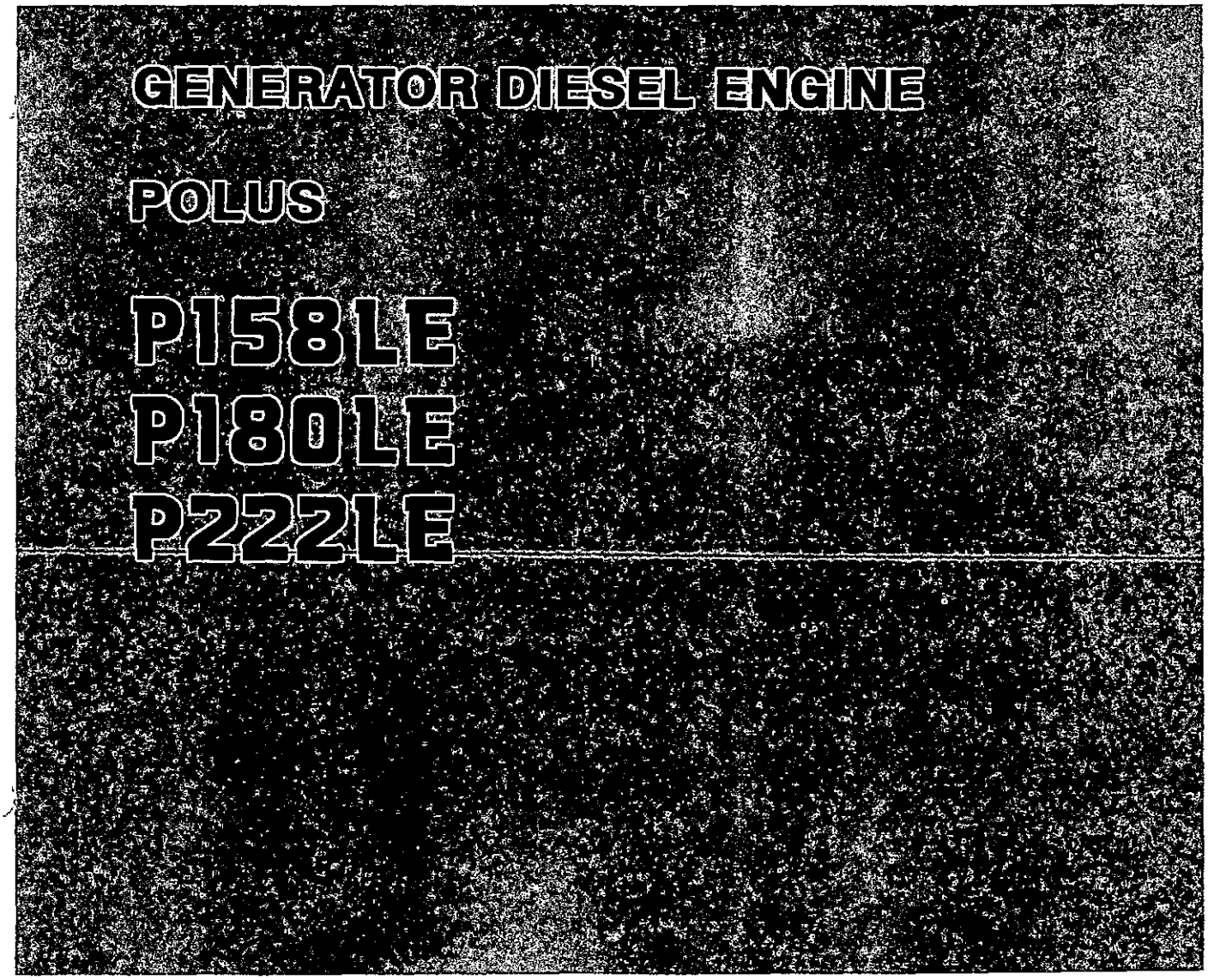
DAEWOO

65.99897-8051

# Maintenance Manual



## P158LE, P180LE, P22LE Engine correct in the maintenance manual

- Page 2 (Contents 1.1.2 Engine Power)
  - P158LE STANDBY POWER **536PS → 563PS**
- Page 12 (Contents 1.3.3 Engine Oil)
  - Engine Oil Intervals **800hr → 200hr**
- Page 13 (Contents 1.3.4 Fuel Filter)
  - Fuel Filter Cartridge Intervals **1200hr → 400hr**
- Page 29 (Contents 1.5.2 General Engine Inspection Cycle)
  - Lubrication System : Change the lubrication oil **800hr → 200hr**

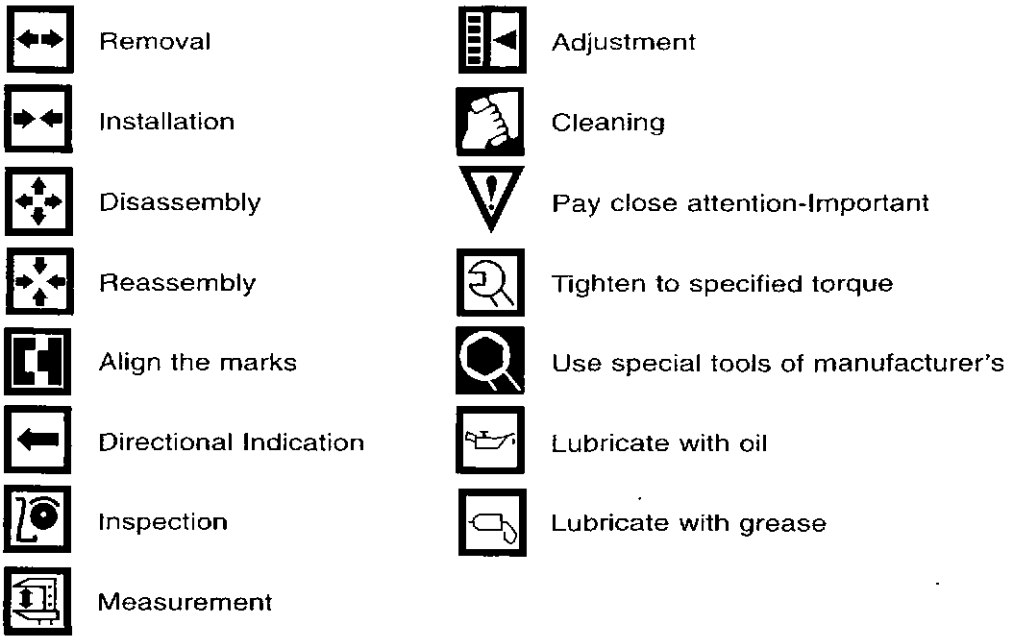
    Replace the oil filter cartridge **800hr → 200hr**
  - Intake & Exhaust system : Change the air cleaner element **600hr → 400hr**
  - Fuel System : Replace the fuel filter element **1200hr → 400hr**
- Page 84 (Contents Speed Control Units for Governor System)
  - GAC governor model **ACE175 → ACB275**

# FOREWORD

This content is the maintenance instruction for Diesel generator Engine of DAEWOO POLUS Series (P158LE, P180LE, and P222LE). POLUS is a composed word that are Power and Plus. This means more powerful engine. P158LE (8 cylinder), P180LE (10 cylinder), P222LE (12 cylinder) engines are 4 strokes, V type, and direct injection mode and thus, are also satisfying with various features required as generator engine such as quiet operation, economical fuel consumption, durability in high speed operation and so forth.

We are very confident that these engine series are quite superior to any high speed engines in economy and efficiency However, high performance and long life cycle will be accomplished when a proper handling and administration of periodic inspections and maintenance should be observed. Readers are desired to know for your reference that those kinds of maintenance matters are explained here in detail by means of figures and diagrams.

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 and diesel fuel 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.

For the last, the content of this maintenance instruction may be changed without notice for some quality improvement and please feel free to contact to our agents near by your location for any services. Thank you.

DAEWOO Heavy Industries LTD.
April. 1999

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# 1. GENERAL INFORMATION

## 1.1. Engine Characteristics

### 1.1.1. 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 X 142 | 10 - 128 X 142 | 12 - 128 X 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 X 1,389 X 1,161.5 | 1,557 X 1,389 X 1,248 | 1,717 X 1,389 X 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 | | |

### 1.1.2. Engine power

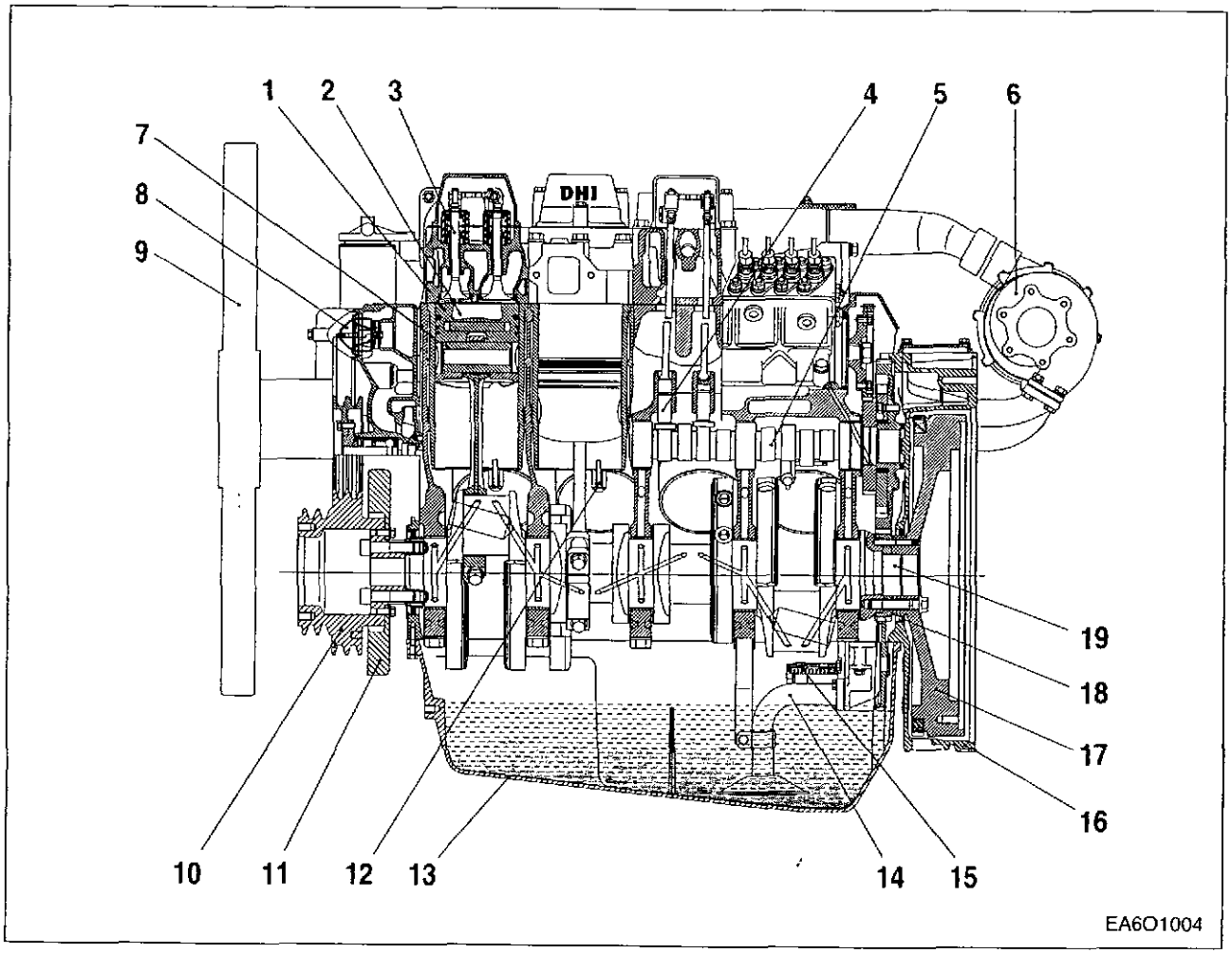
Production tolerance : ±5%

| 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.*

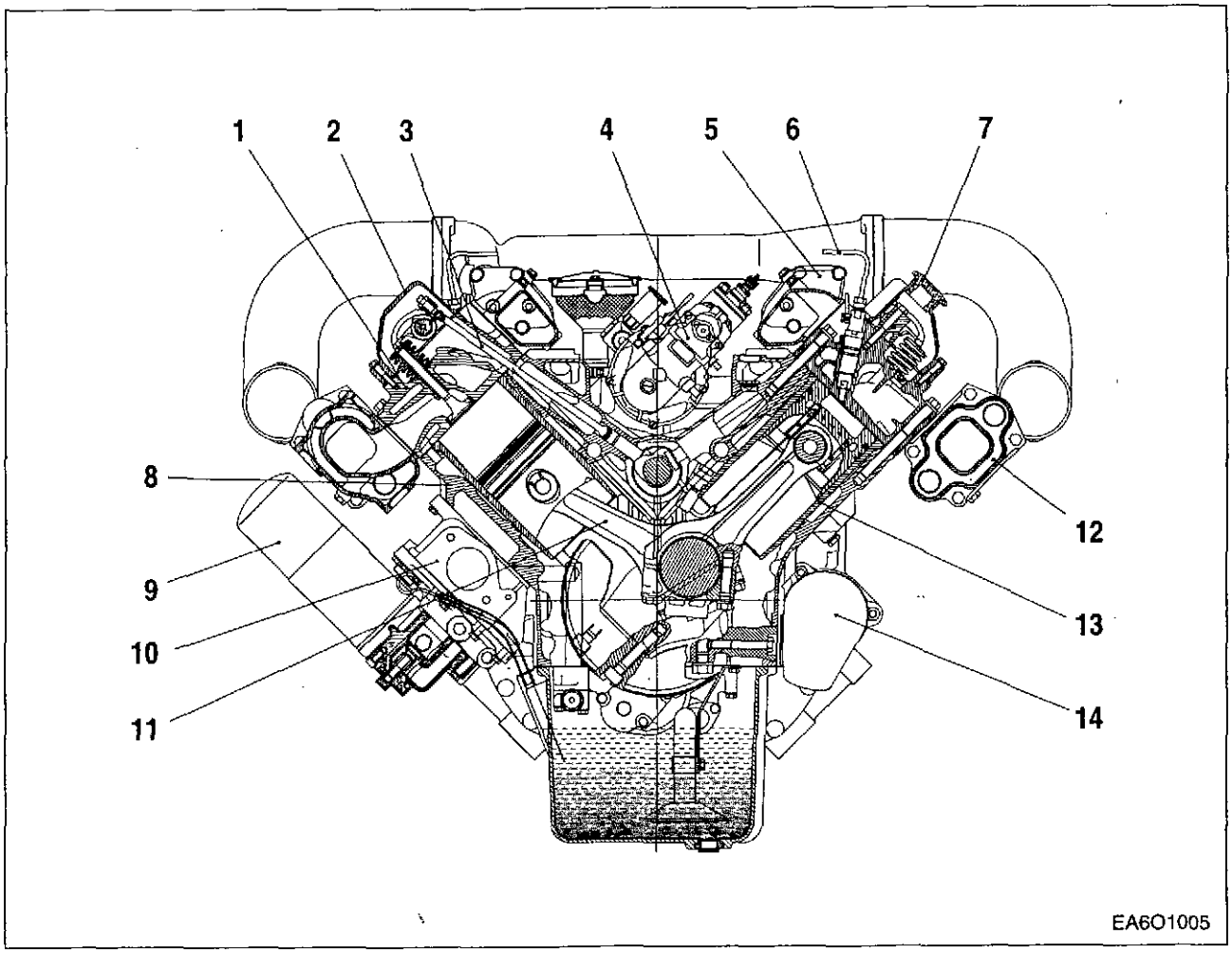
## 1.2 Engine General Views

### 1.2.1. Engine Sectional View (longitudinal)




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

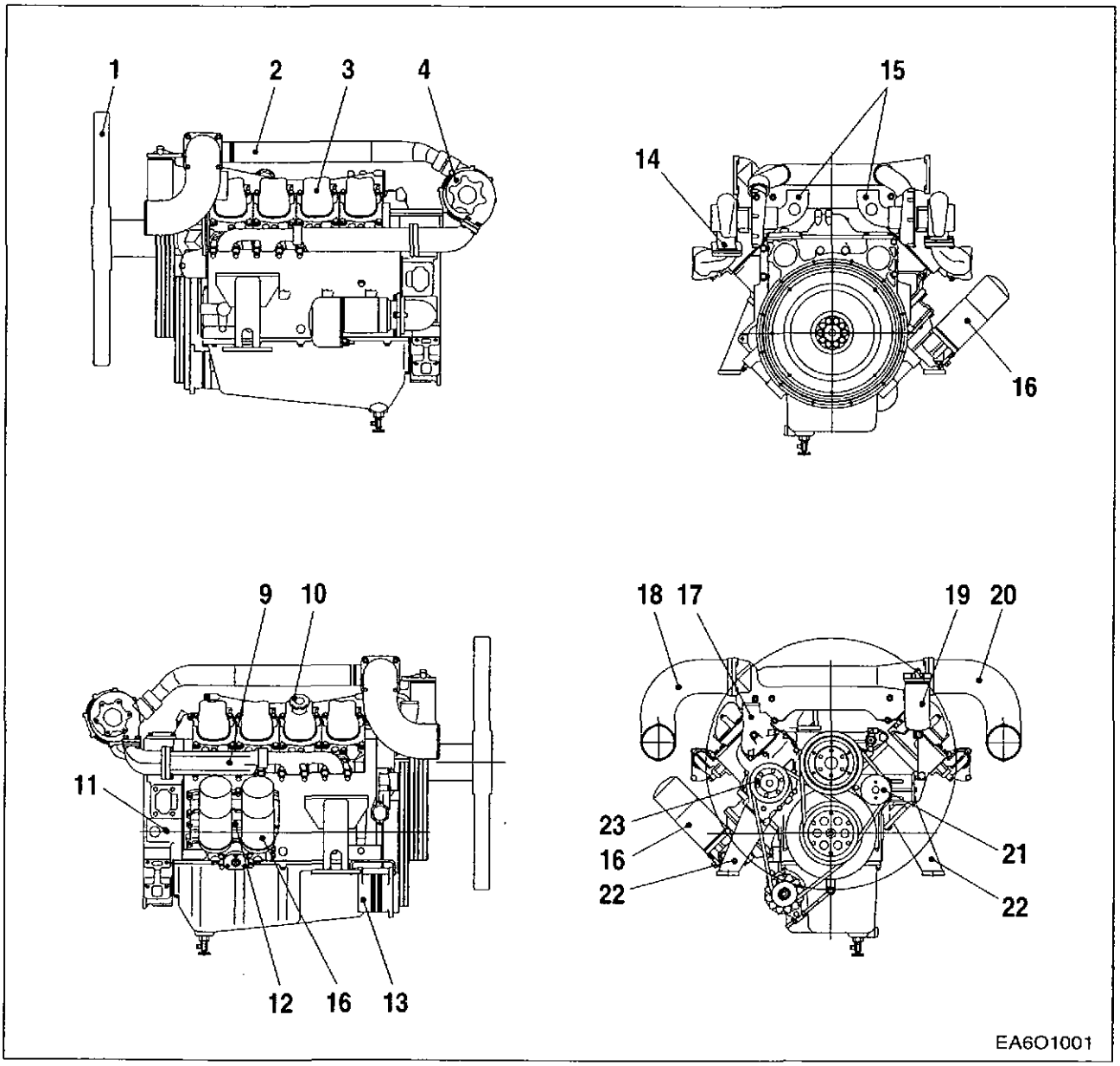
### 1.2.2. Engine Sectional View (cross)




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

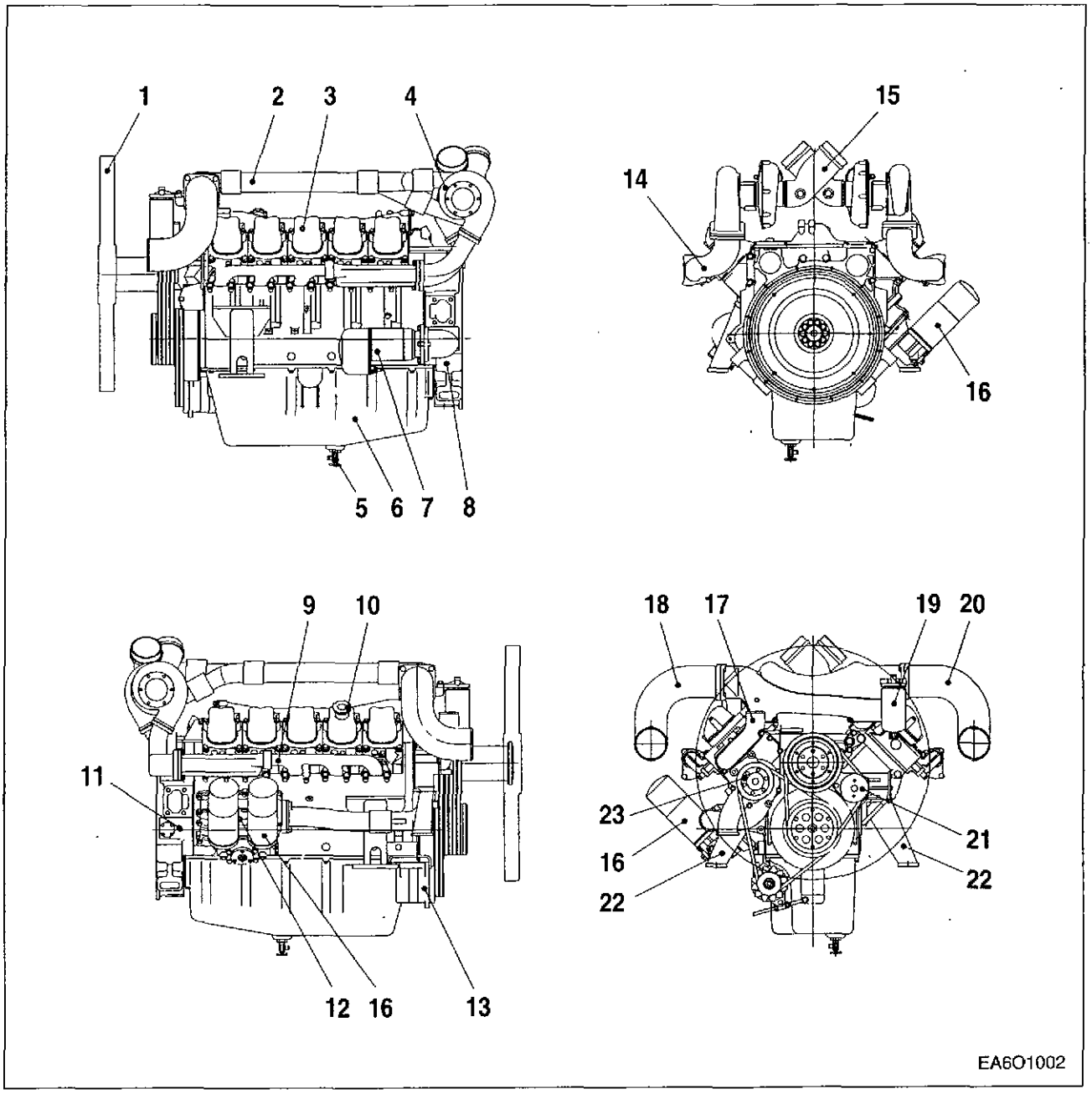
### 1.2.3. Engine Assembly Views

#### 1) P158LE



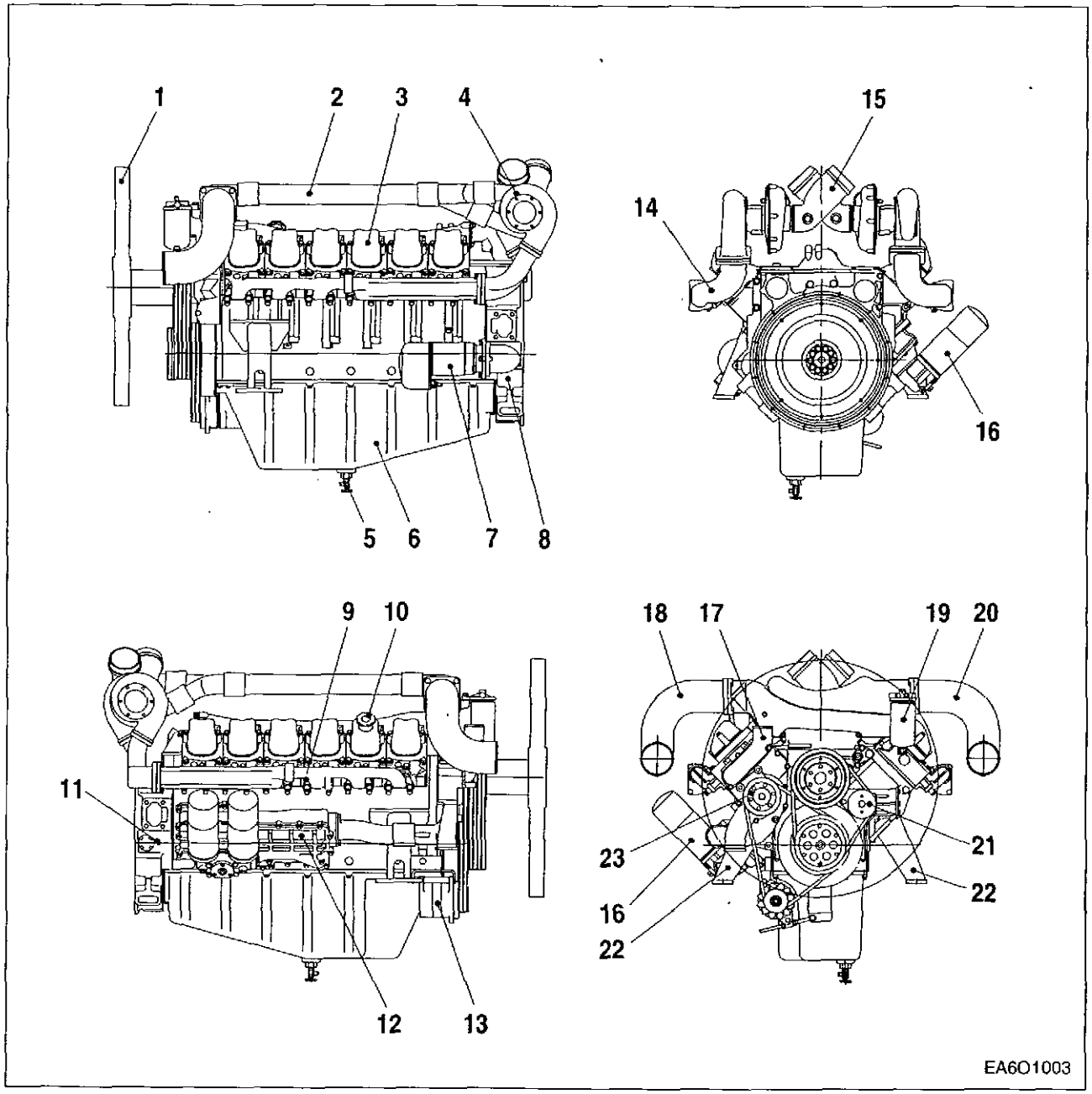

1. Cooling fan
2. Air pipe
3. Cylinder head cover
4. Turbocharger
5. Oil drain valve
6. Oil pan
7. Starter
8. Flywheel housing
9. Exhaust manifold
10. Oil filler cap
11. Pick up sensor
12. Oil cooler
13. Alternator
14. Exhaust elbow
15. Air pipe
    (Air cleaner to turbocharger)
16. Oil filter
17. Cooling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

## 2) 180LE



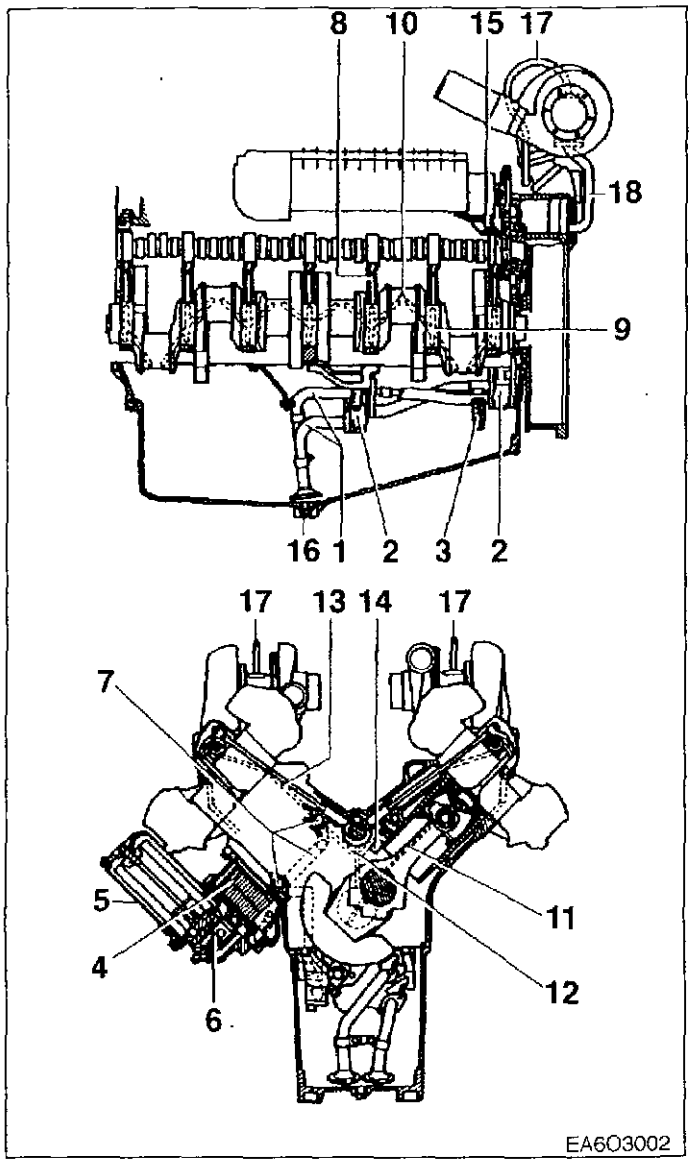

1. Cooling fan
2. Air pipe
3. Cylinder head cover
4. Turbocharger
5. Oil drain valve
6. Oil pan
7. Starter
8. Flywheel housing
9. Exhaust manifold
10. Oil filler cap
11. Pick up sensor
12. Oil cooler
13. Alternator
14. Exhaust elbow
15. Air pipe
    (Air cleaner to turbocharger)
16. Oil filter
17. Cooling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

### 3) P222LE



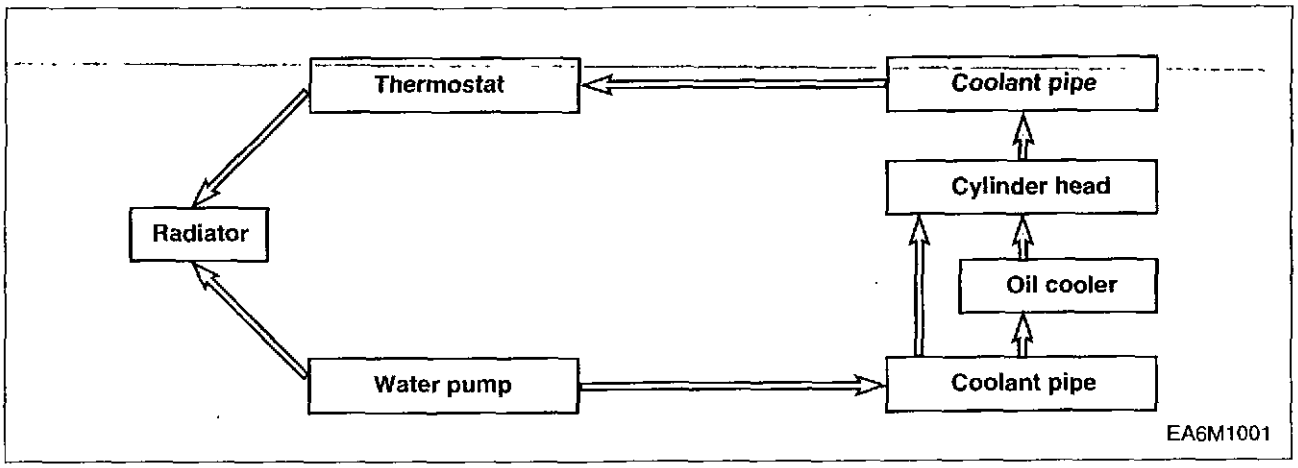

1. Cooling fan
2. Air pipe
3. Cylinder head cover
4. Turbocharger
5. Oil drain valve
6. Oil pan
7. Starter
8. Flywheel housing
9. Exhaust manifold
10. Oil filler cap
11. Pick up sensor
12. Oil cooler
13. Alternator
14. Exhaust elbow
15. Air pipe
    (Air cleaner to turbocharger)
16. Oil filter
17. Cooling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

