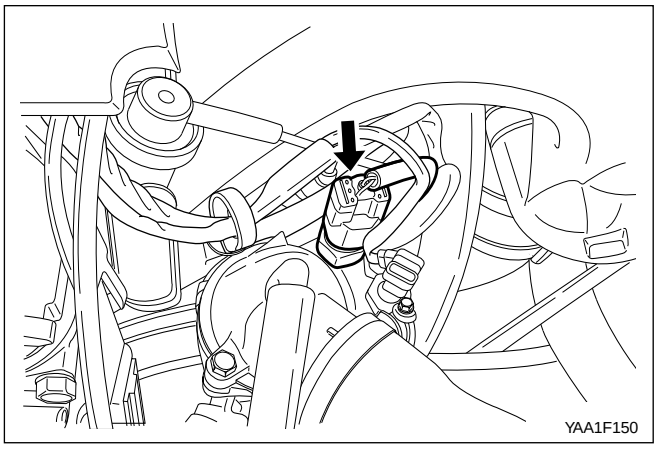
Tightening Torque	25 N•m (18 lb-ft)


KAA1F090

Notice: Before removal, the fuel rail assembly may be cleaned with as pray 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.

Important: 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.


YAA1F150

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.

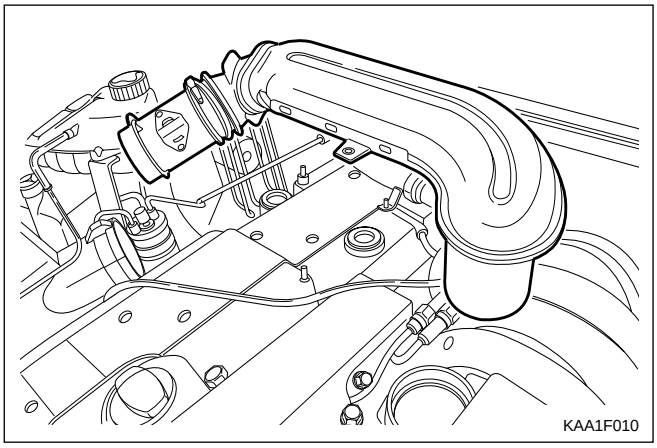
   Notice: Take care when handling the engine coolant temperature sensor. Damage to the sensor will affect the proper operation of the fuel injection system.

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.


KAA1F010

THROTTLE BODY (INTEGRATED WITH THE ACTUATOR)

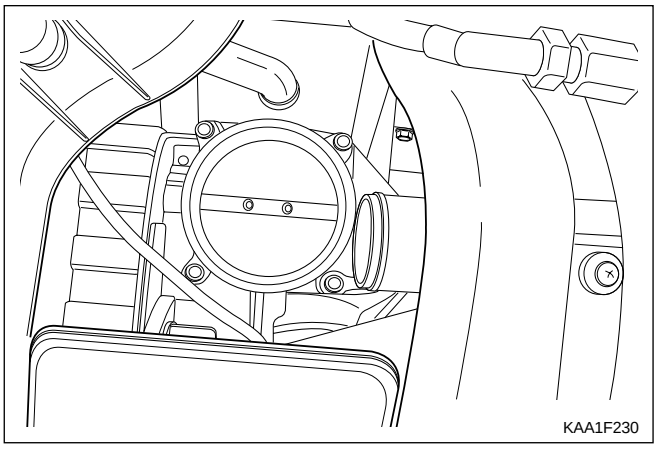
Removal and Installation Procedure

1. Disconnect the negative battery cable.
2. Disconnect the mass air flow sensor connector.
3. Disconnect the mass air flow sensor from the air filter housing.
4. Remove the intake air duct mounting bolts.

Installation Notice

Tightening Torque	9 N•m (80 lb-ft)

5. Remove the air inlet housing clamps.
6. Remove the inlet air housing.

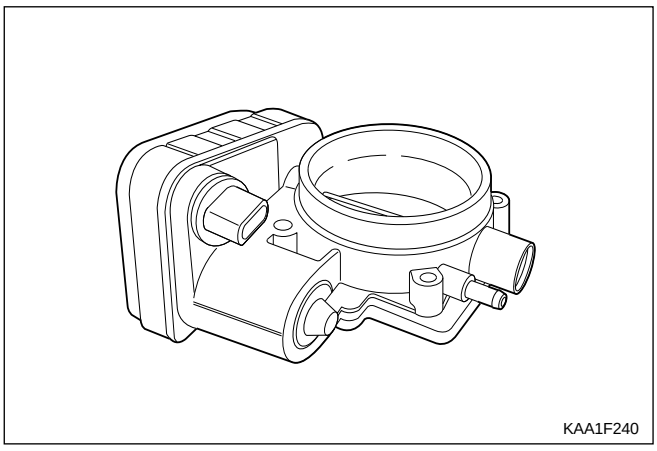

KAA1F230

7. Disconnect the throttle body electrical connector.
8. Remove the throttle body bolts.

Installation Notice

Tightening Torque	12 N•m (106 lb-ft)

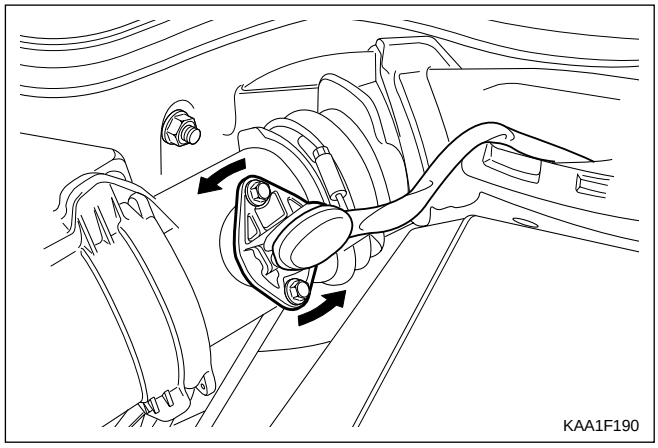
9. Remove the vacuum hose.


KAA1F240

10. Remove the throttle body and discard the gasket.

    Important: Use care in cleaning old gasket material. Sharp tools may damage sealing surfaces.

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


KAA1F190

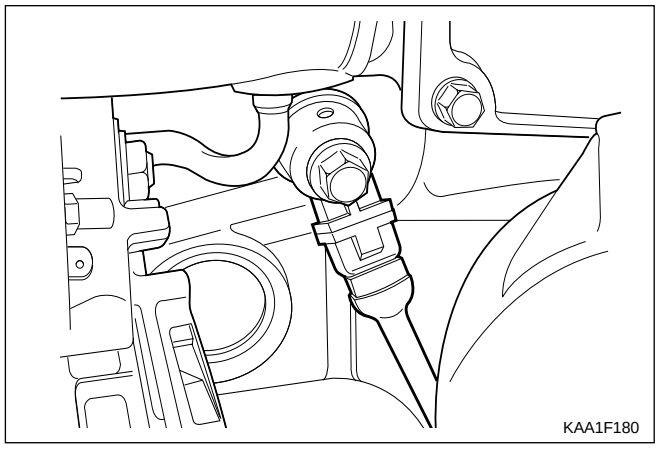
HOT FILM AIR MASS (HFM) SENSOR

Removal and Installation Procedure

1. Disconnect the negative battery cable.
2. Disconnect the Hot Film Air Mass (HFM) sensor electrical connector.
3. Remove the HFM sensor retaining screws.
4. Turn the HFM sensor coupling in the direction shown in the figure in the left so that it gets separated from the contact surface.

   Notice: Make sure the HFM sensor coupling connects completely with the contact surface installation.

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


KAA1F180

KNOCK SENSOR

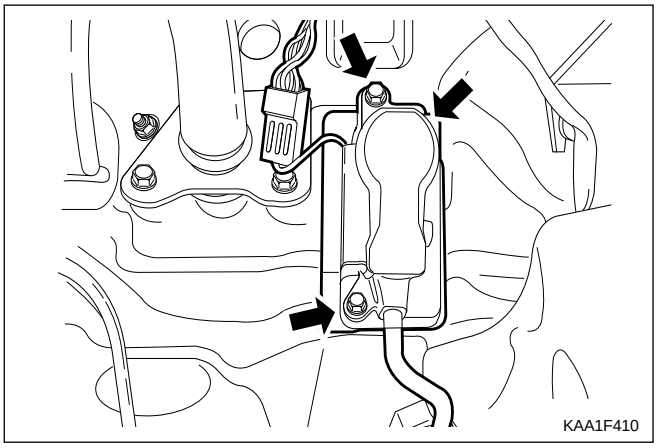
Removal and installation Procedure

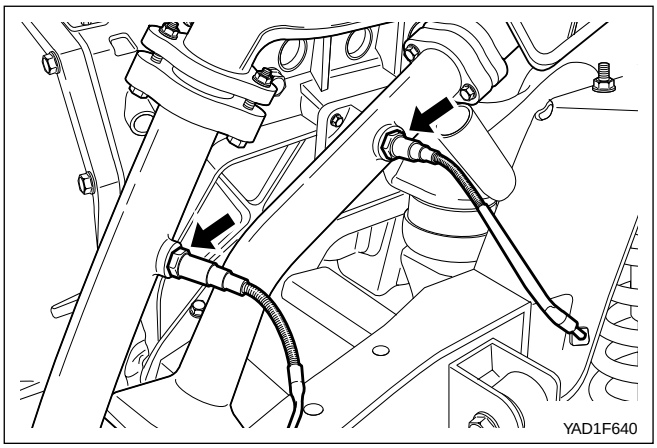
1. Disconnect the negative battery cable.
2. Disconnect the knock sensor electrical connector from the intake manifold bracket.
3. Remove the knock sensor mounting bolt from the knock sensor installed on the cylinder block.

   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-ft)

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.

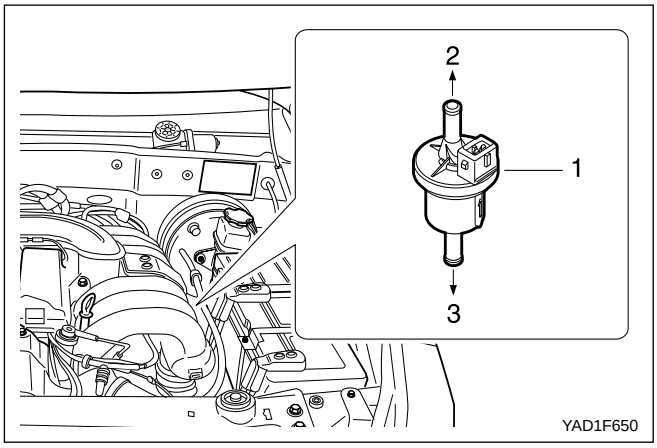
2. Disconnect the electrical connector.
3. Carefully remove the oxygen sensor from the exhaust pipe.

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 a liquid graphite and glass beads. The graphite will burn away, but the glass beads will remain, making the sensor easier to remove. New or serviced sensors will al-ready have the compound applied to the threads. If a sensor is removed from any engine and is to be rein-stalled, the threads must have an anti-seize compound applied before reinstallation.

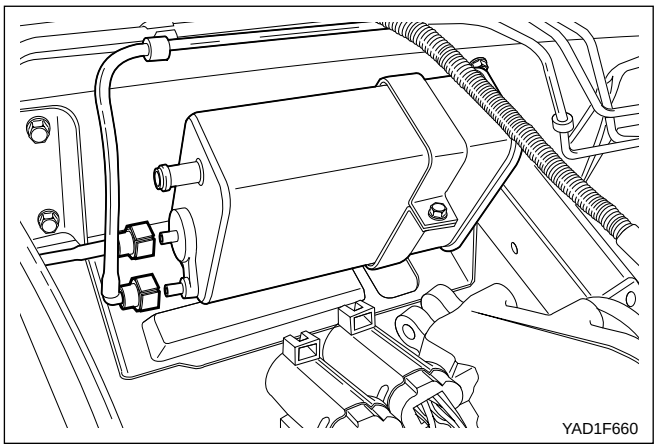
4. Coat the threads of the oxygen sensor with an anti-seize compound, if needed.
5. Installation should follow the removal procedure in the reverse order.



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 procedure in the reverse order.

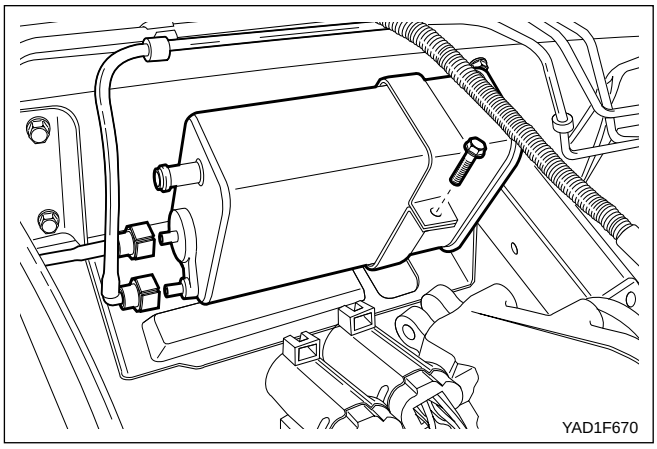


CANISTER

Removal and Installation Procedure

Caution: 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.

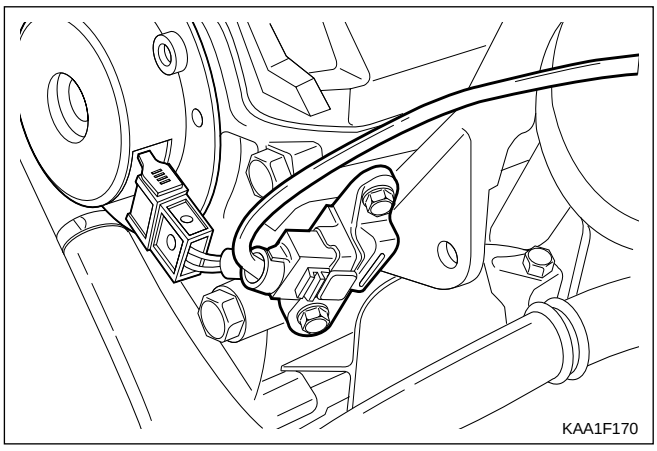


3. Remove the canister mounting bolts.

   Installation Notice

Tightening Torque	6 N•m (53 lb-ft)

4. Remove the canister.
5. Installation should follow the removal procedure in the reverse order.



CAMSHAFT POSITION SENSOR

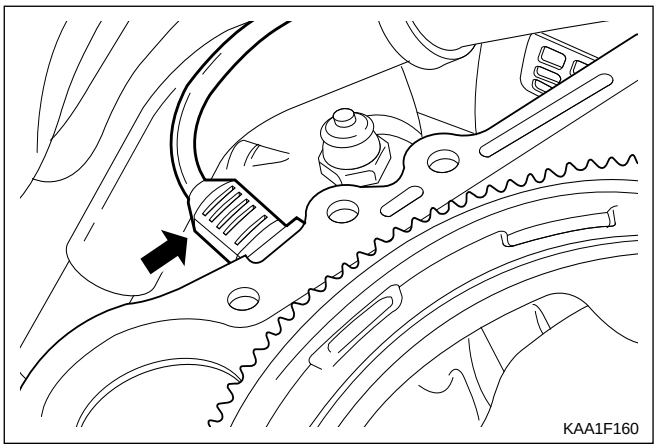
Removal and Installation Procedure

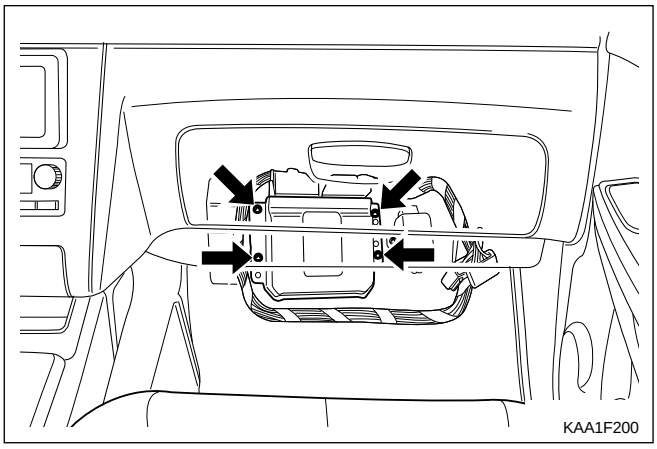
1. Disconnect the negative battery cable.
2. Disconnect the electrical connector from the camshaft position sensor.
3. Remove the camshaft position sensor retaining bolt.

   Installation Notice

Tightening Torque	10 N•m (89 lb-ft)

4. Check the O-ring for damage and replace it if neces sary.
5. Installation should follow the removal procedure in the reverse order.


KAA1F160


KAA1F200

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	25 N•m (18 lb-ft)

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

ENGINE CONTROL MODULE

Removal and installation Procedure

1. Disconnect the negative battery cable.
2. Remove the cowl side trim form passenger side. Refer to *Section 9G, Interior trim.*
3. Remove the four securing nuts for the Engine Control Module (ECM) from the mounting bracket.

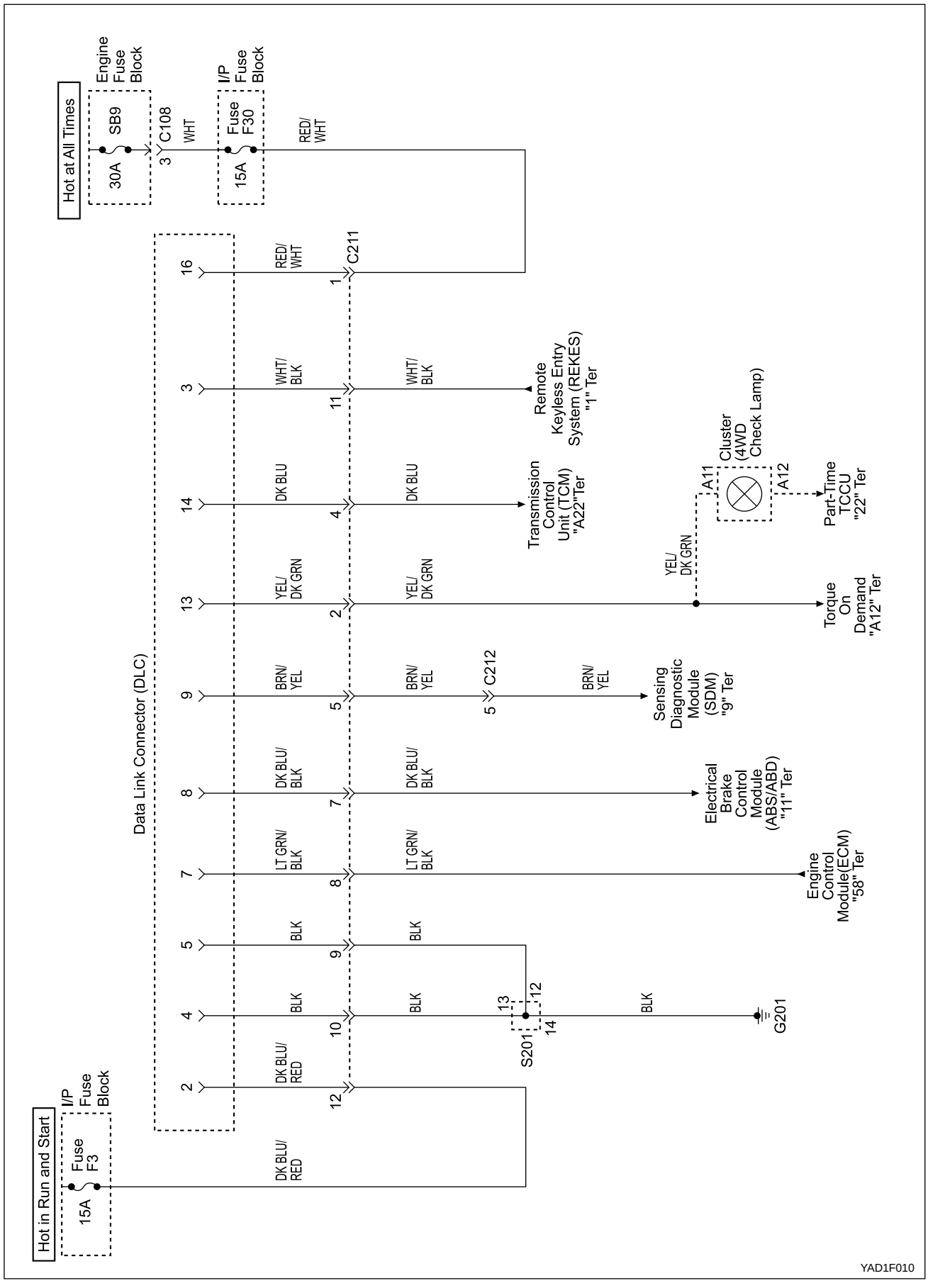
Installation Notice

Tightening Torque	25 N•m (18 lb-ft)

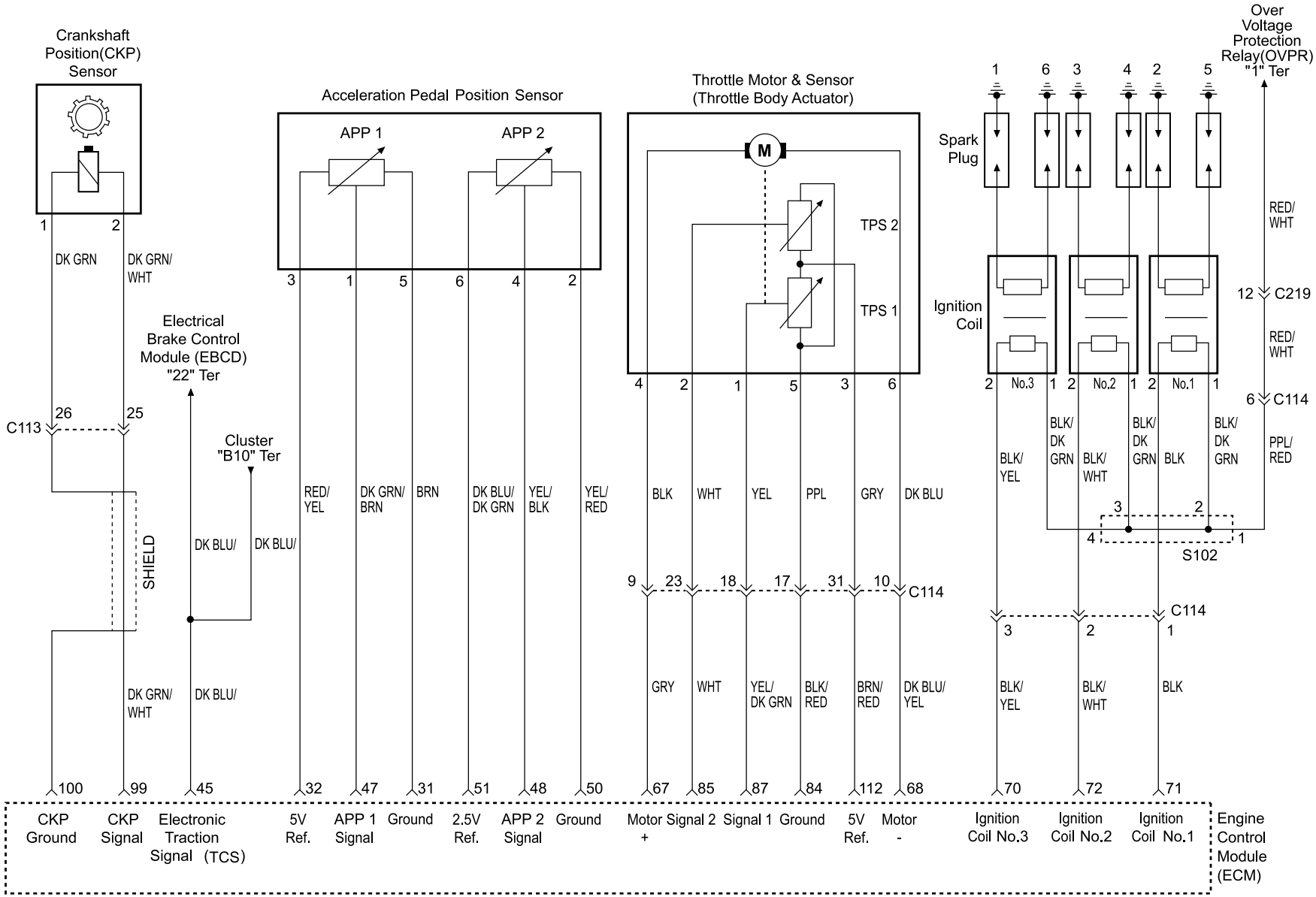
4. Pull out the ECM from the bracket.
5. Disconnect the vehicle side coupling.
6. Installation should follow the removal procedure in the reverse order.

SCHEMATIC AND ROUTING DIAGRAMS

ECM WIRING DIAGRAM (3.2L DOHC - 1 OF 7) (MSE 3.63D)



ECM WIRING DIAGRAM (3.2L DOHC - 2 OF 7) (MSE 3.63D)



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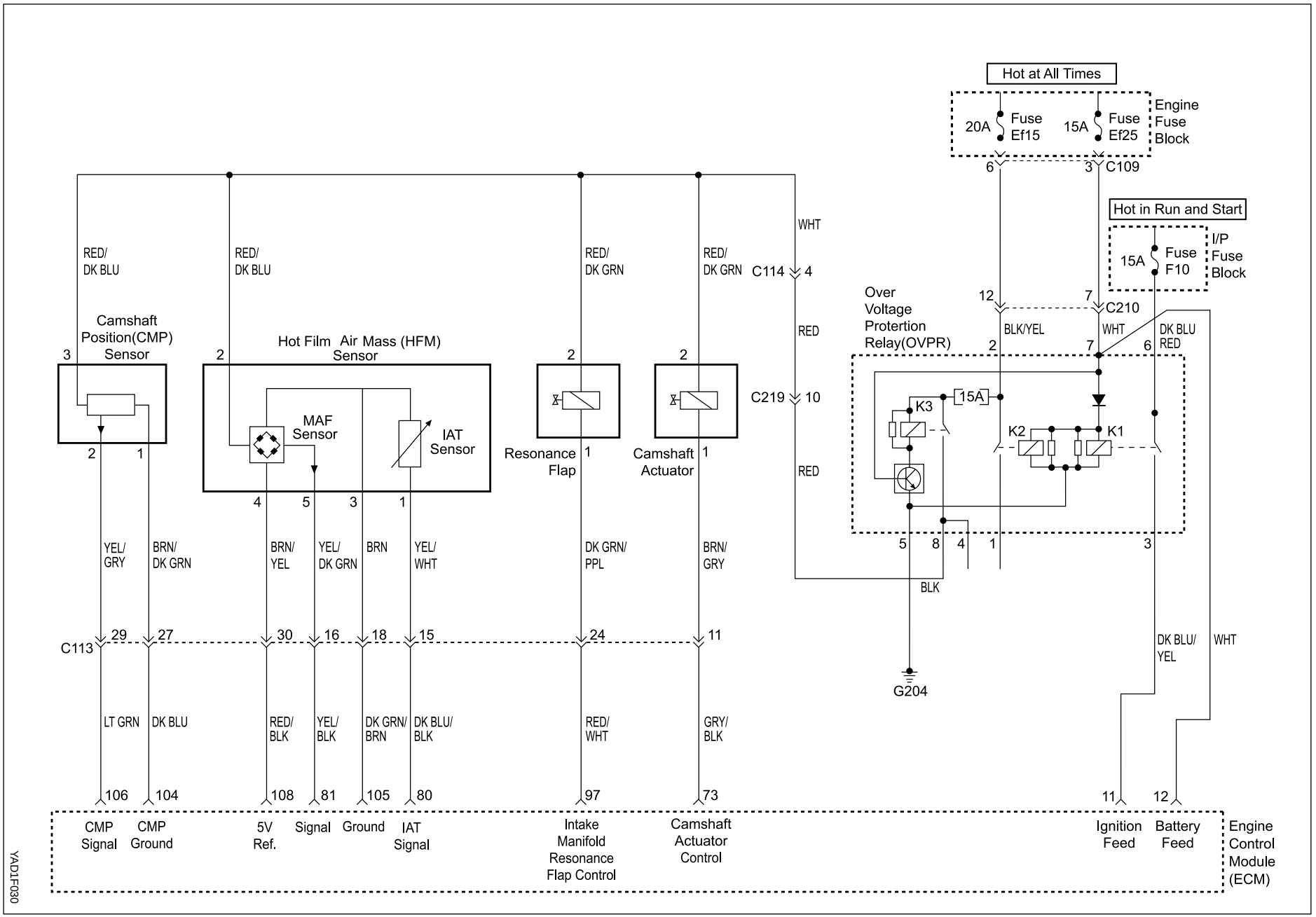
ECM WIRING DIAGRAM (3.2L DOHC - 3 OF 7) (MSE 3.63D)



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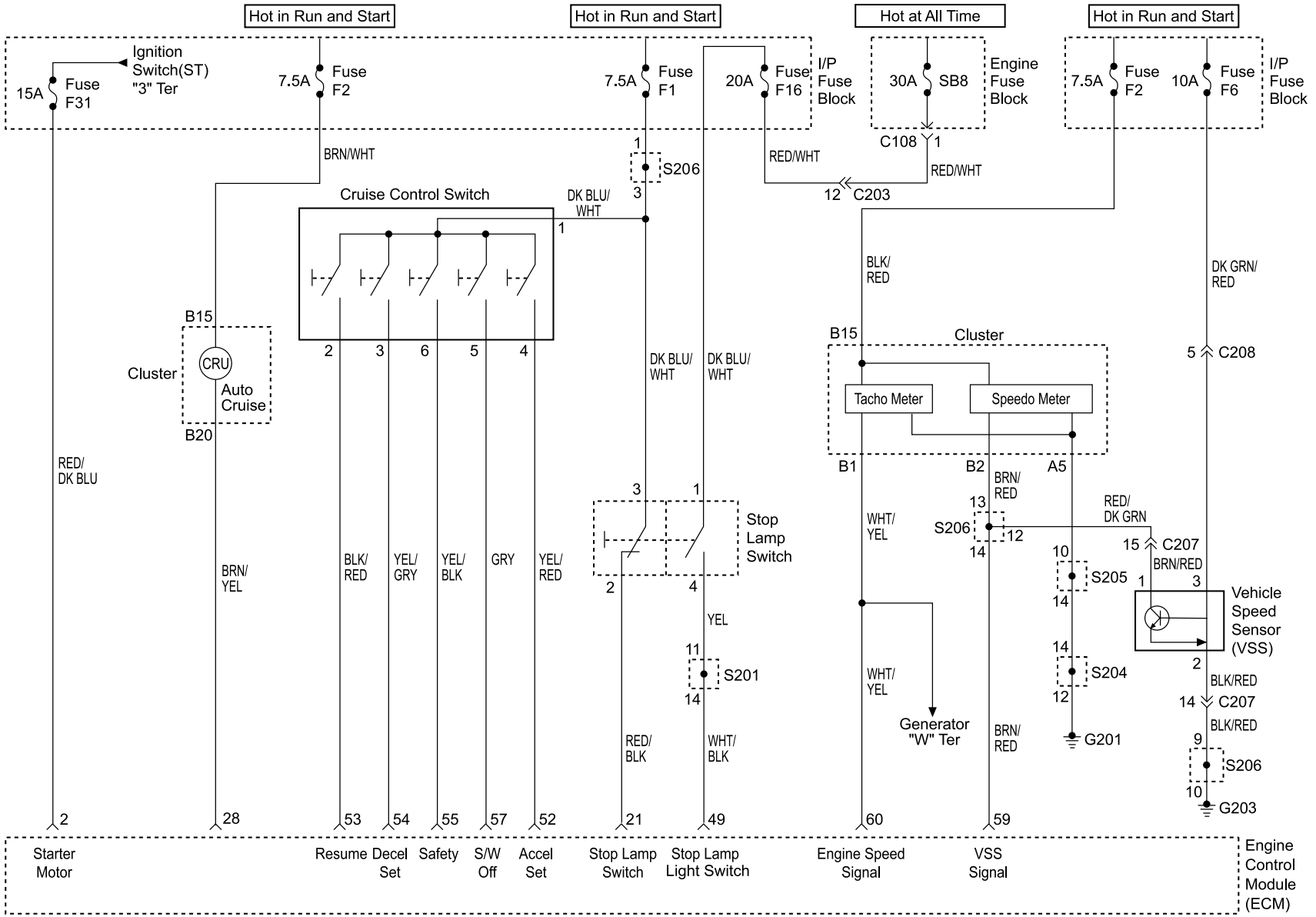
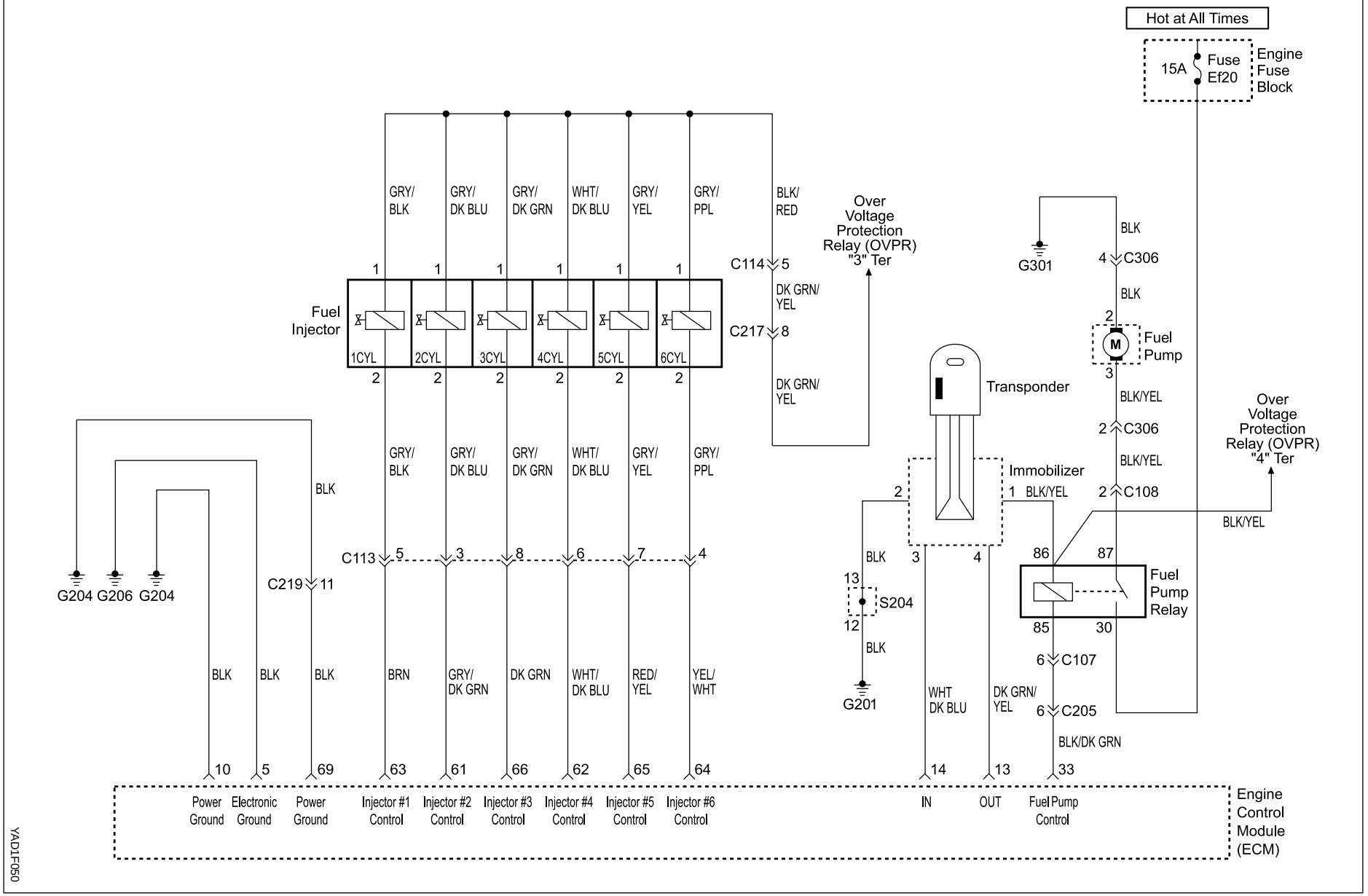
ECM WIRING DIAGRAM (3.2L DOHC - 4 OF 7) (MSE 3.63D)



YAD1F040

ECM WIRING DIAGRAM (3.2L DOHC - 5 OF 7) (MSE 3.63D)



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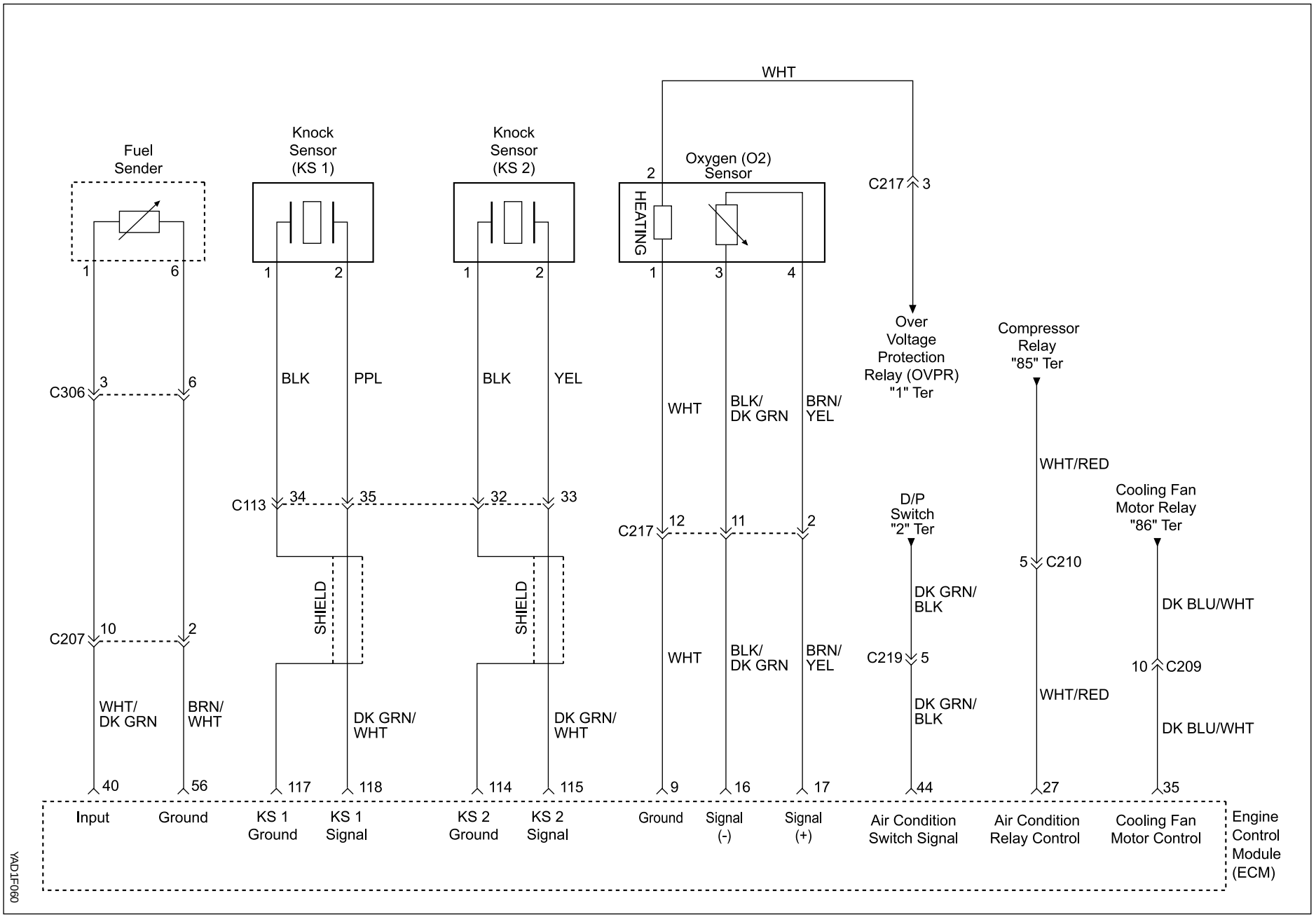
ECM WIRING DIAGRAM (3.2L DOHC - 6 OF 7) (MSE 3.63D)



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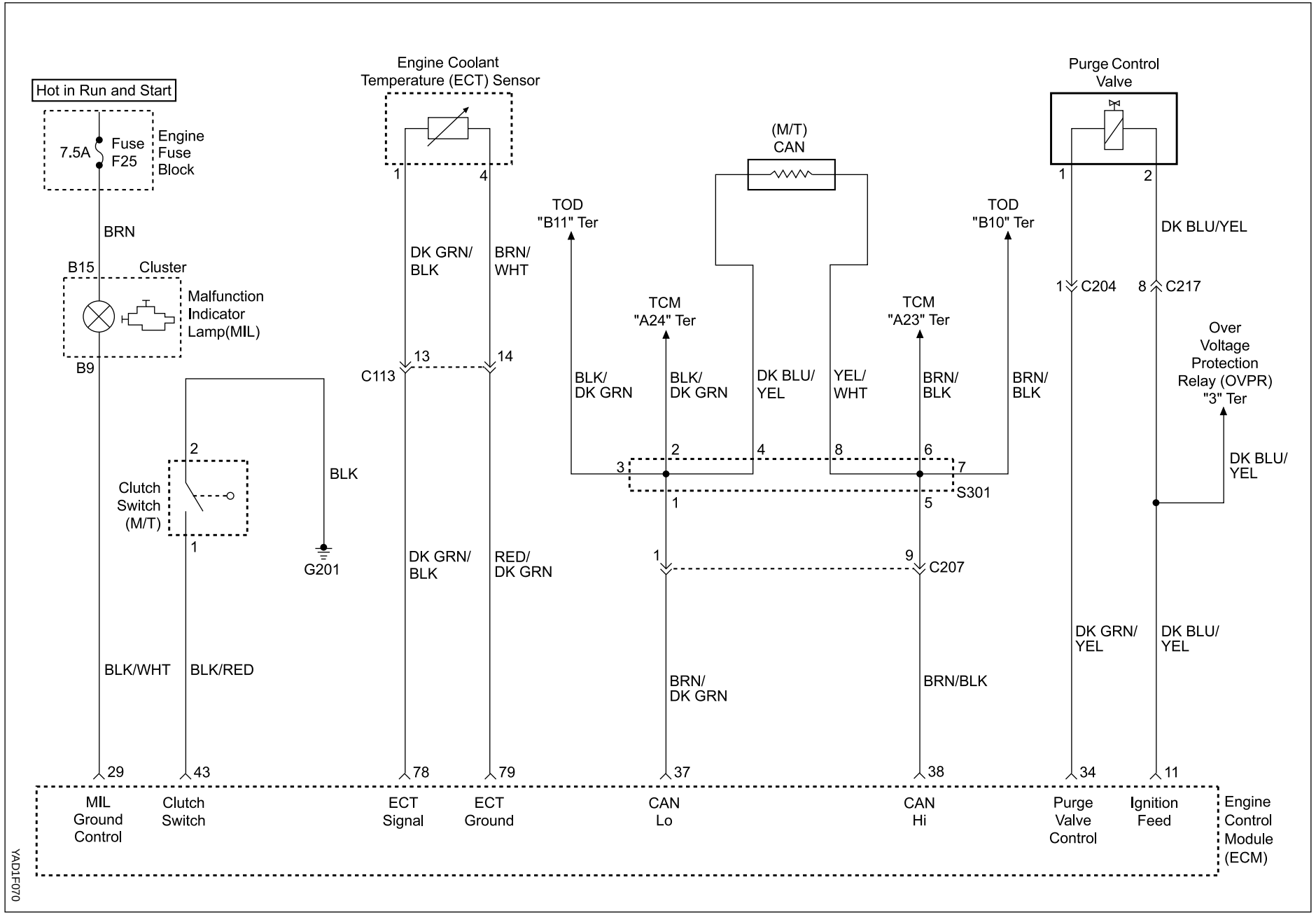
ECM WIRING DIAGRAM (3.2L DOHC - 7 OF 7) (MSE 3.63D)



SPECIFICATIONS

ENGINE DATA DISPLAY TABLE

Parameter	Unit	Value
Engine Coolant Temp.	°C	greater than 95 °C after warm up
Intake Air Temp.	°C	-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 %
Mass Air Flow Meter	Kg/h	16 ~ 25 Kg/h
Throttle Position Angle	°TA	0 °TA (up to 100 °TA at t he wi de 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	-
Ful l 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	-
Intake Air Duct Mounting Bolts	9	-	80
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 theengine.

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, par-ticularly plastic, are fitted to the fuel-dispensing pump.

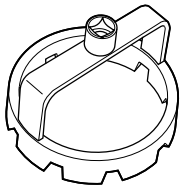
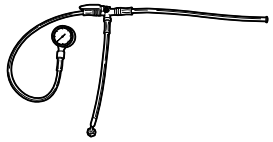
It is therefore recommended that earthed pumps with integrally earthed hoses be used, and that storage containers be properly earthed during all noncommercial fueling operations.

TEMPERATURE VS RESISTANCE

°C	°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

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS TABLE

 YAA1F890	**661 589 00 46 00** **Fuel Tank Cap Wrench**
 KAA1F490	**103 589 00 21 00** **Fuel Pressure Gauge**

SECTION 1F2

M161 ENGINE CONTROLS

CAUTION: Disconnect the negative battery cable before removi ng 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.

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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 (if available)	☐ Normal ☐ Malfunction code(s) (code) ☐ 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

DIAGNOSTIC INFORMATION AND PROCEDURE
FAILURE CODE DIAGNOSIS

CLEARING FAILURE CODES

Notice: To prevent Engine Control Module (ECM) damage, the key must be OFF when disconnecting or reconnecting the power to the ECM (for example battery cable, ECM pigtail connector, ECM fuse, jumper cables, etc.)

Parameters listed in the table may not be exactly the same as your reading due to the type of instrument or other factors. If a failure code is displayed during the “TROUBLE CODE” in scan tool check mode, check the circuit for the code listed in the table below. For details of each code, turn to the page referred to under the “See Page” for the respective “Failure Code” in the below table.

Failure codes should be cleared after repairs have been completed.

FAILURE CODES TABLE

Failure code	See Page	Description
00	1F2-56	Engine coolant temperature sensor low voltage
01	1F2-56	Engine coolant temperature sensor high voltage
02	1F2-56	Engine coolant temperature sensor plausibility
03	1F2-52	Intake air temperature sensor low voltage
04	1F2-52	Intake air temperature sensor high voltage
05	1F2-52	Intake air temperature sensor plausibility
06	1F2-56	Engine coolant temperature insufficient for closed loop fuel control
08	1F2-28	System voltage too low
09	1F2-52	Mass air flow sensor plausibility
10	1F2-52	Mass air flow sensor low voltage
11	1F2-52	Mass air flow sensor high voltage
17	1F2-13	Crankshaft position sensor signal failure (no engine revolution signal)
18	1F2-13	Crankshaft position sensor signal failure (rpm > max. value)
19	1F2-17	Camshaft position sensor signal : No.1 cylinder recognition failure
20	1F2-13	Crankshaft position sensor signal failure (gap recognition failure)
21	1F2-80	Transmission coding failure
23	1F2-78	CAN communication failure : ASR/MSR
24	1F2-78	CAN communication failure : ABS
25	1F2-84	Communication with transponder missing
26	1F2-78	CAN communication failure : TCU (A/T only)
29	1F2-79	CAN communication failure : ID 200h not plausible
30	1F2-79	CAN communication failure : ID 208h not plausible
31	1F2-79	CAN communication failure : communication initialization failure
32	1F2-67	Engine rpm output circuit short circuit to battery
33	1F2-67	Engine rpm output circuit short circuit to ground or open
34	1F2-33	Fuel pump relay short circuit to battery
35	1F2-33	Fuel pump relay short circuit to ground or open
40	1F2-41	Purge control valve short circuit to battery
41	1F2-41	Purge control valve short circuit to ground or open

FAILURE CODES TABLE (Cont'd)

Failure code	See Page	Description
44	1F1-62	Cooling fan (HI) relay short circuit to power
45	1F1-62	Cooling fan (HI) relay short circuit to ground or open
54	1F1-41	Purge control circuit malfunction
56	1F1-23	No.1 knock sensor signal failure
58	1F1-17	Camshaft position sensor signal : No.1 cylinder synchronization failure
59	1F1-79	CAN communication failure : MSR data transmission not plausible
60	1F1-79	CAN communication failure : ASR data transmission not plausible
64	1F1-11	No ignition voltage output (No.1 ignition coil)
65	1F1-11	No ignition voltage output (No.2 ignition coil)
67	1F1-13	Crankshaft position sensor adaptation failure
68	1F1-25	Random/Multiple Misfire
71	1F1-29	Starter signal recognition failure
72	1F1-37	No.1 injector short circuit to battery
73	1F1-37	No.1 injector short circuit to ground or open
74	1F1-37	No.2 injector short circuit to battery
75	1F1-37	No.2 injector short circuit to ground or open
76	1F1-37	No.3 injector short circuit to battery
77	1F1-38	No.3 injector short circuit to ground or open
78	1F1-38	No.4 injector short circuit to battery
79	1F1-38	No.4 injector short circuit to ground or open
80	1F1-72	Oxygen sensor high voltage
81	1F1-73	Bank 1 system short term fuel trim adaptation below lean threshold
82	1F1-72	Oxygen sensor no activity detected
83	1F1-72	Oxygen sensor not lean after overrun fuel shut -off
84	1F1-72	Oxygen sensor slow response
85	1F1-72	Oxygen sensor heater failure
86	1F1-72	Oxygen sensor heater short circuit to battery
87	1F1-72	Oxygen sensor heater short circuit to ground or open
89	1F1-72	Oxygen sensor low voltage
93	1F1-73	Bank 1 system short term fuel trim adaptation above rich threshold
96	1F1-73	Bank 1 system short term fuel trim at rich stop
97	1F1-73	Bank 1 system short term fuel trim at lean stop
98	1F1-73	Bank 1 system idle adaptation failure (above rich threshold)
99	1F1-73	Bank 1 system idle adaptation failure (below lean threshold)
100	1F1-73	Bank 1 system learning control failure (rich, low load)
101	1F1-73	Bank 1 system learning control failure (lean, low load)
102	1F1-73	Bank 1 system learning control failure (rich, high load)
103	1F1-73	Bank 1 system learning control failure (lean, high load)
104	1F1-47	Throttle position sensor 1 low voltage
105	1F1-47	Throttle position sensor 1 high voltage

FAILURE CODES TABLE (Cont'd)

Failure code	See Page	Description
108	1F1-47	Throttle position sensor 2 low voltage
109	1F1-47	Throttle position sensor 2 high voltage
110	1F1-82	Throttle actuator learning data fault
116	1F1-47	Throttle actuator learning control failure
117	1F1-82	Exceed fuel-cut safety time
119	1F1-47	Throttle valve return spring failure
120	1F1-82	Cruise control interruption memory failure
121	1F1-47	Throttle actuator failure
122	1F1-59	Accelerator pedal position sensor signal failure
123	1F1-47	Different Mass air flow sensor signal with throttle position sensor
125	1F1-47	Both throttle position sensors failure
126	1F1-48	Throttle position sensor 1 not plausible with throttle position sensor 2
127	1F1-48	High permanent throttle signal
129	1F1-64	Cruise control "OFF" due to message counter failure
130	1F1-64	Vehicle speed signal failure
131	1F1-64	Vehicle speed signal failure
132	1F1-64	Cruise control lever failure
133	1F1-64	Cruise control acceleration failure
134	1F1-64	Cruise control deceleration failure
135	1F1-66	Stop lamp switch failure
136	1F1-80	ECU failure (RAM)
137	1F1-80	ECU failure (EPROM)
138	1F1-82	Call monitoring
139	1F1-82	Servo motor control output interruption memory failure
140	1F1-82	Servo motor open/short
141	1F1-84	Unprogramed ECU with immobilizer
142	1F1-80	Uncoded/unprogramed ECU
143	1F1-80	ECU failure (EEPROM/Flash-EPROM checksum failure)
144	1F1-80	ECU failure (coding ID checksum failure)
145	1F1-80	ECU failure (coding checksum failure)
146	1F1-80	ECU failure (programing checksum failure)
150	1F1-65	TCS input signal short circuit to battery
151	1F1-65	TCS input signal short circuit to ground or open
160	1F1-59	Accelerator pedal position sensor 1 low voltage
161	1F1-59	Accelerator pedal position sensor 1 high voltage
162	1F1-59	Accelerator pedal position sensor 2 low voltage
163	1F1-59	Accelerator pedal position sensor 2 high voltage
164	1F1-59	Accelerator pedal position sensor 1 not plausible with pedal position sensor 2
167	1F1-59	Both setpoint accelerator pedal position sensor defective
185	1F1-48	Mass air flow sensor and throttle position sensor failure
186	1F1-82	ECU failure (incompatible CPU)

FAILURE CODES TABLE (Cont'd)

Failure code	See Page	Description
187	1F1-82	ECU failure (CPUs communication failure)
188	1F1-82	ECU failure (CPU 2 configuration failure)
189	1F1-82	ECU failure (CPU 2 fault)
190	1F1-82	ECU failure (CPU run time failure between CPUs)
226	1F1-21	Camshaft actuator short circuit to battery
227	1F1-21	Camshaft actuator short circuit to ground or open
228	1F1-63	A/C compressor relay short circuit to battery
229	1F1-63	A/C compressor relay short circuit to ground or open
231	1F1-82	ECU failure (CPU 2 cruise control message counter failure)
232	1F1-82	Over decceleration limit (CPU 2)
233	1F1-82	Over acceleration limit (CPU 2)
234	1F1-82	Cruise control lever dual operation (CPU 2)
235	1F1-82	Cruise control lever safety terminal failure (CPU 2)
236	1F1-82	Unusual pedal position variation (CPU 2)
237	1F1-82	Unusual throttle position variation (CPU 2)
238	1F1-82	Unusual throttle controller monitor data comparison fault (CPU 2)
239	1F1-83	Unusual accelerator pedal position sensor comparison fault (CPU 2)
240	1F1-83	Throttle potentiometer comparision fault (CPU 2)
241	1F1-83	Unusual CPU communication (CPU 2)
242	1F1-83	Unusual CPU configuration (CPU 2)
243	1F1-83	A/D converter failure (CPU 2)
244	1F1-83	Accelerator pedal position sensor setpoint fault between CPU 1 and CPU 2
245	1F1-83	Position controller setpoint fault between CPU 1 and CPU 2
246	1F1-83	MSR setpoint fault between CPU 1 and CPU 2
247	1F1-83	Idle control setpoint fault between CPU 1 and CPU 2
248	1F1-83	A/D converteroverflow (CPU 2)
249	1F1-83	ROM f aul t (CPU 2)
250	1F1-83	RAM f aul t (CPU 2)
251	1F1-83	Cycle monitor fault (CPU 2)

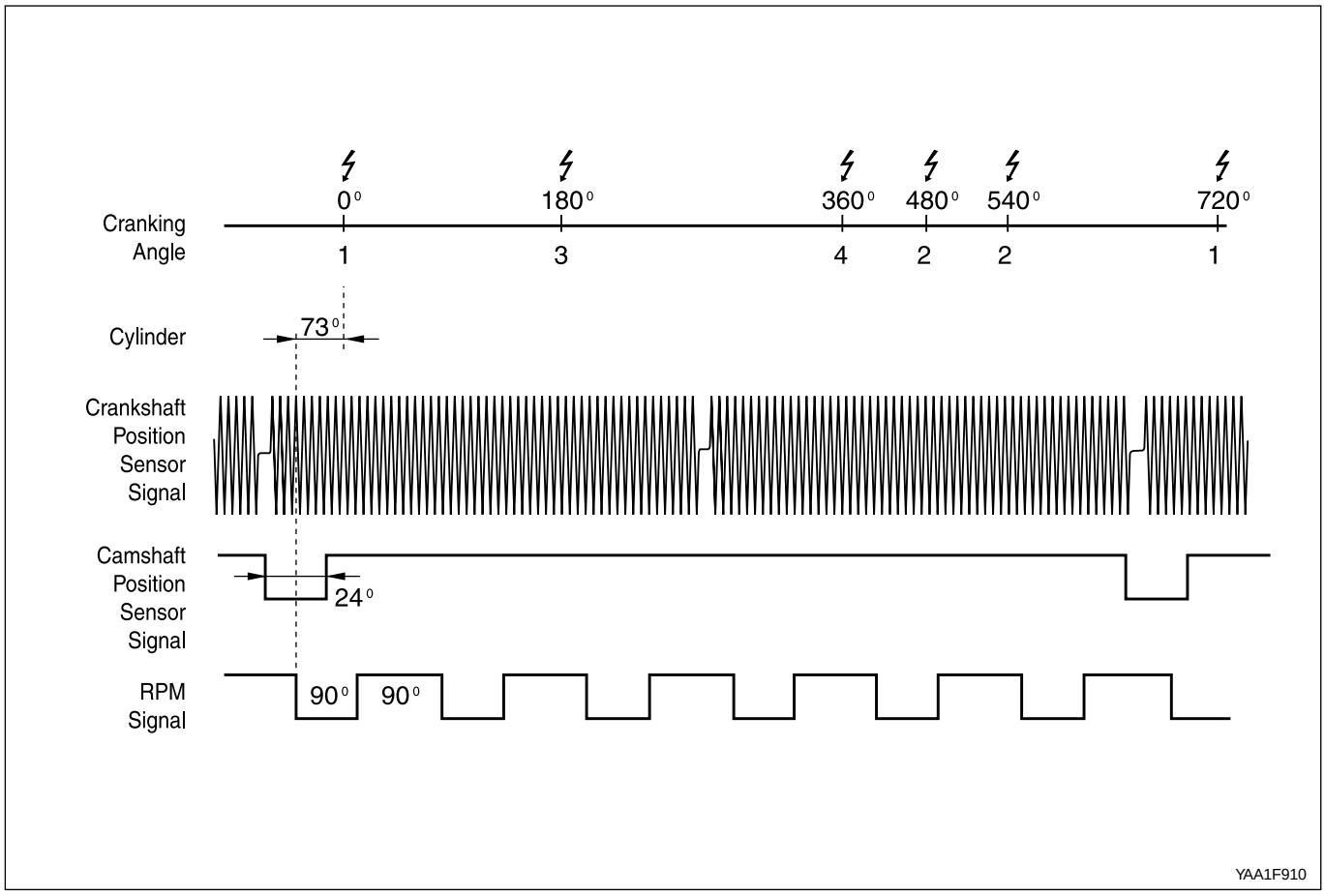
IGNITION SYSTEM

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).



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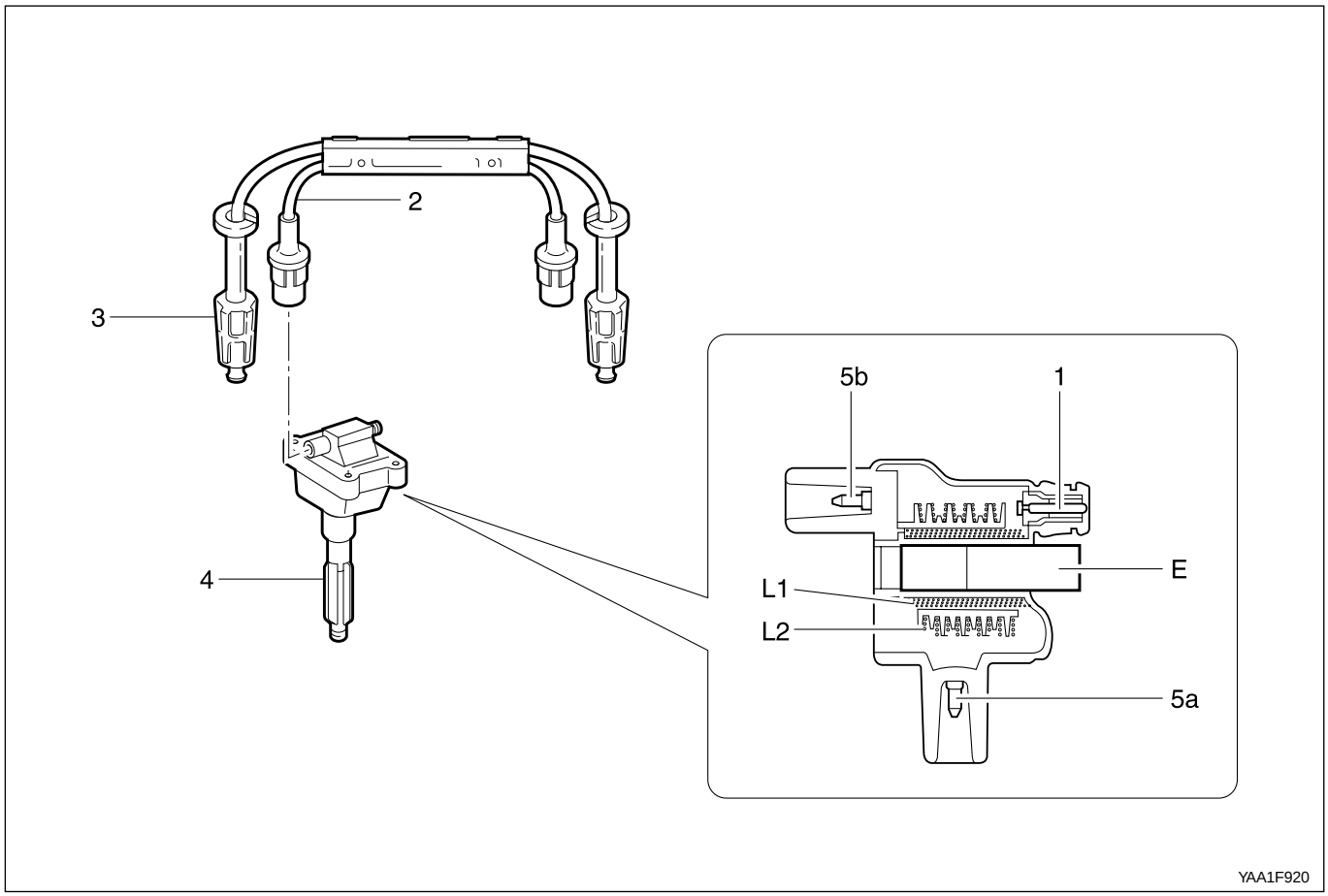
IGNITION COIL



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

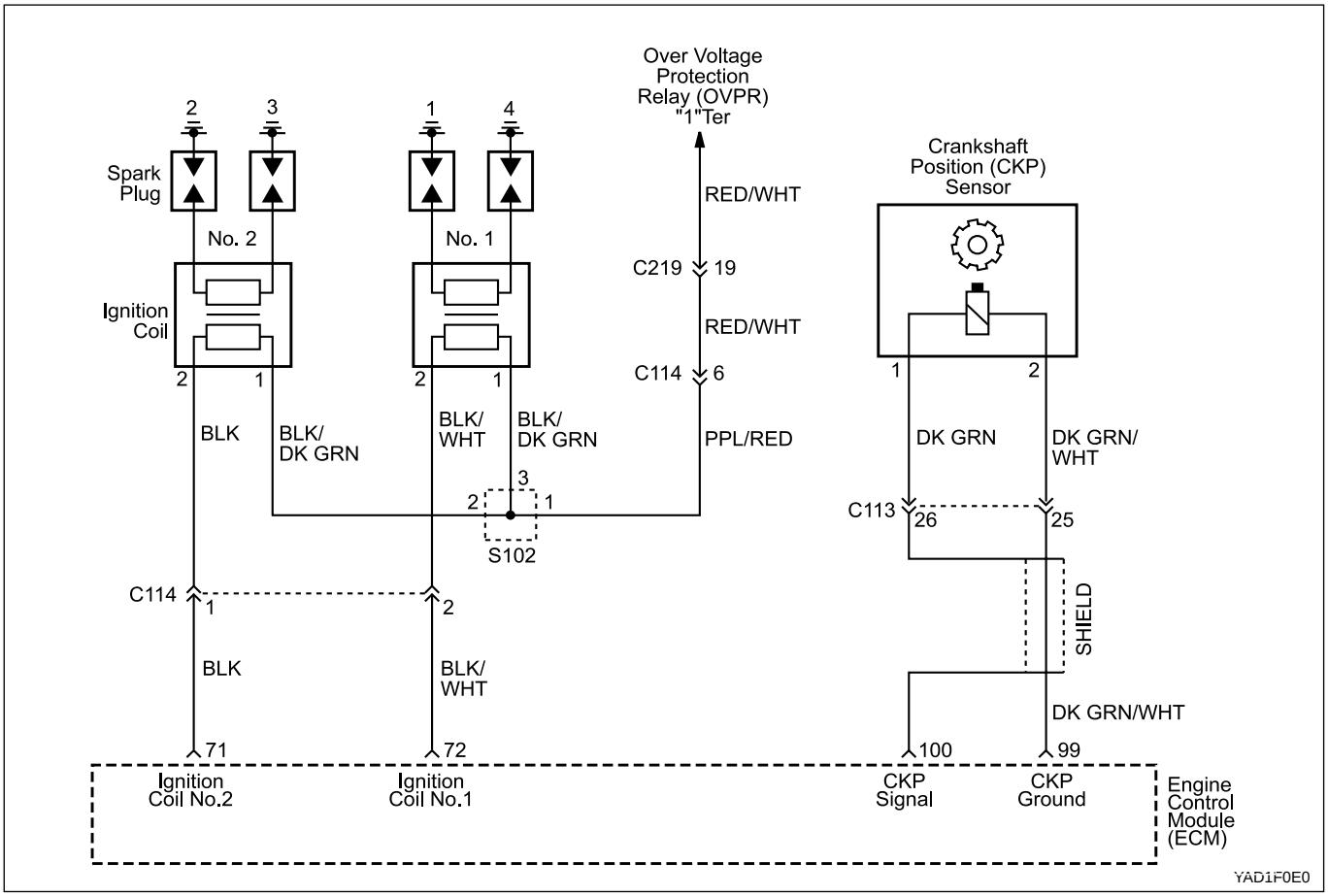
The Electronic Ignition (EI) system ignition coil is located on the cylinder head cover. The double ended coils receive the signal for the Engine Control Module (ECM) which controls the spark advance.

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.



Failure Code	Description	Trouble Area	Maintenance Hint
64	No ignition voltage output (No. 1 ignition coil)	Malfunction of ignition circuit Primary current values or secondary short circuit	• Inspection the ECM pin 71 and 72 about short circuit or open with bad contact • Inspection the power source to ignition coil • Inspection the ignition coil, high tension cords etc. • Inspection the spark plug (wet, cracks, wear, improper gap, burned electrodes, heavy deposit) • Inspection the ECM
65	No ignition voltage output (No. 2 ignition coil)		

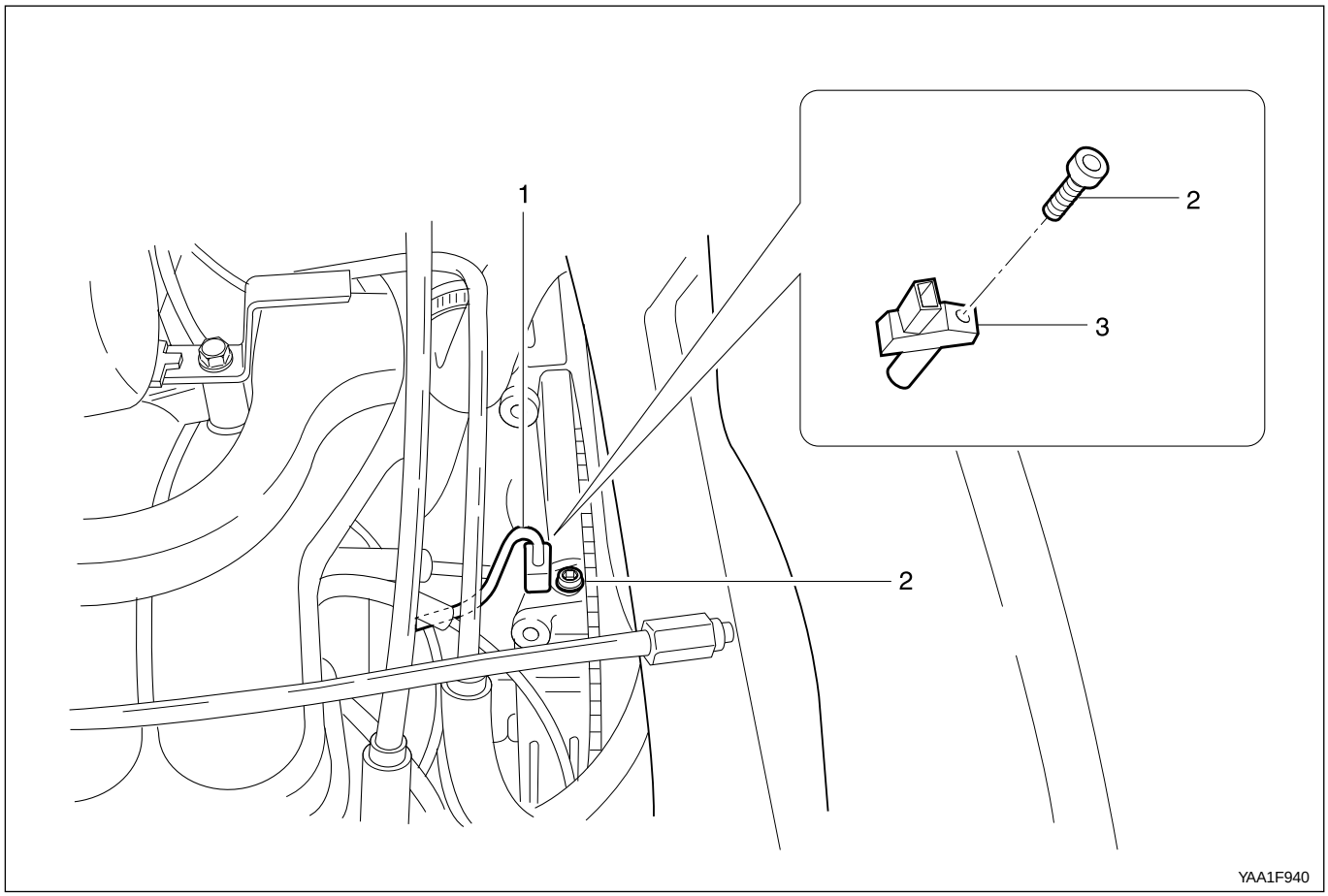
Circuit Description

The Electronic Ignition (EI) system uses a waste spark method of spark distribution. The Crankshaft Position (CKP) sensor sends reference pulses to the ECM. The ECM then triggers the EI system ignition coils. Once the ECM triggers the EI system ignition coils both of the connected spark plugs fire at the same time. One cylinder is on its compression stroke at the same time that the other is on the exhaust stroke, resulting in lower energy needed to fire the spark plug in the cylinder on its exhaust stroke.

This leaves the remainder of the high voltage to be used to fire the spark plug in the cylinder on its compression stroke.

Since the CKP sensor is in a fixed position, timing adjustments are not possible or needed.

CRANKSHAFT POSITION (CKP) SENSOR

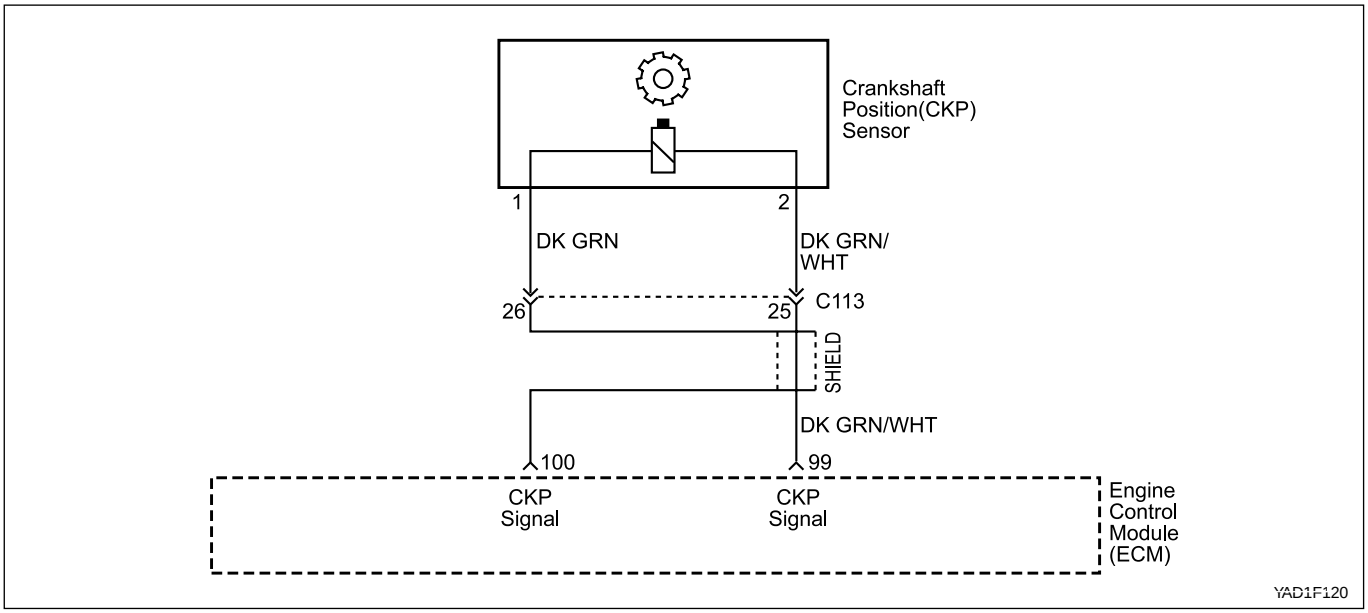


1 Crankshaft Position Sensor Connector
2 Bolt
3 Crankshaft Position Sensor

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.



Failure Code	Description	Trouble Area	Maintenance Hint
17	Crankshaft position sensor signal failure (no engine revolution signal)	Even through cam position recognition is normal, no crankshaft position signal recognition	• Monitoring the actual rpm through or scan tool • Inspection the ECM pin 100, 99 about short circuit with bad contact • Inspection the CKP sensor • Inspection the air gap between sensor and drive plate • Inspection the drive plate (teeth condition) • Inspection the ECM
18	Crankshaft position sensor signal failure (rpm > max. value)	When more than applicable revolution values or implausible to 60-2 teeth.	
20	Crankshaft position sensor signal failure (gap recognition failure)	When implausible recognition of cam and crank angle signal or intermittent sensing the signal or error count of undetected gap.	
67	Crankshaft position sensor adaptation failure	When faulty crank angle sensor adaption	

Circuit Description

The 58X reference signal is produced by the CKP sensor. During one crankshaft revolution, 58 crankshaft pulses will be produced. The ECM uses the 58X reference signal to calculate engine rpm and CKP. The ECM constantly monitors the number of pulses on the 58X reference circuit and compares them to the number of Camshaft Position (CMP) signal pulses being received. If the ECM receives and incorrect number of pulses on the 58X reference circuit, this failure code will set.

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.

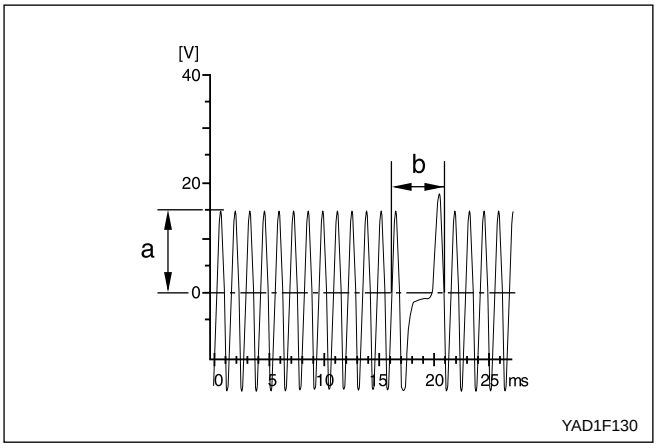
Specified Value	1,050 ~ 1,400 Ω

Notice: Measure the insulator resistance of the CKP sensor if out of the specified value.

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.

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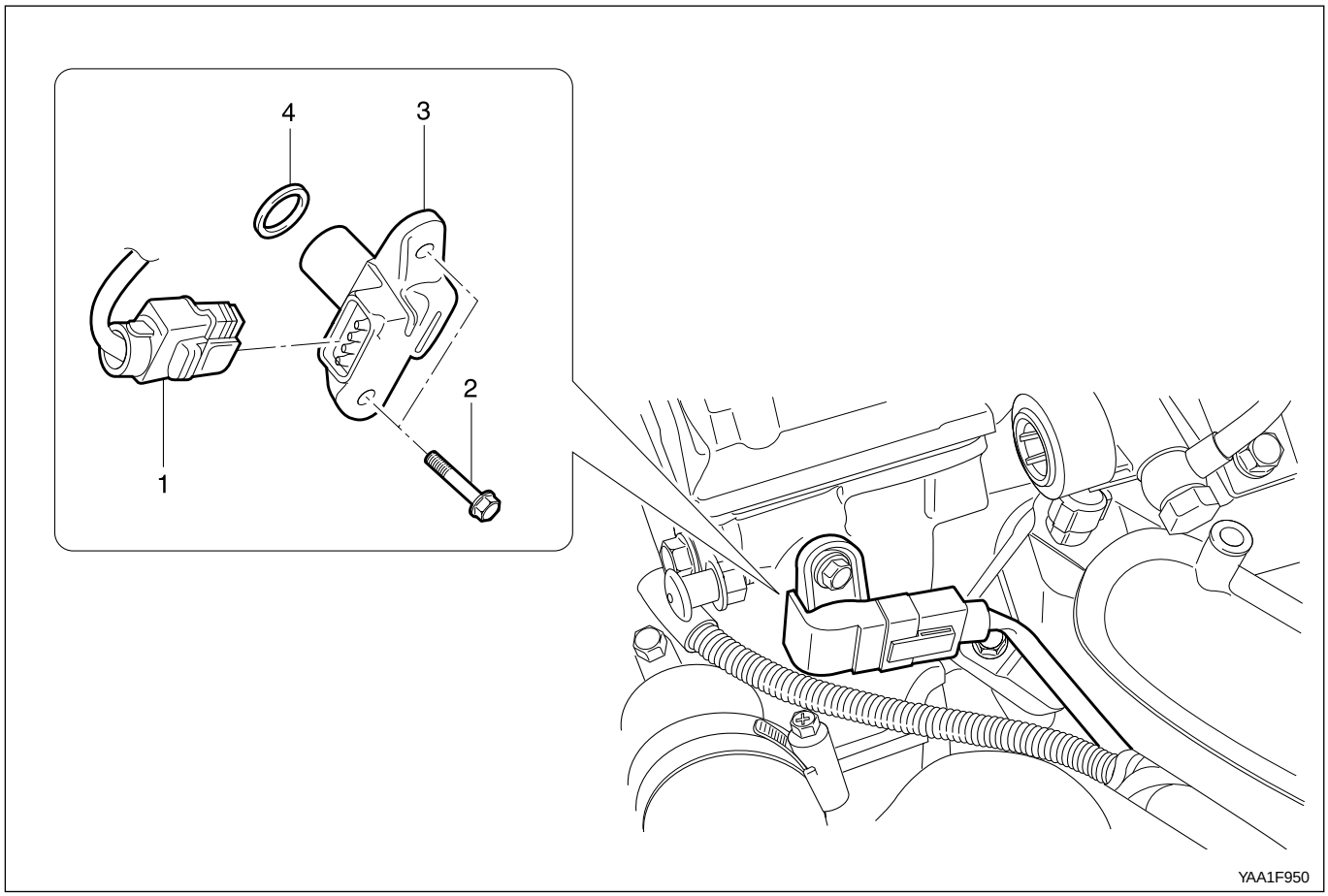
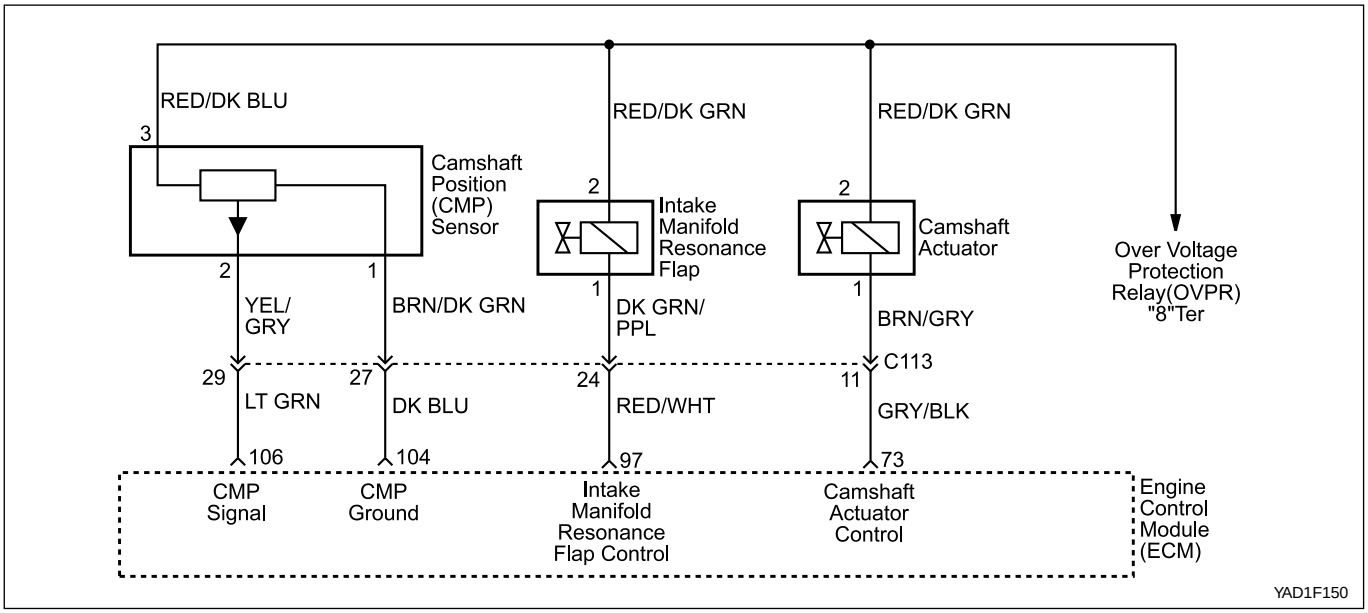
CAMSHAFT POSITION (CMP) SENSOR



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.



Failure Code	Description	Trouble Area	Maintenance Hint
19	Camshaft position sensor signal : No. 1 cylinder recognition failure	When no cam recognition signal during TN 24 counts more. (maintain the constant low or high level)	• Inspection the source voltage of CMP sensor • Inspection the ECM pin 106, 104 about short circuit or open with bad contact • Inspection the CMP sensor • Inspection the damage of sensor or sprocket • Inspection the ECM
58	Camshaft position sensor signal : No. 1 cylinder synchronization failure	When synchronization fault of cylinder 1 (TDC recognition)	

Circuit Description

The CMP sensor sends a cam position signal to the ECM. If the cam position signal is lost while the engine is running, the fuel injection system shifts to a calculated sequential fuel injection mode based on the last fuel injection pulse, and the engine continuous to run.

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.

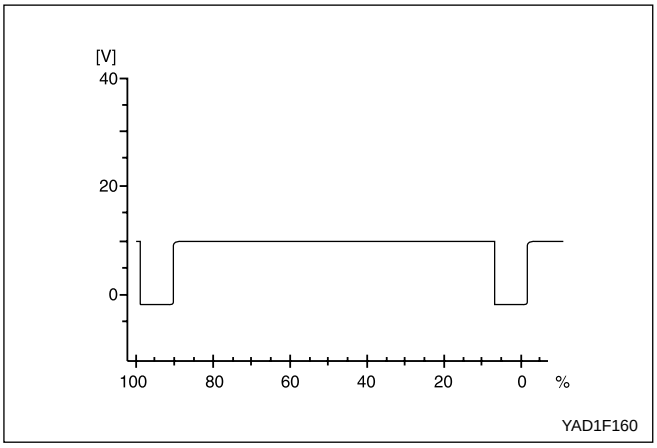
Specified Value	1.2 ~ 1.7 v

Notice: The signal voltage will be changed in the range of 1.2 ~ 1.7 v.

Camshaft Position Sensor Output Wave Inspection

1. Measure the output wave between the ECM terminals No. 104 and No. 106 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 resistance between the No. 1 and No. 3 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.

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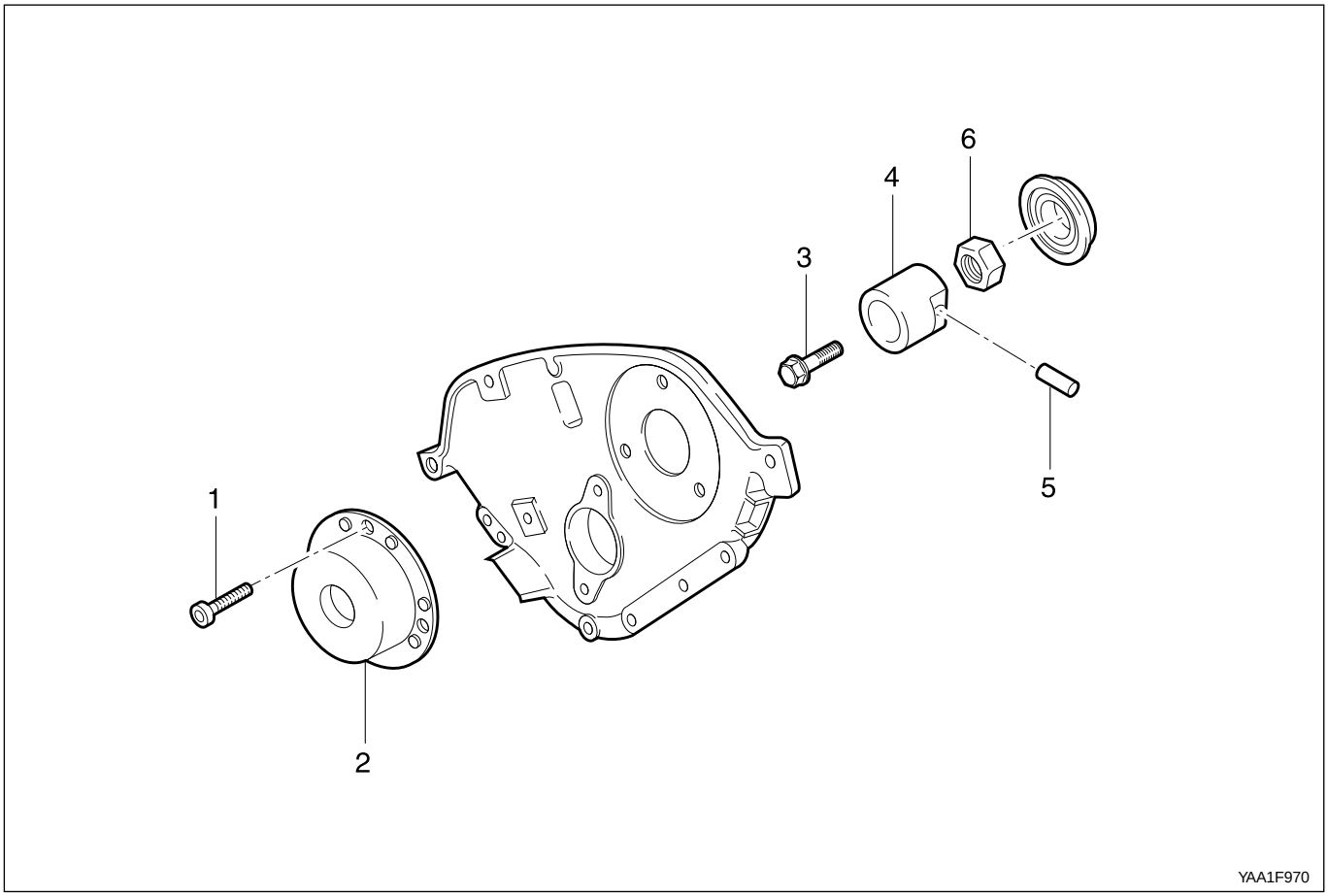
CAMSHAFT ACTUATOR



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.

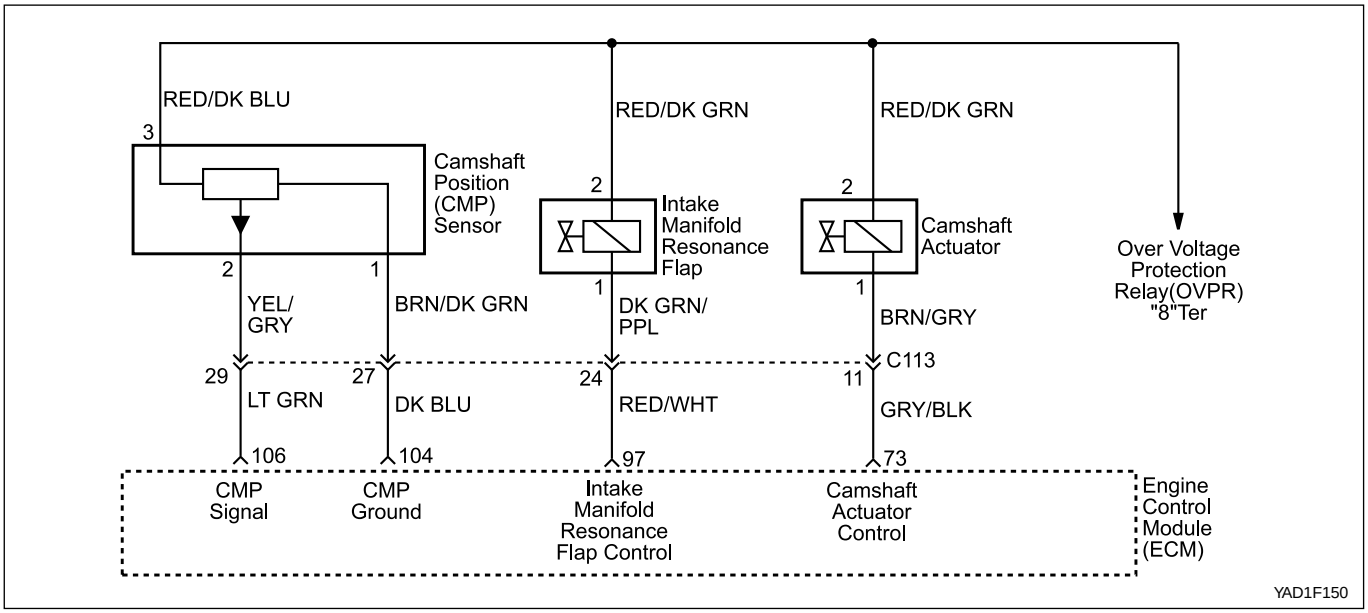
The camshaft actuator is actuated electro-mechanically by the Engine Control Module (ECM).

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



Failure Code	Description	Trouble Area	Maintenance Hint
226	Camshaft actuator short circuit to battery	When malfunction of cam phasing control	• Monitoring the actual operational status through scan tool • Inspection the ECM pin 73 about short circuit or open • Inspection the power source short circuit or open to cam actuator • Inspection the magnet and hardware • Inspection the ECM
227	Camshaft actuator short circuit to ground or open		

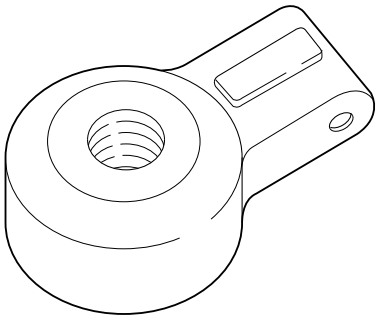
Camshaft Actuator Current Consumption Inspection

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 between the No. 1 and No. 2 pin of the camshaft actuator connector.

Specified Value	1 ~1.5 A

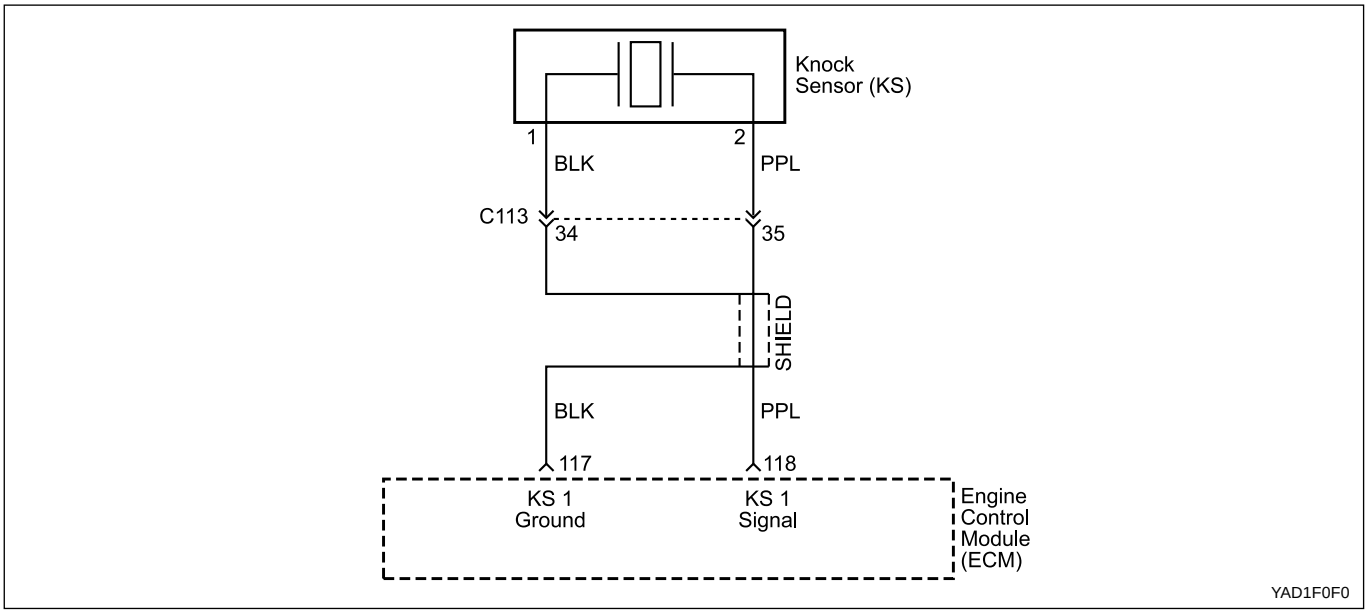
Notice: If the measured value is not within the specified value, check the cable.

KNOCK SENSOR (KS)



YAD1F180

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.



Failure Code	Description	Trouble Area	Maintenance Hint
56	No. 1 knock sensor signal failure	When recognition in more than control gain threshold at normal operational condition of other system during over 75 and 3,000 rpm running area (cylinder 1, 2, 3, 4)	• Inspection the ECM pin 118, 117 about short circuit or open with bad contact • Inspection the KS 1 malfunction • Inspection the ECM

Circuit Description

The KS system is used to detect engine detonation, allowing the ECM to retard the ignition control spark timing based on the KS signal being received. The KS signal's amplitude and frequency depend upon the amount of knock being experienced. The ECM monitors the KS signal and can diagnose the KS sensor and circuitry.

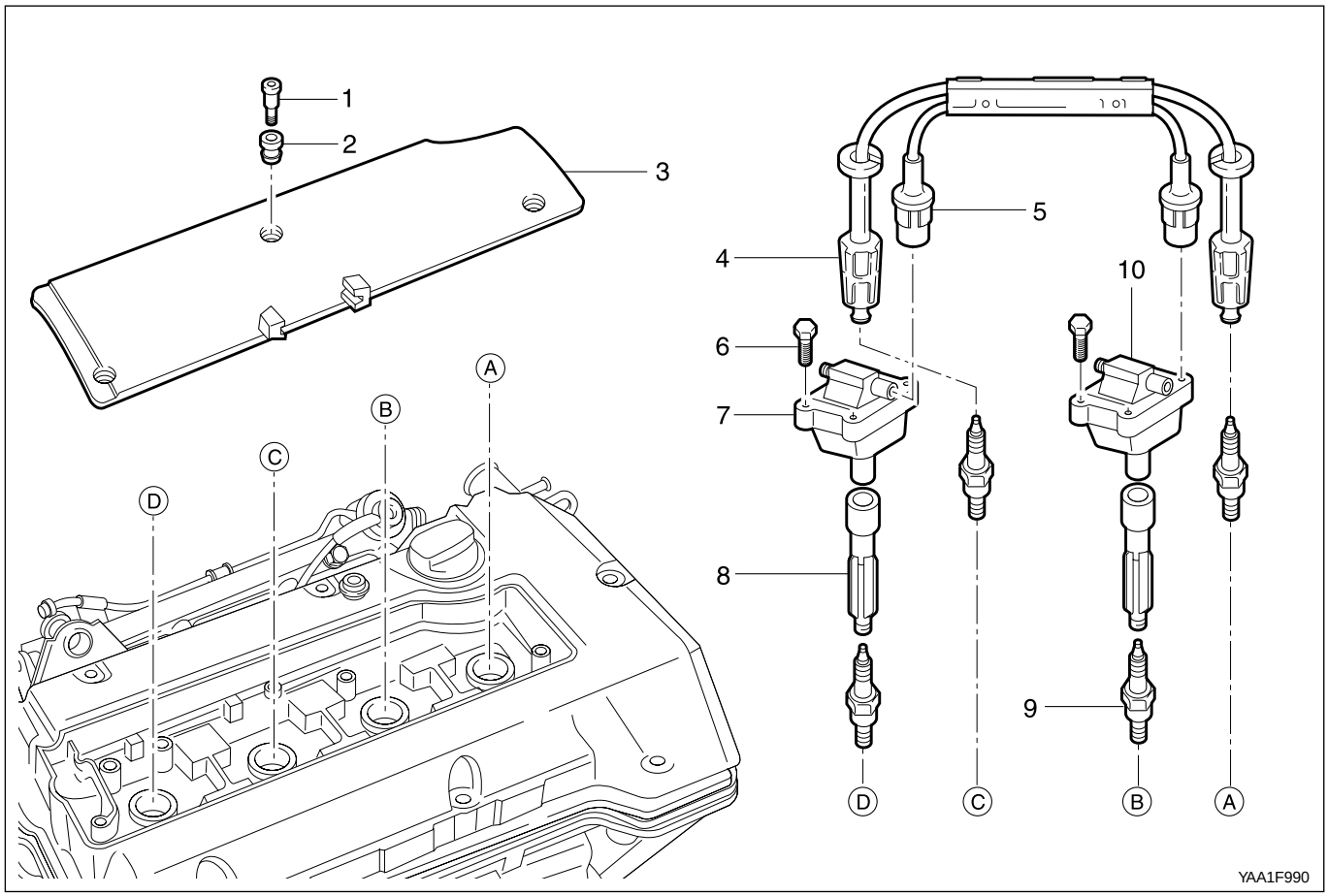
Knock Sensor Resistance Inspection

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.

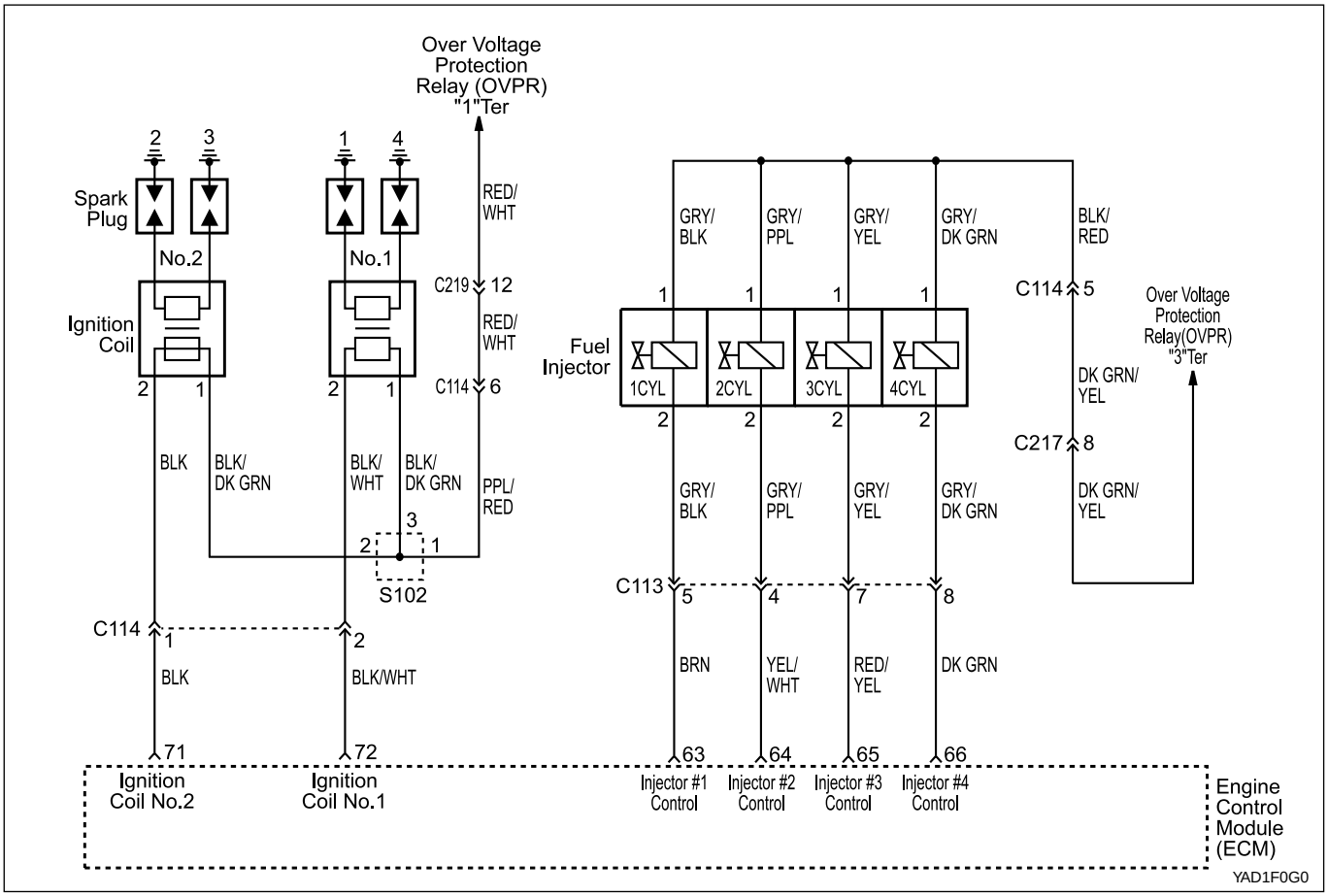
Specified Value	>10 MΩ

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.

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)



Failure Code	Description	Trouble Area	Maintenance Hint
68	Random / Multiple Misfire	When detection misfire of multiple cylinder for source of over the emission threshold or catalyst damage	• Inspection the ignition system • Inspection the injection system • Inspection the fuel pressure • Inspection the compression pressure • Inspection the valve timing or clearance • Inspection the air flow sensor • Inspection the crankshaft position sensor and air gap • Inspection the engine wiring system • Inspection the Engine Control Module (ECM)

Circuit Description

The ECM monitors the crankshaft and camshaft positions to detect if the engine is misfiring. The ECM looks for a quick drop in crankshaft speed. Misfire multiple cylinder is monitored by engine roughness measuring. The actual roughness value is compared with the actual (emission and catalyst damage) threshold.

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.

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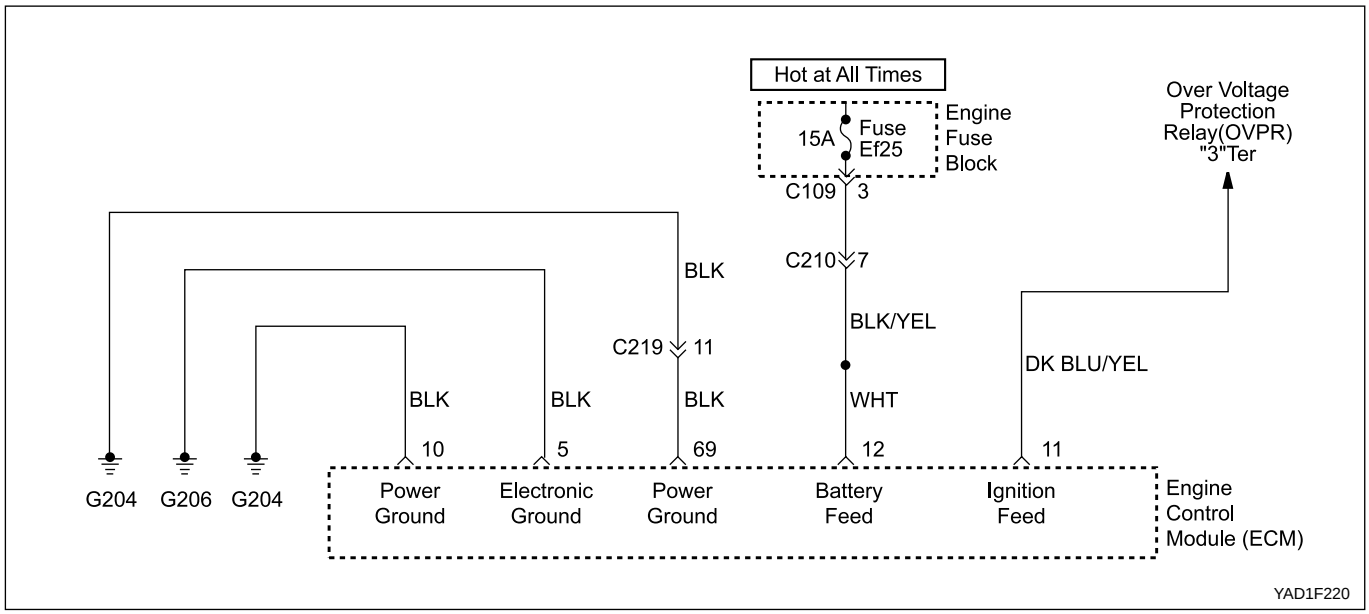
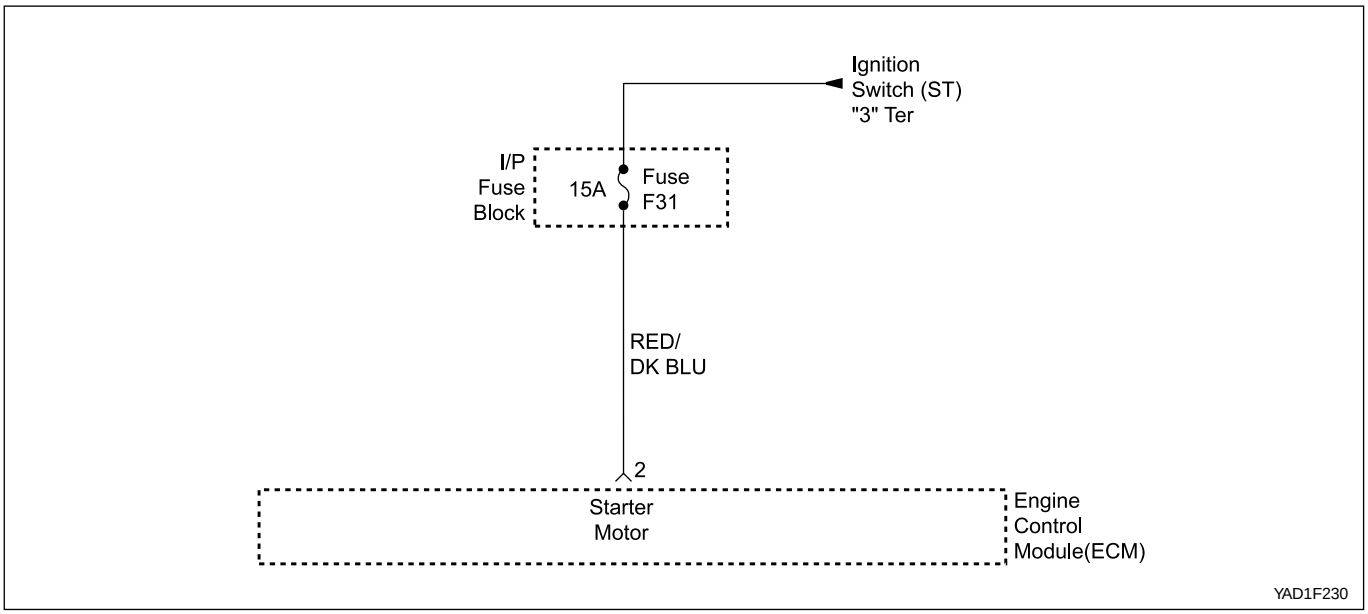
SYSTEM VOLTAGE



Failure Code	Description	Trouble Area	Maintenance Hint
08	System voltage too low	Malfunction in recognition of system source voltage. Less than minimum 8 volts in 2,000 rpm below, or less than 10 volts in 2,000 rpm above.	• Monitoring the actual battery voltages through the scan tool • Inspection the Engine Control Module (ECM) pin 12, 11, 10, 5 about short circuit or open with bad contact • Inspection the over voltage protection relay • Inspection the battery • Inspection ECM

IGNITION SWITCH



Failure Code	Description	Trouble Area	Maintenance Hint
71	Starter signal recognition failure	When not detection of starter signal	• Inspection the Engine Control Module (ECM) pin 2 circuit short or open with bad contact • Inspection ECM

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 Mass Air Flow (MAF) sensor and the oxygen (O2) sensors.

The MAF sensor monitors the mass flow of the air 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. Engine Control Module (ECM) modulates the flow of heating current to maintain the temperature differential between the heated film and the intake air at a constant level. The amount of heating current required to maintain the temperature thus provides an index for the mass air flow. This concept automatically compensates for variations in air density, as this is one of the factors that determines the amount of warmth that the surrounding air absorbs from the heated element. MAF sensor is located between the air filter and the throttle valve.

Under high fuel demands, the MAF sensor reads a high mass flow condition, such as wide open throttle. The ECM uses this information to enrich the mixture, thus increasing the fuel injector on-time, to provide the correct amount of fuel. When decelerating, the mass flow decreases. This mass flow change is sensed by the MAF sensor and read by the ECM, which then decreases the fuel injector on-time due to the low fuel demand conditions.

The O2 sensors are located in the exhaust pipe before catalytic converter. The O2 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 HO2S and calculates the air/fuel ratio based on inputs from the ECT sensor and the MAF sensor. The ECM stays in “open loop” until the following conditions are met:

- The O2 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 O2 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.

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.

