DAEWOO

Operation Manual

GENERATOR DIESEL ENGINE

P158LE
P180LE
P222LE

GENERAL INFORMATION

This instruction describes the essential details in the operation, the usual inspection and the maintenance of POLUS (Power Plus) series (P158LE/ P180LE/ P222LE) generator diesel engine.

These Generator diesel engines (4 stroke, V-line, direct injection, turbocharged and inter cooled type) which have been developed by the accumulated techniques of DAEWOO Heavy Industries R & D Center are the excellent engines in the respects of high performance, low emission, long life-time and high reliability. They are designed to be adapted to various generator systems.

In order to operate the engine in the optimal conditions and to maintain its best performances, the contents in this instruction are to be thoroughly understood and observed.

All warranty claims to be addressed to;

Engine Export Team,
DAEWOO Heavy Industries LTD.
DAEWOO Center 541
Namdaemunro 5-ga, Chung-gu
Seoul, Korea
TEL.: (82-2-726-3205~8), FAX: (82-2-726-3168)

OR to your local DEALER or DISTRIBUTOR.

DAEWOO Heavy Industries LTD.
April. 1999

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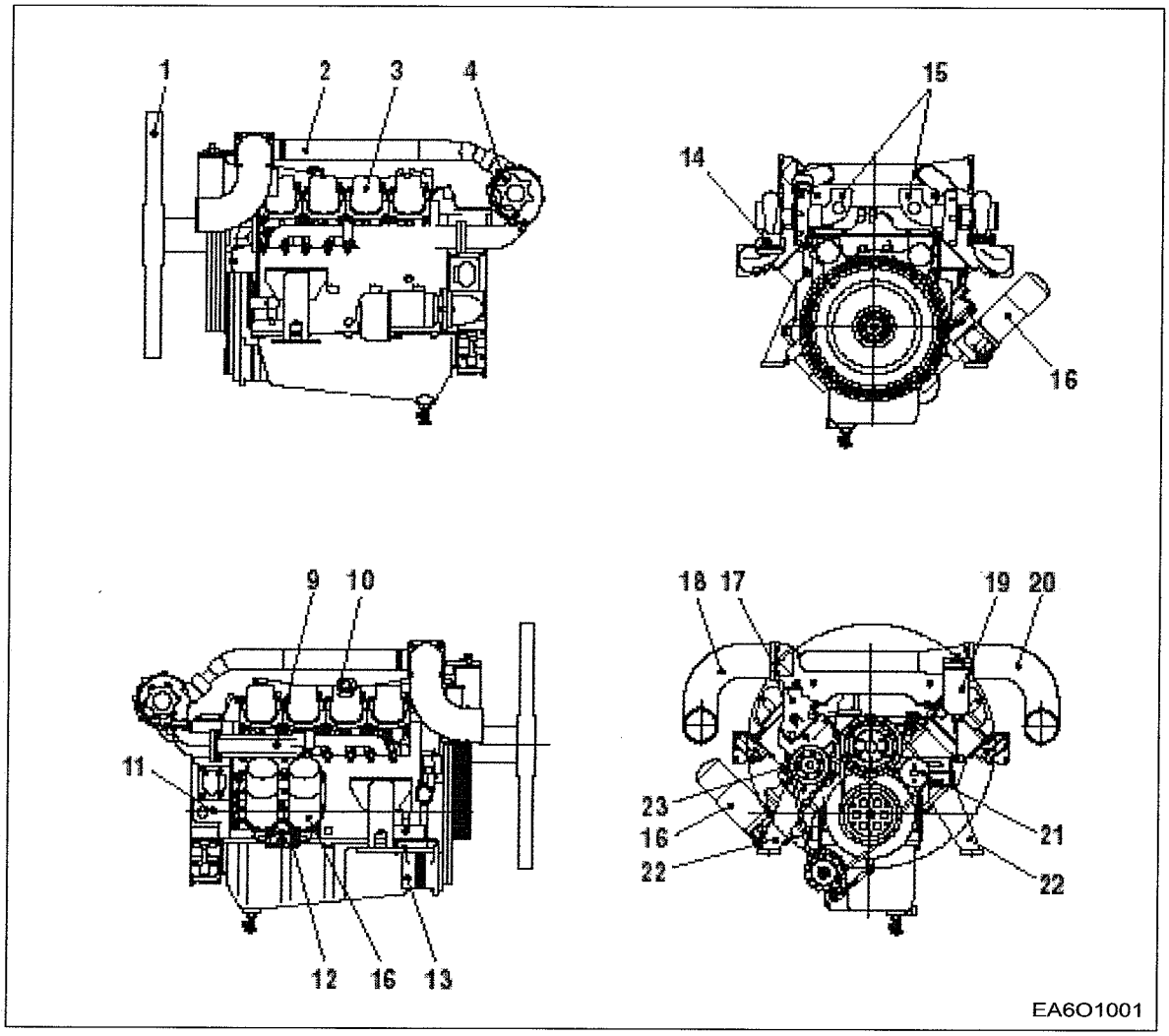
1.1.1. P158LE



1. Cooling fan
2. Air pipe
3. Cylinder head cover
4. Turbocharger
5. Oil drain valve
6. Oil pan
7. Starter
8. Flywheel housing
9. Exhaust manifold
10. Oil filler cap
11. Pick up sensor
12. Oil cooler
13. Alternator
14. Exhaust elbow
15. Air pipe
    (Air cleaner to turbocharger)
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    (Turbocharger to inter cooler)
21. Idle pulley
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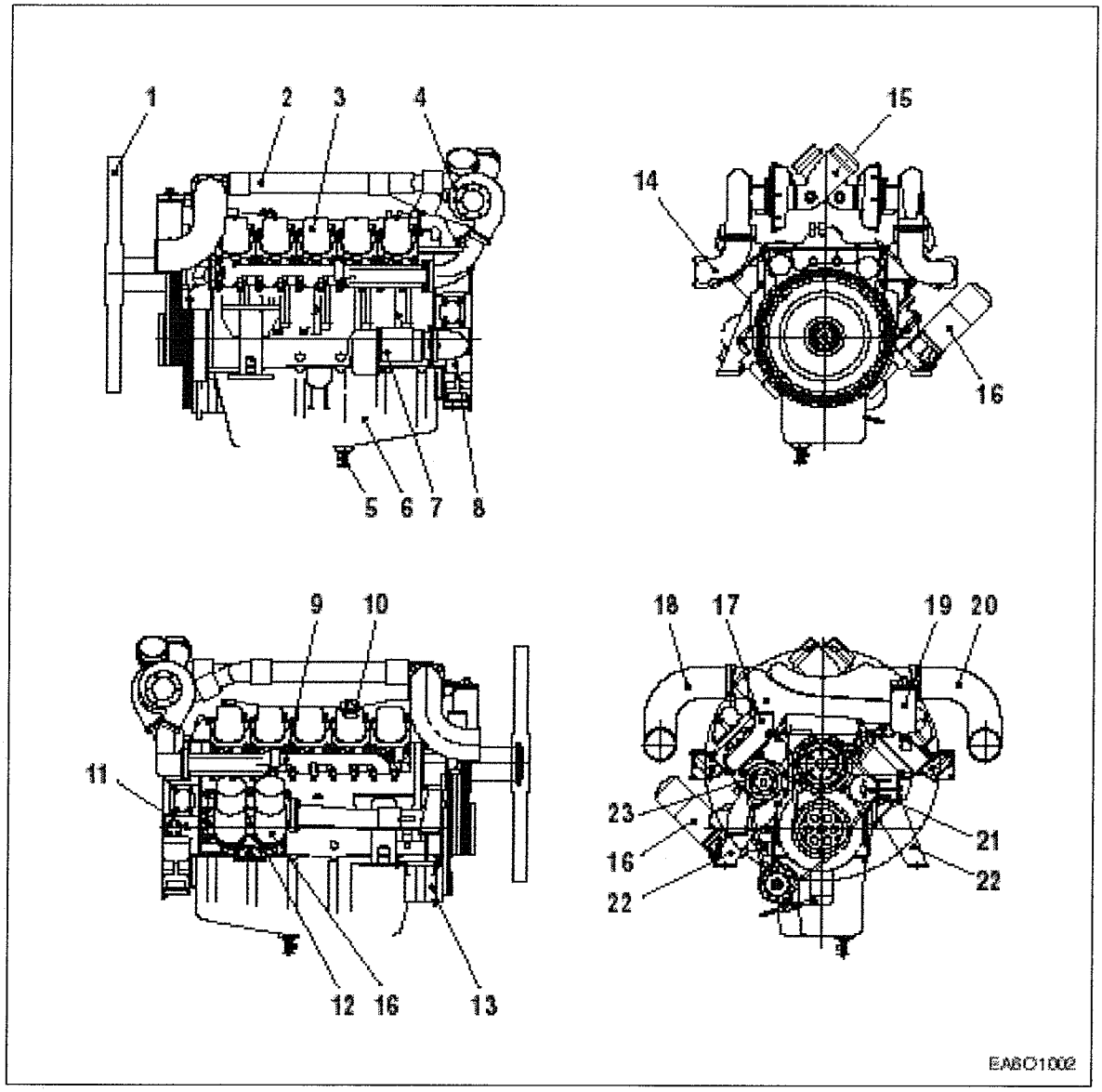
23. Water pump

1.1.2. P180LE



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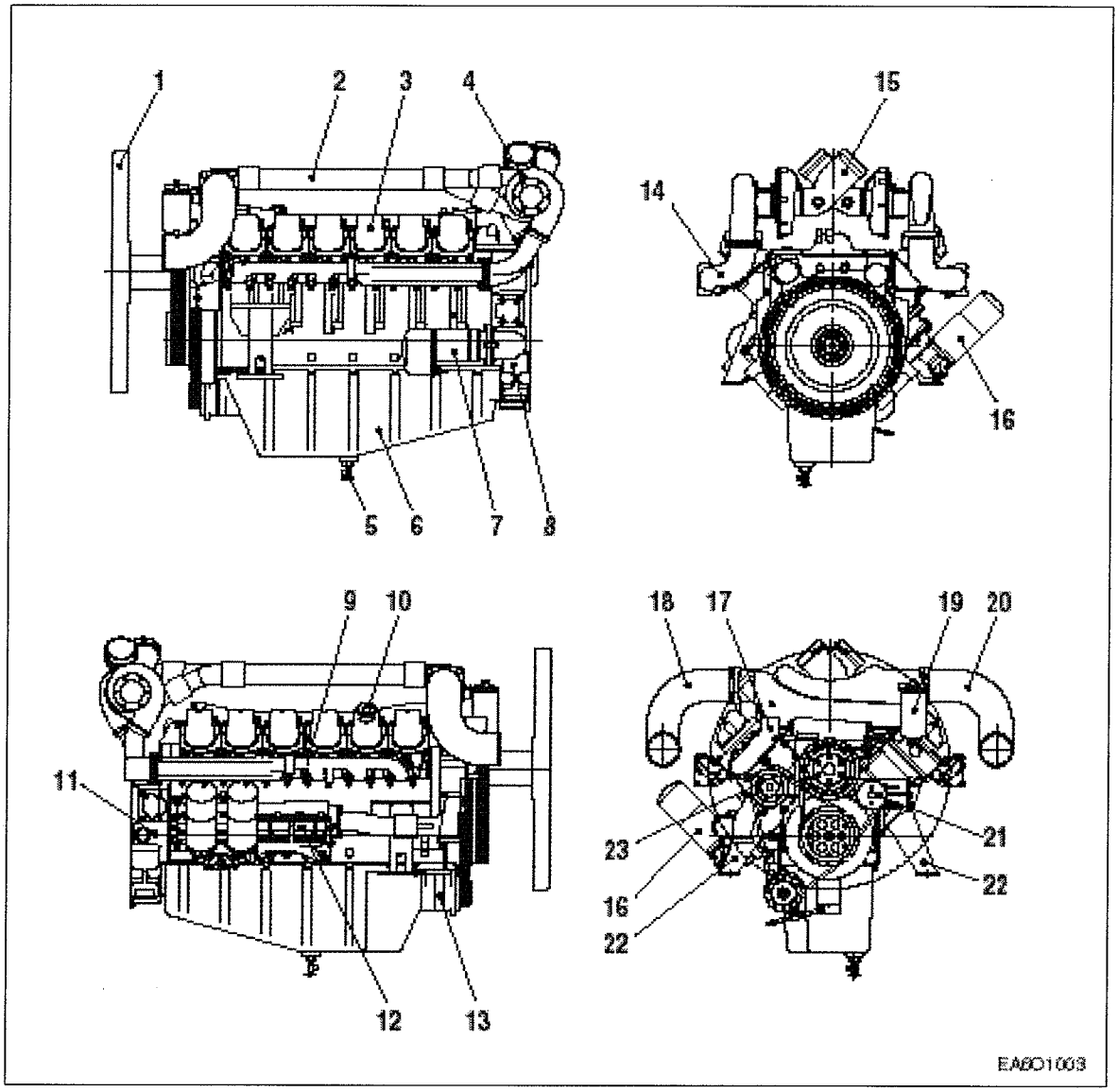
1.1.3. P222LE



