SB4118E01
May. 2007

Service Manual

Diesel Engine 5.8 Liter (DB58S)

D35S-5, D40S-5, D45S-5, D50C-5, D55C-5
D50S-5, D60S-5, D70S-5, D80S-5, D90S-5 (3 speed)
D50S-5, D60S-5, D70S-5 (2 speed)

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.

⚠ WARNING

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.

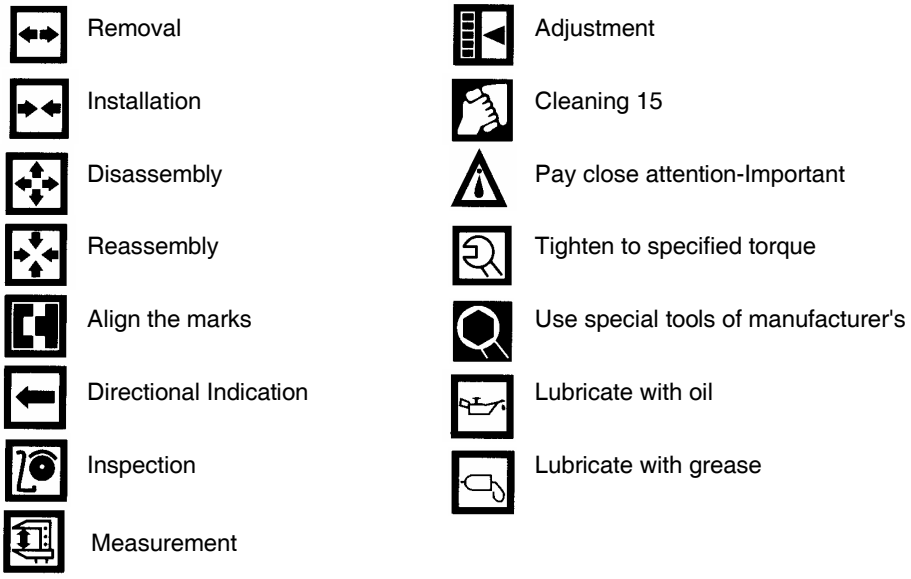
The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given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

FOREWORD

This maintenance manual is designed to serve as a reference for DOOSAN Infracore Ltd's (here after DOOSAN's) customers and distributors who wish to gain basic product knowledge on DOOSAN's **DB58S** Diesel engine.

This economical and high-performance diesel engine (6 cylinders, 4 strokes, in-line, direct injection type) has been so designed and manufactured to be used for the overland transport or industrial purpose. That meets all the requirements such as low noise, fuel economy, high engine speed, and durability.

To maintain the engine in optimum condition and retain maximum performance for a long time, CORRECT OPERATION and PROPER MAINTENANCE are essential.
In this manual, the following symbols are used to indicate the type of service operations to be performed.



During engine maintenance, please observe following instructions to prevent environmental damage;

- Take old oil to an old oil disposal point only.
- Ensure without fail that oil will not get into the sea or rivers and canals or the ground.
- Treat undiluted anti-corrosion agents, antifreeze agents, filter element and cartridges as special waste.
- The regulations of the relevant local authorities are to be observed for the disposal of spent coolants and special waste.

If you have any question or recommendation in connection with this manual, please do not hesitate to contact our head office, dealers or authorized service shops near by your location for any services.

For the last, the content of this maintenance instruction may be changed without notice for some quality improvement. Thank you.

CONTENTS

1. GENERAL INFORMATION

1.1. Engine specifications

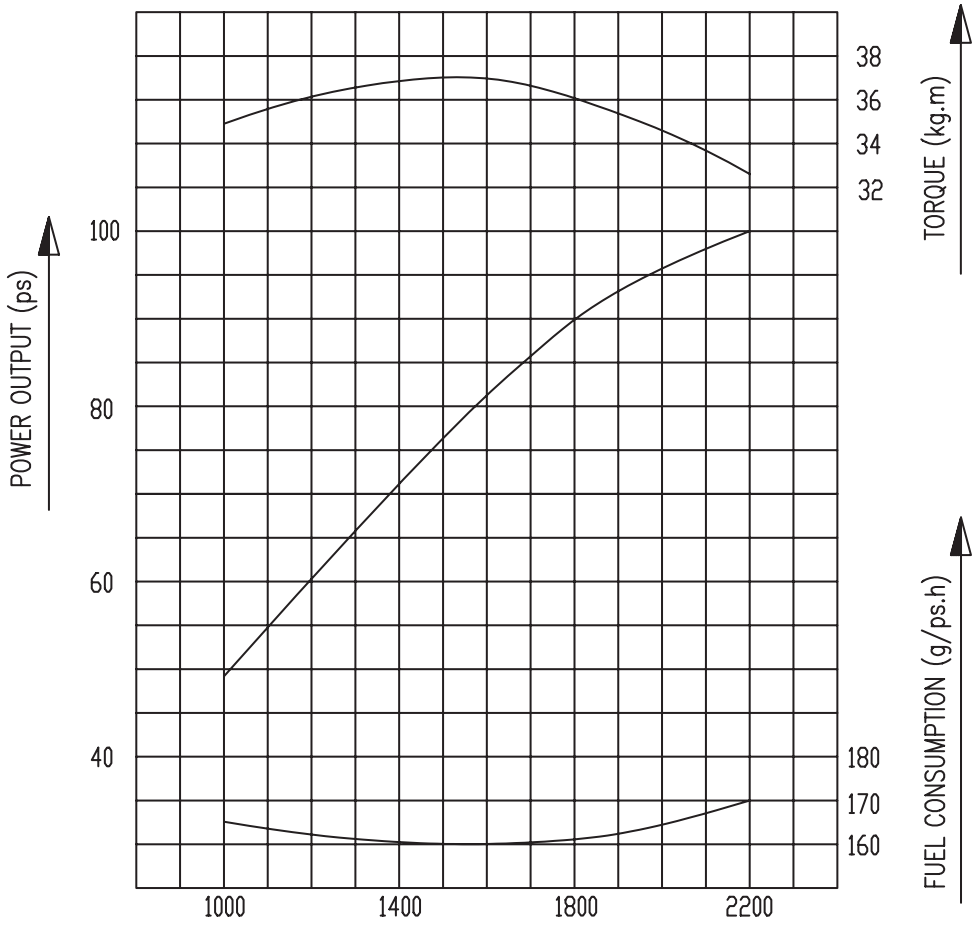
Items \ Engine Model		DB58S ECRFA D50/60/70/80/90S-5 (3 speed)	DB58S ECRFD D35/40/45S-5, D50/55C-5	DB58S ECRFE D50/60/70S-5 (2 speed)
Engine type		4 cycle in-line Naturally aspirated		
Combustion chamber type		Direct injection type		
Cylinder liner type		Dry type		
Timing gear system		Gear driven type		
No. of piston ring		2 Compression 1 ring, oil ring		
No. of cylinder-bore x stroke (mm)		6 – 102 × 118		
Total piston displacement (cc)		5,785		
Compression ratio		17.5 : 1	18.5 : 1	
Engine dimension (length X width X height) (mm)		1,173 x 666 x 793		
Engine weight (kg)		450		
Rotating direction (from fly wheel)		counter clockwise		
Fuel injection order		1 – 5 - 3 – 6 - 2 – 4		
Fuel injection timing (B.T.D.C static)		15°		
Injection pump type		Bosch in-line A type		
Governor type		Mechanical governor RSV type		
Injection nozzle type		Multi-hole type (5 hole)		
Fuel injection pressure (kg/cm²)		220		
Compression pressure (kg/cm²)		28 (at 200 rpm)		
Intake & exhaust valve clearance (mm) (at cold)		0.4		
Intake valve	Open at	17° B.T.D.C		
	Close at	51° A.B.D.C		
Exhaust valve	Open at	60° B.B.D.C		
	Close at	18° A.T.D.C		
Lubrication method		Pressurized circulation		
Oil pump type		Gear type		
Oil filter type		Full-flow, cartridge type		
Lubricating oil capacity (oil pan) (lit)		20.5(19)		
Oil cooler type		Water cooled		
Water pump		Belt driven impeller type		
Cooling Method		Pressurized circulation		
Cooling water capacity(engine only) (lit)		12		
Thermostat type		Wax pallet type (82 ~95°C)		
Cooling fan		10- Ø 520.7 blower	7 – Ø 457 blower	10- Ø 520.7 blower
Starting Motor (voltage – output) (V - kW)		24 – 4.5		

1. 2. Performance curve

1. 2.1. Performance curve (ECRFA), D50/60/70/80/90S-5 (3 speed)

DOOSAN	ENGINE PERFORMANCE CURVE	D50/60/70/80/90S-5 FORK LIFT	DB58S ECRFA
		2003.06.30	REV.

CONDITION	SPEC.
ATMOSPHERE PRE.	(760 mmHg)
WARMING UP	ENOUGH
COOLING FAN	–
GENERATOR	–
AIR CLEANER	YES
MUFFLER	YES

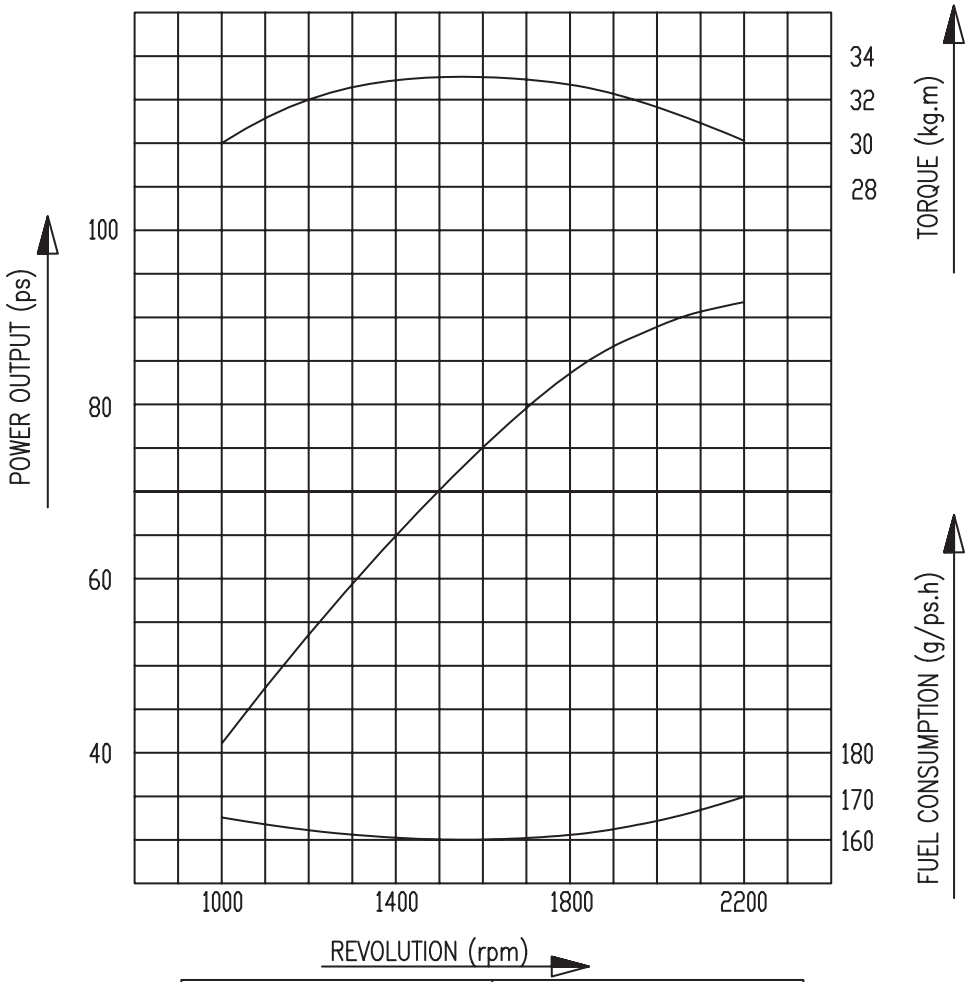


STANDARD	KS-R1004
RATED POWER	100 ps/ 2,200 rpm
MAX. TORQUE	37 kg.m/ 1,600 rpm
SFC @ RATED	170 g/ps.h

1. 2.2. Performance curve (ECRFD), D35/40/45S-5, D50/55C-5

DOOSAN	ENGINE PERFORMANCE CURVE	D45S-5,D50C-5 FORK LIFT	DB58S ECRFD
		2003.07.20	REV.

CONDITION	SPEC.
ATMOSPHERE PRE.	(760 mmHg)
WARMING UP	ENOUGH
COOLING FAN	–
GENERATOR	–
AIR CLEANER	YES
MUFFLER	YES

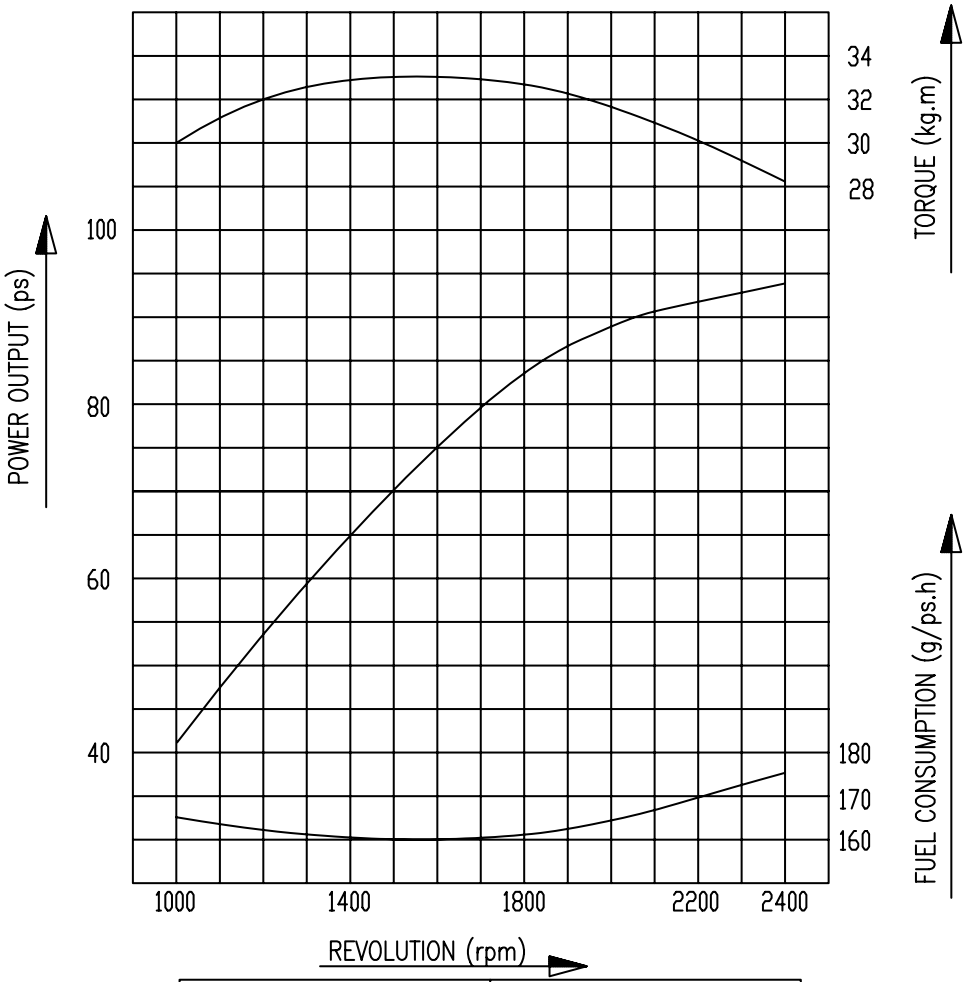


STANDARD	KS-R1004
RATED POWER	92 ps/ 2,200 rpm
MAX. TORQUE	33 kg.m/ 1,600 rpm
SFC @ RATED	170 g/ps.h

1. 2.3. Performance curve (ECRFE), D50/60/70S-5 (2 speed)

DOOSAN	ENGINE PERFORMANCE CURVE	D70S-5(2 SPEED) FORK LIFT	DB58S ECRFE
		2003.07.25	REV.

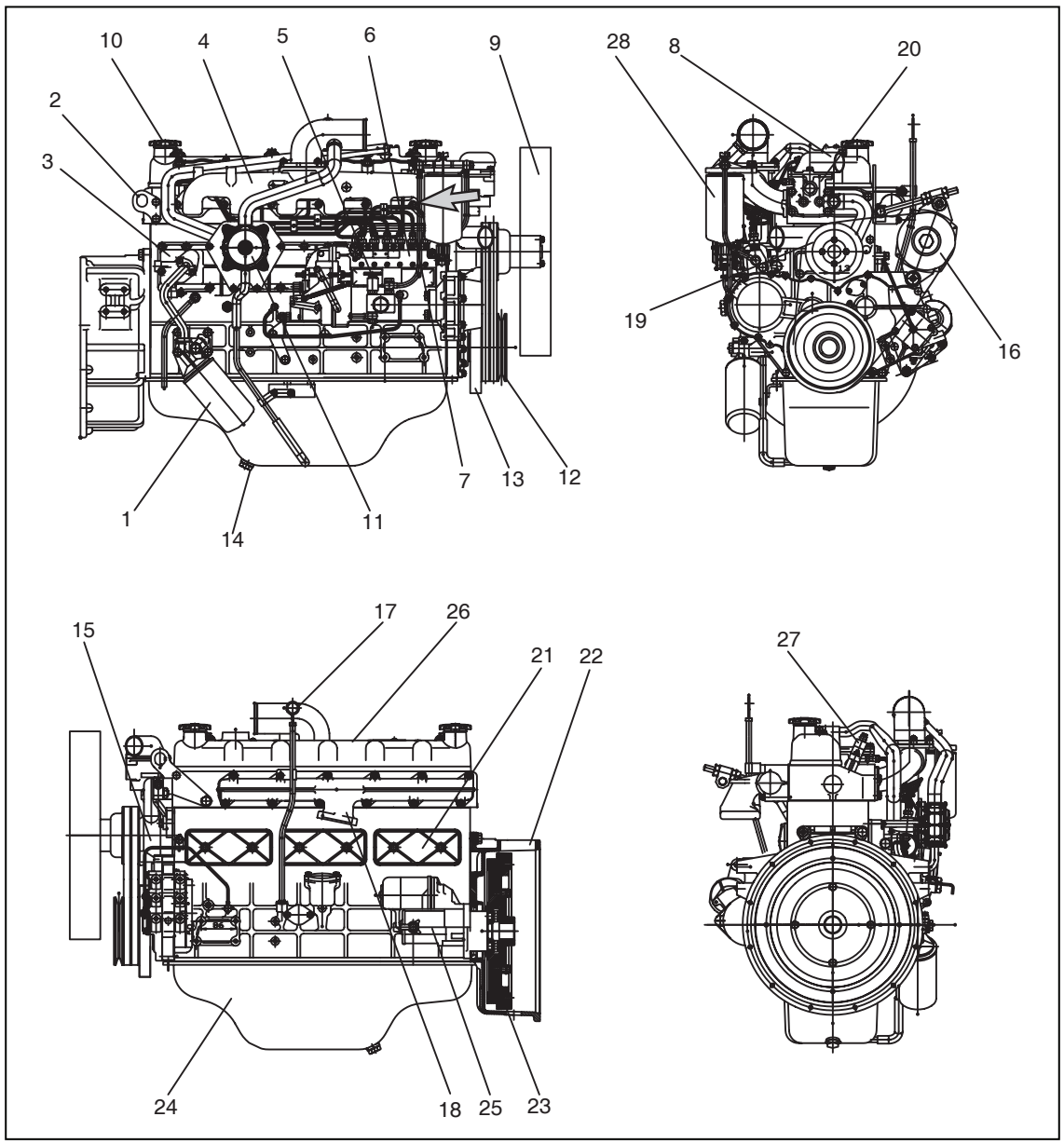
CONDITION	SPEC.
ATMOSPHERE PRE.	(760 mmHg)
WARMING UP	ENOUGH
COOLING FAN	–
GENERATOR	–
AIR CLEANER	YES
MUFFLER	YES



STANDARD	KS-R1004
RATED POWER	94 ps/ 2,400 rpm
MAX. TORQUE	33 kg.m/ 1,600 rpm
SFC @ RATED	175 g/ps.h

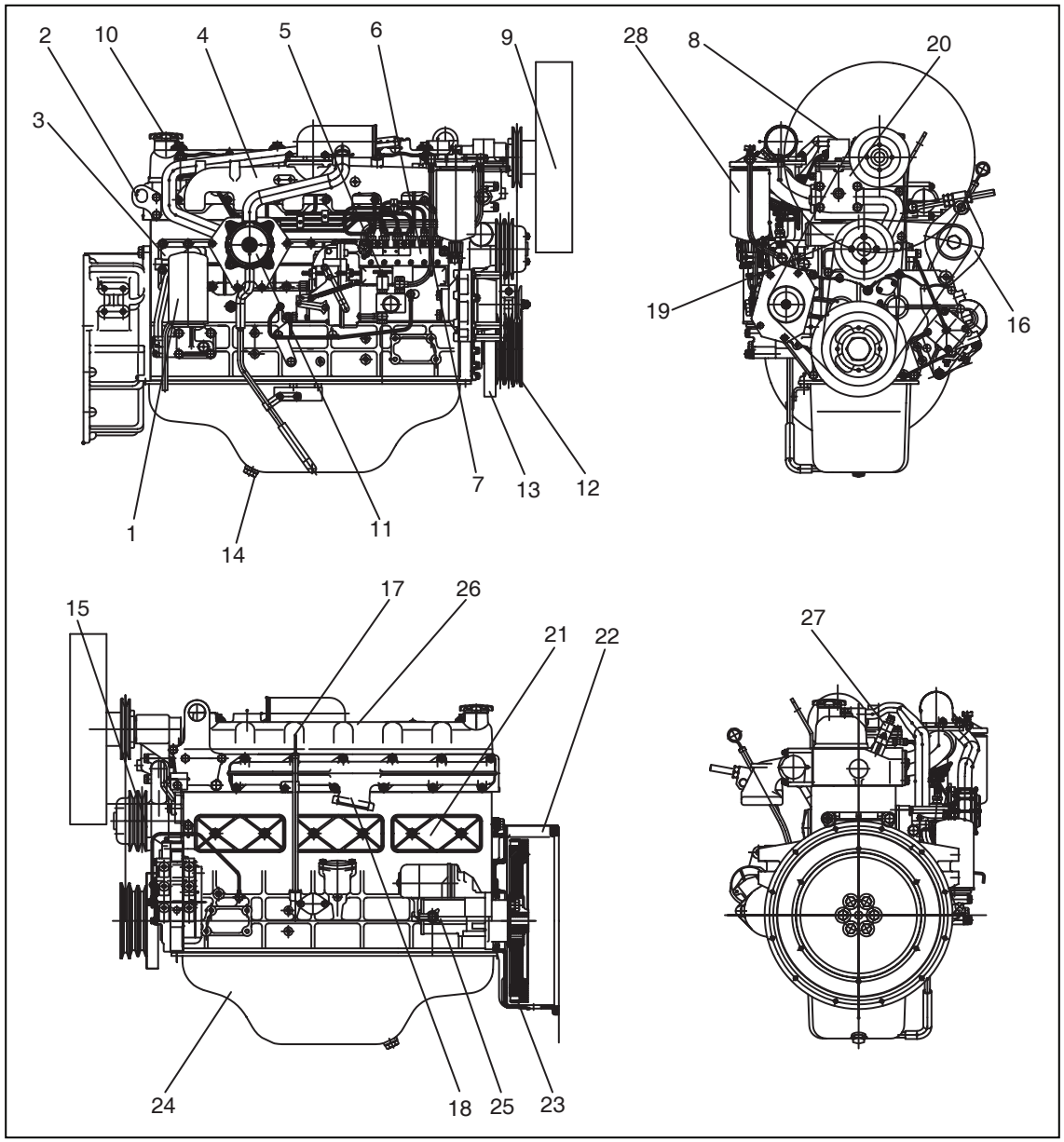
1.3. Engine assembly

1.3.1. Engine assembly view (ECRFA), D50/60/70/80/90S-5 (3 speed)



1	Oil filter	11	C.C.V	21	Push rod chamber cover
2	Lifting hook	12	Crank shaft pulley	22	Flywheel housing
3	Oil cooler	13	Vibration damper	23	Fly wheel
4	Intake manifold	14	Oil drain plug	24	Oil pan
5	Priming pump	15	water pump	25	Starter
6	Fuel injection pump	16	Alternator	26	Cylinder head cover
7	Fuel injection pipe	17	Oil level gauge	27	Fuel injection nozzle
8	Water outlet	18	Exhaust manifold	28	Fuel filter
9	Cooling fan	19	Water pump pulley		
10	Oil filler cap	20	Thermostat housing		

1.3.2. Engine assembly view (ECRFD), D35/40/45S-5, D50/55C-5



1	Oil filter	11	C.C.V	21	Push rod chamber cover
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3	Oil cooler	13	Vibration damper	23	Fly wheel
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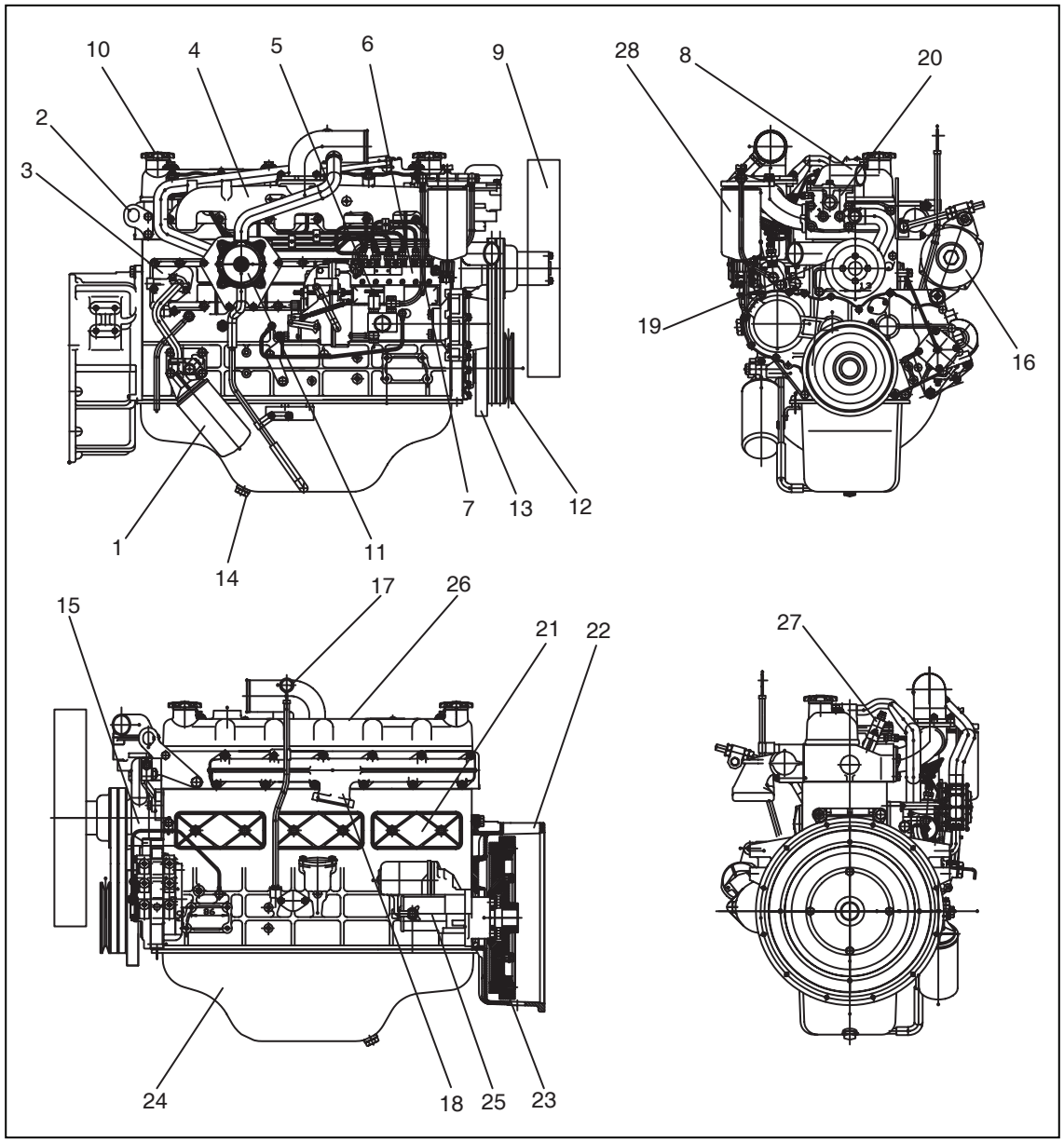
5	Priming pump	15	water pump	25	Starter
6	Fuel injection pump	16	Alternator	26	Cylinder head cover
7	Fuel injection pipe	17	Oil level gauge	27	Fuel injection nozzle
8	Water outlet	18	Exhaust manifold	28	Fuel filter
9	Cooling fan	19	Water pump pulley		
10	Oil filler cap	20	Thermostat housing		

1.3.3. Engine assembly views (ECRFE), D50/60/70S-5 (2 speed)



1	Oil filter	11	C.C.V	21	Push rod chamber cover
2	Lifting hook	12	Crank shaft pulley	22	Flywheel housing
3	Oil cooler	13	Vibration damper	23	Fly wheel
4	Intake manifold	14	Oil drain plug	24	Oil pan
5	Priming pump	15	water pump	25	Starter
6	Fuel injection pump	16	Alternator	26	Cylinder head cover
7	Fuel injection pipe	17	Oil level gauge	27	Fuel injection nozzle
8	Water outlet	18	Exhaust manifold	28	Fuel filter
9	Cooling fan	19	Water pump pulley		
10	Oil filler cap	20	Thermostat housing		

1.4. Safety regulations

1.4.1. General notes

Day-to-day use of power engines and the service products necessary for running them presents no problems if the persons occupied with their operation, maintenance and care are given suitable training and think as they work.

This summary is a compilation of the most important regulations. These are broken down into main sections which contain the information necessary for preventing injury to persons, damage to property and pollution. In addition to these regulations those dictated by the type of engine and its site are to be observed also.

IMPORTANT.
If, despite all precautions, an accident occurs, in particular through contact with caustic acids, fuel penetrating the skin, scalding from oil, antifreeze being splashed in the eyes etc., consult a doctor immediately.

1.4.2. Regulations designed to prevent accidents

a) During commissioning, starting and operation

Before putting the engine into operation for the first time, read the operating instructions carefully and familiarize yourself with the "critical" points. If you are unsure, ask your DOOSAN representative.

- For reasons of safety we recommend you attach a notice to the door of the engine room prohibiting the access of unauthorized persons and that you draw the attention of the operating personal to the fact that they are responsible for the safety of persons who enter the engine room.
- The engine must be started and operated only by authorized personnel. Ensure that the engine cannot be started by unauthorized persons.
- When the engine is running, do not get too close to the rotating parts. Wear close-fitting clothing.
- Do not touch the engine with bare hands when it is warm from operation risk of burns.
- Exhaust gases are toxic. Comply with the installation instructions for the installation of DOOSAN diesel engines which are to be operated in enclosed spaces. Ensure that there is adequate ventilation and air extraction.
- Keep vicinity of engine, ladders and stairways free of oil and grease.
  Accidents caused by slipping can have serious consequences.

b) During maintenance and care

- Always carry out maintenance work when the engine is switched off. If the engine has to be maintained while it is running, e.g. changing the elements of change-over filters, remember that there is a risk of scalding. Do not get too close to rotating parts.
- Change the oil when the engine is warm from operation.

CAUTION
There is a risk of burns and scalding. Do not touch oil drain valve or oil filters with bare hands.

- Take into account the amount of oil in the sump. Use a vessel of sufficient size to ensure that the oil will not overflow.
- Open the coolant circuit only when the engine has cooled down. If opening while the engine is still warm is unavoidable, comply with the instructions In the chapter entitled "Cooling".
- Neither tighten up nor open pipes and hoses (lube oil circuit, coolant circuit and any additional hydraulic oil circuit) during the operation. The fluid which flow out can cause injury.
- Fuel is inflammable. Do not smoke or use naked lights in its vicinity. The tank must be filled only when the engine is switched off.
- Keep service products (anti-freeze) only in containers which can not be confused with drinks containers.
- Comply with the manufacturer's instructions when handling batteries.

CAUTION
Accumulator acid is toxic and caustic. Battery gases are explosive.

c) When carrying out checking, setting and repair work

- Checking, setting and repair work must be carried out by authorized personnel only.
- Use only tools which are in satisfactory condition. Slip caused by the worn open-end wrench could lead to Injury.
- When the engine is hanging on a crane, no-one must be allowed to stand or pass under it. Keep lifting gear in good condition.
- When checking injectors, do not put your hands under the jet of fuel.
- Do not inhale at atomized fuel.
- When working on the electrical system disconnect the battery earth cable first. Connect it up again last in prevent short circuits.

1.4.3. Regulations designed to prevent damage to engine and premature wear

(1) Never demand more of the engine than it was designed to yield for its intended purpose. Detailed information on this can be found in the sales literature. The injection pump must not be adjusted without prior written permission of DOOSAN.

(2) If faults occur, find the cause immediately and have it eliminate in order to prevent more serious of damage.

(3) Use only genuine DOOSAN spare parts. DOOSAN will accept no responsibility for damage resulting from the installation of other parts which are supposedly "just as good".

(4) In addition to the above, note the following points.

- Never let the engine run when dry, i.e. without lube oil or coolant. Use only DOOSAN-approved service products. (engine oil, anti-freeze and anticorrosion agent)
- Pay attention to cleanliness. The Diesel fuel must be free of water. See "Maintenance and care".
- Have the engine maintained at the specified intervals.
- Do not switch off the engine immediately when it is warm, but let it run without load for about 5 minutes so that temperature equalization can take place.
- Never put cold coolant into an overheated engine. See "Maintenance and care".

- Do not add so much engine oil that the oil level rises above the max. marking on the dipstick. Do not exceed the maximum permissible tilt of the engine. Serious damage to the engine may result if these instructions are not adhered to.
- Always ensure that the testing and monitoring equipment (for battery charge, oil pressure, and coolant temperature) function satisfactorily.
- Comply with instructions for operation of the alternator. See "Commissioning and operation".
- Do not let the water pump run dry. If there is a risk of frost, drain the water when the engine switched off.

1.4.4. Regulations designed to prevent pollution

a) Engine oil, filter element, fuel filter

- Take old oil only to an oil collection point. Take strict precautions to ensure that oil does not get into the drains or into the ground.
- The drinking water supply may be contaminated.
- Oil and fuel filter elements are classed as dangerous waste and must be treated as such.

b) Coolant

- Treat undiluted anti-corrosion agent and / or antifreeze as dangerous waste.
- When disposing of spent coolant comply with the regulations of the relevant local authorities.

1.4.5. Notes on safety in handling used engine oil

Prolonged or repeated contact between the skin and any kind of engine oil decreases the skin.
Drying, irritation or inflammation of the skin may therefore occur. Used engine oil also contains dangerous substances which have caused skin cancer in animal experiments. If the basic rules of hygiene and health and safety at work are observed, health risks are not to the expected as a result of handling used engine oil.

<Health precautions>

- Avoid prolonged or repeated skin contact with used engine oil.
- Protect your skin by means of suitable agents (creams etc.) or wear protective gloves.
- Clean skin which has been in contact with engine oil.
- Wash thoroughly with soap and water, A nailbrush is an effective aid.
- Certain products make it easier to clean your hands.
- Do not use petrol, Diesel fuel, gas oil, thinners or solvents as washing agents.
- After washing apply a fatty skin cream to the skin.
- Change oil-soaked clothing and shoes.
- Do not put oily rags into your pockets.

Ensure that used engine oil is disposed of properly.
- Engine oil can endanger the water supply -

For this reason do not let engine oil get into the ground, waterways, the drains or the sewers. Violations are punishable. Collect and dispose of used engine oil carefully.
For information on collection points please contact the seller, the supplier or the local authorities.

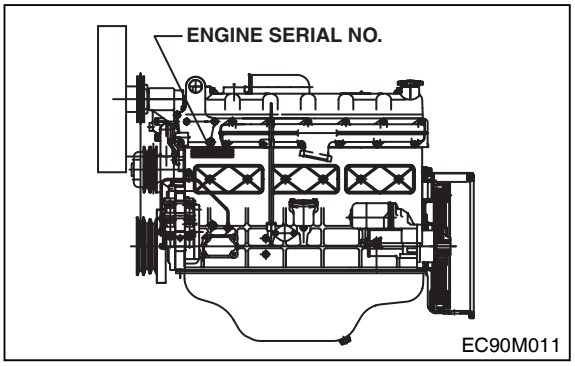
1.4.5. General repair instructions

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 separately 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 sealer on gaskets to prevent leakage.
11. Carefully observe all torque specifications for bolts and nuts.
12. When service operation is completed, make a final check to be sure service has been done properly.

2. TECHNICAL INFORMATION

2.1. Engine model and serial number

The engine model and serial number is located on the engine as illustrated. These numbers are required when requesting warranty and ordering parts. They are also referred to as engine model and serial number because of their location.



Engine serial No. (example : DB58)

DB58S 3 00001 FA

- FA — Engine suffix (ECRFA)
- 00001 — Serial no.
- 3 — Production year (2003)
- DB58S — Engine model

2.2. Engine type

The Engines DB58S are in-line vertical, water-cooled, 6-cylinder four stroke diesel engines with direct injection. DB58S is natural aspiration.

2.2.1. Cylinder block

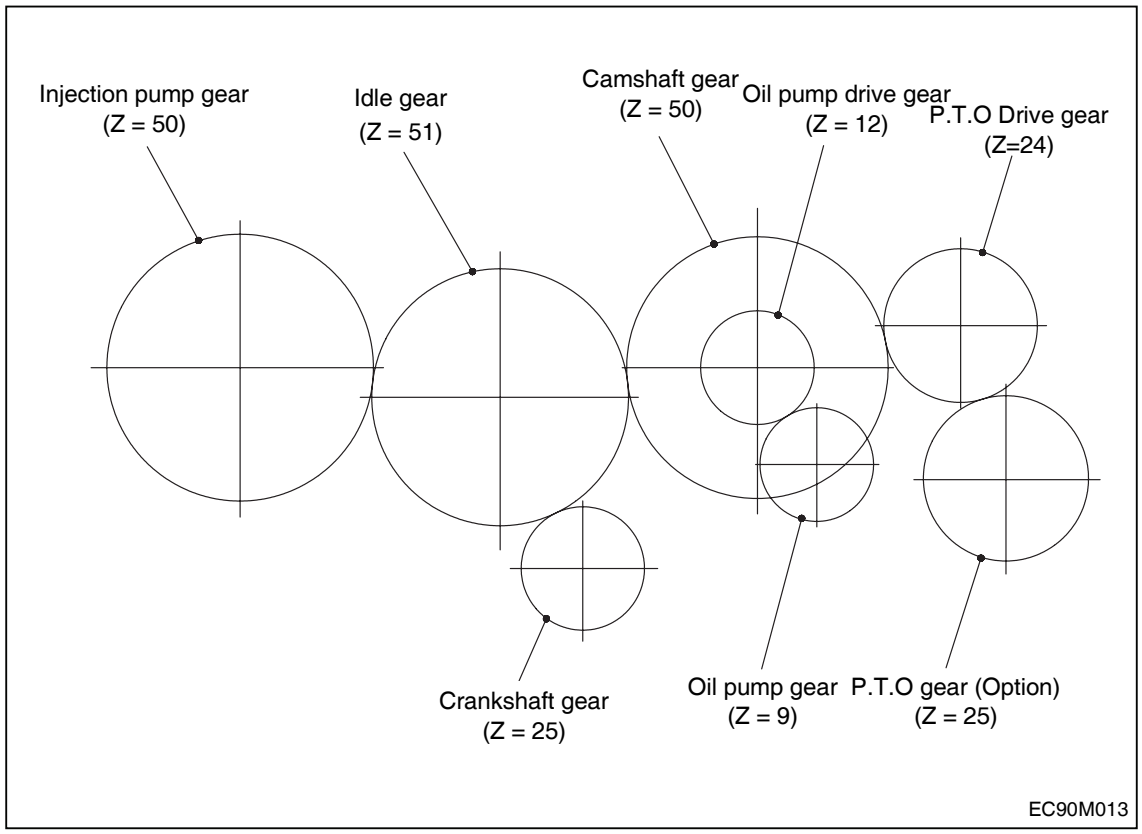
The cylinder block is a single piece of alloy cast iron. To increase its stiffness, it is extended to a level below the crankshaft center line. The engine has replaceable dry cylinder liners and common cylinder heads with struck-in valve seat rings and replaceable valve guides,

2.2.2. Piston con-rod / crankshaft

The forged crankshaft is a integrate type (Counterweight is integrated with crank shaft body). Radial oil seal on crankshaft and flywheel are provided to seal the flywheel housing inside penetrations.
The con-rods (connecting rods) are die-forged and can be removed through the top of the cylinders together with the pistons. Crankshaft and connecting rods run in steel-backed lead bronze ready-to fit type bearings.

2.3. Engine timing

Camshaft, oil pump, PTO (power take off) pump and injection pump are driven by a gear train arranged at the front end.

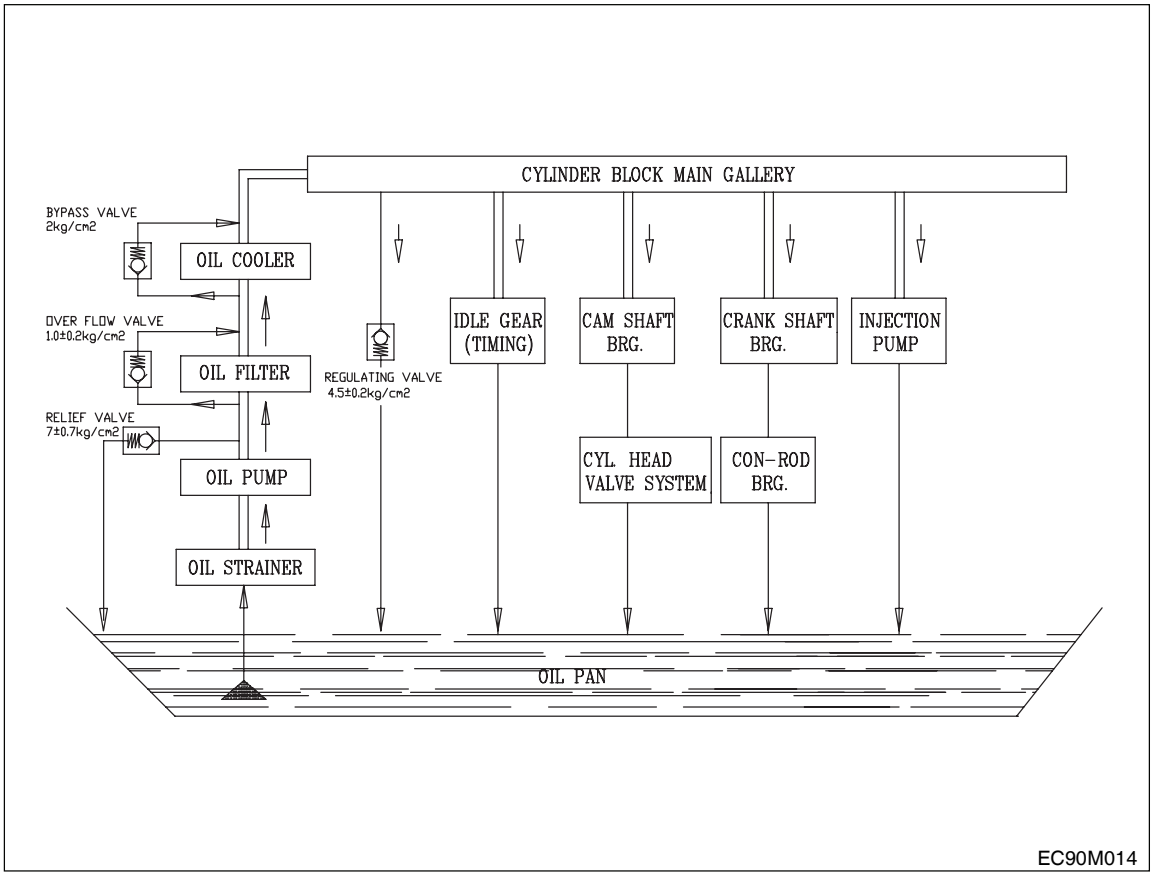


2.4. Valves

The overhead valves are actuated via chilled cast iron tappets, push rods and rocker arms from the camshaft.

2.5. Lubrication system

The engine is equipped with force-feed lubrication.
The pressure is produced by a gear pump whose drive gear is in direct mesh with the camshaft gear at the middle of cylinder block.
The oil pump draws the oil from the oil sump and delivers it through the oil cooler and oil filter to the main distributor gallery and from there to the main bearings, big-end bearings and camshaft bearings as well as to the small-end bearings and the rocker arms.
The injection pump are also connected to the engine lubricating system.
The cylinder block walls and timing gears are splash-lubricated.
The lube oil is cleaned in a full-flow oil filter.



2.5.1. Recommend of lubricating oil

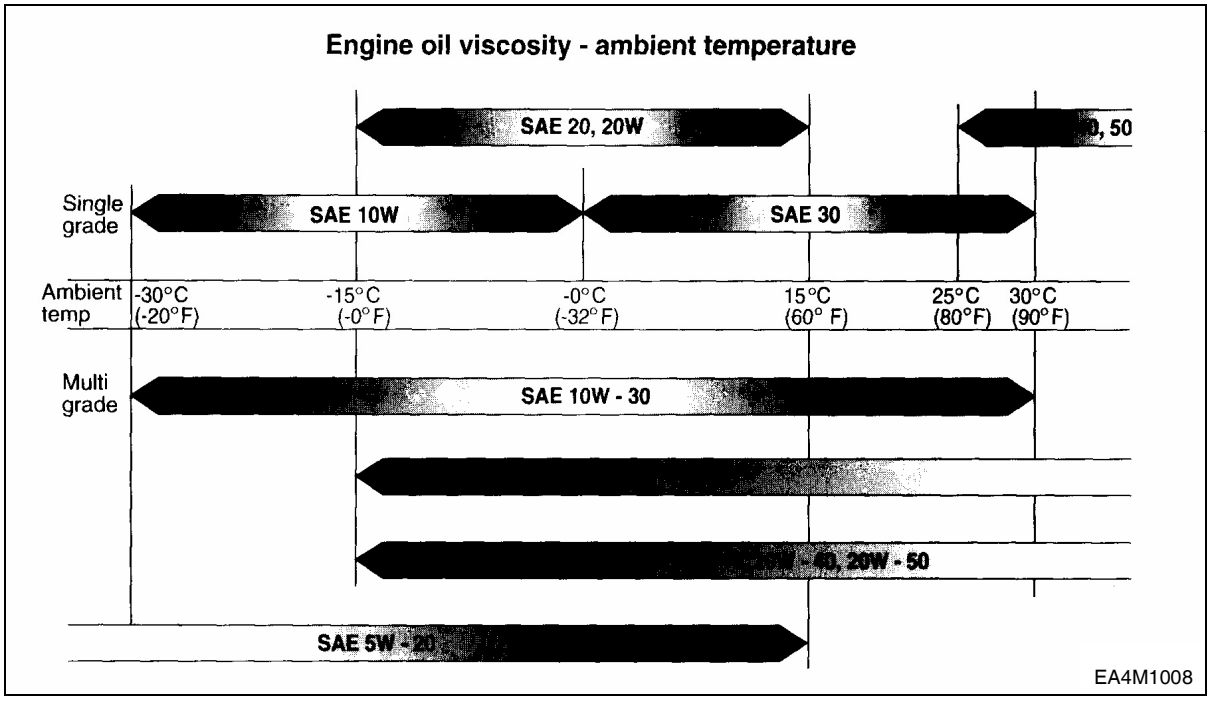
Initial factory fill is high quality break-in oil for API Service. During the break-in period (50 hours), frequently check the oil level. Somewhat higher oil consumption is normal until piston rings are seated. The oil level should be maintained in the safe range between the Min. and Max. marks on the dipstick. The safe range between the marks represents approximately 3 liters. To obtain the best engine performance and engine life, grade of engine oil is recommended. Engine oils are specified by API Service, letter designations and SAE viscosity numbers. If the specified motor oil is not available, use a reputable brand of engine oil labeled for API Service CH-4 and SAE viscosity 30 or 15W40. Refer to oil identification symbol on the container.

- Engine oil should be changed at the specified intervals.
  Oil filter cartridge should be changed simultaneously.
  - First oil change : 50 hr operating
  - After 50hr operation ; 250

- The following oils are also recommended

Engine model	Engine oil capacity			Recommend oil	
	Oil pan		Total (liter)	SAE No.	API No.
	Max. (liter)	Min. (liter)			
DB58S	19	14	20.5	SAE10W40 SAE15W40	ACEA-E2 or ACEA-E3 (API CH-4)

* If long oil change intervals are to be used, ACEA-E3 oil must be used.

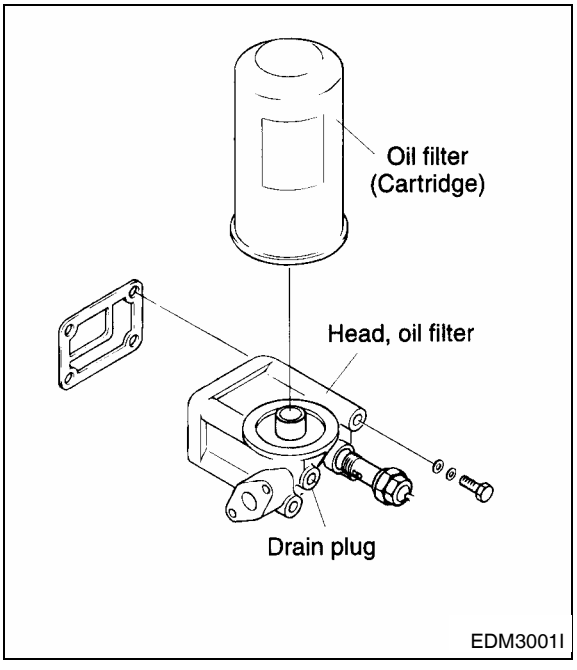


2.5.2. Oil cooler

An oil cooler is provided between the oil filter and the cylinder block. This cooler is a flat tube type with turbulence inserts and operated by the coolant.

2.5.3. Oil filter

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



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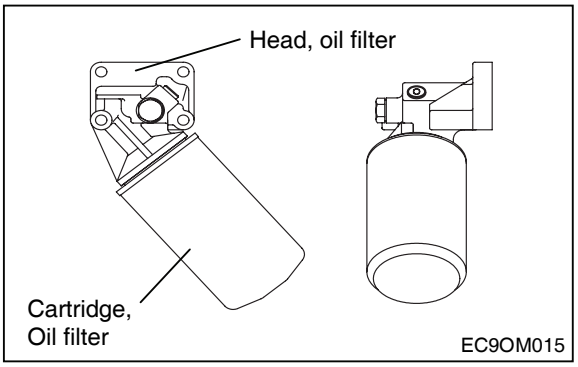
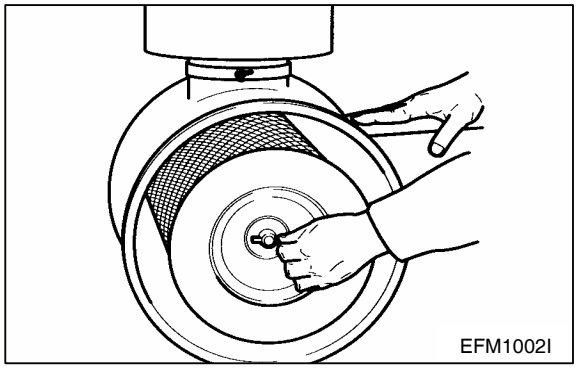


<ECRFA, ECRFE>

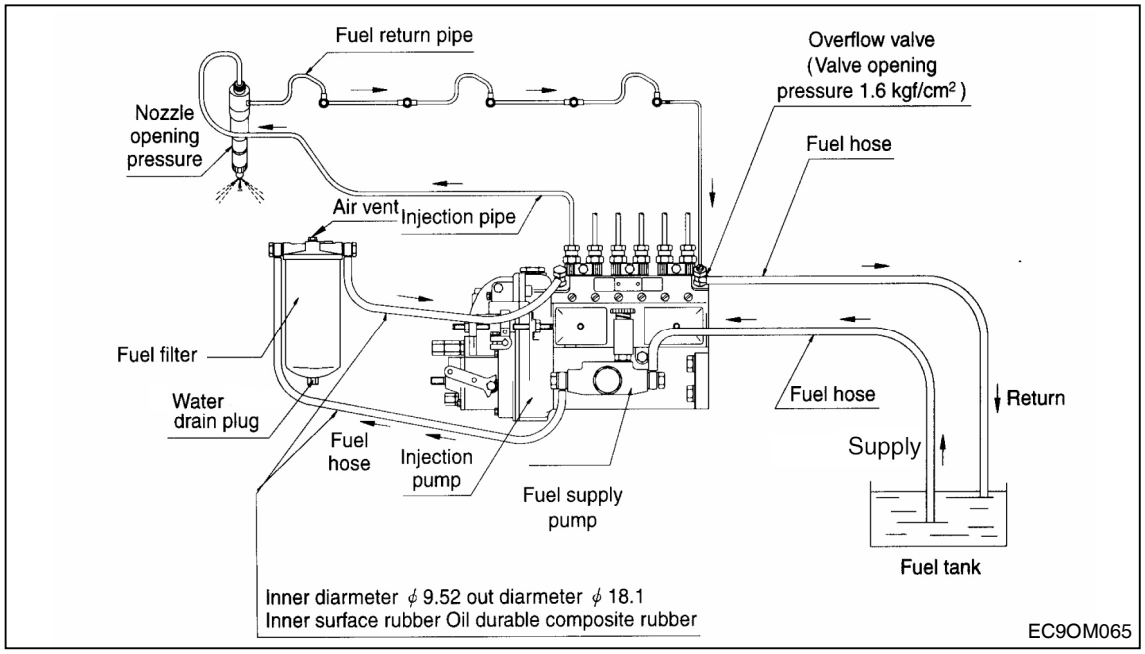
2.6. Air cleaner

In case that elements are deformed, damaged or if the air cleaner has a crack, replace it.
By the definite interval, the elements must be cleaned and replaced.



