



DE08TS Diesel Engine

Specification

System Operation

Testing & Adjusting

D100, D120, D150
D110S-5, D130S-5, D160S-5

Forklifts

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Read and understand all safety precautions and warnings before operating or performing lubrication, maintenance and repair on this product.

Basic safety precautions are listed in the "Safety" section of the Service or Technical Manual. Additional safety precautions are listed in the "Safety" section of the owner/operation/maintenance publication. Specific safety warnings for all these publications are provided in the description of operations where hazards exist. WARNING labels have also been put on the product to provide instructions and to identify specific hazards. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons. Warnings in this publication and on the product labels are identified by the following symbol.



Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

DOOSAN cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by DOOSAN is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. DOOSAN dealers have the most current information available.

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Special Tool List

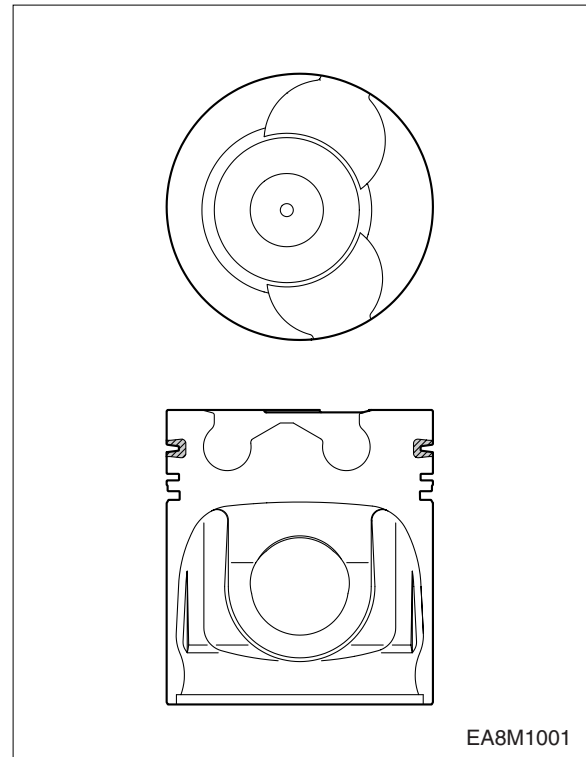
GENERAL INFORMATION

General Repair Instructions

1. Before performing service operation, disconnect the grounding cable from the battery for reducing the chance of cable damage and burning due to short-circuiting.
2. Use covers for preventing the components from damage or pollution.
3. Engine oil and anti-freeze solution must be handled with reasonable care as they cause paint damage.
4. The use of proper tools and special tools where specified is important to efficient and reliable service operation.
5. Use genuine DOOSAN parts necessarily.
6. Used cotter pins, gaskets, O-rings, oil seals, lock washer and self-lock nuts should be discarded and new ones should be prepared for installation as normal function of the parts can not be maintained if these parts are reused.
7. To facilitate proper and smooth reassemble operation, keep disassembled parts neatly in groups. Keeping fixing bolts and nut separate is very important as they vary in hardness and design depending on position of installation.
8. Clean the parts before inspection or reassembly. Also clean oil ports, etc. using compressed air to make certain they are free from restrictions.
9. Lubricate rotating and sliding faces of parts with oil or grease before installation.
10. When necessary, use a sealer on gaskets to prevent leakage.
11. Carefully observe all specifications for bolts and nuts torques.
12. When service operation is completed, make a final check to be sure service has been done properly.
13. Please refer to SB2088E00 manual(D1146) for the disassembly and assembly.

Engine Specific Character

OMEGA combustion bowl



The OMEGA combustion bowl is a unit designed to perform high efficiency, low emission combustion.

As the rim around the combustion bowl port of the upper of the piston has been machined in a smaller size than the interior of the combustion bowl, strong swirl is produced in the combustion bowl and strong squish flow makes the fuel be mixed more sufficiently with air.

Due to the application of OMEGA combustion system and optimal utilization of intake and exhaust port configuration within the cylinder head, the DE08TS diesel engines discharge very low level of hazardous exhaust gases such as smoke, nitrogen oxide, hydrocarbon, or carbon monoxide and thus ensure high performance and low fuel consumption.

Engine Specifications

Specification

Engine Model		DE08TS
Items		
Engine type		4 cycle in-line, Water-cooled type Turbo charged
Combustion chamber type		Direct injection type
Cylinder liner type		Replaceable dry liner
Timing gear system		Gear driven type
No. of piston ring		Compression ring 2, oil ring 1
No. of cylinder-bore stroke (mm)		6 - 111 139
Total piston displacement (cc)		8,071
Compression ratio		19.5 : 1
Engine dimension (length width height) (mm)		1,166 727 1,159
Engine weight (kg)		800
Rotating direction (viewed from flywheel)		Counter clockwise
Fuel injection order		1 - 5 - 3 - 6 - 2 - 4
Fuel injection timing (B.T.D.C static)		9°
Injection pump type		Bosch in-line "AD" Type
Governor type		Mechanical governor pe (RSV)
Injection nozzle type		Multi-hole type (8 hole)
Fuel injection pressure (kg/cm ²)		180 / 280
Compression pressure (kg/cm ²)		28 (at 200 rpm)
Intake and exhaust valve clearance (at cold) (mm)		0.3
Intake valve	Open at	16° (B.T.D.C)
	Close at	36° (A.B.D.C)
Exhaust valve	Open at	46° (B.B.D.C)
	Close at	14° (A.T.D.C)
Lubrication method		Full forced pressure feed type
Oil pump type		Gear type driven by crankshaft
Oil filter type		Cartridge type
Lubricating oil capacity (max. / min.) (lit)		16 / 13
Oil cooler type		Water cooled
Water pump		Centrifugal type driven by belt
Cooling Method		Fresh water forced circulation
Cooling water capacity (engine only) (lit)		14
Thermostat type		Wax pallet type (71 ~ 85°C)

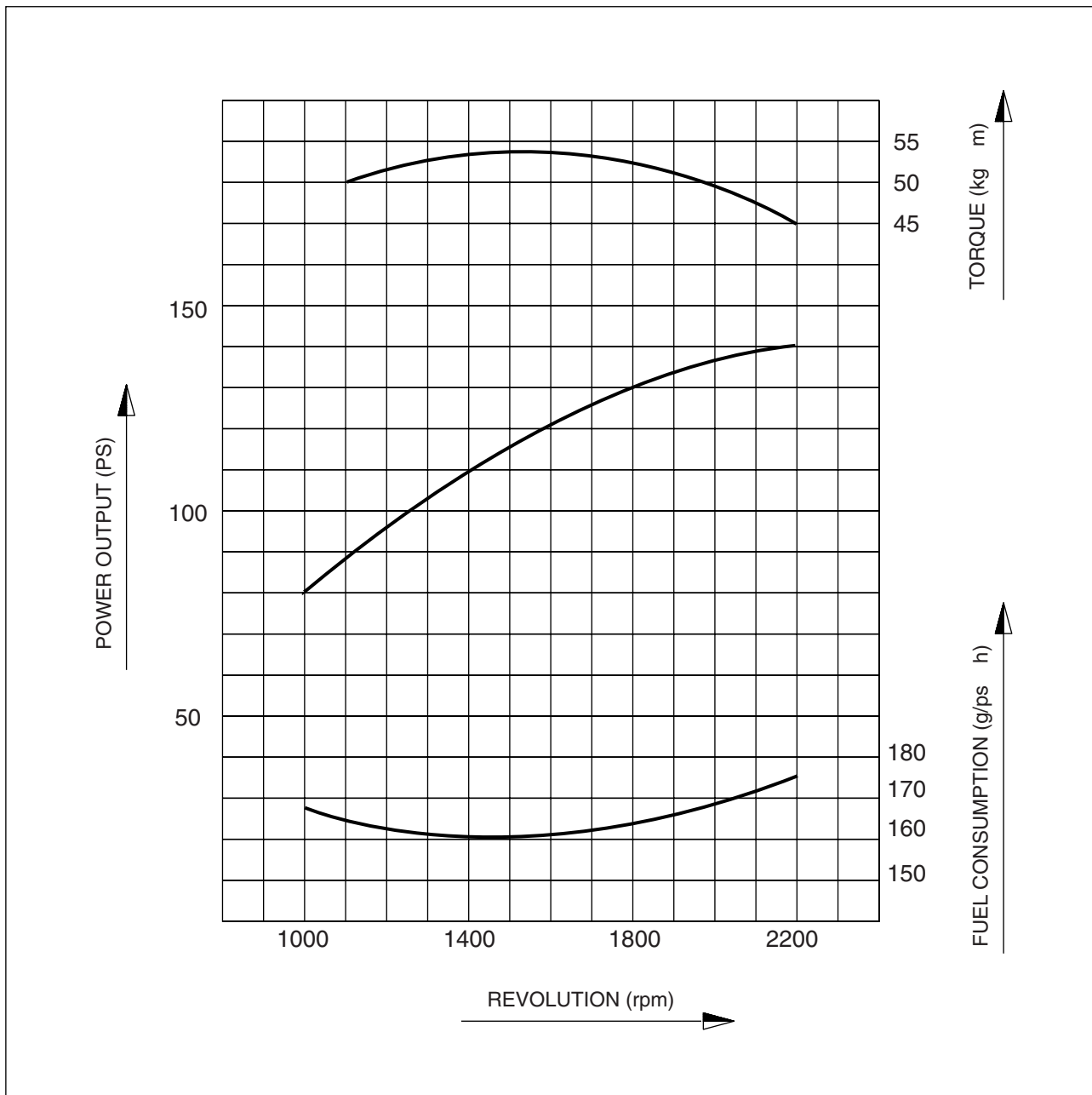
Remove & Install Forks

Production tolerance : 5%

Engine model		Condition					
Model	Suffix	Injection timing (BTDC°)	Power (Ps / rpm)	Torque (kg.m / rpm)	Low idle (rpm)	High idle (rpm)	Remark
DE08TS	EC DFA	9	140 / 2,200	55 / 1,400	750	2,370	TIER-II & STAGE-II
	EC DFB	9	160/2,200	63/1,400	750	2,370	

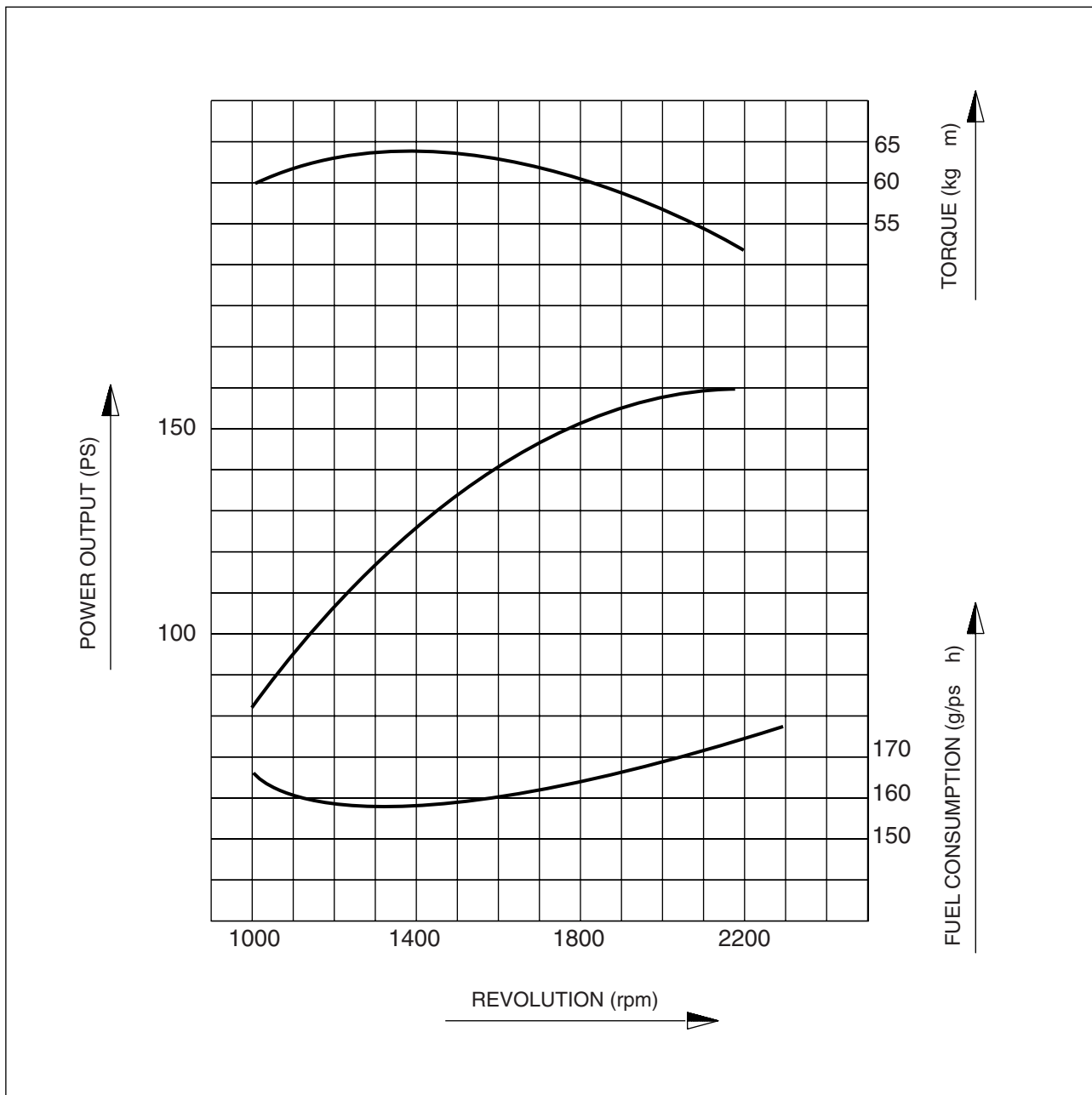
* Note : All data are based on operation without cooling fan at KS-R1004.

Performance curve (DE08TS - 140PS)



Standard	KS-R1004
Rated Power	140 ps / 2,200 rpm
Max Torque	55 kg.m / 1,400 rpm
Fuel consumption	180 g / PS.h

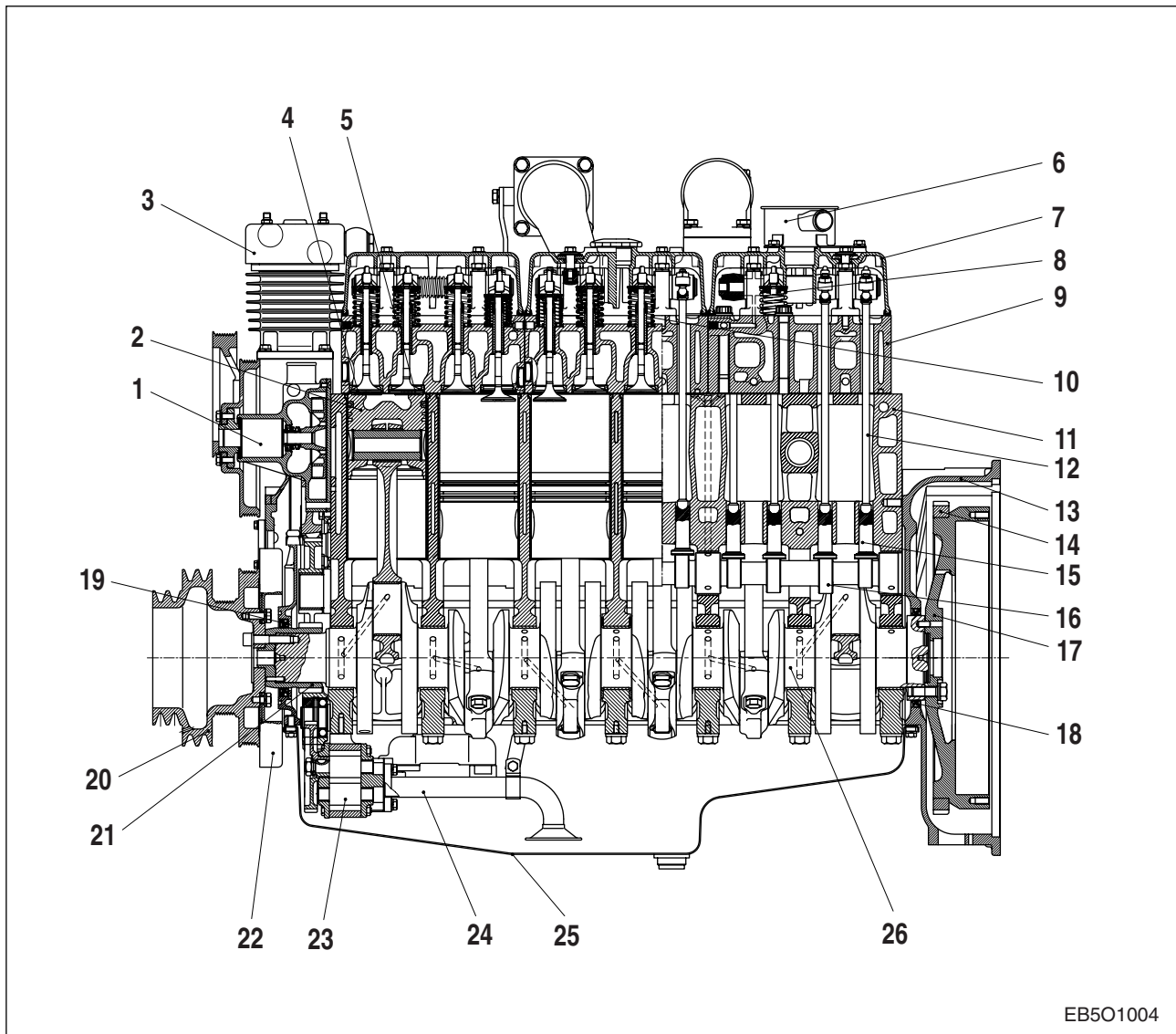
Performance curve (DE08TS - 160PS)



Standard	KS-R1004
Rated Power	160 ps / 2,200 rpm
Max Torque	63 kg.m / 1,400 rpm
Fuel consumption	180 g / PS.h

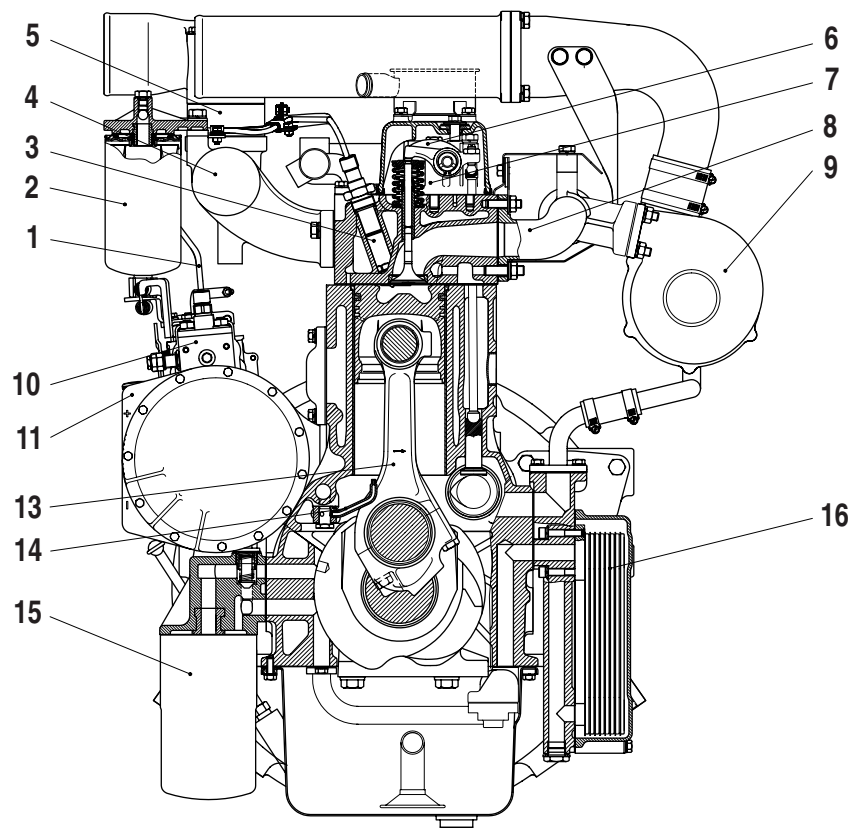
Engine Assembly

Engine sectional view (longitudinal)



- | | | |
|---------------------------------|-------------------------|------------------------|
| 1. Water pump | 10. Intake valve spring | 19. Oil seal (Front) |
| 2. Piston | 11. Cylinder block | 20. Crank shaft pulley |
| 3. Air compressor (if equipped) | 12. Push rod | 21. Crank shaft gear |
| 4. Intake valve | 13. Flywheel housing | 22. Vibration damper |
| 5. Exhaust valve | 14. Ring gear | 23. Oil pump |
| 6. Breather | 15. Tappet | 24. Oil suction pipe |
| 7. Cylinder head cover | 16. Cam shaft | 25. Oil pan |
| 8. Exhaust valve spring | 17. Fly wheel | 26. Crank shaft |
| 9. Cylinder head | 18. Oil seal (Rear) | |

Engine sectional view (cross)

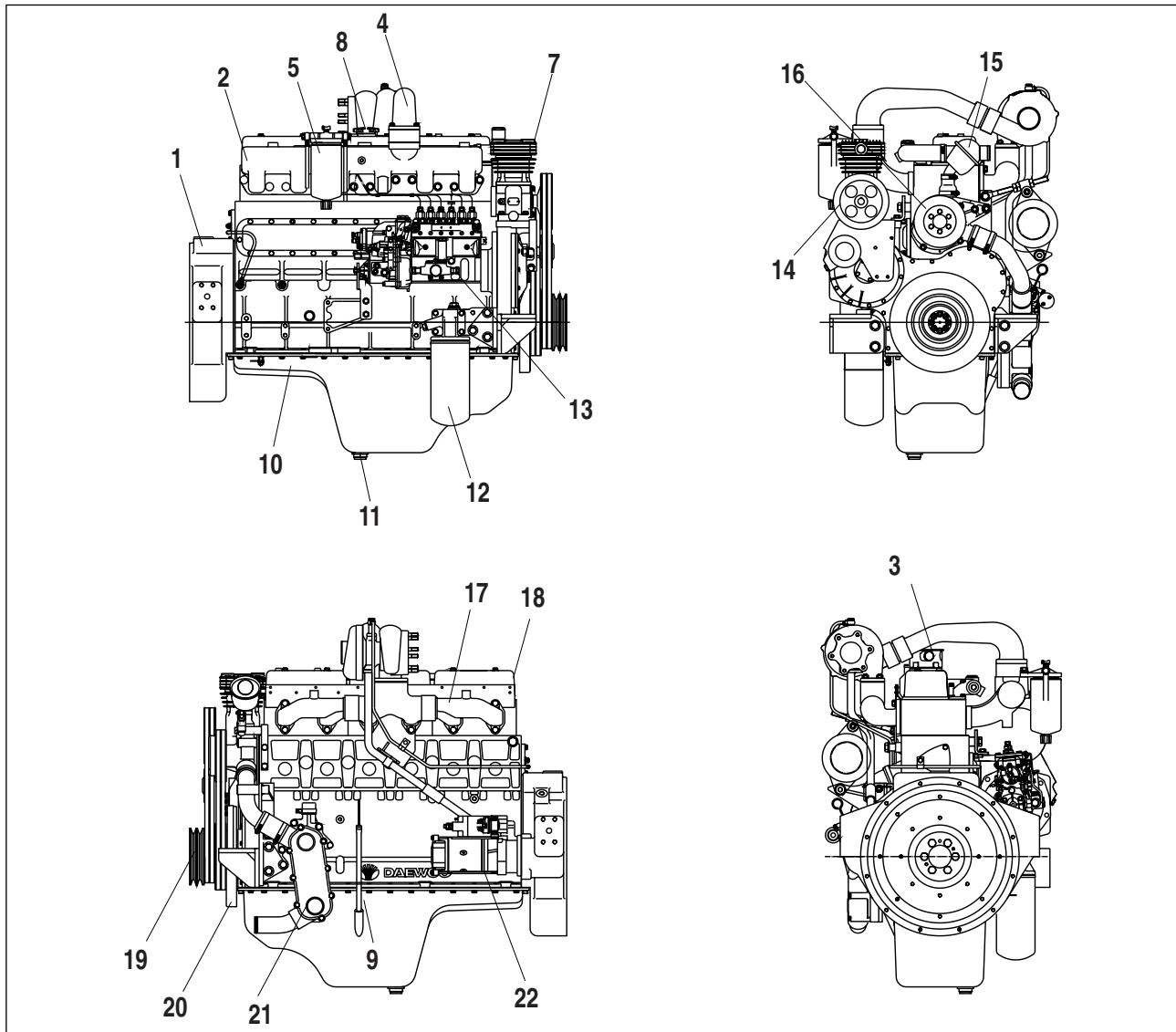


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- | | |
|--------------------------|-------------------------|
| 1. Fuel injection pipe | 9. Turbo charger |
| 2. Fuel filter | 10. Fuel injection pump |
| 3. Fuel injection nozzle | 11. Timing gear case |
| 4. Intake manifold | 13. Connecting rod |
| 5. Air heater | 14. Oil spray nozzle |
| 6. Rocker arm | 15. Oil filter |
| 7. Rocker arm bracket | 16. Oil cooler |
| 8. Exhaust manifold | |

Engine assembly views

a. DE08TS



1. Flywheel housing
2. Intake manifold
3. Breather
4. Air pipe
(Air cleaner to intake manifold)
5. Fuel filter
7. Air compressor (if equipped)

8. Oil filler cap
9. Oil level gauge
10. Oil pan
11. Oil drain plug
12. Oil filter
13. Fuel injection pump
14. Air compressor pulley
15. Thermostat

16. Water pump
17. Exhaust manifold
18. Cylinder head cover
19. Crank shaft pulley
20. Vibration damper
21. Oil cooler
22. Starter

MAJOR MAINTENANCE

Preventive Maintenance

The preventive maintenance means that the operator performs the servicing of engine to obtain long life and best performance from DOOSAN diesel engine.

Cooling Water

1. Regarding the cooling water that is to be used for engine, the soft water not the hard water must be used.
2. The engine cooling water can be used diluting it with antifreezing solution 40% and the additive for rust prevention (DCA4) 3 ~ 5 %.
3. The density of above solution and additive must be inspected every 500 hours to maintain it properly.

NOTE : The proper density control of antifreezing solution and rust preventing additive will be able to prevent the rusting effectively and maintain the stable quality of engine.

For the improper control might give the fatal damage to the cooling water pump and cylinder liners, detail care is needed.

4. Since DE08TS (diesel engine of D1146 series) cylinder liner is dry type, particularly the cooling water control should be applied thoroughly by the cooling water test kit. (Fleetguard CC2602M or DOOSAN 60.99901-0038)
5. The density of antifreezing solution and additive for rust prevention is able to be confirmed by the cooling water test kit. (Fleetguard CC2602M or DOOSAN 60.99901-0038)
6. How to use the cooling water test kit
 - a. When the cooling water temp. of engine is in the range of 10 ~ 55 °C, loosen the plug for cooling water discharge and fill the plastic cup about a half.

NOTE : In taking the cooling water sample, if the water in auxiliary tank were taken, it is hard to measure the accurate density.

Take the cooling water sample necessarily loosening the cooling water discharge plug.

- b. At the state of a test paper soaked in the sampled water, after taking the paper out through water agitation, shake off the water.
- c. Wait for about 45 sec.
Till the color change of test paper.

NOTE : However, it should not elapse longer than 75 sec, and if it did, the hue would change.

- d. Make the numerical value by comparing the test paper which hue has changed with the color list of label on storage bottle.
- e. By comparing the hue changed into yellowish green or so with the green color indication of test paper storage bottle, confirm the density. (Then, the density indication must be in the hue range of 33% to 50%).
- f. The brown at the middle of test paper and the lower pink color indication represent the additive state for rust prevention, and the proper range is that the meeting numerical value of brown (vertical) and pink color (horizontal) locates in the range of 0.3 to 0.8 at the color list of label on the test paper storage bottle.
- g. In case of less than 0.3, replenish the additive for rust prevention (DCA4), and in case of more than 0.8, pour out the cooling water about 50% and then readjust the density after refilling with clean fresh water.

7. Amount of Anti-freeze in winter

Ambient Temperature (°C)	Cooling water (%)	Anti-freeze (%)
Over -10	85	15
-10	80	20
-15	73	27
-20	67	33
-25	60	40
-30	56	44
-40	50	50

Fan belt

1. Use a fan belt of specified dimensions, and replace if damaged, frayed, or deteriorated.
2. Check the fan belt for belt tension.
If belt tension is lower than the specified limit, adjust the tension by relocating the alternator.
(specified deflection: 10 ~ 15 mm when pressed down with thumb)

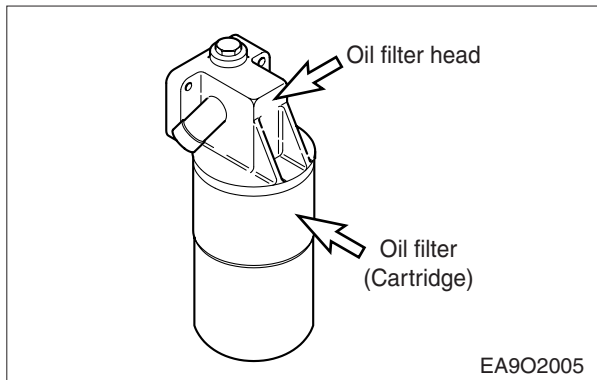
Engine oil

1. Check oil level with the oil level gauge and replenish if necessary.
2. Check the oil level with the engine cooled. If the engine is warm, allow time for 5 ~ 10 minutes for oil drain into the crankcase before checking oil level. The oil level must be between Max and Min. lines on the gauge.
3. Engine oil should be changed at the specified intervals.
Oil filter cartridge should be changed simultaneously.
 - a. First oil change : 50 hr operating
 - b. Every oil chang : 250hr operating

4. The following oils are also recommended.

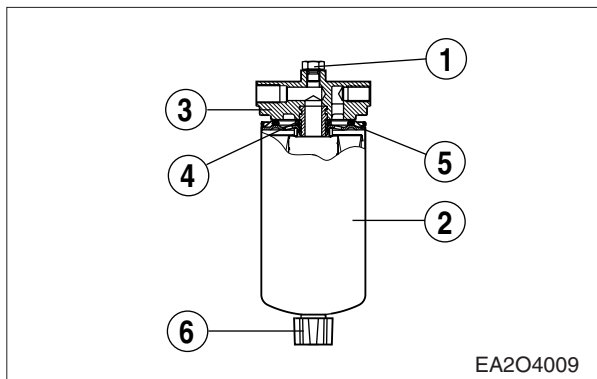
Engine model	Recommend oil	
	SAE No.	API No.
DE08TS	SAE15W40 SAE10W40	ACEA-E2 or ACEA-E3 (API CH-4)

Oil filter



1. Check for oil pressure and oil leaks, and repair or replace the oil filter if necessary.
2. Change the oil filter cartridge simultaneously at every replacement of engine oil.

Fuel filter

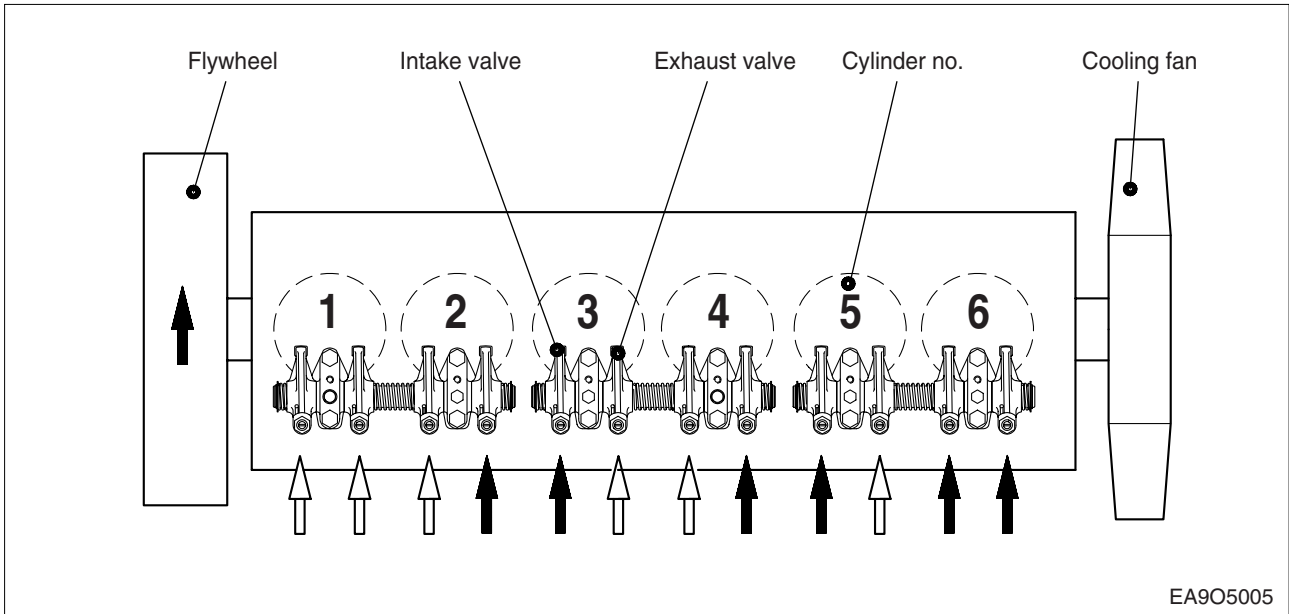


1. Drain water in cartridge with loosening the cock under filter manually (6) from time to time.

Valve clearance adjust procedure

1. After letting the #1 cylinder's piston come at the compression top dead center by turning the crankshaft, adjust the valve clearances.
2. Loosen the lock nuts of rocker arm adjusting screws and push the feeler gauge of specified value between a rocker arm and a valve stem and adjust the clearance with adjusting screw respectively and then tighten with the lock nut.
3. As for the valve clearance, adjust it when in cold, as follows.

Model	Intake Valve	Exhaust Valve
DE08TS	0.3 mm	0.3 mm



- No. 1 cylinder is located at the side where flywheel was installed.

- Rotate the crankshaft to overlap the intake and the exhaust valves of #6, then #1 cylinder become the compression state of top dead center.
- Therefore adjust the valve clearance corresponding to "⇒" of lower figure.
At this time there are no force on the push rods of #1 cylinder.
- Rotating the crankshaft by one revolution, #6 cylinder become the compression state of top dead center.
- Thereafter adjust the valve clearances corresponding to "➡" of lower figure.
- After reinsuring the valve clearances, retighten if necessary.

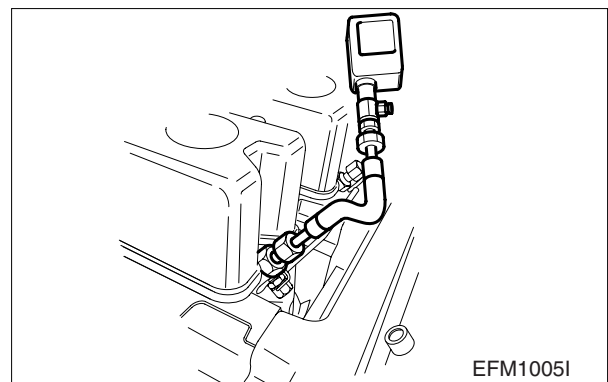
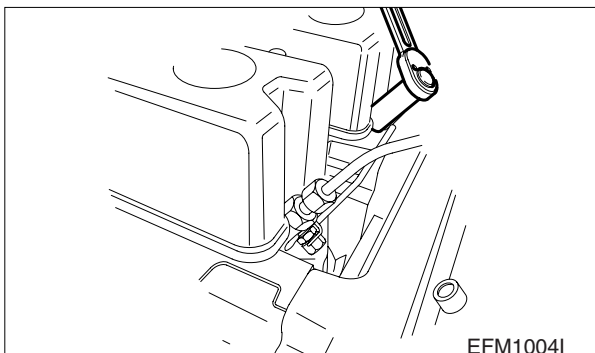
- Install the special tool (compression gauge adapter) at the nozzle holder hole, and connect the compression pressure gauge there.

Standard value	28kg/cm ² over
Limit value	24kg/cm ²
Difference between each cylinder	Within 10 %

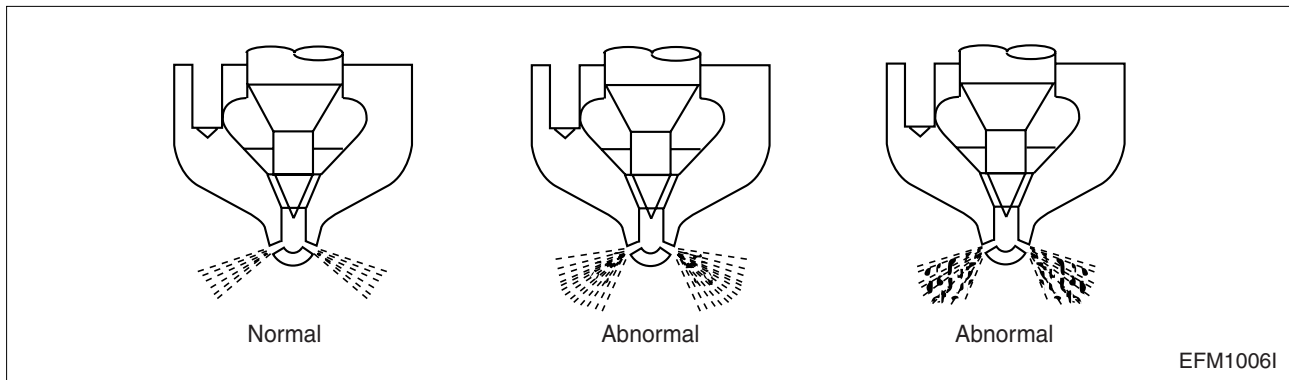
* Condition : Water temperature 20°C, Engine rotation 200rpm (10 rotations)

Cylinder compression pressure

- Stop the engine after warming up, and take out nozzle holder assembly.



Injection nozzle



1. Install a nozzle on the nozzle tester.
2. If the inspected injection pressure is less than the specified value, adjust using the adjusting shims.

Engine Model	DE08TS
Opening pressure	1st : 180 kg/cm ² 2nd : 280 kg/cm ²

3. Check the atomizing state and replace it if abnormal.

Fuel injection pump

1. Check the housing crack, damage etc. and replace it if abnormal.
2. Check if the idle operation and speed regulating lever's sealing is removed.
3. The adjustment and testing of fuel injection pump should necessarily be done at the test bench.

Air removal of fuel system

The suction room of fuel injection pump has the function of air removal continuously during the operation through a relief valve.

In case that the suction room lacks fuel at all, for instance, in case of new installation of injection pump, after loosening the air removing screws of cartridge filter respectively, remove the air by operating the manual pump of fuel supply pump until bubble will disappear.

Fuel supply pump

Every time of engine oil replacement, the fuel strainer installed at the fuel supply pump should be removed and cleaned.

Turbocharger

The turbocharger needs not any special equipment. Every time of engine replacement, a leakage or clogging of oil pipes should be inspected. Air cleaner should be maintained carefully for not 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.

