HYUNDAI INFRACORE

950106-039015EN

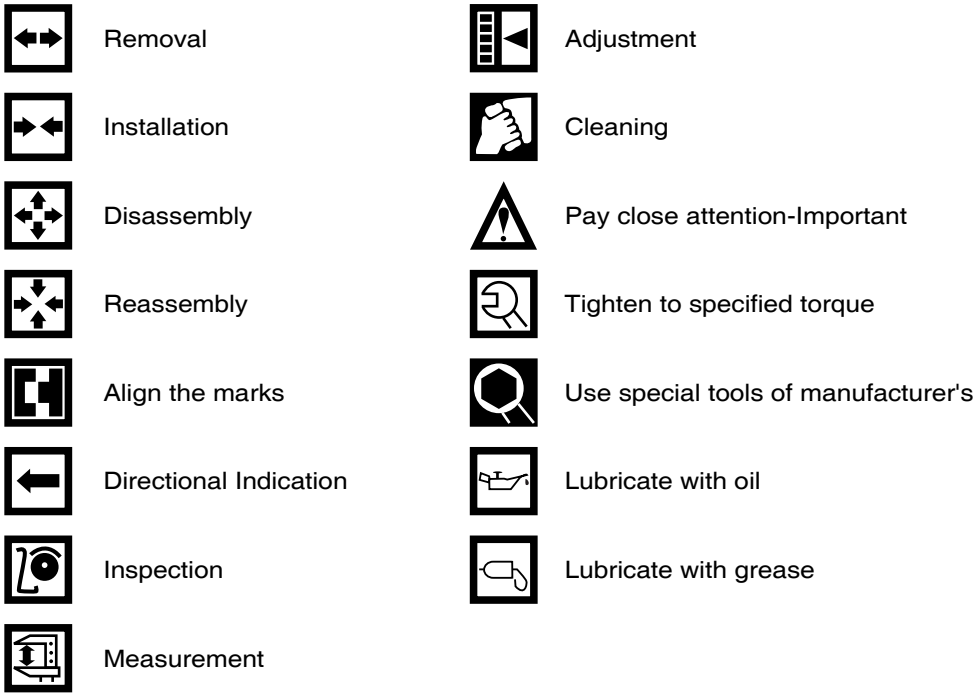
Operation & Maintenance Manual

MARINE ENGINE

4V158TI, 4V222TI, 4AD158TI, 4AD222TI

FOREWORD

This manual is designed to serve as a reference for the operation & Maintenance of **4V158TIH/M/L, 4V222TIH/M/L** Marine engines and **4V158TIH/M/L, 4V222TIH/M/L** Marine generator engines.
The former is explained for operation and the latter is described for maintenance like parts disassembly, maintenance & inspection and re-assembly etc in order to available understanding the maintenance procedure more easily.
To maintain the engine in optimum condition and retain maximum performance for a long time, CORRECT OPERATION and PROPER MAINTENANCE is essential.
In this manual, the following symbols are used to indicate the type of service operations to be performed.



If you have any question or recommendation in connection with this manual, please do not hesitate to contact our head office, dealers or authorized service shops near by your location for any services.
For the last, the content of this manual instruction may be changed without notice for some quality improvement. Thank you.

2025. 07.
950106-039015EN
HD Hyundai Infracore

* 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. Safety Regulations

1.1.1. 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.

1.1.2. During commissioning, starting and operation

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

- For reasons of safety we recommend you attach a notice to the door of the engine room prohibiting the access of unauthorized persons and that you draw the attention of the operating personal to the fact that they are responsible for the safety of persons who enter the engine room.
- The engine must be started and operated only by authorized personnel. Ensure that the engine cannot be started by unauthorized persons.
- When the engine is running, do not get too close to the rotating parts (All pulleys, injection pump drive & propeller shafts, FPTO etc) and install the protector in the rotating parts.
  Wear the close-fitting clothing as possible.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- Do not touch the engine hot parts (Exhaust manifold & turbocharger connection pipes, Inter cooler & heat exchanger connection pipes etc) with bare hands when it is warm from operation risk of burns.
- Exhaust gases are toxic. Comply with the installation instructions for the installation of HD Hyundai Infracore marine diesel engines which are to be operated in enclosed spaces. Ensure that there is adequate ventilation and air extraction.
- Keep vicinity of engine, ladders and stairways free of oil and grease. Accidents caused by slipping can have serious consequences.

1.1.3. During maintenance and care

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

CAUTION:
There is a risk of burns and scalding. Do not touch oil drain plug or oil filter 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 unavoidable, comply with the instructions in the chapter.
- Neither tighten up nor open pipes and hoses (lube oil circuit, coolant circuit and any additional hydraulic oil circuit) during the operation. The fluid which flow out can cause injury.
- Fuel is inflammable. Do not smoke or use naked lights in its vicinity. The tank must be filled only when the engine is switched off.
- When using compressed air, e.g. for cleaning the heat exchanger, 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.

1.1.4. When carrying out checking, setting and repair work

- Checking, setting and repair work must be carried out by authorized personnel only.

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

1.1.5. Regulations Designed to Prevent Damage to Engine and Premature Wear

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

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

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

(4) In addition to the above, note the following points.
- Never let the engine run when dry, i.e. without lube oil, fuel or coolant. Use only our approved service products. (engine oil, anti-freeze and anticorrosion agent)
- Pay attention to cleanliness. The diesel fuel must be free of water.
- Have the engine maintained at the specified intervals.
- Do not switch off the engine immediately when it is warm, but let it run without load for about 5 minutes so that temperature equalization can take place.
- Never put cold coolant into an overheated engine.
- Do not add so much engine oil that the oil level rises above the max. marking on the dipstick. Do not exceed the maximum permissible tilt of the engine. Serious damage to the engine may result if these instructions are not adhered to.
- Always ensure that the testing and monitoring equipment (for battery charge, oil pressure, and coolant temperature) function satisfactorily.
- Do not let the sea water pump run dry. If there is a risk of frost, drain the water when the engine switched off.

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

1.1.6. Regulations Designed to Prevent Pollution

(1) Engine oil, filter element, fuel filter

- Take old oil only to an oil collection point. Take strict precautions to ensure that oil does not get into the drains or into the ground and sea.
- The drinking water supply may be contaminated.
- Oil and fuel filter cartridges 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.

1.1.7. Notes on Safety in Handling Used Engine Oil

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

Health precautions:

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

Ensure that used engine oil is disposed of properly.

- Engine oil can endanger the water supply -

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

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

1.1.8. 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 Hyundai Infracore parts necessarily.
6. Used cotter pins, gaskets, O-rings, oil seals, lock washer, self-lock nuts, and rubber coated seal ring etc. 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.

1.2. Engine Specifications

1.2.1. 4V158TIH/TIM/TIL

Items \ Engine model			4V158TIH	4V158TIM	4V158TIL
Engine type			4 valve, 4 cycle, V-type, direct-injection, water-cooled with wet turbocharger & inter-cooler		
Rating output (B.H.P)		PS (kW)/ rpm	530(390) / 1,800	600(441) / 2,100	800(588) / 2,300
Displacement		cc	14,618		
Cylinder number - bore (ø) x stroke		mm	8 – ø128 × 142		
Valve clearance (at cold)	Intake	mm	0.40		
	Exhaust	mm	0.50		
Low idling		rpm	725 ±25		
No load max.		rpm	Below 2,070	Below 2,415	Below 2,645
Mean effective pressure		kg/cm^2	18.1	17.6	21.4
Mean piston speed		m/sec.	8.52	9.94	10.89
Compression ratio			15.8 : 1		
Firing order			1-5-7-2-6-3-4-8		
Governor type of injection pump			Mechanical variable speed (R.Q.V)		
Fuel consumption		g/PS.h	170	182	186
		liter/h	108	132	179
Starting system			Electric starting by starter motor		
Starting motor capacity		V - kW	24 – 7.0		
Alternator capacity		V - A	24 – 80		
Battery		V - AH	24 – 200		
Cooling system			Indirect sea water cooling with heat exchanger		
Cooling water capacity		liter	Max.: 94, Min.: 83		
Fresh water pump type			Centrifugal type, driven by belt		
Sea water pump type			Rubber impeller type driven by belt		
Lubricating oil (engine)	Pan capacity	liter	Max. 31 / Min. 25 (Engine total: 35)		
	Pressure	kg/cm^2	Full: 3.5, Idle: 1.2		
Direction of revolution	Crankshaft		Counter clockwise viewed from flywheel side		
Engine size (L x W x H)		mm	1,205 × 1,237 × 1,111		
Engine dry weight		kg	1,540	1,540	1,580

1.2.2. 4V222TIH/TIM/TIL

Items \ Engine model			4V222TIH	4V222TIM	4V222TIL
Engine type			4 valve, 4 cycle, V-type, direct-injection, water-cooled with wet turbocharger & inter-cooler		
Rating output (B.H.P)		PS (kW)/ rpm	800(588) / 1,800	880(647) / 2,100	1,200(883) / 2,300
Displacement		cc	21,927		
Cylinder number - bore (ø) x stroke		mm	12 – ø128 × 142		
Valve clearance (at cold)	Intake	mm	0.40		
	Exhaust	mm	0.50		
Low idling		rpm	725 ±25		
No load max.		rpm	Below 2,070	Below 2,415	Below 2,645
Mean effective pressure		kg/cm^2	18.2	17.2	21.4
Mean piston speed		m/sec.	8.52	9.94	10.89
Compression ratio			15.8 : 1		
Firing order			1-12-5-8-3-10-6-7-2-11-4-9		
Governor type of injection pump			Mechanical variable speed (R.Q.V)		
Fuel consumption		g/PS.h	159	173	182
		liter/h	152.9	183.0	262.5
Starting system			Electric starting by starter motor		
Starting motor capacity		V - kW	24 – 7.0		
Alternator capacity		V - A	24 – 80		
Battery		V - AH	24 – 200		
Cooling system			Indirect sea water cooling with heat exchanger		
Cooling water capacity		liter	Max.: 103, Min.: 92		
Fresh water pump type			Centrifugal type, driven by belt		
Sea water pump type			Rubber impeller type driven by belt		
Lubricating oil (engine)	Pan capacity	liter	Max. 40 / Min. 33 (Engine total: 43)		
	Pressure	kg/cm^2	Full: 3.5, Idle: 1.2		
Direction of revolution	Crankshaft		Counter clockwise viewed from flywheel side		
Engine size (L x W x H)		mm	1,521 × 1,243 × 1,236		
Engine dry weight		kg	1,920	1,920	1,960

1.2.3. 4V AD158TI/4V AD222TI

Items \ Engine model				4V AD158TI	4V AD222TI
Engine type				4 valve, 4 cycle, V-type, direct-injection, water-cooled with wet turbocharger & inter-cooler	
Rating output (B.H.P)	50 Hz		PS (kW)/ rpm	442(325) / 1,500 (4AD158TIF)	667(491) / 1,500 (4AD222TIF)
	60 Hz			530(390) / 1,800 (4AD158TIS)	800(588) / 1,800 (4AD222TIS)
Displacement			cc	14,618	21,927
Cylinder number - bore (ø) x stroke			mm	8 – ø128 × 142	12 – ø128 × 142
Valve clearance (at cold)	Intake		mm	0.40	
	Exhaust		mm	0.50	
Low idling			rpm	800 ±50	
No load max. (50Hz / 60Hz)			rpm	1,500 / 1,800	
Mean effective pressure (Initial)			kg/cm^2	18.1 / 18.1	18.3 / 18.2
Mean piston speed (50Hz / 60Hz)			m/sec.	7.1 / 8.52	
Compression ratio				15.8 : 1	
Governor type of injection pump				Electric Governor	
Fuel consumption			g/PS.h	165 / 171.5	159 / 169
			liter/h	88 / 110	128 / 163
Injection timing (B.T.D.C)	50 Hz	CCnR2	deg.	9° ±1°	
		EIAPP		13° ±1°	
	60 Hz	CCnR2		11° ±1°	
		EIAPP		13° ±1°	
Starting system				Electric starting by starter motor	
Starting motor capacity			V - kW	24 – 7.0	
Alternator capacity			V - A	24 – 80	
Battery			V - AH	24 – 200	
Cooling system				Indirect sea water cooling with heat exchanger	
Cooling water capacity			liter	Max.: 94, Min.: 83	Max.: 103, Min.: 92
Fresh water pump				Centrifugal type driven by V-belt	
Sea water pump type				Rubber impeller type driven by belt	
Lubricating oil	Pan capacity		liter	Max.: 31, Min.: 25 (Engine total: 35)	Max.: 40, Min.: 33 (Engine total: 43)
	Pressure		kg/cm^2	Full: 3.5, Idle: 1.2	
Direction of revolution	Crankshaft			Counter clockwise viewed from flywheel side	
Engine dimension (L x W x H)			mm	1,205 × 1,237 × 1,117	1,521 × 1,243 × 1,236
Engine weight			kg	1,540	1,920

NOTE:

Fuel consumption data is based on engine test data, and Fuel efficiency may difference depending on vessel driving habits and sea conditions.

1.3. Engine Power

1.3.1. Engine Power

Production tolerance : ±3%

Engine model			Power rating	Remark
Model	Suffix			
	Base	Final		
4V158TIH	EUZKM	EKZKM	390 kW (530 PS) / 1,800	Heavy duty
4V158TIM	EUZKC	EKZKC	441 kW (600 PS) / 2,100	Medium duty
4V158TIL	EUZKL	EKZKL	588 kW (800 PS) / 2,300	Light duty
4V222TIH	EUYKM	EKYKM	588 kW (800 PS) / 1,800	Heavy duty
4V222TIM	EUYKC	EKYKC	647 kW (880 PS) / 2,100	Medium duty
4V222TIL	EUYKL	EKYKL	883 kW (1,200 PS) / 2,300	Light duty

* Note : All data are based on operation without reduction at ISO 3046.

Engine model			Performance		Remark
			PS	kW	
4V AD158TI	AD158TIF	50 Hz (1,500 rpm)	442	325	
	AD158TIS	60 Hz (1,800 rpm)	530	390	
4V AD222TI	AD222TIF	50 Hz (1,500 rpm)	667	491	
	AD222TIS	60 Hz (1,800 rpm)	800	588	

1.4. Angle of Engine Timing

(BTDC of all dates)

Model / Certificated	4V158TIH	4V158TIM	4V158TIL	4V222TIH	4V222TIM	4V222TIL
IMO Tier 2	13 ±1°	13 ±1°	15 ±1°	13 ±1°	13 ±1°	13 ±1°
Inland water vessel (stage III A)	14	16	20	14	16	18
CCNR II	14	16	20	14	16	18

(BTDC of all dates)

Model / Certificated	4V AD158TI		4V AD222TI	
	50Hz	60Hz	50Hz	60Hz
EIAPP Tier2	15° ±1°	15° ±1°	15° ±1°	15° ±1°

< Operating condition >

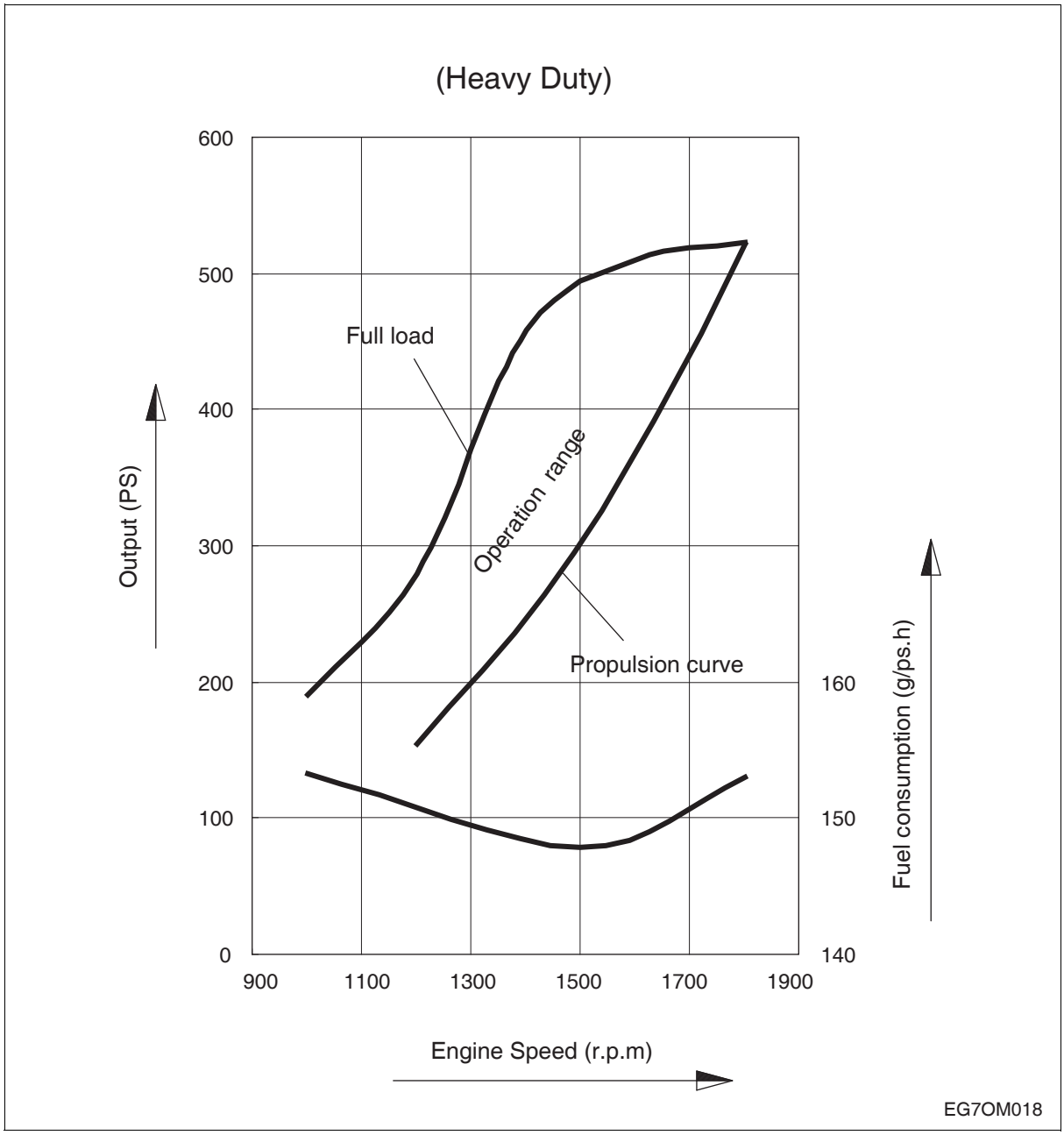
(1) **Heavy Duty :** Operation hours are unlimited per year, at average load is up to 90 %, at full load is up to 80 % typical gearbox ratio : 2.5 ~ 6
(Fishing trawler, Tug boat, Pushing vessel, Cargo boat, Freighter, Ferry)

(2) **Medium Duty :** Operation hours are up to 3,000 per year, at average load is up to 70 % at full load is (up to 30 % / 4hrs per 12 hour operation period) Typical gearbox ratio: 2 ~ 3.5 (Fishing boat, Pilot boat, Escort boat, Passenger boat, Ferry, Cruising vessel)

(3) **Light Duty :** Operation hours are up to 1,000 per year, at average load is up to 50 % at full load is (up to 20 % / 2hrs per 12 hour operation period) typical gearbox ratio: 1 ~ 2.5 (Light weight fishing boat, Yacht, Coastguard boat, Fast boat, Fire pump, Navy)

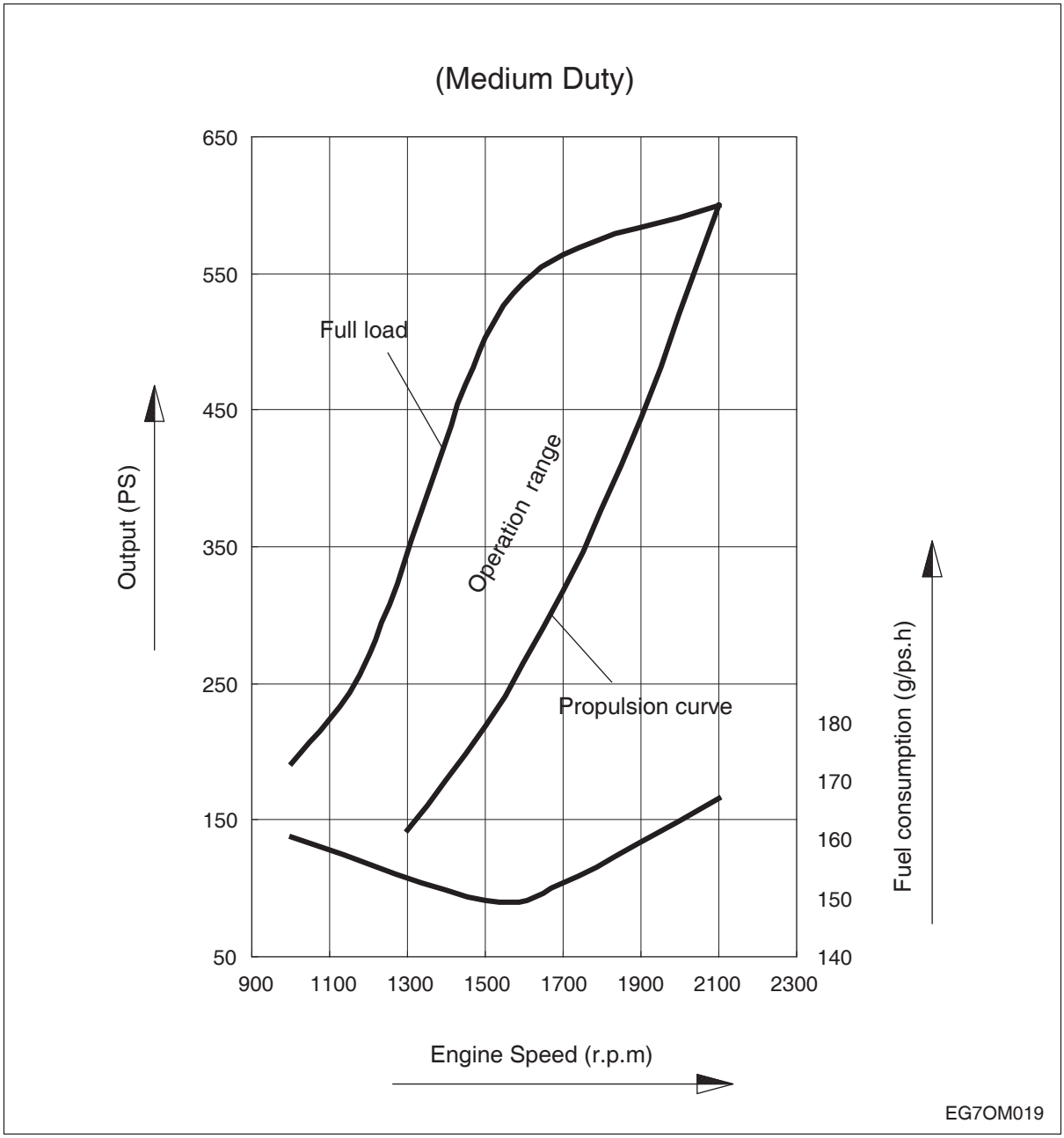
1.5. Engine Performance Curve

1.5.1. 4V158TIH – Heavy duty



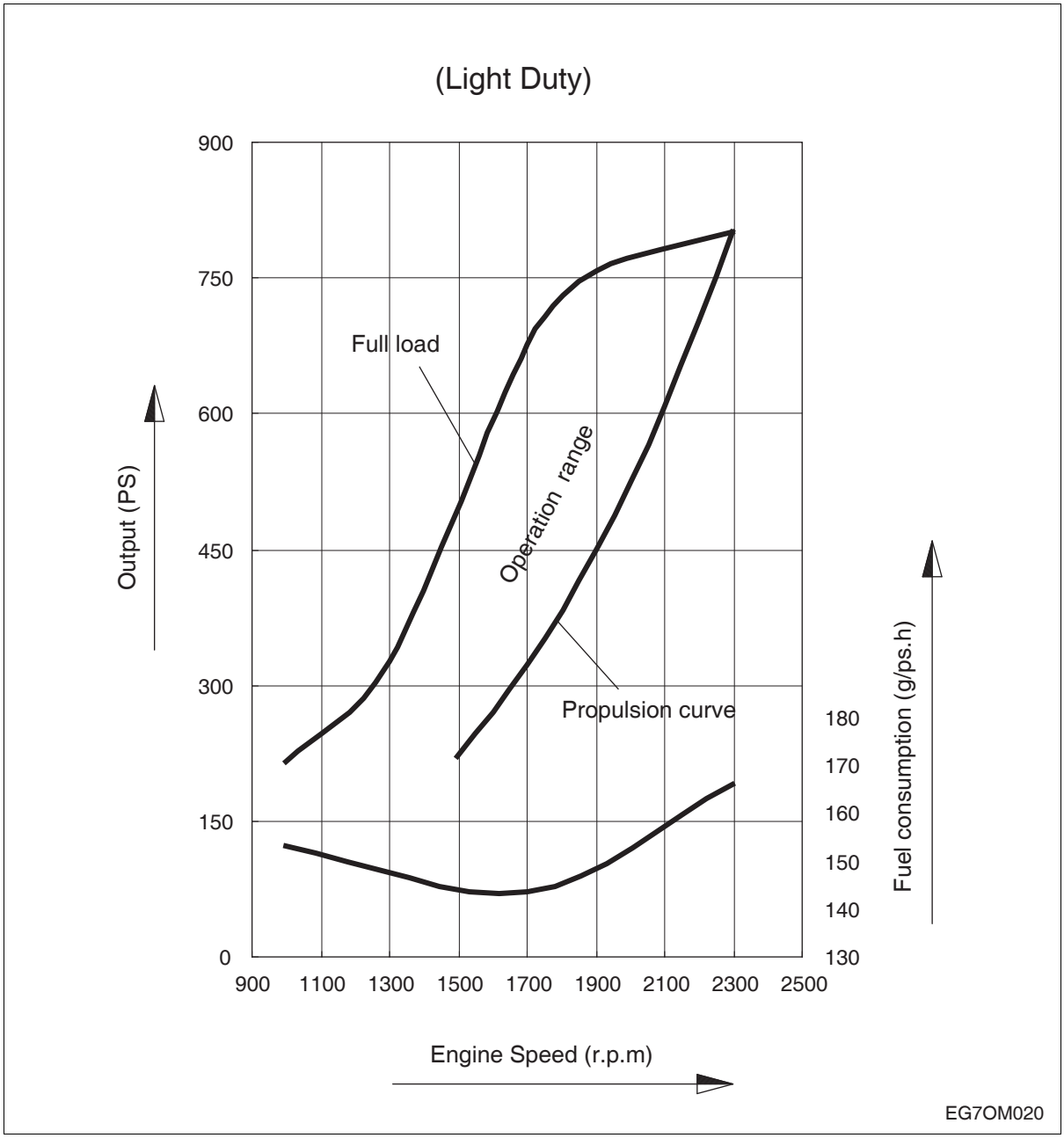
Test condition	ISO 3046
Rating output (B.H.P)	390 kW (530 PS) / 1,800 rpm

1.5.2. 4V158TIM – Medium duty



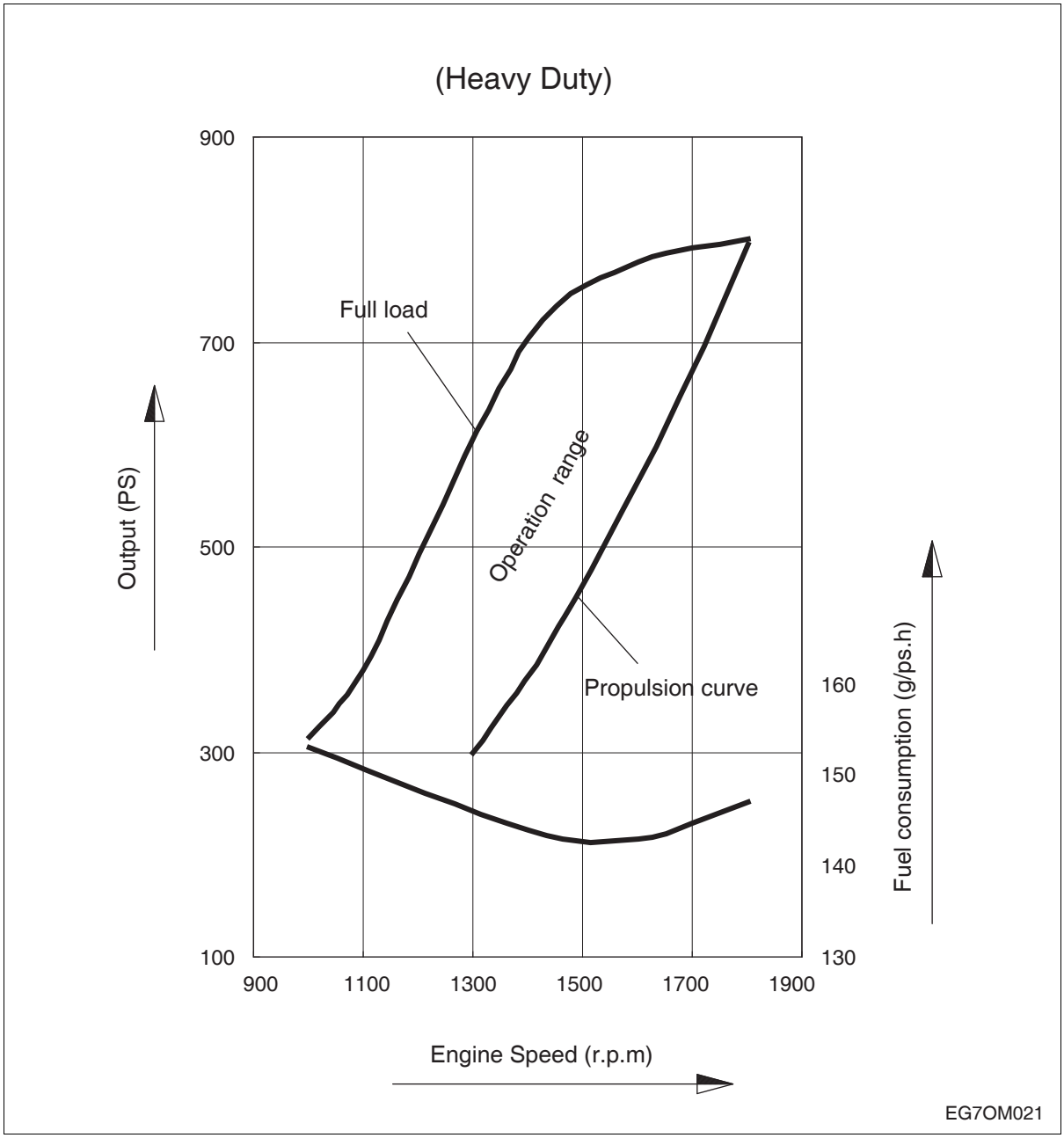
Test condition	ISO 3046
Rating output (B.H.P)	441 kW (600 PS) / 2,100 rpm

1.5.3. 4V158TIL – Light duty



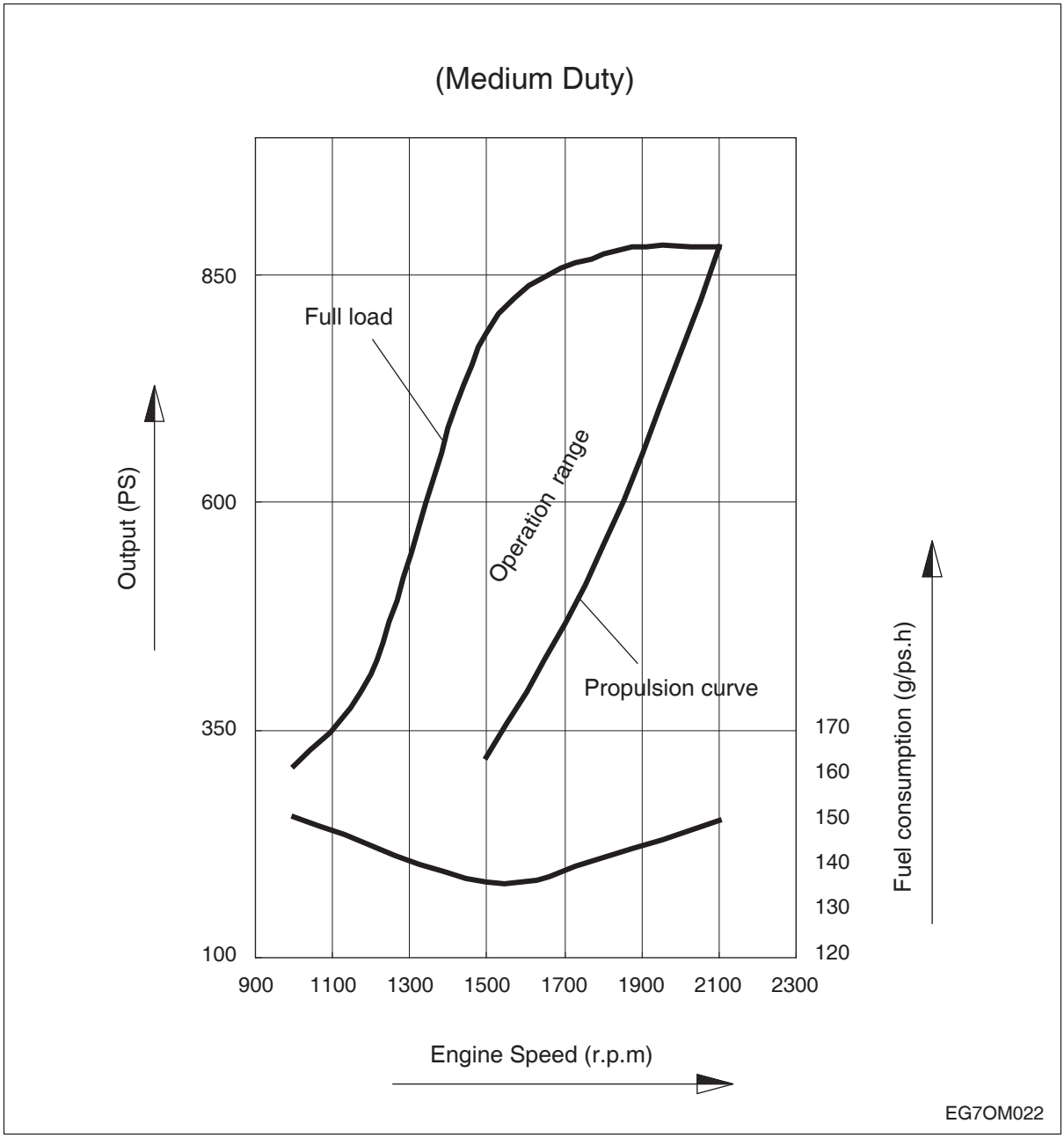
Test condition	ISO 3046
Rating output (B.H.P)	588 kW (800 PS) / 2,300 rpm

1.5.4. 4V222TIH – Heavy duty



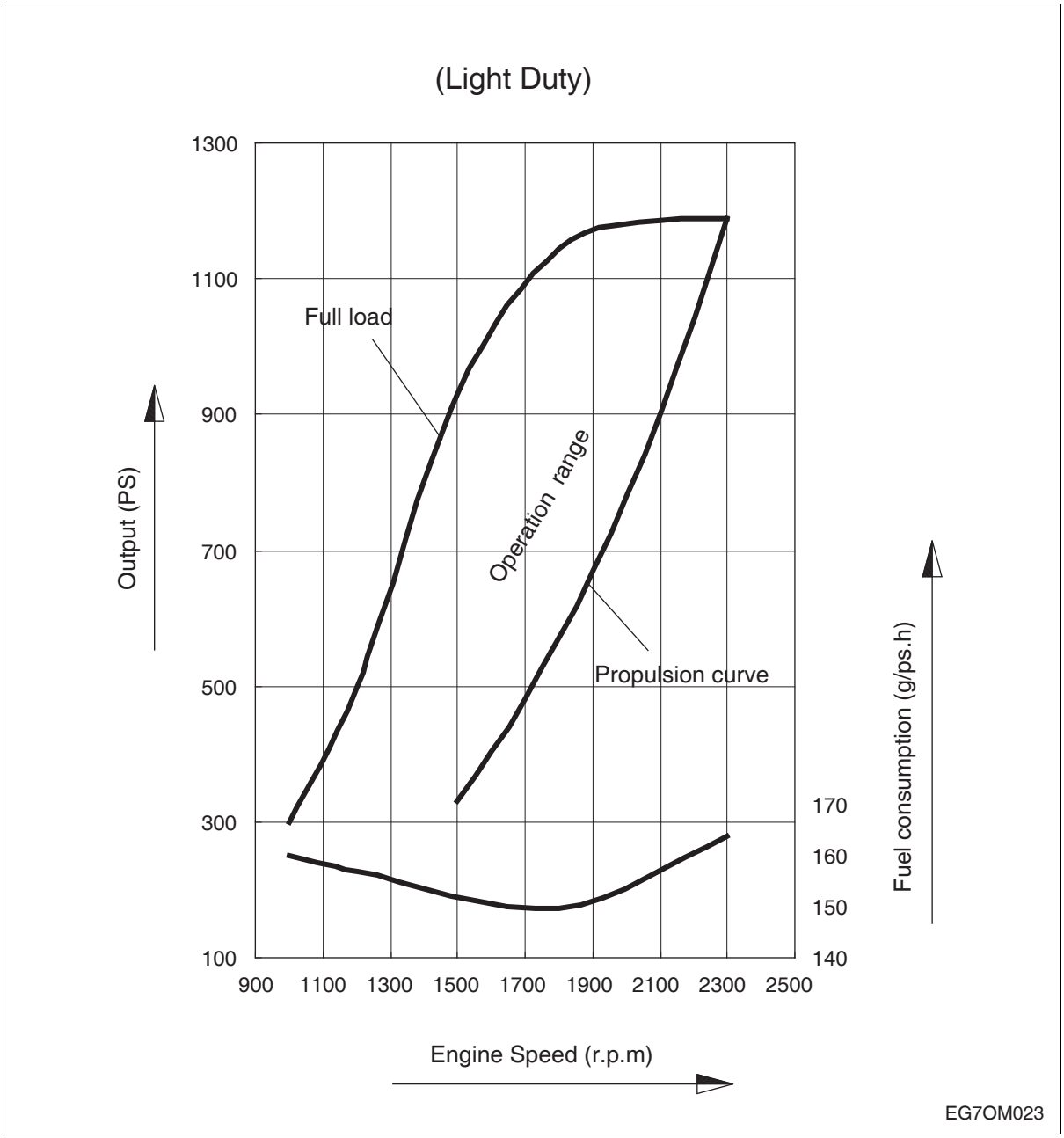
Test condition	ISO 3046
Rating output (B.H.P)	588 kW (800 PS) / 1,800 rpm

1.5.5. 4V222TIM – Medium duty



Test condition	ISO 3046
Rating output (B.H.P)	647 kW (880 PS) / 2,100 rpm

1.5.6. 4V222TIL – Light duty

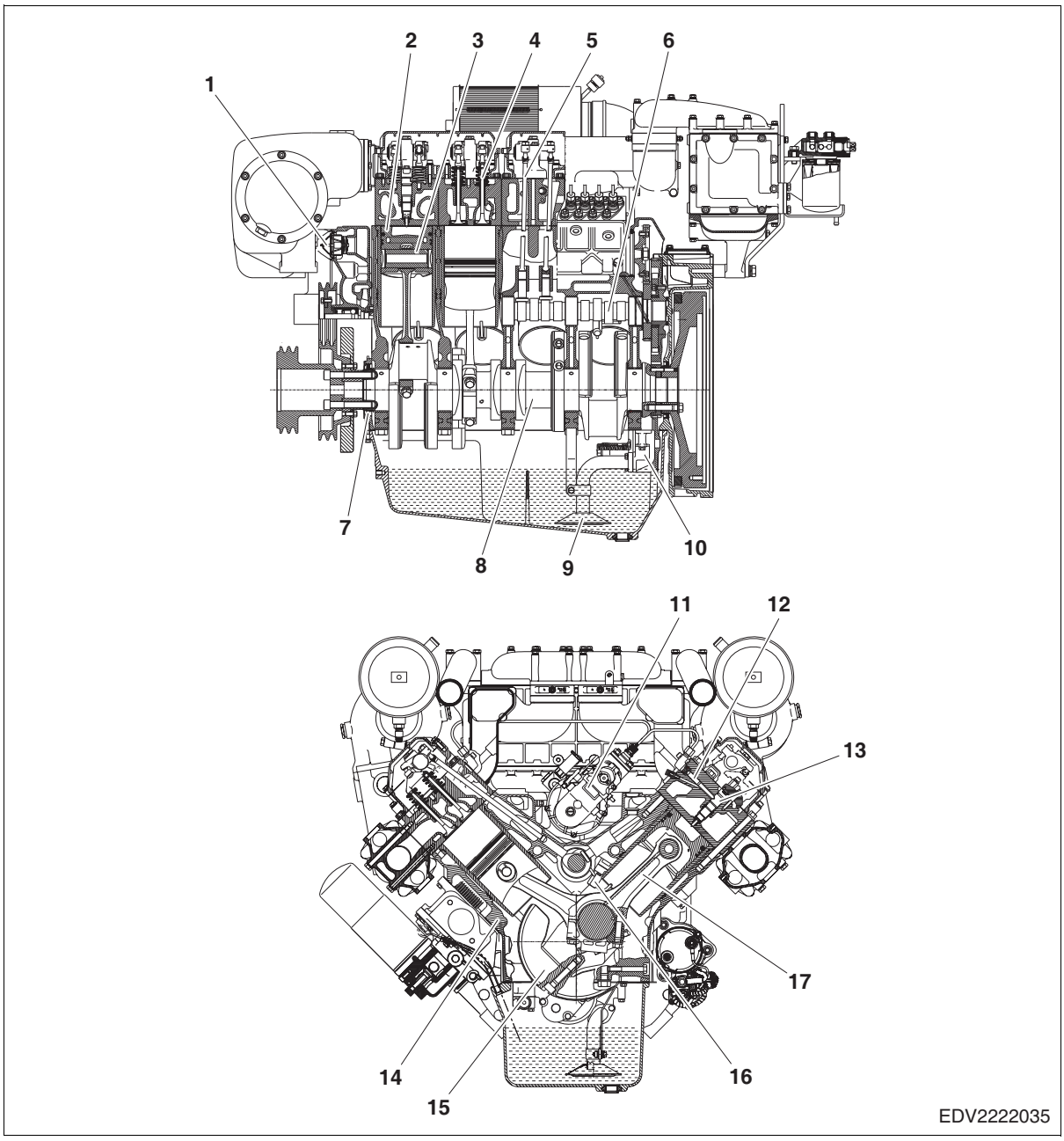


Test condition	ISO 3046
Rating output (B.H.P)	883 kW (1,200 PS) / 2,300 rpm

1.6. Engine Assembly

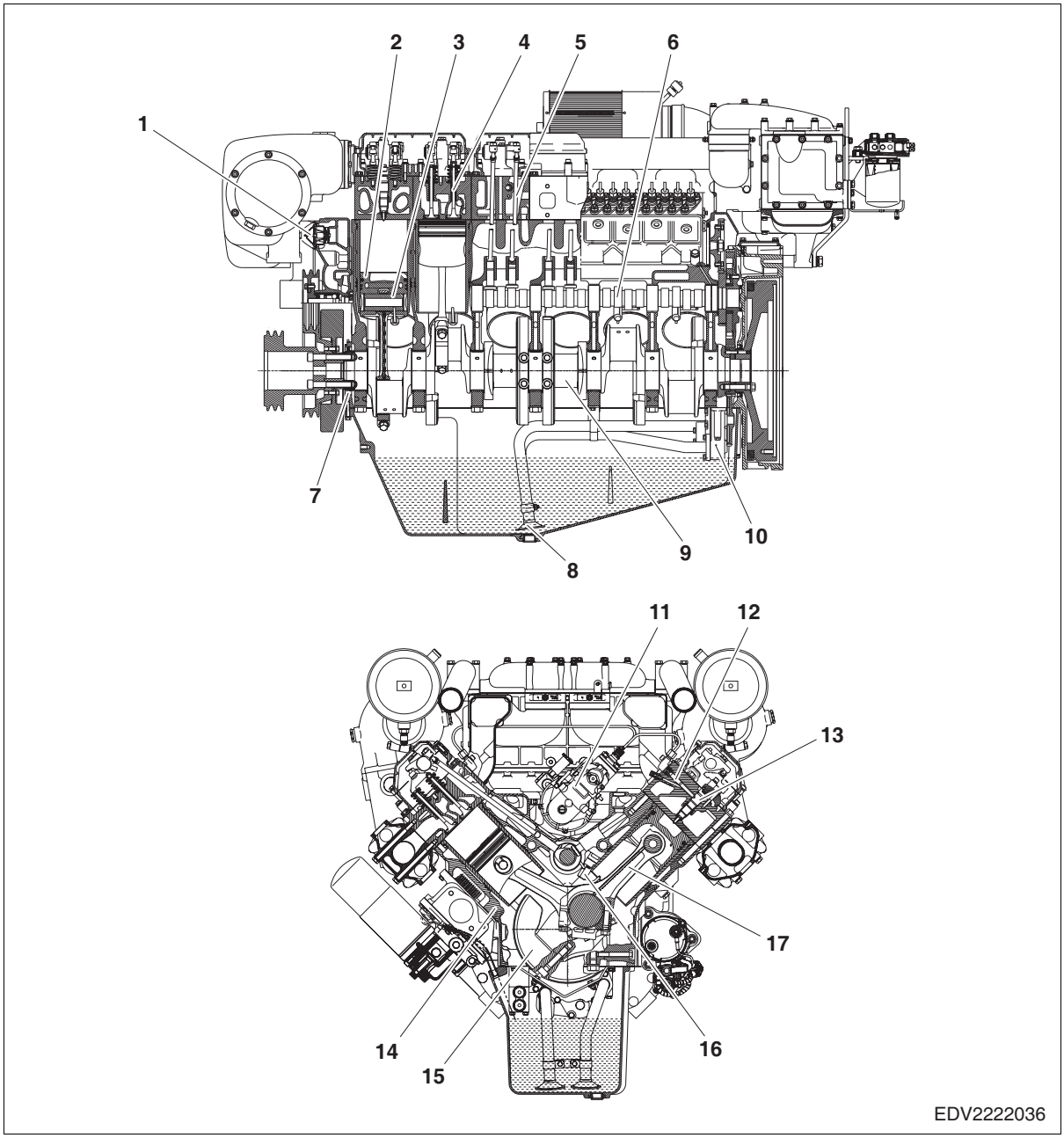
NOTE: The images shown represent the standard model; they do not include all models.

1.6.1. Engine sectional views (4V V158TIH/M/L, 4V AD158TI)



1. Thermostat
2. Piston
3. Piston pin
4. Valve
5. Push rod
6. Cam shaft
7. Front oil seal
8. Crank shaft
9. Oil suction pipe
10. Oil pump
11. Injection pump
12. High pressure connector
13. Injector
14. Cylinder block
15. Balance weight
16. Oil spray nozzle
17. Connecting rod

1.6.2. Engine sectional views (4V V222TIH/M/L, 4V AD222TI)



1. Thermostat
2. Piston
3. Piston pin
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5. Push rod
6. Cam shaft
7. Front oil seal
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10. Oil pump
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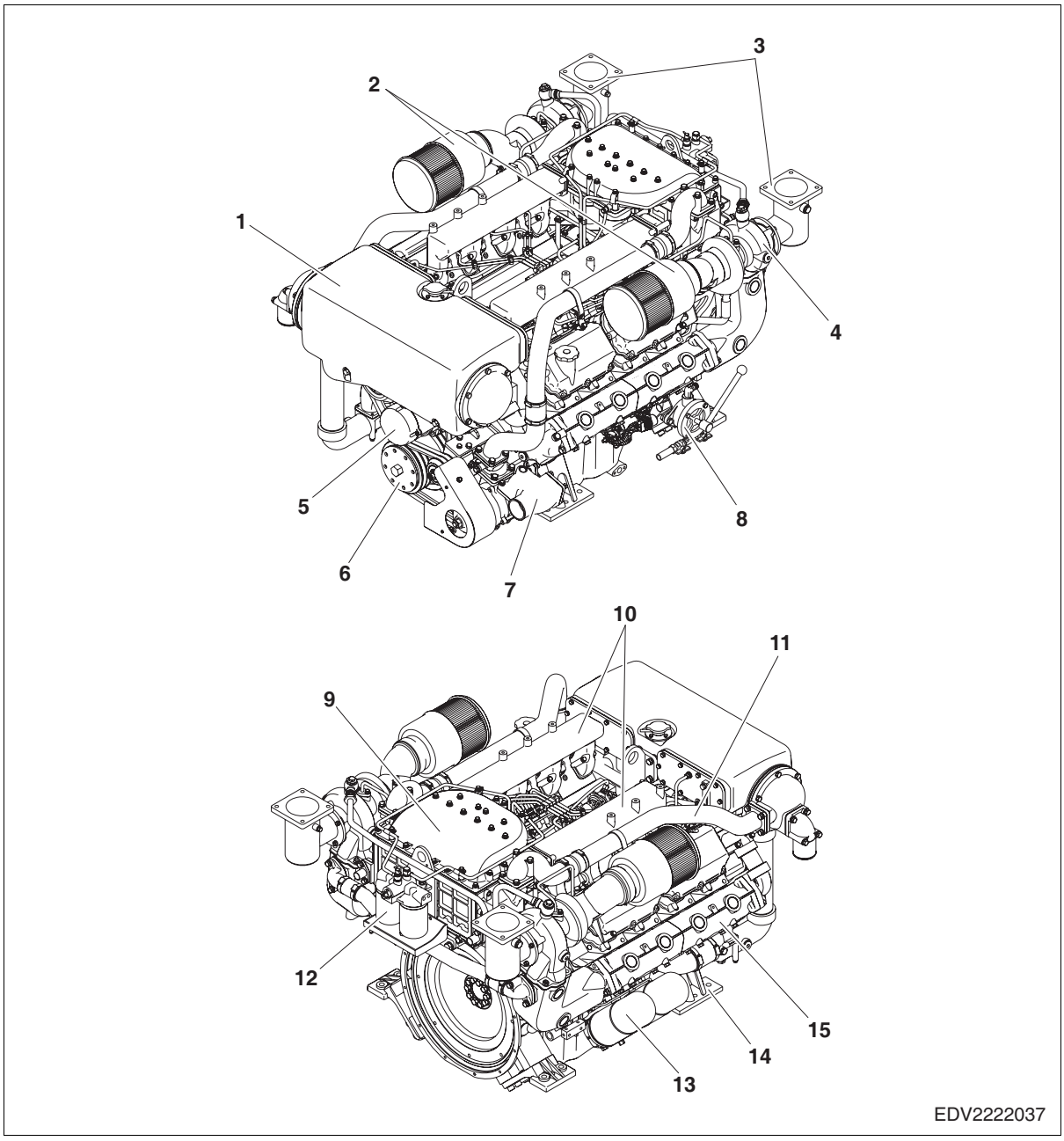
12. High pressure connector
13. Injector
14. Cylinder block
15. Balance weight
16. Oil spray nozzle
17. Connecting rod

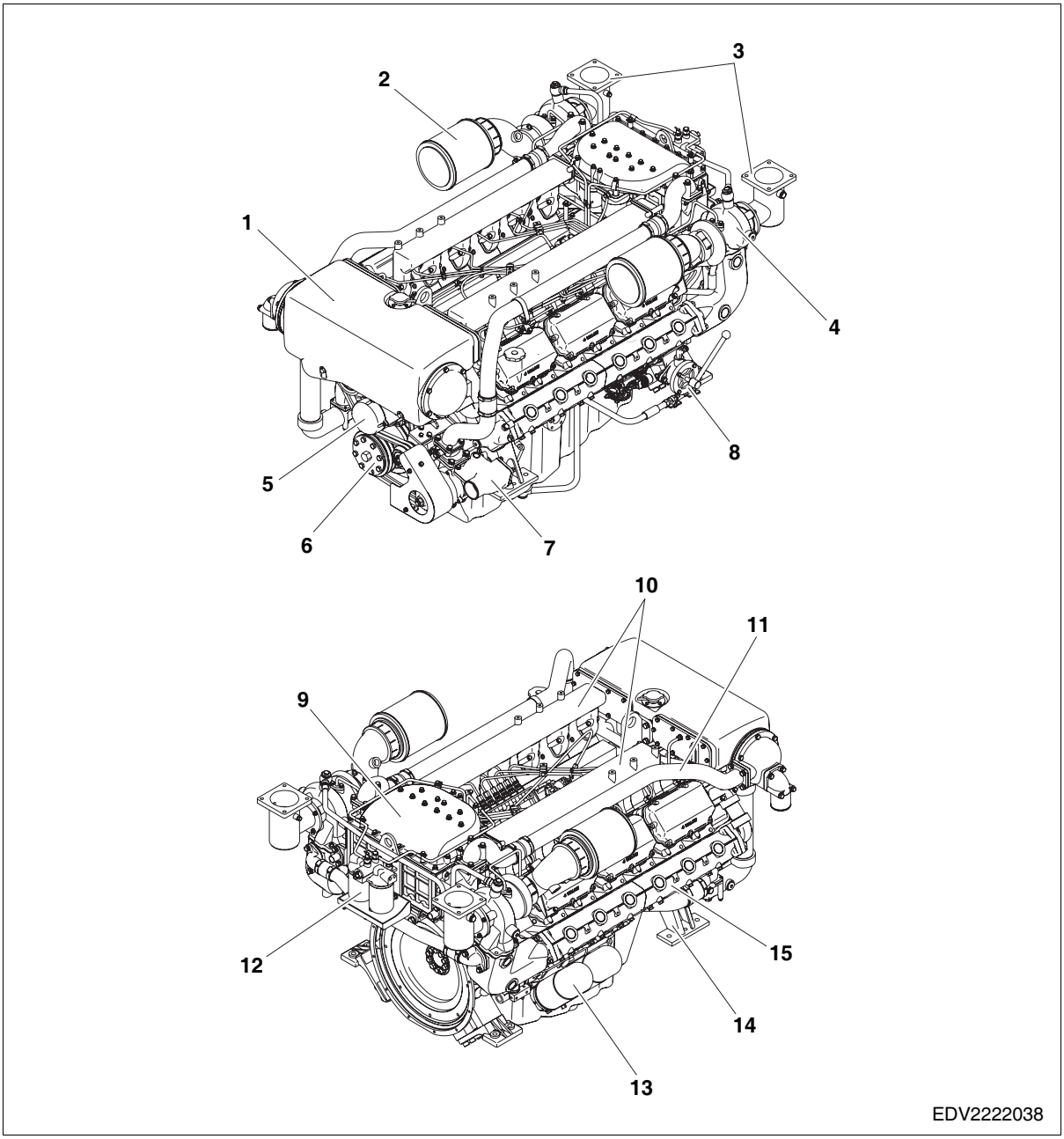
1.6.3. Engine assembly views

(1) 4V V158TIH/M/L, 4V AD158TI



1. Heat exchanger
2. Air cleaner
3. Exhaust elbow
4. Turbo charger
5. Alternator
6. Engine turning device
7. Sea water pump
8. Oil drain pump
9. Inter cooler
10. Intake manifold
11. Cooling water pipe
12. Fuel filter
13. Oil filter
14. Engine mounting bracket
15. Exhaust manifold

(2) 4V V222TIH/M/L, 4V AD222TI

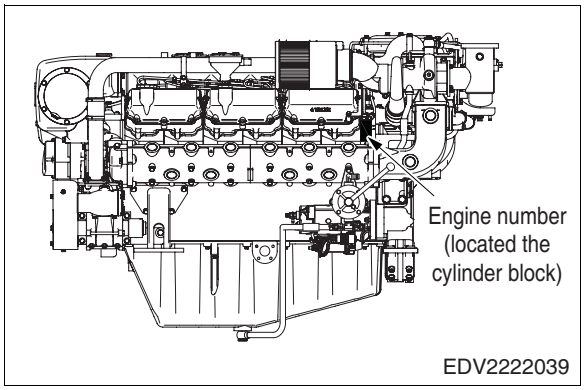


1. Heat exchanger
2. Air cleaner
3. Exhaust elbow
4. Turbo charger
5. Alternator
6. Engine turning device
7. Sea water pump
8. Oil drain pump
9. Inter cooler
10. Intake manifold
11. Cooling water pipe
12. Fuel filter
13. Oil filter
14. Engine mounting bracket
15. Exhaust manifold

2. Technical Information

2.1. Engine Model and Serial Number

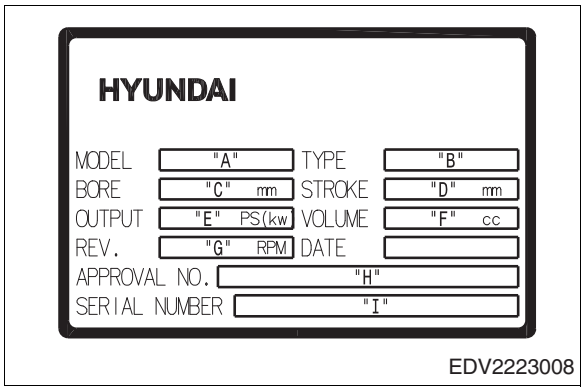
- The engine model and serial number is located on the engine as illustrated.
- These numbers are required when requesting warranty and ordering parts. They are also referred to as engine model and serial number because of their location.



- **Engine serial No. (example 1 : 4V158TI)**

EUZKM 7 00001

- Serial no.
- Production year(2007)
- Engine model suffix
  - EUZKM : 4V158TIH
  - EUZKC : 4V158TIM
  - EUZKL : 4V158TIL



- **Engine serial No. (example 2 : 4V222TI)**

EUYKM 7 00001

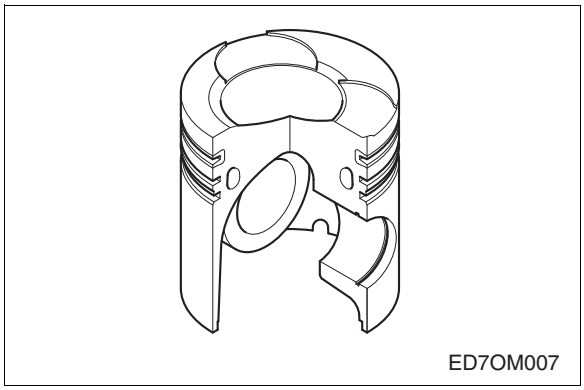
- Serial no.
- Production year(2007)
- Engine model suffix
  - EUYKM : 4V222TIH
  - EUYKC : 4V222TIM
  - EUYKL : 4V222TIL

2.2. Engines Characteristic

The engines **4V V158TIH/M/L, 4V V222TIH/M/L, 4V AD158TI, 4V AD222TI** are V-type liquid-cooled 8/12-cylinder four-stroke, overhead 4-valves, direct injection engines with turbo-charged and inter-cooler.

2.2.1. OMEGA combustion bowl

- The OMEGA combustion bowl is a unit designed to perform high efficiency, low emission combustion. As the rim around the combustion bowl port of the upper of the piston has been machined in a smaller size than the interior of the combustion bowl, strong swirl is produced in the combustion bowl and strong squish flow makes the fuel be mixed more sufficiently with air.


ED7OM007

- Due to the application of **OMEGA** combustion system and optimal utilization of intake and exhaust port configuration within the cylinder head, the **4V V158TIH/M/L, 4V V222TIH/M/L, 4V AD158TI, 4V AD222TI** diesel engines discharge very low level of hazardous exhaust gases such as smoke, nitrogen oxide, hydrocarbon, or carbon monoxide and thus ensure high performance and low fuel consumption.

2.2.2. Engine block

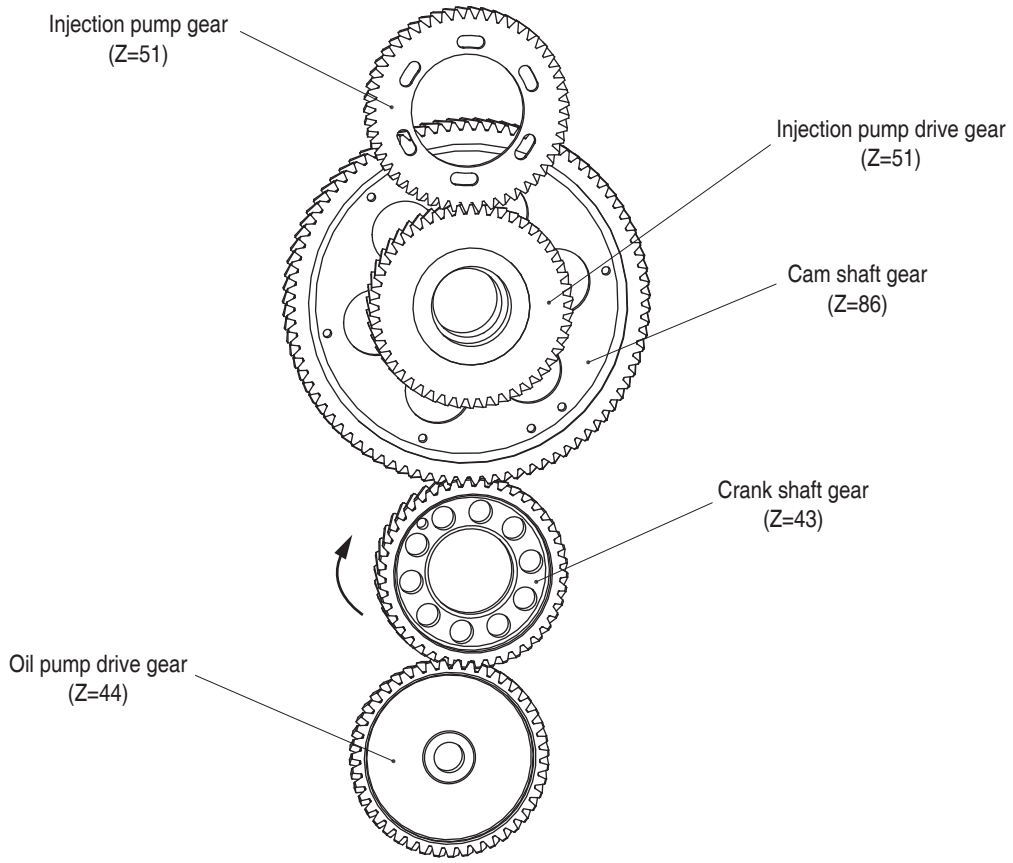
- The cylinder block is a single piece of alloy cast iron. To increase its stiffness, it is extended to a level below the crankshaft center line. The engine has replaceable wet cylinder liners and individual cylinder heads with strung-in valve seat rings and replaceable valve guides.

2.2.3. Piston / Connecting rod / Crank assembly

- 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.

2.2.4. Engine timing

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



View from crankshaft pulley

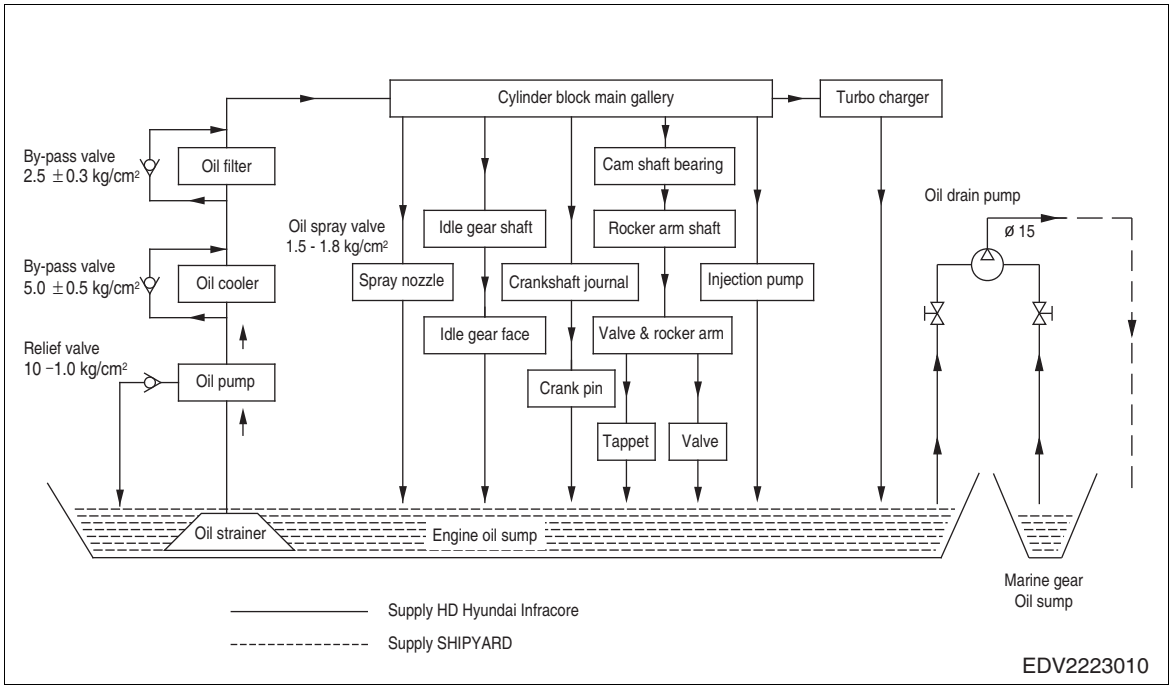
EF8OM008

2.2.5. Valves

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

2.2.6. Engine lubrication

- The engine is equipped with force-feed lubrication. The pressure is produced by a gear pump whose drive gear is in direct mesh with the crankshaft gear at the flywheel end.
- The oil pump draws the oil from the oil sump and delivers it through the oil cooler and oil filter to the main distributor gallery and from there to the main bearings, big-end bearings and camshaft bearings as well as to the small-end bearings and the rocker arms. The injection pump and the turbocharger are also connected to the engine lubricating system. The cylinder walls and timing gears are splash-lubricated. Each cylinder has an oil jet provided for cooling the underside of the pistons. The lube oil is cleaned in a full-flow oil filter.
- Depending on the agreed extent of delivery and the design of the engine, the lube oil circuit can be equipped with oil pressure monitors (advance warning function) which alarm the engine down in the event of a sudden loss of pressure.
- While the oil is still hot, discharge the oil pan or marine gear sump oil by oil drain pump.



2.2.7. Recommend of lubricating oil

- Initial factory fill is high quality oil for API Service CI-4. During the break-in period 50 hours, frequently check the oil level. Somewhat higher oil consumption is normal until piston rings are seated. The oil level should be maintained in the safe range between the **Min.** and **Max.** marks on the dipstick. The safe range between the marks represents approximately 3 liters. To obtain the best engine performance and engine life, grade of engine oil is recommended. Engine oils are specified by API Service, letter designations and SAE viscosity numbers.
- Engine oil should be changed at the specified intervals. Elements in the oil filter should be changed simultaneously.

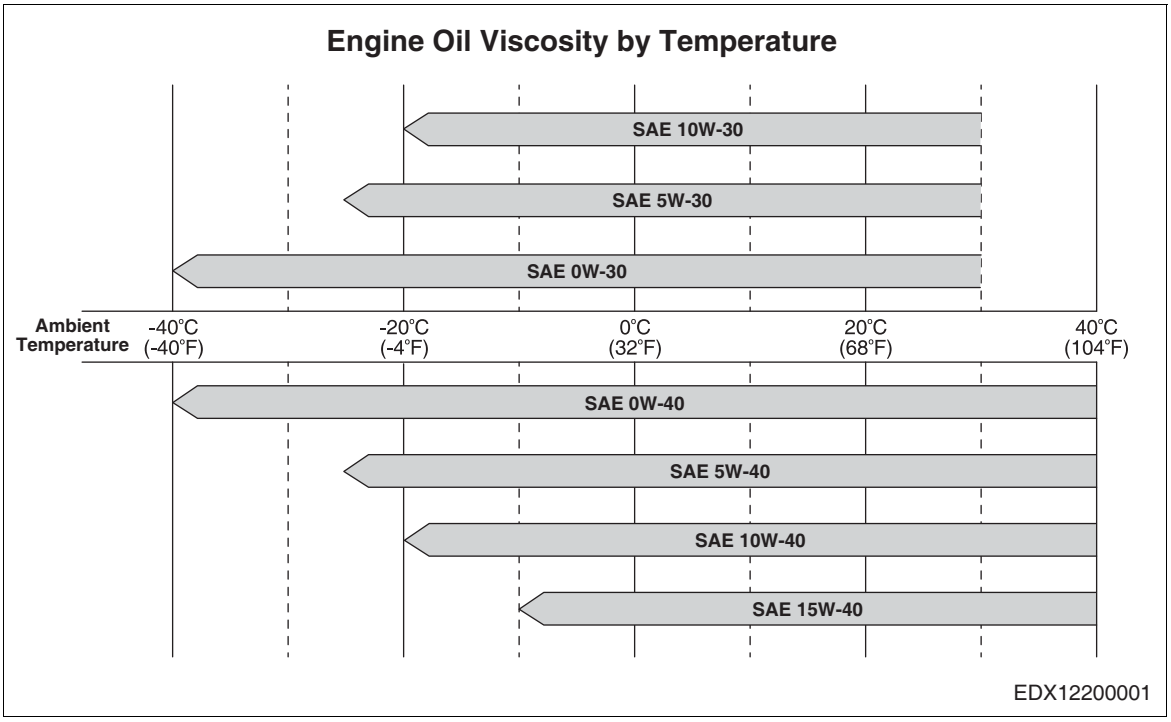
First oil change	After 50hr operation
4V158TIH/TIM/TIL, 4V AD158TI **4V222TIH/TIM/TIL, 4V AD222TI**	every 250 hours

- The following oils are also recommended.

Engine model	**Recommend oil**	
	SAE No.	**API No.**
4V158TIH/TIM/TIL, 4V AD158TI **4V222TIH/TIM/TIL, 4V AD222TI**	SAE10W40	API Service CI-4

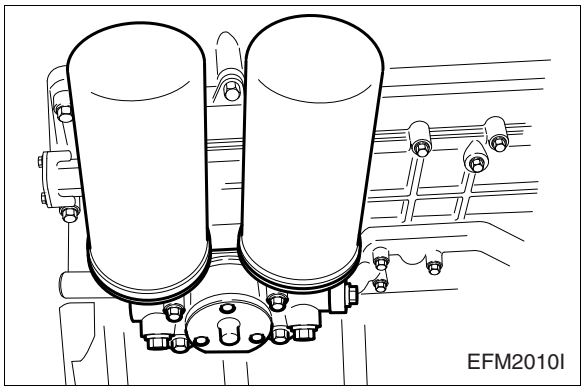
- Engine oil capacity

Engine oil capacity			
Engine model	**in Oil pan**		**Total (lit)**
	Max. (lit)	**Min. (lit)**	
4V158TIH/TIM/TIL, 4AD158TI	31	25	35
4V222TIH/TIM/TIL, 4AD222TI	40	33	43



2.2.8. Oil filter

- At the same time of oil exchange, 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.

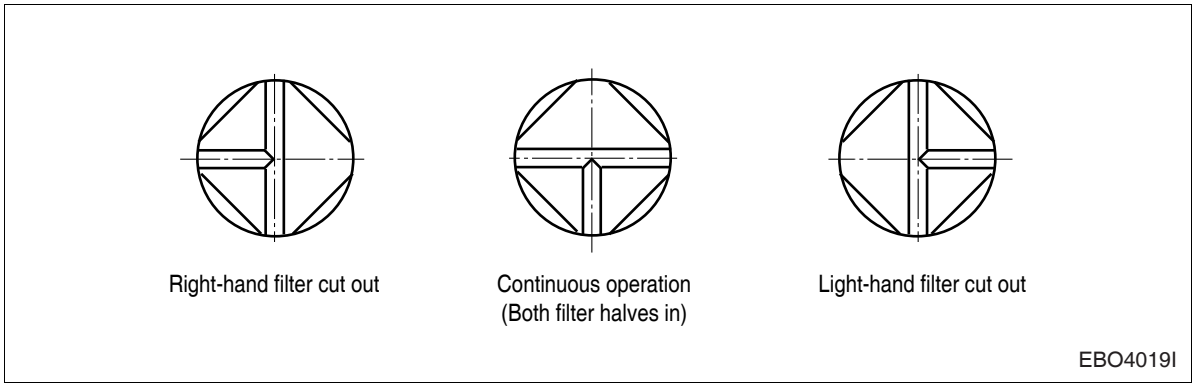
- Loosen the filter by turning it counter-clockwise with a filter wrench.
- With a rag wipe, clean the fitting face of the filter body and the oil filter body so that new oil filter cartridge can be seated properly.

NOTE:
It is strongly advisable to use HD Hyundai Infracore genuine oil filter cartridge for replacement.

- Lightly oil the O-ring and turn the oil filter until sealing face is fitted against the O-ring. Turn 3/4 ~ 1 turns further with the filter wrench.

NOTE:

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

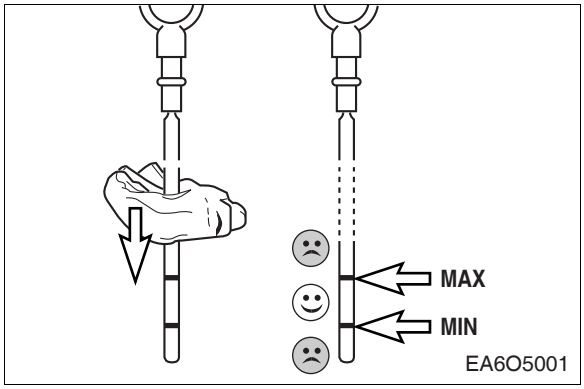


CAUTION:

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

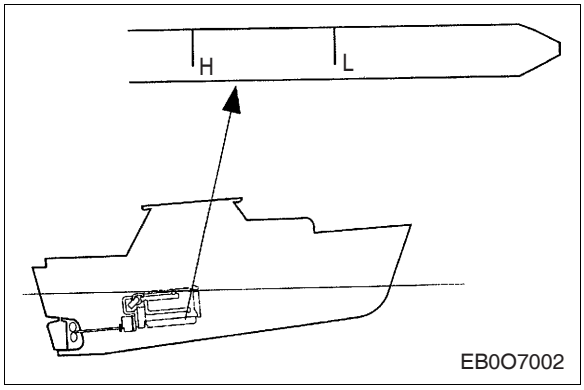
2.2.9. Oil level

- The notches in dipstick must indicate the oil level between high and low permissible when the vessel is in the water that is at normal trim.
- The oil level should be checked at the horizontal position of the boat after waiting about 10 minutes since then the engine has been shut down.
- Examining the viscosity and the contamination of the oil smeared at the dipstick replace the engine oil if necessary.



CAUTION:

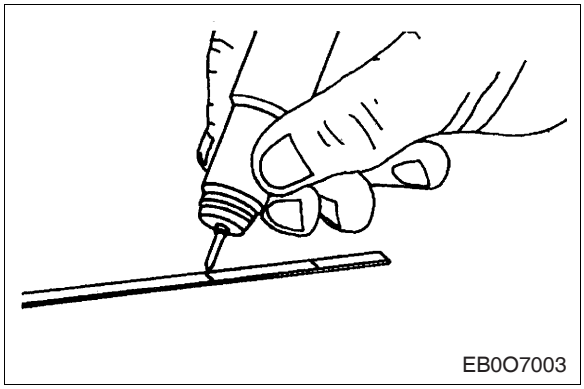
Do not add so much engine oil that the oil level rises above the maximum marking on the dipstick. Over filling will result in damage to the engine like an excessive blow-by gas.



- **How to re-mark the oil dipstick**

  Since the inclination angle of marine engine may differ greatly among vessels, the high and low oil levels on the dipstick should be also changed for over 6 degree of the engine inclination.

  Dipstick should be re-marked by engraving on the lube oil capacity of each engine. Bu sure to check and mark the oil levels between **High** and **Low** when the vessel is commissioning at first. Please note that stamping or notching will weaken the dipstick and the tip of the dipstick may break off in the oil pan.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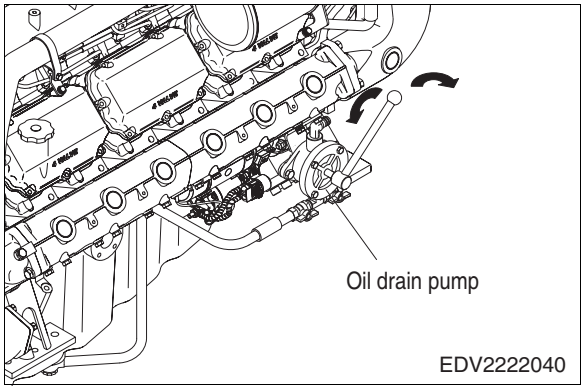
2.2.10. Exchanging of lubrication oil

- While the oil is still hot, discharge the sump oil or marine gear sump oil by motion oil drain pump lever manually 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 conform 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 it necessary.



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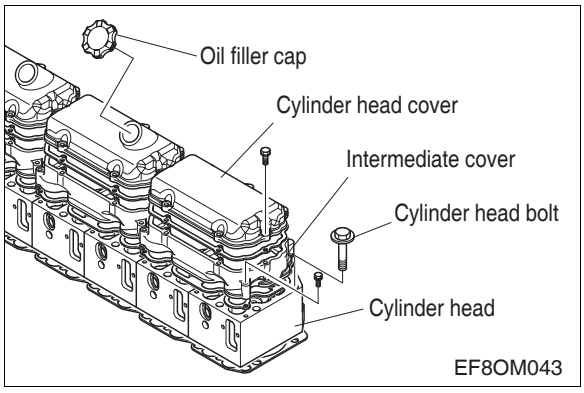

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2.2.11. Check and adjust of V-belt tension

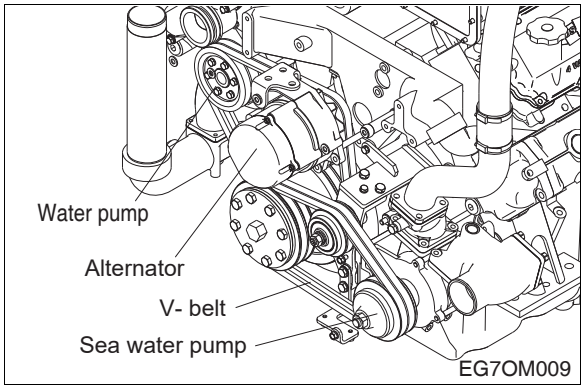
(1) V – belt condition

Check the belt for cracks, oil, overheating and wear.

(2) V-belt tension

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

Water pump



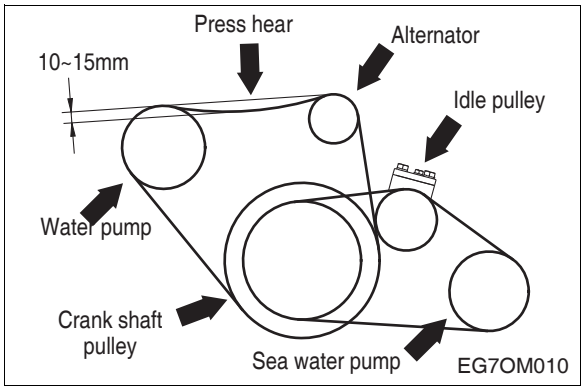
(3) Change the V-belt

Change the belt if necessary after every 2,000 hours of operation.

Upper cover

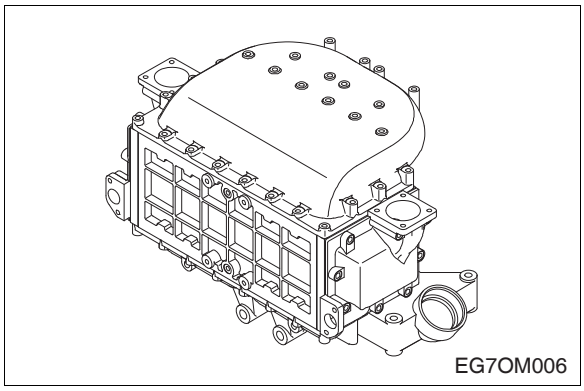
If, in the case of a multiple belt drive, wear or differing tensions are found, always replace the complete set of the belts.

Always apply to HD Hyundai Infracore genuine parts every replacement.



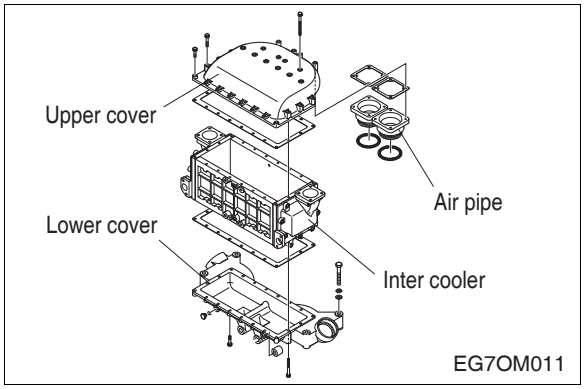
2.2.12. Inter cooler

- Inter cooler depends on the intake air condition greatly. The fouled air pollutes and clog the air fins of the inter cooler. As a result of this, the engine output is decreased and the engine malfunction may be occurred. Therefore always check weather the intake air systems like air filter element are worn or polluted. The inter-cooler has to be removed from the engine for cleaning.


EG7OM006

<Inter cooler cleaning>

- In order to maintain the heat transfer efficiency of the inter-cooler, it is necessary to clean it at regular intervals. For this purpose, dismantle the inter-cooler. In almost all cases, it will suffice to clean the individual parts in a hot alkaline solution, e.g. a 3 to 5% P3-FD solution.
- If hard and firmly adhering scale deposits continue to exist, a second treatment should be made with a descaling agent which will not corrode the cooler core. Use new gaskets when reassembling the inter-cooler.



EG7OM011

- Be sure to clean the sealing surface carefully before installing the gaskets. Observe the specified pressure when making the hydraulic test.

Test gauge pressure	Water side	400 kPa(4bar)
	Charge air side	300 kPa(3bar)

- Cleaning of inter cooler : every 1,000 hours

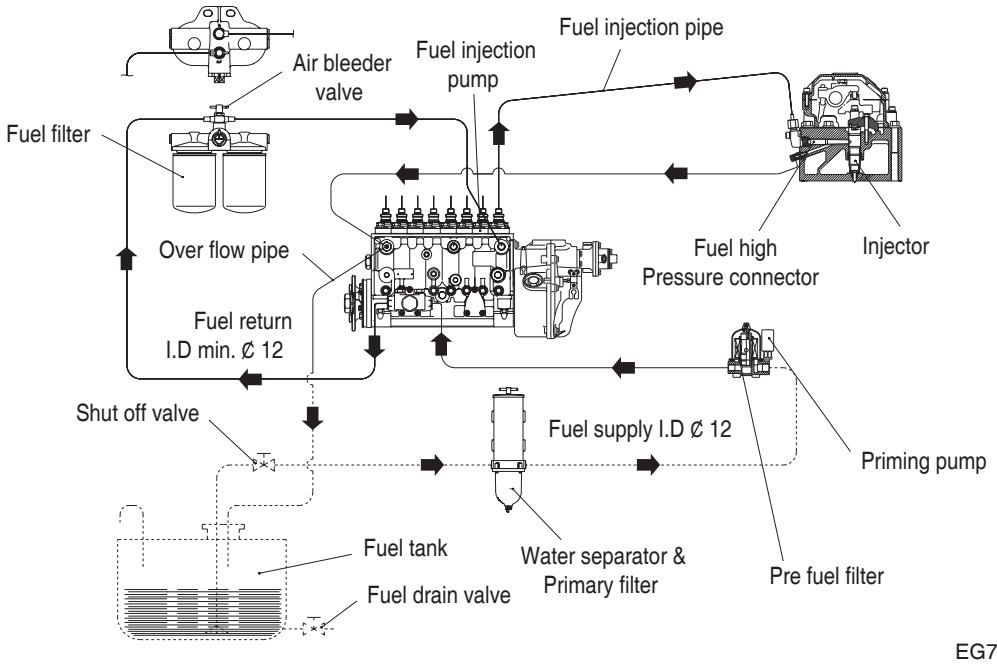
NOTE :

To prevent corrosion of the cooling system, a plug screw type Zinc Anode is applied, and please check it regularly (1 month) and replace it when it is corroded.

2.2.13. Fuel system

- The fuel is delivered by the fuel lift pump via the fuel filter to the injection pump and from there to the injectors.
- The fuel is sprayed into the cylinder through nozzles fitted in screw-fit injections in the cylinder heads
- Excessive fuel delivered and leak fuel from the injectors flow through the return pipe back to the tank.

4V158TIH, 4V158TIM, 4V158TIL engine



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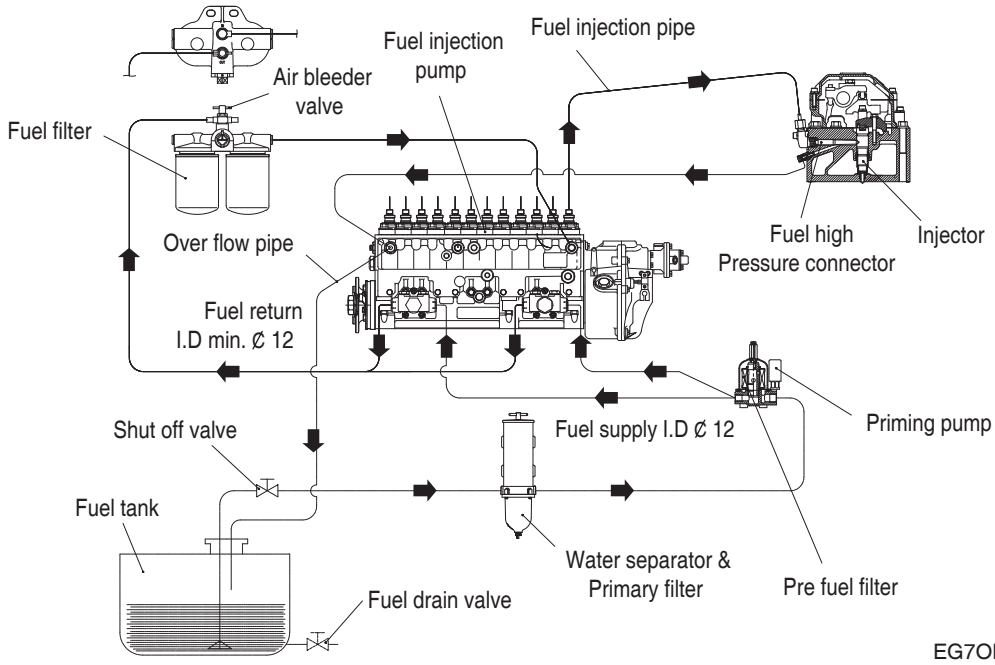
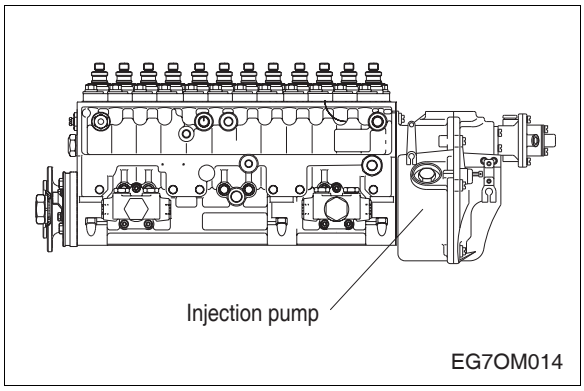
4V222TIH, 4V222TIM, 4V222TIL engine



EG7OM013

2.2.14. Fuel injection pump

- The in-line injection pump is driven via gears from the crankshaft. It is connected to the force-feed lubricating system of the engine and consequently maintenance-free. The electrical governor flange-mounted on the pump casing is a variable range governor designed to keep the speed set by the control electrical constant under conditions of varying load.
- No alterations must be made to the injection pump. It the lead seal is damage the warranty on the engine will become null and avoid.