2.7. Fuel system

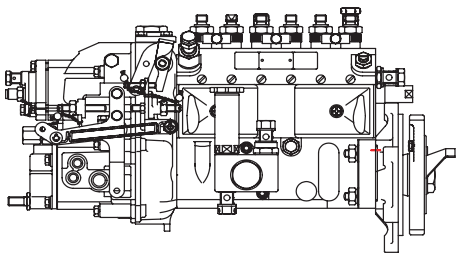
The fuel is delivered by the fuel feed pump via the fuel filter to the injection pump and from there to the injection nozzles.



The fuel is sprayed into the cylinders through nozzles fitted in screw-fit injection nozzle holders in the cylinder heads.
Excessively delivered fuel and leak fuel from the nozzle flow through the return pipe back to the tank.
A strainer is arranged ahead of the fuel feed pump.

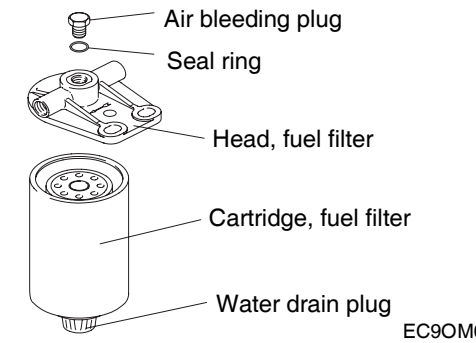
2.7.1. Injection pump

The in-line injection pump is driven via gears from the crankshaft. It is connected to the force feed lubricating system of the engine and consequently maintenance-free. The governor flange-mounted on the pump casing is a variable range governor designed to keep the speed set of varying load.


EC9OM016

2.7.2. Fuel filter

This fuel filter has two functions not only oil filtering but
also water separating
Before entering the suction chamber of the injection pump, the fuel is cleaned in a strainer of fuel feed pump and a fuel filter.
Drain water in filter with loosening the drain plug under filter manually from time to time.
The fuel filter element should be replaced at every 200 hours.



EC9OM017

2.7.3. Fuel requirements

DOOSAN diesel engines was designed to use Number 2-D diesel fuel or equivalent that meets specification DIN 51601-DK. For maximum fuel economy, Number 2-D fuel whenever possible. When temperatures are below -7 °C (20 °F), use Number 1-D fuel. If Number 1-D fuel is not available, the mixture of one kerosene to two gallons of Number 2-D fuel can be used. Once kerosene has been added, the engine should be run for several minutes to mix the fuel.

2.7.4. How to select fuel oil

Fuel quality is an important factor in obtaining satisfactory engine performance, long engine life, and acceptable exhaust emission levels. DOOSAN engines are designed to operate on most diesel fuels marketed today. In general, fuels meeting the properties of ASTM Designation D975 (grades 1-D and 2-D) have provided satisfactory performance.

The ASTM 975 specification, however, does not in itself adequately define the fuel characteristics needed for assurance of fuel quality.

The properties listed in the fuel oil selection chart below have provided optimum engine performance. Grade 2-D fuel is normally available for generator service. Grade 1-D fuel should not be used in pleasure craft engines, except in an emergency.

Fuel Oil Selection Chart

General Fuel Classification	ASTM Test	No. 1 ASTM 1-D	No. 2 ASTM 2-D	DIN 51601
Gravity, °API #)	D 287	40 ~ 44	33 ~ 37	0.815 ~ 0.855
Flash Point Min. °F (°C)	D 93	100 (38)	125 (52)	131 (55)
Viscosity, Kinematic CST 100 °F (40 °C)	D 445	1.3 ~ 2.4	1.9 ~ 4.1	1.8 ~ 10
Cloud Point °F #)	D 2500	See Note 1)	See Note 1)	See Note 1)
Sulfur Content wt%, Max.	D 129	0.5	0.5	0.15
Carbon Residue on 10%, wt%, Max.	D 524	0.15	0.35	0.1
Accelerated Stability Total Insolubles mg/100 ml, Max. #)	D 2274	1.5	1.5	
Ash, wt%, Max.	D 482	0.01	0.01	
Cetane Number, Min. +)	D 613	45	45	> 45
Distillation Temperature, °F(℃) IMP, Typican #) 10% Typical #) 50% Typical #) 90% +) End Point #)	D 86	 350(177) 385(196) 45(218) 500 (260) Max. 550(288) Max.	 375(191) 430(221) 510(256) 625(329) Max. 675(357) Max.	 680(360)
Water & Sediment %, Max.	D 1796	0.05	0.05	0.05

#) Not specified In ASTM D 975

+) Differs from ASTM D 975

NOTE

1) The cloud point should be 6 °C (10 °F) below the lowest expected fuel temperature to prevent clogging of fuel fitters by crystals.

2.8. Cooling system

The engine has a liquid-cooling system. The fresh water pump is a maintenance-free by V-belt from the crankshaft pulley.
Depending on the agreed extent of delivery and the design of the engine, the coolant circuit can be equipped with temperature monitors which, in the event of loss of coolant, shut the engine down.

- Check the coolant level of the expansion tank by removing the expansion tank filler cap, and add coolant if necessary.
- When injecting antifreeze solution, first drain out the old coolant from the cylinder block and radiator, and then clean them with cleaning solution.
- Be sure to mix soft water with antifreeze solution.

2.8.1. Anti-freeze

The anti-freeze, 50% of the whole coolant, is always to be used to prevent the cooling system from the corrosion. And in winter the amount of anti-freeze shown in the following table should be used in accordance with the ambient temperature.

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

As the individual freezing points corresponding to the proportions of antifreeze in the table are subject to change slightly according to the kind of antifreeze, you must follow the specifications provided by the antifreeze manufacturer.
As the ratio of antifreeze in the mixture decrease each time new coolant is added to make up for the loss coolant resulting from engine operation, Check the mix ratio with every replenishment of coolant, and top up as necessary.

2.8.2. Cooling water

- Regarding the engine cooling water, the hard water must be used (Do not use the soft water).
- The engine cooling water can be used diluting it with antifreezing solution 40% and the additive for rust prevention (DCA4) 3 ~ 5 %.
- 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.

- Since DB58 cylinder liner is dry type, particularly the cooling water control should be applied thoroughly.
- The density of antifreezing solution and additive for rust prevention is able to be confirmed by the cooling water test kit. (Fleetguard CC2602M)
- How to use the cooling water test kit
  (1) 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.

(2) At the state of a test paper soaked in the sampled water, after taking the paper out through water agitation, shake off the water.
(3) Wait for about 45 sec. till the color change of test paper.

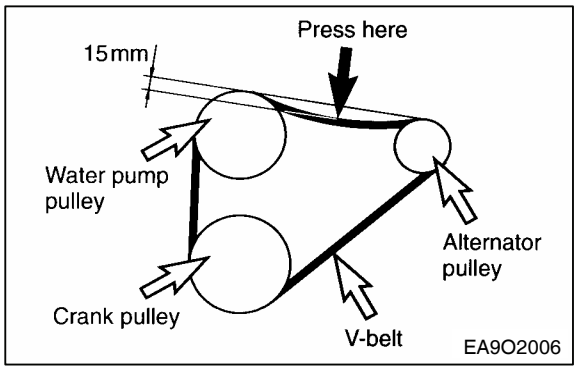
NOTE:
However, it should not elapse longer than 75 sec, and if it did, the hue would change.

(4) Make the numerical value by comparing the test paper which hue has changed with the color list of label on storage bottle.
(5) 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%).
(6) 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) (7) locates in the range of 0.3 to 0.8 at the color list of label on the test paper storage bottle.
(8) 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.

2.9. V-belt tension check and adjust

- **V-Belt**

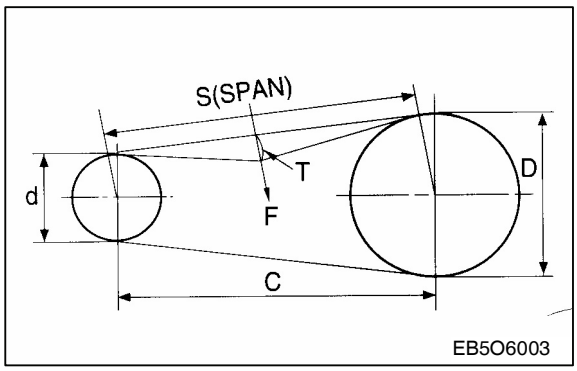
  By the finger-pressure the belt is pressed by 10mm ~ 15mm between the fan pulley and the alternator pulley in normal condition. For the adjustment of the tension, loosen the adjusting bolts which support the alternator, adjust the tension and tighten the bolts again.



- **Poly belt**

  Poly belt will be properly tensioned if the deflection force “F” is applied midway between the belt`s tangent points with the pulley.

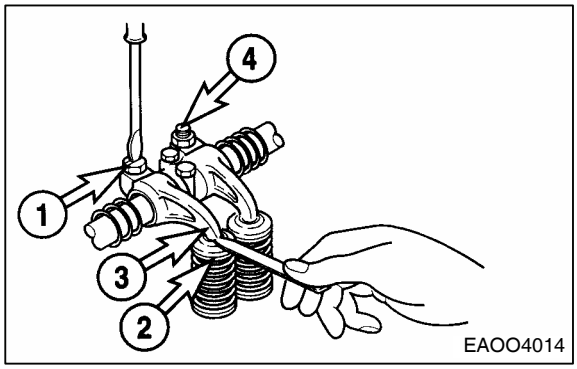
  T = 0.015 x S (about 1.5mm per 100mm)



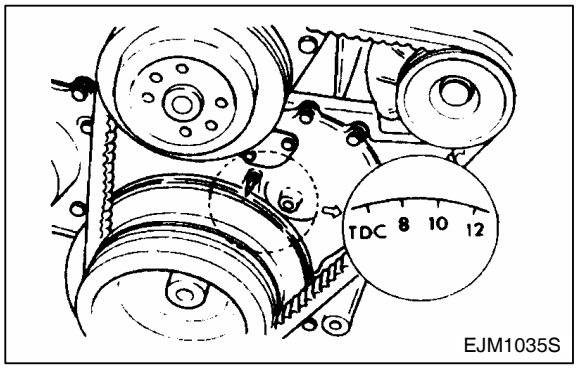
2.10. Valve clearance and adjustment

NOTE:
The cylinder head bolts were previously tightened with the torque wrench. Therefore it is not necessary to retighten the cylinder head bolts before adjusting the valve clearance.

Rocker arm screw lock nut torque	2.6 ±0.5kg.m



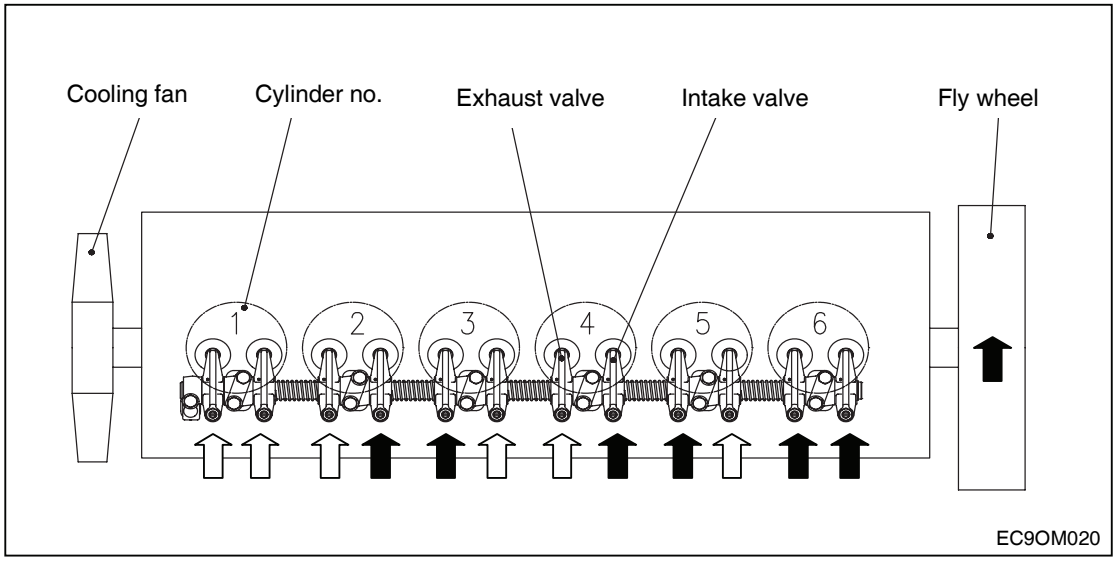
- After letting the #1 cylinder's piston come at the compression top dead center by turning the crankshaft, adjust the valve clearances.
- Loosen the lock nuts of rocker arm adjusting screws and push the feeler gauge of specified value between a rocker arm and a valve stem and adjust the clearance with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



Model	Intake Valve	Exhaust Valve
DB58S	0.4 mm	0.4 mm

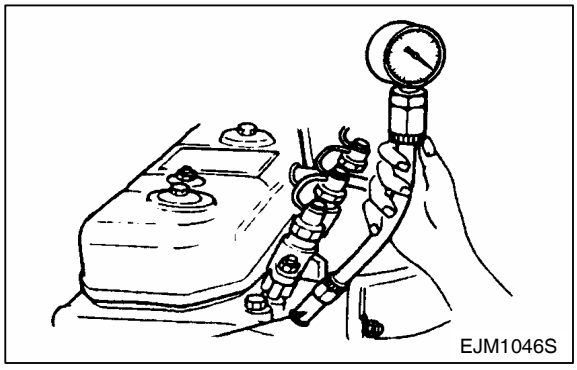
1) Rotate the crankshaft to overlap the intake and the exhaust valves of #6, then #1 cylinder become the compression state of top dead center.
2) Therefore adjust the valve clearance corresponding to " ⇨ " of lower figure. At this time there are no force on the push rods of #1 cylinder.
3) Rotating the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

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



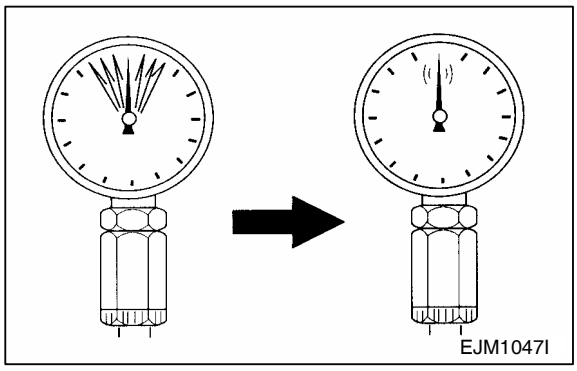
2.11. Cylinder compression pressure

- Stop the engine after warming up, and take out preheating plug and injection pipe.



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

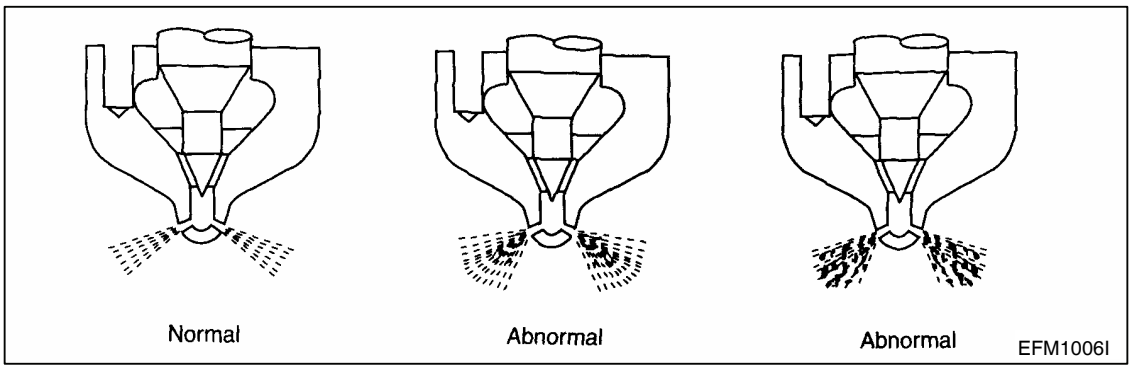
- Check the compression pressure at gauge several times until highest compression reading is reached.



Standard value	28kg/cm² over
Limit value	24kg/cm²
Difference between each cylinder	Within ± 10 %

- Condition : Water temperature 75°C.

2.12. Injection nozzle



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

Engine model	Injection nozzle pressure
DB58S	220 kg/cm²

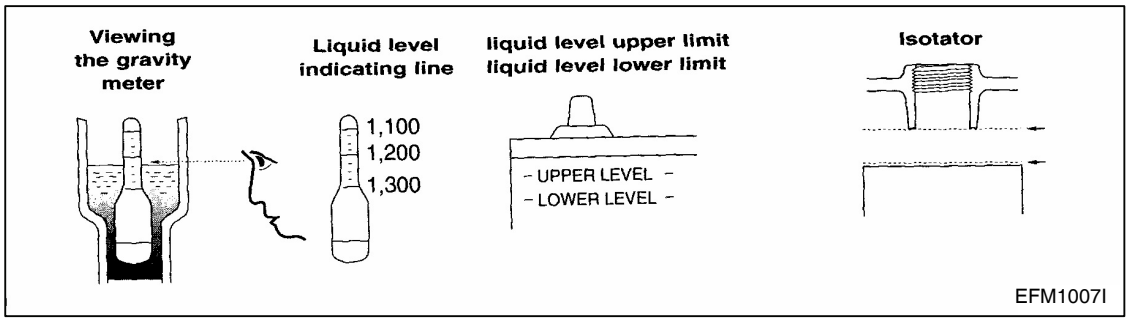
- Check the atomizing state and replace it if abnormal.

2.13. Battery

- Inspect for any leakage of electrolytic solution owing to battery crack, and replace the battery in case of poor condition.
- Inspect for amount of electrolytic solution, and replenish if insufficient.
- Measure the gravity of electrolytic solution, if less than specified value (1.12 ~ 1.28), replenish.

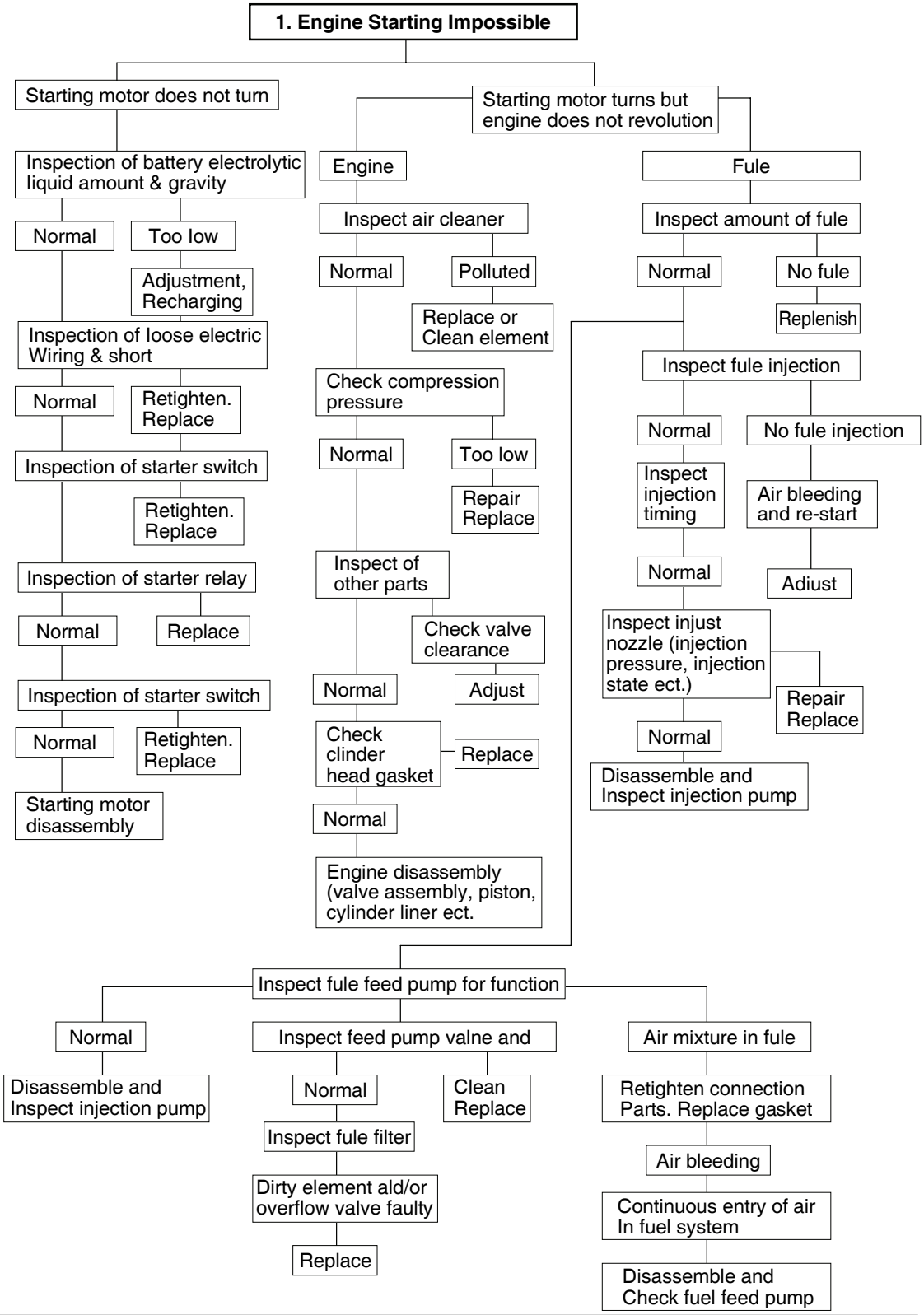
2.14. Starting motor

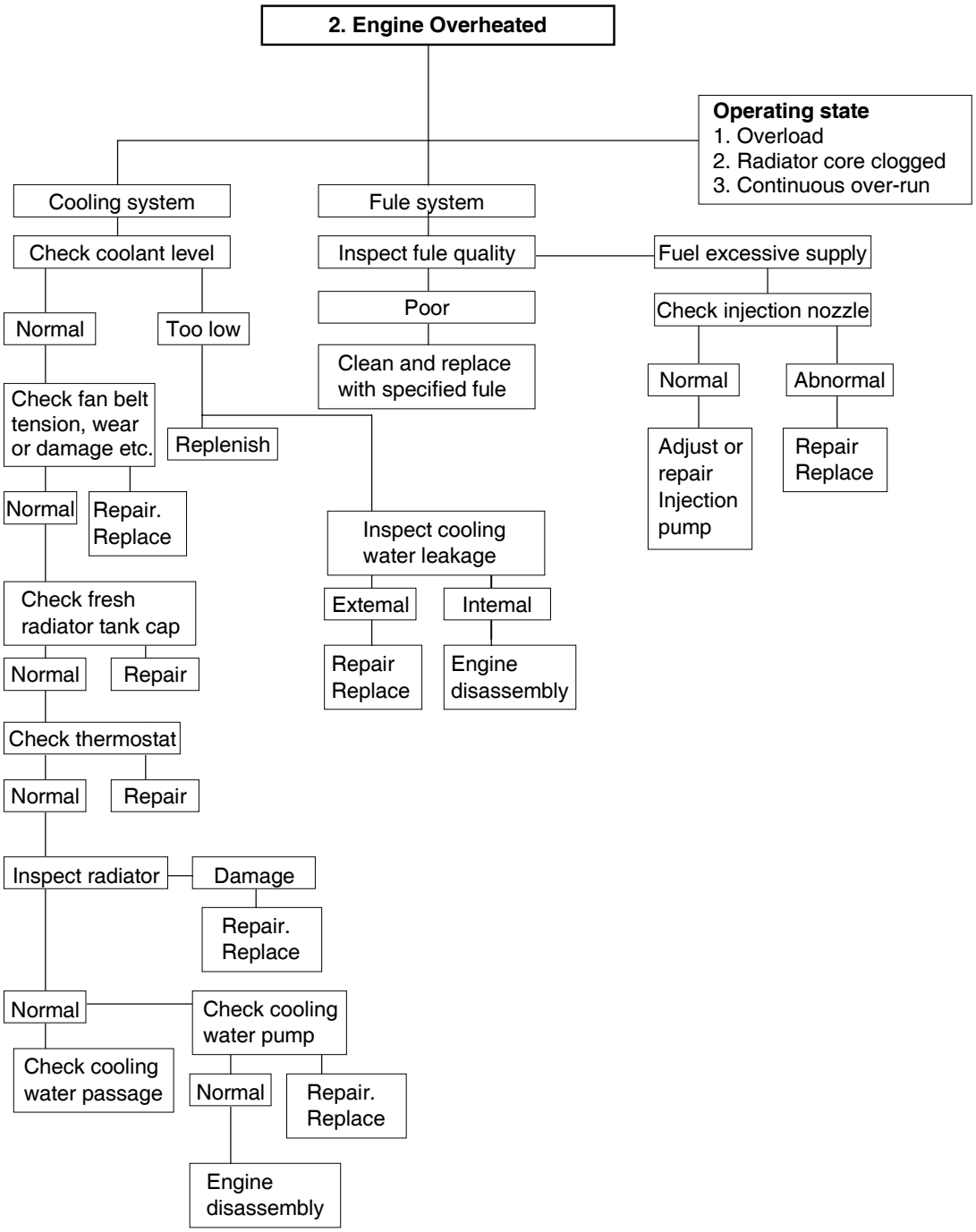
- In case of engine maintenance, clean pinion and ring gear thoroughly putting in the fuel, and coat them with grease.
  Also, in case of washing engine room and so forth, inspect the wiring state being careful for water not to get in.

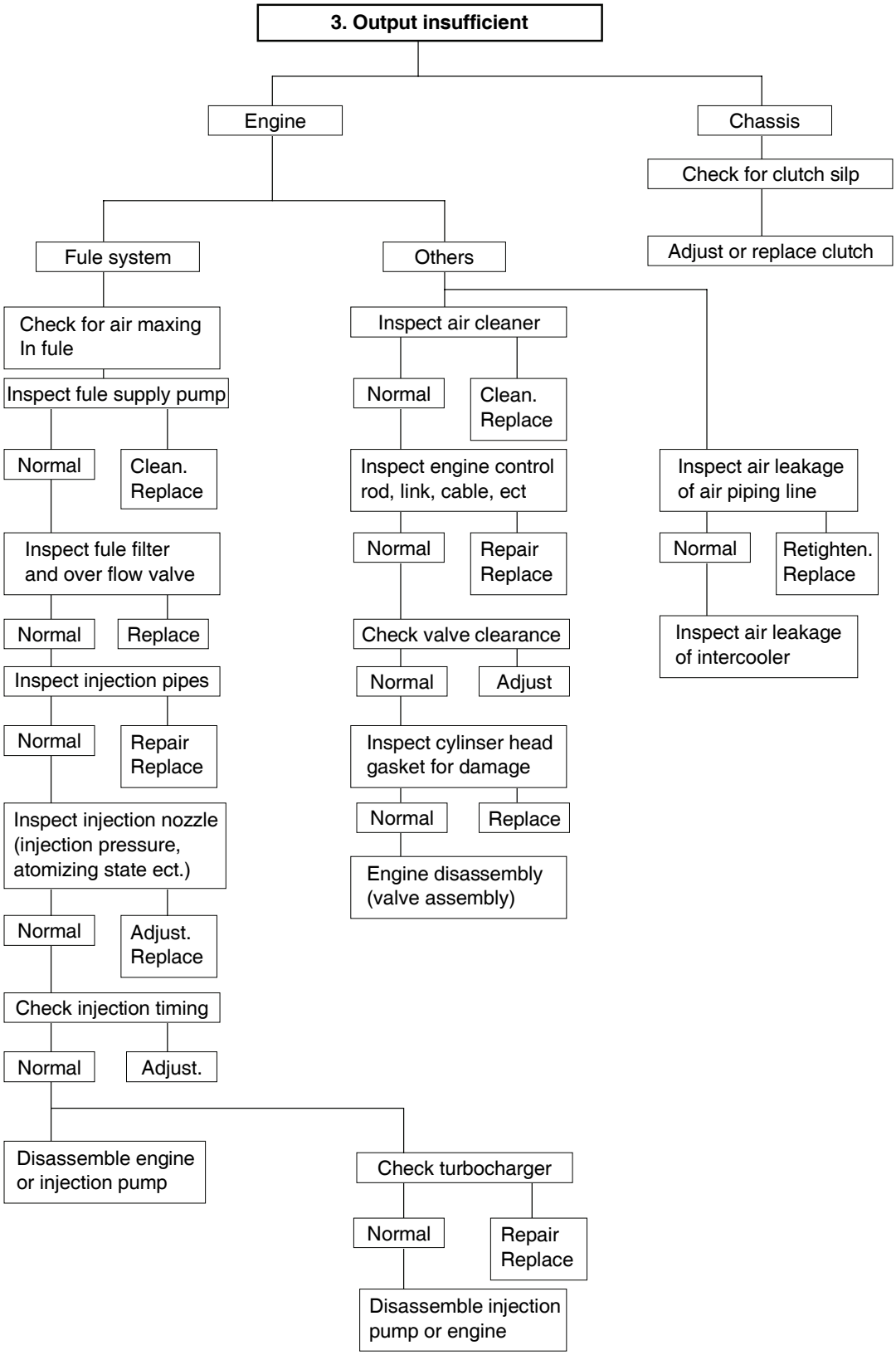


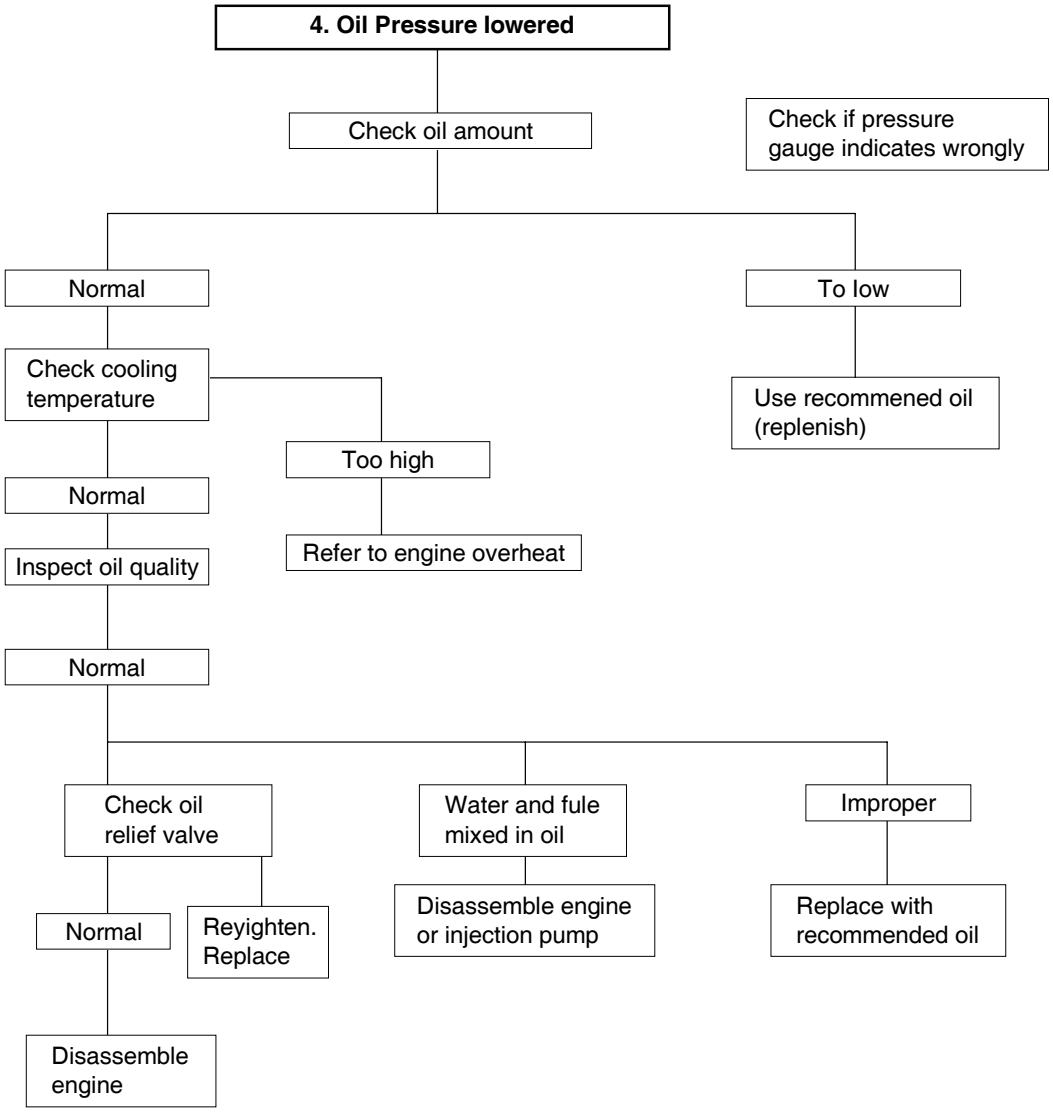
2.15. Diagnosis and remedy

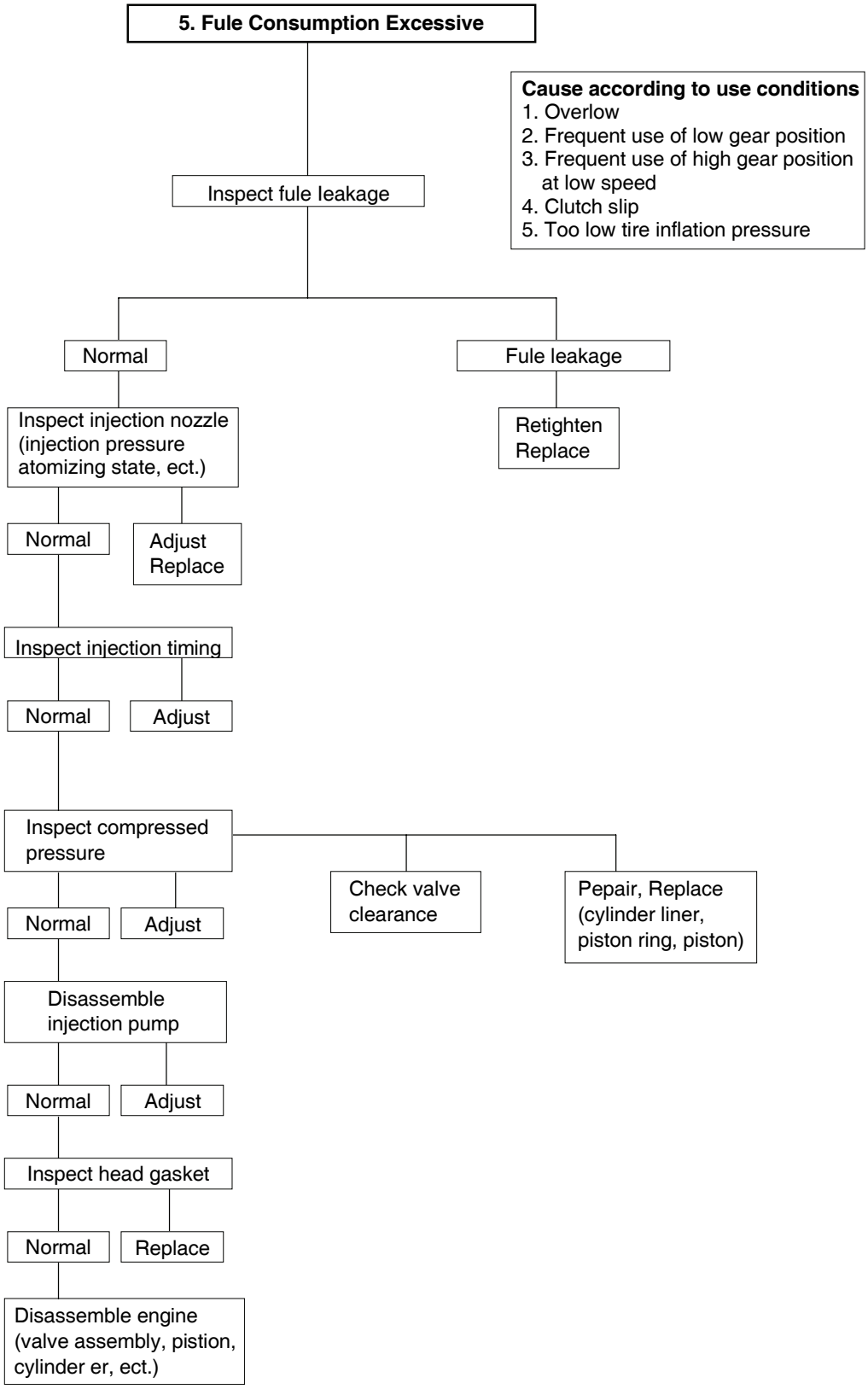
- The following description summarizes the probable cause of and remedy for general failure by item.
- Immediate countermeasures should be taken before a failure is inflamed if any symptom is detected.

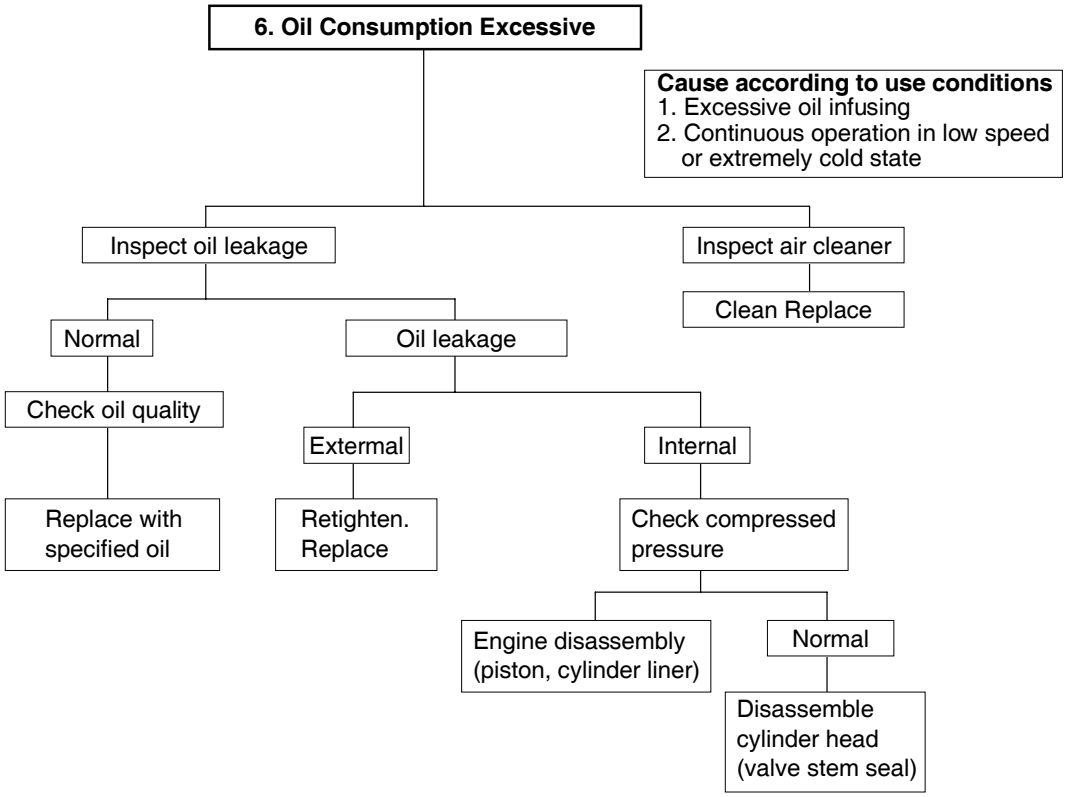


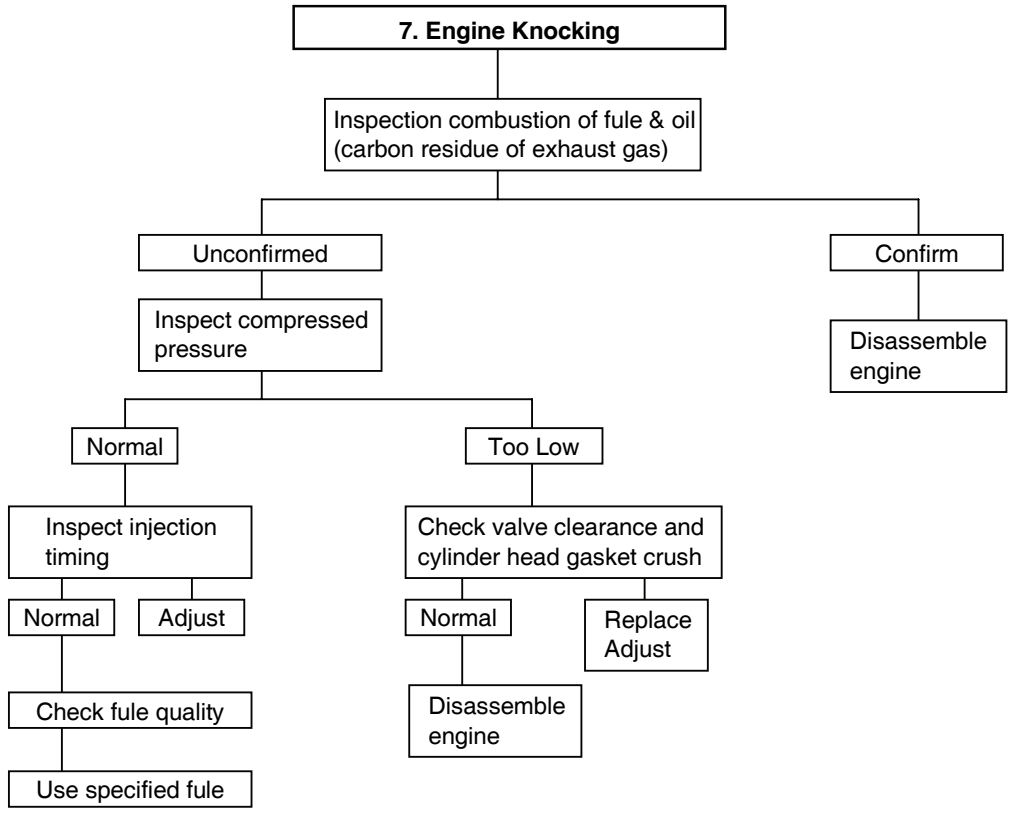


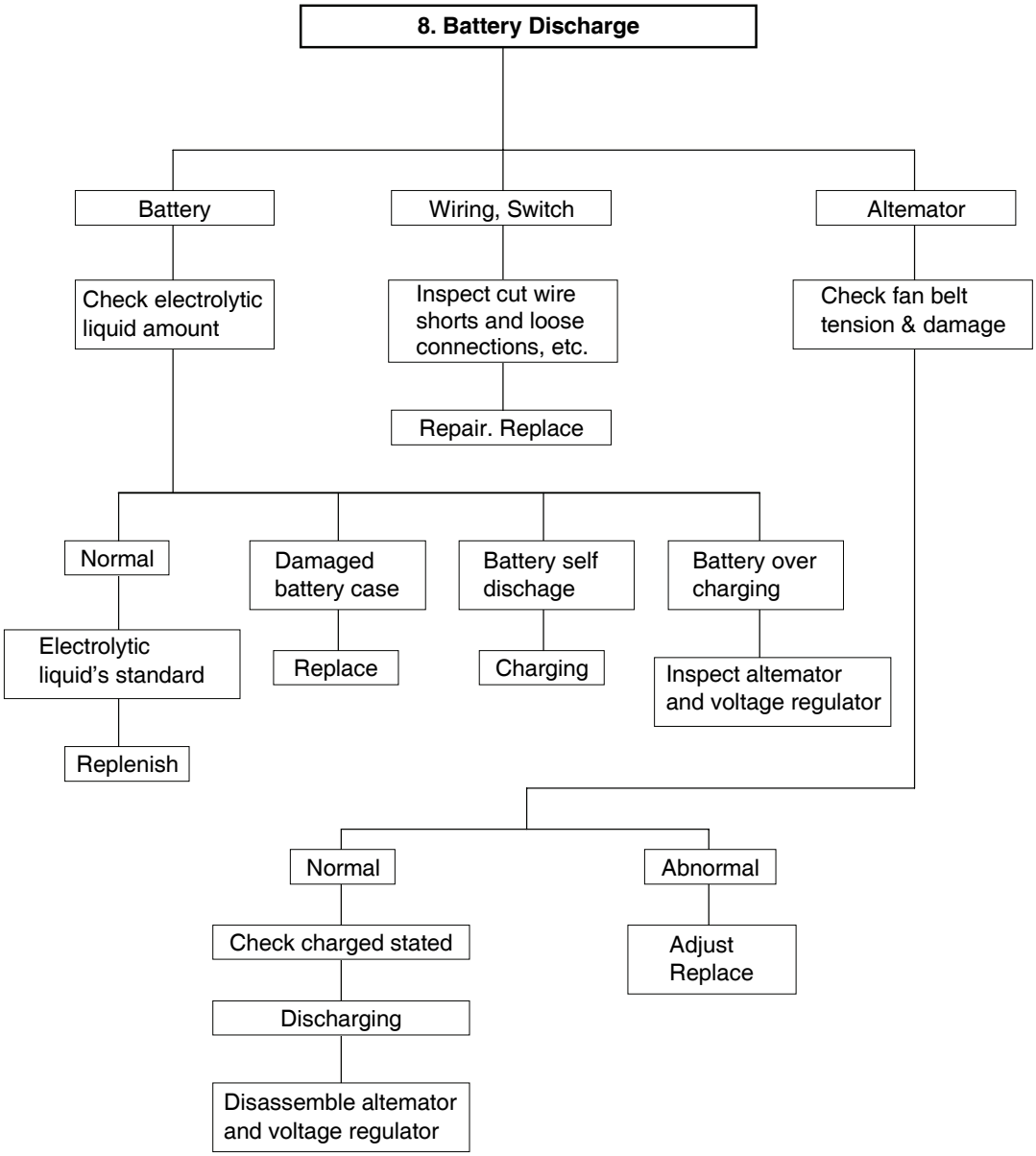












Condition	Causes	Remedies
1) Starting difficult		
(1) Compression pressure	● Valve's poor shut, stem distortion	Repair or replace
	● Valve spring damage	Replace valve spring
	● Cylinder head gasket's leak	Replace gasket
	● Wear of piston, piston ring or liner	Adjust
2) Idle operation abnormal	● Injection timing incorrect	Adjust
	● Air mixing at injection pump	Remove air
3) Engine output insufficient		
(1) Continuous output Insufficient	● Valve clearance incorrect	Adjust
	● Valve tightness poor	Repair
	● Cylinder head gasket's leak	Replace gasket
	● Wear, stick, damage of piston ring	Replace piston ring
	● Injection timing incorrect	Adjust
	● Fuel injection amount insufficient	Adjust injection pump
	● Nozzle injection pressure improper or stuck	Adjust or replace
	● Supply pump's function lowered	Repair or replace
	● Fuel pipe system clogged	Repair
	● Air suction amount insufficient	Clean or replace air cleaner
	● Turbocharger poor	Repair or replace
(2) Output insufficient when in acceleration	● Compression pressure insufficient	Disassemble engine
	● Injection timing incorrect	Adjust
	● Fuel injection amount insufficient	Adjust injection pump
	● Injection pump timer's function insufficient	Repair or replace
	● Nozzle injection pressure, injection angle improper	Repair, replace
	● Supply pump's function lowered	Repair or replace
	● Air intake amount insufficient	Clean or replace air cleaner
4) Overheating	● Engine oil insufficient or poor	Replenish or replace
	● Cooling water insufficient	Replenish or replace
	● Fan belt loosened, worn, damaged	Adjust or replace
	● Cooling water pump's function lowered	Repair or replace
	● Water temperature regulator's operation poor	Replace
	● Valve clearance incorrect	Adjust
	● Exhaust system's resistance increased	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.	Replace bearing & grind crankshaft
	● Lopsided wear of crankshaft	Grind or replace
	● Oil supply insufficient due to oil passage clogging	Clean oil passage
	● Stuck bearing	Replace bearing & grind
(2) Connecting rod and Connecting rod bearing	● Lopsided wear of connecting rod bearing	Replace bearing
	● Lopsided wear of crank pin	Grind crankshaft
	● Connecting rod distortion	Repair or replace
	● Stuck bearing	Replace & grind crankshaft
	● Oil supply insufficiency as clogging at oil passage progresses	Clean oil passage
(3) Piston, piston pin & piston ring	● Piston clearance increase as the wear of piston and piston ring progresses	Replace piston & piston ring
	● Wear of piston or piston pin	Replace
	● Piston stuck	Replace piston
	● Piston insertion poor	Replace piston
	● Piston ring damaged	Replace piston
(4) Others	● Wear of crankshaft, thrust bearing	Replace thrust bearing
	● Camshaft end play increased	Replace thrust plate
	● Idle gear end play increased	Replace thrust washer
	● Timing gear backlash excessive	Repair or replace
	● Valve clearance excessive	Adjust valve clearance
	● Abnormal wear of tappet, cam	Replace tappet, cam
6) Fuel Consumption excessive	● Injection timing incorrect	Adjust
	● Fuel injection amount excessive	Adjust injection pump
7) Oil consumption excessive excessive		
(1) Oil level elevated	● Clearance between cylinder liner & piston	Replace
	● Wear of piston ring, ring groove	Replace piston, piston ring
	● Piston ring's damage, stick, wear	Replace piston ring
	● Piston ring opening's disposition improper	Correct position
	● Piston skirt part damaged or abnormal wear	Replace piston
	● Oil ring's oil return hole clogged	Replace piston ring
	● Oil ring's contact poor	Replace piston ring
(2) Oil level lowered	● Looseness of valve stem & guide	Replace in set
	● Wear of valve stem seal	Replace seal
	● Cylinder head gasket's leak	Replace gasket
(3) Oil leak	● Looseness of connection parts	Replace gasket, repair
	● Various parts' packing poor	Replace packing
	● Oil seal poor	Replace oil seal

2.16. Engine inspection

2.16.1. Stopping engine

After checking the engine for any unusual condition at the idling speed, then turn the key switch to the stop the engine.

2.16.2. General engine inspection cycle

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

- Daily inspections in below figure should be checked every day.
- The following maintenance details should be executed thoroughly at regular internals.

O : Check & adjust ● : Replace

Inspection		Daily	Every 50hrs	Every 200hrs	Every 500hrs	Every 600hrs	Every 1200hrs	Remark
Cooling System	Check for leakage(hoses, clamp)	O						
	Check the water level	O						
	Change the coolant water						●	
	Adjust the V-belt tension	O						Every 2,000hrs
	Clean the radiator						O	
Lubrication System	Check for leakage	O						
	Check the oil level gauge	O						
	Change the lubricating oil		● 1st		●			
	Replace the oil filter cartridge		● 1st		●			
Intake & Exhaust System	Check the leakage for intercooler (hoses, clamp)	O						
	Clean and change the air cleaner element			O clean		●		
Fuel System	Check the leakage fuel line	O						
	Clean the fuel strainer of fuel feed pump			O				
	Remove sediment from fuel tank						O	
	Drain the water in separator			O				
	Replace the fuel filter element				●			
	Check fuel injection timing			O				When necessary
	Check the injection nozzles			O				When necessary
Engine Adjust	Check the state of exhaust gas	O						
	Check the battery charging	O						
	Check the compression pressure						O	When necessary
	Adjust Intake/Exhaust valve clearance		O 1st					When necessary

2.17. Use of original parts for repair and replacement

For engine is being mechanically harmonized with many parts, only when the original parts that the manufacture recommends to use is used, the engine trouble would be preventively maintained and capable to keep up the maximum performances.
For the analogous parts not the original parts are poor in qualities and gives ill performance, it may rather bring early engine failure.

