HD CONSTRUCTION EQUIPMENT

950106-158003EN

Operation & Maintenance Manual

GAS GENERATOR ENGINE

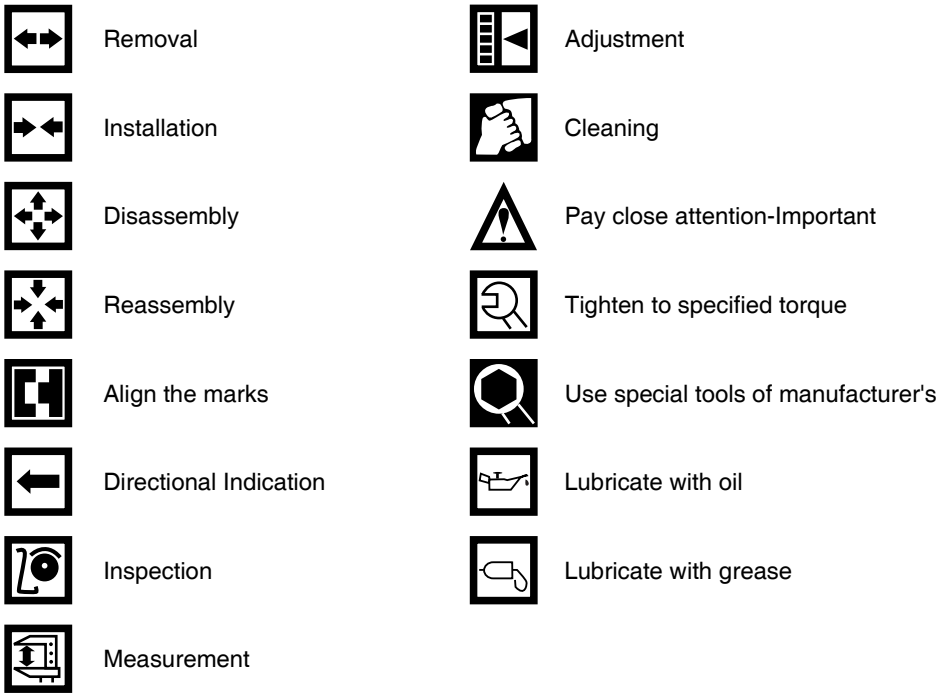
GV22

FOREWORD

This manual is designed to serve as a reference for HD Construction Equipment customers and distributors who wish to gain basic product knowledge on HD Construction Equipment **GV222C** natural gas generator engines.

These economical and high-performance natural gas engines (GV222C 12 cylinders) are 4 strokes and V-type have been so designed and manufactured to be used for the generator & power unit application. They meet all the requirements such as low noise, fuel economy, high engine speed and durability.
To maintain the engine in optimum condition and retain maximum performance for a long time, CORRECT OPERATION and PROPER MAINTENANCE are essential.

In this manual, the following symbols are used to indicate the type of service operations to be performed.



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

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

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

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

2025. 12.
950106-158003EN
HD Construction Equipment

* Items exempted from warranty coverage
  - Malfunctions resulting from failing to comply with the proper handling instructions, regular inspections, and machine storage techniques specified in the user manual
  - Malfunctions resulting from failing to have the machine repaired at a designated dealer or center, or resulting from the use of non-genuine parts
  - Malfunctions resulting from unauthorized modifications, changes, or external hardware
  - Malfunctions resulting from incorrect operation by the user, delayed repairs, accidents, and natural disasters

CONTENTS

1. Safety Regulations & Engine Specifications

1.1. General Notes

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

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

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

1.2. Handle Compressed Natural Gas Safety

Natural gas is highly flammable and explosive and may be extremely cold. The following cautions must be taken to avoid personal injury or engine damage.

- Do not smoke when installing or servicing the engine or fuel system.
- Installation or servicing of natural gas equipment must only be conducted in well ventilated, natural gas compatible areas. Do not install or service equipment in an enclosed area where ignition sources are present without ensuring that an undetected gas leak may be safely vented without being ignited.
- Do not vent natural gas or permit leaks inside an enclosed area.
  Bleed natural gas lines before installing or servicing any component connected to the fuel lines.


EB8O2001


EB8O2002

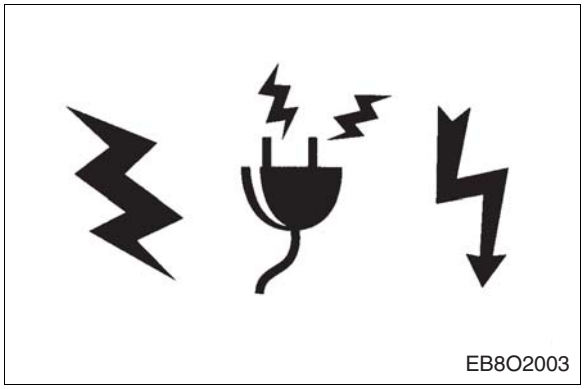
1.2.1. Avoid heating near pressurized fluid lines

- Wear welding goggles and gloves when welding or using an acetylene torch.
- Insure a that metal shield separated the acetylene and oxygen which must be chained to a cart.
- Do not weld or heat areas near fuel tanks or fuel lines.


HDO1049I

1.2.2. Venting an operable engine to relieve natural gas pressure

- To avoid personal injury an operable natural gas engine must be kept in a well ventilated area away from open flames and sparks.
- If the engine can run, use the following venting procedure to relive the natural gas pressure downstream of the shutoff valve.


EB8O2003

1) Shut off manual valves on natural gas supply lines and main shutoff valve on natural gas fuel supply line.
2) Start engine and run until it stalls due to fuel starvation.
3) Check to make sure gauge pressure at point on the natural gas fuel line to be vented has been reduced to zero. If not, repeat step 1) Then repeat step 2).
4) Disconnect vehicle batteries using switch in battery compartment or by disconnecting battery ground cable.
5) Slightly loosen the NG fuel line fitting to be serviced in a well ventilated area to allow any remaining gas to vent.
6) Completely open the fitting that was slightly opened and allow to vent in a well ventilated area.

1.2.3. During commissioning, starting and operation

- This is the safety alert symbol. When you see this symbol in this manual, be alert to the potential for personal injury.

- Carefully read all safety message in this manual and on your safety signs. Be sure new equipment components and repair parts include the current safety signs.

- Avoid possible injury or death from runaway. Do not start engine by shorting across starter terminals.

- Prevent fires by keeping machine clean of accumulated trash, grease, fuel and debris.
- When the engine is running, do not get too close to the rotating parts.

- Do not touch the engine with bare hands when it is warm from operation risk of bums.

- Exhaust gases are toxic. If it is necessary to run an engine in an enclosed area, remove the exhaust gases from the area with an exhaust pipe extension. If you do not have an exhaust pipe extension, open the doors and get outside air into the area.

- Keep vicinity of engine free of oil and grease. Accidents caused by slipping can have serious consequences.

1.2.4. During maintenance and care

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

Caution:
There is a rise of burns and scalding. Do not touch oil drain plug or oil filters with bare hands.

- Take into account the amount of oil in the sump. Use a vessel of sufficient size to ensure that the oil will not overflow.
- Open the coolant circuit only when the engine has cooled down. If opening while the engine is still warm is unavoidable, comply with the instructions in the chapter "Maintenance and Care".
- Neither tighten up nor open pipes and hoses (lube oil circuit, coolant circuit and any additional hydraulic oil circuit) during the operation. The fluids which flow out can cause injury.

- Fuel is inflammable. Do not smoke or use naked lights in its vicinity. The tank must be filled only when the engine is switched off.

- When using compressed air, e.g. for cleaning the radiator, wear goggles.
- Keep service products (anti-freeze) only in containers which can not be confused with drinks containers.
- Comply with the manufacturer's instructions when handling batteries.

Caution:
Accumulator acid is toxic and caustic. Battery gases are explosive.

1.2.5. When carrying out checking, setting and repair work

- Checking, setting and repair work must be carried out by authorized personnel only.
- Use only tools which are in satisfactory condition. Worn open-end wrench slip, which could lead to Injury.
- When the engine is hanging on a crane, no-one must be allowed to stand or pass under it. Keep lifting gear in good condition.
- When working on parts which contain asbestos, comply with the notes.
- When checking spark plug do not put your hands under the electric.

- When working on the electrical system disconnect the battery earth cable first. Connect it up again last in prevent short circuits.

1.2.6. To prevent damage to engine and premature wear

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

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

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

- Never let the engine run when dry, i.e. without lube oil or coolant.
- Use only HD Construction Equipment-approved service products (engine oil, anti-freeze and anti-corrosion agent).
- Have the engine maintained at the specified intervals.
- Do not switch off the engine immediately when it is hot, but let it run without load for about 5 minutes so that temperature equalization can take place.
- Never put cold coolant into an overheated engine. See "Maintenance and care".
- Do not add so much engine oil that the oil level rises above the max. marking on the dipstick. Do not exceed the maximum permissible tilt of the engine. Serious damage to the engine may result if these instructions are not adhered to.
- Always ensure that the testing and monitoring equipment (for battery charge, oil pressure, coolant temperature) function satisfactorily.
- Do not let the raw water pump run dry, If there is a risk of frost, drain the pump when the engine is switched off.

(4) Keep no-load operation to a minimum. During no-load operation combustion chamber temperatures drop to the point where fuel does not burn completely, causing slobbering and white smoke. Always have some load connected when the gen set is run for long periods.

1.2.7. To prevent pollution

(1) Engine oil, filter elements, fuel filters

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

(2) Coolant

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

(3) Cold Start

- The preheat lamp turns on when the key switch is set to "ON" When the preheat lamp goes off, proceed as follows. The pre-heater device activates when the coolant temperature is below 25°C, and the preheating system is automatically adjusted based on the coolant temperature. (The max. preheating time is around 25 seconds) It does not activate when the coolant temperature is over 25°C.

Caution:
The engine is equipped with a preheating system for enhancing cold start ability.

- In order to start the engine after the preheat lamp turns off, turn the key switch to the ignition position. When the key switch is turned to the ignition position, the pre-heater plug or air heater runs continuously to make starting the engine easier and reduce white exhaust gas. If the coolant temperature is over 25°C, it is not necessary to operate the pre-heater plug or air heater.
- When the engine starts, set the key switch in the ON position. The timer runs for another 5 minutes even after the engine starts to heat the intake air and quickly eliminate white exhaust gas.

Caution:
Do not run the start motor for over 10 seconds. If the engine still cannot be started after preheating, wait for 30 seconds and then perform preheating again before the second attempt to start the engine.

1.2.8. Notes on safety in handling used engine oil

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

Health precautions:

- Avoid prolonged or repeated skin contact with used engine oil.
- Protect your skin by means of suitable agents (creams etc.) or wear protective gloves.
- Clean skin which has been in contact with engine oil.

- Wash thoroughly with soap and water, A nailbrush is an effective aid.
- Certain products make it easier to clean your hands.
- Do not use petrol, Diesel fuel, gas oil, thinners or solvents as washing agents.

● After washing apply a fatty skin cream to the skin.

● Change oil-soaked clothing and shoes.

● Do not put oily rags into your pockets.

Ensure that used engine oil is disposed of properly.

- Engine oil can endanger the water supply -

For this reason do not let engine oil get into the ground, waterways, the drains or the sewers. Violations are punishable.

Collect and dispose of used engine oil carefully. For information on collection points please contact the seller, the supplier or the local authorities.

Caution:

Do not spray high-pressure water directly on the engine. It may damage engine parts, electronic parts, and wiring.

1.2.9. General repair instructions

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

1.3. Engine Specifications

1.3.1. Specifications

Items \ Engine Model		GV222C
Engine type		Water-cooled, 4 cycle Vee type Turbocharger & intercooled
Ignition system		Spark plug ignition
Combustion chamber type		Open dish type
Used fuel		NG (Natural Gas)
Fuel supply system		Venturi mixer throttle valve type
Cylinder liner type		Wet type, chromated or casting liner
Timing gear system		Gear driven type
No. of piston ring		2 compression ring, 1 oil ring
No. of cylinder bores x stroke (mm)		12 - 128 x 142
Total piston displacement (cc)		21,927
Compression ratio		10.2 : 1
Engine dimensions (length x width x height) (mm)		1,955 x 1,290 x 1,710
Engine weight (kg)		1,510
Fuel injection order		1-12-5-8-3-10-6-7-2-11-4-9
Fuel ignition timing	Adjust angle	40° (B.T.D.C)
	Operate angle	12° (B.T.D.C)
Engine control system		Controller (WOODWARD, SECM70)
Compression pressure (kg/cm^2)		16 (at 200 rpm)
Valve clearance (at cold)	Intake valve (mm)	0.3 ±0.05
	Exhaust valve (mm)	0.4 ±0.05
Intake valve	Open at.	24° (B.T.D.C)
	Close at.	36° (A.B.D.C)
Exhaust valve	Open at.	63° (B.B.D.C)
	Close at.	27° (A.T.D.C)
Lubrication method		Pressurized circulation
Oil pump type		External spur gear type
Engine oil pressure	Low idle	1
	High idle	3
Oil filler type		Full-flow, cartridge type
Lubricating oil capacity (max./min.) (lit)		40/29
Oil cooler type		Water-cooled
Water pump type		Centrifugal (Pulley type)
Cooling method		Radiator
Cooling water capacity (engine only) (lit)		53
Thermostat type		Unit (Wax-pellet)
Alternator voltage - capacity (V - A)		24 - 45
Starting motor voltage - output (V - kW)		24 - 7.0
Fuel system	System	Air-fuel mixer
	Control	Throttle valve control

Items \ Engine Model		GV222C
Ignition system	Ignition type	One coil per cylinder (no waste spark)
	Spark plug	Iridium / Platinum electrode plug
	Spark plug gap	0.3 ~ 0.4
	Ignition coil	Inductive coil pack
	Ignition timing adjustment	Controlled by ESC and ICM
Control system	Control system	On-highway heavy-duty
	Voltage (V)	24
	Component	ESC, ICM, sensor, harness
Turbo charger	Model	-
	Type	Non watercooled
	Exhaust gas temperature (°C)	Max. 700
Battery capacity	(V - AH)	24 - 200

1.3.2. Engine Power

Production tolerance: ±5%

Suffix	Engine model		Condition			Remark
			Stand-by	Prime	Continuous	
GV22-OOG10	GV22CB	50 Hz (1,500 rpm)	475 kW	444 kW	355 kW	-
		60 Hz (1,800 rpm)	520 kW	473 kW	378 kW	-
GV22-OOG12	GV22CA	50 Hz (1,500 rpm)	405 kW	368 kW	294 kW	-
		60 Hz (1,800 rpm)	470 kW	427 kW	342 kW	-
GV22-MCG20	GV22CBK	50 Hz (1,500 rpm)	475 kW	444 kW	355 kW	-
		60 Hz (1,800 rpm)	520 kW	473 kW	378 kW	-
GV22-MCG22	GV22CAK	50 Hz (1,500 rpm)	405 kW	368 kW	294 kW	-
		60 Hz (1,800 rpm)	470 kW	427 kW	342 kW	-

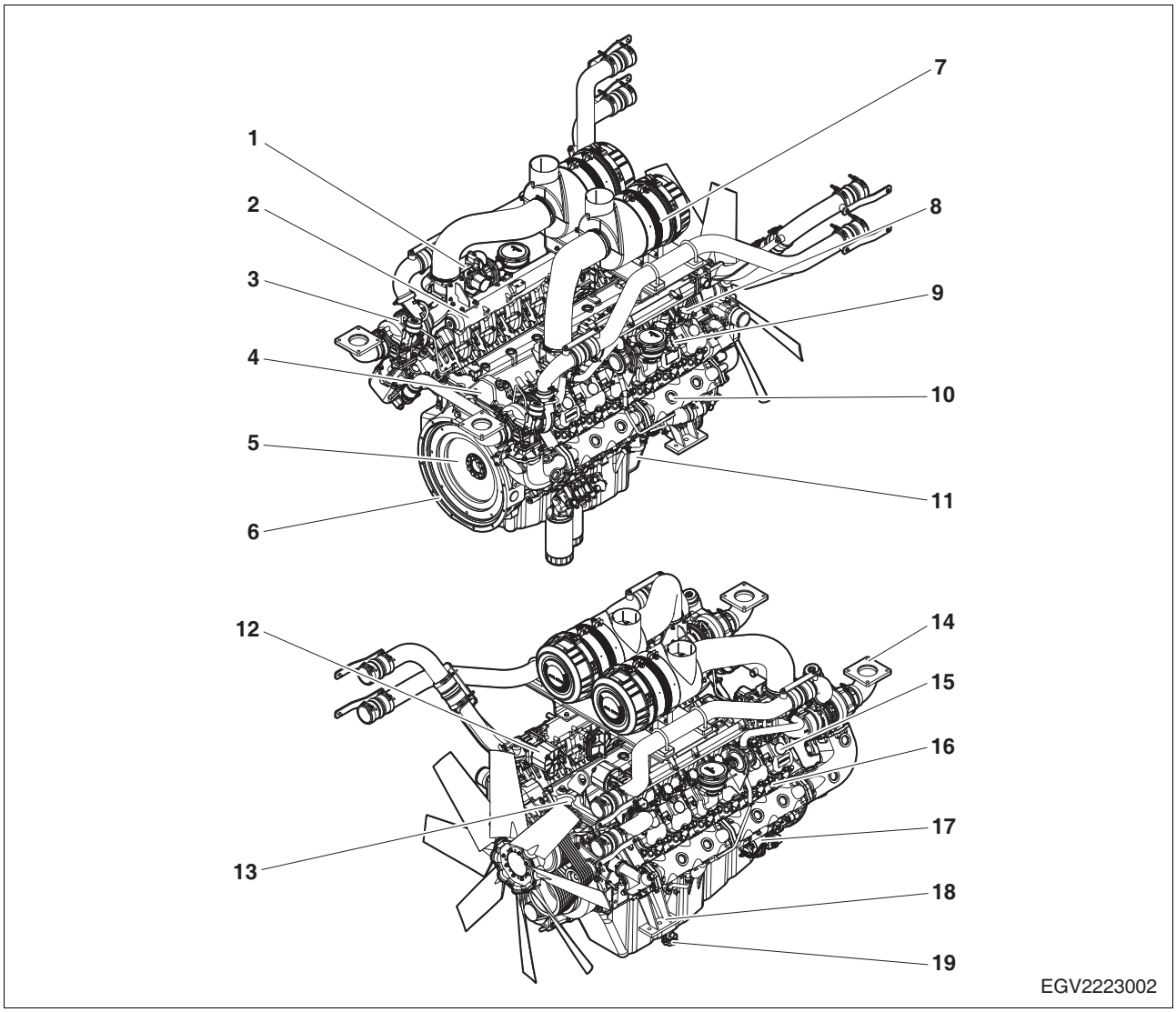
Note: All data are based on operation without cooling fan at ISO 3046.

1.4. Engine Assembly

Note: The images shown represent the standard model; they do not include all models.

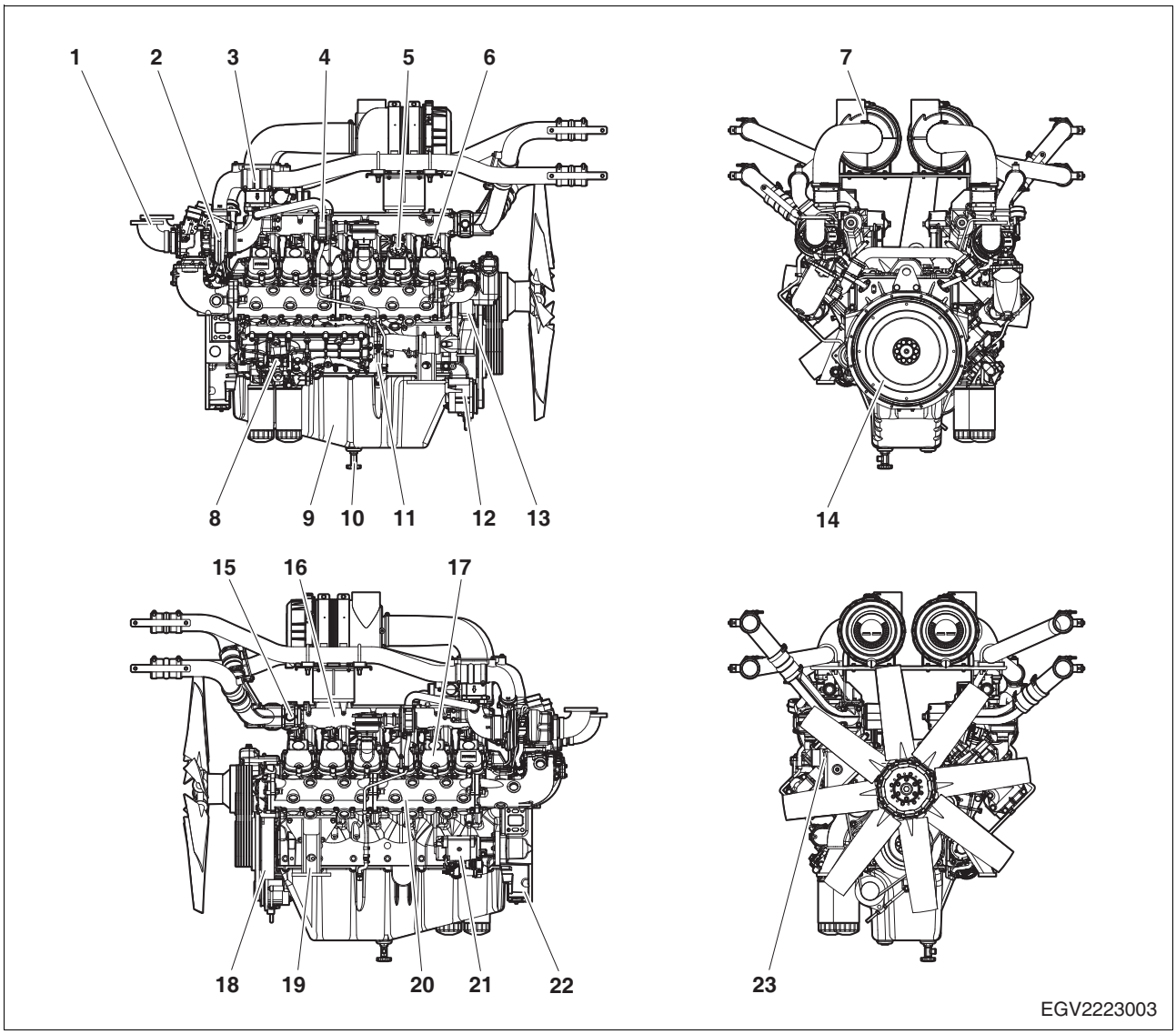
1.4.1. Engine Assembly Diagram

1) Structural Diagram



1. Gas regulator assy (with gas fuel mixer)
2. Intake manifold
3. Turbo charger
4. Flywheel housing cover
5. Flywheel
6. Flywheel housing
7. Air cleaner
8. Ignition coil
9. Oil filler cap
10. Exhaust manifold
11. Oil pan
12. Throttle valve
13. Cylinder head
14. Exhaust elbow
15. Cylinder head cover
16. Cylinder head
17. Starting motor
18. Engine mounting
19. Drain plug

2) Flatness

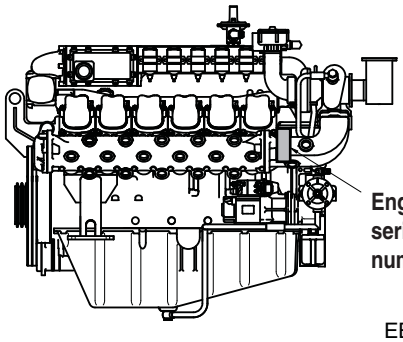


1. Exhaust elbow
2. Turbo charger
3. Gas regulator assy (with gas fuel mixer)
4. Breather
5. Oil filter cap
6. Ignition coil
7. Air cleaner
8. Oil filter & oil cooler
9. Oil pan
10. Drain plug
11. Oil level gauge
12. Alternator
13. Cooling water pump
14. Flywheel
15. Throttle valve
16. Intake manifold
17. Cylinder head cover
18. Vibration damper
19. Engine mounting
20. Exhaust manifold
21. Starting motor
22. Flywheel
23. Water outlet

2. Technical Information

2.1. Engine Model and Serial Number

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



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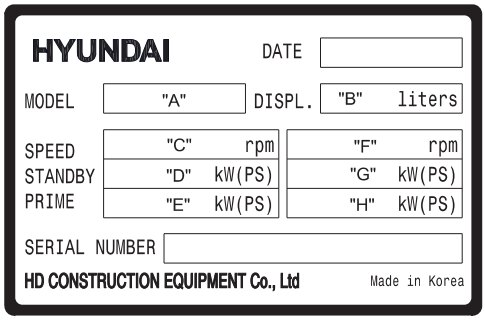
- Engine serial No. (example: GV222C)

GV22OOG30 3 00001

Serial No.
Production year (2023)
Engine suffix



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2.2. Engine Characteristic

The HD Construction Equipment **GV222C** natural gas engine is an overhead valve, turbocharged, air to air cooled, ECU controlled engine.

2.2.1. Design characteristic

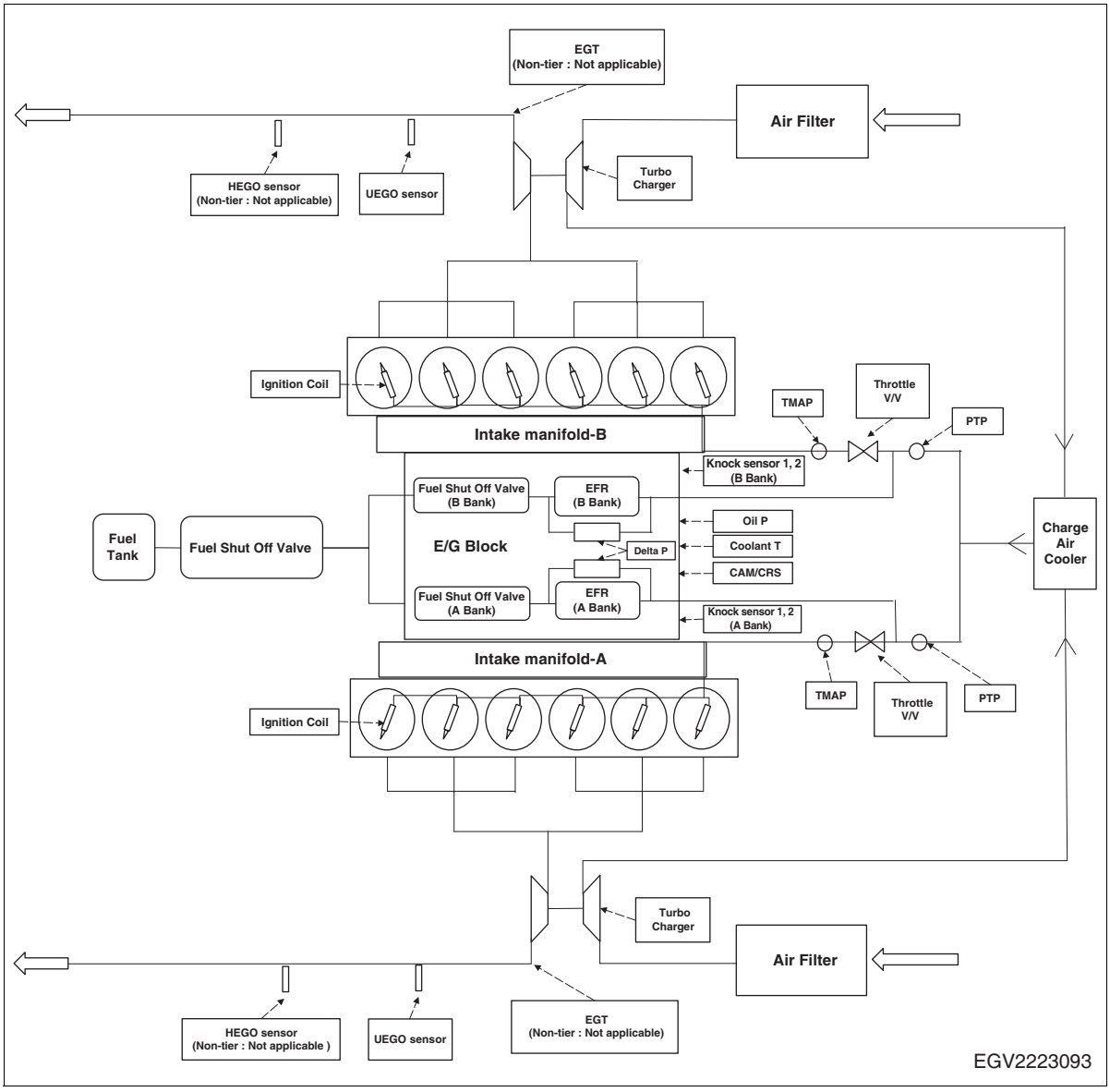
- Spark-ignited by the spark plug.
- Electric engine control through the ECM (Engine Control Module) system.
- Turbocharger with a water cooled bearing-housing

2.2.2. Natural gas

- Natural gas is a clean burning fuel, and offers a low particulate emission. Natural gas is also a very economical fuel.
- From the gas producing areas in the country, the distribution companies and local utilities from a complex nation-wide-delivery-network that supplies natural gas for home and industry use.
  The network is highly developed and extended to all major population center in the country.

2.2.3. Engine ignition system

- This system changes the general combustion concept of the diesel engine. Specifically, it changes a compression-ignition diesel to a spark-ignited engine. However, this engine is unlike the typical generator engine that has spark plugs.
- The primary difference is this system uses a combustion concept. That is, excess air is mixed In with the combustion system. When combined with a gaseous fuel like natural gas, it allows greatly reduced emissions compared to diesel, plus high efficiencies and excellent high-performance.
- The GV222C engine is an integrated package featuring computer controlled electronic engine system by the ECU. This system controls fuel, ignition and speed, and has engine protection features.



2.2.4. Cylinder block

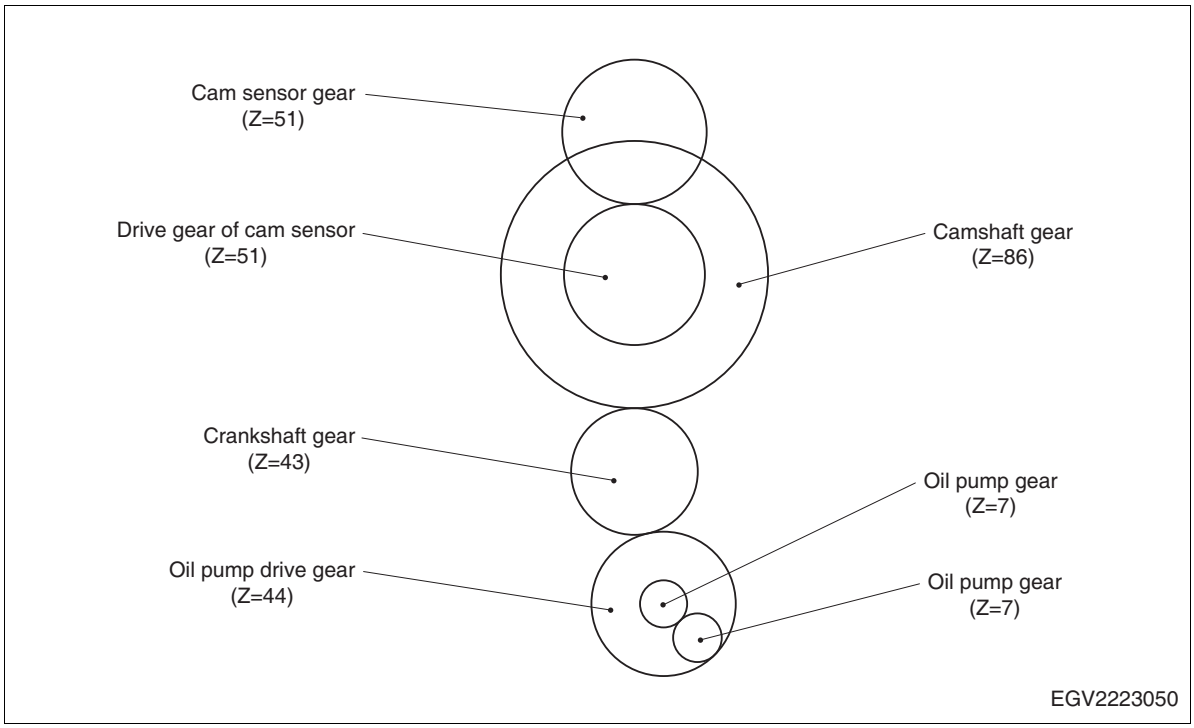
- The cylinder block is a single piece of alloy cast iron. To increase its stiffness, it is extended to a level below the crankshaft center line. The engine has replaceable wet cylinder liners and individual cylinder heads.

2.2.5. Piston, con-rod and crankshaft

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

2.2.6. Engine timing

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

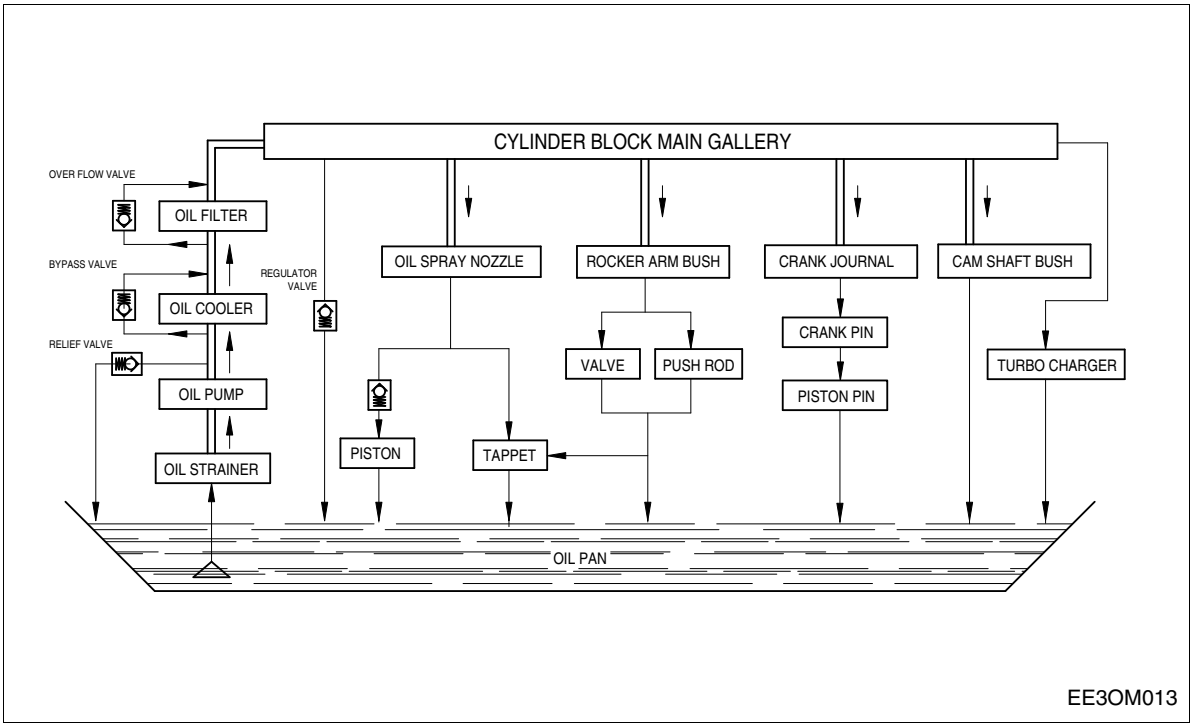


2.2.7. Valves

- The overhead valves are actuated via tungsten carbide tappet, push rods and rocker arms from the camshaft.

2.2.8. Engine lubrication system

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



- Depending on the agreed extent of delivery and the design of the engine, the lube oil circuit can be equipped with oil pressure monitors (advance warning and cut-off function) which shut the engine down in the event of a sudden loss of pressure.

2.2.9. Oil cooler

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

2.2.10. Engine oil

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

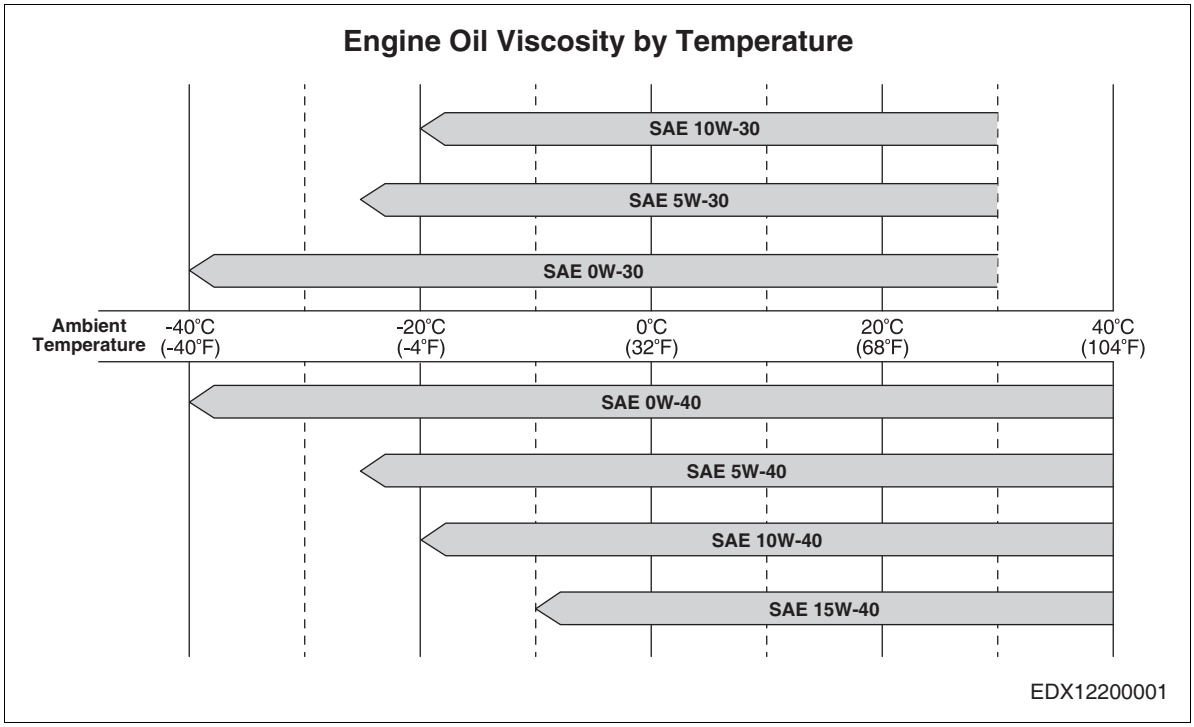
First oil change		After 50 hr operation
Engine model	GV222C	Every 250 hr

- **The following oils are also recommended**

SAE No.	Sulfated ash content
15W40(CNG)	Bellow 0.5%

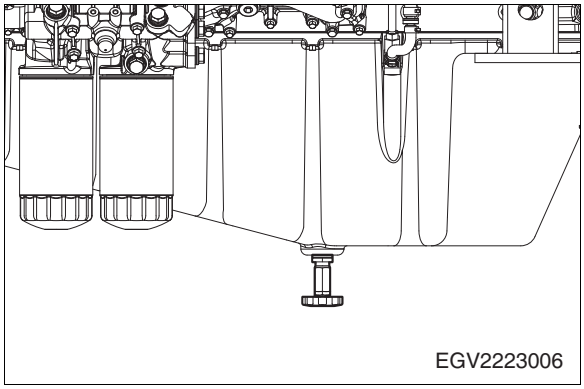
- **Engine oil capacity**

Engine oil capacity			
Engine model	In oil pan		Total (lit)
	Max. (lit)	Min. (lit)	
GV222C	40	29	43



2.2.11. Exchanging of lubrication oil

- Engine oil and the oil filter are important factors affecting engine life. They affect ease of starting, fuel economy, combustion chamber deposits and engine wear.
- Engine oil is discharged through the drain cock as figure.
- Refill new engine oil to the filler neck on the head cover in accordance with the oil capacity of the engine. Be careful about the mixing of dust or contaminator during the supplement of oil. Then confirm whether the oil level gauge indicates the vicinity of its maximum level.
- For a few minutes, operate the engine at idling in order to circulate oil through lubrication system. Thereafter shut down the engine. After waiting for about 10 minutes measure the quantity of oil and refill the additional oil if necessary.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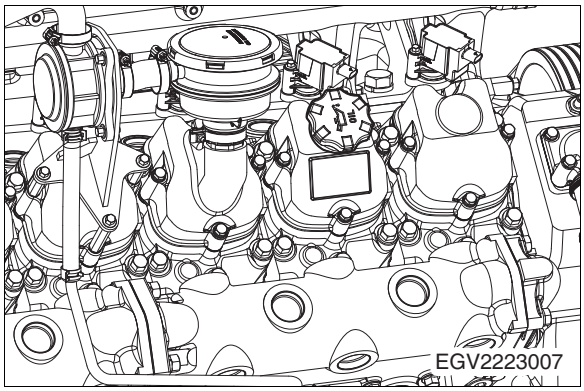
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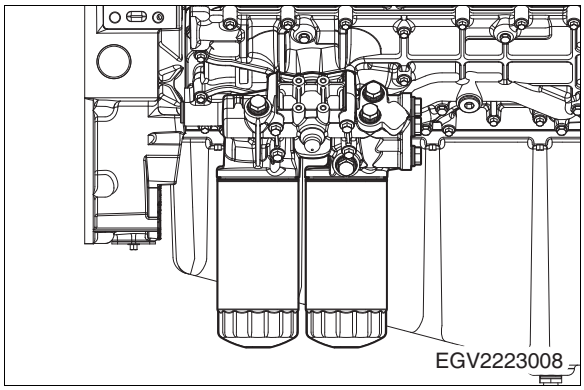
2.2.12. Replacement of oil filter cartridge

- Every time oil exchanges, replace the oil filter cartridge.
- Drain engine oil by loosening the drain plug on the filter head.

Caution:
Don't forget tightening the drain plug after having drained engine oil.

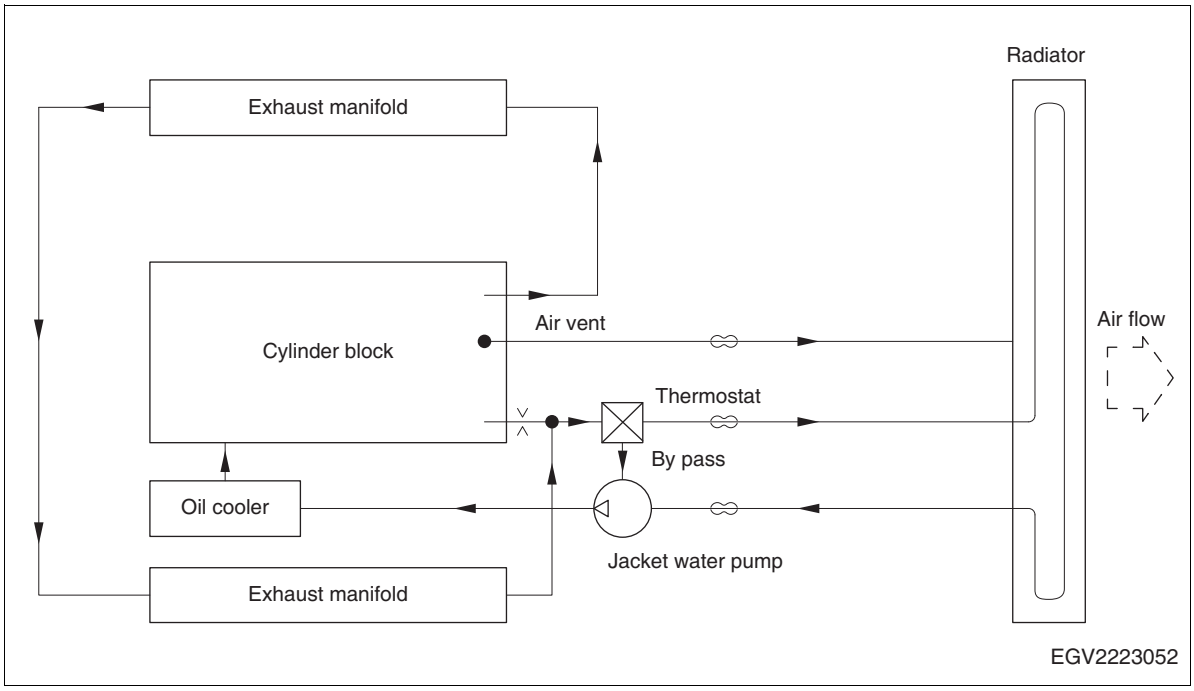
- Remove the oil filter by turning it counter-clockwise with a filter wrench.
- Wipe, clean the fitting face of the filter body and the oil filter body with a rag so that the new oil filter cartridge can be seated properly.
- Lightly oil the O-ring and turn the oil filter until O-ring is fitted against the seal face. And then turn it in addition by 3/4 ~ 1 turns further with hand or the filter wrench.


EGV2223008

Note:
It is strongly advisable to use HD Construction Equipment genuine oil filter cartridge for replacement.

2.2.13. Cooling system

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



2.2.14. Cooling water

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

Note:
The proper density control of antifreezing solution and rust preventing additive will be able to prevent the rusting effectively and maintain the stable quality of engine.
For the improper control might give the fatal damage to the cooling water pump and cylinder liners, detail care is needed.

- Since **GV222C** (Engine of **D28** base engine) cylinder liner is wet type, particularly the cooling water control should be applied thoroughly.
- The density of antifreezing solution and additive for rust prevention is able to be confirmed by the cooling water test kit. (Fleetguard no.: **CC2602M** or HD Construction Equipment no.: **60.99901-0038**)

● How to use the cooling water test kit

(1) When the cooling water temp. of engine is in the range of 10 ~ 55°C, loosen the plug for cooling Water discharge and fill the plastic cup about a half.

Note:

In taking the cooling water sample, if the water in auxiliary tank were taken, it is hard to measure the accurate density. Take the cooling water sample necessarily loosening the cooling water discharge plug.

(2) At the state of a test paper soaked in the sampled water, after taking the paper out through water agitation, shake off the water.

(3) Wait for about 45 sec. till the color change of test paper.

Note:

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

(4) Make the numerical value by comparing the test paper which hue has changed with the color list of label on storage bottle.

(5) By comparing the hue changed into yellowish green or so with the green color indication of test paper storage bottle, confirm the density. (Then, the density indication must be in the hue range of 33% to 50%).

(6) The brown at the middle of test paper and the lower pink color indication represent the additive state for rust prevention, and the proper range is that the meeting numerical value of brown (vertical) and pink color (horizontal) locates in the range of 0.3 to 0.8 at the color list of label on the test paper storage bottle.

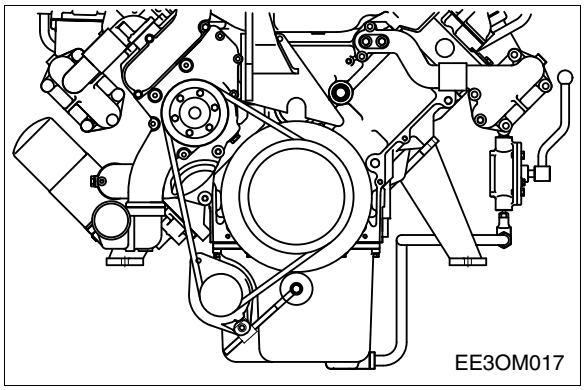
(7) In case of less than 0.3, replenish the additive for rust prevention (DCA4), and in case of more than 0.8, pour out the cooling water about 50% and then readjust the density after refilling with clean fresh water.

● Amount of anti-freeze in winter

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

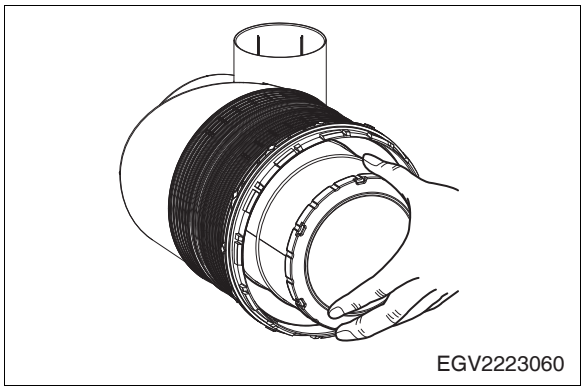
2.2.15. V - belt

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


EE3OM017

2.2.16. Air cleaner

- Air cleaner is mounted on the engine to purify the air for combustion. The intervals at which the air cleaner requires servicing depend on the specific operating conditions encountered. Clogged air filters may cause black smoke and reduce power.
- A check should be made from time to time to see that the fastening elements securing the air cleaner to the intake manifold seal the connection tightly.
  Any ingress of unfiltered air is liable to cause a high rate of cylinder and piston wear.


EGV2223060

2.2.17. Valve clearance adjust procedure

- Adjust the valve clearance.
  - When disassembling the engine or cylinder head.
  - When there is excessive noise in the valve connection.
  - When the engine runs abnormally even if the fuel injection system is normal.

