DV11
DIESEL ENGINE

Shop Manual

65.99897-8111

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This documentation may include attachments and optional equipment that is not available in your machine's package. Please call your distributor for additional items that you may require.

Illustrations used throughout this manual are used only as a representation of the actual piece of equipment, and may vary from the actual item.

1.2. Engine Specifications

Items \ Engine model		DV11
Engine type		Water-cooled, 4 cycle V-type 90°, Turbo charged & intercooled
Combustion chamber type		Direct injection type
Cylinder liner type		Wet type
Timing gear system		Gear driven type
No. of piston ring		2 compression ring, 1 oil ring
No. of cylinder-bore x stroke (mm)		6 - 128 x 142
Total piston displacement (cc)		10,964
Compression ratio		17.0 : 1
Engine dimension (length x width x height) (mm)		1,060 x 1,039 x 1,345
Engine weight (kg)		882
Rotating direction (from flywheel)		Counter clockwise
Firing order		1 - 4 - 2 - 5 - 3 - 6
Fuel high pressure pump type		Bosch CP3.4 fuel high pressure pump type
Engine control type		Electric control type(ECU)
Injector type		Multi-hole(8 x ϕ 0.197 Bosch DLLA146)
Fuel injection pressure (kg/cm^2)		250bar (operating pressure 1,600bar)
Valve clearance	Intake valve	0.4
	Exhaust valve	0.5
Intake valve	Open at	24° (B.T.D.C)
	Close at	30° (A..B.D.C)
Exhaust valve	Open at	52.5° (B.B.D.C)
	Close at	14.5° (A.T.D.C)
Fuel filter type		Full-flow (cartridge)
Oil pressure (kg/cm^2)	at idle speed	1.0 ~ 3.0
	at rated speed	3.0 ~ 5.5
Using lubrication oil		ACEA-E5 (API CI-4 class)
Lubrication method		Full forced pressure feed type
Oil pump type		Gear type driven by crankshaft
Oil filter type		Full-flow (cartridge)
Lubricating oil capacity (max./min.) (lit)		41 / 27
Oil cooler type		Water cooled
Oil pressure indicator		Oil pressure sensor

2.3.1. Cylinder block

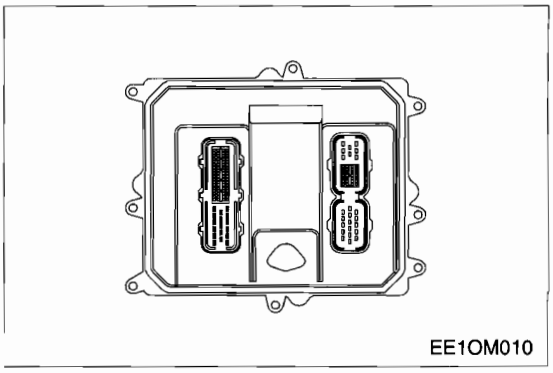
- The cylinder block is a single piece of alloy cast iron. To increase its stiffness, it is extended to a level below the crankshaft center line. The engine has replaceable wet cylinder liners and individual cylinder heads.

2.3.2. Piston/ Connecting rod/ Crank assembly

- The forged crankshaft has screwed-on the balance weights. Radial seals with replaceable wearing rings on crankshaft and flywheel are provided to seal the crankcase penetrations.
- The connecting rods are die-forged, diagonally split and can be removed through the top of the cylinders together with the pistons. Crankshaft and connecting rods run in steel-backed lead bronze ready-to fit type bearings.

2.3.3. Electric control unit : ECU

- This electric control unit is used to control the engine feed fuel.
- ECU is connected with various sensors, control the engine to keep the optimum condition on the basis of input values from this sensors.



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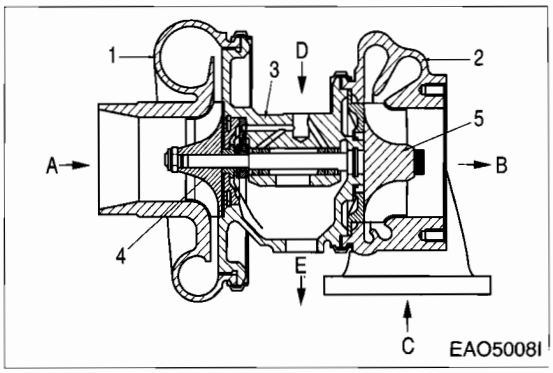
CAUTION:

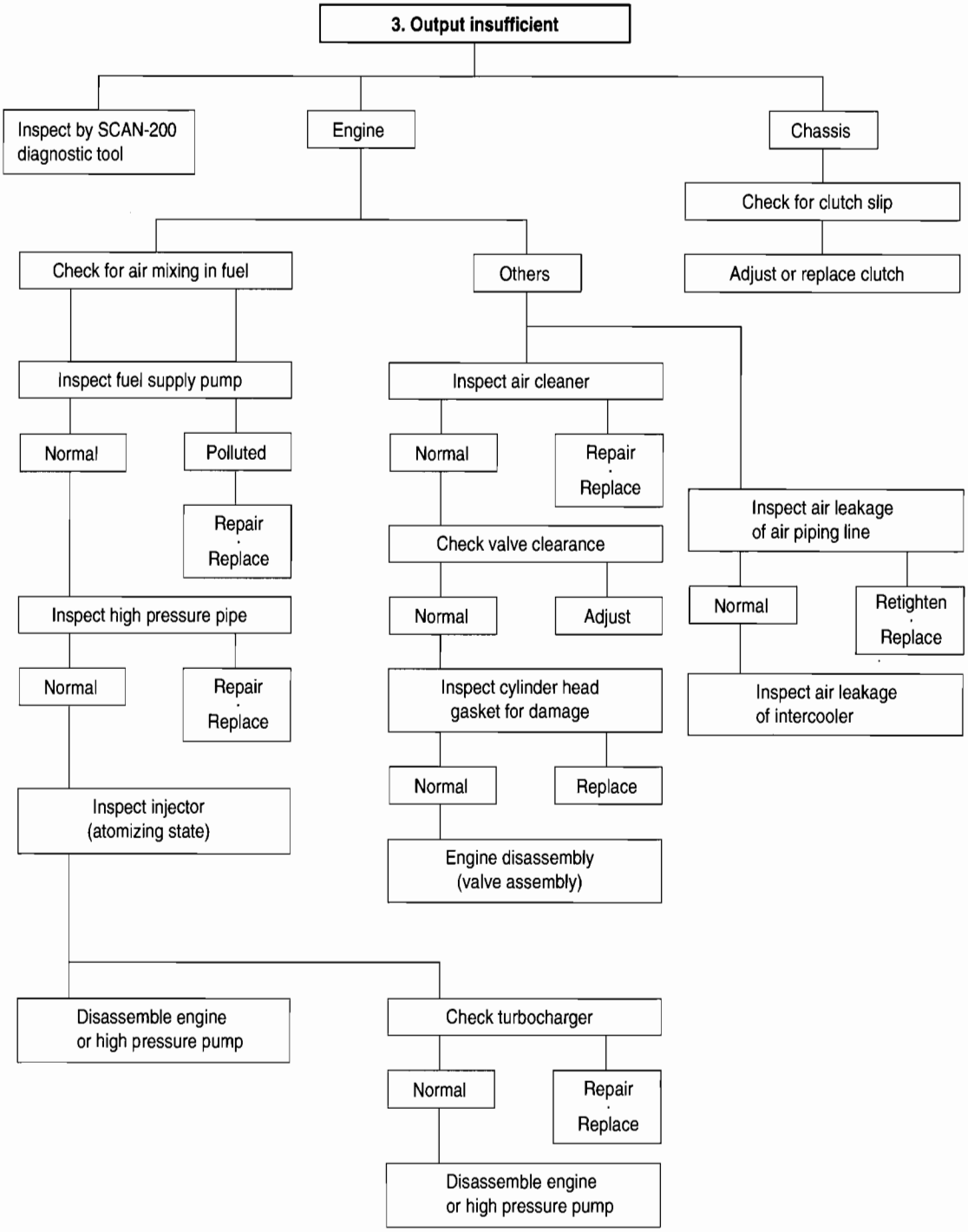
Do not connect or disconnect the ECU to/from the wiring harness without first removing the negative (-) battery cable from the battery. Do not perform remove the inner parts of ECU.

2.3.20. Turbo charger



- The turbocharger needs not any specific maintenance.
- Every time of engine replacement, a leakage or clogging of oil pipes should be inspected.
- Air cleaner should be maintained carefully for nut or foreign material not to get in. Periodic inspection should be applied on the compressed air and exhaust gas pipes, For leaking air will bring the overheat engine, an immediate repair must be done.
- During the operation that is surrounded by the dust and oil mixed air, frequent cleaning must be done on the impellers. Tear down the impeller casing (attention: be careful not to bend) and must clean with non-acid solvent solution. If necessary, use plastic scraper If impeller is severely polluted, dip the impeller into solution and may be better to clean it with stiff brush

  Then one thing to beware is to dip only impeller part and so do not support by impeller but bearing housing.


3. Output insufficient
Inspect by SCAN-200 diagnostic tool
Engine
Chassis
Check for clutch slip
Adjust or replace clutch
Check for air mixing in fuel
Others
Inspect fuel supply pump
Normal
Polluted
Repair
Replace
Inspect high pressure pipe
Normal
Repair
Replace
Inspect injector (atomizing state)
Disassemble engine or high pressure pump
Inspect air cleaner
Normal
Repair
Replace
Check valve clearance
Normal
Adjust
Inspect cylinder head gasket for damage
Normal
Replace
Engine disassembly (valve assembly)
Check turbocharger
Normal
Repair
Replace
Disassemble engine or high pressure pump
Inspect air leakage of air piping line
Normal
Retighten
Replace
Inspect air leakage of intercooler

3. Disassembly and Reassembly of Major Components

3.1. Engine Disassembly

3.1.1. General precautions

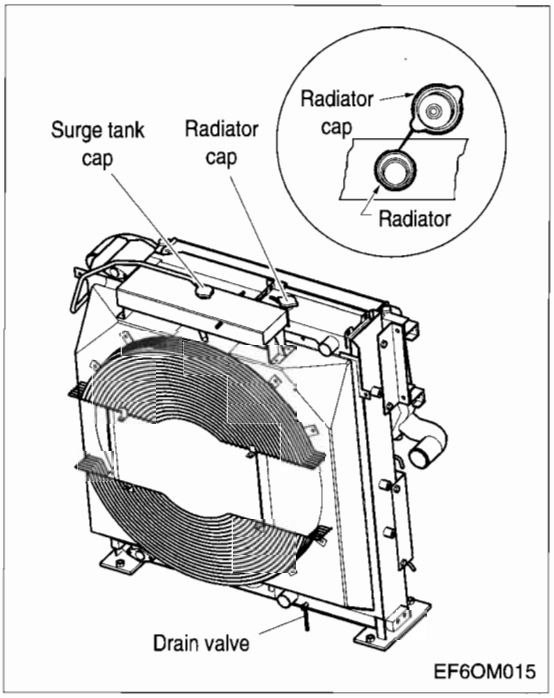
- For the various tool storage before disassembly and parts storage after disassembly, the shelf for parts is prepared.
- At the time of disassembly and reassembly, do the work with the naked and clean hand, and also the working place must be maintained clean.
- The torn parts after disassembly must be kept not to collision each other.
- In disassembling, torn parts should be laid in disassembled order.
- Before performing service operation, disconnect the grounding cable from the battery for reducing the chance of cable damage and burning due to short-circuiting.

