

# Operation & Maintenance Manual

**MARINE ENGINE**

**4L126TI, 4AD126TI**


















## Preface

This manual includes the operation and maintenance information for DX12 marine engines. The first part contains information about handling the engine, while the second part contains information about engine maintenance, disassembling parts, inspections, repairs and reassembly, etc. The information was organized to enhance understanding of related parts and to make it easier to decide on maintenance procedures and repair parts.

The maintenance symbols included in this manual are as follows.

Be sure to observe the following to protect the environment when servicing the engine.

	Remove		Adjust
	Install		Clean
	Disassemble		Requires careful attention - Important
	Reassemble		Tighten to specified torque
	Align marks		Use special tool from manufacturer
	Direction mark		Lubricate with oil
	Inspect		Lubricate with grease
	Measure		

While servicing the engine, be sure to comply with the following instructions in order to prevent environmental damage.

- Take used oil to a used oil recycling facility.
- Never allow oil or diesel fuel to enter the sea, streams, waterways or the ground.
- Dispose of undiluted anticorrosives, antifreeze, filter elements and cartridges as special waste.
- Used coolant and special waste must be disposed of in compliance with the regulations of local institutions.

Some of the pictures in this manual use examples from a representative model for explanations. There may be slight differences with the actual shape of each individual model. Please contact the Marine Division of HD Hyundai Infracore if you have any inquiries or suggestions for improvement regarding the contents of this manual.

Finally, the contents of this service manual may be subject to change without notice in order to improve quality. Thank you.

\* 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

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# 1. General Information

## 1.1. Engine Specifications

Model		Unit	4L126TIC	4L126TIH	4L126TIM	4L126TIL
Specifications						
Engine type			4 cycle, In-line, direct injection, water cooled with turbocharger & Inter-cooler			
Rating output (B.H.P)		PS (kW)/ rpm	400 (294)/ 1,800	450 (331)/ 2,000	495 (364)/ 2,100	545 (401)/ 2,200
Displacement		cc	11,051			
Cylinders number - bore (Ø) x stroke		mm	6 - Ø123 x 155			
Valve clearance at cold		Intake / exhaust	0.4/0.7			
Low idling		rpm	725 ±25			
No load maximum		rpm	2,000	2,200	2,300	2,400
Mean effective pressure		kg/cm <sup>2</sup>	18.1	18.3	19.2	20.2
Mean piston speed		m/sec.	9.3	10.3	10.9	11.4
Compression ratio			16.7 : 1			
Firing order			1-5-3-6-2-4			
Compression pressure (at 200 rpm)		kg/cm <sup>2</sup>	37.7 (Initial condition)			
Governor type of injection pump			Mechanical all speed (RQV-K)			
Fuel consumption		g/PS.h	158	155	157	166
		Liter/h	76	83.9	94.0	108.1
Injection timing (B.T.D,C)		deg	15° ±1°	15° ±1°	17° ±1°	17° ±1°
Fuel injection nozzle opening pressure		kg/cm <sup>2</sup>	306 +14			
Starting system			Electric starting by starter motor			
Starter motor capacity		V-kW	24 - 7			
Alternator capacity		V-A	24 - 80			
Battery		V- Ah	24 - 150			
Cooling system			Indirect sea water cooling with heat exchanger			
Cooling water capacity		Liter	Max.: 42, Min.: 39			
Fresh water pump type			Centrifugal type driven by V-belt			
Sea water pump type			Rubber impeller type driven by V-belt			
Lubricating oil (Engine)		Fan capacity	Liter	Max.: 44, Min.: 20 (Engine total: 47)		
		Pressure	kg/cm <sup>2</sup>	Max.: 3, idle: 1		
Marine gear		Model (Gear ratio)	DMT240H(1.50/1.97/2.44/2.93/3.40), DMT260HL(3.53/4.08/4.52/5.04), DMTP6500(5.11/5.62/5.91/6.57/6.95)			
Direction of revolution		Crankshaft	Counter clockwise viewed from stern side			
		Propeller	Clockwise viewed from stern side			
Engine size (L x W x H)		without M/G	mm 1,311 x 904 x 1,153			
Marine gear (DMT240H)		with M/G	mm 2,031 x 904 x 1,153			
Engine dry weight		without M/G	kg 1,136			
		with M/G (240H)	kg 1,536			