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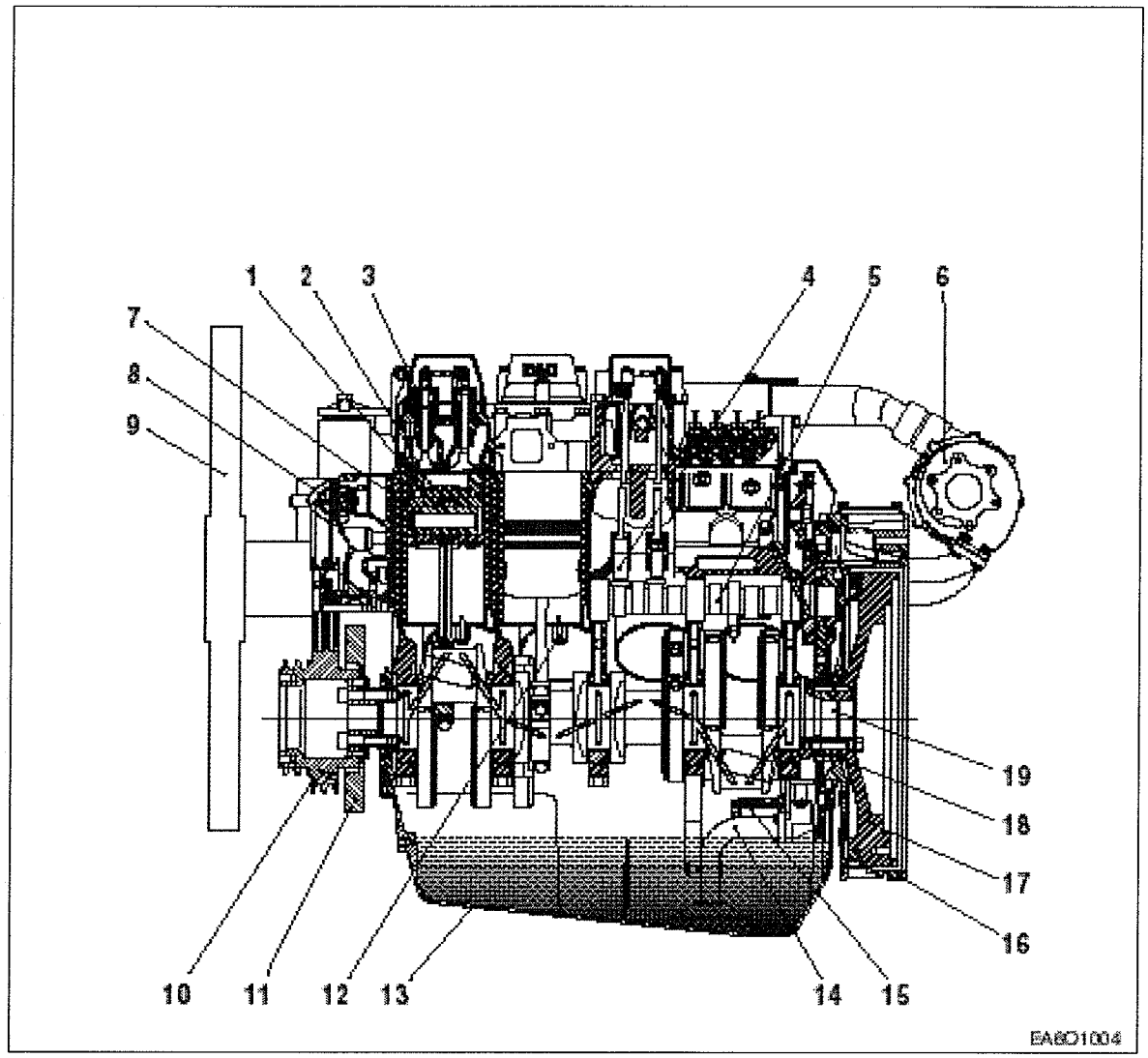
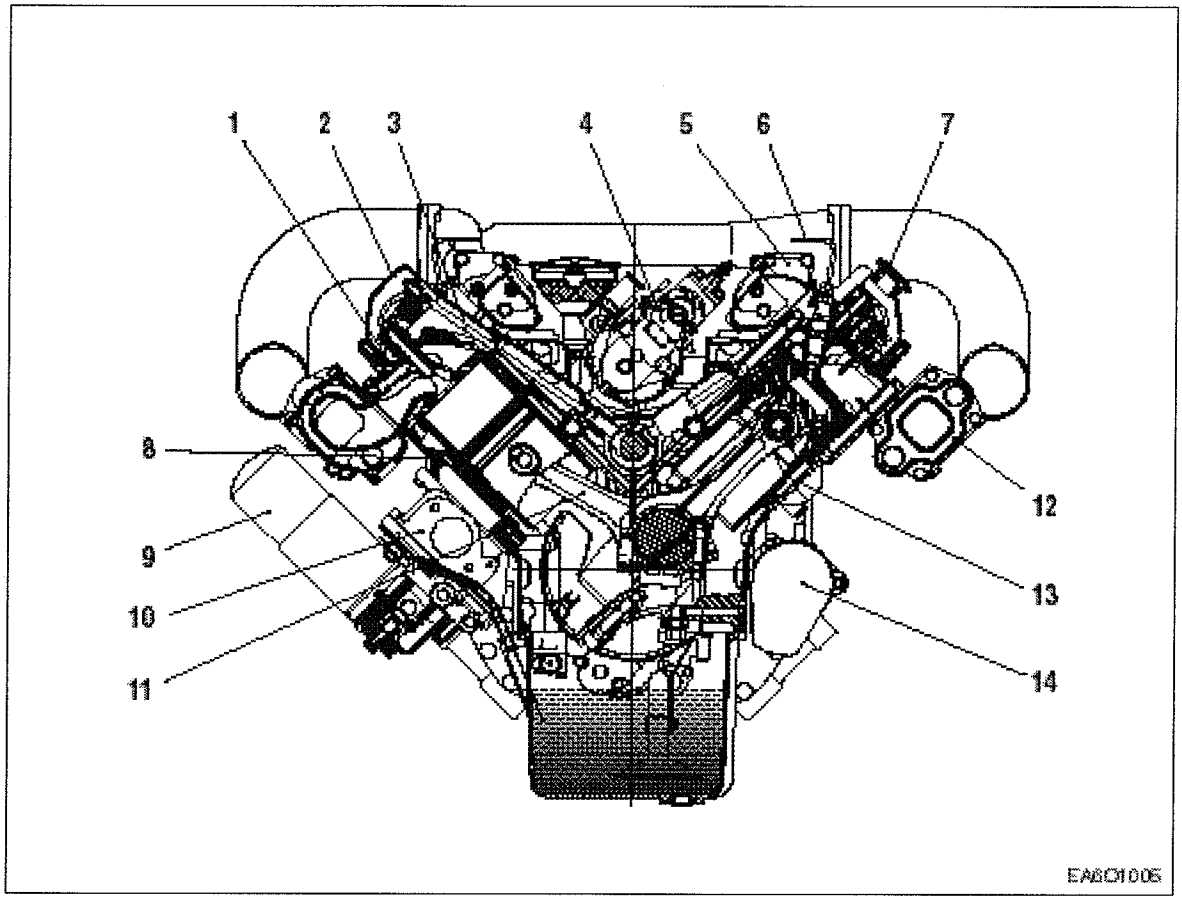
1.2. Engine Sectional Drawing

1.2.1. Longitudinal Section View



1. Piston
2. Combustion chamber
3. Valve
4. Tappet
5. Cam shaft
6. Turbocharger
7. Piston pin
8. Thermostat
9. Cooling fan
10. Crank shaft pulley
11. Vibration damper
12. Oil spray nozzle
13. Oil pan
14. Oil suction pipe
15. Oil pump relief valve
16. Flywheel housing
17. Flywheel
18. Oil seal
19. Crank shaft

1.2.2. Cross Section View (cross)



1. Cylinder head
2. Cylinder head cover
3. Push rod
4. Injection pump
5. Intake manifold
6. Injection pipe
7. Oil filler cap
8. Cylinder block
9. Oil filter
10. Oil cooler
11. Connecting rod
12. Exhaust manifold
13. Cylinder liner
14. Starter

1.3. Engine Specification

1.3.1. Specification

Items \ Engine Model		P158LE	P180LE	P222LE
Engine type		Water-cooled, 4 cycle Vee type Turbo charged & intercooled		
Combustion chamber type		Direct injection type		
Cylinder liner type		Wet type, chromated or casting liner		
Timing gear system		Gear driven type		
No. of piston ring		Compression ring 2, oil ring 1		
No. of cylinder-bore X stroke	(mm)	8 - 128 B 142	10 - 128 B 142	12 - 128 B 142
Total piston displacement	(cc)	14,618	18,273	21,927
Compression ratio		15 : 1		
Engine dimension (length X width X height)	(mm)	1,484 B 1,389 B 1,161.5	1,557 B 1,389 B 1,248	1,717 B 1,389 B 1,288
Engine weight	(kg)	950	1,175	1,575
Fuel injection order		1-5-7-2-6-3-4-8	1-6-5-10-2-7-3-8-4-9	1-12-5-8-3-10-6-7-2-11-4-9
Fuel injection timing (B.T.D.C static)		16°		
Injection pump type		Bosch in-line P type		
Governor type		Electrical governor GAC type		
Injection nozzle type		Multi-hole type (4 hole)		
Fuel injection pressure	(kg/cm^2)	285		
Compression pressure	(kg/cm^2)	28 (at 200 rpm)		
Intake and exhaust valve clearance (at cold)	(mm)	0.25/0.35		
Intake valve	Open at	24°C (B.T.D.C)		
	Close at	36°C (A.B.D.C)		
Exhaust valve	Open at	63°C (B.B.D.C)		
	Close at	27°C (A.T.D.C)		
Lubrication method		Pressurized circulation		
Oil pump type		Gear type		
Oil filter type		Full-flow, cartridge type		
Lubricating oil capacity (max./min.)	(lit)	28/26	35/28	40/33
Oil cooler type		Water cooled		
Water pump		Belt driven centrifugal type		
Cooling Method		Pressurized circulation		
Cooling water capacity (engine only)	(lit)	20	21	23
Thermostat type		Wax pallet type (79 ~ 94 °C)		
Alternator voltage - capacity	(V - A)	24 - 45		
Starting Motor voltage - output	(V - kW)	24 - 6.6		
Battery capacity	(V - AH)	24 - 200		

1.3.2. Engine power

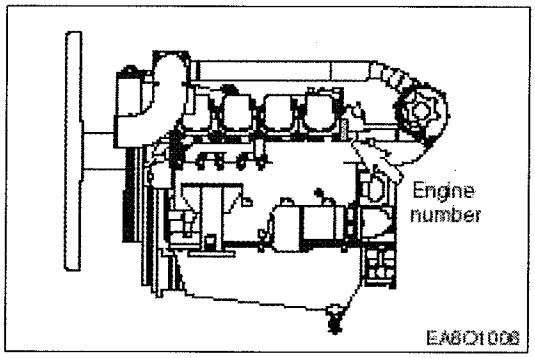
Production tolerance : ± 5%

Engine model			Condition		
			Continuous	Prime	Stand by
P158LE	Standard	50 HZ (1,500 rpm)	438 PS (322 kW)	494 PS (363 kW)	536 PS (414 kW)
		60 HZ (1,800 rpm)	497 PS (366 kW)	547 PS (402 kW)	602 PS (443 kW)
	Type-I	50 HZ (1,500 rpm)	-	444 PS (327 kW)	492 PS (362 kW)
		60 HZ (1,800 rpm)	-	498 PS (366 kW)	546 PS (402 kW)
	Type-II	50 HZ (1,500 rpm)	-	399 PS (293 kW)	437 PS (321 kW)
		60 HZ (1,800 rpm)	-	447 PS (329 kW)	491 PS (361 kW)
P180LE	Standard	50 HZ (1,500 rpm)	541 PS (398 kW)	602 PS (443 kW)	674 PS (496 kW)
		60 HZ (1,800 rpm)	614 PS (452 kW)	676 PS (497 kW)	734 PS (540 kW)
	Type-I	50 HZ (1,500 rpm)	-	548 PS (403 kW)	601 PS (442 kW)
		60 HZ (1,800 rpm)	-	617 PS (454 kW)	677 PS (498 kW)
P222LE	Standard	50 HZ (1,500 rpm)	643 PS (473 kW)	723 PS (532 kW)	781 PS (574 kW)
		60 HZ (1,800 rpm)	730 PS (537 kW)	803 PS (591 kW)	883 PS (649 kW)

Note : All data are based on operation without cooling fan at ISO 3046.

1.4. 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 1 : P158LE)**

EAZGA900001

- Serial No.
- Production Year(1999)
- Engine Model Suffix

● **Engine serial No. (example 2 : P180LE)**

EASGA900001

- Serial No.
- Production Year(1999)
- Engine Model Suffix

● **Engine serial No. (example 3 : P222LE)**

EAYGA900001

- Serial No.
- Production Year(1999)
- Engine Model Suffix

2. SAFETY REGULATIONS

2.1. 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.

2.2. Regulation for Safety

2.2.1. To prevent accidents with injury to persons

1) 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 DHI 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 bums.
- Exhaust gases are toxic. Comply with the instructions for the installation of DHI 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.

2) 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 rise of burns and scalding. Do not touch oil drain plug 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 "Maintenance and Care".
- Neither tighten up nor open pipes and hoses (lube oil circuit, coolant circuit and any additional hydraulic oil circuit) during the operation. The fluids 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.
- When using compressed air, e.g. for cleaning the radiator, wear goggles.
- 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.

3) 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. Worn open-end wrench slip. which 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 working on parts which contain asbestos, comply with the notes at the end of this chapter.
- When checking injectors do not put your hands under the jet of fuel. Do not inhale atomized fuel.
- When working on the electrical system disconnect the battery earth cable first. Connect it up again last in prevent short circuits.

2.2.2. 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 DHI.
2) If faults occur, find the cause immediately and have it eliminated in order to prevent more serious of damage.
3) Use only genuine DHI spare parts. DHI 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 DHI-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, coolant temperature) function satisfactorily.
   - Comply with instructions for operation of the alternator. See "Commissioning and operation".
   - Do not let the raw water pump run dry, If there is a risk of frost, drain the pump when the engine is switched off.

2.2.3. To prevent pollution

1) Engine oil, filter elements, fuel filters

- 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 could be contaminated.
- Filter elements are classed as dangerous waste and must be treated as such.

2) 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.

2.2.4. 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.

3. TECHNICAL INFORMATION

3.1. Engines

The engines P158LE/ P180LE/ P222LE POLUS Series are V-type liquid-cooled 8/ 10/ 12-cylinder four-stroke Diesel engines with direct injection.

1) Engine block

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

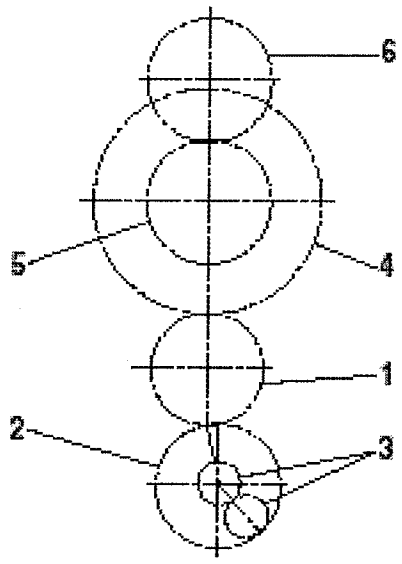
2) Piston/ Connecting rod/ Crank assembly

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

3) Engine timing

Camshaft, oil pump and injection pump are driven by a gear train arranged at the flywheel end.

1. Crankshaft gear
2. Oil pump drive gear
3. Oil pump impeller gears
4. Camshaft drive gear
5. Idler gear
6. Injection pump drive gear



EA6O3001

4) Valves

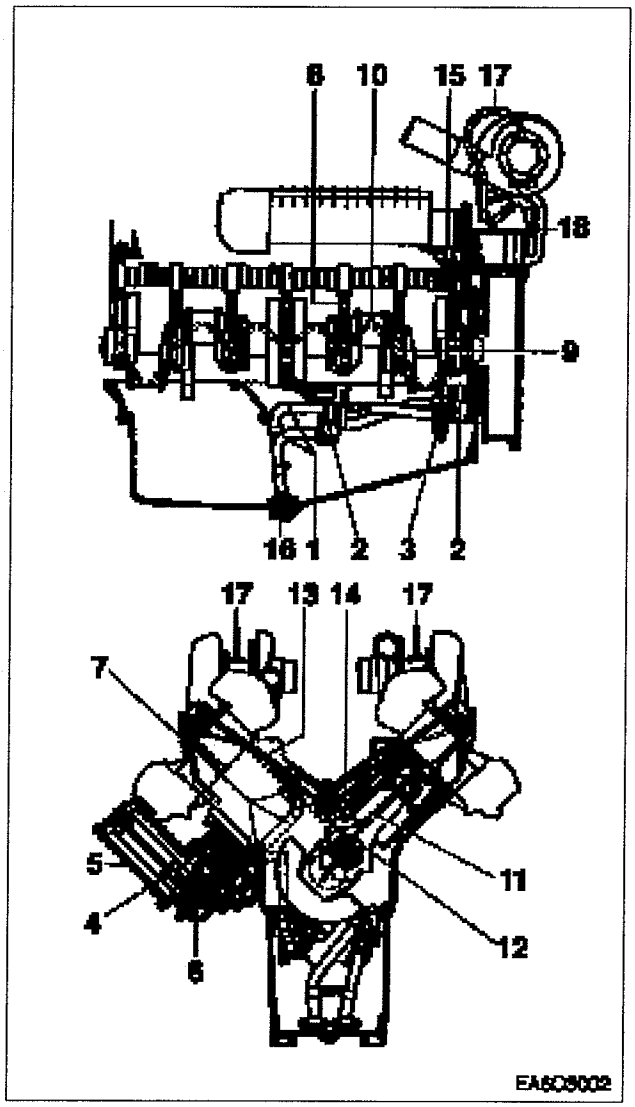
The overhead valves are actuated via chilled cast iron tappets, push rods and rocker arms from the camshaft.

3.2. Engine Lubrication

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 crankshaft gear at the flywheel end.

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.



1. Oil suction pipes
2. Oil pumps
3. Oil relief valves
4. Oil color
5. Oil filter
6. Bypass valve
7. Main oil galleries
8. Oil gallery to crankshaft
9. Ports for main bearing lubrication
10. Ports for big end bearing lubrication
11. Small end bearing lubrication
12. Camshaft bearing lubrication
13. Rocker arm lubrication
14. Jets for piston cooling and cam lubrication
15. Injection pump lubrication
16. Oil drain plug
17. Lube oil pipes to turbochargers
18. Oil return from turbochargers

The injection pump and the turbocharger are also connected to the engine lubricating system.
The cylinder walls and timing gears are splash-lubricated.
Each cylinder has an oil jet provided for cooling the underside of the pistons.
The lube oil is cleaned in a full-flow oil filter.
Depending on the agreed extent of delivery and the design of the engine, the lube oil circuit can be equipped with oil pressure monitors (advance warning and cut-off function) which shut the engine down in the event of a sudden loss of pressure.