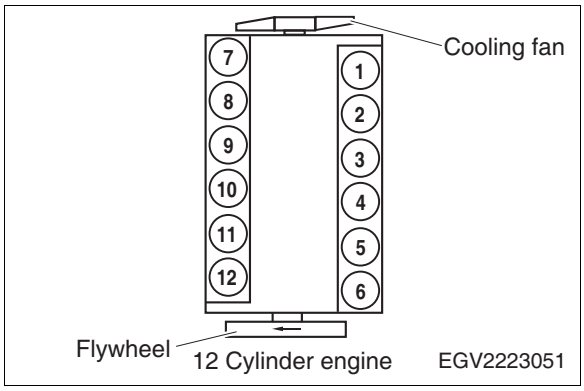
- **Adjusting sequence of valve clearance (1 type)**
  1) Rotate the crankshaft so that #1. cylinder may be positioned at the compression TDC (Top Dead Center).

Note:

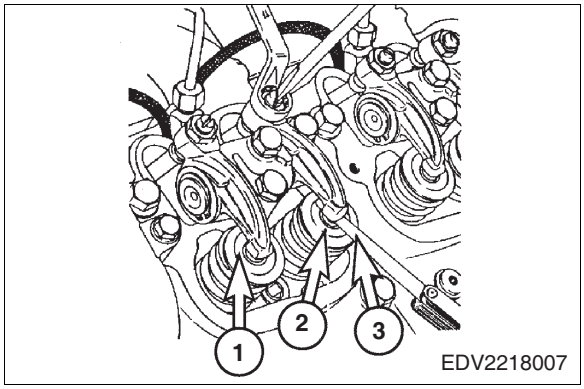
#1. Cylinder is located at the side where cooling water pump was installed.

In case of 8/12 cylinder engine, #6. cylinder is positioned at the valve overlap when #1. cylinder is positioned at the compression TDC (Top Dead Center).

In case of 10 cylinder engine, #7. cylinder is positioned at the valve overlap when #1. cylinder is positoned at the compression TDC (Top Dead center).



2) Loosen the lock nut of the #1. cylinder rocker arm.
3) Push the feeler gauge between a rocker arm and a valve stem.
4) Adjust the clearance screw respectively and then tighten with the lock nut.



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

Specified value		Measurement tolerance	
Intake valve	Exhaust valve	Intake valve	Exhaust valve
0.3 mm	0.4 mm	±0.05 mm	

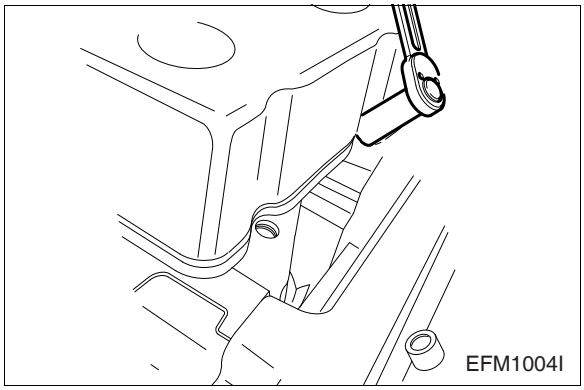
6) Rotate the crankshaft. When a cylinder reaches the compression TDC (Top Dead Center), adjust the valve clearance of the cylinder.
7) When a cylinder valve overlap, adjust the valve clearance cylinder of the compression TDC (Top Dead Center), as follow.

* 12 Cylinder engine (GV222C)

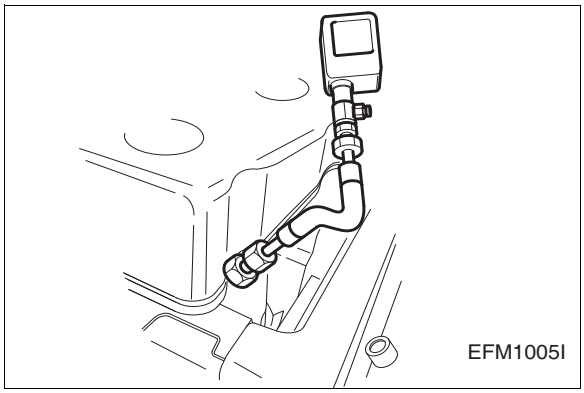
Valve overlapping on cylinder (Intake & Exhaust valve)	1	12	5	8	3	10	6	7	2	11	4	9
Adjusting valves on cylinder (Intake & Exhaust valve)	6	7	2	11	4	9	1	12	5	8	3	10

2.2.18. Cylinder compression pressure

● Stop the engine after warming up, and take out the spark plug.



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



Standard value	16 kg/cm^2 over
Limit value	13 kg/cm^2
Difference between each cylinder	Within ±10%

◆ Condition: water temperature 20°C, engine rotation 200 rpm

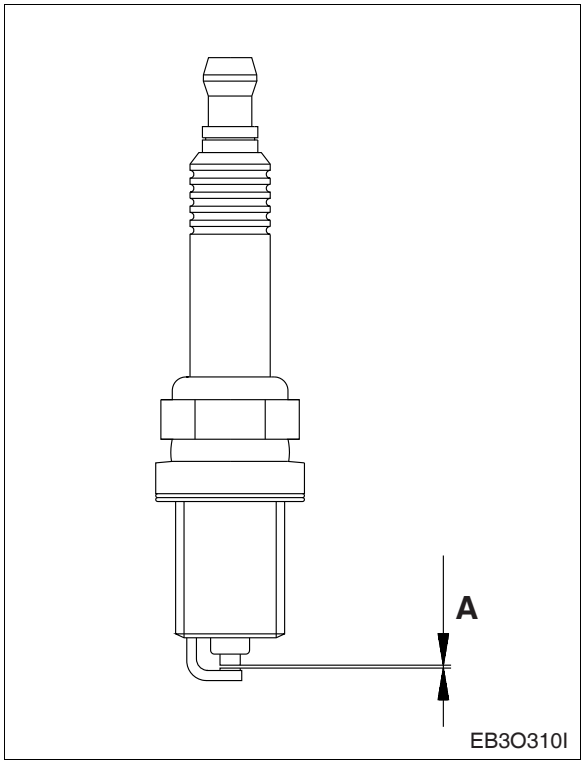
2.2.19. Spark plug

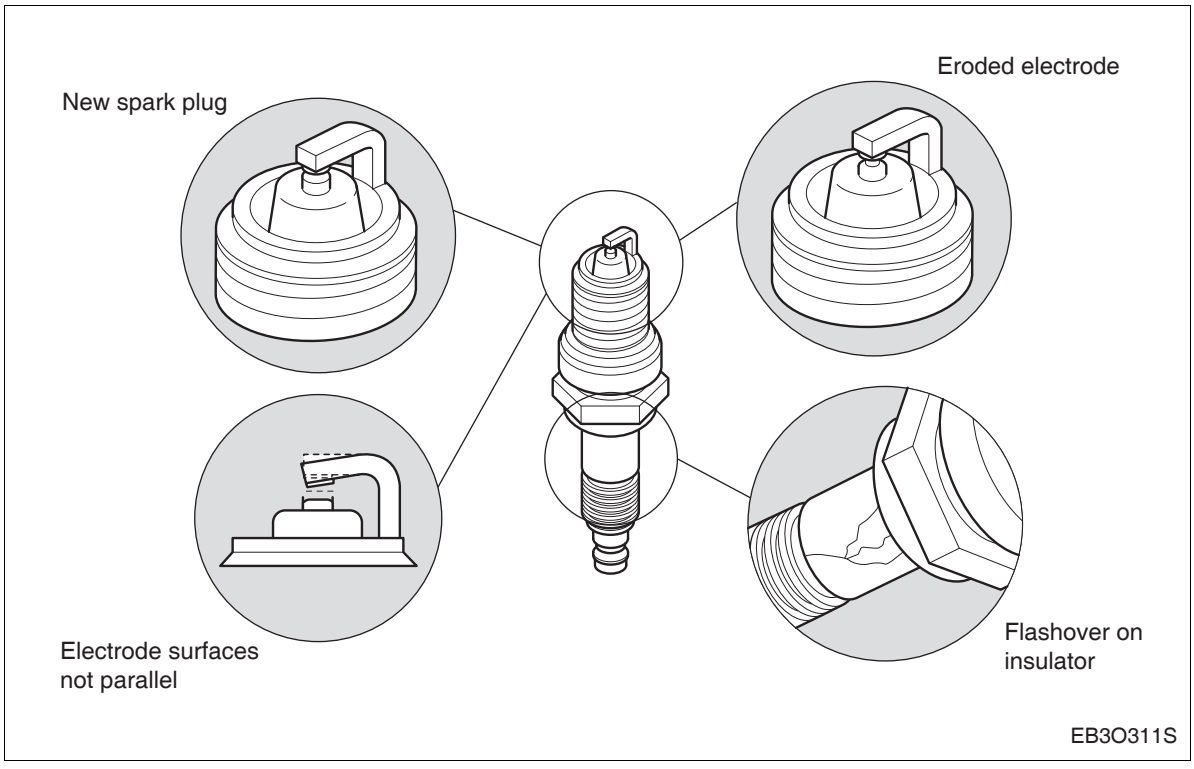
- Remove spark plug. Clean threads by hand with brush and solvent.
- Clean any deposits from electrode and Inspect insulator area.
- Measure the spark plug distance at electrode position. (A)
- Replace spark plug if necessary.

	Standard
Distance (A)	0.3 ~ 0.4 mm

- Install spark plug.

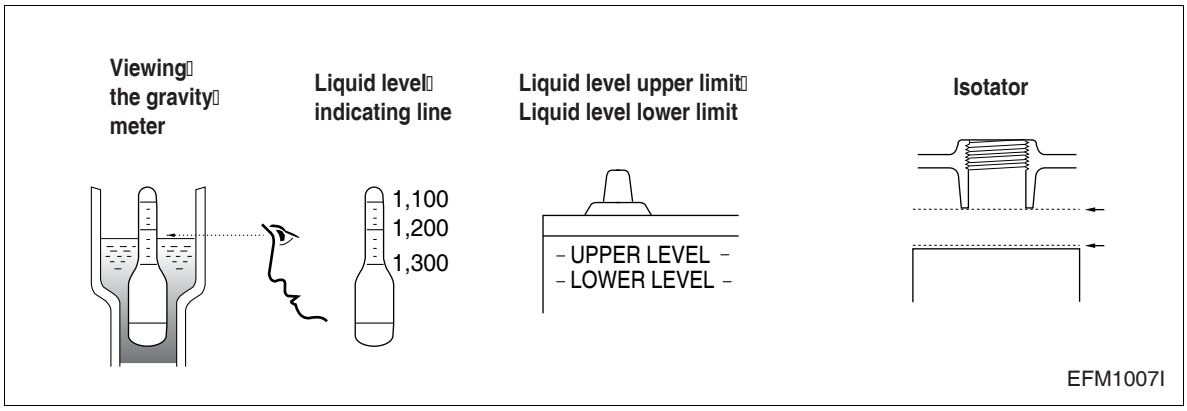
Torque	2.5 ~ 3.0 kg.m





2.2.20. Battery

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

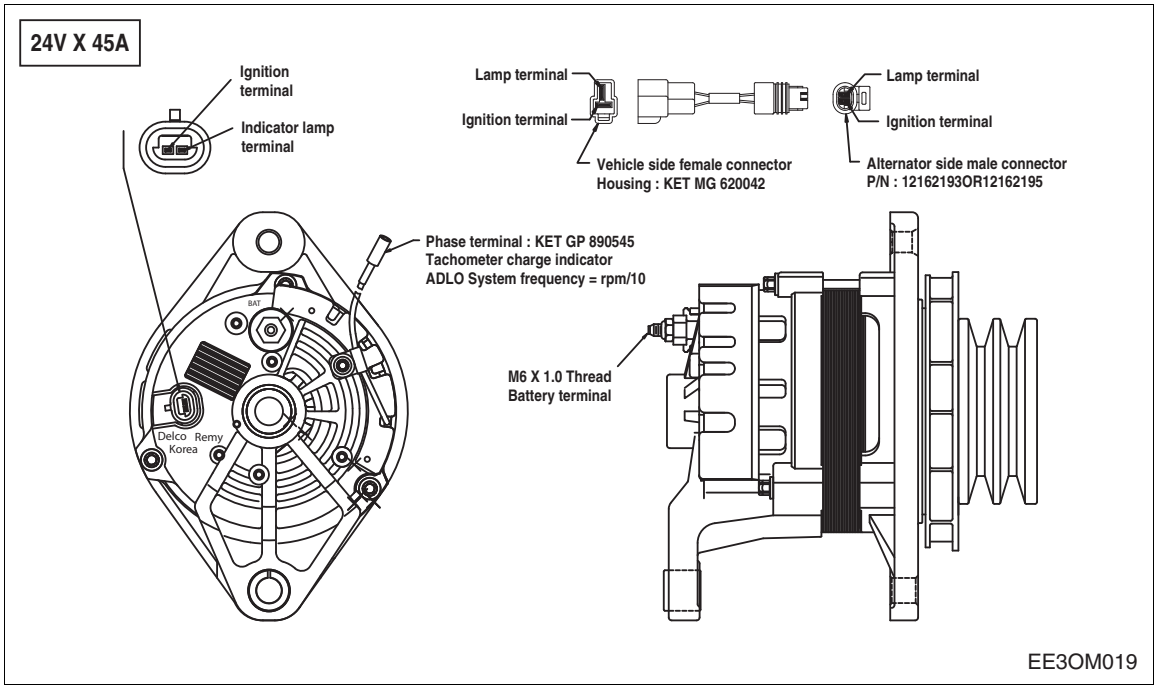


2.2.21. Turbocharger

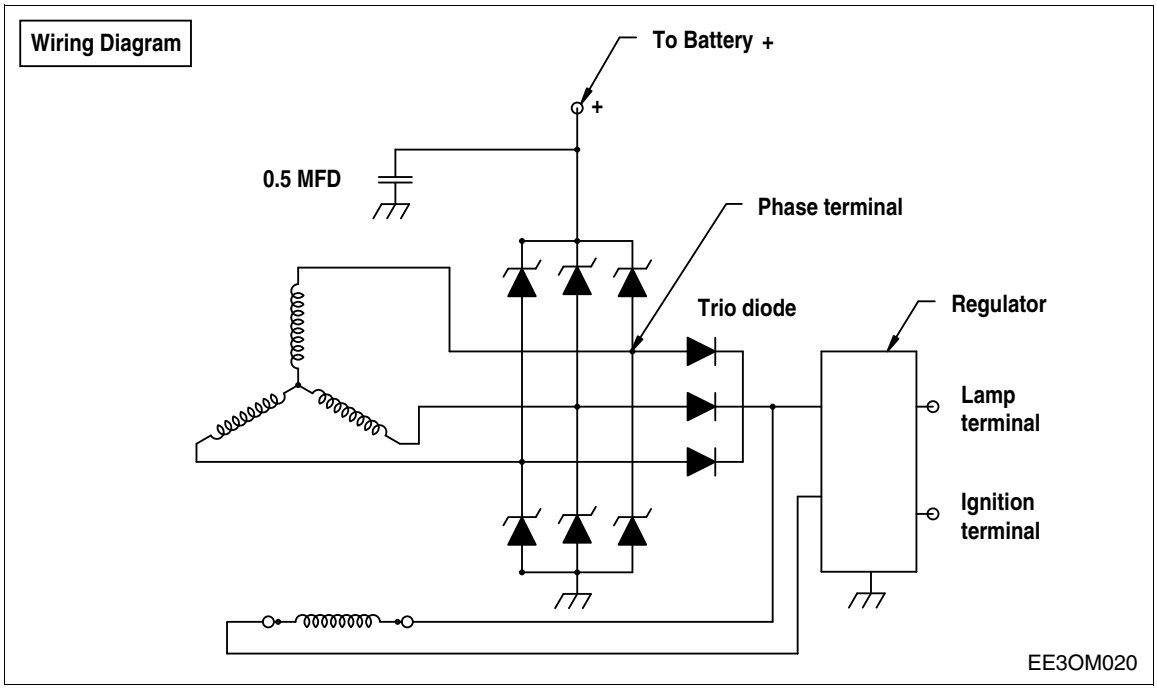
- The turbocharger needs not arty special equipment.
- Every time of engine replacement, a leakage or clogging of oil pipes should be inspected.
  Air cleaner should be maintained carefully for nut or foreign material not to get in. Periodic inspection should be applied on the compressed air and exhaust gas pipes, For leaking air will bring the over-heat engine, an immediate repair must be done.
- During the operation that is surrounded by the dust and oil mixed air, frequent cleaning must be done on the impellers. Tear down the impeller casing (attention: be careful not to bend) and must clean with non-acid solvent solution. If necessary, use plastic scraper If impeller is severely polluted, dip the impeller into solution and may be better to clean it with stiff brush. Then one thing to beware is to dip only impeller part and so do not support by impeller but bearing housing.

2.2.22. Alternator

- The alternator is fitted with integral silicon rectifiers. A transistorized regulator mounted on the alternator body interior limits the alternator voltage. The alternator should not be operated except with the regulator and battery connected in circuit to avoid damage to the rectifier and regulator.



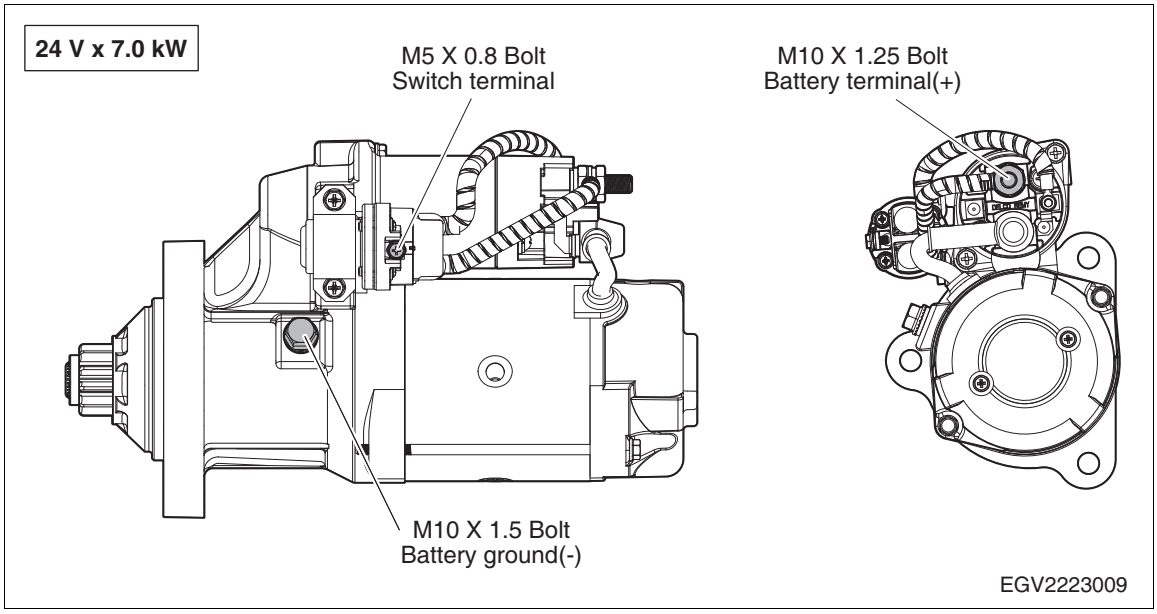
- The alternator is maintenance-free, nevertheless, it must be protected against dust and, above all, against moisture and water.



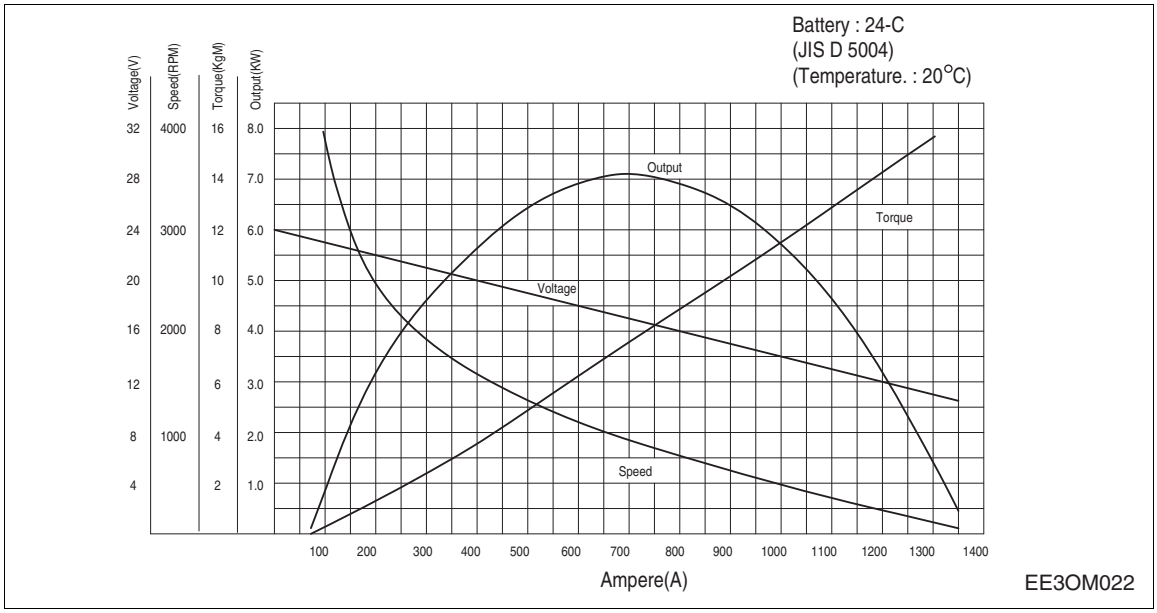
Operate the alternator according to the instructions given in the chapter.

2.2.23. Starting motor

- The sliding-gear starter motor is flanged to the rear of the flywheel housing on the left-hand side. As parts of every engine overhaul, the starter pinion and ring gear should be cleaned with a brush dipped in fuel and then a coat of grease should be applied again.



Always protect starter motor against moisture



IMPORTANT

Always disconnect the battery earth cable before starting work on the electrical system. Connect up the earth cable last, as there is otherwise a risk of short circuits.

2.3.24 Precautions in use

- Pay attention to dropping the battery voltage capacity when they are left for long time even without use.
- As starting may not be done well sometime in cold winter season, do not try it to be continuous
- immediately but try to start again after waiting about 30 seconds.
- Prior to operating the gauge panel, make sure the polarity of battery once again (In majority of polarities, red side is "+" and black one is "-")
- On disassembling the gauge panel may be accompanied a risk of electrical shock, always work after pulling off the connector at rear side of it without fail.
- If the silver paper etc is used for connecting the cut-off fuse, because the excessive current might flow into the parts to damage, when fuse is cut off, after resolving the problem locating the cause, replace it with new fuse.
- Since battery has a danger of explosion by a heat, it must not be placed at the spot where generates a lot of heat.
- When engine is in stop, pull out the key always. Thus, a hazard of fire or wound due to wrong operation may not happen.
- In case of scrapping the batteries, observe the followings.

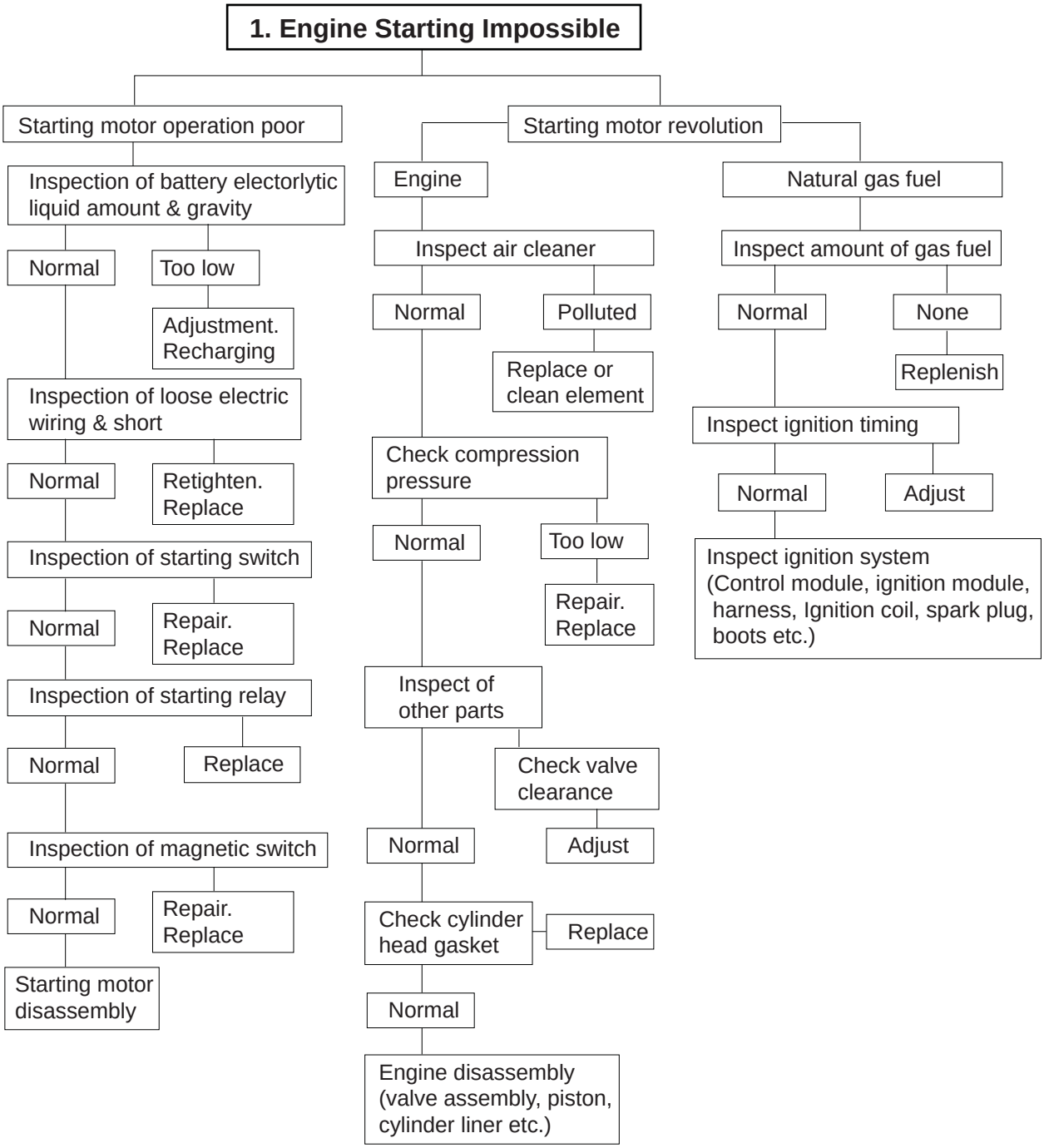
Note:

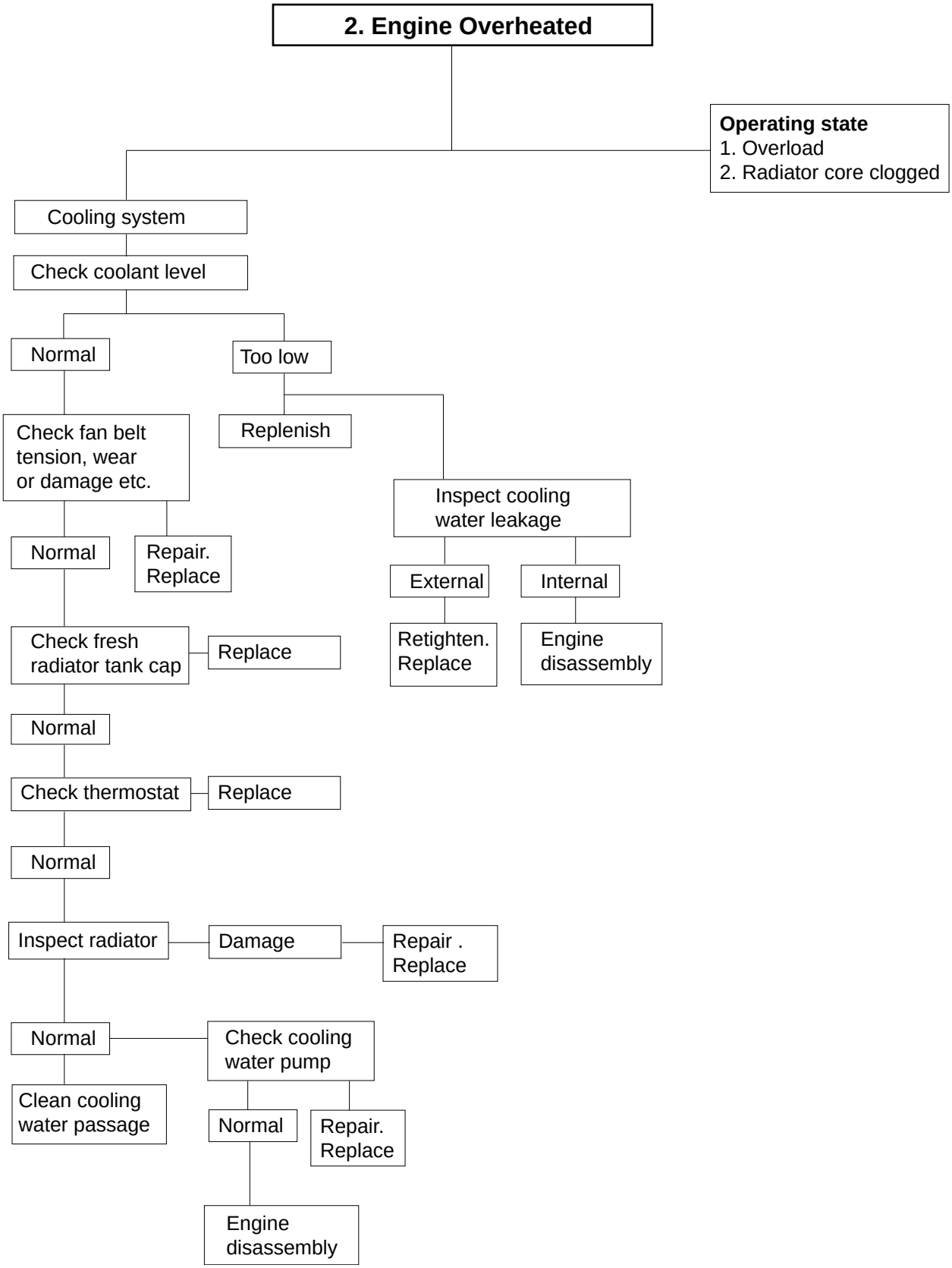
Do not throw it in the fire to scrap. It should not be thrown away into the places where are liable to cause the environmental pollution such as stream, river and mountain. Pack them as far as possible and dispose it as rubbish that is unable to use again.

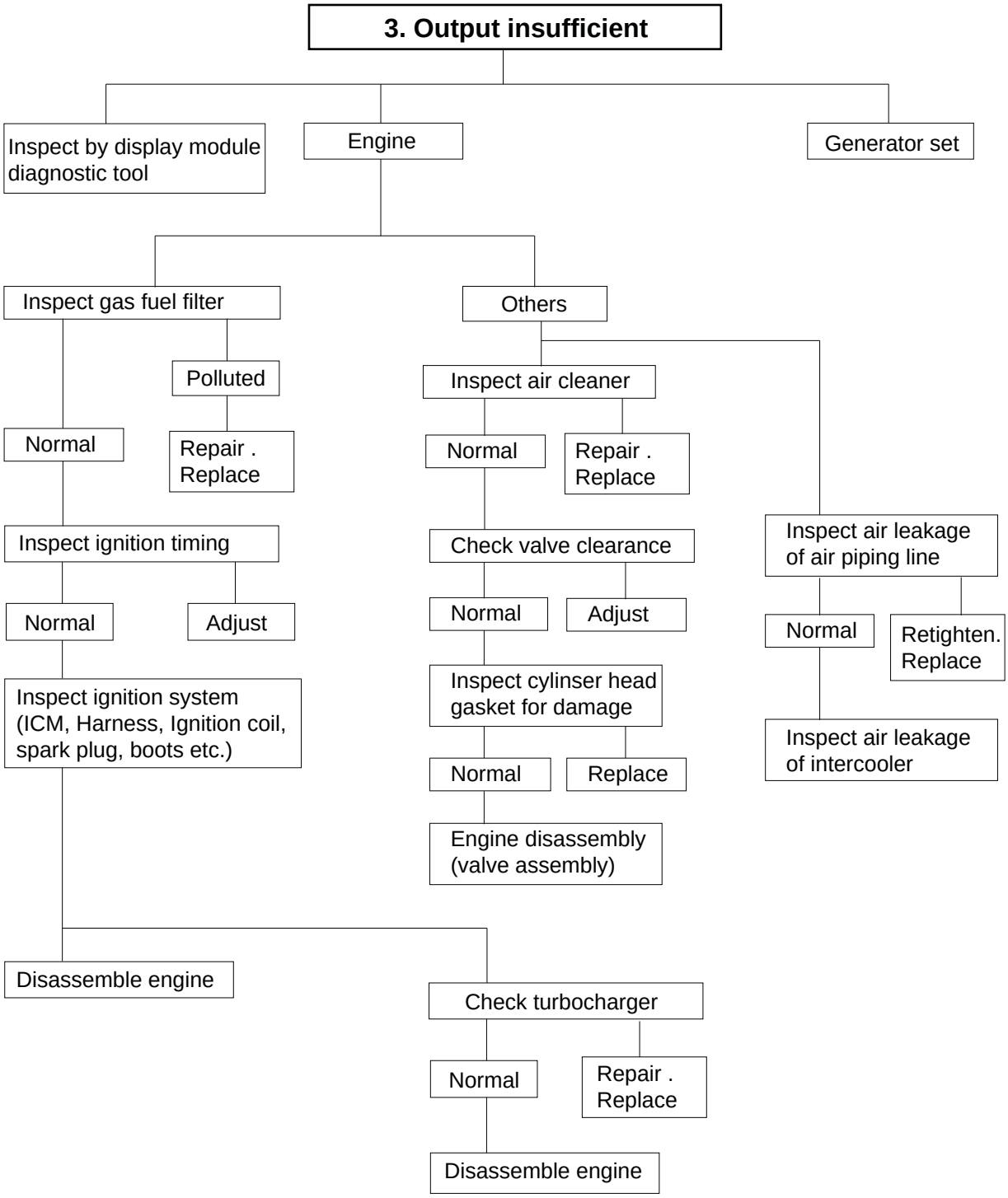
- HD Construction Equipment will not be responsible to the problems that might be raised by the disassembling and structural change of this product without consultation.

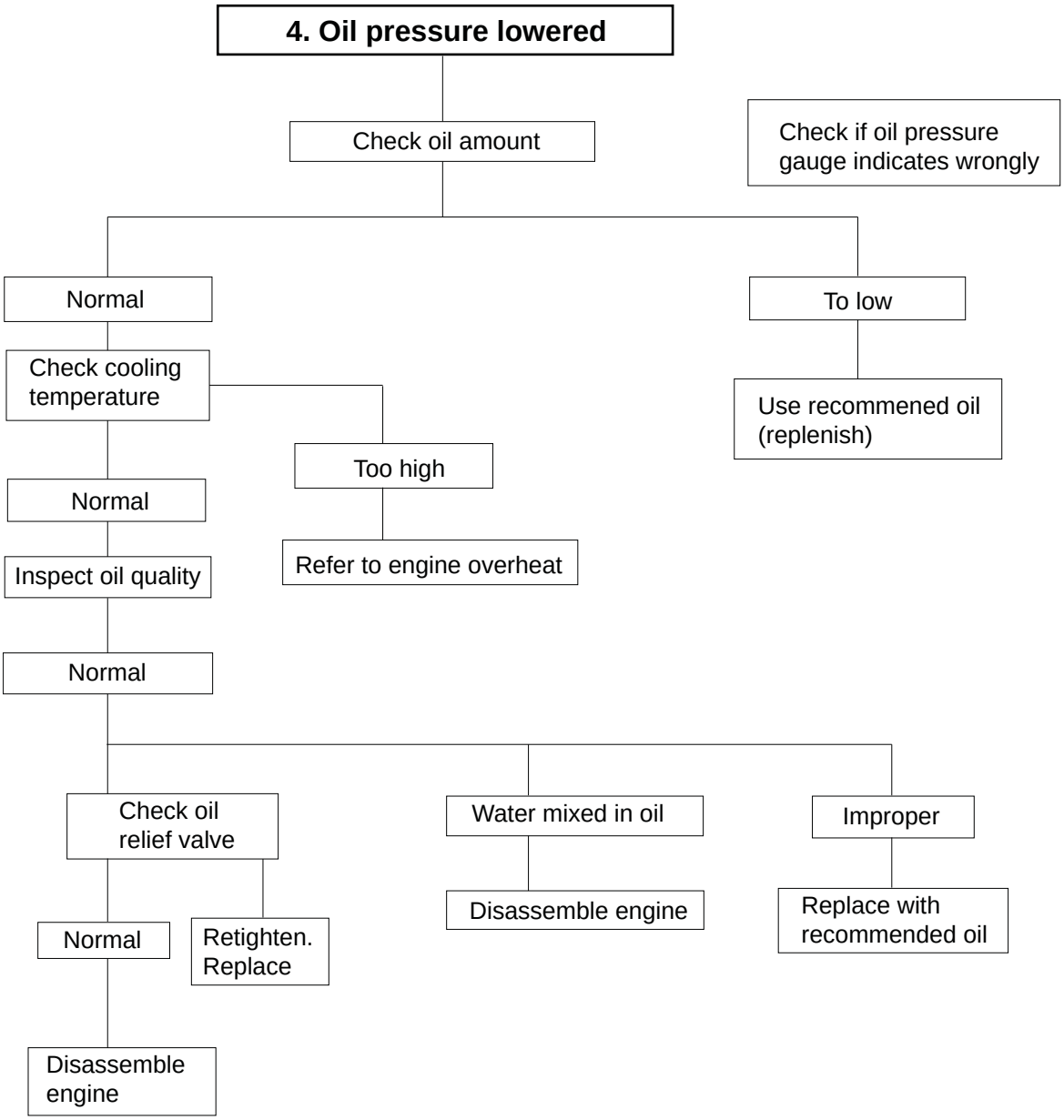
2.3. Diagnosis and Remedy

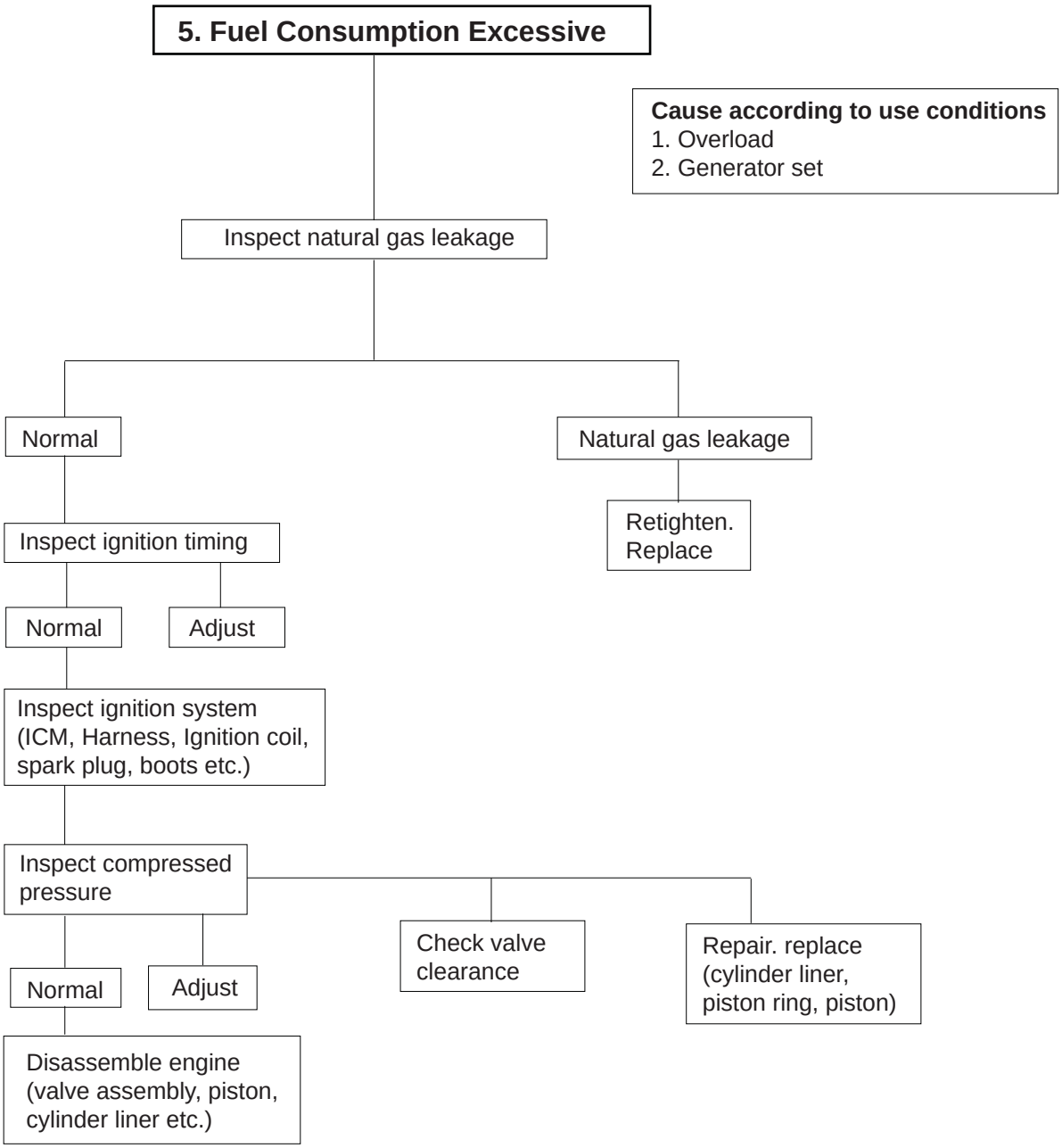
- The following description summarizes the probable cause of and remedy for general failure by item.
- Immediate countermeasures should be taken before a failure is inflamed if any symptom is detected.
- Inspect the electrical parts problem by the display module.




2. Engine Overheated
Operating state
1. Overload
2. Radiator core clogged
Cooling system
Check coolant level
Normal
Too low
Replenish
Check fan belt tension, wear or damage etc.
Inspect cooling water leakage
Normal
Repair. Replace
External
Internal
Check fresh radiator tank cap
Replace
Retighten. Replace
Engine disassembly
Normal
Check thermostat
Replace
Normal
Inspect radiator
Damage
Repair . Replace
Normal
Check cooling water pump
Clean cooling water passage
Normal
Repair. Replace
Engine disassembly


3. Output insufficient
Inspect by display module diagnostic tool
Engine
Generator set
Inspect gas fuel filter
Others
Polluted
Normal
Repair . Replace
Inspect ignition timing
Normal
Adjust
Inspect ignition system (ICM, Harness, Ignition coil, spark plug, boots etc.)
Disassemble engine
Inspect air cleaner
Normal
Repair . Replace
Check valve clearance
Normal
Adjust
Inspect cylinser head gasket for damage
Normal
Replace
Engine disassembly (valve assembly)
Inspect air leakage of air piping line
Normal
Retighten. Replace
Inspect air leakage of intercooler
Check turbocharger
Normal
Repair . Replace
Disassemble engine


4. Oil pressure lowered
Check oil amount
Check if oil pressure gauge indicates wrongly
Normal
To low
Check cooling temperature
Use recommened oil (replenish)
Too high
Normal
Refer to engine overheat
Inspect oil quality
Normal
Check oil relief valve
Water mixed in oil
Improper
Disassemble engine
Replace with recommended oil
Normal
Retighten. Replace
Disassemble engine


5. Fuel Consumption Excessive
Cause according to use conditions
1. Overload
2. Generator set
Inspect natural gas leakage
Normal
Natural gas leakage
Retighten.
Replace
Inspect ignition timing
Normal
Adjust
Inspect ignition system
(ICM, Harness, Ignition coil,
spark plug, boots etc.)
Inspect compressed
pressure
Check valve
clearance
Repair. replace
(cylinder liner,
piston ring, piston)
Normal
Adjust
Disassemble engine
(valve assembly, piston,
cylinder liner etc.)