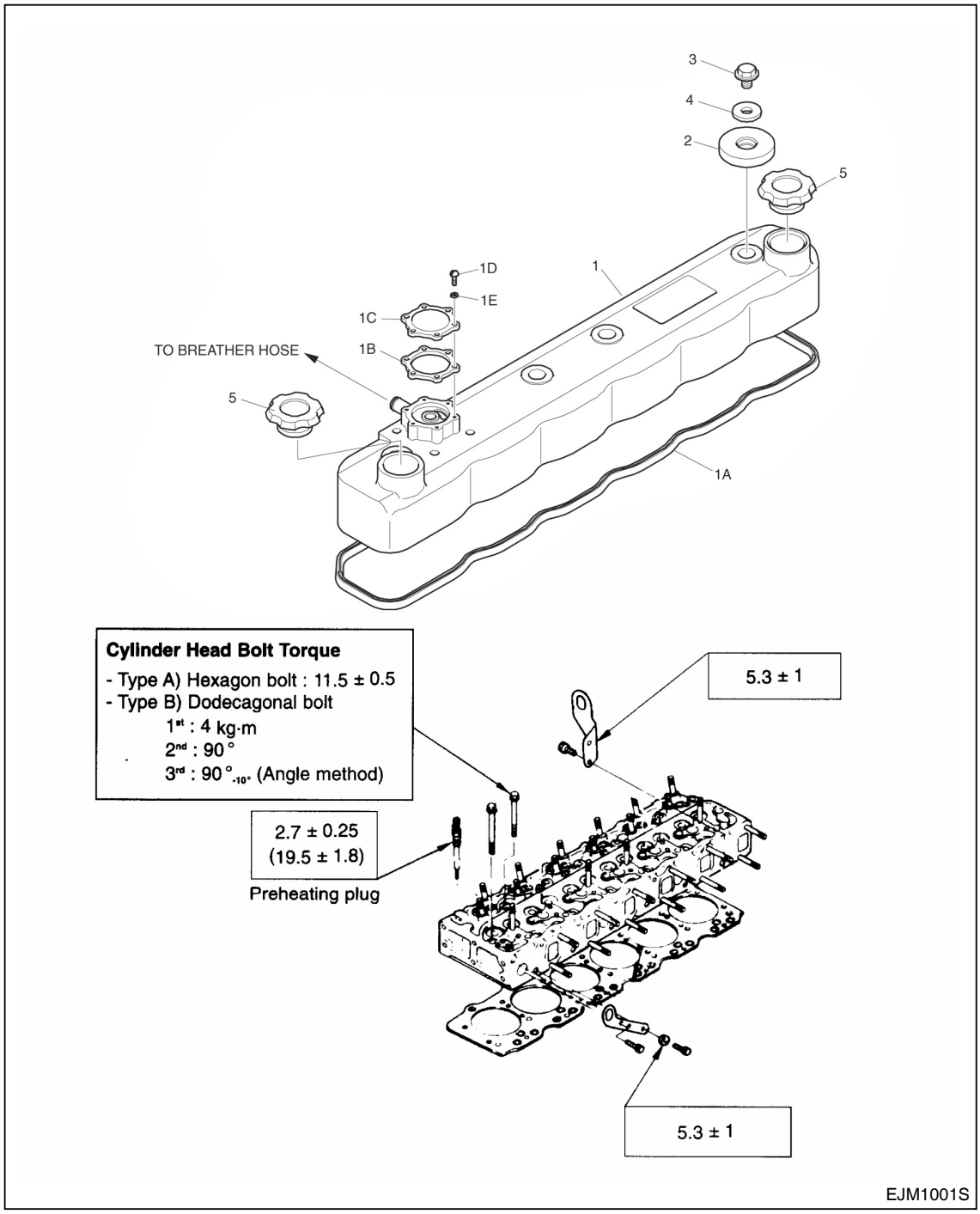
3. Maintenance

3.1. Engine Disassembly

3.1.1. Major part fixing nuts and bolts

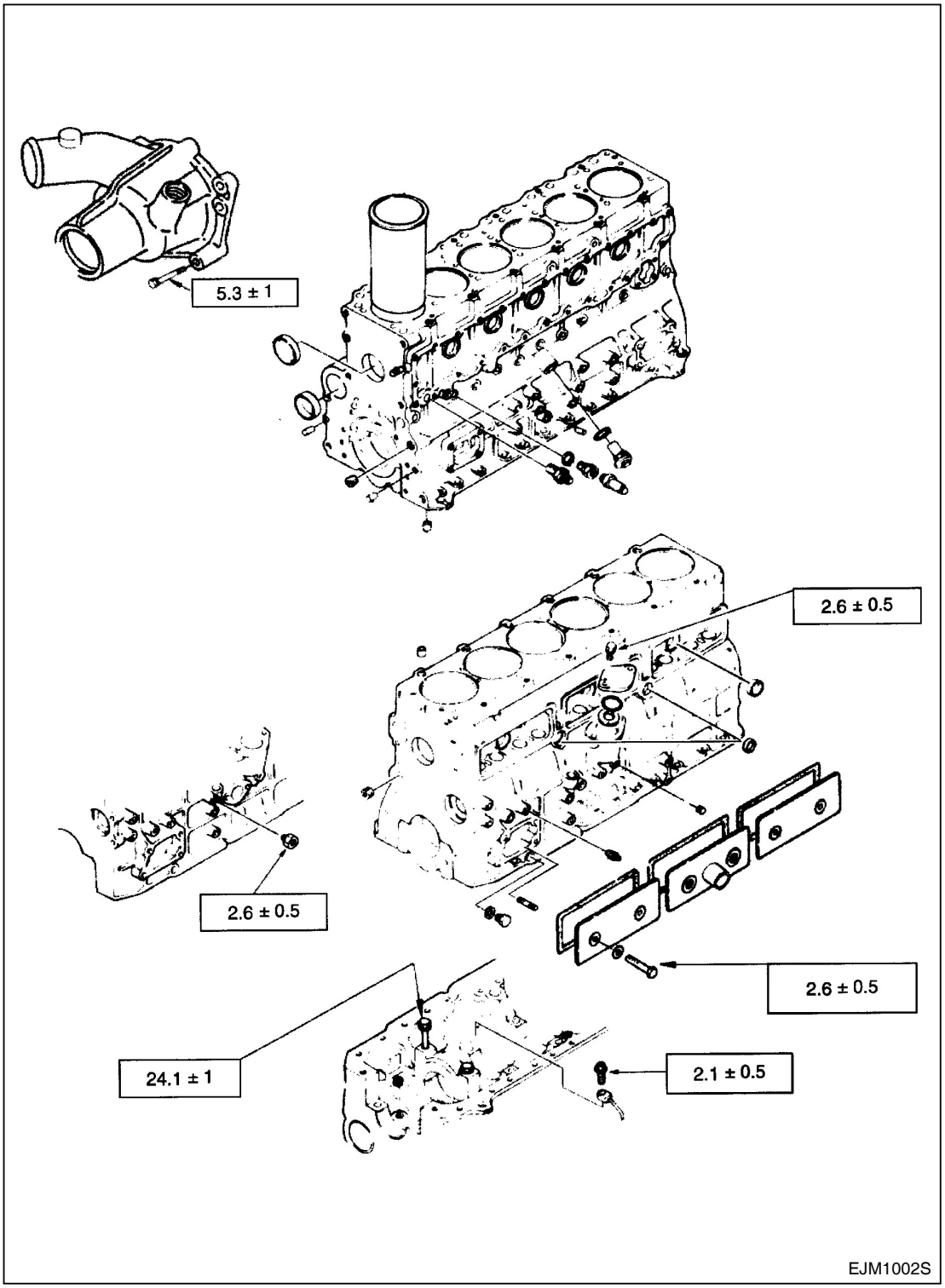
1) Cylinder head cover

(Unit : kg.m)



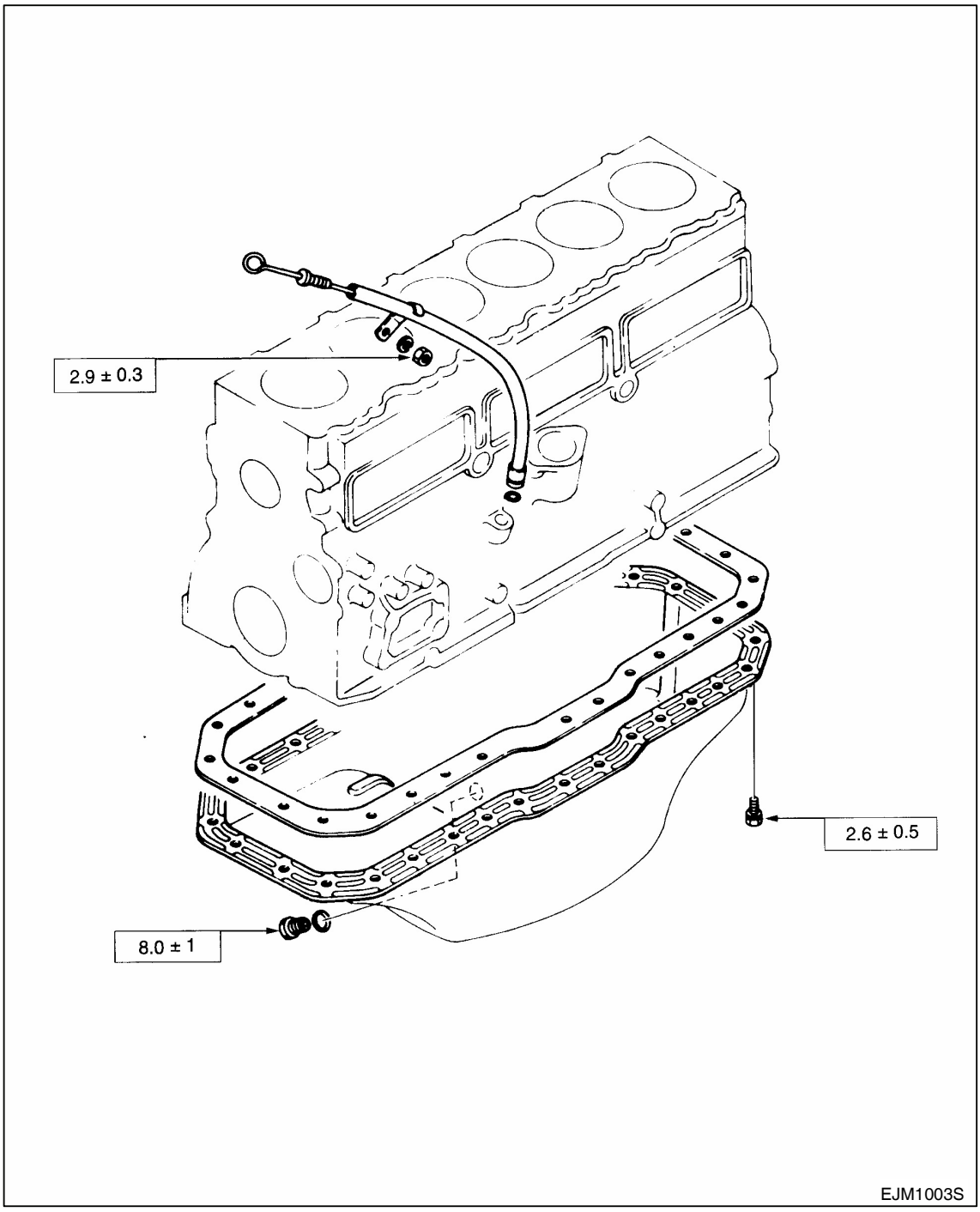
2) Cylinder block

(Unit : kg.m)



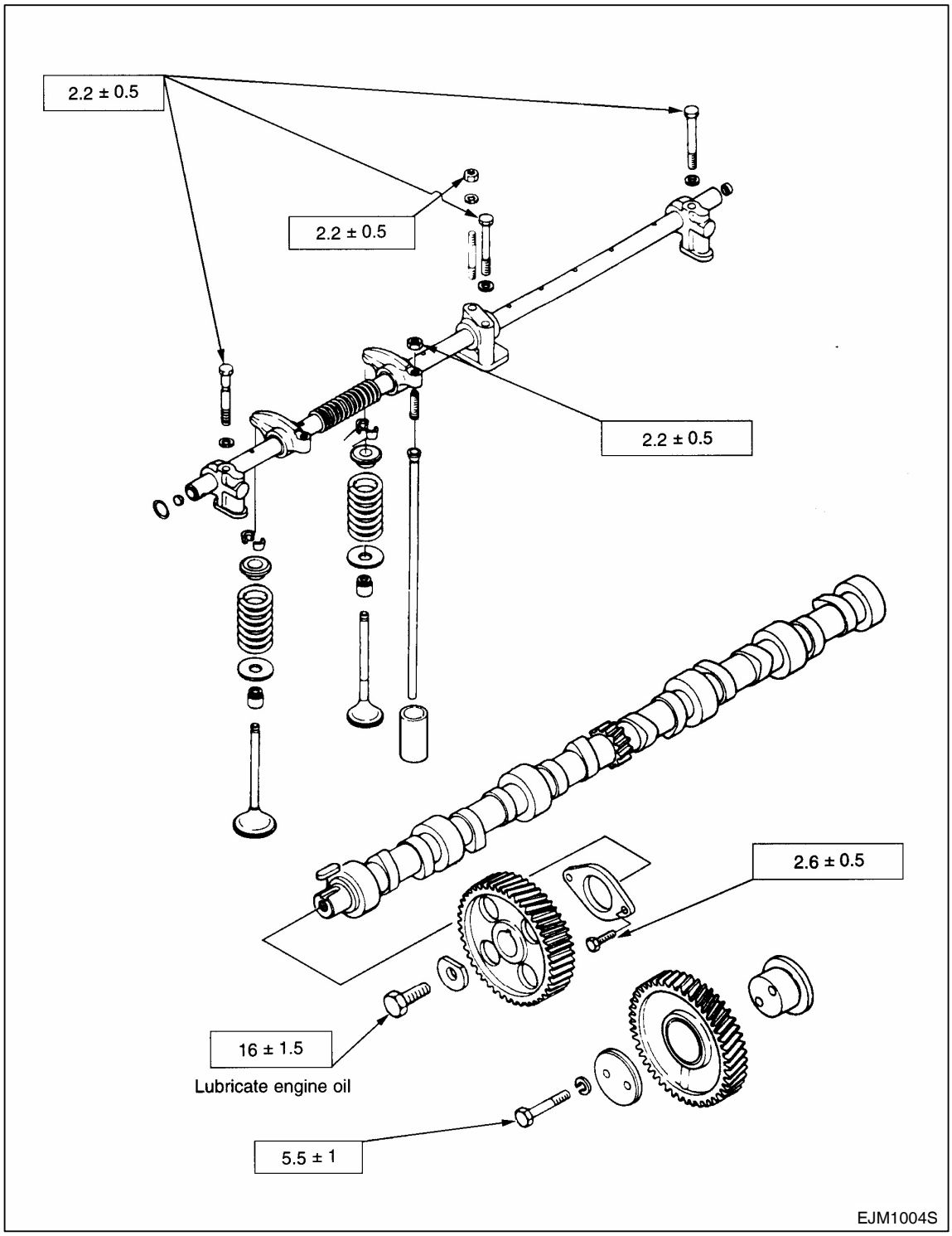
3) Oil pan and level gauge

(Unit : kg.m)



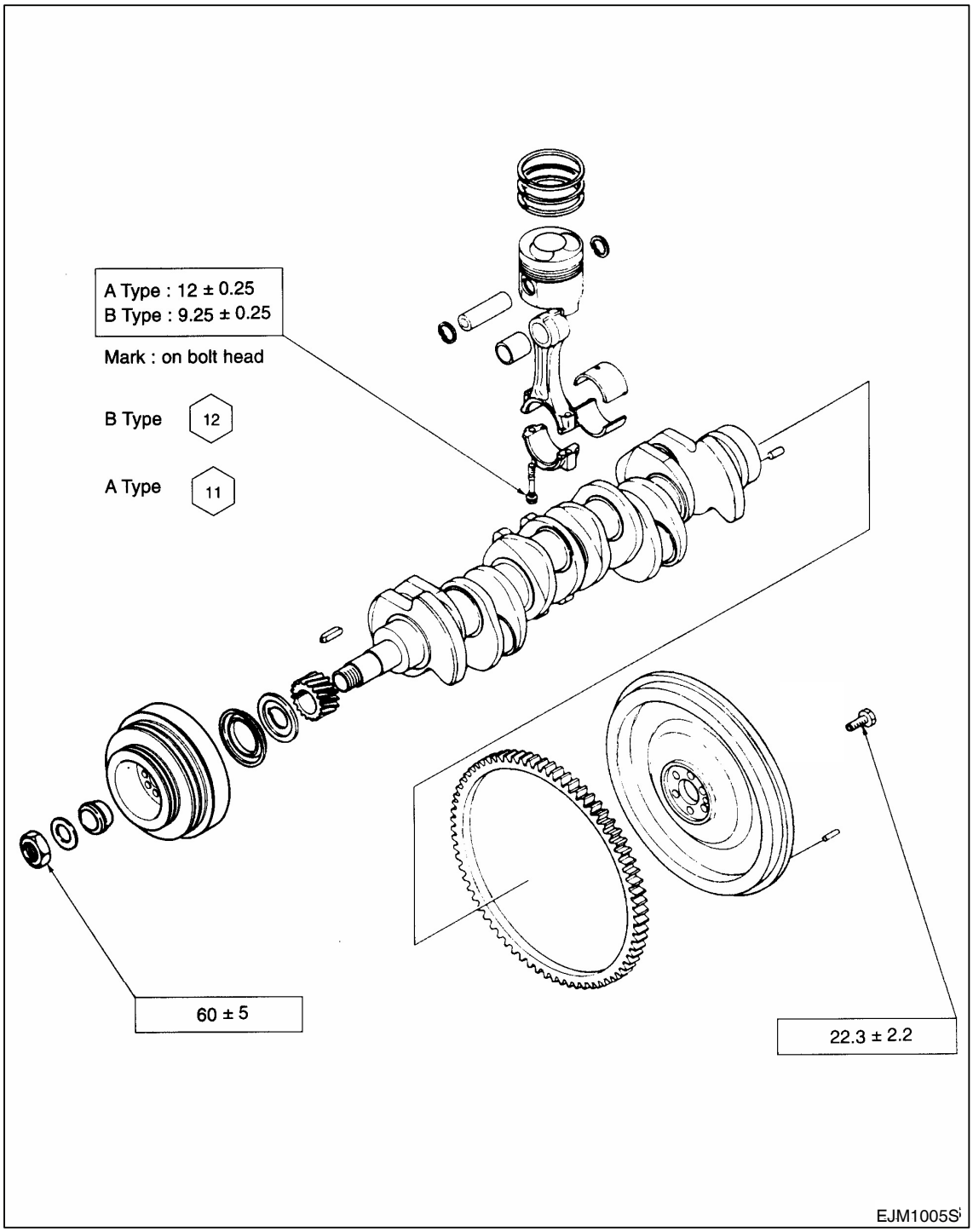
4) Camshaft and rocker arm

(Unit : kg.m)



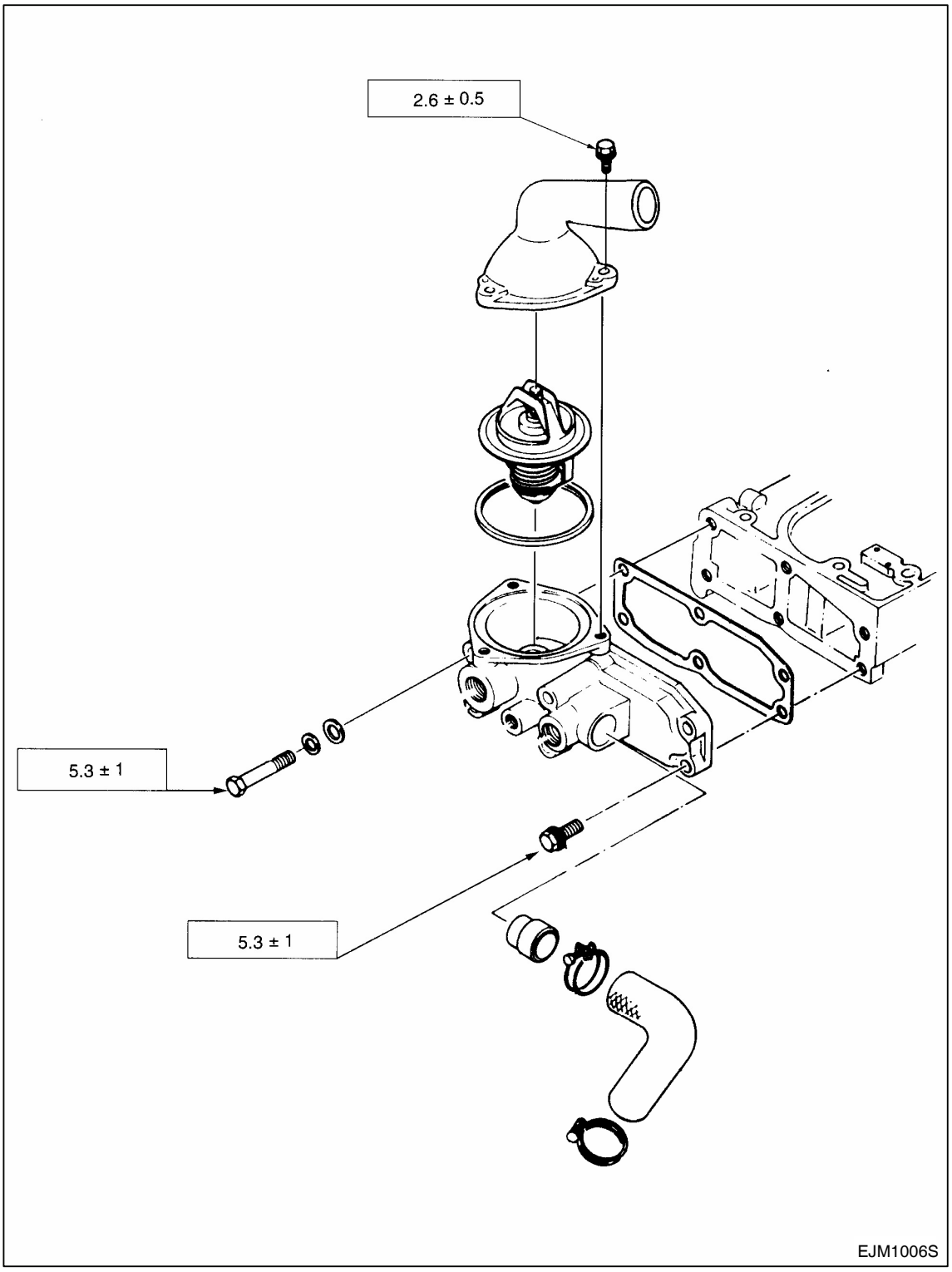
5) Crankshaft, piston and flywheel

(Unit : kg.m)



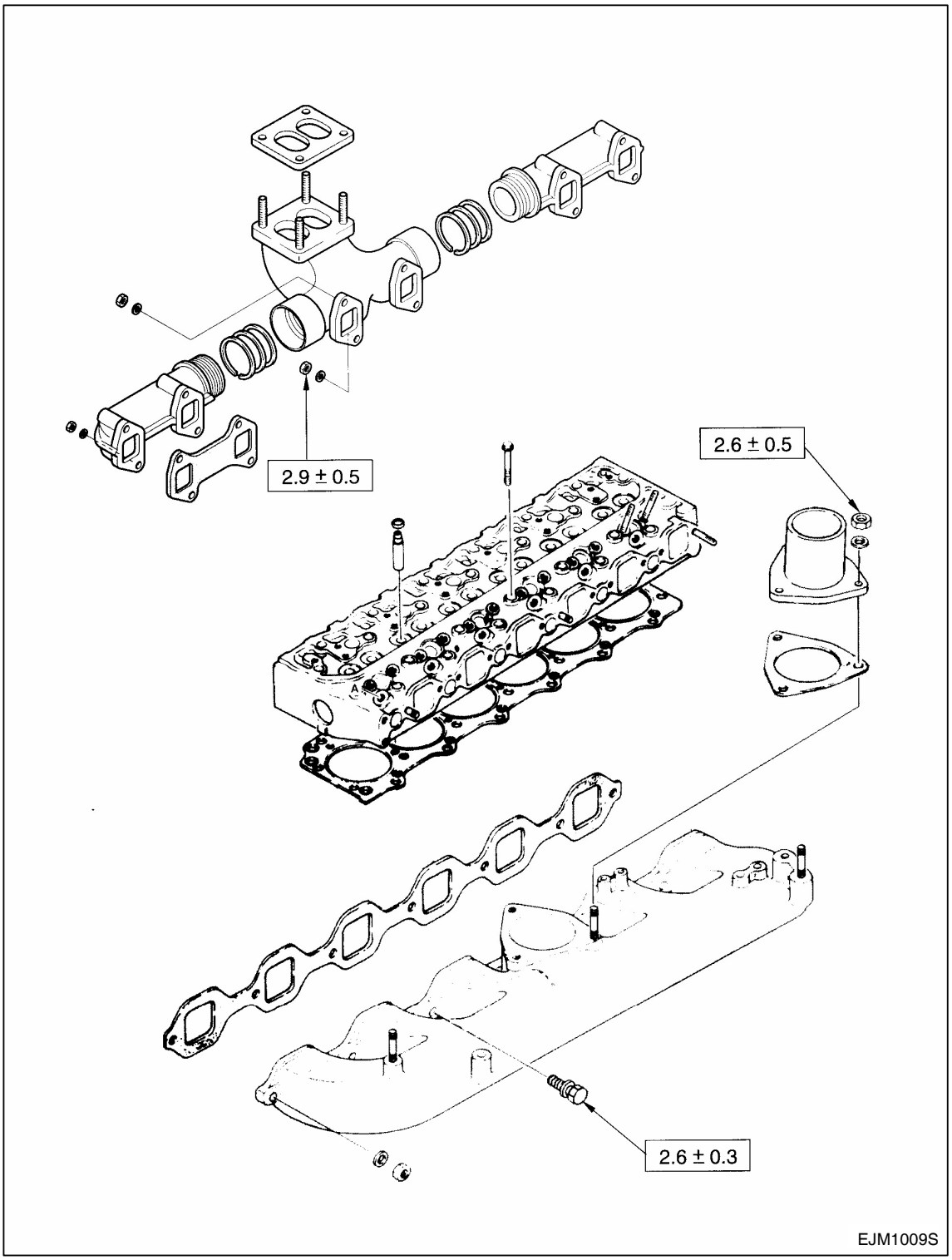
6) Thermostat and housing

(Unit : kg.m)



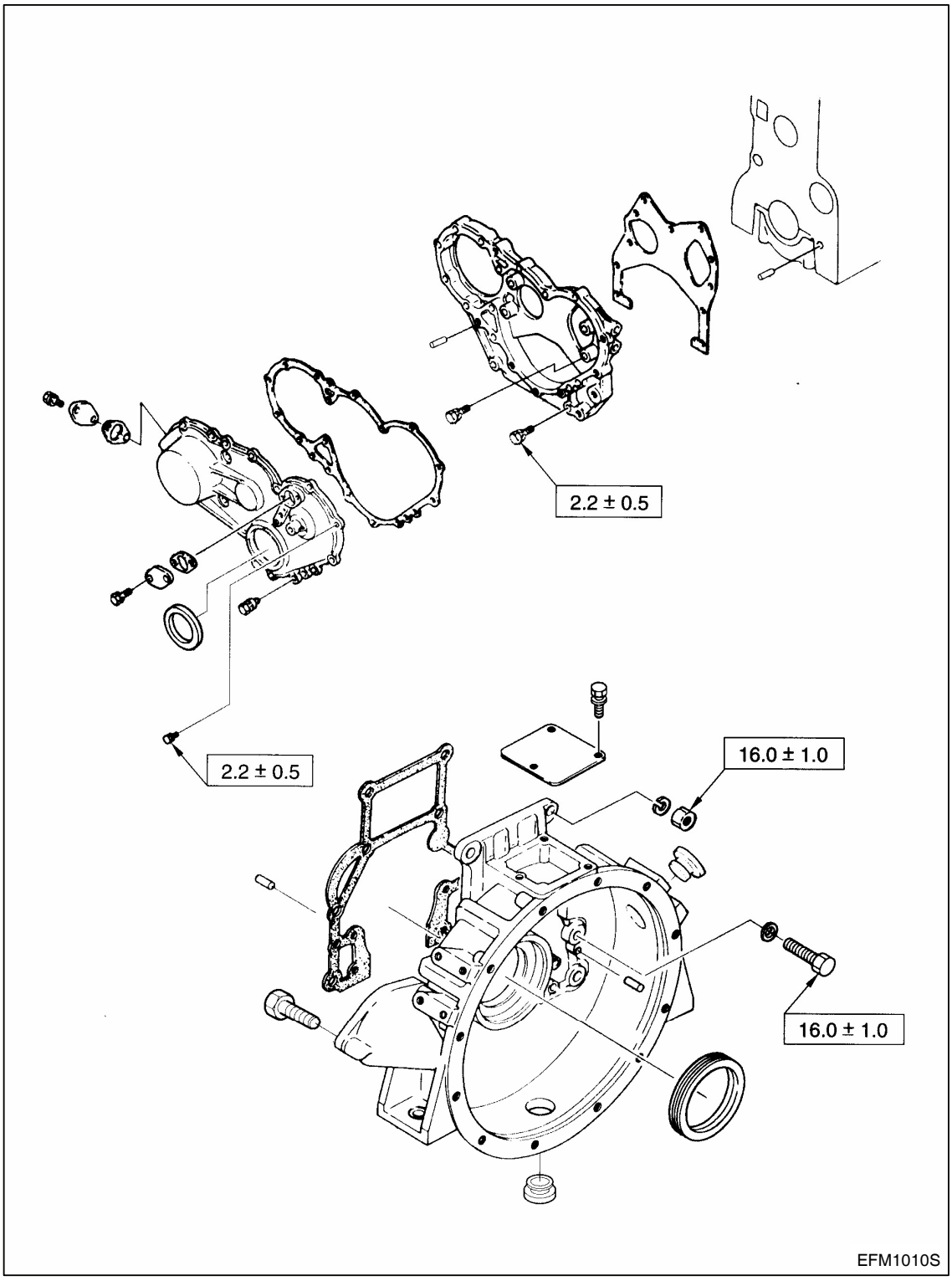
7) Intake and exhaust manifold

(Unit : kg.m)



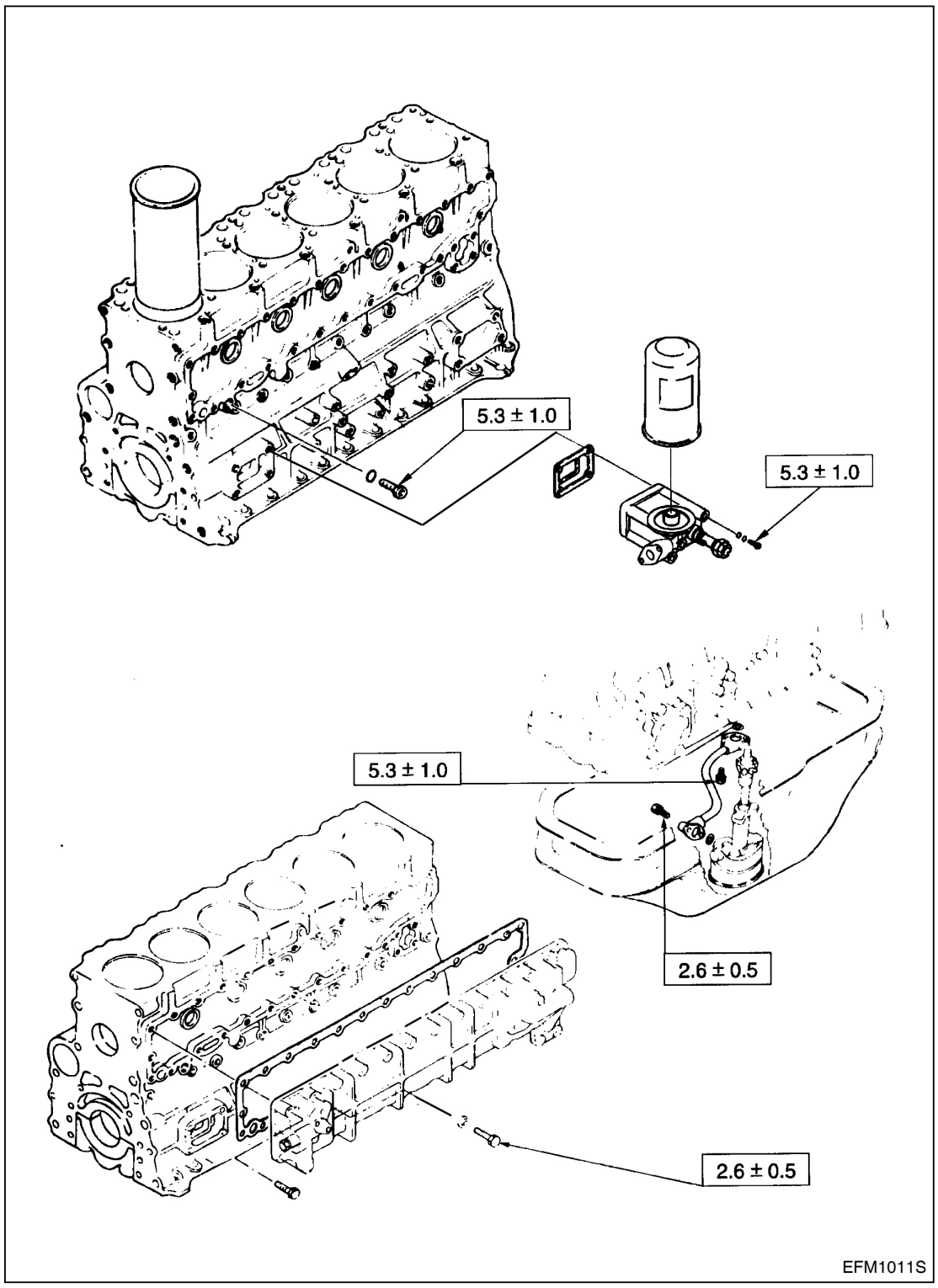
8) Timing gear case and flywheel housing

(Unit : kg.m)



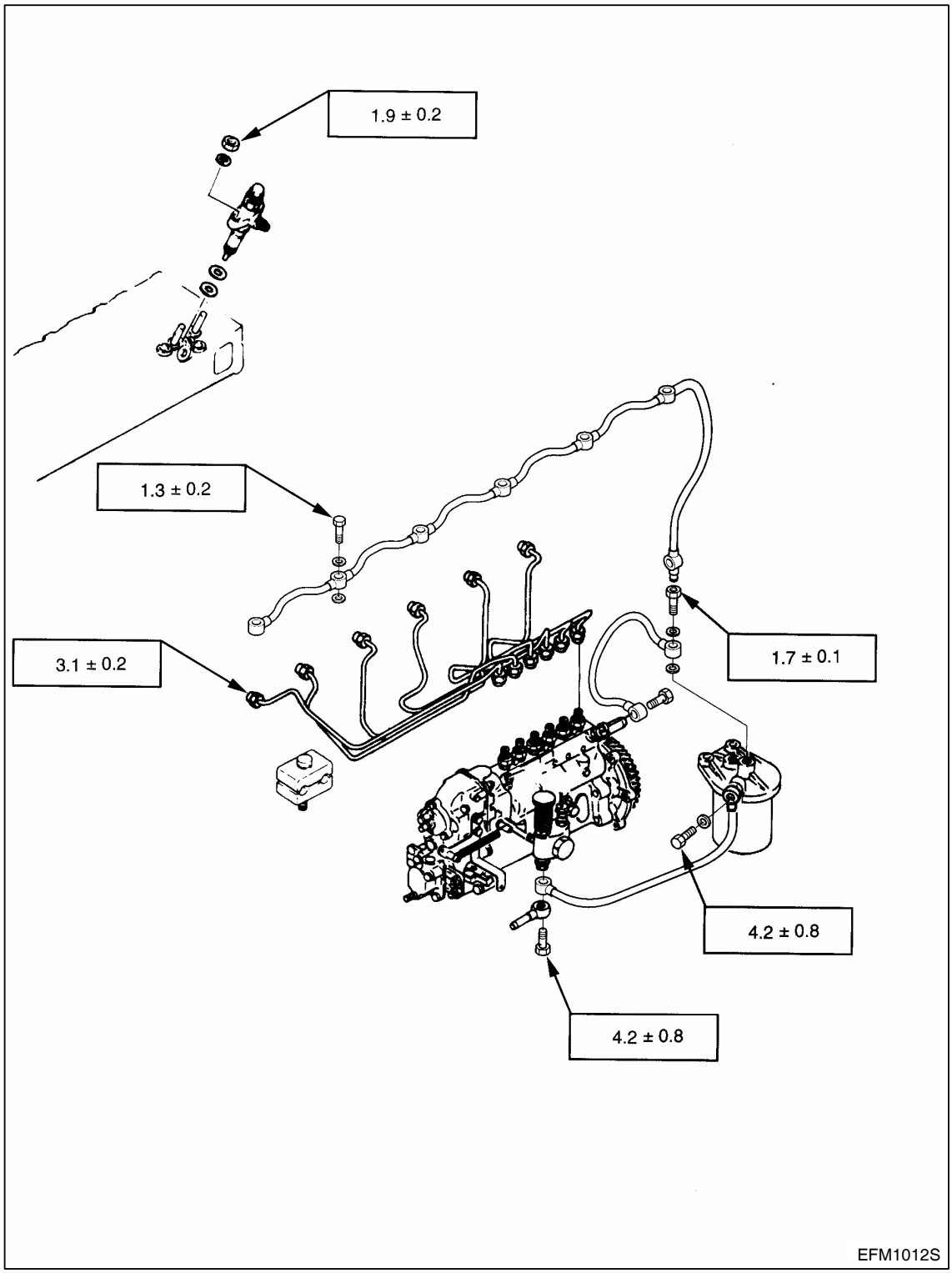
9) Oil cooler, oil filter and oil pump

(Unit : kg.m)

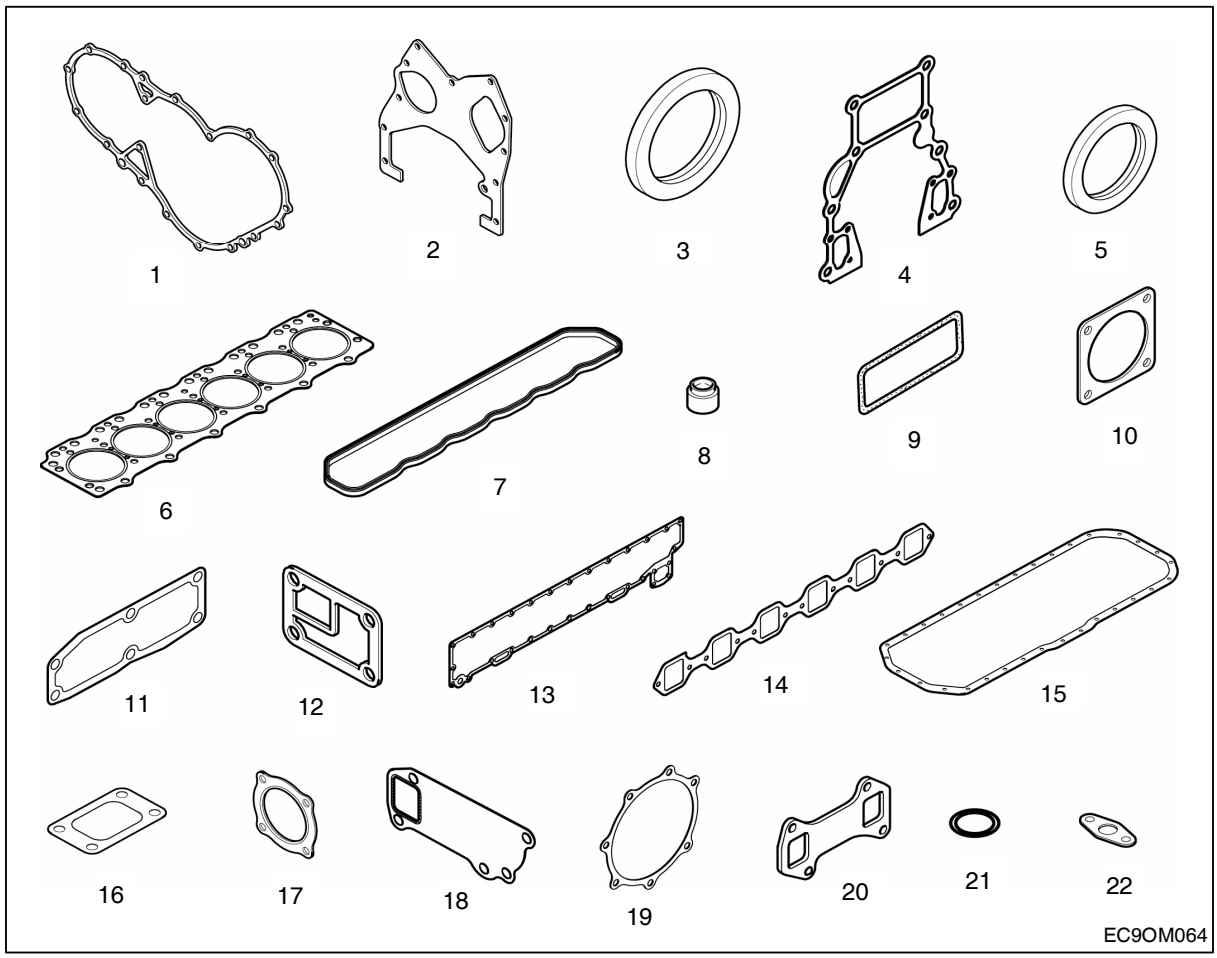


10) Fuel system

(Unit : kg.m)

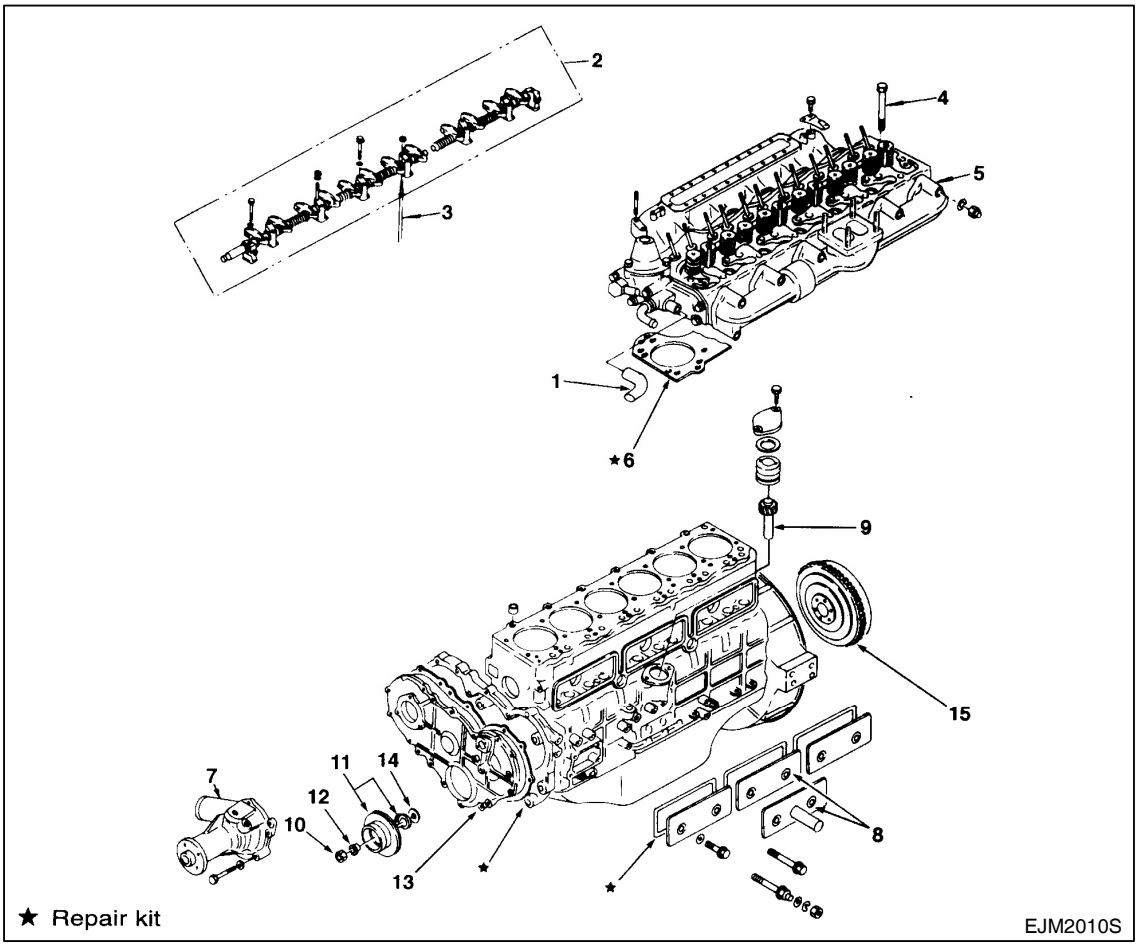


11) Engine repair parts



1. Cover to timing gear case gasket
2. Gear case to cylinder block gasket
3. Timing gear case oil seal
4. Flywheel housing gasket
5. Crank shaft rear oil seal
6. Cylinder head gasket
7. Cylinder head cover gasket
8. Valve guide oil seal
9. Tappet chamber cover gasket
10. Air heater gasket
11. Thermostat housing gasket
12. Oil filter cover gasket
13. Oil cooler gasket
14. Intake manifold gasket
15. Oil pan gasket
16. Turbocharger gasket
17. Turbocharger outlet gasket
18. Water pump gasket
19. Water pump housing gasket
20. Exhaust manifold gasket
21. Thermostat gasket
22. Oil pump hole cover gasket

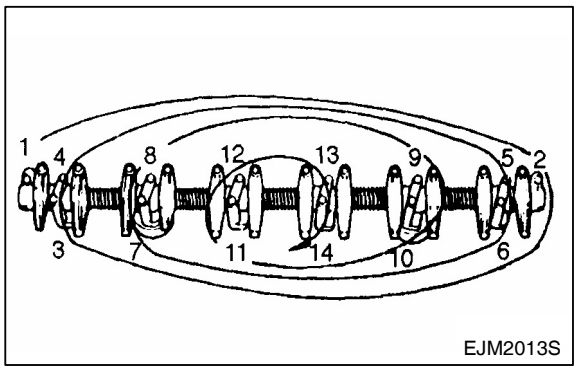
3.1.2. Main structure parts (1)



1. Rubber hose (Coolant by-pass)
▲ 2. Rocker arm shaft assembly
3. Push rod
4. Cylinder head bolt
▲ 5. Cylinder head assembly
6. Cylinder head gasket
7. Coolant pump assembly
8. Tappet chamber cover
9. Oil pump driving pinion
10. Nut
▲ 11. Crankshaft pulley and dust cover
▲ 12. Taper bushing
13. Timing gear cover
14. Oil thrower
▲ 15. Fly wheel

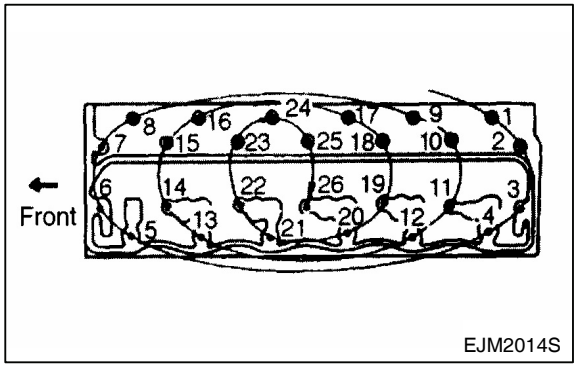
2) Rocker arm shaft

Loosen the rocker arm shaft fixing bolts a little in numerical sequence as specified.



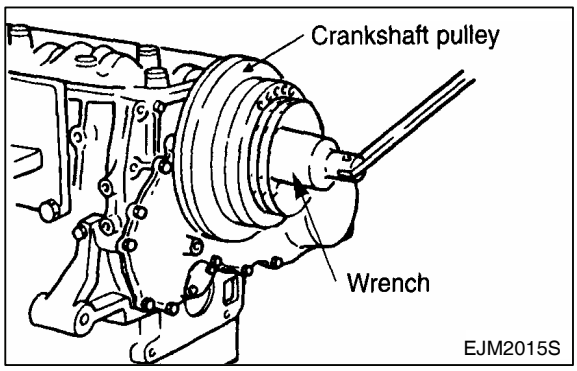
5) Cylinder head

Loosen the cylinder head bolts a little in the numerical order shown in the figure.



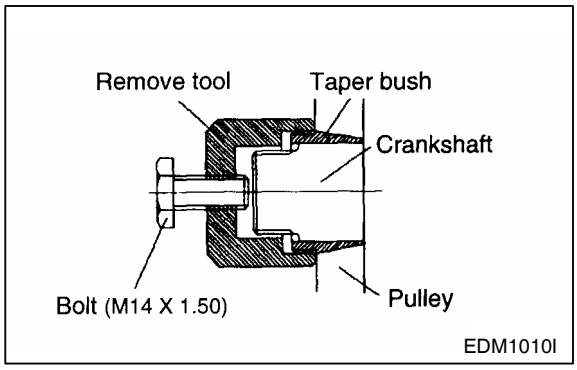
11) Crankshaft pulley

Use an appropriate wrench (54 mm) to remove the crankshaft pulley nut.



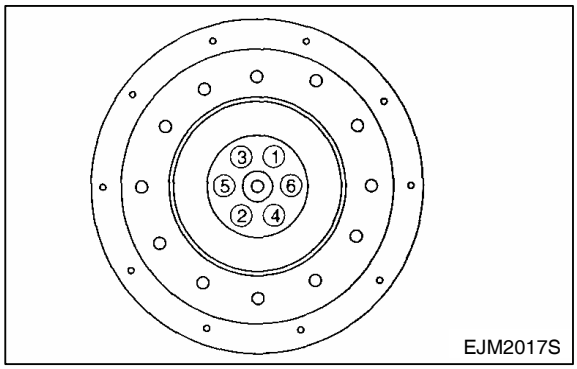
12) Taper bushing

Use the taper bushing remover to remove the crankshaft end taper bushing.

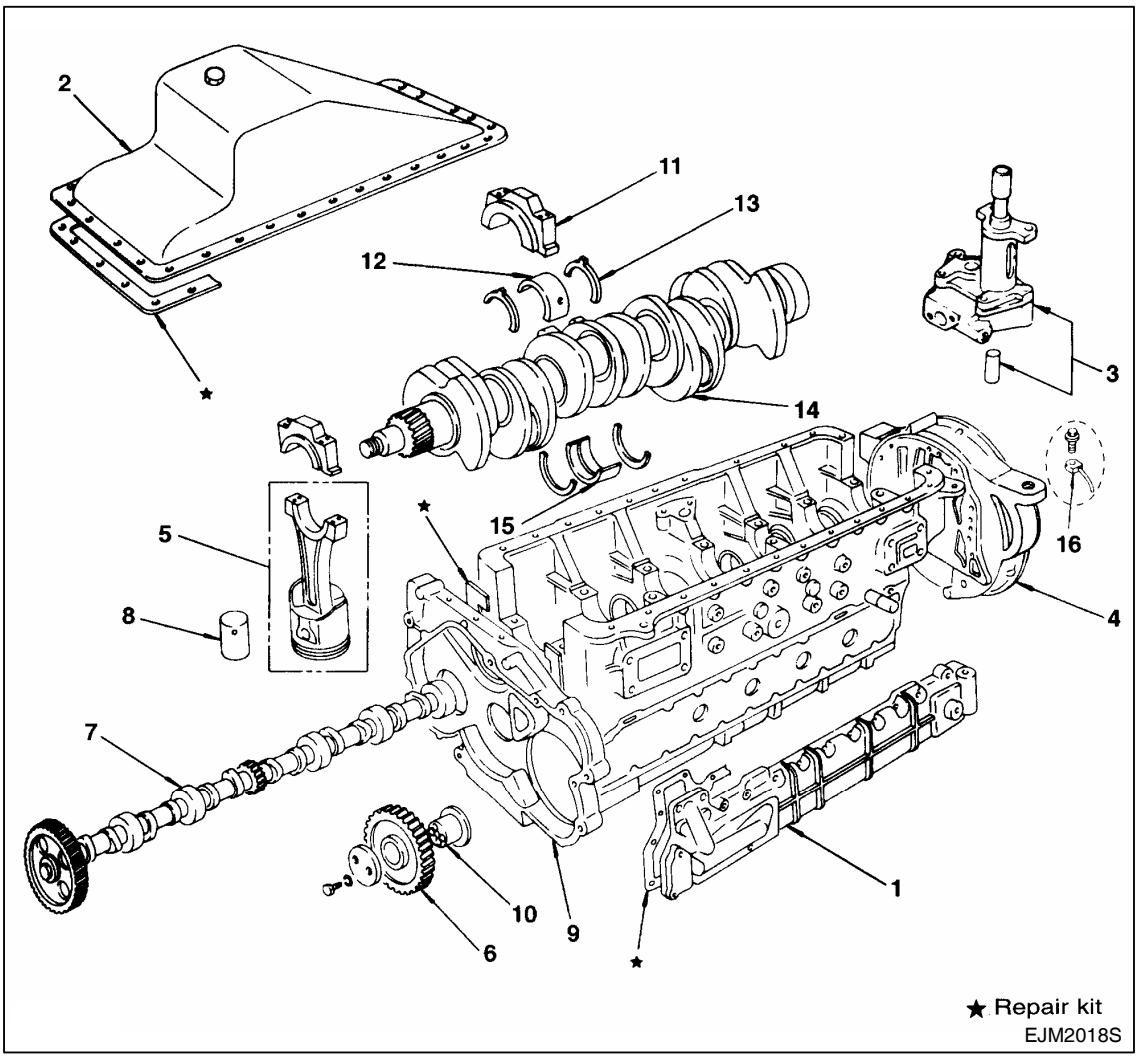


15) Flywheel

Loosen the flywheel bolts a little in the numerical order as specified.