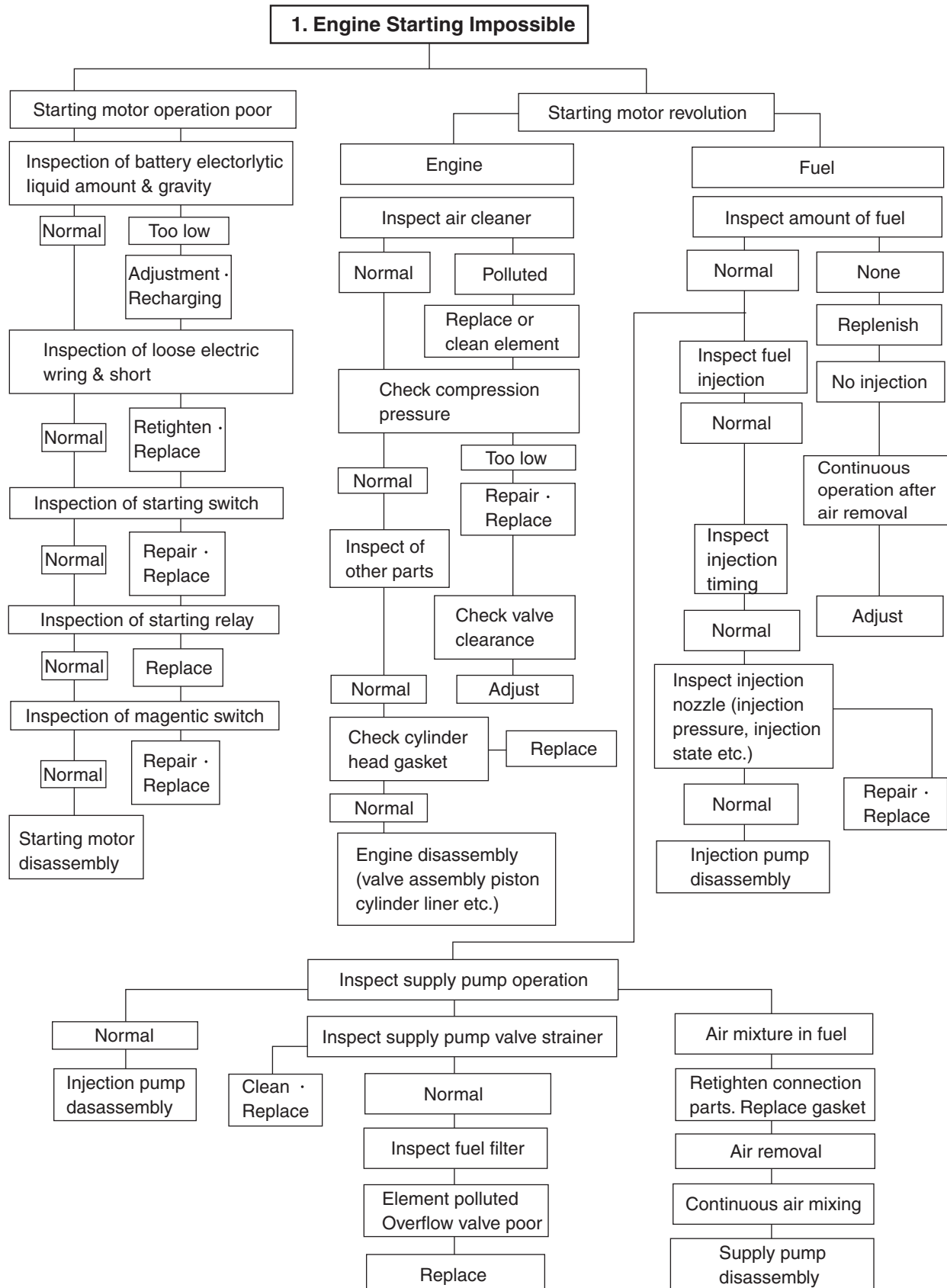
Starting motor

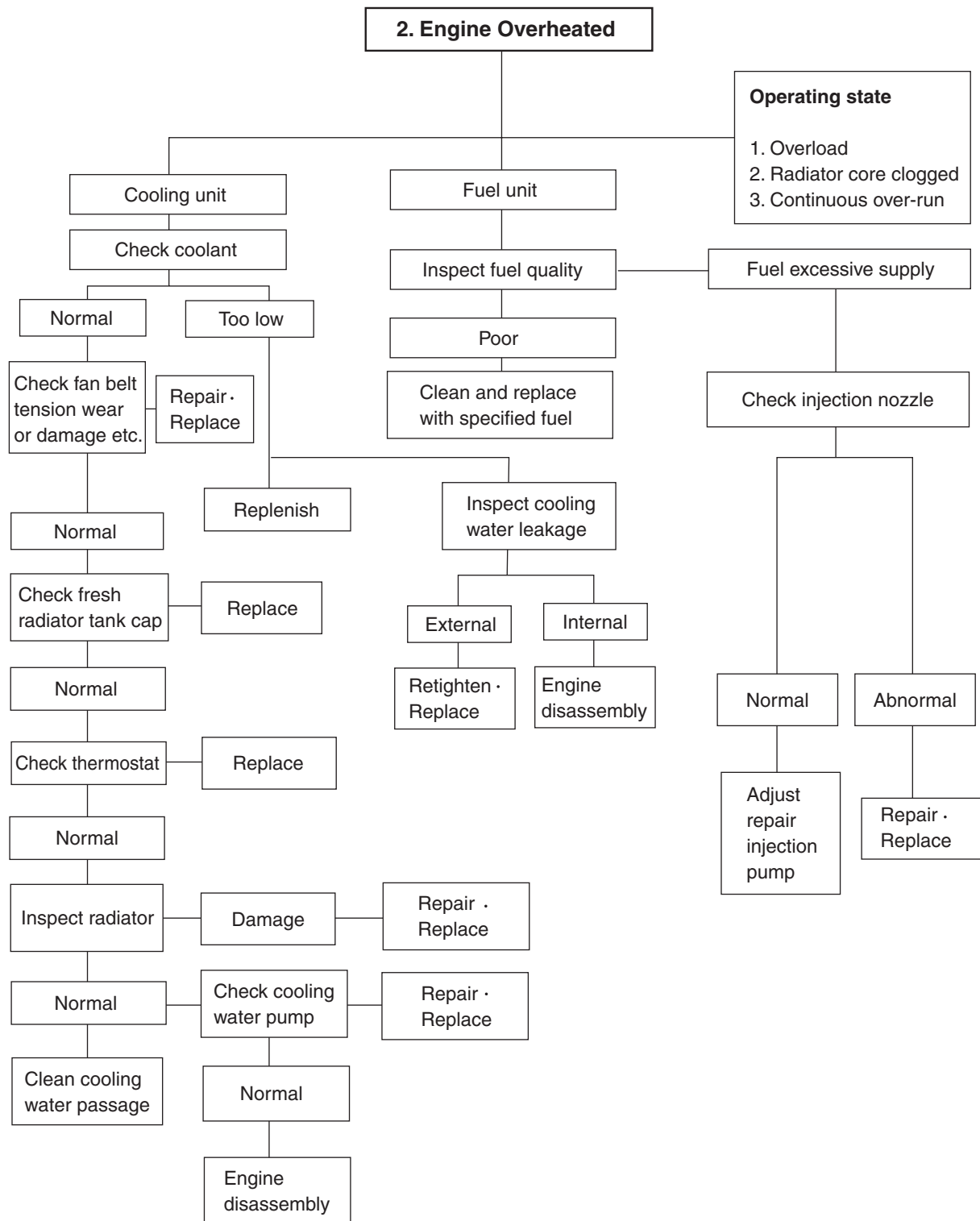
In case of engine maintenance, clean pinion and ring gear thoroughly putting in the fuel, and coat them with grease.

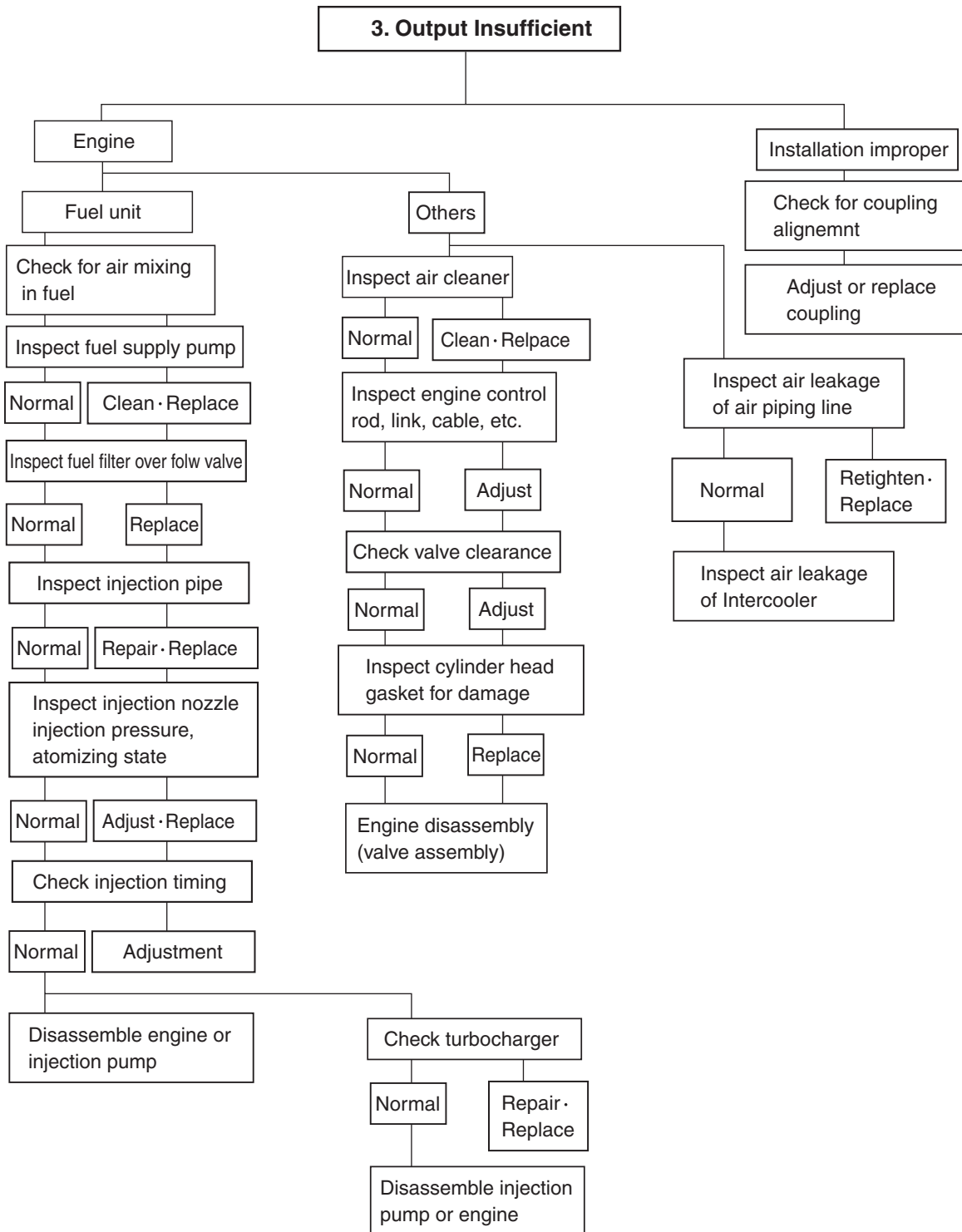
Also, In case of washing engine (room) and so forth, inspect the wiring state being careful for water not to get in.

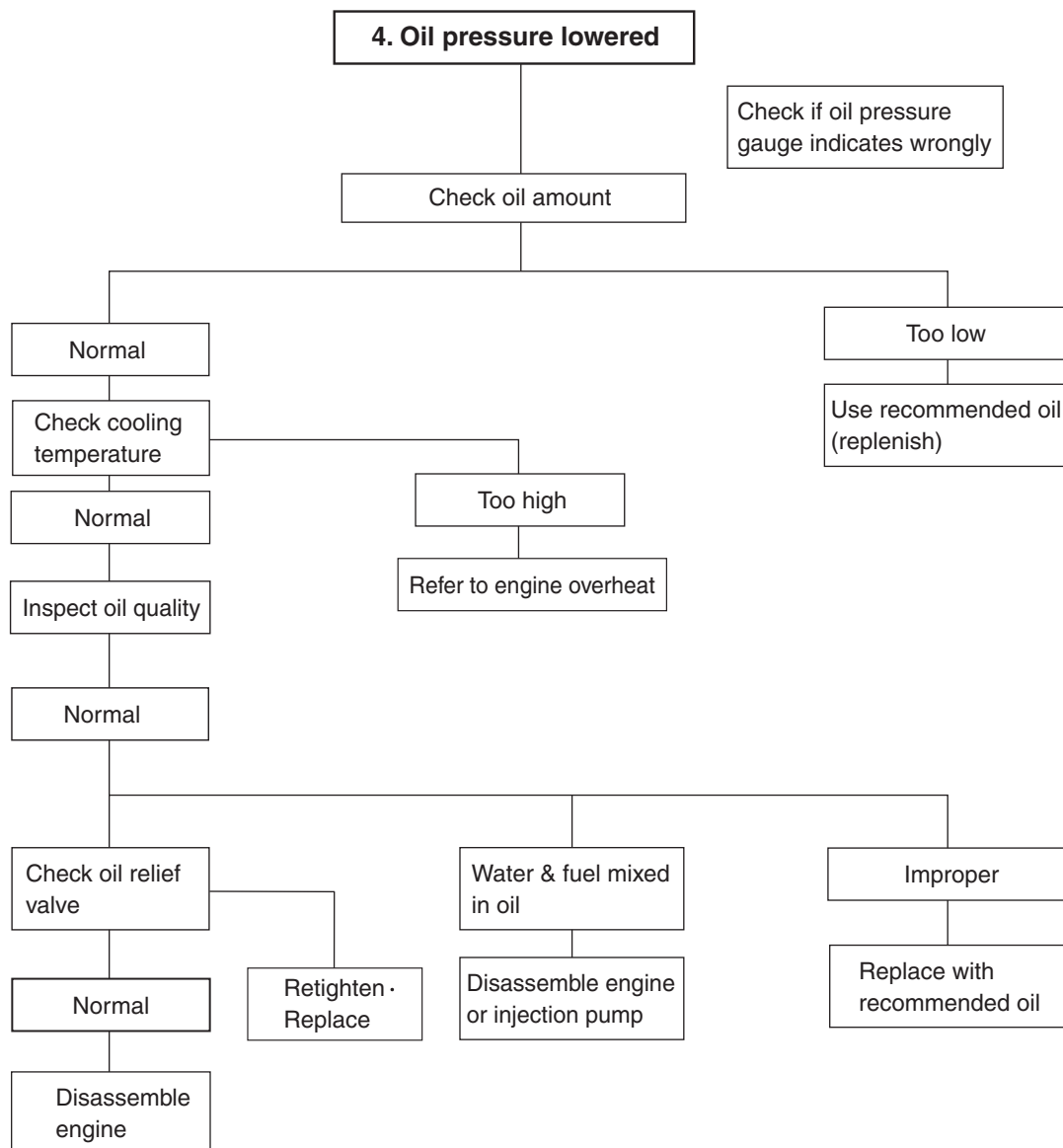
Diagnosis and Remedy

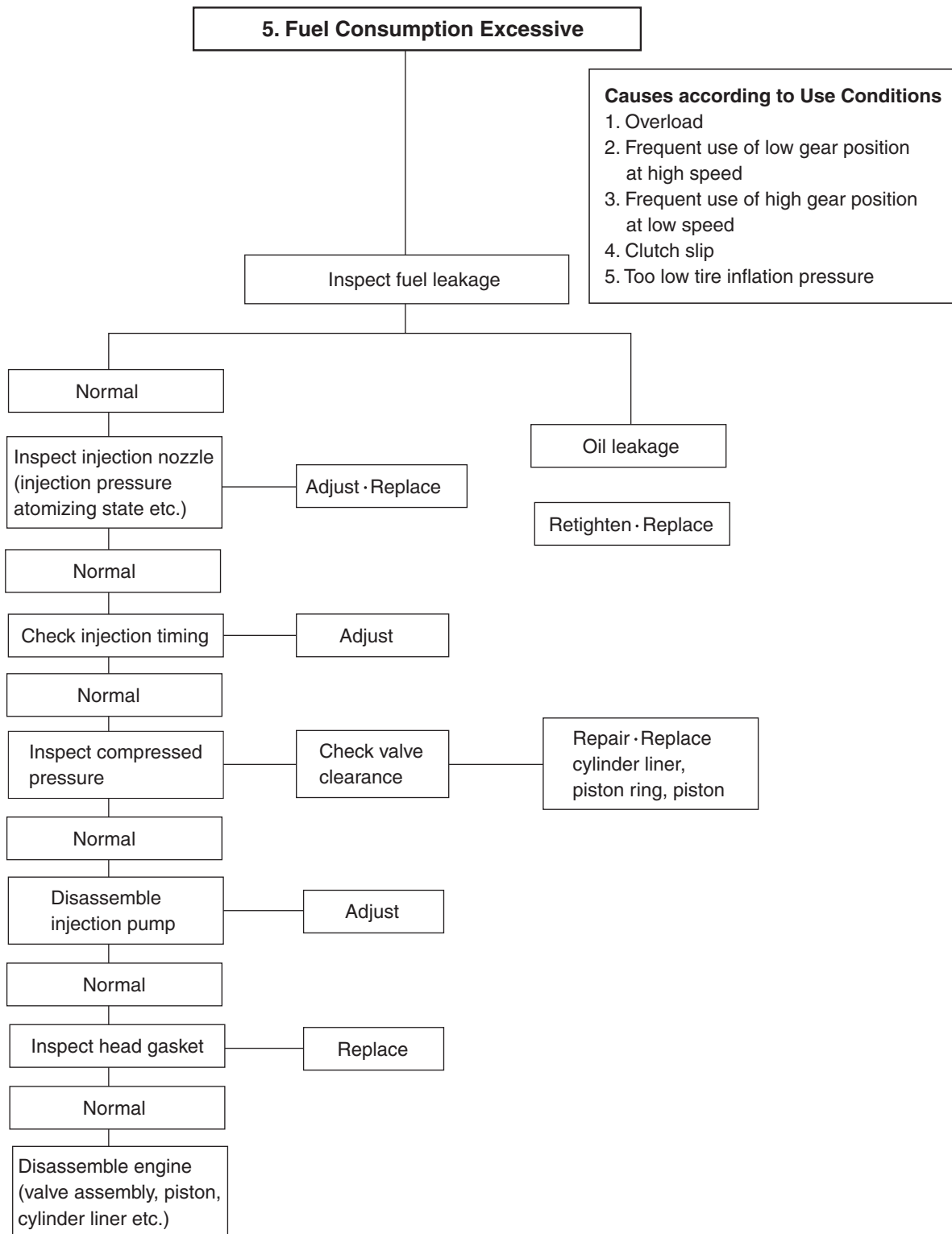
1. The following description summarizes the probable cause of and remedy for general failure by item.
2. Immediate countermeasures should be taken before a failure is inflamed if any symptom is detected.

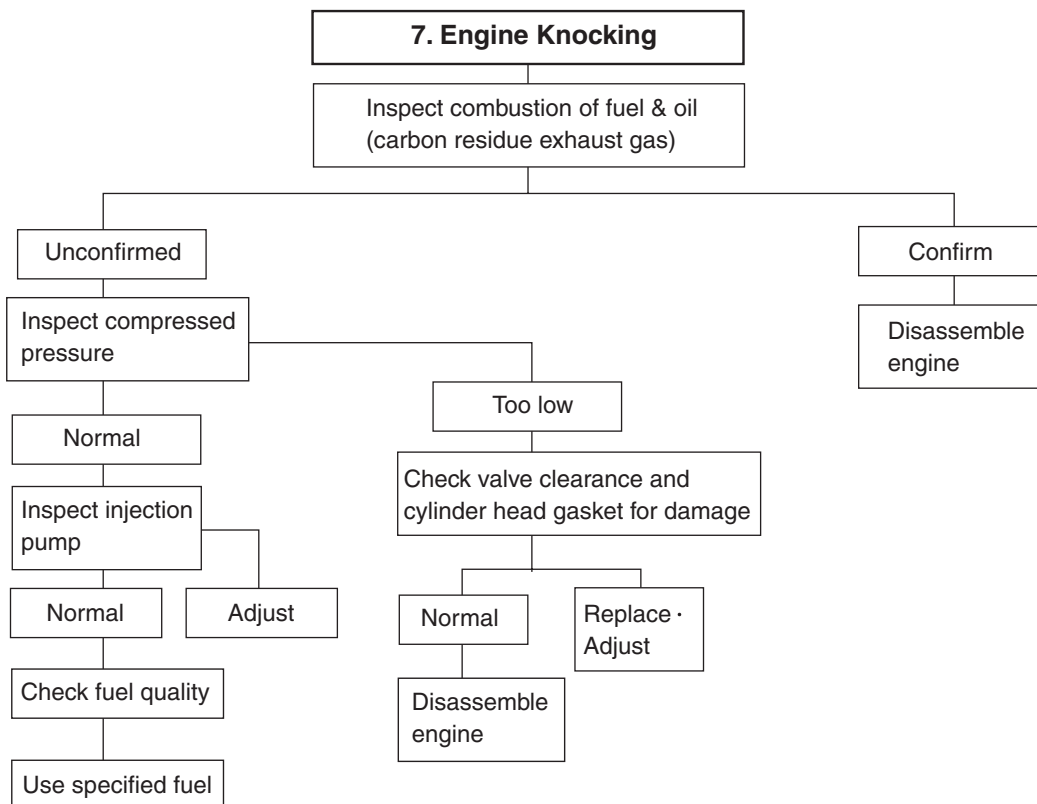
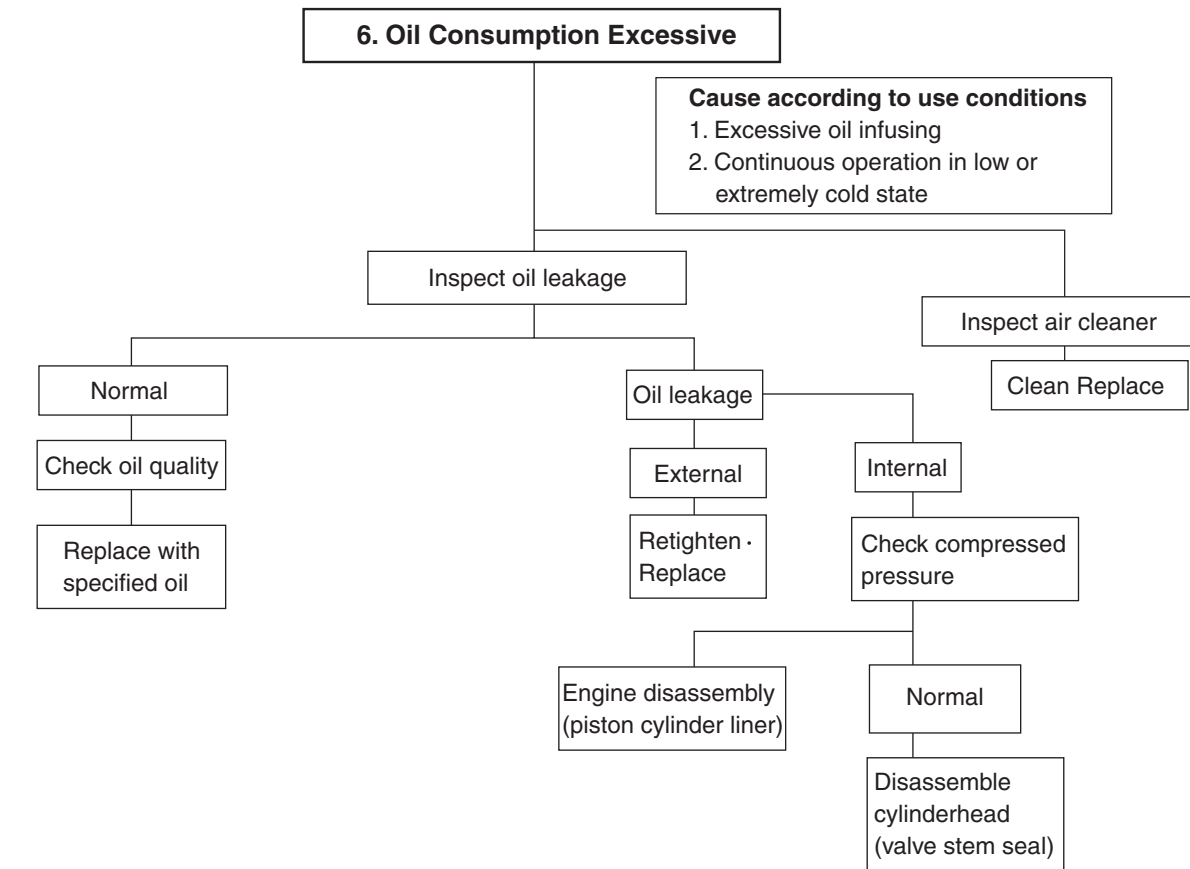


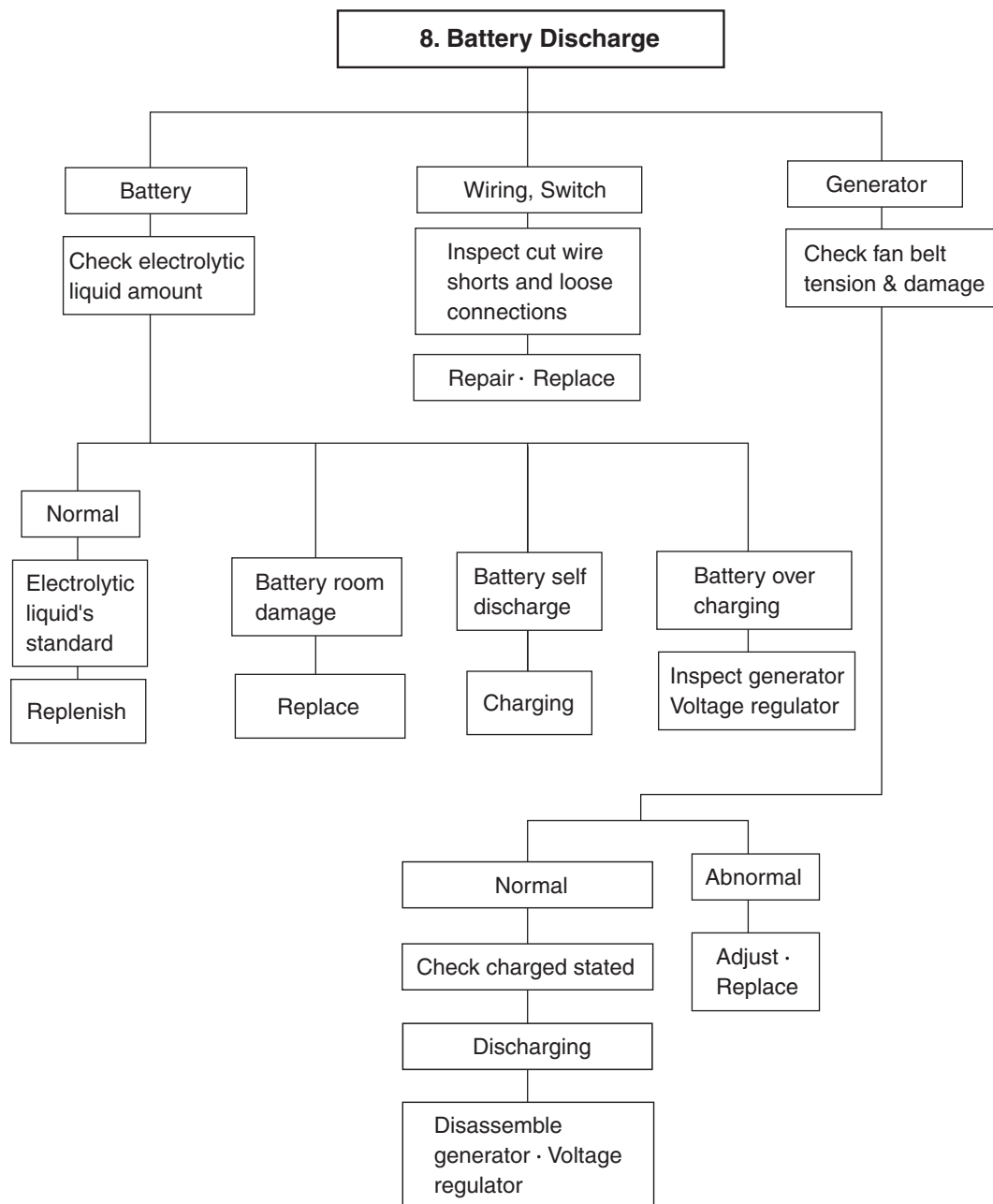












Condition	Causes	Remedies
1) Starting difficult (1) Compression pressure lack	● Valve's poor shut, stem distortion ● Valve spring damage ● Cylinder head gasket's leak ● Wear of piston, piston ring or liner	Repair or replace Replace valve spring Replace gasket Adjust
2) Idle operation abnormal	● Injection timing incorrect ● Air mixing at injection pump	Adjust Remove air
3) Engine output insufficient (1) Continuous output insufficient	● Valve clearance incorrect ● Valve tightness poor ● Cylinder head gasket's leak ● Wear, stick, damage of piston ring ● Injection timing incorrect ● Fuel injection amount insufficient ● Nozzle injection pressure improper or stuck ● Supply pump's function lowered ● Fuel pipe system clogged ● Air suction amount insufficient ● Turbocharger poor	Adjust Repair Replace gasket Replace piston ring Adjust Adjust injection pump Adjust or replace Repair or replace Repair Clean or replace air cleaner Repair or replace
(2) Output insufficient when in acceleration	● Compression pressure insufficient ● Injection timing incorrect ● Fuel injection amount insufficient ● Injection pump timer's function insufficient ● Nozzle injection pressure, injection angle improper ● Supply pump's function lowered ● Air intake amount insufficient	Disassemble engine Adjust Adjust injection pump Repair or replace Repair, replace Repair or replace Clean or replace air cleaner
4) Overheating	● Engine oil insufficient or poor ● Cooling water insufficient ● Fan belt loosened, worn, damaged ● Cooling water pump's function lowered ● Water temp. regulator's operation poor ● Valve clearance incorrect ● Exhaust system's resistance increased	Replenish or replace Replenish or replace Adjust or replace Repair or replace Replace Adjust Clean or replace

Condition	Causes	Remedies
5) Engine noisy	For noises arise compositely such as rotating parts, lapping parts etc., there is necessity to search the cause of noises accurately.	
(1) Crankshaft	● As the wear of bearing or crankshaft progress, the oil clearances increase. ● Lopsided wear of crankshaft ● Oil supply insufficient due to oil passage clogging ● Stuck bearing	Replace bearing & grind crankshaft Grind or replace Clean oil passage Replace bearing & Grind
(2) Con rod and Con rod bearing	● Lopsided wear of con rod bearing ● Lopsided wear of crank pin ● Connecting rod distortion ● Stuck bearing ● Oil supply insufficiency as clogging at oil passage progresses	Replace bearing Grind crankshaft Repair or replace Replace & grind crankshaft Clean oil passage
(3) Piston, piston pin & piston ring	● Piston clearance increase as the wear of piston and piston ring progresses ● Wear of piston or piston pin ● Piston stuck ● Piston insertion poor ● Piston ring damaged	Replace piston & piston ring Replace Replace piston Replace piston Replace piston
(4) Others	● Wear of crankshaft, thrust bearing ● Camshaft end play increased ● Idle gear end play increased ● Timing gear backlash excessive ● Valve clearance excessive ● Abnormal wear of tappet, cam ● Turbocharger inner part damaged	Replace thrust bearing Replace thrust plate Replace thrust washer Repair or replace Adjust valve clearance Replace tappet, cam Repair or replace
6) Fuel Consumption Excessive	● Injection timing incorrect ● Fuel injection amount excessive	Adjust Adjust injection pump
7) Oil Consumption Excessive		
(1) Oil level elevated	● Clearance between cylinder liner & piston	Replace
	● Wear of piston ring, ring groove ● Piston ring's damage, stick, wear ● Piston ring opening's disposition improper ● Piston skirt part damaged or abnormal wear ● Oil ring's oil return hole clogged ● Oil ring's contact poor	Replace piston, piston ring Replace piston ring Correct position Replace piston Replace piston ring Replace piston ring
(2) Oil level lowered	● Looseness of valve stem & guide ● Wear of valve stem seal ● Cylinder head gasket's leak	Replace in set Replace seal Replace gasket
(3) Oil leak	● Looseness of connection parts ● Various parts' packing poor ● Oil seal poor	Replace gasket, repair Replace packing Replace oil seal

MAINTENANCE

Engine Disassembly

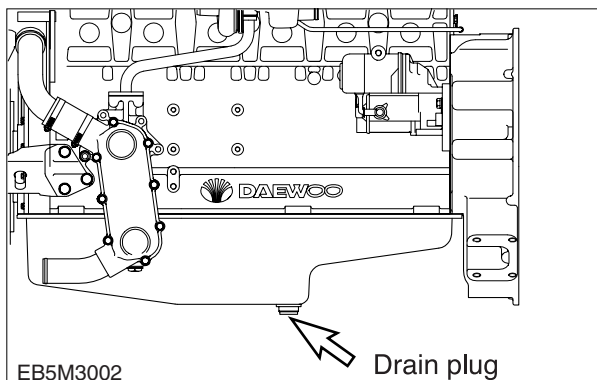
Heed at disassembly

1. Before disassembly, the part shelf should be prepared for various tools and repair parts.
2. When assembling, clean empty hand should be used and clean environment maintained.
3. In case of storing the disassembled parts, each part should not touch each other.
4. In case of disassembly, the parts should be laid in order.

Oil level gauge

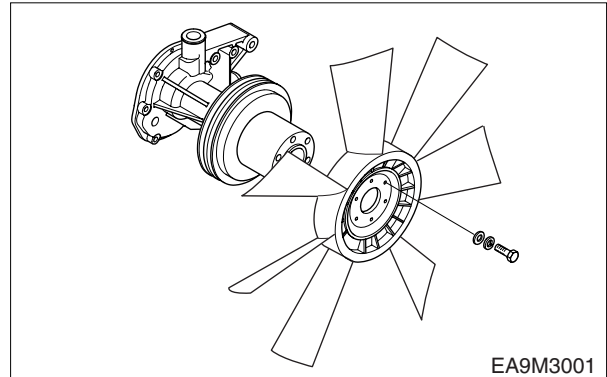
1. Pull out the oil level gauge.

Engine oil



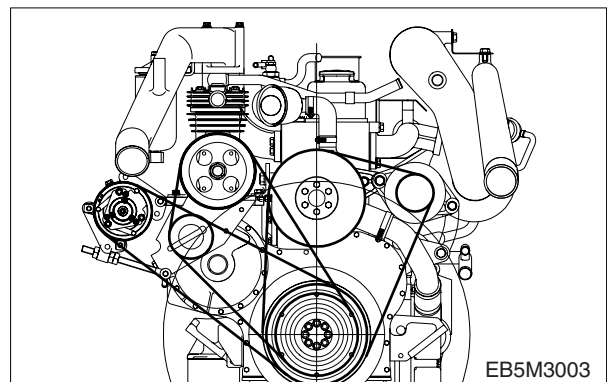
1. Remove the oil drain plug of oil pan and pour the engine oil into the prepared vessel.

Cooling fan



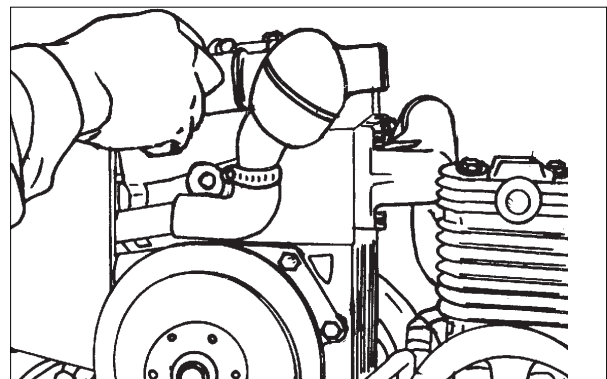
1. Remove the flange fixing bolts, then take off the flange and cooling fan.

Belt



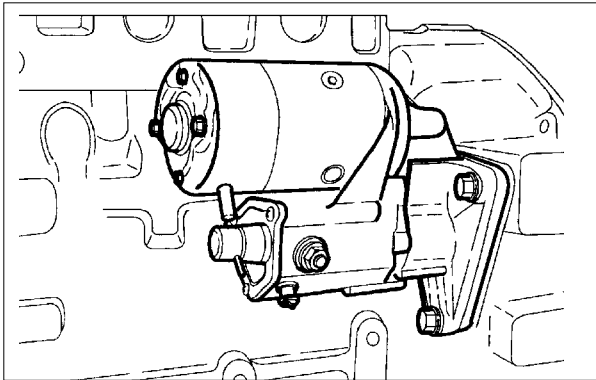
1. Loosen the tension adjusting bolts of the alternator and the idle pulley, and take off the belts.

Thermostat



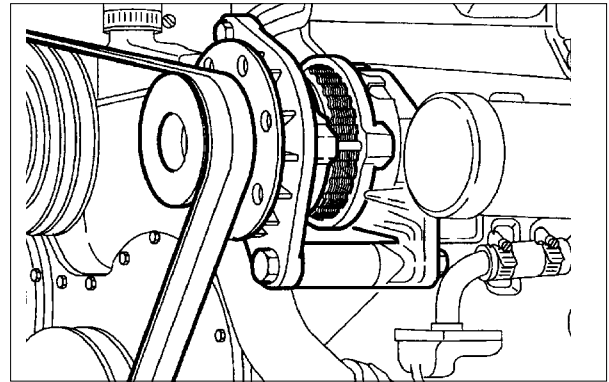
1. Loosen the rubber hose connected to the cooling water pipe and remove the thermostat.
2. Remove the rubber hose of the by-pass line.

Starter



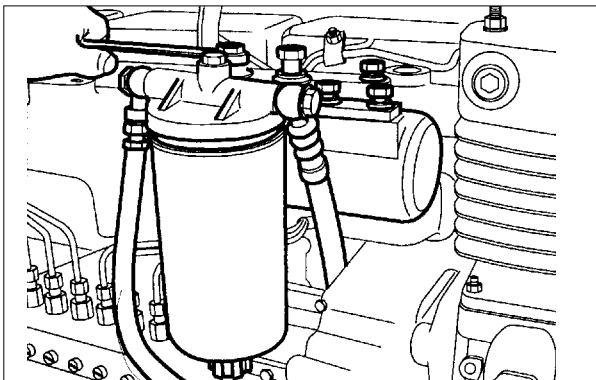
1. Unscrew the starter fixing nuts and remove the starter being careful not to damage its gears.

Breather



1. Loosen the clamp screw to remove the rubber hose.

Fuel filter

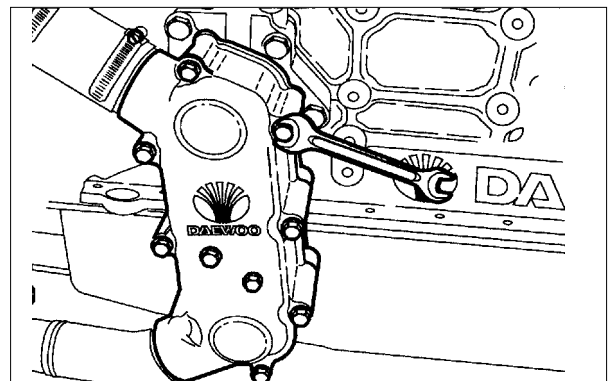


1. Remove the hollow screws of filter and tear down fuel supply and discharge rubber hose.
2. Remove fuel filter fixing bolts and disassemble the fuel filter.
(If the fuel filter is of cartridge type, disassemble the cartridge element only.)

Alternator

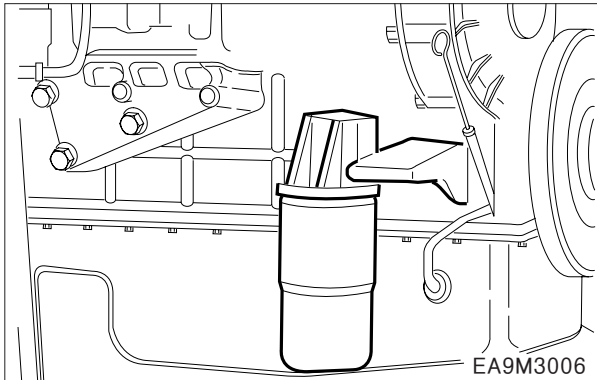
1. Remove the alternator assembling bolts and disassemble the alternator.

Oil cooler



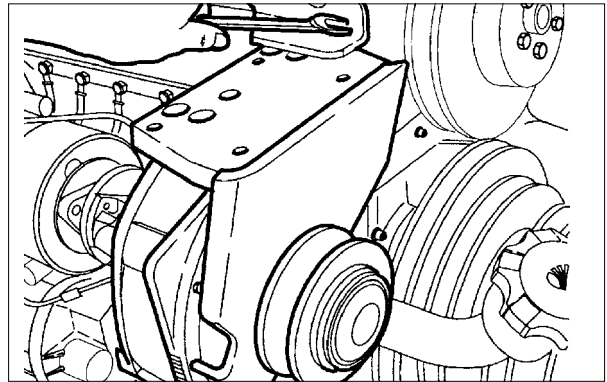
1. Loosen the cooling water pump and the rubber hose clamps of connected pipes, and disassemble it.
2. Remove the oil cooler fixing bolts and take off the oil cooler.

Oil filter



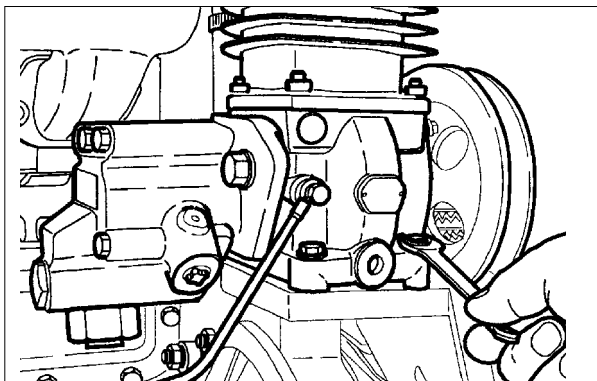
1. Remove the oil filter assembling bolts and disassemble the oil filter assembly.

Idle pulley

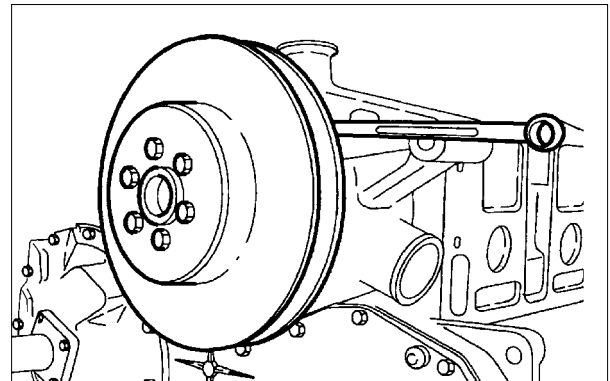


1. Unscrew the idle pulley fixing bolts and take off the idle pulley

Air compressor (if equipped)

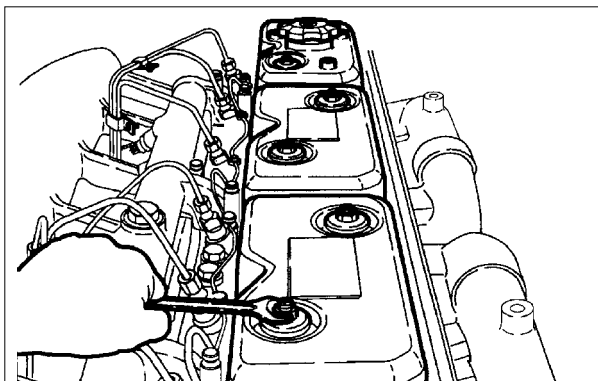


1. Remove the oil pipe between cylinder block and air compressor.
2. Unscrew the air compressor fixing bolts and take off the air compressor.



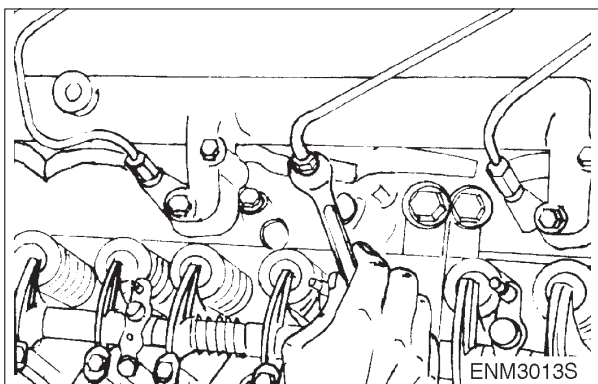
1. Unclamp the rubber hose connected to the oil cooler.
2. Unscrew the water pump fixing bolts from the cylinder block and take off the water pump.