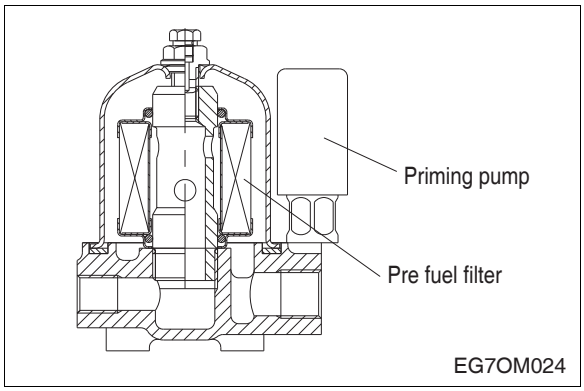


2.2.15. Air bleeding of the fuel system

Whenever fuel filter is changed or the engine is stopped cause of the fuel lack, the air of fuel line must be removed as follows.

Bleed the fuel by manually operating the priming pump with fuel filter outlet joint bolt and injection pump bleeder screw loosened.

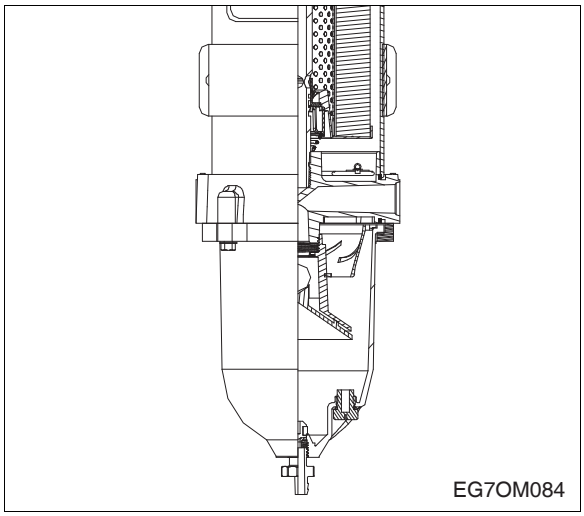
- Press the feed pump cap repetitively until the fuel without bubbles comes out from the bleeding plug screw.
- After the whole air is pulled out, close the plug screws of the filter and the pump.
- Confirm the resistance of fuel delivery by repetition pressing of the feed pump cap, Pressure and turn the priming pump cap simultaneously to close it.



NOTE :

Removing the seal ring(copper seal ring/rubber coated seal ring) when bleeding the fuel system replace it with a new one. Otherwise fuel leaks from the fuel filter joints, causing a critical fault in engine performance.

2.2.16. Water separator for fuel



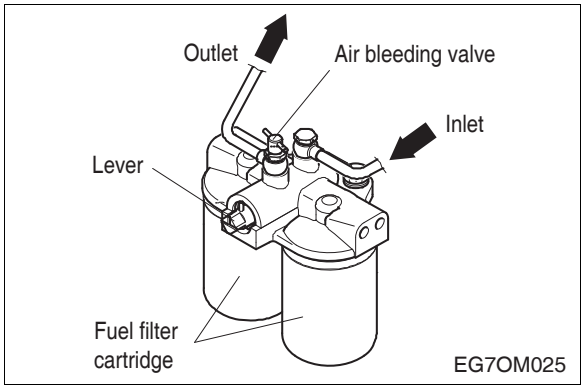
HD Hyundai Infracore recommends the fuel water separator to install between fuel tank and fuel injection pump strongly. Condensation formed in a partially filled tank promotes the growth of microbial organisms that can clog fuel filters and restrict fuel flow and cause the engine power decrease before.

Water in the fuel will decrease the lubrication in the pump and possibly cause a failure of the pump. Injection nozzles are also lubricated by fuel and can also fail as a result of water in the fuel.

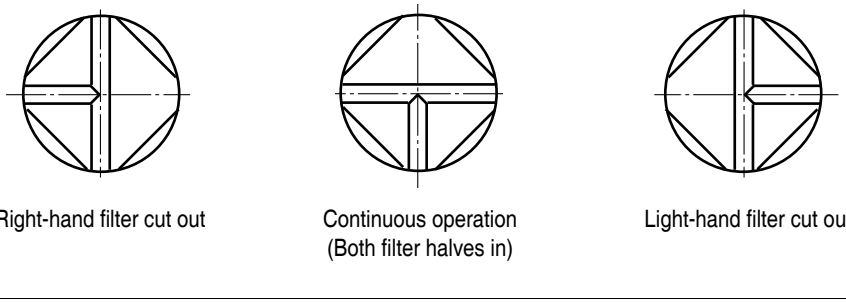
Therefore, it is necessary to remove any water from the fuel before it reaches the fuel pump by using a fuel water separator.

Fuel water separators that are available from HD Hyundai Infracore are recommended. If another fuel water separator is to be sued, it must be sized for the engine's fuel supply flow rate.

2.2.17. Fuel filters



- Loosen the fuel filter by turning it counter-clockwise with the filter wrench. Discard the used filter a designated place.
- Wipe the filter fitting face clean.
- Apply a light coat of engine oil to the O-ring and supply fuel to the new filters.
- Turn the new filter until the filter O-ring is fitted against the sealing face.
- And then turn the filter cartridge about 3/4 ~1 turn more with hands or filter wrench.

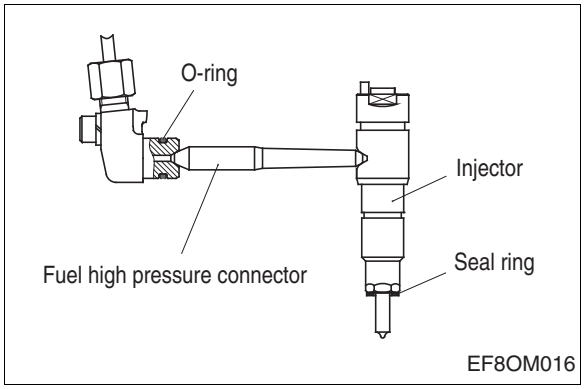


CAUTION:

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

2.2.18. Injector & high pressure connector

- Be careful to mix the foreign matter into the injector and inside of the connector for connecting the high pressure at disassembly and check.
- O-ring and cupper washer should be changed with new one at reassembly.
- Assemble after coat the oil on the O-ring.



2.2.19. Fuel tank cleaning & checking

Fill the tank with recommended fuel. Keeping tanks full reduces water condensation and helps keep fuel cool, which is important to engine performance. Make sure fuel supply valves (if used) are opened. In marine environment, the most likely fuel contaminants are water and microbial growth (black "slime"). Generally, this type of contamination is the result of poor fuel handling practices.
Black "slime" requires water in the fuel to form and grow, so the best prevention is to keep water content to a minimum in storage tanks.
If diesel fuel which contains moisture is used, injection system and cylinder liners, pistons will be damaged. Drain moisture and accumulated sediment from drainage device of storage tank regularly. You'd better change the element of the water separator or fuel filter cartridge several times until fuel of the suction line is cleaned.

IMPORTANT:
A galvanized steel tank should never be used for fuel storage, because fuel oil reacts chemically with the zinc coating to form powdery flakes which can quickly clog the fuel filters and damage the fuel pump and injection nozzles.

2.2.20. Fuel requirements

- HD Hyundai Infracore diesel engines were designed to use Number 2-D diesel fuel or equivalent that meets specification **ASTM D (Grade Low Sulfur).** For maximum fuel economy, Number 2-D fuel whenever possible. When temperatures are below -7 °C, use Number 1-D fuel. If Number 1-D fuel is not available, the mixture of one kerosene to two gallons of Number 2-D fuel can be used. Once kerosene has been added, the engine should be run for several minutes to mix the fuel.

2.2.21. How to select fuel oil

- Fuel quality is an important factor in obtaining satisfactory engine performance, long engine life, and acceptable exhaust emission levels. HD Hyundai Infracore engines are designed to operate on most diesel fuels marketed today. In general, fuels meeting the properties of ASTM Designation D975 (grades 1-D and 2-D : Grade Low Sulfur) have provided satisfactory performance.
- The ASTM 975 specification, however, does not in itself adequately define the fuel characteristics needed for assurance of fuel quality.
- The properties listed in the fuel oil selection chart below have provided optimum engine performance. Grade 2-D fuel is normally available for generator service. Grade 1-D fuel should not be used in pleasure craft engines, except in an emergency.

- **Fuel oil selection chart**

Property	ASTM D975 2GRADE		EN 590:2013	
Flash point, min	No 2D 52°C	D923	55°C	EN2719
Water & sediment, max.	0.05% vol.	D2709		
Water, max.			200 mg/kg	EN ISO 12937
Total contamination, max.			24 mg/kg	EN 12662
Distillation temperature (% vol recovered)	90% 2D 282-338°C	D86	65%: 250°C 85%: 350°C	EN ISO 3405
Kinematic viscosity (at 40°C)	2D 1.9-4.1 mm^2/s	D445	2.0-4.5 mm^2/s	EN ISO 3104
Density (at 15°C)			820-845 kg/m^3	EN ISO 3675 EN ISO 12185
Ester content	5% vol. max.	EN14078	7% vol. max. FAME	EN 14078
Ash, max.	0.01% wt	D482	0.01% wt	EN ISO 6245
Sulfur, max. (by mass)	2D	D5453 D2622 D129[2]	10	EN ISO 20846
	S15 15 mg/kg			EN ISO 20884
	S500 0.50%			EN ISO 13032
	S5000 0.50%			
Copper strip corrosion, max.	No 3	D130	Class 1	EN ISO 2160
Cetane number, min.	40	D613	51	EN ISO 5165
Cetane index, min.			46	EN ISO 4264
- Cetane index	40 min.	D976-80		
- Aromaticity	35% vol. max.	D1319		
PAH, max.			11% wet	EN 12916
Operability, one of: - Cloud point - LTFT/CFPP	Report	D2500 D4539 D6371		
Cloud point			Location & season dependant	EN 23015
CFPP			Location & season dependant	EN 116
Carbon residue on 10% distillation residue, max.	2D: 0.35% wt	D524	0.30% wt	EN ISO 10370
Oxidation stability, max.			25 g/m^3	EN ISO 12205
Lubricity (at 60°C), max.	520 µm	D6079 D7688	460 µm	ISO 12156-1
Conductivity, min.	25 pS/m	D2624 D4308		

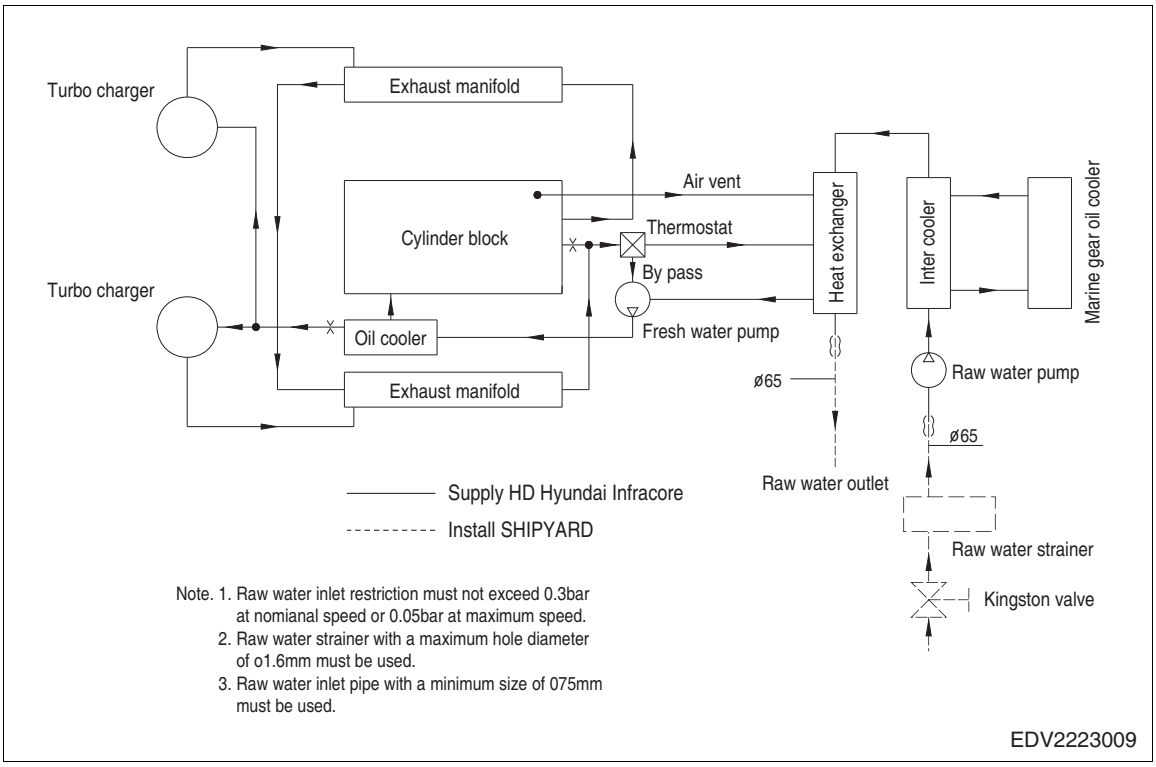
* If the sulfur content of the fuel is more than 0.5%, the replacement and inspection cycle should be cut in half.

Note:

The cloud point should be 6°C below the lowest expected fuel temperature to prevent clogging of fuel fitters by crystals

2.2.22. Cooling system

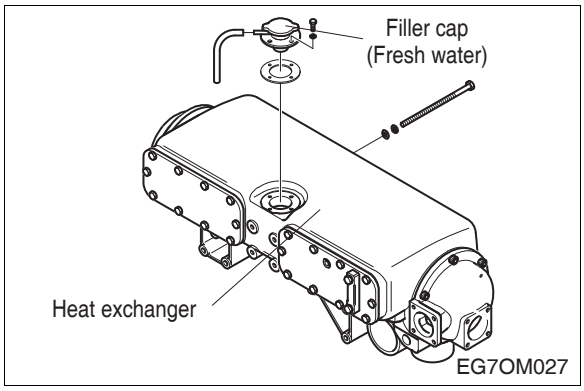
- The engine have indirect cooling circuit cooled the engine coolant in the heat exchanger by sea water. The temperature of engine coolant is usually normal between 71°C and 85°C, and the sea water entry temperature is designed up to 32°C.
- River/sea water is sucked in by the sea water pump and fed through the heat exchanger, where it absorbs the heat conducted away by the engine coolant. After that, the sea water flows to the outside of the boat through inter-cooler and reduction gear oil cooler. In case sea water goes through inter-cooler and gear oil cooler at first and then it goes through the heat exchanger.



2.2.23. Heat exchanger

(1) Heat exchanger cleaning

If the heat exchanger tubes are clogged by many small pieces or polluted by corrosion, the sea water quantity will be reduced gradually also as a result of it engine overheating may be occurred.



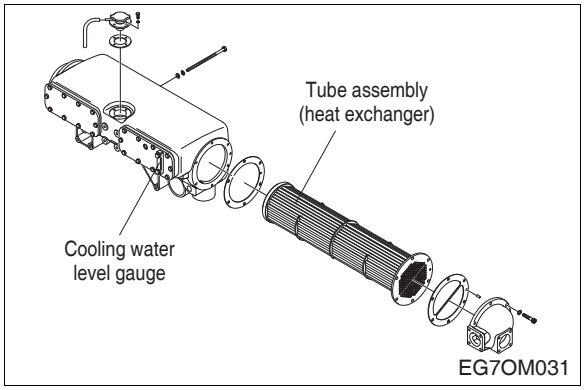
Operating pressure of filler cap

Positive pressure	0.9 ± 0.2kg/cm^2
Negative pressure	0.08 ± 0.02kg/cm^2

NOTE :

Because it is dangerous to open the pressure cap quickly when coolant is hot, after lowering the inside pressure of the tank by slow-opening at first open it fully.

a) Remove the heat exchanger both left and right side covers.
b) Remove the clogged small pieces and clean the heat exchanger tubes.
c) When the heat exchanger tubes do cleaning, and clean outside and inner side of tubes with a small wire brush and pressurized water.



(2) Fresh water line cleaning

If the cooling circuits are polluted with scales or sludge particles, the cooling efficiently will be dropped down.

The poor condition of the cooling system is normally due to use of unsuitable anti-freezing agents so periodically clean the circuit interior with a cleaner.

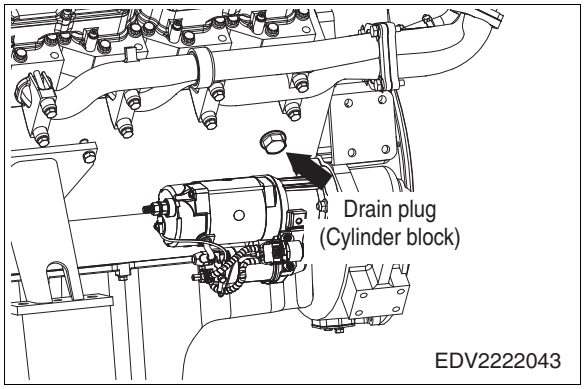
Cleaning of heat exchanger : every 1,200 hours

NOTE :

To prevent corrosion of the cooling system, a plug screw type Zinc Anode is applied, and please check it regularly (1 month) and replace it when it is corroded.

2.2.24. Drain of cooling water

- Open the radiator cap and discharge the cooling water in radiator through a drain cock.
- The cooling water in engine main body is discharged through the drain plug located at the side of the engine cylinder block.
- Remove the drain plug of oil cooler and discharge the cooling water in the oil cooler. Pay particular attention to the discharge of the cooling water in the oil cooler to prevent the oil cooler from freezing and failure in winter.



2.2.25. Cooling water

- We recommend the coolant for engines should be mixture of fresh water and additional agent (33 ~ 50% anti-freeze and 3 ~ 5% anti-corrosion agent).
- Check the quantity of anti-freeze every 600 hours. From time to time, refill the anti-freeze as much as required.

NOTE :

Suitable mixture of anti-freeze and-corrosion agent can protect the engine corrosion from deteriorating and raises a boiling point, but by using unsuitable mixture engine components like water pump impeller and water jacket of cylinder block may be occurred a malfunction by any bad corrosion damage or cavitation.

- You can check the quantity of anti-freeze and anti-corrosion agent by using a FLEETGUARD test kit simply as follow.
  (Fleetguard CC2602M or HD Hyundai Infracore 60.99901-0038)

- **How to use the cooling water test kit**

(1) When the cooling water temperature 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) Shake the bottle filled with sample coolant to mix well and take out one strip from bottle of the test kit. Then dip the strip into coolant sample for 3~5 seconds, take it out and shake it briskly to remove excess liquid.

NOTE:

Do not touch the pads on the end of the strip. Discard the kit if unused strips have turned brown for the nitrite test pad.

(3) Wait for 45 seconds until color of the dipping striped pad is turned into any colors and then compare and record the compared results with the color figure as following order.

NOTE:

All three readings must be completed no later than 75 seconds after dipping striped pad rapidly. Do not touch the striped pad with fingers.

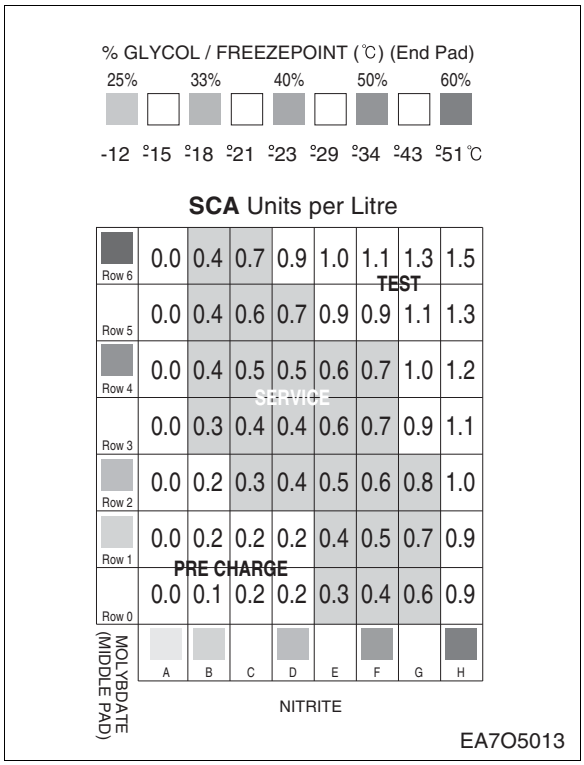
- How to judge the strip

c) b) a)

a) Compare FREEZEPOINT (end pad) to chart and record result.
b) Next compare MOLYBDATE (middle pad) to chart and record result.
c) Finally compare NITRITE test to chart and record result.

(4) Compare the end pad “a)” color of the strip with color block of a row at the upper part of the standard color chart (bellow of the letter “GLYCOL/ FREEZEPOINT”). Same color in the block of the row means the content of anti-freeze in the coolant. (Normal range is between 33% and 50%)

(5) Compare the middle pad “b)” color of the strip with the color that the column block color of MOLYBDATE at the left side of the table intersects the row block color of NITRITE at the bottom (pad “c)” color of the strip) on the table “SCA Units per Litre”.
(Normal range of “SCA Units per Litre” is between 0.3 and 0.8 : “green color area”)



NOTE:
During the comparison, if uncertain about color match, pick the lower numbered block. (example : if the color of NITRITE pad is between standard color “D” and “F”, then use column E)

(6) If the value of “SCA Units per Litre” is less than 0.3, refill the DCA4 liquid (anti-corrosion agent) a little, but larger than 0.8, drain some amount of engine coolant and replenish the fresh water instead. The content of the anti-freeze and anti-corrosion agent can be regulated by this way.

NOTE:
Every year coolant must be replaced. It is essential the coolant should be mixture of fresh water, proper anti-freeze and anti-corrosion agent.

- **Amount of Anti-freeze**

  The anti-freeze, 33 ~ 50% of the whole coolant, is always to be used to prevent the cooling system from the corrosion. And in the winter the amount of anti-freeze shown in the following table should be used in accordance with the ambient temperature.

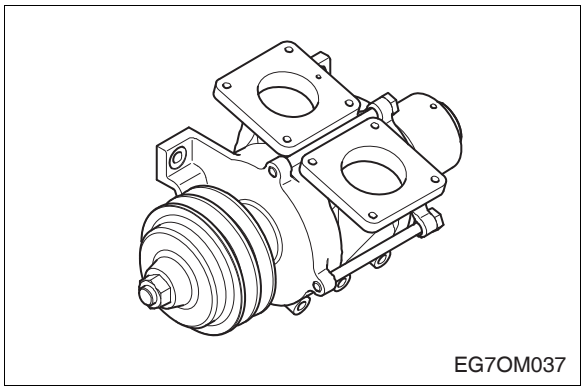
  As the individual freezing points corresponding to the proportions of antifreeze in the table are subject to change slightly according to the kind of antifreeze, you must follow the specifications provided by the antifreeze manufacturer.

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

Any coolant loss due to engine operation must be replenished. But adding fresh water for coolant tends to lower the content of anti-freeze. Always replenish the coolant with a mixture of antifreeze and water, and keep the proper the content of anti-freeze (33 ~ 50%).

2.2.26. Sea water pump

Impeller of the sea water pump is a bronze type, therefore you should install the sea water strainer as right figure in order not to suck in any hard pieces and sharp scales. Install the sea water strainer in adequate size for the engine between Kingston valve and sea water pump.


EG7OM037

- Over-tightened belt will reduce the bearing life of the sea water pump.
- If sea water is not sucked in sea water pump at starting, restart the engine after filling water in the sea water pump housing and inlet hose.
- Make sure that all valves / cocks in the water line are opened before run.
- If there is a risk of freezing weather, drain the water by loosening bolts of end cover.
- Temperature range : 5°C ~ 50°C

2.2.27. Bottom of the engine room

(1) Always keep the bottom clean.

Check the bilge for excessive water accumulation. Always keep the bilge clean and dry.

Never allow the water depth in the bilge to exceed the bottom of the engine.

If water accumulation is unavoidable, you have to install a bilge pump with an automatic control switch.

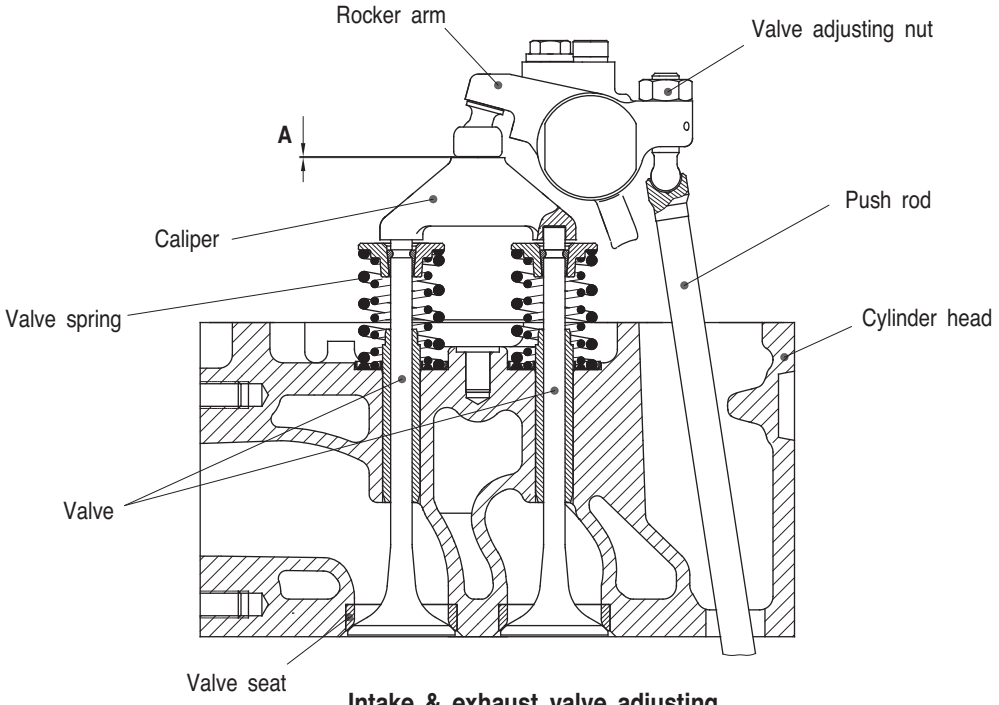
CAUTION:

The water level in the boat's bilge will increase when the boat is operated at a high inclination before rated speed is reached. Excessive water in the bilge can cause engine damage like corrosion, malfunction of engine parts.

2.2.28. Valve clearance adjust procedure

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

Specified value	
Intake valve	Exhaust valve
0.40 mm	0.50 mm



Intake & exhaust valve adjusting

EF8OM020

- **Adjusting sequence of valve clearance**

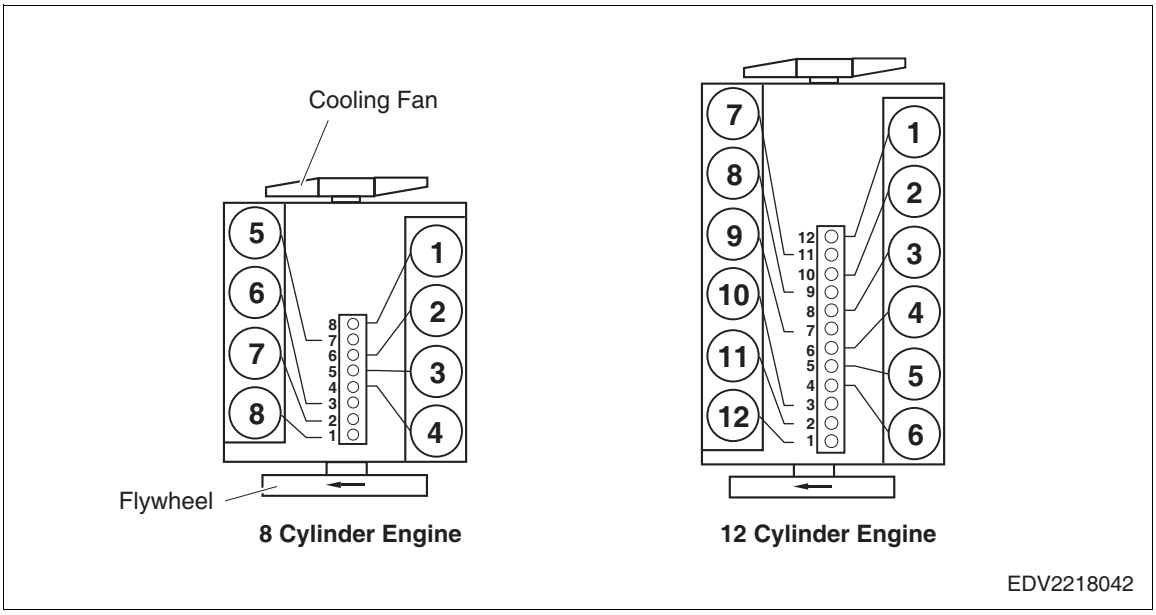
  This is a precision method, but it takes more time.

Method 1

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).



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

*** 8 cylinder engine (4V158TIH/TIM/TIL, 4V AD158TI)**

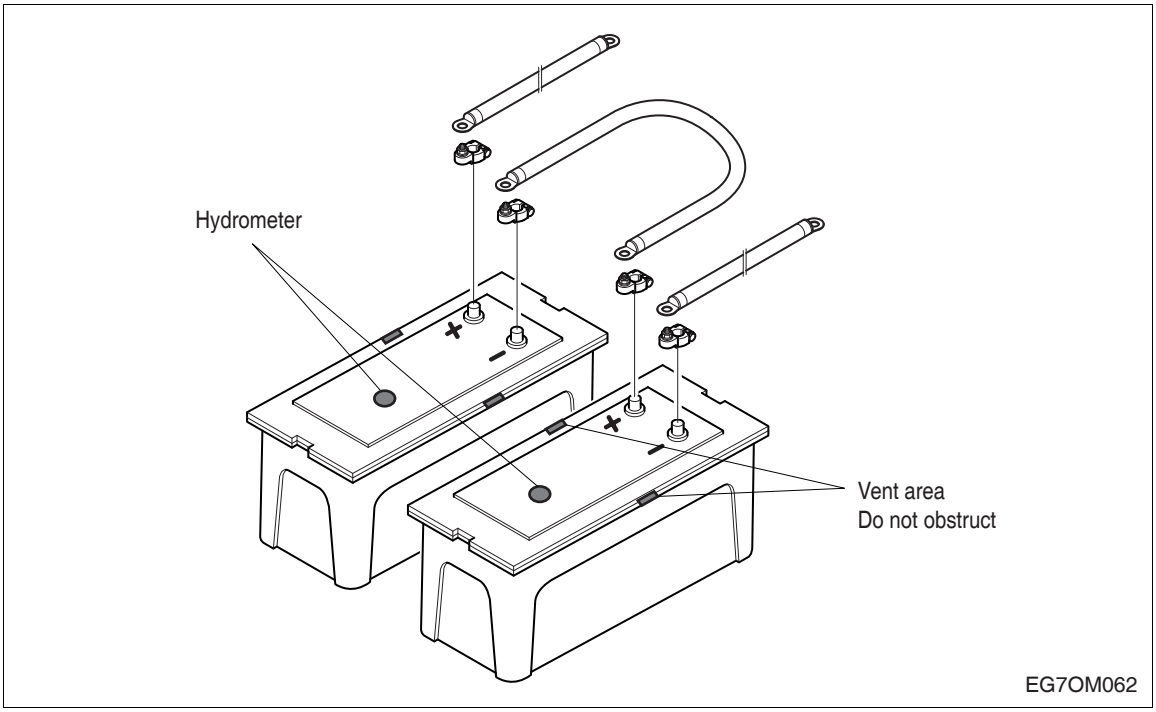
Valve Overlap Cylinder No.							
1	5	7	2	6	3	4	8
6	3	4	8	1	5	7	2
Adjusting Valve Cylinder No. (In./Ex. Valve)							

*** 12 cylinder engine (4V222TIH/TIM/TIL, 4V AD222TI)**

Valve Overlap Cylinder No.											
1	12	5	8	3	10	6	7	2	11	4	9
6	7	2	11	4	9	1	12	5	8	3	10
Adjusting Valve Cylinder No. (In./Ex. Valve)											

2.2.29. Battery

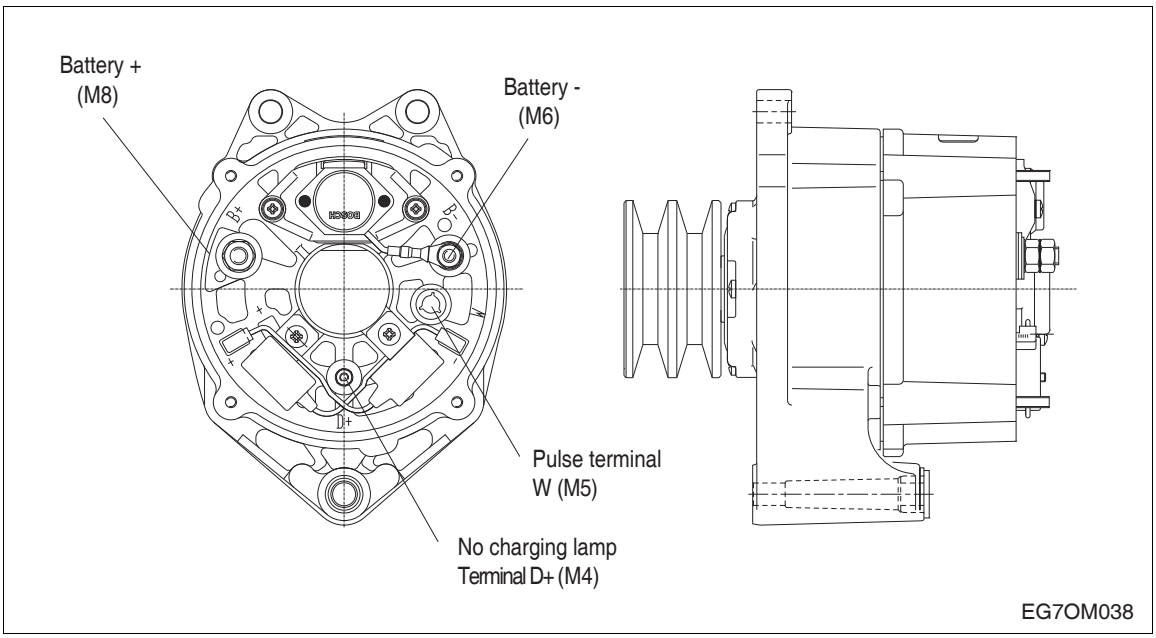
- Inspect for any leakage of electrolytic solution owing to battery crack, and replace the battery in case of poor condition.



2.2.30. Alternator

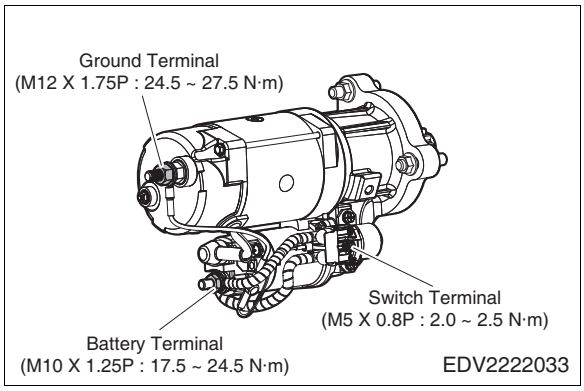
- **Alternator (24Vx50A)**

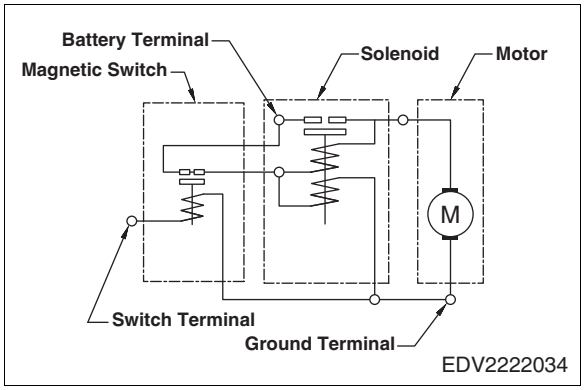
The alternator is fitted with integral silicon rectifiers. A transistorized regulator mounted on the alternator body interior limits the alternator voltage. The alternator should not be operated except with the regulator and battery connected in circuit to avoid damage to the rectifier and regulator.
The alternator is maintenance-free, nevertheless, it must be protected against dust and, above all, against moisture and water.



2.2.31. Starting motor

- The starter motor is installed on the flywheel housing. When the starting key switch is turned on, the starter motor pinion flies out and engages the ring gear of the flywheel. Then the main contact is closed, current flows, and the engine is started.
- After the engine starts, the pinion automatically returns to its initial position when the starting key switch is released. Once the engine starts, the starting key switch should be released immediately. Otherwise, the starter motor may be damaged or burned out.
- In case of repairing the engine, dip the pinion of the starter and ring gear into the fuel and remove the corrosion with brush. After that apply the grease on them to protect the corrosion.
- Whenever you clean the starter, always pay attention not to occur the electric short due to entering the water etc.

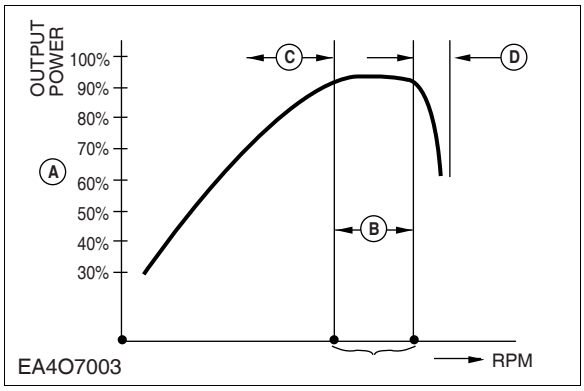




IMPORTANT:

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.

2.2.32. Propeller selection



- Your dealer has chosen a propeller designed to deliver top performance and economy under most conditions. To obtain the maximum percentage of available horsepower (A), the engine rpm at full throttle should be in the specified “Full Throttle Operating Rage” (B). Refer to specifications in performance curve.
- If the engine's full throttle rpm on normal load is below the specified on the low side of the range, use a propeller with less pitch to increase the RPM.
- Should the engine's full throttle RPM want to exceed the specified range (B), the engine RPM is limited by the governor. Use a propeller of higher pitch to stop the limiting by the governor.

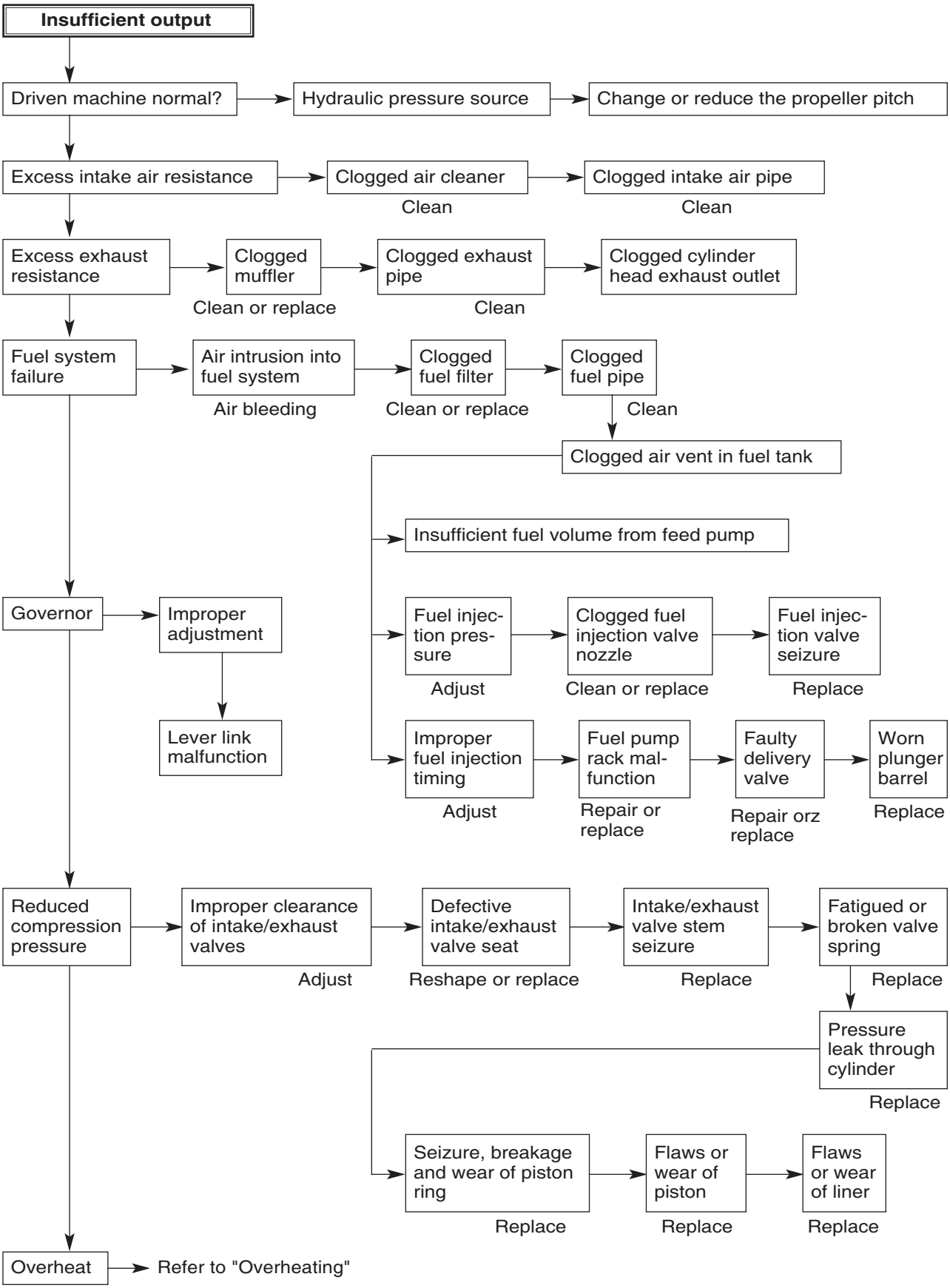
NOTE:

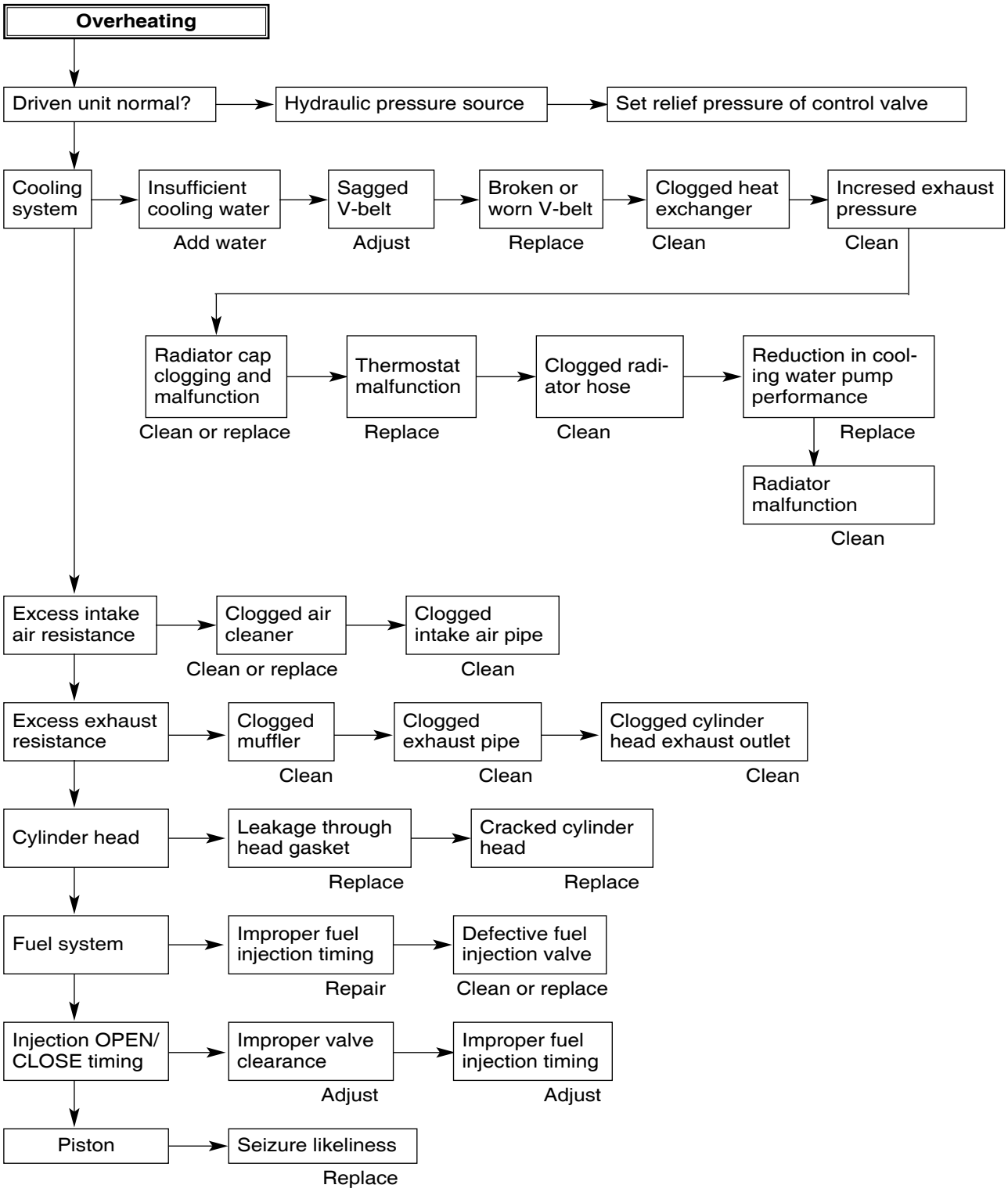
Engine damage can result from incorrect propeller selection which:

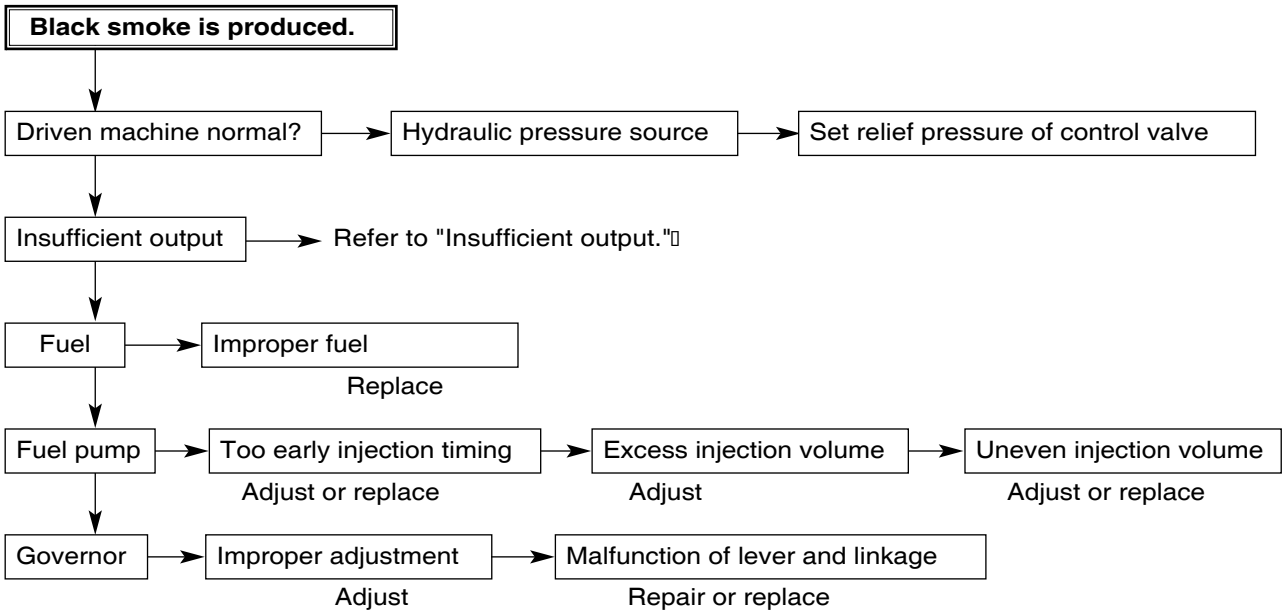
- **(C) Prevents engine RPM from attaining the specified "Full Throttle Operating Range". Engine is laboring, install lower pitch propeller.**
- **(D) Allows engine RPM above the specified "Full Throttle Operating Range". Engine RPM is limited by the governor, install a higher pitch propeller.**

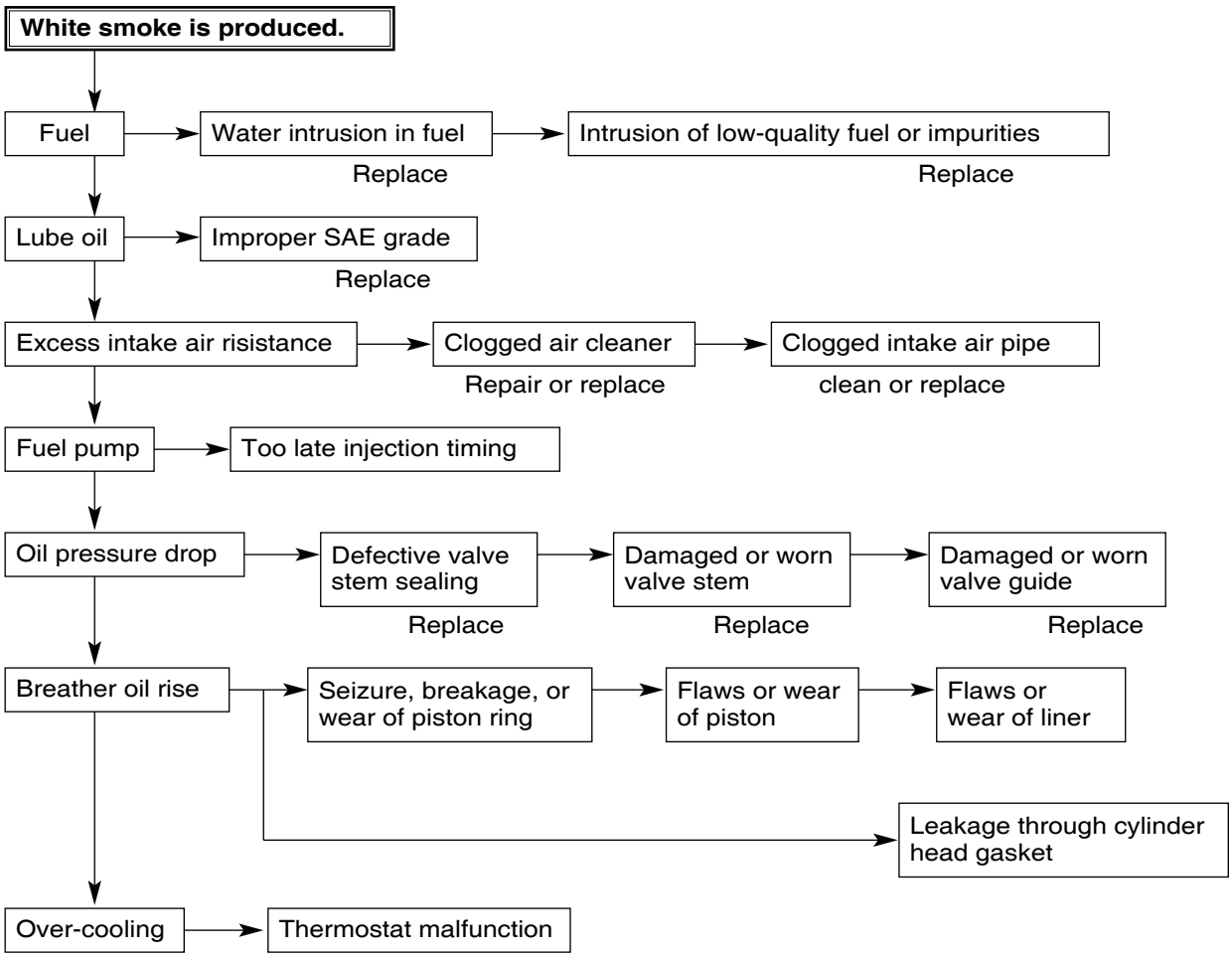
2.3. Diagnosis and Remedy

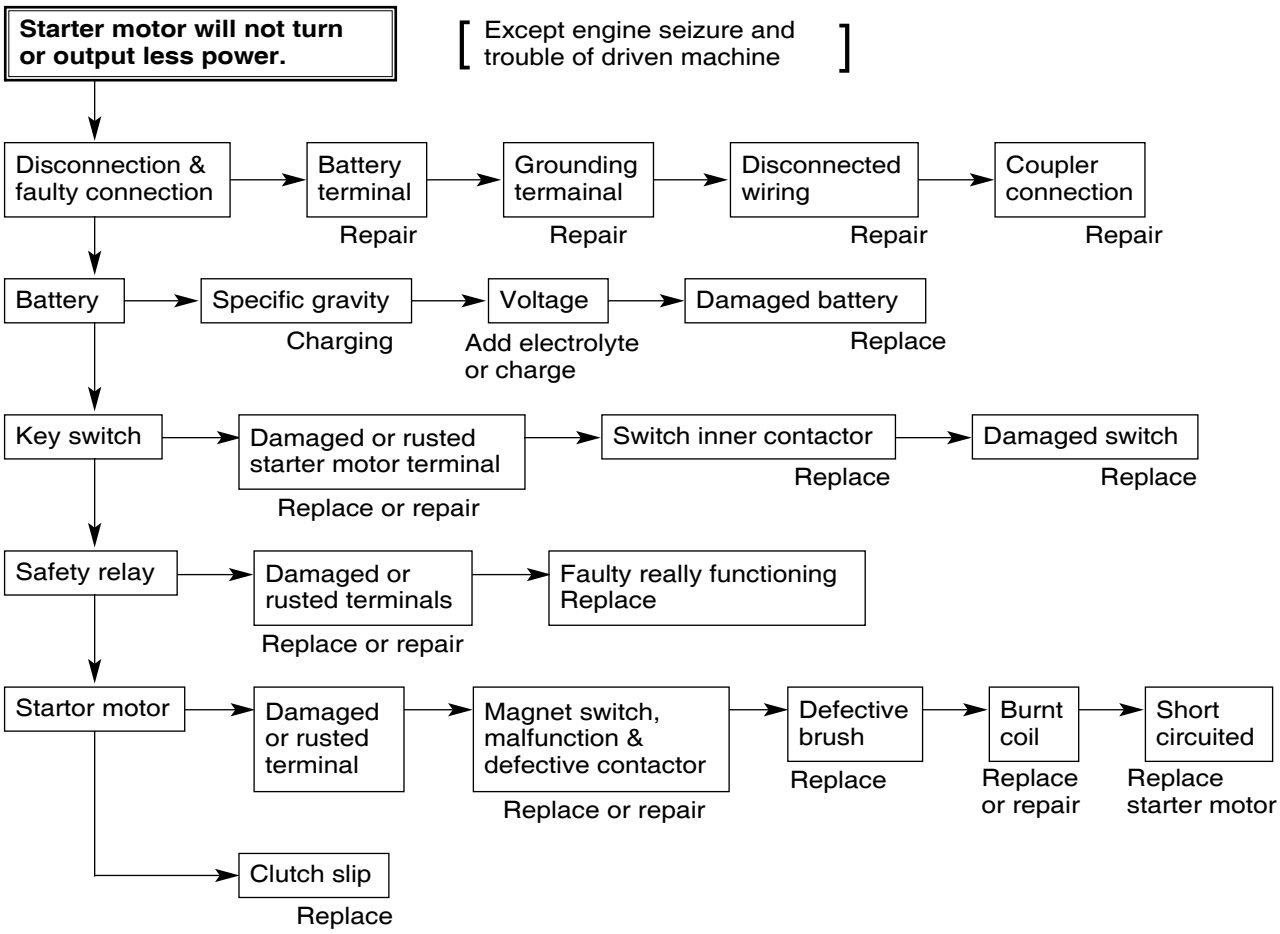
- The following description summarizes the probable cause of and remedy for general failure by item.
- Immediate countermeasures should be taken before a failure is inflamed if any symptom is detected.


Insufficient output
Driven machine normal?
Hydraulic pressure source
Change or reduce the propeller pitch
Excess intake air resistance
Clogged air cleaner
Clean
Clogged intake air pipe
Clean
Excess exhaust resistance
Clogged muffler
Clean or replace
Clogged exhaust pipe
Clean
Clogged cylinder head exhaust outlet
Fuel system failure
Air intrusion into fuel system
Air bleeding
Clogged fuel filter
Clean or replace
Clogged fuel pipe
Clean
Clogged air vent in fuel tank
Insufficient fuel volume from feed pump
Governor
Improper adjustment
Lever link malfunction
Fuel injection pressure
Adjust
Clogged fuel injection valve nozzle
Clean or replace
Fuel injection valve seizure
Replace
Improper fuel injection timing
Adjust
Fuel pump rack malfunction
Repair or replace
Faulty delivery valve
Repair orz replace
Worn plunger barrel
Replace
Reduced compression pressure
Improper clearance of intake/exhaust valves
Adjust
Defective intake/exhaust valve seat
Reshape or replace
Intake/exhaust valve stem seizure
Replace
Fatigued or broken valve spring
Replace
Pressure leak through cylinder
Replace
Seizure, breakage and wear of piston ring
Replace
Flaws or wear of piston
Replace
Flaws or wear of liner
Replace
Overheat
Refer to "Overheating"

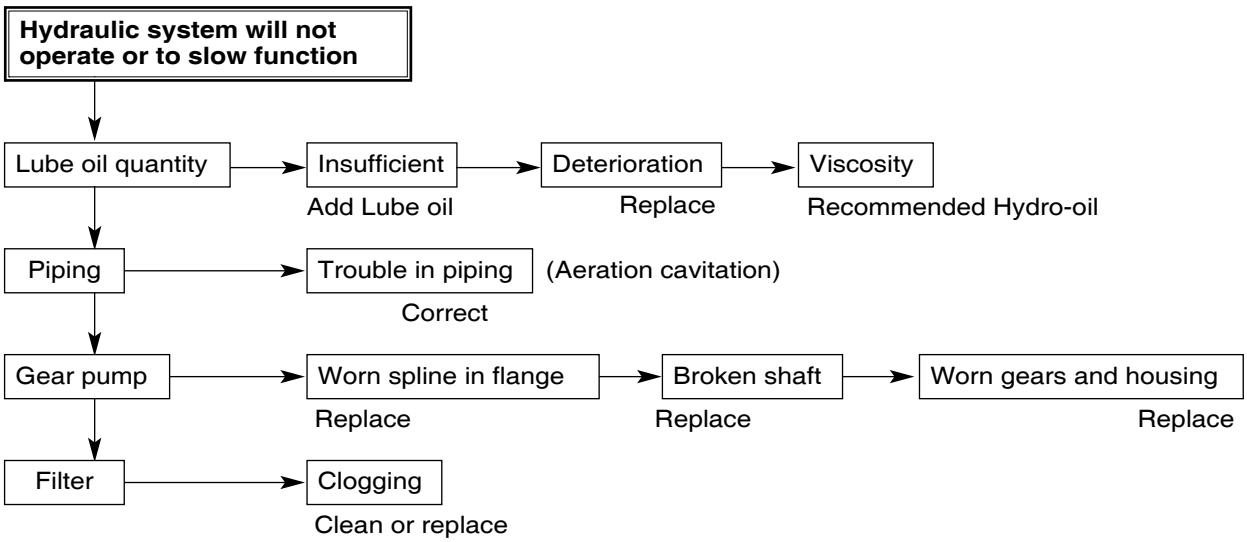

Overheating
Driven unit normal?
Hydraulic pressure source
Set relief pressure of control valve
Cooling system
Insufficient cooling water
Add water
Sagged V-belt
Adjust
Broken or worn V-belt
Replace
Clogged heat exchanger
Clean
Incresed exhaust pressure
Clean
Radiator cap clogging and malfunction
Clean or replace
Thermostat malfunction
Replace
Clogged radiator hose
Clean
Reduction in cooling water pump performance
Replace
Radiator malfunction
Clean
Excess intake air resistance
Clogged air cleaner
Clean or replace
Clogged intake air pipe
Clean
Excess exhaust resistance
Clogged muffler
Clean
Clogged exhaust pipe
Clean
Clogged cylinder head exhaust outlet
Clean
Cylinder head
Leakage through head gasket
Replace
Cracked cylinder head
Replace
Fuel system
Improper fuel injection timing
Repair
Defective fuel injection valve
Clean or replace
Injection OPEN/ CLOSE timing
Improper valve clearance
Adjust
Improper fuel injection timing
Adjust
Piston
Seizure likeliness
Replace

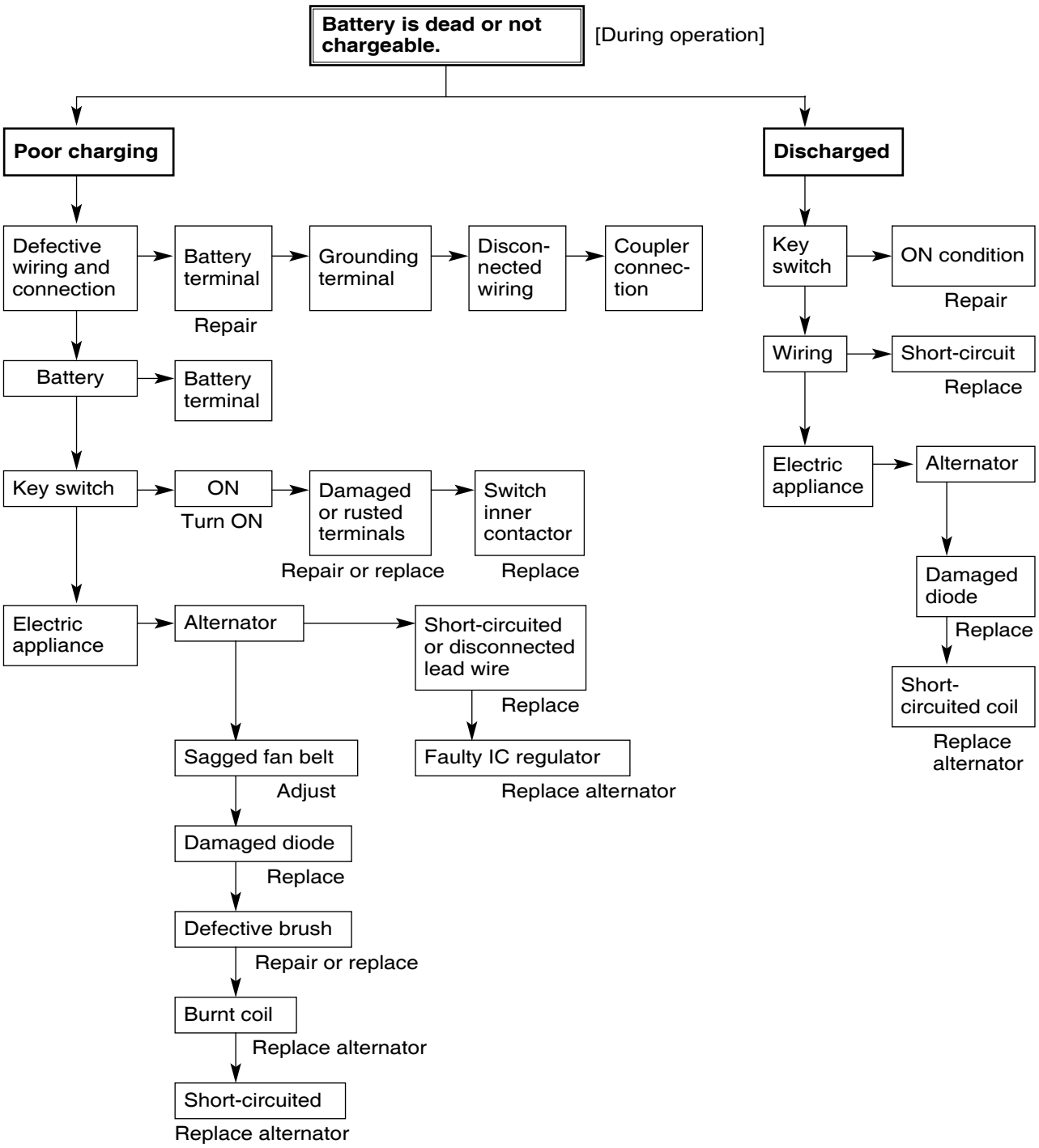

Black smoke is produced.
Driven machine normal?
Hydraulic pressure source
Set relief pressure of control valve
Insufficient output
Refer to "Insufficient output."
Fuel
Improper fuel
Replace
Fuel pump
Too early injection timing
Adjust or replace
Excess injection volume
Adjust
Uneven injection volume
Adjust or replace
Governor
Improper adjustment
Adjust
Malfunction of lever and linkage
Repair or replace


White smoke is produced.
Fuel
Water intrusion in fuel
Replace
Intrusion of low-quality fuel or impurities
Replace
Lube oil
Improper SAE grade
Replace
Excess intake air risistance
Clogged air cleaner
Repair or replace
Clogged intake air pipe
clean or replace
Fuel pump
Too late injection timing
Oil pressure drop
Defective valve stem sealing
Replace
Damaged or worn valve stem
Replace
Damaged or worn valve guide
Replace
Breather oil rise
Seizure, breakage, or wear of piston ring
Flaws or wear of piston
Flaws or wear of liner
Leakage through cylinder head gasket
Over-cooling
Thermostat malfunction



Hydraulic pressure source




Battery is dead or not chargeable.
[During operation]
Poor charging
Discharged
Defective wiring and connection
Battery terminal
Repair
Grounding terminal
Discon-nected wiring
Coupler connec-tion
Battery
Battery terminal
Key switch
ON
Turn ON
Damaged or rusted terminals
Repair or replace
Switch inner contactor
Replace
Electric appliance
Alternator
Short-circuited or disconnected lead wire
Replace
Faulty IC regulator
Replace alternator
Sagged fan belt
Adjust
Damaged diode
Replace
Defective brush
Repair or replace
Burnt coil
Replace alternator
Short-circuited
Replace alternator
Key switch
ON condition
Repair
Wiring
Short-circuit
Replace
Electric appliance
Alternator
Damaged diode
Replace
Short-circuited coil
Replace alternator

Condition	Causes	Remedies
1) Starting difficult		
(1) Starting motor trouble	● Refer to diagnostics	
(2) Fuel system trouble	● Refer to diagnostics	
(3) Compression pressure lack	● Valve's poor shut, stem distortion	Repair or replace
	● Valve spring damage	Replace valve spring
	● Cylinder head gasket's leak	Replace gasket
	● Wear of piston, piston ring or liner	Adjust
2) Idle operation abnormal	● Injection timing incorrect	Adjust
	● Air mixing at injection pump	Remove air
3) Engine output insufficient		
(1) Continuous output insufficient	● Valve clearance incorrect	Adjust
	● Valve tightness poor	Repair
	● Cylinder head gasket's leak	Replace gasket
	● Wear, stick, damage of piston ring	Replace piston ring
	● Injection timing incorrect	Adjust
	● Fuel injection amount insufficient	Adjust injection pump
	● Nozzle injection pressure improper or stuck	Adjust or replace
	● Supply pump's function lowered	Repair or replace
	● Fuel pipe system clogged	Repair
	● Air suction amount insufficient	Clean or replace air cleaner
	● Turbocharger poor	Repair or replace
(2) Output insufficient when in acceleration	● Compression pressure insufficient	Disassemble engine
	● Injection timing incorrect	Adjust
	● Fuel injection amount insufficient	Adjust injection pump
	● Injection pump timer's function insufficient	Repair or replace
	● Nozzle infection pressure, infection angle improper	Repair, replace
	● Supply pump's function lowered	Repair or replace
	● Air intake amount insufficient	Clean or replace air cleaner
4) Overheating	● Engine oil insufficient or poor	Replenish or replace
	● Cooling water insufficient	Replenish or replace
	● Fan belt loosened, worn, damaged	Adjust or replace
	● Cooling water pump's function lowered	Repair or replace
	● Water temp. regulator's operation poor	Replace
	● Valve clearance incorrect	Adjust
	● Exhaust system's resistance increased	Clean or replace

Condition	Causes	Remedies
5) Engine noisy	For noises arise compositely such as rotating parts, lapping parts etc., there is necessity to search the cause of noises accurately.	
(1) Crankshaft	● As the wear of bearing or crankshaft progress, the oil clearances increase.	Replace bearing & grind crankshaft
	● Lopsided wear of crankshaft	Grind or replace
	● Oil supply insufficient due to oil passage clogging	Clean oil passage
	● Stuck bearing	Replace bearing & Grind
(2) Con.-rod and Con.-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
(3) Piston, piston pin & Piston ring	● Piston clearance increase as the wear of piston and piston ring progresses	Replace piston & piston ring
	● Wear of piston or piston pin	Replace
	● Piston stuck	Replace piston
	● Piston insertion poor	Replace piston
	● Piston ring damaged	Replace piston
(4) Others	● Wear of crankshaft, thrust bearing	Replace thrust bearing
	● Camshaft end play increased	Replace thrust plate
	● Idle gear end play increased	Replace thrust washer
	● Timing gear backlash excessive	Repair or replace
	● Valve clearance excessive	Adjust valve clearance
	● Abnormal wear of tappet, cam	Replace tappet, cam
	● Turbocharger inner part damaged	Repair or replace
6) Fuel Consumption Excessive	● Injection timing incorrect	Adjust
	● Fuel injection amount excessive	Adjust injection pump
7) 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 parts' packing poor	Replace packing
	● Oil seal poor	Replace oil seal

2.4. Periodical Inspection and Maintenance

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

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

2.4.1. General engine inspection cycle

○ : Check & adjust ● : Replace

Inspection		Daily	Inspection time (hours)						Remark
			Every 50	Every 100	Every 250	Every 500	Every 600	Every 1,000	
Cooling System	Check coolant level and refill	○							
	Check contamination of the coolant and the quantity of the anti-freeze						○		● 1 year
	Cleaning the heat-exchanger and cooling water line	○							● 1,200 hrs
	Check V-belt and adjustment	○							● 2,000 hrs
	Check the thermostat								● 2 years
	Check impeller of sea water pump	○							● 2,000 hrs
Lubrication System	Check oil level	○							
	Exchange the lubrication oil and oil filter cartridge	○	● 1st		●				
	Exchange the marine gear oil			● 1st			●		
Intake & Exhaust System	Cleaning the air cleaner element and changing			○			●		
	Cleaning the inter-cooler							●	
	Cleaning the turbocharger								● 2,000hrs
Fuel System	Cleaning the priming pump strainer				○				
	Check the fuel tank & cleaning		○						
	Cleaning the water separator			○					
	Exchange the fuel filter element				●				
	Check the fuel injection timing								● 1 year
	Check fuel injection nozzle								● 1 year
Electrical System	Check the warning lamps	○							
	Check the exhaust gas state	○							
	Check the wiring harness						○		
Engine Adjust	Check the compression pressure								When necessary
	Adjust the intake/exhaust valve clearance		○ 1st						When necessary

* If the sulfur content of the fuel is more than 0.5%, the replacement and inspection cycle should be cut in half.

2.4.2. 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

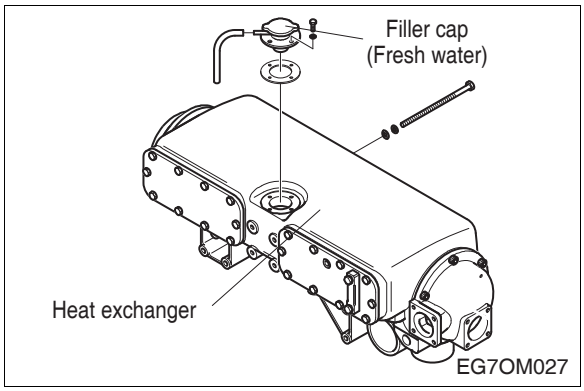
3.1. Engine Disassembly

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 collision each other.
- In disassembling, torn parts should be laid in disassembled order.
- Before performing service operation, disconnect the grounding cable from the battery for reducing the chance of cable damage and burning due to short-circuiting.

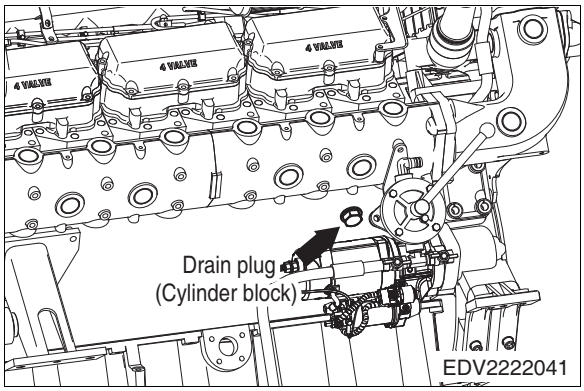
3.1.2. Cooling water

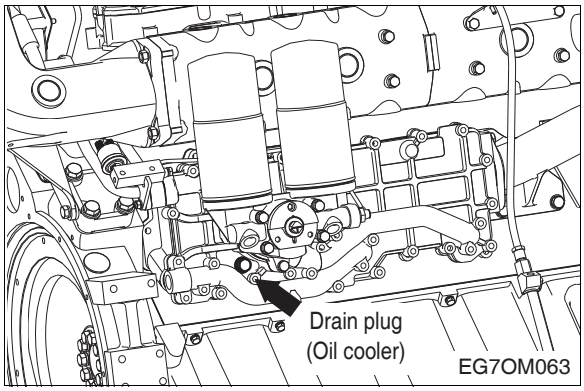
- Open the pressure cap of heat exchanger tank to remove the air pressure.

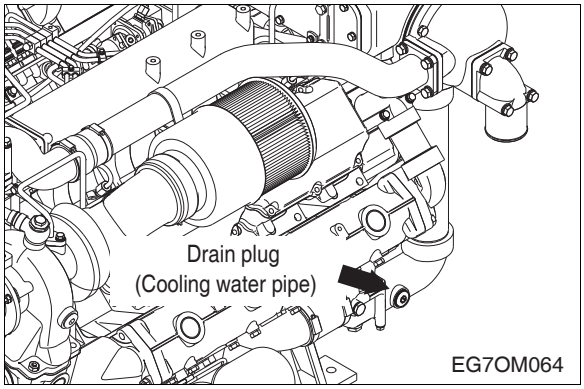


NOTE :
Because it is dangerous to open the pressure cap quickly when coolant is hot, after lowering the inside pressure of the tank by slow-opening at first open it fully.

- 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.

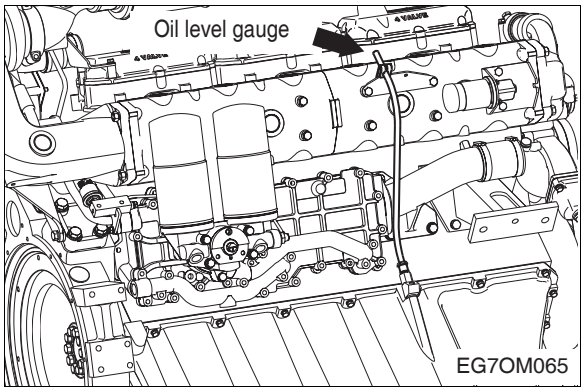






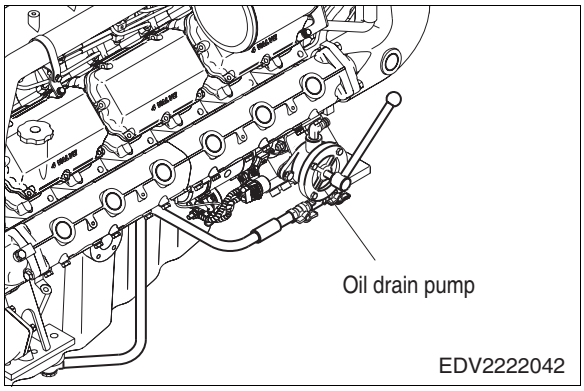
3.1.3. Oil level gauge

- Take out the oil level gauge from the guide tube.



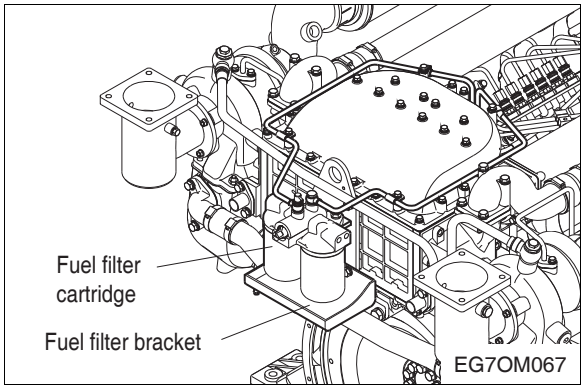
3.1.4. Engine oil

- Remove the oil after opening the oil drain cock of engine or reduction gear side, and let engine oil discharge into the prepared vessel.



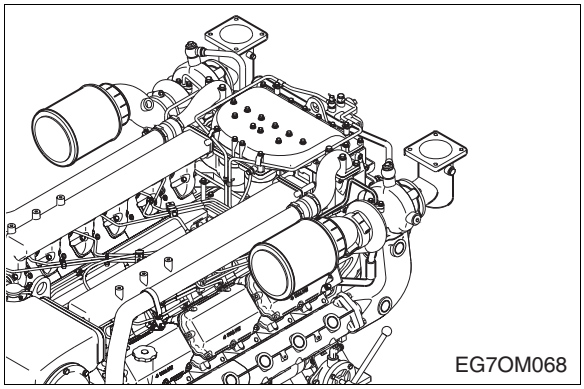
3.1.5. Fuel filter

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



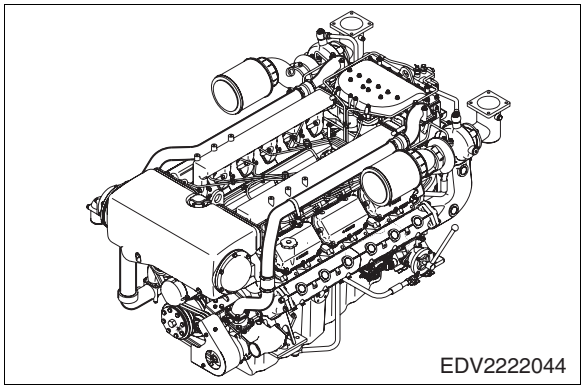
3.1.6. Air cleaner & exhaust elbow

- Remove fixing bolts, then take off the air cleaner and exhaust elbows.
- Be careful about the mixing of foreign material into interior of the turbocharger.



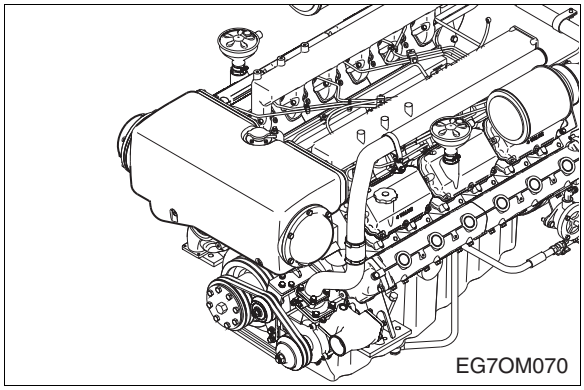
3.1.7. Cooling water pipe

- Remove fixing bolts, then take off the cooling water pipes.
- Be careful about the mixing of foreign material into interior of the sea water pump & inter cooler.



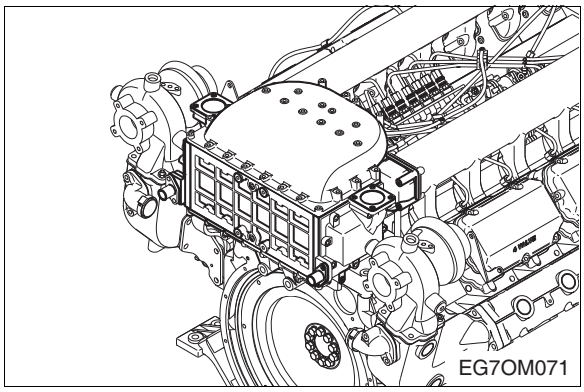
3.1.8. Heater exchanger

- Tear down the various hoses and water pipes from the heat exchanger.
- Remove the heat exchanger fixing bolts and tear it down.



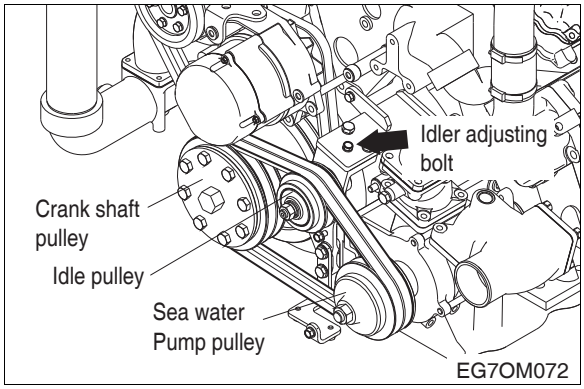
3.1.9. Intercooler

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



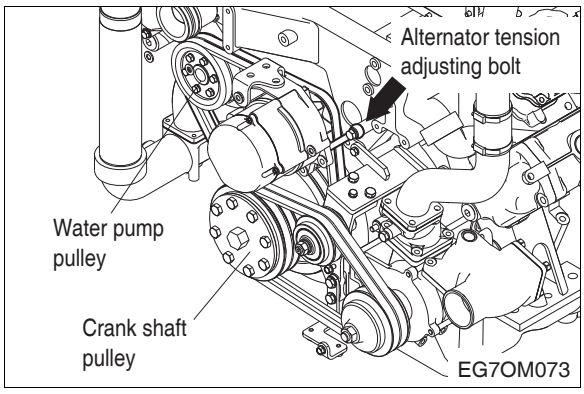
3.1.10. Sea water pump belt

- Loosen the V-belt tension adjusting bolts, and remove the sea water pump belts.



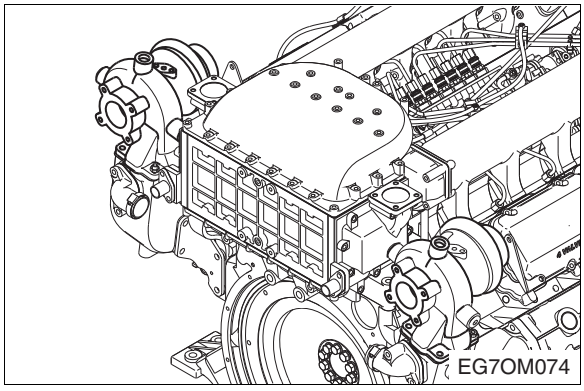
3.1.11. Alternator belt

- Loosen the alternator supporting bolt and remove the water pump belts.



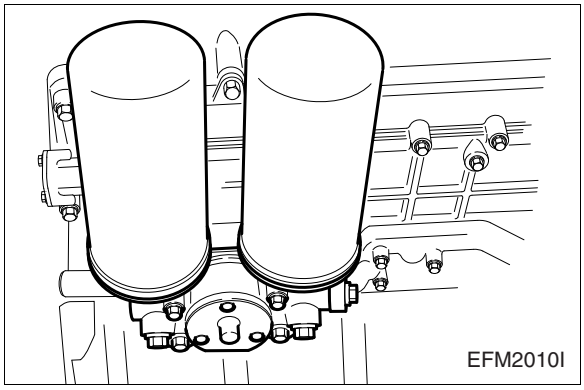
3.1.12. Turbocharger

- Loosen the hose clamp for connecting the intake stake and tear down the air pipe.
- Unscrew the turbo charger connecting bolt and tear down oil pipe & cooling water pipe.
- Unscrew the turbo charger fixing nuts and take off the turbo charger from the exhaust manifold.

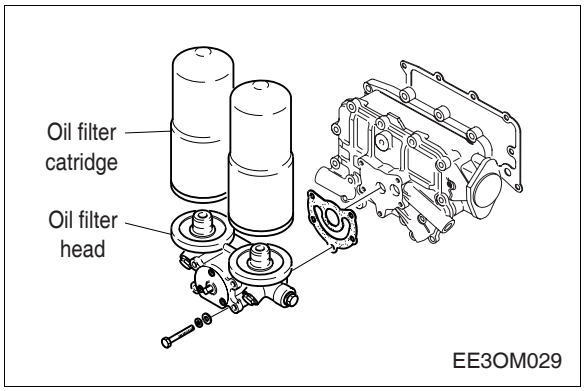


3.1.13. Oil filter

- Disassemble the oil filter cartridge with filter wrench by means of a filter wrench.
- Disassemble jig no : 65.98801-0001
- Do not use again the cartridge removed after use.

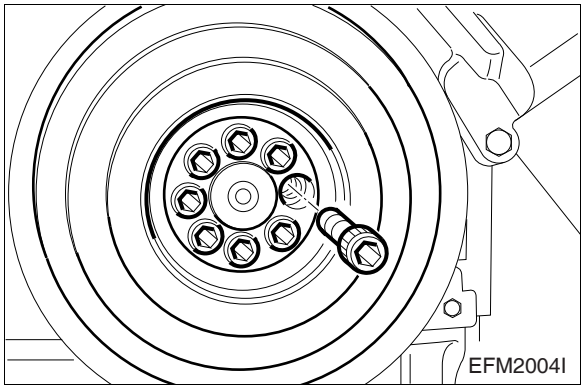


- Remove the oil filter head fixing bolts and disassemble the filter head.



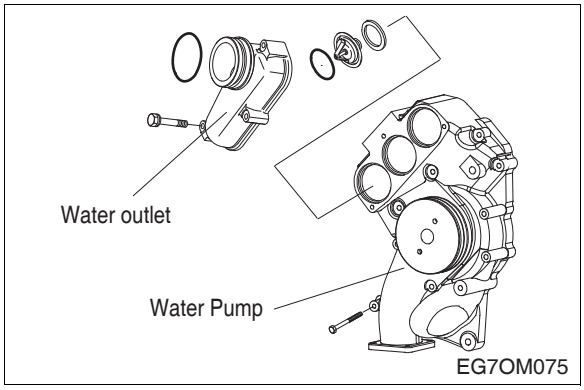
3.1.14. Vibration damper

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



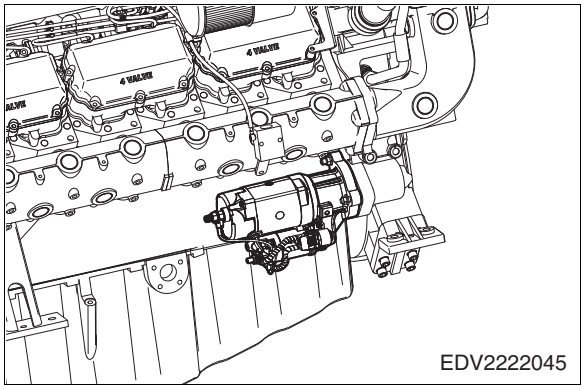
3.1.15. Cooling water pump and thermostat

- 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.