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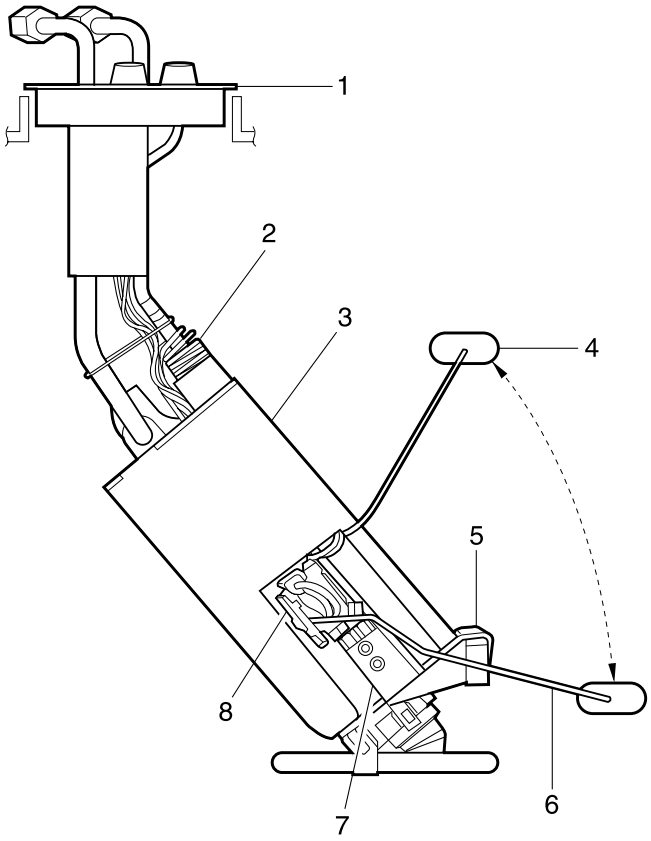
FUEL PUMP

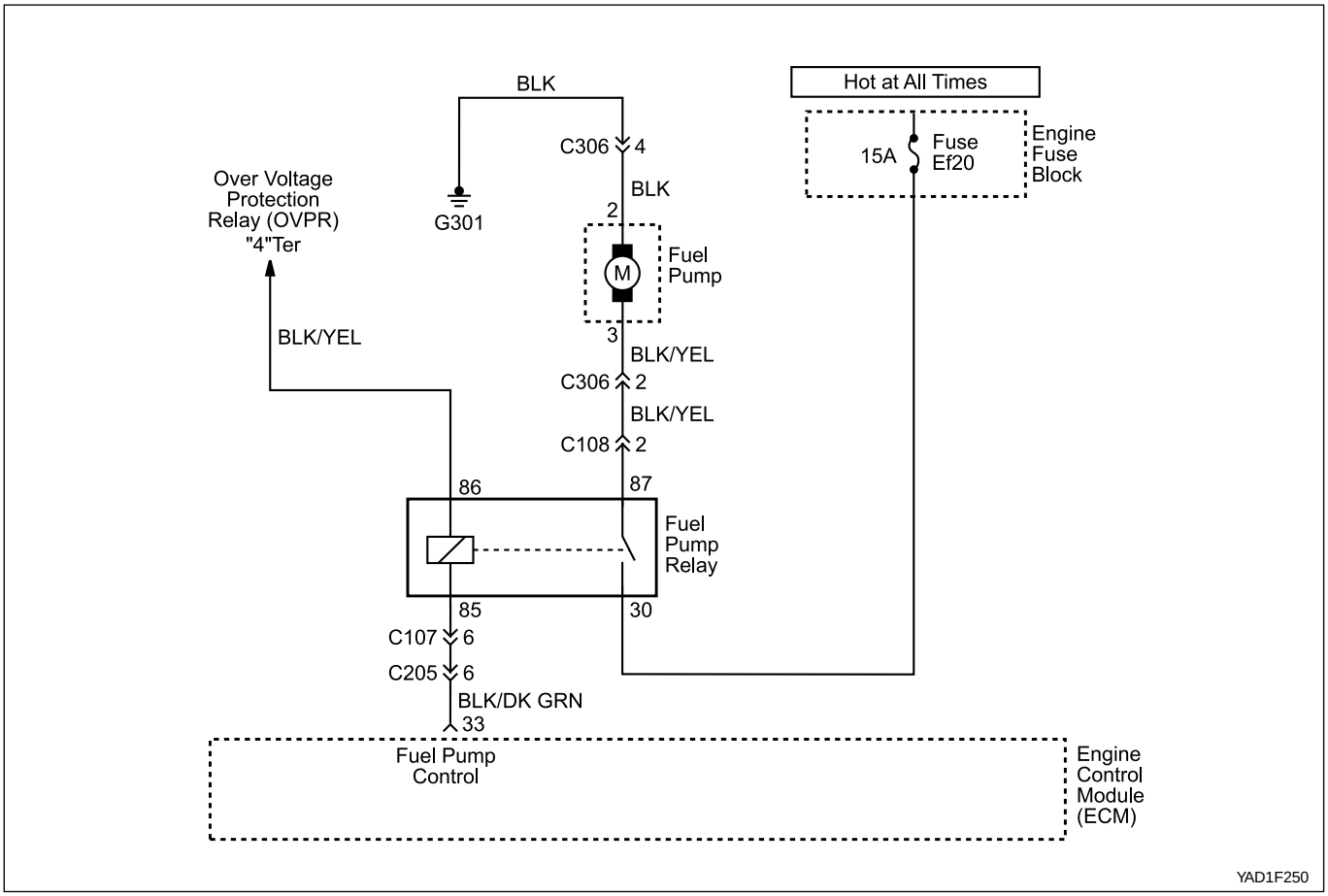


YAD1F240

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	8.5 bar (12 V)	Operating Voltage	8 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)



Failure Code	Description	Trouble Area	Maintenance Hint
34	Fuel pump relay short circuit to battery	When short circuit to power source	• Inspection the Engine Control Module (ECM) pin 33 about short circuit or open with bad contact • Inspection the fuel pump relay • Inspection the ECM
35	Fuel pump relay short circuit to ground or open	When short circuit to ground or open	

Circuit Description

When the ignition switch is turned ON, the ECM will activate the pump relay and run the in-tank fuel pump. The fuel pump will operate as long as the engine is cranking or running and the ECM is receiving ignition reference pulses.

If there are no reference pulses, the ECM will shut off the fuel pump within 2 seconds after the ignitions witch is turned ON, engine stopped or engine stalled.

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.

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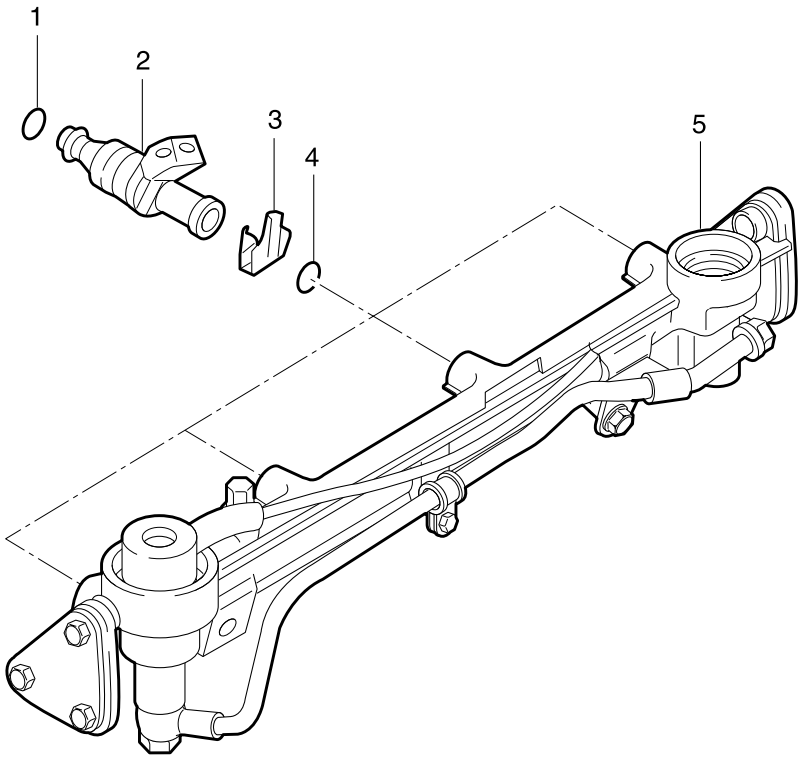
FUEL INJECTOR



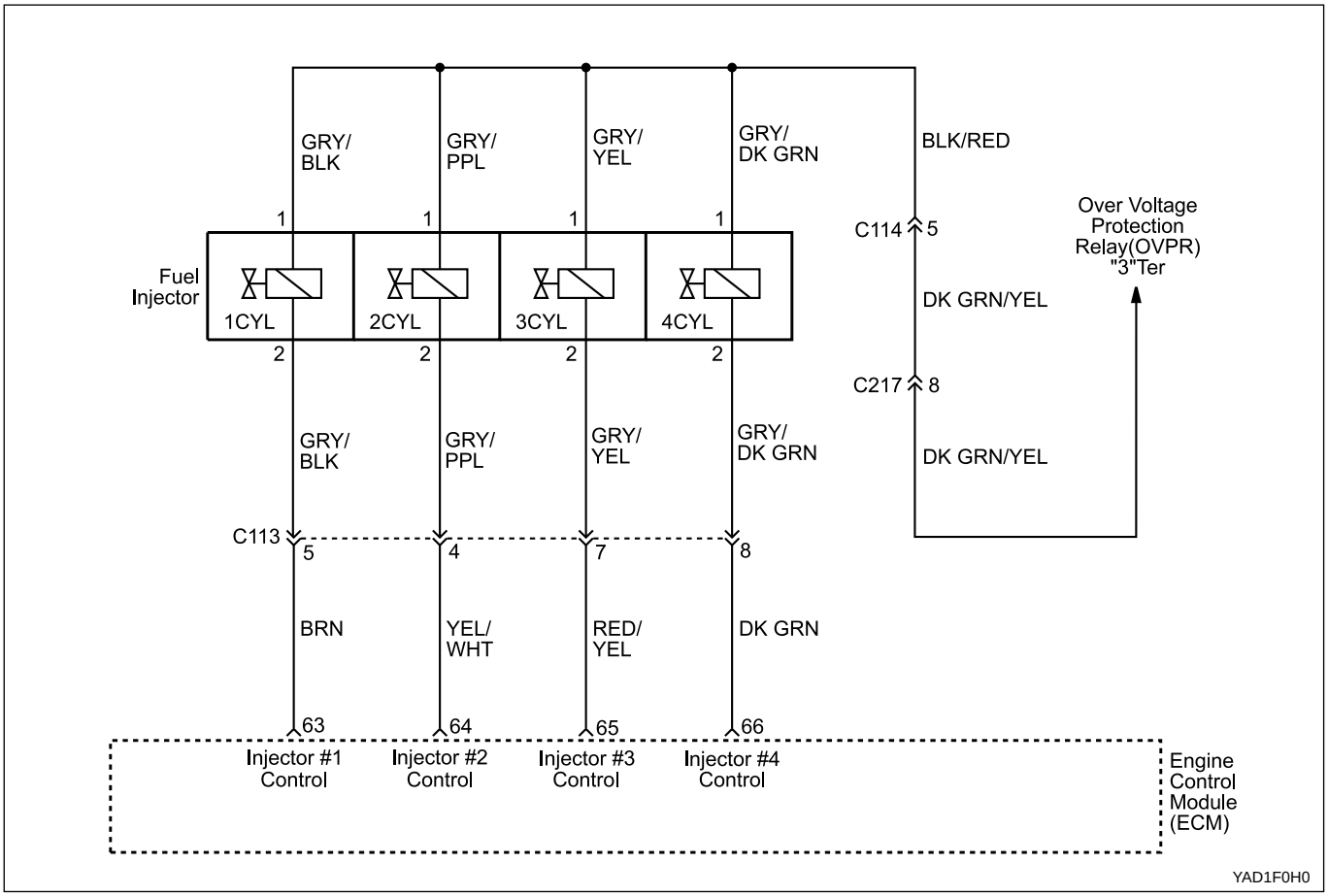
YAA1F0C0

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.

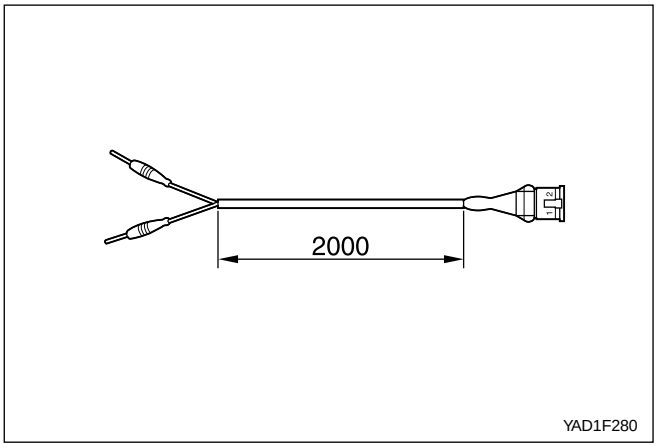
Fuel enters the top feed injector from above and flows through its vertical axis. The lower end extends into the intake valve. Fuel from the tip is directed at the intake valve, causing it to become further atomized and vaporized before entering the combustion chamber.

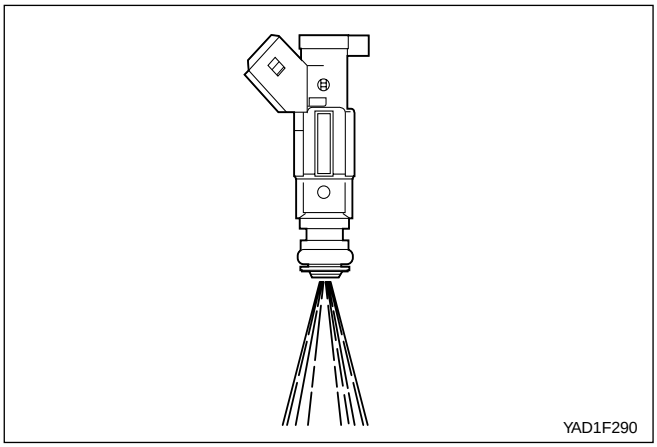
A fuel injector which is stuck partially open would cause a loss of fuel pressure after the engine is shut down. Also, an extended crank time would be noticed on some engines. Dieseling could also occur because some fuel could be delivered to the engine after the ignition is turned off.



Failure Code	Description	Trouble Area	Maintenance Hint
72	No. 1 injector short circuit to battery	When malfunction of injector circuit Injector #1 short circuit to power	• Inspection the power to injector #1 or bad contact • Inspection the injector • Inspection the ECM
73	No. 1 injector short circuit to ground or open	When malfunction of injector circuit Injector #1 short circuit to ground or open	• Inspection the ECM pin 63 about short circuit or open with bad contact • Inspection the injector • Inspection the ECM
74	No. 2 injector short circuit to battery	When malfunction of injector circuit Injector #2 short circuit to power	• Inspection the power to injector #2 or bad contact • Inspection the injector • Inspection the ECM
75	No. 2 injector short circuit to ground or open	When malfunction of injector circuit Injector #2 short circuit to ground or open	• Inspection the ECM pin 64 about short circuit or open with bad contact • Inspection the injector • Inspection the ECM
76	No. 3 injector short circuit to battery	When malfunction of injector circuit Injector #3 short circuit to power	• Inspection the power to injector #3 or bad contact • Inspection the injector • Inspection the ECM

Failure Code	Description	Trouble Area	Maintenance Hint
77	No. 3 injector short circuit to ground or open	When malfunction of injector circuit Injector #3 short circuit to ground or open	• Inspection the ECM pin 65 about short circuit or open with bad contact • Inspection the injector • Inspection the ECM
78	No. 4 injector short circuit to battery	When malfunction of injector circuit Injector #4 short circuit to power	• Inspection the power to injector #4 or bad contact • Inspection the injector • Inspection the ECM
79	No. 4 injector short circuit to ground or open	When malfunction of injector circuit Injector #4 short circuit to ground or open	• Inspection the ECM pin 66 about short circuit or open with bad contact • Inspection the injector • Inspection the ECM





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

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

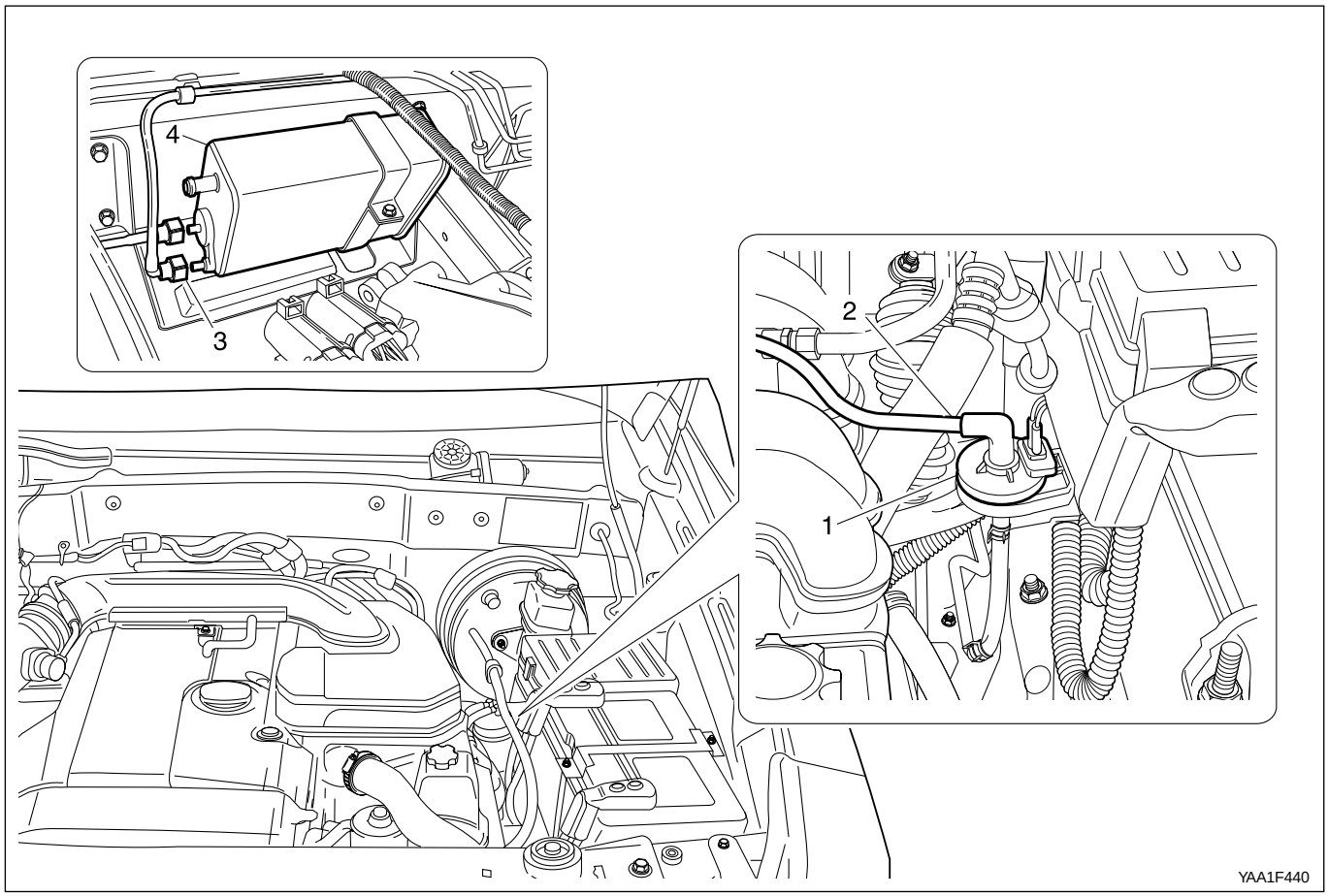
Notice: Replace the fuel injector if the measured value is out of the specified values . Check the connector and wire connection between the ECM and the injector if the measured values are normal.

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



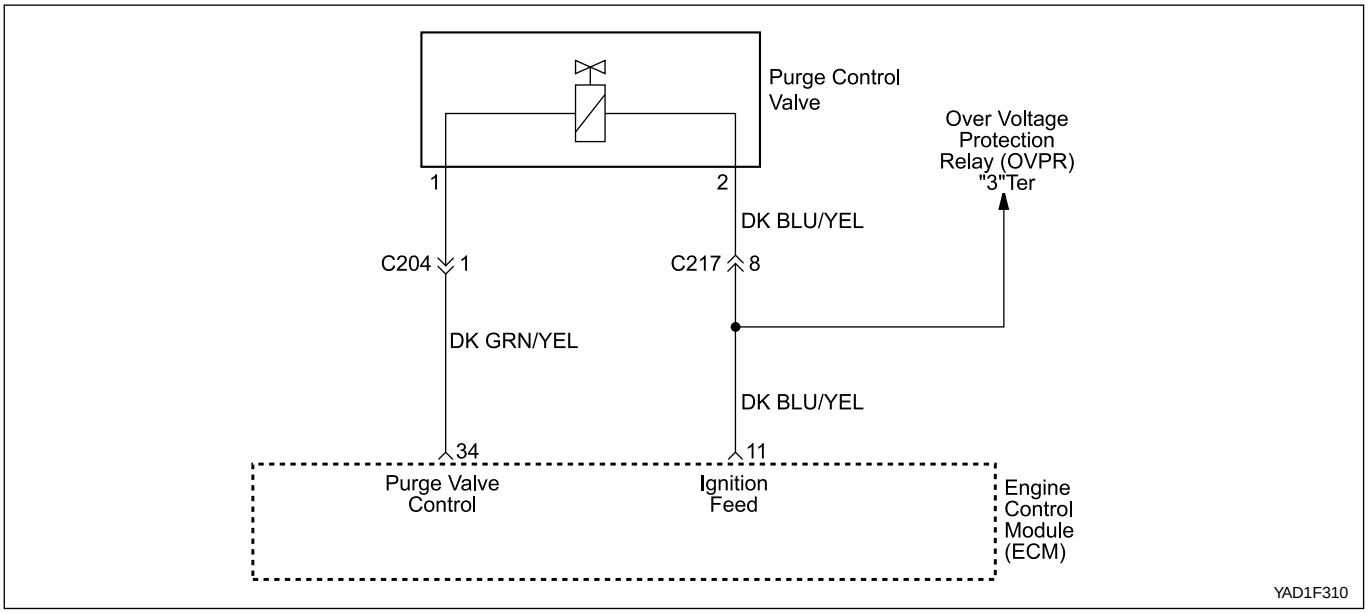
1 Purge Control Valve
2 Line to Engine
3 Line to Canister
4 Canister

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.

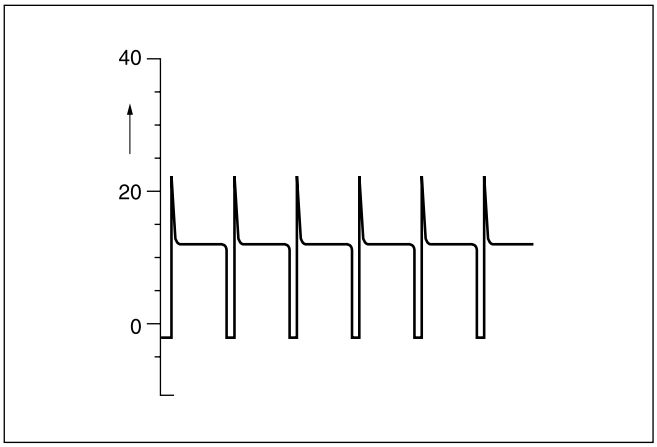
The purge control valve is activated by the ECM frequency according with the engine rotating speed to adjust the purification rate. The purification rate is determined by the continuous valve opening interval.

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



Failure Code	Description	Trouble Area	Maintenance Hint
40	Purge control valve short circuit to battery	When short circuit to power source	• Inspection the ECM pin 34 about short circuit or open with bad contact • Inspection the source power of valve • Inspection the purge control solenoid vale • Inspection the ECM
41	Purge control valve short circuit to ground or open	When short circuit to ground or open	
54	Purge control circuit malfunction	When malfunction of purge control : not work	



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.

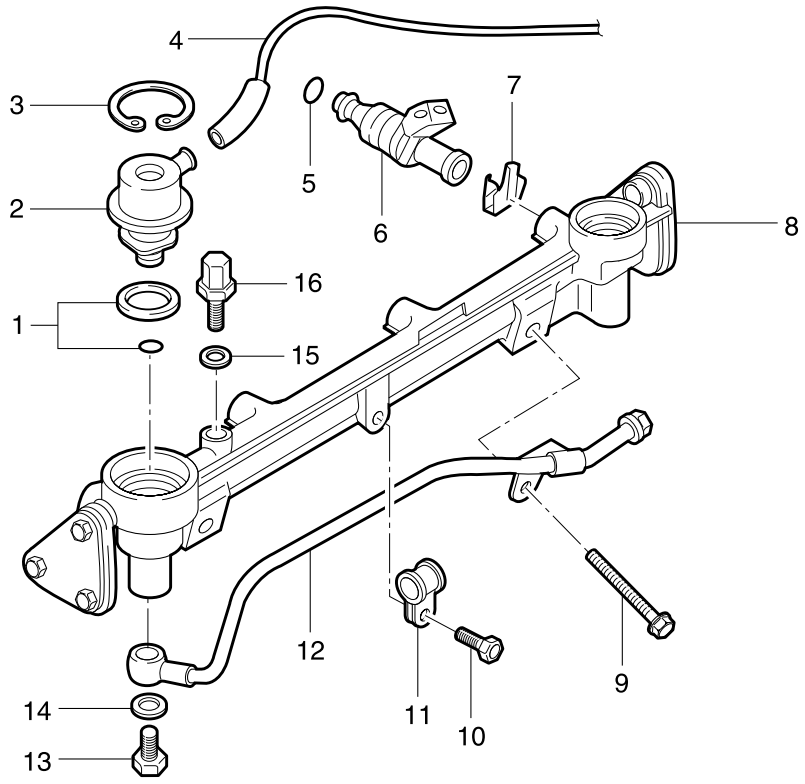
Specified Value	0.3 ~ 0.5 A

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

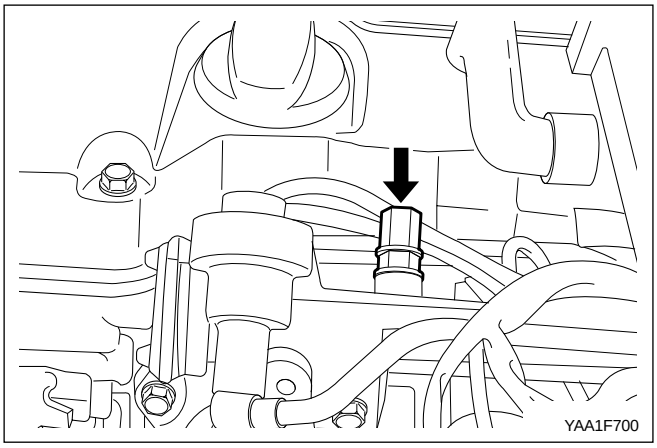
Notice: Test while at normal temperature and at idling state by operating the engine.

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



Fuel Pressure Test

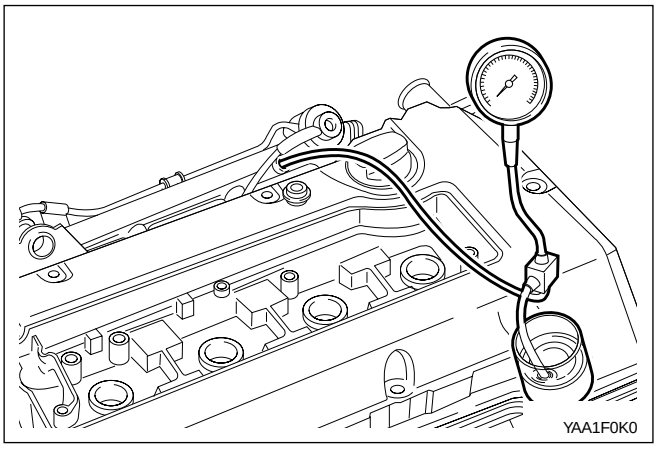
Tools Required

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

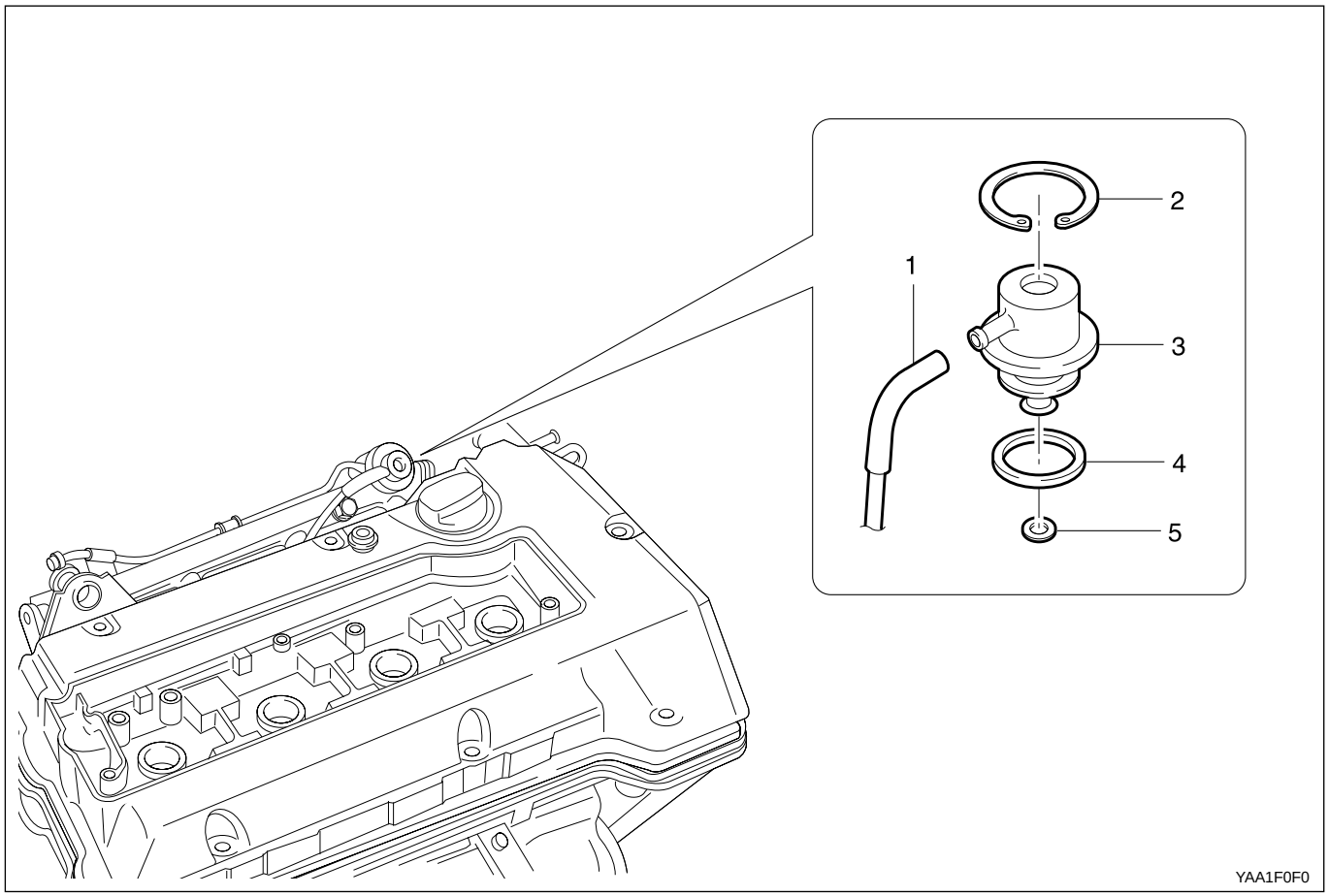
1. Connect the fuel pressure gauge103 589 002100 to the fuel pressure test connector.
2. Stop the engine for approximately 30 minutes and then check the fuel pressure changes.

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

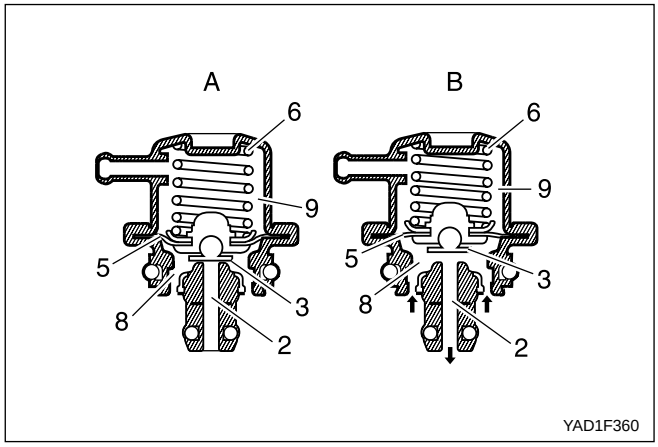
3. If there is no change in fuel pressure and maintain the following pressure over 30minutes, it is normal.

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

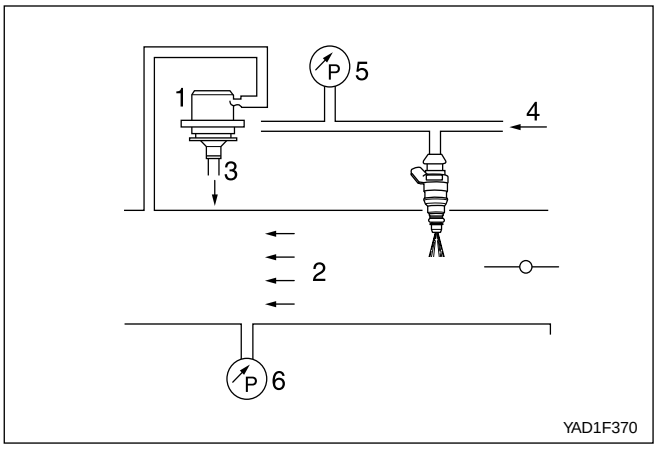
The fuel pressure regulator maintains the fuel pressure in the fuel line with the pressure of 3.2 bars to 3.8 bars according to the intake manifold pressure. This operating pressure cannot be changed, and the fuel injection volume will be only determined by the injection time. Over supplied fuel returns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

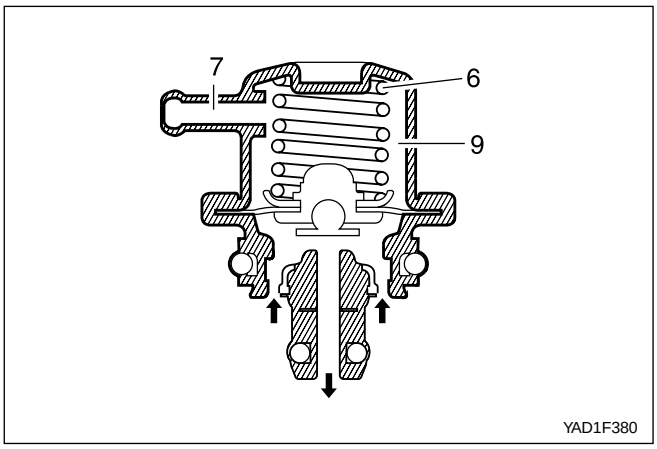
The pressure difference between the fuel pressure and the intake manifold is about 3.8 bars during the full load.



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)

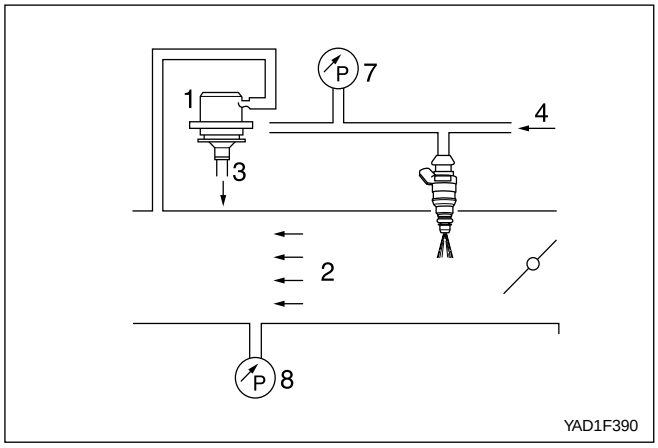
<Operating at Idle and partial load>

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.



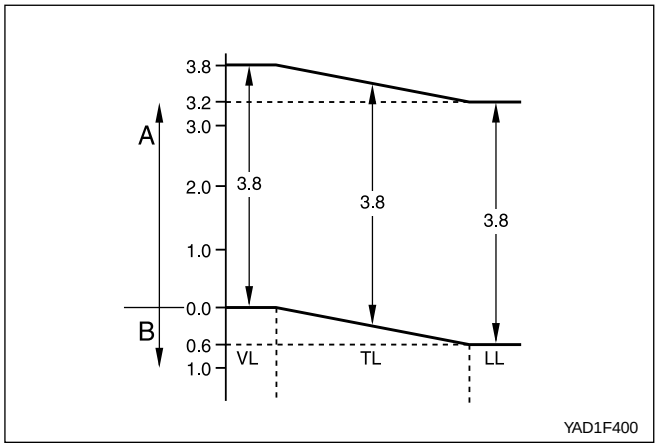
Consequently, the fuel pressure in the fuel distributor changes by the intake manifold's negative pressure, and the injector's fuel pressure gets reduced independently to the throttle valve's position. Thus, the fuel injection volume can only be determined according to the injector's injecting duration.

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



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)

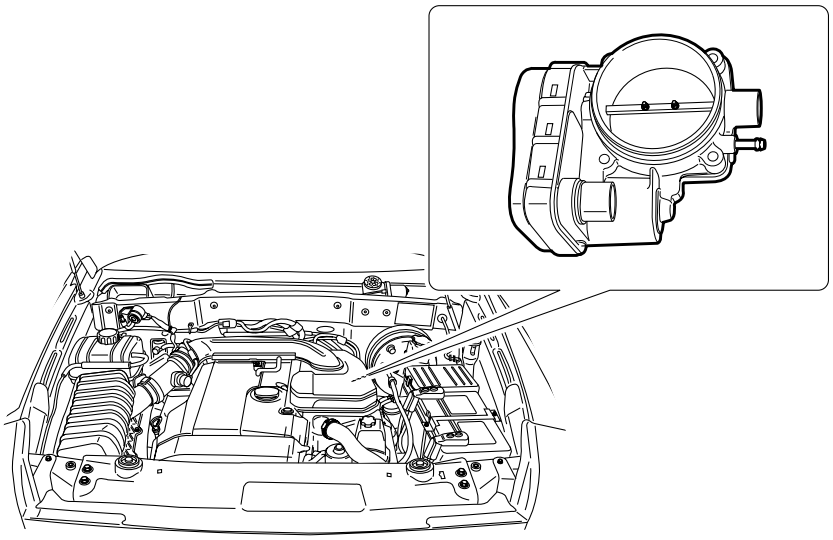
<Fuel Pressure Diagram>



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

INDUCTION SYSTEM

THROTTLE VALVE ACTUATOR



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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.

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.

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

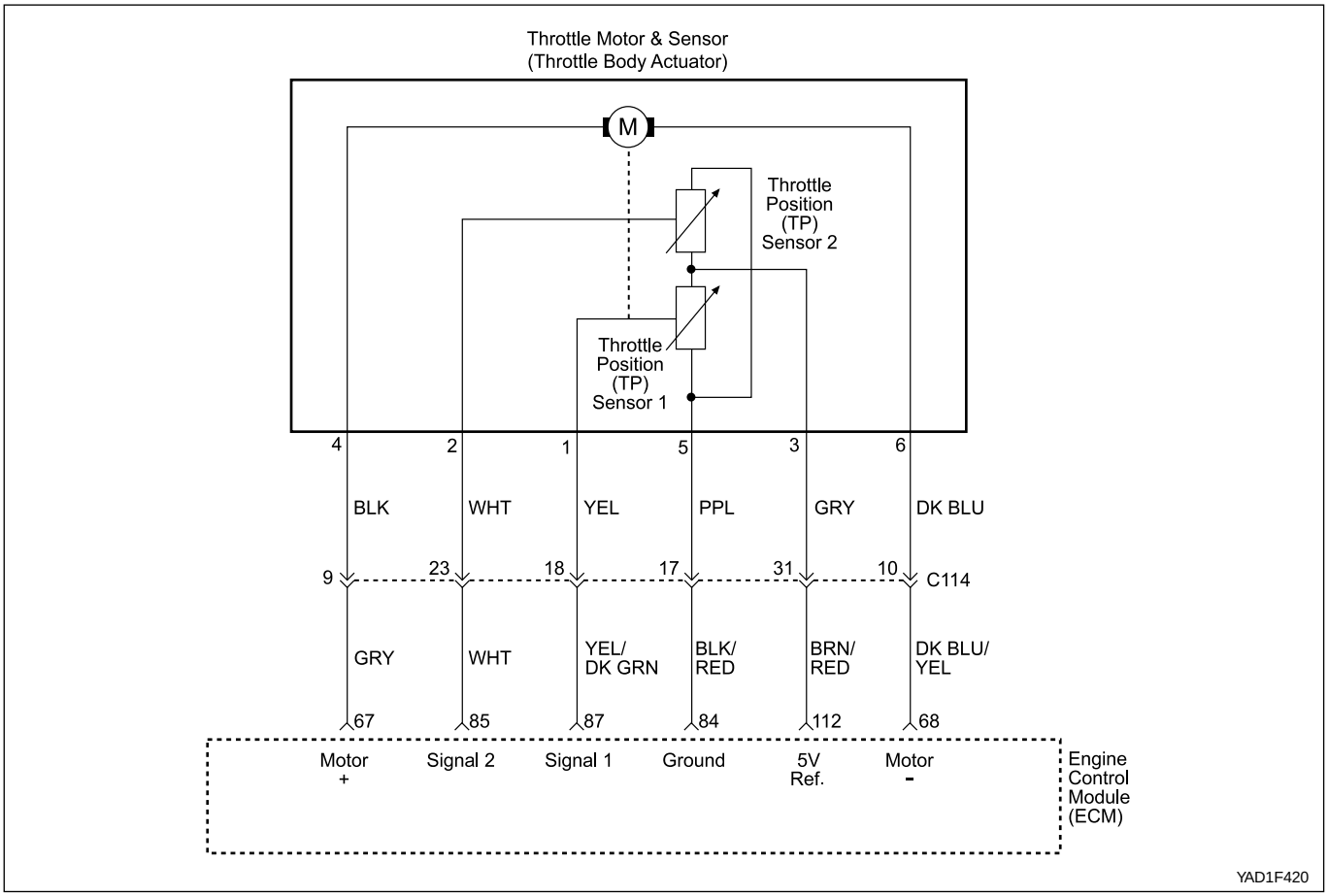
At no load, this produces an engine speed of about 1,800 rpm

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



Failure Code	Description	Trouble Area	Maintenance Hint
104	Throttle position sensor 1 low voltage	TPS 1 short circuit to ground or open	• Monitoring the actual values through scan tool • Inspection the ECM pin 84, 85, 87, 112, 67, 68 about short circuit or open with bad contact • Inspection the throttle valve actuator • Inspection the ECM
105	Throttle position sensor 1 high voltage	TPS 1 short circuit to power	
108	Throttle position sensor 2 low voltage	TPS 2 short circuit to ground or open	
109	Throttle position sensor 2 high voltage	TPS 2 short circuit to power	
116	Throttle actuator learning control failure	When actuat or adaption fluctuation or not meet the condition	
119	Throttle valve return spring failure	When return spring defective of actuator	
121	Throttle act uator failure	When supply voltage of the actuat or short circuit to power	
123	Different mass air flow sensor signal with throttle position sensor	When shut down of out put driver	
125	Both throttle position sensor failure	When defective of both potentiometers	

Failure Code	Description	Trouble Area	Maintenance Hint
126	Throttle position sensor 1 not plausible with Throttle position sensor 2	When difference between TPS 1 and TPS 2	• Monitoring the actual values through scan tool • Inspection the ECM pin 84, 85, 87, 112, 67, 68 about short circuit or open with bad contact • Inspection the throttle valve actuator • Inspection the ECM
127	High permanent throttle signal	When failure of wiring harness or actuator	
185	Mass air flow sensor and throttle position sensor failure	When difference between MAF and TPS signal	

Circuit Description

The ECM supplies a 5 volt reference signal and a ground to the TP sensor. The TP sensor sends a voltage signal back to the ECM relative to the throttle plate opening. The volt age signal will vary from approximately 0.3 ~ 0.9 volts at closed throttle, to over 4.0 ~ 4.6 volts at Wide Open Throttle (WOT).

The TP sensors serve for engine load control according to the drive pedal command. Load adjustments independent of the drive pedal command can be implemented; such functions are, for instance, idle control, speed control, drive slip control, load shock damping, and similar functions .

When the actuator current fails , the throttle valve is returned to emergency operating position by a spring. The throttle valve position, there by the actuator drive position check back is provided by two potentiometers. The motor positions the throttle valve against the return spring force. Motor and return spring are two separate energy sources . Each of them is able to position the throttle valve in emergency position alone. Throttle valve position check back and monitoring is provided by two actual value potentiometers connected to the engine control electronics.

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)

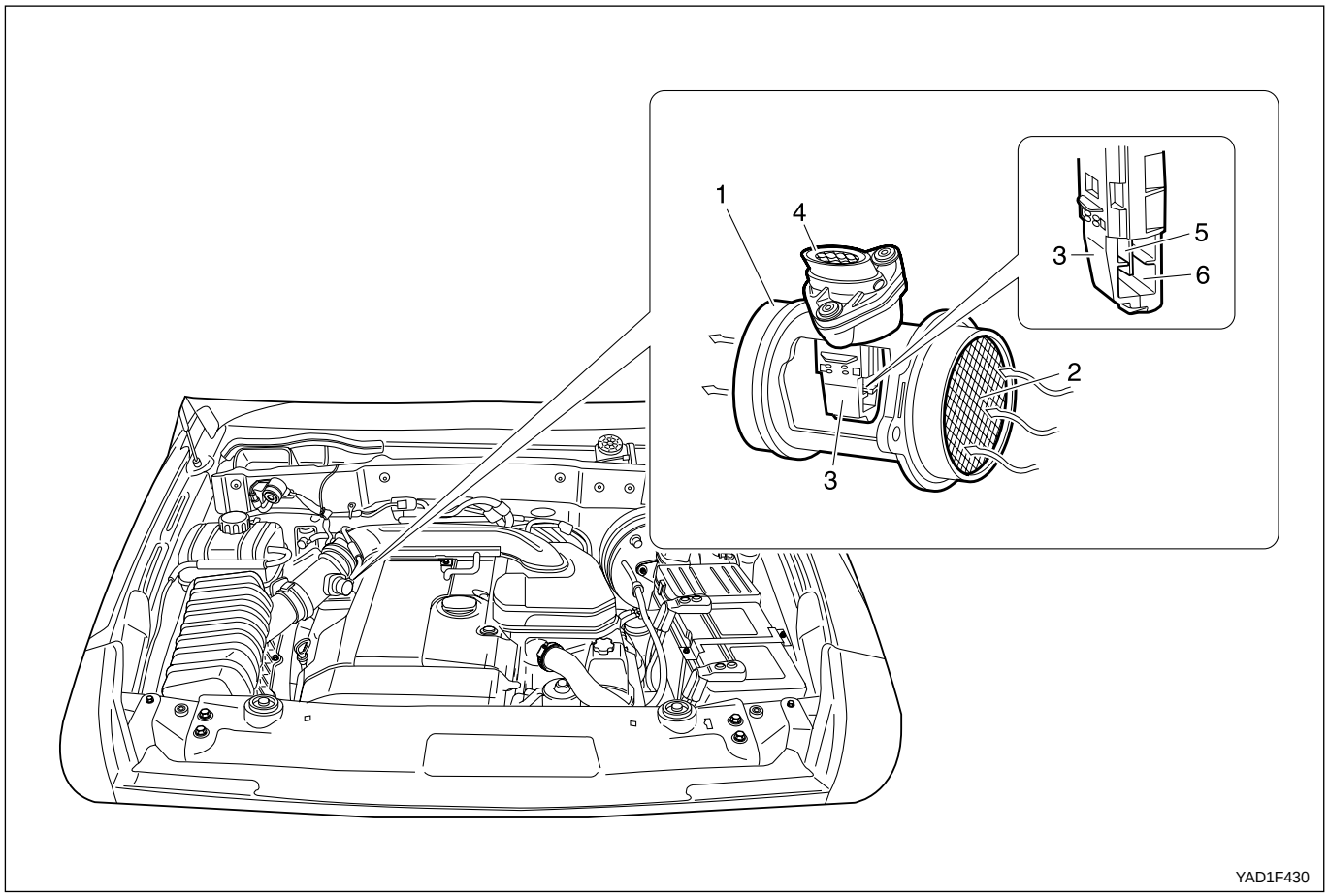
Throttle Actuator DC Motor Resistance

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

BLANK

HOT FILM AIR MASS (HFM) SENSOR



1 Housing
2 Protector Net
3 Electronic Housing
4 Connector
5 Hot Film Air Mass Sensor
6 Measuring Port

The Hot Film Air Mass (HFM) sensor with recognition of flow direction related to pulsating flow is designed for recording load on Engine Control Module (ECM) by measuring the output voltage proportional to the reference voltage of the ECM.

Mass Air Flow Sensor

Mass Air Flow (MAF) is a thermal flow meter whose sensor element with its temperature sensors and heating area is exposed to the MAF to be measured. A heating area located in the center of a thin membraneis controlled to an over temperature by a heating resistor and a temperature sensor of this membrane. And the value of over-temperature depends on the temperature of the in-flowing air.

Two temperature sensors on upstream and downstream of the heating area show the same temperature without incoming flow. With incoming flow, upstream part is cooled down but downstream temperature retains its temperature more or less due to the air heated up in the heating area. This temperature difference in quantity and direction depends on the direction of the incoming flow.

ECM modulates the flow of heating current to maintain the temperature differential between the heated film and the intake air at a constant level. The amount of heating current required to maintain the temperature thus provides an index for the MAF. This concept automatically compensates for variations in air density, as this is one of the factors that determines the amount of warmth that the surrounding air absorbs from the heated element. MAF sensor is located between the air filter and the throttle valve.

Under high fuel demands, the MAF sensor reads a high mass flow condition, such as Wide Open Throttle (WOT). The ECM uses this information to enrich the mixture, thus increasing the fuel injector on-time, to provide the correct amount of fuel. When decelerating, the mass flow decreases. This mass flow change is sensed by the MAF sensor and read by the ECM, which then decreases the fuel injector on-time due to the low fuel demand conditions.

To facilitate the installation of the HFM in the intake passage, lubricating agents may be used. However, when lubricants are used care must be taken to ensure that they do not enter the flow passage and cannot be sucked in with the air flow.

The following tables show the relationship between MAF and output voltage.

Mass Air Flow (kg/h)	Voltage (V)	Mass Air Flow (kg/h)	Voltage (V)
0	0.95 ~ 1.05	250	3.51
10	1.28	370	3.93
15	1.41	480	4.23
30	1.71	640	4.56
60	2.16	800	4.82
120	2.76		

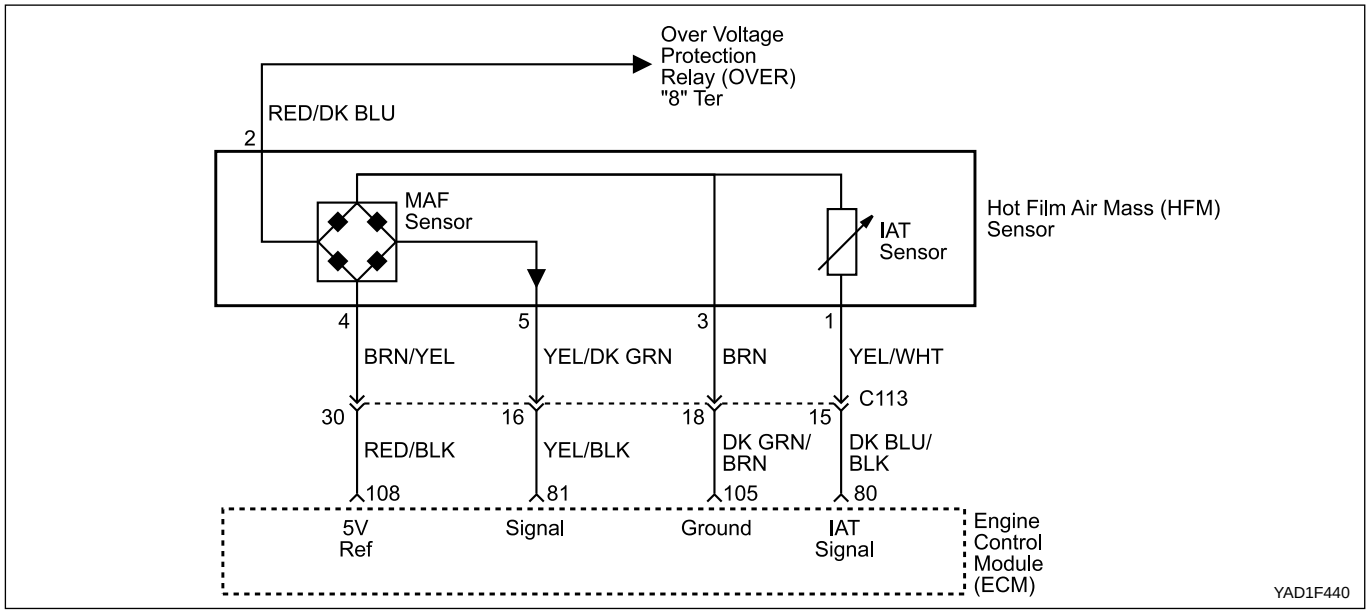
Intake Air Temperature

The Intake Air Temperature (IAT) sensor is a part of Hot Film Air Mass (HFM) sensor and 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	43760
-20	12660	13850	15120
0	5119	5499	5829
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



Failure Code	Description	Trouble Area	Maintenance Hint
03	Intake air temperature sensor low voltage	IAT sensor short circuit to ground or open	• Monitoring the actual air temperature through scan tool • Inspection the ECM pin 80, 79 about short circuit or open with bad contact • Inspection the IAT sensor (integrated in HFM sensor) • Inspection the ECM
04	Intake air temperature sensor high voltage	IAT sensor short circuit to power	
05	Intake air temperature sensor plausibility	Malfunction in recognition of IAT When functional problem	
09	Mass air flow sensor plausibility	Malfunction in recognition of MAF When air mass not plausible	• Monitoring the actual air mass flow through scan tool • Inspection the ECM pin 81, 105 about short circuit or open with bad contact • Inspection the MAF sensor (integrated in HFM sensor) • Inspection the ECM
10	Mass air flow sensor low voltage	MAF sensor short circuit to ground or open	
11	Mass air flow sensor high voltage	MAF sensor short circuit to power	

Circuit Description

The heated element on the MAF is a platinum film resistor (heater). It is located on a ceramic plate together with the other elements in the bridge circuit. The temperature sensitive resistor (flow sensor) also included in the bridge. The separation of heater and flow sensor facilitates design of the control circuitry. Saw cuts are employed to ensure thermal decoupling between the heating element and the intake air temperature (IAT) sensor. The complete control circuitry is located on a single layer. The voltage at the heater provides the index for the mass air flow. The MAF's electronic circuitry then converts the voltage to a level suitable for processing in the ECM. This device does not need a burn off process to maintain its measuring precision over an extended period. In recognition of the fact that most deposits collect on the sensor element's leading edge, the essential thermal transfer elements are located downstream on the ceramic layer. The sensor element is also design to ensure that deposits will not influence the flow pattern around the sensor.

The IAT sensor uses a thermistor to control the signal voltage to the ECM. The ECM supplies 5 volt reference and a ground to the sensor. When the air is cold, the resistance is high; therefore the IAT signal voltage will be high. If the intake air is warm, resistance is low; therefore the IAT signal voltage will be low.

Mass Air Flow Sensor Input Voltage Inspection

1. Turn the ignition switch to “ON” position.
2. Measure the signal voltage between the ECM pin No. 103 and No. 104.

Application		Specified Value
Engine Status	Ignition “ON”	0.9 ~ 1.1 V
	Idling	1.3 ~ 1.7 V (Coolant temperature is over 70°C)

Notice: If the measured value is not within the specified value, the possible cause may be in cable or MAF sensor in itself. Perform the 5 volt power supply inspection procedures.

Mass Air Flow Sensor 5 volt Power Supply Inspection

1. Turn the ignition switch to “OFF” position.
2. Disconnect the HFM sensor connector.
3. Turn the ignition switch to “ON” position.
4. Measure the voltage between the ECM pin No. 108 and MAF sensor connecter terminal No. 3.

Specified Value	4.7 ~ 5.2 V

Notice: If the measured value is not within the specified value, the possible cause may be in cableor ECM coupling.

5. Measure the voltage between the ECM pin No. 105 and MAF sensor connecter terminal No. 4.

Specified Value	4.7 ~ 5.2 V

Notice: If the measured value is not within the specified value, the possible cause may be in cableor ECM coupling.

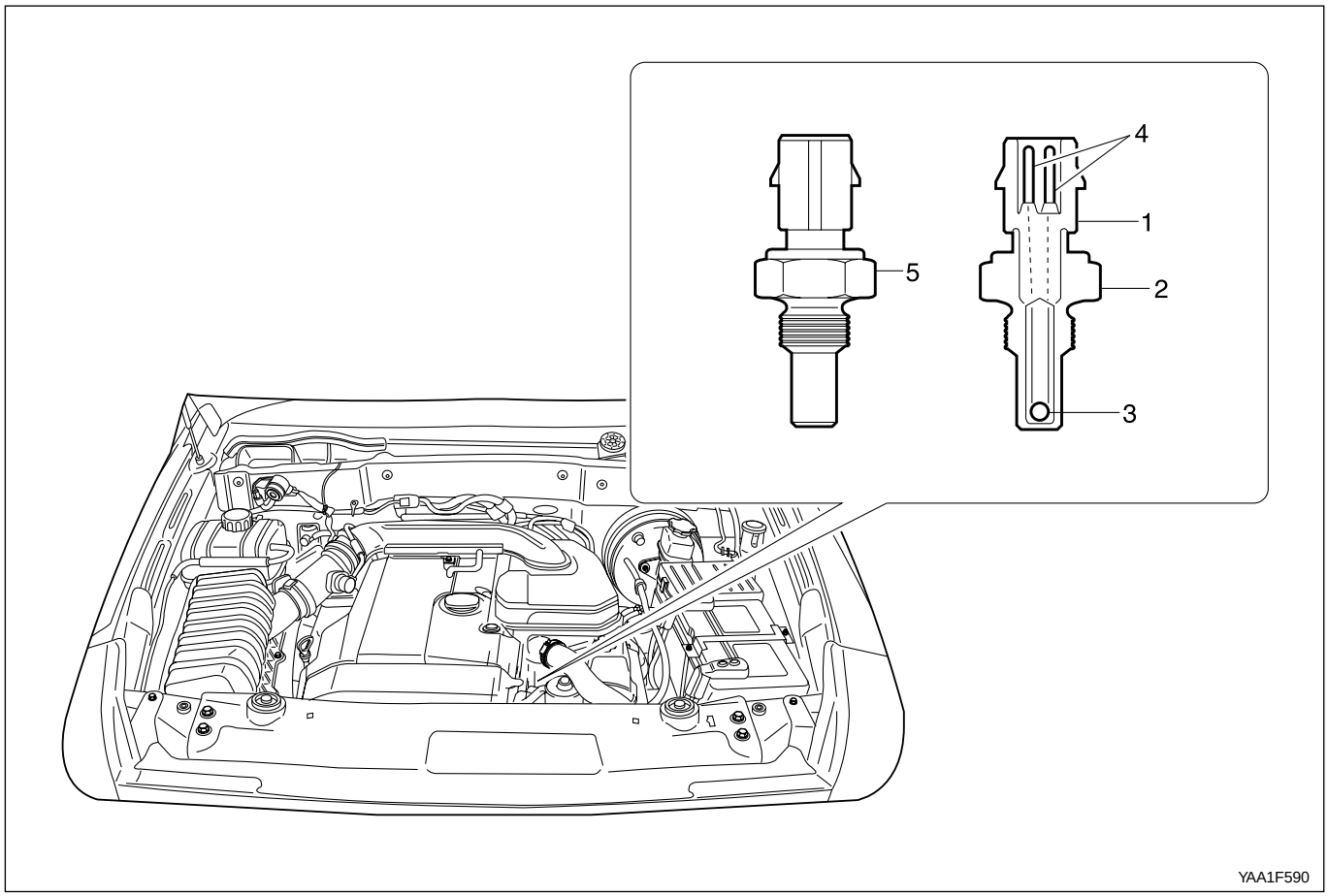
Mass Air Flow Sensor 12 volt Power Supply Inspection

1. Turn the ignition switch to “OFF” position.
2. Disconnect the HFM sensor connector.
3. Turn the ignition switch to “ON” position.
4. Measure the voltage between the ECM pin No. 105 and MAF sensor connecter terminal No. 2.

Specified Value	11 ~ 14 V

Notice: If the measured value is not within the specified value, the possible cause may be in cable or Over Voltage Protection Relay (OVPR).

ENGINE COOLANT TEMPERATURE (ECT) SENSOR



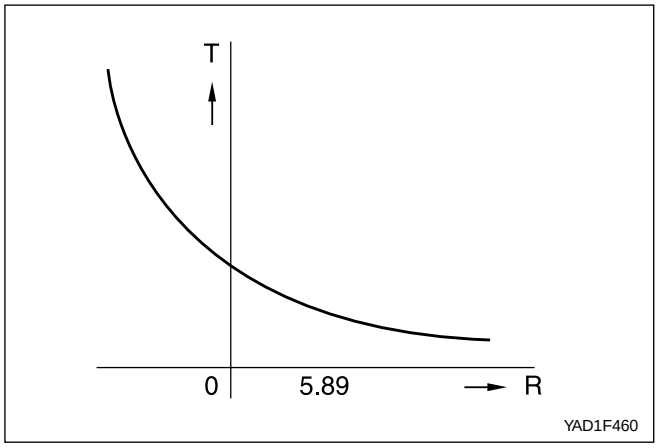
1 Artificial Resin Housing
2 Metal Housing
3 NTC (Negative Temperature Coefficient) Resistor
4 Connector
5 Engine Coolant Temperature Sensor

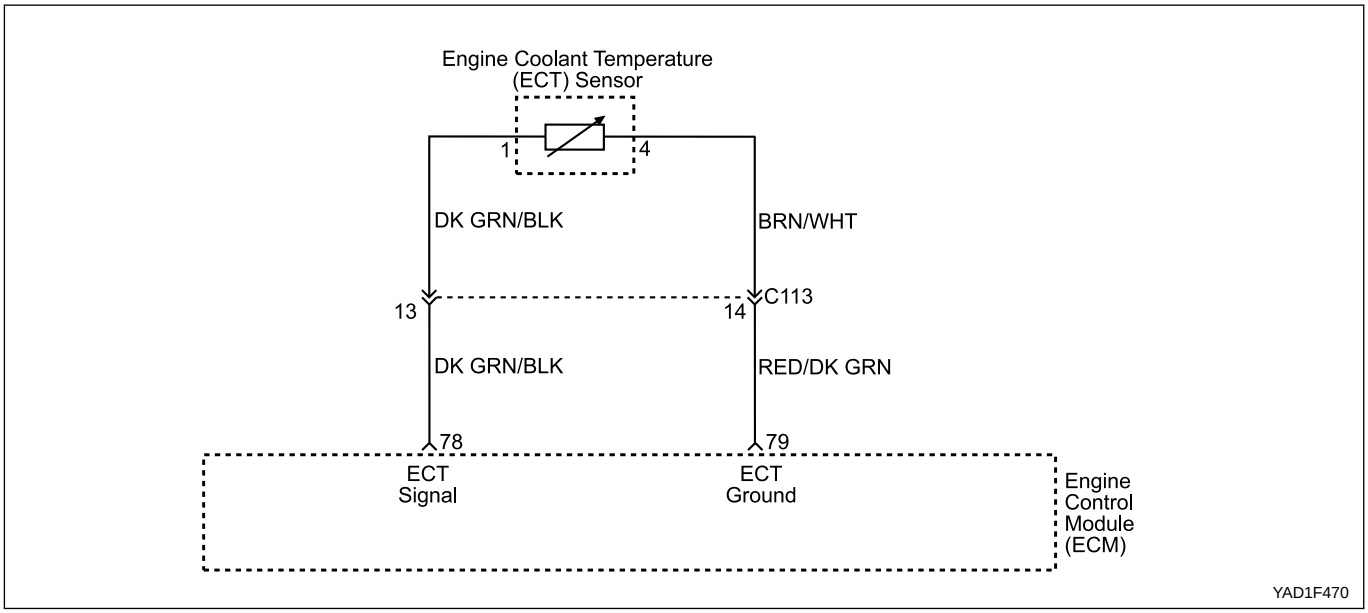
Engine Coolant Temperature (ECT) sensor detects coolant temperature and supplies information to the ECM. It is composed of metal housing with two NTC resistor, 4 pin connector. The ECM provides a 5 volt signal to the ECT sensor through a dropping resistor. When the engine is cold, the ECT sensor provides 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

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





Failure Code	Description	Trouble Area	Maintenance Hint
00	Engine coolant temperature sensor low voltage	ECT sensor short circuit to ground or open	• Monitoring the actual coolant temperature through scan t ool • Inspection the ECM pin 78, 79 about short circuit or open with bad contact • Inspection the ECT sensor • Inspection the ECM
01	Engine coolant temperature sensor high voltage	ECT sensor short circuit to power	
02	Engine coolant temperature sensor plausibility	Malfunction in recognition of ECT When drop to about 50° C below after warm up	
06	Engine coolant temperature insufficient for closed loop fuel control	Malfunction in recognition of ECT When minimum temperature for lambda control after warm up	

Circuit Description

The ECT sensor uses a thermistor to control the signal voltage to the ECM. The ECM supplies a voltage on the signal circuit to the sensor. When the engine coolant is cold, the resistance is high; therefore the ECT signal voltage will be high

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.

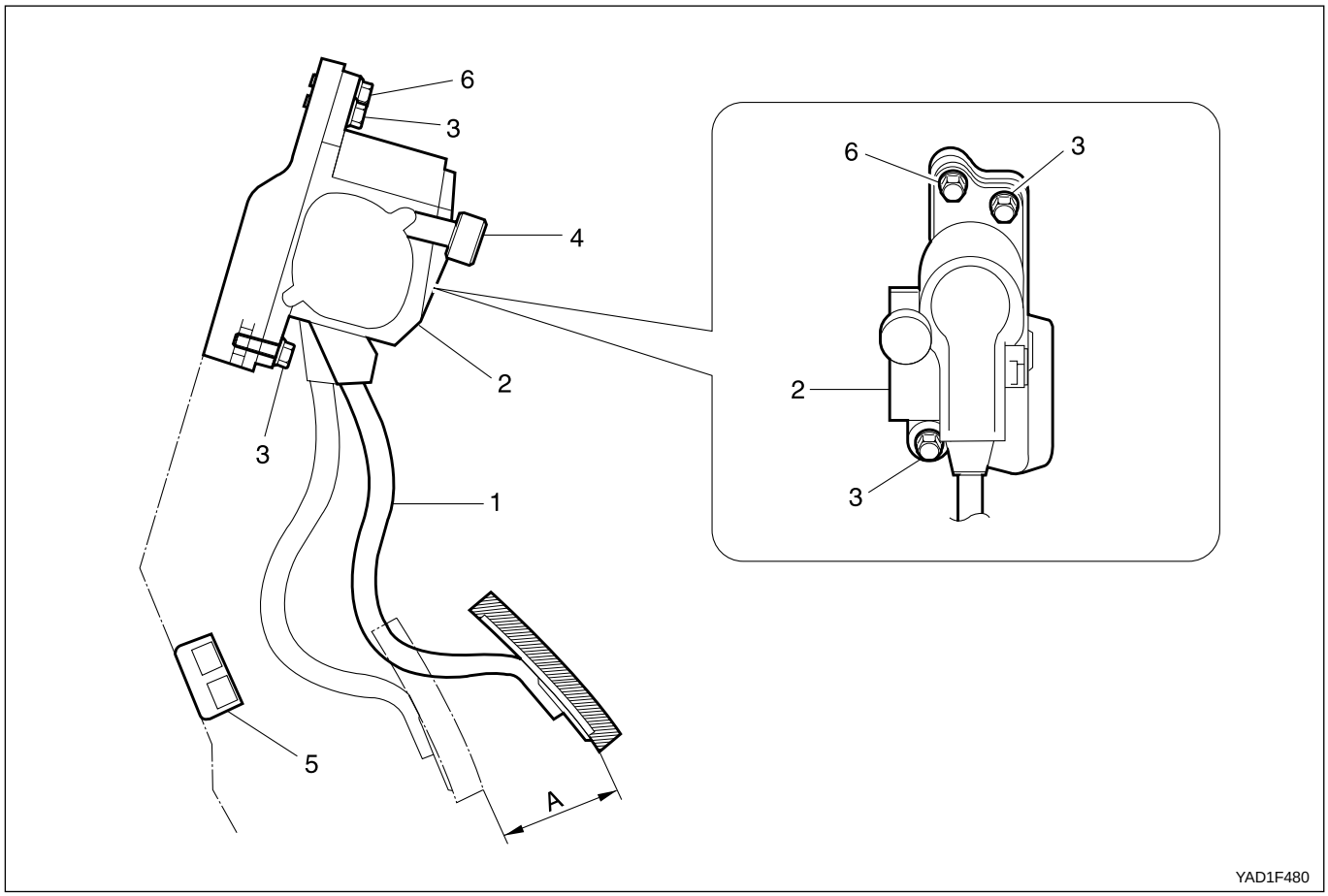
Temperature (°C)	Specified Value (V)
20	3.57
80	1.22
100	0.78

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

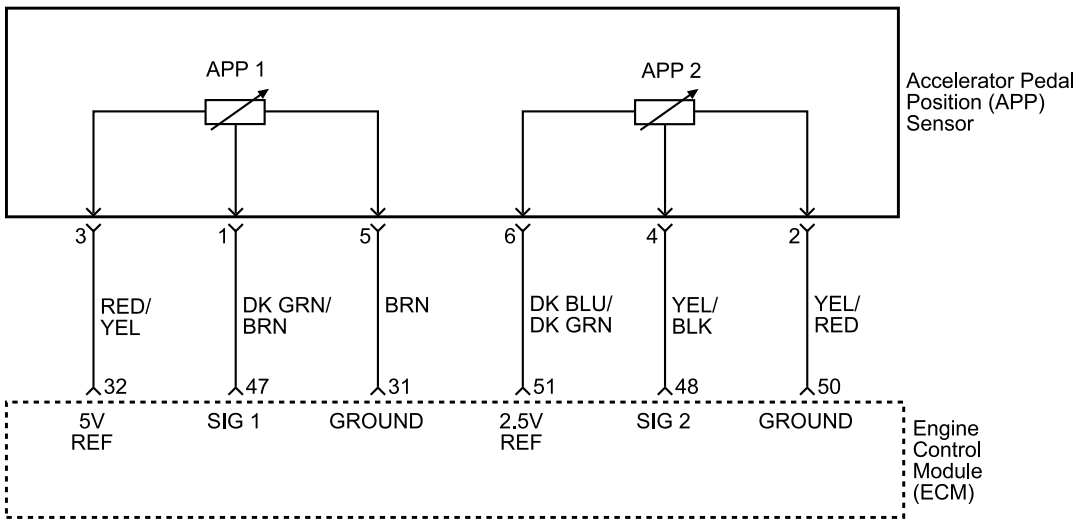
The Acceleration Pedal Position (APP) sensor is mounted on the accelerator pedal assembly. The sensor is actually two individual APP sensors and one housing. This sensor works with theThrottle Position (TP) sensor to provide input to the Engine Control Module (ECM) regarding driver requested accelerator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



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Failure Code	Description	Trouble Area	Maintenance Hint
122	Acceleration pedal position sensor signal failure	When malfunction of APP sensor	• Monitoring the actual values through scan tool • Inspection the ECM pin 31, 47, 32, 48, 59, 51 about short circuit or open with bad contact • Inspection the APP sensor • Inspection the ECM
160	Acceleration pedal position 1 sensor low voltage	APP 1 sensor short circuit to ground or open	
161	Acceleration pedal position sensor 1 high voltage	APP 1 sensor short circuit to power	
162	Acceleration pedal position sensor 2 low voltage	APP 2 sensor short circuit to ground or open	
163	Acceleration pedal position sensor 2 high voltage	APP 2 sensor short circuit to power	
164	Accelerator pedal position sensor 1 not plausible with accelerator pedal position sensor 2	When difference between APP 1 sensor and APP 2 sensor	
167	Both setpoint accelerator pedal position sensor defective	When defective of both APP sensor	

Circuit Description

The ECM supplies a 5 or 2.5 volt reference signal and a ground to the APP sensor 1 or 2. The ECM calculates on these signal lines. The APP sensor output changes as the accelerator pedal is moved. The output of the APP 1 and APP 2 sensor are low, about 0.4 ~ 0.7 volts and 0.2 ~ 0.35 volts respectively at the closed throttle position. As pushing the accelerator pedal, the output increases so that the output voltages will be about 4.3 ~ 4.8 volts and 2.1 ~ 2.4 volts individually when accelerating fully with the kick down, at Wide Open Throttle (WOT).

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.

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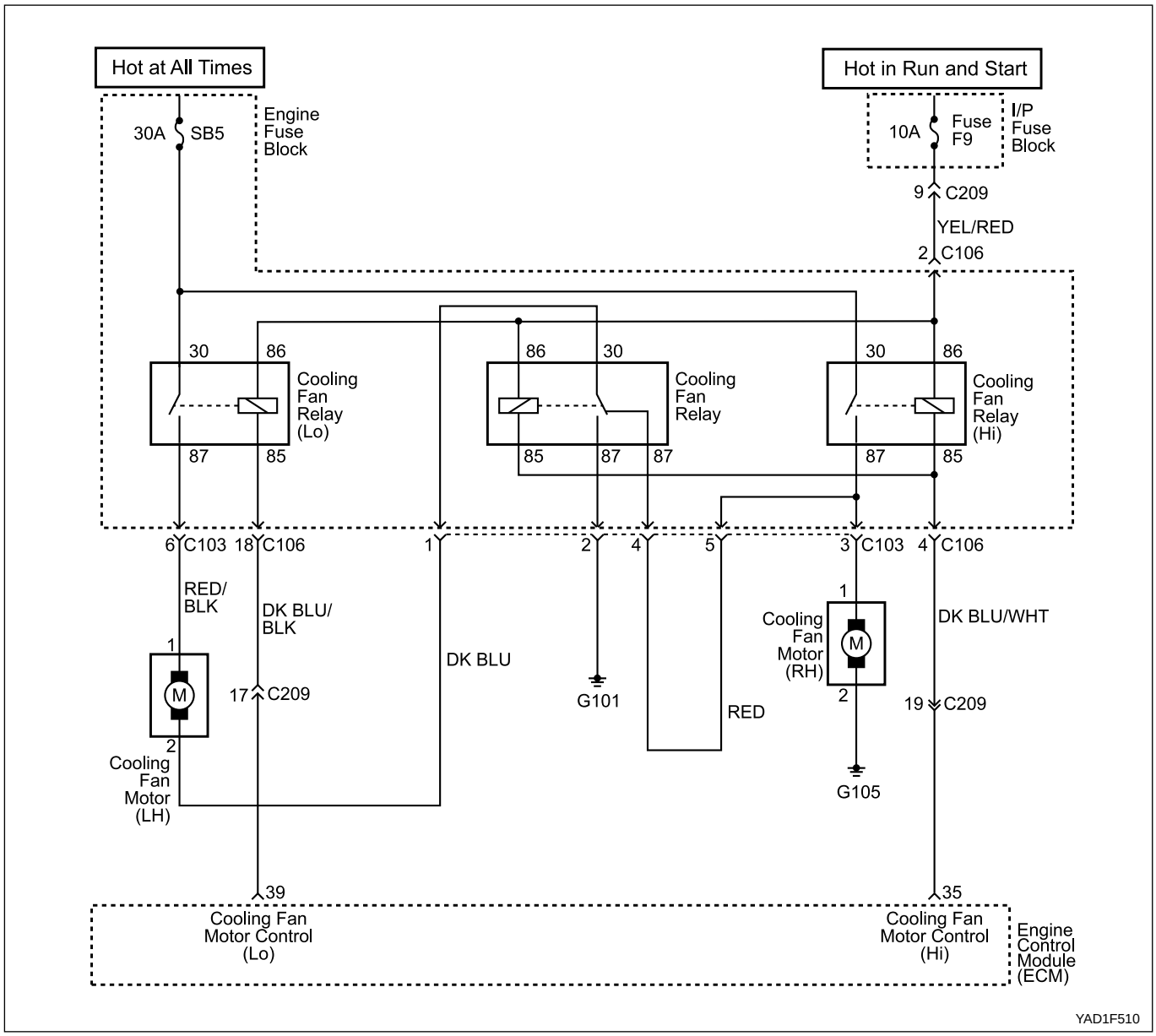
COOLING FAN



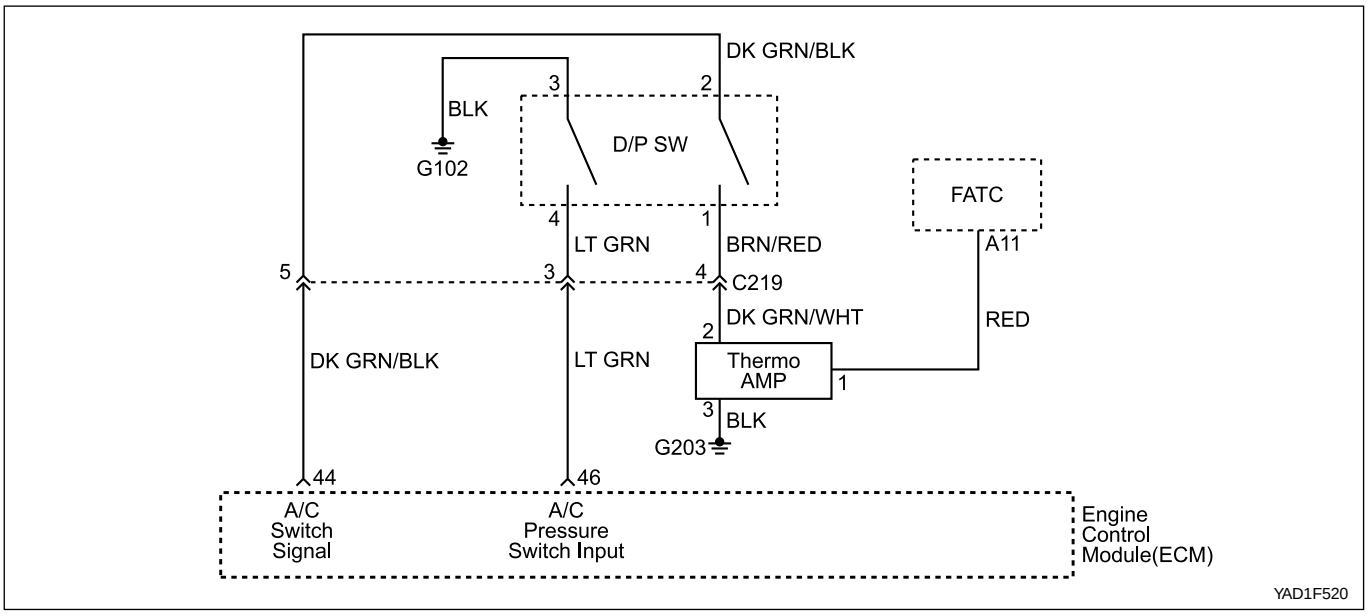
Failure Code	Description	Trouble Area	Maintenance Hint
44	Cooling fan (HI) relay short circuit to power	Cooling fan short circuit to power	• Inspection the Engine Control Module (ECM) pin 35 about short circuit or open with bad contact • Inspection the power source • Inspection the cooling fan • Inspection the ECM
45	Cooling fan (HI) relay short circuit to ground or open	Cooling fan short circuit to ground or open	

Circuit Description

Ignition voltage is supplied directly to the cooling fan relay coil. The ECM controls the relay by grounding the control circuit. When the ECM is commanding a command ON, the voltage of the control circuit should be low (near 0 volt).

When the ECM is commanding the control circuit should be high (near battery voltage). If the fault detection circuit senses a voltage other than what is expected, the fault line status will change causing the fault code to set.

A/C COMPRESSOR RELAY

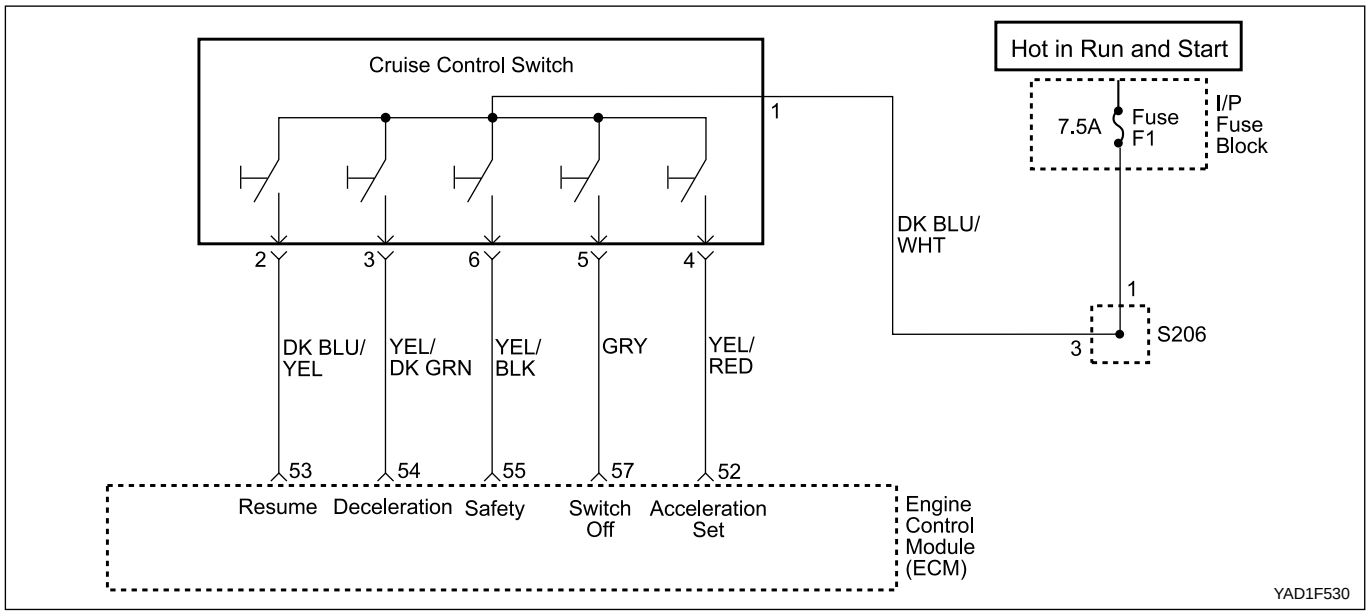


Failure Code	Description	Trouble Area	Maintenance Hint
228	A/C compressor relay short circuit to battery	When malfunction of A/C compressor control	• Monitoring the actual operation through scan tool • Inspection the Engine Control Module (ECM) pin 44 about short circuit or open with bad contact • Inspection the relay short circuit or open • Inspection the ECM
229	A/c compressor relay short circuit to ground or open		

Circuit Description

When the ECM detects that A/C has been requested, the ECM will activated the A/C clutch relay. When the relay has been activated, voltage should be present at both the A/C clutch relay and A/C switch circuit at ECM.

CRUISE CONTROL SWITCH

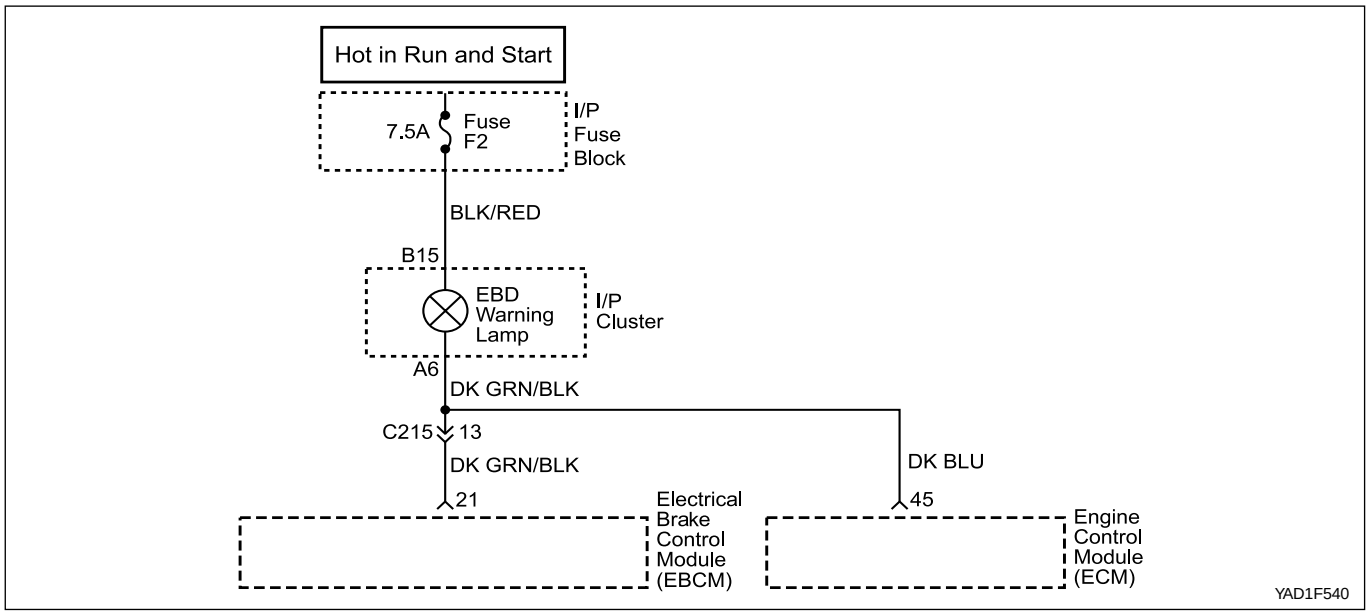


Failure Code	Description	Trouble Area	Maintenance Hint
129	Cruise control “OFF” due to message counter failure	Cruise control system message counter fault	• Monitoring the actual recognition status and vehicle speed signal through scan tool • Inspection the Engine Control Module (ECM) pin 52, 53, 54, 55, 57 about short circuit or open with bad contact • Inspection the CAN and ABS • Inspection the cruise control lever switch • Inspection the ECM
130	Vehicle speed signal failure	When malfunction of auto-cruise system Implausible condition of vehicle speed signal.	
131	Vehicle speed signal failure		
132	Cruise control lever failure	Cruise control lever defective	
133	Cruise control acceleration failure	Cruise control system Implausible condition of acceleration signal	
134	Cruise control deceleration failure	Cruise control system Implausible condition of deceleration signal	

Circuit Description

Cruise control is an automatic speed control system that maintain adesired driving speed with out using the accelerator pedal. The vehicle speed must be greater than 40 km/h to engage cruise control.

TRACTION CONTROL SYSTEM (TCS)

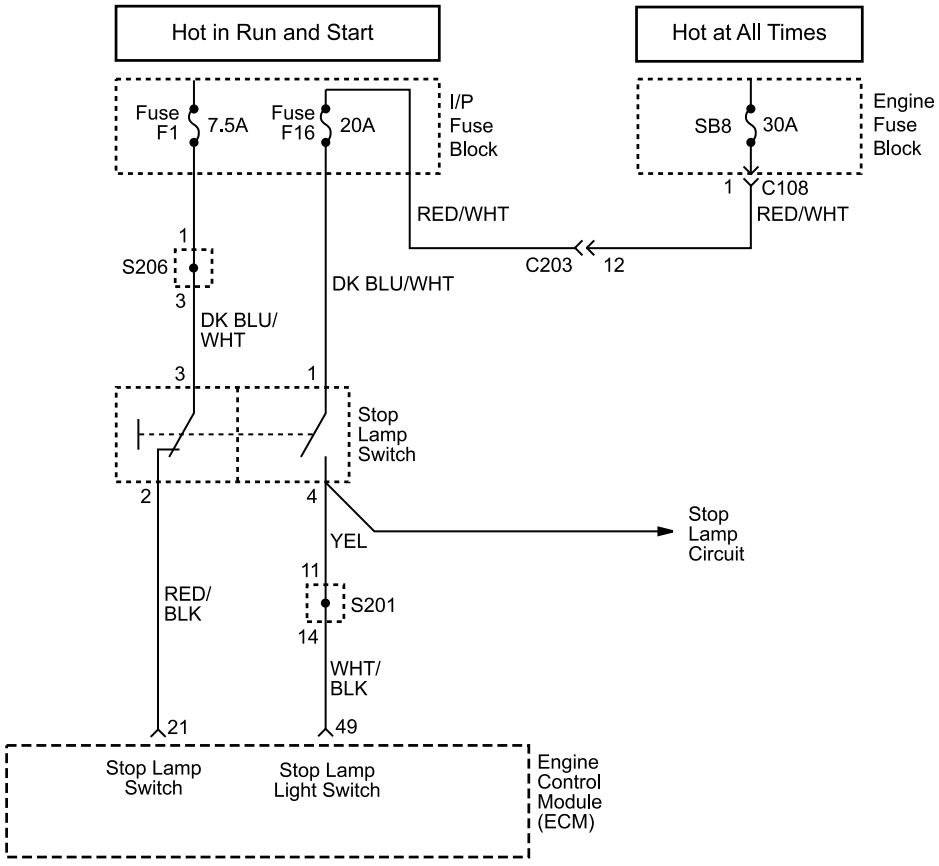


Failure Code	Description	Trouble Area	Maintenance Hint
150	TCS input signal short circuit to battery	TCS short circuit to power	• Inspection the Engine Control Module (ECM) pin 45 about short circuit or open with bad contact • Inspection the TCS lamp of I/P cluster. • Inspection the ECM
151	TCS input signal short circuit to ground or open	TCS short circuit to ground or open	

Circuit Description

Battery voltage is supplied to the TCS warning lamp with the ignition in ON and START. The warning lamp can be activated only by the Electrical Brake Control Module (EBCM) internally supplying ground to terminal 21. If the TCS input circuit is open or short, this failure code will be set.

STOP LAMP SWITCH

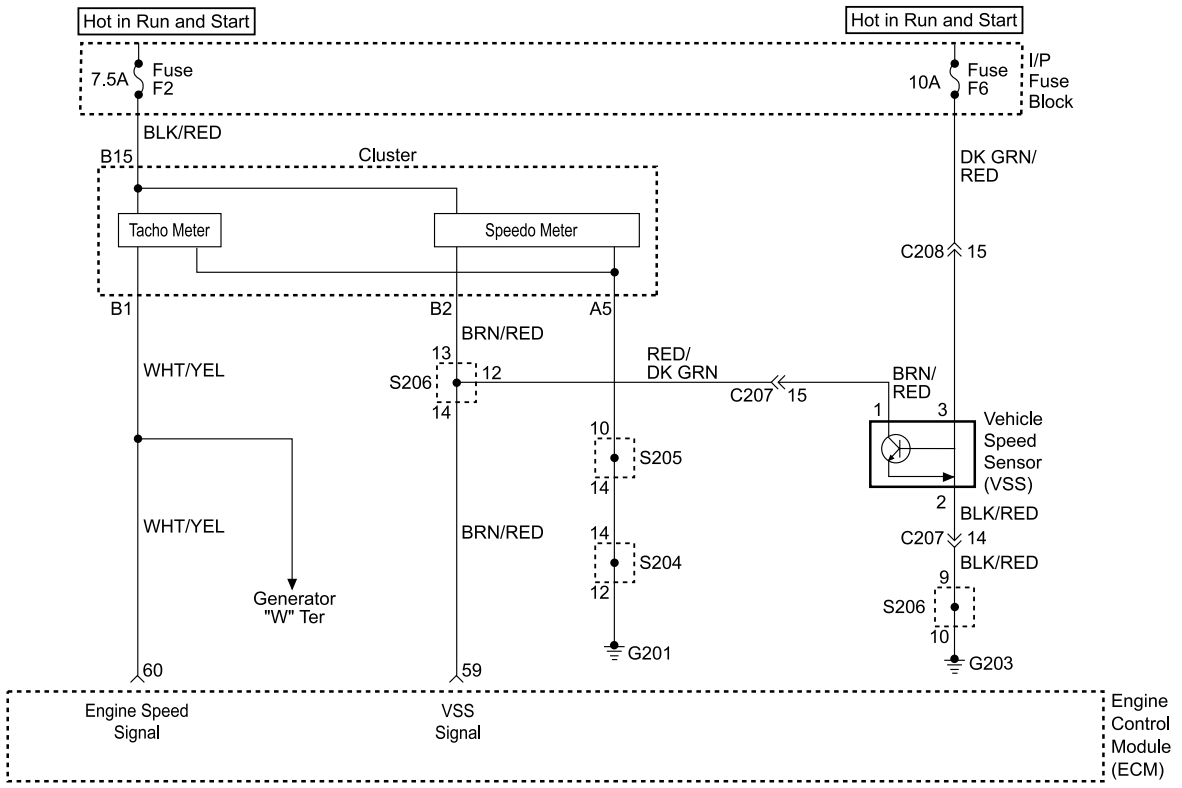


Failure Code	Description	Trouble Area	Maintenance Hint
135	Stop lamp switch failure	When malfunction of stop lamp switch-implausible condition of stop lamp signal input	• Monitoring the actual operational status and vehicle speed signal through scan tool • Inspection the Engine Control Module (ECM) pin 49 about short circuit or open with bad contact • Inspection the contact condition of stop lamp switch • Inspection the ECM

Circuit Description

The stop lamp switch is normally opened. When the ignition switch ON and brake ON, the battery voltage is supplied to the ECM. A scan tool should display ON when brake pedal is depressed and should read OFF with brake pedal released.

ENGINE RPM



Failure Code	Description	Trouble Area	Maintenance Hint
32	Engine rpm output circuit short circuit to battery	When short circuit to battery	• Monitoring the actual rpm in cluster • Inspection the Engine Control Module (ECM) pin 60 about short circuit or open • Inspection the cluster panel board circuit • Inspection the ECM
33	Engine rpm output circuit short circuit to ground or open	When short circuit to ground or open	

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.

$CO + O_2 \rightarrow CO_2$

$HC + O_2 \rightarrow CO_2 + H_2O$

$NO_x \rightarrow N_2 + O_2$

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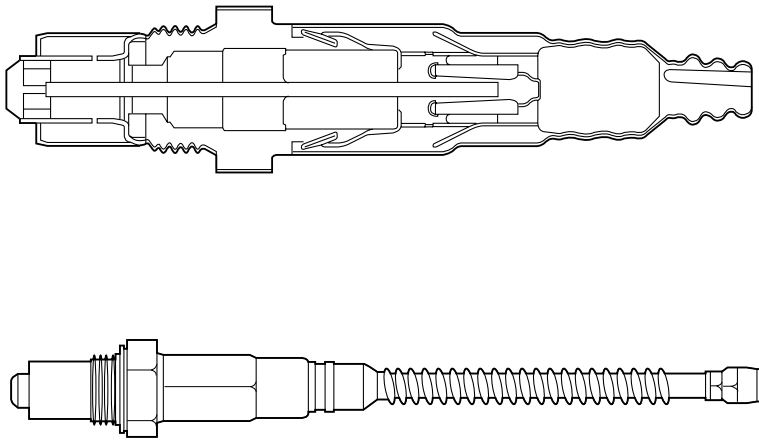
OXYGEN SENSOR



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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).

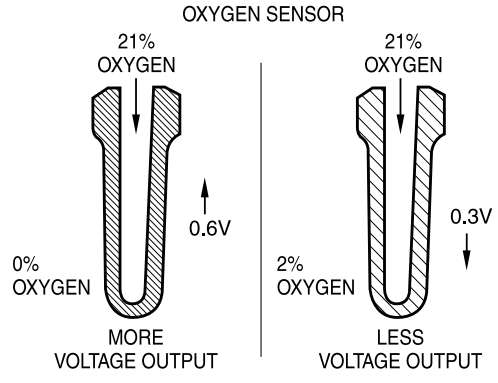
The electrically heated oxygen sensor warms up quickly and remains hot, even at idle when the exhaust manifold may cool down.

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.

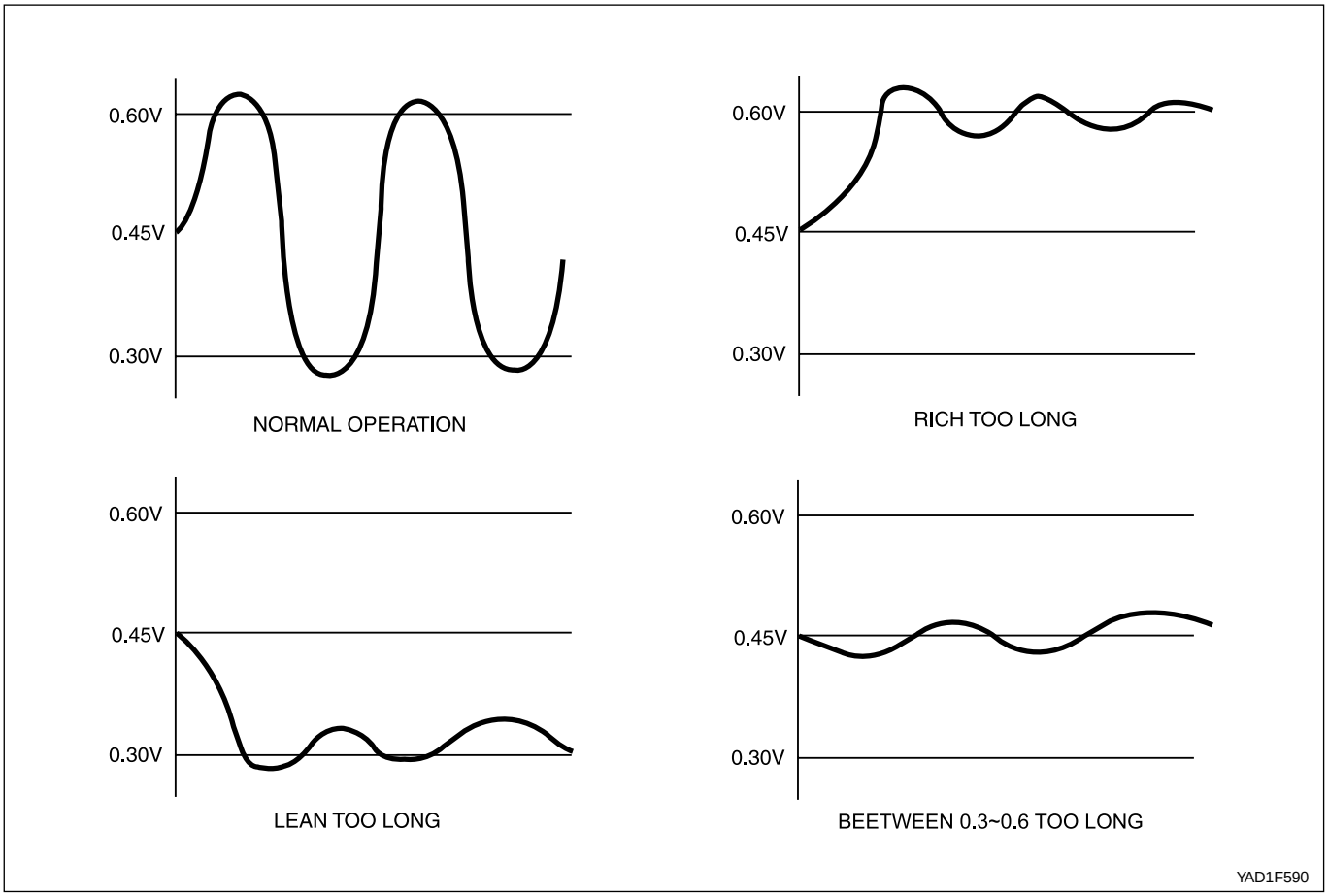
When the exhaust gas is rich (below 14.7:1), the voltage output is high, above 450 mv. When the exhaust gas is lean (above 14.7:1 air/fuel ratio), the sensor's voltage output is low, below 450 mv.

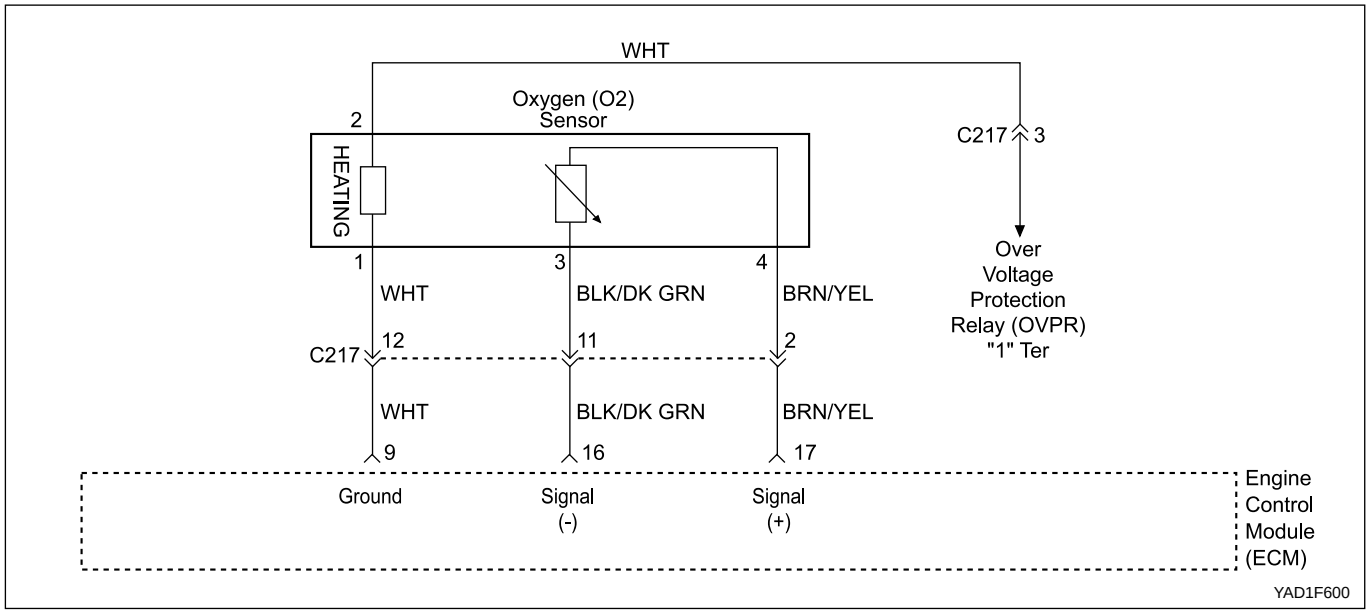
The ECM uses oxygen sensor information for:

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



YAD1F580


0.60V
0.45V
0.30V
NORMAL OPERATION
0.60V
0.45V
0.30V
RICH TOO LONG
0.60V
0.45V
0.30V
LEAN TOO LONG
0.60V
0.45V
0.30V
BEETWEEN 0.3~0.6 TOO LONG
YAD1F590



Failure Code	Description	Trouble Area	Maintenance Hint
80	Oxygen sensor high voltage	When recognition the output that more than nominal threshold, malfunction of sensing voltage.	• Monitoring the actual output signal through scan tool • Inspection the ECM pin 16, 17 about short circuit or open with bad contact • Inspection the oxygen sensor • Inspection the ECM
89	Oxygen sensor low voltage	When recognition the output that more than nominal threshold, malfunction of sensing voltage.	
82	Oxygen sensor no activity detected	When recognition the output that not active the sensor etc.	
83	Oxygen sensor not lean after overrun fuel shut-off	When recognition the output that no lean signal after overrun fuel shut-off	
84	Oxygen sensor slow response	When slow response of sensor signal	
85	Oxygen sensor heater failure	When recognition the heating circuit	• Monitoring the heating status through scan tool • Inspection the ECM pin 9 about short circuit or open with bad contact • Inspection the heating power source • Inspection the heating circuit of oxygen sensor • Inspection the ECM
86	Oxygen sensor heater short circuit to battery	When recognition the heating currents that more or less than set values (less than 0.2 A or more than 2 A)	
87	Oxygen sensor heater short circuit to ground or open	When recognition the heating voltages than less than set values (less than 2 v)	

Failure Code	Description	Trouble Area	Maintenance Hint
81	Bank 1 system short term fuel trim adaptation below lean threshold	When recognition the value less than nominal control threshold, it means that when big deviation in control range of adaptation values through fuel and air mixture formation	• Inspection the intake air leakage • Inspection the injection quantities with injector block or leakage • Inspection the exhaust leakage • Inspection the ECM
93	Bank 1 system short term fuel trim adaptation above rich threshold	When recognition the value more than nominal control threshold, it means that when big deviation in control range of adaptation values through fuel and air mixture formation	
96	Bank 1 system short term fuel trim at rich stop	When recognition the short term fuel trim that more than nominal threshold	
97	Bank 1 system short term fuel trim at lean stop	When recognition the short term fuel trim that less than nominal threshold	
98	Bank 1 system idle adaptationfailure (above rich threshold)	When recognition the long term fuel trim exceeds rich threshold	
99	Bank 1 system idle adaptation failure (below rich threshold)	When recognition the long term fuel trim exceeds lean threshold	
100	Bank 1 system learning control failure (rich, low load)	When recognition the long term fuel trim exceeds rich threshold	
101	Bank 1 system learning control failure (lean, low load)	When recognition the long term fuel trim exceeds lean threshold	
102	Bank 1 system learning control failure (rich, high load)	When recognition the long term fuel trim exceeds rich threshold	
103	Bank 1 system learning control failure (rich, low load)	When recognition the long term fuel trim exceeds lean threshold	

Circuit Description

In order to control emissions, a catalytic converter is used to covert harmful emissions into harmless water vapor and carbon dioxide. The ECM has the ability to monitor this process by using a oxygen sensor. The oxygen sensor produces and output signal which indicates the storage capacity of the catalyst. This in turn indicates the catalyst's ability to convert exhaust emission effectively. If the oxygen sensor pigtail wiring, connector, or terminal is damaged. Do not attempt to repair the wiring, connector, or terminals. In order for the sensor to function properly, it must have a clean air reference provided to it. This clean air reference is obtained by way of the oxygen sensor wire(s). Any attempt to repair the wires, connector, or terminal and degrade the oxygen sensor performance.

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.

Specified Value	0.2 ~ 1.0 V

Notice: If the measured value is not within the specified value, the possible causemay bein cable, oxygen sensor or ECM

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.

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.

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

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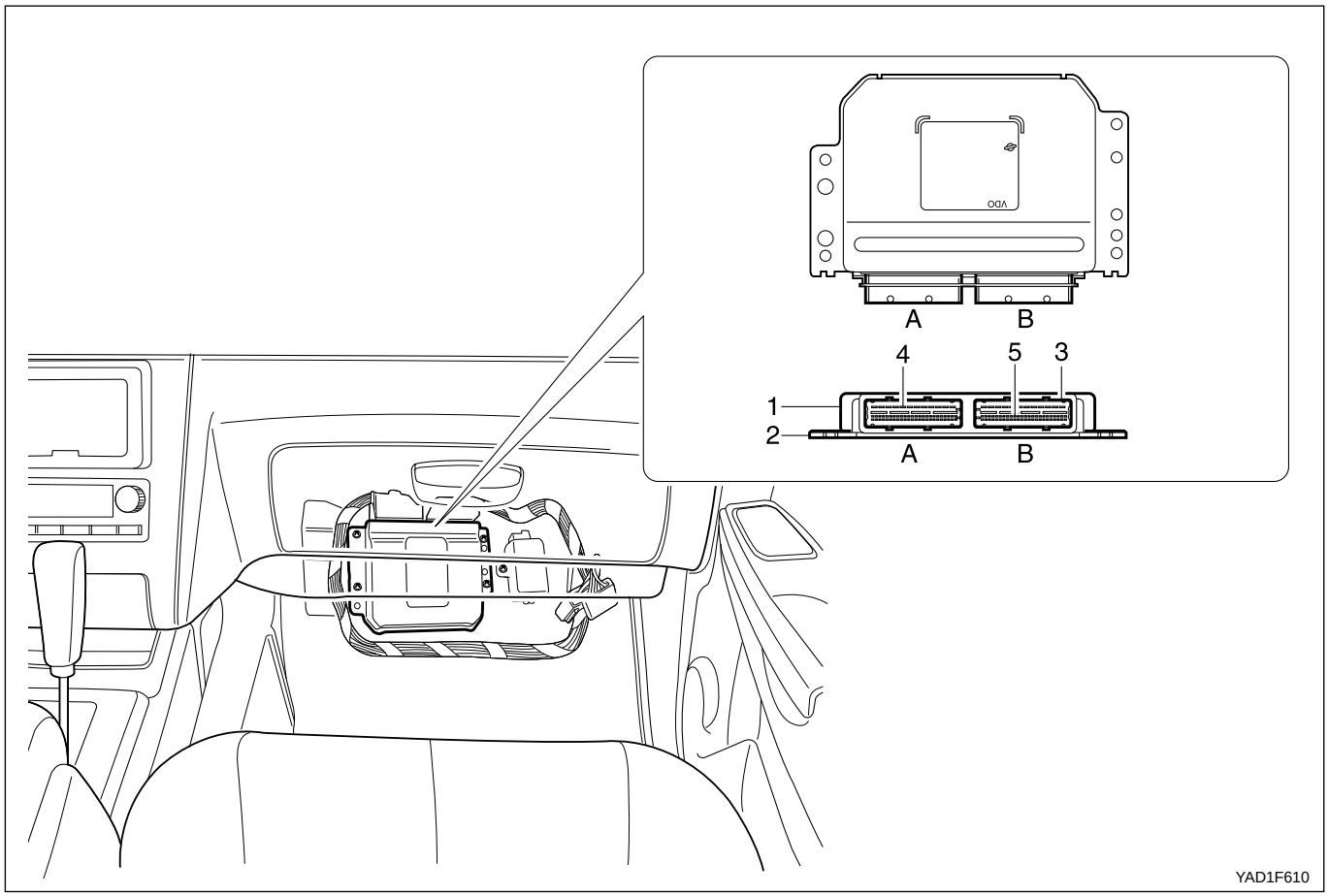
ENGINE CONTROL MODULE



1 Cover
2 Plate
3 Connector
4 Plat Pin
Vehicle Side : No. 1-12
Engine Side : No. 61-72
5 Pin
Vehicle Side : No. 13-60
Engine Side : No. 73-120
A Vehicle Side Connector : Black
B Engine Side Connector : Gray

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.

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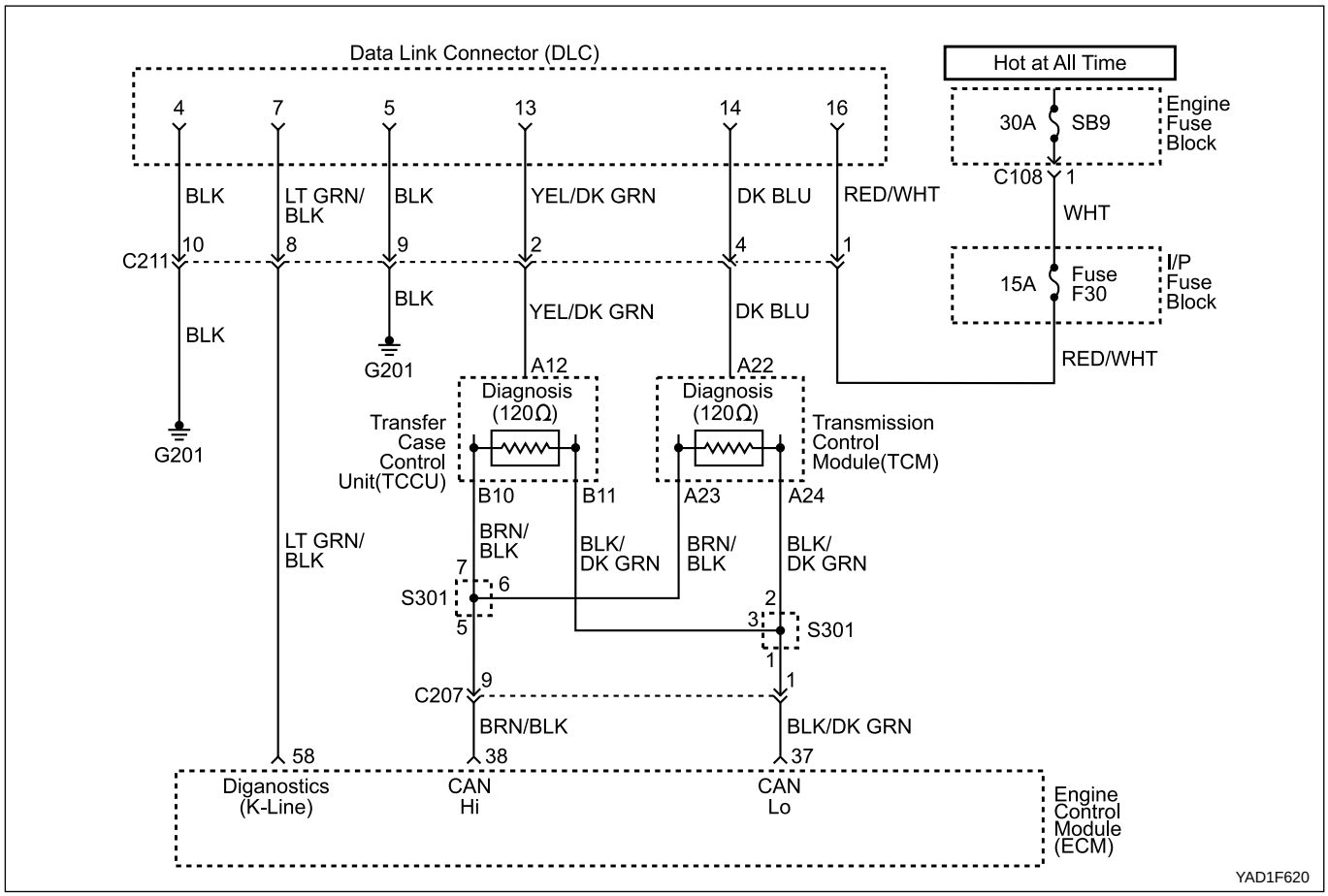
SERIAL DATA COMMUNICATION



Failure Code	Description	Trouble Area	Maintenance Hint
23	CAN communication failure: ASR/MSR	When CAN signal message missing or implausibility for ASR/MSR unit or not initialized condition	• Inspection the ASR unit with CAN connection • Inspection the Engine Control Module (ECM) pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
24	CAN communication failure: ABS	When CAN signal message missing or implausibility for ABS unit or not initialized condition	• Inspection the ABS unit with CAN connection • Inspection the ECM pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
26	CAN communication failure: TCU (A/T only)	When CAN signal message missing or implausibility for TCU unit or not initialized condition	• Inspection the TCM unit with CAN connection • Inspection the ECM pin 38, 37 about short circuit or open with bad contact • Inspection the ECM

Failure Code	Description	Trouble Area	Maintenance Hint
29	CAN communication failure: ID 200h not plausible	When CAN signal message missing or implausibility for ABS/ABD unit or not initialized condition	• Inspection the ABS/ABD unit with CAN connection • Inspection the ECM pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
30	CAN communication failure: ID 208h not plausible	When CAN signal message missing or implausibility for ABS/ABD unit or not initialized condition	• Inspection the ABS/ABD unit with CAN connection • Inspection the ECM pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
31	CAN communication failure: communication initialization failure	When CAN signal message missing or implausibility for each unit (ABS, ASR, TCM, TOD etc.) or not initialized condition	• Inspection the each control unit with CAN connection • Inspection the ECM pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
59	CAN communication failure: MSR data transmission not plausible	When CAN signal message missing or implausibility for MSR unit or not initialized condition	• Inspection the MSR unit with CAN connection • Inspection the Engine Control Module (ECM) pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
60	CAN communication failure: ASR data transmission not plausible	When CAN signal message missing or implausibility for ASR unit or not initialized condition	• Inspection the ASR unit with CAN connection • Inspection the Engine Control Module (ECM) pin 38, 37 about short circuit or open with bad contact • Inspection the ECM

Circuit Description

The provision for communicating with the ECM is the Data Link Connector (DLC). It is located in the instrument panel fuse block. The DLC is used to connect the scan tool. Battery power and ground is supplied for the scan tool through the DLC. CAN line is used to communicate with the other module such as the Transmission Control Module (TCM) and Transfer Case Control Unit (TCCU).

