

# ENGINE SERVICE MANUAL

## Engines:

A1000 - Branson 2200

A1100 - Branson 2500

A1100T - Branson 2900

## 1. ENGINE APPEARANCE, SPECIFICATION AND NAMES OF PARTS

### 1.1. ENGINE APPEARANCE

#### 1.1.1. Natural Aspirated E/G and Turbo engine



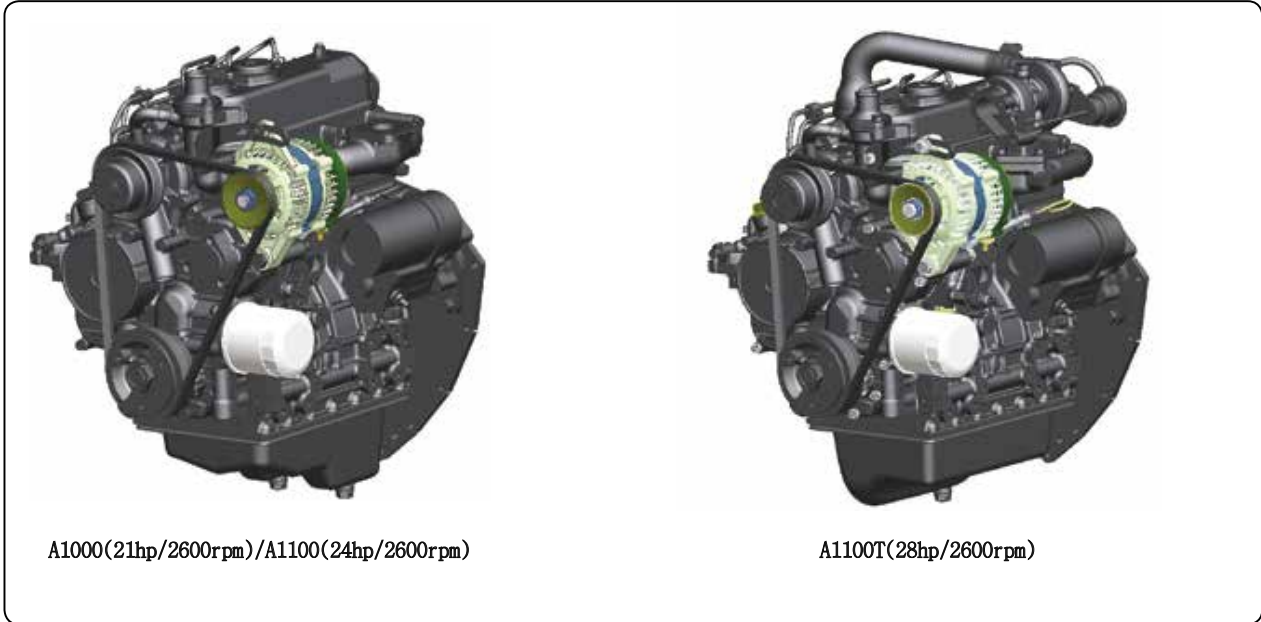
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1.1.2. TURBO CHARGER ENGINE

1.2. Engine specification

1.2.1. Small engines

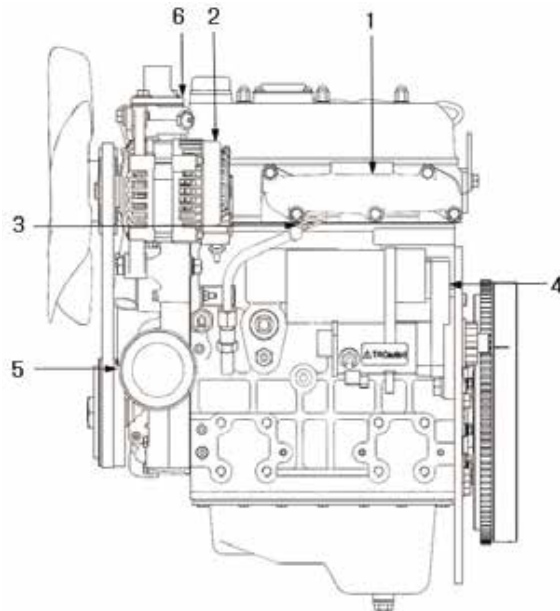


Engine MODEL		단위/Unit	A1000	A1100	A1100T
Type			Vertical Water-Cooled 4Cycle Diesel Engine		
No. of Cylinders			3	3	3
Bore×Stroke		mm	74×82	78×82	78×82
Displacement		cc	1,056	1,175	1,175
Combustion System			Swirl chamber system		
Intake System			Natural Aspirated	Turbo Charger	
Direction of Rotation			CCW from Flywheel Side		
Cooling System			Pressurized Radiator		
Lubricant Capacity	Full capacity	ℓ	2.9	2.9	3
	Valid capacity	ℓ	1.6	1.6	1.8
Starter Capacity		V-kW	12 – 2.2		
Alternator		V-A	12 – 45		
Dimension(L×W×H)		mm	487×414×612		494×417×655
Dry Weight		kg	115	115	120

※ These specification may change for improvements without notice.

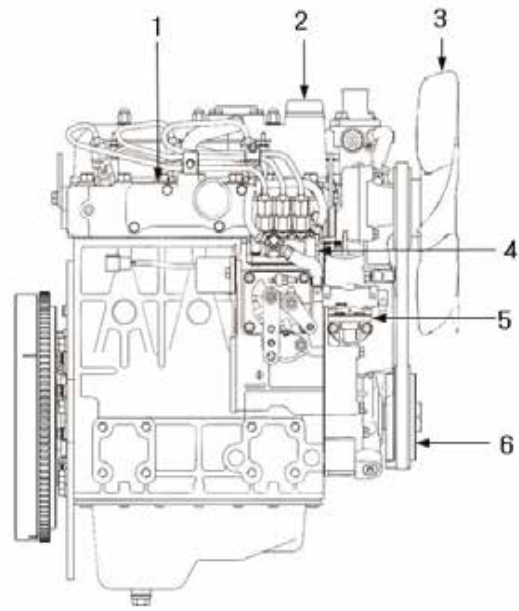
### 1.3. NAMES OF PARTS

These diagrams are to show external parts, filter and for maintenance. Some of the parts may be different depending on engines.



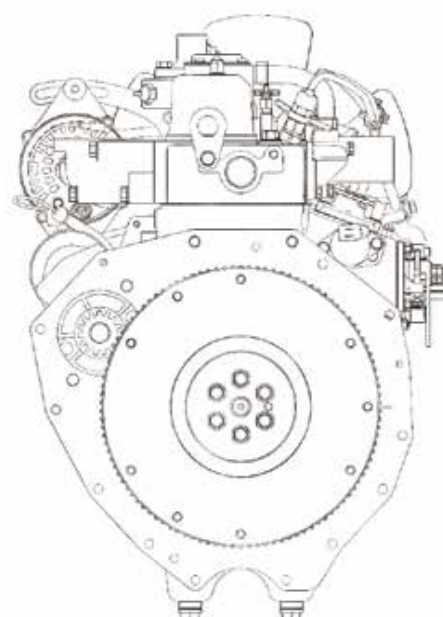
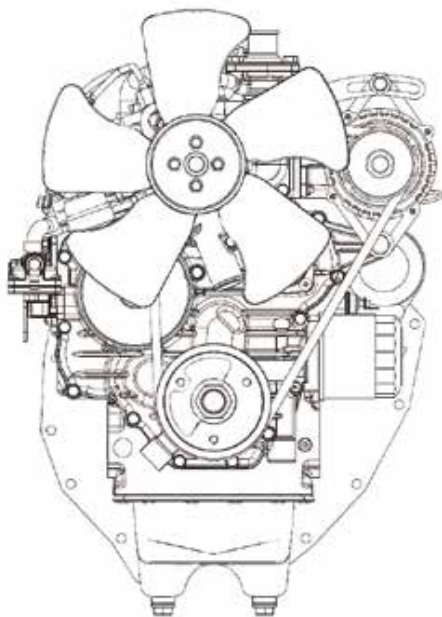
Exhaust side  
(for Natural Aspirated E/G)

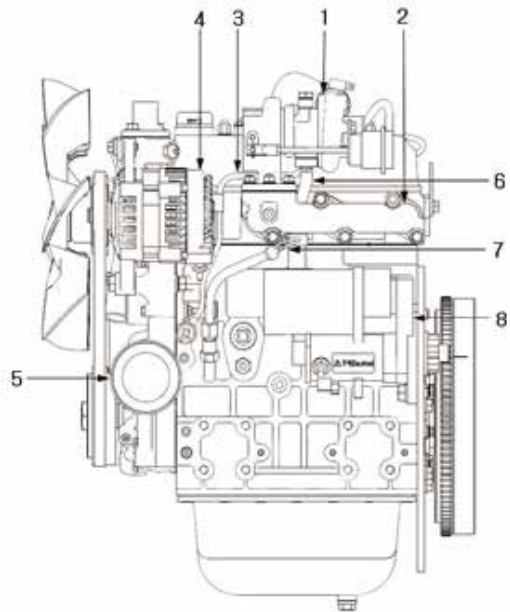
- 1. Exhaust manifold
- 2. Generator
- 3. Oil dipstick
- 4. Starter motor
- 5. Oil filter
- 6. Coolant pump



Intake side  
(for Natural Aspirated E/G)

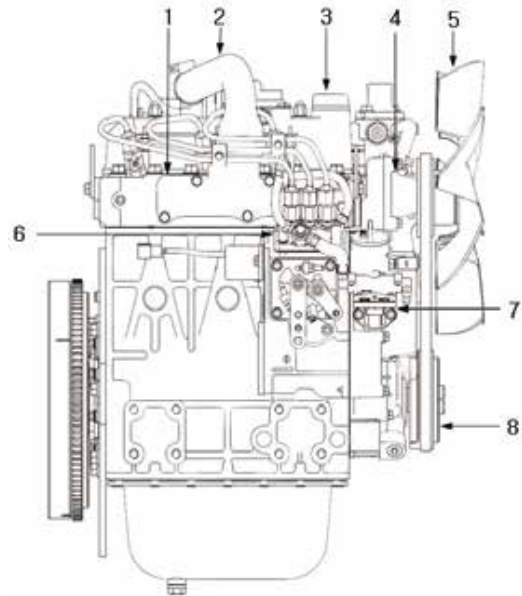
- 1. Intake manifold
- 2. Oil inlet
- 3. Cooling fan
- 4. Fuel injection pump
- 5. Feed pump
- 6. Crank-axis pulley





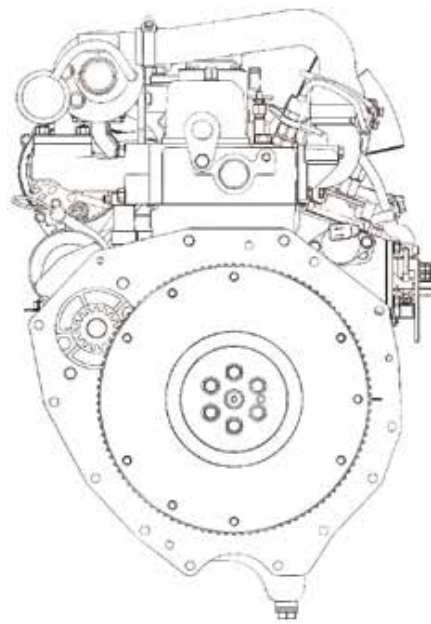
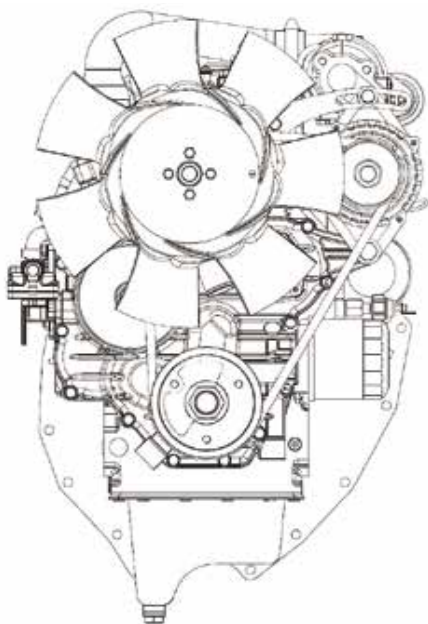
Exhaust side  
(for turbo charger)

- 1. Turbo charger
- 2. Exhaust manifold
- 3. Turbo lubricant pipe (IN)
- 4. Generator
- 5. Oil filter
- 6. Turbo lubricant pipe(OUT)
- 7. Oil dipstick
- 8. Starter motor



Intake side  
(for turbo charger)

- 1. Intake manifold
- 2. Intake hose
- 3. Oil inlet
- 4. Coolant pump
- 5. Cooling fan
- 6. Fuel injection pump
- 7. Feed pump
- 8. Crank-axis pulley



## 2. MAIN FUNCTIONALITY CHECKS AND REGULAR INSPECTIONS

### 2.1. REGULAR INSPECTION LIST

Regular inspections are very important to main the best engine condition. Please adhere to the inspection list shown below for inspection details and periods.

Category	Item	Inspection	every 50 hrs	every 250 hrs	every 500 hrs	1000 hrs. or 1 year	2000 hrs. Or 2 years
Fuel related	Check & add fuel	○					
	Fuel tank cleaning		○				
	Check fuel filter & coolant hose	○					
	Fuel filter de-oiler oil drain		○				
	Fuel filter (element) change				◎		
	Fuel injection valve	Check & adjust pressure					●
	Fuel injection pump	Injection timing adjustment					●
Lubricant related	Check engine oil amount	○					
	Engine oil change		◎ (initial)	◎			
	Oil filter change		◎ (initial)	◎			
Coolant related	Check coolant amount	○					
	Check radiator for blocking	○		○			
	Coolant change				◎		
	Fan belt tension adjust		○ (initial)	○			
	Coolant tubing cleaning, inspection & maintenance						●
	Fuel & coolant pipe inspection & change	○					●
Intake related	Air cleaner cleaning, element change			○	◎		
	Turbo charger blower cleaning					●	
Engine parts	Bolt retightening						● (retightening)
	Valve gap adjustment					●	
	Intake valve wrapping						●
Electrical devices	Warning lights inspection	○					
	Battery fluid check		○				

※ ○: customer inspection/ ◎: part replacement /●: inspection at authorized shop

# MEMO

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## 2.2. MAIN FUNCTIONALITY CHECKS

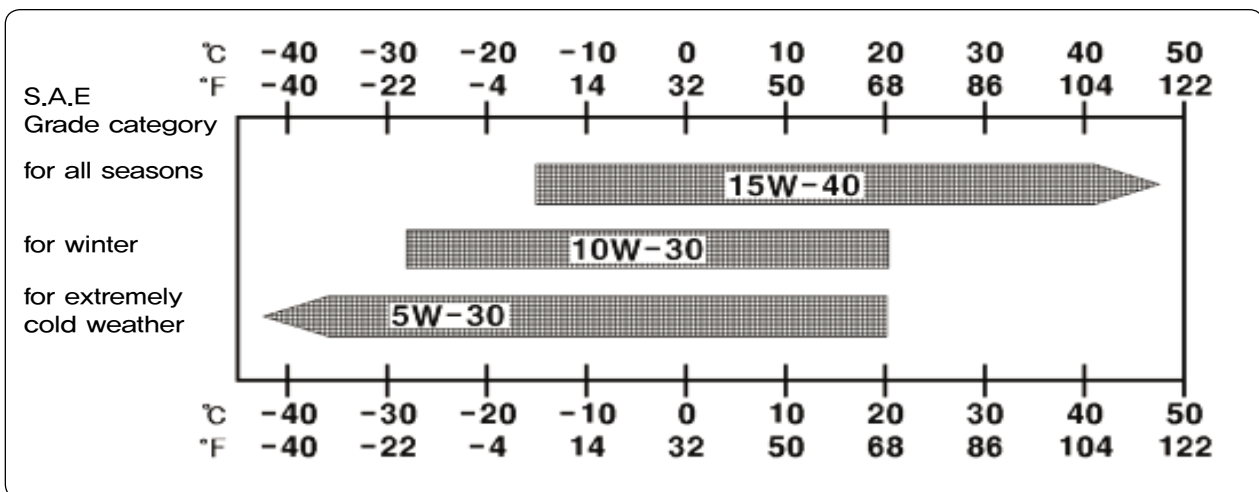
- Main functionality checks are the best for the performance and longevity of the engine.  
Please pay attention to the followings for the engine maintenance.

### 2.2.1. Visual inspections while in use

- Visual inspections around the engine: Check for oil or water leaks of fuel, lubricant and coolant.  
Please check each hoses and V-belt. Check the tightness of climp.  
Check for damaged parts or loose bolts and nuts.
- If any abnormality is found in visual inspection, please repair prior to using it again.

### 2.2.2. Engine oil

- Please make sure to use proper engine oil since diesel engines usually operate under worse conditions that gasoline engines.
- Using low grade engine oil or regular engine oil change is not done, it will be causes for rapid wear and tear or short engine life.
- Please use engine oil of SAE 10W-30 and API CD grade or better.  
※ Please refer to diagram below for proper oil selection.



- Check the oil level with the oil level gage. It is normal if the oil level is between “H(high)” and “L(low)” of the oil dipstick.  
Add oil into the inlet if oil is insufficient. Check for contamination and viscosity to determine to change.

- 1) Stop the engine before the oil inspection.
- 2) Check before starting the engine. Please wait three minutes, if checking after driving.
- 3) Check for oil level again in five to six minutes after adding engine oil.

- Please change oil and oil filter after first 50 hours of operation and every 250 hours thereafter.  
If the engine is being operated in exceptionally dusty area, check more frequently and change engine oil and filter.

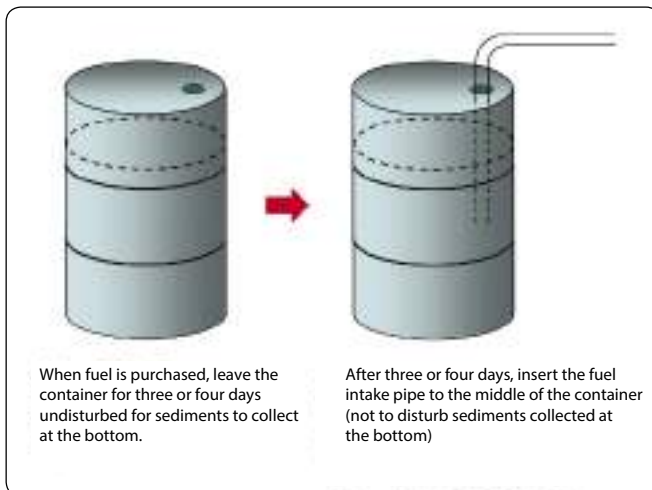


### 2.2.3. FUEL

- The property of fuel for diesel engine (cetane number, specific gravity, viscosity and etc.) influences the engine starting, output power, fuel consumption, fuel system performance, knocking or exhaust gas. Please use 45 or higher cetane number. Be sure to use lower viscosity fuel in low temperature.

- Always use clean fuel since fuel containing excessive moisture and dust may cause serious failure.

1) Please leave the fuel container for three or four days without disturbance for sediments to collect at the bottom. Insert the fuel intake pipe to the middle of the fuel container to use fuel in the midsection of the container.



2) Check the integrated filter for sediments of water or foreign matters. If there is any, drain the sediments completely through the drain valve at the bottom.

- Fuel filter change: Change every 500 hours.  
If there is excessive moisture or dust, change more often.

- Air vent: The fuel system consists of fuel filter, fuel injection pump and pressurized pump. The fuel is provided through the fuel system to fuel injection valve. If there is air within the fuel system, fuel injection will not work. Please vent air as the following.

1) Open the air vent bolt located on upper part of the fuel filter and wait until no more air bubble is present. Place absorbent fabric around the air vent bolt to prevent fuel leak.

2) If there is no air in the fuel, tighten the air vent bolt.

3) Continue pushing until the pump is very tight.

4) Check for fuel leaks.



**WARNING : Do not leave flammable or smoke cigarette around the engine.**

#### 2.2.4. COOLANT

- Use soft water such as tap water for the coolant. Hard water such as well water may leave deposits in the cooling system which may cause the piston scorching due to decreased cooling effect and hot coolant temperature. Use anticorrosive in summer to prevent rusting and antifreeze in winter to prevent freezing.

- Coolant change: Change every 500 hours or 2 years.

Contaminated coolant may cause the piston scorching due to decreased cooling effect and hot coolant temperature.

- Check the amount of coolant in the secondary tank before starting the engine. Check the amount of coolant in the radiator at least once every week.

Insufficient coolant may cause the piston scorching due to decreased cooling effect and hot coolant temperature.

#### 2.2.5. V-BELT

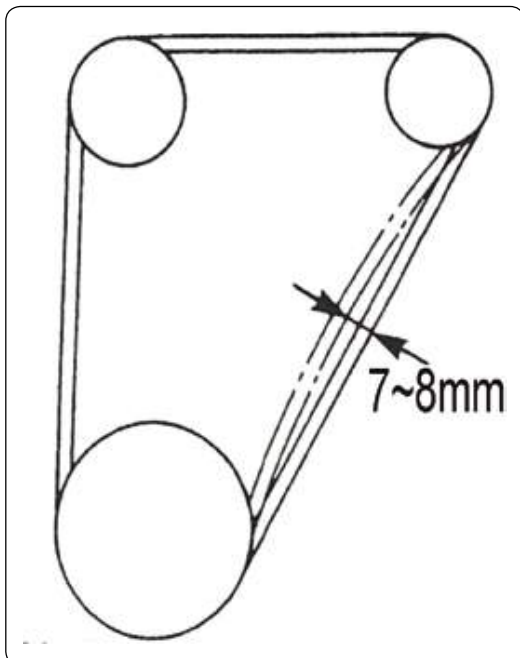
- Adjust fan belt tension since high fan belt tension causes excessive belt wear while low fan belt tension causes overheat and discharge due to not enough revolution in fan pulley and generator. Adjust fan belt tension.

- Proper belt tension is 7~8mm.

- Check the tension by pressing down on the middle of the belt with your finger. Check for contamination of oil or grease contamination or harmful damage on the belt.

- Visually inspect the belt for cracks in both lengthwise or widthwise directions and replace immediately if there are any intersecting cracks.

- Please use genuine V-belt parts. Change if damaged or old.



### 2.2.6. AIR CLEANER

- Contaminated air cleaner may not only reduce the engine output, but also increase the fuel consumption or produce black exhaust gas.
- Change air cleaner if there is any deformation, damage or cracks.
- If it is used in excessively dusty area, clean the dust collector every day, and inspect and clean the element every 50 hours or more often. If it is cleaned with pressurized air (5 ~ 7kgf/cm<sup>2</sup>), clean it from inside of the element and blowing outwards.
- When assembling the dust collector, make sure "TOP" is facing upwards.

### 2.2.7. RADIATOR

- Check for blocked radiator pin:

If the radiator pin is blocked, remove any foreign objects by blowing with pressurized air or wash with water.

- Radiator coolant amount inspections should be done when the engine is completely cooled.
- If the engine is not in use for extended period, drain coolant completely since it may cause freezing of cylinder interior or cracks.



**WARNING :** Do not check the amount of coolant while the radiator is hot. If the cap is open immediately after the engine has stopped, hot steam or coolant may cause burns.

### 2.2.8. Battery

- Check the level of electrolyte and add distilled water if insufficient.
- Measure the specific gravity of the electrolyte. If it is below the required level (1.12 ~ 1.28), please add.
- Separate the negative terminal first when removing the battery. (The negative terminal should be attached later when assembled.)
- Check if terminal is tight, and clean if there is dirt or corrosion.



**WARNING:**

1. Please be careful not to come in contact with electrolyte with skin or clothing since it is strong sulfuric acid.
2. When charging, do it in a well-ventilated area since it produces explosive gas. Do not smoke and prohibit sparks around it.
3. If the electrolyte comes in contact with skin, wash immediately and contact a medical institute.

### 2.2.9. Inspections every 50 hours

- (1) Engine and oil filter change: Change after first 50 hours of engine operation.
- (2) Drain water from the fuel filter de-oiler
- (3) Battery inspection
- (4) Cooler V-belt tension inspection

### 2.2.10. Inspections every 250 hours

- (1) Engine and oil filter change: Change every 250 hours after the initial change in 50 hours
- (2) Radiator pin inspection and cleaning
- (3) Air cleaner cleaning
- (4) Cooler V- belt tension inspectio

### 2.2.11. INSPECTIONS EVERY 500 HOURS

- (1) Engine fuel filter change: Change the fuel filter every 500 hours after the initial change in 50 hours
- (2) Coolant anti-freeze change
- (3) Element of the air cleaner change

### 2.2.12. INSPECTIONS EVERY 1000 HOURS

#### (1) TURBO CHARGER BLOWER WASHING

- If engine revolution is decreased or exhaust gas is darker, it may be caused by dirty turbo charger blower blades. Please wash with a blower washer.

- How to wash:

- 1) Inject specified amount of blower washer into the air inlet while the engine is loaded with 3/4 to 4/4 of its capacity. (20cc per each time)
- 2) Inject clean water (20cc) three to five minutes after the blower washer injection.



**CAUTION : Do not inject excessive amount of blower washer or coolant into the turbo charger in short time may cause serious accident.**

- 3) Repeat the washing in 10 minutes if there are no changes in air pressure or temperature after the initial washing. If there are still no changes after three or four washings, disassemble since it may require other repairs.

- 4) Operate the engine for 15 minutes after the washing to dry.

- (2) Fuel injection valve injecting pressure and condition inspection and adjustment (Please refer to the Section 5.1.2.)