1) Oil cooler

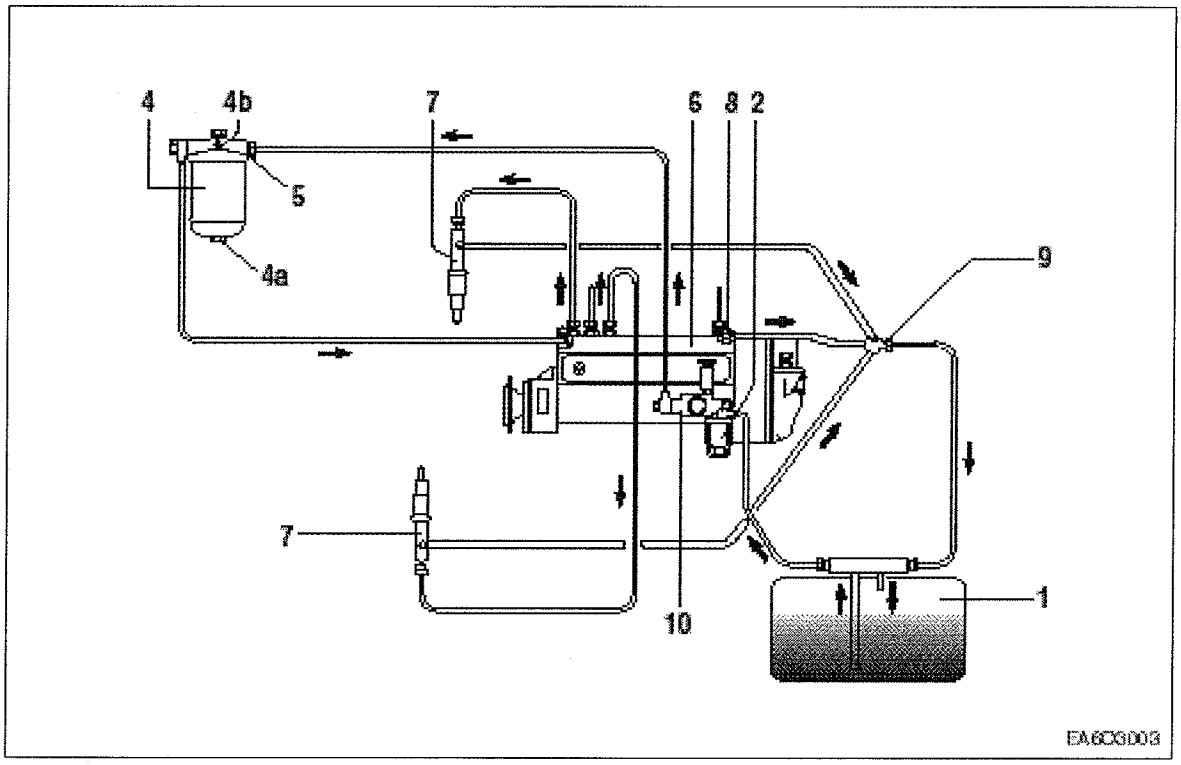
An oil cooler is provided between the oil filter and the crankcase. This cooler is of the flat tube type with turbulence inserts and operated by the coolant.

3.3. Fuel System

The fuel is delivered by the fuel lift pump via the fuel filter to the injection pump and from there to the injectors.

The fuel is sprayed into the cylinder through nozzles fitted in screw-fit injections in the cylinder heads

Excessive fuel delivered and leak fuel from the injectors flow through the return pipe back to the tank.



1. Fuel tank
2. Strainer
3. Fuel Filter
4. Fuel filter ass'y

4a. Fuel water drain plug

4b. Air bleeding plug (for fuel filter)

5. Fuel pipe connector
6. Injection pump
7. Injector
8. Fuel pressure relief valve
9. Fuel return pipe
10. Fuel feed pump

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 centrifugal governor flange-mounted on the pump casing is a variable range governor designed to keep the speed set by the control lever constant under conditions of varying load.

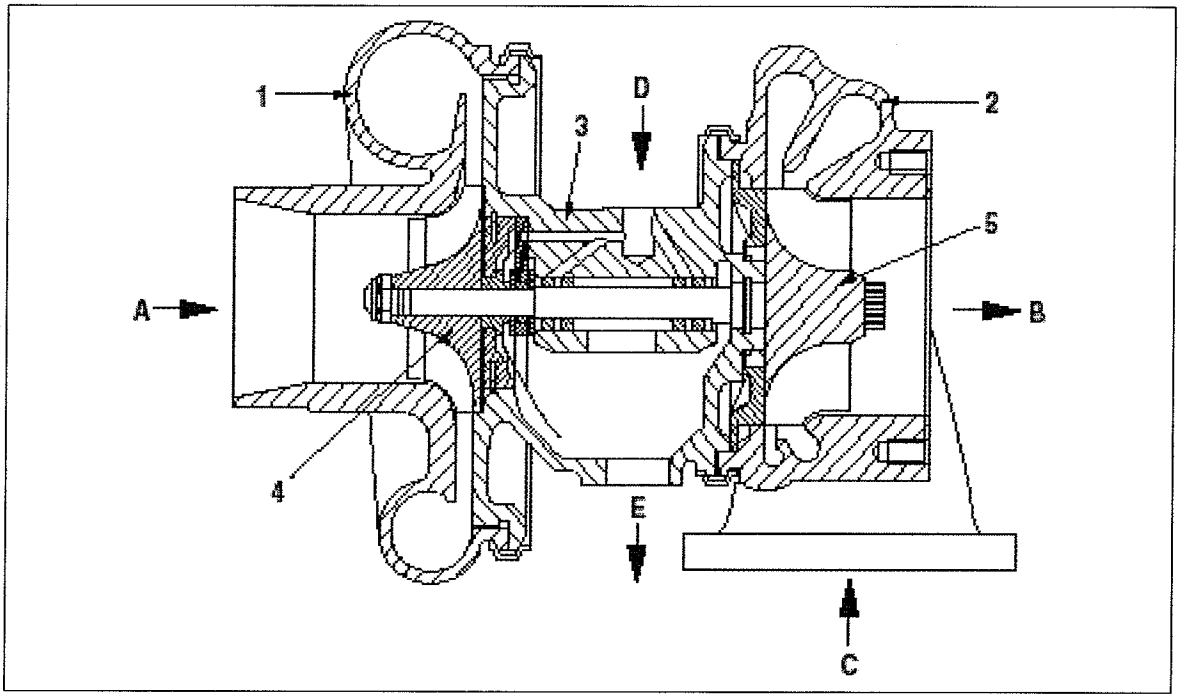
2) Fuel filters

Before entering the suction chamber of the injection pump, the fuel is cleaned in a fuel filter.

3.4. Turbocharger

The exhaust gases of the engine are passed through the turbine rotor of the turbocharger Air impeller mounted on the same shaft draws in fresh air and delivers it at a higher pressure to the cylinders.

The turbocharger is air-cooled. Lubrication of the main bearing is by oil under Pressure from the engine lubricating system.



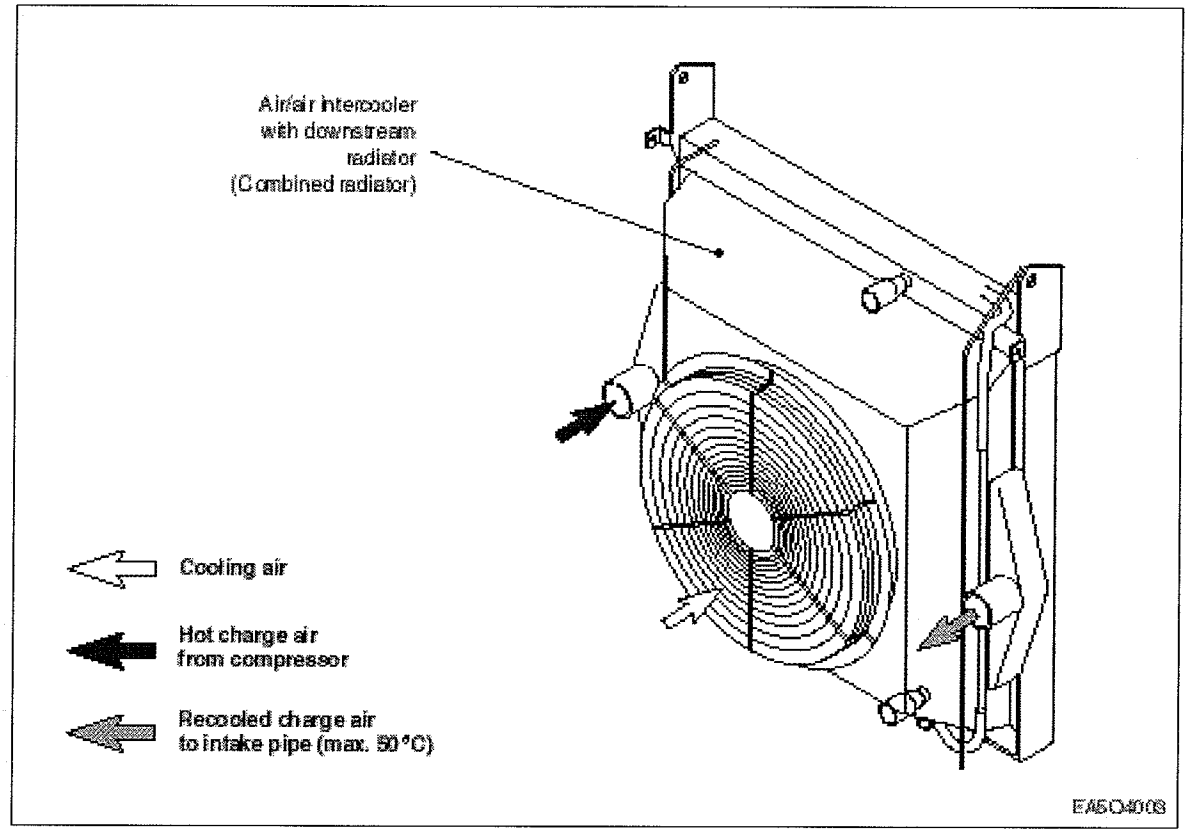
1. Compressor casing
2. Turbine casing
3. Compressor wheel
4. Impeller
5. Turbine

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

3.5. Intercooler

The intercooler is air to air type and has a large cooling fan capacity. The intercooler life and performance depends on the intake air condition greatly. Fouled air pollutes and clogs the air fins of intercooler. As a result of this, the engine output is decreased and engine malfunction is occurred. So you always check whether the intake air systems like air filter element are worn or polluted.

- *Cleaning of intercooler fins: Every 600 hours.*



3.6. Cooling

The engine has a liquid-cooling system.

The water pump is a maintenance-free impeller pump driven by V-belts 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.

3.7. Air Cleaner

Air cleaner is mounted on the engine to purify the air for combustion

The intervals at which the air cleaner requires servicing depend on the specific operating conditions encountered. Clogged air filters may cause black smoke and reduce power.

A check should be made from time to time to see that the fastening elements securing the air cleaner to the intake manifold seal the connection tightly. Any ingress of unfiltered air is liable to cause a high rate of cylinder and piston wear.

3.8. Electrical Equipment

1) Alternator

The alternator is fitted with integral silicon rectifiers.

A transistorized regulator mounted on the alternator limits the alternator voltage. The alternator should not be operated except with the regulator and battery connected in circuit to avoid damage to the rectifier and regulator.

The alternator is maintenance-free, Nevertheless, it must be protected against dust and, above all, against moisture.

Operate the alternator according to the instructions given in the chapter "Commissioning and operation".

2) Starter motor

The sliding-gear starter motor is flanged to the rear of the flywheel housing on the left-hand side.

As part of every engine overhaul, the starter pinion and ring gear should be cleaned with a brush dipped in fuel and then a coat of grease should be applied again.

Always protect starter motor against moisture.

WARNING : Always disconnect the battery earth cable before starting work on theelectrical system.

Connect up the earth cable last, as there is of otherwise a rise of short-circuits.

4. COMMISSIONING AND OPERATION

4.1. Preparations

Before daily starting the engine, check fuel level, coolant level and engine oil level and replenish, if necessary.

The notches in the dipstick indicate the highest and lowest permissible oil levels.

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

The oil required in the sump is specified in the "Engine Specification" at the end of these instructions.

NOTE : The oil required to fill the oil filters and pipes depends upon the engine equipment and use and must be determined individually at the time of initial commissioning. (Make a note of the determined quantity)

Ensure outpost cleanliness when handling fuels, lubricants and coolants.

Use approved fuels, lubricants and coolants only, as otherwise the manufacturer's guarantee will be null and void.

4.2. Starting

- Insert key in starting lock.
- Moving control lever to "Idle speed".
- Key switch rotate clockwise.
- Do not operate for longer than 10 seconds at a time.
- After ignition of the engine, take-off the hands in key switch.
- And adjust control lever for desired speed.
- If engine fails to start, release the key, wait about 1 minute, then operate starter again.
- Avoid running the cold engine for any length of time since in any internal combustion engine this is liable to cause increased wear due to corrosion. Prolonged idling is harmful to the environment.

NOTE : On initial start of an overhauled engine or after long periods without use, press shut-down lever in "stop" position and operate starter motor for a few seconds (max. 10) until oil pressure is indicated.

Only then the engine should be started in the normal way.

4.3. Running In

It is recommended that new or overhauled engines should not be operated at a load higher than about 75% maximum load during the first few hours of operation. Initial run-in should be at varying speeds. After this initial run-in, the engine should be brought up to fuel output gradually.

4.4. During Operation

Do not overload the engine. Do not exceed the maximum permissible engine tilt. If faults occur, find their cause immediately and have them eliminated in order to prevent more serious damage!

During operation the oil pressure in the engine lubrication system must be monitored. If the monitoring devices register a drop in the lube oil pressure, switch off the engine immediately.
The coolant temperature should be approx. 80 to 95 °C.
The charge warning light of the alternator should go out when the engine is running.

1) Alternator

In order to avoid damage to the alternator, observe the following instructions;
While the engine is running

- Do not de-energize the main battery switch!
- Do not disconnect the battery or pole terminals or the cables!
- If during operation, the battery charge lamp suddenly lights up, stop the engine immediately and remedy the fault in the electrical system!
- Do not short-circuit the connections of the alternator with those of the regulator or said connection with ground, not even by briefly bringing the connections into contact!
- Do not operate the alternator without battery connection! of the alternator with those of the regulator or said connections with ground, not even by briefly bringing the connections into contact!
- Do not operate the alternator without battery connection!

4.5. Shutting Down

Cut off the main circuit breaker of the generator control panel to "stop" After the engine has been running at a high load level, do not shut it down immediately but allow it to idle about 5 minutes so that temperatures may equalize.

Remove key from starting lock.

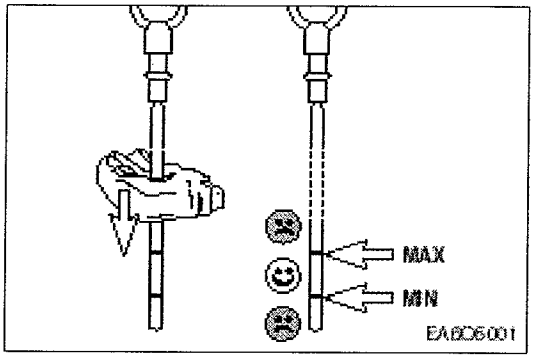
CAUTION : Ensure that the engine can not be started by unauthorized persons.

5. MAINTENANCE AND CARE

5.1. Engine Lubrication

5.1.1. Oil level

Check the oil level in the engine sump daily with a dipstick. The level should be between the two notches cut into the dipstick and should never be allowed to drop below the lower notch,

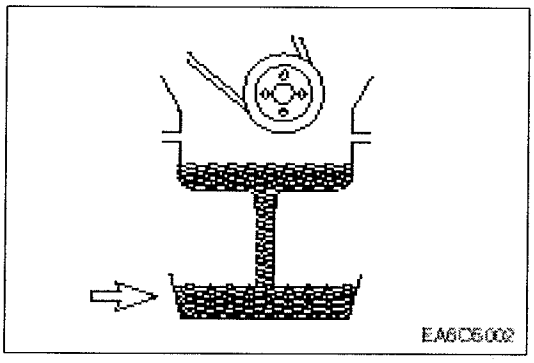


CAUTION : Do not add so much engine oil that the oil level rises above the max. marking on the dipstick. Over filling will result in damage to the engine.