3.1.3. Main structure parts (2)



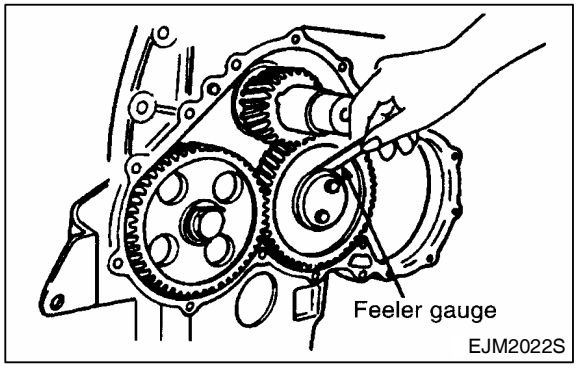
1. Oil cooler
2. Oil pan
3. Oil pump and coupling
4. Flywheel housing
5. Piston and connecting rod
▲ 6. Idler gear
▲ 7. Cam shaft
8. Tappet
9. Timing gear case
10. Idler gear shaft
▲ 11. Crank shaft bearing cap
12. Crank shaft bearing (lower part)
13. Thrust bearing
14. Crank shaft
15. Crank shaft bearing (upper part)

6) Idler gear

Measure the following points before disassembly.

<Idler gear end play>

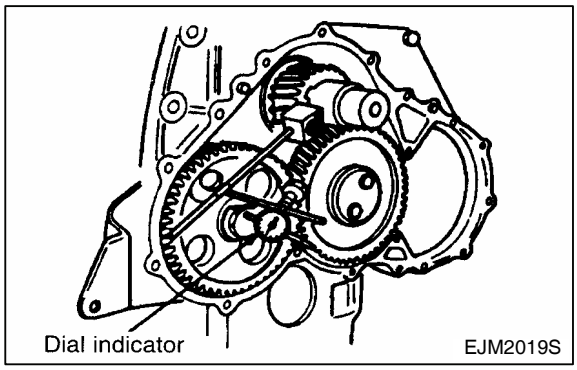
Standard	Limit
0.058 ~ 0.115 mm	0.2 mm



<Timing gear back lash>

Standard	Limit
0.10 ~ 0.17 mm	0.3 mm

Includes the crankshaft gear, the camshaft gear and the idler gear

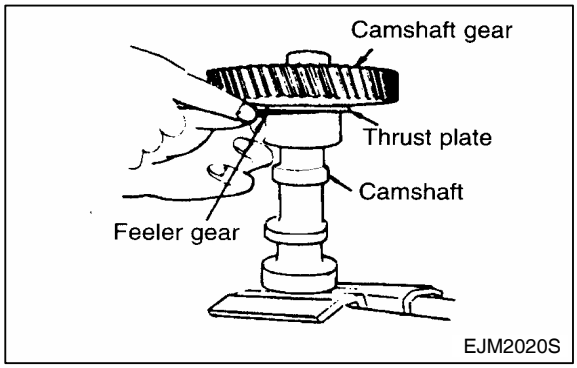


7) Camshaft

Measure the following points before disassembly.

<Cam Gear End Play>

Standard	Limit
0.050 ~ 0.114 mm	0.2 mm

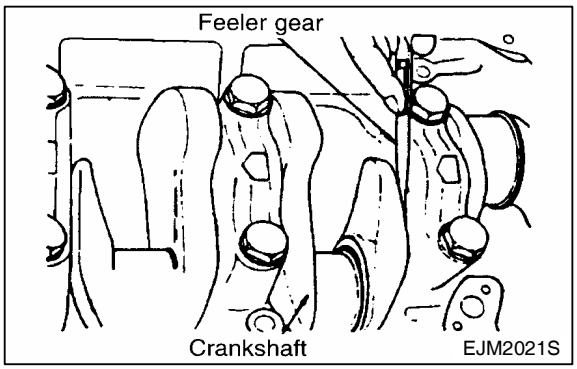


11) Crankshaft bearing cap

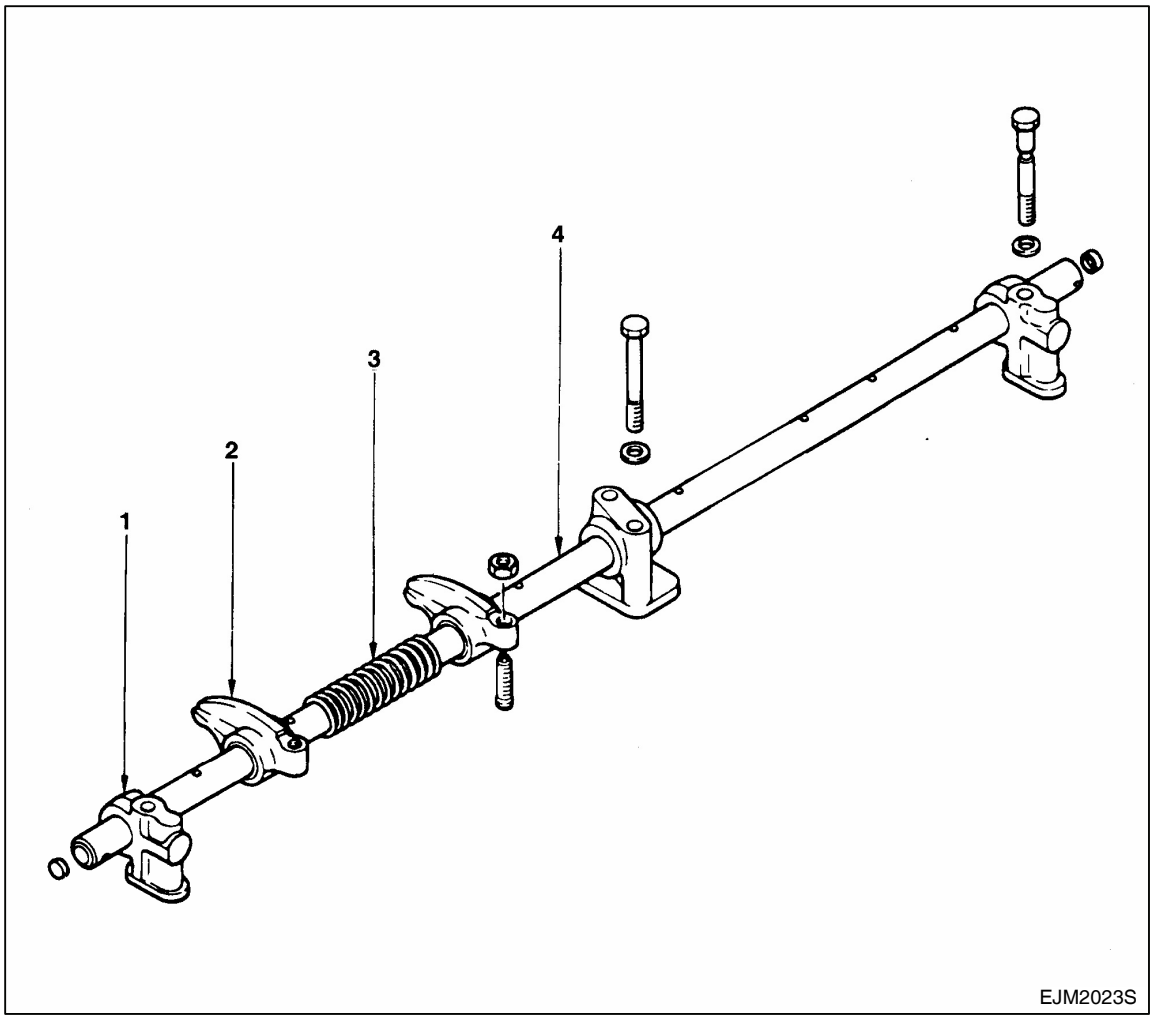
Measure the crankshaft endplay at the thrust bearing (center main bearing) before disassembly.

<Crankshaft End Play>

Standard	Limit
0.15 ~ 0.33 mm	0.4 mm

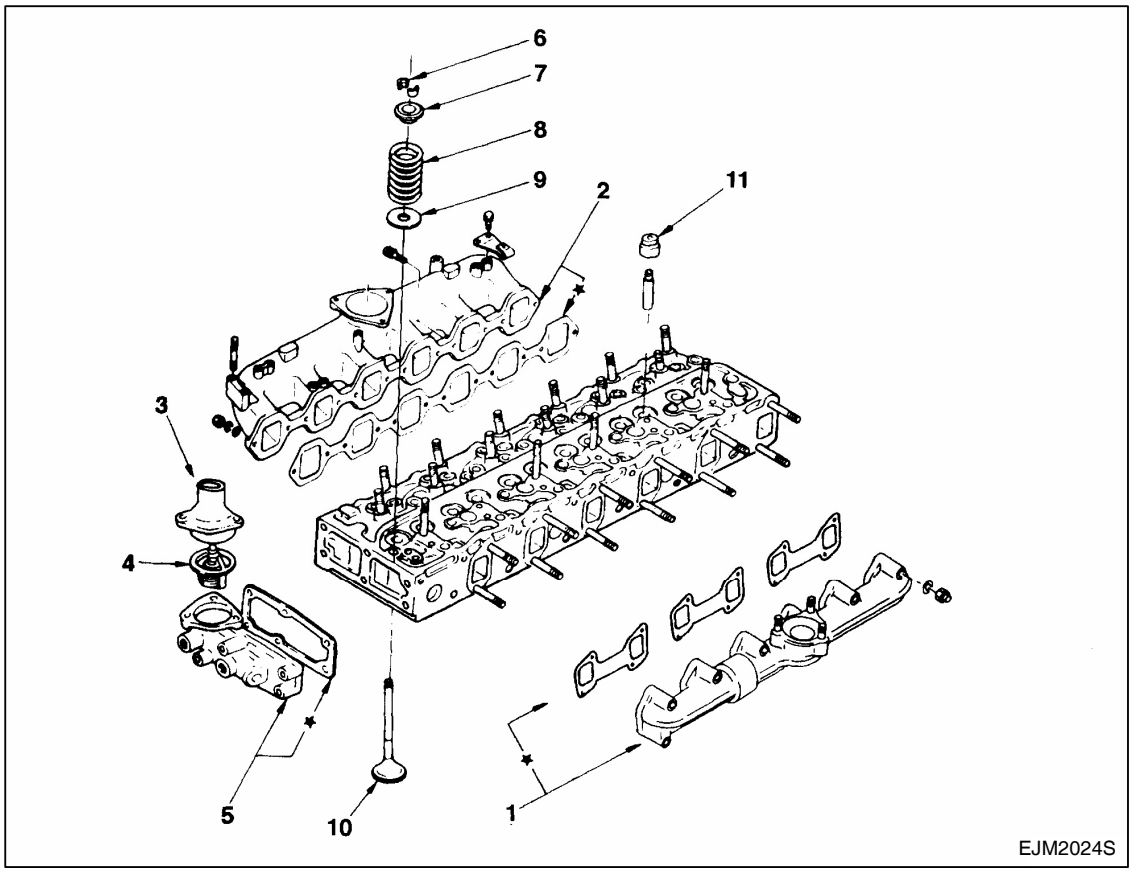


3.1.4. Rocker arm disassembly



1. Bracket
2. Rocker arm
3. Spring
4. Rocker arm shaft

3.1.5. Cylinder head disassembly

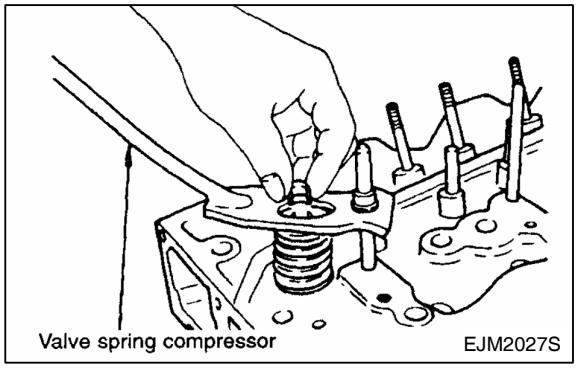


1. Exhaust manifold and gasket
2. Intake manifold and gasket
3. Coolant outlet pipe
4. Thmostat
5. Thermostat housing and gasket
▲ 6. Valve cotter
7. Spring seat (upper)
8. Valve spring
9. Spring seat (lower)
10. Valve
11. Valve stem oil seal

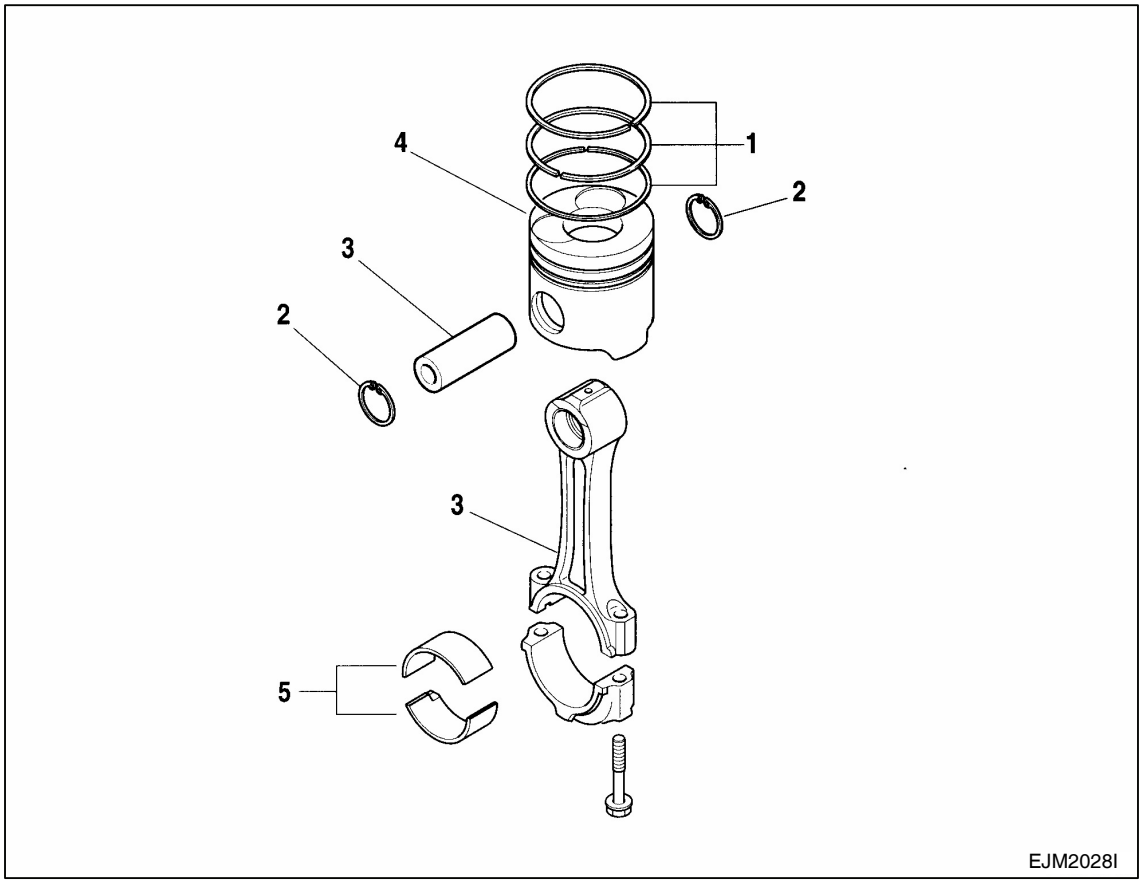
Importance

6) Valve cotter

Use the valve spring compressor to remove the valve cotter.

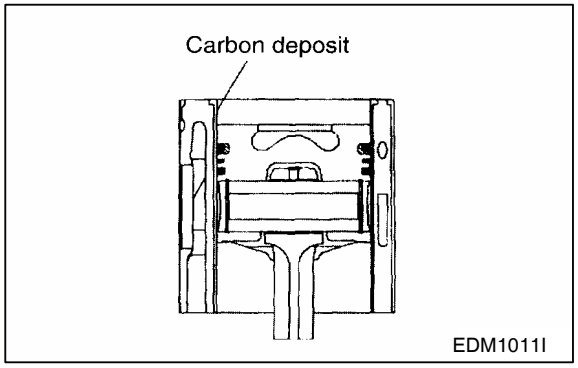


3.1.6. Piston and connecting rod disassembly



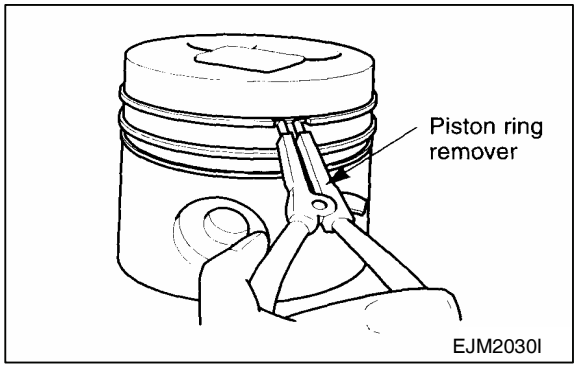
▲ 1. Piston rings
▲ 2. Snap ring
▲ 3. Piston pin and connecting rod
4. Piston
5. Connecting rod bearing

IMPORTANT:
Remove any carbon deposits from the upper part of the cylinder bore.
This will prevent damage to the piston and the piston rings when they are removed from the cylinder bore.



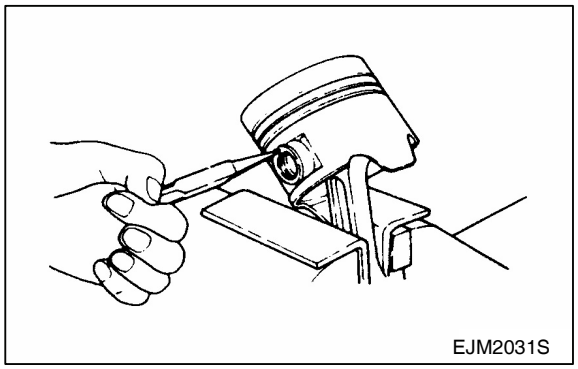
1) Piston rings

Use a piston ring remover to remove the piston rings.
Do not attempt to use other tools. Stretching piston ring will result in reduced piston ring tension.



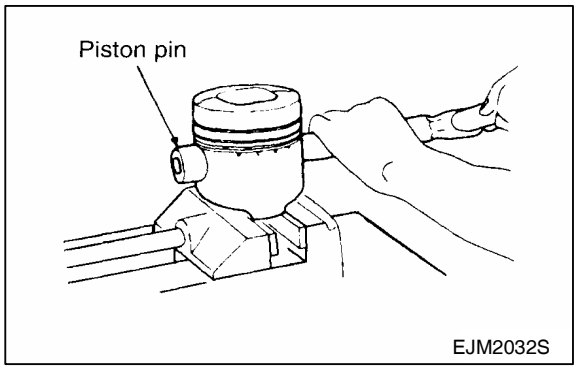
2) Snap ring

Use a pair of snap ring pliers to remove the snap ring.



3) Piston pin

Tap the piston pin out with a hammer and brass bar.



3.2. Engine Inspection

3.2.1. Cylinder block

- Clean the cylinder block thoroughly and make a visual inspection for cracks or damage.
- Replace if cracked or severely damaged, and correct if slightly damaged.
- Check oil and water flow lines for restriction or corrosion.
- Make a hydraulic test to check for any cracks or air leaks.

(Hydraulic test) :

Stop up each outlet port of water/oil passages in the cylinder block, apply air pressure of about 5kg/cm2 against the inlet ports, then immerse the cylinder block in water for about 3 minute to check any leaks. (Water temperature : 70 °C)

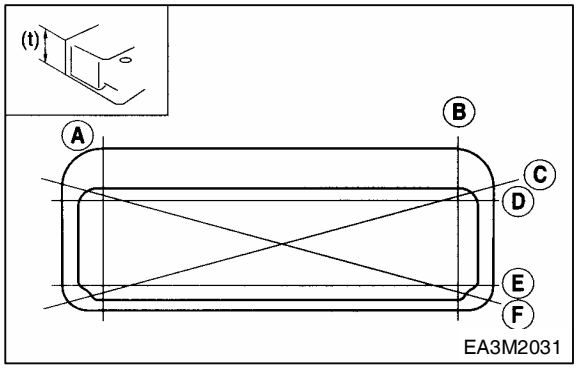
3.2.2. Cylinder head

1) Inspection

- Carefully remove carbon from the lower lace of the cylinder head using nonmetallic material to prevent scratching of the valve seat faces.
- Check the entire cylinder head for very fine cracks or damage invisible to ordinary sight using a hydraulic tester or a magnetic flaw detector.

2) Distortion at the lower face

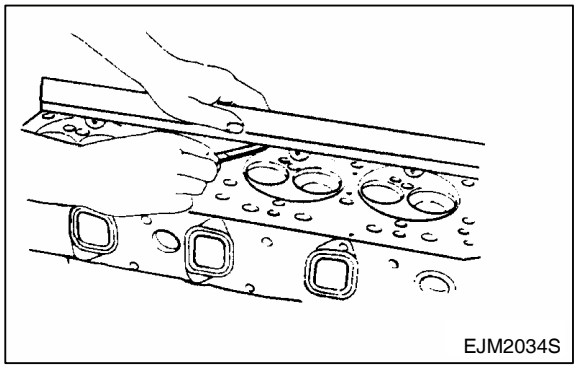
- Measure the amount of distortion using a straight edge and a feeler gauge at six positions (A ~ F) as shown in the right figure.
- If the measured value exceeds the standard value, retrace the head with grinding paper of fine grain size to correct such defect.
- If the measured value exceeds the maximum allowable limit, replace the cylinder head.



EA3M2031

<Lower face warpage and height>

	Standard	Limit
Warpage	0.2 mm or less	0.3 mm
Thickness : t	89.95 ~ 90.05 mm	89.65 mm


EJM2034S

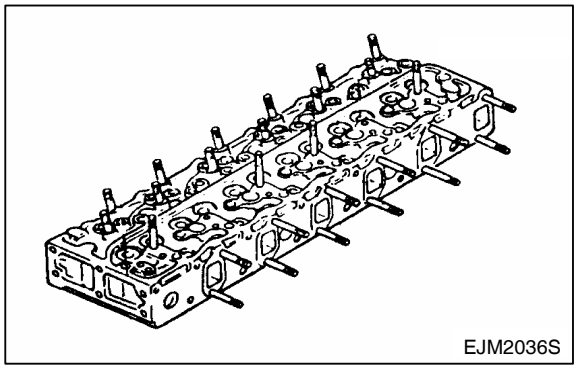
3) Flatness

Measure flatness of the intake/exhaust manifolds fitting surfaces on the cylinder head using a straight edge and a feeler gauge.

Standard	Limit
0.05 mm	0.2 mm

4) Hydraulic test

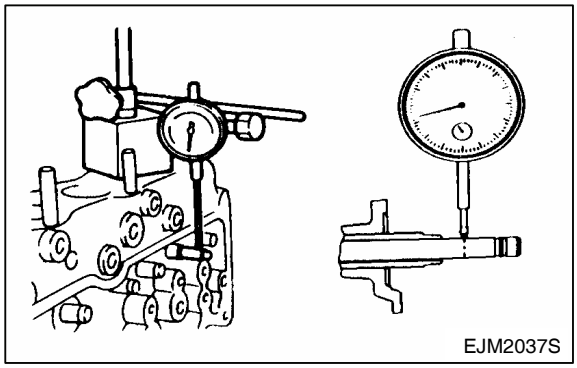
Hydraulic test method for the cylinder head is same as that for cylinder block.


EJM2036S

3.2.3. Valve stem and valve guide clearance

1) Measuring method - I

- After install dial gauge needle on the inserted valve stem, set up calibrator to “0”. (as shown in figure)
- Move valve head from side to side.
- Record total dial indicator reading.
- This valve is the clearance between the valve stem and valve guide.
- Valve and guide set must be replaced if measured value exceed the specified limit

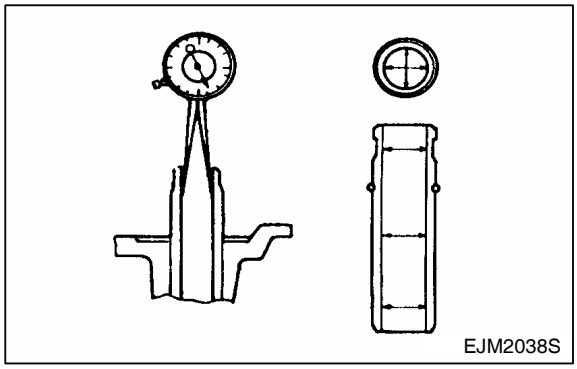

EJM2037S

<Valve stem clearance (T.I.R)>

	Standard	Limit
Intake side	0.039 ~ 0.071mm	0.20mm
Exhaust side	0.064 ~ 0.096mm	0.25mm

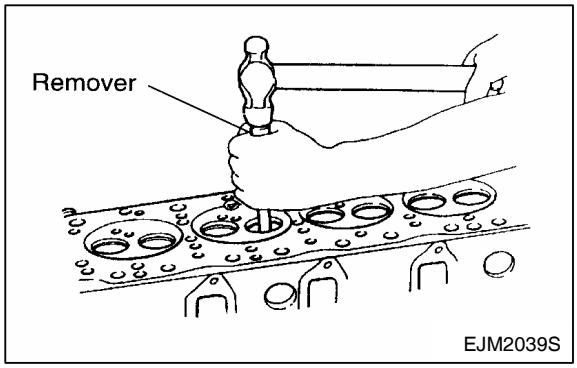
2) Measuring method – II

- Measure valve stem outside diameter.
- Measure valve guide inside diameter by using of caliper calibrator of telescoping gauge.
- The difference between the valve stem outside diameter and the valve guide inside diameter is the valve stem clearance.


EJM2038S

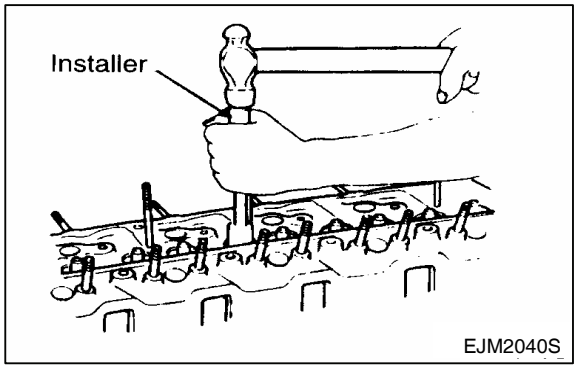
3) Valve guide replacement

- Removal of valve guide
- Pull out the valve guide, by using hammer and valve guide remover, from bottom of cylinder head.



EJM2039S

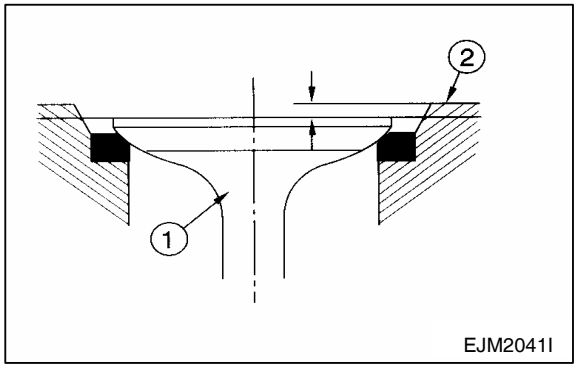
- Install of valve guide
- The height from the bottom of the cylinder head to the edge of valve guide top should be 14.1mm.



EJM2040S

4) Valve depression

- Install the valve① to the cylinder head②.
- Measure valve depression by using the depth gauge or calibrator from the bottom of cylinder head.
- Seat insert and valve must be replaced if the measured value exceed the specified limit.
- If the valve is replaced, the valve guide must be also replaced.



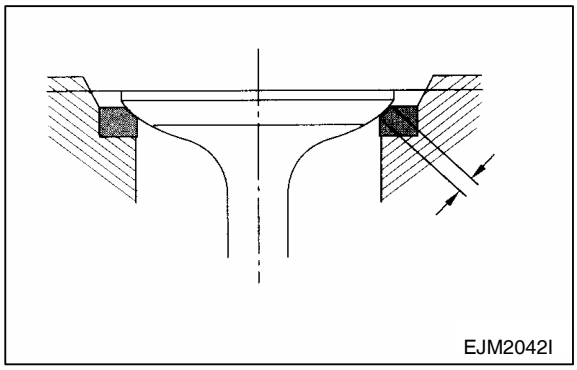
EJM2041I

	Standard	Limit
Intake and exhaust valve depression	1.0 mm	2.5mm

5) Valve contact width

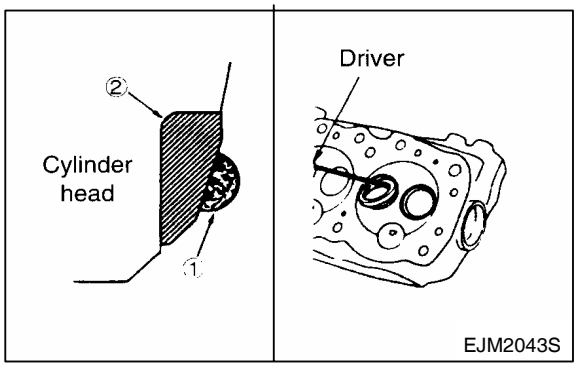
- Inspect the valve contact faces for the roughness and unevenness.
- Make valve contact surfaces smooth.
- Measure the width of valve contact.

	Standard
Valve contact width, Intake	2.4mm
Valve contact width, Exhaust	1.6mm



6) Valve seat replacement

- Arc weld entire inside circumference① of the valve seat②. (see figure)
- Cool valve seat for a few minutes. This will make removal of the valve seat easier.
- Pull out the valve seat by using the inner extractor.
- Carefully remove the carbon and other foreign material from the cylinder head insert bore.

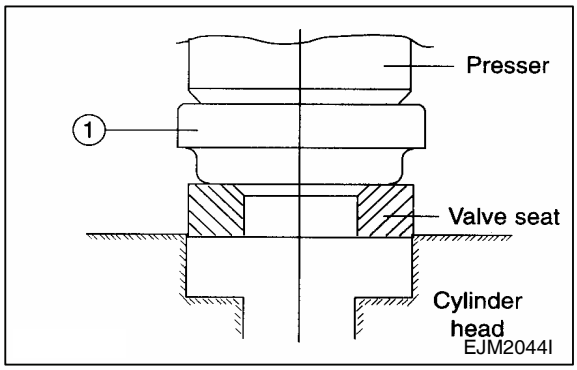


7) Valve seat installation

- Carefully place Jig①.

CAUTION:
The smooth face of jig must contact the valve seat.

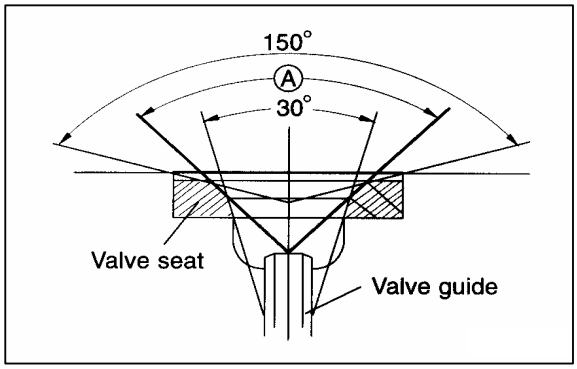
- Assemble valve insert by slowly pressing it against the jig with the bench press. (The amount of needed pressure is more than 2,500kg.)



IMPORTANT:
Do not press the valve seat excessively with the bench press. It may damage the valve seat.

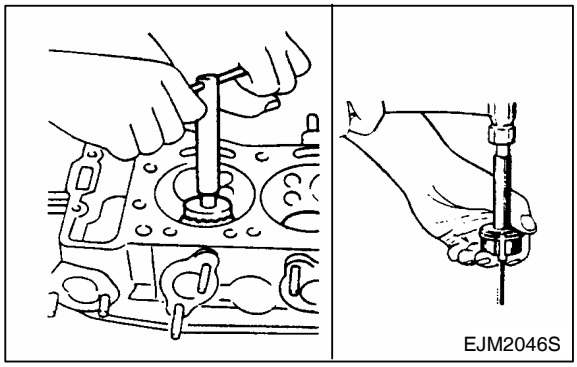
8) Valve seat correction

- Remove the carbon deposits from the valve seat surface.
- Remove the rough areas by using valve cutter. (30°, 90° or 150°)
  Do not cut the valve seat too much.

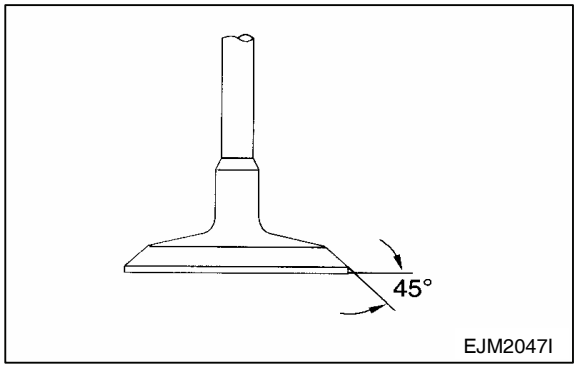


Angle Location	Standard
Intake valve seat	90°
Exhaust valve seat	90°

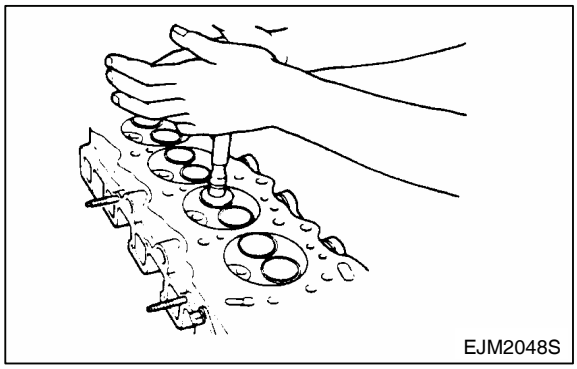
IMPORTANT:
Use an adjustable valve cutter pilot.
Do not allow the cutter pilot to wobble inside the valve guide.



- Spread compound on the surface of valve seat.
- Insert valve into valve guide.
- Lap the valve and valve seat with the lapping tool.
- Check that valve contact width is correct.



- Check that the entire surface of valve seat is in contact with the valve.

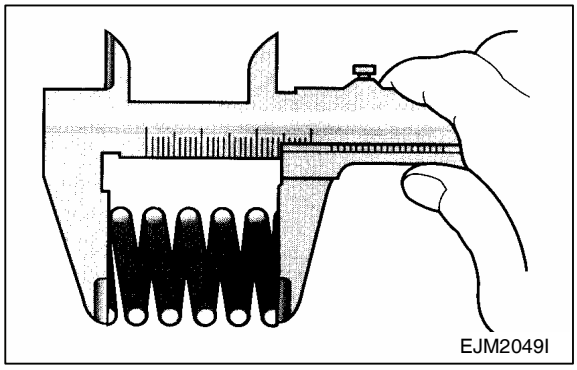


3.2.4. Valve spring

1) Valve spring free length

- Measure the valve spring with the vernier caliper.
- Replace the spring if the measured value is less than the specified limit.

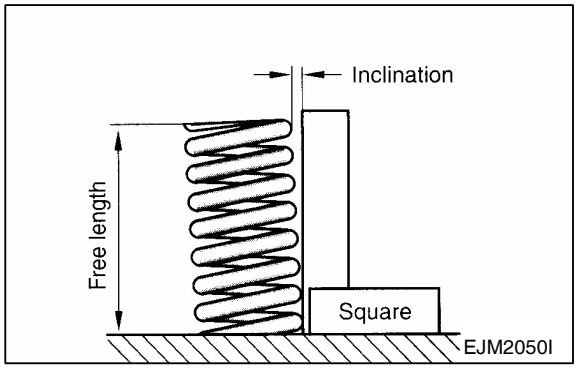
	Standard	Limit
Exhaust and intake valve spring free length	53.65 mm	52 mm



2) Valve spring inclination

- Measure the valve spring inclination by the using of square.
- Replace the valve spring if the measured value exceed the specified limit.

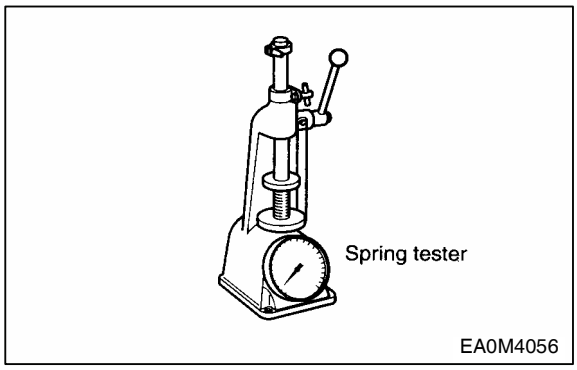
	Standard	Limit
Valve spring Inclination	2.5 mm	3.5 mm



3) Valve spring tension

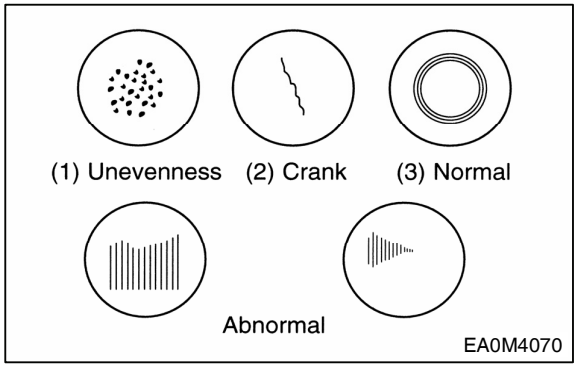
- Measure the valve tension by using spring tester.
- Replace the valve spring if the measured value exceed the specified limit.

	Standard	Limit
Valve spring tension at 44mm set length	22.5 kg	20.0 kg



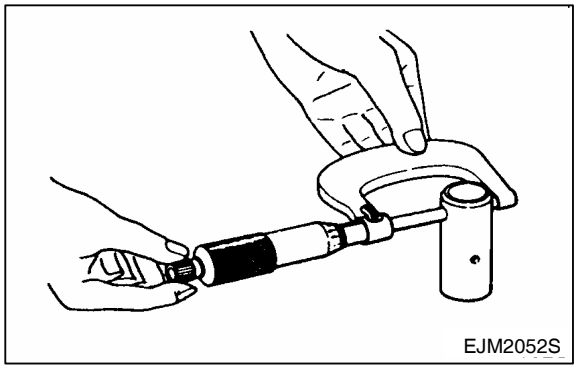
3.2.5. Tappet

- Check the valve tappets for excessive wear, damage or abnormalities.



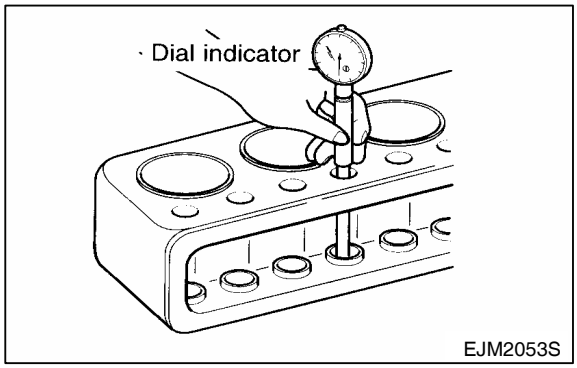
- Measure the outside diameter of tappet with the micrometer.

	Standard	Limit
Tappet outside diameter	∅27.96 ~ ∅27.98mm	∅27.92 mm



- Measure the clearance between tappets and cylinder motion parts by the using dial indicator.

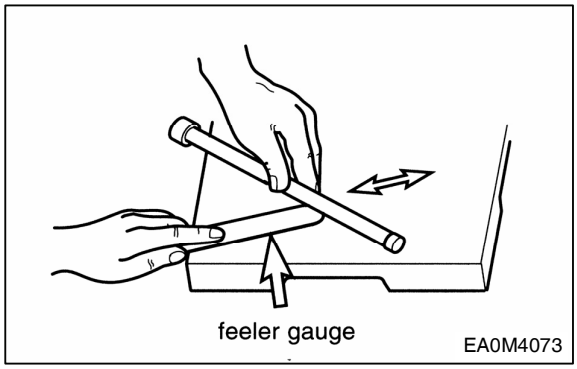
	Standard	Limit
Tappet and tappet bore clearance	0.020 ~ 0.054mm	0.1mm



3.2.6. Push rod

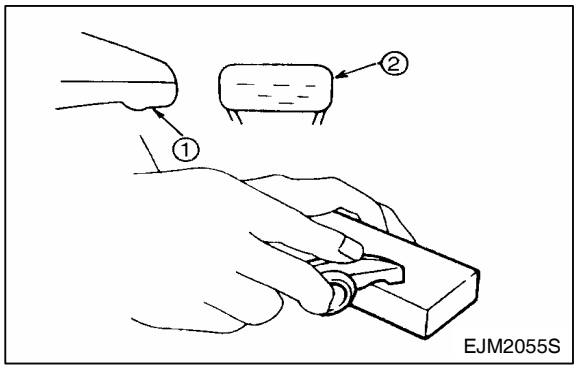
- Measure the run out of push rod with the feeler gauge.
- Roll the push rod along a smooth flat surface as shown in the figure.

	Limit
Push rod of run-out	0.2mm



3.2.7. Rocker arm correction

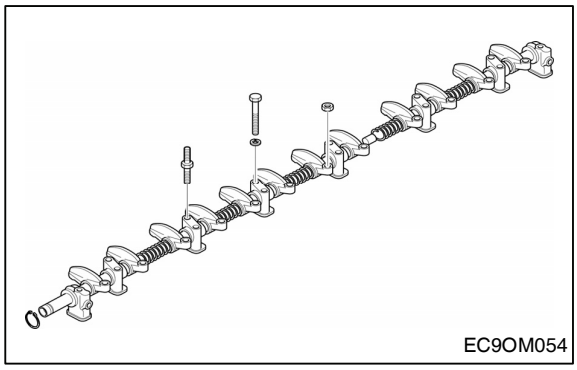
- Check the valve stem contact part of rocker arm.
- Grind contact surface with an oil stone if it is irregularly contacted.
- Replace the rocker arm if it is extremely damaged.



EJM2055S

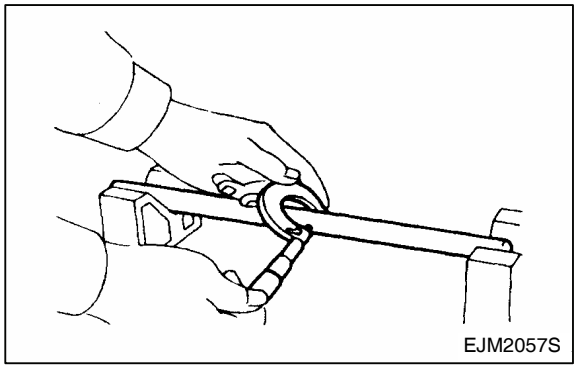
1) Rocker arm and shaft

- Check the disassembled parts for wear, damage and abnormalities.


EC9OM054

2) Rocker arm shaft outside diameter

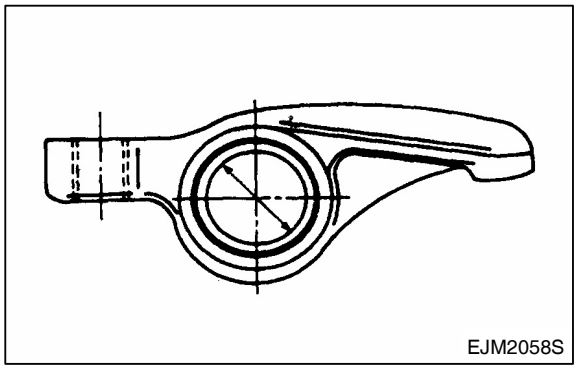
- Measure the outside diameter of rocker arm with the micrometer.
- Replace shaft if measured value exceed the specified limit.


EJM2057S

	Standard	Limit
diameter of rocker arm shaft	∅18.98-∅19.00 mm	∅18.85 mm

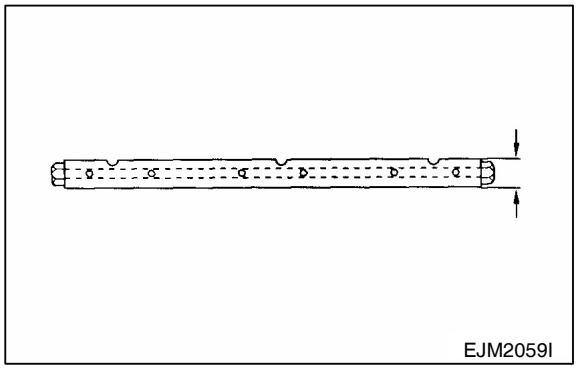
3) Rocker arm and shaft clearance

- Measure the inside diameter of rocker arm bushing with the vernier caliper.
  the out side diameter of rocker arm shaft.
- Replace the rocker arm or rocker arm shaft if measured value exceed the specified limit.


EJM2058S

	Standard	Limit
Diameter of rocker Arm bushing	∅19.02 ~ ∅19.05mm	∅19.07 mm

	Standard	Limit
Rocker arm bushing and rocker arm shaft clearance	0.02 ~ 0.07 mm	0.2 mm

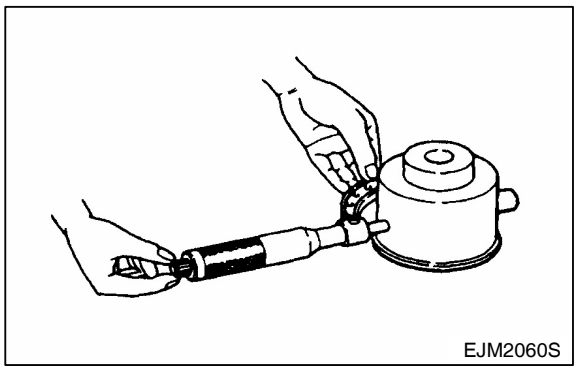

EJM2059I

- Check the rocker arm oil port whether alien substance is in it or not.
- Clean the rocker arm oil port with compressed air if necessary.

3.2.8. Idler gear and shaft

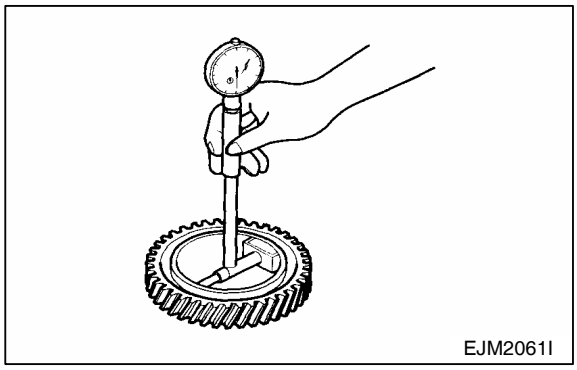
- Replace the idler gear shaft if the measured value exceeds the specified limit.

	Standard	Limit
Diameter of idler gear shaft	∅44.945 ~ ∅44.975 mm	∅44.9 mm


EJM2060S

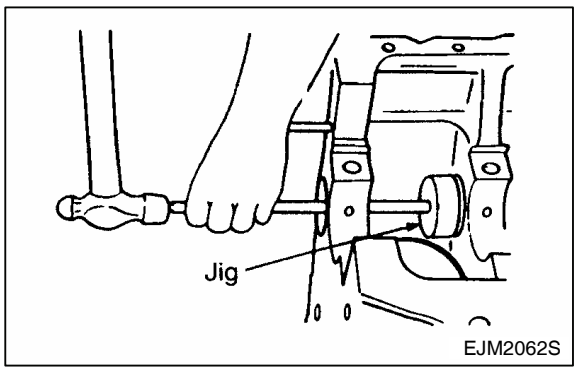
- Measure the inside diameter of idler gear with the dial indicator,

	Standard	Limit
Clearance of idle gear and shaft	0.045 ~ 0.105 mm	0.2 mm


EJM2061I

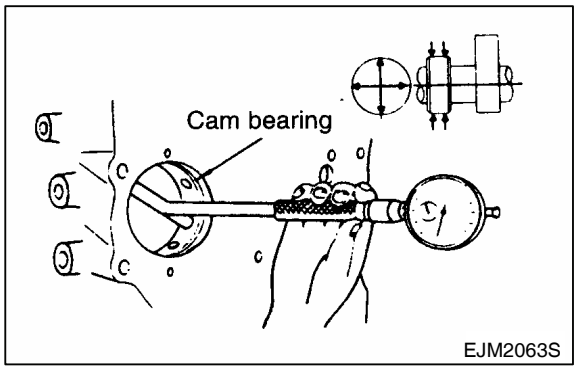
3.2.9. Camshaft

- Use the jig to install or overhaul camshaft bearing in cylinder block.
- Measure the clearance between the cam journal and the camshaft bearing.

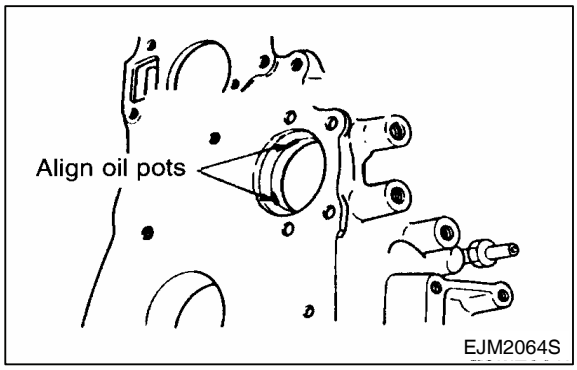


EJM2062S

	Standard	Limit
Clearance of cam journal and cam bearing	0.03 ~ 0.09 mm	0.15 mm

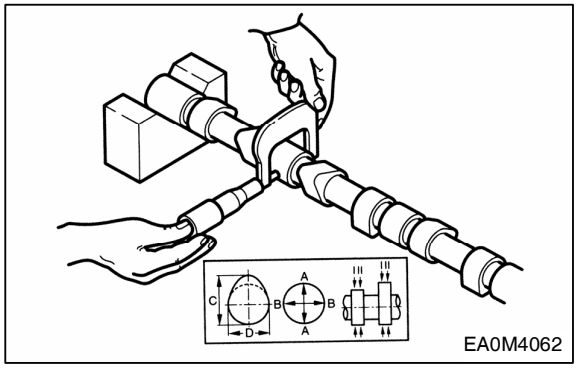


- Align the camshaft bearing oil port with the mating oil port (machined on the cylinder block).



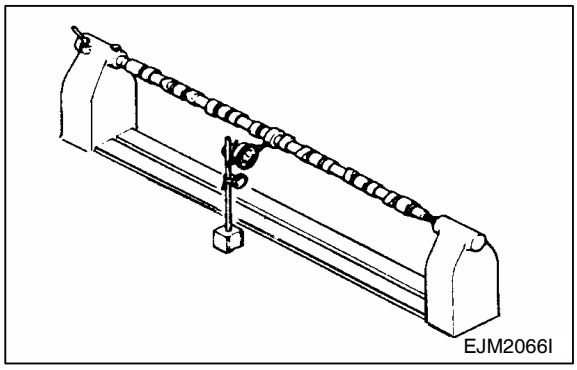
- Measure the cam lobe with the micrometer. Replace the camshaft if the measured values exceed the specified limit.

	Standard	Limit
Cam lobe height (C-D), In	7.44 mm	6.94 mm
Cam lobe height (C-D), Ex	7.71 mm	7.21 mm
Cam journal diameter	∅56.0 mm	∅55.6 mm



- Set up the camshaft on a measuring stand.
- Measure the run out of camshaft with the dial indicator.
  Record the measured value (T.I.R)
  Replace the camshaft if the measured value exceeds the specified limit.

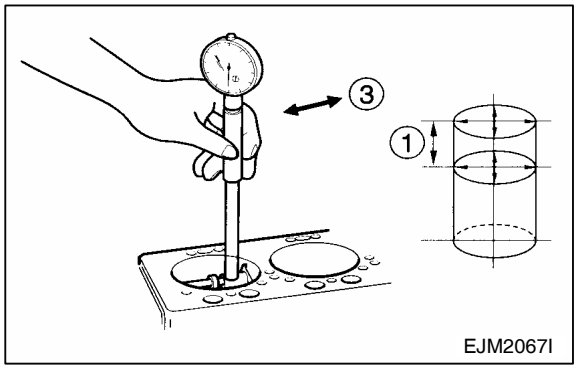
	Limit
Camshaft run-out	0.12 mm



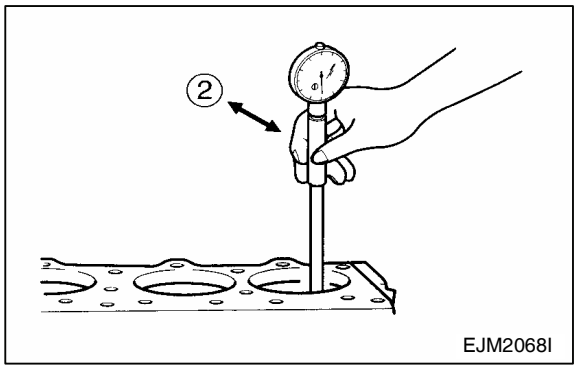
3.2.10. Cylinder liner

1) Cylinder liner bore measurement

- Measure the bore at measuring position ① in line with the crankshaft③ and across the crankshaft②.