### 1.2.4. Engine Lubrication System

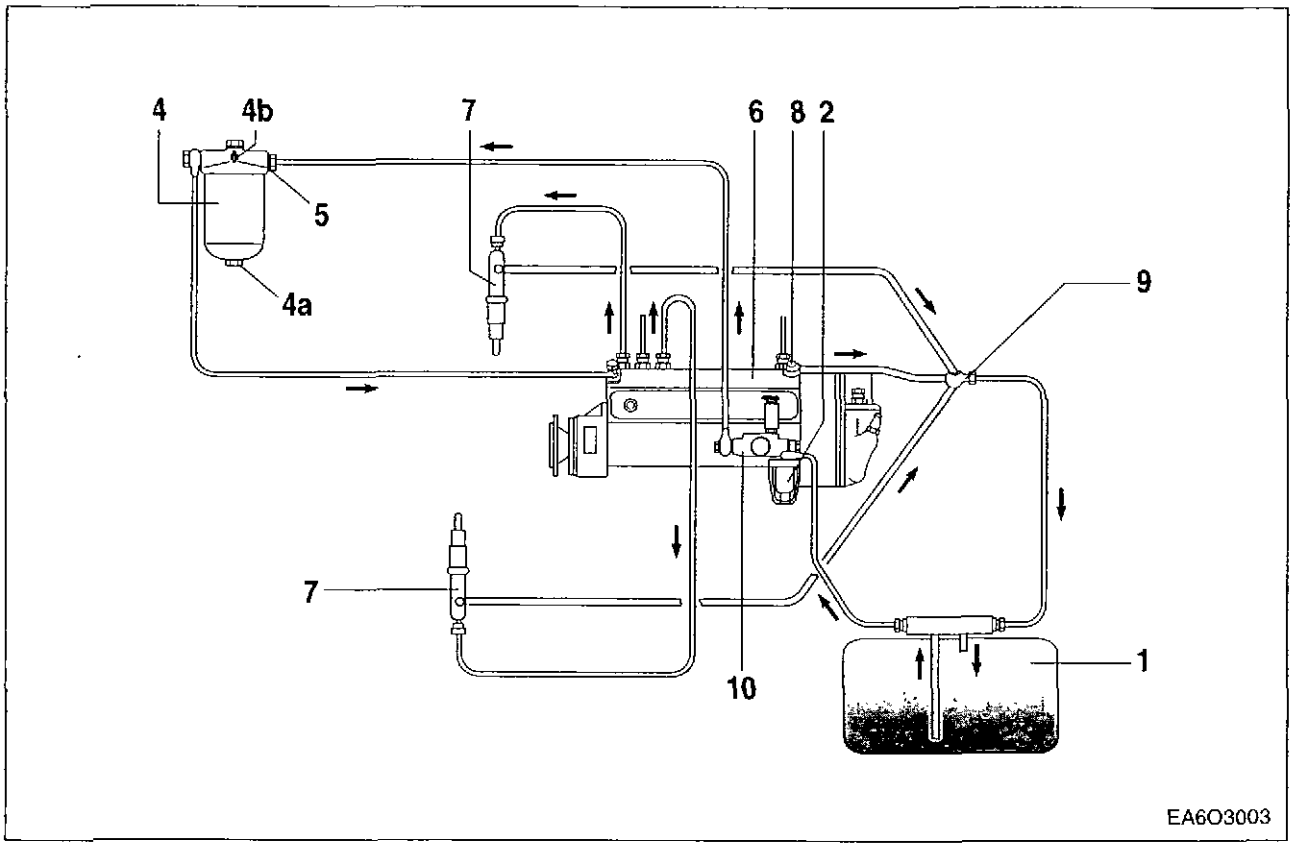



1. Oil suction pipes
2. Oil pumps
3. Oil relief valves
4. Oil color
5. Oil filter
6. Bypass valve
7. Main oil galleries
8. Oil gallery to crankshaft
9. Ports for main bearing lubrication
10. Ports for big end bearing lubrication
11. Small end bearing lubrication
12. Camshaft bearing lubrication
13. Rocker 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

### 1.2.5. Engine Cooling System



## 1.2.6. Engine Fuel System



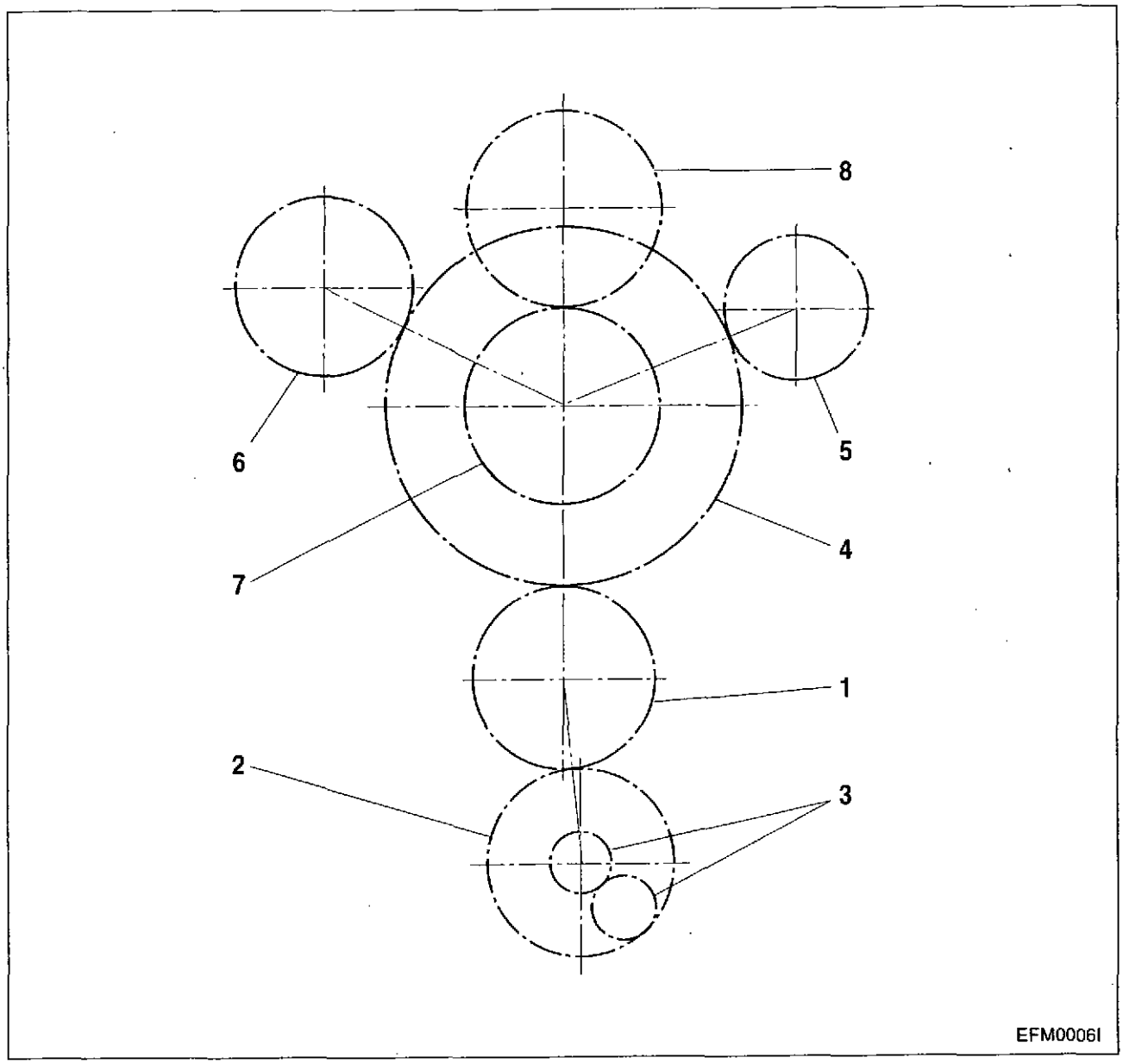

1. Fuel tank
2. Strainer
3. Fuel Filter
4. Fuel filter ass'y

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

### 1.2.7. Engine Timing Gear Diagram




1. Crankshaft gear
2. Oil pump drive gear
3. Oil pump gear
4. Camshaft drive gear
5. Air compressor drive gear
6. PTO drive gear
7. Injection pump drive gear
8. injection pump gear

## 1.3. Preventive Maintenance

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

### 1.3.1. Cooling Water

- Regarding the cooling water that is to be used for engine, the soft water not the hard water must be used.
- 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 main tain it properly.

**NOTE :** *The proper density control of antifreezing solution and rust preventing addi tive 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 P158LE/P180LE/P222LE (POLUS series generator engine of D28 base engine) cylinder liner is wet type, particularly the cooling water control should be applied thor oughly.
- The density of antifreezing solution and additive for rust prevention is able to be con firmed 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 nec essarily 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 indica tion 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 numer ical value of brown (vertical) and pink color (horizontal) locates in the range of 0.3 to 0.8 at the color list of label on the test paper storage bottle.

(7) 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.

- **Amount of Anti-freeze in winter**

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

### 1.3.2. Fan belt

- Use a fan belt of specified dimensions, and replace if damaged, frayed, or deteriorated.
- Check the fan belt for belt tension.

  If belt tension is lower than the specified limit, adjust the tension by relocating the alter nator and idle pulley. (specified deflection: 10 ~ 15 mm when pressed down with thumb)

### 1.3.3. Engine oil

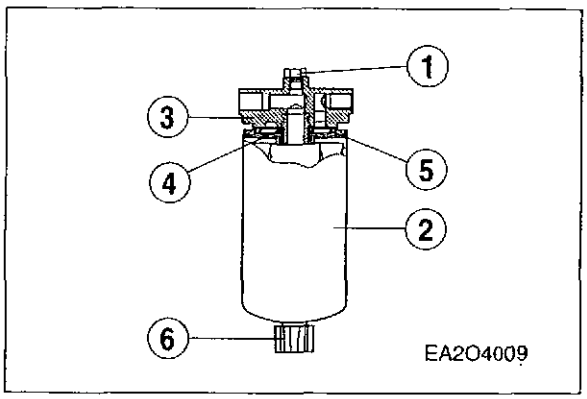
- Check oil level with the oil level gauge and replenish if necessary.
- Check the oil level with the engine cooled. If the engine is warm, allow time for 5 ~ 10 minutes for oil drain into the crankcase before checking oil level. The oil level must be between Max and Min. lines on the gauge.
- Engine oil should be changed at the specified intervals. (800 hr)

  Oil in the oil filter should be changed simultaneously.

  - First oil change : 50 hr operating
- The oil viscosity grades should be selected SAE NO.15W40 and API CD or CE.

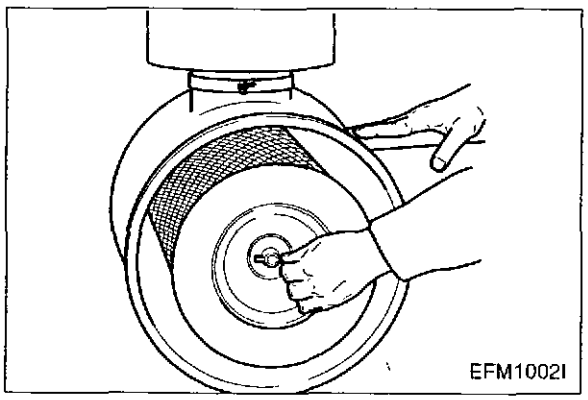
### 1.3.4. Fuel Filter

- Drain water in cartridge with loosening the cock under filter manually (6) from time to time.
- The fuel filter should be replaced at every 1,200 hours.



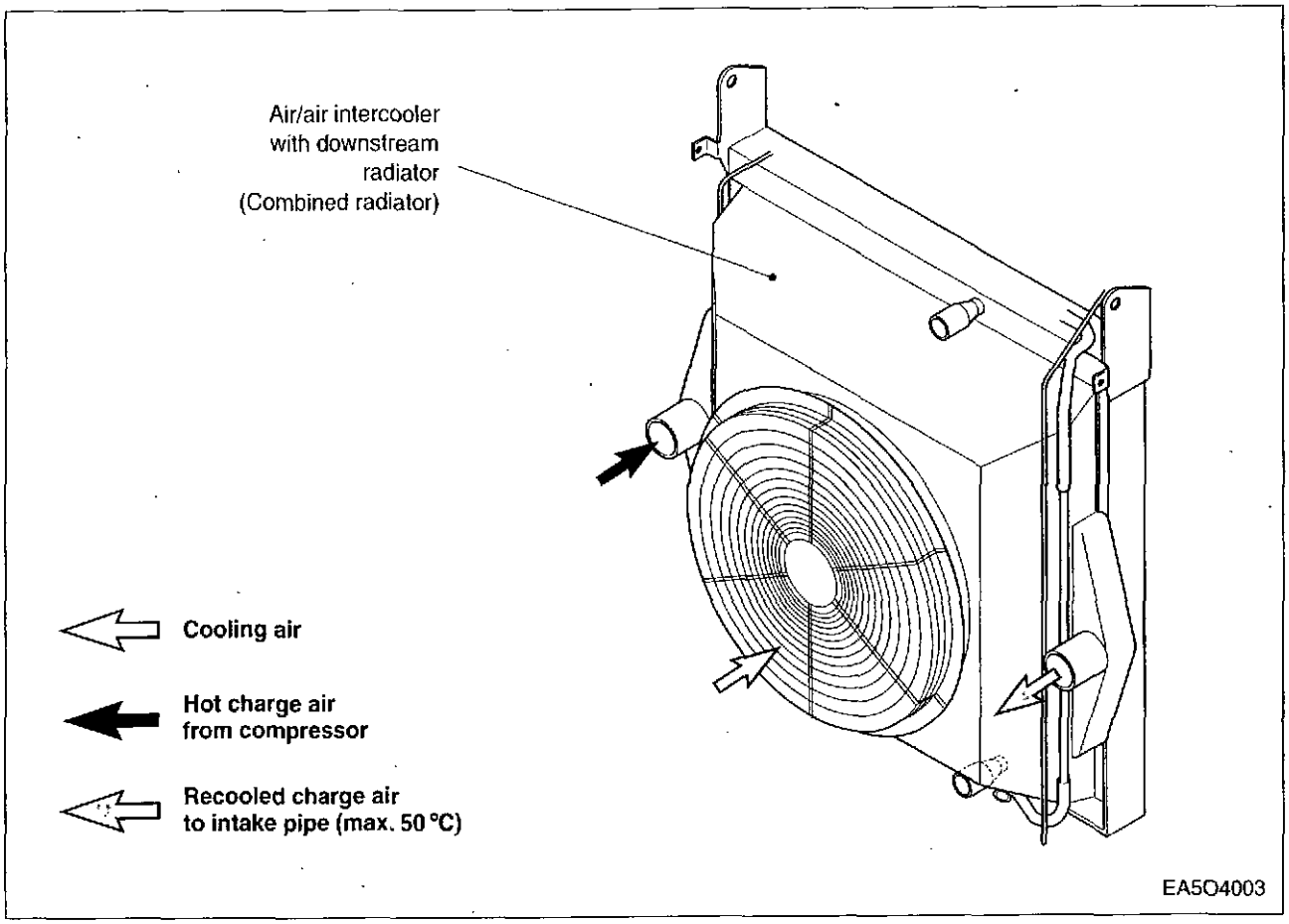

### 1.3.5. Air Cleaner.

- 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.




### 1.3.6. 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.*

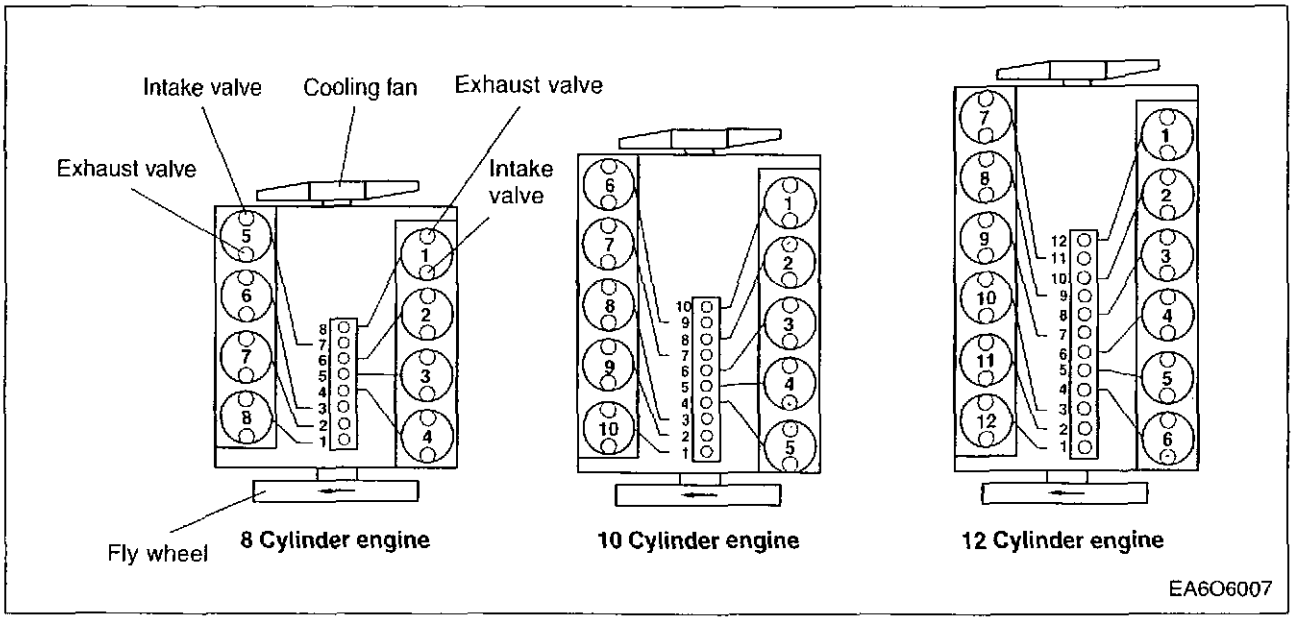
### 1.3.7. Valve Clearance Adjust Procedure

- 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 |
|---|---|---|
| P158LE | | |
| P180LE<br>P222LE | 0.25mm | 0.35mm |

- 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 "●" of lower lists.
- After reinsuring the valve clearances, retighten if necessary.




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

*** 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. : Cylinder*

- *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)**

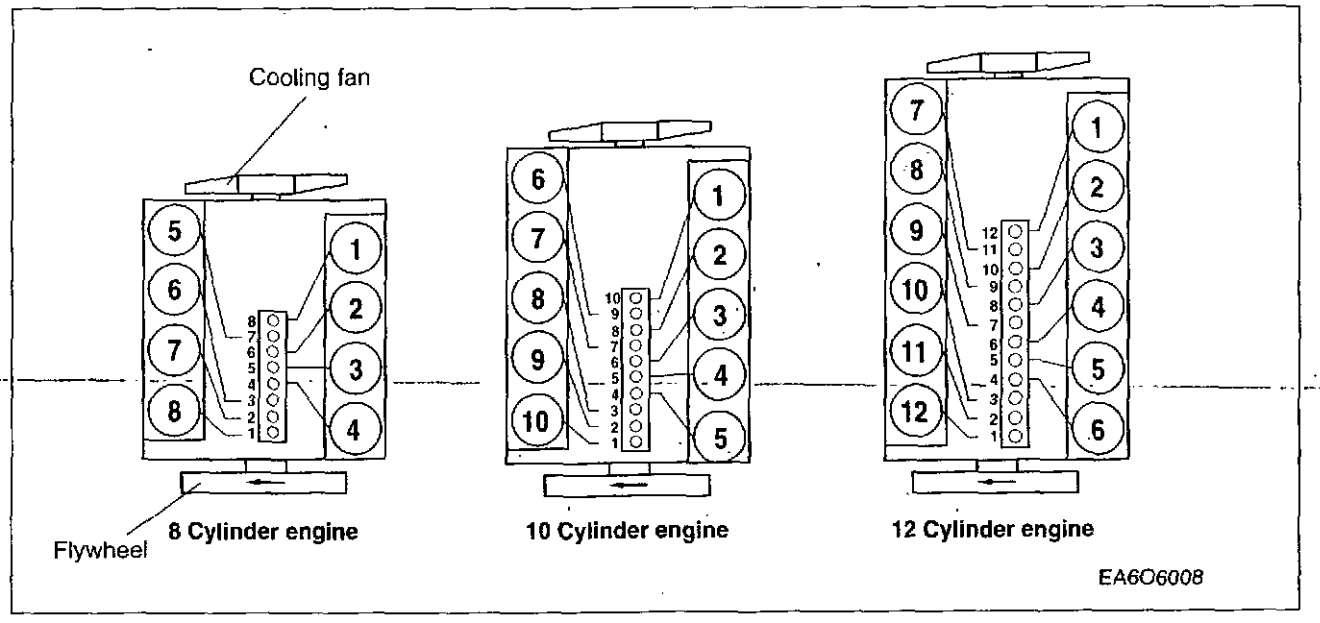
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Valve overlapping on cylinder (Intake & Exhaust valve) | 1 | 5 | 7 | 2 | 6 | 3 | 4 | 8 |
| Adjusting valves on cylinder (Intake & Exhaust valve) | 6 | 3 | 4 | 8 | 1 | 5 | 7 | 2 |

*** 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)**

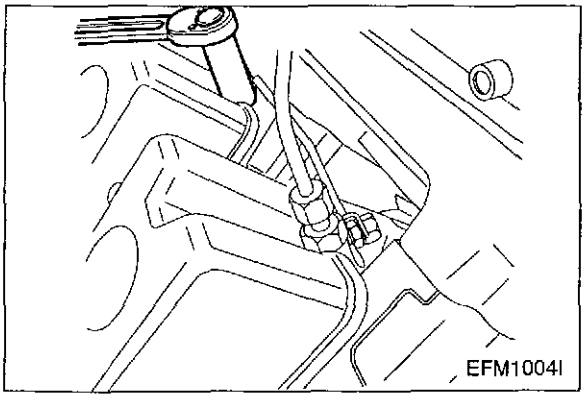
| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Valve overlapping on cylinder (Intake & Exhaust valve) | 1 | 12 | 5 | 8 | 3 | 10 | 6 | 7 | 2 | 11 | 4 | 9 |
| Adjusting valves on cylinder (Intake & Exhaust valve) | 6 | 7 | 2 | 11 | 4 | 9 | 1 | 12 | 5 | 8 | 3 | 10 |



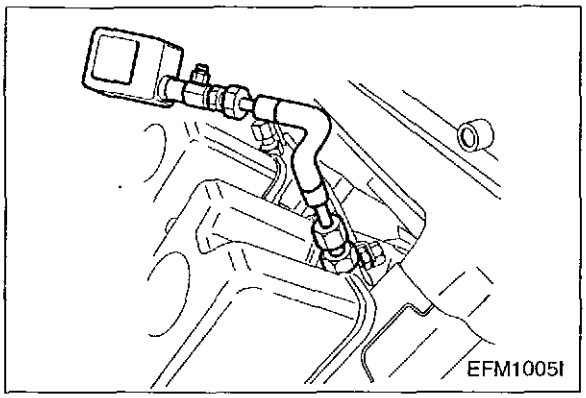

- No. 1 Cylinder is located at the side where cooling water pump was installed.

### 1.3.8. Cylinder Compression Pressure

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


EFM1004I

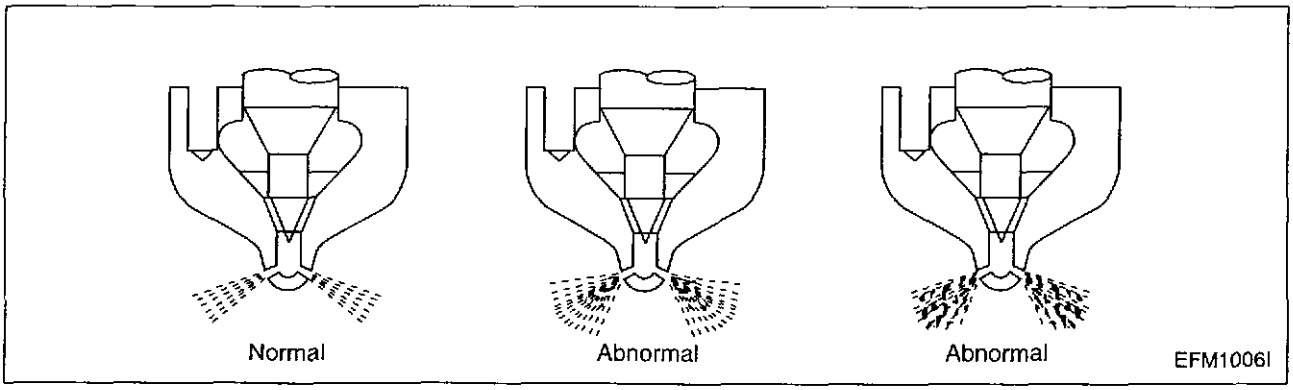
- Install the special tool (compression gauge adapter) at the nozzle holder hole, and connect the compression pressure gauge there.


EFM1005I

| | |
|---|---|
| Standard value | 28kg/cm$^2$ over |
| Limit value | 24kg/cm$^2$ |
| Difference between each cylinder | Within ±10 % |

◆ Condition : Water temperature20°C, Engine rotation 200rpm (10 rotation)

### 1.3.9. Injection Nozzle



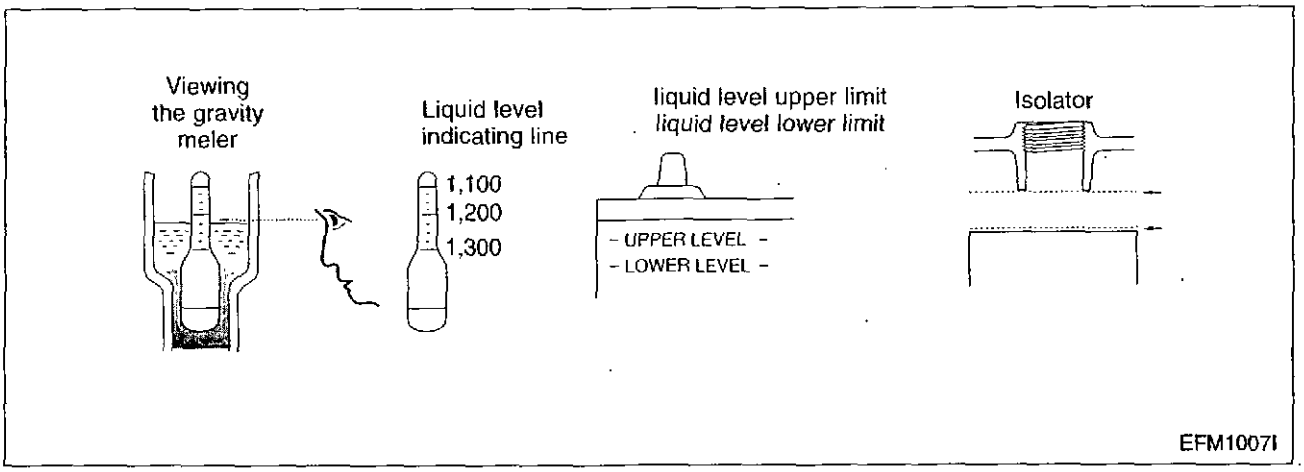

- Install a nozzle on the nozzle tester.
- If the inspected injection pressure is less than the specified value(285 kg/cm$^2$), adjust using the adjusting shims.
- Check the atomizing state and replace it if abnormal.

### 1.3.10. 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.

### 1.3.11. 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.




### 1.3.12. Air removal of Fuel System

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

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

### 1.3.13. Fuel Supply Pump

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

### 1.3.14. Supercharger

The supercharger needs not arty special equipment

Every time of engine replacement, a leakage or clogging of oil pipes should be inspected. Air cleaner should be maintained carefully for nut or foreign material not to get in. Periodic inspection should be applied on the compressed air and exhaust gas pipes, For leaking air will bring the overheat engine, an immediate repair must be done.

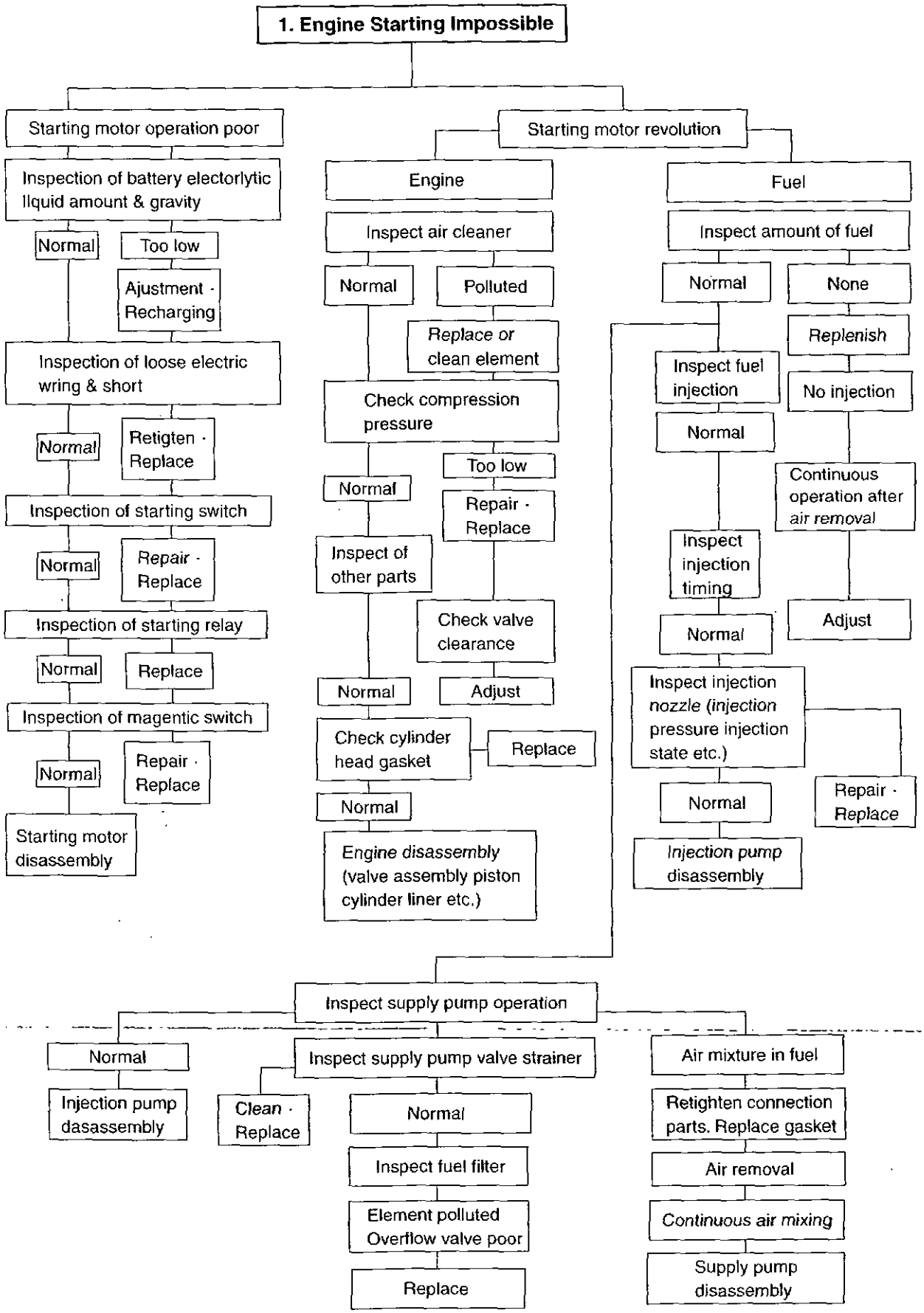
During the operation that is surrounded by the dust and oil mixed air, frequent cleaning must be done on the impellers. Tear down the impeller casing (attention: be careful not to bend) and must clean with non-acid solvent solution. If necessary, use plastic scraper If impeller is severely polluted, dip the impeller into solution and may be better to clean it with stiff brush. Then one thing to beware is to dip only impeller part and so do not support by impeller but bearing housing.