- (3) Valve gap adjustment (Please refer to the Section 4.3.23)

### 2.2.13. Inspections every 2000 hours

- (1) Coolant path cleaning & maintenance: related to coolant path such as radiator, coolant pump, cylinder block & head and oil cooler  
Parts should be cleaned and maintained due to reduced cooling ability when used for a long period

- (2) Fuel oil pipe and coolant pipe inspection and change: Inspect the fuel oil pipe or coolant pipe and change if there are any flaws or deteriorated parts. Please change hoses in every 2 years even if they seem normal.

- (3) Intake and exhaust wrapping: Maintain to ensure the tightness of cylinder heads.

- (4) Fuel injection timing adjustment and fuel injection pump inspection & adjustment: Please refer to the Section 4.3.11.

# MEMO

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## 3. TROUBLE SHOOTING AND SOLUTION

Trouble	Cause	Solution
1. trouble starting (1) Starter is turned on but no pinion	1) insufficient battery capacity	1) Charge or change if discharged. 2) Slowly heat if insufficiency caused by cold weather, recharge or change
	2) Cut in a wire harness, or bad connection in battery and switch terminals	Modify
	3) Faulty spline engaged with pinion of armature shaft	Modify spline
	4) Bad magnetic switch plunger, or cut or short coil	Modify or change
	5) Starter switch malfunctioning	Modify or change
	6) Starter brush malfunctioning	Disassemble and clean, or change broken parts
(2) Pinion is engaged with a ring gear but starter is not turning	1) insufficient battery capacity	Same as 1- 1)
	2) Cut in the cable connecting the battery with the magnetic switch, or Connecting wire between the magnetic switch and motor terminal is not tight enough.	Modify
	3) Bad fit between the pinion and ring gear	Modify or change pinion
	4) Faulty starter	Modify or change
	5) Battery code connection is not tight enough.	Tighten more
(3) Pinion turns without engaging with the ring gear	1) Starter not installed properly.	Reinstall
	2) incorrect plunger & measurement adjustment	Adjust
	3) Bad pinion sleeve spring	Change
(4) Pinion is engaged with the ring gear and starter turns but engine does not turn.	1) Over running clutch fault	Change
	2) Internal fault of the engine	Repair

Trouble	Cause	Solution
1. Trouble starting (5) Engine turns but does not start.	1) No fuel in the fuel tank.	Add fuel.
	2) Air present in fuel system.	Remove air.
	3) Fuel element blocked	Wash or change
	4) Air mixture at the injection pump	Remove air
	5) No electricity at the fuel blocking solenoid valve of the fuel injection pump	Inspect whether there is power with the Key switch on ON position. Inspect fuse or wiring if necessary.
	6) Lose or bad fuel blocking solenoid valve of the fuel injection pump	Tighten the solenoid valve. Check the operation sound with Key switch on ON and Off. Change bad solenoid.
	7) Bad fuel injection pump	Repair or replace
	8) Loose connection of the pressurized pipe	Retighten
	9) Fused fuel injection valve	Modify or change
	10) Insufficient injection from the fuel injection valve	Modify or change
	11) Improper injection pressure	Adjust
	12) Bad glow plug	Inspect and replace if necessary
	13) Insufficient compression pressure – Valve not closing properly – Cylinder head gasket packing fault – Worn piston, piston ring, and cylinder	Inspect valve and valve seat Modify Change Change
(6) Engine starts up but dies immediately.	1) Fuel pipe blocked or filter contaminated	Wash
	2) Air mixed in the fuel	Remove air
	3) Vent blocked in fuel tank cap	Modify
2. Bad idling	1) Accelerating lever adjustment fault	Adjust accelerating lever or cable
	2) Air mixed at the injection pump	Remove air
	3) Bad fuel injecting valve	Modify or change
	4) Bad injection timing	Adjust
	5) Injection pump not working	Replace with a new pump or disassemble to repair
3. Insufficient engine power	1) Improper valve clearance	Adjust
	2) Bad valve engaging	Inspect valve & valve seat
	3) Gas leak at the cylinder head gasket	Change gasket
	4) Abrasion, adhesion or damage to the piston ring	Change piston ring
	5) Insufficient air intake	Air cleaner element cleaning
	6) Bad fuel injection timing	Adjust
	7) Insufficient fuel injection rate	Adjust pump output
	8) Bad injection pressure or scorched	Adjust or change the fuel injection valve

Trouble	Cause	Solution
3. Insufficient engine power	9) Blocked fuel pipe system	Modify
	10) Air mixed in fuel	Remove air
	11) Water mixed in fuel	Fuel change
	12) Frozen or hard wax in fuel line	Place in a warm garage until it is thawed or soft and remove air
	13) Faulty fuel injection pump	Replace with new fuel injection pump
	14) Bad turbo charger	Repair or replace
4. Engine overheat	1) Insufficient coolant or water slime present	Add or wash
	2) Loose, abrasion or damage to fan belt	Adjust or replace
	3) Reduced cooling pump function	Modify or change
	4) Improper valve clearance	Adjust
	5) Reduced resistance to exhaust system	Clean or change
	6) Air way blocked in the radiator	Clean
	7) Improper injection timing	Adjust injection timing
	8) Damaged cylinder head gasket	Change head gasket
	9) Insufficient or bad engine oil	Add or change
5. Engine noise 1) Crank shaft metal	1) Increased clearance due to worn metal or crank shaft	Replace metal or grind crank shaft
	2) Uneven wear in crank shaft	Grind crank shaft or change
	3) Scorched metal	Change metal and grind crank
2) Connecting rod metal	1) Worn crank pin metal	Change metal
	2) Abrasion in crank pin parts	Change crank shaft
	3) Bent connecting rod	Change
	4) Scorched crank pin metal	Change metal and polish crank
	5) Insufficient oil due to blocked path	Clean oil path
3) Piston, piston pin & piston ring	1) Increased piston clearance due to worn piston and piston ring	Change piston & piston ring
	2) Worn piston pins	Change
	3) Scorched piston	Change
	4) Worn or bad piston	Change
	5) Damaged piston ring	Change



Trouble	Cause	Solution
5. Engine noise 4) others	1) Worn crank shaft and thrust bearing	Change thrust bearing
	2) Excessive timing gear back lash	Change timing gear
	3) Excessive valve clearance	Adjust valve clearance
	4) Wear in valve parts	Modify or change
	5) Bad coolant pump bearing	Change coolant pump
	6) Internal damage in turbo charger	Repair or change
6. Excessive fuel consumption	1) Fuel leak	Inspect and change pipes if necessary. Retighten every connections.
	2) Blocked return pipe or hose	<ul style="list-style-type: none"> <li>– Inspect if return line is twisted or crushed. Replace damaged parts.</li> <li>– If line is blocked, use pressurized air to remove air.</li> </ul>
	3) Improper injection timing	Modify
	4) Compression pressure inspection	Modify or change
	5) Bad fuel injection valve (injection or pressure)	Modify or change
	6) Bad injection pump (excessive injection)	Modify or change
	7) Head gasket inspection	Change
7. Excessive oil consumption 1) Oil up	1) Excessive clearance between the cylinder and piston	Change
	2) Worn piston ring and ring groove	Change piston ring
	3) Improper positioning of piston ring inlet	Modify position
	4) Blocked air breather	Wash
	5) Excessive oil supply	Modify
2) Oil down	1) Loose valve stem and valve guide	Change
	2) Bad cylinder head gasket	Change gasket
	3) Bad valve stem seal	Change
3) Oil leak	1) Loose connections	Tighten
	2) Bad packing of parts	Change packing
	3) Bad oil seal	Change oil seal

Trouble	Cause	Solution
8. Decrease in lubricant pressure	1) Improper oil quality	Change to specified oil
	2) Bad pressure control valve	Change
	3) Worn oil pump	Change
	4) Bad oil pipe	Modify or change
	5) Worn crank metal & crank pin metal	Change metal
9. Engine knocking	1) Incorrect injection timing	Adjust
	2) Incorrect injection pressure	Adjust
	3) Bad injection function	Disassemble to modify
	4) Insufficient air intake	Clean the air cleaner
	5) Engine oil in combustion chamber – Oil up – Oil down – Low oil viscosity	Modify Modify Change to proper oil
	6) Low engine temperature	Operate in warm place
10. Excessive exhaust gas 1) white exhaust gas	1) Late injection timing	Adjust
	2) Decreased compression pressure	Modify
	3) Water mixed in the fuel	Change
	4) Not enough air intake	Modify
	5) Engine oil in the combustion chamber	Modify
2) black exhaust gas	1) Late injection timing	Adjust
	2) Over loaded	Adjust to proper load
	3) Excessive injection rate	Bad injection control spring
	4) Irregular injection	Adjust
	5) Bad injection from fuel injection valve	Modify or change
	6) Insufficient air intake	Clean the air cleaner

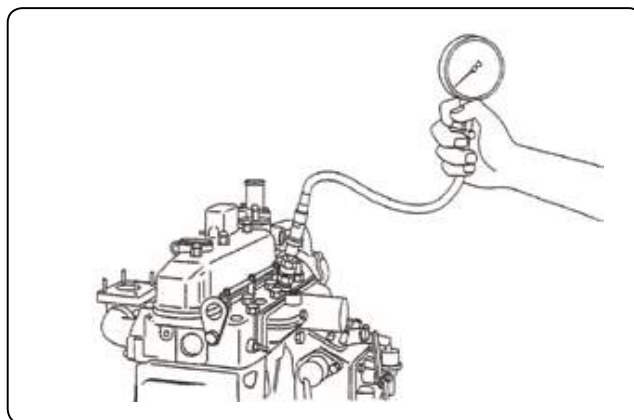


## 4. ENGINE MAINTENANCE

### 4.1. ENGINE INSPECTION

#### 4.1.1 Cylinder compression pressure inspection

- ① Warm up the engine enough then stop the engine.
- ② Disassemble the air cleaner, muffler and injection nozzle.
- ③ Pull the engine stop lever to block the fuel supply.
- ④ Install the pressure gage in the nozzle.
- ⑤ Crank so that each cylinder would turn six or seven times and measure the pressure within the cylinder.
- ⑥ If the cylinder pressure is less than allowed, check the assembly of the gage and measure again.
- ⑦ If the result is same, check the cylinder head assembly, valve gap and piston top clearance.



#### ※CAUTION

- a. Make sure the engine stop lever is fastened properly when cranking.
- b. Fill the battery to its full capacity before the inspection.
- c. Pressure within the cylinder should be less than 10%.
- d. The injection nozzle tap specification is M20xP1.5.

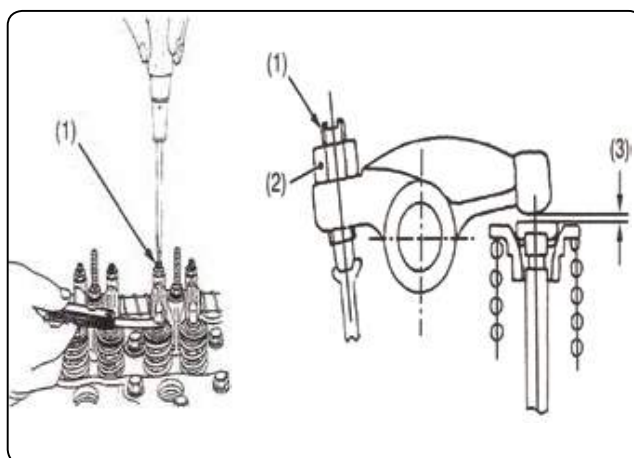
#### 4.1.2 Valve gap inspection

- ① Remove the cylinder head cover.
- ② Turn the fly wheel so that the no. 1 piston is at TDC and then coincide the "1" mark of fly wheel with "T" mark of rear plate.
- ③ Check the gaps in the order shown in Table 4.1.2\_1.(TDC No.1 Piston)
- ④ Turn the fly wheel one turn in counterclockwise to coincide the "1" mark of fly wheel and "T" mark of rear plate.
- ⑤ Check the gaps in the order shown in Table 4.1.2\_1.(OverLap No.1 Piston)

#### ※CAUTION

- a. The TDC mark "T" of the rear plate only applies to no. 1 cylinder.
- b. Measure the gaps two or three times for better accuracy.
- c. Order of the cylinder is 1, 2, and 3 referencing to gear case shaft.

- (1) Adjusting bolt
- (2) Fastening nut
- (3) Gap



Location of no. 1 piston	Piston NO.	Intake valve	Exhaust valve
TDC	NO.1	*	*
	NO.2		*
	NO.3	*	
OverLap	NO.1		
	NO.2	*	
	NO.1,3		*

Table 4.1.2\_1

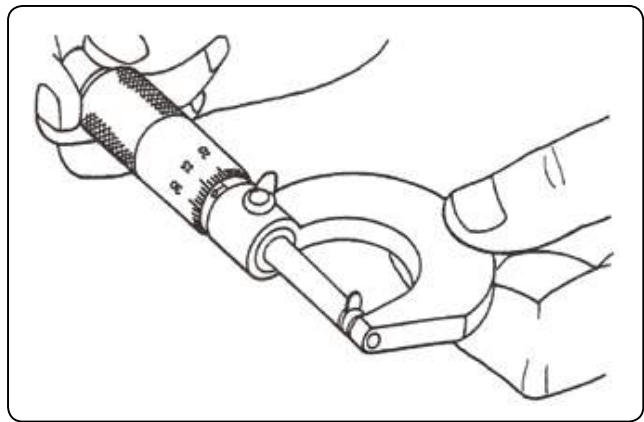
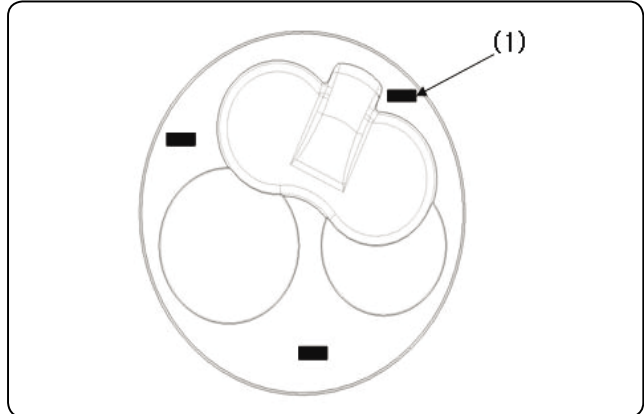
Proper limit	0.15 ~ 0.20mm
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### 4.1.3 Top Clearance measurement

- ① Remove the cylinder head. But do not remove the cylinder head gasket.
- ② Turn the crank shaft so that piston will be at the top inside the cylinder.
- ③ Assemble the cylinder head. Comply with required torque when assembling the head bolt.
- ④ Turn the crank shaft so as to pass the TDC mark of the piston.
- ⑤ Measure the fuse thickness after disassembling the cylinder head.
- ⑥ If measurement is out of range, measure oil clearance of crank pin, crank pin bearing, piston pin and Small end Bushing.

**※CAUTION**

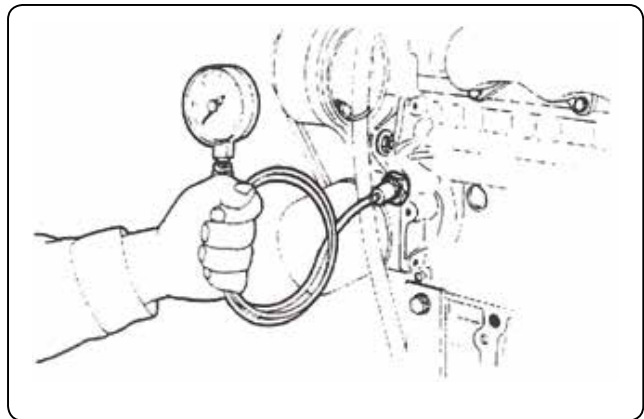
- a. Use a new cylinder head gasket when re-measuring the Top Clearance.
- (1) Fuse



allowance	0.55 ~ 0.75 mm
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### 4.1.4 Oil pressure inspection

- ① Remove the oil pressure switch that is mounted on the block and mount the oil pressure gage.
- ② Measure the oil pressure when idling after engine is warmed up and oil pressure is nominal.
- ③ If the oil pressure is out of proper range or outside of allowance, check whether the engine is normal or not.
  - Check if there is enough oil.
  - Check the oil pump.
  - Check for foreign objects within the oil intake pipe.
  - Check for foreign objects within the oil filter.
  - Check for foreign objects within the oil gallery.
  - Check the Oil Clearance.
  - Check if the Relief valve is normal.



Engine oil pressure	Proper pressure	IDEL	1.5kgf/cm <sup>2</sup>
		RATED	2.0~3.5kgf/cm <sup>2</sup>
	Allowance	RATED	3.0kgf/cm <sup>2</sup>

## 4.2. Engine disassembly

### General caution

- Please select a clean place without dust or foreign objects.
- Pay attention not to have the disassembled parts contaminated or damaged. Prepare a storage container for parts.
- Prepare cleaning agent and pressurized air for washing parts in advance.
- Please have appropriate tools to disassemble and assemble engine. Use them properly according to degree of disassembly and location.
- If disassembly is very complex and there are numerous parts, mark them with identifications so assembly process is easier.

### 4.2.1. Engine oil

- ① Open the drain bolt of the oil pan and discharge the engine oil.



#### CAUTION :

- ② Please avoid touching the hot oil.



#### WARNING :

- ③ Please comply with discarding unusable oil according to legal requirements.

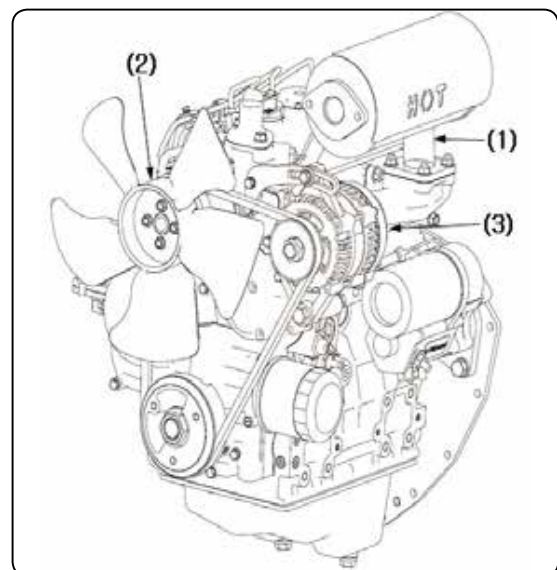
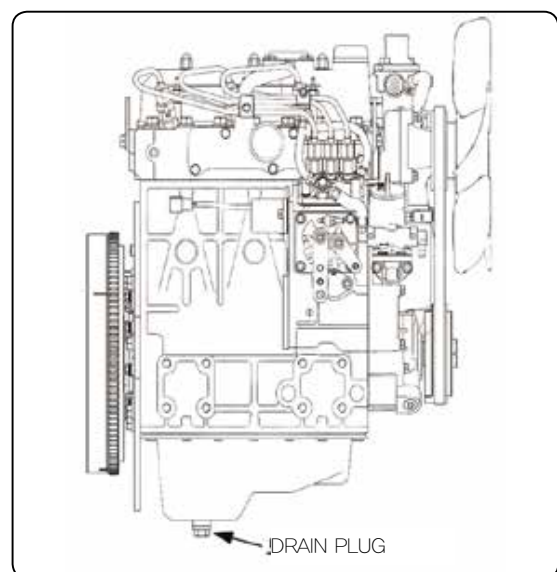
### 4.2.2. Muffler, generator, cooling fan

- ① Disassemble the generator and fan belt.
- ② Disassemble the cooling fan and fan pulley.
- ③ Disassemble the muffler.

#### ※CAUTION

- a. Check abnormality in disassembled muffler, generator and cooling fan.
- b. Check the status of fan belt.
- c. If the fan belt is worn beyond the specification, replace with a new belt.

(1) muffler    (2) cooling fan    (3) generator



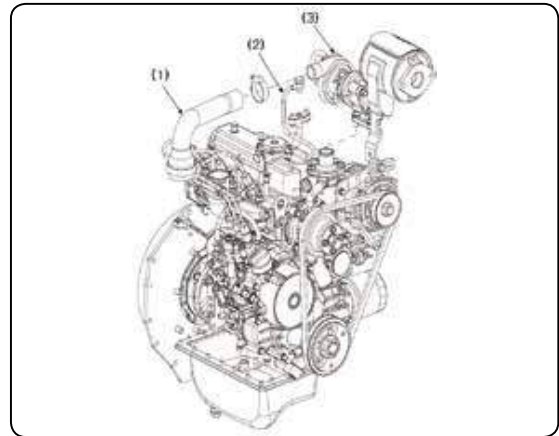
#### 4.2.3. Turbo charger

- ① Disassemble the intake hose.
- ② Disassemble the turbo charger lubricant supply pipe and discharge pipe.
- ③ Disassemble the turbo charger.

**※CAUTION**

- a. Make sure there is no oil leak within the turbo.
- b. Turn the fan with your hand to check for damaged bearing or fan interference.

- (1) Intake hose
- (2) Lubricant supply pipe and discharge pipe
- (3) Turbo charger assembly

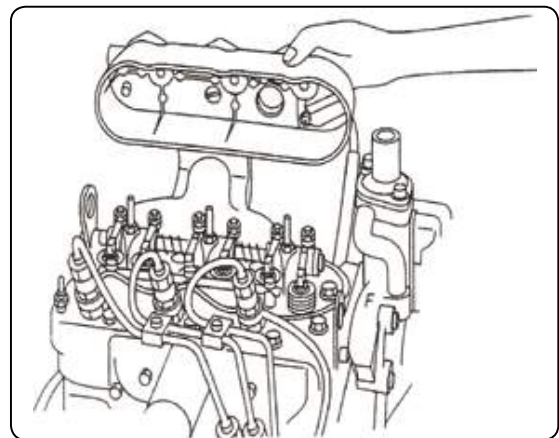


#### 4.2.4. Cylinder head cover

- ① Remove the head cover cap nut.
- ② Remove the head cover.

**※CAUTION**

- a. Check for damage on the head cover and abnormality of the breather valve.
- b. Replace the head cover gasket if it is excessively damaged.

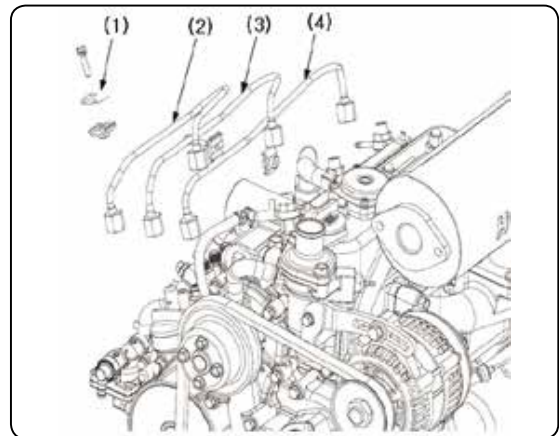


#### 4.2.5. Fuel supply line

- ① Remove the pipe clamp.
- ② Remove high pressure lines in order.

**※CAUTION**

- a. Clean dust with air inside the fuel supply lines.
- (1) pipe clamp                      (3) fuel supply line 2
  - (2) fuel supply line 1          (4) fuel supply line 3



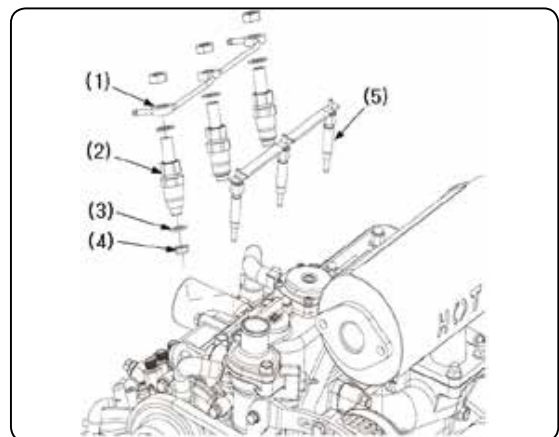
#### 4.2.6. injection nozzle & glow plug

- ① Disassemble the over flow pipe assembly.
- ② Disassemble the injection nozzle.
- ③ Disassemble the copper packing & nozzle spacer.
- ④ Disassemble the glow plug assembly.

**※ CAUTION**

- a. Use new packing and nozzle spacer.

- (1) Over flow pipe assembly      (4) Nozzle spacer
- (2) Injection nozzle                (5) Glow plug
- (3) Copper packing



#### 4.2.7. Fuel injection pump & speed control panel

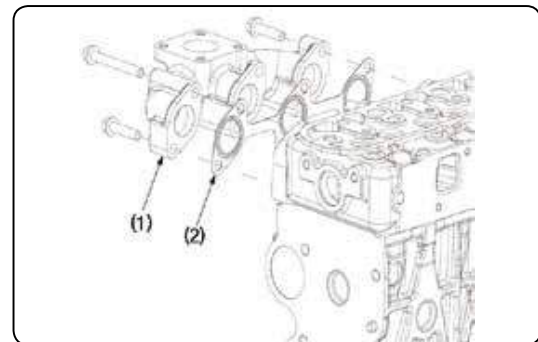
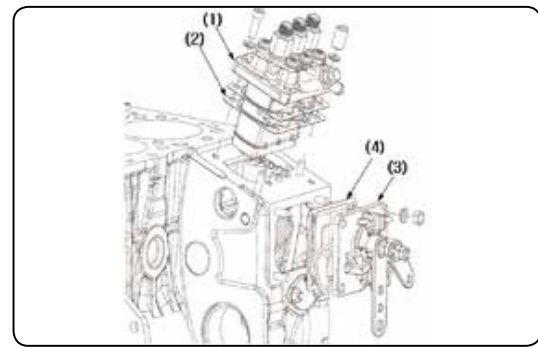
- ① Remove the fuel injection pump fastening bolt & nut.
- ② Remove the fuel injection pump.
- ③ Remove the speed control panel.

##### ※ CAUTION

a. Be careful not to damage the starter spring and speed control spring while removing the fuel injection pump and speed control panel.

b. When assembling the injection pump, make sure the control lock pin is placed inside the thrust lever of the fork lever.