Keyword 2000 Serial Data Communications

Each bit of information can have one of two lengths: long or short. This allows vehicle wiring to be reduced by transmitting and receiving multiple signals over a singles wire. The message carried on KWP 2000 data streams are also prioritized. If two messages attempt to establish communications on the data line at the same time, only the message with higher priority will must wait.

INTERNAL FAILURE

Failure Code	Description	Trouble Area	Maintenance Hint
21	Transmission coding failure	When faulty of variant coding of transmission	• Inspection the coding condition through scan tool • InspectiontheEngine ControlModule (ECM) • Inspection the CAN line • Inspection the TCM
136	ECM failure (RAM)	When malfunction of random access memory - ECM internal error	• Inspection the ECM
142	Uncoded/ unprogramed ECM	When malfunction of ECM coding-required ECM encoding	• Fulfill the ECM variant coding
137	ECM failure (EPROM)	When malfunction of ECM internal	• Inspection the ECM
143	ECM failure (EEPROM/ Flash-EPPOM checksum failure)		
144	ECM failure (coding ID checksum failure)		
145	ECM failure (coding checksum failure)		
146	ECM failure (program-ming checksum failure)		

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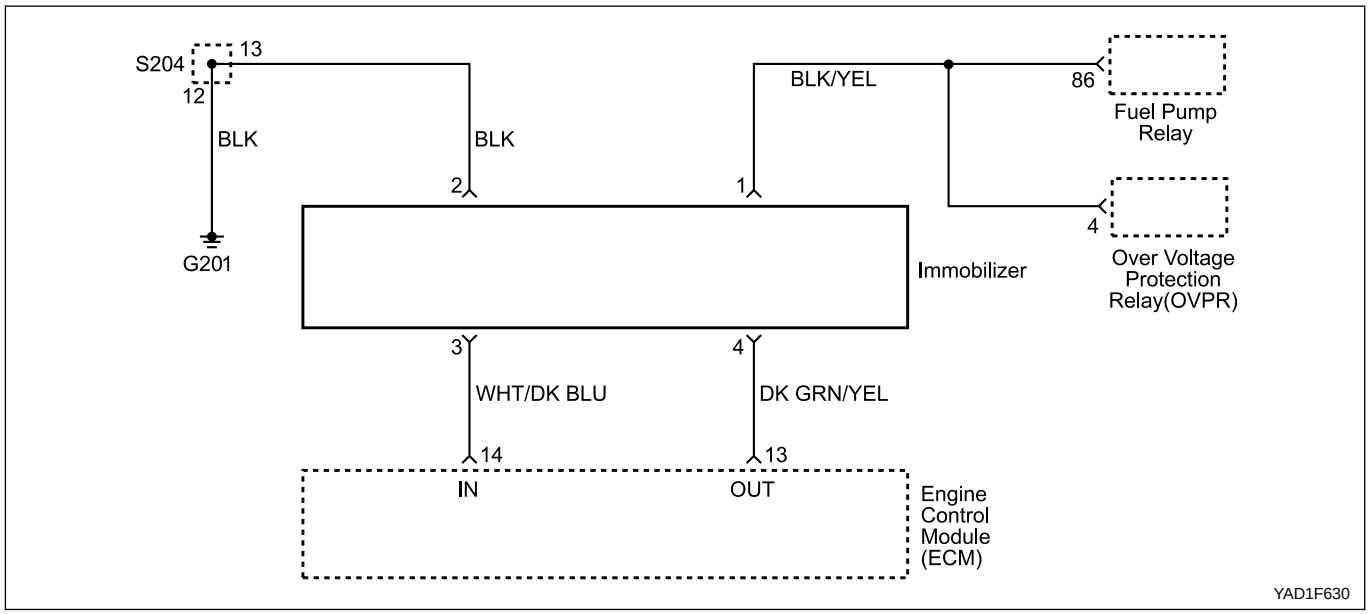
ELECTRONIC THROTTLE CONTROLLER SAFETY MALFUNCTION

Failure Code	Description	Trouble Area	Maintenance Hint
110	Throttle actuator learning data fault	System internal failure	• Inspection the Engine Control Module (ECM)
117	Exceed fuel-cut safety time		
120	Cruise control interruption memory failure		
138	Call Monitoring		
139	Servo motor control output interruption memory failure		
140	Servo motor open/short		
186	ECM failure (incompatible CPU)		
187	ECM failure (CPUs communication failure)		
188	ECM failure (CPU 2 configuration failure)		
189	ECM failure (CPU 2 fault)		
190	ECM failure (CPU run time failure between CPUs)		
231	ECM failure (CPU 2 cruise control message counter failure)		
232	Over deceleration limit (CPU 2)		
233	Over acceleration limit (CPU 2)		
234	Cruise control lever dual operation (CPU 2)		
235	Cruise control lever safety terminal failure (CPU 2)		
236	Unusual pedal position variation (CPU 2)		
237	Unusual throttle position variation (CPU 2)		
238	Unusual throttle controller monitoring data comparison fault (CPU 2)		

Failure Code	Description	Trouble Area	Maintenance Hint
239	Unusual accelerator pedal position sensor comparison fault (CPU 2)	System internal failure	• Inspection the Engine Control Module (ECM)
240	Throttle potentiometer comparison fault (CPU 2)		
241	Unusual CPU communication (CPU 2)		
242	Unusual CPU configuration (CPU 2)		
243	A/D converter failure (CPU 2)		
244	Accelerator pedal position sensor setpoint fault between CPU 1 and CPU 2		
245	Position controller setpoint fault between CPU 1 and CPU 2		
246	MSR setpoint fault between CPU 1 and CPU 2		
247	Idle control setpoint fault between CPU 1 and CPU 2		
248	A/D converter overflow (CPU 2)		
249	ROM fault (CPU 2)		
250	RAM fault (CPU 2)		
251	Cycle monitor fault (CPU 2)		

IMMOBILIZER



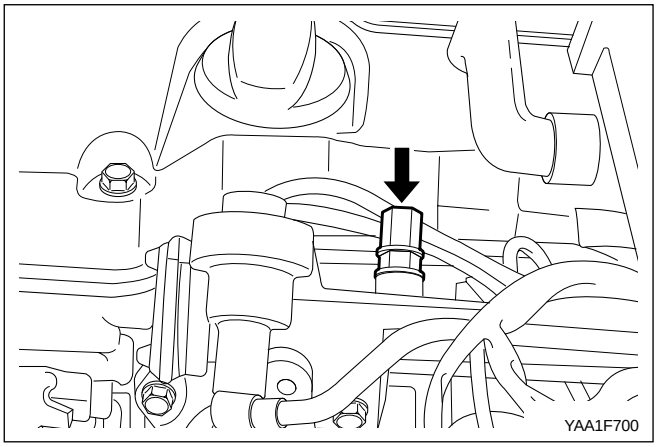
Failure Code	Description	Trouble Area	Maintenance Hint
25	Communication with transponder missing	When missing the transponder signal	• Inspection the Engine Control Module (ECM) pin 13, 14 about short circuit or open with bad contact • Inspection the power source or ground short circuit or open of immobilizer unit • Inspection the transponder condition (broken etc.) • Inspection the ECM
141	Unprogramed ECM with immobilizer	When malfunction of immobilizer Required immobilizer encoding, no paired condition of immobilizer even through start trial	• Fulfill the immobilizer pairing

Circuit Description

Immobilizer is a device disabling vehicle ignition unless a specific key is used and designed to help prevent vehicle theft.

Immobilizer is comprised of two devices, a key with encoded transponder and ECM with the same encoding of the transponder. When a key is inserted into the hole to start vehicle and turned to ON, the ECM reads and decodes the transponder code and, if the same, starts the engine, it is called immobilizer. It means immobilizer system disables starting by stopping fuel supply if the code in the transponder does not match the code stored in ECM each other.

MAINTENANCE AND REPAIR



ON-VEHICLE SERVICE

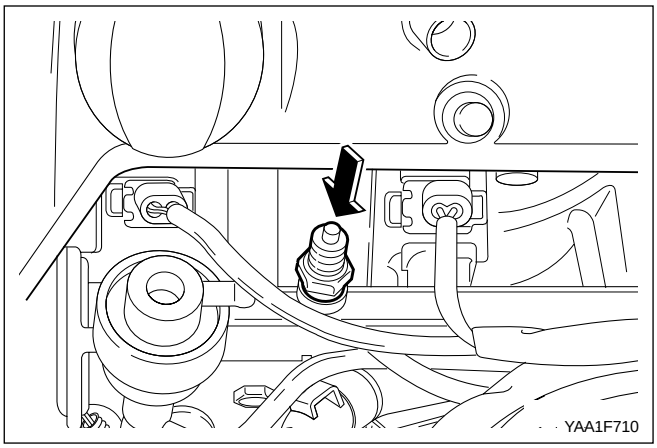
DISCHARGING THE PRESSURE IN FUEL SYSTEM

Removal and Installation Procedure

1. Remove the fuel pressure test connector.

   Installation Notice

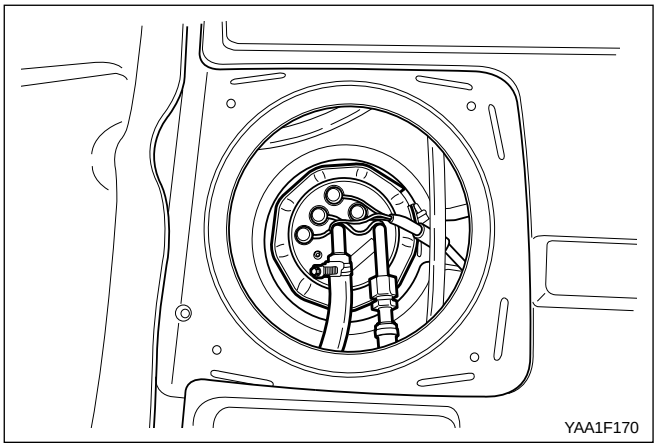
Tightening Torque	25 N•m (18 lb-ft)



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

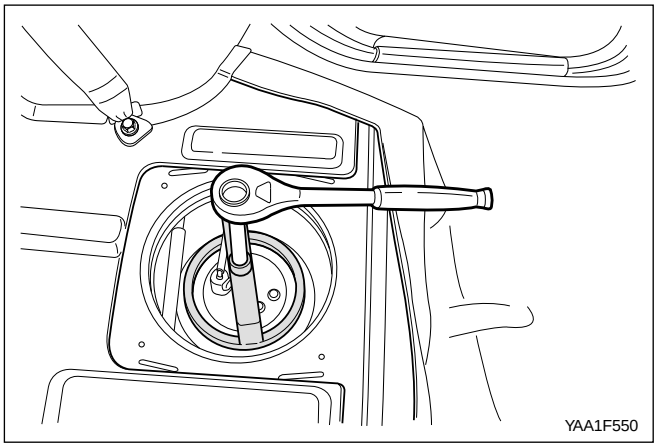
Tools Required

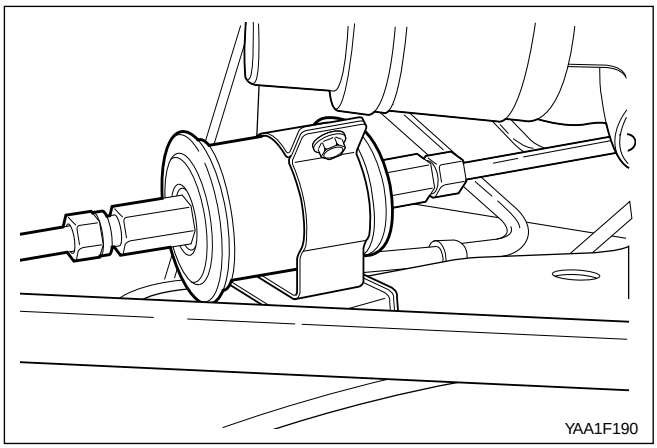
661 589 00 46 00 Fuel Tank Cap Wrench

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.


YAA1F550


YAA1F190

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.

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.

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

   Installation Notice

Tightening Torque	28 N•m (21 lb-ft)

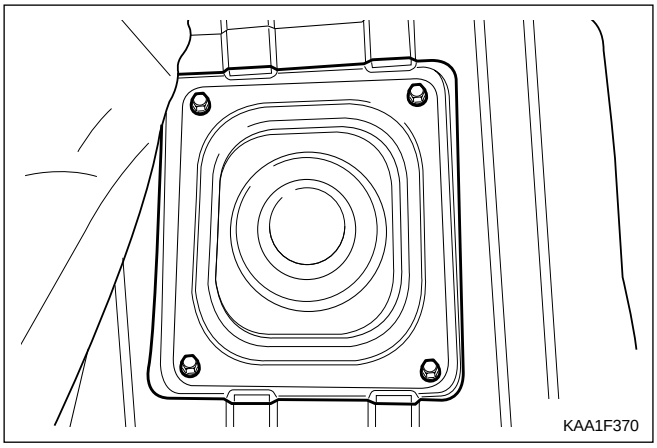
4. Remove the fuel filter mounting bracket bolt .

   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.

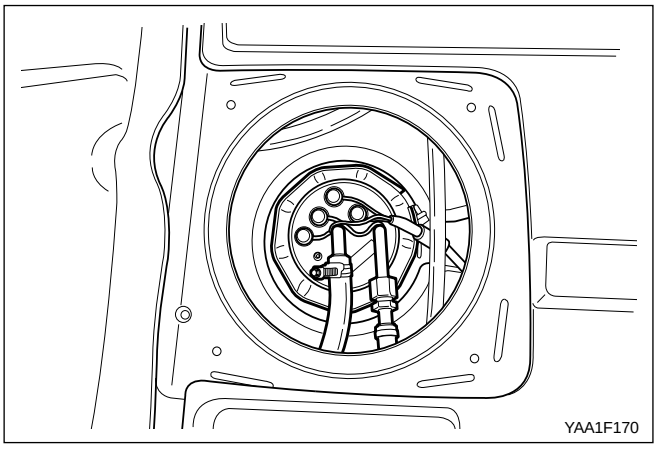

KAA1F370

FUEL TANK

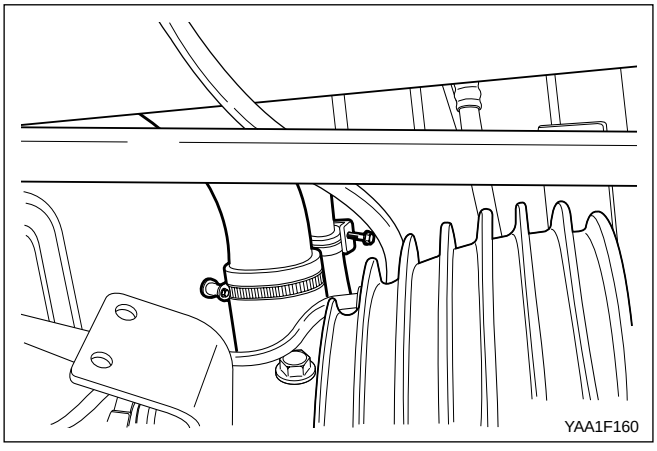
Removal and Installation Procedure

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.


YAA1F170

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.

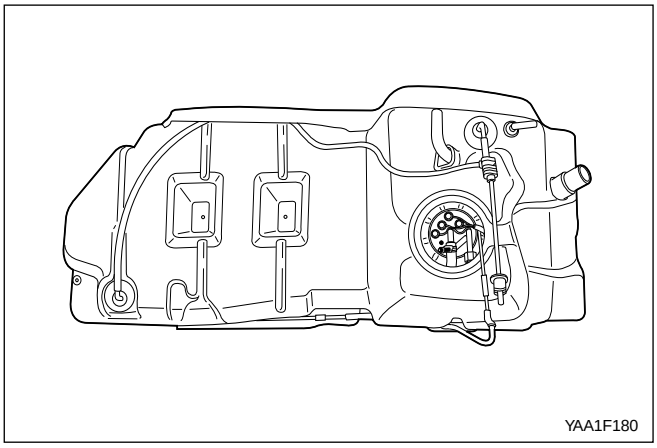

YAA1F160

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

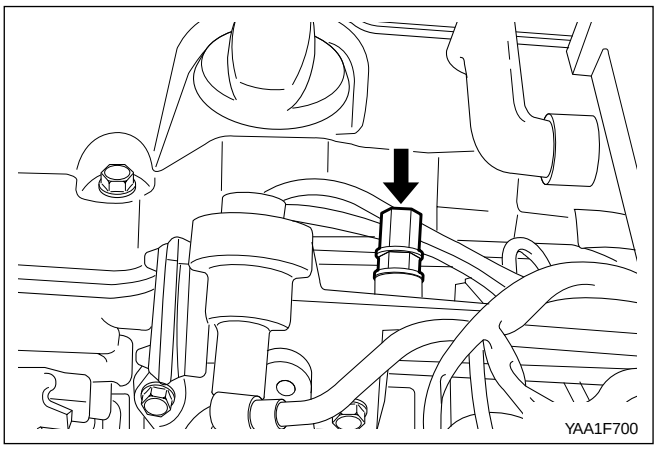
Installation Notice

Tightening Torque	38 N•m (28 lb-ft)

13. Carefully lower the fuel tank.


YAA1F180

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.


YAA1F700

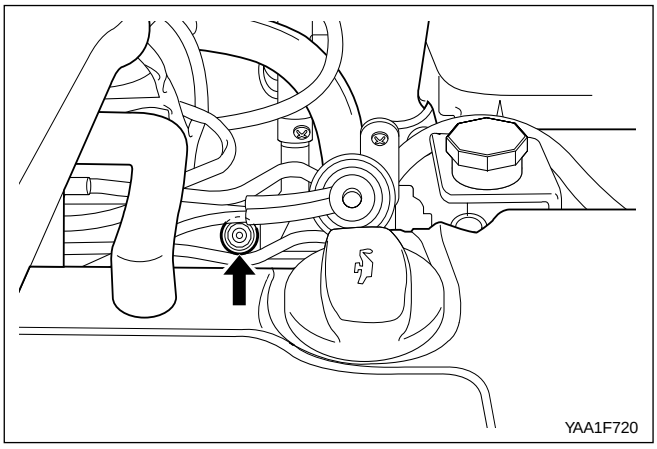
FUEL PRESSURE REGULATOR

Removal and Installation Procedure

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

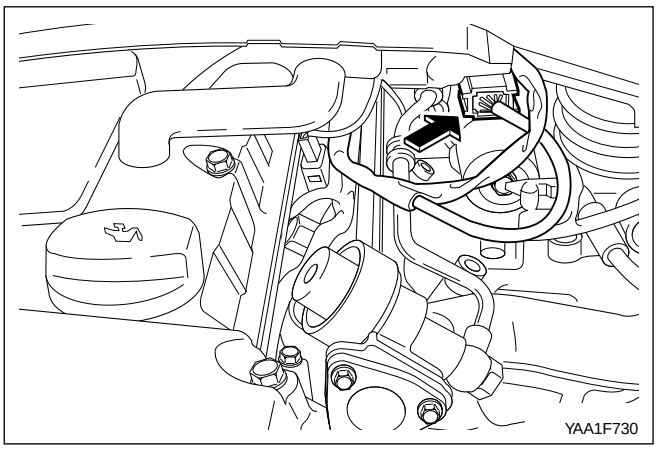
Installation Notice

Tightening Torque	25 N•m (18 lb-ft)

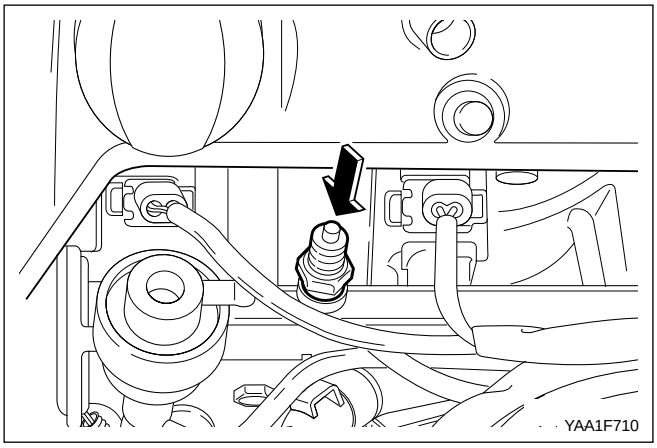

YAA1F720

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.

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


YAA1F730

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.

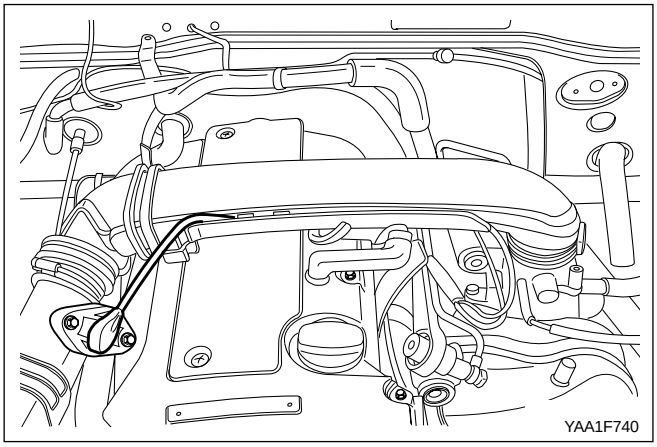


FUEL RAIL AND INJECTORS

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.

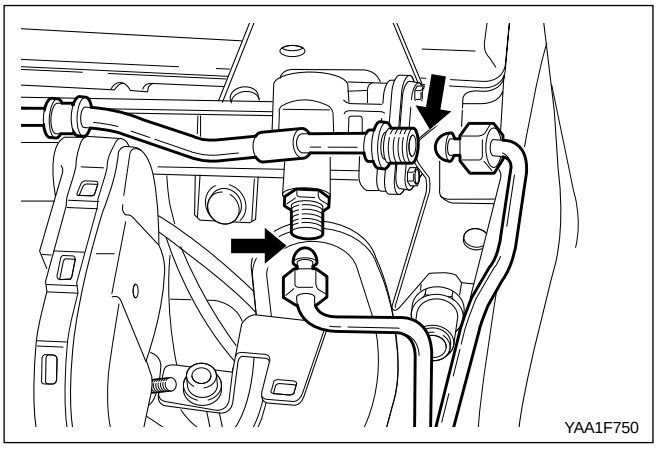


4. Remove the cable guide.
5. Disconnect the Hot Film Air Mass (HFM) sensor connector.
6. Remove the intake air duct mounting bolts.

Installation Notice

Tightening Torque	9 N•m (80 lb-in)

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



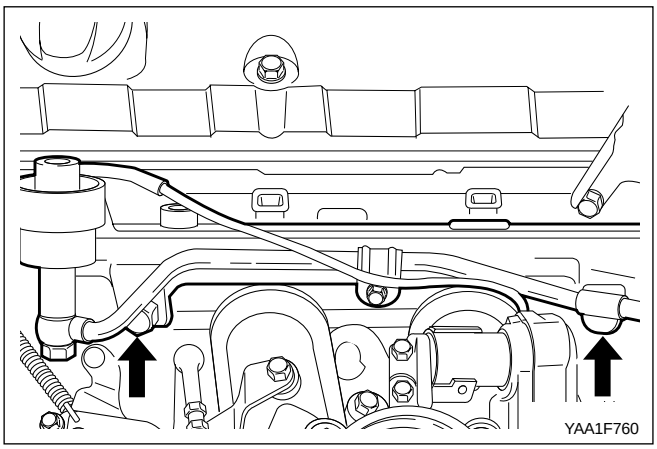
9. Remove the fuel return and supply line.

   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)

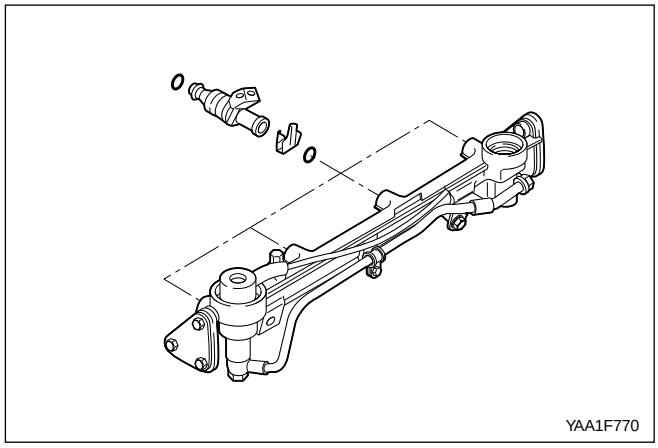
10. Remove the six injector connectors.



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

Installation Notice

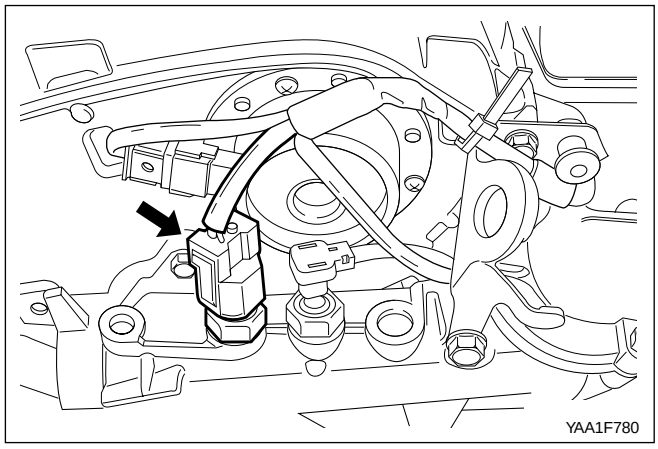
Tightening Torque	25 N•m (18 lb-ft)


YAA1F770

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.

Important: 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.


YAA1F780

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.

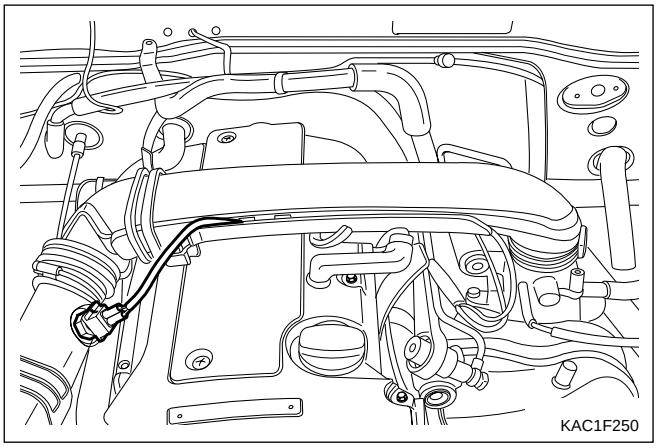
   Notice: Take care when handling the engine coolant temperature sensor. Damage to the sensor will affect the proper operation of the fuel injection system.

4. Remove the engine coolant temperature sensor from the pump hosing.

   Installation Notice

Tightening Torque	30 N•m (22 lb-ft)

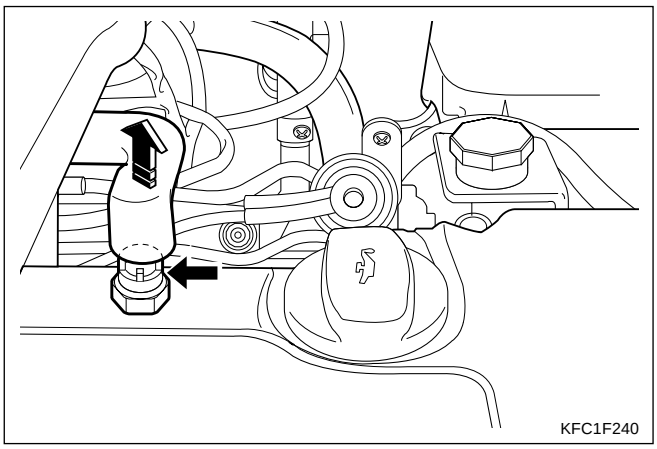
5. Installation should follow the removal procedure in the reverse order.


KAC1F250

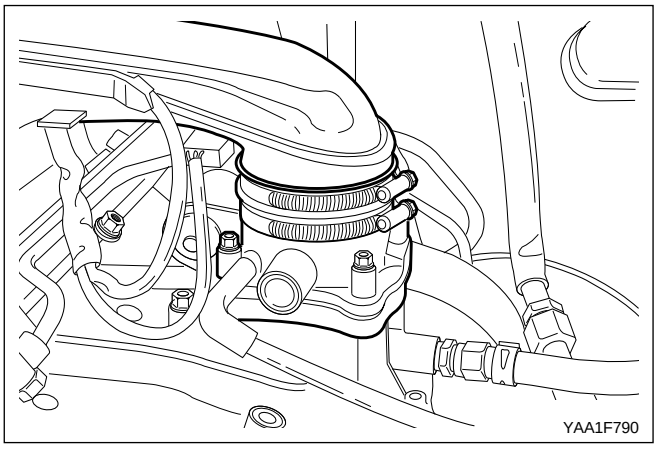
THROTTLE BODY (INTEGRATED WITH THE ACTUATOR)

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.


KFC1F240

4. Remove the blow-by hose.
5. Remove the intake air duck.

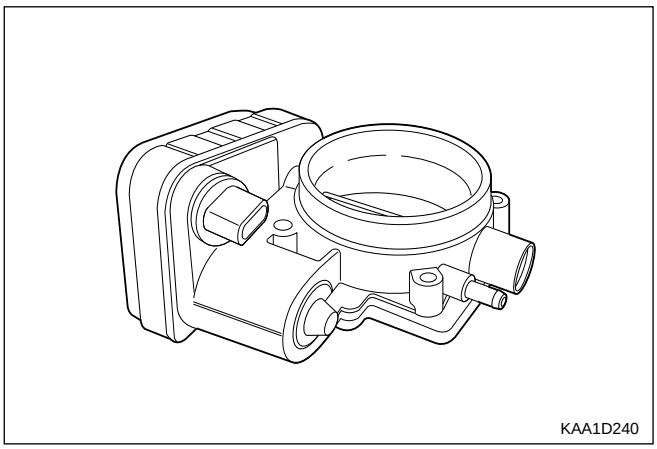

YAA1F790

6. Disconnect the throttle body electrical connector.
7. Remove the throttle body bolts.

Installation Notice

Tightening Torque	12 N•m (106 lb-in)

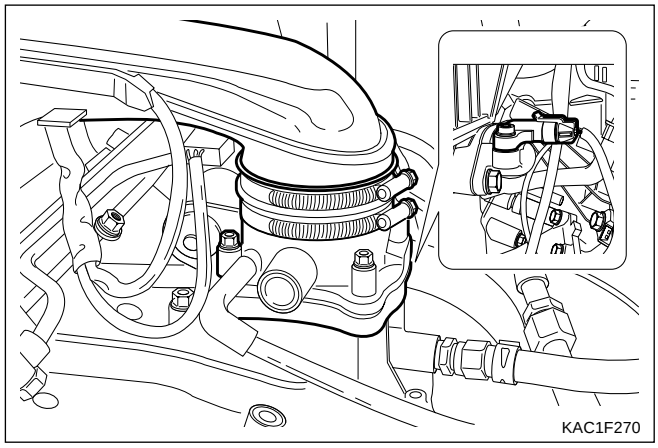
8. Remove the vacuum hose.


KAA1D240

9. Remove the throttle body and discard the gasket.

   Important: Use care in cleaning old gasket material. Sharp tools may damage sealing surfaces.

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



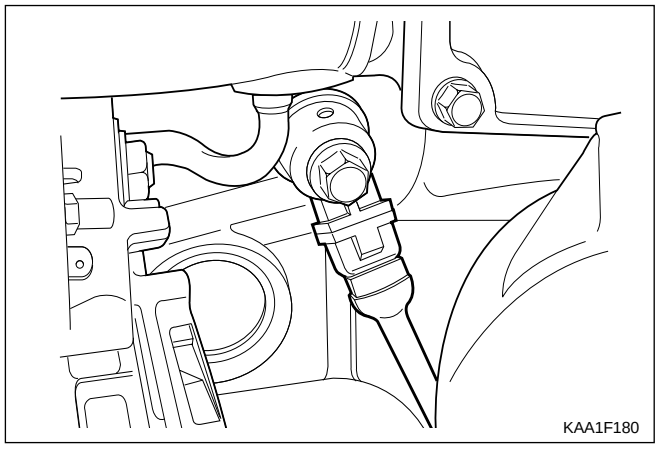
HOT FILM AIR MASS (HFM) SENSOR

Removal and Installation Procedure

1. Disconnect the negative battery cable.
2. Disconnect the Hot Film Air Mass (HFM) sensor electrical connector.
3. Remove the HFM sensor retaining screws.
4. Turn the HFM sensor coupling in the direction shown in the figure in the left so that it gets separated from the contact surface.

   Notice: Make sure the HFM sensor coupling connects completely with the contact surface installation.

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



KNOCK SENSOR

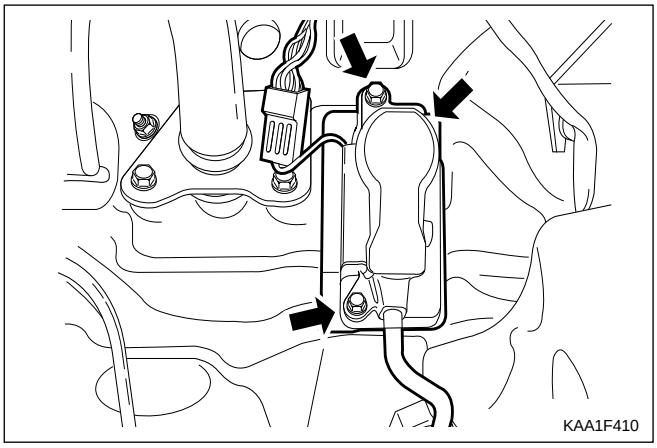
Removal and installation Procedure

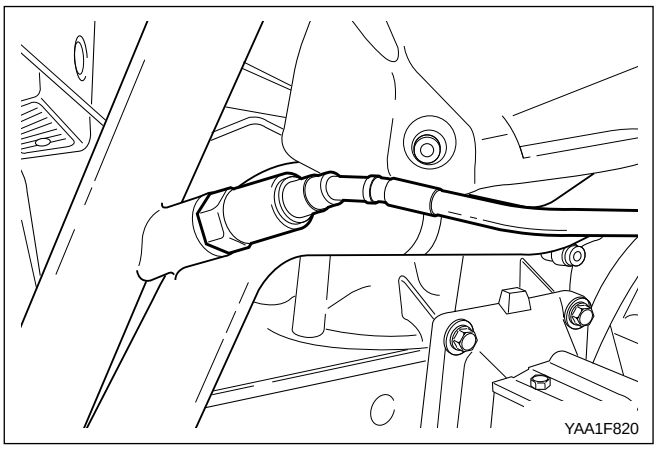
1. Disconnect the negative battery cable.
2. Disconnect the knock sensor electrical connector from the intake manifold bracket.
3. Remove the knock sensor mounting bolt from the knock sensor installed on the cylinder block.

   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.

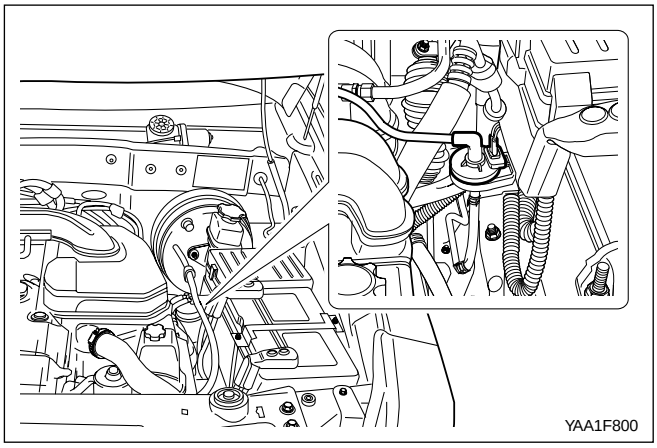
2. Disconnect the electrical connector.
3. Carefully remove the oxygen sensor from the exhaust pipe.

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.

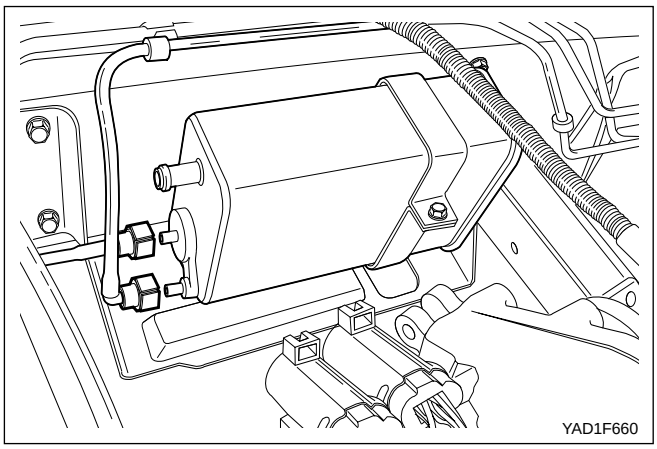
4. Coat the threads of the oxygen sensor with an anti-seize compound, if needed.
5. Installation should follow the removal procedure in the reverse order.



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.

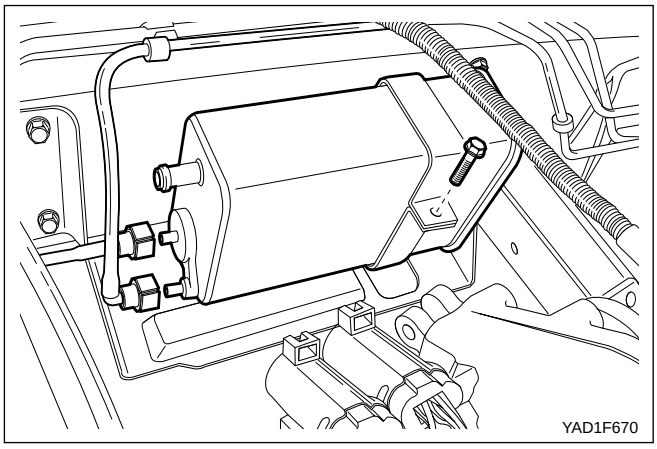


CANISTER

Removal and Installation Procedure

Caution: 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.

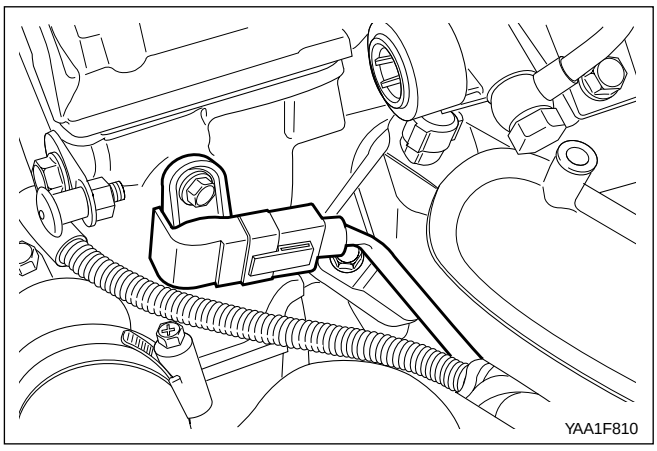


3. Remove the canister mounting bolts.

   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

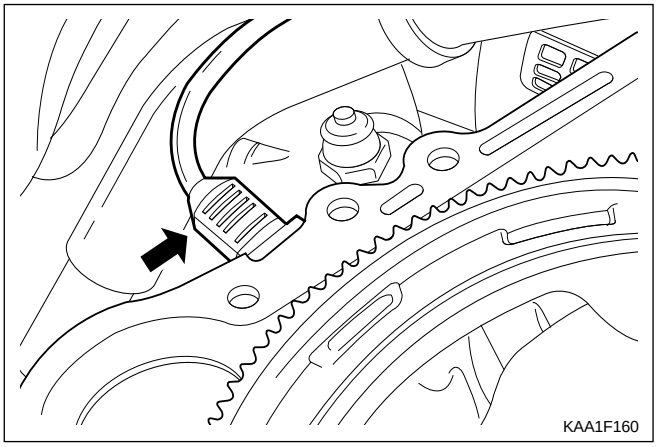
Removal and Installation Procedure

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

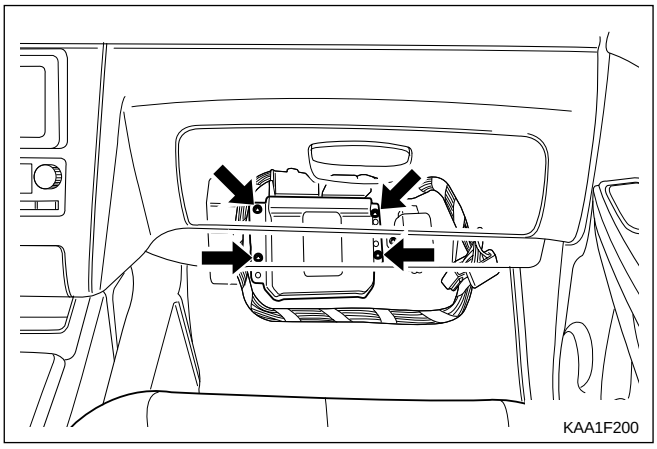
Removal and installation Procedure

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.



ENGINE CONTROL MODULE

Removal and installation Procedure

1. Disconnect the negative battery cable.
2. Remove the cowl side trim form passenger side. Re-er to *Section 9G, Interior trim.*
3. Remove the four securing nuts for the Engine Control Module (ECM) from the mounting bracket.

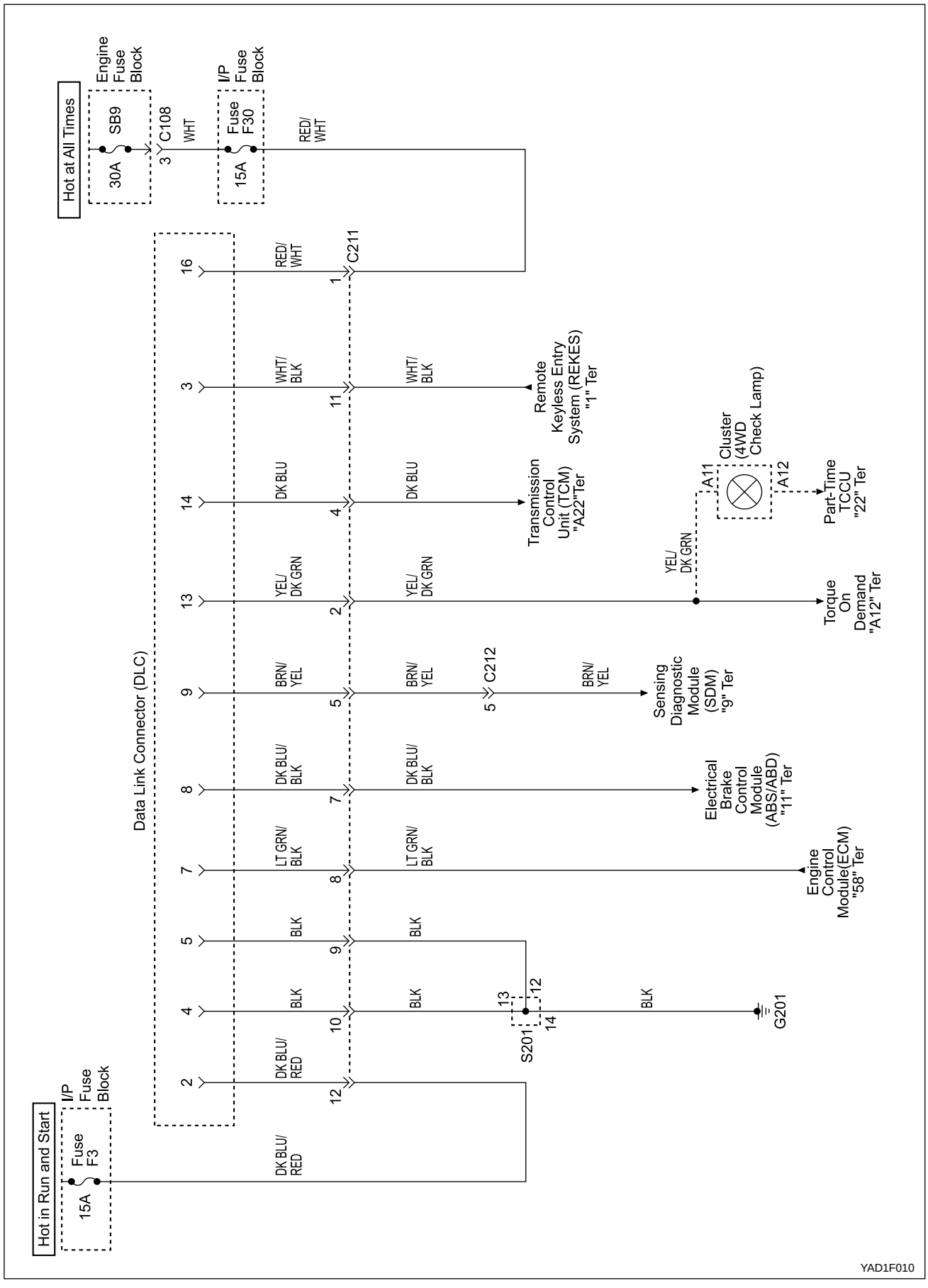
Installation Notice

Tightening Torque	10 N•m (89 lb-in)

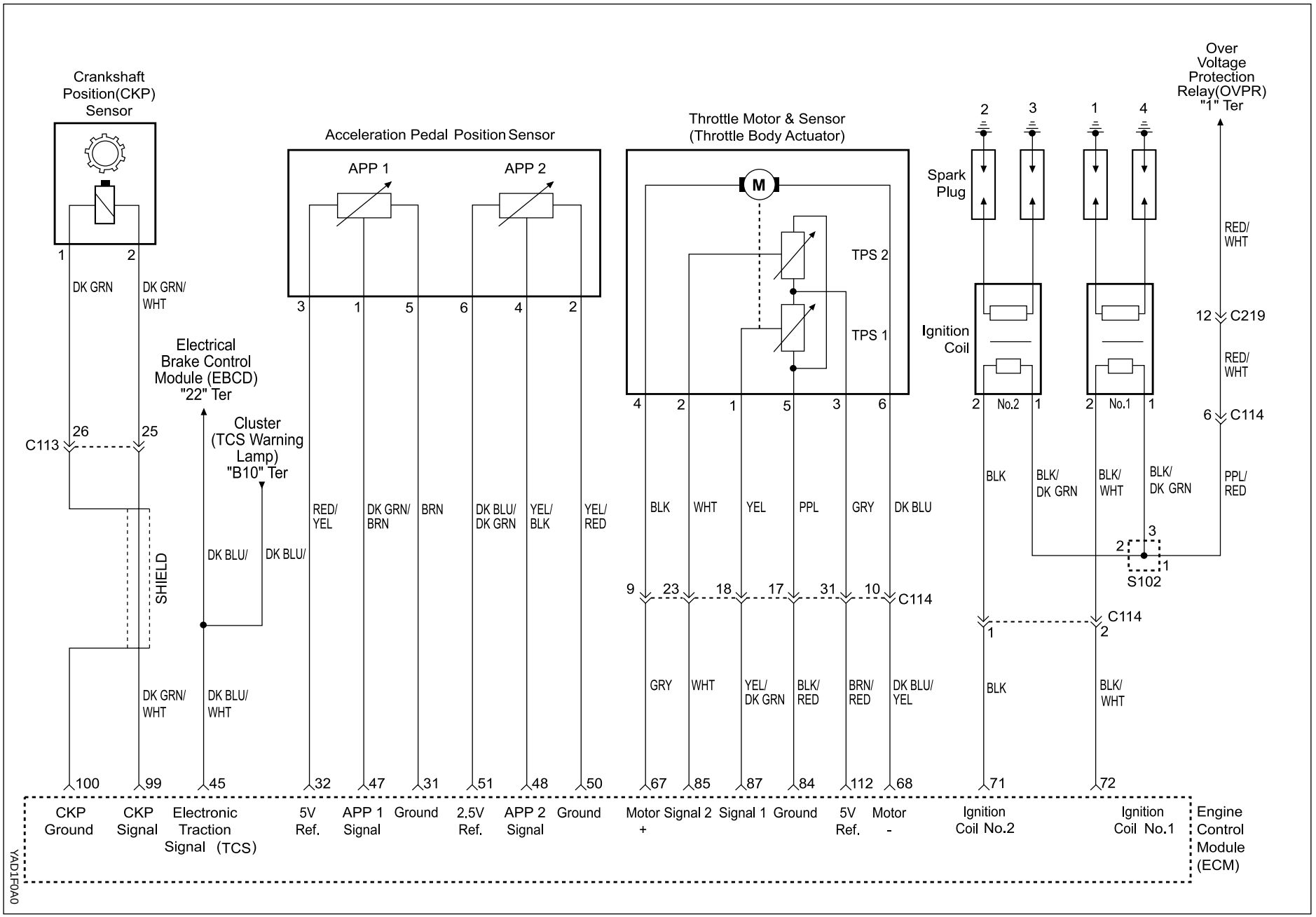
4. Pull out the ECM from the bracket.
5. Disconnect the vehicle side coupling.
6. Installation should follow the removal procedure in the reverse order.

SCHEMATIC AND ROUTING DIAGRAMS

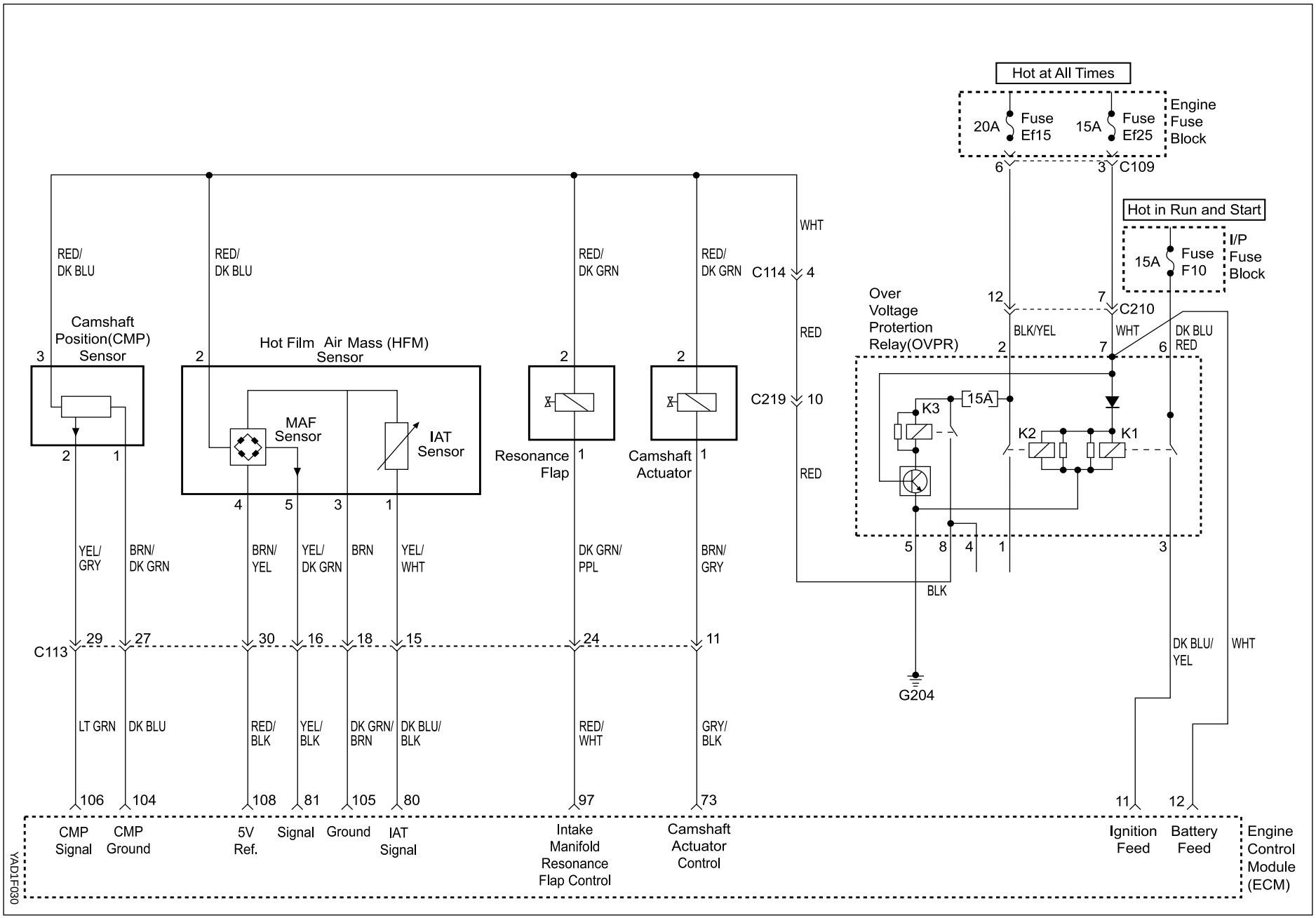
ECM WIRING DIAGRAM (2.3L DOHC - 1 OF 7) (MSE 3.53D)



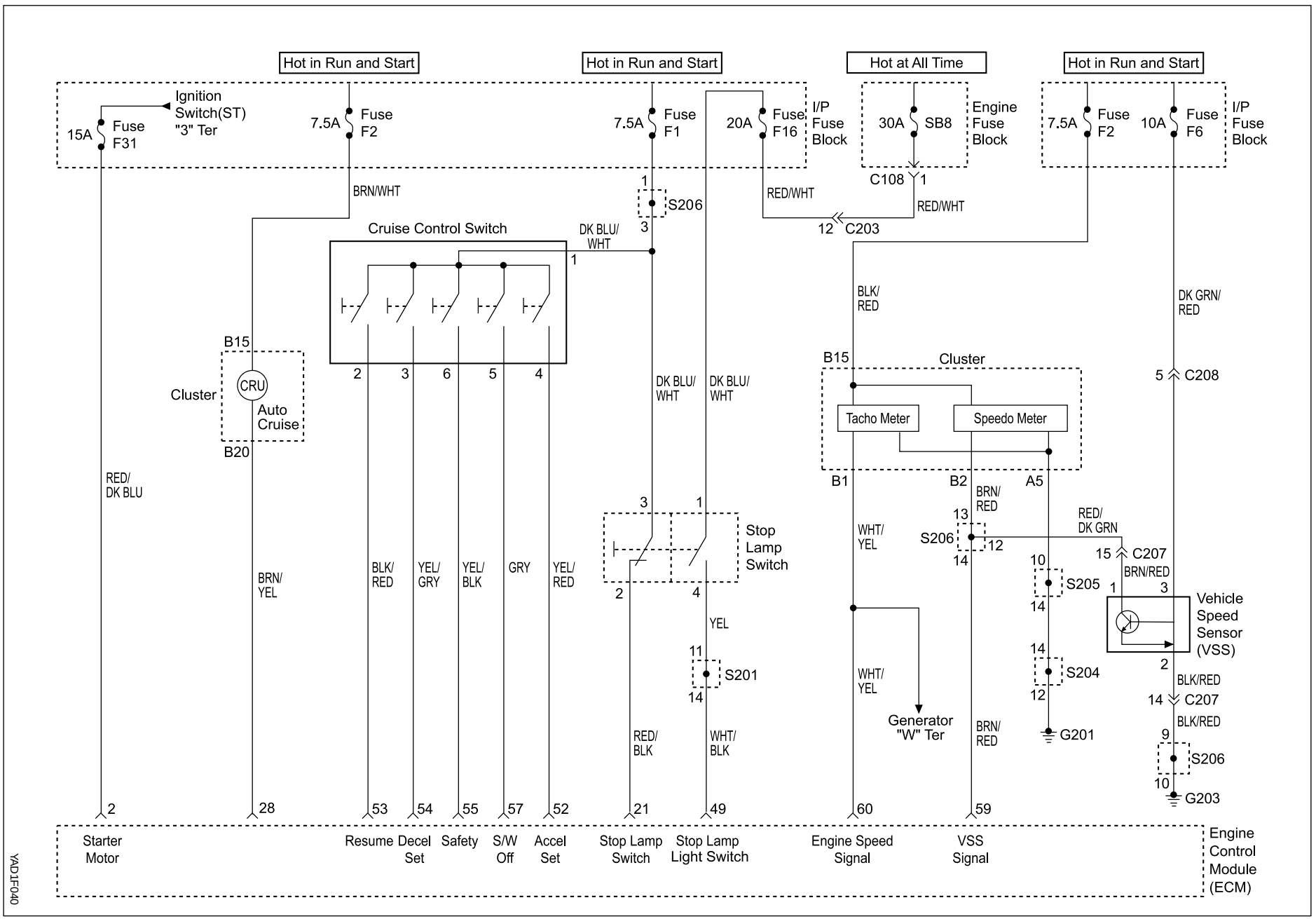
ECM WIRING DIAGRAM (2.3L DOHC - 2 OF 7) (MSE 3.53D)



ECM WIRING DIAGRAM (2.3L DOHC - 3 OF 7) (MSE 3. 53D)



ECM WIRING DIAGRAM (2.3L DOHC - 4 OF 7) (MSE 3.53D)



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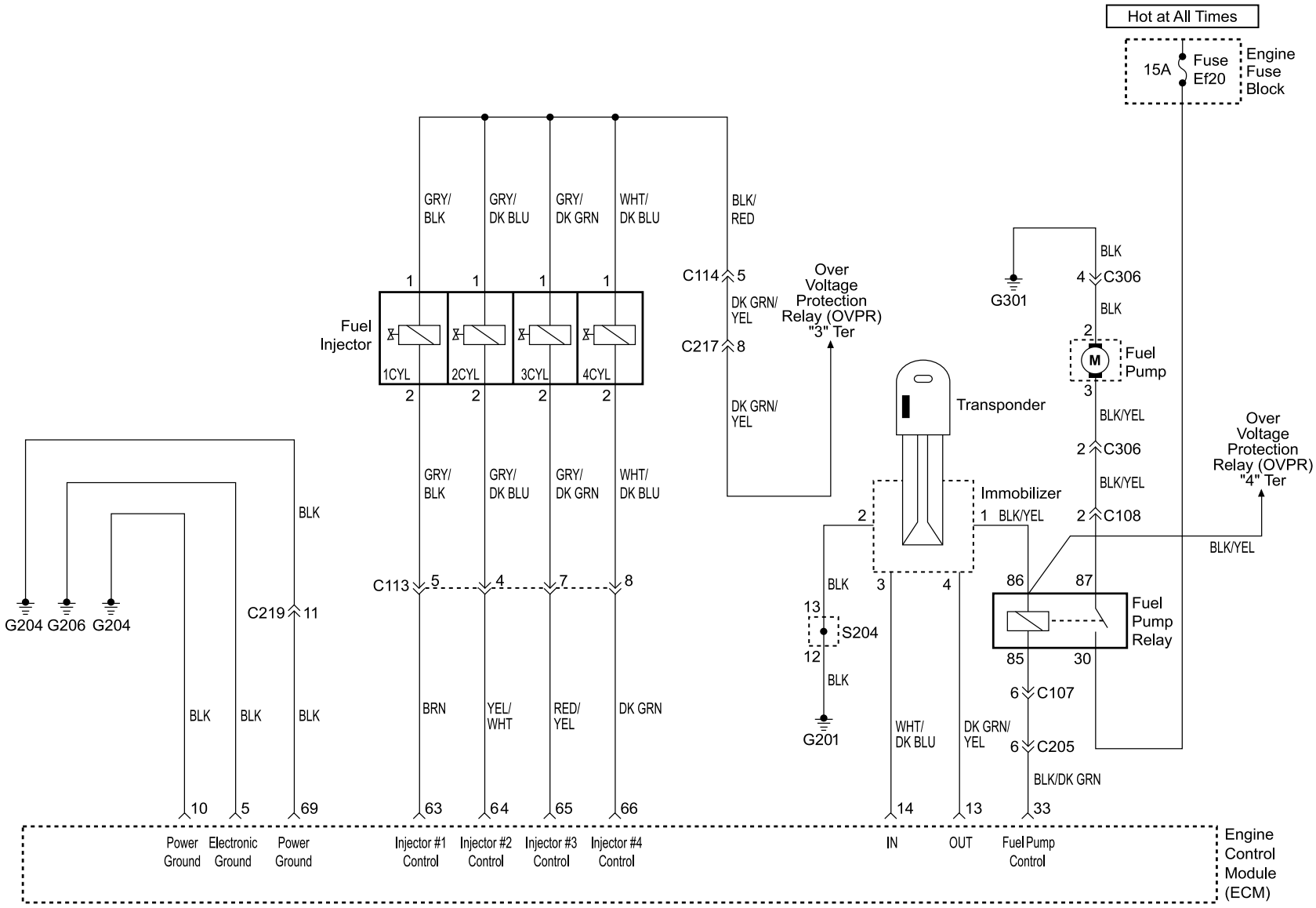
ECM WIRING DIAGRAM (2.3L DOHC - 5 OF 7) (MSE 3.53D)



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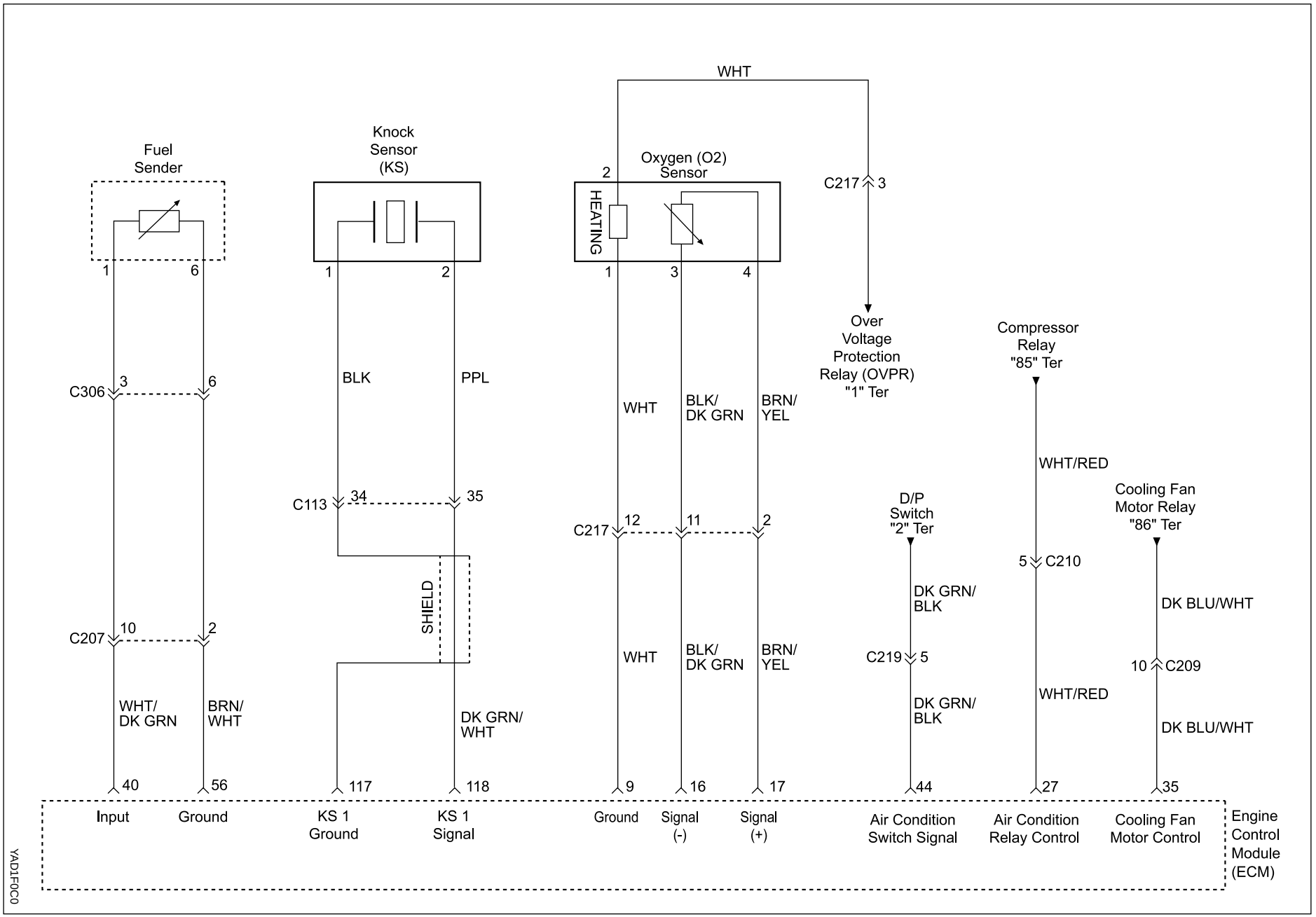
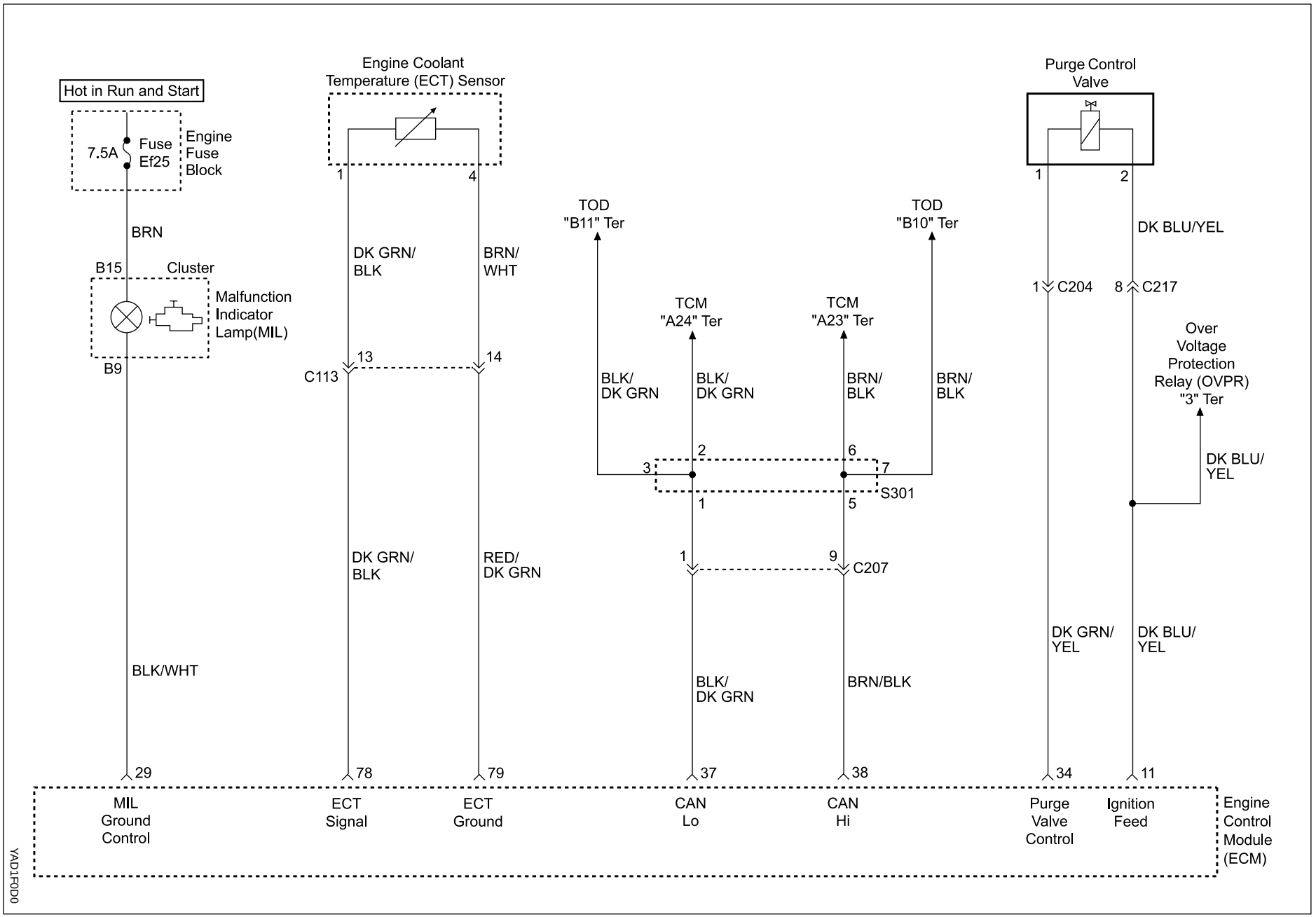
ECM WIRING DIAGRAM (2.3L DOHC - 6 OF 7) (MSE 3.53D)



ECM WIRING DIAGRAM (2.3L DOHC - 7 OF 7) (MSE 3.53D)



SPECIFICATIONS

ENGINE DATA DISPLAY TABLE

Parameter	Unit	Value
Engine Coolant Temp.	°C	greater than 95 °C after warm up
Intake Air Temp.	°C	-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 %
Mass Air Flow Meter	Kg/h	16 ~ 25 Kg/h
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.

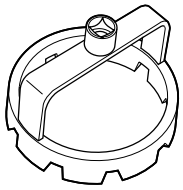
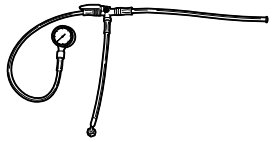
It is therefore recommended that earthed pumps with integrally earthed hoses be used, and that storage containers be properly earthed during all noncommercial fueling operations.

TEMPERATURE VS RESISTANCE

°C	°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

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS TABLE

 YAA1F890	**661 589 00 46 00** **Fuel Tank Cap Wrench**
 KAA1F490	**103 589 00 21 00** **Fuel Pressure Gauge**

SECTION 1F3

DIESEL ENGINE CONTROLS

Caution: 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.

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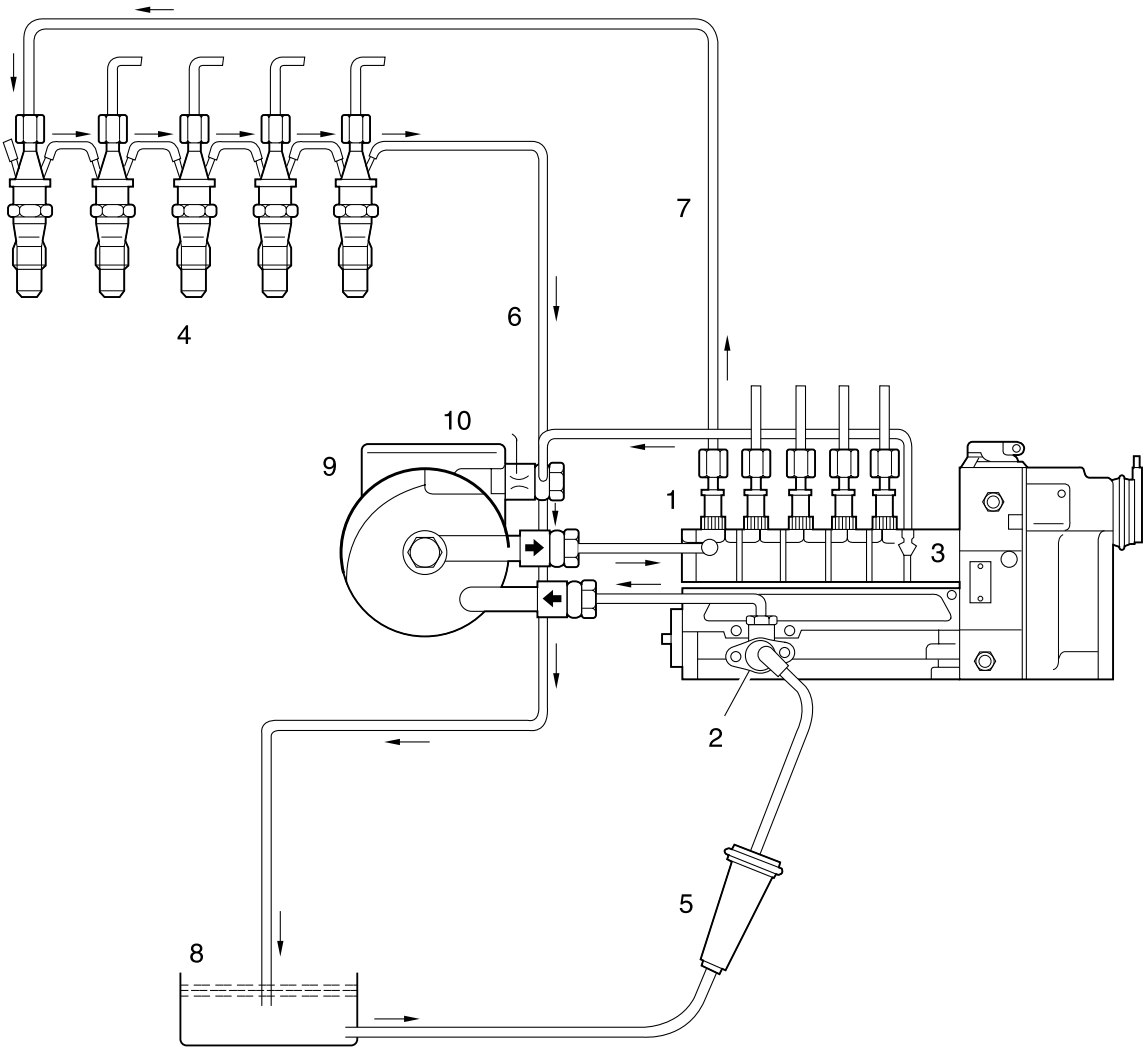
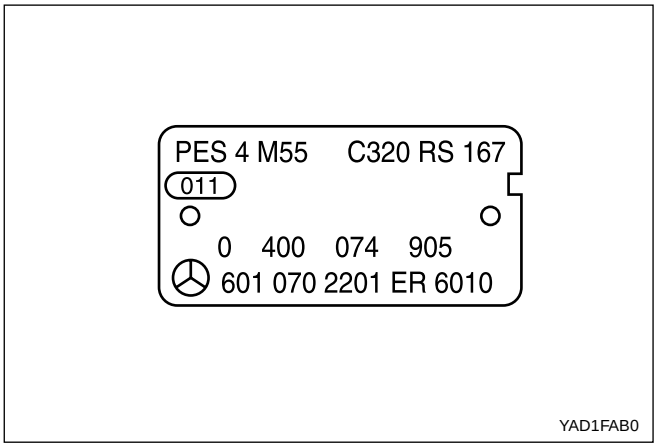
DESCRIPTION AND OPERATION

FUEL SYSTEM

Fuel Injection System



1 Fuel Injection Pump
2 Fuel Feed Pump
3 Overflow Valve
4 Injection Nozzle
5 Pre-filter
6 Fuel Return Hoses
7 Injection Line
8 Fuel Tank
9 Fuel Filter
10 Choke Orifice



Fuel Injection Pump Coding

PES 5M 55C 320 RS 167

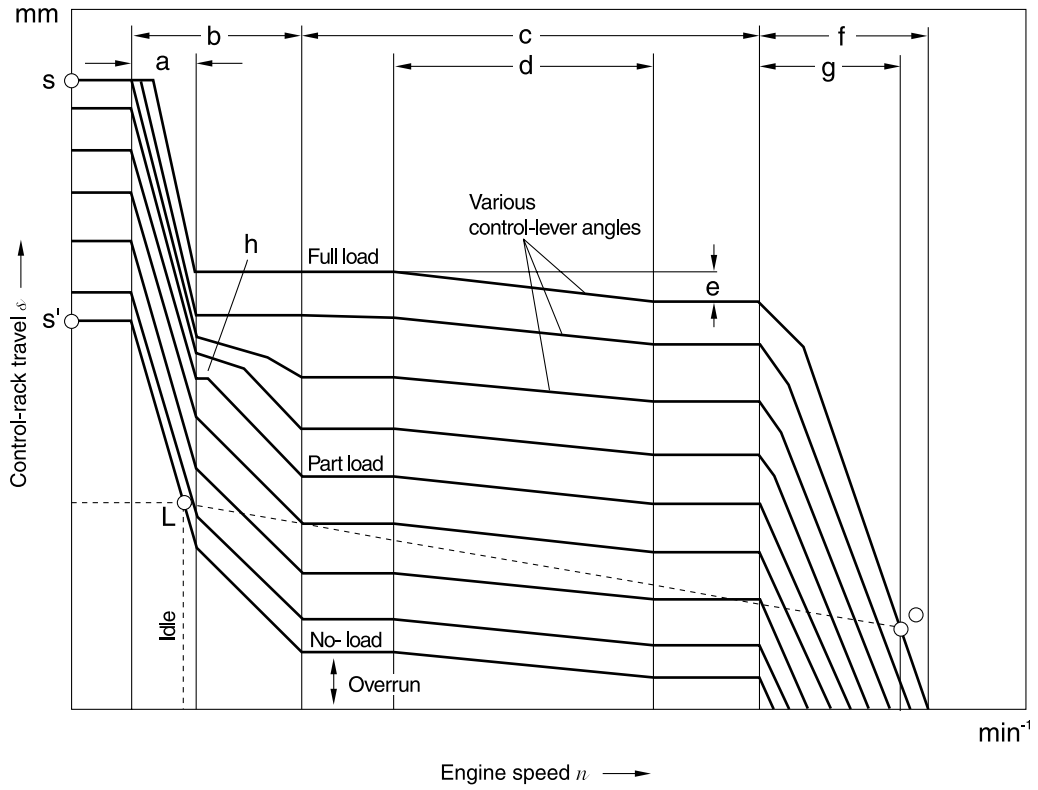
P Injection Pump
E Self - Driven
S End Flange Mounting
5 Number of Cylinders (5EA)
M Pump Size (Flange Stroke)
M - 7 mm
A - 8 mm
M, W - 8 mm, 10 mm
P - 10 mm, 11 mm, 12 mm
Z - 12 mm
O - 15 mm

55 Element Diameter
C Modification Letter
320 Assembly Number
R Direction of Rotation (clockwise)
S167 Special Version

GOVERNOR

RSF Minimum-maximum-speed governor

The RSF mechanical governor was developed specifically as a minimum-maximum-speed governor. It is suitable for use in those on-road vehicles (passenger cars and commercial vehicles) in which control requirements are restricted to low idle and high idle (maximum) speeds.control requirements are restricted to low idle and high idle (maximum) speeds. In the uncontrolled range between these two speed, the driver uses the accelerator pedal to directly adjust the setting of the injection-pump control rack so that the engine develops the right torque.



a Idle Range (Working Range of the Idle Spring)
b Extended Idle Range at No-Load and Minimum Part Load (Working Range of the Idle Spring and the Auxiliary Idle Spring)
c Uncontrolled Range
d Torque-Control Range (Working Range of the Torque-Control Spring)
e Torque-Control Travel
f Speed-Regulation Range (Working Range of the Governor Spring)
g Full-Load Speed Regulation to the High Idle Speed
h Start of the Auxiliary Idle-Spring Shutoff

S Start Setting With Accelerator Pedal fully Depressed (Cold-Start)
S ' Start Setting With Accelerator Pedal Released (Hot/ Warm Start)
L Low-Idle-Speed Setting
O High-Idle-Speed Setting

n_{1u} Low Idle Speed
n_{1o} High Idle Speed
n_{vo} Maximum Full-Load Speed
n_1 Speed at Start of Torque Control
n_2 Speed at End of Torque Control

Speed-sensing mechanism stage 1 (low idle)

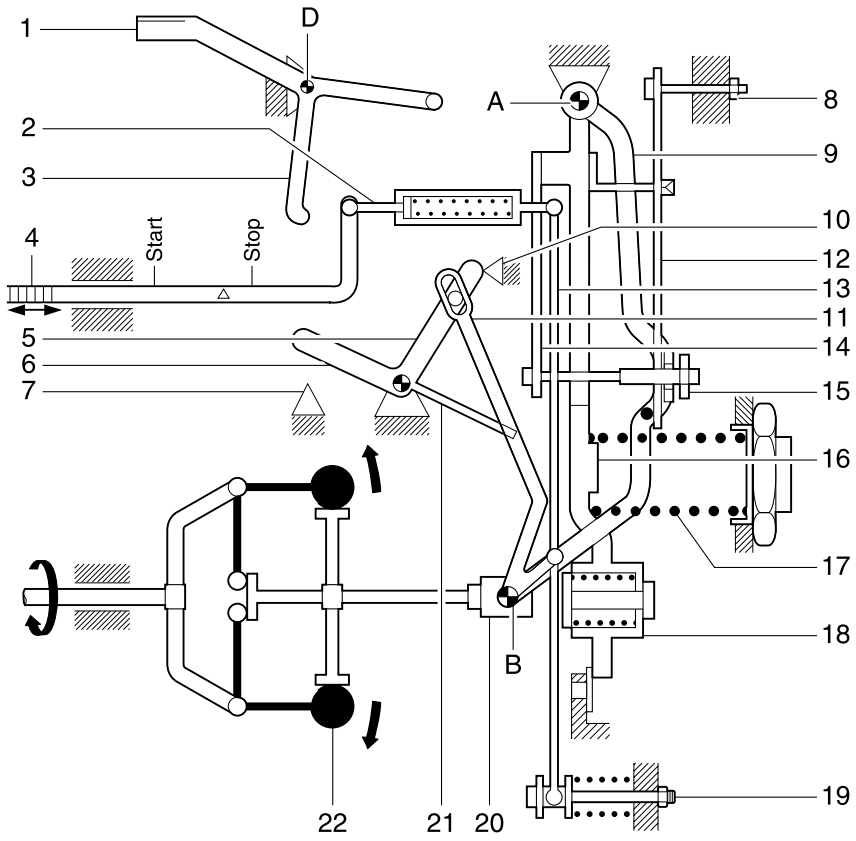
The force path starts at flyweights (22) and travels through sliding sleeve (20) and guide lever (9) to idle spring (12) and auxiliary idle spring (14). Both springs are leaf springs.

Speed-sensing machanism, stage 2 (until full-load speed regulation)

After completion of idle-speed sleeve travel, the force path is from governor sliding sleeve (20) through torque-control spring retainer (18) and tensioning lever (16) to governor spring (17).

The flyweights (22) are fastened directly to the injection-pump camshaft and when they move outward, governor sliding sleeve (20) is moved axially. The sliding sleeve does not move except in the idle, full-load torque-control, and speed-regulation breakaway ranges. The fuel delivery quantity needed for the required engine torque is selected by the actuator-mechanism control lever.

The guide lever (9) is movably connected at pivot point B with the governor sliding sleeve. In addition, guide lever and tensioning lever (16) also pivot at point A.



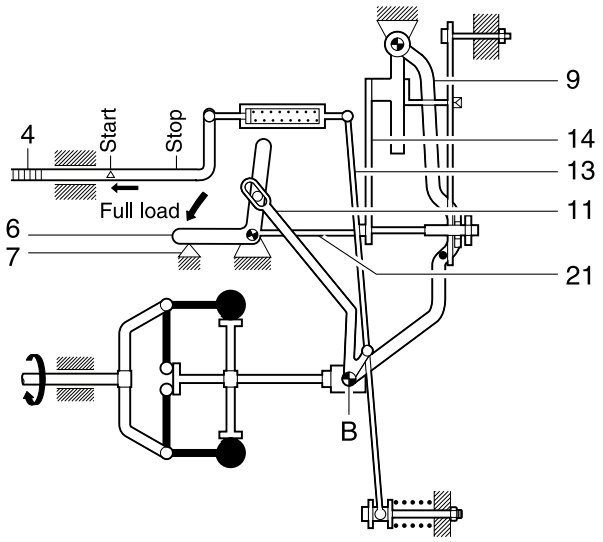
1 Stop(Shutoff) Lever
2 Strap
3 Stop Lever
4 Control Rack
5 Linkage Lever (Inner)
6 Control Lever (Outer)
7 Full-Load Stop
8 Adjusting Screw For Idle Speed
9 Guide Lever
10 Idle Stop
11 Reverse-Transfer Lever
12 Idle-Speed Spring
13 Variable-Fulcrum Lever
14 Auxiliary Idle Spring
15 Adjusting Screw for Auxiliary Idle Spring
16 Tensioning Lever
17 Governor Spring
18 Spring Retainer (Torque Control)
19 Full-Load Adjusting Screw
20 Governor Sliding Sleeve
21 Auxiliary-Idle-Spring Switch-Off Device
22 Flyweight

Actuator mechanism

Input of the desired valve is through control lever (6) linkage lever (5) and reverse-transfer lever (11) to variable fulcrum lever (13), and from there through strap (2) to injection-pump control rack (4). The strap is spring-loaded, and compensates for the extra movement of the fulcrum lever. Similar to the guide lever, the reverse-transfer lever is also flexibly mounted at pivot point B of the sliding sleeve, and is also attached to the fulcrum lever (13) via a shaft and bushing. Full-load delivery at the fulcrum lever's lower bearing point, which also acts as the spring-loaded yield point for the fulcrum lever for absorbing the sliding sleeve's additional travel in case of excessive speed. The bearing shaft of the stop lever (3) protrudes from the governor housing. Attached to its end is a stop (shutoff) lever (1) which switches off the engine, whereby the stop lever pulls the control rack in the stop (shoutoff) direction.

Starting the engine

The engine is to be started according to the vehicle manufacturer's operating instructions. Normally, it can be started without pressing the accelerator pedal. Only with a cold engine at low temperatures is the accelerator pedal to be pushed to the floor so that control lever (6) is shifted up against full-load stop(7) – a fixed stop on the governor housing. Reverse- transfer lever (11) swivels around pivot point B, and in doing so shifts fulcrum lever (13) in the "Start" direction. The result is that the control rack (4) is moved to the start setting and the engine receives the required start quantity. Rapid speed regulation from the governor start setting is made possible by lifting the auxiliary idle spring (14) away from fulcrum lever (9) by a switch-off device (21) when the control lever is in the full-load position.



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4 Control Rack
6 Control Lever (Outer)
7 Full-Load Stop
9 Guide Lever
11 Reverse-Transfer Lever
13 Variable-Fuicrum Lever
14 Auxiliary-Idle Spring
21 Auxiliary-Idle Spring Switch-Off

Cold-start setting (only the components concerned in the governing process shown.)

Operating Characteristics

Low idle speed

Once the engine starts and the accelerator pedal is released, a return spring pulls control lever (6) back to the low-idle position. Linkage lever (5) is now up against idle-speed stop screw(10).

During warm-up, low idle speed follows the idle-speed control curve and stabilizes at Point L.

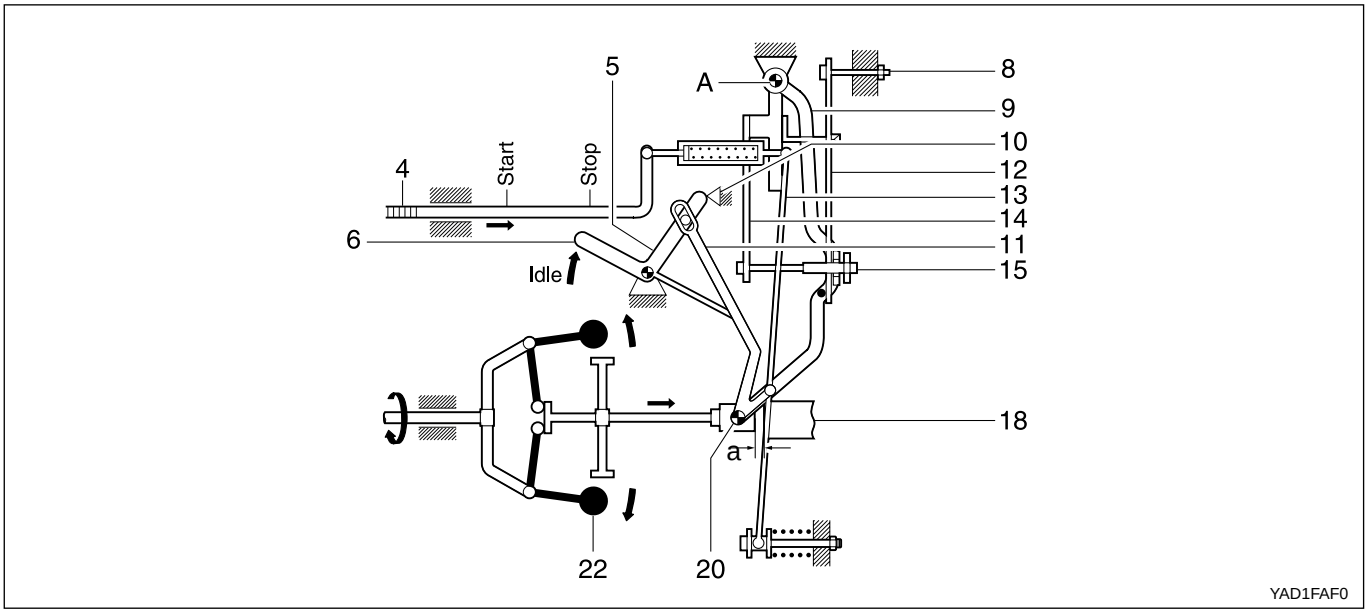
When speed increases, flyweights (22) move outward, and shift governor sliding sleeve (20) to the right. During operation within the idle range, sliding sleeve movement is transmitted through reverse-transfer lever (11) and fulcrum lever (13); moving the control rack (4) toward Stop (shutoff). At the same time, sliding-sleeve movement causes guide lever (9) to swivel about pivot point A, compressing the idle leaf spring (12). This spring's pretension (and thus the low idle speed) is set using adjusting screw(8). At a given speed, the fulcrum lever also comes up against the adjusting nut for auxiliary idle spring (14).

Intermediate speed

After passing through the idle stage (a), governor sliding sleeve (20) and spring retainer (18) for torque control come into contact with each other. In the uncontrolled range between idle and maximum speed, the position of the flyweights (22) remains constant up to high idle (maximum) speed, the only exception being for minor adjustments necessary for torque control. Control-rack setting and therefore delivery quantity are selected directly through control lever (6).

That is, the driver uses the accelerator pedal to select the delivery quantity necessary to increase speed or climb hills (control-lever position between idle stop and full-load stop).

If the driver depresses the accelerator pedal fully, the control rack shifts to the full-load delivery setting.



4 Control Rack
5 Linkage Lever (Inner)
6 Control Lever
8 Adjusting Screw For Idle Speed
9 Guide Lever
10 Idle Stop
11 Reverse-Transfer Lever
12 Idle-Speed Spring
13 Variable-Fulcrum Lever
14 Auxiliary Idle Spring
15 Adjusting Screw for Auxiliary Idle Spring
18 Spring Retainer (Torque Control)
20 Governor Sliding Sleeve
22 Flyweight

Idle-speed setting.

(only the components concerned in the governing process are shown)

Torque control

If torque control is fitted, full-load delivery quantity is reduced when a given speed n_1 is exceeded, because centrifugal force acting on sliding sleeve (20) exceeds the force of the torque-control spring fitted in spring retainer (18). The torque-control spring yields to this force. As a result, if speed increases further, control rack (4) shifts by the torque-control travel distance. Torque control ends at speed n_2.

Instead of positive torque control, the RDF governor can have negative torque control. Here the control-rack setting is controlled by a spring combination.

High idle (maximum) speed

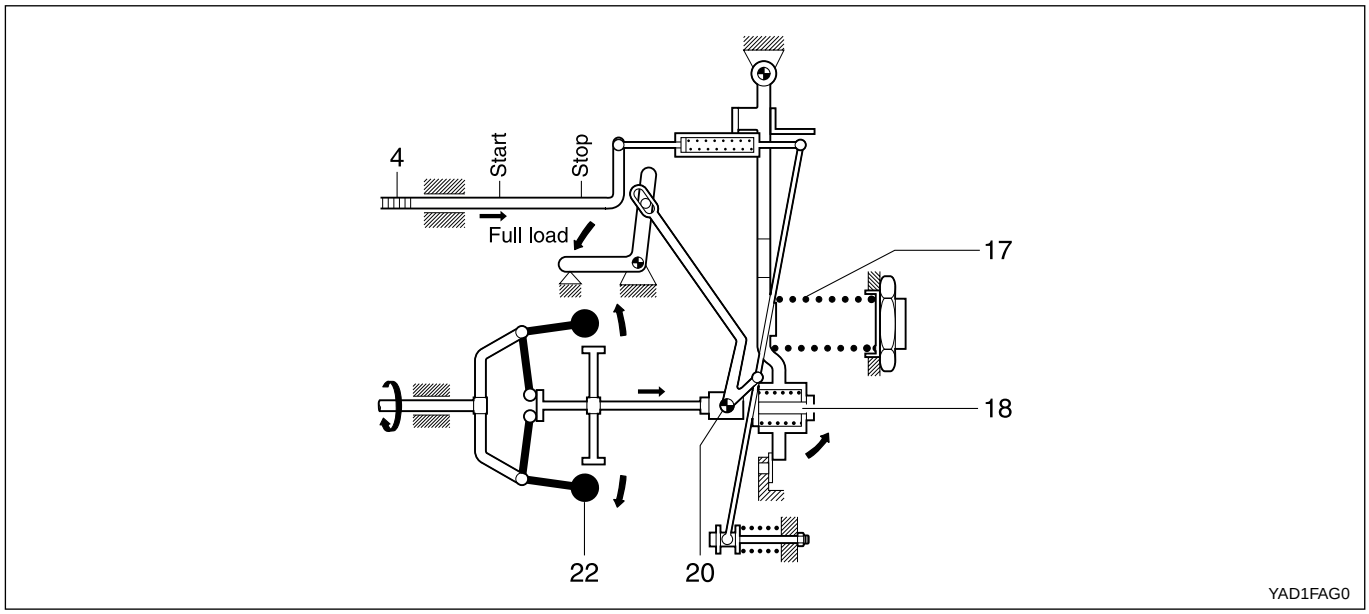
With the accelerator pedal pressed to the floor, the full-load quantity is injected until the maximum full-load speed n_{vo} is reached. If engine speed increases beyond full-load speed, the force exerted by the flyweights (22) suffices to overcome the force of governor spring (17) and full-load-speed regulation starts.

Engine speed increases slightly, and rack travel is reduced due to the rack being moved towards stop (shutoff) and the delivery quantity decreases.

Breakaway depends upon governor spring pretension. The engine adjusts to high idle (maximum) speed n_{10} when all load is removed.

When driving downhill with the accelerator released, the vehicle drives the engine (overrun) and accelerates it.

No fuel is injected during this operating mode (overrun fuel shutoff).



4 Control Rack
17 Governor Spring
18 Spring Retainer (Torque Control)
20 Governor Sliding Sleeve
22 Flyweight

Full-load setting

(only the components concerned in the governing process are shown)

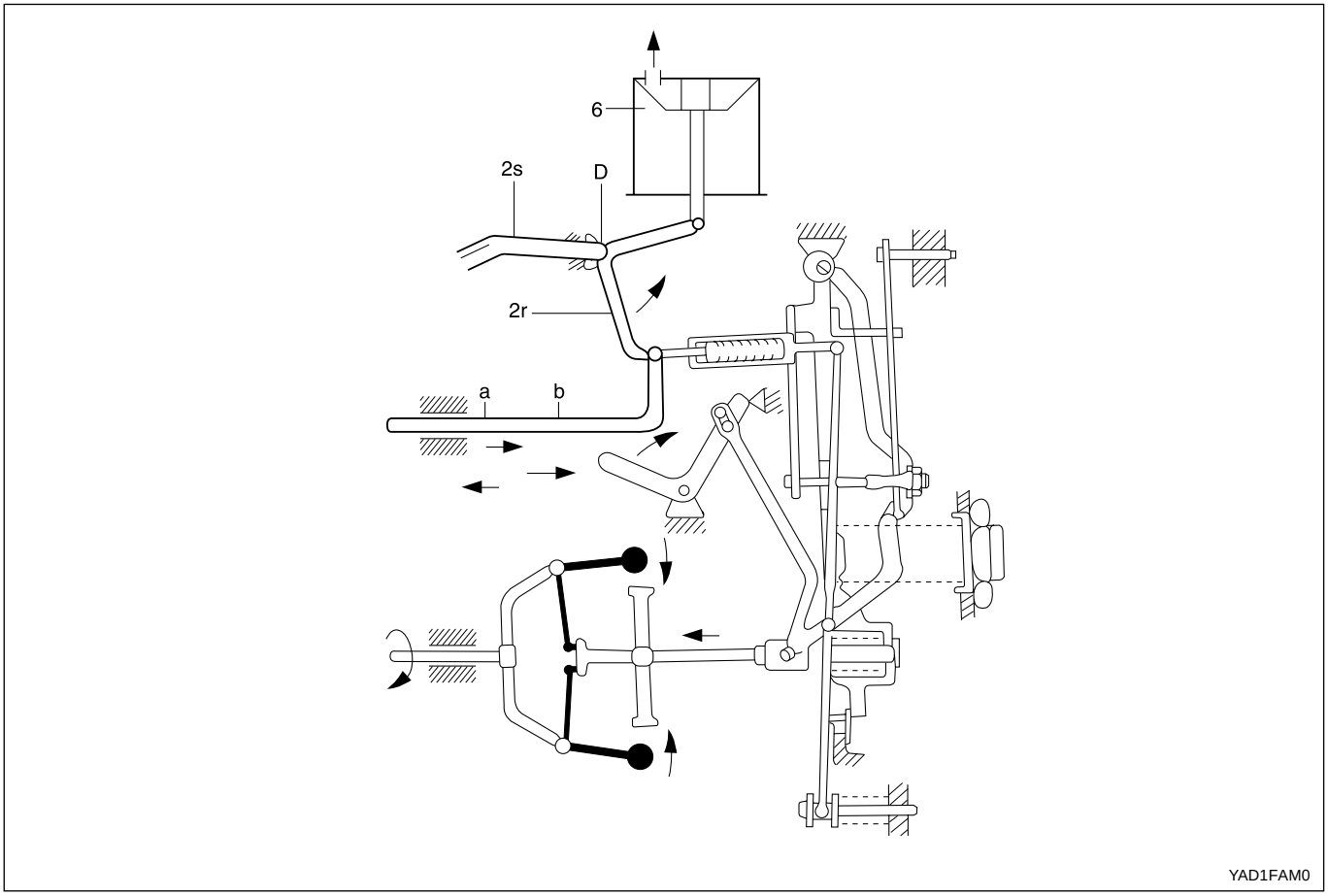
Stopping the engine

When Stop (shutoff) lever (1) is moved by hand, stop lever (3) shifts control rack (4) to the Stop (shutoff) position. The fuel supply is interrupted and the engine stops. A pneumatic shutoff device can also be used for engine switchoff.

Switching off

The vacuum unit (6) is connected to vacuum from the vacuum pump via the glow starter switch of the vehicle. As a result, the diaphragm of the vacuum unit is pulled against the compression spring.

The vacuum unit (6) is connected with a stop lever (2r). This lever pivots around the fulcrum “D” pulling the control rod of the injection pump into the “stop position”. The bypass spring of the fulcrum lever is overcome in this process. Via the emergency stop lever (2s) the control rod can likewise be pulled into “stop position” on the outside of the governor.

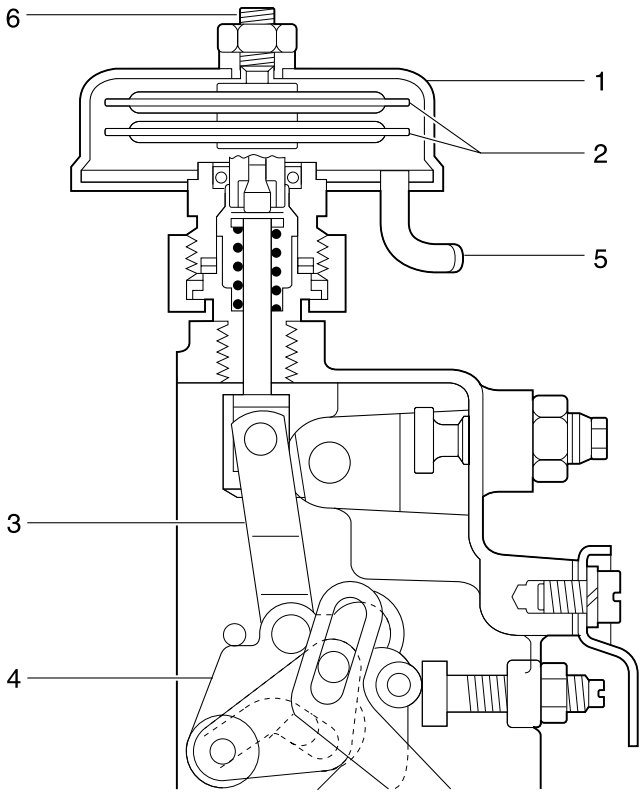


a Start
b Stop

ABSOLUTE METERING MANIFOLD PRESSURE COMPENSATOR (ALDA)

On a pressure-charged engine, the cylinder air charge depends upon the boost pressure, which in turn is influenced by the prevailing atmospheric pressure. The effects of variants in atmospheric pressure have an especially large influence when considerable differences in attitude are encountered in driving.

Because the engine's turbocharger further compresses the prevailing atmospheric pressure, the absolute pressure in the engine's intake manifold is a combination of the atmospheric pressure and the charge-air pressure. The absolute-metering manifold-pressure compensator registers this absolute pressure and adapts the fuel-delivery quantity accordingly.



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1 Adjusting Screw
2 Aneroid Box
3 Connection for the Line to the Engine Manifold
4 Aneroid Capsule
5 Adaptation
6 Guide Plate

PNEUMATIC IDLE SPEED INCREASE (PLA)

Application

The injected fuel quantity needed by a diesel engine at idle decreases along with increasing engine temperature.

When the engine is cold, the temperature-dependent idle-speed increase fitted to the RSF governor raises the idle speed accordingly, there by improving the engine's warm-up behaviour. It also prevents the cold engine stalling when additional loads are switched, such as power-assisted steering, air-conditioner, etc.

The PLA ceases to function above a certain temperature.

Design and Function

Depending upon temperature, pressure is applied to the aneroid capsule's diaphragm which in turn shifts a sliding bolt to change the pretension on the idle spring. The control rack now moves towards "increased fuel quantity" via the governor linkage and the control rack.

Operation

Coolant temparature <0°c

The thermovalve is open. The vacuum of approx. 700 mbar reaches the vacuum unit idle speed increase via the thermovalve. The idle speed is increased by approx 100/min. The choke in the ventilation filter causes a pressure loss of approx 100 mbar.

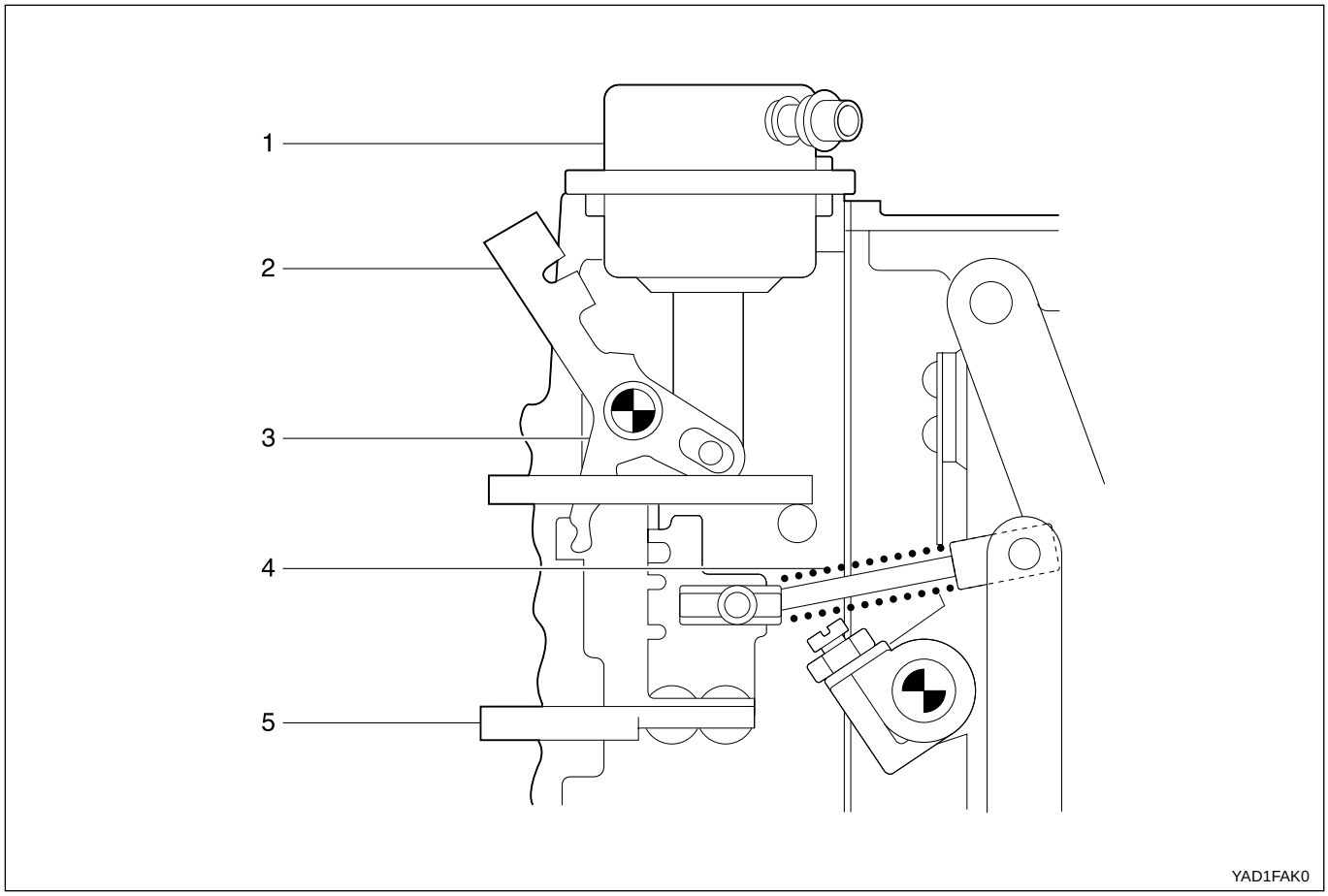
Coolant temperature >0°c

The thermovalve is closed. Atmospheric pressure reaches the vacuum unit through the choke in the ventilation filter. The speed increase is cancelled.

PNEUMATIC SHUT-OFF DEVICE (PNAB)

To shut off the engine, the key in the steering lock is turned to “stop”. This applies vacuum to the shut-off device diaphragm which pulls the control rack to the stop setting.

This device can only be installed on vehicle which are equipped with a vacuum pump.



1 Pneumatic Shut-Off Device
2 Shut-Off Lever for Manual Operation
3 Stop Lever
4 Spring-Loaded Strap
5 Control Rack

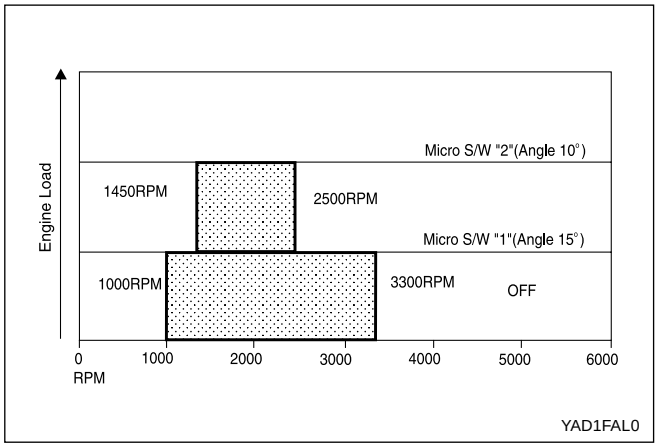
EXHAUST GAS RECIRCULATION (EGR) VALVE

The Exhaust Gas Recirculation (EGR) system is the device to lower the NOx (oxides of nitrogen) emission level caused by high combustion temperature.

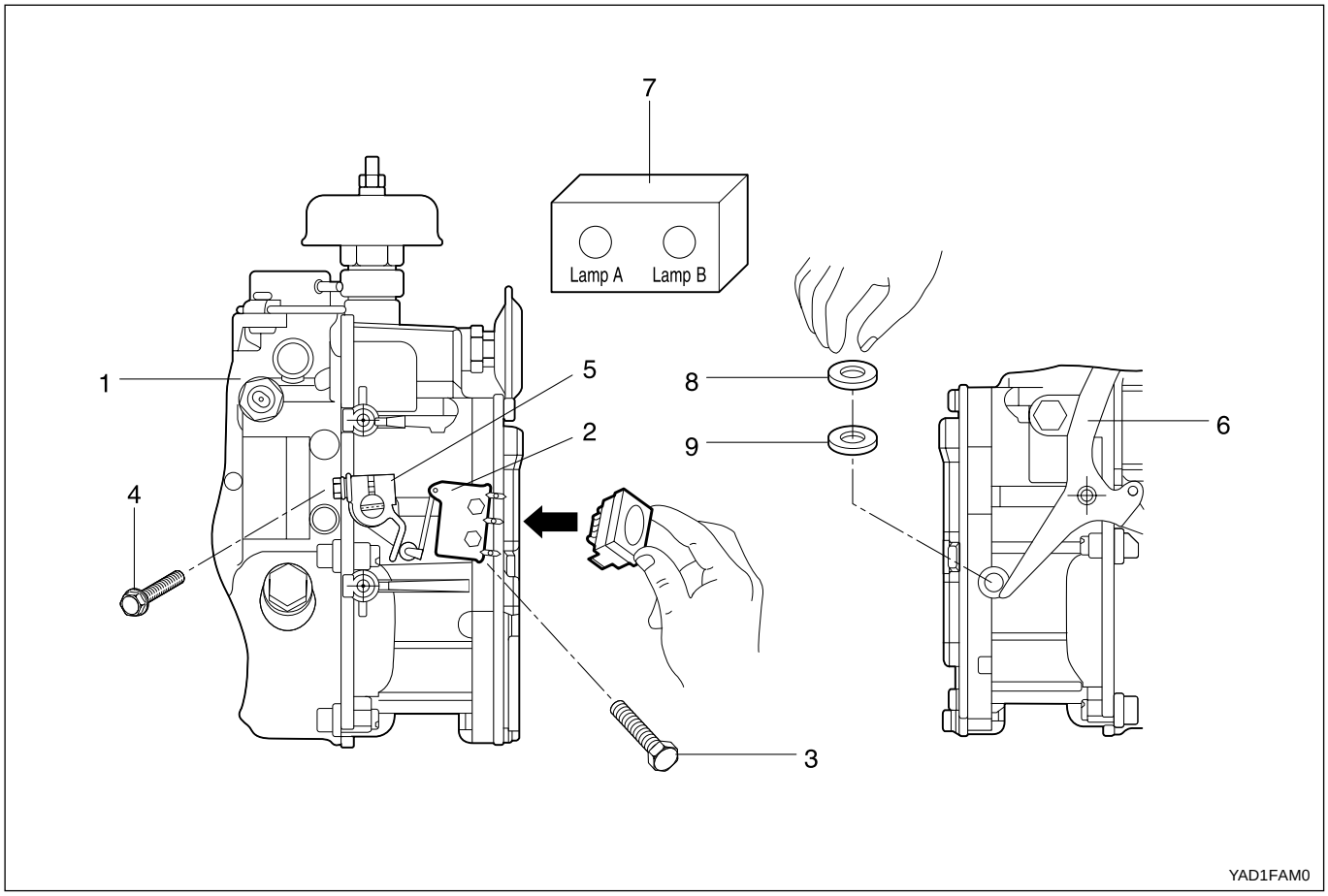
Because the combustion process of the diesel engine always needs excessive air, the exhaust gas contains large amount of NOx.

The EGR valve restricts NOx generation by recirculating some amount of the exhaust gas into the combustion chamber to reduce the combustion temperature.

But the recirculated gas results in reduced charging efficiency of mixture so that the engine performance drops down. Because of this fact, EGR valve is tuned to operate in the area where oxidized substances are generated much.