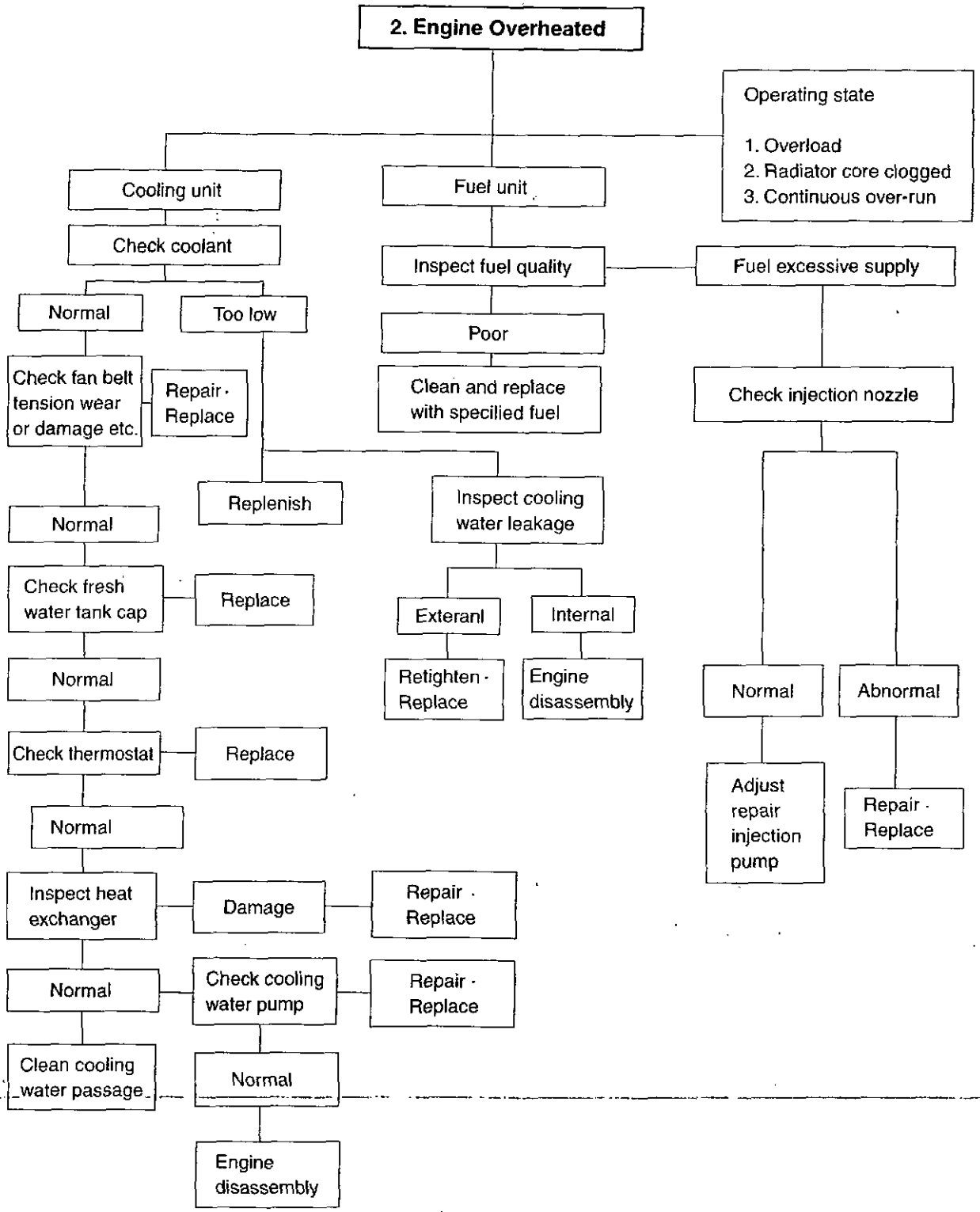
### 1.3.15. Starting Motor

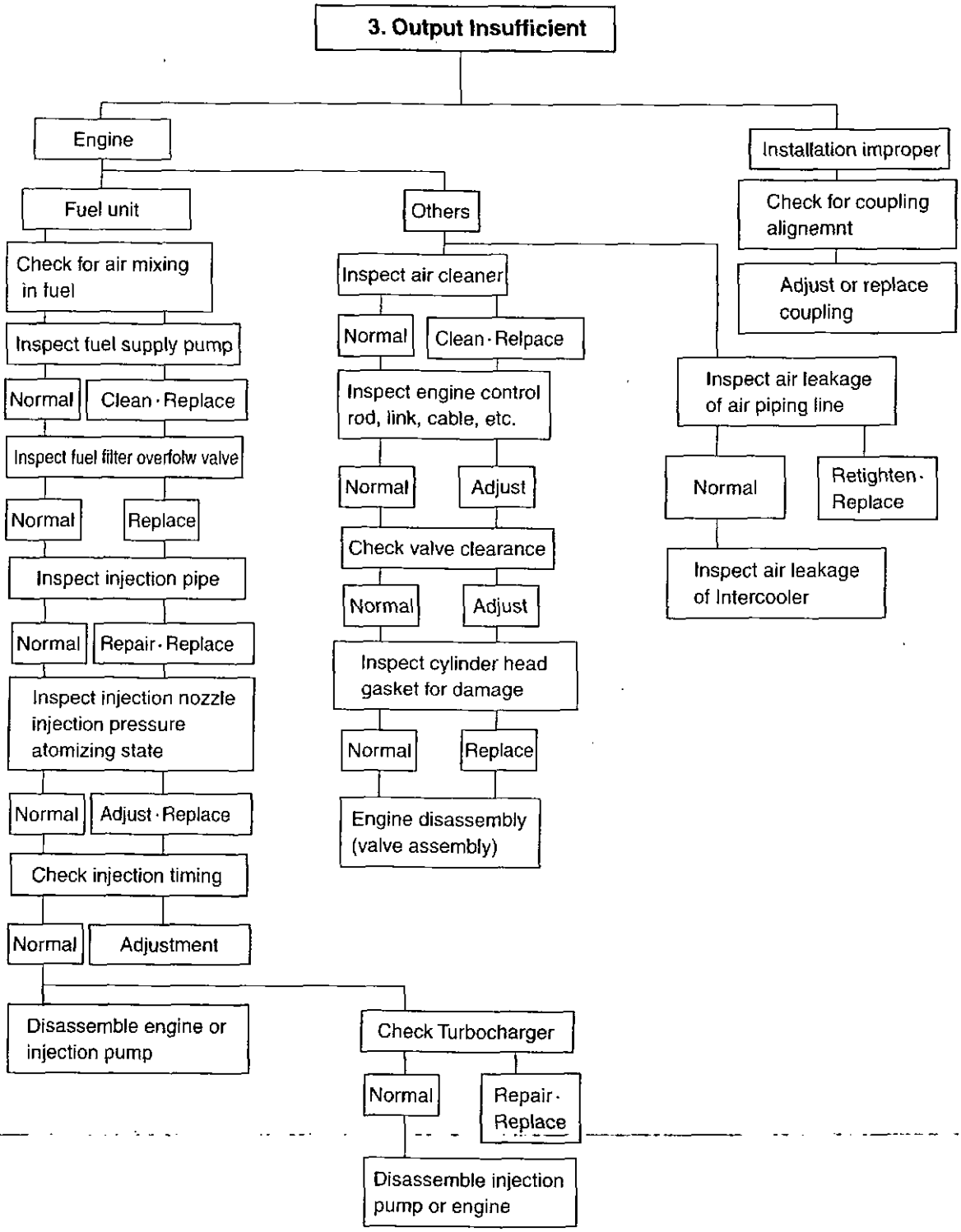
In case of engine maintenance, clean pinion and ring gear thoroughly putting in the fuel, and coat them with grease.

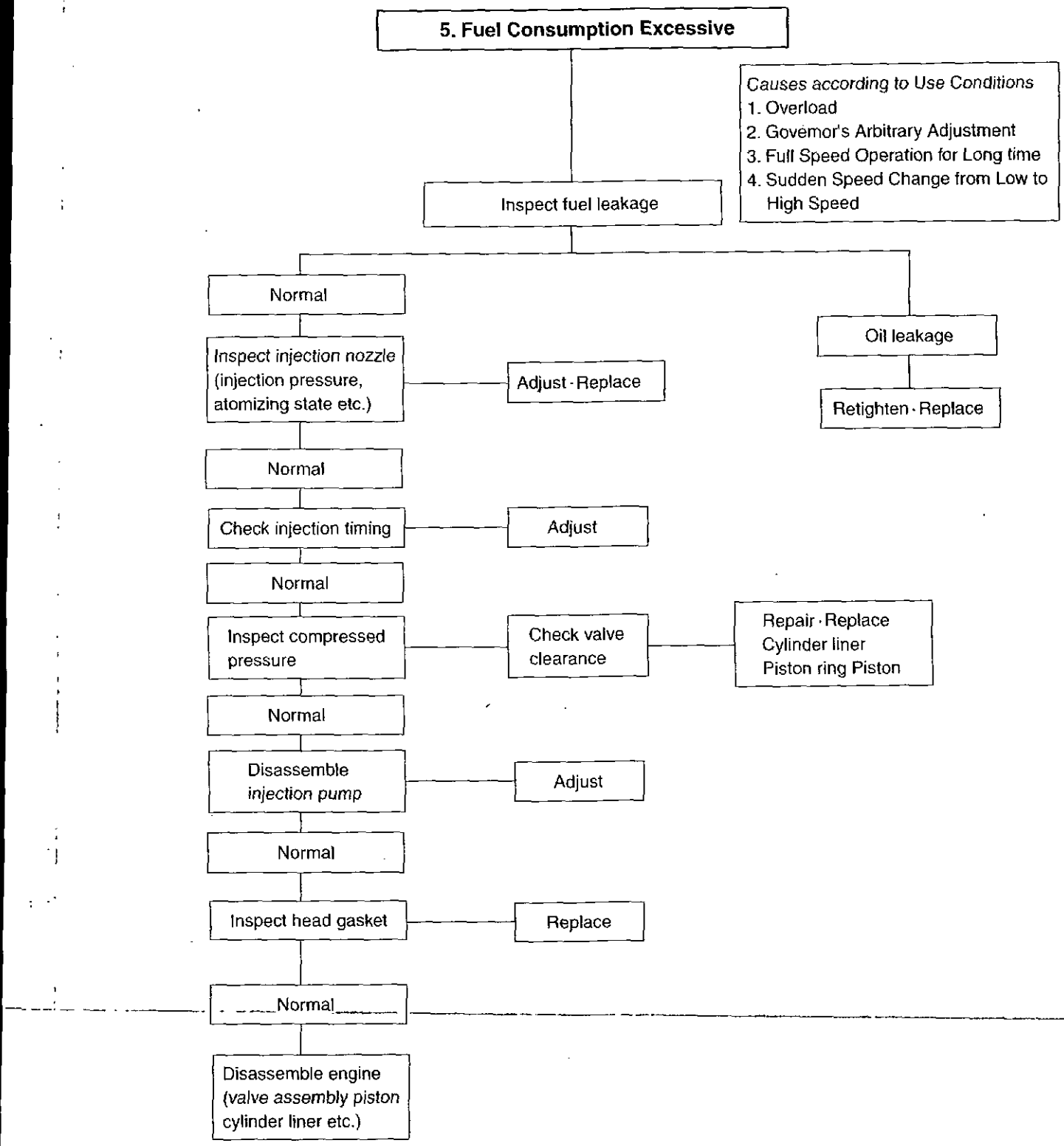
Also, In case of washing car and so forth, inspect the wiring state being careful for not to get

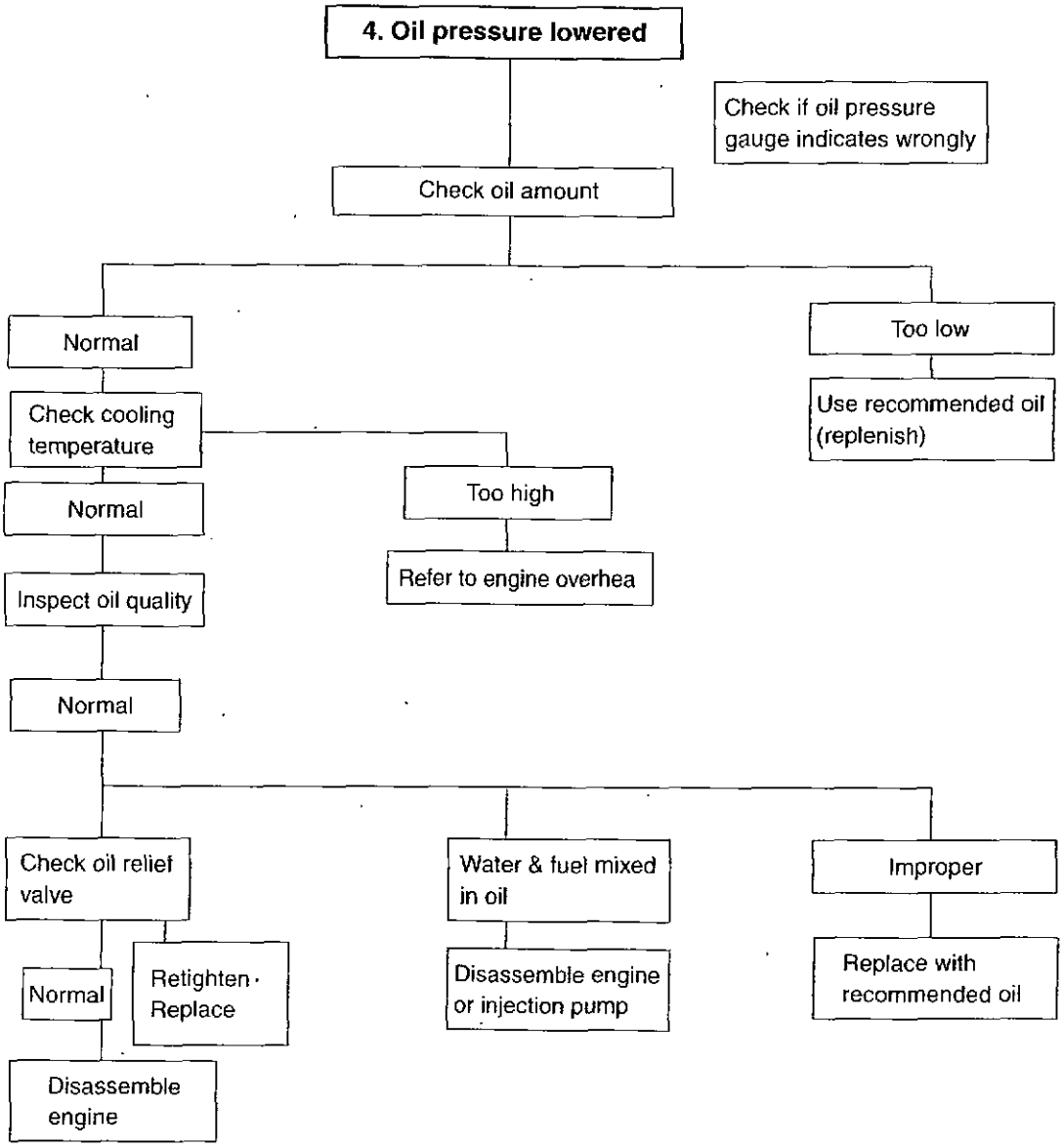
## 1.4. Diagnosis and Remedy

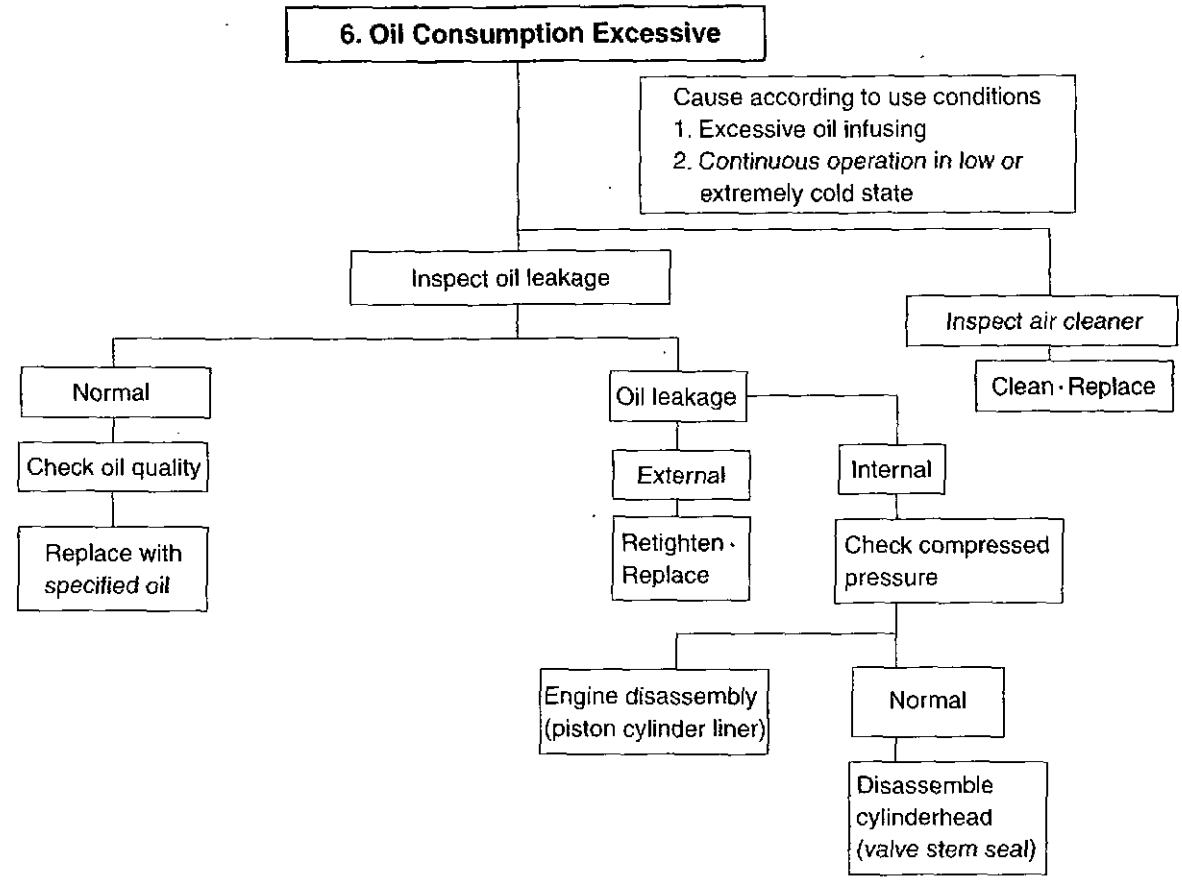


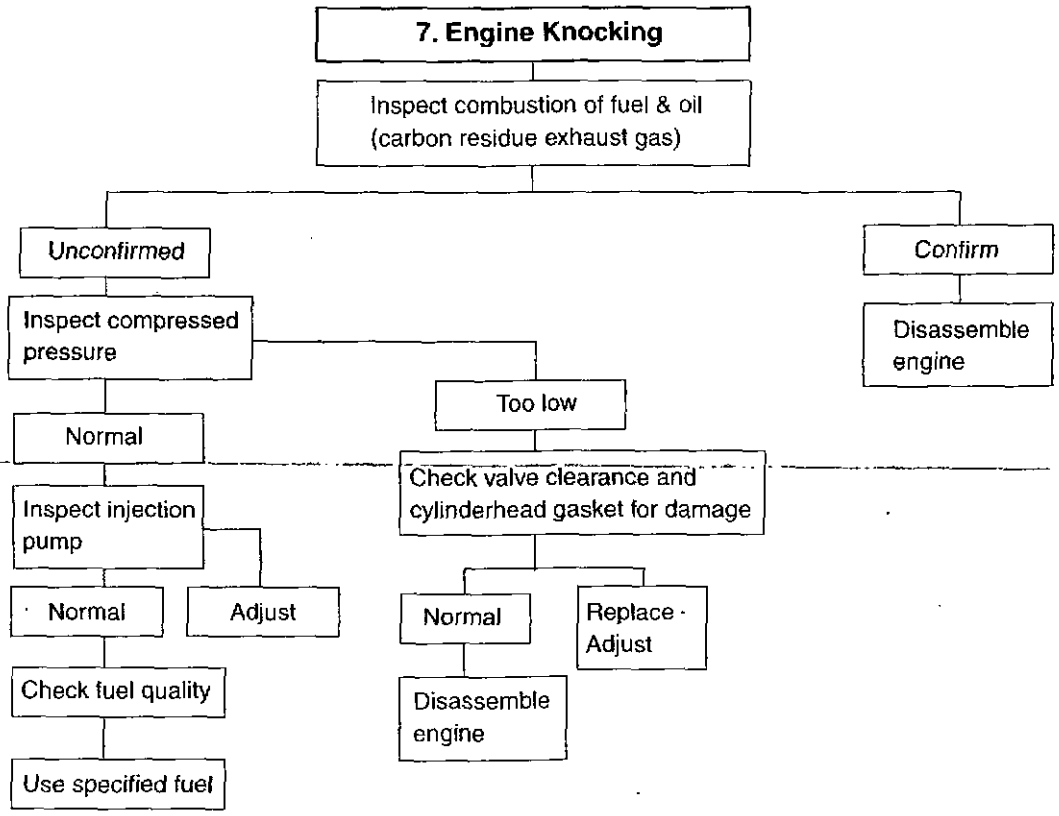

2. Engine Overheated
Operating state
1. Overload
2. Radiator core clogged
3. Continuous over-run
Cooling unit
Fuel unit
Check coolant
Inspect fuel quality
Fuel excessive supply
Normal
Too low
Poor
Check fan belt tension wear or damage etc.
Repair · Replace
Clean and replace with specified fuel
Check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

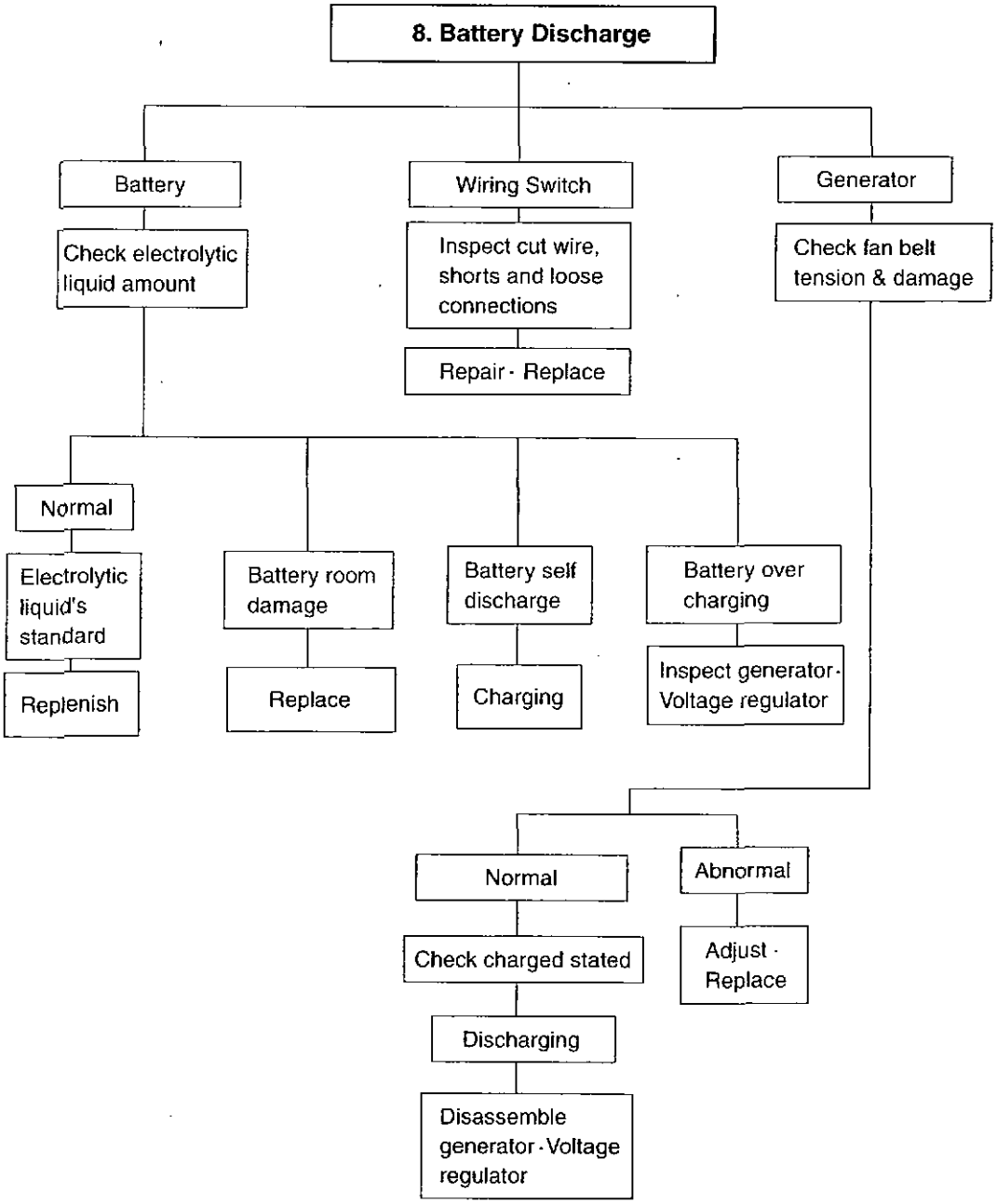

3. Output Insufficient
Engine
Fuel unit
Check for air mixing in fuel
Inspect fuel supply pump
Normal
Clean · Replace
Inspect fuel filter overfolw valve
Normal
Replace
Inspect injection pipe
Normal
Repair · Replace
Inspect injection nozzle injection pressure atomizing state
Normal
Adjust · Replace
Check 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


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
Inspect injection nozzle (injection pressure, atomizing state etc.)
Adjust · Replace
Retighten · 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.)


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


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
Oil leakage
Check oil quality
External
Internal
Replace with specified oil
Retighten · Replace
Check compressed pressure
Engine disassembly (piston cylinder liner)
Normal
Disassemble cylinderhead (valve stem seal)


7. Engine Knocking
Inspect combustion of fuel & oil (carbon residue exhaust gas)
Unconfirmed
Confirm
Inspect compressed pressure
Disassemble engine
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<br>(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<br>(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.<br>• Lopsided wear of crankshaft<br>• Oil supply insufficient due to oil passage clogging<br>• Stuck bearing | Replace bearing & grind crankshaft<br>Grind or replace<br>Clean oil passage<br>Replace bearing & Grind |
| (2) Con rod and Con rod bearing | • Lopsided wear of con rod bearing<br>• Lopsided wear of crank pin<br>• Connecting rod distortion<br>• Stuck bearing<br>• Oil supply insufficiency as clogging at oil passage progresses | Replace bearing<br>Grind crankshaft<br>Repair or replace<br>Replace & grind crankshaft<br>Clean oil passage |
| (3) Piston, piston pin & piston ring | • Piston clearance increase as the wear of piston and piston ring progresses<br>• Wear of piston or piston pin<br>• Piston stuck<br>• Piston insertion poor<br>• Piston ring damaged | Replace piston & piston ring<br>Replace<br>Replace piston<br>Replace piston<br>Replace piston |
| (4) Others | • Wear of crankshaft, thrust bearing<br>• Camshaft end play increased<br>• Idle gear end play increased | Replace thrust bearing<br>Replace thrust plate<br>Replace thrust washer |
| | • Timing gear backlash excessive<br>• Valve clearance excessive<br>• Abnormal wear of tappet, cam<br>• Supercharger inner part damaged | Repair or replace<br>Adjust valve clearance<br>Replace tappet, cam<br>Repair or replace |
| 6) Fuel consumption Exttive | • Injection timing incorrect<br>• Fuel injection amount excessive | Adjust<br>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 | • Looseness of connection parts | Replace gasket, repair |
| | • Various parts' packing poor | Replace packing |
| | • Oil seal poor | Replace oil seal |

## 1.5. Engine Inspection

### 1.5.1. Stopping Engine

Cut off the main circuit breaker of the generator control panel. After checking the engine for any unusual condition at the idling speed, then press the stop button to stop the engine.

### 1.5.2. General Engine Inspection Cycle

○: 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 |

### 1.5.3. 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 performances, it may rather bring early engine failure.

## 2. MAINTENANCE

- For the various tool storage before disassembly and parts storage after disassembly, the shelf for parts is prepared
- At the time of disassembly and reassembly, do the work with the naked and clean hand, and also the working place must be maintained clean
- The torn parts after disassembly must be kept not to collide each other.
- In disassembling, torn parts should be laid in disassembled order.

### 2.1. Engine Disassembly

Engine parts' disassembly procedures are as follows;

#### 2.1.1. Oil Level Gauge

Take out the oil level gauge.

#### 2.1.2. Engine Oil

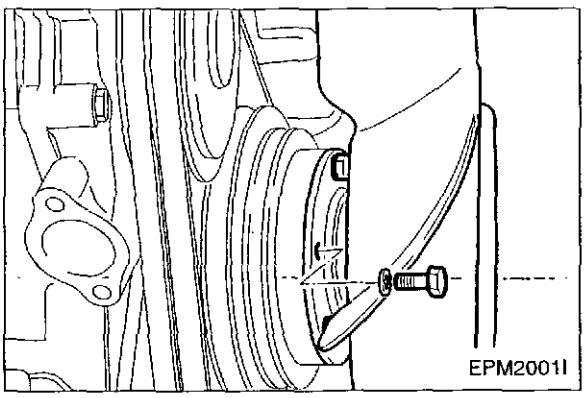
Remove an oil drain cock from the oil pan, and let engine oil discharge into the prepared vessel

#### 2.1.3. Cooling Water

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

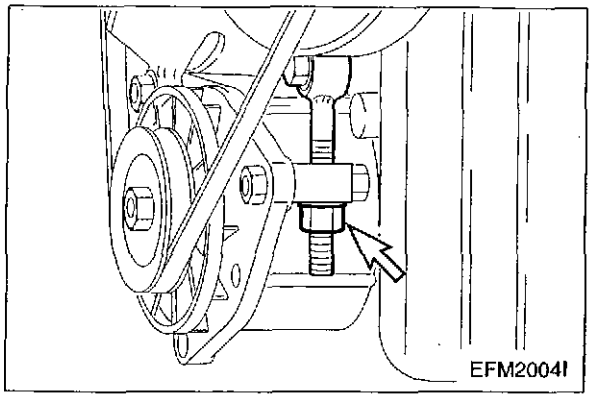
#### 2.1.4. Cooling Fan

Remove fan fixing bolts, then take off the cooling fan.



### 2.1.5. V-belt

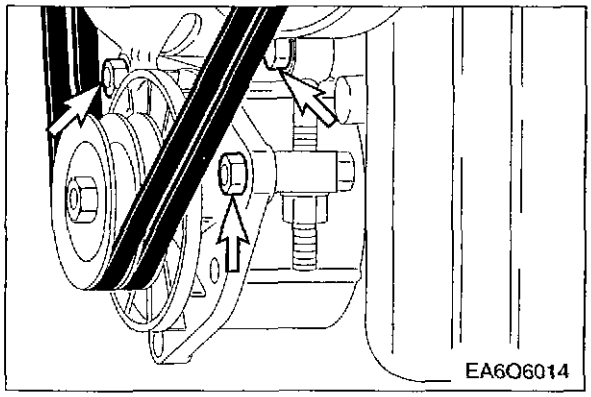
Loosen the V-belt tension adjusting bolts, and remove the V-belt.




### 2.1.6. Alternator

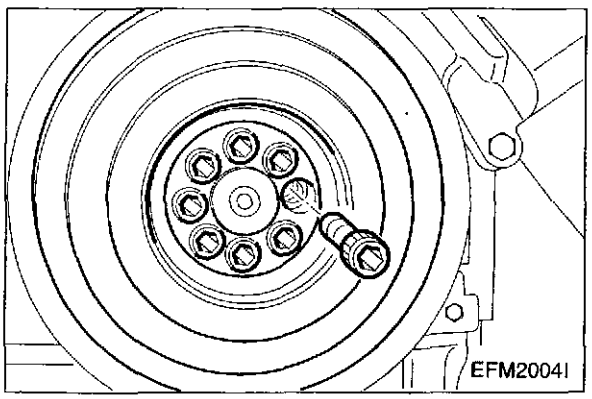
Remove the supporting guide piece for installing the alternator and the bracket bolts.

Disassemble the alternator.



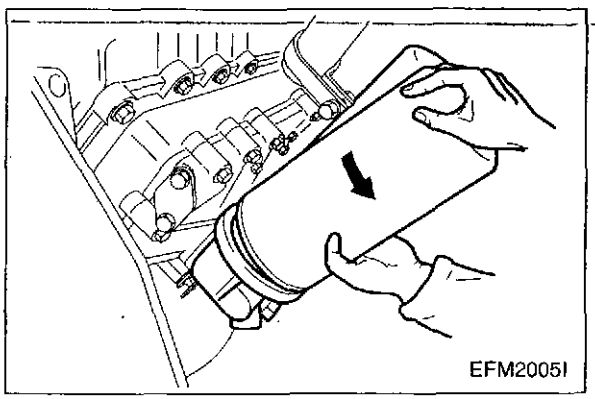

### 2.1.7. Vibration Damper

Remove the fixing bolts for crankshaft pulley in reverse order of assembling and disassemble the crankshaft pulley and vibration damper.

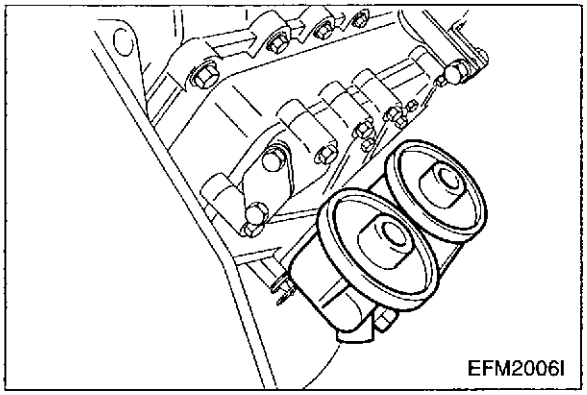



### 2.1.8. Oil Filter Assembly

- Disassemble the oil filter cartridge with filter wrench by means of a filter wrench.
- Do not use again the cartridge removed after use.

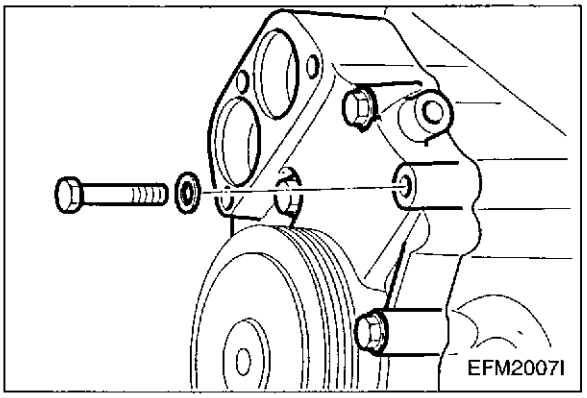


- Remove the oil filter head fixing bolts and disassemble the filter head



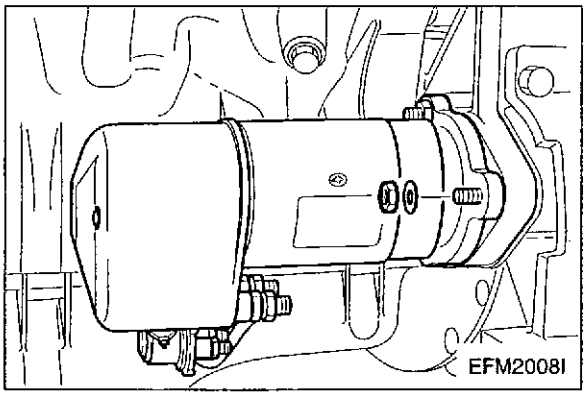

### 2.1.9. Cooling Water Pump

- Loosen the various hose clamps for the connections.
- Remove the cooling water discharging pipe and disassemble the thermostat.
- Remove the cooling water pump fixing bolts and disassemble the cooling water pump.



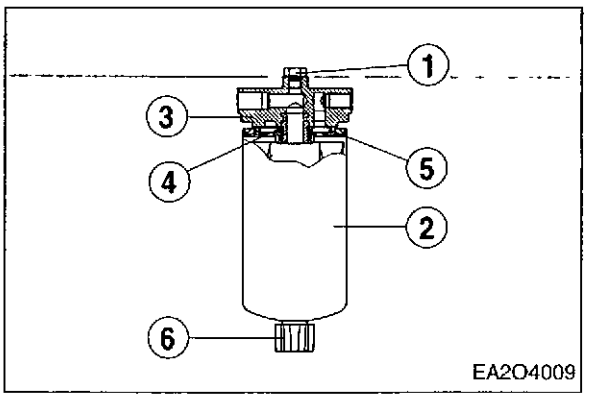

### 2.1.10. Starting Motor

- Remove the starting motor fixing nuts and disassemble the starting motor.




### 2.1.11. Fuel filter

- Disassemble the fuel hose for the fuel supply and suction.
- Remove the fuel filter fixing bolts and disassemble the filter.