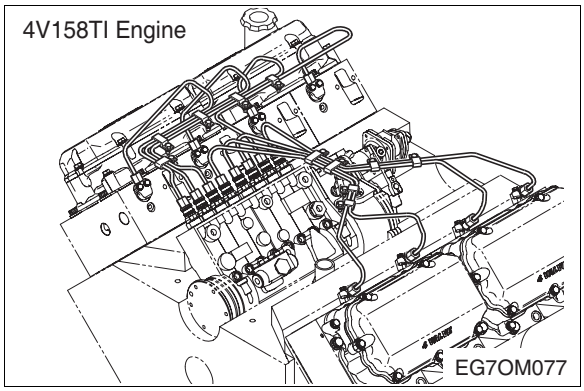
3.1.16. Starting motor

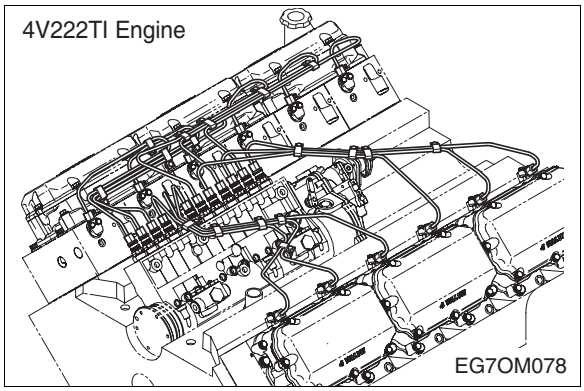
- Remove the starting motor fixing nuts and disassemble the starting motor.



3.1.17. Fuel injection pipe

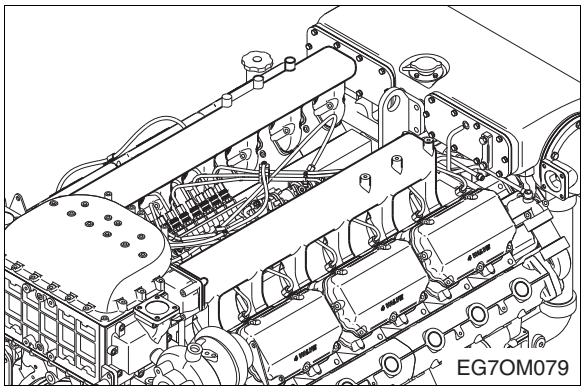
- Disassemble various fuel pipe and hose.
- Disassemble the fuel injection pipe from the high pressure injector and disassemble the fuel injection pump.





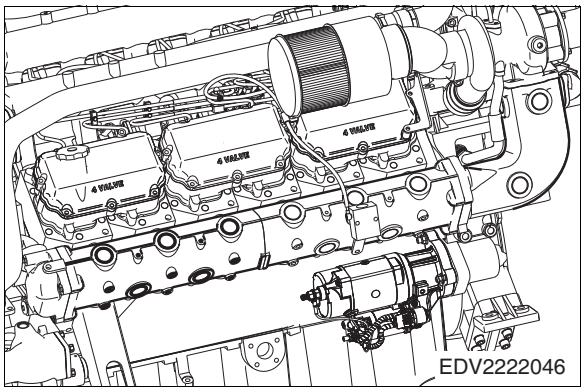
3.1.18. Intake manifold

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



3.1.19. Exhaust manifold

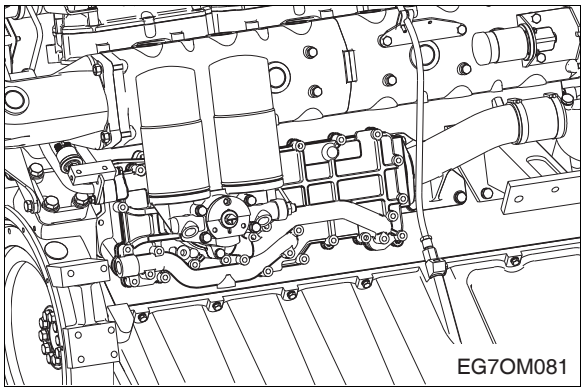
- Remove the exhaust manifold fixing bolts and tear down the manifold from the cylinder head.



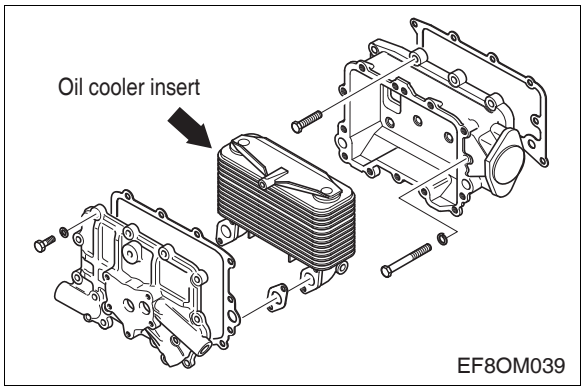
CAUTION:
Be careful not to drop the manifold because it is very heavy.

3.1.20. Oil cooler

- Remove the drain plug from the oil cooler cover and drain out the cooling water.
- Remove the oil cooler cover fixing bolts and disassemble the oil cooler.

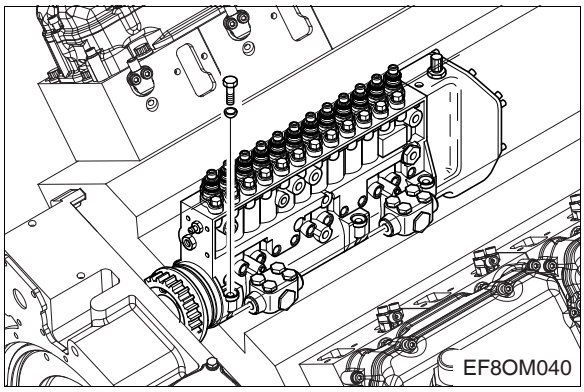


- Clamp the oil cooler assembly to the vise, remove the oil cooler insert fixing bolts, then disassemble the cooler insert.
  (Only need to changed the cooler insert)



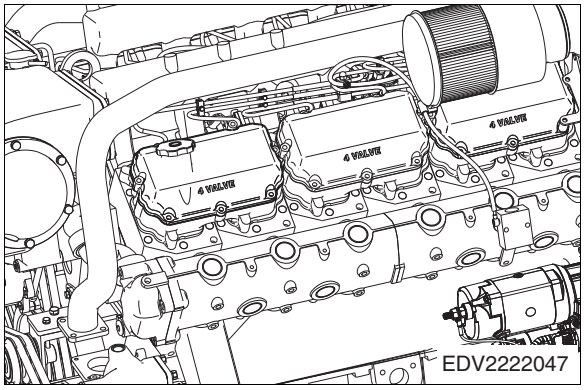
3.1.21. Fuel injection pump

- Remove the oil pipes for lubrication and the fuel hoses.
- Remove the fixing bolts of fuel injection pump and take out the fuel injection pump and O-ring.
- Do not use again the O-ring under the injection pump removed after use.



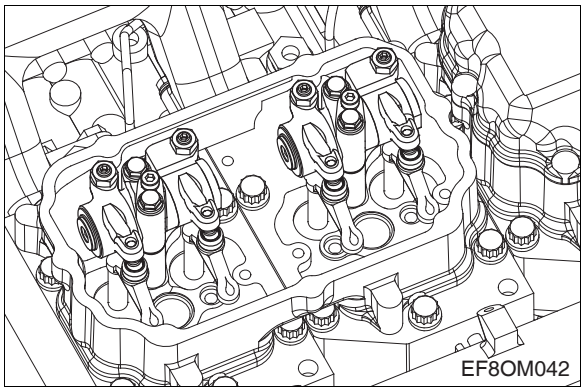
3.1.22. Cylinder head cover

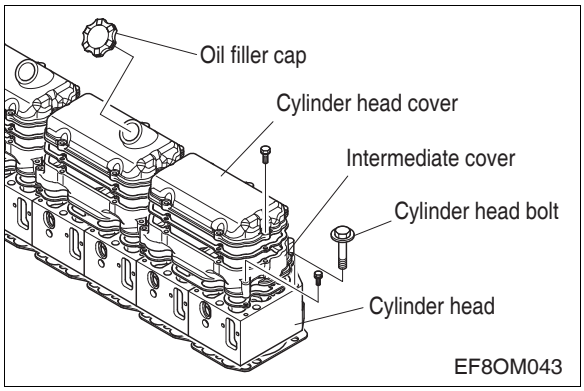
- Remove cylinder head cover fixing bolts and take off the cylinder head cover and oil filler cap.



3.1.23. Rocker arm

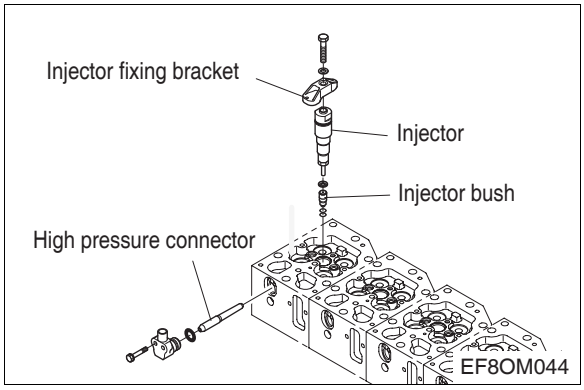
- Remove the rocker arm bracket fixing bolts and take out the rocker arm.
- Pull out the caliper and push rod.





3.1.24. Injector

- Remove the high pressure connecter fixing flange and take off the fuel high pressure connecter.
- Remove injector fixing bracket bolts and take off the injector.
- Be careful about damage of the nozzle when take off the injector.
- Disassemble jig no : EF.120-277
- Take out the sealing from the nozzle hole of the cylinder head and scrap it.



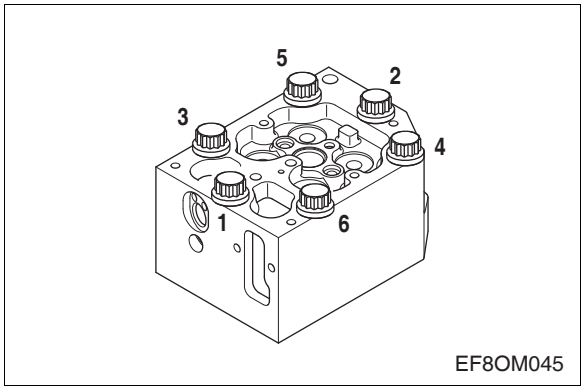
CAUTION:

1) When disassemble the injector, after the fuel high pressure connecter is separated perfectly by removing the fuel high pressure connecter fixing flange, then remove injector caliper fixing bolts and take off the injector.

2) Seal the injector and the fuel high pressure connecter to prevent from mixing foreign material into inside of the injector and the fuel high pressure connecter after disassembling.

3.1.25. 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.

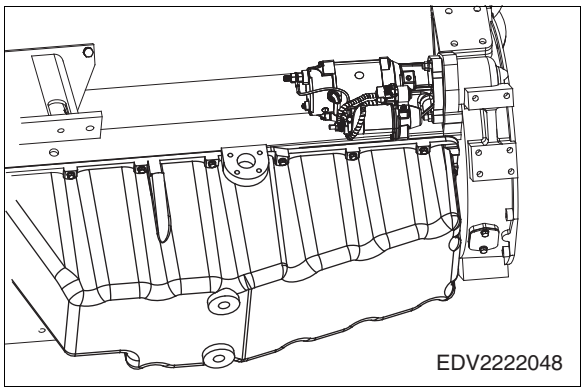


CAUTION:

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

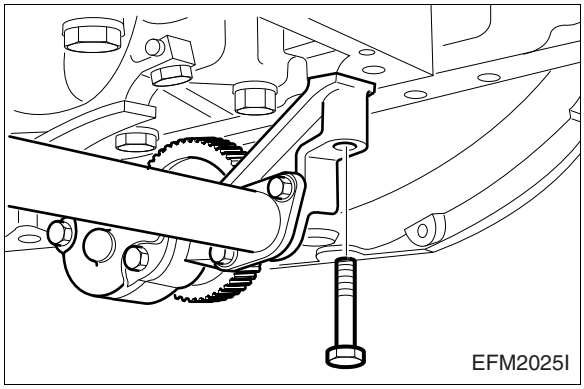
3.1.26. Oil pan

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


EDV2222048

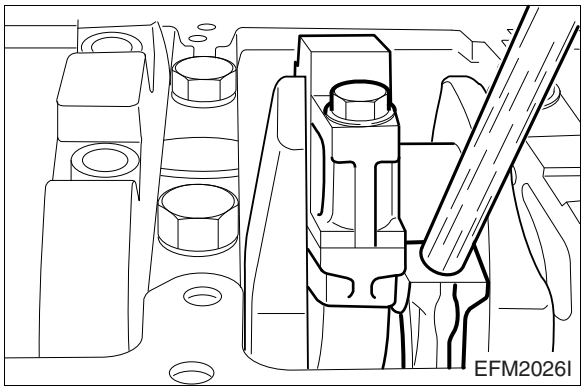
3.1.27. Oil pump

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


EFM2025I

3.1.28. 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.

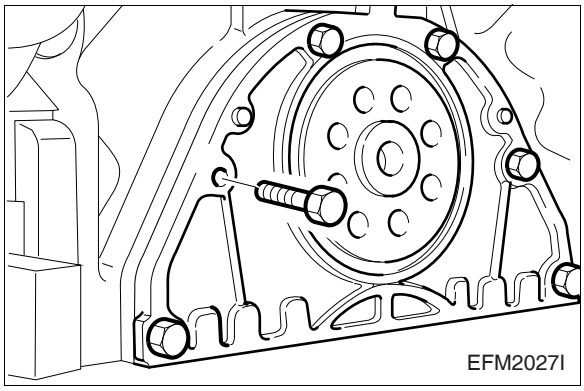

EFM2026I

NOTES:

- **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.)**

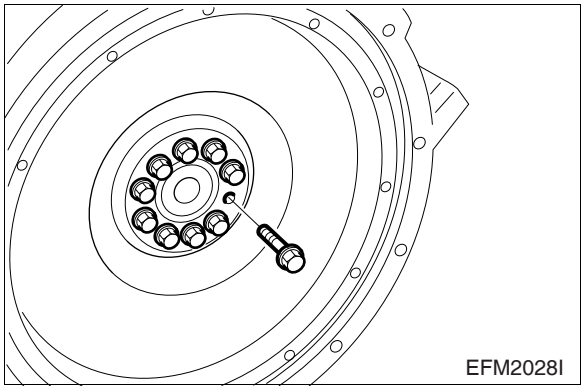
3.1.29. Front oil seal holder

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

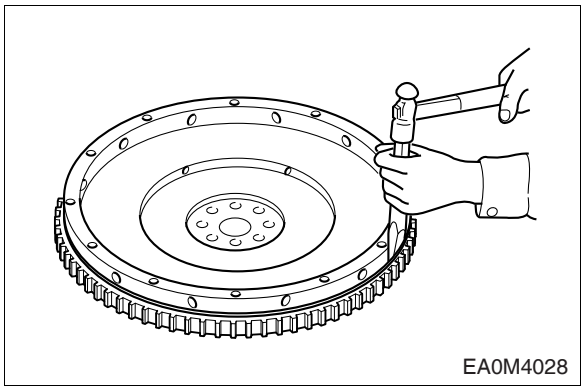

EFM2027I

3.1.30. Flywheel

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


EFM2028I

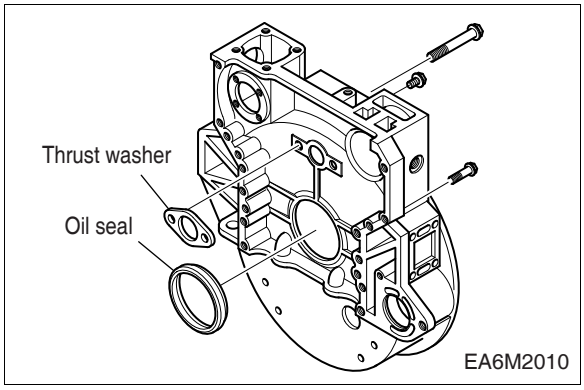
- Remove the flywheel ring gear.
  - Heat the ring gear evenly with a gas burner (up to 200 °C) to invite volumetric expansion.
  - Tapping around the edges of the ring gear with a hammer and brass bar to remove it.


EA0M4028

CAUTION:
Do not damage the flywheel.

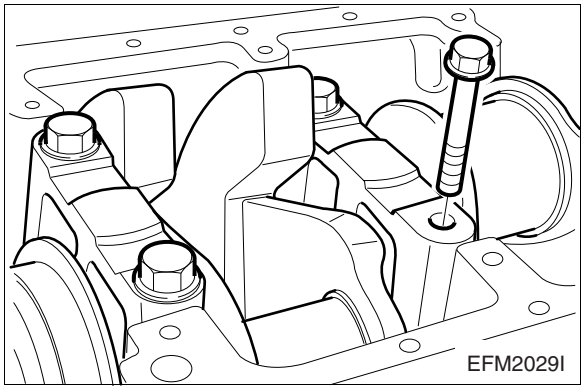
3.1.31. Flywheel housing

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



3.1.32. Crank shaft

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

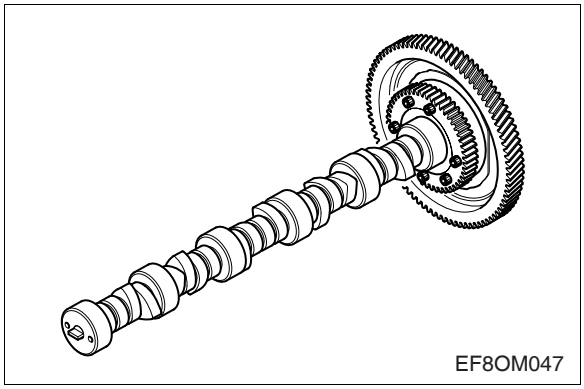


NOTES :

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.

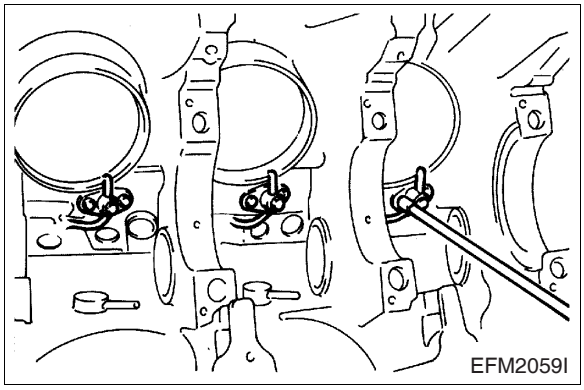
3.1.33. Camshaft and tappet

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



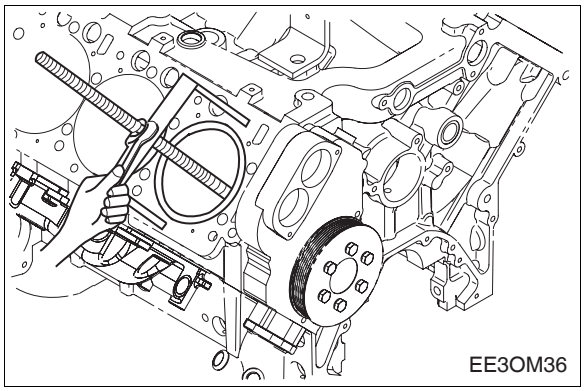
3.1.34. Oil spray nozzle

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



3.1.35. Cylinder liner

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



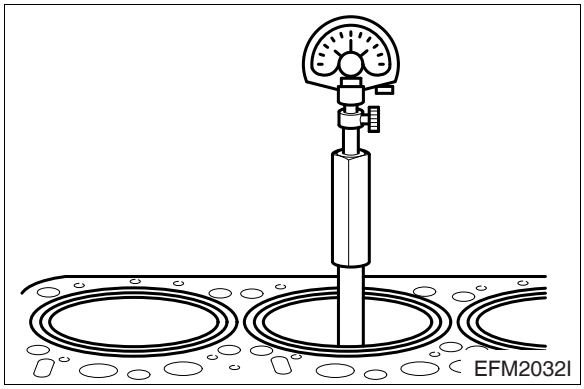
3.2. Measurement and Inspection of Major Parts

3.2.1. Cleaning and inspection of cylinder block

1) Clean the cylinder block and inspect it for any crack or damage.
2) If there is any crack or severe damage, replace it and if there is minor one, correct it.
3) Inspect the oil passage and water passage for any clog and erosion.
4) 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)
5) 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.

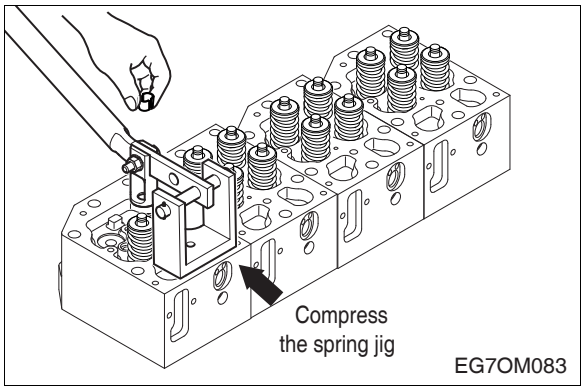


	Standard	Limit
Liner inner diameter	∅127.990 ~ ∅128.010 mm	0.15 mm

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.
- Disassemble jig no : EF.120-281A
- Take out the valve stem seal.
- Pull out the intake and exhaust valves.



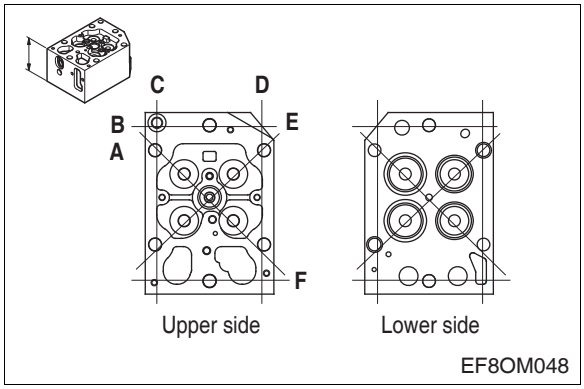
2) Inspection and measurement of cylinder head

a) 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.)

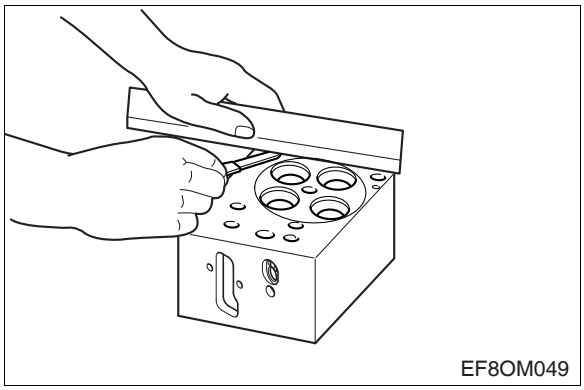
b) Distortion

- As shown in figure, measure the
- cylinder head's distortion at 6 directions with horizontal ruler and clearance gauge
- If the measured value is beyond the limit value, correct it by means of the fine grinding paper or grinding machine.
- If it is beyond the max. allowable value, replace the cylinder head.



< Lower face warpage and thickness>

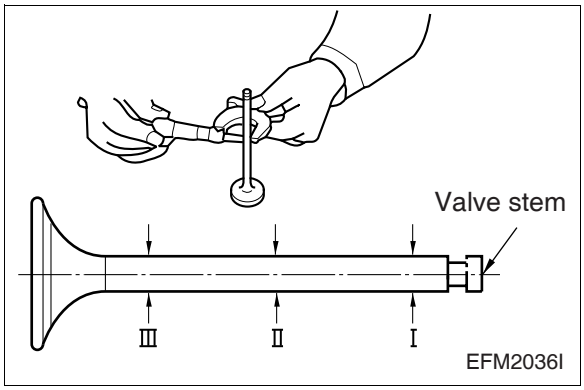
Warpage	Standard	Limit
	0.05 mm or less	0.2 mm
Thickness : t (reference)	116.95 ~ 117.05	116.4



3) Inspection and measurement of valve and valve guide

a) Valve

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

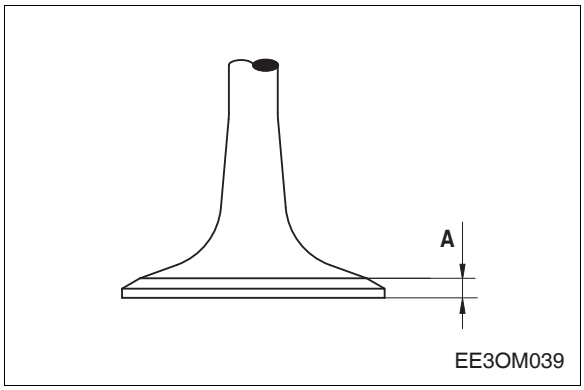


<Valve stem outer diameter>

Valve	Standard	Limit
Intake	∅7.963 ~ ∅7.977 mm	∅7.943 mm
Exhaust	∅7.950 ~ ∅7.964 mm	∅7.920 mm

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

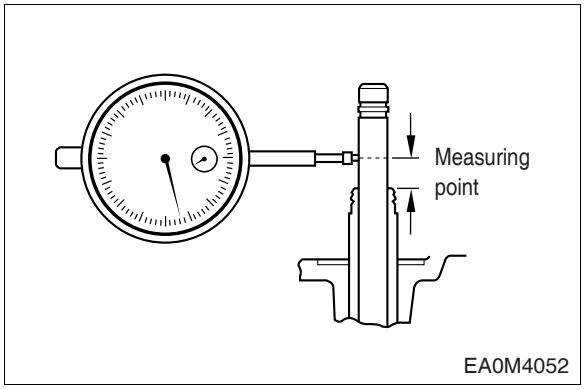
- If valve head thickness (A) becomes less than limit, replace the valve.



Valve	Standard	Limit
Intake	3.0 ~ 3.4 mm	2.5 mm
Exhaust	3.3 ~ 3.7 mm	2.8 mm

b) Check of valve guide

- Insert the valve into valve guide and measure the clearance between valve and valve guide by the shaking degree of valve.
  If the clearance is bigger, measure the valve and then replace the more worn valve guide.
- If the valve guide has already been replaced, measure the center with valve seat if it deviates or not and if abnormal it must be corrected.



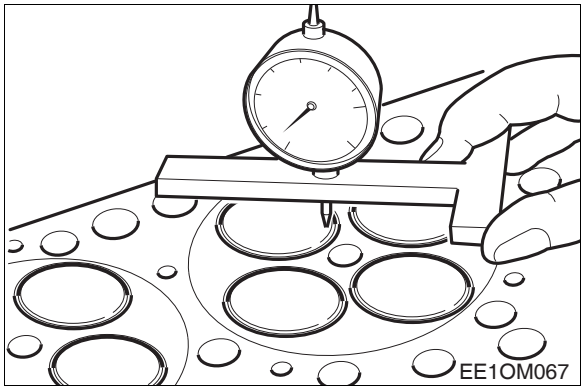
NOTE :
Simultaneously be processed when in guide reamer process.

<Valve stem end play>

Valve	Standard	Limit
Intake	0.036 ~ 0.067 mm	0.10 mm
Exhaust	0.051 ~ 0.080 mm	0.15 mm

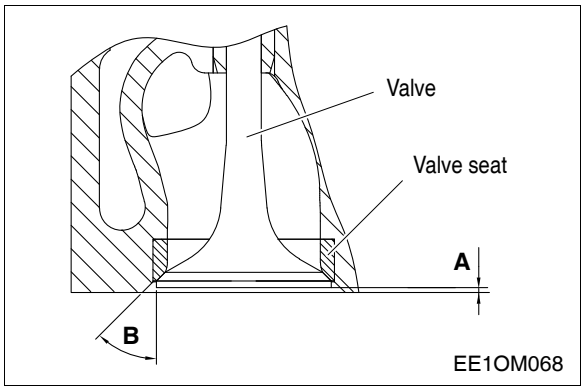
c) Valve seat

- Visual inspection
  Check if the exterior of the valve spring is damaged with the naked eye. Replace it with a new one if required.
- Valve seat thickness and angle
  Assemble the valves at the cylinder head and using the measuring instrument from the lower face, measure the projection amount of valve. If the measured wear is excessive, replace the valve seat. When replacing the valve guide and seat, work simultaneously by special tool.



<Valve projecting amount>

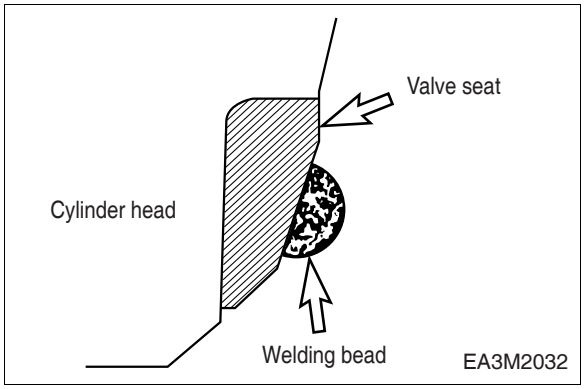
Valve	Limit
Intake (A)	0.8 ~ 1.1 mm
Exhaust (A)	0.8 ~ 1.1 mm



<Valve seat angle>

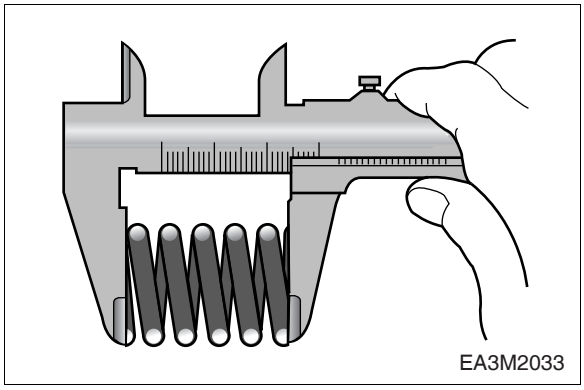
Intake valve (B)	60°
Exhaust valve (B)	45°

- The disassembly of valve seat can be pulled out by means of a special tool with the arc welding done at two points of valve seat rotating tool or valve seat.
- Regarding the valve seat assembling, shrink the valve seat by putting it in the dry ices for about 1 hour or so, and then press it into the cylinder head by means of a special tool.
- It is necessary to work boring of inner diameter of it when replace the valve seat.
- After coating the grinding powder paste on valve head contacting face of valve seat, and after executing a sufficient lapping operation with the rotating and grinding motion of valve, wipe off the grinding agent thoroughly.



d) Valve spring

- Visual inspection
  Check if the exterior of the valve spring is damaged with the naked eye. Replace it with a new one if required.


EA3M2033

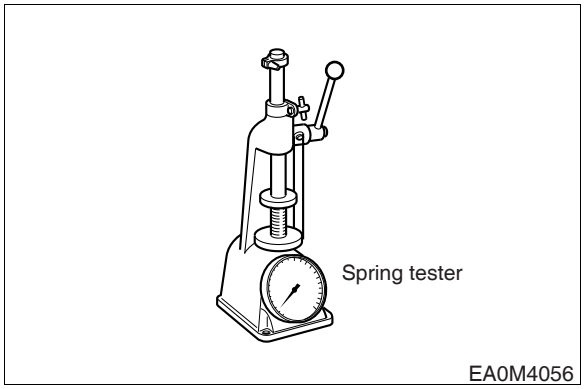
- By means of spring tester, measure the tension and free length.

Items		Free length
Intake	Inside	59.5 mm
	Outside	57.0 mm
Exhaust	Inside	59.5 mm
	Outside	57.0 mm

- Measure the perpendicularity of valve spring. In case that the measured value exceeds the limit value, replace it.

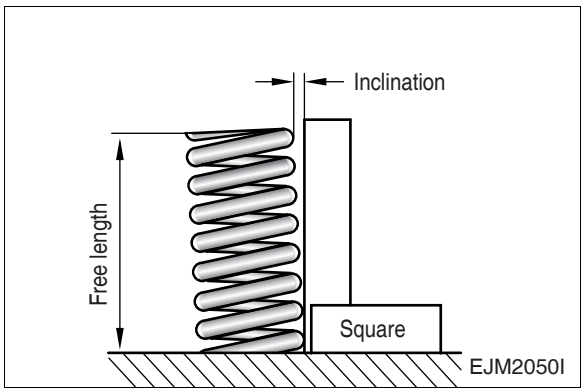
<Perpendicularity regular>

Items		Length P1/P2 (mm)	Spring tension P1/P2 (kg)	Limit P1/P2 (kg)
Intake and Exhaust	Inner	41.0 / 28.6	14.8 / 25.0	±1.5 / ±2.0
		44.0 / 31.6	25.5 / 52.3	±2.0 / ±2.5
	Outer	41.0 / 28.6	14.8 / 25.0	±1.5 / ±2.0
		44.0 / 31.6	25.5 / 52.3	±2.0 / ±2.5



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.

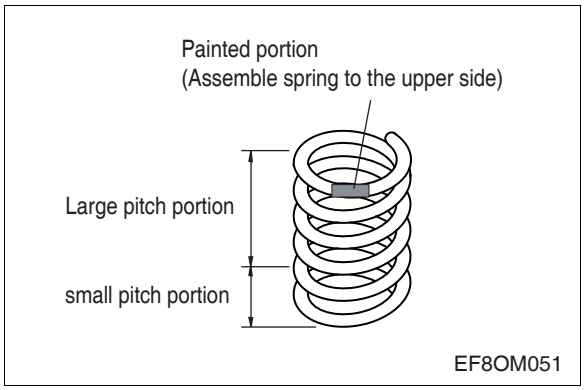


EJM2050I

Items		Standard	Limit
Intake	Inside	1.5 mm	2.0 mm
	Outside	1.5 mm	2.0 mm
Exhaust	Inside	1.5 mm	2.0 mm
	Outside	1.5 mm	2.0 mm

4) Cylinder head assembling

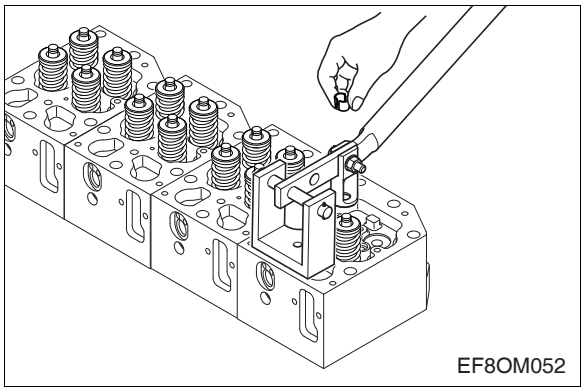
- Clean the cylinder head thoroughly.
- Coat the valve stems and valve guides with engine oil and assemble the valves.
- Replace the valve stem seals with new ones and insert the stem seals to the valve guides of cylinder head with a special tool. (Be careful for the valve stem seals not to be damaged.)
- Assemble jig no : EF.120-246
- Install the valve spring washer to valve guide.
- After putting on the inside, outside spring, install the valve spring seat on them.



NOTES:

Install the valve spring seat with "TOP" (painted in red) side up.

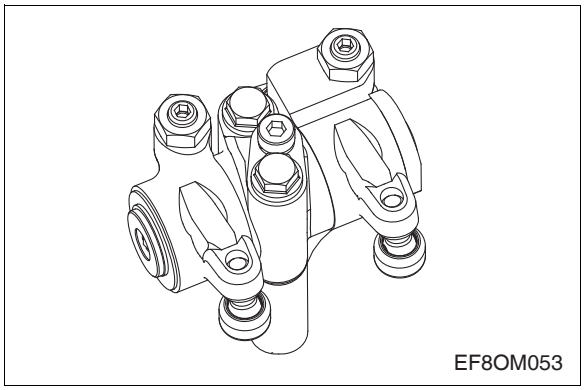
- Pressing the spring down with a special tool, assemble by inserting the valve cotter.
- Assemble jig no : EF.120-281A
- After the valve is assembled, inspect the valve tapping it lightly with the urethane hammer if accurate assembling was done.



3.2.4. Rocker arm

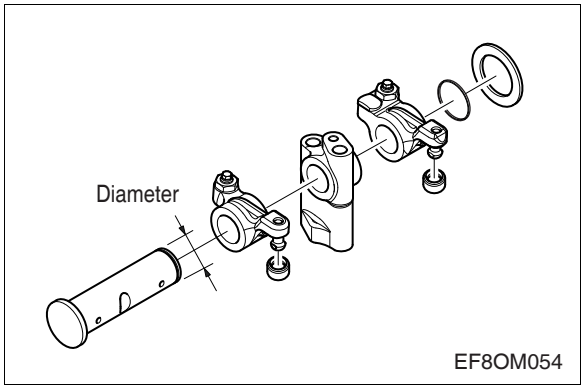
1) Rocker arm disassembling

- Remove the snap rings in one end 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 and measurement

- Rocker arm bracket (Single unit type with a shaft)
  Measure the outer diameter of rocker arm bracket with outside micrometer at the position that the rocker arm is installed, and in case that it exceeds the limit value, replace.



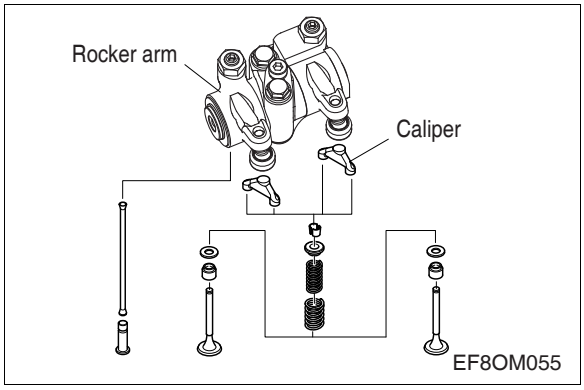
< Rocker arm Specification >

Items	Standard	Limit
Bush inner diameter	∅25.005 ~ ∅25.035 mm	∅25.308 mm
Shaft outer diameter	∅24.953 ~ ∅24.976 mm	∅24.916 mm
Clearance	0.015 ~ 0.059 mm	0.12 mm

a) Rocker arm

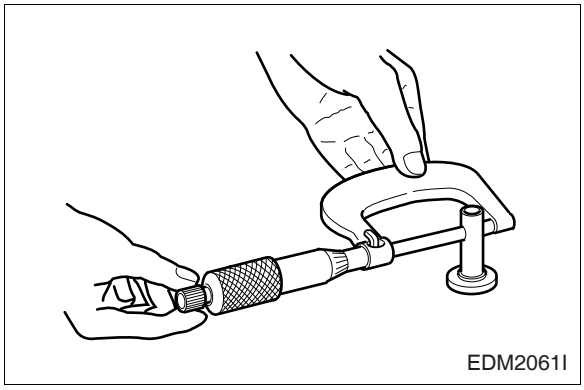
- Inspect the rocker arm surface that contacts with the valve stem for any scratch, step wear and correct the minor degree of wear with an oil stone or the fine grinding paper and replace if they are severe.

NOTE :
If the wear is severe, replace new one.



b) Tappet and push rod

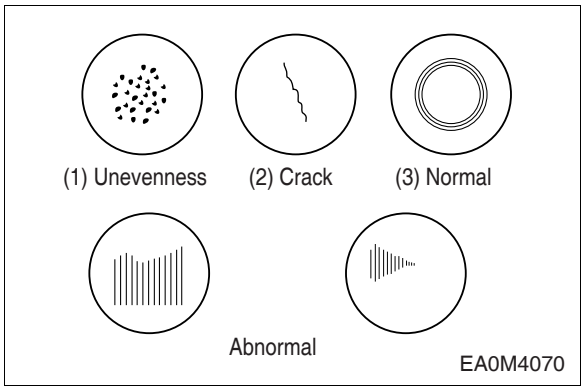
- Tappet clearance
  Measure the outer diameter of a tappet and the inner diameter of the tappet bore. If the reading exceeds the tolerance limit, replace the tappet.


EDM2061I

< Clearance of cylinder block and tappet >

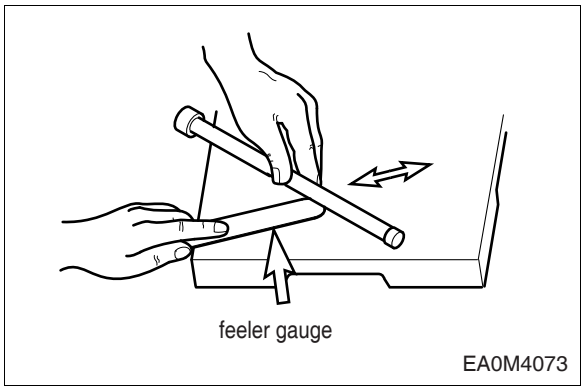
Standard	Limit
0.035 ~ 0.077 mm	0.15 mm

- Inspection if the tappet surface which contacts the camshaft has damage like crack or scratch.
  If the damage is small, correct it with oil stone or fine grinding paper, if excessive, replace it.



EA0M4070

- Warpage of push rod
  Put the push rod on a surface plate, and measure the warpage with a feeler gauge shile spinning it. If the reading exceeds the tolerance limit, replace it.



EA0M4073

<Run-out>

Limit	0.3 mm or less

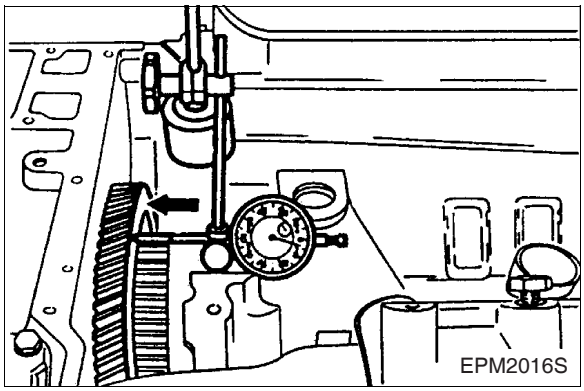
3) Rocker arm reassembling

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

3.2.5. Camshaft

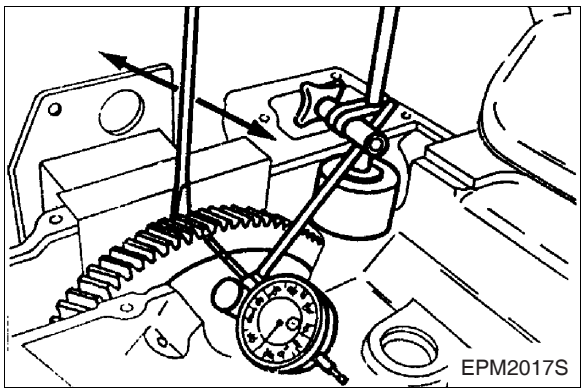
1) Axial end play

- Push the camshaft toward the crankshaft 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.



Item	Standard	Limit
End Play	0.24 ~ 0.86 mm	0.9 mm

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



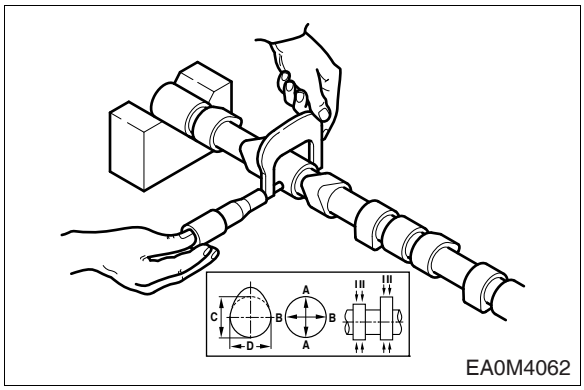
2) Inspection and measurement of camshaft

- **Visual check**

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

- **Cam lobe height and cam journal diameter**

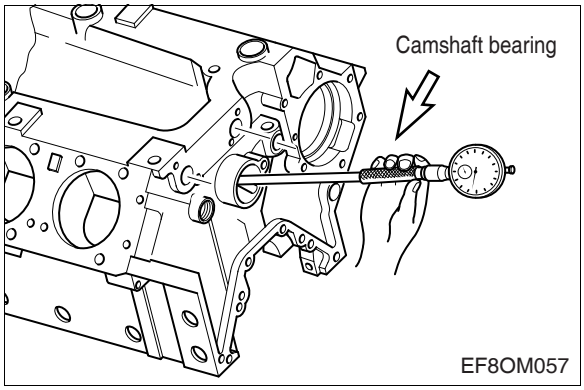
  Use a micrometer to measure the cam lobe height and journal diameter. If the measured number is less than the specified limit, the camshaft must be replaced.



Items		Standard	Limit
Cam lobe height (C)	Intake	55.061 mm	54.731 mm
	Exhaust	55.899 mm	55.563 mm
Cam journal diameter (A, B)		∅69.91 ~ ∅69.94 mm	∅69.560 mm

- **Camshaft bearing diameter**

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



< Cam bearing inside diameter >

Items	Standard	Limit
Thust	∅70.070 ~ ∅70.090 mm	∅69.464 mm
Middle	∅70.000 ~ ∅70.030 mm	∅69.192 mm

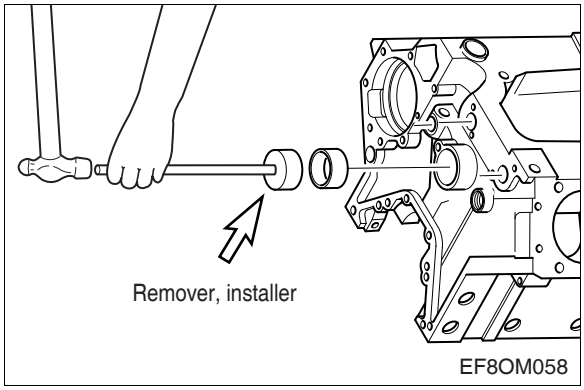
- **Clearance**

Between camshaft journal and body.

Items	Standard	Limit
Thust	0.060 ~ 0.120 mm	0.240 mm
Middle	0.130 ~ 0.180 mm	0.240 mm

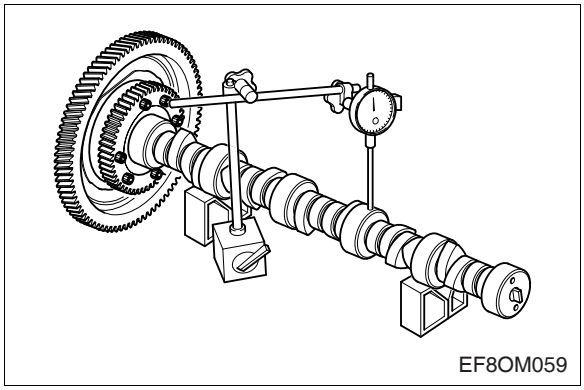
3) Camshaft bearing replacement

- Replace the camshaft bearing with a special tool.



- **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.



< Camshaft run-out >

Standard	Limit
0.05 mm	0.15 mm

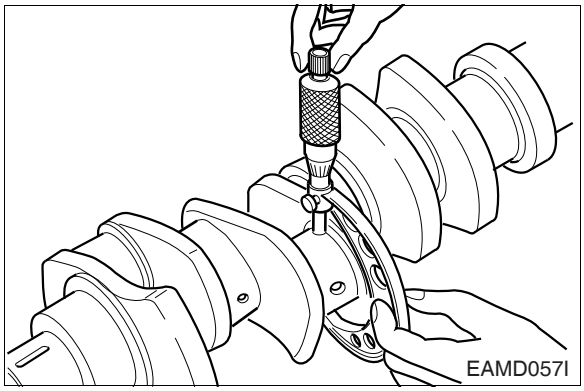
3.2.6. Crankshaft

1) Inspection and measurement

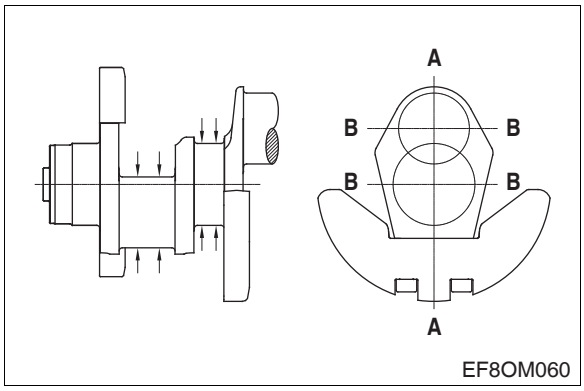
- Inspect for any scratch or damage with naked eyes, and grind to the undersize according to the damaged degree and use the undersized bearing.
- Inspect for any crack by means of magnetic powder and color check, and replace the cracked ones.

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



- If the amount of wear is within the limit, you can correct the wear using an oil stone or oiled grinding paper of fine grain size.
  (be sure to use grinding paper which has been immersed in oil)



< Journal and pin outside diameter>

Items	Standard
Journal diameter	∅103.98 ~ ∅104.00 mm
Pin diameter	∅89.98 ~ ∅90.00 mm

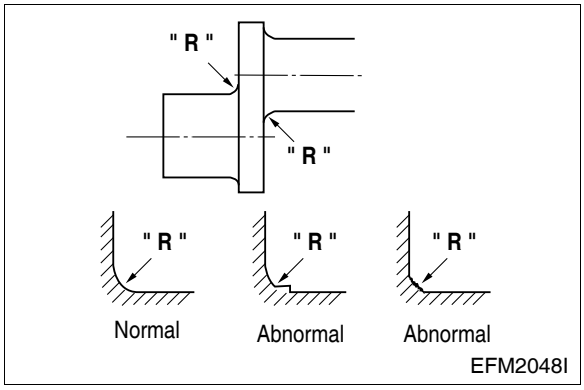
<Kinds of bearings for undersize>

(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)

NOTE:
There are 5 kinds as above, and the crankshaft also can be used by regrinding as above.

NOTE:

In case of crankshaft regrinding, the "R" part at the end of bearing must accurately be ground without fail and should avoid any processed jaw or coarse surface.



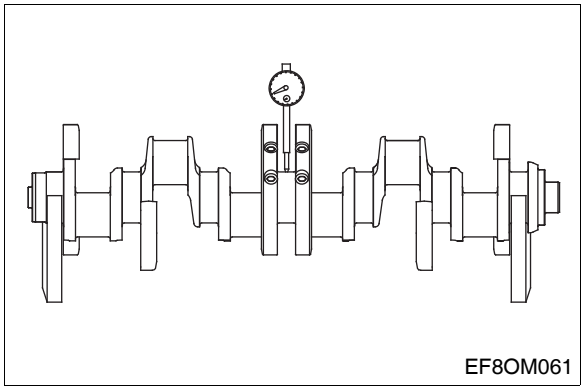
<"R" part standard value>

① Crank pin 'R' : $4.0^{\ 0}_{-0.5}$

② Crank journal 'R' : $4.0^{\ 0}_{-0.5}$

b) 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.



< Run out of crankshaft >

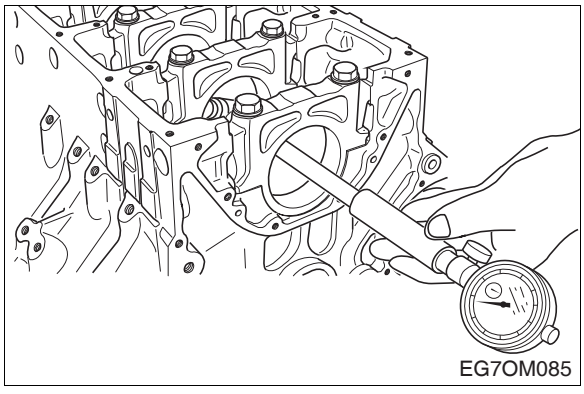
Standard		Limit
4V158TI	0.06 mm	0.4 mm
4V222TI	0.08 mm	0.4 mm

2) 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.

a) Oil clearance of crankshaft and bearing

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



Bearing cap Bolt torque	30 kg·m + 90°

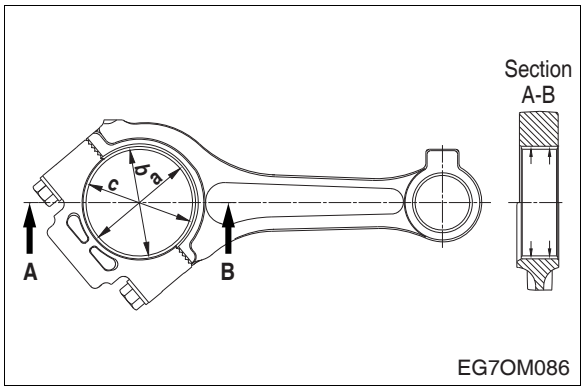
Journal bearing nominal diameter	∅104.066 ~ ∅104.115 mm

Side Bolt	11.2 kg·m

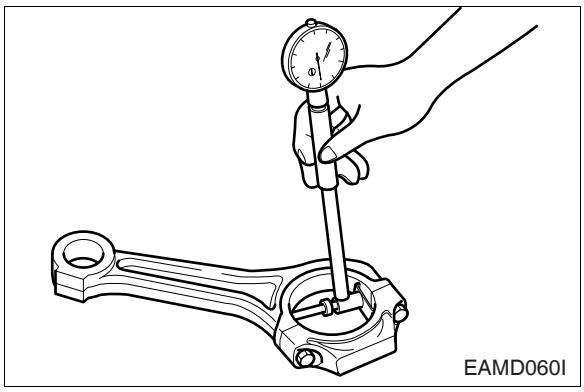
- Assemble the bearing at the bigger end of connecting rod, and after tightening the bearing cap at the specified torque, measure the inside diameter

Connecting rod Bold torque	10 kg·m + 90°

Connecting rod bearing journal diameter	∅90.056 ~ ∅90.098 mm



EG7OM086


EAMD060I

b) Bearing oil clearance

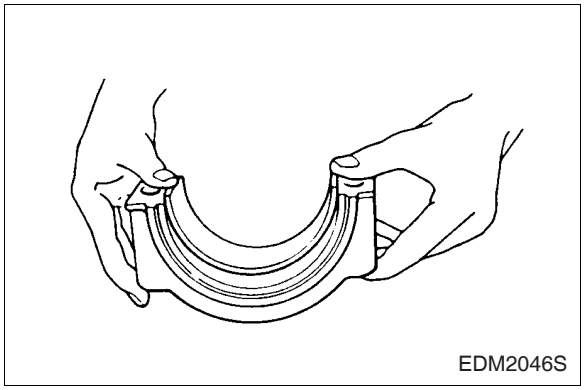
- Compare the two values obtained through measurement of bearing inside diameter (journal bearing, connecting rod bearing) with the outside diameter of journal and pin of crankshaft to determine the oil clearance

Items	Standard	Limit
Journal bearing	0.066 ~ 0.134 mm	0.159 mm
Connecting rod bearing	0.056 ~ 0.118 mm	0.143 mm

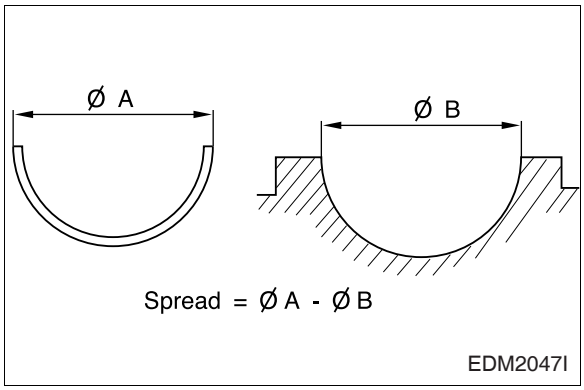
- In case that this clearance value exceeds the limit value, grind the crankshaft journal and pin and then use the undersized bearing.

c) Inspection of journal and connecting rod bearing

- Check to see that the bearing requires a considerable amount of finger pressure at reassembly operation.

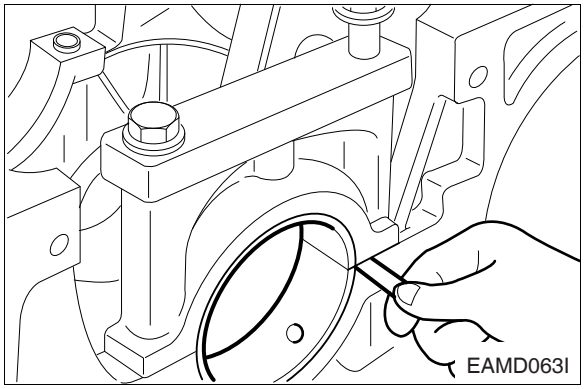

EDM2046S

- The spread of journal bearing and connecting rod bearing should be measured with special tool as a figure, but measure it under condition of assembling as below for convenience of working in the field.



- **Journal bearing**

  Install the bearing and cap in the cylinder block, retighten the bolts to specified torque, unscrew out one bolt completely, then measure the clearance between the bearing cap and cylinder block using a feeler gauge.

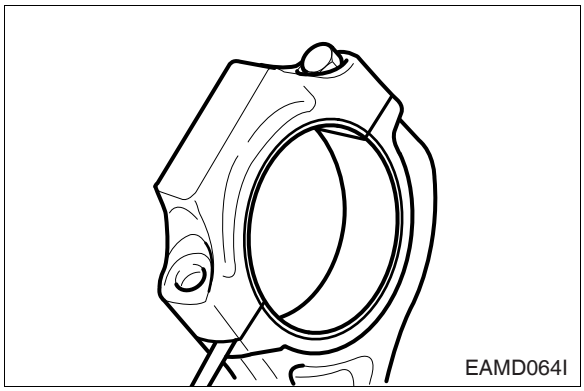


< Crush of main bearing cap >

Standard	0.3 ~ 1.2 mm

- **Connecting rod bearing crush**

  Install the bearing and cap in the connecting rod big end, retighten the bolts to specified torque, unscrew out one bolt completely, then measure the clearance between the bearing cap and connecting rod big end using a feeler gauge.

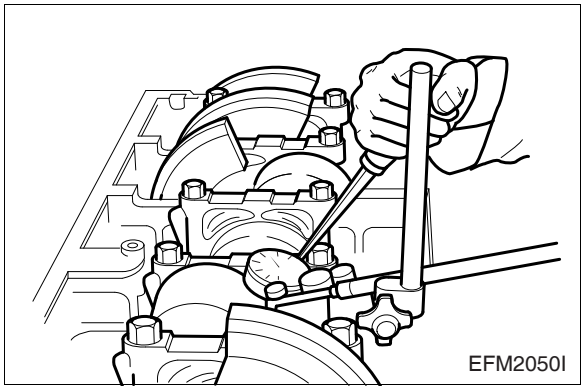


< Crush of connecting rod bearing >

Standard	0.5 ~ 1.4 mm

d) Crank shaft end play

- Assemble the crankshaft to the cylinder block with a dial gauge, measure crankshaft end play.



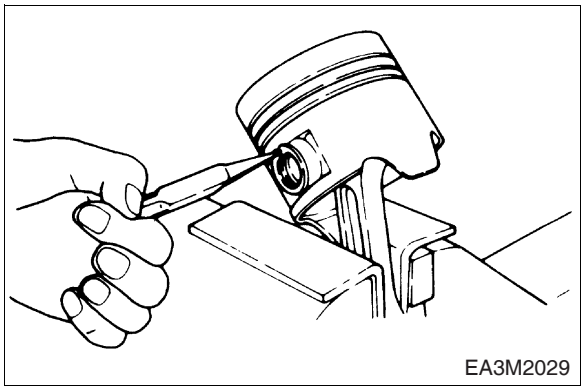
< Crank shaft end play >

Standard	Limit
0.140 ~ 0.361 mm	0.4 mm

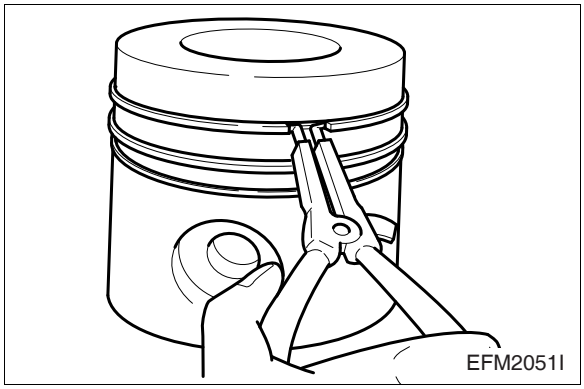
3.2.7. Piston

1) Piston disassembling

- Pull out the snap ring for piston pin and with a pair of snap ring pliers.
- Disassemble jig no : T7610001E
- With a round bar, remove the piston pin.

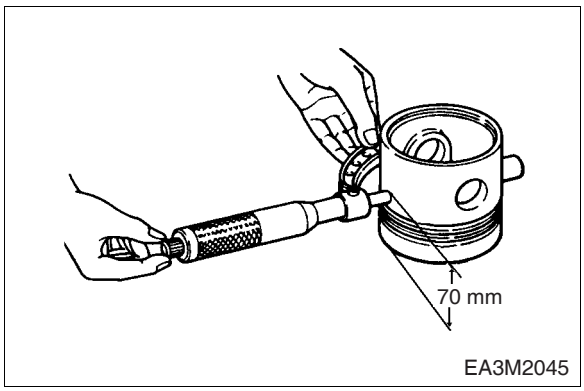

EA3M2029

- With a pair of pliers, remove the piston rings.
- Disassemble jig no : T7621010
- Clean the piston thoroughly.


EFM2051I

2) Check and measurement

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

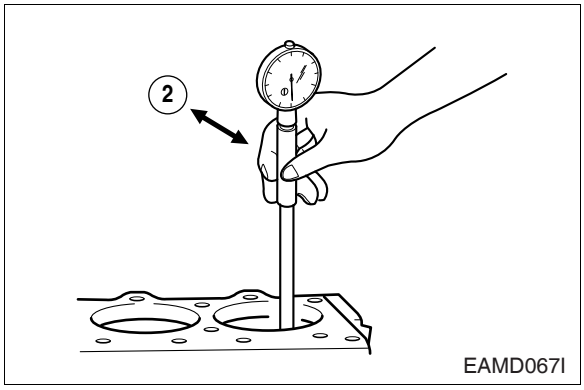


EA3M2045

Standard	∅127.739 ~ ∅127.757 mm

a) Cylinder bore diameter

- Measure cylinder liner inside diameter at 3 points (cylinder top ring contacting face, middle, and oil ring contacting face on BDC) in a direction at an angle of 45°. Take the mean value with the largest and smallest values excepted.



Standard	∅127.99 ~ ∅128.01 mm

b) Piston and cylinder clearance

- The clearance is computed by subtracting the piston outside diameter from the cylinder liner inside diameter. Replace either piston or cylinder liner, whichever damaged more, if the clearance is beyond the specified limit.

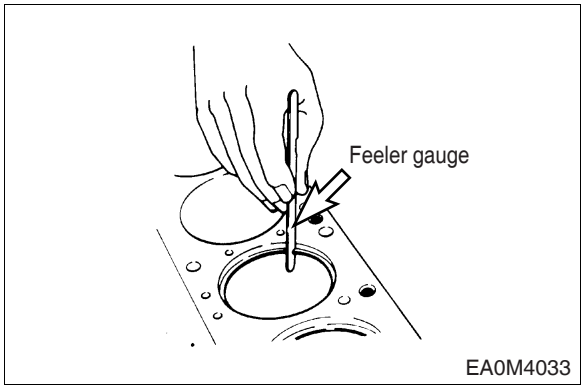
Standard	0.233 ~ 0.271 mm

c) Piston ring and ring groove

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

d) Piston ring cut part clearance

- Measure the piston ring cut part.
- Insert the piston ring at the cylinder liner's upper part perpendicularly.
- With a feeler gauge, measure the gap clearance of piston ring.
- Measure tool no:60.99901-0027
- If the measured value exceeds the limit value, replace it.

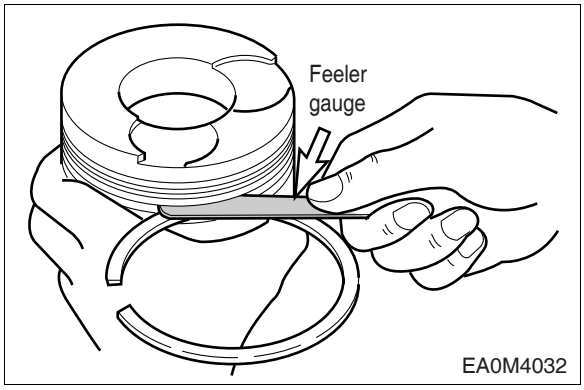


< Piston ring gap >

Division	Standard	Limit
Top ring	0.30 ~ 0.50 mm	1.5 mm
2nd ring	1.10 ~ 1.30 mm	1.5 mm
Oil ring	0.40 ~ 0.70 mm	1.5 mm

e) Piston side clearance.

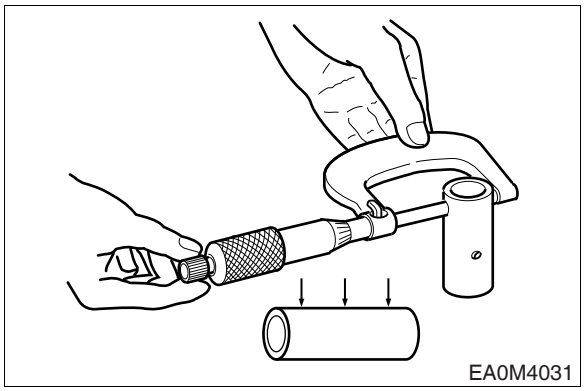
- Assemble the piston ring at the piston.
- Measure the each ring's side clearance and if the measured value exceeds the limit value, replace rings or piston.



Division	Specified value	Limit value
Top ring	0.095 ~ 0.145 mm	1.5 mm
2nd ring	0.05 ~ 0.082 mm	1.5 mm
Oil ring	0.03 ~ 0.07 mm	1.5 mm

f) Piston pin

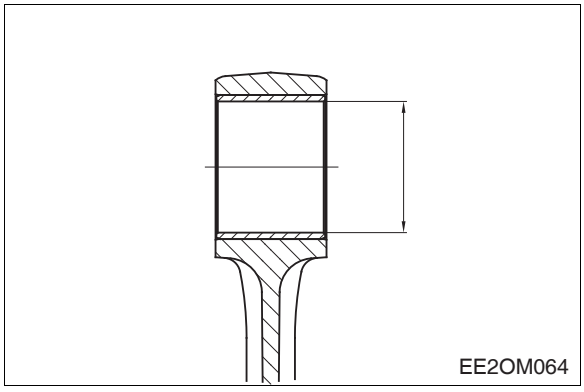
- Measure the amount of wear on the piston pin at the points as shown. The measured values are beyond the limit replace the pin.



Standard	Limit
∅45.994 ~ ∅46.000 mm	∅45.979 mm or less

g) Piston pin and connecting rod bush clearance

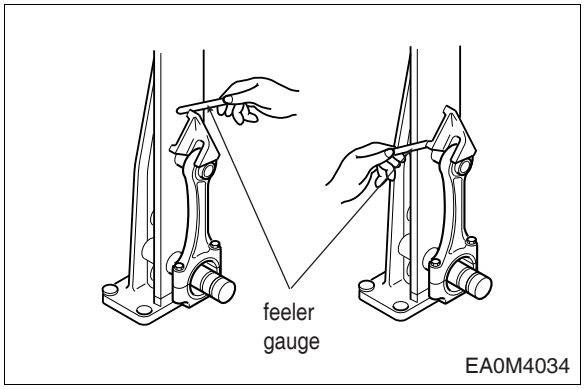
- Inspect the clearance between the piston pin and the connecting rod bush, if it is more than the use limit value, replace either one which exceeds the limit by measurement.



Limit	0.055 ~ 0.071 mm

h) Connecting rod

- Check the connecting rod for distortion. If the connecting rod is found distorted, never re-use it but replace with a new one.
- Measure the alignment of the connecting rod piston pin bushing holes with connecting rod big end holes.



Standard	Limit
0.02 mm	0.1 mm

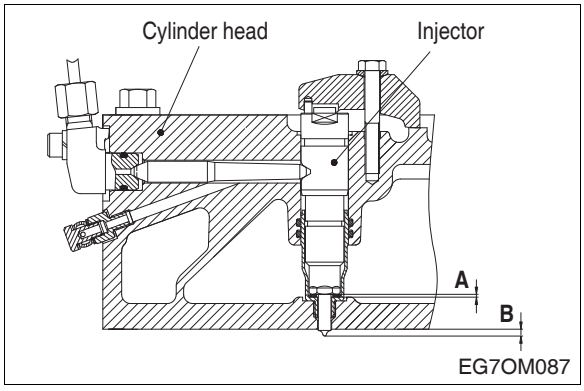
- Assemble the connecting rod to the crankshaft and measure connecting rod big end side clearance using a feeler gauge.

Standard	Limit
0.24 ~ 0.392 mm	0.5 mm

- Assemble the connecting rod to the piston and measure connecting rod small end side clearance.
- If the measured values are beyond the limit, replace the connecting rod.

3.2.8. Injector projection

- Insert a seal ring on the cylinder head and assemble the injector.
- Assemble jig no : EF.120-277
  EF.120-278
- Measure the clearance between the cylinder head bottom and injector. If the measured values are beyond the limit, replace the seal ring.



Items	Standard
A (Thickness of seal ring)	1.0, 1.5, 2.0 mm
B (Projection of injector)	3.0 mm

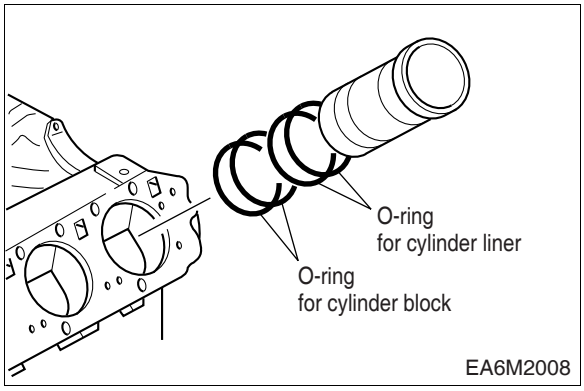
3.3. Engine Reassembly

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.

3.3.2. Cylinder liner

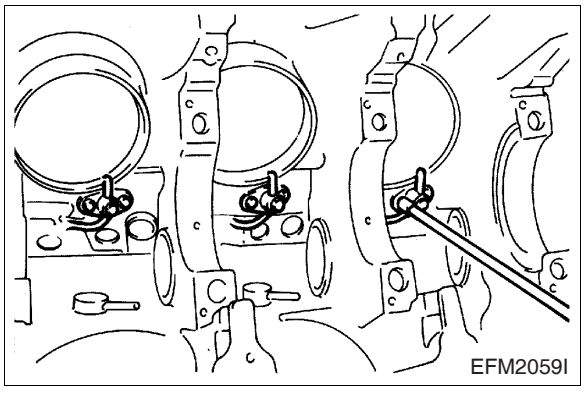
- Replace O-ring with new one without fail and at the upper side, insert to the cylinder liner, but at the lower side, to the cylinder block.
- Coat the joint parts where O-ring contacts with oil.
- After slipping the cylinder liner smoothly into the cylinder block, press it in being careful for O-ring 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

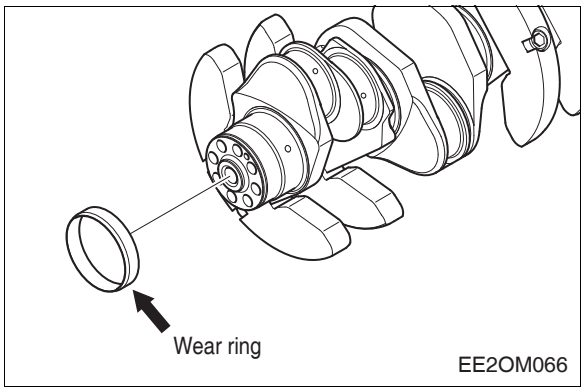
- Tighten the oil injection nozzle flange with hollow screws.
- Assemble the oil injection nozzle with the fixing bolts.

Torque	Fixing bolt	1.2 kg·m
	Hollow screw	4.0 kg·m

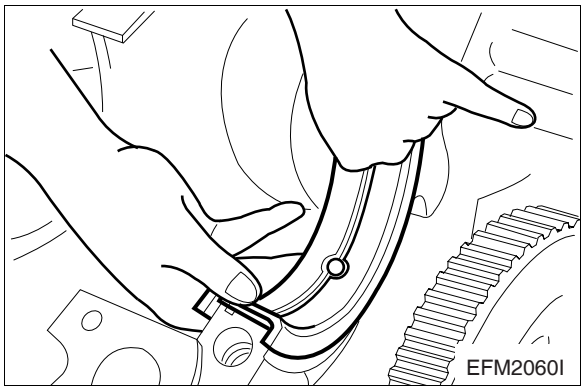


3.3.4. Crank shaft

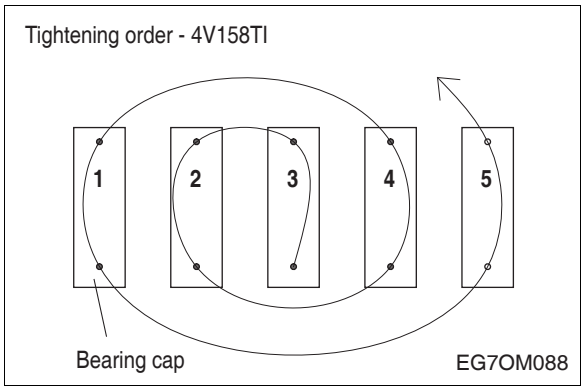
- Put the wear ring into the heater to heat it up to 150 ~ 200 °C level, push it over the crankshaft by means of a jig.
- Assemble jig no : E1.05508-0185



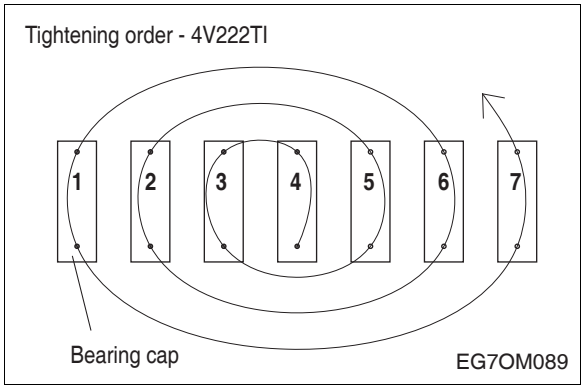
- Assemble the main bearing to the cylinder block and coat it with engine oil. Then assemble the bearing that has a hole to the cylinder block side and one that has no hole to the bearing cap and be careful not to change.



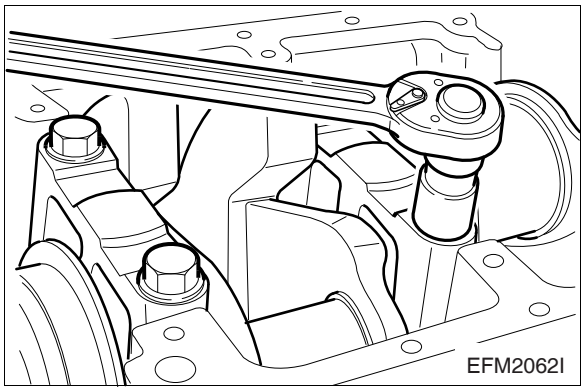
- Assemble temporarily one bolt each at both bolt holes and by connecting the wire to the bolts, lift it with crane or chain block and put down on the cylinder block carefully.



- 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.



- According to the tightening order, tighten the bearing cap bolt with 30kg·m and with rotating angle method (90°+10°) and tightening order are as follows.



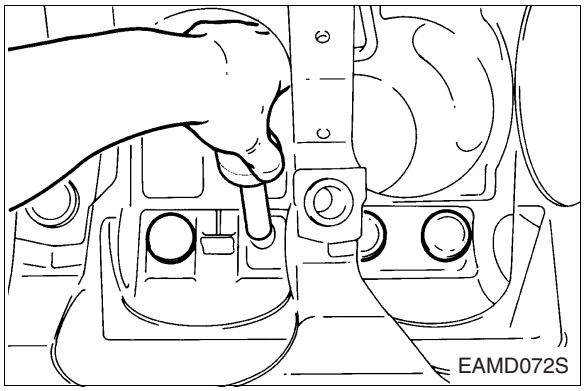
<Bearing cap bolt's Tightening Order>

(1) First step : Screw down 1 ~ 2 threads.
(2) Second step : Tighten with about 15 kg·m by wrench.
(3) Third step : Tighten with about 25kg·m by torque wrench.
(4) Fourth step : Tighten with 30kg·m by torque wrench.
(5) Fifth step : Tighten with final rotating angle method 90° +10°.
However, according to above tightening order, tighten step by step.

- Inspect if the crankshaft'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.

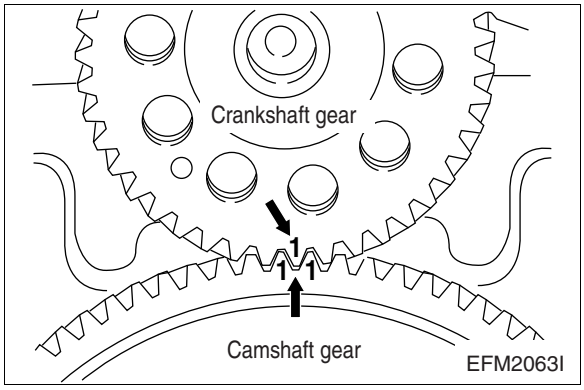
3.3.5. Tappet

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



3.3.6. Cam shaft

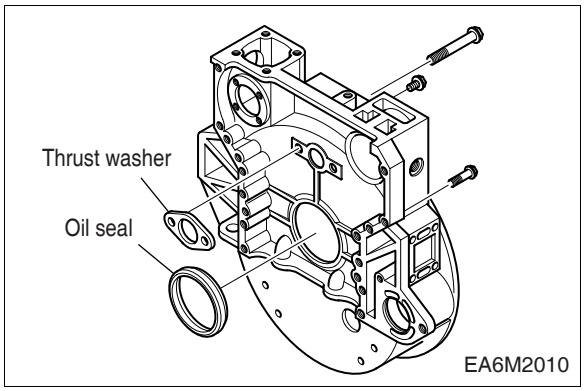
- Coat the cam bush of cylinder block and camshaft with engine oil.
- Assemble the cam bush and camshaft for them not to be damaged.
- Assemble the crankshaft gear and the camshaft gear making sure that the gear marks on both gears are aligned together.



3.3.7. Flywheel housing

- Assemble the following parts in the flywheel housing before installing the flywheel housing onto the cylinder block.
- Apply loctite to the fixing bolt and assemble the thrust washer.

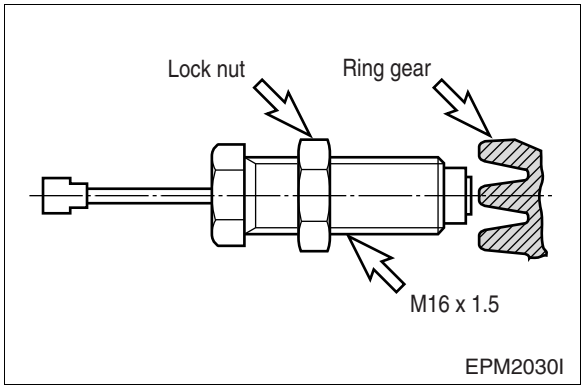
Torque	M8	3.1 kg·m
	M12 x 1.5	11.2 kg·m

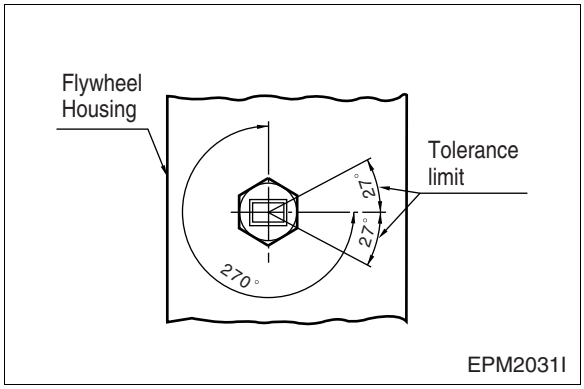


- Coat the oil seal (P.T.F.E.) with lubricating oil and assemble the oil seal carefully for it not to deviate or be damaged by means of special tool.
- (Assemble jig no : EF.120-029)
- Attach the gasket on the surface of cylinder block where the flywheel housing is to be installed. (In order to prevent 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.

3.3.8. Magnetic pick up sensor

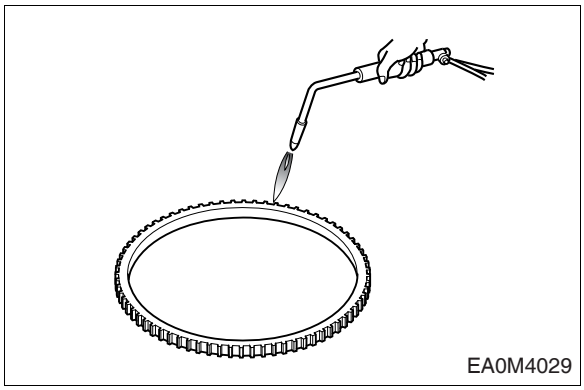
- Move the lock nut to hexagonal side of sensor completely.
- Rotate (CW) the pick up sensor on flywheel housing, until the end of it reach on flywheel ring gear.
- Rotate (CCW) the pick up sensor for 270° (gap 1.0 mm) and fix lock nut.
- Tolerance limit is 27°. (gap ± 0.1 mm)



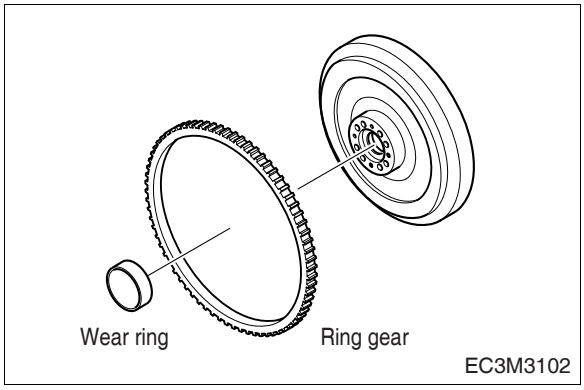


3.3.9. Fly wheel

- 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).

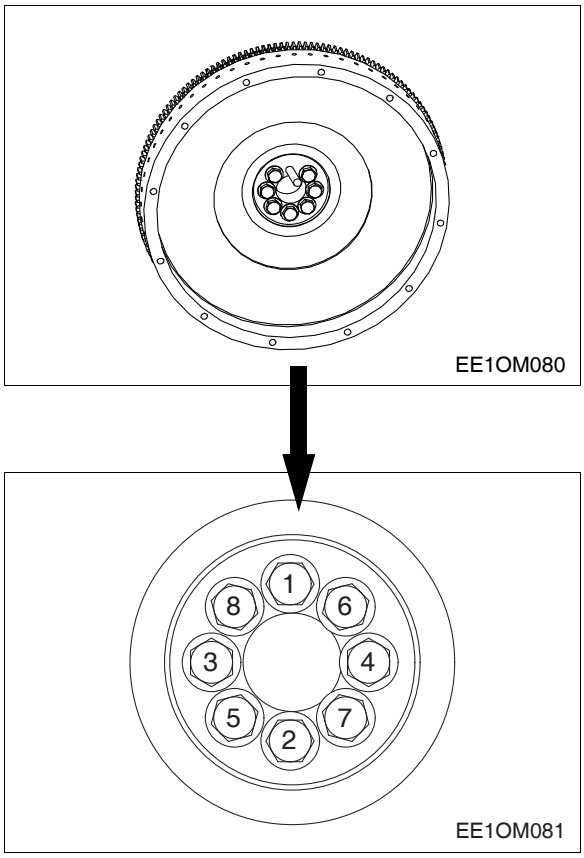


- Heat the wear ring evenly until heat (150°C±10°C) expansion takes place, then install it using a special tool.
- Apply the loctite #262 on the wear ring seat face of the fly wheel before assemble the wear ring.
- Assemble jig no : E1.05508-0025



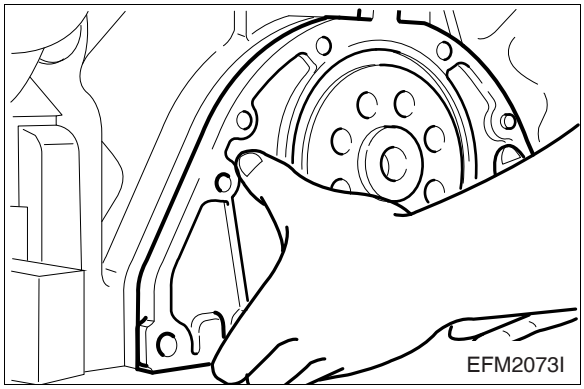
- Install two guide bolts for installing the flywheel to the crankshaft.
- After letting the guide pin insert through the flywheel holes and engaging the fixing bolts by 2 ~ 3 threads temporarily, tighten them to the specified torque according to lightening order. (Zigzag order)

Torque	26 kg·m



3.3.10. Front oil seal holder

- After placing the oil seal in the oil seal holder hole properly, press it in with a special tool. (Be careful for oil seal not be damaged.)
- Assemble jig no : EF.120-030
- Attach a gasket at the oil seal holder.

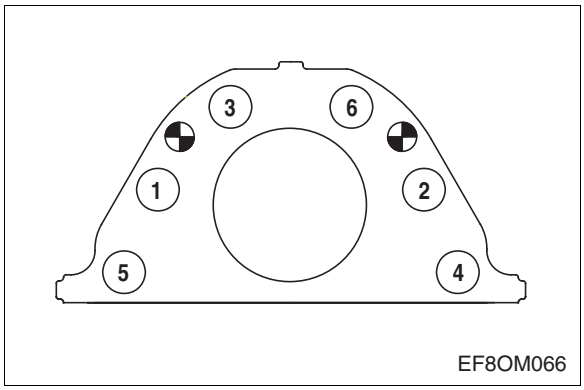


- Align the dowel pin with the oil seal holder dowel hole and assemble them by tapping lightly the dowel pin part with the urethane hammer when in assembling, take care not to hurt the oil seal by the crankshaft.

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

- Apply lubricating oil to the inside of oil seal and tighten the fixing bolts in right orders.