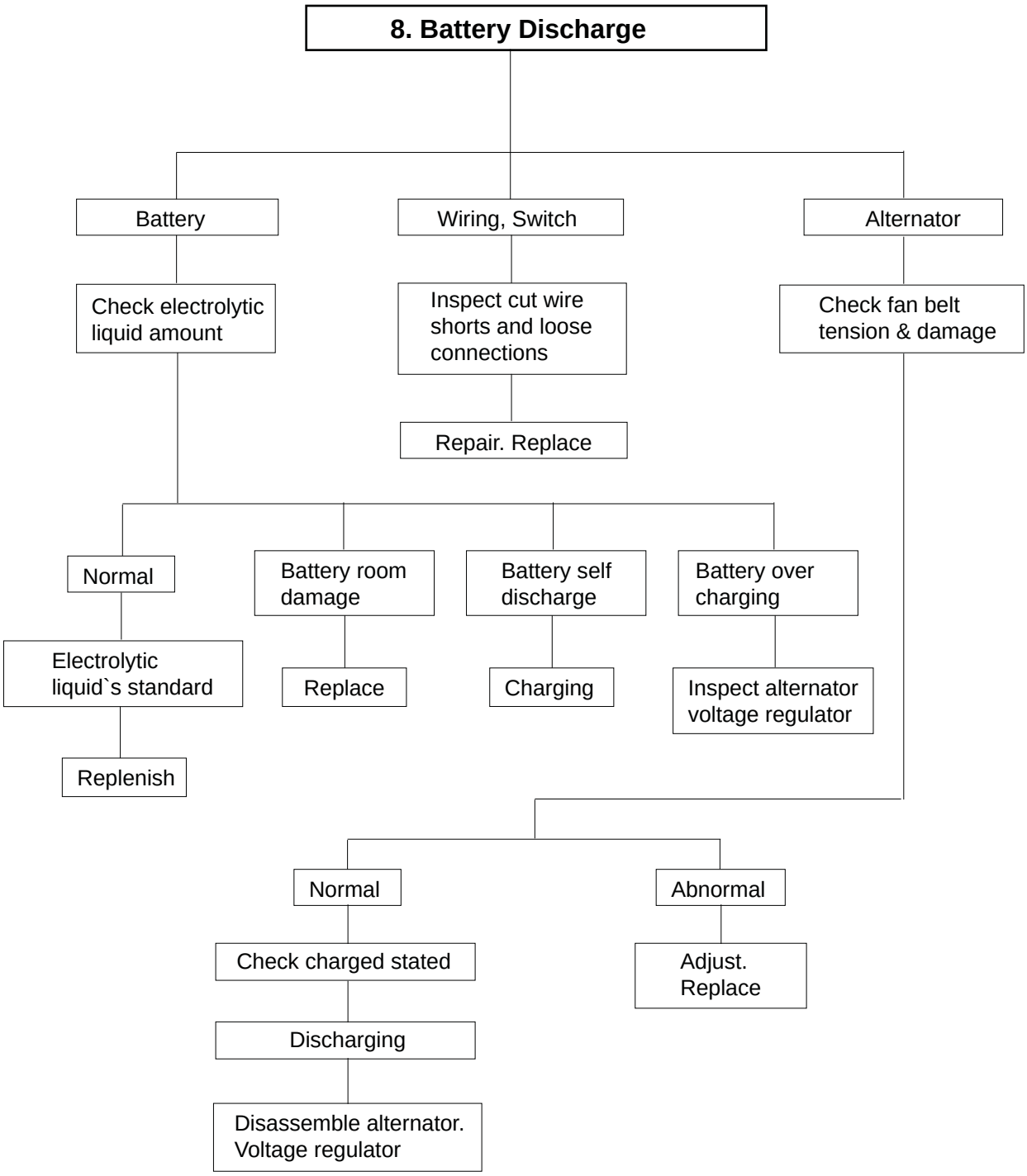
6. Oil Consumption Excessive

Cause according to use conditions
1. Excessive oil infusing
2. Continuous operation in low speed or extremely cold state

- Inspect oil leakage
  - Normal
    - Check oil quality
      - Replace with specified oil
  - Oil leakage
    - External
      - Retighten. Replace
    - Internal
      - Check compressed pressure
        - Engine disassembly (piston, cylinder liner)
        - Normal
          - Disassemble cylinder head (valve stem seal)
- Inspect air cleaner
  - Clean. Replace

7. Engine Knocking

- Inspect combustion of fuel & oil (carbon residue of exhaust gas)
  - Unconfirmed
    - Inspect compressed pressure
      - Normal
        - Inspect ignition timing
          - Normal
            - Check gas fuel quality
              - Use specified gas fuel
          - Adjust
      - Too low
        - Check valve clearance and cylinder head gasket crush
          - Normal
            - Disassemble engine
          - Replace. Adjust
  - Confirm
    - Disassemble engine


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

Condition	Causes	Remedies
1) Starting difficult		
(1) Compression pressure	● Valve's poor shut, stem distortion	Repair or replace
	● Valve spring damage	Replace valve spring
	● Cylinder head gasket's leak	Replace gasket
	● Wear of piston, piston ring or liner	Adjust
2) Idle operation abnormal	● Ignition timing incorrect	Adjust
3) Engine output insufficient		
(1) Continuous output Insufficient	● Valve clearance incorrect	Adjust
	● Valve tightness poor	Repair
	● Cylinder head gasket's leak	Replace gasket
	● Wear, stick, damage of piston ring	Replace piston ring
	● Ignition timing incorrect	Adjust
	● Damage of spark plug & ignition coil	Adjust or replace
	● Air suction amount insufficient	Clean or replace air cleaner
	● Turbocharger poor	Repair or replace
(2) Output insufficient when in acceleration	● Compression pressure insufficient	Disassemble engine
	● Ignition timing incorrect	Adjust
	● Damage of spark plug & ignition coil	Repair or replace
	● Air intake amount insufficient	Clean or replace air cleaner
4) Overheating	● Engine oil insufficient or poor	Replenish or replace
	● Cooling water insufficient	Replenish or replace
	● Fan belt loosened, worn, damaged	Adjust or replace
	● Cooling water pump's function lowered	Repair or replace
	● Thermostat operation poor	Replace
	● Valve clearance incorrect	Adjust
	● Exhaust system's resistance increased	Clean or replace
5) Engine noisy	For noises arise compositely such as rotating parts, lapping parts etc., there is necessity to search the cause of noises accurately.	
(1) Crankshaft	● As the wear of bearing or crankshaft progress, the oil clearances increase.	Replace bearing &grind crankshaft
	● Lopsided wear of crankshaft	Grind or replace
	● Oil supply insufficient due to oil passage clogging	Clean oil passage
	● Stuck bearing	Replace bearing &grind
(2) Connecting rod and connecting rod bearing	● Lopsided wear of con rod bearing	Replace bearing
	● Lopsided wear of crank pin	Grind crankshaft
	● Connecting rod distortion	Repair or replace
	● Stuck bearing	Replace & grind crankshaft
	● Oil supply insufficiency as clogging at oil passage progresses	Clean oil passage

Condition	Causes	Remedies
(3) Piston, piston pin &piston ring	● Piston clearance increase as the wear of piston and piston ring progresses	Replace piston & piston ring
	● Wear of piston or piston pin	Replace
	● Stuck piston	Replace piston
	● Piston insertion poor	Replace piston
	● Piston ring damaged	Replace piston
(4) Others	● Wear of crankshaft, thrust bearing	Replace thrust bearing
	● Camshaft end play increased	Replace thrust plate
	● Idle gear end play increased	Replace thrust washer
	● Timing gear backlash excessive	Repair or replace
	● Valve clearance excessive	Adjust valve clearance
	● Abnormal wear of tappet, cam	Replace tappet, cam
	● Turbocharger inner part damaged	Repair or replace
6) Oil Consumption excessive		
(1) Oil level elevated	● Clearance between cylinder liner & piston	Replace
	● Wear of piston ring, ring groove	Replace piston, piston ring
	● Piston ring's damage, stick, wear	Replace piston ring
	● Piston ring opening's disposition improper	Correct position
	● Piston skirt part damaged or abnormal wear	Replace piston
	● Oil ring's oil return hole clogged	Replace piston ring
	● Oil ring's contact poor	Replace piston ring
(2) Oil level lowered	● Looseness of valve stem & guide	Replace in set
	● Wear of valve stem seal	Replace seal
	● Cylinder head gasket's leak	Replace gasket
(3) Oil leak	● Looseness of connection parts	Replace gasket, repair
	● Various part's packing poor	Replace packing
	● Oil seal poor	Replace oil seal

2.4. Fault Code

Grouping	SFC*	Description	P-Code	P-code Description	Fault Action Route 1	Fault Action Route 1 Condition	Fault Action Route 2	Fault Action Route 2 Condition	Fault Action Route 3	Fault Action Route 3 Condition	Fault Action Route 4	Fault Action Route 4 Condition	Fault Action Route 5	Fault Action Route 5 Condition
Boost Control System	694	Overboost	P2263	Turbocharger/ Supercharger Boost System Performance	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 1 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
Boost Control System	694	Overboost	P2263	Turbocharger/ Supercharger Boost System Performance	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 1 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
UEGO Heater	456	UEGO INRC Open Fault	P1751	UEGO INRC Circuit Open	Turn On Minor Alarm	Test Failed Since Key Cycle	DisableO2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
	457	UEGO INRC Short to GND Fault	P1752	UEGO INRC Circuit Short to Ground	Turn On Minor Alarm	Test Failed Since Key Cycle	DisableO2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
	458	UEGO INRC Short to Batt Fault	P1753	UEGO INRC Circuit Short to BATT	Turn On Minor Alarm	Test Failed Since Key Cycle	DisableO2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
	463	UEGO Heater Open Fault	P0036	HO2S Heater Control Circuit	Turn On Minor Alarm	Test Failed Since Key Cycle	DisableO2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
	451	UEGO Heater Short to gnd Fault	P1754	UEGO heater circuit is shorted to Ground.	Turn On Minor Alarm	Test Failed Since Key Cycle	DisableO2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
	452	UEGO Heater Short to battery Fault	P1755	UEGO heater circuit is shorted to power.	Turn On Minor Alarm	Test Failed Since Key Cycle	DisableO2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
	136	UEGO Heater Temperature LTE	P0037	HO2S Heater Control Circuit Low	Turn On Minor Alarm	Test Failed Since Key Cycle	DisableO2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
	137	UEGO Heater Temperature HTE	P0038	HO2S Heater Control Circuit High	Turn On Minor Alarm	Test Failed Since Key Cycle	DisableO2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
	139	UEGO Heater Temperature Control	P0053	HO2S Heater Resistance	Turn On Minor Alarm	Test Failed Since Key Cycle	DisableO2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
UEGO Measurement	443	UEGO IP Fault	P1123	UEGO pump current line short circuit. Open circuits not detected.	Turn On Minor Alarm	Test Failed Since Key Cycle	DisableO2Ctrl	Test Failing	None	None	None	None	None	None
	453	UEGO SNS Open Fault	P1756	UEGO SNS Circuit Open	Turn On Minor Alarm	Test Failed Since Key Cycle	DisableO2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
	454	UEGO SNS Short to GND Fault	P1757	UEGO SNS Circuit Short to Ground	Turn On Minor Alarm	Test Failed Since Key Cycle	DisableO2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
	455	UEGO SNS Short to BATT Fault	P1758	UEGO SNS Circuit Short to BATT	Turn On Minor Alarm	Test Failed Since Key Cycle	DisableO2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
	459	UEGO SR Open Fault	P1759	UEGO SR Circuit Open	Turn On Minor Alarm	Test Failed Since Key Cycle	DisableO2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
	461	UEGO SR Short to GND Fault	P175A	UEGO SR Circuit Short to Ground	Turn On Minor Alarm	Test Failed Since Key Cycle	DisableO2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
	462	UEGO SR Short to BATT Fault	P175B	UEGO SR Circuit Short to BATT	Turn On Minor Alarm	Test Failed Since Key Cycle	DisableO2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None

Grouping	SFC*	Description	P-Code	P-code Description	Fault Action Route 1	Fault Action Route 1 Condition	Fault Action Route 2	Fault Action Route 2 Condition	Fault Action Route 3	Fault Action Route 3 Condition	Fault Action Route 4	Fault Action Route 4 Condition	Fault Action Route 5	Fault Action Route 5 Condition
Engine Coolant Temperature	263	ECT Over Temp Fault	P0217	Engine Coolant Over Temperature Condition	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 1 Torque Limit	None	None	None	None	None	None	None
	265	ECT Over Heat Fault	P1770	Engine Coolant Temperature has measured an excessive coolant temperature typically due to the engine overheating.	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 3 Torque Limit	None	None	None	None	None	None	None
	261	ECT Voltage High	P0118	Engine Coolant Temperature Sensor 1 Circuit High	Turn On Minor Alarm	Test Failed Since Key Cycle	Disable Pre Cat O2 Adapt	Test Failed Since Key Cycle	None	None	None	None	None	None
	262	ECT Voltage Low	P0117	Engine Coolant Temperature Sensor 1 Circuit Low	Turn On Minor Alarm	Test Failed Since Key Cycle	Disable Pre Cat O2 Adapt	Test Failed Since Key Cycle	None	None	None	None	None	None
PTP	371	PTP Voltage High	P0238	Turbocharger/ Supercharger Boost Sensor "A" Circuit High	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	372	PTP Voltage Low	P0237	Turbocharger/ Supercharger Boost Sensor "A" Circuit Low	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
Fuel Adaption	471	Adaptive Learn Correction on Hi Limit	P0171	System Too Lean or Post Catalyst Fuel Trim System Too Lean	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 3 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	472	Adaptive Learn Correction on Lo Limit	P0172	System Too Rich or Post Catalyst Fuel Trim System Too Rich	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 3 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
OverSpeed	429	Engine OverSpeed	P0219	Engine Overspeed Condition	Turn On Minor Alarm	Test Failed Since Key Cycle	Engine Shut Down	Test Failed Since Key Cycle	None	None	None	None	None	None
Encorder	426	CAM Sensor Other Fault	P0344	Camshaft Position Sensor "A" Circuit Intermittent	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	421	CAM Sensor Loss Fault	P0340	Camshaft Position Sensor "A" Circuit	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	424	CAM Sensor Phase Fault	P0016	Crankshaft Position – Camshaft Position Correlation	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	422	Crank Sensor Loss Fault	P0335	Crankshaft Position Sensor "A" Circuit	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
Lock off	251	Natural Gas Fuel LockOff Short Open Fault	P0005	Fuel Shutoff Valve "A" Control Circuit/Open	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	252	Propane Gas Fuel LockOff Short Open Fault	P2665	Fuel Shutoff Valve "B" Control Circuit/Open	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None

Grouping	SFC*	Description	P-Code	P-code Description	Fault Action Route 1	Fault Action Route 1 Condition	Fault Action Route 2	Fault Action Route 2 Condition	Fault Action Route 3	Fault Action Route 3 Condition	Fault Action Route 4	Fault Action Route 4 Condition	Fault Action Route 5	Fault Action Route 5 Condition
MAP	342	MAP Voltage High	P0108	Manifold Absolute Pressure/Barometric Pressure Circuit High	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 2 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	341	MAP Voltage Low	P0107	Manifold Absolute Pressure/Barometric Pressure Circuit Low	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 2 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	375	PTP/MAP KeyOn Check	P023D	Manifold Absolute Pressure – Turbocharger/ Supercharger Boost Sensor "A" Correlation	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	357	PTP/MAP Connectors Switches	P006C	MAP – Turbocharger/ Supercharger Inlet Pressure Correlation	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	346	MAP Bank1 Bank2 Comparison	P1775	Bank 1 and Bank 2 Manifold Absolute Pressure sensor value are not same.	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 2 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
MAT	233	MAT Higher Than Expected	P0127	Intake Air Temperature Too High	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 3 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	231	MAT Voltage High	P0098	Intake Air Temperature Sensor 2 Circuit High	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	232	MAT Voltage Low	P0097	Intake Air Temperature Sensor 2 Circuit Low	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
Exhaust Gas Temperature	741	EGT Overtemperature	P2429	Exhaust Gas Temperature Too High	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 3 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	742	Engine EGT - Voltage High	P0549	Exhaust Gas Temperature Sensor Circuit High	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	743	Engine EGT - Voltage Low	P0548	Exhaust Gas Temperature Sensor Circuit Low	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
O2 PostCat	187	PostCat O2 Heater Short Open Fault	P0147	O2 Sensor Heater Circuit B1S2	Turn On Minor Alarm	Test Failed Since Key Cycle	DisablePostO 2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
	181	PostCat O2 Voltage High	P0144	O2 Sensor Circuit High Voltage B1S2	Turn On Minor Alarm	Test Failed Since Key Cycle	DisablePostO 2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
	182	PostCat O2 Voltage Low	P0143	O2 Sensor Circuit Low Voltage B1S2	Turn On Minor Alarm	Test Failed Since Key Cycle	DisablePostO 2Ctrl	Test Failed Since Key Cycle	None	None	None	None	None	None
Closed Loop Correction	141	O2 Closed Loop Correction Fuel Multiplier On Low Limit	P1776	The closed loop fuel control multiplier reaches low limit	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 3 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	142	O2 Closed Loop Correction Fuel Multiplier	P1777	The closed loop fuel control multiplier reaches high limit.	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 3 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
Oil Pressure	192	Oil Pressure Voltage High	P0523	Engine Oil Pressure Sensor/Switch High	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	191	Oil Pressure Voltage Low	P0522	Engine Oil Pressure Sensor/Switch Low	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	195	Oil Pressure Low	P0524	Engine Oil Pressure Too Low	Turn On Major Alarm	Test Failed Since Key Cycle	Engine Shut Down	Test Failed Since Key Cycle	None	None	None	None	None	None

Grouping	SFC*	Description	P-Code	P-code Description	Fault Action Route 1	Fault Action Route 1 Condition	Fault Action Route 2	Fault Action Route 2 Condition	Fault Action Route 3	Fault Action Route 3 Condition	Fault Action Route 4	Fault Action Route 4 Condition	Fault Action Route 5	Fault Action Route 5 Condition
Power Supplies	165	Battery Voltage Higher Than Expected	P2504	Charging System Voltage High	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 1 Torque Limit	Test Failed Since Key Cycle	Engine Actuators_ Disable	Test Failed Since Key Cycle	None	None	None	None
	166	Battery Voltage Lower Than Expected	P2503	Charging System Voltage Low	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 1 Torque Limit	Test Failed Since Key Cycle	Engine Actuators_ Disable	Test Failed Since Key Cycle	None	None	None	None
	169	DRVP Higher than Expected	P0563	System Voltage High	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	161	XDRP (+5V) Voltage HTE	P0643	Sensor Reference Voltage "A" Circuit High	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	162	XDRP (+5V) Voltage LTE	P0642	Sensor Reference Voltage "A" Circuit Low	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	151	2.5 Reference Voltage HTE	P0699	Sensor Reference Voltage "C" Circuit High	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	152	2.5 Reference Voltage LTE	P0698	Sensor Reference Voltage "C" Circuit Low	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
Automotive Throttle	541	TPS1 Voltage High	P2128	Throttle/Pedal Position Sensor/Switch "E" Circuit High	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 4 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	542	TPS1 Voltage Low	P2127	Throttle/Pedal Position Sensor/Switch "E" Circuit Low	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 4 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	545	TPS2 Voltage High	P2123	Throttle/Pedal Position Sensor/Switch "D" Circuit High	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 4 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	546	TPS2 Voltage low	P2122	Throttle/Pedal Position Sensor/Switch "D" Circuit Low	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 4 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	549	TPSSensor Conflict	P2138	Throttle/Pedal Position Sensor/Switch "D"/"E" Voltage Correlation	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 4 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	552	Throttle Valve H bridge Fault	P2101	Throttle Actuator Control Motor Circuit Range/ Performance	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 4 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	553	Throttle Valve Open Fault	P2100	Throttle Actuator Control Motor Circuit/Open	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 4 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	555	Throttle Valve Stuck	P0638	Throttle Actuator Control Range/Performance	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 4 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
EFR Valve	633	EFR Position Voltage High	P0004	Fuel Volume Regulator Control Circuit High	Turn On Minor Alarm	Test Failed Since Key Cycle	Disable Pre Cat O2 Adapt	Test Failed Since Key Cycle	None	None	None	None	None	None
	634	EFR Position Voltage Low	P0003	Fuel Volume Regulator Control Circuit Low	Turn On Minor Alarm	Test Failed Since Key Cycle	Disable Pre Cat O2 Adapt	Test Failed Since Key Cycle	None	None	None	None	None	None
	631	EFR Position adapt low Fault	P1779	EFR Low Adapt Min Faults	Turn On Minor Alarm	Test Failed Since Key Cycle	Disable Pre Cat O2 Adapt	Test Failed Since Key Cycle	None	None	None	None	None	None
	632	EFR Position adapt high Fault	P177A	EFR Low Adapt Max Faults	Turn On Minor Alarm	Test Failed Since Key Cycle	Disable Pre Cat O2 Adapt	Test Failed Since Key Cycle	None	None	None	None	None	None

Grouping	SFC*	Description	P-Code	P-code Description	Fault Action Route 1	Fault Action Route 1 Condition	Fault Action Route 2	Fault Action Route 2 Condition	Fault Action Route 3	Fault Action Route 3 Condition	Fault Action Route 4	Fault Action Route 4 Condition	Fault Action Route 5	Fault Action Route 5 Condition
Memory	621	CPU Load Higher than Expected	P0606	ECM/PCM Processor	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	623	SRAM Memory Fault	P0604	Internal Control Module Random Access Memory (RAM) Error	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	622	Flash Memory Fault	P0605	Internal Control Module Read Only Memory (ROM) Error	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	781	Knock Sensor Open Circuit	P0327	Knock Sensor 1 Circuit Low	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 3 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	782	Knock Sensor short Circuit	P0328	Knock Sensor 1 Circuit High	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 3 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	783	Knock 2 Sensor Open Circuit	P0332	Knock Sensor 2 Circuit Low	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 3 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	784	Knock 2 Sensor short Circuit	P0333	Knock Sensor 2 Circuit High	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 3 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
deltaP Sensor	473	delta Pressure - Voltage High	P172A	Woodward's P Code	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 3 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	474	delta Pressure - Voltage Low	P172B	DeltaP Sensor signal line has shorted to XDRG or Ground, or deltaP Sensor signal line has opened.	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 3 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	475	FuelShutOffStuckOpen	P172C	Lockoff valve is not closing	Turn On Minor Alarm	Test Failed Since Key Cycle	Level 3 Torque Limit	Test Failed Since Key Cycle	None	None	None	None	None	None
	476	Low Fuel Pressure	P0087	Fuel Rail/System Pressure – Too Low	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
	479	deltaP Zero Offset Fault	P172F	Delta pressure has significant sensor drift at zero pressure condition.	Turn On Minor Alarm	Test Failed Since Key Cycle	None	None	None	None	None	None	None	None
External Shutdown	571	External Shutdown	P1731	External Shutdown has been activated	Turn On Major Alarm	Test Failed Since Key Cycle	Engine Shutdown	Test Failed Since Key Cycle	None	None	None	None	None	None

* SFC : Specification

2.5. Engine Inspection

2.5.1. Stopping engine

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

2.5.2. General engine inspection cycle

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

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

○ : Check & adjust ● : Replace

Inspection item		Daily	Every 50hrs	Every 200hrs	Every 250hrs	Every 500hrs	Every 1,500hrs	Every 3,000hrs	Remark
Cooling system	Check for leakage (hoses, clamp)	○							
	Check the water level	○							
	Adjust the V-belt tension	○							
	Change the coolant water								● 1 year
Lubrication system	Check for leakage	○							
	Check the oil level gauge	○							
	Change the lubricating oil		● 1st		●				Every 250hr
	Replace the oil filter cartridge		● 1st		●				Every 250hr
Intake & exhaust system	Check the leakage for intercooler (hoses, clamp)	○							Intercooler cleaning cycle 1,500 hours
	Check the air cleaner indicator	○							
	Replace air cleaner element					●			Every day inspection
	Clean the exhaust system							○	
Fuel system	Check the leakage fuel line	○							
	Check the fuel mixer								○ 1 year
	Check the throttle body								○ 1 year
	Check the speed controller								○ 1 year
	Check the gas regulator assy (with gas fuel mixer)								○ 1 year
Ignition system	Check the state of ignition timing								When necessary
	Check the spark plug						●	●	
	Check the ignition cable								● 1 year
	Check the ignition coil								○ 1 year
	Check the sensors (ignition or timing)	○							
Engine adjust	Check the state of exhaust gas	○							
	Check the exhaust gas pressure								When necessary
	Check the battery charging	○							
	Check the compression pressure								When necessary
	Adjust Intake/exhaust valve clearance		○ 1st			○			When necessary

2.5.3. Use of original parts for repair and replacement

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

3. Disassembly and Reassembly of Major Components

3.1. Engine Disassembly

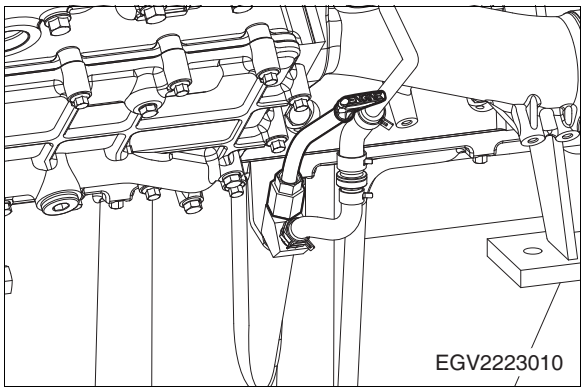
- Engine parts' disassembly procedures are as follows;

3.1.1. General precautions

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

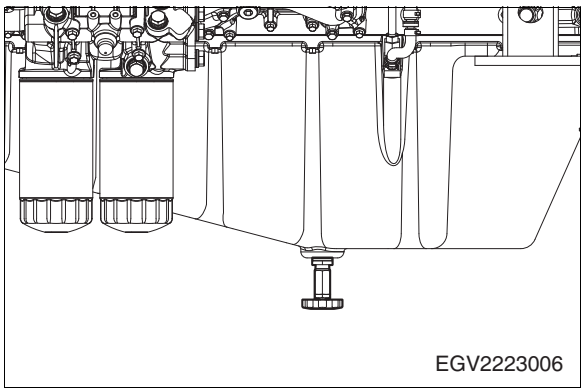
3.1.2. Oil level gauge

- Take out the oil level gauge.



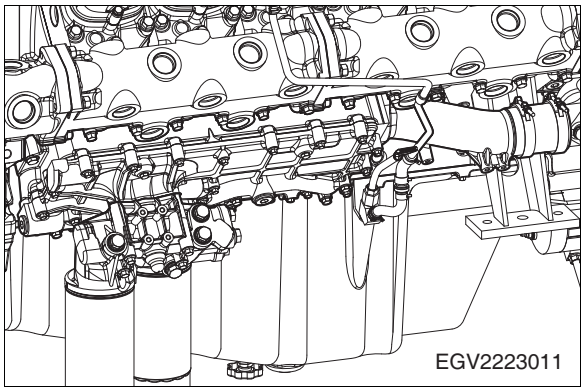
3.1.3. Engine oil

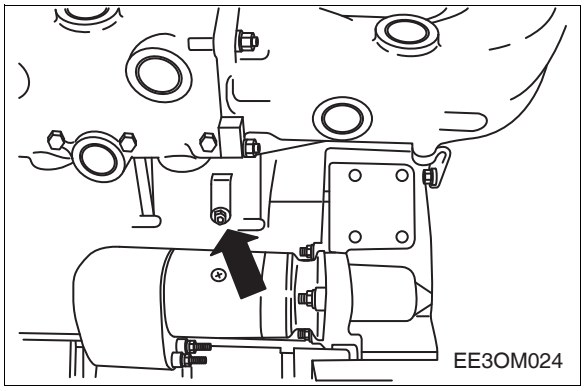
- Turn the valve opening and then move the oil drain pump lever as figure by hand, and let engine oil discharge into the prepared vessel.



3.1.4. Cooling water

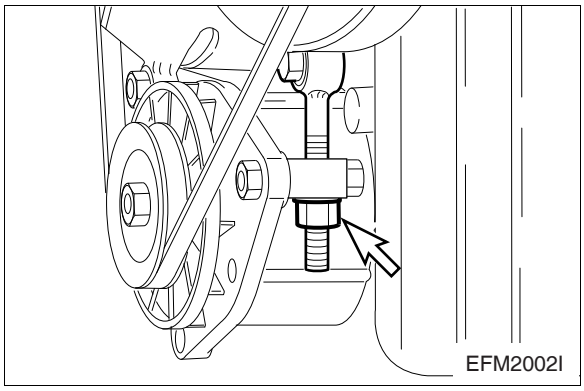
- Remove the cooling water drain plug from the cylinder block and oil cooler, various pipes, etc. and let the cooling water discharge into the prepared vessel.





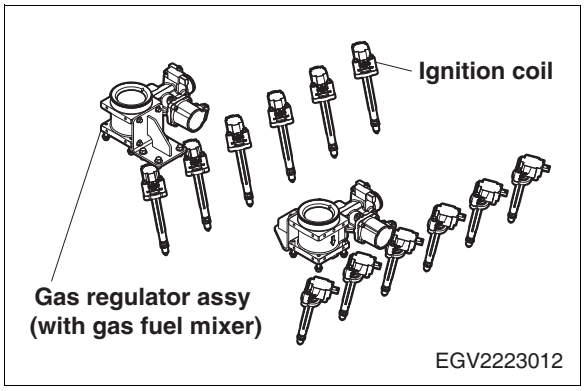
3.1.5. V-belt

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



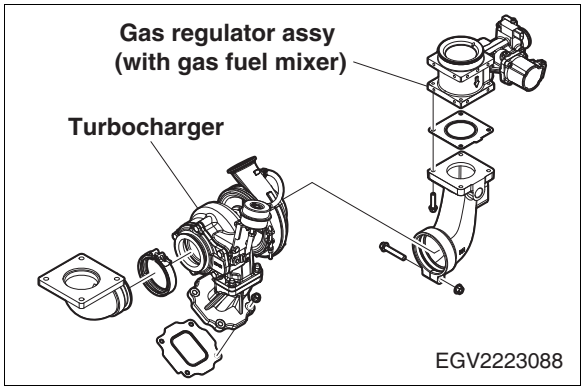
3.1.6. Ignition coil & gas regulator assy (with gas fuel mixer)

- Remove the high voltage cable by hand from each cylinder.
- Remove the gas regulator assy (with gas fuel mixer) fixing bolts and then tear down the gas regulator assy (with gas fuel mixer) arid others parts.



3.1.7. Turbocharger and gas regulator assy (with gas fuel mixer)

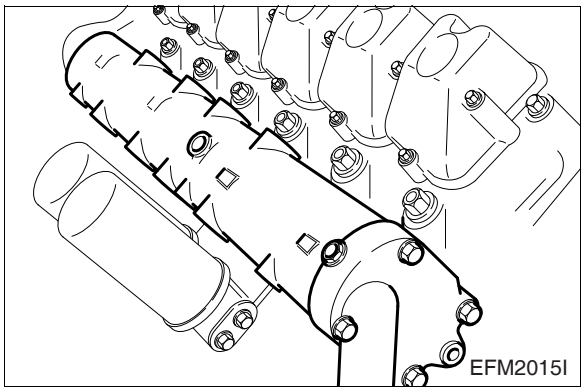
- Loosen the air cleaner hose for connecting the gas regulator assy (with gas fuel mixer).
- Loosen the fixing bolt for connecting the turbocharger and then tear down the air intake stake and gas regulator assy (with gas fuel mixer).
- Remove the turbocharger fixing routs and separate the turbocharger from the exhaust manifold.



3.1.8. Exhaust manifold

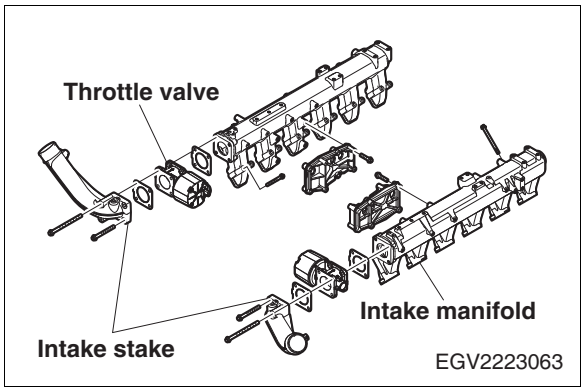
- Remove the exhaust manifold fixing bolts and tear the manifold from the cylinder head.

Caution:
Be careful not to drop the manifold because it is very heavy.



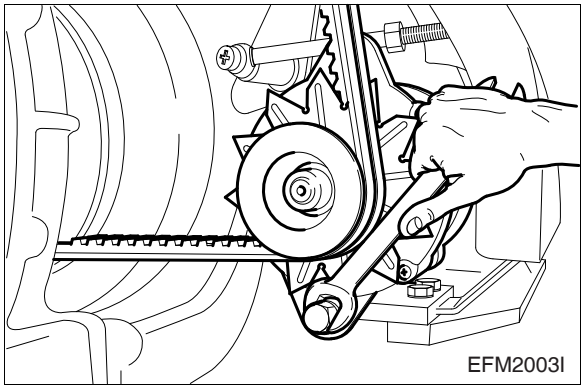
3.1.9. Intake manifold & throttle valve

- Remove the throttle valve fixing bolts and tear the throttle valve down from the intake stake.
- Remove the manifold fixing bolts and tear the manifold down from the cylinder head.



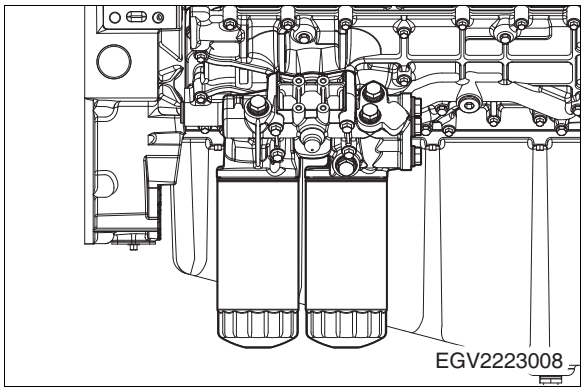
3.1.10. Alternator

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

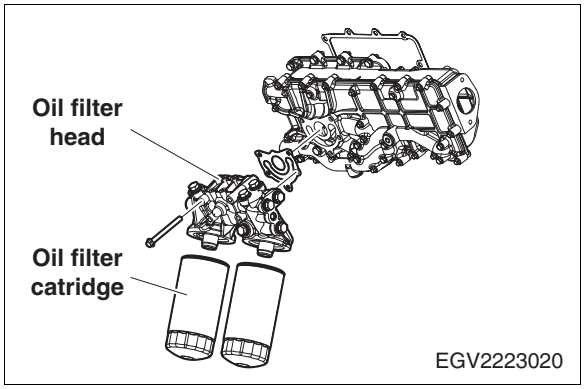


3.1.11. Oil filter

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

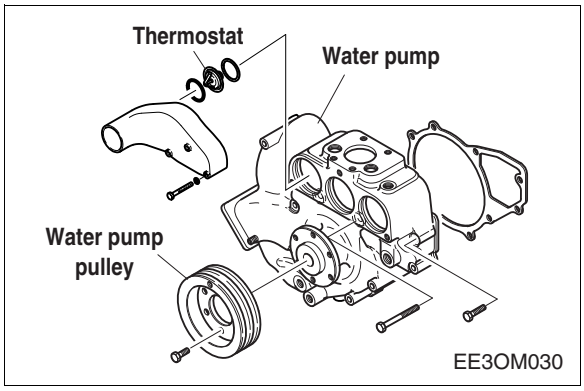


- Remove the oil filter head fixing bolts and disassemble the filter head.



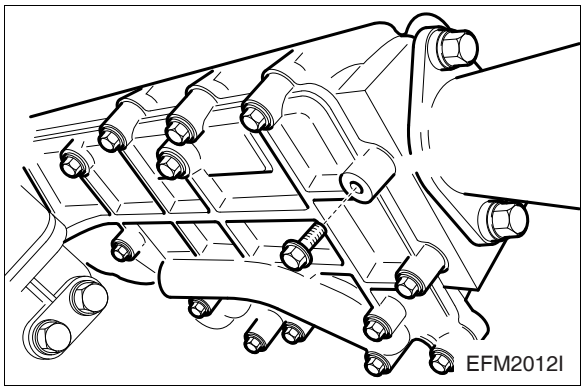
3.1.12. Cooling water pump

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

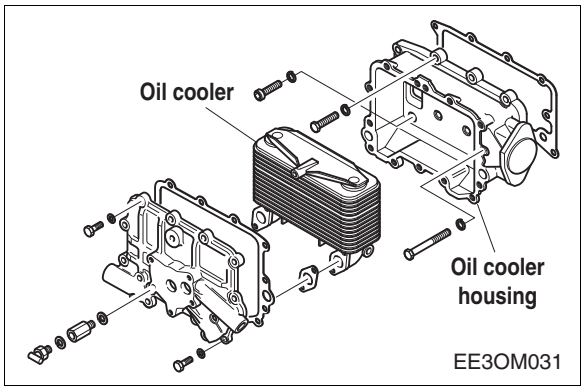


3.1.13. Oil cooler

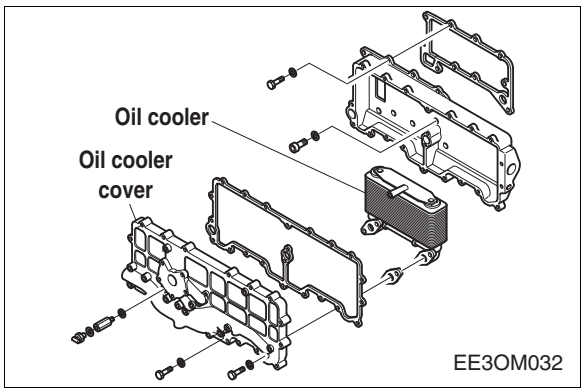
- By removing the plug screw of cooling water discharge port, the cooling water is discharged.
- Remove the oil cooler cover fixing bolts and disassemble the oil cooler.



● By removing the cooler housing fixing bolts and disassemble the oil cooler housing from the cylinder block.

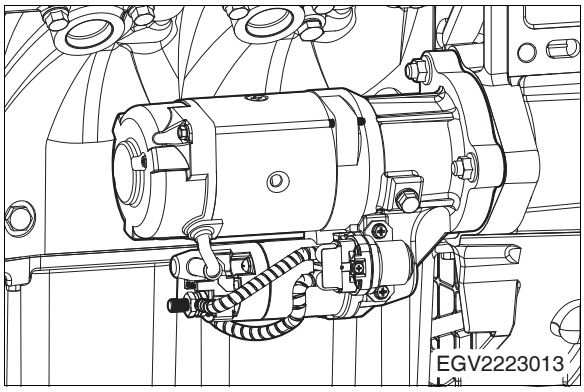


● Remove the oil cooler insert fixing bolts, and then disassemble the cooler insert.



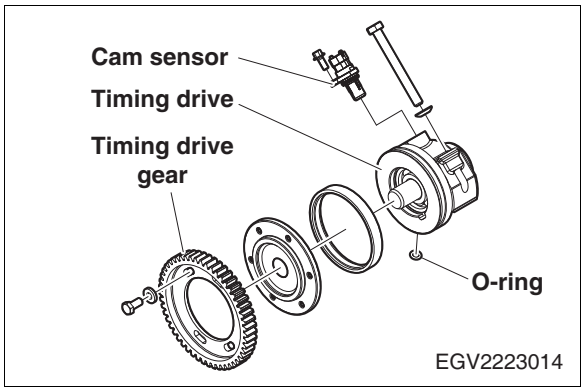
3.1.14. Starting motor

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



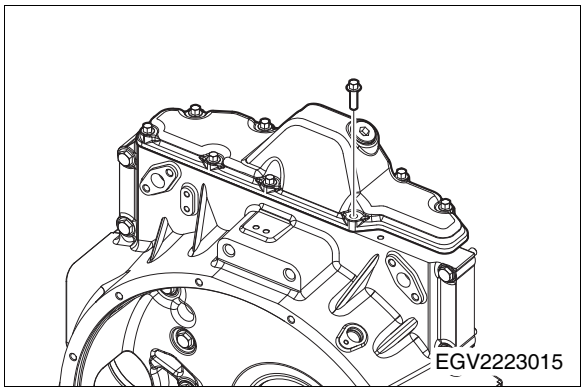
3.1.15. Timing drive & sensor

● Remove the timing drive fixing bolts and disassemble the timing drive and cam sensor.



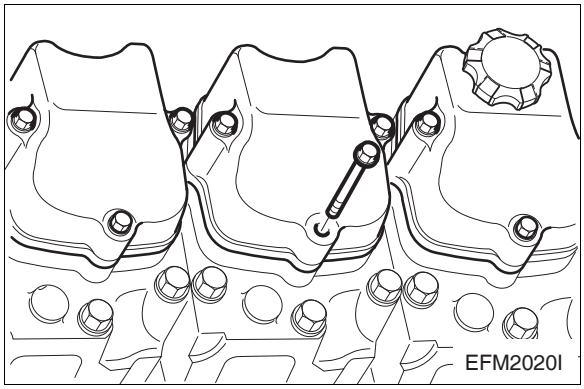
3.1.16. Flywheel housing cover

- Separate the side cover.
- Disassemble the fly wheel housing cover.



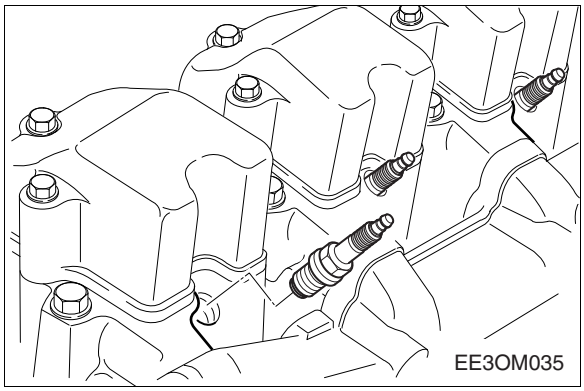
3.1.17. Cylinder head cover

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



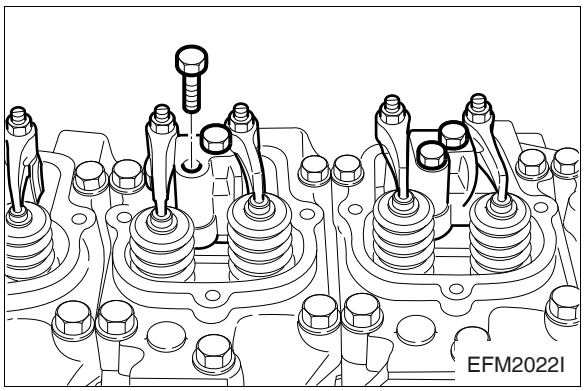
3.1.18. Spark plug

- By means of a long impact tool, loosen the spark plug and take it out.



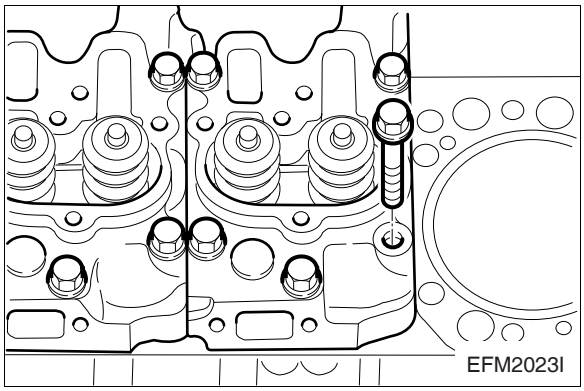
3.1.19. Rocker arm

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



3.1.20. Cylinder head

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

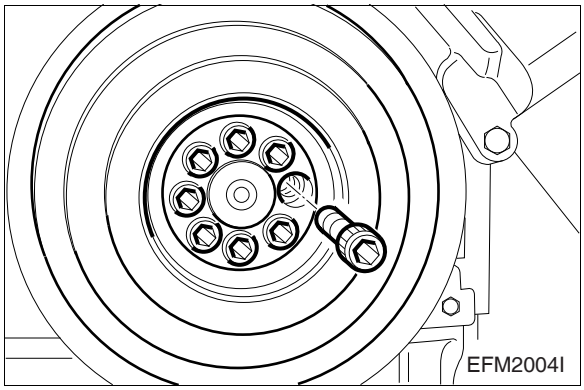


Note:

Be careful not to damage the cylinder head face where its gasket contacts.

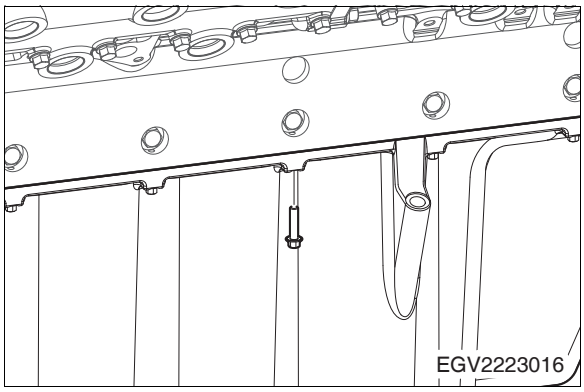
3.1.21. Vibration damper

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



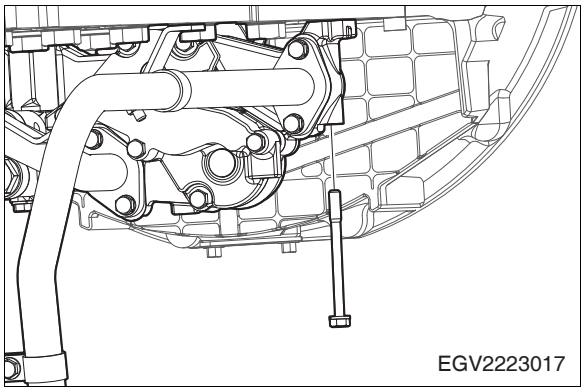
3.1.22. Oil pan

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



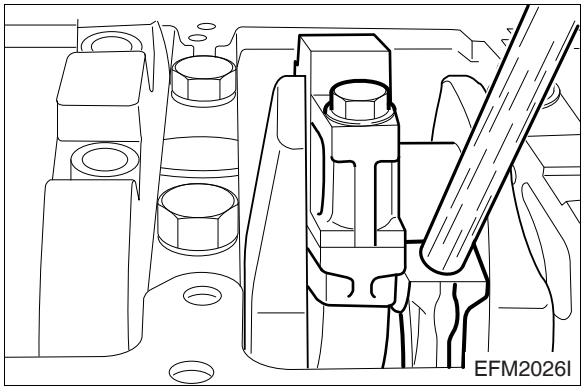
3.1.23. Oil pump

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


EGV2223017

3.1.24. Piston

- Remove the connecting rod cap bolts in the reverse order of assembling and follow the similar method as in the cylinder head bolt removal.
- Tapping the upper and lower connecting rod caps lightly with an urethane hammer, separate them and take the bearings out.
- By pushing the piston assembly with a wooden bar toward the cylinder head's direction remove the piston.

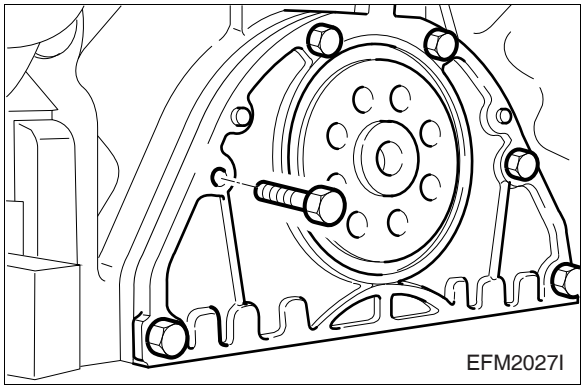

EFM2026I

Note:

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

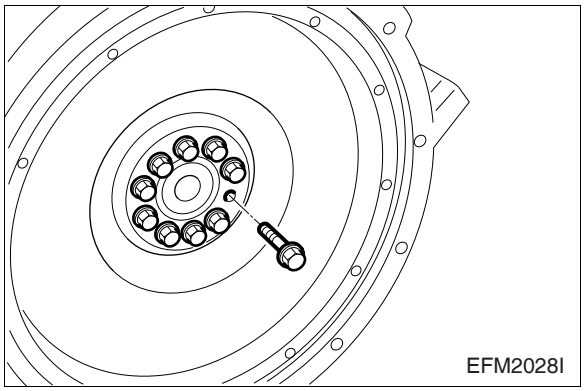
3.1.25. Front oil seal holder

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

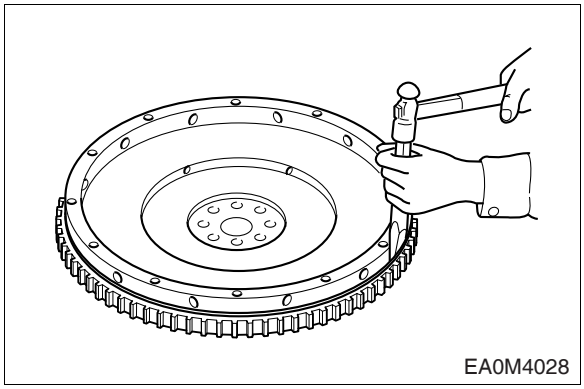

EFM2027I

3.1.26. Fly wheel

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


EFM2028I

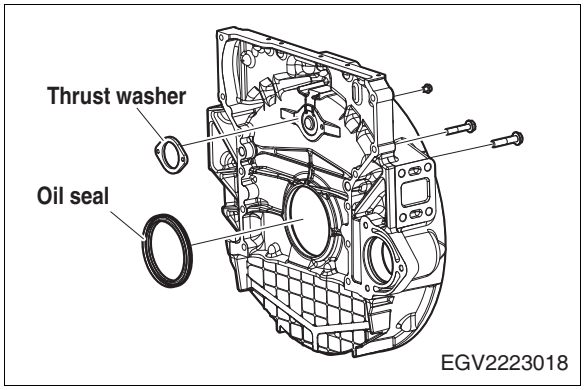
- Remove the flywheel ring gear.
  - Heat the ring gear evenly with a gas burner (up to 200°C) to invite volumetric expansion.
  - Tapping around the edges of the ring gear with a hammer and brass bar to remove it.


EA0M4028

Caution:
Do not damage the flywheel.

3.1.27. Flywheel housing

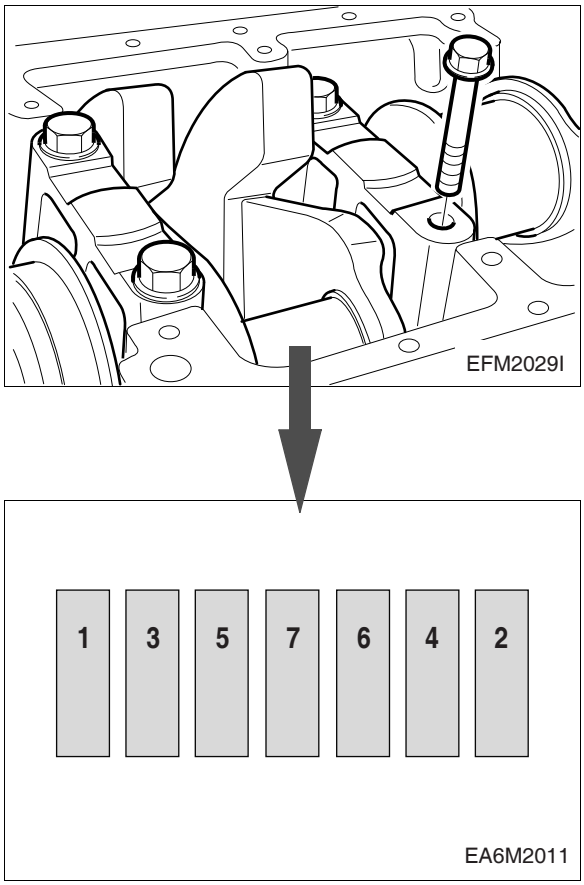
- Remove the flywheel housing fixing bolts and take them out.
- Remove the oil seal from the flywheel housing.



EGV2223018

3.1.28. Crankshaft

- Remove the bolts from bearing caps.
- Remove the main bearing cap fixing bolts in the reverse order of assembling.
- Maintain the removed bearing caps in the order of cylinders.
- Temporarily install the bolts at the both side of crankshaft, and lift the shaft with a rope.



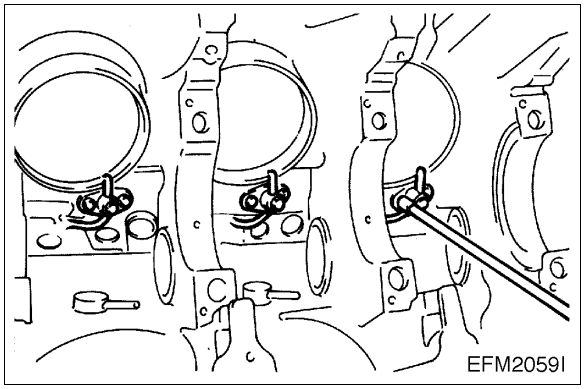
Note:
Do not mingle with the metal bearings and bearing caps randomly. To prevent mixing, temporarily assemble the metal bearings to the corresponding bearing caps in turn.