- |                                  |                     |
|----------------------------------|---------------------|
| (1) Fuel injection pump          | (2) Adjusting shaft |
| (3) Speed control panel assembly | (4) Gasket          |



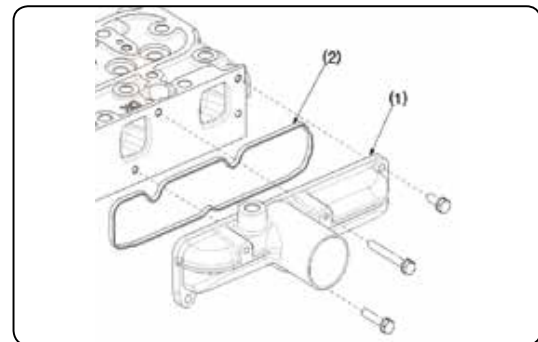
#### 4.2.8. Exhaust manifold

- ① Disassemble the exhaust manifold fastening bolt.
- ② Remove the exhaust manifold.

##### ※ CAUTION

a. If a new exhaust manifold is used in reassembly, make sure it is in a right place.

- |                             |
|-----------------------------|
| (1) Exhaust manifold        |
| (2) Exhaust manifold gasket |



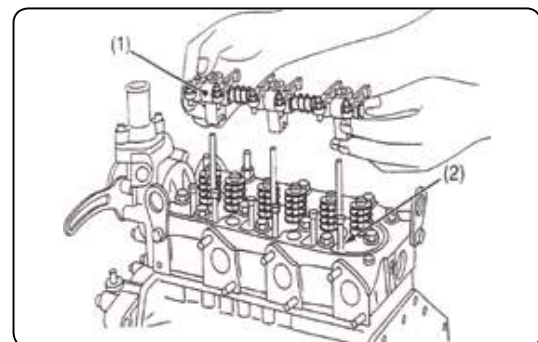
#### 4.2.9. Intake manifold

- ① Disassemble the intake manifold fastening bolt.
- ② Remove the intake manifold.

##### ※ CAUTION

a. Make sure the intake manifold gasket is in the right place.

- |                            |
|----------------------------|
| (1) Intake manifold gasket |
| (2) Intake manifold        |



#### 4.2.10. Rocker arm & push rod

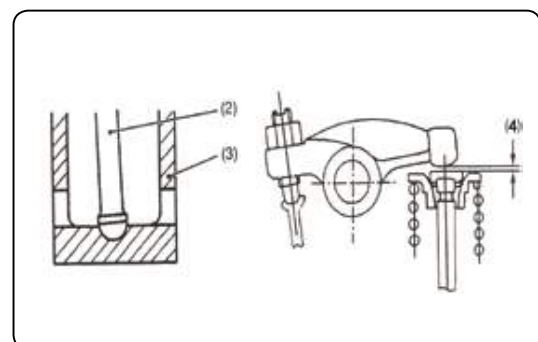
- ① Disassemble the rocker arm fastening nut.
- ② Remove the rocker arm.
- ③ Disassemble the push rod.

##### ※ CAUTION

a. Check the valve gap before disassembling the rocker arm. Make sure the push rod assembly is in good condition. (valve gap: 0.15 ~ 0.20)

b. Check if the push rod is deformed or not after the disassembly.

- |                       |               |
|-----------------------|---------------|
| (1) Lock arm assembly | (2) Push rod  |
| (3) Tappet            | (4) Valve gap |





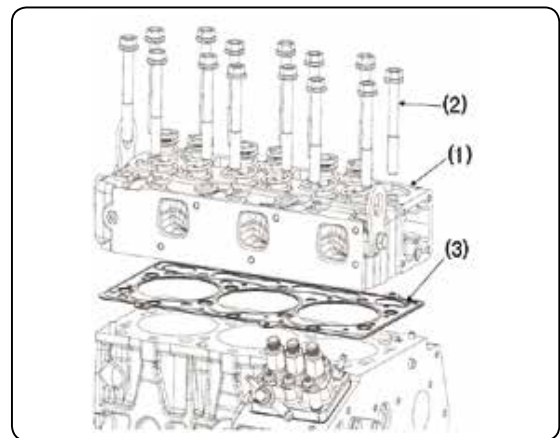
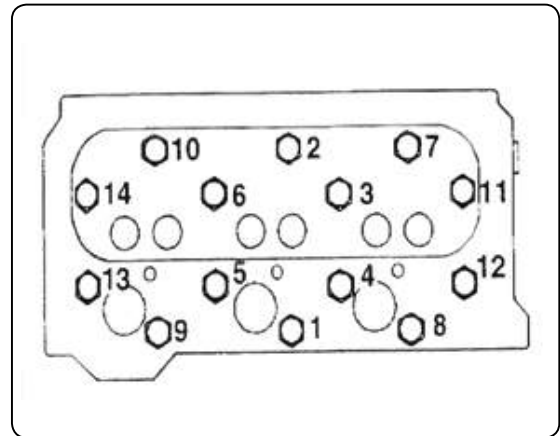
#### 4.2.11. Cylinder head

- ① Disassemble the cylinder head bolt in descending order from 14 to 1.
- ② Remove the cylinder head.

##### ※ CAUTION

- a. Be careful not to damage the bottom and block sides while disassembling the cylinder head.
- b. Use a new head gasket when reassembling.
- c. Assemble the head bolts in the order from 1 to 14.
- d. Check the head bolt torque again after operating for 30 minutes when assembled.

- (1) Head bolt
- (2) Cylinder head
- (3) Gasket (Cylinder head)



#### 4.2.12. Tappet

- ① Remove the tappet from the crank case.
- ② Mark on the tappet according to disassembling order and piston position not to have the order confused.

##### ※ CAUTION

- a. Make sure the bottom the tappet is worn evenly in circular motion.
- b. Pay attention not to confuse the order of tappets while assembling and apply oil on the surfaces that come in contact.

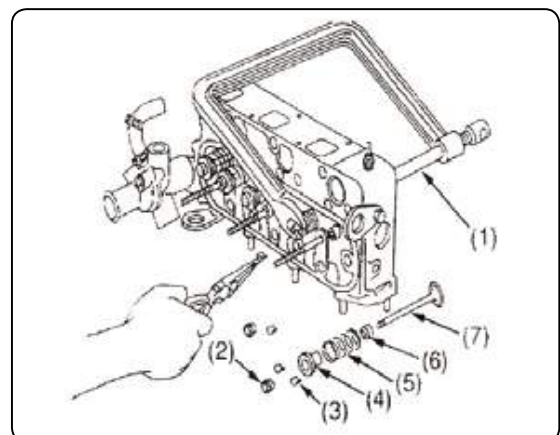
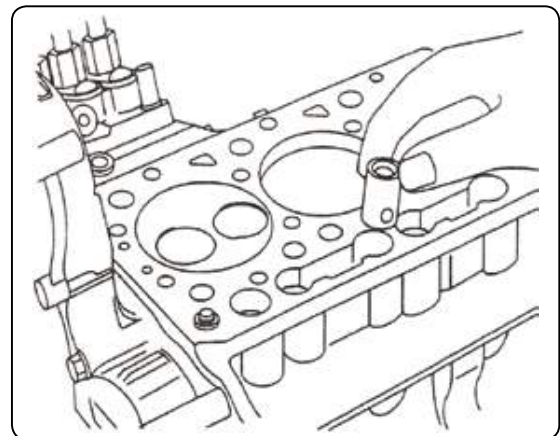
#### 4.2.13. Valve

- ① Remove the valve cap.
- ② Push down the valve spring retainer with a zig and remove the valve spring cotter.
- ③ Remove the valve spring retainer, valve spring and valve stem seal, in that order.
- ④ Remove the valve.

##### ※ CAUTION

- a. Check the status of the stem seal before removing the valve stem seal and check for oil leak.
- b. Replace the valve if necessary.
- c. Make sure the order of valve is correct when assembling.

- (1) Valve spring puller    (2) Valve cap
- (3) Valve spring cotter    (4) Valve spring retainer
- (5) Valve spring    (6) Valve stem seal
- (7) Valve

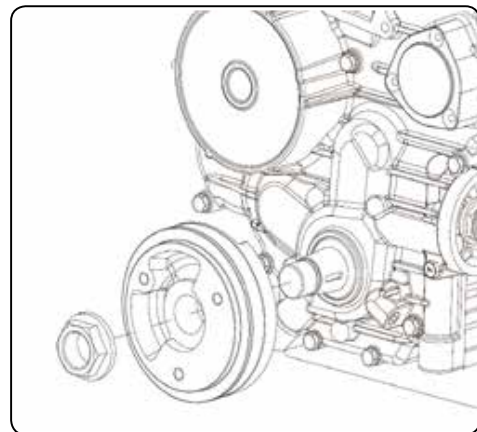


#### 4.2.14. V-pulley

- ① Remove the V-pulley bolt on the crank shaft.
- ② Remove the V-pulley.
- ③ Remove the parallel pin mounted on the crank shaft.

※ **CAUTION**

a. Use the dedicated zig to remove the V-pulley. Do not stand in front of the pulley since it might pop out.



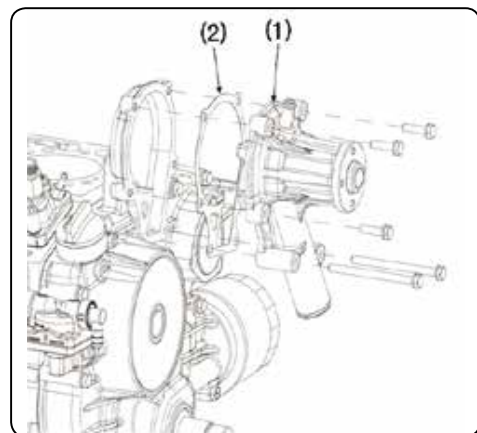
#### 4.2.15. Cooler pump

- ① Disassemble the coolant returning hose, then the coolant pump fastening bolt.
- ② Disassemble the coolant pump.

※ **CAUTION**

a. Do not reuse the coolant pump gasket.

- (1) Coolant pump assembly  
 (2) Gasket



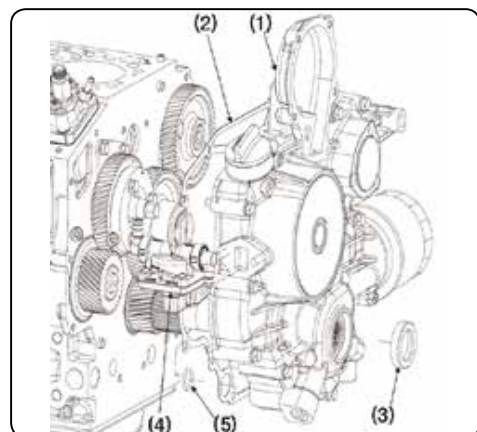
#### 4.2.16. Gear case

- ① Disassemble the fuel tube connected to the injection pump first, and remove the feed pump.
- ② Remove the gear cast fastening bolt, and remove the gear case.

※ **CAUTION**

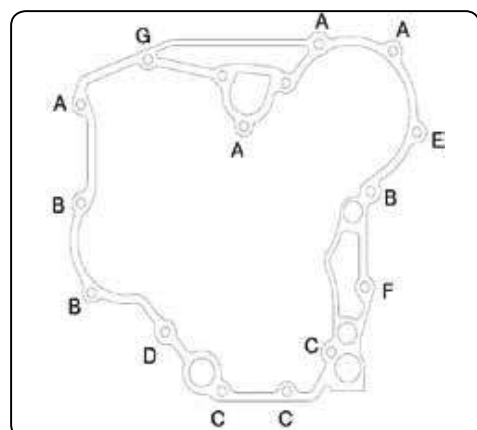
- a. Pay attention not to damage the oil seal when removing the gear case.
- b. Replace four O rings on the rear side of the gear case appropriately when reassembling.
- c. Remove gasket remaining on the rear side of gear case and cylinder block completely and replace with a new gasket in reassembly.
- d. Assemble the feed pump after the gear case is assembled first to prevent damage to the feed pump.

- (1) Gear case           (2) Gear case gasket  
 (3) Oil seal           (4) Feed pump  
 (5) O-ring



※ Length of bolts (mm)

A. 45	E. 65
B. 50	F. 68
C. 55	G. 너트
D. 60	



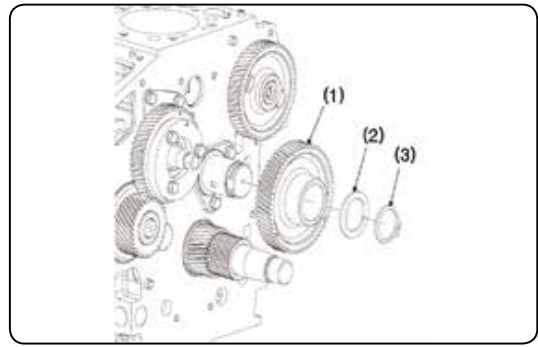
#### 4.2.17. Idle gear

- ① Disassemble the snap ring using the snap ring puller.
- ② Remove the idle gear collar.
- ③ Remove the idle gear.

#### ※ CAUTION

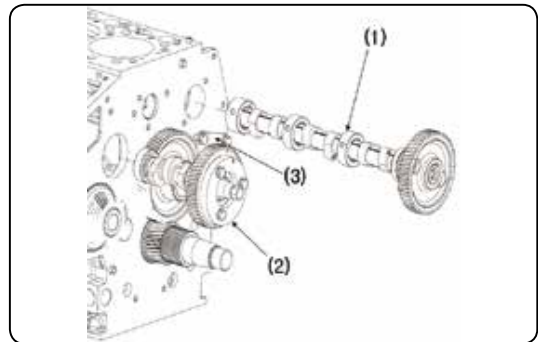
a. While assembling the gear, check the steering angle of cam shaft gear, crank shaft gear and fuel cam shaft gear.

- (1) Idle gear (2) Idle gear bush  
(3) Snap ring



#### 4.2.18. Cam shaft and fuel cam shaft

- ① Turn the cam shaft gear until the fastening bolt inside is visible. Then disassemble the bolt.
  - ② Remove the cam shaft.
  - ③ Disassemble the fuel cam shaft stopper.
  - ④ Remove the fuel cam shaft.
- (1) Cam shaft (2) Fuel cam shaft  
(3) Fuel cam shaft stopper



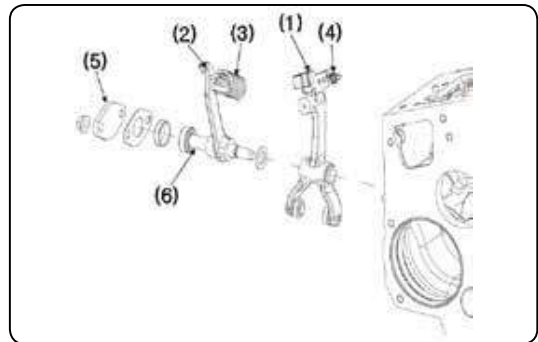
#### 4.2.19. Fork lever

- ① Remove the starter spring.
- ② Remove the fork lever shaft cover.
- ③ Remove the fork lever shaft using the tool shown in the diagram.

#### ※ CAUTION

a. Reassemble in correct order.  
b. Use a new gasket.  
c. Assemble so that the mark "UP" on the lever shaft cover is pointing upward.

- (1) For lever A (2) For lever B  
(3) Governor spring (4) Starter spring  
(5) Fork lever shaft cover (6) Fork lever shaft



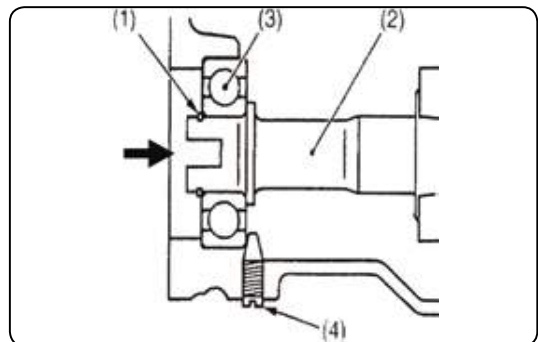
#### 4.2.20. Governor

- ① Disassemble the snap ring with the snap ring remover.
- ② Remove the governor in the direction of the arrow.

#### ※ CAUTION

a. Be careful not to damage the ball bearing while removing the governor.

- (1) Snap ring (2) Governor shaft  
(3) Ball bearing (4) Stop bolt



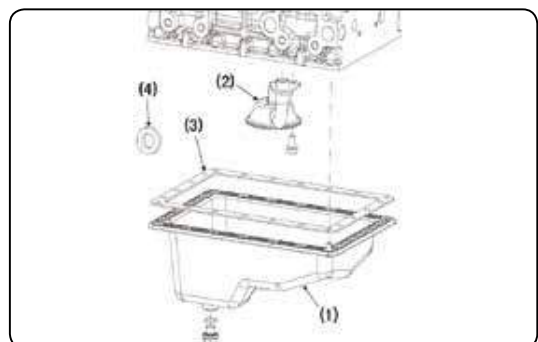
#### 4.2.21. Oil pan and oil inlet

- ① Remove the oil pan fastening bolt.
- ② Tap the oil pan with a rubber mallet to remove.
- ③ Remove the oil inlet bolt.
- ④ Remove the oil inlet.

#### ※ CAUTION

a. Use a new oil pan gasket when reassembling.  
b. Make sure the magnet is located on the oil inlet.

- (1) Oil pan (2) Oil inlet  
(3) Oil pan gasket (4) magnet

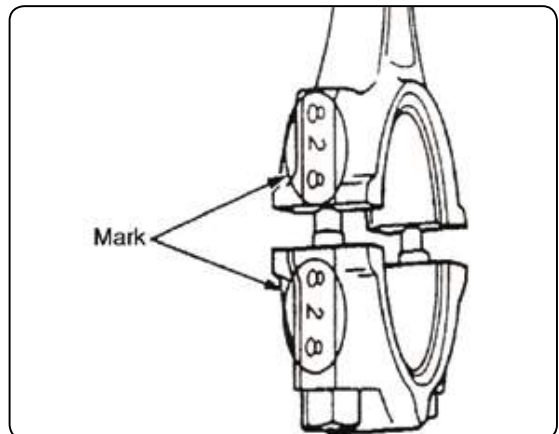
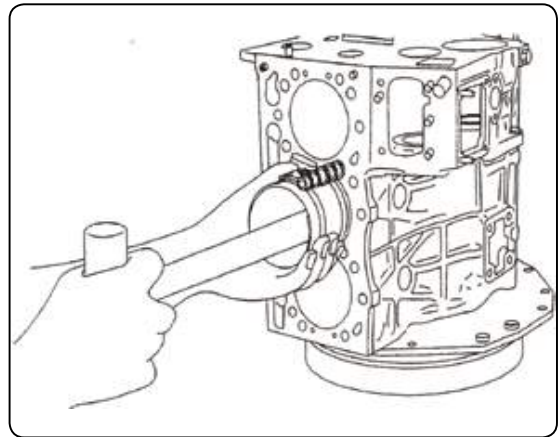
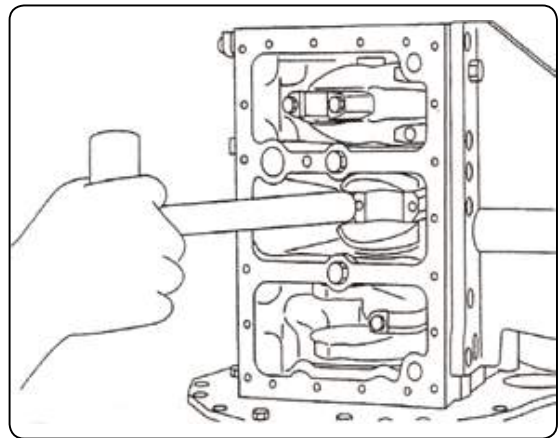
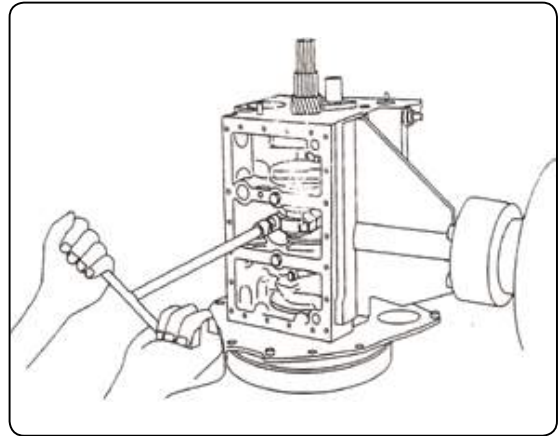


#### 4.2.22. Connecting rod and piston

- ① Remove the connecting rod cap.
- ② Tap with a rubber mallet to remove the piston and connection rod.

#### ※ CAUTION

- a. Be careful to align the mark and number on the connecting rod when reassembling.(Figure 4.2.22\_5)
- b. Use the dedicated jig to assemble the piston and check the position of the piston ring.
- c. Direct the piston clover toward the nozzle.



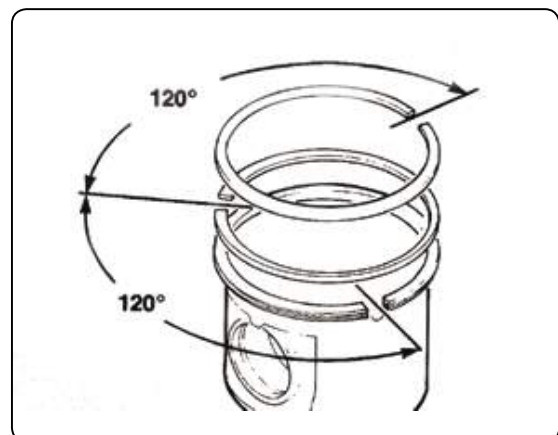
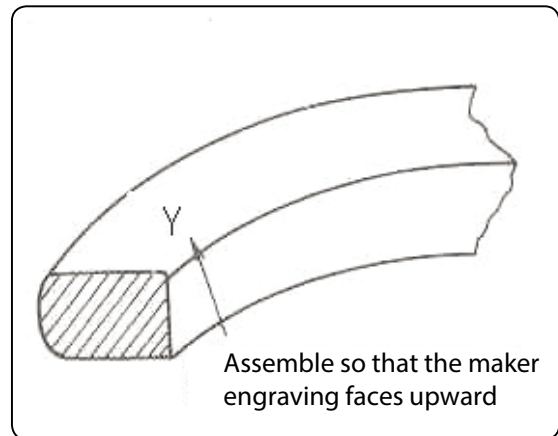
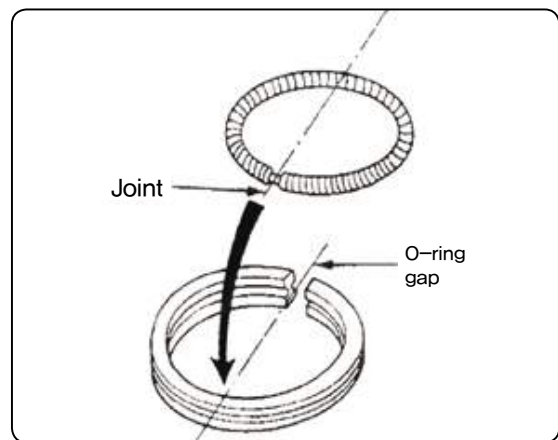
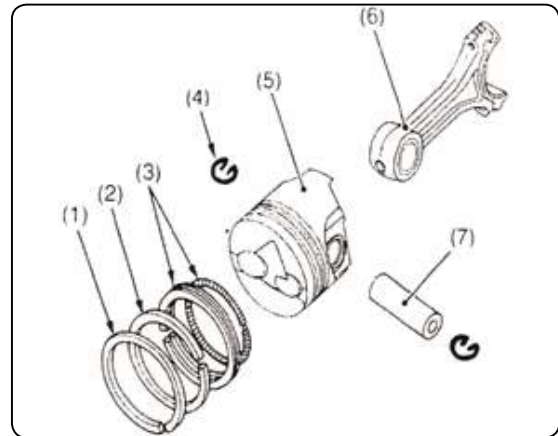
4.2.23. Piston and piston ring

- ① Remove the piston pin snap ring and piston pin.
- ② Disassemble in order after removing the piston.

※ CAUTION

- a. Assemble the piston ring in the order of the Oil Ring, Second Ring and Top.
- b. Make sure the “Y” mark on the top side of the piston ring is facing upward (Figure 4.2.23\_2).
- c. While assembling the Oil Ring, spring joint and the oil gap should face opposite of each other.
- e. Assemble with piston gaps separated by 120°. (Figure 4.2.23\_4)

- (1) TOP Ring                      (2) Second Ring
- (3) Oil Ring                      (4) Piston snap ring
- (5) Piston                         (6) Connecting rod
- (7) Piston pin

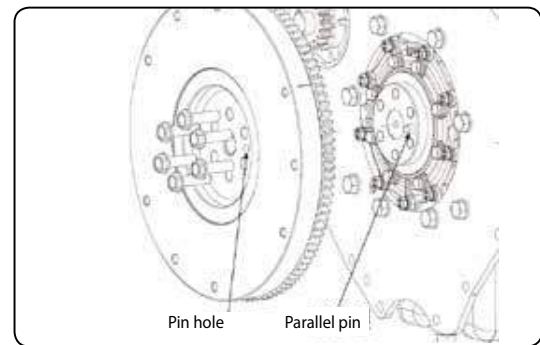


#### 4.2.24. Fly wheel

- ① Disassemble the fly wheel bolt.
- ② Remove the fly wheel.

#### ※ CAUTION

- a. While assembling the fly wheel, fly pin hole should be aligned with crank shaft pin.