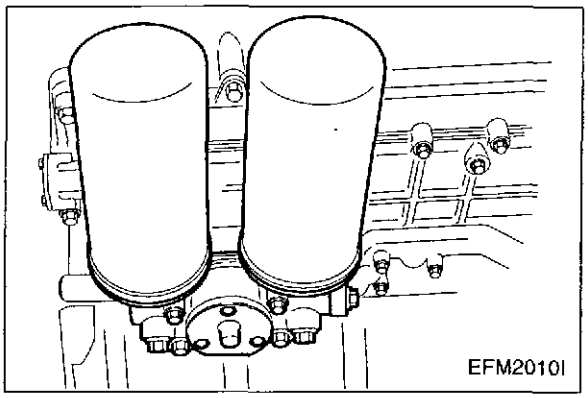



### 2.1.12. Injection pipe

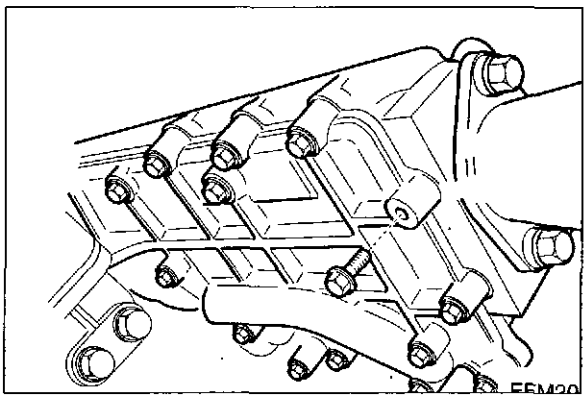
- Disassemble various fuel pipe and hose.
- Disassemble the injection pipe from the nozzle holder and fuel injection pump.

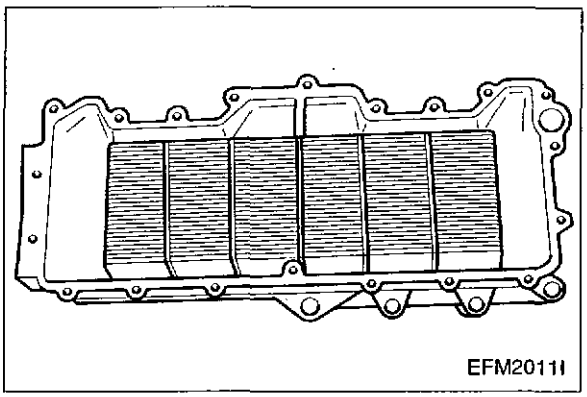
### 2.1.13. Oil Cooler Assembly

- By removing the plug screw of cooling water discharge port, the cooling water is discharged.



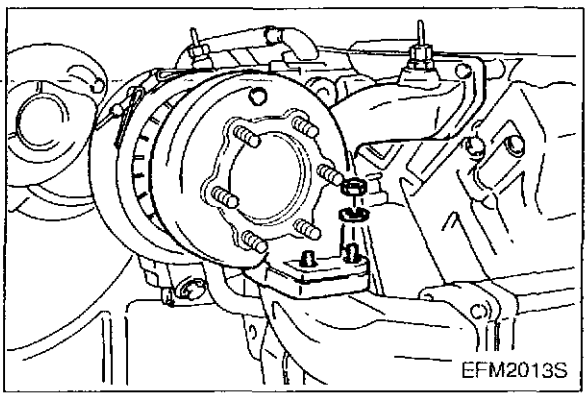

- Remove the oil cooler cover fixing bolts and disassemble the oil cooler.
- By removing the cooler housing fixing bolts and disassemble the oil cooler housing from the cylinder block.





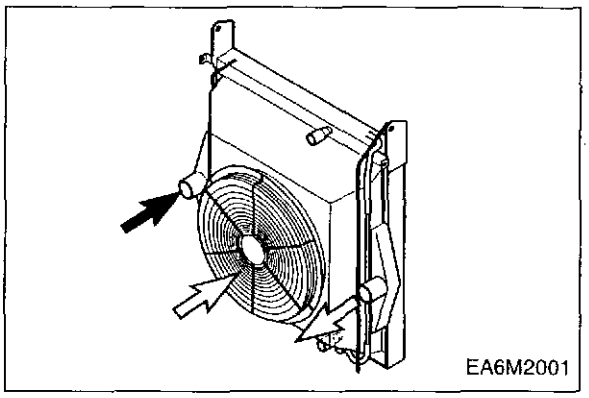

### 2.1.14. Turbocharger

- Loosen the hose clamp for connecting the intake stake and tear down the air intake stake.
- Loosen the clamp for connecting the air intake manifold.
- Remove the hollow screws of pipes for turbocharger lubrication and its discharge, and tear the pipes down.
- Remove the turbocharger fixing nuts and separate the turbocharger from the exhaust manifold.



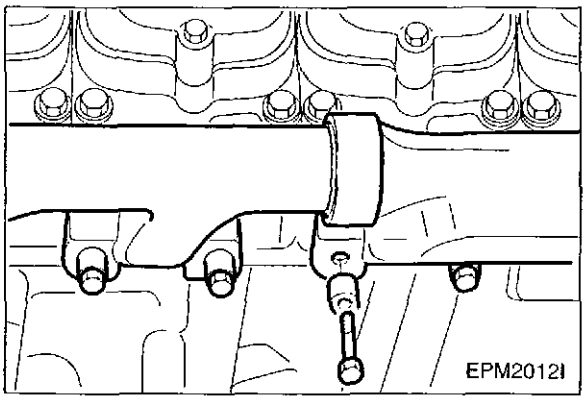
### 2.1.15. Intercooler

- Tear down the various hoses and air pipes from the inter cooler.
- Remove the intercooler fixing bolts and tear it down.



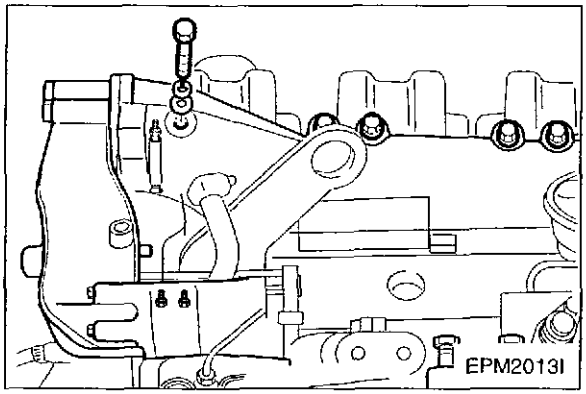

### 2.1.16. Exhaust Manifold

- Remove the exhaust manifold fixing bolts and tear the manifold from the cylinder head.



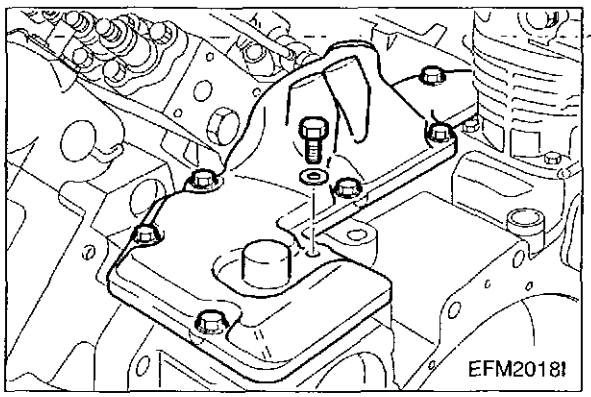

### 2.1.17. Intake Manifold

- Remove the manifold fixing bolts and tear the manifold down from the cylinder head.



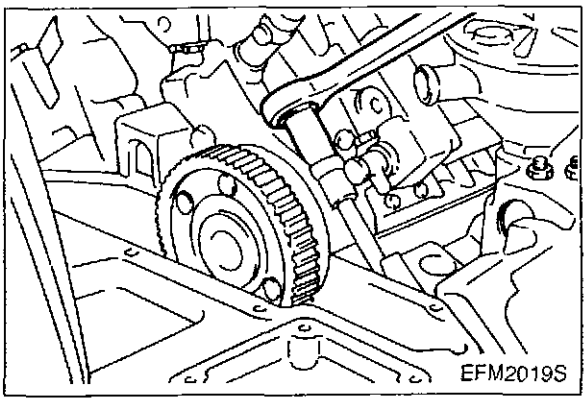

### 2.1.18. Flywheel Housing Cover

- Separate the side cover.
- Disassemble the flywheel housing cover.



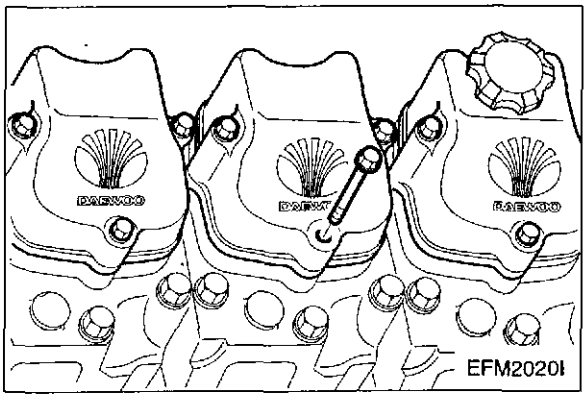
### 2.1.19. Fuel Injection Pump

- Remove the oil hoses for lubrication and the fuel hoses.
- Remove the fixing bolts of fuel injection pump and take out the fuel Injection pump.



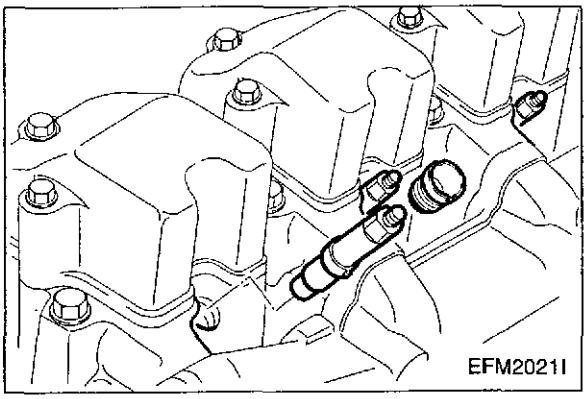

### 2.1.20. Cylinder head cover

- Remove the fixing bolts and tear the cylinder head cover down



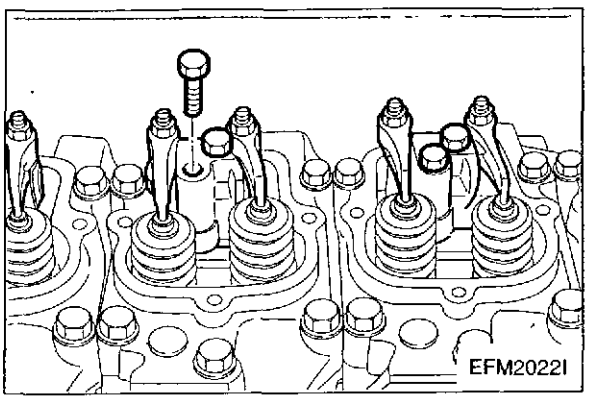

### 2.1.21. Nozzle holder

- By means of a special tool, loosen the nozzle holder assembly and take it out.



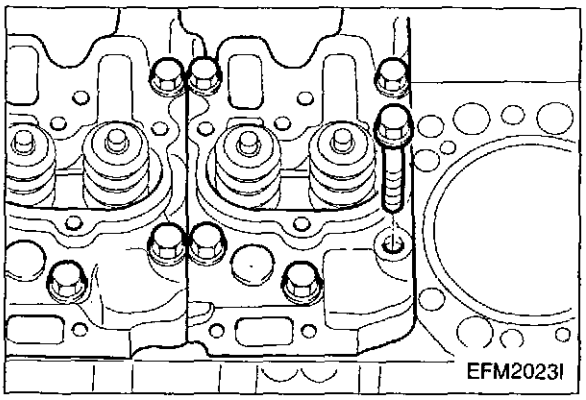

### 2.1.22. Rocker arm

- Remove the rocker arm bracket fixing bolts and take the rocker arm assembly out.
- Pull out the push rod.



### 2.1.23. Cylinder Head

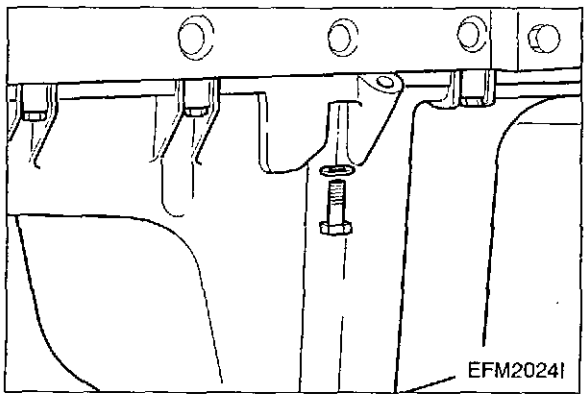
- Loosen the cylinder head fixing bolts in the reverse order of assembling, and remove them all and then take the cylinder head out.
- Remove the cylinder head gasket and scrap it.
- Eliminate the residue from the cylinder head face and cylinder block face.


EFM2023I

**NOTE :** *Be careful not to damage the cylinder head face where its gasketcontacts.*

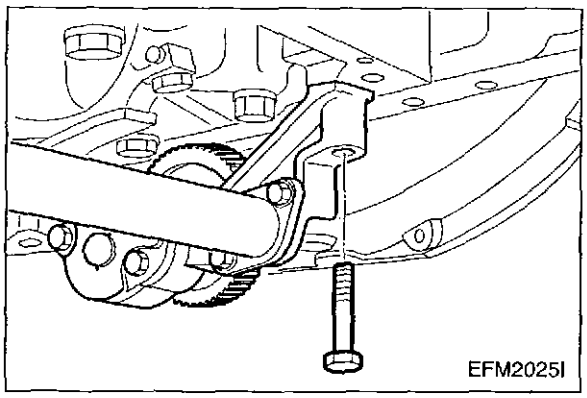
### 2.1.24. Oil Pan

- Remove the oil pan fixing bolts and separate the pan.
- Remove the oil pan gasket and scrap it.


EFM2024I

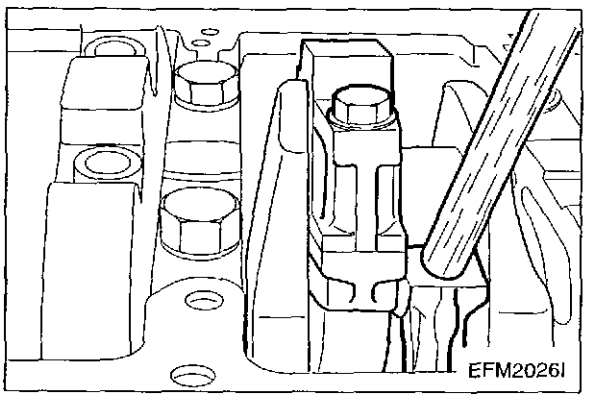
### 2.1.25. Oil Pump

- Remove the oil suction pipe fixing bolts and tear them down.
- Remove the oil relief valve fixing bolts and take them out.
- Remove the oil pump fixing bolts and separate it.


EFM2025I

### 2.1.26. Piston

- Remove the connecting rod cap bolts in the reverse order of assembling and follow the similar method as in the cylinder head bolt removal.
- Tapping the upper and lower connecting rod caps lightly with an urethane hammer, separate them and take the bearings out.

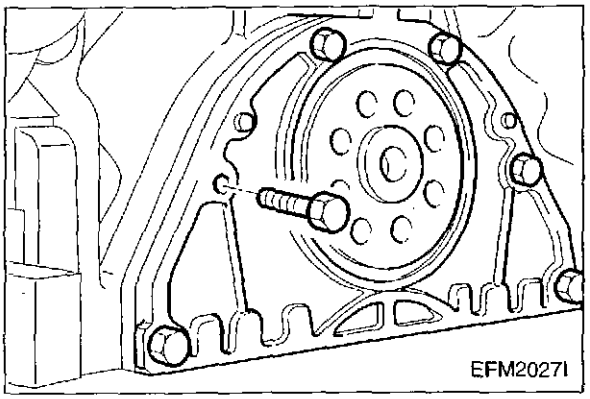

EFM2026I

- By pushing the piston assembly with a wooden bar toward the cylinder head's direction remove the piston.

**NOTE :** *Be careful for the removed pistons not to collide each other or with the other parts. At the storage of pistons, maintain them in the order of cylinders.(In order for connecting rod caps not to mix one another, temporarily assemble them to the corresponding connecting rods.)*

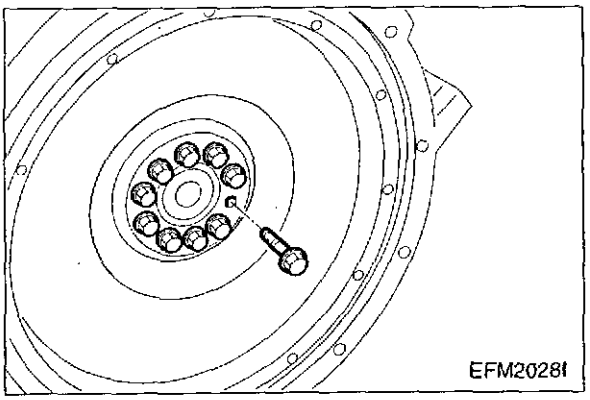
### 2.1.27. Front Oil Seal Holder

- Remove the oil seal holder fixing bolts and tear down.
- Remove the oil seal and gasket from the oil seal holder and scrap them.


EFM2027I

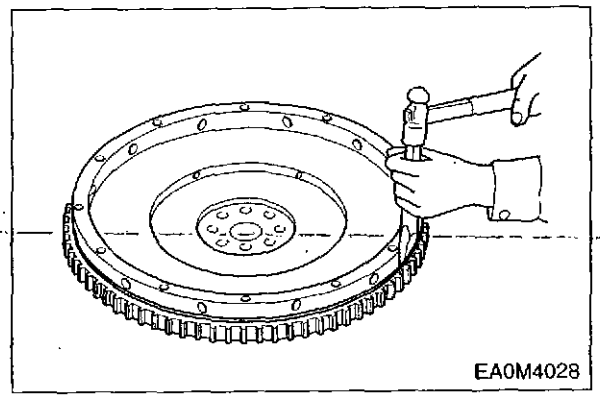
### 2.1.28. Flywheel

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


EFM2028I

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

**Caution :** *Do not damage the flywheel.*

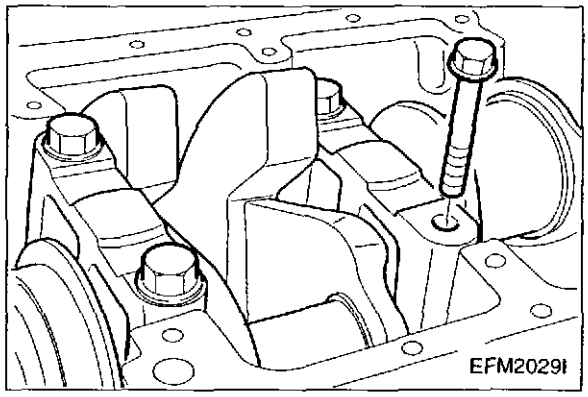

EA0M4028

### 2.1.29. Flywheel Housing

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

### 2.1.30. Crankshaft

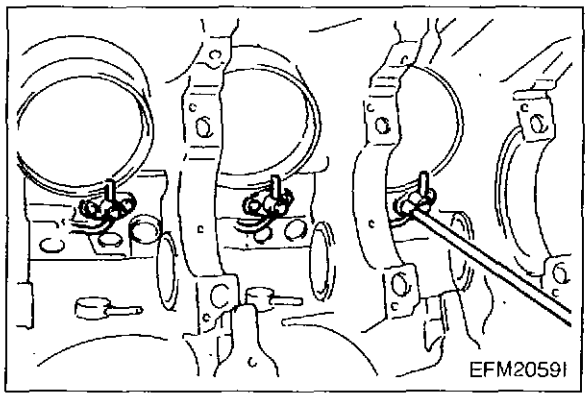
- Remove the bolts from bearing caps.
- Remove the main bearing cap fixing bolts in the order of assembling.
- (Remove them in /the same way of the cylinder head bolts.)
- Maintain the removed bearing caps in the order of cylinders.
- Temporarily install the bolts at the both side of crankshaft, and lift the shaft with a rope.




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

### 2.1.31. Camshaft and Tappet

- Pull out the tappets from the cylinder block.
- Remove the camshaft being careful not to damage the camshaft and its bearings.

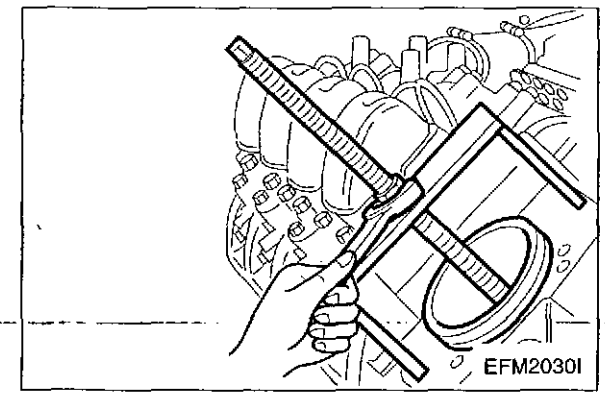



### 2.1.32. Oil Spray Nozzle

Remove the oil injection nozzle fixing bolts and tear down the oil injection nozzles.

### 2.1.33. Cylinder Liner

By means of a special tool (Extractor), pull out the liner from the cylinder block.



## 2.2. Measurement and Inspection of Major Parts

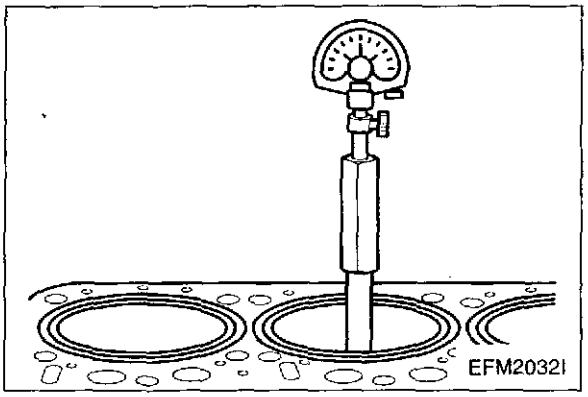
### 2.2.1. Cleaning and Inspection of Cylinder Block

- Clean the cylinder block and inspect it for any crack or a damage.
- Inspect the oil passage and water passage for any clog and erosion
- By performing the hydraulic test, inspect for any leaks. With plugging the water and oil passages of cylinder block, put in the air of 5 kg/cm$^2$ pressure in the Inlet port of cylinder block and then soak the cylinder block in the water for about 1 minute to check for any leaks (water temperature: 70 °C)
- Inspect the cylinder block's camshaft bush to any damage and the alignment of oil supply holes and if abnormal, replace it.

### 2.2.2. Cylinder Liner Measurement

- Assemble the cylinder liner at the cylinder block and measure inner diameters at upper, middle, lower 3 levels by 45° interval and calculate the average values after eliminating the max and min values.
- If the measured values are very close to the limit value or beyond, Ireplace it.

| Liner | Standard | Limit |
|---|---|---|
| inner dia. | ϕ127.990 ~ ϕ 128.010 mm | 0.15 mm |

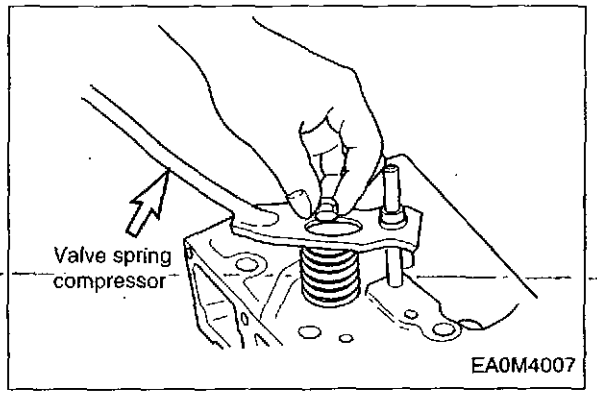



### 2.2.3. Cylinder Head

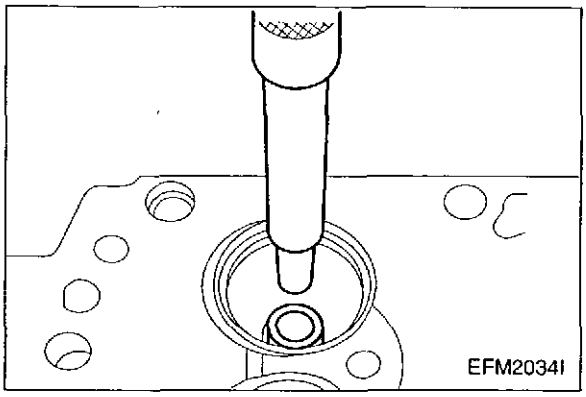
#### 1) Cylinder head disassembly

**NOTE :** *Be careful for the cylinder head gasket contacting surface of cylinder head not to be damaged.*

- Remove the cotter pin pressing the valve spring by means of a special tool.



- Take out the valve stem seal.
- Pull out the intake and exhaust valves.
- Remove the valve guides from the combustion room side of cylinder head by means of a special tool.




**2) Inspection and measurement of Cylinder Head**

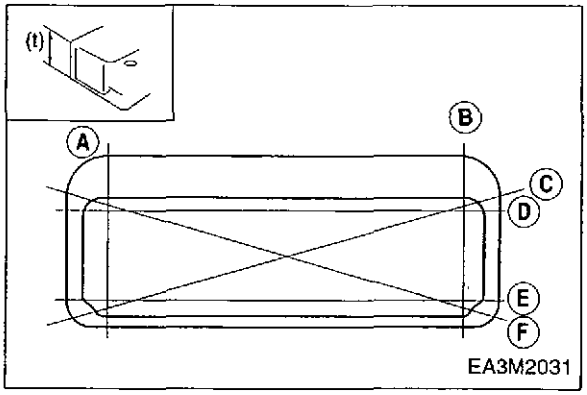
Damage check inspect the cylinder head for any crack or damage.

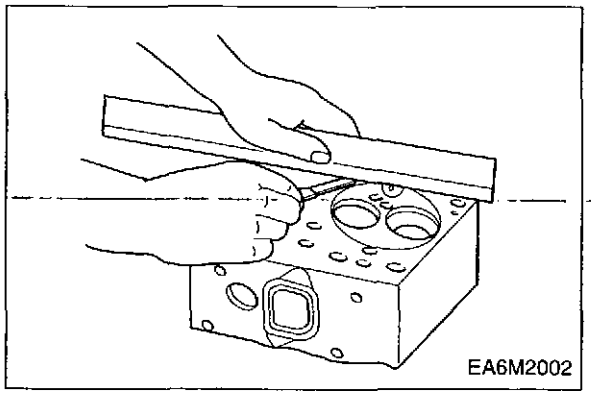
- Eliminate the carbon residue and gasket piece from the cylinder head lower face thoroughly. Then be careful for the valve seat not to be damaged.
- The cracks or damages that are difficult to search may be inspected by a hydraulic test or a magnetic powder test. (Hydraulic test is same as for cylinder block.)

**Distortion**

Measure the flatness degree (any distortion) of cylinder head. Even beyond the limit value of maintenance, it may be corrected by grinding. (if more than limit value of use, replace it.)

| | Standard | Limit |
|---|---|---|
| Warpage | 0.05 mm or less | 0.2 mm |

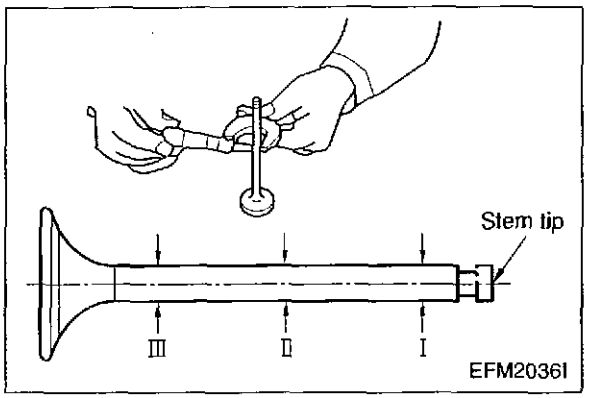


### 2) Inspection and Measurement of valve *and valve guide*

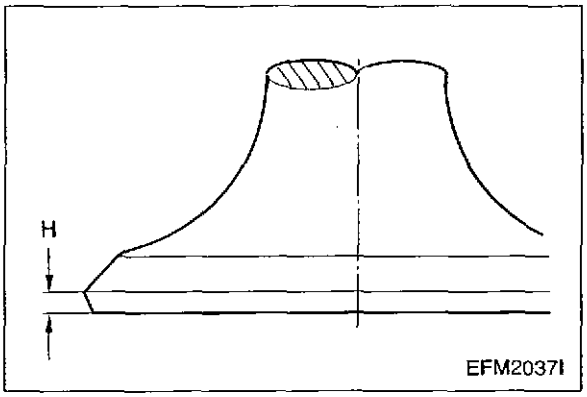
#### a) Valve

- After cleaning the valves with clean diesel oil, measure the valve stem's outside diameter at upper, middle, and lower to determine the wears and when the wear limit is more than 0.15mm, replace the valves.




| Valve | Standard | Limit |
|---|---|---|
| Intake | ϕ11.969 ~ ϕ11.980 mm | ϕ12.130 mm |
| Exhaus | ϕ11.945 ~ ϕ11.955 mm | ϕ12.105 mm |

- Inspect the scratch and wear of valve stem seal contacting face, and if necessary correct with the grinding paper but if severe replace it.

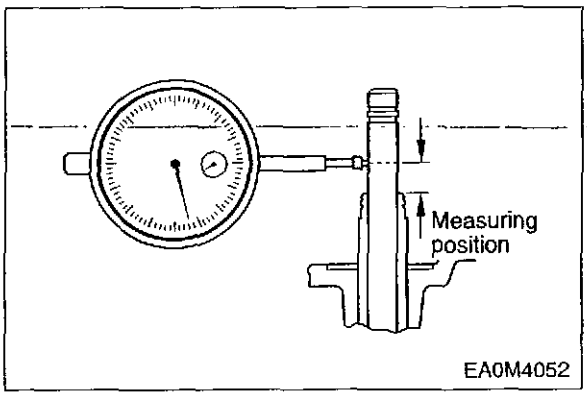



- If valve head thickness (H) becomes less than 1.6mm for intake and 1.3mm for exhaust, replace the valve.

| Valve | Standard | Limit |
|---|---|---|
| Intake | 2.6 ~ 3.0 mm | 1.6 mm |
| Exhaus | 1.9 ~ 2.3 mm | 1.3 mm |

#### b) Valve guide

- Insert the valve into valve guide and measure the clearance between valve and valve guide by the shaking degree of valve. If the clearance is bigger, measure the valve and then replace the more worn valve guide.



- If the valve guide has already been replaced, measure the center with valve seat if it deviates or not and if abnormal it must be corrected. (Simultaneously be processed when in guide reamer process.)

| Valve | Standard | Limit |
|---|---|---|
| Intake | 0.020 ~ 0.049 mm | 0.20 mm |
| Exhaus | 0.045 ~ 0.074 mm | 0.25 mm |

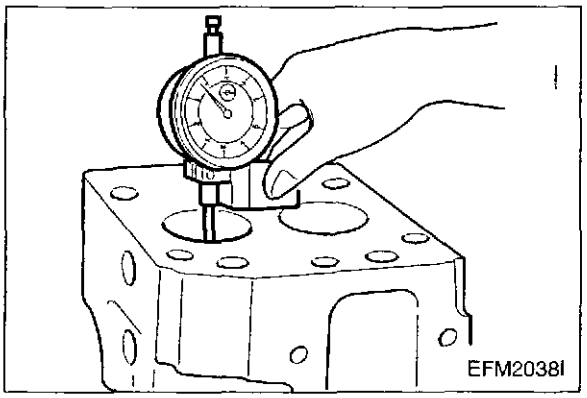
**C) Valve seat**

- Inspect the damage and wear of valve seat and if necessary replace.
- Valve seat thickness and angle

Assemble the valves at the cylinder head and using the measuring instrument from the lower face, measure the projection amount of valve. If the measured value is more than the use limit, replace the valve seat.

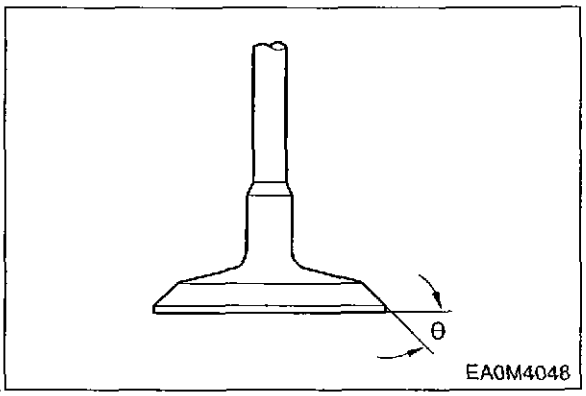
**<Valve seat thickness>**

| Standard | Limit |
|---|---|
| 0.65 ~ 0.95 mm | 2.5 mm |

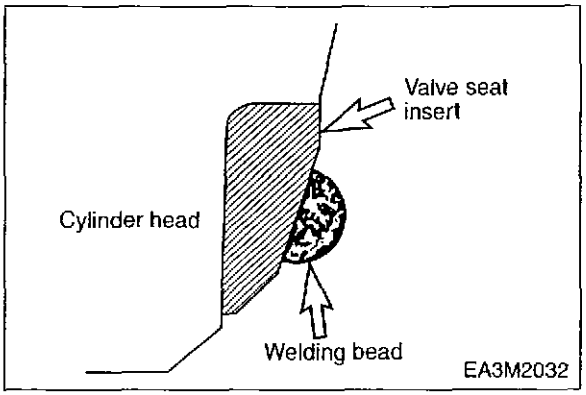



**<Valve seat angle>**

| | |
|---|---|
| Intake Valve | 30° |
| Exhaust Valve | 45° |



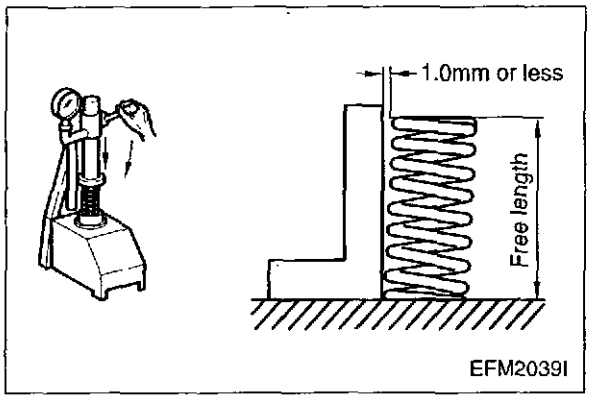

- The disassembly of valve seat can be pulled out by means of a special tool with the arc welding done at two points of valve seat rotating tool or valve seat.