The oil level should be checked with the engine horizontal and only after it has been shut down for about 5 minutes.

5.1.2. Oil drainage

With the engine at operating temperature, remove the oil drain valve on the oil sump and the oil cartridge bowl and allow the old oil to drain off completely. Use a vessel of sufficient size to ensure that the oil does not overflow. Refit the oil drain valve.



CAUTION : The oil is hot-risk of scalding. Do not touch the oil drain plug with bare fingers. Oil is an environmental hazard. Handle ii with care!

5.1.3. Refilling with oil

Refill with fresh engine oil at the oil filler neck.

After refilling with oil, rotate the engine with the starter and move the shut-down lever to "stop" at the same time until the oil pressure warning light goes out and the oil pressure gauge shows a pressure.

Then start the engine and allow it to run at medium speed for a few minutes. Check oil pressure and tightness of system.

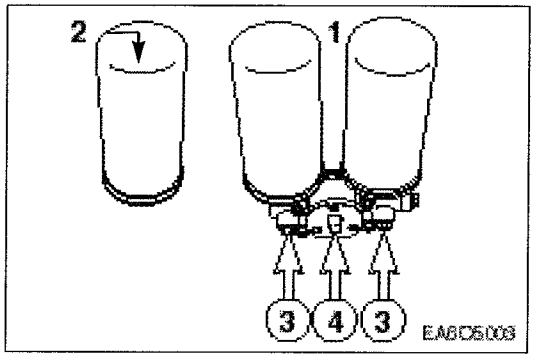
Then shut down the engine. After about 5 minutes, check the oil level. The oil level should now be at the upper notch of the dipstick, but not higher.

Add any necessary oil to the upper dipstick mark.

5.1.4. Lubricating oil filter

Cleaning of the lubricating oil is effected in a full-flow oil filter with paper cartridges. A bypass valve ensures continuity of oil supply if the filter elements should be clogged.

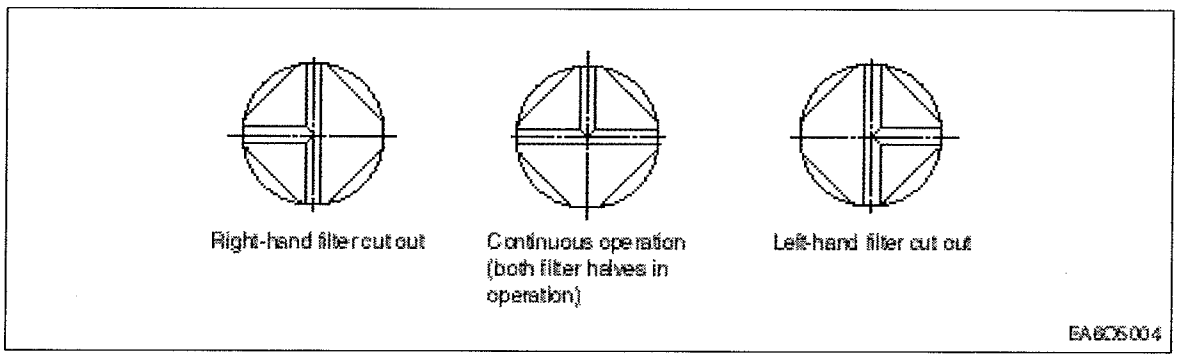
After draining off the oil release tie screw. Remove filter bowl. Renew filter cartridge. Thoroughly clean all other parts in cleaning fluid. Use new gaskets for re-assembly.



1. Oil filter(Change over-type)
2. Element
3. Oil drain pulg
4. Selector cock

During continuous operation the selector lever that both filter halves are in operation.

Observe positions of selector level.



CAUTION : Do not leave selector lever in any intermediate position because this would be liable to interfere with oil supply.

5.1.5. Renewal of filter cartridges

- Allow the filter content to run off along drain plugs. Hold a suitable vessel under hole.

CAUTION : Oil is hot and under pressure!

- After releasing the clamping bolts remove filter bowls.
- Renew filter cartridges. Thoroughly clean all other parts in cleaning fluid. (do not allow cleaning fluid to enter the oil circuit)

NOTE : To prevent the seal from twisting hold the filter bowl firmly when tightening the tensioning screw.

- Every time an oil change is made, the two oil filter cartridges should be renewed!

CAUTION : Use oil filters are classed as dangerous waste and must be disposed of accordingly.

5.2. Fuel System

5.2.1. Fuel

If Diesel fuel which contains moisture is used the injection system and the cylinder liners / pistons will be damaged. This can be prevented to same extent by filling the tank as soon as the engine is switched off while the fuel tank is still warm (formation of condensation is prevented). Drain moisture from storage tanks regularly. Installation of a water trap upstream of the fuel filter is also advisable.

<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 (°C)	D 86			
IMP, Typican #)		350(177)	375(191)	
10% Typical #)		385(196)	430(221)	
50% Typical #)		45(218)	510(256)	680(360)
90% +)		500 (260) Max.	625(329) Max.	
End Point #)		550(288) Max.	675(357) Max.	
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 -12°C (10°F) below the lowest expected fuel temperature to prevent clogging of fuel fitters by crystals.

5.2.2. Injection pump

No alterations must be made to the injection pump. If the lead seal is damaged the warranty on the engine will become null and avoid.

- Faults

  We strongly recommend that any faults developing in the injection pump should be taken care of by authorized specialist personnel.

- Bleeding the fuel system

  Bleeding the fuel filter is by releasing the bleed screws and operating the manual primer. The suction chamber of the injection pump is continuously bled via the relief valve during operation If the suction chamber is completely empty, e.g., when fitting a new pump, filling and bleeding it is by actuating the manual primer.

- Fuel lift pump

  The fuel lift pump is operated by the injection pump camshaft via the roller tappet.

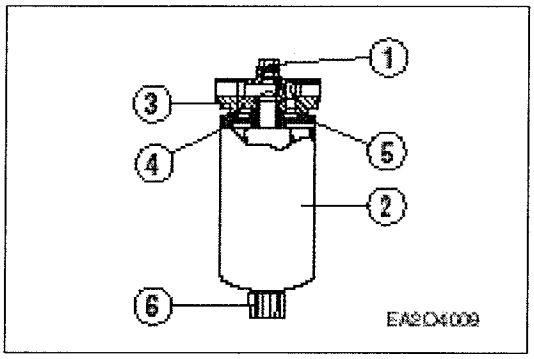
- Strainer

  After every 200 hours of operation the fuel strainer connected upstream of the fuel lift pump should be cleaned.

5.2.3. Fuel filter

- After every 1,200 hour of operation, drain the water and sediment from the fuel-water separator.
- Shut off the engine. Use your hand to open the drain valve⑥.

  Turn the valve counter clockwise approximately 2 ~ 3 turns until draining occurs. Drain the filter sump of water until close fuel is visible.
- Turn the valve clockwise to close the drain valve. Do not over tighten the valve, overtightening can damage the threads.



5.2.4. Replacement of fuel filter

- Clean the area around the fuel filter head ③.
- Remove the fuel filter ②.
- Remove the fuel filter thread adapter seal ring ④.

  Use a clean lint free cloth to clean the gasket surface of the fuel filter head ③.
- Install the new thread adapter seal ring ④ supplied with the new filter.

  Use clean oil to lubricate the filter seal ⑤, and fill the new filter with clean fuel.

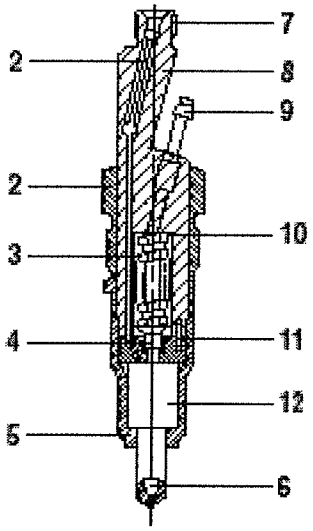
- Install the filter on the filter head ⑤ .
  Tighten the filter until the gasket contacts the filter head surface.
  Tighten the filter on additional one-half to three-fourths of a turn, on as specified by the filter manufacturer.

NOTE : Mechanical over tightening of the filter can distort the thread or damage the filter element seal.

5.3. Injector Maintenance

The injectors are designed to spray the fuel delivered by the injection pump directly into the spherical combustion chamber in the piston crown.
The injector consists of the nozzle and the nozzle holder.
A copper gasket fitted to the injector ensures gas-tight seating and good heat dissipation.
The opening pressure of the nozzle is adjusted by means of shims at the compression spring.

1. Rod type filter
2. Cap nut
3. Compression spring
4. Compression pin
5. Cap nut for fixed nozzle
6. Nozzle needles
7. Connect hole for fuel delivery
8. Nozzle holder
9. Connect tube for overflow
10. Shim
11. Pin
12. Nozzle bush



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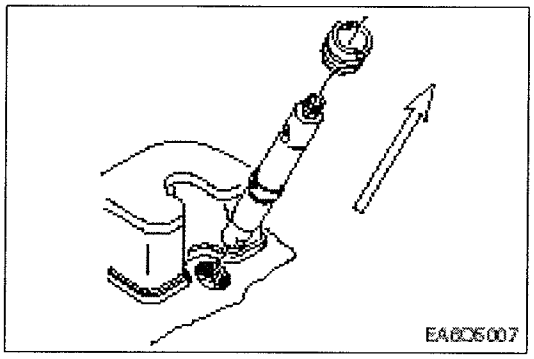
5.3.1. Removal, dismantling and cleaning

- Unscrew delivery pipe at nozzle holder and at the injection pump.
- Remove leak-off pipe.
- Release union screw of nozzle holder with special wrench. (EI.03004-0225)
- Remove nozzle holder with gasket from the cylinder head.

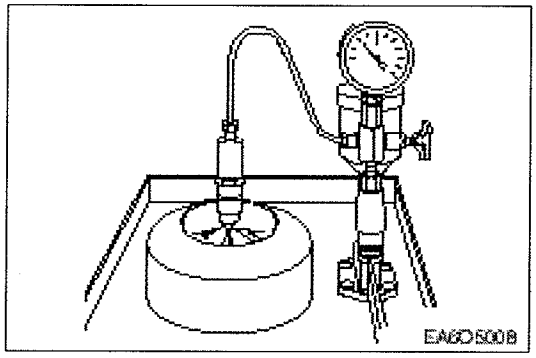


Note for cleaning nozzles

- Clean nozzle body externally from soot and carbon, When cleaning several nozzles at the same time, make sure nozzle bodies and needles are not mixed up. Visually inspect needle and body.
- Cleaning is useless if the seat of the needle is indented or the pintle is damaged and the nozzle should be replaced.
- Clean annular groove with scraper over full circumference. Wash out dislodged carbon deposits and dirt.
- Scrape needle seat with cleaning cutter, Dip cutter in test oil before use. The cutter can also be clamped in a lathe.
- Polish needle seat with wooden cleaning tool, preferably by chucking the needle in a lathe at the pintle end.
- Clean the spray holes of nozzles by chucking a cleaning needle of suitable diameter in the collect. If the carbon deposits in the spray holes cannot be removed by rotating and pressing, have the needle project only slightly from the collect and drive out the carbon by lightly tapping on the tool.
- Before reassembly thoroughly wash nozzle body and needle in clean test oil.
- Hold the needle at the pintle end only ; to avoid corrosion, do not touch the lapped surfaces of the needle with you fingers.
- Thoroughly clean all other parts of the nozzle holder with clean fuel.
- Check nozzle discharge pressure in nozzle tester.
  The edge-type filter should not be pressed into the nozzle holder by more than about 5mrn. If this depth is exceeded the injector must be replaced.

<operating pressure>

New nozzle holder	300 + 8 kg/cm²
Used nozzle holder	285 + 8 kg/cm²

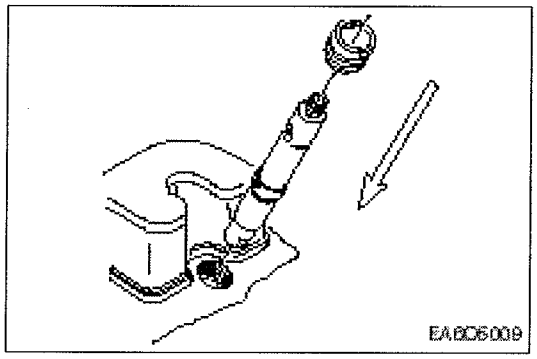


CAUTION : Do not hold your hands under the fuel jet, as there is a rise of injury.
Do not inhale the atomized oil fuel. If possible, work under an extraction system.

5.3.2. Installation

- Clean seat in cylinder head.
- Insert nozzle holder with new gasket.
  Tighten union nut with 120 N.m.
- Install injection lines free of constraint.
  Install leak fuel lines.

Torque	12 kg.m



CAUTION : The injection lines are designed for high operating pressures and should thus be handled with particular core.

- When mounting the pipes to the engine take care of good fitness.
- Do not bend pipes to permanent deformation. (not for replacing the nozzles either)
- Do not mount any heavily bent pipes.
- Avoid bending the pipes at the ends by more than 2 to 3 degrees.
- In case of faults in the injection system which might have resulted in excessive operating pressures, not only the failed part but also the injection line has to be replaced.

5.4. Cooling

Fill the cooling system of the engine with a mixture of drinkable tap water and antifreeze agent on ethylene glycol basis or anti-corrosion agent.

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

5.4.1. Filling-in of coolant

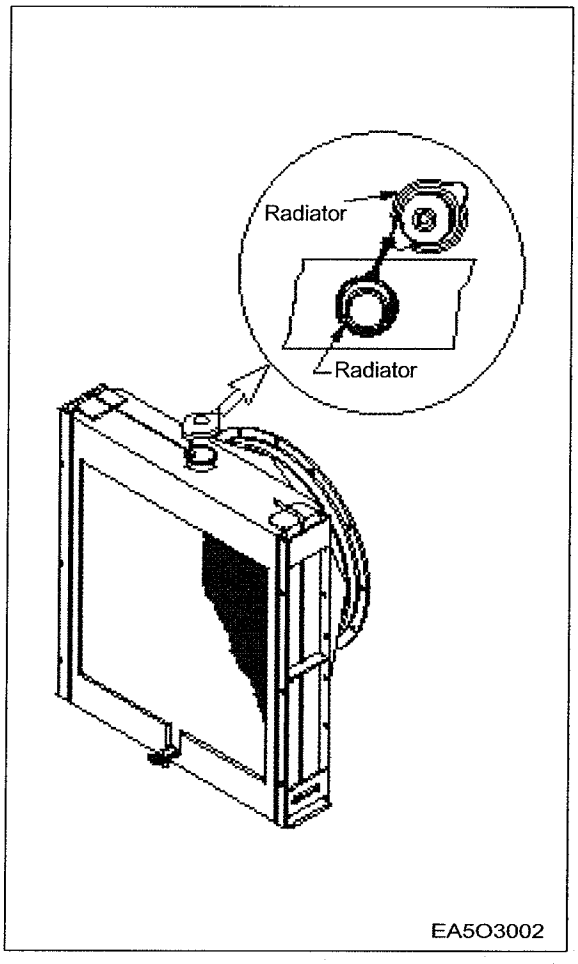
(only when engine has cooled down)

- Fill in the coolant slowly.
- Make sure that all air can escape from the cooling system.
- Run the engine briefly and then check coolant level once more.

If, in an exceptional case, the coolant level has to be checked when the engine is warm from operation, first turn the somewhat smaller cap with working valves to the first notch. Let off pressure and then close this cap again. After this the cap on filler neck can be removed without risk of scalding.

Coolant must be added at the filler neck only. Do not put cold coolant into an engine which is warm from operation. If no hot water (80 ˚C) is available, add normal warm water very slowly as the engine runs until the coolant level is correct.

Ensure that the ratio of water to antifreeze is correct. Find the cause of the loss of coolant and have it eliminated.