3.1.2. Cooling water

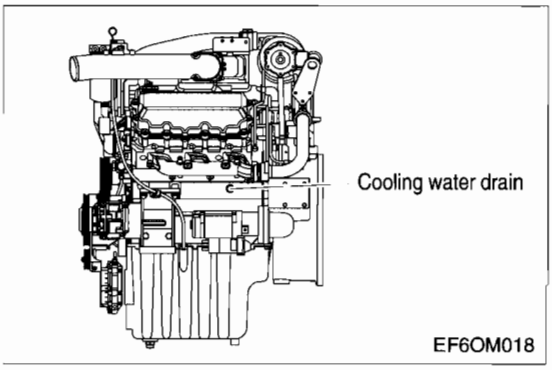
- Remove the radiator cap. Open the drain valve at the radiator lower part to drain the coolant as the right figure.

CAUTION :

When removing surge tank cap or radiator filler cap while the engine is still hot, cover the cap with a rag, then turn it slowly to release the internal steam pressure. This will prevent a person from scalding with hot steam spouted out from the filler port.

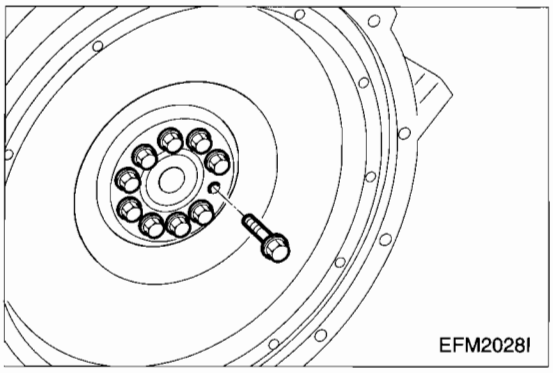


- Remove the cooling water drain plug from the cylinder block and oil cooler, various pipes, etc. and let the cooling water discharge into the prepared vessel.

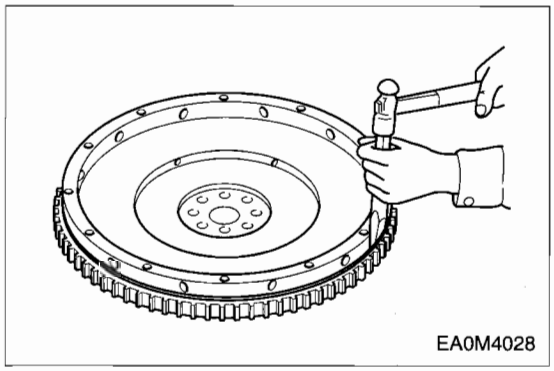


3.1.30. Fly wheel

- Remove the flywheel fixing bolts in the order of disassembling and remove the flywheel.



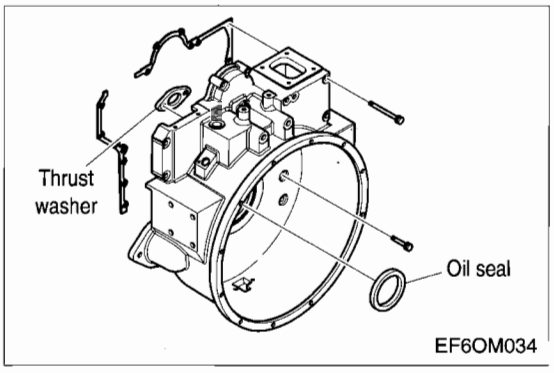
- Remove the flywheel ring gear.
- Heat the ring gear evenly with a gas burner (up to 200°C) to invite volumetric expansion.
- Tapping around the edges of the ring gear with a hammer and brass bar to remove it.



CAUTION :
Do not damage the flywheel.

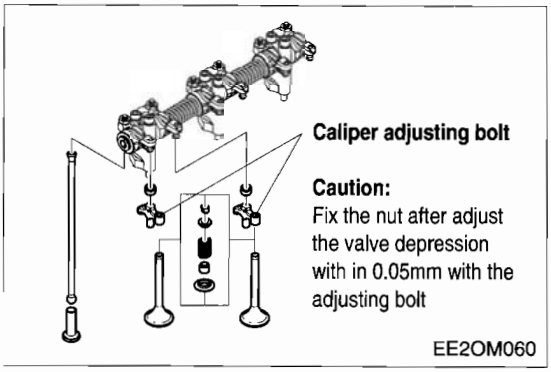
3.1.31. Flywheel housing

- Remove the flywheel housing fixing bolts and take them out.
- Remove the oil seal from the flywheel housing.



a) Rocker arm

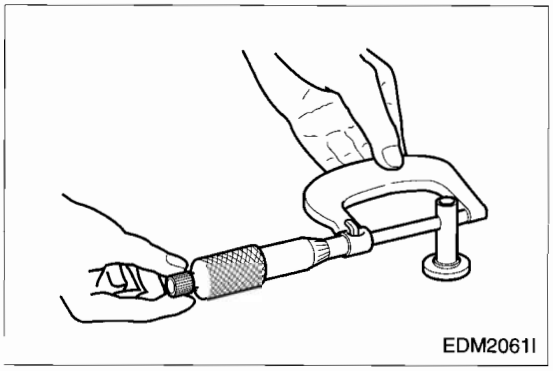
● Inspect the rocker arm surface that contacts with the valve stem for any scratch, step wear and correct the minor degree of wear with an oil stone or the fine grinding paper and replace if they are severe.



b) Tappet & push rod

● By means of outside micrometer, measure the clearance of the tappet and tappet holes of the cylinder block. If the value is beyond the specified limit, replace tappets.