Torque	2.2 kg·m



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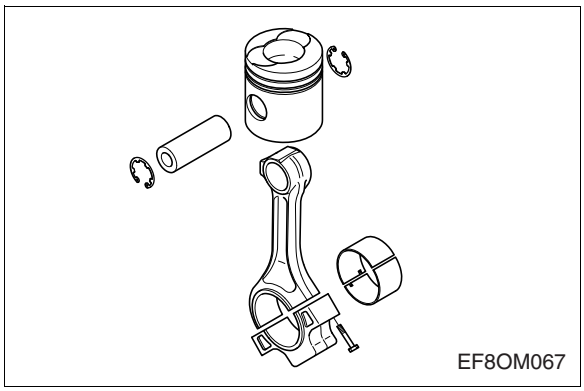
3.3.11. Piston

- 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.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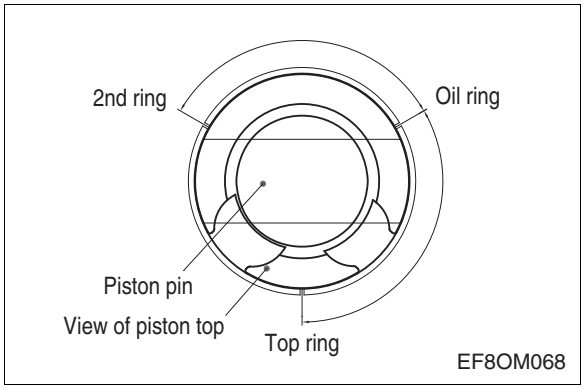
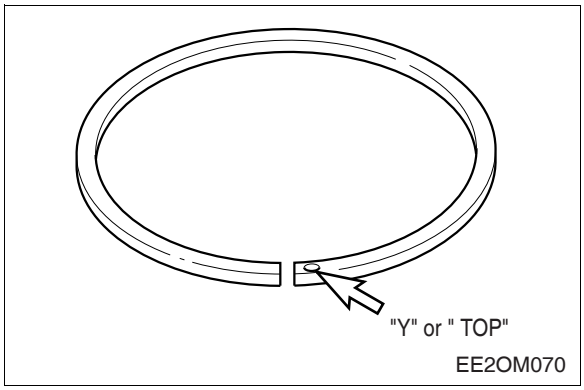
- By means of a special tool, insert the piston rings and adjust the angles between the ring gaps at 120°.
- Assemble jig no : T7621010E



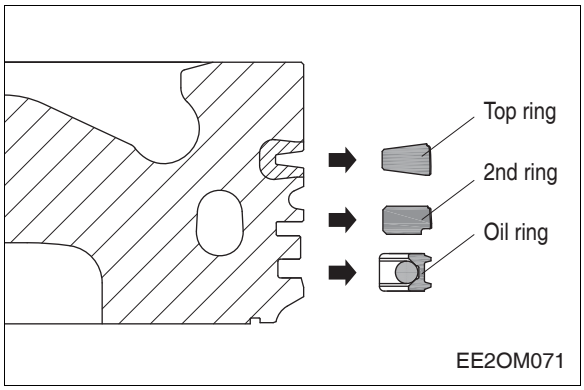
EF8OM068

- Identify the mark "**Y**" or "**TOP**" on the ring end to prevent the top and bottom of the piston ring from being interchanged and make the marked portion face upward.
  (The surface marked as "**Y**" or "**TOP**" is upper surface.)

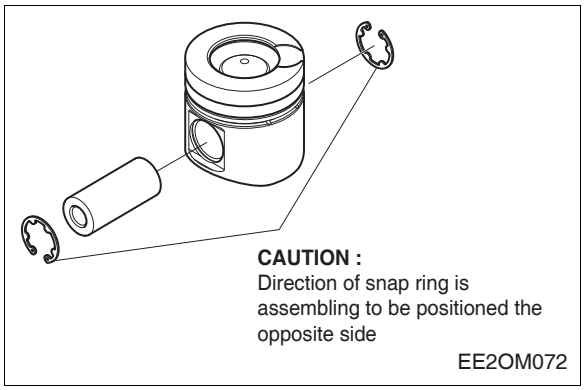


EE2OM070

- Push in the piston with hands or wooden bar into cylinder. (Be careful for piston and rings not be damaged.)
- Assemble jig no : EF.120-208
- 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 the connecting rod bolts to the specified torque. (10 kg·m + 90°$^{+10°}$)

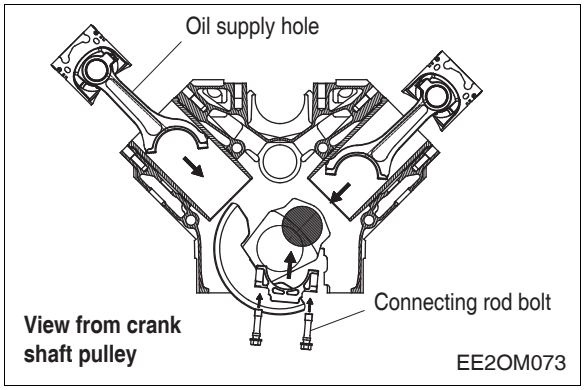


<Connecting rod bolt Tightening Order>

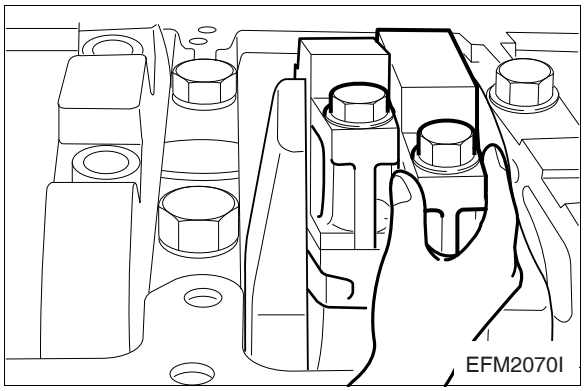
(1) First step : Engage 2 ~ 3 threads by hands.
(2) Second step : Tighten to about 7kg·m with wrench.
(3) Third step : By means of torque wrench tighten to 10 kg·m.
(4) Fourth step : Finally assemble by means of rotation angle method 90°$^{+10°}$.
However, according to above tightening order, tighten them 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

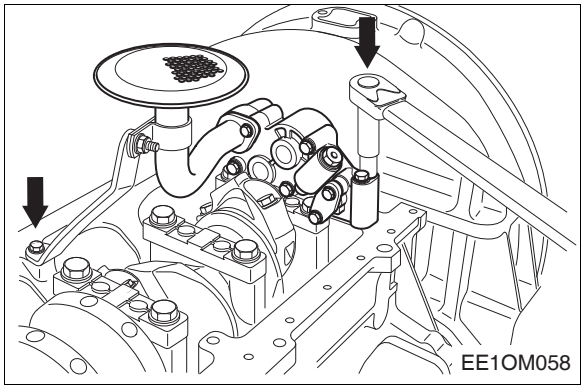


- By moving the connecting rod bearing cap by hands, make sure if there is any play in left and right.
- With the same method as above, assemble in each cylinder rotating the crankshaft.



3.3.12. 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.



Oil pump back lash	0.1 ~ 0.45 mm

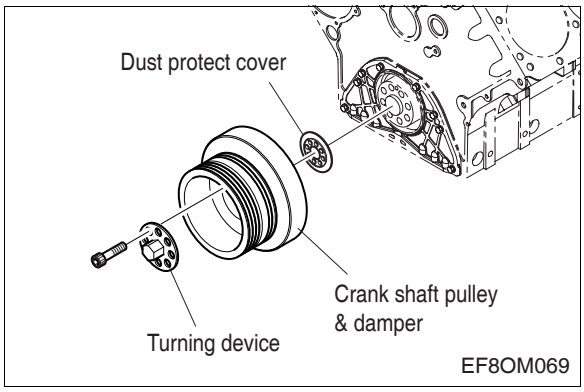
- Attach a gasket at the surface of the oil pump where the oil suction pipe is to be installed, and install the oil suction pipe by tightening the fixing bolts.
- Assemble the pipe bracket on the cylinder block side with bolts.

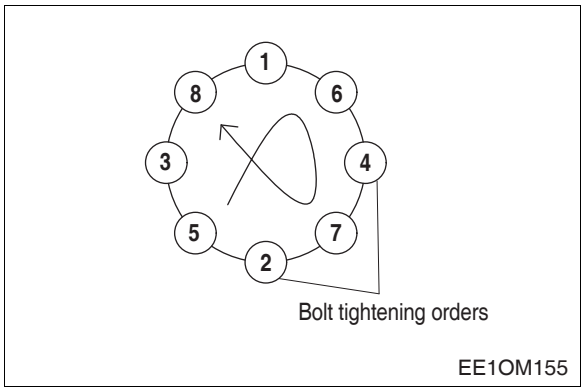
Torque	2.2 kg·m

3.3.13. Vibration damper

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

Torque	21 kg·m



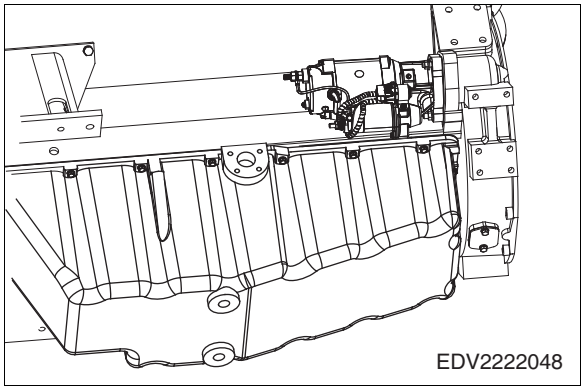


3.3.14. Oil pan

- 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.
- Apply silicon to each joint and 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.

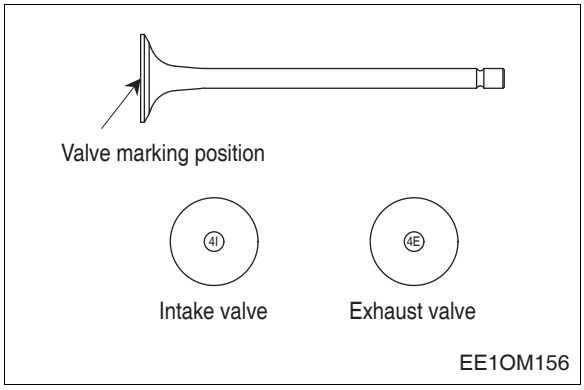
Torque	Fixing bolt	2.2 kg·m
	Drain plug	10 kg·m

- Install the guide tube and insert the oil level gauge.



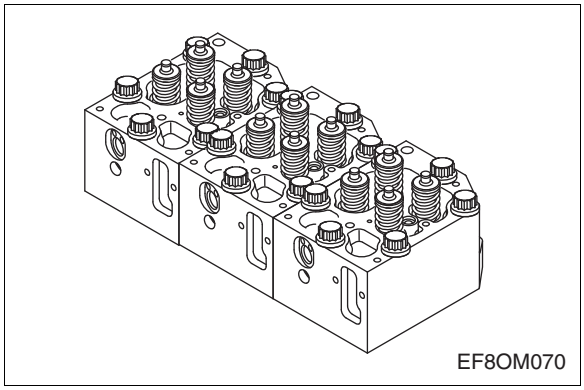
3.3.15. Intake & exhaust valve

- Identify the marks of **"4I"** and **"4E"** 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 on the valve guide.
- Assemble jig no : EF.120-246

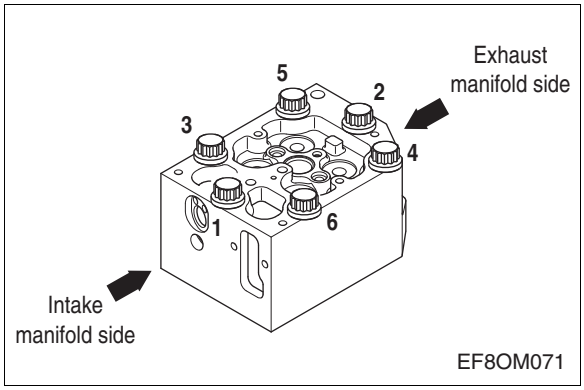


3.3.16. Cylinder head

- 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.

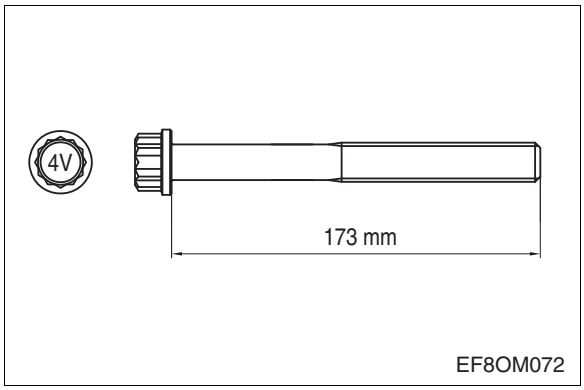


- Position the cylinder head assembly on the cylinder block aligning with its dowel pin. (Take care not to damage the head gasket.)



- Tighten them to the specified torque according to step by step.

Standard length	Use limit
173 mm	175.5 mm or less (assemble less 3 times)



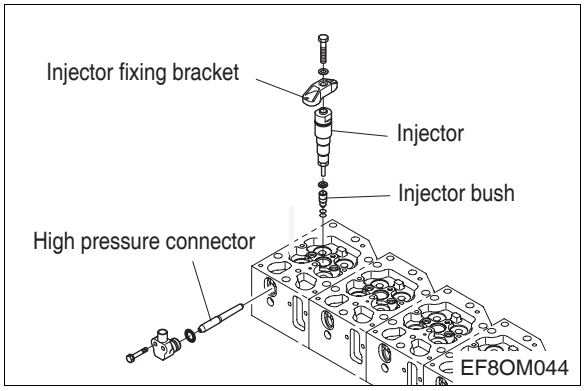
< Cylinder head bolts tightening order >

1) First step : Tighten temporarily 1 ~ 2 threads by hands.
2) Second step : Tighten to about 6 kg·m with a wrench.
3) Third step : Rotate 90° by rotation angle method.
4) Forth step : Rotate 90° by rotation angle method.
5) Fifth step : Rotate 90° by rotation angle method.
6) Sixth step : Finally tighten additionally rotating 30°.

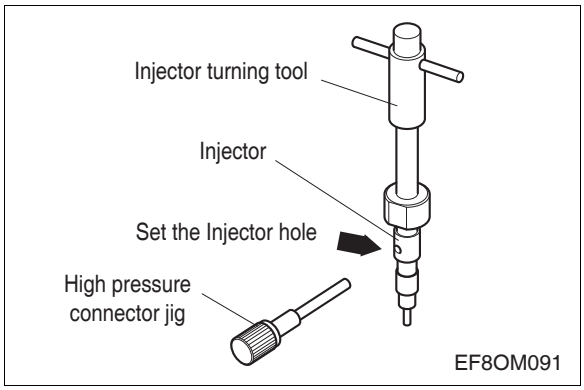
NOTE:
Take care for the foreign material not to get into the cylinder head suction passages.

3.3.17. Injector

- The injector should be assembled correctly by the following order.
- Put the O-ring into the injector and coat the circumference face of it with engine oil.
- High pressure connector assemble jig no : EF.120-278
- Injector assemble jig no : EF.120-277



- The sealing set to injector hole of cylinder head, then the injector insert. (The side groove face of injector set to the fuel high pressure connector with injector turning jig)



- The injector set to injector fixing bracket with the fixing bolt, then assemble temporarily it.

Temporarily torque	Injector fixing bracket	Fuel high pressure connector fixing nut
	0.3 kg·m	0.25 kg·m

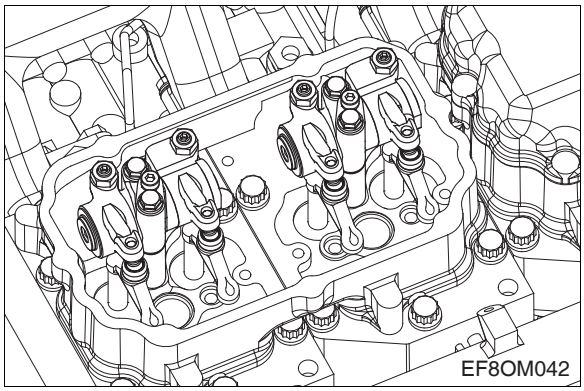
- Assemble the injector fixing bracket bolt with specified torque, and assemble the fuel high pressure connector fixing bolts.

Torque	Injector fixing bracket bolt	3.5 ~ 4.0 kg·m
	Fuel high pressure connector fixing bolt	1.0 kg·m

3.3.18. Rocker arm

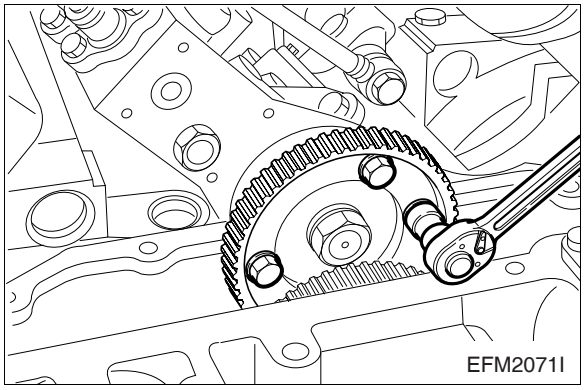
- Coat the push rod with engine oil and put it into the push rod hole.
- Position the rocker arm assembly on the cylinder head and tighten the fixing bolts to the specified tightening torque.

Torque	6.2 kg·m

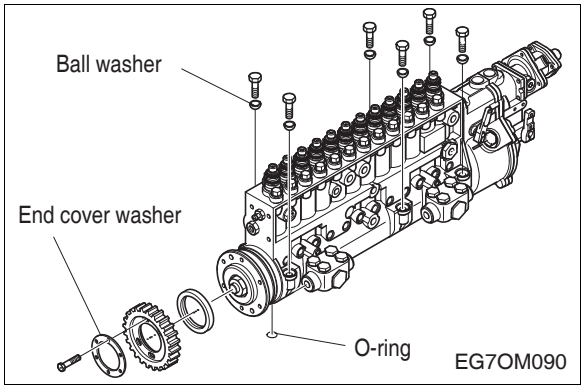


3.3.19. Fuel injection pump

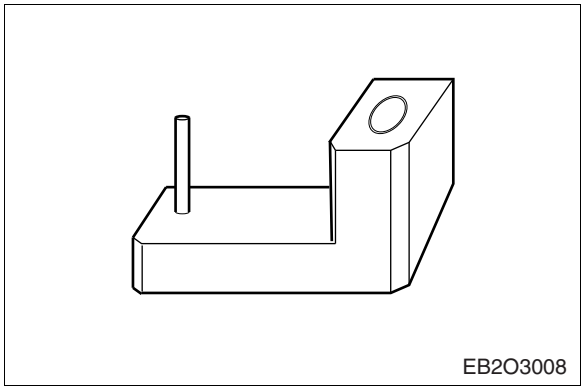
- Turn the crankshaft so as to let the cylinder No. 6 for 4V158TI, 4V222TI engines and the cylinder No. 7 for 4V180TI come to TDC (top dead center).
- Rotate the crankshaft to reverse about 30° (in order to remove a backlash) and then rotate it to engine rotating direction to set the fuel injection timing angle.



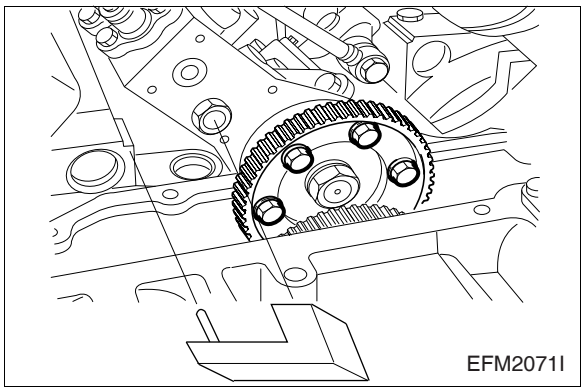
- Coat the O-ring with grease and insert it at the lower part of fuel injection pump. (Be careful O-ring not to be removed)
- Prior to install the fuel pump drive gear, fit the rubber gasket first.
- Tighten temporarily the fuel injection pump drive gear with aligning the pointer on drive gear with injection pump pointer.



- Fit the injection pump in the appropriate position using a special tool.
- After fixing the jig hole on the limit cap of the injection pump rotate the jig counterclockwise and align the jig pin to the machined corner of the cylinder block, then assemble the injection pump.
- Assemble jig no : EF.120-189



- After completing the preparation for injection pump assembling, install the injection pump and tighten the bolts in the zigzag method.
- After assembling the injection pump, find out whether the injection pump pointer and drive gear's pointer is aligned, and if aligned, tighten the fixing bolts that were temporarily tightened.

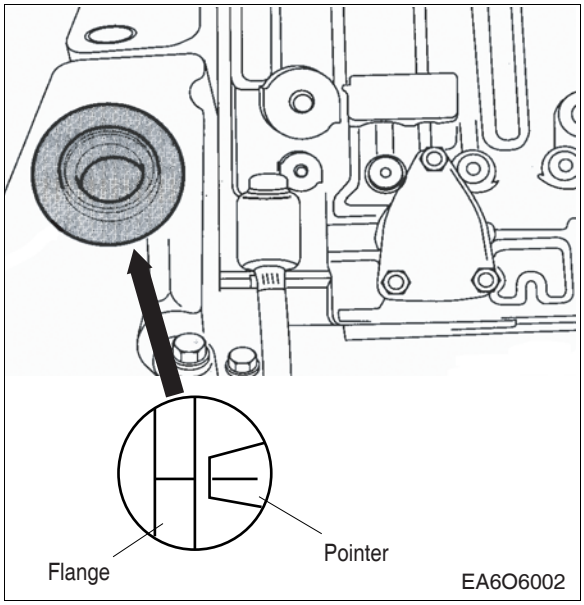


- However, if not aligned, loosen the fixing bolts and turn the fuel pump so as to align the pointers then tighten the fixing bolts.

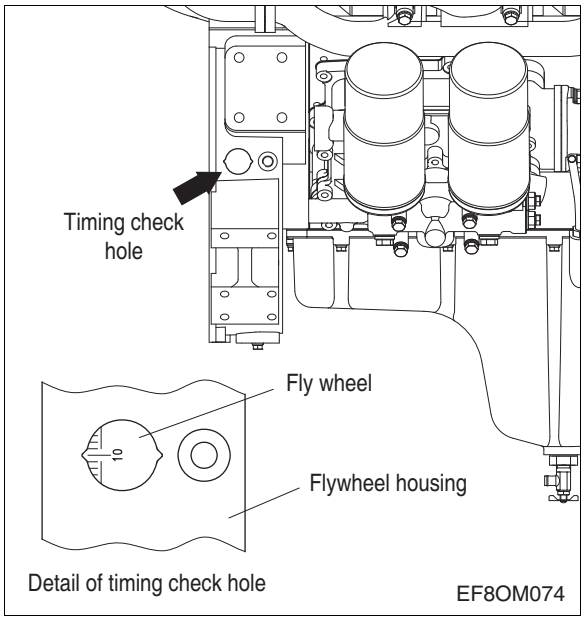
Torque	3.1 kg·m

3.3.20. Injection timing

- How to check the injection timing
  Check the current injection timing of the engine as follows before adjusting it but if the injection timing is wrong should do it.
  1) Remove the plug screw assembled in case cover on the injection pump drive gear.(Some cases are needed to remove cover assembly)
     And turn the crank pulley so that the mark on pointer provided on injection pump coincides with matching mark on the flange surface of the drive gear.



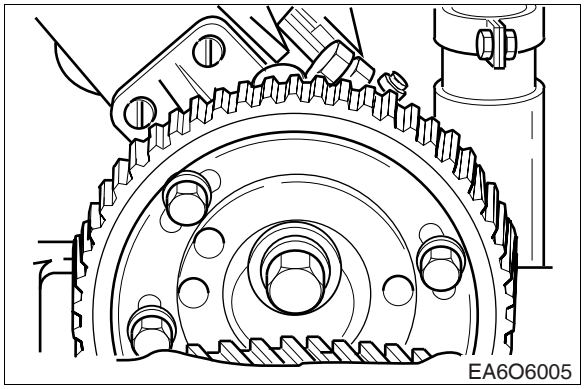
  2) Check the injection timing degree whether the V-type edge of the flywheel housing sight hole coincides with the engine injection timing degree marked on the flywheel corresponding to fuel delivery position.



- **How to adjust injection timing**

  If upper pre-checked injection timing degree is wrong, follow as below.

  1) Loosen the fixing bolts(M8) of the injection pump driving gear in order to adjust the injection timing slightly.
  2) Turn the crank pulley clockwise until V-groove of the flywheel housing sight hole is aligned with the injection timing degree of the engine.
  3) Coincide the mark on pointer provided in injection pump with the matching mark on the flange surface of the drive gear by turning the flange in the oblong holes of the drive gear.
  4) Tighten the bolt (M8) to specified torque (3.1 kg·m) not to move the drive gear.
  5) After confirmation that fastening bolts are completely tightened check the start point (injection timing degree) of fuel delivery setting once more if not right repeat it again as same as upper way.


EA6O6005

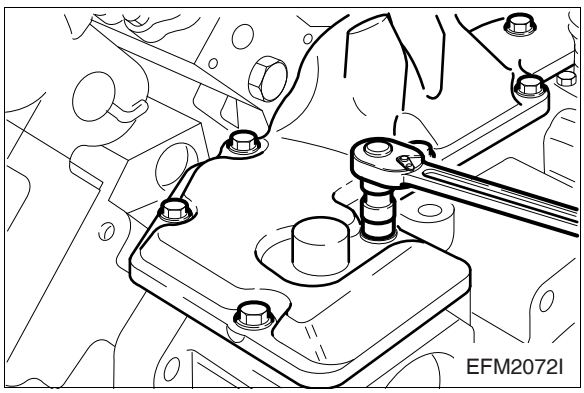
<Fuel injection timing degree>

- Refer the fuel injection timing degree on 1.3. Engine Power.

3.3.21. 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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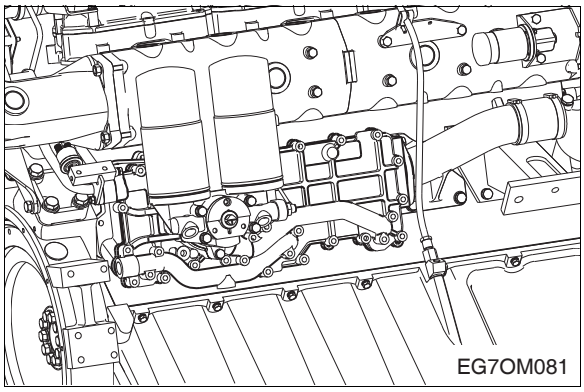
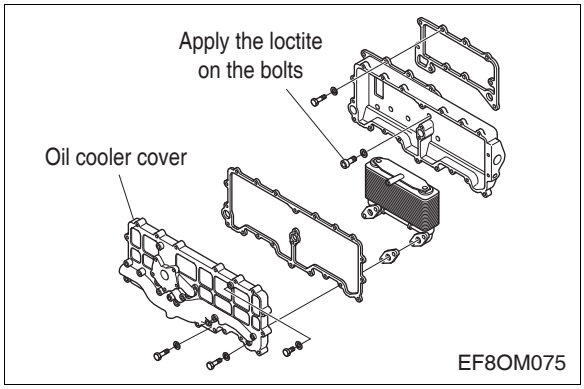
3.3.22. Oil cooler

- 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	4.4 kg·m
	M10	5.5

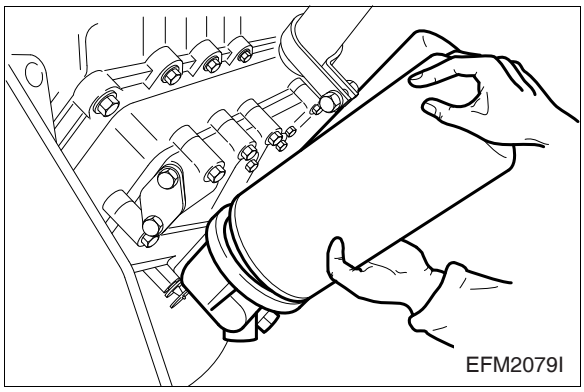


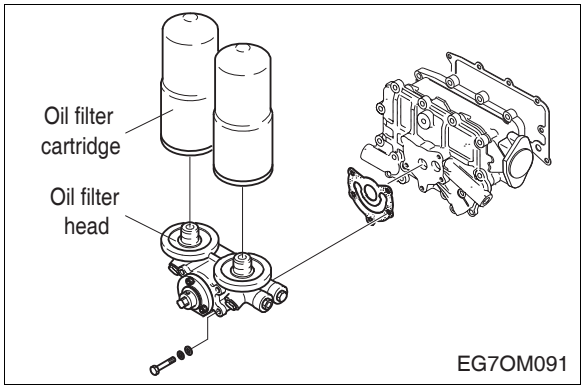


3.3.23. Oil filter

- Attach a gasket on the surface in the oil cooler cover, then assemble the oil filter housing.
- Install the oil filter cartridge.

Torque	7.5 kg·m



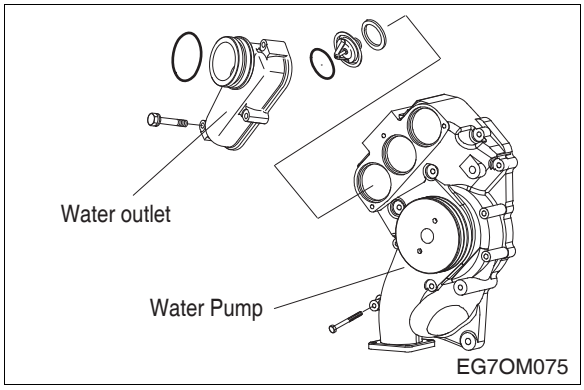


3.3.24. Cooling water pump

- Attach a gasket at the cooling water pump and apply the sealant on the gasket face of cylinder block side.

Torque	4.4 kg·m

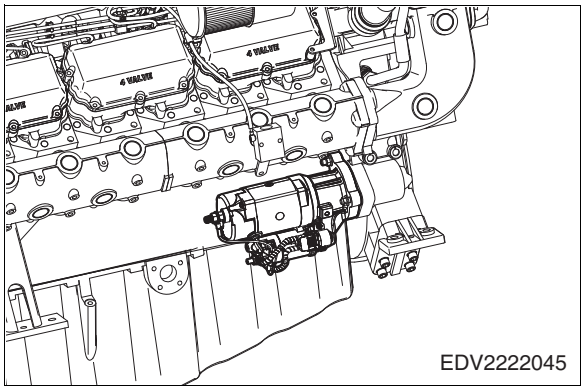
- Assemble the cooling water pump by tightening the fixing bolts. (zigzag method)
- Insert the O-ring to the thermostat and assemble the cooling water pipes by tightening the fixing bolts.



3.3.25. Starting motor

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

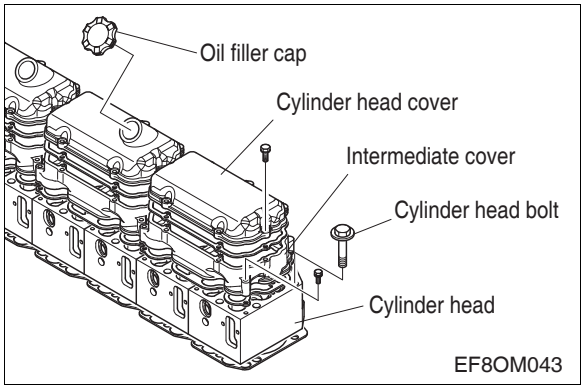
Torque	8 kg·m



3.3.26. Cylinder head cover and intermediate cover

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

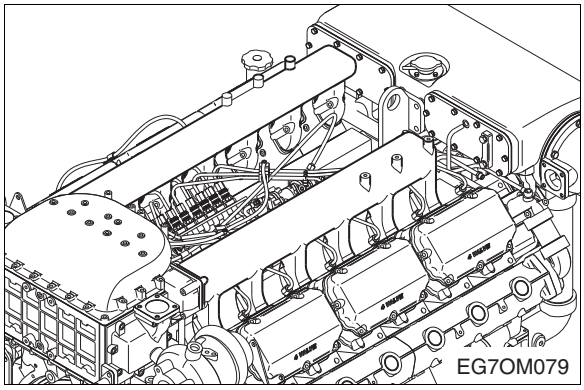
Torque of Intermediate cover bolt	2.2 kg·m



3.3.27. Intake manifold

- Attach a new gasket to the cylinder head side.
- Assemble the intake manifold by tightening the fixing bolts.

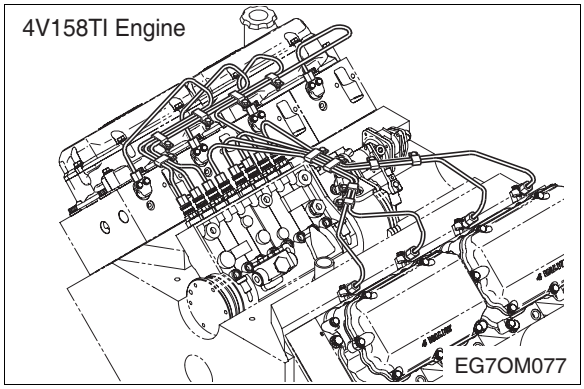
Torque	4 kg·m

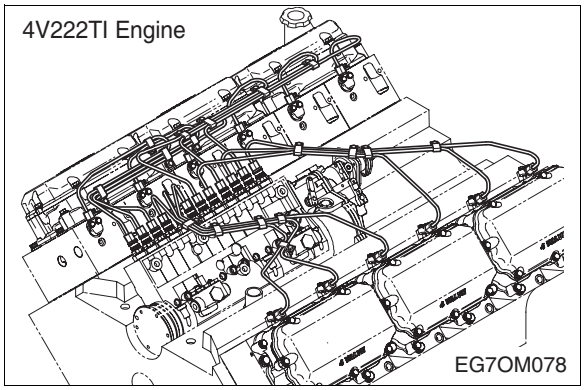


3.3.28. Fuel injection pipe

- Connect the fuel injection pipes between the fuel injection pump and the high pressure connector of cylinder head, and then tighten clamping nuts.
- Fix the fuel return pipe by tightening hollow screw.

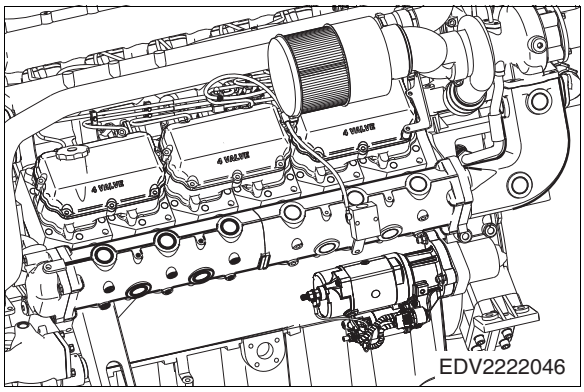
Torque of injection pipe nut	3 kg·m





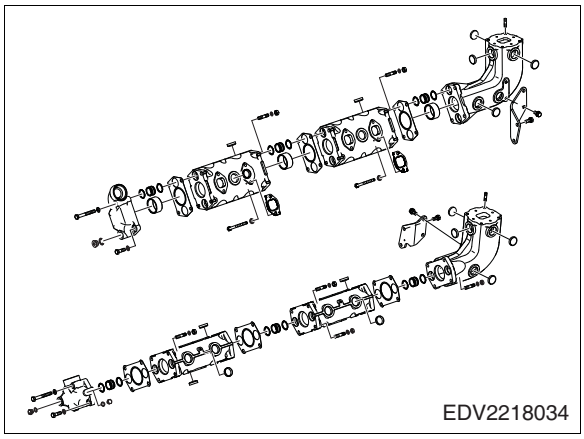
3.3.29. Exhaust manifold

- Connect the exhaust manifold that is consists of two sets after inserting the exhaust gas ring between them.
- Attach a new gasket to the exhaust manifold.



- Attach a gasket to the exhaust elbow that is connected to the exhaust manifold, and assemble the elbow by tighten the bolts for connection.
- Assemble both sides in the same method as above.

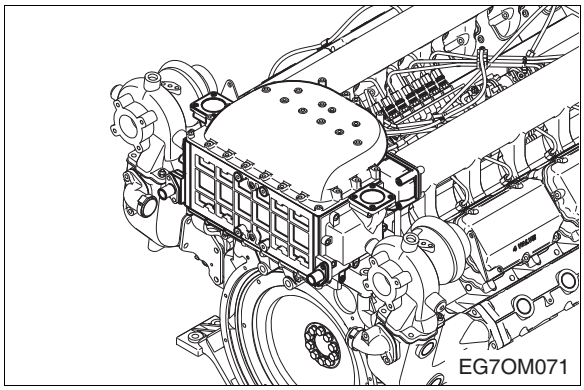
Torque	8 kg·m



3.3.30. Turbocharger

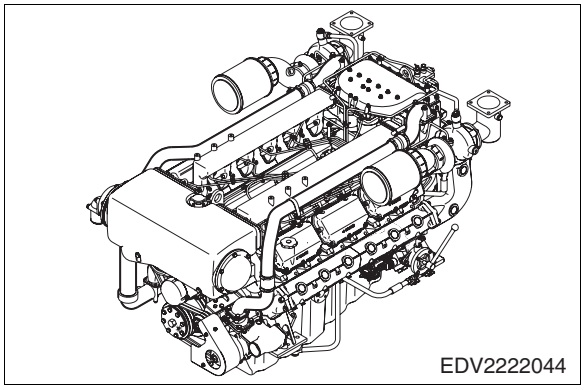
- Attach a gasket to the exhaust elbow and assemble the turbocharger with fixing nuts.
- Attach a gasket on the oil supply pipe and assemble the pipe with the fixing bolts.
- Attack a gasket on the oil discharge pipe and assemble the pipe by tightening the bolts.
- At the same method as above, both sides are assembled.

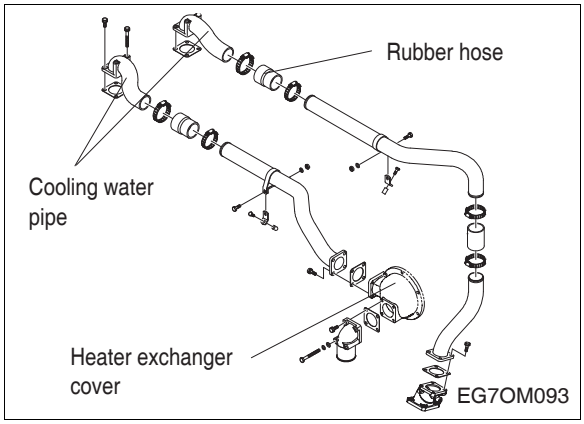
Torque of turbocharger fixing nut	6.2 kg·m



3.3.31. Cooling water pipe

- Install the cooling water pipes and hoses between the intercooler and sea water pump. Then it is assembled with the hose clamps.

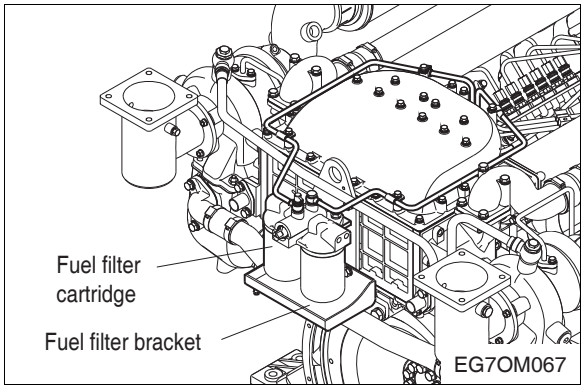




3.3.32. Fuel filter

- Assemble the fuel filter to the intake stake by tightening bolts.
- Assemble the fuel feed hose according to the direction of an arrow impressed on the fuel filter head

Torque	4 kg·m

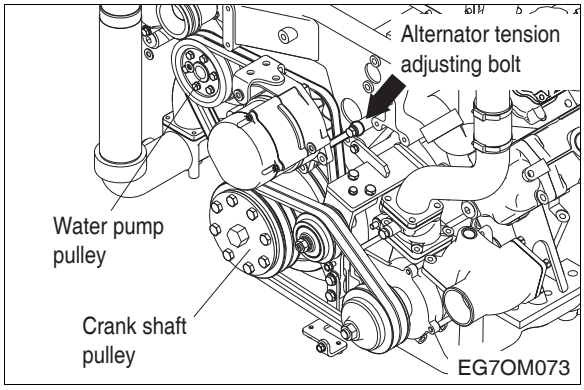


3.3.33. Hoses and pipes

- Connect fuel strainer to fuel feed pump and assemble the fuel hoses therewith.
- Connect fuel delivery and return hoses

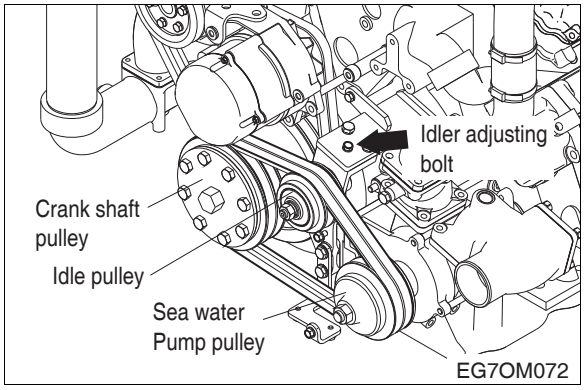
3.3.34. Alternator

- Assemble the alternator mounting bracket to lower part of heater exchanger by tightening the fixing bolts.
- Install the alternator adjusting bolt.
- Connect the crankshaft and the alternator and water pump pulley with V-belts by inserting them into the respective pulleys.
- Adjust the alternator support nut until the belt tension can be 10mm ~ 15mm by pushing with thumb.



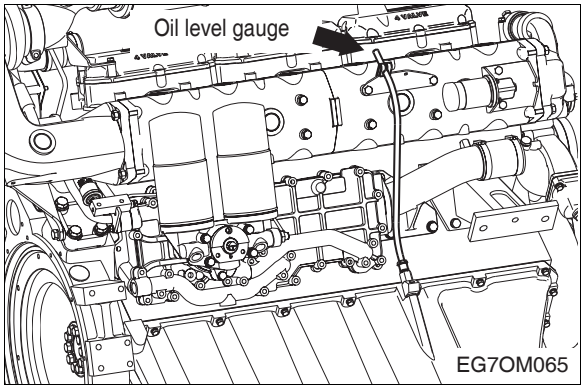
3.3.35. Sea water pump belt

- Assemble the idle pulley bracket on the cylinder block.
- Connect the crankshaft and the idle pulley and water pump pulley with V-belts by inserting them into the respective pulleys.
- Adjust the idle pulley adjusting bolt until the belt tension can be 10mm ~ 15mm by pushing with thumb.



3.3.36. Oil level gauge and guide tube

- Assemble the guide tube on the oil pan and then insert the oil level gauge.



3.3.37. Others

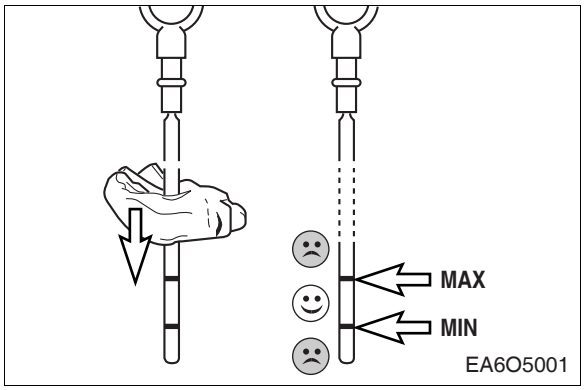
- Assemble by connecting the other sensor, harness, oil and fuel lines.

4. Commissioning and Operation

4.1. Preparations

At the time of initial commissioning of a new or overhauled engine make sure to have observed the Technical information for the installation HD Hyundai Infracore marine engines.

- **Oil filler neck on cylinder head cover**
  Before daily starting of the engine, check the fuel, coolant and oil level, replenish if necessary.
- The oil level must be between Max. and Min. lines on the gauge. The notches in the oil level gauge indicate the highest and lowest permissible oil levels.



IMPORTANT:
Do not fill above the top of the mark by over lifting. Over lifting will result in damage to the engine.

- **Cleanliness**
  Ensure outmost cleanliness when handling fuels, lubricants and coolants, be careful about mixing of the foreign matter during the supplement.
  In case that HD Hyundai Infracore recommended the fuel and lubrication oil and coolant do not used, HD Hyundai Infracore do not guarantee the field claim.

4.2. Starting the Engine

4.2.1. Operation 1

- After checking the warning lamps of the gauge panel and the NEUTRAL position of reduction gear control lever, turn the key switch to the START position to crank the engine, at once.
- Behavior - When the key switch is placed in the START position.

4.2.2. Operation 2

- After the engine is cranked, convert the key switch to the ACC position quickly.
- Behavior - As the engine is cranked, don't fix the key switch too long (over 4 seconds) in the "START" position. If you do, the starter may be malfunction.
- If you fail the engine starting at first, restart the engine after waiting for 30 seconds at least to prevent the circuit malfunction of the starter.

4.3. Engine Break-in

- During the first 20 hours of operation, you must follow the **Engine Break-In** procedure to ensure maximum performance and long engine life.

NOTE:
Failure to follow the "Engine Break-in" procedure may result in serious engine damage.

4.3.1. New engine break-in 20 hours

- All HD Hyundai Infracore marine engines have been run for a short period of time as a final test at the factory. You must follow the "**Engine Break-In"** procedure during the first 20 hours of operation to ensure maximum performance and longest engine life.

NOTE:
To ensure proper lubrication during the break-in period, do not remove factory break-in oil until 20 hours break-in is completed.

4.3.2. Initial two hours of break-in

- For the first five to ten minutes of operation, operate engine at a fast idle (below 1,300 rpm). During the remaining first two hours of operation, accelerate to bring boat onto plane quickly and bring throttle back to maintain a planing attitude. During this period, vary the engine speed frequently by accelerating to approximately three-fourths throttle (1500~1600 rpm) for two to three minutes, then back to minimum planing speed (700~800 rpm).
- After the engine has reached operating temperature, momentarily reduce engine speed, then increase engine speed, to assist the "**break-in"** of rings and bearings. Maintain planing boat attitude to avoid excessive engine load.

NOTE:
Do not run engine at any constant rpm for prolonged periods of time for this initial two hours of break-in.

4.3.3. Next 8 hours

- During the next 8 hours, continue to operate at approximately three-fourths throttle or less (minimum planing speed). Occasionally reduce throttle to idle speed for a cooling period. During these 8 hours of operation it is permissible to operate at full throttle for periods of less than two minutes only 2 times.

NOTE:
Do not run engine at a constant rpm for prolonged periods of time during the break-in period.

4.3.4. Final 10 hours

- During the final 10 hours of *break-in*, it is permissible to operate at full throttle for five to ten minutes at a time. After warming engine to operating temperature, momentarily reduce then increase engine speed. Continue to operate at approximately three-fourths throttle. Occasionally reduce engine speed to idle to provide cooling periods.

NOTE:
Do not run engine at a constant rpm for prolonged periods of time during the break-in period.

- During the break-in period, be particularly observe as follows:
- Check engine oil level frequently. Maintain oil level in the safe range, between the **"Min."** and **"Max."** marks on dipstick.
- Watch the oil pressure warning lamp. If the lamp blinks whenever the boat attitude (i.e. turning, climbing on plane, etc.) is changed, 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.

NOTE:
Oil pressure will rise as RPM increases, and fall as the engine 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.

- Watch the engine water temperature gauge and be sure there is proper water circulation. The water temperature gauge needle may fluctuate if water level in expansion tank is too low.

NOTE:
Failure to follow the break-in procedure will avoid the engine warranty.

- When the engine operation become to reach 50 hours in total including the break-in period 20 hours, replace the engine oil and oil filter to new ones. Fill oil pan with recommended engine oil.

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

4.3.5. Operating after break-in 20 hours

- When starting a cold engine, always allow the engine to warm up gradually. Never run the engine at full throttle until the engine is thoroughly warmed up.
- And you'd better run the engine at three-fourths throttle (about 1600 rpm) before initial 50 hours as possible. Be sure to check the oil level frequently during the first 50 hours of operation since the oil consumption will be high until the piston rings are properly seated.

4.4. Inspections after Starting

- During operation the oil pressure in the engine lubrication system must be monitored. If the monitoring devices register a drop in the lube oil pressure, switch off the engine immediately. And the charge warning lamp of the alternator should go out when the engine is running.
  - Do not disconnect the battery or pole terminals or the cables!
  - If, during operation, the battery charge lamp suddenly lights up, stop the engine immediately and remedy the fault in the electrical system!
  - Engine should be stopped if the color, the noise or the odor of exhaust gas is not normal.
  - Confirm the following things through warning lamps and gauge panel.

4.4.1. Pressure of lubricating oil

- The normal pressure comes up to 1 bar at idling and 3 ~ 5 bar at rated speed. If the pressure fluctuates at idling or does not reach up to the expected level at high speed, shut down the engine immediately and check the oil level and the oil line leakage.

4.4.2. Temperature of cooling water

- The cooling water temperature should be 75 ~ 85°C in normal operating conditions. Abnormally high cooling water temperature could cause the overheating of engine and the sticking of cylinder components. And excessively low cooling water temperature increases the fuel consumption, accelerates the wears of cylinder liners and shortens the engine life-time.

4.5. Check after Initial 50 Hours Operation.

To insure your continued boating enjoyment, you should check as follows:

- Change engine oil and oil filter cartridge.
- Change fuel filter cartridge.
- Check coolant level.
- Check the tension of all drive belts.
- Check all engine mounts screws for tightness.
- Check for any deficiencies, malfunctions, signs of abuse, etc. Correction of any problems at this time will prevent the worsening of a minor problem and help ensure a trouble free boating season.

NOTE:

This is an opportune time to discuss with your dealer any questions about your boat and stern drive unit which may have arisen after the first 50 hours of operation and establish a routine preventive maintenance schedule.

4.6. Operation in Winter

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

4.6.1. Prevention against the freeze of cooling water

- When not using anti-freeze, completely discharge the whole cooling water after engine running. The freeze of cooling water causes the fatal damages of the engine. Because the anti-freeze is used to prevent cooling water from freeze and corrosion, it is always to be filled with the anti-freeze 35~40% of the whole coolant.

4.6.2. Prevention against excessive cooling

- Drop of thermal efficiency caused by excessive cooling increases fuel consumption. Therefore should prevent the engine from excessive cooling. If the temperature of coolant does not reach to normal condition (75 ~ 85°C) after continuous operation, examine the thermostat or the other cooling lines.

4.6.3. Lubricating oil

- As cold weather leads to the rise of oil viscosity, engine speed becomes unstable after starting. Therefore the lubricating oil for winter should be used to prevent this unstableness.

4.7. Long Term Stored Engine and Its Test Run

- In case of the engine is not used for long time, preserve the engine from corrosion, faulty matters in order to run the engine operation easily and keep it long maintenance.
- Especially the main external and internal components of the engine are likely to corrode as follows.

4.7.1. How to store the engine

1) 1~3 month stored engine

- Engine in the box : should be stored in an dry space.
- Engine outside : start up the engine more than once a month

2) 4 ~ 6 month stored engine

- Engine should be subject to internal / external anti-rusting treatment
- Close the kingston valve of the sea water line tightly, Specially likely to freeze, drain the water of the heat exchanger, inter cooler and marine gear oil cooler. And also last don't forget to detach the sea water pump impeller and preserve it a dark place.

4.7.2. Procedure of test run

1) Stored the engine 6 to 12 month

- Turn the crankshaft 2 or 3 turns by hand, and check the each line.
- If the turning is not possible, go check the cause and correct it.

a) Fuel line

- Remove the injection nozzle and check its spray pattern
- Check the stickiness of injection pump

b) Cooling water line

- Prepare the solution (water + speed flush)
- Connect the cooling water in / out line with solution vessel
- Start up the engine and do idling with max. rpm 10 ~ 15 minutes
- Cool down the engine, and drain out the solution completely.
- Clean out the engine inside with clean water

c) Oil line

- Check the oil leakage and rust
- Drain out the engine oil, and replenish the recommended engine oil
- Drain the marine gear oil completely and then refill the specified oil (SAE #30) up to the maximum level of the oil dipsticks.

d) Turbo charger and air cleaner

- Remove the oil delivery pipe, and supply the engine oil into the turbo charger shaft.
- Clean the air filter element and if worn severely change it new one.

e) Valve clearance

- Check the valve clearance and adjust it if necessary.

f) Filter replacement

- Replace the fuel / oil filter with genuine ones.

g) Preliminary test run

- After doing a) through f), by hand or by starter, turn the engine so that the oil go through every parts of engine.

h) Unload test run

- Do the un-load test run at idle rpm more than 5 minutes and run at max rpm more then 5 minutes.
- As doing the un-load test, check the points stated in article g).

2) Stored the engine above 12 month

a) Replace the engine oil and cooling water

b) The cylinder liners should be inspected by opening the cylinder head. If no traces of corrosion can be found on the cylinder walls, on the underside of the cylinder head or on the valves.

c) If the rust found, overhaul the engine and follow the sequences for test run

d) If the rust not found the engine, follow the sequence 6 to 12 month

e) If the engine has been stored in an improper manner, i.e. in damp room etc. or considerable longer than 2 years. Please contact the service manager of HD Hyundai Infracore before putting it into operation.

3) Check point when test run

a) Check the engine for interference between moving parts and its adjacent parts.

b) During the unload test with max rpm, check for air leakage and intake exhaust valve.

c) During the unload test, check the cooling system for water leakage

d) During the unload test, check the fuel / oil line for fuel / oil leakage

e) During the unload test with max. rpm, check the combustion sound to decide if it's normal or not

f) As a designated test, accelerate and decelerate the engine 2 ~ 3 times, and check the oil supplies the rocker arm.

g) As a designated test, accelerate the engine speed slowly and then fast, check unusual sound on rotor and bearings.

h) During the unload test with idle rpm and max rpm, check the oil pressure is correct for the engine.

4.8. When the Engine is Sunk

If the engine is sunk to water, remove the moisture of all engine parts as soon as possible and ask your HD Hyundai Infracore dealer for service of the engine at once.

Repair man disassembles all parts of the engine and remove the salty moisture of each disassembled component then apply oil to the parts at once.

At last check whether the components of the engine is dried and eroded away or damaged especially components of the fuel system. This action must be finished quickly without delay time or maybe results engine fatal damage from salty corrosion. Be sure to install the auto bilge pump in the bottom of the boat to keep the water level below the flywheel housing and to prevent overflowing with water.

5. Maintenance of Major parts

5.1. Electric System

5.1.1. Checking the warning lamps

- Check the lamps of the gauge panel carefully whether the lamp is switch on or not while the engine is running. If the oil warning lamp is switched on below 0.5 bar of the oil pressure and the water temperature warning lamp is switched off, over 95 °C of water temperature, their function is normal.

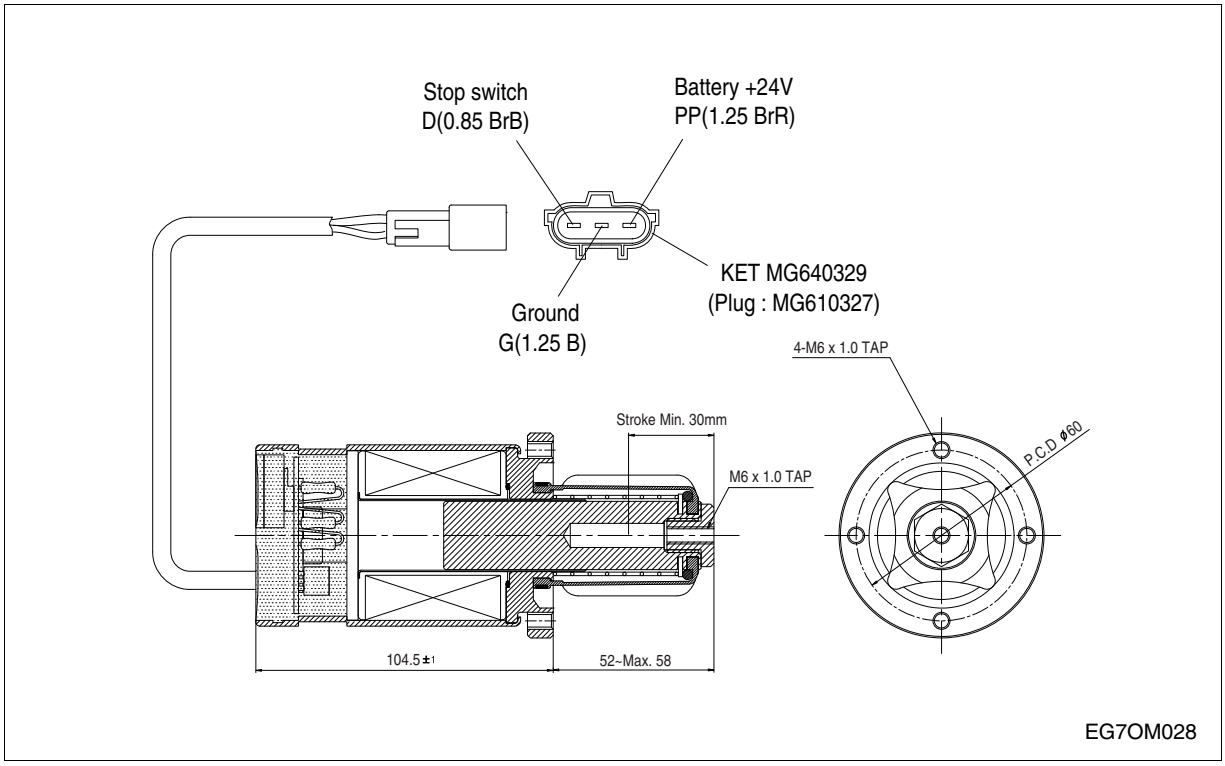
5.1.2. Checking the battery charge

- Always check whether the battery capacity is sufficient or not before sailing far away from harbor.

5.1.3. Checking the wiring of the engine

- Check the engine wiring is loosened , shorted or worn every 600 hours.

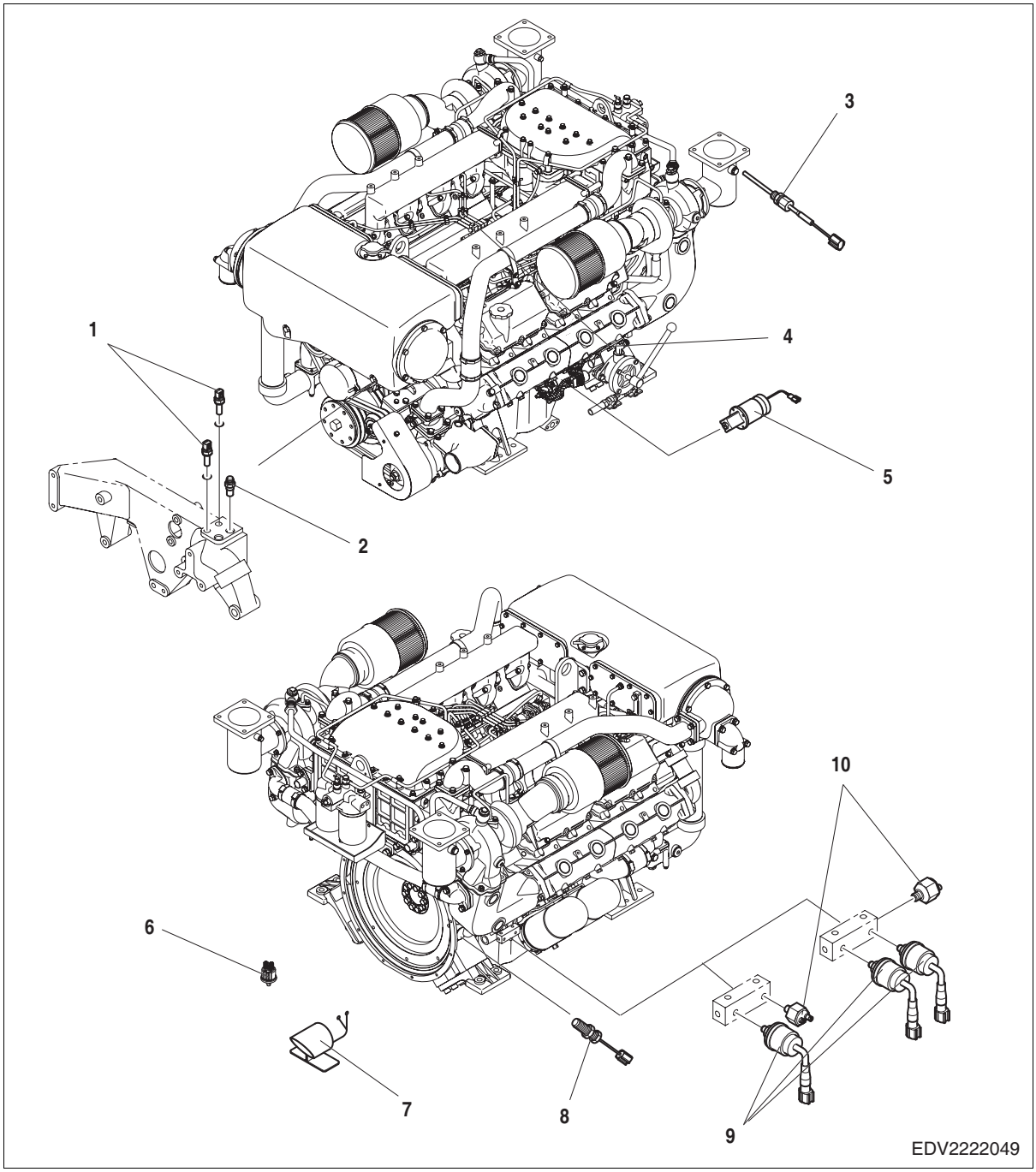
5.2. Stop Solenoid of Engine



Using volt	DC 20 ~ DC 30V
Using temperature	-20°C ~ 80°C
Pull current	bellow 22A / sec
Hold current	bellow 1.2A / sec

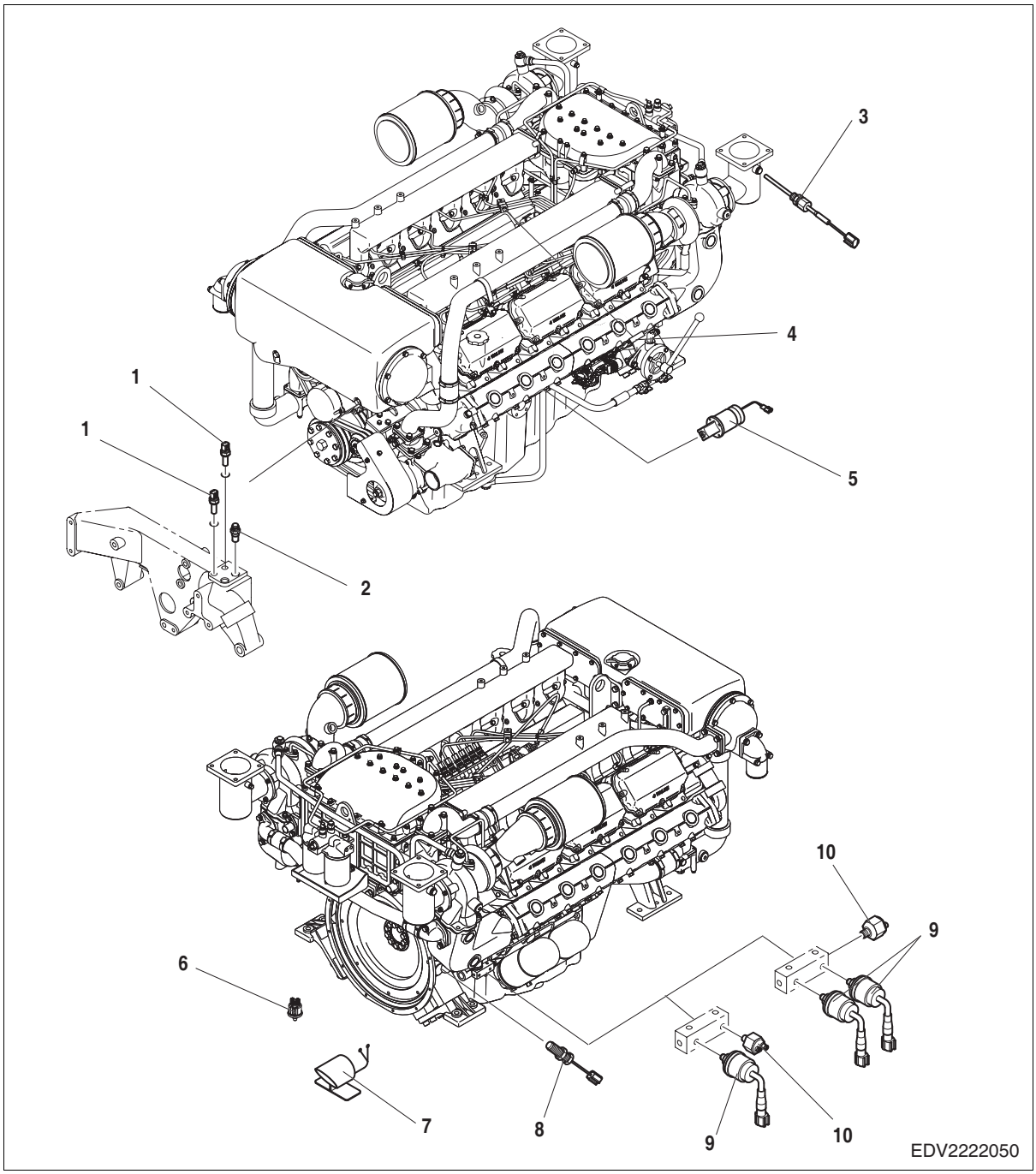
5.3. Electrical Parts

5.3.1. Electrical parts (4V V158TIH/M/L, 4V AD158TI)



1. Water temperature sensor
2. Water temperature switch
3. Exhaust gas temperature sensor
4. Fuel leakage sensor
5. Engine stop solenoid
6. Oil pressure sensor(marine gear)
7. Buzzer
8. Engine tacho sensor
9. Oil pressure sensor
10. Oil pressure switch

5.3.2. Electrical parts (4V V222TIH/M/L, 4V AD222TI)



1. Water temperature sensor
2. Water temperature switch
3. Exhaust gas temperature sensor
4. Fuel leakage sensor
5. Engine stop solenoid
6. Oil pressure sensor(marine gear)
7. Buzzer
8. Engine tacho sensor
9. Oil pressure sensor
10. Oil pressure switch

5.4. Fuel Injection System

5.4.1. Injection pump calibration of 4V158TIH engine

(1) Injection pump ass'y : 65.11101-7425 (0 402 648 721 BOSCH)
- Injection pump : PE8P120A520/4LS7973 (0 412 628 958)
- Governor : RQV250…900PA1434 (0 421 814 223)
- Plunger & barrel : 2 418 455 545
- Delivery valve : 2 418 559 045
- Feed pump : FP/KD22P78-2 (0 440 008 152)
- Prestroke : 4.08 ±0.05mm at 11.62 ±1.5mm

(2) Nozzle holder assembly : 65.10101-7097 (0 432 191 241)

(3) Nozzle : 65.10102-6067 (0 433 171 969)

(4) Injection pipe : 65.10301-6185, 65.10301-6186

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

(A) Test condition for injection pump	Nozzle & Holder Ass'y	1 688 901 105	Opening pressure : 208.5 ±1.5 bar
	Injection pipe(ID x OD - L)	-	∅3.0 x ∅8.0 – 600 mm
	Test oil	ISO4113	Temperature : 40 ±5°C
(B) Engine standard parts	Nozzle & holder Ass'y	65.10101-7097	286 kg/cm^2
	Nozzle	65.10102-6067	Nozzle (8 x ∅0.284)
	Injection pipe(ID x OD - L)	65.10301-6185 65.10301-6186	∅2 x ∅6.35 - 700mm

Rack diagram and setting valve at each point

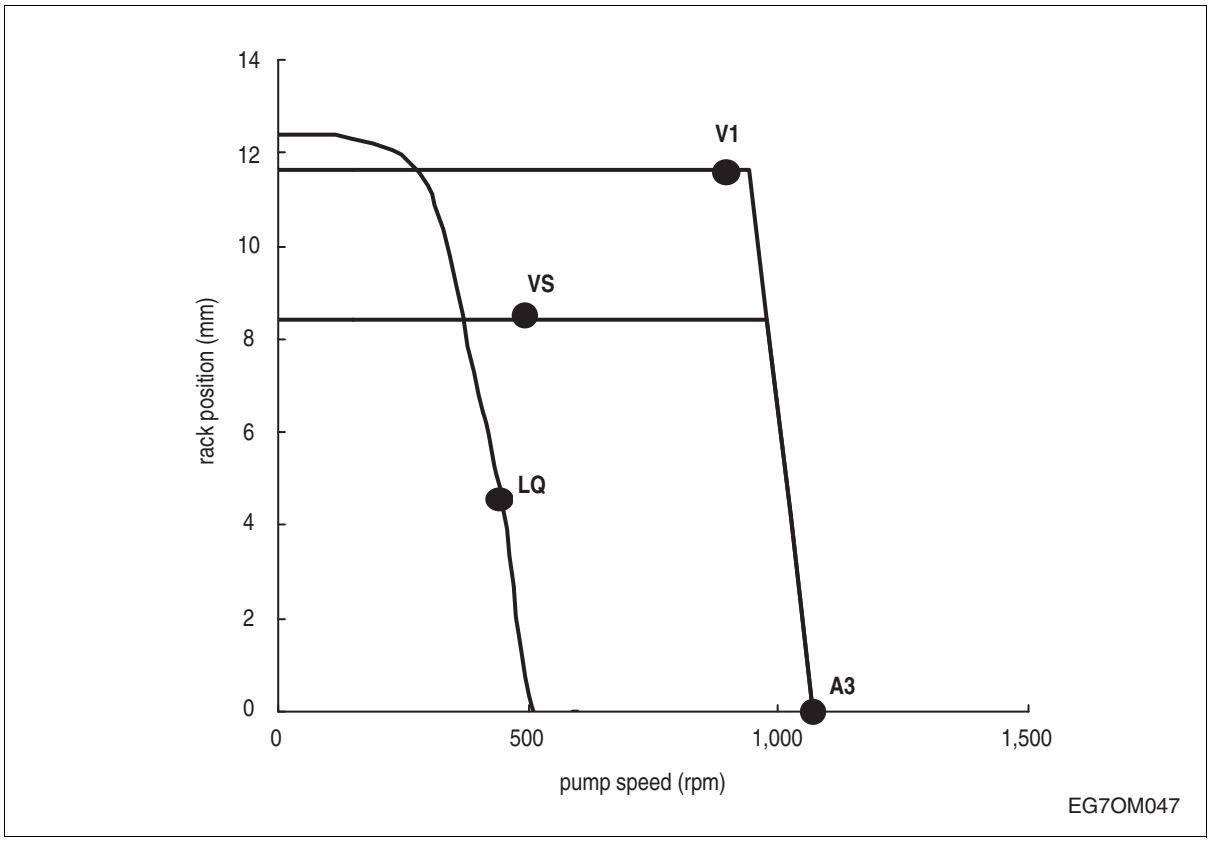
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 / 1,000 st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Rack diagram	V1	11.62	900	293.8 ±3	-	1500
	VS	8.44	500	187 ±3	-	-
	A3	0.00	1070	-	-	-
	LQ	4.40	450	46.2 ±3	-	-
		W/CAP	100	309.8	-	-

Boost compensator spring operation point

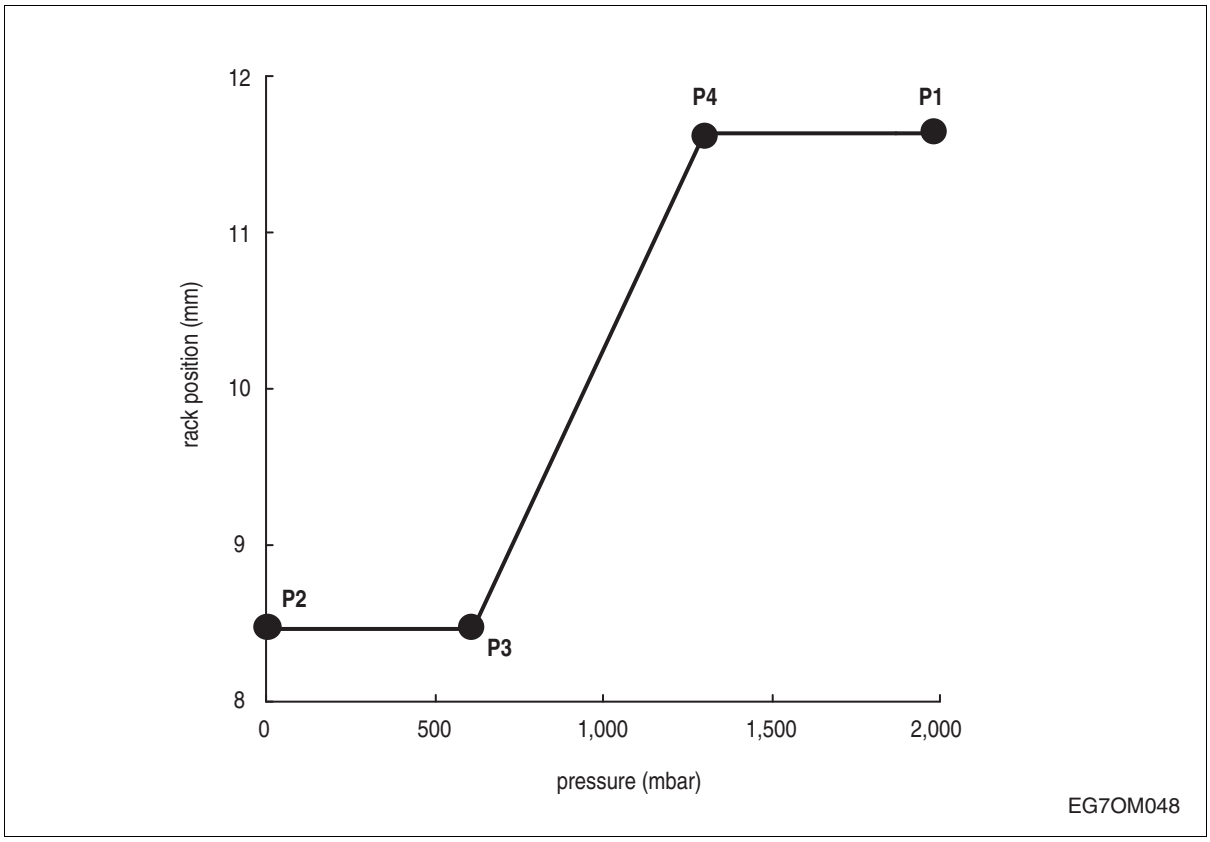
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 / 1,000 st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Boost pressure	P1	11.64	500			1500
	P2	8.46				0
	P3	8.46				460
	P4	11.64				975

Weight	Weight = 630kg	Lever ratio(min/max)	Not fixed
Idle spring	K=14.03 N/mm	Plunger	∅12
Middle spring	K=57.14 N/mm	Delivery valve retraction volume	90mm^3/st
Inner spring	K=21.98 N/mm	Delivery valve opening pressure	-
LDA spring	K=30.5 N/mm	Delivery valve spring	K=7.2 N/mm
Feed pump	Double action	Timer	None

(6) Rack diagram



(7) Boost compensator pressure



5.4.2. Injection pump calibration of 4V158TIM engine

(1) Injection pump ass'y : 65.11101-7425 (0 402 648 721 BOSCH)
- Injection pump : PE8P120A520/4LS7973 (0 412 628 958)
- Governor : RQV250…900PA1434 (0 421 814 223)
- Plunger & barrel : 2 418 455 545
- Delivery valve : 2 418 559 045
- Feed pump : FP/KD22P78-2 (0 440 008 152)
- Prestroke : 4.08 ±0.05mm at 12.49 ±1.5mm

(2) Nozzle holder assembly : 65.10101-7097 (0 432 191 241)
(3) Nozzle : 65.10102-6067 (0 433 171 969)
(4) Injection pipe : 65.10301-6185, 65.10301-6186
(5) Injection order : 1 - 5 - 7 - 2 - 6 - 3 - 4 – 8

(A) Test condition for injection pump	Nozzle & Holder Ass'y	1 688 901 105	Opening pressure : 208.5 ±1.5 bar
	Injection pipe(ID x OD - L)	-	∅3.0 x ∅8.0 – 600 mm
	Test oil	ISO4113	Temperature : 40 ±5°C
(B) Engine standard parts	Nozzle & holder Ass'y	65.10101-7097	286 kg/cm^2
	Nozzle	65.10102-6067	Nozzle (8 x ∅0.284)
	Injection pipe(ID x OD - L)	65.10301-6185 65.10301-6186	∅2 x ∅6.35 - 700mm

Rack diagram and setting valve at each point

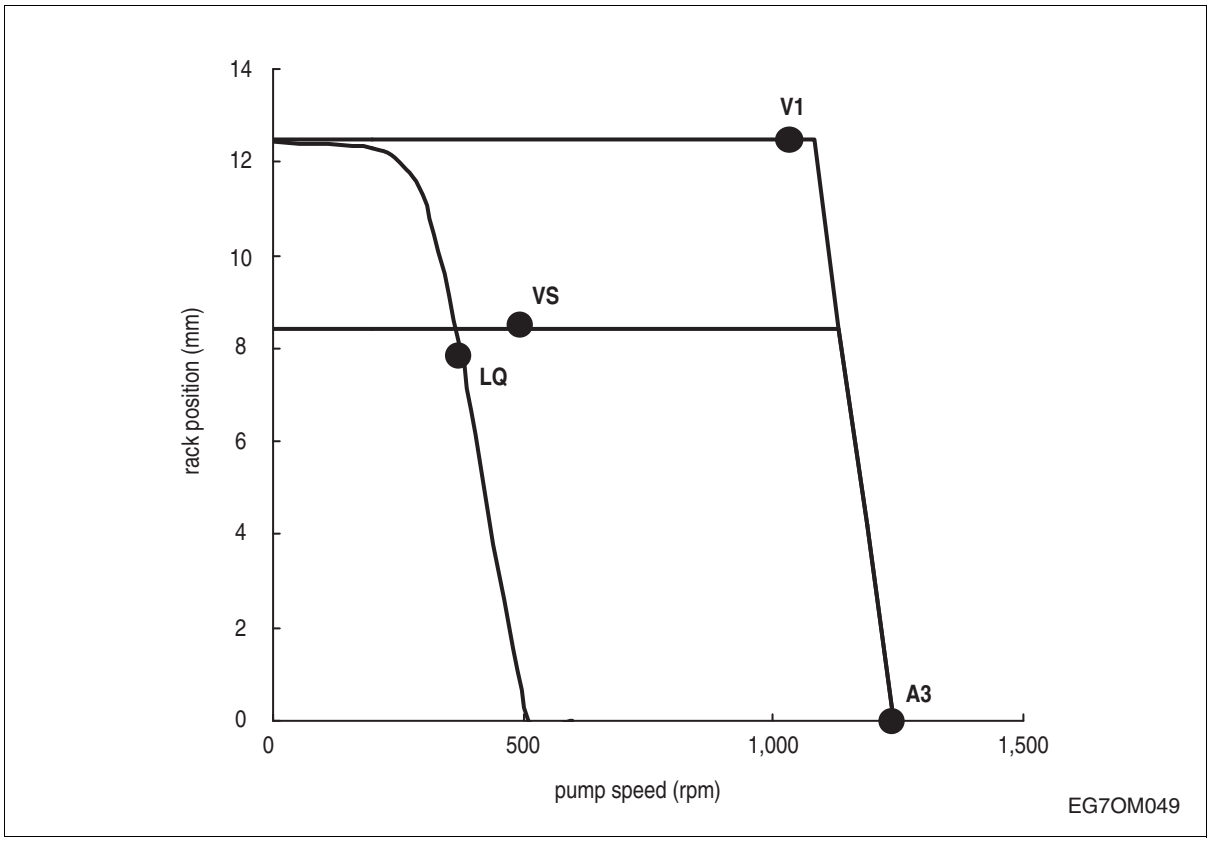
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 / 1,000 st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Rack diagram	V1	12.49	1050	309.5 ±3	-	1500
	VS	8.43	500	191.0 ±3	-	-
	A3	0.00	1240	-	-	-
	LQ	7.98	375	168.5 ±3	-	-
		W/CAP	100	328.3	-	-

Boost compensator spring operation point

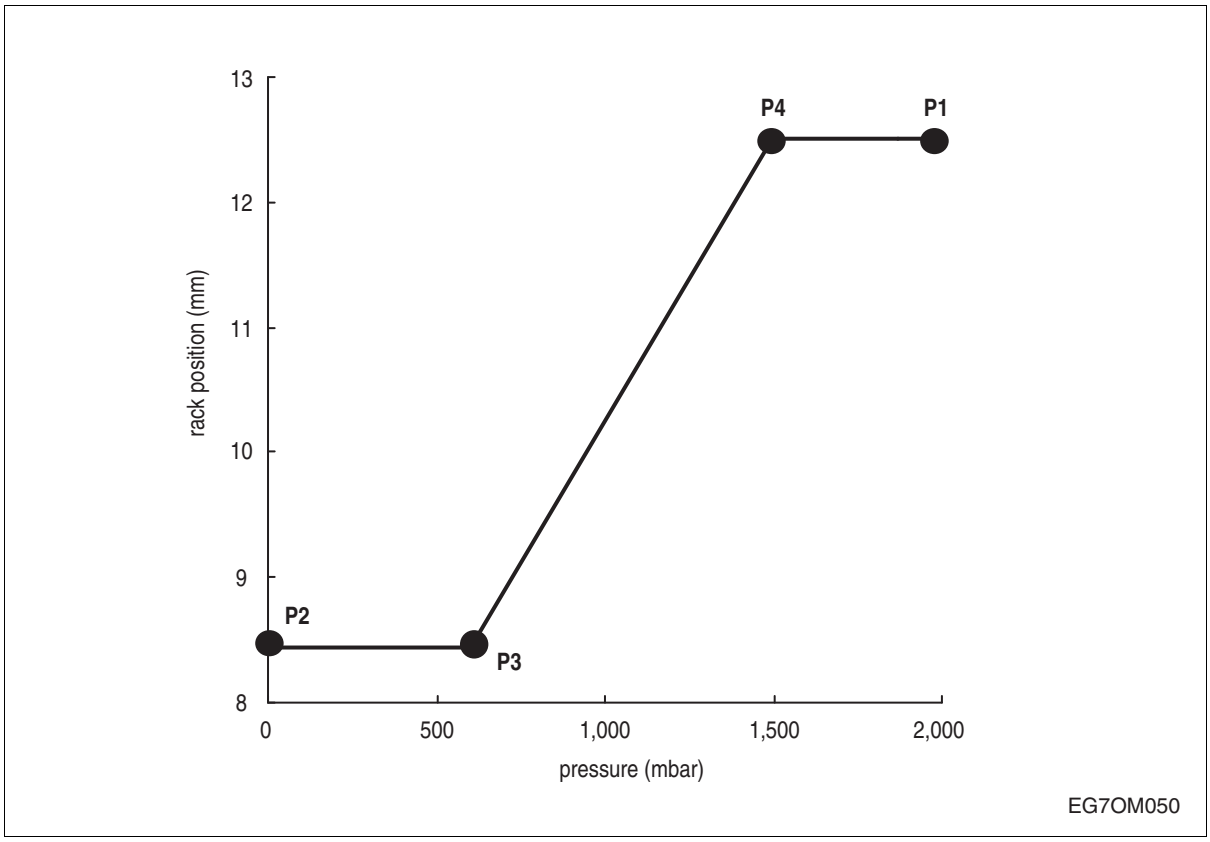
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 / 1,000 st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Boost pressure	P1	12.5	500			1500
	P2	8.44				0
	P3	8.44				460
	P4	12.5				975

Weight	Weight = 630kg	Lever ratio(min/max)	Not fixed
Idle spring	K=14.03 N/mm	Plunger	∅12
Middle spring	K=57.14 N/mm	Delivery valve retraction volume	90mm^3/st
Inner spring	K=21.98 N/mm	Delivery valve opening pressure	-
LDA spring	K=30.5 N/mm	Delivery valve spring	K=7.2 N/mm
Feed pump	Double action	Timer	None

(6) Rack diagram



(7) Boost compensator pressure



5.4.3. Injection pump calibration of 4V158TIL engine

(1) Injection pump ass'y : 65.11101-7425 (0 402 648 721 BOSCH)
- Injection pump : PE8P120A520/4LS7973 (0 412 628 958)
- Governor : RQV250…900PA1434 (0 421 814 223)
- Plunger & barrel : 2 418 455 545
- Delivery valve : 2 418 559 045
- Feed pump : FP/KD22P78-2 (0 440 008 152)
- Prestroke : 4.08 ±0.05mm at 15.67 ±1.5mm

(2) Nozzle holder assembly : 65.10101-7097 (0 432 191 241)
(3) Nozzle : 65.10102-6067 (0 433 171 969)
(4) Injection pipe : 65.10301-6185, 65.10301-6186
(5) Injection order : 1 - 5 - 7 - 2 - 6 - 3 - 4 – 8

(A) Test condition for injection pump	Nozzle & Holder Ass'y	1 688 901 105	Opening pressure : 208.5 ±1.5 bar
	Injection pipe(ID x OD - L)	-	∅3.0 x ∅8.0 – 600 mm
	Test oil	ISO4113	Temperature : 40 ±5°C
(B) Engine standard parts	Nozzle & holder Ass'y	65.10101-7097	286 kg/cm^2
	Nozzle	65.10102-6067	Nozzle (8 x ∅0.284)
	Injection pipe(ID x OD - L)	65.10301-6185 65.10301-6186	∅2 x ∅6.35 - 700mm

Rack diagram and setting valve at each point

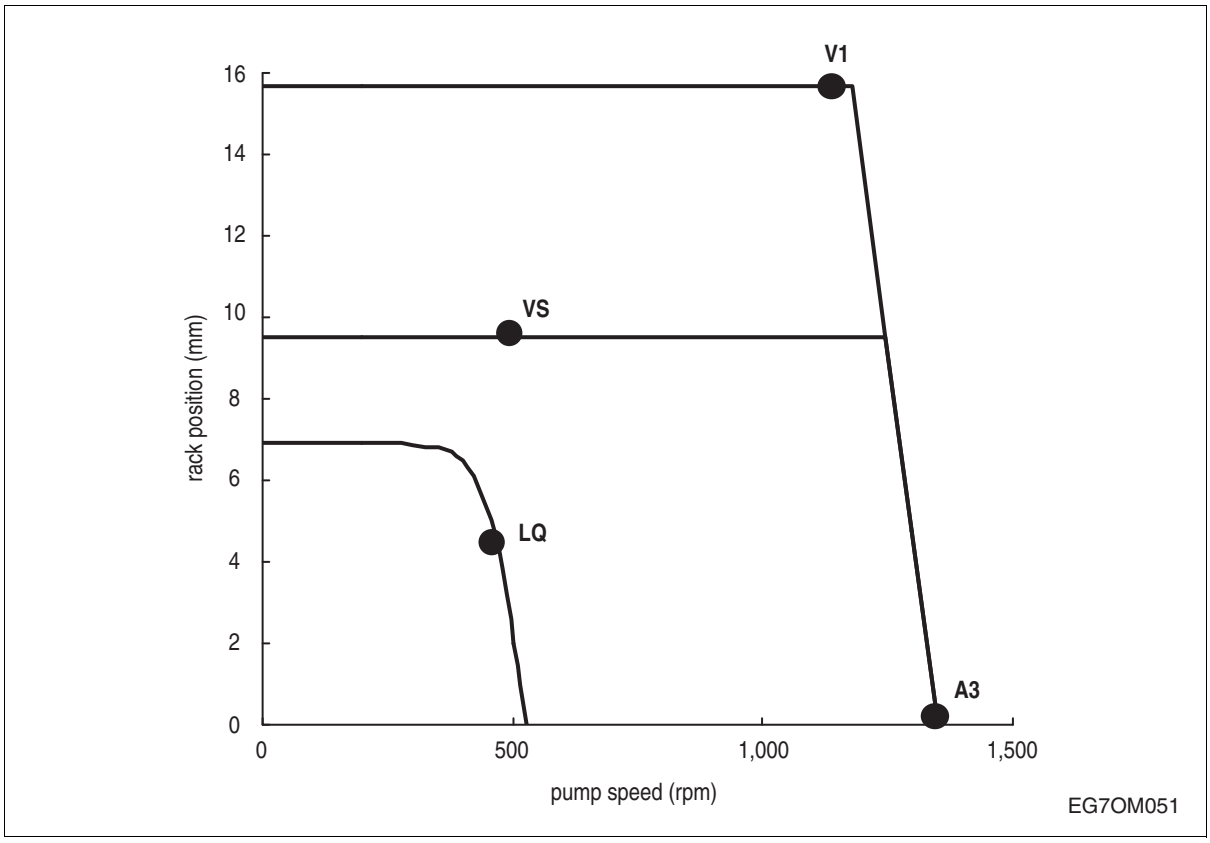
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 / 1,000 st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Rack diagram	V1	15.67	1150	419.0 ±3	-	1500
	VS	9.43	500	237.0 ±3	-	-
	A3	0.00	1350	-	-	-
	LQ	4.42	470	50.8 ±3	-	-
		W/CAP	100	35.1	-	-