- Measured position: 20 mm from the top of liner. (max. wear portion)
- Replace the cylinder liner if the measured value exceeds specified limit.

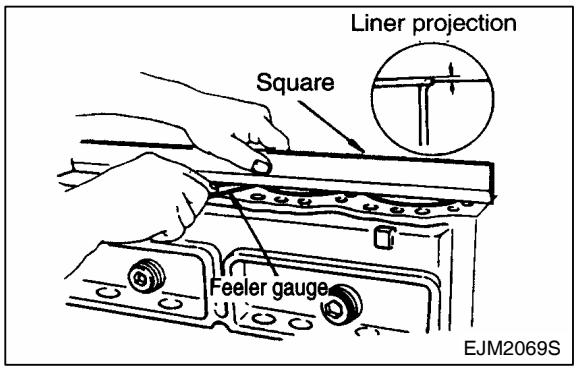


	Standard	Limit
Diameter of cylinder liner bore	∅102.017~ ∅102.046 mm	∅102.20 mm

CAUTION:
The casting liner is specially honed without the chrome plating inside, so that chrome plated ring (top ring and oil ring) must be used.

2) Cylinder liner inspection

- Set up the straight square along the top edge of cylinder liner.
- Measure liner projection with the feeler gauge.

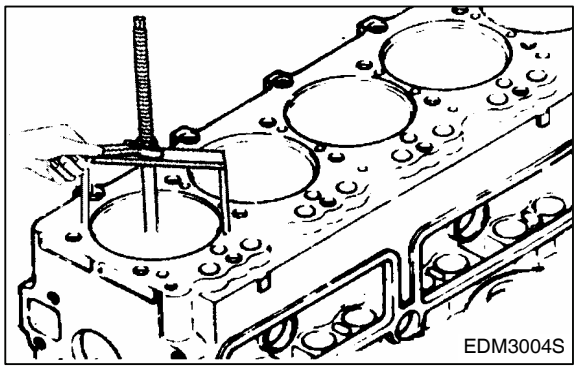


	Standard	
Cylinder liner projection	Cast liner	0.02 ~ 0.07 mm
	Steel liner	0.015 ~ 0.115mm

- The difference in the liner projection height between any two adjacent cylinders must NOT exceed 0.3mm

3) Cylinder liner replacement

- Set the cylinder liner remover to the cylinder liner.
- Check that cylinder liner remover shaft ankle is firmly gripping the cylinder liner bottom edge.
- Slowly turn the remover shaft handle counter-clockwise to pull the cylinder liner free.

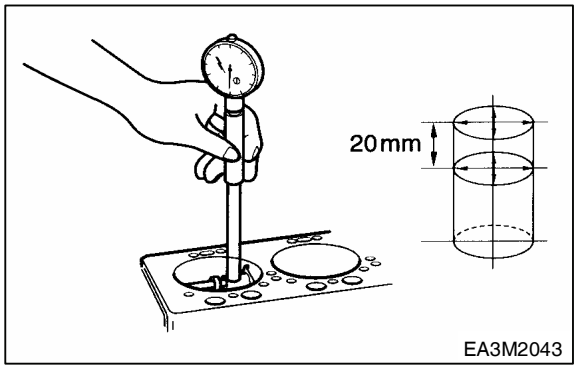

EDM3004S

IMPORTANT:
Take care not to damage the cylinder body upper face when remove the cylinder liner.

3.2.11. Cylinder block

1) Grade selection of cylinder liner

- Select a grade from the outside diameter of the cylinder liner and inside diameter of block combination.
- Determine a grade of the cylinder liner after measuring the inside diameter of the cylinder block.
- Loose fitting cylinder liners (the liner is too small for the cylinder bore) will adversely affect engine cooling efficiency and may lead to serious engine damage. Cylinder liners which are too large for the cylinder bore will be difficult to install.



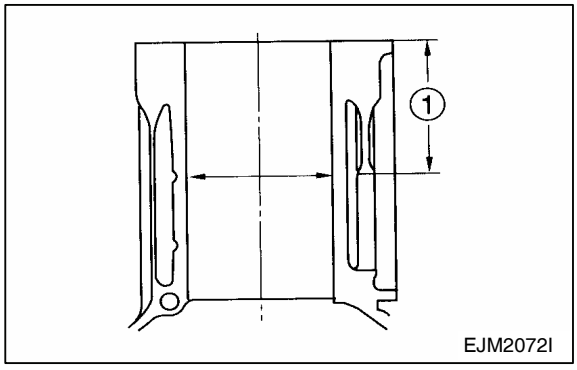
EA3M2043

2) Cylinder block bore measurement

- Measure at measuring point① across the positions W- W, X-X, Y-Y and Z-Z.

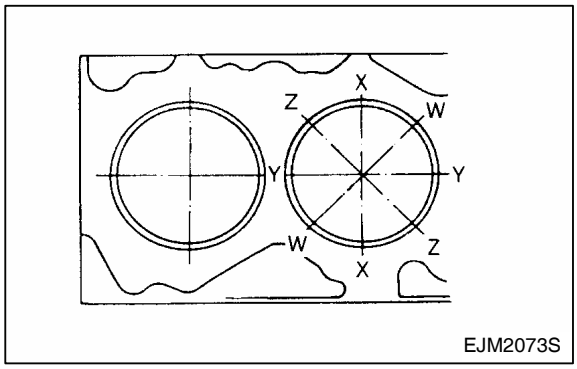
  Measuring point□ diameter : 115 mm

- Calculate average value of four measurements to determine the correct cylinder liner grade.



EJM2072I

Grade marking	Cylinder block bore diameter
1	∅105.090 ~ ∅106.000 mm
2	∅106.000 ~ ∅106.010 mm

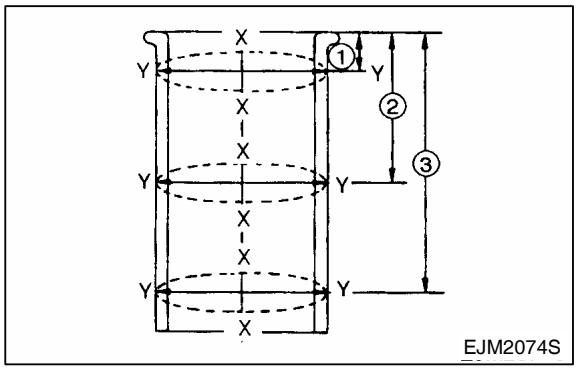


EJM2073S

3) Cylinder liner outside diameter

- Measure the liner outside diameter at ①, ② and ③measuring point across X-X, Y-Y.

  Measuring Points :
  ① 20.0 mm
  ② 105.0 mm
  ③ 185.0 mm



EJM2074S

- Calculate the average value of 6 measurements to determine the correct cylinder liner grade.
- Combination of the cylinder bore and the cylinder liner outside diameter.

	Steel liner (tightness)	Cast iron liner (clearance)
Cylinder liner fitting clearance	0.001 ~ 0.019mm	0.005 ~ 0.026mm

<Cylinder bore and liner outside diameter>

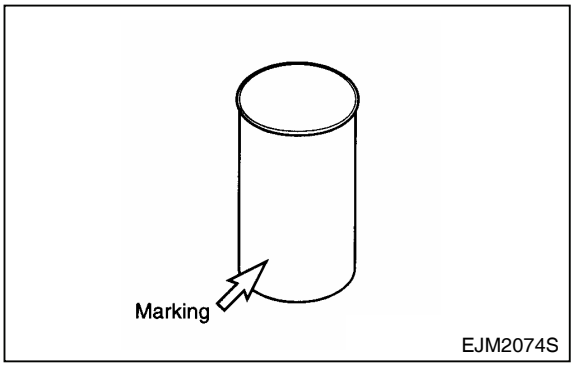
(A) Steel cylinder liner

Grade	Cylinder bore	Cylinder liner outside diameter
1	∅105.001 ~ ∅105.010mm	∅105.011 ~ ∅105.020mm
2	∅105.011 ~ ∅105.020mm	∅105.021 ~ ∅105.030mm
3	∅105.021 ~ ∅105.030mm	∅105.031 ~ ∅105.040mm

(B) Cast iron cylinder liner

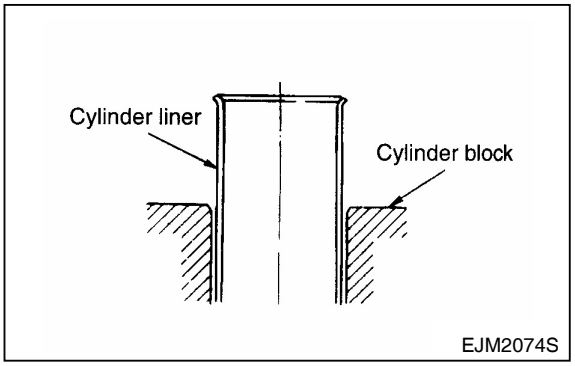
	Cylinder liner diameter		Grade marking
	② position	①, ③ position	
∅D (Inner diameter)	∅102.020 ~ ∅102.031mm	∅102.017 ~ ∅102.035mm	1
	∅102.031 ~ ∅102.042mm	∅102.028 ~ ∅102.046mm	2
∅E (Outer diameter)	∅105.973 ~ ∅105.984mm	∅105.970 ~ ∅105.988mm	A
	∅105.984 ~ ∅105.995mm	∅105.981 ~ ∅105.999mm	B

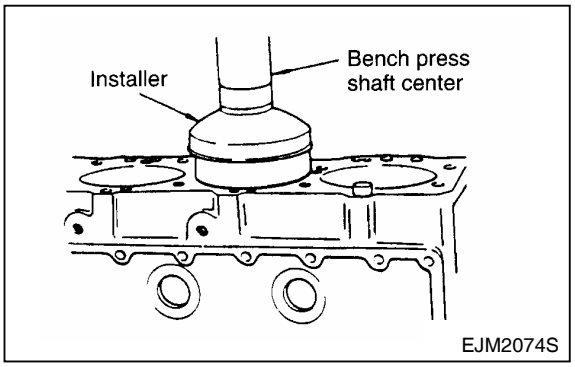
Part no of cylinder liner grade	Cylinder liner diameter		Marking
	Outer	Inner	
65.01201-0068	1	A	1A
65.01201-0069	1	A	1B
65.01201-0070	2	B	2A
65.01201-0071	2	B	2B



4) Cylinder liner assembly

- Carefully wipe away any foreign material from the cylinder liner inside and outside surfaces and the cylinder bore.
- Cleanly wash cylinder liner and bore surfaces with new kerosene or diesel oil.
- Use a clean rag to remove all traces of kerosene or diesel oil from cylinder liner and bore surfaces.
- Insert the cylinder liner into cylinder block from the top of the cylinder block.
- Set the cylinder liner installer to the top of the cylinder liner.
- Position the cylinder body so that the installer center is directly beneath the bench press shaft center.
- Check that the cylinder liner is set perpendicular to the cylinder.
- Use the bench press to apply an initial seating force of 500kg to the cylinder liner.
- Use the bench press to apply a final seating force of 2,500kg to fully seat the cylinder liner.
- After installing the cylinder liner, measure the cylinder liner projection.





5) Piston grade selection

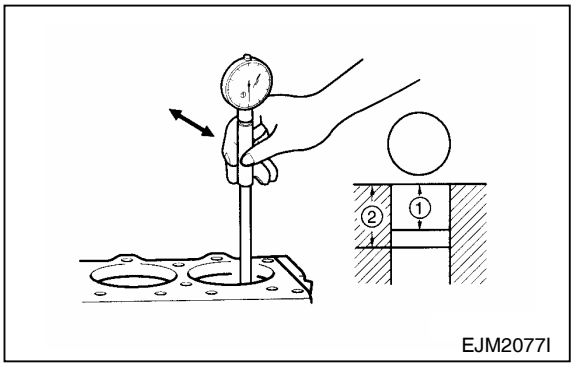
- ”Piston grade” refers to the piston diameter and the cylinder liner bore combination.
- Selection of the proper piston grade will ensure efficient engine operation, free from cylinder liner and piston problems.
- Measure the cylinder liner bore after installing the cylinder liner.
- Determine the appropriate piston grade after measuring cylinder liner bore.

6) Cylinder liner bore measurement

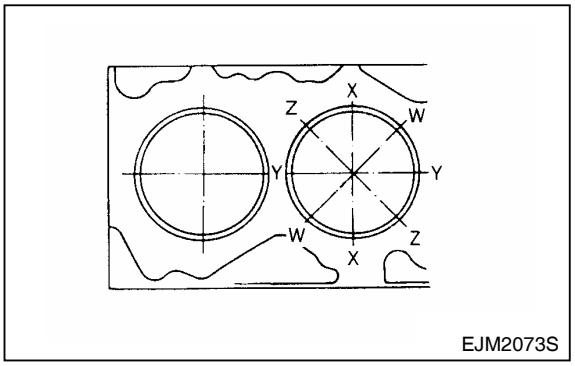
- Loacte the two measuring points.

  Cylinder liner measuring point

  - ① **: 20mm**
  - ② **: 105mm**
- Measure cylinder liner bore at measuring points ① and ② in four different directions (X-X, Y-Y, W-W and Z-Z).
- Calculate the average value of the 8 measurements.



	Standard
Cylinder liner bore	∅102.020 ~ ∅102.042 mm



CAUTION:

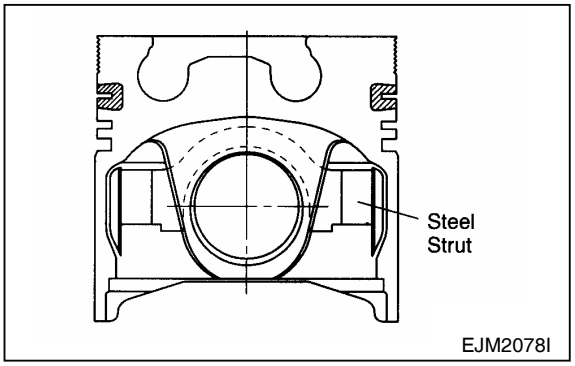
It is most important to use correct piston-liner combination. Incorrect combination will result in piston seizure.

Always measure the cylinder bore and select the appropriate piston grade.

3.2.12. Piston

1) Piston outside diameter

- Piston outside diameter vary depending on the piston type to be used.
- Measure the piston outside diameter ② (see figure).

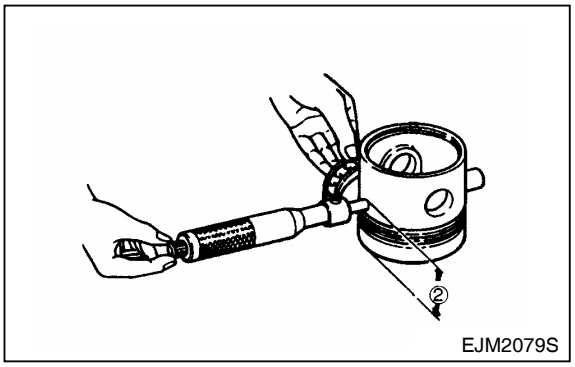


<Piston grade>

Grade	Limit
A	∅101.953 ~ ∅101.967 mm
B	∅101.963 ~ ∅101.977 mm

<Cylinder liner bore and piston>

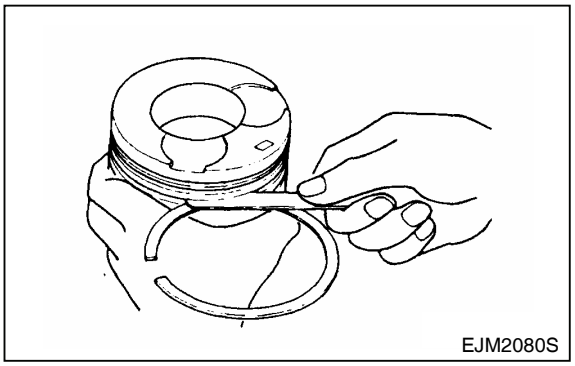
Clearance	0.053 ~ 0.077 mm



CAUTION:
The cylinder liner-piston kit clearances are preset. However, the cylinder liner installation procedure may result in slight decreases in the cylinder liner bore clearances.
Always measure the cylinder liner bore clearance after installation to be sure that it is correct.

2) Piston ring and piston groove clearance

- Measure the piston ring and the piston ring groove clearance with a feeler gauge.
- Measure it at several points around the piston.
- Replace the piston ring If the measured value exceeds the specified limit.

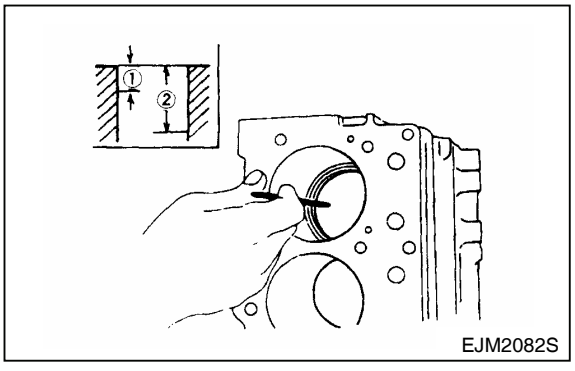


<Piston ring and piston groove clearance>

	Standard	Limit
Top ring	0.070 ~ 0.120 mm	0.20
2nd ring	0.050 ~ 0.085 mm	0.15
Oil ring	0.030 ~ 0.070 mm	0.15

3) Piston ring gap

- Insert the piston ring horizontally (in the position it will assume if it were installed to the piston) into the cylinder liner.
- Push the piston ring with an inverted piston into the cylinder liner until it reaches measuring point ① or ②.
  The cylinder liner diameter is the smallest at these two points.
  Do not allow the piston ring to slant to one side or the other. It must be perfectly horizontal.
  Cylinder liner measuring point
  - ① **: 10mm**
  - ② **: 130mm**



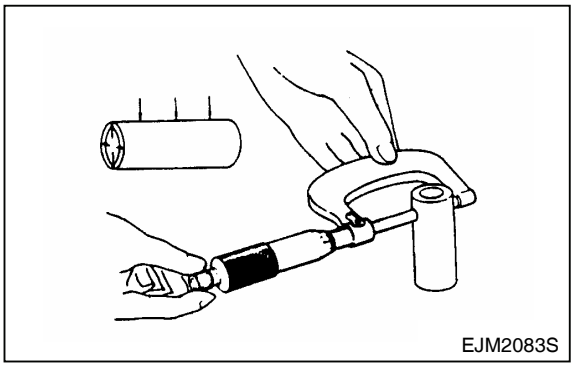
- Measure piston ring gap with a feeler gauge.
- The piston ring must be replaced if the measured value exceeds the specified limit.

	Standard	Limit
Top ring gap	0.25-0.45 mm	1.50 mm
2nd ring gap	0.40-0.60 mm	1.50 mm
Oil ring gap	0.20-0.40 mm	1.50 mm

4) Piston pin

- Measure piston pin outside diameter with micrometer at several points.
- Replace the piston pin if the measured value exceeds the specified limit.

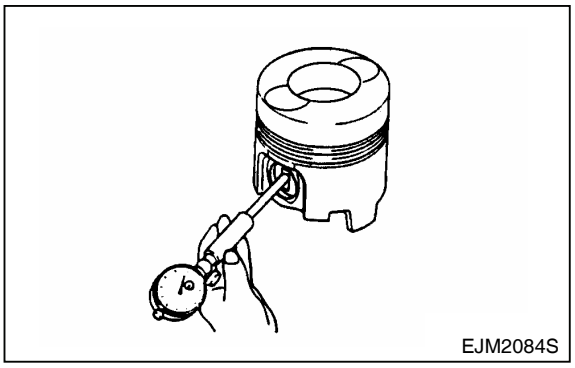
	Standard	Limit
Piston pin outside diameter	Ø35.000 ~ Ø35.005mm	∅34.95 mm


EJM2083S

5) Piston pin hole

- Measure diameter of the piston pin hole with inside dial gauge.

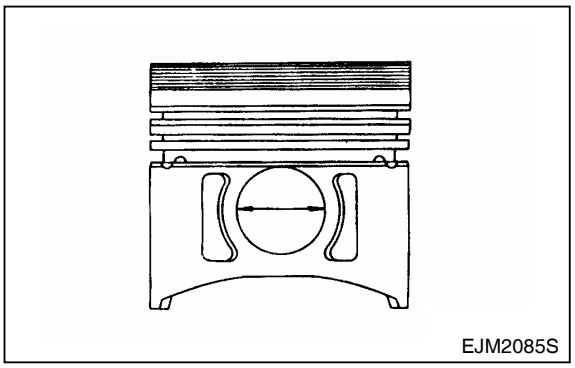
	Standard
Piston pin and piston clearance	Ø35.010 ~ Ø35.018 mm


EJM2084S

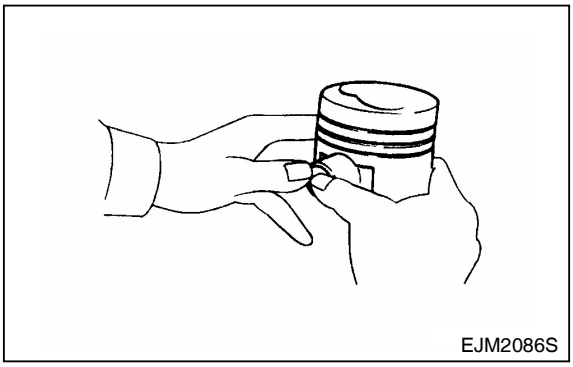
6) Piston pin and piston pin hole clearance

- Determine the clearance between the piston pin and the piston pin hole by calculating the difference between the piston pin hole diameter and the piston pin outside diameter.

	Limit
Piston pin and piston pin hole clearance	0.005 ~ 0.018 mm


EJM2085S

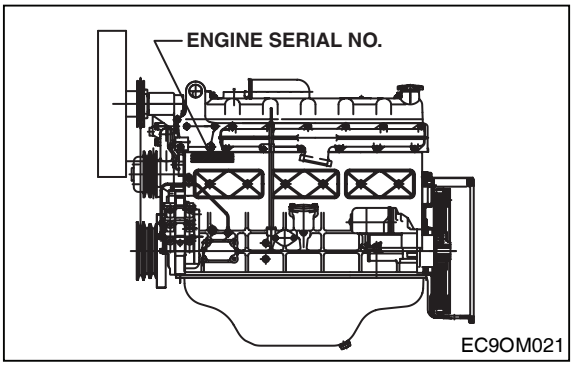
- If an inside dial indicator is not available, use the following procedure to check the piston pin fit.
  (1) Heat piston to approximately 60°C with the piston heater.
  (2) Push strongly against the piston pin with your thumb. The piston pin fitting should feel tight.


EJM2086S

3.2.13. Maintenance of cylinder block, cylinder liner and piston

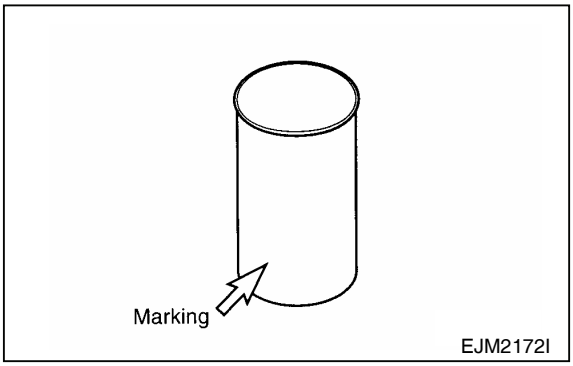
To maintain the engine in optimum condition and retain maximum performance for a long time, the cylinder block, cylinder liner and piston which have the same grade marking number (the same size tolerance) should be assembled. The marking number (the part's grade) and marking position is as follows.

- **Cylinder block**
  a) Marking number ; **1** or **2**
  (Size grade for of cylinder bore diameter)
  b) Marking position ; Top of the cylinder block side surface



EC9OM021

- **Cylinder liner**
  a) Marking number; **1A, 1B, 2A** or **2B**
  1A
  Can used the piston **A** grade
  Can used the cylinder block **1**
  b) Marking position ; Cylinder liner lower surface



EJM2172I

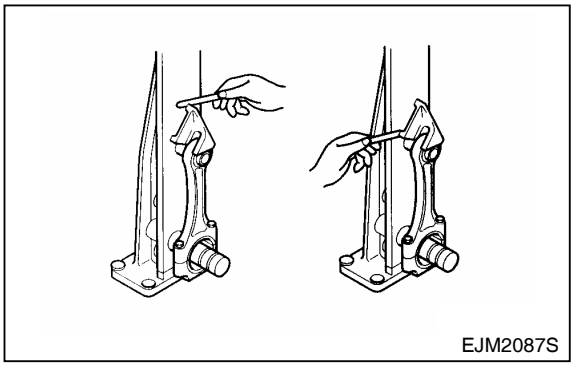
- **Piston**
  a) Marking number ; **A** or **B**
  (Size grade for piston outer diameter)
  b) Marking position ; Center of the piston upper surface

- Assembly process of cylinder block, cylinder liner and piston
  (1) Check the marking number (1 or 2) of cylinder block. (Top of side surface)
  (2) Then assemble the liner whose first digit of the marking (1A, 1B, 2A, 2B) is just the same with it on the cylinder block.
  (3) Assemble the piston whose marking is just same with the second digit (A or B) of the assembled cylinder liner's marking.

3.2.14. Connecting rod

1) Connecting rod alignment

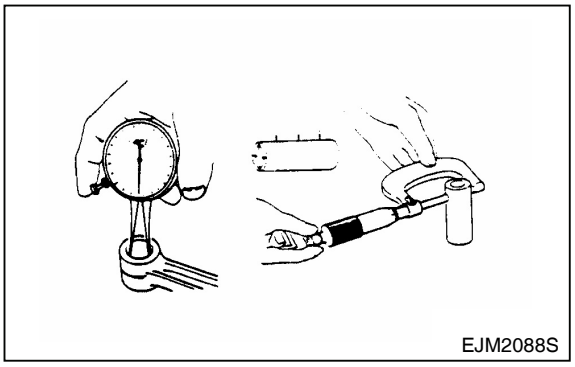
- Measure the parallelism between the connecting rod big end hole and small end hole with a connecting rod aligner.
- Replace the connecting rod if the measured value exceeds the specified limit.


EJM2087S

	Standard	Limit
Connecting rod parallelism	0.05mm or less	0.20 mm

2) Piston pin and bush clearance

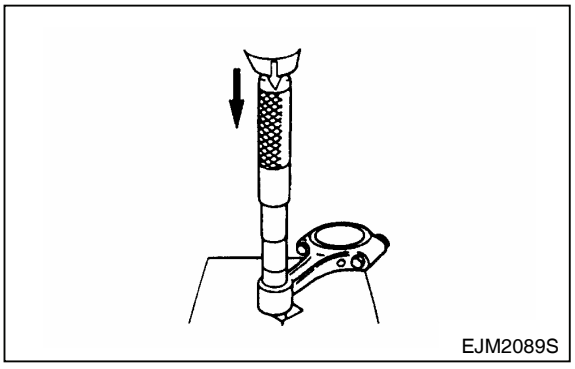
- Measure an inside of connecting rod bushing and outside of piston pin with the caliper gauge and micrometer.
- Replace a connecting rod bush or piston pin if the measured value exceeds the specified.


EJM2088S

	Standard	Limit
Piston pin and bushing clearance	0.012 ~ 0.030mm	0.05 mm

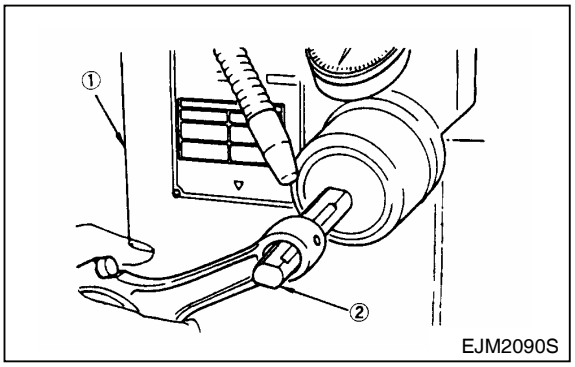
3) Connecting rod bush replacement

- Connecting rod bush removal
  1) Clamp the connecting rod in a vise.
  2) Pull out connecting rod bush by using a brass bar with a bench press or a hammer.
- Connecting rod bush assembly
  (1) Use special jig to assemble the connecting rod bush.


EJM2089S

IMPORTANT:
Align the connecting rod bush oil hole with the connecting rod oil hole.

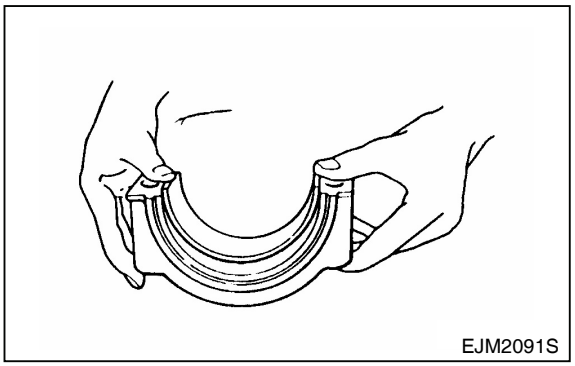
(2) Use a piston pin hole grinder① fitted with a reamer② or an adjustable pilot reamer to ream the piston pin hole.



	Standard
Connecting rod bush inside diameter	Ø35.017 ~ Ø35.030 mm

4) Connecting rod bearing Inspection

- Fit the connecting bearing lower half into the connecting rod bearing cap.
- Check the tension of the connecting rod bearing lower half.
- If the tension is insufficient, the bearing must be replaced.
- Tighten the connecting rod and the bearing cap to the specified torque.

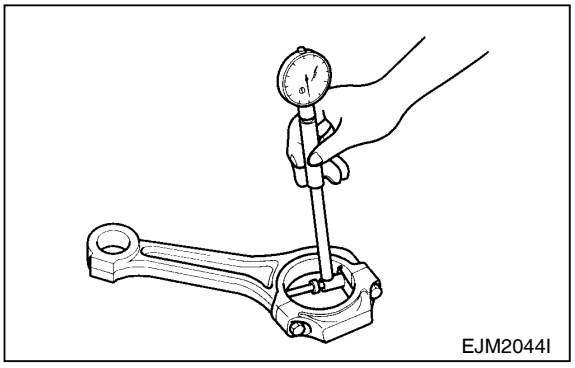


	A type	B type
Connecting rod bolt torque	12 0± 0.25kg.m	9.75± 0.25kg.m

A type : 11 marked on bolt head

B type : TY 11 **or** TY 12

- Measure the inside diameter of the connecting rod bearing with an inside dial gauge.



	Standard
Connecting rod bearing diameter	Ø63.974 ~ Ø64.005 mm

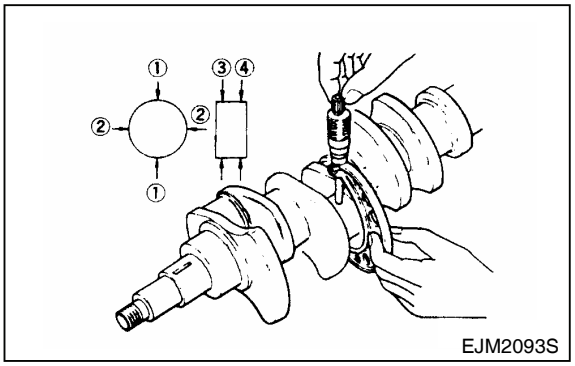
3.2.15. Crankshaft

1) Crankshaft and bearing inspection

- Check the crankshaft journal surfaces and pin surfaces for excessive wear and damage.
- Check oil seal fitting surfaces of the crankshaft front and rear ends for excessive wear and damage.
- Replace or repair the crankshaft if any excessive wear or damage is discovered.
- Check the crankshaft oil ports for obstructions.
- Clean oil port with high pressure air if necessary.

2) Crankshaft journal and pin diameter

- Measure the crankshaft journal outside diameter with the micrometer across ①-① and ②-②.
- Measure crankshaft journal outside diameter at two points ③ and ④ by using the micrometer.
- Repeat step 1 and 2 to measure the crankshaft outside diameter.
- The crankshaft must be reground if the measured value of the crank pin outside diameter and/or crankshaft journal diameter exceeds the specified limit.



	Standard
Crankshaft journal outside diameter	Ø79.905 ~ Ø79.925mm

	Standard
Crankshaft pin outside diameter	Ø63.924 ~ Ø63.944 mm

- Measure the crankshaft journal outside diameter (and/or crankshaft pin outside diameter) and bearing inside diameter to determine the bearing clearance.

3) Crankshaft journal and bearing clearance

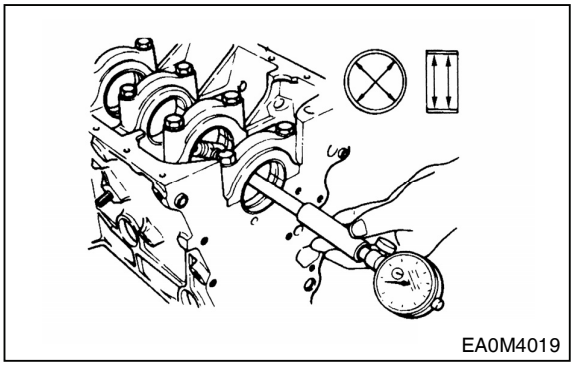
- If the bearing clearance exceeds the specified limit, the crankshaft must be reground and/or the bearing must be replaced.

	Standard	Limit
Main bearing clearance	0.025 ~ 0.090 mm	0.11 mm

	Standard	Limit
Rod bearing clearance	0.03 ~ 0.073 mm	0.10 mm

4) Crankshaft bearing diameter

- Install the main bearing cap with bearings to the cylinder block with the specified torque and facing the arrow mark on the bearing cap toward front. Place them in order of punched cylinder numbers.
- Measure the main bearing diameter with an inside dial gauge.

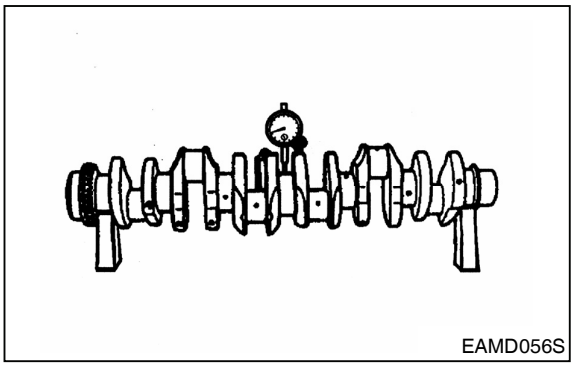

EA0M4019

Main bearing cap torque	24.1±1kg.m

Main bearing diameter	Ø80 mm

5) Crankshaft run-out

- Mount the crankshaft on a set of V-blocks.
- Set the dial gauge to the center of the crankshaft journal.
- Gently rotate the crankshaft in the normal direction of engine rotation.
- Read the dial indicator (TIR) as you turn the crankshaft.
- The crankshaft must be replaced if the measured value exceeds the specified limit.

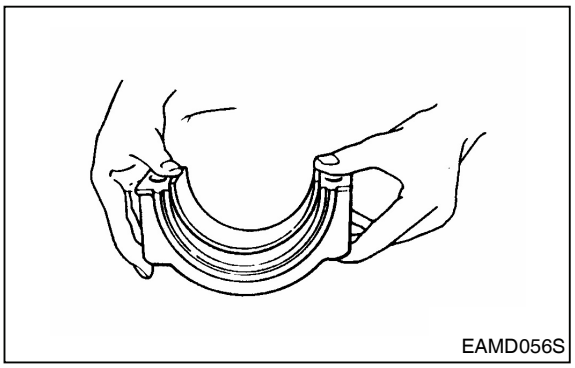

EAMD056S

	Standard	Limit
Crankshaft run-out	0.05 mm	0.40 mm

- If the repaired crankshaft generated a crack, replace it.

6) Main bearing and con-rod bearing tension

- Check to see if the bearing has enough tension, and set bearing into its regular position with the finger pressure.


EAMD056S

7) Crankshaft regrinding

- Pay close attention to the following steps in order to ensure the reground-crankshaft reliability.

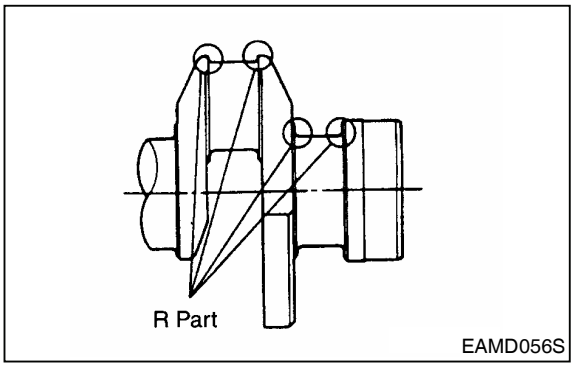
Undersize bearing Availability	0.25 mm	0.50 mm

<Crankshaft regrinding procedure>

(1) Grind the crankshaft journal part and pin part.

(2) Fillet the crankshaft journal and crank pin radius to a minimum of R3.5±0.2. There must be no stepping around the fillet area.

(3) Finish the crankshaft journal, crank pin and oil hole corners to a smooth surface having a chamfer radius of 1mm.



EAMD056S

Crankshaft Journal and crank pin roughness	0.4μ or less

(4) Measure the clearance between crankshaft journal and crank pin.

(5) Measure the crankshaft run-out.

8) Crankshaft grinding limit

Classification	Limit
Crank journal outside Diameter	∅79.419 mm
Crank pin outside Diameter	∅63.424mm

- Undersize bearings (0.25 and 0.5 mm) are available to compensate for excessive clearance between the crankshaft journal bearing and the crankshaft. Regrinding of the crankshaft to fit the undersize bearings is require

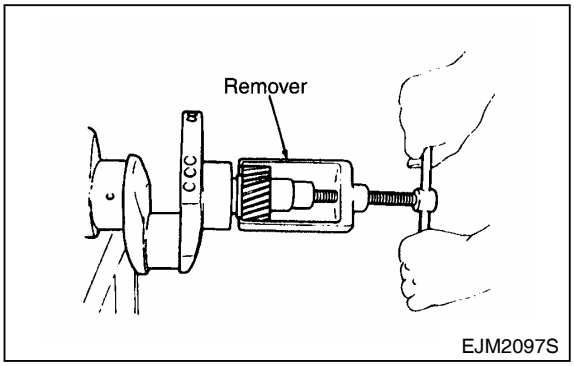
	Standard	Limit
Main bearing clearance	0.039 ~ 0.098 mm	0.11 mm

	Standard	Limit
Connecting rod bearing	0.03 ~ 0.073 mm	0.10 mm

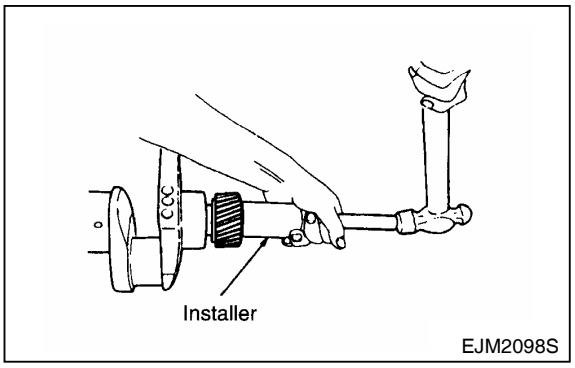
9) Crankshaft gear replacement

- Visually inspect the crankshaft gear.
- Replace the crankshaft gear as following steps if excessive wear or damage is discovered.

(1) Disassemble the crankshaft gear by using the crankshaft remover.



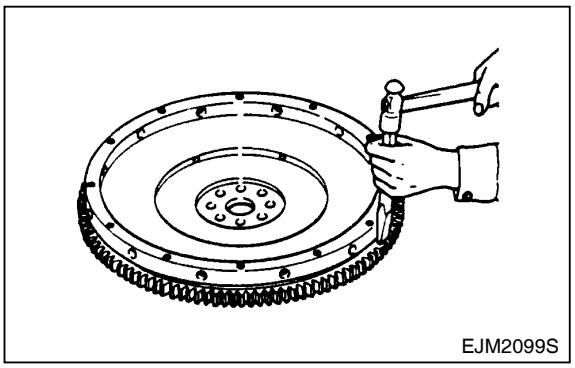
(2) Replace new part.
(3) Heat the crankshaft gear for at least 10 minutes to 120oC
(4) Use the crankshaft gear installer to install the crankshaft gear.



3.2.16. Flywheel and flywheel housing

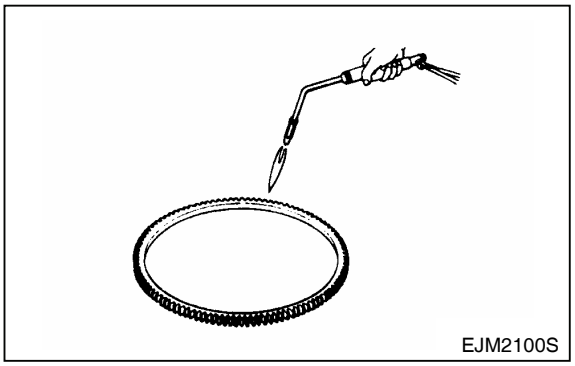
1) Ring gear inspection

- Inspect the ring gear.
- If the ring gear teeth are broken or excessively worn the ring gear must be replaced.


EJM2099S

2) Ring gear replacement

- Strike around the edges of the ring gear with a hammer and chisel to remove it.

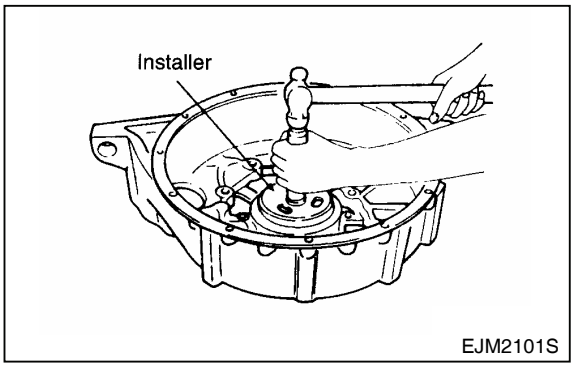

EJM2100S

3) Ring gear installation

- Heat the ring gear evenly with a gas burner to invite thermal expansion.
  Pay attention that temperature of ring gear is not exceeded 200°C.
- Use a hammer to install the ring gear when it is sufficiently heated.

4) Oil seal replacement (rear)

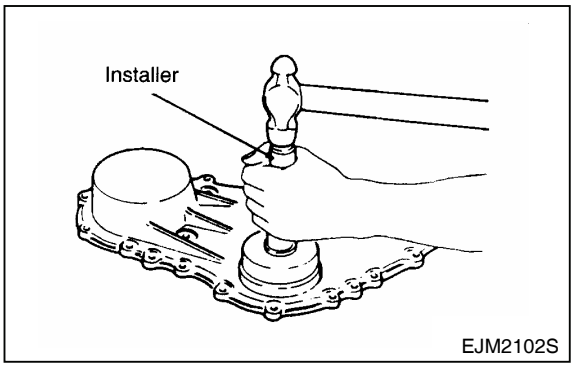
- Use a pry bar to remove the flywheel housing oil seal.
- Assemble the oil seal to flywheel housing by using the oil seal assemble jig.



EJM2101S

5) Oil seal replacement (front)

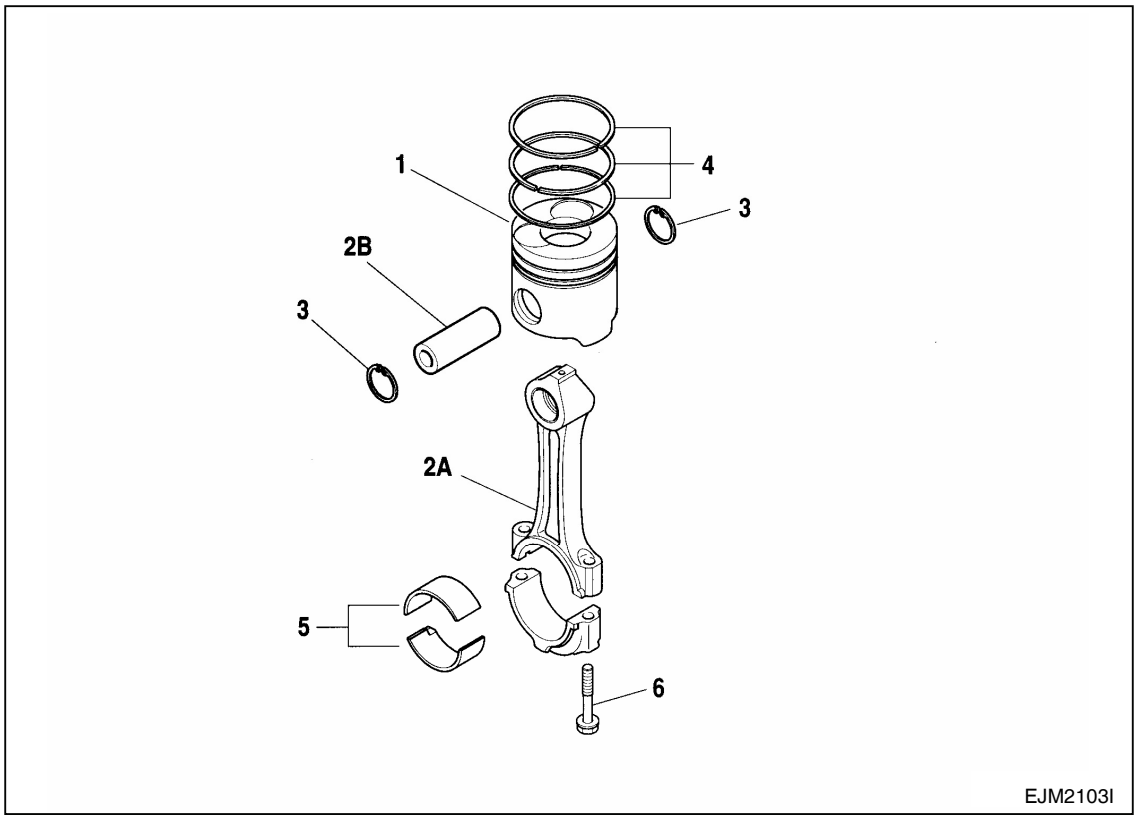
- Use an adapter and a hammer to remove the crankshaft front end oil seal.
- Assemble the oil seal to flywheel housing by using the oil seal assemble jig.



EJM2102S

3.3. Engine Reassembly

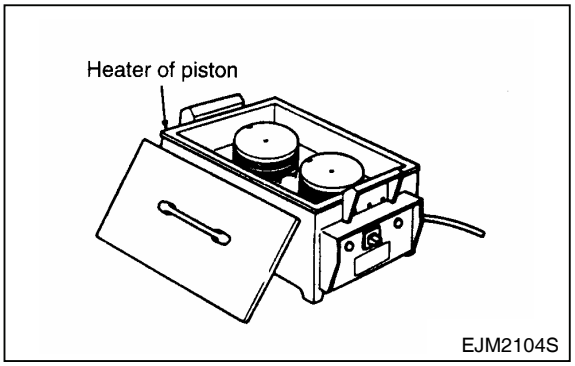
3.3.1. Piston and connecting rod assembly



- ▲ 1. Piston
- ▲ 2. Piston Pin and connecting rod
- ▲ 3. Snap ring
- ▲ 4. Piston ring
- ▲ 5. Connecting rod
- 6. Connecting rod bolt

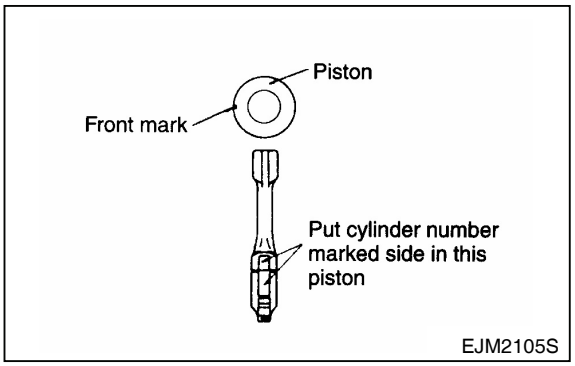
1) Piston

- Use a piston heater to heat piston to approximately 60°C.



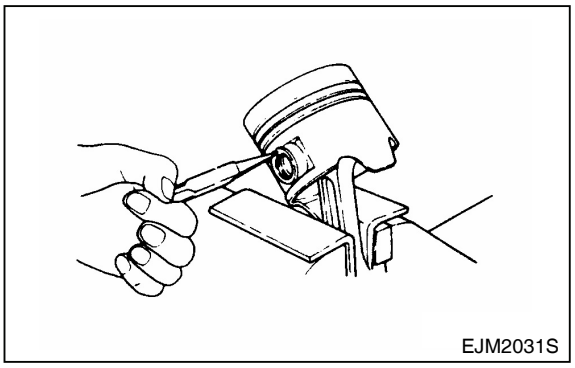
2) Connecting rod

- Install the piston and connecting rod with setting the marks as illustrated.
- Assemble the piston pin into the piston and connecting rod bushing.



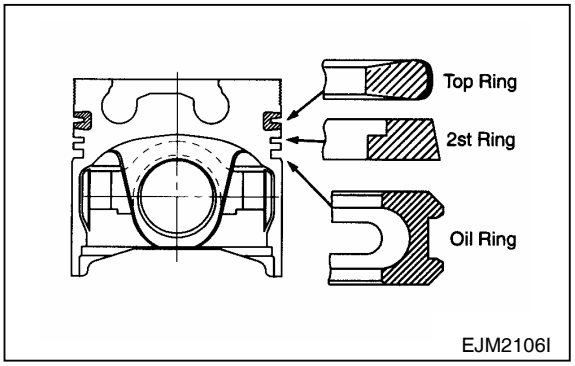
3) Snap ring

- Assemble the snap rings by using snap ring flyer.
- Check that the piston moves smoothly on the piston pin.



4) Piston ring

- Assemble the piston ring by using piston ring assembly jig.
- Systematically assemble piston rings as follows:
  (1) Oil ring
  (2) 2nd compression ring
  (3) 1st compression ring
  Rightly assemble the 1st and 2nd compression rings that the marked side must be facing ”up”.
  Oil ring may be assembled any way because it is not indicated.

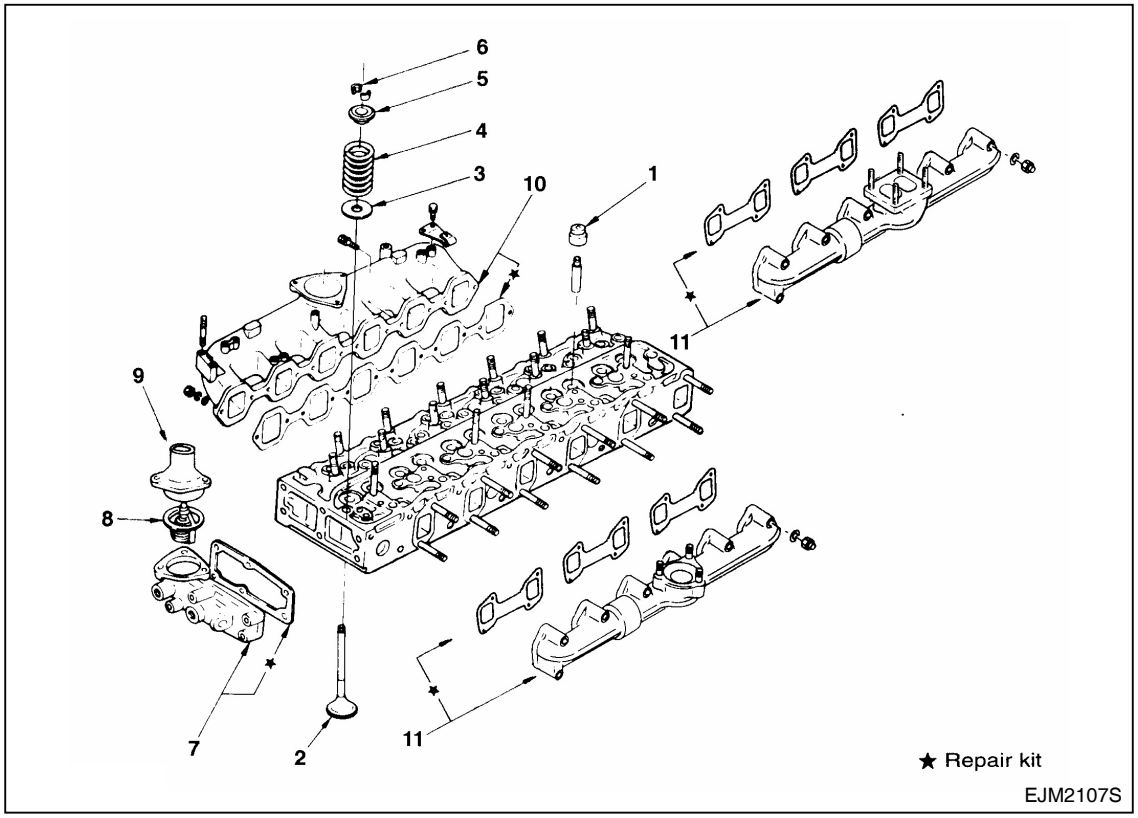


- Lubricate the surface of piston ring with engine oil.
- Check it whether piston rings are smoothly rotating in the piston ring grooves.