- Regarding the valve seat assembling, shrink the valve seat by putting it in the dry ices for about 1 hour or so, and then press it into the cylinder head by means of a special tool.
- After coating the grinding powder paste on valve head contacting face of valve seat, and after executing a sufficient lapping operation with the rotating and grinding motion of valve, wipe off the grinding agent thoroughly.

**d) Valve spring**

- Inspect the outlook of valve spring and if necessary replace it.
- By means of spring tester, measure the tension and free length.
- Measure the perpendicularity of valve spring.
- In case that the measured value exceeds the limit value, replace it.




**<Perpendicularity regular>**

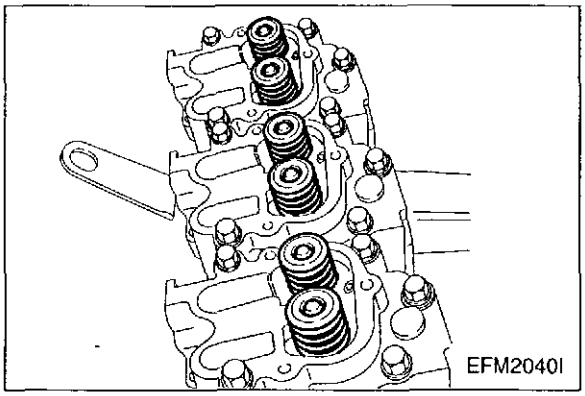
| | | |
|---|---|---|
| Inside Spring | Free length | 65.5 mm |
| | When given a regular load (15 ~ 17 kg) | 46.3 mm |
| Outside Spring | Free length | 64 mm |
| | When given a regular load (37 ~ 41 kg) | 46.3 mm |

**e) Assembling Cylinder head**

- Clean the cylinder head thoroughly.
- Coat the valve stems and valve guides with engine oil and assemble the valves.
- Replace the valve stem seals with new ones and insert the stem seals to the valve guides of cylinder head with a special tool. (Be careful for the valve stem seals not to be damaged)
- Install the valve spring washer to valve guide.
- After putting on the inside, outside spring, install the valve spring seat on them.

**NOTE :** *Install the valve spring seat with "TOP" (painted in yellow) side up.*

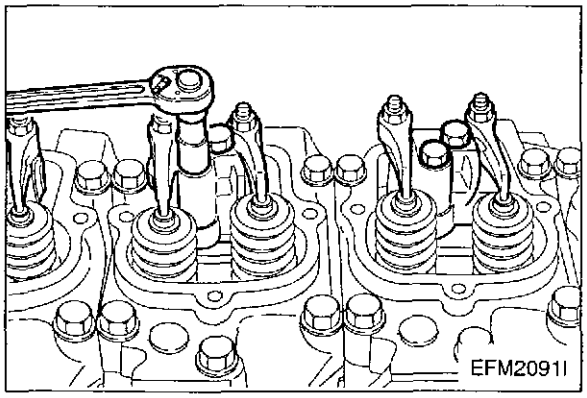
- Pressing the spring down with a special tool, assemble by inserting the valve cotter.
- After the valve is assembled, inspect the valve tapping it lightly with an urethane hammer if accurate assembling was done.


EFM2040I

## 2.2.4. Rocker Arm

### 1) Rocker arm disassembling

- Remove the snap rings in both ends of rocker arm with a pair of pliers.
- Tear down washer, rocker arm.
- Disassemble the rocker arm bush by means of a press.


EFM2091I

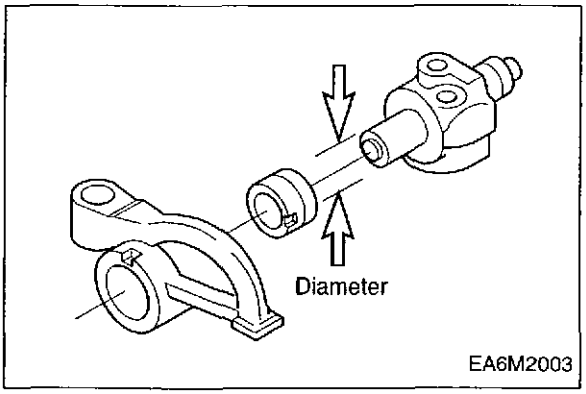
### 3) Inspection and Measurement

**a) Rocker arm bracket**

*(Single unit type with a shaft)*

Measure the outer diameter of rocker arm bracket with outside micrometer at the position that the rocker arm is installed, and in case that it exceeds the limit value, replace.

| | Standard | Limit |
|---|---|---|
| Bush Inner Dia. | ϕ25.005~ 25.035 mm | ϕ25.055 mm |
| Shaft outer Dia. | ϕ24.967 ~ 24.990 mm | ϕ24.837 mm |
| Clearance | 0.015 ~ 0.068 mm | 0.25 mm |



EA6M2003

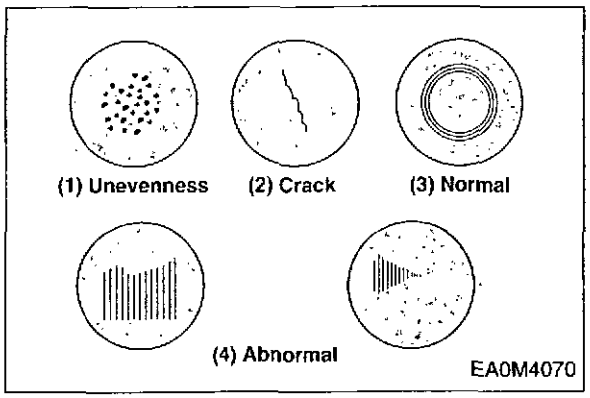
**B) Rocker arm**

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

### C) Tappet and push rod

- By means of outside micrometer, measure the outer diameter of tappet and replace the severe ones.

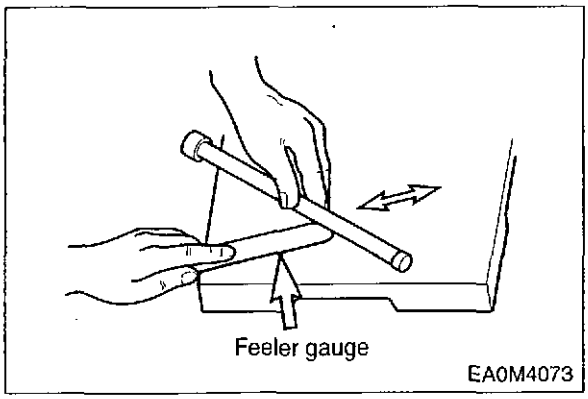
| | Standard | Limit |
|---|---|---|
| Tappet clearance | 0.035 ~ 0.077 mm | 0.25 mm |




- By inspecting the tappet surface that contacts with the camshaft's cam for any crack and scratch etc., and if the degree is small, correct them with an oil stone or the grinding paper but if severe replace them.
- Place the push rod on the surface plate and rolling it, Inspect the curving degree with a clearance gauge and if abnormal, replace it.

**<Run-out>**

| | |
|---|---|
| Limit | 0.3 mm or less |



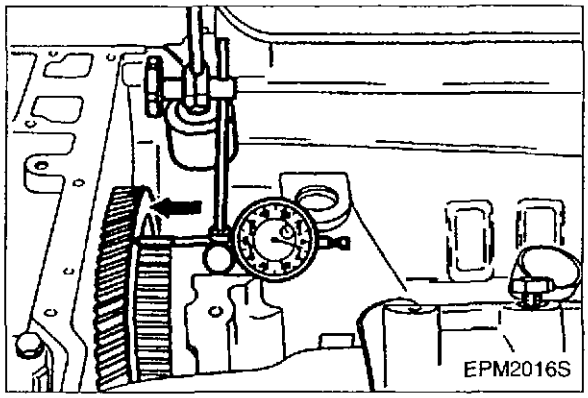

### D) Rocker Arm Reassembling

Inspect the oil passages of rocker arm and rocker arm bracket for any clogs and reassemble them in the reverse order of disassembling after thorough cleaning.

## 2.2.5. Camshaft

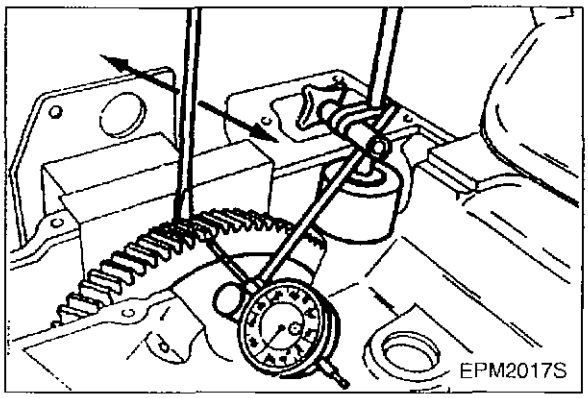
### 1) Axial end play

- Push the camshaft toward the pulley side.
- Place a dial gauge onto the camshaft gear.




- Measure the camshaft's axial end play, moving the camshaft gear by means of a driver.

| Limit | 0.2 ~ 0.9mm |
|---|---|




- If excessive end play, assemble it by means of other thrust washer.

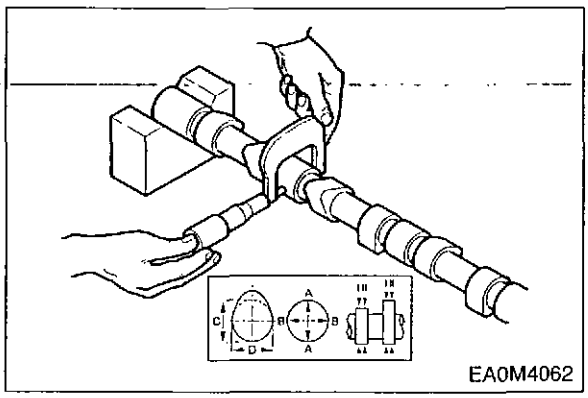
### 2) Inspection and measurement

- With inspecting the cam surface for any damage with naked eyes and correct any minor scratch by means of an oil stone grinding and if severe, replace it.

**Cam lobe height**

| | Standard | Limit |
|---|---|---|
| Cam lobe height (C) | 47.7 mm | 46.5 mm |
| Cam journal diameter (A,B) | ∅56.0 mm | ∅55.6 mm |

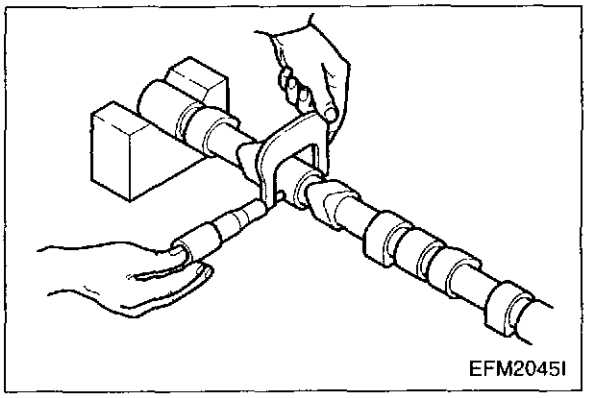
Use a micrometer to measure the cam lobe height and journal diameter.
If the measured number is less than the specified limit, the camshaft must replaced.



**Cam journal diameter**

By means of outside micrometer, measure the camshaft journal.

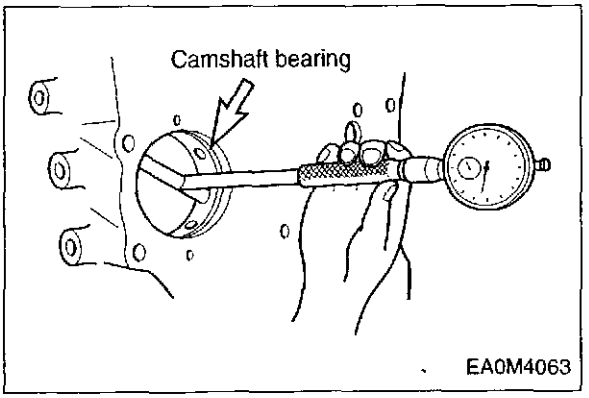
| | |
|---|---|
| Standard | ϕ69.91 ~ ϕ69.94 mm |


EFM2045I

**Cam bearing diameter**

Measure the camshaft bush inside diameter with a cylinder gauge and by comparing the inside and outside diameters, replace if abnormal.

| | |
|---|---|
| Standard | ϕ70.077 ~ ϕ70.061 mm |



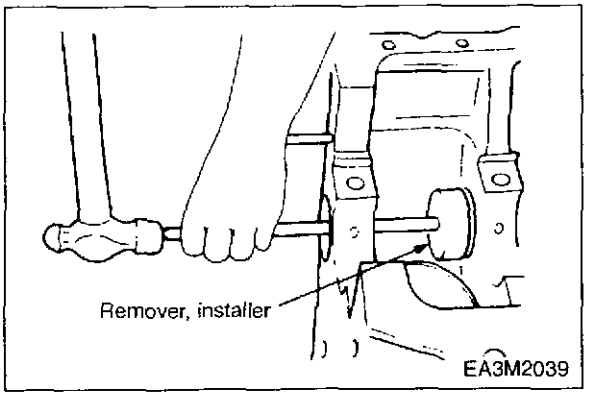
EA0M4063

**Clearance between camshaft journal and body**

| Standard | Limit |
|---|---|
| 0.060 ~ 0.120 mm | 0.18 mm |

**Camshaft bearing replacement**

Remover, installer

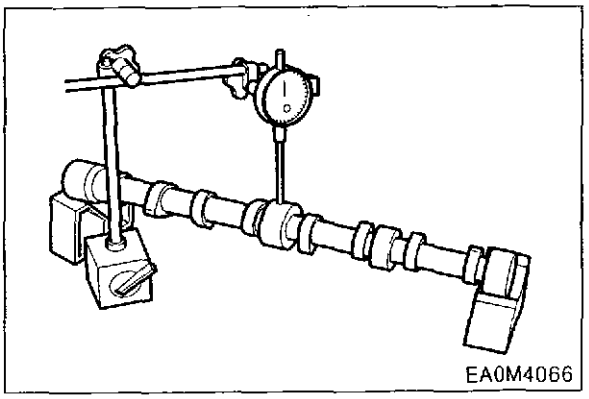


EA3M2039

**Camshaft run-out**

With placing the camshaft on the 2ea of V-blocks, and inspect the run-out of the camshaft, adjust or replace the severe *one*.

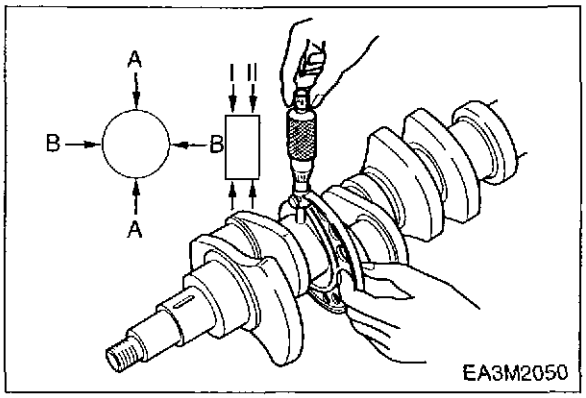
| | |
|---|---|
| Standard | 0.1 mm |


EA0M4066

## 2.2.6. Crankshaft

### 1) Inspection and measurement

- Inspect for any scratch or damage with naked eyes, and grind to the undersize according to the damaged degree and use the undersized bearing.
- Inspect for any crack by means of magnetic powder and color check, and replace the cracked ones.




**Journal and pin diameter**

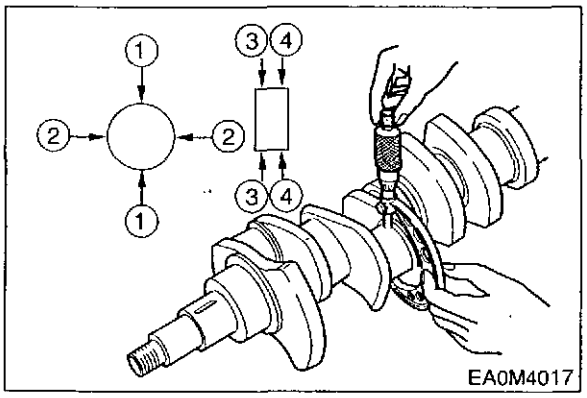
With outside micrometer, measure the outside diameter of crank journal and crank pin at the direction and position of the figure shown and take the wear.

**<Crankshaft journal outside diameter>**

| | |
|---|---|
| Standard | ϕ103.98 ~ ϕ104.00 mm |

**<Crankshaft pin outside diameter>**

| | |
|---|---|
| Standard | ϕ89.98 ~ ϕ90.00 mm |

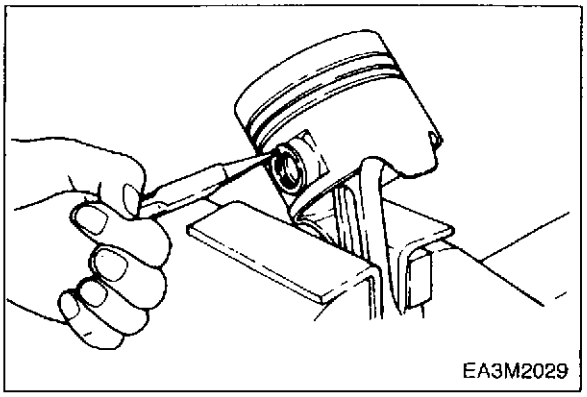



- In case that the lopsided wear is more than the limit value, grind to the undersize, and use the undersized bearing.

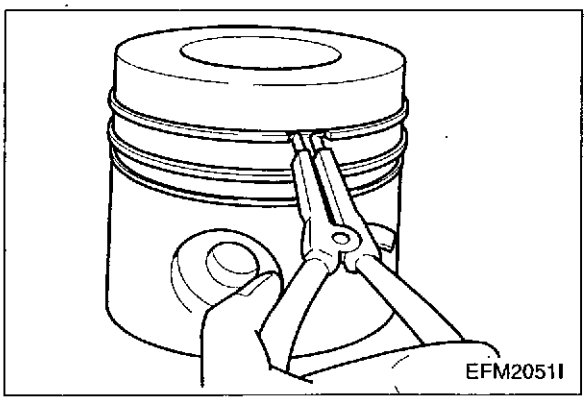
## 2.2.7. Piston

### 1) Piston disassembling

- Pull out the snap ring for piston pin and with a pair of snap ring pliers.
- With a round bar, remove the piston pin.


EA3M2029

- With a pair of pliers, remove the piston rings.
- Clean the piston thoroughly.

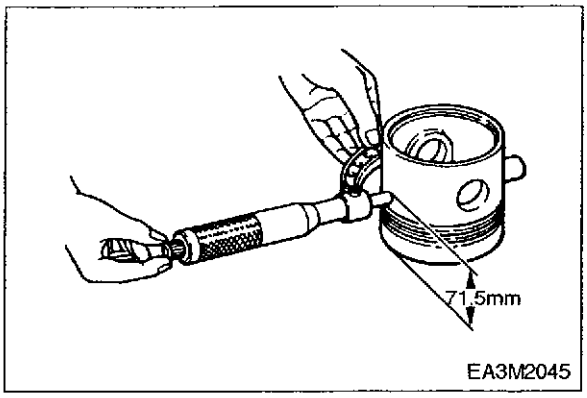

EFM2051I

### 2) Piston

- With naked eyes, inspect the piston for any wear, crack and scratch and particularly inspect carefully at the ring grooves for any wear.

- With the outside micrometer, measure the piston's outside diameter the measuring position is 71.5mm from the piston lower end, and the direction of measurement must be perpendicular to the piston pin direction.

| | |
|---|---|
| Standard | ϕ127.739 ~ ϕ127.757 mm |



EA3M2045

- By comparing the measured value of the piston outside diameter with the cylinder liner inside diameter, the bigger clearance is replaced.

### 3) Piston ring and ring groove

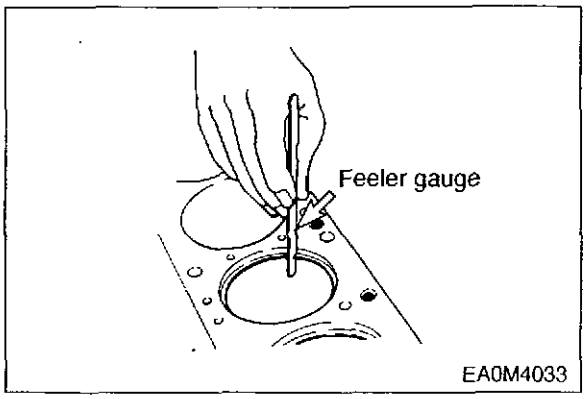
**Inspection**

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

**Gap clearance**

Measure the piston ring cut part.

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

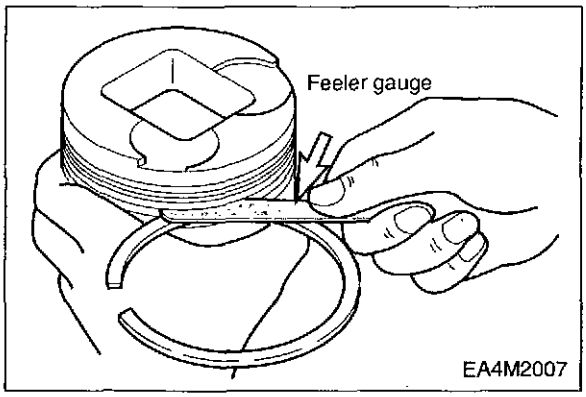



- **Piston ring gap**

| Division | Standard | Limit |
|---|---|---|
| Top ring | 0.35 ~ 0.55 mm | 1.5 mm |
| 2nd ring | 0.40 ~ 0.60 mm | 1.5 mm |
| Oil ring | 0.35 ~ 0.55 mm | 1.5 mm |

**Piston side clearance**

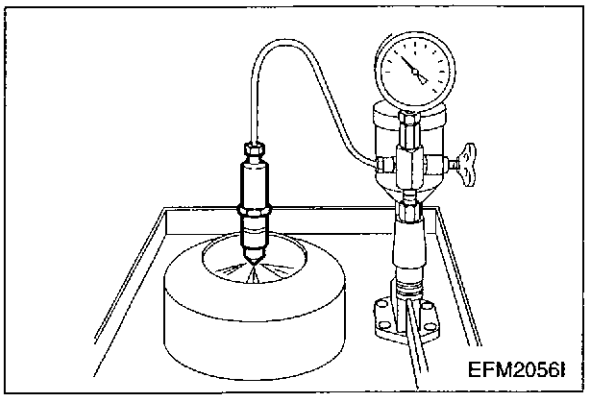
- Assemble the piston ring at the piston.
- Measure the each ring's side clearance and if the measured value exceeds the limit value, replace rings or piston.




- **Piston side clearance**

| Division | Specified value | Limit |
|---|---|---|
| Top ring | 0.35 ~ 0.55 mm | 1.5 mm |
| 2nd ring | 0.050 ~ 0.082 mm | 1.5 mm |
| Oil ring | 0.030 ~ 0.062mm | 1.5 mm |

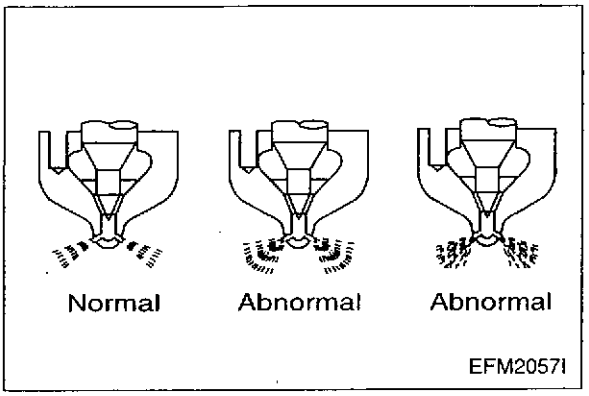
- Inspect the disassembled parts if there is any damage, replace it.
- Assembling can be done in the reverse order of disassembling.
- After assembling the nozzle, set it in the injection pressure measuring tester.
- By manipulating the tester handle, inspect the injection pressure and atomizing state.




**<Operating pressure>**

| | |
|---|---|
| New nozzle holder | 300 + 8 kg/cm$^2$ |
| Used nozzle holder | 285 + 8 kg/cm$^2$ |

- In case of low or high injection pressure, adjust by adding or reducing the spring tension adjusting shims.
- In case that atomizing state is not good, it should be replaced.



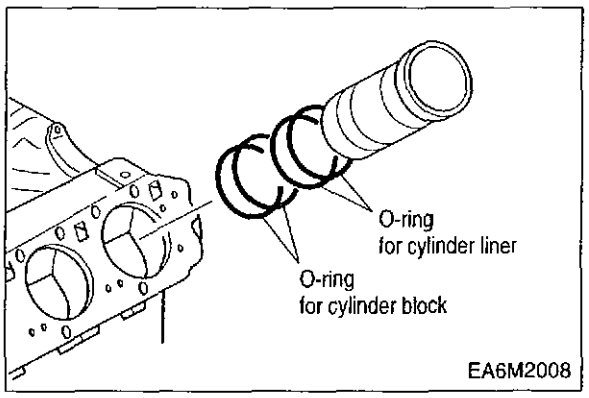
## 2.3. Engine Reassembly

### 2.3.1. Preparation and Precaution Before and After Engine Reassembly

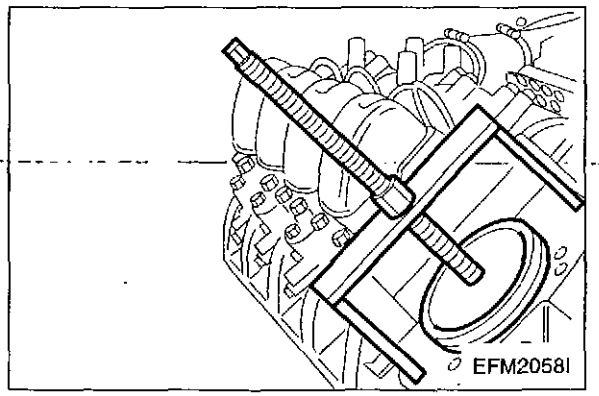
- Clean all the parts thoroughly and also clean thoroughly by blowing into each passage of oil and cooling water.
- Disposition the various special and general tools for assembling in order.
- In order to coat the lapping parts with engine oil, prepare the clean engine oil.
- Prepare the sub-material such as an adhesive etc.
- Use three bond as an adhesive in the engine oil system and use silicone in the cooling system.
- Scrap the used gasket and seal ring, consumable parts etc. and replace with new ones.
- Tighten the various bolts in the specified tightening torque, and also according to the tightening order but the excessive torque must be avoided.
- Inspect if the movement of engine is smooth after assembling.
- After completion of assembling, whether various bolts are loose or not should necessarily be insured.
- Make sure that there is any missing parts or insufficient parts after full completion of assembling.
- Work only with clean hands.

### 2.3.2. Cylinder Liner

- Replace O-ring with new one without fail and at the upper side, insert to the cylinder liner, but at the lower side, to the cylinder block.
- Coat the joint parts where O-ring contacts with oil.



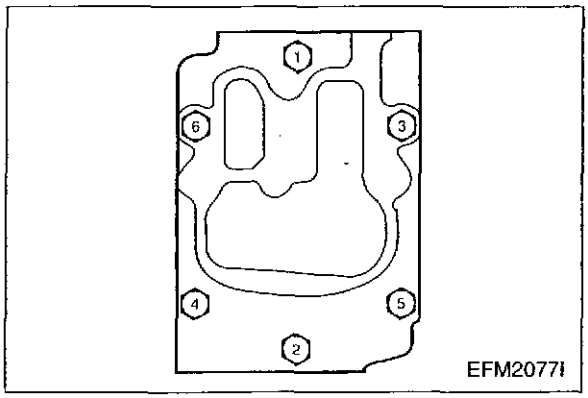

- After slipping the cylinder liner smoothly into the cylinder block, press it in being careful for O-ring not to damage.
- After completion of assembling the cylinder liner, confirm no leaks with 4 kg/cm$^2$ hydraulic test.



- Position the cylinder head assembly on the cylinder block aligning with its dowel pin. (Take care not to damage the head gasket.)
- Coat the cylinder head bolts with engine oil and tighten them to the specified torque according to step by step. However, prior to tightening the bolts, with a long steel rule, the *parallelness between the cylinder heads must be adjusted.*

**<Cylinder head bolts tightening order>**

1) First step: Coat bolts with engine oil.
2) Second step: Tighten temporarily 1 ~ 2 threads by hands.
3) Third step: Tighten to about 8 kg.m with a wrench.
4) Forth step: Tighten to 15kg.m with a torque wrench.
5) Fifth step: Rotate 90° by rotation angle method.
6) Sixth step: Finally tighten additionally rotating 90°.



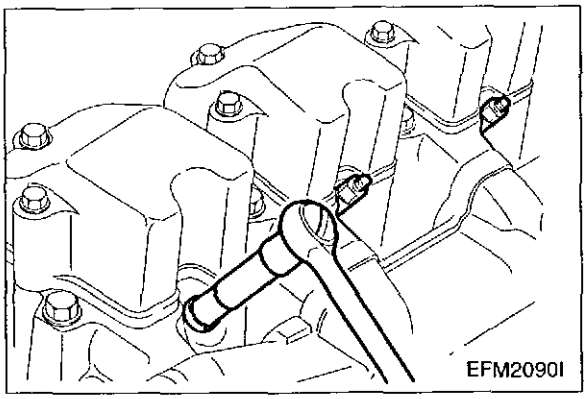

★ **Standard length of bolt and use limit :** from the head seat face to tip

| Bolt No. | Standard length | Use limit |
|---|---|---|
| 3, 6 | 168 mm | 171 mm |
| 2, 4, 5 | 144 mm | 147 mm |
| 1 | 109 mm | 112 mm |

- *Take care for the foreign material not to get into the cylinder head suction passages.*

### 2.3.19. Nozzle

Put a new seal ring in the nozzle hole of cylinder head and after inserting the nozzle assembly into it, tighten to assemble However, coat the nozzle outer part with the stuck preventing agents and assemble it.

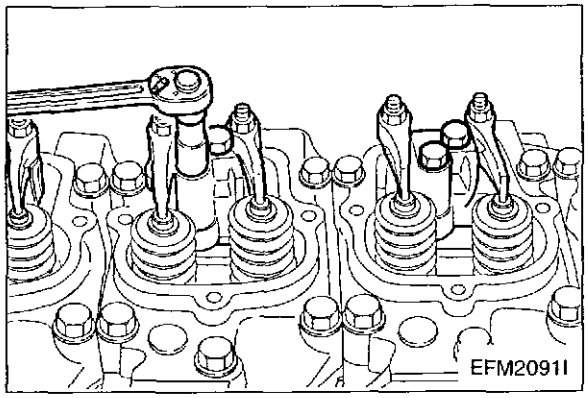



### 2.3.20. Rocker Arm

- Coat the push rod with engine oil and put it into the push rod hole.
- Position the rocker arm assembly on the cylinder head and tighten the fixing bolts to the specified tightening torque.

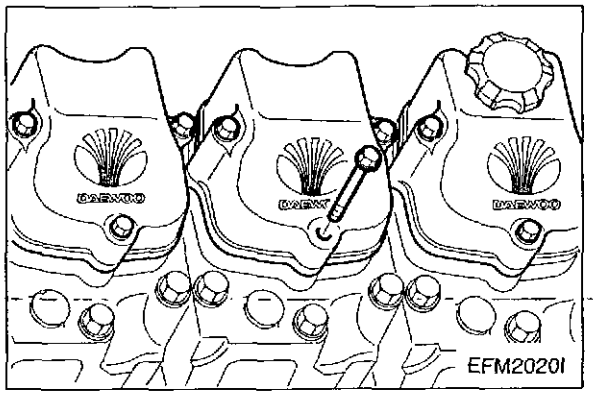
| Torque | 6.5 kg.m |
|---|---|

- Adjust the valve clearance. Regarding the adjustment, refer to theregular maintenance part.




### 2.3.21. Cylinder Head Cover

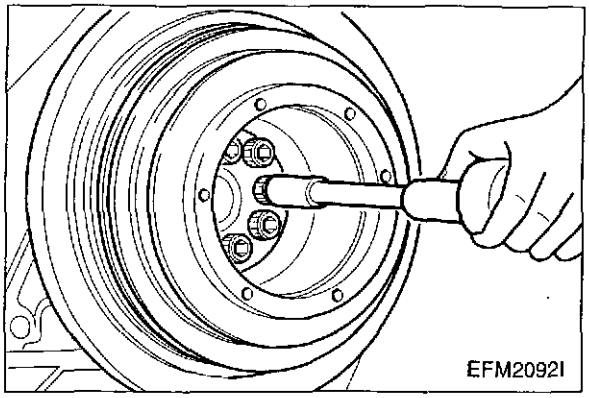
- Attach a new gasket on the surface of cylinder head where the cover is to be installed.
- Assemble the cylinder head cover by tightening the fixing bolts.
- Insert the oil filler cap.
- After inserting the oil bleeder pipe, assemble by tightening clamp.