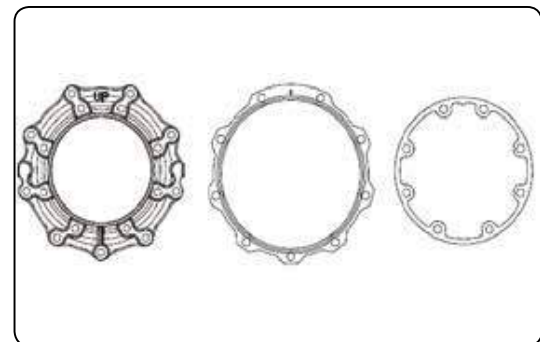
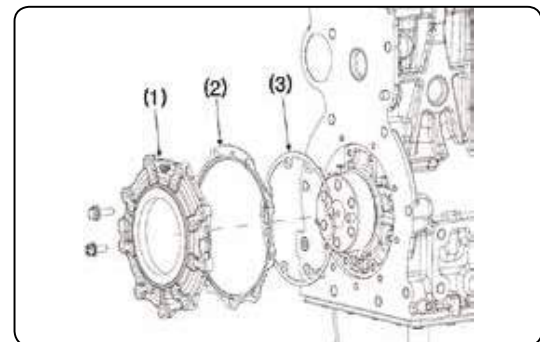
#### 4.2.25. Main bearing case cover

- ① Remove the bearing case cover bolt.
- ② Remove the bearing case cover.

#### ※ CAUTION

- a. Be careful not to damage the oil seal when removing the bearing case cover.
- b. Use a new gasket when reassembling. Place the gasket and bolt hole accurately.
- c. Be careful there are two types of bearing case cover bolt: block fastening bolt and bearing case fastening bolt.

- (1) Main bearing case cover
- (2) Gasket (bearing case cover)
- (3) Gasket (bearing case)



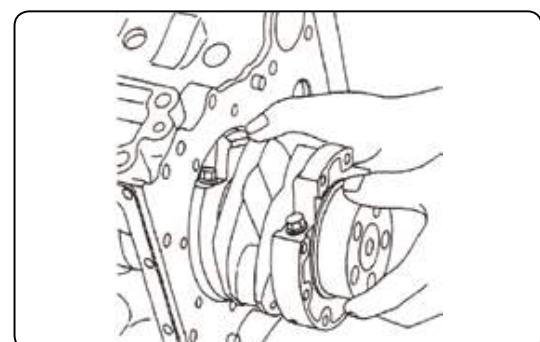
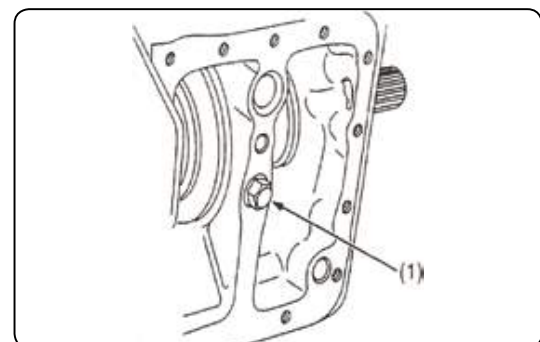
#### 4.2.26. Crank shaft & main bearing case

- ① Remove two main bearing case bolts.
- ② Remove the crank shaft.

#### ※ CAUTION

- a. Be careful not to damage the main bearing case when removing the crank shaft.
- b. Adjust the main bearing case location so that the bolt holes of the cylinder block and bearing case coincide when assembling.

- (1) Main bearing case bolt\_2



4.2.27. Main bearing case

- ① Remove the bearing case bolt 1.
- ② Separate the bearing case top and bottom to remove.

※ CAUTION

a. There are A, B and C types of bearing cases. Be careful not to mix them up.

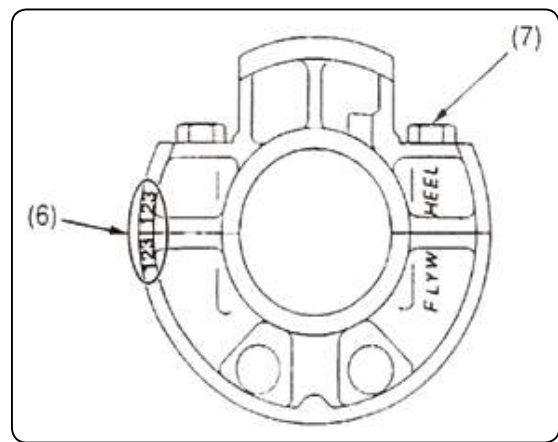
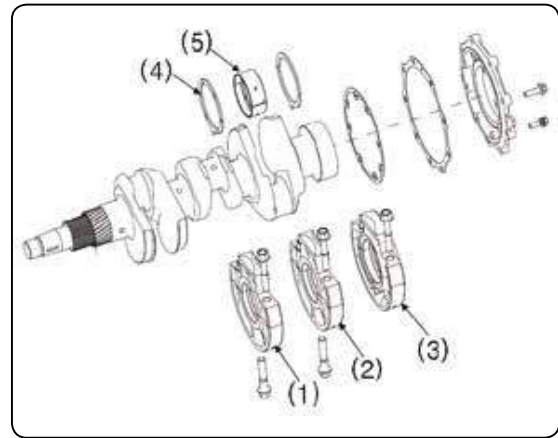
b. Make sure the engraved number on the bearing case and “FLYWHEEL” marking are aligned when assembling.

(1) Main bearing case A (2) Main bearing case B

(3) Main bearing case C (4) Thrust bearing

(5) Crank shaft metal (6) Mark

(7) Main bearing case bolt 1



MEMO

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### 4.3. MAJOR PARTS INSPECTION AND MAINTENANCE

#### 4.3.1. CYLINDER HEAD

##### 1) Cylinder head

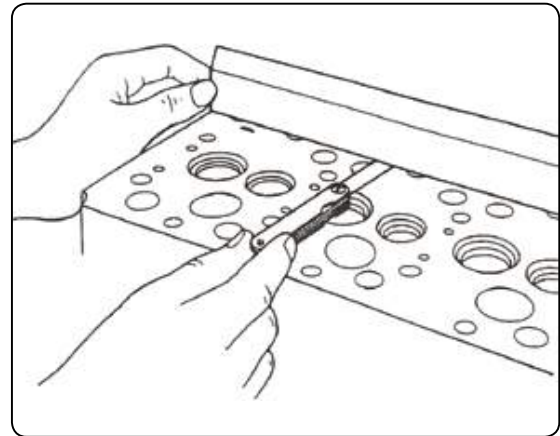
(1) Before washing the cylinder head, check for any leaks, damage or crack.

- Check the cracks on the combustion side of the head using the color check.

(2) Inspect with hydrostatic test or magnetic particle testing for any invisible cracks.

(3) If there is gas leak on the cylinder head gasket, measure the flatness of the bottom side.

- Replace the cylinder head if it is misaligned more than the allowance.



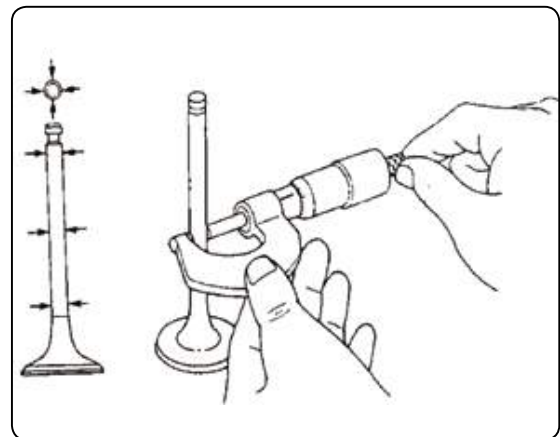
Allowance	Over 0,15 mm
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##### 2) Intake & exhaust valve and valve guide

##### (1) Valve

- Measure the outer circumference of the valve stem. Replace the valve if it is worn more than the allowance.

Standard	Allowance
6,95 ~ 6,96 mm	6,9 mm



##### (2) Valve seat contact side

- Inspect the valve seat contact side and polish or replace as needed.

(3) Measure the margin (or valve head thickness) and replace if it is less than the allowance.

Standard	Allowance
1,2 mm	0,5 mm

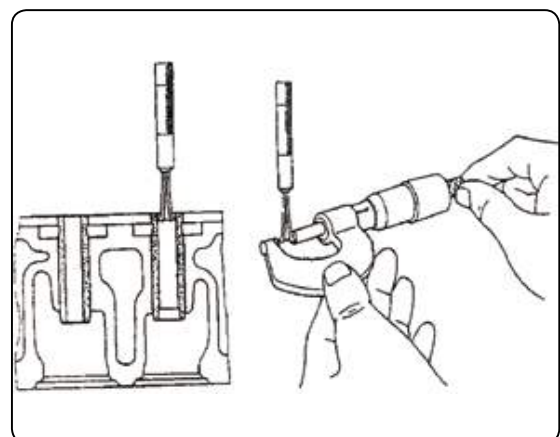
##### (4) Valve guide

- Measure the gap between the valve guide and valve stem. Replace either or both if the valve gap is more than the allowance.

Standard	Allowance
7,015 ~ 7,000 mm	7,1 mm

- The valve guide and valve seat have to be processed at the same time. (Assemble the valve guide using a press.)

- Protrusion from the valve guide head: 9 mm



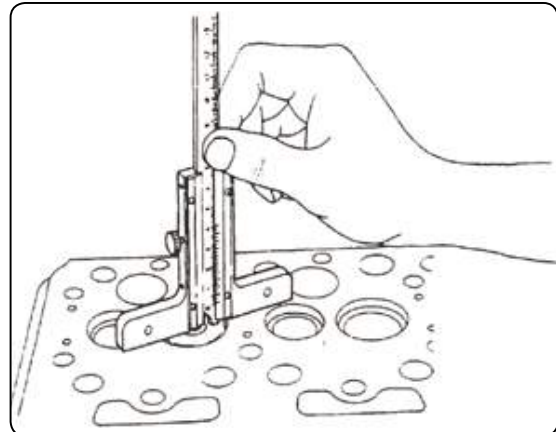
(5) Valve seat

- Measure the valve difference. If the indentation is more than the allowance, change the valve.

Standard	Allowance
0.05~0.15 mm	0.40 mm

- Valve seat modification
  - When modifying the valve seat, change the valve guide if necessary.
  - Modify the seat width and angle according to specification using a special tool or the valve grinder.

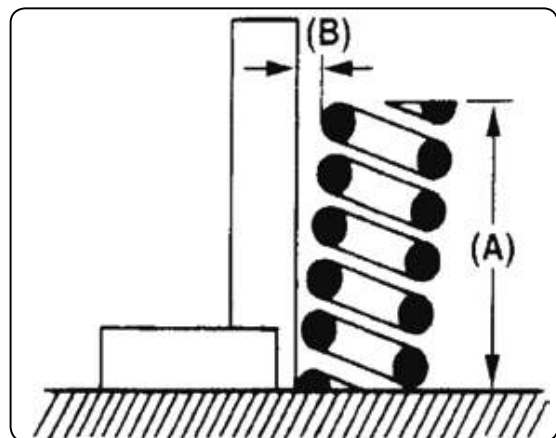
Intake valve seat angle	Exhaust valve seat angle
120°	90°



(6) Valve spring

- Make sure the check the valve spring perpendicular angle, free field or deformation when disassembling since it is a direct cause to valve stem uneven wear or damage.
- Change if it does not comply with the specifications.

Category	Standard	Allowance
Free field(A)	37.25 mm	—
Inclination(B)	—	1.0 mm
Spring load	12.0 kgf/31.0 mm	



4.3.2. CYLINDER BLOCK

1) Cylinder block inspection

- (1) Crack inspection in each part
- Visually check damages by freezing or turn over and perform the color check if damaged.
  - Check cylinder head bolt and screw for cracks.
  - Change the cylinder block if the damage is severe or modify for lesser damage.
  - Perform a pressure test to check for cracks or water leak.
  - Apply adhesive on the exterior surface of the plug when changing plug to prevent freezing. (Three Bond 1194 of better products)

(2) Cylinder inner circumference measurement

- Measure the cylinder inner circumference and change if it is more than the allowance.

(mm)

Category	Standard	Allowance
cylinder inner circumference	78.015 ~ 78.025	88.20
Cylinder roundness	0.0 ~ 0.01	0.03
Cylindericity	0.015	0.03

- Measurement locations: within 20mm of upper part (A), Middle (B) and lower (C) part of engine front and thrust. (average value)

4.3.3. Valve device

Valve rocker arm is directly related to opening and closing of the valve and the timing affects the engine power and performance. Please maintain it accurately.

1) Rocker arm

(1) Rocker arm shaft outer circumference & rocker arm inner circumference

- Measure the shaft outer circumference and rocker arm inner circumference and change if they are more than the allowances.

(mm)

Category	Standard	Allowance
Shaft outer circumference	11.973 ~ 11.984	0.10
Rocker arm inner circumference	12.000 ~ 12.018	
clearance	0.020 ~ 0.070	0.14

(2) Tappet

- Measure the tappet outer circumference and cylinder block tappet hole and change if they are more than the allowances.

(mm)

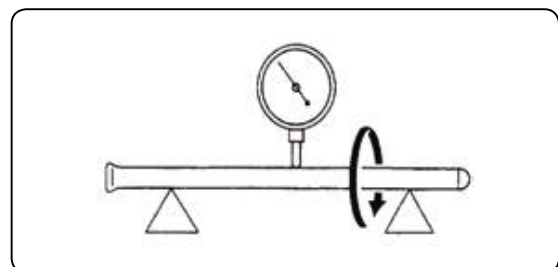
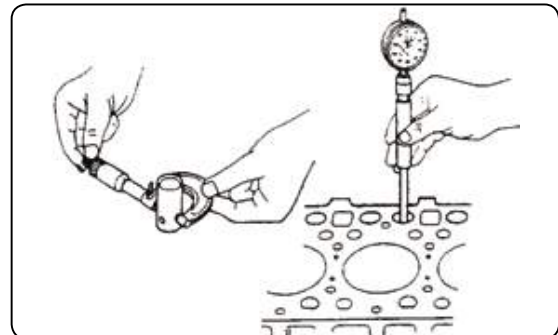
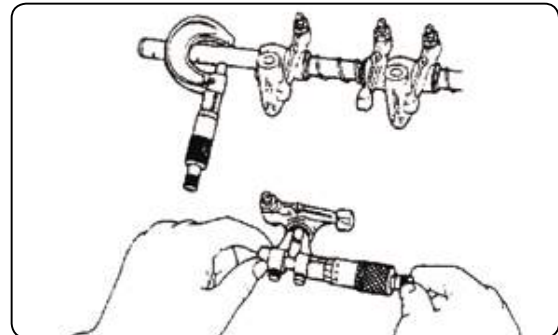
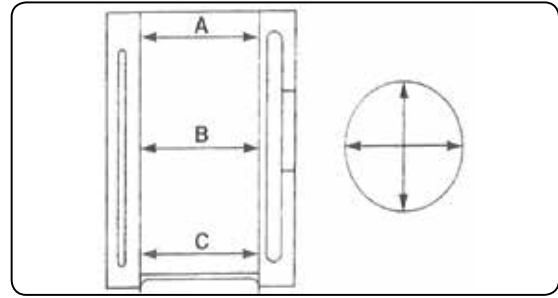
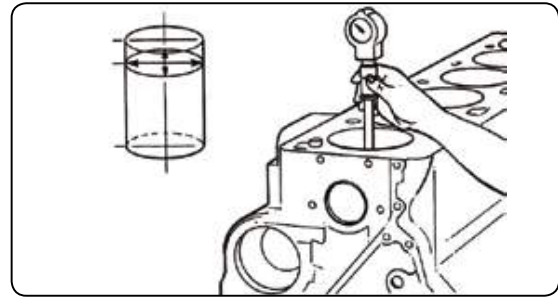
Category	Standard	Allowance
Tappet outer circumference	19.959 ~ 19.980	0.070
Guide inner circumference	20.000 ~ 20.021	
clearance	0.020 ~ 0.062	0.12

- Contact of cam shaft of the tappet: Replace if wear or deformation is excessive.

(3) Push rod

- Measure the push rod place on a flat surface and using a gap gauge and replace if it is bent more than the allowance.

Allowance	0.25 mm
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#### 4.3.4. Piston and piston ring

##### 1) 1) Piston inspection

##### (1) Piston outer circumference

- Measure each major parts and change if any of them are more than the allowance.
- Change if there is any damage or scar on the outer surface.
- Piston outer circumference

Category	Standard	Allowance
Piston outer circumference	77.953~77.972 mm	77.90 mm
Minimum gap to the cylinder	0.041 ~ 0.059 mm	—

##### (2) Piston ring

- Clean the ring groove when changing the piston ring and assemble with the maker mark facing toward top of the piston. Check if it is moving smoothly.
- When assembling the piston ring, misalign about 120 degrees so that the cut is not placed on the side pressure point.
- Measure each major parts and change if any of them are more than the allowance.
- Measure the piston ring gap.

(mm)

Category	Standard	Allowance
No. 1 ring	0.15 ~ 0.30	1.5
No. 2 ring	0.30 ~ 0.50	1.5
Oil ring	0.20 ~ 0.40	1.5

- Measure the piston ring and ring groove gap.

(mm)

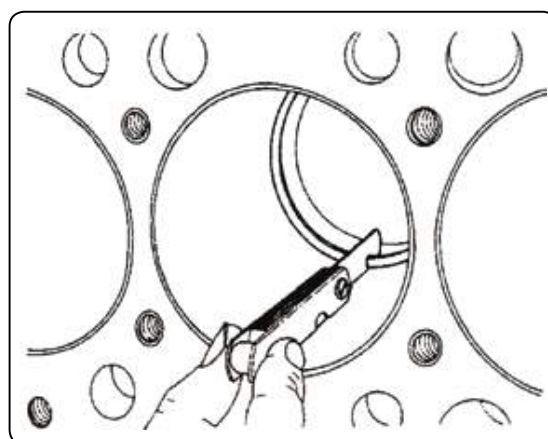
Category	Standard	Allowance
No. 1 ring	0.15 ~ 0.30	—
No. 2 ring	0.085 ~ 0.112	0.20
Oil ring	0.020 ~ 0.055	0.15

##### (3) Piston pin

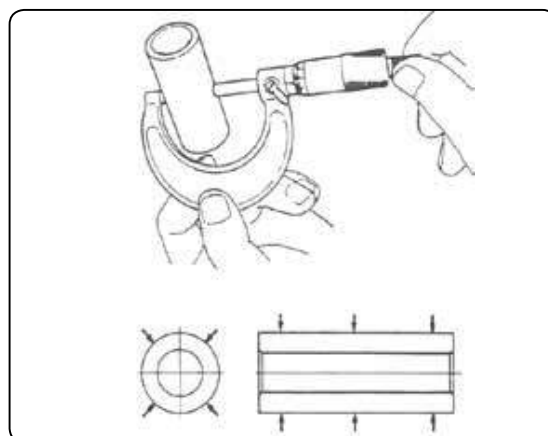
- Measure the major parts and change if any of them worn more than the allowance or unevenly worn.

(mm)

Category	Standard	Allowance
Piston pin outer circumference	21.999 ~ 22.005	21.90
Pin bush inner circumference	22.002 ~ 22.007	22.02
Gap	0.003 ~ 0.008	0.10



4



(4) Connecting rod

- Measure the twist and parallel of the large and small section and change if they are more than the allowances.

Category	Standard	Allowance
twist	100 mm	0.05 mm
parallel	0.03 mm	

- Connecting rod large section inspection (mm)

Category	Standard	Allowance
Large section inner circumference	43.0 ~ 43.016	—
Metal thickness	1.487 ~ 1.500	—
Crank pin outer circumference	39.959 ~ 39.975	39.89
Oil gap	0.025 ~ 0.087	0.15

- Measure and change the pin bearing if it is more that the allowance. Change the connecting rod if needed.

2) Piston change

A. Keep it clean while assembling the piston ring and connecting rod.

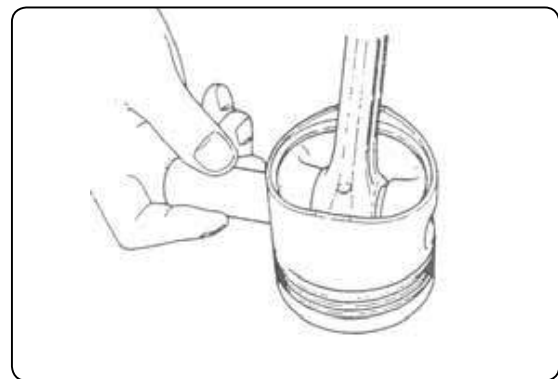
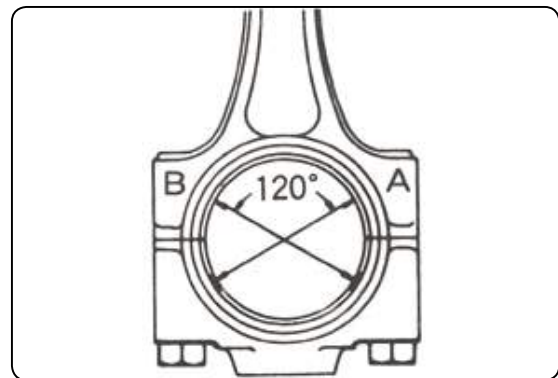
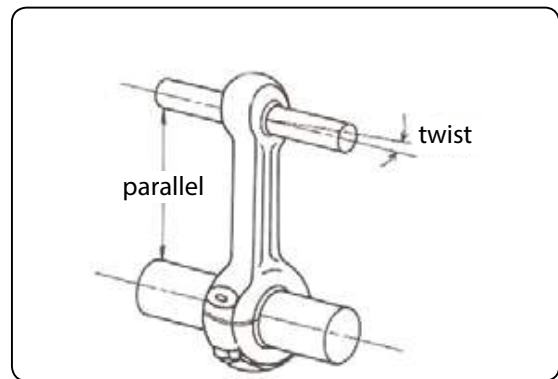
B. Make sure the piston is moving smoothly after the piston ring is assembled.

C. Assemble the piston pin stopper ting on one side of the piston.

D. Apply oil on the piston pin and assemble the connecting rod.

E. Assemble the piston pin stopper ring.

F. When changing the piston, change the piston pin.



### 4.3.5. Crank shaft

1) Crank shaft inspection

(1) Crank shaft journal inspection

- Change if there is crack or damage.
- Measure each major parts and change main bearing if it is more than the allowance. Change the crank shaft if necessary.

(mm)

Category	Standard	Allowance
Crank journal outer circumference	51.921 ~ 51.940	51.91
Metal thickness	2.002 ~ 2.015	—
Oil gap	0.020 ~ 0.081	0.10

(2) Crank shaft bend inspection

- Measure the crank shaft bend.

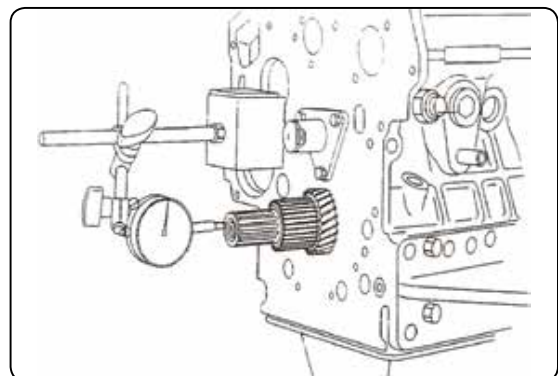
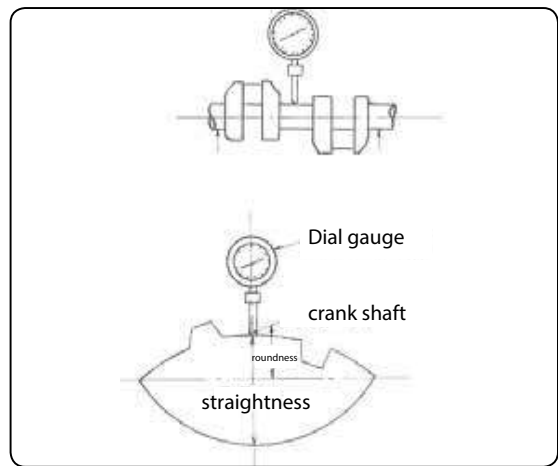
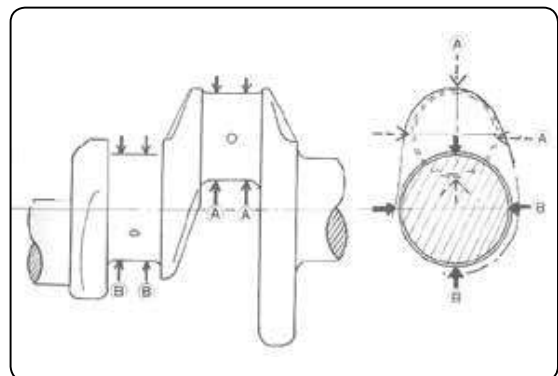
Place both ends of crank shaft journal on V block on top of a flat surface and turn the crank shaft to measure with a dial gauge. Change if the straightness of center of the crank shaft is more than the allowance.

Bend standard	0.02 mm or less
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(3) Crank shaft side clearance inspection

- Measure the crank shaft side clearance.
- Install a magnetic base at the end of the crank shaft and mount a dial gauge on top. Measure the crank shaft-wise side clearance and change the thrust bearing or crank shaft if the measurement is more than the allowance.

Category	Standard
Thrust gap	0.15 ~ 0.31 mm



4.3.6. Cam shaft

1) Cam shaft inspection

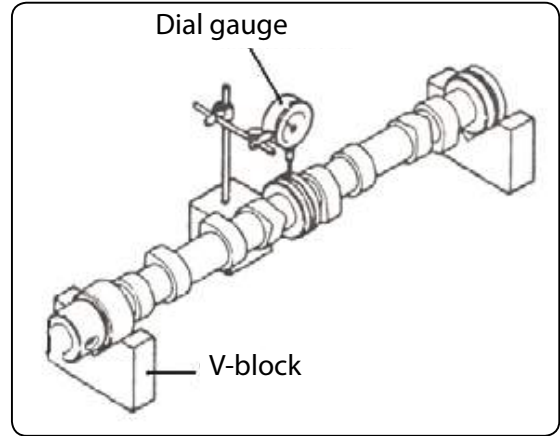
(1) Cam shaft exterior inspection

- Check for wear between the tappet and cam or for damage to cam gear.