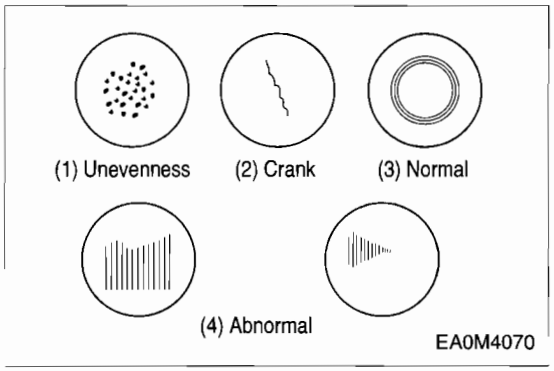
Standard	Φ 19.944 ~ Φ 19.965 mm



<Clearance of block and tappet>

Standard	Limit
0.035 ~ 0.077 mm	0.13 mm

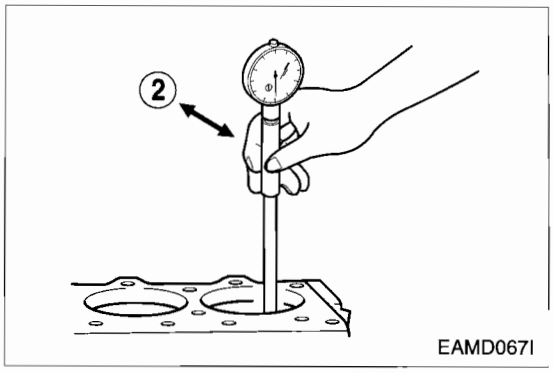
● By inspecting the tappet surface that contacts with the camshaft's cam for any crack and scratch etc., and if the degree is small, correct them with an oil stone or the grinding paper but if severe replace them.



a) Cylinder bore diameter

- Measure cylinder liner inside diameter at 3 points (cylinder top ring contacting face, middle, and oil ring contacting face on BDC) in a direction at an angle of 45°. Take the mean value with the largest and smallest values excepted.

Standard	Φ 127.990 ~ Φ 128.010 mm



b) Piston and cylinder clearance

- The clearance is computed by subtracting the piston outside diameter from the cylinder liner inside diameter. Replace either piston or cylinder liner, whichever damaged more, if the clearance is beyond the specified limit.

Standard	0.233 ~ 0.271 mm

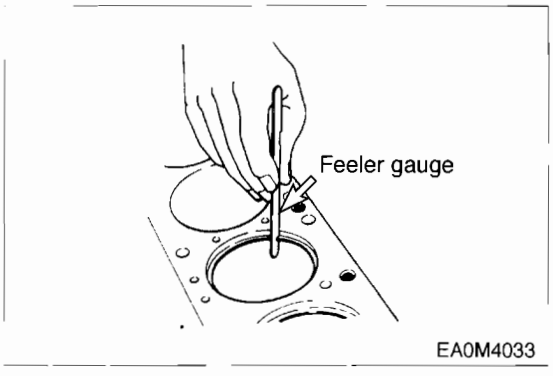
c) Piston ring and ring groove

- In case of piston ring's wear, damage or engine overhaul, replace piston rings.

d) Piston ring cut part clearance

- Measure the piston ring cut part.
- Insert the piston ring at the cylinder liner's upper part perpendicularly.
- With a feeler gauge, measure the gap clearance of piston ring.
- If the measured value exceeds the limit value, replace it

	Standard	Limit
Top ring	0.35 ~ 0.55 mm	1.5 mm
2nd ring	0.80 ~ 0.95 mm	1.5 mm
Oil ring	0.40 ~ 0.70 mm	1.5 mm

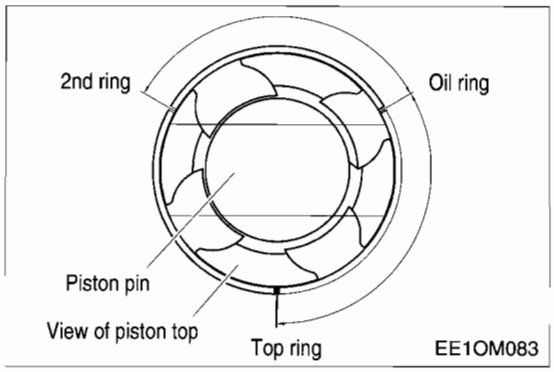


- Apply lubricating oil to the inside of oil seal and tighten the fixing bolts in the zigzag method.

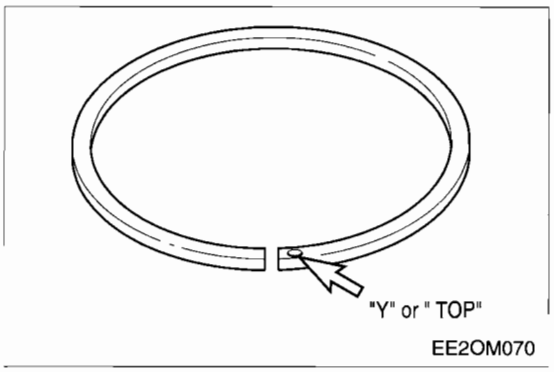
Torque	2.2 kg.m

3.3.10. Piston

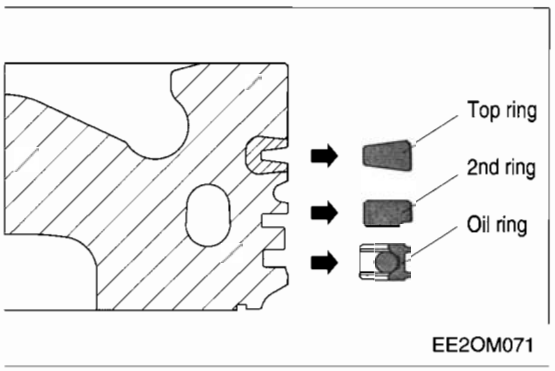
- Line up the piston assembly in the order of cylinders and fit the bearings to the connecting rods and bearing caps. However, take care not to swap between the connecting rods and bearing caps.
- Coat the pistons and connecting rod bearings sufficiently with clean engine oil.