### 2.3.22. Vibration Damper

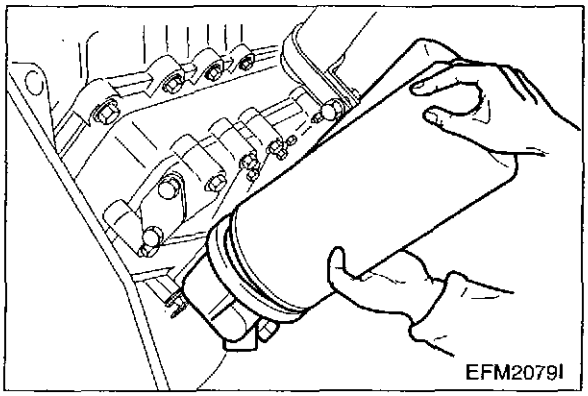
- Assemble the vibration damper tightening firstly by the crankshaft pulley and the fixing bolts.
- Insert the crankshaft pulley assembly to the crankshaft and tighten the fixing bolts in the method of zigzag to the specified torque.

| Torque | 21 kg.m |
|---|---|



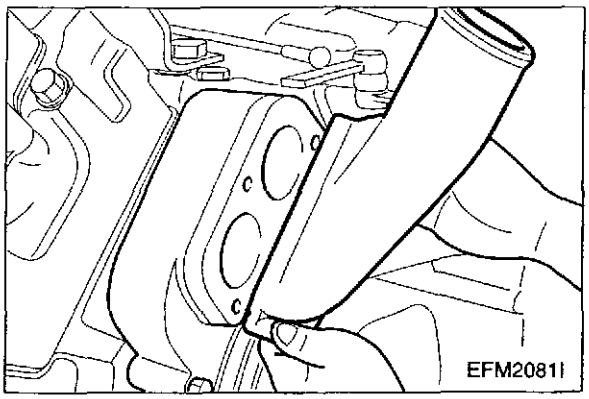

### 2.3.23. Oil filter

- Install the oil filter cartridge.



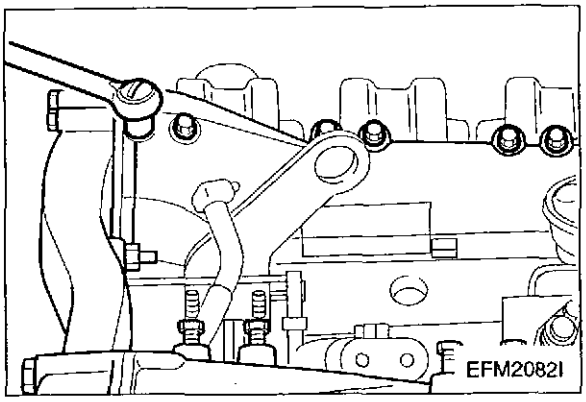

### 2.3.24. Cooling Water Pump

- Attach a gasket at the cooling water pump. (at cylinder block side)
- Assemble the cooling water pump by tightening the fixing bolts. (zigzag method)
- Insert the thermostat of cooling water pump.
- Insert the O-ring to the thermostat and assemble the cooling water pipes by tightening the fixing bolts.



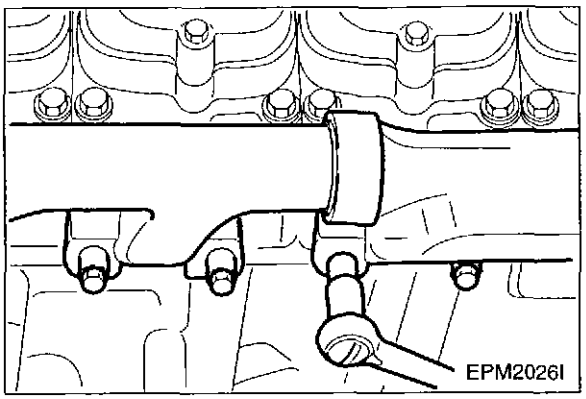
### 2.3.25. Intake Manifold

- Attach a new gasket to the cylinder head side.
- Assemble the intake manifold by tightening the fixing bolts.
- Attach a gasket to the inlet flange and assemble by tightening the fixing bolts.
- Assemble both sides by the above method.
- Attach a gasket to the equalizing pipe that connects the intake manifolds of both sides and assemble both manifolds by tightening the fixing bolts.



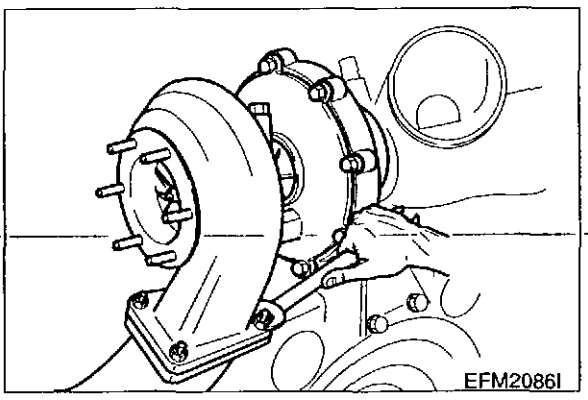

### 2.3.26. Exhaust Manifold

- Connect the exhaust manifold that is consists of two sets after inserting the exhaust gas ring between them.
- Attach a new gasket to the exhaust manifold.
- Attach a gasket to the exhaust elbow that Is connected to the exhaust manifold, and assemble the elbow by tighten the nuts for connection.
- Assemble both sides in the same method as above.




### 2.3.27. Turbocharger

- Attach a gasket to the exhaust elbow and assemble the turbocharger with fixing bolts.
- Install the connecting pipes and an O- ring between the inlet flange and turbocharger–Then, it is assembled with the O-ring that was coated with engine oil.
- Attach a gasket on the oil supply pipe and assemble the pipe with the fixing bolts.
- Attack a gasket on the oil discharge pipe and assemble the pipe by tightening the bolts.



## 3.4. Handling

### 3.4.1. Precautions at Engine

Operation following items must be observed at the starting, operation and stop of engine.

| Item | Care | Items |
|---|---|---|
| At starting | 1) Inspect oil quantity<br>2) After confirming that oil pressure rises by starting engine with starter (until the pointer of oil pressure gauge moves or pressure indicating lamp operates), the starting must be done.<br>3) In case that oil, oil filter and lubricating system's part are replaced or engine was stalled for long time (more than a week), and in case of operation under cold weather, loosen the oil pipe connecting parts of turbocharger inlet, and operate the starting motor until oil comes out the connecting parts. Care must be paid that after the confirming above, retighten the pipe connecting parts without fail, and proceed with the normal starting. | 2) If engine is started quickly, of course beginning with every parts of engine, for it revolves without oil that is to reach to the turbocharger, the bearing's abnormal wear or stuck may be caused.<br>3) In case that engine stalled for long time and of cold weather, the fluidity of oil may be get worse. |
| Immediately after starting | 1) Perform idling operation for about 5 min. immediately after engine starting. | 1) Sudden load at time soon after engine starting and at the state when turbocharger did not yet reach to smooth revolution, if abrupt load is applied to engine, some parts where oil did still not reach may cause a burn to be stuck. |
| | 2) Various inspections must insure that there are no leakage of oil, gas and air. | 2) If there are the leakage of oil, gas, air, particularly oil, for the oil pressure lowers, it causes a burn of bearing to be stuck. |

| Item | Care | Items |
|---|---|---|
| During operation | Following items must be confirmed.<br>1 ) Oil pressure at<br>idling: 90 ~ 300 kPa (0.9 ~ 3.0 bar)<br>at full load 300 ~ 650 kPa (3.0 ~ 6.5 bar)<br>2) When abnormal noises and vibration are generated, slow down the revolution and must stop it to investigate the causes. | 1) If the pressure is too low, abnormal wear or stuck may be caused. Or if too high, the oil leak may be generated.<br>2) If the engine operation were continued with abnormal noises and vibration, it causes the engine trouble that can not be repaired or some other troubles. |
| At stop | 1) At stopping the engine, perform the idling operation for 5min. and then stop it. | 1) After heavy load operation, if the engine were stopped suddenly, the heat would be conducted to bearing parts from red hot turbine wings that would result in burning the oil to cause the stuck bearing metal and revolving shaft. |

## 3.5. Routine Inspection and Maintenance

Since the state of turbocharger depends largely on the state of engine maintenance, to perform the specified up keep thoroughly is needed.

### 3.5.1. Intake Air

System in the intake air system, care must be taken to the air cleaner. In case of oil passing type air cleaner, if the oil level is lower than the specified value, the cleaning efficiency get worse, if higher, the sucked oil pollutes a case. Particularly, for if the rotor were polluted, the balance adjusted precisely would be deviated to cause a vibration that may cause the stuck or abnormal wear by loading large force to the bearing, the perfect air cleaner must always be used. In case of dry type filter, according to the indication of a dust indicator, cleaning must be done to make the intake air resistance as small as possible

### 3.5.2. Exhaust System

In exhaust system, a care must be taken to the gas leak and the stuck prevention If exhaust gas leaks from the exhaust pipe and turbocharger etc., for the super charging effect will be lowered, the installed states of various parts must be paid with careful attention. Since the parts that reach to high temperature during operation such as the turbine room use the anti-heat nuts, a care must be paid not to mix with the general nuts and at the same time, bolt stuck preventing paint should be coated on the nut for the designated places.

### 3.5.3. Fuel System

If the full load stopper that restricts the maximum fuel injection quantity of fuel injection pump and the maximum speed stopper that restricts the maximum speed are adjusted without the pump tester, the turbocharger may overrun to be damaged. Also, if the atomizing state of fuel injection nozzle becomes worse or the injection timing gets wrong, for the raised temperature of exhaust gas will influence badly to the turbocharger, the nozzle testing must be done.

### 3.5.4. Lubricating System

In the lubricating system, a care must be paid to the oil quality and oil element replacement cycle. For the oil deterioration of turbocharger equipped engine, needless to speak of engine assembly itself, influences badly to the turbocharger too, the specified engine oil (15W40, CE class) should used.

## 3.6. Periodic Inspection and Maintenance

The turbocharger assembly must be inspected periodically.

### 3.6.1. Revolving State and Inspection Points of Rotor

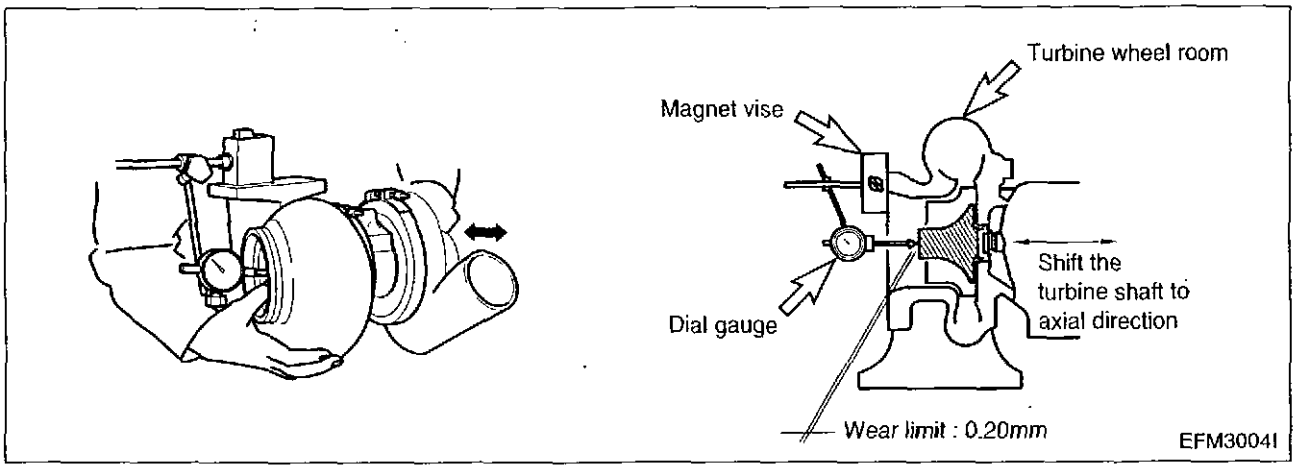
Inspection on the revolving state of rotor is performed according to abnormal noises. In case of using an acoustic bar, touch the turbocharger housing with a tip of bar and raise the engine revolution slowly, Then, in case that high sound is heard by every 2 ~ 3 sec. continuously, for there should be the possibility to be abnormal metal and rotor, replace or repair the turbocharger.

### 3.6.2. End play Inspecting Points of Rotor

Disassemble the turbocharger from the engine and should inspect the end plays in axial and circumference direction. In case of disassembling the turbocharger, the oil inlet and outlet should necessarily be sealed with a tape.

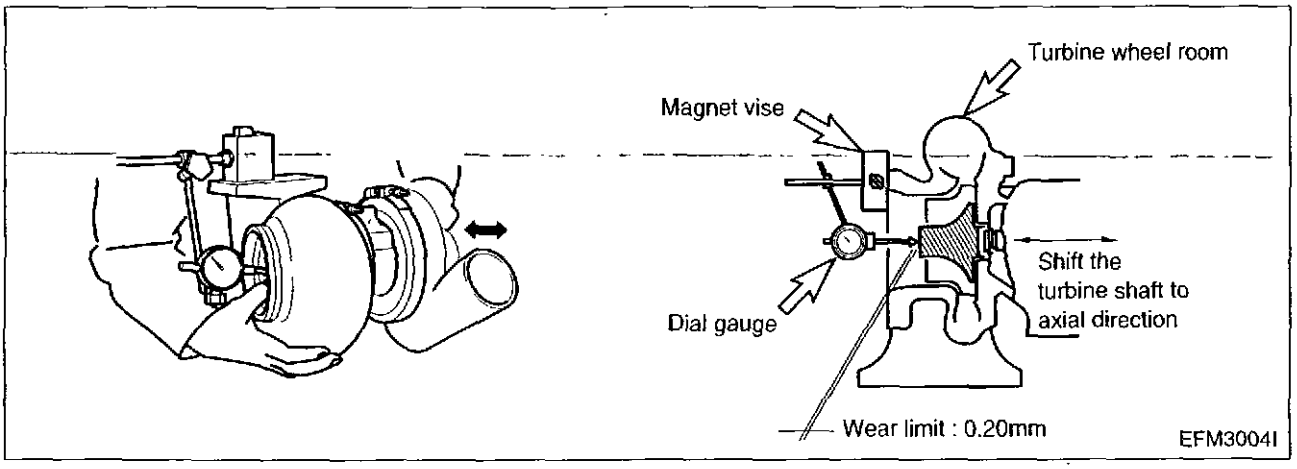
1) Axial Direction End Play

- Wear limit : 0.20mm




2) Rotor's Circumference Direction End Play.

- Wear limit : 0.65mm




3) In case that the end plays to axial and circumference directions, replace or repair the turbocharger.

### 3.6.3. Overhaul and cleaning points

Disassemble the turbocharger from engine and perform a cleaning and inspection, and in this case, the oil inlet and outlet should necessarily be sealed with tape etc.

### 3.6.4. Precautions in Assembling Engine

When in assembling the turbocharger or the handling after assembling should work observing the following precautions necessarily. Particularly, precise care should be taken for foreign material not to get into the turbocharger.

**1) Lubricating system**

- Prior to assembling it into the engine, fill new oil into oil Inlet and turning turbine shaft with hand, lubricate journal and thrust bearing.
- Clean the pipe and oil outlet pipe between engine and oil inlet, and confirm if there is any pipe damage or foreign material.
- In order for oil not to leak from various connections, assemble securely.

**2) Air intake system**

- Confirm if there is any foreign material inside the air intake system
- Assemble securely the air intake duct and air cleaner so that the connections from them may not leak an air.

**3) Exhaust system**

- Confirm if there is any foreign material in the exhaust system.
- Bolts and nuts must be made of anti-heat steel and in assembling, care should be taken not use the general nuts and coat the bolts and nuts with the anti-stuck agents at the same time.
- Assemble securely for gas not to leak from various connecting parts of exhaust pipes

## 3.7. Trouble Cause Diagnosis and Remedy

| Condition | Causes | Remedies |
|---|---|---|
| 1. Exhaust gas excessive | 1) Air cleaner elements clogged | Replace or clean |
| | 2) Air Inlet port clogged | Inspect or repair |
| | 3) Air leaks from air intake system | Inspect or repair |
| | 4) Turbocharger impossible to rotate due to stuck | Overhaul and repair or replace |
| | 5) Turbine wing's contact | Overhaul and repair or replace |
| | 6) Piping deformation or clogging of exhaust system | Inspect and repair |
| 2. White smoke excessive | 1) Oil leaks into turbine and compressor. | Overhaul and repair or replace |
| | 2) Seal ring's abnormal wear or damage | Overhaul and repair or replace |
| 3. Output lowered | 1) Gas leak from various parts of exhaust system | Inspect and repair |
| | 2) Air cleaner's elements clogged | Replace or clean |
| | 3) Turbocharger's pollution or damage | Overhaul and repair or replace |
| | 4) Air leaks from discharge part of compressor side | Inspect and repair |
| 4. Abnormal noises or vibrations | 1) Revolving parts' contact | Overhaul and repair or replace |
| | 2) Revolving imbalance of rotor | Overhaul and repair or replace |
| | 3) Stuck | Overhaul and repair or replace |
| | 4) Various connections loose | Inspect and repair |

### 4.2.3. P222LE Engine

1) Injection pump : 65.11101-7303 (0 402 610 807 BOSCH)
- Model : PE12P120A500LS7937 (0 412 620 854)
- Governor : GAC Governor
- Plunger & barrel : 2 418 455 545
- Delivery valve : 2 418 559 045
- Feed pump : FP/KD22P80-1 (0 440 008 090)
  FP/KD22P78-2 (0 440 008 152)
- Prestroke : 4.5 ±0.05mm at 13 ±1.5mm

(2) Nozzle holder assembly : 65.10101-7051 (0 432 131 667)

(3) Nozzle : 65.10102-6047 (0 433 171 174)

(4) Injection pipe : 65.10301-6057 , 65.10301-6058

(5) Injection order : 1 - 12 - 5 - 8 - 3 - 10 - 6 - 7 - 2 - 11 - 4 -9

(6) Injection timing : BTDC 16°

| | | | |
|---|---|---|---|
| (A) Test condition for injection pump | Nozzle & Holder Ass'y | 1 688 901 105 | Opening pressure : 208.5 ±1.5 bar |
| | Injection pipe(ID, OD, L) | - | ϕ3.0 x ϕ8.0- 600 mm |
| | Test oil | ISO4113 | Temperature :40 ± 5°C |
| (B) Engine standard parts | Nozzle & holder ass'y | 65.10101-7051 | Nozzle (5 x ϕ0.26) |
| | | | 285 kg/cm² |
| | Injection pipe(ID, OD, L) | 65.10301-6057<br>65.10301-6058 | ϕ2 x ϕ6 - 750mm |

Rack diagram and setting valve at each point

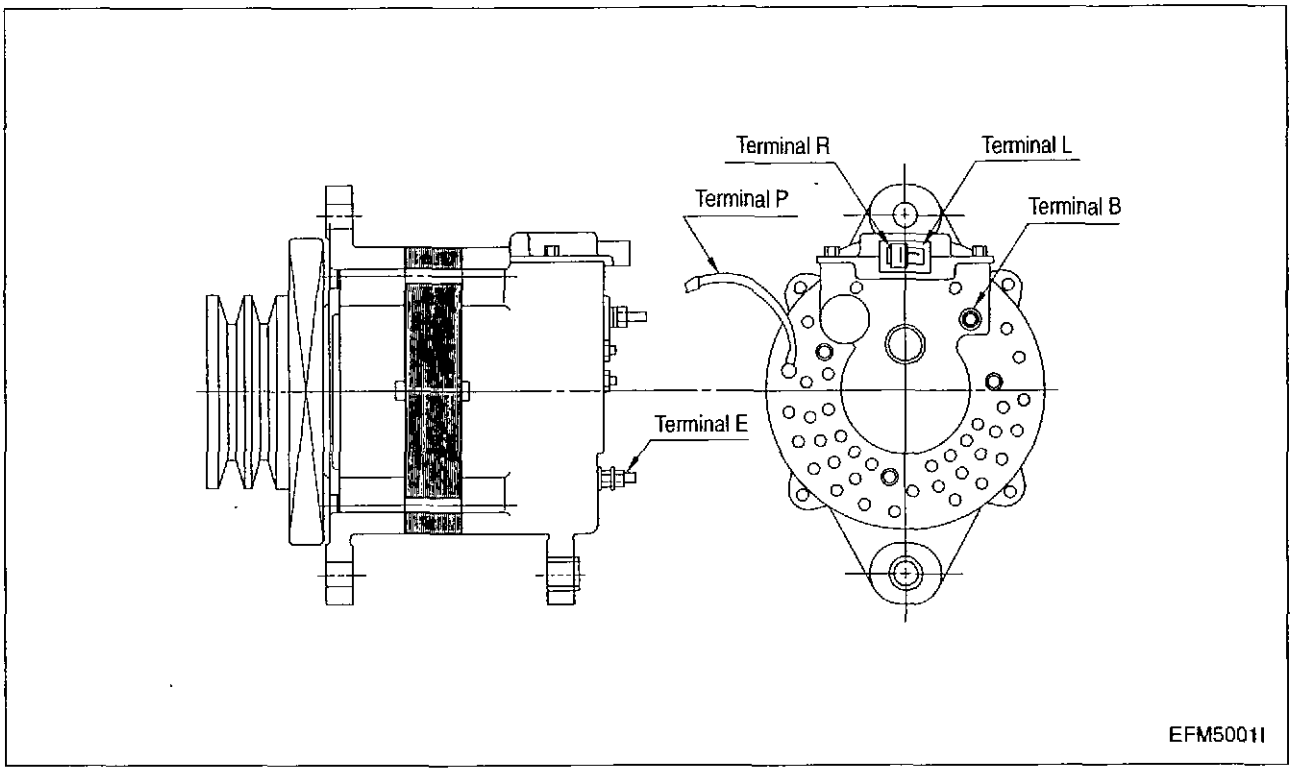
| | Check point | Rack position (mm) | Pump speed (rpm) | Injection Q'ty on RIG (mm³ / 1,000 st) | | Press. (mmHg) |
|---|---|---|---|---|---|---|
| | | | | (A) Test condition for inj. pump | (B) Engine standard parts | |
| Standby power | A | 12.6 | 700 | 304 ± 3 | - | - |
| | - | - | - | - | - | - |
| | - | - | - | - | - | - |
| | - | - | - | - | - | - |
| | - | - | - | - | - | - |

Boost pressure : zero boost

# 5. ELECTRIC SYSTEM

## 5.1. Alternator Inspection Points

### 5.1.1. Structural Drawing (external shape)



## 5.2. Inspection Point

### 5.2.1. In Case of Abnormal Charging

1) Voltage Measurement between Terminal and Body of Alternator During Operation

**<Voltages during operation>**

| Measuring position | Voltage |
|---|---|
| Terminal B - Body | about DC38V ~ 29V |
| Terminal L - Body | about DC38V ~ 29V |
| Terminal R - Body | about DC38V ~ 29V |

**<Voltages during stop>**

| Measuring position | Voltage |
|---|---|
| Terminal B - Body | about DC24V |
| Terminal L - Body | about DC24V |
| Terminal R - Body | about DC24V |

❖ For the confirmation of wiring state, measurement of voltages is needed only at the terminals even during stop.

2) Inspection Points on the Voltage Regulator

**<Resistance value between voltage regulator's terminals>**

| Terminal | | Resistance Value | | Terminal (KΩ) | | Resistance Value (KΩ) |
|---|---|---|---|---|---|---|
| + | - | | | + | - | |
| L | E | about 2 | | | | |
| R | E | about 53 | | E | R | ∞ |
| F | E | about 50 | | | | |
| L | F | about 50 | | | | |
| H | L | about 50 | | L | R | ∞ |
| R | F | about 168 | | F | R | ∞ |

### 5.2.2. Precautions in Use

- For battery voltages drop when they are left for long time even without use, care should be paid.
- In cold winter season, for the starting may not be done well sometime, do not try unreasonably but try to start several times dividedly.
- Prior to operating the gauge panel, make sure the polarity of battery once again (In majority of polarities, red side is + and black one is -)
- For disassembly of gauge panel accompanies a risk of electrical shock, always work after pulling off the connector at rear side without fail
- If the silver paper etc is used for connecting the blown fuse, because the excessive current might flow into the parts to damage, when fuse is blown, after resolving the problem locating the cause, replace it with new fuse.

- Since battery has a danger of explosion by a heat, it must not be placed at the spot where generates a lot of heat.
- When engine is in stop, pull out the key always. Thus, a hazard of fire or wound due to wrong operation may not happen.
- In case of scrapping the batteries, observe the followings.

**NOTE :** *Do not throw it in the fire to scrap.*
*It should not be thrown away into the places where are liable to cause the environmental pollution such as stream, river and mountain. Pack them as far as possible and dispose it as rubbish that is unable to use again.*

- This company will not be responsible to the problems that might be raised by the disassembling and structural change of this product without consultation.

| Items | | D28 series | Remarks |
|---|---|---|---|
| Crank shaft | Main bearing journal's roundness | 0.01 | |
| | Main bearing journal's parallelness | 0.005 | |
| | Medium main bearing journal's shake | 0.06 | no 1, no 5 support |
| | Wear ring press in part's journal diameter | ϕ99.985 ~ ϕ100.020 | ϕ100 j7 |
| | Wear ring's inside diameter | ϕ99.907 ~ ϕ99.942 | ϕ100 S7 |
| | Overlap | 0.043 ~ 0.113 | |
| | Thrust bearing width | | |
| | Standard | 37.74 ~ 37.81 | |
| | Oversize | 38.24 ~ 38.31 | |
| | Oversize | 38.74 ~ 38.81 | |
| | Crankshaft's axial direction's clearance | 0.190 ~ 0.322 | |
| | Main bearing thickness | | |
| | Standard | 3.460 ~ 3.472 | |
| | Oversize 0.10 | 3.510 ~ 3.522 | |
| | Oversize 0.25 | 3.585 ~ 3.597 | |
| | Oversize 0.50 | 3.710 ~ 3.722 | |
| | Oversize 0.75 | 3.835 ~ 3.847 | |
| | Oversize 1.00 | 3.960 ~ 3.972 | |
| | Main bearing oil gap | 0.066 ~ 0.132 | |
| | Main bearing spread | 0.3 ~ 1.2 | |
| | Thrust bearing's spread | 0.3 ~ 1.2 | |
| Flywheel | Ring Gear assembly part's Outside diameter | ϕ432.490 ~ ϕ432.645 | |
| | Ring gear inside diameter | ϕ432.000 ~ ϕ432.155 | |
| | Overlap | 0.335 ~ 0.645 | |
| | Heat fitting temp. ((C) | 200 ~ 230 | |
| | Allowable shaking amount after assembly | 0.5 | |
| | Outside diameter after reassembly used ring | ϕ114.980 ~ ϕ115.015 | |
| Cylinder head & valve | Head gasket thickness (after tightening bolts) | 1.205 ~ 1.295 | |
| | Cylinder head height | 113.9 ~ 114.0 | |
| | Cylinder head seal surface roughness | Max 16μ | |
| | Valve projecting amount | - 0.65 ~ - 0.95 | |
| | Exhaust valve | | |
| | Stem diameter | ϕ11.945 ~ ϕ11.955 | |
| | Radius direction clearance | 0.045 ~ 0.073 | |
| | Seat angle | 45° | |

| Items | | D28 series | Remarks |
|---|---|---|---|
| | Head diameter | ϕ50.9 ~ ϕ51.1 | |
| | "H" thickness of valve head | 1.9 ~ 2.3 | |
| | Valve seat part diameter of head | ϕ53.00 ~ ϕ53.03 | |
| | Outside diameter of valve seat | ϕ53.10 ~ ϕ53.11 | |
| Cylinder | Intake valve | | |
| head | Stem diameter | ϕ11.969 ~ ϕ11.980 | |
| & valve | Radius direction clearance | 0.020 ~ 0.049 | |
| | Seat angle | 30° | |
| | Head diameter | ϕ57.85 ~ ϕ58.15 | |
| | "H" thickness of valve head | 2.6 ~ 3.0 | |
| | Valve seat part diameter of head | ϕ61.00 ~ ϕ61.03 | ϕ61 H7 |
| | Outside dia. of valve seat | ϕ61.10 ~ ϕ61.11 | |
| | Depth of head's valve seat assembly part | 12.5 ~ 12.6 | |
| | Valve guide inside diameter | ϕ12.000 ~ ϕ12.018 | ϕ12 H7 |
| | Valve guide's inside diameter of head | ϕ18.000 ~ ϕ18.018 | ϕ18 H7 |
| | Valve guide's outside diameter | ϕ18.028 ~ ϕ18.046 | ϕ18.25 S7 |
| | Valve guide assembly locking piece | 0.010 ~ 0.046 | |
| | Valve seat's shaking | 0.04 | reference to valve guide |
| Valve | Valve lift | 14.1 | |
| | Projecting amount of valve guide | 17.1 ~ 17.5 | Above valve spring |
| | Free length of inside spring | 72.43 | |
| | Spring load of inside spring | 15 ~ 17kg | at 46.3mm |
| | Spring load of inside spring | 27 ~ 32kg | at 32.3mm |
| | Free length of outside spring | 68.17 | |
| | Spring load of outside spring | 37 ~ 41kg | at 46.3mm |
| | Spring load of outside spring | 66.5 ~ 76.5kg | at32.8mm |
| Timing | Rocker arm bush's inside diameter | ϕ25.005 ~ ϕ25.035 | when assembled |
| | Rocker arm bearing journal's diameter | ϕ24.967 ~ ϕ24.990 | |
| | Bearing's clearance | 0.015 ~ 0.068 | |
| | Push rod's shaking | 0.3 | |
| | Valve tappet ass'y part's inside dia. of block | ϕ20.000 ~ ϕ20.021 | ϕ20 H7 |
| | Push rod's outside diameter | ϕ19.944 ~ ϕ19.965 | |
| | Tappet clearance | 0.035 ~ 0.077 | |

| Items | | D28 series | Remarks |
|---|---|---|---|
| Timing | Bush assembly's inside diameter of block | ϕ70.077 ~ ϕ70.061 | |
| | Camshaft diameter | ϕ69.910 ~ ϕ69.940 | ϕ70 e7 |
| | Camshaft bearing oil gap | 0.060 ~ 0.120 | |
| | Camshaft axial direction play | 0.20 ~ 0.90 | |
| | Backlash (crank gear-camshaft gear) | 0.118 ~ 0.242 | |
| | Backlash (driving gear - injection pump gear) | 0.102 ~ 0.338 | |
| | Intake valve clearance | 0.25 | |
| | Exhaust valve clearance | 0.35 | |
| Engine lubricating system | Oil pressure at idling | 0.9 ~ 3.0bar | |
| | Oil pressure at rated speed operation | 3.0 ~6.5bar | |
| | Oil temperature | less than 100°C | |
| | Instantaneous allowable temperature | max. 110°C | |
| | Bypass valve opening pressure | 1.8 ~ 2.4bar | |
| | Pressure regulating valve of oil pump | 8.5 ~10bar | |
| | Spray nozzle | | |
| | Operating pressure | 1.6 ~ 1.9bar | |
| | Crossing pressure | 1.3 ~ 1.6bar | |
| | Tip diameter | ϕ2 | |
| | Backlash (crankshaft gear-oil pump drive gear) | 0.10 ~0.45 | |
| | Oil pump housing's depth/gear width | 43.000 ~ 43.039 | 43 H8 |
| | | 42.910 ~ 42.950 | 43 e8 |
| | Oil pump housing axial play | 0.050 ~ 0.128 | |
| Engine cooling system | Cooling water pump shaft diameter | ϕ21.930 ~ ϕ21.950 | |
| | Bearing gap | 0.050 ~ 0.091 | |
| | Impeller clearance (impeller - body) | 1.0 ~ 1.5 | |
| | Thermostat Operating temperature (°C) | 79°C | |
| Inspection on compressed pressure | Good | above 28bar | |
| | Possible to use | 25 ~ 28bar | |
| | Need up keep | bellow 24bar | |
| | Allowable max pressure difference between cylinders | 4bar | |
| Fuel system | Overflow valve's operating pressure of injection pump | 1.3 ~ 1.8bar | |
| | Mode of fuel injection pump | Bosch | |
| | Governor model | GAC electronic | |
| | Injection nozzle's manufacture | Bosch | |
| | Injection nozzle hole's diameter | 4 - ϕ0.40 | |

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## 3.3. Function

### 3.3.1. Turbine

The exhaust gas that is discharged from combustion chamber passes through turbine housing conveying an energy to turbine wings to give the rotating power, This is called as the turbine and in order not to influence a bad effect at bearing part, there are the seal ring and heat dissipator.

### 3.3.2. Compressor

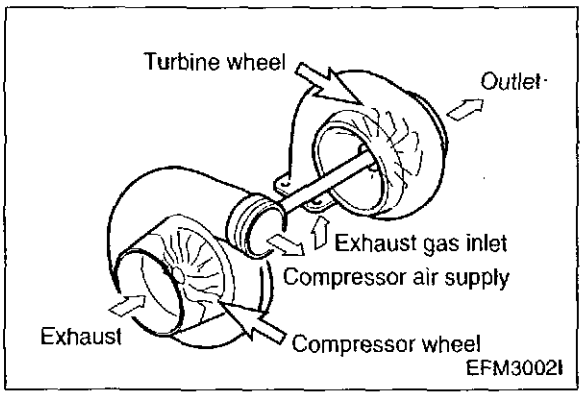
It is connected to the same shaft with the turbine to make a revolving assembly, and receive the revolving force of turbine, and sends air to the suction manifold by suctioning and compressing it. This is called as the compressor.

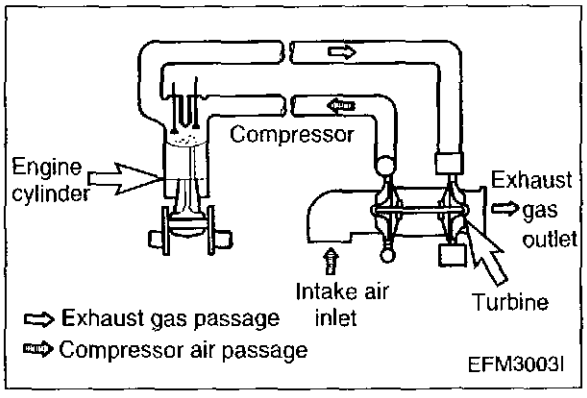
### 3.3.3. Bearing

- Thrust bearing force is applied to the turbine wheel and an arrangement is made for the shaft not to shift.
- Journal bearing (floating bearing) is adopted and it forms the double oil films at the in out surfaces in comparison to the general stationary type so that the bearing may be able to rotate independently and consequently the double layers of films act as the damper to make the slipping speed on the bearing surface less than the rotating speed of shaft so that the dynamic stability may be obtained.

### 3.3.4. Sealing at Compressor shaft

In order for the compressed intake air and lubricating oil not to leak, a seal plate and a seal ring are made to the double structures.