(2) Can shaft bend measurement

- Measure the can shaft bend.

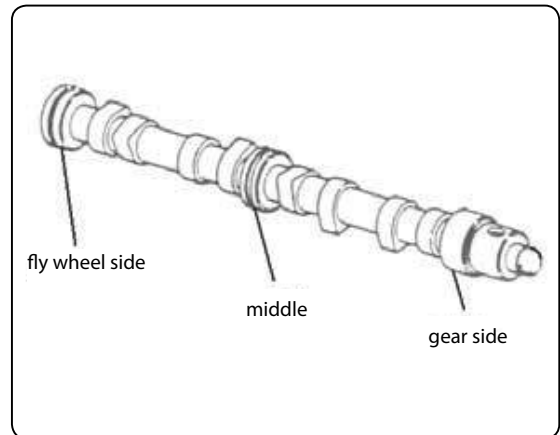
Place both ends of cam shaft journal on V block on top of a flat surface and turn the cam shaft to measure the cam journal shaking with a dial gauge. One half of the journal shaking is the bend.



Category	Standard	Allowance
Cam shaft bend	0,02 mm or less	0,05 mm

(3) Cam shaft journal inspection

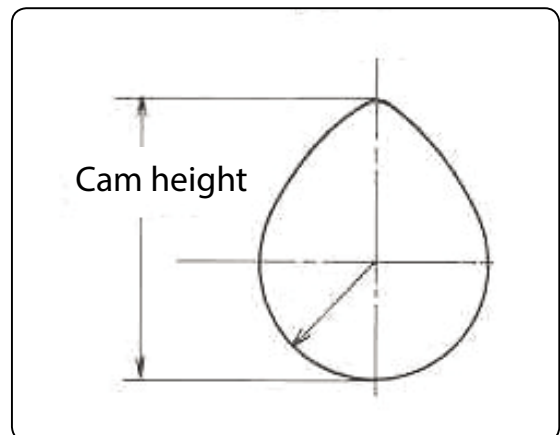
- Measure the cam shaft outer circumference using a micrometer. Measure the cylinder block can shaft inner circumference with a cylinder gauge, then calculate the oil gap from the difference with the cam shaft outer circumference.



Category		Standard	Standard
Gear side	Cam shaft outer circumference	35,934 ~ 35,950	35,89
	Oil gap	0,050 ~ 0,091	—
middle	Cam shaft outer circumference	35,934 ~ 35,950	35,89
	Oil gap	0,050 ~ 0,091	—
Fly wheel side	Cam shaft outer circumference	34,934 ~ 35,950	35,89
	Oil gap	0,050 ~ 0,091	—

(4) Intake and exhaust cam height inspection

category		Standard	Allowance
Cam height	intake	28,80	28,75
	exhaust	29,00	28,95



### 4.3.7. Gear

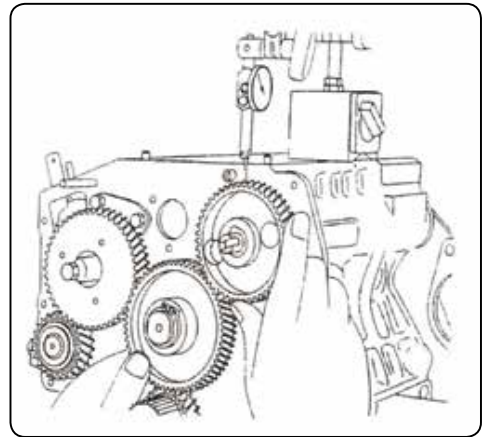
1) Gear inspection

(1) Gear inspection

- Inspect the gear teeth and change if there is damage or excessive wear.

(2) Gear back lash

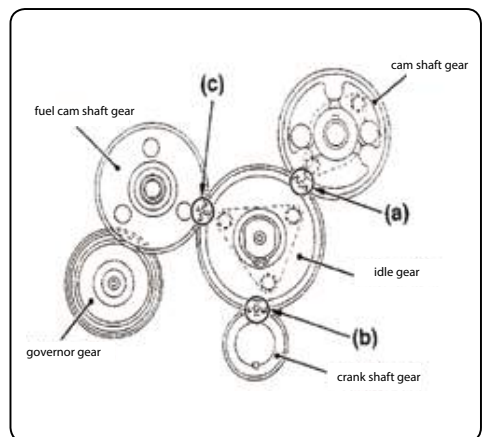
	Item	Standard	Note
Back lash	Crank gear ~ idle gear	0.032~0.115	
	idle gear ~ injection pump gear	0.032~0.115	
	idle gear ~ cam gear	0.032~0.115	
	cam gear ~ compression pump gear	0.036~0.114	
	Crank gear ~ oil pump gear	0.032~0.115	



(3) Gear train

- When assembling the gear, make sure of the contact mark.
  - The contact marks can be confirmed by number of points.

a. 1 point    b. 2 points    c. 3 points





# MEMO

Ruled area for writing the memo content.

## 4.4. ENGINE OPERATION

### 4.4.1. Preparation before the operation

- 1) Add new engine oil in the oil tank.
- 2) Connect the cooling hose and add coolant.
- 3) Connect the fuel hose to the fuel tank.
- 4) Remove air from the fuel line.

### 4.4.2. Engine operation

Please pay attention to the following since the oil film on the unbroken new engine may be overloaded due to over-speed which shortens the engine longevity.

#### First 50 hours

- 1) Drive within the range of 1200 ~ 1500rpm without any load until the engine temperature reaches normal condition.
- 2) Avoid overloading or continuous over speeding.
- 3) Avoid over speeding without load.
- 4) Avoid sudden acceleration or braking.
- 5) Perform the inspections and tests.

### 4.4.3. To break the engine in

Please comply with the following while driving to break in the engine.

- 1) Check the engine oil level often. (Maintain the oil level between the maximum and the minimum.)
- 2) Check the oil pressure warning lamp.  
If the lamp is on, check for insufficient oil or problem in lubricating system.
- 3) Make sure the coolant circulation is normal by observing the engine coolant gauge.

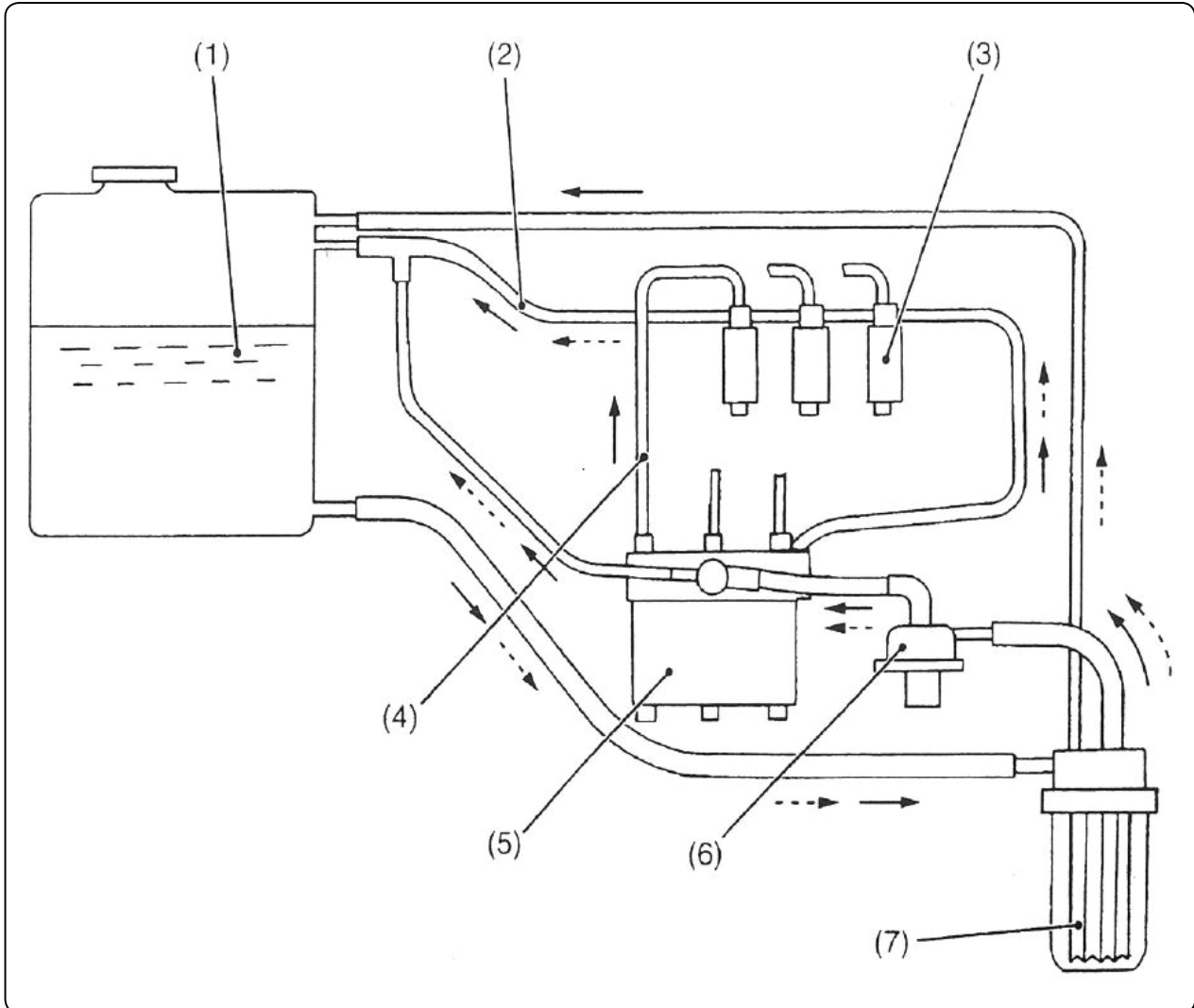
Change engine oil and oil filter at the end of the first 50 hours of driving.

(Use appropriate engine oil for local weather)

## 5. MAJOR ENGINE PART MAINTENANCE

### 5.1. FUEL DEVICE

- The fuel system consists of the fuel tank, fuel supply feed pump, fuel filter, fuel injection pump, fuel injection valve and parts to connect all these devices.



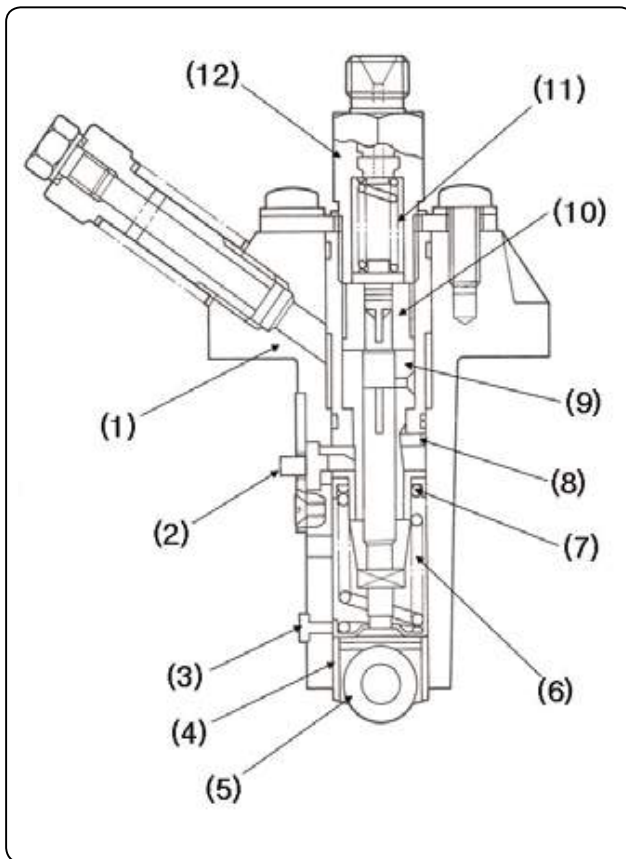
- (1). Fuel tank
- (2). Fuel over flow pipe
- (3). Injection nozzle
- (4). Injection pipe

- (5). Injection pump
- (6). Fuel feed pump
- (7). Fuel filter

5.1.1. Fuel injection pump

- The fuel injection pump is a distributing type (VE) and mounted on the gear cover plate. It is operated by the injection pump gear.

As a plunger rotates, fuel is distributed to each piston. Fuel is sent to the injection pump through the fuel filter coming from the fuel tank by the external feed pump and built-in feed pump. Fuel with low pressure is adjusted by the regulating valve when it enters the pump chamber. Fuel reaches the high pressure chamber passing the barrel intake port through the injection pump head path from the pump chamber. Pressurized fuel by the plunger is injected through the fuel injection valve in the injection order. Any excessive fuel within the injection pump is returned to the fuel tank through the overflow valve and fuel returning hose. Through such fuel circulation, the fuel injection pump is cooled and lubricated. Any remaining fuel left in the fuel injection valve is returned to the fuel tank through the overflow hose after collected in the injection pump. Any moisture in the fuel causes short pump longevity, so please be careful and maintain the fuel system not to be contaminated with moisture or dust.



Names of the fuel injection pump

- (1) Fuel injection pump housing
- (2) Control rod
- (3) Pin
- (4) Tappet
- (5) Roller
- (6) Plunger spring
- (7) Control sleeve
- (8) pion
- (9) Plunger assembly
- (10) Delivery assembly
- (11) Delivery valve spring
- (12) Delivery valve holder

- Specification

Item	Specification	Note
Fuel filter specification		Cartridge filtering type
Fuel injection pump	Type	PFR
	Injection sequence	1-2-3
	Governor type	All Speed
	Fuel blocking solenoid	12V / 8Ω
Fuel injection valve	Nozzle type	Semi-Throttle Type
	Holder type	Screw insert type

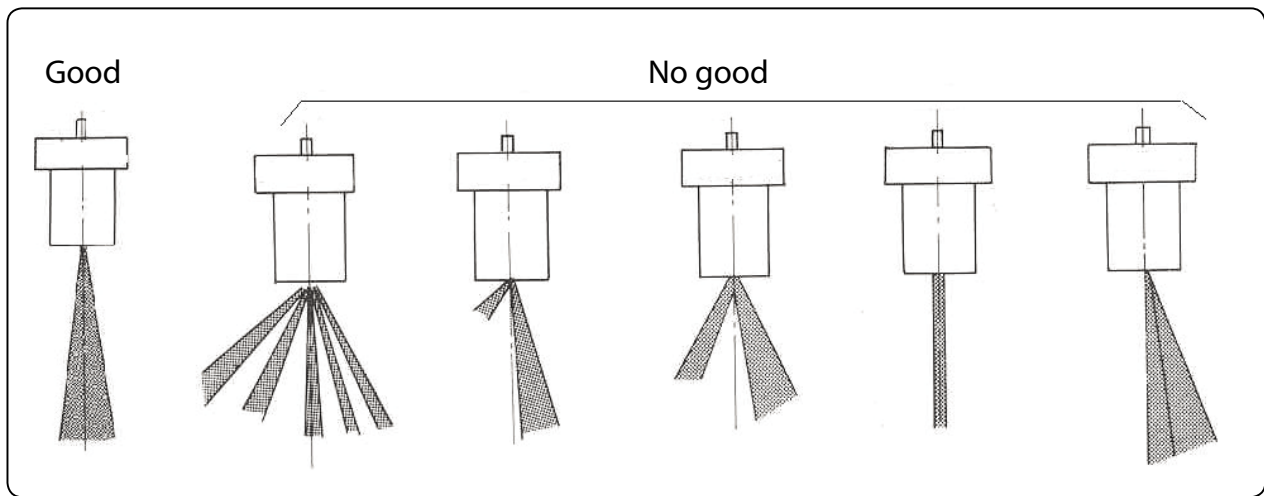
5.1.2. Fuel injection valve

● The injection type of the fuel injection valve is very important in the performance of the diesel engine. Please adjust and maintain properly.

1) Nozzle injection check

Adjust the nozzle injection pressure to  $140 \pm 5 \text{ kg/cm}^2$ , mount it on the nozzle tester, operate the lever for four to six times per second and check the injection. If there is abnormality, clean or change the nozzle.

- (1) Check if the injection is normal.
- (2) If not good, disassemble the fuel injection valve to change the nozzle tube or the assembly.
- (3) Check for residual after the injection has stopped.
- (4) If not good, disassemble the fuel injection valve to change the nozzle tube or the assembly.



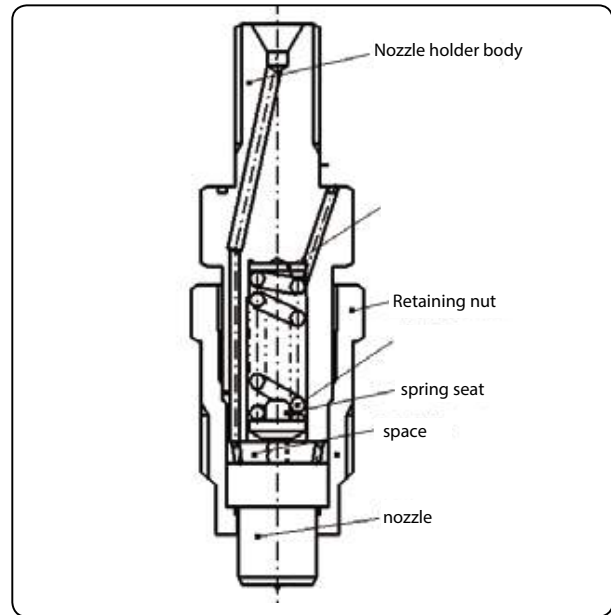
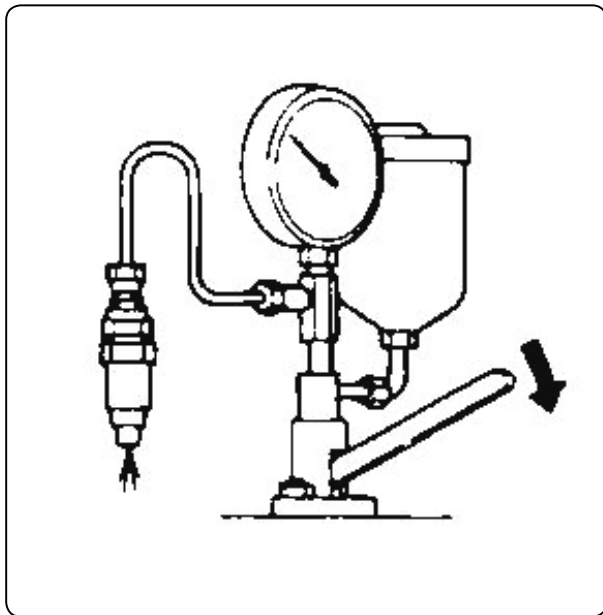
2) Nozzle inspection and adjustment: Initial injection pressure inspection and adjustment

- (1) Mount the nozzle holder on the nozzle tester.
- (2) Operate the nozzle tester handle once per second.
- (3) Indicating needle of the pressure measure slowly rises and the needle may shake during the injection. Read the needle indication at the moment the needle begins to shake and check if that initial pressure is within the standard range.

Standard pressure	Altered pressure	140 kg/cm <sup>2</sup>	A1000, A1100(T)
	Adjusting pressure	145 ~ 155 kg/cm <sup>2</sup>	
Upper limit		140kg/cm <sup>2</sup> 이상	

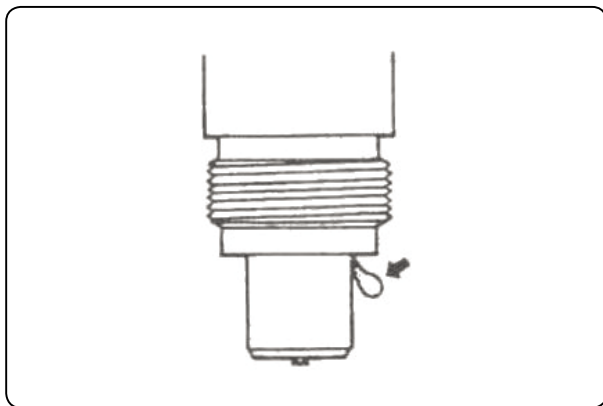
**CAUTION** : Avoid dust while disassembling the nozzle holder.

- (4) If the initial injection pressure is not adjusted with a different thickness, change the assembly.



### 3) Nozzle oil-tightness inspection

- (1) After injecting several times with the nozzle tester lever, wipe fuel off the injecting head and check if there is any fuel leak from the nozzle tube while increasing the pressure from  $20\text{kg}/\text{cm}^2$  to  $130\text{kg}/\text{cm}^2$ .
- (2) If no good, disassemble the fuel injection valve and change the nozzle tube or the assembly.



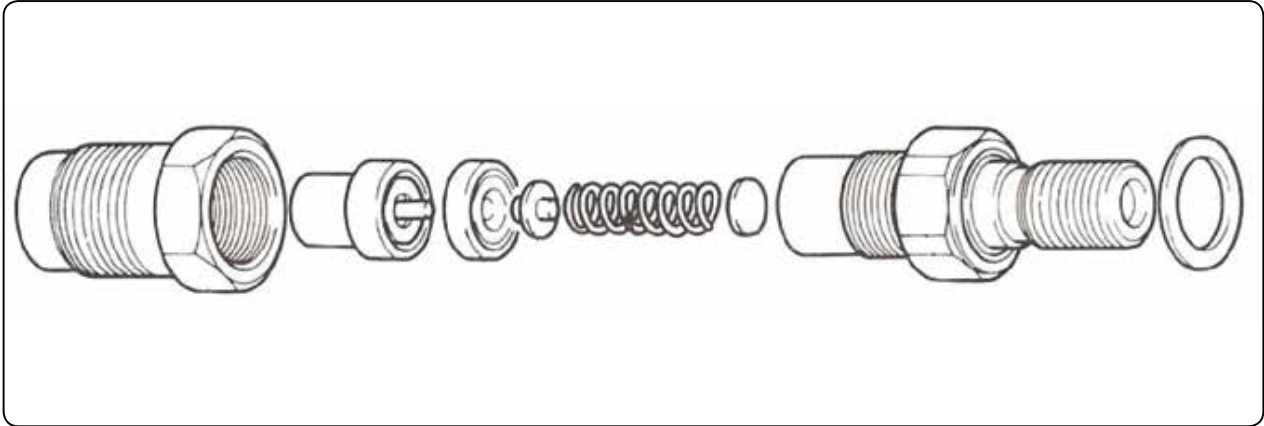
### 4) Combustion chamber insulation packing

- Insulation inspection is necessary since the swirl type combustion chamber is equipped with insulation packing on the nozzle valve to improve the nozzle durability.
- Clean the cylinder head fuel injection valve hole and use a new gasket.  
(Replace used or damaged ones.)

## 5) Nozzle holder

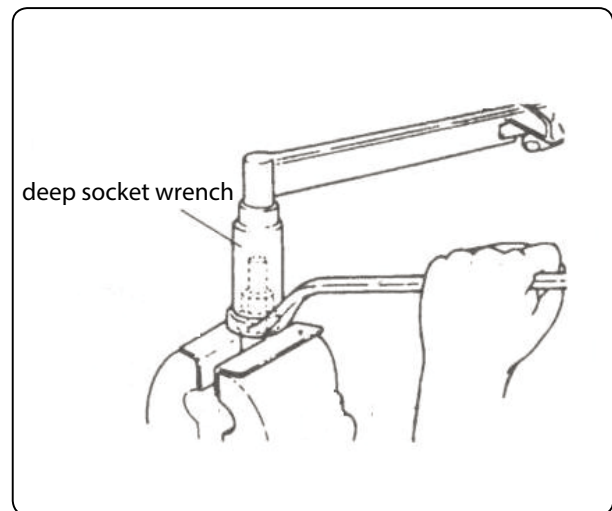
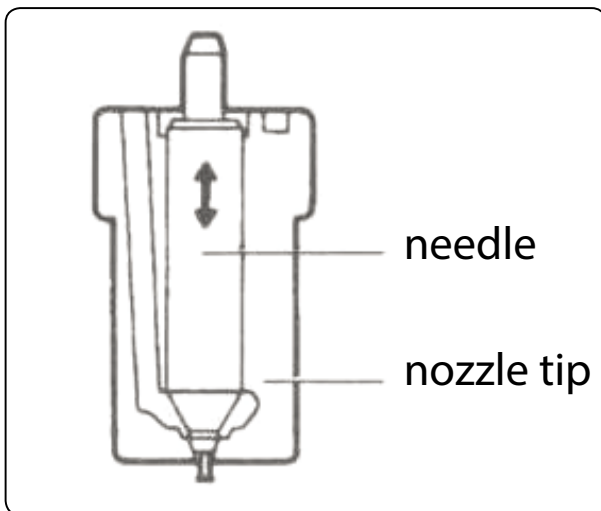
## ● Disassembly

- (1) Lightly secure the retaining nut using a cushion bracket.
- (2) Secure the retaining nut with a box wrench and disassemble the nozzle holder body with a deep socket wrench.



## ● Nozzle tip inspection

- (1) Check if carbon is attached on the nozzle tip. If so, remove the carbon, clean the parts with cleaning oil and soak in diesel. Be careful not to damage the needle valve nozzle tip.
- (2) Soak the nozzle tip in diesel and check if the needle valve operates smoothly. Change it, if not. Wash new nozzle tip in diesel before using it.