- By means of a special tool, insert the piston rings and adjust the angles between the ring gaps at 120°.
- Identify the mark "**Y**" or "**TOP**" on the ring end to prevent the top and bottom of the piston ring from being interchanged and make the marked portion face upward.
  (The surface marked as "**Y**" or "**TOP**" is upper surface.)



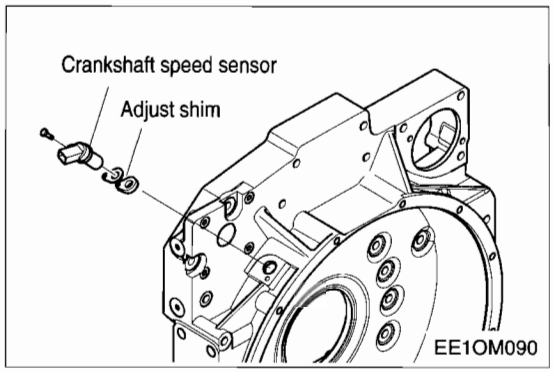
- Push in the piston with hands or wooden bar into cylinder. (Be careful for piston and rings not be damaged.
- Pushing the piston down, rotate the crankshaft about 180° and fit the bearing cap to the connecting rod.



3.3.25. Crankshaft speed sensor

- Measure the clearance of the assembling part of the sensor and fly wheel, then assemble it with the adjust shim.

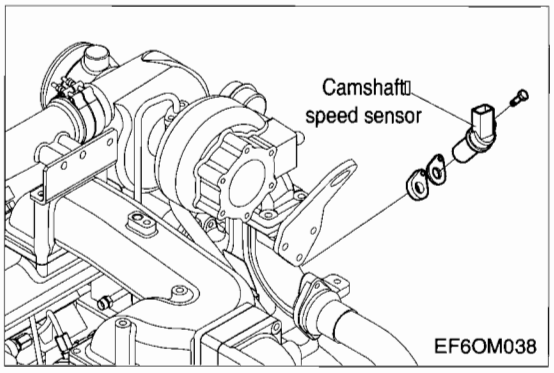
Clearance	1.0 ± 0.1 mm
Torque	1.0 kg.m



3.3.26. Camshaft speed sensor

- Measure the clearance of the assembling part of the sensor and timing gear, then assemble it with the adjust shim.

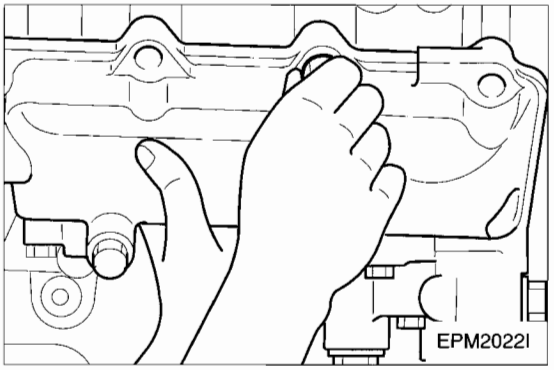
Clearance	1.0 ± 0.1 mm
Torque	1.0 kg.m



3.3.27. Oil cooler

- Attach a gasket on the surface in the oil cooler housing where the oil cooler is installed.
- Tighten the oil cooler with fixing bolts.
- Install the oil cooler assembly by tightening the fixing bolts in the zigzag order.