Cylinder head cover



1. Remove the head cover fixing bolts and lift the cylinder head cover.

Fuel injection nozzle



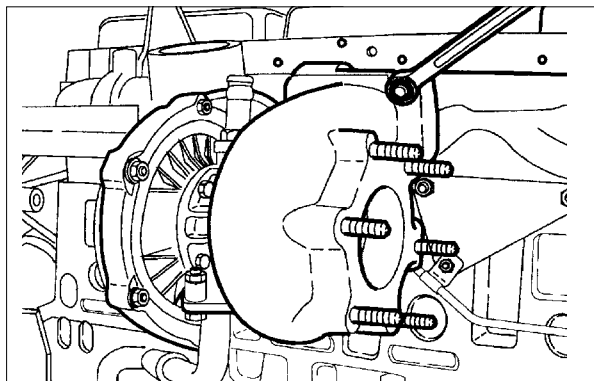
1. Unscrew the fuel injection pipe between the injection pump and nozzle and take off the pipe.
2. Install a special jig on the nozzle holder, and then pull out the nozzle as striking the hammer of the jig backwardly.

WARNING

Take care not to damage the nozzle at disassembly.

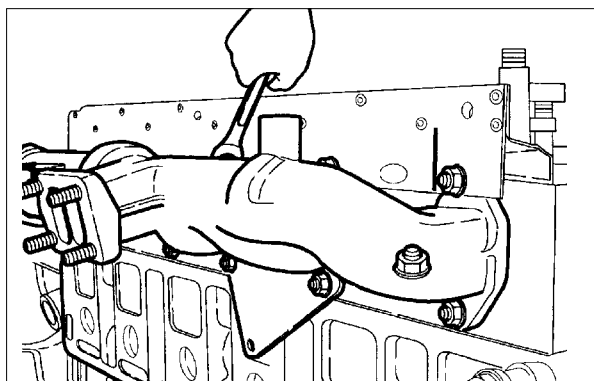
3. Take out the seal ring from the nozzle hole of the cylinder head and discard it.

Turbo charger



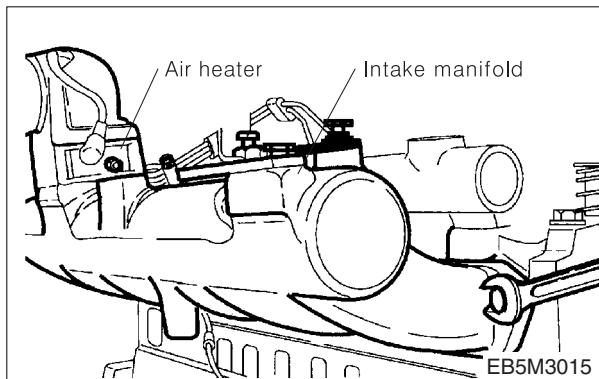
1. Remove the oil supply pipe and oil return pipe between the turbo charger and the cylinder block.
2. Unclamp the rubber hose connected the intercooler and air cleaner.
3. Unscrew the turbo charger fixing nuts and take off the turbo charger from the exhaust manifold.

Exhaust manifold



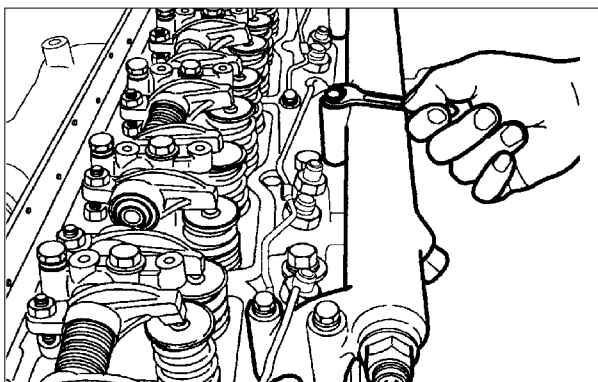
1. Unscrew the exhaust manifold fixing nuts and remove the heat shield from the exhaust manifold.
2. Then disassemble the exhaust manifold and gasket.
3. Scrap the used gasket.

Intake manifold



1. Unscrew the intake manifold fixing bolts and remove the intake manifold from the cylinder head.
2. Disassemble the intake manifold gasket and discard it.

Cooling water pipe

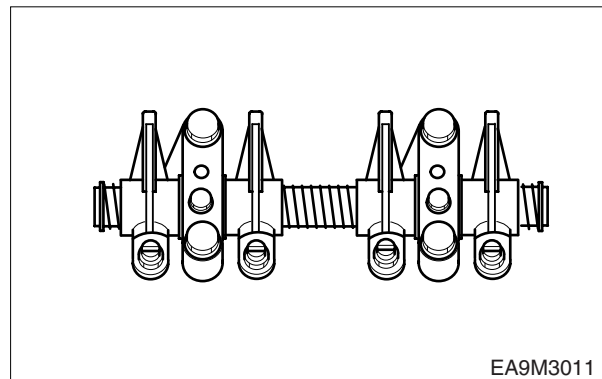


1. Unscrew the cooling water pipe fixing bolts and remove the cooling water pipe from the cylinder head.
2. Remove the cooling water pipe gasket and finish the surface with a scraper.

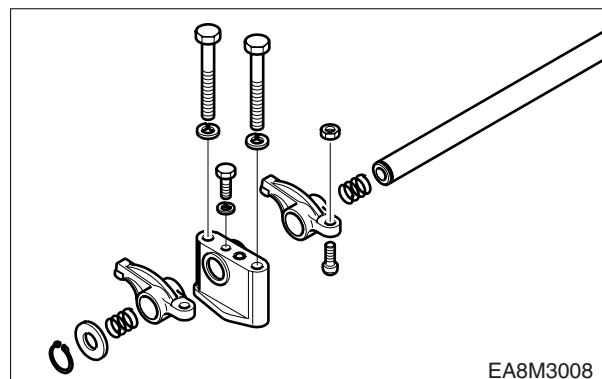
WARNING

Be sure that piece of the gasket do not come into the cooling water passage.

Rocker arm



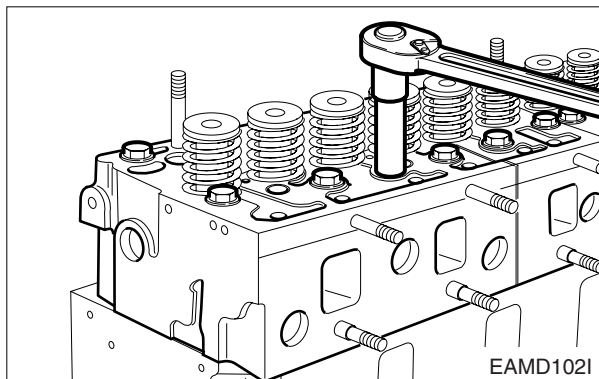
1. Remove the rocker arm bracket fixing bolts in reverse order (zigzag method) of assembling and disassemble the rocker arm.
2. Take out the push rod upwards.
3. Disassembly of rocker arm assembly
 - a. Remove the snap ring from the both ends of rocker arm shaft by means of a plier.
 - b. Remove the washer, rocker arm, bracket and spring from the rocker arm shaft in sequence.
 - c. Press out the rocker arm bush.



WARNING

When reassembling the bush, cool the bush in dry ice and press the bush while aligning the bush with the oil hole of the rocker arm.

Cylinder head



1. Remove the cylinder head bolts in the reverse order of tightening but remove it step by step.

First step : Loosen 1 ~ 2 threads

Second step : Remove by loosening fully.

However, remove the total bolts simultaneously by the step of 1 and 2.

2. Lay the removed bolts orderly not to damage the threads at all and store.

WARNING

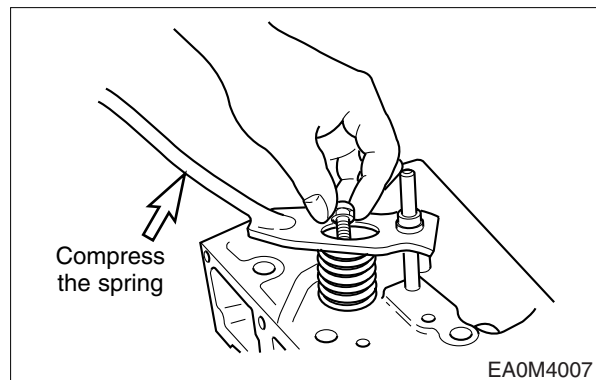
Prevent a collision between the bolt thread each other.

3. Take out the cylinder head gasket and scrap it.
4. Remove the foreign residues from the cylinder head surface and block surface.

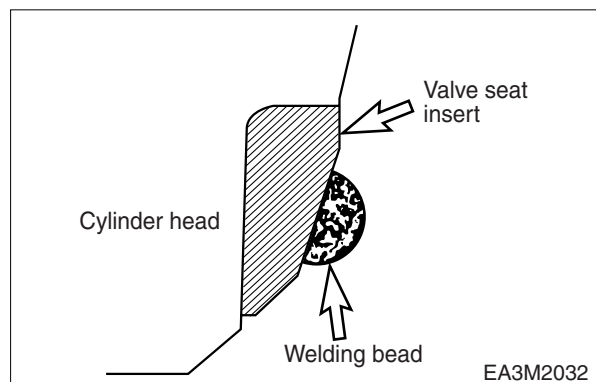
WARNING

Try not to make any damage on the contact surfaces.

• Disassembly of cylinder head

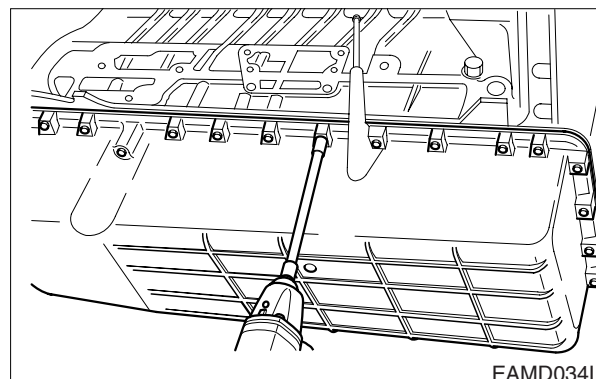


- a. Place the cylinder head on a individual shelf.
- b. As pressing the valve spring with a special tool, remove the cotter pin, valve spring.
- c. Take out the intake and exhaust valves.



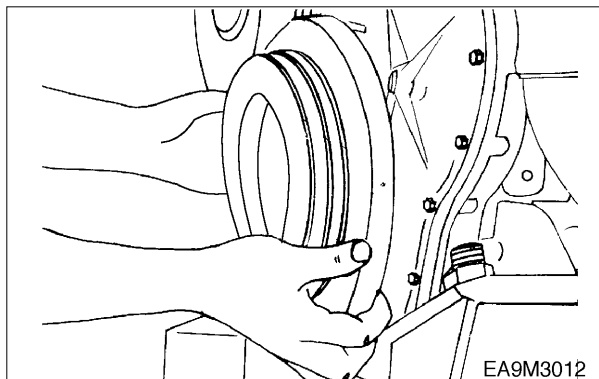
- d. For removal of the valve seat, apply arc welding work to two points of valve seat insert, and pull out the valve seat insert with inner extractor.

Oil pan



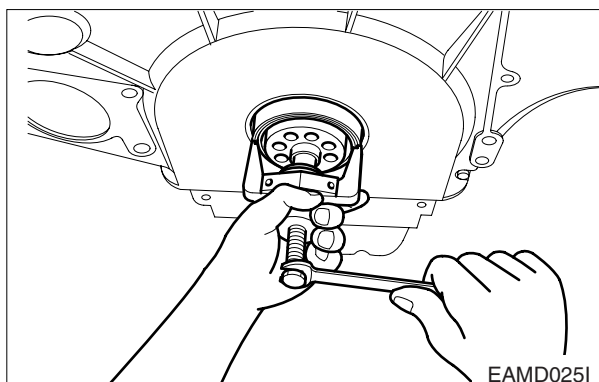
1. Unscrew the oil pan fixing bolts and remove the oil pan.
2. Remove the oil pan gasket and discard it.

Vibration damper



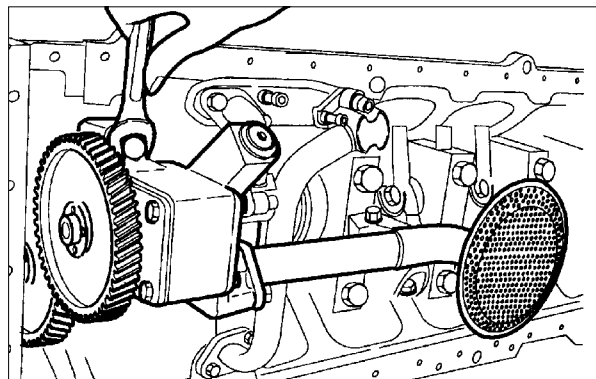
1. Unscrew the vibration damper fixing bolts in reverse sequence of installing sequence and remove the vibration damper assembly.

Timing gear case cover



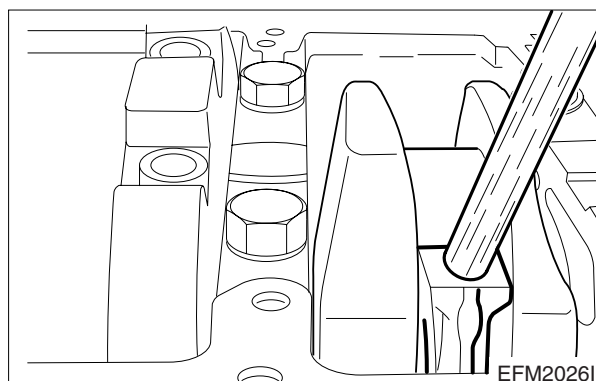
1. Disassemble the oil seal using an oil seal removing jig.
2. Remove the cover fixing bolts and disassemble the cover from the timing gear case.

Oil pump



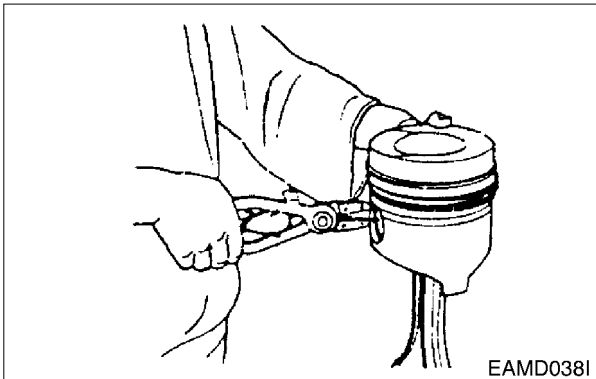
1. Unscrew the bracket fixing bolts of the oil suction pipe.
2. Unscrew the pipe fixing bolts of oil pump and disassemble the suction and supply oil pipe.
3. Unscrew the oil pump fixing bolts, and disassemble the oil pump.

Piston and connecting rod

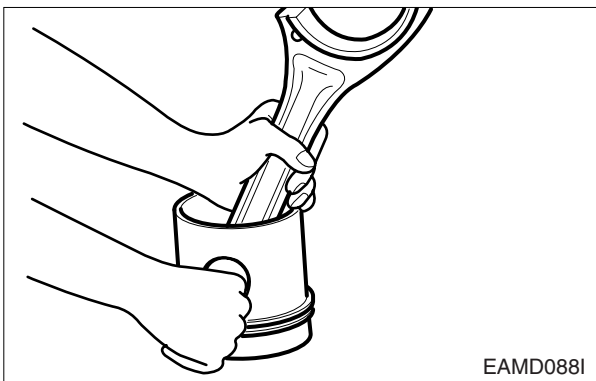


1. Remove the connecting rod cap bolts in the reverse order of assembling but do same as the cylinder head bolt removal.
2. Disassemble the upper/lower of connecting rod caps by tapping lightly with urethane hammer, and remove the bearing.
3. By pushing the connecting rod with wooden bar from the direction of oil pan toward cylinder head, disassemble the piston assembly.
4. The disassembled piston assembly should be handled to prevent bumping each other, and stored as the cylinder's order.
5. In order for connecting rod cap not to be swapped, temporarily assemble to the corresponding connecting rod.

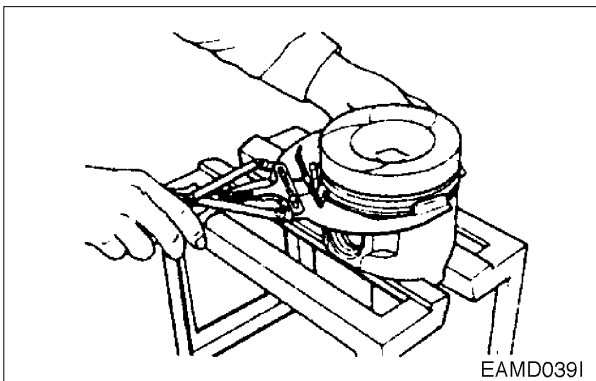
<Disassembly of piston>



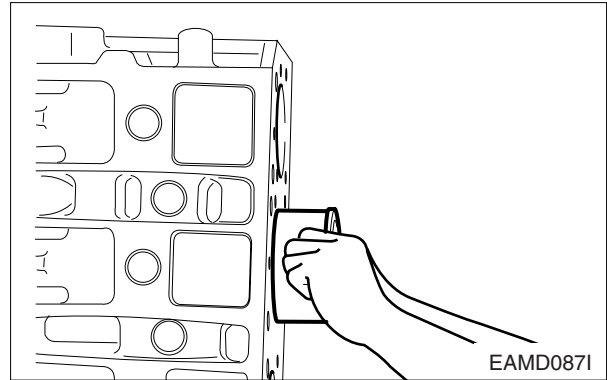
1. Remove the snap rings by means of a plier.



2. Heat the piston with a electric heater, then take out the piston pin from the piston as tapping it with a round wooden bar.



3. Remove the piston ring with a plier.

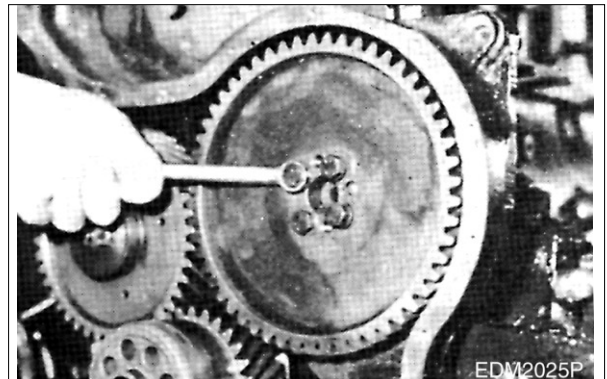


4. Clean the piston thoroughly.

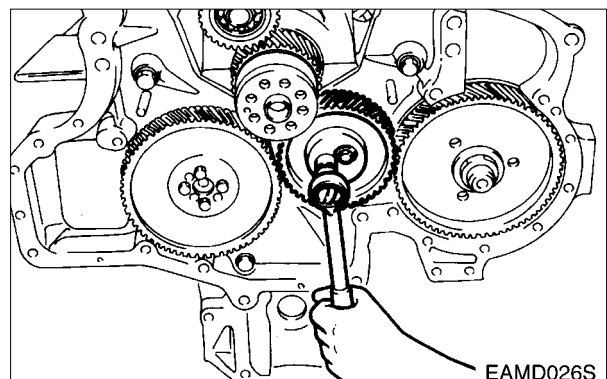
Cylinder liner

1. Disassemble the cylinder liner with a special tool or hand but be careful not to generate any damage at cylinder block.

Cam shaft gear and idle gear

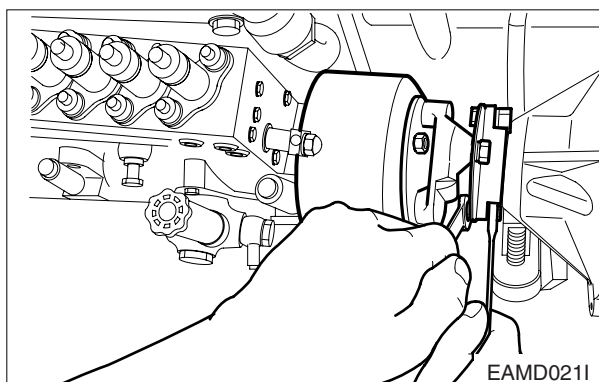


1. Unscrew the camshaft gear fixing bolts and remove the camshaft gear.

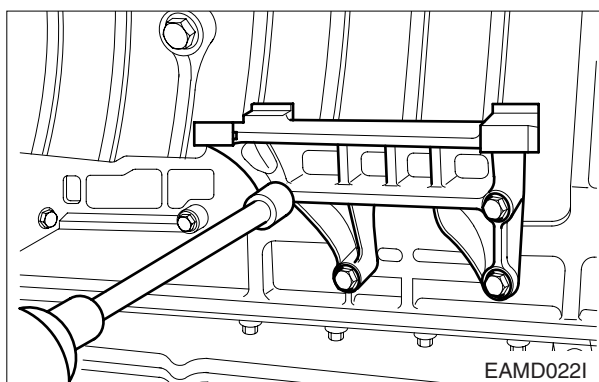


2. Unscrew the camshaft gear fixing bolts and remove the camshaft gear.

Fuel injection pump



1. Disassembly the oil hose for lubrication.
2. Remove the bolts and nuts of injection pump flange.
3. Unscrew the injection pump fixing bolts and remove the injection pump by lifting it up.

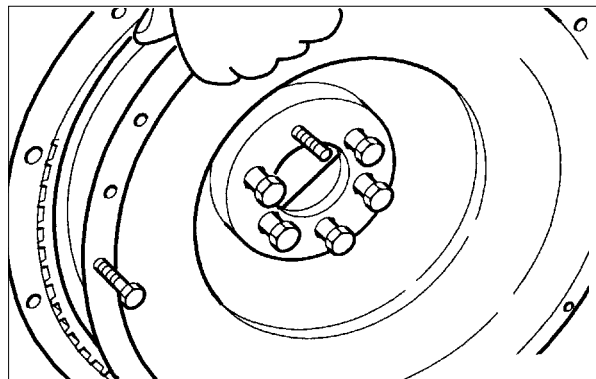


4. Remove the bracket fixing bolts of injection pump, and disassemble by pulling the injection pump backward.

Water chamber cover

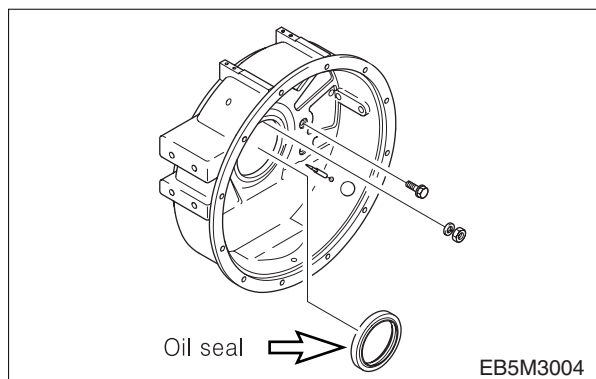
1. Unscrew the fixing bolts and remove the water chamber cover.
2. Remove the remnant gasket thoroughly.

Fly wheel



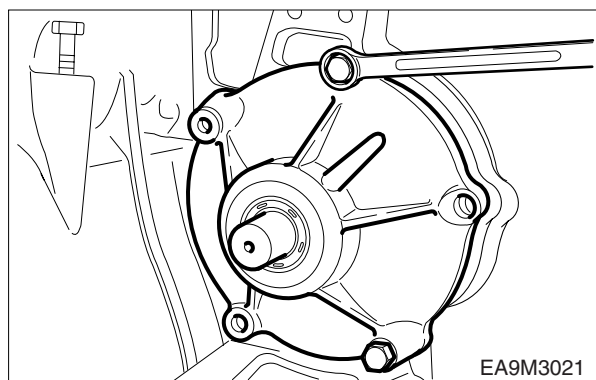
1. Remove the flywheel fixing bolts and disassemble it.
2. The bolt removal is done by the reverse order of assembling and by the steps.

Fly wheel housing



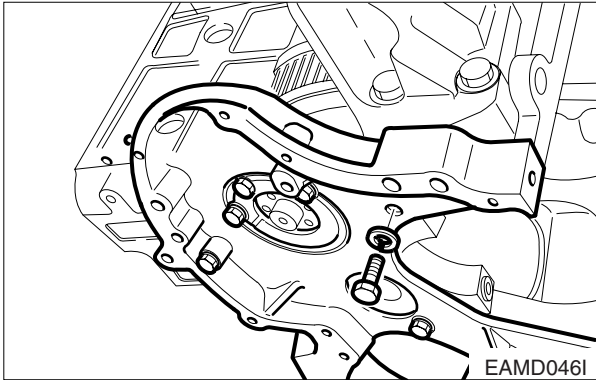
1. Remove the flywheel housing fixing bolts and disassemble the flywheel housing.
2. Disassemble the oil seal of flywheel housing.

Injection pump drive gear



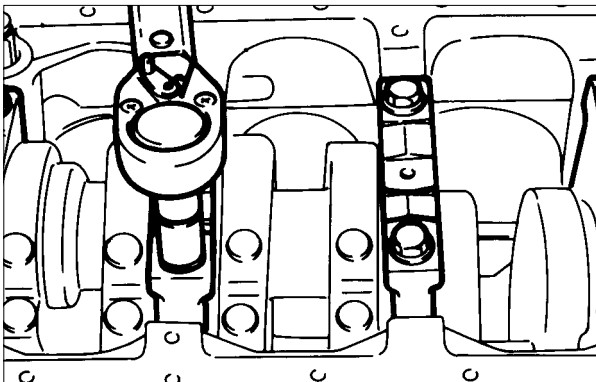
1. Unscrew the drive gear housing fixing bolts and remove the drive gear assembly.

Timing gear case



1. Remove the timing gear case assembling bolts.
2. By tapping lightly with a urethane hammer the right and left back of timing gear case's connecting part, disassemble the timing gear case.

Bearing cap



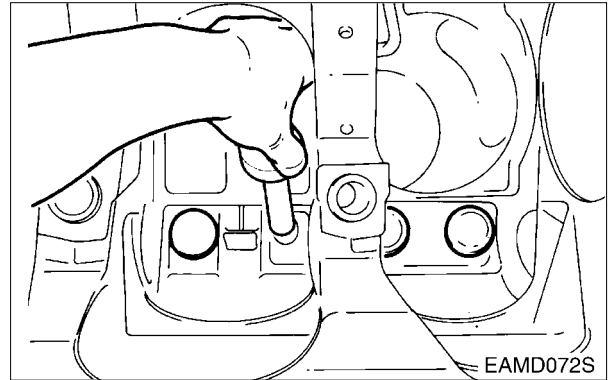
1. Remove the bearing cap assembling bolts by the step in the reverse order of assembling, and disassemble the bearing cap. (Remove by the same way as the cylinder head bolts' removal.)
2. Disassembled bearing caps are kept laid in order.

Crankshaft

1. Assemble the bolts on the both side of crankshaft temporarily.
2. Connect the rope to the bolts and lift the crankshaft by means of crane being careful not to give any damage on it.
3. In order for the disassembled crankshaft to be prevented from bends or damage, put it on the special lathe and store.
4. Disassemble the metal bearings in turn and store them.

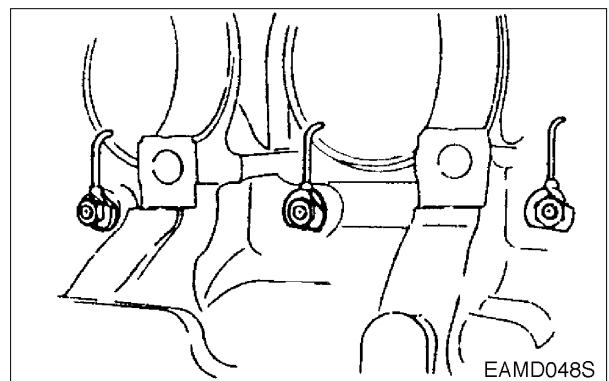
NOTE : Do not mingle with the metal bearings and bearing caps randomly. To prevent mixing, temporarily assemble the metal bearings to the corresponding bearing caps in turn.

Camshaft and tappet



1. In order for camshaft not to be damaged, disassemble turning it.
2. In order for the disassembled camshaft to be prevented from bends or damage, put it on the special lathe and store.
3. Pull out the tappet.
4. As required, pull out the camshaft bush from the cylinder block by a press.
5. Check for damage, scratch, wearing state and if abnormal, tear down.

Oil spray nozzle



1. Remove the valve screws of oil spray nozzle and disassemble it.

Inspection and Measurement on Major Parts

Cylinder block

1. Clean the cylinder block thoroughly, and check for any crack or damage.
2. If there is any crack or severe damage, replace it and if there is minor one, correct it.
3. Check for any clogging or corrosion in the oil passage and water passage.
4. Carry out a leakage test for any crack or air leaking. (Hydraulic test)
5. Plug each cylinder block's water and oil discharge ports, and apply the air pressure of about 4kg/cm² to intake port and soak it in water for about 1 minute to check if there is any leakage. (Water temperature : 70°C)

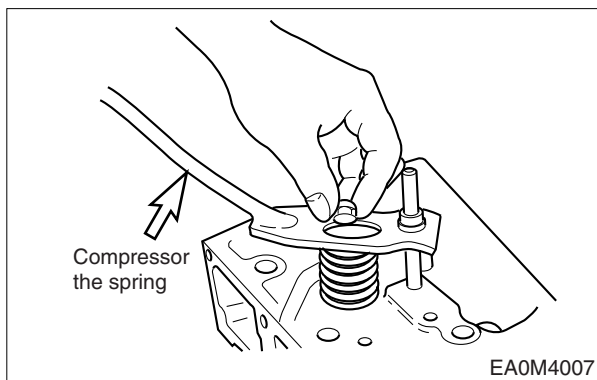
Cylinder head

1. Cylinder head assembly & disassembly

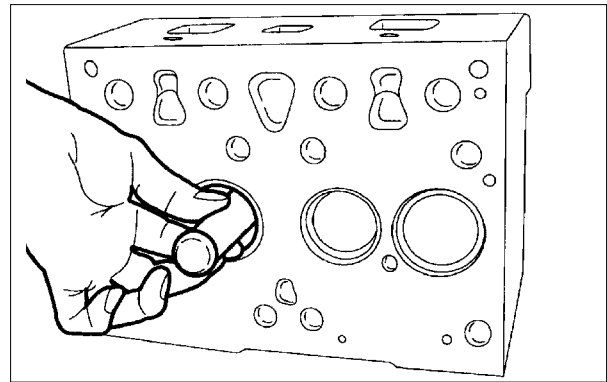
- a. Disassemble the cylinder assembly, and put it on the shelf for assembly or clean lathe.

⚠ WARNING

Try not to make any damage on the contact surfaces.



- b. Disassemble the cotter pin, spring, spring seat pushing valve spring by a special tool.
- c. Pull out the intake and exhaust valves.
- d. The disassembled parts are kept laid in turn.
- e. Disassemble the valve stem seal.



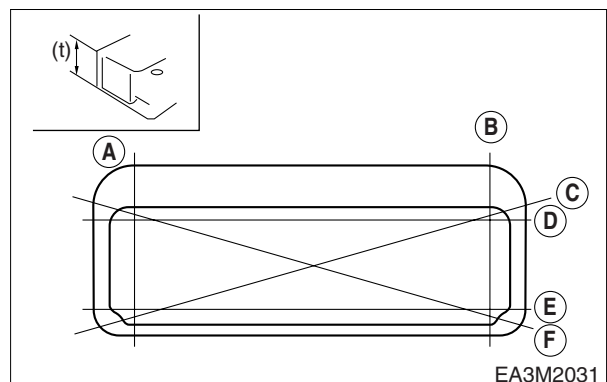
- f. By means of the special tool, punch, pull out a valve guide.

2. Inspection of cylinder head

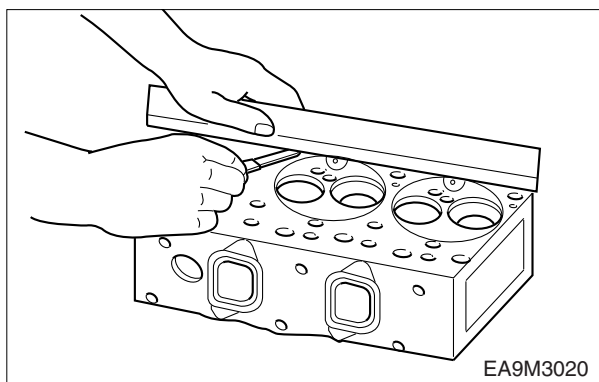
a Check for the cylinder head.

- Remove carbon from the cylinder head lower surface, and then should be careful not to scratch the surface.
- Check any crack or damage that can not found by naked eyes through the hydraulic or magnetic particle test.

b. Distortion of lower surface



- As shown in figure, measure the cylinder head's distortion at 6 directions with horizontal ruler and clearance gauge.
- If the measured value is beyond the limit value, correct it by means of the fine grinding paper or grinding machine.
- If it is beyond the max. allowable value, replace the cylinder head



• Valve stem outer diameter

Measure the valve stem outer diameter at 3 positions (top, middle, and bottom), and check for any wear and if beyond the limit value, replace the valve.

Dimension Description	Standard	Limit
Intake valve stem	8.950 ~ 8.970 mm	8.93 mm
Exhaust valve stem	8.935 ~ 8.955 mm	8.91 mm

<Lower face warpage and height>

	Standard	Limit
Warpage	0.2 mm or less	0.3 mm
Thickness : t (reference)	109.9 ~ 110.1 mm	108.4 mm

c. Flatness

Check the flatness of the installing surface of cylinder head's intake and exhaust manifolds with horizontal ruler and clearance gauge.

Standard	Limit
0.05 mm	0.2 mm

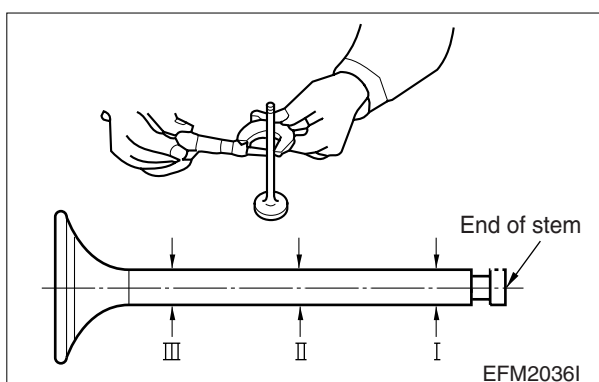
d. The hydraulic test

The hydraulic test of cylinder head is same as the cylinder block test.

3. Inspection of valve and valve guide

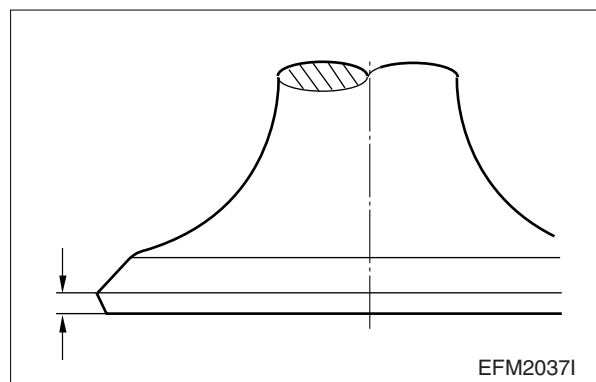
a. Valve

After cleaning valve with fuel, check it.



• Valve seat contacting faces

Check the valve seat contact surface for any crack and wear, and if necessary, correct with grinding paper, and if excessive, replace it.

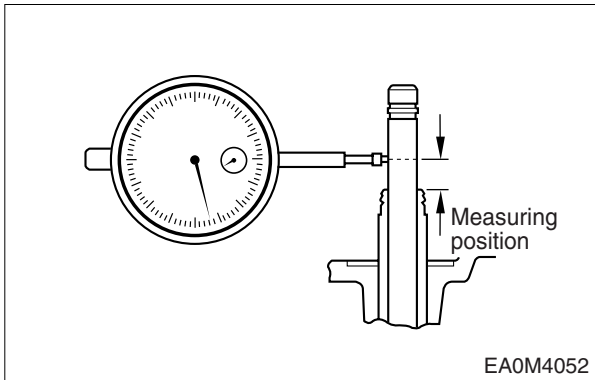


• Valve head thickness

Measure the thickness of valve head and if beyond the limit value, replace the valve.

Dimension Description	Standard	Limit
Intake valve	2.7 mm	1 mm or less
Exhaust valve	2.2 mm	1 mm or less

b. Valve guide



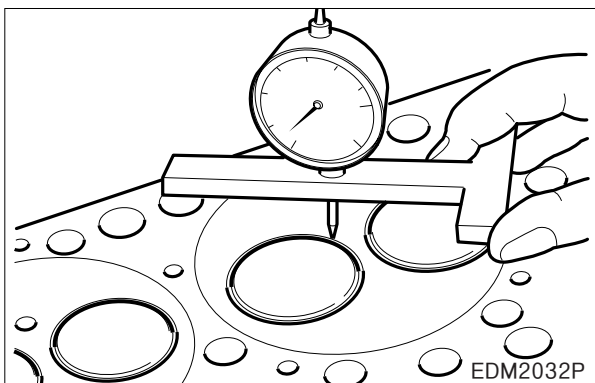
- Insert a valve into cylinder head and measure the clearance between valve guide and valve by valve movement. If the clearance is excessive, measure the valve and replace the excessively worn valve or valve guide.

<Valve stem end play>

Dimension Description	Standard	Limit
Intake valve	0.04 ~ 0.07 mm	0.2 mm
Exhaust valve	0.06 ~ 0.09 mm	0.25 mm

- Assemble the valve at cylinder head's valve guide and see if it is centered with the valve seat using a special tool.

c. Valve seat

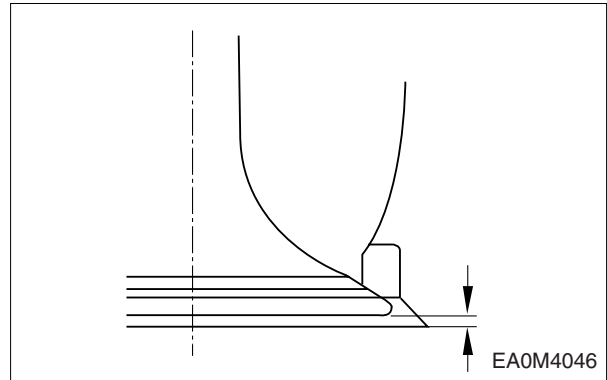


• Contacting face amount

As for the valve seat's wear, measure the width of the contact surface with intake valve seat and exhaust valve seat. If beyond the limit value, replace the valve seat.

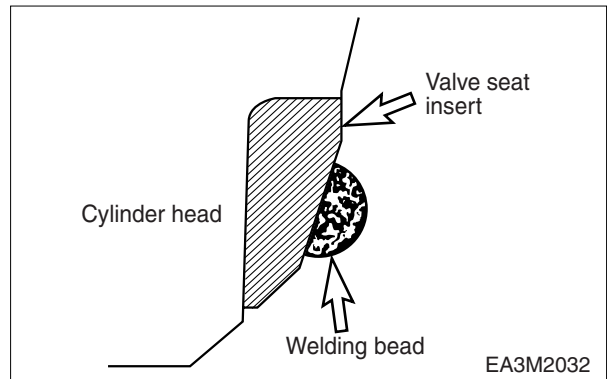
- Assemble the valve at the valve seat of the cylinder head, and check the amount of depression of the valve from the lower portion of the cylinder head using a dial gauge.

<Valve depression>



	Standard	Limit
Intake & Exhaust	0 ~ 0.3 mm	0.55 mm

If the amount of depression is beyond the specified limit, replace the valve seat.



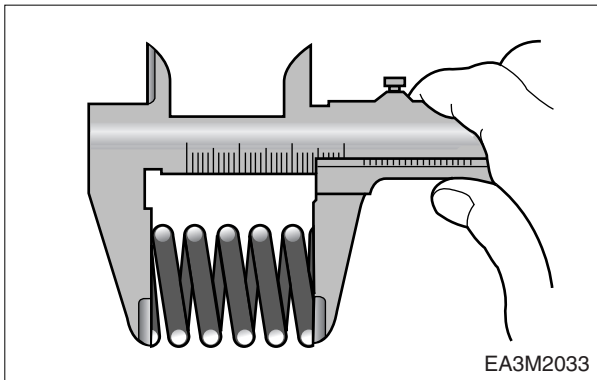
- For the disassembling of valve seat, by welding the welding bead to a valve seat rotating tool or valve seat, pull it out with a special tool.
- For the assembling of a new valve seat, by putting it among the dry ices of an ice box previously for about 2 hours for the cold shrinkage, and press it in the cylinder head by a special tool. (bench press)
- Apply valve lapping compound to the valve head seating face on the valve seat and lap the valve seat by turning it until it is seated in position, then wipe out the lapping compound.

d. Valve spring

• Visual check

Check the appearance of valve spring and if necessary replace the spring.

• Valve spring free length

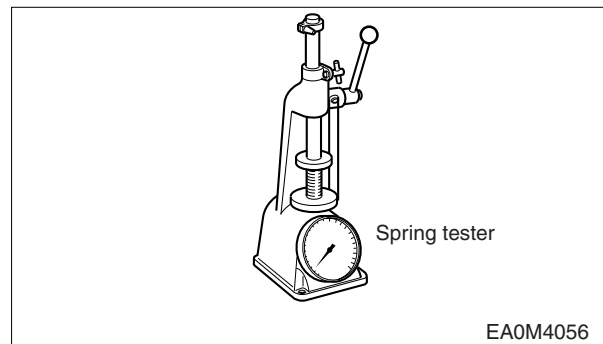


Use a vernier caliper to measure the valve spring free length.
If the measured value is less than the specified limit, the valve spring must be replaced.