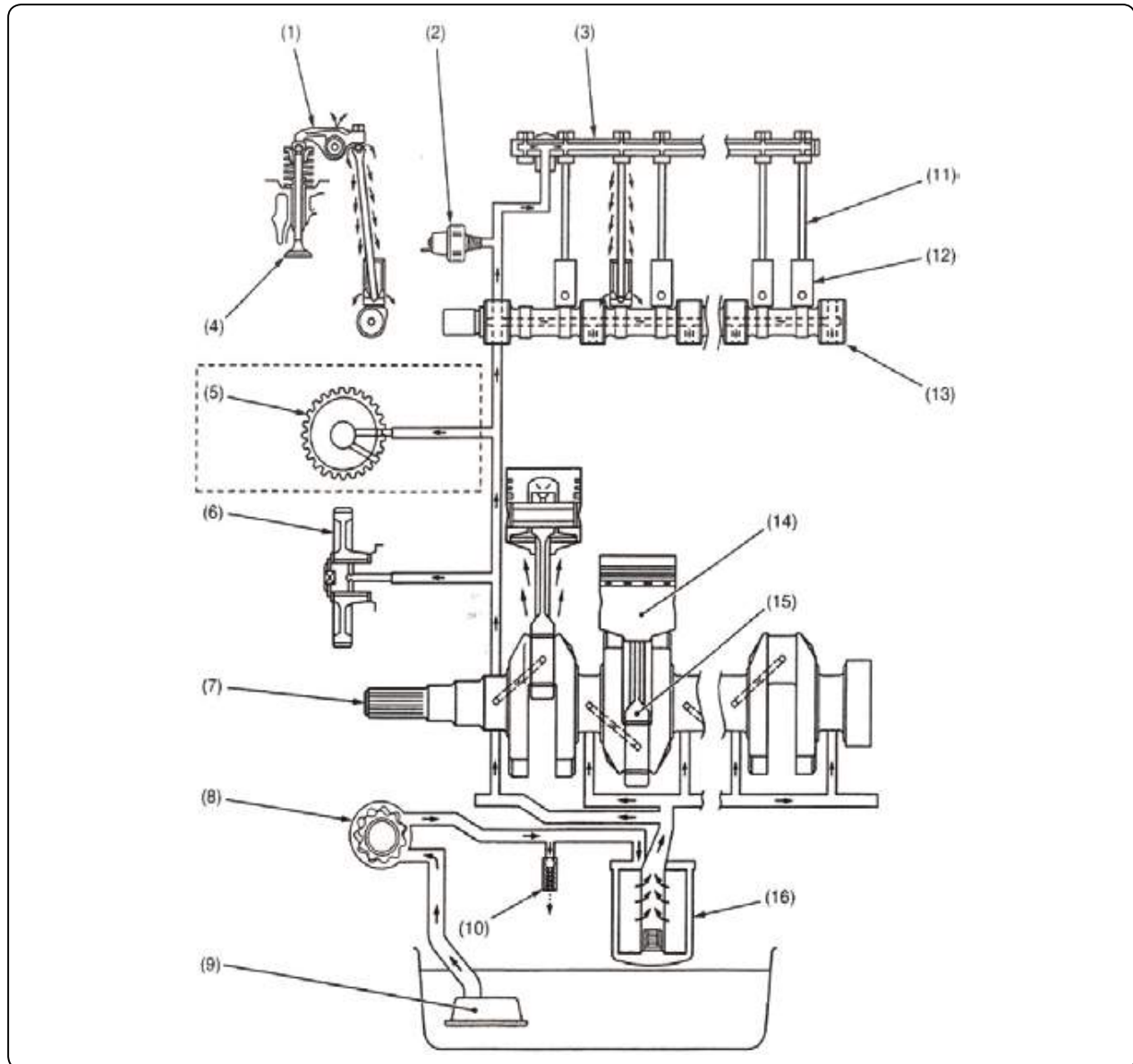


## ● Retaining nut assembly

- (1) Tighten the nozzle holder body firmly with a hand.
- (2) Lightly secure the retaining nut using a vice with a cushion plate.
- (3) Secure the retaining nut with a box wrench and assemble the nozzle holder body with a deep socket wrench to required torque.

## 5.2. LUBRICATING DEVICE

- Engine oil is pumped in through the oil suction pipe by the oil pump, moved through the oil filter and supplied to each lubricating parts.



- (1). Rocker arm
- (2). Oil pressure switch
- (3). Rocker arm shaft
- (4). Valve
- (5). Governor shaft
- (6). Idle gear
- (7). Crank shaft
- (8). Oil pump
- (9). Oil suction pipe

- (10). Relief valve
- (11). Push rod
- (12). Tappet
- (13). Cam shaft
- (14). Piston
- (15). Connecting rod
- (16). Oil filter



1) Oil pump

- The oil pump is a trochoid type pump which is operated by the crank shaft gear. It is compact, has less pressure fluctuation and delivers 3,5kg/cm<sup>2</sup> of pressure to each parts.

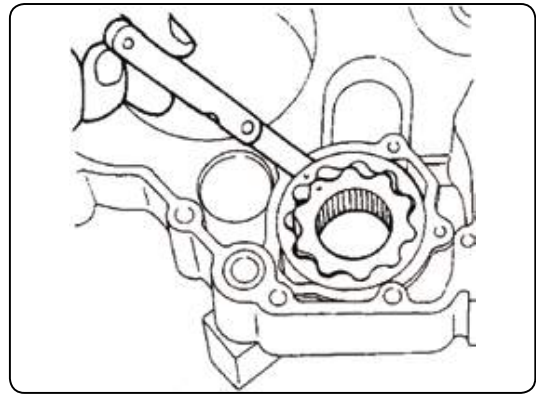
- Check the oil amount if the lubricant pump output pressure is low. Inspect the lubricant pump in the following ways if there is nothing wrong.

- Gap between the outer rotor and inner rotor  
Measure the gap between the outer rotor and inner rotor using a gap gauge.

division	standard	allowance
gap (mm)	0.07	0.15

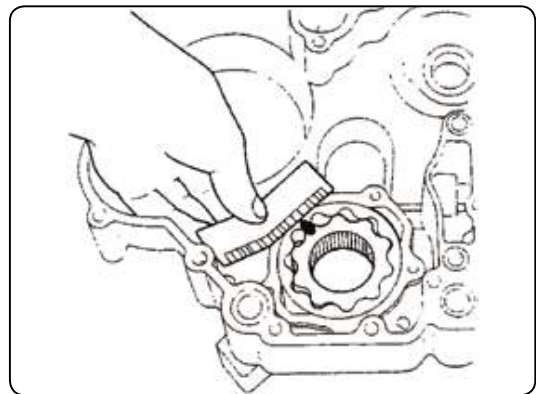
- Gap between the pump and outer rotor, or inner rotor  
Measure the gap between the outer rotor and pump body using a gap gauge.

division	standard	allowance
gap (mm)	0.100	0.180



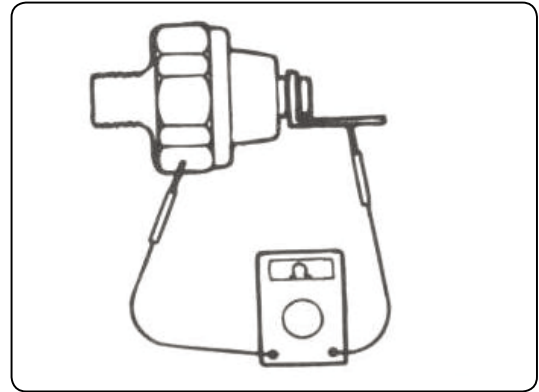
- Gap between the inner rotor shaft and oil pump cover  
Measure the gap between the rotor and oil pump cover.

division	standard	allowance
gap (mm)	0.030	0.085

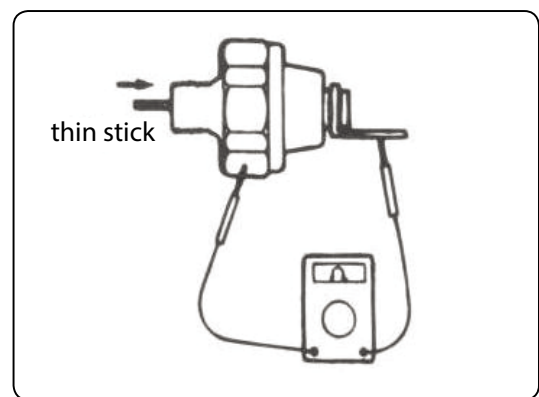


## 2) Oil pressure switch

- Connect a tester between the terminal and body to check the electricity. It is normal if there is electricity. If not, change the switch.



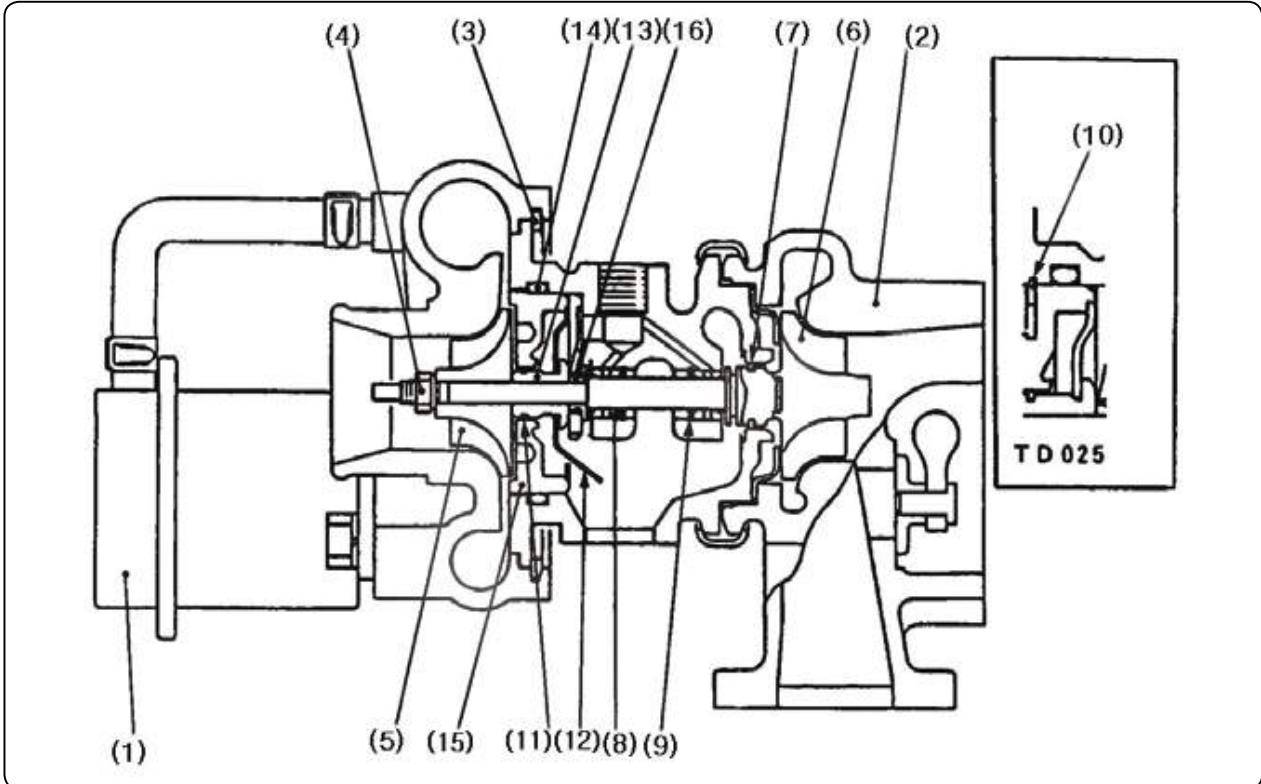
- Lightly press in the oil hole with a thin stick. It is normal to have no electricity. If there is, change the switch.



- It is normal to have no electricity with 0.5 kg/cm<sup>2</sup> of air pressure in the oil hole. Check if there is air leak. If there is, change the switch since this indicates a damaged diaphragm.

5.3. TURBO CHARGER

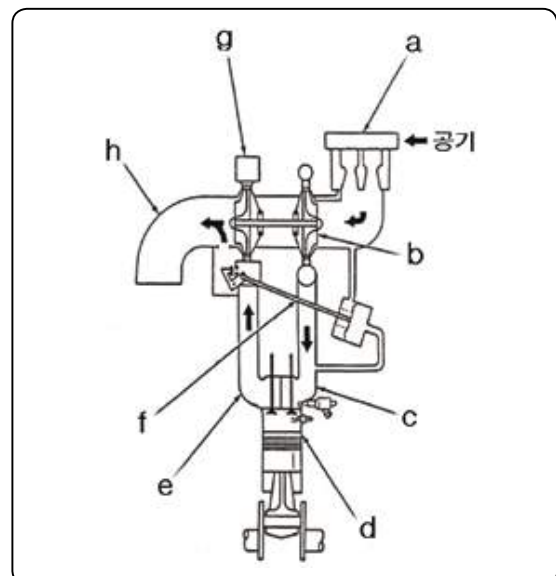
• The turbo charger is operated using the exhaust gas. It pressurizes the air intake to supply to the combustion chamber so that engine power is increased.



- |                     |                       |                        |                     |
|---------------------|-----------------------|------------------------|---------------------|
| (1) Actuator        | (5) Compressing wheel | (9) snap ring          | (13) Thrust sleeve  |
| (2) Turbine housing | (6) turbine wheel     | (10) snap ring (TD025) | (14) O-ring         |
| (3) snap ring       | (7) piston ring       | (11) piston ring       | (15) thrust bearing |
| (4) Locking nut     | (8) bearing           | (12) oil diffracter    | (16) thrust ring    |

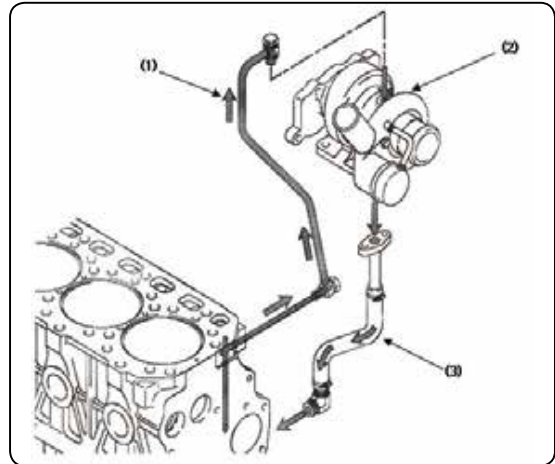
1) Turbo charger operation summary

- a. Air intake comes in through the air cleaner.
- b. Revolving pressure wheel pushed air into the engine
- c. Pressurized air is mixed with injector fuel to taken into the combustion chamber.
- d. Pressurized and charged gas mixture generates more horse power in the combustion process.
- e. Exhaust gas goes out to the exhaust manifold through the turbine.
- f. As the intake manifold pressure reaches the appropriate pressure, part of exhaust gas bypasses through open valve of the west gate.
- g. Turbine wheel is turned by the exhaust pressure and high heat energy. The pressure wheel is also turned.
- h. Cold and expanded exhaust gas leave through the exhaust system by the turbine housing.

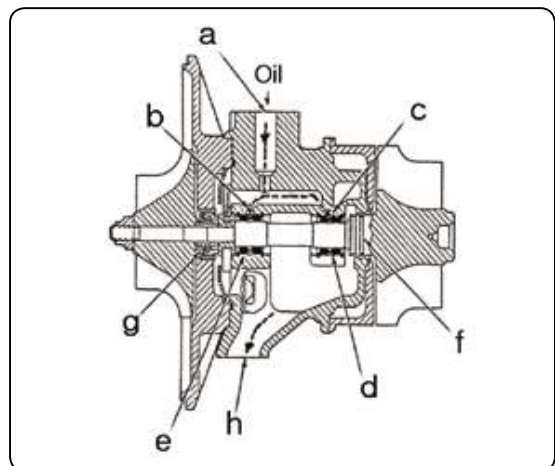


2) Turbo charger oil schematic

- (1). Lubricant moves into the turbo charger from the cylinder block through the lubricant tubing.
- (2). It lubricates within the turbo charger.
- (3). It returns to the cylinder block through the return tubing from the turbo charger.



- a. This is the turbo charger lubricant inlet,
- b. This is the pressurizer oil route.
- c. It directly lubricates through the center housing bearing.
- d. There is a hole to aid in the bearing oil circulation.
- e. This is pressurizer end bearing.
- f. A piston ring seal is used at the end of the turbine wheel shaft to prevent engine oil leak into the turbine wheel housing.
- g. Carbon seal is used at the end of the pressurizer wheel shaft to prevent engine oil leak into the pressurizer wheel housing.
- h. Oil drain from the turbo charger is done through the return hole in the center housing.

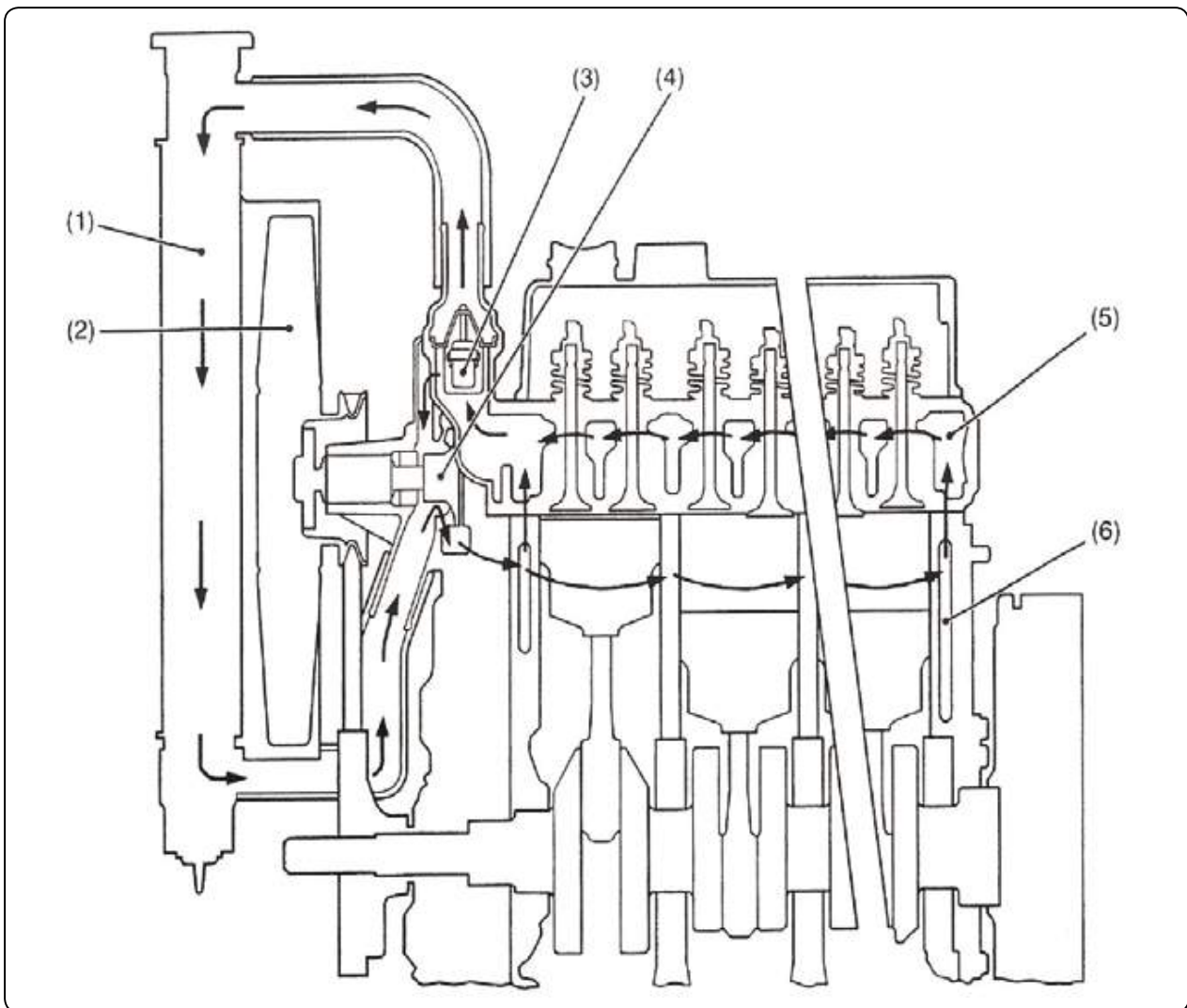


#### 5.4. COOLING PROCESS

● This engine is water cooled. The coolant absorbs the combustion heat and engine oil heat and dissipates to the outside for a normal engine operation.

The cooling system supplies coolant through the coolant pump and circulates the oil cooler to absorb the oil heat through the cooling hose. Combustion heat is also absorbed while it goes through the cylinder block coolant jacket and cylinder coolant tubing.

The coolant that absorbed oil heat and combustion heat moves to the thermostat. If the coolant is cooler than the valve opening temperature, coolant recirculates to cylinder. If the coolant is hotter, then it flows into the radiator. The radiator cools the coolant by dissipating heat and the coolant recirculates to the coolant pump.



- (1). Radiator
- (2). Cooling fan
- (3). Thermostat
- (4). Coolant pump

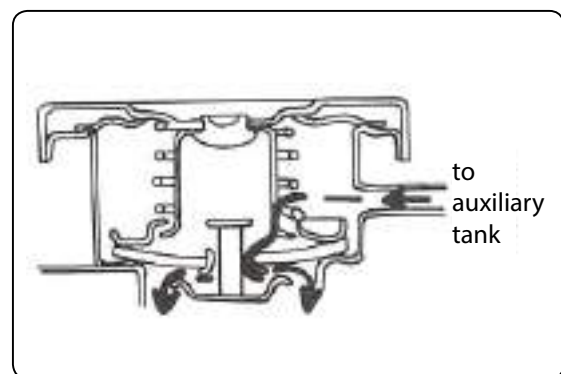
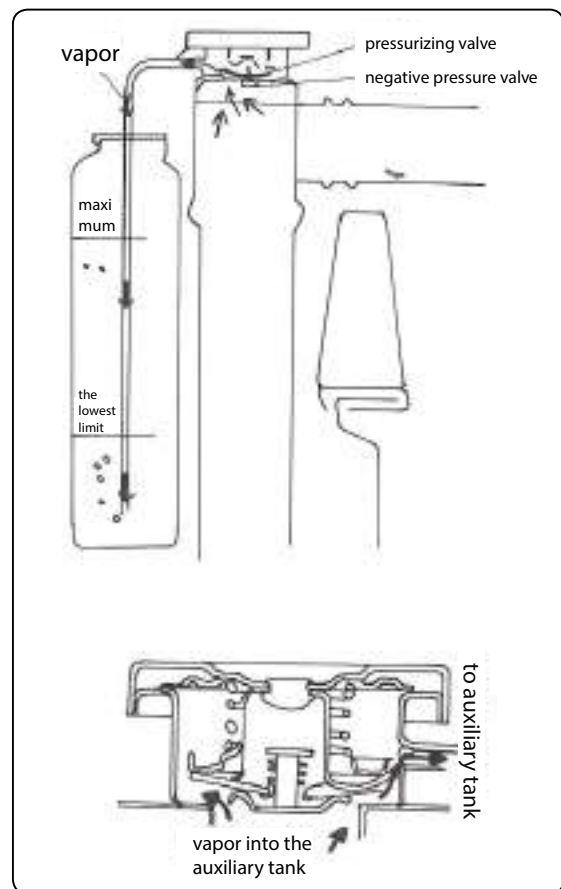
- (5). Cylinder head water jacket
- (6). Cylinder block water jacket

### 1) Auxiliary tank (Coolant time extended)

When the coolant becomes hot from the engine operation, it is cooled in the radiator by the sucked in air. However, overload or long driving will increase the water temperature and vapor pressure within the radiator. If the vapor pressure is more than  $0.9\text{kg/cm}^2$ , the pressure valve is opened to discard the steam at which time the coolant is consumed.

The auxiliary tank prevents the consumption of coolant by collecting the vapor in it to liquefy. If engine is not running or there is no load, radiator pressure becomes negative so coolant in the tank is sucked into the radiator. This is the reason for long driving without adding coolant.

When inspecting the coolant amount, there is no need to remove the radiator cap. Just check the level of the auxiliary tank, which eliminates a danger of burn from the hot steam.



### 2) Cooling pump inspection

- Inspect the coolant pump and the followings. If abnormal, change the coolant pump with assembly.
  - 1) Coolant leak (check if there is leak from the pump body while driving)
  - 2) Coolant pump bodily damage or crack
  - 3) Impeller damage or crack
  - 4) Bearing damage (Turn the pump shaft lightly to check if it turns smoothly without wobbling.)

3) Coolant temperature sensor inspection

- Leave the sensor in water and add heat slowly to measure the resistance. (Resistance between the terminal and body)

temperature (°C)	80	115
resistance (Ω)	118	42

4) Glow plug control sensor inspection

- Measure the sensor resistance. (Resistance between the terminal and body)

temperature (°C)	-15	20
resistance (Ω)	9.6	2.4

5) Over heat warning sensor inspection

- Heat engine oil and check if sensor is turned on when the engine oil reached certain temperature.

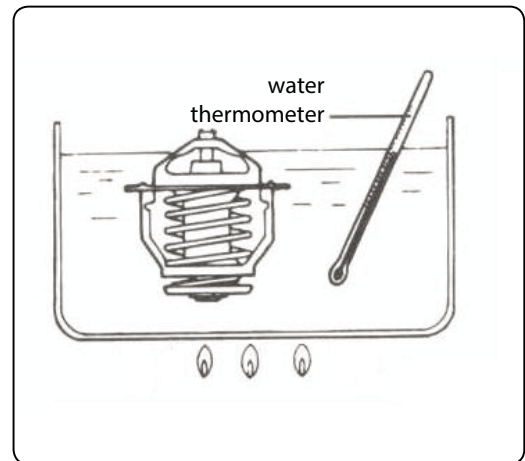
ON	OFF
110 ± 2°C	100°C 이상

6) 써모스탯

- Thermostat maintains the coolant temperature at proper level and prevent heat loss to improve the engine heat effectiveness.
- Check the valve opening temperature while heating the thermostat in water.