- Condition of working the EGR valve
  - 100 seconds after starting the engine
  - More than 200 RPM



1 Injection Pump
2 Micro Switch
3 Bolt
4 Screw ..... 5 N•m (44 lb-in)
5 Cam
6 Lever
7 Micro Switch
8 Adjusting Disc “A” Setting Indicator (10 inch)
9 Adjusting Disc “B” Setting Indicator (11 inch)

EGR Micro Switch Setting Procedure

Tools Required

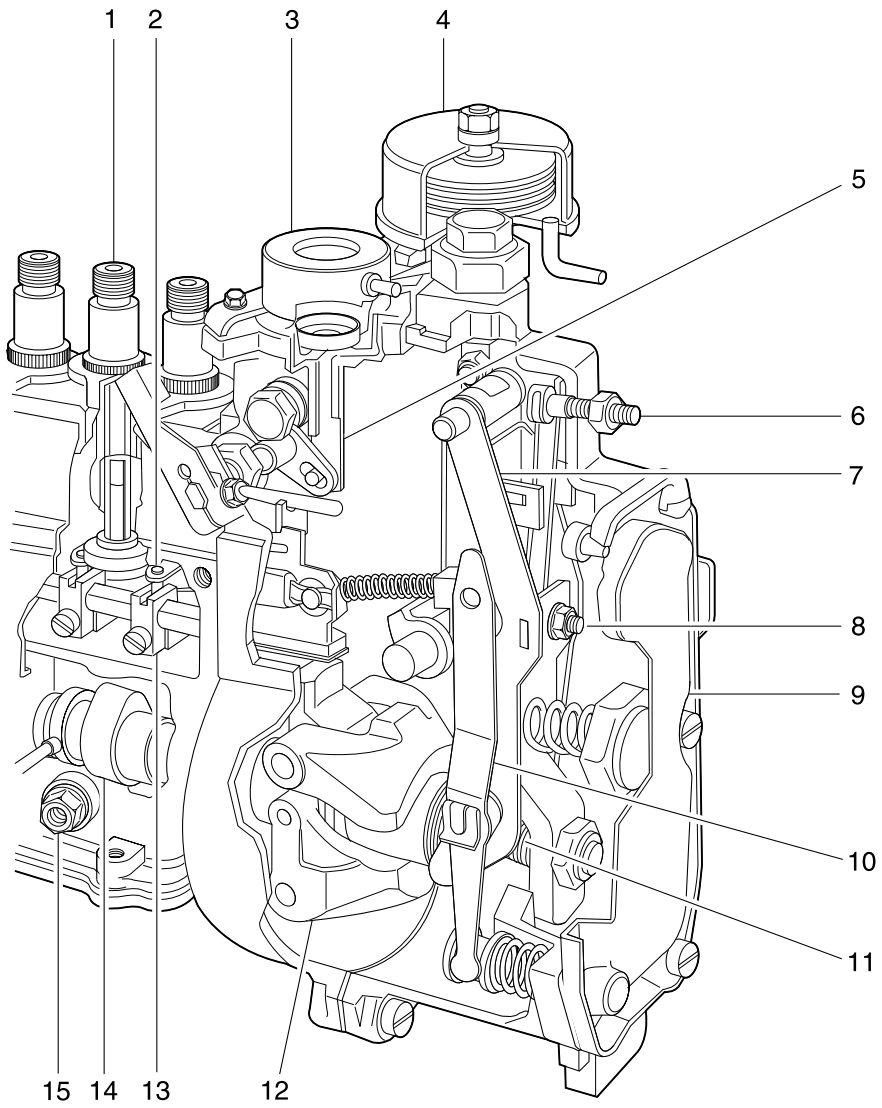
617 589 08 21 01 Micro switch Setting Device.

In turbo equipped vehicle, the timing of injection pump must be adjusted after repairing or replacement as follows:

1. Hold the injection with clamp (special) on the work bench.
2. Install the micro switch setting device 017 589 08 21 01 in the injection pump.
3. Adjust and fix the lever (6) at 10° ±1°
4. Insert the harness into the micro switch setting device 617 589 08 21 01.
5. Install the cam on the injection pump when the both lamps are “on”.
6. Install the screw.
7. At this moment, loosen the clamp and insert the adjusting disc “A” to the lever and check again.
8. If the lamp “A” is “on”, the setting is correct, thus, timing of injection pump is OK.
   If the both lamps are “on”, perform the setting as above procedure.

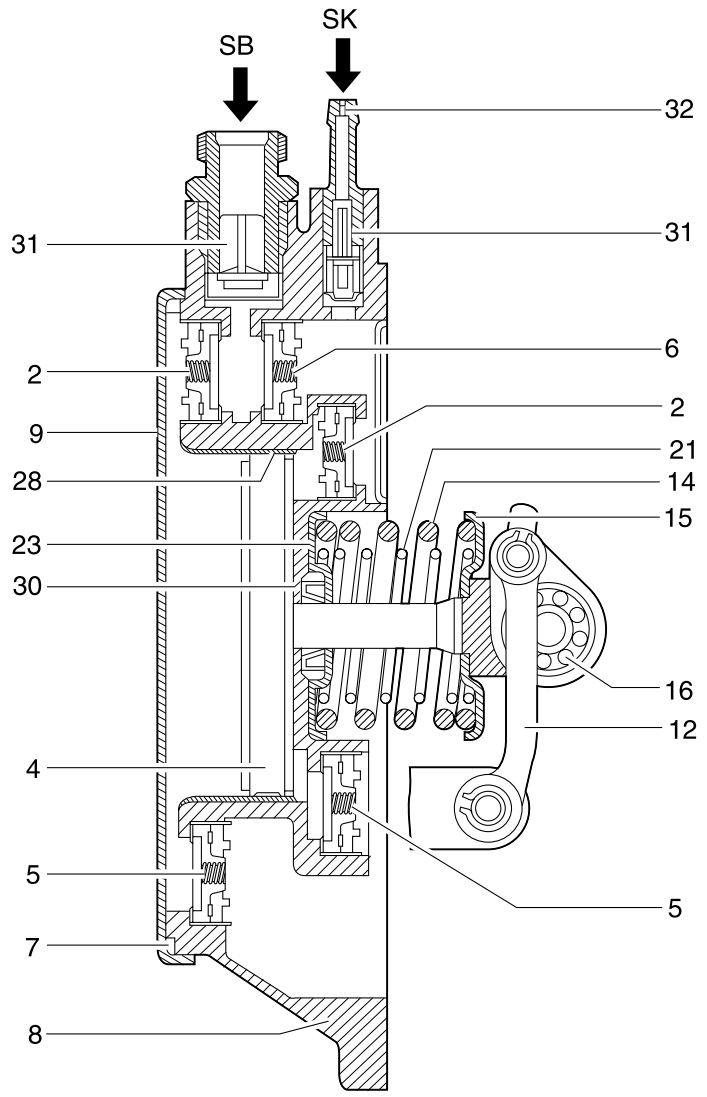
COMPONENT LOCATOR

FUEL INJECTION PUMP



1 Delivery Valve Holder
2 Control Lever
3 Engine Stop Unit
4 Idle Speed Adjustment (ALDA)
5 Stop Lever
6 Adjusting Screw for Idle Speed
7 Guide Lever
8 Adjusting Screw for Auxiliary Idle Speed
9 Governor Assembly
10 Hinge Lever
11 Spring Retainer (Torque Control)
12 Fly Weight
13 Clamping Piece
14 Plunger Driving Cam
15 Fuel Pump Driving Cam

VACUUM PUMP (SECTIONAL VIEW)

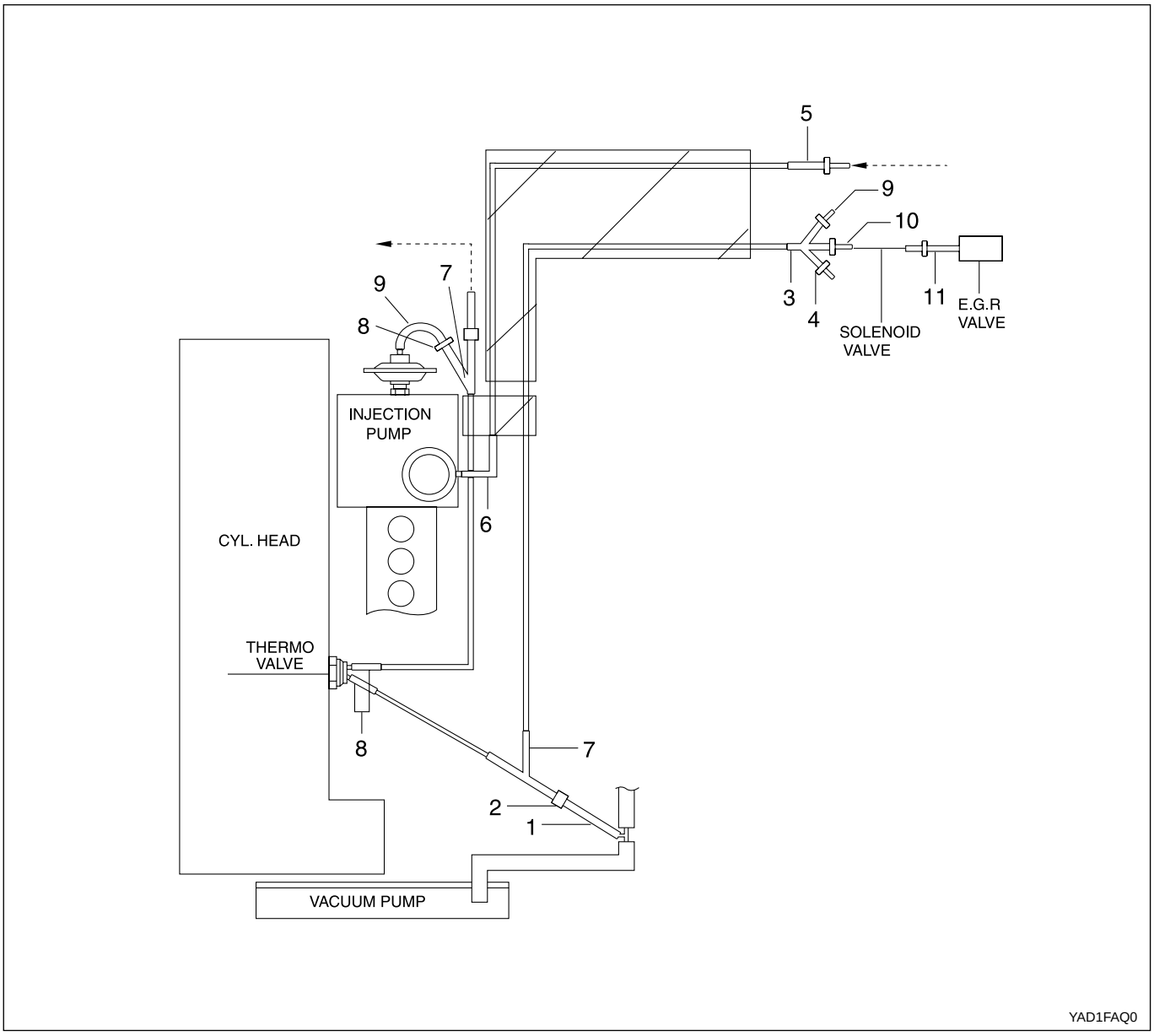


YAD1FAP0

2 Suction Valve
4 Piston
5 Pressure Valve
6 Safety Valve
7 O-Ring
8 Pump Housing
9 Pump Cover
12 Lever
14 Outer Return Spring
15 Inner Spring Retainer
16 Roller Cam
17 Piston Rod
21 Inner Return Spring
23 Upper Spring Retainer
28 Piston Ring
30 Seal Ring
31 Oil Return Valve
32 Restrictor
SB To Brake Booster
SK To Vacuum Lines

DIAGNOSTIC INFORMATION AND PROCEDURE

VACUUM CONTROL SYSTEM TEST



1 Rubber Hose
2 Air Filter
3 Distributor
4 Chock
5 Rubber Hose
6 Molding Hose
7 Distributor
8 Molding Hose
9 Connector
10 Chock Filter
11 Molding Hose

Service Data

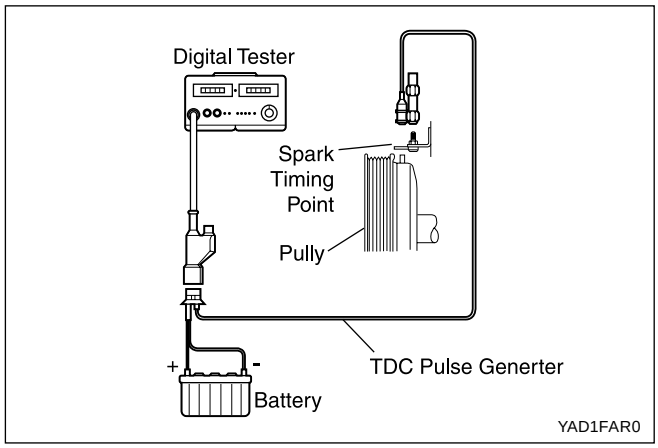
Idle Speed Increase	At least 100 rpm at approx. 500 mbr
Permissible Pressure Drop of System	400 - 500 mbar approx. 1 min

Tools Required

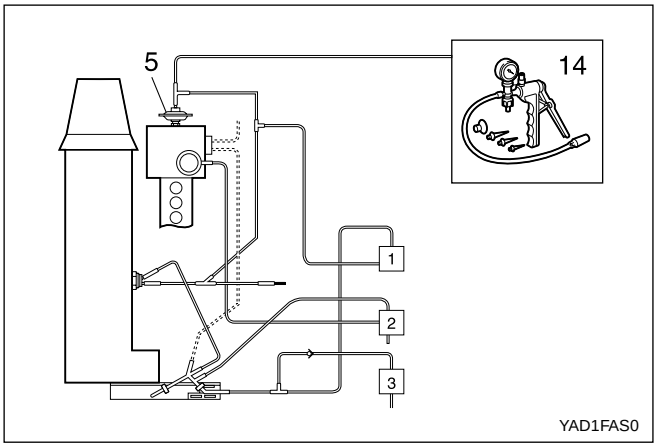
001 589 73 21 00 Vacuum Pump
201 589 13 21 00 Vacuum Tester
667 589 00 21 00 TDC pulse generator

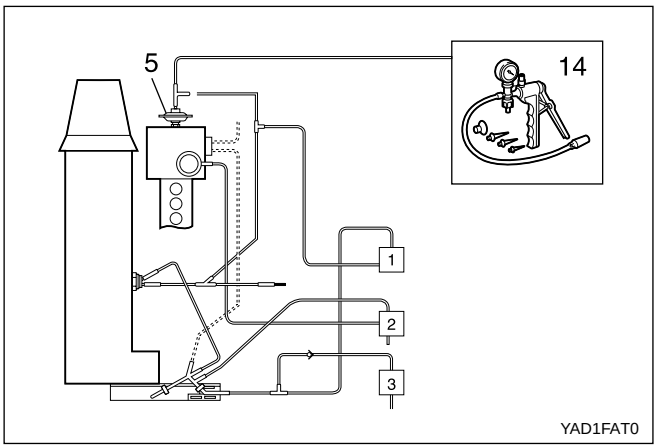
Commercial Tools

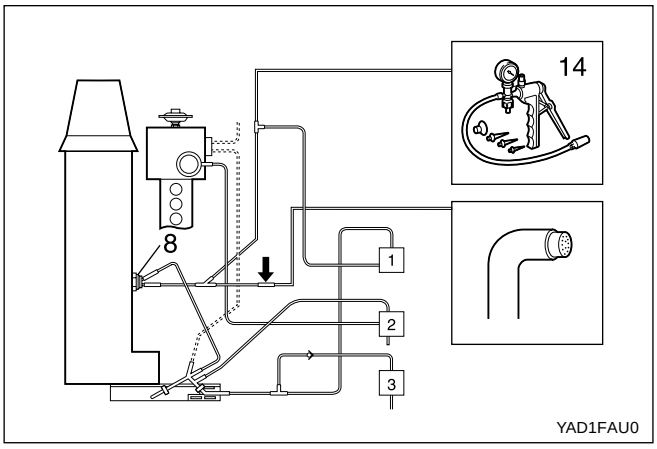
Digital tester	e.g Bosch MOT 001.03 Sun DIT 9000
Temperature measuring instrument with test probe WB24	e.g Ahlborm, Therm 2263 - 2 Eichenfeldstrabe 1 - 3 D - 8150 Holzkirichen

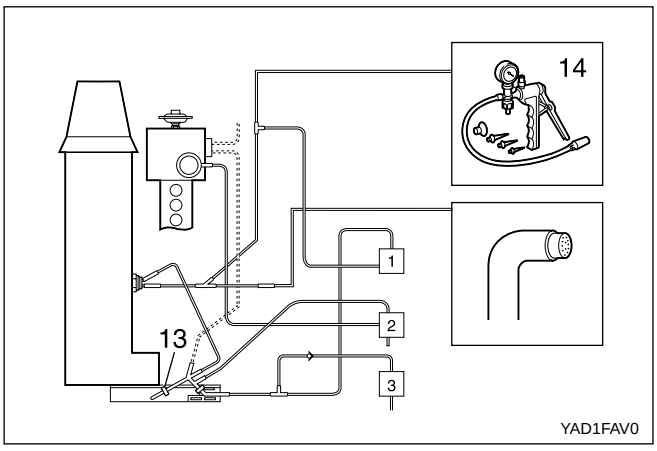


Tester Connection









Test step 1 (Coolant Temp. ≤ 0°C)

Connect vacuum pump (14) with Y adapter to PLA vacuum unit (5). Run engine at idle speed.

Vacuum ≧ 500 mbar?

YES

NO

Lines and connections leaking.
Faulty PLA vacuum unit.

(Remove the connection hose from vacuum pump)

Connect vacuum pump (14) direct to PLA vacuum unit (5) and pressurize with vacuum.

Vacuum is built up and idle speed increases approx. 150-200 rpm ?

YES

NO

Faulty PLA vacuum unit

(Coolant Temperature 0 ± 3°C)

Stop the engine and seal the air admission line with plug (arrow). Connect the vacuum pump to line to thermovalve and pressurize the line with vacuum.

Vacuum is built up?

YES

NO

Lines and connections leaking.
Faulty thermovalve.

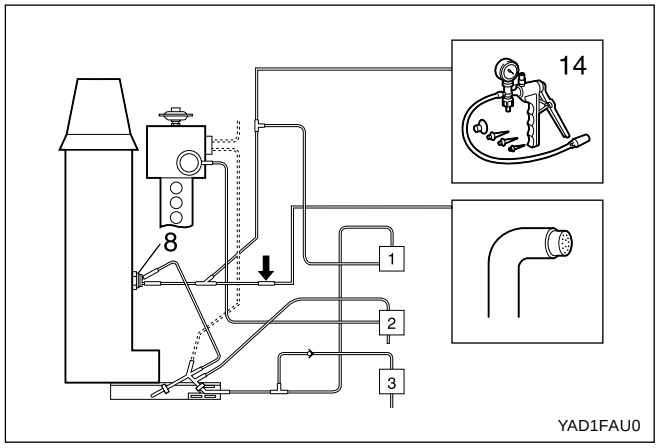
Detach line downstream of air admission filter (13).

Vacuum drops off?

YES

NO

Faulty thermovalve



Fit the line onto air admission filter. Built up vacuum with vacuum pump. Detach the plug from air admission line.

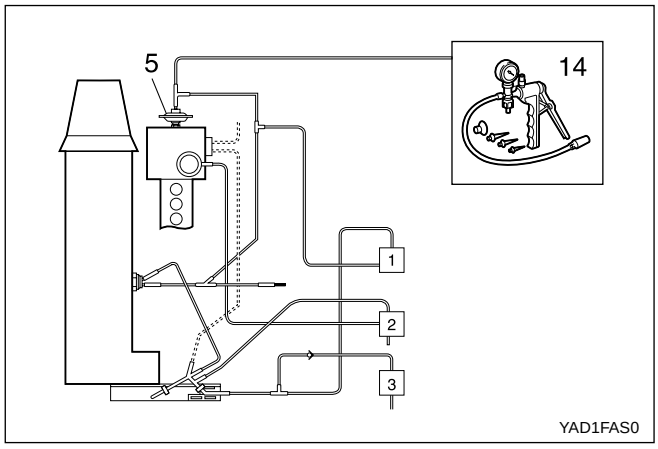
Vacuum drops off?

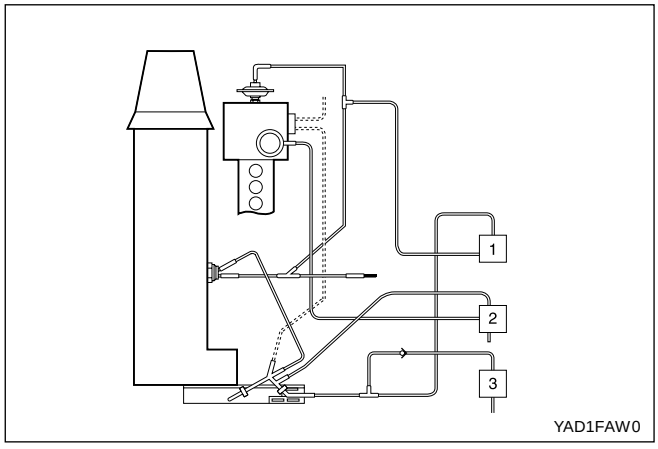
YES

NO

Faulty filter with restriction.

Go to test step 2.





Test step 2

Connect vacuum pump (14) with Y adapter to PLA vacuum unit (5). Run the engine at idle speed.

Vacuum drops to '0' at approx. ± 3°C of the thermovalve.

YES

NO

Faulty thermovalve. Defective filter with restriction.

Stop the engine. Detach the filter with restriction.

Filter with restriction is clear.

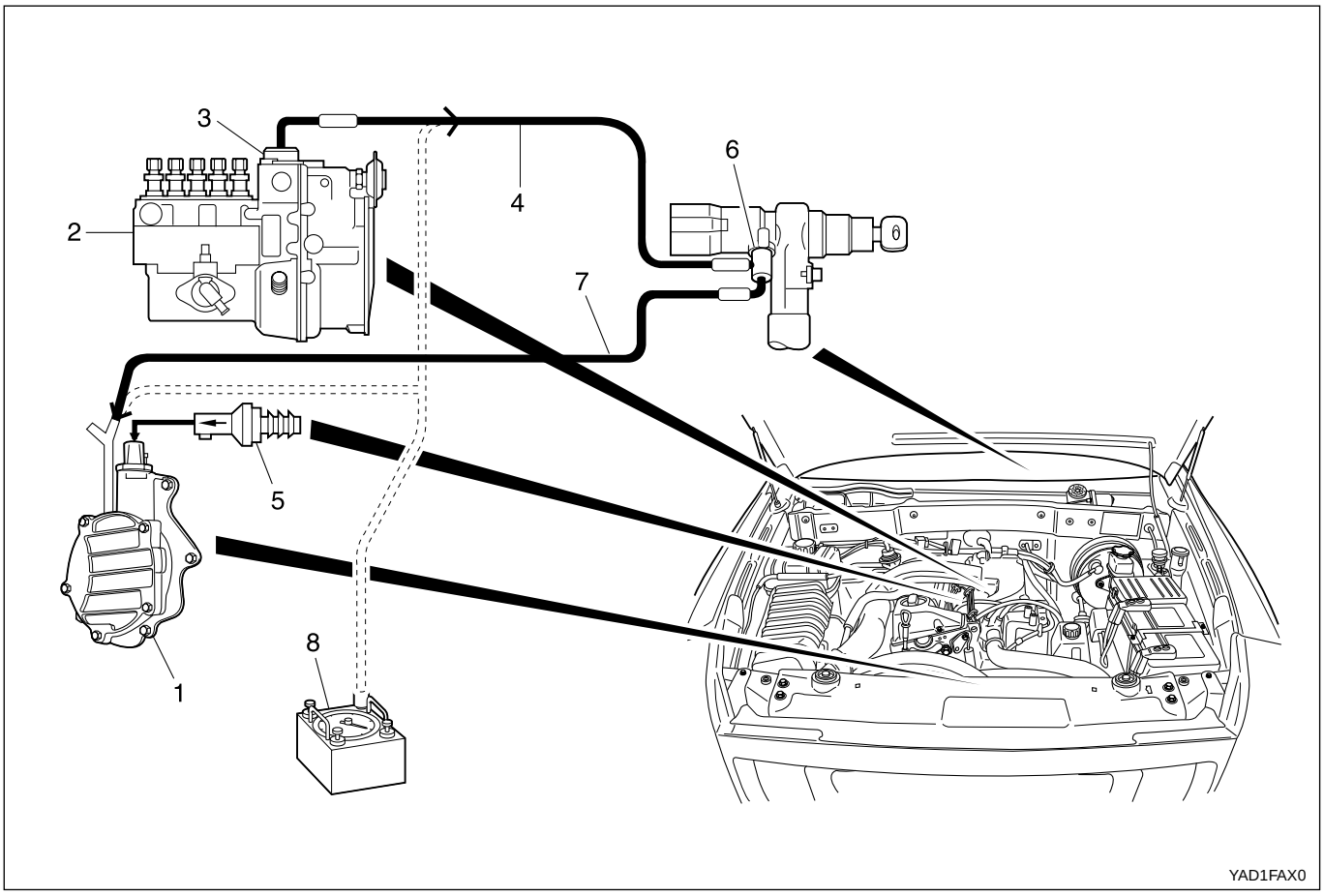
YES

NO

Defective filter with restriction.

OK

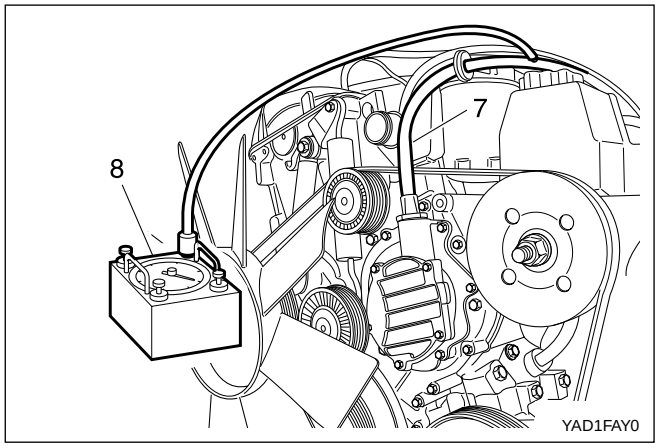
VACUUM SHUT-OFF LEAK TEST

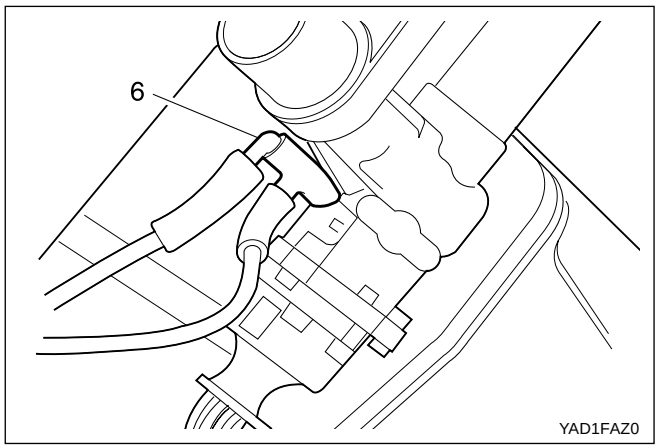


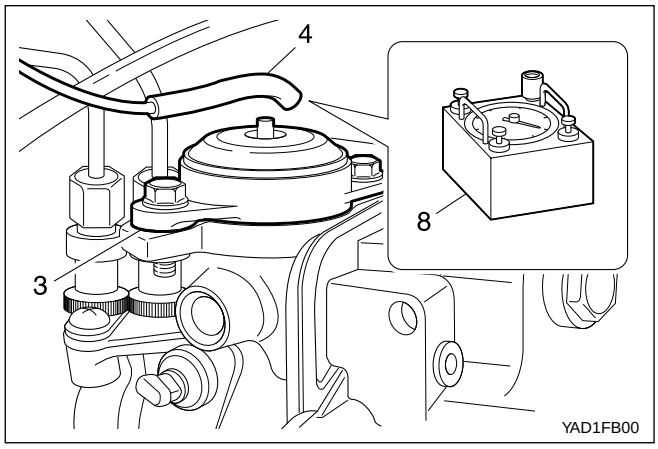
1 Vacuum Pump
2 Fuel Injection Pump
3 Engine Stop Unit
4 Control Line
5 Check Valve (to Brake Booster)
6 Engine Shut-Off Valve
7 Suction Line
8 Vacuum Tester

Service Data

Model	Permissible loss of vacuum
Entire System at 400 + 50 mbar Vacuum	6 mbar / min.
Individual Part at 300 + 50 mbar Vacuum	5 mbar / min.







Tools Required

201 589 13 21 00 Vacuum Tester

1. After fully warming up the engine, turn the ignition switch to 'LOCK' position.
2. Disconnect the suction (7) line from vacuum pump.
3. Connect the vacuum teater 201 589 13 21 00 (8) to suction line (7) and apply vacuum of 400 + 50 mbar.

Permissible loss of vacuum	6 mbar / min

If a vacuum drop is more than sperified value, check the engine shut-off valve or vacuum unit.

4. Engine Shut-off valve test
   - Turn the ignition switch to 'ON' position.
   - Connect the vacuum tester 201 589 13 21 00 to engine shut-off valve (6) and apply vacuum of 300 + 50 mbar.

Permissible loss of vacuum	5 mbar / min

If a vacuum drop is more than specified value, replace the engine shut-off valve (6)

Notice: Before replacing the valve for the glow starter system and the vacuum unit of the injection pump, check the hose lines and connections.

5. Vacuum Stop Unit Test.
   - Disconnect the control line (4) from the vacuum stop unit (3).
   - Connect the vacuum tester 201 589 13 21 00 to vacuum stop unit (3) and apply vacuum of 300 + 50 mbar.

Permissible loss of vacuum	5 mbar / min

   - If a vacuum drop is more than specified valve, replace the vacuum stop unit.

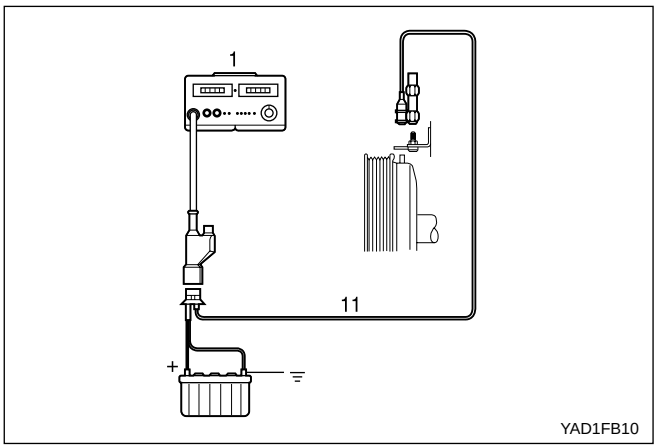
IDLE SPEED ADJUSTMENT

Service Data

Engine	Idle Speed
OM662LA Engine	720 - 820 rpm

Commercial Tool

Digital tester	e.g. Bosch, MOT 001.03
	Sun, DIT 9000



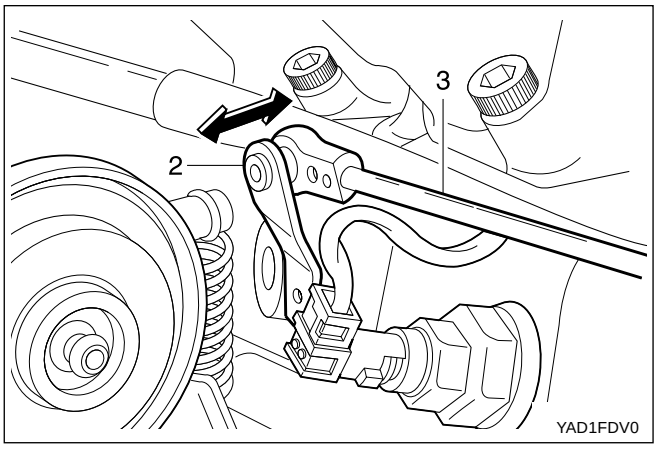
Tools Required

001 589 73 21 00 Vacuum Pump

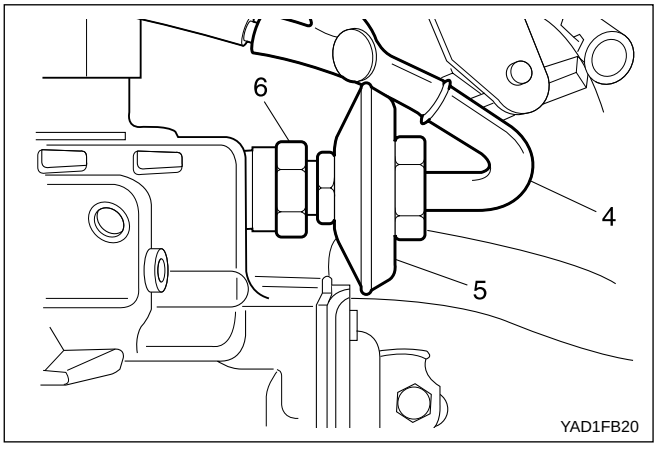
667 589 00 73 21 TDC Pulse Generator

Adjustment Procedure

1. Connect the digital tester (1) and TDC pulse generator 667 589 02 21 00 (11).
2. Run the engine and warm up the coolant to 60~80°C.



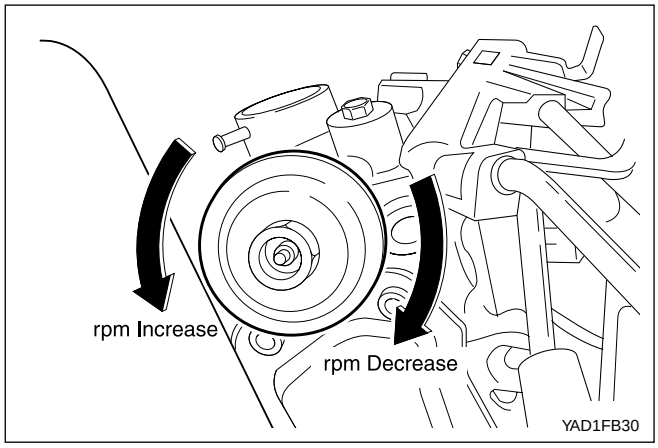
3. Disconnect the connecting rod (3) from control lever (2).



4. Disconnect the vacuum hose (4) from the PLA unit to check idle speed with tester.
5. Check idle speed with tester.

Idle Speed	720 - 820 rpm

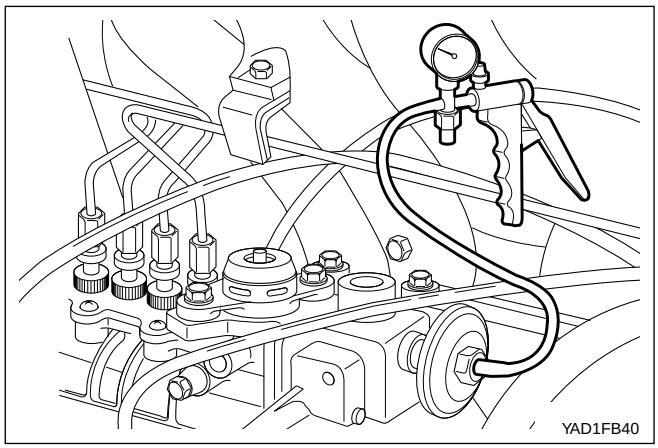
Notice: To adjust idle speed, loosen the locking nut (6) of PLA unit.



6. Ensure not to damage the idle spring in the governor and adjust idle speed by turning the PLA unit (5) slowly.

Clockwise	RPM Decrease
Counterclockwise	RPM Increase

Notice: Do not rotate the PLA unit over ½ turn from the position marking. If do, idle spring in the governor will be severely damaged.

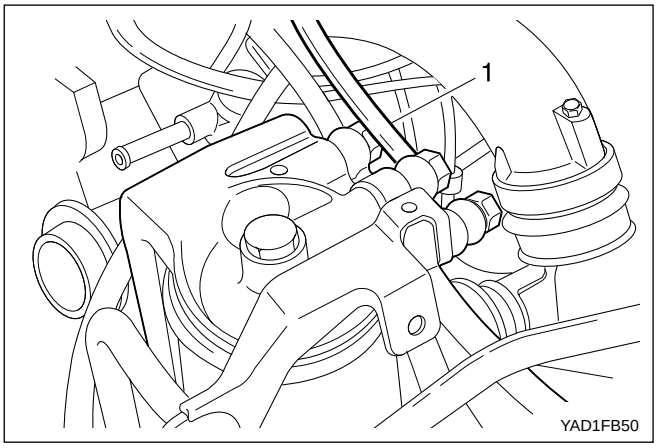


7. After adjustment, tighten the locking nut and place the position marking with different color of paint.

   Notice: If there are no changes in idle speed with PLA unit adjustment, perform the service at a BOSCH Service Center.

8. Connect the vacuum pump 001 589 73 21 00 to the PLA vacuum unit and build up vacuum approx. 500 mbar. If engine rpm increases by approx. 150 rpm. It is normal.

9. Connect the vacuum line (4).
10. Install the connecting rod.
11. Switch on all ancillaries and check the idle speed.



FUEL PUMP TEST

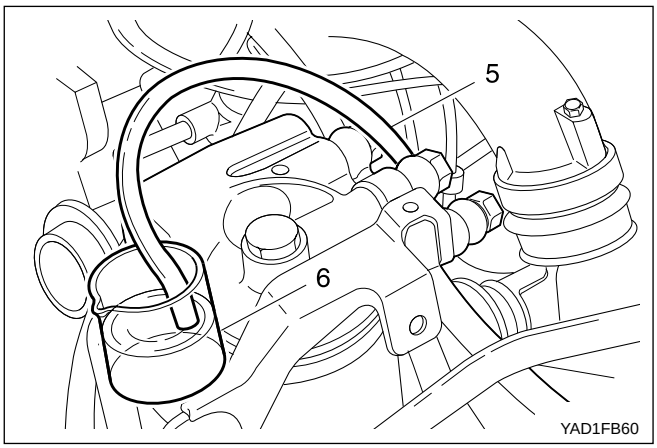
Notice: Before test, replace the fuel filter cartridge and fuel prefilter.

Fuel Feed Test

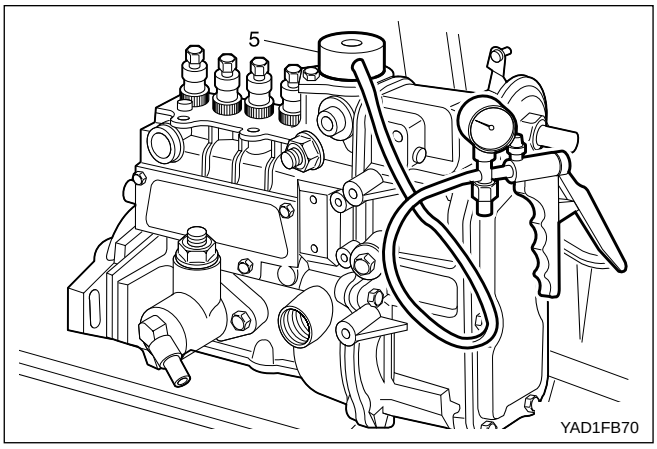
Tools Required

001 589 73 21 00 Vacuum Pump

1. Disconnect the fuel return line (1) and seal up it with plug.



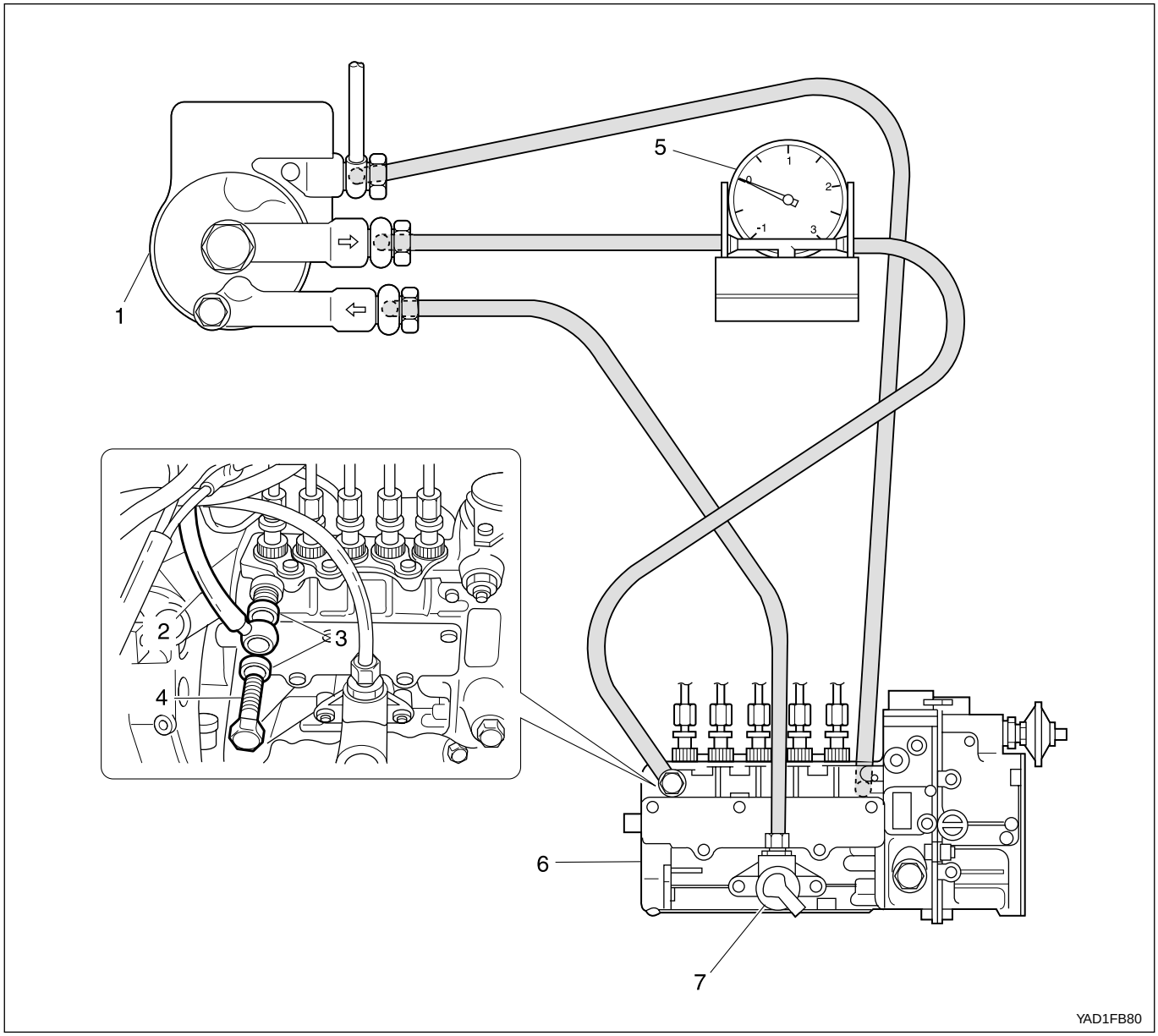
2. Insert the plastic hose (5) and put the end into the measuring beaker (6).



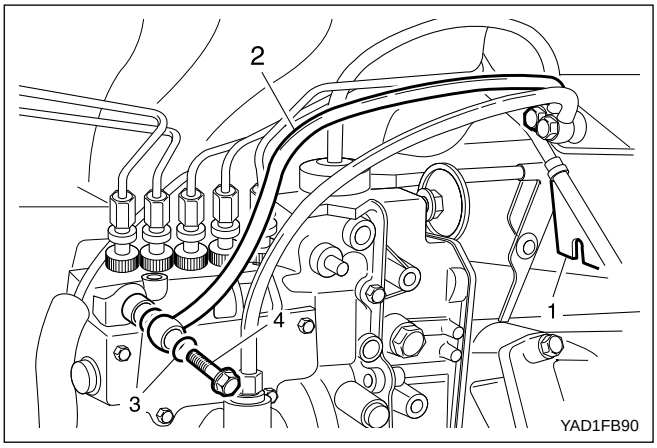
3. Disconnect the vacuum line from vacuum unit (engine stop) (5) and connect the vacuum pump 001 589 73 21 00 to the vacuum unit.
4. To avoid the engine starting, build up vacuum (approx. 500 mbar).
5. Operate the starter motor for exactly 30 seconds and measure fuel volume in the beaker.

Min. volume	150 cm^3 for 30 seconds

Fuel Pressure Test



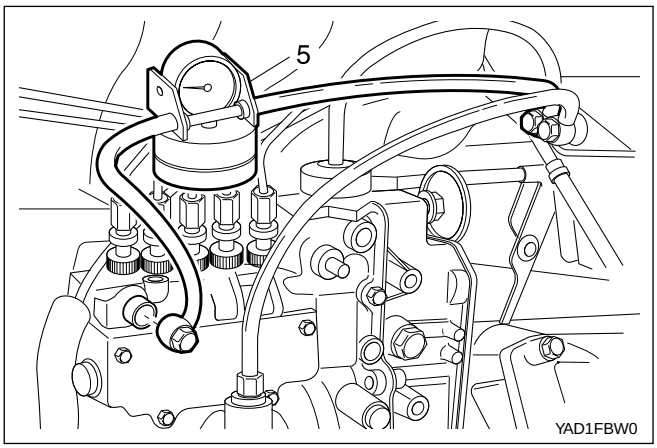
1 Fuel Filter Housing
2 Fuel Line
3 Seal ..... Replace
4 Bolt ..... 13 N•m (10 lb-ft)
5 Tester ..... At Idle Speed > 0.3 bar
..... At Full Load > 0.5 bar
6 Fuel Injection Pump
7 Fuel Pump



Tools Required

617 589 04 21 00 Tester

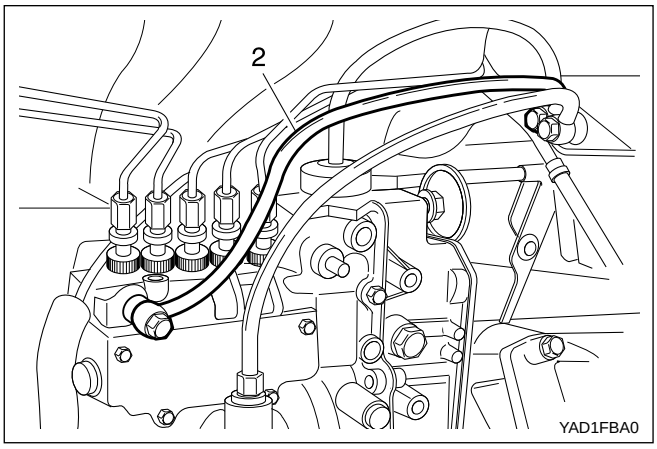
1. Disconnect the fuel line (2) from the fuel filter.
2. Remove the banjo bolt (4) from the fuel injection pump and remove the seals (3) and fuel line (2).



3. Connect the tester 617 589 04 21 00 (5).
4. Start the engine and read off the fuel pressure on tester 617 589 04 21 00 (5).

At Idle Speed	> 0.3 bar
At Full Load	> 0.5 bar

Notice: If out of standard, replace the fuel feed pump.



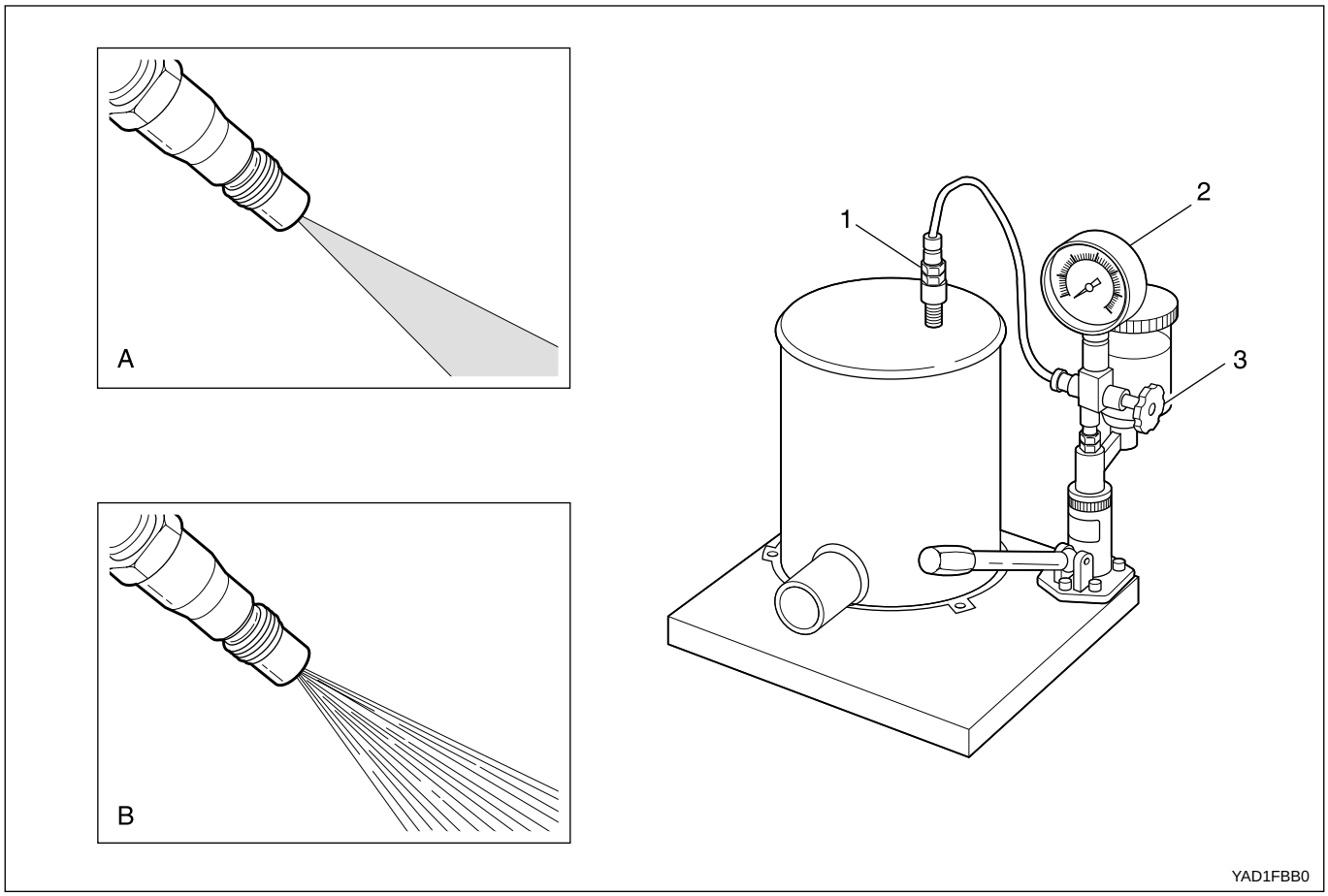
5. Stop the engine.
6. Remove the tester 617 589 04 21 00.
7. Replace the seal and connect the fuel line (2).

Inatallation Notice

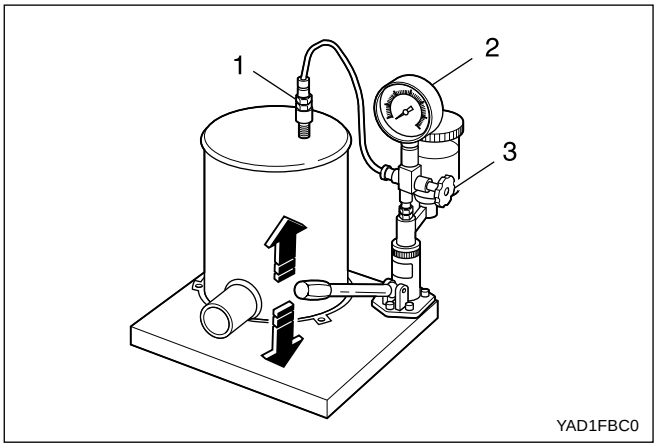
Tightening Torque	13 N•m (10 lb-ft)

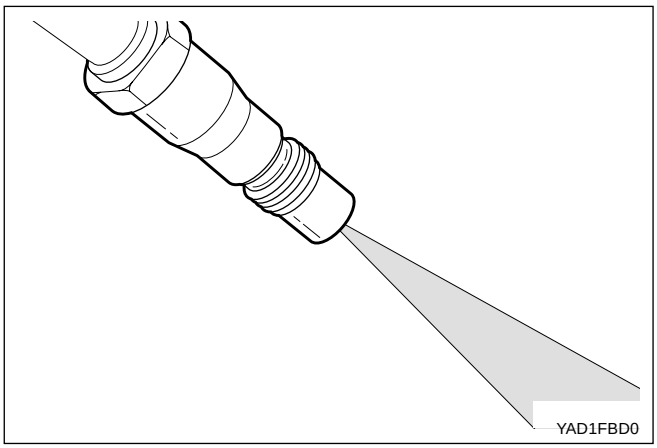
INJECTION NOZZLE TEST

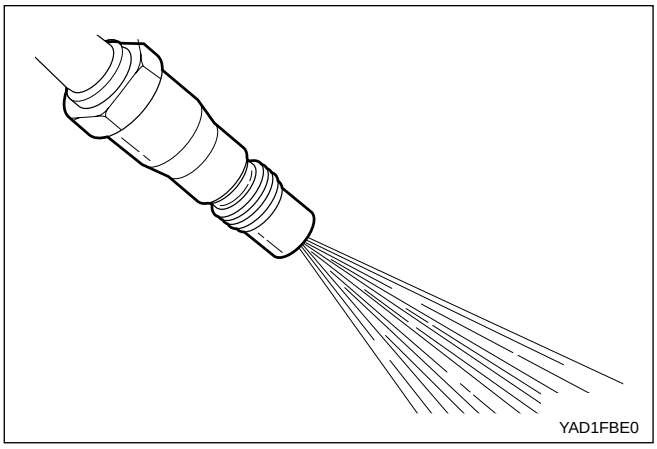
Preceding Work: Removal of fuel injection nozzle



1 Fuel Injection Nozzle .....New : 135 - 143 bar
..... Used : min. 120 bar
2 Tester
3 Valve
A Closed Spray = good
B Stringy Spray = poor







Tools Required

000 589 14 27 00 Fuel Injection Nozzle Tester

Notice: When testing the injection nozzle, do not place your hand into the spray of a nozzle. The spray will penetrate deep into the skin and destroy the tissue.

1. Connect the fuel injection nozzle to the fuel injection nozzle tester 000 589 14 27 00.
2. Close the valve (3) and pump 5 times strongly.
3. Chatter test :

   Slowly operate the hand lever at tester (approx. 1 stroke per second). The nozzle must spray with a gentle chattering.

4. Spray pattern test :

   Operate the hand lever at tester rapidly (approx. 2~3 strokes per second).

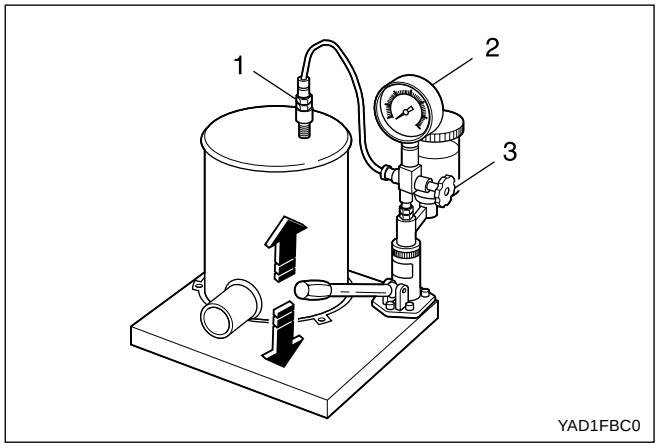
   - Good

     The spray pattern shows closed and well atomized.

   - Poor

     The spray pattern shows split, too wide and stringy.

     (Repair the fuel injection nozzle)



5. Opening pressure test :

   Open the valve (3) and slowly operate the hand lever at tester (approx. 1 stroke / second) and measure opening pressure.

New Nozzle	135 - 143 bar
Used Nozzle	Min. 120 bar
Difference Between Nozzles	Max. 5 bar

   Notice: If out of standard, repair the injection nozzle.

6. Leak test

   Slowly operate the hand lever at the tester until get a pressure of approx. 90 bar. Maintain this pressure for more than 20 seconds and within this period no drop of fuel should build up at the nozzle tip.

CHECKING AND ADJUSTING START OF DELIVERY

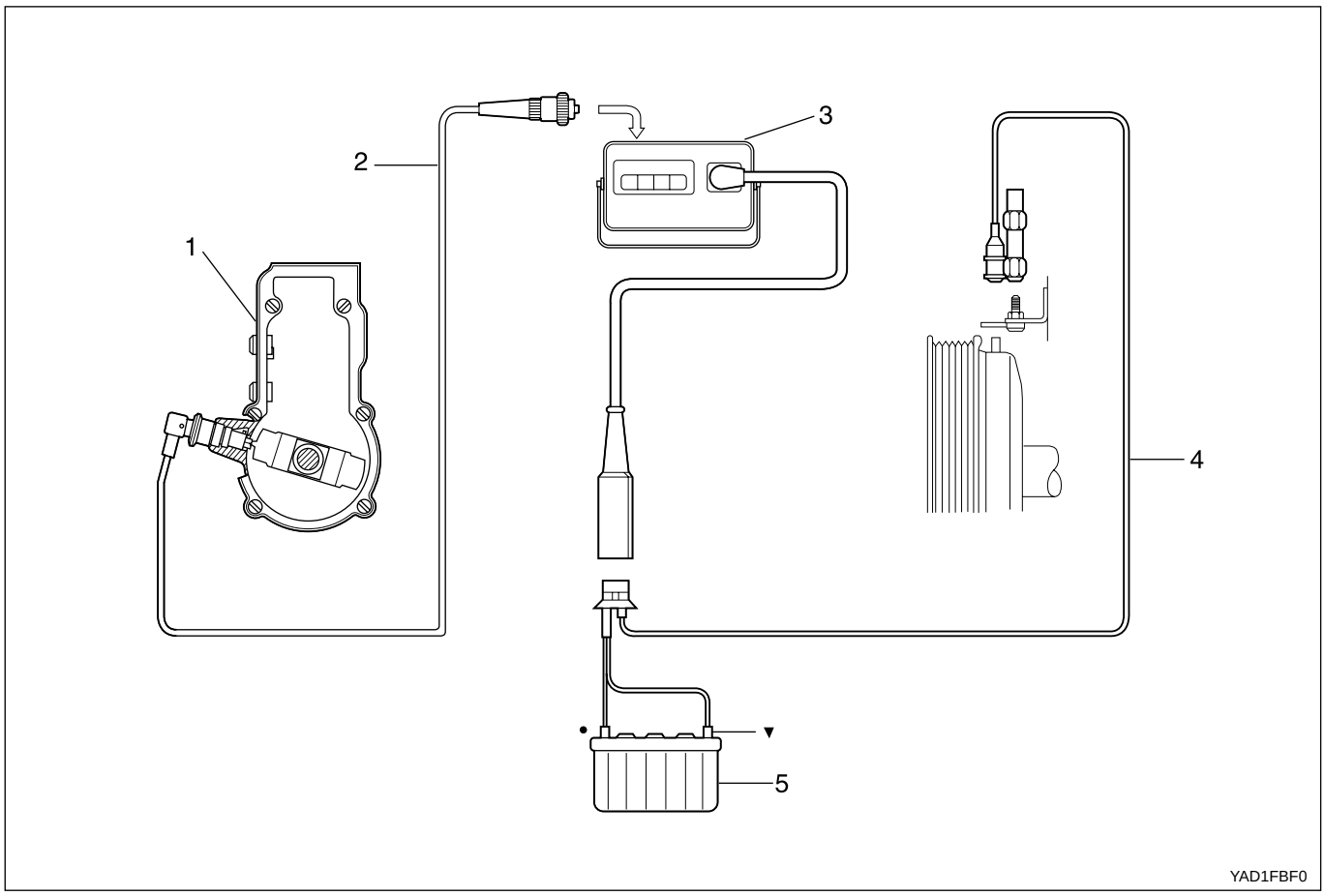
Governor Impulse Method (RIV)

In order to be able to register the relationship of the injection pump relative to the engine two signals are required.

- TDC impulse from the crankshaft.
- Governor impulse from the injection pump.

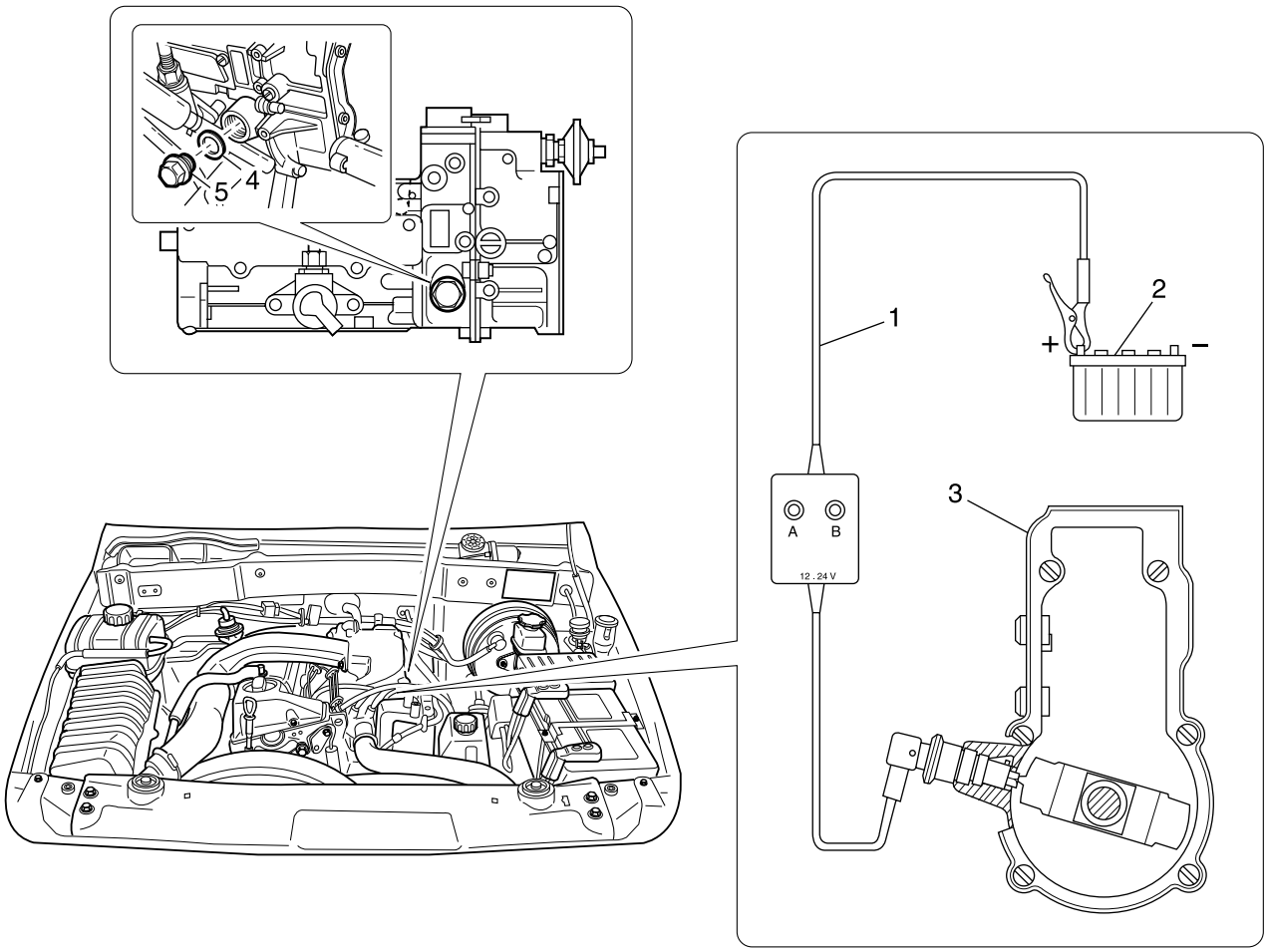
Both impulses are supplied by pulse generators.

In order to obtain a measuring signal the sensor pins must be moved past the pulse generators with a minimum speed (idle speed). A measuring instrument measures the time interval of the two impulses, converting the result into an angular value which is then indicated.



1 Fuel Injection Pump
2 RI Sensor
3 Digital Testor
4 TDC Pluse Sender Unit
5 Battery

Position Sensor, RIV Method

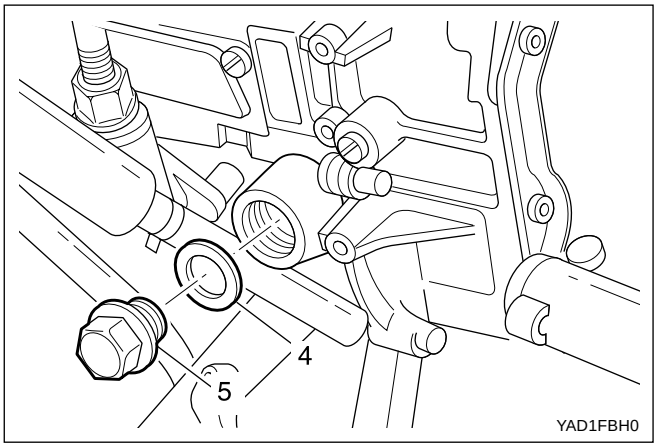


YAD1FBG0

1 Position Sensor
2 Battery
3 Fuel Injection Pump
4 Seal ..... Replace
5 Screw Plug ..... 30 N•m (22 lb-ft)

Service Data

Start of Delivery (RIV)	ATDC 14° - 16°



Tools Required

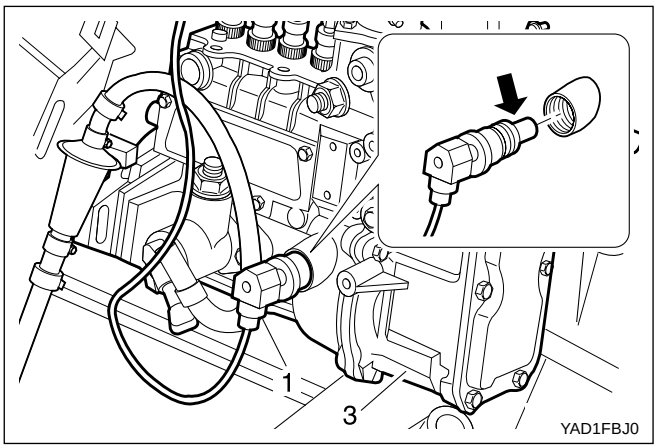
617 589 08 21 00 Position Sensor

Test Procedure

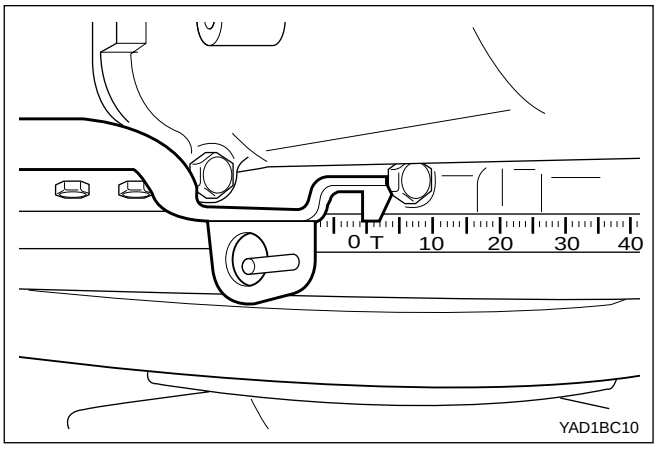
1. Remove the screw plug (5) and seal (4) and collect oil in a suitable vessel.

   Installation Notice

Tightening Torque	30 N•m (22 lb-ft)



2. Install the position sensor 617 589 08 21 00 (1) into the governor housing of the injection pump to be the guide pin of the position sensor facing up.
3. Connect the battery terminal of position sensor 617 589 08 21 00 (1) to positive terminal (+) of battery.

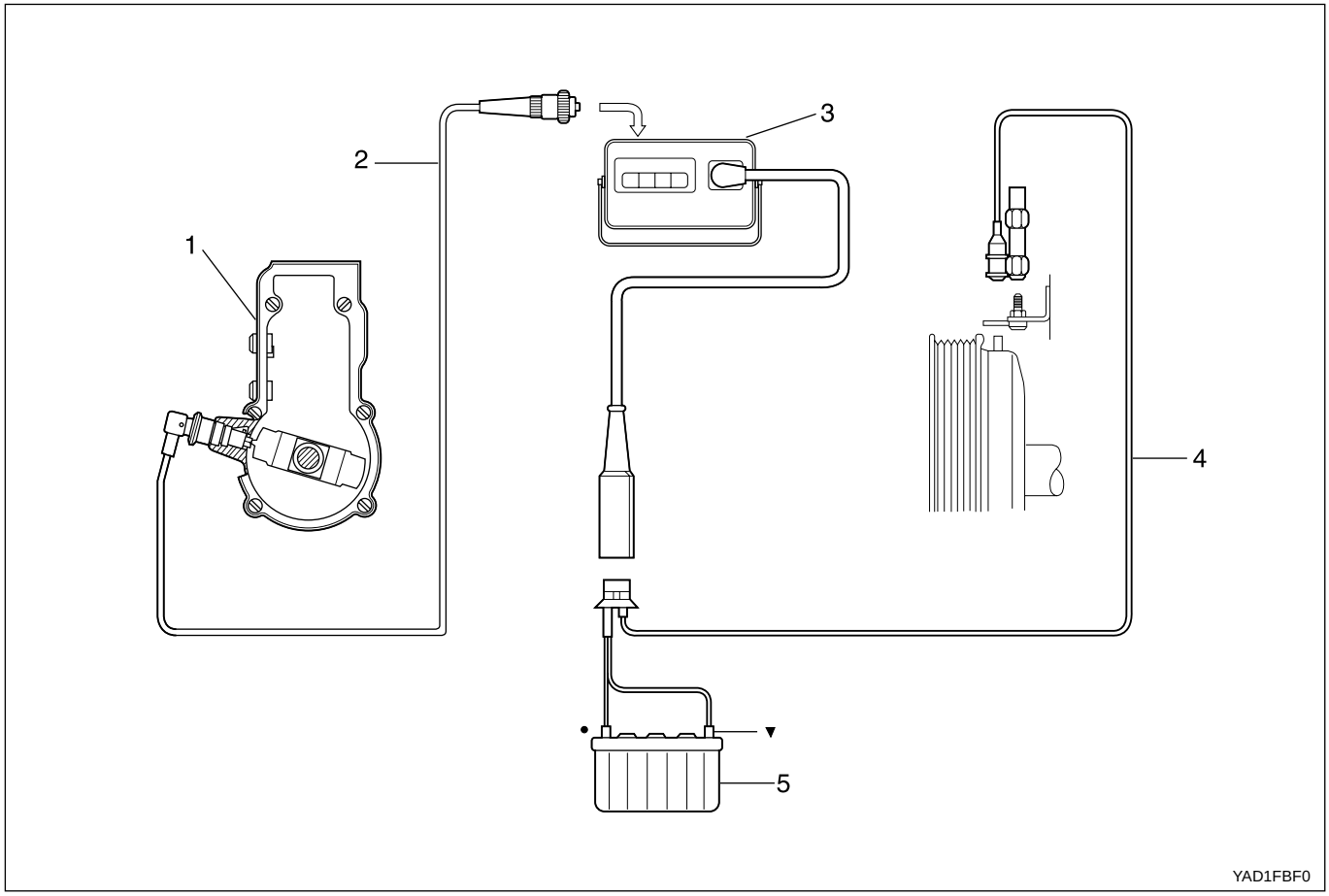


4. Rotate the crankshaft by hand (in direction of engine rotation) until the lamp ‘B’ lights up. Rotate the crankshaft carefully further until both lamps ‘A and B’ come on. In this position, check the RI value on the crankshaft vibration damper.

Specification	ATDC 14° - 16°

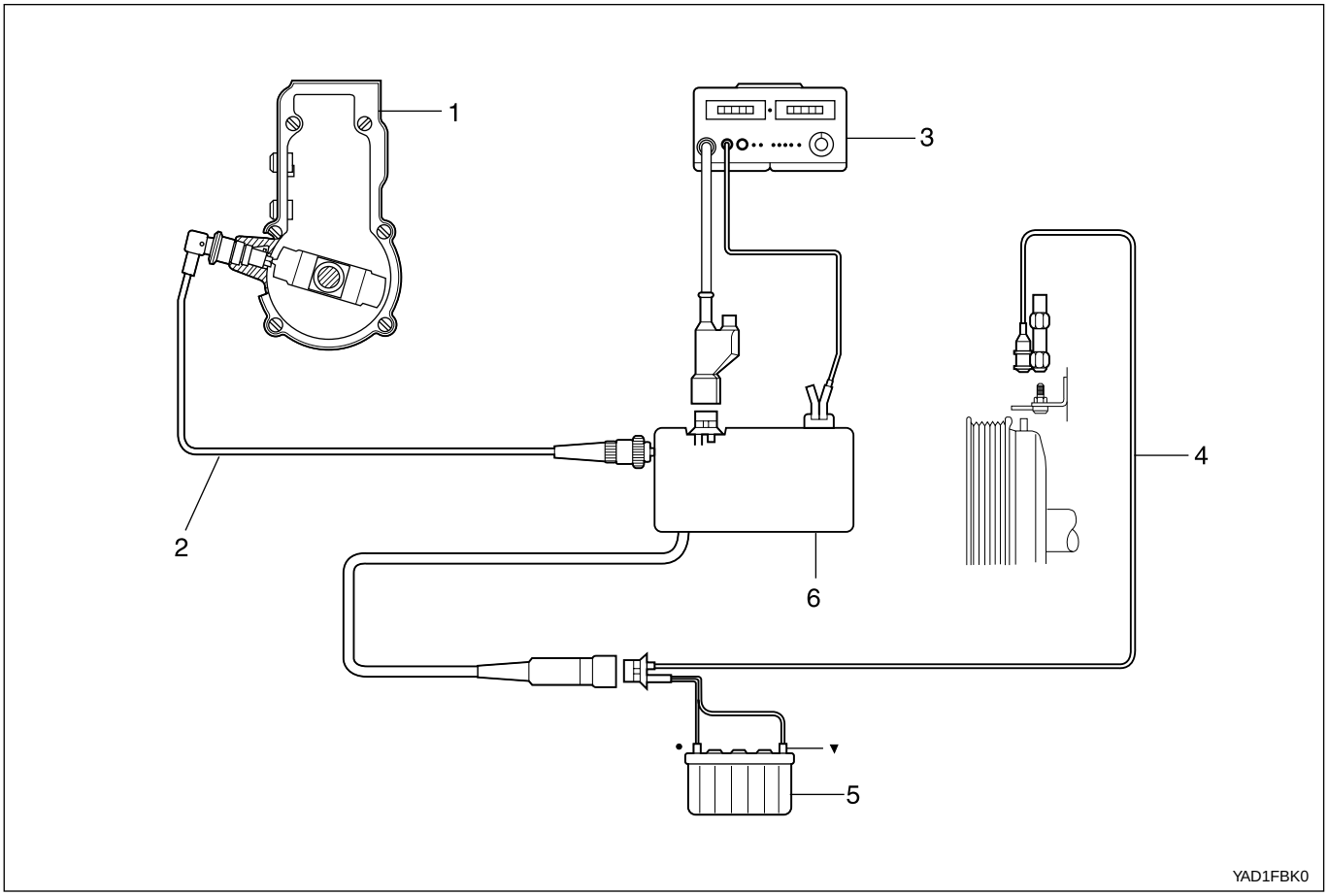
Notice: If only lamp ‘A’ lights up, repeat the test and if out of specification, adjust start of delivery.

Digital Tester, RIV Method
(Connection Diagram for Testers Without Adapter)



1 Fuel Injection Pump
2 Rl Sensor
3 Digital Tester
4 TDC Pulse Generator
5 Battery

(Connection Diagram for Testers With Adapter)



1 Fuel Injection Pump
2 RI Sensor
3 Digital Tester
4 TDC Pulse Sender Unit
5 Battery
6 RI Pulse Generator

Service Data

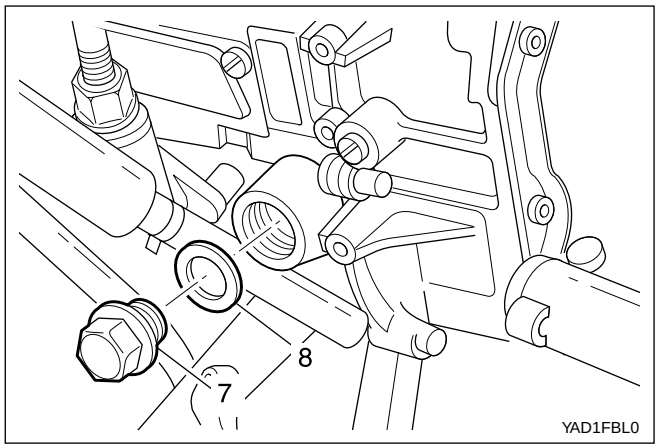
Start of Delivery (RIV)	ATDC 14° - 16°
Idle Speed	720 - 820 rpm

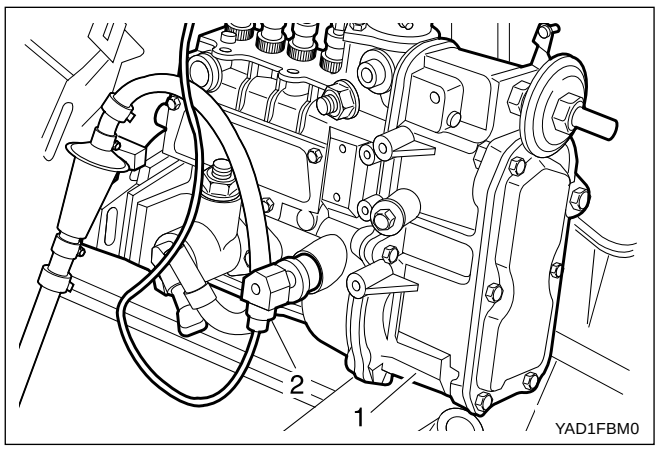
Tools Required

617 589 09 21 00 RI Adapter
617 589 10 21 00 RI Sensor
667 589 00 21 00 TDC Pulse Generator

Commercial Tools

Item		Tools
Digital Tester	With Pluse Generator	Bosch, MOT 001.03
		Hartmann & Braun. EOMT3
	Without Pulse Generator	Bosch, ETD 019.00
		Sun, DIT 9000
		ALV, Diesel - Tester 875





Test Procedure

1. Remove the screw plug (7) and seal (8) collect oil in a suitable vessel.
2. Install the RI sensor 617 589 10 21 00 into the governor housing of injection pump (1).
3. Connect the digital tester and TDC pulse generator 667 589 00 21 00 according to connection diagram.
4. Run the engine at idle speed and check the RI value on the digital tester

RI valve	ATDC 14° - 16°

Notice: If out of standard, adjust the start of delivery.

5. Stop the engine.
6. Remove the RI sensor, digital tester and TDC pulse generator.
7. Replace the seal and tighten the plug.

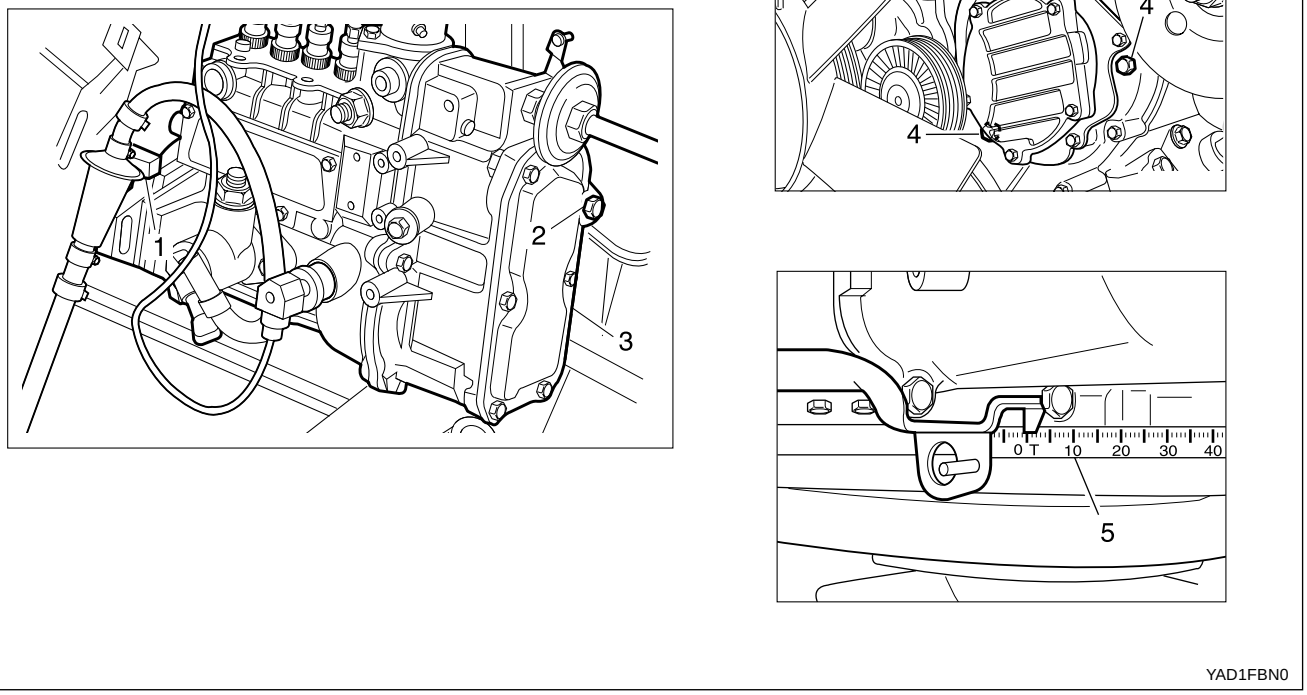
Installation Notice

Tightening Torque	30 N•m (22 lb-ft)

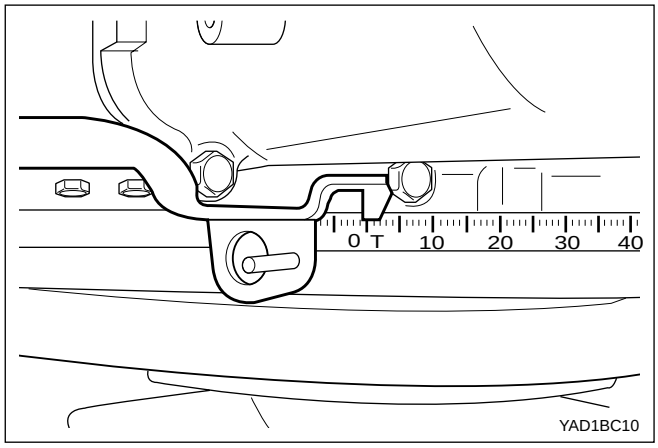
8. Check engine oil level and adjust if necessary.

After Testing - Position Sensor (RIV Method)

Preceding Work: Start of delivery test



1 Adjusting Screw
2 Bolt ..... 23 N•m (17 lb-ft)
3 Fuel Injection Pump
4 Bolt ..... 23 N•m (17 lb-ft)
5 Scale ..... RI start of delivery = 14° - 16° ATDC



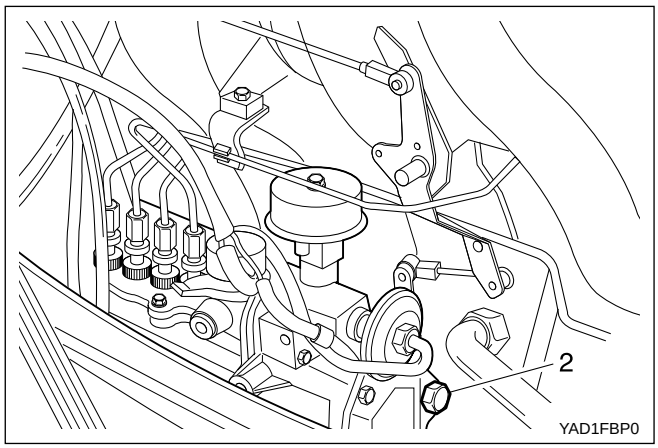
Tools Required

617 589 08 21 00 Position Sensor

Adjustment Procedure

1. Position the No. 1 cylinder at ATDC 15°

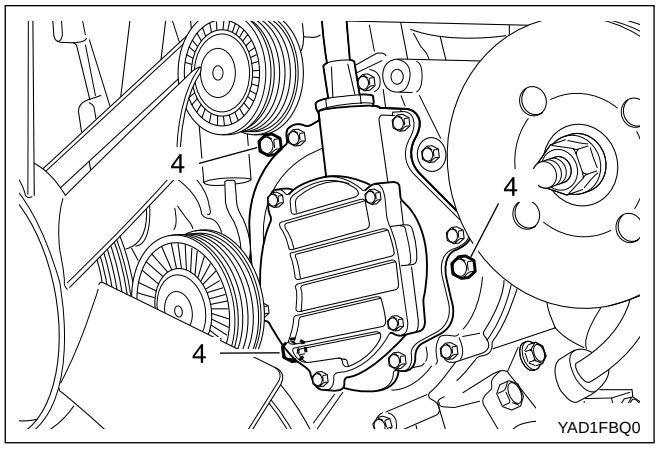
   Notice: Do not rotate the engine in opposite direction of engine rotation.



2. Remove the bolt (2) at the supporting bracket.

   Installation Notice

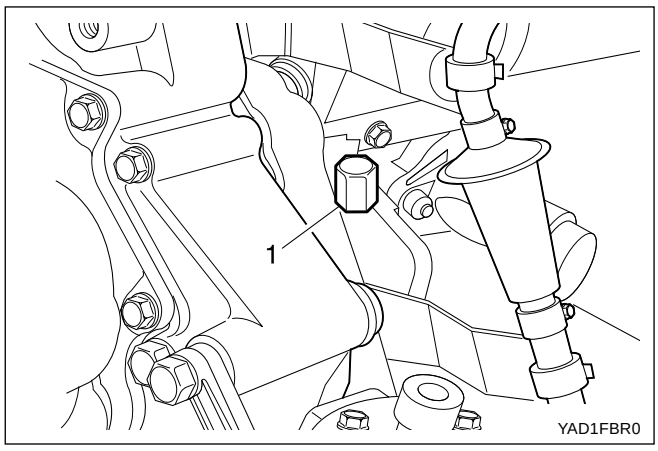
Tightening Torque	23 N•m (17 lb-ft)



3. Remove the bolt (4) at the timing case cover.

   Installation Notice

Tightening Torque	23 N•m (17 lb-ft)



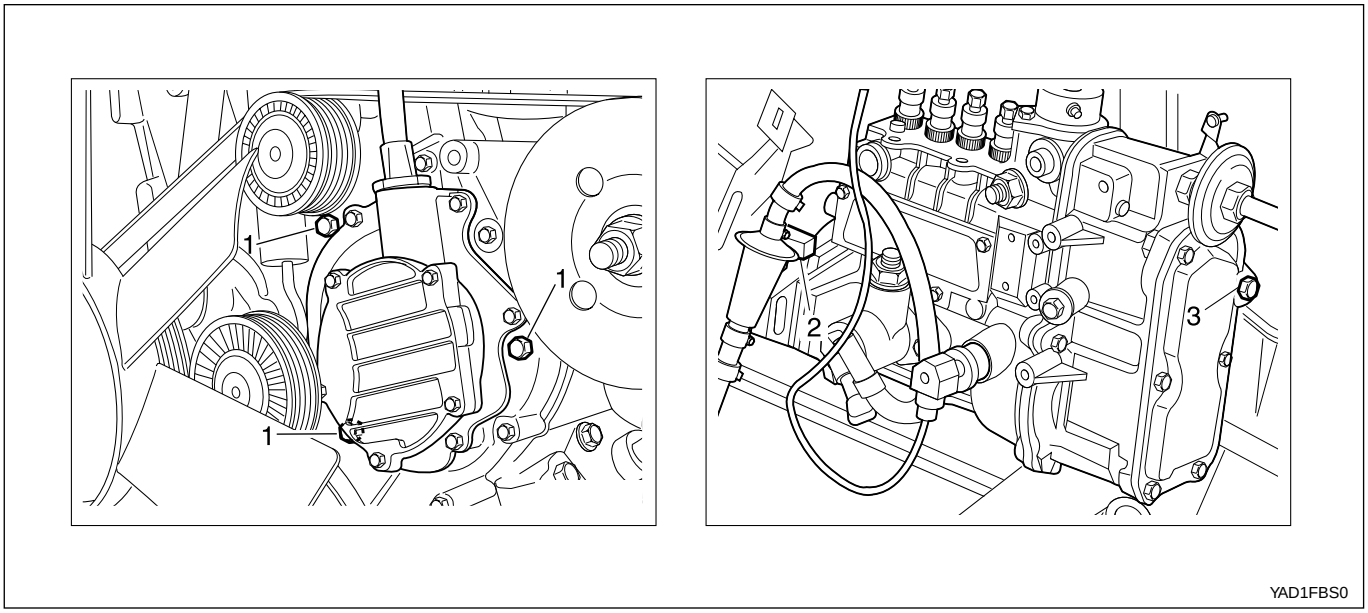
4. Turn the adjusting screw (1) until both lamps ‘A’, ‘B’ on the position sensor 617 589 08 21 00 light up.

To the right	Start of Delievery Retarded
To the left	Star of Delivery Advanced

   Notice: If the adjustment range is not adequate, remove the injection pump and reinstall.

5. After adjusting, retighten all the bolt to the specified torque.

After Testing - Digital Tester (RIV Method)



1 Bolt..... 23 N•m (17 lb-ft)
2 Adjusting
Screw .... To the right : start of delivery retarded
To the left : start of delivery advanced
3 Bolt..... 23 N•m (17 lb-ft)

Service Data

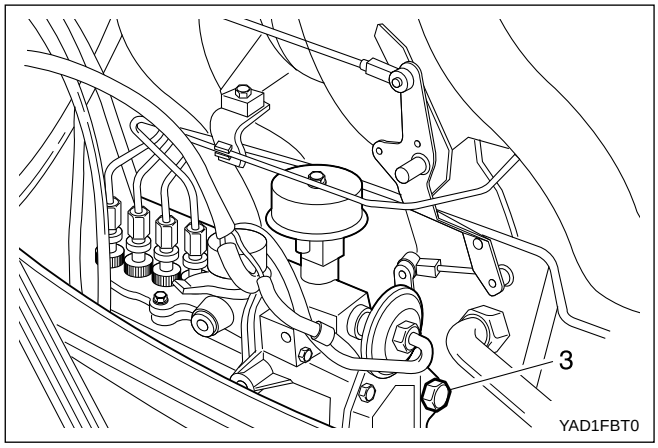
Start of Delivery (RIV)	ATDC 14° - 16°
Ldling Speed	720 - 820 rpm

Tools Required

617 589 09 21 00 RI Adaptor
617 589 10 21 00 RI Sensor
667 589 00 21 00 TDC Pulse Generator

Commercial Tools

Item		Tools
Digital Tester	With Pulse Generator	Bosch, MOT 001.03
		Hartmann & Braun, EOMT3
	Without Pulse Generator	Bosch, ETD 019.00
		Sun, DIT 9000
		ALV, Diesel - Tester 875

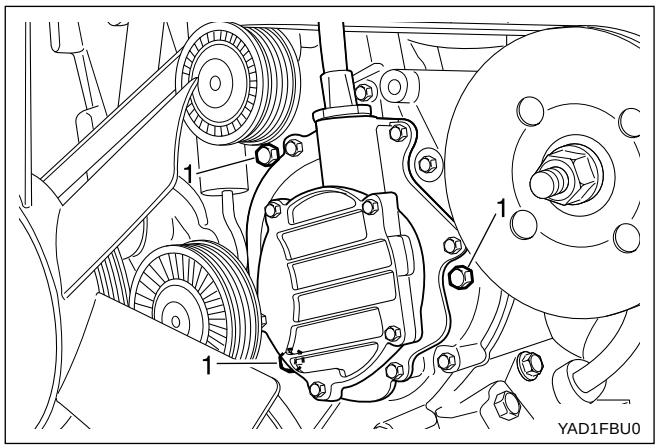


Adjustment Procedure

1. Remove the bolt (3) at the supporting bracket.

Installation Notice

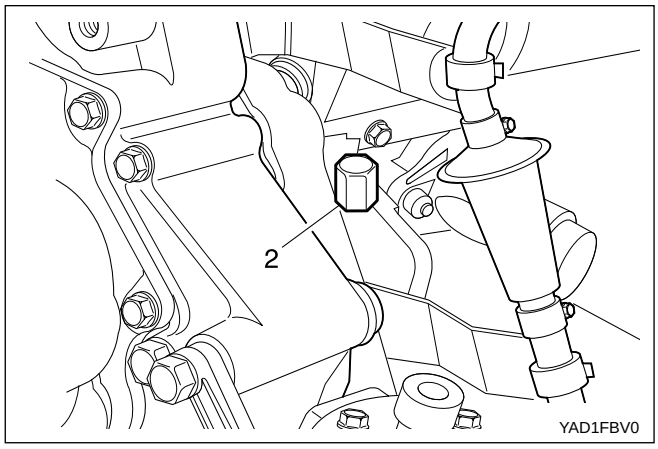
Tightening Torque	23 N•m (17 lb-ft)



2. remove the bolts (1) at the timing case cover.

Installation Notice

Tightening Torque	23 N•m (17 lb-ft)



3. Run the engine at idle speed.
4. Turn the adjusting screw (2) until the specification (15° ± 1° ATDC) is indicated on the digital tester.

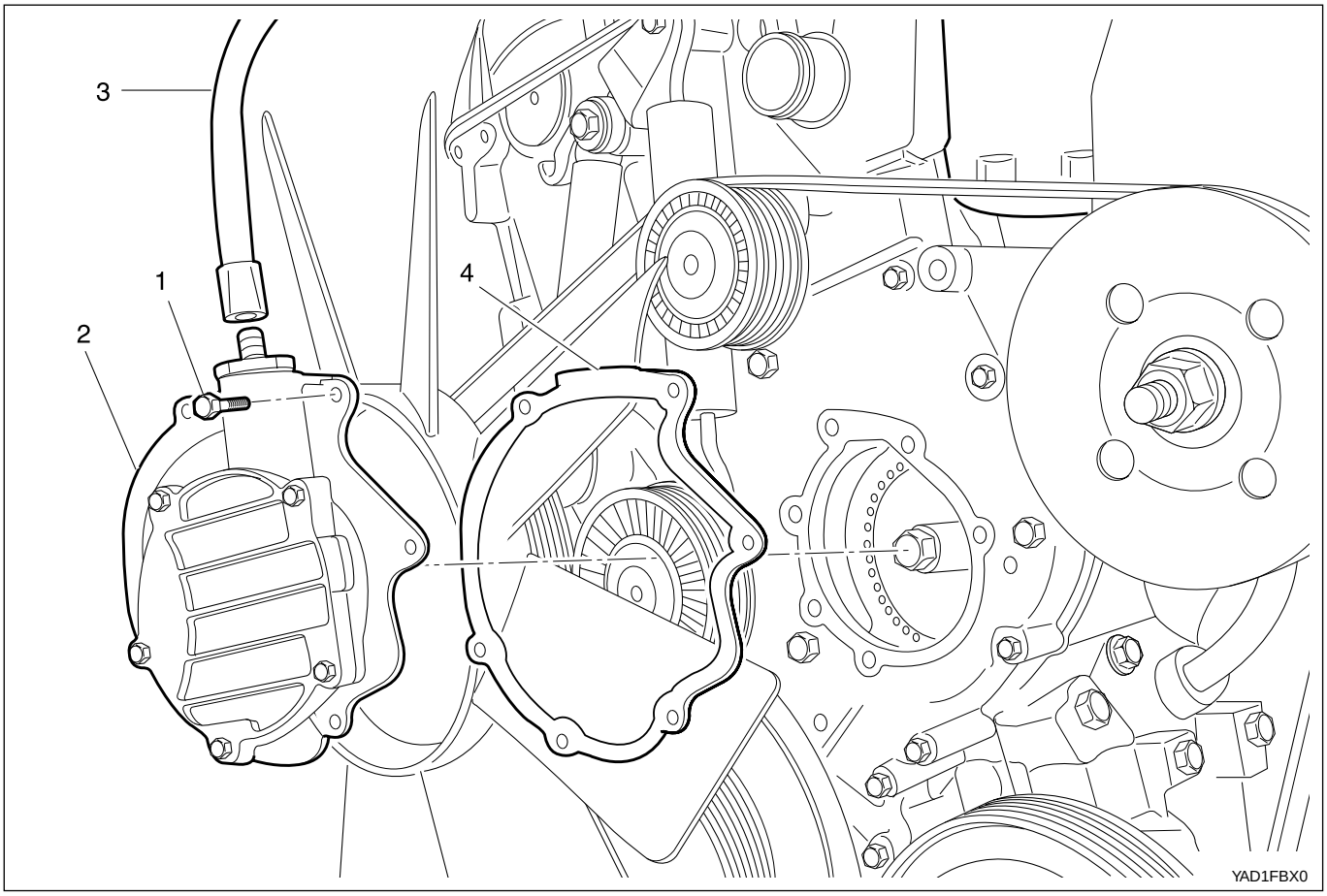
To the Right	Start of Delivery Retarded
To the Left	Start Delivery Advanced

REPAIR INSTRUCTIONS

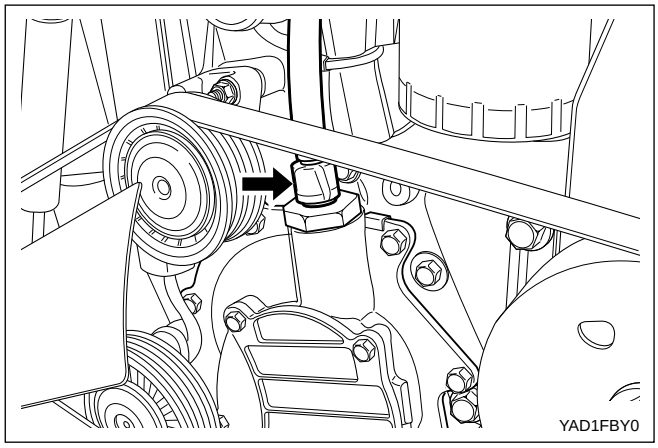
ON-VEHICLE SERVICE

VACUUM PUMP

Preceding Work: Removal the poly V-belt

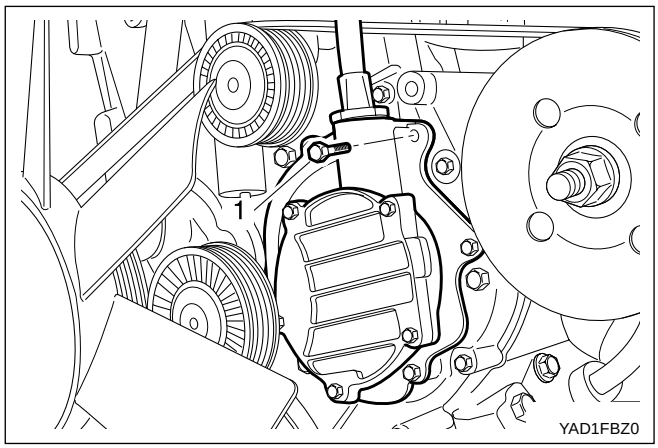


1 Bolt ..... 10 N•m (89 lb-in)
2 Vacuum Pump
3 Vacuum Line
4 Gasket ..... Replace



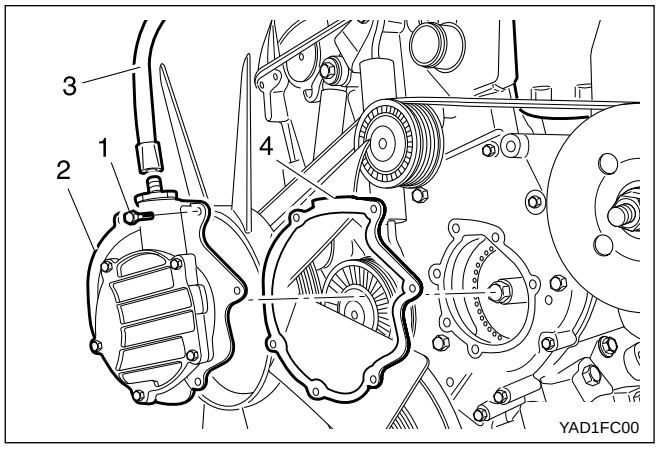
Removal & Installation Procedure

1. Remove the vacuum line.



2. Remove the bolts (1) evenly.

   Notice: If necessary, rotate the engine until the pressure on the tappet of the vacuum pump is released.



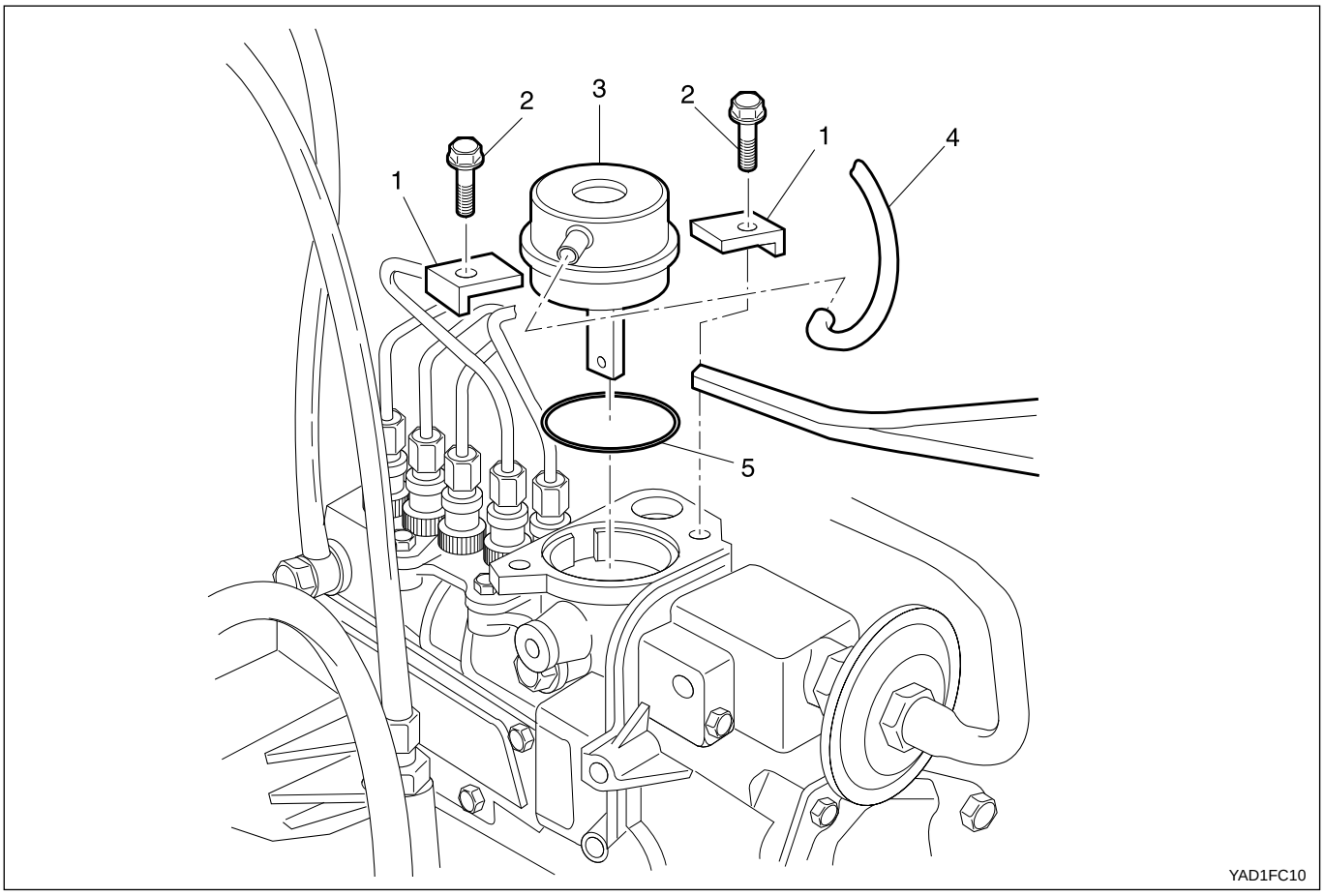
3. Remove the vacuum pump (2).
4. Install the vacuum pump (2).

   Installation Notice

Tightening Torque	10 N•m (89 lb-in)

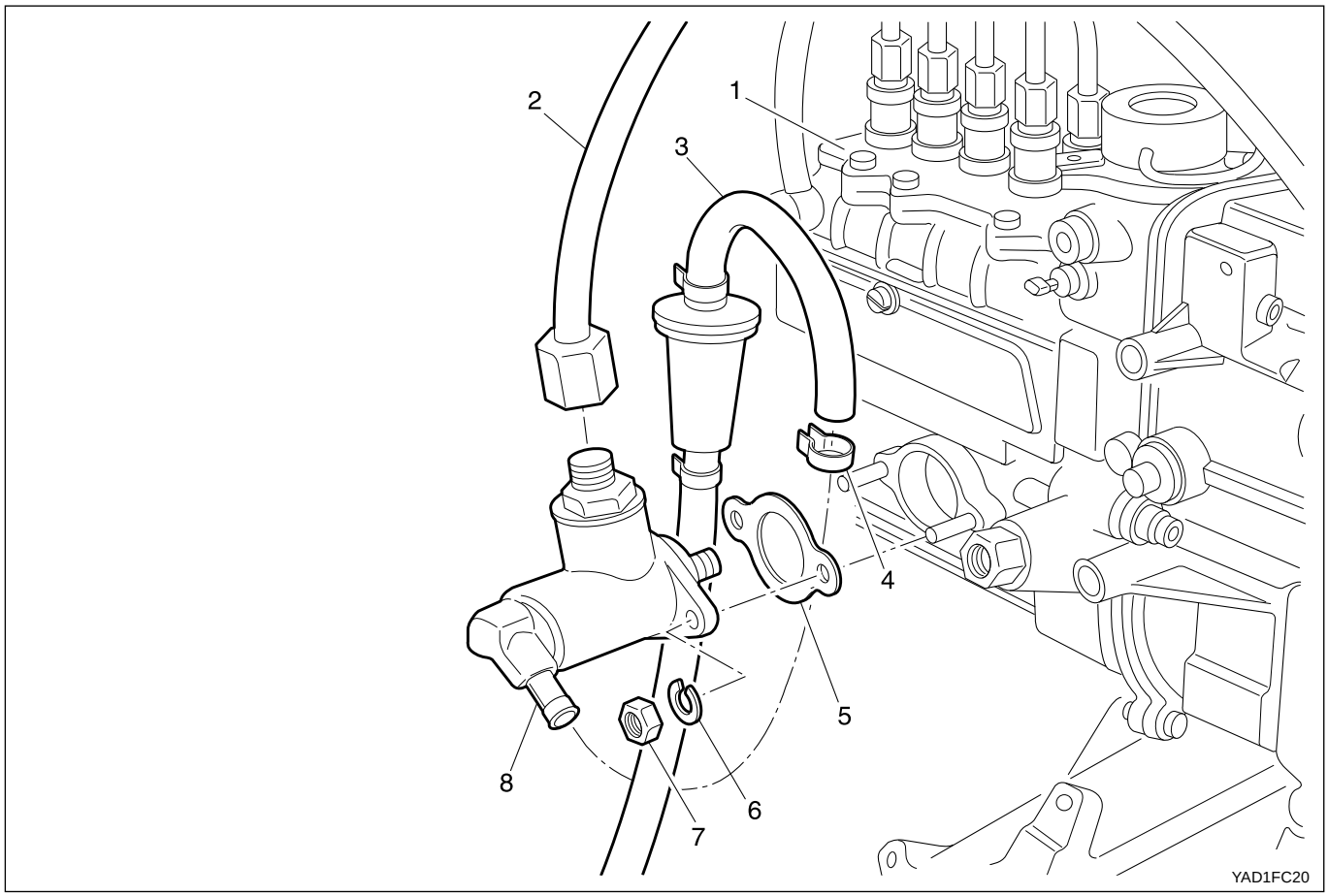
   Clean the gasket residues of sealing surface of vacuum pump and replace the gasket (5).
5. Connect the vacuum line.

VACUUM UNIT REPLACEMENT

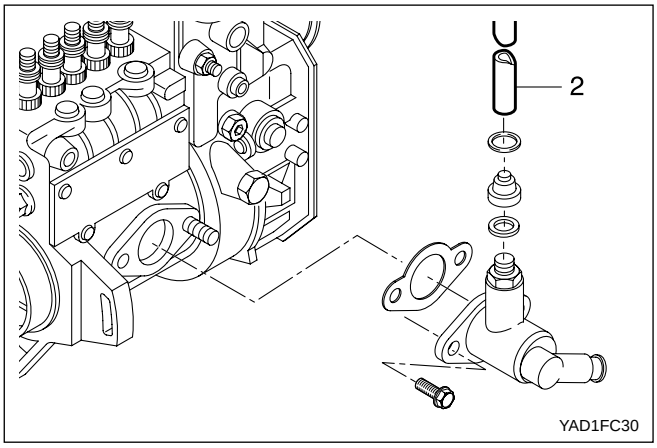


1 Bracket
2 Bolt
3 Vacuum Unit
4 Vacuum Line
5 Seal ..... Replace

FUEL PUMP



1 Fuel Injection Pump
2 Pressure Line ..... 13 N•m (10 lb-ft)
3 Suction Line
4 Hose Clip ..... Replace
5 Gasket ..... Replace
6 Spring Lock Washer
7 Hexagon Nuts ..... 18 N•m (13 lb-ft)
8 Fuel Pump

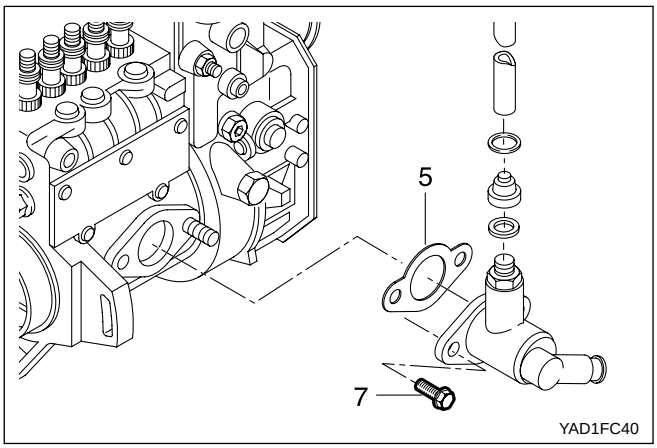


Removal & Installation procedure

1. Disconnect the fuel pressure and suction line.

   Installation Notice

Tightening Torque	13 N•m (10 lb-ft)

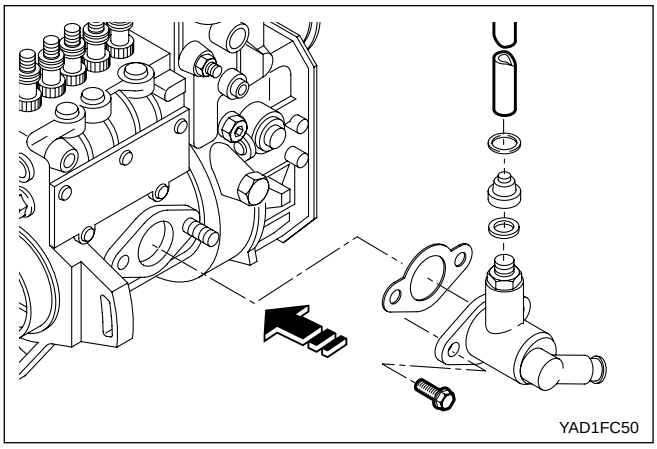


2. Remove the fuel pump mounting bolts.

   Installation Notice

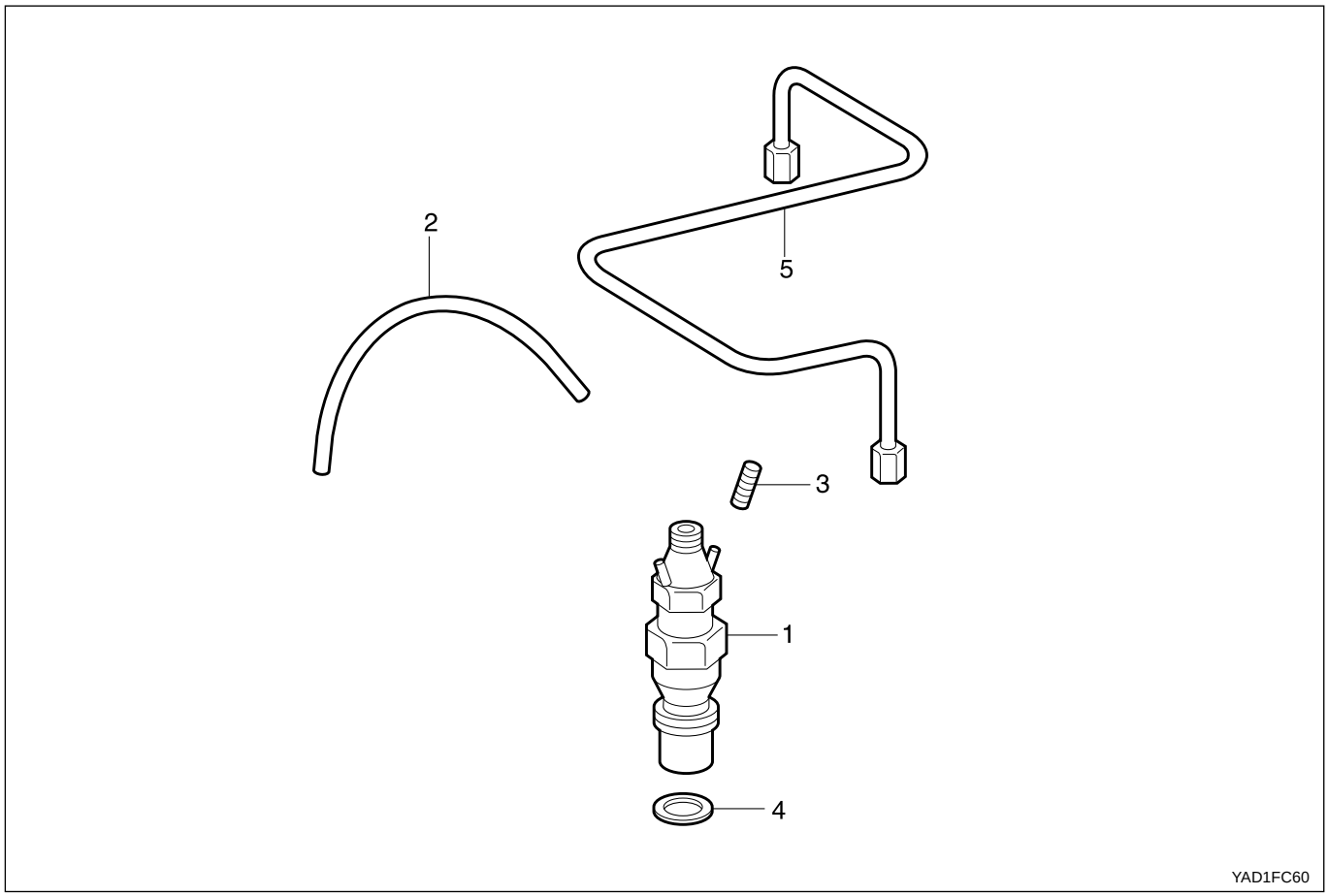
Tightening Torque	17 N•m (10 lb-ft)

3. Remove the fuel pump and gasket.

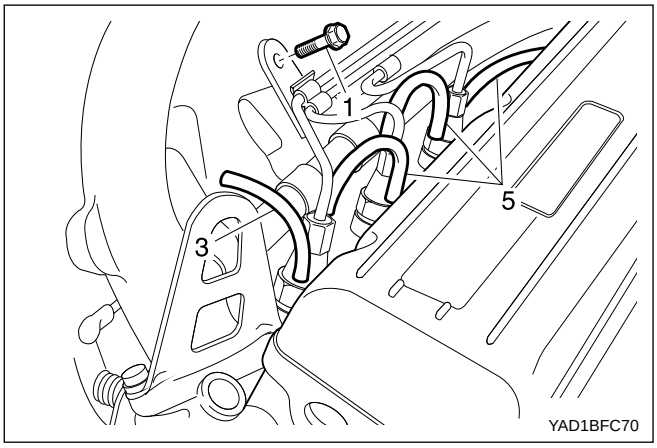


4. Installation should follow the removal procedure in the reverse order.

INJECTION NOZZLES



1 Fuel Injection Nozzle . 35 - 40N•m (26 - 30 lb-ft)
2 Fuel Return Hose
3 Plug
4 Nozzle Washer ..... Replace
5 Fuel Injection Pipe ..... 18 N•m (13 lb-ft)

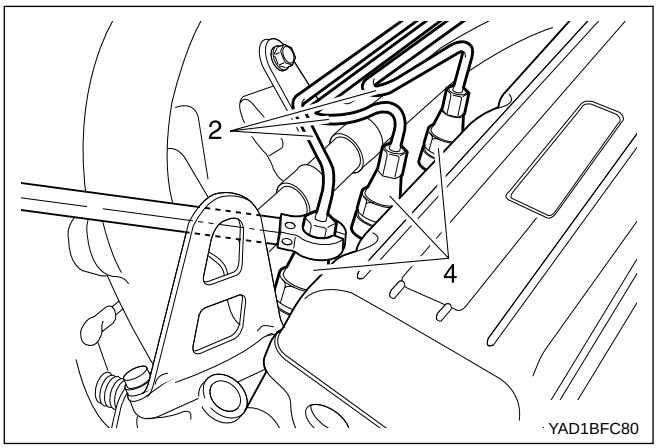


Tools Required

001 589 65 09 00 Serration Wrench

Removal & Installation Procedure

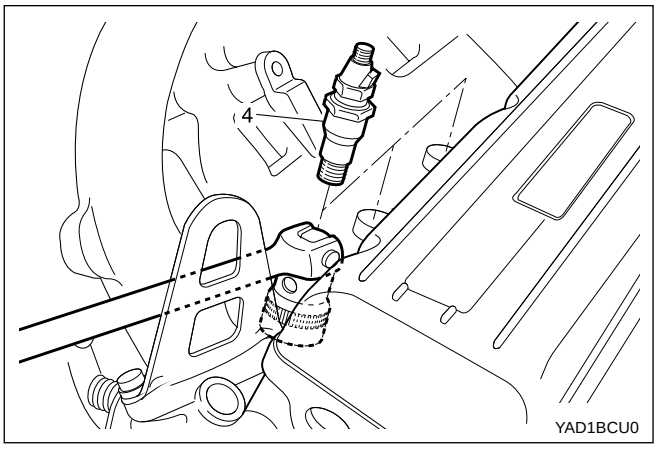
1. Remove the plastic clip from the injection pipe
2. Remove the fuel return hose (5).
3. Remove the plug(3).