5) Connecting rod bearing

- Assemble the connecting rod bearing to the big end and the cap.
- Lubricate the bearing with engine oil.
- Assemble the connecting rod and connecting rod bearing, and tighten cap bolt as the specified torque.

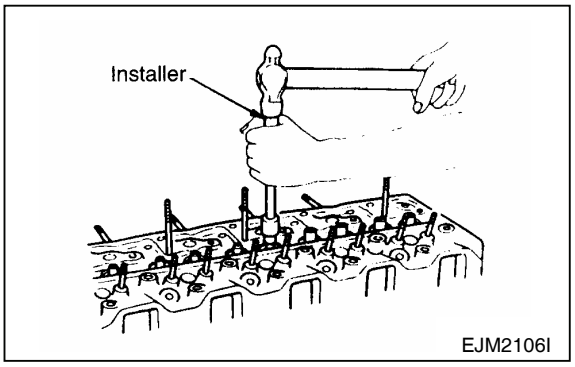
3.3.2. Cylinder head assembly parts



- ▲ 1. Valve stem oil seal
- ▲ 2. Intake and exhaust valve
- 3. Spring seat (lower)
- ▲ 4. Intake and exhaust valve spring
- ▲ 5. Spring seat (upper)
- ▲ 6. Valve cotter
- 7. Thermostat housing and gasket
- 8. Thermostat
- 9. Cooling water outlet
- ▲ 10. Intake manifold and gasket)
- ▲ 11. Exhaust manifold and gasket

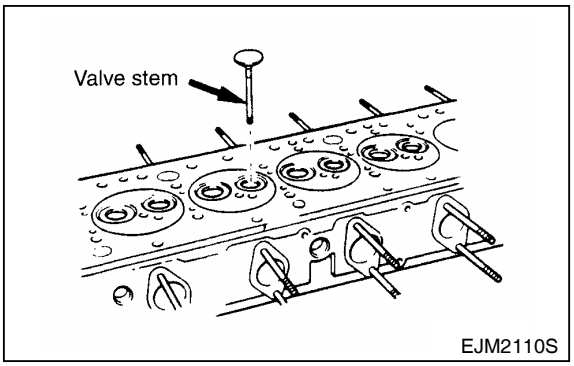
1) Valve stem oil seal

- Lubricate the oil seals and valve stem sealing area with engine oil.
- Assemble the valve stem oil seal by using oil seal installer.



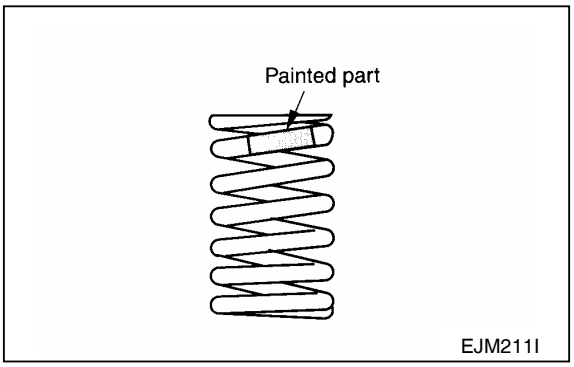
2) Intake and exhaust valves

- Place the cylinder head on a flat wooden surface.
- Lubricate valve stem with the engine oil.
- Assemble the valves to the intake or exhaust valve guides.



4) Intake and exhaust valve springs

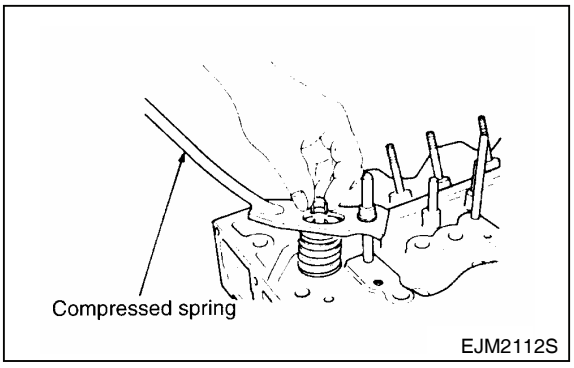
- Assemble the valve spring with their painted end facing top.



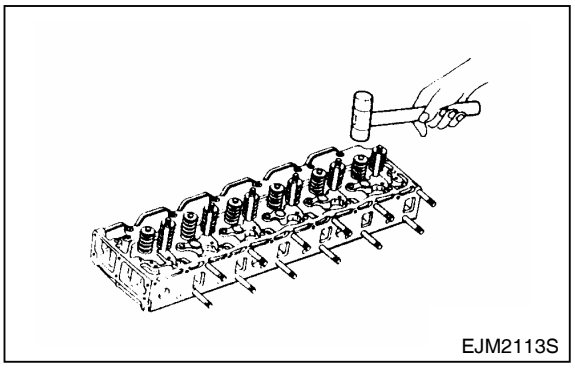
5) Spring seat

6) Valve cotter

- Use a spring compressor to push the valve spring into position.
- Install the spring seat split collar.

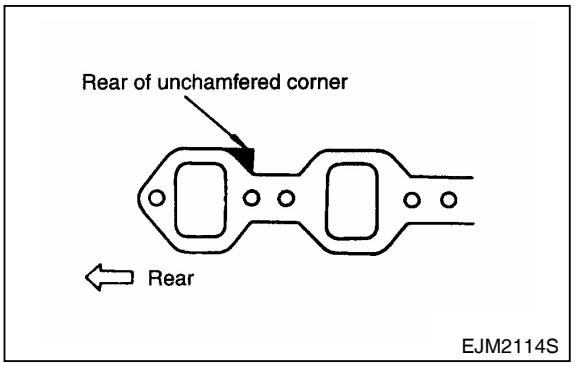


- Set the spring seat split collar by tapping lightly around the head of the collar with a rubber hammer.



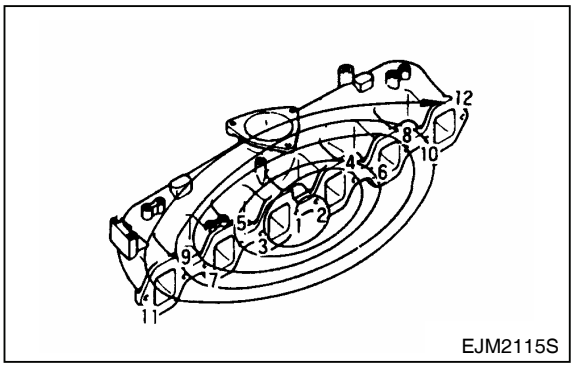
10) Intake manifold and gasket

- Assembly the intake manifold gasket.
  The intake manifold gasket must be installed with its unchamfered corner facing “up” and to the front of the engine.



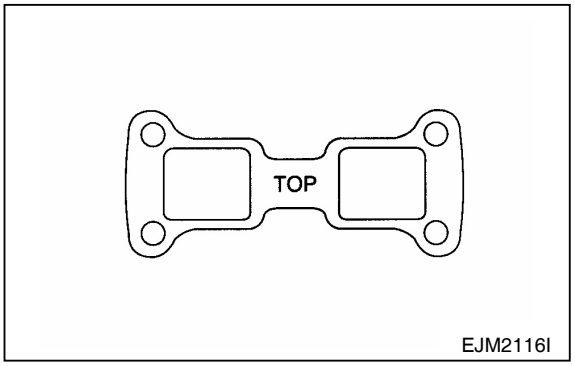
- Assemble the intake manifold.
- Tighten the intake manifold bolts to the specified torque a little at a time in the numerical order. (see figure)

Intake manifold bolt torque	2.2 kg.m



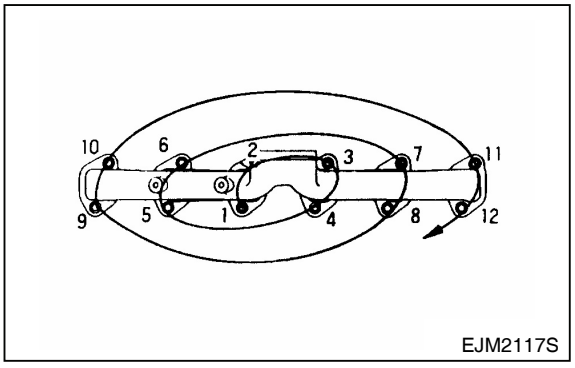
11) Exhaust manifold and gasket

- Install the exhaust manifold gasket.
- The **“TOP”** mark must be facing up.

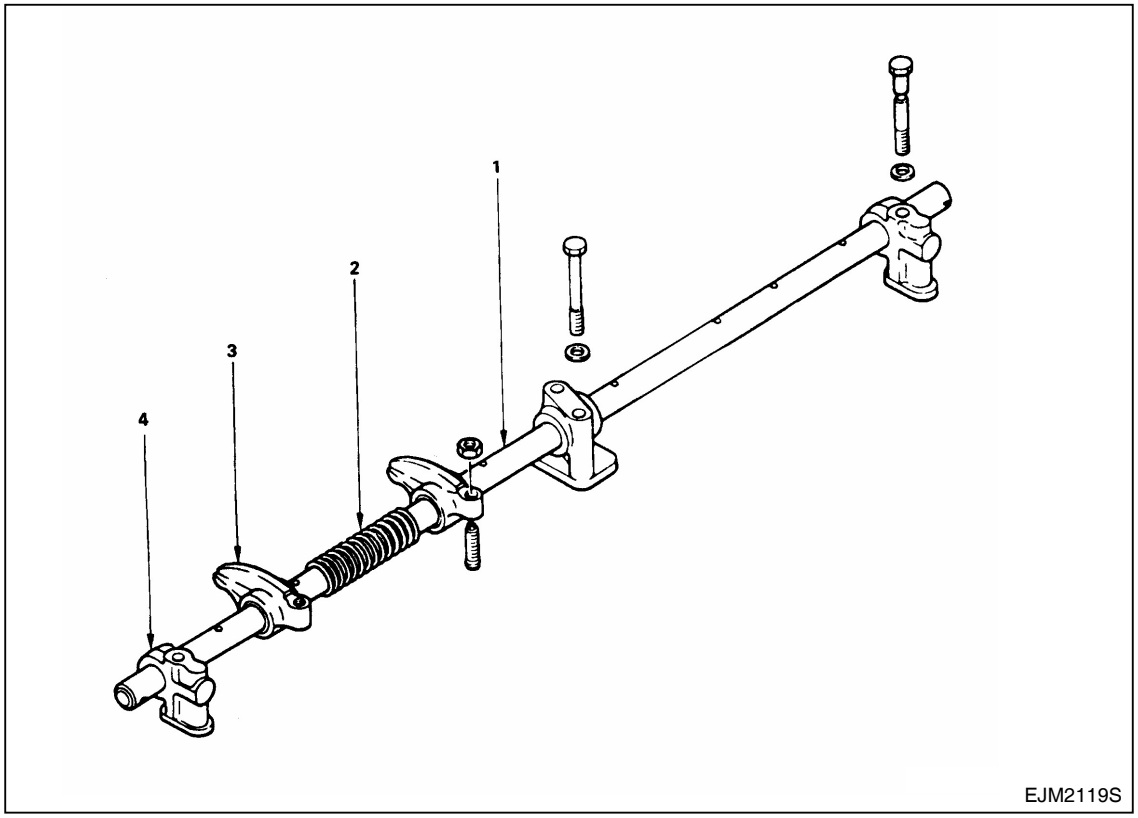


- Install the exhaust manifold
- Tighten the exhaust manifold bolts to the specified torque a little at a time in the numerical order. (see figure)

Exhaust manifold bolt torque	2.2 kg.m



3.3.3. Rocker arm and shaft assembly

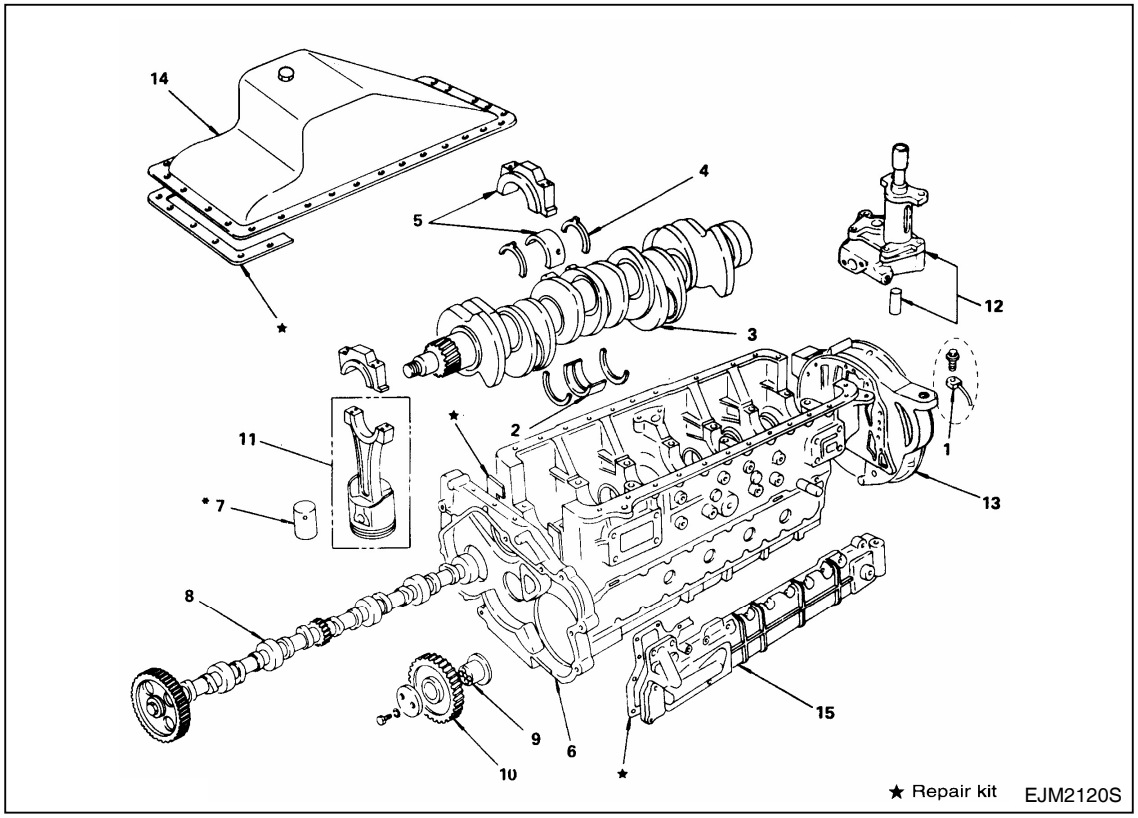


▲1. Rocker arm shaft
2. Spring
3. Rocker arm
4. Bracket

1) Rocker arm shaft

- The rocker arm shaft must be installed with the oil holes facing up.

3.3.4. Main components

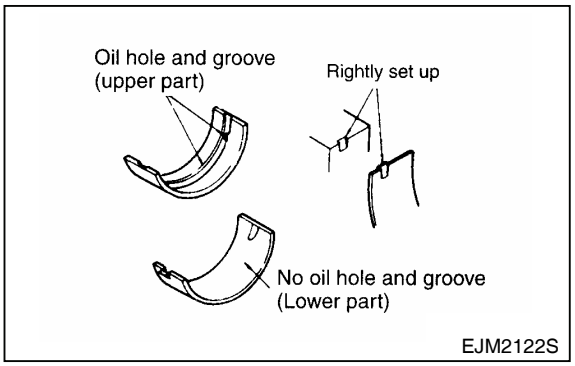


▲2.	Crankshaft bearing (lower)	▲ 9.	Idler gear shaft
▲3.	Crank shaft	▲10.	Idler gear
▲4.	Thrust washer	▲11.	Piston and connection rod
▲5.	Crank shaft bearing (upper) and cap	▲12.	Oil pump and coupling
▲6.	Timing gear case	▲13.	Flywheel housing
7.	Tappet	▲14.	Oil pan
▲8.	Camshaft	▲15.	Oil cooler

* The tappet must be installed before the camshaft installation.

2) Crankshaft bearing (lower)

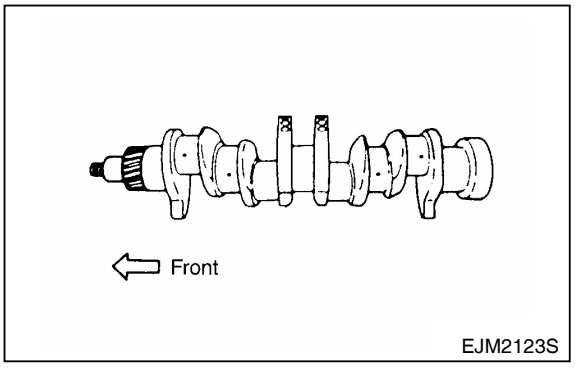
- There is no oil hole and oil groove on the lower bearing. But opposite upper bearing has oil hole and oil groove.



3) Crankshaft

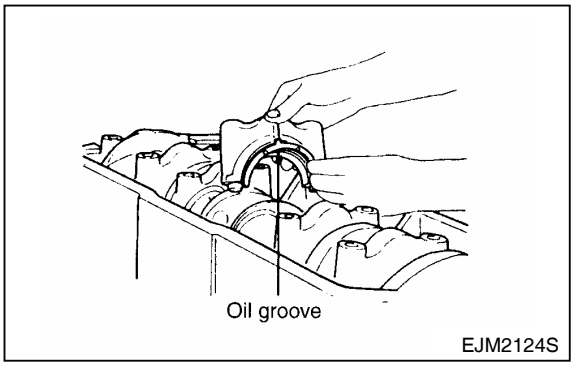
- Assemble the crankshaft gear in front side.

CAUTION:
Make sure the part number of crankshaft because its counterweight size may be different depending upon engines.



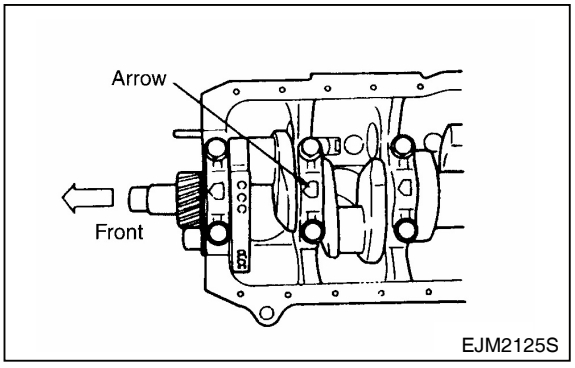
4) Thrust washer

- Assemble thrust washer with the oil groove side facing the crankshaft sliding face.



5) Crankshaft bearing cap

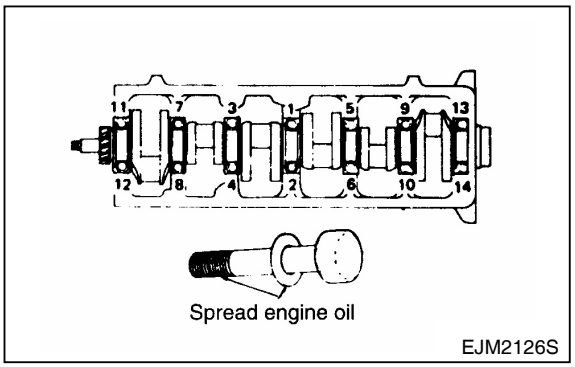
- Lubricate the bearing cap bolts with engine oil.
- Assemble the bearing caps to the crankshaft.
  The arrow mark must be pointing to the front of the engine.



- Tighten the bearing cap bolts to the specified torque a little at a time in the numerical order. (see figure)

Crankshaft bearing cap bolt torque	24.0±1kg.m

- Check that the crankshaft turns smoothly by manually rotating it.

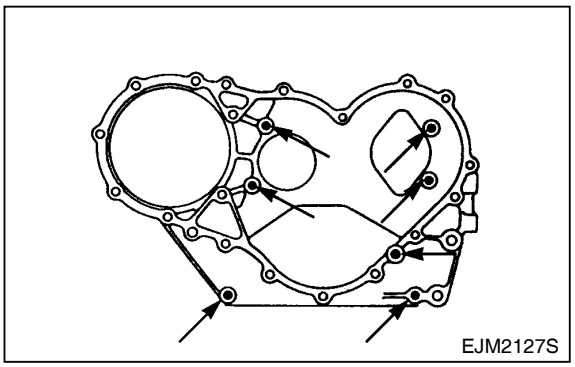


6) Timing gear case

- Tighten timing gear case bolt to the specified torque.

Timing gear case bolt torque	2.2 kg.m

- Apply silicon to the indicated area. (see figure)

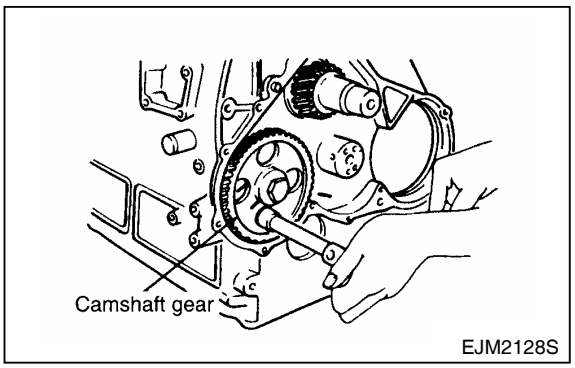


8) Camshaft

- Tighten thrust plate bolt through the camshaft gear hole.

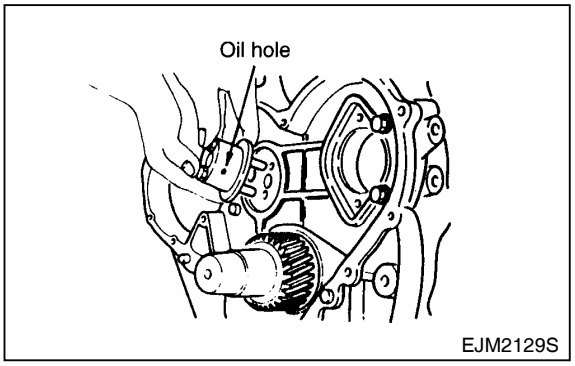
Thrust plate bolt torque	2.2 kg.m

Camshaft gear bolt torque	13 kg.m



9) Idler gear shaft

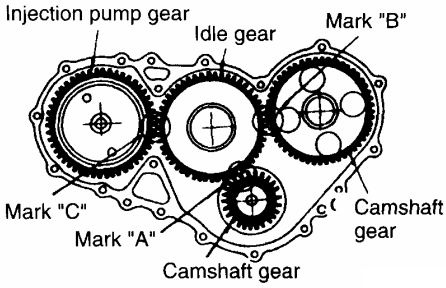
- Assemble an idler gear shaft by using the thrust collar fixing bolt as a guide.
- The oil hole must be facing the camshaft.
- Lubricate the idle gear shaft with engine oil.



10) Idler gear

- Assemble the idle gear.
  Set the timing marks “A”, ”B”, and ”C” as shown in the figure.
- Tighten the idle gear bolts seating the thrust collar to the specified torque.
- The thrust collar must be installed with the chamfered side facing the front of the engine.

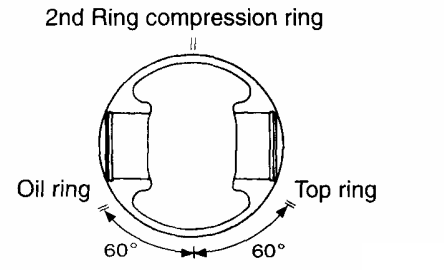
Idle gear bolt torque	4.4 kg m



EJM2130S

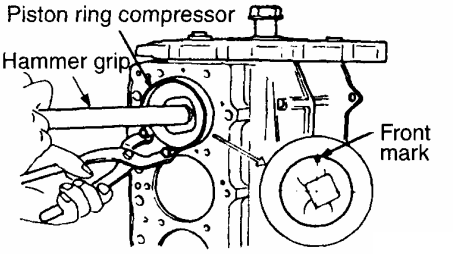
11) Piston and connecting rod

- Set the piston ring gaps as shown in the figure.
- Lubricate the piston, the piston ring and the connecting rod bearings with engine oil.



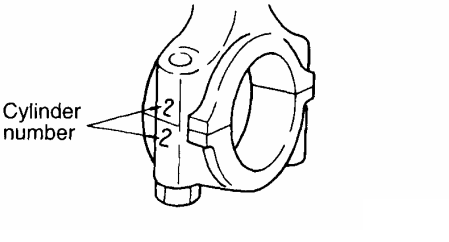
EJM2131S

- Position the piston front mark towards the front of the engine.
- Use the piston ring compressor to compress the piston rings.
- Push the piston in until it makes contact with the crank pin by using a hammer grip.
  At the same time, rotate the crankshaft until the crank pin reaches its highest point.



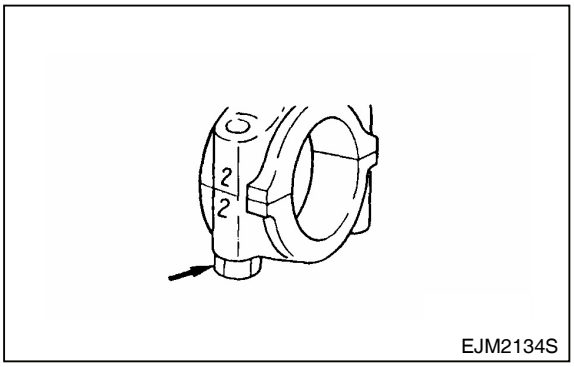
EJM2132S

- Set the bearing cap cylinder number marks and the connecting rod cylinder number marks.
- Lubricate the connecting rod cap bolt threads and setting face with MoS2 grease.
- Tighten the connecting rod cap bolts to the specified torque.
  Refer to the following table.



EJM2133S

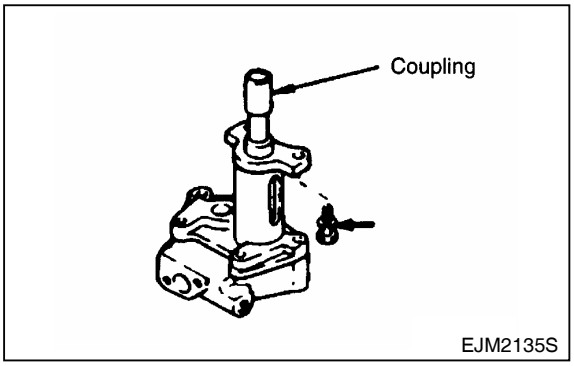
Torque	12± 0.25kg.m	9.75± 0.25kg.m
Bolt head	11	TY 11 TY 12



12) Oil pump assembled

- Lubricate the oil pump with the specified engine oil.
- Install the oil pump with the coupling.
- Tighten the oil pump bolts to the specified torque.

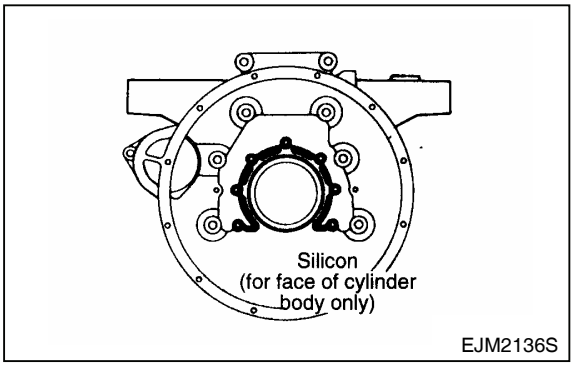
Oil pump bolt torque	5.0 kg.m



13) Flywheel housing

- Apply silicon to the shaded area. (see figure)
- Install the flywheel housing.
- Tighten the flywheel housing bolts to the specified torque.

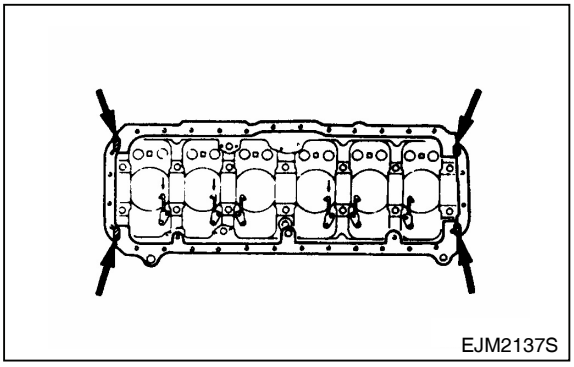
M14 x 1.5	13 kg.m
M14 x 1.5	18 kg.m



14) Oil pan

- Apply liquid gasket to the area indicated by the arrows in the figure.
- Install the gasket and oil pan.
- Tighten the oil pan bolts to the specified torque.

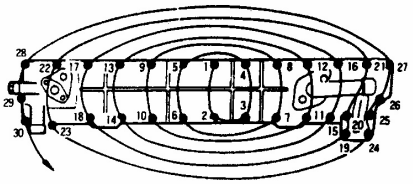
Oil pan bolt torque	2.2 kg m



15) Oil cooler

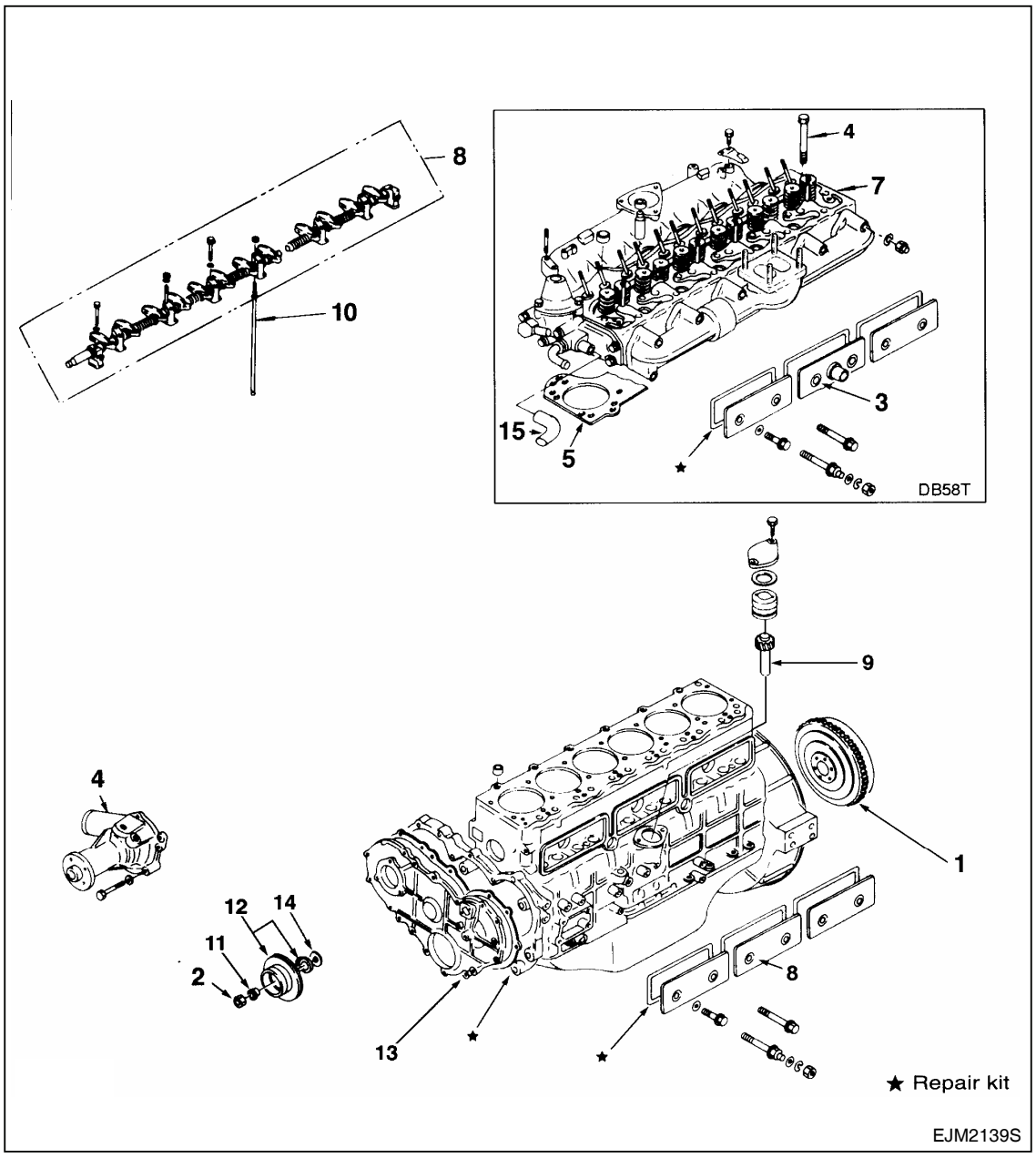
- Assemble the oil cooler with gasket after applying sealant to the oil cooler gasket.
- Tighten the oil cooler bolts to the specified torque. in the numerical order (see figure)

Oil Cooler Torque	2.2 kg m



EJM2138S

3.3.5. Major component assembly

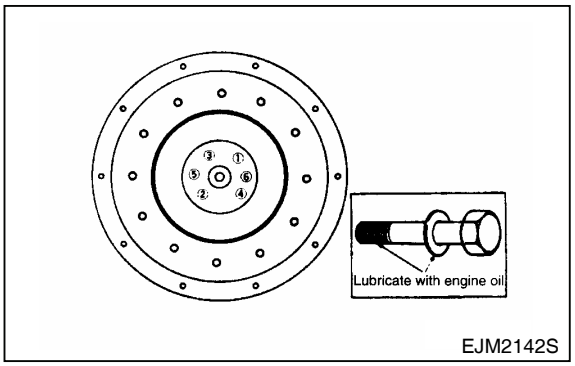


▲ 1. Flywheel
▲ 2. Crankshaft pulley nut
▲ 3. Tappet chamber cover
▲ 4. Water pump
▲ 5. Cylinder head gasket
▲ 6. Cylinder head bolt
▲ 7. Cylinder head
▲ 8. Rocker arm shaft Assembly
9. Oil pump driving pinion
10. Push rod
11. Taper bushing
12. Crankshaft pulley and dust cover
13. Timing gear cover
14. Oil thrower
15. Rubber hose

1) Flywheel

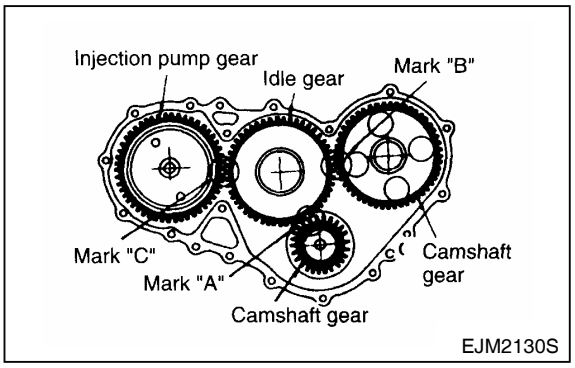
- Lubricate the flywheel bolt with engine oil.
- Install the flywheel.
  Tighten the flywheel bolts to the specified torque in the numerical order. (see figure)

Flywheel Bolt torque	18 kg.m



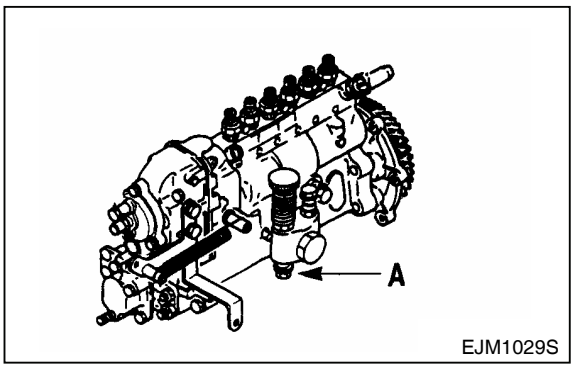
2) Injection pump

- Align the injection pump gear "C" timing mark with the idler gear “C” timing mark.



- Tighten the injection pump bolts to the specified torque.

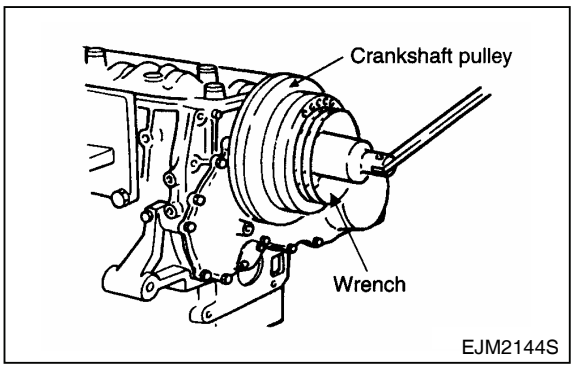
Injection Pump Bolt Torque	2.2 kg.m



3) Crankshaft pulley nut

- Tighten the crankshaft pulley nut to the specified torque by using a wrench.

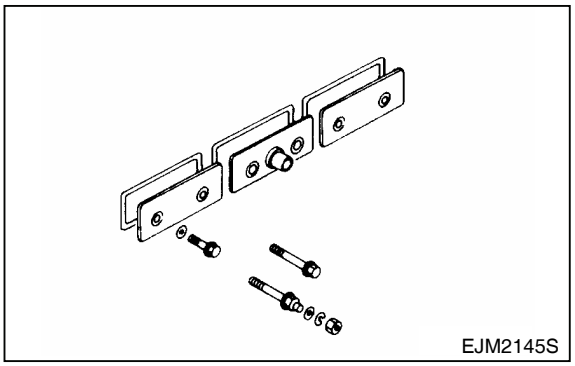
Crankshaft pulley nut torque	60 kg.m



3) Tappet chamber cover

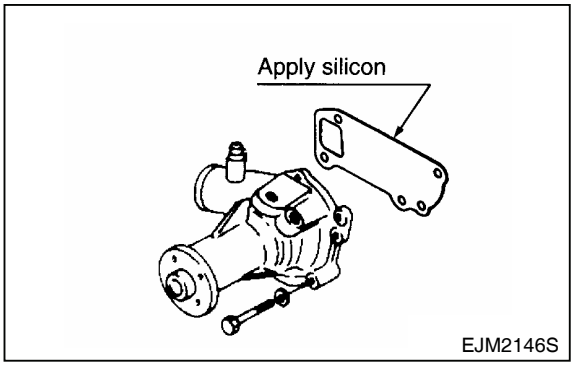
- Apply silicon to the tappet chamber cover gasket.
- Assemble the tappet chamber cover and tighten the bolts to the specified torque.

Tappet chamber cover bolt torque	2.2 kg.m


EJM2145S

4) Water pump

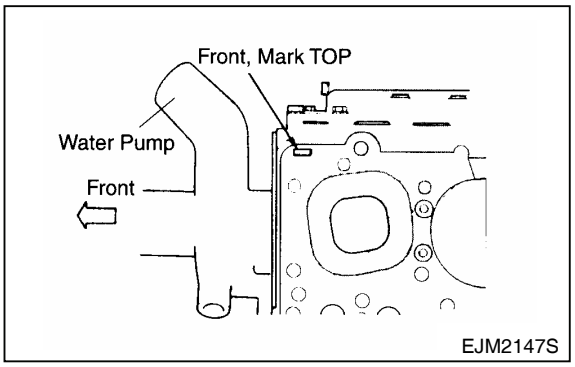
- Apply silicon to the pump gasket before installing the water pump.



EJM2146S

5) Cylinder head gasket

- The gasket “TOP" mark should be faced up and "FRONT" mark is towards the front of the engine.

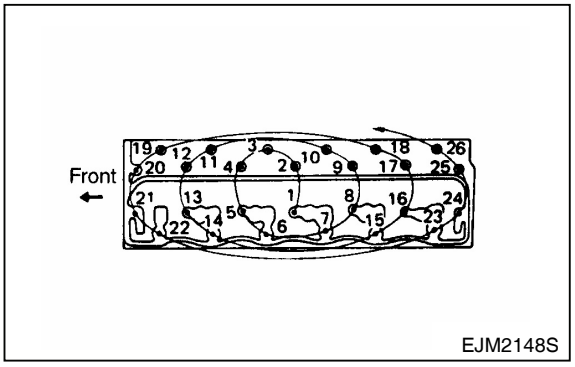


EJM2147S

6) Cylinder head bolts

7) Cylinder head

- Carefully place the cylinder head on the cylinder block.
- Tighten the cylinder head bolts to the specified steps and torque in the numerical order as figure and following table.



EJM2148S

Bolt type	Torque
hexagonal bolt	1st step : 7.0kg.m 2nd step: 11.5+0.5kg.m
Dodecagonal bolt	1st step : 4.4 kg.m 2nd step : 90° 3rd step : 90°

<12-gonal bolt limited value>

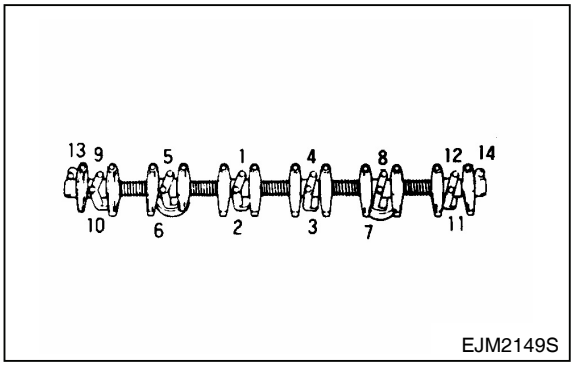
Standard(mm)	Limit(mm)
115	116.2
102	103.2

- Apply engine oil to the cylinder head bolts threads and setting faces.

8) Rocker arm shaft assembly

- Tighten the rocker arm bolts to the specified torque a little at a time in the numerical order. (see figure)

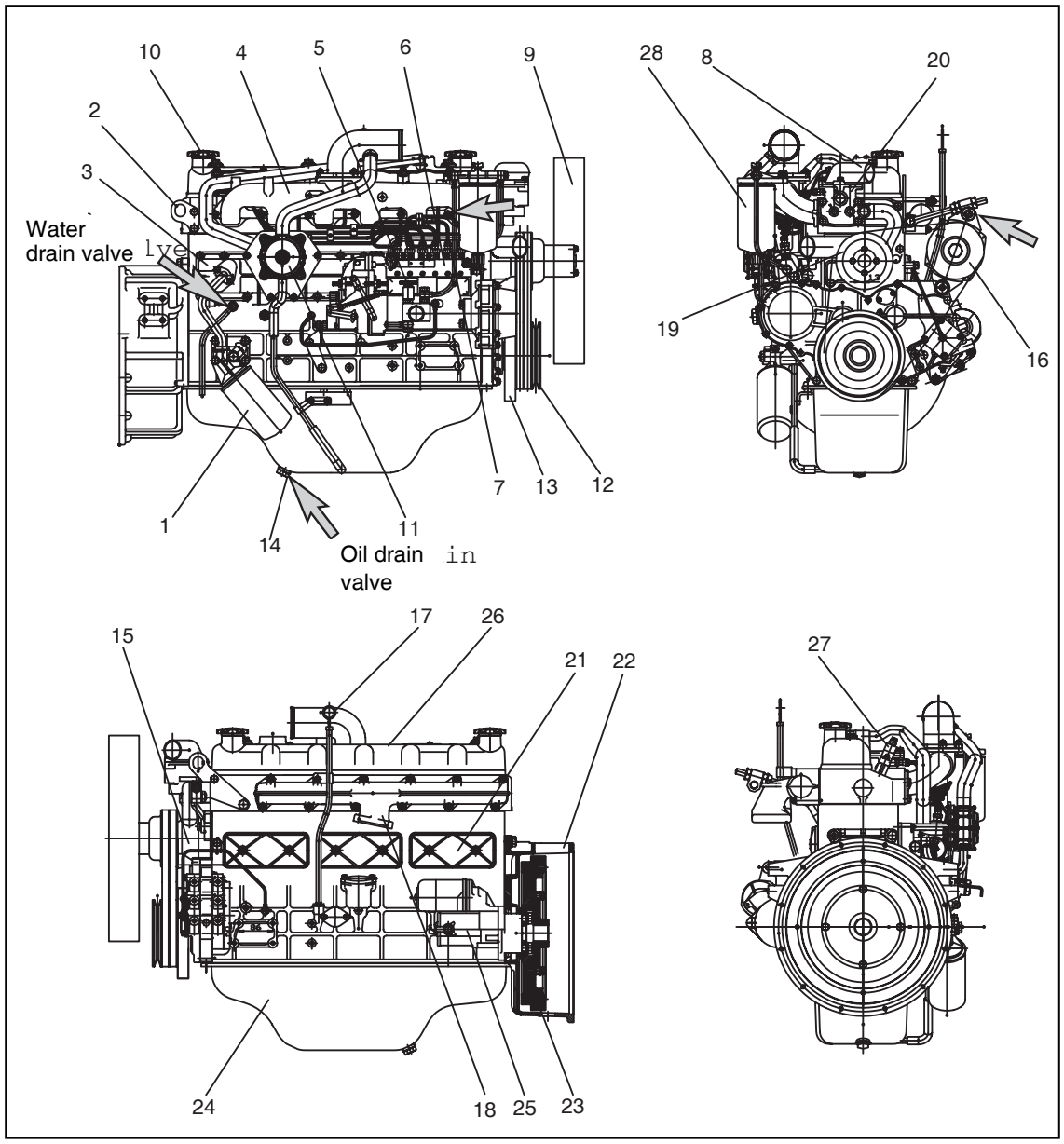
Rocker arm shaft bracket bolt torque	3.1 kg m



- Lubricate the rocker arm and the rocker arm shaft with engine oil.
- Adjust valve clearance.

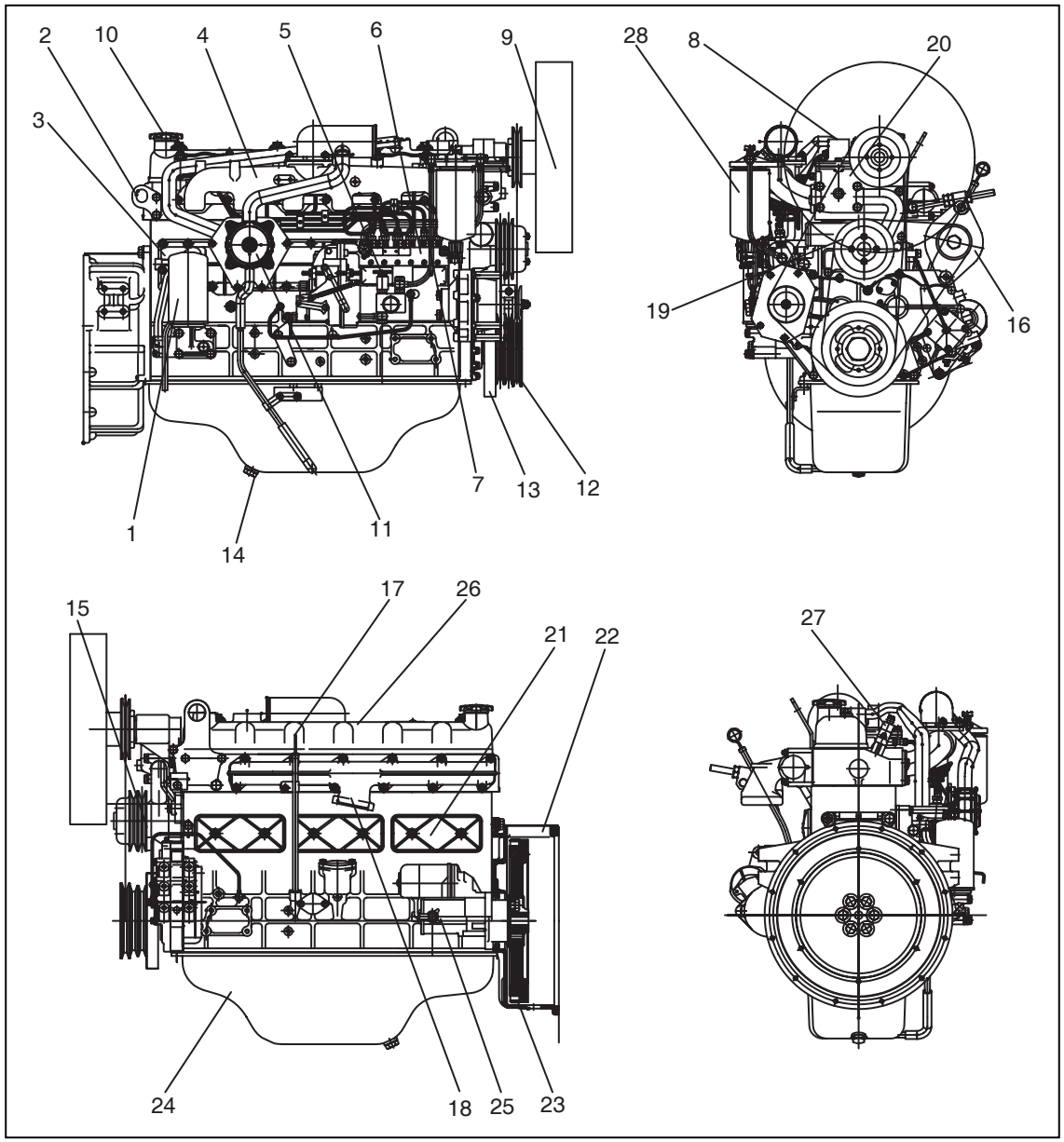
3.3.6. External parts

Engine assembly view (ECRFA), D50/60/70/80/90S-5(3 speed)



1	Oil filter	11	C.C.V	21	Push rod chamber cover
2	Lifting hook	12	Crank shaft pulley	22	Flywheel housing
3	Oil cooler	13	Vibration damper	23	Fly wheel
4	Intake manifold	14	Oil drain plug	24	Oil pan
5	Priming pump	15	water pump	25	Starter
6	Fuel injection pump	16	Alternator	26	Cylinder head cover
7	Fuel injection pipe	17	Oil level gauge	27	Fuel injection nozzle
8	Water outlet	18	Exhaust manifold	28	Fuel filter
9	Cooling fan	19	Water pump pulley		
10	Oil filler cap	20	Thermostat housing		

Engine assembly view (ECRFD), D35/40/45S-5, D50/55C-5



1	Oil filter	11	C.C.V	21	Push rod chamber cover
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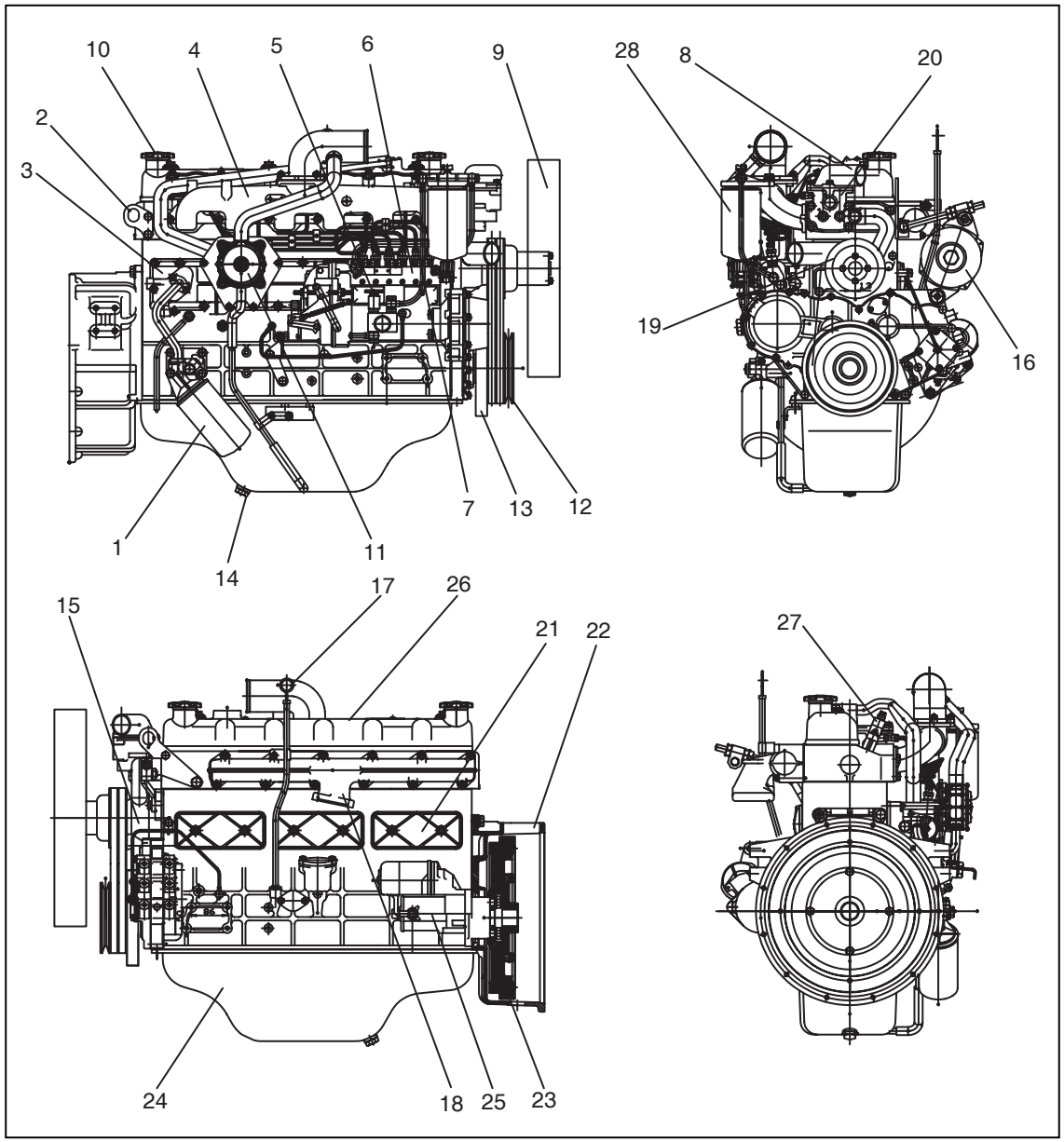
4	Intake manifold	14	Oil drain plug	24	Oil pan
5	Priming pump	15	water pump	25	Starter
6	Fuel injection pump	16	Alternator	26	Cylinder head cover
7	Fuel injection pipe	17	Oil level gauge	27	Fuel injection nozzle
8	Water outlet	18	Exhaust manifold	28	Fuel filter
9	Cooling fan	19	Water pump pulley		
10	Oil filler cap	20	Thermostat housing		

Engine assembly views (ECRFE), D50/60/70S-5 (2speed)

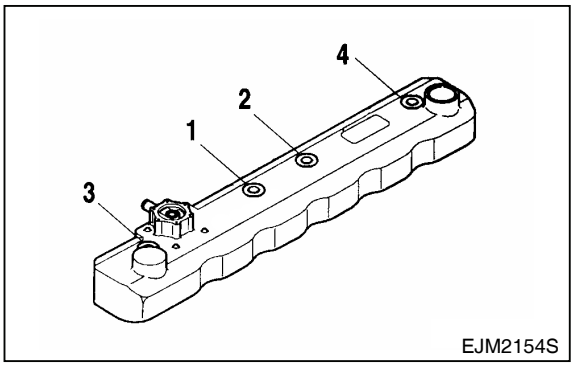


1	Oil filter	11	C.C.V	21	Push rod chamber cover
2	Lifting hook	12	Crank shaft pulley	22	Flywheel housing
3	Oil cooler	13	Vibration damper	23	Fly wheel
4	Intake manifold	14	Oil drain plug	24	Oil pan
5	Priming pump	15	water pump	25	Starter
6	Fuel injection pump	16	Alternator	26	Cylinder head cover
7	Fuel injection pipe	17	Oil level gauge	27	Fuel injection nozzle
8	Water outlet	18	Exhaust manifold	28	Fuel filter
9	Cooling fan	19	Water pump pulley		
10	Oil filler cap	20	Thermostat housing		

1) Cylinder head cover

- Tighten the cylinder head cover bolts to the specified torque a little at a time in the sequence. (see figure)

Cylinder head cover bolt torque	2.2 kg.m



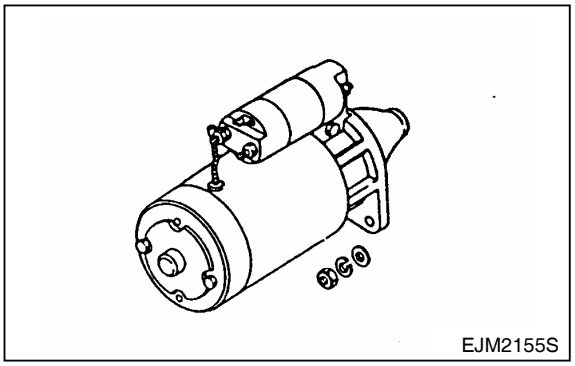
Fan belt

- Adjust the fan belt tension.