(mm)

Spring free Length		Standard
Intake valve		64
Exhaust valve	Inner	60
	Outer	71

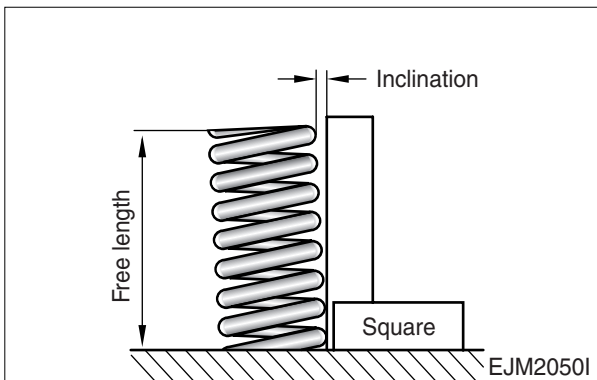
• Valve spring tension



Use a spring tester to measure the valve spring tension if the measured value is less than the specified limit, the valve spring must be replaced.

	Set Length		Spring force	Limit
Intake valve	Valve Spring Tension at 41mm Set Length		70 kg	3kg
Exhaust valve	Inner	38 mm	: 28.6 kg	6 %
	Outer	41mm	: 66 kg	5 %

• Valve spring inclination

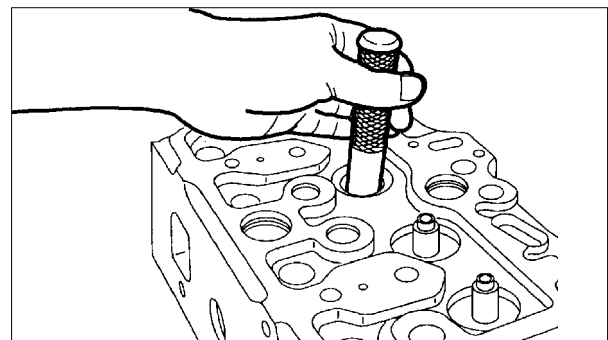


Use a surface plate and a square to measure the valve spring inclination.
If the measured value exceeds the specified limit, the valve spring must be replaced.

(mm)

	Standard	Limit
Valve Spring Inclination	Less than 1.8	2.7

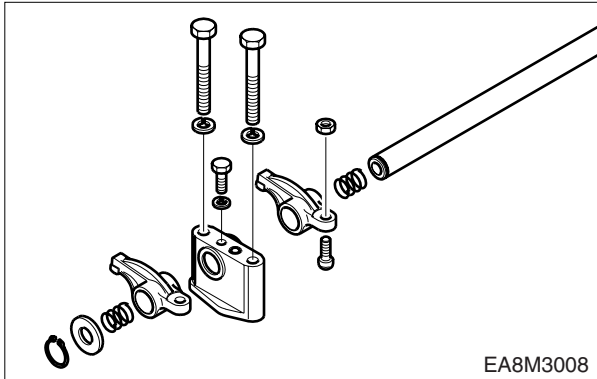
e. Assembling cylinder head



- Clean the cylinder head thoroughly.
- Replace the valve stem seal with new one, and by means of a special tool, press the stem seal into the valve guide of cylinder head.
- Coat engine oil to valve stem and valve guide and assemble the valve. However, be careful for the damage of valve stem seal.
- Install the lower seat of valve spring to the valve guide of cylinder head.
- After putting inner, outer springs, install the spring upper seat on it.
- Assemble the valve by inserting the valve cotter pressing the valve spring with a special tool.
- After installing the valve, check whether the valve is correctly installed or not tapping it lightly with urethane hammer.

Rocker arm assembly

1. Disassembly

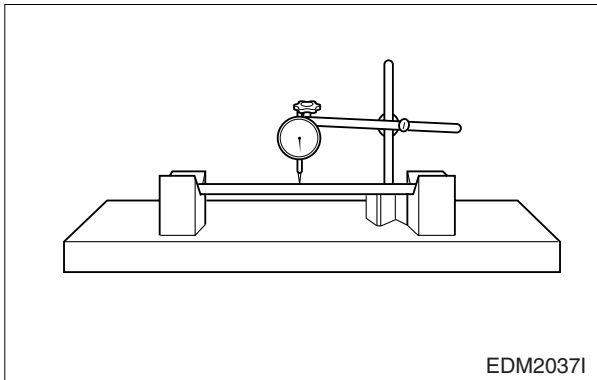


- Disassemble the snap rings that are located at both ends of rocker arm shaft by a plier.
- Disassemble in the order of washer, rocker arm bracket, rocker arm spring, rocker arm.

2. Inspection of rocker arm assembly

a. Rocker arm shaft

• Rocker arm shaft run-out

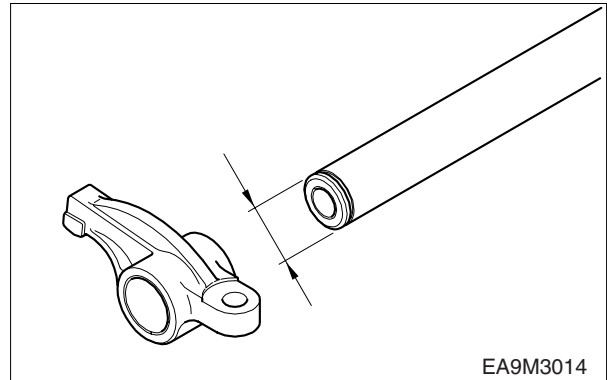


Place the rocker arm shaft on two V blocks and inspect the shaft for bend using a dial gauge.

If the amount of this run-out is small, press the shaft with a bench press to correct the run-out. Replace the shaft if the measured value exceeds the limit.

Limit	0.2 mm
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• Rocker arm shaft diameter



With an outside micrometer, measure the rocker arm shaft diameter at the point where the rocker arms have been installed. Replace the rocker arm if the amount of wear is beyond the specified limit.

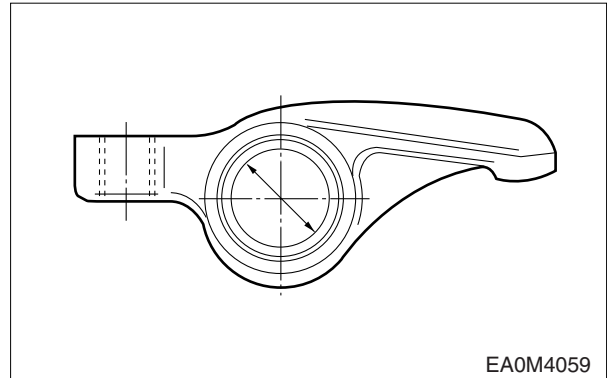
Standard	Limit
23.978 ~ 23.959 mm	23.75 mm

b. Rocker arm

• Visual check

Visually check the face of the rocker arm in contact with the valve stem end for scores and step wear. If the wear is small, correct it with an oil stone or grinding paper of fine grain size. Rocker arm with a considerable amount of step wear should be replaced.

• Rocker arm bushing diameter



Measure the inside diameter of the rocker arm bushing with an inside micrometer or vernier calipers, and compare the measured values with the rocker arm shaft diameter. If the clearance exceeds the limit, replace either bushing or shaft, whichever worn more.

Standard	Limit
0.020 ~ 0.093 mm	0.3 mm or less

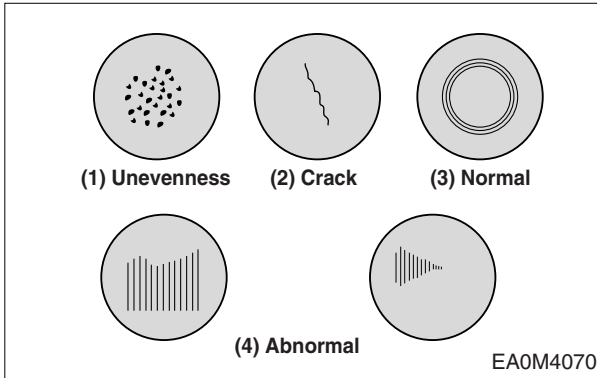
c. Tappet and push rod

• Clearance

Measure the clearance of the tappet and tappet holes of the cylinder block. If the value is beyond the specified limit, replace tappets.

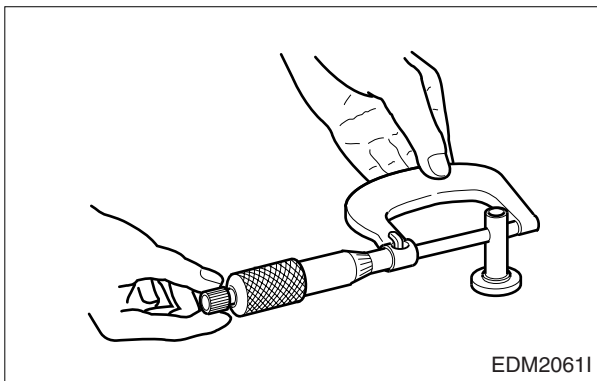
Standard	Limit
0.035 ~ 0.077 mm	0.15 mm

• Visual check of tappet



Visually check the face of the tappets in contact with the cam for pitting, scores or cracks, and replace if severely damaged. If the amount of cracks or pitting is small, correct with an oil stone or grinding paper.

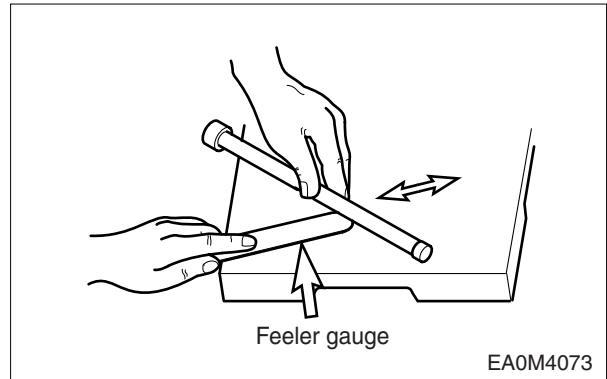
• Outside diameter of tappet



With an outside micrometer, measure the tappet outside diameter. If the measured value is beyond the limit, replace tappets.

Standard	Limit
19.944 ~ 19.965 mm	

• Push rod run-out



Limit	0.3 mm or less
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Use a feeler gauge to measure the push rod run-out. Roll the push rod along a smooth flat surface as shown in the figure.

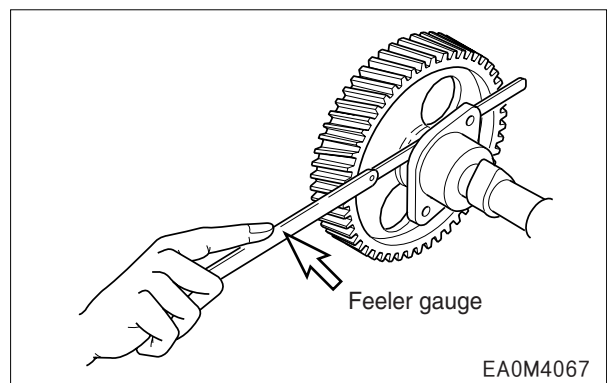
d. Reassembling rocker arm assembly

Reassembling can be done in the reverse order of disassembling and following things should be heeded

- Check the oil supply hole of rocker arm shaft for any clog and clean thoroughly.
- Be careful not to occur any swap of position and reverse assembly.

Camshaft

1. Camshaft end play

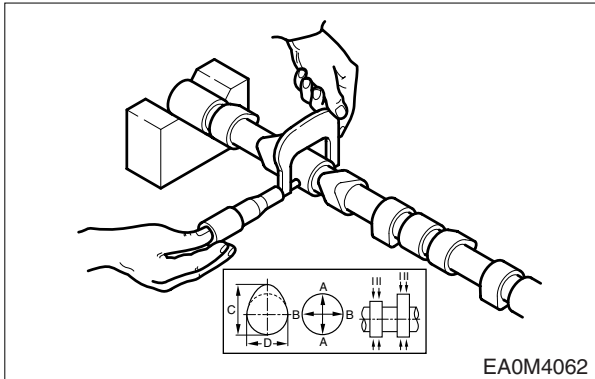


- Push the thrust plate toward the cam gear
- With a feeler gauge, measure the clearance between the thrust plate and camshaft journal.
- If the end play is excessive, replace the thrust plate.

Standard	Limit
0.28~ 0.43 mm	0.6 mm

2. Cam

• Cam lobe height



unit : mm

		Standard	Limit
Cam lobe height (C)	Intake	49.15	48.85
	Exhaust	49.35	49.00
Cam journal diameter (A,B)		57.86 ~ 57.88	57.52

Use a micrometer to measure the cam lobe height and journal diameter.

If the measured number is less than the specified limit, the camshaft must be replaced.

• Cam surface

Inspect the cam face for scratch or damage. Slight step wear or damage on the cam face may be corrected with oil stone or oiled grinding paper. But, replace if severely damaged.

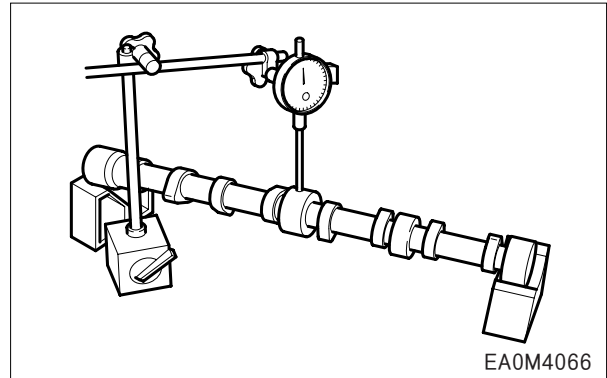
bushing on the cylinder block using a cylinder bore indicator, and compare the measured value with the camshaft outside diameter to determine the clearance.

<Clearance>

Standard	Limit
0.12~ 0.17 mm	0.24 mm

Replace the bushing if the measured value is beyond the specified limit.

• Run-out



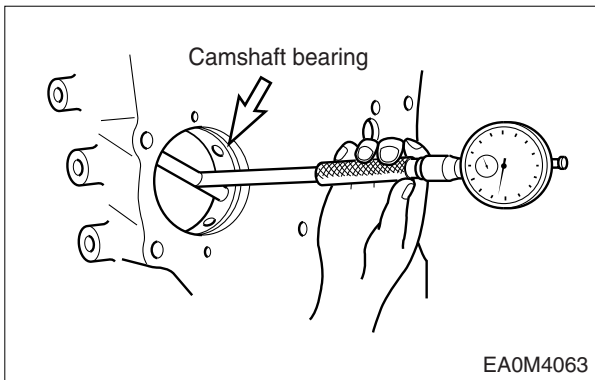
Support the camshaft on two V blocks and check for run-out using a dial indicator. Correct or replace the camshaft if the amount of run-out is beyond the value indicating need for servicing.

Standard	Limit
0.05 mm	0.2 mm

3. Cam shaft

• Clearance

between camshaft journal and camshaft bush



- With an outside micrometer, measure the camshaft journal diameter.
- Measure the inside diameter of the camshaft

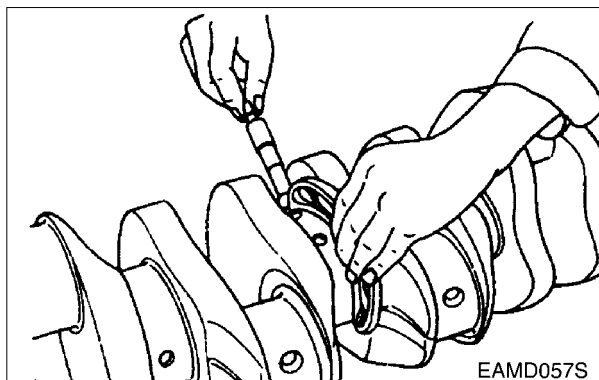
Crankshaft

1. Inspection of crankshaft

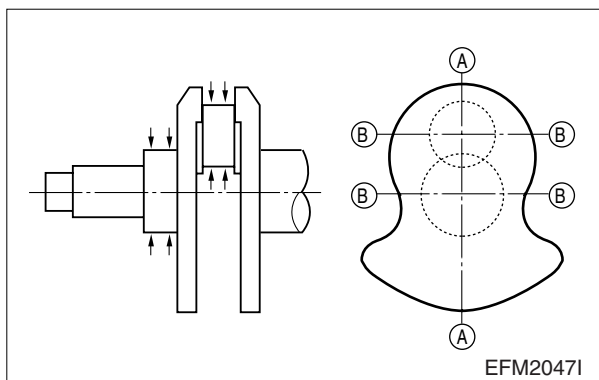
a. Defect check

- By naked eyes, check for any scratch or damage on the crankshaft journal and crank pin.
- By means of magnetic particle test and color check, check the crankshaft for any crack and if found, replace it.

b. Wear measuring

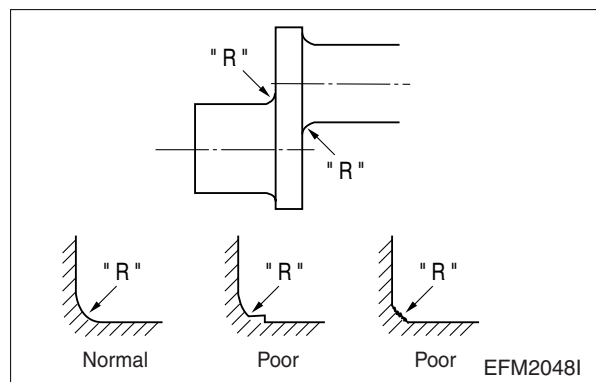


- With an outside micrometer measure the diameter of the crankshaft journals and pins in the directions as shown, and compare the measured values to determine the amount of wear.



- If the amount of wear is beyond the limit, have the crankshaft ground and install undersize bearings. However, if the amount of wear is within the limit, you can correct the wear using an oil stone or oiled grinding paper of fine grain size. (Be sure to use grinding paper which has been immersed in oil.)

	Standard	Limit
Journal diameter	83.966 ~ 83.988	83.000 mm
Pin diameter	70.971 ~ 70.990	70.000 mm



- In case that pin's wear is more than the limit value, grind the crankshaft journal and crank pin, and use the undersized bearings.

⚠ WARNING

Be sure to use grinding paper which has been immersed in oil.

<Undersize bearings available>

- Standard
- 0.25 (Inside diameter is 0.25 mm lesser than the standard size.)
- 0.50 (Inside diameter is 0.50 mm lesser than the standard size.)
- 0.75 (Inside diameter is 0.75 mm lesser than the standard size.)
- 1.00 (Inside diameter is 1.00 mm lesser than the standard size.)

Undersize bearings are available in 4 different sizes as indicated above, and the crankshaft can be reused through the regrinding as described above.

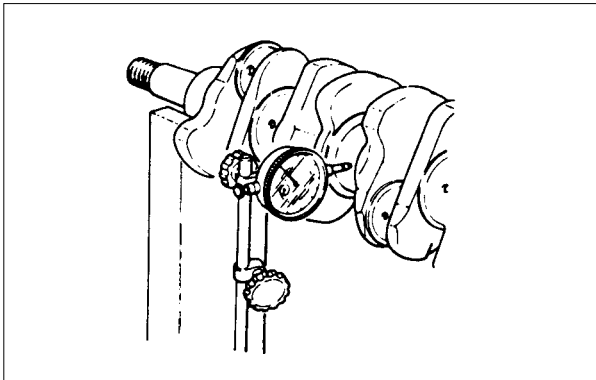
* "R" part's specified value

- ① Crank Pin's "R" : $4.5 \begin{smallmatrix} 0 \\ -0.2 \end{smallmatrix}$
- ② Crank journal "R" : $4 \begin{smallmatrix} 0 \\ -0.2 \end{smallmatrix}$

⚠ WARNING

In case of regrinding, the grinding the "R" part of bearing end should be correctly done and keep in mind to remove any jaws or coarse surface absolutely.

c. Crankshaft run-out



- Support the crankshaft on V blocks.
- Turn the crankshaft with a dial indicator placed on the surface plate and take the amount of crankshaft run-out.

Standard	Limit
0.05 mm	0.1 mm

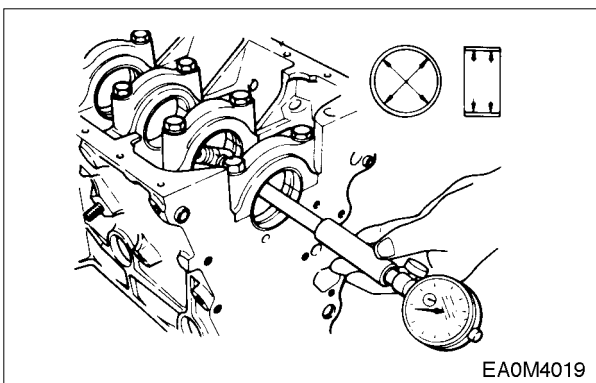
2. Crankshaft bearing and connecting rod

a. Visual check

Visually check the crankshaft bearing and connecting rod bearing for scores, uneven wear or damage.

b. Oil clearance between crankshaft and bearing (Method 1 : dial gauge)

• Main bearing clearance



Install the main bearing in the cylinder block, tighten the bearing cap to specified torque, then measure the inside diameter.

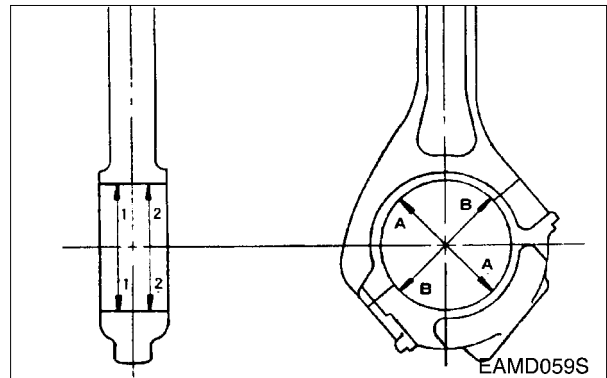
Torque	30 kg•m
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Compare the two values obtained through measurement of main bearing inside diameter with the outside diameters of crankshaft journals to determine the oil clearance.

<Main bearing oil clearance>

Standard	Limit
0.052 ~ 0.122 mm	0.25 mm

• Connecting rod bearing clearance

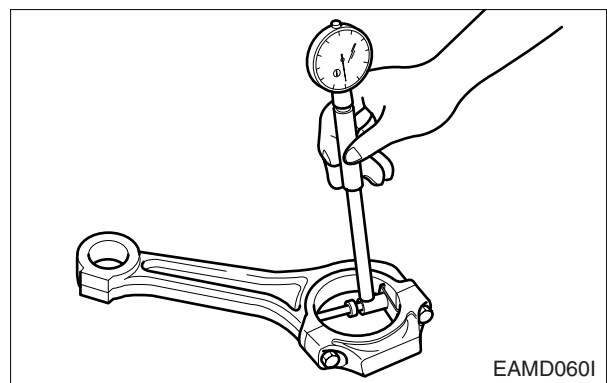


Install the connecting rod bearing in the connecting rod bearing cap, tighten the connecting rod cap bolts to the specified torque, then measure the inside diameter.

Torque	18 kg•m
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Compare the two values obtained through measurement of connecting rod bearing inside diameter with the outside diameters of crankshaft pins to determine the oil clearance.

Standard	Limit
0.034 ~ 0.098 mm	0.25 mm



- If the clearance deviates from the specified range, have the crankshaft journals and pins ground and install undersize bearings.

c. Oil clearance between crankshaft and bearing (Method 2 : plastic gauge)

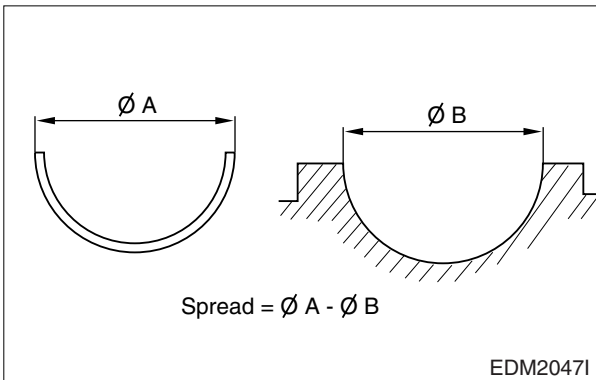
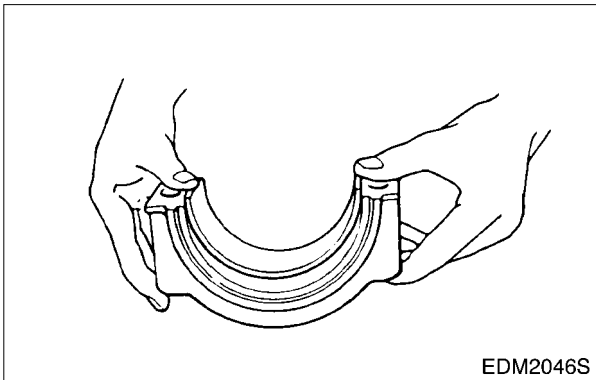
- Assemble the crankshaft on the cylinder block and put plastic gauge on the journal and pin of crank-

shaft and then after assembling bearing cap, tighten the bolts at the specific torque. Again after disassembling the bearing cap by removing the bolts, take out the flatted plastic gauge and measure the width of plastic gauge by means of plastic gauge measuring scale. This is the oil clearance.

- The oil clearance too can be measured in the same manner

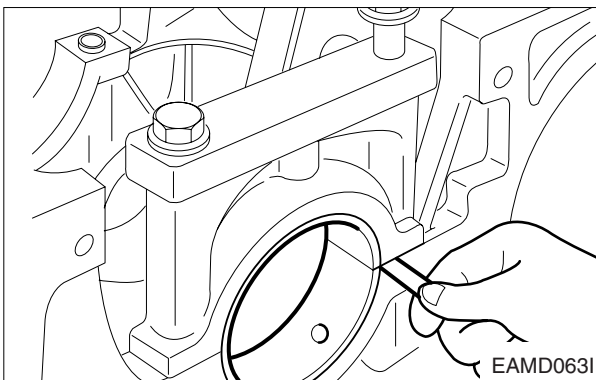
d. Bearing spread and crush

• Inspection



Check to see that the bearing requires a considerable amount of finger pressure at reassembly operation.

• Crankshaft bearing crush

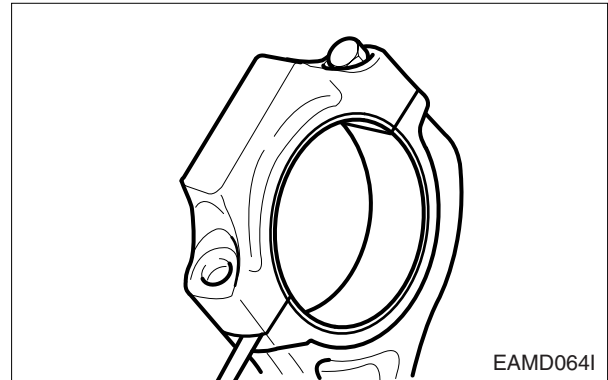


Install the bearing and cap in the cylinder block,

retighten the bolts to specified torque, unscrew out one bolt completely, then measure the clearance between the bearing cap and cylinder block using a feeler gauge.

Standard	0.19 ~ 0.22 mm
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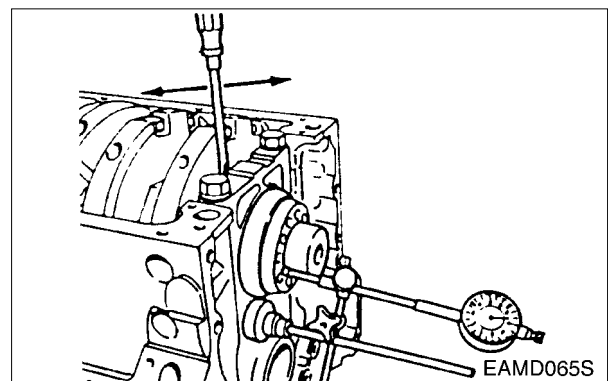
• Connecting rod bearing crush



Install the bearing and cap in the connecting rod big end, retighten the bolts to specified torque, unscrew out one bolt completely, then measure the clearance between the bearing cap and connecting rod big end using a feeler gauge.

Standard	0.3 ~ 0.5 mm
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e. Crank shaft end play



- Assemble the crankshaft to the cylinder block.
- With a dial gauge, measure crankshaft end play.

Standard	Limit
0.15 ~ 0.325 mm	0.5 mm

Piston assembly

1. Disassembly of piston assembly

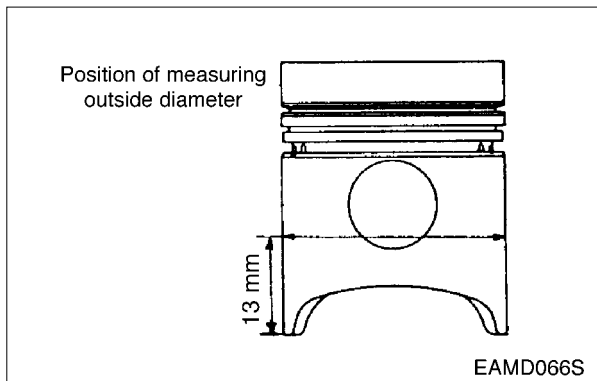
Disassemble piston according to the disassembly process.

2. Piston inspection

a. Visual check

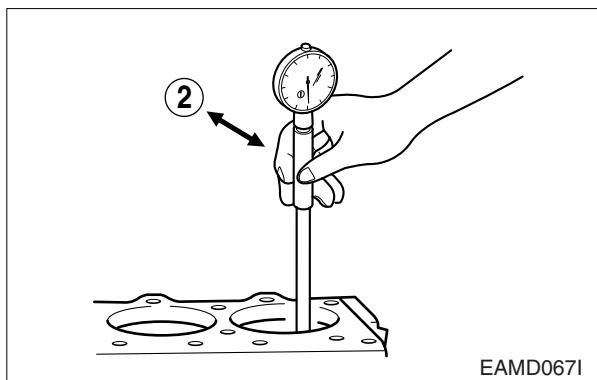
Visually check the pistons for cracks, scuff or wear, paying particular attention to the ring groove.

b. Clearance between the piston and cylinder liner



- With an outside micrometer, measure the piston outside diameter at a point 13mm away from the lower end of piston skirt in a direction at a right angle to the piston pin hole.

Standard	110.833 ~ 110.897 mm
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- Using a cylinder bore gauge, 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	Limit
111 ~ 111.022 mm	111.122 mm

- 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.

<Clearance between piston and liner>

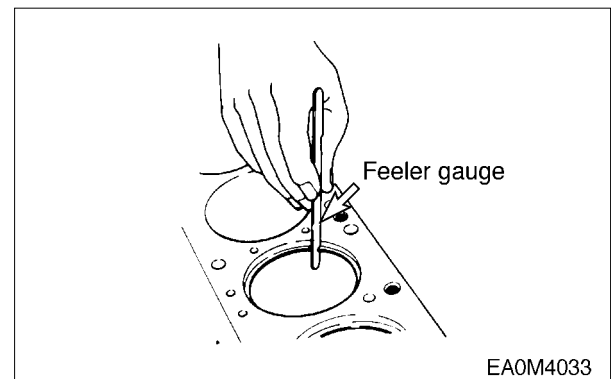
Standard	0.103~ 0.139 mm
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3. Piston rings

a. Visual check

Replace the piston rings with new ones if detected worn or broken when the engine is overhauled.

b. Piston ring gap

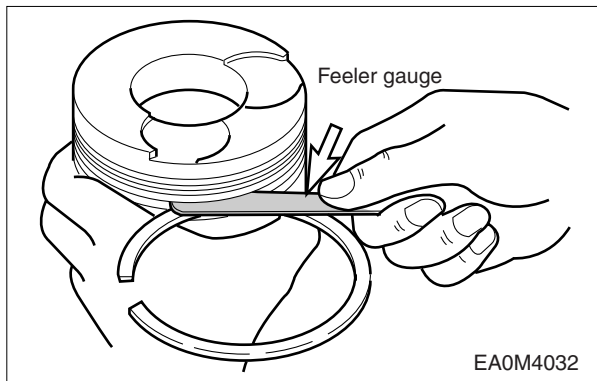


- Insert the piston ring into the upper portion of the cylinder liner bore so that it is held at a right angle to the cylinder liner wall.
- Measure the piston ring gap with a feeler gauge.

	Standard	Limit
Top ring	0.40 ~ 0.60 mm	1.5 mm
2nd ring	0.40 ~ 0.60 mm	1.5 mm
Oil ring	0.30 ~ 0.50 mm	1.5 mm

- Replace piston rings with new ones if the gap is beyond the limit

c. Piston ring side clearance



- Fit the compression ring and oil ring in the piston ring groove.
- With a feeler gauge, measure side clearance of each ring, and replace either the ring or piston if the measured value is beyond the specified limit.

	Standard	Limit
Top ring	-	-
2nd ring	0.07 ~ 0.102 mm	0.15 mm
Oil ring	0.05 ~ 0.085 mm	0.15 mm

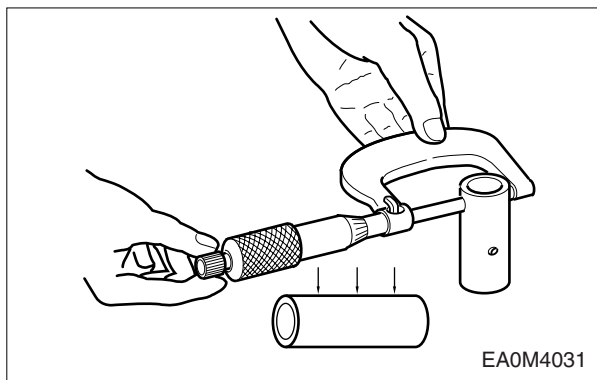
d. Piston ring tension

With a tension tester, measure piston ring tension. Replace the piston ring if the measured value is beyond the limit.

	Standard
Top ring	2.58 ~ 3.88 kg
2nd ring	1.81 ~ 2.71 kg
Oil ring	3.57 ~ 5.03 kg

4. Piston pin inspection

a. Wear

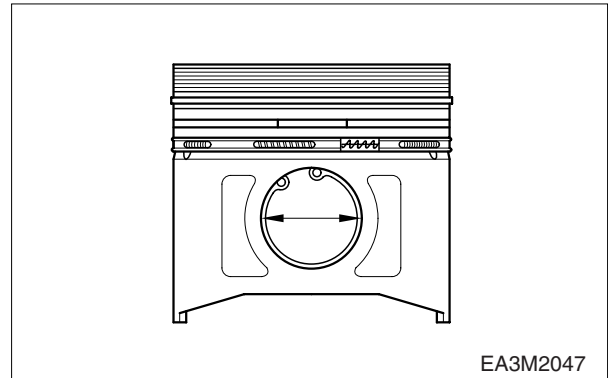


Measure the amount of wear on the piston pin at the

points as shown. The measured values are beyond the limit (0.08 mm or greater), replace the pin.

Standard	Limit
41.994 ~ 42.000 mm	41.94 mm

b. Clearance



Measure the clearance between the piston pin and connecting rod bushing, and replace either of them, whichever damaged more, if the measured value is beyond the limit.

Standard	Limit
0.003 ~ 0.015 mm	0.08 mm

c. Condition check

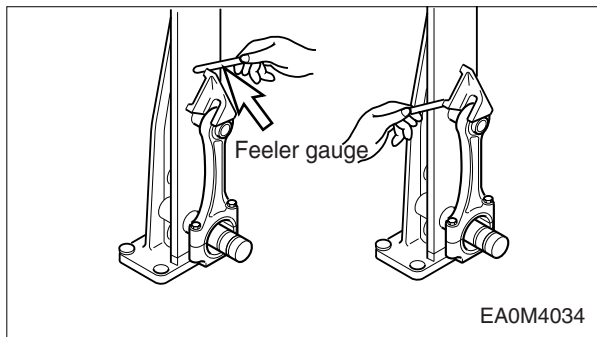
Check the engaged condition of the piston and piston pin. If it is possible to force the pin into the piston heated with piston heater, the piston is normal. When replacing the piston, be sure to replace the piston pin together.

5. Connecting rod inspection

a. Distorsion

Check the connecting rod for distortion. As shown in the figure below, install the connecting rod to the connecting rod tester, and check for distortion using a feeler gauge. If the connecting rod is found distorted, never re-use it but replace with a new one.

b. Holes alignment (parallelism)



Measure the alignment of the connecting rod piston pin bushing holes with connecting rod big end holes. At this time also, use both connecting rod tester and feeler gauge.

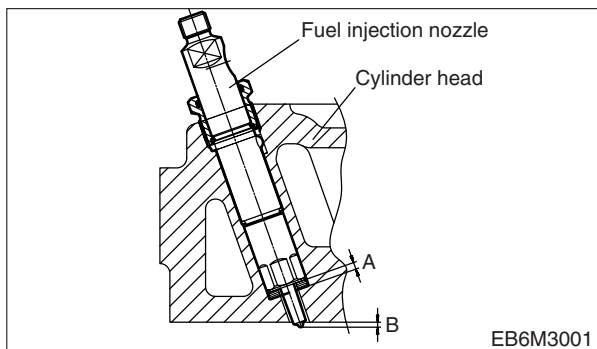
Standard	Limit
0.05 mm	0.1 mm or less

c. Wear

- Assemble the connecting rod to the crankshaft and measure connecting rod big end side clearance using a feeler gauge.
- Assemble the connecting rod to the piston and measure connecting rod small end side clearance.
- If the measured values are beyond the limit, replace the connecting rod.

Limit	0.5 mm
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Fuel injection nozzle projection



1. Insert a seal ring on the cylinder head and assemble the injection nozzle
2. Measure the clearance between the cylinder head bottom and nozzle tip. If the measured values are beyond the limit, replace the seal ring.

	Standard
A (Thickness of seal ring)	3.5 0.1 mm
B (Projection of nozzle)	2.43 ~ 2.80 mm

Engine Reassembly

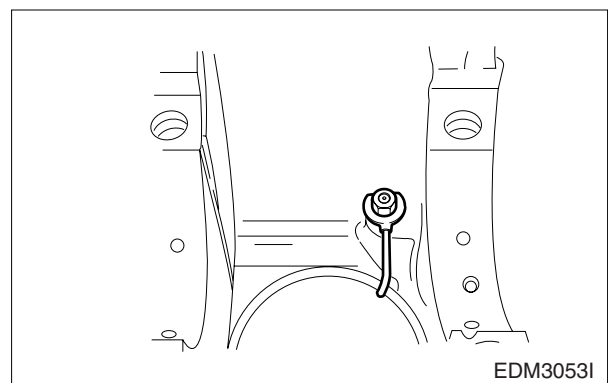
General precautions

1. Clean all the disassembled parts, particularly oil and water ports, using compressed air, then check that they are free from restrictions.
2. Arrange the general and special tools in order for engine assembly operation.
3. To wet each sliding part, prepare the clean engine oil.
4. Prepare service materials such as sealant, gaskets, etc.
5. Discard used gaskets, seal rings, and consumable parts, and replace with new ones.
6. Apply only the specified torque for bolts in the specified tightening order and avoid over-tightening.
7. Be sure to check that all the engine parts operate smoothly after being reassembled.
8. Check the bolts for looseness after reassembly.
9. After completing the engine reassembly operation, check if there is missing parts or shortage of parts.
10. Keep your hands clean during the working.

Cylinder block

Cover the floor of the workshop with wood plate or thick paper to prevent damage to the cylinder head and place the cylinder block with the head fitting surface facing downward.

Oil spray nozzle

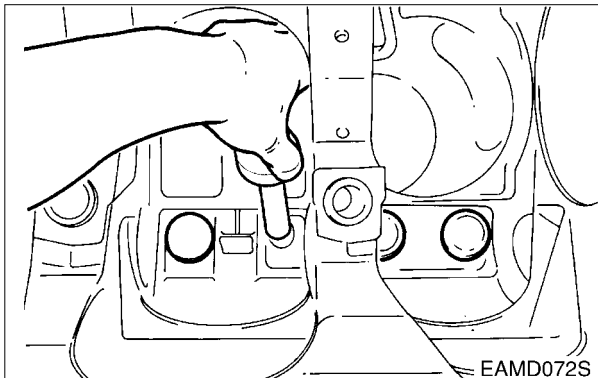


Tighten and assemble the oil spray nozzle flange with fixing bolts using the spray nozzle jig.

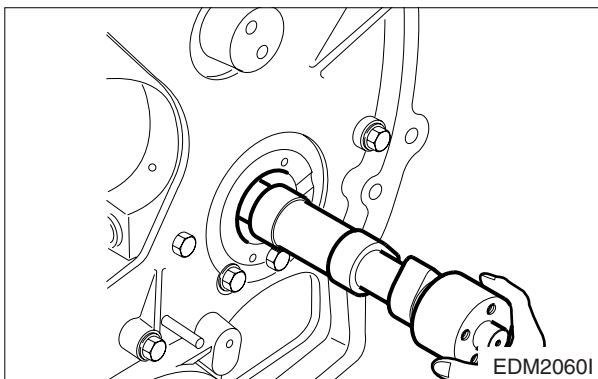
Torque	7 kg•m
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Tappet and cam shaft

1. Undercool a new bush with dry ice for about 2 hours and press it into position in the cylinder block using a bench press. After the pressing operation, measure the inside diameter of the cam bush to check if it is not deformed.



2. Apply engine oil to the entire face of the tappets and slide them into the tappet holes on the cylinder block.



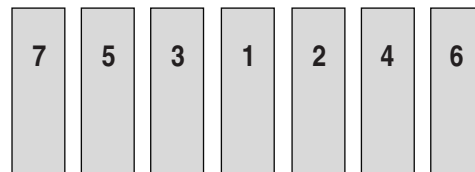
3. Wet the cam bush inside diameter and camshaft with oil, and carefully assemble them while turning the camshaft.