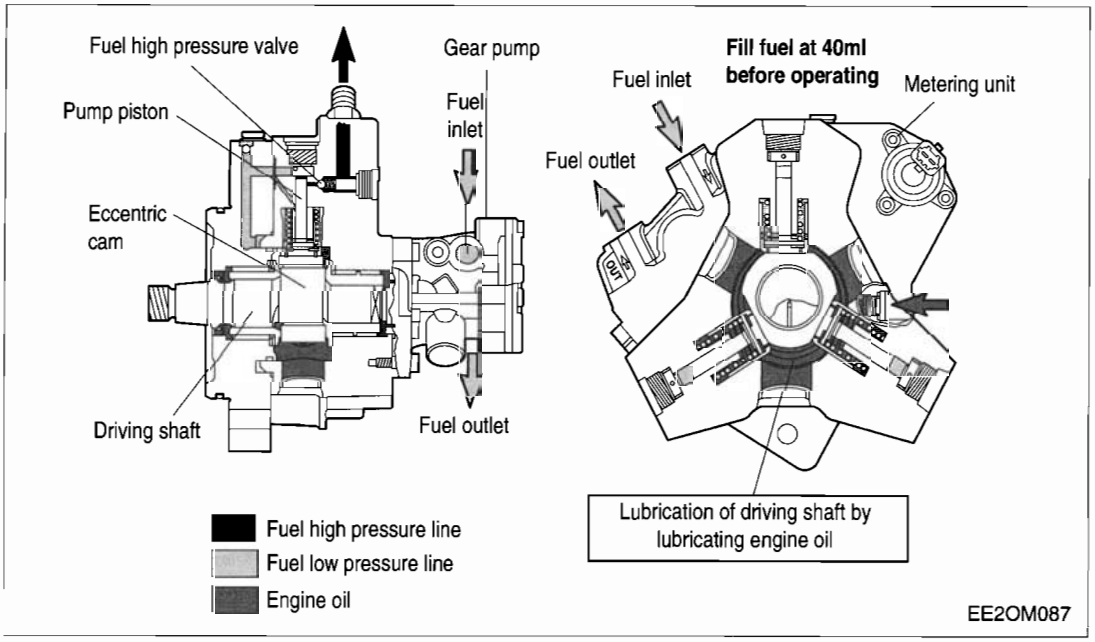
Torque	4.4 kg.m



3.4.11. Construction of the fuel high pressure pump

1) Function

The high pressure pump is the interface between the low-pressure and the high pressure stages. Under all operating conditions, it is responsible for providing adequate high pressure fuel throughout the vehicle's complete service life. This also includes the provision of extra fuel as needed for rapid starting and for rapid build-up of pressure in the rail. The high pressure pump continually generates the system pressure as needed in the common rail.



2) Construction of the fuel high pressure pump

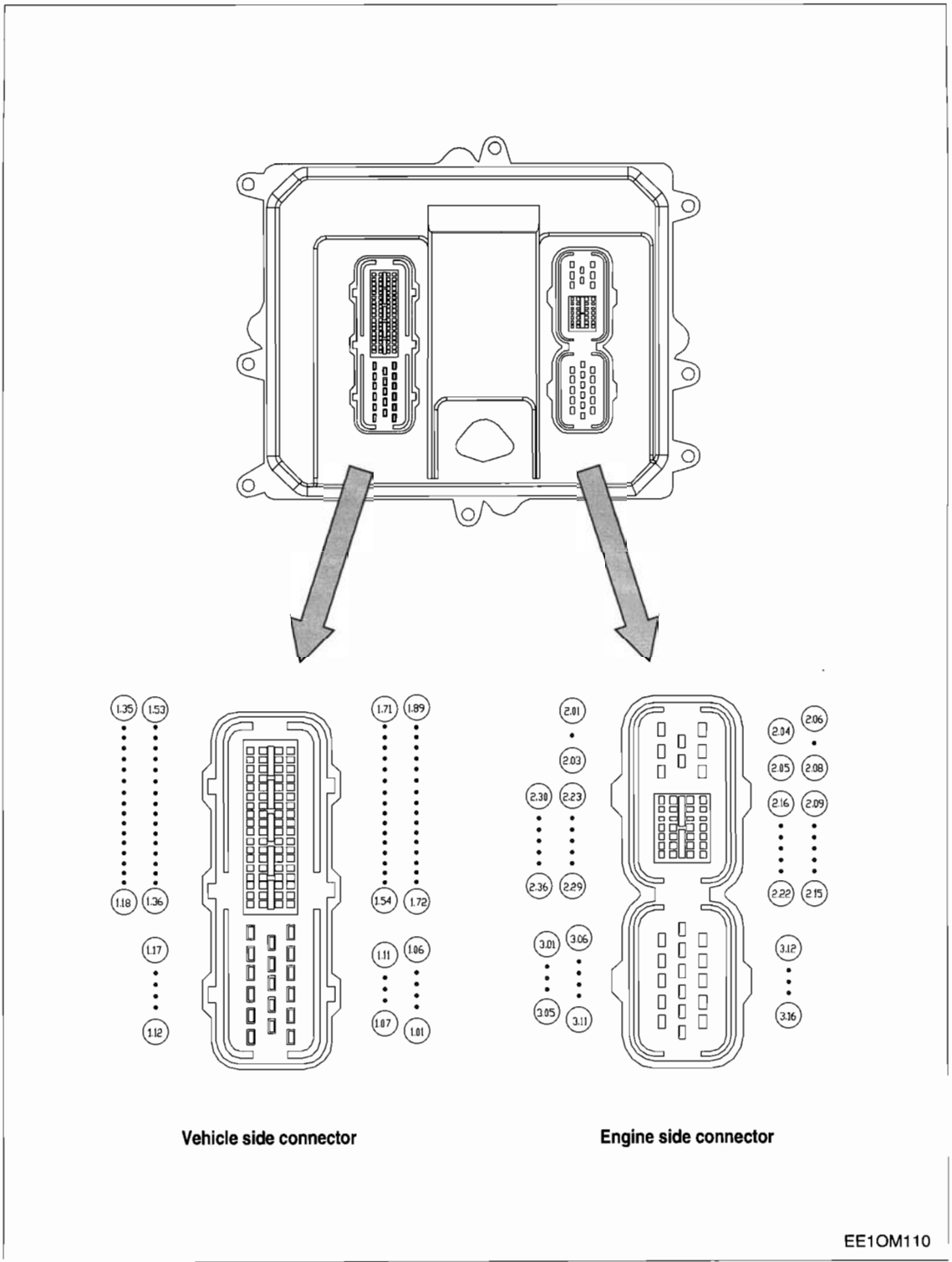
The fuel is compressed with three radially arranged pump pistons which are at an angle of 120° to each other. Since three delivery strokes take place for every revolution, only low peak drive torques are generated so that the stress on the pump drive remains uniform. The driving torque of the common rail is only about 1/9 of torques to drive existing pump system.

3) Method of operation

The fuel supply pump fuel from the tank to the high pressure pump through the fuel inlet and the safety valve. It forces the fuel through the safety valve into the high pressure pump. The driveshaft with its eccentric cams moves the piston of the pump up and down in accordance with the shape of the cam.