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EAZGA32-2906

| Item | Care | Items |
|---|---|---|
| During operation | Following items must be confirmed.<br>1 ) Oil pressure at<br>idling: 90 ~ 300 kPa (0.9 ~ 3.0 bar)<br>at full load 300 ~ 650 kPa (3.0 ~ 6.5 bar)<br><br>2) When abnormal noises and vibration are generated, slow down the revolution and must stop it to investigate the causes. | 1) If the pressure is too low, abnormal wear or stuck may be caused. Or if too high, the oil leak may be generated.<br>2) If the engine operation were continued with abnormal noises and vibration, it causes the engine trouble that can not be repaired or some other troubles. |
| At stop | 1) At stopping the engine, perform the idling operation for 5min. and then stop it. | 1) After heavy load operation, if the engine were stopped suddenly, the heat would be conducted to bearing parts from red hot turbine wings that would result in burning the oil to cause the stuck bearing metal and revolving shaft. |

## 3.5. Routine Inspection and Maintenance

Since the state of turbocharger depends largely on the state of engine maintenance, to perform the specified up keep thoroughly is needed.

### 3.5.1. Intake Air

System in the intake air system, care must be taken to the air cleaner. In case of oil passing type air cleaner, if the oil level is lower than the specified value, the cleaning efficiency get worse, if higher, the sucked oil pollutes a case. Particularly, for if the rotor were polluted, the balance adjusted precisely would be deviated to cause a vibration that may cause the stuck or abnormal wear by loading large force to the bearing, the perfect air cleaner must always be used. In case of dry type filter, according to the indication of a dust indicator, cleaning must be done to make the intake air resistance as small as possible

### 3.5.2. Exhaust System

In exhaust system, a care must be taken to the gas leak and the stuck prevention If exhaust gas leaks from the exhaust pipe and turbocharger etc., for the super charging effect will be lowered, the installed states of various parts must be paid with careful attention. Since the parts that reach to high temperature during operation such as the turbine room use the anti-heat nuts, a care must be paid not to mix with the general nuts and at the same time, bolt stuck preventing paint should be coated on the nut for the designated places.

### 3.5.3. Fuel System

If the full load stopper that restricts the maximum fuel injection quantity of fuel injection pump and the maximum speed stopper that restricts the maximum speed are adjusted without the pump tester, the turbocharger may overrun to be damaged. Also, if the atomizing state of fuel injection nozzle becomes worse or the injection timing gets wrong, for the raised temperature of exhaust gas will influence badly to the turbocharger, the nozzle testing must be done.

### 3.5.4. Lubricating System

In the lubricating system, a care must be paid to the oil quality and oil element replacement cycle. For the oil deterioration of turbocharger equipped engine, needless to speak of engine assembly itself, influences badly to the turbocharger too, the specified engine oil (15W40, CE class) should used.

## 3.6. Periodic Inspection and Maintenance

The turbocharger assembly must be inspected periodically.

### 3.6.1. Revolving State and Inspection Points of Rotor

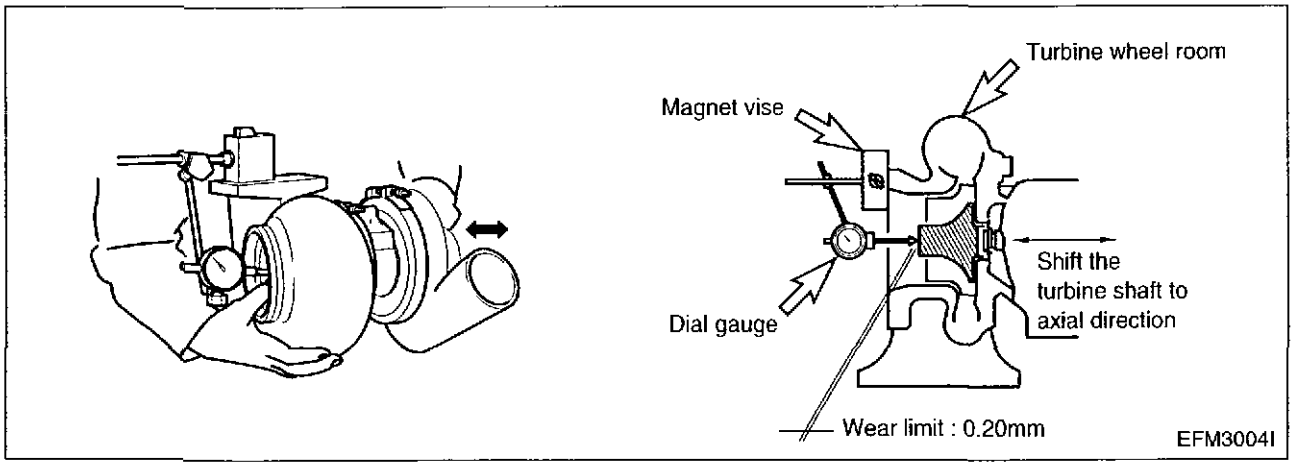
Inspection on the revolving state of rotor is performed according to abnormal noises. In case of using an acoustic bar, touch the turbocharger housing with a tip of bar and raise the engine revolution slowly, Then, in case that high sound is heard by every 2 ~ 3 sec. continuously, for there should be the possibility to be abnormal metal and rotor, replace or repair the turbocharger.

### 3.6.2. End play Inspecting Points of Rotor

Disassemble the turbocharger from the engine and should inspect the end plays in axial and circumference direction. In case of disassembling the turbocharger, the oil inlet and outlet should necessarily be sealed with a tape.

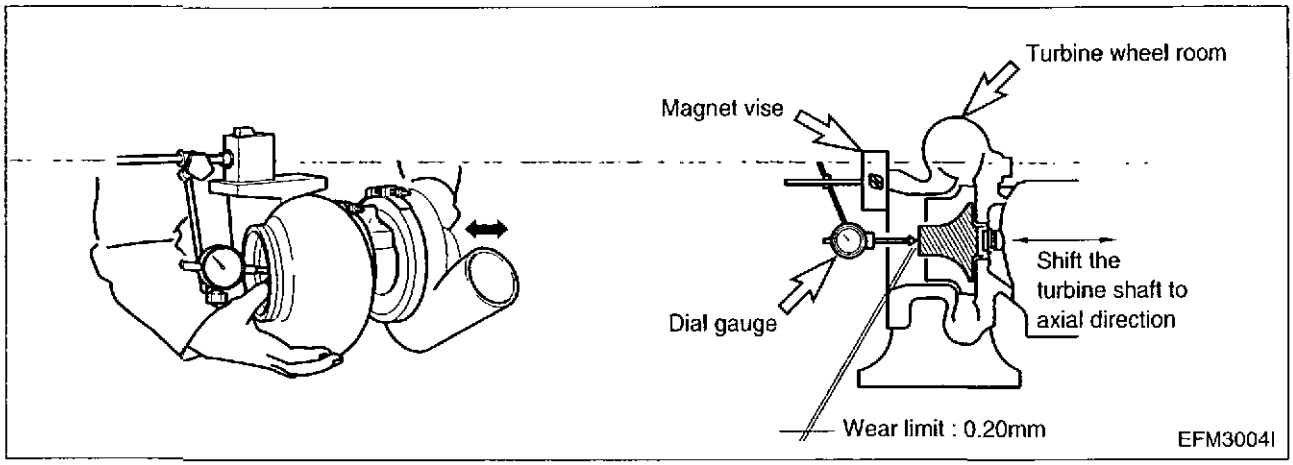
1) Axial Direction End Play

- *Wear limit : 0.20mm*




2) Rotor's Circumference Direction End Play.

- Wear limit : 0.65mm




3) In case that the end plays to axial and circumference directions, replace or repair the turbocharger.

### 3.6.3. Overhaul and cleaning points

Disassemble the turbocharger from engine and perform a cleaning and inspection, and in this case, the oil inlet and outlet should necessarily be sealed with tape etc.

### 3.6.4. Precautions in Assembling Engine

When in assembling the turbocharger or the handling after assembling should work observing the following precautions necessarily. Particularly, precise care should be taken for foreign material not to get into the turbocharger.

**1) Lubricating system**

- Prior to assembling it into the engine, fill new oil into oil Inlet and turning turbine shaft with hand, lubricate journal and thrust bearing.
- Clean the pipe and oil outlet pipe between engine and oil inlet, and confirm if there is any pipe damage or foreign material.
- In order for oil not to leak from various connections, assemble securely.

**2) Air intake system**

- Confirm if there is any foreign material inside the air intake system
- Assemble securely the air intake duct and air cleaner so that the connections from them may not leak an air.

**3) Exhaust system**

- Confirm if there is any foreign material in the exhaust system.
- Bolts and nuts must be made of anti-heat steel and in assembling, care should be taken not use the general nuts and coat the bolts and nuts with the anti-stuck agents at the same time.
- Assemble securely for gas not to leak from various connecting parts of exhaust pipes

## 3.7. Trouble Cause Diagnosis and Remedy

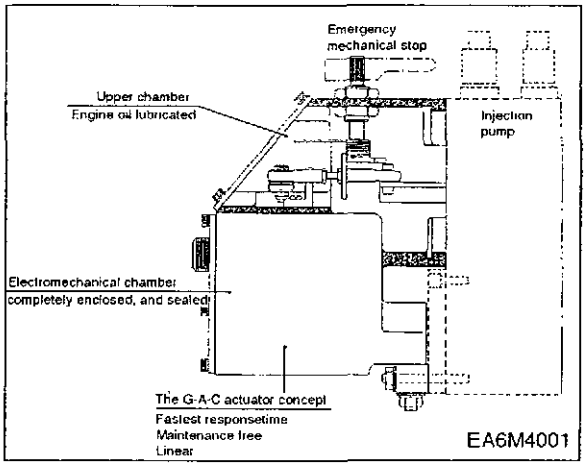
| Condition | Causes | Remedies |
|---|---|---|
| 1. Exhaust gas excessive | 1) Air cleaner elements clogged | Replace or clean |
| | 2) Air Inlet port clogged | Inspect or repair |
| | 3) Air leaks from air intake system | Inspect or repair |
| | 4) Turbocharger impossible to rotate due to stuck | Overhaul and repair or replace |
| | 5) Turbine wing's contact | Overhaul and repair or replace |
| | 6) Piping deformation or clogging of exhaust system | Inspect and repair |
| 2. White smoke excessive | 1) Oil leaks into turbine and compressor. | Overhaul and repair or replace |
| | 2) Seal ring's abnormal wear or damage | Overhaul and repair or replace |
| 3. Output lowered | 1) Gas leak from various parts of exhaust system | Inspect and repair |
| | 2) Air cleaner's elements clogged | Replace or clean |
| | 3) Turbocharger's pollution or damage | Overhaul and repair or replace |
| | 4) Air leaks from discharge part of compressor side | Inspect and repair |
| 4. Abnormal noises or vibrations | 1) Revolving parts' contact | Overhaul and repair or replace |
| | 2) Revolving imbalance of rotor | Overhaul and repair or replace |
| | 3) Stuck | Overhaul and repair or replace |
| | 4) Various connections loose | Inspect and repair |

# 4. FUEL INJECTION PUMP

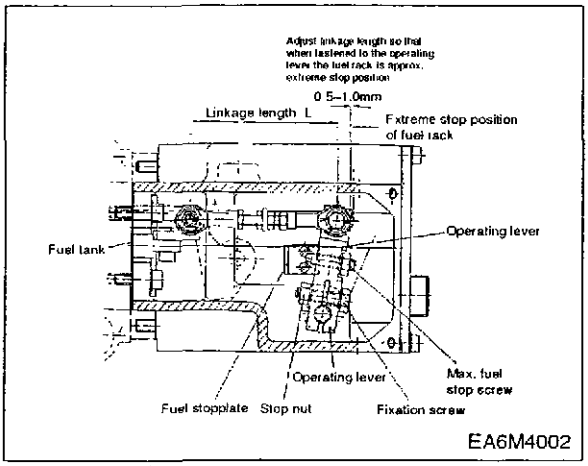
## 4.1. Governor System

Governor system for fuel injection pump consists of "Integral Actuator" and "Speed Control Unit".

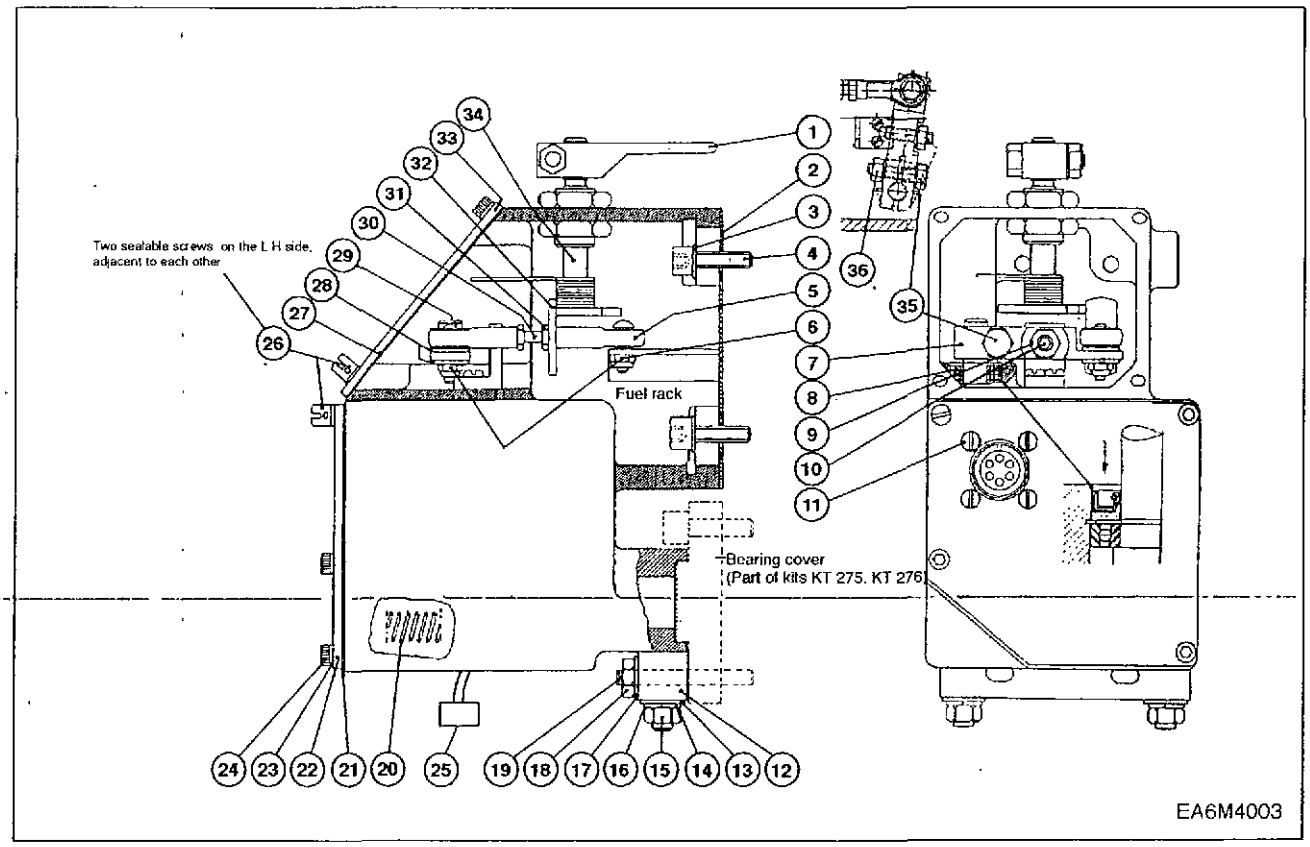
### 4.1.1. Integral Actuator




<Side View>




<Top View>



| Fig. No. | Description | Q'ty | Remark |
|---|---|---|---|
| 1 | stop lever (emergency) | 1 | |
| 2 | pump gasket | 1 | |
| 3 | washer | 4 | |
| 4 | allen screw | 4 | 7 ~ 9 N.m |
| 5 | ball link | 2 | * |
| 6 | stop nut | 2 | 3.5 ~ 4.0 N.m * |
| 7 | operating lever | 1 | |
| 8 | oil seal | 1 | |
| 9 | counter nut | 1 | 4.5 ~ 6.0 N.m |
| 10 | stop screw | 1 | |
| 11 | connector screw | 4 | |
| 12 | mounting bar | 1 | |
| 13 | flat washer | 2 | |
| 14 | lock washer | 2 | |
| 15 | nut | 2 | 17 ~ 21 N.m |
| 16 | flat washer | 2 | |
| 17 | lock washer | 2 | |
| 18 | nut | 2 | 7 ~ 9 N.m |
| 19 | threaded bolt (part of bearing kit) | 2 | |
| 20 | actuator spring | 1 | |
| 21 | gasket, lower cover | 1 | |
| 22 | lower cover | 1 | |
| 23 | washer | 8 | |
| 24 | allen screw | 6 | 2.0 ~ 3.0 N.m |
| 25 | receptacle | 1 | |
| 26 | sealing screw | 2 | 3.5 ~ 4.5 N.m |
| 27 | gasket, upper cover | 1 | |
| 28 | flat washer | 2 | |
| 29 | screw, ball link | 2 | * |
| 30 | connecting rod | 1 | * |
| 31 | nut | 2 | * |
| 32 | stop plate | 1 | * |
| 33 | top cover | 1 | |
| 34 | manual stop device complete | 1 | |
| * | linkage complete<br>comprise pos. 5,6,28,29,30,31,32 | 1 | |
| 35 | fixing screw | 1 | 12.5 ~ 13.0 N.m |
| 36 | stop nut | 1 | 12.5 ~ 13.0 N.m |

### 4.1.2. Speed Control Unit for Governor System

The ESD5550 Series speed control unit is an all electronic device designed to control engine speed with fast and precise response to transient load changes. This closed loop control, when connected to a proportional electric actuator and supplied with a magnetic speed sensor signal, will control a wide variety of engines in an isochronous or droop mode. It is designed for high reliability and built ruggedly to withstand the engine environment.

implicity of installation and adjustment was foremost in the design. Non-interacting performance controls allow near optimum response to be easily obtained.

The primary features of the ESD5550 Series speed control unit are the engine STARTING FUEL and SPEED RAMPING adjustments. The use of these features will minimize engine exhaust smoke experienced prior to attaining engine operating speed.

Other features include adjustable droop and idle operation, inputs for accessories used in multi-engine or special applications, protection against reverse battery voltage, transient voltages, accidental short circuit of the actuator and fail safe design in the event of loss of speed sensor signal or battery supply.

| | **P158LE, P180LE, P222LE engine** |
|---|---|
| GAC governor model | ACE 175 |
| Speed control unit model | ESD5550 |

### 1) Specification

| | |
|---|---|
| **PERFORMANCE** | |
| Isochronous Operation/steady State Stability | ± 0.25% or better |
| Speed Range/Governor | ±1 K ~ 7.5 KHz continuous |
| Speed Drift with Temperature | ± 1% Maximum |
| Idle Adjust CW | 60% of set speed |
| Idle Adjust CCW | Less than 1,200 Hz. |
| Droop Range | 1 ~ 5 % regulation* |
| Droop Adj. Max. (K-L Jumpered) | 400 Hz ± 75 Hz per 1.0 A change |
| Droop Adj. Min. (K-L Jumpered) | 15 Hz ± 6 Hz. per 1.0 A change |
| Speed Trim Range | ± 200 HZ |
| Remote Variable Speed Range | 500 ~ 7.5 Hz or any part thereof |
| Terminal Sensitivity | |
| J | 100 Hz ± 15 Hz/Volt @ 5.0 K Impedance |
| L | 735 Hz ± 60 Hz/Volt @ 65 K Impedance |
| N | 148 Hz ± 10 Hz/Volt @ 1 Meg. Impedance |
| P | 10 VDC Supply @ 20 ma Max. |
| Speed switch adjustment range | 1,000 ~ 10,000 Hz |
| **ENVIRONMENTAL** | |
| Ambient Operating Temperature Range | - 40 ° to 180°F (- 40 ° to + 85 °C) |
| Relative Humidity | up to 95 % |
| All Surface Finishes | Fungus Proof and Corrosion Resistant |
| **INPUT POWER** | |
| Supply | 12 or 24 VDC Battery Systems (Transient and Reverse Voltage Protected)** |
| Polarity | Negative Ground (Case Isolated) |
| Power Consumption | 50 ma continuous plus actuator current |
| Actuator Current Range @ 77 °F (25 °C) -(Inductive Load) | Min.2.5 Amps/ Max. 10 Amps continuous *** |
| Speed Sensor Signal | 0.5 ~ 120 Volts RMS |
| Speed switch relay contacts (N.O. and N.C.) | 10 Amps |
| **RELIABILITY** | |
| Vibration | 1G @ 20 ~ 100 Hz |
| Testing | 100% Functionally Tested |
| **PHYSICAL** | |
| Dimensions | See Outline |
| Weight | 1.8 lbs (820 grams) |
| Mounting | Any Position, Vertical Preferred |

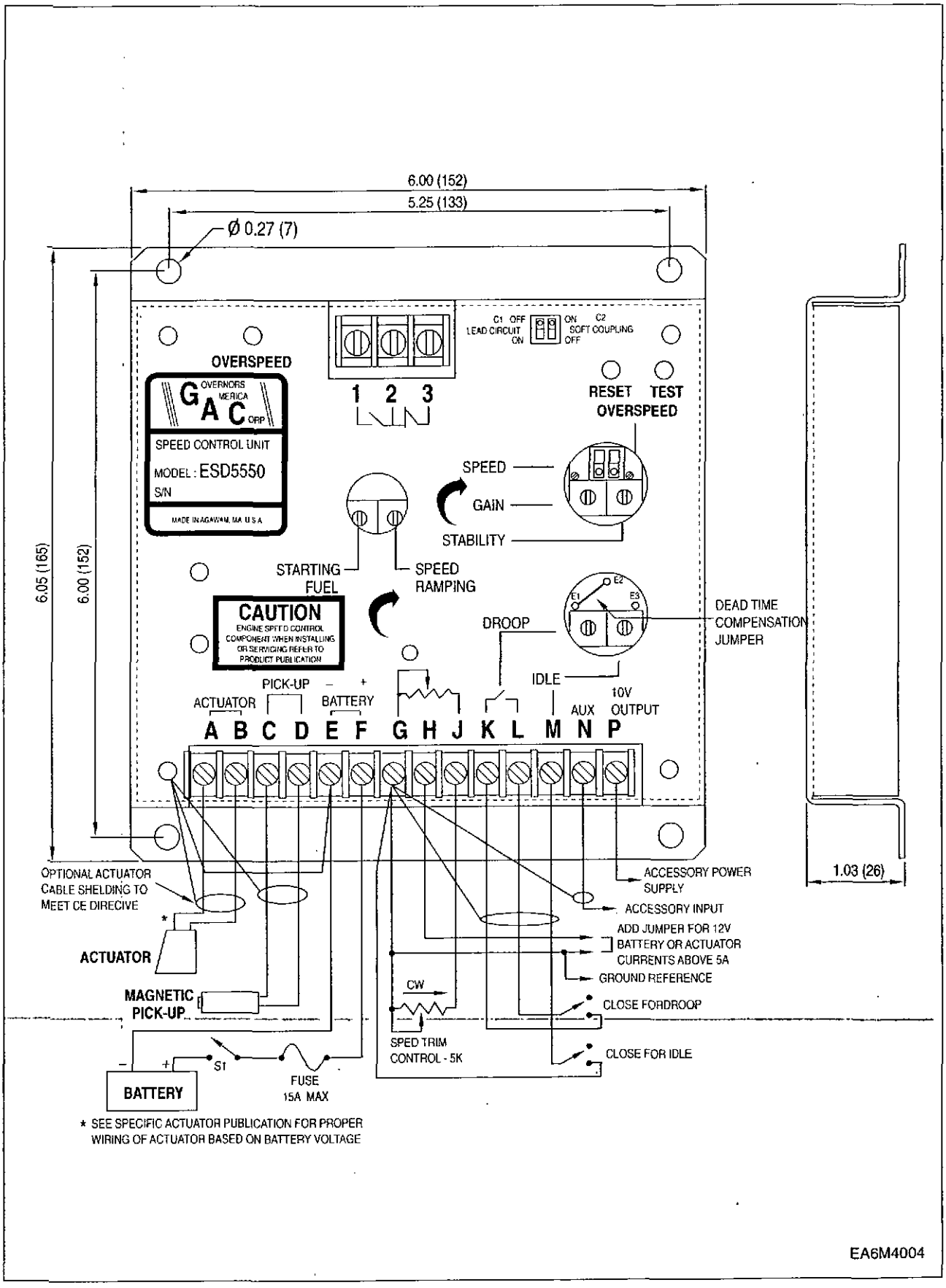
**NOTES :**

** Droop is based on a speed sensor frequency of 4,000 Hz and an actuator current change of 1 amp from no load to full load. Applications with higher speed sensor signals will experience less percentage of droop. Applications with more actuator current change will experience higher percentages of droop. See droop description for specific details on operation of droop ranges.*

*** Protected against reverse voltage by a series diode. A 15 Amp. fuse must be Installed in the positive battery lead,*

**** Protected against short circuit to actuator (shuts off current to actuator), unit automatically turns back on when shorts is removed.*

## 2) Diagram


6.00 (152)
5.25 (133)
Ø 0.27 (7)
6.05 (165)
6.00 (152)
OVERSPEED
GAC GOVERNORS AMERICA CORP
SPEED CONTROL UNIT
MODEL : ESD5550
S/N
MADE IN AGAWAM, MA U.S.A.
1 2 3
C1 OFF LEAD CIRCUIT ON
ON C2 SOFT COUPLING OFF
RESET TEST OVERSPEED
SPEED
GAIN
STABILITY
STARTING FUEL
SPEED RAMPING
CAUTION
ENGINE SPEED CONTROL COMPONENT. WHEN INSTALLING OR SERVICING REFER TO PRODUCT PUBLICATION
DROOP
E1 E2 E3
DEAD TIME COMPENSATION JUMPER
IDLE
PICK-UP
ACTUATOR
BATTERY
10V OUTPUT
AUX
A B C D E F G H J K L M N P
1.03 (26)
OPTIONAL ACTUATOR CABLE SHELDING TO MEET CE DIRECIVE
ACCESSORY POWER SUPPLY
ACCESSORY INPUT
ADD JUMPER FOR 12V BATTERY OR ACTUATOR CURRENTS ABOVE 5A
GROUND REFERENCE
CLOSE FORDROOP
CLOSE FOR IDLE
ACTUATOR
MAGNETIC PICK-UP
CW
SPED TRIM CONTROL - 5K
BATTERY
S1
FUSE 15A MAX
* SEE SPECIFIC ACTUATOR PUBLICATION FOR PROPER WIRING OF ACTUATOR BASED ON BATTERY VOLTAGE
EA6M4004

**NOTE :**

- *If wire leads are longer than 3 meters (10 ft), a shielded cable should be used. Ground shield at one end only.*
- *The speed control unit is rugged enough to be placed in a control cabinet or engine mounted enclosure with other dedicated control equipment. If water, mist, or condensation may come in contact with the controller, it should be mounted vertically. This will allow the fluid to drain away from the speed control unit.*
- *Extremely heat should be avoided.*

**CAUTION :**

*An overspeed shutdown device, independent of the governor system, should be provided to prevent loss of engine control which may cause personal injury or equipment damage. Do not rely exclusively on the governor system electric actuator to prevent overspeed. A secondary shutoff device, such as a fuel solenoid must be used.*

**3) Wiring**

Basic electrical connections are illustrated above. Actuator and battery connections to Terminals A, B, E, and F should be #16 AWG (1.3 $mm^2$) or larger. Long cables require an increased wire size to minimize voltage drops.

The battery positive (+) input, Terminal F, should be fused for 15 amps as illustrated.

Magnetic speed sensor connections to Terminals C and D MUST BE TWISTED AND/OR SHIELDED for their entire length. The speed sensor cable shield should only be connected to terminal D. The shield should be insulated to insure no other part of the shield comes in contact with engine ground, otherwise stray speed signals may be introduced to the speed control unit. With the engine stopped, adjust the gap between the magnetic speed sensor and the ring gear teeth. The gap should not be any smaller than 0.020 in, (0.45 mm). Usually, backing out the speed sensor 3/4 turn after touching the ring gear tooth will achieve a satisfactory air gap. The magnetic speed sensor voltage should be at least 1 VAC RMS during cranking.

**4) System trouble shooting**

- ***System inopertive***

If the engine governing system does not function, the fault may be determined by performing the voltage tests described in Steps 1, 2, 3, and 4. (+) and (-) refer to meter polarity. Should normal values be indicated as a result of following the trouble shooting steps, the fault may be with the actuator or the wiring to the actuator See the actuator publication for testing details.

| Step | Terminals | Normal Reading | Probable Cause Of Abnorma Reading |
|---|---|---|---|
| 1 | F(+) & E(-) | Battery supply voltage (12 or 24 VDC) | 1. DC battery power not connected. Check for blown fuse<br>2. Low battery voltage.<br>3. Wiring error. |
| 2 | C & D | 1.0 VAC RMS min., while cranking | 1. Gap between speed sensor and gear teeth too great. Check gap.<br>2. Improper or defective wiring to the speed sensor. Resistance between terminals C and D should be 30 to 1,200 ohms.<br>3. Defective speed sensor. |
| 3 | P(+) & G(-) | 10 VDC, Internal Supply | 1. Short on terminal P (This will cause a defective unit.)<br>2. Defective Speed Control. |
| 4 | F(+) & A(-) | 1.0~ 2.0 VDC while cranking | 1. SPEED adjustment set too low<br>2. Short/open in actuator wiring.<br>3. Defective speed control.<br>4. Defective actuator. |

- **UNSATISFACTORY PERFORMANCE**

If the governing system functions poorly, perform the following tests.

| Symptom | Test | Probable Fault |
|---|---|---|
| Engine overspeeds | 1. Do not crank. Apply DC power to the governor system | 1. Actuator goes to full fuel. Then, disconnect speed sensor at Terminals C & D. If actuator still at full fuel speed control unit defective. If actuator at minimum fuel position - erroneous speed signal. Check speed sensor data. |
| | 2. Manually hold the engine at the desired running speed. Measure the DC voltage between Terminals A(-) & F(+) on the speed control unit. | 1. If the voltage reading is 1.0 to 2.0 VDC. a) SPEED adjustment set above desired speed. b) Defective speed control unit. |
| | | 2. If the voltage reading is above 2.0 VDC, a) Actuator or linkage binding. |
| | | 3. If the voltage reading is below 1.0 VDC, a) Defective speed control unit. |
| | | 4. Gain set too low. |
| Actuator does not energize fully. | 1. Measure the voltage at the battery while cranking. | 1. If the voltage is less than 7V for a 12V system, or14V for a 24V system, replace the battery if it is weak or undersized. |
| | 2. Momentarily connect Terminals A and F The actuator should move to the full fuel position. | 1. Actuator or battery wiring in error. |
| | | 2. Actuator or linkage binding. |
| | | 3. Defective actuator. |
| | | 4. Fuse opens. Check for short in actuator or actuator wiring harness. |
| Engine remains below desired governed speed. | 1. Measure the actuator output. Terminals A & B, while running under governor control. | 1. If voltage measurement is within approximately 2 volts of the battery supply voltage, then fuel control restricted from reaching full fuel position. Possibly due to interference from the mechanical governor, carburetor spring or linkage alignment. |
| | | 2. Speed setting too low. |

## 4.2. Injection Pump Calibration

### 4.2.1. P158LE Engine

1) Injection pump : 65.11101-7301 (0 402 618 813 BOSCH)
- Model : PE8P120A500/4LS7935 (0 412 628 937)
- Governor : GAC Governor
- Plunger & barrel : 2 418 455 545
- Delivery valve : 2 418 559 045
- Feed pump : FP/KD22P78-2 (0 440 008 152)
- Prestroke : 4.5 ± 0.05mm at 13 ± 1.5mm

2) Nozzle holder assembly : 65.10101-7051 (0 432 131 667)

3) Nozzle : 65.10102-6047 (0 433 171 174)

4) Injection pipe : 65.10301-6053 , 65.10301-6054

5) Injection order : 1 - 5 - 7 - 2 - 6 - 3 - 4 - 8

6) Injection timing : BTDC 16°

| | | | |
|---|---|---|---|
| (A) Test condition for injection pump | Nozzle & Holder Ass'y | 1 688 901 105 | Opening pressure : 208.5 ±1.5 bar |
| | Injection pipe(ID, OD, L) | - | ϕ3.0 x ϕ8.0- 600 mm |
| | Test oil | ISO4113 | Temperature :40 ± 5°C |
| (B) Engine standard parts | Nozzle & holder Ass'y | 65.10101-7051 | Nozzle (4 x ϕ0.40) |
| | | | 285 kg/cm² |
| | Injection pipe(ID, OD, L) | 65.10301-6053<br>65.10301-6054 | ϕ2 x ϕ6 - 650mm |

Rack diagram and setting valve at each point

| | Check point | Rack position (mm) | Pump speed (rpm) | Injection Q'ty on RIG (mm³ / 1,000 st) | | Press. (mmHg) |
|---|---|---|---|---|---|---|
| | | | | (A) Test condition for inj. pump | (B) Engine standard parts | |
| Standby power | A | 12.6 | 700 | 304 ± 3 | - | - |
| | - | - | - | - | - | - |
| | - | - | - | - | - | - |
| | - | - | - | - | - | - |
| | - | - | - | - | - | - |
| | Boost pressure : zero boost | | | | | |

### 4.2.2. P180LE Engine

1) Injection pump : 65.11101-7302 (0 402 619 802 BOSCH)
- Model : PE10P120A500LS7936 (0 412 629 815)
- Governor : GAC Governor
- Plunger & barrel : 2 418 455 545
- Delivery valve : 2 418 559 045
- Feed pump : FP/KD22P80-1 (0 440 008 090)
  FP/KD22P78-2 (0 440 008 152)
- Prestroke : 4.5 ± 0.05mm at 13 ± 1.5mm