WARNING

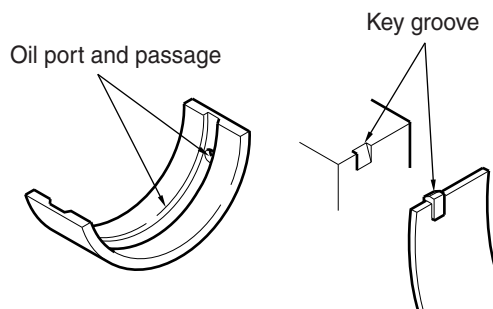
Be careful not to generate a damage to camshaft and bush.

4. Check to see that the camshaft rotates smoothly.

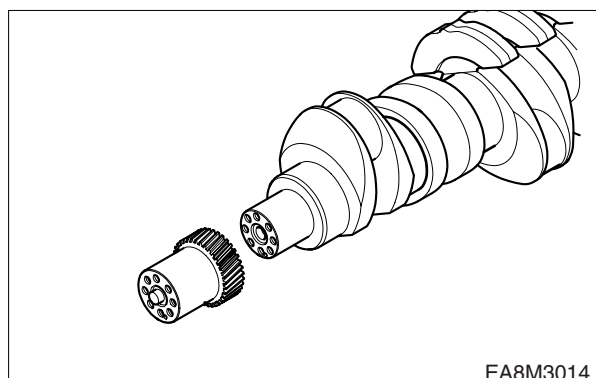
Crankshaft



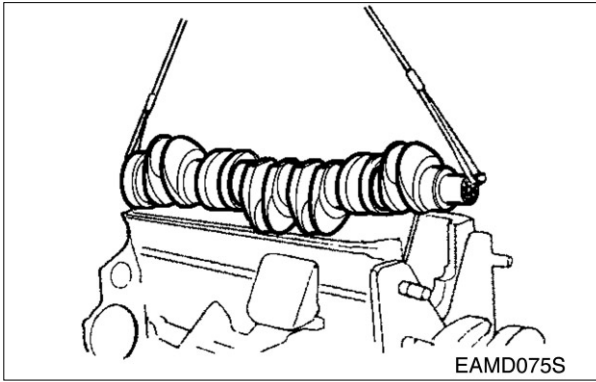
EFM2061I



1. Install the main bearing (refer to assemble sequence : right figure) machined with two holes in the cylinder block so that the key is aligned with the key groove, then apply oil to the bearing surface.



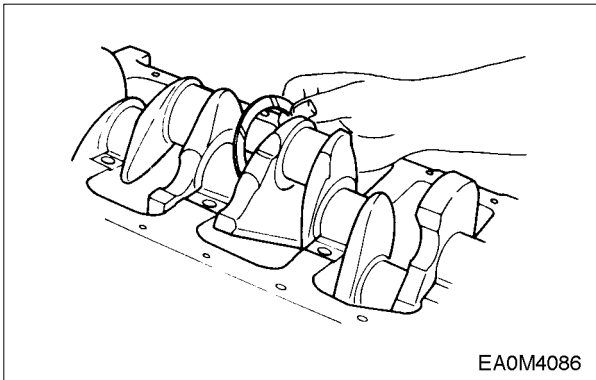
2. Heat the crankshaft gear for at least 10 minutes to 120°C, then apply sealant (Loctite # 641) to the inside wall of the heated crankshaft gear evenly before inserting it to the end of crankshaft.



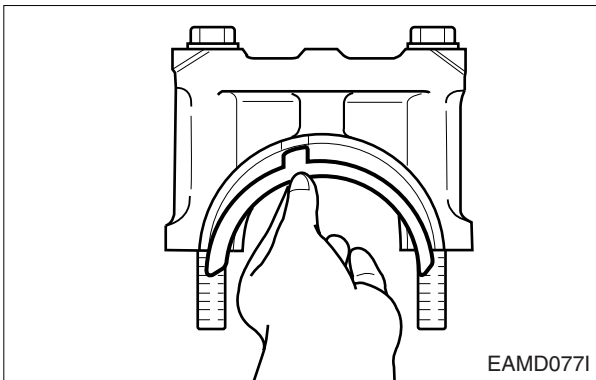
3. Semi-tighten a bolt at both sides of the crankshaft, apply engine oil to journals and pins, then assemble the crankshaft with the cylinder block by tightening the fixing bolts.

⚠ WARNING

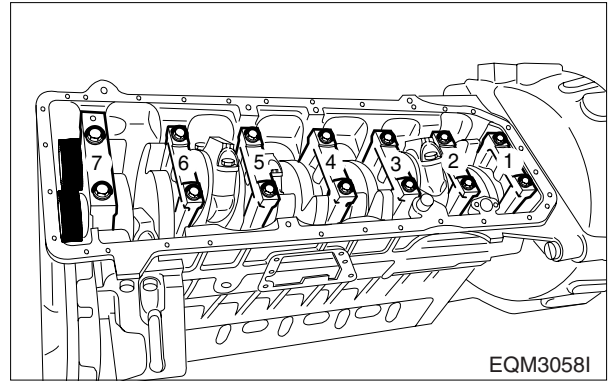
Coat engine oil to the pin and journal of crankshaft.



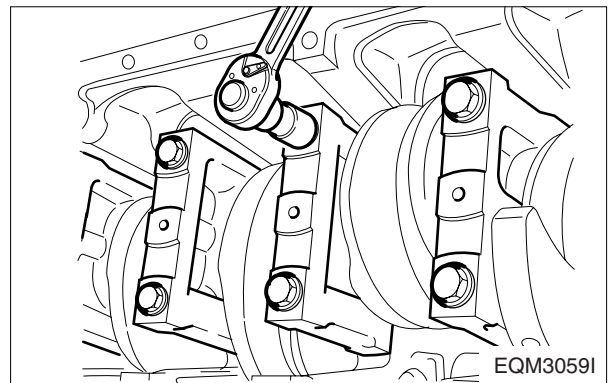
4. Install the oiled thrust washers with the oil groove facing outward.



5. Install the bearing and thrust washers to the bearing cap and apply oil to the bearing and thrust washers.



6. Install the bearing cap by matching the cylinder block No. with the bearing cap No.



7. Apply oil to the entire part of the bearing cap bolts, then tighten in tightening sequence to specified torque.

Torque	30 kg·m
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8. After semi-tightening both bolts evenly, tighten them diagonally to the specified torque using a torque wrench as follows.

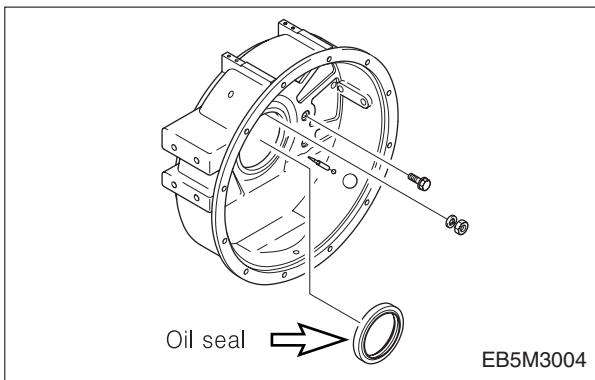
<Tightening order>

- a. First stage : Coat the cap bolts with engine oil
- b. Second stage : Temporary bolt screwing about 1 ~ 2 threads
- c. Third stage : With impact wrench, tighten up to about 15 kg.m
- d. Fourth stage : With torque wrench, tighten up to about 25 kg.m
- e. Fifth stage : By means of torque wrench, tighten finally in the specified torque. (30 kg.m).

- Tighten the bearing cap in the sequence of 4-3-5-2-6-1-7.

- Check to see that the assembled crankshaft turns smoothly with hand.

Flywheel housing



1. Temporarily install the guide bar on the cylinder block.
2. Apply gasket to the cylinder block.
3. Using the dowel pin and guide bar, install the flywheel housing and tighten the fixing bolts in a diagonal sequence to specified torque. (Zigzag method)

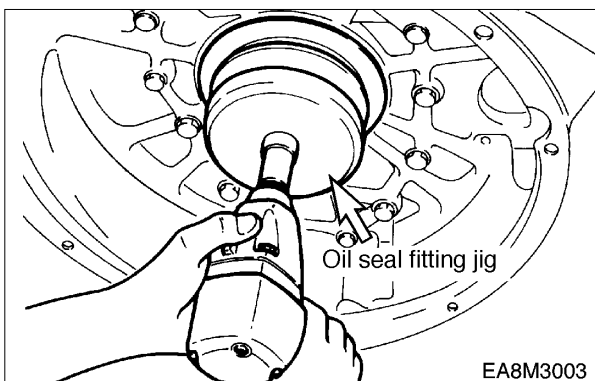
Torque	8 kg•m
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WARNING

When the bolts are tightened, remove the guide bar.

4. The flywheel housing is assembled after the new oil seal was pressed (Coat engine oil over the outside of oil seal) before in the housing by a press.
5. If any peripheral scar was generated due to oil seal at the oil seal contact surface of crankshaft, after inserting about 1 mm shim or thereabout in front of oil seal (Direction toward crankshaft.), measure and adjust.

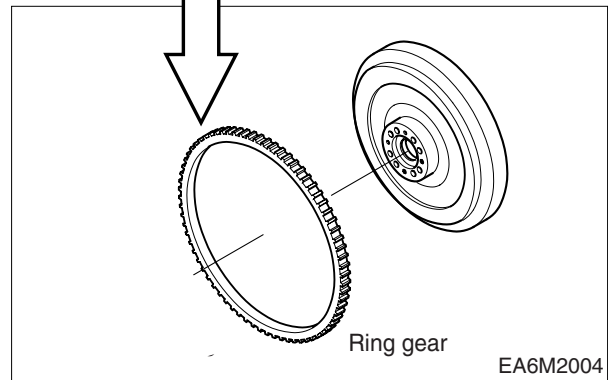
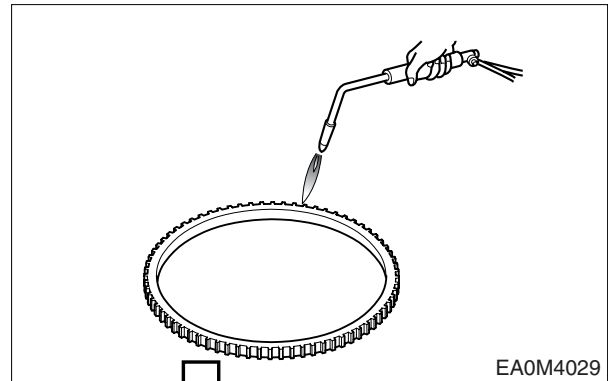
Oil seal (Rear side)



1. Apply lubricating oil to the outside of the oil seal and flywheel housing inside diameter and fit them over the crank shaft, then assemble the oil seal using an oil seal fitting jig.

Flywheel

• Installation of flywheel ring gear

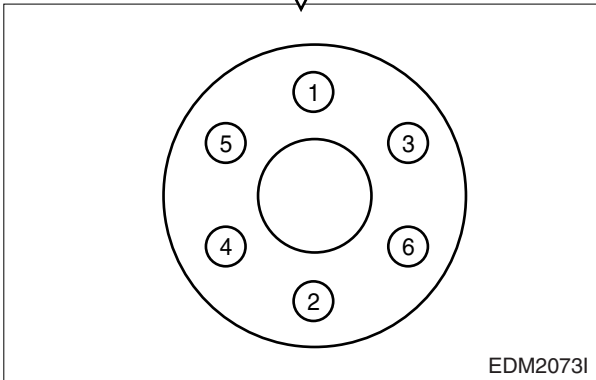
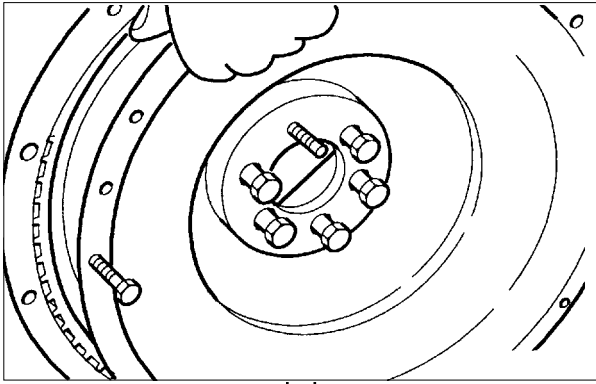


With a gas burner, heat the ring gear evenly until heat expansion takes place, then install it using a hammer.

WARNING

Do not allow the temperature of the ring gear to exceed 200 °C (390 °F).

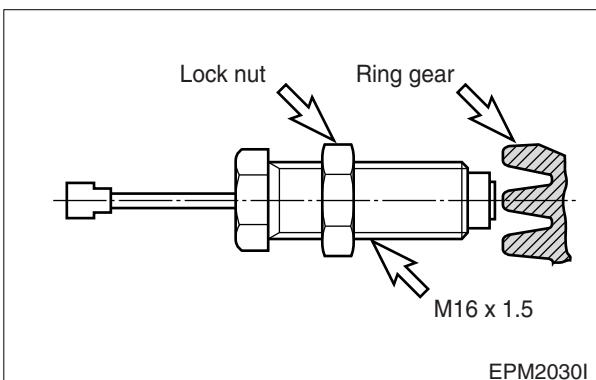
2. By means of mandrel, assemble pilot bearing to the flywheel.
3. By means of mandrel, press in the wear ring at the backward face.



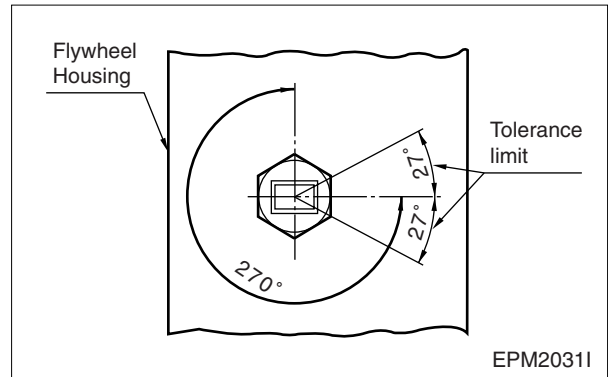
4. Install a guide bar into a bolt hole on the crank shaft, and lift the flywheel to align the dowel pin with the pin hole on the flywheel for temporary assembly operation.
5. Coat the adhesive (#271 Loctite) over the assembling bolts and install bolts in the remaining holes. After that take out the guide bar, then install a bolt in the hole where the guide bar had been inserted.
6. According to the order of tightening tighten the fixing bolts using a torque wrench in a diagonal sequence to specified torque.

Torque	18 kg•m
---------------	----------------

Magnetic pick-up sensor



7. Move the lock nut to hexagonal side of sensor completely.
8. Rotate (Clockwise) the pick-up sensor on fly wheel housing, until the end of it reach on fly wheel ring gear.

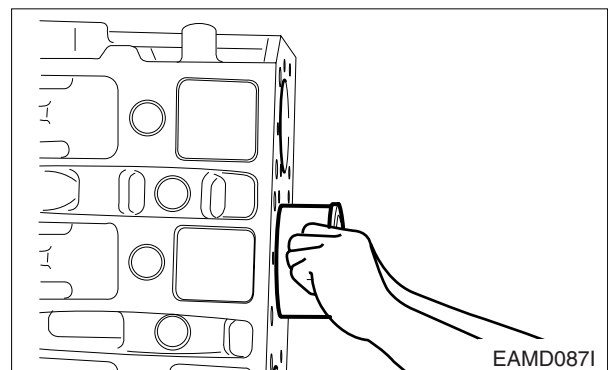


9. Then rotate (Counter clockwise) the pick-up sensor for 270° (gap 1.0 mm) and fix lock nut.
10. Tolerance limit is 27°. (gap L 0.1 mm)

Water chamber cover

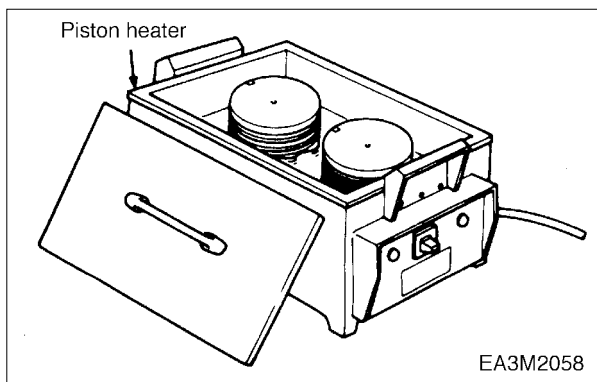
1. Coat the adhesive over the water chamber cover (Particular around bolt holes) and after attaching the gasket, assemble it to the cylinder block using the bolts for assembling.
2. As for tightening of bolts, after primarily tightening the bolts located at the both ends of cover (4ea at both sides) and middle bolts (Upper, lower 2ea) , tighten the rest.

Cylinder liner

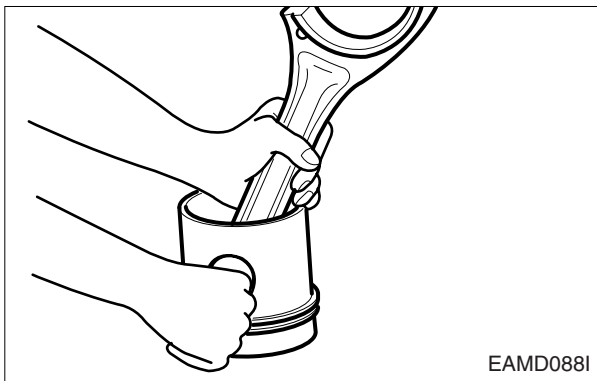


1. Stand the cylinder block so that the flywheel faces downward.
2. Thoroughly clean the liner flange fitting surface and bore inside with compressed air to prevent the entry of foreign substances.
3. After the cleaning operation, make the cylinder liner dried up and push it into the cylinder block by hand.
4. Wet the liner inside diameter with engine oil.

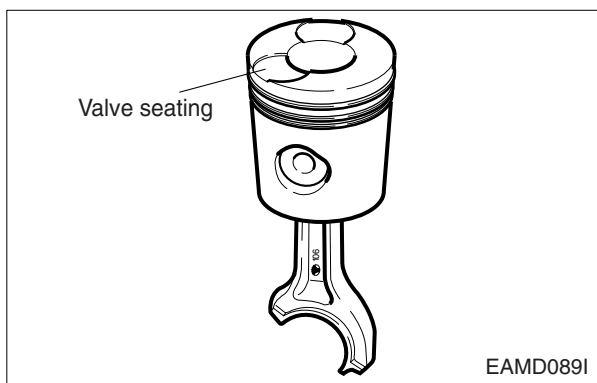
Piston and connecting rod



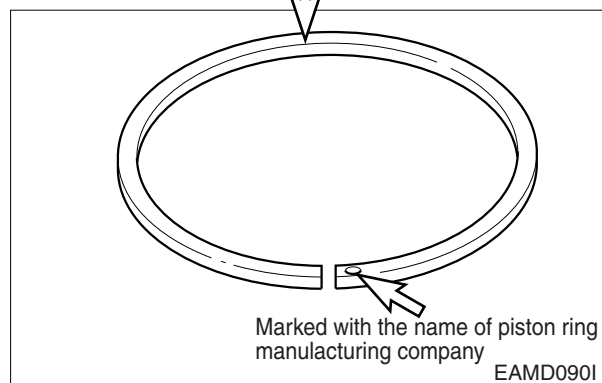
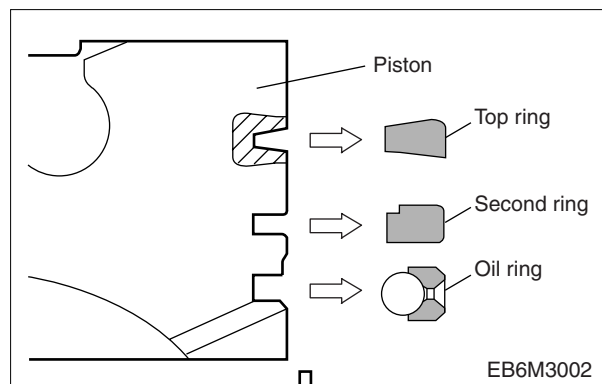
1. Use a piston heater to heat the piston approximately 100 °C (212 °F) for 5 minutes.



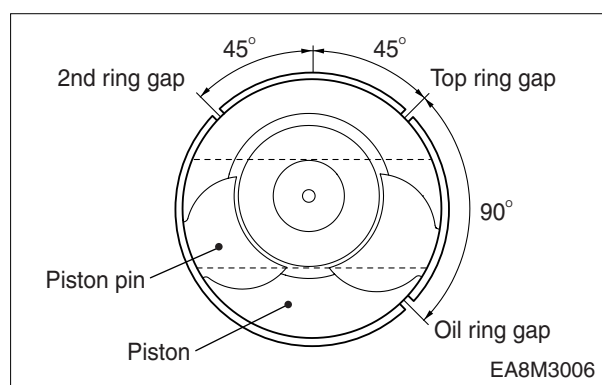
2. Align the piston pin hole with the oiled connecting rod small end and press the piston pin (by lightly tapping with a rubber hammer) to assemble the connecting rod with the piston.



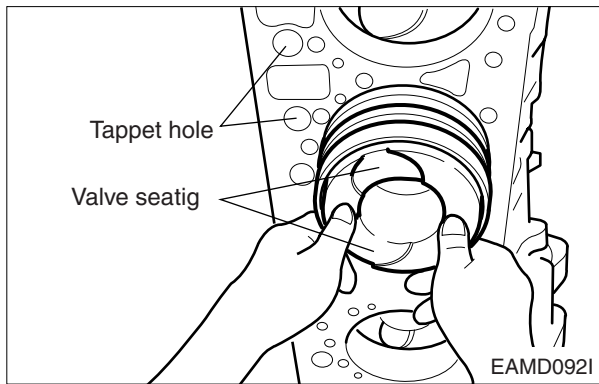
3. Nothing the direction of the piston, make the longer side(machined with key groove on the bearing) of the connecting rod big end.
4. On the piston head surface, the longer side connecting rod big end is in opposite direction from the valve seating surface as well as in the same direction with the narrow margin of the combustion chamber.



5. Install the snap rings and check to see that it is securely assembled.
6. Install the piston ring in the piston using piston ring pliers.
7. 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" is upper surface.)



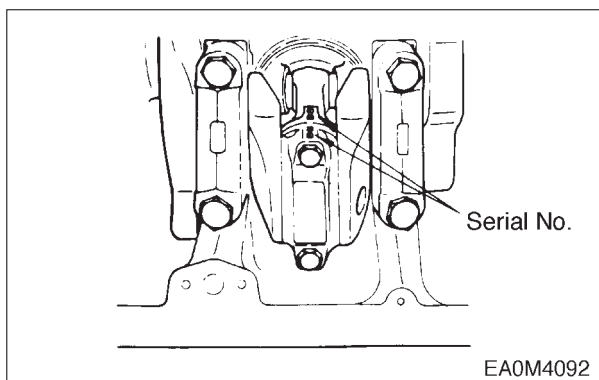
8. Adjust the angle among individual piston ring gaps to 90° and fit a piston assembling jig onto the piston, Use care not to match the ring gaps with the pin direction.
9. Install the bearing by aligning it with the connecting rod key groove and apply oil to the bearing and piston.



10. Position the valve seating surface toward the tappet hole and insert the piston with hand.

⚠ WARNING

Use care not to damage the cylinder liner and piston, and slightly lift and insert the piston into the cylinder so that the ring may not be damaged by the fillet of the liner.



11. Install the bearing in the connecting rod cap and apply oil.

⚠ WARNING

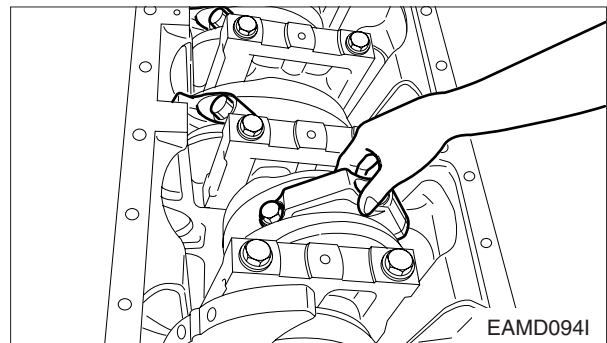
Make sure that the manufacture serial numbers impressed on the connecting rod cap and connecting rod big end are identical, and install the connecting rod cap by aligning it with dowel pin.

12. Loosen the tension adjusting bolts of the alternator and the idle pulley, and take off the belts.

<Tightening order>

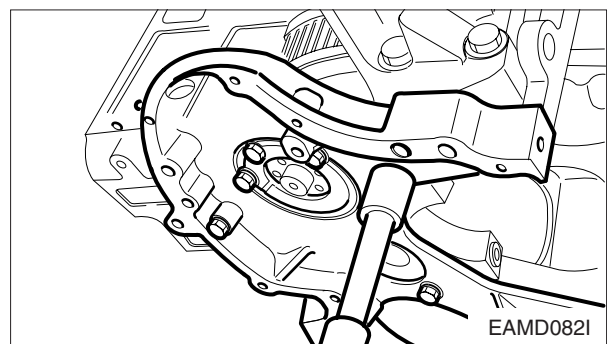
- (1) First stage : Coat engine oil over bolts.
- (2) Second stage : Temporary bolt screwing about 1 ~ 2 threads
- (3) Third stage : With torque wrench, tighten up to about 10 kg.m
- (4) Fourth stage : With torque wrench, tighten up to about 15 kg.m
- (5) Fifth stage : By means of torque wrench, tighten finally in the specified torque. (18 kg.m).

Torque	18 kg•m
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13. When the connecting rod bearing cap bolts are tightened, check the connecting rod end play to the right and left with hand. If no end play is found,, remove and reinstall or replace the connecting rod bearing cap.

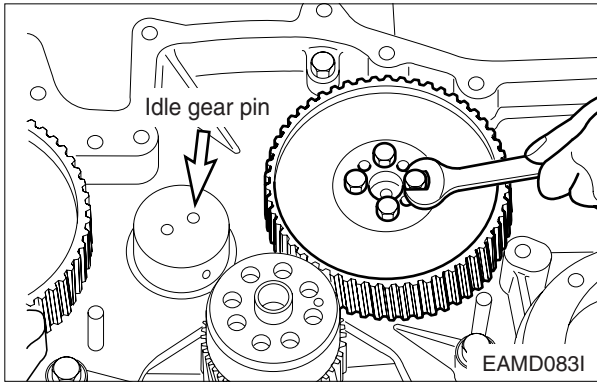
Timing gear case



1. Mount a new gasket using dowel pin on the cylinder block.
2. Put the time gear case to the cylinder block by aligning the dowel pin hole of timing gear case with its pin, and then assemble it by tapping lightly with an urethane hammer to the right and left (Particularly around dowel pin).
3. Tighten the bolts for assembling to the specified torque.

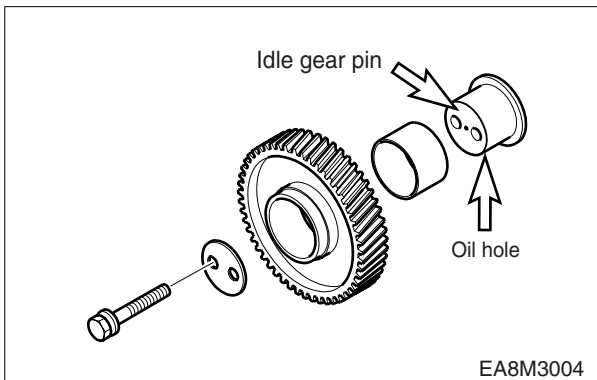
However, in case of tightening the bolts, tighten primarily the bolts of both end parts and then do the rest.

Timing gear and idle gear pin

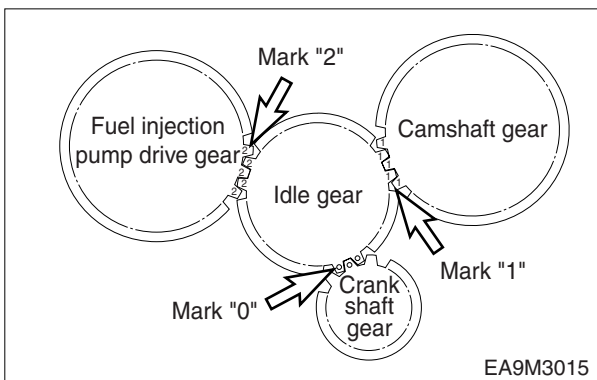


1. Install the oil pump idle gear onto the No.7 bearing cap.
2. Install a thrust washer over the camshaft and assemble the cam gear by aligning it with camshaft dowel pin. Tighten the cam gear assembling bolts to the specified torque. (Zigzag method)

Torque	2.2 kg•m
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3. With the oil port on the idle gear pin facing the cylinder block, install the idle gear pin.
4. Idler gear pin with oil hole is assembled toward cylinder block.



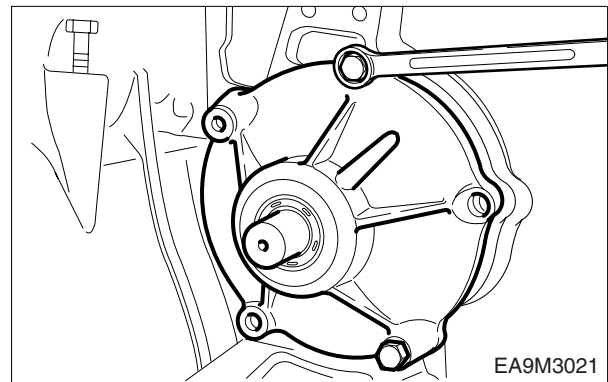
5. Install the idle gear by coinciding the marks impressed on the crank gear, cam gear, fuel injection pump drive gear, and idle gear.
6. Install a thrust washer on the idle gear and tighten to specified torque.

Torque	3.1 kg•m
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7. Check and adjust the amount of backlash between gears using a feeler gauge.

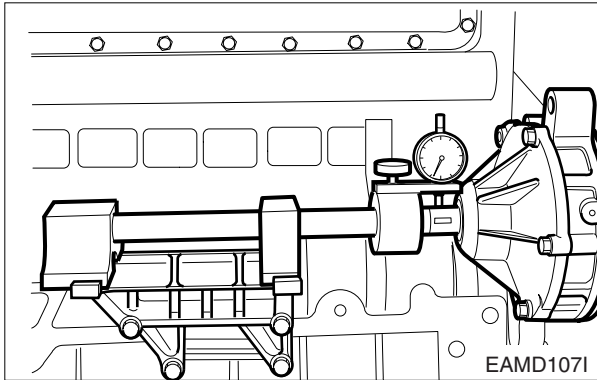
Measuring position (between)	Backlash	Limit
cam gear & idle gear	0.16 ~ 0.28 mm	0.35 mm
crank gear & idle gear	0.16 ~ 0.28 mm	0.35 mm
injection pump & idle gear	0.16 ~ 0.28 mm	0.35 mm

Injection pump flange



1. After assembling the fuel injection pump gear to the idle gear, tighten the assembling bolts of the injection pump flange.
2. Mount gasket by aligning the bolt holes with the pin holes on the bearing housing.
3. Turning the flywheel, adjust the pointer to the position of the engraved scale.
4. After adjusting the injection timing of fuel injection pump drive gear, tighten the fixing bolts in the direction of fuel injection pump.

Fuel injection pump



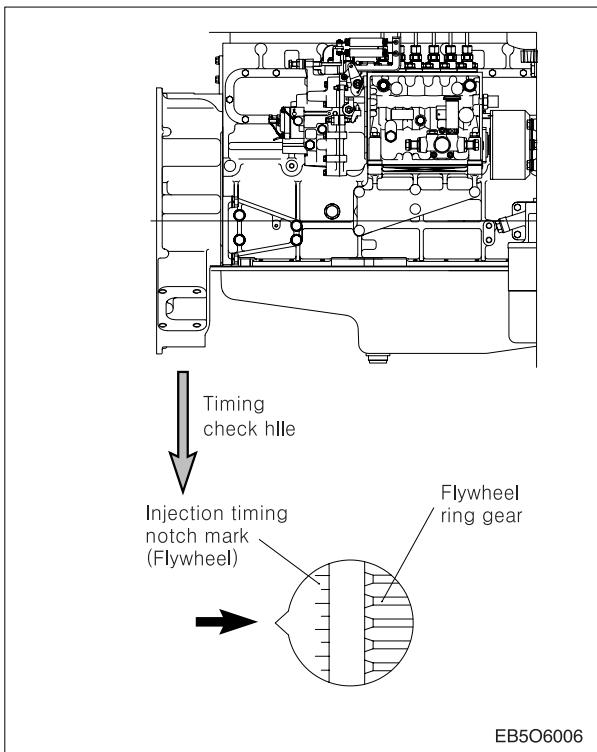
1. Install the injection pump bracket in the cylinder block.
2. After measuring the amount of run-out with an alignment setting jig, disassemble the bracket, adjust the shims, then reassemble it.

Run - out	0.2 mm or less
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3. Mount the top/bottom adjusting shims in the bracket and then mount the fuel injection pump.
4. Tighten the fixing bolts in a diagonal sequence to specified torque.

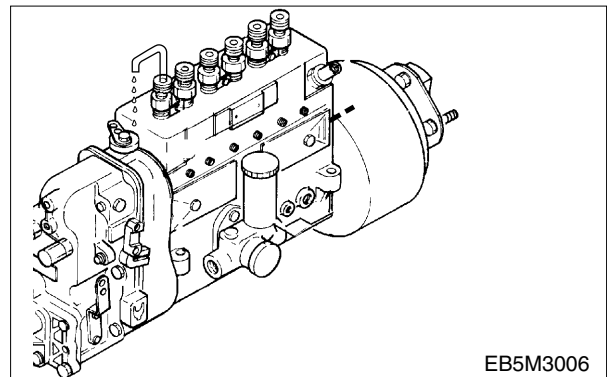
Torque	4.4 kg•m
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<Injection Timing Adjustment>



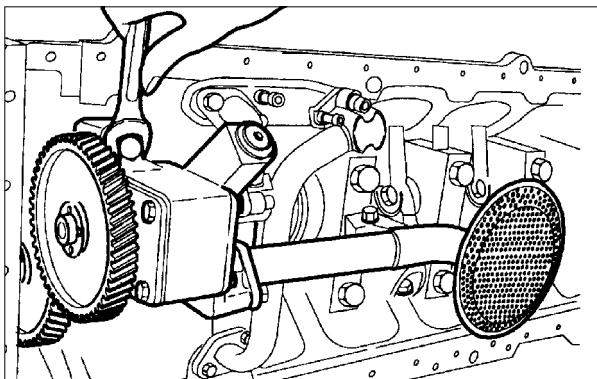
5. Bring the piston of #1 cylinder to the compression TDC (OT) by turning the crankshaft. Again, turn 60° in the reverse direction of engine rotation.
6. Disassemble the fuel injection pipe that connect the fuel injection pump and #1 injection nozzle.
7. Disassemble the fuel injection pump delivery valve holder, and after removing the valve and valve spring, again assemble the valve holder and then, on it assemble the pipe of "U" shape on it.
8. Operating the priming pump of supply pump, turn the crankshaft slowly in the direction of engine rotation until the fuel will drop at the rate of a drop for 6 ~ 8 sec.
9. Confirm then whether the indication point at the flywheel housing inspection hole and the engraved specified injection angle are coincided or not, and if the injection timing is not correct, adjust as follows.
 - a. As above adjusting method, Please coincide the indication point() at the flywheel housing's inspection hole with the flywheel's inspection angle.

Fuel injection timing : BTDC 9°



- b. Loosen the drive gear fixing bolt of injection pump a bit.
- c. After turning slowly the coupling of injection pump until the fuel will drop from #1 plunger at the rate of a drop for 6 ~ 8 sec., tighten the driving gear fixing bolt of fuel pump.

Oil pump and oil pipe

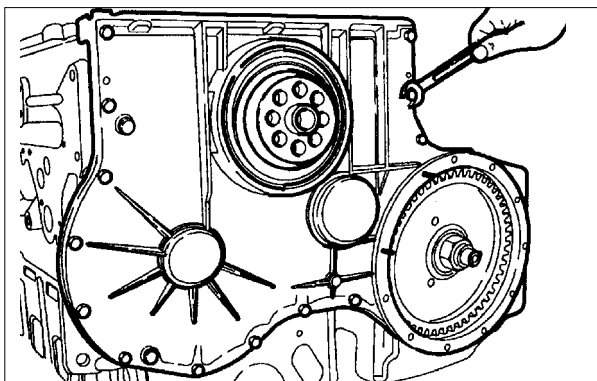


1. Install a dowel pin in the No.7 bearing cap, then assemble the oil pump by tapping lightly with urethane hammer.
2. Tighten the assembling bolts with specified torque.

Torque	4.4 kg•m
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3. Assemble the oil suction pipe with the delivery pipe to oil pump by the bolts.

Timing gear case cover

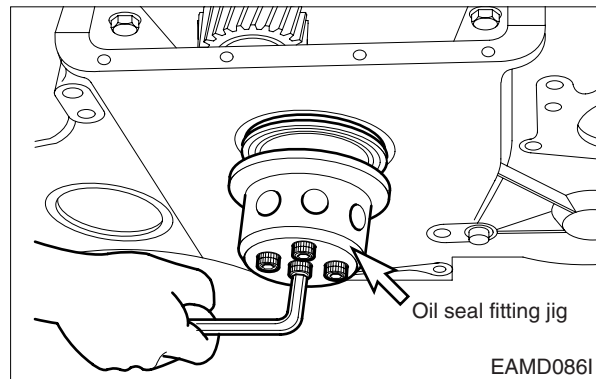


1. Install dowel pin on the timing gear case.
2. Mount a gasket by aligning the fixing bolt holes with those on the gasket.
3. Align the dowel pin with the cover pin hole, then install the cover with light tap.
4. Tighten the fixing bolts beginning with the oil pan fitting face.

WARNING

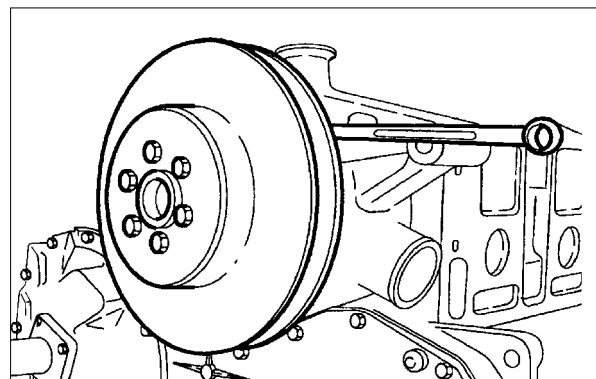
In the assembling, be careful not to be damaged by the crankshaft.

Front oil seal



1. Apply lubricating oil to the outside of the oil seal and the oil seal hole of the timing gear case cover.
2. Put the new oil seal on the oil seal hole of timing gear case cover aligning the center of them, then assemble the oil seal using an oil seal fitting jig.

Water pump

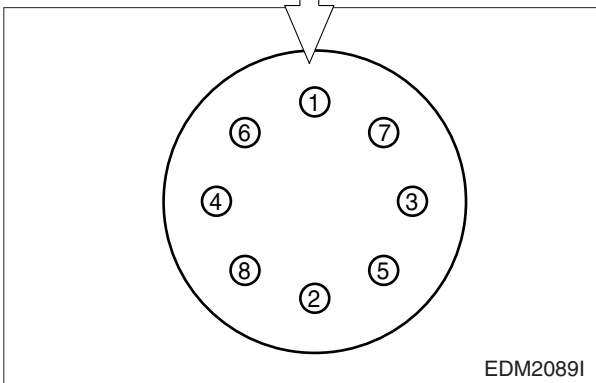
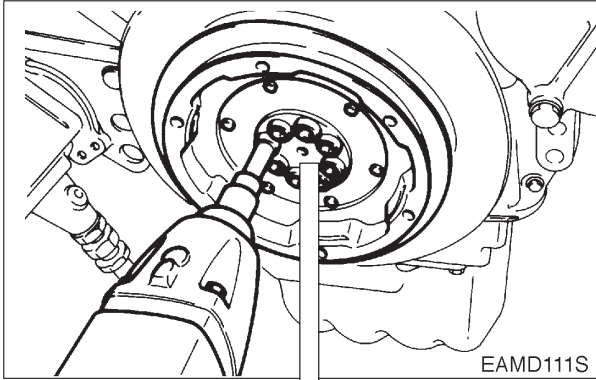


1. Mount a new gasket.
2. Install the water pump on the cylinder block and tighten the assembling bolts with specified torque.

Torque	2.2 kg•m
---------------	----------

3. Connect water pipes and by-pass pipe to the water pump.
4. Connect a water pipe to the expansion tank.

Vibration damper



1. Insert the vibration damper to the crankshaft, and assemble by tightening the assembling bolts at the specified tightening torque according to bolt tightening order. (refer to right figure.)

Torque	13 kg•m
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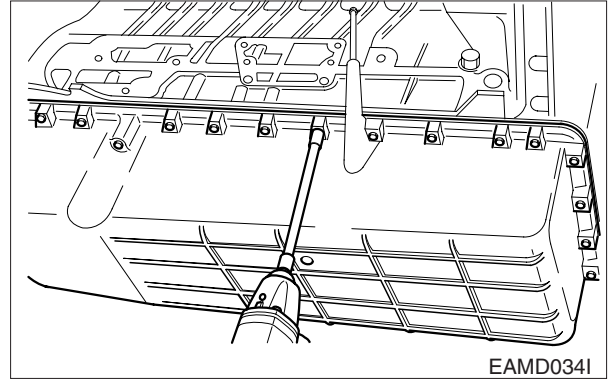
Oil pan

1. Remove the gaskets thoroughly that project at the timing gear case, case cover of cylinder block, and the contacting part of flywheel housing by means of a scraper.

⚠ WARNING

Be careful for the gasket pieces not fall into the engine during the work.