As soon as the delivery pressure exceeds the safety valve's opening pressure (0.5 ~ 0.5 bar), the fuel supply pump can force fuel through the high pressure pump's inlet valve into the pumping-element chamber whose pump piston is moving downwards(suction stroke). The inlet valve closes when the pump piston passes through the bottom dead center (BDC) and, since it is impossible for the fuel in the pumping-element chamber to escape, it can now be compressed beyond the delivery pressure. The increasing pressure opens the outlet valve as soon as the rail pressure is reached, and the compressed fuel enters the high pressure circuit. The pump piston continues to deliver fuel until it reaches TDC, after which the pressure collapses so that the outlet valve closes. The fuel

3.5.3. Connector of electrical control unit (ECU)



Fault code	Contents of trouble	Grade	Condition of occurring
E046	Initialization is not good after power supply to ECU	C	ECU initialization is abnormal
E047	Pressure limit valve of common rail is opened by excessive rail pressure	B	Pressure limit value is opened compulsory when rail pressure is occurred at excessive pressure more than rail pressure or high pressure pump
E048	Power supplying source is abnormal	N	Battery voltage is abnormal : ECU, battery and alternator is abnormal
E049	Supplying voltage of injector (#1,5,3) is abnormal	B	* Injector cable / connector is abnormal or ECU is trouble
E051	Supplying voltage of injector (#6,2,4) is abnormal	B	
E058	Relation to connecting of injector #1 harness is abnormal	B	* Injector cable / connector is abnormal
E059	Relation to connecting of injector #5 harness is abnormal	B	
E061	Relation to connecting of injector #3 harness is abnormal	B	
E062	Relation to connecting of injector #6 harness is abnormal	B	
E063	Relation to connecting of injector #2 harness is abnormal	B	
E064	Relation to connecting of injector #4 harness is abnormal	B	
E066	Relation to air heater lamp is abnormal	N	Lamp / harness is abnormal
E072	Air heater operation relay is abnormal	C	Air heater relay / harness is abnormal
E083	Relation to high pressure pump control is abnormal	C	Fuel metering unit of high pressure pump / harness is abnormal
E091	Abnormal starting	B	Starting procedure is abnormal, ECU is abnormal, power supplying is abnormal
E092	Ignition of #1 cylinder is not good	C	* Injector is abnormal, compression pressure is a drop, camshaft / crankshaft speed sensor signal is abnormal
E093	Ignition of #5 cylinder is not good	C	
E094	Ignition of #3 cylinder is not good	C	
E095	Ignition of #6 cylinder is not good	C	
E096	Ignition of #2 cylinder is not good	C	
E097	Ignition of #4 cylinder is not good	C	

4.5. Engine Components Check after Long Time Running

- The purpose of an engine tune-up is to restore power and performance that's been lost through wear, corrosion or deterioration of one or more parts or components.
- In the normal operation of an engine, these changes can take place gradually at a number of points, so that it's seldom advisable to attempt an improvement in performance by correction of one or two items only. Thorough procedure of analysis and correction, it is desirable to change or correct of all items affecting power and performance.
- In case that the engine is perform in advance the prevention against trouble, the engine can be run safely during a long time as that time , there can be used more reliably.
- Economical, trouble-free operation can better be ensured if a complete tune-up is performed once every years, preferably in the spring.
- Below components that affect power and performance to be checked are:.
  - Components affecting intake & exhaust
    Air cleaner, inter-cooler, turbo charger, silencer, etc
  - Components affecting lubrication & cooling
    Air & oil filter, anti- freeze, etc

4.6. Maintenance and Care

4.6.1. Periodical Inspection and Maintenance

In order to insure maximum, trouble-free engine performance at all times, regular inspection, adjustment and maintenance are vital.

- Daily inspections in bellow figure should be checked every day.
- The maintenance should be executed thoroughly at regular intervals.
  (refer to appendix "General engine inspection cycle".)

4.6.2. Exchanging of lubrication oil

Engine oil and the oil filter are important factors affecting engine life. They affect ease of starting, fuel economy, combustion chamber deposits and engine wear.

At the end of the break-in period, change the oil sump oil and replace the oil filter cartridge.

● **Replacing thermostat and precautions for handling**

(1) Precautions for handling

The wax pallet type thermostat does not react as quickly as bellows type one to a variation of temperature of coolant. Such relatively slow reaction is mainly due to the large heat capacity of the wax pellet type thermostat. Therefore, to avoid a sharp rise of coolant temperature, it is essential to idle the engine sufficiently before running it. In cold weather, do not run the engine at overload or overspeed it immediately after engine starting.

(2) When draining out or replenishing coolant, do it slowly so that air is bled sufficiently from the entire cooling system.

(3) Replacing thermostat

If the thermostat is detected defective, retrace with a new one.

5.3.6. Periodical servicing

Make it a rule to check the turbocharger assembly for condition and contamination periodically.