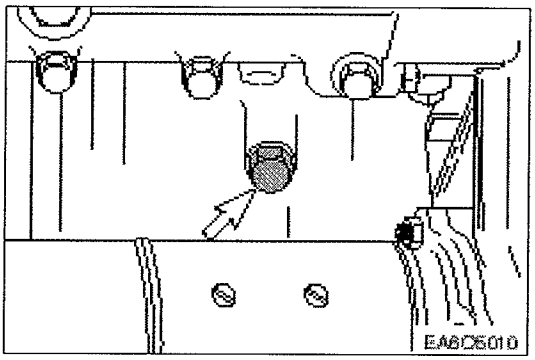


WARNING : If the cap with the working valves is opened, there is the rise that it will not close tightly again afterwards. The excess pressure required in the system will then no longer build up. Premature boiling occurs and coolant is lost. To prevent damage to the engine, open this cap only in exceptional circumstances and fit a new one as soon as possible afterwards.

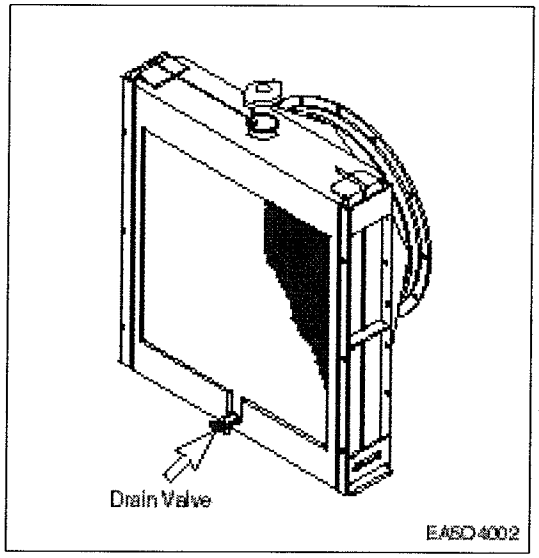
5.4.2. Draining of coolant

Drain coolant as follows when cooling system has cooled down;

- Remove cover from filler neck of radiator.
- Remove drain plug in the cylinder block.



Improper mixing of anti-freeze and corrosion inhibitors may lead to lime and corrosion deposits in the engine cooling system which can jeopardize cooling efficiency.
In such cases it is necessary to clean the cooling system at suitable intervals.



5.5. Turbocharger

5.5.1. Maintenance

The turbochargers do not call for any specific maintenance.

The only points to be observed are the oil pipes which should be checked at every oil change for leakage and restrictions.

The air cleaners should be carefully serviced.

Furthermore, a regular check should be kept on charge air and exhaust gas pipes. Any leakage should be attended to at once because they are liable to cause overheating of the engine.

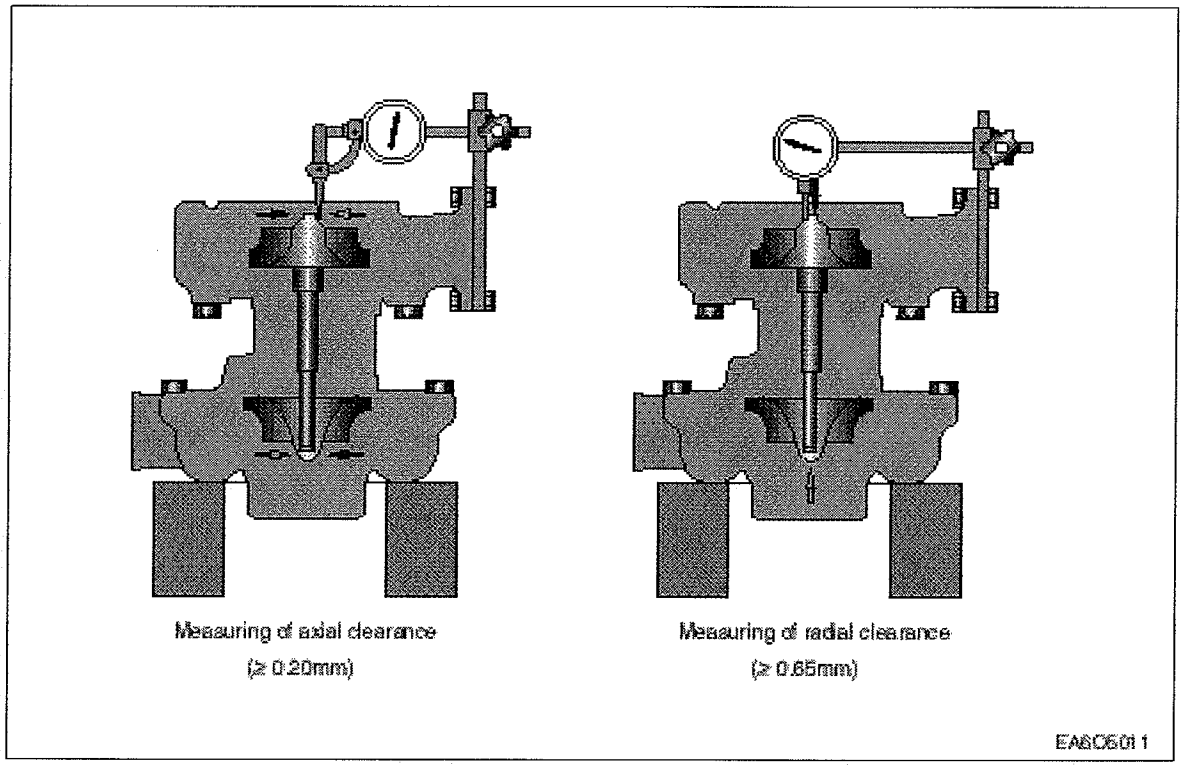
When operating in highly dust or oil laden atmospheres, cleaning of the air impeller may be necessary from time to time. To do this, remove compressor casing (Caution: Do not skew it!) and clean in non-acid solvent, if necessary using a plastic scraper.

If the air compressor should be badly fouled, it is recommended that the wheel be allowed to soak in a vessel with solvent and to clean it then with a stiff brush. In doing so, take care to see that only the compressor wheel is immersed and that the turbocharger is supported on the bearing casing and not on the wheel.

5.5.2. Special hints

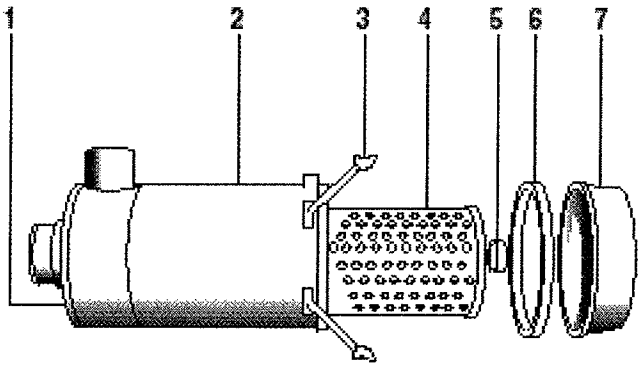
It is recommended that the radial and axial clearances of the rotor be checked after every 3,000 hours operation.

This precaution will enable any wear of the bearings to be detected in good time before serious damage is caused to the rotor and bearings.



5.6. Air Cleaner

1. Connection port, fouling indicator
2. Cleaner housing
3. Clamp
4. Element
5. Hexagon nut
6. Cover
7. Dust bowl



EA6D6012

5.6.1. Maintenance

(only when engine is switched off)

Empty the dust bowl (7) regularly. The bowl should never be filled more than halfway with dust. On slipping off the two clamps (3), the dust bowl can be removed. Take off the cover (6) of the dust bowl and empty.

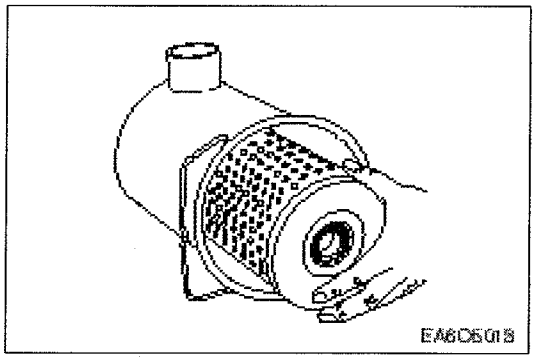
Be careful to assemble cover and bowl correctly.

There is a recess in the cover rim and a lug on the collector which should register. Where the filter is installed horizontally, watch for "top" mark on cleaner bowl.

5.6.2. Changing filter element

CAUTION : Do not allow dirt to get into the clean air end.

On removing the hexagon nut, take out the dirty cartridge and renew or clean. Wipe the cleaner housing with a damp cloth, in particular the sealing surface for the element.



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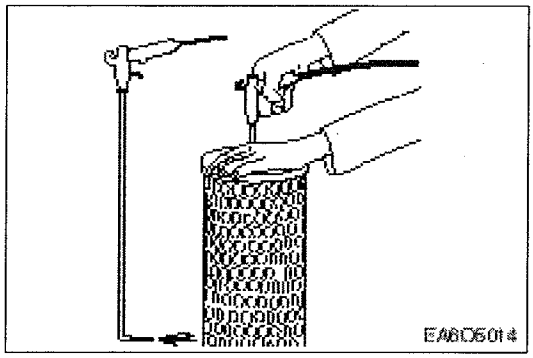
NOTE : Unless the maximum number of cleanings (up to 5 x) have been done, the filter cartridge should be renewed every two years or 4,000 hours operation.

5.6.3. Cleaning filter elements

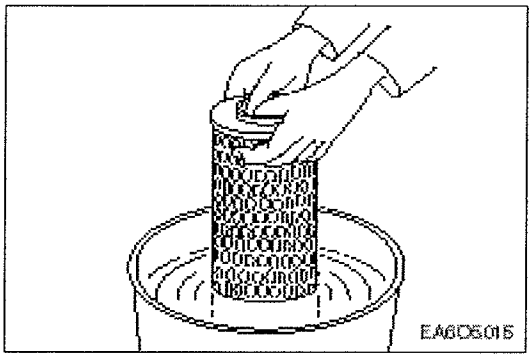
- **By compressed air**
  (wear goggles)

  For the purpose, the air gun should be fitted with a nozzle extension which is bent 90° at the discharge end and which is long enough to reach down inside to the bottom of the element.
  Moving the air gun up and down, blow out the element from the inside (maximum 500kPa - 5 bar) until no more dust comes out of the filter pleats.



- **By washing**

  Before washing, the element should be precleaned by means of compressed air, as described above.
  Then allow the element to soak in lukewarm washing solvent for10 minutes, and then move it to and for in the solvent for about 5 minutes.
  Rinse thoroughly in clean water, shake out and allow drying at room temperature. The cartridge must be dry before it is reinstalled. Never use steam sprayers, petrol (gasoline), alkalis or hot liquids etc. to clean the filter elements.



- **Knocking out dirt by hand**

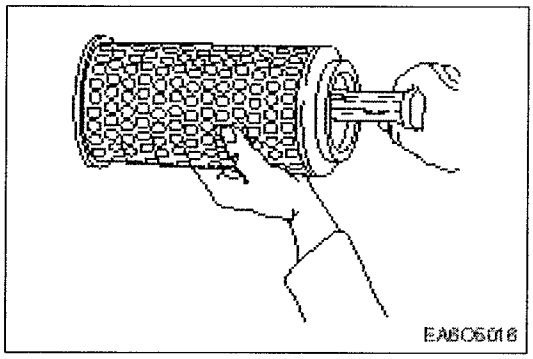
  In emergencies, when no compressed air or cleaning agent is available, it is possible to clean the filter cartridge provisionally by hitting the end disk of the cartridge with the ball of one's thumb.
  Under no circumstances should the element be hit with a hard object or knocked against a hard surface to loosen dirt deposits.

- **Checking the filter cartridge**

  Before reinstalling the cartridge, it must be checked for damage e.g. to the paper pleats and rubber gaskets, or for bulges and dents etc. in the metal jacket.

  Cracks and holes in the paper pleating can be established by inspecting the cartridge with a flashlight.

  Damaged cartridges should not be reused under any circumstances. In cases of doubt, discard the cartridge and install a new one.

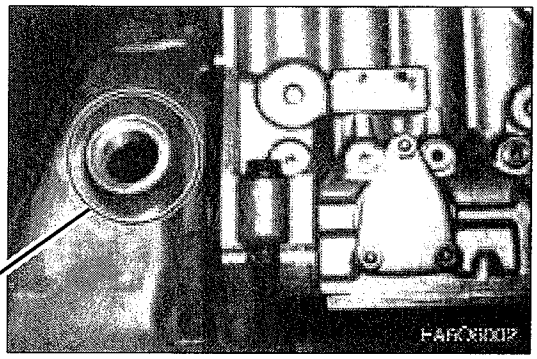


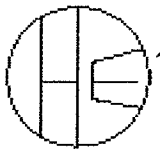
6. CHECKING AND SETTING

6.1. Checking and Adjusting Injection Timing

6.1.1. Checking

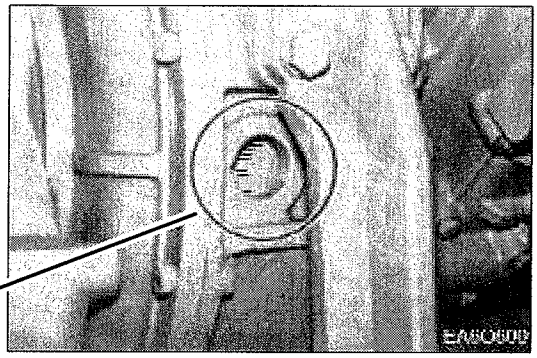
- Remove screw plug in case cover on injection pump drive gear. (Same cases are needed to remove cover assembly)
- Then turn engine so that mark on pointer provided on injection pump coincides with matching mark on drive gear.





EA6C8001

- The reference edge in the sight hole of the flywheel housing shouted now coincide with the degree marked on the flywheel corresponding to the specified start on fuel delivery position.
- If not, the start of delivery setting has to be corrected.



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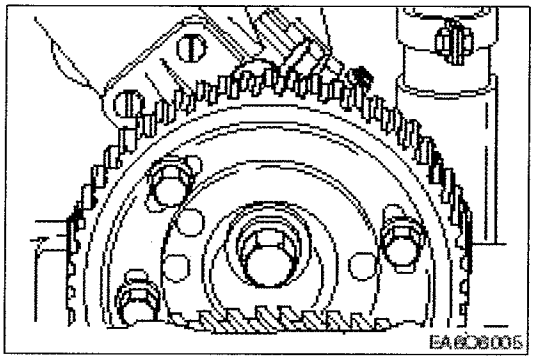
6.1.2. Adjustment

- Correct start of delivery setting by turning the pump drive flange in the oblong holes of the drive gear.
- Mark sure after every adjustment that fastening bolts are carefully tightened.
- Check start of delivery setting once more.



EA6C8005

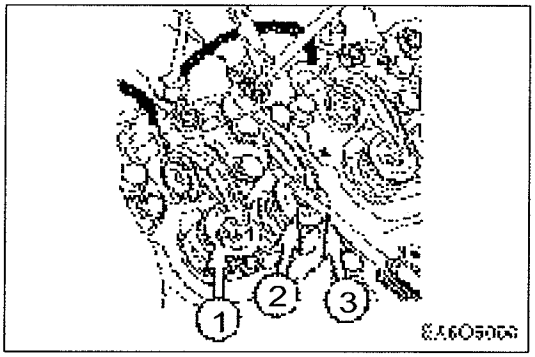
P158LE	P180LE	P222LE
16°	16°	16°

6.2. Checking and Adjusting Valve Clearance

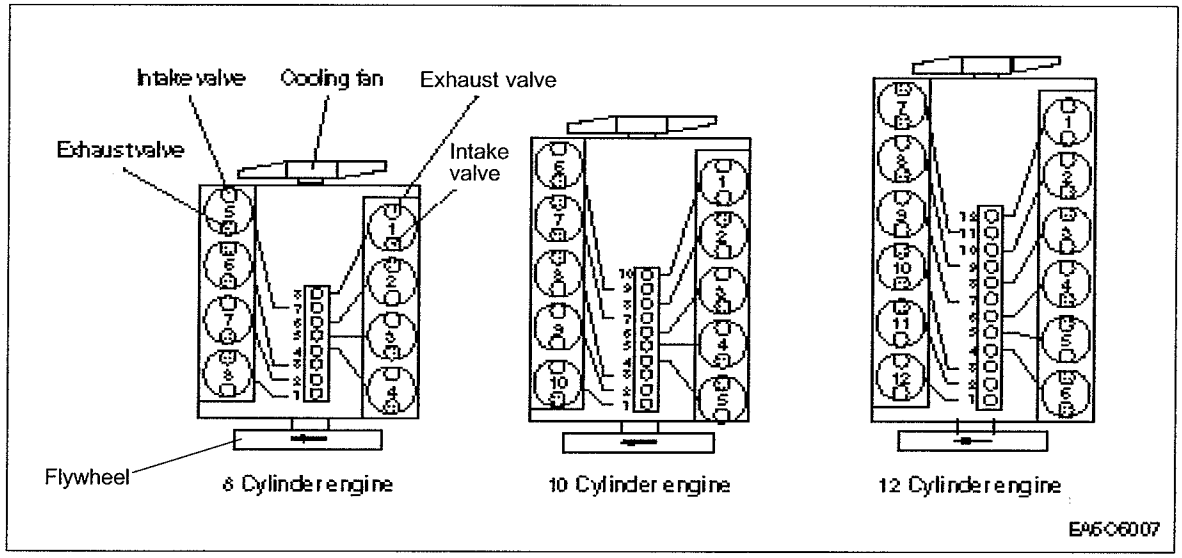
The valve clearance should be checked when necessary.