Specifications		Model	Unit	Auxiliary	
				4AD126TIF	4AD126TIS
Engine type			4 cycle, In-line, direct injection, water cooled with turbocharger & Inter-cooler		
Rating output (B.H.P)	50 Hz	PS (kW)/ rpm	257 (350)/1,500		-
	60 Hz		-		302 (410)/1,800
Displacement		cc	11,051		
Cylinders number - bore (Ø) x stroke		mm	6 - Ø123 x 155		
Valve clearance at cold	Intake / exhaust	mm	0.4 / 0.7		
Low idling		rpm	725 ±25		
No load maximum (50 Hz/60 Hz)		rpm	1,500	1,800	
Mean effective pressure (Initial)		kg/cm <sup>2</sup>	19.0	18.6	
Mean piston speed (50 Hz/60 Hz)		m/sec.	7.75	9.3	
Compression ratio			16.7 : 1		
Governor type of injection pump			Electric governor		
Fuel consumption (SG: 0.832 g/cc)		g/PS.h	160	165	
		Liter/h	67	82	
Injection timing (B.T.D.C)		deg	17° ±1°		
Starting system			Electric Starting by starter motor		
Starter motor capacity		V-kW	24 - 7		
Alternator capacity		V-A	24 - 80		
Battery		V- Ah	24 - 150		
Cooling system			Heat exchanger		
Coolant water capacity		Liter	Max.: 42, Min.: 39		
Fresh water pump type			Centrifugal type driven by V-belt		
Sea water pump type			Rubber impeller type driven by V-belt		
Lubricating oil (Engine)	Fan capacity	Liter	Max.: 44, Min.: 20 (Engine total: 47)		
	Pressure	kg/cm <sup>2</sup>	Max.: 3, idle: 1		
Direction of revolution	Crankshaft		Counter clockwise viewed from stern side		
Engine size (L x W x H)		mm	1,312 x 904 x 1,153		
Engine dry weight		kg	1,128		

Specifications		Model	Unit	Emergency		
				4AD126TIF	4AD126TIS	
Engine type			4 cycle, In-line, direct injection, water cooled with turbocharger & Inter-cooler			
Rating output (B.H.P)	50 Hz	PS (kW)/ rpm	257 (350)/1,500	-	-	
	60 Hz		-	302 (410)/1,800	302 (410)/1,800	
Displacement		cc	11,051			
Cylinders number - bore (∅) x stroke		mm	6 - ∅123 x 155			
Valve clearance at cold	Intake / exhaust	mm	0.4 / 0.7			
Low idling		rpm	725 ±25			
No load maximum (50 Hz/60 Hz)		rpm	1,500	1,800	1,800	
Mean effective pressure (Initial)		kg/cm <sup>2</sup>	19.0	18.6	18.6	
Mean piston speed (50 Hz/60 Hz)		m/sec.	7.75	9.3	9.3	
Compression ratio			16.7 : 1			
Governor type of injection pump			Electric governor	Mechanical/(R.S.V)	Electric governor	
Fuel consumption (SG: 0.832 g/cc)		g/PS.h	160	165	165	
		Liter/h	67	82	82	
Injection timing (B.T.D.C)		deg	17° ±1°			
Starting system			Electric Starting by starter motor			
Starter motor capacity		V-kW	24 - 7			
Alternator capacity		V-A	24 - 80			
Battery		V- Ah	24 - 150			
Cooling system			Radiator			
Coolant water capacity		Liter	Max.: 32, Min.: 30			
Fresh water pump type			Centrifugal type driven by V-belt			
Sea water pump type			Rubber impeller type driven by V-belt			
Lubricating oil (Engine)	Fan capacity	Liter	Max.: 44, Min.: 20 (Engine total: 47)			
	Pressure	kg/cm <sup>2</sup>	Max.: 3, idle: 1			
Direction of revolution	Crankshaft		Counter clockwise viewed from stern side			
Engine size (L x W x H)		mm	1,409 x 877 x 1,1136			
Engine dry weight		kg	1,047			



Note:

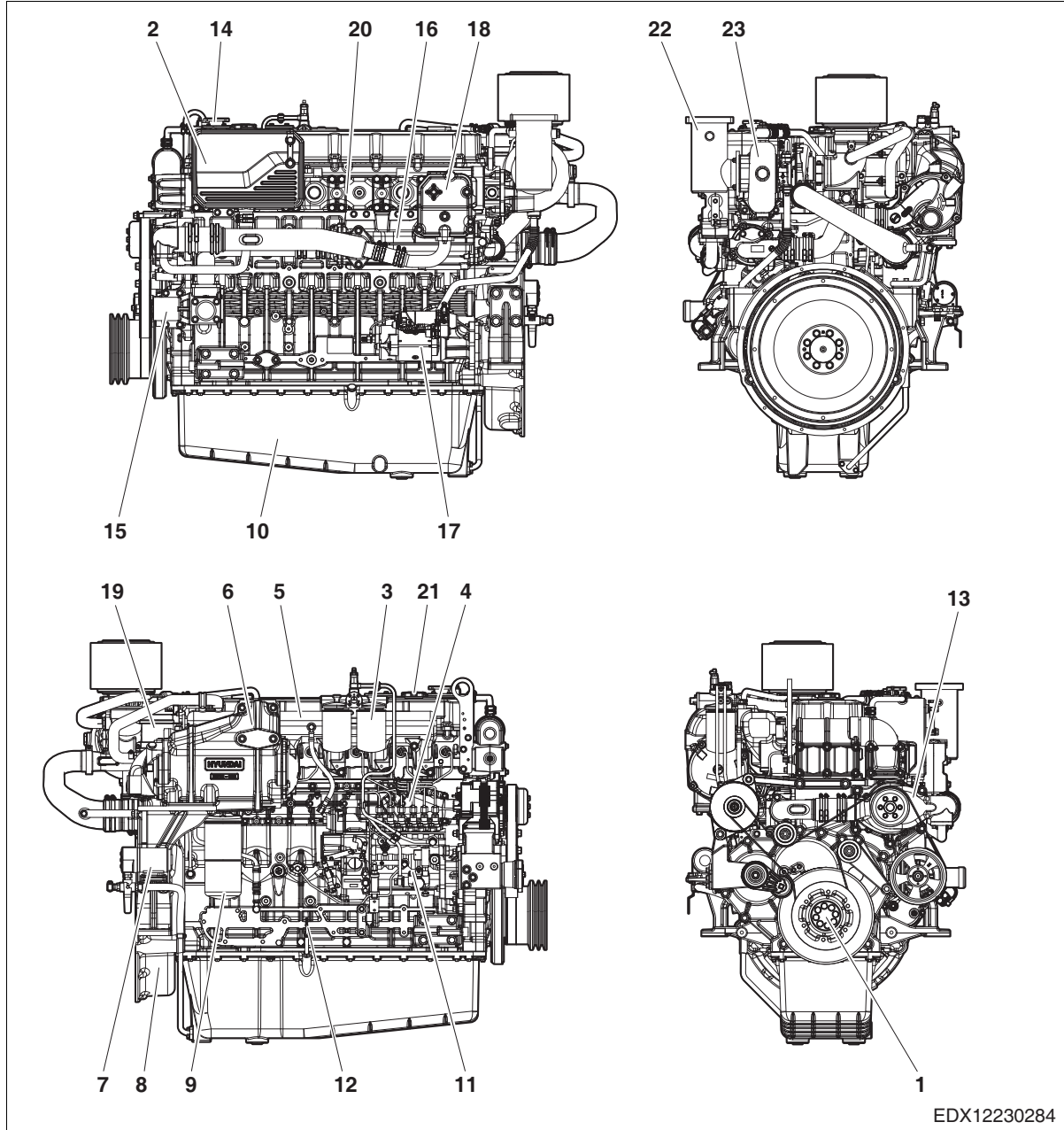
Fuel consumption data is based on engine test data, and Fuel efficiency may difference depending on vessel driving habits and sea conditions.