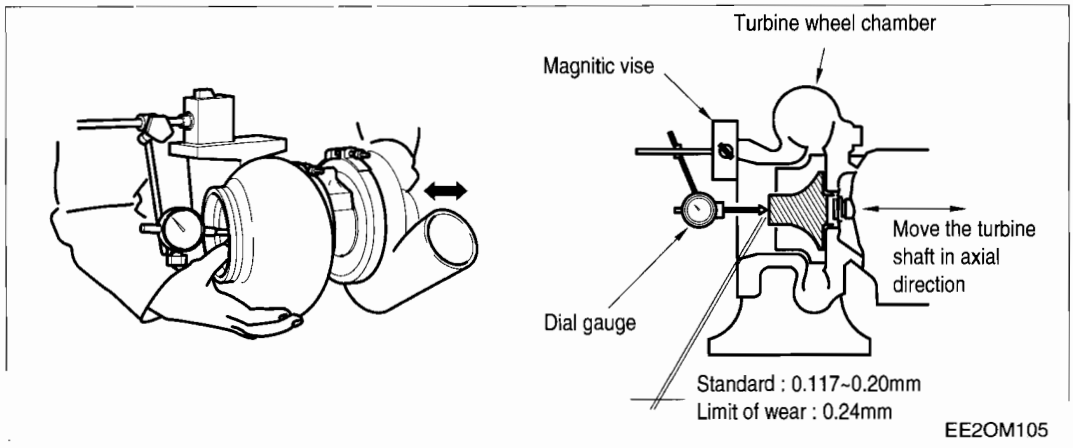
1) Guide for checking the rotor for rotating condition

The inspection of the rotor assembly for rotating condition should be performed by the degree of unusual sound. If a sound detecting bar is used, install its tip on the turbocharger housing and increase the engine revolutions slowly. If a high-pitch sound is heard continuously, it means that the rotor assembly is not normal. In this case, as the metal bearing and rotor are likely to be in abnormal conditions, the turbocharger should be replaced or repaired.

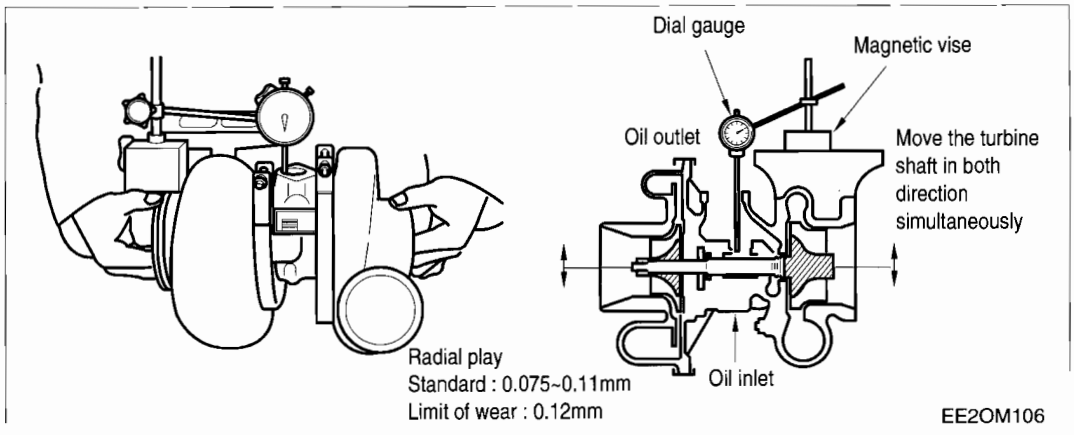
2) Guide for checking rotor end play

Disassemble the turbocharger from the engine, then check the rotor axial play and radial play. When disassembling the turbocharger, be sure to plug the oil inlet and outlet ports with taps, etc.

(1) Rotor axial direction end play



(2) Rotor radial direction end play



(3) If the measured axial and radial end plays are beyond the limit of wear, replace or repair the turbocharger.

● **Maintenance specification table**

(unit : mm)

Group	Part	Inspection item		Stand value for assembly	Limit for use	Correction	Remark
Cylinder block	Cylinder block & liner	Inside diameter of cylinder liner		Φ 127.990 ~ Φ 128.010	Φ 128.122	Replace liner	Measure unworn portion beneath the rim of the upper side
		Liner's roundness & columness (upper)		0.005	-		From top up to 168mm
		Liner's roundness & columness (lower)		0.008	-		From bottom up to 85mm
		Amount of liner projection		0.04~0.08	-		Measure at upper side of cylinder block
		The flatness of upper surface of cylinder block		0.03	-	Correct with a surface grinder	Referenced length : 150mm
		Hydraulic test for 1 minute (kg/cm²)		4	-	Replace if leaky	Temperature 70°C
	Cylinder head & valve	Valve seat depression	Intake	-0.39 ~ -0.41	0.55	Replace valve seat	Depression of valve from lower face of cylinder head
			Exhaust	-0.39 ~ -0.41	0.55		
		Cylinder head height		116.9~117.1	116.4	Replace cylinder head	
		The flatness of lower surface of cylinder head		0.08	0.1		
		Thick of cylinder head gasket(at assembly status)		1.215~1.285	-		
		Hydraulic test for 1 minute (kg/cm²)		4	-	Replace if leaky	Temperature 70°C
Major moving parts	Piston	Outer diameter of piston		Φ 127.739 ~ Φ 127.757	-	Replace liner	Measure at 56.8 mm away from piston head(long diameter)
		Clearance between piston and liner		0.233 ~ 0.271	0.35	Replace one worn more	
		Inner diameter of piston pin		Φ 46.010 ~ Φ 46.016	-		Standard diameter
		Width of piston ring grooves	Top ring	3.5	-	Replace piston if groove width is beyond specified value	Measure at 125mm of top ring groove
			2nd ring	3.040~3.060	-		
			Oil ring	4.020~4.040	-		
		Piston projection from cylinder block upper surface		0 ~ 0.12	-	Must exist	Measure unworn portion beneath the rim of the upper side
		Permissible weight difference of each piston		50g	50g ↓	Replace piston	
	Piston ring	Width of piston ring	Top ring	3.34~3.36	-	Replace ring	
			2nd ring	2.975~2.990	-		
			Oil ring	3.97~3.99	-		
		Piston ring gap	Top ring	0.35~0.55	1.5	Replace ring	Standard gauge inside diameter : Φ 128
			2nd ring	0.80~0.95	1.5		
			Oil ring	0.40~0.70	1.5		