On new or overhauled engines and also after removing a cylinder head, the valve clearance should be checked after 10 to 20 hours operation.

The valve clearance should be adjusted so that the feeler gauge can be removed between the valve stem and the rocker arm with slight resistance. Adjustment is made with the adjusting screw after releasing the lock nut.



1. Exhaust valve
2. Intake valve
3. Feeler gauge



Note : No. 1 Cylinder is located at the side where cooling water pump was installed.

- **Adjusting Sequence of Valve Clearance (Type 1)**
  - By cranking the engine, let #1 cylinder's valves overlap.
  - In time, adjust the valve clearance corresponding to "●" of lower lists.
  - In time, turning crankshaft one full turn, let the valves of #7 (10 cylinder engine) or #6 (8 cylinder engine and 12 cylinder engine) cylinder's valves overlap.
  - Adjust the valve clearance corresponding to "O" of lower lists.
  - After reinsuring the valve clearances, retighten if necessary.

*** 8 Cylinder Engine (P158LE)**

Cyl. No.	1		2		3		4		5		6		7		8	
Valve	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex
No.6 Overlap	○	○	○			○		○	○				○			○
No.1 Overlap				●	●		●			●	●	●		●	●	

*** 10 Cylinder Engine (P180LE)**

Cyl. No.	1		2		3		4		5		6		7		8		9		10	
Valve	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex
No.7 Overlap	○	○	○			○		○	○		○					○	○	○	○	
No.1 Overlap				●	●		●			●		●	●	●	●					●

*** 12 Cylinder Engine (P222LE)**

Cyl. No.	1		2		3		4		5		6		7		8		9		10		11		12	
Valve	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex	In	Ex
No.6 Overlap	○	○		○	○			○	○						○		○	○				○	○	○
No.1 Overlap			●			●	●			●	●	●	●	●		●			●	●	●			

Note : In : Intake valve Ex. : Exhauust valve Cyl. : Cylinde

- **Adjusting Sequence of Valve Clearance (Type 2)**

  Type 1 is the conventional and simple method, but if you have some problem to adjust your engine, please try type 2 sequence. This is a precision method, but it takes more time.

*** 8 Cylinder Engine (P158LE)**

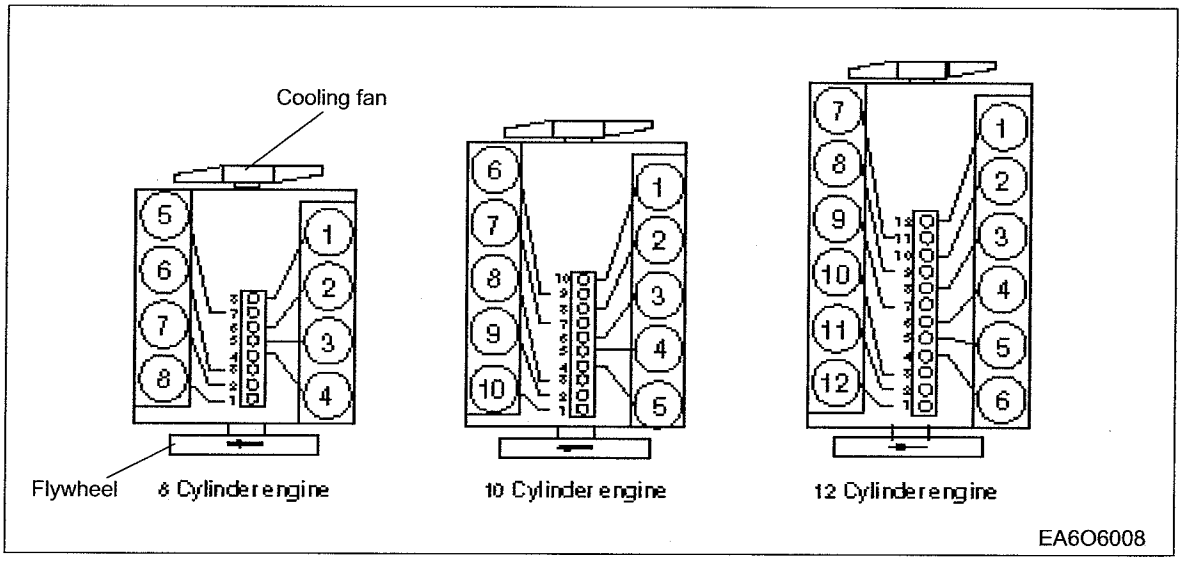
Valve overlapping on cylinder (Intake & Exhaust valve)	1	5	7	2	6	3	4	8
Adjusting valves on cylinder (Intake & Exhaust valve)	6	3	4	8	1	5	7	2

*** 10 Cylinder Engine (P180LE)**

Valve overlapping on cylinder (Intake & Exhaust valve)	1	6	5	10	2	7	3	8	4	9
Adjusting valves on cylinder (Intake & Exhaust valve)	7	3	8	4	9	1	6	5	10	2

*** 12 Cylinder Engine (P222LE)**

Valve overlapping on cylinder (Intake & Exhaust valve)	1	12	5	8	3	10	6	7	2	11	4	9
Adjusting valves on cylinder (Intake & Exhaust valve)	6	7	2	11	4	9	1	12	5	8	3	10



- NO. 1 Cylinder is located at the side where cooling water pump was installed.

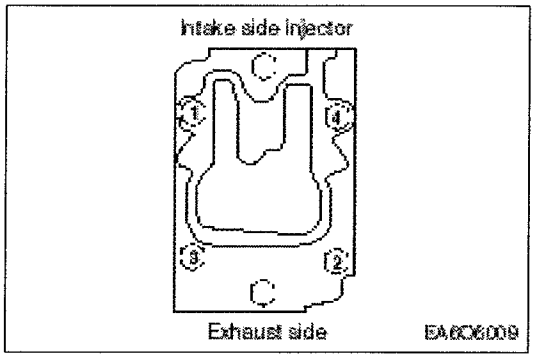
6.3. Tightening Cylinder head Bolts

1) Retightening cylinder head bolts on new engines
by authorized specialist personnel
(engine cold or warm)

The cylinder heads are mounted with cylinder head bolts which are tightened by the angle-of-rotation method. On new engines the cylinder head bolts are tightened up for the first time at the factory after the engine has been broken in.

After the first 400 hours of operation retighten cylinder head bolts 1 to 4 in the order shown in right figure by a further 90° (1/4 revolution).

The two outer screws (intake and exhaust sides) must not be retightened.



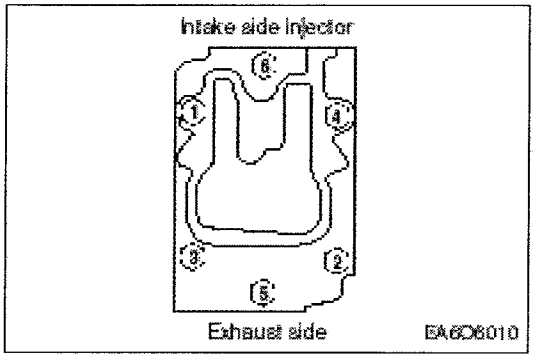
NOTE : The cylinder head bolts to be retightened must not be loosened first, but simply tightened by a further 90° (1/4 revolution) from their actual position.

2) Tightening cylinder head bolts after a repair
by authorized specialist personnel
(engine cold)

Before inserting the cylinder head bolts oil them with engine oil on the thread (not to the bore) and coat the contact face of the bolt head with "Optimoly White T" assembly paste. Do not use any oils or oil additives that contain MoS_2.

The bolts must be tightened by the angle-of-rotation method as shown in right figure.

- 1st pretightening step = to 10 N.m
- 2nd pretightening step = to 80 N.m
- 3rd pretightening step = to 150 N.m
- 4th pretightening step = turn by 90°
- Final tightening = turn by 90°



3) Retightening cylinder head bolts after repairs by authorized specialist personnel (engine cold or warm)

After the first 10 to 20 hours of operation after a repair turn the cylinder head bolts by a further 90° (1/4 revolution) in the order shown in above figure. ((2) Tightening cylinder head bolts after repair)

The cylinder head bolts to be retightened must not be loosened first, but simply tightened by a further 90° (1/4 revolution) from their actual position.

Attach the sticker "First retightening of cylinder head bolts ..." (Remove any other stickers which may already be attached).

After the first 400 hours of operation after a repair tighten cylinder head bolts 1 to 4 in the order shown in above figure ((1) Retightening cylinder head bolts on new engines) again by a further 90° (1/4 revolution).

The two outside screws (intake and exhaust side) must not be retightened,

NOTE : When a cylinder head has been removed the cylinder head gasket must always be changed.

6.4. V-belts

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

1) Change the V-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.

2) Checking condition

Check V-belts for cracks, oil, overheating and wear.

3) Testing by hand

The tension is correct if the V-belts can be pressed in by about the thickness of the V-belt. (no more midway between the belt pulleys)

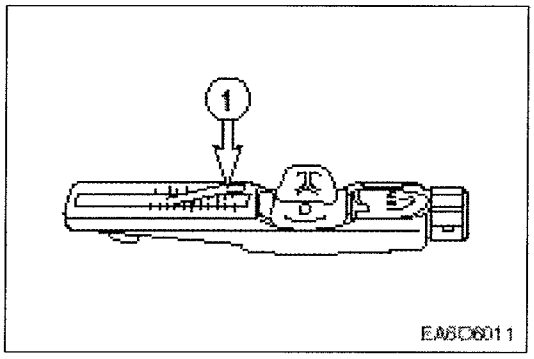
A more precise check of the V-belt tension is possible only by using a V-belt tension tester.

4) Measuring tension

① Lower indicator arm (1) into the scale.

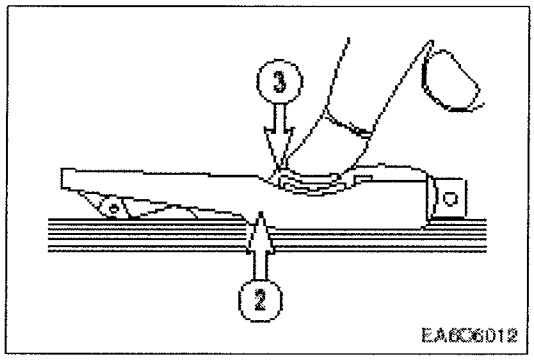
- Apply tester to belt at a point midway between two pulleys so that edge of contact surface (2) is flush with the V- belt.
- Slowly depress pad (3) until the spring can be heard to disengage. This will cause the indicator to move upwards.

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.



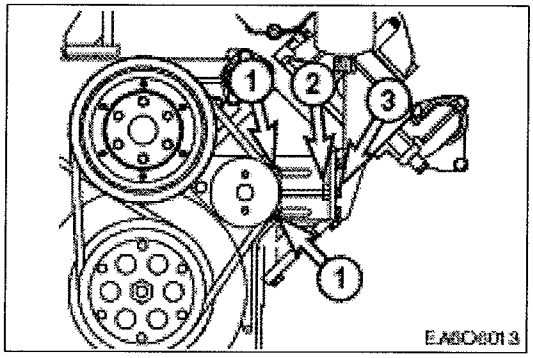
Type	Drive belt width	Tensioning forces on the tester		
		new installation		When servicing after long running time
		Installation	After 10 min. running time	
M	9.5 mm	50 kg	45 kg	40 kg
A *	11.8 mm	55 kg	50 kg	45 kg
B	15.5 mm	75 kg	70 kg	60 kg
C	20.2 mm	75 kg	70 kg	60 kg

*: Adopted in P158LE, P180LE, P222LE

5) Tensioning and changing V-belt

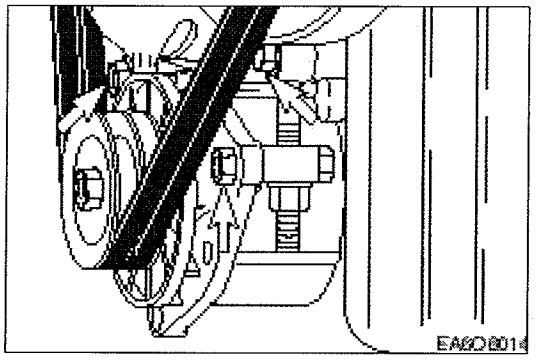
- Remove fixing bolts. (1)
- Remove lock nut. (2)
- Adjust bolt (3) until V-belts have correct tensions.
- Retighten lock nut and fixing bolts.

To change the V-belts loosen mounting bolts (1) and lock nut (2) and push tension pulley inwards by turning adjusting bolt (3).



- Remove fixing bolts.
- Remove lock nut.
- Adjust nut until V-belts have correct tensions.
- Retighten lock nut and fixing bolts.

To replace the V-belts loosen lock nut and swing alternator inwards.