2. Coat the silicone at the gasket part that was removed (Contacting part), and attach the new oil pan gasket.



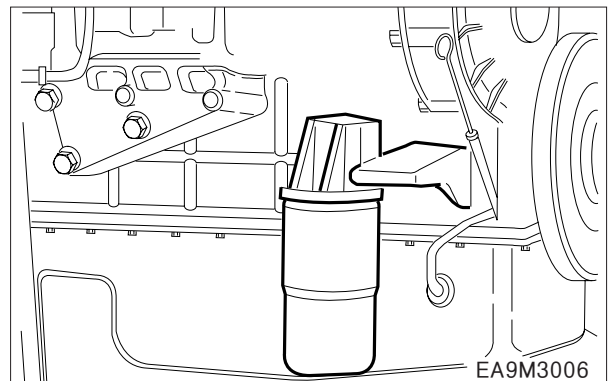
3. Assemble the oil pan by tightening the oil pan assembling bolts, and when tightening bolts, primarily tighten the bolts (4ea) at the both ends, and then tighten the rest bolts to specified torque.

Torque	2.2 kg•m
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⚠ WARNING

Align the bolt holes with gasket holes to prevent damage to the gasket and tighten.

Oil filter

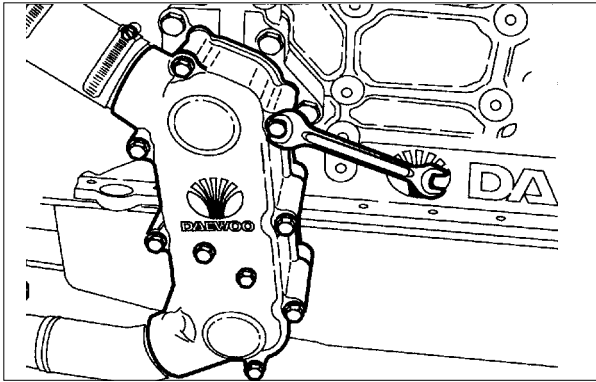


1. Install the oil filter onto the cylinder block, and tighten the fixing bolts.

Torque	2.2 kg•m
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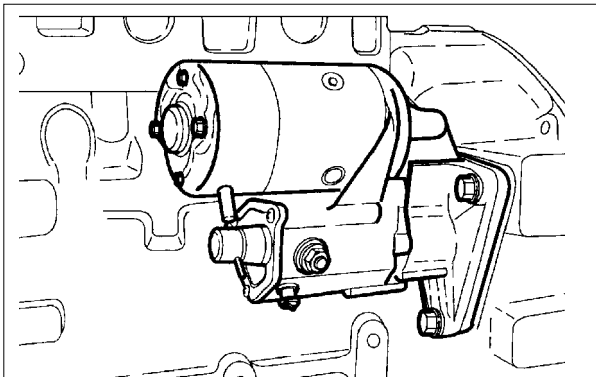
2. Apply engine oil to the oil filter cartridge o-ring and assemble the cartridge using a filter wrench.

Oil cooler



1. Install the gasket on the cylinder block.
2. Assemble the oil cooler by tightening the assembling bolts.
3. Connect the cooling water pipe with the cooling water pump and tighten a hose clamp.

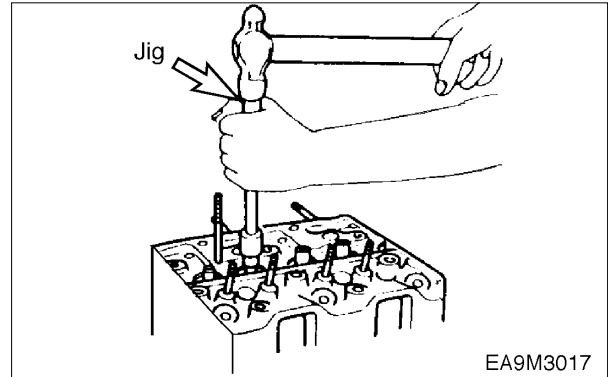
Starter



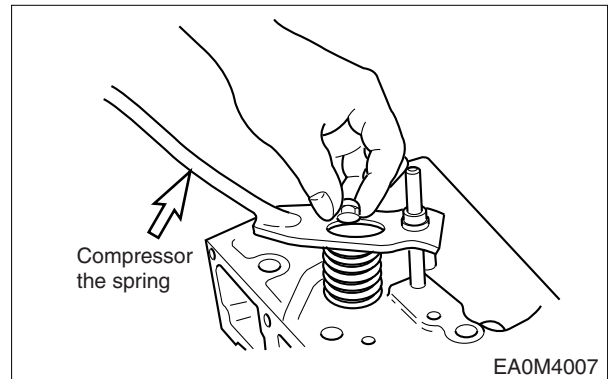
1. Assemble the starter in position on the flywheel housing.

Torque	8.0 kg•m
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Intake and exhaust valves



1. Identify the marks of "IN" and "EX" impressed on the valve head before assembling the valve with the valve head.
2. With a valve stem seal fitting jig, assemble the valve stem seal on the valve guide.



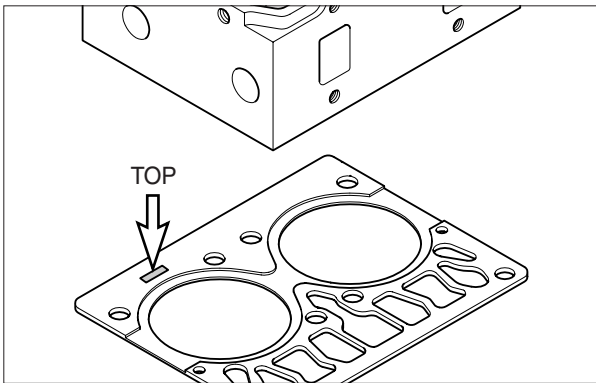
3. After installing valve springs and spring retainer, press the retainer with a jig, then install the cotter pin.
4. Tap the valve stem lightly with a rubber hammer to check that the valve is assembled correctly.

Cylinder head

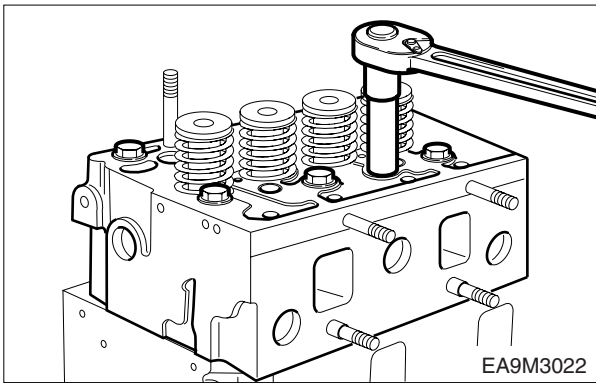
1. Blow the bolt holes of cylinder block with a compressed air and remove the foreign matter.
2. Clean the head gasket contact surface thoroughly.

⚠ WARNING

However, be careful for the foreign material not to enter into the combustion chamber.



3. Assemble the new head gasket by aligning the holes with dowel pins of cylinder block with "TOP" mark facing upward.



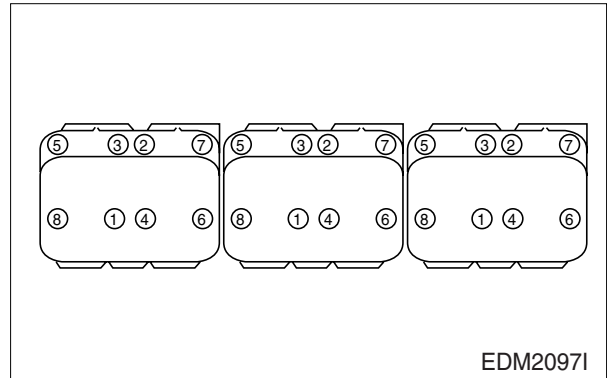
4. Check the inside of combustion chamber for foreign substances, and carefully mount the cylinder head assembly in the block by aligning the dowel pin with the dowel pin hole.

⚠ WARNING

Be careful not to damage the cylinder head gasket. If the dowel pin is not in alignment, lift the cylinder head again and then remount it.

⚠ WARNING

After tightening the cylinder head bolts, even at disassembling, the cylinder head gasket should be changed a new one.



5. Coat the cylinder head bolts with engine oil, and tighten in proper sequence to the specified torque according to bolt tightening order (refer to the figure).

<Cylinder head bolts>

	Type 2
Specification	 M14 1.5 150
Torque	6 kg•m +180°+150° (Angle torque)

6. However, before tightening bolts, the side parallel degree between cylinder heads should be adjusted.

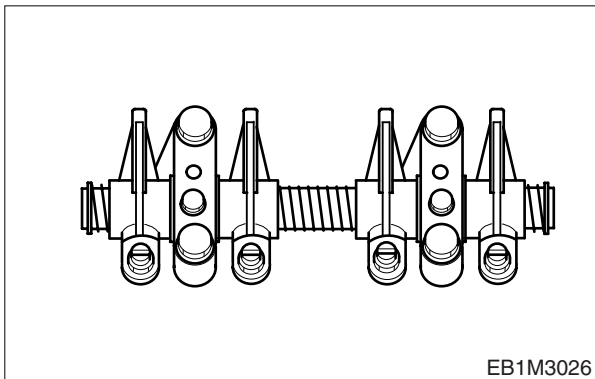
<Tightening order of bolts by steps>

- (1) First stage : Coat the bolts with engine oil.
- (2) Second stage : Tighten 1 ~ 2 threads with hands.
- (3) Third stage : Tighten at about 6 kg.m with a wrench.
- (4) Fourth stage : Tighten at rotating angle method 180° with a wrench.
- (5) Fifth stage : Finally, tighten at rotating angle method 150° with a torque wrench.

However, all bolts are tightened simultaneously by above steps.

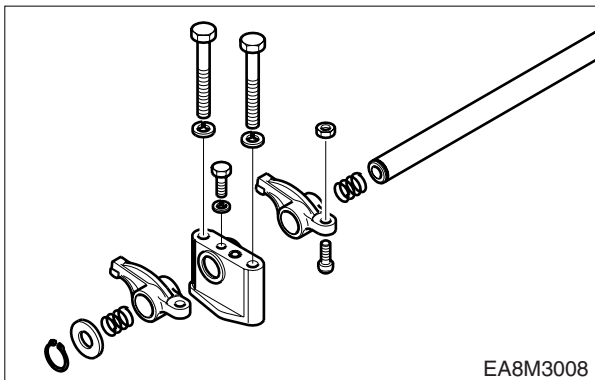
7. Coat the push rod with engine oil and insert it into the push rod hole.

Rocker arm assembly



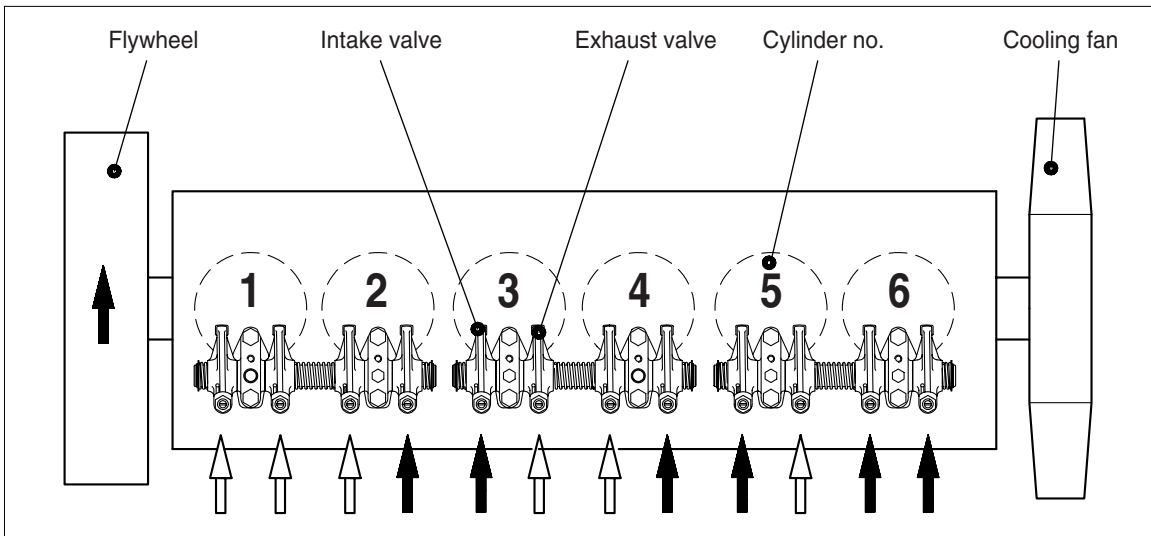
1. Apply lubricating oil to the rocker arm bush and shaft, and assemble the intermediate bracket with the rocker arm (rocker arm assembly) on the cylinder block using fixing bolts. In tightening the bolts, it must be done at the specified value using zigzag method.

Torque	M10	1.5	4.4 kg·m
	M12	1.5	8.0 kg·m

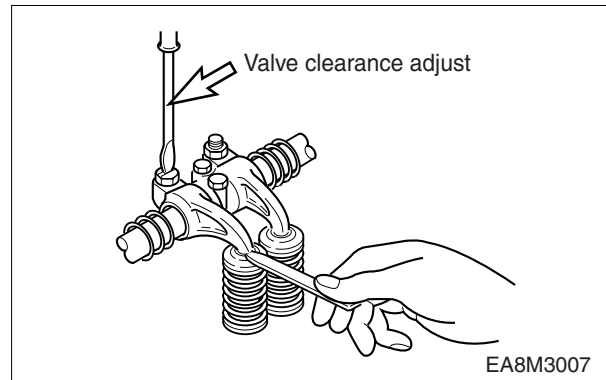


2. Semi-install valve clearance adjusting bolts onto the rocker arm.
3. Install the spring, rocker arm, bracket, rocker arm, spring, washer, and snap ring in the described sequence.
4. Install the rocker arm and bracket in the same direction.
5. Adjust the valve clearance as following guide.

<Guide for valve clearance adjustment>



- By turning the crankshaft, when the intake and exhaust of #6 cylinder (the sixth cylinder from the flywheel) overlap, that is, when #1 cylinder's piston come at the compression top dead center (OT), adjust the valve clearances by mark indicated.
- After having turned the crankshaft by 360° and Intake & exhaust valves of #1 cylinder overlap, that is, when #6 cylinder is in the state of compression TDC (OT), the clearance indicated by mark is adjusted.
- To adjust the clearance, loosen the locknuts of rocker arm adjusting screws and push the feeler gauge of specified value between a rocker arm and a valve stem (to measure the clearance of the valve and rocker arm contacting part) and adjust the clearance with adjusting screw respectively and then tighten with the lock nut.
- As for the valve clearance, adjust it when in cold.



- Adjust valve clearance with a feeler gauge and tighten the fixing nuts to specified torque.

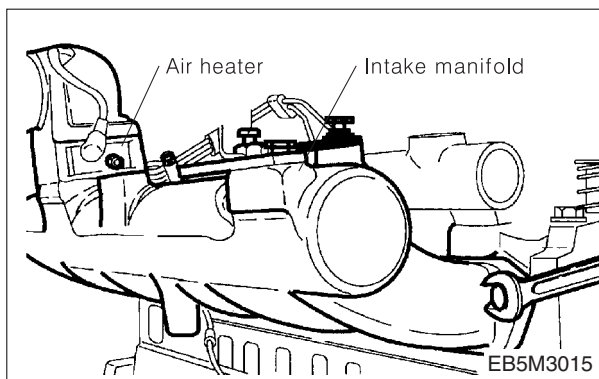
Torque	5.0 kg•m
---------------	-----------------

Model	Intake valve	Exhaust valve
DE08TS	0.3 mm	0.3 mm

WARNING

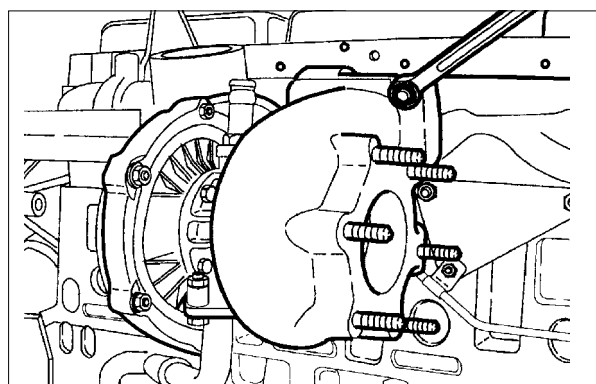
- Crankshaft revolution is done by hands without using a starting motor.
- Turn it to the direction of engine rotation, but do not use the installing bolts at the turn.
- The cylinder no. and the order of intake and exhaust can be determined from the crank shaft pulley.

Intake manifold



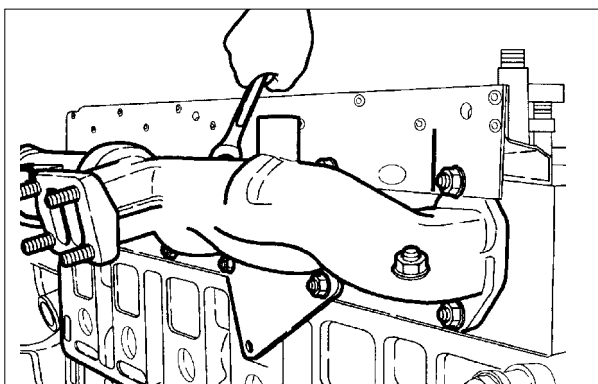
1. Put in the new gasket between the cylinder head and manifold, and assemble the intake manifold by tightening the assembling bolts.

Turbocharger



1. Fit a new gasket over the stud bolts of the exhaust manifold before tightening those turbocharger fixing nuts.
2. Install the oil supply pipe and return pipe.
3. Tighten the clamps of rubber hose that is connected air pipe to the intercooler.

Exhaust manifold

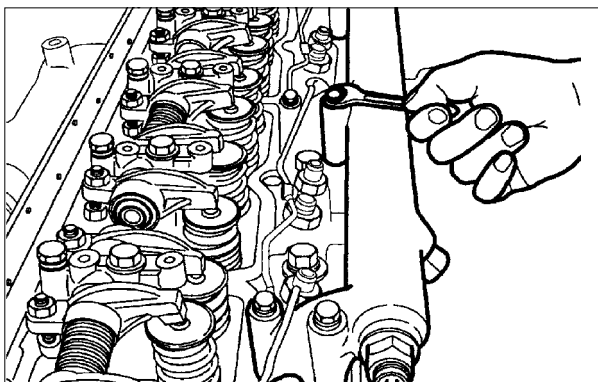


1. Install the exhaust manifold gasket over the stud bolts by aligning the gasket with the exhaust port on the cylinder head so that the face and back of the gasket can be positioned correctly.
2. Semi-assemble the exhaust manifold and install the heat resisting plate.
3. Assemble them by tightening the assembling bolts. The tightening order of bolts is from the middle to left and right alternately.

WARNING

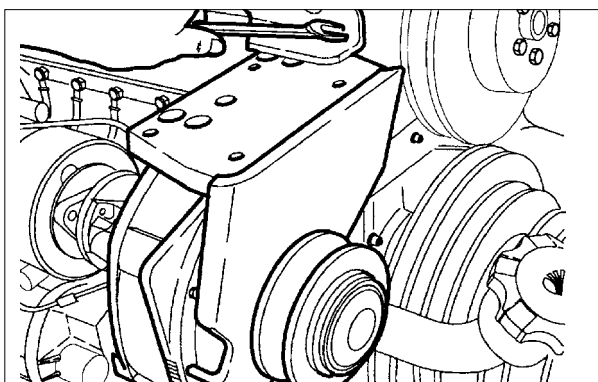
For upper and lower bolts differ in the length, so use the correct bolts.

Cooling water pipe



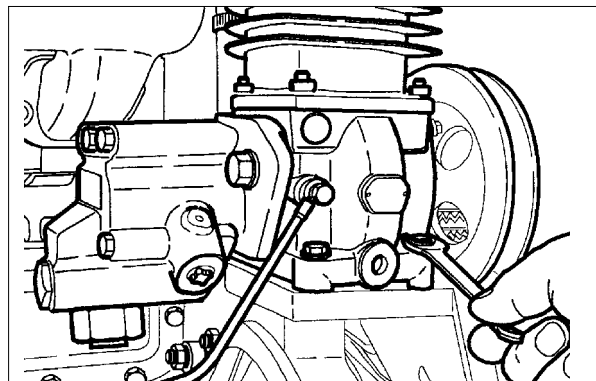
1. Attach a new gasket on the cylinder head.
2. Install the cooling water pipe and tightening the fixing bolt on it.

Idle pulley



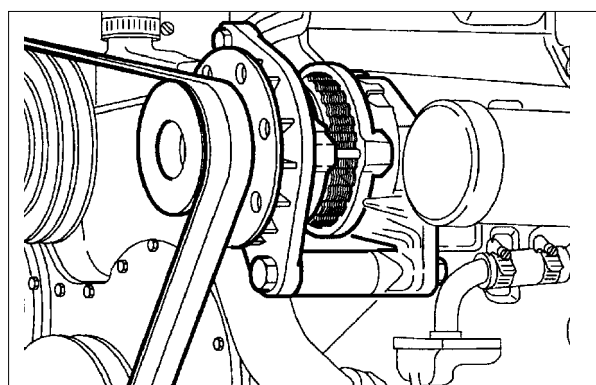
1. Assemble the air compressor (if equipped) mounting bracket on the timing gear case.
2. Install the idle pulley on the air compressor (if equipped) mounting bracket and tightening the fixing bolt.

Air compressor (if equipped) & power steering pump



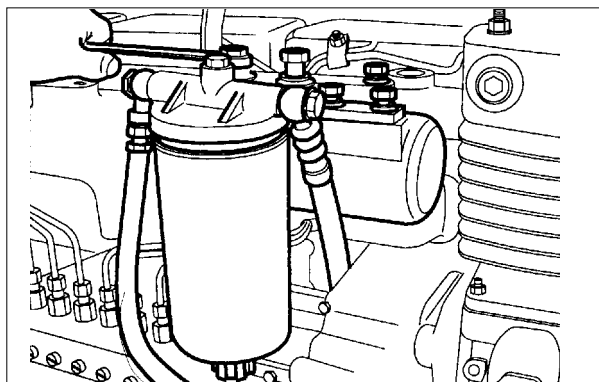
1. Couple the power steering oil pump to the air compressor with the driving dog engaged.
2. Insert the O-ring coated with grease into the oil outlet of the air compressor.
3. Place the air compressor on the mounting bracket carefully and tighten the fixing bolts to the specified torque.
(Carefully damage the O-ring)
4. Assemble the oil feed pipe.

Alternator



1. Install the alternator mounting bracket and supporter to the cylinder block, then tighten the fixing bolts.
2. Install the alternator with fixing bolts to the mounting bracket.

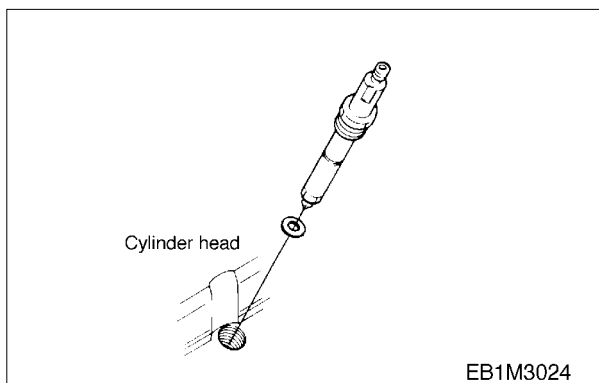
Fuel filter



1. Assemble the fuel filter with the intake manifold.
2. Assemble the fuel feed hose according to the direction of an arrow impressed on the fuel filter head so that fuel can be fed in the sequence of

**FUEL FEED PUMP → FUEL FILTER
→ FUEL INJECTION PUMP.**

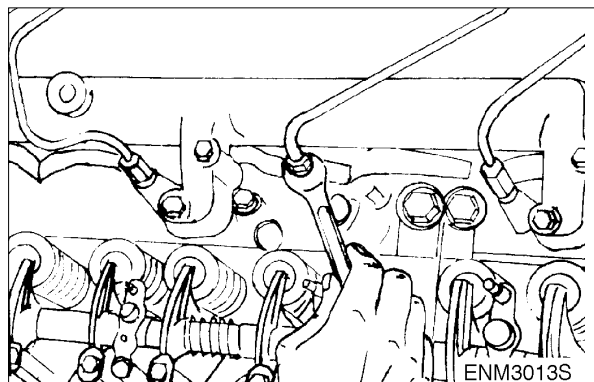
Injection nozzle



1. Install a new seal ring in the nozzle hole of the cylinder head.
2. As aligning the ball of nozzle with a groove in the nozzle hole, Insert the nozzle into the cylinder head and tighten the nozzle.

Torque	7.0 kg•m
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Fuel injection pipe



1. Semi-assemble a nut at both ends of the fuel injection pipe and tighten them up one by one to specified torque.

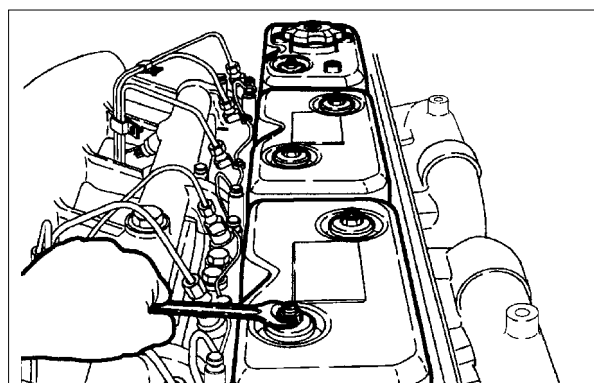
Torque	3.0 kg•m
---------------	----------

2. Assemble the fuel return pipe on the nozzle holder.
3. Connect the injection pump lubricating oil pipe with a hollow screw.

WARNING

Be sure not to damage the connection part due to over-tightening the hollow screw.

Cylinder head cover

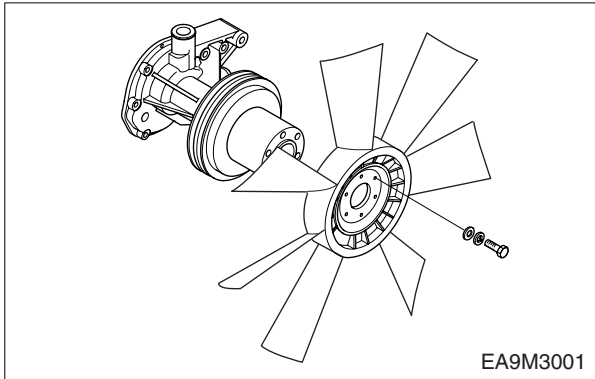


1. Attach a new gasket on the cylinder head cover.
2. Assemble the cylinder head cover to the cylinder head by tightening the cap bolts for fixing the cylinder head cover.

Torque	1.2 kg•m
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3. Assemble the breather and breather hose.
4. Fit the oil filler cap on the cylinder head cover.

Cooling fan



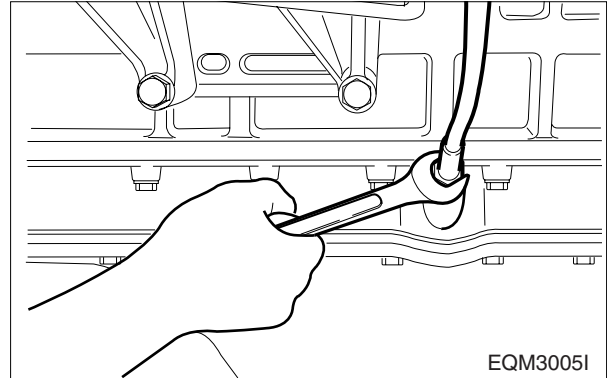
1. Install the flange to the water pump pulley, then assemble the cooling fan to the pulley by tightening the fixing bolts.

Torque	4.4 kg•m
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3. Poly belt will be properly tensioned if the deflection force "F" is applied midway between the belt's tangent points with the pulley.

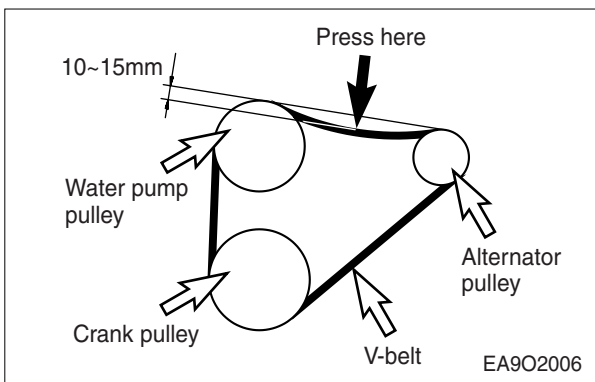
$$T = 0.015 \times S \text{ (about 1.5 mm per 100 mm)}$$

Oil level gauge

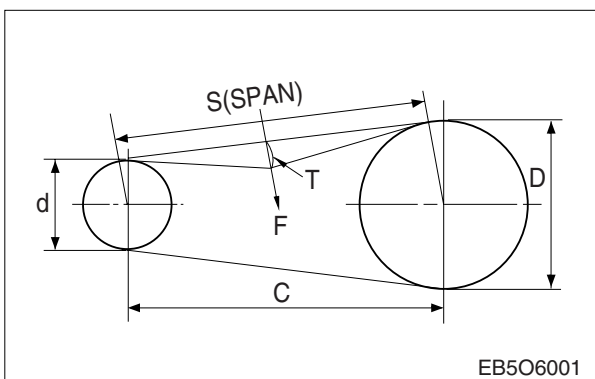


1. Apply sealant (Locktite #262) to the bottom side of the guide tube.
2. Then assemble the guide tube and oil level gauge on the oil pan

Belt



1. Install the V-belt on the crank pulley, alternator pulley and water pump pulley..
2. Adjust the V-belt tension using the tension adjusting support.



Others

1. Assemble by connecting the other oil and fuel hoses.

Breaking in

Preparations for breaking-in

1. Fill of new engine oil through the oil filler cap.
2. When measuring the oil level with the oil level gauge with the engine mounted, the oil level must indicate about 10mm above the max. line.
3. Connect water hoses and fill up cooling water.
4. Connect the fuel hoses to the fuel tank and to top(radiator or surge tank).
Check the air bleeding of the fuel system.
5. Connect the electrical systems such as starter, air heater, etc. with power source.

Operation of a new engine (Break-In)

Because the sliding surfaces of a new engine are not lapped enough, the oil film can be destroyed easily by overload or overspeed and the engine life-time may be shortened.

Therefore the following things must be obeyed by all means.

Up to the first 50 hours

1. Engine should be run at fast idling until the temperature of the engine becomes normal operating condition.
2. Overload or continuous high speed operation should be avoided.
3. High speed operation with no load should be prevented.
4. Abrupt start and stop of the engine should be avoided.
5. Engine speed must be under 70% of its maximum speed.
6. Maintenance and inspection must be accomplished thoroughly.

Check points for break-in

During the break-in (the initial running of the engine) period, be particularly observant as follows :

- a. Check engine oil level frequently. Maintain oil level in the safe range, between the "min." and "max." marks on dipstick.

NOTE : If you have a problem getting a good oil level reading on dipstick, rotate the level gauge 180° and re-insert for check.

- b. Watch the oil pressure warning lamp. If the lamp blinks, it may be oil pick-up screen is not covered with oil. Check oil level gauge. Add oil to the oil pan, if required. Do not overfill. If level is correct and the status still exists, see your DEALER for possible switch or oil pump and line malfunction.

NOTE : Oil pressure will rise as RPM increases, and fall as RPM decreases. In addition, cold oil will generally show higher oil pressure for any specific RPM than hot oil. Both of these conditions reflect normal engine operation.

- c. Watch the engine water temperature gauge and be sure there is proper water circulation. The water temperature gauge needle will fluctuate if water level in expansion tank is too low.

At the end of the break-in period, remove break-in oil and replace the oil filter. Fill oil pan with recommended engine oil. Refer to following table.

<Recommended Engine oil and capacity>

Engine oil capacity				Recommend oil
Model	Max.line (lit)	Min line (lit)	Total (lit)	API No.
DE08TS	16	13	18.5	API CH-4 above

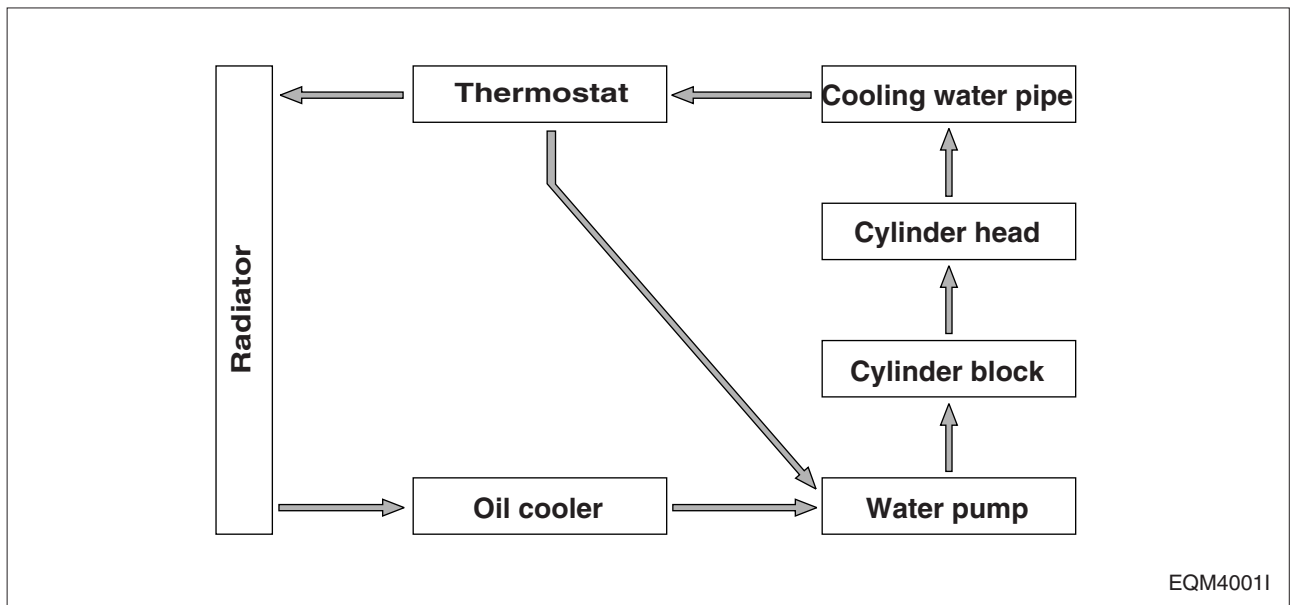
Maintenance of Major Components

Cooling System

General information

This engine is water-cooling type. Heat from the combustion chamber and engine oil heat are cooled down by coolant and radiated to the outside, resulting in the normal operation of the engine.

The water absorbing the oil heat and combustion chamber heat goes on to the thermostat through the water pipe, and circulates to the water pump if water temperature is lower than the valve opening temperature on the thermostat, while circulating to the radiator at water temperature higher than the valve opening temperature. At the radiator, the heat absorbed in the coolant is radiated to cool down and the coolant recirculates to the water pump.

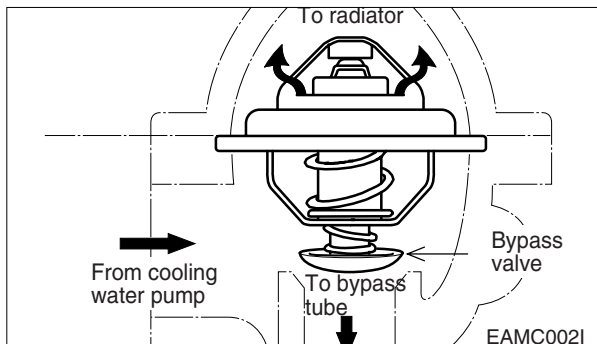


Specification

Item		Specifications	
1. Water pump	Type	Centrifugal type	
	Pump speed	2,000 rpm	2,700 rpm
	Delivery capacity	about 190 liter/min	about 280 liter/min
	Operation pressure	0.5 bar	0.8 bar
	Allowable back pressure	bellow 0.5 bar	
2. Thermostat	Operating temperature	71°C	
	Valve lift	8mm or more (at 85°C)	
	Operating temperature	79 ~ 94°C	
3. Cooling fan and belt			
Fan diameter - Number of blades		625mm - 9	
Fan belt tension		15mm deflection by thumb	

Thermostat

1. General descriptions and main data



The thermostat maintains a constant temperature of coolant and improves thermal efficiency of the engine by preventing heat loss.

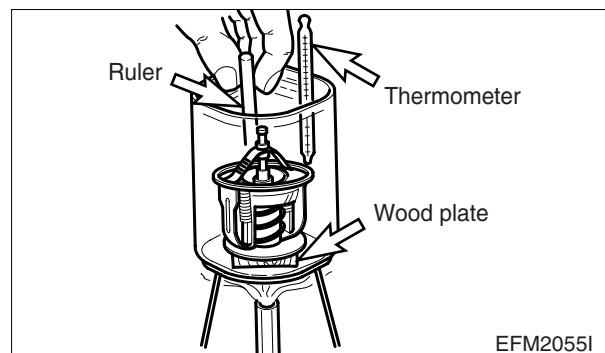
Namely, when the temperature of coolant is low, the thermostat valve is closed to make the coolant bypass to directly enter the water pump; when the coolant temperature rises to open wide the thermostat valve, the bypass circuit is closed and the water passage to the radiator is opened so that the coolant is forced to flow into the radiator.

Item	Specifications
Type	Wax-pallet type
Open at	71 °C
Open wide at	85°C
Valve lift	8 mm or more

WARNING

There are 3 kinds of thermostats according to surrounding and operating conditions. One is named by 71 °C , 79°C type and the other is 83 °C.

2. Inspecting



- Check the wax pallet and spring for damage.
- Put the thermostat in a container of water, then heat the water slowly and check temperature with a thermometer. If the valve lift is 0.1 mm (starting to open) at temperature of 71 °C and 10 mm or more (full open) at temperature of 85 °C, the thermostat is normal.

3. Replacing thermostat and precautions for handling

- 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 starting off.
- When draining out or replenishing coolant, do it slowly so that air is bled sufficiently from the entire cooling system.
- Replacing thermostat
If the thermostat is detected defective, replace with a new one.

Diagnostics and troubleshooting

Complaints	Possible causes	Corrections
1. Engine overheating	● Lack of coolant ● Radiator cap pressure valve spring weakened ● Fan belt loosened or broken ● Fan belt fouled with oil ● Thermostat inoperative ● Water pump defective ● Restrictions in water passages due to deposit of scales ● Injection timing incorrect ● Restriction in radiator core ● Gases leaking into water jacket due to broken cylinder head gasket	● Replenish coolant ● Replace cap ● Adjust or replace fan belt ● Replace fan belt ● Replace thermostat ● Repair or replace ● Clean radiator and water passages ● Adjust injection timing correctly ● Clean exterior of radiator ● Replace cylinder head gasket
2. Engine overcooling	● Thermostat inoperative ● Ambient temperature too low	● Replace thermostat ● Install radiator curtain
3. Lack of coolant	● Radiator leaky ● Radiator hoses loosely connected or damaged ● Radiator cap valve spring weakened ● Water pump leaky ● Heater hoses loosely connected or broken ● Cylinder head gasket leaky ● Cylinder head or cylinder block cracked	● Correct or replace ● Retighten clamps or replace hoses ● Replace cap ● Repair or replace ● Tighten or replace hoses ● Replace cylinder head gasket ● Replace cylinder head block
4. Cooling system noisy	● Water pump bearing defective ● Fan loosely fitted or bent ● Fan out of balance ● Fan belt defective	● Replace bearing ● Retighten or replace fan ● Replace fan ● Replace fan belt

Lubricating system

General descriptions and specifications

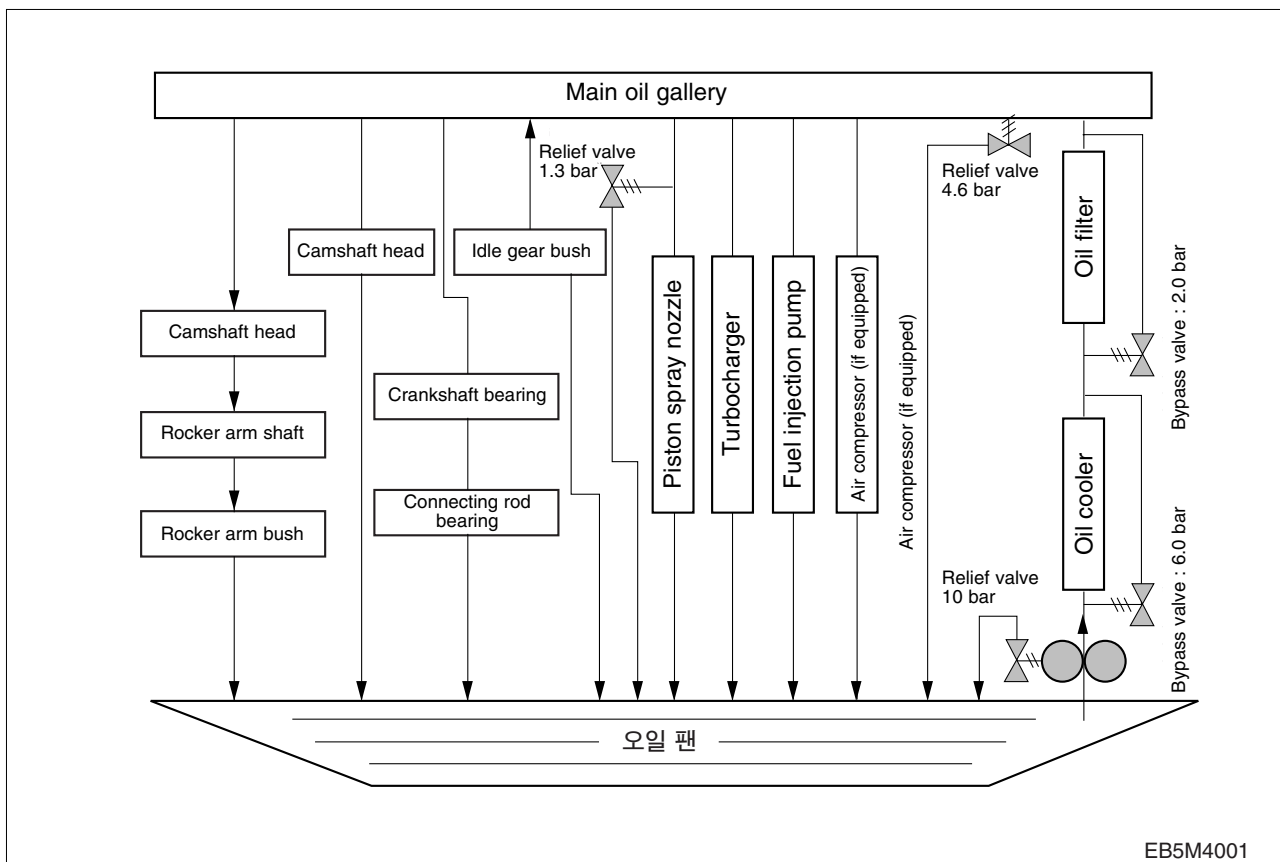
1. General descriptions

All the engine oil pumped up from the oil pan by the gear type oil pump is filtrated through the oil cooler and oil filter, and this filtrated oil is forced through the main oil gallery in the cylinder block from where it is distributed to lubricate the various sliding parts, and fuel injection pump in order to ensure normal engine performance.