2) Starter

- Tighten the starter bolts to the specified torque after install the starter to the flywheel housing.

Starter fixing nuts torque	2.2 kg.m

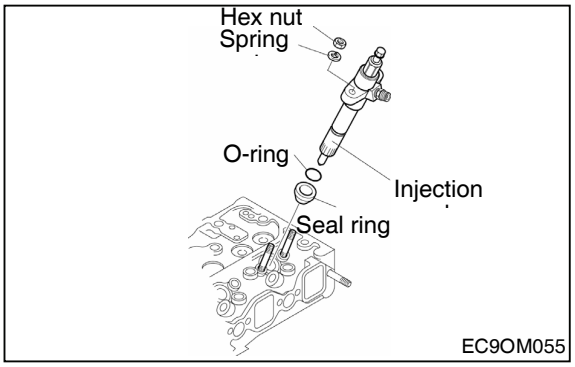


3) Injection nozzle

- Install the injection nozzle with the injection nozzle gaskets.

Injection nozzle nuts torque	2.2 kg.m

- Be careful not to damage the nozzle tips.

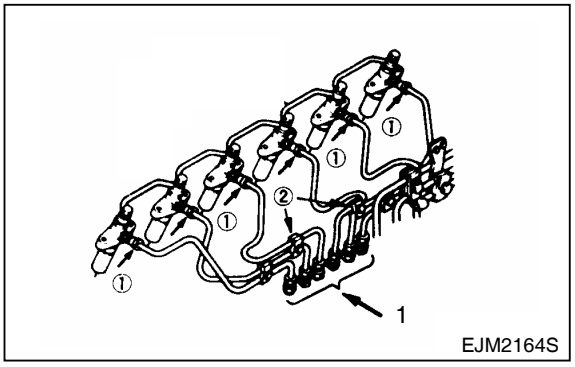


4) Fuel injection pipe

- Install the fuel injection pipes① and tighten the bolts to the specified torque.

Injection pipe torque	3.0 kg.m

- Carefully position and set the clips②.
  It is very important that each clip be positioned correctly.



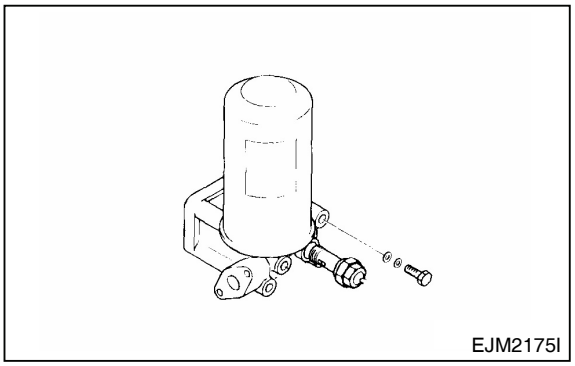
An improperly positioned clip will result in objectionable fuel pulsing noise and injection pipe breakage.

- Install the fuel return pipes③.

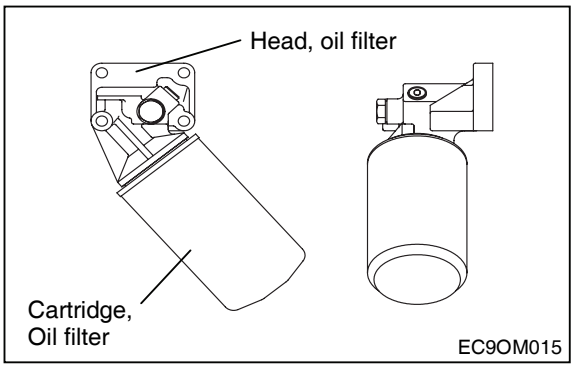
5) Oil filter

- Install the oil filter assembly with tightening the bolts securely.

Oil filter assembly mounting bolts torque	5.0 kg.m



<ECRFD>



<ECRFA, ECRFE>

6) Fuel pipe

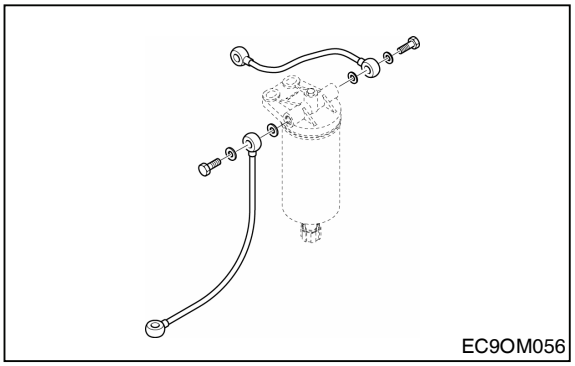
- Install the fuel pipe and tighten the fuel pipe joint bolts to the specified torque.
- Take care not to interchange the check valves and joint bolts.

Fuel pipe joint bolt torque	1.7 kg.m

7) Fuel hose

- Install the fuel filter hoses and tighten the hollow screws to the specified torque

Fuel filter hose bolt torque	4.2 kg.m



4. Commissioning and Operation

4.1. Preparation

At the time of initial commissioning of a new or overhauled engine make sure to have observed the "Technical Information for the installation DB58S engine".

- Oil filler neck on cylinder head cover
- Before daily starting of the engine, check the fuel, coolant and oil level, replenish if necessary.
- The notches in the dipstick indicate the highest and lowest permissible oil levels.
- The oil required in the sump is specified in the "Engine Specification".

NOTE

The oil required to fill the oil fillers and pipes depends upon the engine and use and must be determined individually at the time of initial commissioning. (Make the Max and Min. marks of the determined quantity on the oil level gauge.)

- **Cleanliness**

  Ensure outmost cleanliness when handling fuels, lubricants and coolants

4.1.1. Starting

For engine starting, please confer the instruction.

NOTE:

1. **Preheating devices are attached to the engine for improving the starting abilities at extremely low temperature.**
2. **Do not actuate the starter for longer than 10 seconds. If starting fails regardless of the preheating, start the preheating again after 30 seconds.**

a) Pre-heating system

Operation 1: Turn the key switch to the HEAT position, then the pilot lamp lights up for about 20 seconds When the pilot lamp is extinguished, do operation 2

Behavior - When the coolant temperature is below 10 °C in cold weather, you'd better operate the pre-heating system (Glow plug)

- If the pre-heating is not necessary, the pre-heating system is not operated with the pilot lamp.

Operation 2: After checking the pilot lamp, turn the key switch to the START position to crank the engine, at once.

Behavior - When the key switch is placed in the START position, glow plug is continuously heated to facilitate starting operation

- If the coolant temperature is above 10 °C, glow plug needs not be heated.

Operation 3: After the engine is cranked, convert the key switch to the ON position.

4.2. Starting and operation

4.2.1. 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 150 hours

- Engine should be run at fast idling until the temperature of the engine becomes normal operating condition.
- Overload or continuous high speed operation should be avoided.
- High speed operation with no load should be prevented.
- Abrupt start and stop of the engine should be avoided.
- Maintenance and inspection must be accomplished thoroughly.

4.2.2. 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 dipstick 180° and re-insert for check.

When adding engine oil, refer to Lubrication Section.

b) Watch the oil pressure warning lamp. If the lamp blinks, it may be the oil pick-up screen is not covered with oil. Check oil dipstick. 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 element. Fill oil pan with recommended engine oil. Refer to Lubricating System.

- Engine oil should be changed at the specified intervals.
  Oil filter cartridge should be changed simultaneously.
  - First oil change : 50 hr operating
  - After 50hr operation ; 250hr

- The following oils are also recommended
  * If long oil change intervals are to be used, ACEA-E3 oil must be used.

Engine model	Recommend oil	
	SAE No.	API No.
DB58S	SAE15W40 SAE10W40	ACEA-E2 or ACEA-E3 OVER(API CH-4)

4.3. Inspections after starting

- It is advisable to operate an engine at idling until the engine reaches up to normal operating temperature.
- Engine should be stopped if the color, the noise or the odor of exhaust gas is not normal.
- Confirm the following things through warning lamps and gauge panel.

- Pressure of lubricating oil

The normal pressure comes up to 100 kPa (1.0 bar) at idling and 300 ~ 480 kPa (3.0 ~ 4.8 bar) at maximum speed. If the pressure fluctuates at idling or does not reach up to the expected level at high speed, shut down the engine immediately and check the oil level and the leakage.

- Temperature of cooling water

The cooling water temperature should be 80 ~ 95 °C in normal operating conditions. Abnormally high cooling water temperature could cause the overheating of engine and the sticking of cylinder components. And excessively low cooling water temperature increases the fuel consumption, accelerates the wears of cylinder liners and shortens the engine life-time.

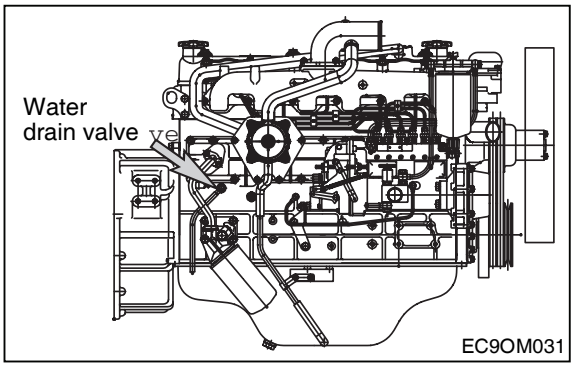
NOTE:
When engine is overheated, do not stop the engine immediately. Lower the engine load and run the engine and its cooling systems continuously.

4.4. Operation in winter time

Pay special attention to the freezing of cooling water and the viscosity of lubricating oil.

4.4.1. Prevention against the freeze of cooling water

When not using anti-freeze, completely discharge the whole cooling water after engine running. The freeze of cooling water causes the fatal damages of the engine. Because the anti-freeze is used to prevent cooling water from freeze, consult "The amount of anti-freeze".



4.4.2. Prevention against excessive cooling

Drop of thermal efficiency caused by excessive cooling increases fuel consumption, therefore prevent the engine from excessive cooling. If the temperature of coolant does not reach to normal condition (80 ~ 95 °C) after continuous operation, examine the thermostat or the other cooling lines.

4.4.3. Lubricating oil

As cold weather leads to the rise of oil viscosity, engine speed becomes unstable after starting. Therefore the lubricating oil for winter should be used to prevent this unstability. Refer to Lubrication System section.

4.4.4. Starting of engine in winter

It is necessary to preheat engine satisfactorily under 10 °C (50 °F) in winter. Refer to Starting.

4.4.5. Tuning the engine

The purpose of an engine tune-up is to restore power and performance that's been lost through wear, corrosion or deterioration of one or more parts or components. In the normal operation of an engine, these changes can take place gradually at a number of points, so that it's seldom advisable to attempt an improvement in performance by correction of one or two items only. Time will be saved and more lasting results will be obtained by following a definite and thorough procedure of analysis and correction of all items affecting power and performance.

Economical, trouble-free operation can better be ensured if a complete tune-up is performed once every years, preferably in the spring. Components that affect power and performance to be checked are:

- Components affecting fuel injection ;
  Nozzle, delivery valve, fuel filter, water separator, etc.
- Components affecting Intake & exhaust ;
  Air filter, inter-cooler, turbo, silencer, etc.
- Components affecting lubrication & cooling ;
  Air & oil filter, anti- freeze, etc.

4.5. Maintenance and care

4.5.1. Periodical inspection and maintenance

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

- Daily inspections in below figure should be checked every day.
- The maintenance should be executed thoroughly at regular internals.

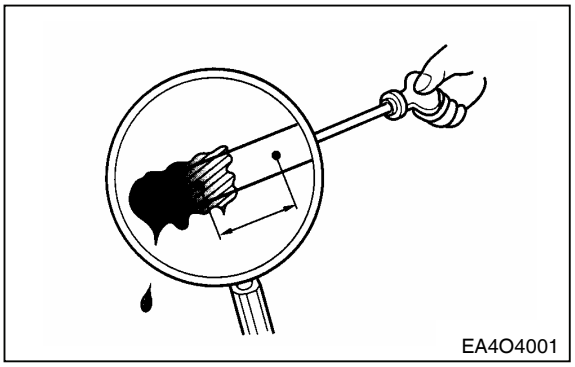
4.5.2. Exchanging of lubrication oil

Engine oil and the oil filter are important factors affecting engine life. They affect ease of starting, fuel economy, combustion chamber deposits and engine wear. Refill and drain oil pan every 500 hours of operation whichever occurs first. At the end of the break-in period (50 hours), change the oil sump oil and replace the oil filter.

4.5.3. Oil level

Check the oil level in the engine sump daily with a dipstick.

- The notches in dipstick must indicate the oil level between the max. and the min. permissible.
- The oil level should be checked with the engine horizontal and only after it has been shut down for about 5 minutes.
- Examining the viscosity and the contamination of the oil smeared at the dipstick replace the engine oil if necessary.

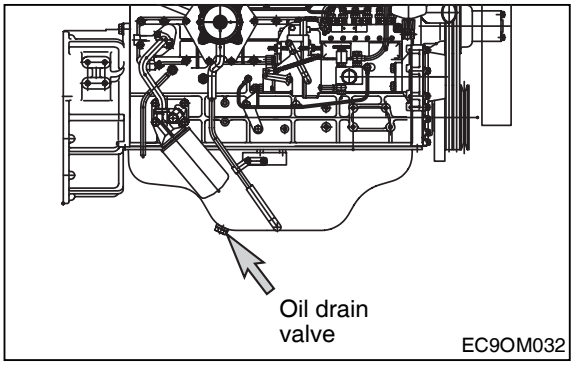

EA4O4001

IMPORTANT:
Do not add so much engine oil that the oil level rises above the max. marking on the dipstick. Over lifting will result in damage to the engine.

4.5.4. Oil exchange procedure

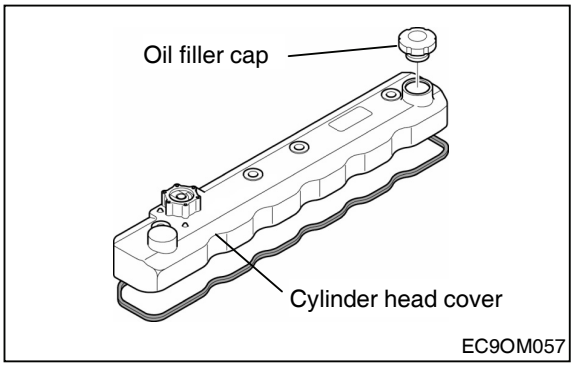
While the oil is still hot, exchange oil as follows:

- Take out the oil dip dipstick.
- Remove the drain valve from oil pan, then drain out the engine oil into a container.



EC9OM032

- Refill with new engine oil at the oil filler neck on the head cover and the lubricating oil in accordance with the oil capacity of the engine through oil filler. Be careful about the mixing of dust or contaminator during the supplement of oil. Then confirm that oil level gauge indicates the vicinity of its maximum level.
- For a few minutes, operate the engine at idling in order to circulate oil through lubrication system.
- Thereafter shut down the engine. After waiting for about 10 minutes measure the quantity of oil and refill the additional oil if necessary.



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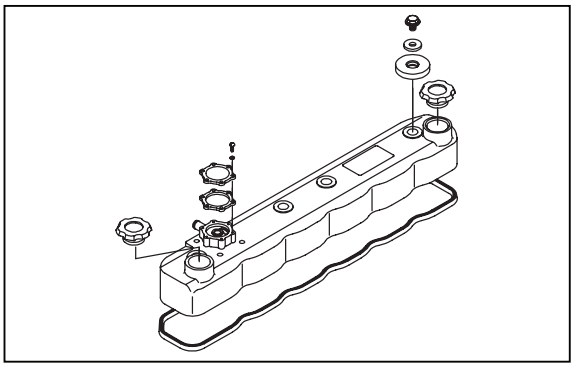

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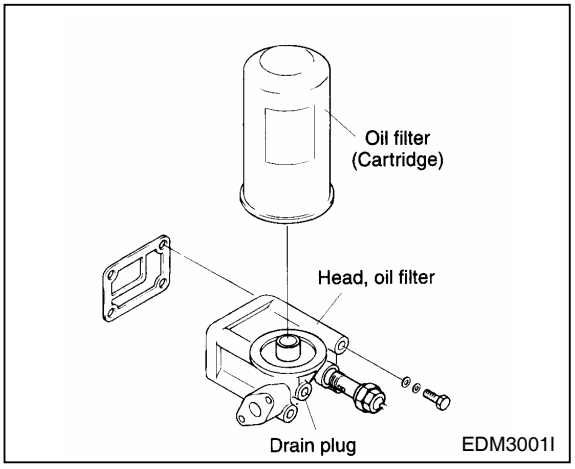
4.5.5. Replacement of oil filter cartridge

At the same times of oil exchanges, replace the oil filter cartridge.

IMPORTANT:
Don't forget tightening the drain valve after having drained engine oil.

- Loosen the oil filter by turning it counter-clockwise with a filter wrench.
- With a rag wipe clean the fitting face of the filter body and the oil filter body so that new oil filter cartridge can be seated properly.
- Lightly oil the O-ring and turn the oil filter until sealing face is fitted against the O-ring. Turn 1-1/4 turns further with the filter wrench.

IMPORTANT:
It is strongly advisable to use DOOSAN genuine oil filter cartridge for replacement.



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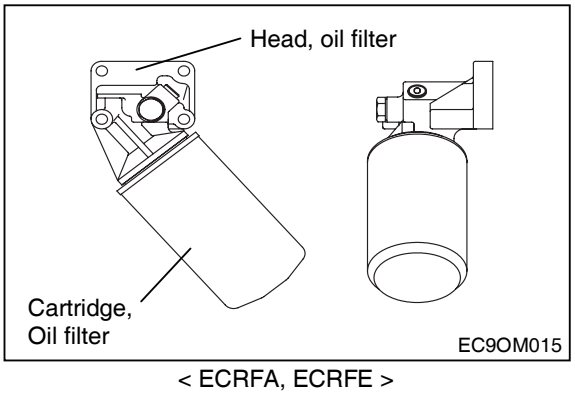

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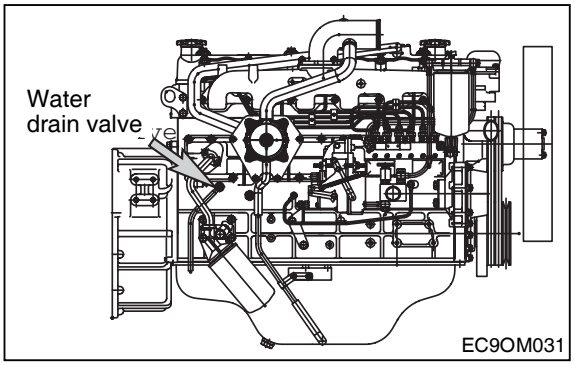
4.6. Cooling system

The coolant must be changed at intervals of 1,200 hours operation or six months whichever comes first. If the coolant is being fouled greatly, it will lead an engine overheat or coolant blow off from the expansion tank.

4.6.1. Coolant draining

- Remove the pressure cap.
- Open the drain valve at the radiator lower part to drain the coolant as the right figure.
- Loosen the coolant drain plug of the cylinder block and oil cooler.

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



4.6.2. Cleaning of the cooling inside system circuit

(by authorized specialist personnel)

When the cooling system circuit are fouled with water scales or sludge particles, the cooling efficiency will be lowered.

Investigations have shown that in many cases the poor condition of the coolant and /or the cooling system accounts for damage to the water pump mechanical seal, The poor condition of the cooling system is normally due to use of unsuitable or no anti-freezing agents and corrosion inhibitor or defect, not early enough replaced covers for filler neck and working valves.

If twice in a short time the water pump of an engine develops leases or the coolant is heavily contaminated (dull, brown, mechanically contaminated, grey or black sings of a leakage on the water pump casing) clean the cooling system prior to removing that water pump as follows.

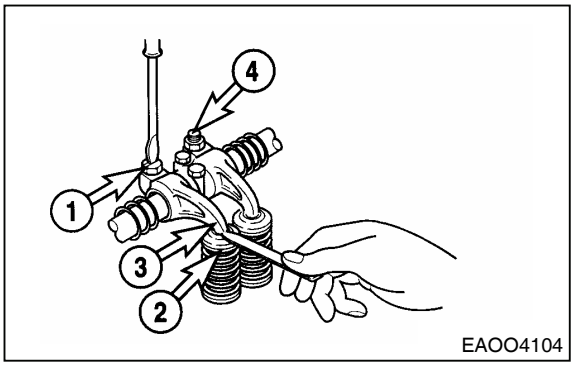
a) Drain coolant.
b) Remove thermostats, so that the whole cooling system is immediately flown through when cleaned.
c) Fill the cooling system with a mixture of potable water and 1.5% by volume of cleaner. (Henkel P3T5175)
d) Warm up engine under load. After a temperature of 60°C is reached, run engine for a further 15 minutes.
e) Drain cleaning fluid.
f) Repeat steps c) and d).
g) Flush cooling system.
h) Replace drain plug by drain plug with a bore of 8mm diameter.
i) Fill cooling system with hot water.
j) Run engine at idle for 30 minutes. At the same time continuously replenish the water leaking from the bore in drain plug by adding fresh water.

CAUTION:
Periodically clean the circuit interior with a cleaner.

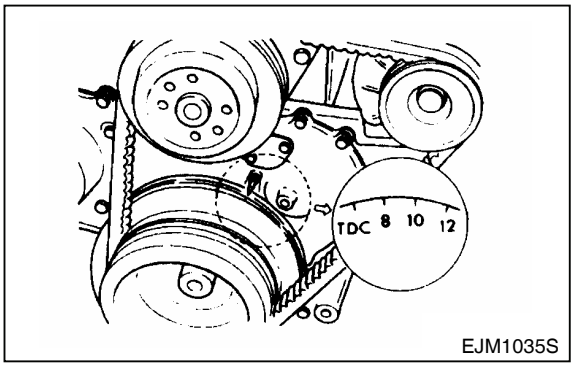
4.7. Valve clearance and adjustment

NOTE:
The cylinder head bolts were previously tightened with the torque wrench. Therefore it is not necessary to retighten the cylinder head bolts before adjusting the valve clearance.

Rocker arm screw lock nut torque	2.6 kg.m



- After letting the #1 cylinder's piston come at the compression top dead center by turning the crankshaft, adjust the valve clearances.
- 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.



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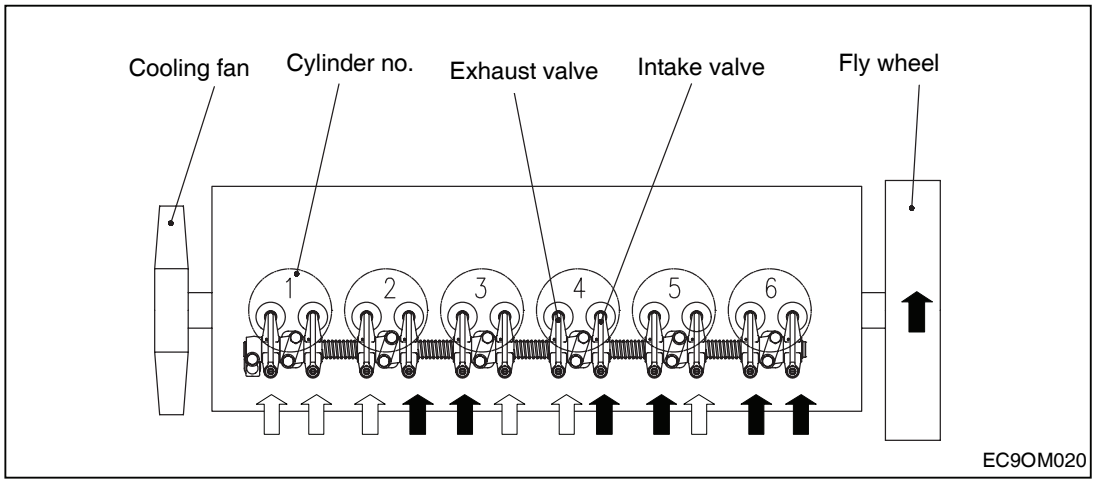
- As for the valve clearance, adjust it when in cold, as follows.

Model	Intake Valve	Exhaust Valve
DB58S	0.4 mm	0.4 mm

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

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



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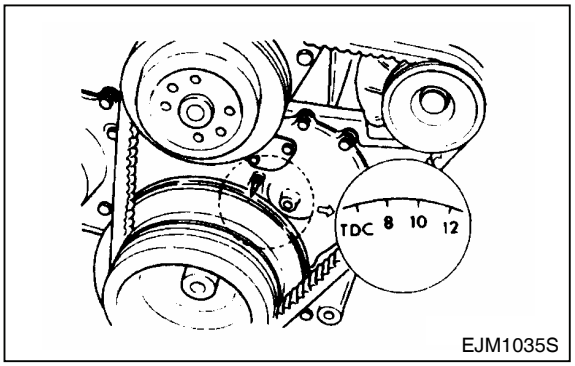
4.8. Injection timing

CAUTION:
Take care to avoid entry of dust or foreign particles into the pump interior when the timing adjustment is made.

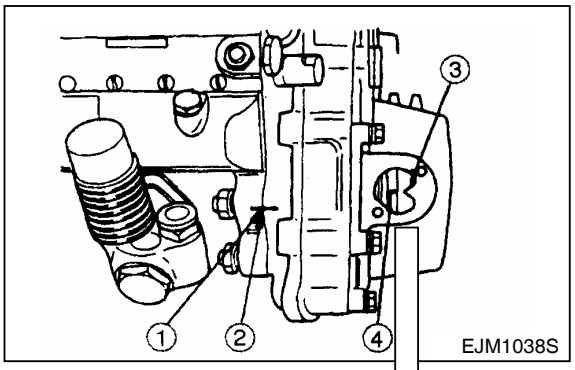
<Check procedure>

- Align the crankshaft pulley TDC mark with the pointer.
- Remove the inspection hole cover at the front of the injection pump on the timing gear case cover.



EJM1035S

- Check the alignment between the pointer ④ on the injection pump gear nut lock plate and the projection area mark③ on the injection pump gear case.
- If it is in misalignment, recheck with turningthe crankshaft pulley one more turn to repeat the foregoing procedure to mark sure that it is in alignment.



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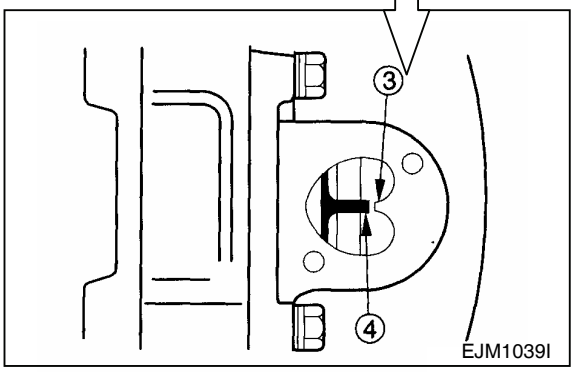
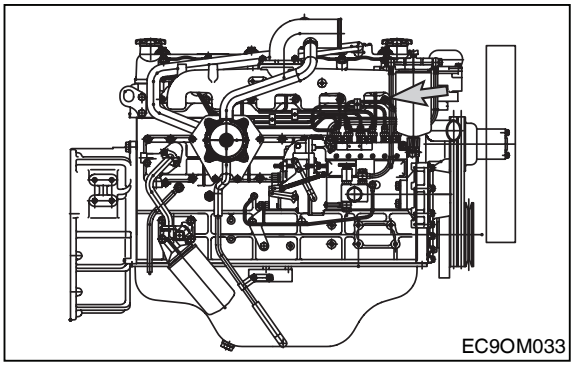
- Check the alignment of the notched lines① and ②. (These notched lines were aligned at the factory to set the injection pump body and the mounting flange.)
  Next, inspect the crank angle position of the injection timin



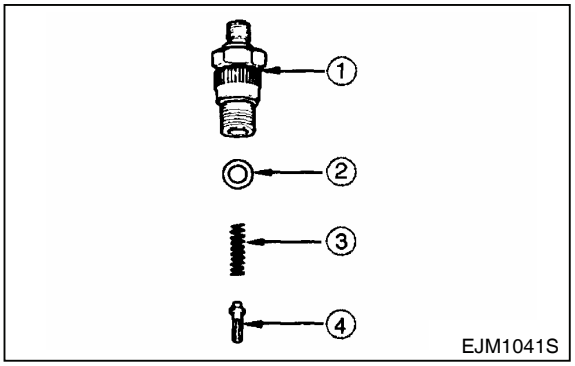
EJM1039I

<Check procedure>

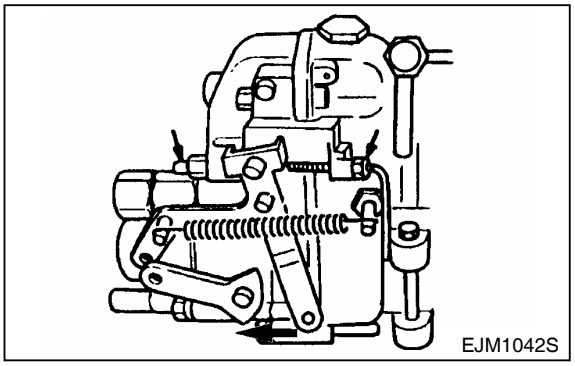
- Turn the crankshaft pulley counterclockwise about 30° crank angle.
- Disconnect the injection pipe from the No.1 plunger.
  This will allow you to visually check the full injection starting flow at No. 1 plunger.



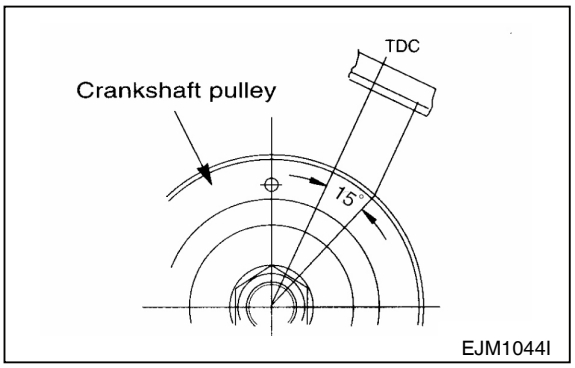
- Remove the delivery valve holder①, the valve seat②, valve spring③, and the delivery valve④ from the No.1 plunger.
- Assemble the delivery holder① and tighten it to the specified torque.
  Do not reassemble the delivery valve, the delivery valve spring and the valve seat. These parts will be reassembled later.



- Hold the fuel control lever at the fully open position.
- Slowly turn the crankshaft pulley clockwise, at the same time, continue to feed the fuel with pumping the priming pump.
  When the fuel stop to flow out from the No.1 delivery valve holder, stop the pump instantaneously.
  This crank angle position is the injection starting of the engine.

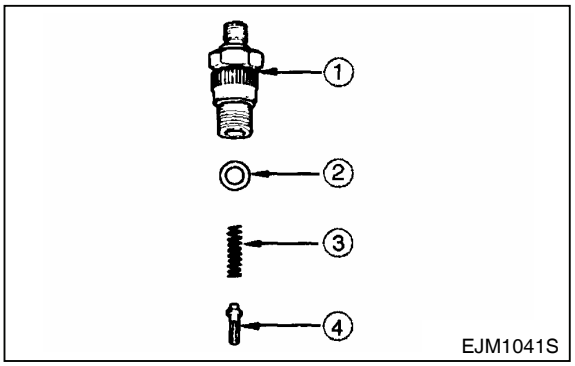


- Observe and make sure that mark (injection starting angle line αo) on the crankshaft pulley is aligning with the pointer.
  Blow out the remaining fuel from the delivery valve holder.
  Make sure that there is no fuel being delivered from the priming pump.



- Remove the delivery valve holder from the No.1 plunger
- Reassemble the delivery valve internal parts to the delivery valve holder.
- Reassemble the delivery valve holder assembly to the No.1 plunger and tighten it to the specified toque.

Delivery valve holder torque	4.25 kg m



- Assemble the No.1 cylinder injection pipe and tighten it to the specified torque.

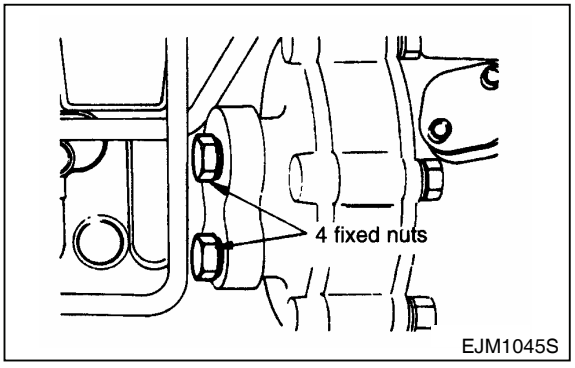
Injection pipe nut torque	3.1 kg m

INPORTANT:
1) Do not overtighten the injection pump body. The injection pump body is made of aluminum.
2) Overtighten will distort the injection pump body shape and adversely affect control rack operation.

<Adjusting procedure>

- Align the pointer and the specified timing mark on the crank pulley.
- Perform the steps of “checking procedure” of Injection Timing.
- Loosen the 4 injection pump fixing nuts.

- Timing adjustment
  To advance the timing
  Pivot the injection pump at the pump drive shaft toward out.
  To retard the timing
  Pivot the injection pump at the pump drive shaft toward in. (toward the cylinder block)

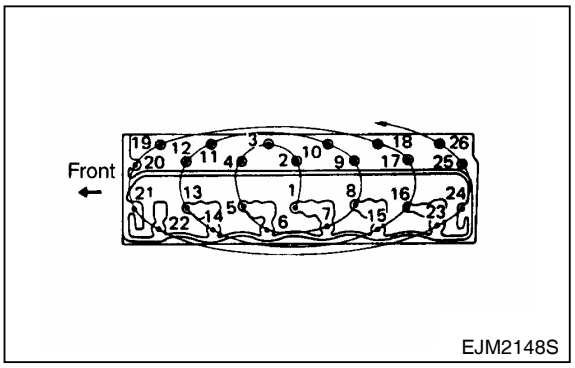


IMPORTANT:
The 1 mm misalignment between the two setting mark lines corresponds to about 2o in crank angle.

- Do a fine injection pump position adjustment, while continue the pumping operation to feed the fuel, and stop to pivot the injection pump when the fuel stop to flow out from the No. 1 delivery valve holder.
- Tighten the four injection pump fixing nuts.
- Once remove the No. 1 delivery valve holder, and reassemble the delivery valve, spring and the valve holder with the specified torque.
- Install the No.1 injection pipe and tighten it to the specified torque.

4.9. Tightening the cylinder head bolts

- The cylinders head bolts are to be tightened in the sequence shown in the illustrations. First tighten the bolts slightly, then slightly more again and finally tighten with a torque wrench as follows.
- The tightening by excessive torque may cause the damages of the cylinder head gaskets, the flanges of cylinder liners and the cylinder head bolts, therefore obey the regular torque.



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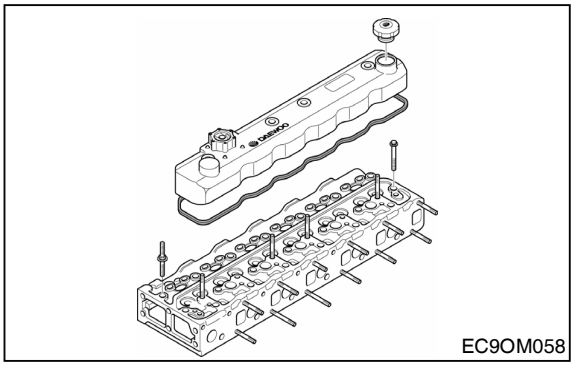
Bolt type	Torque
hexagonal bolt	1st step : 7.0kg.m 2nd step: 11.5+0.5kg.m
dodecagonal bolt	1st step : 4.4kg.m 2nd step : 90° 3rd step : 90°

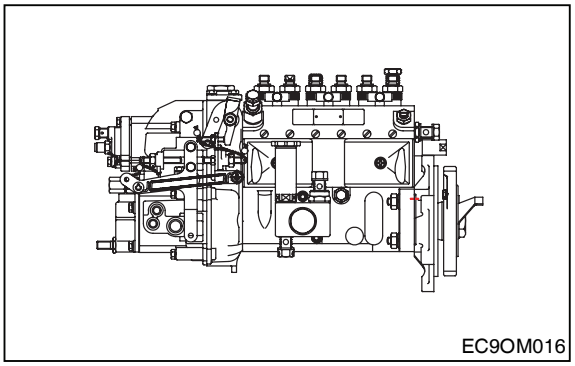
<Dodecagonal bolt limited value>

Standard(mm)	Limit(mm)
115	116.2
102	103.2


EC9OM058

4.10. Fuel injection pump

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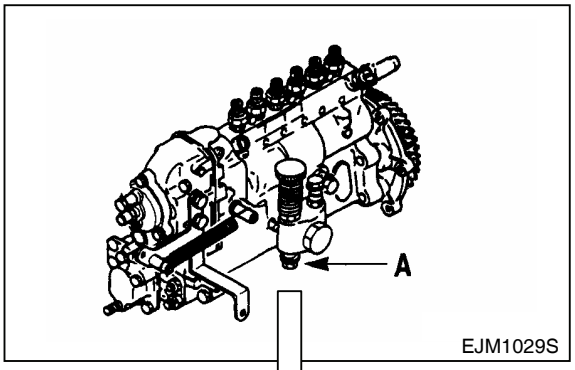
4.11. Feed pump strainer

- Release joint bolt **A.**
- Remove the strainer with a screwdriver and wash the strainer with clean diesel fuel.



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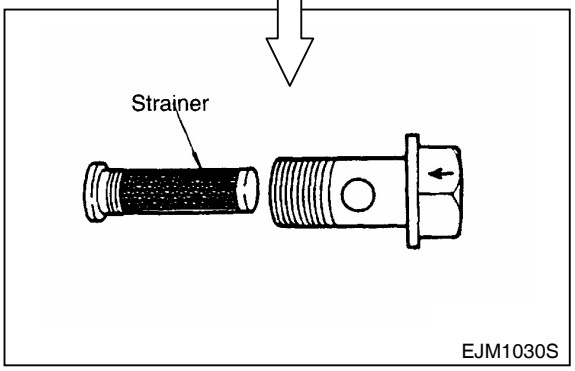
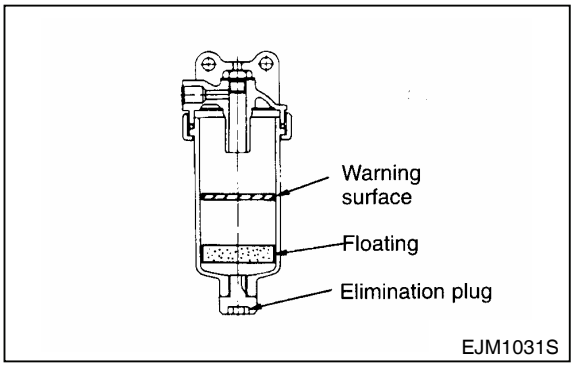


EJM1030S

4.12. Separator (Add if necessary)

- Check water level of the separator.
- Release the plug at the bottom to eliminate water when water level (floating) reaches the warning point.

Elimination plug torque	1.2 kg.m



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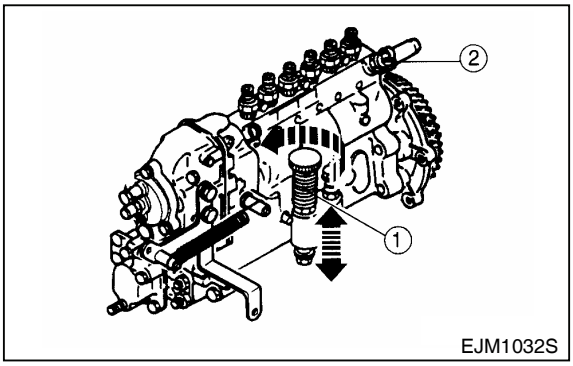
4.13. Air bleeding

- Loosen the priming pump cap(1) on the Injection pump.
- Loosen the hollow screw for air bleed(2).
- Operate the priming pump until there are no more bubbles visible in the fuel being discharged from the fuel filter fuel return eye bolt.
- Retighten the hollow screw.
- Operate the priming pump several times and check for fuel leakage around the injection pump and the fuel filter.



EJM1032S

4.14. Belts

The tension of the belts should be checked after every 2,000 hours of operation.

1) Change the belts if necessary

If in the case of a multiple belt drive, wear or differing tensions are found, always replace the complete set of belts.

Checking condition

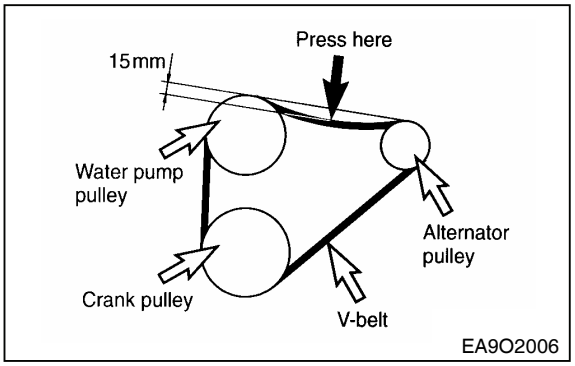
2) Check belts for cracks, oil, overheating and wear.

3) Testing by hand

- **V-belt**

  By the finger-pressure the belt is pressed by 10-15mm between the pulleys in normal condition.(Pressed mid-way between the belt pulleys)

  A more precise check of the V-belt tension is possible only by using a V-belt tension tester.



- **Poly belt**

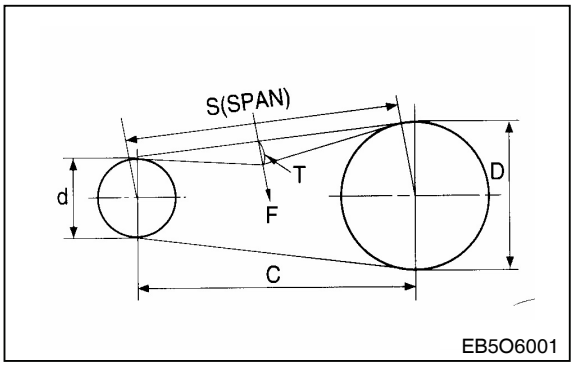
  Poly belt will be properly tensioned if the deflection force “F” is applied mid-way between the belt’s tangent points with the pulley.

  T = 0.015 x S(about 1.5mm per 100mm)

  T = 0.015 x *S (mm)
  (T : Deflection , S : Span)

$$^{*}S = \sqrt{C^2 - \frac{(D-d)^2}{2}} \quad \text{(mm)}$$

  C : Distance of pulleys (mm),
  D : Large pulley diameter (mm),
  d : Small pulley diameter (mm)

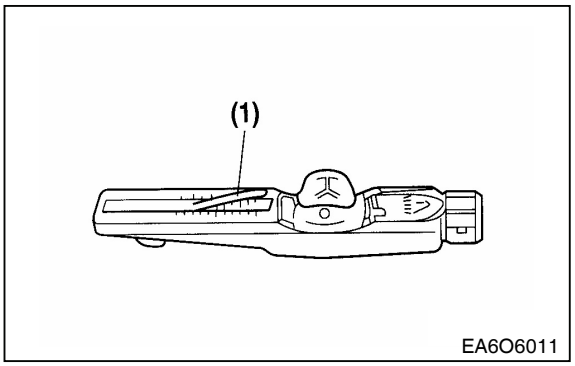


4) Measuring tension

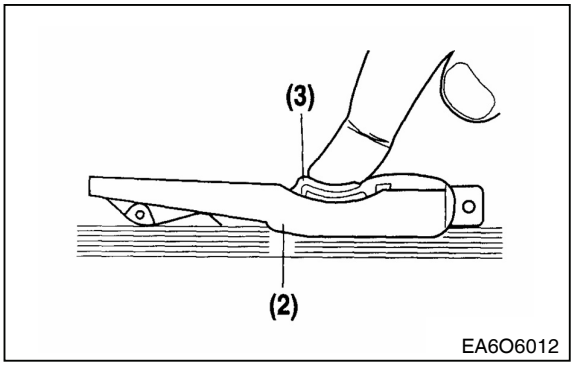
① Lower indicator arm (1) into the scale.

- Apply tester to belt at a point midway between two pulleys so that edge of contact surface (2) is flush with the V-belt.
- Slowly depress pad (3) until the spring can be heard to disengage. This will cause the indicator to move upwards.
  If pressure is maintained after the spring has disengaged a false reading will be obtained!

② Reading of tension



- Read of the tensioning force of the belt at the point where the top surface of the indicator arm (1) intersects with the scale.
- Before taking readings make ensure that the indicator arm remains in its position.

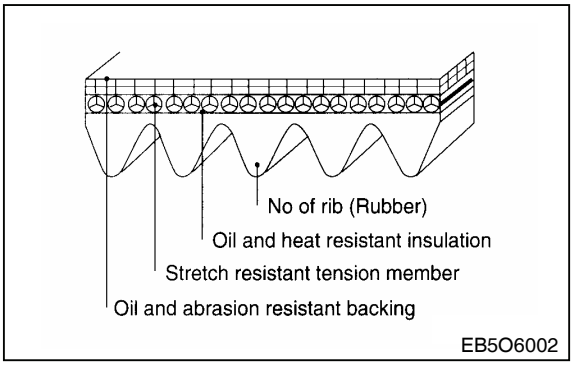


- **V-belt tension**

Type	Drive belt width	Tensioning forces on the tester		
		new installation		When servicing after long running time
		Installation	After 10 min. running time	
M	9.5 mm	50 kg	45 kg	40 kg
A	11.8 mm	55 kg	50 kg	45 kg
B	15.5 mm	75 kg	70 kg	60 kg
C	20.2 mm	75 kg	70 kg	60 kg

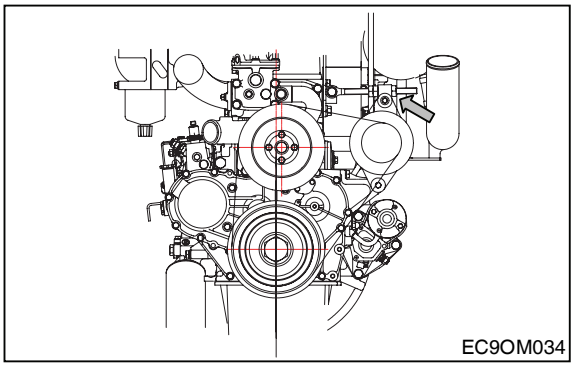
- **Poly belt tension**

No of rib (PK type)	Force(kgf)
3	20 - 27
4	27 - 36
5	34 – 45
6	41 – 57
7	48 – 66
8	59 - 73



5) Tensioning and changing belts

- Loosen fixing bolts and nuts.
- Adjust the alternator until belts have correct tensions.
- Retighten fixing bolts and nuts.
- To change the belts loosen fixing bolts and nuts. Then push the alternator toward water pump pulley by hand.

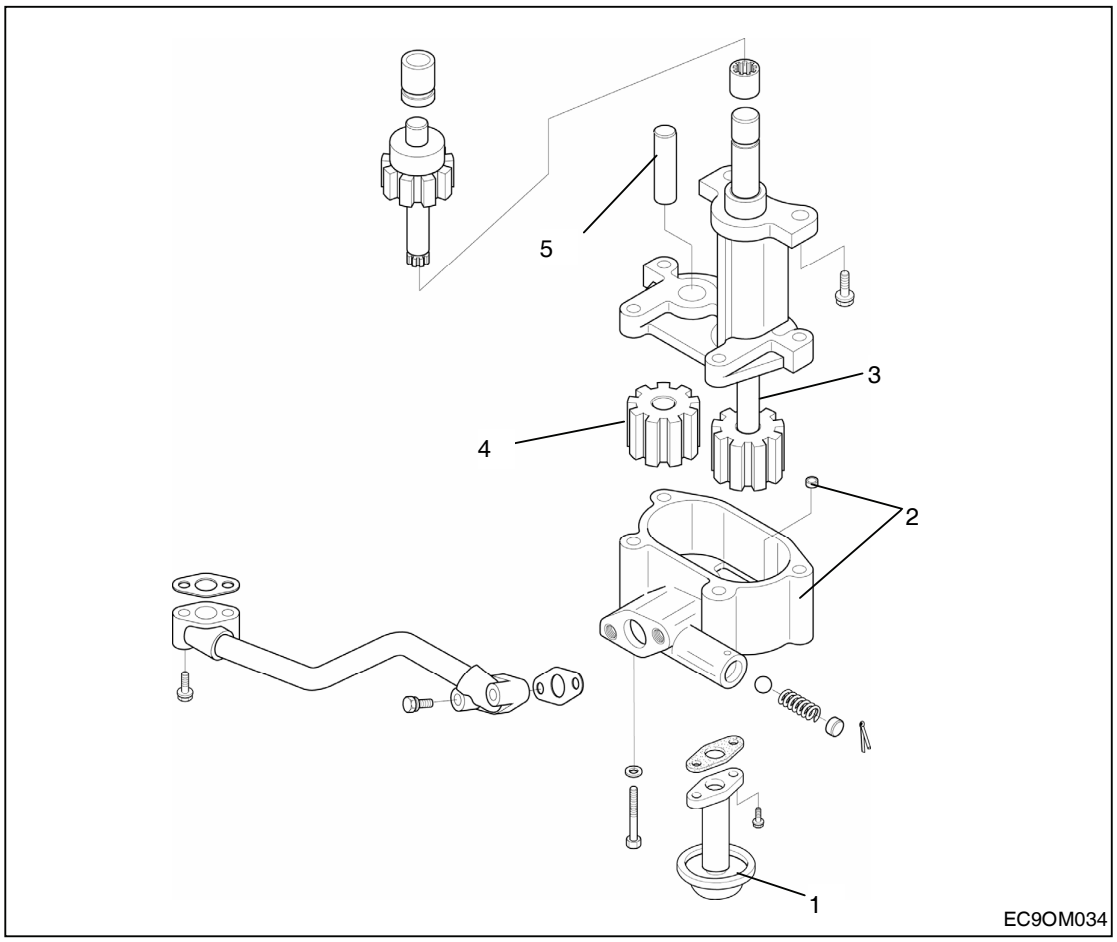


5. Maintenance of Major Components

5.1. Lubrication system

5.1.1. Oil pump

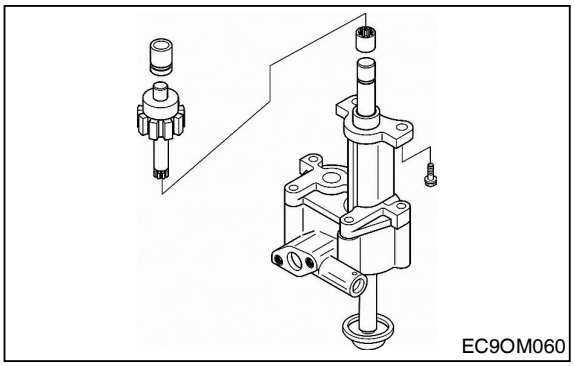
1) Disassembly



1. Oil suction pipe
2. Cover and dowel
3. Drive shaft and gear
4. Pinion Gear
5. Pinion gear shaft

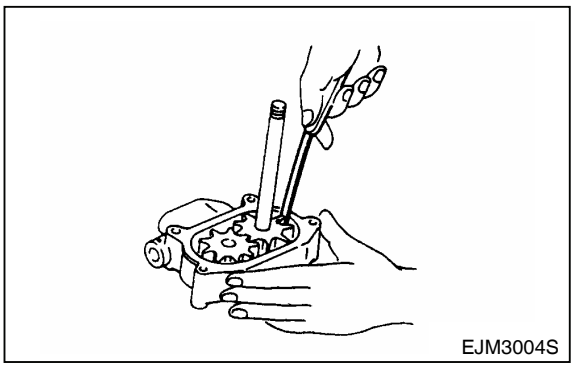
2) Inspection

- Visually inspect the disassembled parts for the excessive wear and damage.
- Correct or replace the parts if the wear or damage is discovered during inspection.