7. MAINTENANCE TIP

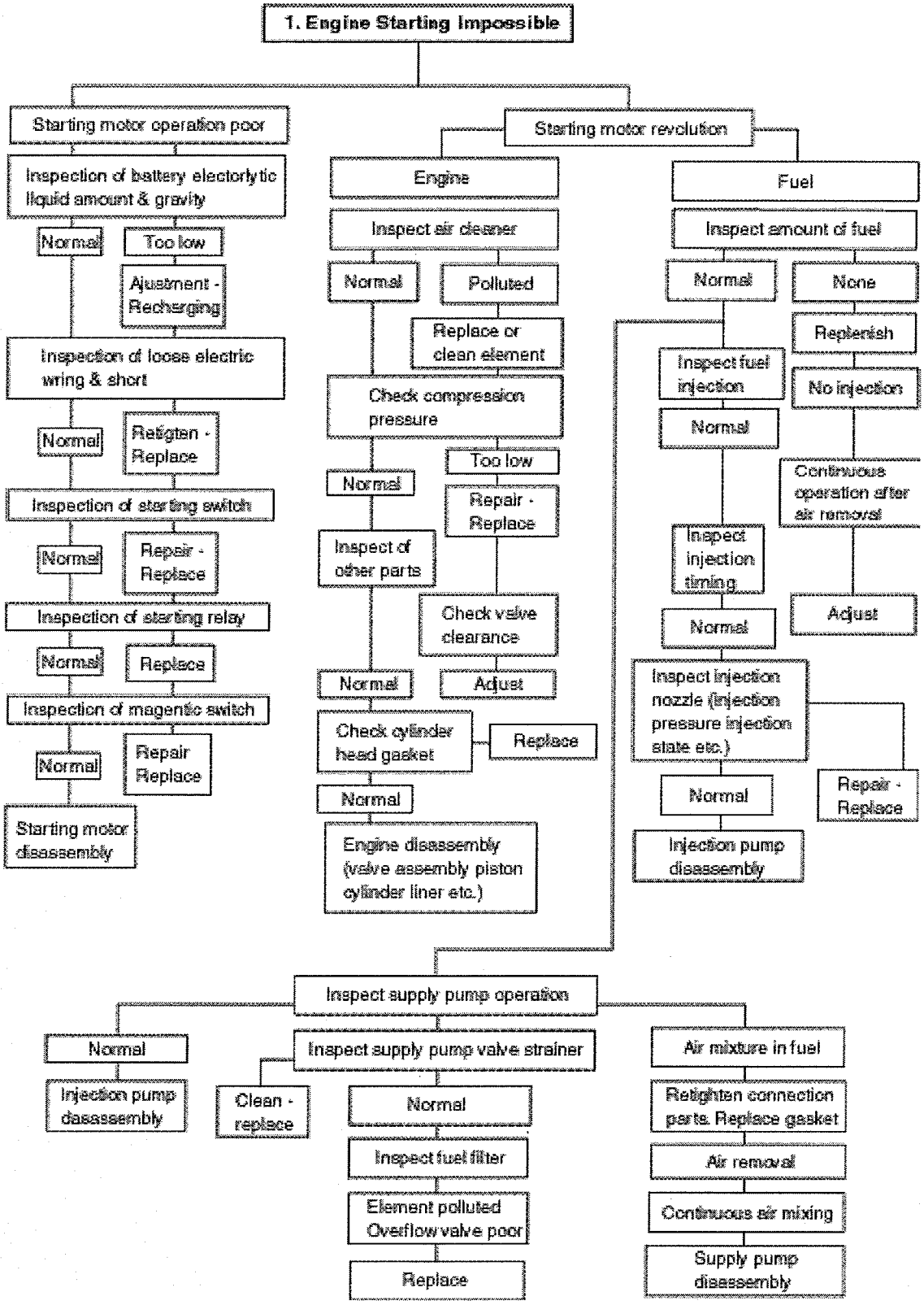
7.1. Maintenance Chart

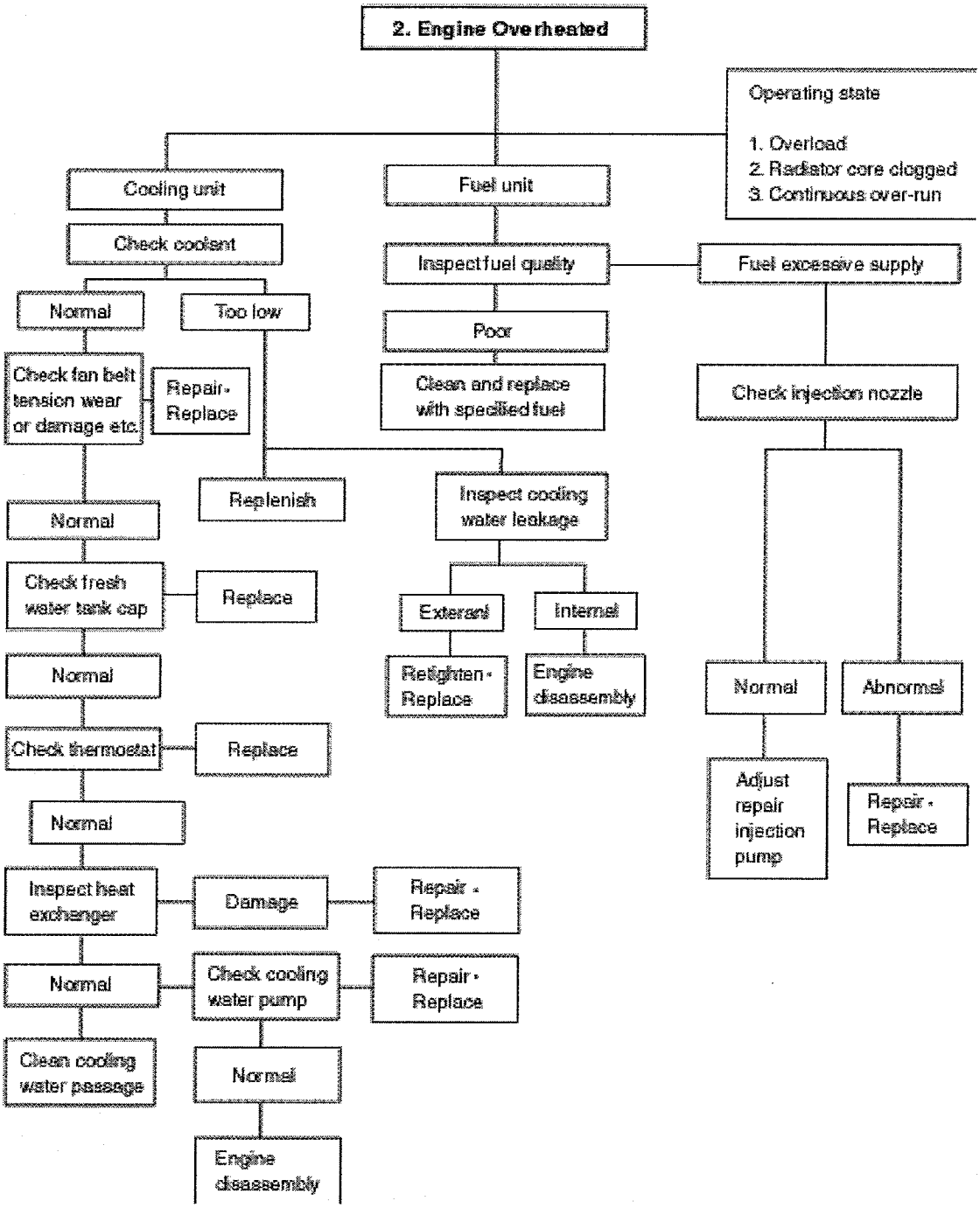
Always comply with safety regulation.

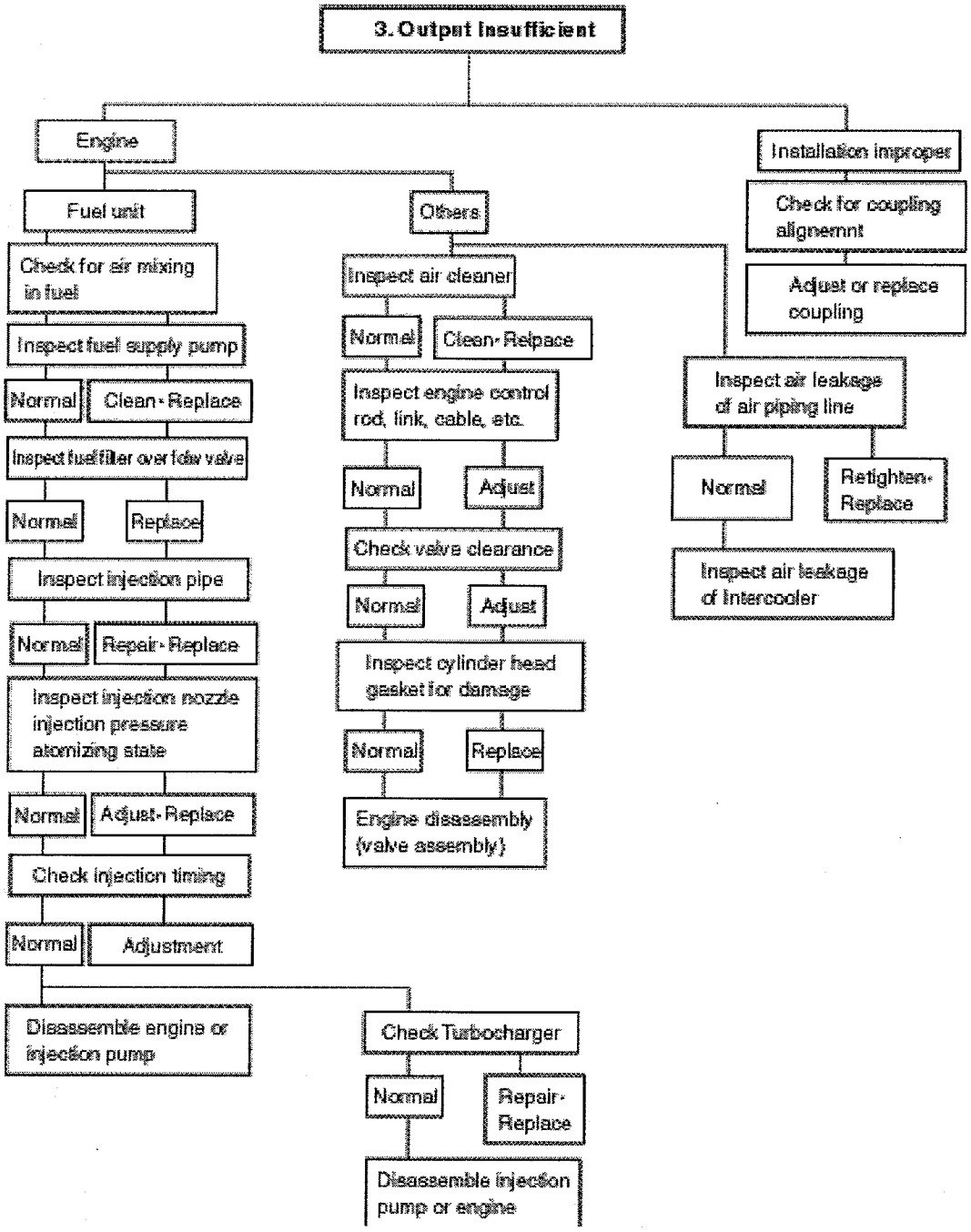
○: Check & adjust ●: Replace

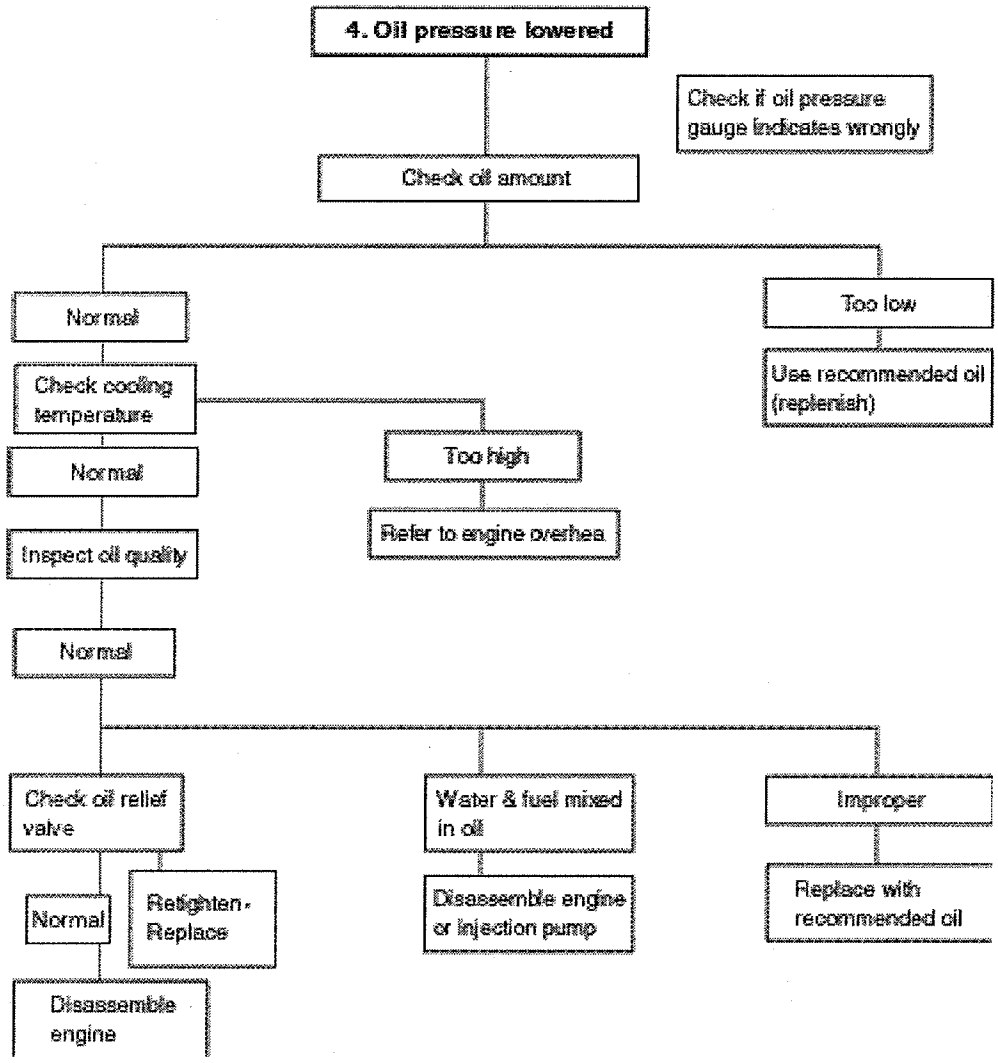
Inspection		Daily	Every 50hrs	Every 200hrs	Every 600hrs	Every 800hrs	Every 1200hrs	Remark
Cooling System	Check for leakage(hoses, clamp)	○						
	Check the water level	○						
	Change the coolant water						●	
	Adjust the V-belt tension	○						Every 2,000hrs
	Clean the radiator						○	
Lubrication System	Check for leakage	○						
	Check the oil level gauge	○						
	Change the lubricating oil		● 1st			○		
	Replace the oil filter cartridge		● 1st			○		
Intake & Exhaust System	Check the leakage for intercooler (hoses, clamp)	○						
	Clean and change the air cleaner element			○ clean	●			
	Clean the inter-cooler air fins				○			
	Clean the turbo-charger							Every 2,000hrs
Fuel System	Check the leakage fuel line	○						
	Clean the fuel strainer of fuel feed pump						○	
	Remove sediment from fuel tank						○	
	Drain the water in separator			○				
	Replace the fuel filter element						●	
	Check fuel Injection timing			○				When necessary
	Check the injection nozzles			○				When necessary
Engine Adjust	Check the state of exhaust gas	○						
	Check the battery charging	○						
	Check the compression pressure						○	When necessary
	Adjust Intake/Exhaust valve clearance		○ 1st					When necessary