4. Disconnect the injection pipes from the injection nozzles and push them to the side.

Installation Notice

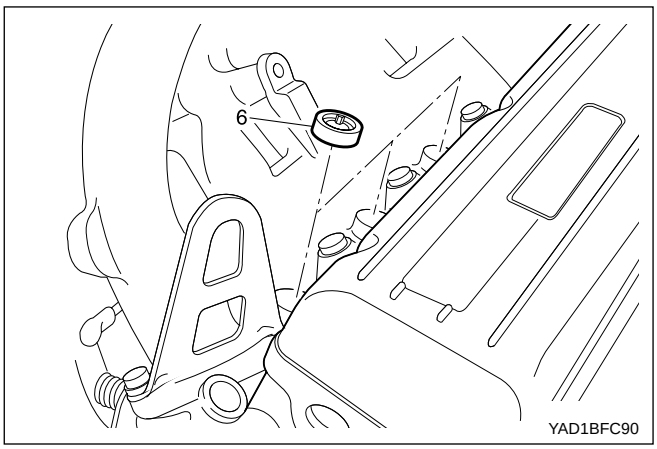
Tightening Torque	18 N•m (13 lb-ft)



5. Remove the fuel injection nozzle (4) with serration wrench 001 589 65 09 00.

Installation Notice

Tightening Torque	35 - 40 N•m (26 - 30 lb-ft)

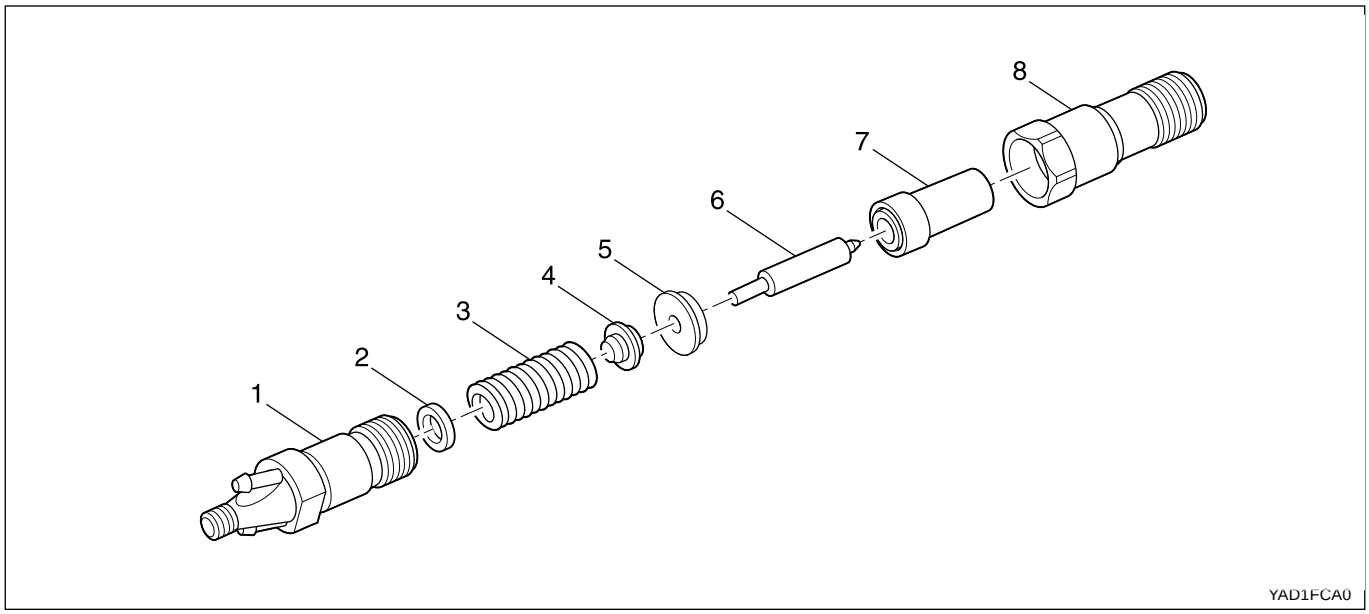


6. Replace the washers (6).
7. Installation should follow the removal procedure in the reverse order.

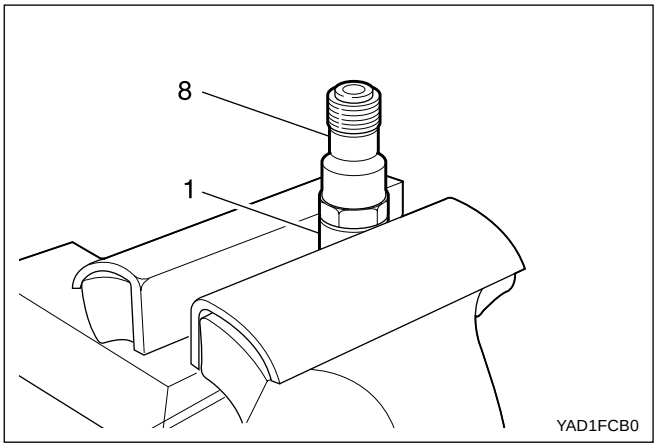
Notice: Pay attention to the installation position of new nozzle washer and tightening torque.

INJECTION NOZZLE REPAIR

Preceding Work: Removal of fuel injection nozzle



1 Nozzle Holder
2 Steel Washer
3 Compression Spring
4 Thrust Pin
5 Intermediate Disc
6 Nozzle Needle
7 Nozzle Body
8 Nozzle Tensioning Nut ..... 80 N•m (59 lb-ft)



Tools Required

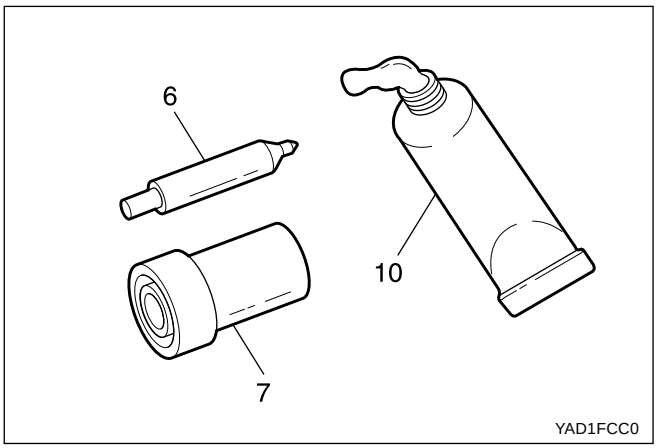
000 589 00 68 00 Cleaning Set

Repair Procedure

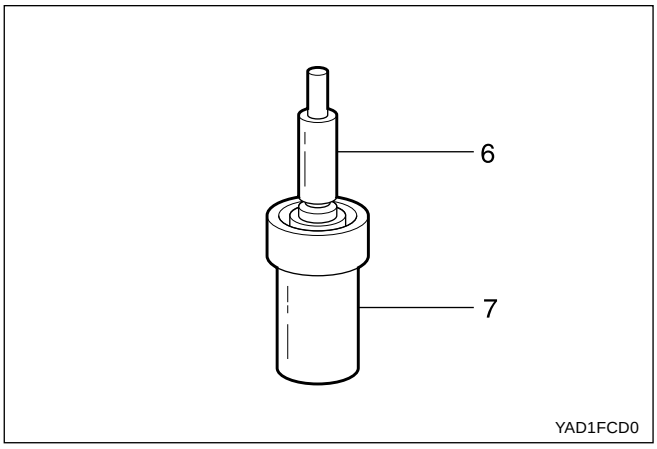
1. Clamp the nozzle holder (1) in a vice and remove the nozzle tensioning nut (8).

   Notice: Use protective jaws for clamping.

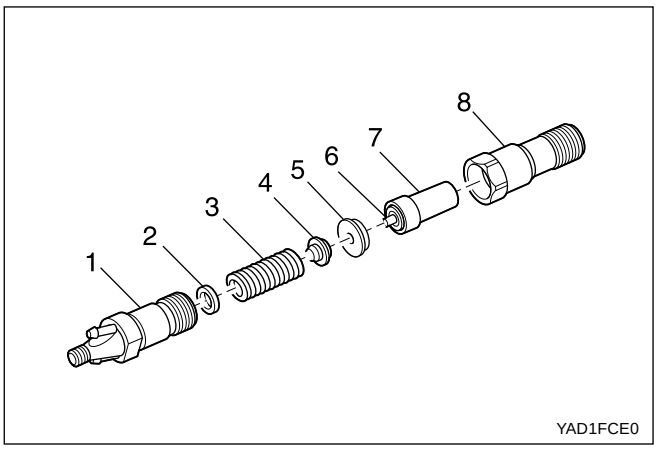
2. Disassemble the fuel injection nozzle.



3. Clean the nozzle needle (6) and nozzle body (7) with an abradant.
4. Clean the nozzle seat with cleaning cutter.



5. Immerse nozzle needle (6) and nozzle body (7) in filtered diesel fuel. When the nozzle body is held vertical, the weight of the nozzle needle must cause it to slide down toward the nozzle needle seat.



6. Assemble the injection nozzle so that the tip of the thrust (4) pin is facing toward the nozzle holder.

   Installation Notice

Tightening Torque	80 N•m (59 lb-ft)

   Nozzle needle (6) and nozzle body (7) should always be replaced as a pair.

7. Check the fuel injection nozzle and adjust opening pressure if necessary.

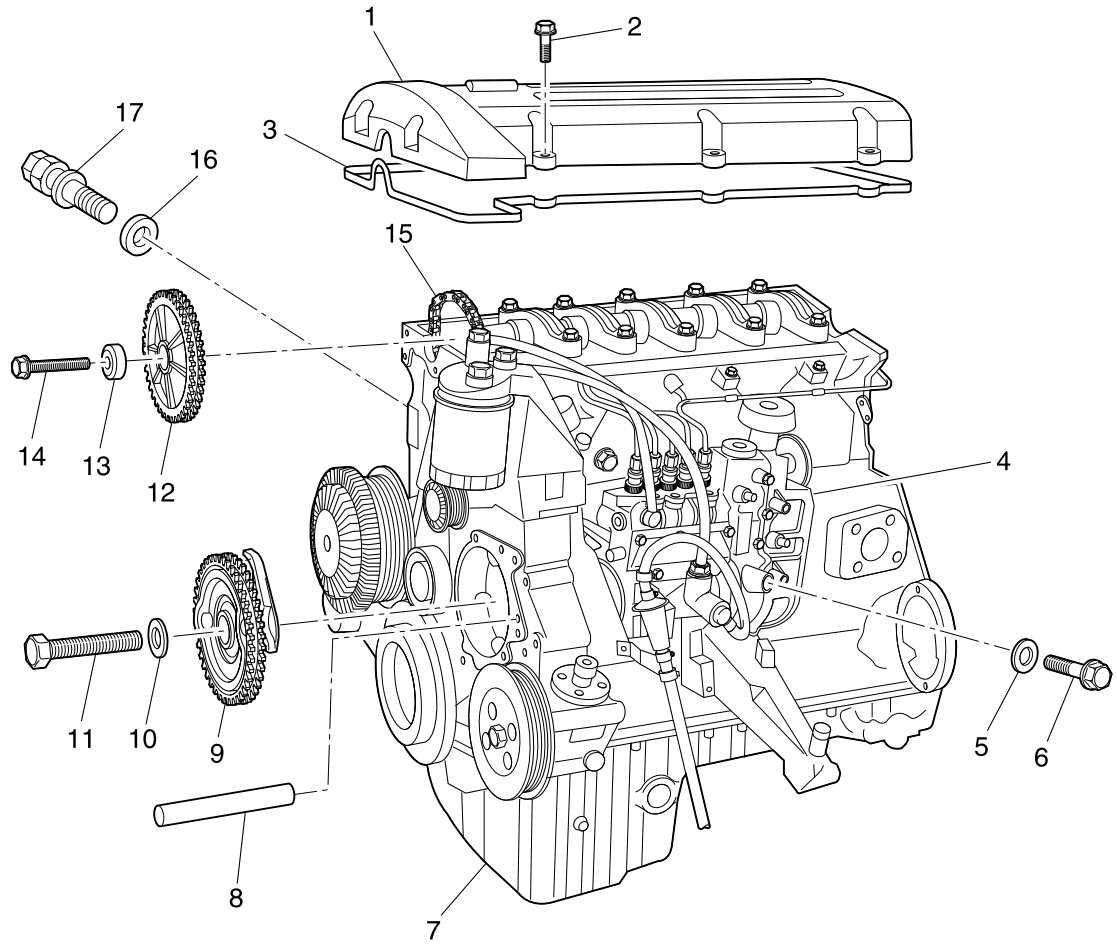
   Opening pressure adjustment

   Disassemble the fuel injection nozzle and replace the steel washer (2).

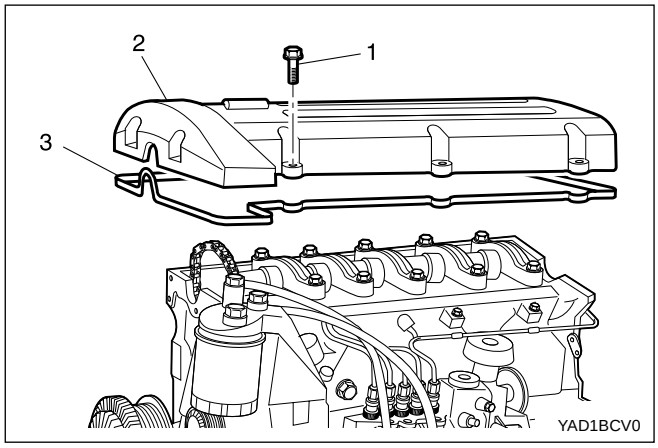
   Notice: Each 0.05 mm thickness of the washer results in a pressure difference of approx. 3 bar.

INJECTION TIMING DEVICE ASSEMBLY

Preceding Work : Removal of vacuum pump



1 Cylinder Head Cover
2 Bolt ..... 10 N•m (89 lb-in)
3 Gasket ..... Replace
4 Fuel Injection Pump
5 Seal ..... Replace
6 Screw Plug ..... 30 N•m (22 lb-ft)
7 Oil Pan
8 Locking Pin
9 Injection Timing Device
10 Washer
11 Bolt (Left-Hand Thread) ..... 46 N•m (34 lb-ft)
12 Camshaft Sprocket
13 Washer
14 12-Sided Stretch Bolt .... Check, 25 N•m (18 lb-ft)+ 90°
15 Timing Chain
16 Seal
17 Chain Tensioner ..... 80 N•m (59 lb-ft)



Tools Required

116 589 02 34 00 Threaded Bolt
116 589 20 33 00 Sliding Hammer
601 589 00 08 00 Flange
601 589 05 21 00 Locking Screw
667 589 04 63 00 Retaining Plate

Removal & Installation Procedure

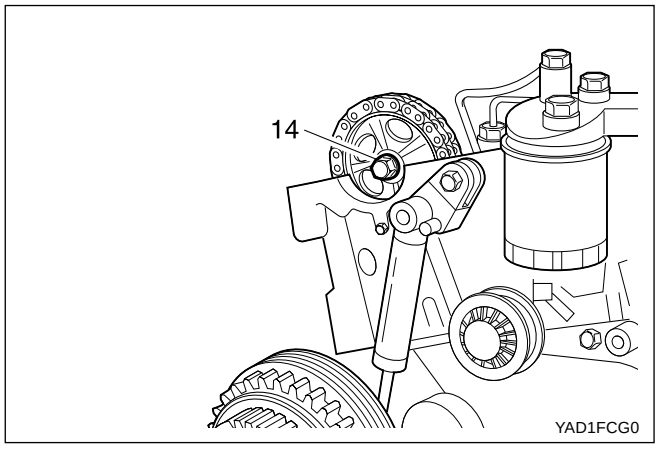
1. Remove the bolts (2) and then remove the cylinder head cover (1) and gasket (3).

   Installation Notice

Tightening Torque	10 N•m (89 lb-in)

   Replace the gasket.

   Rotate the engine 1 revolution by hand and check TDC marking of the crankshaft and camshaft.



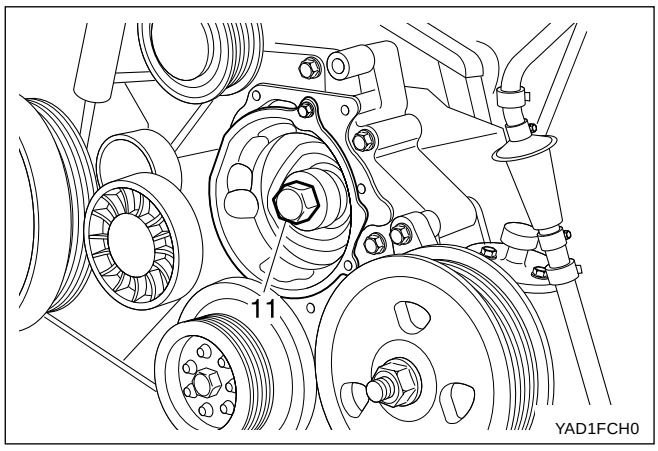
2. Loosen the camshaft sprocket bolt (14).

   Installation Notice

Tightening Torque	25 N•m (18 lb-ft)+ 90°

   Do not remove the bolt.

   If max. length of bolt exceeds 53.6 mm, replace it.

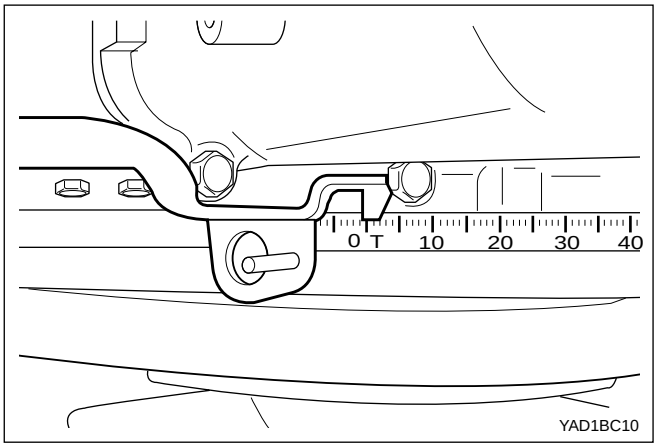


3. Loosen the bolt (11) (left-hand thread).

   Installation Notice

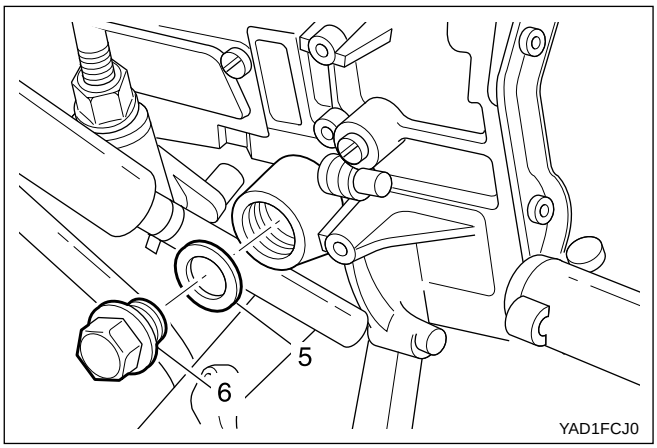
Tightening Torque	46 N•m (34 lb-ft)

   Do not remove the bolt.



4. Position the no.1 cylinder at ATDC 15°.

   Notice: Do not rotate the engine with camshaft sprocket bolt or opposite direction of the engine rotation.

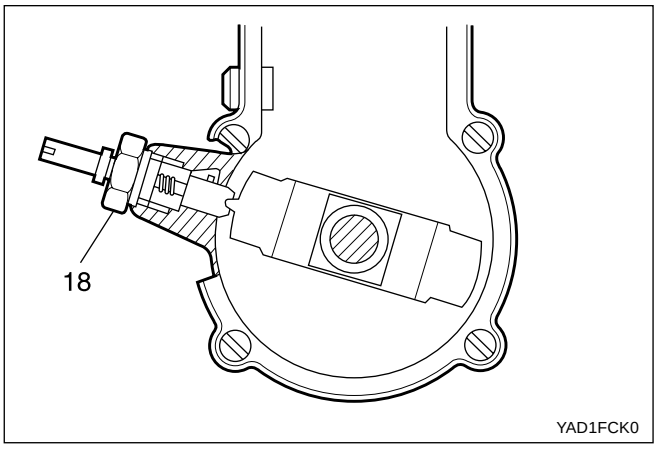


5. Remove the plug (6) and seal (5) from the fuel injection pump and collect oil in a suitable vessel.

   Installation Notice

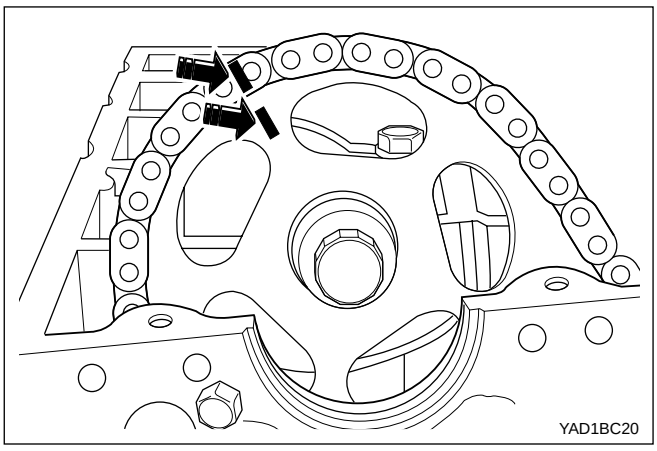
Tightening Torque	30 N•m (22 lb-ft)

   Replace the seal.

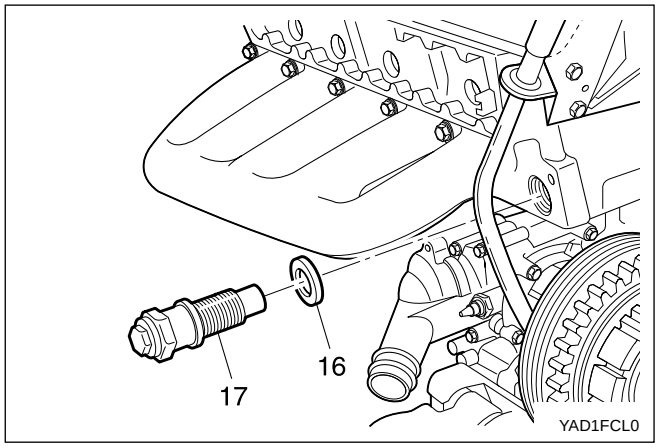


6. Install the locking screw 601 589 05 21 00 (18) into the injection pump.

   Notice: Before tightening the bolts for the injection timing device and the camshaft sprocket, always remove the locking screw 601 589 05 21 00 from the injection pump and reinstall the plug.



7. Place alignment marks (arrow) on the timing chain (12) and camshaft sprocket (15).

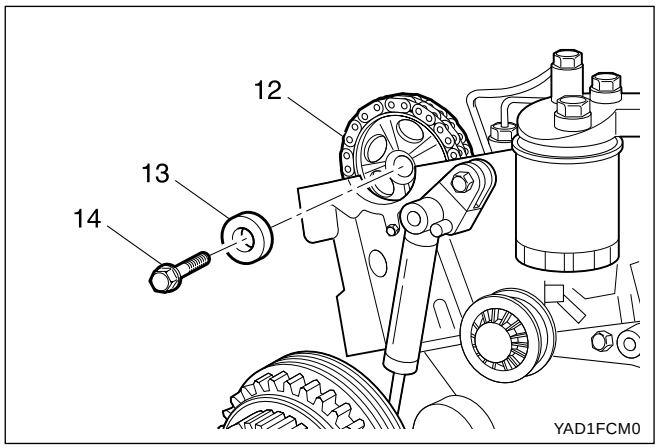


8. Remove the chain tensioner (17).

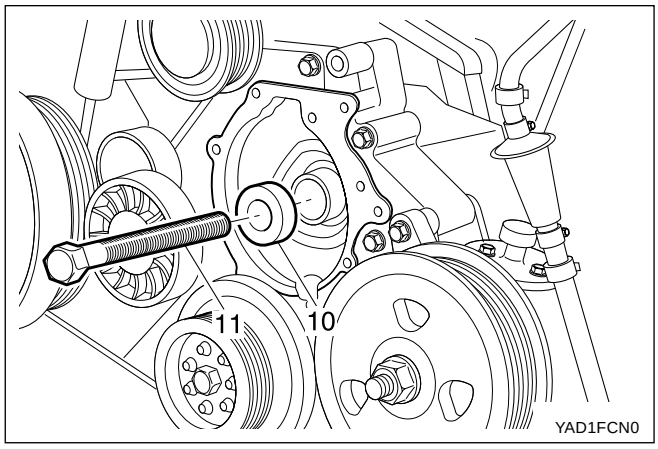
Installation Notice

Tightening Torque	80 N•m (59 lb-ft)

Replace the seal (16).

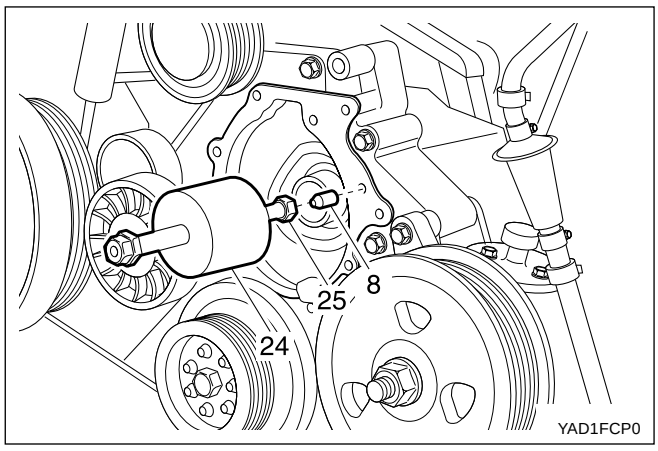


9. Pull out the 12-sided stretch bolt (14) and washer and remove the camshaft sprocket (12).

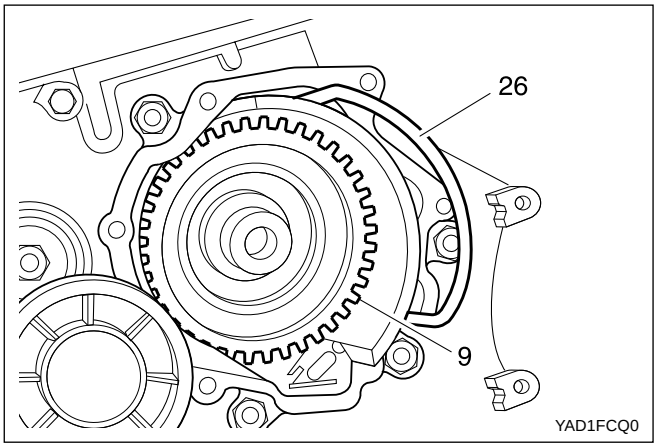


10. Pull out the bolt (11) and washer (10).

Notice: Be careful that the bolt is left-hand thread.



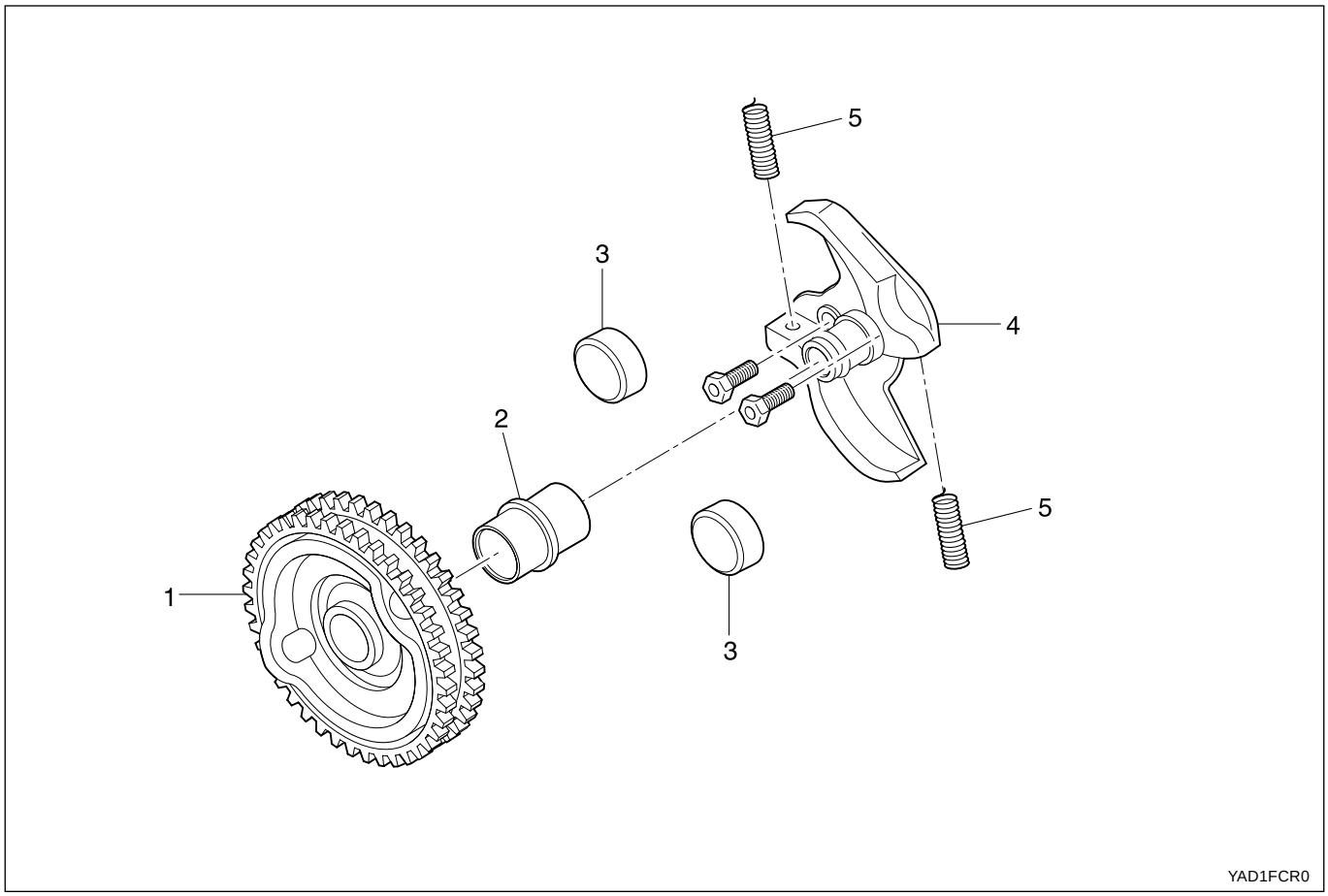
11. Using special tool (Sliding Hammer 116 589 20 33 00 - 24,Threaded bolt 116 589 02 34 00 - 25), remove the locking pin (8).



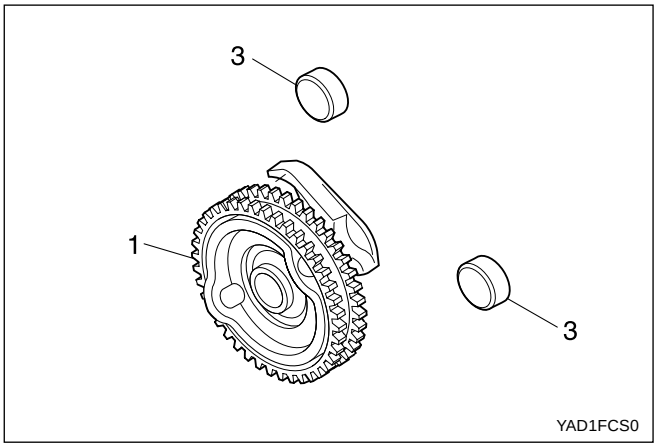
12. Push back the timing chain with retaining plate 667 589 04 63 00 (26) and remove the injection timing device (9).
13. Installation should follow the removal procedure in the reverse order.
14. After assembling the engine, check start of delivery and adjust if necessary.

INJECTION TIMING DEVICE

Preceding Work: Removal of injection timing device assembly

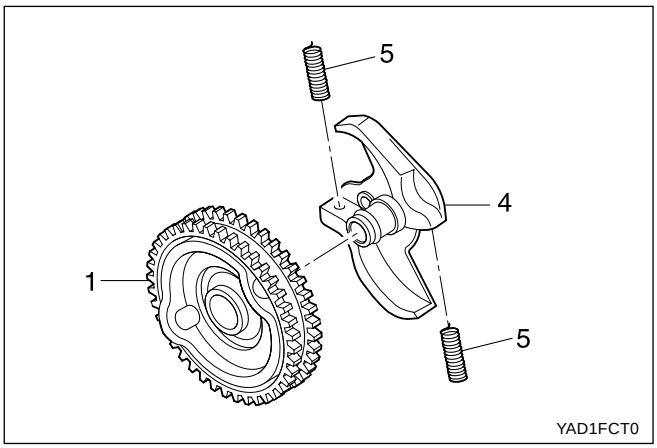


1 Cam Sprocket ..... Check
2 Bushing ..... Check
3 Governor Weights
4 Segment Flange and Drive Hub
5 Compression Springs

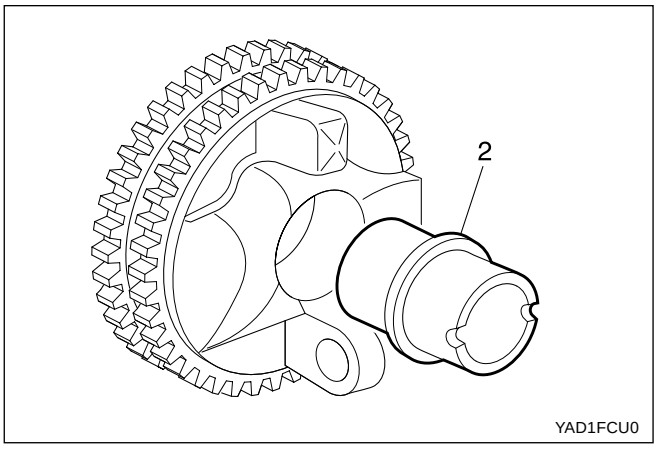


Removal & Installation Procedure

1. Remove the governor weights (3).



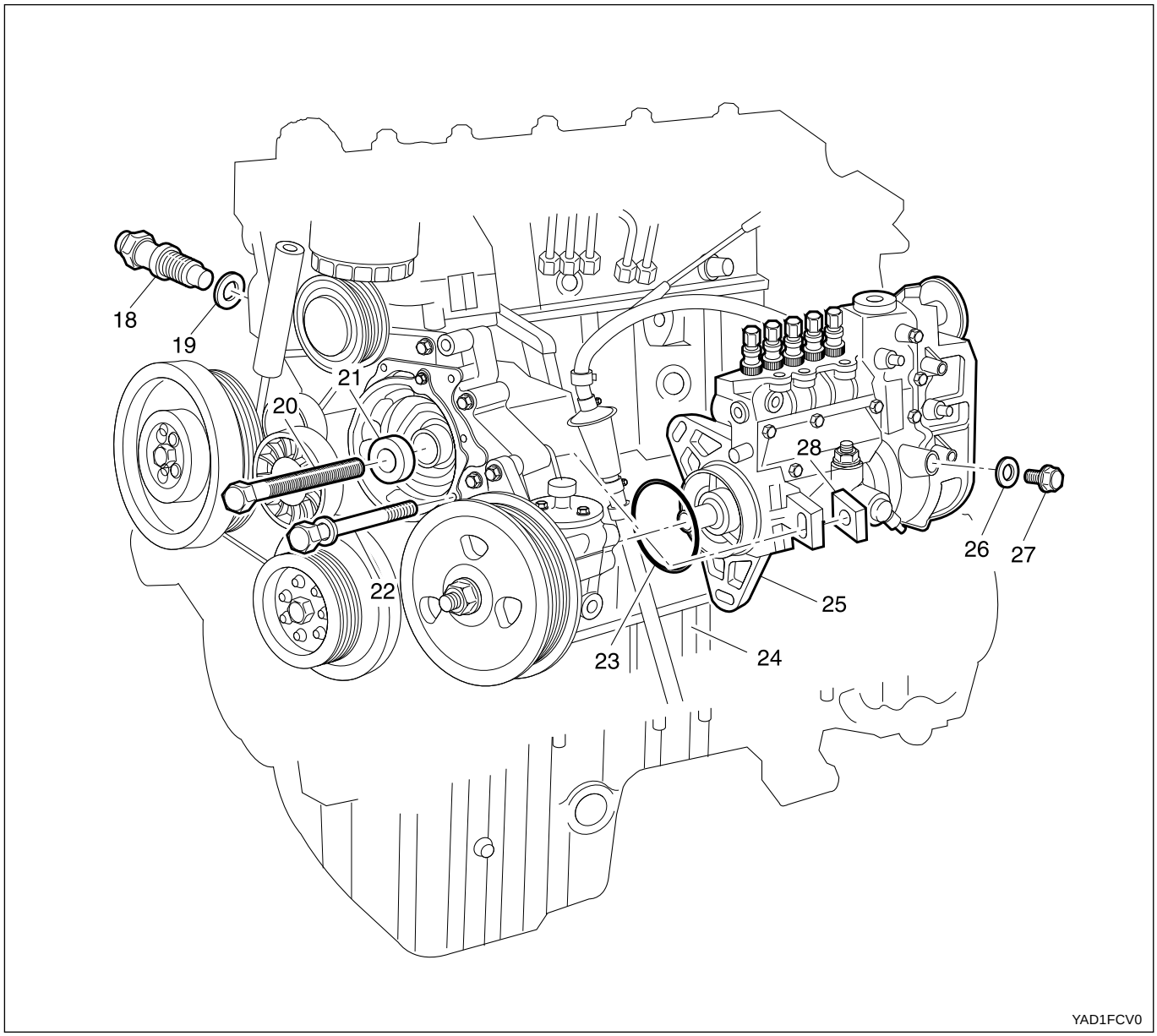
2. Pull out the compression springs (5) and cam sprocket (1) from the segment flange (4).



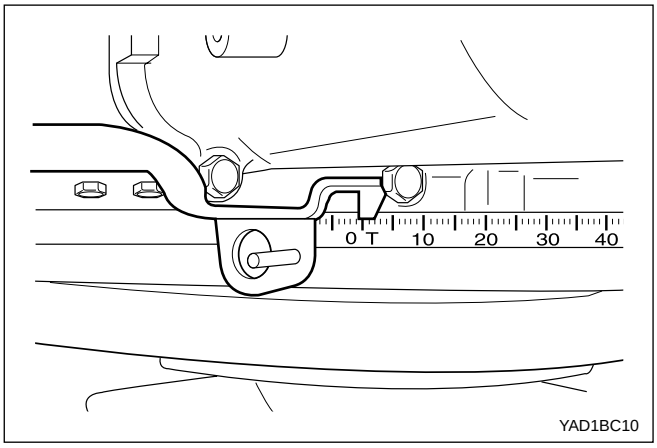
3. Knock out the bushing (2) with a proper drift.
4. Installation should follow the removal procedure in the reverse order.

FUEL INJECTION PUMP

Preceding Work: Removal of vacuum pump
Removal of air cleaner housing
Removal of intake manifold



18 Chain Tensioner ..... 80 N•m (59 lb-ft)
19 Seal ..... Replace
20 Bolt(Left-Hand Thread) ..... 46 N•m (34 lb-ft)
21 Washer
22 Bolt ..... 23 N•m (17 lb-ft)
23 Seal ..... Replace
24 Oil Pan
25 Fuel Injection Pump
26 Seal ..... Replace
27 Screw Plug ..... 30 N•m (22 lb-ft)
28 Square Nut



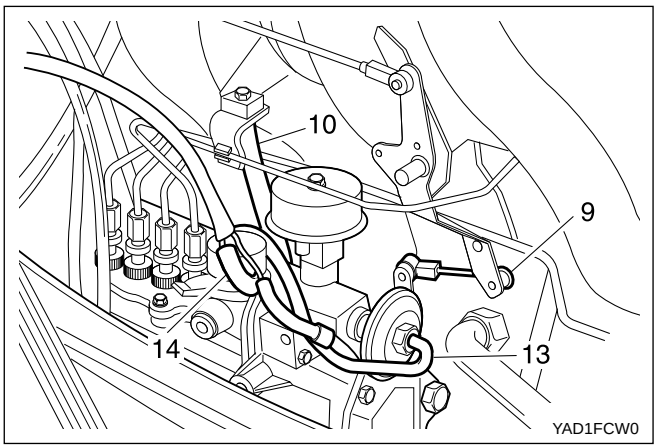
Tools Required

000 589 77 03 00	Box Wrench Insert
601 589 00 08 00	Flange
601 589 05 21 00	Locking Screw
601 589 05 14 00	Assembly Cage

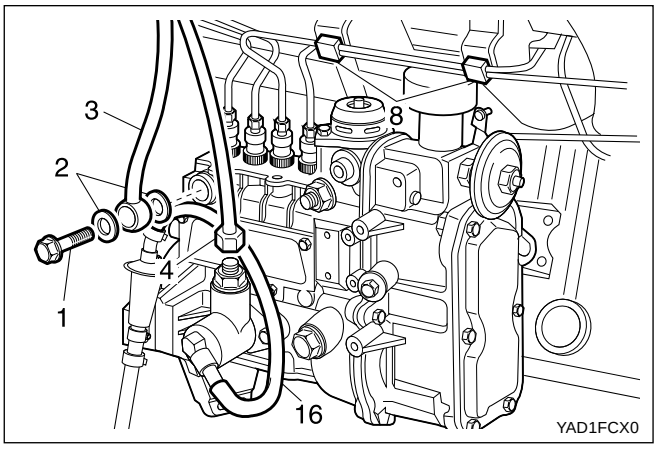
Removal Procedure

1. Position the no.1 cylinder at 15° ATDC.

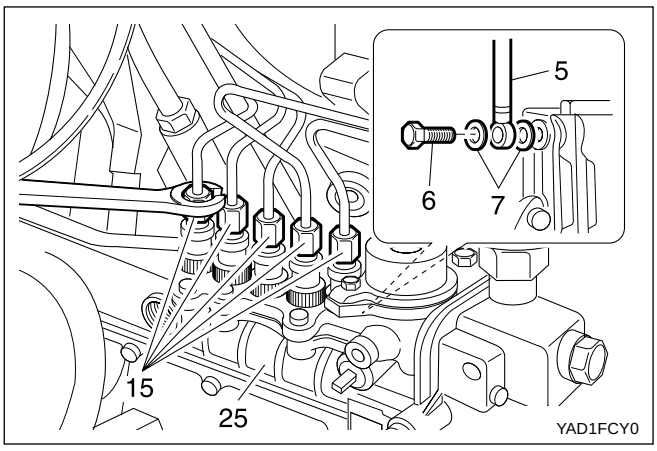
   Notice: Do not rotate the engine in opposition direction of engine rotation.



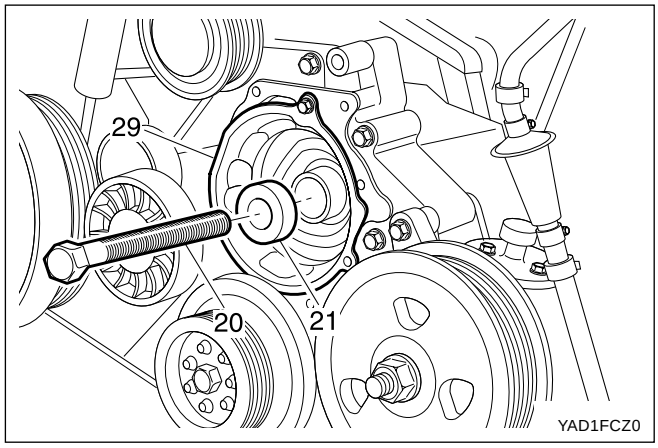
2. Remove the connecting rod (9).
3. Disconnect the vacuum lines (13, 14).
4. Remove the accelerator control damper (10).
   (Manual transmission vehicle)



5. Remove the suction line (16) and pressure line (4).
6. Remove the banjo bolt (1) and then remove the seal (2) and fuel line (3).
7. Remove the plastic clip (8) on the injection line.

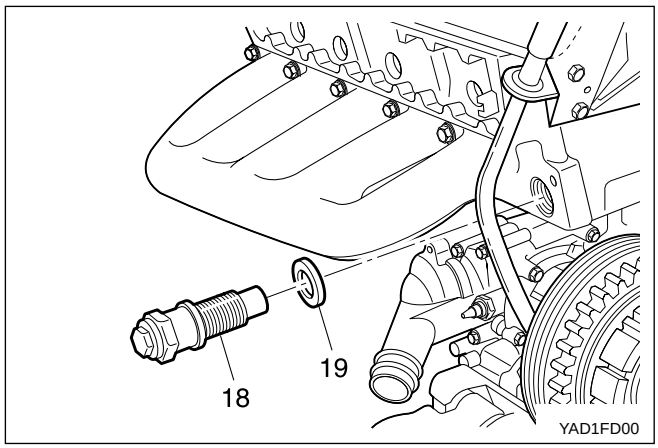


8. Disconnect the injection lines (15) from the injection pump (25).
9. Remove the banjo bolt (6) and then remove the seal (7) and return line (5).

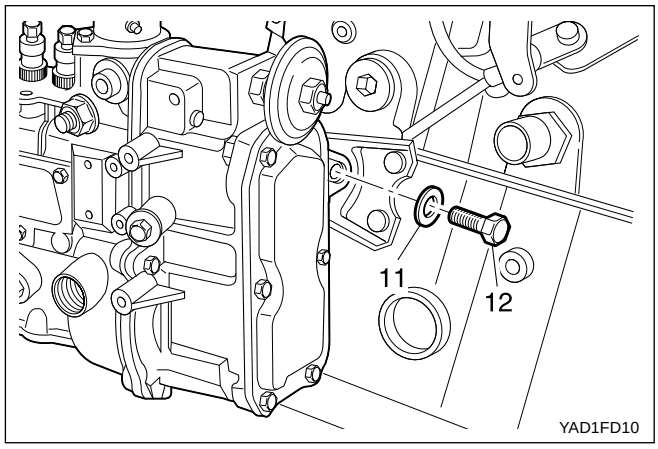


10. Install the assembly cage 601 589 05 14 00 (29) and remove the bolt (20) and pull off the washer (21).

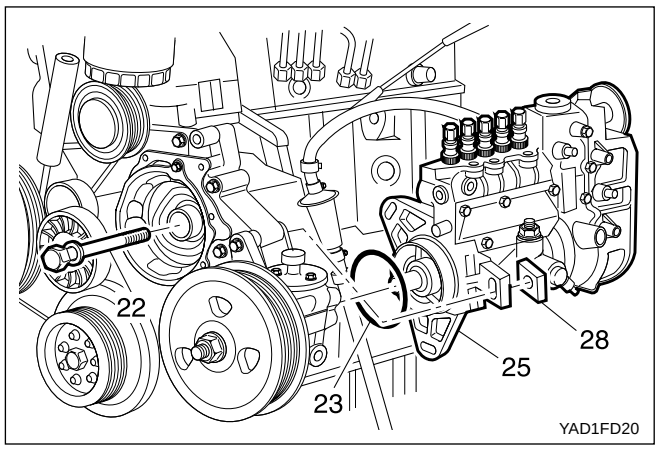
    Notice: Be careful that the bolt (20) is left hand thread.



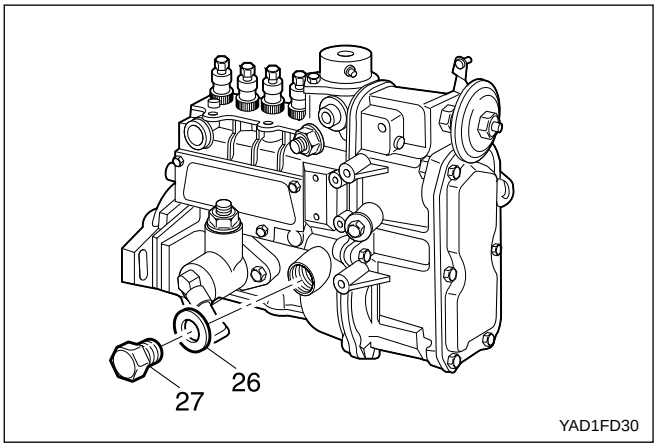
11. Remove the chain tensioner (18) and seal (19).



12. Remove the bolt (12) and pull off the washer (11).

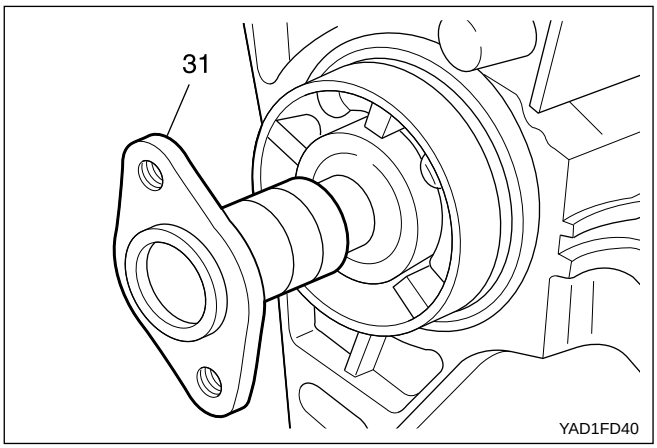


13. Remove the bolt (22) and pull off the square nut (28).
14. Pull out the fuel injection pump (25) and seal (23).

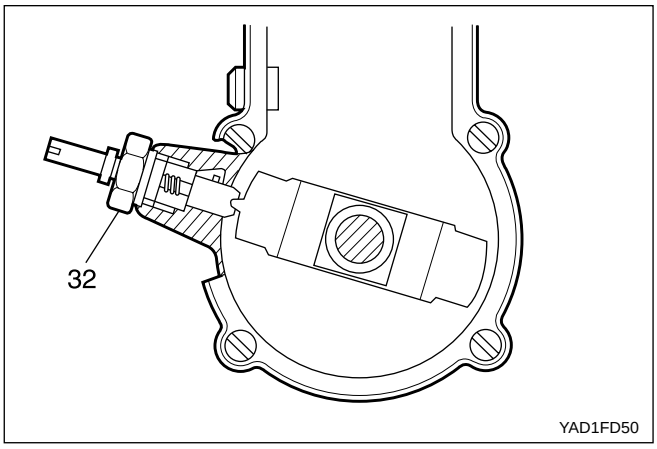


Installation Procedure

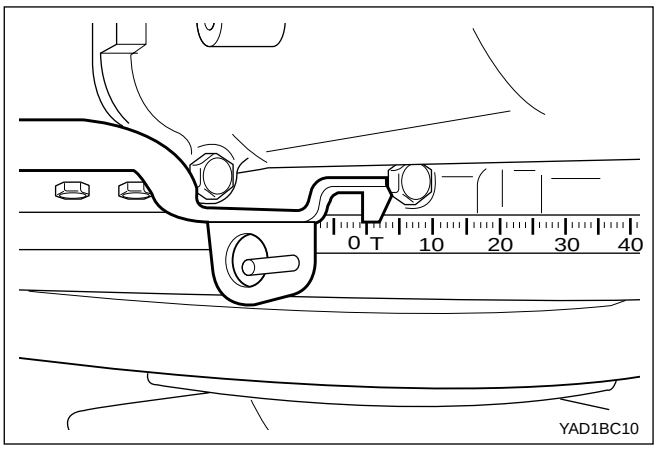
1. Remove the screw plug (27) and seal (26) and collect oil in a vessel.



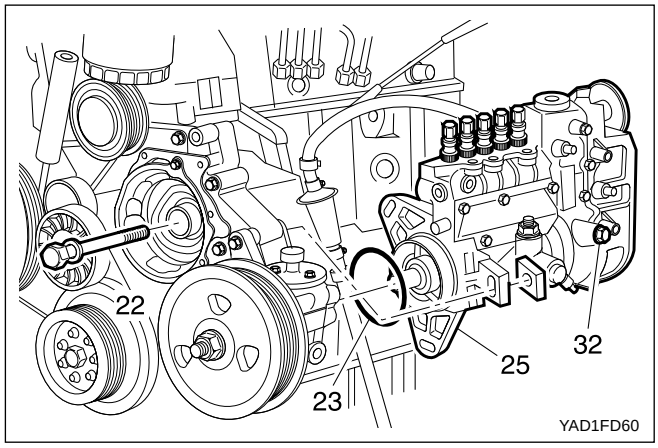
2. Insert flange 601 589 00 08 00 (31) onto the injection pump camshaft and turn until the cam of the governor is visible in the hole.



3. Tighten the locking screw 601 589 05 21 00.



4. Ensure that the no.1 cylinder is positioned at ATDC 15°.

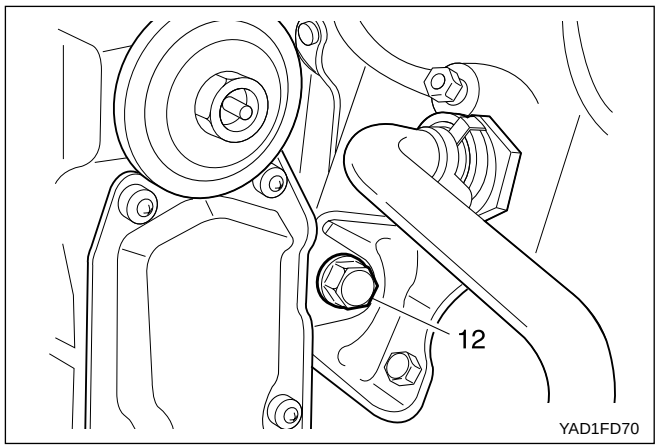


5. Coat the new seal (23) with engine oil and install it.
6. Insert the fuel injection pump (25) and tighten the bolts (22).

Installation Notice

Tightening Torque	23 N•m (17 lb-ft)

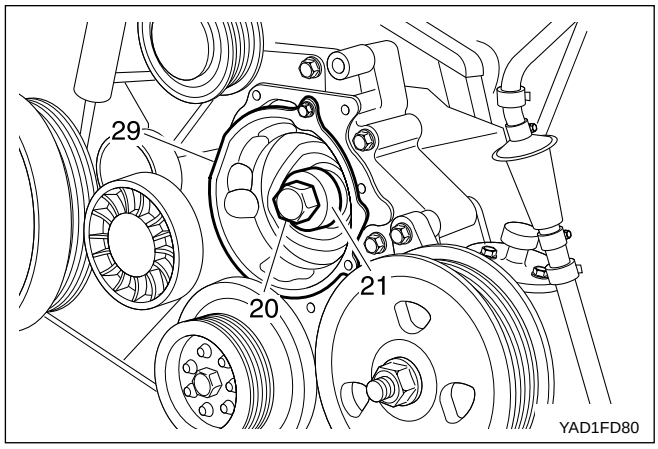
7. Remove the locking screw (32).



8. Tighten the bolt (12).

Installation Notice

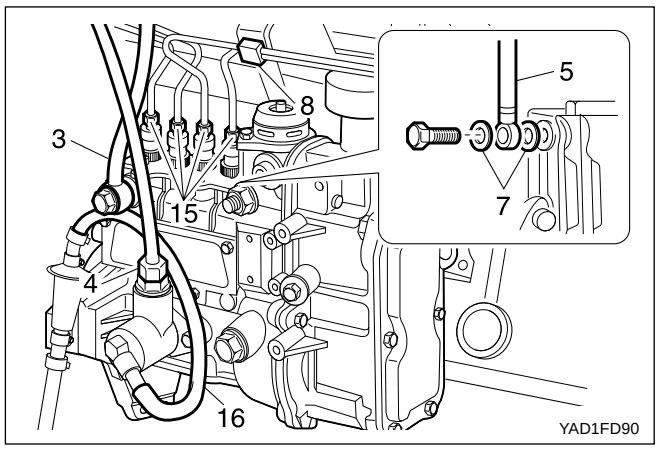
Tightening Torque	23 N•m (17 lb-ft)



9. Insert the washer (21) and tighten the bolts (20) and then remove the assembly cage 601 589 05 14 00 (29).

Installation Notice

Tightening Torque	46 N•m (34 lb-ft)



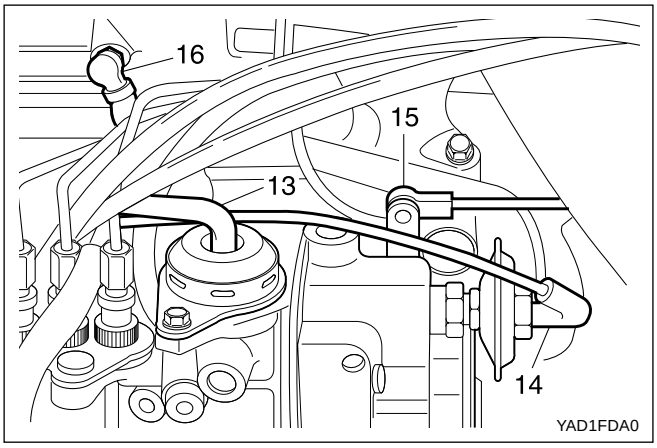
10. Connect the fuel pipes

Installation Notice

Return Line (5)	13 N•m (10 lb-ft)
Fuel Injection Line (15)	18 N•m (13 lb-ft)
Fuel feed Line (3)	13 N•m (10 lb-ft)
Suction and Pressure Line (4)	13 N•m (10 lb-ft)

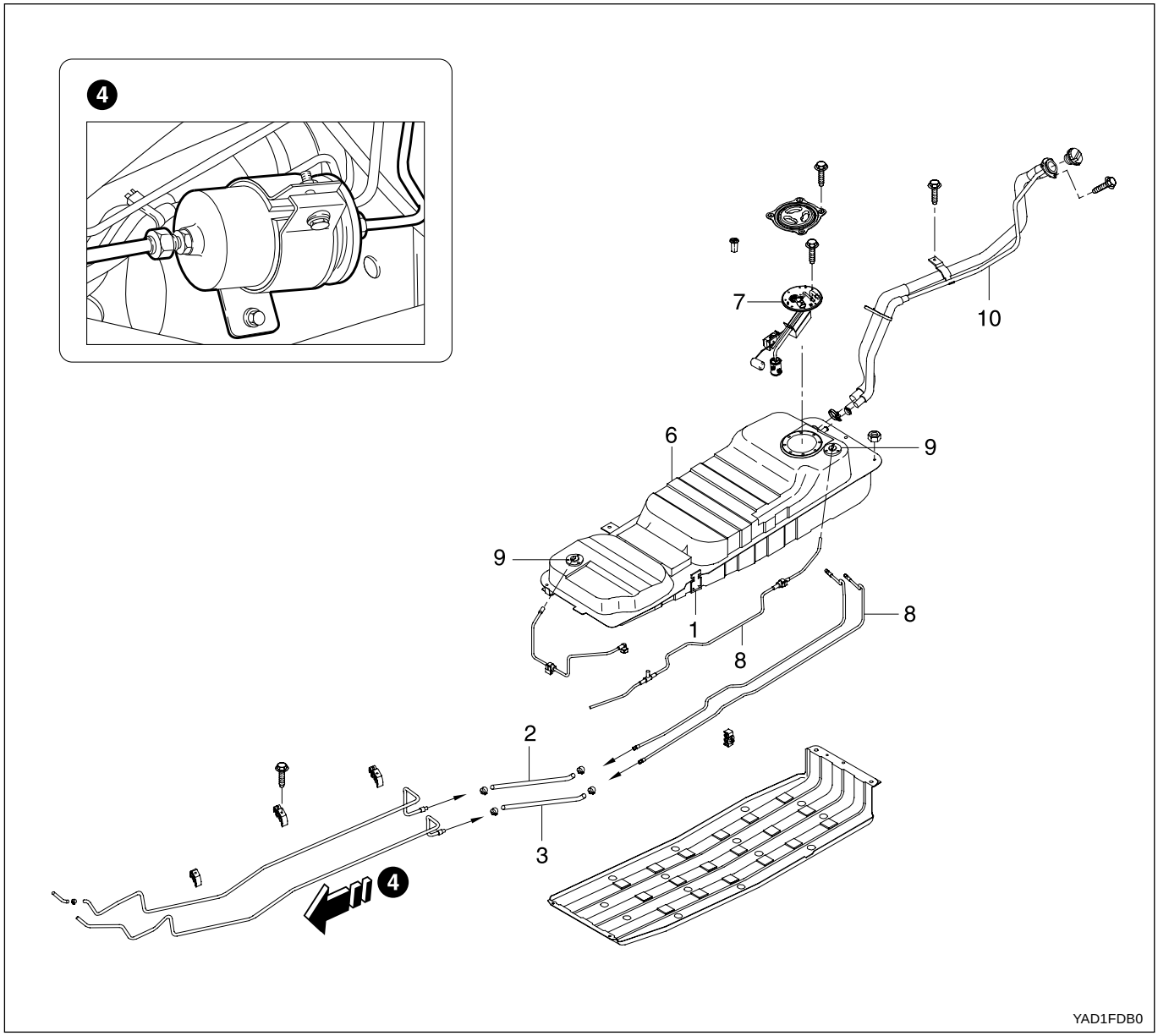
Replace the seal.

11. Assemble the plastic clip (8).

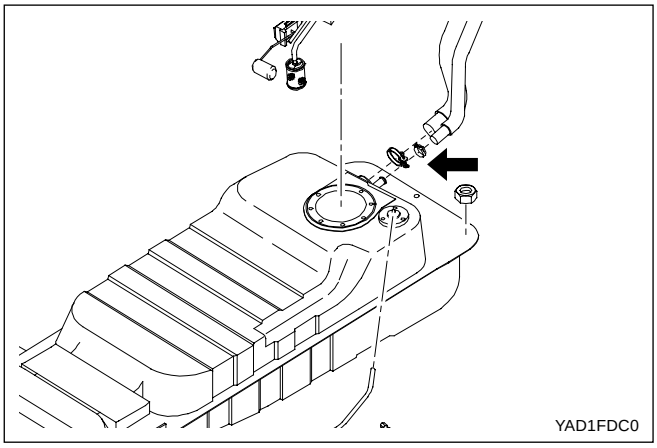


12. Connect the vacuum line (13, 14).
13. Connect the connecting rod (15).
14. connect the accelerator control damper (16). (Manual transmission vehicle)
15. Install the chain tensioner.
16. Install the vacuum pump.
17. Check the start of delivery.
18. Adjust the idle speed.

FUEL TANK



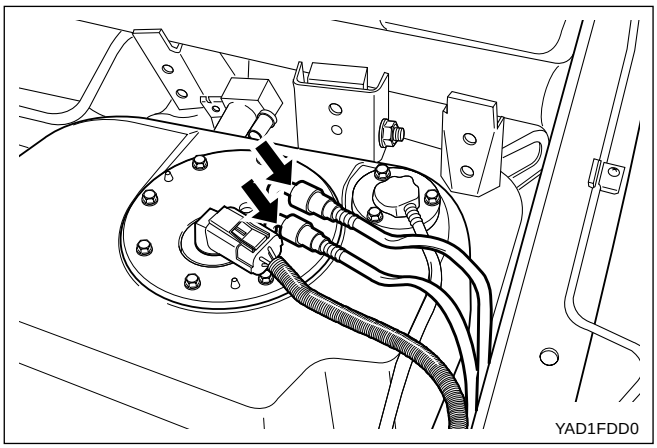
1 Fuel Tank Mounting Bracket
2 Fuel Return Line
3 Fuel Supply Line
4 Fuel Filter
6 Fuel Tank
7 Fuel Pump
8 Fuel Tank Rear Pipe
9 Fuel Tank Air Cap
10 Fuel Filler Assembly



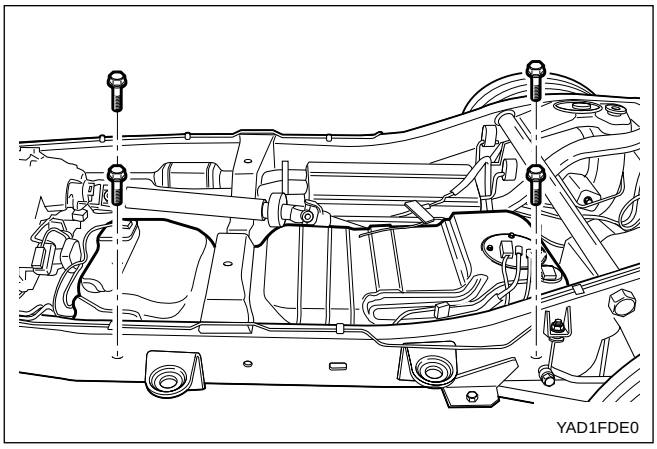
Removal & Installation Procedure

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. Disconnect the negative battery cable.
2. Disconnect the fuel filler hoses.



3. Put aside the floor carpet to remove the fuel pump access cover.
4. Remove the fuel pump access cover.
5. Disconect the fuel return and supply line.
6. Disconnect the fuel pump wiring connector.



7. Remove the fuel pump moumting bolts and bracket.
8. Carefully lower the fuel tank.
9. Installation should follow the removal precedure in the reverse order.

SPECIFICATIONS

GENERAL SPECIFICATIONS

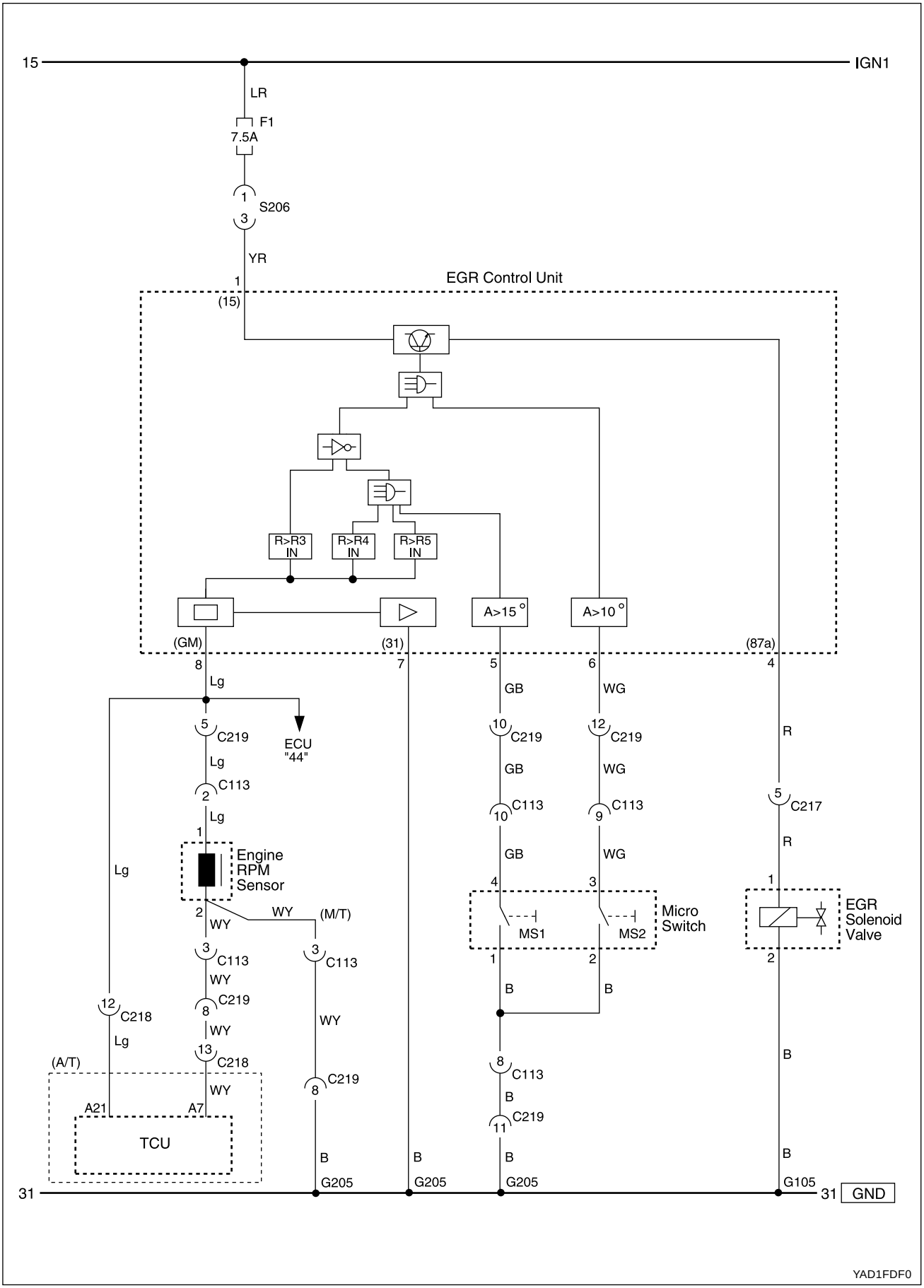
Fuel Distribution Type	Individual Injection Type (Same Number of Cylinder and Plunger)
Number of Cylinders	5 Cylinder
Mounting Type	End Flange Mounting
Drive Type	Inside Chain Connected with Camshaft
Flange Stroke	7 mm
Flange Outside Diameter	5.5 mm
Rack Movement	21 mm
Max. Speed	2,500 rpm
Injected Fuel Quantity / Stroke	35 mm^3 / Stroke
Lubrication Type	Sump Lubrication Type (Connected with Engine Oil Passage)

FASTENER TIGHTENING SPECIFICATIONS

Application	N•m	Lb - Ft	Lb - In
Camshaft Sprocket Bolt	25 + 90°	18 + 90°	-
Chain Tensioner	80	59	-
Cylinder Head Cover Bolt	10	-	89
Fuel Feed Line (at Fuel Injection Pump)	13	10	-
Fuel Injection Nozzle	35 - 40	26 - 30	-
Fuel Injection Pipe	18	13	-
Fuel Injection Pump Mounting Bolt (at the Timing Cast Cover)	23	17	-
Fuel Injection Pump Supporting Bracket Bolt	23	17	-
Fuel Line Bolt (at Fuel Filter)	13	10	-
Fuel Pressure Line (at Fuel Pump)	13	10	-
Fuel Return Line (at Fuel Injection Pump)	13	10	-
Injection Timing Device Bolt	46	34	-
Nozzle Tensioning Nut	80	59	-
Screw Plug	30	22	-
Vacuum Pump Mounting Bolt	10	-	89

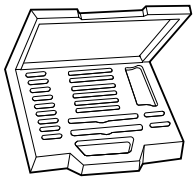
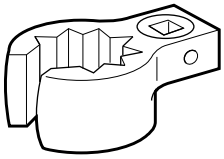
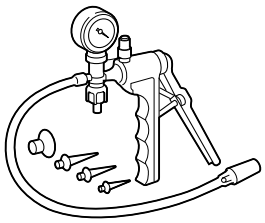
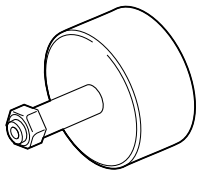
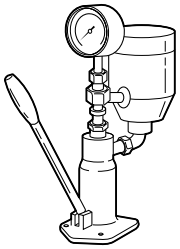
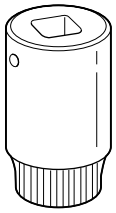
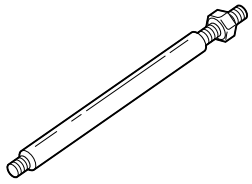
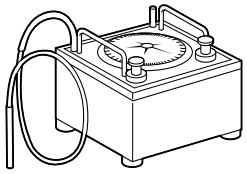
SCHEMATIC AND ROUTING DIAGRAMS

EGR SYSTEM



SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS TABLE

 YAD1FDU0	**000 589 00 68 00** **Cleaning Set**
 YAD1FDT0	**000 589 77 03 00** **Box Wrench Insert**
 YAD1A190	**001 589 73 21 00** **Vacuum Pump**
 YAD1B580	**116 589 20 33 00** **Sliding Hammer**
 YAD1FDK0	**000 589 14 27 00** **Fuel Injection Nozzle Tester**
 YAD1BKB0	**001 589 65 09 00** **Serration Wrench**
 YAD1BLH0	**116 589 02 34 00** **Threaded Bolt**
 YAD1FDG0	**201 589 13 21 00** **Vacuum Tester**

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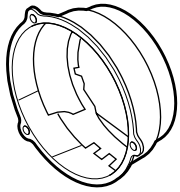
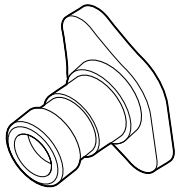
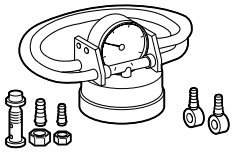
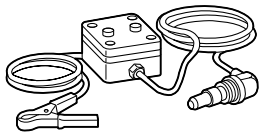
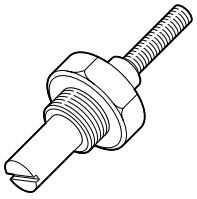
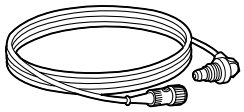
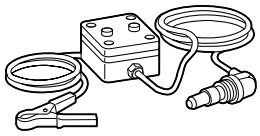
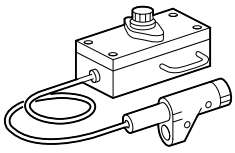
 YAD1FDS0	**601 589 05 14 00** **Assembly Cage**
 YAD1FDP0	**610 589 00 08 00** **Flange**
 YAD1FDJ0	**617 589 04 21 00** **Tester**
 YAD1FDL0	**617 589 08 21 00** **Position Sensor**

 YAD1FDQ0	**601 589 05 21 00** **Locking Sensor**
 YAD1FDN0	**617 589 00 21 00** **Ri Sensor**
	**617 589 08 21 01** **Micro Switch Setting Device**
 YAD1FDM0	**617 589 09 21 00** **Ri Adapter**

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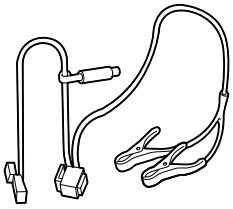
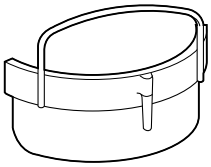
 YAD1FDH0	**667 589 00 21 00** **TDC Pulse Generator**
 YAD1FDR0	**667 589 04 63 00** **Retaining Plate**

SECTION 1G

ENGINE INTAKE & EXHAUST

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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)

Notice: 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.

Notice: 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).

DOC (DIESEL OXIDATION CATALYST)

System and Principle

Oxidation catalytic technology for diesel engine is basically the same with it of gasoline engine used before development of 3 primary catalyst (2 primary catalyst), and its effect and performance were already proved.

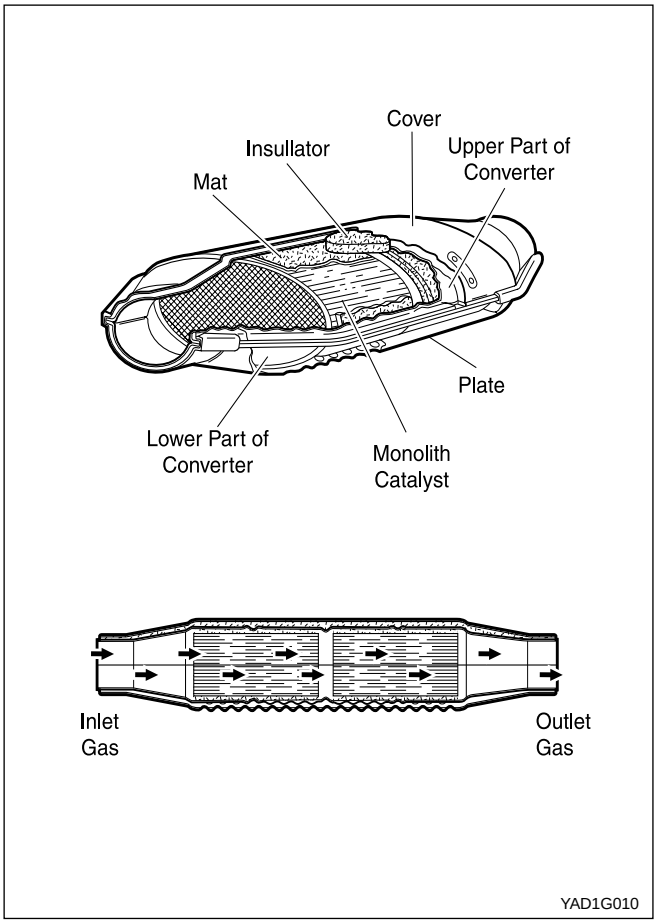
DOC (Diesel Oxidation Catalyst) reduces HO and CO contained exhaust gas over 80%, and removes SOF (Soluble Organic Fraction) over 50~80%, but because its portion in total PM is low, it reduces approx, 20~40% of TPM (Total Particulate Material).

Because of low reducing rate for PM of DOC, in order to guarantee safety rate of PM regulation, this technology is being used mainly.

And it should keep over 80% of PM reducing rate, and at present it plays a role as a transition stage.

And also it reduces diesel odor and black smoke, platinum or palladium are being used as a catalyst.

On the other hand, it is a problem that it makes the reaction of oxidation, which SO_2 produce SO_3 and H_2 SO_4 by reacting to oxygen in exhaust gas, if temperature of exhaust gas becomes over 300°C, and this produced gas is very harmful to human body. To prevent is, previously it is requested that the sulfur content rate of fuel should be below 0.05%, and in the future it is being expected to keep it below 0.01%.



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.

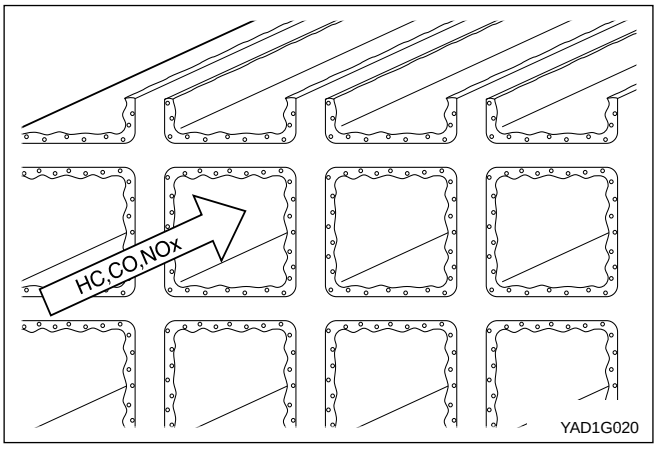
Monolith type is lighter than other types, easy to manufacture and quickly approaches to proper temperature.

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.



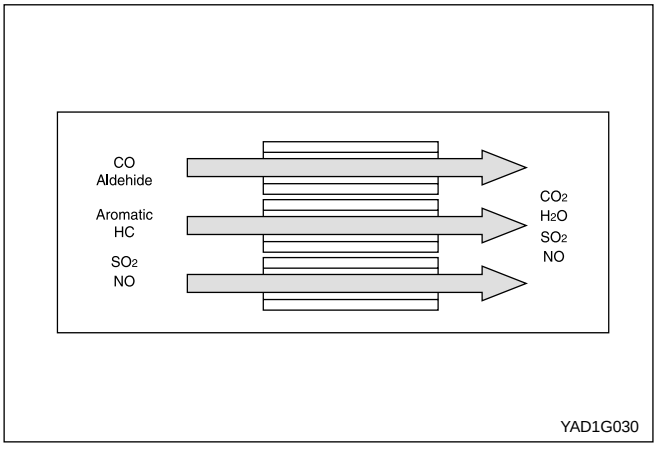
Catalytic Converter and Temperature

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.

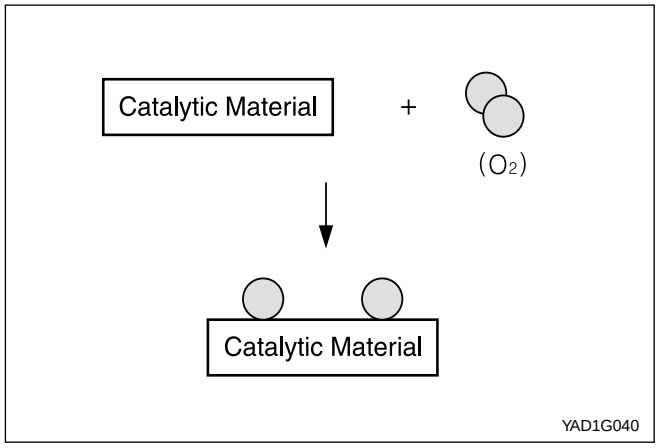


Purification of Catalytic Converter

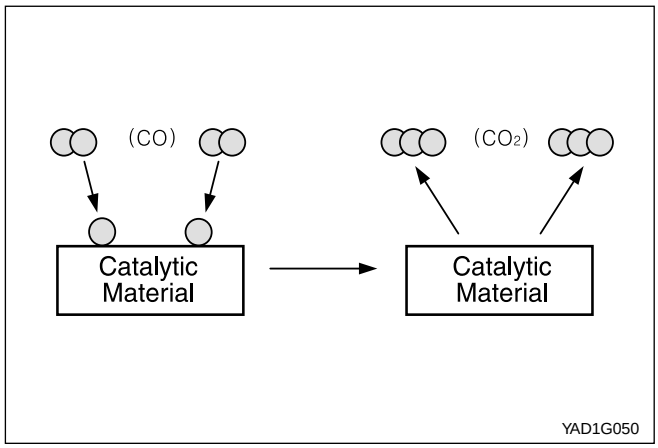
- Adhesion of soluble organic fraction (SOF) below 180°C
- Purification of soluble organic fraction (SOF) over 180°C

  Chemical reaction formula

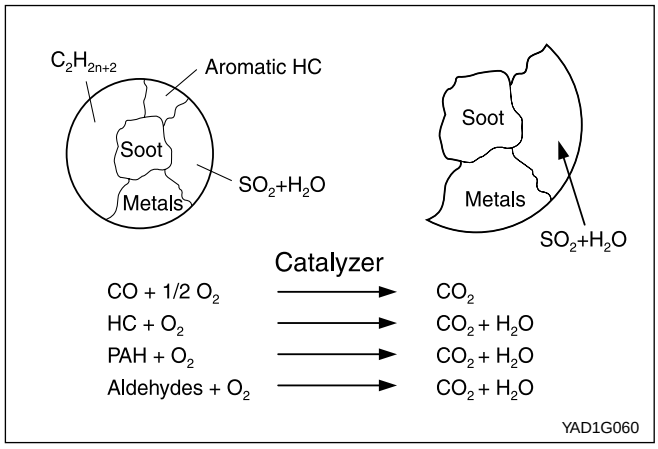
  - SOF(HC)+O_2 → CO_2+H_2O
  - 2CO+O_2 → 2CO_2
  - 2C_2H_6+7O_2 → 4CO_2+6H_20
- By catalytic action of two primary catalytic converter, oxidation occurs in order to decrease HC and CO.



- Oxygen adheres to catalytic material : below 180°C



- Catalytic material supplies each CO and HC with O_2 for their oxidation : above 180°C



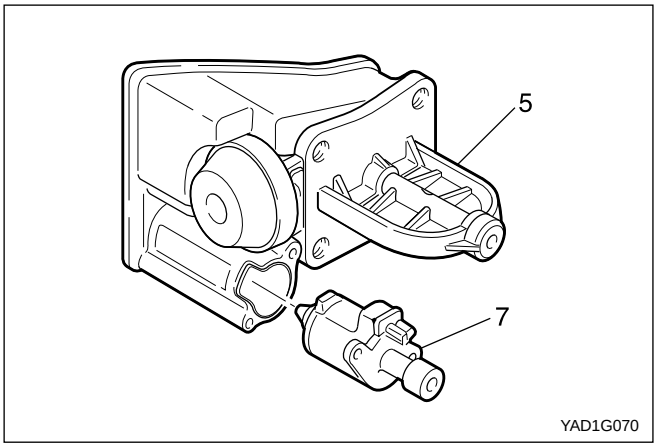
- Catalytic material conversion process by DOC

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.

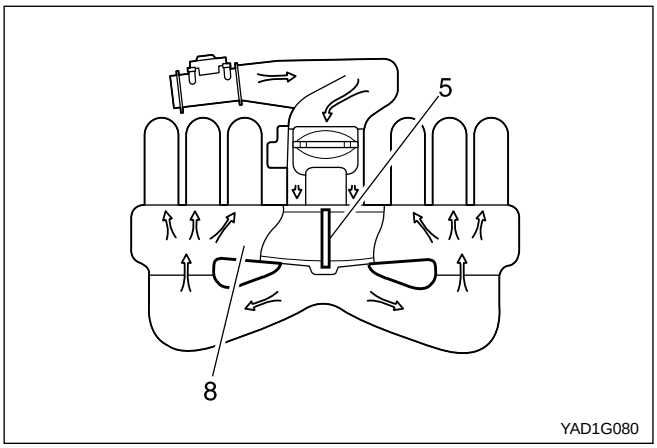
  And micro switch is installed together to control EGR valve.
- The setting method of micro switch is identical with the existing one.



RESONANCE FLAP (GASOLINE ENGINE)

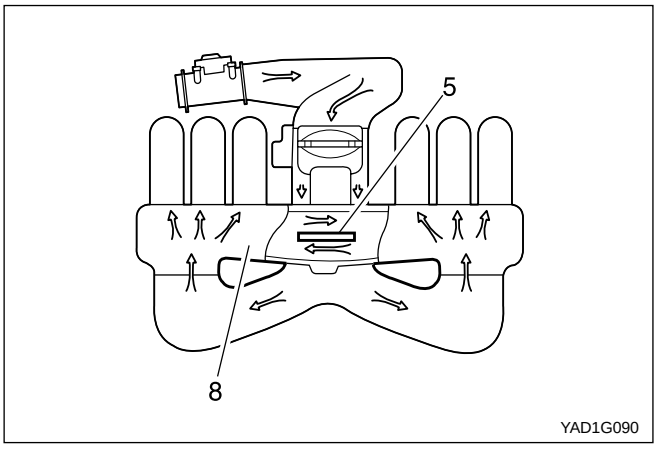
Function

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.



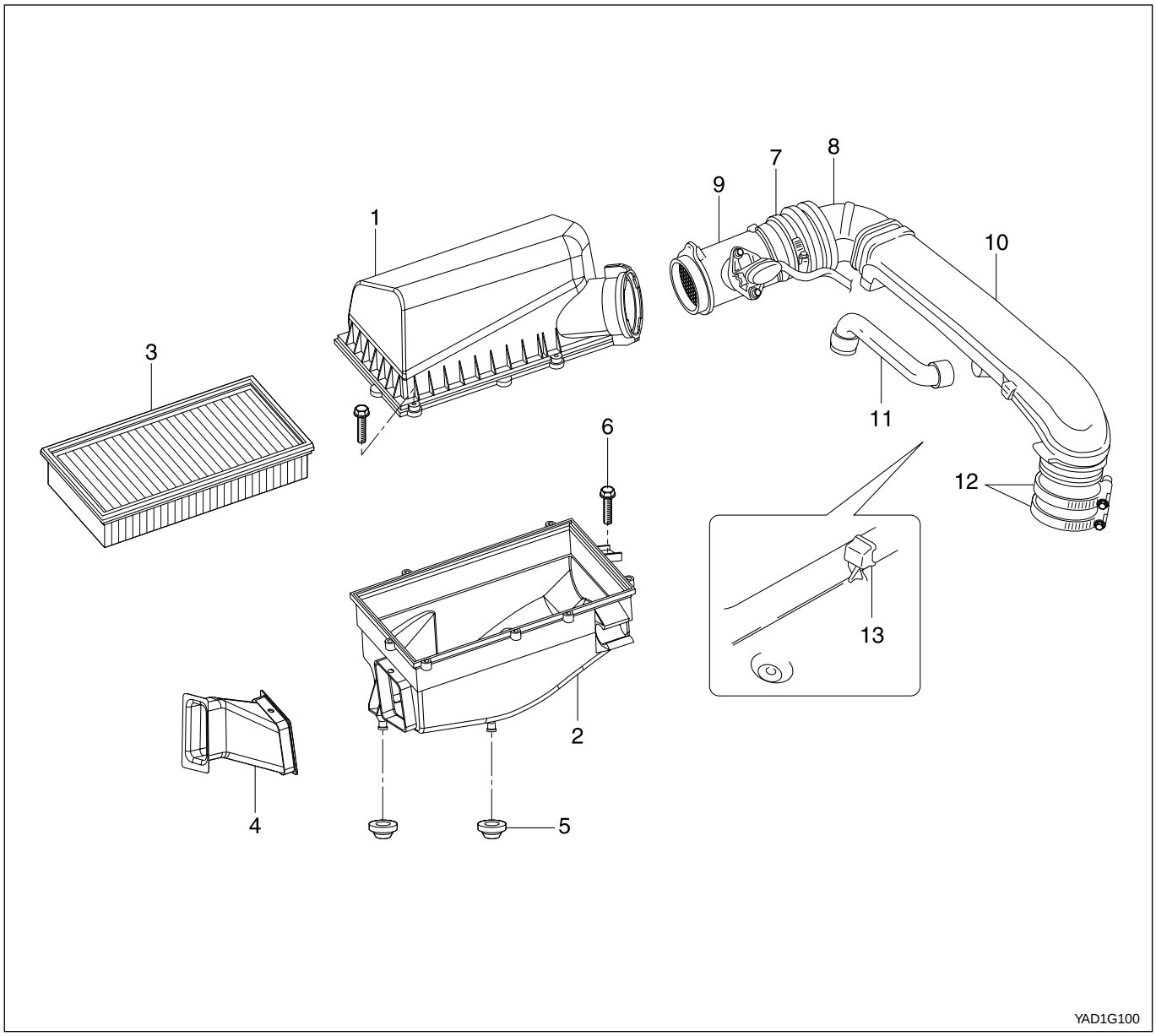
Resonance flap open (at full load : over 3,800/rpm)

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.

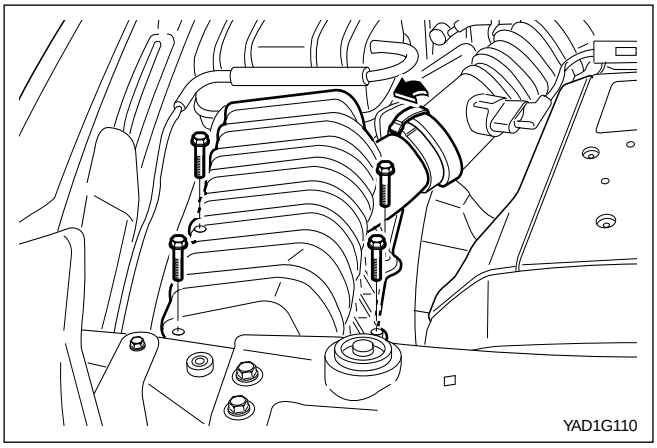
REPAIR INSTRUCTIONS

ON-VEHICLE SERVICE

AIR CLEANER AND INTAKE AIR DUCT (GASOLINE ENGINE)

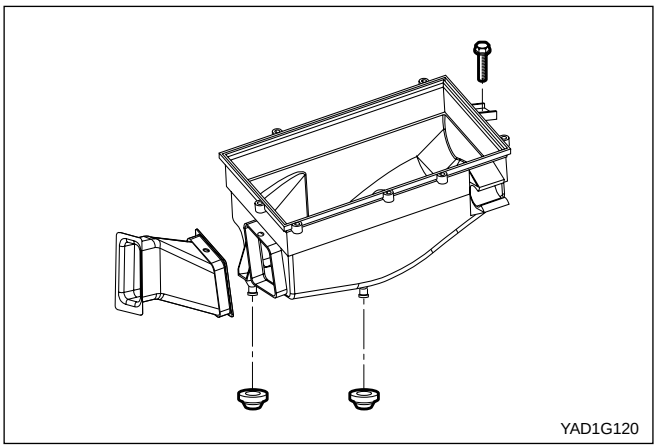


1 Air Cleaner Upper Housing
2 Air Cleaner Lower Housing
3 Element
4 Air Duct Inlet
5 Insulator
6 Bolt
7 Clamp
8 Sleeve
9 HFM Sensor
10 Intake Air Duct
11 Blow-by Hose
12 Clamp (2 Pieces)
13 Intake Air Duct Mounting Clamp

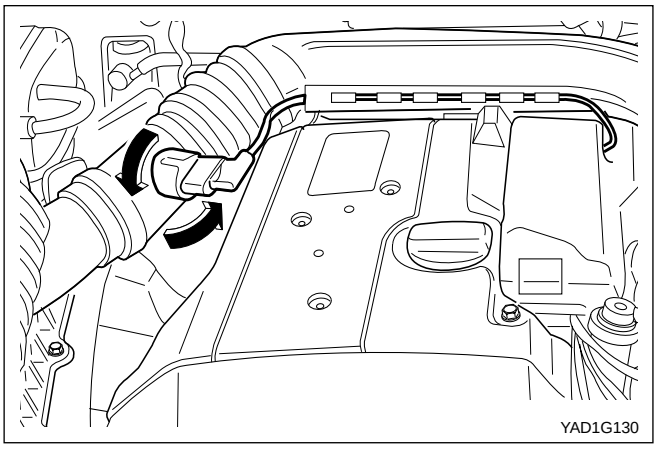


Removal & Installation Procedure

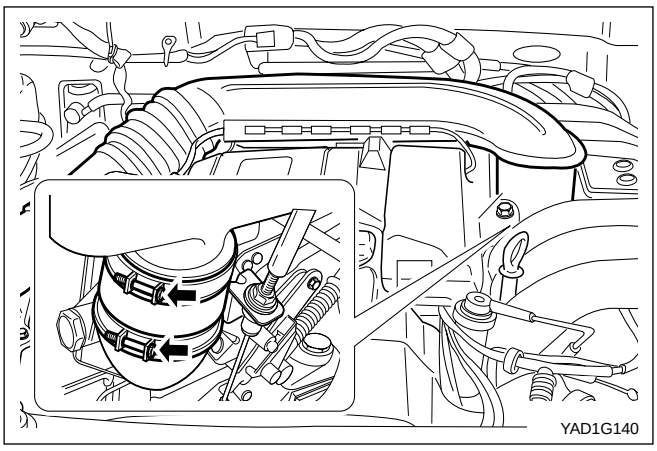
1. Remove the air cleaner upper housing clamp and mounting bolts and remove the air cleaner upper housing and element.



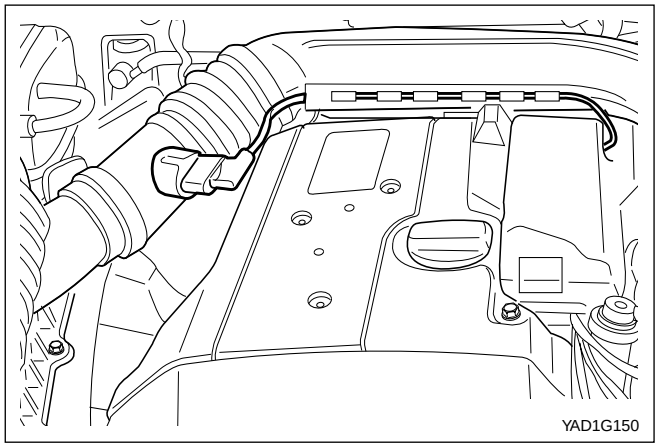
2. remove the air cleaner lower housing bolt and air cleaner lower housing and insulators.



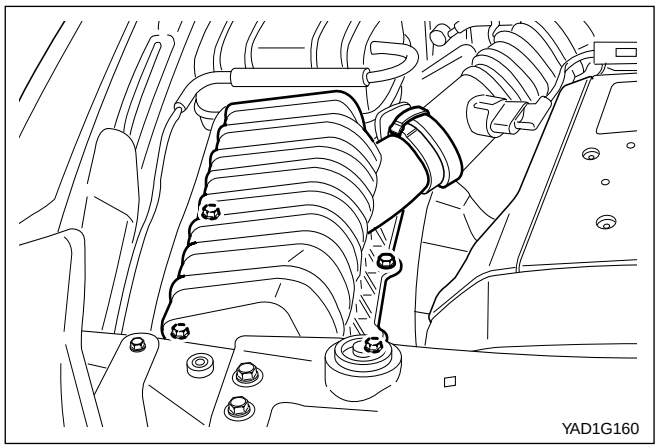
3. Disconnect the HFM sensor connector.



4. Remove the intake air duct housing clamp and intake air duct assembly.

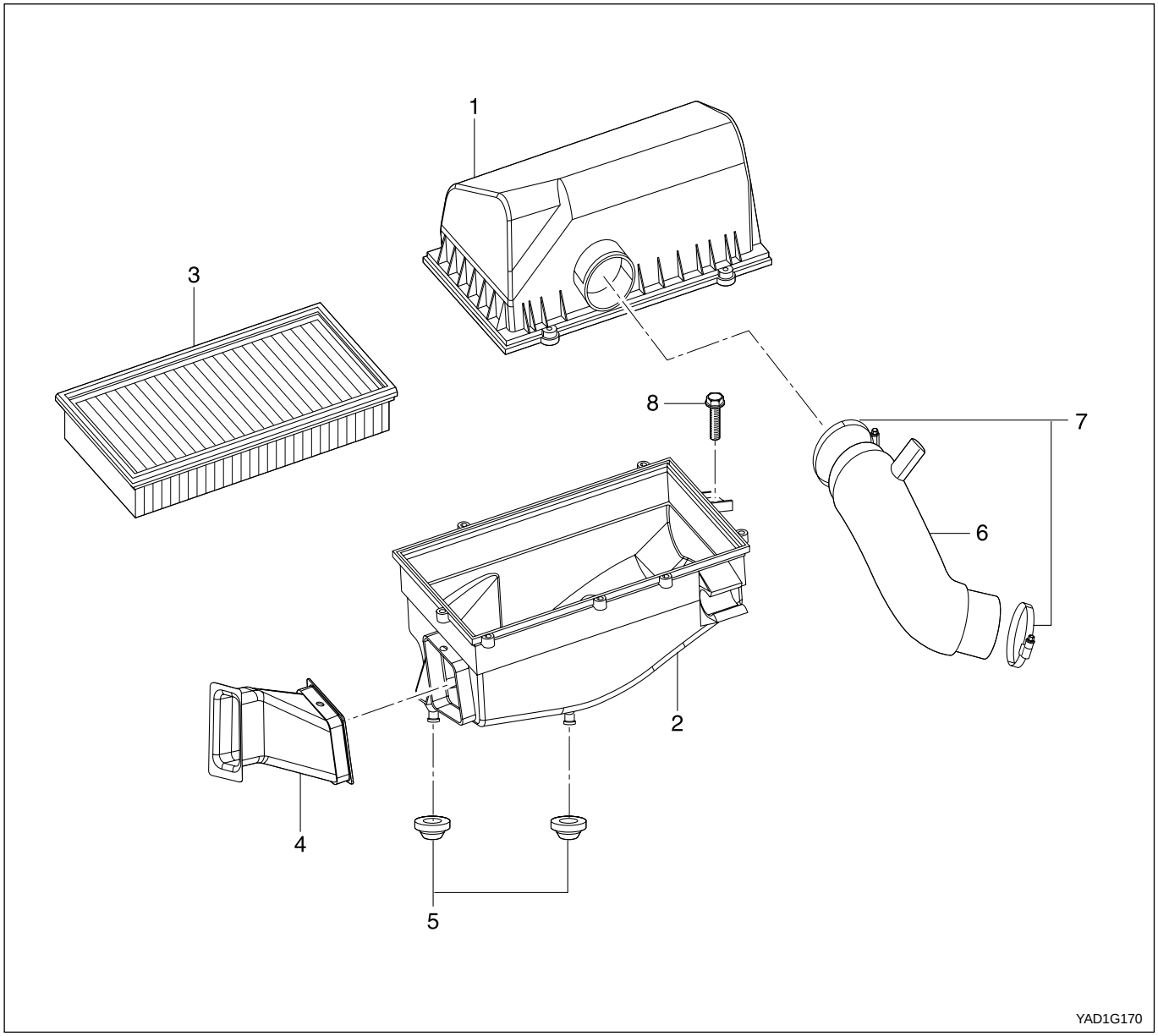


5. Install the intake air duct to intake manifold and intake air duct mounting clamp.
6. Connect the HFM sensor connector.

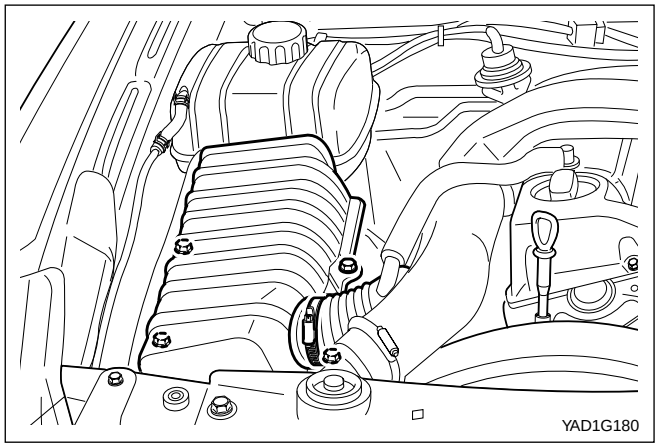


7. Install the air cleaner housing assembly.

AIR CLEANER (DIESEL ENGINE)



1 Air Cleaner Upper Housing
2 Air Cleaner Lower Housing
3 Element
4 Air Duct Inlet
5 Insulator
6 Air Cleaner to T/C Hose
7 Clamp
8 Bolt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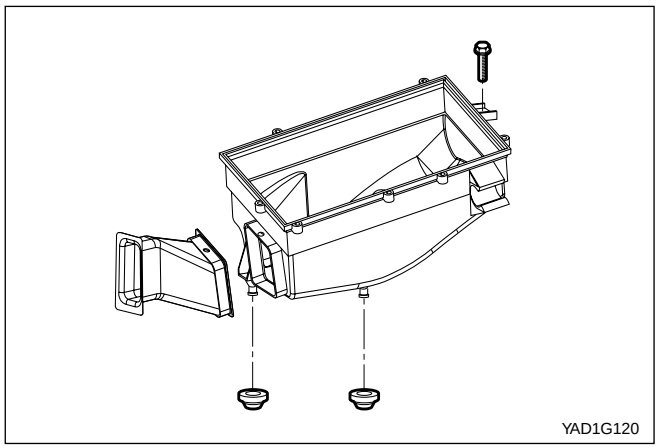
Removal & Installation Procedure

1. Remove the air cleaner upper housing clamp and mounting bolts and remove the air cleaner upper housing and element.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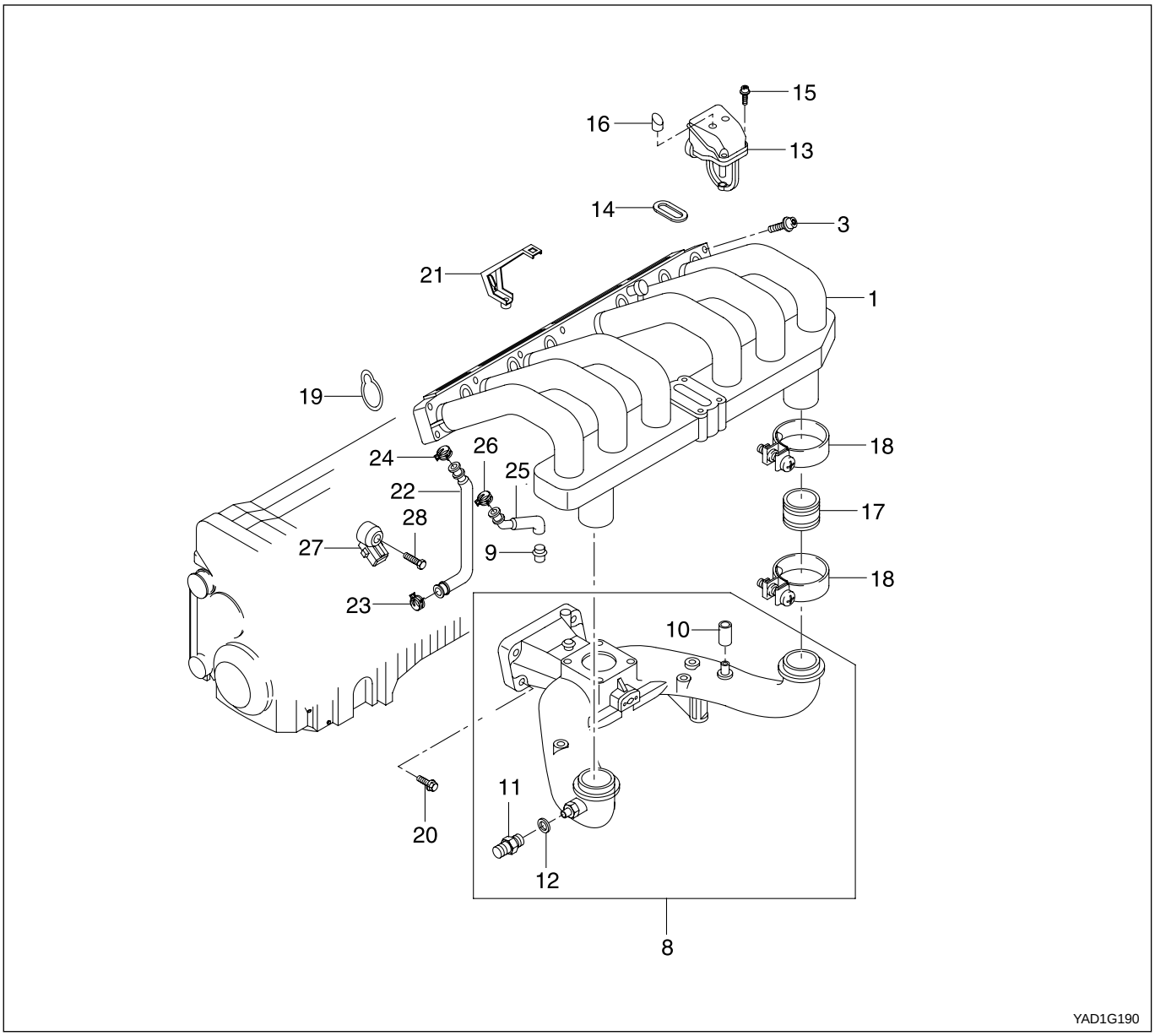
2. Remove the air cleaner lower housing bolt, air cleaner lower housing, air duct inlet and insulators.

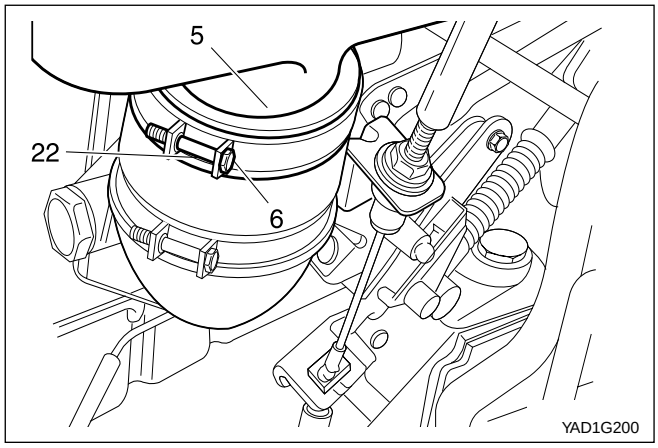
3. Installation should follow the removal procedure in the reverse order.

INTAKE MANIFOLD (GASOLINE ENGINE)

Preceding Work : Removal of fuel distributor and injection valve



1 Bolt (M6 X 40, 4 pieces) .....9-11 N•m (80-97 lb-in)
2 Softcap
3 Resonance Flap
4 Gasket..... Replace
5 Upper Intake Manifold
6 Bolt (M8 X 50, 9 pieces) .....22.5-27.5 N•m (16.6-20.3 lb-ft)
7 Gasket..... Replace
8 Blow-by Hose
9 Blow-by Hose
10 Clamp
11 Blow-by Nipple
12 Inlet Air Housing
13 Bolt (M6 X 40, 4 pieces) .....9-11 N•m (80-97 lb-in)
14 Throttle Body-Electric
15 Gasket..... Replace
16 Lower Intake Manifold
17 Bolt (M8 X 40, 4 pieces) .....22.5-27.5 N•m (16.6-20.3 lb-ft)
18 Nipple
19 Seal Ring
20 Connector
21 Connection House
22 Clamp
23 Noise Damper Assembly
24 Tapping Screw



Removal & Installation Procedure

Upper Intake Manifold

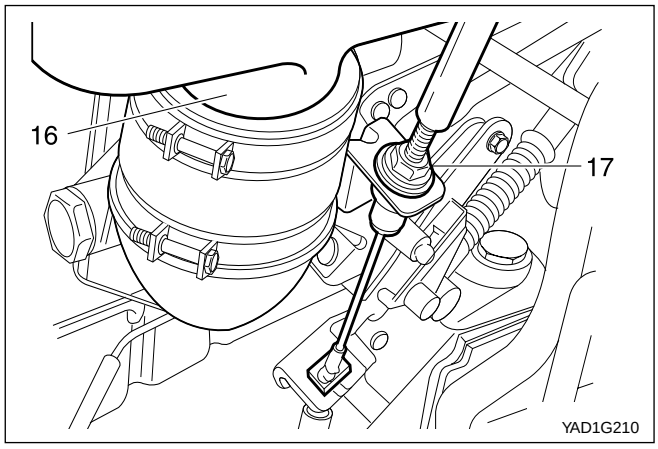
1. Disconnect the vacuum hose (8, 9).
2. Loosen the clamp (22).
3. Remove the upper intake manifold (5) after unscrewing the bolt (6).