3) Oil Pump Drive Gear

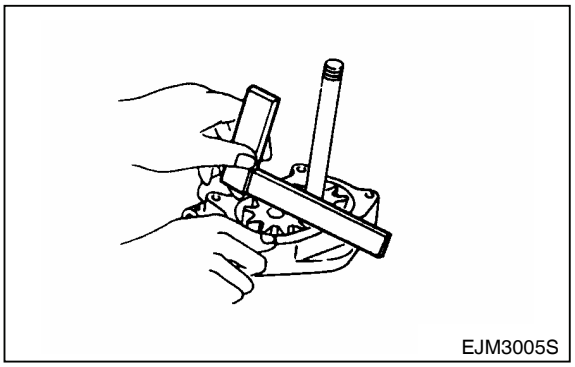
- Use a feeler gauge to measure the clearance between the oil pump cover (oil pump case) inside surface and the drive gear.
- If the clearance exceeds the specified limit, the drive gear and/or the oil pump cover must be replaced.



	Limit
0il pump cover and drive gear clearance	0.18 mm

4) Oil pump pinion gear

- Use a feeler gauge to measure the clearance between the oil pump case cover inside surface and the pinion gear.
- If the clearance exceeds the specified limit, the pinion gear and/or the oil pump cover must be replaced.



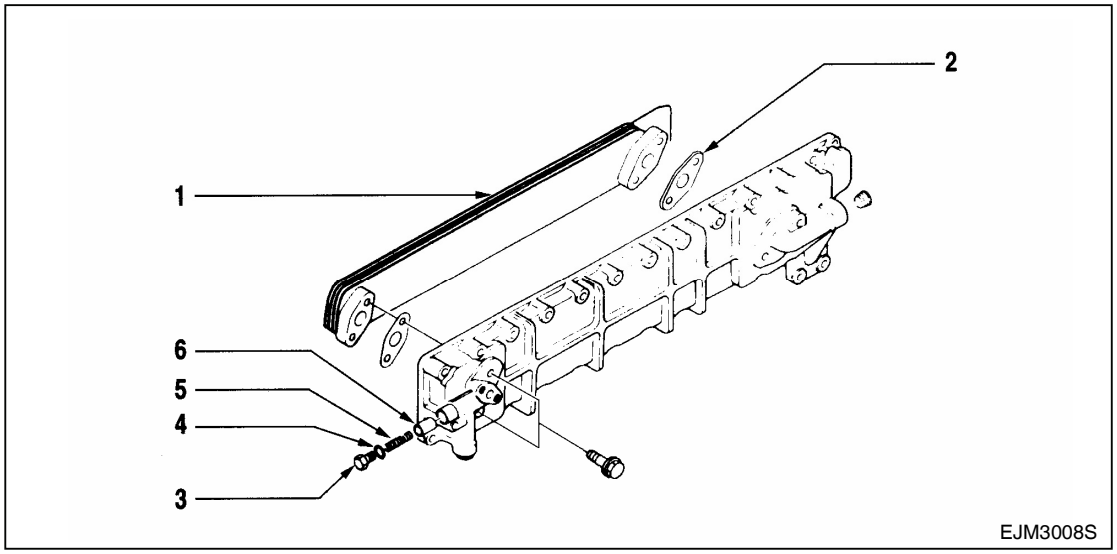
	Limit
0il pump cover and pinion gear clearance	0.12 mm

5) Oil pump reassembly

- To assemble, follow the disassembly procedures in reverse order.

5.1.2. Oil cooler

1) Disassembly



1. Oil cooler element
2. Gasket
3. By-pass plug
4. O-ring
5. By-pass valve spring
6. By-pass valve

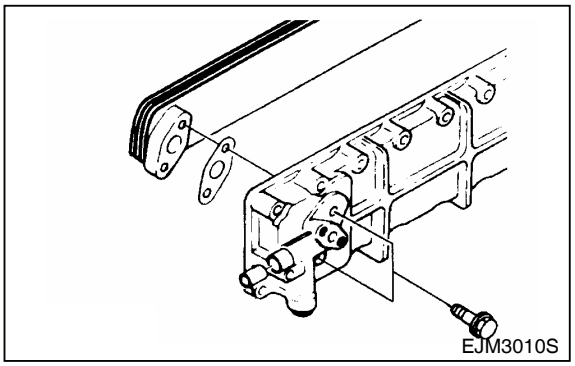
2) Inspection

- Correct or replace the part if the wear or damage is discovered during inspection.

3) Oil cooler element

- Install the oil cooler element to the oil cooler, then tighten the oil cooler element fixing bolts to the specified torque.

Oil cooler element fixing bolts torque	2.2 kg.m



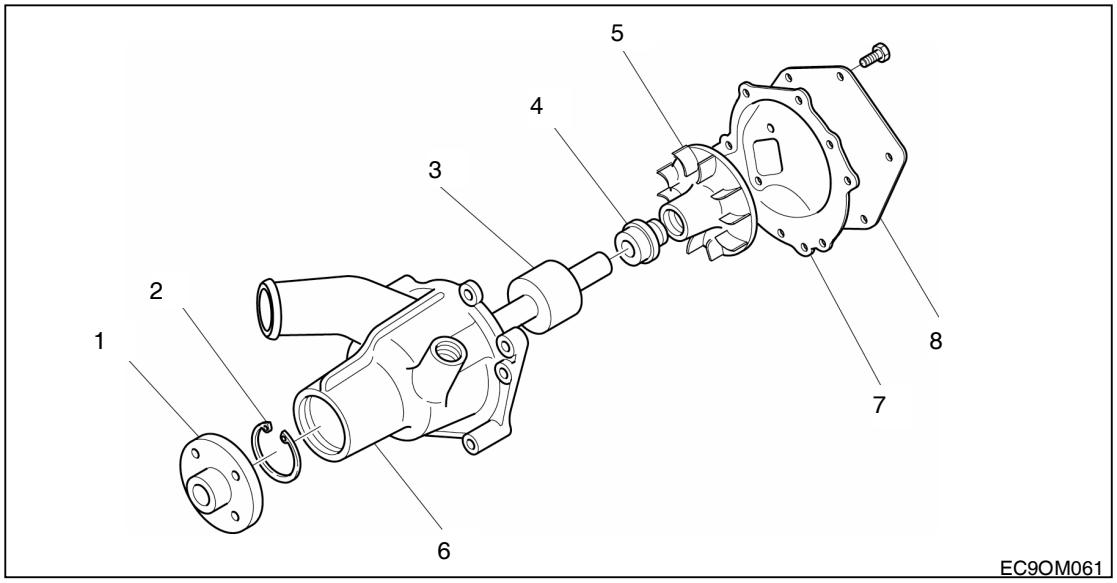
4) Oil cooler reassembly

- To assemble, follow the disassembly procedures in reverse order.

5.2. Cooling system

5.2.1. Water pump

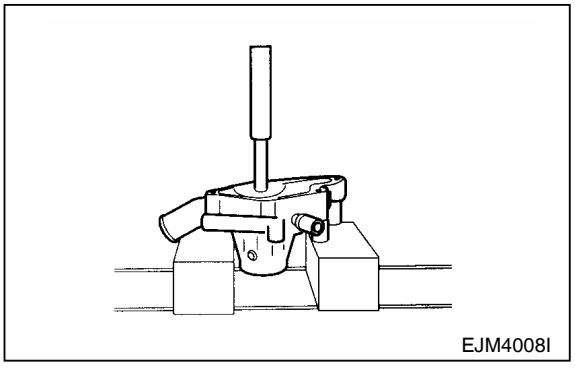
1) Disassembly



1. Pulley flange
▲ 2. Snap ring
▲ 3. Unit bearing
4. Mechanical seal
▲ 5. Impeller
6. Pump housing
7. Cover
8. Gasket

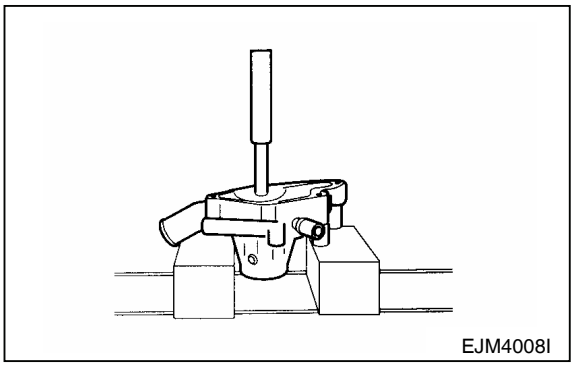
(1) Impeller

- Remove the impeller by using the jig.



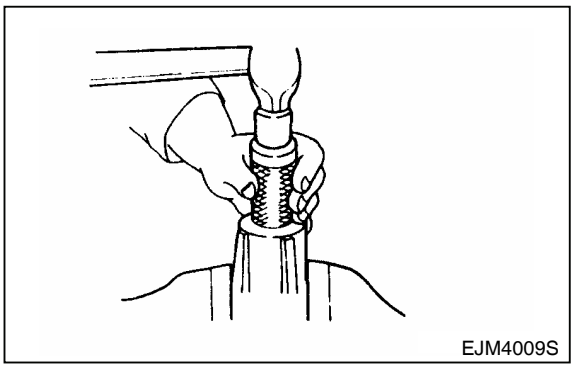
(2) Unit bearing

- Remove the unit bearing by using a bench press and a suitable remover.


EJM4008I

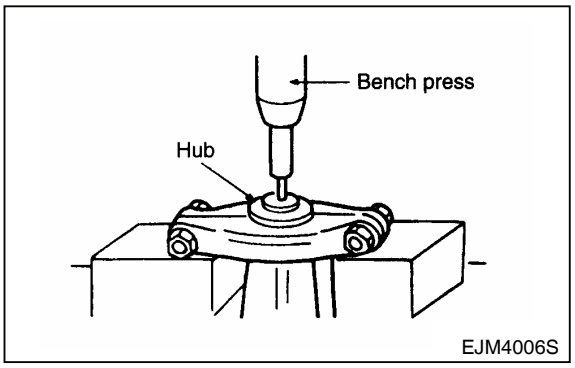
(3) Mechanical seal

- Remove the mechanical seal by using a suitable remover.


EJM4009S

(4) Hub

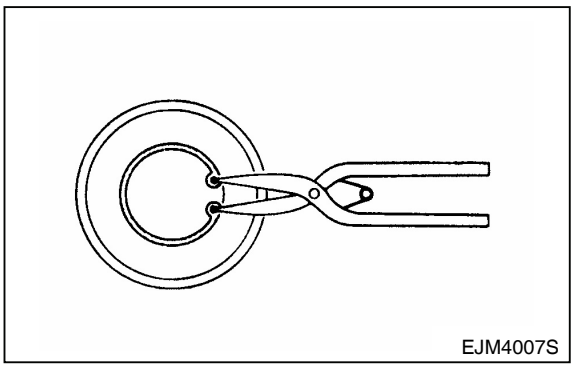
- Remove the hub by using a bench press and a suitable rod.



EJM4006S

(5) Snap ring

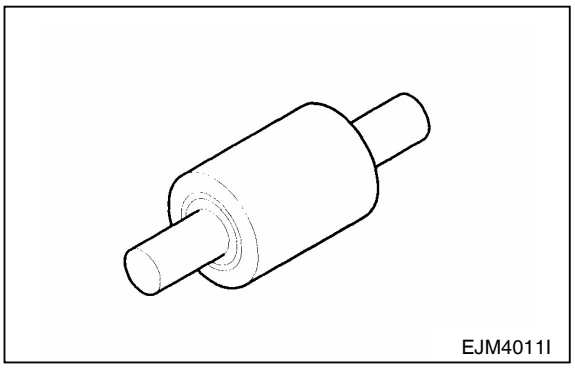
- Remove the snap ring by using a pair of the snap ring plier.


EJM4007S

2) Inspection

(1) Unit bearing

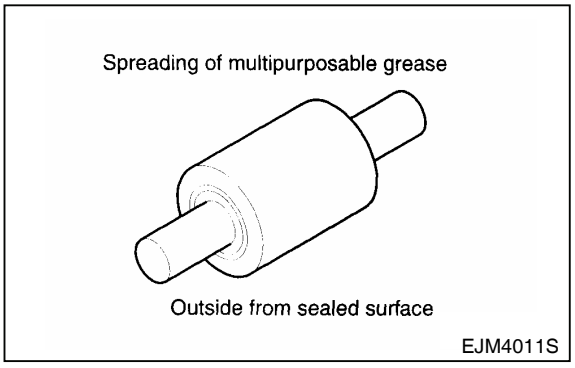
- Correct or replace the part if the wear, defect or other damage is discovered during inspection.


EJM4011I

3) Water pump reassembly

(1) Unit bearing

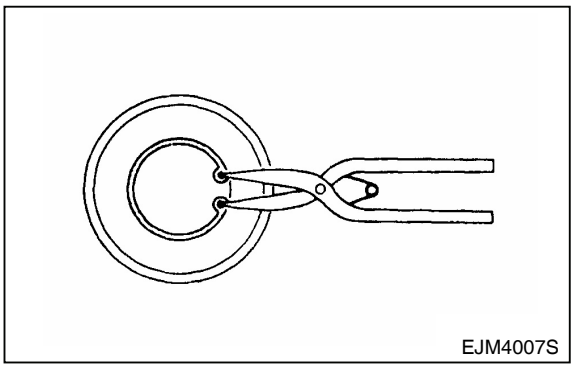
- Lubricate the bearing with multipurpose grease.
- Use a bench press to assemble the unit bearing at the pump.



EJM4011S

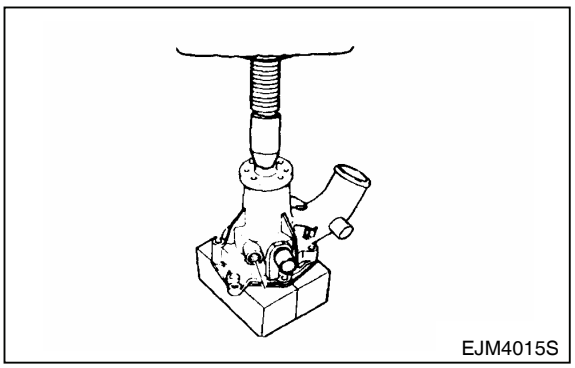
(2) Snap Ring

- Use a pair of snap ring plier to install the snap ring.


EJM4007S

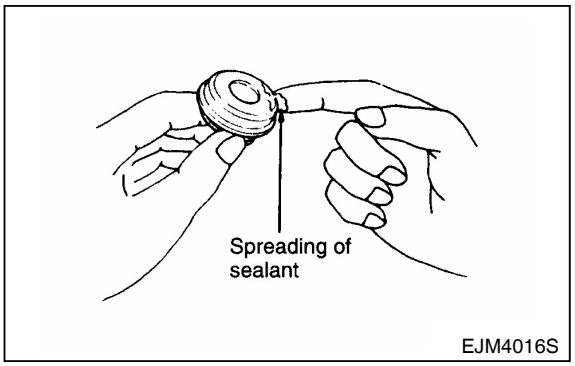
(3) Hub

- Use a bench press and a bar to install the hub.

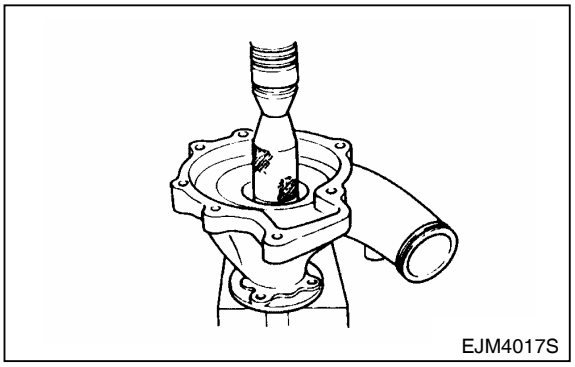

EJM4015S

(4) Mechanical seal

- Apply sealant to the seal unit outer periphery before installation.



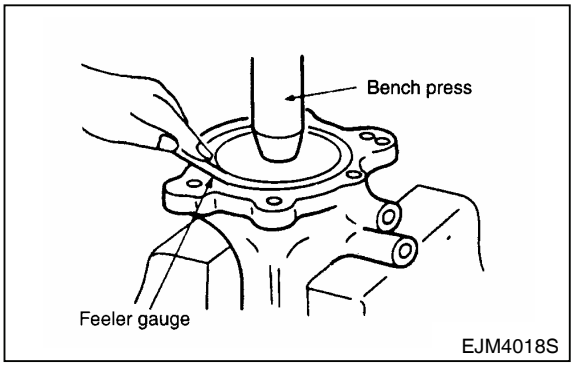
- Use a bench press and a bar to install the seal unit into the pump body.



(5) Impeller

- Use a bench press to install the impeller to the shaft.
- Use a feeler gauge to measure the clearance between the impeller and the pump body.

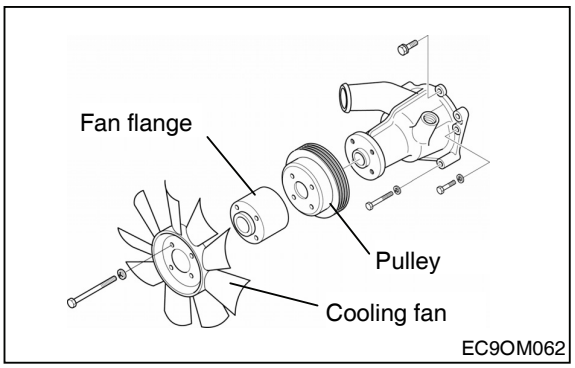
Clearance between impeller and pump body	0.3 ~ 0.8mm



(6) Pulley

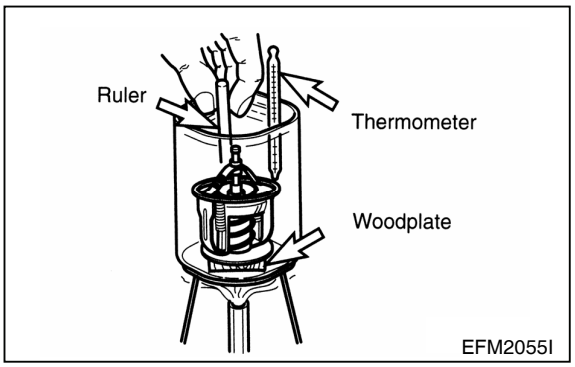
- Install the pulley and tighten the pulley bolts to the specified torque.

Pulley fixing bolts torque	2.2 kg.m



5.2.2. Thermostat

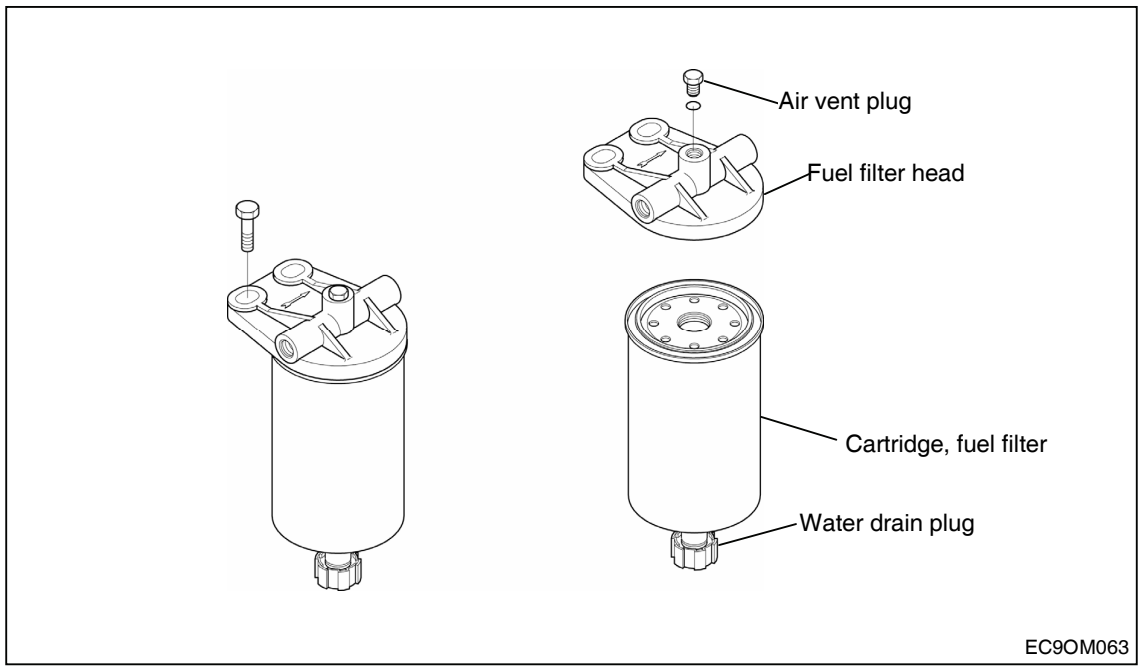
- Correct or replace thermostat if the wear, defect or other damage is discovered during inspection.



5.3. Fuel system

5.3.1. Fuel filter

1) Cartridge type



2) Inspection

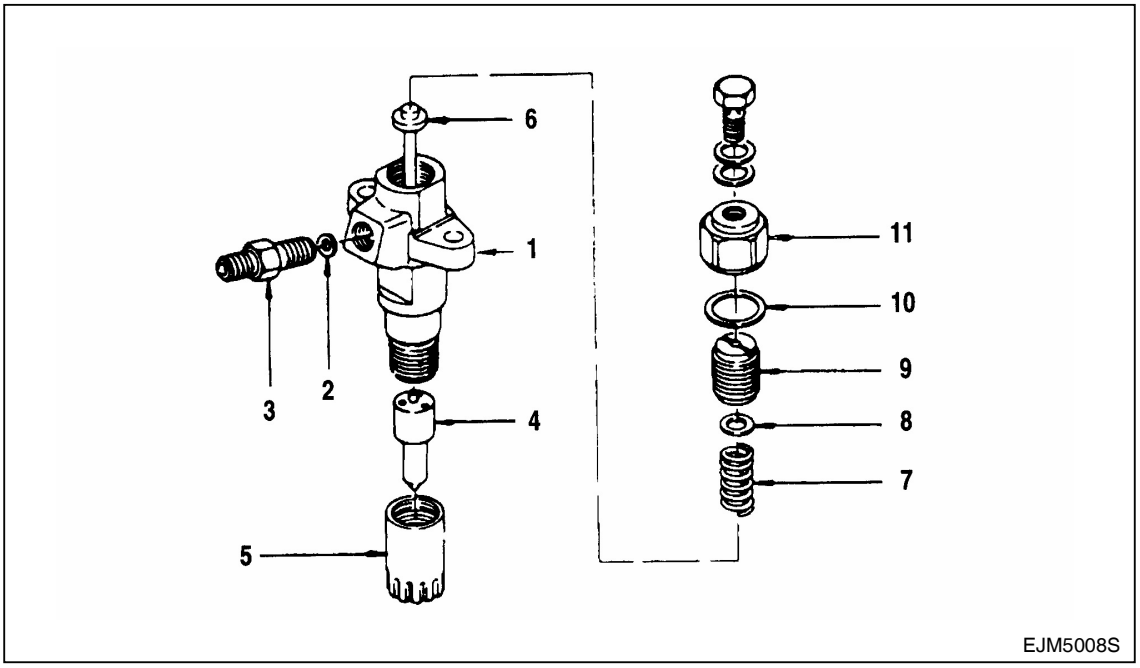
- Make the necessary adjustments, repairs and part replacements if excessive wear or damage is discovered during inspection.

3) Fuel filter reassembly

- To reassemble the fuel filter, follow the disassembly procedure in the reverse order.

5.3.2. Injection nozzle

1) Disassembly



1. Nozzle holder body
2. Seal ring
3. Injection pipe connector
▲ 4. Injection nozzle
5. Retaining nut
6. Nozzle holder push rod
7. Push rod spring
8. Spring seat
9. Nozzle adjusting screw
11. Nozzle holder cap nut

2) Injection nozzle

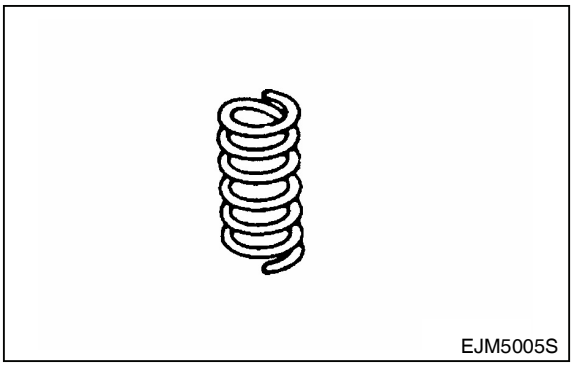
- Remove the nozzle assembly from the nozzle body. Keep the parts separately to maintain the proper needle valve to body combination.

3) Inspection

- Make the necessary adjustments, repairs and parts replacements if excessive wear or damage is discovered during inspection.

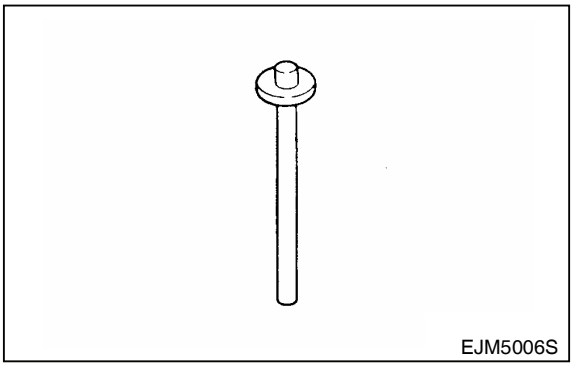
(1) Push rod spring

- Check the push rod spring for wear, weakness and corrosion.


EJM5005S

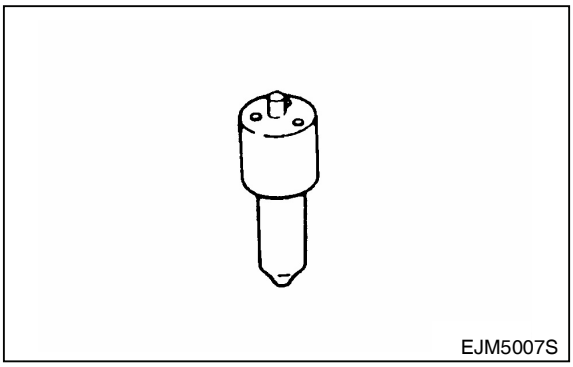
(2) Nozzle holder push rod

- Check the nozzle holder push rod curvature.
- Check the nozzle holder push rod and needle valve contact surface for excessive wear and poor contact.


EJM5006S

(3) Injection nozzle

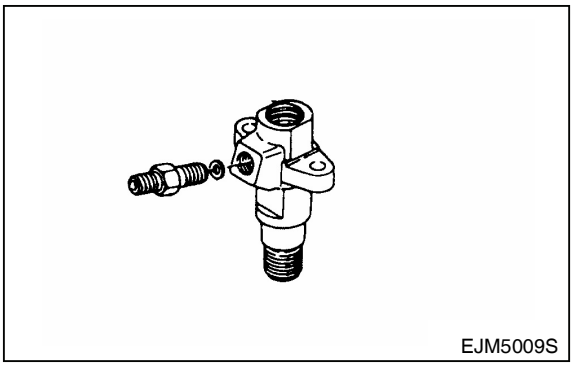
- Check the injection nozzle needle valve, the valve seat, and the injection nozzle hole for carbon deposits.
  If carbon deposits are present, the injection nozzle and the needle valve must be replaced.
  Hold the nozzle body vertically.
- Pull the needle valve about one-third of the way out of the nozzle body. Release the needle valve.
  Check that the needle valve falls back into the nozzle body as far as the valve seat.
  If the needle does not fall back into the nozzle body as far as the valve seat, the injection nozzle and the needle valve must be replaced.


EJM5007S

4) Reassembly

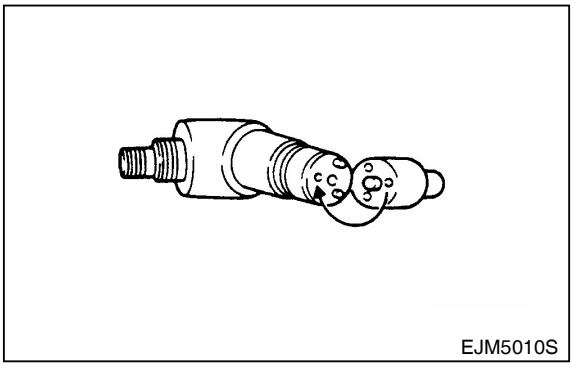
(1) Injection pipe connector

Injection pipe connector torque	5.5 kg.m


EJM5009S

(2) Injection nozzle

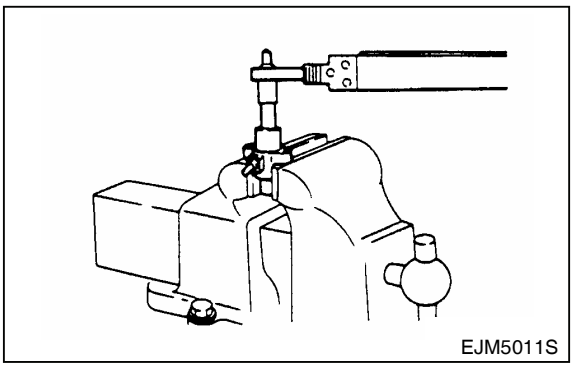
- There must be no oil on the contact surface of the injection nozzle and the injection nozzle holder.
- Clean these contact surface with diesel fuel before installation.
- The nozzle dowel pin must be aligned with the dowel hole in the nozzle holder body.


EJM5010S

(3) Retaining nut

- Clamp the injection nozzle in a vise.
- Tighten the retaining nut to the specified torque by using a wrench.

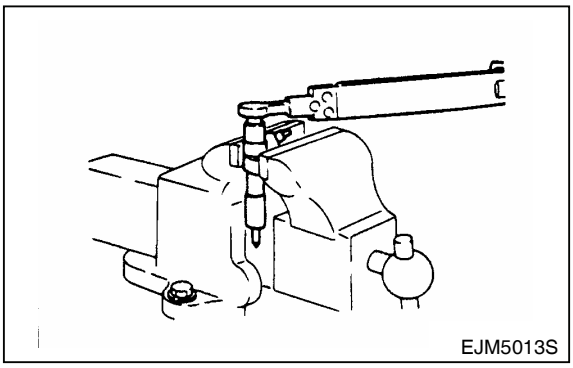
Nozzle retaining nut Torque	7 kg.m


EJM5011S

(4) Nozzle holder cap nut

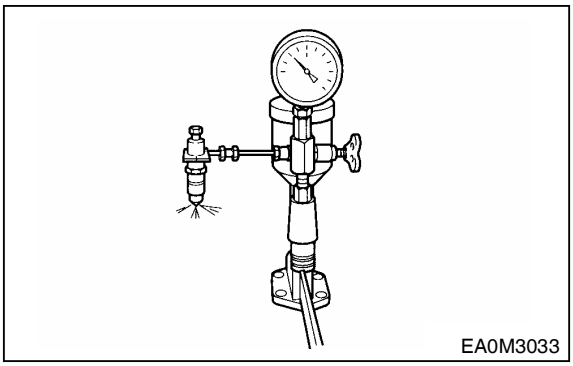
- Clamp the injection nozzle in a vise.
- Tighten the nozzle holder cap nut to the specified torque by using a wrench.

Nozzle holder cap nut torque	4.5 kg.m

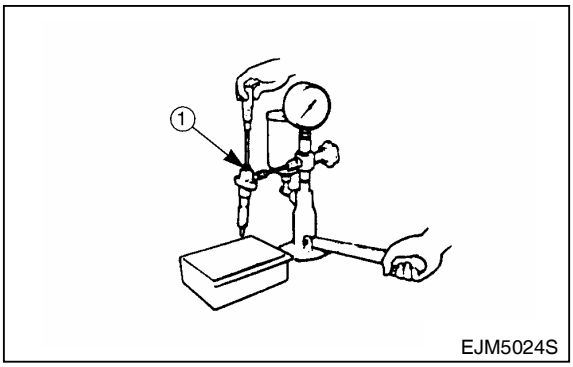

EJM5013S

(5) Nozzle adjusting screw (injection starting pressure check)

- Attach the injection nozzle holder to the injection nozzle tester.


EA0M3033

- Loosen the adjustment screw①.



EJM5024S

- Check the injection nozzle starting pressure and the spray condition by operating the injection tester.

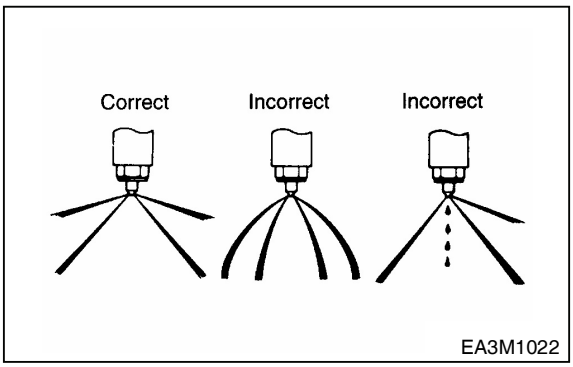
<spray condition check>

Operate the injection nozzle tester hand lever 4 to 6 times while looking for abnormal injection nozzle spray conditions. (See figure)

(1) Correct (Good)

(2) Incorrect (Bad - orifice)

(3) Incorrect (Bad - dripping)



EA3M1022

- Adjust the injection nozzle starting pressure.

Turn the adjusting screw clockwise while operating the injection nozzle tester handle.

CAUTION:

Keep away your skin from the tester because pressure of nozzle tester is very high when inject.

5.3.3. Injection Pump Calibration

1) DB58S engine (ECRFD)

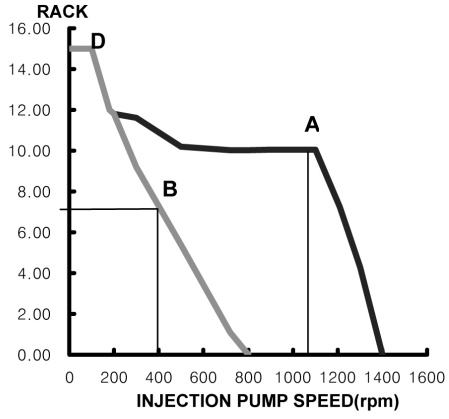
DOOSAN	**INJ.PUMP CALIBRATION DATA**				D.H.I NO.	65.11101-7404
					MAKER NO.	101605-996H(DOOWON)
					DATE	2003. 11. 04
	E/G MODEL	DB58S	SUFFIX	ECRFD	FOR USE	D35/40/45S,D50C-2 F/L

INJ.PUMP BODY :101062-830A (KP-PES6A95C410RS2000)	GOVERNOR :105419-1340 (KP-EP/RSV200-1450AQ43A311)	TIMING DEVICE : LESS

TEST CONDITION	NOZZLE & HOLDER ASS'Y	105780-8140	(FOR E/G : 105160-465B)
	NOZZLE	105780-0000	(FOR E/G : 105025-138B)
	NOZZLE HOLDER	105780-2080	(FOR E/G : 105031-386D)
	NOZZLE OPENING PRESSURE	175 kg/㎠	(FOR E/G : 220 kg/㎠)
	TRANSFER PUMP PRESSURE	1.6 kg/㎠	
	INJ.PIPE(BENCH)	INNER x OUTER x LENGH = Ø2.0 x Ø6.0 x 600 mm	
	INJ.PIPE(ENGINE)	INNER x OUTER x LENGH = Ø1.6 x Ø6.0 x 580 mm	
	TEST OIL	ISO4113 or SAE STANDARD TEST OIL(SAE J967d) or KS2	
		OIL TEMPERATURE : 40 ±5 ℃	
	OVERFLOW VALVE OPENING PRESSURE	1.6 kg/㎠	

INJ.TIMING : NO.1 PLUNGER 4.3 ±0.05mm	INJ.ORDER : 6-2-4-1-5-3 DRIVE SIDE

GOVERNOR ADJUSTMENT



INJ.QUANTITY(FOR BENCH STATE)

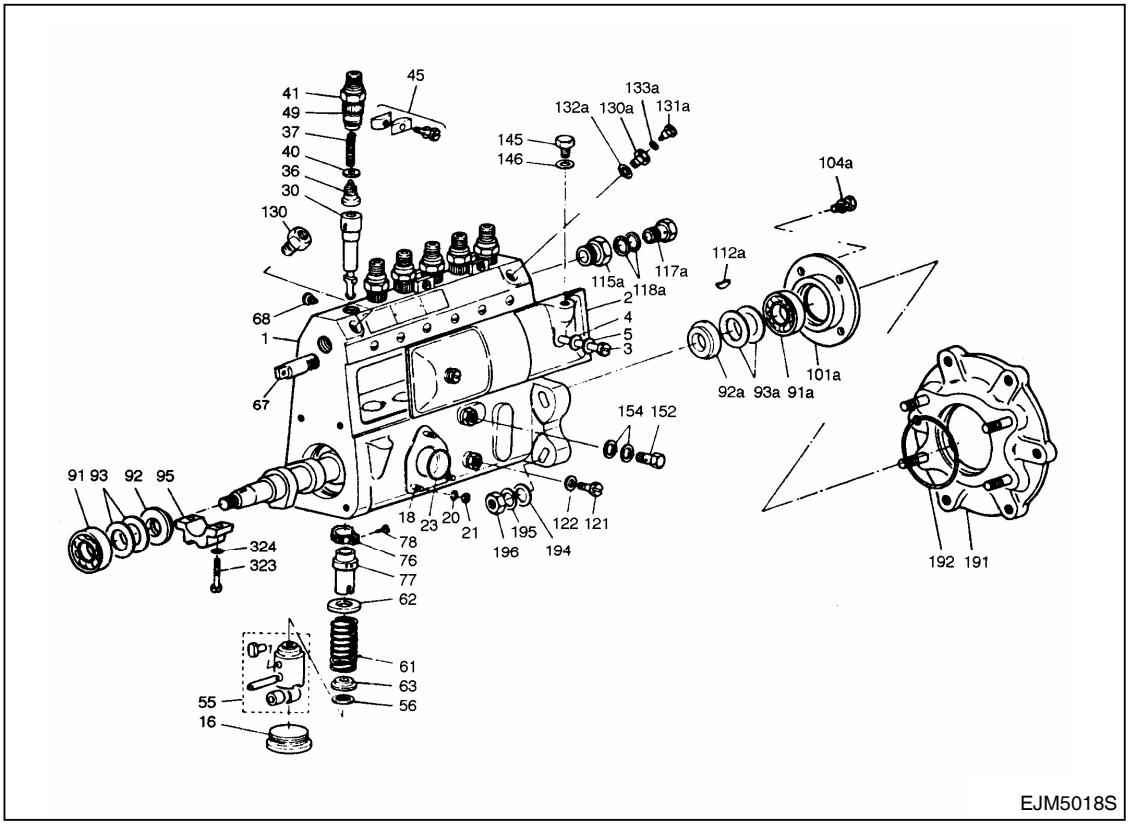
CHECK POINT	RACK POSITION (mm)	PUMP SPEED (rpm)	INJ. QUANTITY (cc/1000ST)	VARIATION RATE (%)	REMARK
A	10.3	1100	70.0	±4	기준
B	7.3	400	8.0	±14	
D	-	100	40.0	-	Rack limit

SPRING CONSTANT(kg/mm)		FLY WEGHT (g)		740
GOVERNOR	12.0	PLUNGER LEAD		20˚
IDLING	1.9	DEL.V/V HDR MARK		-
IDLE SUB	2.1	DAMPING V/V ORIF.DIA		-
START	0.005	D.V RET. VOL. (Ø6X2.5mm/t=0.11mm)		59 mm3/st
DEL.VALVE	1.63			
ADAPTER	11	LEVER RATIO	MINIMUM	1 : 1.2
			MAXIMUM	1 : 1.2

TIMING DIVICE	BOOST COMPENSATOR
LESS	LESS

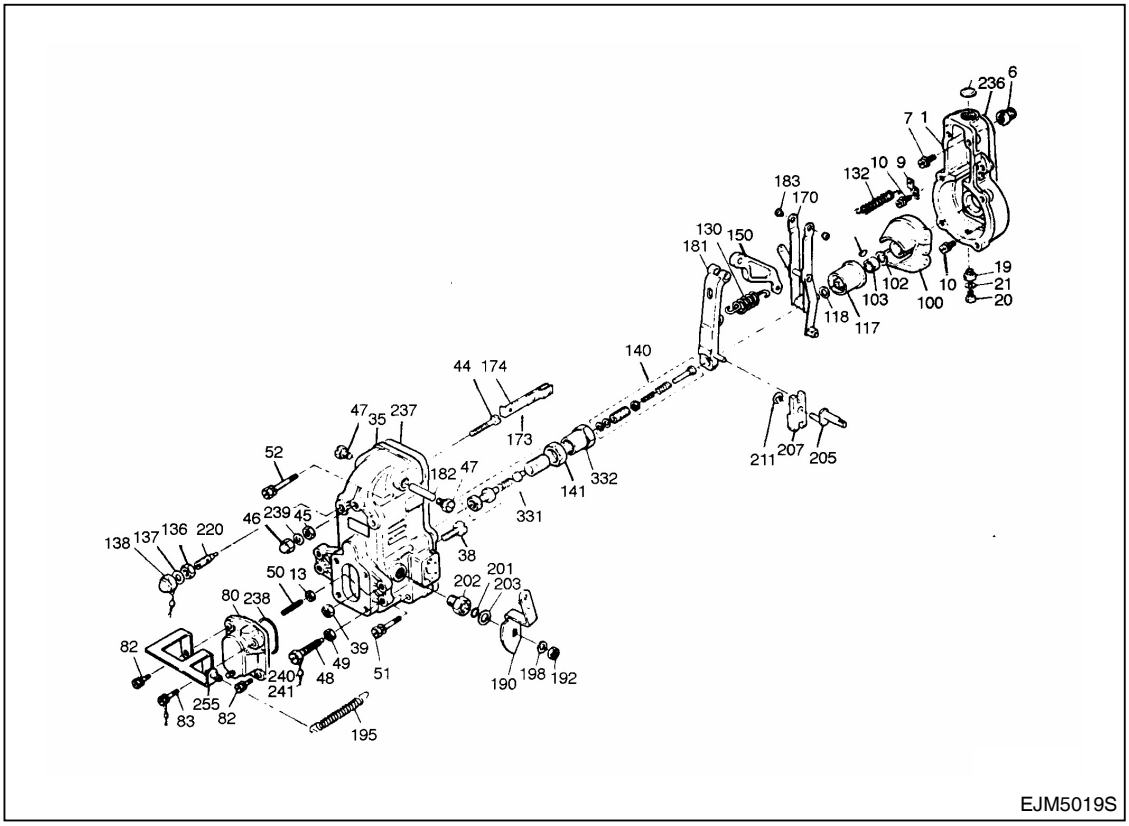
REMARK	DRY WEIGHT

2) Injection pump



1. Pump housing
2. Cover assembly
3. Bolt, cover
4. O-ring
5. Gasket
16. Screw, plug
18. Bolt, stud
20. Spring washer
21. Nut
23. O-ring
30. Plunger
36. Delivery valve
37. Delivery valve spring
40. Delivery valve holder
45. Lock plate assembly
49. O-ring
55. Tappet
115a. Adapter
56. Shim
61. Plunger spring
62. Seat, spring(upper)
63. Seat, spring(lower)
67. Control rack
68. Stop bolt
76. Pinion
77. Sleeve
78. Bolt
90. Camshaft
91.91a. Taper roller bearing
92.92a Camshaft ring
93.93a. Shim
95. Center bearing
101a. Bearing cover
104a Bolt
112a. Woodruf key
196. Nut
117a. Connection bolt
118a. Gasket
121. Plug screw
122. Gasket
130. Connect
130a. Adapter
131a. Bolt
132a. Gasket
133a. Gasket
145. Plug screw
146 Gasket
152. Connection bolt
154. Packing
191. Bracket
192. O-ring
194. Washer
195. Spring washer

3) Governor



1. Governor housing
4. Plate
6. Adapter
7. Bolt
9. Spring
10. Bolt
13. Nut
19. Adapter
20. Bolt
21. Gasket
35. Governor cover
38. Tension lever bolt
39. Nut
44. Stop bolt
46. Cap
47. Plug
48. Adjusting bolt
49. Nut
50. Stop bolt
51. Bolt
52. Bolt
80. Cover
82. Bolt
83. Bolt
100.Fly wheel
101. Woodruf key
102. Spring washer
103. Nut
117. Sleeve
118. Shim
130. Governor spring
132. Starting spring
136. Nut
137. Gasket
138. Cap
140. Idle spring
141. Nut
150. Speed setting lever
170. Guide lever
173. Split pin
174. Floating lever link
181. Tension lever
182. Lever shaft
183. Collar
190. Control lever
192. Nut
195. Return spring
198. Spring washer
201. O-ring
202. Bush
203. Shim
205. Shaft lever
207. Support lever
211. Snap ring
220. Damper spring
236. Gasket
239. Gasket
240. Lead seal
241. Wire, lead seal
255. Bracket
331. Angleich spring
332. Connection nut

5.3.4. 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.	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) 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.	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) Check each part for leakage of oil, gas, and air, and take proper measure.	1) 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	1) Excessively low oil pressure causes unusual wear or seizure of the bearing. Too high pressure causes oil leakage.
	2) If unusual sound or vibration is heard or felt, reduce engine revolutions slowly and locate the cause.	2) The engine Is operated continuously with unusual sound or vibration not corrected, it can be damaged beyond repair.

5.3.5. 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) Lubricating system

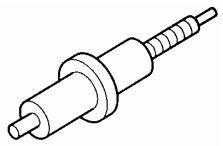
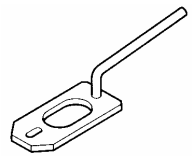
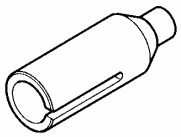
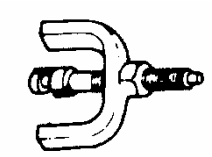
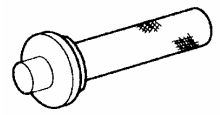
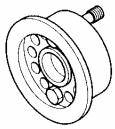
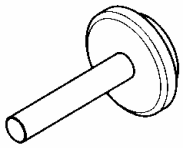
Pay particular attention to oil quality and oil filter change intervals when servicing the lubricating system. Deteriorated engine oil affects adversely not only the engine but torso the turbocharger. Suggested engine oils for the turbocharger-mounted engine are as follows:

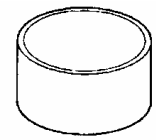
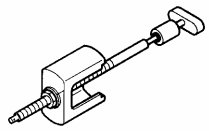
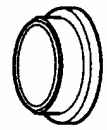
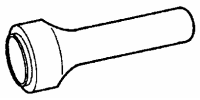
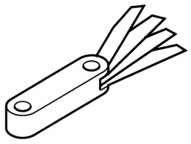
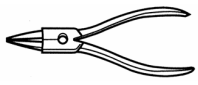
Engine model	Recommend oil	
	SAE No.	API No.
DB58S	SAE15W40 SAE10W40	ACEA-E2 or ACEA-E3 (API CH-4)

5.3.6. Diagnostics and troubleshooting

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

6. Special Tool List

No.	Part No.	Figure	Tool Name	Remark
1	EU.2-0529		Compression gauge adapter	
2	EF122-249		Valve spring compressor	
3	EF.122-265		Crankshaft gear punch	
4	EF.122-253		Crankshaft pilot bearing remover	
5	EF.122-251		Pilot bearing punch	
6	EF.122-262A		Crankshaft rear oil seal installer	
7	EF.122-255		Crankshaft front oil seal installer	
8	EF.122-289		Valve stem oil seal installer	

No.	Part No.	Figure	Tool Name	Remark
9	E1.03901-0124		Piston insert sleeve	
10	EF.122-281		Cylinder liner remover	
11	EF122-261		Cylinder liner installer	
12	EU.1-0022		Pulley bush puncher	
13	EU.2-0328		Pulley bush puller	
14	60.99901-0027		Feeler gauge	
15	T7610001E		Snap ring plier	
16	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	M12 x 1.5	10.9T	1st : 4.4 kg.m 2nd : 150° (Angle method)	
Connecting rod bearing cap bolt	M12 x 1.5	12.9T	9.75 kg.m	
Crankshaft main bearing cap bolt	M16 x 2	12.9T	24.0 kg.m	
Flywheel housing fixing bolt	M14 x 1.5 M16 x 1.5	10.9T 10.9T	13 kg.m 16 kg.m	
Flywheel fixing bolt	M16 x 1.5	10.9T	18 kg.m	
Crankshaft pulley fixing nut	M36 x 1.5	8.8T	60 kg.m	
Oil spray nozzle hollow screw (Relief valve assembly)	M10 x 1.25	-	2.1 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 x 1.5	-	7.0 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 x 1.5	8.8T	25.0 kg.m	
Injection pipe nut	M14 x 1.5	8.8T	3.0 kg.m	
Injection pump delivery valve holder	-	-	11.0 ~ 12.0 kg.m	

3) 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

4) Standard bolt tightening torque table

Refer to the following table for bolts other then described above

Diameter x 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	0.50	0.75	0.90
M6	0.28	0.30	0.45	0.40	0.55	0.47	0.77	0.85	0.90	1.25	0.50
M7	0.43	0.46	0.70	0.63	0.83	0.78	1.20	1.30	1.40	1.95	2.35
M8	0.70	0.75	1.10	1.00	1.40	1.25	1.90	2.10	2.20	3.10	3.80
M8x1	0.73	0.80	1.20	1.10	1.50	1.34	2.10	2.30	2.40	3.35	4.10
M10	1.35	1.40	2.20	1.90	2.70	2.35	3.70	4.20	4.40	6.20	7.40
M10x1	1.50	1.60	2.50	2.10	3.10	2.80	4.30	4.90	5.00	7.00	8.40
M12	2.40	2.50	3.70	3.30	4.70	4.20	6.30	7.20	7.50	10.50	12.50
M12x1.5	2.55	2.70	4.00	3.50	5.00	4.60	6.80	7.70	8.00	11.20	13.40
M14	3.70	3.90	6.00	5.20	7.50	7.00	10.00	11.50	12.00	17.00	20.00
M14x1.5	4.10	4.30	6.60	5.70	8.30	7.50	11.10	12.50	13.00	18.50	22.00
M16	5.60	6.00	9.00	8.00	11.50	10.50	17.90	18.50	18.00	26.00	31.00
M16x1.5	6.20	6.50	9.70	8.60	12.50	11.30	17.00	19.50	20.00	28.00	33.00
M18	7.80	8.30	12.50	11.00	16.00	14.50	21.00	24.20	25.00	36.00	43.00
M18x1.5	9.10	9.50	14.50	12.50	18.50	16.70	24.50	27.50	28.00	41.00	49.00
M20	11.50	12.00	18.00	16.00	22.00	19.00	31.50	35.00	36.00	51.00	60.00
M20x1.5	12.80	13.5	20.50	18.00	25.00	22.50	35.00	39.50	41.00	58.00	68.00
M22	15.50	16.00	24.50	21.00	30.00	26.00	42.00	46.00	49.00	67.00	75.00
M22x1.5	17.00	18.50	28.00	24.00	34.00	29.00	47.00	52.00	56.00	75.00	85.00
M24	20.50	21.50	33.00	27.00	40.00	34.00	55.00	58.00	63.00	82.00	92.00
M24x1.5	23.00	25.00	37.00	31.00	45.00	38.00	61.00	67.00	74.00	93.00	103.0

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