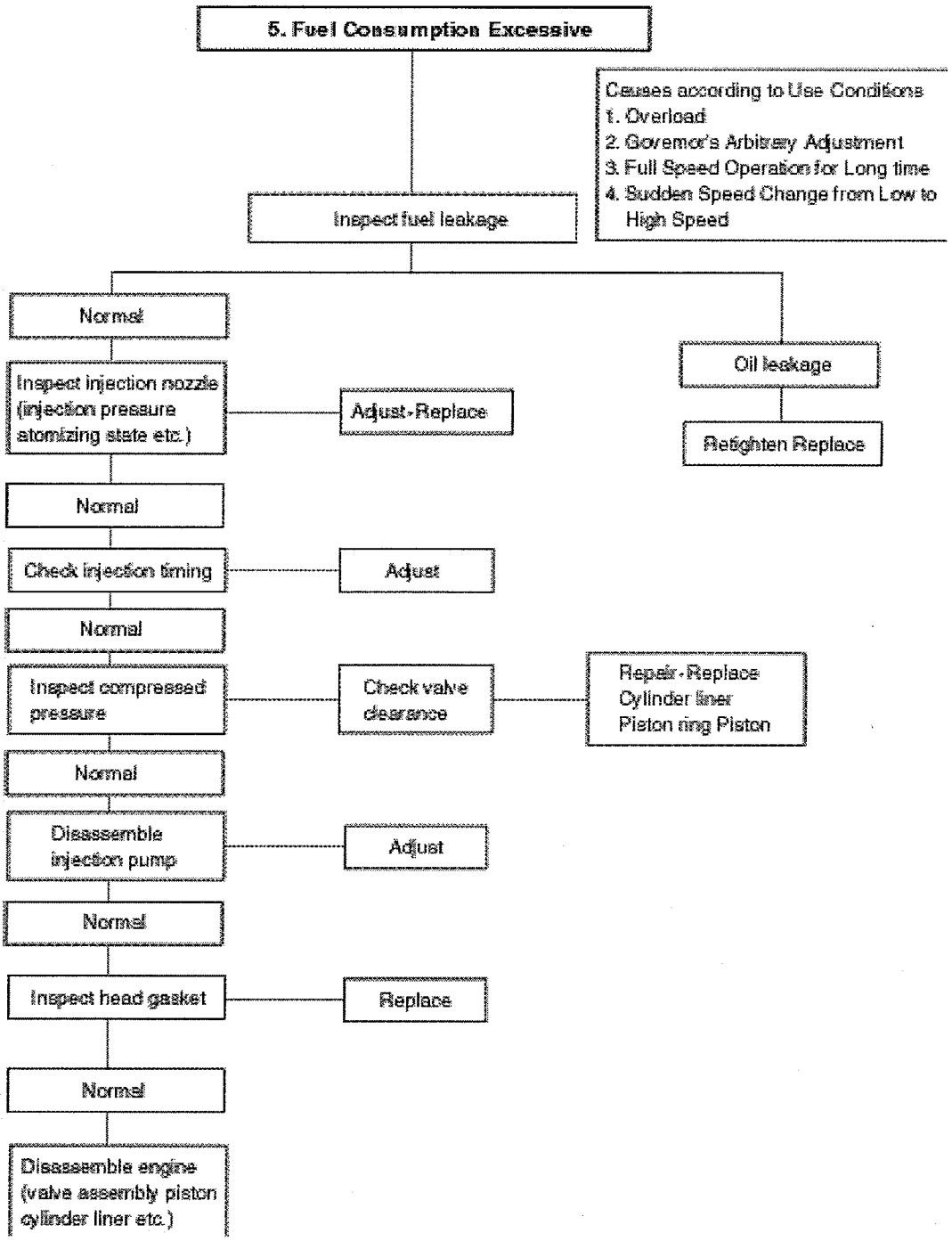
7.2. Diagnosis and Remedy

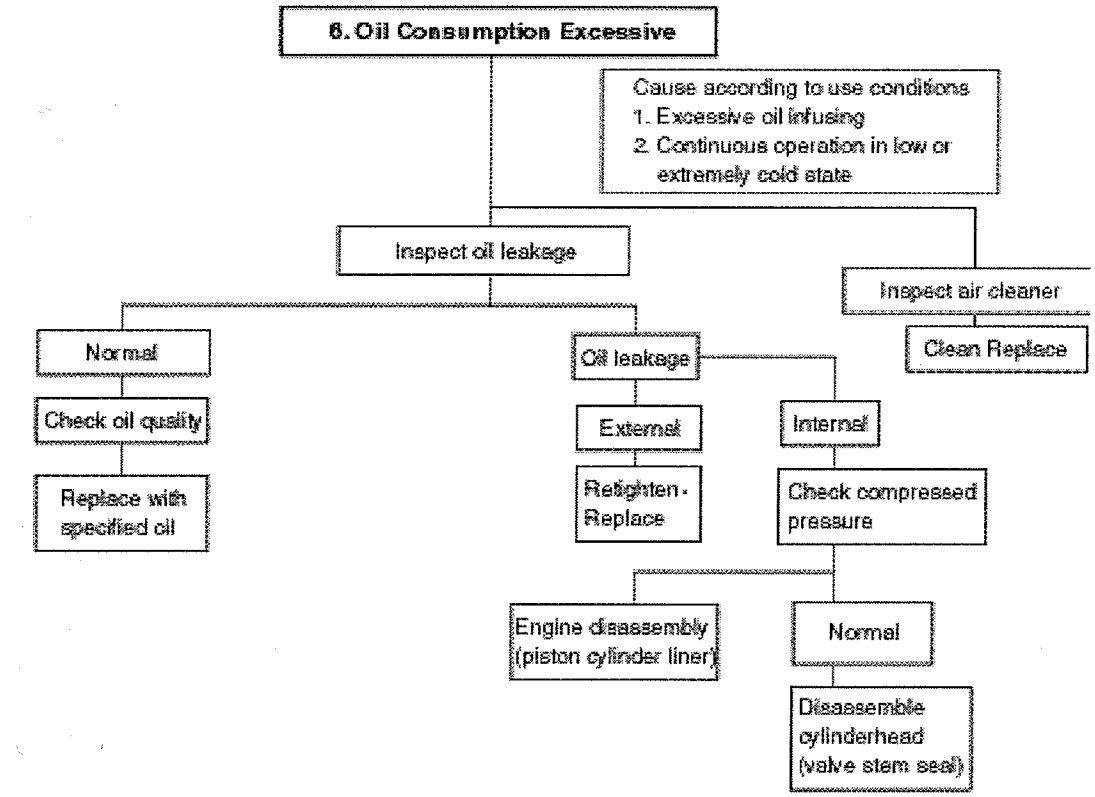


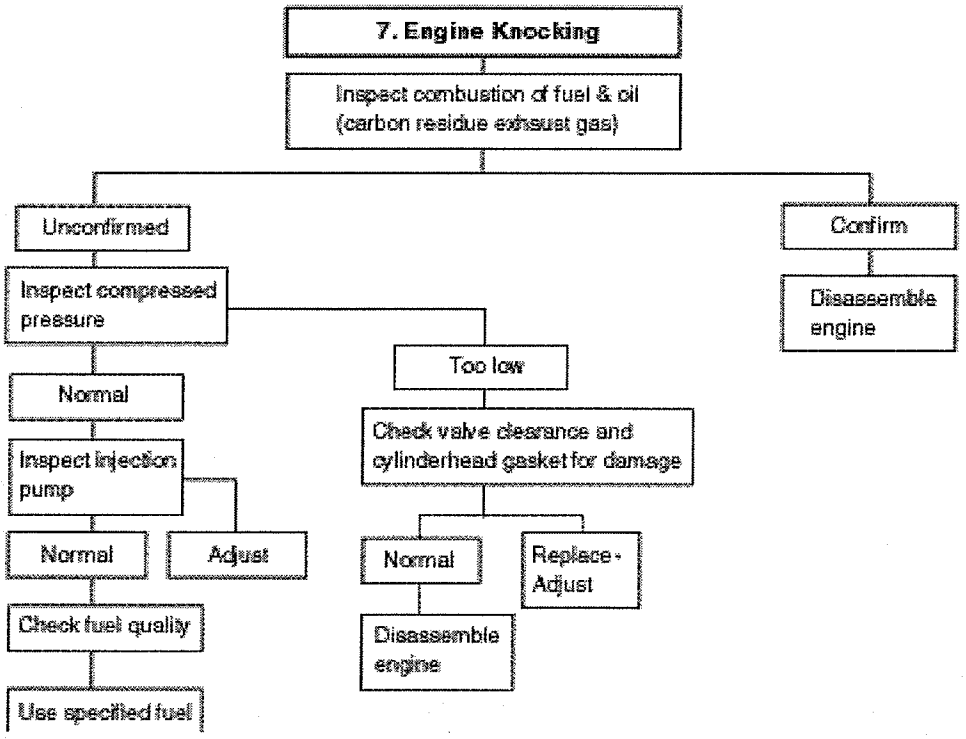

2. Engine Overheated
Operating state
1. Overload
2. Radiator core clogged
3. Continuous over-run
Cooling unit
Check coolant
Normal
Too low
Check fan belt tension wear or damage etc.
Repair · Replace
Normal
Check fresh water tank cap
Replace
Normal
Check thermostat
Replace
Normal
Inspect heat exchanger
Damage
Repair · Replace
Normal
Check cooling water pump
Repair · Replace
Clean cooling water passage
Normal
Engine disassembly
Replenish
Fuel unit
Inspect fuel quality
Poor
Clean and replace with specified fuel
Inspect cooling water leakage
External
Internal
Retighten · Replace
Engine disassembly
Fuel excessive supply
Check injection nozzle
Normal
Abnormal
Adjust repair injection pump
Repair · Replace

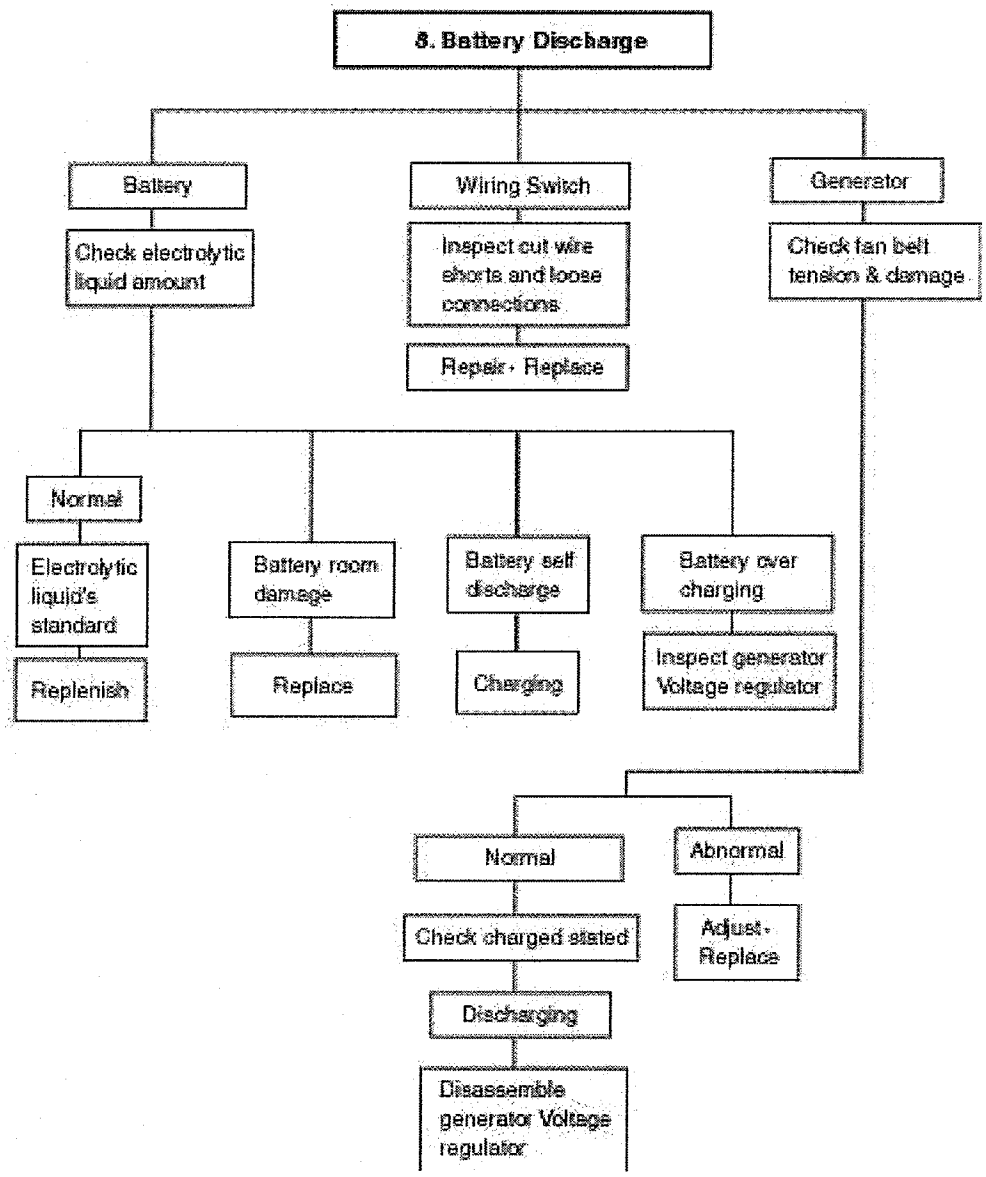

3. Output Insufficient
Engine
Fuel unit
Check for air mixing in fuel
Inspect fuel supply pump
Normal
Clean · Replace
Inspect fuel filter over flow valve
Normal
Replace
Inspect injection pipe
Normal
Repair · Replace
Inspect injection nozzle injection pressure atomizing state
Normal
Adjust · Replace
Check injection timing
Normal
Adjustment
Disassemble engine or injection pump
Others
Inspect air cleaner
Normal
Clean · Relpace
Inspect engine control rod, link, cable, etc.
Normal
Adjust
Check valve clearance
Normal
Adjust
Inspect cylinder head gasket for damage
Normal
Replace
Engine disassembly (valve assembly)
Check Turbocharger
Normal
Repair · Replace
Disassemble injection pump or engine
Installation improper
Check for coupling alignemnt
Adjust or replace coupling
Inspect air leakage of air piping line
Normal
Retighten · Replace
Inspect air leakage of Intercooler


4. Oil pressure lowered
Check if oil pressure gauge indicates wrongly
Check oil amount
Normal
Too low
Use recommended oil (replenish)
Check cooling temperature
Too high
Refer to engine overhea
Normal
Inspect oil quality
Normal
Check oil relief valve
Water & fuel mixed in oil
Improper
Normal
Retighten · Replace
Disassemble engine or injection pump
Replace with recommended oil
Disassemble engine


5. Fuel Consumption Excessive
Causes according to Use Conditions
1. Overload
2. Governor's Arbitrary Adjustment
3. Full Speed Operation for Long time
4. Sudden Speed Change from Low to High Speed
Inspect fuel leakage
Normal
Oil leakage
Retighten Replace
Inspect injection nozzle (injection pressure atomizing state etc.)
Adjust-Replace
Normal
Check injection timing
Adjust
Normal
Inspect compressed pressure
Check valve clearance
Repair-Replace
Cylinder liner
Piston ring Piston
Normal
Disassemble injection pump
Adjust
Normal
Inspect head gasket
Replace
Normal
Disassemble engine (valve assembly piston cylinder liner etc.)


6. Oil Consumption Excessive
Cause according to use conditions
1. Excessive oil infusing
2. Continuous operation in low or extremely cold state
Inspect oil leakage
Inspect air cleaner
Clean Replace
Normal
Check oil quality
Replace with specified oil
Oil leakage
External
Retighten · Replace
Internal
Check compressed pressure
Engine disassembly (piston cylinder liner)
Normal
Disassemble cylinderhead (valve stem seal)


7. Engine Knocking
Inspect combustion of fuel & oil (carbon residue exhsust gas)
Unconfirmed
Confirm
Disassemble engine
Inspect compressed pressure
Too low
Normal
Check valve clearance and cylinderhead gasket for damage
Inspect injection pump
Normal
Adjust
Normal
Replace · Adjust
Check fuel quality
Disassemble engine
Use specified fuel


8. Battery Discharge
Battery
Wiring Switch
Generator
Check electrolytic liquid amount
Inspect cut wire shorts and loose connections
Check fan belt tension & damage
Repair · Replace
Normal
Electrolytic liquid's standard
Replenish
Battery room damage
Replace
Battery self discharge
Charging
Battery over charging
Inspect generator Voltage regulator
Normal
Check charged stated
Discharging
Disassemble generator Voltage regulator
Abnormal
Adjust · Replace

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 pump	Adjust injection
	• 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
	• Supercharger poor	Repair or replace
(2) Output insufficient when in acceleration	• Compression pressure insufficient	Disassemble engine
	• Injection timing incorrect	Adjust
	• Fuel injection amount insufficient pump	Adjust injection
	• Injection pump timer's function insufficient	Repair or replace
	• Nozzle infection pressure, infection 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 temp. regulator's operation poor	Replace
	• Valve clearance incorrect	Adjust
	• Exhaust system's resistance increased	Clean or replace

Condition	Cause	Remedies
5) Engine noisy	For noises arise compositely such asrota ting parts, lapping parts etc., there is nec essity to search the cause of noises accu rately.	
(1) Crankshaft	• As the wear of bearing or crankshaft progress, the oil clearances increase. • Lopsided wear of crankshaft • Oil supply insufficient due to oil passage clogging • Stuck bearing	Replace bearing & grind crankshaft Grind or replace Clean oil passage Replace bearing & Grind
(2) Con rod and Con rod bearing	• Lopsided wear of con rod bearing • Lopsided wear of crank pin • Connecting rod distortion • Stuck bearing • Oil supply insufficiency as clogging at oil passage progresses	Replace bearing Grind crankshaft Repair or replace Replace & grind crankshaft Clean oil passage
(3) Piston, piston pin & piston ring	• Piston clearance increase as the wear of piston and piston ring progresses • Wear of piston or piston pin • Piston stuck • Piston insertion poor • Piston ring damaged	Replace piston & piston ring Replace Replace piston Replace piston Replace piston
(4) Others	• Wear of crankshaft, thrust bearing • Camshaft end play increased • Idle gear end play increased • Timing gear backlash excessive • Valve clearance excessive • Abnormal wear of tappet, cam • Supercharger inner part damaged	Replace thrust bearing Replace thrust plate Replace thrust washer Repair or replace Adjust valve clearance Replace tappet, cam Repair or replace
6) Fuel Consumption Exttive	• Injection timing incorrect • Fuel injection amount excessive	Adjust Adjust injection pump

Condition	Cause	Remedies
7) Oil Consumption Excessive		
(1) Oil level elevated	• Clearance between cylinder iner & 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 repair	• Looseness of connection parts	Replace gasket,
	• Various parts' packing poor	Replace packing
	• Oil seal poor	Replace oil seal