Boost compensator spring operation point

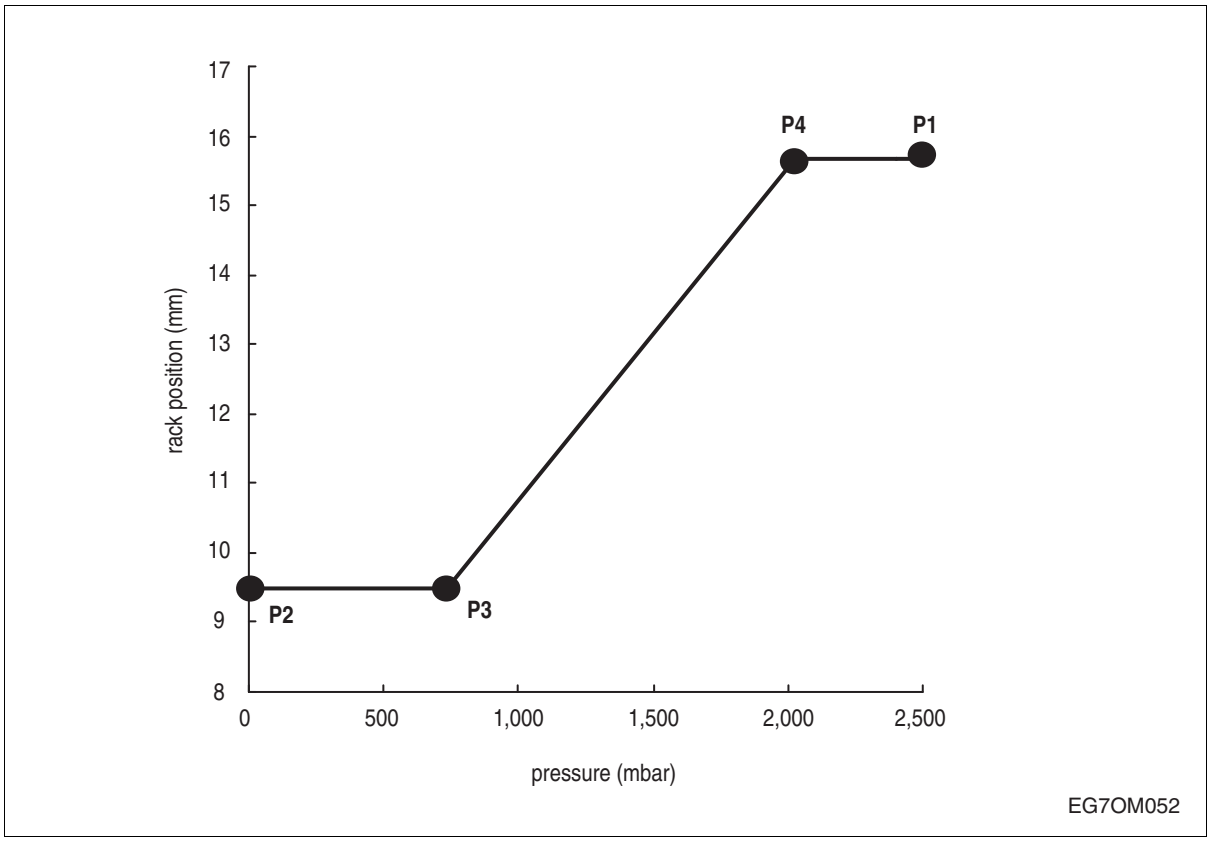
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 / 1,000 st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Boost pressure	P1	15.67	500			1875
	P2	9.49				-
	P3	9.49				-
	P4	15.67				-

Weight	Weight = 630kg	Lever ratio(min/max)	Not fixed
Idle spring	K=14.03 N/mm	Plunger	∅12
Middle spring	K=57.14 N/mm	Delivery valve retraction volume	90mm^3/st
Inner spring	K=21.98 N/mm	Delivery valve opening pressure	-
LDA spring	K=30.5 N/mm	Delivery valve spring	K=7.2 N/mm
Feed pump	Double action	Timer	None

(6) Rack diagram



(7) Boost compensator pressure



5.4.4. Injection pump calibration of 4V222TIH engine

(1) Injection pump ass'y : 65.11101-7426 (0 402 640 852 BOSCH)
- Injection pump : PE12P120A520LS7972 (0 412 620 869)
- Governor : RQV250…900PA1434 (0 421 814 223)
- Plunger & barrel : 2 418 455 545
- Delivery valve : 2 418 559 045
- Feed pump : FP/KD22P78-1 (0 440 008 090)
  FP/KD22P78-2 (0 440 008 152)
- Prestroke : 4.08 ±0.05mm at 11.25±1.5mm

(2) Nozzle holder assembly : 65.10101-7097 (0 432 191 241)

(3) Nozzle : 65.10102-6067 (0 433 171 969)

(4) Injection pipe : 65.10301-6187A, 65.10301-6188A
65.10301-6189A, 65.10301-6190A

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

(A) Test condition for injection pump	Nozzle & Holder Ass'y	1 688 901 105	Opening pressure : 208.5 ±1.5 bar
	Injection pipe(ID x OD - L)	-	∅3.0 x ∅8.0 – 600 mm
	Test oil	ISO4113	Temperature : 40 ±5°C
(B) Engine standard parts	Nozzle & holder Ass'y	65.10101-7097	286 kg/cm^2
	Nozzle	65.10102-6067	Nozzle (8 x ∅0.284)
	Injection pipe(ID x OD - L)	65.10301-6187A 65.10301-6188A 65.10301-6189A 65.10301-6190A	∅2 x ∅6.35 – 775mm

Rack diagram and setting valve at each point

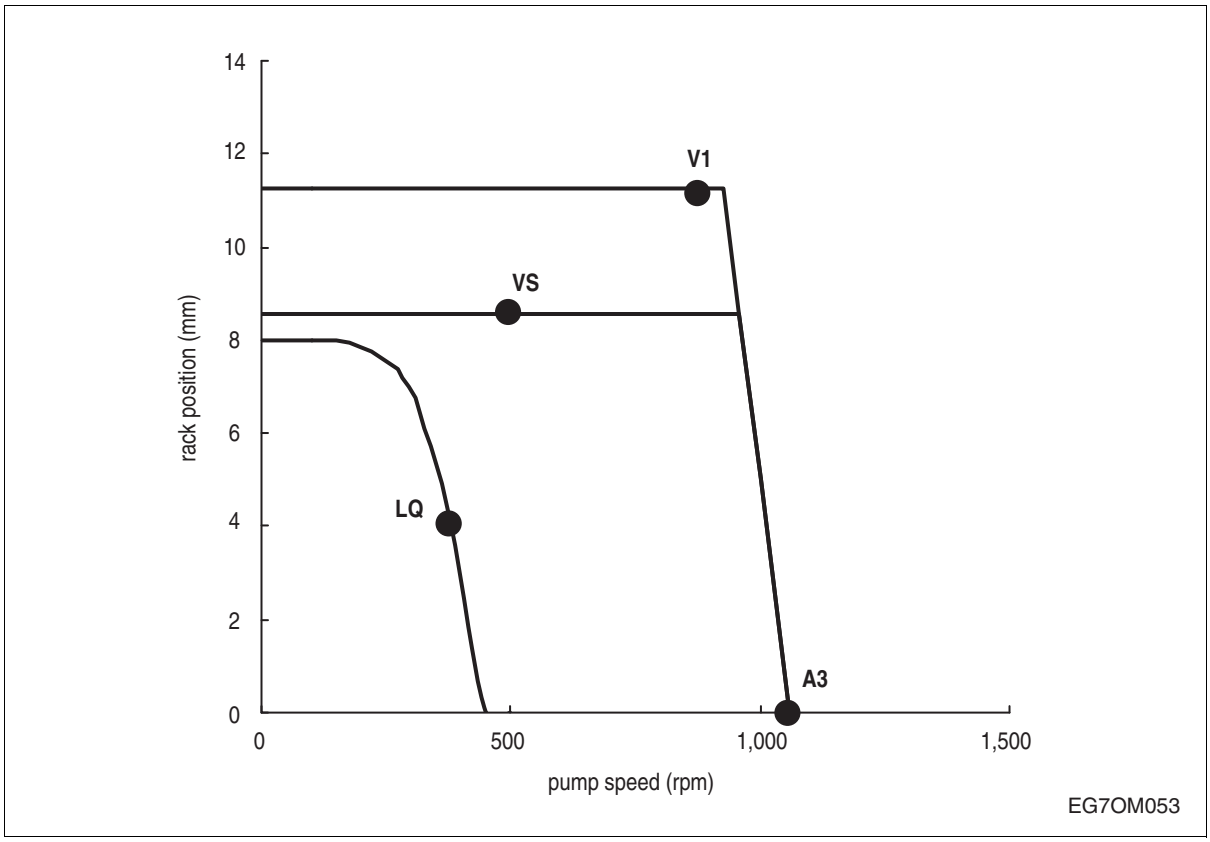
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 / 1,000 st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Rack diagram	V1	11.25	900	281.8 ±3	-	1500
	VS	8.55	500	192.7 ±3	-	-
	A3	0.00	1050	-	-	-
	LQ	4.06	380	29.1 ±3	-	-
		W/CAP	100	101.2	-	-

Boost compensator spring operation point

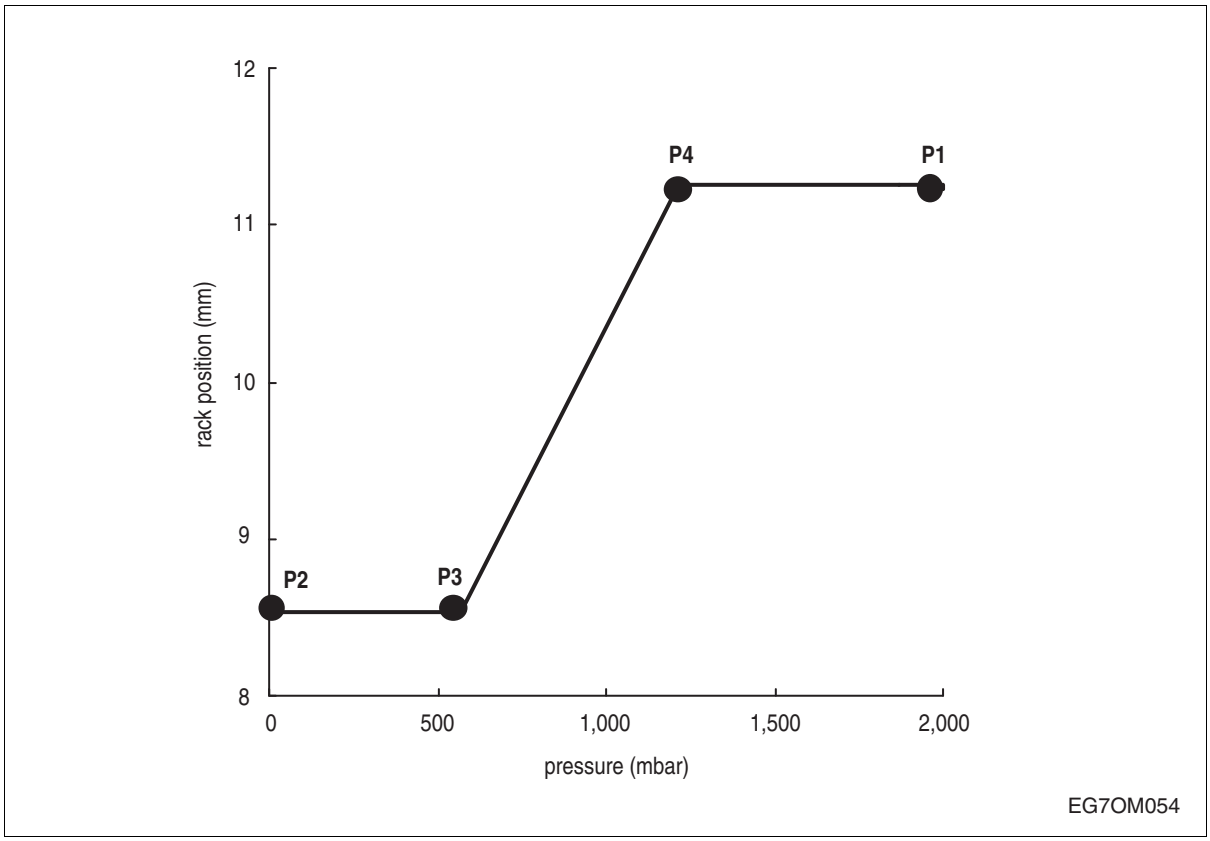
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 / 1,000 st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Boost pressure	P1	11.25	500			1500
	P2	8.54				0
	P3	8.54				425
	P4	11.25				910

Weight	Weight = 630kg	Lever ratio(min/max)	Not fixed
Idle spring	K=14.03 N/mm	Plunger	∅12
Middle spring	K=57.14 N/mm	Delivery valve retraction volume	90mm^3/st
Inner spring	K=21.98 N/mm	Delivery valve opening pressure	-
LDA spring	K=30.5 N/mm	Delivery valve spring	K=7.2 N/mm
Feed pump	Double action	Timer	None

(6) Rack diagram



(7) Boost compensator pressure



5.4.5. Injection pump calibration of 4V222TIM engine

(1) Injection pump ass'y : 65.11101-7426 (0 402 640 852 BOSCH)
- Injection pump : PE12P120A520LS7972 (0 412 620 869)
- Governor : RQV250…900PA1434 (0 421 814 223)
- Plunger & barrel : 2 418 455 545
- Delivery valve : 2 418 559 045
- Feed pump : FP/KD22P78-1 (0 440 008 090)
  FP/KD22P78-2 (0 440 008 152)
- Prestroke : 4.08 ±0.05mm at 11.97±1.5mm

(2) Nozzle holder assembly : 65.10101-7097 (0 432 191 241)

(3) Nozzle : 65.10102-6067 (0 433 171 969)

(4) Injection pipe : 65.10301-6187A, 65.10301-6188A
65.10301-6189A, 65.10301-6190A

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

(A) Test condition for injection pump	Nozzle & Holder Ass'y	1 688 901 105	Opening pressure : 208.5 ±1.5 bar
	Injection pipe(ID x OD - L)	-	∅3.0 x ∅8.0 – 600 mm
	Test oil	ISO4113	Temperature : 40 ±5°C
(B) Engine standard parts	Nozzle & holder Ass'y	65.10101-7097	286 kg/cm²
	Nozzle	65.10102-6067	Nozzle (8 x ∅0.284)
	Injection pipe(ID x OD - L)	65.10301-6187A 65.10301-6188A 65.10301-6189A 65.10301-6190A	∅2 x ∅6.35 – 775mm

Rack diagram and setting valve at each point

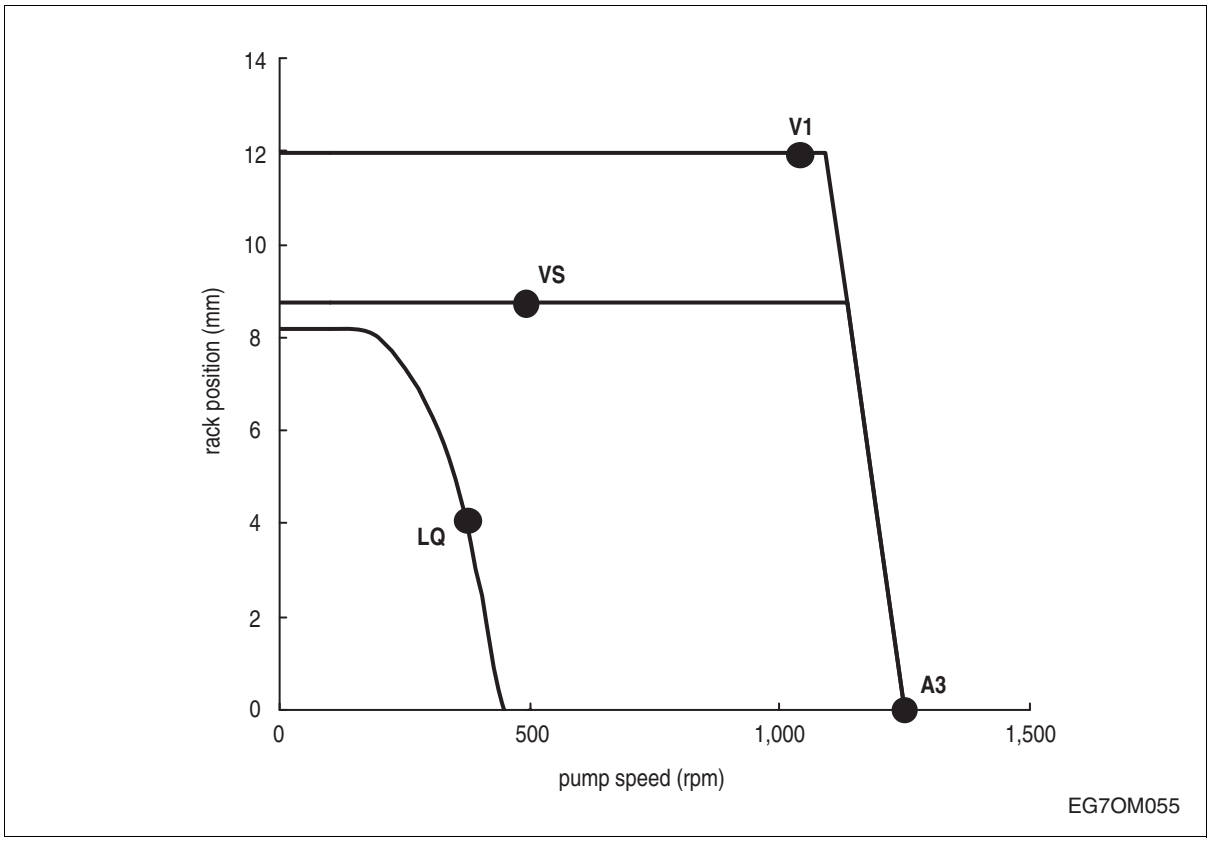
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm³ / 1,000 st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Rack diagram	V1	11.97	1050	290.7 ±3	-	1500
	VS	8.75	500	201.3 ±3	-	-
	A3	0.00	1250	-	-	-
	LQ	4.00	375	11.0 ±3	-	-
		W/CAP	100	102.2	-	-

Boost compensator spring operation point

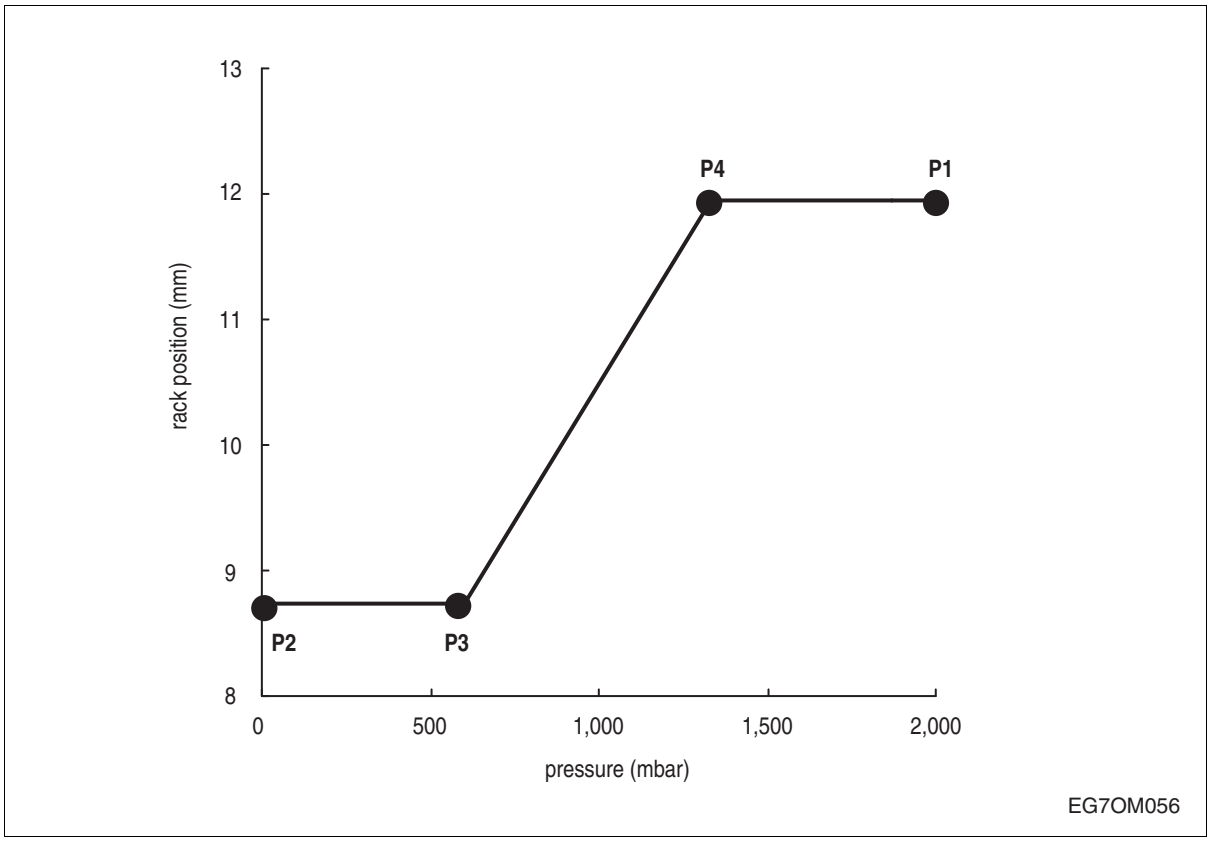
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm³ / 1,000 st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Boost pressure	P1	11.94	500			1500
	P2	8.74				0
	P3	8.74				450
	P4	11.94				1000

Weight	Weight = 630kg	Lever ratio(min/max)	Not fixed
Idle spring	K=14.03 N/mm	Plunger	∅12
Middle spring	K=57.14 N/mm	Delivery valve retraction volume	90mm³/st
Inner spring	K=21.98 N/mm	Delivery valve opening pressure	-
LDA spring	K=30.5 N/mm	Delivery valve spring	K=7.2 N/mm
Feed pump	Double action	Timer	None

(6) Rack diagram



(7) Boost compensator pressure



5.4.6. Injection pump calibration of 4V222TIL engine

(1) Injection pump ass'y : 65.11101-7426 (0 402 640 852 BOSCH)
- Injection pump : PE12P120A520LS7972 (0 412 620 869)
- Governor : RQV250…900PA1434 (0 421 814 223)
- Plunger & barrel : 2 418 455 545
- Delivery valve : 2 418 559 045
- Feed pump : FP/KD22P78-1 (0 440 008 090)
  FP/KD22P78-2 (0 440 008 152)
- Prestroke : 4.08 ±0.05mm at 12.97±1.5mm

(2) Nozzle holder assembly : 65.10101-7097 (0 432 191 241)

(3) Nozzle : 65.10102-6067 (0 433 171 969)

(4) Injection pipe : 65.10301-6187A, 65.10301-6188A
65.10301-6189A, 65.10301-6190A

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

(A) Test condition for injection pump	Nozzle & Holder Ass'y	1 688 901 105	Opening pressure : 208.5 ±1.5 bar
	Injection pipe(ID x OD - L)	-	⌀3.0 x ⌀8.0 – 600 mm
	Test oil	ISO4113	Temperature : 40 ±5°C
(B) Engine standard parts	Nozzle & holder Ass'y	65.10101-7097	286 kg/cm²
	Nozzle	65.10102-6067	Nozzle (8 x ⌀0.284)
	Injection pipe(ID x OD - L)	65.10301-6187A 65.10301-6188A 65.10301-6189A 65.10301-6190A	⌀2 x ⌀6.35 – 775mm

Rack diagram and setting valve at each point

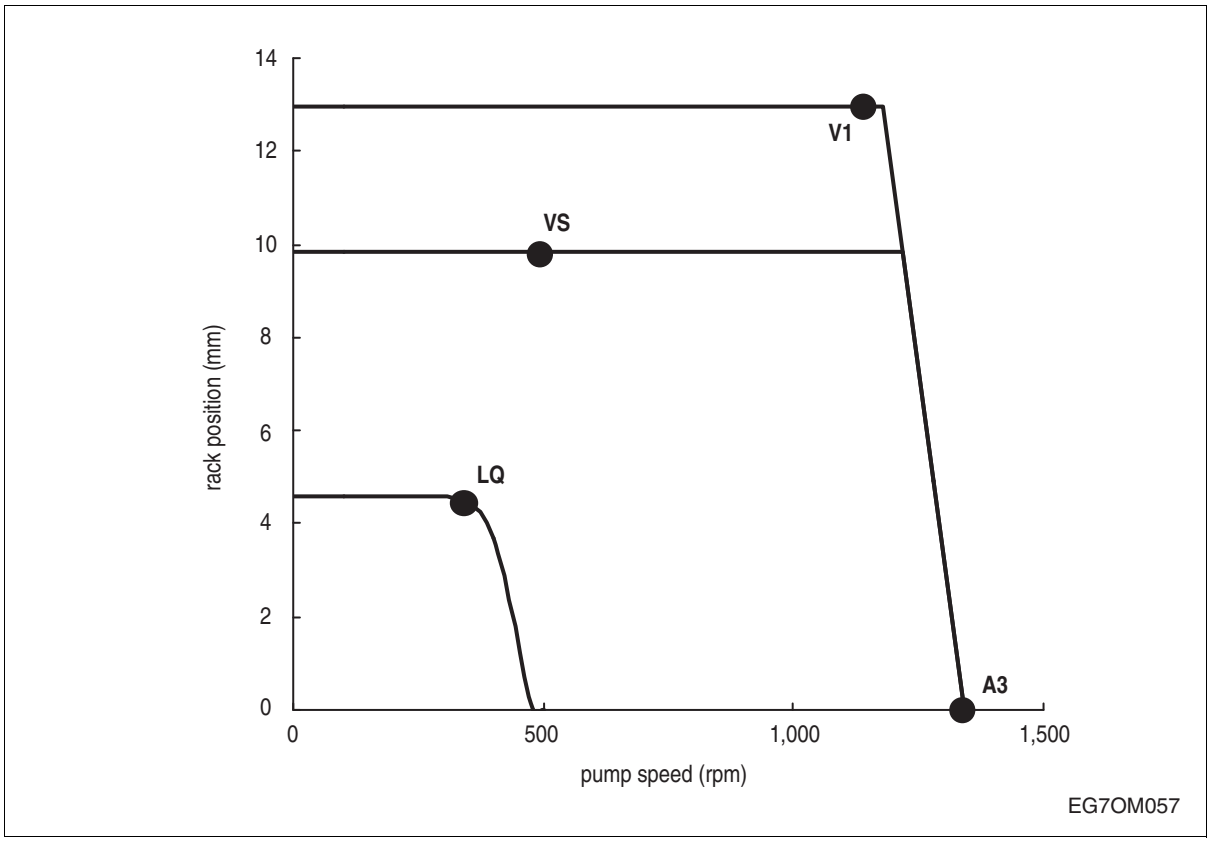
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm³ / 1,000 st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Rack diagram	V1	12.97	1150	322.3 ±3	-	1500
	VS	9.83	500	247.8 ±3	-	-
	A3	0.00	1340	-	-	-
	LQ	4.50	340	29.7 ±3	-	-
	-	W/CAP	100	0.4	-	-

Boost compensator spring operation point

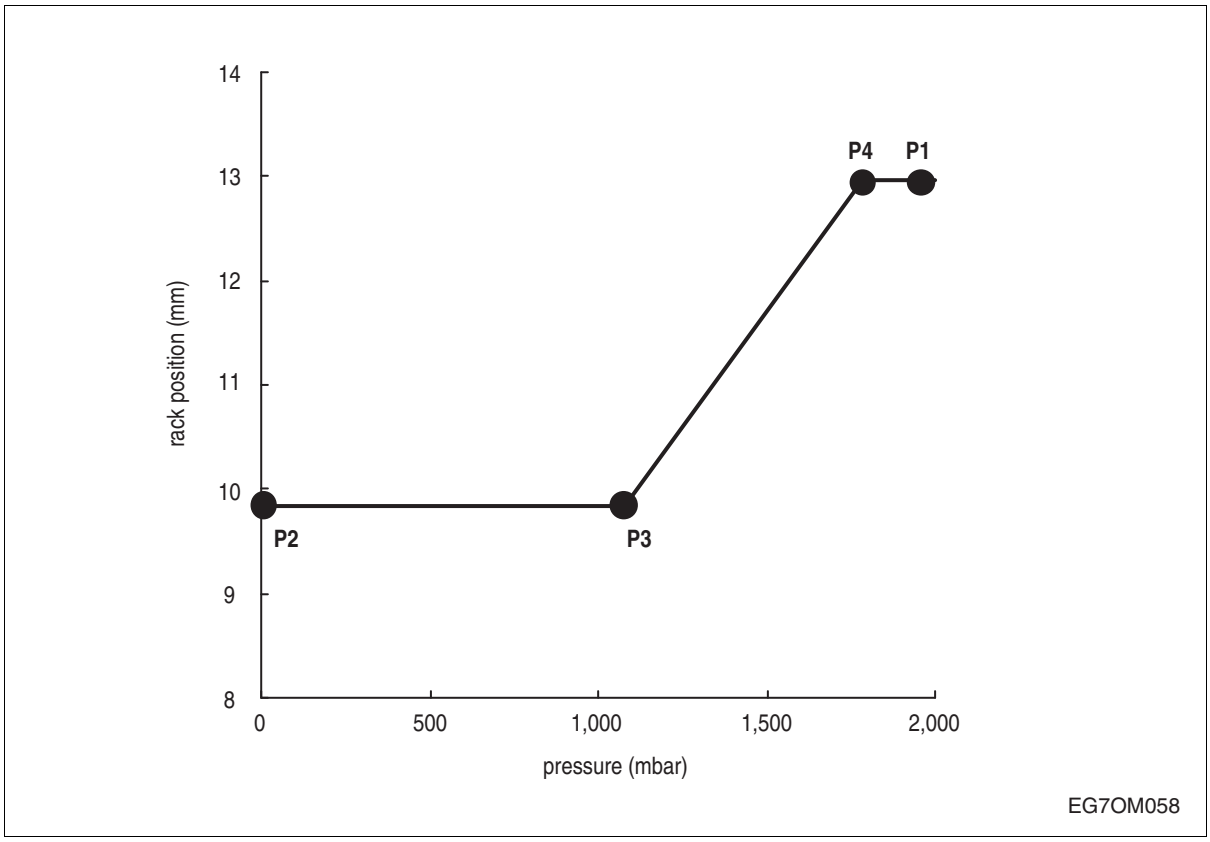
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm³ / 1,000 st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Boost pressure	P1	12.97	500			1500
	P2	9.83				0
	P3	9.83				810
	P4	12.97				1340

Weight	Weight = 630kg	Lever ratio(min/max)	Not fixed
Idle spring	K=14.03 N/mm	Plunger	⌀12
Middle spring	K=57.14 N/mm	Delivery valve retraction volume	90mm³/st
Inner spring	K=21.98 N/mm	Delivery valve opening pressure	-
LDA spring	K=30.5 N/mm	Delivery valve spring	K=7.2 N/mm
Feed pump	Double action	Timer	None

(6) Rack diagram



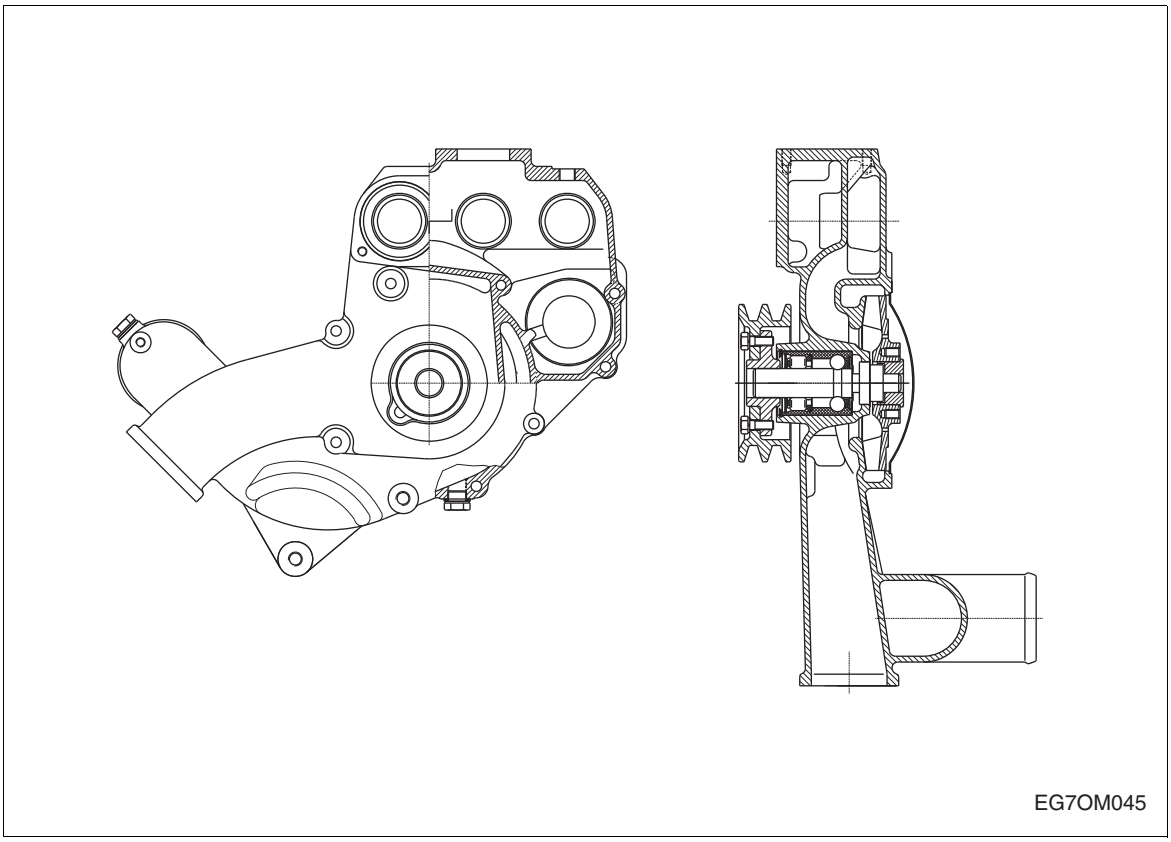
(7) Boost compensator pressure



5.5. Cooling System

5.5.1. Water pump

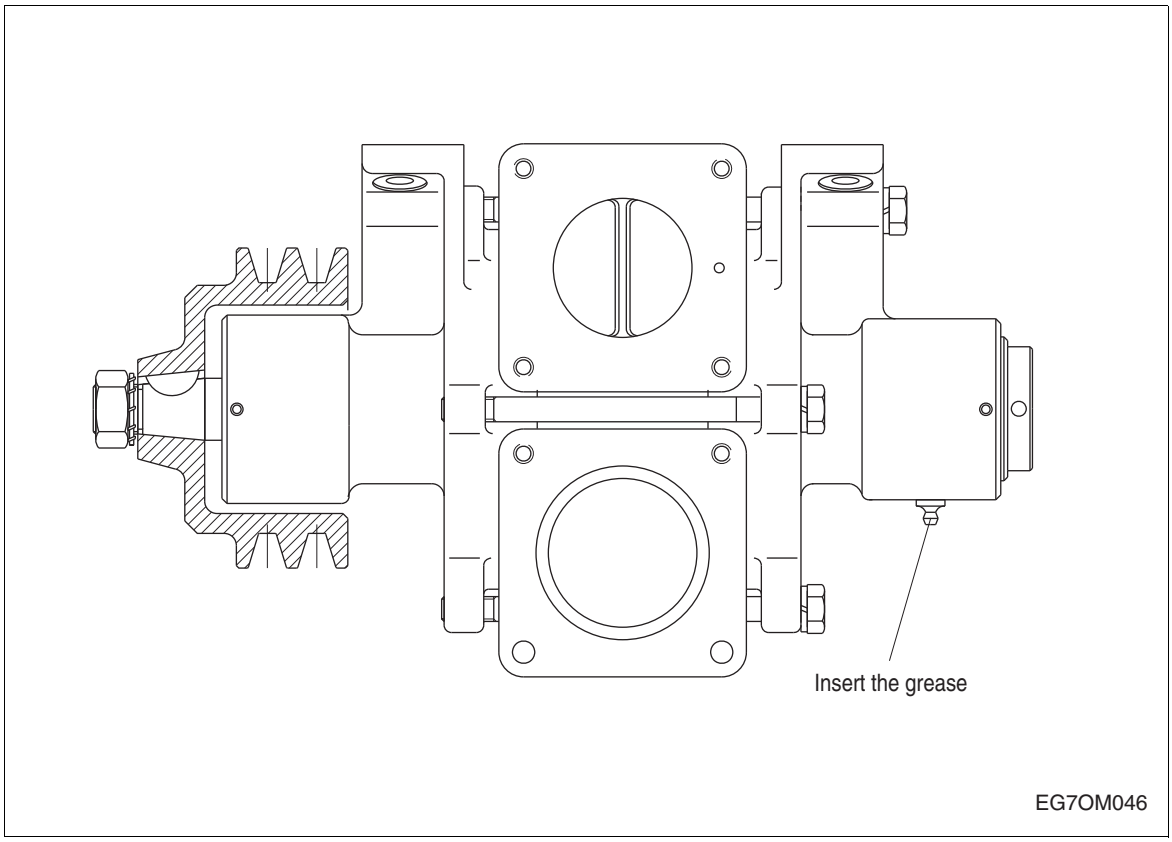
1) Fresh water pump



- **Specification of fresh water pump**

Item	Specification
1. Water pump	
Type	Centrifugal type
Delivery	About 700 liter/min
Pumping speed	3,500 rpm
2. Thermostat	
Operating temperature	79 ~ 94°C

2) Sea water pump



- **Specification of sea water pump**

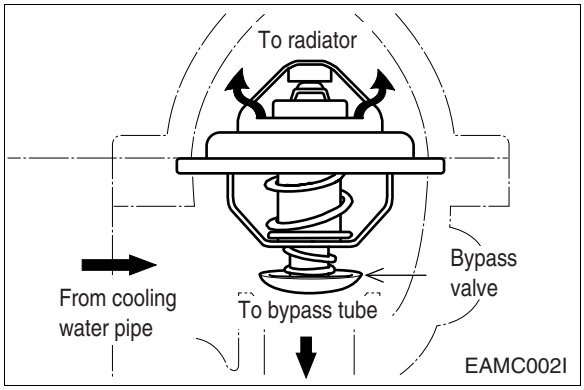
Item	Specification
1. Water pump	
Type	Centrifugal type
Delivery	About 370 liter/min
Pumping speed	2,500 rpm
Hose power	15

5.5.2. Thermostat

- **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.

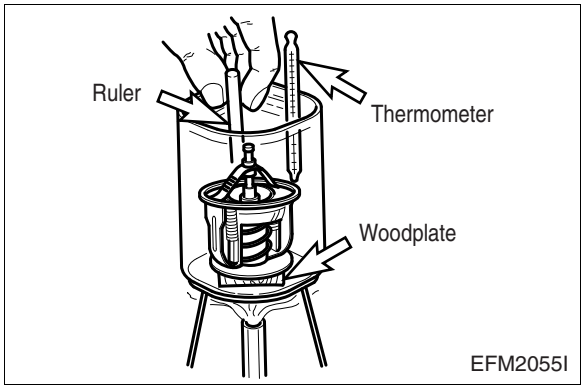


Item	Specifications
	In moderate climates
Type	Wax-pallet type
Open at	79 °C
Open wide at	94 °C
Valve lift	8 mm or more

- **Inspecting**

(1) Check the wax pallet and spring for damage.

(2) 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 83 °C and 8 mm or more (opening wide) at temperature of 95 °C, the thermostat is normal.



- **Replacing thermostat and precautions for handling**

(1) 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 engine starting.

(2) When draining out or replenishing coolant, do it slowly so that air is bled sufficiently from the entire cooling system.

(3) Replacing thermostat

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

5.5.3. Cleaning of the fresh water system circuit

When the cooling system circuits are fouled with water scales or sludge particles, the cooling efficiency will be lowered. When the cooling system circuits are clogged, the water pump mechanical seal is damaged.

The poor condition of the cooling system is normally due to use of unsuitable or no anti-freezing agents and corrosion inhibitor or defect.

If twice in a short time (within 6 months) the water pump of an engine develops leases or the coolant is heavily contaminated (dull, brown, mechanically contaminated, gray or black sings of a leakage on the water pump casing) clean the cooling system prior to removing that water pump as follows.

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

CAUTION:
Periodically clean the circuit interior with a cleaner.

5.5.4. Diagnostics and troubleshooting

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

5.6. Lubricating System

5.6.1. General descriptions and main data

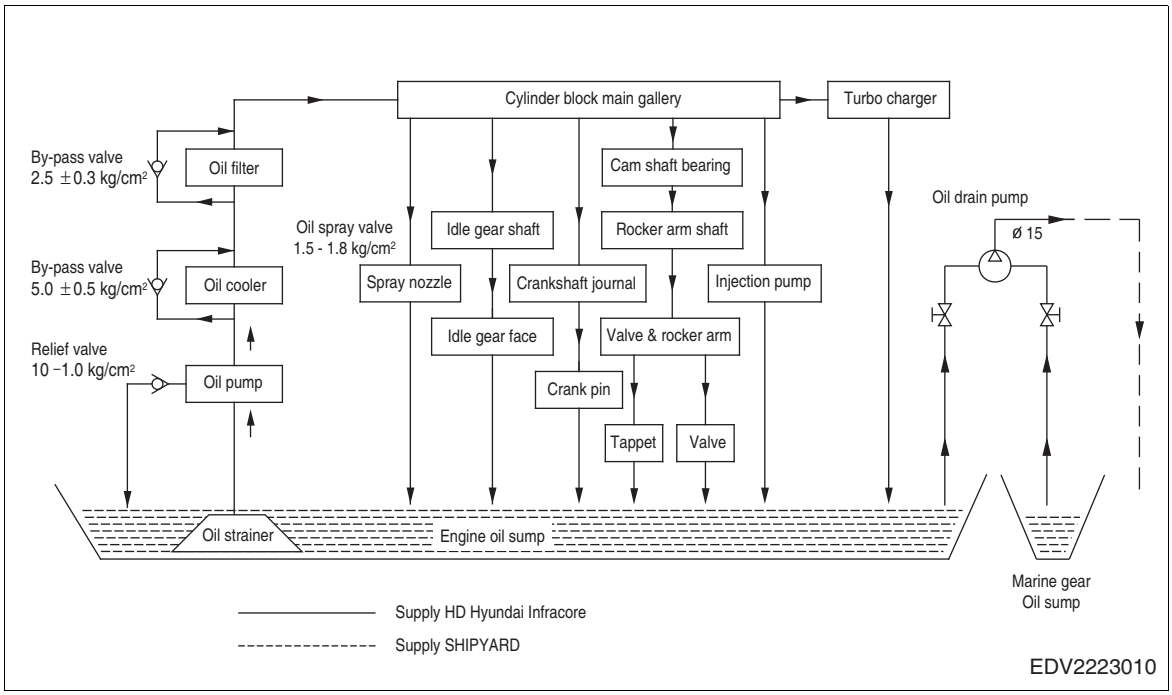
- **General descriptions**

  All the engine oil pumped up from the oil pan by the gear type oil pump is filtrated through the oil cooler and oil filter, and this filtrated oil is forced through the main oil gallery in the cylinder block from where it is distributed to lubricate the various sliding parts, and fuel injection pump in order to ensure normal engine performance.

- **Specifications**

Item	Specifications	Item	Specifications
Lubricating system	Forced pressure circulation	Oil filter type	Full flow
		Bypass for filter element	
Oil pump type	Gear type	Valve opening pressure	2.5 ±0.3 kg/cm^2
Relief valve opening pressure	10 -10 kg/cm^2	Bypass for oil cooler	
Adjusting valve for spray nozzle		Valve opening pressure	5.0 ±0.5 kg/cm^2
Opening pressure	1.5 ~ 1.8 kg/cm^2		

- **Diagram of lubricating system**



5.6.2. Diagnostics and troubleshooting

Complaints	Possible causes	Corrections
1. Oil consumption excessive	● Poor oil ● Oil seal or packing leaky ● Pistons or piston rings worn ● Cylinder liner worn ● Piston rings sticking ● Valve guide oil seals or valve guides, or valve stem worn	● Use suggested oil ● Replace ● Replace pistons and/or piston rings ● Replace cylinder liner ● Replace pistons and/or piston rings ● Replace
2. Oil pressure too low	● Poor oil ● Relief valve sticking ● Restrictions in oil pump strainer ● Oil pump gear worn ● Oil pump feed pipe cracked ● Oil pump defective ● Oil pressure gauge defective ● Various bearings worn	● Use suggested oil ● Replace ● Clean strainer ● Replace ● Replace ● Correct or replace ● Correct or replace ● Replace
3. Oil deteriorates quickly	● Restriction in oil filter ● Gases leaking	● Replace filter element ● Replace piston rings and cylinder liner

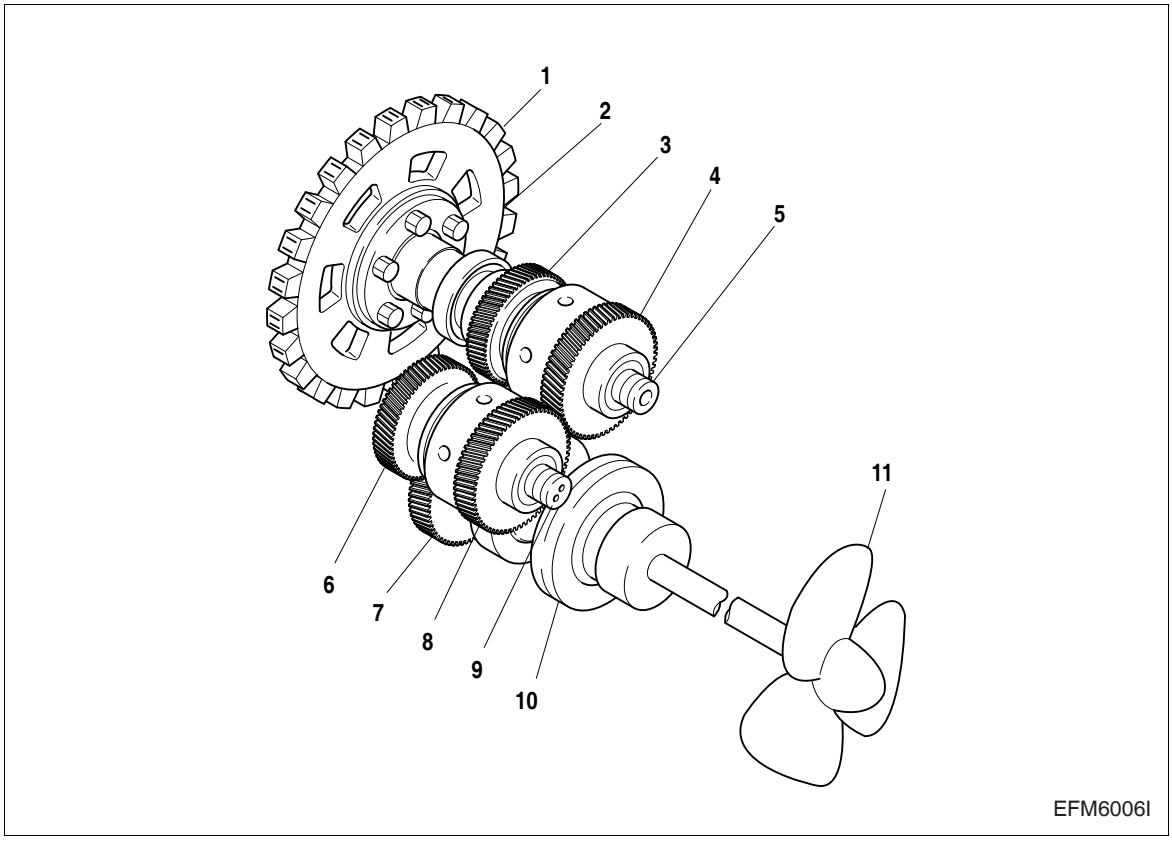
5.7. Marine Gear System

5.7.1. Marine gear

- Refer to “reduction gear manual” provided with engine separately for detail operation and maintenance of reduction & maintenance.

5.7.2. Construction and operation

- The reduction gear is used for high-speed engine and consists of 4 major components such as input shaft, gear shaft, output shaft, and housing.
- The clutch for forward and reverse movements is composed of a hydraulic wet-type and multi-plate type, and the construction and power line is as follows;



<Power line>

Neutral : 1-2-5-4-8

Forward : 1-2-5-3-7-10

Reverse : 1-2-5-4-8-9-6-7-10

1. Rubber block
2. Spider
3. Forward pinion
4. Reverse drive gear
5. Input shaft
6. Reverse pinion
7. Output shaft
8. Reverse drive gear
9. Gear shaft
10. Propeller shaft

5.7.3. Characteristics

- The hydraulic-type clutch is composed of forward main body, reverse main body, output shaft, and selector valve.
- The selector valve assembly installed on the external part is a device designed to control forward, neutral, and reverse movements and also it can be remote-controlled. The oil pumped up at the pump supplies hydraulic pressure for the clutch assembly, lubricating portions on gear and bearings, and cooling system. But when assembling this hydraulic type clutch, use care so that it is aligned with the engine correctly.

5.7.4. Operation

1) Before operation

- Check the tightening bolts and nuts on the components as a whole for looseness.
- Check the oil level with the oil level gauge.
- (Run the engine at idle for a few minutes, then stop it before checking the oil level.)
- Place the control lever in the neutral position before starting the engine.

2) Starting

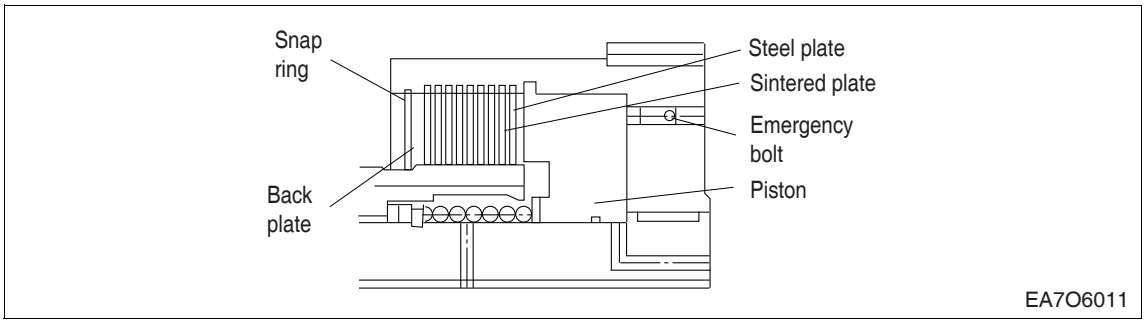
- Run the engine at idle for about 10 minutes.
- Check for oil leaks, unusual sound, temperature, etc. while idling the engine.
- While checking the clutch pressure, increase the engine rpm.

3) Driving and stopping

- Check to see that the specified pressure is obtained when engaging the clutch.
- The pressure may drop slightly at low engine rpm, but it does not affect the operation of the engine.
- When attempting to change gears for forward or reverse movement, first put the engine rpm to idle.
- The temperature of oil at operation must be 60 ~ 90 °C.
- When attempting to stop the engine, be sure to place the control lever in the neutral position.

4) Emergency bolt

- The emergency bolt is designed to couple the clutch mechanically when the clutch indicates abnormal condition or slip at clutch coupling operation. The reverse clutch pack has no emergency bolt. When using the emergency bolt, first loosen the tightening bolts to remove the control block, tighten the 8mm wrench bolt on the forward disc pack using a 6mm L-shaped wrench, then reassemble the control block in the reverse order. Be sure to use this emergency bolt literally in case of emergency.

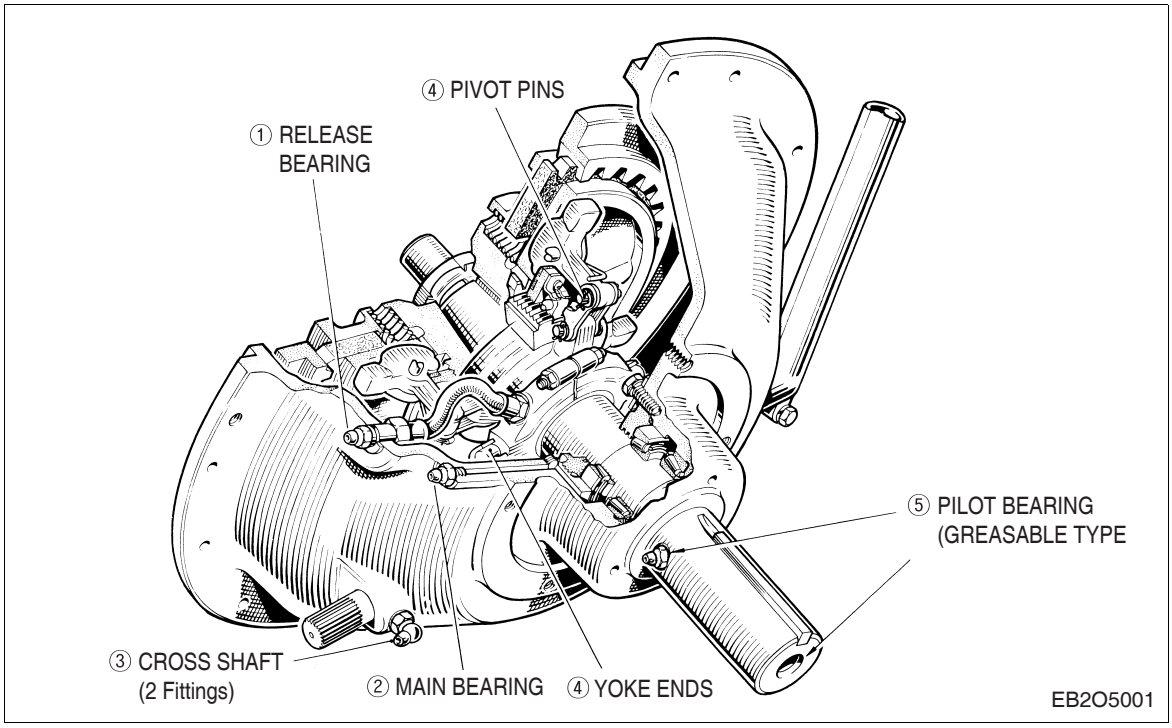


5.8. Front Power Take Off System (FPTO)

5.8.1. PTO for twin clutch type

<PTO engagement procedure>

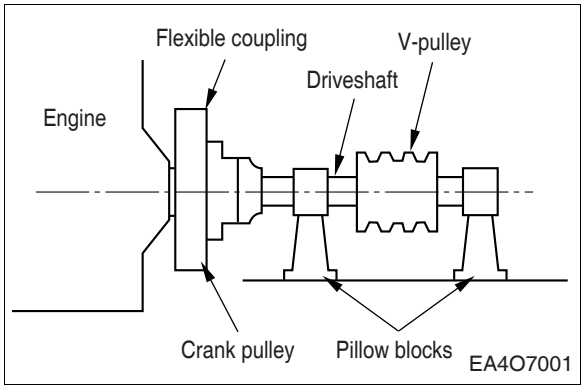
- Start the engine and run until sufficiently “warm up” to maintain normal engine idle speed. With the engine running at, or slightly above, idle speed but not in excess of 1,200 rpm, push handle firmly and quickly, without stalling the engine, until the handle snaps into engaged position.



- Do not slip the PTO excessively during engagement. Engagement of the PTO at engine speeds above 1,200 rpm and/or excessive slipping of the PTO during engagement or operation can cause clutch failure and will void the clutch warranty.

5.8.2. PTO for medium power (twin bridge type)

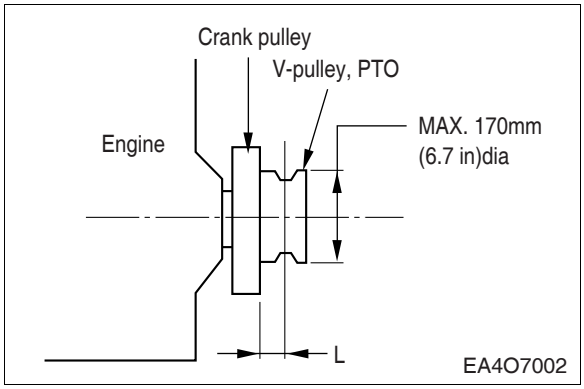
- For front power take-off in line with crankshaft, it is a standard procedure to support driveshaft and V-pulley by two pillow blocks by using flexile coupling for connection to engine.
- When the front PTO is installed, be sure to take deflection reading. Radial run-out should be no more than 0.02 mm.
- Be sure to limit the front PTO output within the maximum allowable horsepower as specified for each model in figure below. (Torque represents when there is no propeller load)



Model	Load (kW)	Engine speed (rpm)
4V V158TIH/M/L 4V V222TIH/M/L	176	1,500
4V AD158TI 4V AD222TI	265	1,500

5.8.3. PTO for small power (cantilever type)

- The right figure is applicable to the drive arrangement in which the distance between the end face of the engine pulley and the centerline through pulley groove is not greater than 60mm. The distance is indicated as **"L"** in right figure.



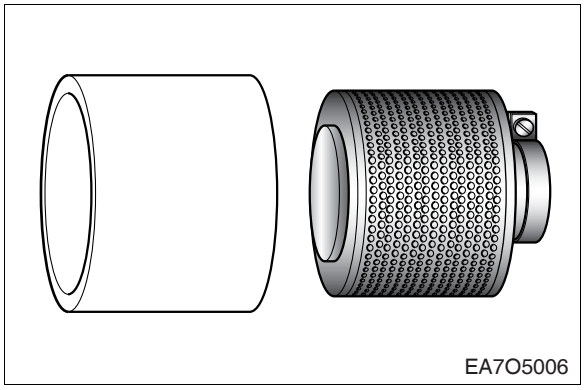
Model	L mm	Allowable load of belt driven side (kW)	Engine speed (rpm)
4V V158TIH/M/L 4V V222TIH/M/L	60	95	1,500
4V AD158TI 4V AD222TI		265	

5.9. Air Cleaner System

- The engine life and performance depends on the intake air condition greatly.
- A fouled air filter element result a decreased intake air amount leading the engine output decrease and finally may cause an engine malfunction.
- Further, a damaged a filter element results wear on the cylinder component or the valve mechanism etc. leading increased engine output, finally leads to shorten the engine life.

5.9.1. Cleaning air cleaner of metal type

- Wash the polluted element in warm water non-sudsy household detergent.
- Rinse the element with clean water.
- Dry it thoroughly with natural air or electric fan.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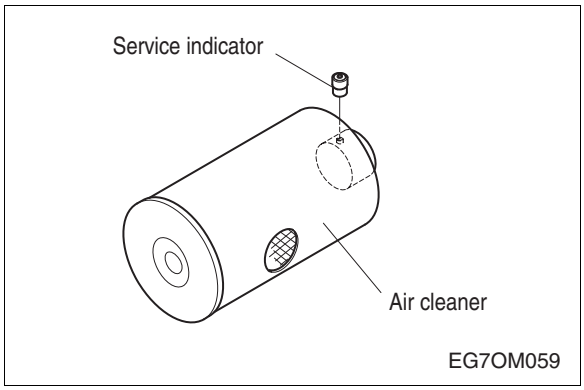
NOTE:
Don't use a flame or compressed air for dry. It makes damages to the element.

Cleaning of the air filter element	Every 100 hours
Exchange of the air filter element	Every 400 hours

- Conform inside of the element clean and dry.
- Replace the new element if tears, rips or damages are found.

5.9.2. Cleaning air cleaner of paper element type

- Remove the wing nut on the air cleaner, take out the dirty cartridge and renew or clean.
- Wipe the cleaner housing with a damp cloth, in particular the sealing surface for the element.



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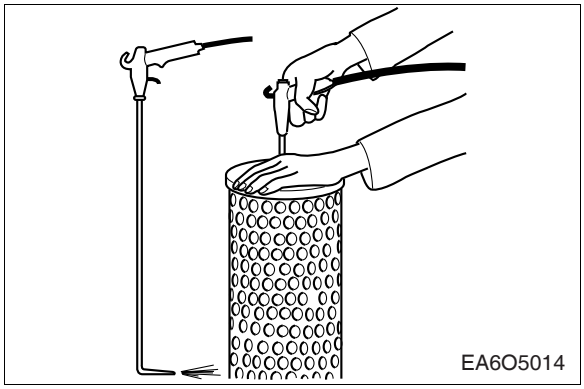
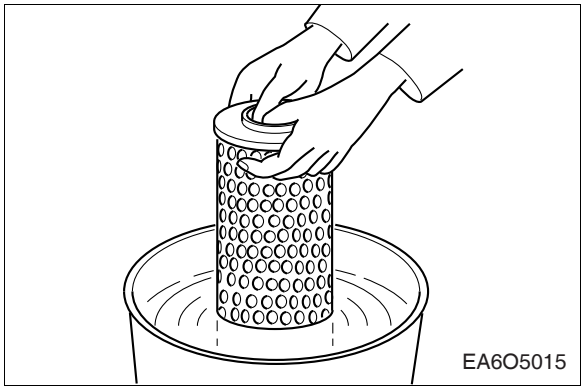
- **By compressed air**

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



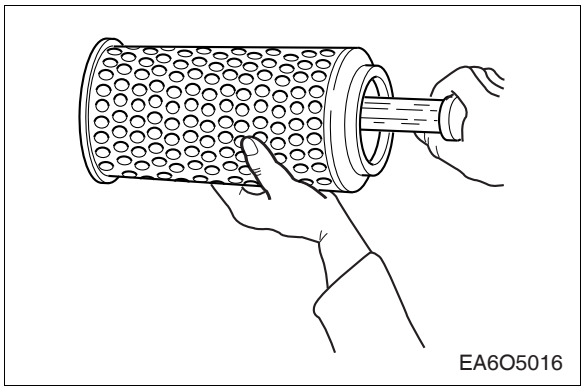
- **By washing**

  - Before washing, the element should be precleaned by means of compressed air, as described above.
  - Then allow the element to soak in lukewarm washing solvent for 10 minutes, and then move it to and fro in the solvent for about 5 minutes
  - Rinse thoroughly in clean water, shake out and allow drying at room temperature. The cartridge must be dry before it is reinstalled.
  - Never use steam sprayers, petrol (gasoline), alkalis or hot liquids etc. to clean the air cleaner elements.



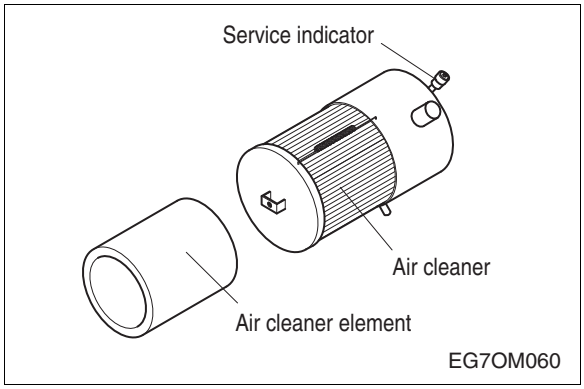
- **Knocking out dirt by hand**

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



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

5.9.3. Cleaning air cleaner of Walker AIRSEP type



- The vacuum limiter must be cleaned when the red service indicator is visible, and also after 250 operating hours.
- Rinse the vacuum limiter with low-pressure tap water, proceeding from the clean towards the dirty side.
- Shake off water completely, and allow vacuum limiter to dry in the atmosphere.
- Coat the bottom of each filter pleat with air filter oil.
- Allow the air filter oil to act for approx. 20 minutes.
- All stains still visible after that must be oiled once more
- To re-assemble, proceed in the reverse sequence.

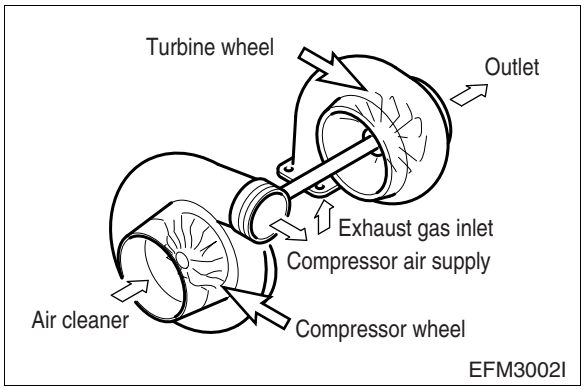
5.10. Turbo Charger System

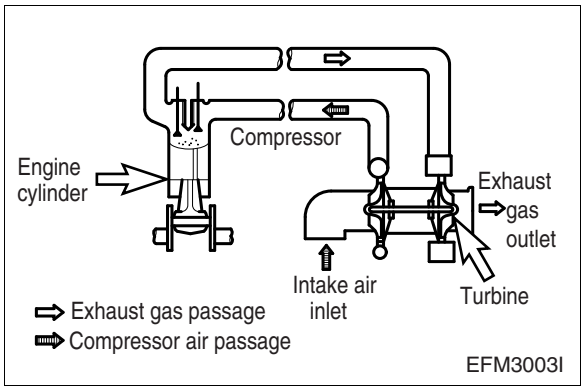
5.10.1. Specification

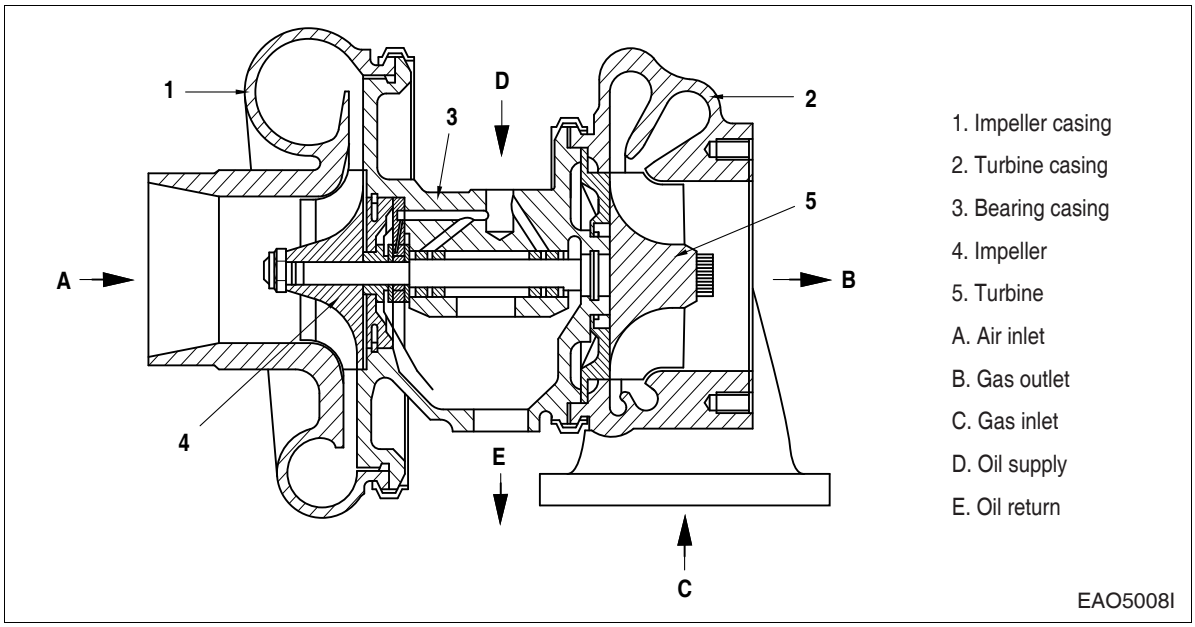
Engine Model	4V158TIH / 4V158TIM	4V222TIH / 4V222TIM
Output	600 PS / 2,100 RPM	880 PS / 2,100 RPM
Turbocharger model	HX35M	HX50M
Maximum allowable temperature of exhaust gas at turbine inlet	700°C	
Lubricating system	External oil supply	

Engine Model	4V158TIL	4V222TIL
Output	800 PS / 2,300 RPM	1,200 PS / 2,300 RPM
Turbocharger model	HX40M	HE551M
Maximum allowable temperature of exhaust gas at turbine inlet	700°C	
Lubricating system	External oil supply	

5.10.2. Operating principle

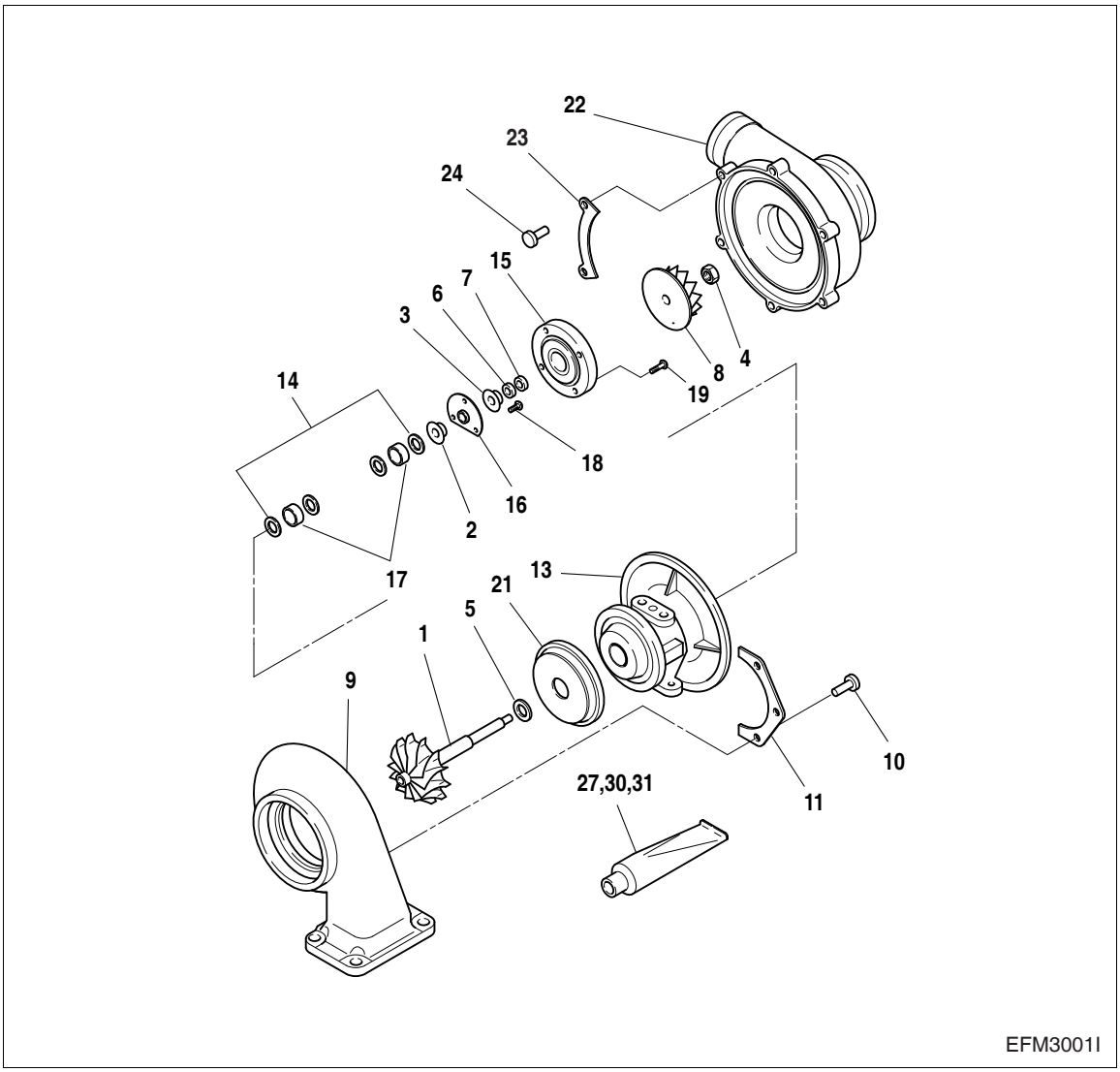






5.10.3. Construction

- Make sure that servicing should be performed at the professional maintenance shop as authorized by Holset Company.



1. Turbine shaft
2. Thrust bush
3. Oil shut off
4. Fixing nut
5. Seal ring
6. Seal ring
7. Seal ring
8. Compressor wing wheel
9. Turbine housing
10. Bolt
11. Clamp
13. Bearing housing
14. Retainer ring
15. Seal plate
16. Thrust bearing
17. Journal bearing
18. Screw
19. Screw
21. Heat dissipator
22. Compressor housing
23. Clamp
24. Bolt
27. Liquid gasket
30. Loctite
31. Liquid anti-burn agents

5.10.4. 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 super charging, and super charging by means of exhaust gas energy that discharges to the atmosphere is called as the turbo charging.

5.10.5. 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 dissipator.

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.

5.10.6. 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.	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 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.	3) In case that engine stalled for long time and of cold weather, the fluidity of oil may be get worse.
Immediately After starting	1) Perform idling operation for about 5 min. immediately after engine starting.	1) Sudden load at time soon after engine starting and at the state when turbocharger did not yet reach to smooth revolution, if abrupt load is applied to engine, some parts where oil did still not reach may cause a burn to be stuck.
	2) Various inspections must insure that there are no leakage of oil, gas and air.	2) If there are the leakage of oil, gas, air, particularly oil, for the oil pressure lowers, it causes a burn of bearing to be stuck.
During operation	Following items must be confirmed.	
	1) Oil pressure at idling: 90 ~ 300 kPa (0.9 ~ 3.0 bar) at full load 300 ~ 650 kPa (3.0 ~ 6.5 bar)	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) When abnormal noises and vibration are generated, slow down the revolution and must stop it to investigate the causes.	2) If the engine operation were continued with abnormal noises and vibration, it causes the engine trouble that can not be repaired or some other troubles.
At stop	1) At stopping the engine, perform the idling operation for 5min. and then stop it.	1) After heavy load operation, if the engine were stopped suddenly, the heat would be conducted to bearing parts from red hot turbine wings that would result in burning the oil to cause the stuck bearing metal and revolving shaft.

5.10.7. Routine inspection and maintenance

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

1) Air intake system

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

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) Fuel system

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

4) Lubricating system

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

5.10.8. Periodical servicing

The turbocharger assembly must be inspected periodically.

1) Rotating condition of the rotor and checking tips

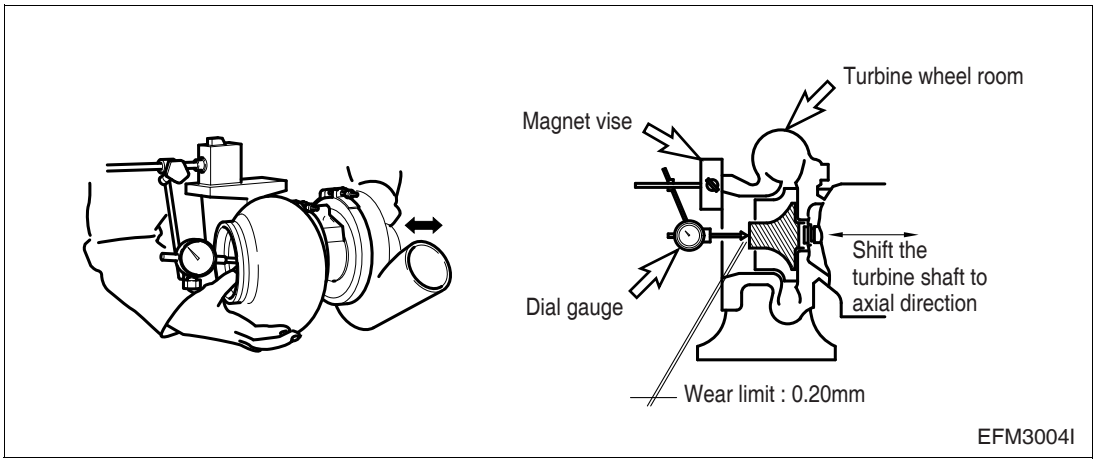
- Inspection on the revolving state of rotor is performed according to abnormal noises. In case of using an acoustic bar, touch the turbocharger housing with a tip of bar and raise the engine revolution slowly, Then, in case that high sound is heard by every 2 ~ 3 sec. continuously, for there should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

2) Measuring rotor clearance

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

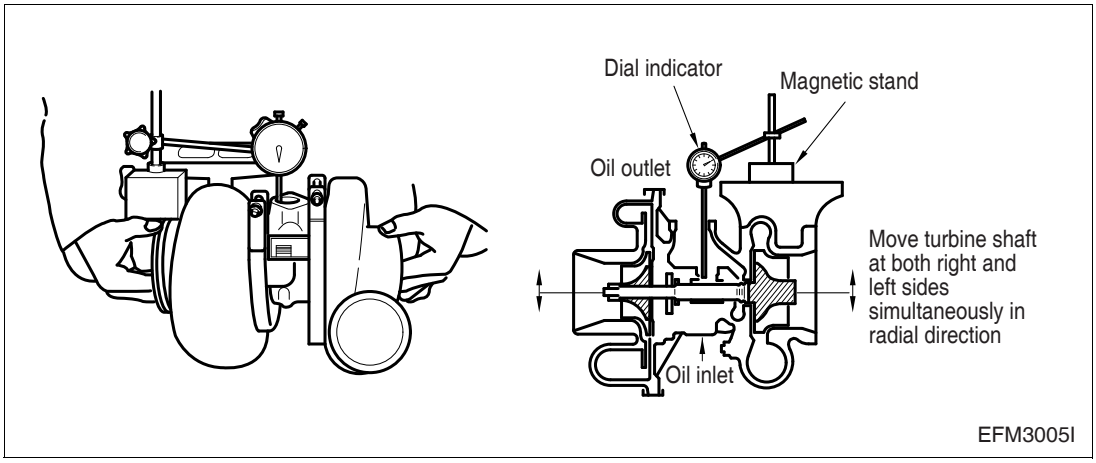
a) Rotor axial direction end play

- Wear limit : 0.20mm



b) Rotor's circumference direction end play.

- Wear limit : 0.65mm



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

3) Overhaul and cleaning points

Be sure to dismantle the turbocharger from the engine before cleaning. Also, make sure to seal the oil inlet and outlet with tape or similar.

4) 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.
- Clean the pipe and oil outlet pipe between engine and oil inlet, and confirm if there is any pipe damage or foreign material.
- In order for oil not to leak from various connections, assemble securely.

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.

5.10.9. Trouble cause diagnosis and remedy

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

5.11. V-Belts System

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

1) Change the belts if necessary

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

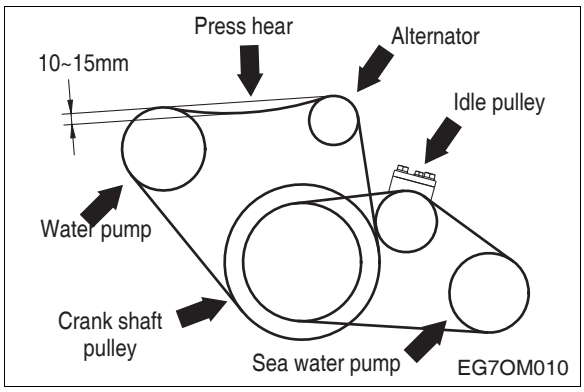
2) Checking condition

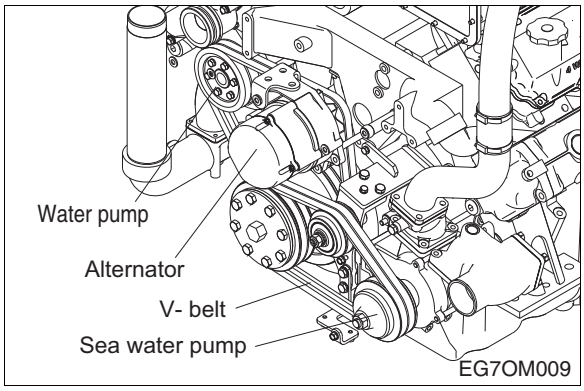
Check belts for cracks, oil, overheating and wear.

3) Testing by hand

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

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

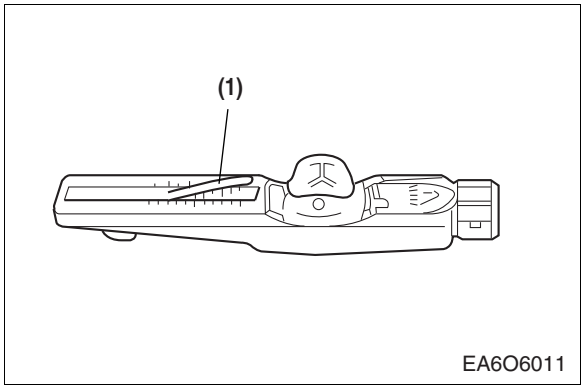




4) Measuring tension

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

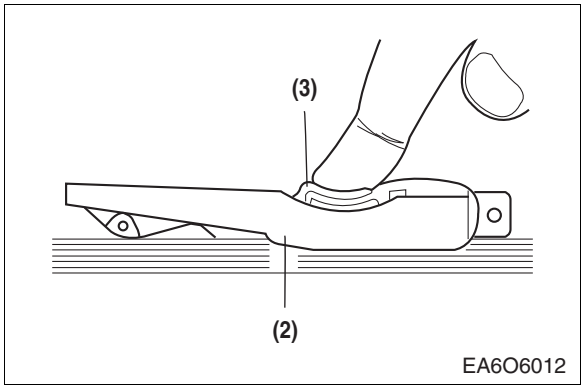
- Apply tester to belt at a point midway between two pulleys so that edge of contact surface (2) is flush with the V- belt.
- Slowly depress pad (3) until the spring can be heard to disengage. This will cause the indicator to move upwards.



- 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.



c) V-belt tension

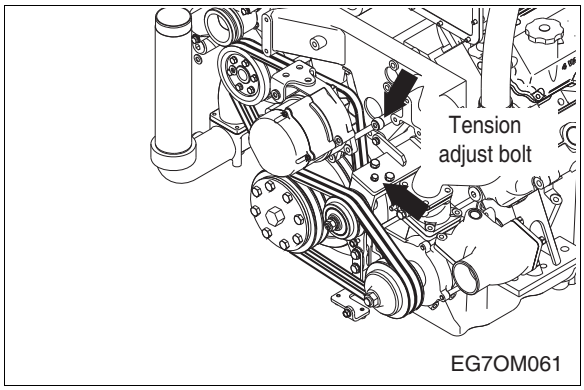
Type	Drive belt width	Tensioning forces on the tester		
		new installation		When servicing after long running time
		Installation	After 10 min. running time	
M	9.5 mm	50 kg	45 kg	40 kg
A	11.8 mm	55 kg	50 kg	45 kg
*B	15.5 mm	75 kg	70 kg	60 kg
C	20.2 mm	75 kg	70 kg	60 kg

Note : 4V158TI, 4V222TI engine is adopted *B type of belt

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.



Appendix

● Tightening torque for major parts

Major parts	Screw (Diameter x pitch)	Strength (Grade)	Tightening torque
Cylinder block bearing cap			
- Main bolt	M18 x 2.0	12.9T	Initial 30 kg·m + angle torque 90°
- Side bolt	M12 x 1.5	10.9T	11.2 kg·m
Oil spray nozzle			
- Valve	M14 x 1.5	-	7 kg·m
- Fixing bolt	M6	8.8T	1.2 kg·m
Flywheel housing	M12 x 1.5	10.9T	11.2 kg·m
	M10 x 1.5	12.9T	7.5 kg·m
Balance weight	M16 x 1.5	10.9T	Initial 14 kg·m + angle 90°
Crank pulley	M16 x 1.5	12.9T	21 kg·m
Vibration damper	M10 x 1.5	10.9T	6 kg·m
Flywheel	M16 x 1.5	12.9T	26 kg·m
Connecting rod cap	M16 x 1.5	10.9T	Initial 10 kg·m + angle torque 90°
Cylinder head	M15 x 2.0	-	6kg·m + 90°+ 90° + 90° + 30°
Cylinder intermediate cover	M8	8.8T	2.2 kg·m
Cylinder head cover	M8	8.8T	2.2 kg·m
Rocker arm bracket	M10 x 1.5	10.9T	6.2 kg·m
Lock nut (adjusting screw)	M10 x 1.0	8.8T	4.4 kg·m
Oil pump mounting	M8	8.8T	2.2 kg·m
Oil filter	M10	10.9T	4.4 kg·m
Oil cooler	M10	10.9T	5.5 kg·m
Oil pan	M8	8.8T	2.2 kg·m
Oil pan drain plug	M26 x 1.5	-	10 kg·m
Exhaust manifold	M10 x 1.5	-	8.0 kg·m
Intake manifold	M8	8.8T	4.4 kg·m
Hanger bracket bolt (rear side)	M16 x 1.5	-	18.5 kg·m
Starting motor	M12 x 1.5	8.8T	8 kg·m
Alternator bracket	M14 x 1.5	8.8T	12 kg·m
Coolant temperature sensor	M12 x 1.5	-	2.2 kg·m (max. 2.5 kg·m)

● Tightening torque for fuel injection system

Major parts	Screw (Diameter x pitch)	Strength (Grade)	Tightening torque
Fuel injection pipe nut	M12 x 1.5	8.8T	3.0 kg·m
Fuel filter bolt	M12 x 1.5	8.8T	4.0 kg·m
Fuel injector fixing bracket bolt	M8	10.9T	3.5 kg·m
Fuel high pressure connector flange bolt	M6	8.8T	1.0 kg·m

● 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	0.5
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
M8x1	0.73	0.8	1.2	1.1	1.5	1.34	2.1	2.3	2.4	3.35	4.1
M10	1.35	1.4	2.2	1.9	2.7	2.35	3.7	4.2	4.4	6.2	7.4
M10x1	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
M12x1.5	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
M14x1.5	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
M16x1.5	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
M18x1.5	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
M20x1.5	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
M22x1.5	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
M24x1.5	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.