3.1.29. Camshaft and tappet

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

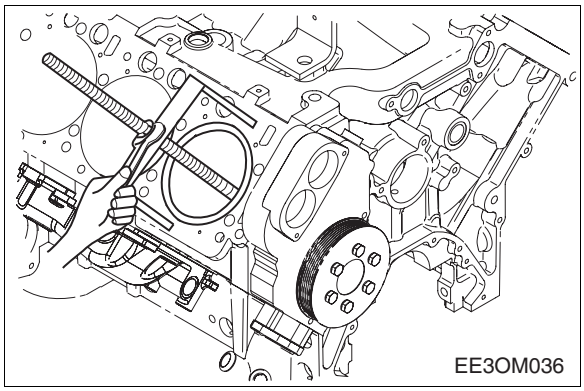
3.1.30. Oil spray nozzle

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



3.1.31. Cylinder liner

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



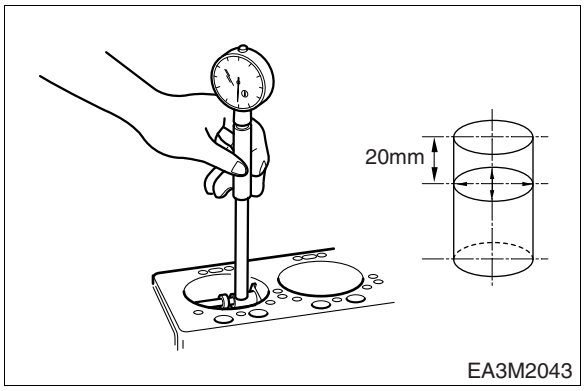
3.2. Measurement and Inspection of Major Parts

3.2.1. Cleaning and inspection of cylinder block

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

3.2.2. Cylinder liner measurement

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

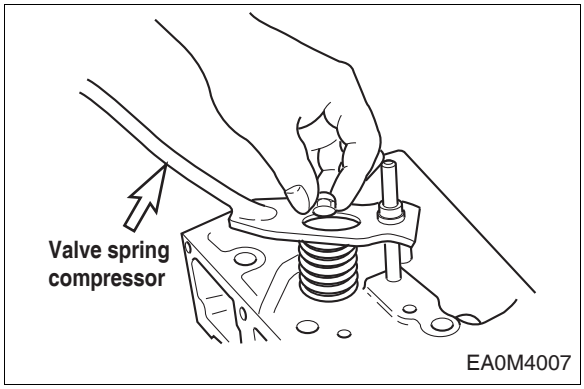


	Standard	Limit
Liner inner dia.	ø127.990 ~ ø128.010 mm	0.15 mm

3.2.3. Cylinder head

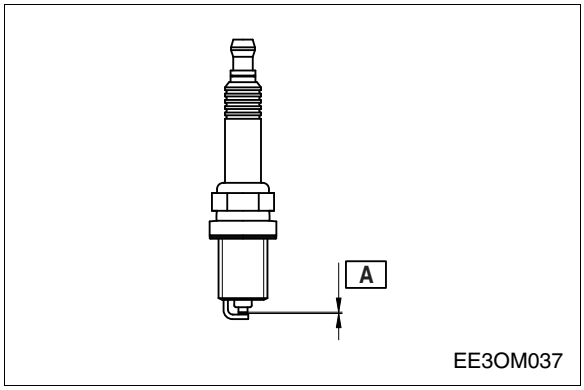
1) Cylinder head disassembly

- Be careful for the cylinder head gasket contacting surface of cylinder head not to be damaged.
- Remove the cotter pin pressing the valve spring by means of a special tool.
- Take out the valve stem seal.
- Pull out the intake and exhaust valves.



3.2.4. Spark plug

- Remove spark plug. Clean threads by hand with brush and solvent.
- Clean any deposits from electrode and inspect insulator area.
- Measure the spark plug distance at electrode position. (A)
- Correct or replace the spark plug if necessary.

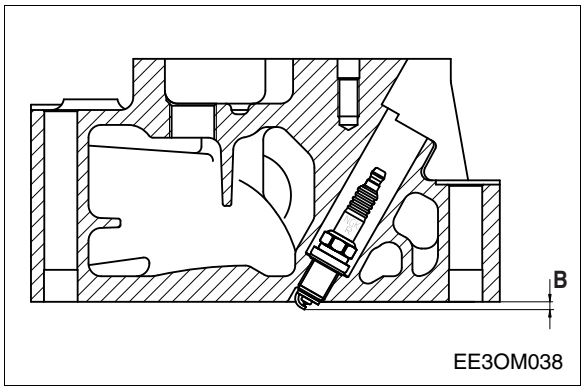


Standard (A)	0.3 ~ 0.4 mm

- Insert the spark plug into cylinder head and measure distance. (B)

Torque	2.5 ~ 3.0 kg.m

Standard (B)	3.38 ~ 3.76 mm



3.2.5. Inspection and measurement of cylinder head

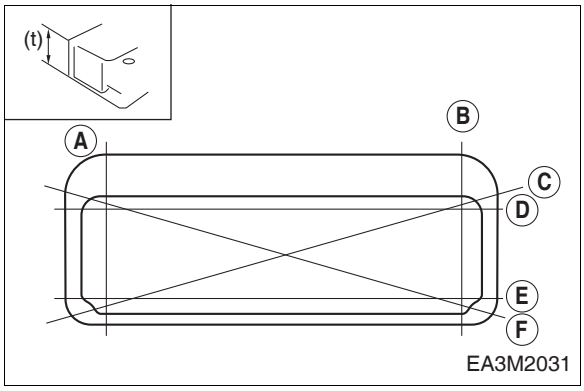
1) Damage check

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

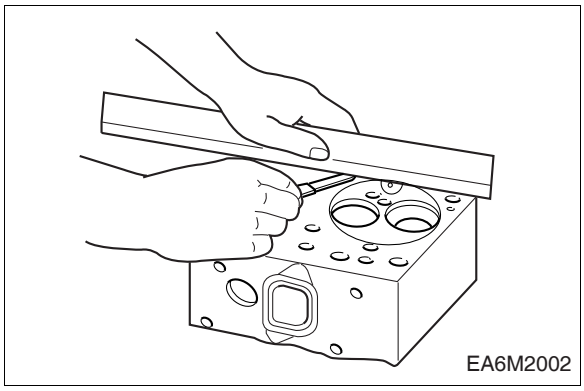
2) Distortion

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

Warpage	Standard	Limit
	0.05 mm or less	0.2 mm



EA3M2031

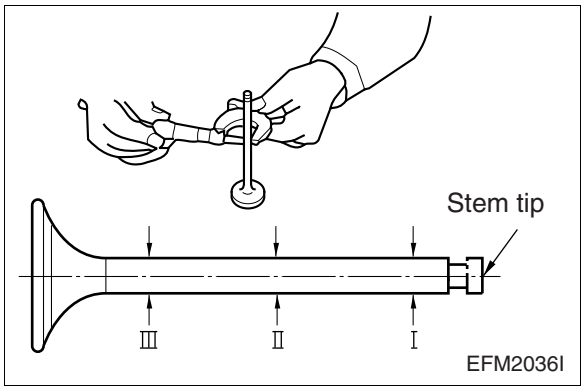

EA6M2002

3.2.6. Inspection and measurement of valve and valve guide

1) Valve

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

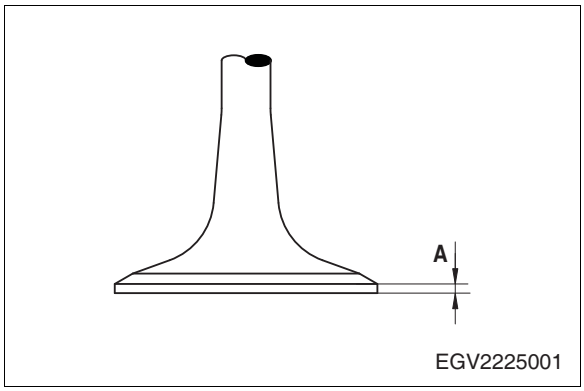
Valve	Standard	Limit
Intake	ø11.954 ~ ø11.965 mm	ø11.934 mm
Exhaust	ø11.935 ~ ø11.955 mm	ø11.905 mm



EFM2036I

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

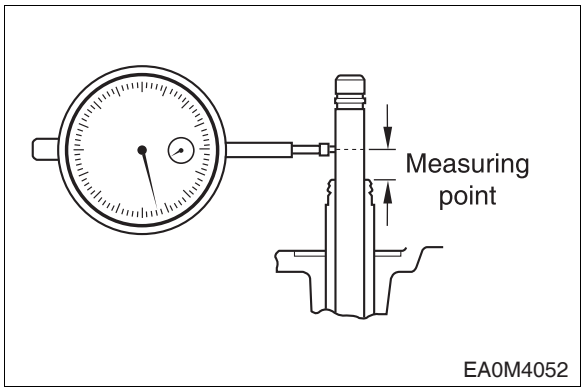
● If valve head thickness (A) becomes less than 2.1 mm for intake and 1.4 mm for exhaust, replace the valve.



Valve	Standard	Limit
Intake (A)	2.6 ~ 3.0 mm	2.1 mm
Exhaust (B)	1.9 ~ 2.3 mm	1.4 mm

2) Valve guide

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

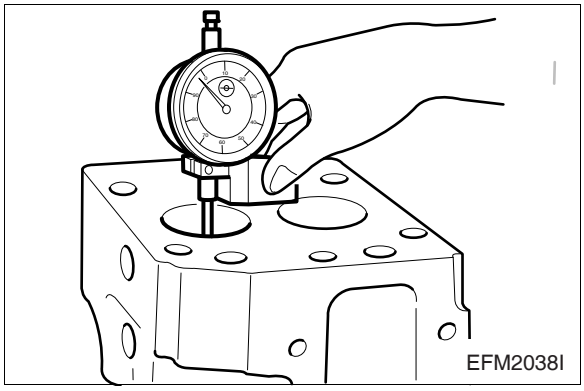


Valve	Standard	Limit
Intake	0.035 ~ 0.064 mm	0.20 mm
Exhaust	0.045 ~ 0.083 mm	0.25 mm

3) Valve seat

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

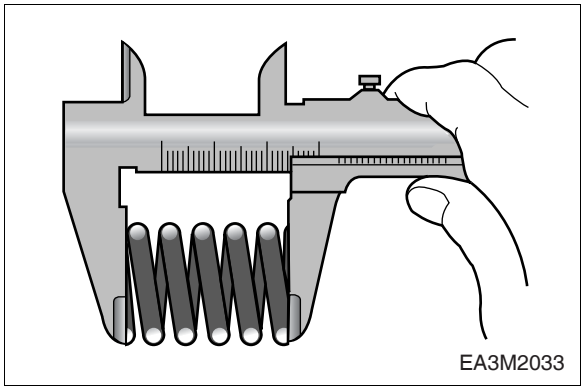
<Valve Projection amount (Valve Recess)>



Valve	Standard	Limit
Intake (A)	0.65 ~ 0.95 mm	2.5 mm
Exhaust (A)	0.65 ~ 0.95 mm	2.5 mm

3.2.7. Valve spring

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


EA3M2033

< Dual spring perpendicularity regular >

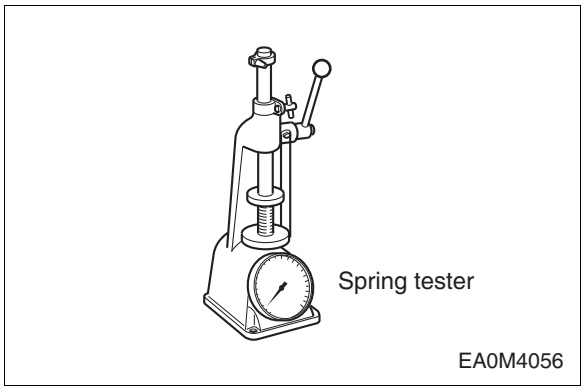
		Free length
Spring	**Inside**	65.5 mm
	Outside	64 mm

< Single spring perpendicularity regular >

		Free length
Intake/ exhaust	**Outside**	61.9 mm

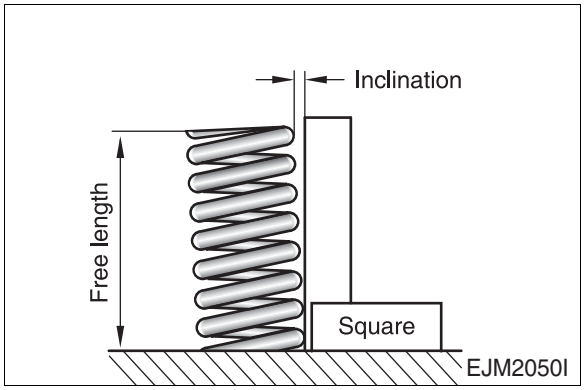
< Valve spring tension standard >

		Length (mm)	Spring tension (kg)	Limit
Intake/ exhaust	**Out-side**	46.8/ 32.8	47.0/ 90.5	±2.5/ ±4.5



EA0M4056

- Squareness of valve spring:
  Measure the sequareness of the valve spring with the surface plate and the right-angle square. If the reading exceeds the tolerance limit, replace the valve spring.

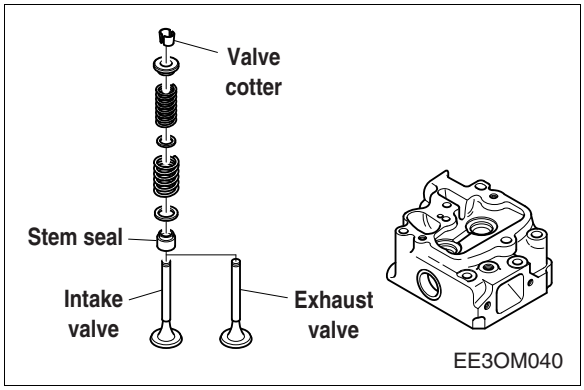


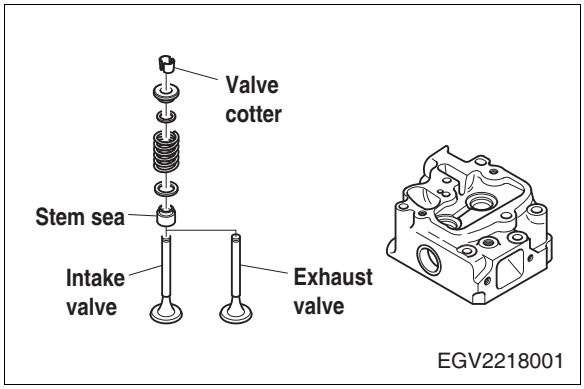
EJM2050I

		Standard	Limit
Intake/ exhaust	**Outside**	1.2 mm	2.0 mm

3.2.8. Valve spring

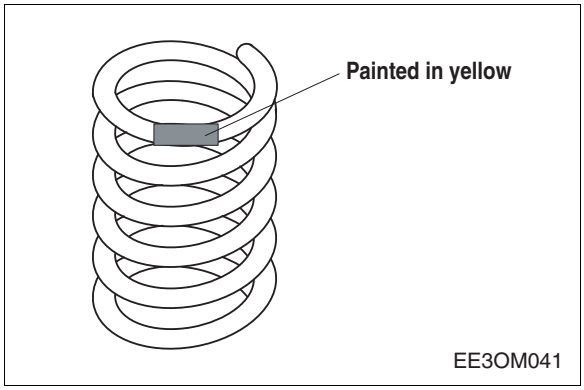
- Clean the cylinder head thoroughly.
- Coat the valve stems and valve guides with engine oil and assemble the valves.
- Replace the valve stem seals with new ones and insert the stem seals to the valve guides of cylinder head with a special tool. (Be careful for the valve stem seals not to be damaged)



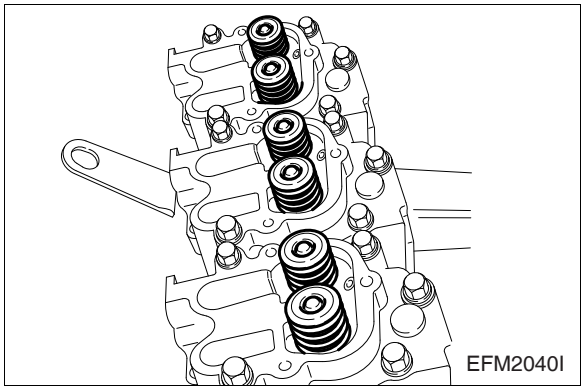


- Install the valve spring washer to valve guide.
- After putting on the inside, outside spring, Install the valve spring seat on them.

Note:
Install the valve spring seat with "TOP" (painted in Yellow) side up.



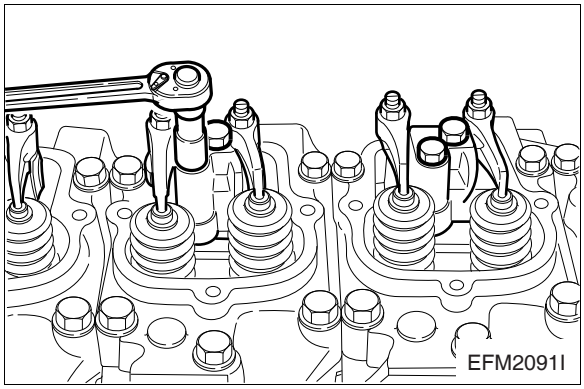
- Pressing the spring down with a special tool, assemble by inserting the valve cotter.
- After the valve is assembled, inspect the valve tapping it lightly with an urethane hammer if accurate assembling was done.



3.2.9. Rocker arm

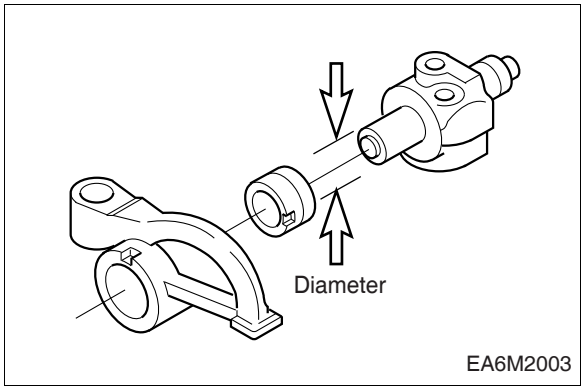
1) Rocker arm disassembling

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



2) Inspection rocker arm bracket

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



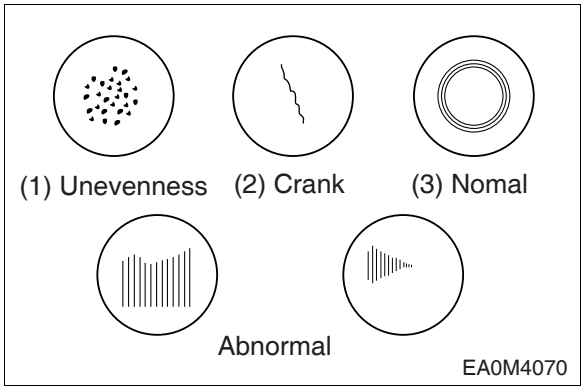
	Standard	Limit
Bush inner dia.	ø25.005 ~ ø25.035 mm	ø25.325 mm
Shaft outer dia.	ø24.967 ~ ø24.990 mm	ø24.930 mm
Clearance	0.015 ~ 0.068 mm	0.14 mm

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

3.2.10. Tappet and push rod

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

Tappet clearance	Standard	Limit
	0.035 ~ 0.077 mm	0.15 mm

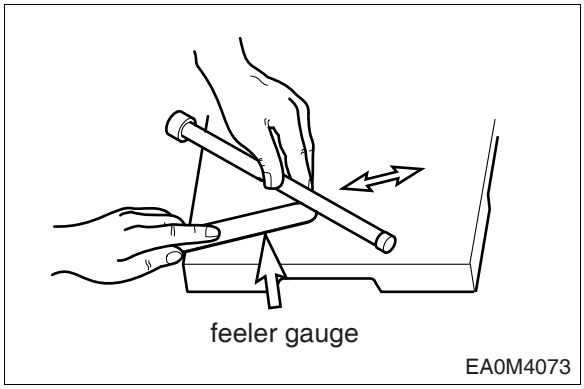


● By inspecting the tappet surface that contacts with the camshaft's cam for any crack and scratch etc., and if the degree is small, correct them with an oil stone or the grinding paper but if severe replace them.

● Place the push rod on the surface plate and rolling it, Inspect the curving degree with a clearance gauge and if abnormal, replace it.

< Run-out >

Limit	0.3 mm or less



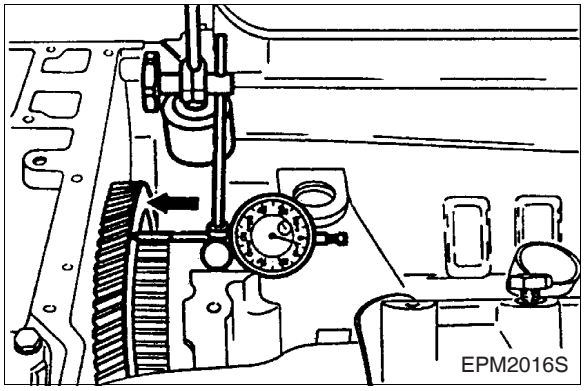
● Inspect the oil passages of rocker arm and rocker arm bracket for any clogs and reassemble them in the reverse order of disassembling after thorough cleaning.

3.2.11. Camshaft

1) Axial end play

● Push the camshaft toward the pulley side.

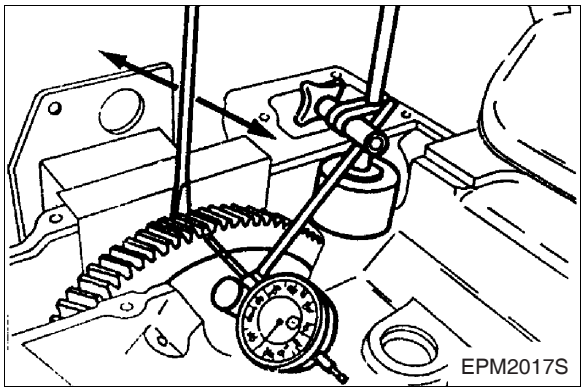
● Place a dial gauge onto the camshaft gear.



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

End play	Standard	Limit
	0.24 ~ 0.86 mm	0.9 mm

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


EPM2017S

2) Inspection and measurement

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

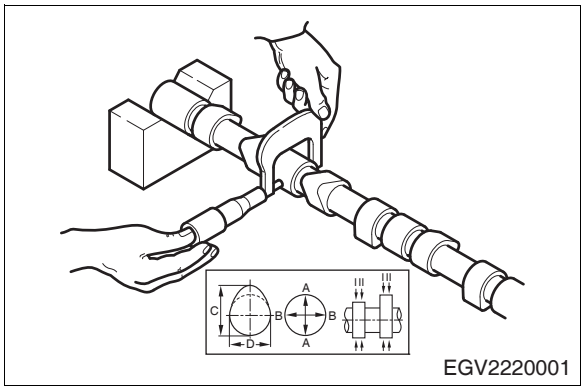
3) Cam lobe height

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

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

(mm)

		Standard	Limit
Cam lobe height (C)	Intake	56.37	56.032
	Exhaust	56.43	56.091

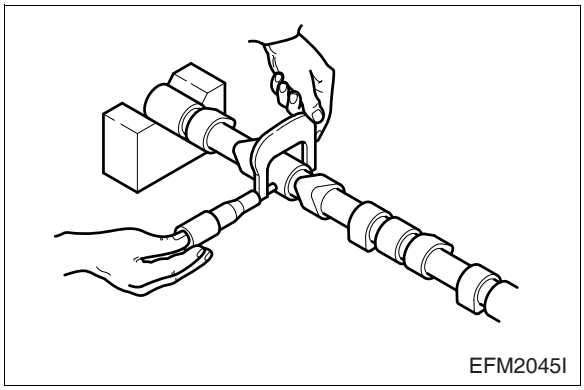


EGV2220001

4) Cam journal diameter

● By means of outside micrometer, measure the camshaft journal.

Cam journal diameter (A, B)	Standard	Limit
	ø69.91 ~ ø69.94	ø69.560

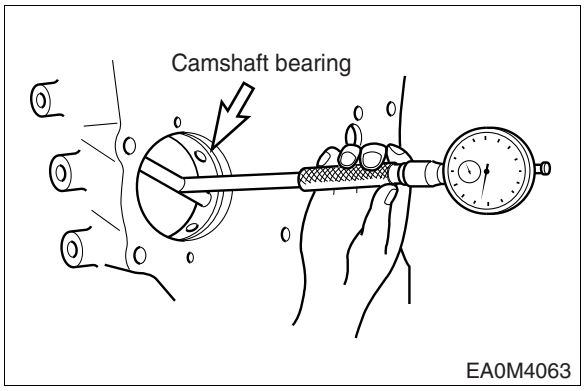

EFM2045I

5) Cam bearing diameter

- Measure the camshaft bush inside diameter with cylinder gauge and by comparing the inside and outside diameters (after press-fit bearing fabricated) with the following standard, replace if abnormal.

(mm)

	Standard	Limit
Thrust	ø70.07 ~ ø70.09	ø69.464
Middle	ø70.00 ~ ø70.03	ø69.192



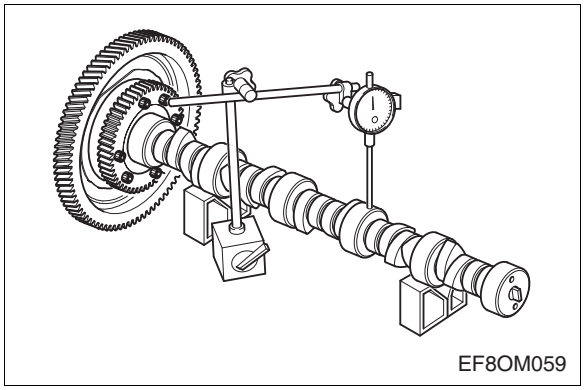
- Clearance between camshaft outside diameter and bush inner diameter of cylinder block.

(mm)

	Standard	Limit
Thrust	0.060 ~ 0.120	0.240
Middle	0.130 ~ 0.180	0.240

6) Camshaft bearing replacement

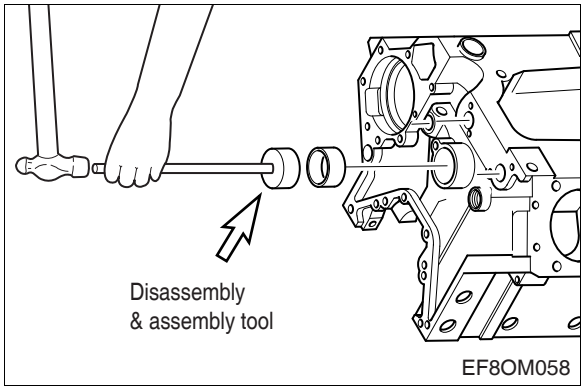
- Remover, installer



7) Camshaft run-out

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

Standard	Limit
0.05 mm	0.15 mm



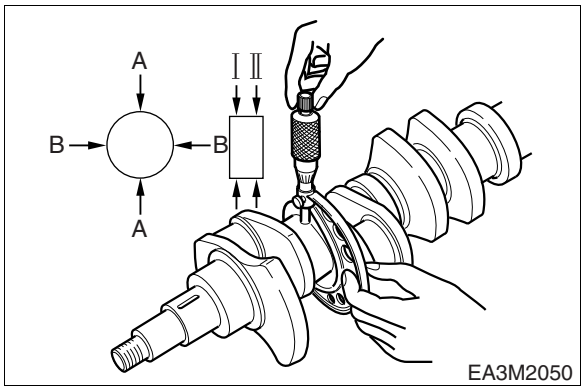
3.2.12. Crank shaft

1) Inspection and measurement

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

2) Journal and pin diameter

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

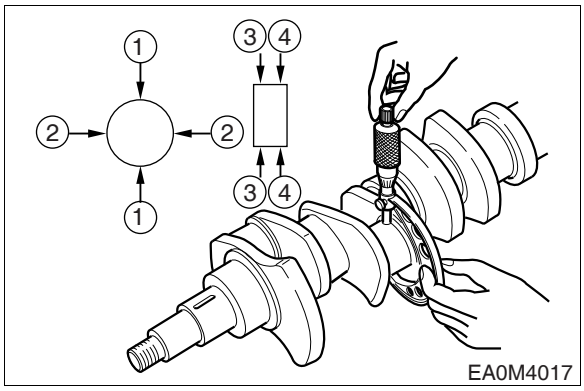


<Crankshaft journal outside diameter>

Standard	ø103.98 ~ ø104.00 mm

<Crankshaft pin outside diameter>

Standard	ø89.98 ~ ø90.00 mm



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

<Main bearing >

(a) Standard

(b) 0.10 (Inside diameter 0.10 mm less than standard)

(c) 0.25 (Inside diameter 0.25 mm less than standard)

(d) 0.50 (Inside diameter 0.50 mm less than standard)

(e) 0.75 (Inside diameter 0.75 mm less than standard)

(f) 1.00 (Inside diameter 1.00 mm less than standard)

<Connecting rod bearing >

(a) Standard

(b) 0.25 (Inside diameter 0.25 mm less than standard)

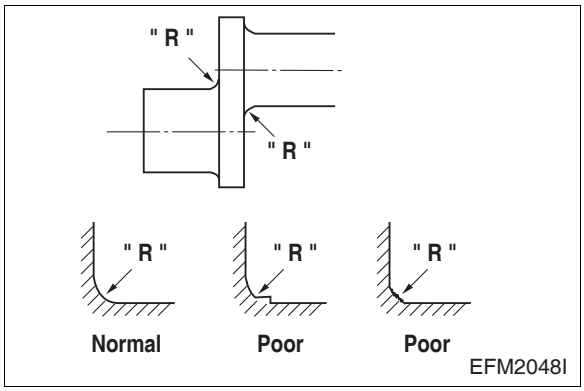
(c) 0.50 (Inside diameter 0.50 mm less than standard)

● There are 4 kinds as above, and the crankshaft also can be used by regrinding as above.

<"R part" standard value >

(a) Crank pin "R part" : $4.0^{0}_{-0.5}$

(b) Crank journal "R part" : $4.0^{0}_{-0.5}$



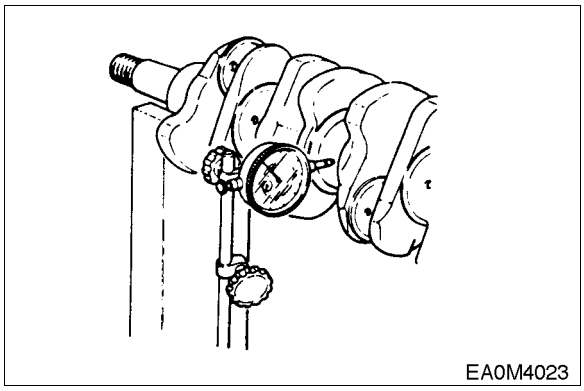
Note:
In case of crankshaft regrinding, the "R part" at the end of bearing must accurately be ground with out fall and should avoid any processed jaw or coarse surface.

3) Run out of crankshaft

● Place the crankshaft on the V-block.

● Place the dial gauge on the surface plate and measure the run out of crankshaft rotating the crankshaft.

Standard	Limit
0.06 mm	0.4 mm



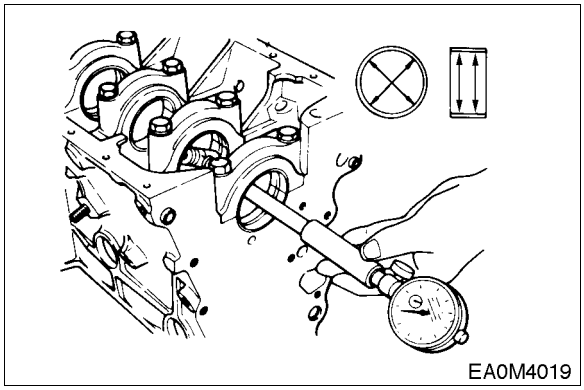
4) Inspection on crankshaft bearing and connecting rod bearing

● Inspect the crankshaft bearing and connecting rod bearing for any damages such as lopsided wear, scratch etc. and if abnormal, replace it.

● Inspect the oil clearance between the crankshaft and bearing.

(a) How to utilize the cylinder gauge

● Assemble the main bearing at the cylinder block and after tightening the bearing cap at the specified torque, measure the inside diameter.

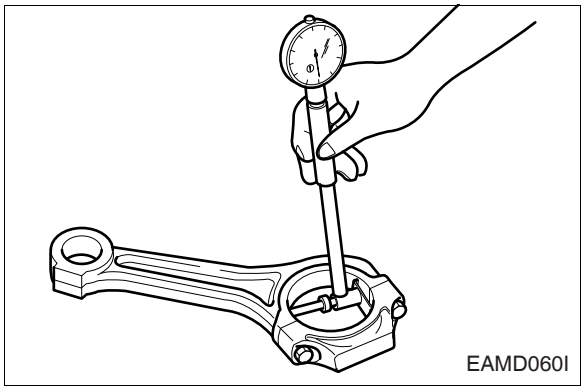

EA0M4019

Journal bearing nominal diameter	ø104.066 ~ ø104.115 mm

Bearing cap bolt torque	30 (+3) kgf.m + 90° (+10°)

Caution:
Do not reuse main bearing bolts replace them with new ones.

● Assemble the bearing at the bigger end of connecting rod, and after tightening the bearing cap at the specified torque, measure the inside diameter.

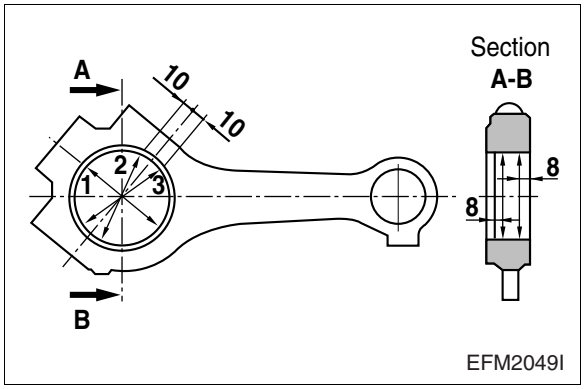

EAMD060I

Connecting rod bearing journal diameter	ø90.056 ~ ø90.098 mm

Connecting rod bolt torque	10 (+1) kgf.m + 90° (+10°)

Caution:
Do not reuse connecting rod bolts replace them with new ones.

● Crankshaft pin and bearing clearance value exceeds the limit value, grind the crankshaft journal and pin and then use the undersized bearing.



EFM2049I

Standard	Limit
0.056 ~ 0.118 mm	0.143 mm

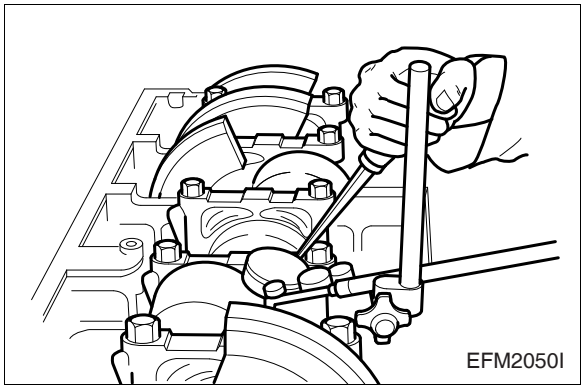
(b) How to utilize plastic gauge

- Install the crankshaft in the cylinder block and place the plastic gauge on the crankshaft journal and pin at axial direction and then after tightening the bearing cap at the specified torque and again after tearing apart the bearing cap, measure the flatten plastic gauge thickness by pick it up. This is the oil clearance.
- With the same points, the oil clearance of connecting rod also can be measured.

5) End play

- Assemble the crankshaft in the cylinder block.
- Install the dial gauge, and measure the end play of crankshaft by pushing the crankshaft to axial direction.

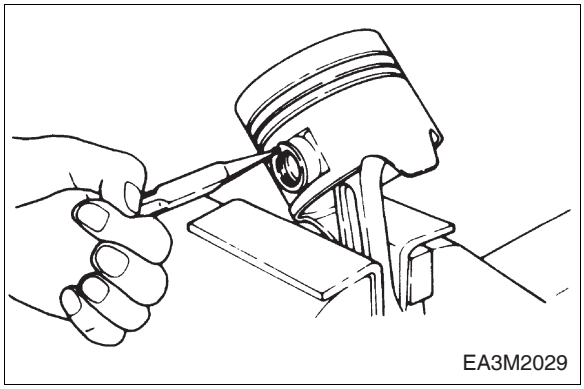
Standard	Limit
0.140 ~ 0.361 mm	0.4 mm


EFM2050I

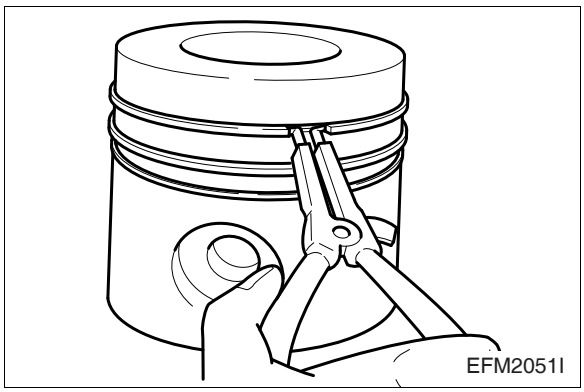
3.2.13. Piston

1) Piston disassembling

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


EA3M2029

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

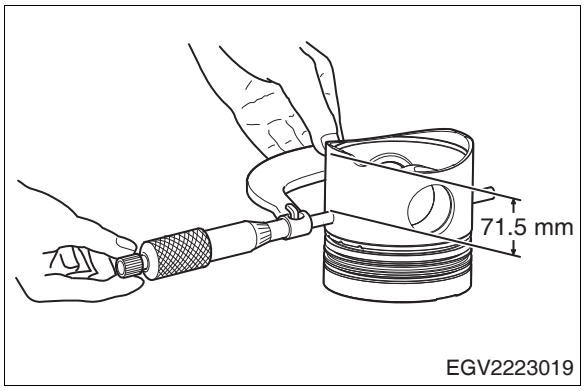

EFM2051I

2) Piston inspection

- With naked eyes, inspect the piston for any wear, crack and scratch and particularly inspect carefully at the ring grooves for any wear.
- With the outside micrometer, measure the piston's out side diameter the measuring position is 71.5 mm from the piston lower end, and the direction of measurement must be perpendicular to the piston pin direction.

Standard	ø127.739 - ø127.757 mm

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

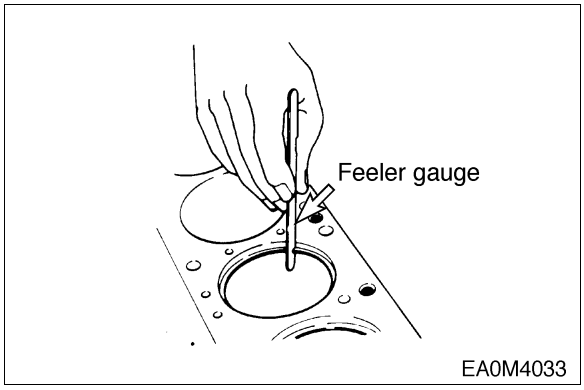


3) Piston ring and ring groove

- In case of piston ring's wear, damage or engine overhaul, replace piston rings.
- Insert the piston ring at the cylinder liner's upper part perpendicularly.
- With a feeler gauge, measure the gap clearance of piston ring.
- If the measured value exceeds the limit value, replace it.

<Piston ring gap>

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

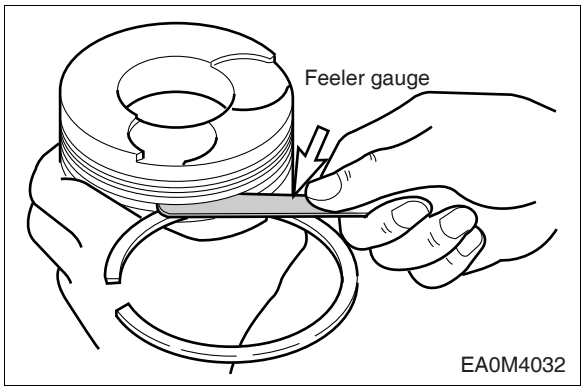


4) Piston side clearance

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

<Piston side clearance>

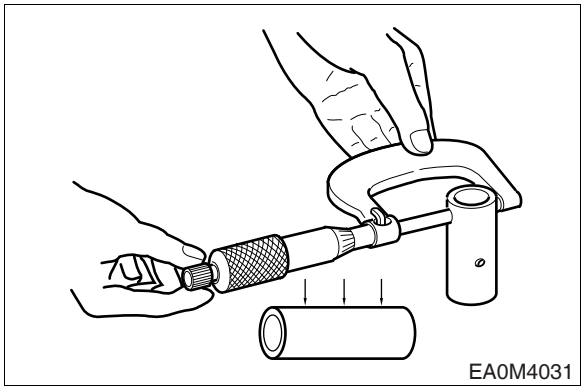
Division	Specified value	Limit value
Top ring	0.075 ~ 0.125 mm	1.5 mm
2nd ring	0.070 ~ 0.102 mm	1.5 mm
Oil ring	0.03 ~ 0.07 mm	1.5 mm



5) Piston pin

- With the outside micrometer, measure the piston pin's outside diameter and if the value is same as the use limit value or less, replace it.

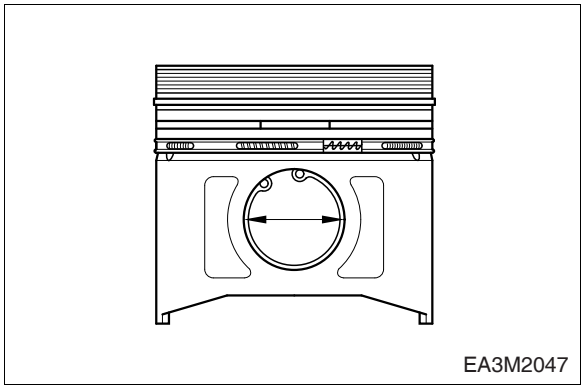
Standard	Limit
ø45.994 ~ ø46.000 mm	ø45.983 mm or less



6) Piston pin and connecting rod bush clearance

- Inspect the clearance between the piston pin and the connecting rod bush, if it is more than the use limit value, replace either one that is more severe.

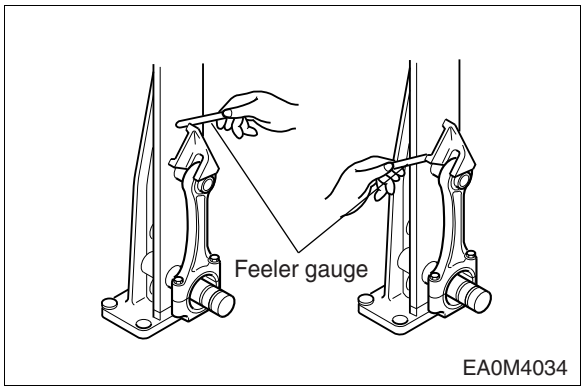
Standard	Limit
0.060 ~ 0.076 mm	0.1 mm



7) Connecting rod

● Inspect and measure the bigger end bearing hole and the smaller end bearing hole with respect to the parallelness and if abnormal, replace the rod.

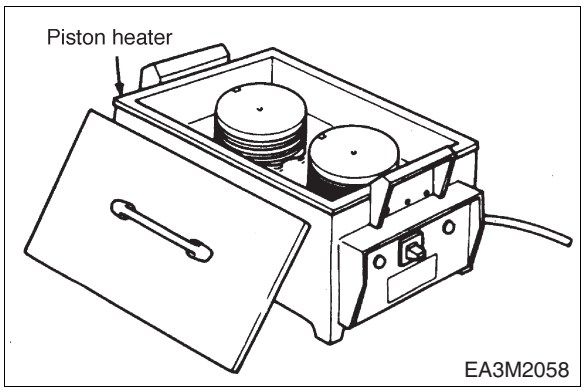
Standard	Limit
0.02 mm	0.2 mm



8) Piston reassembling

● After heating the piston at the piston heater for about 5 min (120 ~ 150°C), by aligning the piston pin hole with the pin hole of connecting rod's smaller end, insert the oil coated piston pin.

Note:
Confirm the direction of connecting rod and assemble.

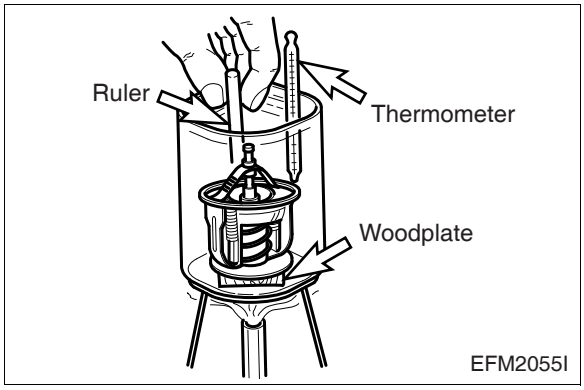


● With the snap ring plier, insert the piston pin snap ring.
● With confirming the upper side indication of piston ring, after assembling the ring in the piston ring groove, inspect if the movement of ring is smooth.
● Keep in order of the assembled piston as the cylinder No. turn.

3.2.14. Thermostat

● Inspect the wax case and spring for any damage.

● With putting the water temperature gauge in to water and heating the water at the indirect method, when the water temp reaches to 71°C (Opening temperature), the valve begin to open and fully open when it reaches to 85°C (FuII opening temperature).



● Measure the valve opening temperature and the valve full opening temperature and inspect if the valve lift is more than 8 mm and if abnormal, replace it.

No.	Opening temperature	Full opening temperature
300738 -00159	71°C	85°C
300738-00161	83°C	95°C

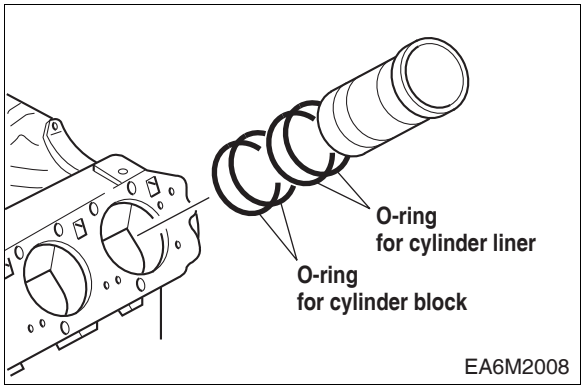
3.3. Engine Reassembly

3.3.1. Preparation and precaution before and after engine reassembly

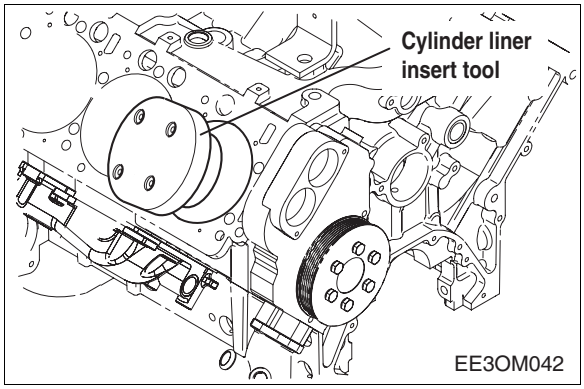
- Clean all the parts thoroughly and also clean thoroughly by blowing into each passage of oil and cooling water.
- Disposition the various special and general tools for assembling in order.
- In order to coat the lapping parts with engine oil, prepare the clean engine oil.
- Prepare the sub-material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

3.3.2. Cylinder liner

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



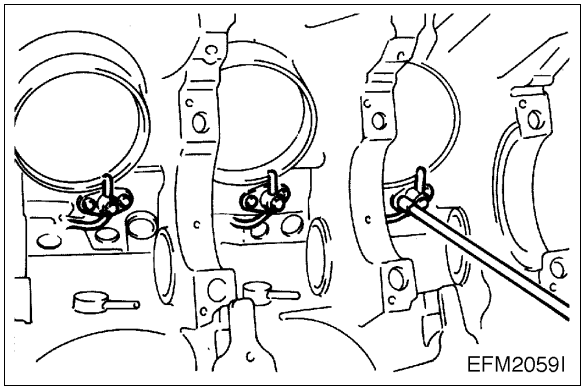
- After slipping the cylinder liner smoothly into the cylinder block, press it in being careful for O-ring not to damage.
- After completion of assembling the cylinder liner, confirm no leaks with 4 kg/cm^2 hydraulic test.



3.3.3. Oil spray nozzle

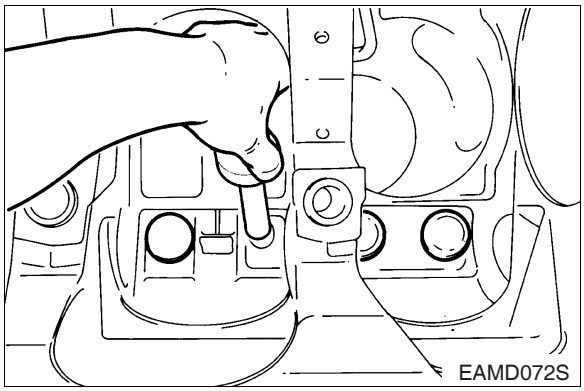
- Tighten the oil injection nozzle flange with hollow screws.
- Assemble the oil injection nozzle with the fixing bolts.

Torque	1.25 ±0.12 kg.m



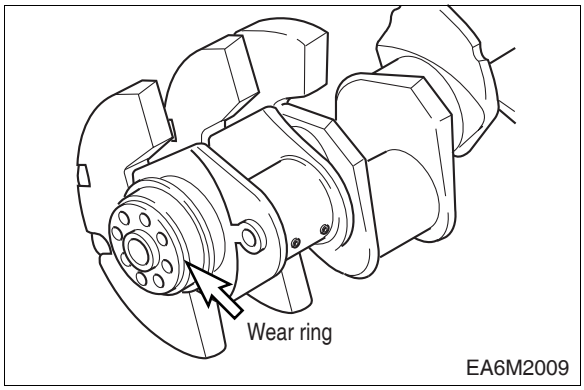
3.3.4. Tappet

- Coat the tappet wholly clean oil and push in the tappet hole of the cylinder block.

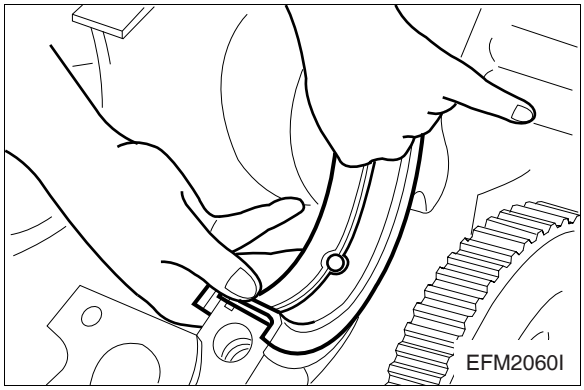


3.3.5. Crank shaft

- Put the wear ring into the heater to heat it up to 150 ~ 200°C level, push it over the crankshaft by means of a jig.