## 1.2. Schematic Diagram of Engine

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

### 1.2.1. Outside Drawing of Engine (4L126TIH/ 4L126TIM/ 4L126TIL)

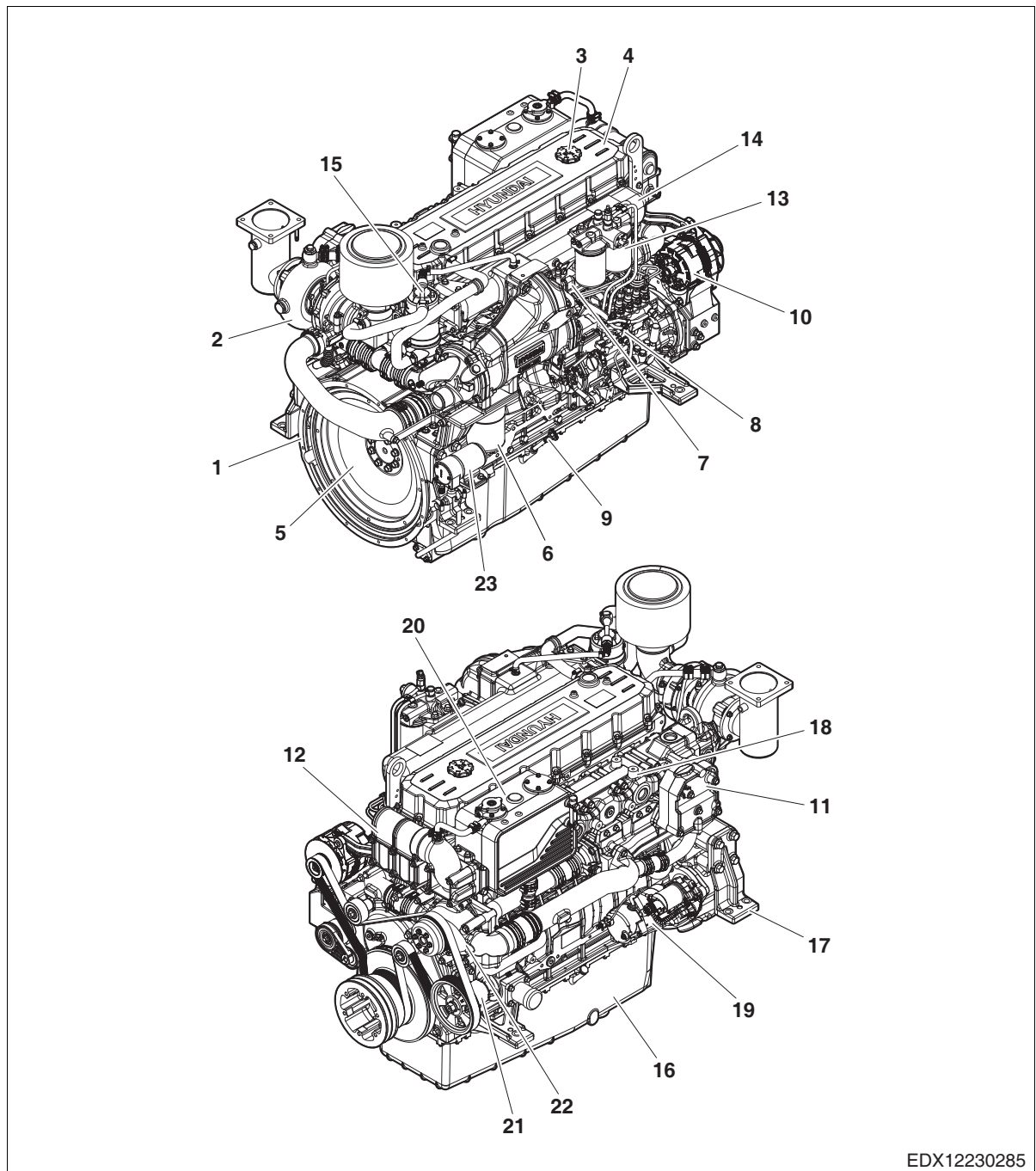
● Plane View



EDX12230284

- |                      |                         |                            |
|----------------------|-------------------------|----------------------------|
| 1. Crankshaft pulley | 9. Oil filter           | 17. Start motor            |
| 2. Reservoir tank    | 10. Oil pan             | 18. Thermostat             |
| 3. Fuel filter       | 11. Fuel injection pump | 19. Breather               |
| 4. Oil cooler        | 12. Oil level gauge     | 20. Exhaust manifold       |
| 5. Intake manifold   | 13. Fresh water pump    | 21. Oil filler cap         |
| 6. Intercooler       | 14. Coolant filler cap  | 22. Exhaust discharge pipe |
| 7. Oil drain pump    | 15. Saltwater pump      | 23. Turbocharger           |
| 8. Flywheel housing  | 16. Heat exchanger      |                            |