● **Tightening torque for plug screw**

M10	M12	M14	M16	M18	M22	M24	M26	M30
5.0	5.0	8.0	8.0	10.0	10.0	12.0	12.0	15.0

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

	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 Hyundai Infracore engine

● Maintenance specification table

(unit: mm)

Group	Part	Inspection item		Stand value for assembly	Limit for use	Correction	Remark
Cylinder block	Cylinder block & liner	Inside diameter of cylinder liner		ø127.99 ~ ø128.01	ø128.122	Replace liner	Measure unworn portion beneath the rim of the upper side
		Liner's roundness & columness (upper)		0.005	–		From top up to 168 mm
		Liner's roundness & columness (lower)		0.008	–		From bottom up to 85 mm
		Amount of liner projection		0.04 ~ 0.09	–		Measure at upper side of cylinder block
		The flatness of upper surface of cylinder block		0.03	–	Correct with a surface grinder	0.015 for a length of 150 mm
		Hydraulic test for 1 minute (kg/cm^2)		4	–	Replace if leaky	Temperature 70°C
	Cylinder head & valve	Valve seat depression	Intake	0.8 ~ 1.1	–	Replace valve seat	0.25↓ @250 hr valve clearance inspection interval
			Exhaust	0.8 ~ 1.1	–		
		Cylinder head height		116.95 ~ 117.05	116.4	Replace cylinder head	
		The flatness of lower surface of cylinder head		0.015	0.1		
		Inner diameter of valve guide	Intake	ø8.015 ~ ø8.030	–		
			Exhaust	ø8.015 ~ ø8.030	–		
		Thick of cylinder head gasket (at assembly status)		1.215 ~ 1.285	–		
		Hydraulic test for 1 minute (kg/cm^2)		4	–	Replace if leaky	Room temperature
Major moving parts	Piston	Outer diameter of piston		ø127.739 ~ ø127.757	–	Replace piston	Measure at 56.8 mm away from piston head (long diameter)
		Clearance between piston and liner		0.233 ~ 0.271	0.35	Replace one worn more	
		Inner diameter of piston pin		ø46.010 ~ ø46.016	–		Standard diameter
		Width of piston ring grooves	Top ring	3.20 ~ 3.23	–	Replace piston if groove width is beyond specified value	Measure at 125 mm of top ring groove
			2nd ring	3.040 ~ 3.060	–		
			Oil ring	4.020 ~ 4.040	–		
		Piston projection from cylinder block upper surface		0.18 ~ 0.47	–		Measure unworn portion beneath the rim of the upper side
		Permissible weight difference of each piston		50 g	50 g ↓	Replace piston	

(unit: mm)

Group	Part	Inspection item		Stand value for assembly	Limit for use	Correction	Remark
Major moving parts	Piston ring	Width of piston ring	Top ring	3.075 ~ 3.095	–	Replace ring	
			2nd ring	2.975 ~ 2.990	–		
			Oil ring	3.97 ~ 3.99	–		
		Piston ring gap	Top ring	0.30 ~ 0.45	0.70	Replace ring	Standard gauge inside diameter: ø128
			2nd ring	1.10 ~ 1.30	1.45		
			Oil ring	0.40 ~ 0.70	0.95		
		Piston ring side clearance	Top ring	0.105 ~ 0.150	0.30	Replace ring or piston	Limit for use is if for standard clearance
			2nd ring	0.05 ~ 0.082	0.15		
			Oil ring	0.030 ~ 0.070	0.15		
		Direction of ring gap		–	–	Cross Install by 120°	
	Piston pin	Outer diameter of piston pin		ø45.994 ~ ø46.000	ø45.94	Replace piston pin	
		Clearance between piston pin and its bush		0.010 ~ 0.022	0.08	Replace one worn more	
	Crank shaft	Radial run-out of journal and pin		0.02	–	Correct with a grinder	Measure in horizontal and vertical directions
		Outside diameter of journal		ø103.98 ~ ø104.00	ø102.98	Use under sized bearings respectively (0.10, 0.25, 0.5, 0.75, 1.0)	
		Outside diameter of pin		ø89.980 ~ ø90.000	ø88.980		
		Width of thrust journal		38.000 ~ 38.062	37.000		
		Ellipticity of journal and pin		0.01	0.025		
		Taper of journal and pin		0.02	0.03		
		Clearance between crankshaft and bearing		0.066 ~ 0.134	0.166	Replace bearings	Measure at crown part not parting line
		End play of crankshaft		0.140 ~ 0.361	0.452	Replace thrust bearing	
		Balance of crankshaft (g·cm)		60 ↓	60 or less	Check dynamic balance	Measure at 400 rpm
		Torque of journal bearing cap bolt		30 kg·m + 90°	–	Coat the bolt with engine oil	Clean out foreign objects on joining surface.
		Crush height of Journal bearing cap	Main	0.3 ~ 1.2	–		Measure after tightening metal cap and releasing one bolt
			Thrust	0.3 ~ 1.2	–		
		Out diameter of wear ring after assembled		ø104.86 ~ ø105.00	–		5 minutes or more at 220°C
		Oil seal for wear (crank shaft rear)		–	–	Replace oil seal if oil leaking	

(unit: mm)

Group	Part	Inspection item		Stand value for assembly	Limit for use	Correction	Remark
Major moving parts	Connecting rod	Width of connecting rod	Small end	38.7 ~ 39.0	–		
			Big end	35.38 ~ 35.341	–		
			Cap	32.8 ~ 33.1	–		
		Inner diameter of small end with bush		ø50.6 ~ ø50.9	–		
		Outer diameter of big end with bearing		ø94.97 ~ ø94.99	–		
		End play of connecting rod	Big end	0.15 ~ 0.351	0.50	Replace connecting rod	
			Small end	1.5	–		
		Clearance between connecting rod bearing and crank pin		0.056 ~ 0.118	0.154	Replace bearing	
		Clearance between small end bush & piston pin		0.055 ~ 0.071	0.12		
		Crush height of connecting rod bearing cap		0.125 ~ 0.155	–		Measure after installing the bearing and releasing one bolt
		Perpendicularity of big end inner diameter		0.035	0.08	Replace connecting rod	
		Roundness of big end inner diameter		0.005	0.01		
		Parallelness of small end side and big end		0.02	0.1		
		Allowable weight difference per con-rods		50g ↓	–		
		Torque value of connecting rod bearing cap bolt (kg·m)		10kg·m + 90°	–	Coat the bolt with engine oil	Clean out foreign objects on joining surface
	Cam shaft	Diameter (bearing) of cam shaft side of cylinder block	Inner diameter of thrust bush	ø70.07 ~ ø70.09	–		
			Inner diameter of cam bush	ø70.00 ~ ø70.03	–		
		Diameter of cam shaft journal		ø69.910 ~ ø69.940	ø69.560		
		Clearance between camshaft and thrust bushing		0.130 ~ 0.180	0.24	Replace cam bush	
		Clearance between cam shaft and cam bush		0.060 ~ 0.120	0.24	Replace cam bush	
		End play of camshaft		0.24 ~ 0.86	0.9	Replace thrust washer	
		Run-out of camshaft		0.05	0.15	Correct or replace the cam shaft	

(unit: mm)

Group	Part	Inspection item		Stand value for assembly	Limit for use	Correction	Remark
Major moving parts	Fly wheel	Ring gear assembly part's outer diameter		ø432.590 ~ ø432.700	–		Heating temperature at ring gear assembly (200 ~ 230°C)
		Ring gear inner diameter		ø432.000 ~ ø432.200	–		
		Overlap		0.390 ~ 0.700	–		
		Allowable shaking amount after assembly		0.5	–		
		Outer diameter after assembly wear ring		ø119.860 ~ ø120.000	–		
Valve system	Valve and valve guide	Outer diameter of valve stem	Intake	ø7.963 ~ ø7.977	ø7.943	Replace valve	When replacing valve guide & seat, work simultaneously by special tools
			Exhaust	ø7.950 ~ ø7.964	ø7.920		
		Clearance between valve stem and valve guide	Intake	0.038 ~ 0.067	0.1		
			Exhaust	0.051 ~ 0.08	0.15		
		Degree of valve seat	Intake	60°	–		
			Exhaust	45°	–		
		Diameter of valve head	Intake	ø42.9 ~ ø43.1	–		
			Exhaust	ø39.9 ~ ø40.1	–		
		Thickness of valve head	Intake	3.0 ~ 3.4	2.5 or less		
			Exhaust	3.3 ~ 3.7	2.8 or less		
		Projection amount of valve guide and valve spring seat	Intake	14.8 ~ 15.2	–	Use with assembly jig	To upper side of valve guide from spring seat side of cylinder head
			Exhaust	14.8 ~ 15.2	–		
		Valve seat assembly part's inner diameter of cylinder head	Intake	ø43.500 ~ ø43.525	–		
			Exhaust	ø41.500 ~ ø41.525			
		Diameter of valve seat	Intake	ø43.554 ~ ø43.570	–		
			Exhaust	ø41.554 ~ ø41.570			
		Valve seat assembly part's depth of cylinder head		11.9 ~ 12.1	–		
		Inner diameter of valve guide (not reamer)		ø8.015 ~ ø8.030	–		When replacing valve guide & seat, work simultaneously by special tools
		Valve guide assembly part's inner diameter of cylinder head		ø14.000 ~ ø14.018	–		
		Outer diameter of valve guide		ø14.028 ~ ø14.039	–		
		Clearance between valve guide and cylinder head installing hole		–0.010 ~ –0.039	–		Apply oil over valve guide and press it into the hole
		Concentricity between valve seat and valve guide		0.05	–	Replace valve spring	Without spring seat

(unit: mm)

Group	Part	Inspection item			Stand value for assembly	Limit for use	Correction	Remark
Valve system	Valve and valve guide	Intake and exhaust valve spring (inner)	Free length		59.5	–	Replace valve spring	
			Tension force (kg)	41 mm	14.8	13.3 or less		
				28.6 mm	25	23 or less		
			Inclination (free length)		1.5 mm	2.0 or less		
		Intake and exhaust valve spring (outer)	Free length		57.0	–	Replace valve spring	
			Tension force (kg)	44 mm	25.5	23.5 or less		
				31.6 mm	52.3	49.8 or less		
			Inclination (free length)		1.5 mm	2.0 or less		
	Rocker arm & push rod	Joining surface of valve stem and rocker arm bush			–	–	Grind or replace if severely pitted on tip of rocker arm and stem	
		Inner diameter of rocker arm bush			ø24.991 ~ ø25.012	–		
		Diameter of rocker arm shaft			ø24.953 ~ ø24.976	ø24.916		
		Clearance between rocker arm shaft & rocker arm bush			0.015 ~ 0.059	0.12	Replace bush or shaft	
		Run-out of push rod			0.3	0.3 or less	Replace or correct	
	Tappet	Tappet assembly part's inner diameter of cylinder head			ø20.000 ~ ø20.021	–		
		Diameter of tappet			ø19.944 ~ ø19.965	–	Replace tappet	
		Clearance between tappet & tappet hole of cylinder block			0.035 ~ 0.077	0.15	Replace tappet	
		Tappet face in contact with cam			–	–	Replace if severely worn or deformed	

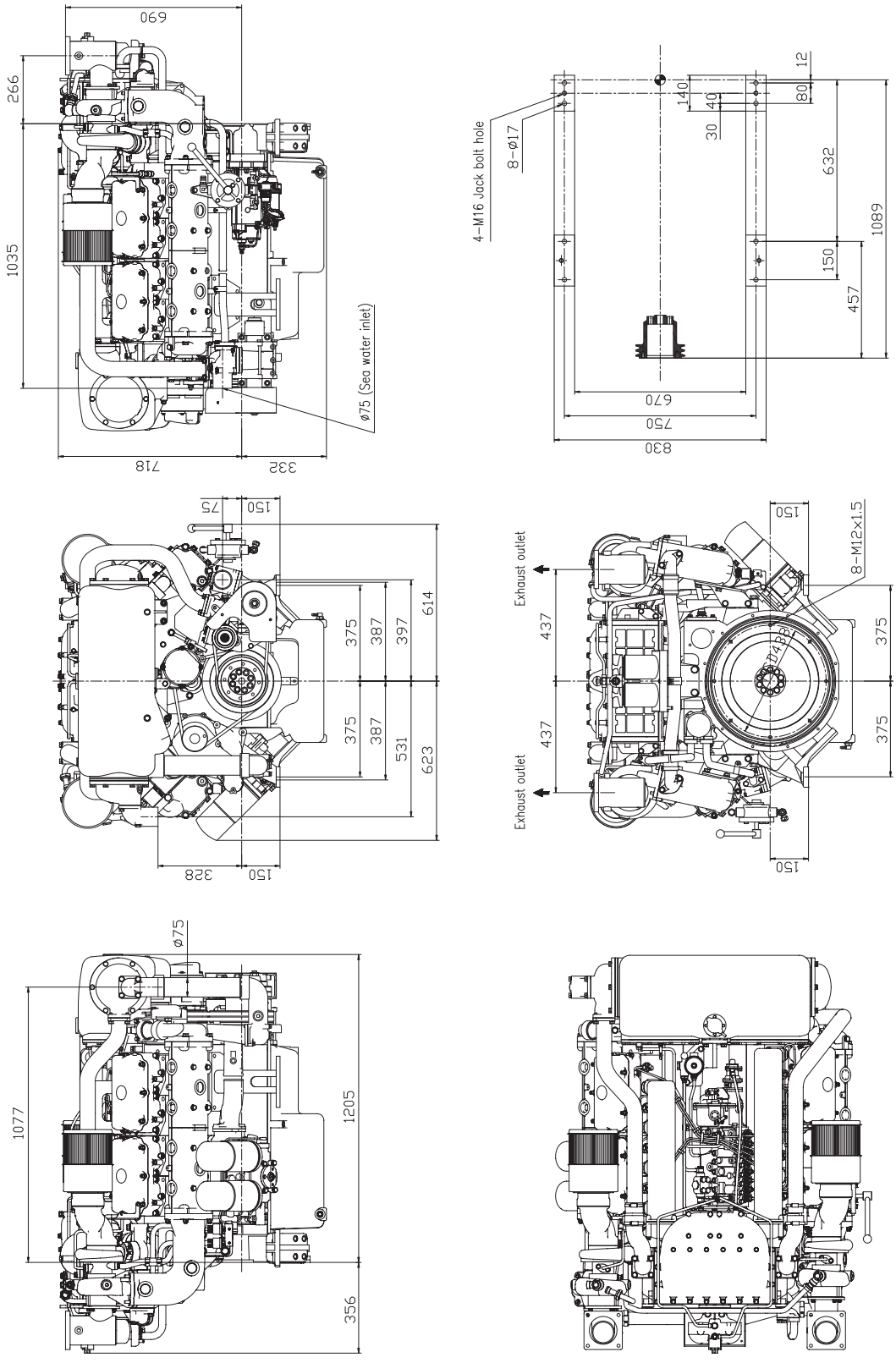
(unit: mm)

Group	Part	Inspection item	Stand value for assembly	Limit for use	Correction	Remark
Lubricating system	Engine oil	Oil pressure (kg/cm^2) (at rated speed)	3.0 ~ 6.5	–	Check oil leakage and clearance between each part	
		Oil pressure (kg/cm^2) (at idle speed)	1.0 ~ 3.0	0.8 or more	Use recommended oil	
		Oil temperature (°C)	110 or less	–		Must not exceed this value
		Permissible oil temperature in short time (°C)	Max. 120	–		
	Oil spray nozzle	Operating pressure	1.5 ~ 1.9		Replace valve	
	Oil pump	Delivery volume lit/min – Pump rpm: 2,440 rpm – Oil temperature: 50°C	275 or more	–	Replace gear or cover	
		Oil pump pressure control valve (kg/cm^2)	9 ~ 10	–	Replace valve	
	Oil filter and oil cooler	Damage of oil filter element	–	–	Clean or replace	
		By-pass valve pressure of oil filter (kg/cm^2)	2.2 ~ 2.5			
		By-pass valve pressure of oil cooler (kg/cm^2)	4.5 ~ 5.5			
Cooling system	Radiator	Radiator & water pump for corrosion, damage & improper connecting	–	–	Correct or replace	
		Test for leakage by air pressure (kg/cm^2)	1.2 ~ 1.3	–	Submerge in water and replace if air bubbles found	
		Pressure valve for opening pressure (kg/cm^2)	0.9	–		
		Pressure valve for vacuum (kg/cm^2)	0.05			
	Water pump	Delivery volume lit/min – Pump speed: 3,500 rpm – Water temp.: 25°C – Pressure: 1.8 kg/cm^2	700 or more	–	Check the water passage	
		Fan belt depression	Refer to adjust table	–	Adjust	

(unit: mm)

Group	Part	Inspection item	Stand value for assembly	Limit for use	Correction	Remark
Cooling system	Cooling water temperature	Operating temperature (°C)	79 ~ 95	–	Must not exceed this value	
		Permissible temperature in a short time (°C)	–	105		
	Thermostat	Operating temperature (°C)	71	–	Replace	
		Full opening temperature (°C)	85	–	Replace if defective Stroke: min. 8 mm	
Fuel system	Fuel injection pump maker		Bosch	–		
	Fuel piping & others	Fuel pipe, injection pipe & injector for damage, cracks, improper O-ring	–	–	Replace	
		Damage of fuel filter cartridge	–	–	Replace cartridge	
	Injector opening pressure (kg/cm^2)		285.5 ~ 297.8	–		
	Operating pressure of overflow valve (kg/cm^2)		1.33 ~ 1.84	–	Replace valve	
	Diameter of injector nozzle		8 – ø0.284	–		
	Projection height of nozzle from the cylinder head surface (mm)		3.0	–	Replace sealing	
Drive system	Gear back lash	Between crank gear & oil pump drive gear	0.099 ~ 0.451	–	Adjust back lash	
		Between crank gear & cam shaft gear	0.143 ~ 0.292	0.3		
		Between drive gear & fuel pump gear	0.102 ~ 0.338	0.45		

1. Engine assembly drawing - 4V158TIL (Air cleaner of AIRSET type)



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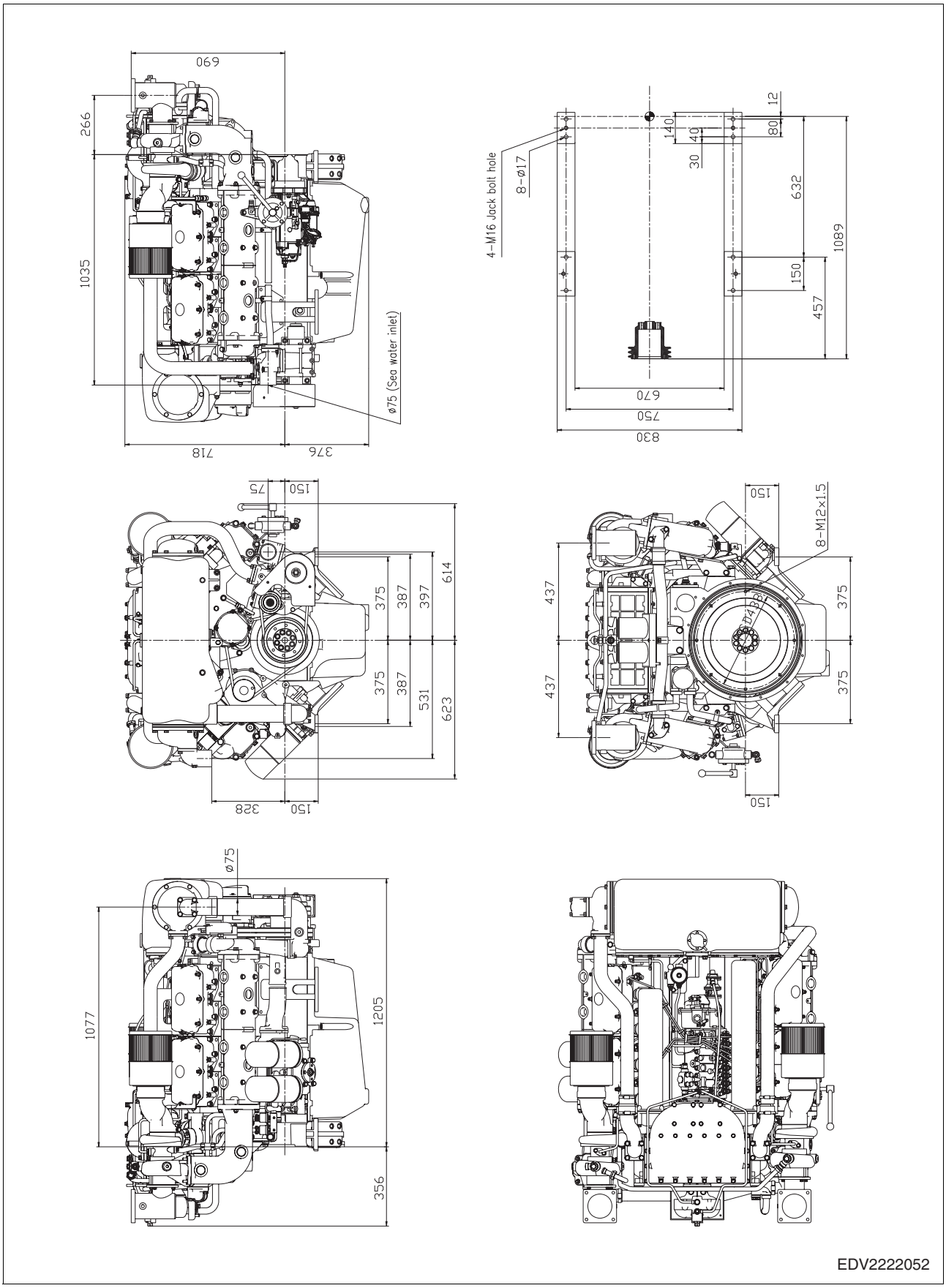
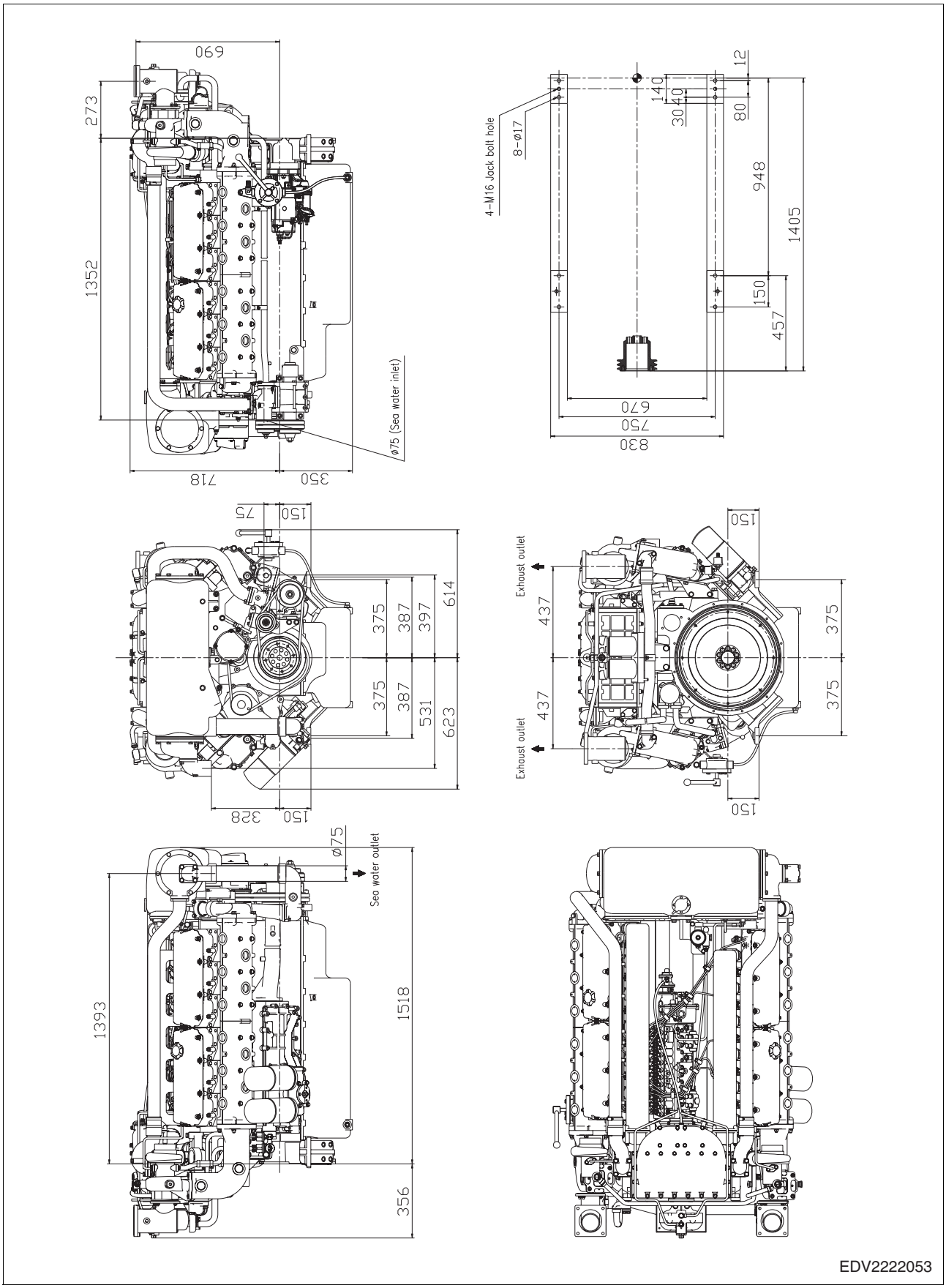
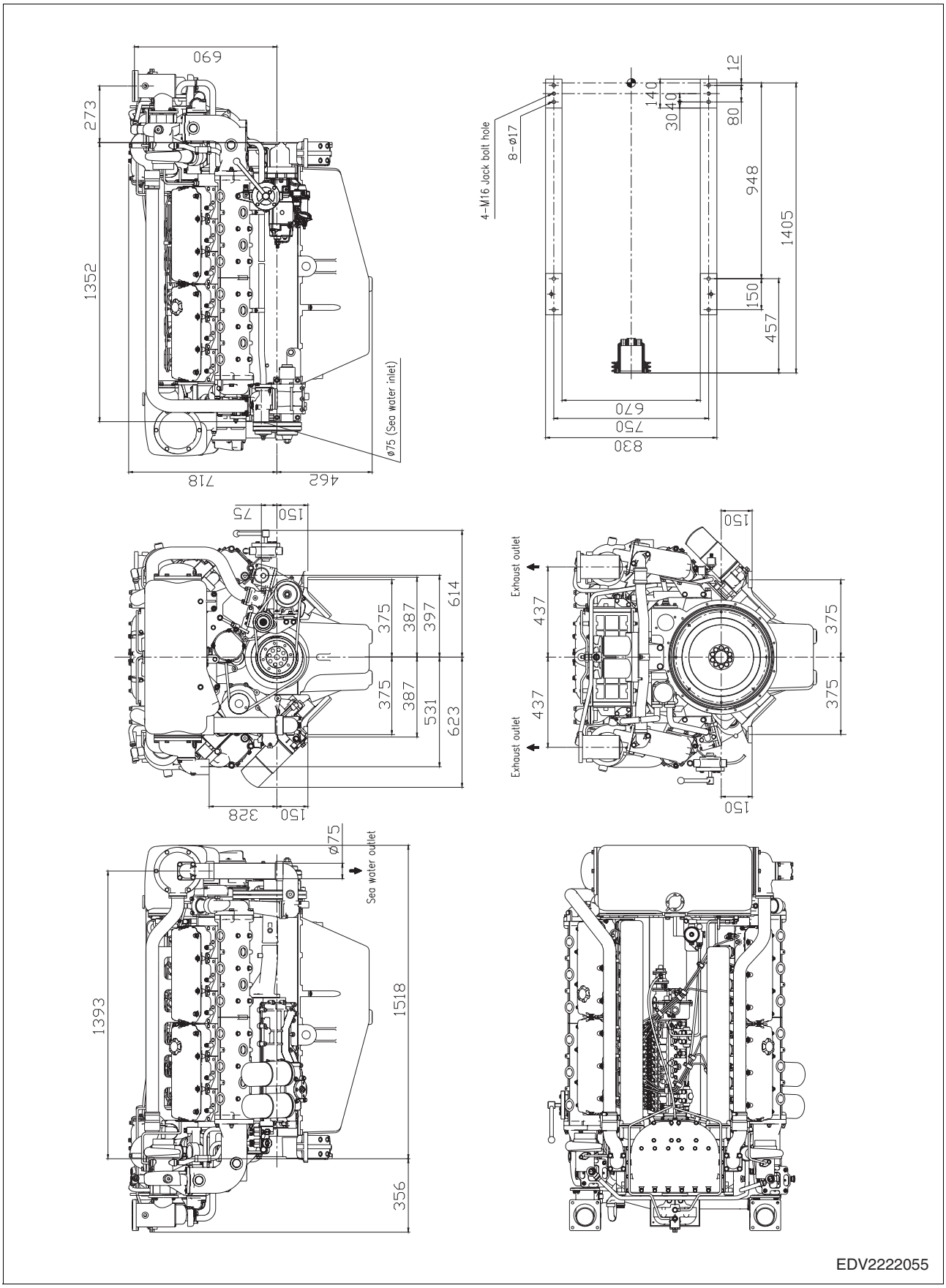
2. Engine assembly drawing - 4V158TIM / 4V158TIH (Air cleaner of AIRSET type)



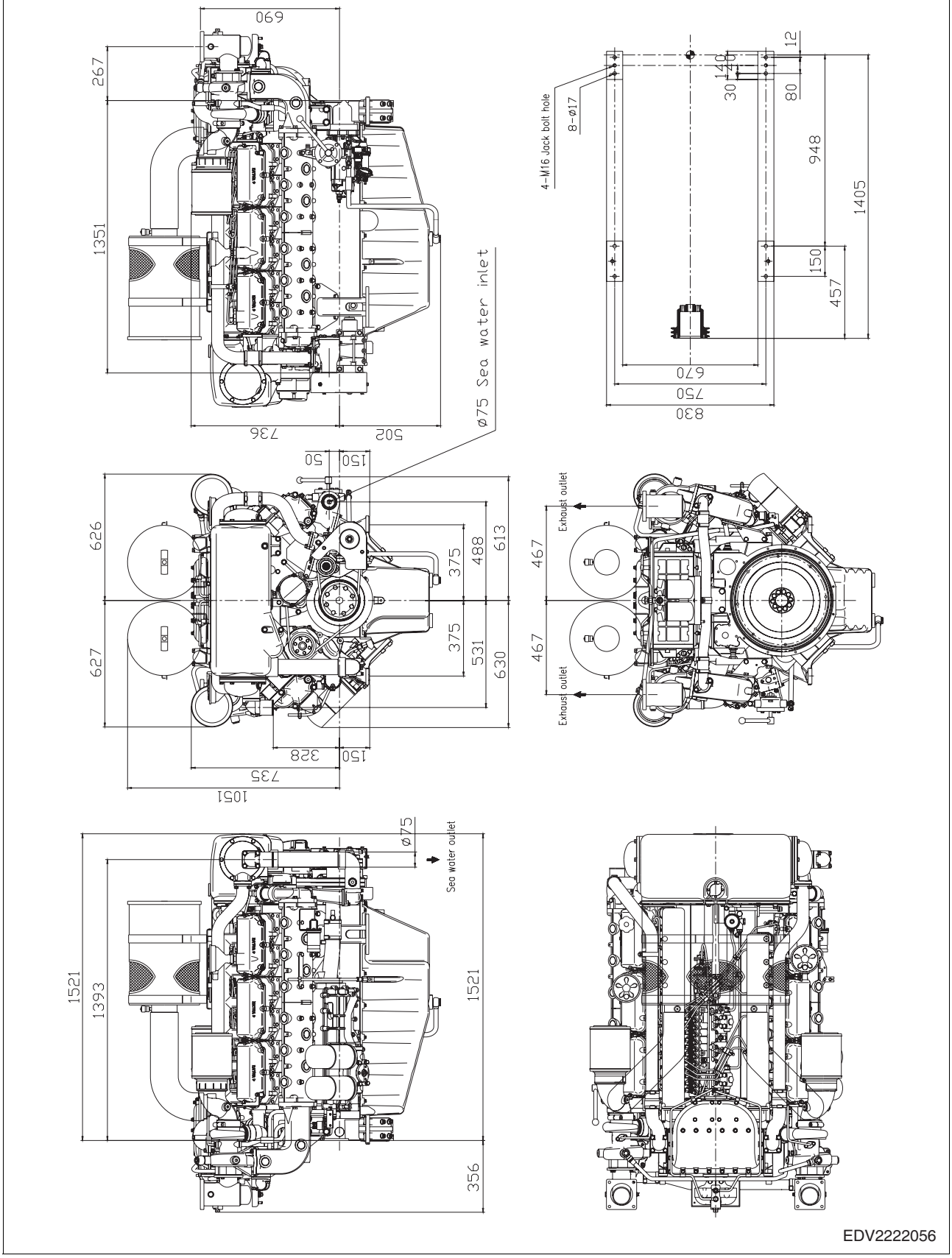
3. Engine assembly drawing - 4V222TIL (Air cleaner of AIRSET type)



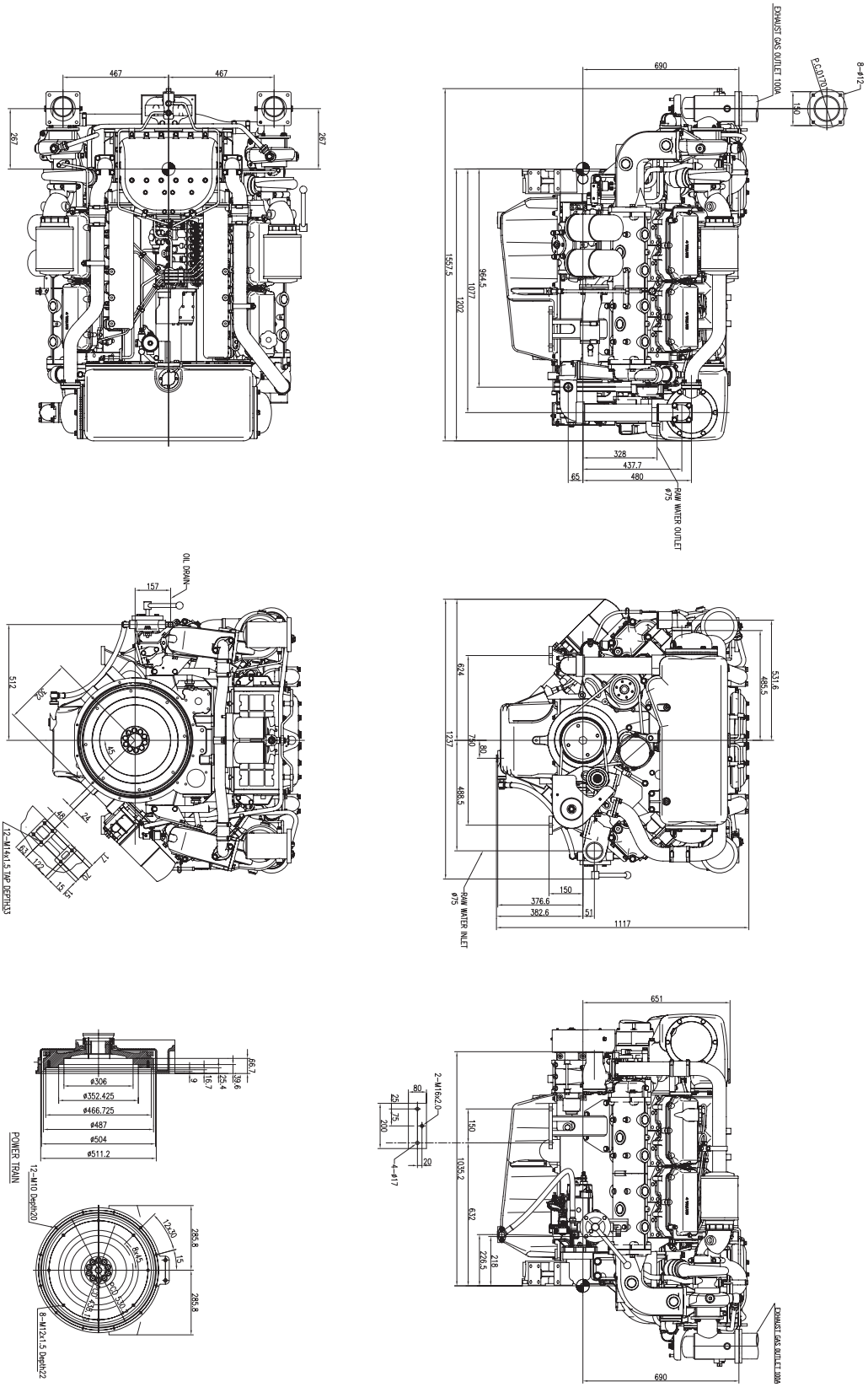
4. Engine assembly drawing - 4V222TIM / 4V222TIH (Air cleaner of AIRSET type)



5. Engine assembly drawing - 4V222TI (Air cleaner of paper element type)



6. Engine assembly drawing - 4AD 158TI



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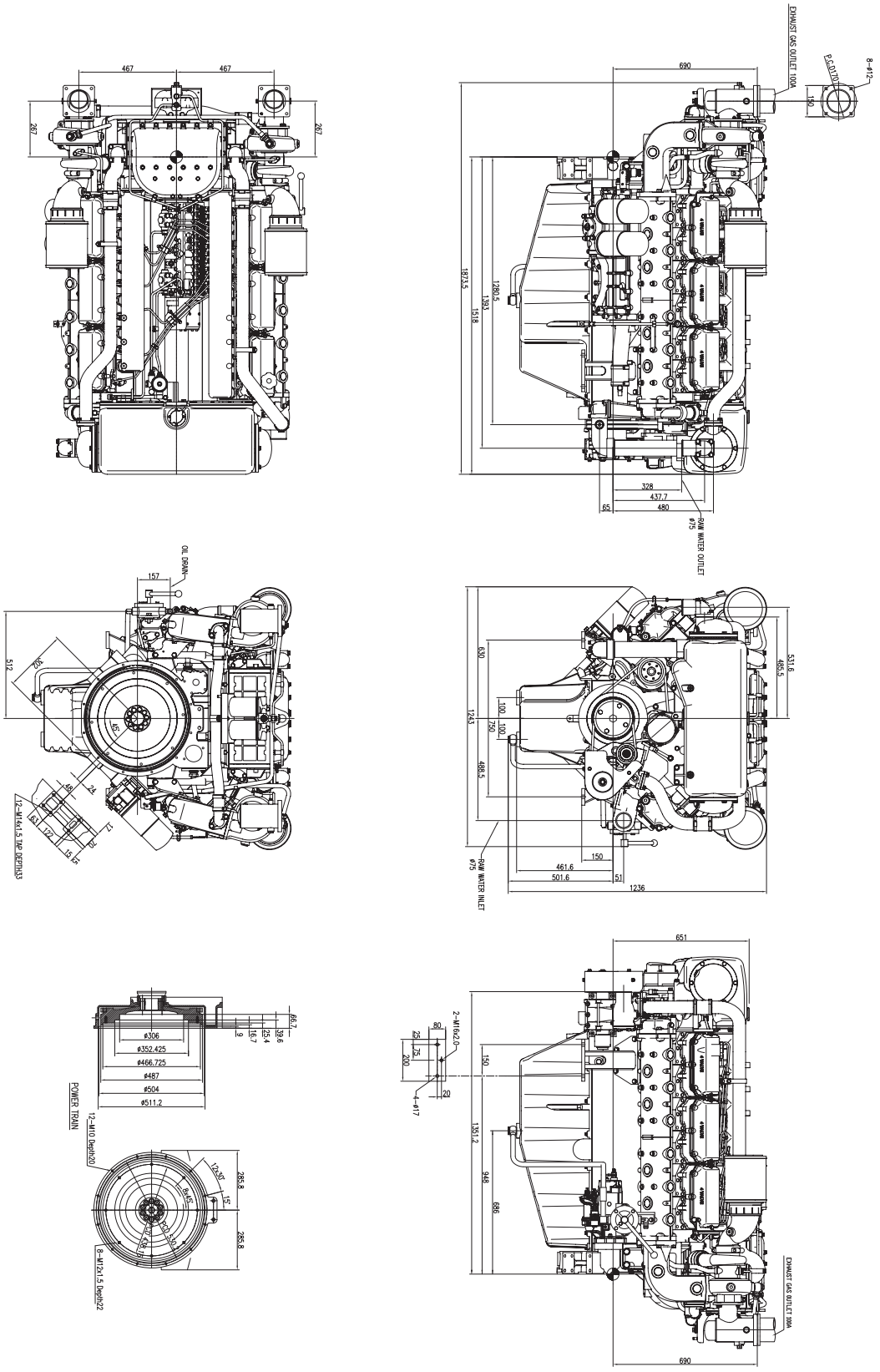
7. Engine assembly drawing - 4AD 222TI



EDV2222058

Paper Size : 120mmx165mm

Diesel Engine for Generators (Land/Marine)

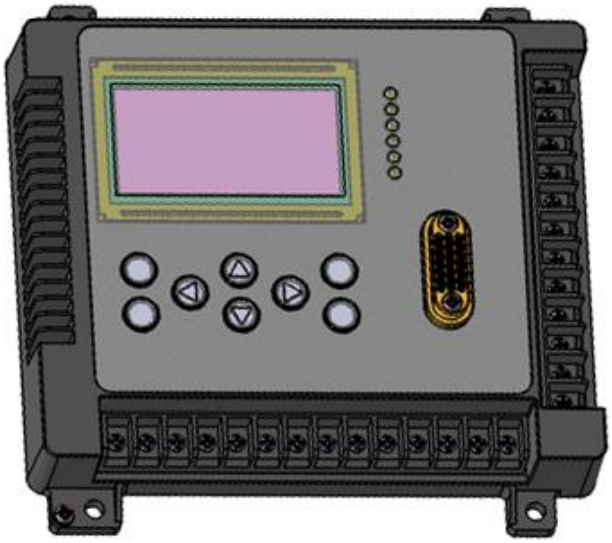
Digital Speed Controller

User Manual

Ver_1.07

300611-01127A(Land)

300611-01440(Marine)



HYUNDAI

HD Hyundai Infracore

Contents

1. Product Overview and General Specification

1.1 Product Information

Digital Speed Controller (300611-01127A/01440) is applicable to generator (vehicles and vessels) engines as a high performance embedded electronic control system designed based on PID control for fast and precise control of engine speed with an enhanced micro controller unit (MCU) that minimizes analog circuits vulnerable to user environments.

This product features PID auto setting functions along with battery voltage, pick-up sensors and actuator condition checking. It also has a black box function that manages engine operation records when faults are detected for users to have more convenience in operating this precise digital speed controller.

[Product Features]

- Rigid and stable case structure and easily recognizable front design
- Readily understandable GUI (graphic user interface) with graphic LCD displays
- Easy and simple setup with 8 button keys without manual controls by users
- Fast setting available by migrating initial settings depending on types of the engines
- Listing fault messages (over speed, pick-up error, etc.) and recording messages
- RS232 and CAN ports available for communication
- Digital inputs and PID auto setup functions for PID control parameters
- Application of digital clock for fault timing and engine operating hours

1.2 Product Appearance

Digital Speed Controller is made of a rigid aluminum case taking into account anti-shock, electromagnetic resistance and environmental protection. An embedded system containing graphic LCD and high performance MCU is inside the controller and a heat sink is located on the outside of the case for protection and precise control of actuator operating elements.

A terminal block is located on the bottom and right of the front side for easy connection to external devices. Over speed, run and crank signals are displayed on the front LED and contact points (a or b) are also available for outputs on external controllers or indicators.

RS232 and CAN communication is available and DSUB-9 connector enables universal use of RS232 communication.

Users can easily input and adjust values for parameter inputs using 8 button keys. In addition, graphic LCD shows graphic displays, bar graphs and design symbols so that users can readily identify the control information while external LED displays important conditions of the engine.

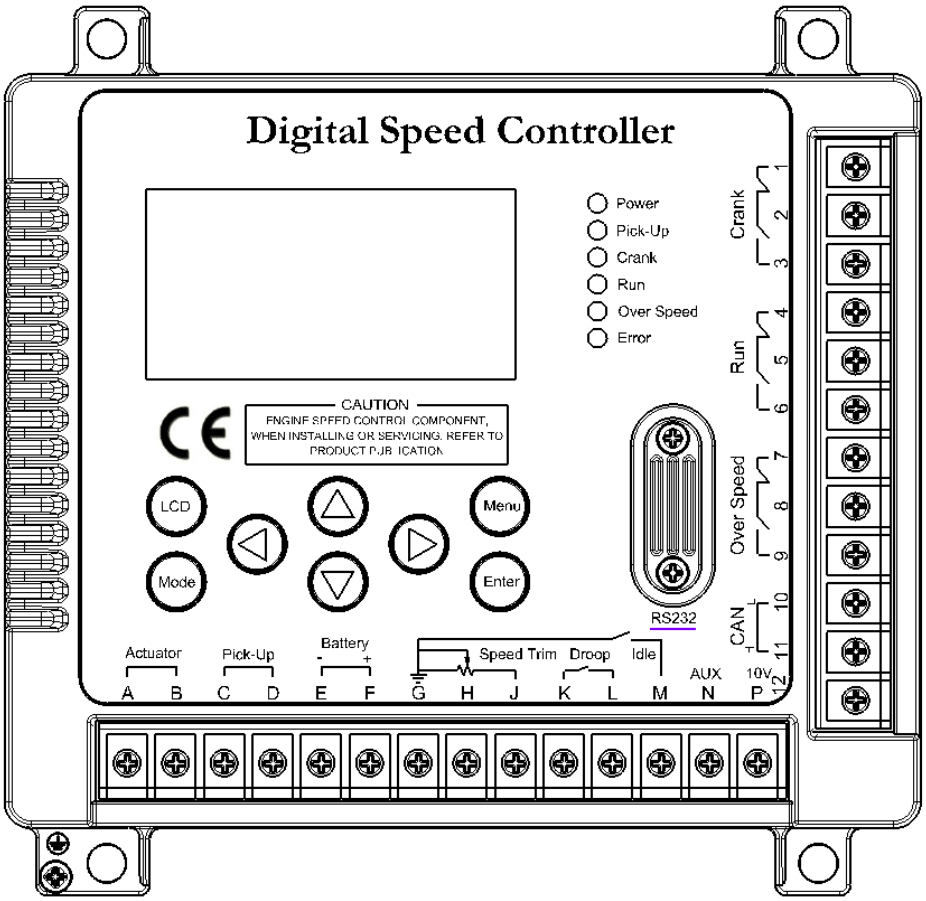


Figure 1: Product Front View

1.3 Product Specification

No.	Item	Description
1	MCU	16-bit DSC dsPIC33FJ256
2	Display	Graphic LCD 128*64
		LED: 6 EA
3	Keypad	8 Button Keys
4	Output	3 Contact Points (a and b)
5	Input	RMS 3V (Min)
6	Memory	128Mb
7	Communication	RS232 57600bps
		CAN (J1939) / 250kbps
8	Rated Power	DC 24V (12V to 32V)
9	Current Consumption	120mA
10	Operating Temperature	-20 to +70℃
11	Storing Temperature	-30 to +80℃
12	Operating Humidity	0 to 95%

1.4 Product System Diagram

Cautions on wiring

- **The total length of the Actuator(15AWG), Pick-up(24AWG_Shield Cable), and Battery(15AWG) connections shall be limited to 10m or less.**
- **Refer to the system diagram (Figure 2) to wire the circuit and check the cable type.**
- **Wiring assembly must be checked before use as it will cause fatal damage to the controller.**
- **The fuse 10A for circuit protection is always provided at the front end of the battery input terminal "F".**
- **RS232 communication cable should use designated dedicated cable.**
- **It does not guarantee the fault of the product caused by not following the system diagram and wiring connection precautions.**

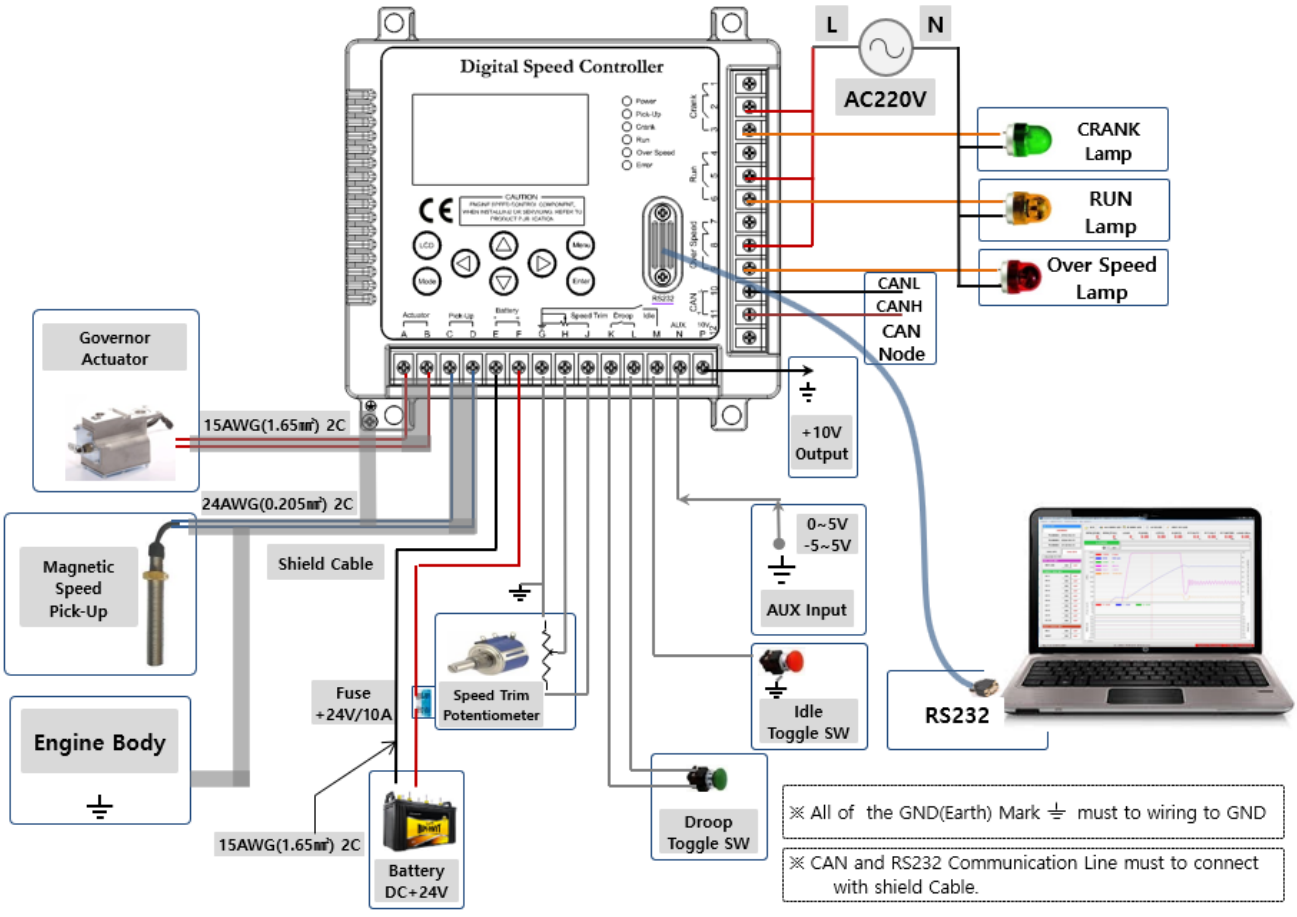


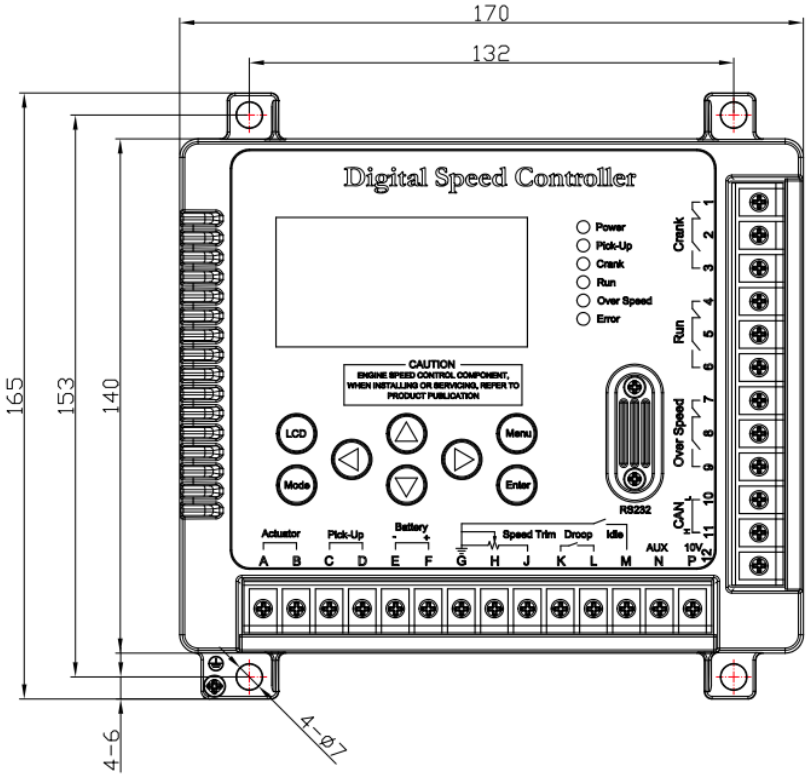
Figure 2: System Diagram for Digital Speed Controller

1.5 Product I/O Signals

No	Terminal	I/O type	Terminal Functions
1	Actuator (A, B)	Output	Outputs are actuator control signals. Wiring should be 15AWG (105℃) or better. (However, terminals A and B can be used regardless of their polarities. Actuator's shied cable terminal should be connected to Ground(Engine body). (Voltage measuring terminals are A and E.)
2	Pick-Up (C, D)	Input	Inputs are RPM sensor signals. Terminal D should be connected to the ground(Engine body) in connection with the shield cable. Gap between the RPM sensor and the gear tooth should be adjusted between 0.9 and 1.1mm (sensor inputs should be at least 3V AC RMS). Pick-up voltage shown on System monitor menu is Peak value
3	Battery Voltage (-E, +F)	Input	It is a power input terminal for the controller and inputs are DC +24V/10A. The positive pole of the battery should be connected to the terminal F. (Back voltage protection circuit is built in.)
4	Speed Trim (G, H, J)	Input (G)	It has a ground signal and is connected to the ground of the potentiometer.
5		Input (H)	Inputs are RPM trim signal values and the voltage level is between 0 and 5V. It is connected to the output of the potentiometer.
6		Input (J)	Outputs are DC +5V and it is connected to VCC of the potentiometer.
7	Droop (K, L)	Input	Terminal K receives droop function selecting information. Terminal L has a ground signal and the switch is connected to terminals K and L. Once the terminal K is connected to the ground, droop starts to operate.
8	Idle (M)	Input	Terminal M receives idle function selection signals. Once it is connected to the ground, idle operation starts.
9	AUX (N)	Input	Terminal N receive load sharing and synchronization signal for parallel operation. The signal level is an input between DC -5 and +5V.
10	10V (P)	Output	Outputs are +10V/20mA ratings and it can be used for various purposes including power to external auxiliary devices.
11	Crank Contact Point (1, 2, 3)	Output	The second crank contact point is a shared terminal while terminals 1 and 2 are for the contract point b and terminals 2 and 3 for the contact point a. The contact point a starts to operate when the digital speed controller reaches at the RPM delivering control signals to the actuator after the engine is activated.
12	Run Contact Point (4, 5, 6)	Output	The fifth run contact point is a shared terminal while terminals 4 and 5 are for the contact point b and terminals 5 and 6 for the contact point a. The contact point a starts to operate when the engine reaches its designated normal speed RPM.
13	Over Speed Contact Point (7, 8, 9)	Output	The eighth over speed contact point is a shared terminal while terminals 7 and 8 are for the contact point b and terminals 8 and 9 for the contact point a. The contact point a starts to operate when the engine reaches its designated over speed RPM.
14	CAN (10, 11)	I/O	Terminal 10 is for CAN-L communication and 11 is for CAN-H communication. CAN-H and CAN-L are used for CAN communication.

15	Power LED	Output	When DC+24V power is supplied to the controller, the LED turns on in red on the power level.
16	Pick-Up LED	Output	When the controller receives normal input signals from the pick-up sensor, the LED turns on in green on the pick-up level.
17	Crank LED	Output	The 2- and 3-terminal contact point a starts to operate and the LED turns on in yellow on the crank level when the digital speed controller reaches at the RPM delivering control signals to the actuator after the engine is activated. When Cranking Rpm is exceeded, Crank LED turns off.
18	Run LED	Output	The LED turns on in green on the run level when the engine reaches its designated normal speed RPM with 5- and 6-terminal contact point a starting to operate.
19	Over Speed LED	Output	The LED turns on in red on the over speed level when the engine reaches its designated over speed RPM with 8- and 9-terminal contact point a starting to operate..
20	Error LED	Output	The LED turns on in red on the error level when abnormal events of the controller occur.
21	RS232	I/O	D-SUB 9PIN (male) is connected to the host through RS232 communication port. The specified dedicated line should be used and only terminals 2, 3, 5 shall be connected, and the other terminals shall not be connected.
22	Ground	Ground	GND part and earthing should be jointly connected before being earthed to generator's engine body.

1.6 Product Dimension



2. Installation

Cautions for installing the digital speed controller

- **Mount the controller unit vertically to the surface of a control cabinet to protect from water and high humidity, and do not expose the controller unit to the radiant heat.**
- **Do not rely solely on the electronic governor's actuator function to prevent overspeed, and use an independent fuel cut-off solenoid auxiliary device.**
- **When welding around the controller and charging the battery, the controller battery terminal is disconnected.**
- **We can not guarantee the failure of the product caused by installation neglect.**

Digital Speed Controller should be connected to the pick-up sensor attached on the engine and the actuator. Speed trim, droop, idle and aux terminals can be used for additional functions in connection with surrounding circuits. Contact points a or b can also be used to operate external devices using crank, run and over speed functions. RS232 and CAN port allow communication with PCs or external host computers for data transfer and monitoring functions.

2.1 Connecting to the Engine

2.1.1 Battery, Pick-Up and Actuator Connection Diagram

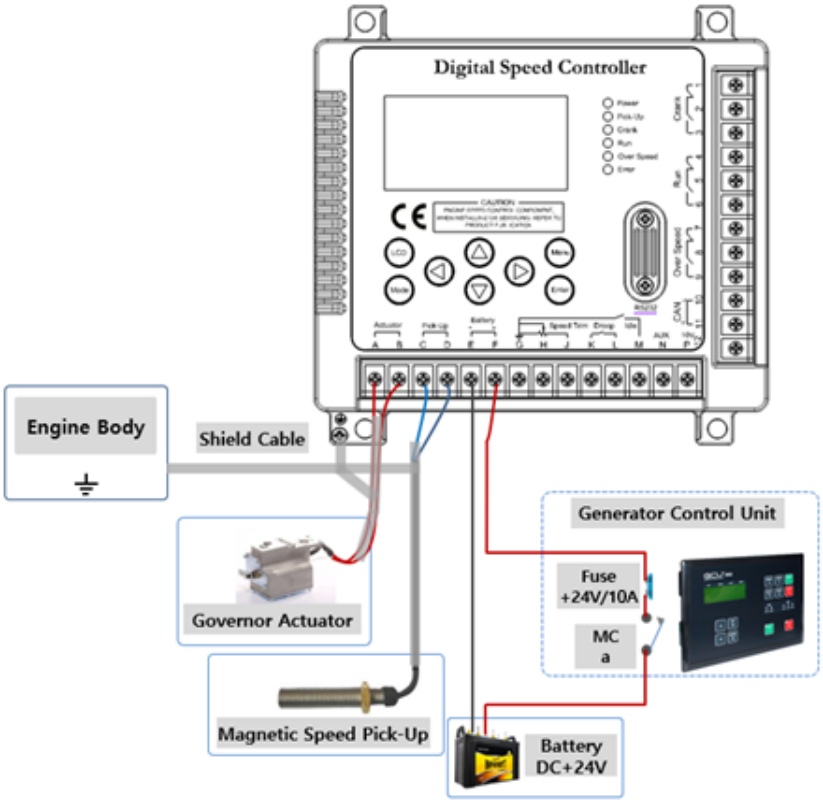


Figure 3: Battery, Pick-Up and Actuator Connection Diagram

2.1.2 Connecting to Batteries

Battery voltage is DC +24V and the battery is connected to the controller matching **E (-)** and **F (+)** with the respective polarities of the battery. **E (-)** is connected to **(-)** of the battery and **F (+)** to **(+)** of the battery. The circuit protection fuse 10A must be formed between the F (+) and the battery. Depending on cases, wiring can be done in a serial connection to the contact point a of MC and the fuse (DC +24V/10A) when connecting to system panels or generator control devices.

2.1.3 Connecting to Actuators

The actuator is also called governor and controls the amount of the fuel spray to the engine cylinder. The controller is connected to the actuator attached on the engine by connecting two wires of the controller terminal to A and B of the actuator regardless of their polarities. Use more than 15AWG(105℃) for the connection wire, and when using a shielded cable, the shield terminal should be connected to Ground(Engine body).

2.1.4 Connecting to Pick-Up Sensors

The pick-up sensor lets users know the engine speed and is connected to terminals **C** and **D** that can receive signals of AC RMS 3V or higher. Gap between the pick-up sensor and the gear tooth should be adjusted between 0.9 and 1.1mm. the shield terminal should be connected to Ground(Engine body).

2.1.5 Operating Sequence for Digital Speed Controller

● **Power On/Off:** It means that DC +24V power is either supplied or terminated through **E (-)** and **F (+)** of the battery matching with their respective polarities.

● **LCD On/Off:** It means to turn **on** or **off** the LCD display alone while DC +24V power is supplied through **E (-)** and **F (+)** of the battery matching with their respective polarities and the controller is in operation.

[Operating Sequence for the Controller]

Step1) When DC +24V power is supplied to the controller, the controller starts to operate. It indicates that power LED turns on and the power is being normally supplied.

Step2) Inputs for speed trim, droop and idle functions are received.

Step3) The controller checks the signals of the speed pick-up sensor.

Step4) Actuator control signals are output together with designated values of other information for crank, run and over speed functions according to the PID control values.

Step5) The controller checks the operation condition and displays LED outputs and fault messages according to the detected information.

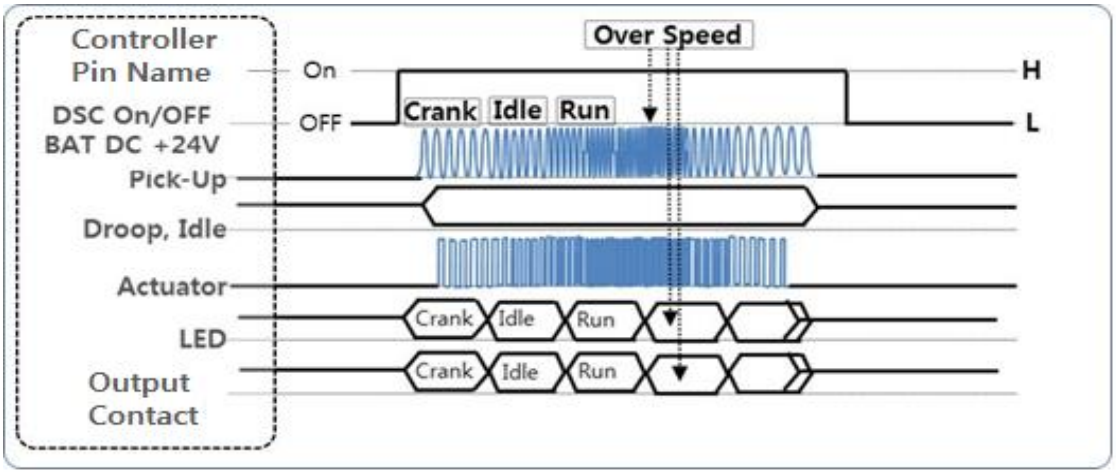


Figure 4: Time Chart for Operation of the Controller

2.2 Connecting to Speed Trim, Droop, Idle and Other Inputs

2.2.1 Speed Trim, Droop, Idle and Other Inputs Diagram

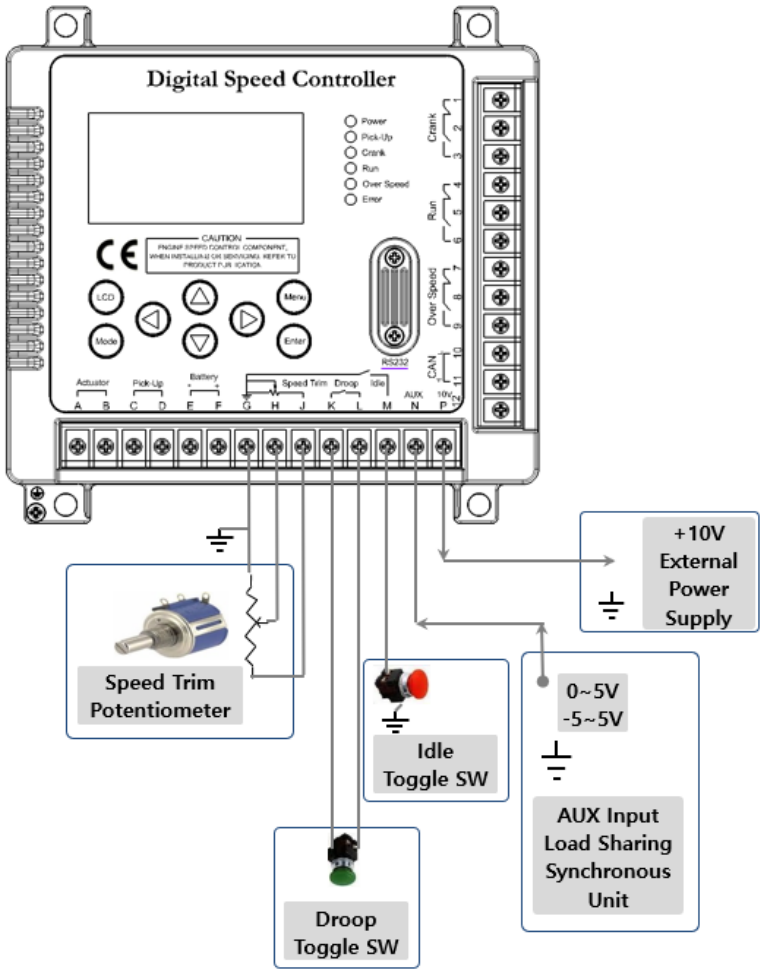


Figure 5: Speed Trim, Droop, Idle and Other Inputs Diagram

2.2.2 Connecting to Speed Trim

Speed trim is an analog voltage signal port for input to fine-tune the engine speed. A potentiometer is used for precise adjustment of the resistance values. The potentiometer needs to be connected to terminals **G**, **H** and **J**. Terminal **G** should be connected to the ground and it is recommended to use shielded cables. Terminal H is the terminal to which the fine adjustment voltage value (0 ~ 5V) is input. Terminal J is a terminal that is connected to VCC of the potentiometer with DC + 5V output.

2.2.3 Connecting to Droop

The switch is connected to terminals **K** and **L**. Signals indicating whether **droop** function works or not serve as inputs to the controller by keeping K and L either **open** or **close**. Inputs can be done by toggle or converting switches.

2.2.4 Connecting to Idle

The port on one side of the switch is connected to terminal **M** and the port on the other side to the **ground**. Connection between terminal **M** and the **ground** becomes either **open** or **close** by keeping the switch **open** or **close**. When connection between the terminal and the **ground** becomes **close**, the controller will have **idle** function. Inputs can be done by toggle or converting switches.

2.2.5 Connecting to AUX

AUX is a terminal for control signal inputs from load sharing devices or synchronization devices through terminal **N**. It shares load from the generator in parallel operation and receives signal inputs from synchronization devices for the controller to control changes to load. Input signal level is between **DC -5** and **5V** and it is recommended to use shielded cables for signal wires.

2.2.6 Connecting Power to External Devices

It can supply power output of **10V/20mA** to external devices through terminal **P**. Users can easily use this terminal when external auxiliary devices need power supply.

However, power supply of **20mA** or higher should not be used and care should be given to prevent short circuits.

2.3 Connecting to Crank, Run, Over Speed and Communication

2.3.1 Crank, Run, Over Speed and Communication Connection Diagram

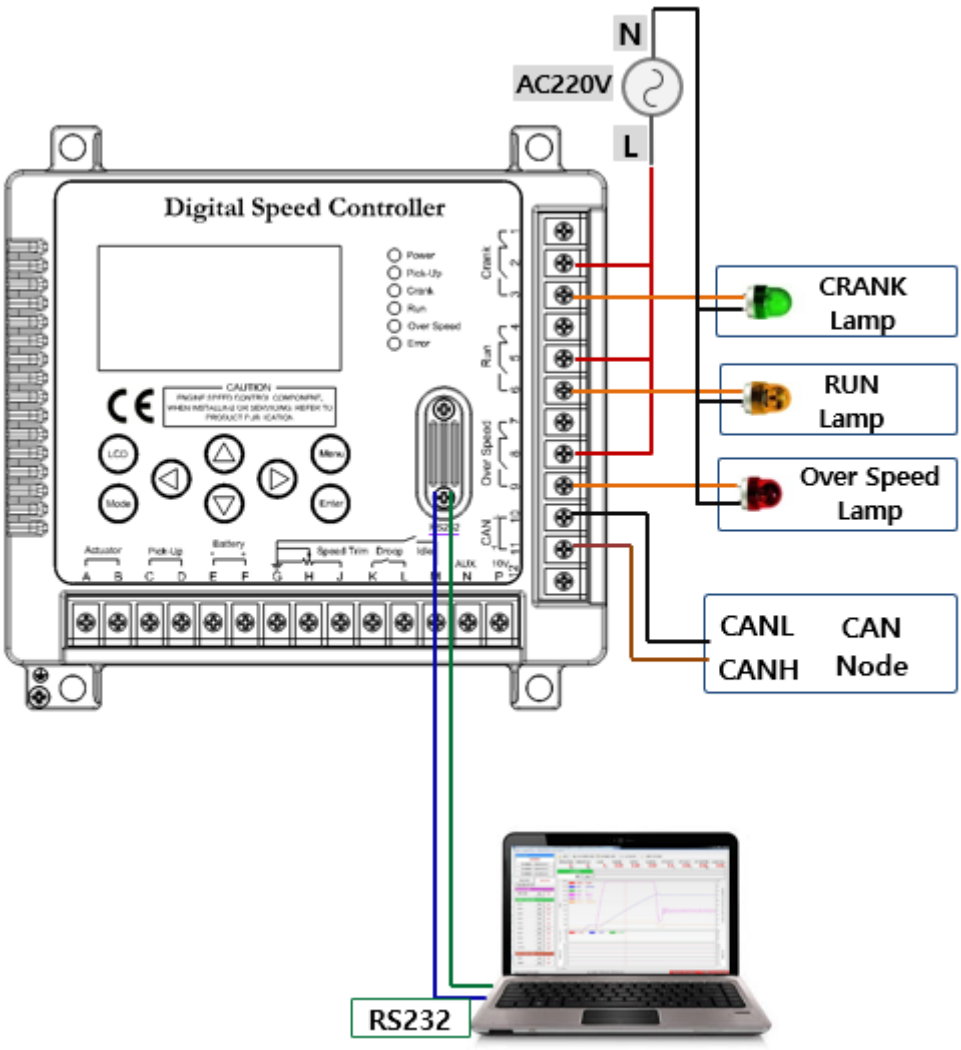


Figure 6: Crank, Run, Over Speed and Communication Connection Diagram

It is used to deliver operation information to external devices by activating contact point (a or b) when activating crank, run or over speed functions.

RS232 and CAN communication is connected to external PCs or hosts so that the controller can transmit system settings or operation information.

2.3.2 Connecting to Crank Terminals

Terminals **1**, **2** and **3** are the ones for **crank** output contact point and the contact point will be in operation when the controller activates the crank function. The second crank contact point is a shared terminal while terminals **1** and **2** are for the contact point **b** and terminals **2** and **3** for the contact point **a**.

Contact points **a** and **b** start to operate when the controller reaches at the RPM delivering control signals to the actuator after the engine is activated. The diagram shows wiring to operate AC220V lamp. The shared terminal is for 220V inputs and the **crank** lamp turns **on** when the contact point a starts to operate.

2.3.3 Connecting to Run Terminals

Terminals **4**, **5** and **6** are the ones for **run** output contact point and the contact point will be in operation when the controller activates the **run** function. The fifth crank contact point is a shared terminal while terminals **4** and **5** are for the contact point **b** and terminals **5** and **6** for the contact point **a**.
Contact points **a** and **b** start to operate when the engine reaches its designated normal speed RPM. The diagram shows wiring to operate AC220V lamp. The shared terminal is for 220V inputs the **run** lamp turns **on** when the contact point a starts to operate.

2.3.4 Connecting to Over Speed

Terminals **7**, **8** and **9** are the ones for **over speed** output contact point and the contact point will be in operation when the controller activates the **over speed** function. The eighth **over speed** contact point is a shared terminal while terminals **7** and **8** are for the contact point **b** and terminals **8** and **9** for the contact point **a**.

Contact points **a** and **b** start to operate when the engine reaches its designated over speed RPM. The diagram shows wiring to operate AC220V lamp. The shared terminal is for 220V inputs the **over speed** lamp turns **on** when the contact point a starts to operate.

2.3.5 Connecting to CAN Communication

Terminal **10** is for **CAN-L** communication and terminal **11** for **CAN-H** communication. **CAN-H** and **CAN-L** are used for CAN communication with remote control and monitoring of the controller operation. The communication code is based on **J1939**.

2.3.6 Connecting to RS232 Communication

D-SUB 9pin (female) is for RS232 communication for connection to external PCs or hosts. The specified dedicated line should be used and only terminals 2, 3, 5 shall be connected, and the other terminals shall not be connected. It can configure system parameters of the controller or communicate with analytic applications.

3. Configuration and Operation

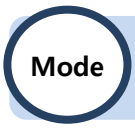
The controller can be configured and operated by input keys according to the menus on the LCD display by selecting proper ones and assigning values in the selected menu to input control information to the system. Input information should immediately apply to the controller system once updated.

3.1 Input Keys

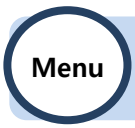
The controller has 8 input keys including LCD, Mode, Menu, Enter, Up, Down, Left and Right.

Each key as respective functions as follows:

LCD key turns on and off the display.



Mode key switches the display to either operation mode or wave form display.



Menu key lets users change the menu display and go back to the previous menu.

Enter key applies designated values on the LCD display to the system.

Up key lets users go up or increase values in the selected menu on the LCD display.

Down key lets users go down or decrease values in the selected menu on the display.

Left key lets users move to the left in the selected menu.

Right key lets users move to the right in the selected menu.

3.2 LCD Display Menu

The overall menu tree of the controller is as follows:

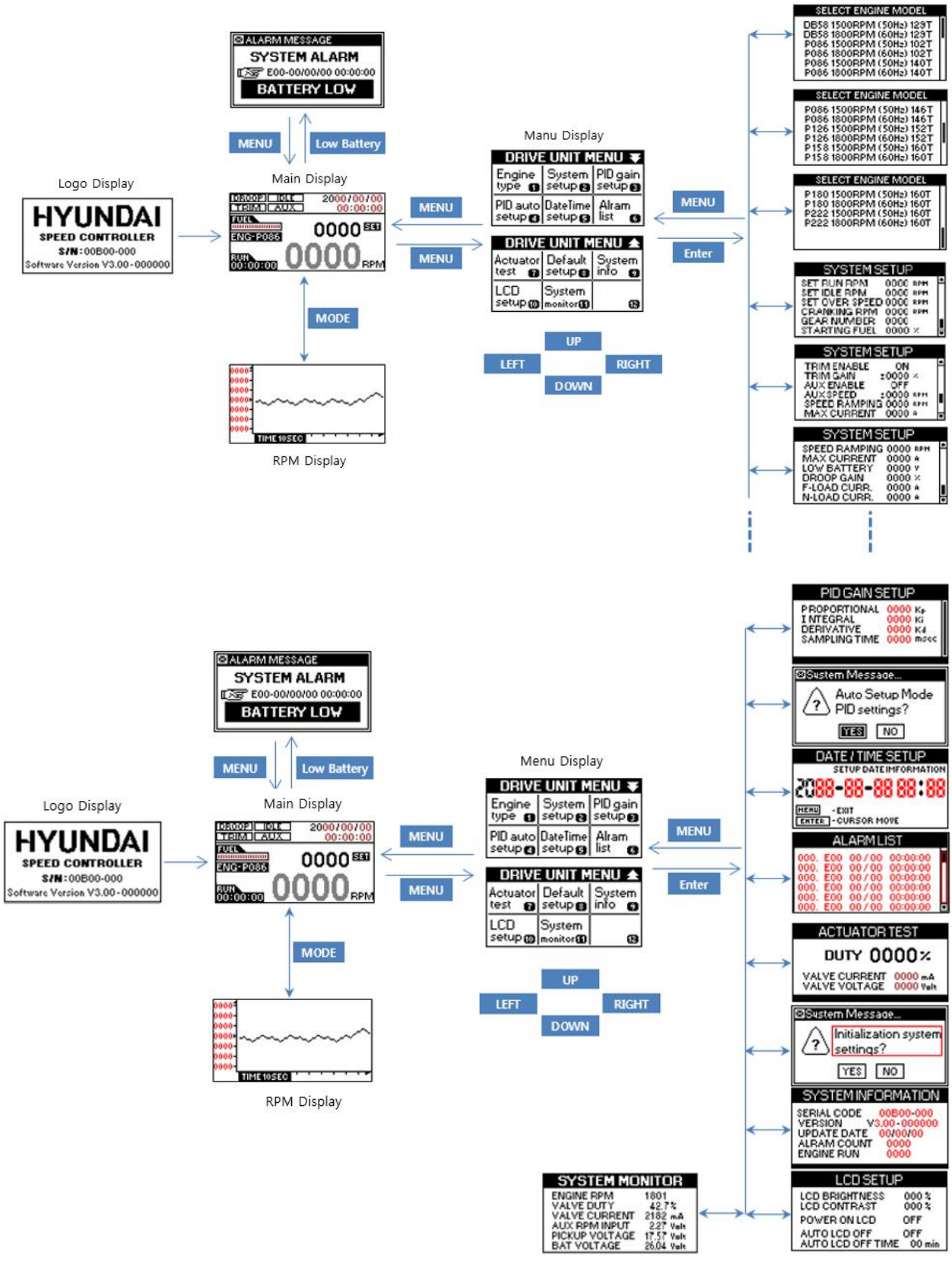


Figure 7: Overall LCD Menu Tree Diagram

3.2.1 LCD Displays After Powered On

When DC +24V power is supplied to the battery terminal (E (-), F (+)) of the controller, the **power** LED in the front side of the controller turns on in **red** and the **error** LED turns on in **red** where there are fault conditions. At this moment, the LCD display is not activated and HYUNDAI logo will appear for 1 second followed by the operation display after pressing the **LCD** button.

The controller will start control based on information from pick-up sensor and other input devices and designated parameter values. At this moment, where breakdowns of the surrounding devices or system errors occur, the LCD display will show such errors and processing messages.

Step 1) DC +24V power supply to the terminals E (-) and F (+)

When DC +24V power is supplied to the terminals E (-) and F (+), the controller will start to operate with the LCD display off. After pressing the **LCD** button, HYUNDAI logo will appear for 1 second as shown below followed by the controller operation display. Then, the LCD display will switch between on and off by pressing the **LCD** button.

Figure 8: HYUNDAI Logo

Step 2) The operation display will show 1 second after the logo appears.

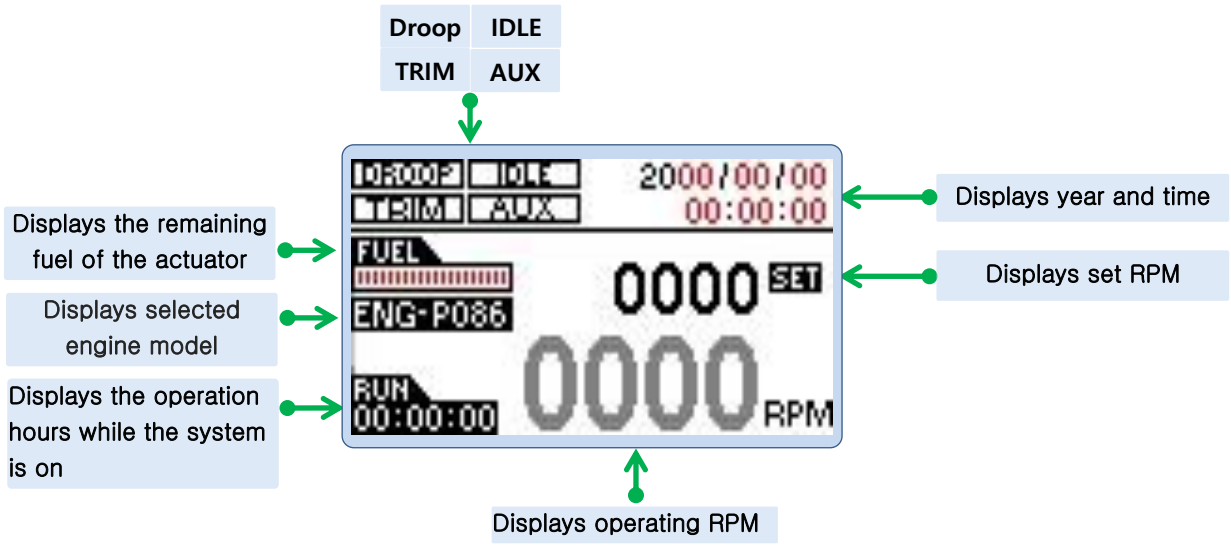
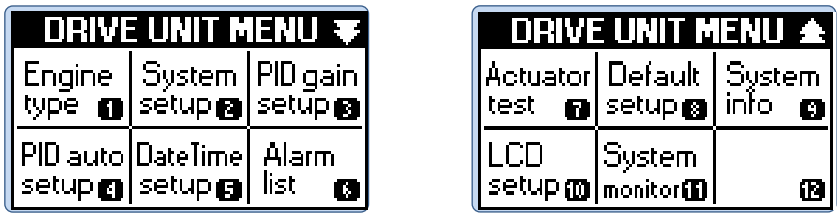


Figure 9: Operation Display

3.2.2 LCD Main Menu Display

Displays main menu screen of the controller

The main menu of the controller has 10 sub-menus.



Menu 1: Main Menu of the Controller - 1 to 2

1) **Engine type**

   The controller can start operation once the initial system values are configured.

   Users can load preset values depending on types of the engines by selecting the type.

2) **System setup**

   It consists of sub-menus related to system settings including RUN/IDLE/OVERSPEED/CRANK/GEARNUMBER.

3) **PID gain setup**

   It consists of sub-menus to designate Kp, Ki and Kd parameter values related to the engine PID control.

4) **PID auto setup**

   It offers function for automatic designation of Kp, Ki and Kd parameter values related to the engine PID control.

5) **DateTime setup**

   It offers function for users to move to the screen for designating year, month, day and hour.

6) **Alarm list**

   It offers function for users to move to the alarm display for the alarm list.

7) **Actuator Test**

   It offers menu to test the impedance (X_L) of the actuator and any problems in operating load current. It displays current and voltage according to the duty values.

8) **Default setup**

   It offers menu to apply designated default values to the selected engine.

9) **System info**

   It offers menu that shows information of the controller. Such information includes the serial number, software version, last update date, alarm count and engine runs.

10) **LCD setup**

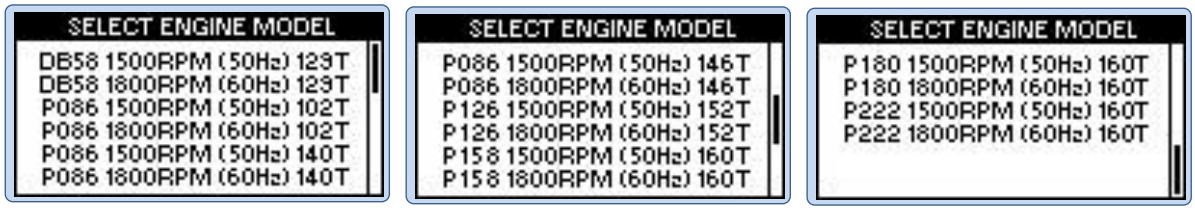
    It offers menu to configure LCD operating conditions including brightness, auto on/off and off hours.

11) **System monitor**

    It offers menu to monitor the controller operation. It shows values for Engine RPM, Valve Duty, Valve Current, Aux RPM Input, Pickup Voltage and Bat Voltage.

3.2.3 Engine Type Setup Menu

This menu offers function to configure setting values of the controller depending on types of the engines in advance and apply such preset values to the selected engine.

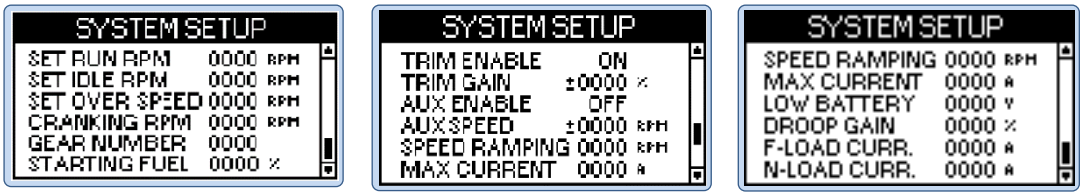


Menu 2: Engine Type Selection Menu

3.2.4 System Setup Menu

System Setup Menu Display of the Controller

It consists of sub-menus for the system configuration items of the controller including the one for configuring RUN/IDLE/OVERSPEED/CRANK/GEAR NUMBER related to RPM setting. Depending on additional functions, users can designate values for STARTING FUEL/SPEED RAMPING/ACTUATOR MAX/LOW BATTERY.



Menu 3: System Setup Menu - 1 to 3

1) SET RUN RPM

Users can designate normal speed (target RPM) of the engine.

Users need to input different normal speed values depending on the specification of the selected engine.

2) SET IDLE RPM

Users can designate the idle speed values of the engine as RPM.

Users need to input values to control the idle operating speed of the engine.

3) SET OVER SPEED

Users can designate RPM values to activate engine protection function when the speed exceeds the normal level (target RPM) and reaches the overspeed range that may cause problems to the engine.

When the engine RPM reaches the over speed RPM range, the engine immediately stops with error messages and alarms.

4) CRANKING RPM

Users can designate RPM values to activate the actuator when the engine starts to operate.

5) GEAR NUMBER

Users can input the number of flywheel teeth in the engine to the controller so that the controller can calculate the accurate RPM depending on the values of the pick-up sensor from the engine.

6) STARTING FUEL

Users can designate the amount of fuels used when the engine starts to operate and the operating current for the controller to activate the actuator changes based on these values.