Valve opening temperature	72 ± 2°C (starts to open)
	85 ± 2°C (completely open)

- valve deploy lift: 8mm or more



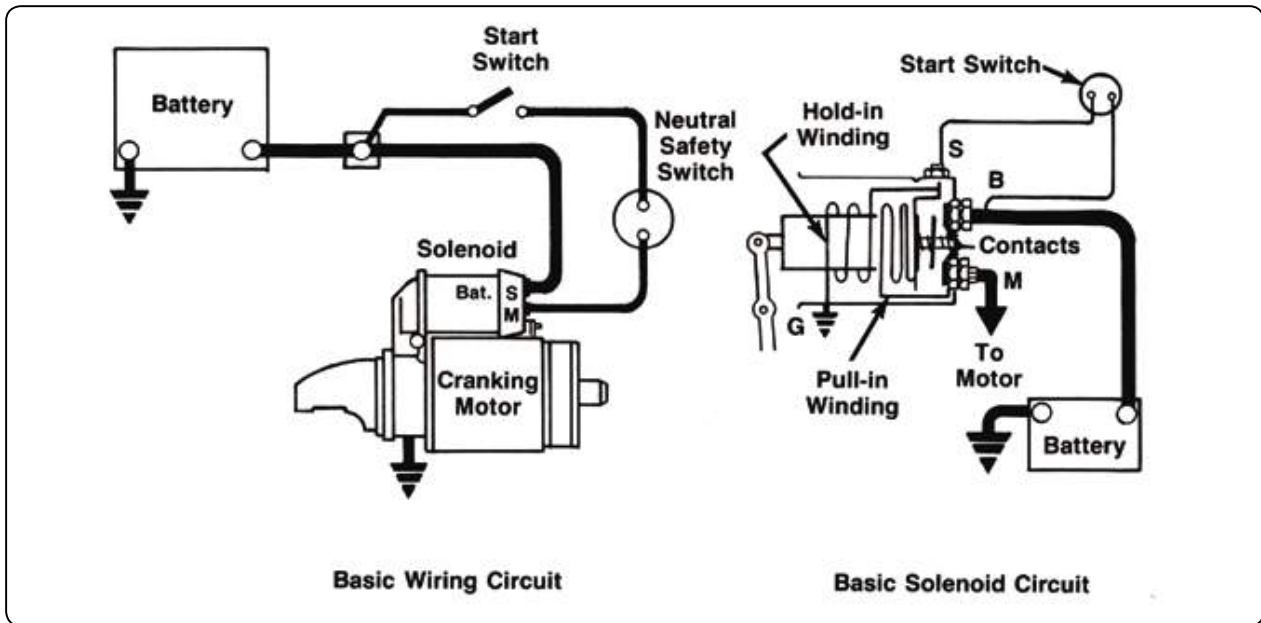
7) Over Heat

- If engine is stopped when it is over heated, coolant circulation also stops which may temporarily increase the over heat. If engine is cooled in short time, block could develop cracks. Do not panic. Let the engine operate in low revolution to cool the coolant naturally.

5.5. ELECTRICAL SYSTEM

5.5.1. Starter

- Circuit diagram



- Specification

item	detail	note
output	12V / 2.2kW	
Number of pinion teeth	15	
Electricity without load	12,5V	

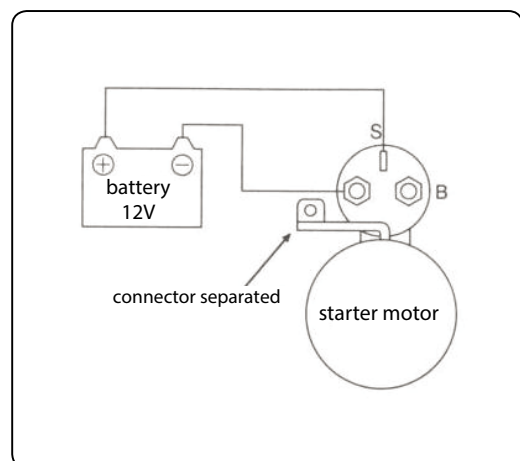
- Inspection

1) Pull in coil test of the magnetic switch (solenoid)

The pull-in coil is normal if plunger is sucked in and pinion pops out with the battery in contact between the magnetic switch S-M terminals. If not, change the magnetic switch.



- While the inspection, remove the M terminal from the connector.
- Do not leave in contact more than 10 seconds.





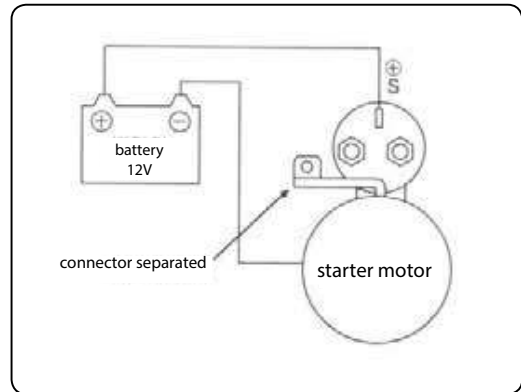
2) Holding coil of the magnetic switch test

Manually pull the pinion to the stopper location while the battery is in contact between the magnetic switch S terminal and body. The hold in winding is normal, if it returns when let go.



**CAUTION**

Do not leave in contact more than 10 seconds.



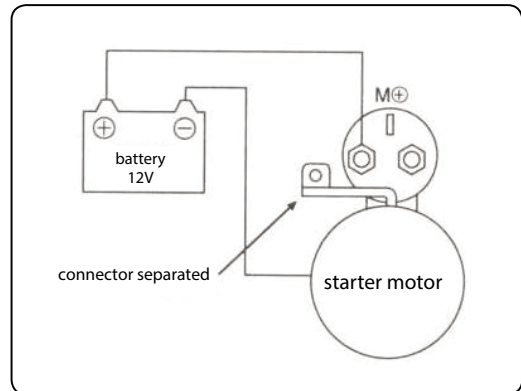
3) magnetic switch return test

Manually pull the pinion to the stopper location while the battery is in contact between the magnetic switch M terminal and body. Both coil are normal if they return when let go.



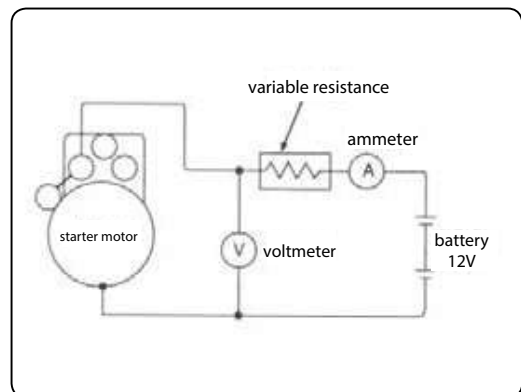
**CAUTION**

Do not leave in contact more than 10 seconds.



4) No loading test

1. As shown in diagram, connect the starter motor, battery, voltmeter, ammeter and variable resistance.
2. The starter motor is normal, if it turns smoothly with maximum resistance and switch ON. Adjust the voltmeter to be 11.5V. If voltage and revolution are not within the standard values, estimate the cause according to the following table and repair.



Trouble	Cause
High voltage, fast turning (torque is not that strong.)	<ul style="list-style-type: none"> <li>- metal stained, oil polluted</li> <li>- worn armature core pole piece</li> <li>- armature coil short</li> </ul>
High voltage, no turning	<ul style="list-style-type: none"> <li>- Electronic switch grounding</li> <li>- armature coil, field coil grounding</li> <li>- Scorched metal</li> </ul>
No voltage, no turning	<ul style="list-style-type: none"> <li>- armature coil, field coil short</li> <li>- Brush and pig tail short</li> <li>- commutator soiled, bad contact between brush and commutator due to Biotite (Highmica)</li> </ul>
Weak voltage, slow turning (torque is not that strong.)	<ul style="list-style-type: none"> <li>- bad contact of field coil ( shunt coil short or bad contact cause fast turning.)</li> </ul>
High voltage, fast turning (torque is not that strong)	<ul style="list-style-type: none"> <li>- Field coil short</li> </ul>

● Starter parts cleaning

- 1) Do not soak parts in solvent. When yoke, field coil assembly or commutator is soaked in solvent, their insulation will be damaged. When these parts are dirty, wipe then with cloth.
- 2) Do not soak the driver unit in detergent since washing in detergent will clean out the clutch oil of the over running clutch which is oiled at the manufacturer.
- 3) Clean the driver unit with a brush wet with cleaning liquid and dry with cloth.

● Commutator inspection

- 1) Place the commutator on a set of V block and check the roundness with a dial gauge.

standard	0 ~ 0,03 mm
allowance	0,1 mm

- 2) Check the undercut depth between segments.

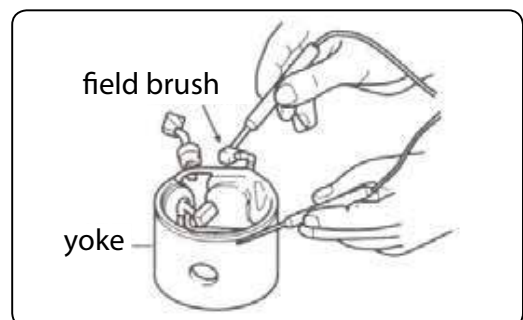
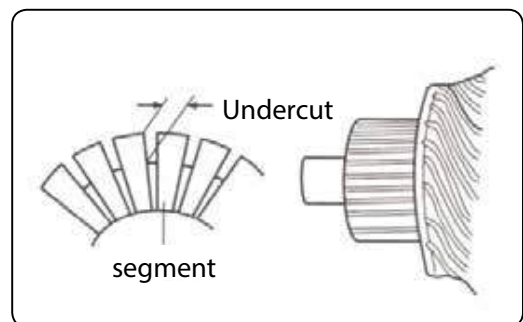
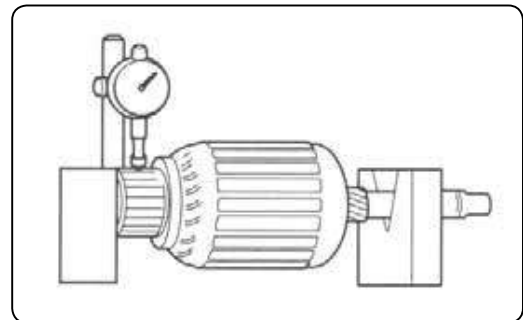
standard	0,5 mm
allowance	0,2 mm

- 3) Field coil conductivity test

This is to test conductivity between the field brushes. It is normal if it is not conductive.

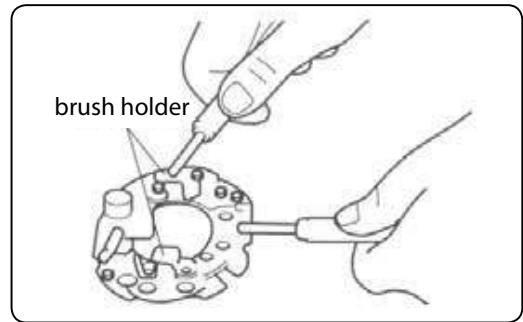
- 4) File coil grounding test

This is to test conductivity between the field coil brush and yoke. It is normal if it is not conductive.



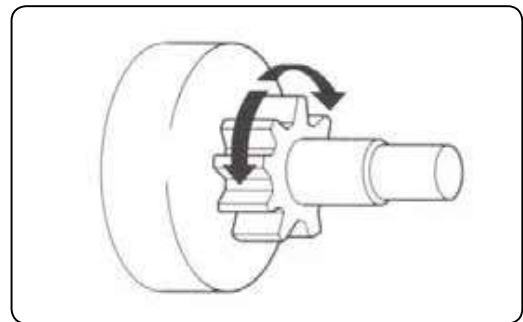
5) Brush holder

This is to test conductivity between the brush holder and plate holder. It is normal if it is not conductive.



6) Over running clutch

1. Check if the pinion is locked when turned to left and turns smoothly when turned to right.
2. Inspect wear and damage to pinion.

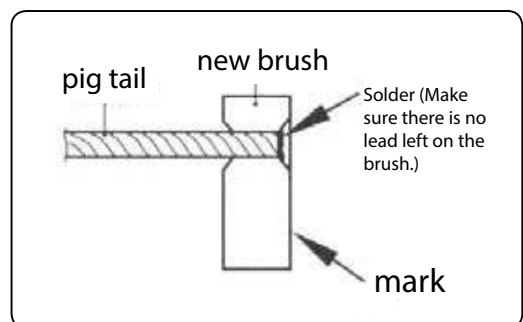
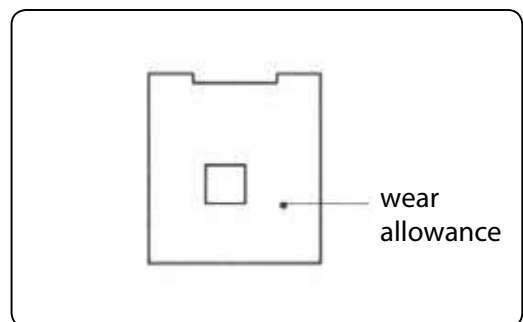


● Brush inspection

1. Check roughness of commutator and brush length.

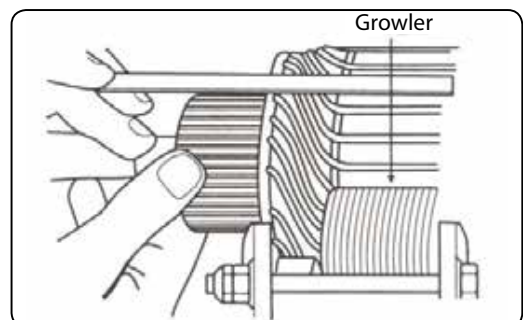
standard	Wear allowance
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2. Modify the commutator contact surface with sandpaper when the contact surface is modified or brush is changed.
3. Be careful not to damage the pig tail when remaining brush is removed with a flyer.
4. Polish the pig tail with a sandpaper to induce better soldering.
5. Solder a pigtail in the new brush hole. Make sure there is no lead left on the brush.



2) Commutator coil short test

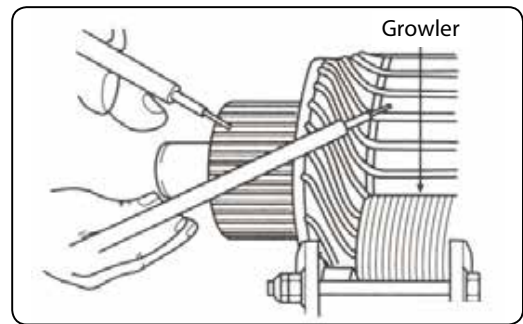
1. Install the commutator on the growler.
2. Place a thin plate parallel to the commutator. Turn the commutator slowly. It is normal if the plate is not sucked in or vibrates.



Remove all attachment on the commutator and test again

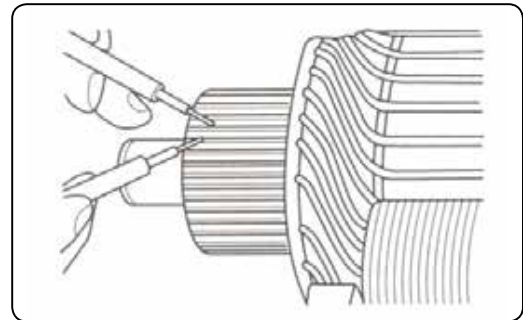
### 3) Commutator coil grounding test

Check between the commutator segment and armature coil cores. It is normal if it is not conductive.



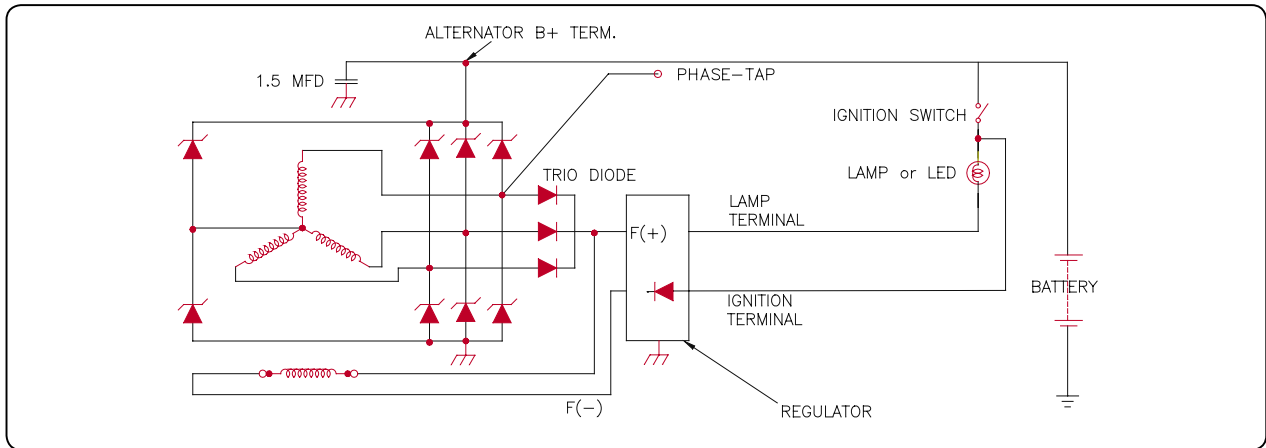
### 4) Armature coil short

Check the conductivity between each segment. It is normal if it is conductive.



5.5.2. Generator (alternator)

- Basic circuit diagram



- Specification

Item	detail	Remarks
Type	AC generating rectifier-type	
Output	12V / 50A	
Motor speed	1,000~18,000 rpm	
Regulator setting voltage	14.7 ± 0.3V	
Temperature compensation	-7 ± 3mV/°C	

- Inspection

1) Generator output measurement while the engine is running

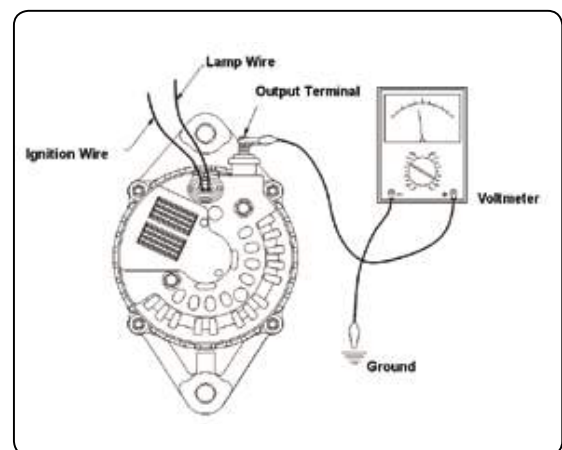
(1) Connect the positive (+) terminal of the voltmeter to the output (B+) terminal of the generator and ground the negative (-) terminal of the voltmeter.

(2) The measurement should be between 13.4 and 15.7 V while the engine is running in 1500ERPM with all the devices turned on.

(3) If the measurement is not obtainable or the voltage is not regular, check for output circuit damage, loose or dirty.

(4) If above condition persists, check for the brush or slip ring wear, foreign objects or damage.

(5) If the brush and slip ring are normal, the failure is due to internal damage to the generator.

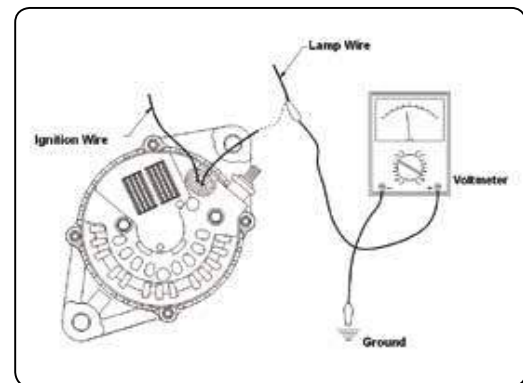


## 2) Lamp circuit test while the engine is on

(1) Connect the positive (+) terminal of the voltmeter to the lamp line and ground the negative (-) terminal of the voltmeter.

(2) If the lamp is not on or there is no output while the engine is running, then lamp line or lamp may be short.

(3) If the output is very weak, then regulator circuit or rotating magnetic field coil may be short.

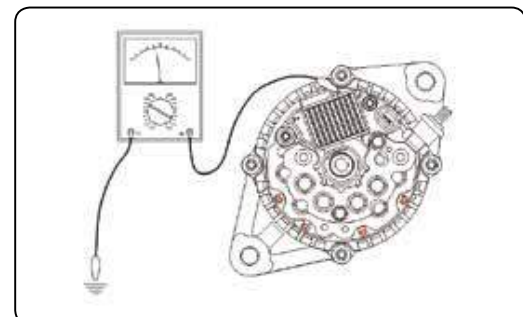
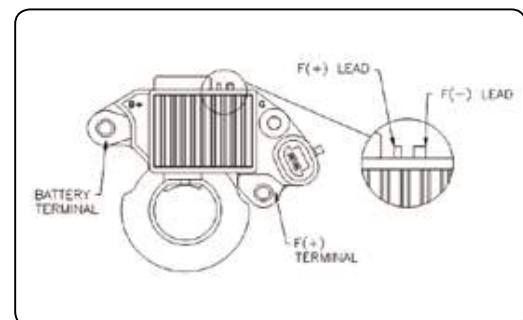


## 3) Lamp circuit test while the engine is running

(1) Connect the positive (+) terminal of the voltmeter to the lamp line and ground the negative (-) terminal of the voltmeter.

(2) If the lamp is not on or there is no output, then regulator circuit, rotating magnetic field coil or commutator diode may be short.

(3) Remove the cover, connect the positive (+) terminal of the voltmeter to F(+) terminal of brush and regulator assembly and ground the negative (-) terminal of the voltmeter to the generator. If there is no measurement from the battery, then there is a problem with regulator or commutator. The regulator or commutator has to be replaced.

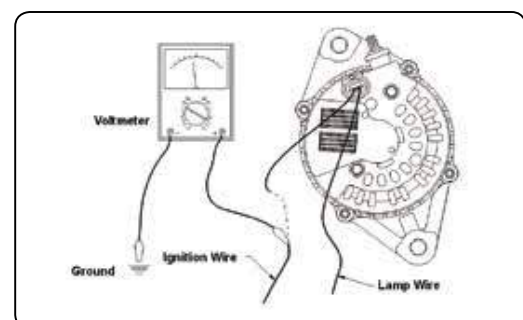


## 4) Starter circuit test while the engine is on

(1) Unplug the ignition plug from the voltage regulator.

(2) Connect the positive (+) terminal of the voltmeter to the ignition line of the ignition wiring harness and ground the negative (-) terminal of the voltmeter.

(3) There should be a measurement on the voltmeter. If not, check whether the ignition circuit is dirty or damaged.

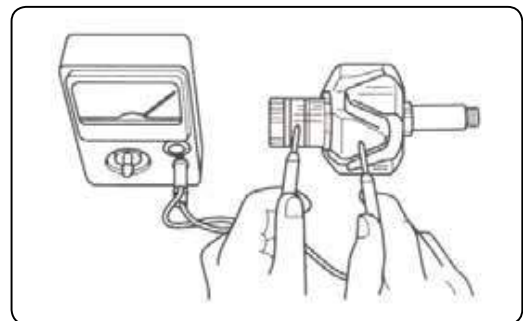
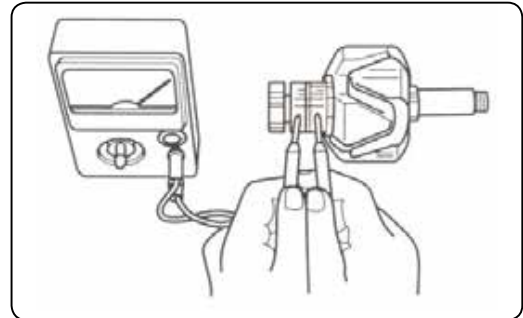


## 5) Rotor

1. This is a rotor coil conductivity test to check the conductivity between the slip rings. Measure the resistance of the rotor. If the resistance is very low, that means it is shorted. If there is no conductivity or a short, replace the rotor assembly.

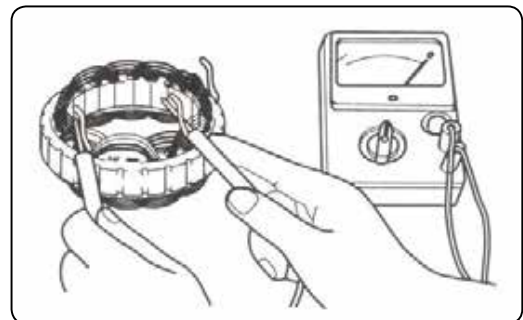
standard	Approx. $27,5\Omega$ / $20^{\circ}\text{C}$
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2. Check the rotor coil grounding. Check for conductivity between the slip ring and grounding. If there is, replace the rotor assembly.