- Assemble the main bearing to the cylinder block and coat it with engine oil. Then assemble the bearing that has a hole to the cylinder block side and one that has no hole to the bearing cap and be careful not to change.

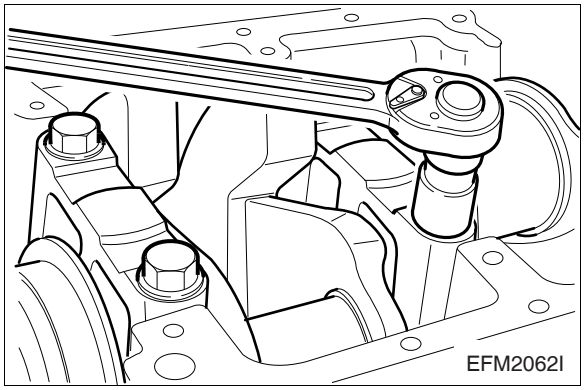


● Assemble temporarily one bolt each at both bolt holes and by connecting the wire to the bolts, lift it with crane or chain block and put down on the cylinder block carefully.

● Coat the crankshaft journal and pin parts with engine oil, and after fitting the main bearing into the bearing cap and assemble it to the cylinder block making sure of the number in order not to change the bearing cap.

EFM2061

● According to the tightening order, tighten the bearing cap bolts with 30 kg.m and with rotating angle method (90° $^{+10°}$) and tightening order are as follows.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< Bearing cap bolt's tightening order >

(1) First step : Tighten with a bout 30 (+3) kg.m by wrench.

(2) Second step : Tighten with final rotating angle method 90° (+10°)

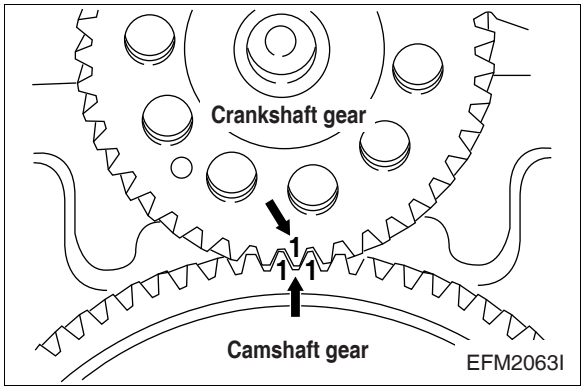
However, according to above tightening order, tighten step by step.

● Inspect if the crank shaft's rotation is smooth.

● Assemble the crankshaft gear on the crankshaft and coat a white paint mark on "1" part in order to find easily.

3.3.6. Camshaft

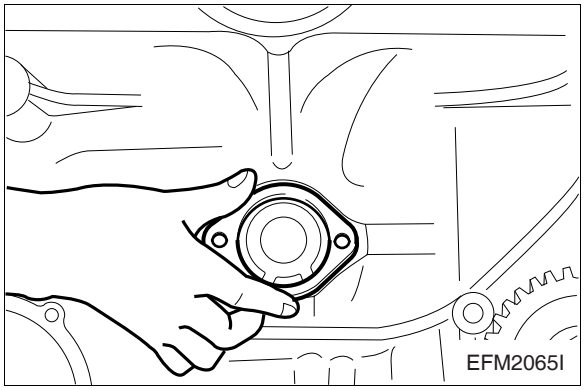
- Coat the cam bush of cylinder block and camshaft with engine oil.
- Assemble the cam bush and camshaft for them not to be damaged.
- Assemble the crankshaft gear and the camshaft gear making sure that the gear marks on both gears are aligned together.



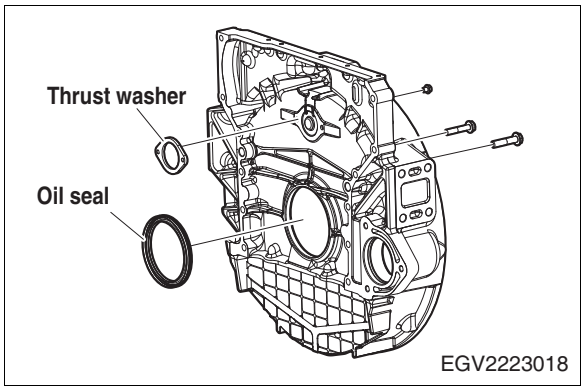
3.3.7. Flywheel housing

- Coat the thrust washer fixing bolt with an adhesive and tighten it with specified torque.

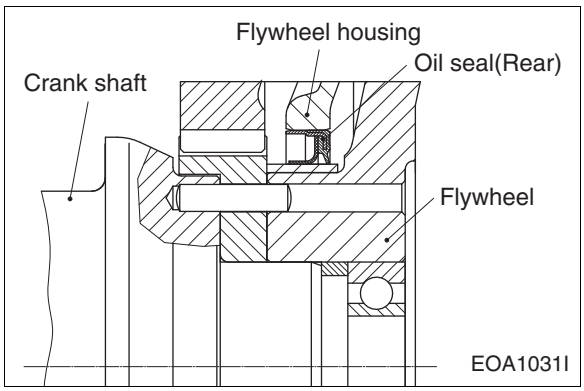
Torque	3.1 kg.m



- Coat the oil seal (P.T.F.E.) with lubricating oil and assemble the oil seal carefully for it not to deviate or be damaged by means of special tool. (Mandrel for assembling).



- Attach the gasket on the surface of cylinder block where the flywheel housing is to be installed. (In order to prevent the gasket slip down, coat a grease on the cylinder block surface.)
- Temporarily assemble 2ea of guide bolts for installing the flywheel housing to the cylinder block.

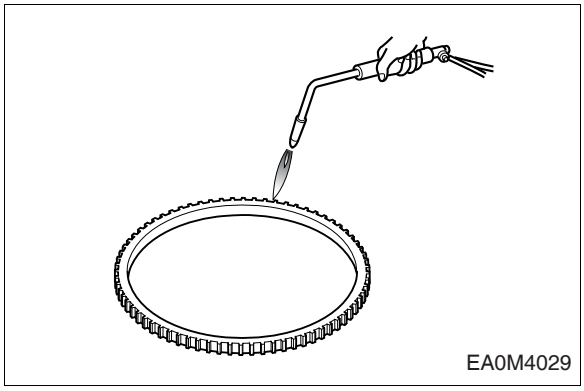


- After fitting the flywheel housing holes to the guide pins and engage temporarily 2 ~ 3 threads of fixing bolts, and according to the tightening order (zigzag method) tighten them in the specified torque.

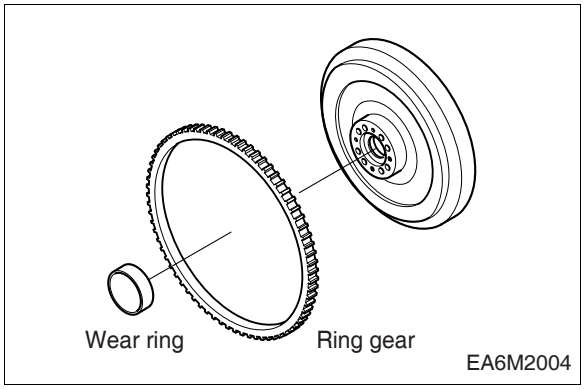
Torque	M12 x 1.5	11.2 ±1.12 kg.m
	M10 x 1.5	7.4 ±0.74 kg.m

3.3.8. Flywheel

- Installation of flywheel ring gear with a gas burner, heat the ring gear evenly until heat expansion takes place, then install it using a hammer.
- Do not allow the temperature of the ring gear to exceed 200°C (390°F).
- By means of mandrel, assemble pilot bearing to the flywheel.


EA0M4029

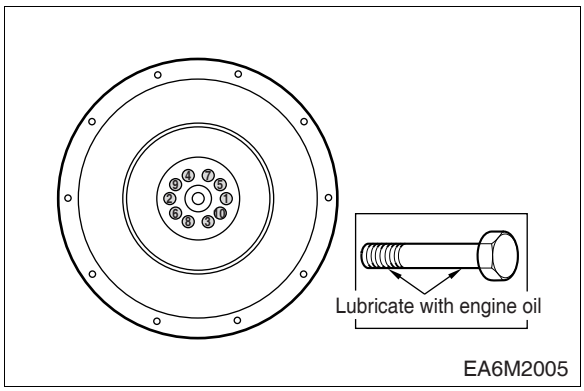
- By means of mandrel, press in the wear ring at the backward face.
- Install two guide bolts for installing the flywheel to the crankshaft.



EA6M2004

- After letting the guide pin insert through the flywheel holes and engaging the fixing bolts by 2 ~ 3 threads temporarily, tighten them to the specified torque according to lightening order. (Zigzag order).

Torque	26 kg.m



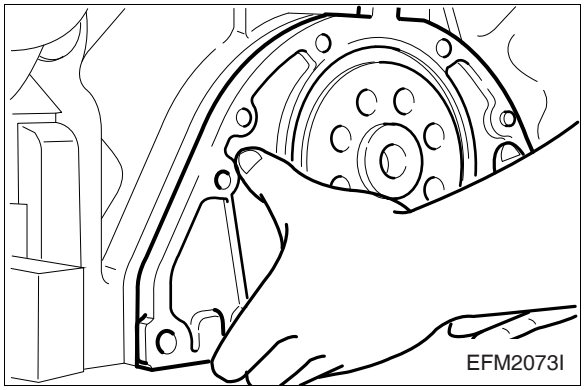
EA6M2005

Caution:

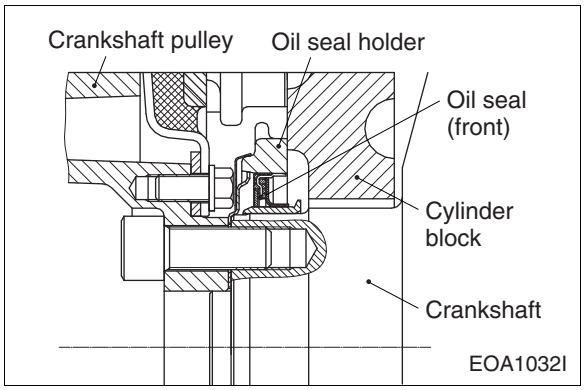
Flywheel fixing bolts can only be reused up to 3 times; reusing them more than that may cause damage.

3.3.9. Front oil seal holder

- After placing the oil seal in the oil holder hole properly, press it in with a mandrel. (Be careful for oil seal must not be damaged.)
- Attach a gasket at the oil seal holder.



- Align the dowel pin with the oil seal holder dowel hole and assemble them by tapping lightly the dowel pin part with an urethane hammer when in assembling, take care not to hurt the oil seal by the crankshaft.

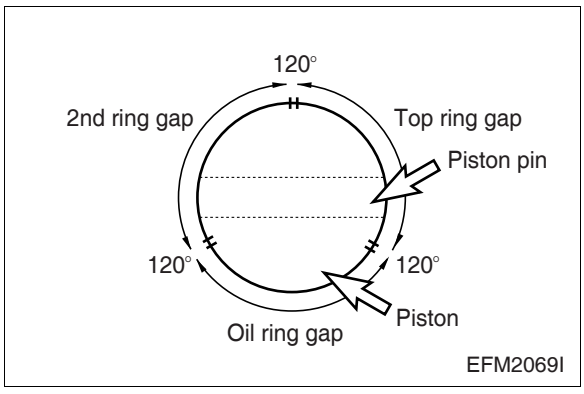


Note:
Without coating the oil seal with oil or lubricant, assemble it in the dry state.

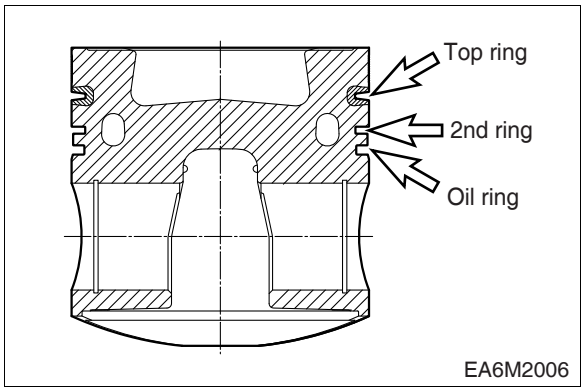
- Tighten the fixing bolts in the zigzag method.

3.3.10. Piston

- Line up the piston assembly in the order of cylinders and fit the bearings to the connecting rods and bearing caps. However, take care not to swap between the connecting rods and bearing caps.
- Coat the pistons and connecting rod bearings sufficiently with clean engine oil.



- By means of a special tool, insert the piston rings and adjust the angles between the ring gaps at 120°.
- Push in the piston with hands or wooden bar into cylinder. (Be careful for piston and rings not be damaged.)
- Pushing the piston down, rotate the crankshaft about 180° and fit the bearing cap to the connecting rod.
- After engaging 2 ~ 3 threads of bolts primarily rind then tighten them to the specified torque. (10 kg.m + 90° $^{+10°}$)



< Connecting rod bolt tightening order >

(1) First step : Engage 2 ~ 3 threads by hands.

(2) Second step : Tighten to about 7 kg.m with wrench.

(3) Third step : By means of torque wrench tighten to 10 kg.m.

(4) Fourth step : Finally assemble means of rotating angle method 90° $^{+10°}$

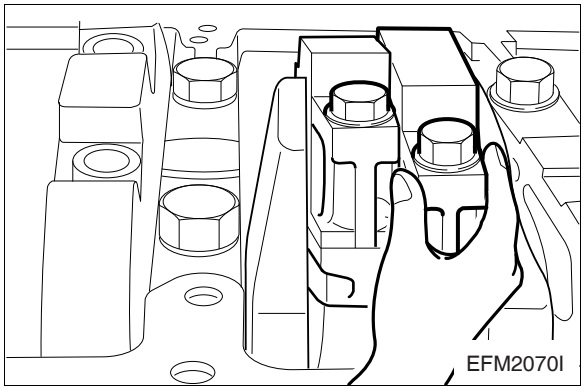
However, according to above tightening order, tighten step by step.

*** Standard length of bolt and use limit:**

- From head seat to bolt tip

Standard length	Use limit
67.5$^{-0.3}$ mm	69 mm

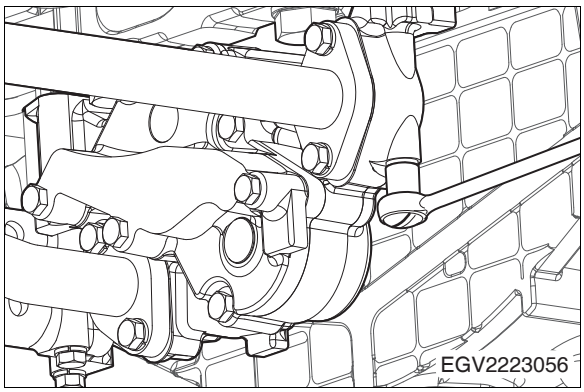
- By moving the connecting rod bearing cap by hands, make sure if there is any play in left and right.
- With the same method as above, assemble in each cylinder rotating the crankshaft.



3.3.11. Oil pump

- Put the oil pump at the place to be installed on the cylinder block.
- Attach a gasket at the surface of oil pump where the pressure regulating valve is to installed and place the regulating valve on a gasket.
- Assemble the oil pump by tightening the fixing bolts.

Torque	2.2 ±0.22 kg.m



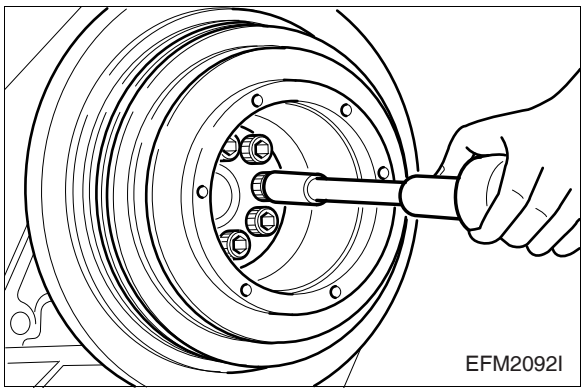
- Attach a gasket at the surface of the oil pump where the oil suction pipe is to be installed, and install the oil suction pipe by tightening the fixing bolts.
- Assemble the pipe bracket on the cylinder block side with bolts.

Torque	2.2 kg.m

3.3.12. Vibration damper

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

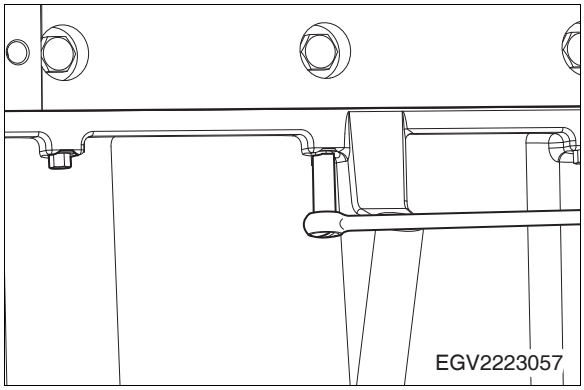
Torque	30 ±3.0 kg.m



3.3.13. Oil pan

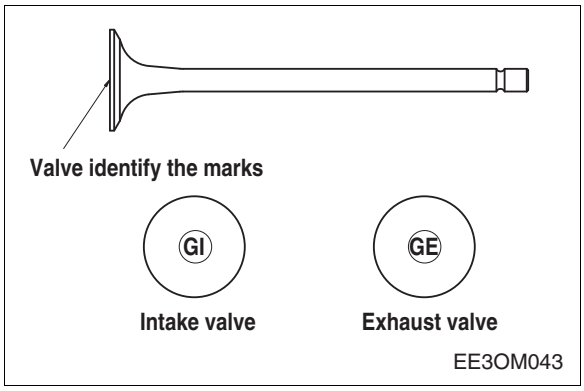
- Clean thoroughly the gasket that is projecting at the junction parts of front oil seal holder and flywheel housing of cylinder block' s lower face with a scraper.
- In the process of gasket removal, be careful for the gasket pieces not to get into the engine inside.
- Attach a gasket to the cylinder block.
- Install the oil pan and tighten the fixing bolts. Then takes care not to squeeze out the gasket.
- Install the guide tube and insert the oil level gauge.

Torque	2.2 ±0.22 kg.m



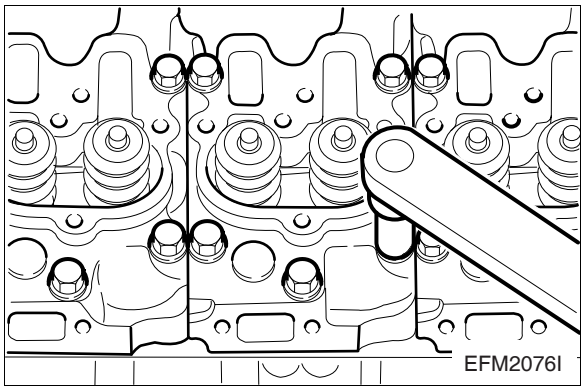
3.3.14. Intake and exhaust valve

- Identify the marks of "**GI**" and "**GE**" impressed on the valve head before assembling the valve with the valve head.
- With a valve stem seal fitting jig, assemble the valve stem seal with the valve guide.



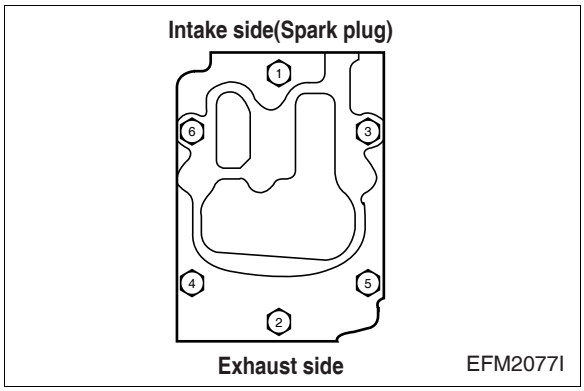
3.3.15. Cylinder head

- Blow the cylinder head bolt holes with compressed air to remove the foreign material cleanly.
- Wipe off cleanly the junction part of cylinder block's head gasket.
- After confirming whether there is foreign material or not necessarily, if there is, remove it.
- Assemble a gasket fitting with the fixing pin of cylinder block.
- Position the cylinder head assembly on the cylinder block aligning with its dowel pin. (Take care not to damage the head gasket.)



● Tighten the cylinder head bolts to the specified torque according to step by step.

● However, prior to tightening the bolts, with a long steel rule, the parallelness between the cylinder heads must be adjusted.



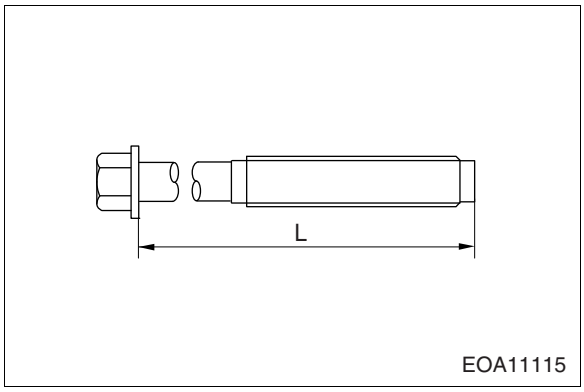
< Cylinder head bolts tightening order >

(1) First step : Tighten temporarily 1 ~ 2 threads by hands.
(2) Second step : Tighten to a bout 8 kg.m with wrench.
(3) Third step : Tighten to 15 kg.m with a torque wrench.
(4) Fourth step : Rotate 90 by rotation angle method.
(5) Fifth step : Finally tighten additionally rotating 90°.

*** Standard length of bolt and use limit:**

- From the head seat face to tip

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



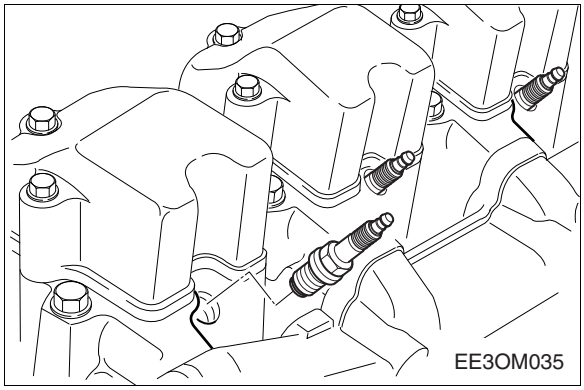
Caution:
Take care for the foreign material not to get into the cylinder head suction passages.

Caution:
Do not reuse cylinder head bolts replace them with new ones.

3.3.16. Spark plug

● Put the spark plug hole of cylinder head and after inserting the spark plug assembly into it, tighten to assemble.

Torque	2.5 ~ 3.0 kg.m

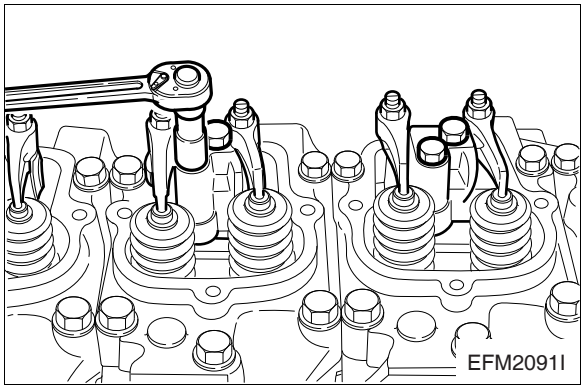


3.3.17. Rocker arm

● Coat the push rod with engine oil and put it into the push rod hole.

● Position the rocker arm assembly on the cylinder head and tighten the fixing bolts to the specified tightening torque.

Torque	6.2 ±0.62 kg.m

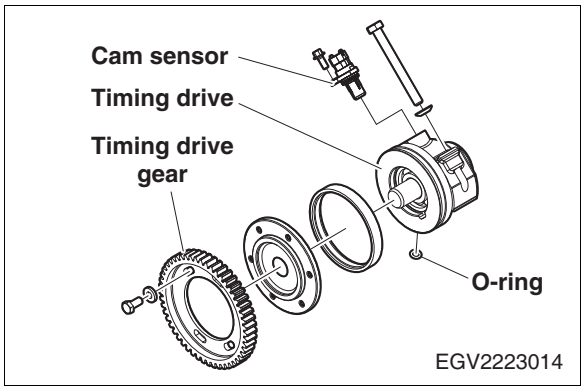


● Adjust the valve clearance. Regarding the adjustment, refer to the regular maintenance part.

3.3.18. Timing drive & sensor

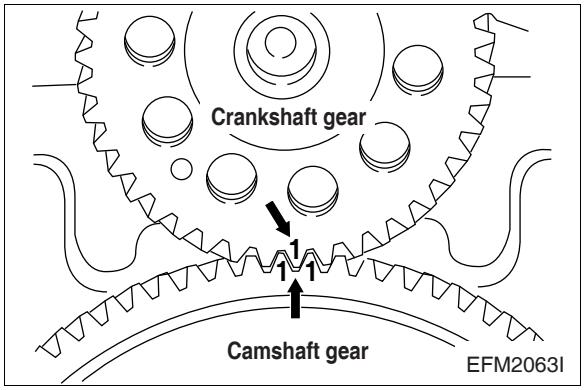
● Attach an O-ring to the cylinder block and install the timing drive on the cylinder block and then tighten the fixing bolts.

Description	Torque
Cam sensor bolt (1ea)	1.0 kg.m
Cam sensor housing bolt (2ea)	6.2 kg.m
Timing drive gear bolt (4ea)	3.1 kg.m

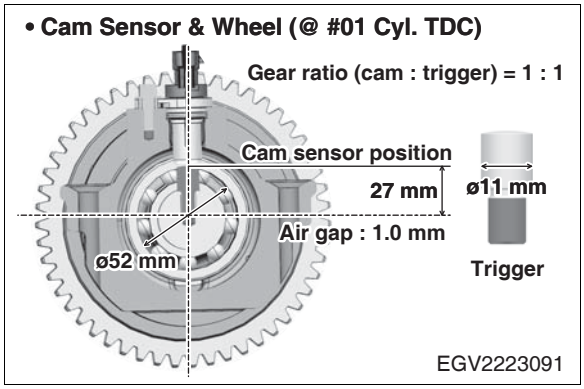


3.3.19. Cam sensor & wheel position

- Assemble the sensor in #1 TDC state (align the engraving position of cam & CRS gear).



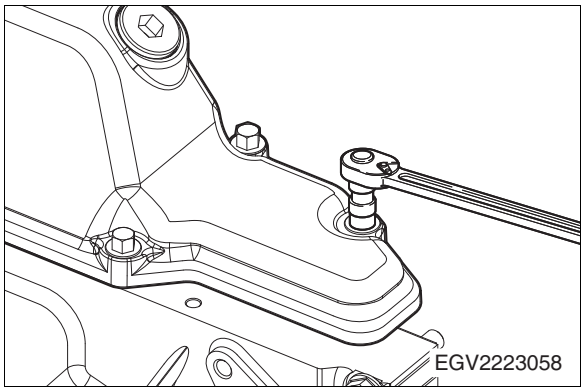
- Fix the cam shaft trigger to the top.



3.3.20. Flywheel housing cover

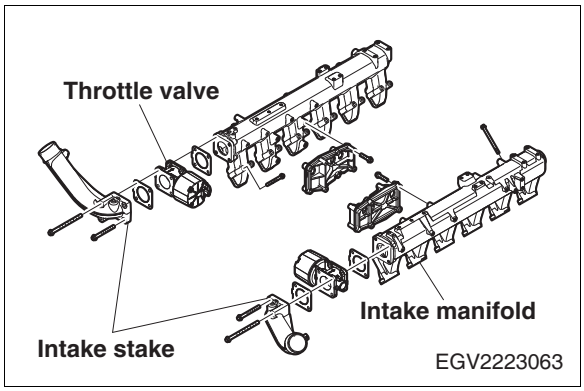
- Attach a gasket to the flywheel housing cover.
- Install the flywheel housing cover and tighten the fixing bolts by the zigzag method.

Torque	2.2 kg.m



3.3.21. Intake manifold & throttle valve

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

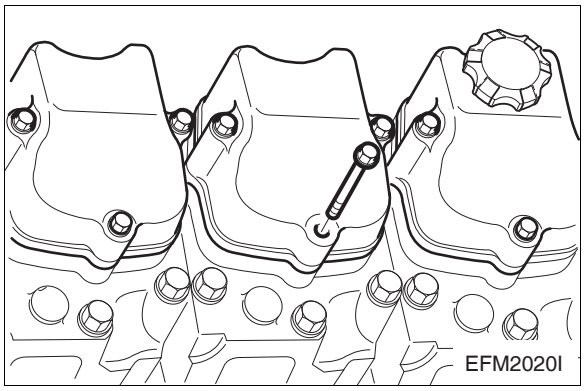


Caution:
Check assembled after the all engine parts install and tighten fuel line.
Open fuel line valve and check for leaks using soapy water or commercial leak detector.

3.3.22. Cylinder head cover

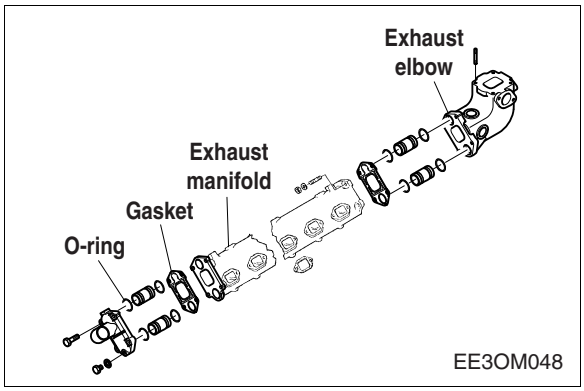
- Attach a new gasket on the surface of cylinder head where the cover is to be installed.
- Assemble the cylinder head cover by tightening the fixing bolts.
- Insert the oil filler cap.

Torque	2.2 ±0.22 kg.m



3.3.23. Exhaust manifold

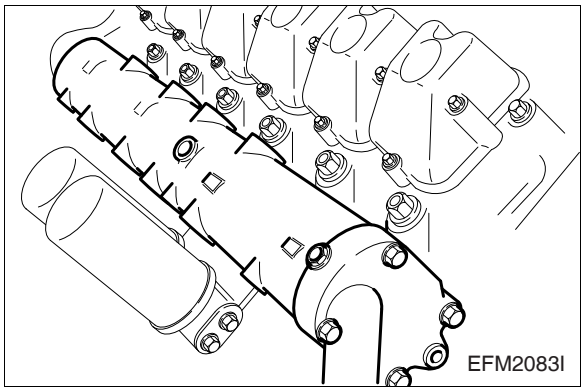
- Prior to assembling the exhaust manifold, attach a gasket firstly to the cover and exhaust elbow pipe and assemble them tightening the bolts evenly as the right figure.



- Attach new gaskets to the exhaust manifold and then assemble the exhaust manifold with the fixing bolts.

Torque	6.2 ±0.62 kg.m

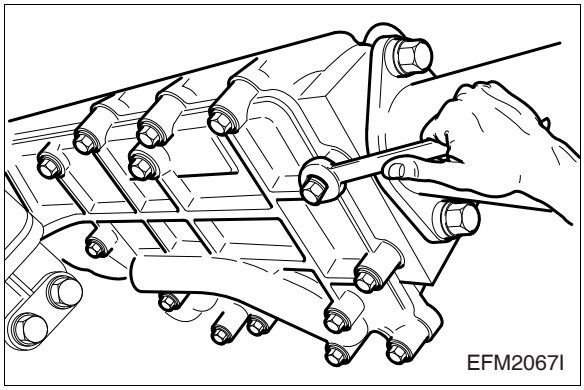
Caution:
Be careful not to drop the manifold because it is very heavy.



3.3.24. Oil cooler

- Attach a gasket on the surface in the oil cooler housing where the oil cooler is installed.
- Tighten the oil cooler with fixing bolts.
- Install the oil cooler assembly by tightening the fixing bolts in the zigzag order.

Torque	M8 x 1.25	3.1 ±0.56 kg.m
	M10 x 1.5	6.2 ±1.12 kg.m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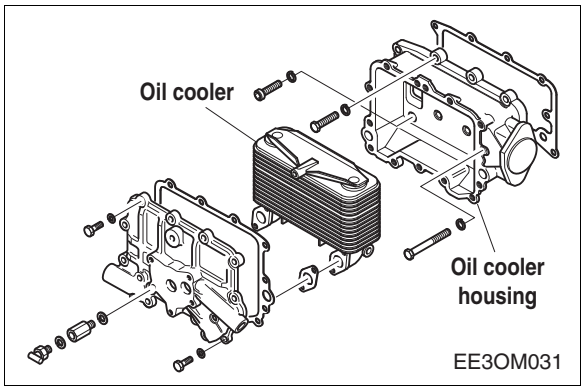

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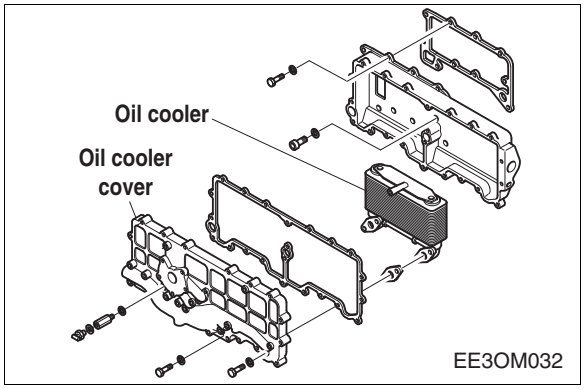
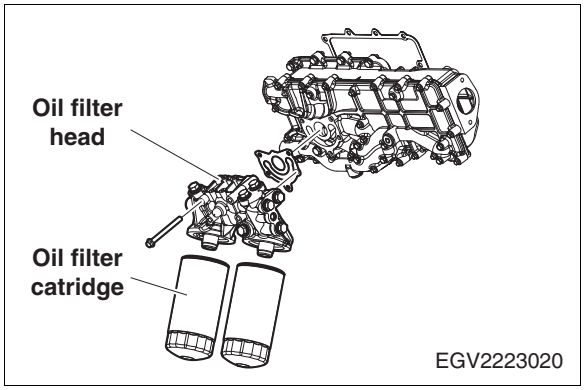


EE3OM032

3.3.25. Oil filter

- Attach the oil filter gasket on the oil cooler.
- Install the filter head on the oil cooler and then tighten bolts in a diagonal sequence.

Torque	6.2 kg.m



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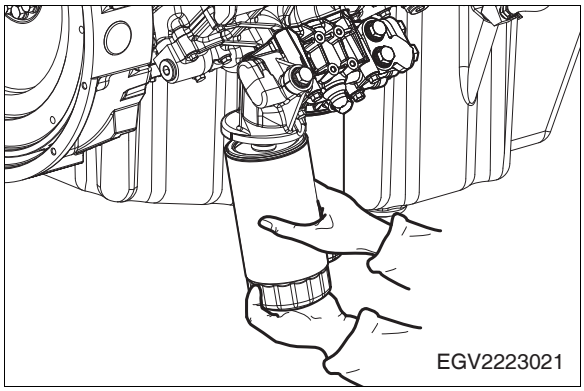
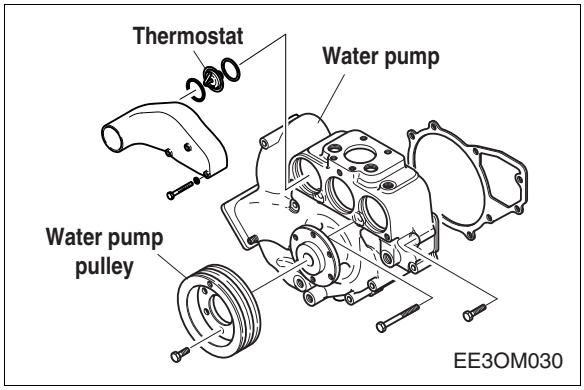
- Lubricate the cartridge gasket and spin filter until gasket contacts oil filter head, then tighten additional 3/4 to 1 turn.
- Start engine and check for licks.



3.3.26. Cooling water pump

- Attach a gasket at the cooling water pump. (at cylinder block side)
- Assemble the cooling water pump by tightening the fixing bolts. (zigzag method)



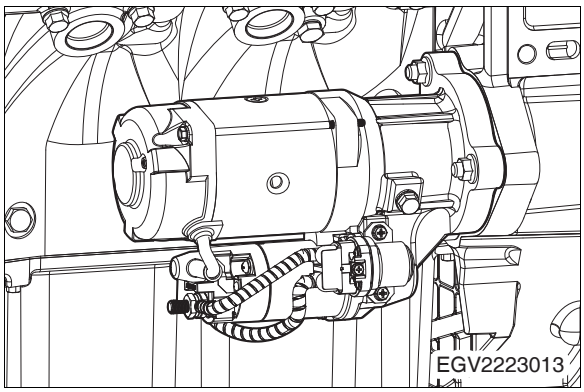
Torque	Water pump	2.2 kg.m
	Water pump pulley	2.2 kg.m

- Insert the thermostat of cooling water pump.
- Insert the O-ring to the thermostat and assemble the cooling water pipes by tightening the fixing bolts.

Thermostat torque	2.2 kg.m

3.3.27. Starting motor

- Install stud bolts at the bolt holes on the flywheel housing for installing the starter.
- Insert the starter into the fly wheel housing and tighten the fixing bolts.

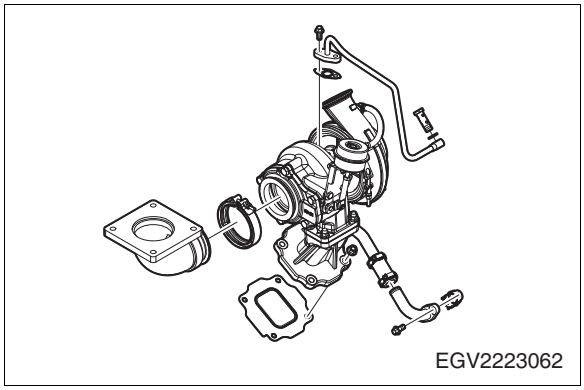


Torque	8 ±2 kg.m

3.3.28. Turbocharger

- Attach a gasket to the exhaust elbow and assemble the turbocharger with fixing bolts.

Torque	M8	2.2 kg.m
	M10	6.2 kg.m


EGV2223062

- Attach a gasket on the oil supply pipe and assemble the pipe with the fixing bolts.
- Attach a gasket on the oil return pipe and assemble the pipe by tightening the bolts.
- At the same method as above, both sides are assembled.

Precautions for turbocharger reassembly

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

a) Lubricating system

- **Prior to assembling it into the engine, fill new oil into oil Inlet and turning turbine shaft with hand, lubricate journal and thrust bearing.**
- **In order for oil not to leak from various connections, assemble securely.**

b) Air intake system

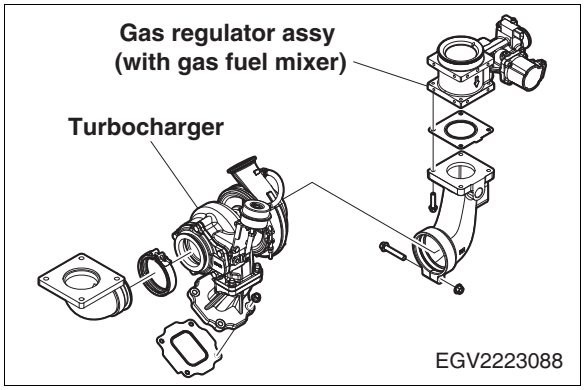
- **Confirm if there is any foreign material inside the air intake system.**
- **Assemble securely the air intake duct and air cleaner so that the connections from them may not leak an air.**

c) Exhaust system

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

3.3.29. gas regulator assy (with gas fuel mixer)

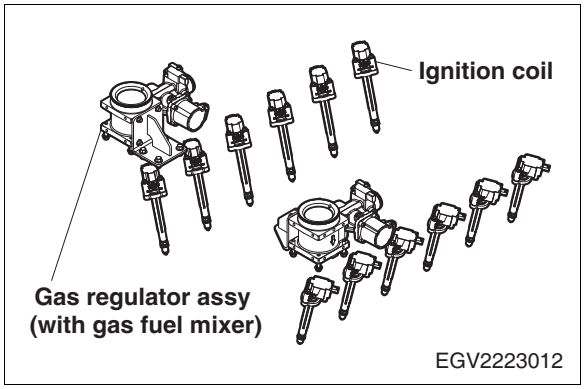
- Attach a gasket to the intake elbow and assemble the gas regulator assy (with gas fuel mixer) with fixing bolts.
- At the same method as above, both sides are assembled.



Caution:
Check assembled after the all engine parts install and tighten fuel line.
Open fuel line valve and check for leaks using soapy water or commercial leak detector.

3.3.30. Ignition coil & gas regulator assy (with gas fuel mixer)

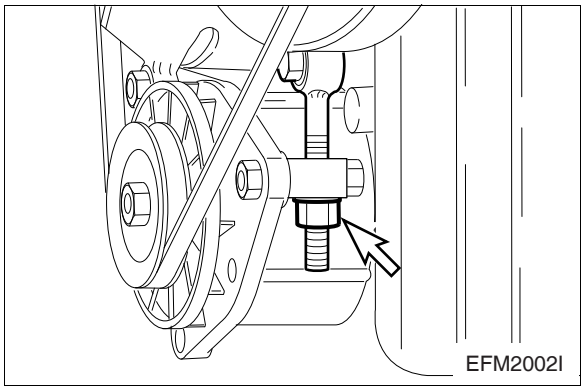
- Attach a bracket to the intake manifold and assemble the gas regulator assy (with gas fuel mixer) with fixing bolts.
- Assemble the ignition coil and high voltage cable.



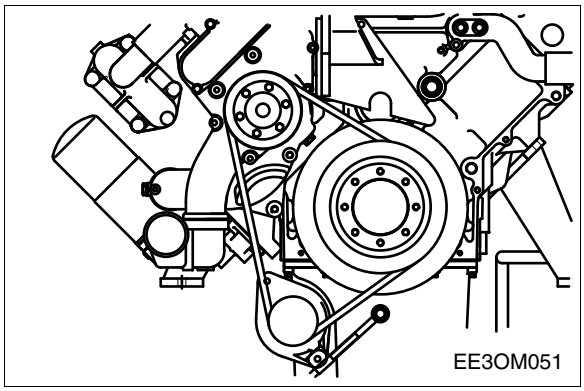
Caution:
Check assembled after the all engine parts install and tighten fuel line.
Open fuel line valve and check for leaks using soapy water or commercial leak detector.

3.3.31. Alternator

- Assemble the alternator bracket to the lower part of cylinder block by tightening the fixing bolts.
- Install the alternator supporting plate (belt tension plate) to the oil pan by means of bolts.
- Assemble the alternator to the bracket and supporting plate tightening the bolts.



- Connect the crankshaft pulley and the alternator pulley and water pump Pulley with V-belts by inserting them into the respective pulleys.
- Adjust the driving belt tension by regulating the alternator supporting plane.
  (Belt tension adjusting bolts: 10 mm ~ 15 mm by pushing with thumb)



3.4. Starting and Trial Operation

3.4.1. Preparations for breaking-in

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

3.4.2. Operation of a new engine (Break-In)

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

Up to the first 50 hours

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

3.4.3. Check points for break-in

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

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

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

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

Note:

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

c) Watch the engine water temperature gauge and be sure there is proper water circulation. The water temperature gauge needle will fluctuate if water level in expansion tank is too low. At the end of the breaker-in period, remove break-in oil and replace the oil filter. Fill oil pan with recommended engine oil. Refer to following table.

Engine model	Engine oil capacity			Recommend oil	
	In oil pan		Total (lit)	API No.	Sulfated ash content
	Max. (lit)	Min. (lit)			
GV222C	40	29	43	SAE 15W40	Bellow 0.5%

Caution:

Check assembled after the all engine parts install and tighten fuel line.

Open fuel line valve and check for leaks using soapy water or commercial leak detector.