● Structural Diagram

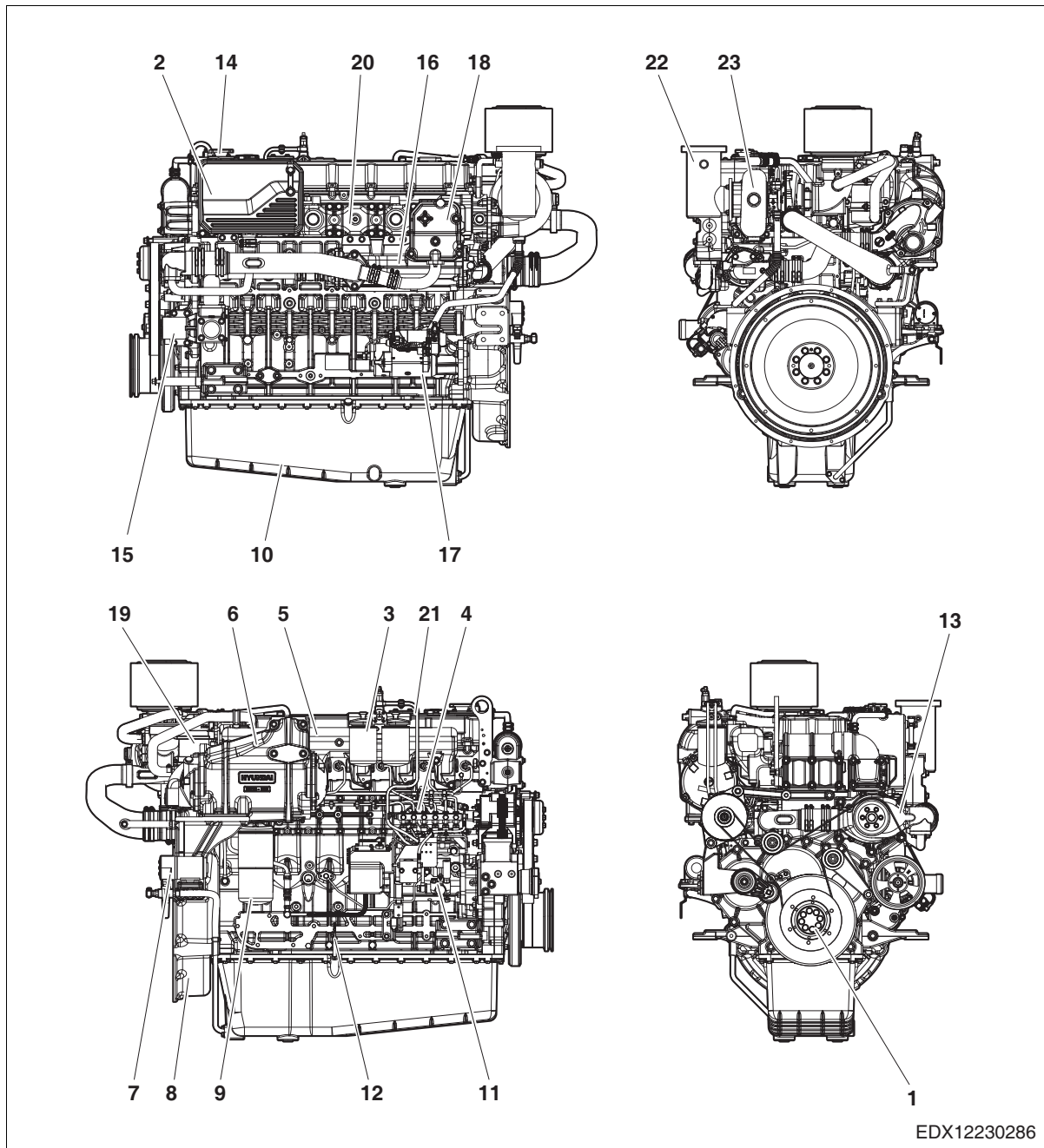


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- |                        |                     |                      |
|------------------------|---------------------|----------------------|
| 1. Flywheel housing    | 9. Oil level gauge  | 17. Mounting bracket |
| 2. Turbocharger        | 10. Generator       | 18. Exhaust manifold |
| 3. Oil filler cap      | 11. Thermostat      | 19. Start motor      |
| 4. Cylinder head cover | 12. Water chamber   | 20. Reservoir tank   |
| 5. Flywheel            | 13. Fuel filter     | 21. Saltwater pump   |
| 6. Oil filter          | 14. Intake manifold | 22. Fresh water pump |
| 7. Oil cooler          | 15. Breather        | 23. Oil drain pump   |
| 8. Injection pump      | 16. Oil pan         |                      |