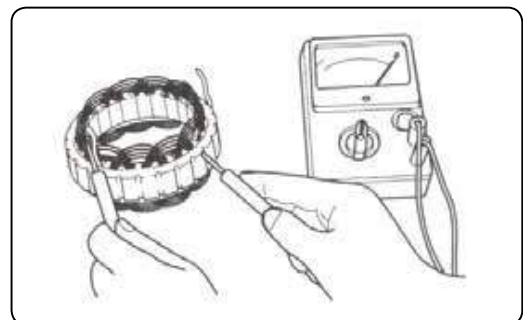


## 6) Stator

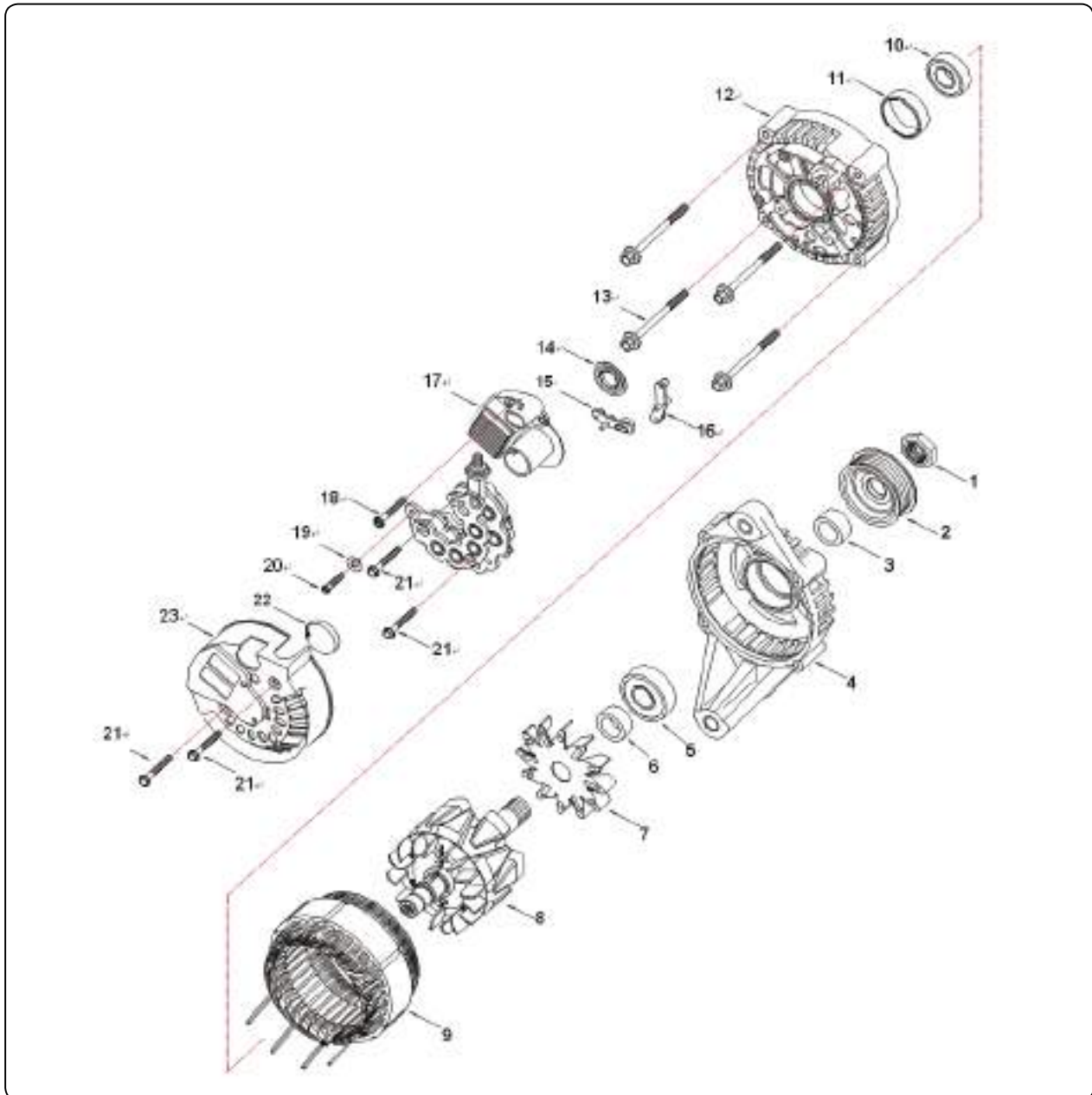
1. Test the stator conductivity. Check for the conductivity between the coil and lead. If not, replace the stator assembly.



2. Check for the coil grounding. Check for the conductivity between the coil and core. If not, replace the stator assembly.



● Disassembled diagram and parts



1. nut  
2. pulley  
3, 6. spacer  
4. moving frame  
5. bearing (front)  
7. fan (front)

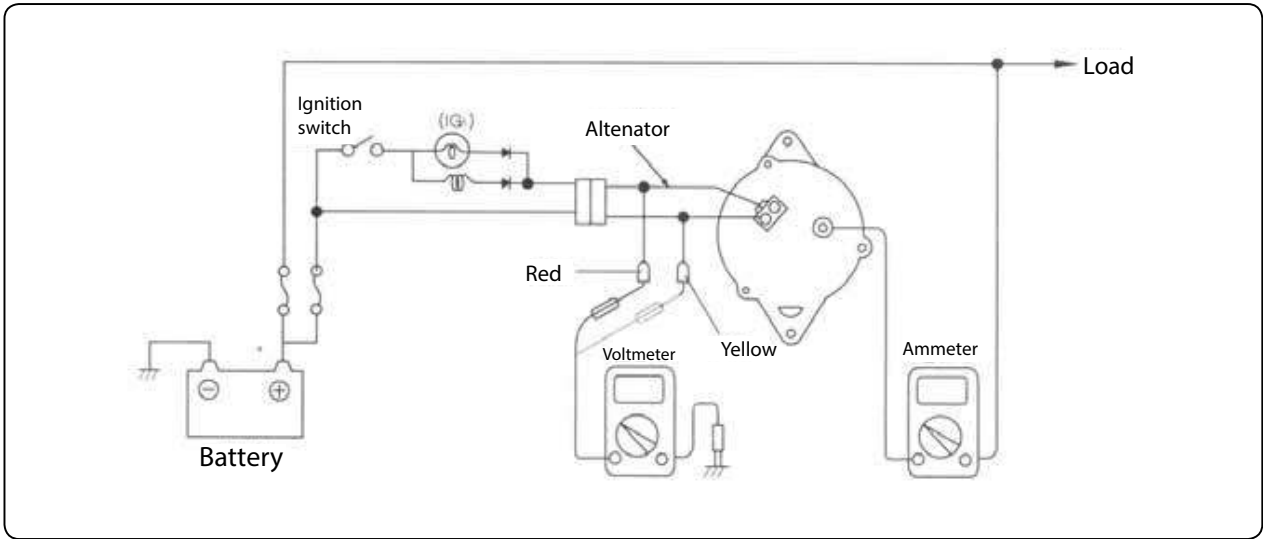
8. rotor assembly  
9. stator assembly  
10. bearing (rear)  
11. gap ring  
12. rotating frame  
13. bolt (4EA)

14. separating plate  
15, 16, 19. insulation  
17. brush, adjustor combination  
18, 20, 21. screws  
22. brush fastening rubber  
23. cover



- Regulating voltage inspection of the IC regulator (with no load)

1) Specialty wiring connector, voltmeter and ammeter are set as shown in diagram below.



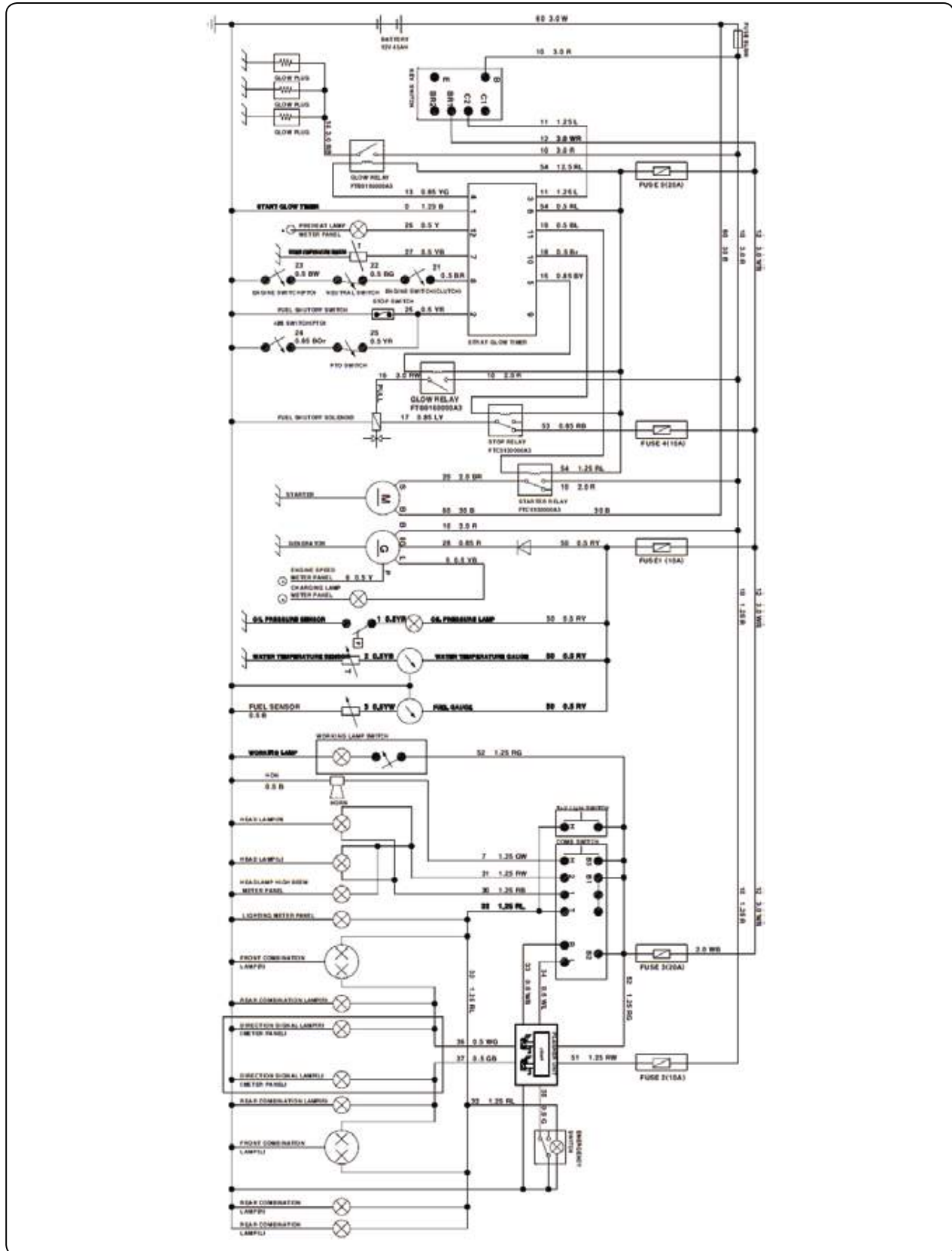
2) Inspect in the order shown in the table below.

order	Inspection item	operation	determination		cause	treatment
			normal	failure		
1	Voltage between L terminal and grounding	Ignition switch : OFF	0V	Voltage generated	Bad wiring or alternator	Modify wiring or repair the alternator
		Ignition switch: ON	2~5V	Battery voltage		
2	Voltage between S terminal and grounding	Ignition switch: OFF	Battery voltage	0V	Wiring or fusible link short	Modify wiring or replace link
		Ignition switch: ON				
3	Voltage between S terminal and grounding	Turn the engine on and maintain 2000~3000rpm.	14.4±0.5 V (at 20°C)	Over the standard in excess	IC regulator fault	Repair the alternator
				Less than the standard	In case of more than 5A output	Use fully charged battery .
					Bad alternator if less than 5A output	Repair alternator

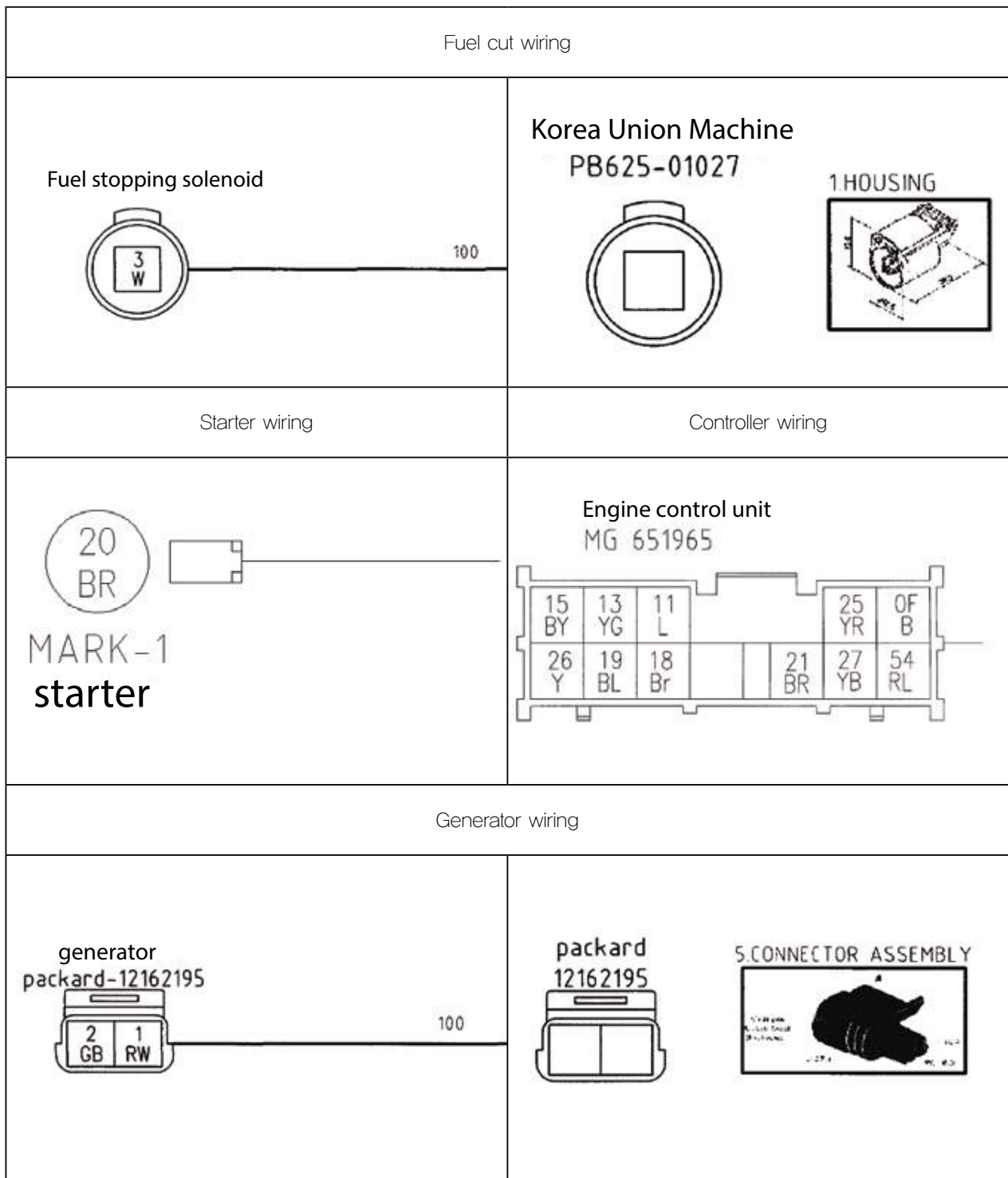
### 5.5.3. ELECTRICAL WIRING

#### 5.5.3.1. Electrical wiring diagram

- The following electrical wiring is a representative example.



5.4.3.2. Electrical wiring connector



### 5.5.3.3. Electrical wiring

#### 1) Generator (alternator)

- Do not connect the battery in opposite terminals.

If plus and minus terminals of battery cable are connected in reverse, generator diode may be damaged and the battery will not be charged. The stator coil will also be damaged. To prevent the reverse connection, adjust the battery cable length or there should be solution to prevent it from the manufacturer.

- Do not use the charging output voltage for the purpose of control since the engine revolution and the output voltage do not proportionally related to each other.

- Lamp control

After fully charged and charging lamp is off, the lamp will not come on since the engine revolution is decreased. If the charging circuit is normal, the lamp will not be turned on again. If the lamp comes on, check for damaged V-belt.

- Use only specified V-belt.

- Do not use pressurized washer to clean.

Any moisture in the brush due to high pressure will cause insufficient charge.

#### 2) Starter (starting motor)

- Use specified battery.

Engine starting up depends mainly on the battery. The battery performance is influenced by temperature and its operational period. Therefore, use only battery required for the conditions.

- Battery cable (+,-) line resistance should be less than  $2/1000\Omega$ .

If excessive, it may cause lost function or failure of the starter motor.

- If the starter motor circuit line resistance is in excess of the specification

Round trip line resistance between the starter motor and Key switch (or power relay, safety relay: when used) should be less than  $5/100\Omega$ .

- If there is no Safety relay

Main reason of the starter motor failure is overrun time (energized too long). Overrun causes armature coil burn out or clutch failure. Please be careful.

- Do not use pressurized washer to clean.

Do not leave the starter motor in water and use a pressurized washer to clean since the starter motor is waterproofed for only general rain or water.

#### 3) Current limiter

- Do not used over-discharged (8V or less) battery. If used, other electronic devices may be damaged by its high voltage ability. Do not recharge the over-discharged battery to use.

- Do not remove the battery while driving. It may cause a current limiter failure depending on the electronic devices which causes control failure. It might generate high voltage to damage other electronic devices.



## 6. MAINTENANCE STANDARD TABLE

## 6.1. MAIN PARTS TIGHTENING TORQUE

Item	Size	Width of hexagonal side(mm)	Clamping torque (kgf · m)	Remarks
Cylinder head bolt	M10×1,25	14	6.75±0.25	
Connecting rod bolt	M8×1,0	13	4.5±0.2	
Fly wheel mounting bolt	M10×1,25	14	6.75±0.25	
Metal cap mounting bolt	M8×1,25	12	3.25±0.25	
Crank shaft V-pulley mounting bolt	M22×1,5	32	17.5±0.5	
Glow plug	M10×1,25	12	1.75±0.25	
Fuel injection valve	M20×1,5	22	7.5±0.5	

## 6.2. GENERAL BOLT TIGHTENING TORQUE TABLE

(unit: kgf·m)

dimension	4T		7T		9T	
	Division	Subdivision	Division	Subdivision	Division	Subdivision
M 5	40±5		60±10		90±10	
M 6	60±10		130±10		135±10	
M 8	150±20		270±30		330±20	
M 10	300±50	240±40	530±70	420±60	690±30	550±30
M 12	530±70	420±60	900±100	720±80	1130±70	900±60
M 14	780±70	620±60	1350±150	1080±120	1850±150	1480±120
M 16	1250±150	1000±120	1900±200	1520±160	2580±220	2060±220
M 18	1750±150	1400±120	2650±250	2120±200	3800±300	3040±240
M 20	2450±250	1960±200	3700±400	2960±320	5400±400	4320±320

PT plug	dimension	1/8	1/4	3/8	1/2	3/4
	aluminum	150±20	200±30	250±30	350±50	460±50
	Casting type	200±20	250±30	360±30	560±50	770±50

Hollow bolt	M 8	M 12	M 14	M 16
	150±20	300±50	450±50	550±50

## 6.3. ENGINE ASSEMBLY TOLERANCE

## 6.3.1. Cylinder head

Model		A1000, A1100, A1100T		Remarks
Item		standard	allowance	
Cylinder head combustion surface bent		0.03 or less	0.15	
Belt seat angle	Intake	120°	—	
	Exhaust	90°	—	
Belt seat width	Intake	1.6±0.1	2.23	
	Exhaust	1.6±0.1	2.62	
Intake valve	valve stem outer circumference	φ7 -0.040 -0.050	φ6.9	
	valve guide inner circumference	φ7 +0.015 0	φ7.1	
	Oil clearance	0.055 ~ 0.065	0.15	
Exhaust valve	valve stem outer circumference	φ7 -0.040 -0.040	φ6.9	
	valve guide inner circumference	φ7 +0.015 0	φ7.1	
	Oil clearance	0.040 ~ 0.055	0.15	
valve guide protrusion (from head surface)		13	—	
valve depression depth	Intake valve	0.4±0.1	0.7	
	Exhaust valve	0.4±0.1		
valve head thickness	Intake valve	1.9±0.15	0.5	
	Exhaust valve	1.9±0.15		
intake valve timing	Open	b. TDC	—	
	Close	a. BDC		
Exhaust valve timing	Open	b. BDC	—	
	Close	a. TDC		
valve spring	Free field	37.25	—	
	inclination	—	1.0	
	load(1mm pressure)	1,902	—	
Intake · Exhaust valve gap		■ 0.15 ~ 0.05	—	—

## 6.3.2 Cylinder block

Model		A1000		A1100, A1100T		note
Item		standard	allowance	standard	allowance	
Cylinder block inner circumference	L	$\phi 74 +0.020$ $+0.015$	-	$\phi 78 +0.025$ $+0.015$	-	20mm below from the head assembly within the cylinder
	S	$\phi 84 +0.015$ 0		$\phi 78 +0.015$ 0		
Cylinder block inner circumference roundness		0 ~ 0.015		0 ~ 0.015	-	

## 6.3.3 Valve rocker arm

Model		A1000, A1100, A1100T		Note
Item		Standard	Allowance	
Intake and exhaust rocker arm Rocker arm inner circumference Oil clearance	Rocker arm shaft outer circumference	$\phi 13 -0.020$ $-0.045$	$\phi 12.95$	
		$\phi 13 +0.025$ 0	$\phi 13.09$	
		0.020 ~ 0.070	0.14	
Push rod bend		0.25 or less	-	-
Tappet	Tappet stem outer circumference	$\phi 20f7 -0.020$ $-0.041$	$\phi 14.18$	
	Tappet guide hole inner circumference	$\phi 20f7 +0.020$ 0	$\phi 14.30$	
	Oil clearance	0.020 ~ 0.062	0.12	

## 6.3.4 Piston

Model		A1000		A1100, A1100T		note
Item		Standard	Allowance	Standard	Allowance	
Piston outer circumference	A	$\phi 73.966 \pm 0.009$	$\phi 73.9$	$\phi 77.966 \pm 0.009$	$\phi 77.90$	
Minimum gap between piston and cylinder block		0.041 ~ 0.059	-	0.041 ~ 0.059	-	
Top clearance		■ $0.66 \pm 0.15$	-	■ $0.66 \pm 0.15$	-	
Piston and piston pin	piston pin outer circumference	$\phi 22 +0.005$ $-0.001$	$\phi 21.90$	$\phi 22 +0.005$ $-0.001$	$\phi 21.90$	
	piston pin hole inner circumference	$\phi 22 +0.007$ $+0.002$	$\phi 22.02$	$\phi 22 +0.007$ $+0.002$	$\phi 22.02$	
	Oil clearance	0.003 ~ 0.008	0.10	0.003 ~ 0.008	0.10	



## 6.3.5 Piston ring

Model		A1000, A1100, A1100T		note
Item		standard	allowance	
Top ring	Ring groove width	1.896±0.01	—	
	Ring width	1.803 0 -0.024	—	
	Gap between ring and ring groove	0.15 ~ 0.30	—	
	End gap	0.15 ~ 0.30	1.5	
2 <sup>nd</sup> ring	Ring groove width	1.5 +0.09 +0.07	—	
	Ring width	1.5 -0.09 -0.03	—	
	Gap between ring and ring groove	0.080 ~ 0.120	—	
	End gap	0.30 ~ 0.50	1.5	
Oil ring	Ring groove width	3.0 +0.03 +0.01	—	
	Ring width	3.0 -0.01 -0.03	—	
	Gap between ring and ring groove	0.020 ~ 0.060	—	
	End gap	0.20 ~ 0.40	1.5	

## 6.3.6 Connecting rod

Model		A1000, A1100, A1100T		note
Item		standard	allowance	
Crank pin part	Crank pin inner circumference	φ43 0 +0.016	—	
	Crank pin metal thickness	1.487 ~ 1.500	—	
	Crank pin outer circumference	φ39.9 +0.059 +0.075	φ39.89	
	Oil clearance	0.025 ~ 0.087	0.15	
Piston pin part	Piston pin bush inner circumference	φ22 +0.005 +0.001	φ22.10	
	Piston pin outer circumference	φ22 +0.040 +0.025	φ21.90	
	Oil clearance	0.014 ~ 0.038	0.2	
Large & small end parallelism (twisting)		φ0.03/100mm or less	φ0.05	

## 6.3.7 Cam axis

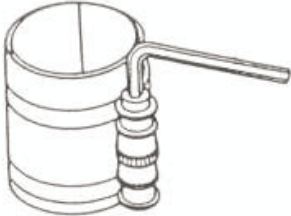
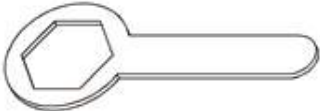
Model		A1000, A1100, A1100T		note
Item		standard	allowance	
Gear side	Cam shaft journal outer circumference	$\phi 36 -0.050$ $-0.066$	$\phi 35.89$	
	Oil clearance	0.050 ~ 0.091	—	
middle	Cam shaft journal outer circumference	$\phi 36 -0.050$ $-0.066$	$\phi 35.89$	
	Oil clearance	0.050 ~ 0.091	—	
Fly wheel side	Cam shaft journal outer circumference	$\phi 36 -0.050$ $-0.066$	$\phi 35.89$	
	Oil clearance	0.050 ~ 0.091	—	

## 6.3.8 Cranking axis

Model		A1000, A1100, A1100T		note
Item		standard	allowance	
Crank journal	Crank journal outer circumference	$\phi 52 -0.060$ $-0.079$	$\phi 51.91$	
	Bearing metal thickness	2.0 +0.015 +0.002	—	
	Oil clearance	0.020 ~ 0.081	0.10	
Degree of bend		0.02 or less	—	—

6.4 SPECIAL TOOLS

Tool	Tool specification (unit: mm)	diagram
Stem seal pressurizing zig		
Flywheel oil seal pressurizing zig		
Gear case oil seal pressurizing zig		
Plate-type plug pressurizing zig		
Governor axis gear pressurizing zig		

Tool	Tool specification (unit: mm)	diagram
Piston assembling jig	Available in regular retail market (applicable to $\phi 60 \sim \phi 125$ )	
Piston ring assembling jig	Available in regular retail market	
Oil filter wrench	Available in regular retail market	

# MEMO

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