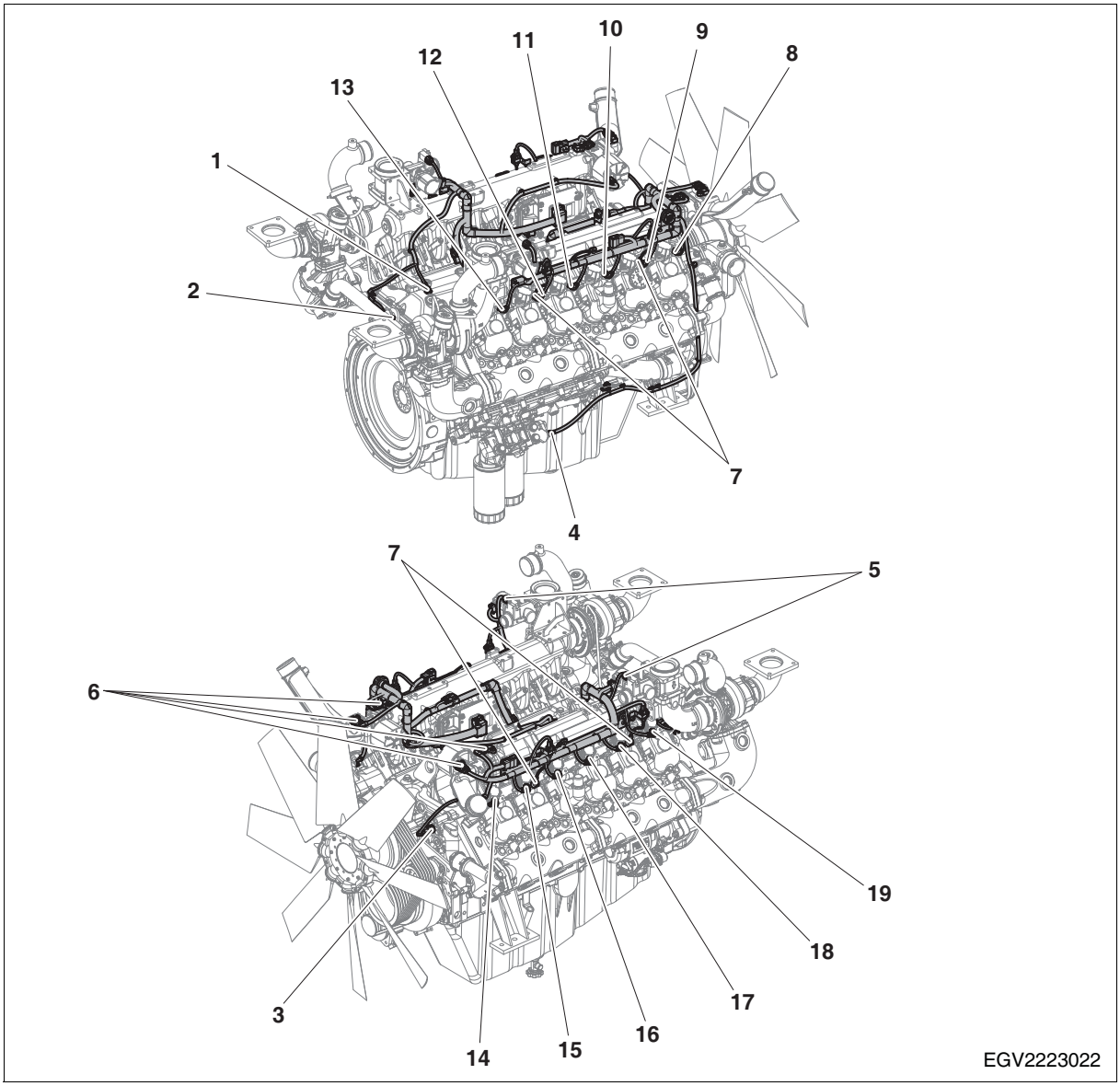
3.5. Diagnosis and Remedies of Trouble Causes

● Prior to asking for repair, please check the following items

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

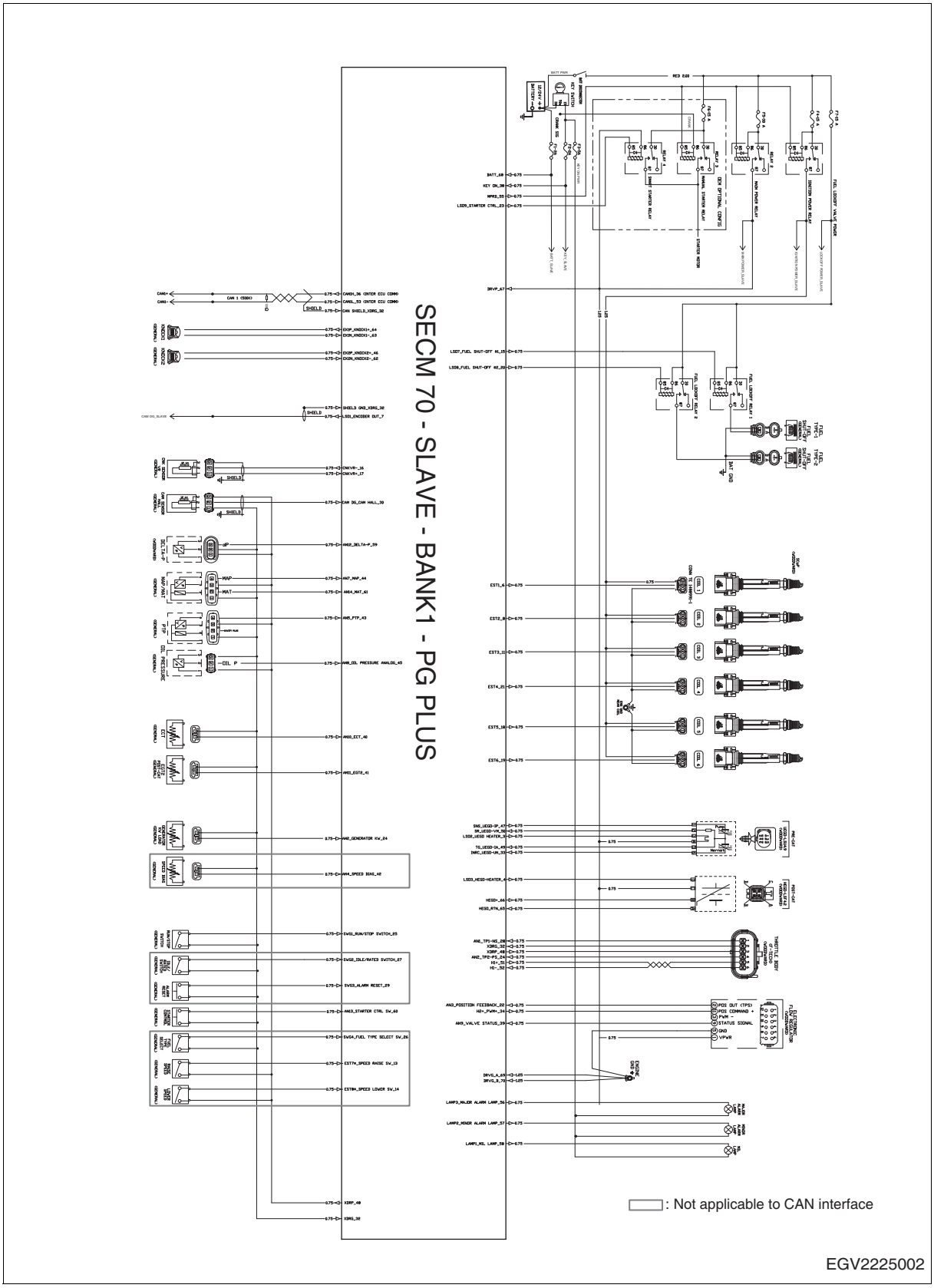
4. Electronic System

4.1. Electric Parts

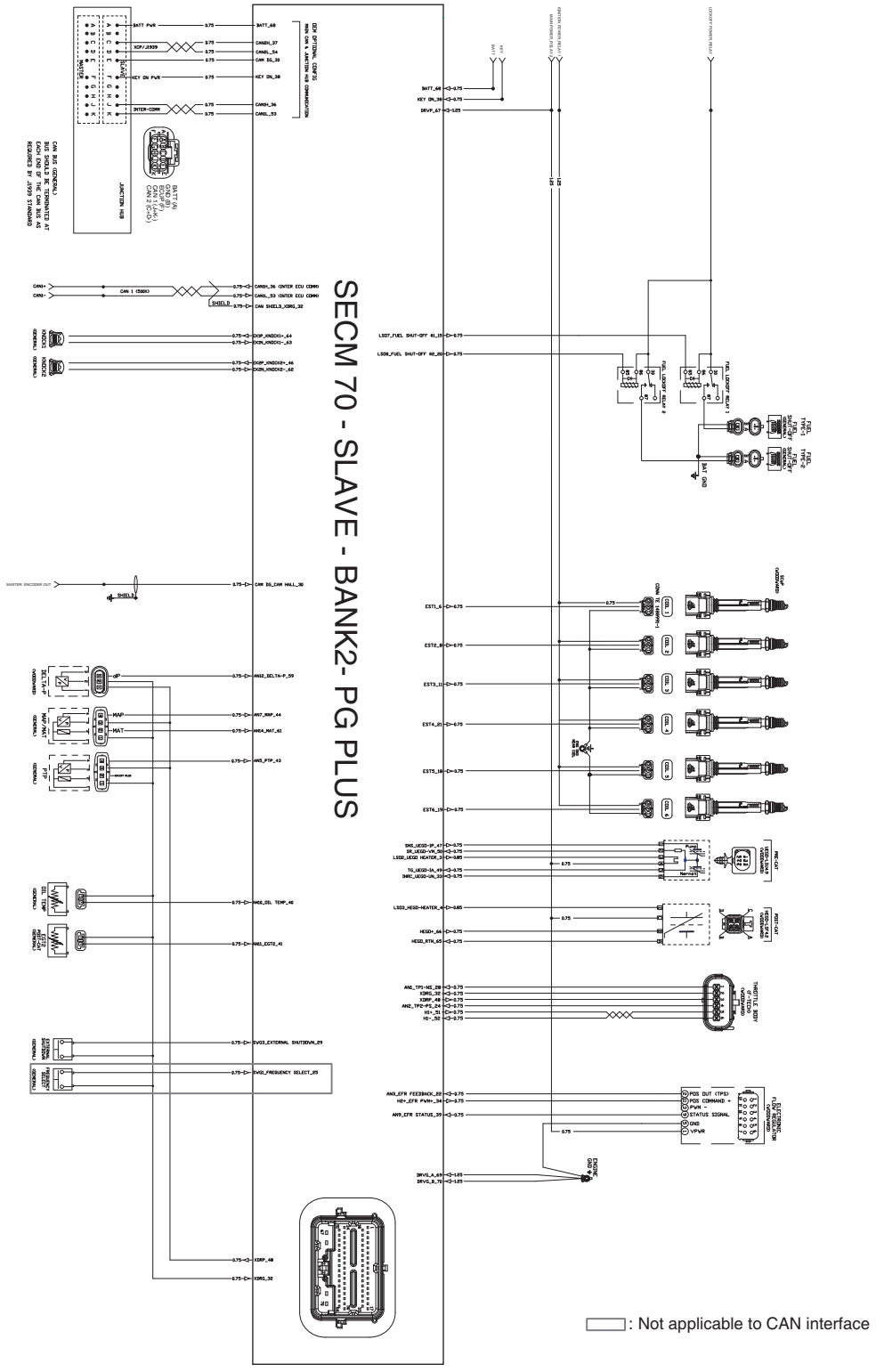


1. CAM: CAM Shaft Position Sensor
2. CRK: Crank Shaft Position Sensor
3. WTS: Water Temperature Sensor
4. OPS: Oil Pressure Sensor
5. Regulator press sensor
6. T-MAP Sensor
7. Knock Sensor (4ea)
8. Ignition Coil #1
9. Ignition Coil #2
10. Ignition Coil #3
11. Ignition Coil #4
12. Ignition Coil #5
13. Ignition Coil #6
14. Ignition Coil #7
15. Ignition Coil #8
16. Ignition Coil #9
17. Ignition Coil #10
18. Ignition Coil #11
19. Ignition Coil #12

4.2. Electrical Wiring Diagram



See "Inter Connector (INT)" on page 108.


SECM 70 - SLAVE - BANK2- PG PLUS
: Not applicable to CAN interface
EGV2225003

4.3. Engine Control Unit (ECU) Engine Connectors

4.3.1. Master

No.	Wire Label	Size (mm^2)	Color	Circuit Description	From	No.	To	No.	Remark
1	M69	1.25	B	Engine GND	Engine GND1 (GND1)	1	ECU Master (ECUM)	69	
2	EGND	1.25	B	Ignition GND	Engine GND2 (GND2)	1	Splice SP1	SP1	Splice SP1
3	IG1	0.75	B	Ignition GND	Ignition 1 (IGN 1)	1	Splice SP1	SP1	Splice SP1
4	M06	0.75	Y	Ignition Signal	Ignition 1 (IGN 1)	2	ECU Master (ECUM)	6	
5	IP1	0.75	R	Ignition Supply	Ignition 1 (IGN 1)	3	Splice SP2	SP2	Splice SP2
6	IG2	0.75	B	Ignition GND	Ignition 2 (IGN 2)	1	Splice SP1	SP1	Splice SP1
7	M08	0.75	Y	Ignition Signal	Ignition 2 (IGN 2)	2	ECU Master (ECUM)	8	
8	IP2	0.75	R	Ignition Supply	Ignition 2 (IGN2)	3	Splice SP2	SP2	Splice SP2
9	IG3	0.75	B	Ignition GND	Ignition 3 (IGN 3)	1	Splice SP1	SP1	Splice SP1
10	M11	0.75	Y	Ignition Signal	Ignition 3 (IGN 3)	2	ECU Master (ECUM)	11	
11	IP3	0.75	R	Ignition Supply	Ignition 3 (IGN 3)	3	Splice SP2	SP2	Splice SP2
12	IG4	0.75	B	Ignition GND	Ignition 4 (IGN 4)	1	Splice SP1	SP1	Splice SP1
13	M21	0.75	Y	Ignition Signal	Ignition 4 (IGN 4)	2	ECU Master (ECUM)	21	
14	IP4	0.75	R	Ignition Supply	Ignition 4 (IGN 4)	3	Splice SP2	SP2	Splice SP2
15	IG5	0.75	B	Ignition GND	Ignition 5 (IGN 5)	1	Splice SP1	SP1	Splice SP1
16	M18	0.75	Y	Ignition Signal	Ignition 5 (IGN 5)	2	ECU Master (ECUM)	18	
17	IP5	0.75	R	Ignition Supply	Ignition 5 (IGN 5)	3	Splice SP2	SP2	Splice SP2
18	IG6	0.75	B	Ignition GND	Ignition 6 (IGN 6)	1	Splice SP1	SP1	Splice SP1
19	M19	0.75	Y	Ignition Signal	Ignition 6 (IGN 6)	2	ECU Master (ECUM)	19	
20	IP6	0.75	R	Ignition Supply	Ignition 6 (IGN 6)	3	Splice SP2	SP2	Splice SP2
21	M45	0.75	Br	Oil Pressure Sensor Signal	Oil Press Sensor (OPS)	1	ECU Master (ECUM)	45	
22	M32S6	0.75	B	Oil Pressure Sensor GND	Oil Press Sensor (OPS)	2	Splice M32	M32	Splice M32
23	M48S5	0.75	R	Oil Pressure Sensor Supply	Oil Press Sensor (OPS)	3	Splice M48	M48	Splice M48
24	M28	0.75	Y	TP1-NS	Throttle Body (THR)	1	ECU Master (ECUM)	28	
25	M32	0.75	B	XDRG	Throttle Body (THR)	2	ECU Master (ECUM)	32	
26	M48	0.75	R	XDRP	Throttle Body (THR)	3	ECU Master (ECUM)	48	
27	M24	0.75	W	TP2-PS	Throttle Body (THR)	4	ECU Master (ECUM)	24	
28	M51	0.75	R	H1+	Throttle Body (THR)	5	ECU Master (ECUM)	51	Twist Pair (M51/M52)
29	M52	0.75	Br	H1-	Throttle Body (THR)	6	ECU Master (ECUM)	52	Twist Pair (M51/M52)
30	M47	0.75	Or	UEGO-IP	Inter Connector for TWC (INTT)	1	ECU Master (ECUM)	47	

No.	Wire Label	Size (mm^2)	Color	Circuit Description	From	No.	To	No.	Remark
31	M50	0.75	W	UEGO-VM	Inter Connector for TWC (INTT)	2	ECU Master (ECUM)	50	
32	M03	0.75	Y	UEGO-Heater	Inter Connector for TWC (INTT)	3	ECU Master (ECUM)	3	
33	M67S6	0.75	R	UEGO-Supply	Inter Connector for TWC (INTT)	4	Splice M67	M67	Splice M67
34	M49	0.75	Or	UEGO-IA	Inter Connector for TWC (INTT)	5	ECU Master (ECUM)	49	
35	M33	0.75	Br	UEGO-UN	Inter Connector for TWC (INTT)	6	ECU Master (ECUM)	33	
36	M04	0.75	Y	HEGO-Heater	Inter Connector for TWC (INTT)	7	ECU Master (ECUM)	4	
37	M67S7	0.75	R	HEGO-Supply	Inter Connector for TWC (INTT)	8	Splice M67	M67	Splice M67
38	M66	0.75	W	HEGO+	Inter Connector for TWC (INTT)	9	ECU Master (ECUM)	66	
39	M65	0.75	Br	HEGO-RTN	Inter Connector for TWC (INTT)	10	ECU Master (ECUM)	65	
40	M32S12	0.75	B	EGT Sensor GND	Inter Connector for TWC (INTT)	11	Splice M32	M32	Splice M32
41	M41	0.75	W	EGT Sensor Signal	Inter Connector for TWC (INTT)	12	ECU Master (ECUM)	41	
42	M67S1	0.75	R	Regulator Supply	Electronic Flow Regulator (EFR)	1	Splice M67	M67	Splice M67
43	M22	0.75	Y	Regulator Feedback	Electronic Flow Regulator (EFR)	2	ECU Master (ECUM)	22	
44	M69S	0.75	B	Regulator GND	Electronic Flow Regulator (EFR)	5	Splice M69	M69	Splice M69
45	M39	0.75	Br	Regulator Status	Electronic Flow Regulator (EFR)	9	ECU Master (ECUM)	39	
46	M34	0.75	W	Regulator Command +	Electronic Flow Regulator (EFR)	11	ECU Master (ECUM)	34	
47	M48S7	0.75	R	Regulator Press Sensor Supply	Regulator Press Sensor (RPS)	1	Splice M48	M48	Splice M48
48	M32S11	0.75	B	Regulator Press Sensor GND	Regulator Press Sensor (RPS)	2	Splice M32	M32	Splice M32
49	M59	0.75	Or	Regulator Press Sensor Signal	Regulator Press Sensor (RPS)	3	ECU Master (ECUM)	59	
50	M32S5	0.75	B	PTP GND	PTP (PTP)	1	Splice M32	M32	Splice M32
51	M48S4	0.75	R	PTP Supply	PTP (PTP)	3	Splice M48	M48	Splice M48
52	M43	0.75	Or	PTP Signal	PTP (PTP)	4	ECU Master (ECUM)	43	
53	M32S4	0.75	B	MAP/MAT GND	TMAP Sensor (TMAP)	1	Splice M32	M32	Splice M32
54	M61	0.75	Y	MAT Signal	TMAP Sensor (TMAP)	2	ECU Master (ECUM)	61	

No.	Wire Label	Size (mm^2)	Color	Circuit Description	From	No.	To	No.	Remark
55	M48S3	0.75	R	MAP Supply	TMAP Sensor (TMAP)	3	Splice M48	M48	Splice M48
56	M44	0.75	Br	MAP Signal	TMAP Sensor (TMAP)	4	ECU Master (ECUM)	44	
57	IPS	1.25	R	Ignition Power	Inter Connector (INT)	4	Splice SP2	SP2	Splice SP2
58	M67	1.25	R	Main Power	Inter Connector (INT)	5	ECU Master (ECUM)	67	
59	M55	0.75	Br	Power Relay D	Inter Connector (INT)	6	ECU Master (ECUM)	55	
60	M68	1.25	R	BATT+	Inter Connector (INT)	7	ECU Master (ECUM)	68	
61	M38	0.75	Y	Key On (T15)	Inter Connector (INT)	8	ECU Master (ECUM)	38	
62	M56	0.75	Or	Major Alarm Lamp	Inter Connector (INT)	9	ECU Master (ECUM)	56	
63	M57	0.75	Br	Minor Alarm Lamp	Inter Connector (INT)	10	ECU Master (ECUM)	57	
64	M58	0.75	W	MIL Lamp	Inter Connector (INT)	11	ECU Master (ECUM)	58	
65	M23	0.75	Y	Starter Control Relay	Inter Connector (INT)	12	ECU Master (ECUM)	23	
66	M48S	0.75	R	ECU Output-Supply	Inter Connector (INT)	13	Splice M48	M48	Splice M48
67	M32S	0.75	B	GND	Inter Connector (INT)	14	Splice M32	M32	Splice M32
68	M25	0.75	Y	Run/Stop Switch	Inter Connector (INT)	16	ECU Master (ECUM)	25	
69	M27	0.75	W	Idle Rated Switch	Inter Connector (INT)	17	ECU Master (ECUM)	27	
70	M29	0.75	Br	External Shutdown	Inter Connector (INT)	18	ECU Master (ECUM)	29	
71	M60	0.75	Br	Starter Control	Inter Connector (INT)	19	ECU Master (ECUM)	60	
72	M26	0.75	Or	Fuel Type Select	Inter Connector (INT)	20	ECU Master (ECUM)	26	
73	M13	0.75	W	Raise Speed	Inter Connector (INT)	21	ECU Master (ECUM)	13	
74	M14	0.75	W	Lower Speed	Inter Connector (INT)	22	ECU Master (ECUM)	14	
75	M54S	0.75	Br	CAN2 Low	Inter Connector (INT)	23	Splice M54	M54	Twist Pair (M54S/M37S)
76	M37S	0.75	R	CAN2 High	Inter Connector (INT)	24	Splice M37	M37	Twist Pair (M54S/M37S)
77	I25	0.75	B	GND	Inter Connector (INT)	25	Inter Connector for LH (INTL)	18	

No.	Wire Label	Size (mm^2)	Color	Circuit Description	From	No.	To	No.	Remark
78	I26	0.75	Br	External Shutdown	Inter Connector (INT)	26	Inter Connector for LH (INTL)	19	
79	I27	0.75	W	Shut Off#1-LH Signal	Inter Connector (INT)	27	Inter Connector for LH (INTL)	20	
80	I28	0.75	Y	Shut Off#2-LH Signal	Inter Connector (INT)	28	Inter Connector for LH (INTL)	21	
81	M20	0.75	W	Shut Off#2-RH Signal	Inter Connector (INT)	1	ECU Master (ECUM)	20	
82	M15	0.75	Y	Shut Off#1-RH Signal	Inter Connector (INT)	3	ECU Master (ECUM)	15	
83	M38S	0.75	Y	Key On (T15)	Inter Connector for LH (INTL)	1	Splice M38	M38	Splice M38
84	M68S	1.25	R	BATT++	Inter Connector for LH (INTL)	2	Splice M68	M68	Splice M68
85	M67S5	1.25	R	Main Power	Inter Connector for LH (INTL)	4	Splice M67	M67	Splice M67
86	IPS1	0.75	R	Ignition Power	Inter Connector for LH (INTL)	3	Splice SP2	SP2	Splice SP2
87	M53	0.75	B	CAN1 Low	Inter Connector for LH (INTL)	6	ECU Master (ECUM)	53	Shield (M53/M36)
88	M36	0.75	W	CAN1 High	Inter Connector for LH (INTL)	7	ECU Master (ECUM)	36	Shield (M53/M36)
89	SHD5	0.75	B	Shield Drain	Shield Drain		Splice M32	M32	Shield Drain (M53/M36), Splice M32
90	SHD6	0.75	B	Shield Drain	Inter Connector for LH (INTL)	5	Shield Drain		Shield Drain (M53/M36)
91	S54	0.75	Br	CAN2 Low	Inter Connector for LH (INTL)	8	COMM. Connector (COMM)	7	Twist Pair (S54/S37)
92	S37	0.75	R	CAN2 High	Inter Connector for LH (INTL)	9	COMM. Connector (COMM)	8	Twist Pair (S54/S37)
93	M16	0.75	Br	Crank Shaft Sensor Negative	Inter Connector for LH (INTL)	10	ECU Master (ECUM)	16	Twist Pair (M16/M17)
94	M17	0.75	R	Crank Shaft Sensor Positive	Inter Connector for LH (INTL)	11	ECU Master (ECUM)	17	Twist Pair (M16/M17)
95	M48S6	0.5	W	Cam Shaft Sensor Supply	Inter Connector for LH (INTL)	12	Splice M48	M48	Shield (M48S6/ M30/M32S9), Splice M48
96	M30	0.5	Gr	Cam Shaft Sensor Output	Inter Connector for LH (INTL)	13	ECU Master (ECUM)	30	Shield (M48S6/ M30/M32S9)
97	M32S9	0.5	BW	Cam Shaft Sensor GND	Inter Connector for LH (INTL)	14	Splice M32	M32	Shield (M48S6/ M30/M32S9), Splice M32
98	SHD3	0.75	B	Shield Drain	Inter Connector for LH (INTL)	15	Shield Drain		Shield Drain (M48S6/M30/ M32S9)

No.	Wire Label	Size (mm^2)	Color	Circuit Description	From	No.	To	No.	Remark
99	M32S10	0.75	B	ECT GND	Inter Connector for LH (INTL)	16	Splice M32	M32	Splice M32
100	M40	0.75	W	ECT Signal	Inter Connector for LH (INTL)	17	ECU Master (ECUM)	40	
101	SHD4	0.75	B	Shield Drain	Shield Drain		Splice M69	M69	Splice M69
102	M69S1	0.75	B	GND	COMM. Connector (COMM)	3	Splice M69	M69	Splice M69
103	M68S1	0.75	R	BATT+	COMM. Connector (COMM)	4	Splice M68	M68	Splice M68
104	M54	0.75	Br	CAN2 Low-Master	COMM. Connector (COMM)	1	ECU Master (ECUM)	54	Twist Pair (M54/M37)
105	M37	0.75	R	CAN2 High-Master	COMM. Connector (COMM)	2	ECU Master (ECUM)	37	Twist Pair (M54/M37)
106	M38S1	0.75	Y	Key On (T15)	COMM. Connector (COMM)	6	Splice M38	M38	Splice M38
107	M63	0.75	Br	Knock Sensor 1-Negative	Knock Sensor 1 (KNS 1)	1	ECU Master (ECUM)	63	Twist Pair (M63/M64)
108	M64	0.75	R	Knock Sensor 1-Positive	Knock Sensor 1 (KNS 1)	2	ECU Master (ECUM)	64	Twist Pair (M63/M64)
109	M62	0.75	Br	Knock Sensor 2-Negative	Knock Sensor 2 (KNS 2)	1	ECU Master (ECUM)	62	Twist Pair (M62/M46)
110	M46	0.75	R	Knock Sensor 2-Positive	Knock Sensor 2 (KNS 2)	2	ECU Master (ECUM)	46	Twist Pair (M62/M46)
111	M70	1.25	B	GND	ECU Master (ECUM)	70	Splice M69	M69	Splice M69
112	M53S	0.75	B	CAN1 Low	Resistance 1 (R1)	1	Splice M53	M53	Twist Pair (M53/M36), Splice M53
113	M36S	0.75	W	CAN1 High	Resistance 1 (R1)	2	Splice M36	M36	Twist Pair (M53/M36), Splice M36
114	M54S1	0.75	Br	CAN2 Low	Resistance 2 (R2)	1	ECU Master (ECUM)	54	Twist Pair (M54S1/ M37S1)
115	M37S1	0.75	R	CAN2 High	Resistance 2 (R2)	2	ECU Master (ECUM)	37	Twist Pair (M54S1/ M37S1)
116	S25	0.75	W	SWG1_Frequency Select	Inter Connector for LH (INTL)	23	Inter Connector (INT)	31	
117	M07	0.75	W	CAM DG_Cam Hall	Inter Connector for LH (INTL)	24	ECU Master (ECUM)	7	
118	SHD7	0.75	B	Shield Drain	Shield Drain		Splice M32	M32	Splice M32
119	SHD8	0.75	B	Shield Drain	Inter Connector for LH (INTL)	25	Shield Drain		
120	M42	0.75	Br	AN4_Speed BIAS	Inter Connector (INT)	30	ECU Master (ECUM)	42	

4.3.2. Slave

No.	Wire Label	Size (mm^2)	Color	Circuit Description	From	No.	To	No.	Remark
1	S69	1.25	B	Engine GND	Engine GND1 (GND1)	1	ECU Slave (ECUS)	69	
2	EGND	1.25	B	Ignition GND	Engine GND2 (GND2)	1	Splice SP1	SP1	Splice SP1
3	IG1	0.75	B	Ignition GND	Ignition 7 (IGN 7)	1	Splice SP1	SP1	Splice SP1
4	S06	0.75	Y	Ignition Signal	Ignition 7 (IGN 7)	2	ECU Slave (ECUS)	6	
5	IP1	0.75	R	Ignition Supply	Ignition 7 (IGN 7)	3	Splice SP2	SP2	Splice SP2
6	IG2	0.75	B	Ignition GND	Ignition 8 (IGN 8)	1	Splice SP1	SP1	Splice SP1
7	S08	0.75	Y	Ignition Signal	Ignition 8 (IGN 8)	2	ECU Slave (ECUS)	8	
8	IP2	0.75	R	Ignition Supply	Ignition 8 (IGN 8)	3	Splice SP2	SP2	Splice SP2
9	IG3	0.75	B	Ignition GND	Ignition 9 (IGN 9)	1	Splice SP1	SP1	Splice SP1
10	S11	0.75	Y	Ignition Signal	Ignition 9 (IGN 9)	2	ECU Slave (ECUS)	11	
11	IP3	0.75	R	Ignition Supply	Ignition 9 (IGN 9)	3	Splice SP2	SP2	Splice SP2
12	IG4	0.75	B	Ignition GND	Ignition 10 (IGN 10)	1	Splice SP1	SP1	Splice SP1
13	S21	0.75	Y	Ignition Signal	Ignition 10 (IGN 10)	2	ECU Slave (ECUS)	21	
14	IP4	0.75	R	Ignition Supply	Ignition 10 (IGN 10)	3	Splice SP2	SP2	Splice SP2
15	IG5	0.75	B	Ignition GND	Ignition 11 (IGN 11)	1	Splice SP1	SP1	Splice SP1
16	S18	0.75	Y	Ignition Signal	Ignition 11 (IGN 11)	2	ECU Slave (ECUS)	18	
17	IP5	0.75	R	Ignition Supply	Ignition 11 (IGN 11)	3	Splice SP2	SP2	Splice SP2
18	IG6	0.75	B	Ignition GND	Ignition 12 (IGN 12)	1	Splice SP1	SP1	Splice SP1
19	S19	0.75	Y	Ignition Signal	Ignition 12 (IGN 12)	2	ECU Slave (ECUS)	19	
20	IP6	0.75	R	Ignition Supply	Ignition 12 (IGN 12)	3	Splice SP2	SP2	Splice SP2
21	S28	0.75	Y	TP1-NS	Throttle Body (THR)	1	ECU Slave (ECUS)	28	
22	S32	0.75	B	XDRG	Throttle Body (THR)	2	ECU Slave (ECUS)	32	
23	S48	0.75	R	XDRP	Throttle Body (THR)	3	ECU Slave (ECUS)	48	
24	S24	0.75	W	TP2-PS	Throttle Body (THR)	4	ECU Slave (ECUS)	24	
25	S51	0.75	R	H1+	Throttle Body (THR)	5	ECU Slave (ECUS)	51	Twist Pair (S51/S52)
26	S52	0.75	Br	H1-	Throttle Body (THR)	6	ECU Slave (ECUS)	52	Twist Pair (S51/S52)
27	S47	0.75	Or	UEGO-IP	Inter Connector for TWC (INTT)	1	ECU Slave (ECUS)	47	
28	S50	0.75	W	UEGO-VM	Inter Connector for TWC (INTT)	2	ECU Slave (ECUS)	50	
29	S03	0.75	Y	UEGO-Heater	Inter Connector for TWC (INTT)	3	ECU Slave (ECUS)	3	
30	S67S6	0.75	R	UEGO-Supply	Inter Connector for TWC (INTT)	4	Splice S67	S67	Splice S67
31	S49	0.75	Or	UEGO-IA	Inter Connector for TWC (INTT)	5	ECU Slave (ECUS)	49	

No.	Wire Label	Size (mm^2)	Color	Circuit Description	From	No.	To	No.	Remark
32	S33	0.75	Br	UEGO-UN	Inter Connector for TWC (INTT)	6	ECU Slave (ECUS)	33	
33	S04	0.75	Y	HEGO-Heater	Inter Connector for TWC (INTT)	7	ECU Slave (ECUS)	4	
34	S67S7	0.75	R	HEGO-Supply	Inter Connector for TWC (INTT)	8	Splice S67	S67	Splice S67
35	S66	0.75	W	HEGO+	Inter Connector for TWC (INTT)	9	ECU Slave (ECUS)	66	
36	S65	0.75	Br	HEGO-RTN	Inter Connector for TWC (INTT)	10	ECU Slave (ECUS)	65	
37	S32S12	0.75	B	EGT Sensor GND	Inter Connector for TWC (INTT)	11	Splice S32	S32	Splice S32
38	S41	0.75	W	EGT Sensor Signal	Inter Connector for TWC (INTT)	12	ECU Slave (ECUS)	41	
39	S67S1	0.75	R	Regulator Supply	Electronic Flow Regulator (EFR)	1	Splice S67	S67	Splice S67
40	S22	0.75	Y	Regulator Feedback	Electronic Flow Regulator (EFR)	2	ECU Slave (ECUS)	22	
41	S69S	0.75	B	Regulator GND	Electronic Flow Regulator (EFR)	5	Splice S69	S69	Splice S69
42	S39	0.75	Br	Regulator Status	Electronic Flow Regulator (EFR)	9	ECU Slave (ECUS)	39	
43	S34	0.75	W	Regulator Command +	Electronic Flow Regulator (EFR)	11	ECU Slave (ECUS)	34	
44	S48S7	0.75	R	Regulator Press Sensor Supply	Regulator Press Sensor (RPS)	1	Splice S48	S48	Splice S48
45	S32S11	0.75	B	Regulator Press Sensor GND	Regulator Press Sensor (RPS)	2	Splice S32	S32	Splice S32
46	S59	0.75	Or	Regulator Press Sensor Signal	Regulator Press Sensor (RPS)	3	ECU Slave (ECUS)	59	
47	S32S5	0.75	B	PTP GND	PTP (PTP)	1	Splice S32	S32	Splice S32
48	S48S4	0.75	R	PTP Supply	PTP (PTP)	3	Splice S48	S48	Splice S48
49	S43	0.75	Or	PTP Signal	PTP (PTP)	4	ECU Slave (ECUS)	43	
50	I25	0.75	B	GND	Inter Connector for RH (INTR)	18	Splice S32	S32	Splice S32
51	S29	0.75	Br	External Shutdown	Inter Connector for RH (INTR)	19	ECU Slave (ECUS)	29	
52	S38	0.75	Y	Key On (T15)	Inter Connector for RH (INTR)	1	ECU Slave (ECUS)	38	
53	S68	1.25	R	BATT++	Inter Connector for RH (INTR)	2	ECU Slave (ECUS)	68	
54	S67	1.25	R	Main Power	Inter Connector for RH (INTR)	4	ECU Slave (ECUS)	67	
55	IPS1	0.75	R	Ignition Power	Inter Connector for RH (INTR)	3	Splice SP2	SP2	Splice SP2

No.	Wire Label	Size (mm^2)	Color	Circuit Description	From	No.	To	No.	Remark
56	S53	0.75	B	Can1 Low	Inter Connector for RH (INTR)	6	ECU Slave (ECUS)	53	Shield (S53/36)
57	S36	0.75	W	Can1 High	Inter Connector for RH (INTR)	7	ECU Slave (ECUS)	36	Shield (S53/36)
58	SHD4	0.75	B	Shield Drain	Shield Drain		Splice S32		Splice S32, Shield Drain (S53/S36)
59	SHD5	0.75	B	Shield Drain	Inter Connector for RH (INTR)	5	Shield Drain		Shield Drain (S53/S36)
60	S54	0.75	Br	Can2 Low	Inter Connector for RH (INTR)	8	ECU Slave (ECUS)	54	Twist Pair (S54/S37)
61	S37	0.75	R	Can2 High	Inter Connector for RH (INTR)	9	ECU Slave (ECUS)	37	Twist Pair (S54/S38)
62	M16	0.75	Br	Crank Shaft Sensor Negative	Inter Connector for RH (INTR)	10	Crank Shaft Sensor (CRS)	1	Twist Pair (M16/M17)
63	M17	0.75	R	Crank Shaft Sensor Positive	Inter Connector for RH (INTR)	11	Crank Shaft Sensor (CRS)	2	Twist Pair (M16/M17)
64	M48	0.5	W	Cam Shaft Sensor Supply	Inter Connector for RH (INTR)	12	Cam Shaft Sensor (CAS)	3	Shield (M48/M30/ M32)
65	M30	0.5	Gr	Cam Shaft Sensor Output	Inter Connector for RH (INTR)	13	Cam Shaft Sensor (CAS)	2	Shield (M48/M30/ M32)
66	M32	0.5	BW	Cam Shaft Sensor GND	Inter Connector for RH (INTR)	14	Cam Shaft Sensor (CAS)	1	Shield (M48/M30/ M32)
67	SHD3	0.75	B	Shield Drain	Inter Connector for RH (INTR)	15	Shield Drain		Shield Drain (M48/M30/ M32)
68	SHD8	0.75	B	Shield Drain	Shield Drain		Splice S32		Splice S32, Shield Drain (M48/M30/ M32)
69	M32A	0.75	B	ECT GND	Inter Connector for RH (INTR)	16	Coolant Temp Sensor (CTS)	2	
70	M40	0.75	W	ECT Signal	Inter Connector for RH (INTR)	17	Coolant Temp Sensor (CTS)	1	
71	S15	0.75	W	Shut Off#1-LH Signal	Inter Connector for RH (INTR)	20	ECU Slave (ECUS)	15	
72	S20	0.75	Y	Shut Off#2-LH Signal	Inter Connector for RH (INTR)	21	ECU Slave (ECUS)	20	
73	S63	0.75	Br	Knock Sensor 3-negative	Knock Sensor 3 (KNS 3)	1	ECU Slave (ECUS)	63	Twist Pair (S63/S64)
74	S64	0.75	R	Knock Sensor 3-positive	Knock Sensor 3 (KNS 3)	2	ECU Slave (ECUS)	64	Twist Pair (S63/S64)

No.	Wire Label	Size (mm^2)	Color	Circuit Description	From	No.	To	No.	Remark
75	S62	0.75	Br	Knock Sensor 4-negative	Knock Sensor 4 (KNS 4)	1	ECU Slave (ECUS)	62	Twist Pair (S62/S46)
76	S46	0.75	R	Knock Sensor 4-positive	Knock Sensor 4 (KNS 4)	2	ECU Slave (ECUS)	46	Twist Pair (S62/S46)
77	S70	1.25	B	Engine GND	ECU Slave (ECUS)	70	Splice S69	S69	Splice S69
78	S53S1	0.75	B	Can1 Low	Resistance 1 (R1)	1	Splice S53	S53	Splice S53, Twist Pair (S53/S36)
79	S36S1	0.75	W	Can1 High	Resistance 1 (R1)	2	Splice S36	S36	Splice S36, Twist Pair (S53/S36)
80	S54S	0.75	Br	Can2 Low	Resistance 2 (R2)	1	Splice S54	S54	Splice S54, Twist Pair (S54/S37)
81	S37S	0.75	R	Can2 High	Resistance 2 (R2)	2	Splice S37	S37	Splice S37, Twist Pair (S54/S37)
82	S32S4	0.75	B	MAP/MAT GND	TMAP Sensor (TMAP)	1	Splice S32	S32	Splice S32
83	S61	0.75	Y	MAT Signal	TMAP Sensor (TMAP)	2	ECU Slave (ECUS)	61	
84	S48S3	0.75	R	MAP Supply	TMAP Sensor (TMAP)	3	Splice S48	S48	Splice S48
85	S44	0.75	Br	MAP Signal	TMAP Sensor (TMAP)	4	ECU Slave (ECUS)	44	
86	S25	0.75	W	SWG1_frequency Select	Inter Connector for RH (INTR)	23	ECU Slave (ECUS)	25	
87	S30	0.75	Or	CAM DG_Cam Hall	Inter Connector for RH (INTR)	24	ECU Slave (ECUS)	30	Shield (S30)
88	SHD6	0.75	B	Shield Drain	Inter Connector for RH (INTR)	25	Shield Drain		Shield Drain (S30)
89	SHD7	0.75	B	Shield Drain	Shield Drain		Splice S69		Splice S69, Shield Drain (S30)

4.4. Switches and Sensors

4.4.1. Master

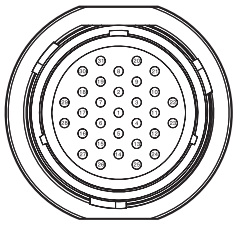
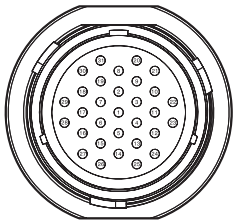
Figure	No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
Inter Connector for LH (INTR) 	1	M38S	Y	FLR91X-A or Equivalent	Key On (T15)	Inter Connector for LH (INTL)	1	Splice M38	M38
	2	M68S	R	FLR91X-A or Equivalent	BATT++	Inter Connector for LH (INTL)	2	Splice M68	M68
	3	IPS1	R	FLR91X-A or Equivalent	Ignition Power	Inter Connector for LH (INTL)	3	Splice SP2	SP2
	4	M67S5	R	FLR91X-A or Equivalent	Main Power	Inter Connector for LH (INTL)	4	Splice M67	M67
	5	SHD6	B	FLR91X-A or Equivalent	Shield Drain	Inter Connector for LH (INTL)	5	Shield Drain	
	6	M53	B	FLR91X-A or Equivalent	CAN1 Low	Inter Connector for LH (INTL)	6	ECU Master (ECUM)	53
	7	M36	W	FLR91X-A or Equivalent	CAN1 High	Inter Connector for LH (INTL)	7	ECU Master (ECUM)	36
	8	S54	Br	FLR91X-A or Equivalent	CAN2 Low	Inter Connector for LH (INTL)	8	Comm. Connector (COMM)	7
	9	M37	R	FLR91X-A or Equivalent	CAN2 High - Master	COMM. Connector (COMM)	2	ECU Master (ECUM)	37
	10	M16	Br	FLR91X-A or Equivalent	Crank Shaft Sensor Negative	Inter Connector for LH (INTL)	10	ECU Master (ECUM)	16
	11	M17	R	FLR91X-A or Equivalent	Crank Shaft Sensor Positive	Inter Connector for LH (INTL)	11	ECU Master (ECUM)	17
	12	M48S6	W	AEXF 3core Shield	Cam Shaft Sensor Supply	Inter Connector for LH (INTL)	12	Splice M48	M48
	13	M30	Gr	AEXF 3core Shield	Cam Shaft Sensor Output	Inter Connector for LH (INTL)	13	ECU Master (ECUM)	30
	14	M32S9	BW	AEXF 3core Shield	Cam Shaft Sensor GND	Inter Connector for LH (INTL)	14	Splice M32	M32
	15	SHD3	B	FLR91X-A or Equivalent	Shield Drain	Inter Connector for LH (INTL)	15	Shield Drain	
	16	M32S10	B	FLR91X-A or Equivalent	ECT GND	Inter Connector for LH (INTL)	16	Splice M32	M32
	17	M40	W	FLR91X-A or Equivalent	ECT Signal	Inter Connector for LH (INTL)	17	ECU Master (ECUM)	40
	18	I25	B	FLR91X-A or Equivalent	GND	Inter Connector (INT)	25	Inter Connector for LH (INTL)	18
	19	I26	Br	FLR91X-A or Equivalent	External Shutdown	Inter Connector (INT)	26	Inter Connector for LH (INTL)	19
	20	I27	W	FLR91X-A or Equivalent	Shut Off#1-LH Signal	Inter Connector (INT)	27	Inter Connector for LH (INTL)	20
	21	I28	Y	FLR91X-A or Equivalent	Shut Off#2-LH Signal	Inter Connector (INT)	28	Inter Connector for LH (INTL)	21
	22	-							
	23	S25	W	FLR91X-A or Equivalent	SWG1_Frequency Select	Inter Connector for LH (INTL)	23	Inter Connector (INT)	31
	24	M07	W	FLR91X-A or Equivalent	CAM DG_Cam Hall	Inter Connector for LH (INTL)	24	ECU Master (ECUM)	7
	25	SHD8	B	FLR91X-A or Equivalent	Shield Drain	Inter Connector for LH (INTL)	25	Shield Drain	

Figure	No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
Inter Connector (INT) 	1*	M20	W	FLR91X-A or Equivalent	Shut Off#2-RH Signal	Inter Connector (INT)	1	ECU Master (ECUM)	20
	2	-							
	3	M15	Y	FLR91X-A or Equivalent	Shut Off#1-RH Signal	Inter Connector (INT)	3	ECU Master (ECUM)	15
	4	IPS	R	FLR91X-A or Equivalent	Ignition Power	Inter Connector (INT)	4	Splice SP2	SP2
	5	M67	R	FLR91X-A or Equivalent	Main Power	Inter Connector (INT)	5	ECU Master (ECUM)	67
	6	M55	Br	FLR91X-A or Equivalent	Power Relay D	Inter Connector (INT)	6	ECU Master (ECUM)	55
	7	M68	R	FLR91X-A or Equivalent	BATT+	Inter Connector (INT)	7	ECU Master (ECUM)	68
	8	M38	Y	FLR91X-A or Equivalent	Key On (T15)	Inter Connector (INT)	8	ECU Master (ECUM)	38
	9	M56	Or	FLR91X-A or Equivalent	Major Alarm Lamp	Inter Connector (INT)	9	ECU Master (ECUM)	56
	10	M57	Br	FLR91X-A or Equivalent	Minor Alarm Lamp	Inter Connector (INT)	10	ECU Master (ECUM)	57
	11	M58	W	FLR91X-A or Equivalent	MIL Lamp	Inter Connector (INT)	11	ECU Master (ECUM)	58
	12	M23	Y	FLR91X-A or Equivalent	Starter Control Relay	Inter Connector (INT)	12	ECU Master (ECUM)	23
	13	M48S	R	FLR91X-A or Equivalent	ECU Output-supply	Inter Connector (INT)	13	Splice M48	M48
	14	M32S	B	FLR91X-A or Equivalent	GND	Inter Connector (INT)	14	Splice M32	M32
	15	-							
	16	M25	Y	FLR91X-A or Equivalent	Run/Stop Switch	Inter Connector (INT)	16	ECU Master (ECUM)	25
	17*	M27	W	FLR91X-A or Equivalent	Idle Rated Switch	Inter Connector (INT)	17	ECU Master (ECUM)	27
	18*	M29	Br	FLR91X-A or Equivalent	Alarm reset	Inter Connector (INT)	18	ECU Master (ECUM)	29
	19	M60	Br	FLR91X-A or Equivalent	Starter Control	Inter Connector (INT)	19	ECU Master (ECUM)	60
	20*	M26	Or	FLR91X-A or Equivalent	Fuel Type Select	Inter Connector (INT)	20	ECU Master (ECUM)	26
	21*	M13	W	FLR91X-A or Equivalent	Raise Speed	Inter Connector (INT)	21	ECU Master (ECUM)	13
	22*	M14	W	FLR91X-A or Equivalent	Lower Speed	Inter Connector (INT)	22	ECU Master (ECUM)	14
	23	M54S	Br	FLR91X-A or Equivalent	CAN2 Low	Inter Connector (INT)	23	Splice M54	M54
	24	M37S	R	FLR91X-A or Equivalent	CAN2 High	Inter Connector (INT)	24	Splice M37	M37
	25	I25	B	FLR91X-A or Equivalent	GND	Inter Connector (INT)	25	Inter Connector for LH (INTL)	18
	26	I26	Br	FLR91X-A or Equivalent	External Shutdown	Inter Connector (INT)	26	Inter Connector for LH (INTL)	19
	27	I27	W	FLR91X-A or Equivalent	Shut Off#1-LH Signal	Inter Connector (INT)	27	Inter Connector for LH (INTL)	20
	28*	I28	Y	FLR91X-A or Equivalent	Shut Off#2-LH Signal	Inter Connector (INT)	28	Inter Connector for LH (INTL)	21
	29	-							
	30*	M42	Br	FLR91X-A or Equivalent	AN4_Speed BIAS	Inter Connector (INT)	30	ECU Master (ECUM)	42
	31*	S25	W	FLR91X-A or Equivalent	SWG1_Frequency Select	Inter Connector for LH (INTL)	23	Inter Connector (INT)	31

*: Option

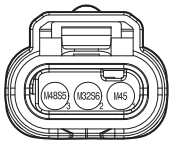
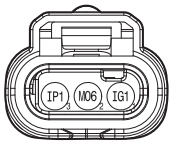
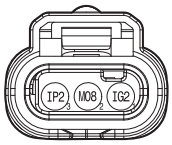
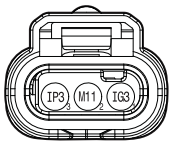
Figure	No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
Engine GND 1 	1	M69	B	FLR91X-A or Equivalent	Engine GND	Engine GND1 (GND1)	1	ECU Master (ECUS)	69
Engine GND 2 	1	EGND	B	FLR91X-A or Equivalent	Ignition GND	Engine GND2 (GND2)	1	Splice SP1	SP1
Oil Press Sensor (OPS) 	1	M45	Br	FLR91X-A or Equivalent	Oil Pressure Sensor Signal	Oil Press Sensor (OPS)	1	ECU Master (ECUM)	45
	2	M32S6	B	FLR91X-A or Equivalent	Oil Pressure Sensor GND	Oil Press Sensor (OPS)	2	Splice M32	M32
	3	M48S5	R	FLR91X-A or Equivalent	Oil Pressure Sensor Supply	Oil Press Sensor (OPS)	3	Splice M48	M48
Ignition 1 (IGN 1) 	1	IP1	R	FLR91X-A or Equivalent	Ignition Supply	Ignition 1 (IGN 1)	3	Splice SP2	SP2
	2	M06	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 1 (IGN 1)	2	ECU Master (ECUM)	6
	3	IG1	B	FLR91X-A or Equivalent	Ignition GND	Ignition 1 (IGN 1)	1	Splice SP1	SP1
Ignition 2 (IGN 2) 	1	IP2	R	FLR91X-A or Equivalent	Ignition Supply	Ignition 2 (IGN2)	3	Splice SP2	SP2
	2	M08	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 2 (IGN 2)	2	ECU Master (ECUM)	8
	3	IG2	B	FLR91X-A or Equivalent	Ignition GND	Ignition 2 (IGN 2)	1	Splice SP1	SP1
Ignition 3 (IGN 3) 	1	IP3	R	FLR91X-A or Equivalent	Ignition Supply	Ignition 3 (IGN 3)	3	Splice SP2	SP2
	2	M11	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 3 (IGN 3)	2	ECU Master (ECUM)	11
	3	IG3	B	FLR91X-A or Equivalent	Ignition GND	Ignition 3 (IGN 3)	1	Splice SP1	SP1

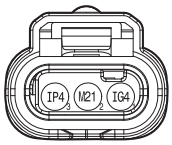
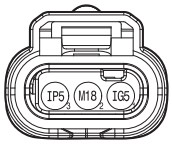
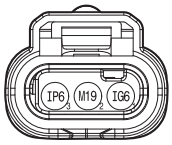
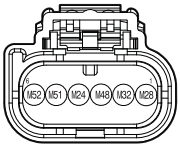
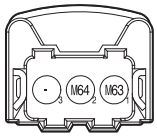
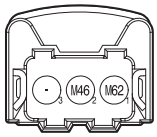
Figure	No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
Ignition 4 (IGN 4) 	1	IP4	R	FLR91X-A or Equivalent	Ignition Supply	Ignition 4 (IGN 4)	3	Splice SP2	SP2
	2	M21	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 4 (IGN 4)	2	ECU Master (ECUM)	21
	3	IG4	B	FLR91X-A or Equivalent	Ignition GND	Ignition 4 (IGN 4)	1	Splice SP1	SP1
Ignition 5 (IGN 5) 	1	IP5	R	FLR91X-A or Equivalent	Ignition Supply	Ignition 5 (IGN 5)	3	Splice SP2	SP2
	2	M18	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 5 (IGN 5)	2	ECU Master (ECUM)	18
	3	IG5	B	FLR91X-A or Equivalent	Ignition GND	Ignition 5 (IGN 5)	1	Splice SP1	SP1
Ignition 6 (IGN 6) 	1	IP6	R	FLR91X-A or Equivalent	Ignition Supply	Ignition 6 (IGN 6)	3	Splice SP2	SP2
	2	M19	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 6 (IGN 6)	2	ECU Master (ECUM)	19
	3	IG6	B	FLR91X-A or Equivalent	Ignition GND	Ignition 6 (IGN 6)	1	Splice SP1	SP1
Throttle Body (THR) 	1	M28	Y	FLR91X-A or Equivalent	TP1-NS	Throttle Body (THR)	1	ECU Master (ECUM)	28
	2	M32	B	FLR91X-A or Equivalent	XDRG	Throttle Body (THR)	2	ECU Master (ECUM)	32
	3	M48	R	FLR91X-A or Equivalent	XDRP	Throttle Body (THR)	3	ECU Master (ECUM)	48
	4	M24	W	FLR91X-A or Equivalent	TP2-PS	Throttle Body (THR)	4	ECU Master (ECUM)	24
	5	M51	R	FLR91X-A or Equivalent	H1+	Throttle Body (THR)	5	ECU Master (ECUM)	51
	6	M52	Br	FLR91X-A or Equivalent	H1-	Throttle Body (THR)	6	ECU Master (ECUM)	52
Knock Sensor 1 (KNS 1) 	1	M63	Br	FLR91X-A or Equivalent	Knock Sensor 1-Negative	Knock Sensor 1 (KNS 1)	1	ECU Master (ECUM)	63
	2	M64	R	FLR91X-A or Equivalent	Knock Sensor 1-Positive	Knock Sensor 1 (KNS 1)	2	ECU Master (ECUM)	64
	3	-							
Knock Sensor 2 (KNS 2) 	1	M62	Br	FLR91X-A or Equivalent	Knock Sensor 2-Negative	Knock Sensor 2 (KNS 2)	1	ECU Master (ECUM)	62
	2	M46	R	FLR91X-A or Equivalent	Knock Sensor 2-Positive	Knock Sensor 2 (KNS 2)	2	ECU Master (ECUM)	46
	3	-							