## 1.2.2. Outside Drawing of Engine (4AD126TI)

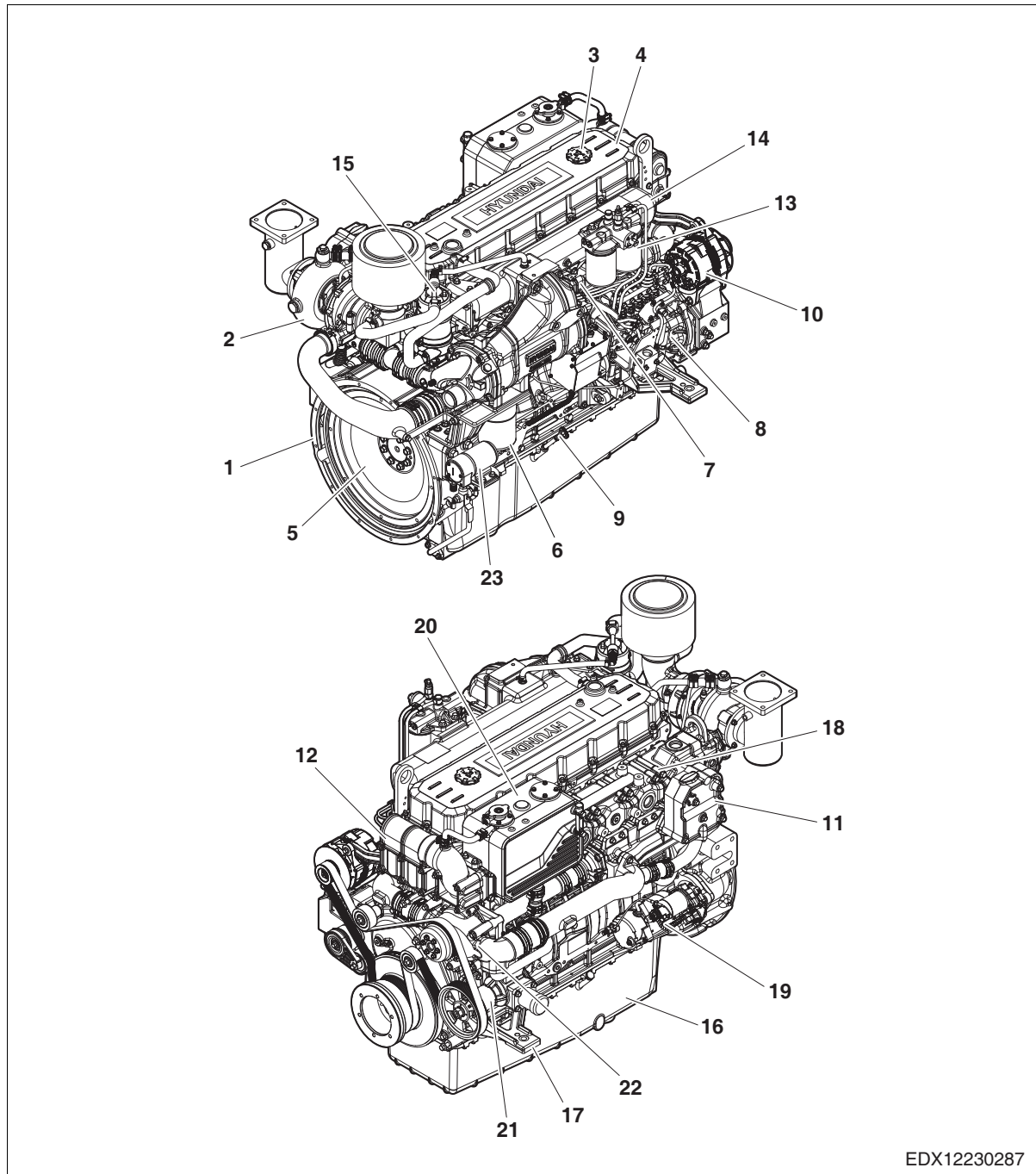
### ● Plane View



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- |                      |                         |                            |
|----------------------|-------------------------|----------------------------|
| 1. Crankshaft pulley | 9. Oil filter           | 17. Start motor            |
| 2. Reservoir tank    | 10. Oil pan             | 18. Thermostat             |
| 3. Fuel filter       | 11. Fuel injection pump | 19. Breather               |
| 4. Oil cooler        | 12. Oil level gauge     | 20. Exhaust manifold       |
| 5. Intake manifold   | 13. Fresh water pump    | 21. Oil filler cap         |
| 6. Intercooler       | 14. Coolant filler cap  | 22. Exhaust discharge pipe |
| 7. Oil drain pump    | 15. Saltwater pump      | 23. Turbocharger           |
| 8. Flywheel housing  | 16. Heat exchanger      |                            |