2) Nozzle holder assembly : 65.10101-7051 (0 432 131 667)
3) Nozzle : 65.10102-6047 (0 433 171 174)
4) Injection pipe : 65.10301-6055 , 65.10301-6056
5) Injection order : 1 - 6 - 5 - 10 - 2 - 7 - 3 - 8 - 4 - 9
6) Injection timing : BTDC 16°

| | | | |
|---|---|---|---|
| (A) Test condition for injection pump | Nozzle & Holder Ass'y | 1 688 901 105 | Opening pressure : 208.5 ±1.5 bar |
| | Injection pipe(ID, OD, L) | - | ϕ3.0 x ϕ8.0- 600 mm |
| | Test oil | ISO4113 | Temperature :40 ± 5°C |
| (B) Engine standard parts | Nozzle & holder Ass'y | 65.10101-7051 | Nozzle (4 x ϕ0.40) |
| | | | 285 kg/cm² |
| | Injection pipe(ID, OD, L) | 65.10301-6055<br>65.10301-6056 | ϕ2 x ϕ6 - 750mm |

Rack diagram and setting valve at each point

Standby power

| Check point | Rack position (mm) | Pump speed (rpm) | Injection Q'ty on RIG (mm³ / 1,000 st) (A) Test condition for inj. pump | (B) Engine standard parts | Press. (mmHg) |
|---|---|---|---|---|---|
| A | 12.6 | 700 | 304 ± 3 | - | - |
| - | - | - | - | - | - |
| - | - | - | - | - | - |
| - | - | - | - | - | - |
| - | - | - | - | - | - |

Boost pressure : zero boost

### 4.2.3. P222LE Engine

1) Injection pump : 65.11101-7303 (0 402 610 807 BOSCH)
- Model : PE12P120A500LS7937 (0 412 620 854)
- Governor : GAC Governor
- Plunger & barrel : 2 418 455 545
- Delivery valve : 2 418 559 045
- Feed pump : FP/KD22P80-1 (0 440 008 090)
  FP/KD22P78-2 (0 440 008 152)
- Prestroke : 4.5 ±0.05mm at 13 ±1.5mm

(2) Nozzle holder assembly : 65.10101-7051 (0 432 131 667)

(3) Nozzle : 65.10102-6047 (0 433 171 174)

(4) Injection pipe : 65.10301-6057 , 65.10301-6058

(5) Injection order : 1 - 12 - 5 - 8 - 3 - 10 - 6 - 7 - 2 - 11 - 4 -9

(6) Injection timing : BTDC 16°

| | | | |
|---|---|---|---|
| (A) Test condition for injection pump | Nozzle & Holder Ass'y | 1 688 901 105 | Opening pressure : 208.5 ±1.5 bar |
| | Injection pipe(ID, OD, L) | - | ϕ3.0 x ϕ8.0- 600 mm |
| | Test oil | ISO4113 | Temperature :40 ± 5°C |
| (B) Engine standard parts | Nozzle & holder ass'y | 65.10101-7051 | Nozzle (5 x ϕ0.26) |
| | | | 285 kg/cm² |
| | Injection pipe(ID, OD, L) | 65.10301-6057<br>65.10301-6058 | ϕ2 x ϕ6 - 750mm |

Rack diagram and setting valve at each point

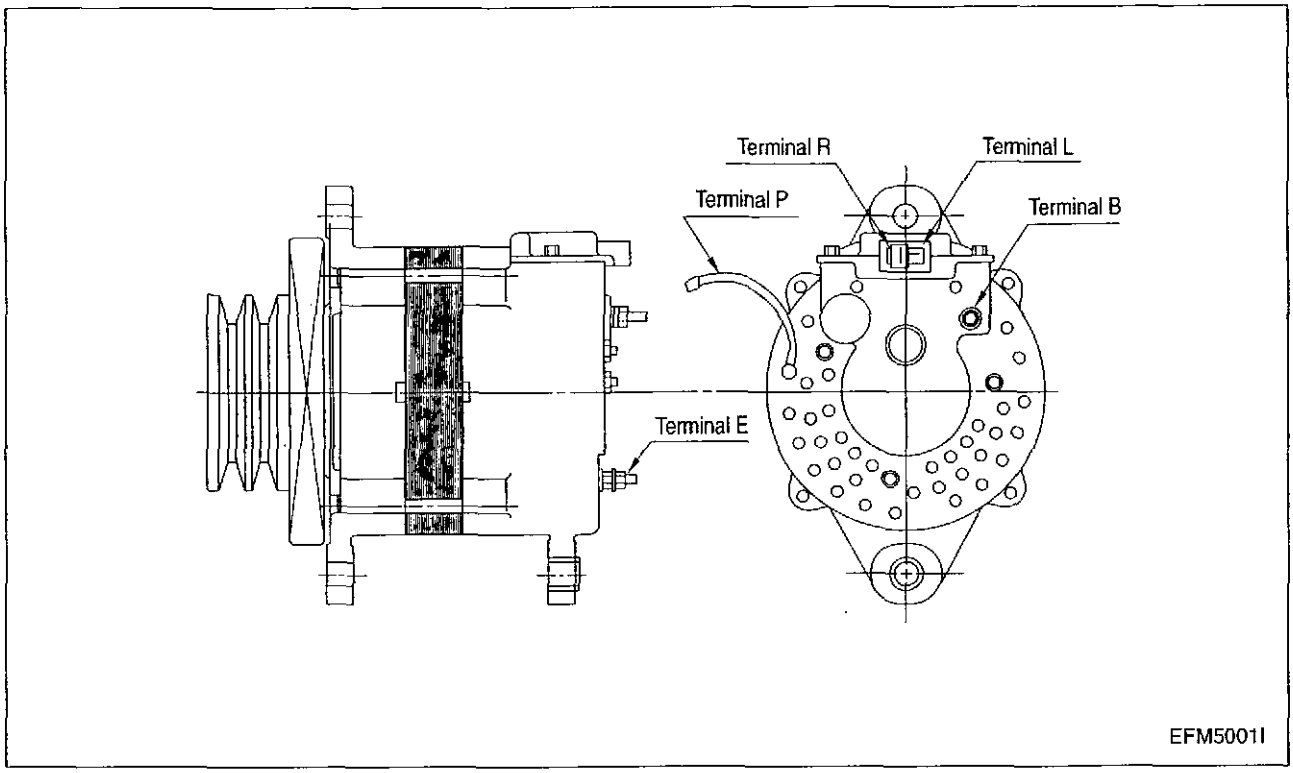
| | Check point | Rack position (mm) | Pump speed (rpm) | Injection Q'ty on RIG (mm³ / 1,000 st) (A) Test condition for inj. pump | (B) Engine standard parts | Press. (mmHg) |
|---|---|---|---|---|---|---|
| Standby power | A | 12.6 | 700 | 304 ± 3 | - | - |
| | - | - | - | - | - | - |
| | - | - | - | - | - | - |
| | - | - | - | - | - | - |
| | - | - | - | - | - | - |

Boost pressure : zero boost

# 5. ELECTRIC SYSTEM

## 5.1. Alternator Inspection Points

### 5.1.1. Structural Drawing (external shape)



## 5.2. Inspection Point

### 5.2.1. In Case of Abnormal Charging

1) Voltage Measurement between Terminal and Body of Alternator During Operation

**<Voltages during operation>**

| Measuring position | Voltage |
|---|---|
| Terminal B - Body | about DC38V ~ 29V |
| Terminal L - Body | about DC38V ~ 29V |
| Terminal R - Body | about DC38V ~ 29V |

**<Voltages during stop>**

| Measuring position | Voltage |
|---|---|
| Terminal B - Body | about DC24V |
| Terminal L - Body | about DC24V |
| Terminal R - Body | about DC24V |

❖ For the confirmation of wiring state, measurement of voltages is needed only at the terminals even during stop.

2) Inspection Points on the Voltage Regulator

**<Resistance value between voltage regulator's terminals>**

| Terminal | | Resistance Value | | Terminal (KΩ) | | Resistance Value (KΩ) |
|---|---|---|---|---|---|---|
| + | - | | | + | - | |
| L | E | about 2 | | | | |
| R | E | about 53 | | E | R | ∞ |
| F | E | about 50 | | | | |
| L | F | about 50 | | | | |
| H | L | about 50 | | L | R | ∞ |
| R | F | about 168 | | F | R | ∞ |

### 5.2.2. Precautions in Use

- For battery voltages drop when they are left for long time even without use, care should be paid.
- In cold winter season, for the starting may not be done well sometime, do not try unreasonably but try to start several times dividedly.
- Prior to operating the gauge panel, make sure the polarity of battery once again (In majority of polarities, red side is + and black one is -)
- For disassembly of gauge panel accompanies a risk of electrical shock, always work after pulling off the connector at rear side without fail
- If the silver paper etc is used for connecting the blown fuse, because the excessive current might flow into the parts to damage, when fuse is blown, after resolving the problem locating the cause, replace it with new fuse.

- Since battery has a danger of explosion by a heat, it must not be placed at the spot where generates a lot of heat.
- When engine is in stop, pull out the key always. Thus, a hazard of fire or wound due to wrong operation may not happen.
- In case of scrapping the batteries, observe the followings.

**NOTE :** *Do not throw it in the fire to scrap.*
*It should not be thrown away into the places where are liable to cause the environmental pollution such as stream, river and mountain. Pack them as far as possible and dispose it as rubbish that is unable to use again.*

- This company will not be responsible to the problems that might be raised by the disassembling and structural change of this product without consultation.

### 5.2.3. Diagnosis and Remedies of Trouble Causes

Prior to asking for repair, please check the following items

| Generated Problem | Inspection Items | Inspecting Position |
|---|---|---|
| Starting failure, starting motor not rotate | –Confirm connector that connects electric wiring to gauge panel if it is correctly connected<br>–Confirm connection of electric wiring and batteries if it is connected correctly.<br>–Confirm connection of electric wiring and starting motor if it is connected correctly. | Backward of gauge panel<br>Battery terminal<br>Starting motor terminal |
| Starting motor rotates but starting fail | –Make sure that fuel quantity is sufficient. | Fuel tank |
| Engine revolution meter not operates | –Confirm connector that connects wiring and gauge panel if it is correctly connected.<br>–Check if terminal resistance of tacho sensor is pulled out | Backward of gauge panel<br>Tacho sensor terminal |
| Cooling water temp. gauge fails | –Confirm connector that connects wiring and gauge panel if it is correctly connected.<br>–Confirm connector of cooling temp sensor if it is correctly connected. | Backward of gauge panel<br>Cooling water pipe |
| Engine oil pressure gauge not operate | –Confirm connector that is connected to engine oil pressure sensing sensor if it is pulled out. | Side of oil filter |
| Charging abnormality warning lamp lights continuously | –Confirm that the electric wiring terminal that is connected to generator's L terminal if it is pulled out and touched to engine body. | Alternator terminal |
| Though engine stopped, engine revolution meter works continuously | –Characteristics of engine revolution meter is so designed that it may slowly drop down, and so it's not trouble. | Starting key |
| Cooling water temp. gauge and engine revolution meter not operate simultaneously. | –Confirm if the present position of start switch is at ACC.<br>–For power source of gauge panel goes from starting key, if the start key is at OFF, though engine is running, gauge panel does not move.<br>–Confirm connector that connects wiring and gauge panel if it is correctly connected.<br>–Confirm if connector that connected to solenoid and wiring is pulled out. | backward of gauge panel |
| Though engine switch is pushed, it does not stall. | –Confirm if the cable that connects GAC governor and injection pump is cut. | GAC governor |

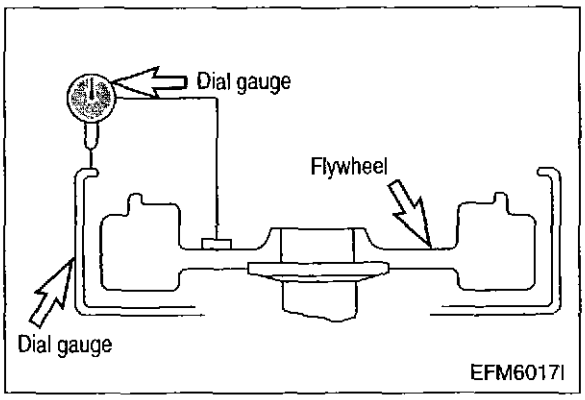
## 5.3. Inspection Prior to Installation

### 5.3.1. Inspection Prior to Installation

Measure the correctness of flywheel and flywheel housing. Prior to inspection, clean the flywheel and flywheel housing.

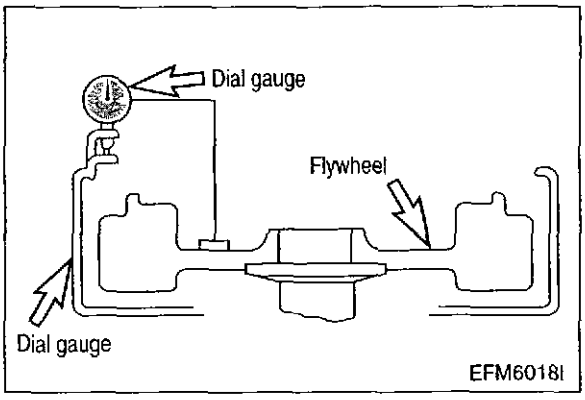
**1) Measuring flywheel housing**

Measure the flywheel housing surface and install the dial gauge (1/1,000) at the flywheel so as to be vertical to the flywheel housing, and let the gauge stem to contact to the flange. Rotate the flywheel, and measure the surface error of flywheel housing flange. The surface error should not exceed 0.2mm.



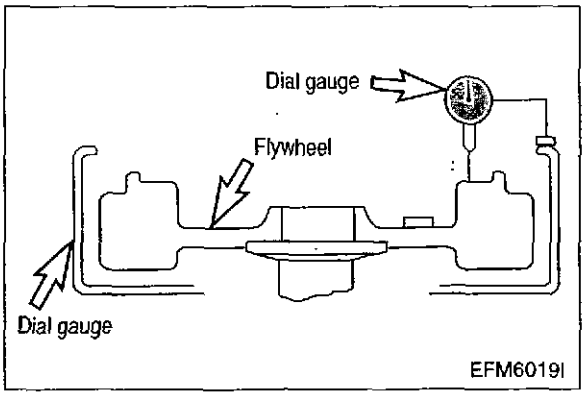

**2) Measuring bore of flywheel**

Housing Attach the gauge as above so that the gauge stem may contact the flywheel housing bore as the right figure. Measure the eccentrics of flywheel housing bore by rotating the flywheel. The eccentrics should not exceed 0.2 mm.



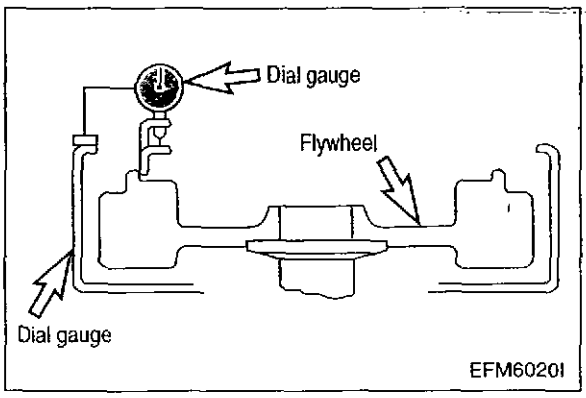

**3) Measuring deformation of flywheel Installing Surface**

Fix the dial gauge to the flywheel housing so as for the gauge stem to be vertical to the surface to be installed. The deviation quantity should not exceed 0.127 mm/inch.




**4) Measuring pilot bore of flywheel**

Install the gauge as below so as for the gauge stem to contact to the pilot bore of the surface to be installed. The eccentrics of the pilot bore of flywheel should not exceed 0.127mm at maximum.



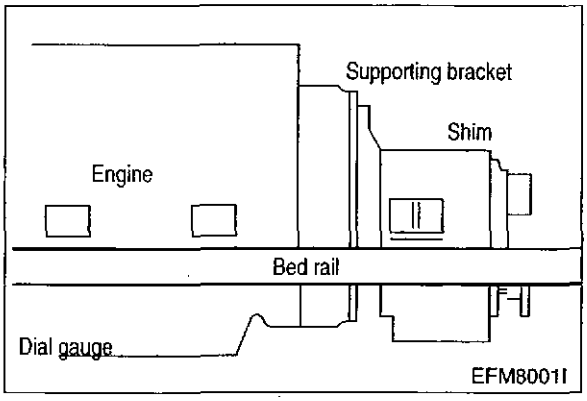
# 6. INSTALLATION

## 6.1. Installing

The center alignment of engine and Generator set is the most important factor for the extension of performance and life. Although aligning the center perfectly and accurately requires only few minutes, it is able to prevent unnecessary mechanical trouble at the future.

**1) Bed rail**

At the installation of Generator set's bed rail, use steel, If the bed rail is strong enough, the center alignment of engine with Generator gets worse so that the excessive vibration may occur.




**2) Supporting**

As in the engine installation, the supporting brackets are used even at the installation of Generator.

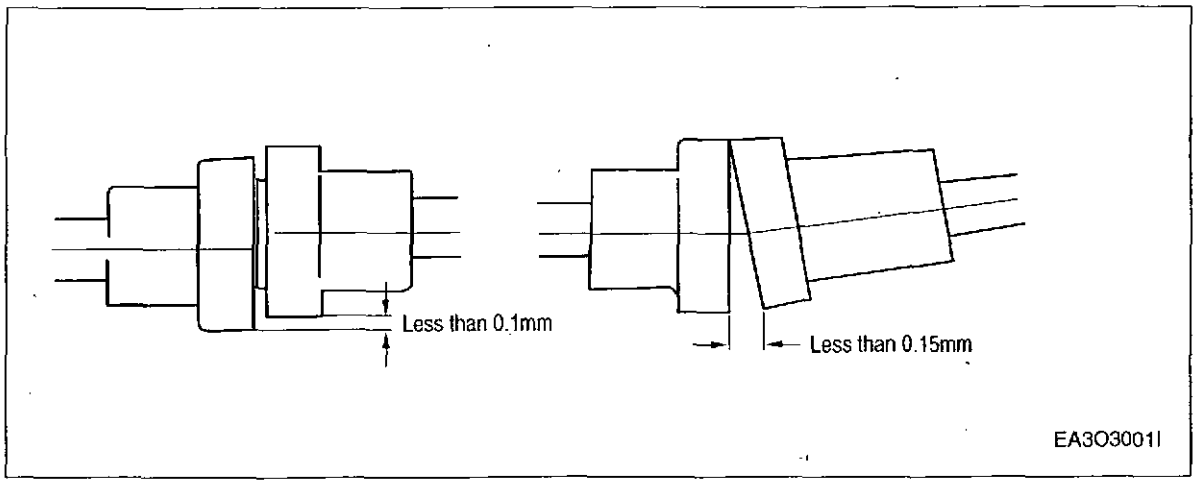
The bracket must be solidly fixed at the Generator installing platform and the bed rail.

**3) Aligning center**

The center alignment of engine and Generator is the most important factor for the extension of life cycle.

- Output shaft flange and opponent side flange of Generator should be aligned in their centers horizontal and parallel direction
- The adjustment between flange surfaces at the lower part should maintain less than 0.15 mm when the upper part's surfaces just meet and the deviation around the circumference should be maintained within 0.1 mm as following figure.

| | |
|---|---|
| Surface (TIR) | Less than 0.15 mm |
| Center (TIR) | Less than 0.1 mm |

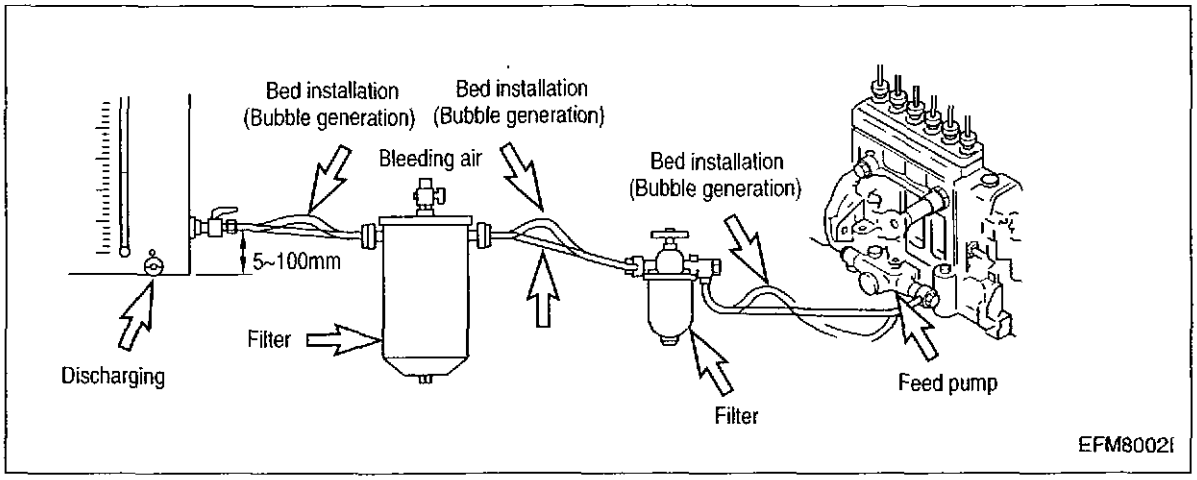



For bed rail is apt to deform for 6 months after initial performance, adjusting the center should be checked after 1 ~ 2 months.

## 6.2. Installing Fuel System

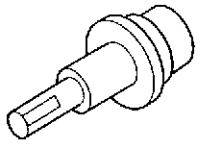
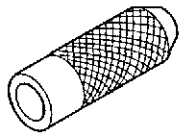
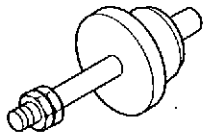
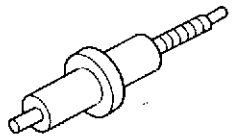
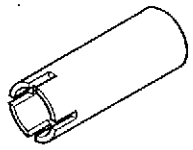
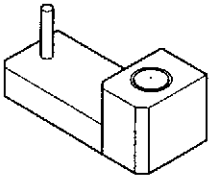
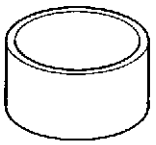
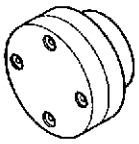
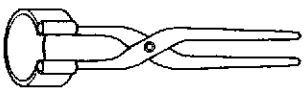
Oil purifier should be installed between fuel tank and engine. For tank is always surrounded with humidity, water part often Infiltrates into fuel and then engine to result in the nozzle stuck and engine efficiency drop etc.

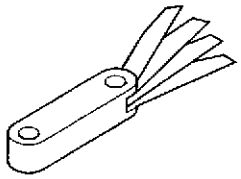
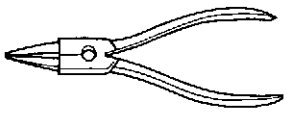
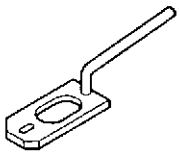
- **Example of fuel system installation**




The position of fuel tank should be high than the engine fuel pump but when it is compelled to install at lower position, its lift should be within 1 m, and the fuel pipe be straight in order to prevent air bubble generation.

## 7. Special Tool List

| No. | Part No. | Figure | Tool Name |
|---|---|---|---|
| 1 | EF.120-029 |  | Oil seal insert Assembly (RR) |
| 2 | EF.120-183 |  | Valve stern oil seal installer |
| 3 | EI.00308-0084 |  | Nozzle holder extractor |
| 4 | EU.2-0532 |  | Compression gauge adapter |
| 5 | EI.03004-0225 |  | Nozzle plug socket |
| 6 | EF.120-189 |  | Injection pump alignment |
| 7 | EF.120-031 |  | Piston sleeve |
| 8 | EF.120-028 |  | Liner assembly |
| 9 | T7621010E |  | Piston ring plier |

| No. | Part No. | Figure | Tool Name |
|---|---|---|---|
| 10 | 60.99901-0027 |  | Feeler gauge |
| 11 | T7610001E |  | Snap ring plier |
| 12 | EI.00308-0084 |  | Valve cotter extracotr |

# APPENDIX

- **Standard table of tightening torque**

| Specification | Screw | Strength | Tightening Torque kg•m |
|---|---|---|---|
| Cylinder block bearing cap | | 12.9 | Initial 30 kg•m + rotating angle 90° |
| - main bolt | M18 x 2 | 10.9 | 8 |
| - side bolt | M12 x 1.5 | | |
| Flywheel housing | | | |
| - tightening bolt | M12 x 1.5 | 10.9 | 10 |
| | M10 | 12.9 | 7.5 |
| - cover bolt | M8 | 8.8 | 2.2 |
| Counter weight | M16 x 1.5 | 10.9 | Initial 10 kg•m + rotating angle 90° |
| Crant pulley | M16 x 1.5 | 10.9 | 21 |
| Vibration damper | M10 | 10.9 | 6 |
| Flywheel | M16 x 1.5 | 12.9 | 26 |
| Cooling fan | M8 | 8.8 | 2.2 |
| Connecting rod cap | M16 x 1.5 | 10.9 | Initial 10 kg•m + rotating angle 90° |
| Cylinder head | M15 x 2 | 12.9 | 8kg•m + 15kg•m + Angle 90° + Angle 90° |
| Cylinder head cover | M8 | 8.8 | 2.2 |
| Fuel injection nozzle holder | M28 | CK60 | 7 ±0.5 |
| Fuel injection pipe | M14 x 1.5 | | 2.5 |
| Cam shaft timer | M10 | 10.9 | 9 |
| Rocker arm bracket | M10 | 10.9 | 6.5 |
| Lock nut (adjusting screw) | M12 x 1 | 8.8 | 5 |
| Oil pump cover | M8 | 8.8 | 2.2 |
| Oil pump | M8 | 8.8 | 2.2 |
| Oil cooler | M12 | 10.9 | 5 |
| Oil pan | M8 | 8.8 | 2.2 |
| Oil pan plug | M26 x 1.5 | | 8 |
| Exhaust manifold | M10 | 10.9 | 5.0 |
| Intake manifold | M8 | 8.8 | 2.2 |
| Fuel injection pump(cylinder block) | M10 | 10.9 | 6.5 |
| Fuel filter | M12 x 1.5 | 8.8 | 8 |
| Starting motor | M12 x 1.5 | 8 | 8 |
| Alternator bracket | M14 | 8.8 | 12 |

| Specification | Screw | Strength | Tightening Torque kg•m |
|---|---|---|---|
| Oil pressure switch | PT1/8 | | 2 |
| Water temperature switch | M14 | 8.8 | 2 |
| Plug screw | M12 x 1.5 | | 5 |
| | M14 x 1.5 | | 8 |
| | M16 x 1.5 | | 8 |
| | M18 x 1.5 | | 10 |
| | M22 x 1.5 | | 10 |
| | M24 x 1.5 | | 12 |
| | M26 x 1.5 | | 12 |
| | M30 x 1.5 | | 15 |
| | AM10 x 1.0 | | 5 |
| | AM14 x 1.5 | | 8 |

| Items | | D28 series | Remarks |
|---|---|---|---|
| Crank shaft | Main bearing journal's roundness | 0.01 | |
| | Main bearing journal's parallelness | 0.005 | |
| | *Medium main bearing journal's shake* | *0.06* | *no 1, no 5 support* |
| | Wear ring press in part's journal diameter | ϕ99.985 ~ ϕ100.020 | ϕ100 j7 |
| | Wear ring's inside diameter | ϕ99.907 ~ ϕ99.942 | ϕ100 S7 |
| | Overlap | 0.043 ~ 0.113 | |
| | Thrust bearing width | | |
| | Standard | 37.74 ~ 37.81 | |
| | Oversize | 38.24 ~ 38.31 | |
| | Oversize | 38.74 ~ 38.81 | |
| | Crankshaft's axial direction's clearance | 0.190 ~ 0.322 | |
| | Main bearing thickness | | |
| | Standard | 3.460 ~ 3.472 | |
| | Oversize 0.10 | 3.510 ~ 3.522 | |
| | Oversize 0.25 | 3.585 ~ 3.597 | |
| | Oversize 0.50 | 3.710 ~ 3.722 | |
| | Oversize 0.75 | 3.835 ~ 3.847 | |
| | Oversize 1.00 | 3.960 ~ 3.972 | |
| | Main bearing oil gap | 0.066 ~ 0.132 | |
| | Main bearing spread | 0.3 ~ 1.2 | |
| | Thrust bearing's spread | 0.3 ~ 1.2 | |
| Flywheel | Ring Gear assembly part's Outside diameter | ϕ432.490 ~ ϕ432.645 | |
| | Ring gear inside diameter | ϕ432.000 ~ ϕ432.155 | |
| | Overlap | 0.335 ~ 0.645 | |
| | Heat fitting temp. ((C) | 200 ~ 230 | |
| | *Allowable shaking amount after assembly* | *0.5* | |
| | Outside diameter after reassembly used ring | ϕ114.980 ~ ϕ115.015 | |
| Cylinder head & valve | Head gasket thickness (after tightening bolts) | 1.205 ~ 1.295 | |
| | Cylinder head height | 113.9 ~ 114.0 | |
| | Cylinder head seal surface roughness | Max 16μ | |
| | Valve projecting amount | - 0.65 ~ - 0.95 | |
| | Exhaust valve | | |
| | Stem diameter | ϕ11.945 ~ ϕ11.955 | |
| | Radius direction clearance | 0.045 ~ 0.073 | |
| | Seat angle | 45° | |

| Items | | D28 series | Remarks |
|---|---|---|---|
| | Head diameter | ϕ50.9 ~ ϕ51.1 | |
| | "H" thickness of valve head | 1.9 ~ 2.3 | |
| | Valve seat part diameter of head | ϕ53.00 ~ ϕ53.03 | |
| | Outside diameter of valve seat | ϕ53.10 ~ ϕ53.11 | |
| Cylinder | Intake valve | | |
| head | Stem diameter | ϕ11.969 ~ ϕ11.980 | |
| & valve | Radius direction clearance | 0.020 ~ 0.049 | |
| | Seat angle | 30° | |
| | Head diameter | ϕ57.85 ~ ϕ58.15 | |
| | "H" thickness of valve head | 2.6 ~ 3.0 | |
| | Valve seat part diameter of head | ϕ61.00 ~ ϕ61.03 | ϕ61 H7 |
| | Outside dia. of valve seat | ϕ61.10 ~ ϕ61.11 | |
| | Depth of head's valve seat assembly part | 12.5 ~ 12.6 | |
| | Valve guide inside diameter | ϕ12.000 ~ ϕ12.018 | ϕ12 H7 |
| | Valve guide's inside diameter of head | ϕ18.000 ~ ϕ18.018 | ϕ18 H7 |
| | Valve guide's outside diameter | ϕ18.028 ~ ϕ18.046 | ϕ18.25 S7 |
| | Valve guide assembly locking piece | 0.010 ~ 0.046 | |
| | Valve seat's shaking | 0.04 | reference to valve guide |
| Valve | Valve lift | 14.1 | |
| | Projecting amount of valve guide | 17.1 ~ 17.5 | Above valve spring |
| | Free length of inside spring | 72.43 | |
| | Spring load of inside spring | 15 ~ 17kg | at 46.3mm |
| | Spring load of inside spring | 27 ~ 32kg | at 32.3mm |
| | Free length of outside spring | 68.17 | |
| | Spring load of outside spring | 37 ~ 41kg | at 46.3mm |
| | Spring load of outside spring | 66.5 ~ 76.5kg | at32.8mm |
| Timing | Rocker arm bush's inside diameter | ϕ25.005 ~ ϕ25.035 | when assembled |
| | Rocker arm bearing journal's diameter | ϕ24.967 ~ ϕ24.990 | |
| | Bearing's clearance | 0.015 ~ 0.068 | |
| | Push rod's shaking | 0.3 | |
| | Valve tappet ass'y part's inside dia. of block | ϕ20.000 ~ ϕ20.021 | ϕ20 H7 |
| | Push rod's outside diameter | ϕ19.944 ~ ϕ19.965 | |
| | Tappet clearance | 0.035 ~ 0.077 | |

| Items | | D28 series | Remarks |
|---|---|---|---|
| Timing | Bush assembly's inside diameter of block | ϕ70.077 ~ ϕ70.061 | |
| | Camshaft diameter | ϕ69.910 ~ ϕ69.940 | ϕ70 e7 |
| | Camshaft bearing oil gap | 0.060 ~ 0.120 | |
| | Camshaft axial direction play | 0.20 ~ 0.90 | |
| | Backlash (crank gear-camshaft gear) | 0.118 ~ 0.242 | |
| | Backlash (driving gear - injection pump gear) | 0.102 ~ 0.338 | |
| | Intake valve clearance | 0.25 | |
| | Exhaust valve clearance | 0.35 | |
| Engine lubricating system | Oil pressure at idling | 0.9 ~ 3.0bar | |
| | Oil pressure at rated speed operation | 3.0 ~6.5bar | |
| | Oil temperature | less than 100°C | |
| | Instantaneous allowable temperature | max. 110°C | |
| | Bypass valve opening pressure | 1.8 ~ 2.4bar | |
| | Pressure regulating valve of oil pump | 8.5 ~10bar | |
| | Spray nozzle | | |
| | Operating pressure | 1.6 ~ 1.9bar | |
| | Crossing pressure | 1.3 ~ 1.6bar | |
| | Tip diameter | ϕ2 | |
| | Backlash (crankshaft gear-oil pump drive gear) | 0.10 ~0.45 | |
| | Oil pump housing's depth/gear width | 43.000 ~ 43.039 | 43 H8 |
| | | 42.910 ~ 42.950 | 43 e8 |
| | Oil pump housing axial play | 0.050 ~ 0.128 | |
| Engine cooling system | Cooling water pump shaft diameter | ϕ21.930 ~ ϕ21.950 | |
| | Bearing gap | 0.050 ~ 0.091 | |
| | Impeller clearance (impeller - body) | 1.0 ~ 1.5 | |
| | Thermostat Operating temperature (°C) | 79°C | |
| Inspection on compressed pressure | Good | above 28bar | |
| | Possible to use | 25 ~ 28bar | |
| | Need up keep | bellow 24bar | |
| | Allowable max pressure difference between cylinders | 4bar | |
| Fuel system | Overflow valve's operating pressure of injection pump | 1.3 ~ 1.8bar | |
| | Mode of fuel injection pump | Bosch | |
| | Governor model | GAC electronic | |
| | Injection nozzle's manufacture | Bosch | |
| | Injection nozzle hole's diameter | 4 - ϕ0.40 | |

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