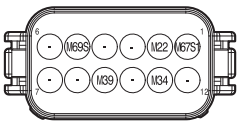
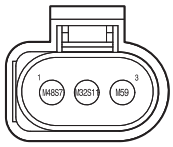
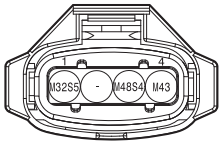
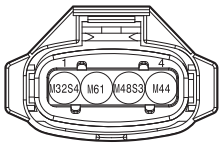
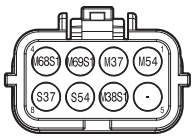
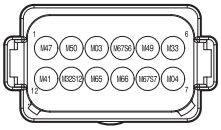
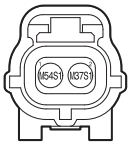
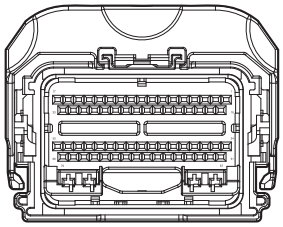
Figure	No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
Electronic Flow Regulator (EFR) 	1	M67S1	R	FLR91X-A or Equivalent	Regulator Supply	Electronic Flow Regulator (EFR)	1	Splice M67	M67
	2	M22	Y	FLR91X-A or Equivalent	Regulator Feedback	Electronic Flow Regulator (EFR)	2	ECU Master (ECUM)	22
	3	-							
	4	-							
	5	M69S	B	FLR91X-A or Equivalent	Regulator GND	Electronic Flow Regulator (EFR)	5	Splice M69	M69
	6	-							
	7	-							
	8	-							
	9	M39	Br	FLR91X-A or Equivalent	Regulator Status	Electronic Flow Regulator (EFR)	9	ECU Master (ECUM)	39
	10	-							
	11	M34	W	FLR91X-A or Equivalent	Regulator Command +	Electronic Flow Regulator (EFR)	11	ECU Master (ECUM)	34
	12	-							
Regulator Press Sensor 	1	M48S7	R	FLR91X-A or Equivalent	Regulator Press Sensor Supply	Regulator Press Sensor (RPS)	1	Splice M48	M48
	2	M32S11	B	FLR91X-A or Equivalent	Regulator Press Sensor GND	Regulator Press Sensor (RPS)	2	Splice M32	M32
	3	M59	Or	FLR91X-A or Equivalent	Regulator Press Sensor Signal	Regulator Press Sensor (RPS)	3	ECU Master (ECUM)	59
PTP (PTP) 	1	M32S5	B	FLR91X-A or Equivalent	PTP GND	PTP (PTP)	1	Splice M32	M32
	2	-							
	3	M48S4	R	FLR91X-A or Equivalent	PTP Supply	PTP (PTP)	3	Splice M48	M48
	4	M43	Or	FLR91X-A or Equivalent	PTP Signal	PTP (PTP)	4	ECU Master (ECUM)	43
TMAP Sensor (TMAP) 	1	M32S4	B	FLR91X-A or Equivalent	MAP/MAT GND	TMAP Sensor (TMAP)	1	Splice M32	M32
	2	M61	Y	FLR91X-A or Equivalent	MAT Signal	TMAP Sensor (TMAP)	2	ECU Master (ECUM)	61
	3	M48S3	R	FLR91X-A or Equivalent	MAP Supply	TMAP Sensor (TMAP)	3	Splice M48	M48
	4	M44	Br	FLR91X-A or Equivalent	MAP Signal	TMAP Sensor (TMAP)	4	ECU Master (ECUM)	44

Figure	No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
COMM. Connector (COMM) 	1	M54	Br	FLR91X-A or Equivalent	CAN2 Low - Master	COMM. Connector (COMM)	1	ECU Master (ECUM)	54
	2	M37	R	FLR91X-A or Equivalent	CAN2 High - Master	COMM. Connector (COMM)	2	ECU Master (ECUM)	37
	3	M69S1	B	FLR91X-A or Equivalent	GND	COMM. Connector (COMM)	3	Splice M69	M69
	4	M68S1	R	FLR91X-A or Equivalent	BATT+	COMM. Connector (COMM)	4	Splice M68	M68
	5	-							
	6	M38S1	Y	FLR91X-A or Equivalent	Key On (T15)	COMM. Connector (COMM)	6	Splice M38	M38
	7	S54	Br	FLR91X-A or Equivalent	CAN2 Low	Inter Connector for LH (INTL)	8	COMM. Connector (COMM)	7
	8	S37	R	FLR91X-A or Equivalent	CAN2 High	Inter Connector for LH (INTL)	9	COMM. Connector (COMM)	8
Inter Connector for TWC (INTT) 	1	M47	Or	FLR91X-A or Equivalent	UEGO-IP	Inter Connector for TWC (INTT)	1	ECU Master (ECUM)	47
	2	M50	W	FLR91X-A or Equivalent	UEGO-VM	Inter Connector for TWC (INTT)	2	ECU Master (ECUM)	50
	3	M03	Y	FLR91X-A or Equivalent	UEGO-Heater	Inter Connector for TWC (INTT)	3	ECU Master (ECUM)	3
	4	M67S6	R	FLR91X-A or Equivalent	UEGO-Supply	Inter Connector for TWC (INTT)	4	Splice M67	M67
	5	M49	Or	FLR91X-A or Equivalent	UEGO-IA	Inter Connector for TWC (INTT)	5	ECU Master (ECUM)	49
	6	M33	Br	FLR91X-A or Equivalent	UEGO-UN	Inter Connector for TWC (INTT)	6	ECU Master (ECUM)	33
	7	M04	Y	FLR91X-A or Equivalent	HEGO-Heater	Inter Connector for TWC (INTT)	7	ECU Master (ECUM)	4
	8	M67S7	R	FLR91X-A or Equivalent	HEGO-Supply	Inter Connector for TWC (INTT)	8	Splice M67	M67
	9	M66	W	FLR91X-A or Equivalent	HEGO+	Inter Connector for TWC (INTT)	9	ECU Master (ECUM)	66
	10	M65	Br	FLR91X-A or Equivalent	HEGO-RTN	Inter Connector for TWC (INTT)	10	ECU Master (ECUM)	65
	11	M32S12	B	FLR91X-A or Equivalent	EGT Sensor GND	Inter Connector for TWC (INTT)	11	Splice M32	M32
	12	M41	W	FLR91X-A or Equivalent	EGT Sensor Signal	Inter Connector for TWC (INTT)	12	ECU Master (ECUM)	41
Resistance 1 	1	M53S	B	FLR91X-A or Equivalent	CAN1 Low	Resistance 1 (R1)	1	Splice M53	M53
	2	M36S	W	FLR91X-A or Equivalent	CAN1 High	Resistance 1 (R1)	2	Splice M36	M36
Resistance 2 	1	M54S1	Br	FLR91X-A or Equivalent	CAN2 Low	Resistance 2 (R2)	1	ECU Master (ECUM)	54
	2	M37S1	R	FLR91X-A or Equivalent	CAN2 High	Resistance 2 (R2)	2	ECU Master (ECUM)	37

ECU Master (ECUM)



1	2	3	4	5
-	-	M03	M04	-
6	7	8	9	10
M06	M07	M08	-	-
11	12	13	14	15
M11	-	M13	M14	M15
16	17	18	19	20
M16	M17	M18	M19	M20
21	22	23	24	25
M21	M22	M23	M24	M25
26	27	28	29	30
M26	M27	M28	M29	M30
31	32	33	34	35
-	M32	M33	M34	-
36	37	38	39	40
M36	M37	M38	M39	M40
41	42	43	44	45
M41	M42	M43	M44	M45
46	47	48	49	50
M46	M47	M48	M49	M50
51	52	53	54	55
M51	M52	M53	M54	M55
56	57	58	59	60
M56	M57	M58	S59	M60
61	62	63	64	65
M61	M62	M63	M64	M65
66	67	68	69	70
M66	M67	M68	M69	M70

No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
1	-							
2	-							
3	M03	Y	FLR91X-A or Equivalent	UEGO-Heater	Inter Connector for TWC (INTT)	3	ECU Master (ECUM)	3
4	M04	Y	FLR91X-A or Equivalent	HEGO-Heater	Inter Connector for TWC (INTT)	7	ECU Master (ECUM)	4
5	-							
6	M06	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 1 (IGN 1)	2	ECU Master (ECUM)	6
7	M07	W	FLR91X-A or Equivalent	CAM DG_Cam Hall	Inter Connector for LH (INTL)	24	ECU Master (ECUM)	7
8	M08	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 2 (IGN 2)	2	ECU Master (ECUM)	8
9	-							
10	-							
11	M11	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 3 (IGN 3)	2	ECU Master (ECUM)	11
12	-							
13	M13	W	FLR91X-A or Equivalent	Raise Speed	INter Connector (INT)	21	ECU Master (ECUM)	13
14	M14	W	FLR91X-A or Equivalent	Lower Speed	Inter Connector (INT)	22	ECU Master (ECUM)	14
15	M15	Y	FLR91X-A or Equivalent	Shut Off#1-RH Signal	Inter Connector (INT)	3	ECU Master (ECUM)	15
16	M16	Br	FLR91X-A or Equivalent	Crank Shaft Sensor Negative	Inter Connector for LH (INTL)	10	ECU Master (ECUM)	16
17	M17	R	FLR91X-A or Equivalent	Crank Shaft Sensor Positive	Inter Connector for LH (INTL)	11	ECU Master (ECUM)	17
18	M18	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 5 (IGN 5)	2	ECU Master (ECUM)	18
19	M19	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 6 (IGN 6)	2	ECU Master (ECUM)	19
20	M20	W	FLR91X-A or Equivalent	Shut Off#2-RH Signal	Inter Connector (INT)	1	ECU Master (ECUM)	20
21	M21	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 4 (IGN 4)	2	ECU Master (ECUM)	21
22	M22	Y	FLR91X-A or Equivalent	Regulator Feedback	Electronic Flow Regulator (EFR)	2	ECU Master (ECUM)	22
23	M23	Y	FLR91X-A or Equivalent	Starter Control Relay	Inter Connector (INT)	12	ECU Master (ECUM)	23
24	M24	W	FLR91X-A or Equivalent	TP2-PS	Throttle Body (THR)	4	ECU Master (ECUM)	24

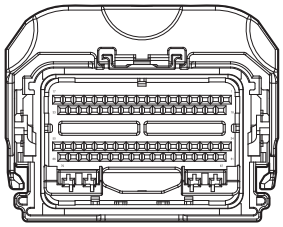
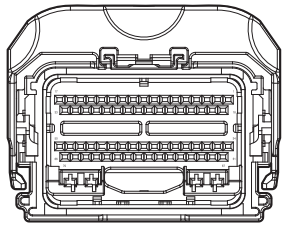
Figure	No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
ECU Master (ECUM)  1 2 3 4 5 - - M03 M04 - 6 7 8 9 10 M06 M07 M08 - - 11 12 13 14 15 M11 - M13 M14 M15 16 17 18 19 20 M16 M17 M18 M19 M20 21 22 23 24 25 M21 M22 M23 M24 M25 26 27 28 29 30 M26 M27 M28 M29 M30 31 32 33 34 35 - M32 M33 M34 - 36 37 38 39 40 M36 M37 M38 M39 M40 41 42 43 44 45 M41 M42 M43 M44 M45 46 47 48 49 50 M46 M47 M48 M49 M50 51 52 53 54 55 M51 M52 M53 M54 M55 56 57 58 59 60 M56 M57 M58 S59 M60 61 62 63 64 65 M61 M62 M63 M64 M65 66 67 68 69 70 M66 M67 M68 M69 M70	25	M25	Y	FLR91X-A or Equivalent	Run/Stop Switch	Inter Connector (INT)	16	ECU Master (ECUM)	25
	26	M26	Or	FLR91X-A or Equivalent	Fuel Type Select	Inter Connector (INT)	20	ECU Master (ECUM)	26
	27	M27	W	FLR91X-A or Equivalent	Idle Rated Switch	Inter Connector (INT)	17	ECU Master (ECUM)	27
	28	M28	Y	FLR91X-A or Equivalent	TP1-NS	Throttle Body (THR)	1	ECU Master (ECUM)	28
	29	M29	Br	FLR91X-A or Equivalent	External Shutdown	Inter Connector (INT)	18	ECU Master (ECUM)	29
	30	M30	Gr	AEXF 3core Shield	Cam Shaft Sensor Output	Inter Connector for LH (INTL)	13	ECU Master (ECUM)	30
	31	-							
	32	M32	B	FLR91X-A or Equivalent	XDRG	Throttle Body (THR)	2	ECU Master (ECUM)	32
	33	M33	Br	FLR91X-A or Equivalent	UEGO-UN	Inter Connector for TWC (INTT)	6	ECU Master (ECUM)	33
	34	M34	W	FLR91X-A or Equivalent	Regulator Command +	Electronic Flow Regulator (EFR)	11	ECU Master (ECUM)	34
	35	-							
	36	M36	W	FLR91X-A or Equivalent	CAN1 High	Inter Connector for LH (INTL)	7	ECU Master (ECUM)	36
	37	M37	R	FLR91X-A or Equivalent	CAN2 High - Master	COMM. Connector (COMM)	2	ECU Master (ECUM)	37
	38	M38	Y	FLR91X-A or Equivalent	Key On (T15)	Inter Connector (INT)	8	ECU Master (ECUM)	38
	39	M39	Br	FLR91X-A or Equivalent	Regulator Status	Electronic Flow Regulator (EFR)	9	ECU Master (ECUM)	39
	40	M40	W	FLR91X-A or Equivalent	ECT Signal	Inter Connector for LH (INTL)	17	ECU Master (ECUM)	40
	41	M41	W	FLR91X-A or Equivalent	EGT Sensor Signal	Inter Connector for TWC (INTT)	12	ECU Master (ECUM)	41
	42	M42	Br	FLR91X-A or Equivalent	AN4_Speed BIAS	Inter Connector (INT)	30	ECU Master (ECUM)	42
	43	M43	Or	FLR91X-A or Equivalent	PTP Signal	PTP (PTP)	4	ECU Master (ECUM)	43
	44	M44	Br	FLR91X-A or Equivalent	MAP Signal	TMAP Sensor (TMAP)	4	ECU Master (ECUM)	44
	45	M45	Br	FLR91X-A or Equivalent	Oil Pressure Sensor Signal	Oil Press Sensor (OPS)	1	ECU Master (ECUM)	45
	46	M46	R	FLR91X-A or Equivalent	Knock Sensor 2-Positive	Knock Sensor 2 (KNS 2)	2	ECU Master (ECUM)	46
	47	M47	Or	FLR91X-A or Equivalent	UEGO-IP	Inter Connector for TWC (INTT)	1	ECU Master (ECUM)	47

Figure	No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
ECU Master (ECUM) 	48	M48	R	FLR91X-A or Equivalent	XDRP	Throttle Body (THR)	3	ECU Master (ECUM)	48
	49	M49	Or	FLR91X-A or Equivalent	UEGO-IA	Inter Connector for TWC (INTT)	5	ECU Master (ECUM)	49
	50	M50	W	FLR91X-A or Equivalent	UEGO-VM	Inter Connector for TWC (INTT)	2	ECU Master (ECUM)	50
	51	M51	R	FLR91X-A or Equivalent	H1+	Throttle Body (THR)	5	ECU Master (ECUM)	51
	52	M52	Br	FLR91X-A or Equivalent	H1-	Throttle Body (THR)	6	ECU Master (ECUM)	52
	53	M53	B	FLR91X-A or Equivalent	CAN1 Low	Inter Connector for LH (INTL)	6	ECU Master (ECUM)	53
	54	M54	Br	FLR91X-A or Equivalent	CAN2 Low - Master	COMM. Connector (COMM)	1	ECU Master (ECUM)	54
	55	M55	Br	FLR91X-A or Equivalent	Power Relay D	Inter Connector (INT)	6	ECU Master (ECUM)	55
	56	M56	Or	FLR91X-A or Equivalent	Major Alarm Lamp	Inter Connector (INT)	9	ECU Master (ECUM)	56
	57	M57	Br	FLR91X-A or Equivalent	Minor Alarm Lamp	Inter Connector (INT)	10	ECU Master (ECUM)	57
	58	M58	W	FLR91X-A or Equivalent	MIL Lamp	Inter Connector (INT)	11	ECU Master (ECUM)	58
	59	M59	Or	FLR91X-A or Equivalent	Regulator Press Sensor Signal	Regulator Press Sensor (RPS)	3	ECU Master (ECUM)	59
	60	M60	Br	FLR91X-A or Equivalent	Starter Control	Inter Connector (INT)	19	ECU Master (ECUM)	60
	61	M61	Y	FLR91X-A or Equivalent	MAT Signal	TMAP Sensor (TMAP)	2	ECU Master (ECUM)	61
	62	M62	Br	FLR91X-A or Equivalent	Knock Sensor 2-Negative	Knock Sensor 2 (KNS 2)	1	ECU Master (ECUM)	62
	63	M63	Br	FLR91X-A or Equivalent	Knock Sensor 1-Negative	Knock Sensor 1 (KNS 1)	1	ECU Master (ECUM)	63
	64	M64	R	FLR91X-A or Equivalent	Knock Sensor 1-Positive	Knock Sensor 1 (KNS 1)	2	ECU Master (ECUM)	64
	65	M65	Br	FLR91X-A or Equivalent	HEGO-RTN	Inter Connector for TWC (INTT)	10	ECU Master (ECUM)	65
	66	M66	W	FLR91X-A or Equivalent	HEGO+	Inter Connector for TWC (INTT)	9	ECU Master (ECUM)	66
	67	M67	R	FLR91X-A or Equivalent	Main Power	Inter Connector (INT)	5	ECU Master (ECUM)	67
	68	M68	R	FLR91X-A or Equivalent	BATT+	Inter Connector (INT)	7	ECU Master (ECUM)	68
	69	M69	B	FLR91X-A or Equivalent	Engine GND	Engine GND1 (GND1)	1	ECU Master (ECUM)	69
	70	M70	B	FLR91X-A or Equivalent	GND	ECU Master (ECUM)	70	Splice M69	M69

1	2	3	4	5
-	-	M03	M04	-
6	7	8	9	10
M06	M07	M08	-	-
11	12	13	14	15
M11	-	M13	M14	M15
16	17	18	19	20
M16	M17	M18	M19	M20
21	22	23	24	25
M21	M22	M23	M24	M25
26	27	28	29	30
M26	M27	M28	M29	M30
31	32	33	34	35
-	M32	M33	M34	-
36	37	38	39	40
M36	M37	M38	M39	M40
41	42	43	44	45
M41	M42	M43	M44	M45
46	47	48	49	50
M46	M47	M48	M49	M50
51	52	53	54	55
M51	M52	M53	M54	M55
56	57	58	59	60
M56	M57	M58	S59	M60
61	62	63	64	65
M61	M62	M63	M64	M65
66	67	68	69	70
M66	M67	M68	M69	M70

4.4.2. Slave

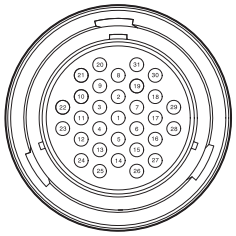
Figure	No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
Inter Connector for RH (INTR) 	1	S38	Y	FLR91X-A or Equivalent	Key On (T15)	Inter Connector for RH (INTR)	1	ECU Slave (ECUS)	38
	2	S68	R	FLR91X-A or Equivalent	BATT++	Inter Connector for RH (INTR)	2	ECU Slave (ECUS)	68
	3	IPS1	R	FLR91X-A or Equivalent	Ignition Power	Inter Connector for RH (INTR)	3	Splice SP2	SP2
	4	S67	R	FLR91X-A or Equivalent	Main Power	Inter Connector for RH (INTR)	4	ECU Slave (ECUS)	67
	5	SHD5	B	FLR91X-A or Equivalent	Shield Drain	Inter Connector for RH (INTR)	5	Shield Drain	
	6	S53	B	FLR91X-A or Equivalent	CAN1 Low	Inter Connector for RH (INTR)	6	ECU Slave (ECUS)	53
	7	S36	W	FLR91X-A or Equivalent	CAN1 High	Inter Connector for RH (INTR)	7	ECU Slave (ECUS)	36
	8	S54	Br	FLR91X-A or Equivalent	CAN2 Low	Inter Connector for RH (INTR)	8	ECU Slave (ECUS)	54
	9	S37	R	FLR91X-A or Equivalent	CAN2 High	Inter Connector for RH (INTR)	9	ECU Slave (ECUS)	37
	10	M16	Br	FLR91X-A or Equivalent	Crank Shaft Sensor Negative	Inter Connector for RH (INTR)	10	Crank Shaft Sensor (CRS)	1
	11	M17	R	FLR91X-A or Equivalent	Crank Shaft Sensor Positive	Inter Connector for RH (INTR)	11	Crank Shaft Sensor (CRS)	2
	12	M48	W	AEXF 3core Shield	Cam Shaft Sensor Supply	Inter Connector for RH (INTR)	12	Cam Shaft Sensor (CAS)	3
	13	M30	Gr	AEXF 3core Shield	Cam Shaft Sensor Output	Inter Connector for RH (INTR)	13	Cam Shaft Sensor (CAS)	2
	14	M32	BW	AEXF 3core Shield	Cam Shaft Sensor GND	Inter Connector for RH (INTR)	14	Cam Shaft Sensor (CAS)	1
	15	SHD3	B	FLR91X-A or Equivalent	Shield Drain	Inter Connector for RH (INTR)	15	Shield Drain	
	16	M32A	B	FLR91X-A or Equivalent	ECT GND	Inter Connector for RH (INTR)	16	Coolant TEMP Sensor (CTS)	2
	17	M40	W	FLR91X-A or Equivalent	ECT Signal	Inter Connector for RH (INTR)	17	Coolant TEMP Sensor (CTS)	1
	18	I25	B	FLR91X-A or Equivalent	GND	Inter Connector for RH (INTR)	18	Splice S32	S32
	19	S29	Br	FLR91X-A or Equivalent	External Shutdown	Inter Connector for RH (INTR)	19	ECU Slave (ECUS)	29
	20	S15	W	FLR91X-A or Equivalent	Shut Off#1-LH Signal	Inter Connector for RH (INTR)	20	ECU Slave (ECUS)	15
	21	S20	Y	FLR91X-A or Equivalent	Shut Off#2-LH Signal	Inter Connector for RH (INTR)	21	ECU Slave (ECUS)	20
	22	-							
	23	S25	W	FLR91X-A or Equivalent	SWG1_Frequency Select	Inter Connector for RH (INTR)	23	ECU Slave (ECUS)	25
	24	S30	Or	FLR91X-A or Equivalent	CAM DG_Cam Hall	Inter Connector for RH (INTR)	24	ECU Slave (ECUS)	30
	25	SHD6	B	FLR91X-A or Equivalent	Shield Drain	Inter Connector for RH (INTR)	25	Shield Drain	

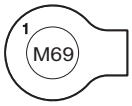
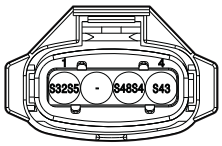
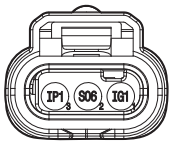
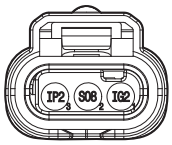
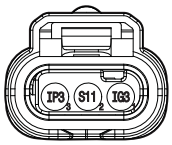
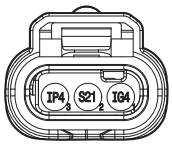
Figure	No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
Engine GND 1 (GND 1) 	1	S69	B	FLR91X-A or Equivalent	Engine GND	Engine GND1 (GND1)	1	ECU Slave (ECUS)	69
Engine GND 2 (GND 2) 	1	EGND	B	FLR91X-A or Equivalent	Ignition GND	Engine GND2 (GND2)	1	Splice SP1	SP1
PTP (PTP) 	1	S32S5	B	FLR91X-A or Equivalent	PTP GND	PTP (PTP)	1	Splice S32	S32
	2	-							
	3	S48S4	R	FLR91X-A or Equivalent	PTP Supply	PTP (PTP)	3	Splice S48	S48
	4	S43	Or	FLR91X-A or Equivalent	PTP Signal	PTP (PTP)	4	ECU Slave (ECUS)	43
Ignition 7 (IGN 7) 	1	IG1	B	FLR91X-A or Equivalent	Ignition GND	Ignition 7 (IGN 7)	1	Splice SP1	SP1
	2	S06	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 7 (IGN 7)	2	ECU Slave (ECUS)	6
	3	IP1	R	FLR91X-A or Equivalent	Ignition Supply	Ignition 7 (IGN 7)	3	Splice SP2	SP2
Ignition 8 (IGN 8) 	1	IG2	B	FLR91X-A or Equivalent	Ignition GND	Ignition 8 (IGN 8)	1	Splice SP1	SP1
	2	S08	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 8 (IGN 8)	2	ECU Slave (ECUS)	8
	3	IP2	R	FLR91X-A or Equivalent	Ignition Supply	Ignition 8 (IGN 8)	3	Splice SP2	SP2
Ignition 9 (IGN 9) 	1	IG3	B	FLR91X-A or Equivalent	Ignition GND	Ignition 9 (IGN 9)	1	Splice SP1	SP1
	2	S11	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 9 (IGN 9)	2	ECU Slave (ECUS)	11
	3	IP3	R	FLR91X-A or Equivalent	Ignition Supply	Ignition 9 (IGN 9)	3	Splice SP2	SP2
Ignition 10 (IGN 10) 	1	IG4	B	FLR91X-A or Equivalent	Ignition GND	Ignition 10 (IGN 10)	1	Splice SP1	SP1
	2	S21	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 10 (IGN 10)	2	ECU Slave (ECUS)	21
	3	IP4	R	FLR91X-A or Equivalent	Ignition Supply	Ignition 10 (IGN 10)	3	Splice SP2	SP2

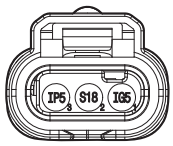
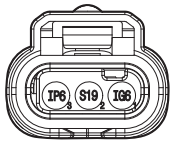
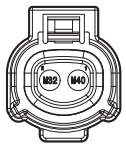
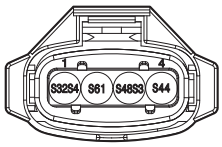
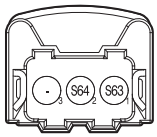
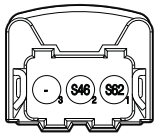
Figure	No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
Ignition 11 (IGN 11) 	1	IG5	B	FLR91X-A or Equivalent	Ignition GND	Ignition 11 (IGN 11)	1	Splice SP1	SP1
	2	S18	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 11 (IGN 11)	2	ECU Slave (ECUS)	18
	3	IP5	R	FLR91X-A or Equivalent	Ignition Supply	Ignition 11 (IGN 11)	3	Splice SP2	SP2
Ignition 12 (IGN 12) 	1	IG6	B	FLR91X-A or Equivalent	Ignition GND	Ignition 12 (IGN 12)	1	Splice SP1	SP1
	2	S19	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 12 (IGN 12)	2	ECU Slave (ECUS)	19
	3	IP6	R	FLR91X-A or Equivalent	Ignition Supply	Ignition 12 (IGN 12)	3	Splice SP2	SP2
Coolant Temp Sensor (CTS) 	1	M40	W	FLR91X-A or Equivalent	ECT Signal	Inter Connector for RH (INTR)	17	Coolant TEMP Sensor (CTS)	1
	2	M32	BW	AEXF 3core Shield	Cam Shaft Sensor GND	Inter Connector for RH (INTR)	14	Cam Shaft Sensor (CAS)	1
TMAP Sensor (TMAP) 	1	S32S4	B	FLR91X-A or Equivalent	MAP/MAT GND	TMAP Sensor (TMAP)	1	Splice S32	S32
	2	S61	Y	FLR91X-A or Equivalent	MAT Signal	TMAP Sensor (TMAP)	2	ECU Slave (ECUS)	61
	3	S48S3	R	FLR91X-A or Equivalent	MAP Supply	TMAP Sensor (TMAP)	3	Splice S48	S48
	4	S44	Br	FLR91X-A or Equivalent	MAP Signal	TMAP Sensor (TMAP)	4	ECU Slave (ECUS)	44
Knock Sensor 3 (KNS 3) 	1	S63	Br	FLR91X-A or Equivalent	Knock Sensor 3-negative	Knock Sensor 3 (KNS 3)	1	ECU Slave (ECUS)	63
	2	S64	R	FLR91X-A or Equivalent	Knock Sensor 3-positive	Knock Sensor 3 (KNS 3)	2	ECU Slave (ECUS)	64
	3	-							
Knock Sensor 4 (KNS 4) 	1	S62	Br	FLR91X-A or Equivalent	Knock Sensor 4-negative	Knock Sensor 4 (KNS 4)	1	ECU Slave (ECUS)	62
	2	S46	R	FLR91X-A or Equivalent	Knock Sensor 4-positive	Knock Sensor 4 (KNS 4)	2	ECU Slave (ECUS)	46
	3	-							

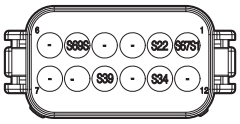
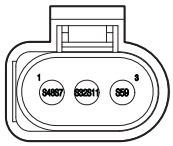
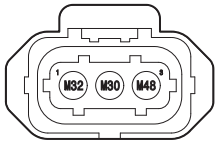
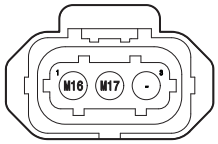
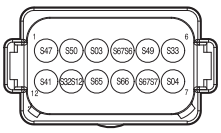
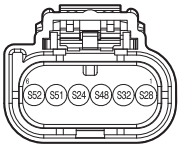
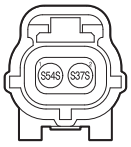
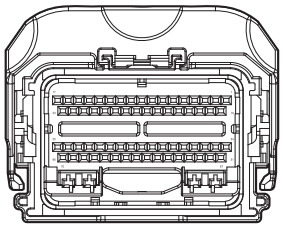
Figure	No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
Electronic Flow Regulator (EFR) 	1	S67S1	R	FLR91X-A or Equivalent	Regulator Supply	Electronic Flow Regulator (EFR)	1	Splice S67	S67
	2	S22	Y	FLR91X-A or Equivalent	Regulator Feedback	Electronic Flow Regulator (EFR)	2	ECU Slave (ECUS)	22
	3	-							
	4	-							
	5	S69S	B	FLR91X-A or Equivalent	Regulator GND	Electronic Flow Regulator (EFR)	5	Splice S69	S69
	6	-							
	7	-							
	8	-							
	9	S39	Br	FLR91X-A or Equivalent	Regulator Status	Electronic Flow Regulator (EFR)	9	ECU Slave (ECUS)	39
	10	-							
	11	S34	W	FLR91X-A or Equivalent	Regulator Command +	Electronic Flow Regulator (EFR)	11	ECU Slave (ECUS)	34
	12	-							
Regulator Press Sensor (RPS) 	1	S48S7	R	FLR91X-A or Equivalent	Regulator Press Sensor Supply	Regulator Press Sensor (RPS)	1	Splice S48	S48
	2	S32S11	B	FLR91X-A or Equivalent	Regulator Press Sensor GND	Regulator Press Sensor (RPS)	2	Splice S32	S32
	3	S59	Or	FLR91X-A or Equivalent	Regulator Press Sensor Signal	Regulator Press Sensor (RPS)	3	ECU Slave (ECUS)	59
Cam Shaft Speed Sensor (CAS) 	1	M32	BW	AEXF 3core Shield	Cam Shaft Sensor GND	Inter Connector for RH (INTR)	14	Cam Shaft Sensor (CAS)	1
	2	M30	Gr	AEXF 3core Shield	Cam Shaft Sensor Output	Inter Connector for RH (INTR)	13	Cam Shaft Sensor (CAS)	2
	3	M48	W	AEXF 3core Shield	Cam Shaft Sensor Supply	Inter Connector for RH (INTR)	12	Cam Shaft Sensor (CAS)	3
Crank Shaft Speed Sensor (CRS) 	1	M16	Br	FLR91X-A or Equivalent	Crank Shaft Sensor Negative	Inter Connector for RH (INTR)	10	Crank Shaft Sensor (CRS)	1
	2	M17	R	FLR91X-A or Equivalent	Crank Shaft Sensor Positive	Inter Connector for RH (INTR)	11	Crank Shaft Sensor (CRS)	2
	3	-							

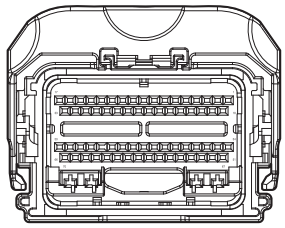
Figure	No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
Inter Connector for TWC (INTT) 	1	S47	Or	FLR91X-A or Equivalent	UEGO-IP	Inter Connector for TWC (INTT)	1	ECU Slave (ECUS)	47
	2	S50	W	FLR91X-A or Equivalent	UEGO-VM	Inter Connector for TWC (INTT)	2	ECU Slave (ECUS)	50
	3	S03	Y	FLR91X-A or Equivalent	UEGO-Heater	Inter Connector for TWC (INTT)	3	ECU Slave (ECUS)	3
	4	S67S6	R	FLR91X-A or Equivalent	UEGO-Supply	Inter Connector for TWC (INTT)	4	Splice S67	S67
	5	S49	Or	FLR91X-A or Equivalent	UEGO-IA	Inter Connector for TWC (INTT)	5	ECU Slave (ECUS)	49
	6	S33	Br	FLR91X-A or Equivalent	UEGO-UN	Inter Connector for TWC (INTT)	6	ECU Slave (ECUS)	33
	7	S04	Y	FLR91X-A or Equivalent	HEGO-Heater	Inter Connector for TWC (INTT)	7	ECU Slave (ECUS)	4
	8	S67S7	R	FLR91X-A or Equivalent	HEGO-Supply	Inter Connector for TWC (INTT)	8	Splice S67	S67
	9	S66	W	FLR91X-A or Equivalent	HEGO+	Inter Connector for TWC (INTT)	9	ECU Slave (ECUS)	66
	10	S65	Br	FLR91X-A or Equivalent	HEGO-RTN	Inter Connector for TWC (INTT)	10	ECU Slave (ECUS)	65
	11	S32S12	B	FLR91X-A or Equivalent	EGT Sensor GND	Inter Connector for TWC (INTT)	11	Splice S32	S32
	12	S41	W	FLR91X-A or Equivalent	EGT Sensor Signal	Inter Connector for TWC (INTT)	12	ECU Slave (ECUS)	41
Throttle Body (THR) 	1	S28	Y	FLR91X-A or Equivalent	TP1-NS	Throttle Body (THR)	1	ECU Slave (ECUS)	28
	2	S32	B	FLR91X-A or Equivalent	XDRG	Throttle Body (THR)	2	ECU Slave (ECUS)	32
	3	S48	R	FLR91X-A or Equivalent	XDRP	Throttle Body (THR)	3	ECU Slave (ECUS)	48
	4	S24	W	FLR91X-A or Equivalent	TP2-PS	Throttle Body (THR)	4	ECU Slave (ECUS)	24
	5	S51	R	FLR91X-A or Equivalent	H1+	Throttle Body (THR)	5	ECU Slave (ECUS)	51
	6	S52	Br	FLR91X-A or Equivalent	H1-	Throttle Body (THR)	6	ECU Slave (ECUS)	52
Resistance 1 (R1) 	1	S53S1	B	FLR91X-A or Equivalent	CAN1 Low	Resistance 1 (R1)	1	Splice S53	S53
	2	S36S1	W	FLR91X-A or Equivalent	CAN1 High	Resistance 1 (R1)	2	Splice S36	S36
Resistance 2 (R2) 	1	S54S	Br	FLR91X-A or Equivalent	CAN2 Low	Resistance 2 (R2)	1	Splice S54	S54
	2	S37S	R	FLR91X-A or Equivalent	CAN2 High	Resistance 2 (R2)	2	Splice S37	S37

ECU Slave (ECUS)

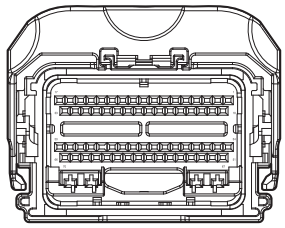


1	2	3	4	5
-	-	S03	S04	-
6	7	8	9	10
S06	-	S08	-	-
11	12	13	14	15
S11	-	-	-	S15
16	17	18	19	20
-	-	S18	S19	S20
21	22	23	24	25
S21	S22	-	S24	S25
26	27	28	29	30
-	-	S28	S29	S30
31	32	33	34	35
-	S32	S33	S34	-
36	37	38	39	40
S36	S37	S38	S39	-
41	42	43	44	45
S41	-	S43	S44	-
46	47	48	49	50
S46	S47	S48	S49	S50
51	52	53	54	55
S51	S52	S53	S54	-
56	57	58	59	60
-	-	-	S59	-
61	62	63	64	65
S61	S62	S63	S64	S65
66	67	68	69	70
S66	S67	S68	S69	S70

No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
1	-							
2	-							
3	S03	Y	FLR91X-A or Equivalent	UEGO-Heater	Inter Connector for TWC (INTT)	3	ECU Slave (ECUS)	3
4	S04	Y	FLR91X-A or Equivalent	HEGO-Heater	Inter Connector for TWC (INTT)	7	ECU Slave (ECUS)	4
5	-							
6	S06	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 7 (IGN 7)	2	ECU Slave (ECUS)	6
7	-							
8	S08	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 8 (IGN 8)	2	ECU Slave (ECUS)	8
9	-							
10	-							
11	S11	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 9 (IGN 9)	2	ECU Slave (ECUS)	11
12	-							
13	-							
14	-							
15	S15	W	FLR91X-A or Equivalent	Shut Off#1 - LH Signal	Inter Connector for RH (INTR)	20	ECU Slave (ECUS)	15
16	-							
17	-							
18	S18	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 11 (IGN 11)	2	ECU Slave (ECUS)	18
19	S19	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 12 (IGN 12)	2	ECU Slave (ECUS)	19
20	S20	Y	FLR91X-A or Equivalent	Shut Off#2 - LH Signal	Inter Connector for RH (INTR)	21	ECU Slave (ECUS)	20
21	S21	Y	FLR91X-A or Equivalent	Ignition Signal	Ignition 10 (IGN 10)	2	ECU Slave (ECUS)	21
22	S22	Y	FLR91X-A or Equivalent	Regulator Feedback	Electronic Flow Regulator (EFR)	2	ECU Slave (ECUS)	22
23	-							
24	S24	W	FLR91X-A or Equivalent	TP2-PS	Throttle Body (THR)	4	ECU Slave (ECUS)	24

Figure	No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
ECU Slave (ECUS) 	25	S25	W	FLR91X-A or Equivalent	SWG1_Frequency Select	Inter Connector for RH (INTR)	23	ECU Slave (ECUS)	25
	26	-							
	27	-							
	28	S28	Y	FLR91X-A or Equivalent	TP1-NS	Throttle Body (THR)	1	ECU Slave (ECUS)	28
	29	S29	Br	FLR91X-A or Equivalent	External Shutdown	Inter Connector for RH (INTR)	19	ECU Slave (ECUS)	29
	30	S30	Or	FLR91X-A or Equivalent	CAM DG_CAM Hall	Inter Connector for RH (INTR)	24	ECU Slave (ECUS)	30
	31	-							
	32	S32	B	FLR91X-A or Equivalent	XDRG	Throttle Body (THR)	2	ECU Slave (ECUS)	32
	33	S33	Br	FLR91X-A or Equivalent	UEGO-UN	Inter Connector for TWC (INTT)	6	ECU Slave (ECUS)	33
	34	S34	W	FLR91X-A or Equivalent	Regulator Command +	Electronic Flow Regulator (EFR)	11	ECU Slave (ECUS)	34
	35	-							
	36	S36	W	FLR91X-A or Equivalent	CAN1 High	Inter Connector for RH (INTR)	7	ECU Slave (ECUS)	36
	37	S37	R	FLR91X-A or Equivalent	CAN2 High	Inter Connector for RH (INTR)	9	ECU Slave (ECUS)	37
	38	S38	Y	FLR91X-A or Equivalent	Key On (T15)	Inter Connector for RH (INTR)	1	ECU Slave (ECUS)	38
	39	S39	Br	FLR91X-A or Equivalent	Regulator Status	Electronic Flow Regulator (EFR)	9	ECU Slave (ECUS)	39
	40	-							
	41	S41	W	FLR91X-A or Equivalent	EGT Sensor Signal	Inter Connector for TWC (INTT)	12	ECU Slave (ECUS)	41
	42	-							
	43	S43	Or	FLR91X-A or Equivalent	PTP Signal	PTP (PTP)	4	ECU Slave (ECUS)	43
	44	S44	Br	FLR91X-A or Equivalent	MAP Signal	TMAP Sensor (TMAP)	4	ECU Slave (ECUS)	44
	45	-							
	46	S46	R	FLR91X-A or Equivalent	Knock Sensor 4-positive	Knock Sensor 4 (KNS 4)	2	ECU Slave (ECUS)	46
	47	S47	Or	FLR91X-A or Equivalent	UEGO-IP	Inter Connector for TWC (INTT)	1	ECU Slave (ECUS)	47

1	2	3	4	5
-	-	S03	S04	-
6	7	8	9	10
S06	-	S08	-	-
11	12	13	14	15
S11	-	-	-	S15
16	17	18	19	20
-	-	S18	S19	S20
21	22	23	24	25
S21	S22	-	S24	S25
26	27	28	29	30
-	-	S28	S29	S30
31	32	33	34	35
-	S32	S33	S34	-
36	37	38	39	40
S36	S37	S38	S39	-
41	42	43	44	45
S41	-	S43	S44	-
46	47	48	49	50
S46	S47	S48	S49	S50
51	52	53	54	55
S51	S52	S53	S54	-
56	57	58	59	60
-	-	-	S59	-
61	62	63	64	65
S61	S62	S63	S64	S65
66	67	68	69	70
S66	S67	S68	S69	S70

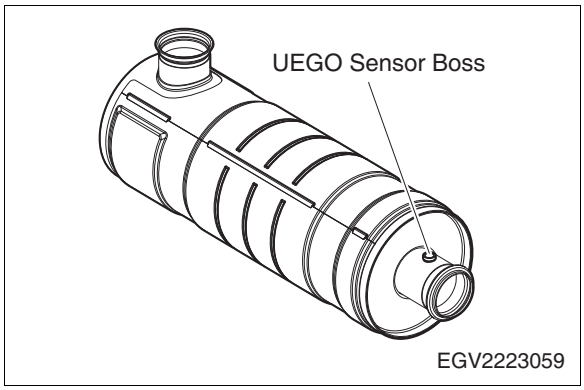
Figure	No.	Circuit	Color	Insulation	Circuit Description	From	Pin	To	Pin
ECU Slave (ECUS) 	48	S48	R	FLR91X-A or Equivalent	XDRP	Throttle Body (THR)	3	ECU Slave (ECUS)	48
	49	S49	Or	FLR91X-A or Equivalent	UEGO-IA	Inter Connector for TWC (INTT)	5	ECU Slave (ECUS)	49
	50	S50	W	FLR91X-A or Equivalent	UEGO-VM	Inter Connector for TWC (INTT)	2	ECU Slave (ECUS)	50
	51	S51	R	FLR91X-A or Equivalent	H1+	Throttle Body (THR)	5	ECU Slave (ECUS)	51
	52	S52	Br	FLR91X-A or Equivalent	H1-	Throttle Body (THR)	6	ECU Slave (ECUS)	52
	53	S53	B	FLR91X-A or Equivalent	CAN1 Low	Inter Connector for RH (INTR)	6	ECU Slave (ECUS)	53
	54	S54	Br	FLR91X-A or Equivalent	CAN2 Low	Inter Connector for RH (INTR)	8	ECU Slave (ECUS)	54
	55	-							
	56	-							
	57	-							
	58	-							
	59	S59	Or	FLR91X-A or Equivalent	Regulator Press Sensor Signal	Regulator Press Sensor (RPS)	3	ECU Slave (ECUS)	59
	60	-							
	61	S61	Y	FLR91X-A or Equivalent	MAT Signal	TMAP Sensor (TMAP)	2	ECU Slave (ECUS)	61
	62	S62	Br	FLR91X-A or Equivalent	Knock Sensor 4-negative	Knock Sensor 4 (KNS 4)	1	ECU Slave (ECUS)	62
	63	S63	Br	FLR91X-A or Equivalent	Knock Sensor 3-negative	Knock Sensor 3 (KNS 3)	1	ECU Slave (ECUS)	63
	64	S64	R	FLR91X-A or Equivalent	Knock Sensor 3-positive	Knock Sensor 3 (KNS 3)	2	ECU Slave (ECUS)	64
	65	S65	Br	FLR91X-A or Equivalent	HEGO-RTN	Inter Connector for TWC (INTT)	10	ECU Slave (ECUS)	65
	66	S66	W	FLR91X-A or Equivalent	HEGO+	Inter Connector for TWC (INTT)	9	ECU Slave (ECUS)	66
	67	S67	R	FLR91X-A or Equivalent	Main Power	Inter Connector for RH (INTR)	4	ECU Slave (ECUS)	67
	68	S68	R	FLR91X-A or Equivalent	BATT++	Inter Connector for RH (INTR)	2	ECU Slave (ECUS)	68
	69	S69	B	FLR91X-A or Equivalent	Engine GND	Engine GND1 (GND1)	1	ECU Slave (ECUS)	69
	70	S70	B	FLR91X-A or Equivalent	Engine GND	ECU Slave (ECUS)	70	Splice S69	S69

1	2	3	4	5
-	-	S03	S04	-
6	7	8	9	10
S06	-	S08	-	-
11	12	13	14	15
S11	-	-	-	S15
16	17	18	19	20
-	-	S18	S19	S20
21	22	23	24	25
S21	S22	-	S24	S25
26	27	28	29	30
-	-	S28	S29	S30
31	32	33	34	35
-	S32	S33	S34	-
36	37	38	39	40
S36	S37	S38	S39	-
41	42	43	44	45
S41	-	S43	S44	-
46	47	48	49	50
S46	S47	S48	S49	S50
51	52	53	54	55
S51	S52	S53	S54	-
56	57	58	59	60
-	-	-	S59	-
61	62	63	64	65
S61	S62	S63	S64	S65
66	67	68	69	70
S66	S67	S68	S69	S70

5. After Treatment System

5.1. General Information

A three-way catalyst is applied as an after-treatment device to meet the strict emission regulations.



5.2. Three Way Catalyst

The aftertreatment system which applied to the GV22 is a three-way catalytic muffler that simultaneously reduces nitrogen oxides (NOx), carbon monoxide (CO), and hydrocarbons (HC) among exhaust gas components.

In addition, by applying a catalyst to the existing silencer, it also functions as a silencer.

The three-way catalyst device is a device that reduces harmful exhaust gas by using engine control and catalysts, and does not require a separate injection device or urea solution.

The chemical mechanism for exhaust gas reduction of the three-way catalyst device is shown below.

Oxidation : Carbon monoxide (CO) and hydrocarbons (HC) are oxidized to harmless carbon dioxide (CO_2) and water (H_2O).

$C_xH_y + (x + y/4)\ O_2 \rightarrow x\ CO_2 + y/2\ H_2O$

$CO + 1/2\ O_2 \rightarrow CO_2$

Reduction : Nitrogen oxides (NOx) is reduced harmless carbon dioxide (CO_2) and water (H_2O).

$NO + CO \rightarrow 1/2\ N_2 + CO_2$

$NO + H_2 \rightarrow 1/2\ N_2 + H_2O$

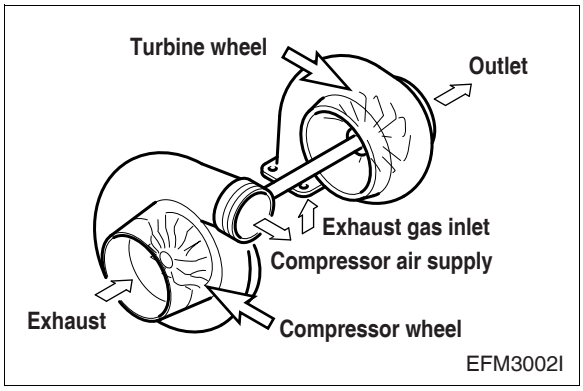
$(2 + y/2)\ NO + C_xH_y \rightarrow (1 + y/4)\ N_2 + x\ CO_2 + Y/2\ H_2O$

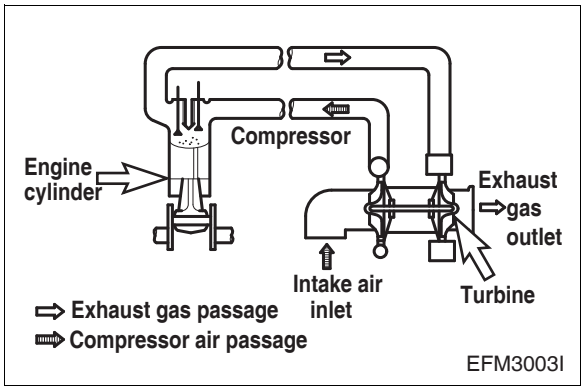
6. Maintenance of Major Parts

6.1. Turbocharger General Information

6.1.1. General information

- The engine output depends upon the supplied fuel quantity and the engine efficiency. In order to transform into the effective work of engine by burning the supplied fuel fully, the sufficient air to burn the fuel should be supplied to the cylinder.
- Therefore, the engine output is essentially determined by the size of the cylinder, and for if the air is supplied to the given volume of cylinder with the air being compressed, the air quantity in the cylinder will Increase as much to result in that it may burn more fuel, the output will also be able to increase.
- Supplying the air by compressing like this into the engine cylinder is called as supercharging, and super charging by means of exhaust gas energy that discharges to the atmosphere is called as the turbocharging.