7) AUX SPEED

Users can adjust values to ensure safe operation of the engine based on the AUX signal values when AUX is enabled.

8) SPEED RAMPING

Users can input ratio values of speed changes when the speed increases or decreases in the idle condition of the engine.

9) MAX CURRENT

Users can designate the maximum operating current for the **actuator** of the engine.

10) LOW BATTERY

It measures the battery voltage supplied to the controller. When the measured values are lower than the present voltage values, it will be alarmed. Usually, the acceptable battery voltage is between 20 and 22V (without load).

11) DROOP GAIN

Users can designate the droop values applicable to maximum load based on the current consumption of the **actuator**.

12) F-LOAD CURR

Users can designate the maximum current values when the generator is in full load.

13) N-LOAD CURR

Users can designate the operating current values of the actuator when the generator has no load.

3.2.5 PID Gain Setup Menu

Users can input Kp, Ki and Kd values as inputs to the PID control of the engine. Kp means proportional values while Ki means integral of the proportional values and Kd means differential of the proportional values.

Menu 4: PID Gain Setup Menu

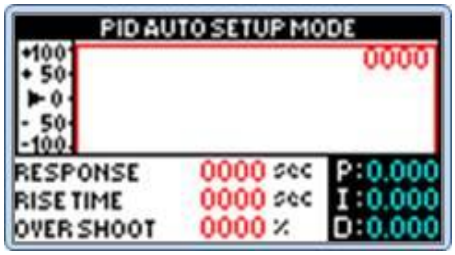
3.2.6 PID Auto Setup Menu

The menu offers function for automatic designation of the P, I and D parameter values related to the engine PID control.

After starting the engine, select **DRIVE UNIT MENU** in the main menu while the engine has no load and then **PID auto setup** menu, press Enter. Then, the system message shows "Auto Setup Mode PID setting?" with YES or NO option. If you select YES, the controller will repeatedly change the RPM to automatically calculate the optimized P, I and D values.

If the controller identifies the optimized P, I and D values within 30 cycles, it will display "PID Auto Setup Complete, OK". When you press Enter, it will apply tuned P, I and D values and close the menu.

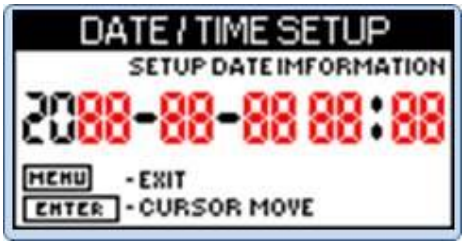
If the controller fails to identify the optimized P, I and D values within 30 cycles, it will display "PID No Successful, OK". When you press Enter, it will apply the final P, I and D values and close the menu.



Menu 5: PID auto setup menu

3.2.7 Date/Time Setup Menu

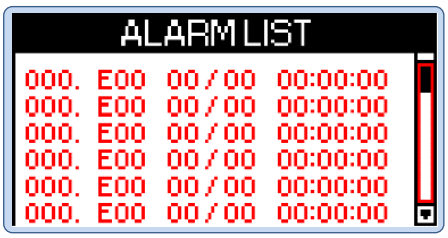
Users can designate year, month, day, hour and minute for the controller and the designated time will be used to monitor the system and manage fault messages.



Menu 6: DATE/TIME SETUP Menu

3.2.8 Alarm List Menu

This menu displays year, month, day, hour and minute for the errors in the controller and types of the faults in codes which are used in troubleshooting.



Menu 7: ALARM LIST Menu

3.2.9 Default Setup Menu

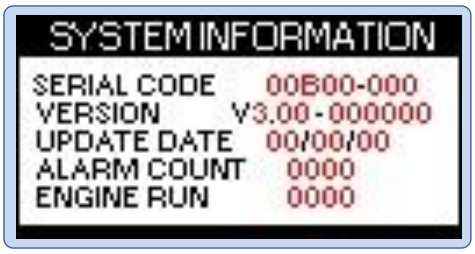
When you cannot identify the type of the control engine by the controller, this menu offers the most common parameter setting values. For default setup, select YES and then press Enter button. If you don't want to implement this function, press No button.

If you press YES, all the configuration values will be changed to the default ones of the engine.

Menu 8: Default Setup Menu

3.2.10 System Info Menu

The controller displays its information including the serial number, software version, last update date, alarm count and engine runs.



Menu 9: System Info Menu

3.3 Engine Configuration

3.3.1 Engine Type Configuration

Users can store control setting information depending on types of the engines in the internal memory of the controller. If you select your engine type, applicable parameters will be automatically configured accordingly. This feature is available for 21 different types of engines.

Designated Parameters by Engine Type (Land use)

No	Menu Name	Run RPM	Over Speed	Gear Teeth	Starting Fuel	PID Value
1	DB58 1500RPM (50Hz) 129T	1500RPM	1725RPM	129	65%	Optimized Value
2	DB58 1800RPM (60Hz) 129T	1800RPM	2070RPM	129	65%	Optimized Value
3	P086 1500RPM (50Hz) 102T	1500RPM	1725RPM	102	65%	Optimized Value
4	P086 1800RPM (60Hz) 102T	1800RPM	2070RPM	102	65%	Optimized Value
5	P086 1500RPM (50Hz) 140T	1500RPM	1725RPM	140	65%	Optimized Value
6	P086 1800RPM (60Hz) 140T	1800RPM	2070RPM	140	65%	Optimized Value
7	P086 1500RPM (50Hz) 146T	1500RPM	1725RPM	146	65%	Optimized Value
8	P086 1800RPM (60Hz) 146T	1800RPM	2070RPM	146	65%	Optimized Value

9	P126 1500RPM (50Hz) 152T	1500RPM	1725RPM	152	65%	Optimized Value
10	P126 1800RPM (60Hz) 152T	1800RPM	2070RPM	152	65%	Optimized Value
11	P126 1500RPM (50Hz) 106T	1500 RPM	1725RPM	106	65%	Optimized Value
12	P126 1800RPM (60Hz) 106T	1800 RPM	2070RPM	106	65%	Optimized Value
13	P158 1500RPM (50Hz) 160T	1500 RPM	1725RPM	160	65%	Optimized Value
14	P158 1800RPM (60Hz) 160T	1800 RPM	2070RPM	160	65%	Optimized Value
15	P158 2350RPM (60Hz) 160T	2350 RPM	2467RPM	160	65%	Optimized Value
16	P180 1500RPM (50Hz) 160T	1500 RPM	1725RPM	160	65%	Optimized Value
17	P180 1800RPM (60Hz) 160T	1800 RPM	2070RPM	160	65%	Optimized Value
18	P180 2350RPM (60Hz) 160T	2350 RPM	2467RPM	160	65%	Optimized Value
19	P222 1500RPM (50Hz) 160T	1500 RPM	1725RPM	160	65%	Optimized Value
20	P222 1800RPM (60Hz) 160T	1800 RPM	2070RPM	160	65%	Optimized Value
21	P222 2350RPM (60Hz) 160T	2350 RPM	2467RPM	160	65%	Optimized Value

Designated Parameters by Engine Type (marine use)

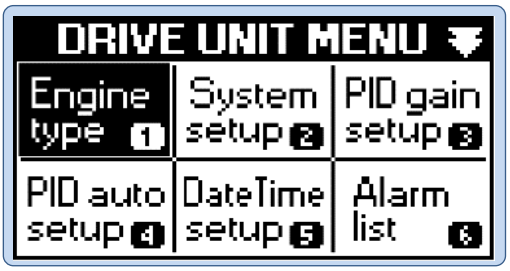
No	Menu Name	Run RPM	Over Speed	Gear Teeth	Starting Fuel	PID Value
1	AD066TI 1500RPM (50Hz) 129T	1500 RPM	1725RPM	129	60%	Optimized Value
2	AD066TI 1800RPM (60Hz) 129T	1800 RPM	2070RPM	129	60%	Optimized Value
3	AD086TI 1500RPM (50Hz) 140T	1500 RPM	1725RPM	140	60%	Optimized Value
4	AD086TI 1800RPM (60Hz) 140T	1800 RPM	2070RPM	140	60%	Optimized Value
5	AD126TI 1500RPM (50Hz) 152T	1500 RPM	1725RPM	152	60%	Optimized Value
6	AD126TI 1800RPM (60Hz) 152T	1800 RPM	2070RPM	152	60%	Optimized Value
7	4AD126TIF 1500RPM (50Hz) 106T	1500 RPM	1725RPM	106	60%	Optimized Value
8	4AD126TIS 1800RPM (60Hz) 106T	1800 RPM	2070RPM	106	60%	Optimized Value
9	AD136 1500RPM (50Hz) 140T	1500 RPM	1725RPM	140	60%	Optimized Value
10	AD136 1800RPM (60Hz) 140T	1800 RPM	2070RPM	140	60%	Optimized Value
11	AD136T 1500RPM (50Hz) 140T	1500 RPM	1725RPM	140	60%	Optimized Value
12	AD136T 1800RPM (60Hz) 140T	1800 RPM	2070RPM	140	60%	Optimized Value
13	AD136TI 1500RPM (50Hz) 140T	1500 RPM	1725RPM	140	60%	Optimized Value
14	AD136TI 1800RPM (60Hz) 140T	1800 RPM	2070RPM	140	60%	Optimized Value
15	AD158TI 1500RPM (50Hz) 160T	1500 RPM	1725RPM	160	60%	Optimized Value
16	AD158TI 1800RPM (60Hz) 160T	1800 RPM	2070RPM	160	60%	Optimized Value
17	4AD158TI 1500RPM (50Hz) 160T	1500 RPM	1725RPM	160	60%	Optimized Value
18	4AD158TI 1800RPM (60Hz) 160T	1800 RPM	2070RPM	160	60%	Optimized Value
19	AD180TI 1500RPM (50Hz) 160T	1500 RPM	1725RPM	160	60%	Optimized Value
20	AD180TI 1800RPM (60Hz) 160T	1800 RPM	2070RPM	160	60%	Optimized Value
21	AD196TI 1500RPM (50Hz) 152T	1500 RPM	1725RPM	152	60%	Optimized Value
22	AD196TI 1800RPM (60Hz) 152T	1800 RPM	2070RPM	152	60%	Optimized Value
23	AD222TI 1500RPM (50Hz) 160T	1500 RPM	1725RPM	160	60%	Optimized Value
24	AD222TI 1800RPM (60Hz) 160T	1800 RPM	2070RPM	160	60%	Optimized Value
25	4AD222TI 1500RPM (50Hz) 160T	1500 RPM	1725RPM	160	60%	Optimized Value
26	4AD222TI 1800RPM (60Hz) 160T	1800 RPM	2070RPM	160	60%	Optimized Value

Table 1: Configuration Values by Engine Type

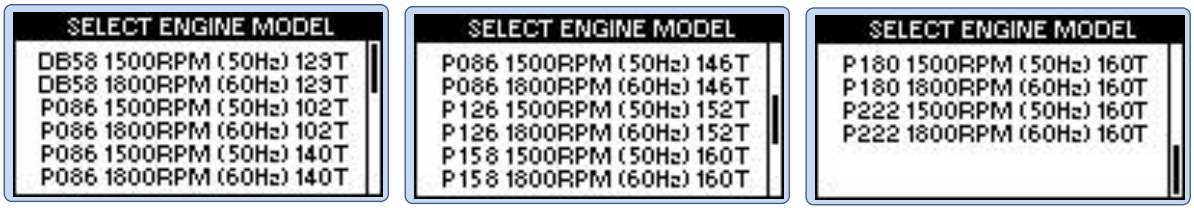
- **Engine Configuration Procedure**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **Engine Type** by using **Up** and **Down** buttons in **DRIVE UNIT MENU** and then press **Enter** button.



Step3) Go to **Engine Type** menu and select your engine type using **Up** and **Down** buttons. Then, press **Enter** button. At this moment, setting values according to the selected type of the engine are designated and will be used as information for the controller to control the actuator.



Menu 10: Selection List by Engine Type

3.3.2 System Setup Configuration

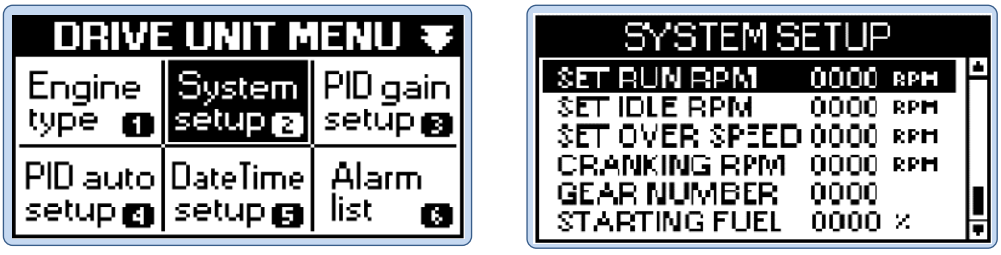
Main setting items of the controller includes **GEAR NUMBER, CRANKING RPM** and **SET RUN RPM**. You need to designate setting values to these items. Other system setup items are optional and therefore you can designate values for those items as necessary.

- Configuring **SET RUN RPM**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **SET RUN RPM** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the normal operating speed of the engine and then press **Enter** button.

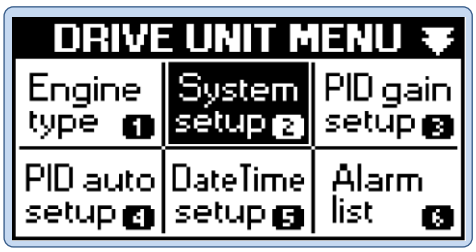


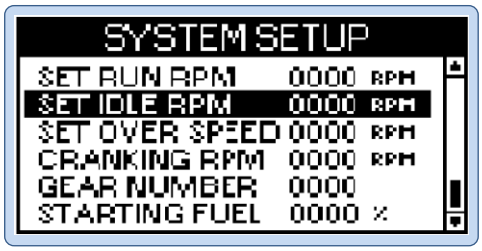
- Configuring **SET IDLE RPM**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **SET IDLE RPM** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the **idle** operating speed of the engine and then press **Enter** button.



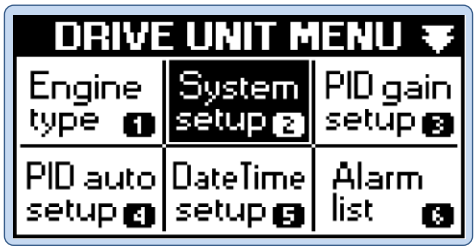


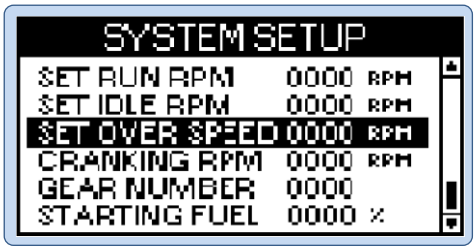
- Configuring **SET OVER SPEED**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **SET OVER SPEED** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the **over speed** values of the engine and then press **Enter** button.



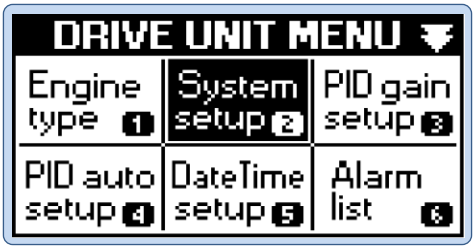


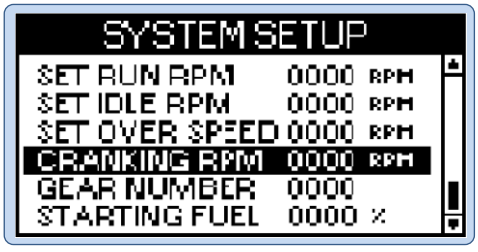
- Configuring **CRANKING RPM**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **CRANKING RPM** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the **RPM** values at which the controller starts to control the **actuator** when the engine starts to operate and then press **Enter** button.



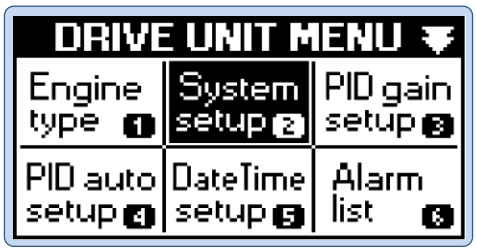


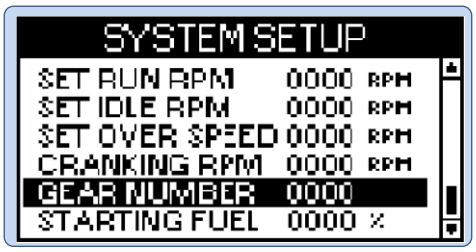
- Configuring **GEAR NUMBER**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **GEAR NUMBER** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the number of gear teeth in the engine and then press **Enter** button.



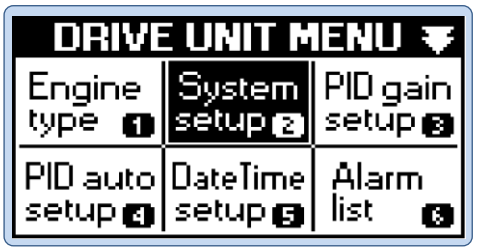


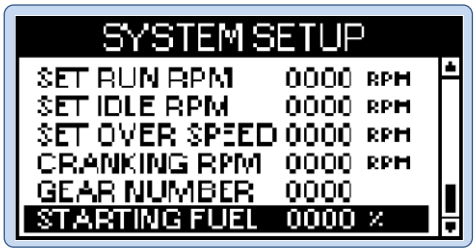
- Configuring **STARTING FUEL**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **STARTING FUEL** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the percentage for the amount of fuel sprayed when the engine starts and then press **Enter** button.



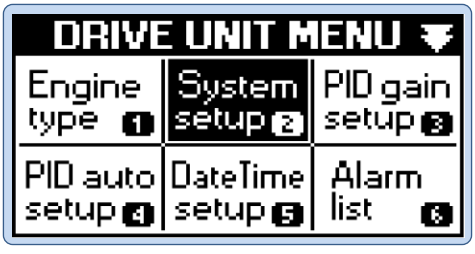


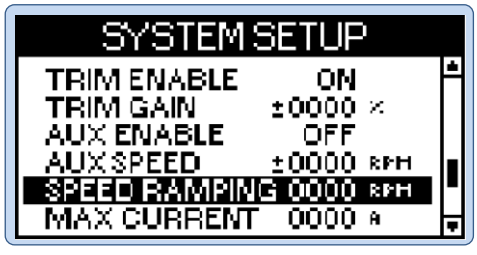
- Configuring **SPEED RAMPING**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **SPEED RAMPING** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the ratio of changes to the speed when increasing from the idle speed or decreasing from the increased speed and then press **Enter** button.



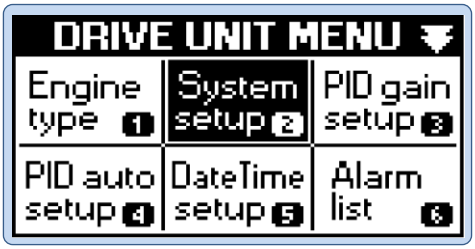


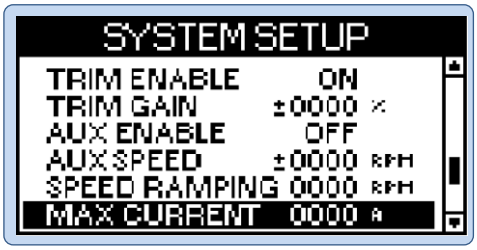
- Configuring **MAX CURRENT**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **MAX CURRENT** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the limit of the maximum current consumption of the **actuator** and then press **Enter** button (Max. 10A).



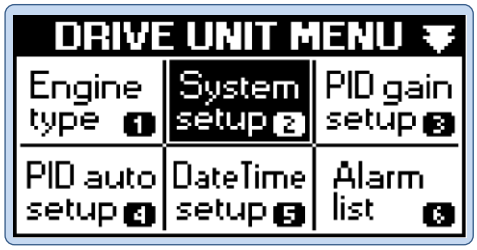


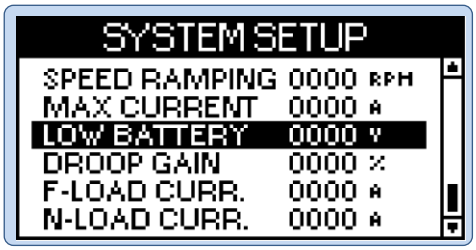
- Configuring **LOW BATTERY**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **LOW BATTERY** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to input voltage values at which low battery alarms are activated and then press **Enter** button.



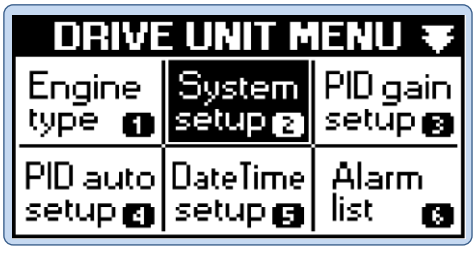


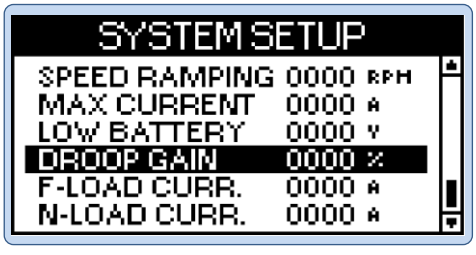
- Configuring **DROOP GAIN**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **DROOP GAIN** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the RPM values with adjusted ratio to decrease at the maximum load when the generator is in parallel operation and then press **Enter** button.





DROOP Function

Droop function is indicated in percentages as follows: RPM with no load is subtracted by RPM with maximum load and then divided by RPM with no load.

$$\textbf{Droop}\% = \frac{\text{RPM with no load} - \text{RPM with maximum load}}{\text{RPM with no load}}$$

(Example for 3% Droop)

Assuming that RPM with no load is 1,800 and RPM with maximum load is 1,854 then the percentage will be 3%. It means that the generator output will be changed by 33.3% as the frequency changes by 1% due to the actuator control.

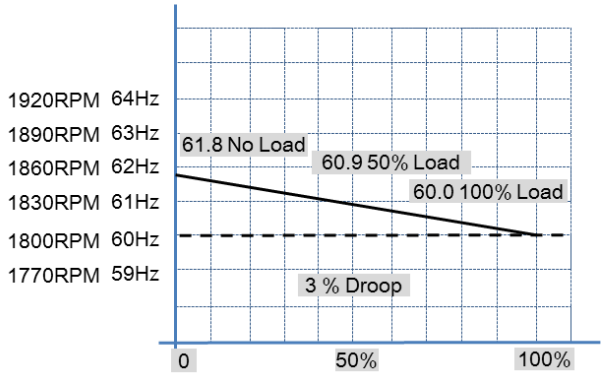


Figure 10: 3% Droop

(Example for 7% Droop)

Assuming that RPM with no load is 1,800 and RPM with maximum load is 1,926 then the percentage will be 7%. It means that the generator output will be changed by 14.3% as the frequency changes by 1% due to the actuator control.

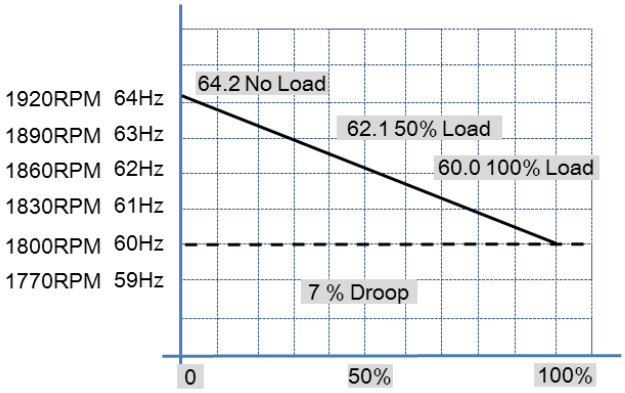


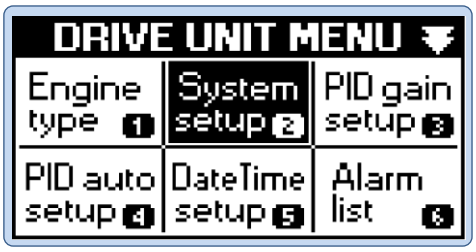
Figure 11: 7% Droop

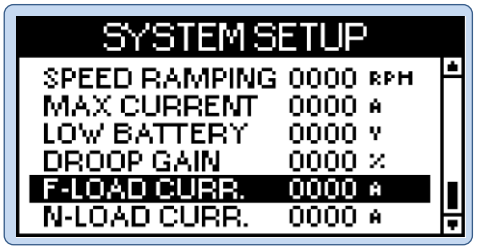
- **F-LOAD CURR.**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **F-LOAD CURR.** in SYSTEM SETUP menu and then press **Enter** button. Use **Up** and **Down** buttons to input the maximum current values of the **actuator** for the generator with full load and then press **Enter** button.



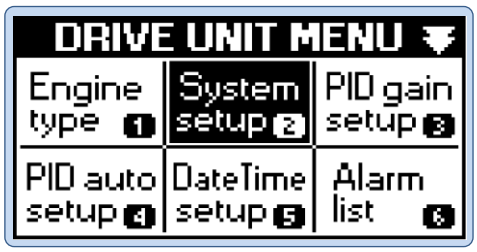


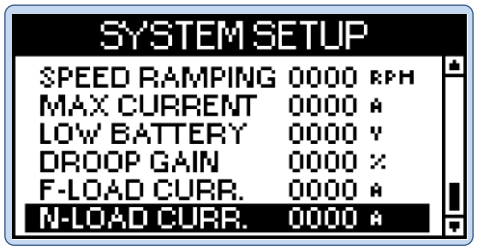
- **N-LOAD CURR.**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

Step2) Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

Step3) Select **N-LOAD CURR.** in SYSTEM SETUP menu and then press **Enter** button. Use **Up** and **Down** buttons to input the operating current values of the **actuator** for the generator with no load and then press **Enter** button.





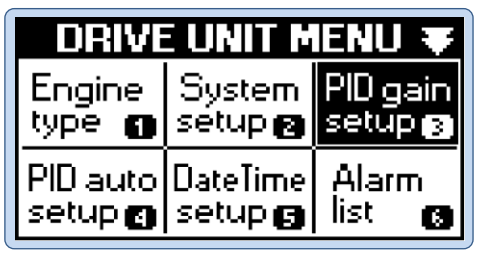
3.3.3 PID Gain Setup Configuration

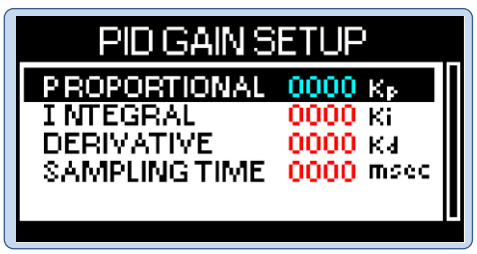
- Configuring **PID Gain Kp, Ki and Kd Values**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up, Down, Left** and **Right** buttons to select **PID gain setup** menu and then press **Enter** button.

Step2) Use **Up** and **Down** buttons in **PID GAIN SETUP** to select **PROPORTIONAL, INTEGRAL** or **DERIVATIVE** and then press **Enter** button**.**

In PID GAIN SETUP, if a user sets the value over than 100 about each P, I, D, we could not the warrant of the product quality.

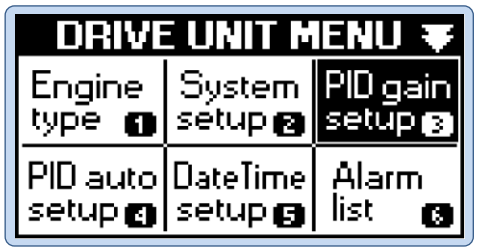


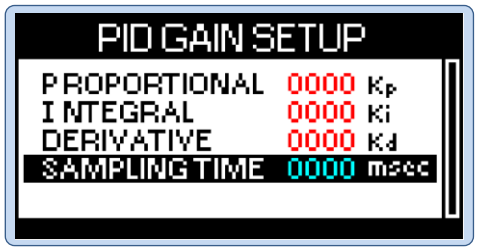


- Configuring **PID SAMPLING TIME**

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up, Down, Left** and **Right** buttons to select **PID gain setup** menu and then press **Enter** button.

Step2) Use **Up** and **Down** buttons in **PID GAIN SETUP** to select **SAMPLING TIME** and then press **Enter** button**.** Use **Up** and **Down** buttons to input **SAMPLING TIME** values and then press **Enter** button.



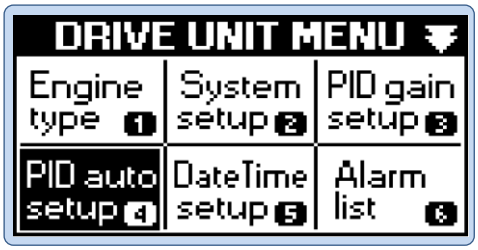


3.3.4 PID Auto Setup Value Configuration

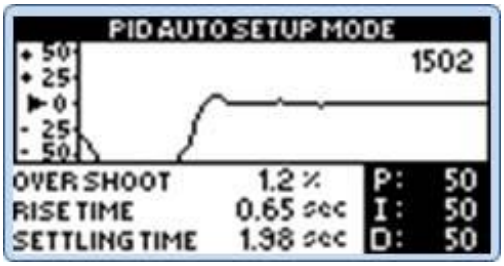
Step1) Select your type in Engine Type menu and then start the engine with the preset configuration values maintaining it with no load.

Step2) During the normal operation, press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up**, **Down**, **Left** and **Right** buttons to select **PID auto setup** menu and then press **Enter** button.

Step3) The menu offers function for automatic designation of the P, I and D parameter values related to the engine PID control. Select PID auto setup menu in **DRIVE UNIT MENU** and then press Enter button to see the system message "Auto Setup Mode PID setting?" with YES or NO options.



Step4) Press YES and then the system message "PID AUTO SETUP MODE" will appear. As PID auto setup was initiated during the operation, PID auto tuning is already in progress.



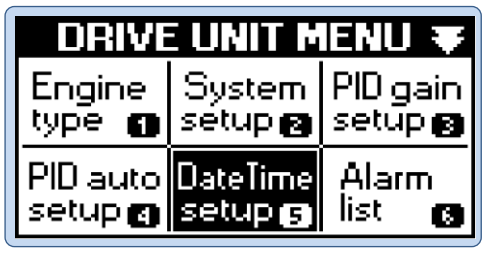
Step5) PID tuning repeats a process to obtain PID values and a window to indicate whether the process succeeded or failed will appear in several minutes (approx. 4 to 6 minutes). If the process succeeded, the system message window will appear together with OK button. If you press Enter button, you will go back to normal operation window and the auto-tuned values will apply to the normal operation that will be continued.

Step6) If auto-tuning failed to identify optimized P, I and D values within 4 to 6 minutes, the system message window will display failure. If you press Enter button, you will go back to normal operation window. If you want to repeat the process, you need to start with Step1 again.

3.3.5 DATE/TIME Value Configuration

Step1) press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use direction buttons to select **DateTime setup** menu.

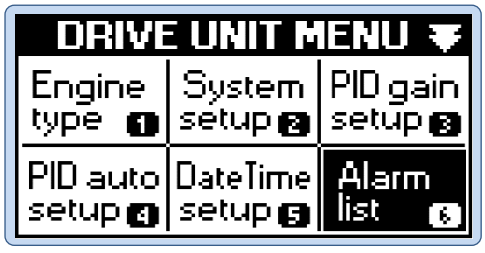
Step2) Use **Up**, **Down**, **Left** and **Right** buttons to input year, month, day and hour and then press **Enter** button.

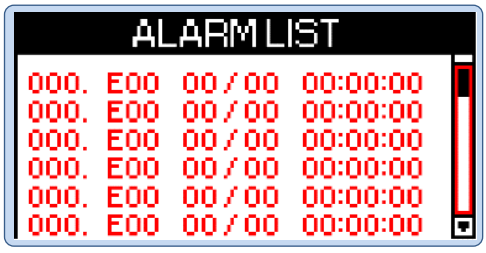


3.3.6 ALARM LIST

Step1) press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use direction buttons to select **Alarm List** menu and then press **Enter** button.

Step2) Use **Up**, **Down**, **Left** and **Right** buttons in **ALARM LIST** menu to confirm the fault messages.





[Alarm Code Table]

Alarm Code	Alarm Item	Description	Identified Alarm Output
E01	Battery Low	When the battery voltage continues to be lower than Low Battery voltage values for more than 5 seconds	LCD alarm message, Error LED lamp
E02	Battery High	When the battery maintains its voltage exceeding 30VDC for more than 5 seconds	LCD alarm message, Error LED lamp
E03	Pick-up Error	Problems in sensor signals when the engine starts. (Engine RPM lower than 600)	LCD alarm message, Error LED lamp
E04	Pick-up Error	Problems in sensor signals during the engine operation (Engine RPM 600 or higher)	LCD alarm message, Error LED lamp
E05	Actuator Current Short	Disconnection in the actuator or the connecting circuits	LCD alarm message, Error LED lamp
E06	Actuator Current Broken	Short-circuits in the actuator or the connecting circuits	LCD alarm message, Error LED lamp
E07	Over Speed	Engine RPM exceeding the configured over speed values	LCD alarm message, Error LED lamp
E08	FET Drive Error	Damages to components in the actuator output section inside the controller	LCD alarm message, Error LED lamp
E09	Pick-Up Lost	Pick-Up signal lost. (Engine RPM higher than 600rpm)	LCD alarm message, Error LED lamp

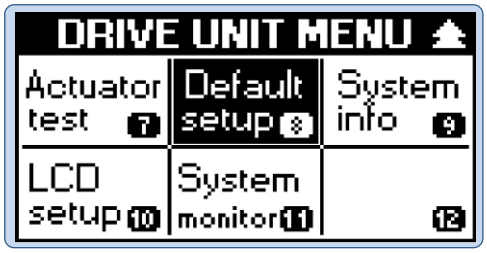
3.3.7 Actuator test

The menu offers function to test whether there is any problem in operating load current of the actuator attached to the engine. It indicates voltage and current for on/off.

3.3.8 Default setup Functions

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up**, **Down**, **Left** and **Right** buttons to select **Default setup** menu and then press **Enter** button. At this moment, the system message **"Initialization system setting?"** will appear**.**

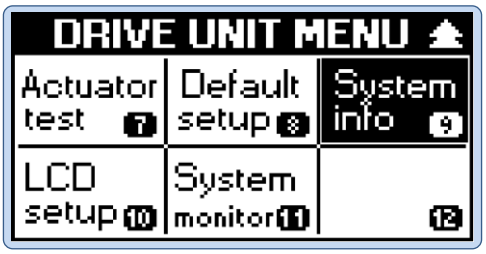
Step2) Use **Left** and **Right** buttons to select either **YES** or **NO** in **System Message** and then press **Enter** button.

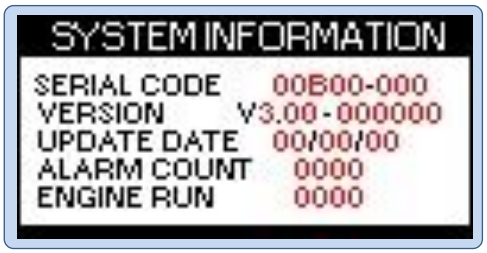


Default setup will change the configuration values of the engine to the default values. In order to initiate default setup, you need to select **YES** and then press **Enter** button. Press **No** button if you don't want to.

3.3.9 System info Functions

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up**, **Down**, **Left** and **Right** buttons to select **System info** menu and then press **Enter** button.



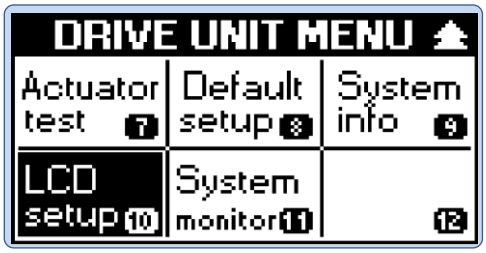


The menu displays information of the controller and the information includes the serial number, software version, last update date, alarm count and engine runs.

3.3.10 LCD setup Functions

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up**, **Down**, **Left** and **Right** buttons to select **LCD setup** menu and then press **Enter** button.

Step2) Use **Up** and **Down** buttons to select menus including **LCD BRIGHTNESS** and **LCD CONTRAST** for adjustment and then press **Enter** button. Use **Up** and **Down** buttons to input setting values and then press **Enter** button.



3.3.11 System monitor Functions

Step1) Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up**, **Down**, **Left** and **Right** buttons to select **System monitor** menu and then press **Enter** button. It offers menu to monitor the controller operation. It shows values for Engine RPM, Valve Duty, Valve Current, Aux RPM Input, Pickup Voltage(Peak Value) and Bat Voltage.

4. How to Operate

4.1 Operating Sequence for Digital Speed Controller

STEP1) Supply DC +24V power to the battery terminals (E (-), F (+)) of the controller.

STEP2) Configure parameter values required for selection of the engine type and control of the engine.

STEP3) Install the controller on the generator system and complete circuit wiring.

STEP4) The controller will activate the actuator with power supply and pick-up sensor input.

4.2 Detailed Operating Sequence

STEP1) Supply DC +24V power to the battery terminals (E (-), F (+)) of the controller.

Power supply to the controller can be done by direct connection to the battery or power supply controlled by external control devices. Fuses (15A/24V) are required for power supply to the controller through the terminal.

When the controller displays **Low Battery** Fault message, you need to charge the battery or replace it with the one having normal voltage before starting the controller.

STEP2) Configure parameter values required for selection of the engine type and control of the engine.

There are 3 ways to configure parameters required for the controller:

1. Using default setup
2. Designating the engine type in Engine Type menu
3. Configuring each parameter in System setup menu

For more information, see **Chapter 3**. Configuration and Operation.

STEP3) Install the controller on the generator system and complete circuit wiring.

Once the configuration is completed, the controller will be in **Stand By** condition preparing to receive input information from **pick-up** sensor and surrounding terminals and operate.

STEP4) The controller will activate the actuator with power supply and pick-up sensor input.

When the power is supplied and the **pick-up** terminal delivers normal sensor inputs as the **engine** starts, the **controller** activate the **actuator**.

5. Troubleshooting

5.1 Alarm List Check

Where there are problems in the system operation, you need to review the alarm list menu of the controller and then check the engine and the system in reference to the alarm codes.

Land/marine

Alarm Code	Alarm Item	Alarm Condition	Output Control	Measures
E01	Battery Low	When the battery voltage continues to be lower than Low Battery voltage values for more than 5 seconds	1. Alarm message pop-up on LCD 2. Error LED on	1. Check the battery line 2. Replace the battery
E02	Battery High	When the battery maintains its voltage exceeding 30VDC for more than 5 seconds	1. Alarm message pop-up on LCD 2. Error LED on	1. Check the battery line 2. Replace the battery
E03	Pick-up Error	Problems in sensor signals when the engine starts (Engine RPM lower than 600)	1. Alarm message pop-up on LCD 2. Error LED on 3. Actuator control signal off	1. Check the RPM sensor and connecting circuits 2. Replace the RPM sensor
E04	Pick-up Error	Problems in sensor signals during the engine operation (Engine RPM 600 or higher)	1. Alarm message pop-up on LCD 2. Error LED on 3. Actuator control signal off	1. Check the RPM sensor and connecting circuits 2. Replace the RPM sensor
E05	Actuator Current Short	Disconnection in the actuator or the connecting circuits	1. Alarm message pop-up on LCD 2. Error LED on	1. Check the disconnection in the actuator and connecting circuits 2. Replace the actuator
E06	Actuator Current Broken	Short-circuits in the actuator or the connecting circuits	1. Alarm message pop-up on LCD 2. Error LED on	1. Check the disconnection in the actuator and connecting circuits 2. Replace the actuator
E07	Over Speed	Engine RPM exceeding the configured over speed values	1. Alarm message pop-up on LCD 2. Error LED on 3. Actuator control signal off	1. Check the speed setting 2. Adjust PID setting values
E08	FET Drive Error	Damages to components in the actuator output section inside the controller	1. Alarm message pop-up on LCD 2. Error LED on 3. Actuator output power cutoff	1. Check the actuator and connecting circuits 2. Replace the controller
E09	Pick-Up Lost	Pick-Up signal lost. (Engine RPM higher than 600rpm)	1. Alarm message pop-up on LCD 2. Error LED on 3. Actuator output power cutoff	1. Check the RPM sensor and connecting circuits 2. Replace the RPM sensor

1) When problems described in alarm codes E03, E04, E07, E08 or E09 occur, the engine is not available for safe operation and therefore the engine will stop as the controller will turn off the actuator for safety.

2) When problems described in alarm codes E03, E04, E07 or E08 occur, the engine will not be able to restart as long as the alarm is not released.
3) When alarms occur, you can release them by turning off the power of the controller.

5.2 System Checks and Measures

For initial installation, it is recommended for you to check any disconnection in circuits before taking measures described here (see Chapter 2. Installation for how to install the controller).

You can check the controller for failure diagnosis in accordance with the following procedure.

Step1) Check the battery voltage whether it is higher than the Low Voltage setting value. If normal, supply power to the controller and then operate it. If the voltage is lower than the setting value, you need to charge the battery or replace it before operating the system.

Step2) Check the input resistance in the DC +24V input terminals (-E, +F) of the battery whether the resistance is higher than approx. 10K Ohm. If the resistance does not meet this condition, do not supply power to the controller and contact our A/S center for service request.

Step3) Check whether the power LED turns on or not after supplying power to DC +24V input terminals (-E, +F) of the battery. If the LED does not turn on, cut the power off and contact our A/S center for service request.

Step4) Check whether the power LED turns on and HYUNDAI logo appears on the LCD display after supplying power to DC +24V input terminals (-E, +F) of the battery. If you cannot see the logo, press LCD key button to check the LCD display once again. If you cannot still see the logo, cut the power off and contact our A/S center for service request.

Step5) Check the controller terminals (C & D) with AC meter or oscilloscope to check whether signal inputs of AC RMS 3V or higher are detected. If no signal detected, check whether the pick-up sensor maintains the gap between 0.9 and 1.1mm and then check whether the pick-up sensor has resistance of 110 Ohms (±10%). If you cannot still detect no signal, replace the pick-up sensor and then operate the controller.

6. Warranty and A/S Service

6.1 Warranty

As this manual contains important contents related to safety, use and maintenance of the product. So please read this manual carefully and then use the product in a proper manner.

Those who are not familiar with the product should keep this manual close to it.

We are not responsible for human injuries or property damages caused by the following reasons:

- Where you use the product for purposes other than the ones described in this manual
- Where you alter the product or its components at discretion
- Where you disassemble the product at discretion to resolve problems
- Where you use accessories or parts not supplied or recommended by us

※ Where you use accessories or parts manufactured by other companies, please contact our service center to check their compatibility.

6.2 A/S Service Information

- When you request A/S service, please let us know the model name, breakdown conditions and your contact information.
- Please ask the seller.

Digital Panel for Marine Engines

User Manual

Ver.1.2

HYUNDAI

Contents

Contents

1. General Information

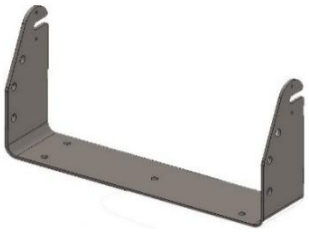
1.1 Product Information

The name of the product model is a digital panel applicable to ships, generators and other various marine engines. The product is intended to improve problems of existing analog panels and allow users to check engine controls and conditions by means of a digital visualization product. It provides information in analog graphic gauges and digital displays for enhanced user experiences.

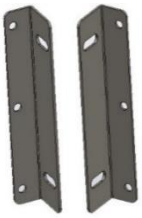
1.2 Components and Optional Accessories

Components

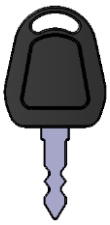
① Digital Panel



② Desk Mounting Type Bracket

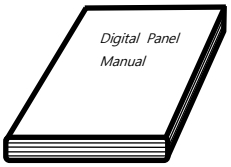


③ Flush Mounting Type Bracket



④ Key x 2

⑤ Desk Mounting Type Parts x 2



⑥ Manual

Optional Accessories

① CCTV (Analog)

② Coaxial Cable (Shielded)

1. General Information

1.3 Product Specification

Digital Panel Specification

No.	Item	Description
1	Microprocessor	• Cortex-A8, dsPIC33FJ256
2	Software	• Windows CE 6.0 R2
3	Display	• 10.2" Color TFT LCD • 800 * 480 (Pixels) • 16:9
4	Flash Memory	• 256MB (Flash) • 8GB (MicroSD card)
5	RAM	• 512MB
6	Operating Voltage	• DC 24V (16 to 30V)
7	USB	• USB 2.0 1 Port
8	Operating Temperature	• - 20℃ to 70℃
9	Internal Buzzer	• Piezo Buzzer 98dB
10	Communication	• J1939 CAN Communication • RS232
11	Dimensions	• W 343.5 x H 270.5 x D 120

[Table 1-1]

2. Product Installation

2.1 Cautions

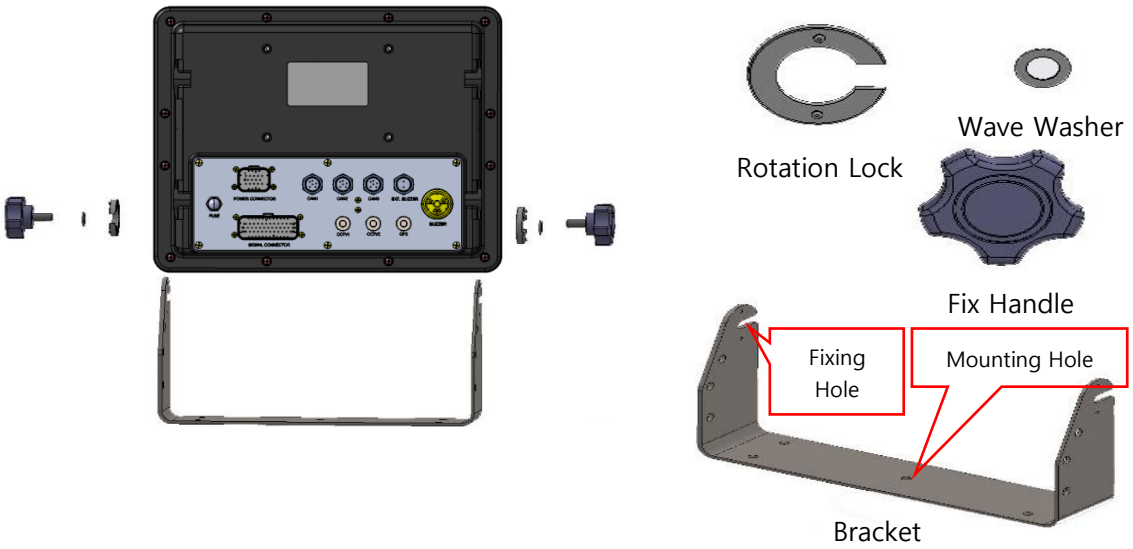
- Unskilled personnel should read this manual before use.
- Do not use or keep the product close to combustible sprays or inflammable.
- Use soft and dry cloth to clean the monitor.
- Turn off the product, pull out the harness cable and then contact our service center when you see smoke from the monitor or have strange smells.
- When you see an alarm on, you always need to check the product before operation.
- Do not disassemble the product cover at discretion (warranty does not cover unauthorized disassembly).
- Excessive impact may damage the display although a reinforced display is used.
- Use connectors matching each other when connecting them to the back of the product.
- Do not contact or remove connectors while the power is on. It may cause electric shock or lead to malfunction.
- Do not exercise excessive force when rotating to ON/OFF with the key inserted.
- Do not use the product with wet hands.
- Use protective caps for back side connectors that are not used.

2. Product Installation

2.2 Desk Mounting Type

Desk Mounting types are installed in the bridge by using desk mounting brackets delivered with the product.

※ Mounting Hole Spec: M6 bolt



[Fig. 2-1] Desk Mounting Type Diagram

▶ Installing Desk Mounting type digital panel

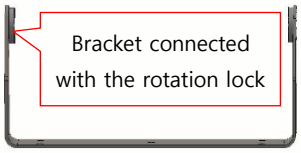
① Check whether the bridge has engine harness wiring.

② Use the mounting hole to fix the bracket in a place within reach of the engine harness wiring.

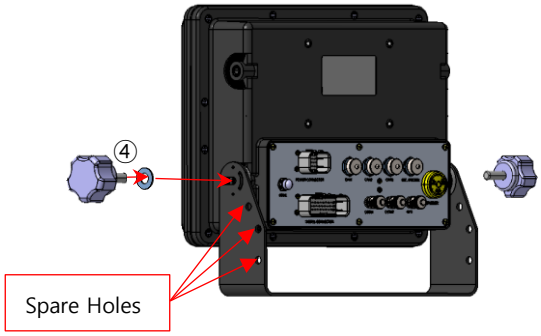
③ Place the product inside the bracket connected with the rotation lock to connect it with the rotation lock.

④ Put the wave washer in the fix handle and connect it with the fix handle to the direction indicated by an arrow and adjust the viewing angle of the LCD.

※ Where there are things to which the product can be fixed, use spare holes with the bolt or other accessories.



[Fig. 2-2]



[Fig. 2-3]

2. Product Installation

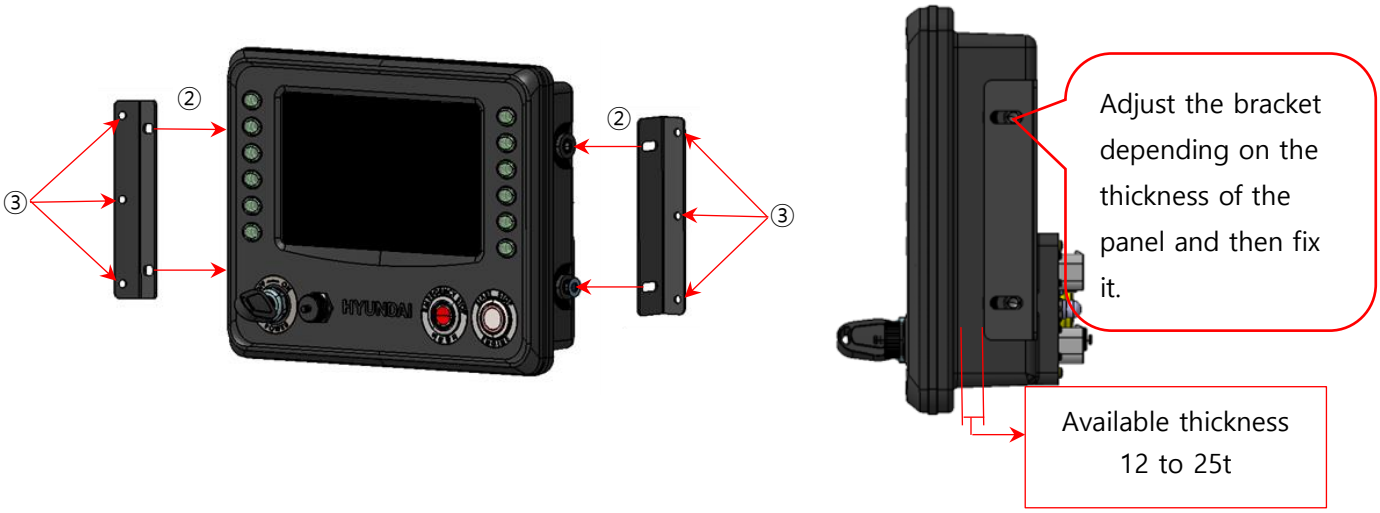
2.3 Flush Mounting Type

- Flush Mounting types are installed in the bridge by using optional mounting brackets (2pcs).
  ※ Bolt Spec: ① M6 ② M8, Length - 12mm

[Fig. 2-4] Flush Mounting Type Diagram

▶ Installing Flush Mounting type digital panel

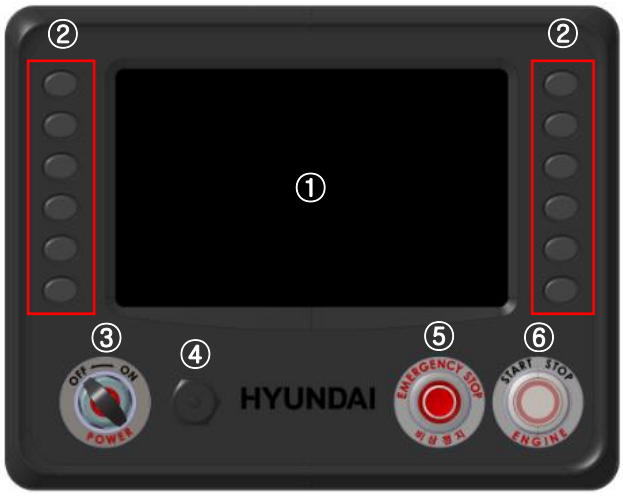
① Check whether the bridge has engine harness wiring.
② As shown in Fig. 2-6, fix the mounting brackets to both sides of the panel.
③ Check the location within reach of the engine harness wiring and the mounting location and then mount the panel using proper bolts.
④ Finish gaps between the product and the structure depending on the mounting conditions and connect the engine harness (you may connect the engine harness first depending on conditions).



[Fig. 2-5]

3. Part Names, Operation and Settings

3.1 Front

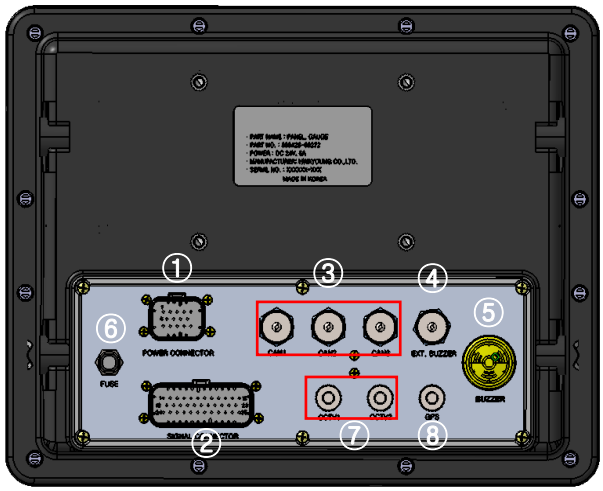


[Fig. 3-1]

No.	Name	Reference
①	LCD	-
②	Function Keys	Page 14
③	Key Switch	Page 12
④	USB	Page 12
⑤	Emergency Stop	Page 13
⑥	Start/Stop Button	Page 13

[Table 3-1]

3.2 Rear



[Fig. 3-2]

No.	Name	Reference
①	Power Connector	Page 9
②	Signal Connector	Page 10
③	CAN/RS-232	Page 11
④	External Buzzer	Page 11
⑤	Built in Buzzer	Page 12
⑥	Fuse	Page 12
⑦	CCTV (Optional)	Page 11
⑧	GPS (TBD)	-

[Table 3-2]

3. Part Names, Operation and Settings

3.3 External Connection Terminals

- External connection terminals are used for inputs and outputs of engine control signals and each sensor signals.

3.3.1 Power Connector

- Power connector supplies power and power signals.

No.	Pin Description	Notes
1	Alternator In	Battery Voltage
2	-	-
3	Battery (+) (DC 24V)	Fuse Input
4		
5	Starter Signal	-
6	Valve Battery (+)	-
7	Valve Battery (+)	-
8	Starter Signal	-
9	Starter Signal	-
10	DC 12V Out	-
11	DC 5V Out	-
12	GND	Power
13	GND	
14	Battery (+) (DC 24V)	Fuse Input

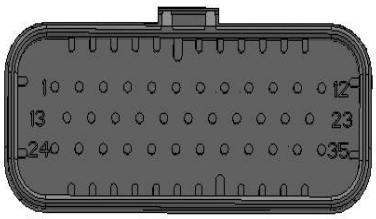
[Table 3-3]

POWER CONNECTOR

[Fig. 3-3]

3. Part Names, Operation and Settings

3.3.2 Signal Connector



SIGNAL CONNECTOR

[Fig. 3-4]

No.	Pin Description	Notes	No.	Pin Description	Notes
1	Exhaust Gas Temperature Sensor 1 **(+)**	-	19	Spare Analog Input 3	-
2	Engine Water Temperature Sensor	-	20	Pickup Sensor **(+)**	-
3	Engine Oil Pressure Sensor	-	21	-	-
4	Engine Oil Temperature Sensor	-	22	-	-
5	*Boost Air Pressure Sensor	-	23	GND	Sensor
6	*Fuel Level Sensor	-	24	Valve Out	Valve Control Signal
7	Spare Analog Input 2	-	25	Exhaust Gas Temperature Sensor 2 **(+)**	-
8	Spare Analog Input 4	-	26	Exhaust Gas Temperature Sensor 2 **(-)**	-
9	Spare Digital Input 1	-	27	Valve Out	-
10	-	-	28	-	-
11	Fuel Leakage Switch	-	29	-	-
12	GND	Sensor	30	-	-
13	Exhaust Gas Temperature Sensor 1 **(-)**	-	31	-	-
14	Engine Water Pressure Sensor	-	32	-	-
15	Gearbox Oil Pressure Sensor	-	33	-	-
16	*Engine Water Level Sensor	-	34	-	-
17	*Boost Air Temperature Sensor	-	35	GND	Sensor
18	Spare Analog Input 1	-	-	-	-

* Sensor for IMO Tier 3

[Table 3-4]

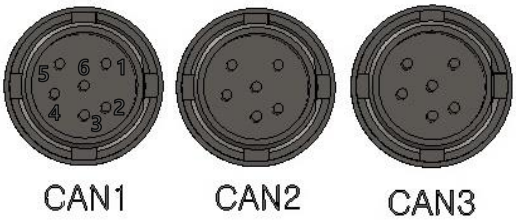
3. Part Names, Operation and Settings

3.3.3 CAN Communication Connector

- CAN harness (optional) connection
- CAN1 / CAN2 : for multi panels
- CAN3 : PC communication, firmware download

No.	CAN1	CAN2	CAN3
1	+12V Out	+12V Out	+12V Out
2	GND	GND	GND
3	CAN1_H	CAN1_H	CAN2_H
4	CAN1_L	CAN1_L	CAN2_L
5	Battery (+)	Battery (+)	PC_RXD1
6	GND	GND	PC_TXD1

[Table 3-5]



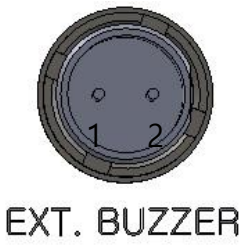
[Fig. 3-5]

3.3.4 External Buzzer Connector

- Additional connection for external buzzer harness
- Generating external buzzer alarms for warnings

No.	Name
1	Battery (+) – Fuse Output
2	Alarm Out

[Table 3-6]



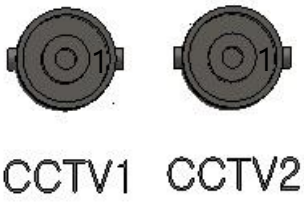
[Fig. 3-6]

3.3.5 CCTV Connector (Optional)

- CCTV cable (optional) connection
- Installation available up to 2 devices with channels 1 & 2

No.	Name
1	CCTV Signal In

[Table 3-7]



[Fig. 3-7]

3. Part Names, Operation and Settings

3.3.6 USB Connector

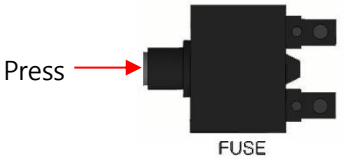
- USB memory can be inserted for data backup.
  (Only FAT32 format available)

[Fig. 3-8]

3.4 Fuse and Internal Buzzer

3.4.1 Fuse

- Shut down the power for overcurrent exceeding 6A
- Press the fuse button for 10 seconds to restore fuse operation.



[Fig. 3-9]

3.4.2 Internal Buzzer

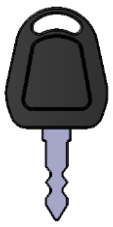
- Generate alarms for sensor problems

[Fig. 3-10]

3.5 Key Switch

- Key switch is used to boot and turn off the digital panel system or stop the engine.

1) Use the key contained in the product to insert it and rotate to the right by 90° (ON) (when the key is ON, the key should remain inserted).
2) When the key is ON, the product will boot and the gauge display will appear in about 17 seconds.
3) Rotate the key to the left by 90° (OFF) to turn it off.
   - When rotating the key to the left (OFF) while the power is on, the display will show a popup message for 300 seconds. The engine will stop and the event will be saved after 300 seconds.
   - When the popup window appears, rotate the key to the right (ON) to remove the window and keep the engine on.



Key
[Fig. 3-11]

Key Switch
[Fig. 3-12]

3. Part Names, Operation and Settings

3.6 Start/Stop Button

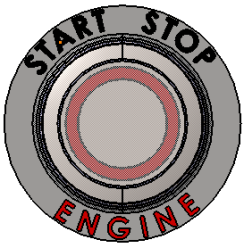
- Start/Stop button is used to start/stop control for the engine.

1) Press the button for more than 1 second while the key is ON, the engine will start (the button LED will flash when pressing the button).
2) Press the button for more than 1 second while the key is ON and the engine is in operation to stop the engine.

※ You can set the time to 1~3 second for emergency response in Digital Panel Manager.

※ Plastic protection cover label installed.

※ Be careful of strong force because it can be confirmed by LED flashing during pushing operation.



Start/Stop Button

[Fig. 3-13]

3.7 Emergency Stop Button

- Emergency Stop Button is used to urgent engine stop for the emergency situation.

1) Press immediately when an emergency situation occurs in the engine run state.
   → Red LED on while pressing
2) Engine RPM drops while depressed.
3) Release the button after the engine is completely stopped.
   → LED off when released

※ If you release the button before stopping the engine, the engine will restart.

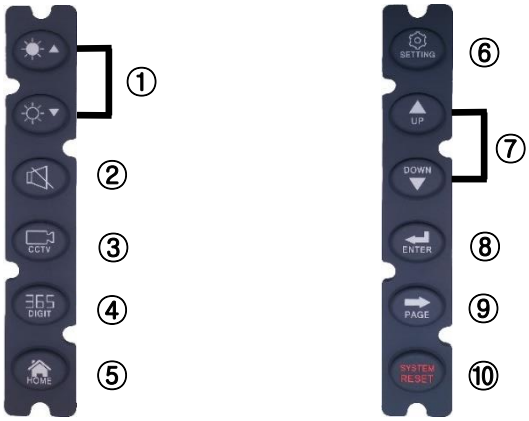
Emergency Stop Button

[Fig. 3-14]

3. Part Names, Operation and Settings

3.8 Function Keys

- Function keys are used to adjust LCD brightness, stop alarming (mute), configure CCTV, Digit, Home and other settings, move to and select menus, and reset the system.



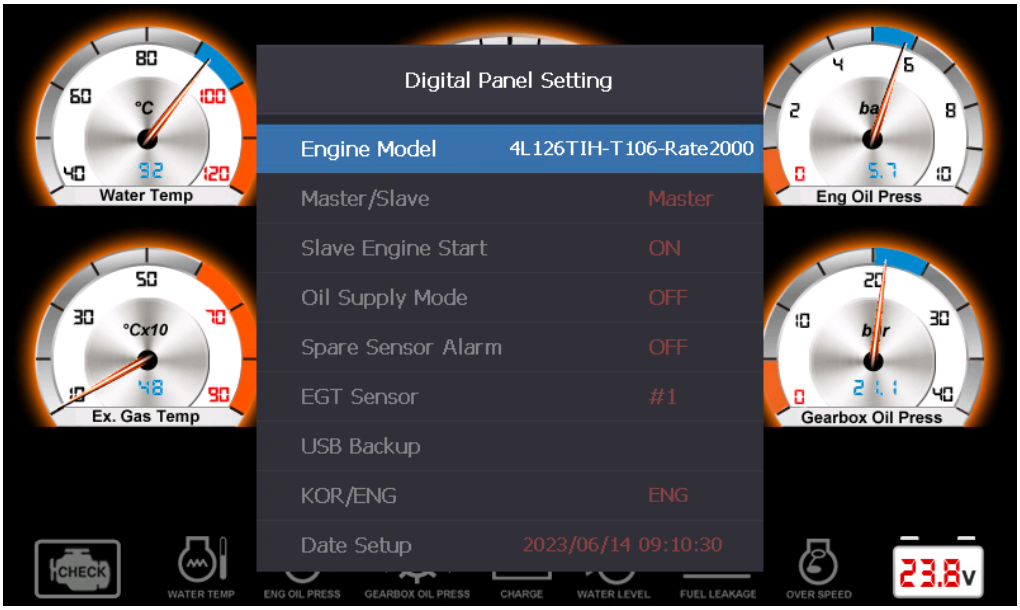
[Fig. 3-15] Function Keys

No.	Function Key	Action Feature
①	LCD dimmer	• LCD brightness adjustable for 5 different levels (when rebooting the system, the previous setting will be maintained).
②	Alarm Mute	• Turn off the buzzer sound
③	CCTV	• Switching between CAM1 and CAM2 (optional)
④	Digit On/Off	• Default On • Press once : number light will be off • Press once again : number light will be on
⑤	Home	• Move to main gauge display. • Move to main display without saving when pressing it in page mode.
⑥	Configuration	• Engine Model setting • Master/Slave setting and ON/OFF setting to start the slave • ON/OFF setting for over speed testing • Oil Supply Mode • ON/OFF setting for spare sensor light • Select EGTS • USB backup and time (year/month/hour) settings • Convert Korean/English • Set date
⑦	Up/Down	• Move the cursor up and down in setting window
⑧	Select	• Select menus or functions in the setting window
⑨	Page	• Move to spare sensor display (display page 2) / Move to event summary display (display page 3)
⑩	System Reboot	• Rebooting for system errors (press it for more than 3 seconds to reboot)

[Table 3-8]

3. Part Names, Operation and Settings

3.8.1 Detailed Settings



[Fig. 3-16] Detailed Settings

▶ Setting Functions and Descriptions

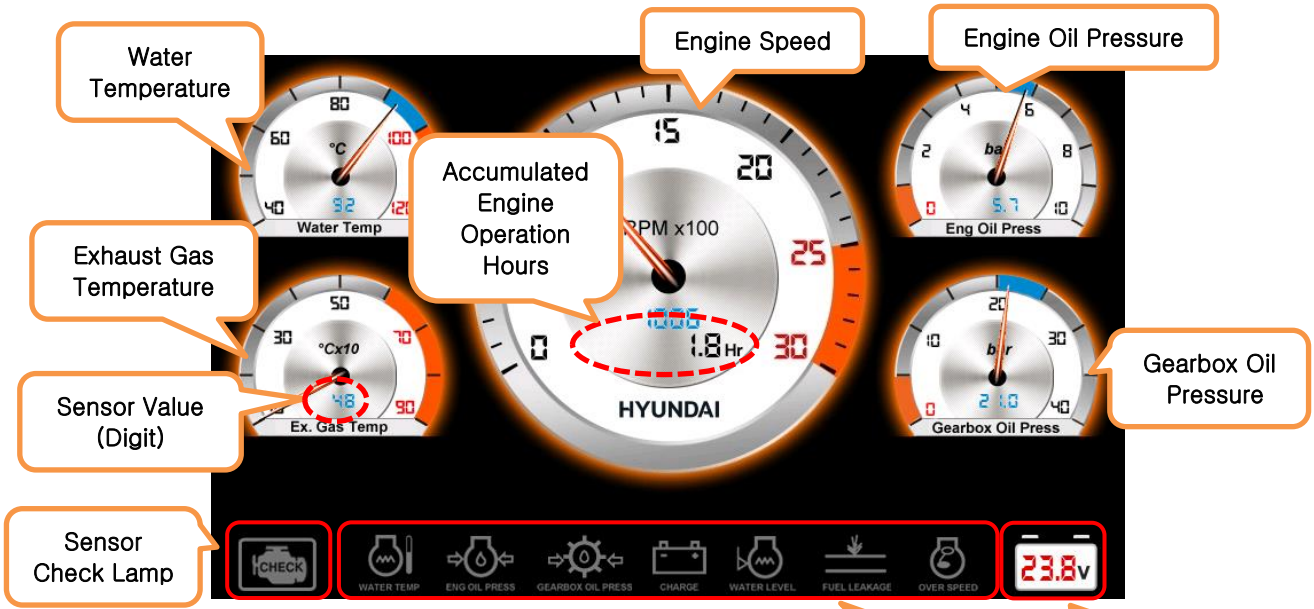
- Press SETTING button and then use UP or DOWN button to move to functions to be changed.
- Press SETTING button to go back to gauge display (changes will be automatically saved).

No.	Function	Description	Function Key
1	Engine Model	• Engine model setting (refer to the appendix for the list of engine models)	ENTER UP DOWN
2	Master / Slave	• Master/Slave setting for multi panels	ENTER
3	Slave Engine Start	• ON/OFF setting to start from the slave	ENTER
4	Oil Supply Mode	• Supply Engine oil by idling	ENTER
5	Spare Sensor Alarm	• ON/OFF setting for spare check sensor light	ENTER
6	EGT Sensor	• Select Exhaust gas sensor number(for DX12)	ENTER
7	USB Back Up	• USB backup for event save files	ENTER
8	KOR/ENG	• Convert Korean to English	ENTER
9	Date Setup	• Date and time setting	ENTER UP DOWN

[Table 3-9]

3. Part Names, Operation and Settings

3.9 Display Structure



[Fig. 3-17] Gauge Display

- Gauge display shows various gauge data including pick up (RPM) sensor, coolant temperature, exhaust gas temperature, engine oil pressure and gearbox oil pressure.
- It also includes battery voltage indication, accumulated engine operation hours, coolant temperature, engine oil pressure, gearbox oil pressure, charging, fuel leakage and overspeed alarms.

3.9.1 Engine Speed (Tachometer)

- It shows engine RPM in gauge and digital values and counts accumulated engine operation hours.

[Fig. 3-18]
Engine Speed Gauge

1) It shows the RPM indicated by the gauge hand in digital values (blue) for better accuracy (however, it is available off by the 'DIGIT' button).
2) It shows accumulated engine operation hours by hour unit (engine speed of 400RPM or faster will be counted and the function is always on)
3) Starter Off RPM setting is available between 300 and 600RPM after the engine starts (The service team can configure the setting in Digital Panel PC Manager).

3. Part Names, Operation and Settings

3.9.2 Engine Water Temperature

- It shows the coolant temperature in gauge and digital values.

[Fig. 3-19]

Engine Water Temperature Gauge

1) It shows the temperature indicated by the gauge hand in digital values (blue) for better accuracy (however, it is available off by the 'DIGIT' button).
2) It shows the open/short diagnosis for sensor problems.
   ☞ Open: 'ERROR' / Short (GND): '-----'
3) It also serves as the water temperature switch.
4) It activates alarm and warning beep when the temperature increases up to 93℃ or higher.
5) When the temperature increases up to 103℃ or higher, the engine will stop.

3.9.3 Engine Oil Pressure

- It shows engine oil pressure in gauge and digital values.

[Fig. 3-20]

Engine Oil Pressure Gauge

1) It shows the pressure indicated by the gauge hand in digital values (blue) for better accuracy (however, it is available off by the 'DIGIT' button).
2) It shows the open/short diagnosis for sensor problems.
   ☞ Open: '-----' / Short (Power): 'ERROR'
3) It also serves as the engine oil pressure switch.
4) It activates alarm and warning beep when the pressure is 1bar or lower (detects in 10 seconds).
5) When the pressure is 0.5bar or lower, the engine will stop(detects in 10 seconds).
6) Alarm won't work before the engine starts but at normal stop.

3.9.4 Exhaust Gas Temperature

- It shows exhaust gas temperature in gauge and digital values.

[Fig. 3-21]

Exhaust Gas Temperature

1) It shows the temperature indicated by the gauge hand in digital values (blue) for better accuracy (however, it is available off by the 'DIGIT' button).
2) It shows the open/short diagnosis for sensor problems.
   ☞ Open: 'ERROR' / Short (GND): '-----'
3) The alarm will be activated when the temperature is 600℃ or higher while the engine is in operation.

3. Part Names, Operation and Settings

3.9.5 Gearbox Oil Pressure

- It shows gearbox oil pressure in gauge and digital values.

[Fig. 3-22]
Gearbox Oil Pressure

1) It shows the pressure indicated by the gauge hand in digital values (blue) for better accuracy (however, it is available off by the 'DIGIT' button).
2) It shows the open/short diagnosis for sensor problems.
   ☞ Open: '-----' / Short (Power): 'ERROR'
3) It activates alarm and warning beep when the pressure is 1bar or lower (detects in 10 seconds).

3.9.6 Battery Voltage

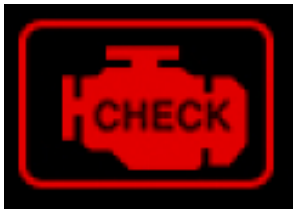
- It shows battery voltage to indicate its conditions.

[Fig. 3-23] Battery Voltage

1) It will show in blue for voltage of 24V or higher or red for voltage lower than 24V.
2) It activates warning beep when the voltage is 20V or lower (regardless of whether the engine is in operation or not).

3.9.7 Check Sensor Light

- When there are sensor errors (Open or Short), the check sensor light will turn on.



[Fig. 3-24] Check Sensor Light

1) When the check sensor light is on, it will show in yellow.

※ Open and Short gauge displays for sensor problems

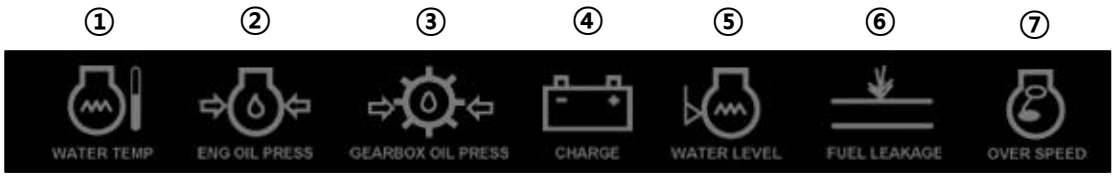
Open

Short

3. Part Names, Operation and Settings

3.9.8 Engine Alarms

- The alarm will be activated with buzzer beeping when problems for coolant temperature, engine oil pressure, gearbox oil pressure, charging, coolant level, fuel leakage and over speed are detected.



[Fig. 3-25] Engine Alarms

No.	Alarm	Action Feature
①	Coolant temperature	• Alarm (buzzer) will be activated when the temperature is **93℃** or higher
②	Engine oil pressure	• Alarm (buzzer) will be activated on when the pressure is **1 bar** or lower
③	Gearbox oil pressure	• Alarm (buzzer) will be activated on when the pressure is **1 bar** or lower
④	Charging	• Alarm (buzzer) will be activated when the battery voltage is lower than **18V**
⑤	Water level	• Alarm (buzzer) will be activated when the level is lower than **30%**
⑥	Fuel leakage	• Alarm (buzzer) will be activated when oil leak occurs (default setting is 'disabled')
⑦	Engine over speed	• Alarm (buzzer) will be activated when the speed exceeds **117%** of the rate speed

[Table 3-10] Alarm Features

※ How to deactivate the engine alarm

- Press SYSTEM RESET button on the right for 3 seconds, the system will reboot and the alarm will be deactivated (rebooting is available while the ship navigates without causing problems).

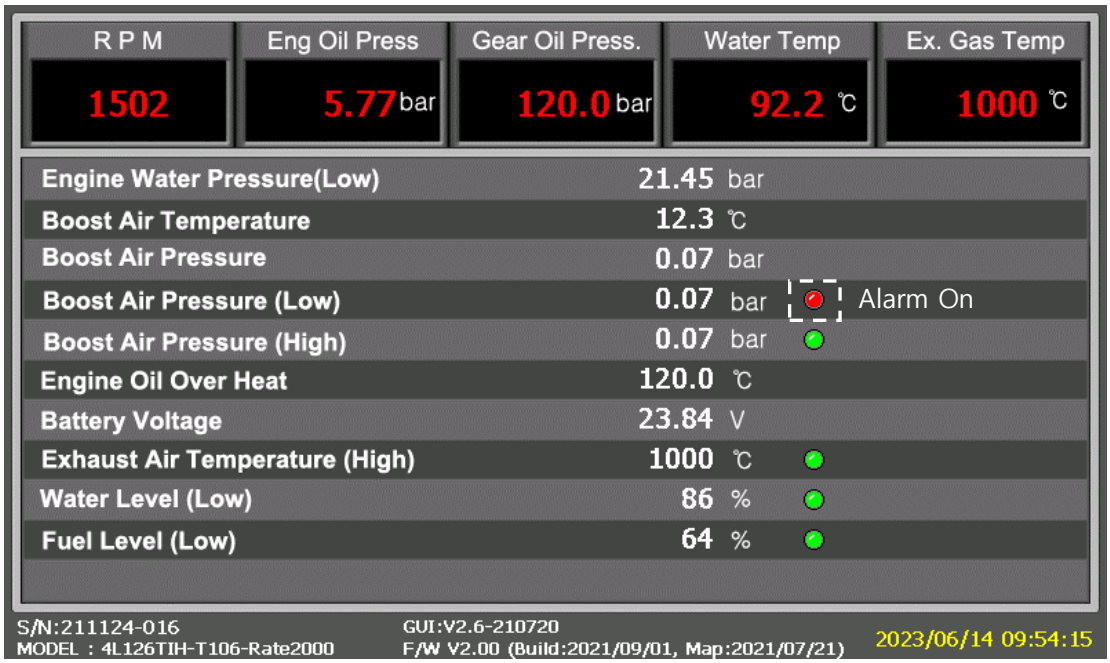
3.9.9 Engine Shutdown

1) When the over speed exceeds **117%** of the rate speed → Enable/Disable engine stop
2) When the coolant temperature exceeds **103℃** → Enable/Disable engine stop
3) When the oil pressure is **0.5bar** or lower → Enable/Disable engine stop
4) When fuel leakage occurs → Enable/Disable engine stop
5) Stop Valve → the stop button will be activated by users (when the engine continues at **0** RPM for 7 seconds)

3. Part Names, Operation and Settings

3.10 Spare Sensor

- It identifies the status of spare sensor, product S/N, F/W version, and date/time. Press PAGE button of the function key to move to spare sensor page.



[Fig. 3-26] Spare Sensor and S/W information

Item	Condition
Gearbox Oil Pressure	• Alarm will be activated when the gearbox oil temperature is 1bar or lower
*Boost Air Temperature	• Current temperature
*Boost Air Pressure (Low)	• Alarm will be activated when the boost air pressure is 1bar or lower
*Boost Air Pressure (High)	• Alarm will be activated when the boost air pressure is 3bar or higher
*Engine Oil Over Heat	• Alarm will be activated when the engine oil temperature is 120℃ or higher
Battery Voltage	• Current voltage
Exhaust Air Temperature (High)	• Alarm will be activated when the exhaust air temperature is 600℃ or higher
*Water Level (Low)	• Alarm will be activated when the coolant level is 30% or lower
*Fuel Level (Low)	• Alarm will be activated when the fuel level is 30% or lower

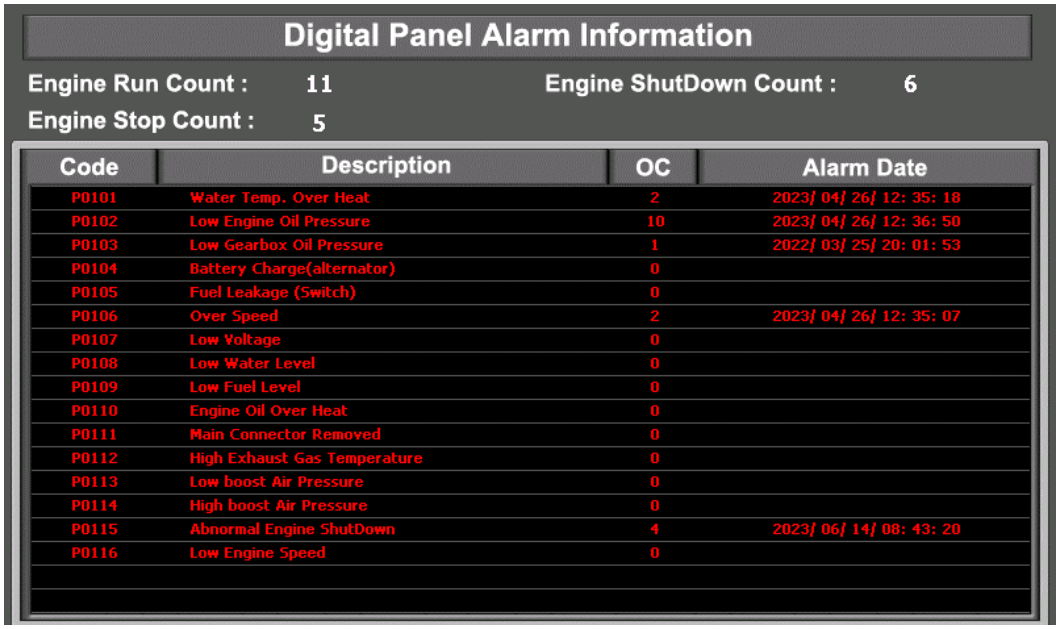
* Sensor for IMO Tier 3

[Table 3-11] Spare Sensor Conditions

3. Part Names, Operation and Settings

3.11 Event Summary

- It shows the numbers of normal operations, normal stops, emergency stops and sensor errors together with dates of recent errors.
- Press PAGE button in spare sensor page to move to event summary page.



[Fig. 3-27] Event Summary Screen

Event List			
P0101	Water Over Heat	P0109	*Low Fuel Level
P0102	Low Engine Oil Pressure	P0110	Engine Oil Over Heat
P0103	Low Gearbox Oil Pressure	P0111	Main Connector Removed
P0104	Battery Charge(Alternator)	P0112	High Exhaust Gas Temperature
P0105	Fuel Leakage(Switch)	P0113	*Low Boost Air Pressure
P0106	Over Speed	P0114	*High Boost Air Pressure
P0107	Low Voltage	P0115	Abnormal Engine Shutdown
P0108	*Low Water Level	P0116	Low Engine Speed

* Sensor for IMO Tier 3

[Table 3-12] Event List

3. Part Names, Operation and Settings

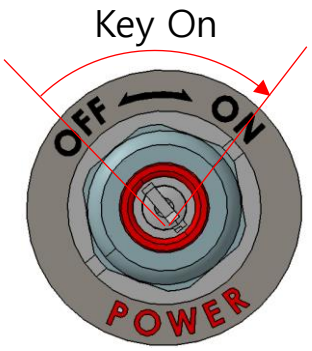
3.12 System Booting and Functional Check

- You can check whether the product is properly installed or not.

▶ Normal System Booting

1) Insert the key into the key switch and rotate it to the right (ON).
2) HYUNDAI logo will appear for 17 seconds while the system is booting (refer to the image).
   ※ If the logo does not appear after rotating the key,
   - Rotate it to the left (OFF) and then to the right (ON) again
   - Check the harness connection at the back of the panel
   - Check whether the battery is discharged
3) The gauge display will appear after normal booting.
   - Gauge: check whether each gauge hand is within the normal range and 'ERROR' or '-----' is displayed on the screen.

   ※ Where 'ERROR' or '-----' is displayed on the screen
   - Check the harness connection
   - Function keys: check whether each function key is active on the screen by pressing them.
   - Alarm: check whether the alarm is turned on.
   - Battery: Check whether the battery is ok.
4) Where the initial gauge screen is normal, press START button for 1 second to start the engine (the time can be set to 1~3 second. Refer to Digital Panel Manager).
5) Check whether the operation is in normal RPM (initial operation in 400RPM or faster with the oil pressure of 1bar or higher) and whether is turned on.



[Fig. 3-28] Key Switch

[Fig. 3-29] Booting Logo

[Fig. 3-30] Gauge Display

4. Multi Panel Structure

4.1 Multi Panels

- Panels can be installed up to 4 units except Master in the ship and you can check the ship conditions and control those panels at any places of installation.

[Fig. 4-2] Slave 1

[Fig. 4-3] Slave 3

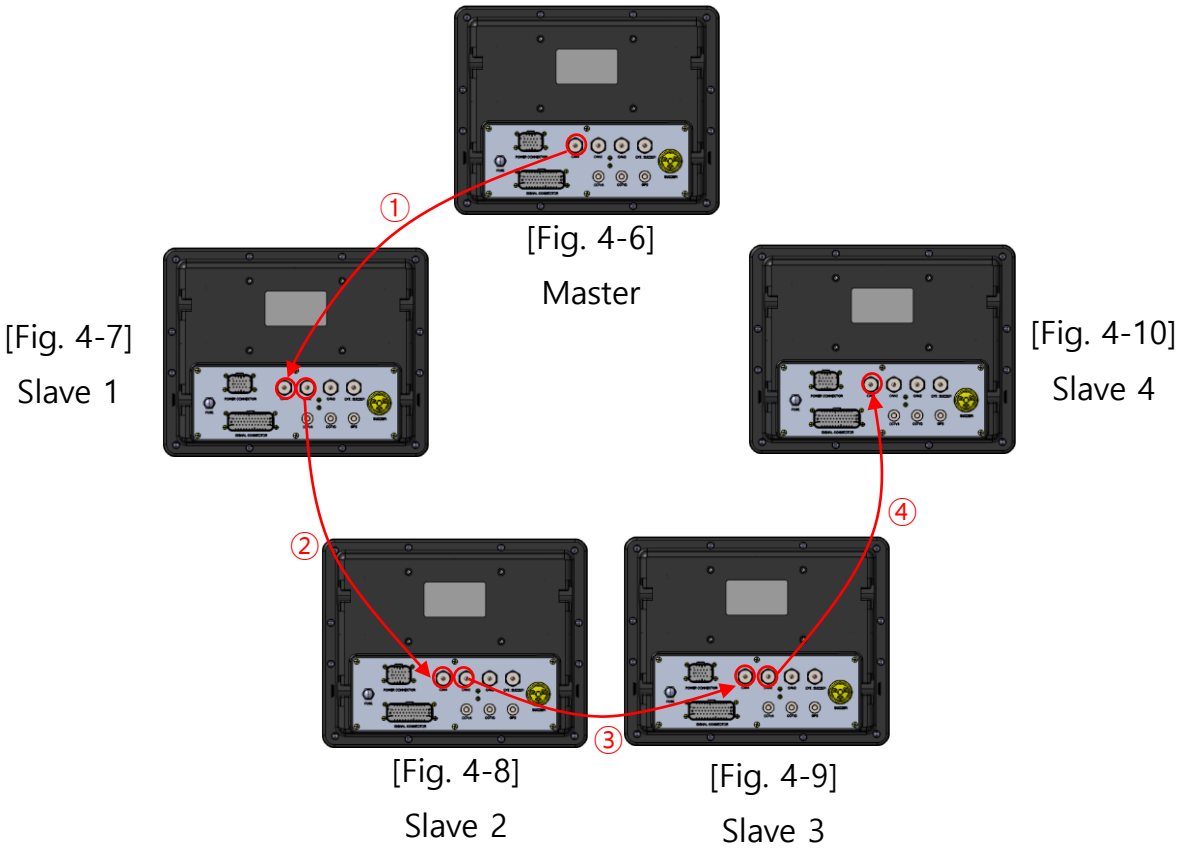
[Fig. 4-1] Master

[Fig. 4-4] Slave 2

[Fig. 4-5] Slave 4

4. Multi Panel Structure

4.2 How to Install Multi Panels



[Fig. 4-6] Master

[Fig. 4-7] Slave 1

[Fig. 4-10] Slave 4

[Fig. 4-8] Slave 2

[Fig. 4-9] Slave 3

※ In order to install multi panels, all the necessary cables should be ready in advance (use the cables with specification recommended by HYUNDAI).