Installation Notice

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

Check the gasket and replace it if necessary.

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



Lower Intake Manifold

Preceding work : removal of upper intake manifold

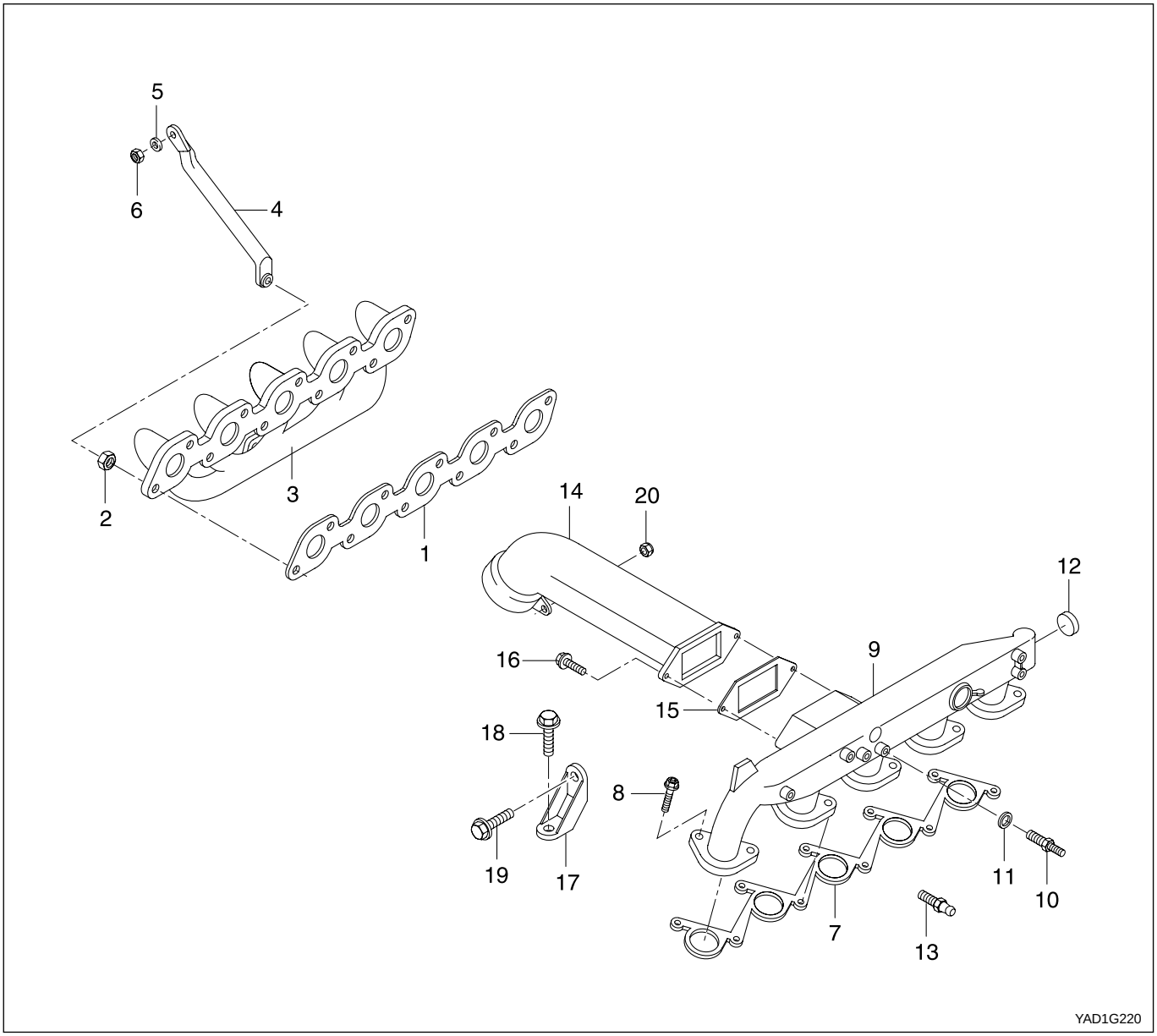
1. Remove the hose of brake booster vacuum line and idle speed connector.
2. Disconnect the water inlet pipe from the bottom of lower intake manifold.
3. Unscrew the bolt (17) and remove the lower intake manifold (16).

Installation Notice

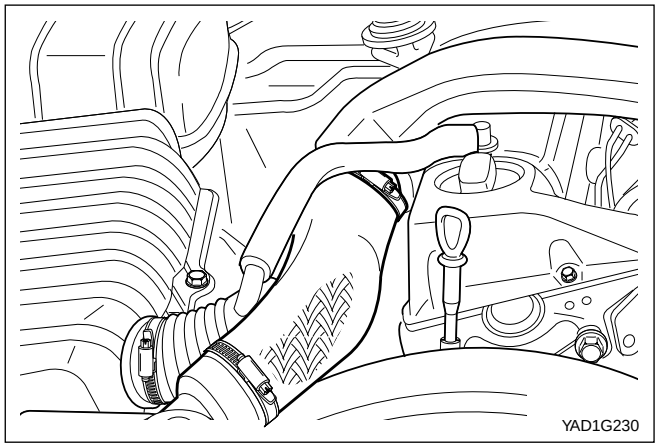
Tightening Torque	22.5 - 27.5 N•m (16.6 - 20.3 lb-ft)

4. Installation should follow the removal procedure in the reverse order.
5. Start the engine and check for leaks at each connection part.

INTAKE MANIFOLD (DIESEL ENGINE)

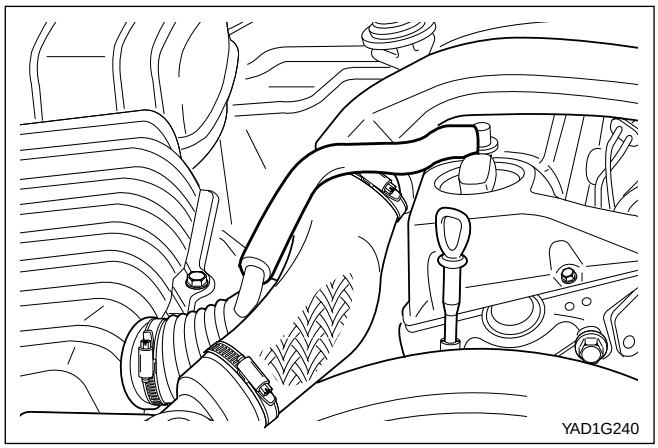


1 Gasket
2 Nut ..... 22.5-27.5 N•m (16.6-20.3 lb-ft)
3 Exhaust Manifold
4 Support Assembly
5 Washer
6 Nut ..... 22.5-27.5 N•m (16.6-20.3 lb-ft)
7 Gasket
8 Bolt..... 22.5-27.5 N•m (16.6-20.3 lb-ft)
9 Intake Manifold
10 Stud Bolt
11 Seal Ring
12 Expansion Plug
13 Ball Pivot
14 Intake Air Duct
15 Gasket
16 Bolt..... 22.5-27.5 N•m (16.6-20.3 lb-ft)
17 Bracket
18 Bolt
19 Bolt
20 Nut

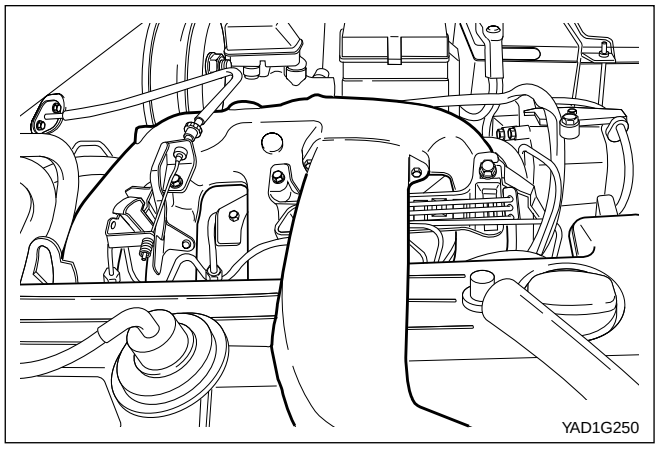


Removal & Installation Procedure

1. Loosen the air hose clamp from the intake air duct and remove the air hose.



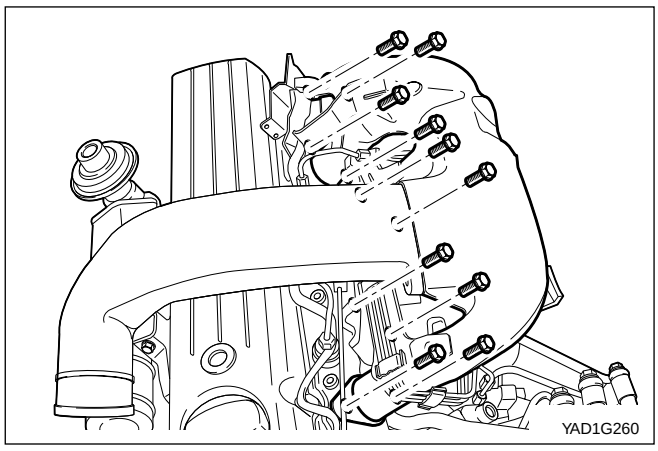
2. Disconnect the blow-by hose.
3. Disconnect the air cleaner and turbo charger hoses.
4. Disconnect the intercooler hoses.



5. Remove the intake air duct mounting bolts and intake air duct.

Installation Notice

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

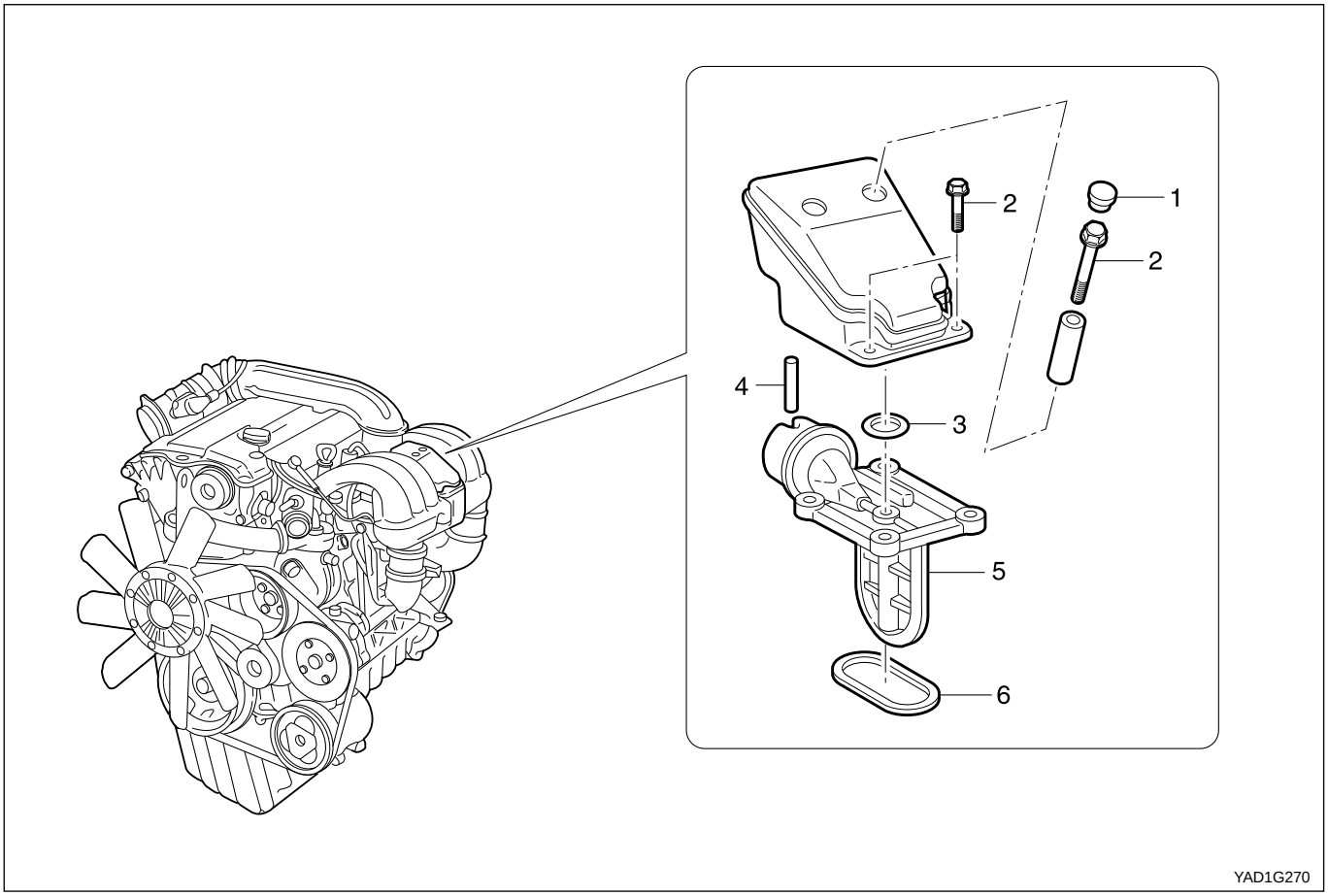


6. Remove the intake manifold mounting bolts and intake monifold.

Installation Notice

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

RESONANCE FLAP (GASOLINE ENGINE)



1 Soft Cap (2)
2 Bolt (M6 X 40, 4 piecesc) ..... 9-11 N•m80-97 lb-in)
3 O-ring
4 Vacuum Hose
5 Resonance Flap
6 Gasket ..... Replace

Removal & Installation Procedure

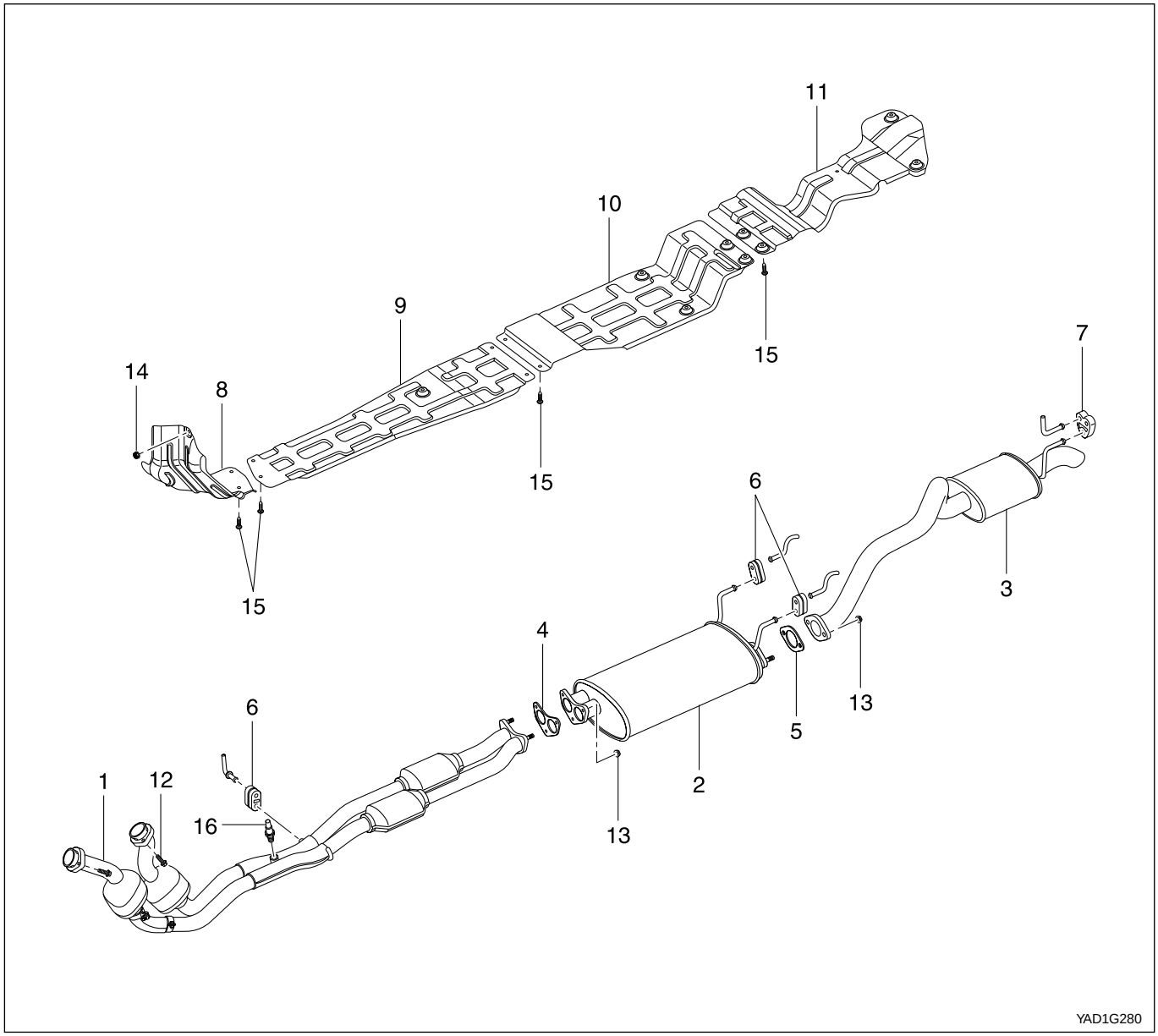
1. Remove the 2 soft caps (1).
2. Remove the upper resonance flap coupling after removing 4 bolt (2).

Installation Notice

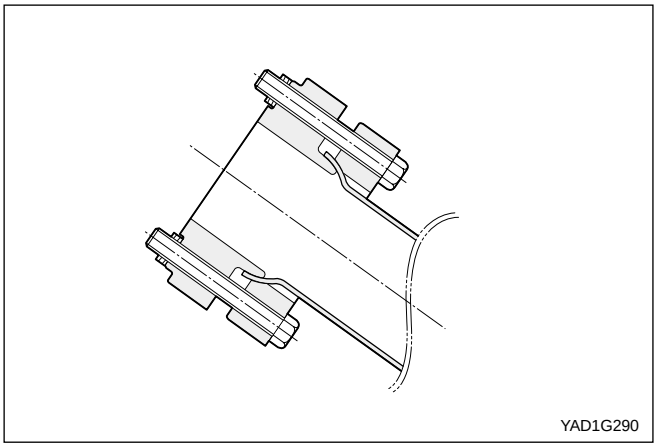
Tightening Torque	9 - 11 N•m (80 - 97 lb-ft)

3. Check the O-ring (3) and replace it if necessary.
4. Remove the lower resonance flap (5).
5. Replace the gasket (6).
6. Installation should follow the removal procedure in the reverse order.

EXHAUST LINE (GASOLINE ENGINE)



1 Front Exhaust Pipe
2 Muffler
3 Tail Exhaust Pipe
4 Gasket ..... Replace
5 Gasket ..... Replace
6 Hanger
7 Hanger
8 Heat Protector No. 1
9 Heat Protector No. 2
10 Heat Protector No. 3
11 Heat Protector No. 4
12 Bolt ..... 15-28 N•m (11-21 lb-ft)
13 Nut ..... 28-47 N•m (21-35 lb-ft)
14 Nut ..... 8-18 N•m (6-13 lb-ft)
15 Screw
16 Oxygen Sensor

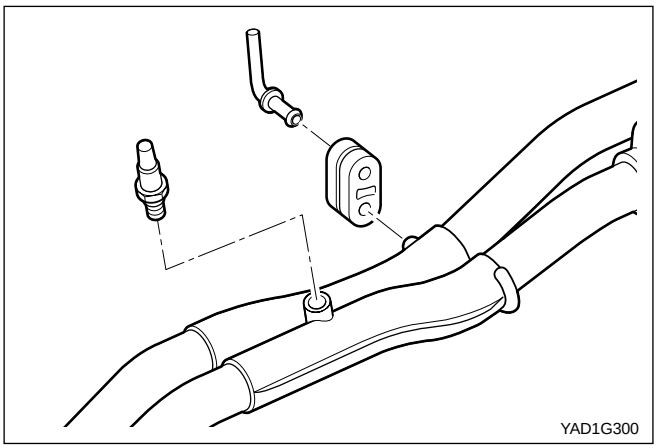

YAD1G290

Removal & Installation Procedure

1. Disconnect the oxygen sensor electrical connectors.
2. Remove the exhaust manifold to front exhaust pipe nuts.

Installation Notice

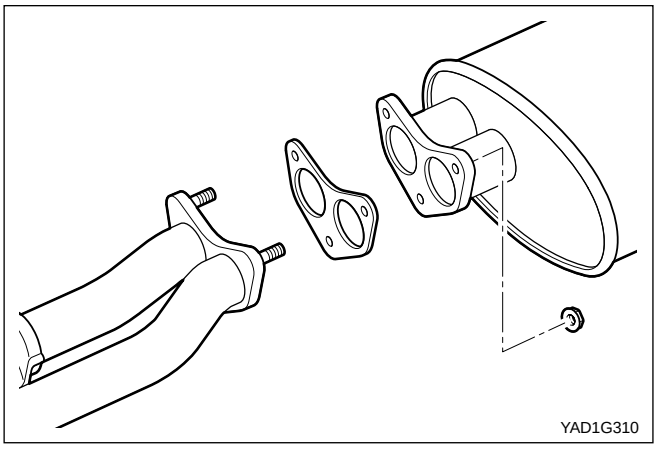
Tightening Torque	15 - 28 N•m (11 - 21 lb-ft)


YAD1G300

3. Remove the oxygen sensor and hanger from the front exhaust pipe.
4. Remove the front exhaust pipe to muffler nuts.

Installation Notice

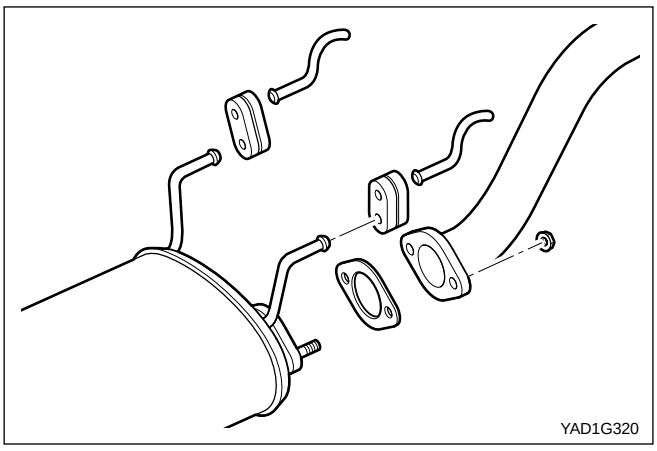
Tightening Torque	28 - 47 N•m (21 - 35 lb-ft)


YAD1G310

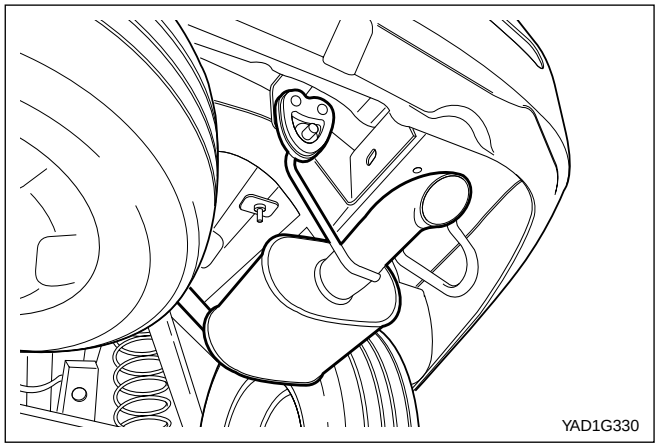
5. Remove the muffler to tail exhaust pipe nuts.

Installation Notice

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

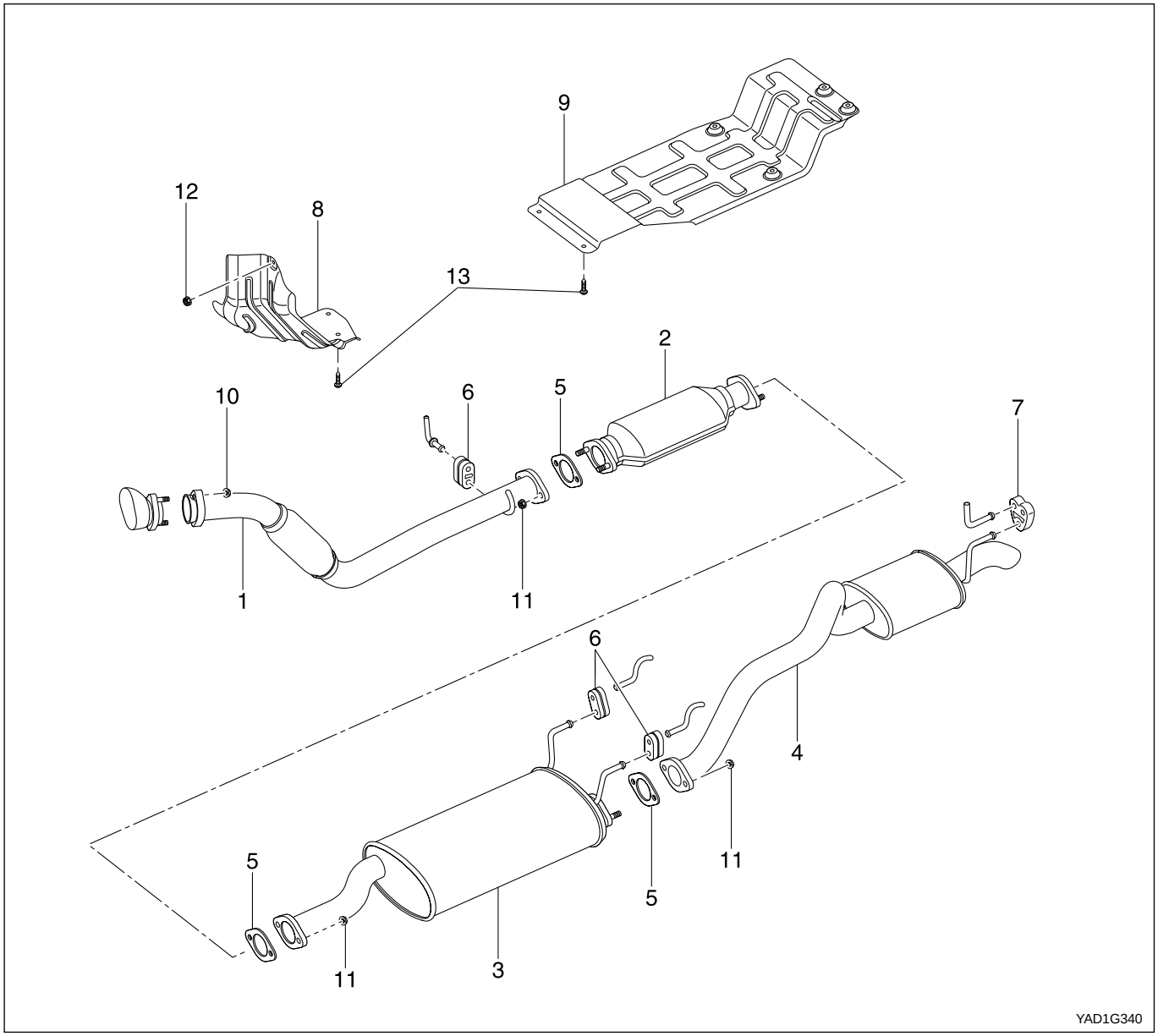

YAD1G320

6. Remove the Mounting hunger and muffler.

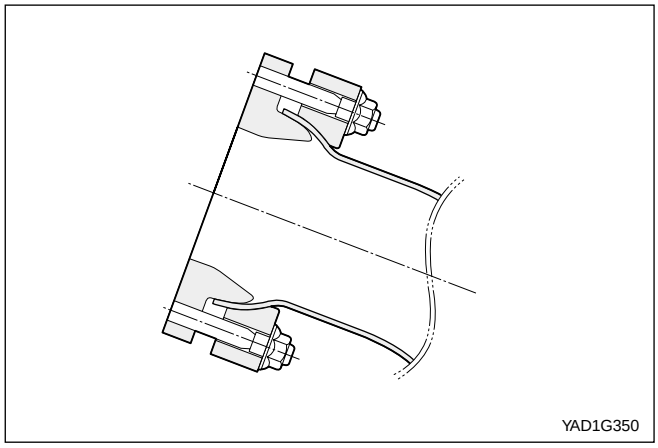


7. Remove the mounting hanger and tail exhaust pipe.
8. Check the muffler and pipes for holes, damage, open seams, or other deterioration. Which could permit exhaust fumes to seep into the passenger compartment or the trunk.
9. Installation should follow the removal procedure in the reverse order.

EXHAUST LINE (DIESEL ENGINE)



1 Front Exhaust Pipe
2 Diesel Oxidation Catalyst Converter
3 Muffler
4 Tail Exhaust Pipe
5 Gasket
6 Hanger
7 Hanger
8 Heat Protector No. 1
9 Heat Protector No. 3
10 Nut ..... 15-28 N•m (11-21 lb-ft)
11 Nut ..... 28-47 N•m (21-35 lb-ft)
12 Nut ..... 8-18 N•m (6-13 lb-ft)
13 Screw

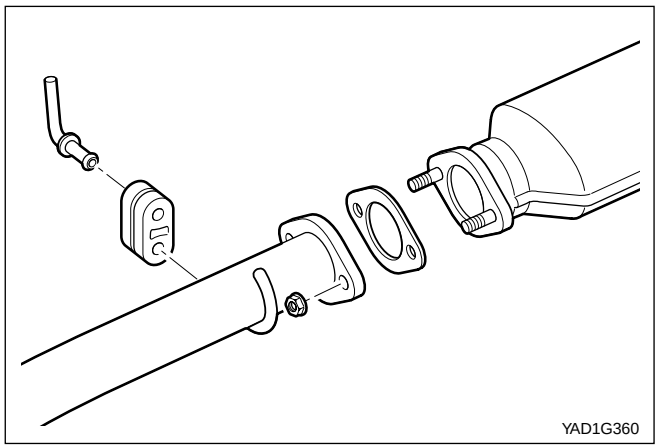

YAD1G350

Removal & Installation Procedure

1. Remove the exhaust manifold to front exhaust pipe nuts and mounting hanger.

Installation Notice

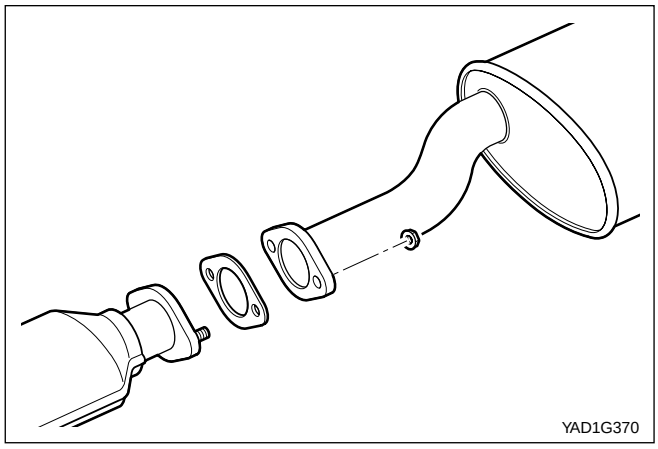
Tightening Torque	15 - 28 N•m (11 - 21 lb-ft)


YAD1G360

2. Remove the front exhaust pipe to diesel oxidation catalyst converter nuts and front exhaust pipe.

Installation Notice

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


YAD1G370

3. Remove the diesel oxidation catalyst converter to muffler nuts and diesel oxidation catalyst converter.

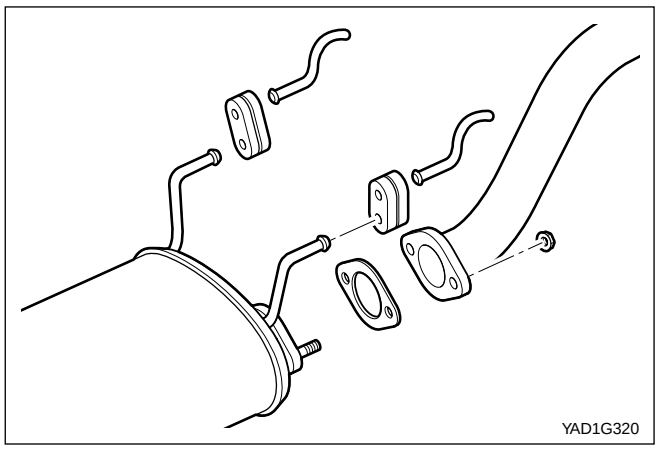
Installation Notice

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

4. Remove the muffler to tail exhaust pipe nuts.

Installation Notice

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


YAD1G320

5. Remove the mounting hangers and then remove the muffler and tail exhaust pipe.
6. Check the muffler and pipes for holes, damage, open seams, or other deterioration which could permit exhaust fumes to seep into the passenger compartment or the trunk.
7. Installation should follow the removal procedure in the reverse order.

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

SECTION 1F2

M161 ENGINE CONTROLS

CAUTION: Disconnect the negative battery cable before removi ng 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.

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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 (if available)	☐ Normal ☐ Malfunction code(s) (code) ☐ 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

DIAGNOSTIC INFORMATION AND PROCEDURE
FAILURE CODE DIAGNOSIS

CLEARING FAILURE CODES

Notice: To prevent Engine Control Module (ECM) damage, the key must be OFF when disconnecting or reconnecting the power to the ECM (for example battery cable, ECM pigtail connector, ECM fuse, jumper cables, etc.)

Parameters listed in the table may not be exactly the same as your reading due to the type of instrument or other factors. If a failure code is displayed during the “TROUBLE CODE” in scan tool check mode, check the circuit for the code listed in the table below. For details of each code, turn to the page referred to under the “See Page” for the respective “Failure Code” in the below table.

Failure codes should be cleared after repairs have been completed.

FAILURE CODES TABLE

Failure code	See Page	Description
00	1F2-56	Engine coolant temperature sensor low voltage
01	1F2-56	Engine coolant temperature sensor high voltage
02	1F2-56	Engine coolant temperature sensor plausibility
03	1F2-52	Intake air temperature sensor low voltage
04	1F2-52	Intake air temperature sensor high voltage
05	1F2-52	Intake air temperature sensor plausibility
06	1F2-56	Engine coolant temperature insufficient for closed loop fuel control
08	1F2-28	System voltage too low
09	1F2-52	Mass air flow sensor plausibility
10	1F2-52	Mass air flow sensor low voltage
11	1F2-52	Mass air flow sensor high voltage
17	1F2-13	Crankshaft position sensor signal failure (no engine revolution signal)
18	1F2-13	Crankshaft position sensor signal failure (rpm > max. value)
19	1F2-17	Camshaft position sensor signal : No.1 cylinder recognition failure
20	1F2-13	Crankshaft position sensor signal failure (gap recognition failure)
21	1F2-80	Transmission coding failure
23	1F2-78	CAN communication failure : ASR/MSR
24	1F2-78	CAN communication failure : ABS
25	1F2-84	Communication with transponder missing
26	1F2-78	CAN communication failure : TCU (A/T only)
29	1F2-79	CAN communication failure : ID 200h not plausible
30	1F2-79	CAN communication failure : ID 208h not plausible
31	1F2-79	CAN communication failure : communication initialization failure
32	1F2-67	Engine rpm output circuit short circuit to battery
33	1F2-67	Engine rpm output circuit short circuit to ground or open
34	1F2-33	Fuel pump relay short circuit to battery
35	1F2-33	Fuel pump relay short circuit to ground or open
40	1F2-41	Purge control valve short circuit to battery
41	1F2-41	Purge control valve short circuit to ground or open

FAILURE CODES TABLE (Cont'd)

Failure code	See Page	Description
44	1F1-62	Cooling fan (HI) relay short circuit to power
45	1F1-62	Cooling fan (HI) relay short circuit to ground or open
54	1F1-41	Purge control circuit malfunction
56	1F1-23	No.1 knock sensor signal failure
58	1F1-17	Camshaft position sensor signal : No.1 cylinder synchronization failure
59	1F1-79	CAN communication failure : MSR data transmission not plausible
60	1F1-79	CAN communication failure : ASR data transmission not plausible
64	1F1-11	No ignition voltage output (No.1 ignition coil)
65	1F1-11	No ignition voltage output (No.2 ignition coil)
67	1F1-13	Crankshaft position sensor adaptation failure
68	1F1-25	Random/Multiple Misfire
71	1F1-29	Starter signal recognition failure
72	1F1-37	No.1 injector short circuit to battery
73	1F1-37	No.1 injector short circuit to ground or open
74	1F1-37	No.2 injector short circuit to battery
75	1F1-37	No.2 injector short circuit to ground or open
76	1F1-37	No.3 injector short circuit to battery
77	1F1-38	No.3 injector short circuit to ground or open
78	1F1-38	No.4 injector short circuit to battery
79	1F1-38	No.4 injector short circuit to ground or open
80	1F1-72	Oxygen sensor high voltage
81	1F1-73	Bank 1 system short term fuel trim adaptation below lean threshold
82	1F1-72	Oxygen sensor no activity detected
83	1F1-72	Oxygen sensor not lean after overrun fuel shut -off
84	1F1-72	Oxygen sensor slow response
85	1F1-72	Oxygen sensor heater failure
86	1F1-72	Oxygen sensor heater short circuit to battery
87	1F1-72	Oxygen sensor heater short circuit to ground or open
89	1F1-72	Oxygen sensor low voltage
93	1F1-73	Bank 1 system short term fuel trim adaptation above rich threshold
96	1F1-73	Bank 1 system short term fuel trim at rich stop
97	1F1-73	Bank 1 system short term fuel trim at lean stop
98	1F1-73	Bank 1 system idle adaptation failure (above rich threshold)
99	1F1-73	Bank 1 system idle adaptation failure (below lean threshold)
100	1F1-73	Bank 1 system learning control failure (rich, low load)
101	1F1-73	Bank 1 system learning control failure (lean, low load)
102	1F1-73	Bank 1 system learning control failure (rich, high load)
103	1F1-73	Bank 1 system learning control failure (lean, high load)
104	1F1-47	Throttle position sensor 1 low voltage
105	1F1-47	Throttle position sensor 1 high voltage

FAILURE CODES TABLE (Cont'd)

Failure code	See Page	Description
108	1F1-47	Throttle position sensor 2 low voltage
109	1F1-47	Throttle position sensor 2 high voltage
110	1F1-82	Throttle actuator learning data fault
116	1F1-47	Throttle actuator learning control failure
117	1F1-82	Exceed fuel-cut safety time
119	1F1-47	Throttle valve return spring failure
120	1F1-82	Cruise control interruption memory failure
121	1F1-47	Throttle actuator failure
122	1F1-59	Accelerator pedal position sensor signal failure
123	1F1-47	Different Mass air flow sensor signal with throttle position sensor
125	1F1-47	Both throttle position sensors failure
126	1F1-48	Throttle position sensor 1 not plausible with throttle position sensor 2
127	1F1-48	High permanent throttle signal
129	1F1-64	Cruise control "OFF" due to message counter failure
130	1F1-64	Vehicle speed signal failure
131	1F1-64	Vehicle speed signal failure
132	1F1-64	Cruise control lever failure
133	1F1-64	Cruise control acceleration failure
134	1F1-64	Cruise control deceleration failure
135	1F1-66	Stop lamp switch failure
136	1F1-80	ECU failure (RAM)
137	1F1-80	ECU failure (EPROM)
138	1F1-82	Call monitoring
139	1F1-82	Servo motor control output interruption memory failure
140	1F1-82	Servo motor open/short
141	1F1-84	Unprogramed ECU with immobilizer
142	1F1-80	Uncoded/unprogramed ECU
143	1F1-80	ECU failure (EEPROM/Flash-EPROM checksum failure)
144	1F1-80	ECU failure (coding ID checksum failure)
145	1F1-80	ECU failure (coding checksum failure)
146	1F1-80	ECU failure (programing checksum failure)
150	1F1-65	TCS input signal short circuit to battery
151	1F1-65	TCS input signal short circuit to ground or open
160	1F1-59	Accelerator pedal position sensor 1 low voltage
161	1F1-59	Accelerator pedal position sensor 1 high voltage
162	1F1-59	Accelerator pedal position sensor 2 low voltage
163	1F1-59	Accelerator pedal position sensor 2 high voltage
164	1F1-59	Accelerator pedal position sensor 1 not plausible with pedal position sensor 2
167	1F1-59	Both setpoint accelerator pedal position sensor defective
185	1F1-48	Mass air flow sensor and throttle position sensor failure
186	1F1-82	ECU failure (incompatible CPU)

FAILURE CODES TABLE (Cont'd)

Failure code	See Page	Description
187	1F1-82	ECU failure (CPUs communication failure)
188	1F1-82	ECU failure (CPU 2 configuration failure)
189	1F1-82	ECU failure (CPU 2 fault)
190	1F1-82	ECU failure (CPU run time failure between CPUs)
226	1F1-21	Camshaft actuator short circuit to battery
227	1F1-21	Camshaft actuator short circuit to ground or open
228	1F1-63	A/C compressor relay short circuit to battery
229	1F1-63	A/C compressor relay short circuit to ground or open
231	1F1-82	ECU failure (CPU 2 cruise control message counter failure)
232	1F1-82	Over decceleration limit (CPU 2)
233	1F1-82	Over acceleration limit (CPU 2)
234	1F1-82	Cruise control lever dual operation (CPU 2)
235	1F1-82	Cruise control lever safety terminal failure (CPU 2)
236	1F1-82	Unusual pedal position variation (CPU 2)
237	1F1-82	Unusual throttle position variation (CPU 2)
238	1F1-82	Unusual throttle controller monitor data comparison fault (CPU 2)
239	1F1-83	Unusual accelerator pedal position sensor comparison fault (CPU 2)
240	1F1-83	Throttle potentiometer comparision fault (CPU 2)
241	1F1-83	Unusual CPU communication (CPU 2)
242	1F1-83	Unusual CPU configuration (CPU 2)
243	1F1-83	A/D converter failure (CPU 2)
244	1F1-83	Accelerator pedal position sensor setpoint fault between CPU 1 and CPU 2
245	1F1-83	Position controller setpoint fault between CPU 1 and CPU 2
246	1F1-83	MSR setpoint fault between CPU 1 and CPU 2
247	1F1-83	Idle control setpoint fault between CPU 1 and CPU 2
248	1F1-83	A/D converteroverflow (CPU 2)
249	1F1-83	ROM f aul t (CPU 2)
250	1F1-83	RAM f aul t (CPU 2)
251	1F1-83	Cycle monitor fault (CPU 2)

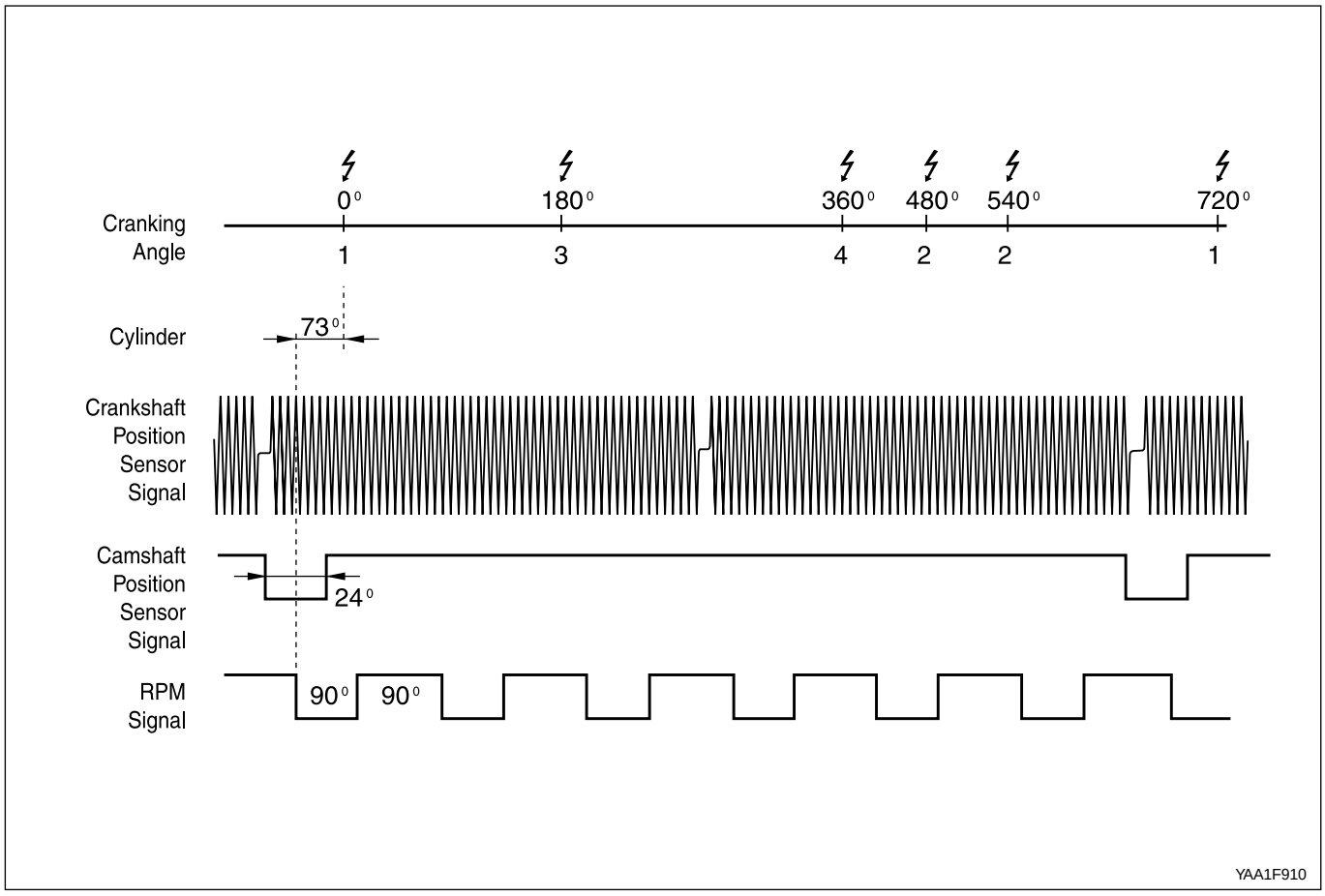
IGNITION SYSTEM

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).



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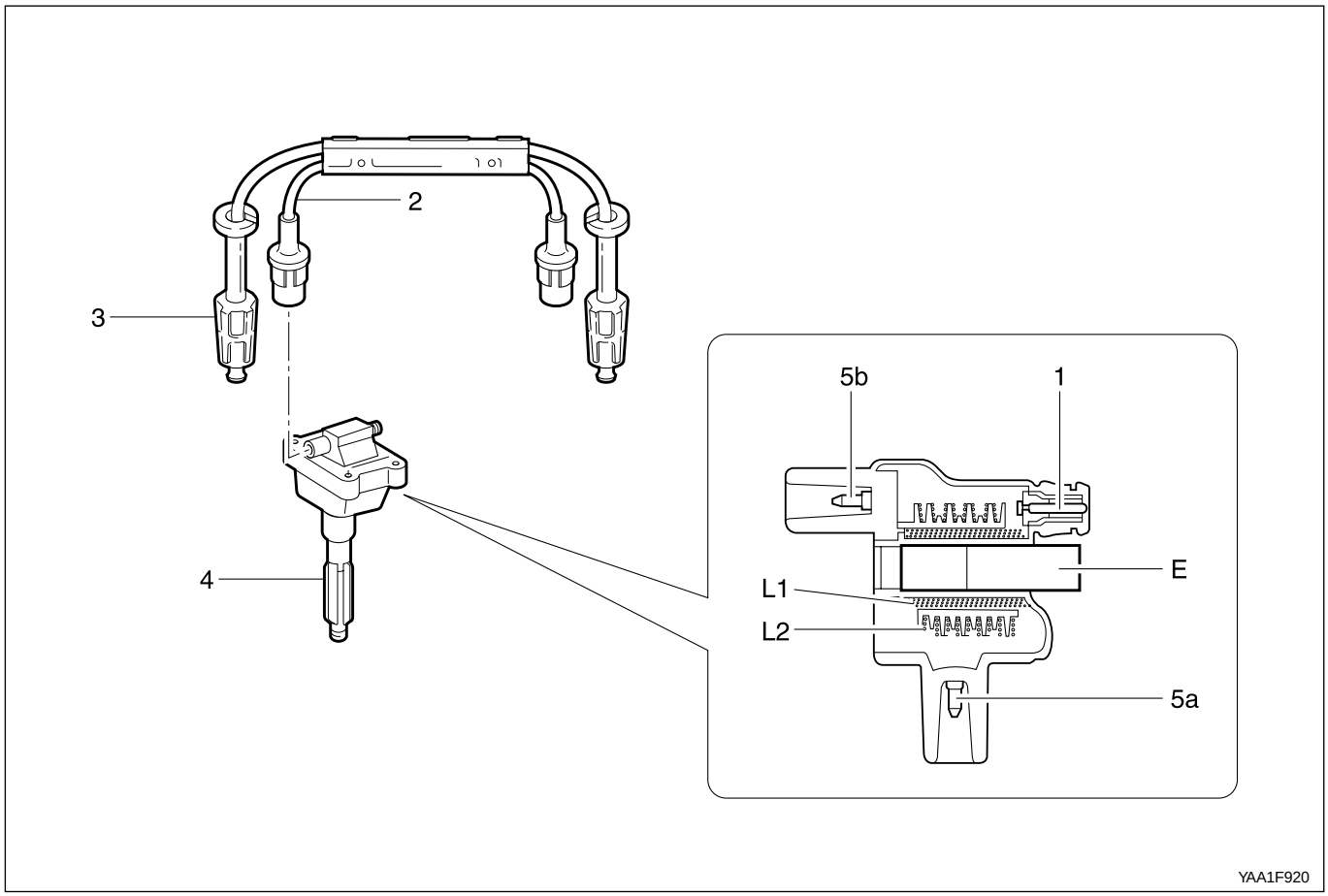
IGNITION COIL



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

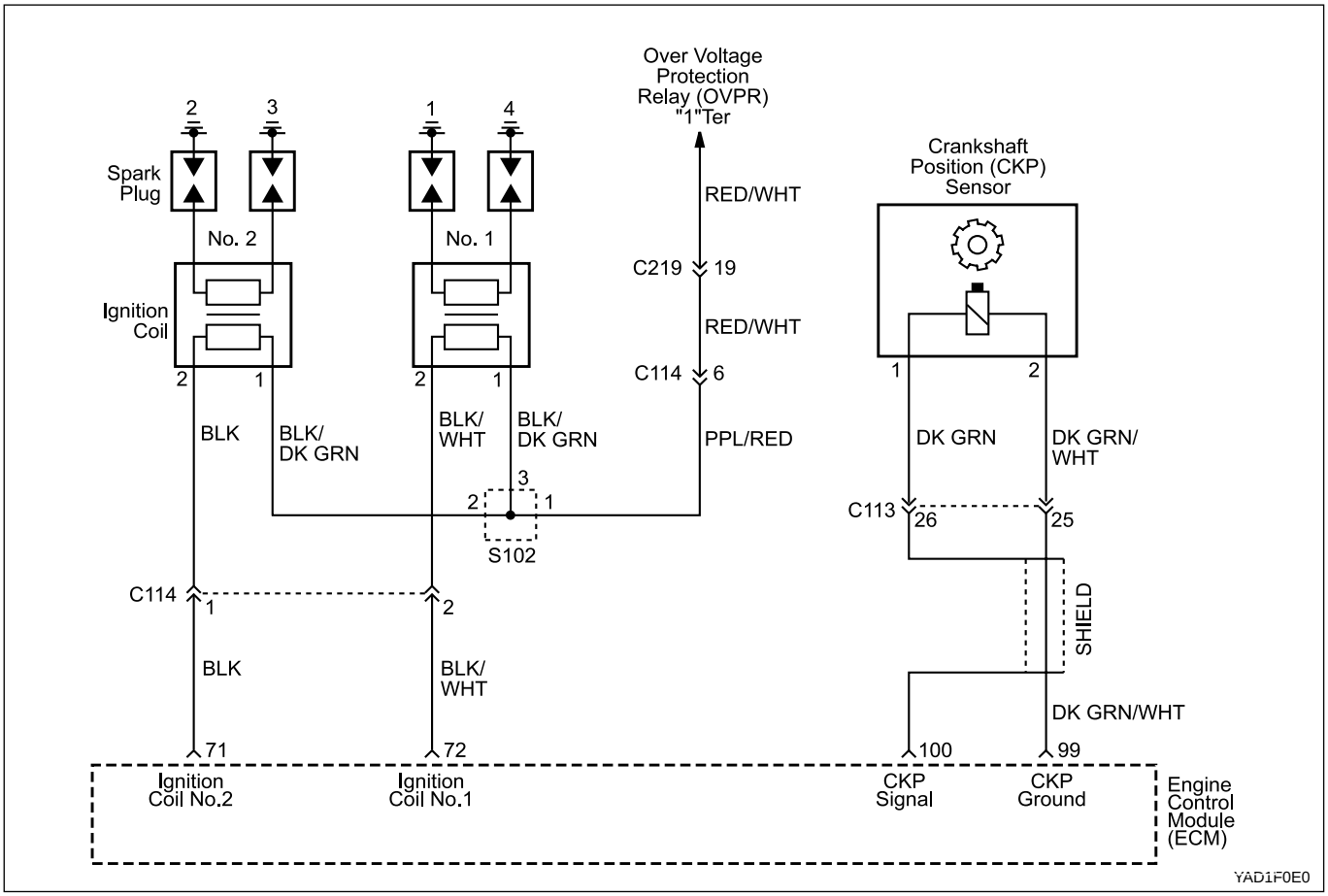
The Electronic Ignition (EI) system ignition coil is located on the cylinder head cover. The double ended coils receive the signal for the Engine Control Module (ECM) which controls the spark advance.

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.



Failure Code	Description	Trouble Area	Maintenance Hint
64	No ignition voltage output (No. 1 ignition coil)	Malfunction of ignition circuit Primary current values or secondary short circuit	• Inspection the ECM pin 71 and 72 about short circuit or open with bad contact • Inspection the power source to ignition coil • Inspection the ignition coil, high tension cords etc. • Inspection the spark plug (wet, cracks, wear, improper gap, burned electrodes, heavy deposit) • Inspection the ECM
65	No ignition voltage output (No. 2 ignition coil)		

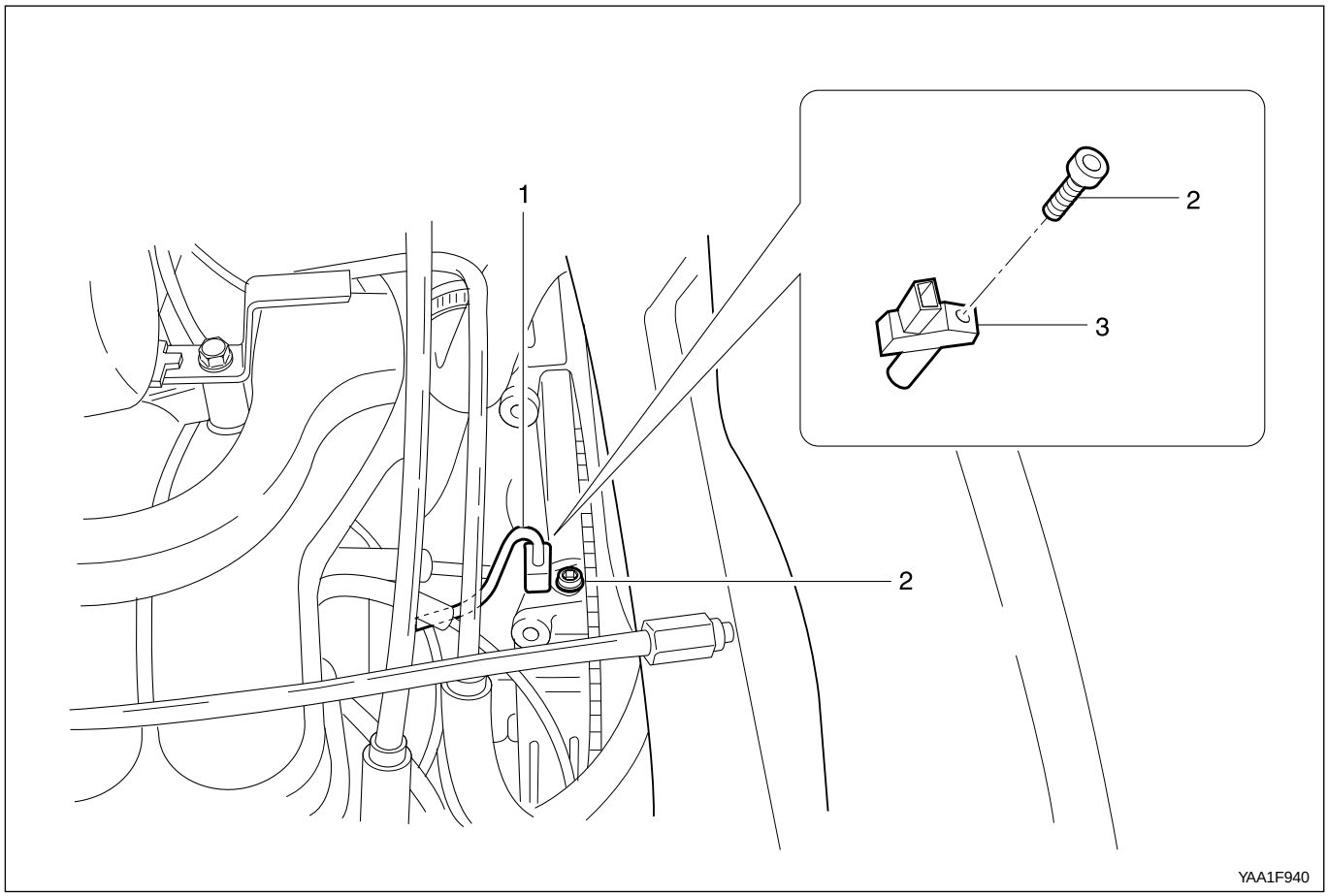
Circuit Description

The Electronic Ignition (EI) system uses a waste spark method of spark distribution. The Crankshaft Position (CKP) sensor sends reference pulses to the ECM. The ECM then triggers the EI system ignition coils. Once the ECM triggers the EI system ignition coils both of the connected spark plugs fire at the same time. One cylinder is on its compression stroke at the same time that the other is on the exhaust stroke, resulting in lower energy needed to fire the spark plug in the cylinder on its exhaust stroke.

This leaves the remainder of the high voltage to be used to fire the spark plug in the cylinder on its compression stroke.

Since the CKP sensor is in a fixed position, timing adjustments are not possible or needed.

CRANKSHAFT POSITION (CKP) SENSOR

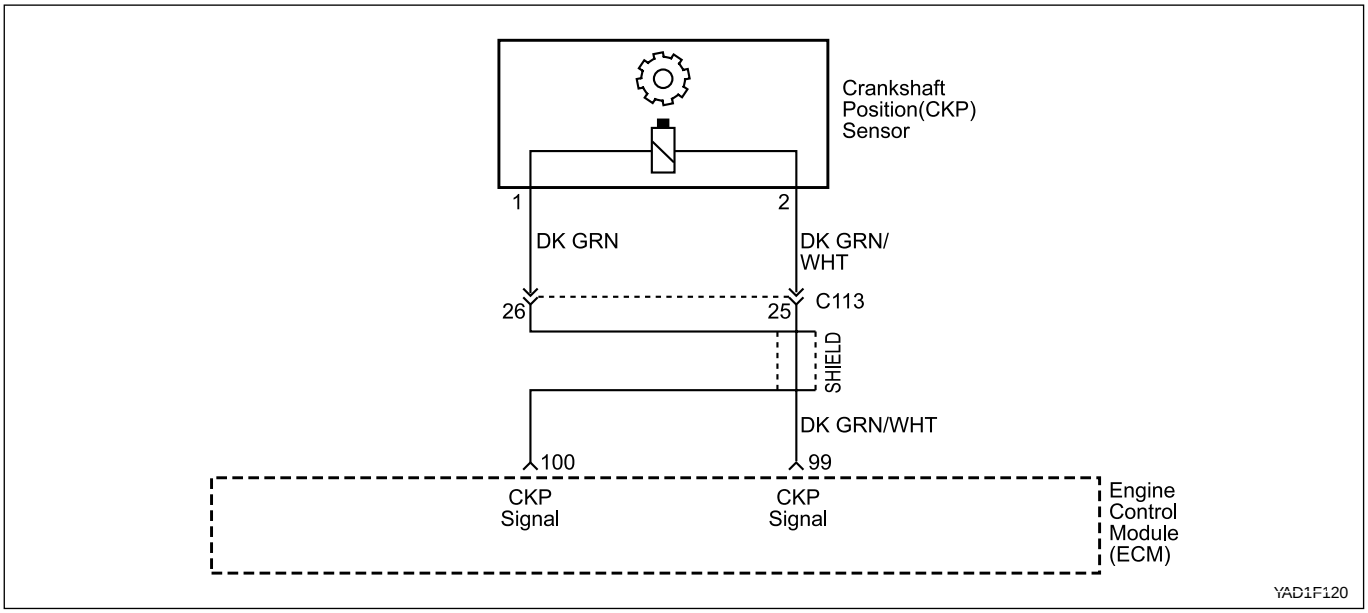


1 Crankshaft Position Sensor Connector
2 Bolt
3 Crankshaft Position Sensor

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.



Failure Code	Description	Trouble Area	Maintenance Hint
17	Crankshaft position sensor signal failure (no engine revolution signal)	Even through cam position recognition is normal, no crankshaft position signal recognition	• Monitoring the actual rpm through or scan tool • Inspection the ECM pin 100, 99 about short circuit with bad contact • Inspection the CKP sensor • Inspection the air gap between sensor and drive plate • Inspection the drive plate (teeth condition) • Inspection the ECM
18	Crankshaft position sensor signal failure (rpm > max. value)	When more than applicable revolution values or implausible to 60-2 teeth.	
20	Crankshaft position sensor signal failure (gap recognition failure)	When implausible recognition of cam and crank angle signal or intermittent sensing the signal or error count of undetected gap.	
67	Crankshaft position sensor adaptation failure	When faulty crank angle sensor adaption	

Circuit Description

The 58X reference signal is produced by the CKP sensor. During one crankshaft revolution, 58 crankshaft pulses will be produced. The ECM uses the 58X reference signal to calculate engine rpm and CKP. The ECM constantly monitors the number of pulses on the 58X reference circuit and compares them to the number of Camshaft Position (CMP) signal pulses being received. If the ECM receives and incorrect number of pulses on the 58X reference circuit, this failure code will set.

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.

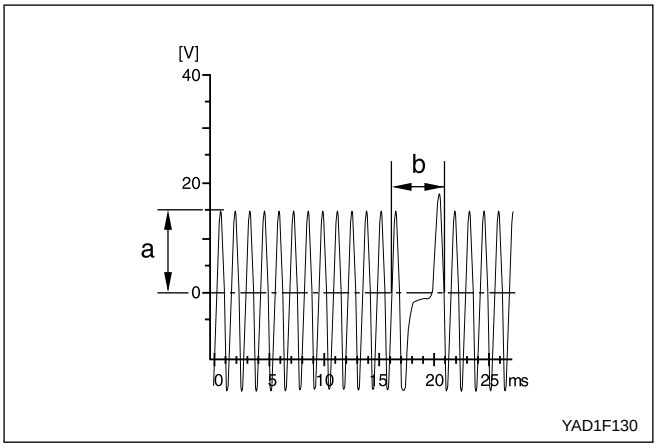
Specified Value	1,050 ~ 1,400 Ω

Notice: Measure the insulator resistance of the CKP sensor if out of the specified value.

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.

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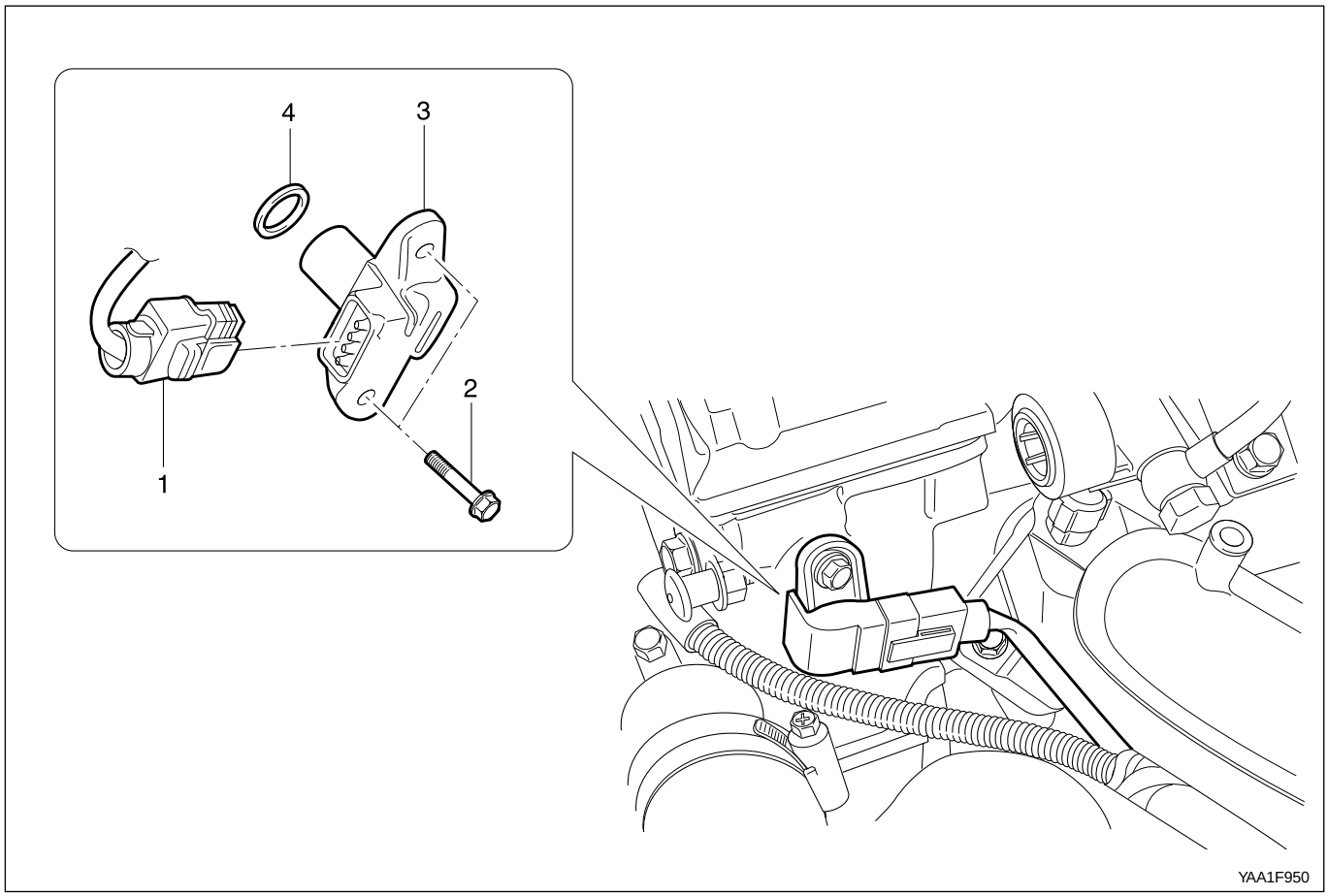
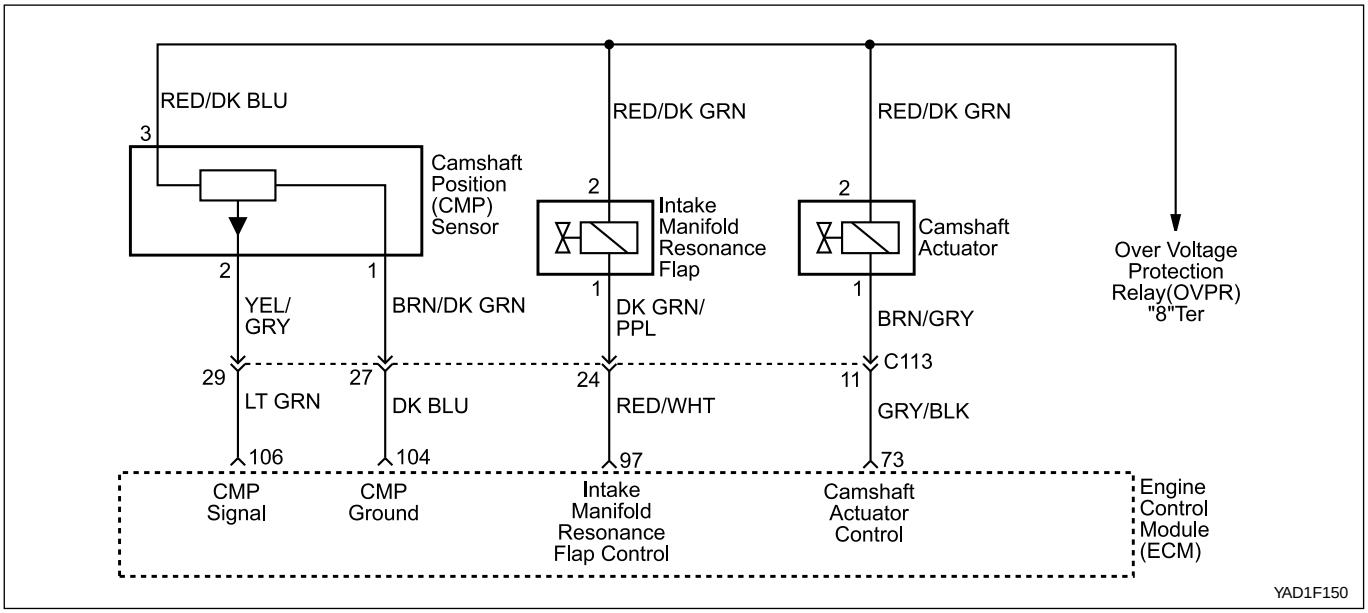
CAMSHAFT POSITION (CMP) SENSOR



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.



Failure Code	Description	Trouble Area	Maintenance Hint
19	Camshaft position sensor signal : No. 1 cylinder recognition failure	When no cam recognition signal during TN 24 counts more. (maintain the constant low or high level)	• Inspection the source voltage of CMP sensor • Inspection the ECM pin 106, 104 about short circuit or open with bad contact • Inspection the CMP sensor • Inspection the damage of sensor or sprocket • Inspection the ECM
58	Camshaft position sensor signal : No. 1 cylinder synchronization failure	When synchronization fault of cylinder 1 (TDC recognition)	

Circuit Description

The CMP sensor sends a cam position signal to the ECM. If the cam position signal is lost while the engine is running, the fuel injection system shifts to a calculated sequential fuel injection mode based on the last fuel injection pulse, and the engine continuous to run.

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.

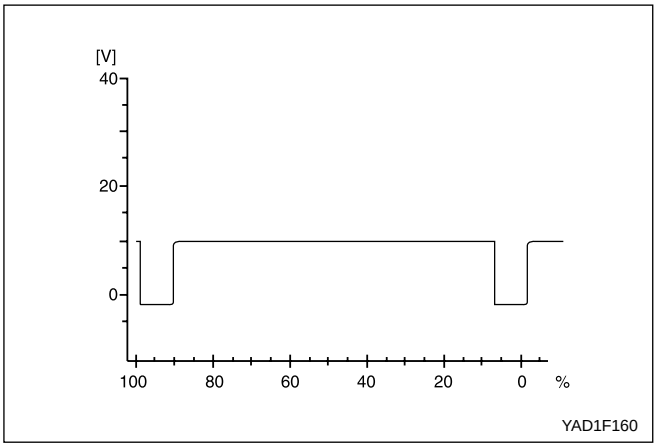
Specified Value	1.2 ~ 1.7 v

Notice: The signal voltage will be changed in the range of 1.2 ~ 1.7 v.

Camshaft Position Sensor Output Wave Inspection

1. Measure the output wave between the ECM terminals No. 104 and No. 106 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 resistance between the No. 1 and No. 3 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.

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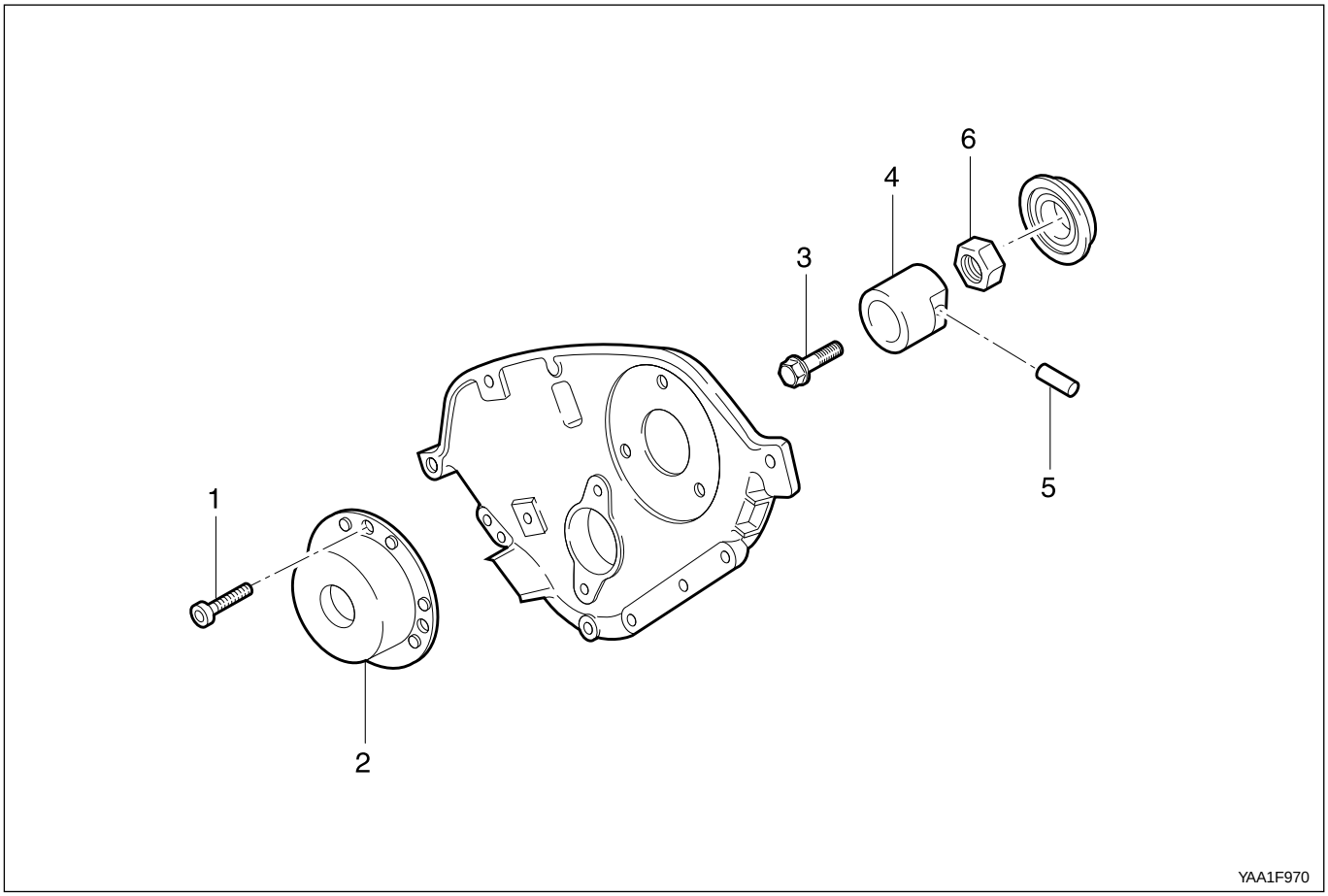
CAMSHAFT ACTUATOR



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.

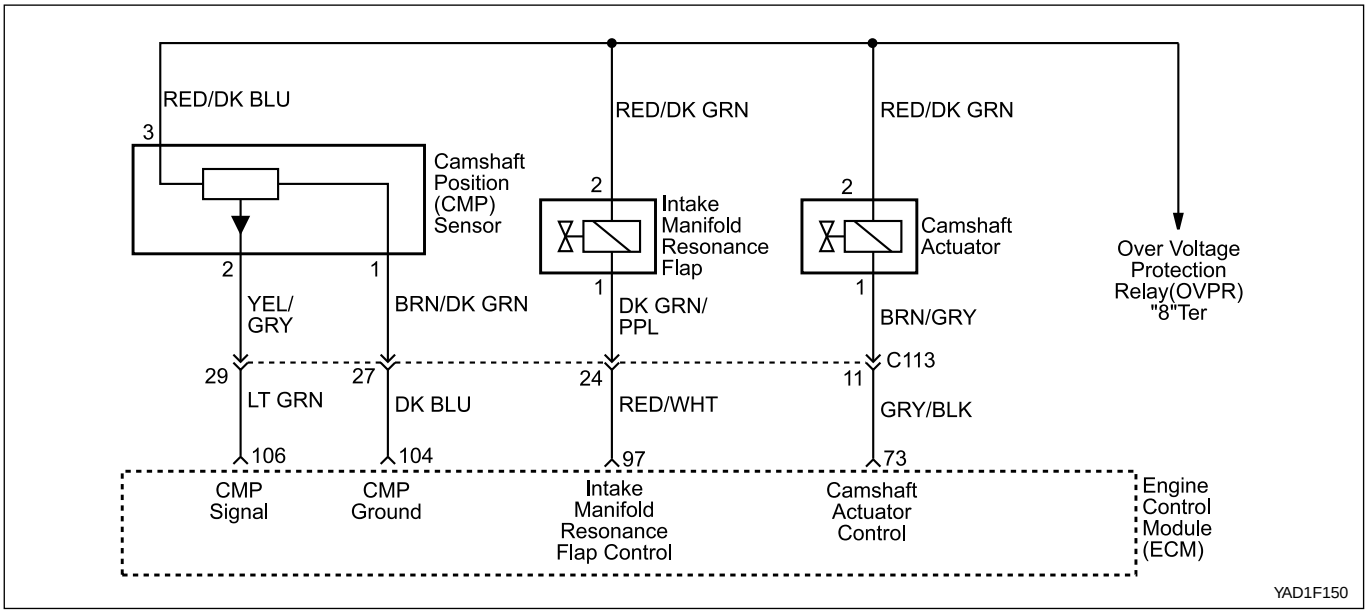
The camshaft actuator is actuated electro-mechanically by the Engine Control Module (ECM).

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



Failure Code	Description	Trouble Area	Maintenance Hint
226	Camshaft actuator short circuit to battery	When malfunction of cam phasing control	• Monitoring the actual operational status through scan tool • Inspection the ECM pin 73 about short circuit or open • Inspection the power source short circuit or open to cam actuator • Inspection the magnet and hardware • Inspection the ECM
227	Camshaft actuator short circuit to ground or open		

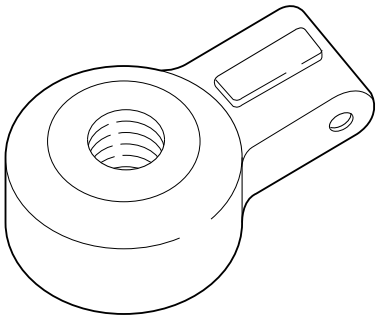
Camshaft Actuator Current Consumption Inspection

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 between the No. 1 and No. 2 pin of the camshaft actuator connector.

Specified Value	1 ~1.5 A

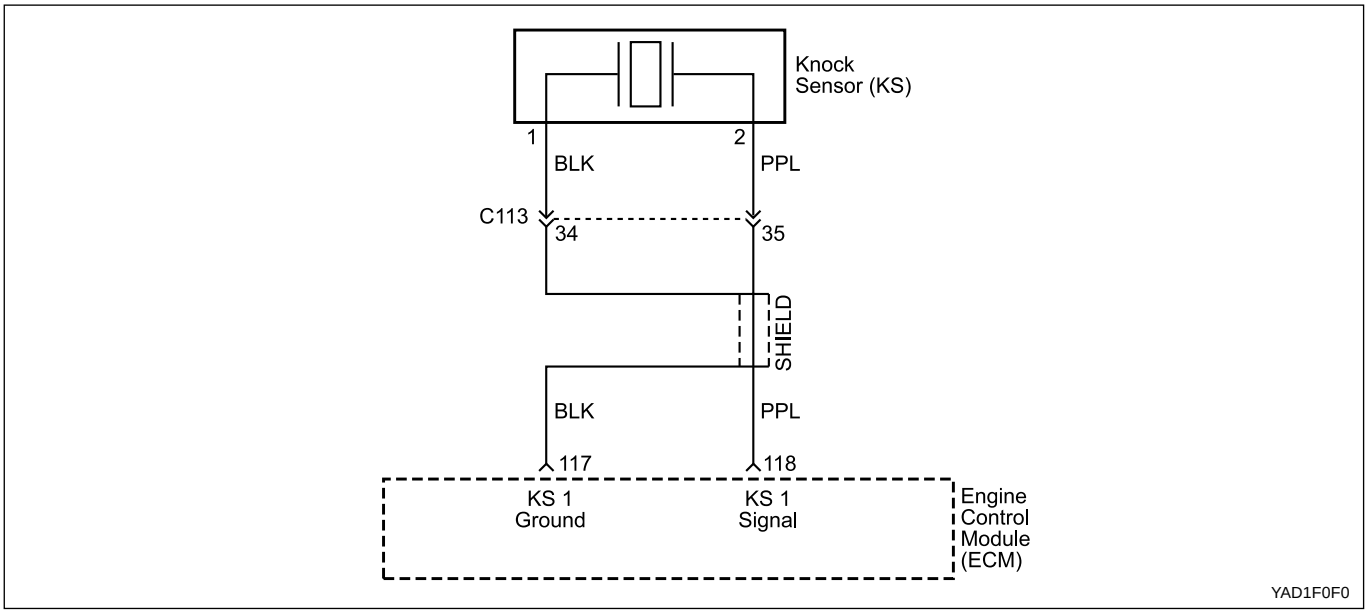
Notice: If the measured value is not within the specified value, check the cable.

KNOCK SENSOR (KS)



YAD1F180

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.



Failure Code	Description	Trouble Area	Maintenance Hint
56	No. 1 knock sensor signal failure	When recognition in more than control gain threshold at normal operational condition of other system during over 75 and 3,000 rpm running area (cylinder 1, 2, 3, 4)	• Inspection the ECM pin 118, 117 about short circuit or open with bad contact • Inspection the KS 1 malfunction • Inspection the ECM

Circuit Description

The KS system is used to detect engine detonation, allowing the ECM to retard the ignition control spark timing based on the KS signal being received. The KS signal's amplitude and frequency depend upon the amount of knock being experienced. The ECM monitors the KS signal and can diagnose the KS sensor and circuitry.

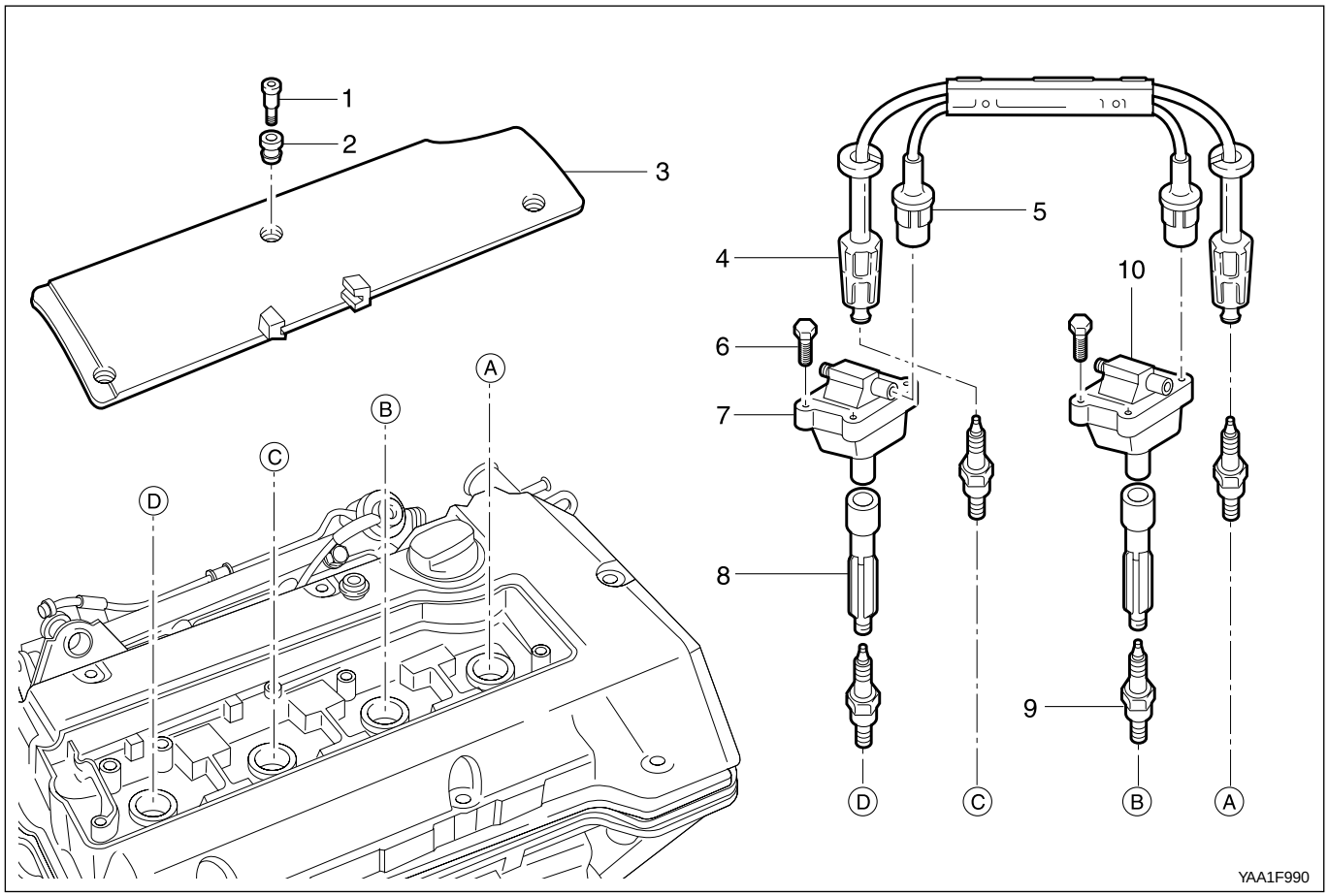
Knock Sensor Resistance Inspection

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.

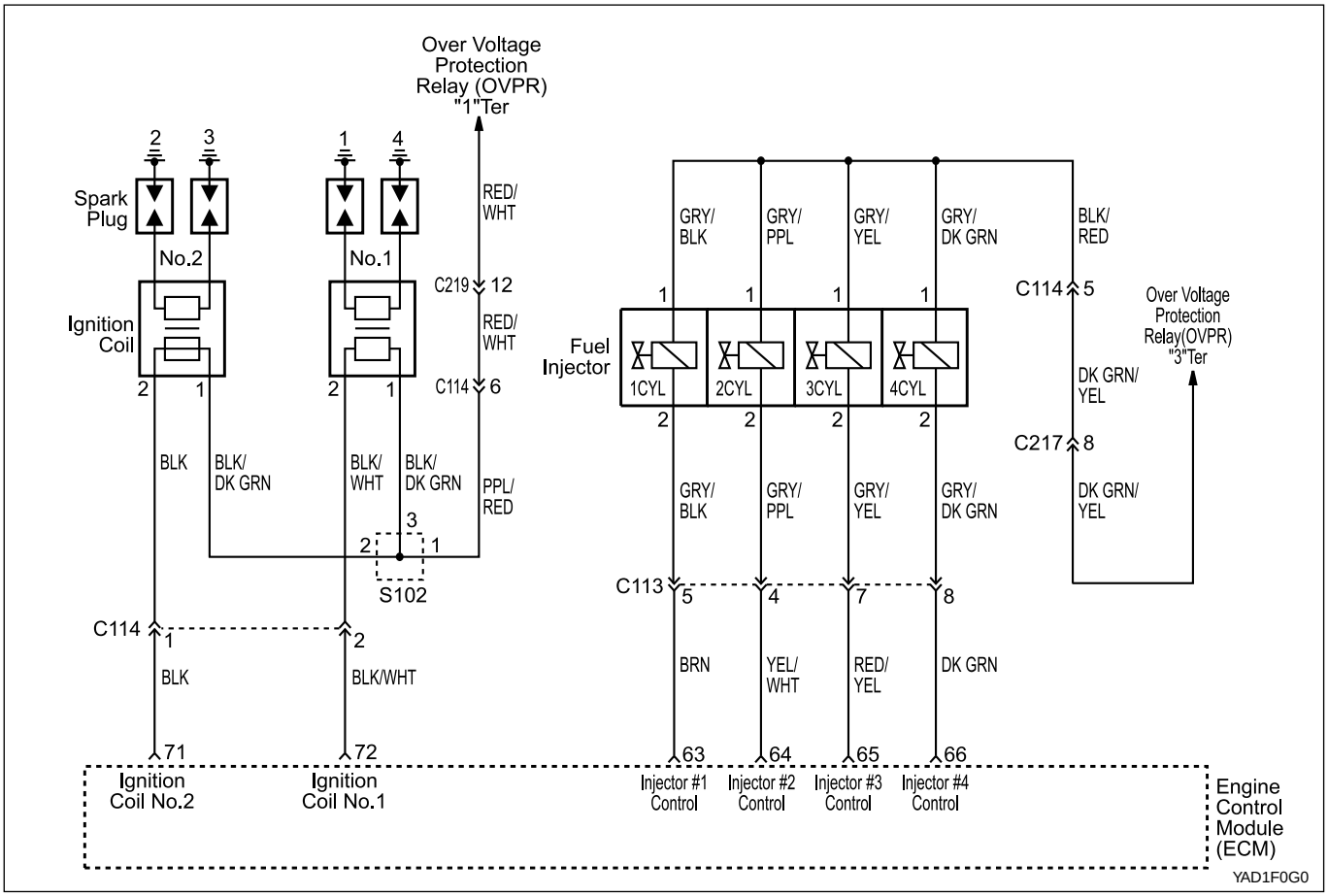
Specified Value	>10 MΩ

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.

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)



Failure Code	Description	Trouble Area	Maintenance Hint
68	Random / Multiple Misfire	When detection misfire of multiple cylinder for source of over the emission threshold or catalyst damage	• Inspection the ignition system • Inspection the injection system • Inspection the fuel pressure • Inspection the compression pressure • Inspection the valve timing or clearance • Inspection the air flow sensor • Inspection the crankshaft position sensor and air gap • Inspection the engine wiring system • Inspection the Engine Control Module (ECM)

Circuit Description

The ECM monitors the crankshaft and camshaft positions to detect if the engine is misfiring. The ECM looks for a quick drop in crankshaft speed. Misfire multiple cylinder is monitored by engine roughness measuring. The actual roughness value is compared with the actual (emission and catalyst damage) threshold.

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.

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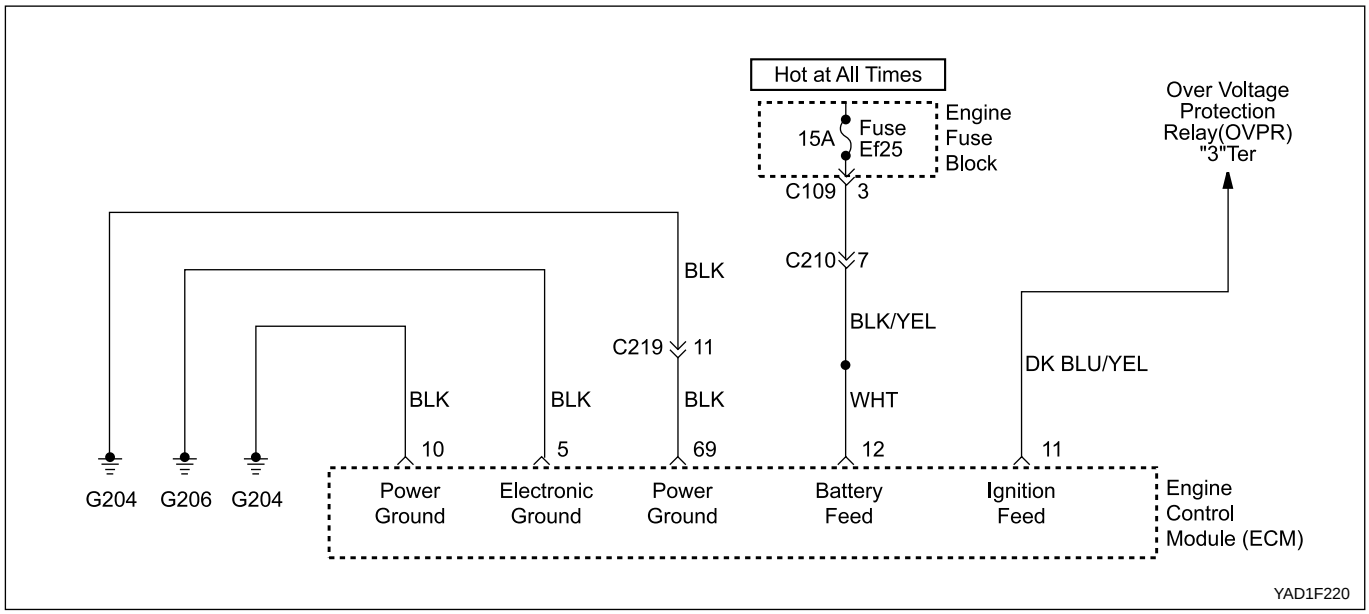
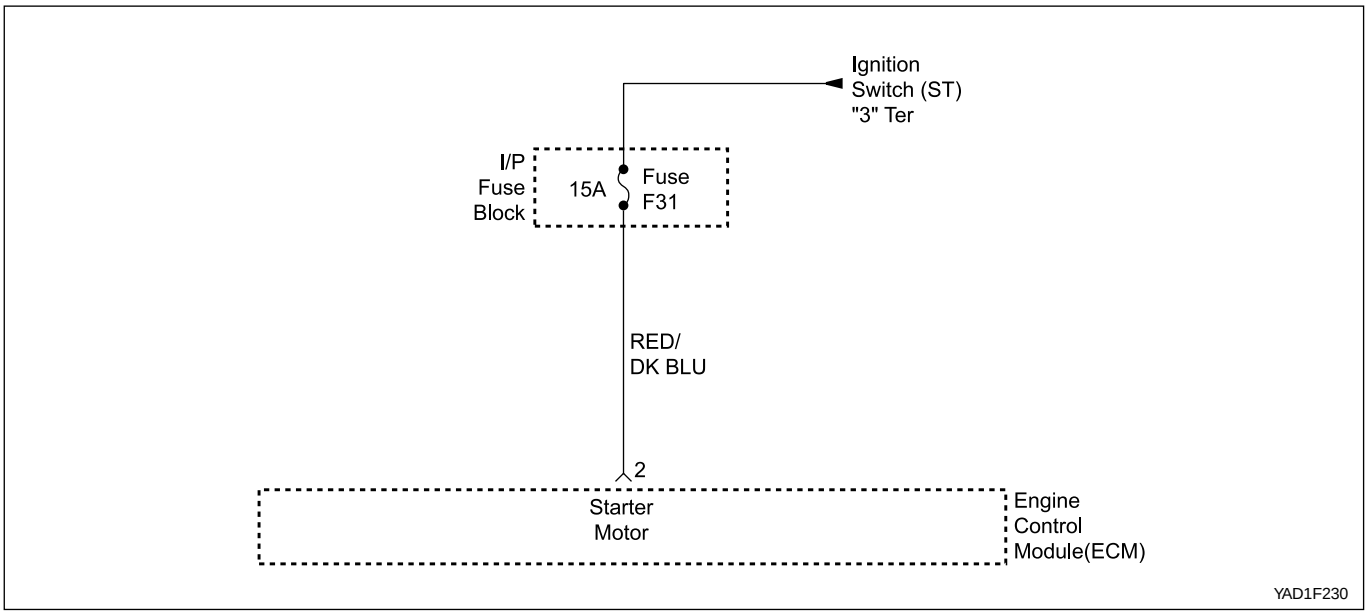
SYSTEM VOLTAGE



Failure Code	Description	Trouble Area	Maintenance Hint
08	System voltage too low	Malfunction in recognition of system source voltage. Less than minimum 8 volts in 2,000 rpm below, or less than 10 volts in 2,000 rpm above.	• Monitoring the actual battery voltages through the scan tool • Inspection the Engine Control Module (ECM) pin 12, 11, 10, 5 about short circuit or open with bad contact • Inspection the over voltage protection relay • Inspection the battery • Inspection ECM

IGNITION SWITCH



Failure Code	Description	Trouble Area	Maintenance Hint
71	Starter signal recognition failure	When not detection of starter signal	• Inspection the Engine Control Module (ECM) pin 2 circuit short or open with bad contact • Inspection ECM

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 Mass Air Flow (MAF) sensor and the oxygen (O2) sensors.

The MAF sensor monitors the mass flow of the air 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. Engine Control Module (ECM) modulates the flow of heating current to maintain the temperature differential between the heated film and the intake air at a constant level. The amount of heating current required to maintain the temperature thus provides an index for the mass air flow. This concept automatically compensates for variations in air density, as this is one of the factors that determines the amount of warmth that the surrounding air absorbs from the heated element. MAF sensor is located between the air filter and the throttle valve.

Under high fuel demands, the MAF sensor reads a high mass flow condition, such as wide open throttle. The ECM uses this information to enrich the mixture, thus increasing the fuel injector on-time, to provide the correct amount of fuel. When decelerating, the mass flow decreases. This mass flow change is sensed by the MAF sensor and read by the ECM, which then decreases the fuel injector on-time due to the low fuel demand conditions.

The O2 sensors are located in the exhaust pipe before catalytic converter. The O2 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 HO2S and calculates the air/fuel ratio based on inputs from the ECT sensor and the MAF sensor. The ECM stays in “open loop” until the following conditions are met:

- The O2 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 O2 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.

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.

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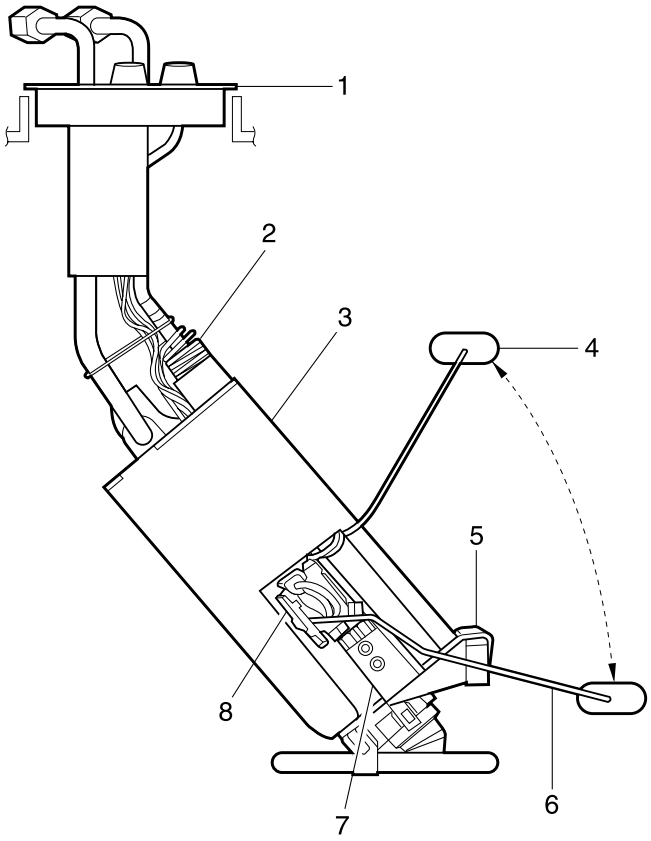
FUEL PUMP

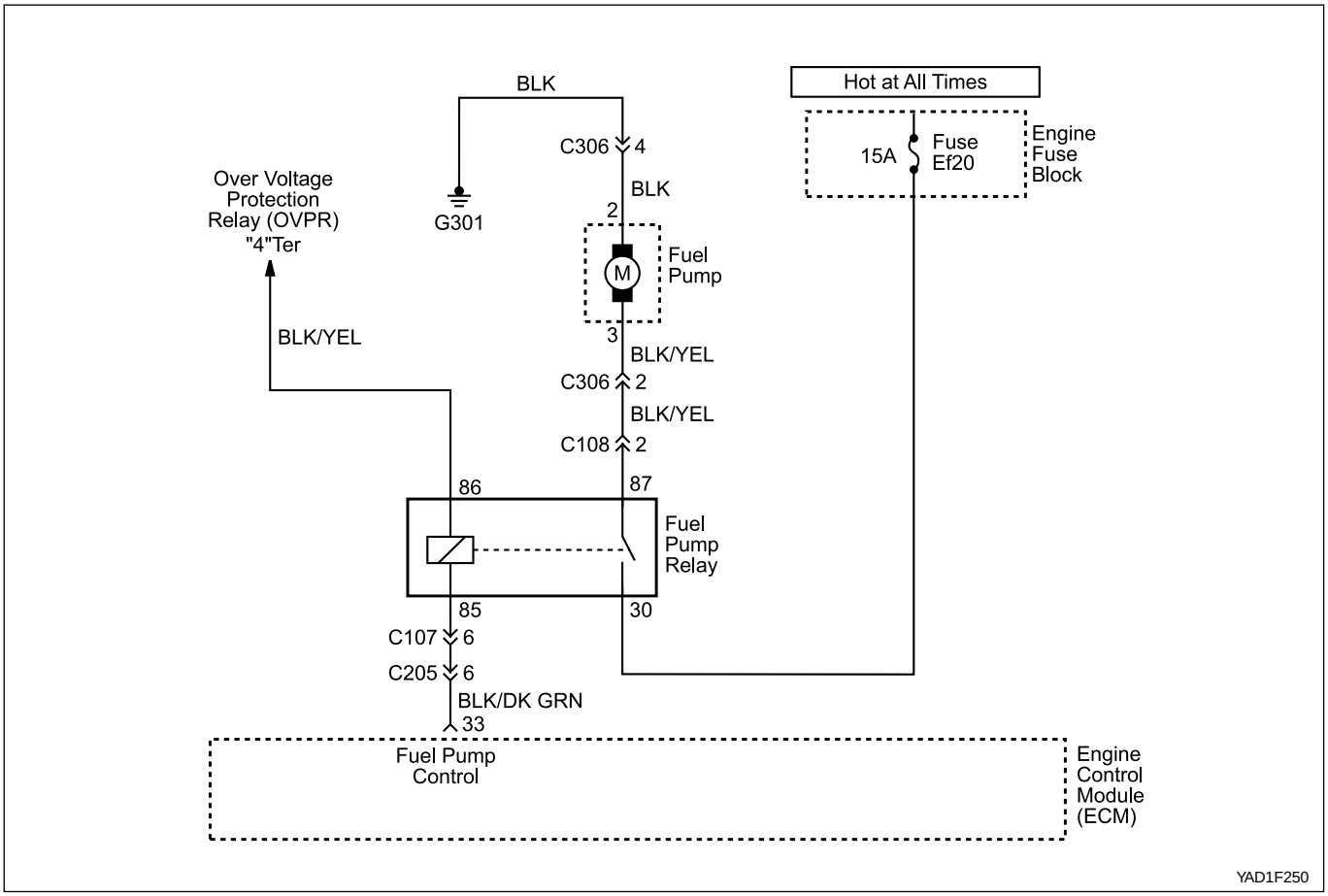


YAD1F240

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	8.5 bar (12 V)	Operating Voltage	8 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)



Failure Code	Description	Trouble Area	Maintenance Hint
34	Fuel pump relay short circuit to battery	When short circuit to power source	• Inspection the Engine Control Module (ECM) pin 33 about short circuit or open with bad contact • Inspection the fuel pump relay • Inspection the ECM
35	Fuel pump relay short circuit to ground or open	When short circuit to ground or open	

Circuit Description

When the ignition switch is turned ON, the ECM will activate the pump relay and run the in-tank fuel pump. The fuel pump will operate as long as the engine is cranking or running and the ECM is receiving ignition reference pulses.

If there are no reference pulses, the ECM will shut off the fuel pump within 2 seconds after the ignitions witch is turned ON, engine stopped or engine stalled.

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.

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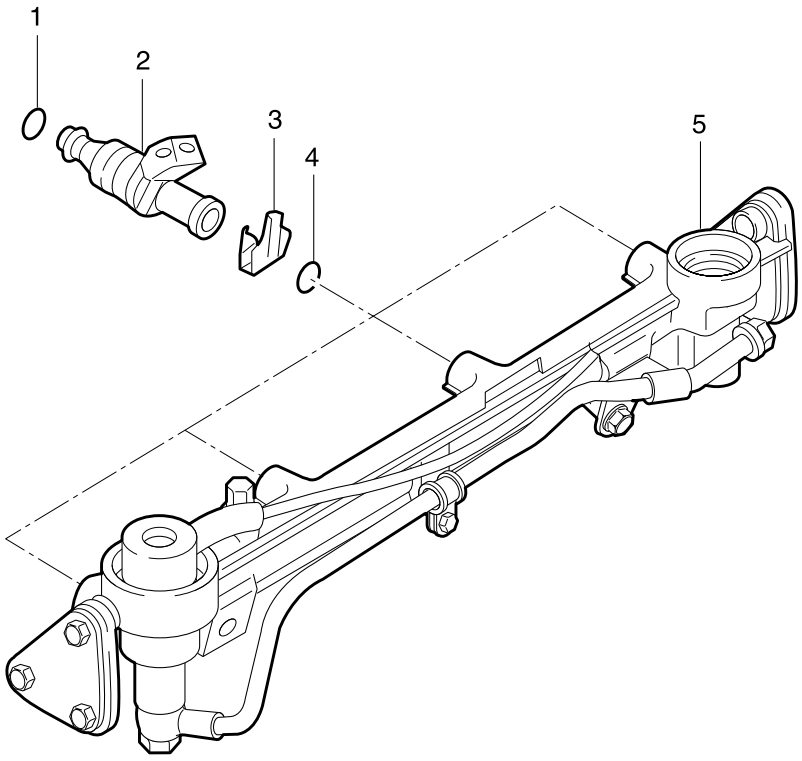
FUEL INJECTOR



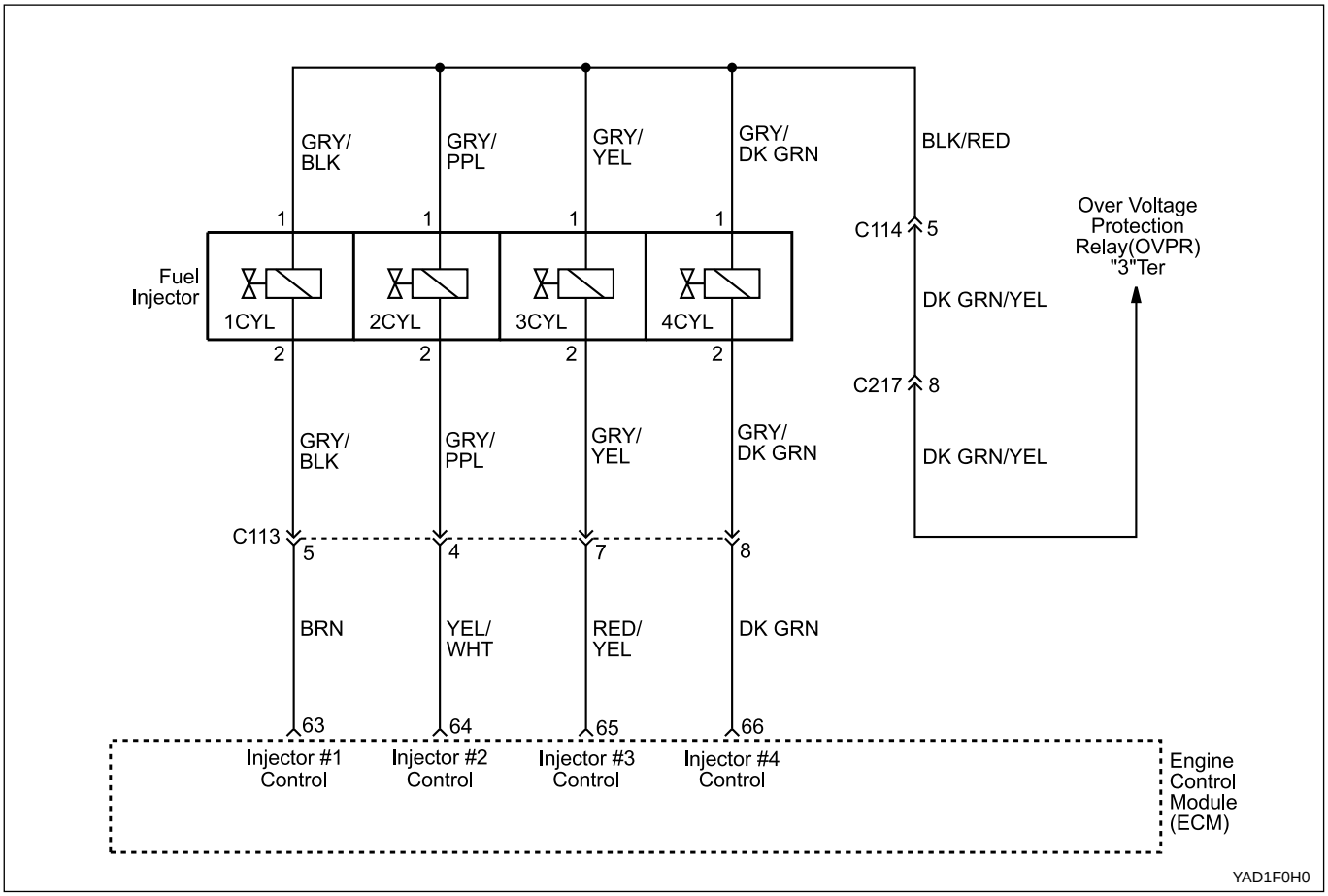
YAA1F0C0

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.

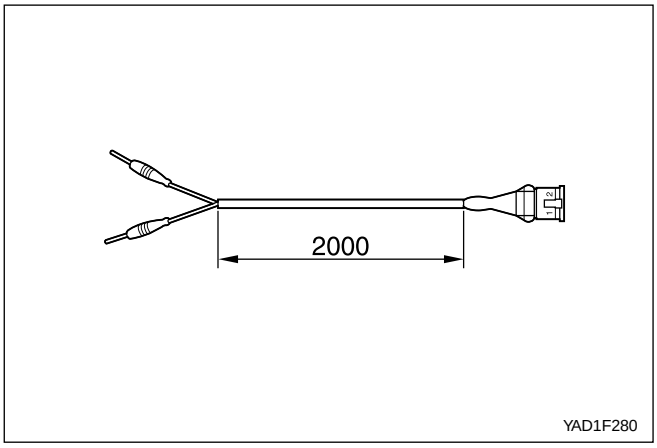
Fuel enters the top feed injector from above and flows through its vertical axis. The lower end extends into the intake valve. Fuel from the tip is directed at the intake valve, causing it to become further atomized and vaporized before entering the combustion chamber.

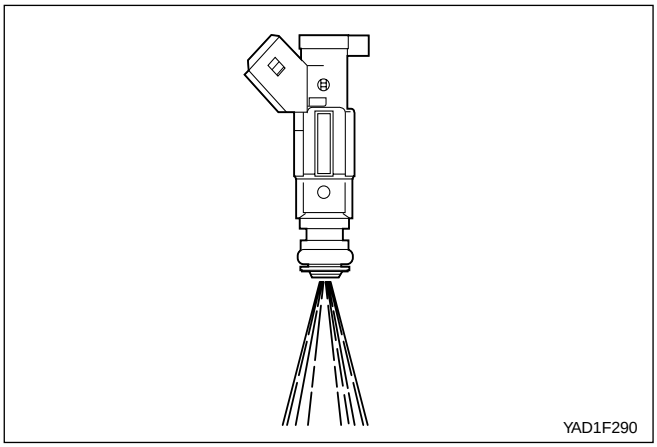
A fuel injector which is stuck partially open would cause a loss of fuel pressure after the engine is shut down. Also, an extended crank time would be noticed on some engines. Dieseling could also occur because some fuel could be delivered to the engine after the ignition is turned off.