2. Specifications

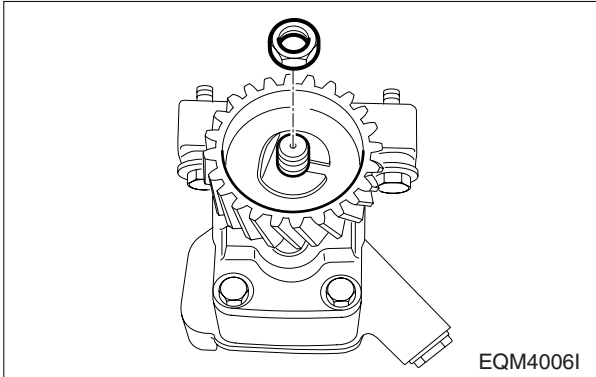
Item	Specifications	Item	Specifications
Lubricating system	Forced pressure circulation	Oil filter type	Full flow
Oil pump type	Gear type	Bypass for filter element	
Relief valve opening pressure	10 1.5 kg/cm ²	Valve opening pressure	1.8 ~ 2.3 kg/cm ²
Bypass for oil cooler		Bypass for entire oil filter	
Opening pressure	5+1 kg/cm ²	Valve opening pressure	4.0 ~ 4.8 kg/cm ²
Adjusting valve for spray nozzle			
Opening pressure	1.5 ~ 1.8 kg/cm ²		

3. Diagram of lubricating system



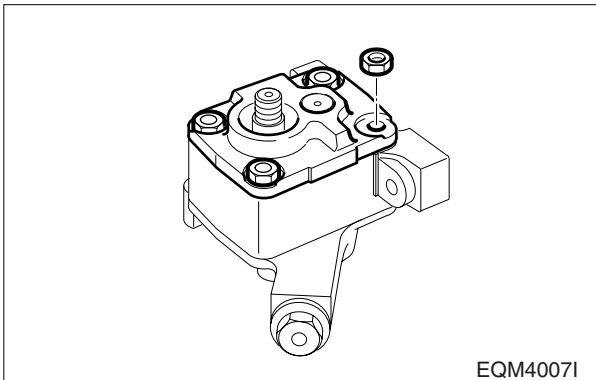
Oil pump

1. Disassembly



a. Disassembly of oil pump drive gear

- Unscrew the screw and disassemble the oil relief valve.
- Unfold the washer for the oil pump drive gear fixing nut and remove the nut.
- Disassemble the drive gear.



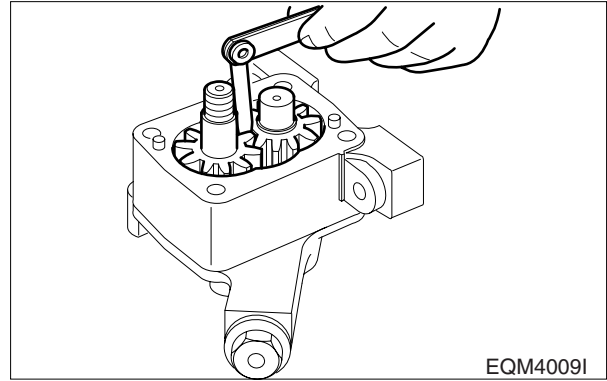
b. Remove the oil pump cover fixing nuts and disassemble the oil pump cover.

The oil pump cover is fixed with the two dowel pins.

c. Disassemble the drive gear and driven gear.

- a. With steel rule and feeler gauge, measure the axial end play of the oil pump gear. Replace if the measured value is beyond the limit.

End play limit	0.025 ~ 0.089 mm
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- b. With a feeler gauge, measure the amount of backlash between the oil pump drive gear and driven gear. Replace if the measured value is beyond the limit.

Backlash limit	0.50 ~ 0.64 mm
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c. Measuring clearance between drive shaft and bushing

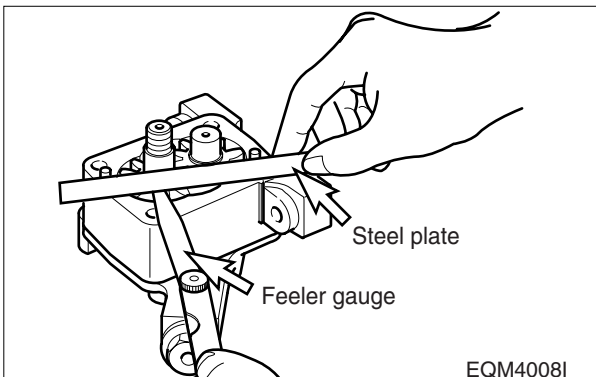
- Measure the outside diameters of the drive shaft and driven shaft, and replace if the measured values are less than the limit (N16.95mm)

Standard	16.95 ~ 16.968 mm
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- Measure the inside diameter of the pump body bushing to determine the clearance between the bushing and shaft, and compare the measured value with the standard value to determine whether to replace or not.

Clearance	0.032 ~ 0.077 mm
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2. Inspection and correction



3. Reassembly

- a. For reassembly, reverse the disassembly sequence.

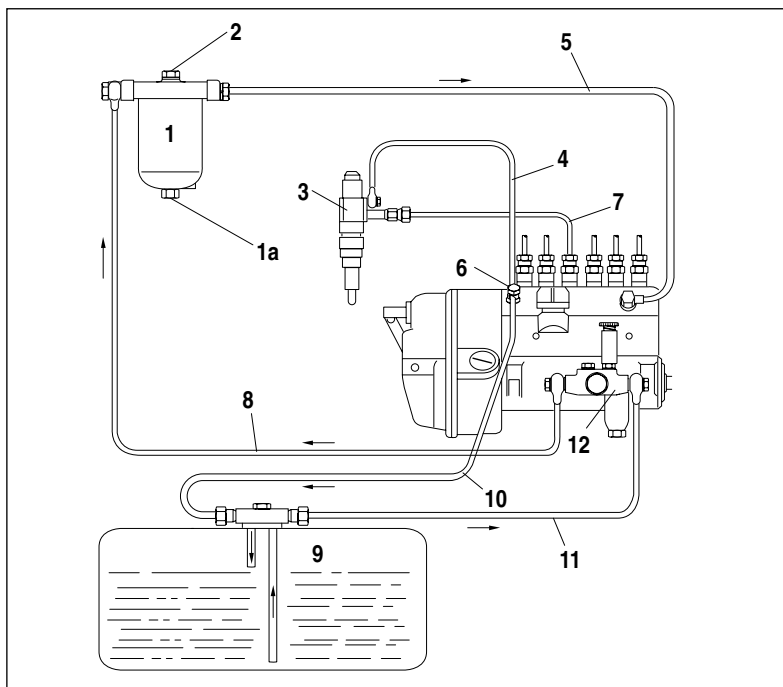
Diagnostics and troubleshooting

Complaints	Possible causes	Corrections
1. Oil consumption excessive	● Poor oil ● Oil seal or packing leaky ● Pistons or piston rings worn ● Cylinder liner worn ● Piston rings sticking ● Valve guide oil seals or valve guides, or valve stem worn	● Use suggested oil ● Replace ● Replace pistons and/or piston rings ● Replace cylinder liner ● Replace pistons and/or piston rings ● Replace
2. Oil pressure too low	● Poor oil ● Relief valve sticking ● Restrictions in oil pump strainer ● Oil pump gear worn ● Oil pump feed pipe cracked ● Oil pump defective ● Oil pressure gauge defective ● Various bearings worn	● Use suggested oil ● Replace ● Clean strainer ● Replace ● Replace ● Correct or replace ● Correct or replace ● Replace
3. Oil deteriorates quickly	● Restriction in oil filter ● Gases leaking ● Wrong oil used	● Replace filter element ● Replace piston rings and cylinder liner ● Use suggested oil

Fuel Injection Pump

General information of fuel system

The fuel system consists of the fuel tank, injection pump, injection nozzle, fuel filter, and fuel lines such as pipes and hoses necessary to connect those components.



1. Fuel filter
- 1a. Water separator
2. Air bleeding screw (for fuel filter)
3. Injection nozzle
4. Overflow tube
5. Fuel pipe (filter → injection pump)
6. Overflow valve
7. Fuel injection pump
8. Fuel pipe (manual pump → filter)
9. Fuel tank
10. Fuel return pipe
11. Suction pipe
12. Feed pump
13. Injection pump

Injection pump

The components relating to the injection pump should be serviced at regular intervals as the plunger and delivery valve may be worn after a given length of time for use and cause the deterioration of the engine.

Make sure that servicing should be performed at the professional maintenance shop as authorized by Bosch or Zexel Company.

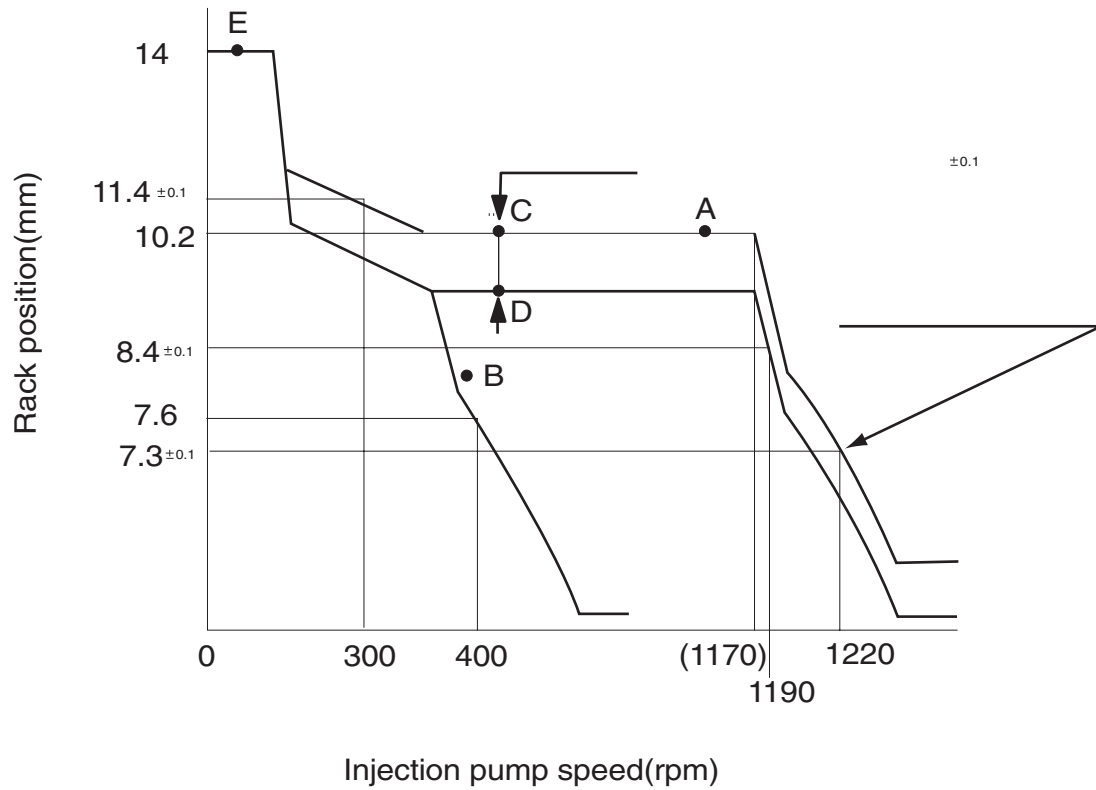
For adjustment of fuel injection volume, refer to the 'Specifications of fuel injection pump' described on the following pages.

1. DE08TS (D100/120)

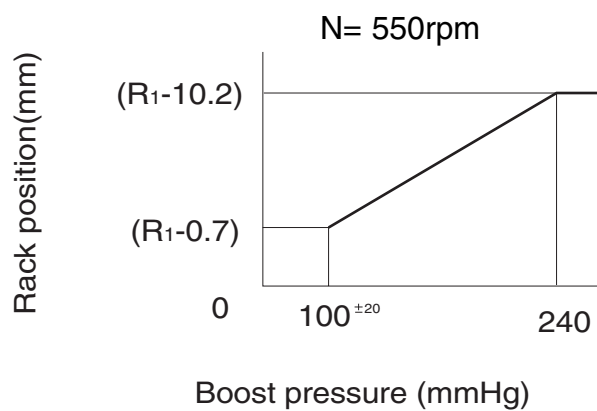
- a. Injection pump ass'y : 65.11101-7388 (101609-904F)
 - Injection pump : KP-PES6AD95B410RS2 (101062-8240)
 - Governor : KP-EPRSV200-1300AQ39C311 (105411-215A)
 - Fuel feed pump : KP-FP/KE-ADS (105210-5610)
 - Plunger & barrel : 131153-1720
 - Delivery valve : 131160-3620
- b. Nozzle holder assembly : 65.10101-7088 (Y430 K02 049)
- c. Nozzle : 65.10102-6058 (0432 131 644)
- d. Injection pipe : 65.10301-6048C
- e. Firing order : 1 - 5 - 3 - 6 - 2 - 4
- f. Injection timing : BTDC 9°
- g. Governor adjustment

(A) Test condition for injection pump	Nozzle & holder ass'y	105780-8140	Opening pressure : 175 bar			
	Injection pipe (ID x OD - L)	-	2.0 x 6.0 – 600 mm			
	Test oil	ISO4113	Temperature : 40 ± 5			
(B) Engine standard parts	Nozzle & holder Ass'y	65.10102-6058	Nozzle (7 x 0.22)			
		65.10101-7088	1st: 180 kg/cm ² 2st : 280 kg/cm ²			
	Injection pipe (ID x OD - L)	65.10301-6048C	2 x 6 – 650 mm			
Rack diagram and setting valve at each point						
Power	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q`ty on RIG(mm³/st)	VARIATION RATE (%)	Press. (mmHg)
	A	10.2	1100	95 ± 2	-	250
	B	8.2	400	20 ± 1.5	-	-
	C	R1(10.2)	550	(92)	-	250
	D	R1-0.7	550	(71)	-	-
	E	14.0	100	(146)	-	-
	Boost pressure : zero boost					
Governor weight	740 g		Lever ratio (min/max)		1 : 1.2 / 1 : 1.2	
Governor spring (outer)	k = 7.2 kgf/mm		Governor spring (inner)		k=2.5 kgf/mm	
Idle spring (outer)	k = 1.9 kgf/mm		Idle spring (inner)		-	
Start spring	k = 0.01 kgf/mm		Delivery Valve	retraction pressure	70mm³/st , t=2.5	
Plunger	9.5 Left hand 20 + 45 lead			opening pressure	23.1 kgf/cm²	
				spring	k=1.63 kgf/mm	

2. Governor adjustment (D100/120)



Boost adjustment (DE08TS)

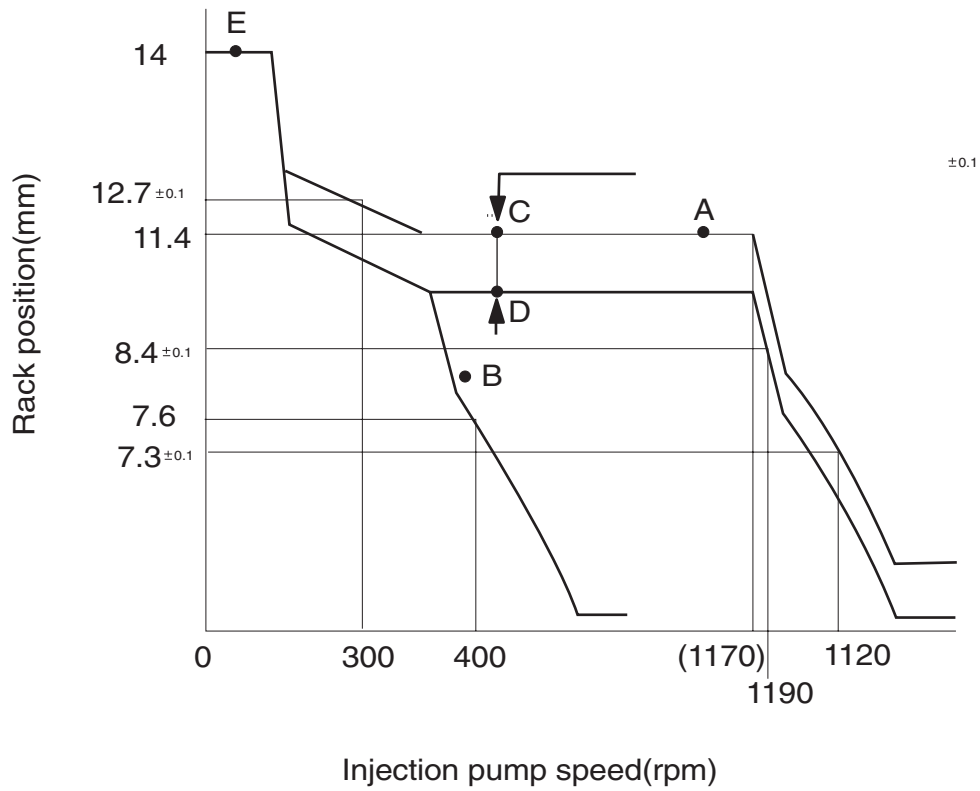


3. DE08TS (D150)

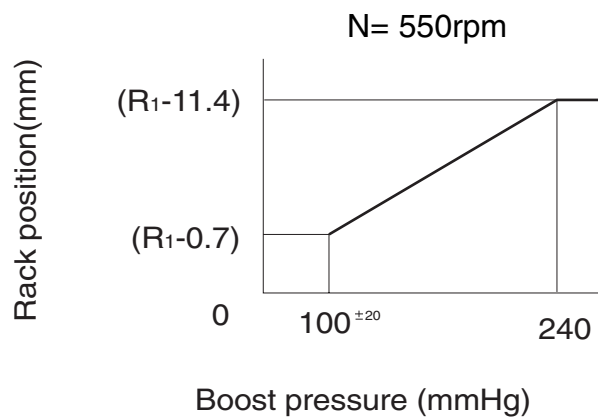
- a. Injection pump ass'y : 65.11101-7388 (101609-904F)
 - Injection pump : KP-PES6AD95B410RS2 (101062-8240)
 - Governor : KP-EPRSV200-1300AQ39C311 (105411-215A)
 - Fuel feed pump : KP-FP/KE-ADS (105210-5610)
 - Plunger & barrel : 131153-1720
 - Delivery valve : 131160-3620
- b. Nozzle holder assembly : 65.10101-7088 (Y430 K02 049)
- c. Nozzle : 65.10102-6058 (0432 131 644)
- d. Injection pipe : 65.10301-6048C
- e. Firing order : 1 - 5 - 3 - 6 - 2 - 4
- f. Injection timing : BTDC 9°
- g. Governor adjustment

(A) Test condition for injection pump	Nozzle & holder ass'y	105780-8140	Opening pressure : 175 bar			
	Injection pipe (ID x OD - L)	-	2.0 x 6.0 – 600 mm			
	Test oil	ISO4113	Temperature : 40 5			
(B) Engine standard parts	Nozzle & holder Ass'y	65.10102-6026	Nozzle (5 x 0.22)			
		65.10101-7050	1st: 180 kg/cm ² 2st : 280 kg/cm ²			
	Injection pipe (ID x OD - L)	65.10301-6036A	2 x 6 – 650 mm			
Rack diagram and setting valve at each point						
Power	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q`ty on RIG(mm³/st)	VARIATION RATE (%)	Press. (mmHg)
	A	11.4	1100	104 2	-	250
	B	8.2	400	20 1.5	-	-
	C	R1(11.4)	550	(100)	-	250
	D	R1-0.7	550	(87)	-	-
	E	14.0	100	(166)	-	-
	Boost pressure : zero boost					
Governor weight	740 g		Lever ratio (min/max)		1 : 1.2 / 1 : 1.2	
Governor spring (outer)	k = 1.8 kgf/mm		Governor spring (inner)		k=2.5 kgf/mm	
Idle spring (outer)	k = 1.9 kgf/mm		Idle spring (inner)		-	
Start spring	k = 0.01 kgf/mm		Delivery Valve	retraction pressure	70mm³/st , t=2.5	
Plunger	9.5 Left hand 20 + 45 lead			opening pressure	23.1 kgf/cm²	
				spring	k=1.63 kgf/mm	

4. Governor adjustment (D150)



2. Boost adjustment (DE08TS)



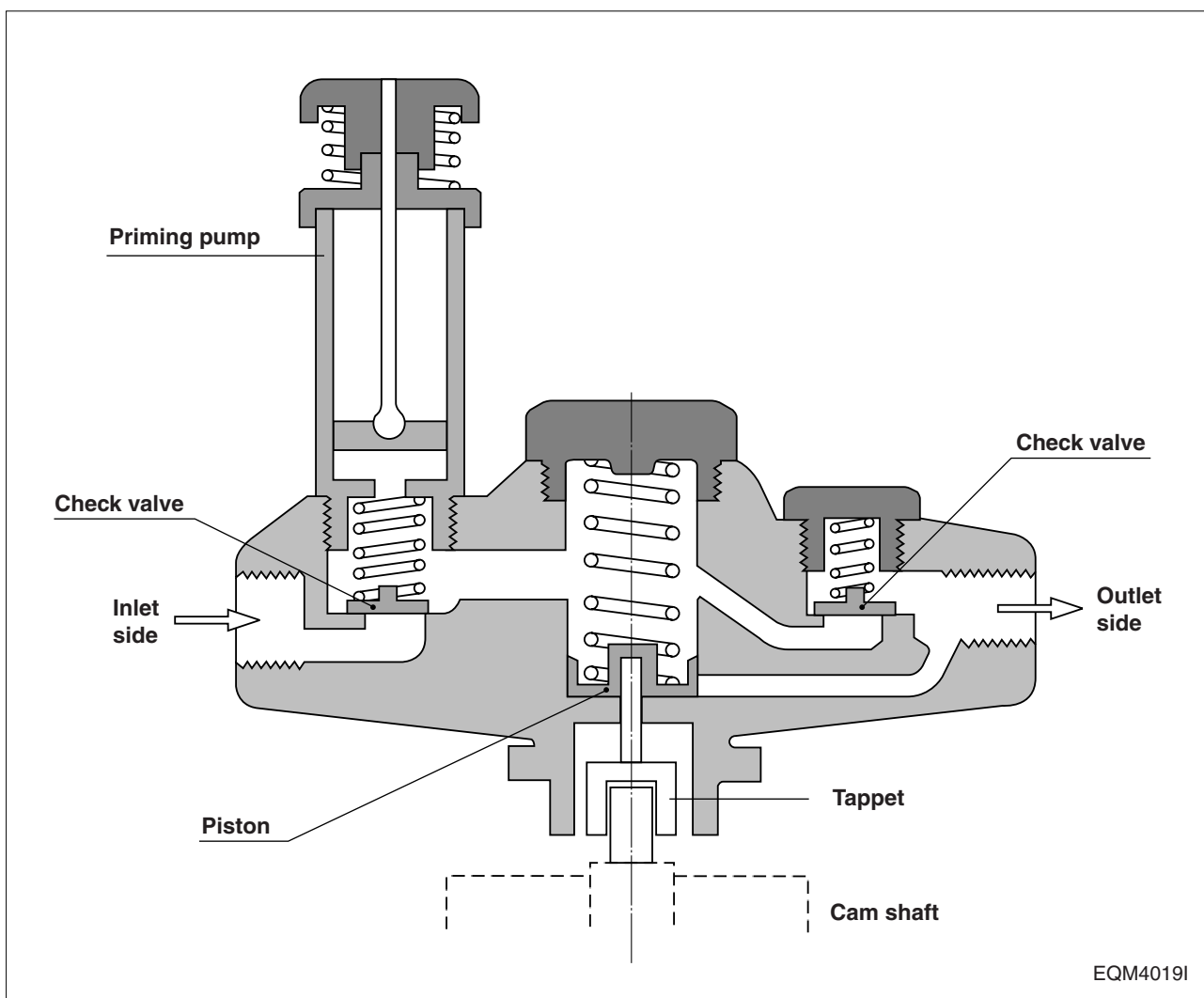
Fuel feed pump

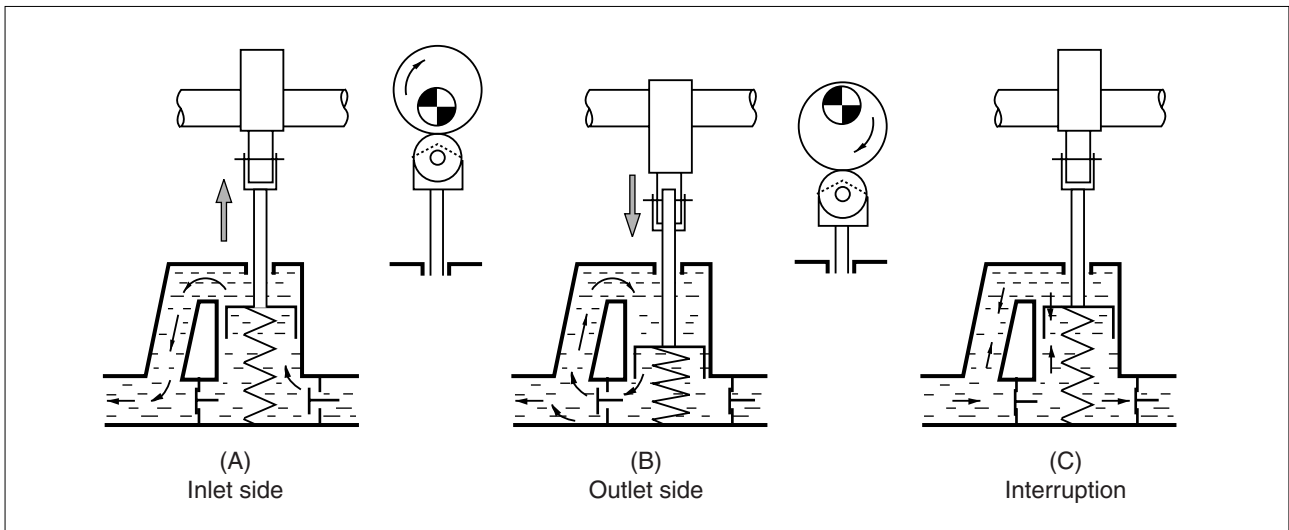
1. General descriptions and construction

The P-type injection pump is mounted with K-ADS or KP type feed pump. These pumps have the same basic construction and operation, and the general descriptions of the KP type pump are given below:

The figures show its construction (right figure) and operation (below figure). The piston in the fuel feed pump is driven by the push rod and tappet via the camshaft of injection pump and performs reciprocating operation to control the suction and delivery of fuel. When the cam reaches the Bottom Dead Center as shown in the figure, the fuel is drawn in through the check valve on the inlet side.

The fuel pressurized as the cam rotates on flows through the check valve on the outlet side as shown in (B). If the feeding pressure increases abnormally, the spring is compressed, resulting in interrupting further delivery of fuel as shown in (C).

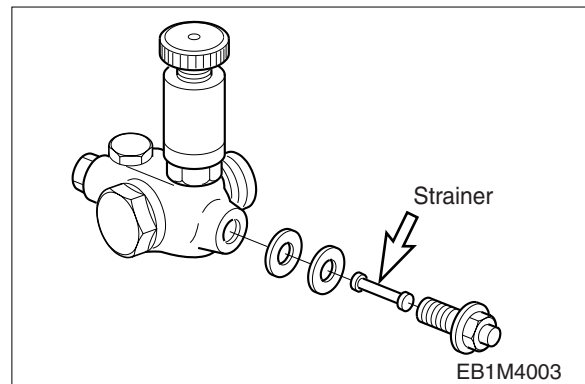




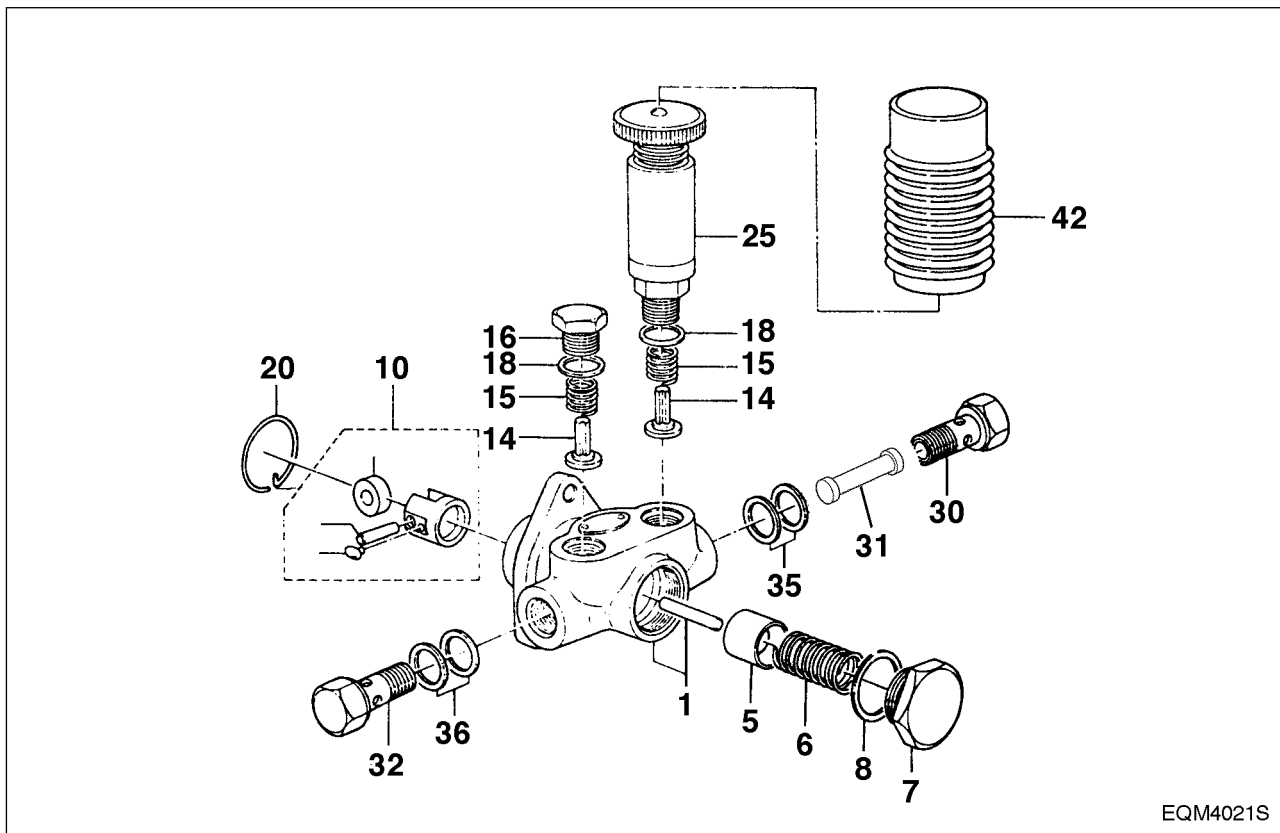
This feed pump is mounted with a priming pump designed to permit manual feeding of fuel from the fuel tank with the injection pump mounted in the engine. During the manual feeding operation, air must be bled from the fuel lines.

When using the priming pump, fix it securely to prevent the possible entry of moisture or other foreign substances in the inside of feed pump.

In addition, a strainer is fitted into joint bolt on the inlet side of the fuel feed pump to filtrate any foreign substances possibly mixed in fuel.



2. disassembly



- Clamp the feed pump with a vise and disassemble the hollow screw (30, 32), strainer (31) and seal ring (35, 36).
- Take off the priming pump (25), plug (16), both seal rings (18), spring (15), and check valve (14).
- Take off the plug (7), seal ring (8), spring (6), and piston (5) on the piston side.
- Pull out the snap ring (20) holding the tappet (10).
- Disassemble the snap ring, then take off the tappet (10) and push rod (1).

3. Inspection

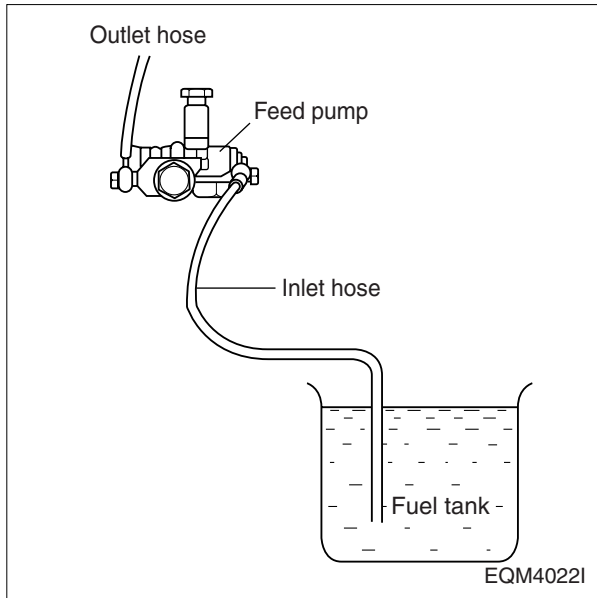
- If the check valve is damaged or scored on its seat face, replace it with a new one.
- Inspect the piston and tappet for damage.
- Replace the push rod if excessively worn, and replace together with the pump housing if required. The inspection for wear should be performed in the same procedure as for suction pressure test described below.

4. Reassembly

Reassembly operation is performed in reverse order of disassembly. All the gaskets must be replaced with new ones at reassembly.

5. Testing

a. Suction capacity test

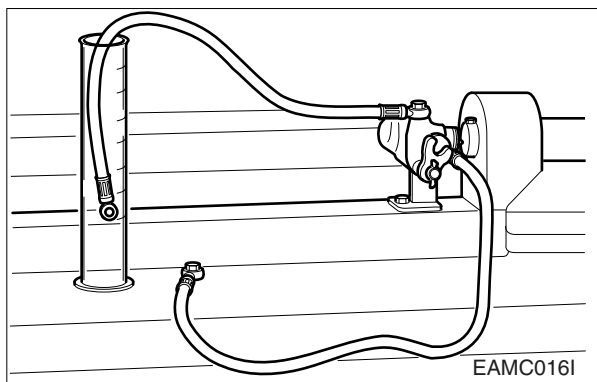


Connect one end of a hose to the inlet side of the feed pump and immerse the other end of it into the fuel tank as illustrated.

Hold the feed pump in position about 1 m above the level of fuel in the fuel tank.

Operate the tappet at the rate of 100 rpm and check to see if fuel is drawn in and delivered for 40 seconds or so.

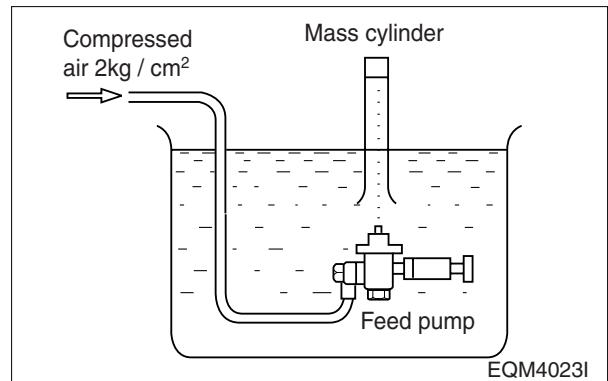
b. Delivery test



Make a test with the feed pump mounted on a pump tester as illustrated.

Operate the pump at the rate of 1,000 rpm and check to see if the pump delivery is more than 405 cc/15 seconds.

c. Sealing test

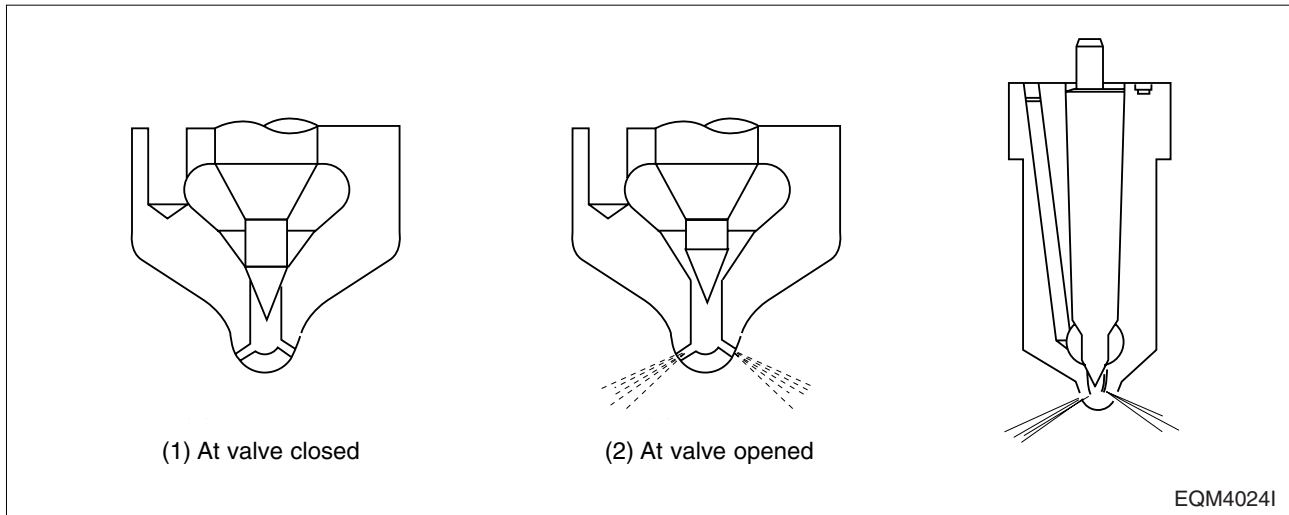


Plug up the delivery port on the feed pump and apply compressed air of 2 kg/cm² into the inlet side.

Submerge the feed pump in a container of diesel fuel and check for air leak.

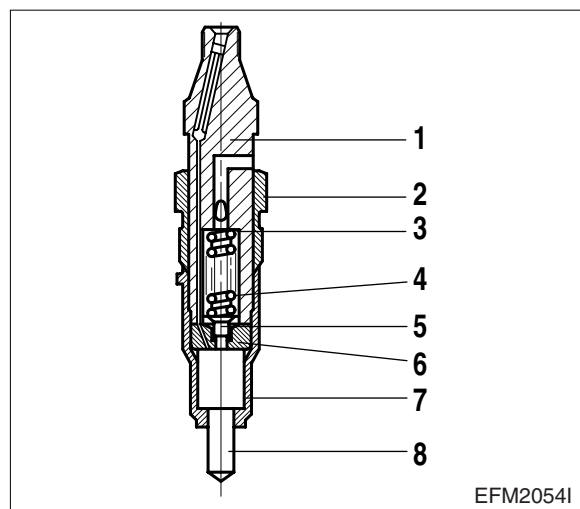
Injection nozzle

1. General descriptions



Pressurized fuel delivered from the fuel injection pump is sprayed into the combustion chamber past the injection nozzle at proper spray pressure and spray angle, then burnt completely to achieve effective engine performance.

2. Construction



1. Nozzle holder
2. Union nut
3. Shim
4. Spring
5. Guide bush
6. Intermediate washer
7. Cap nut
8. Nozzle ass'y

3. Disassembly

- a. Clamp the nozzle assembly and remove the nozzle holder.
- b. Remove the nozzle nut and components inside.

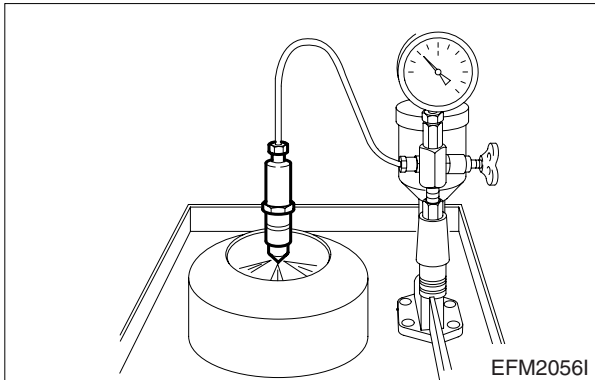
4. Inspection

- a. Visually inspect the disassembled components for damage.