6.1.2. Function

1) Turbine

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

2) Compressor

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

3) Bearing

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

4) Sealing at compressor shaft

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

6.1.3. How to handle the engine

1) Precautions for operation of the engine

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

Operation	Caution	Reason
At starting	1) Inspect oil quantity 2) After confirming that oil pressure rises by starting engine with starter (until the pointer of oil pressure gauge moves or pressure indicating lamp operates), the starting must be done. 3) In case that oil, oil filter and lubricating system's part are replaced or engine was stalled for long time (more than a week), and in case of operation under cold weather, loosen the oil pipe connecting parts of turbocharger inlet, and operate the starting motor until oil comes out the connecting parts. Care must be paid that after the confirming above, retighten the pipe connecting parts without fail, and proceed with the normal starting.	2) If engine is started quickly, of course beginning with every parts of engine, for it revolves without oil that is to reach to the turbocharger, the bearing's abnormal wear or stuck may be caused. 3) In case that engine stalled for long time and of cold weather, the fluidity of oil may be get worse.
Immediately after starting	1) Perform idling operation for about 5 min. immediately after engine starting. 2) Various inspections must insure that there are no leakage of oil, gas and air.	1) Sudden load at time soon after engine starting and at the state when turbocharger did not yet reach to smooth revolution , if abrupt load is applied to engine, some parts where oil did still not reach may cause a burn to be stuck. 2) If there are the leakage of oil, gas, air, particularly oil, for the oil pressure lowers, it causes a burn of bearing to be stuck.
During operation	Following items must be confirmed. 1) Oil pressure at idling: 0.9 ~ 3.0 bar at full load: 3.0 ~ 6.5 bar 2) When abnormal noises and vibration are generated, slow down the revolution and must stop it to investigate the causes.	1) If the pressure is too low, abnormal wear or stuck may be caused. Or if too high, the oil leak may be generated. 2) If the engine operation were continued with abnormal noises and vibration, it causes the engine trouble that can not be repaired or some other troubles.

Operation	Caution	Reason
At stop	1) At stopping the engine, perform the idling operation for 5 min. and then stop it.	1) After heavy load operation, if the engine were stopped suddenly, the heat would be conducted to bearing parts from red hot turbine wings that would result in burning the oil to cause the stuck bearing metal and revolving shaft.

6.1.4. Routine inspection and maintenance

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

1) Air intake system

- Dry type filter, according to the indication of a dust indicator, cleaning must be done to make the intake air resistance as small as possible.

2) Exhaust system

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

3) Lubricating system

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

6.1.5. Trouble cause diagnosis and remedy

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

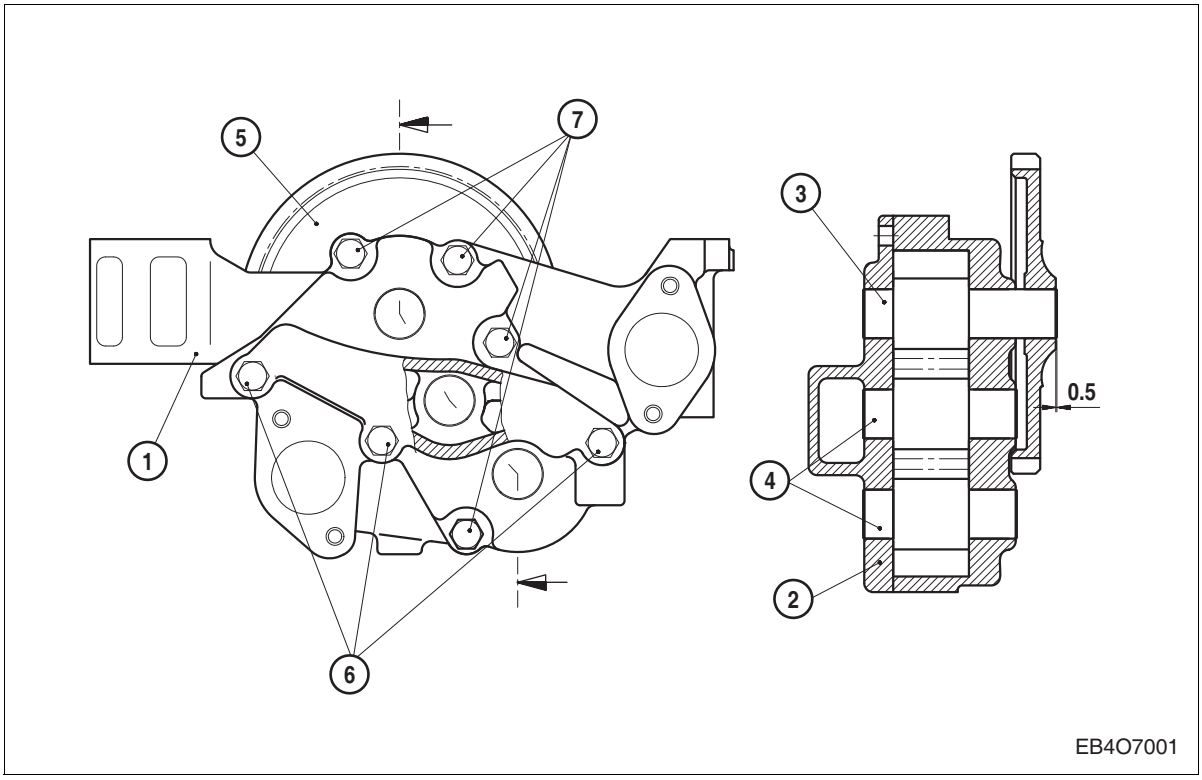
6.2. Lubricating System

● Lubricating oil pumped by the gear oil pump in the oil pan is filtrated in the oil filter. This filtrated oil passed on the oil cooler and next the main oil gallery of the cylinder block where is distributed to lubricate the various sliding parts and turbocharger etc also in order to ensure normal engine performance.

6.2.1. Specifications

Item	Specifications	Item	Specifications
Lubricating system	Forced pressure circulation	Oil filter type	Full flow
Oil pump type	Gear type	Filter element type	Cartridge type
Relief valve opening pressure	10 -1.0 kg/cm^2	Bypass valve opening pressure	2.5 ±0.3 kg/cm^2
Adjusting valve for spray nozzle opening pressure	1.5 - 1.9 kg/cm^2	Bypass for oil cooler valve opening pressure	5.0 ±0.5 kg/cm^2

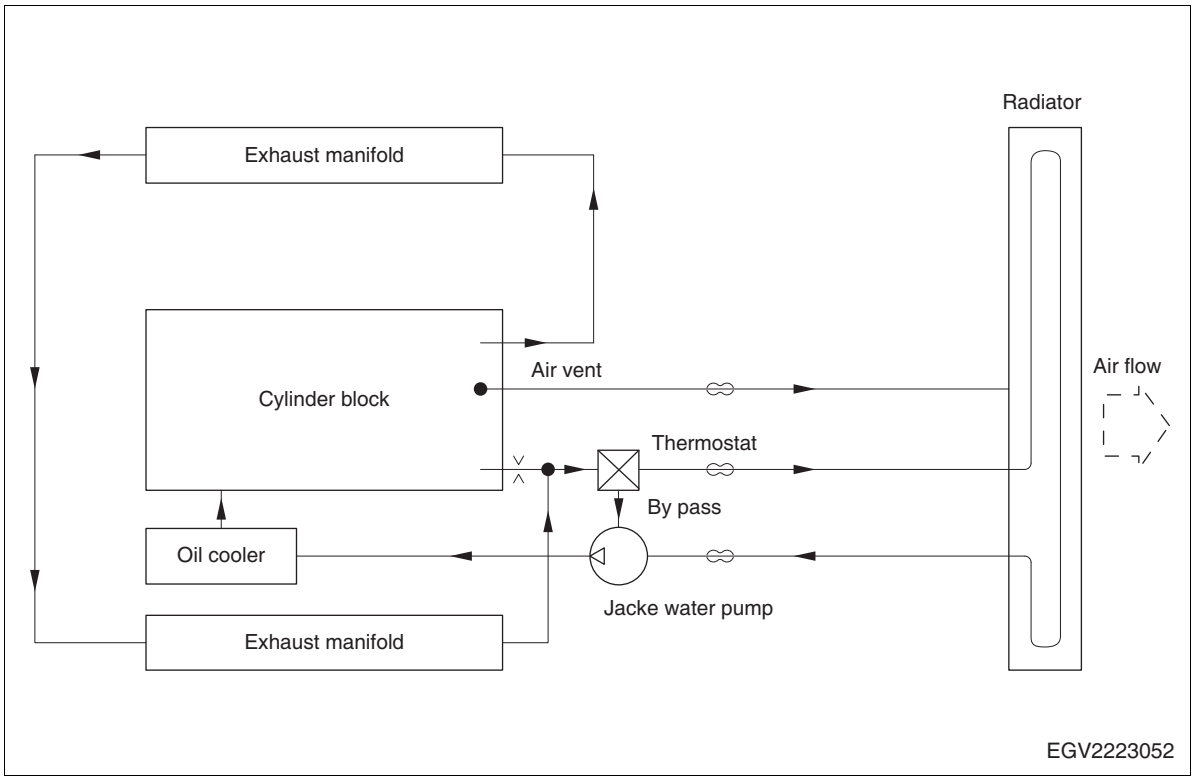
6.2.2. Oil pump



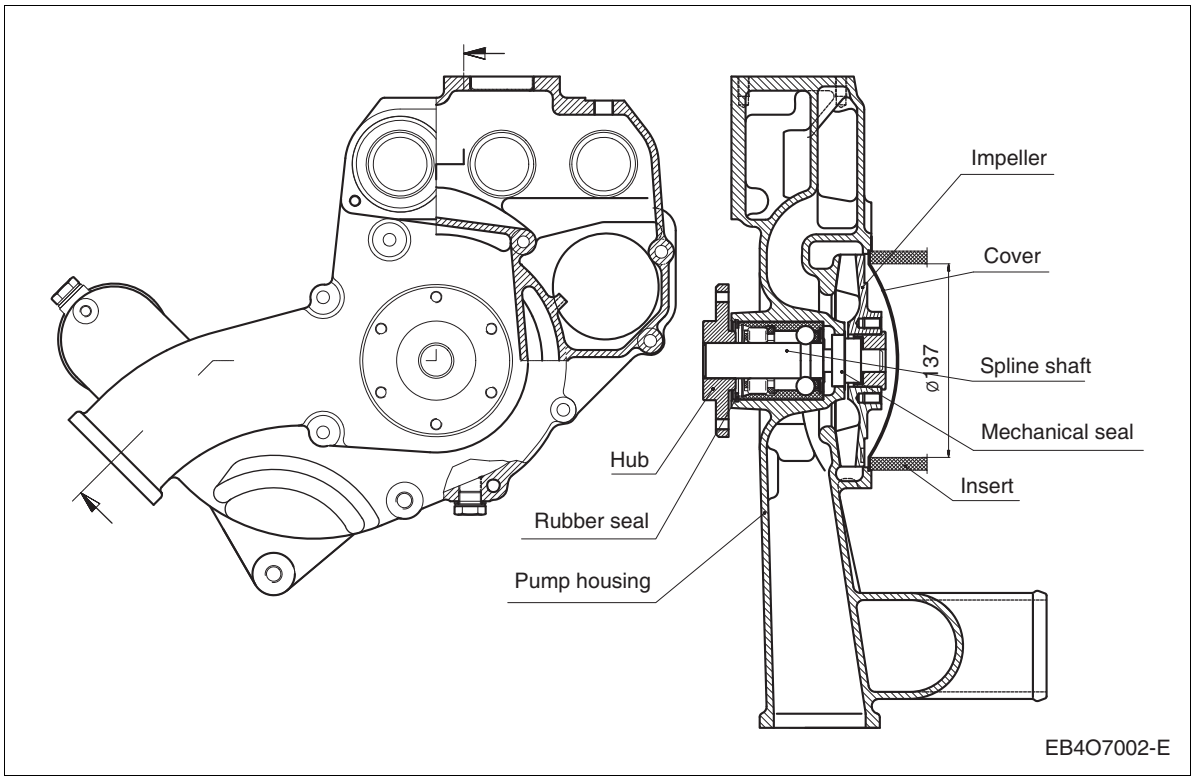
1. Oil pump housing
2. Cover
3. Oil pump gear
4. Oil pump gear
5. Oil pump drive gear
6, 7. Hex bolt

6.3. Cooling System

- The engine has a liquid-cooling system. The water pump is a maintenance-free impeller pump driven by v-belts from the crankshaft pulley.



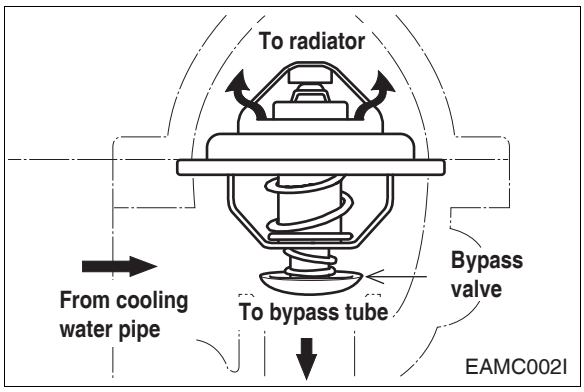
6.3.1. Cooling water pump



6.4. Thermostat

6.4.1. General descriptions and main data

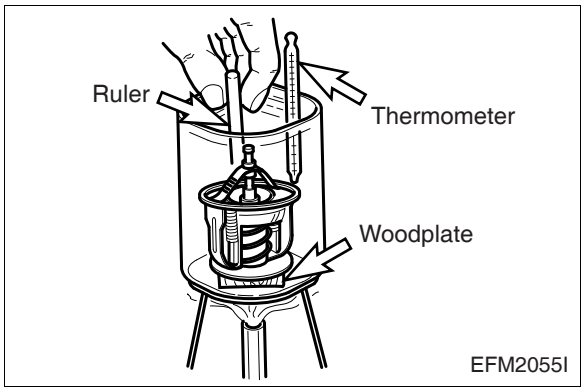
- The thermostat maintains a constant temperature of coolant (90 - 95°C) and improves thermal efficiency of the engine by preventing heat loss.
- Namely, when the temperature of coolant is low, the thermostat valve is closed to make the coolant bypass to directly enter the water pump; when the coolant temperature rises to open wide the thermostat valve, the bypass circuit is closed and the water passage to the radiator is opened so that the coolant is forced to flow into the radiator.



Item	Specification	
Part No.	300738- 00159	300738-00161
Type	Wax-pallet type	
Open temperature	71°C	83°C
Full open temperature	85°C	95°C
Valve lift	8 mm or more	

6.4.2. Inspecting

- Check the wax pallet and spring for damage.
- Put the thermostat in a container of water, then heat the water slowly and check temperature with a thermometer.
  If the valve lift is 0.1 mm (starting to open) at temperature of 71°C (Opening temperature) at and 8 mm or more (opening wide) at temperature of 85°C (Full opening temperature), the thermostat is normal.



No.	Opening temperature	Full opening temperature
300738 -00159	71°C	85°C
300738-00161	83°C	95°C

6.4.3. Replacing thermostat and precautions for handling

- Precautions for handling

  The wax pallet type thermostat does not react as quickly as bellows type one to a variation of temperature of coolant. Such relatively slow reaction is mainly due to the large heat capacity of the wax pellet type thermostat. Therefore, to avoid a sharp rise of coolant temperature, it is essential to idle the engine sufficiently before running it. In cold weather, do not run the engine at overload or overspeed it immediately after starting off.
- When draining out or replenishing coolant, doing it slowly so that air is bleed sufficiently from the entire cooling system.
- Replacing thermostat

  If the thermostat is detected defective, replace with a new one.

6.4.4. Diagnostics and troubleshooting

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

6.5. V-Belts

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

6.5.1. Change the belts if necessary

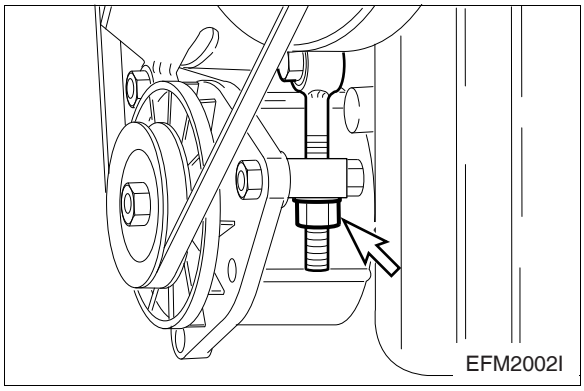
- If in the case of a multiple belt drive, wear or differing tensions are found, always replace the complete set of belts.

6.5.2. Checking condition

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

6.5.3. Testing by hand

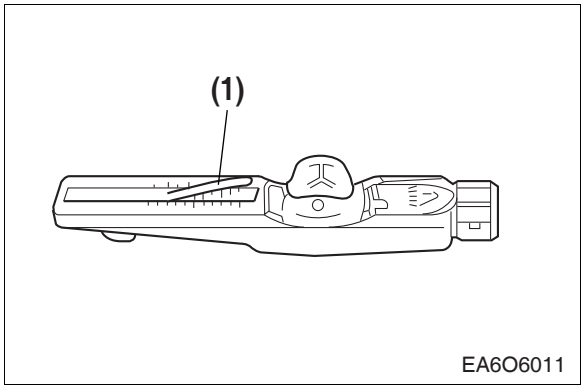
- By the finger-pressure the belt is pressed by 10 ~ 15 mm between the pulleys in normal condition. (Pressed midway between the belt pulleys)
- A more precise check of the V-belt tension is possible only by using a V-belt tension tester.



6.5.4. Measuring tension

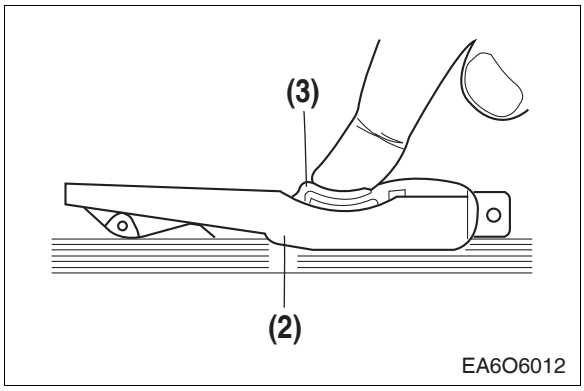
a) Lower indicator arm (1) into the scale.

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



b) Reading of tension

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



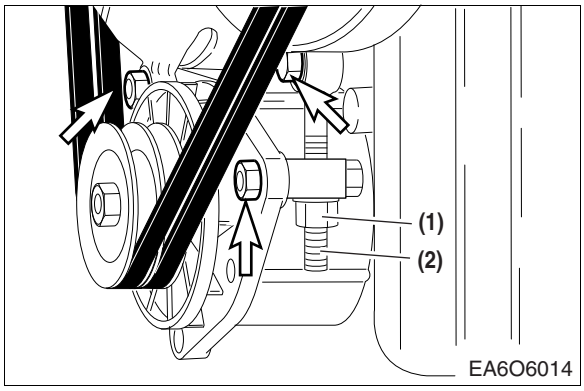
- V-belt tension

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

* : Adopted in GV222C engine

6.5.5. Tensioning and changing belts

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

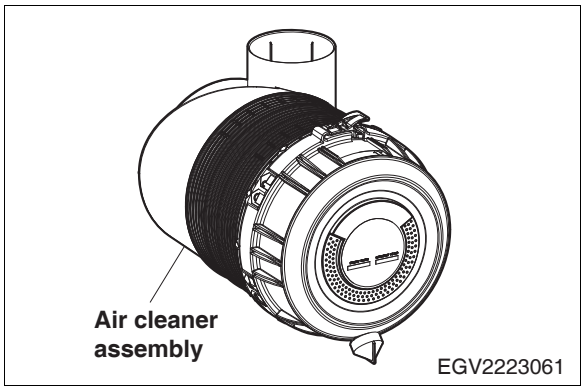


6.6. Air Intake System

6.6.1. Maintenance (with the engine stopped)

Empty the dust ejection valve regularly.

Never let the valve fill more than halfway with dust.



Caution

When removing the cover to replace the element, the valve can be detached during the disassembly and assembly. Make sure that the valve is in position after its reassembly.

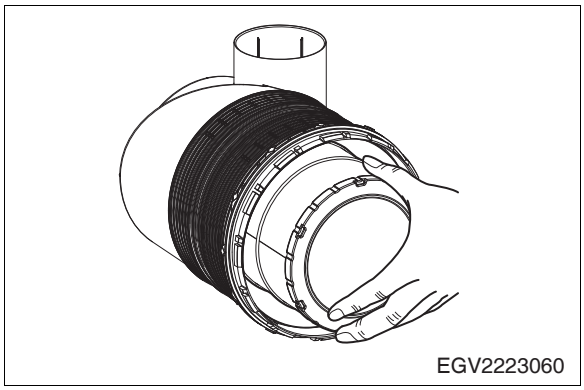
Note:

Replace it at every 500 hours.

6.6.2. Replacing the Filter Element

Caution

Make sure that dust does not enter the inside of the case



To remove the twist lock cover, raise the lift and place the cover in the open position as shown in the figure.

When removing the element, twist and pull it out to avoid damage to the gasket.

Clean the sealing surface and housing inner surface.

Insert a new element into the housing and reinstall the twist lock cover.

Place the twist lock cover in the lock position as shown in the figure, and then lower the lift to seal the air cleaner.

6.6.3. Cleaning the Filter Element

Cleaning the filter element is not recommended.

The element's dust capture capability can be deteriorated by approx. 25% compared to a new one after its cleaning. Every subsequent cleaning can further decrease such capability.

Deterioration of the dust capture capability shortens the service life of the element, leading to more frequent maintenance service and a risk of incorrect maintenance, which is an additional danger.

The filter media can be weakened and ruptured by cleaning. Even a small rupture can reduce the filter efficiency and let dust enter the engine/equipment, thereby leading to severe damage, shutdown, and repairs.

A new element features approx. 99.9% efficiency during its service life.

A cleaned element with approx. 95% efficiency passes dust into the engine 50 times more than an intact element. Nevertheless, if still decide to clean the air filter, a few risks will come along with that action.

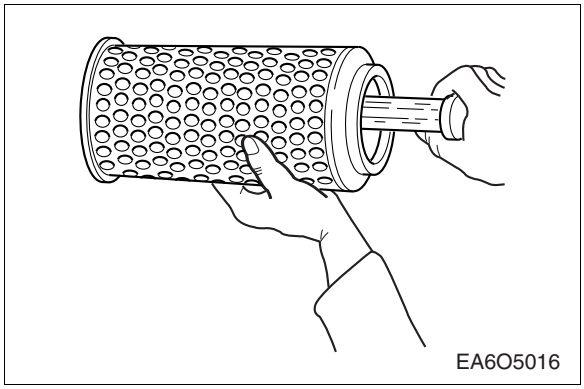
As DIY cleaning techniques and instant cleaning tools can bring considerable risks to the integrity of the element, they should be avoided.

A commercial element cleaning service is equipped with fine tools for cleaning air filters as well as the use of reliable techniques.

When using a commercial cleaning fluid, use one with high performance and an effective cleaning method.

● **Checking the filter cartridge**

- Before reinstalling the cartridge, it must be checked for damage e.g. to the paper pleats and rubber gaskets, or for bulges and dents etc. in the metal jacket.
- Cracks and holes in the paper pleating can be established by inspecting the cartridge with a flashlight.
- Damaged cartridges should not be reused under any circumstances. In cases of doubt, discard the cartridge and install a new one.



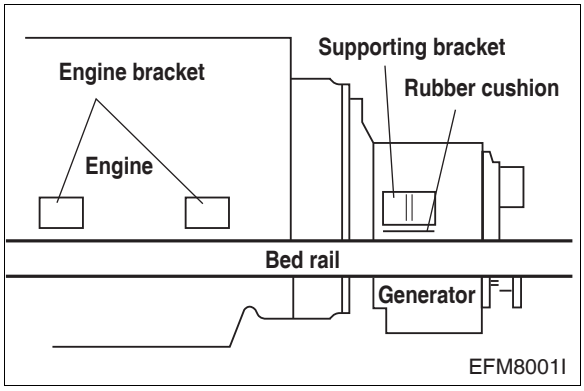
7. Engine Installation

7.1. Installing

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

7.1.1. Bed rail

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



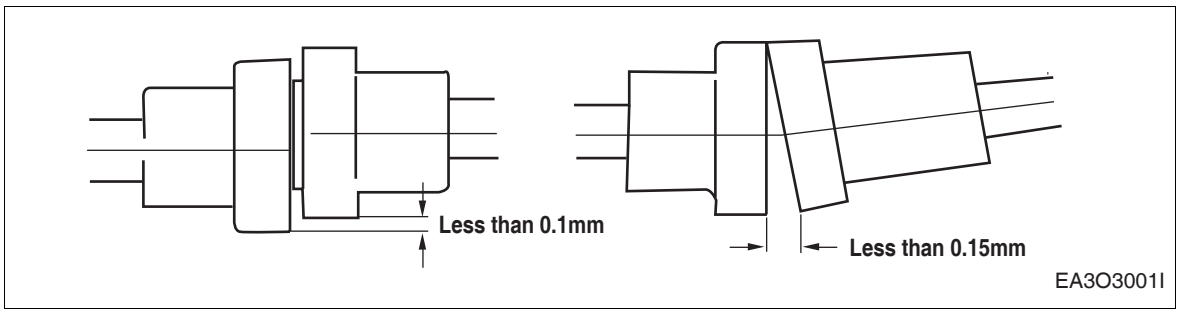
7.1.2. Supporting

- As in the engine installation, the supporting brackets are used even at the installation of Generator.
- The bracket must be solidly fixed at the Generator installing platform and the bed rail.

7.1.3. Aligning center

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

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



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

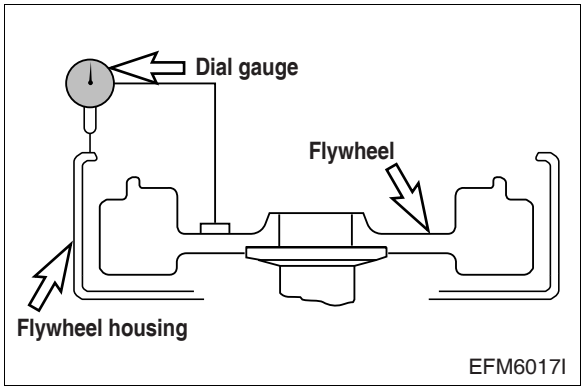
7.2. Inspection Prior to Installation

7.2.1. Inspection prior to installation

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

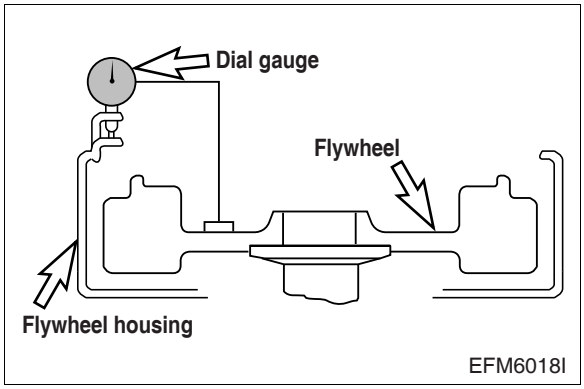
1) Measuring flywheel housing

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



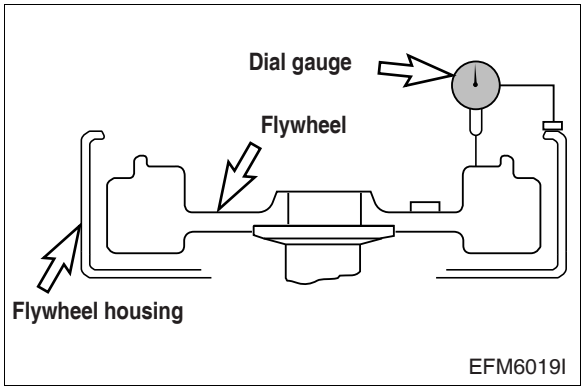
2) Measuring bore of flywheel housing

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



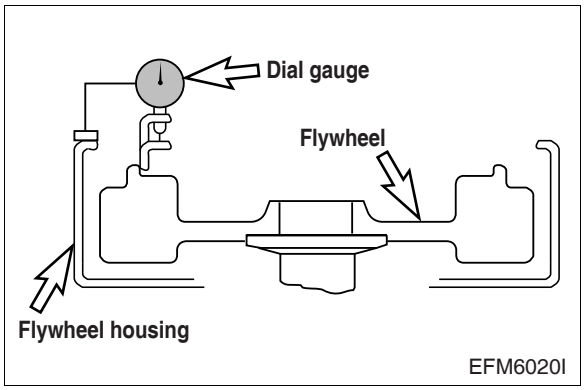
3) Measuring deformation of flywheel installing surface

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



4) Measuring pilot bore of flywheel

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



Appendix

● Standard table of tightening torque

Major Parts		Screw	Strength	Tightening Torque
Cylinder Block	Main Bearing Cap Bolt	M18 x 2.0	12.9T	30 (+3) kgf.m + 90° (+10°)
	Side Bolt	M12 x 1.5	10.9T	11.2 ±1.12 kgf.m
Oil Spray Nozzle		M6 x 1.0	10.9T	1.25 ±0.12 kgf.m
Flywheel Housing Bolt		M12 x 1.5	10.9T	11.2 ±1.12 kgf.m
		M10 x 1.5	12.9T	7.4 ±0.74 kgf.m
Damper Pulley		M16 x 1.5	12.9T	30 ±3.0 kgf.m
Conrod Bearing Bolt		M16 x 1.5	10.9T	10 (+1) kgf.m + 90° (+10°)
Flywheel Bolt		M16 x 1.5	12.9T	26 kgf.m
Head Bolt		M15X2.0	107 ~ 122 kg/mm^2	6 ±0.6 kgf.m → 90° ±9° → 90° ±9° → 90° ±9° → 30° ±3°
Head Cover Bolt		M8 x 1.25	8.8T	2.2 ±0.22 kgf.m
EX Manifold Bolt		M10 x 1.5	10.9T	6.2 ±0.62 kgf.m
Intake Manifold Bolt		M8 x 1.25	8.8T	2.2 ±0.22 kgf.m
Oil Pump		M8 x 1.25	8.8T	2.2 ±0.22 kgf.m
Oil Pan		M8 x 1.25	8.8T	2.2 ±0.22 kgf.m
Oil Cooler		M8 x 1.25	10.9T	3.1 ±0.56 kgf.m
		M10 x 1.5	10.9T	6.2 ±1.12 kgf.m
Water Pump		M8 x 1.25	8.8T	2.2 ±0.22 kgf.m
Starter		M12 x 1.5(Nut)	8.8T	8 ±2 kgf.m
Rocker Arm Bolt		M10 x 1.5	10.9T	6.2 ±0.62 kgf.m
Alternator		M12 x 1.5	8.8T	8 ± 2 kgf.m

● Tightening torque for plug screw

Diameter x pitch	M10 x 1.0	M12 x 1.5	M14 x 1.5	M16 x 1.5	M18 x 1.5	M22 x 1.5	M26 x 1.5	M30 x 1.5
Torque (kg.m)	5.0	5.0	8.0	8.0	10.0	12.0	12.0	15.0

● **Tightening torque for hollow screw(4-hole)**

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

*: Adopted in HD Construction Equipment engine

● **Standard bolt tightening torque table**

Refer to the following table for bolts other then described above

Diameter x pitch (mm)	Degree of strength										
	3.6	4.6	4.8	5.6	5.8	6.6	6.8	6.9	8.8	10.9	12.9
	(4A)	(4D)	(4S)	(5D)	(5S)	(6D)	(6S)	(6G)	(8G)	(10K)	(12K)
	Limit value for elasticity (kg/mm^2)										
	20	24	32	30	40	36	48	54	64	90	108
	Tightening torque (kg.m)										
M5	0.15	0.16	0.25	0.22	0.31	0.28	0.43	0.48	0.5	0.75	0.9
M6	0.28	0.30	0.45	0.4	0.55	0.47	0.77	0.85	0.9	1.25	1.5
M7	0.43	0.46	0.7	0.63	0.83	0.78	1.2	1.3	1.4	1.95	2.35
M8	0.7	0.75	1.1	1	1.4	1.25	1.9	2.1	2.2	3.1	3.8
M8 x 1	0.73	0.8	1.2	1.1	1.5	1.34	2.1	2.3	2.4	3.35	4.1
M10	1.36	1.4	2.2	1.9	2.7	2.35	3.7	4.2	4.4	6.2	7.4
M10 x 1	1.5	1.6	2.5	2.1	3.1	2.8	4.3	4.9	5	7	8.4
M12	2.4	2.5	3.7	3.3	4.7	4.2	6.3	7.2	7.5	10.5	12.5
M12 x 1.5	2.55	2.7	4	3.5	5	4.6	6.8	7.7	8	11.2	13.4
M14	3.7	3.9	6	5.2	7.5	7	10	11.5	12	17	20
M14 x 1.5	4.1	4.3	6.6	5.7	8.3	7.5	11.1	12.5	13	18.5	22
M16	5.6	6	9	8	11.5	10.5	17.9	18.5	18	26	31
M16 x 1.5	6.2	6.5	9.7	8.6	12.5	11.3	17	19.5	20	28	33
M18	7.8	8.3	12.5	11	16	14.5	21	24.2	25	36	43
M18 x 1.5	9.1	9.5	14.5	12.5	18.5	16.7	24.5	27.5	28	41	49
M20	11.5	12	18	16	22	19	31.5	35	36	51	60
M20 x 1.5	12.8	13.5	20.5	18	25	22.5	35	39.5	41	58	68
M22	15.5	16	24.5	21	30	26	42	46	49	67	75
M22 x 1.5	17	18.5	28	24	34	29	47	52	56	75	85
M24	20.5	21.5	33	27	40	34	55	58	63	82	92
M24 x 1.5	23	25	37	31	45	38	61	67	74	93	103

Others:

1. The above torque rating have been determined to 70% or so of the limit value for bolt elasticity.
2. Tension is calculated by multiplying tensile strength by cross section of thread.
3. Special screws should be tightened to 85% or so of the standard value.
   For example, a screw coated with MoS_2 should be tightened to 60% or so of the standard value.

● **Engine assembly tolerance**

(Unit: mm)

	Items	Specifications	Remark
Cylinder block	Inside dia. of liner forced in joint part (upper part)	ø145.800 ~ ø145.840	ø145.8 H7
	Inside dia. of liner forced in joint part (lower part)	ø144.500 ~ ø144.540	ø144.5 H7
	Inside dia. of liner color forced in part	ø153.900 ~ ø154.150	ø153.9 H11
	Liner colored surface depth	9.965 ~ 9.995	
Cylinder liner	Outside dia. of liner forced in joint part (upper)	ø145.761 ~ ø145.786	ø145.8 g6
	Outside dia. of liner forced in joint part (lower)	ø144.432 ~ ø144.457	ø144.5 f6
	Outside dia. of liner color part	ø153.65 ~ ø0153.75	ø153.8
	Liner collar height	10.03 ~ 10.05	
	Liner forced in joint part (upper)	0.014 ~ 0.099	
	Liner forced in joint part (lower)	0.043 ~ 0.108	
	Liner collar part clearance	0.150 ~ 0.500	
	Inside dia. of liner	ø127.990 ~ ø128.010	ø128 ±0.01
	Liner's roundness & columness (upper)	0.01	From top up to 168 mm
	Liner's roundness & columness (lower)	0.015	From bottom up to 85 mm
	Liner's projection	0.04 ~ 0.08	Measure at 4 place
Piston	Outside diameter of piston	ø127.739 ~ ø127.757	Measure 71.5 mm part from bottom (long length)
	Inside diameter of piston pin	ø 46.003 ~ ø46.009	
	Max. allowable weight per engine	50g	
	1st ring groove width	3.5	
	2nd ring groove width	3.040 ~ 3.060	
	Oil ring home width	4.020 ~ 4.040	
Piston ring	Top ring height (thickness)	3.075 ~ 3.095	
	2nd ring height (thickness)	2.978 ~ 2.990	
	Oil ring height (thickness)	3.97 ~ 3.99	
	Top ring axial direction clearance	0.095 ~ 0.145	
	2nd ring axial direction clearance	0.050 ~ 0.082	
	Oil ring axial direction clearance	0.030 ~ 0.070	
	Top ring end part clearance	0.30 ~ 0.45	
	2nd ring end part clearance	0.40 ~ 0.60	
	Oil ring end part clearance	0.40 ~ 0.70	
Piston pin	Piston pin's outside diameter	ø45.994 ~ ø46.000	
	Clearance between piston pin & pin hole	0.003 ~ 0.015	
Connecting rod	Con rod small end part width	38.700 ~ 39.000	
	Con rod large end part width	35.341 ~ 35.380	35.5 C8
	Con rod cap	32.800 ~ 33.100	32.8 + 0.3
	Con rod axial direction clearance	0.240 ~ 0.392	
	Con rod small end part axial direction clearance	0.064 ~ 0.126	
	Con rod bush oil clearance	0.055 ~ 0.071	
	Con rod small end inside diameter (w/h bush)	ø46.055 ~ ø46.065	

(Unit: mm)

	Items	Specifications	Remark
Connecting rod	Con rod small end inside diameter (w/o bush)	ø50.600 ~ ø50.630	ø50.6 H7
	Con rod bush's diameter	ø50.670 ~ ø50.700	
	Tighteness	0.04 ~ 0.10	
	Con rod large end part's inside diameter	ø95.000 ~ ø95.022	ø95 H6
	Con rod bearing spread (MIBA)	95.5 ~ 97.0	
	Con rod max. weight tolerance per engine	50g	
	Perpendicularity of large end inside diameter	0.035	Reference to con -rod side face
	Large end part's inside roundness & cylindricity	0.04/0.015	
	Large end part's inside straightness	0.01	
	Parallelness of small end inside with large end	0.02	
Crank shaft	Bearing housing diameter	ø111.000 ~ ø111.022	ø111H7
	Maximum shaking	ø0.05	
	Main bearing journal diameter		
	Standard	ø103.98 ~ ø104.00	
	Undersize 0.10	ø103.88 ~ ø103.90	
	Undersize 0.25	ø103.73 ~ ø103.75	
	Undersize 0.50	ø103.48 ~ ø103.50	
	Undersize 0.75	ø103.23 ~ ø103.25	
	Undersize 1.00	ø102.98 ~ ø103.00	
	Thrust bearing journal width		
	Standard	38.000 ~ 38.062	38H9
	Con rod bearing journal diameter		
	Standard	ø89.98 ~ ø90.00	
	Undersize 0.25	ø89.73 ~ ø89.75	
	Undersize 0.50	ø89.48 ~ ø89.50	
	Main bearing journal's roundness	0.005	
	Main bearing journal's cylindricity	0.010	
	Medium main bearing journal's shake	0.06	No 1, No 5 support
	Wear ring press in part's journal diameter	ø99.985 ~ ø100.020	ø100 j7
	Wear ring's inside diameter	ø99.9907 ~ ø99.942	ø100 S7
	Overlap	0.043 ~ 0.113	
	Thrust bearing width		
	Standard	37.74 ~ 37.81	
	Oversize	38.24 ~ 38.31	
	Oversize	38.74 ~ 38.81	
	Crankshaft's axial direction's clearance	0.14 ~ 0.361	
	Main bearing thickness	3.585 ~ 3.597	
	Standard	3.454 ~ 3.467	
	Oversize 0.10	3.504 ~ 3.517	
	Oversize 0.25	3.579 ~ 3.592	
	Oversize 0.50	3.704 ~ 3.717	
	Oversize 0.75	3.829 ~ 3.842	
	Oversize 1.00	3.954 ~ 3.967	
	Main bearing oil gap	0.066 ~ 0.134	
	Main bearing spread	0.3 ~ 1.2	
	Thrust bearing's spread	0.3 ~ 1.2	

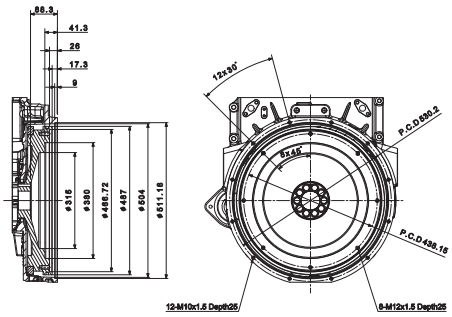
(Unit: mm)

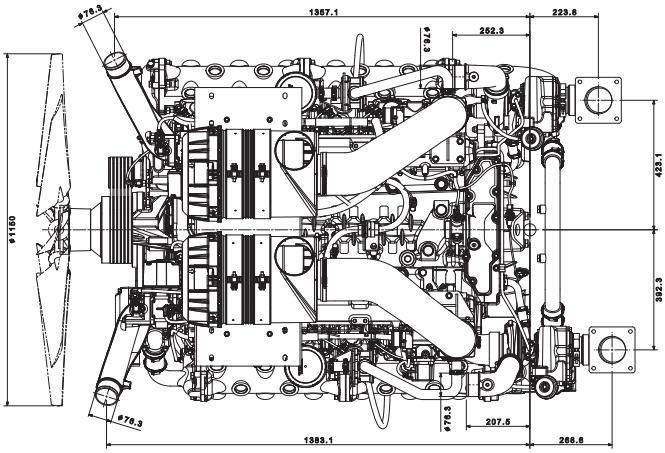
	Items	Specifications	Remark
Flywheel	Ring gear assembly part's outside diameter	ø432.490 ~ ø432.645	
	Ring gear inside diameter	ø432.000 ~ ø432.200	
	Overlap	0.290 ~ 0.645	
	Heat fitting temp. (°C)	200 ~ 230	
	Allowable shaking amount after assembly	0.5	
	Outside diameter after reassembly used ring	ø114.980 ~ ø115.015	
Cylinder head & valve	Head gasket thickness (after tightening bolts)	1.205 ~ 1.295	
	Cylinder head height	113.9 ~ 114.0	
	Cylinder head seal surface roughness	Max. 16μ	
	Valve projecting amount	-0.65 ~ -0.95	
	Exhaust valve		
	Stem diameter	ø11.954 ~ ø11.965	
	Radius direction clearance	0.045 ~ 0.083	
	Seat angle	45°	
	Head diameter	ø50.9 ~ ø51.1	
	"A" thickness of valve head	4.33 ~ 4.83	
	Valve seat part diameter of head	ø53.00 ~ ø53.03	
	Outside diameter of valve seat	ø53.10 ~ ø53.11	
	Intake valve		
	Stem diameter	ø11.935 ~ ø11.955	
	Radius direction clearance	0.035 ~ 0.064	
	Seat angle	30°	
	Head diameter	ø57.85 ~ ø58.15	
	"A" thickness of valve head	4.6 ~ 5.0	
	Valve seat part diameter of head	ø61.00 ~ ø61.03	ø61 H7
	Outside dia. of valve seat	ø61.10 ~ ø61.11	
	Depth of head's valve seat assembly part	12.5 ~ 12.6	
	Valve guide inside diameter	ø12.000 ~ ø12.018	ø12 H7
	Valve guide's inside diameter of head	ø18.000 ~ ø18.018	ø18 H7
	Valve guide's outside diameter	ø18.028 ~ ø18.046	ø18.25 S7
	Valve guide assembly locking piece	0.010 ~ 0.046	
	Valve seat's shaking	0.04	Reference to valve guide
Valve spring	Valve lift	14.1	
	Spring projecting amount of valve guide	17.1 ~ 17.5	Above valve spring
	Free length of inside spring	72.43	
	Spring load of inside spring	15 ~ 17 kg	at 46.3 mm
	Spring load of inside spring	27 ~ 32 kg	at 32.3 mm
	Free length of outside spring	61.9	
	Spring load of outside spring	44.5 ~ 49.5 kg	at 46.8 mm
	Spring load of outside spring	86 ~ 95 kg	at 32.8 mm

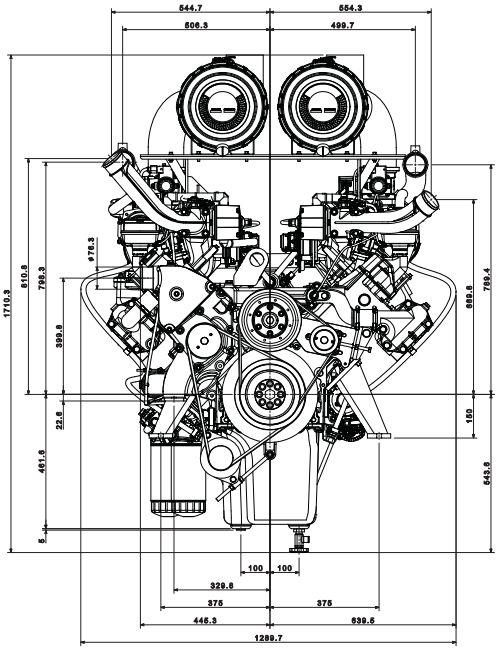
(Unit: mm)

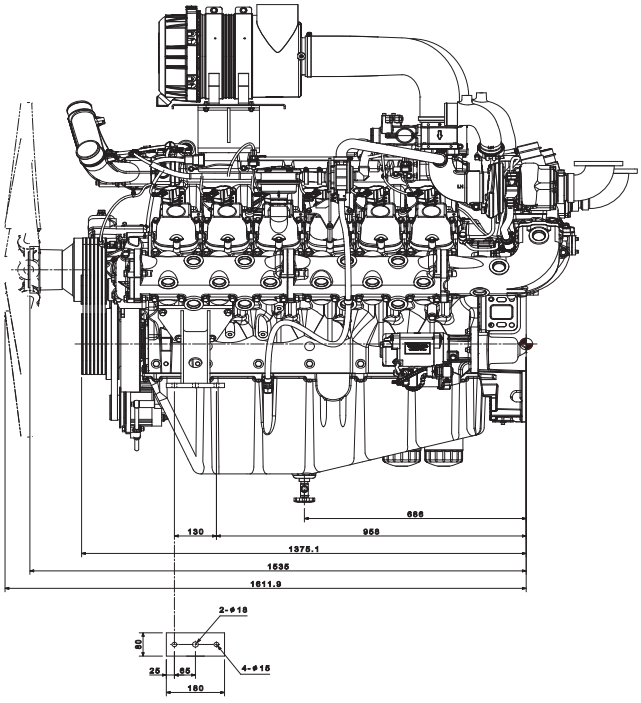
	Items	Specifications	Remark
Timing	Rocker arm bush's inside diameter	ø25.005 ~ ø25.035	When assembled
	Rocker arm bearing journal's diameter	ø24.967 ~ ø24.990	
	Bearing's clearance	0.015 ~ 0.068	
	Push rod's shaking	0.3	
	Valve tappet ass'y part's inside dia. of block	ø20.000 ~ ø20.021	
	Push rod's outside diameter	ø19.944 ~ ø19.965	ø20 H7
	Tappet clearance	0.035 ~ 0.077	
	Bush assembly's inside diameter of block	ø70.077 ~ ø70.061	
	Camshaft diameter	ø69.910 ~ ø69.940	ø70 e7
	Camshaft bearing oil gap (thrust)	0.060 ~ 0.120	
	Camshaft bearing oil gap (middle)	0.130 ~ 0.180	
	Camshaft axial direction play	0.24 ~ 0.86	
	Backlash (crank gear - camshaft gear)	0.118 ~ 0.242	
	Backlash (driving gear - injection pump gear)	0.102 ~ 0.338	
	Intake valve clearance	0.3 ±0.05	
	Exhaust valve clearance	0.4 ±0.05	
Engine lubricating system	Oil pressure at idling	0.9 ~ 3.0 bar	
	Oil pressure at rated speed operation	3.0 ~ 6.5 bar	
	Oil temperature	Less than 110°C	
	Instantaneous allowable temperature	Max. 100°C	
	Bypass valve opening pressure	1.8 ~ 2.4 bar	
	Pressure regulating valve of oil pump	8.5 ~ 10 bar	
	Spray nozzle		
	Operating pressure	1.5 ~ 1.9 bar	
	Crossing pressure	1.3 ~ 1.6 bar	
	Tip diameter	ø2	
	Backlash (crankshaft gear-oil pump drive gear)	0.10 ~ 0.45	
	Oil pump housing's depth/gear width	43.000 ~ 43.039	43 H8
		42.910 ~ 42.950	43 e8
	Oil pump housing axial play	0.050 ~ 0.128	
Engine cooling system	Cooling water pump shaft diameter	ø21.930 ~ ø21.950	
	Bearing gap	0.050 ~ 0.091	
	Impeller clearance (impeller - body)	1.0 ~ 1.5	
	Thermostat operating temperature (°C)	71°C	
Inspection on compressed pressure	Good	Above 16 bar	
	Need up keep	Bellow 13 bar	
	Allowable max pressure difference between cylinders	4 bar	
Fuel ignition system	Ignition plug clearance	0.3 ~ 0.4	
	Project ignition plug from cylinder head low surface	3.38 ~ 3.76	

● GV222C Engine assembly









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