Failure Code	Description	Trouble Area	Maintenance Hint
72	No. 1 injector short circuit to battery	When malfunction of injector circuit Injector #1 short circuit to power	• Inspection the power to injector #1 or bad contact • Inspection the injector • Inspection the ECM
73	No. 1 injector short circuit to ground or open	When malfunction of injector circuit Injector #1 short circuit to ground or open	• Inspection the ECM pin 63 about short circuit or open with bad contact • Inspection the injector • Inspection the ECM
74	No. 2 injector short circuit to battery	When malfunction of injector circuit Injector #2 short circuit to power	• Inspection the power to injector #2 or bad contact • Inspection the injector • Inspection the ECM
75	No. 2 injector short circuit to ground or open	When malfunction of injector circuit Injector #2 short circuit to ground or open	• Inspection the ECM pin 64 about short circuit or open with bad contact • Inspection the injector • Inspection the ECM
76	No. 3 injector short circuit to battery	When malfunction of injector circuit Injector #3 short circuit to power	• Inspection the power to injector #3 or bad contact • Inspection the injector • Inspection the ECM

Failure Code	Description	Trouble Area	Maintenance Hint
77	No. 3 injector short circuit to ground or open	When malfunction of injector circuit Injector #3 short circuit to ground or open	• Inspection the ECM pin 65 about short circuit or open with bad contact • Inspection the injector • Inspection the ECM
78	No. 4 injector short circuit to battery	When malfunction of injector circuit Injector #4 short circuit to power	• Inspection the power to injector #4 or bad contact • Inspection the injector • Inspection the ECM
79	No. 4 injector short circuit to ground or open	When malfunction of injector circuit Injector #4 short circuit to ground or open	• Inspection the ECM pin 66 about short circuit or open with bad contact • Inspection the injector • Inspection the ECM





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

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

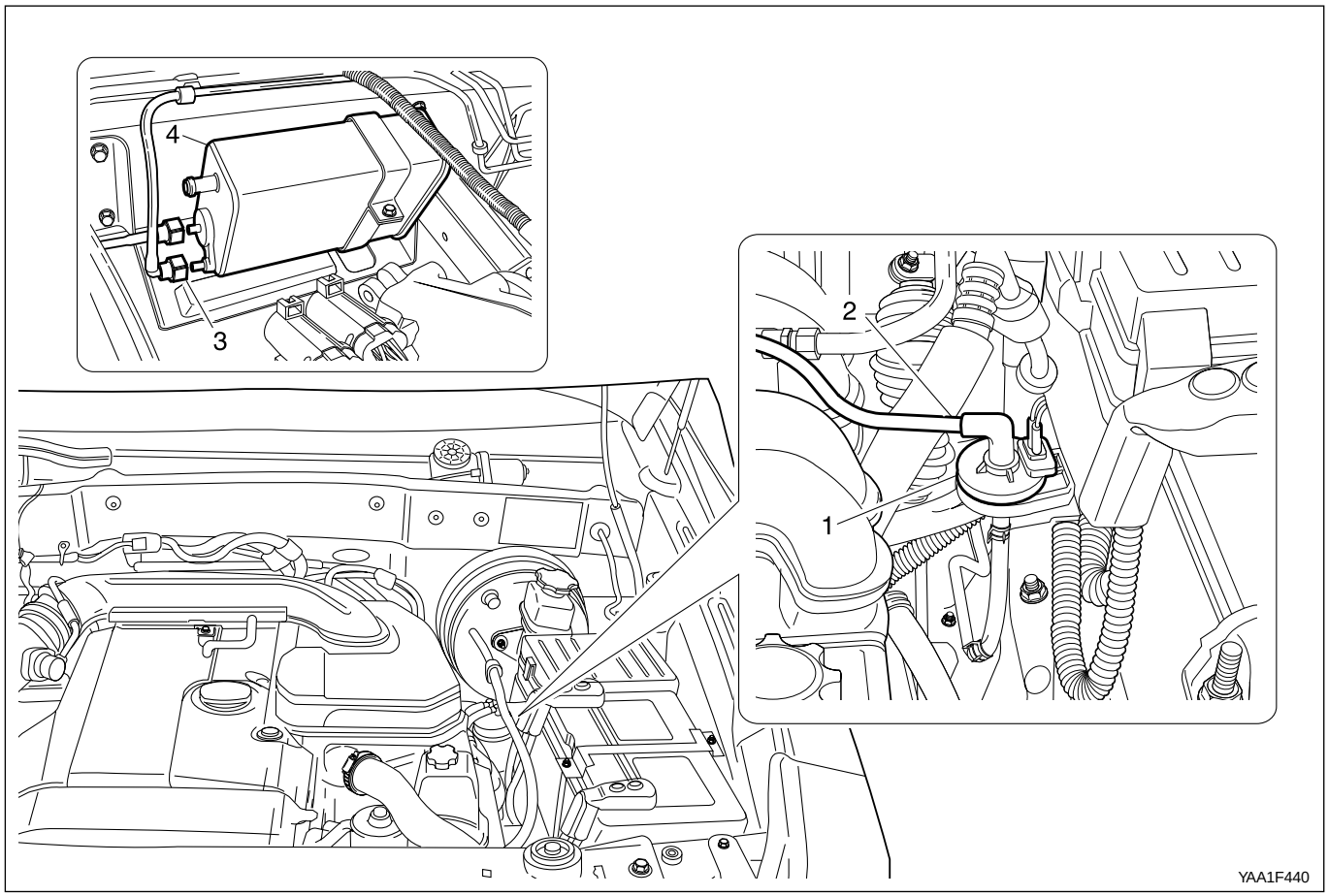
Notice: Replace the fuel injector if the measured value is out of the specified values . Check the connector and wire connection between the ECM and the injector if the measured values are normal.

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



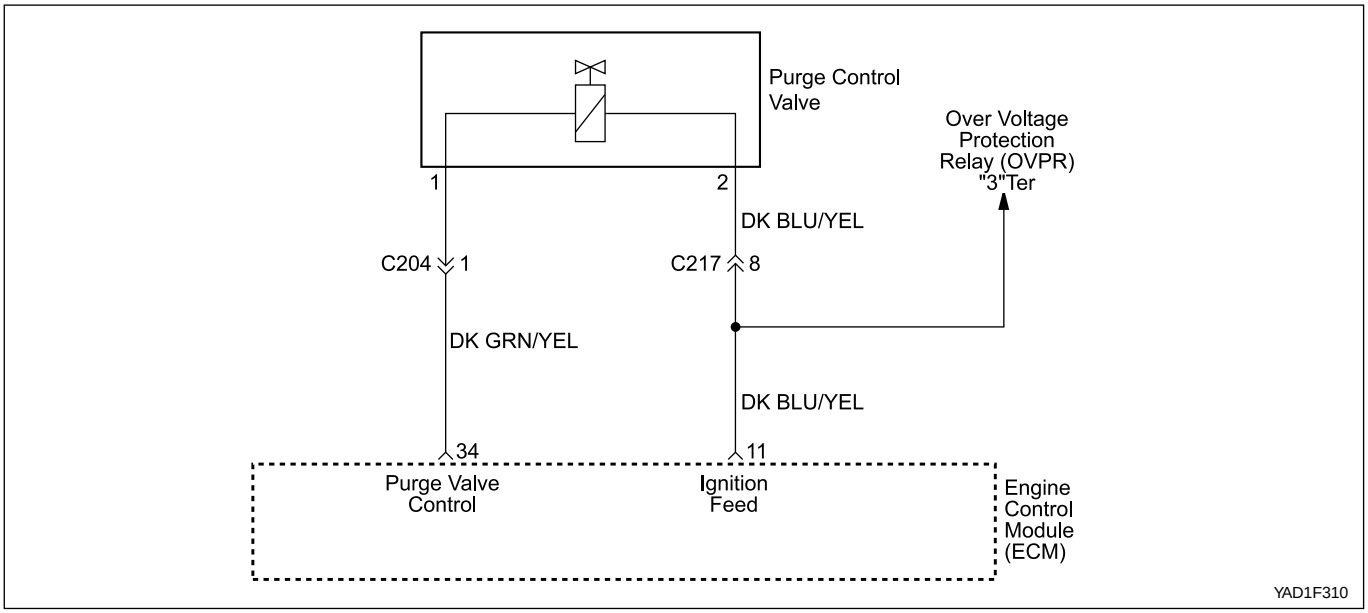
1 Purge Control Valve
2 Line to Engine
3 Line to Canister
4 Canister

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.

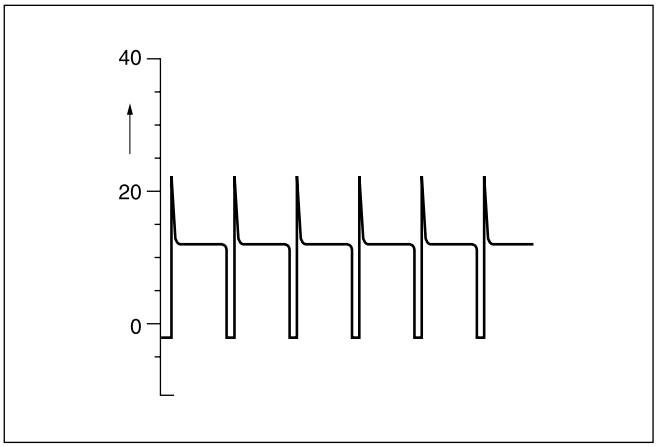
The purge control valve is activated by the ECM frequency according with the engine rotating speed to adjust the purification rate. The purification rate is determined by the continuous valve opening interval.

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



Failure Code	Description	Trouble Area	Maintenance Hint
40	Purge control valve short circuit to battery	When short circuit to power source	• Inspection the ECM pin 34 about short circuit or open with bad contact • Inspection the source power of valve • Inspection the purge control solenoid vale • Inspection the ECM
41	Purge control valve short circuit to ground or open	When short circuit to ground or open	
54	Purge control circuit malfunction	When malfunction of purge control : not work	



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.

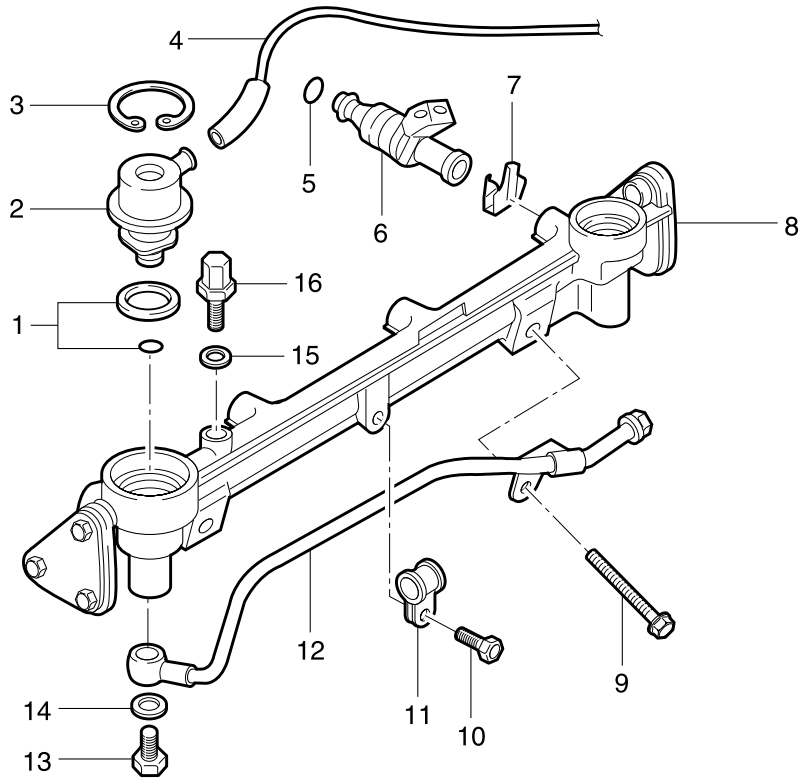
Specified Value	0.3 ~ 0.5 A

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



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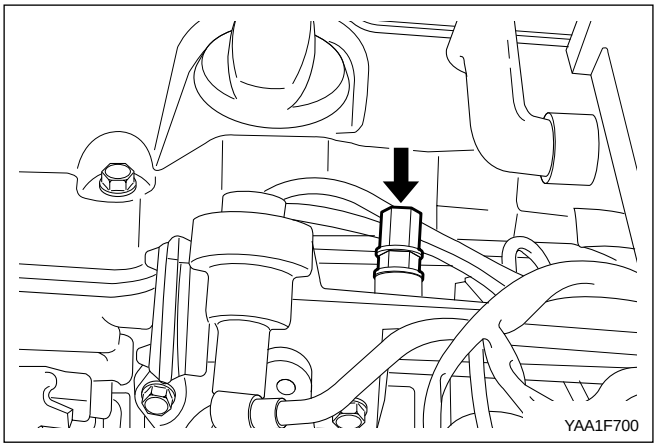
1 O-Ring
2 Fuel Pressure Regulator
3 Circlip
4 Vacuum Hose
5 O-Ring
6 Injector
7 Injector Bracket
8 Fuel Rail
9 Combination Bolt
10 Bolt
11 Clamp
12 Fuel Return Line
13 Hollow Bolt
14 Seal Ring
15 Seal Ring
16 Fuel Pressure Test Connector



Fuel Pressure Test

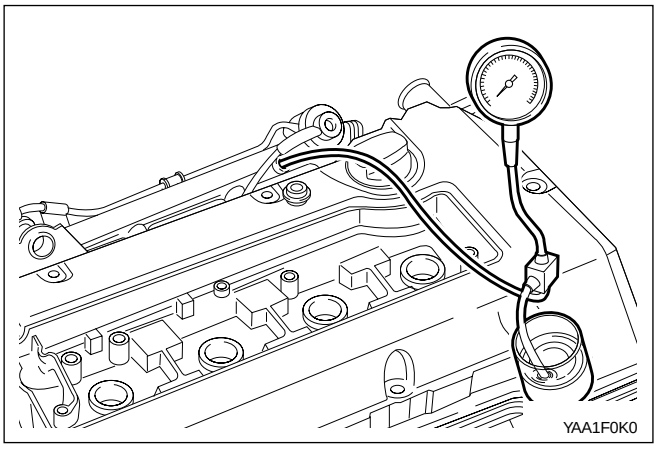
Tools Required

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

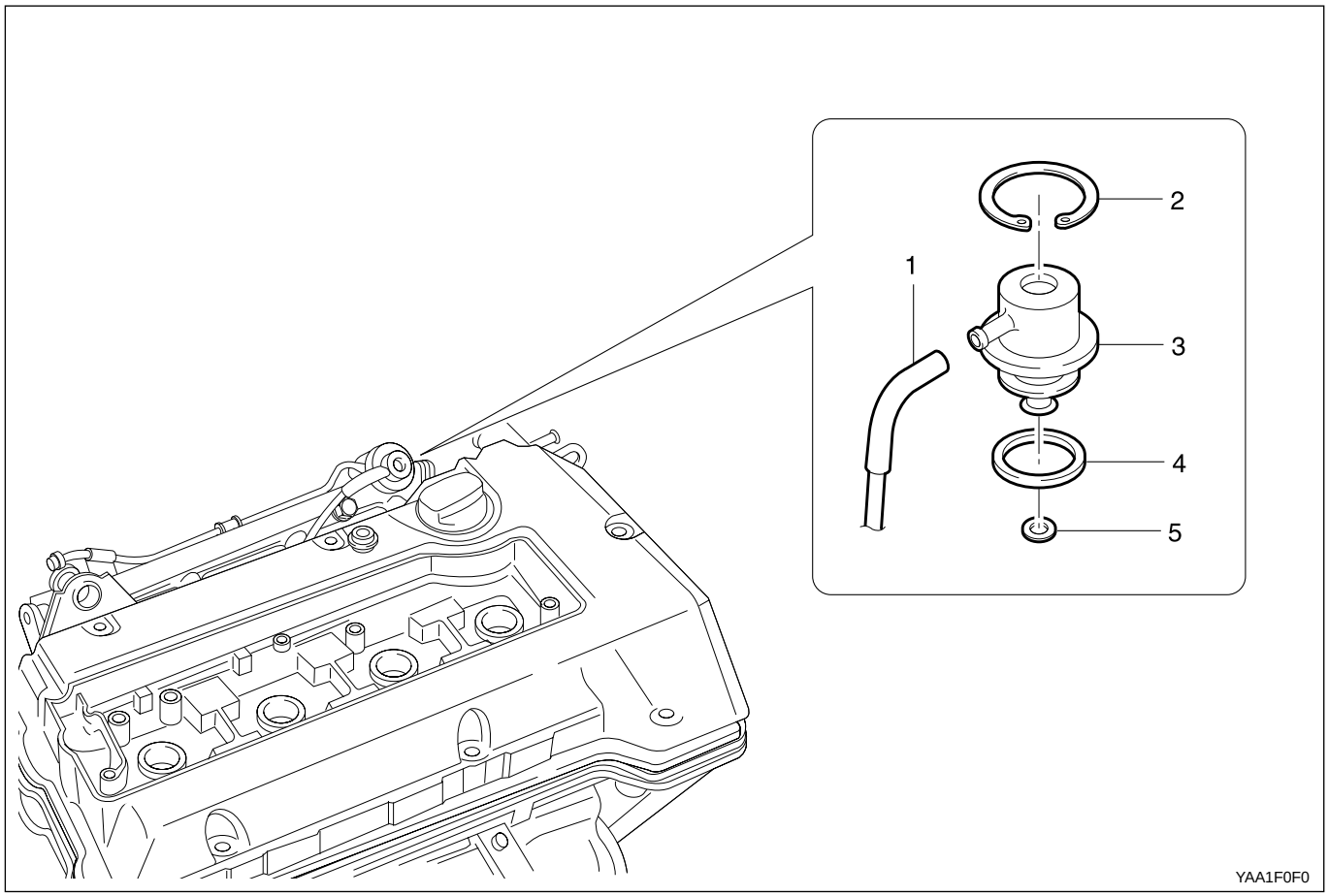
1. Connect the fuel pressure gauge103 589 002100 to the fuel pressure test connector.
2. Stop the engine for approximately 30 minutes and then check the fuel pressure changes.

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

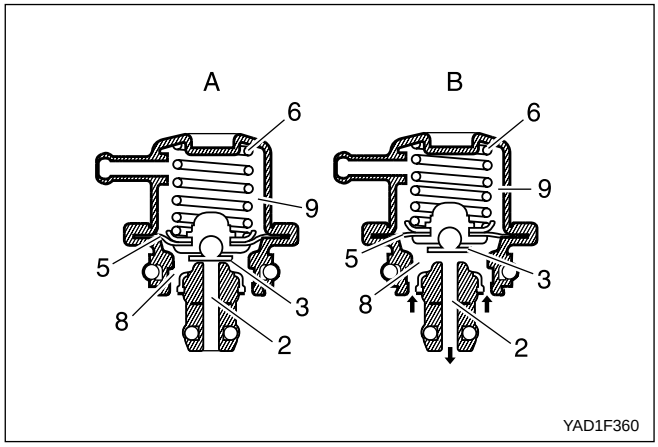
3. If there is no change in fuel pressure and maintain the following pressure over 30minutes, it is normal.

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

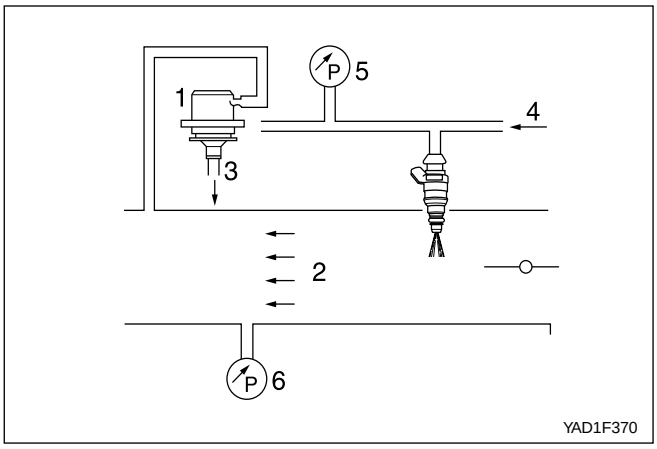
The fuel pressure regulator maintains the fuel pressure in the fuel line with the pressure of 3.2 bars to 3.8 bars according to the intake manifold pressure. This operating pressure cannot be changed, and the fuel injection volume will be only determined by the injection time. Over supplied fuel returns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

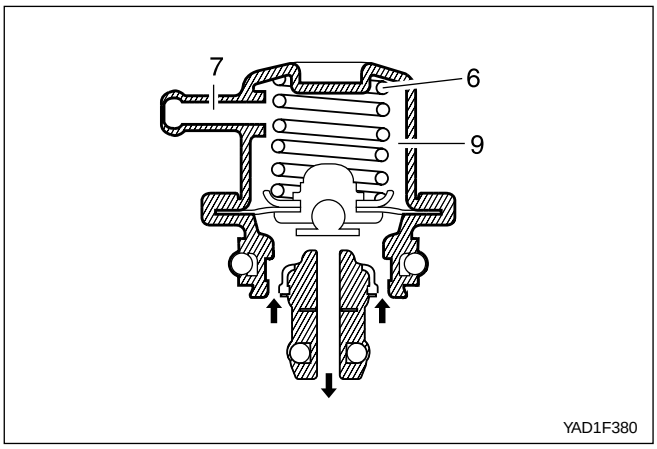
The pressure difference between the fuel pressure and the intake manifold is about 3.8 bars during the full load.



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)

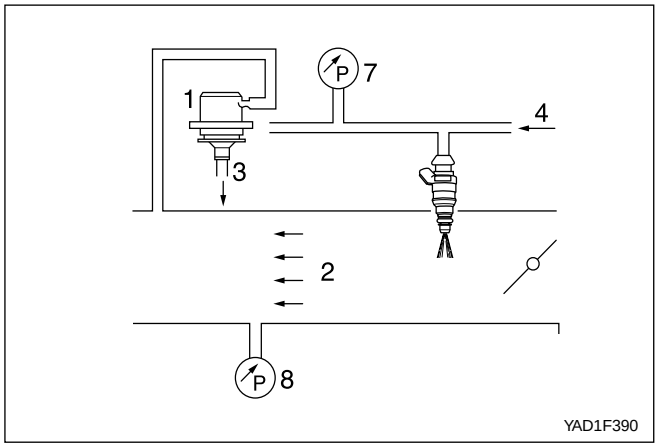
<Operating at Idle and partial load>

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.



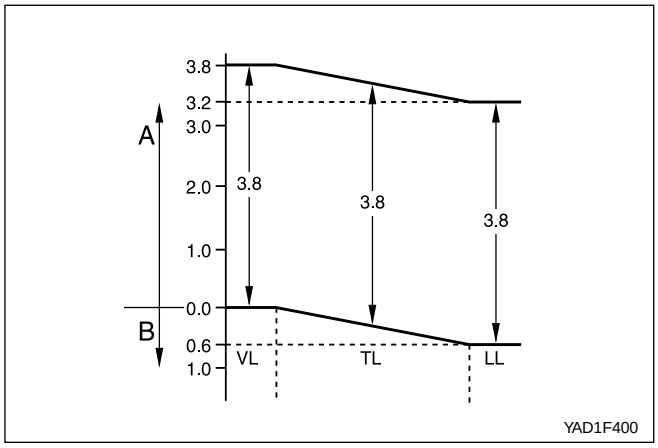
Consequently, the fuel pressure in the fuel distributor changes by the intake manifold's negative pressure, and the injector's fuel pressure gets reduced independently to the throttle valve's position. Thus, the fuel injection volume can only be determined according to the injector's injecting duration.

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



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)

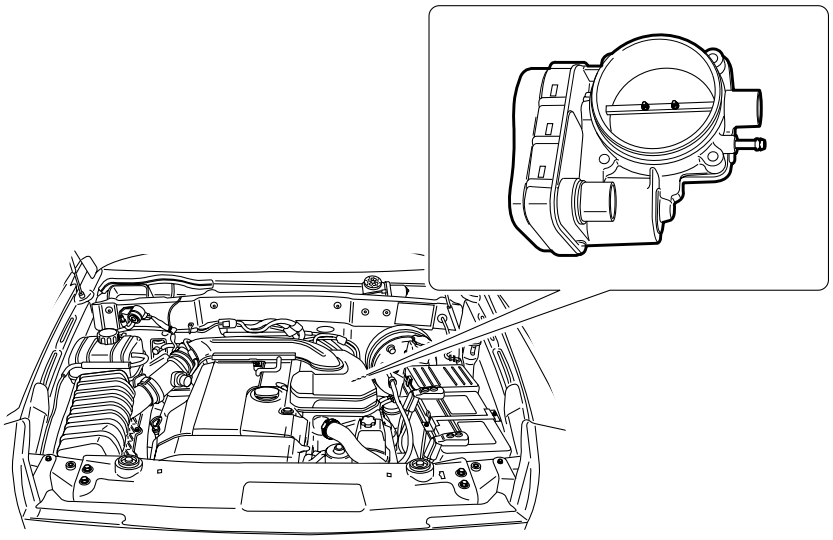
<Fuel Pressure Diagram>



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

INDUCTION SYSTEM

THROTTLE VALVE ACTUATOR



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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.

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.

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

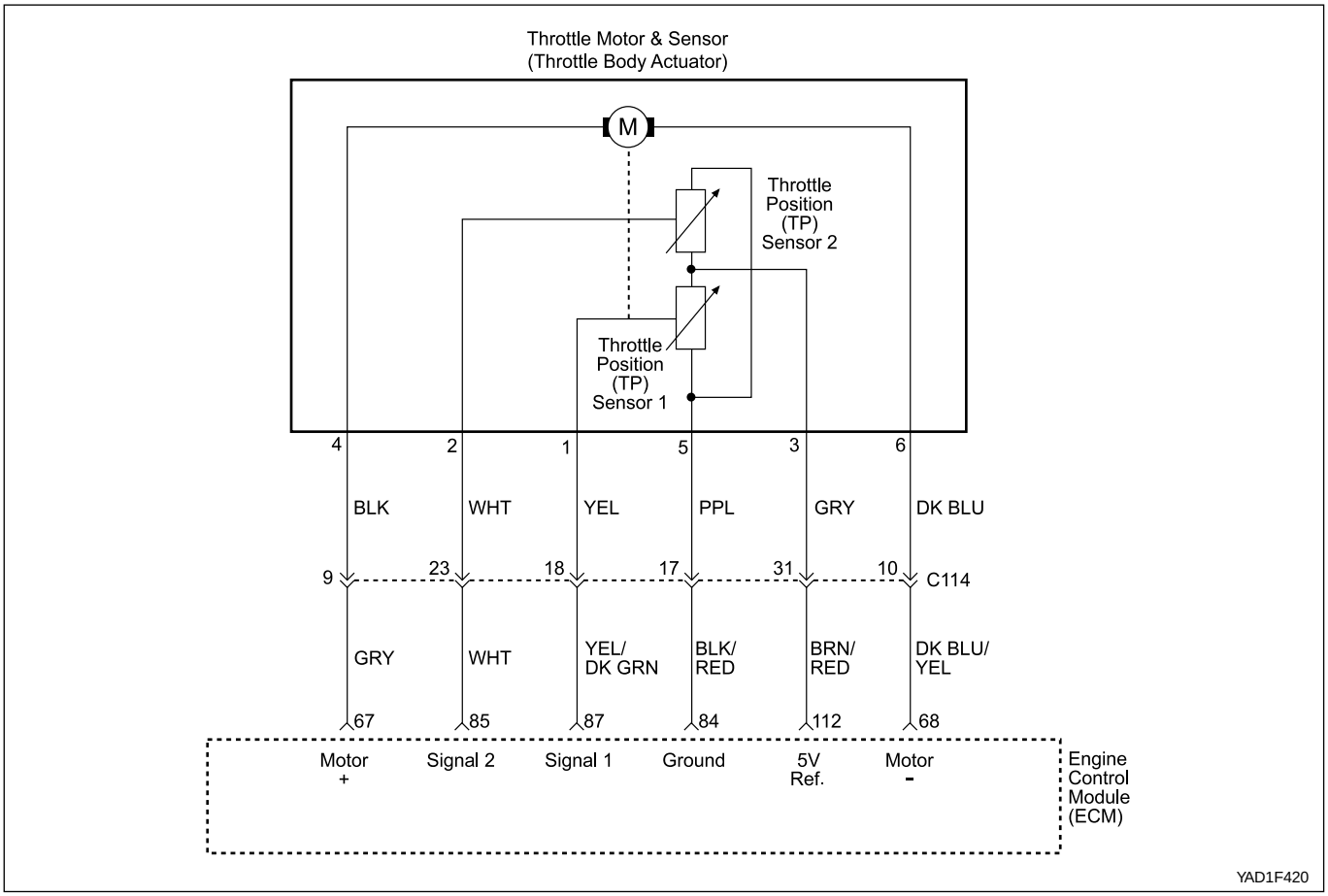
At no load, this produces an engine speed of about 1,800 rpm

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



Failure Code	Description	Trouble Area	Maintenance Hint
104	Throttle position sensor 1 low voltage	TPS 1 short circuit to ground or open	• Monitoring the actual values through scan tool • Inspection the ECM pin 84, 85, 87, 112, 67, 68 about short circuit or open with bad contact • Inspection the throttle valve actuator • Inspection the ECM
105	Throttle position sensor 1 high voltage	TPS 1 short circuit to power	
108	Throttle position sensor 2 low voltage	TPS 2 short circuit to ground or open	
109	Throttle position sensor 2 high voltage	TPS 2 short circuit to power	
116	Throttle actuator learning control failure	When actuat or adaption fluctuation or not meet the condition	
119	Throttle valve return spring failure	When return spring defective of actuator	
121	Throttle act uator failure	When supply voltage of the actuat or short circuit to power	
123	Different mass air flow sensor signal with throttle position sensor	When shut down of out put driver	
125	Both throttle position sensor failure	When defective of both potentiometers	

Failure Code	Description	Trouble Area	Maintenance Hint
126	Throttle position sensor 1 not plausible with Throttle position sensor 2	When difference between TPS 1 and TPS 2	• Monitoring the actual values through scan tool • Inspection the ECM pin 84, 85, 87, 112, 67, 68 about short circuit or open with bad contact • Inspection the throttle valve actuator • Inspection the ECM
127	High permanent throttle signal	When failure of wiring harness or actuator	
185	Mass air flow sensor and throttle position sensor failure	When difference between MAF and TPS signal	

Circuit Description

The ECM supplies a 5 volt reference signal and a ground to the TP sensor. The TP sensor sends a voltage signal back to the ECM relative to the throttle plate opening. The volt age signal will vary from approximately 0.3 ~ 0.9 volts at closed throttle, to over 4.0 ~ 4.6 volts at Wide Open Throttle (WOT).

The TP sensors serve for engine load control according to the drive pedal command. Load adjustments independent of the drive pedal command can be implemented; such functions are, for instance, idle control, speed control, drive slip control, load shock damping, and similar functions .

When the actuator current fails , the throttle valve is returned to emergency operating position by a spring. The throttle valve position, there by the actuator drive position check back is provided by two potentiometers. The motor positions the throttle valve against the return spring force. Motor and return spring are two separate energy sources . Each of them is able to position the throttle valve in emergency position alone. Throttle valve position check back and monitoring is provided by two actual value potentiometers connected to the engine control electronics.

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

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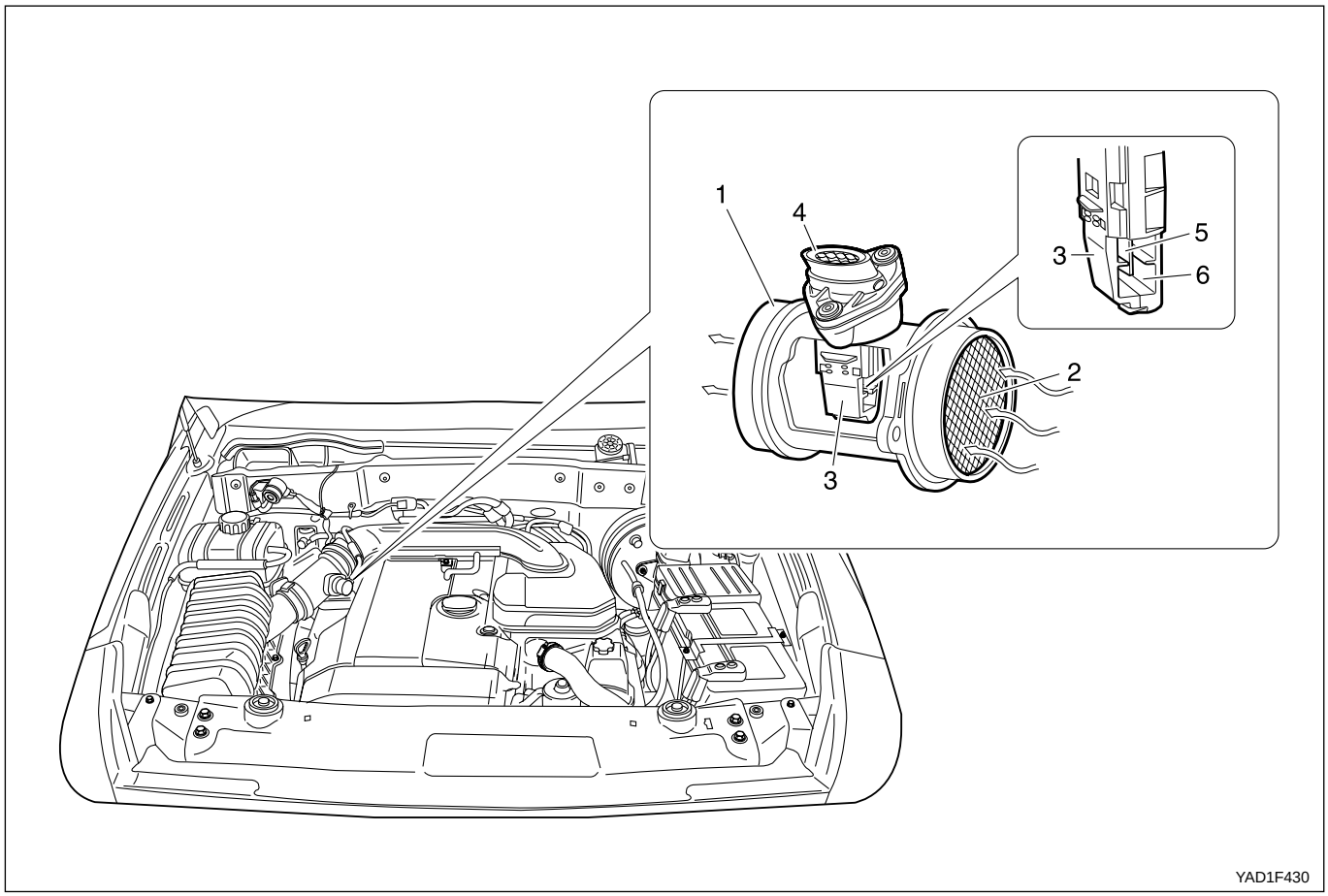
HOT FILM AIR MASS (HFM) SENSOR



1 Housing
2 Protector Net
3 Electronic Housing
4 Connector
5 Hot Film Air Mass Sensor
6 Measuring Port

The Hot Film Air Mass (HFM) sensor with recognition of flow direction related to pulsating flow is designed for recording load on Engine Control Module (ECM) by measuring the output voltage proportional to the reference voltage of the ECM.

Mass Air Flow Sensor

Mass Air Flow (MAF) is a thermal flow meter whose sensor element with its temperature sensors and heating area is exposed to the MAF to be measured. A heating area located in the center of a thin membraneis controlled to an over temperature by a heating resistor and a temperature sensor of this membrane. And the value of over-temperature depends on the temperature of the in-flowing air.

Two temperature sensors on upstream and downstream of the heating area show the same temperature without incoming flow. With incoming flow, upstream part is cooled down but downstream temperature retains its temperature more or less due to the air heated up in the heating area. This temperature difference in quantity and direction depends on the direction of the incoming flow.

ECM modulates the flow of heating current to maintain the temperature differential between the heated film and the intake air at a constant level. The amount of heating current required to maintain the temperature thus provides an index for the MAF. This concept automatically compensates for variations in air density, as this is one of the factors that determines the amount of warmth that the surrounding air absorbs from the heated element. MAF sensor is located between the air filter and the throttle valve.

Under high fuel demands, the MAF sensor reads a high mass flow condition, such as Wide Open Throttle (WOT). The ECM uses this information to enrich the mixture, thus increasing the fuel injector on-time, to provide the correct amount of fuel. When decelerating, the mass flow decreases. This mass flow change is sensed by the MAF sensor and read by the ECM, which then decreases the fuel injector on-time due to the low fuel demand conditions.

To facilitate the installation of the HFM in the intake passage, lubricating agents may be used. However, when lubricants are used care must be taken to ensure that they do not enter the flow passage and cannot be sucked in with the air flow.

The following tables show the relationship between MAF and output voltage.

Mass Air Flow (kg/h)	Voltage (V)	Mass Air Flow (kg/h)	Voltage (V)
0	0.95 ~ 1.05	250	3.51
10	1.28	370	3.93
15	1.41	480	4.23
30	1.71	640	4.56
60	2.16	800	4.82
120	2.76		

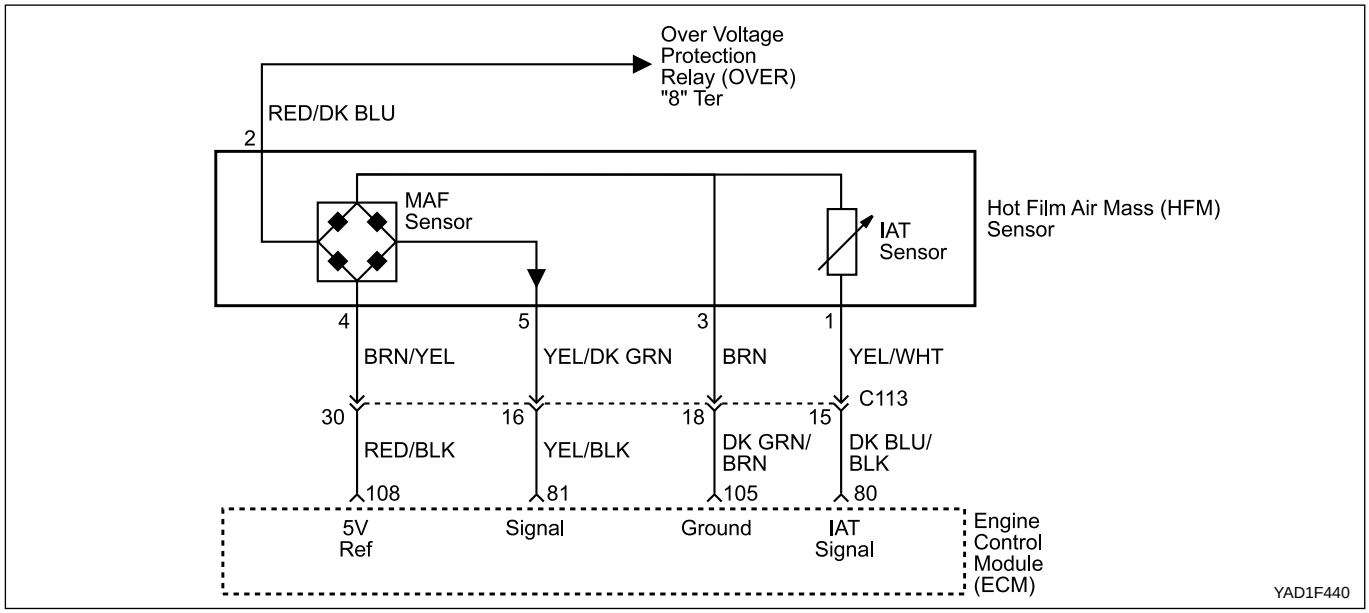
Intake Air Temperature

The Intake Air Temperature (IAT) sensor is a part of Hot Film Air Mass (HFM) sensor and 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	43760
-20	12660	13850	15120
0	5119	5499	5829
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



Failure Code	Description	Trouble Area	Maintenance Hint
03	Intake air temperature sensor low voltage	IAT sensor short circuit to ground or open	• Monitoring the actual air temperature through scan tool • Inspection the ECM pin 80, 79 about short circuit or open with bad contact • Inspection the IAT sensor (integrated in HFM sensor) • Inspection the ECM
04	Intake air temperature sensor high voltage	IAT sensor short circuit to power	
05	Intake air temperature sensor plausibility	Malfunction in recognition of IAT When functional problem	
09	Mass air flow sensor plausibility	Malfunction in recognition of MAF When air mass not plausible	• Monitoring the actual air mass flow through scan tool • Inspection the ECM pin 81, 105 about short circuit or open with bad contact • Inspection the MAF sensor (integrated in HFM sensor) • Inspection the ECM
10	Mass air flow sensor low voltage	MAF sensor short circuit to ground or open	
11	Mass air flow sensor high voltage	MAF sensor short circuit to power	

Circuit Description

The heated element on the MAF is a platinum film resistor (heater). It is located on a ceramic plate together with the other elements in the bridge circuit. The temperature sensitive resistor (flow sensor) also included in the bridge. The separation of heater and flow sensor facilitates design of the control circuitry. Saw cuts are employed to ensure thermal decoupling between the heating element and the intake air temperature (IAT) sensor. The complete control circuitry is located on a single layer. The voltage at the heater provides the index for the mass air flow. The MAF's electronic circuitry then converts the voltage to a level suitable for processing in the ECM. This device does not need a burn off process to maintain its measuring precision over an extended period. In recognition of the fact that most deposits collect on the sensor element's leading edge, the essential thermal transfer elements are located downstream on the ceramic layer. The sensor element is also design to ensure that deposits will not influence the flow pattern around the sensor.

The IAT sensor uses a thermistor to control the signal voltage to the ECM. The ECM supplies 5 volt reference and a ground to the sensor. When the air is cold, the resistance is high; therefore the IAT signal voltage will be high. If the intake air is warm, resistance is low; therefore the IAT signal voltage will be low.

Mass Air Flow Sensor Input Voltage Inspection

1. Turn the ignition switch to “ON” position.
2. Measure the signal voltage between the ECM pin No. 103 and No. 104.

Application		Specified Value
Engine Status	Ignition “ON”	0.9 ~ 1.1 V
	Idling	1.3 ~ 1.7 V (Coolant temperature is over 70°C)

Notice: If the measured value is not within the specified value, the possible cause may be in cable or MAF sensor in itself. Perform the 5 volt power supply inspection procedures.

Mass Air Flow Sensor 5 volt Power Supply Inspection

1. Turn the ignition switch to “OFF” position.
2. Disconnect the HFM sensor connector.
3. Turn the ignition switch to “ON” position.
4. Measure the voltage between the ECM pin No. 108 and MAF sensor connecter terminal No. 3.

Specified Value	4.7 ~ 5.2 V

Notice: If the measured value is not within the specified value, the possible cause may be in cableor ECM coupling.

5. Measure the voltage between the ECM pin No. 105 and MAF sensor connecter terminal No. 4.

Specified Value	4.7 ~ 5.2 V

Notice: If the measured value is not within the specified value, the possible cause may be in cableor ECM coupling.

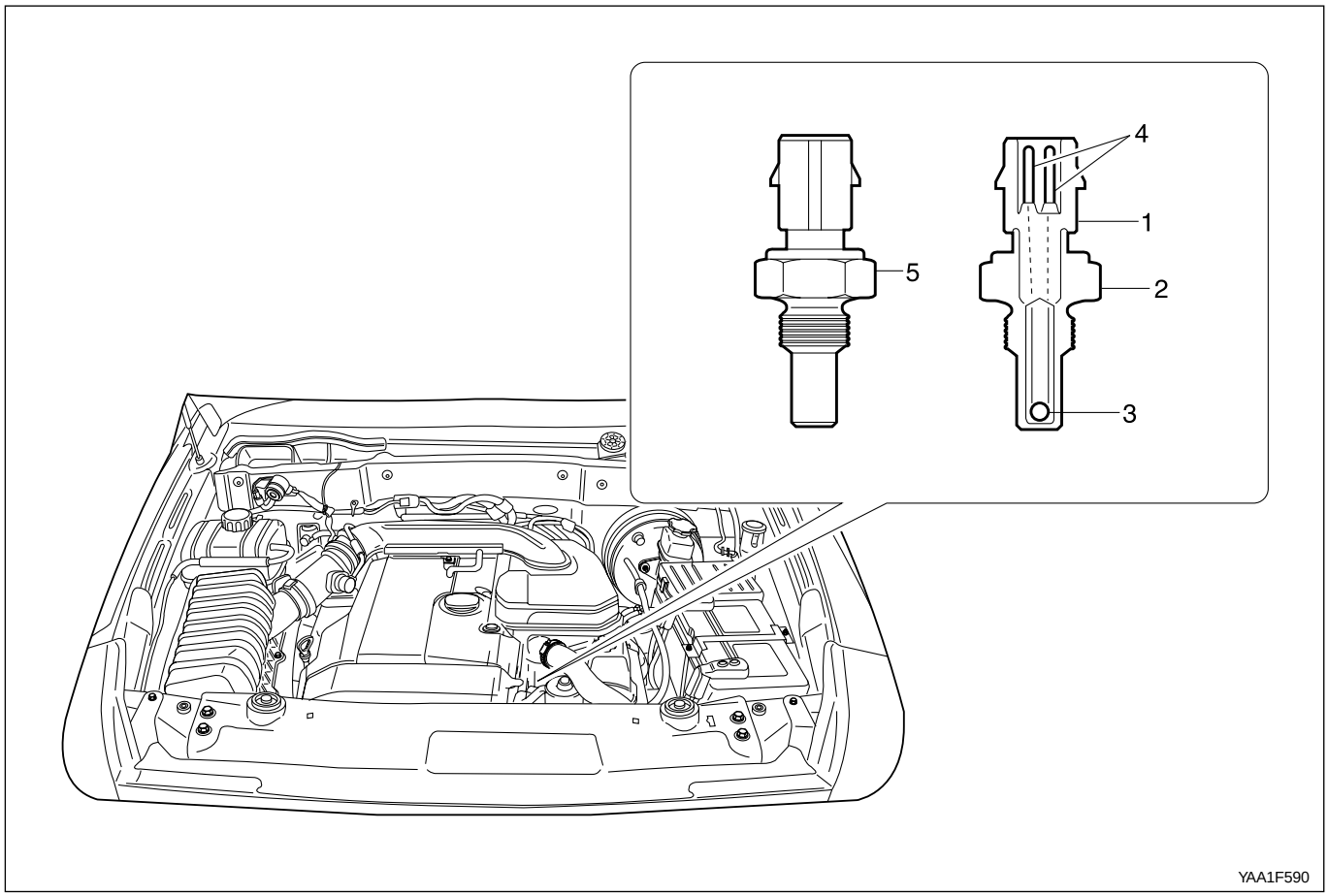
Mass Air Flow Sensor 12 volt Power Supply Inspection

1. Turn the ignition switch to “OFF” position.
2. Disconnect the HFM sensor connector.
3. Turn the ignition switch to “ON” position.
4. Measure the voltage between the ECM pin No. 105 and MAF sensor connecter terminal No. 2.

Specified Value	11 ~ 14 V

Notice: If the measured value is not within the specified value, the possible cause may be in cable or Over Voltage Protection Relay (OVPR).

ENGINE COOLANT TEMPERATURE (ECT) SENSOR



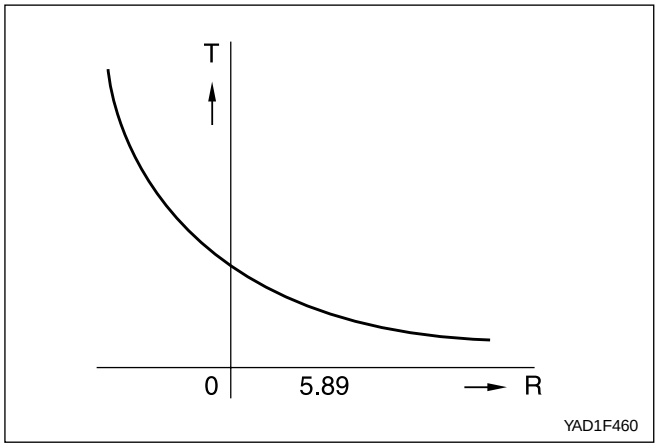
1 Artificial Resin Housing
2 Metal Housing
3 NTC (Negative Temperature Coefficient) Resistor
4 Connector
5 Engine Coolant Temperature Sensor

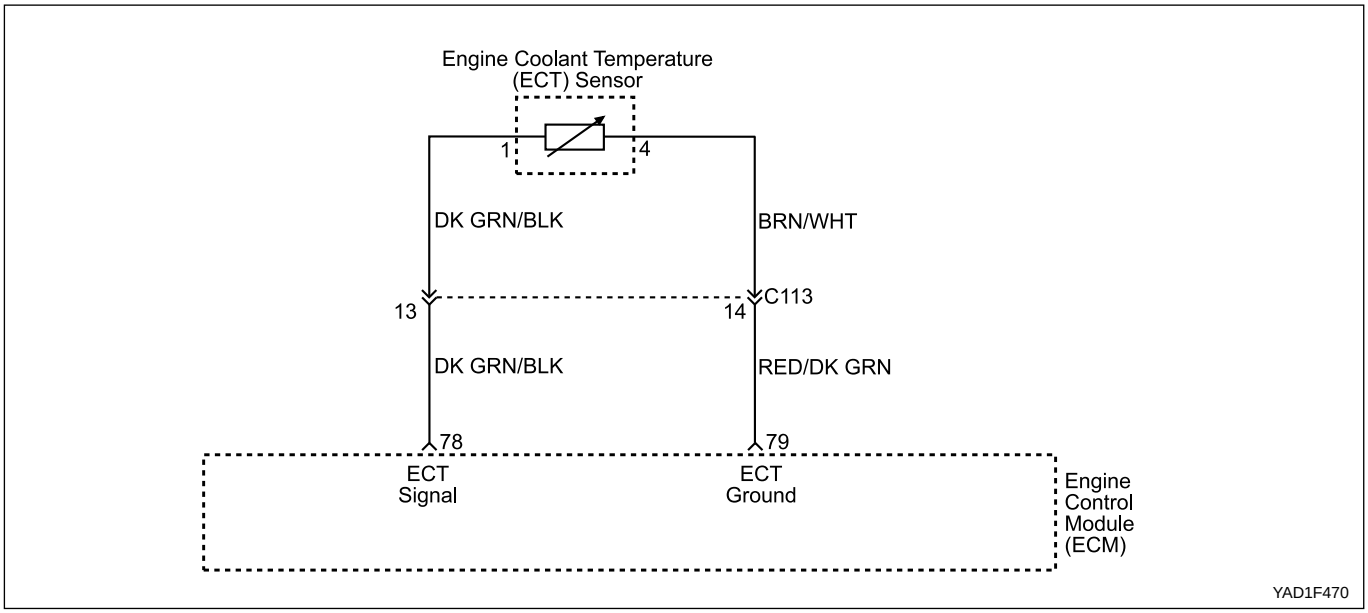
Engine Coolant Temperature (ECT) sensor detects coolant temperature and supplies information to the ECM. It is composed of metal housing with two NTC resistor, 4 pin connector. The ECM provides a 5 volt signal to the ECT sensor through a dropping resistor. When the engine is cold, the ECT sensor provides 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

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





Failure Code	Description	Trouble Area	Maintenance Hint
00	Engine coolant temperature sensor low voltage	ECT sensor short circuit to ground or open	• Monitoring the actual coolant temperature through scan t ool • Inspection the ECM pin 78, 79 about short circuit or open with bad contact • Inspection the ECT sensor • Inspection the ECM
01	Engine coolant temperature sensor high voltage	ECT sensor short circuit to power	
02	Engine coolant temperature sensor plausibility	Malfunction in recognition of ECT When drop to about 50° C below after warm up	
06	Engine coolant temperature insufficient for closed loop fuel control	Malfunction in recognition of ECT When minimum temperature for lambda control after warm up	

Circuit Description

The ECT sensor uses a thermistor to control the signal voltage to the ECM. The ECM supplies a voltage on the signal circuit to the sensor. When the engine coolant is cold, the resistance is high; therefore the ECT signal voltage will be high

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.

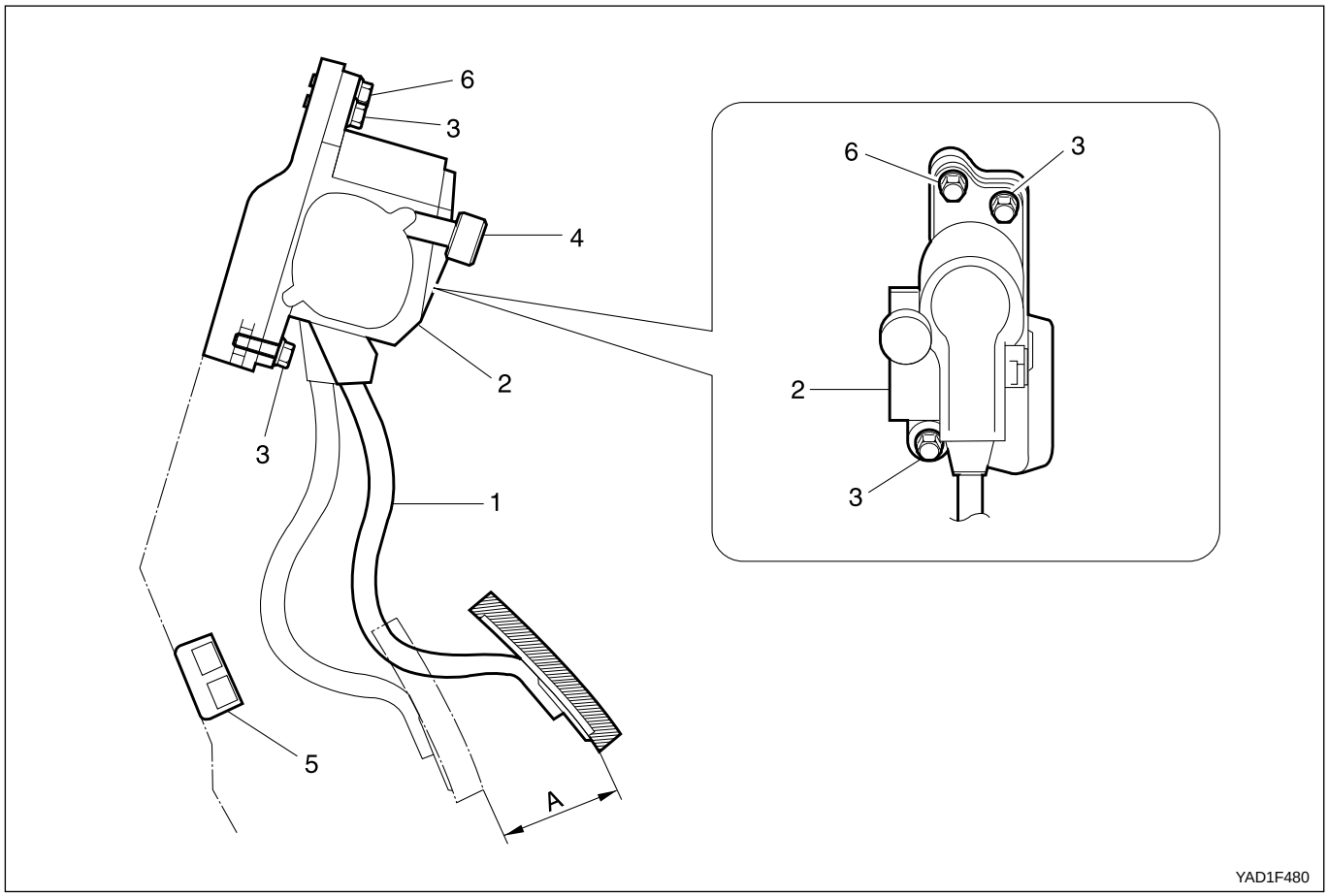
Temperature (°C)	Specified Value (V)
20	3.57
80	1.22
100	0.78

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

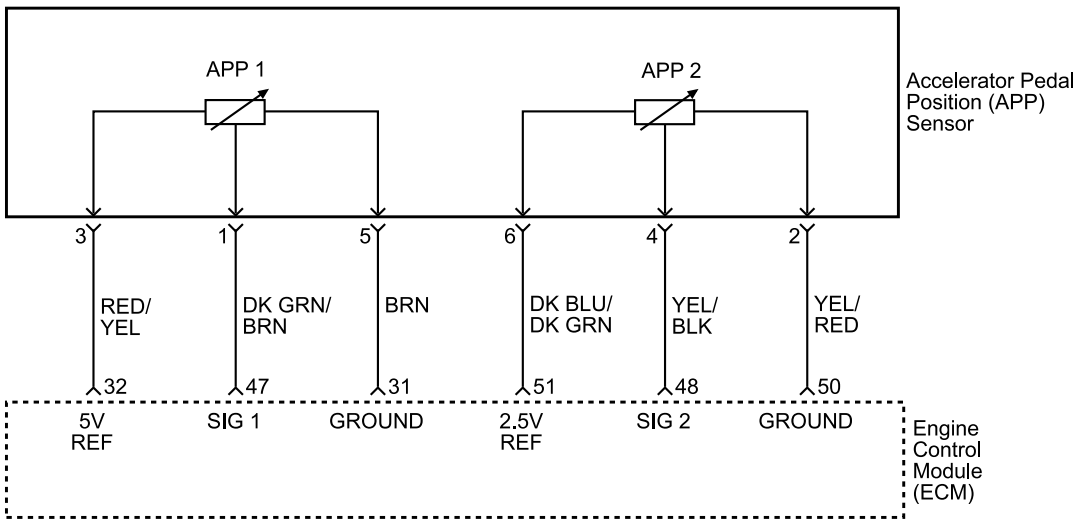
The Acceleration Pedal Position (APP) sensor is mounted on the accelerator pedal assembly. The sensor is actually two individual APP sensors and one housing. This sensor works with theThrottle Position (TP) sensor to provide input to the Engine Control Module (ECM) regarding driver requested accelerator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



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Failure Code	Description	Trouble Area	Maintenance Hint
122	Acceleration pedal position sensor signal failure	When malfunction of APP sensor	• Monitoring the actual values through scan tool • Inspection the ECM pin 31, 47, 32, 48, 59, 51 about short circuit or open with bad contact • Inspection the APP sensor • Inspection the ECM
160	Acceleration pedal position 1 sensor low voltage	APP 1 sensor short circuit to ground or open	
161	Acceleration pedal position sensor 1 high voltage	APP 1 sensor short circuit to power	
162	Acceleration pedal position sensor 2 low voltage	APP 2 sensor short circuit to ground or open	
163	Acceleration pedal position sensor 2 high voltage	APP 2 sensor short circuit to power	
164	Accelerator pedal position sensor 1 not plausible with accelerator pedal position sensor 2	When difference between APP 1 sensor and APP 2 sensor	
167	Both setpoint accelerator pedal position sensor defective	When defective of both APP sensor	

Circuit Description

The ECM supplies a 5 or 2.5 volt reference signal and a ground to the APP sensor 1 or 2. The ECM calculates on these signal lines. The APP sensor output changes as the accelerator pedal is moved. The output of the APP 1 and APP 2 sensor are low, about 0.4 ~ 0.7 volts and 0.2 ~ 0.35 volts respectively at the closed throttle position. As pushing the accelerator pedal, the output increases so that the output voltages will be about 4.3 ~ 4.8 volts and 2.1 ~ 2.4 volts individually when accelerating fully with the kick down, at Wide Open Throttle (WOT).

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.

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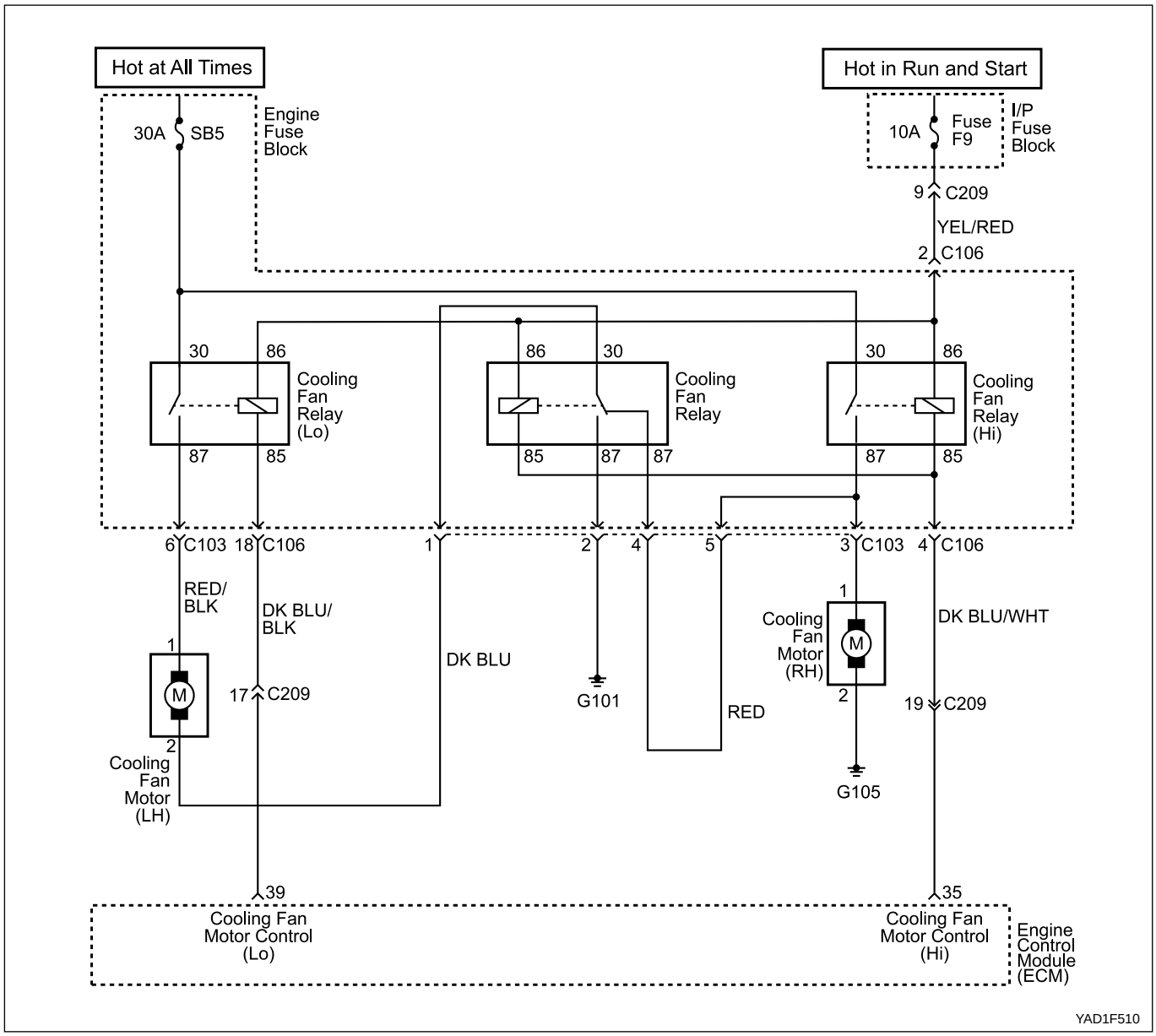
COOLING FAN



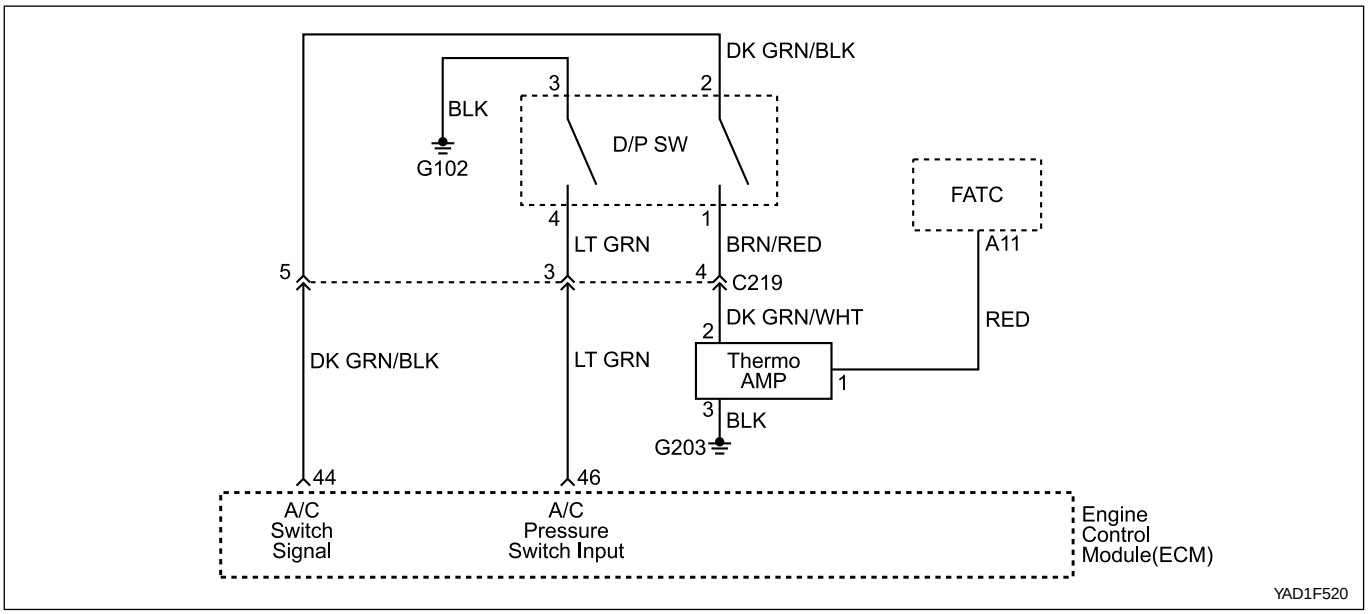
Failure Code	Description	Trouble Area	Maintenance Hint
44	Cooling fan (HI) relay short circuit to power	Cooling fan short circuit to power	• Inspection the Engine Control Module (ECM) pin 35 about short circuit or open with bad contact • Inspection the power source • Inspection the cooling fan • Inspection the ECM
45	Cooling fan (HI) relay short circuit to ground or open	Cooling fan short circuit to ground or open	

Circuit Description

Ignition voltage is supplied directly to the cooling fan relay coil. The ECM controls the relay by grounding the control circuit. When the ECM is commanding a command ON, the voltage of the control circuit should be low (near 0 volt).

When the ECM is commanding the control circuit should be high (near battery voltage). If the fault detection circuit senses a voltage other than what is expected, the fault line status will change causing the fault code to set.

A/C COMPRESSOR RELAY

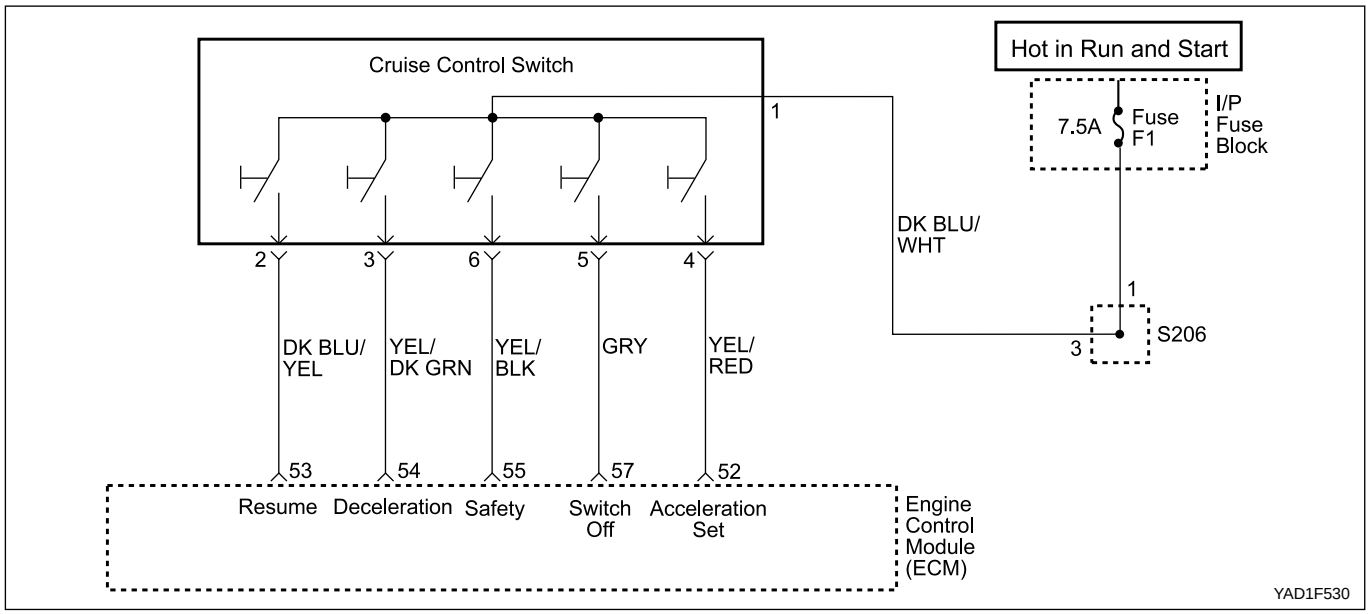


Failure Code	Description	Trouble Area	Maintenance Hint
228	A/C compressor relay short circuit to battery	When malfunction of A/C compressor control	• Monitoring the actual operation through scan tool • Inspection the Engine Control Module (ECM) pin 44 about short circuit or open with bad contact • Inspection the relay short circuit or open • Inspection the ECM
229	A/c compressor relay short circuit to ground or open		

Circuit Description

When the ECM detects that A/C has been requested, the ECM will activated the A/C clutch relay. When the relay has been activated, voltage should be present at both the A/C clutch relay and A/C switch circuit at ECM.

CRUISE CONTROL SWITCH

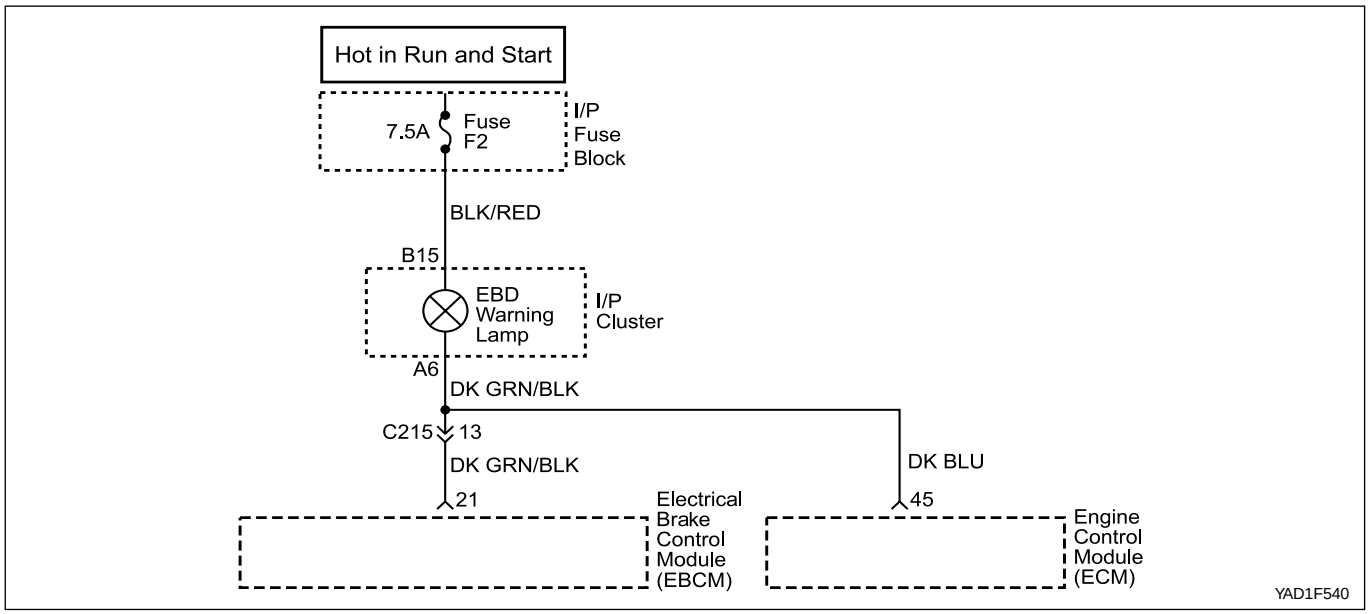


Failure Code	Description	Trouble Area	Maintenance Hint
129	Cruise control “OFF” due to message counter failure	Cruise control system message counter fault	• Monitoring the actual recognition status and vehicle speed signal through scan tool • Inspection the Engine Control Module (ECM) pin 52, 53, 54, 55, 57 about short circuit or open with bad contact • Inspection the CAN and ABS • Inspection the cruise control lever switch • Inspection the ECM
130	Vehicle speed signal failure	When malfunction of auto-cruise system Implausible condition of vehicle speed signal.	
131	Vehicle speed signal failure		
132	Cruise control lever failure	Cruise control lever defective	
133	Cruise control acceleration failure	Cruise control system Implausible condition of acceleration signal	
134	Cruise control deceleration failure	Cruise control system Implausible condition of deceleration signal	

Circuit Description

Cruise control is an automatic speed control system that maintain adesired driving speed with out using the accelerator pedal. The vehicle speed must be greater than 40 km/h to engage cruise control.

TRACTION CONTROL SYSTEM (TCS)

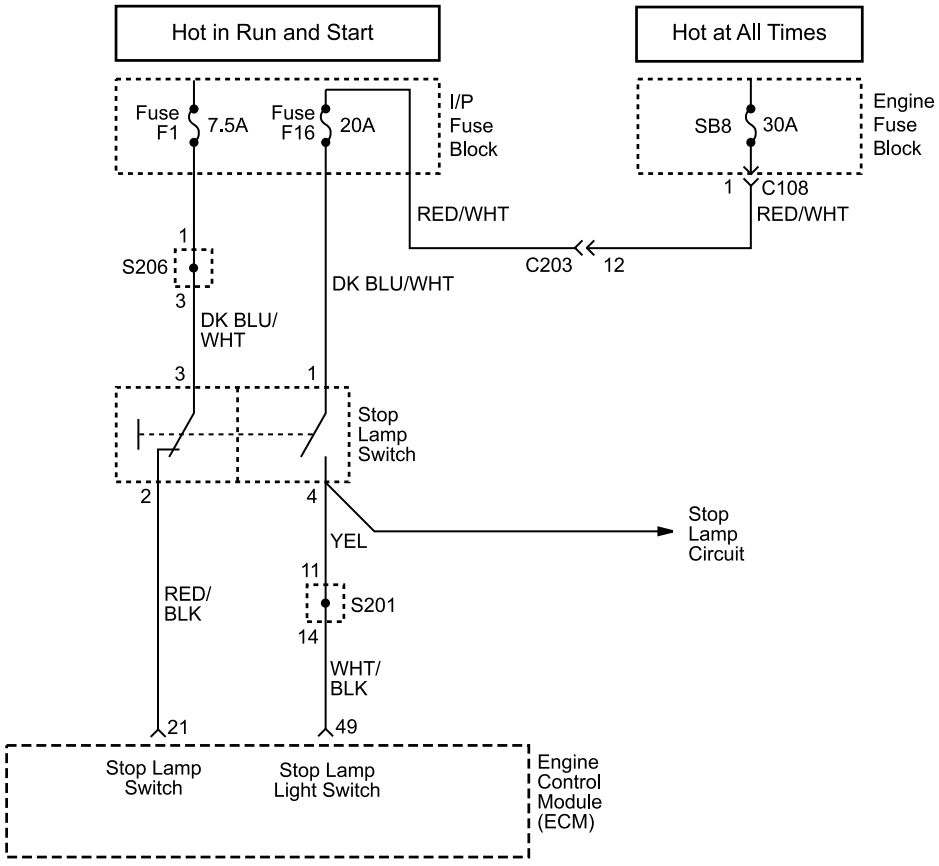


Failure Code	Description	Trouble Area	Maintenance Hint
150	TCS input signal short circuit to battery	TCS short circuit to power	• Inspection the Engine Control Module (ECM) pin 45 about short circuit or open with bad contact • Inspection the TCS lamp of I/P cluster. • Inspection the ECM
151	TCS input signal short circuit to ground or open	TCS short circuit to ground or open	

Circuit Description

Battery voltage is supplied to the TCS warning lamp with the ignition in ON and START. The warning lamp can be activated only by the Electrical Brake Control Module (EBCM) internally supplying ground to terminal 21. If the TCS input circuit is open or short, this failure code will be set.

STOP LAMP SWITCH

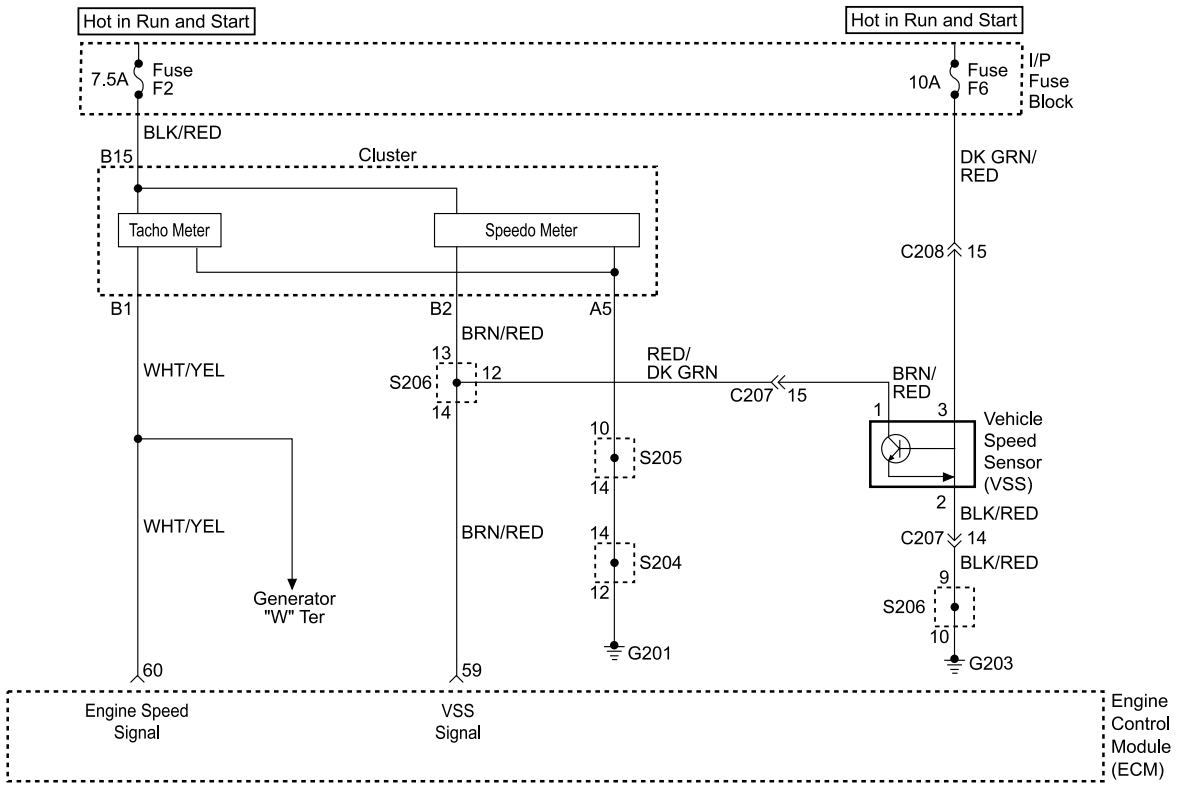


Failure Code	Description	Trouble Area	Maintenance Hint
135	Stop lamp switch failure	When malfunction of stop lamp switch-implausible condition of stop lamp signal input	• Monitoring the actual operational status and vehicle speed signal through scan tool • Inspection the Engine Control Module (ECM) pin 49 about short circuit or open with bad contact • Inspection the contact condition of stop lamp switch • Inspection the ECM

Circuit Description

The stop lamp switch is normally opened. When the ignition switch ON and brake ON, the battery voltage is supplied to the ECM. A scan tool should display ON when brake pedal is depressed and should read OFF with brake pedal released.

ENGINE RPM



Failure Code	Description	Trouble Area	Maintenance Hint
32	Engine rpm output circuit short circuit to battery	When short circuit to battery	• Monitoring the actual rpm in cluster • Inspection the Engine Control Module (ECM) pin 60 about short circuit or open • Inspection the cluster panel board circuit • Inspection the ECM
33	Engine rpm output circuit short circuit to ground or open	When short circuit to ground or open	

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.

$CO + O_2 \rightarrow CO_2$

$HC + O_2 \rightarrow CO_2 + H_2O$

$NO_x \rightarrow N_2 + O_2$

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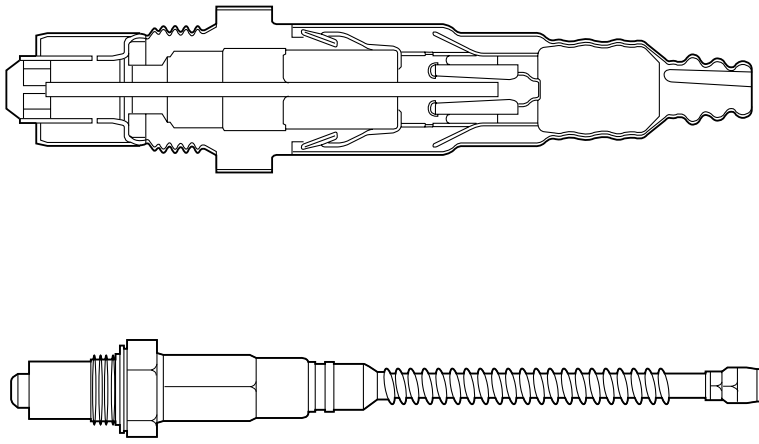
OXYGEN SENSOR



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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).

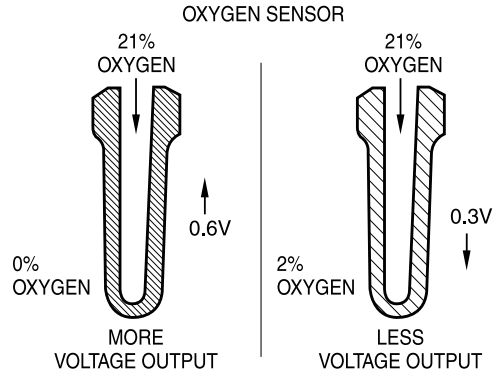
The electrically heated oxygen sensor warms up quickly and remains hot, even at idle when the exhaust manifold may cool down.

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



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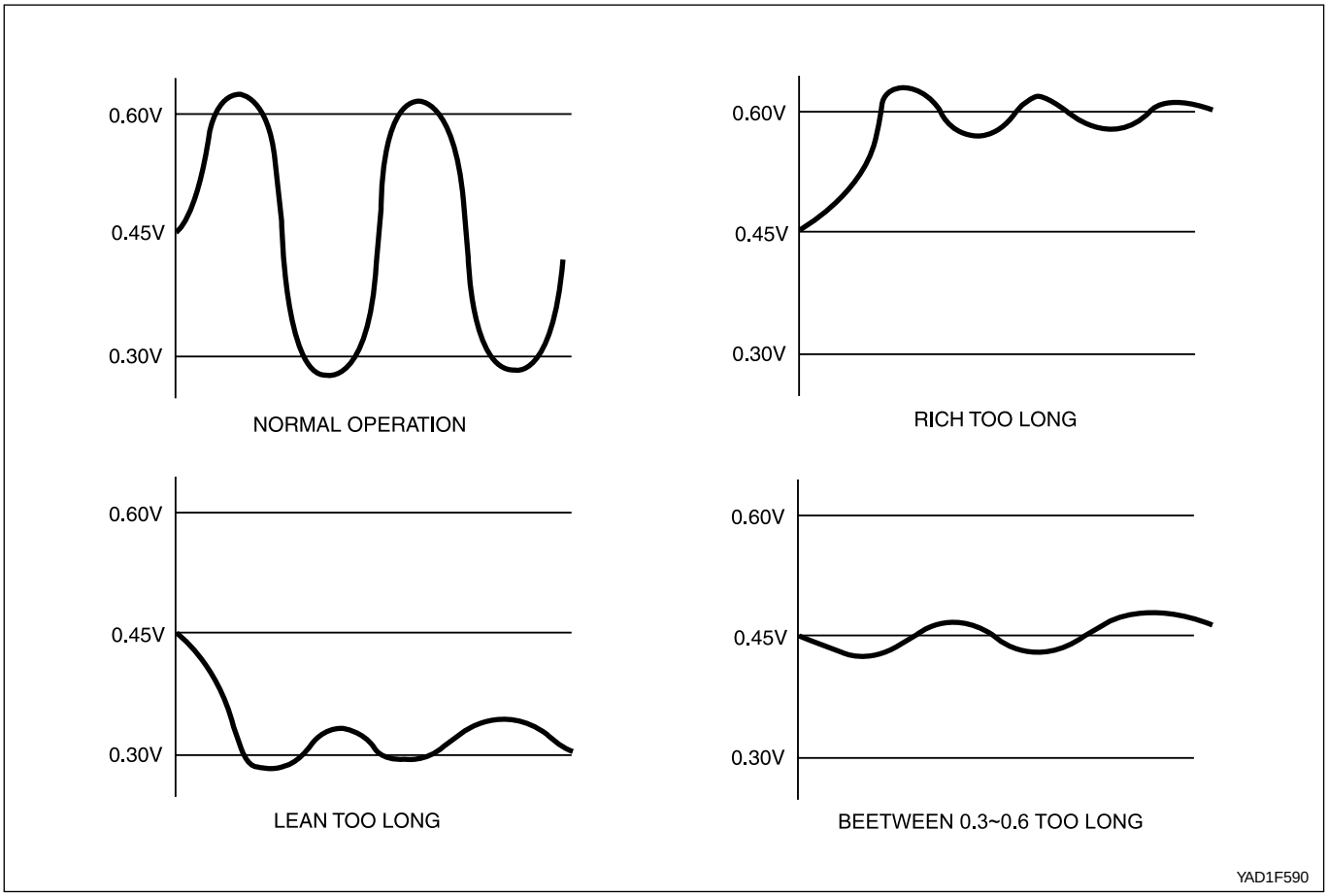
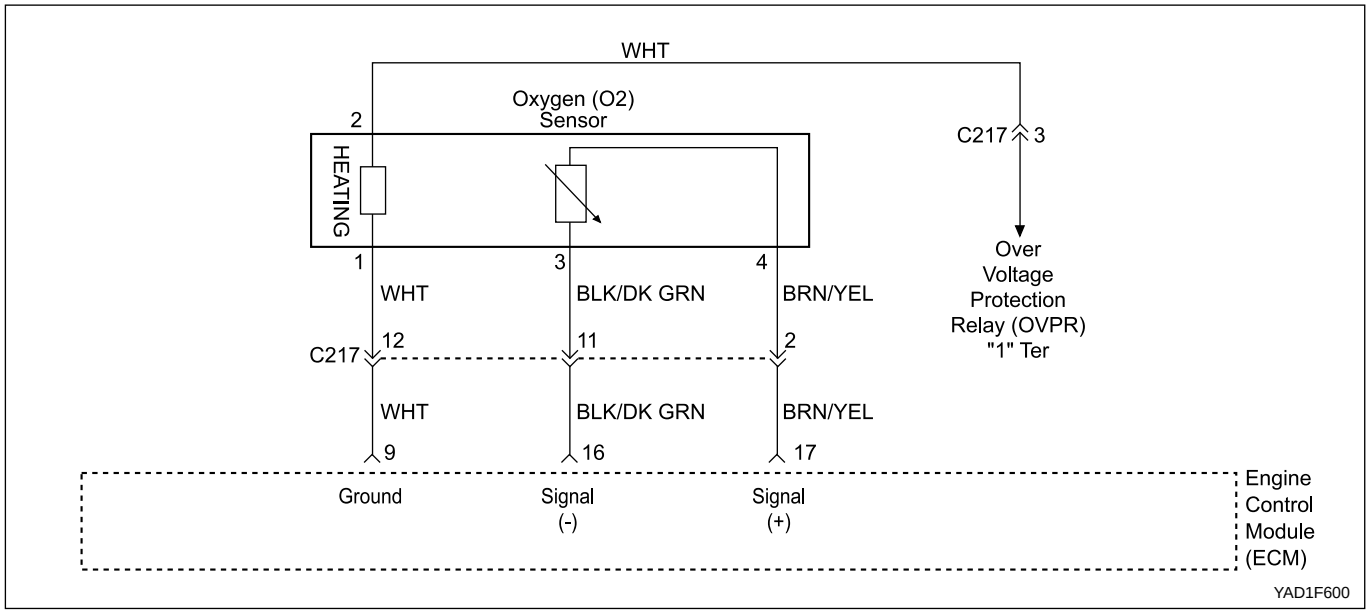

0.60V
0.45V
0.30V
NORMAL OPERATION
0.60V
0.45V
0.30V
RICH TOO LONG
0.60V
0.45V
0.30V
LEAN TOO LONG
0.60V
0.45V
0.30V
BEETWEEN 0.3~0.6 TOO LONG
YAD1F590



Failure Code	Description	Trouble Area	Maintenance Hint
80	Oxygen sensor high voltage	When recognition the output that more than nominal threshold, malfunction of sensing voltage.	• Monitoring the actual output signal through scan tool • Inspection the ECM pin 16, 17 about short circuit or open with bad contact • Inspection the oxygen sensor • Inspection the ECM
89	Oxygen sensor low voltage	When recognition the output that more than nominal threshold, malfunction of sensing voltage.	
82	Oxygen sensor no activity detected	When recognition the output that not active the sensor etc.	
83	Oxygen sensor not lean after overrun fuel shut-off	When recognition the output that no lean signal after overrun fuel shut-off	
84	Oxygen sensor slow response	When slow response of sensor signal	
85	Oxygen sensor heater failure	When recognition the heating circuit	• Monitoring the heating status through scan tool • Inspection the ECM pin 9 about short circuit or open with bad contact • Inspection the heating power source • Inspection the heating circuit of oxygen sensor • Inspection the ECM
86	Oxygen sensor heater short circuit to battery	When recognition the heating currents that more or less than set values (less than 0.2 A or more than 2 A)	
87	Oxygen sensor heater short circuit to ground or open	When recognition the heating voltages than less than set values (less than 2 v)	

Failure Code	Description	Trouble Area	Maintenance Hint
81	Bank 1 system short term fuel trim adaptation below lean threshold	When recognition the value less than nominal control threshold, it means that when big deviation in control range of adaptation values through fuel and air mixture formation	• Inspection the intake air leakage • Inspection the injection quantities with injector block or leakage • Inspection the exhaust leakage • Inspection the ECM
93	Bank 1 system short term fuel trim adaptation above rich threshold	When recognition the value more than nominal control threshold, it means that when big deviation in control range of adaptation values through fuel and air mixture formation	
96	Bank 1 system short term fuel trim at rich stop	When recognition the short term fuel trim that more than nominal threshold	
97	Bank 1 system short term fuel trim at lean stop	When recognition the short term fuel trim that less than nominal threshold	
98	Bank 1 system idle adaptationfailure (above rich threshold)	When recognition the long term fuel trim exceeds rich threshold	
99	Bank 1 system idle adaptation failure (below rich threshold)	When recognition the long term fuel trim exceeds lean threshold	
100	Bank 1 system learning control failure (rich, low load)	When recognition the long term fuel trim exceeds rich threshold	
101	Bank 1 system learning control failure (lean, low load)	When recognition the long term fuel trim exceeds lean threshold	
102	Bank 1 system learning control failure (rich, high load)	When recognition the long term fuel trim exceeds rich threshold	
103	Bank 1 system learning control failure (rich, low load)	When recognition the long term fuel trim exceeds lean threshold	

Circuit Description

In order to control emissions, a catalytic converter is used to covert harmful emissions into harmless water vapor and carbon dioxide. The ECM has the ability to monitor this process by using a oxygen sensor. The oxygen sensor produces and output signal which indicates the storage capacity of the catalyst. This in turn indicates the catalyst's ability to convert exhaust emission effectively. If the oxygen sensor pigtail wiring, connector, or terminal is damaged. Do not attempt to repair the wiring, connector, or terminals. In order for the sensor to function properly, it must have a clean air reference provided to it. This clean air reference is obtained by way of the oxygen sensor wire(s). Any attempt to repair the wires, connector, or terminal and degrade the oxygen sensor performance.

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.

Specified Value	0.2 ~ 1.0 V

Notice: If the measured value is not within the specified value, the possible causemay bein cable, oxygen sensor or ECM

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.

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.

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

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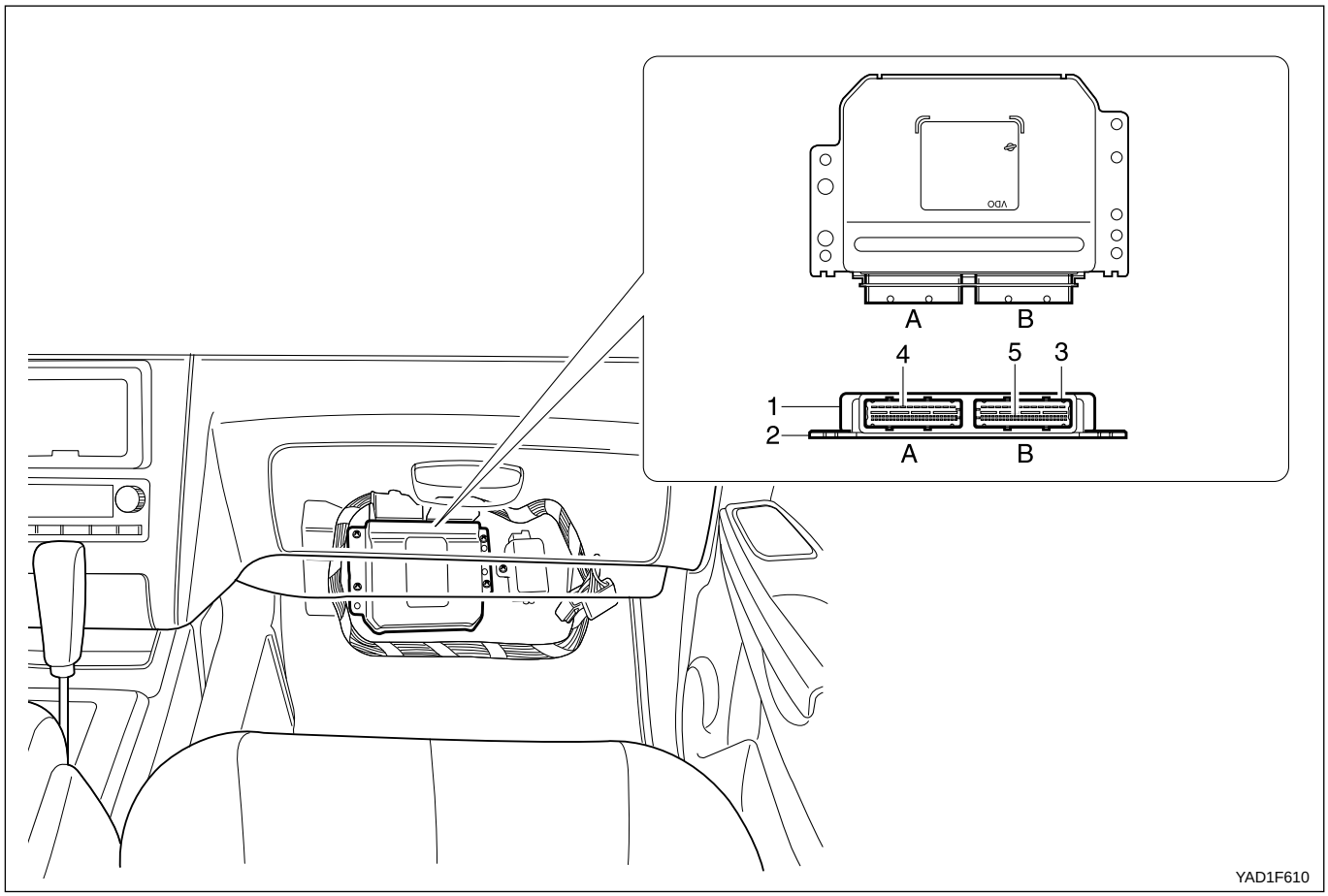
ENGINE CONTROL MODULE



1 Cover
2 Plate
3 Connector
4 Plat Pin
Vehicle Side : No. 1-12
Engine Side : No. 61-72
5 Pin
Vehicle Side : No. 13-60
Engine Side : No. 73-120
A Vehicle Side Connector : Black
B Engine Side Connector : Gray

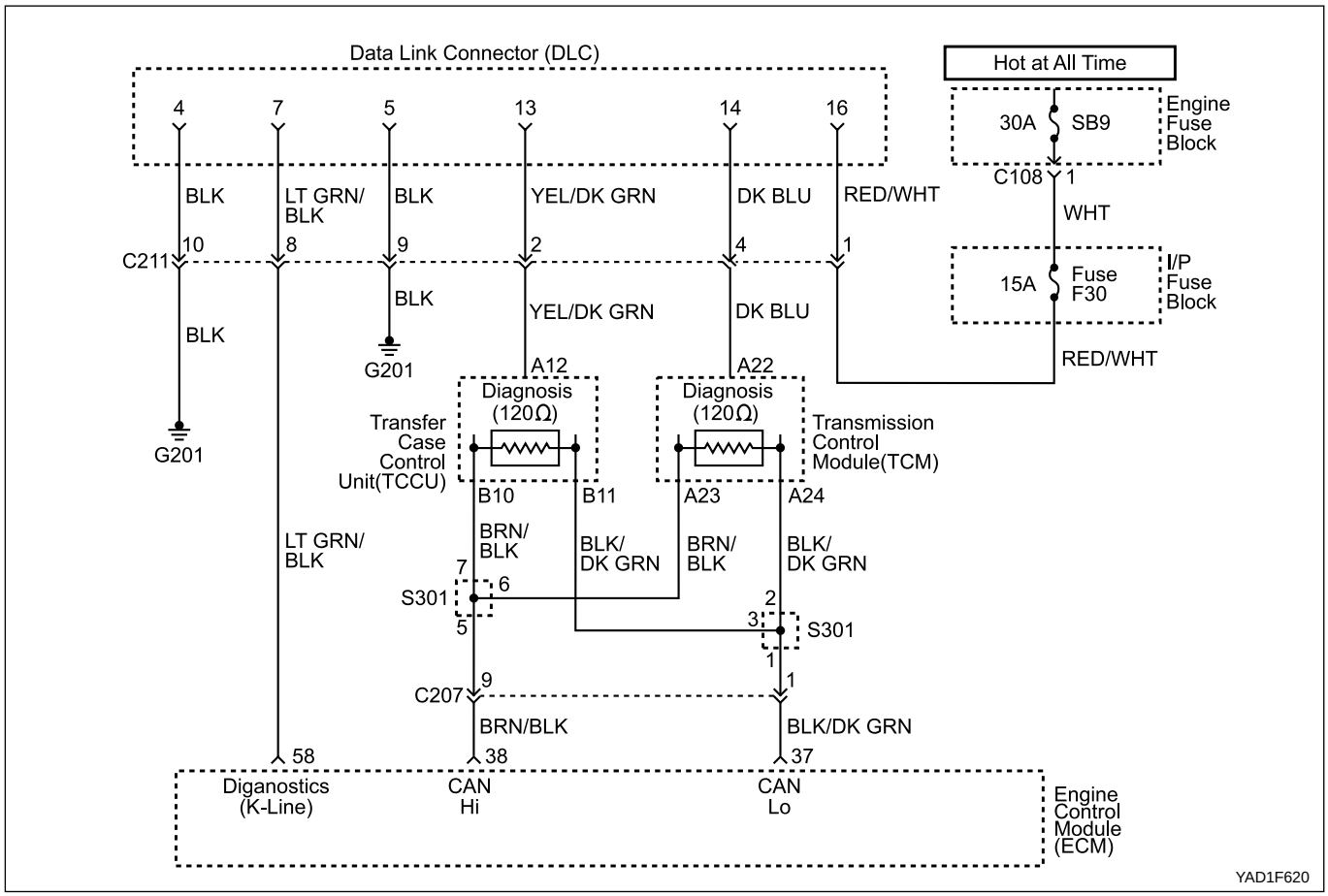
The Engine Control Module (ECM), located inside the right side kick panel, is the control center of the fuel injection system. It constantly looks at the information fromvarious sensors and controls the systems that affect the vehicle's performance. Engine rpm and air mass are used to measure the air 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.

BLANK

SERIAL DATA COMMUNICATION



Failure Code	Description	Trouble Area	Maintenance Hint
23	CAN communication failure: ASR/MSR	When CAN signal message missing or implausibility for ASR/MSR unit or not initialized condition	• Inspection the ASR unit with CAN connection • Inspection the Engine Control Module (ECM) pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
24	CAN communication failure: ABS	When CAN signal message missing or implausibility for ABS unit or not initialized condition	• Inspection the ABS unit with CAN connection • Inspection the ECM pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
26	CAN communication failure: TCU (A/T only)	When CAN signal message missing or implausibility for TCU unit or not initialized condition	• Inspection the TCM unit with CAN connection • Inspection the ECM pin 38, 37 about short circuit or open with bad contact • Inspection the ECM

Failure Code	Description	Trouble Area	Maintenance Hint
29	CAN communication failure: ID 200h not plausible	When CAN signal message missing or implausibility for ABS/ABD unit or not initialized condition	• Inspection the ABS/ABD unit with CAN connection • Inspection the ECM pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
30	CAN communication failure: ID 208h not plausible	When CAN signal message missing or implausibility for ABS/ABD unit or not initialized condition	• Inspection the ABS/ABD unit with CAN connection • Inspection the ECM pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
31	CAN communication failure: communication initialization failure	When CAN signal message missing or implausibility for each unit (ABS, ASR, TCM, TOD etc.) or not initialized condition	• Inspection the each control unit with CAN connection • Inspection the ECM pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
59	CAN communication failure: MSR data transmission not plausible	When CAN signal message missing or implausibility for MSR unit or not initialized condition	• Inspection the MSR unit with CAN connection • Inspection the Engine Control Module (ECM) pin 38, 37 about short circuit or open with bad contact • Inspection the ECM
60	CAN communication failure: ASR data transmission not plausible	When CAN signal message missing or implausibility for ASR unit or not initialized condition	• Inspection the ASR unit with CAN connection • Inspection the Engine Control Module (ECM) pin 38, 37 about short circuit or open with bad contact • Inspection the ECM

Circuit Description

The provision for communicating with the ECM is the Data Link Connector (DLC). It is located in the instrument panel fuse block. The DLC is used to connect the scan tool. Battery power and ground is supplied for the scan tool through the DLC. CAN line is used to communicate with the other module such as the Transmission Control Module (TCM) and Transfer Case Control Unit (TCCU).

Keyword 2000 Serial Data Communications

Each bit of information can have one of two lengths: long or short. This allows vehicle wiring to be reduced by transmitting and receiving multiple signals over a singles wire. The message carried on KWP 2000 data streams are also prioritized. If two messages attempt to establish communications on the data line at the same time, only the message with higher priority will must wait.

INTERNAL FAILURE

Failure Code	Description	Trouble Area	Maintenance Hint
21	Transmission coding failure	When faulty of variant coding of transmission	• Inspection the coding condition through scan tool • InspectiontheEngine ControlModule (ECM) • Inspection the CAN line • Inspection the TCM
136	ECM failure (RAM)	When malfunction of random access memory - ECM internal error	• Inspection the ECM
142	Uncoded/ unprogramed ECM	When malfunction of ECM coding-required ECM encoding	• Fulfill the ECM variant coding
137	ECM failure (EPROM)	When malfunction of ECM internal	• Inspection the ECM
143	ECM failure (EEPROM/ Flash-EPPOM checksum failure)		
144	ECM failure (coding ID checksum failure)		
145	ECM failure (coding checksum failure)		
146	ECM failure (program-ming checksum failure)		

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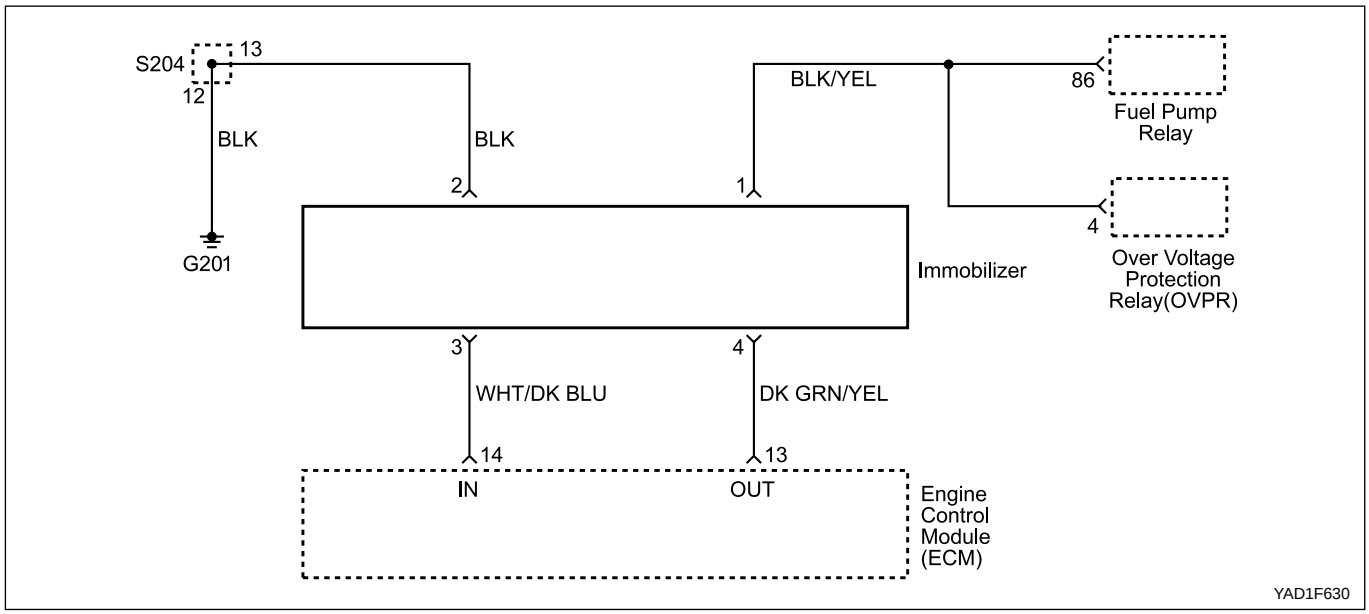
ELECTRONIC THROTTLE CONTROLLER SAFETY MALFUNCTION

Failure Code	Description	Trouble Area	Maintenance Hint
110	Throttle actuator learning data fault	System internal failure	• Inspection the Engine Control Module (ECM)
117	Exceed fuel-cut safety time		
120	Cruise control interruption memory failure		
138	Call Monitoring		
139	Servo motor control output interruption memory failure		
140	Servo motor open/short		
186	ECM failure (incompatible CPU)		
187	ECM failure (CPUs communication failure)		
188	ECM failure (CPU 2 configuration failure)		
189	ECM failure (CPU 2 fault)		
190	ECM failure (CPU run time failure between CPUs)		
231	ECM failure (CPU 2 cruise control message counter failure)		
232	Over deceleration limit (CPU 2)		
233	Over acceleration limit (CPU 2)		
234	Cruise control lever dual operation (CPU 2)		
235	Cruise control lever safety terminal failure (CPU 2)		
236	Unusual pedal position variation (CPU 2)		
237	Unusual throttle position variation (CPU 2)		
238	Unusual throttle controller monitoring data comparison fault (CPU 2)		

Failure Code	Description	Trouble Area	Maintenance Hint
239	Unusual accelerator pedal position sensor comparison fault (CPU 2)	System internal failure	• Inspection the Engine Control Module (ECM)
240	Throttle potentiometer comparison fault (CPU 2)		
241	Unusual CPU communication (CPU 2)		
242	Unusual CPU configuration (CPU 2)		
243	A/D converter failure (CPU 2)		
244	Accelerator pedal position sensor setpoint fault between CPU 1 and CPU 2		
245	Position controller setpoint fault between CPU 1 and CPU 2		
246	MSR setpoint fault between CPU 1 and CPU 2		
247	Idle control setpoint fault between CPU 1 and CPU 2		
248	A/D converter overflow (CPU 2)		
249	ROM fault (CPU 2)		
250	RAM fault (CPU 2)		
251	Cycle monitor fault (CPU 2)		

IMMOBILIZER



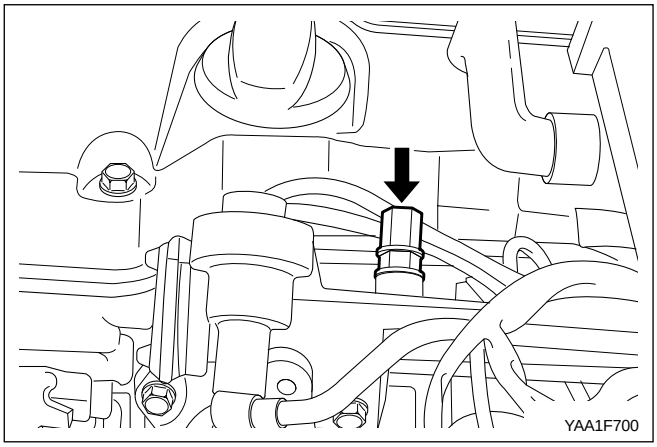
Failure Code	Description	Trouble Area	Maintenance Hint
25	Communication with transponder missing	When missing the transponder signal	• Inspection the Engine Control Module (ECM) pin 13, 14 about short circuit or open with bad contact • Inspection the power source or ground short circuit or open of immobilizer unit • Inspection the transponder condition (broken etc.) • Inspection the ECM
141	Unprogramed ECM with immobilizer	When malfunction of immobilizer Required immobilizer encoding, no paired condition of immobilizer even through start trial	• Fulfill the immobilizer pairing

Circuit Description

Immobilizer is a device disabling vehicle ignition unless a specific key is used and designed to help prevent vehicle theft.

Immobilizer is comprised of two devices, a key with encoded transponder and ECM with the same encoding of the transponder. When a key is inserted into the hole to start vehicle and turned to ON, the ECM reads and decodes the transponder code and, if the same, starts the engine, it is called immobilizer. It means immobilizer system disables starting by stopping fuel supply if the code in the transponder does not match the code stored in ECM each other.

MAINTENANCE AND REPAIR



ON-VEHICLE SERVICE

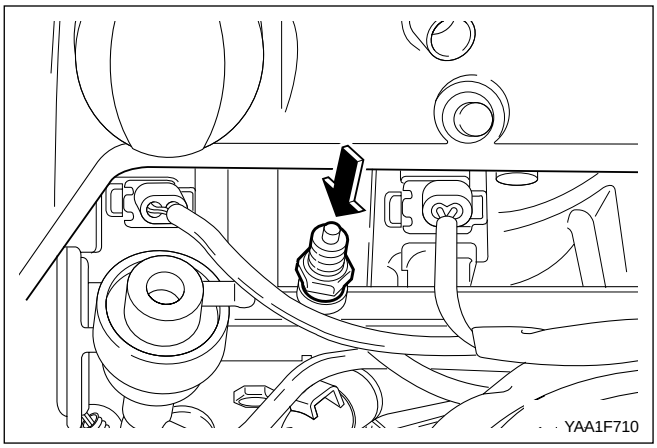
DISCHARGING THE PRESSURE IN FUEL SYSTEM

Removal and Installation Procedure

1. Remove the fuel pressure test connector.

   Installation Notice

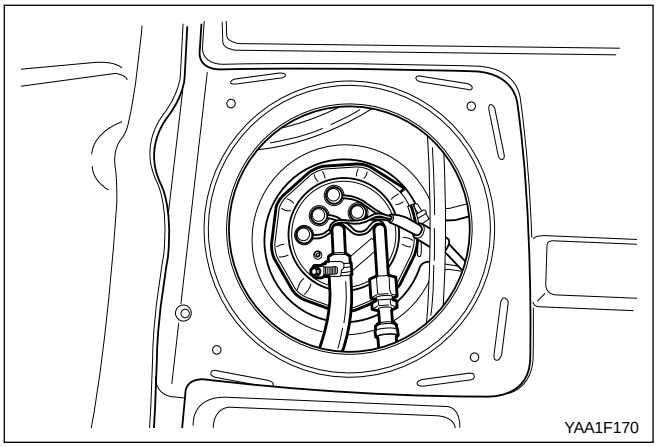
Tightening Torque	25 N•m (18 lb-ft)



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

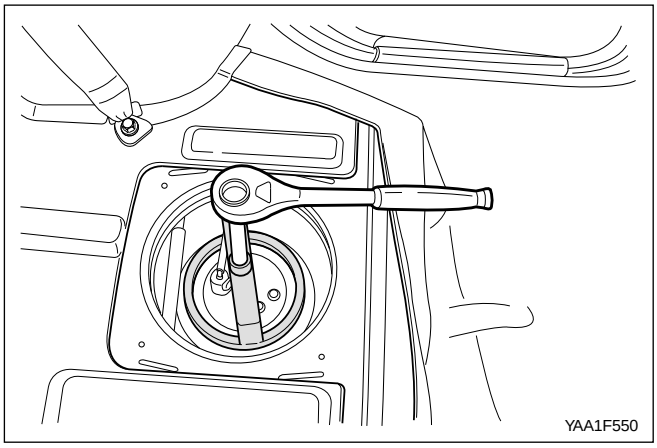
Tools Required

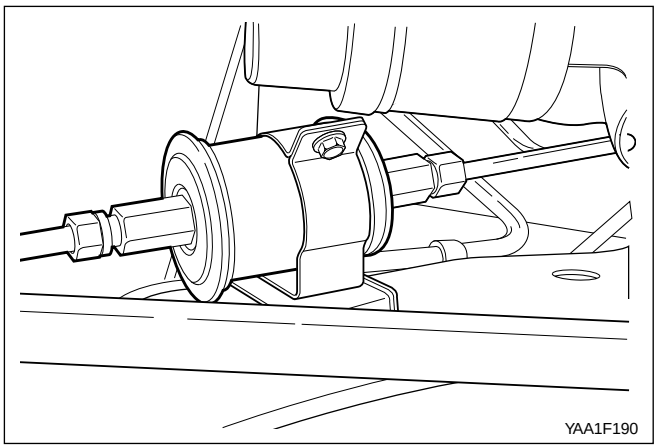
661 589 00 46 00 Fuel Tank Cap Wrench

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.