● Structural Diagram

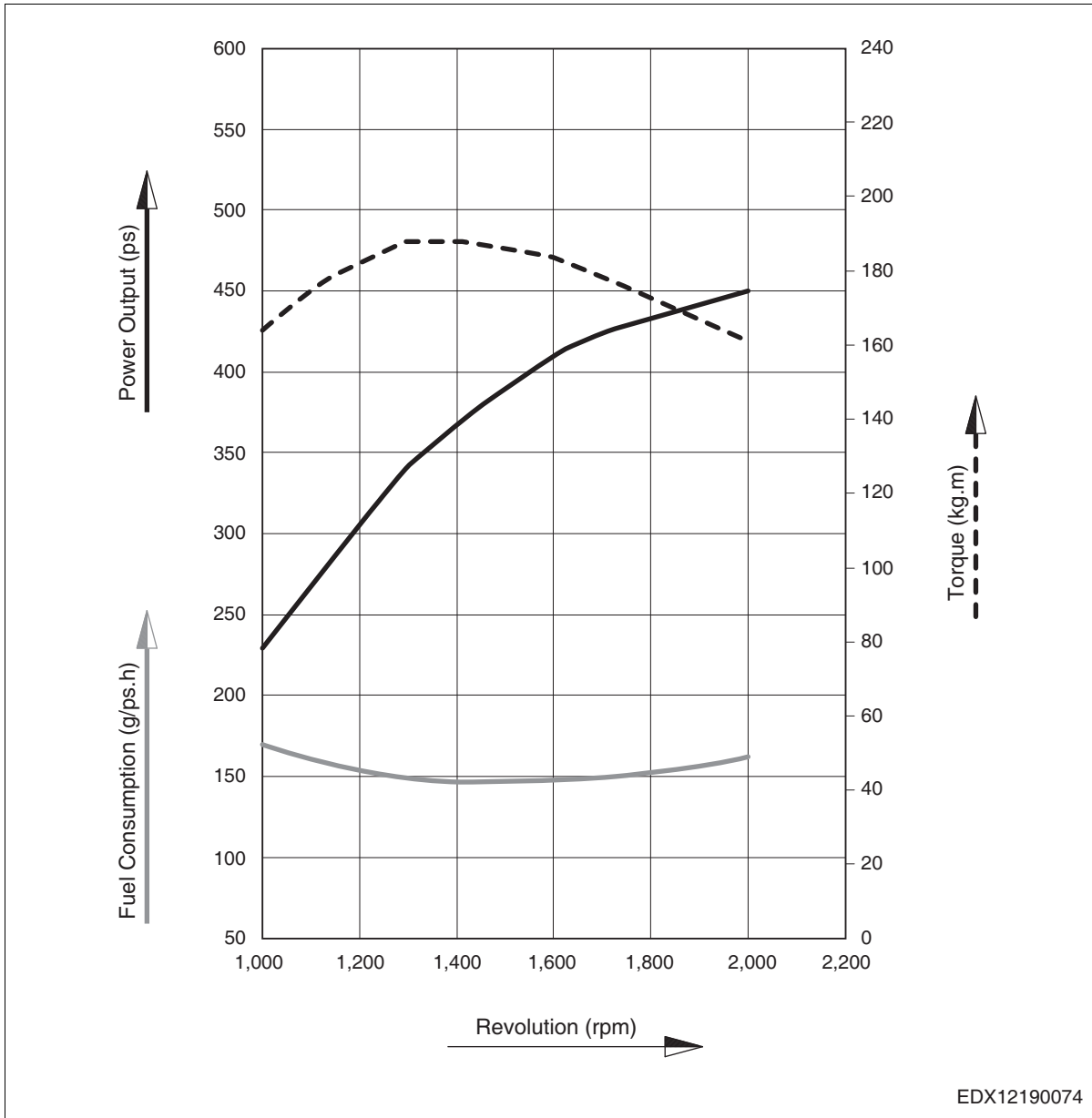


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- |                        |                     |                      |
|------------------------|---------------------|----------------------|
| 1. Flywheel housing    | 9. Oil level gauge  | 17. Mounting bracket |
| 2. Turbocharger        | 10. Generator       | 18. Exhaust manifold |
| 3. Oil filler cap      | 11. Thermostat      | 19. Start motor      |
| 4. Cylinder head cover | 12. Water chamber   | 20. Reservoir tank   |
| 5. Flywheel            | 13. Fuel filter     | 21. Saltwater pump   |
| 6. Oil filter          | 14. Intake manifold | 22. Fresh water pump |
| 7. Oil cooler          | 15. Breather        | 23. Oil drain pump   |
| 8. Injection pump      | 16. Oil pan         |                      |