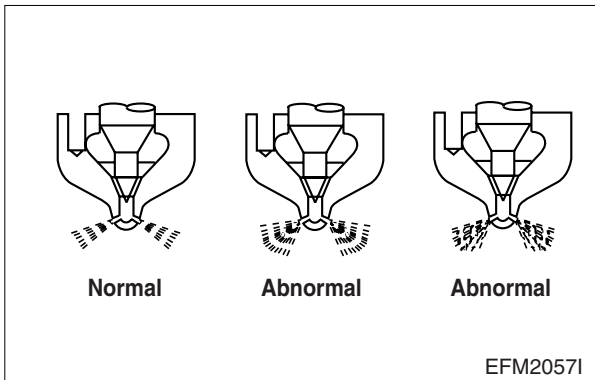
5. Reassembly

- a. After removing carbon deposit, submerge the nozzle in diesel oil and clean it.
- b. Replace all the seal rings with new ones.
- c. Assemble the parts and tighten them to specified torque

6. Adjustment

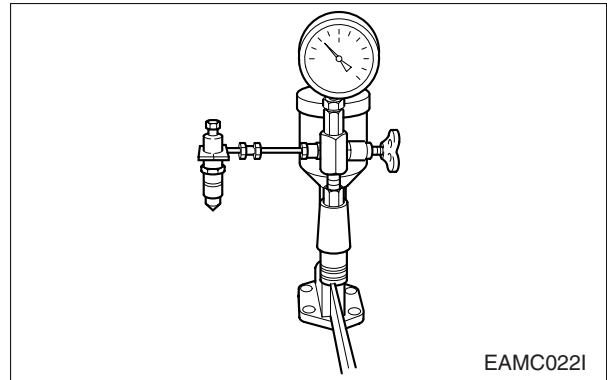


- After reassembly, install the nozzle on a tester.
- With the adjusting screw loosened, operate the nozzle 2 ~ 3 times to bleed it.
- Operate the nozzle tester lever at the specified rate.
- Adjust the injection pressure to the standard pressure by spring tension shims.
- After adjusting the injection pressure, tighten the cap nut to specified torque.



- Re-check the injection pressure and see if the spray pattern is normal. Spray pattern should be uniform and free of spattering.

7. Testing



With the nozzle assembled to a nozzle tester and specified pressure applied, check the nozzle for fuel leakage.

Engine Model	DE08TS
Opening pressure	1st : 180 kg/cm ² 2nd : 280 kg/cm ²

Diagnostics and troubleshooting

Complaints	Possible causes	Corrections
1. Engine won't start 1) Fuel not being pumped out from feed pump 2) Fuel not being injected from injection pump 3) Fuel injection timing Incorrect 4) Injection nozzles inoperative	● Fuel pipes clogged or air into pipe line ● Feed pump valve defective ● Feed pump piston or Push rod sticking	Correct Replace Disassemble, correct
	● Fuel filter element restricted ● Air in fuel filter or injection pump ● Plunger and/or delivery valve sticking or defective	Clean Bleed Disassemble, correct
	● Injection pump not properly installed on pump bracket ● Injection pump tappet incorrectly adjusted ● Cams on cam shaft worn excessively	Check, correct Check, correct Replace
	● Needle valves sticking ● Fuel leaking past clearance between nozzle and needle valve ● injection pressure incorrect	Correct or replace Correct or replace Adjust
2. Engine starts but stalls immediately	● Pipe from feed pump to injection pump clogged or filter clogged ● Air in fuel ● Feed pump delivery insufficient ● Fuel delivery insufficient due to clogging of fuel tank air breather	Clean Bleed Disassemble, correct Replace breather
3. Engine lacks power	● Plunger worn excessively ● Injection timing incorrect ● Delivery valves defective ● Nozzle leaks excessively ● Nozzle not working normally	Replace Adjust Replace Correct or replace Disassemble, correct
4. Engine knocking	● Injection timing too fast ● Nozzle injection pressure too high ● Nozzles not working normally	Adjust Adjust Disassemble, correct
5. Engine knocks seriously producing excessive exhaust smoke	● Injection timing incorrect ● Nozzle injection pressure too low ● Nozzle spring broken ● Nozzles not working normally ● Plungers worn excessively ● Delivery valves seat defective ● Supply of fuel excessively	Adjust Adjust Replace Replace Adjust Replace Check feed pump

Complaints	Possible causes	Corrections
6. Engine output unstable	● supply of fuel insufficient ● Air in fuel ● Water in fuel ● Operation of plungers unsmooth ● Movement of control rack sluggish ● Nozzles defective ● Injection starting pressure of each barrel incorrect ● Automatic timer defective	Check feed pump Bleed Replace fuel Disassemble, correct Disassemble, correct Disassemble, correct Adjust Disassemble, correct
7. Engine does not reach maximum speed	● Nozzles not working normally ● Governor defective	Disassemble, correct Disassemble, correct
8. Engine idling unstable sluggish	● Movement of control rod ● Operation of plungers unsmooth ● Control pinions not engaged with control rod correctly	Disassemble, correct Disassemble, correct Disassemble, correct

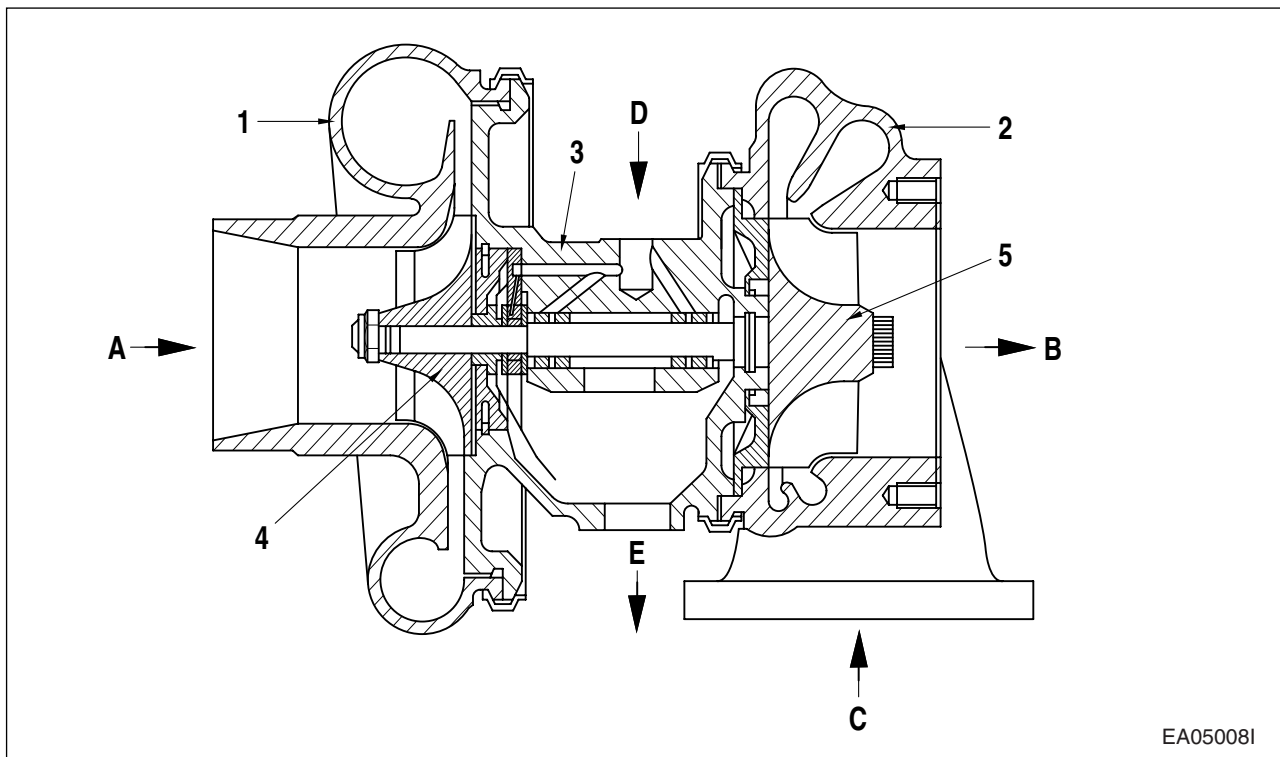
Turbocharger

Main data and specifications

1. Main data and specifications

Specification		DE08TS
Turbocharger model		ALLIED SIGNAL 466721-7
At maximum output	Air pressure at compressor outlet	1.26 kg/cm ²
	Air suction volume	16.8 m ³ /min
	Speed of turbine revolution	102,800 rpm
Maximum allowable speed		126,150 rpm
Max. allowable temperature of exhaust gas at turbine inlet		750 °C
Lubricating system		External oil supply
Weight		9.5 kg

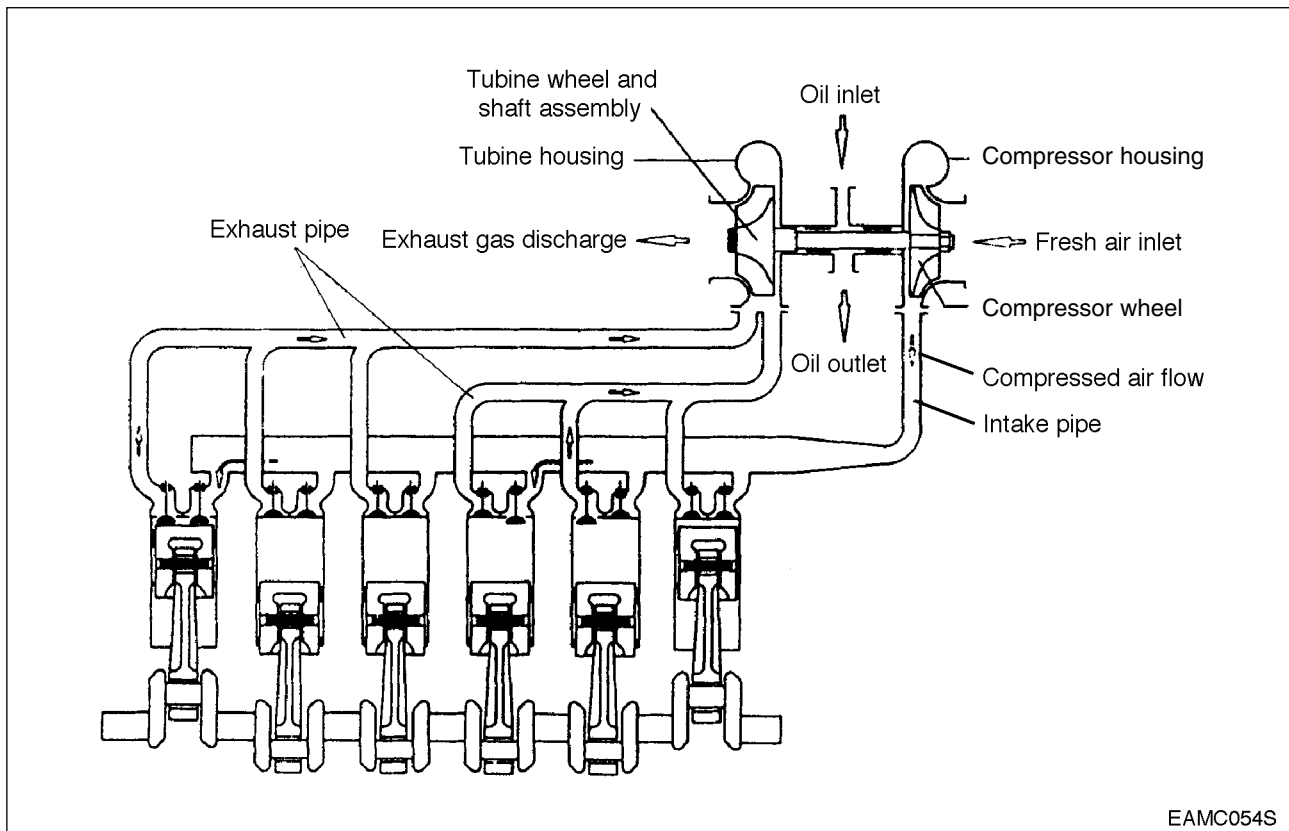
2. Construction



1. Impeller casing
2. Turbine casing
3. Bearing casing
4. Impeller
5. Turbine

- A. Air inlet
- B. Gas outlet
- C. Gas inlet
- D. Oil supply
- E. Oil return

3. Operating principle



The turbocharger is a system designed to make use of the engine exhaust gas energy to charge high-density air into the cylinders, thereby to increase the engine output.

General descriptions

The engine output is determined by the fuel delivery volume and engine efficiency.

To burn the supplied fuel completely to change into effective power for the engine, the volume of air enough to burn the fuel completely should be supplied into the cylinders.

Therefore, the engine output is determined substantially by the cylinder capacity, and a greater volume of compressed air is charged into cylinders of given capacity, the greater engine output can be obtained as a greater volume of air charged into the cylinders burns so much more fuel.

As explained, the compressing of air to supply into the cylinders is called "Supercharging" and the making use of the energy of exhaust gas discharged from the combustion chamber to charge the compressed air into the cylinders is called "Turbocharging".

Functions

1. Turbine

Exhaust gas discharged from the combustion chamber distributes its own energy to the turbine blades while passing the inside of the turbine housing, with the result that the turbine shaft can get rotating force.

This is the operating principle of 'turbine', which is mounted with seal rings and heat protector to prevent exhaust gas from affecting the bearings adversely.

2. Compressor

The compressor, which is connected to the turbine over the one and same shaft to form a rotating body, takes in and compresses ambient air with rotating force transmitted from the turbine shaft.

Then, the compressed air is delivered to the intake stake. This is the operating principle of the compressor.

3. Bearings

a. Thrust bearing

The turbine wheel creates thrust force. Therefore, exercise care so that the shaft is not deviated from its the original position due to this thrust.

b. Journal bearing

This journal bearing of floating type forms a dual oil film on both the inside and outside of the bearing so that the bearing can rotate independently.

As the dual oil film plays a role as a damper, the sliding speed of the bearing surface becomes lower than the rotating speed of the shaft, resulting in assurance of stability in its movement.

c. Sealing-Compressor shaft

The compressor is of a dual construction type composed of seal plate and seal ring to prevent the leak of compressed air or lubricating oil.

Precautions for operation

1. Precautions for operation of engine

The following precautions should be observed when starting, operating, or stopping the engine:

Operations	Precautions	Reasons
When starting the engine	1) Check oil level 2) Crank the engine with starter to check the increase in oil pressure(until the needle of pressure gauge starts to move or pressure indicator lamp is actuated) before starting the engine. 3) When having replaced oil, oil filter element, or lubricating parts, or when having stopped the engine for extended period of time, or in a cold place, loosen the oil pipe connections and operate the starter motor until oil is discharged. After completing the operation, be sure to retighten the oil pipe connections portion before starting the engine.	2) Abrupt starting of the engine causes the engine to rotate with oil not being distributed not only to each part but also to the turbocharger, resulting in abnormal wear or seizure on the bearing due to insufficient supply of oil. 3) In the case of the engine stopped for extended time or in a cold place, oil fluidity within the pipes can be deteriorated
Immediately after starting	1) Run the engine at idle for 5 minutes after starting off. 2) Check each part for leakage of oil, gas, and air, and take proper measure.	1) Applying load abruptly If load is abruptly applied with the engine and turbocharger rotating unsmoothly, such parts that a sufficient amount of oil has not reached can be seized up. 2) Leakage of oil, gas, and air (especially, oil leak) causes drop in oil pressure and loss of oil results in seizure of the bearing.
During operation	Check the followings: 1) Oil pressure At idle: 0.8 kg/cm² or more At full load: 3.0 ~ 4.8 kg/cm² 2) If unusual sound or vibration is heard or felt, reduce engine revolutions slowly and locate the cause.	1) Excessively low oil pressure causes unusual wear or seizure of the bearing. Too high pressure causes oil leakage. 2) The engine is operated continuously with unusual sound or vibration not corrected, it can be damaged beyond repair.
When stopping the engine	1) Run the engine at idle for 5 minutes before stopping.	1) If the engine is put to a stop after being operated at high load, heat from the red-hot turbine blades is transmitted to the bearing portion and burns oil to cause seizure of the bearing metal and rotating shaft.

Walk-around check and servicing

As the condition of turbocharger depends greatly on how well the engine is serviced, it is very important to maintain the engine in accordance with the specified maintenance procedure.

1. Intake system

Pay particular attention to the air cleaner when servicing the intake system.

In the case of wet-type air cleaner, if the level of oil surface is lower than specified, cleaning effect is poor; if too high, the cleaner draws in oil to foul the case.

Especially, if the rotor is fouled, the sophisticatedly-tuned balance is broken to create vibration and to cause seizure and unusual wear to the bearing.

Therefore, it is very important to use a good quality air cleaner all the time.

In the case of dry-type air cleaner, it is essential to clean it to reduce intake resistance as much as possible.

2. Exhaust system

Pay particular attention to prevent gas leaks and seizure when servicing the exhaust system because leakage of exhaust gas from discharge pipes, turbocharger fixing portions, etc. lowers charging effect.

As such components as turbine chamber that becomes red-hot during operation use heat resisting steel nuts, do not interchange these nuts with ordinary steel nuts.

In addition, apply anti-seizure coating to fixing nuts on the portions as designated.

3. Fuel system

If the full load stopper regulating the maximum injection volume and the maximum speed stopper regulating the maximum speed in the fuel injection pump are adjusted without using a pump tester, the turbocharger rotates at excessively rapid speed and may suffer damage.

Besides of it, if spray pattern from the fuel injection nozzles is bad or the injection timing is incorrect, temperature of exhaust gas rises up to affect the turbocharger adversely.

To avoid such trouble, be sure to make a nozzle test.

4. Lubricating system

Pay particular attention to oil quality and oil filter change intervals when servicing the lubricating system. Deteriorated engine oil affects adversely not only the engine but also the turbocharger.

Suggested engine oils for the turbocharger-mounted engine are as follows :

Periodical checking and 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.

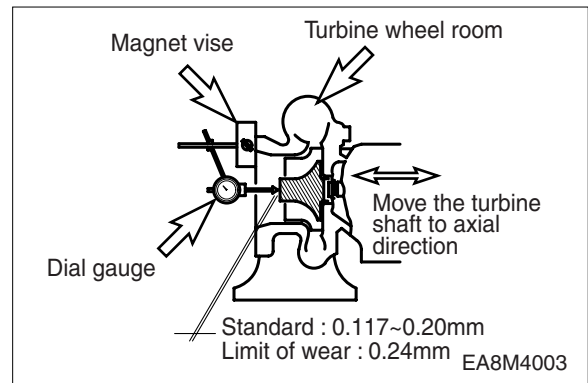
In this case, as the metal bearing and rotor are likely to be in abnormal conditions, the turbocharger should be replaced or repaired.

2. Guide for checking rotor end play

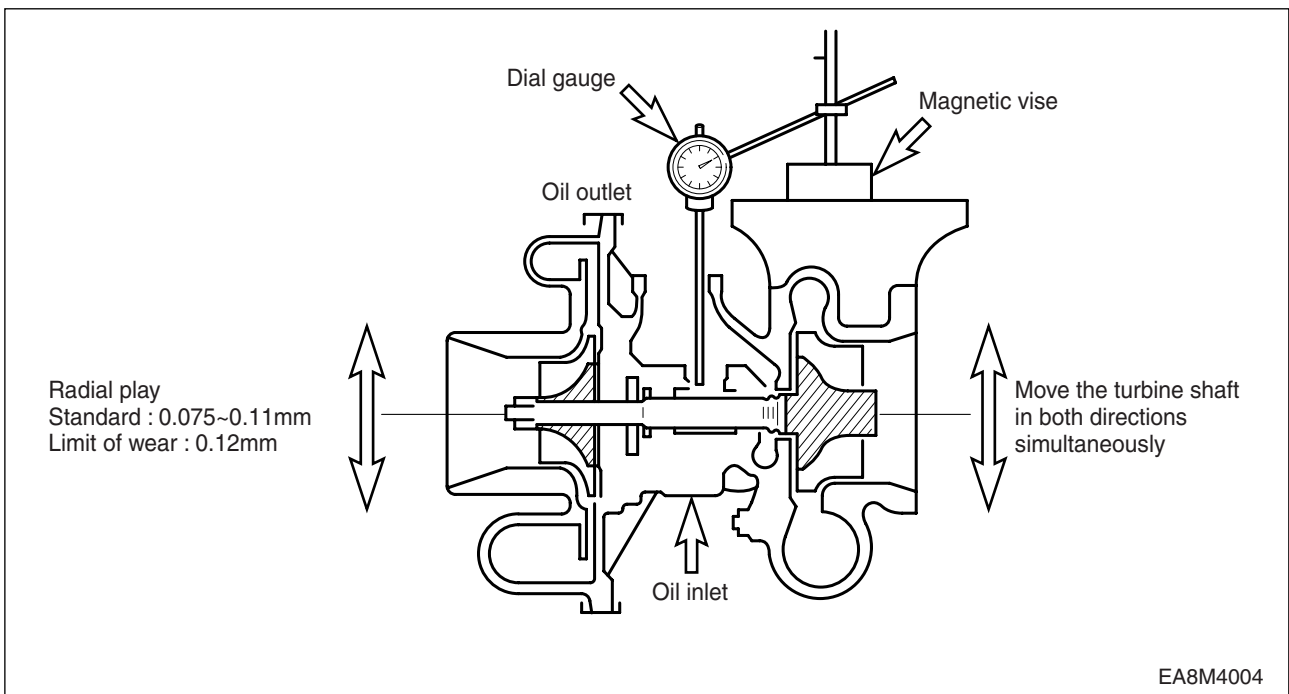
Disassemble the turbocharger from the engine, then check the rotor axial play and radial play.

When disassembling the turbocharger, be sure to plug the oil inlet and outlet ports with taps, etc.

a. Rotor axial play



b. Rotor radial play



c. If the measured axial and radial plays are beyond the limit of wear, replace or repair the turbocharger.

3. Guide for disassembling/cleaning and checking the turbocharger

First, disassemble the turbocharger from the engine and clean/check it with the oil inlet and outlet plugged with tape and so on.

4. Precautions for reassembling the turbocharger onto the engine

For reassembly of the turbocharger or handling it after reassembly operation, be sure to observe the following precautions :

Especially, exercise extreme care to prevent foreign matters from entering the inside of the turbocharger.

a. Lubricating system

- Before reassembling the turbocharger onto the engine, inject new oil in the oil inlet port and lubricate the journal and thrust bearings by rotating them with hand.
- Clean not only the pipes installed between the engine and oil inlet port but also the oil outlet pipe and check them for damage or foreign matters.
- Assemble each joint on oil pipes securely to prevent oil leaks.

b. Intake system

- Check the inside of the intake system for foreign matters.
- Assemble each joint on the intake duct and air cleaner securely to prevent air leaks.

c. Exhaust system

- Check the inside of the exhaust system for foreign matters.
- Be sure to use heat resisting steel bolts and nuts. Do not interchange them with ordinary steel bolts and nuts when performing reassembly operation.

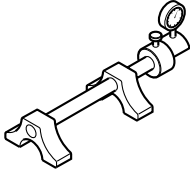
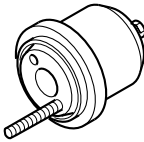
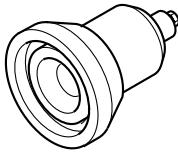
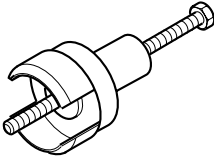
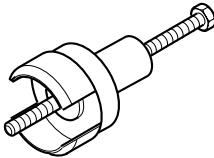
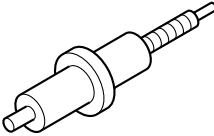
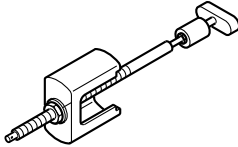
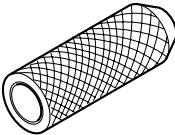
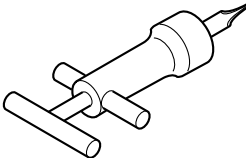
Apply anti-seizure coating to the bolts and nuts.

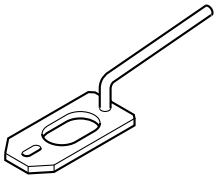
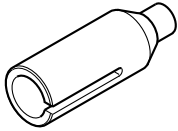
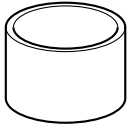
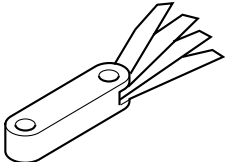
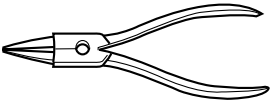
- Assemble each joint on the exhaust pipes securely to prevent gas leaks.

Diagnostics and troubleshooting

Complaints	Possible causes	Corrections
1. Excessive black smoke	1) Air cleaner element clogged 2) Restrictions in air duct 3) Leakage at intake manifold 4) Turbocharger seized up and not rotating 5) Turbine blades and compressor blades coming in contact with each other or damaged 6) Exhaust piping deformed or clogged	Replace or clean Check and correct Check and correct Disassemble/repair or replace Disassemble/repair or replace Check and correct
2. Excessive white smoke	1) Oil leak into turbine and compressor 2) Worn or damaged seal ring due to excessive wear of bearing	Disassemble/repair or replace Disassemble/repair or replace
3. Low engine output	1) Gas leak at each part of exhaust system 2) Air cleaner element restricted 3) Turbocharger fouled or damaged 4) Leakage at discharge port on compressor side	Check and correct Replace or clean Disassemble/repair or replace Check and correct
4. Unusual sound or vibration	1) Rotor assembly coming in contact 2) Unbalanced rotation of rotor 3) Seized up 4) Each joint loosened	Disassemble/repair or replace Disassemble/repair or replace Disassemble/repair or replace Check and correct

Special Tool List

No.	Part No.	Figure	Tool Name	Remark
1	EF.123-014		Injection pump setting ass'y	D1146/TI
	EF.123-015			DE08TIS
2	EF.123-127		Oil seal insert ass'y (Front)	CR : made USA (up to 2000. Apr.)
	EF.123-173			NOK : made Japan (From 2000. may.)
3	EF.123-043		Oil seal insert ass'y (Rear)	CR : made USA (up to 2000. Apr.)
	EF.123-184			NOK : made Japan (From 2000. may.)
4	EF.123-052		Oil seal puller ass'y (Front)	
5	EF.123-048		Oil seal puller ass'y (Rear)	
6	EU.2-0530		Cylinder pressure tester adapter	
7	EU.123-086		Cylinder liner puller ass'y	
8	EF.123-179		Valve stem seal punch	
9	EU.2-0131		Valve clearance adjust ass'y	

No.	Part No.	Figure	Tool Name	Remark
10	EF.123.-065		Valve spring press	
11	EU.2-0647		Crankshaft gear punch	
12	EF.123-064		Piston sleeve	D1146/TI DE08TIS
	EF.120-208			All engine
13	60.99901-0027		Feeler gauge	
14	T7610001E		Snap ring plier	
15	T7621010E		Piston ring plier	

Appendix

1. Tightening torque for major parts

Major Parts	Screw (Diameter x pitch)	Strength (grade)	Tightening Torque	Remarks
Cylinder head bolt	M14 1.5	10.9T	1st : 6.0 kg•m 2nd : 180° 3rd : 150° (Angle method)	
Connecting rod bearing cap bolt	M14 1.5	12.9T	1st : 10 kg•m 2nd : 15 kg•m 3rd : 18 kg•m	
Crankshaft main bearing cap bolt	M16 1.5	12.9T	1st : 15 kg•m 2nd : 25 kg•m 3rd : 30 kg•m	
Balance weight fixing bolt	M12 1.5	10.9T	9.0 kg•m	
Flywheel housing fixing bolt	M14 1.5	10.9T	8.0 kg•m	
Flywheel fixing bolt	M14 1.5	10.9T	21.5 kg•m	
Crankshaft pulley fixing bolt	M12 1.5	10.9T	13.4 kg•m	
Oil spray nozzle	M14 1.5	-	7.0 kg•m	

2. Tightening torque for fuel injection pump system

Major Parts	Screw (Diameter x pitch)	Strength (grade)	Tightening Torque	Remarks
Injection nozzle nut	M28 1.5	-	7.0 0.5 kg•m	
Injection pump bracket bolt	M10	8.8T	4.4 kg•m	
Injection pump coupling bolt	-	-	6.0 ~ 6.5 kg•m	
Injection pump driving gear nut	M24 1.5	8.8T	25.0 kg•m	
Injection pipe nut	M14 1.5	8.8T	3.0 kg•m	
Injection pump delivery valve holder	-	-	11.0 ~ 12.0 kg•m	

3. Standard bolt tightening torque table

Refer to the following table for bolts other then described above

Diameter pitch (mm)	Degree of strength										
	3.6	4.6	4.8	5.6	5.8	6.6	6.8	6.9	8.8	10.9	12.9
	(4A)	(4D)	(4S)	(5D)	(5S)	(6D)	(6S)	(6G)	(8G)	(10K)	(12K)
	Limit value for elasticity (kg/mm ²)										
	20	24	32	30	40	36	48	54	64	90	108
Tightening torque (kg·m)											
M5	0.15	0.16	0.25	0.22	0.31	0.28	0.43	0.48	0.5	0.75	0.9
M6	0.28	0.30	0.45	0.4	0.55	0.47	0.77	0.85	0.9	1.25	0.5
M7	0.43	0.46	0.7	0.63	0.83	0.78	1.2	1.3	1.4	1.95	2.35
M8	0.7	0.75	1.1	1	1.4	1.25	1.9	2.1	2.2	3.1	3.8
M8 1	0.73	0.8	1.2	1.1	1.5	1.34	2.1	2.3	2.4	3.35	4.1
M10	1.35	1.4	2.2	1.9	2.7	2.35	3.7	4.2	4.4	6.2	7.4
M10 1	1.5	1.6	2.5	2.1	3.1	2.8	4.3	4.9	5	7	8.4
M12	2.4	2.5	3.7	3.3	4.7	4.2	6.3	7.2	7.5	10.5	12.5
M12 1.5	2.55	2.7	4	3.5	5	4.6	6.8	7.7	8	11.2	13.4
M14	3.7	3.9	6	5.2	7.5	7	10	11.5	12	17	20
M14 1.5	4.1	4.3	6.6	5.7	8.3	7.5	11.1	12.5	13	18.5	22
M16	5.6	6	9	8	11.5	10.5	17.9	18.5	18	26	31
M16 1.5	6.2	6.5	9.7	8.6	12.5	11.3	17	19.5	20	28	33
M18	7.8	8.3	12.5	11	16	14.5	21	24.2	25	36	43
M18 1.5	9.1	9.5	14.5	12.5	18.5	16.7	24.5	27.5	28	41	49
M20	11.5	12	18	16	22	19	31.5	35	36	51	60
M20 1.5	12.8	13.5	20.5	18	25	22.5	35	39.5	41	58	68
M22	15.5	16	24.5	21	30	26	42	46	49	67	75
M22 1.5	17	18.5	28	24	34	29	47	52	56	75	85
M24	20.5	21.5	33	27	40	34	55	58	63	82	92
M24 1.5	23	25	37	31	45	38	61	67	74	93	103

Others : 1. The above torque rating have been determined to 70% or so of the limit value for bolt elasticity.
 2. Tension is calculated by multiplying tensile strength by cross section of thread.
 3. Special screws should be tightened to 85% or so of the standard value.
 For example, a screw coated with MoS2 should be tightened to 60% or so of the standard value.

4. Tightening torque for hollow screw (4-hole)

Material	M8	M10	M12	M14	M16	M18	M22	M26	M30	M38
SM25C	-	1.6	2.5	3.5	4.5	5.5	9.0	13.0	18.0	30.0
*SUM22L	0.8	1.8	3.0	4.0	5.5	6.5	11.0	16.0	20.0	35.0
STS304	0.8	1.8	3.0	4.0	5.5	6.5	11.0	16.0	20.0	35.0

* : Adopted in DOOSAN engine

5. Maintenance specification table

(unit : mm)

Group	Part	Inspection Item		Stand value for assembly	Limit for use	Correction	Remark
Engine body	Cylinder block & liner	Inside diameter of Cylinder liner for wear		111 ~ 111.022	111.122	Replace liner	Measure unworn portion beneath the rim of the upper side
		Amount of liner projection		0.03 ~ 0.08	-	Need amount of projection without fail	Projection difference between adjacent liners : 0.15 ↓
		The flatness of upper surface of cylinder block		0.05	-	Correct with a surface grinder	Referenced length : 200mm
		Hydraulic test for 1 minute (kg/cm²)		4		Replace if leaky	
	Cylinder head & valve	Valve seat depression	Intake	0~0.3	0.55	Replace valve seat	
			Exhaust	0~0.3	0.55		
		Cylinder head height		109.9 ~ 110.1	108.4	Replace cyl. head	
		Hydraulic test for 1 minute (kg/cm²)		4	-	Replace if leaky	Water temp. 70°C
Major moving parts	Piston	Outer dia. piston		110.883~ 110.897		Replace liner	Measure at 13mm away from lower surface of piston
		Clearance between piston and liner		0.103~0.139	0.3 more	Replace one worn	
		Width of piston ring grooves	Top ring	-		Replace piston if groove width is beyond specified value	
			2nd ring	3.06~3.08			
			Oil ring	4.04~4.06			
		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		±15 g	96 g ↓	Replace piston	
	Piston ring	Piston ring gap	Top ring	0.40~0.60	1.5	Replace ring	Standard gauge inside diameter : 108
			2nd ring	0.40~0.60	1.5		
			Oil ring	0.30~0.50	1.5		
		Piston ring side clearance	Top ring	-	-	Replace ring or piston	Limit for use if for standard clearance
			2nd ring	0.07~0.102	0.15		
			Oil ring	0.05~0.085	0.15		
		Direction of ring gap		-	-	Cross Install by 120°	
	Piston pin	Outer diameter of piston pin		41.994 ~ 42	41.94	Replace piston pin	
		Clearance between piston pin and its bush		0.003 ~ 0.015	0.08	Replace one worn more	

(unit : mm)

Group	Part	Inspection Item	Stand value for assembly	Limit for use	Correction	Remark
Major moving parts	Crank shaft	Radial run-out of journal and pin	-	0.01	Correct with a grinder	Measure In horizontal installing the bearing and releasing one bolt
		Outside diameter of journal	83.966 ~ 83.988	83	Use under sized bearings	
		Outside diameter of pin	70.971~ 70.990	70	respectively(0.25, 0.5, 0.75, 1.0)	
		Ellipticity of journal and pin	0.008	0.025		
		Concentricity of journal and pin	0.01	0.03		
		Taper of journal and pin	0.02	0.03		
		Clearance between crankshaft and bearing	0.052~0.122	0.25	Replace bearing	Measure at crown part not parting line
		End play of crankshaft	0.15~0.325	0.5	Replace thrust bearing	
		Run-out of crankshaft	0.06	0.1 ↓	Adjust by a press if bended	Measure at No.4 bearing (No. 1 & 7 bearing supported)
		Balance of crankshaft(g•cm)	60 ↓	60 or less	Check dynamic balance	Measure at 400 rpm
		Torque valve journal bearing cap bolt (kg•m)	30		Coat the bolt with engine oil	Clean out foreign objects on joining surface
		Crush height of journal bearing	0.08~0.110	-		Measure after tightening metal cap and releasing one stud
		Oil seal for wear (crank shaft rear)	-	-	Replace oil seal if oil leaking	
	Connecting rod	End play of con-rod	0.170 ~ 0.248	0.50	Replace con-rod	
		Clearance between con-rod bearing and crank pin	0.034 ~ 0.098	0.25	Replace bearing	
		Clearance between small end bush & piston pin	0.050~0.081	0.12		
		Crush height of con-rod bearing	0.04~0.07	-		Measure after installing the bearing and releasing one bolt
		Side clearance of big-end and small-end	-	0.50	Replace con-rod	
		Allowable weight difference per con-rods	30 g ↓	-		
		Torque valve of con-rod bearing cap bolt (kg•m)	18	-	Coat the bolt with engine oil	Clean out foreign objects on joining surface
	Cam shaft	Diameter of cam shaft journal	57.86~ 57.88	57.52		
		Clearance between cam shaft and cam bush	0.12~0.17	0.24	Replace cam bush	
		End play of camshaft	0.28~0.43	0.6	Replace thrust washer	
		Run-out of camshaft	0.05	0.2	Correct or replace the cam shaft	

(unit : mm)

Group	Part	Inspection Item		Stand value for assembly	Limit for use	Correction	Remark
Major moving parts	Timing gear	Clearance between idle shaft bush and idle shaft		0.025~0.091	0.15		
		End play of idle gear shaft		0.043~0.167	0.3	Replace thrust collar	
		Back-lash between gears(cam, idle, crank and injection)		0.16~0.28	0.35	Correct or replace gear	
Valve system	Valve	Diameter of intake valve stem		8.950~ 8.970	8.93	Replace valve & valve guide	When replacing valve, replace valve guide alike
		Diameter of exhaust valve stem		8.935~ 8.955	8.91		
		Clearance between valve stem and valve guide	Intake	0.030~0.065	0.15	Replace valve or valve guide	Replace one worn more
			Exhaust	0.045~0.080	0.15		
		Thickness of valve head	Intake	2.7	Max. 1	Replace valve	
			Exhaust	2.2			
		Clearance between valve guide and valve spring seat	Intake	2.0	-		
			Exhaust	2.0	-		
		Clearance between valve guide and cyl. head installing hole		-0.039~-0.010 (Press fit)			Spread oil over valve guide and press it into the hole
		Concentricity between valve stem and valve head		0.05			Without spring seat
		Intake valve spring	Free length(mm)	Approx.64	-	Replace valve spring	
			Tension force (when pressed to 41mm)kg	67~73	66.5		
			Squareness (along free length direction)	1.5°			
		Exhaust valve spring	Free length (mm)	D1146/TI : 60 DE08TIS : 73.8	-	Replace valve spring	
			Tension force(when pressed to 38mm)kg	D1146/TI : 26.9~30.3 DE08TIS : 36~40			
			Squareness (along free length direction)	1.5°			
		O u t e r	Free length	D1146/TI : 71 DE08TIS : 77.7	-	Replace valve spring	
			Tension force(when pressed to 41mm)kg	D1146/TI : 62.7~69.3 DE08TIS : 71~79			
			Squareness (along free length direction)	1.5°			

(unit : mm)

Group	Part	Inspection Item		Stand value for assembly	Limit for use	Correction	Remark
Valve system	Tappet	Valve clearance (at cold)	Intake	0.3	-	Adjust	
			Exhaust	0.3	-		
		Joining surface of valve stem and rocker arm bush		-	-	Grind or replace if severely pitted on tip of rocker arm and stem	
		Clearance between rocker arm shaft & rocker arm bush		0.040~0.113	0.2	Replace bush or shaft	
		Diameter of rocker arm shaft for wear		23.939 ~ 23.96	23.75	Replace	
		Run-out of push rod		-	0.3	Replace	
		Clearance between tappet & tappet hole of cyl.bolck		0.035 ~ 0.077	0.15	Replace tappet	
		Diameter of tappet		19.944 ~ 19.965	-	Replace tappet	
Lubricating system	Oil pressure	Oil pressure (at normal speed)kg/cm ²		4.8 or less	3.5	Check oil leakage and clearance between each part	
		Oil pressure (idling)kg/cm ²		0.8~1.4	0.6	Use recommended oil	
	Oil temperature	Max. permissible oil temperature (°C)		-	105		Must not exceed this valve
		Permissible oil temperature in short time (°C)		-	120		
	Oil pump	Axial play of oil pump gear		0.055 ~ 0.105	-	Replace gear or cover	
		Clearance between gear shaft & oil pump cover hole		0.032 ~ 0.077	-		
		Clearance between drive gear shaft and cover hole		0.040 ~ 0.094	-	Replace bush or cover	
		Diameter of gear shaft		16.950 ~ 16.968		Replace gear shaft	17e7
		Diameter of driving gear bush		28.000 ~ 28.033		Replace bush	28e7
		Backlash	Between crank gear & idle gear	0.15 ~ 0.25	0.8	Adjust back-lash	
			Between oil pump drive gear & idle gear	0.15 ~ 0.25	0.8		

(unit : mm)

Group	Part	Inspection Item	Stand value for assembly	Limit for use	Correction	Remark
Lubricating system	Valve opening pressure	Oil pressure control valve (kg/cm ²)	4.0 ~ 4.8	-	Replace valve	
		By-pass valve for filter element (kg/cm ²)	1.8 ~ 2.3	-		
		By-pass valve for full oil filter (kg/cm ²)	4.0 ~ 4.8	-		
		Relief valve for oil pump (kg/cm ²)	8.5 ~ 11.5	-	Replace valve	
		Spray nozzle control valve (kg/cm ²)	1.5 ~ 1.8	-		
	Oil filter	Damage of oil filter cartridge	-	-	Clean or replace	
Cooling system	Radiator	Radiator & water pump for corrosion, damage & improper connecting	-	-	Correct or replace	
		Test for leakage (air pressure) (kg/cm ²)	1.0	-	Submerge in water and replace if air bubbles found	
		Pressure valve for opening pressure (kg/cm ²)	0.5	-		
		Negative pressure valve for opening pressure (mmHg)	20	-		
	Water pump	Delivery volume l/min - Engine speed 2,700rpm - Water temp. 80 °C - Back pressure : 0.8 kg/cm ²	280	-	Check the water passage	For any restrictions
		Clearance between impeller & housing	0.35	-	Replace if impeller & housing are damaged	
		Perpendicularity of pulley	0.3		Adjust by a bench press	
		Fan belt depression(with thumb) mm	Approx. 15		Adjust	
	Cooling water temp	Operating temperature (permissible temp.) °C	79 ~ 95	-	Must not exceed this valve	
		Permissible temperature in a short time. °C	-	105		
	Thermostat	Thermostat opening temp. °C (under atmospheric pressure)	79	-	Replace	Type-II - Opening temp. : 83°C - Full opening temp. : 95°C
		Full opening temp. °C	94	-	Replace if defective Stroke min. 8mm	

(unit : mm)

Group	Part	Inspection Item	Stand value for assembly	Limit for use	Correction	Remark
Fuel system	Piping & others	Fuel pipe, injection pipe & nozzle holder for damage, cracks, improper packing, etc.	-	-	Repair or replace	
		Fuel filter cartridge for damage or dimple	-	-	Replace cartridge	
		Injection pressure of injection nozzle (kg/cm ²)	D1146 : 210 D1146TI : 214 DE08TIS : 1st 184 2nd 286	-	Adjust by shim	
		Operating pressure of overflow valve (kg/cm ²)	1.0 ~ 1.5	-	Replace valve	
		Projection height of nozzle from the cyl. head surface(mm)	2.53	-	Replace seal ring	
Inspection at completion	Running-in the engine		-	-	Refer to supplement "running-in"	
	Cylinder pressure	Compression pressure of cylinder (kg/cm ²)	24 ~ 28	24 or more	Correct	at 200rpm or more more(20 °C)
		Compression pressure difference of each cylinder	10% or less against average		Correct	