YAA1F550


YAA1F190

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.

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.

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

   Installation Notice

Tightening Torque	28 N•m (21 lb-ft)

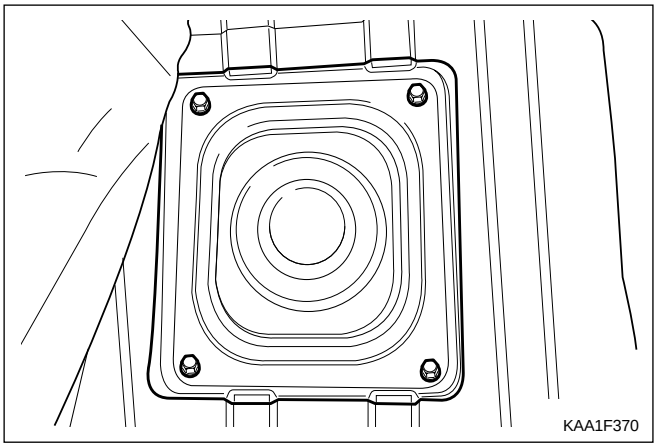
4. Remove the fuel filter mounting bracket bolt .

   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.

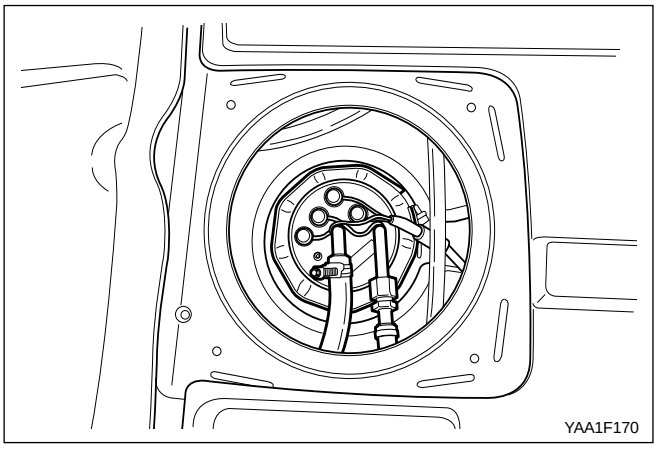

KAA1F370

FUEL TANK

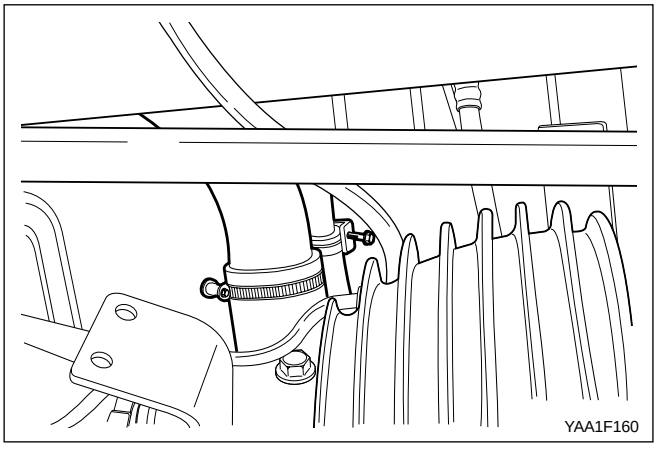
Removal and Installation Procedure

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.


YAA1F170

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.

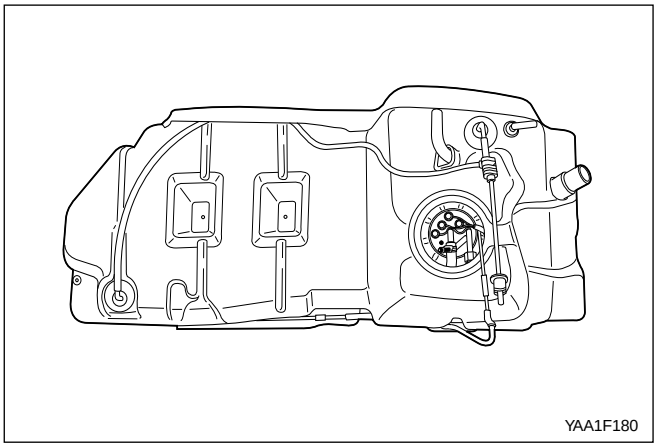

YAA1F160

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

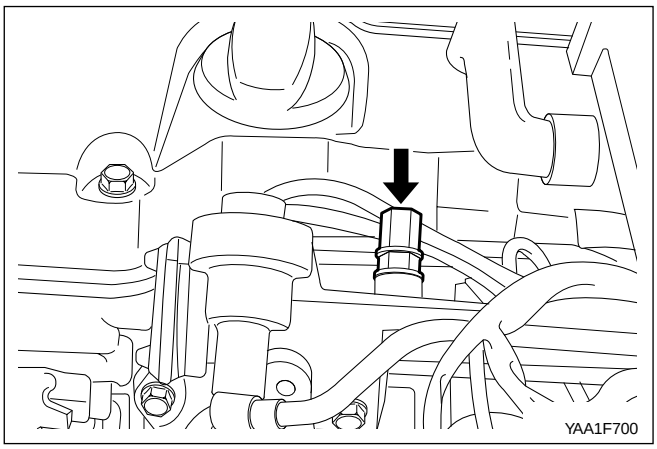
Installation Notice

Tightening Torque	38 N•m (28 lb-ft)

13. Carefully lower the fuel tank.


YAA1F180

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.


YAA1F700

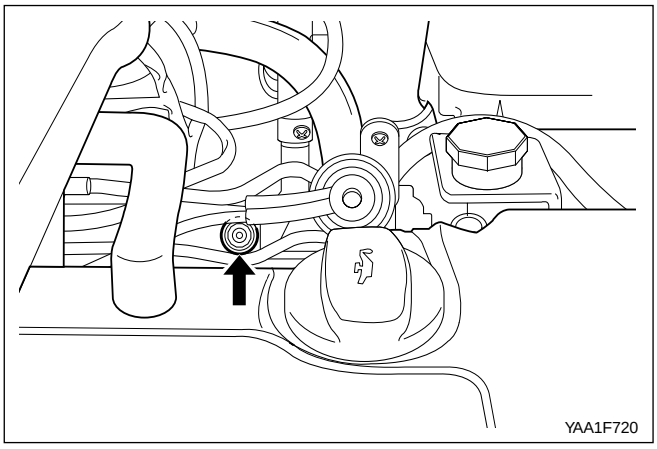
FUEL PRESSURE REGULATOR

Removal and Installation Procedure

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

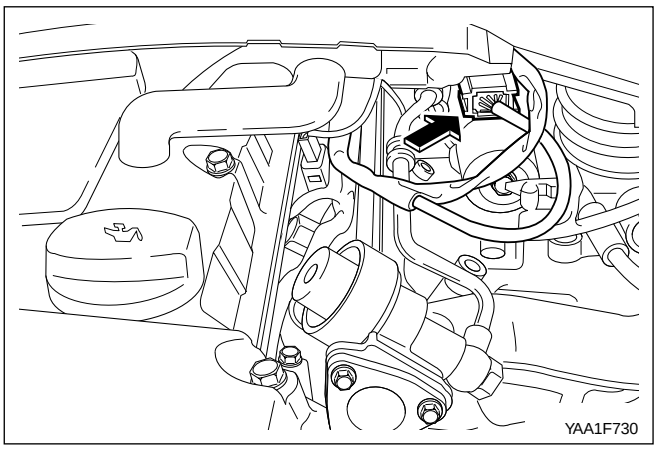
Installation Notice

Tightening Torque	25 N•m (18 lb-ft)

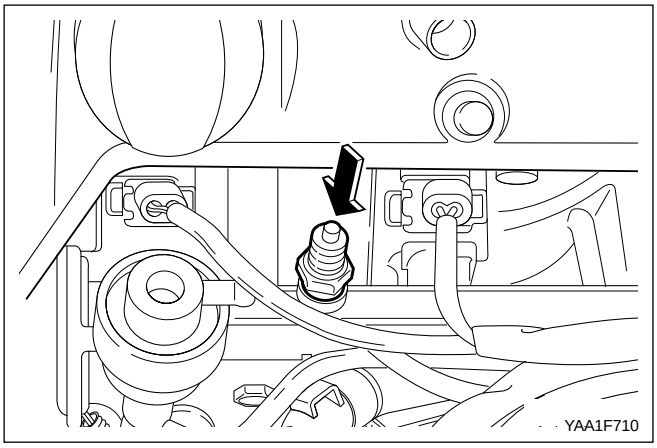

YAA1F720

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.

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


YAA1F730

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.

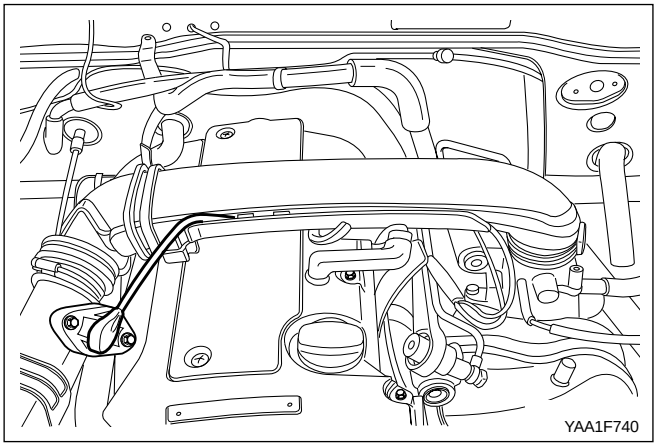


FUEL RAIL AND INJECTORS

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.

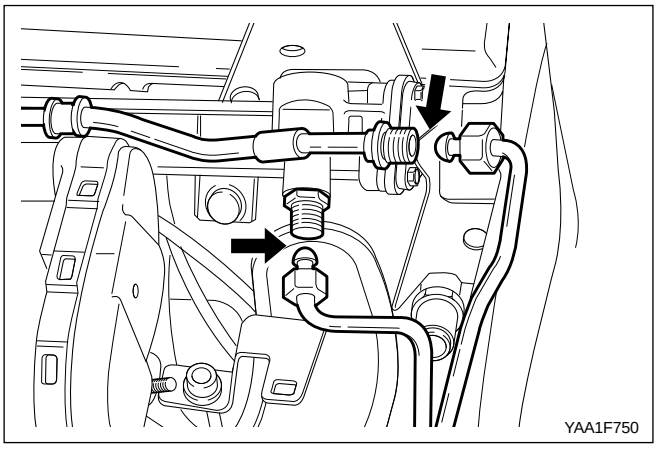


4. Remove the cable guide.
5. Disconnect the Hot Film Air Mass (HFM) sensor connector.
6. Remove the intake air duct mounting bolts.

Installation Notice

Tightening Torque	9 N•m (80 lb-in)

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



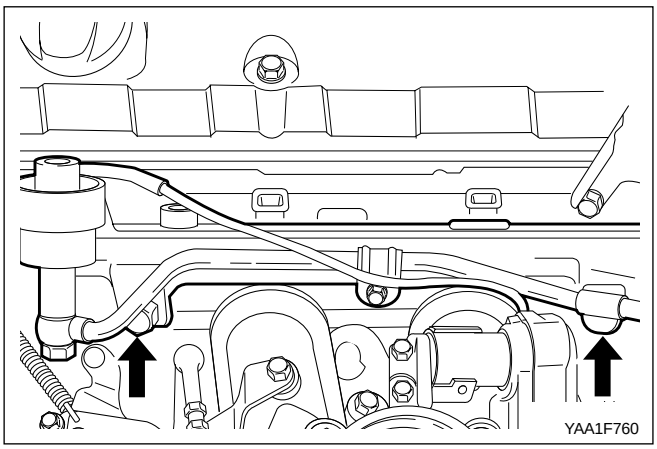
9. Remove the fuel return and supply line.

   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)

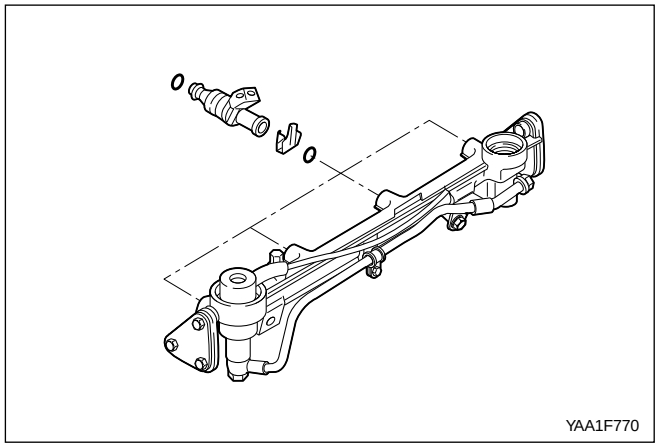
10. Remove the six injector connectors.



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

Installation Notice

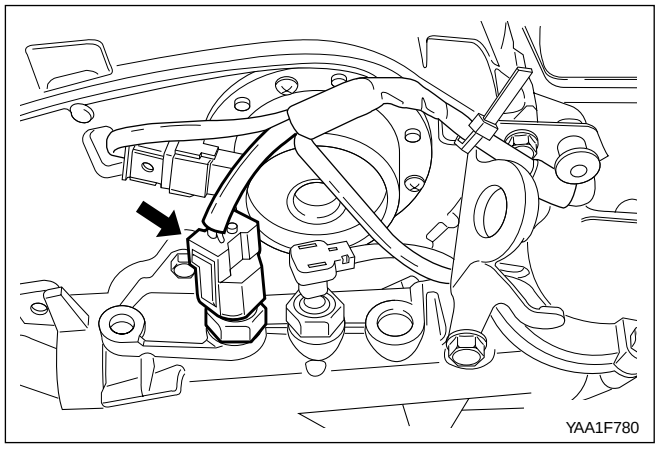
Tightening Torque	25 N•m (18 lb-ft)


YAA1F770

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.

Important: 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.


YAA1F780

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.

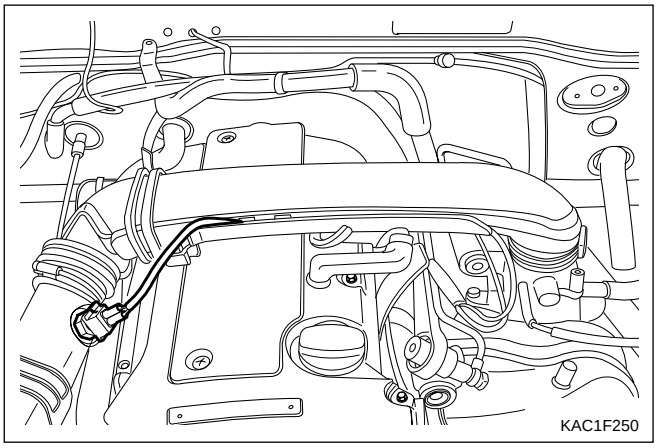
   Notice: Take care when handling the engine coolant temperature sensor. Damage to the sensor will affect the proper operation of the fuel injection system.

4. Remove the engine coolant temperature sensor from the pump hosing.

   Installation Notice

Tightening Torque	30 N•m (22 lb-ft)

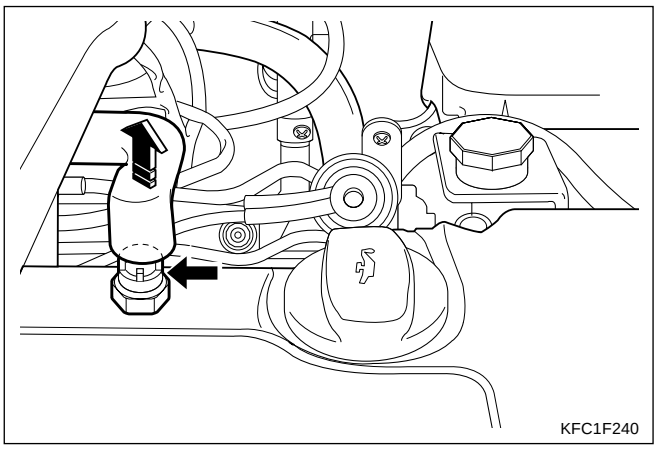
5. Installation should follow the removal procedure in the reverse order.


KAC1F250

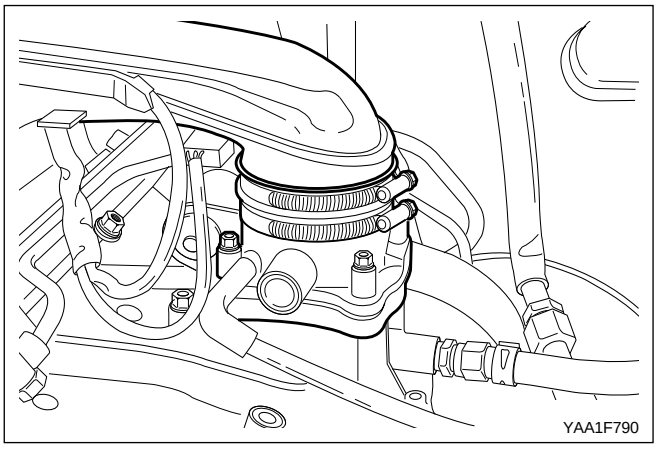
THROTTLE BODY (INTEGRATED WITH THE ACTUATOR)

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.


KFC1F240

4. Remove the blow-by hose.
5. Remove the intake air duck.

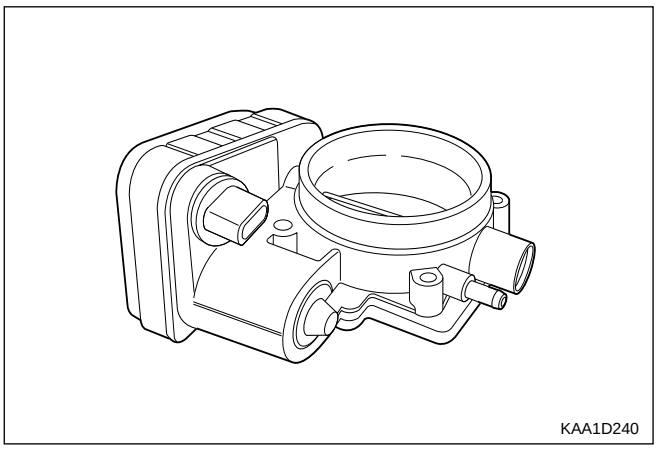

YAA1F790

6. Disconnect the throttle body electrical connector.
7. Remove the throttle body bolts.

Installation Notice

Tightening Torque	12 N•m (106 lb-in)

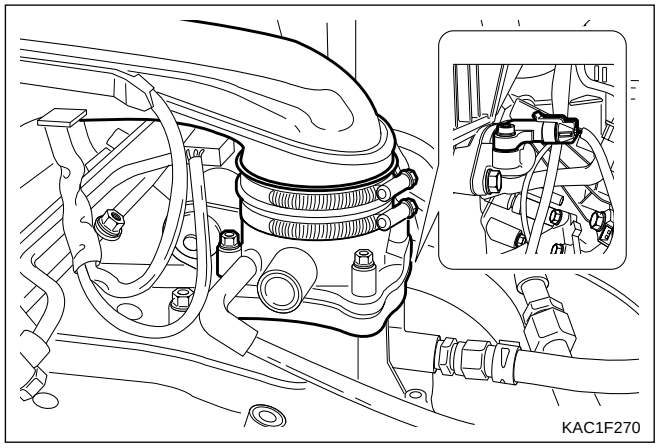
8. Remove the vacuum hose.


KAA1D240

9. Remove the throttle body and discard the gasket.

   Important: Use care in cleaning old gasket material. Sharp tools may damage sealing surfaces.

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



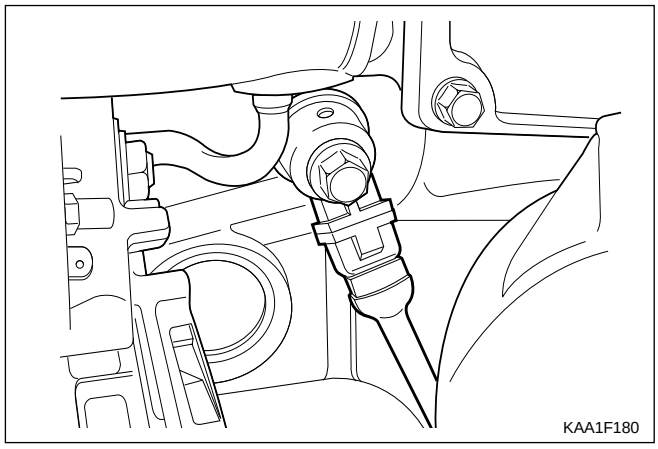
HOT FILM AIR MASS (HFM) SENSOR

Removal and Installation Procedure

1. Disconnect the negative battery cable.
2. Disconnect the Hot Film Air Mass (HFM) sensor electrical connector.
3. Remove the HFM sensor retaining screws.
4. Turn the HFM sensor coupling in the direction shown in the figure in the left so that it gets separated from the contact surface.

   Notice: Make sure the HFM sensor coupling connects completely with the contact surface installation.

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



KNOCK SENSOR

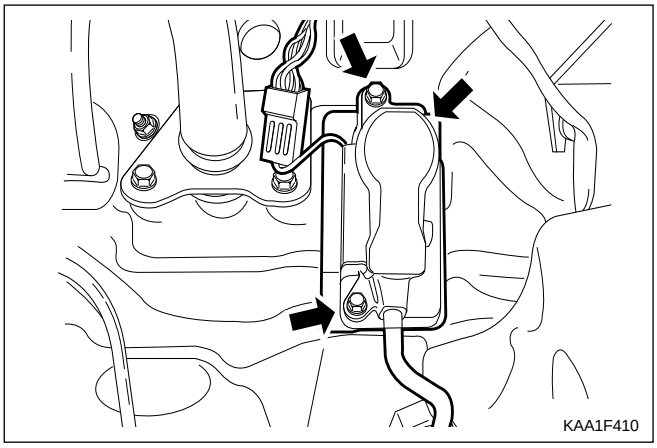
Removal and installation Procedure

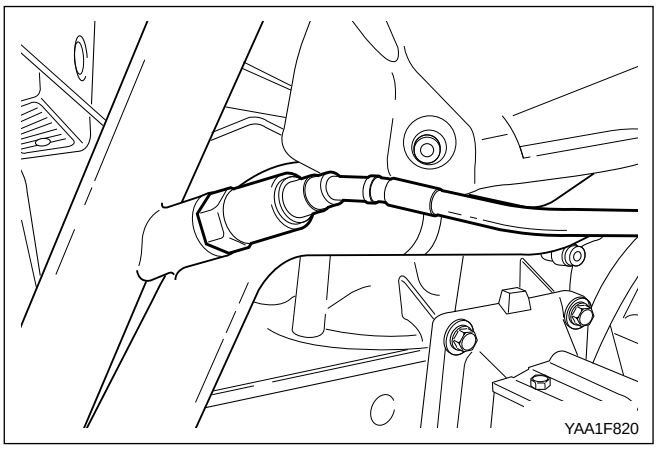
1. Disconnect the negative battery cable.
2. Disconnect the knock sensor electrical connector from the intake manifold bracket.
3. Remove the knock sensor mounting bolt from the knock sensor installed on the cylinder block.

   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.

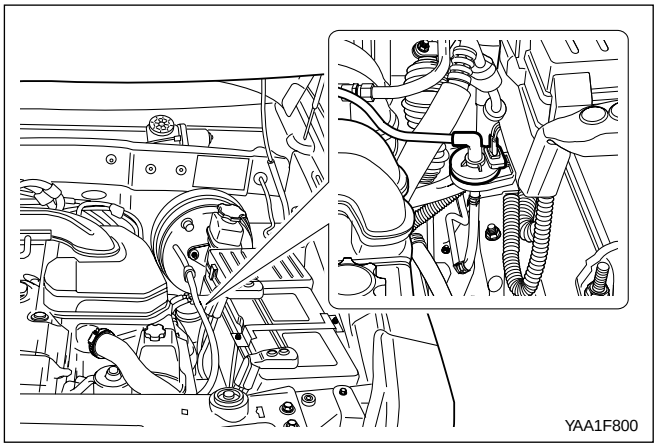
2. Disconnect the electrical connector.
3. Carefully remove the oxygen sensor from the exhaust pipe.

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.

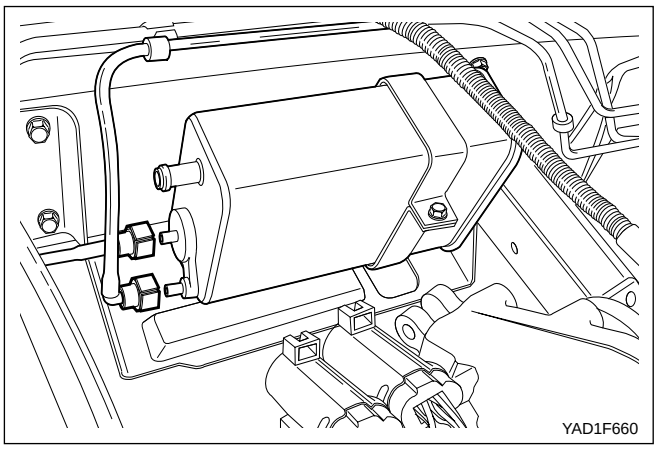
4. Coat the threads of the oxygen sensor with an anti-seize compound, if needed.
5. Installation should follow the removal procedure in the reverse order.



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.

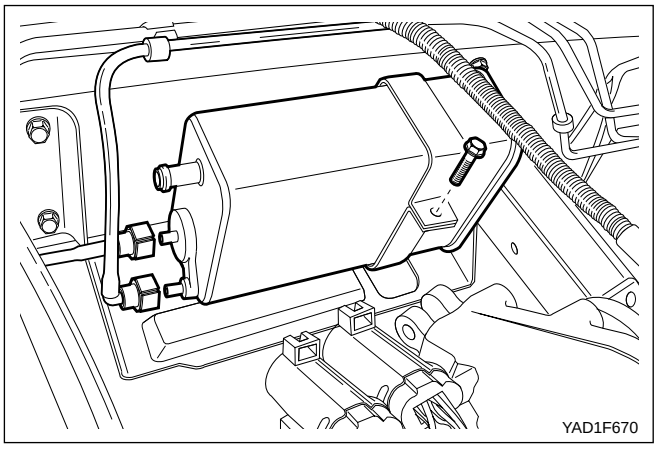


CANISTER

Removal and Installation Procedure

Caution: 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.

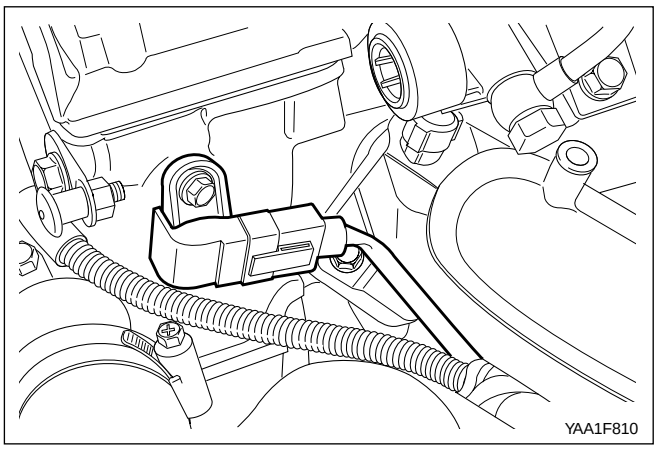


3. Remove the canister mounting bolts.

   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

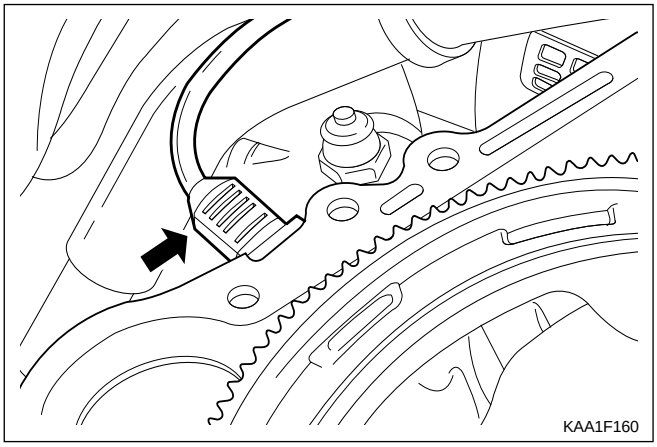
Removal and Installation Procedure

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

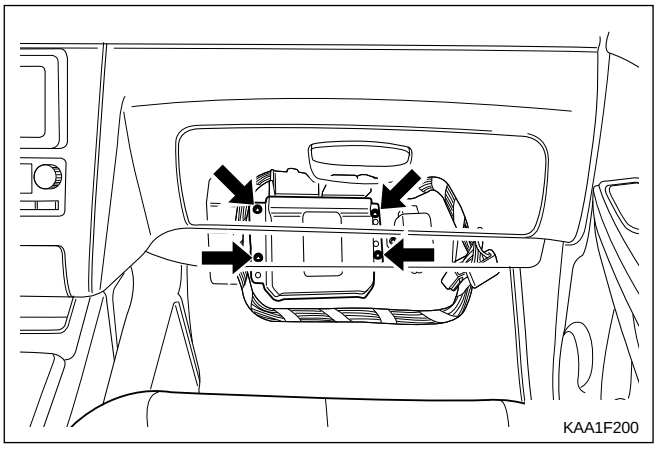
Removal and installation Procedure

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.



ENGINE CONTROL MODULE

Removal and installation Procedure

1. Disconnect the negative battery cable.
2. Remove the cowl side trim form passenger side. Re-er to *Section 9G, Interior trim.*
3. Remove the four securing nuts for the Engine Control Module (ECM) from the mounting bracket.

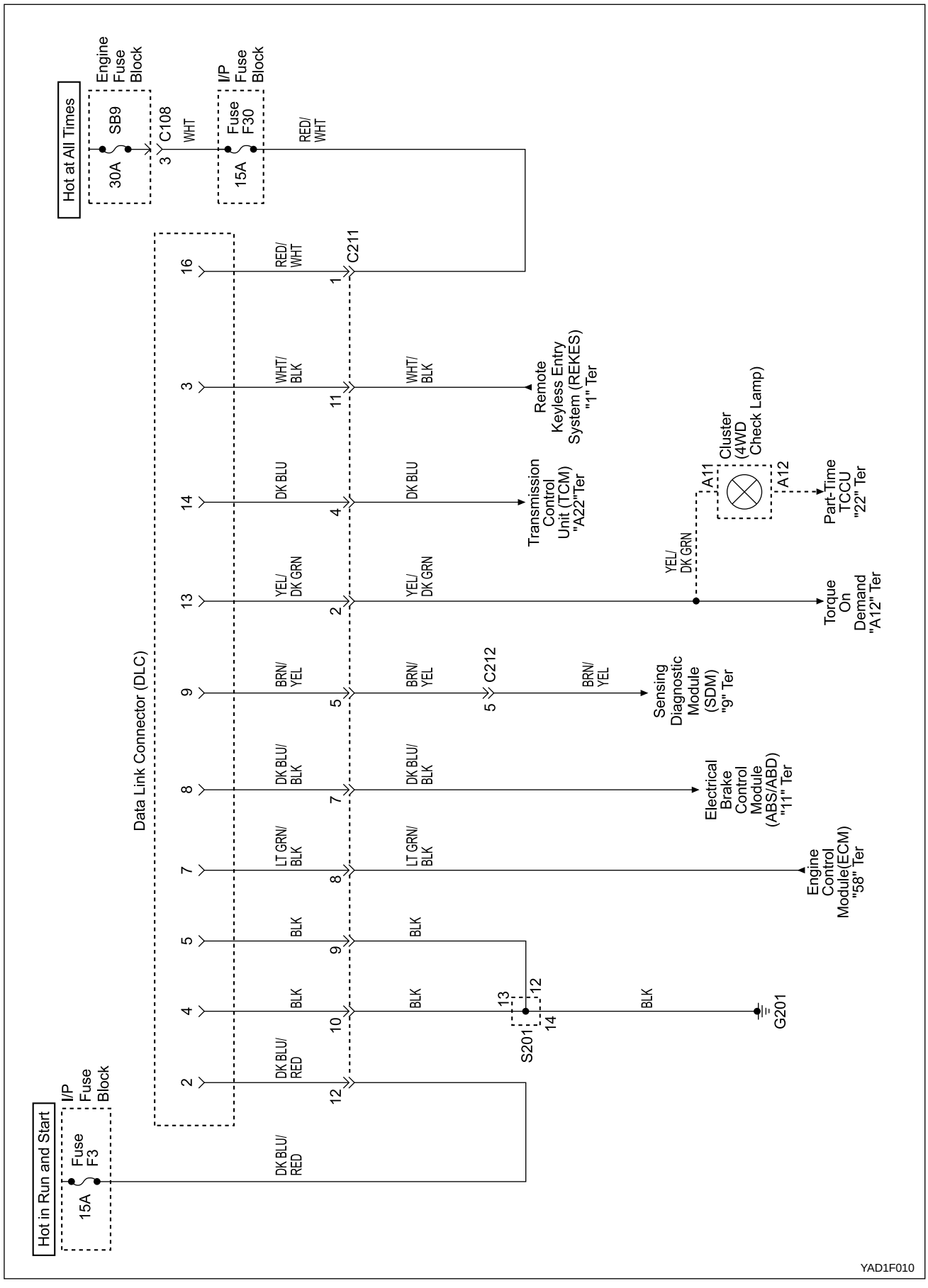
Installation Notice

Tightening Torque	10 N•m (89 lb-in)

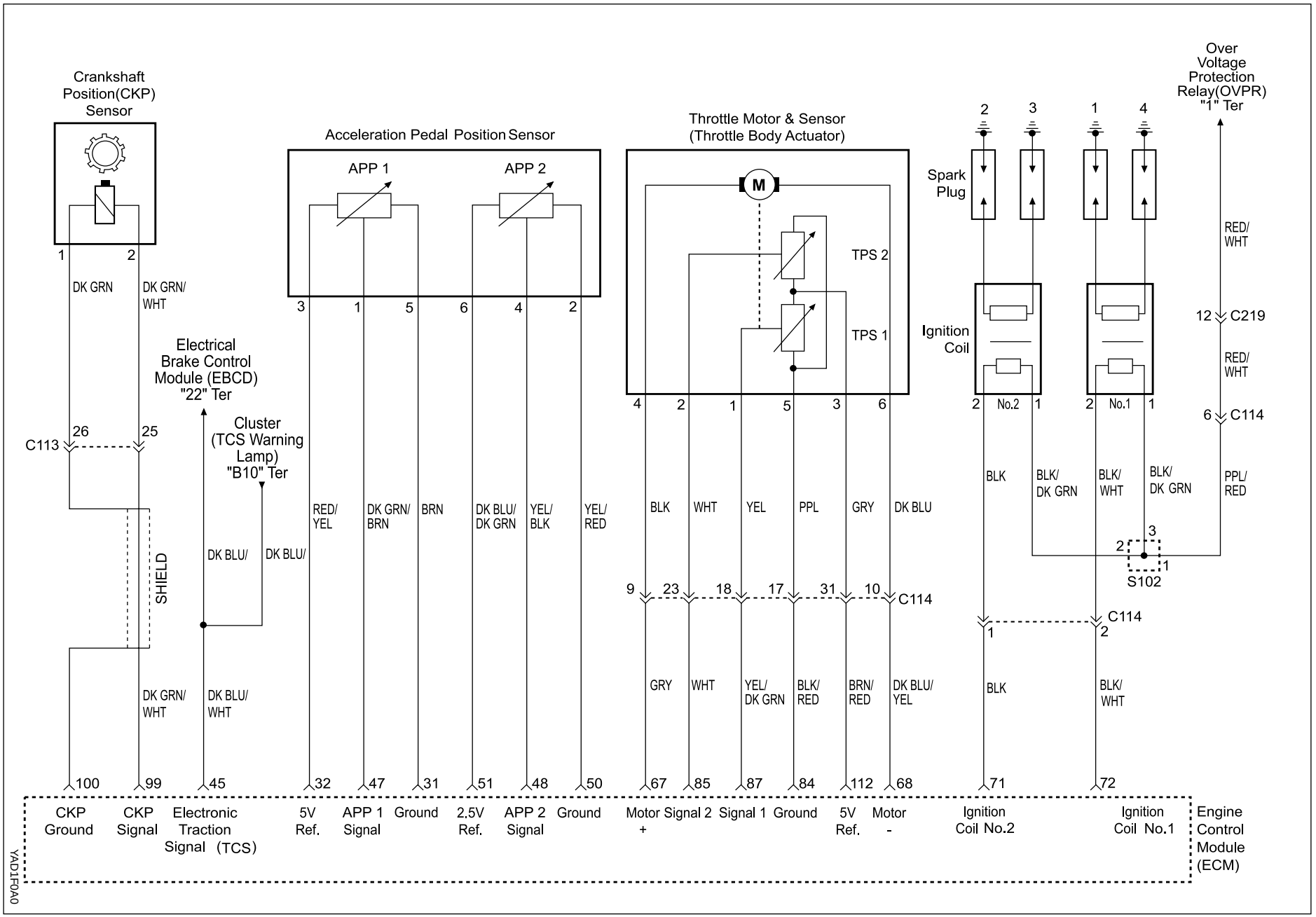
4. Pull out the ECM from the bracket.
5. Disconnect the vehicle side coupling.
6. Installation should follow the removal procedure in the reverse order.

SCHEMATIC AND ROUTING DIAGRAMS

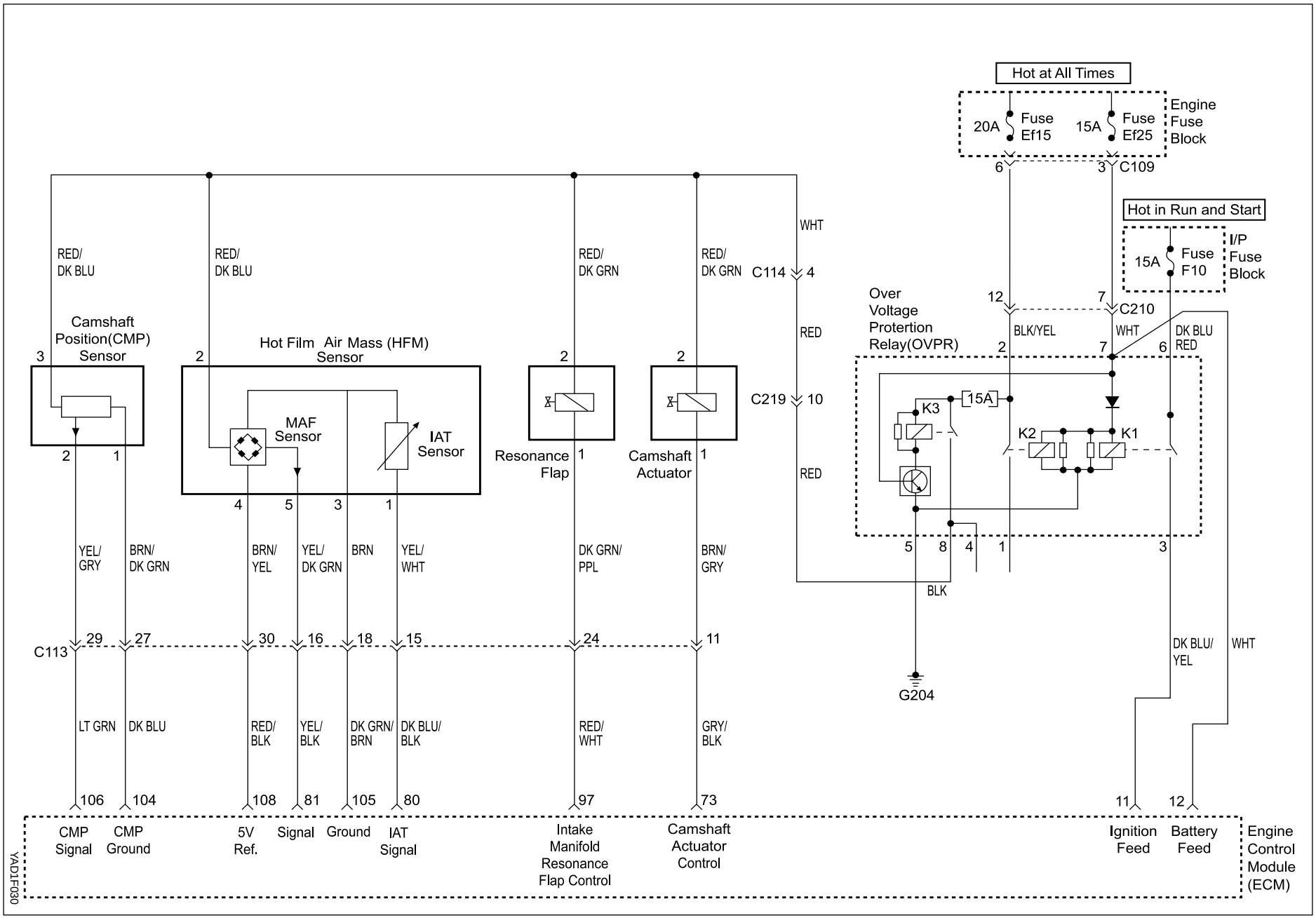
ECM WIRING DIAGRAM (2.3L DOHC - 1 OF 7) (MSE 3.53D)



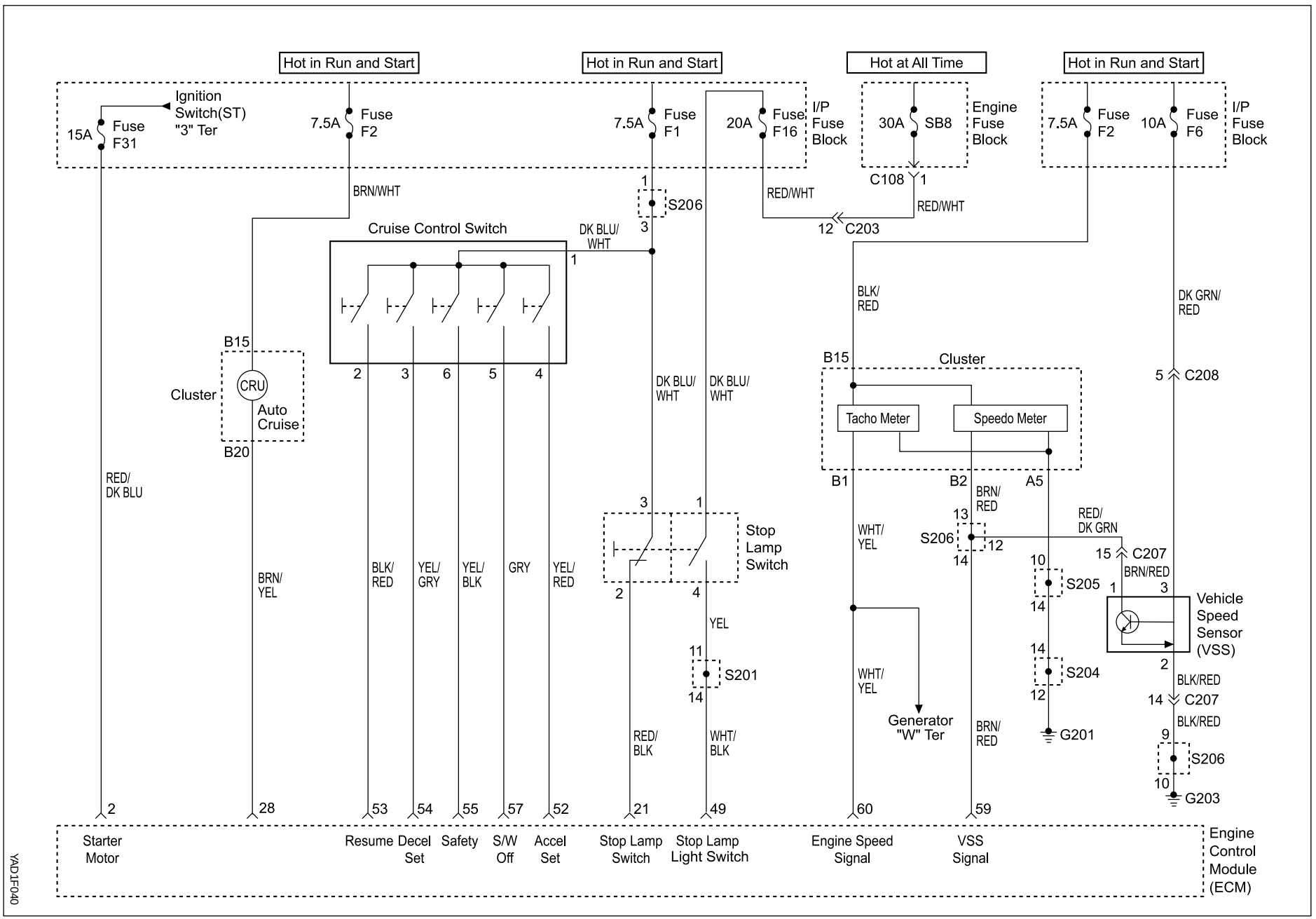
ECM WIRING DIAGRAM (2.3L DOHC - 2 OF 7) (MSE 3.53D)



ECM WIRING DIAGRAM (2.3L DOHC - 3 OF 7) (MSE 3. 53D)



ECM WIRING DIAGRAM (2.3L DOHC - 4 OF 7) (MSE 3.53D)



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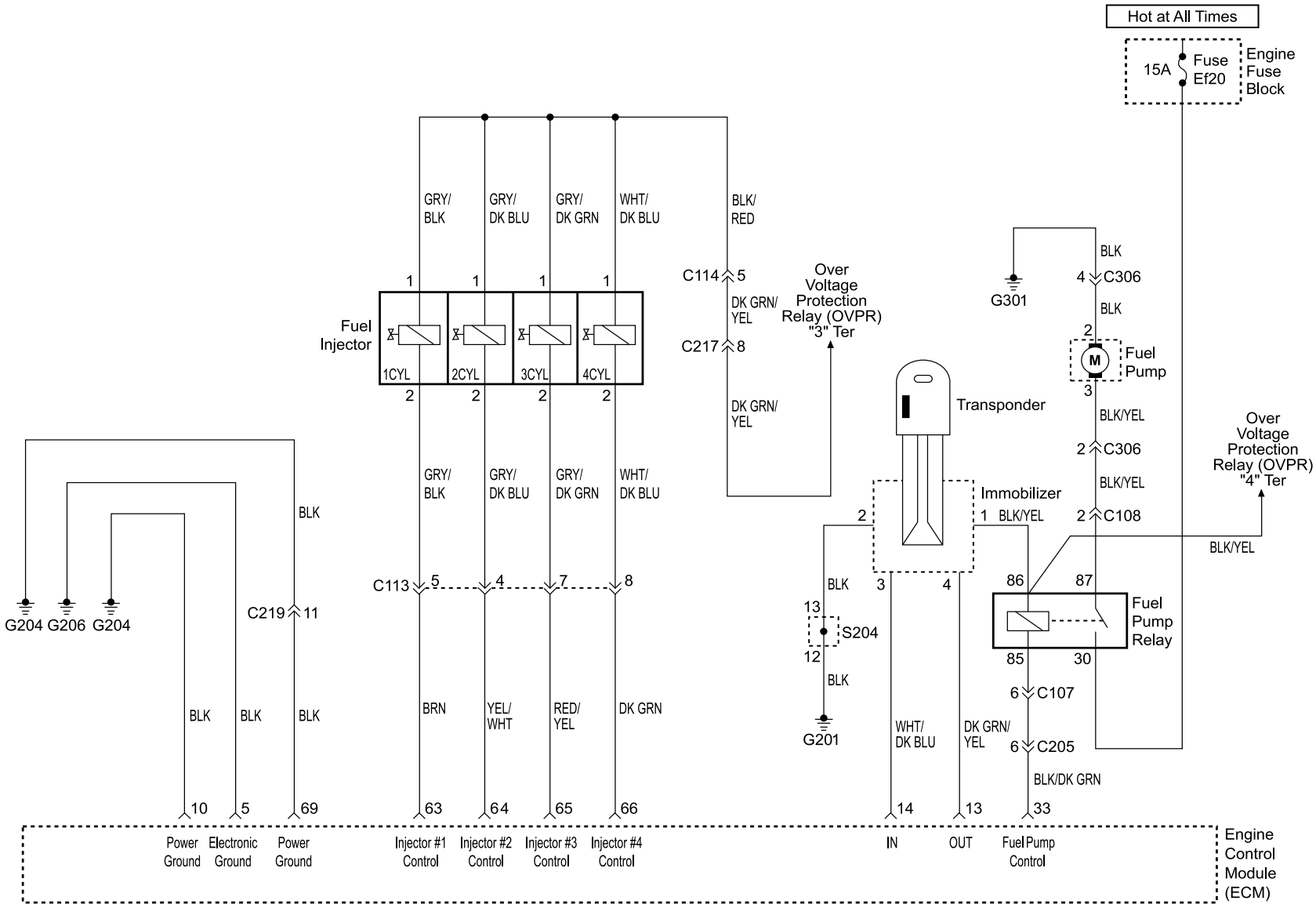
ECM WIRING DIAGRAM (2.3L DOHC - 5 OF 7) (MSE 3.53D)



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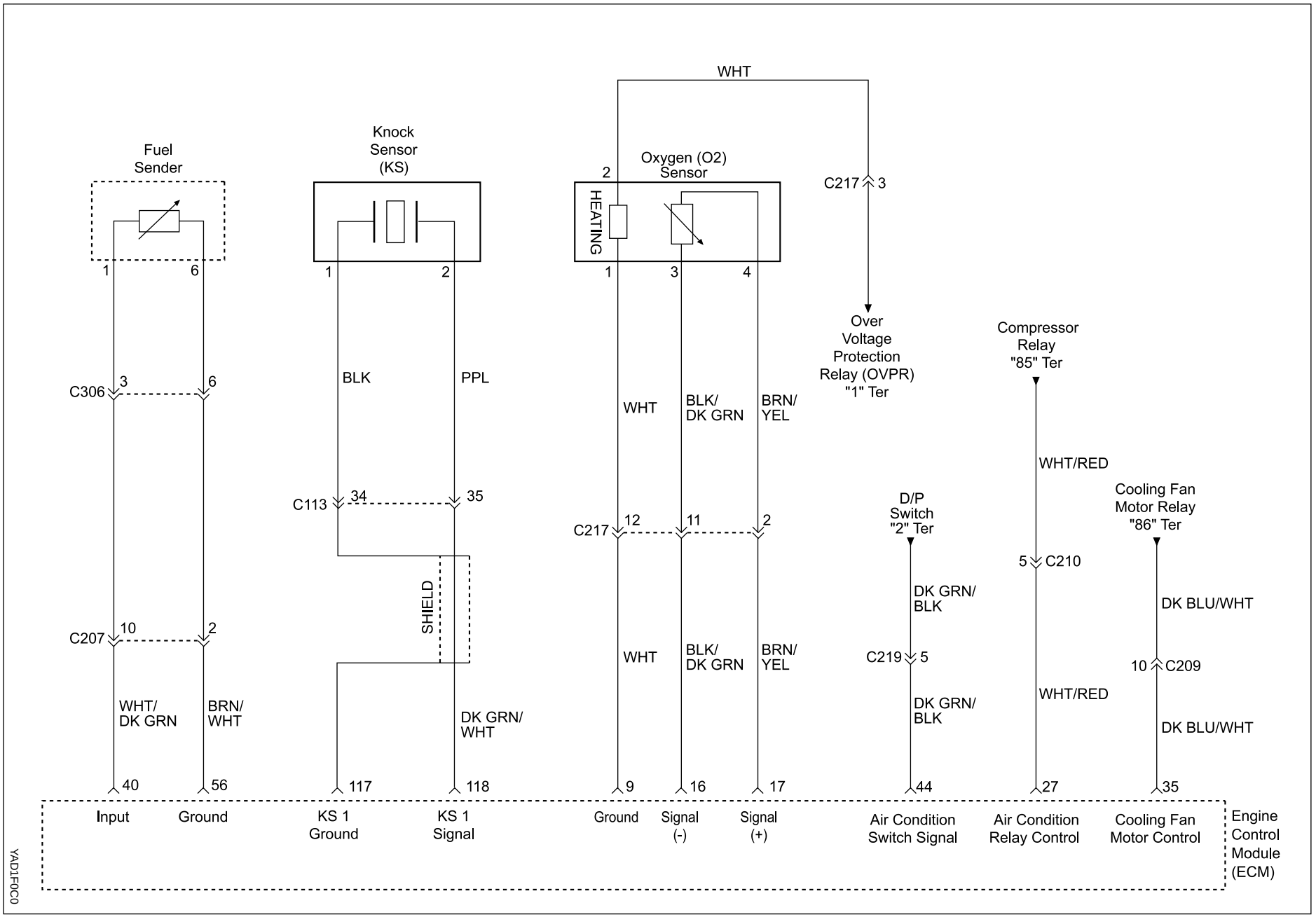
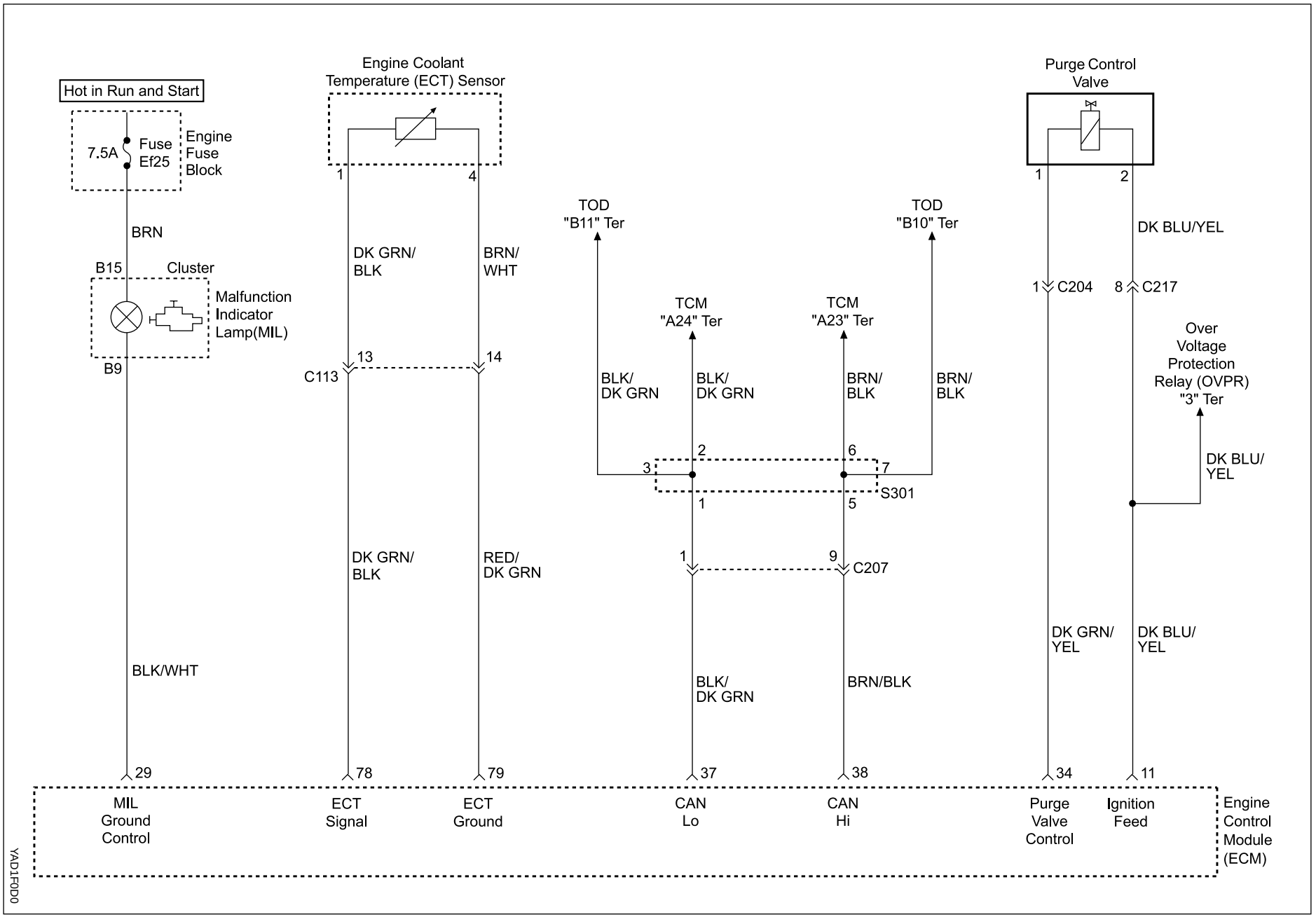
ECM WIRING DIAGRAM (2.3L DOHC - 6 OF 7) (MSE 3.53D)



ECM WIRING DIAGRAM (2.3L DOHC - 7 OF 7) (MSE 3.53D)



SPECIFICATIONS

ENGINE DATA DISPLAY TABLE

Parameter	Unit	Value
Engine Coolant Temp.	°C	greater than 95 °C after warm up
Intake Air Temp.	°C	-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 %
Mass Air Flow Meter	Kg/h	16 ~ 25 Kg/h
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.

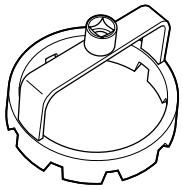
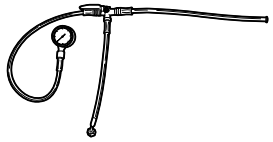
It is therefore recommended that earthed pumps with integrally earthed hoses be used, and that storage containers be properly earthed during all noncommercial fueling operations.

TEMPERATURE VS RESISTANCE

°C	°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

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS TABLE

 YAA1F890	**661 589 00 46 00** **Fuel Tank Cap Wrench**
 KAA1F490	**103 589 00 21 00** **Fuel Pressure Gauge**

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

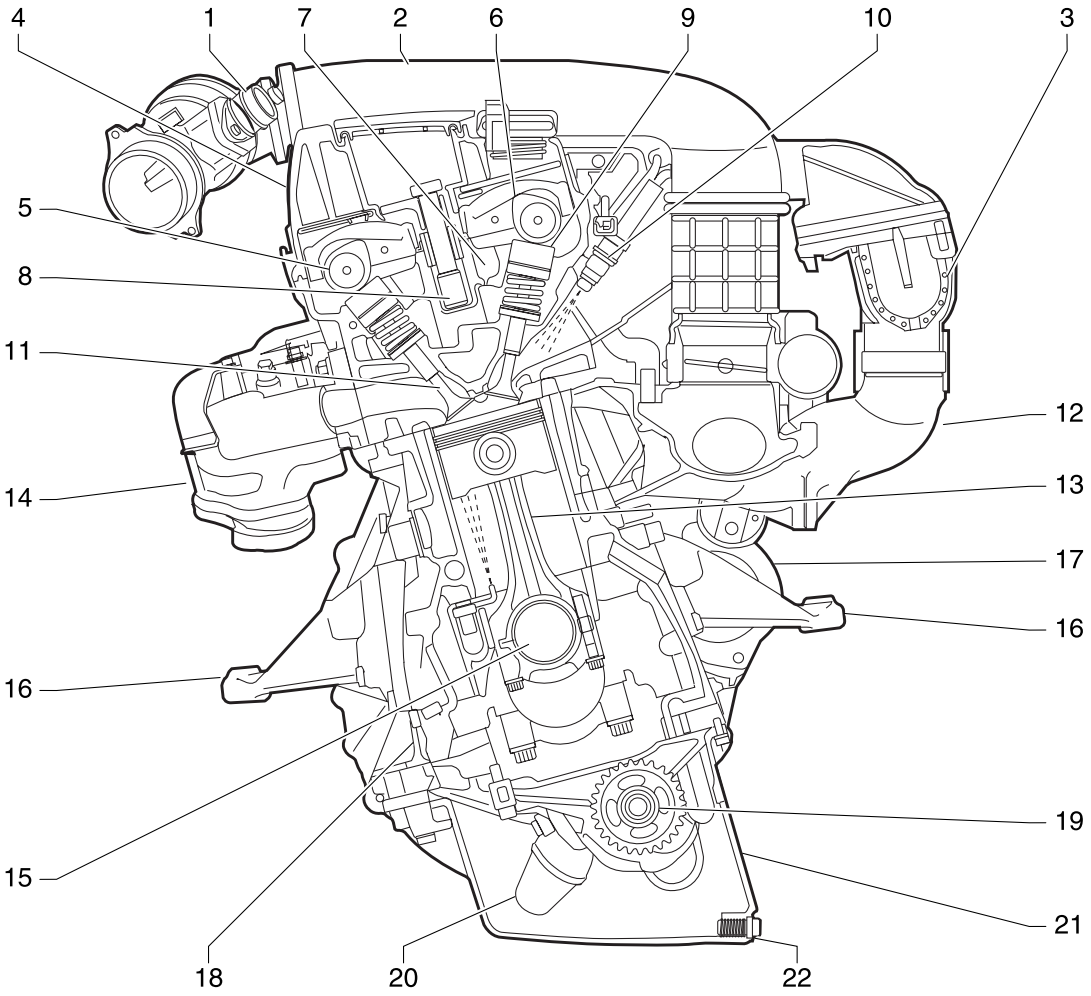
Caution: Disconnect the negative battery cable before removing or installing any electrical unit, or when a tool or equipment could easily come in contact with exposed electrical terminals. Disconnecting this cable will help prevent personal injury and damage to the vehicle. The ignition must also be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

COMPONENT LOCATOR

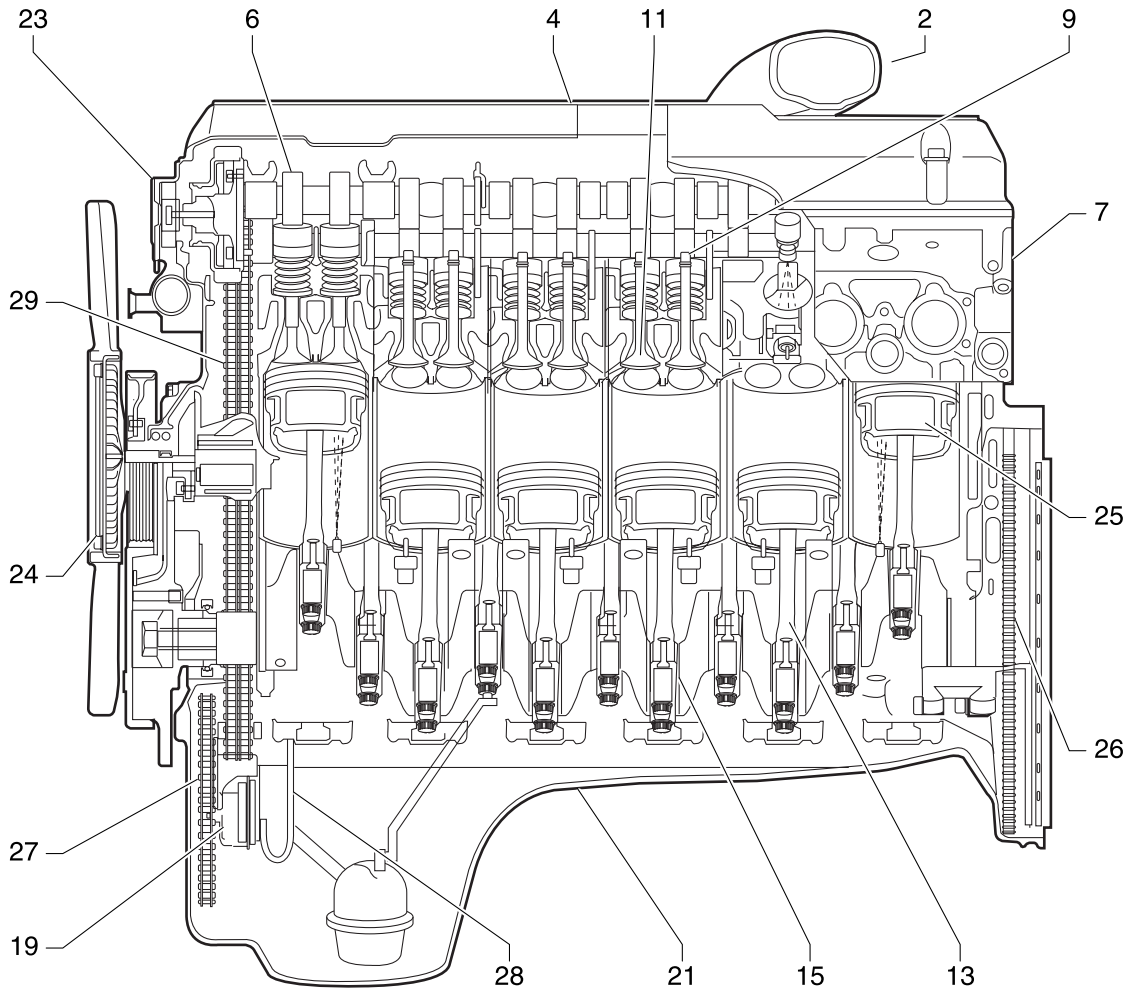
M162 ENGINE

Front View



1 HFM Sensor
2 Intake Air Duct
3 Resonance Flap
4 Cylinder Head Cover
5 Exhaust Camshaft
6 Intake Camshaft
7 Cylinder Head
8 Spark Plug Connector
9 Valve Tappet
10 Injector
11 Exhaust Valve
12 Intake Manifold
13 Connecting Rod
14 Exhaust Manifold
15 Crankshaft
16 Engine Mounting Bracket
17 Starter
18 Crankcase
19 Oil Pump Sprocket
20 Oil Strainer
21 Oil Pan
22 Drain Plug

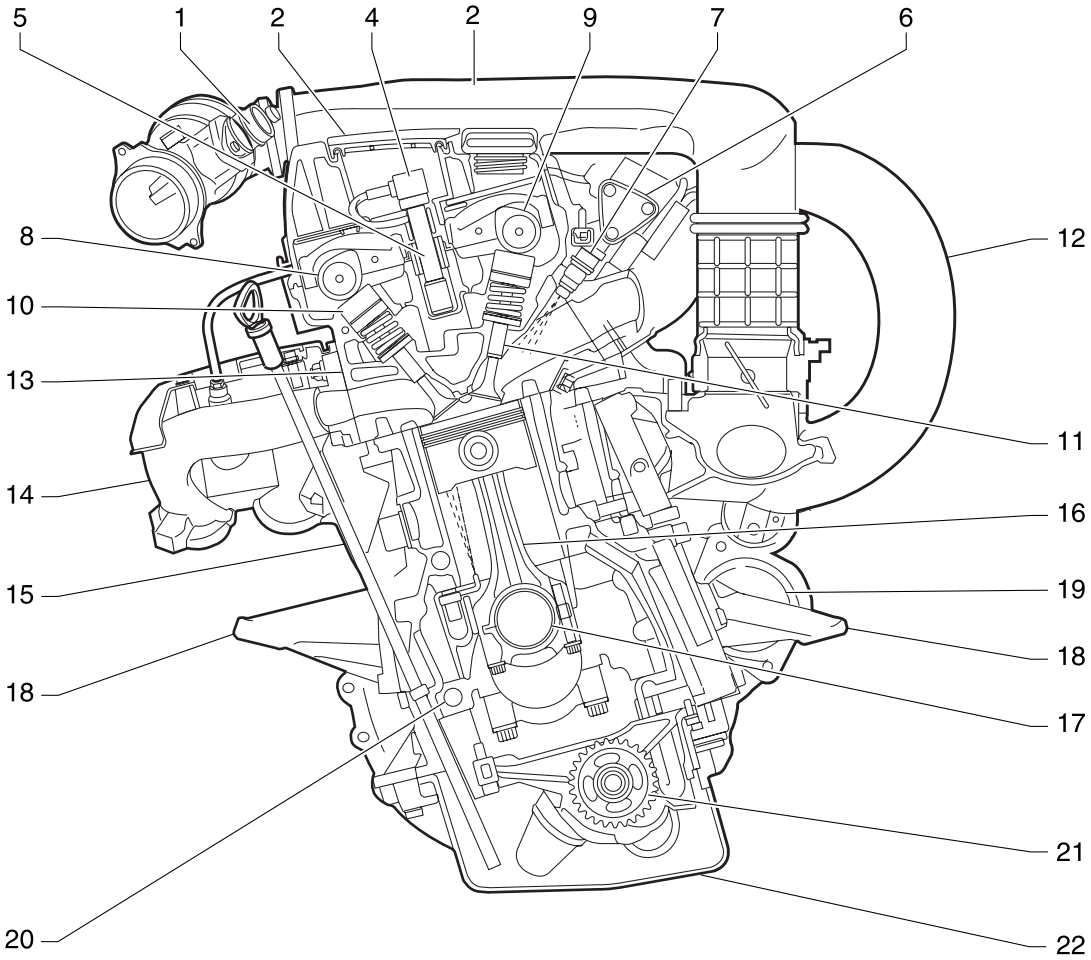
Side View



23 Camshaft Adjuster
24 Cooling Fan and Viscous Clutch
25 Piston
26 Flywheel of Drive Plate
27 Oil Pump Drive Chain
28 Oil Return Pipe
29 Timing Chain
30 Oil Pump

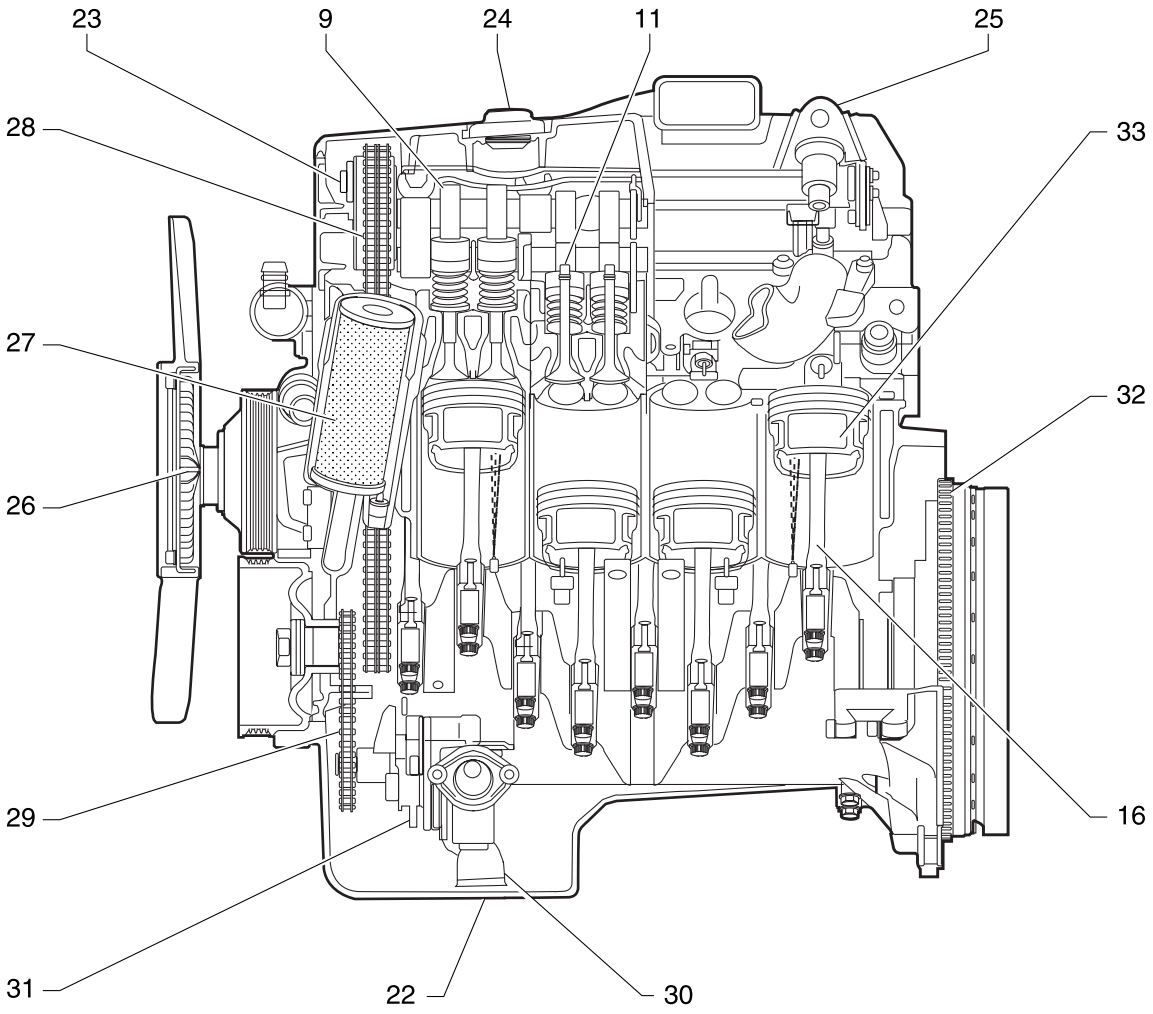
M161 ENGINE

Front View



1 HFM 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

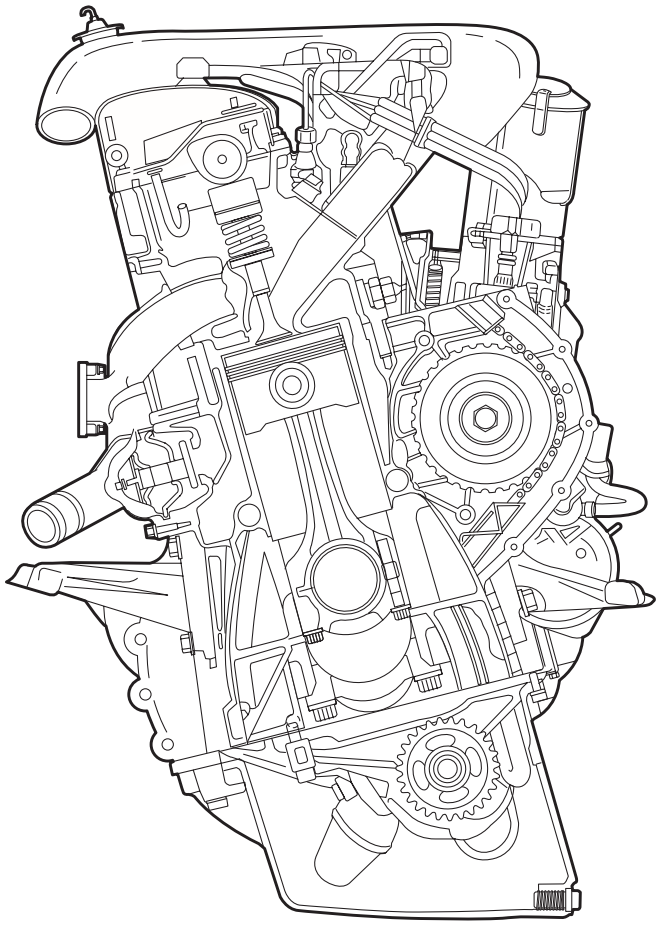
Side View



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

DIESEL ENGINE

Front View



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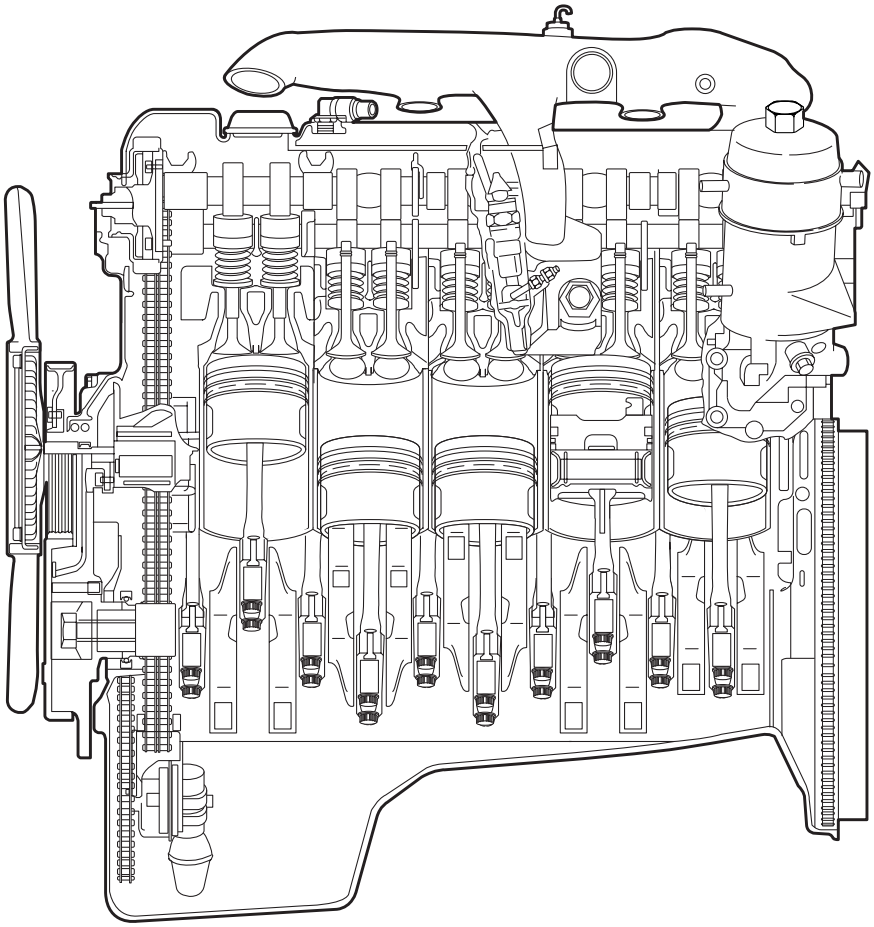
Side View



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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.

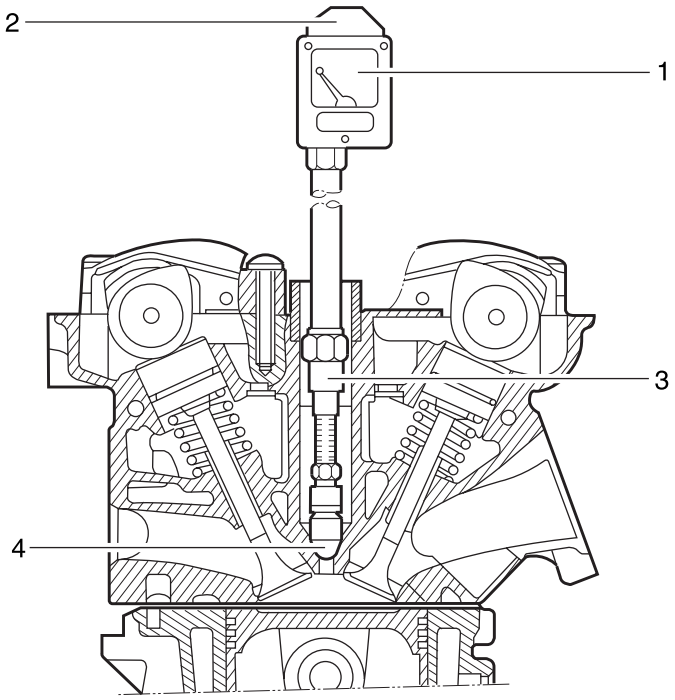
Gaskets

- 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 (GASOLINE ENGINE)



YAD1A070

1 Compression Pressure Tester
2 Diagram Sheet
3 Adaptor
4 Sealing Cone

Standard Service Data

Application	M162 Engine	M161 Engine
Compression Ratio	10 : 1	10.4 : 1
Normal Engine Temperature	80 °C (176 °F)	←
Normal Compression Pressure	Min. 10 bar, Max. 14 bar	Min. 11 bar, Max. 15 bar
Permissible Pressure Difference Between Individual Cylinders	Max. 1.5 bar	←

Tools Required

001 589 76 21 00 Compression Pressure Tester

119 589 01 09 00 Spark Plug Wrench

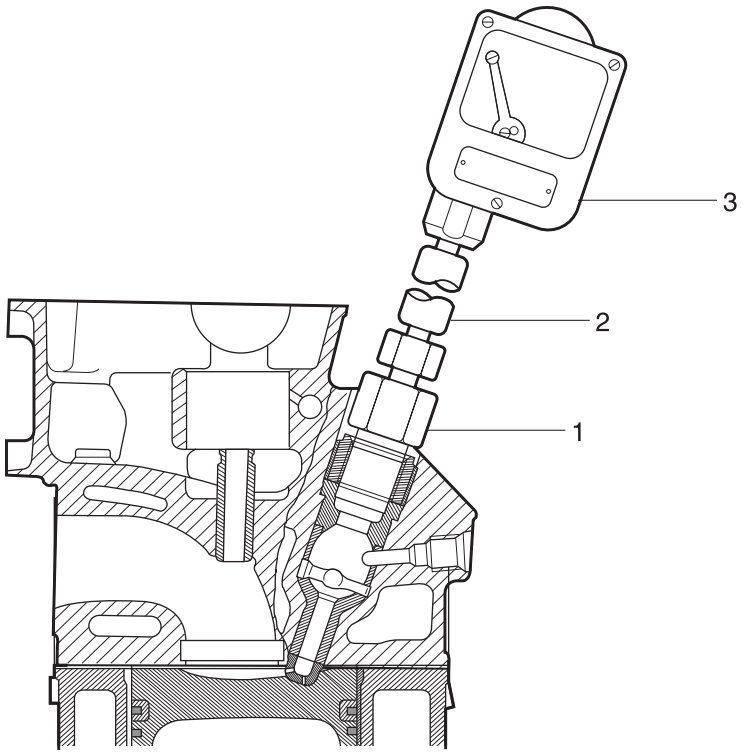
Measuring Procedure

1. Warm the engine up to normal operating temperature.
2. Remove the spark plugs using the spark plug wrench 119 589 01 09 00.
3. Place the diagram sheet to compression pressure tester 001 589 76 21 00.
4. Connect the adaptor to compression pressure tester 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 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.

COMPRESSION PRESSURE TEST (DIESEL ENGINE)

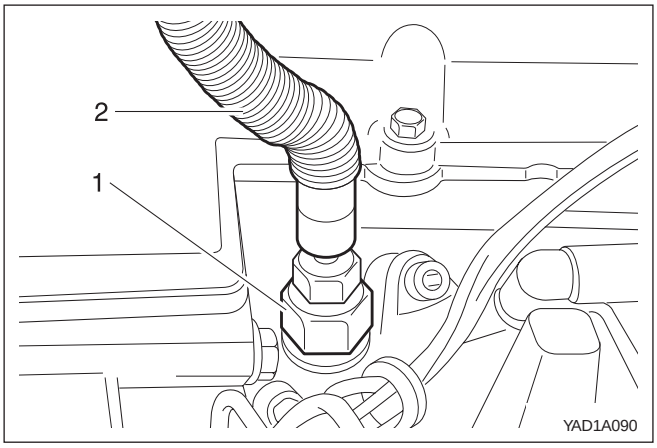


YAD1A080

1 Test Adaptor
2 Flexible Connector
3 Compression Pressure Tester

Standard Service Data

Compression Ratio	22 : 1
Normal Engine Temperature	80 °C (176 °F)
Normal Compression Pressure	28bar
Minimum Compression Pressure	Approx.18bar
Permissible Pressure Difference Between Individual Cylinders	Max. 3bar



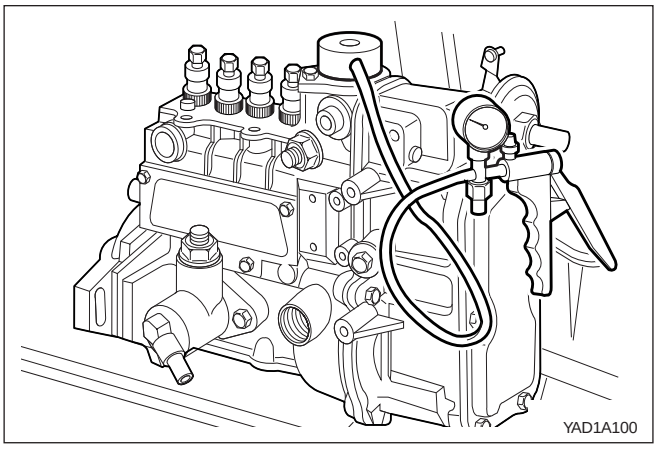
Tools Required

001 589 76 21 00 Compression Pressure Tester
001 589 73 21 00 Hand Vacuum Pump
601 589 65 09 00 Socket

Measuring Procedure

Notice: Ensure that no gear is engaged and that the vehicle is protected from rolling.

1. Run the engine to be the coolant temperature 80 °C (176 °F).
2. Remove the fuel injection nozzle.
3. Install the test adapter (1) and connect the flexible connector (2) to the compression pressure tester 001 589 76 21 00.



4. Disconnect the vacuum line from the stop unit and connect the hand vacuum pump 001 589 73 21 00 to the stop unit.
5. Pump the hand vacuum pump 001 589 73 21 00 and make the fuel injection pump in stop position.

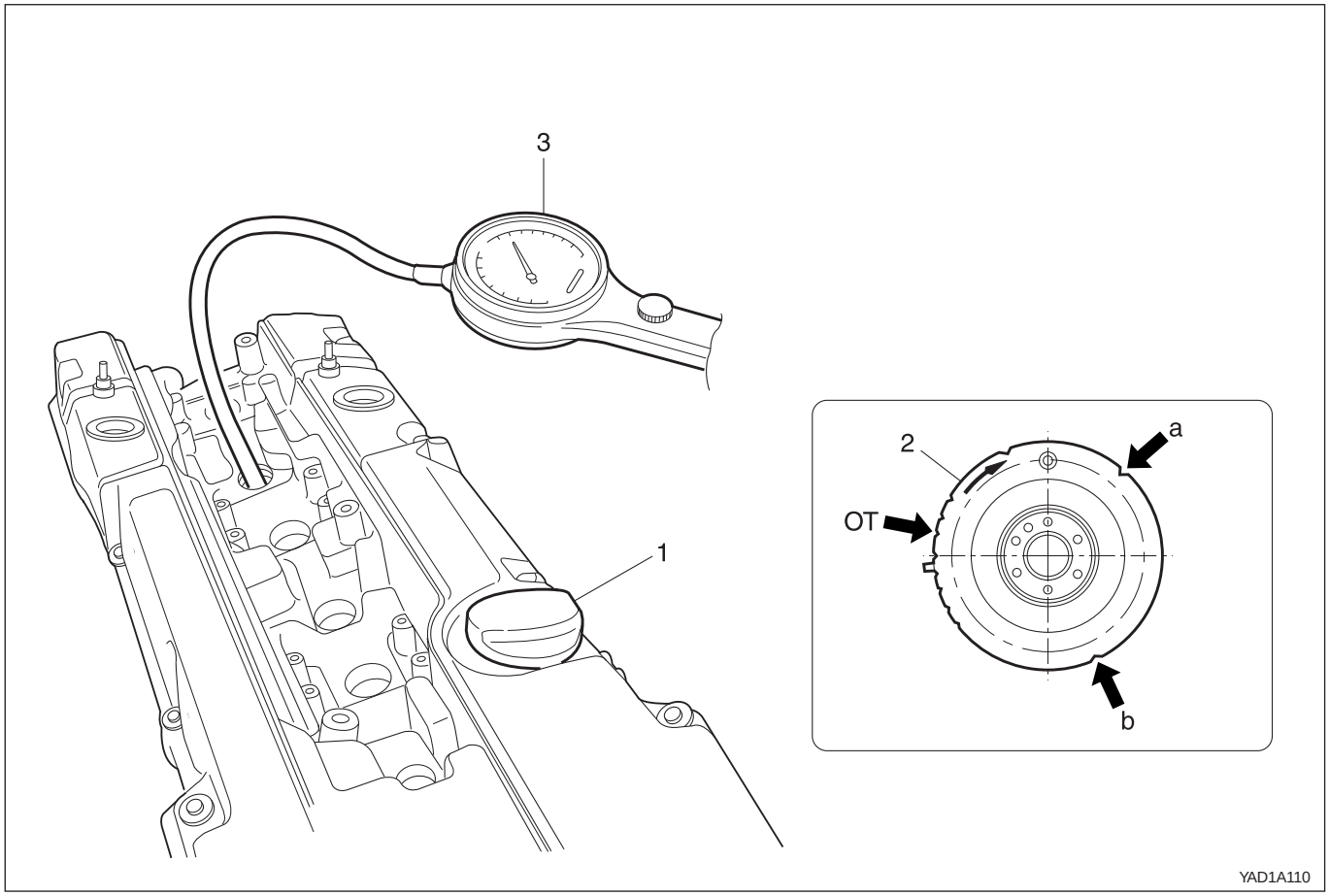
Operating Pressure	Approx. 500bar

6. Using a starter motor, crank the engine 8 revolutions.
7. Measure the remaining cylinder compression pressure in the same manner and compare it with service data.

   Notice: If out of standard, do cylinder pressure leakage test.

8. Remove the compression pressure tester 001 589 76 21 00.
9. Install the fuel injection nozzle.

CYLINDER PRESSURE LEAKAGE TEST (GASOLINE ENGINE)



1 Engine Oil Filler Cap
2 Vibration Damper
3 Cylinder Pressure Leakage Tester with Connecting Hose

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 By Mark On Vibration Damper At TDC

TDC Mark (M162 Engine)	**OT (TDC)**	**a (120 °)**	**b (240 °)**
Cylinder Number	1, 6	2, 5	3, 4
TDC Mark (M161 Engine)	**OT (TDC)**		**UT (BDC 180 °)**
Cylinder Number	1, 4		2, 3

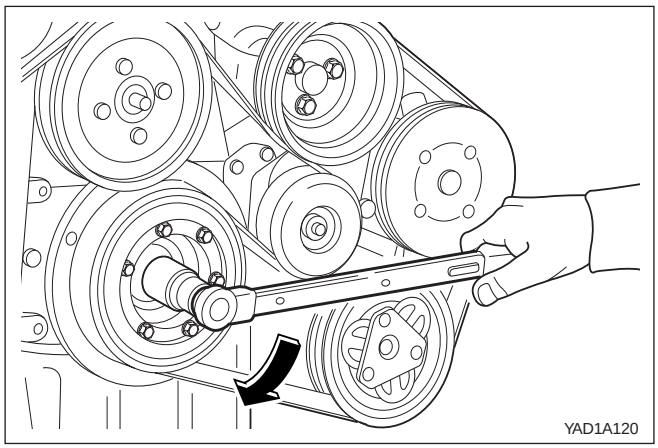
Universal Tool

Cylinder Pressure Leakage Tester	Bosch, EFAW 210A 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.

M162 Engine



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.

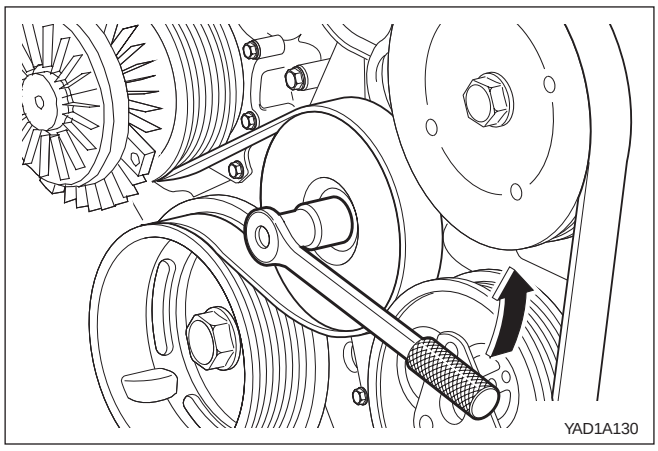
   Notice: Measure the leakage volume in the completely opening condition of throttle valve by pulling the acceleration cable.
10. Perform the pressure test according to the firing order.

    Notice:

    Firing Order

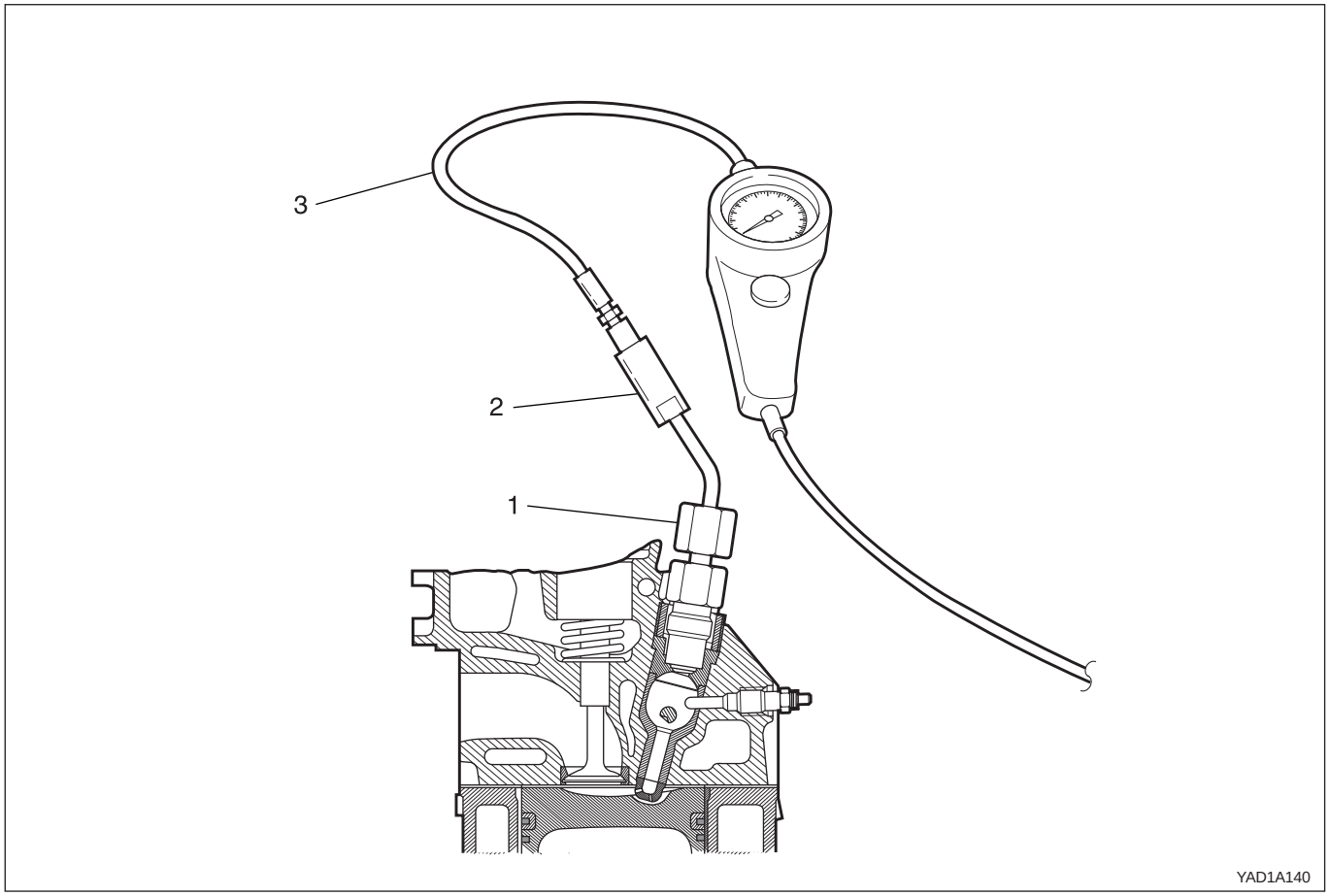
    - M162 Engine: 1 - 5 - 3 - 6 - 2 - 4
    - M161 Engine: 1 - 3 - 4 - 2

M161 Engine



11. Compare the leakage pressure with the specifications.

CYLINDER PRESSURE LEAKAGE TEST (DIESEL ENGINE)



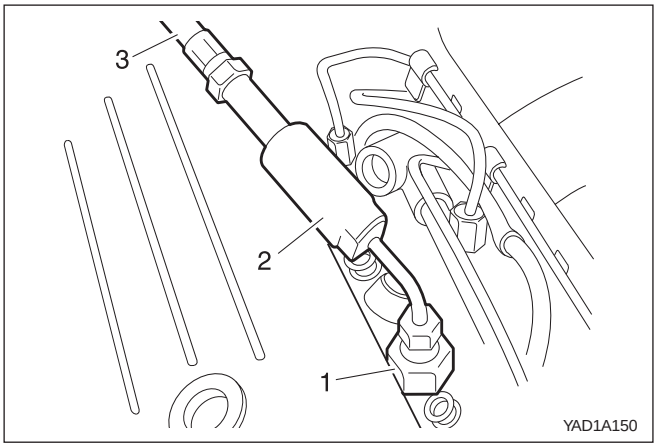
1 Connector
2 Connection Piece
3 Connection Hose

Permissible Pressure Leakage (Engine at Normal Operating Temperature of 80°C)

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

Universal Tools

Cylinder Pressure Leakage Tester	Bosch, EFAW 210 A or Sun CLT 228
Connection Piece	Bosch order no. 1 687 010 016



Leakage Test

1. Run the engine to be the coolant temperature 80 °C (176 °F).
2. Remove the fuel injection nozzle.
3. Open the coolant reservoir.
4. Check the coolant level and replenish if necessary.
5. Open the oil filler cap.
6. Remove the air cleaner cover and element.
7. Position the piston at TDC.
8. Install the connector (1) and connection piece (2).
9. Calibrate the tester and connect the connection hose (3)
10. Pressurize with compressed air and compare the pressure changes with permissible pressure leakage.
11. If permissible pressure leakage is out of standard, check followings :
    - Intake and exhaust lines.
    - Sounds in oil filler area.
    - Air bubbles in radiator coolant.
12. Do pressure leakage test for the remaining cylinders according to the firing order.
    - firing order: 1-2-4-5-3
13. Remove the tester.
14. Close the coolant reservoir cap and oil filler cap.
15. Install the air cleaner element and cover.
16. Install the fuel injection nozzle.

GENERAL DIAGNOSIS

Condition		Probable Cause	Correction
Hard Starting (With normal cranking)	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.
		• Improper ignition timing.	• Adjust the ignition timing.
		• Faulty ignition coil.	• Replace the ignition coil.
	Malfunction of Fuel System	• Lock 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	• Improper ignition timing.	• Adjust the ignition timing.
		• 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-10".	• Refer to "Page 1A-10".
	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.
		• Poor ignition timing.	• Adjust the ignition timing.
		• 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-10".	• Refer to "Page 1A-10".
	Malfunction of Ignition System	• Poor ignition timing.	• Adjust the ignition timing.
		• 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.
	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-10".	• Refer to "Page 1A-10".
	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.
	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 Fuel System	• Abnormal spark plug.	• Replace the spark plug.
		• Poor ignition timing.	• Adjust the ignition timing
		• Electric leakage or poor connection of the high tension cable.	• Connect the cable correctly or replace it.
	Malfunction of Ignition System	• Clogged or contaminated fuel filter and fuel pipe.	• Clean or replace the fuel filter and the fuel pipe.
	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-10".	• Refer to "Page 1A-10".
	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	• Improper ignition timing.	• Adjust the ignition timing.
		• 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.
		• Low oil pressure.	• Refer to "Page 1A-21" in this section.

SPECIFICATIONS

ENGINE SPECIFICATIONS

Application			M162 Engine	M161 Engine	Diesel Engine
Engine Model			M162.990	M161.970	Four-Stroke Diesel
Displacement (CC)			3199	2295	2874
Cylinder (Bore x Stroke) (mm)			89.9 x 84.0	90.9 x 88.4	89 x 92.4
Fuel Injection / Ignition System			MSE 3.63D	MSE 3.53D	PES 5 M55 C320 RS 168
Compression Ratio			10 : 1	10.4 : 1	22 : 1
Number of Cylinders			6	4	5
Camshaft Valve Arrangement			DOHC	DOHC	SOHC
Camshaft Drive Type			Chain-Driven	←	←
Max. Output (ps/rpm)			220 / 6000	149 / 5500	120 / 4000
Max. Torque (kg•m/rpm)			31.6 / 3900	22.4 / 4000	25.5 / 4000
Firing Order			1 - 5 - 3 - 6 - 2 - 4	1 - 3 - 4 - 2	1 - 2 - 4 - 5 - 3
Ignition Type			Distributorless Double Ignition	←	-
Ignition Timing			BTDC 8°	BTDC 6° ± 2°	BTDC 18° ± 10°
Valve Timing	Intake	Open/ Close	ATDC 11° / ABDC 34°	ATDC 13.15° / ABDC 13.57°	ATDC 11.33° / ABDC 17°
	Exhaust	Open/ Close	BBDC 31° / BTDC 14°	BBDC 16.58° / BTDC 17.05°	BBDC 28° / BTDC 15.25°
Valve Clearance Adjustment			Automatic Control	←	←
Idle Speed (rpm)			700 ± 50	750 ± 50	720 - 820
Fuel Injection Pressure (kg/cm²)			3 - 4	3.2 - 4.2	138 - 146
Oil Capacity (liter)			8.2	7.5	8.0 - 9.5
Lubrication Type			Forced by Gear Pump	←	←
Oil Filter Type			Full Flow with Paper Filter	←	Combined Full-Flow and Partial Flow Filter
Fuel			Unleaded Gasoline	←	Diesel

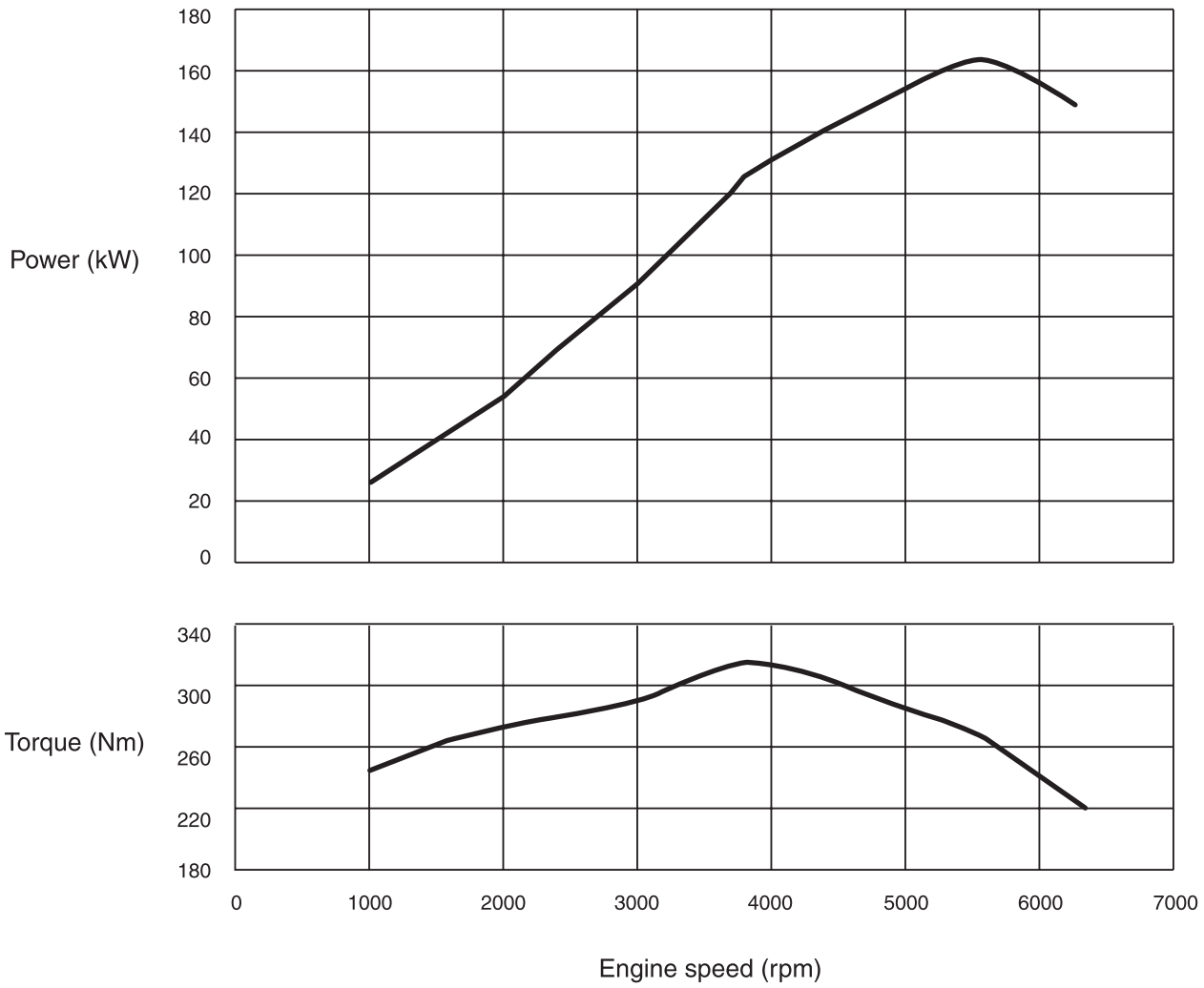
MSE : Engine Control Module

3.63D : 6 Cylinder Version

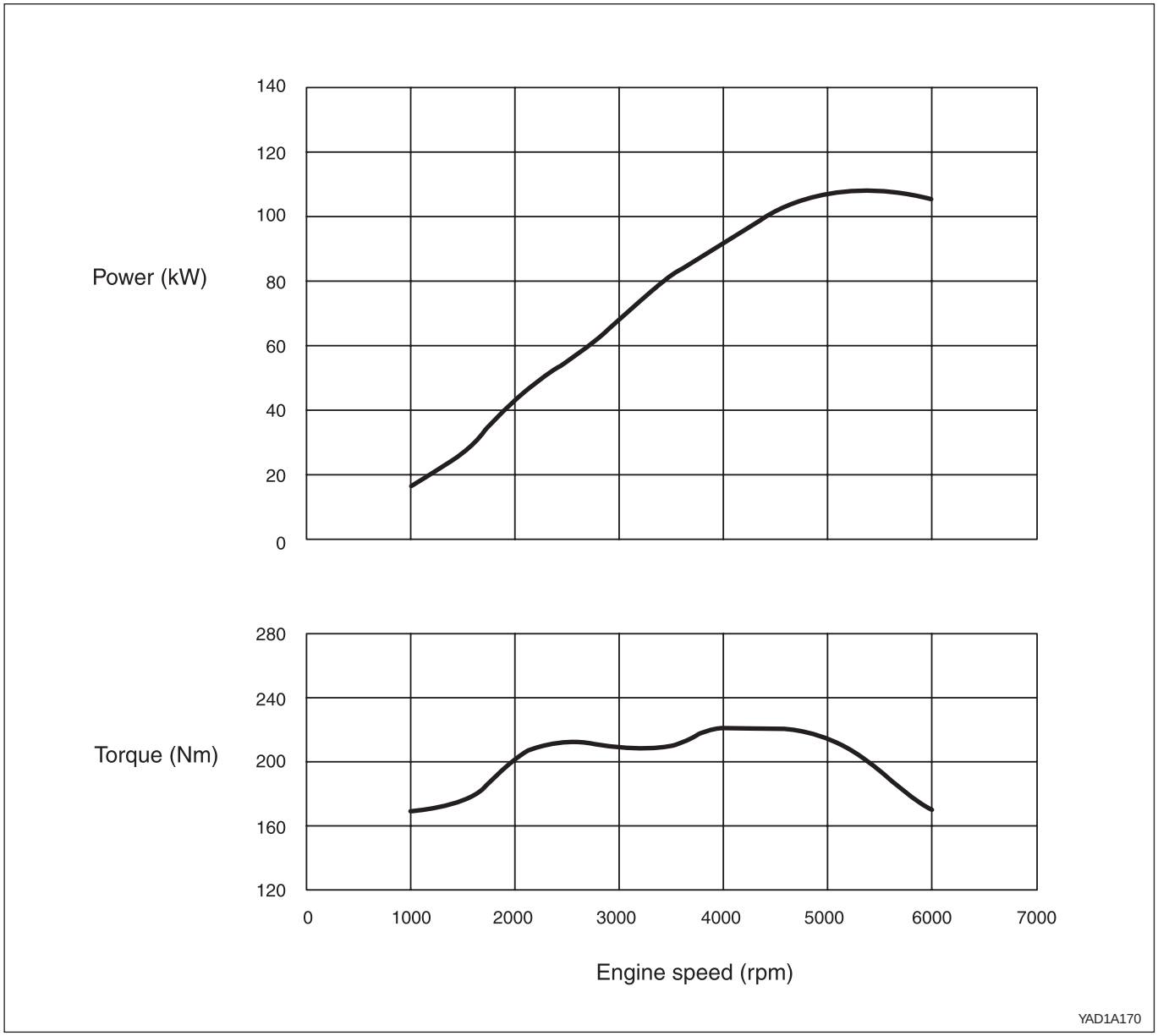
3.53D : 4 Cylinder Version

PERFORMANCE CURVE

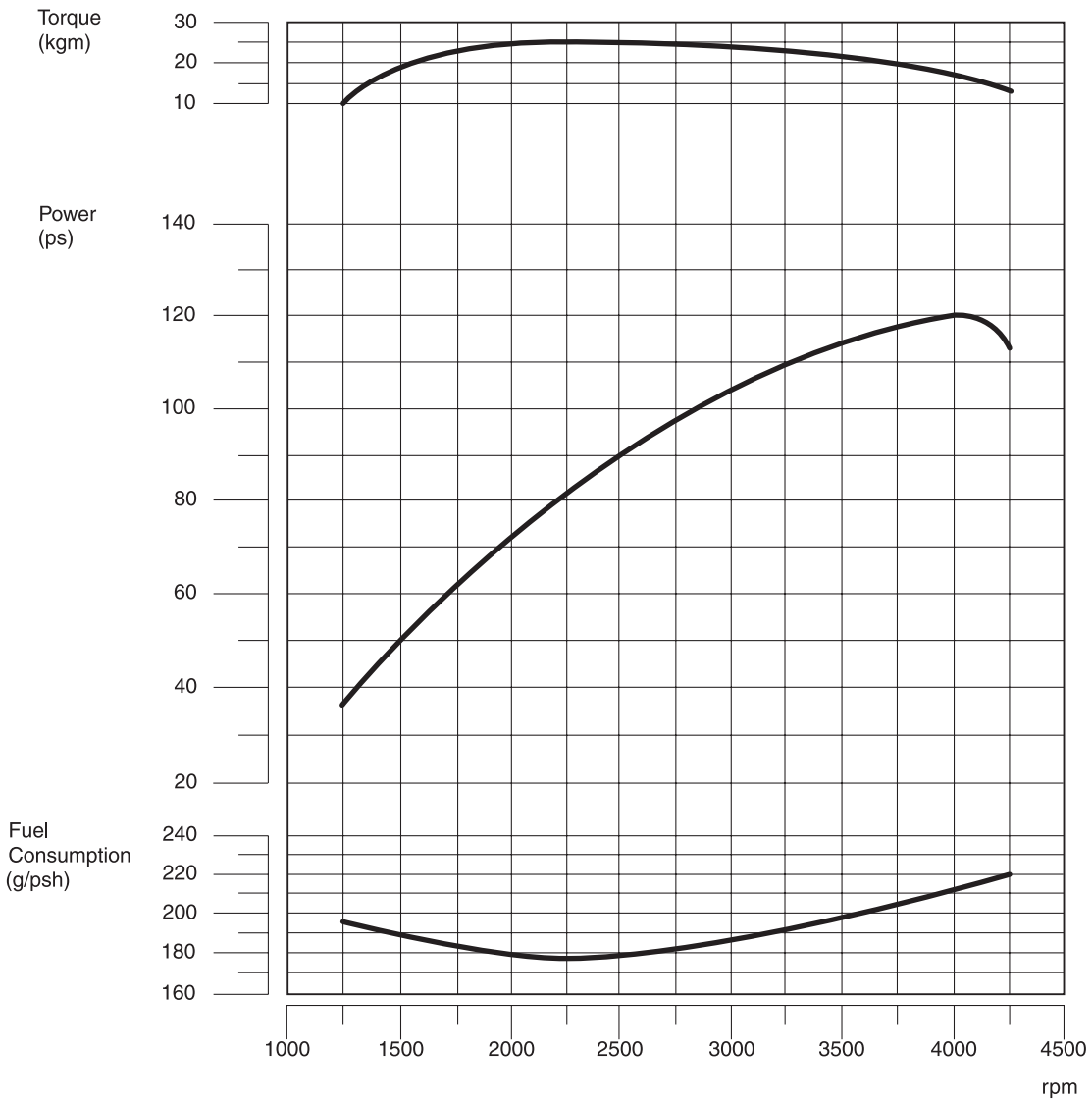
M162 Engine



M161 Engine

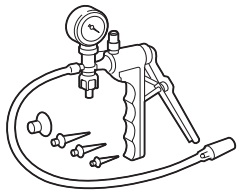
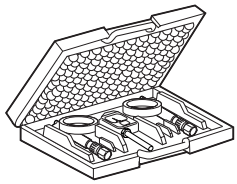
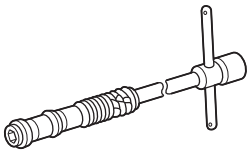
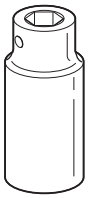

Power (kW)
140
120
100
80
60
40
20
0
Torque (Nm)
280
240
200
160
120
0
1000
2000
3000
4000
5000
6000
7000
Engine speed (rpm)
YAD1A170

Diesel Engine



SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS TABLE

 YAD1A190	**001 589 73 21 00 Hand Vacuum Pump**
 YAD1A210	**001 589 76 21 00 Compression Pressure Tester**
 YAD1A220	**120 589 02 09 00 Spark PlugWrench**
 YAD1A200	**610 589 65 09 00 Socket**