(1) Connect the CAN1 terminal of the Master panel and the CAN1 terminal of the Slave 1 panel as shown in ① (2 panels).

- Master and Slave 1 connection completed

(2) Connect Slave 1 (CAN2) and Slave 2 (CAN1) as shown in ② while maintaining connection as described in ① (3 panels).

- Master, Slave 1 and Slave 2 connection completed

(3) Connect Slave 2 (CAN2) and Slave 3 (CAN1) as shown in ③ while maintaining connection as described in ② (4 panels).

- Master, Slave 1, Slave 2 and Slave 3 connection completed

(4) Connect Slave 3 (CAN2) and Slave 4 (CAN1) as shown in ④ while maintaining connection as described in ③ (5 panels)

- Master, Slave 1, Slave 2, Slave 3 and Slave 4 connection completed

4. Multi Panel Structure

4.3 Multi Panel Settings

(1) Press SETTING button of the panel to be configured as Slave.

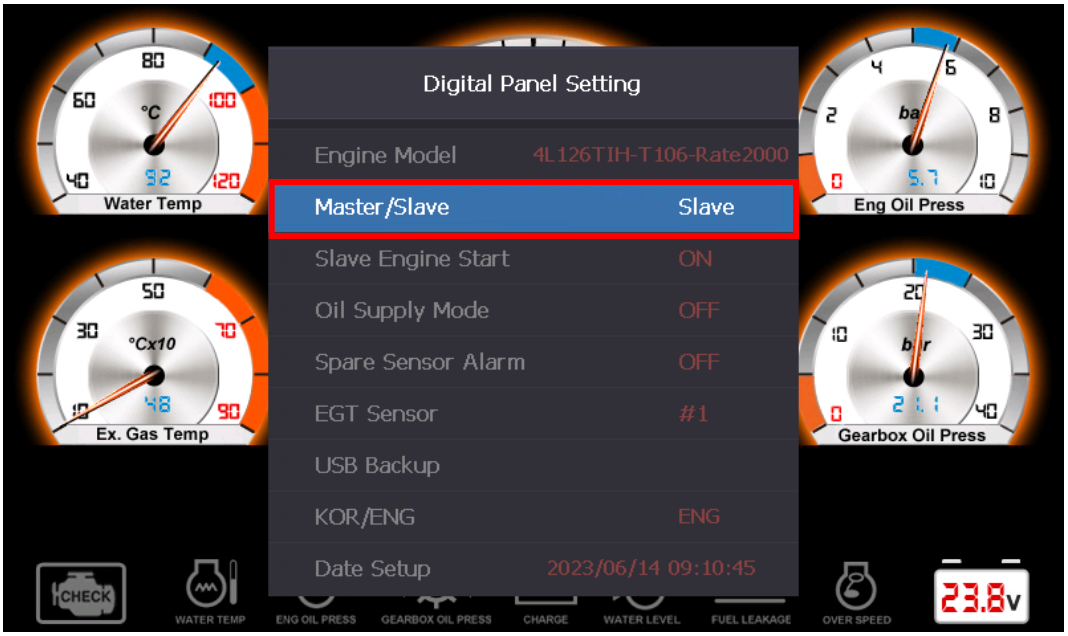
(2) Move to ① when the setting screen appears (use UP or DOWN button to move).

(3) Press ENTER button to switch configuration between Master and Slave.

(4) Configure the Master panel as described above.

※ Notes

- Master mode is available for one panel only and Slave mode is available up to 4 units.
- You can permit Slaves to start the engine with Master panel only. Where you enable Slave Engine Start setting, all Slave panels will be able to start the engine.



[Fig. 4-11] Multi Panel Setting Window

5. Maintenance

5.1 Maintenance

- To maintain the performance of the device, regular maintenance is required.

1. Use soft cloth to clean the LCD without damaging it.
    1) Clean the LCD after turning the power off.
    2) Do not use cleaners with acids or ammonia.
    3) Do not use neutral detergents to remove oil stains.
    4) Use cloth slightly wet in clean water to remove salt residuals or dust particles for natural drying. If there remain stains, clean them with soft cloth (microfibers) once again.
2. Check whether the connectors or harnesses at the back of the device are properly connected or whether they have dust or other foreign substances.
3. Check whether cables are damaged.
4. Request for checking when the software needs upgrade as follows:
   - When the manufacturer releases official software for performance improvements

5.2 Troubleshooting

- It describes possible measures for users to resolve problems while using the device.

1. The device is not turned on.
    1) Check whether harness cables at the back of the product are properly connected.
    2) Where harness cables have too much dust or moisture, remove them and clean the dust or moisture. Connect them once again after a while.
    3) Check whether the fuse button at the back of the product is pulled out.
    4) Check whether the battery is discharged.
2. You can see lines or shaking on the screen.
    1) Reboot the product.
    2) As the LCD is connected inside the product, do not disassemble it and contact the service team.
3. You can see distortions on CCTV screens.
    1) Check whether CCTV connectors or connectors at the back of the product are properly connected.
    2) Check whether cables are worn out.
4. You can see alarm or hear warning beeps at the bottom of the product screen.
    1) Check where the alarm occurs and then take measures as necessary (if you need to confirm which alarm occurs, refer to Page 20 of this manual).
5. You cannot control buttons.
    1) Check whether there are foreign substances at the panel buttons.
    2) As the button connecting parts may be damaged, do not disassemble the product and contact the service team.

6. Warranty and A/S Service

6.1 Warranty

As this manual contains important contents related to safety, use and maintenance of the product. So please read this manual carefully and then use the product in a proper manner.

Those who are not familiar with the product should keep this manual close to it.

We are not responsible for human injuries or property damages caused by the following reasons:

- Where you use the product for purposes other than the ones described in this manual
- Where you alter the product or its components at discretion
- Where you disassemble the product at discretion to resolve problems
- Where you use accessories or parts not supplied or recommended by us

※ Where you use accessories or parts manufactured by other companies, please contact our service center to check their compatibility.

6.2 A/S Service Information

- When you request A/S service, please let us know the model name, breakdown conditions and your contact information.
- Please ask the seller.

7. Appendix

7.1 List of Engine Models

- List of compatible engine models

Engine		Number of Gear Teeth	Rate Speed	Over Speed	
DB58TI	L066TIH	129	2,200	115%	2,530
D1146	L136	140	2,200	115%	2,530
D1146T	L136T	140	2,200	115%	2,530
	L136TL	140	2,500	115%	2,875
D1146TI	L136TI	140	2,200	115%	2,530
D1146TIB	L086TIH	140	2,200	115%	2,530
	L086TIM	140	2,300	115%	2,645
	L086TIL	140	2,500	115%	2,875
DE12T	MD196T	152	2,000	115%	2,300
DE12TI	MD196TI	152	2,000	115%	2,300
DE12TIB	L126TIH	152	2,000	115%	2,300
	L126TIM	152	2,100	115%	2,415
DX12	4L126TIH	106	2,000	117%	2,340
	4L126TIM	106	2,100	117%	2,415
	4L126TIL	106	2,200	117%	2,574
D2848LB	V158TIH	160	1,800	115%	2,070
	V158TIM	160	2,100	115%	2,415
	V158TIL	160	2,300	115%	2,645
D2840LB	V180TIH	160	1,800	115%	2,070
	V180TIM	160	2,100	115%	2,415
	V180TIL	160	2,300	115%	2,645
D2842LB	V222TIH	160	1,800	115%	2,070
	V222TIM	160	2,100	115%	2,415
	V222TIL	160	2,300	115%	2,645
4VD2848LB	4V158TIH	160	1,800	115%	2,070
	4V158TIM	160	2,100	115%	2,415
	4V158TIL	160	2,300	115%	2,645
4VD2842LB	4V222TIH	160	1,800	115%	2,070
	4V222TIM	160	2,100	115%	2,415
	4V222TIL	160	2,300	115%	2,645

User Manual for 8 Inch Digital Panel and Controller for Mechanical Marine Propulsion Engine.

Ver.2.1

HYUNDAI

Contents

Contents

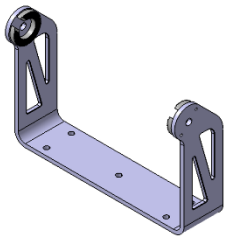
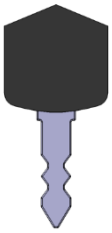
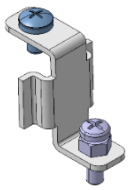
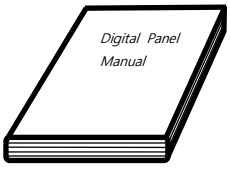
1. General Information

1.1 Product Information

This product is a digital panel for mechanical marine propulsion engines and can be applied to various small marine engines. The DACU (Data Acquisition Control Unit) acquires engine status data, and users can monitor the engine's status through the DGP (Digital Gauge Panel) feature. The product is designed with digital visualization to provide clear visibility of engine control and status information. It incorporates graphical analog gauges and digital displays to enhance user convenience and is designed to withstand harsh maritime environments.

1.2 Components and Optional Accessories

- Refer to Table 1-1 below for product components

NO	Components	Component Name	NO	Components	Component Name
1		DGP DACU	4		Desk Mounting Type Parts 1set
2		Desk Mounting Type Bracket	5		Key 2EA
3		Flush Mounting Type Bracket 4EA	6		User Manual

[Table. 1-1]

1. General Information

1.3 Product Specification

- Refer to Table 1-2 below for the hardware specifications of the digital panel for this mechanical engine.

Digital Gauge panel product Specification

No.	Item	Remark
1	Microprocessor	• NXP4330Q / S32K144
2	Software	• Linux OS GUI + F/W
3	Display	• 8″ Color TFT LCD • 1280 * 720(Pixel) • 16 : 9
4	Flash Memory	• 4GB(eMMC)
5	Ram	• 1GB
6	Operating Voltage	• DC 24V (9 ~ 32V)
7	USB	• USB 2.0 1Port
8	Operating Temperature	• - 20℃ ~ 70℃
9	Internal Buzzer	• Piezo Buzzer 98dB
10	Communication	• J1939 CAN communication • RS232
11	Dimensions	• W 287 x H 245.8 x D 108.15(DGP) • W 236 x H 186.6 x D 80(DACU)

[Table 1-2]

2. Product Installation

2.1 Cautions

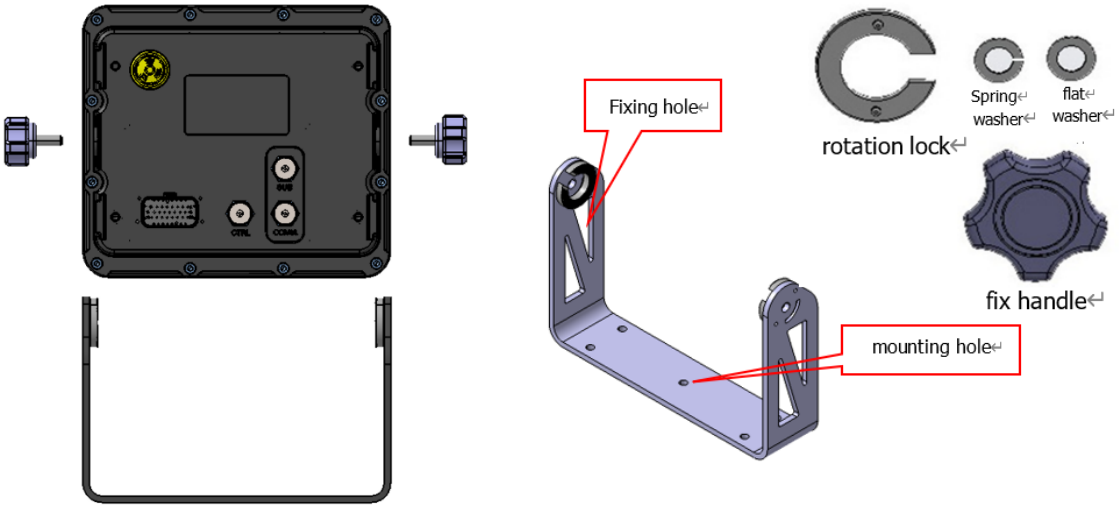
- Unskilled personnel should read this manual before use.
- Do not use or keep the product close to combustible sprays or inflammable.
- Use soft and dry cloth to clean the panel LCD.
- Turn off the product, pull out the harness cable and then contact our service center when you see smoke from the panel or have strange smells.
- When you see an alarm on, you always need to check the product before operation.
- Do not disassemble the product cover at discretion (warranty does not cover unauthorized disassembly).
- Excessive impact may damage the display although a reinforced display is used.
- Use connectors matching each other when connecting them to the back of the product.
- Do not contact or remove connectors while the power is on. It may cause electric shock or lead to malfunction.
- Do not exercise excessive force when rotating to ON/OFF with the key inserted in.
- Do not use the product with wet hands.
- Put protective caps on back side connectors when they are not in use.

2. Product Installation

2.2 Desk Mounting Type

※ Desk Mounting Types are installed in the Bridge or engine room by using desk mounting brackets delivered with the product.

※ Mounting Hole Spec: M6 bolt

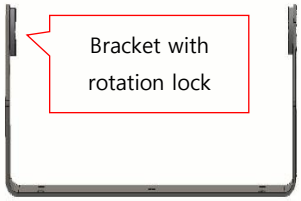


[Fig. 2-1] Desk Mounting Type Diagram

▶ Installing Desk Mounting Type digital panel

① Check if there is cable wiring available in the Bridge or engine room.

② Fix the bracket using mounting hole of the product at the position where the cable wiring reaches.

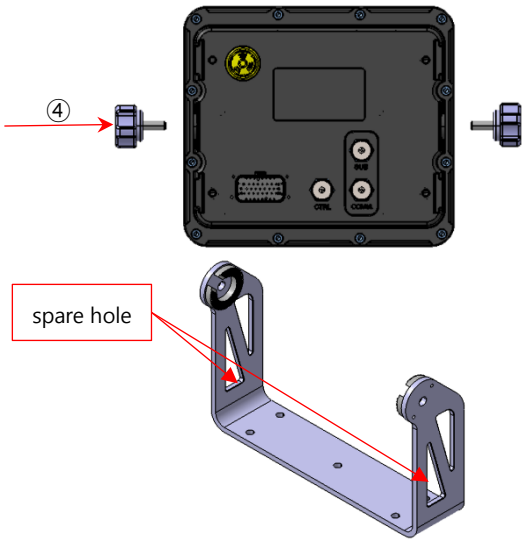


[그림 2-2]

③ Place the product inside the bracket connected with the rotation lock to connect it with the rotation lock.

④ Connect it with the fix handle to the direction indicated by an arrow and adjust the viewing angle of the LCD

※ Where there are things to which the product can be fixed, use spare holes with the bolt or other accessories.



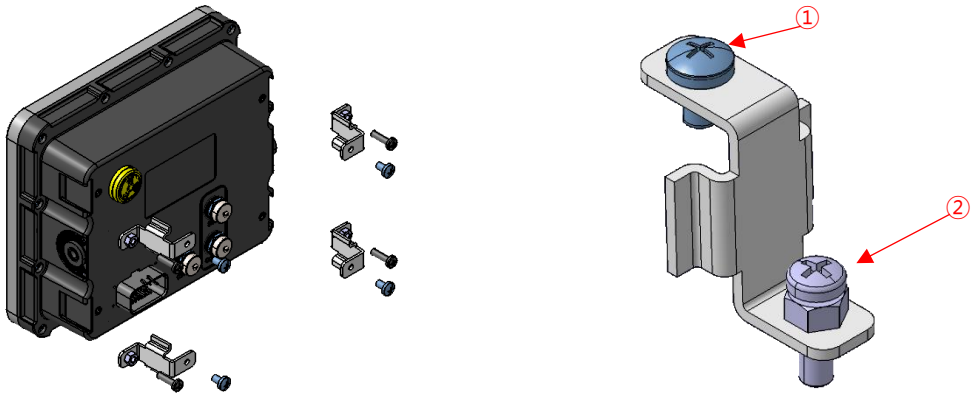
[Fig. 2-3]

2. Product Installation

2.3 Flush Mounting Type

- Flush Mounting types are installed in a **Bridge** or engine room by using optional mounting brackets (2pcs).

  ※ Bolt Spec: ① M6 X 10L ② M6 X 20L



[Fig. 2-4] Flush Mounting Type Diagram

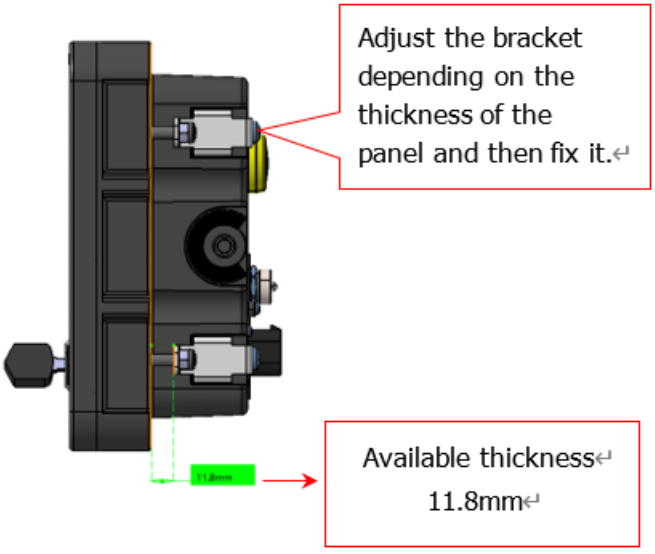
▶ Installing Flush Mounting Type digital panel

① Check the harness is wired in the Bridge or engine room.

② As shown in [Fig. 2-5], fix the mounting brackets to both sides of the panel.

③ Check the location within reach of the harness wiring and the mounting location and then mount the panel using proper bolts.

④ Finish gaps between the product and the structure depending on the mounting conditions and connect the engine harness (you may connect the engine harness first depending on conditions)



[Fig 2-5]

3. Part Names, Operation and Settings

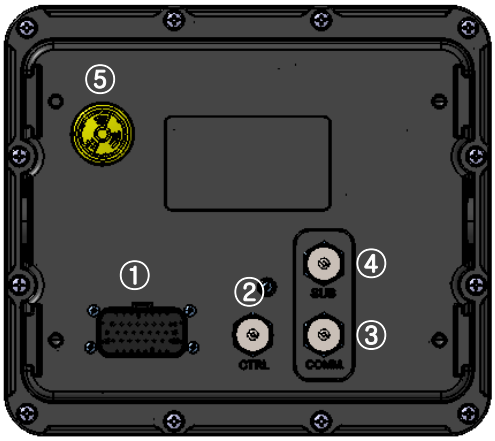
3.1 Front Side

[Fig. 3-1]

No.	Name	Reference
①	LCD	-
②	Function Keys	13 Page
③	Key Switch	11 Page
④	USB	10 Page
⑤	Emergency Stop Switch	12 Page
⑥	Emergency Start Switch	12 Page

[Table. 3-1]

3.2 Back Side



[Fig. 3-2]

No.	Name	Reference
①	Main Connector	9 Page
②	Engine Control (External Buzzer and Function for Ship Generator)	12 Page
③	COMM.	12 Page
④	SUB	12 Page
⑤	Internal Buzzer	13 Page

[Table. 3-2]

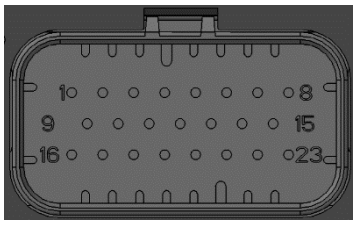
3. Part Names, Operation and Settings

3.3 External Connection Terminals

- Input/output connector connecting DGP and DACU
- Input/output connector for various control signals including sensors between DACU and engine

3.3.1 DGP 23Pin Main Connector

- Interface connector for receiving power and engine operation information from DACU and transmitting and receiving CAN signals with ECU (For Ship Generator)



[Fig. 3-3]

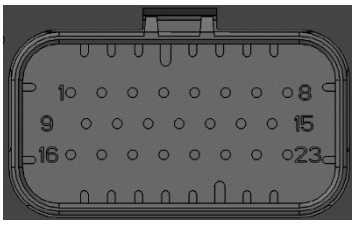
No.	Pin Description	Notes	No.	Pin Description	Notes
1	Battery In	-	13	(opt) PC RXD1	-
2	Battery In	-	14	(opt) PC TXD1	-
3	Power GND	-	15	Alternator In	Electronic panel only
4	Power GND	-	16	Wait to Disconnect Signal	
5	Key On	-	17	Wait to Disconnect Common	
6	Starter Signal	-	18	Gearbox Oil Pressure Supply	
7	Emergency Switch Power	-	19	Gearbox Oil Pressure Signal	
8	Emergency Switch Signal	-	20	Fuel Leakage Switch	
9	CAN 1 High	-	21	GND Sensor	
10	CAN 1 Low	-	22	Water In Fuel Switch	
11	(opt) CAN 2 High	Option	23	GND Sensor	
12	(opt) CAN 2 Low		-	-	-

[Table 3-3]

3. Part Names, Operation and Settings

3.3.2 DACU 23Pin Main Connector

- Interface connector to provide DGP power and engine operation information



[Fig. 3-4]

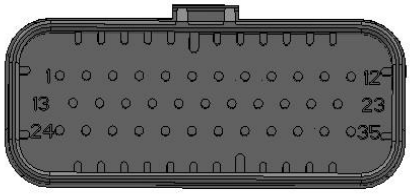
No.	Pin Description	Notes	No.	Pin Description	Notes
1	CAN 1 Low	-	13	Power GND	-
2	CAN 1 High	-	14	DSC RPM Pick-up (GND)	Generator only
3	(opt) CAN 2 High	-	15	DSC Actuator A	Generator only
4	(opt) PC TXD1	-	16	Battery In	-
5	Key On	-	17	DSC CAN 2 Low	Generator only
6	Starter Signal	-	18	DSC CAN 2 High	Generator only
7	DSC RPM Pick-up Signal	Generator only	19	Emergency Switch Signal	
8	DSC Battery	Generator only	20	Emergency Switch Power	
9	Battery In	-	21	Power GND	
10	(opt) CAN 2 Low	-	22	DSC GND	
11	(opt) PC RXD1	-	23	DSC Actuator B	Generator only
12	-	-			

[Table. 3-4]

3. Part Names, Operation and Settings

3.3.3 DACU 35Pin Main Connector

- Engine harness interface connector that is connected to the engine harness to receive power and analog sensor information of the engine and supply start control signals to the engine



[Fig. 3-5]

No.	Pin Description	Notes	No.	Pin Description	Notes
1	Alternator In	-	19	Water Pressure Signal	-
2	Stop Solenoid Signal	-	20	Stop Solenoid Power	-
3	Fuel Leakage Switch	-	21	Starter Motor Power	-
4	Engine Oil Temp Signal	-	22	-	-
5	Exhaust Gas Temp2+	-	23	Power GND	-
6	Exhaust Gas Temp1+	-	24	DSC Actuator B	Generator only
7	Engine Oil Pressure Signal	-	25	RPM Pick-up Signal	
8	Stop Solenoid Power	-	26		
9	Starter Motor Power	-	27		
10	Starter Motor Power	-	28		
11	Power GND	-	29		
12	Power GND	-	30	GND Sensor	
13	DSC Actuator A	Generator only	31	GND Sensor	
14	RPM Pick-up (GND)		32	Stop Solenoid Power	
15	Water Temp Signal	-	33	Battery In	
16	Exhaust Gas Temp2-	-	34	Battery In	
17	Exhaust Gas Temp1-		35	Battery In	
18	Gearbox Oil Pressure Signal	-	-		

[Table. 3-5]

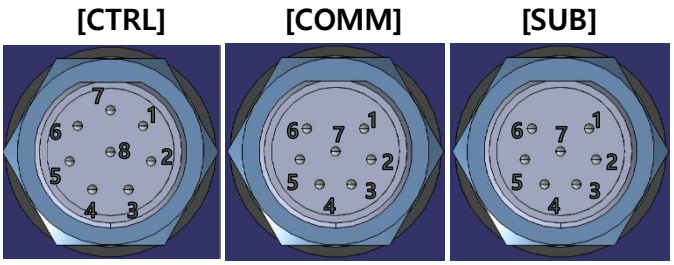
3. Part Names, Operation and Settings

3.3.4 Circular Interface Connector

- CTRL : Buzzer output connector for external buzzer connection
- COMM. : Multi-panel[OUT], communication connector for power and CAN communication
- SUB : Multi-panel[IN], communication connector for power and CAN communication

No.	CTRL	COMM.	SUB
1	Buzz Battery	Key On	Key On
2	Buzz Out	Battery In	Battery In
3	VCC	CAN2 H	CAN2 H
4	RPM_TRIM	CAN2 L	CAN2 L
5	GND	CAN1 H	CAN1 H
6	ISO_AUX+	CAN1 L	CAN1 L
7	ISO_AUX-	GND	GND
8	GND	-	-

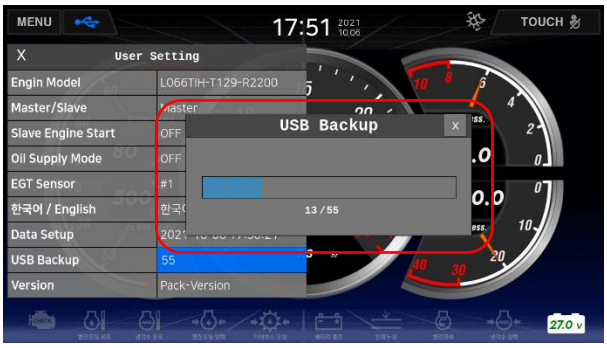
[Table. 3-6]



[Fig 3-6]

3.3.5 USB Connector

- When backing up driving record data and upgrading software, insert a USB memory (FAT32 format is used)



[Fig. 3-7-1]

[Fig. 3-7-2]

3. Part Names, Operation and Settings

3.4 Internal Buzzer

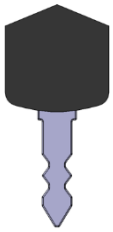
- Buzzer sound when an alarm occurs due to engine abnormality
- It operates at 98dB, and an external large-capacity buzzer can be additionally installed.

[Fig. 3-8]

3.5 Key Switch

- Digital panel system boot, engine start, and engine stop functions.

1) After inserting the key included in the product in the key switch and turning it to the position of 45º to the right (ACC), the product is booted.
2) Engine starts at the position of 90º turn (ON) and it returns to 45º position (If the key is in the ON state, keep the key lock state)
3) When ACC is ON, the product boots within 5 seconds and the gauge screen is output after the introduction screen.
4) Turn the key 45º to the left (OFF) when the engine is stopped



Key
[Fig. 3-9]

Key Switch
[Fig. 3-10]

3. Part Names, Operation and Settings

3.6 Emergency Start Button

- Used to force the engine to start in an emergency situation.

1) In the OFF state of the key, rotate the key to ON while pressing it with an available device for the buttonhole.

※ Application of safety accident prevention function

※ Hole Size : Ø7

※ It should be used only in emergency situations and product life may be affected when used.

EMG. Start Button

[Fig. 3-11]

3.7 Emergency Stop Button

- Used to stop the engine in an emergency situation

1) Press immediately in case of emergency with engine running.
   → Stop solenoid actuation while pressing and warning beep.
2) Engine RPM decreases while pressed
3) Release the press when the RPM drop

※ If the button is released within a short period of time, the engine may not be stopped

※ Emergency stop should only be used in emergency situations, as it can potentially impact the lifespan of the product.

EMG.STOP

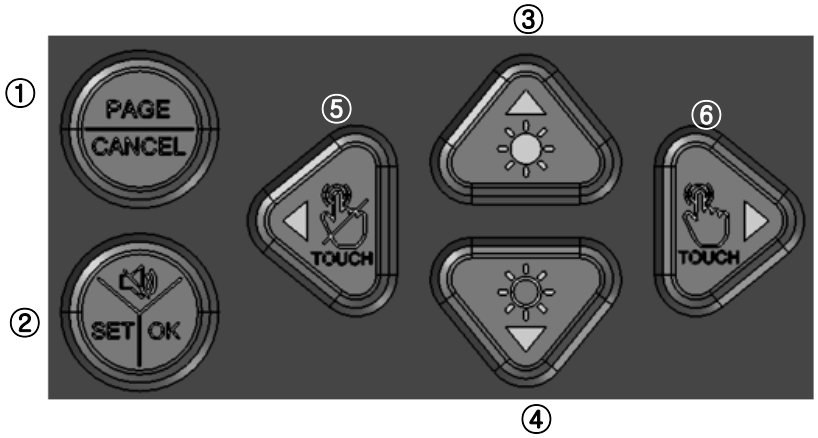
EMG. Stop Button

[Fig. 3-12]

3. Part Names, Operation and

3.8 Function Keys

- Functions such as panel setting, alarm stop, menu movement and selection.



[Fig. 3-13] Function Keys

NO.	Function	Action Characteristics
①	Page	· Switch page / cancel
②	Ok	· Enter setting, save setting value
③	Up	· Cursor movement (up), setting value change (increase), screen brightness increase
④	Down	· Cursor movement (down), setting value change (decrease), screen brightness decrease
⑤	Left	· Cursor movement (left), Lock LCD touch function
⑥	Right	· Cursor movement (right), unlock LCD touch function

[Table. 3-7]

3. Part Names, Operation and Settings

3.8.1 Detailed User Setting

[Fig. 3-14] Detailed Settings

▶ User Setting Function and Description

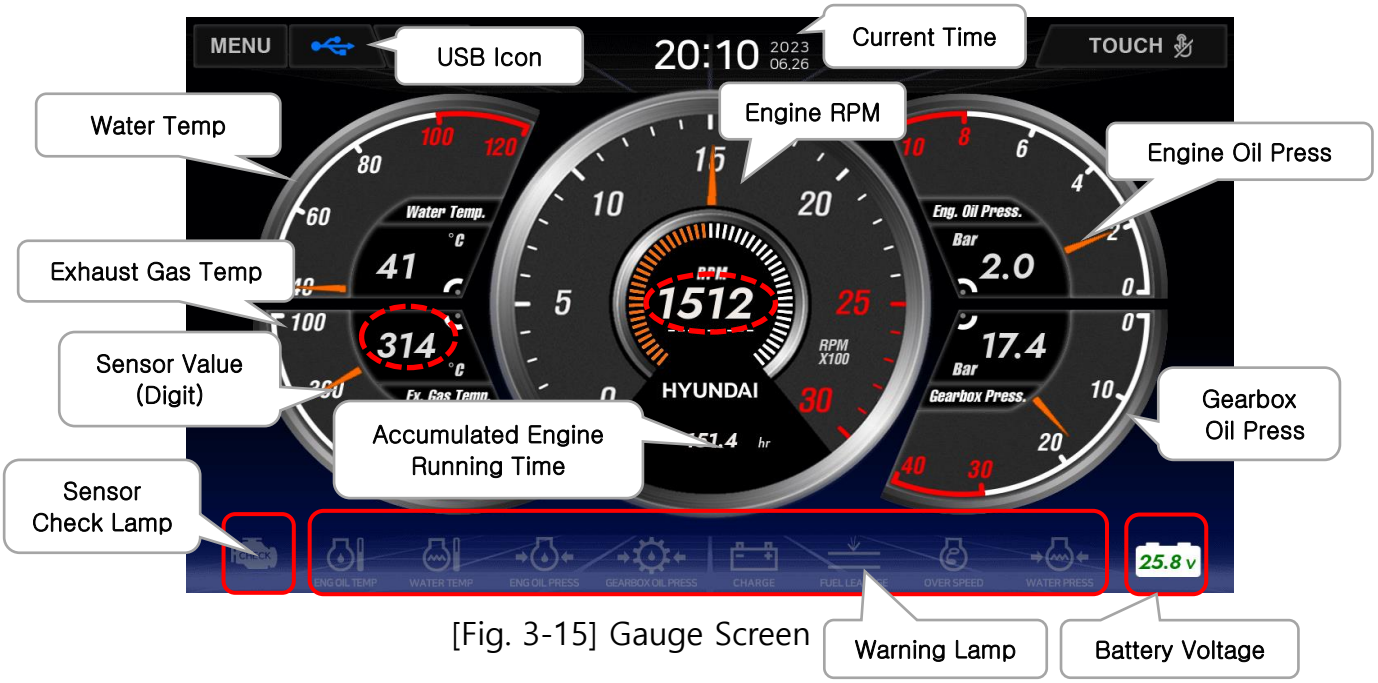
- Press and hold the settings button for 3 seconds on the main screen to enter the user settings.
- Use the arrow keys to move to the function you want to change.
- Press the Ok button to go to the gauge screen. (Auto save on change)

No.	Function	Description	Remark
1	Engine Model	· Setting the Engine Model Installed on the Ship	-
2	Master / Slave	· Master / Slave setting when using multi-panel	-
3	Slave Engine Start	· Slave start authorization On / Off	-
4	Oil Supply Mode	· On / Off function for lubrication inside the engine at idle · Can be set for a total of 5 seconds in 1 second increments	-
5	EGT Sensor	· Exhaust gas temperature sensor selection (for DX12 engine)	-
6	Korean/English	· Korean / English conversion	-
7	Date Setup	· Set date and time	-
8	USB Back up	· Backup event and driving history files to USB	-
9	Version	· Show as full integrated version of software	Select S/W update item

[Table. 3-8]

3. Part Names, Operation and Settings

3.9 Screen Layout



[Fig. 3-15] Gauge Screen

- The gauge functions include engine RPM, coolant temperature, exhaust gas temperature, engine oil pressure, gearbox oil gauge and more.
- Current time, USB detection icon, battery voltage, engine operation accumulated time, high coolant temperature, low engine oil pressure, overspeed, charging, CAN communication abnormality, moisture detection, fuel leakage and gearbox oil gauge warning lights.

3.9.1 Engine RPM

- The engine rpm is displayed as a gauge and a digital value, and the accumulated engine running time is counted.

[Fig. 3-16] Speed Gauge

1) The rpm value indicated by the needle is expressed more precisely as a digital number (digit) (The digit is always ON)
2) Displays the accumulated engine running time in 1hour increments.
   (Counts over 400rpm and is always on)
3) After starting the engine, Starter Off RPM 300 ~ 500rpm can be set

3. Part Names, Operation and Settings

3.9.2 Engine Cooling Water Temperature

- Cooling water temperature is displayed digitally with a gauge.

[Fig. 3-17]
Engine Cooling Water Temperature

1) The temperature of the coolant pointed to by the needle is more precisely expressed as a digital number (digit) (The digit is always ON)
2) In case of sensor failure, open/short diagnosis is displayed.
3) Warning lamp and warning sound when starting state is over 93℃
4) Stop the engine when the starting state is over 103 ℃

3.9.3 Engine Oil Pressure

- Displays engine oil pressure with gauge and digital.

[Fig. 3-18]
Engine Oil Pressure Gauge

1) The oil pressure value indicated by the needle is more precisely expressed as a digital value (digit) (The digit is always ON)
2) In case of sensor failure, open/short diagnosis is displayed.
3) Warning light and warning sound when less than 1 bar (Detected when holding for 10 seconds)
4) Engine stop when less than 0.5 bar (Detected when holding for 10 seconds)
5) Alarm does not work before starting, but alarm works when normal engine stops

3.9.4 Exhaust Gas Temperature

- Displays exhaust gas temperature with gauge and digital.

[Fig. 3-19]
Exhaust Gas Temperature

1) Express the exhaust gas temperature pointed by the needle more precisely as a digital number (digit) (The digit is always ON)
2) In case of sensor failure, open/short diagnosis is displayed.
3) Preliminary sensor warning light operates when the starting state is over 600 ℃

3. Part Names, Operation and Settings

3.9.5 Gearbox Oil Pressure

- Displays gearbox oil pressure with gauge and digital.

[Fig. 3-20]
Gearbox Oil Pressure

1) The gearbox oil pressure value indicated by the needle is more precisely expressed as a digital value (digit)
2) Diagnose open or short circuit when a sensor malfunction occurs.
3) When the ignition state is below 1 bar, a warning light and alarm sound are activated (if detected for more than 10 seconds).

3.9.6 Battery Voltage

- Displays the battery voltage to inform you of the battery status.

[Fig. 3-21] Battery Voltage

1) Green for more than 24V / Red for less than 24V
2) Fault code P0562 and warning sound when battery is low voltage

➔ Low battery voltage

3.9.7 Check Sensor Light

- When a sensor error (open, short) occurs or communication fault between DACU and Sensors, the sensor check light turns on.

[Fig. 3-22] Check Sensor Light

1) When a sensor error occurs, the check light turns on in red.
2) Lights orange when an error has ended.

※ In case of engine oil pressure sensor failure, open or short gauge screen is displayed.

Open Short

[Fig. 3-23] Check Sensor Light

3. Part Names, Operation and Settings

3.9.8 Engine Alarm

- In case of coolant temperature, engine oil pressure, gearbox oil pressure, charging, moisture detection, overspeed, or fuel leakage, warning lights flash and a buzzer sound.

[Fig. 3-24] Engine Alarm

NO.	Alarm	Action Characteristics
①	Water Temperature	· Warning light (buzzer) On when over 93℃
②	Engine Oil Pressure	· Warning light (buzzer) On when less than 1 bar
③	Gearbox Oil Pressure	· Warning light (buzzer) On when less than 1 bar
④	Charge	· Warning light (buzzer) On when battery voltage is less than about 18V
⑤	Fuel Leakage	· Warning light (buzzer) on in case of fuel leakage (Default: Disable)
⑥	Over Speed	· Warning light (buzzer) On when over 117% of Rate Speed

[Table. 3-9] Warning light characteristics

3.9.9 Engine Stop

1) When engine overspeed is more than 117% of Rate Speed → Enable/Disable engine stop
2) When the coolant temperature is over 103℃ → Enable/Disable engine stop
3) When the engine oil pressure is kept less than 0.5 bar for more than 10 seconds → Engine stop Enable/Disable possible
4) When fuel leakage occurs → Engine stop Enable/Disable possible
5) When activated Stop Valve → Stop Button is actuated by the user (at 0 RPM for 7 seconds)

※ How to turn off the engine warning light

- When the alarm condition is cleared and it is maintained for 3 seconds, the buzzer and lamp are automatically released and the lamp changes to orange color

3. Part Names, Operation and Settings

3.10 Spare Sensor

- It displays the status of other sensors, product S/N, ECU MAP VERSION, and GUI/FIRMWARE version. Pressing the menu key among the function keys moves to the spare sensor page.

[Fig. 3-25] Spare Sensor (Including Classification Applied Sensor) Information

Item	**Action Characteristics**
Exhaust Gas Temperature1 (High)	· Warning light turns on when exhaust temperature is over 600℃
Exhaust Gas Temperature2 (High)	· Warning light turns on when exhaust temperature is over 600℃
Water Pressure	· Warning light turns on when coolant pressure is less than 0.2 bar
Engine Oil Over Heat	· Warning light turns on when engine oil exceeds 120℃

[Table. 3-10] Spare Sensor

3. Part Names, Operation and Settings

3.11 Alarm Page

- The number of normal starts / number of normal stops / number of abnormal stops / number of emergency starts / number of emergency stops accumulated number of sensor alarm occurrences and information of the latest date of alarm are displayed in the digital panel itself.
- If you press the menu button on the other sensor page, the screen switches to the event summary page.

[Fig. 3-26] Fault Code List

Alarm List	
Water Temp. Over Heat	Low Voltage
Low Engine Oil Pressure	Engine Oil Over Heat
Low Gearbox Oil Pressure	Main Connector Removed
Battery Charge (Alternator)	High Exhaust Gas Temperature
Fuel Leakage (Switch)	Main Connector Removed
Over Speed	-

[Table. 3-11] Alarm List

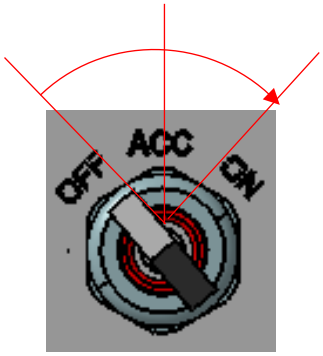
3. Part Names, Operation and Settings

3.12 System Booting and Functional Check

- A checkup is conducted to ensure the proper installation of the product.

▶ Normal System Booting

1) After inserting the key into the key switch, if the key is rotated in the ON direction (right), it returns to the central point and is fixed.



[Fig. 3-27] Key Switch

2) HYUNDAI logo is displayed when the system is booted

※ In case, the screen is not output when the key is rotated

- Key OFF and then ON again
- Check the harness connection behind the panel
- Check for battery discharge

3) After booting normally, the gauge screen appears.

- Gauge : Check that each gauge needle is within the normal range and check if it is displayed on the 'OPEN' or 'SHORT' screen

※ When 'OPEN' or 'SHORT' occurs

- Check the harness connection status
- Function keys: Check whether each function key is operated normally
- Warning light: Check if the warning light is on
- Battery: Check if the battery voltage is normal

4) If there is no problem in the initial gauge screen, turn the key to start the engine.

5) Check RPM operation (initial 400RPM or higher, oil pressure 1bar or higher) and warning light on (red lamp blinks when warning light is on)

4. Multi Panel Structure

4.1 Multi Panel

- It is possible to install up to 3 additional units except for the Master in the vessel, and it is possible to check and control the vessel status at any time depending on the setting. (Be careful of the battery voltage drops as the length of the harness increases.)

[Fig. 4-1] Master

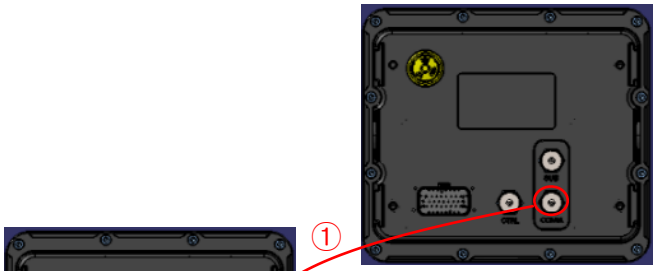
[Fig. 4-2] Slave 1

[Fig. 4-3] Slave 3

[Fig. 4-4] Slave 2

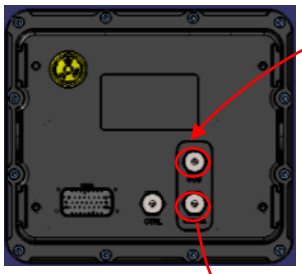
4. Multi Panel Structure

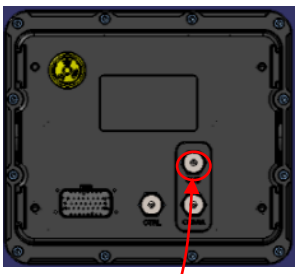
4.2 How to Install Multi Panel



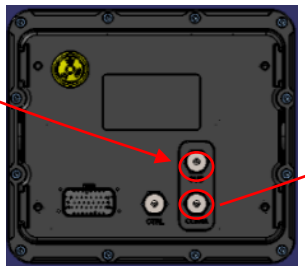
[Fig. 4-5]
Master

[Fig. 4-6]
Slave 1





[Fig. 4-8]
Slave 3



[Fig. 4-7]
Slave 2

※ Before installing the multi-panel, the necessary cables should already be prepared.
(Cables should use Hyundai's recommended specifications)

(1) Connect the SUB terminal of the Master panel to the main connector terminal of the Slave 1 panel as shown in ①. (2 panels)

● Master and Slave 1 connection completed

(2) In the state connected as in ① above, as in ②, that is, connect Slave1(COMM) to Slave2(SUB). (3 panels)

● Master and Slave 1, Slave 2 connection completed

(3) In the state connected as in ② above, as in ③, that is, connect Slave2(COMM) to Slave3(SUB). (4 panels)

● Master, Slave 1, Slave 2, Slave 3 connection completed

4. Multi Panel Structure

4.3 Multi Panel Setting

(1) Press and hold the OK button of the panel to be set in Slave mode for 3 seconds.

(2) When the Settings window opens, navigate to Figure ① (Use the directional keys to navigate).

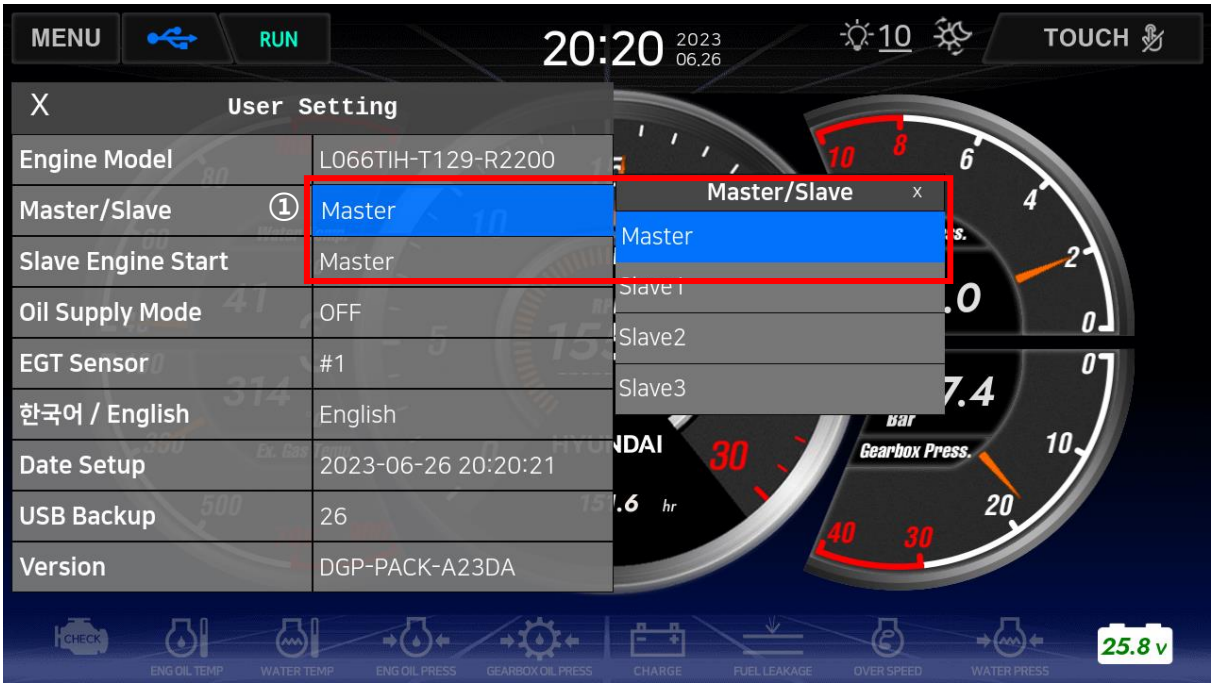
(3) Press the OK button to switch between Master / Slave1 / Slave2 / Slave3.

※ Note: When connecting multiple Slaves, the Slave mode settings should not overlap.

(4) Set the panel to Master mode using the same method as above

※ Note

- Only one product can be set in Master mode, and up to two Slaves are recommended.
- If the cable length between Master and Slaves is more than 30m, there may be a voltage drop of more than 1V, so it needs to be checked.
- Granting engine start permission to Slave panels can only be done from the Master panel and when the "slave engine start setting" is On, the selected slave panel has the starting authority.
- Emergency start is only possible from the Master panel, while emergency stop is possible from all panels.
  - The emergency stop of the Slave operates through CAN communication.
- During engine operation (RUN), re-engaging the starter is not possible.



[Fig. 4-9] Multi Panel Setting Popup

5. Maintenance

5.1 Maintenance

- To maintain the performance of the device, regular maintenance is required.

1. Use soft cloth to clean the LCD without damaging it.
    1) Clean the LCD after turning the power off.
    2) Do not use cleaners with acids or ammonia.
    3) Do not use neutral detergents to remove oil stains.
    4) Use cloth slightly wet in clean water to remove salt residuals or dust particles for natural drying. If there remain stains, clean them with soft cloth (microfibers) once again.
2. Check whether the connectors or harnesses at the back of the device are properly connected or whether they have dust or other foreign substances.
3. Check whether cables are damaged.
4. Request for checking when the software needs upgrade as follows:
    - When the manufacturer releases official software for performance improvements

5.2 Troubleshooting

- It describes possible measures for users to resolve problems while using the device.

1. The device is not turned on.
    1) Check whether harness cables at the back of the product are properly connected.
    2) Where harness cables have too much dust or moisture, remove them and clean the dust or moisture. Connect them once again after a while.
    3) Check whether the fuse button at the back of the product is pulled out.
    4) Check whether the battery is discharged.
2. You can see lines or shaking on the screen.
    1) Reboot the product.
    2) As the LCD is connected inside the product, do not disassemble it and contact the service team.
3. You can see alarm or hear warning beeps at the bottom of the product screen.
    1) Check where the alarm occurs and then take measures as necessary (if you need to confirm which alarm occurs, refer to Page 20 of this manual).
4. You cannot control buttons.
    1) Check whether there are foreign substances at the panel buttons.
    2) As the button connecting parts may be damaged, do not disassemble the product and contact the service team.

6. Warranty and A/S Service

6.1 Warranty

- As this manual contains important contents related to safety, use and maintenance of the product. So please read this manual carefully and then use the product in a proper manner.

Those who are not familiar with the product should keep this manual close to themselves.

- We are not responsible for human injuries or property damages caused by the following reasons:

- Where you use the product for purposes other than the ones described in this manual
- Where you alter the product or its components at discretion
- Where you disassemble the product at discretion to resolve problems
- Where you use accessories or parts not supplied or recommended by us

※ Where you use accessories or parts manufactured by other companies, please contact our service.

6.2 A/S Service Information

- When you request A/S service, please let us know the model's name, breakdown conditions and your contact information.
- Please ask the seller.

7. Appendix

7.1 List of Engine Models

- List of compatible engine models

- Engine		Gear 잇수	Rate Speed	Over Speed	
DB58TI	L066TIH	129	2,200	115%	2,530
D1146	L136	140	2,200	115%	2,530
D1146T	L136T	140	2,200	115%	2,530
	L136TL	140	2,500	115%	2,875
D1146TI	L136TI	140	2,200	115%	2,530
D1146TIB	L086TIH	140	2,200	115%	2,530
	L086TIM	140	2,300	115%	2,645
	L086TIL	140	2,500	115%	2,875
DE12T	MD196T	152	2,000	115%	2,300
DE12TI	MD196TI	152	2,000	115%	2,300
DE12TIB	L126TIH	152	2,000	115%	2,300
	L126TIM	152	2,100	115%	2,415
D2848LB	V158TIH	160	1,800	115%	2,070
	V158TIM	160	2,100	115%	2,415
	V158TIL	160	2,300	115%	2,645
D2840LB	V180TIH	160	1,800	115%	2,070
	V180TIM	160	2,100	115%	2,415
	V180TIL	160	2,300	115%	2,645
D2842LB	V222TIH	160	1,800	115%	2,070
	V222TIM	160	2,100	115%	2,415
	V222TIL	160	2,300	115%	2,645
4VD2848LB	4V158TIH	160	1,800	115%	2,070
	4V158TIM	160	2,100	115%	2,415
	4V158TIL	160	2,300	115%	2,645
4VD2842LB	4V222TIH	160	1,800	115%	2,070
	4V222TIM	160	2,100	115%	2,415
	4V222TIL	160	2,300	115%	2,645

Digital Panel for Marine Generator's

User Manual

Ver.1.2

HYUNDAI

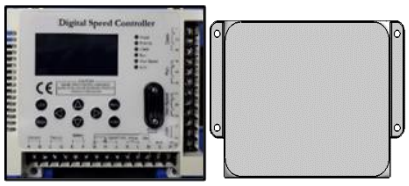
▶ Index

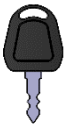
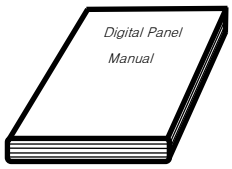
1. General Information

1.1 Product Information

The name of the product model is DGP-2000 applicable to various marine generator engines. The product is intended to improve problems of existing analog panels and allow users to check engine controls and conditions by means of a digital visualization product. It provides information in analog graphic gauges and digital displays for enhanced user experiences.

1.2 Components

Items	Image	Qty	Description	Remark
DGP-2000 ASM		1	Body of Digital Panel for Marine Gen.	
DSC-2000		1	Digital Speed Controller for Marine & Cover	
DSC Bracket		1	Assembly DGP-2000 and DSC-2000	
Desk Mounting Type Bracket		1	To install DGP-2000	

Fix handle		2	Tilting DGP-2000	
Key		2	To boot DGP-2000	
Manual		1	User manual	

[Table 1-1]

1.3 Product Specification

No.	Items	DGP-2000	DSC-2000
		Description	
1	CPU	• Cortex-A8, dsPIC33FJ256(16bit)	• dsPIC33FJ256(16bit)
2	S/W	• Windows CE 6.0 R2(OS)	• Firmware
3	Display	• 10.2" Color TFT LCD • 800 * 480(pixel) • 16 : 9	• Graphic LCD 128*64
4	Flash Memory	• 256MB(Flash) • 8GB(MicroSD card)	• 128MB
5	RAM	• 512MB	• -
6	Operating Volt.	• DC 24V (16 ~ 30V)	• DC 24V (12V~30V)
7	USB	• USB2.0 1Port	• -
8	Operating Temp.	• - 20℃ ~ 70℃	• -20~+70℃
9	Buzzer	• Piezo Buzzer 98dB	• -
10	Communication	• J1939 CAN • RS232	• RS232 57600bps • CAN(J1939)/250kbps
11	Size	• W 344 x H 271 x D 160	• W 170 x H 165 x D 30

[Table 1-2]

2. Installation

2.1 Cautions

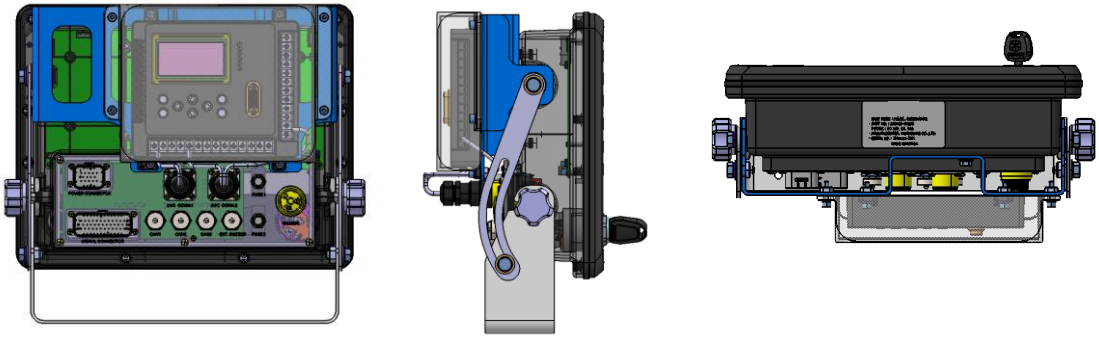
- Unskilled personnel should read this manual before use.
- Do not use or keep the product close to combustible sprays or inflammable.
- Use soft and dry cloth to clean the monitor.

  Turn off the product, pull out the harness cable and then contact our service center when you see smoke from the monitor or have strange smells.
- When you see an alarm on, you always need to check the product before operation.
- Do not disassemble the product cover at discretion (warranty does not cover unauthorized disassembly).
- Excessive impact may damage the display although a reinforced display is used.
- Use connectors matching each other when connecting them to the back of the product.

  Do not contact or remove connectors while the power is on. It may cause electric shock or lead to malfunction.
- Do not exercise excessive force when rotating to ON/OFF with the key inserted.
- Do not use the product with wet hands.
- Use protective caps for back side connectors that are not used.

2.2 Installation

- Install DGP-2000 in the engine room by using Desk Mounting brackets delivered with the product.



※ Spec. of mounting hole : M6 bolt [Fig 2-1]

▶ Installation Sequence for DGP-2000

1) Check whether the engine room has engine harness wiring.

2) Separate the temporary assembled bracket from product.

3) Use the mounting hole to fix the bracket in a place within reach of the engine harness wiring.

4) Place the product inside the bracket connected with the rotation lock to connect it with the rotation lock.

5) Put the wave washer in the fix handle and connect it with the fix handle. Then adjust the viewing angle of the LCD.

※ Where there are things to which the product can be fixed, use spare holes with the bolt or other.

3. Part Names, Operation and Settings

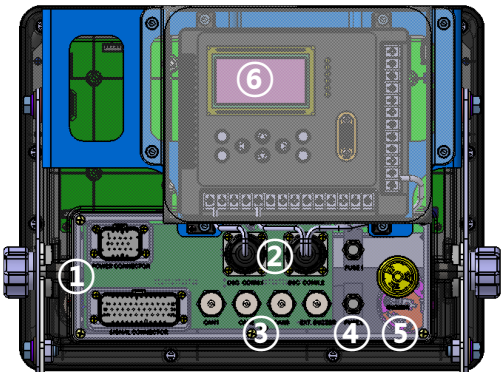
3.1 Front Side

[Fig 3-1]

No.	Name	Ref.
①	LCD	p15
②	Function Key	p13
③	Key Switch	p11
④	USB	p11
⑤	Buzzer	p11
⑥	Start/Stop Button	p12

[Table 3-1]

3.2 Back Side



[Fig 3-2]

No.	Name	Ref.
①	Main Connector(2EA)	p8
②	DSC Connector(2EA)	p10
③	CAN & PC Communication	p10
④	Fuse(6A, 10A)	p11
⑤	Buzzer	p11
⑥	DSC	-

[Table 3-2]

3.3 External Connections

- External connection terminals are used for inputs and outputs of generator engine control signals and each sensor signals.

3.3.1 Power Connector

- Power connector supplies power and power signals.

POWER CONNECTOR

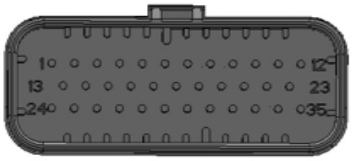
[Fig 3-3]

No.	Pin Description	Remark
1	Alternator In	Battery
2	-	-
3 4	Battery(+)(DC 24V)	Input to fuse
5	Starter Signal	-
6	-	-
7	-	-
8	Starter Signal	-
9	Starter Signal	-
10	Actuator A	-
11	Actuator B	-
12	GND	Power
13	GND	
14	Battery(+)(DC 24V)	Input to fuse

[Table 3-3]

3.3.2 Signal Connector

- Signal connector supplies sensor signals.



SIGNAL CONNECTOR

[Fig 3-4]

* : Only for IMO Tier3

No.	Pin Description	Remark	No.	Pin Description	Remark
0	Exhaust Gas Temp. Sensor 1 **(+)**	-	19	Spare Analog Input 3	-
2	Engine Water Temp. Sensor	-	20	Pickup Sensor **(+)**	-
3	Engine Oil Pressure Sensor	-	21	-	-
4	*Engine Oil Temp. Sensor	-	22	-	-
5	*Boost Air Pressure Sensor	-	23	GND	Sensor
6	*Fuel Level Sensor	-	24	-	
7	-	-	25	Exhaust Gas Temp. Sensor 2 **(+)**	-
8	Spare Analog Input 4	-	26	Exhaust Gas Temp. Sensor 2 **(-)**	-
9	Spare Digital Input 1	-	27	-	-
10	-	-	28	-	-
11	Fuel Leakage Switch	-	29	-	-
12	GND	Sensor	30	-	-
13	Exhaust Gas Temp. Sensor 1 **(-)**	-	31	-	-
14	Engine Water Press. Sensor	-	32	-	-
15	-	-	33	-	-
16	*Engine Water Level Sensor	-	34	-	-
17	*Boost Air Temperature Sensor	-	35	GND	Sensor
18	Spare Analog Input 1	-	-	-	-

[Table 3-4]

3.3.3 CAN Connectors

- CAN harness (optional) connection
- CAN1/CAN2: for multi panels
- CAN3: PC communication, firmware download

[Fig 3-5]

No.	CAN1	CAN2	CAN3
1	+12V Out	+12V Out	+12V Out
2	GND	GND	GND
3	CAN1_H	CAN1_H	CAN2_H
4	CAN1_L	CAN1_L	CAN2_L
5	Battery(+)	Battery(+)	PC_RXD1
6	GND	GND	PC_TXD1

[Table 3-5]

3.3.4 External Buzzer Connector

- Additional connection for external buzzer harness
- Generating external buzzer alarms for warnings

[Fig 3-6]

No.	Pin map
1	Battery(+) – Output of fuse
2	Alarm Out

[Table 3-6]

3.3.5 DSC Connector

- Connecting DGP-2000 with DSC-2000
- Function of DSC-2000 power supply, pick-up signal transmission, actuator signal transmission and CAN communication function

[Fig 3-7]

Pin No.	Pin Name	Description	Remark
A	Actuator A	Control signal for actuator	
B	Actuator B	Power for actuator	
C	-	-	

[Table 3-7]

[Fig 3-8]

Pin No.	Pin Name	Description	Remark
1	Batt. +	Power	DSC power on(off) by engine start(stop)
2	Batt. -	Power	
3	RPM	Pick-up signal	Original pickup signal through digital panel
4	CAN H	CAN High	DSC Inform., Idle/Run Switch
5	CAN L	CAN Low	
6-7	-	-	-

[Table 3-8]

3.3.6 USB Connector

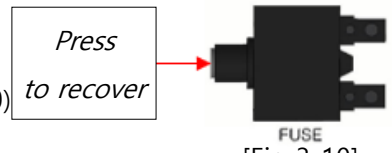
- USB memory can be inserted for data backup.

[Fig 3-9]

3.4 Fuse and Buzzer

3.4.1 Fuse

- It consists of 6A(for digital panel) fuse and 10A(DSC-2000) fuse
- 10 seconds after fuse operation, press fuse button to recover



[Fig 3-10]

3.4.2 Buzzer

- Generate alarms for sensor problems

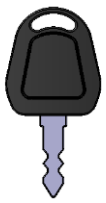
[Fig 3-11]

3.5 Key Switch

- Key switch is used to boot and turn off the digital panel or stop the engine.

1) Use the key contained in the product to insert it and rotate to the right over 45° (ON) (when the key is ON, the key should remain inserted).

2) When the key is ON, the product will boot and the gauge display will

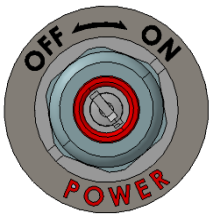


[Fig 3-12]

appear in about 15 seconds.

3) Rotate the key to the left by 45º (OFF) to turn it off.

- When rotating the key to the left (OFF) while the power is on, the display will show a popup message for 300 seconds. The engine will stop and the event will be saved after 300 seconds.
- When the popup window appears, rotate the key to the right (ON) to remove the window and keep the engine on.



Key Switch
[Fig 3-13]

3.6 Start/Stop Button

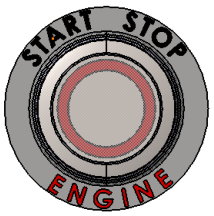
- Start/Stop button is used to start/stop control for the generator engine.

1) Press the button for more than 1 second while the key is ON,
the engine will start (the button LED will flash when pressing the button).

2) Press the button for more than 1 second while the key is ON and the engine is in operation to stop the engine.

※ The time can be set from 1 to 3 seconds. Ask for the service member.

※ Installed the protection cover to prevent object come in.



Start/Stop Button
[Fig 3-14]

3.7 Emergency Stop Button

- Emergency Stop Button is used to urgent engine stop for the emergency situation.

1) Press immediately when an emergency situation occurs in the engine run state.
→ Red LED on while pressing

2) Release the button after the engine is completely stopped.
→ LED off when released

※ If you release the button before stopping the engine, the engine will restart.

Emergency Stop Button
[Fig. 3-15]

3.8 Function Keys

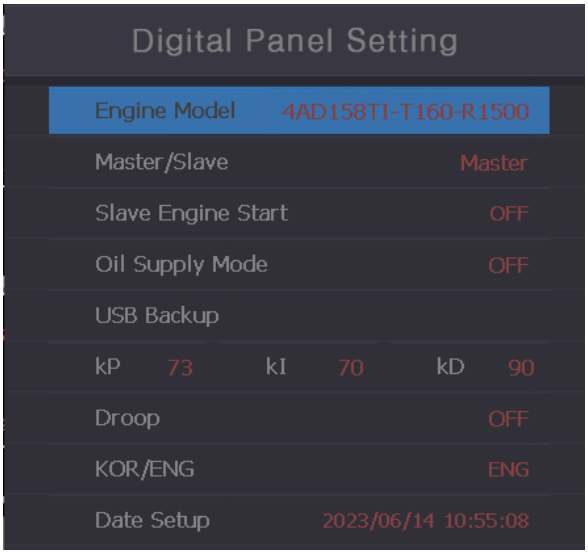
- Function keys are used to adjust LCD brightness, alarm mute, Idle/Run, Digit on/off, Home and other settings, move to and select menus, and reset the system.

[Fig 3-16]

No.	Function Key	Action Feature
①	LCD Brightness	- LCD brightness adjustable for 5 different levels (when rebooting the system, the previous setting will be maintained)
②	Alarm Mute	- Turn off the buzzer sound
③	Idle/Run	- Changing the engine status Idle to Run
④	Digit	- Digit is default on - Press **DIGIT,** the number light will be off - Press while the display is off, the number light will turn on
⑤	Home	- Move to main gauge display - Move to main display without saving when pressing it in page mode
⑥	Setting	- Engine Model setting - Master/Slave setting and ON/OFF setting to start the slave - ON/OFF oil supply mode - USB backup and date(year/month/hour) settings - Setting PID - Droop On/Off
⑦	Up/Down	- Move the cursor up and down in setting window
⑧	Enter	- Select menus or functions in the setting window
⑨	Page	- Move to spare sensor display (display page 2) / Move to event summary display (display page 3)
⑩	System Reboot	- Rebooting for system errors (press it for more than 3 seconds to reboot)

[Table 3-9]

3.8.1 Setting Items



[Fig 3-17]

▶ Setting Functions and Descriptions

- Press ***Setting*** button and then use ***Up*** or ***Down*** button to move to functions to be changed.
- Press ***Setting*** button to go back to gauge display (changes will be automatically saved).

No.	Function	Description	Remark
1	Engine Model	Engine model setting (refer to the appendix for the list of engine models)	
2	Master / Slave	Master/Slave setting for multi panels	
3	Slave Engine Start	ON/OFF setting to start by slave	
4	Oil Supply Mode	Engine cranking	
5	USB Back Up	USB backup for the saved event files	
6	Droop	Setting the engine's droop mode	
7	PID	Changing PID values	
8	Date Setup	Date and time setting	

[Table 3-10]

3.9 Display Structure

[Fig 3-18]

- Gauge display shows various gauge data including pick up(RPM) sensor, coolant temperature, exhaust gas temperature and engine oil pressure.
- DSC-2000 information icons to monitor the generator's status.
- It also includes battery voltage indication, accumulated engine operation hours, coolant temperature, engine oil pressure, gearbox oil pressure, charging, coolant level, fuel leak and overspeed alarm.

3.9.1 Engine Speed (Tachometer)

- It shows engine RPM in gauge and digital values and counts accumulated engine operation hours.
- Harness → Digital Panel → DSC → CAN → Digital Panel

[Fig 3-19]

1) It shows the RPM indicated by the gauge hand in digital values(red) for better accuracy.
2) It shows accumulated engine operation hours by hour unit. (engine speed of 400RPM or faster will be counted and the function is always on)
3) Starter Off RPM setting is available between 300 and 600RPM after the engine starts.
(The service team can configure the setting in PC Manager)
4) Engine stop(DSC function) and alarm lamp, buzzer at 115% of rate speed

3.9.2 Engine Water Temperature

- It shows the coolant temperature in gauge and digital values.

1) It shows the temperature indicated by the gauge hand in digital values(blue) for better accuracy.

2) It shows the open/short diagnosis for sensor problems.

☞ Open: 'ERROR' / Short (GND): '-----'

3) It also serves as the water temperature switch.

4) It activates alarm and warning beep when the temperature increases up to 93℃ or higher.

5) When the temperature increases up to 103℃ or higher, the engine will stop.

[Fig 3-20]

3.9.3 Engine Oil Pressure

- It shows engine oil pressure in gauge and digital values.

1) It shows the pressure indicated by the gauge hand in digital values (blue) for better accuracy.

2) It shows the open/short diagnosis for sensor problems.

☞ Open: '-----' / Short (Power): 'ERROR'

3) It also serves as the engine oil pressure switch.

4) It activates alarm and warning beep when the pressure is 1bar or lower (detects in 10 seconds)

5) When the pressure is 0.5bar or lower, the engine will stop

6) It will not work before the engine starts.

[Fig 3-21]

3.9.4 Exhaust Gas Temperature

- It shows exhaust gas temperature in gauge and digital values.

1) It shows the temperature indicated by the gauge hand in digital values(blue) for better accuracy.

2) It shows the open/short diagnosis for sensor problems.

☞ Open: 'ERROR' / Short (GND): '-----'

3) It warning light turns on at 600 ℃ or higher (spare sensor page)

[Fig 3-22]

3.9.5 Battery Voltage

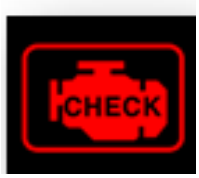
- It shows battery voltage to indicate its conditions.

1) It shows in blue for voltage of 24V or higher and red for voltage lower than 24V. [Fig 3-23]

2) It activates warning beep when the voltage is under 18V(regardless of whether the engine is in operation or not). ☞ Possible battery degradation when over 28.9V (overcharge)

3.9.6 Engine Check Lamp

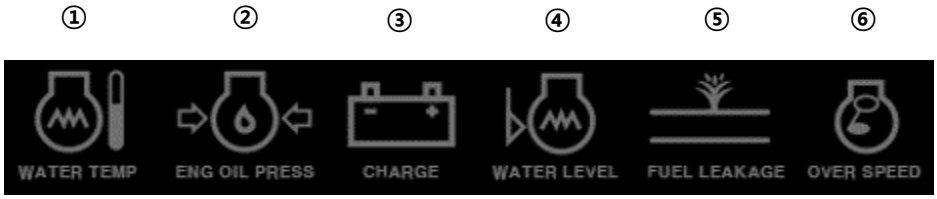
- When there are sensor errors (Open or Short), the check sensor lamp will flicker with buzzer.



[Fig 3-24]

3.9.7 Engine Alarm Lamp

- The alarm lamp will flicker with buzzer beeping when problems for coolant temperature, engine oil pressuree, charging, coolant level, fuel leakage and over speed are detected.



[Fig 3-25]

NO.	Lamp	Conditions
①	WATER TEMP(Coolant temperature)	· When the temp is **93℃** or higher
②	ENGINE OIL PRESS(Engine oil pressure)	· When the pressure is **1 bar** or lower
③	CHARGE(Battery Charge)	· When the battery voltage is lower than 18V
④	WATER LEVEL(Coolant level)	· When the level is **30%** or lower(Default 'disable')
⑤	FUEL LEAKAGE(Fuel leakage)	· When oil leak occurs(Default 'disable')
⑥	OVER SPEED(Engine over speed)	· When the speed exceeds **115%** of the rate speed

[Table 3-11]

※ How to deactivate the engine alarm

- Press SYSTEM RESET button on the right for 3 seconds, the system will reboot and the alarm will be deactivated(rebooting is available while the ship navigates without causing problems).

3.9.8 DSC-2000 information icons

[Fig 3-26]

No.	Description
①	Target RPM for generator
②	Duty rate of the current actuator for generator
③	Indication for Power on/off status of DSC-2000
④	Indication for PICK-UP signal input status
⑤	Indication for generator OVER SPEED
⑥	Indication for generator CRANK status
⑦	Indication for generator RUN status
⑧	Indication for generator ERROR status
⑨	Indication for generator IDLE ON/OFF status
⑩	Indication for generator DROOP ON/OFF status

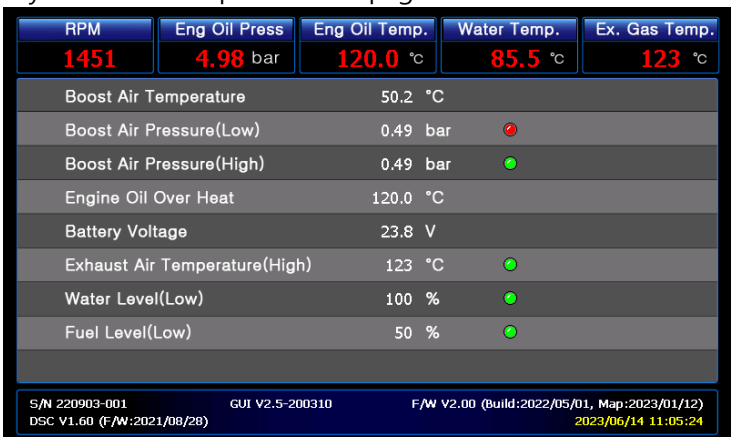
[Table 3-12]

3.9.9 Engine Stop

- When the over speed exceeds **115%** of the rate speed → **Function of DSC-2000**
- When the coolant temperature exceeds **103℃** → Enable/Disable engine stop
- When the oil pressure is lower than **0.5bar** → Enable/Disable engine stop
- When fuel leakage occurs → Enable/Disable engine stop
- When the coolant level is **15%** or lower → Enable/Disable engine stop
- When 300 seconds alarm message pop up due to key off during engine run
- When the stop button will be activated by users(Digital Speed Controller power off)

3.10 Spare Sensors

- It identifies the status of spare sensors, product S/N, S/W version and date. Press ***Page*** button of the function keys to move to spare sensor page.



[Fig 3-27]

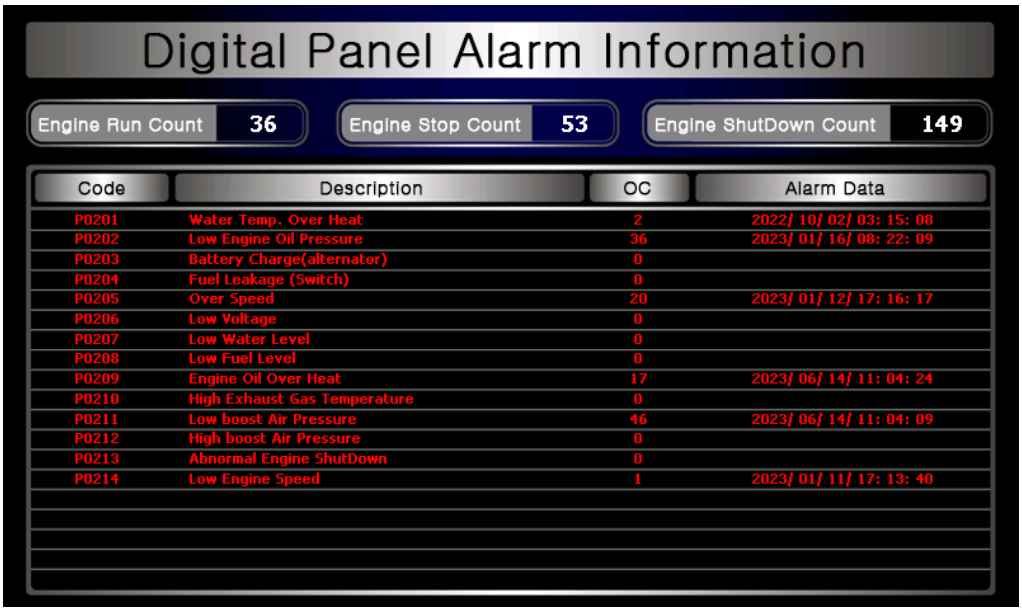
Items	Conditions
*Boost Air Temperature	• Current temperature of BATS(No alarm)
*Boost Air Pressure	• Normal when the pressure is between 1.1 and 2.9bar
*Boost Air Pressure (Low)	• Alarm when the pressure is lower than 1bar
*Boost Air Pressure (High)	• Alarm when the pressure is higher than 3bar
*Engine Oil Over Heat	• Alarm when the temperature is higher than 120℃
Battery Voltage	• Current battery voltage
Exhaust Air Temperature(High)	• Alarm when the temperature is higher than 600℃
*Water Level (Low)	• Alarm when the coolant level is lower than 30%
*Fuel Level (Low)	• Alarm when the fuel level is lower than 30%

* : Sensor for IMO Tier3

[Table 3-13]

3.11 Event Summary

- It shows the numbers of normal operations, normal stops, emergency stops and sensor errors together with dates of recent errors.
- Press ***Page*** button in spare sensor page to move to event summary page.



[Fig 3-28]

Event List			
P0201	Water Temp. Over Heat	P0208	*Low Fuel Level
P0202	Low Engine Oil Pressure	P0209	Engine Oil Over Heat
P0203	Battery Charge(Alternator)	P0210	High Exhaust Gas Temperature
P0204	Fuel Leakage(Switch)	P0211	*Low Boost Air Pressure
P0205	Over Speed	P0212	*High Boost Air Pressure
P0206	Low Voltage	P0213	Abnormal Engine Shutdown
P0207	*Low Water Level	P0214	Low engine Speed

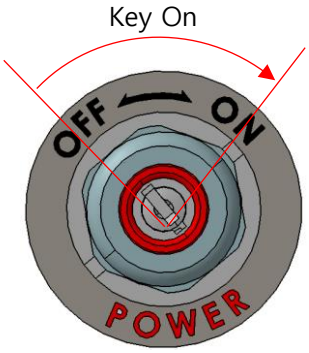
* : Sensor for IMO Tier3

[Table 3-14]

3.12 System Booting and Functional Check

- You can check whether the product is properly installed or not.

▶ Normal System Booting



[Fig 3-29]

1) Insert the key into the key switch and rotate it to the right (ON).

2) HYUNDAI logo will appear for 17 seconds while the system is booting (refer to the image).

※ If the logo does not appear after rotating the key,

●Rotate it to the left (OFF) and then to the right (ON) again

●Check the harness connection at the back of the panel

●Check whether the battery is discharged

3) The gauge display will appear after normal booting.

●Gauge: check whether each gauge hand is within the normal range and 'ERROR' or '-----' is displayed on the screen

※ Where 'ERROR' or '-----' is displayed on the screen

●Check the harness connection

●Function keys : check whether each function key is active on the screen by pressing them

●Alarm : check whether the alarm is turned on

●Battery : check whether the battery voltage is 18V or lower

4) Where the initial gauge screen is normal, press START button for 1 second to start the engine (the time can be set from 1 to 3 seconds by the service team)

5) Check whether the operation is in normal RPM (initial operation in 400RPM or faster with the oil pressure of 1bar or higher) and whether alarm is turned on.

[Fig 3-30]

4. Multi Panel Structure

4.1 Multi Panel

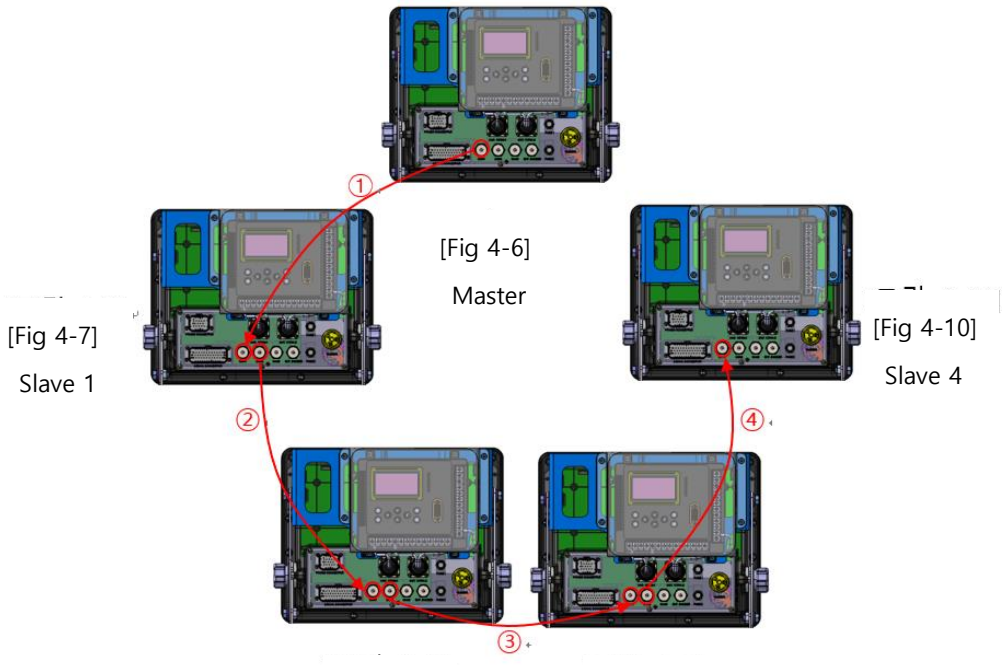
- Panels can be installed up to 4 units except Master in the ship and you can check the ship conditions and control those panels at any places of installation.

[Fig 4-2] Slave 1 [Fig 4-3] Slave 3

[Fig 4-1] Master

[Fig 4-4] Slave 2 [Fig 4-5] Slave 4

4.2 How to Install Multi Panel



[Fig 4-6] Master

[Fig 4-7] Slave 1

[Fig 4-10] Slave 4

[Fig 4-8] Slave 2

[Fig 4-9] Slave 3

※ In order to install multi panels, all the necessary cables should be ready in advance(use the cables with specification recommended by HYUNDAI).

1) Connect the CAN1 terminal of the Master panel and the CAN1 terminal of the Slave 1 panel as shown in ① (2 panels).
- ●Master and Slave 1 connection completed

2) Connect Slave 1 (CAN2) and Slave 2 (CAN1) as shown in ② while maintaining connection as described in ① (3 panels).
- ●Master, Slave 1 and Slave 2 connection completed

3) Connect Slave 2 (CAN2) and Slave 3 (CAN1) as shown in ③ while maintaining connection as described in ② (4 panels).
- ●Master, Slave 1, Slave 2 and Slave 3 connection completed

4) Connect Slave 3 (CAN2) and Slave 4 (CAN1) as shown in ④ while maintaining connection as described in ③ (5 panels).
- ●Master, Slave 1, Slave 2, Slave 3 and Slave 4 connection completed

4.3 Multi Panel Settings

1) Press ***Setting*** button of the panel to be configured as Slave.

2) Move to ① when the setting screen appears (click ***Up*** or ***Down*** button to move).

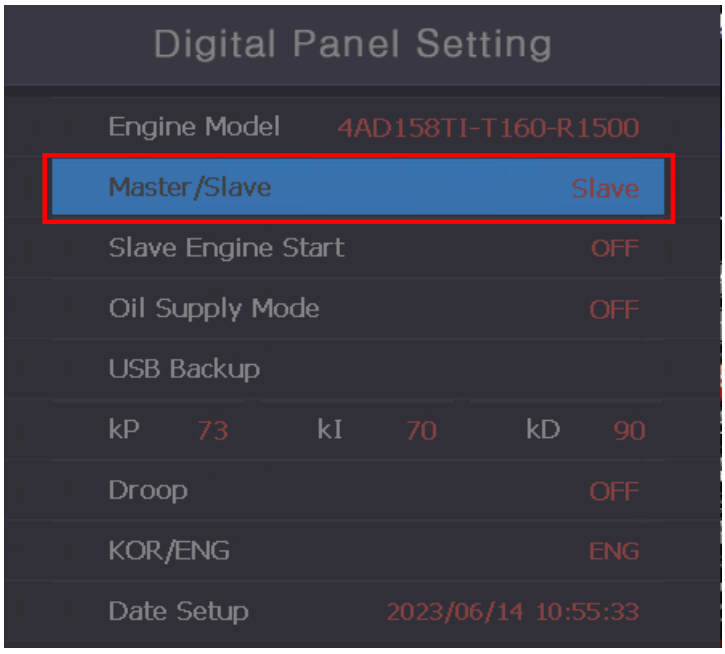
3) Press ***Enter*** button to switch configuration between Master and Slave..

4) Configure the Master panel as described above.

※ Notes

●Master mode is available for one panel only and Slave mode is available up to 4 units.

●You can permit Slaves to start the engine with Master panel only. Where you enable Slave Engine Start setting, all Slave panels will be able to start the engine.



[Fig 4-11]

5. Maintenance

5.1 Maintenance

- To maintain the performance of the device, regular maintenance is required.

1. Use soft cloth to clean the LCD without damaging it.
   1) Clean the LCD after turning the power off.
   2) Do not use cleaners with acids or ammonia.
   3) Do not use neutral detergents to remove oil stains.
   4) Use cloth slightly wet in clean water to remove salt residuals or dust particles for natural drying. If there remain stains, clean them with soft cloth (microfibers) once again.
2. Check whether the connectors or harnesses at the back of the device are properly connected or whether they have dust or other foreign substances.
3. Check whether cables are damaged.
4. Request for checking when the software needs upgrade as follows:
   - When the manufacturer releases official software for performance improvements
5. Don't give a large shock to the product.

5.2 Troubleshooting

- It describes possible measures for users to resolve problems while using the device.

1. The device is not turned on.
   1) Check whether harness cables at the back of the product are properly connected.
   2) Where harness cables have too much dust or moisture, remove them and clean the dust or moisture. Connect them once again after a while.
   3) Check whether the fuse button at the back of the product is pulled out.
   4) Check whether the battery is discharged.
2. You can see lines or shaking on the screen.
   1) Reboot the product.
   2) As the LCD is connected inside the product, do not disassemble it and contact the service team.
3. You can see alarm or hear warning beeps at the bottom of the product screen.
   1) Check where the alarm occurs and then take measures as necessary (if you need to confirm which alarm occurs, refer to Page 20 of this manual).
4. You cannot control buttons.
   1) Check whether there are foreign substances at the panel buttons.
   2) As the button connecting parts may be damaged, do not disassemble the product and contact the service team.

6. Warranty and A/S Service

6.1 Warranty

- As this manual contains important contents related to safety, use and maintenance of the product. So please read this manual carefully and then use the product in a proper manner. Those who are not familiar with the product should keep this manual close to it.

We are not responsible for human injuries or property damages caused by the following reasons:

- Where you use the product for purposes other than the ones described in this manual
- Where you alter the product or its components at discretion
- Where you disassemble the product at discretion to resolve problems
- Where you use accessories or parts not supplied or recommended by us

※ Where you use accessories or parts manufactured by other companies, please contact our service center to check their compatibility.

6.2 A/S Service Information

- When you request A/S service, please let us know the model name, breakdown conditions and your contact information.
- Please ask the seller.

7. Appendix

7.1 Generator Engine List

Engine Name	Product Name	RPM	Tooth
DB58TI	AD066TI	1500	129
		1800	
D1146	AD136	1500	140
		1800	
D1146T	AD136T	1500	
		1800	
D1146TI	AD136TI	1500	
		1800	
D1146TIB	AD086TI	1500	
		1800	
DE12TI	AD196TI	1500	
		1800	
DE12TIB	AD126TI	1500	152
		1800	
DX12	4AD126TIF 4AD126TIS	1500	106
		1800	
D2848LB	AD158TI	1500	
		1800	
D2840LB	AD180TI	1500	
		1800	
D2842LB	AD222TI	1500	160
		1800	
4VD2848LB	4AD158TI	1500	
		1800	
4VD2842LB	4AD222TI	1500	
		1800	

[Table 7-1]