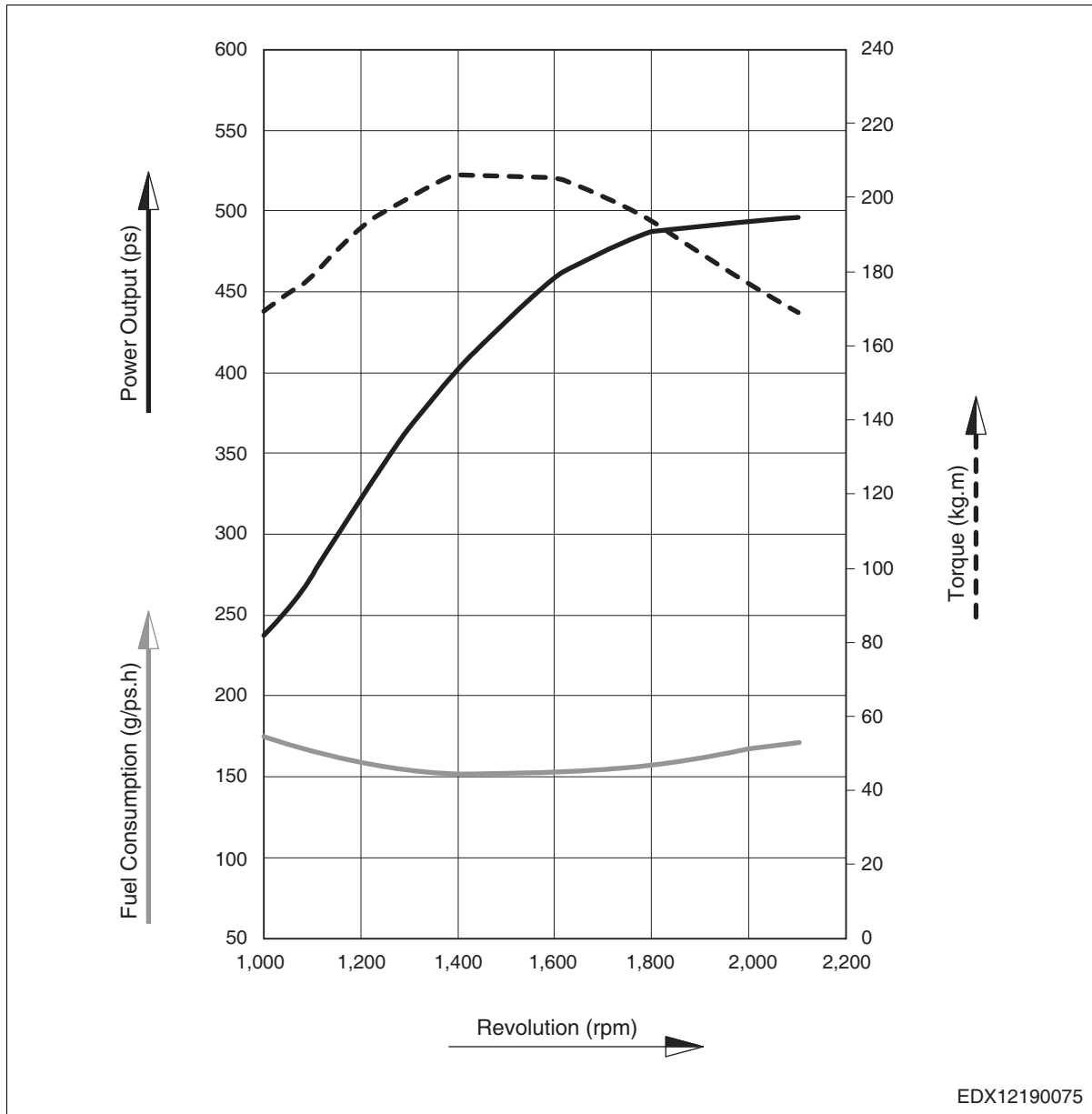
### 1.3. Engine Performance Curve

#### 1.3.1. Performance Curve (4L126TIH)



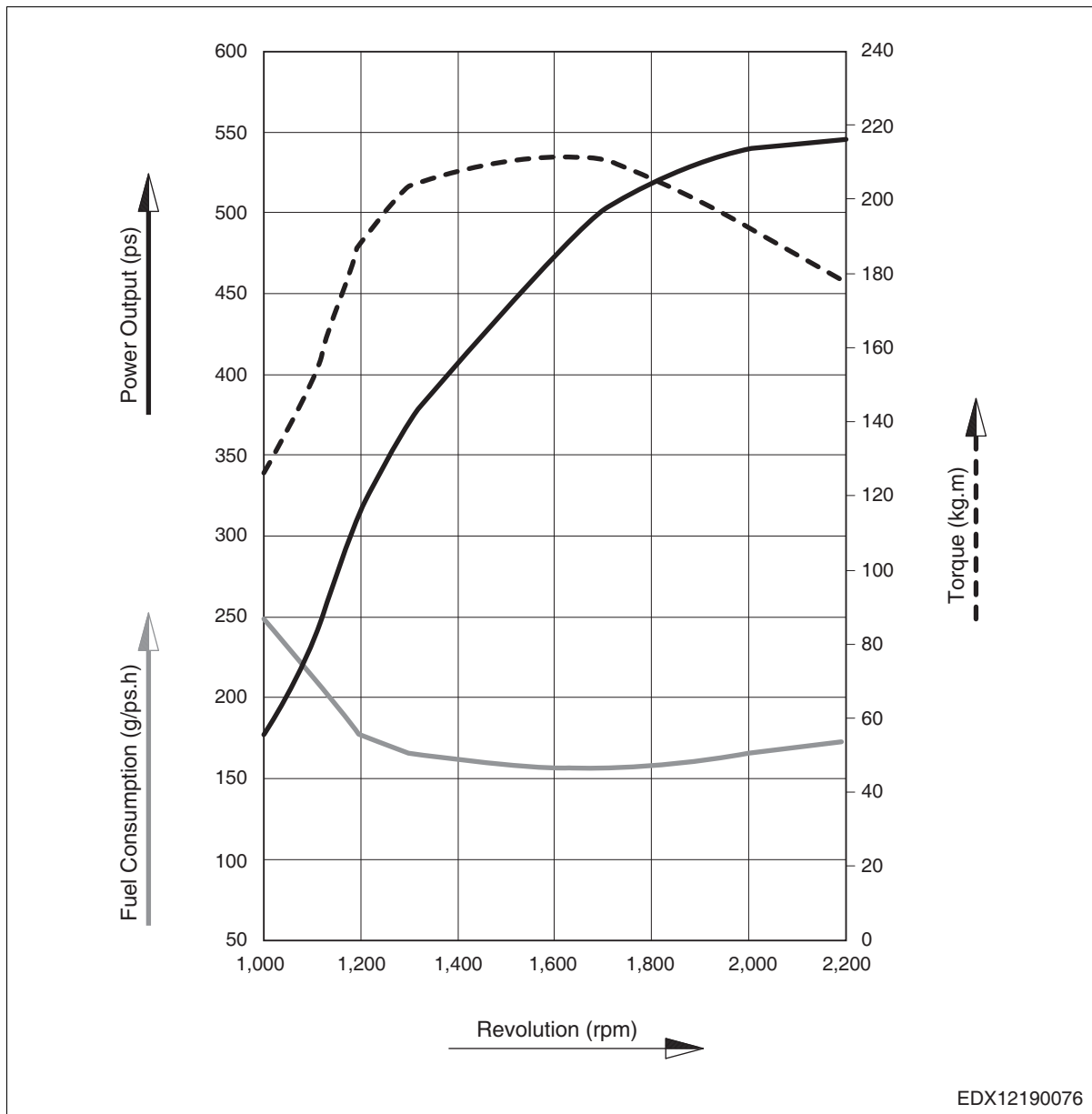
<b>Testing and evaluation method</b>	<b>KS - R0071</b>
Engine power(max.)	450 ps / 2,000 rpm
Fuel consumption(rated)	162 g/ps.h

### 1.3.2. Performance Curve (4L126TIM)



<b>Testing and evaluation method</b>	<b>KS - R0071</b>
Engine power(max.)	495 ps / 2,100 rpm
Fuel consumption(rated)	170 g/ps.h

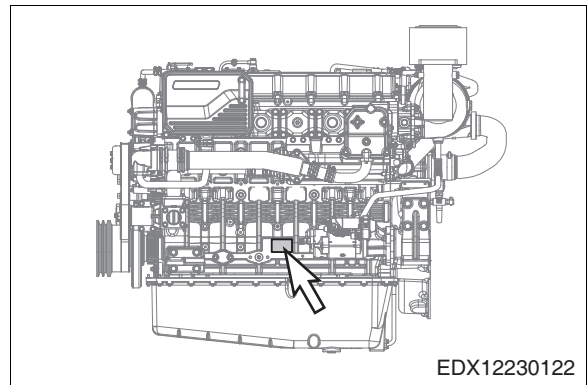
### 1.3.3. Performance Curve (4L126TIL)



<b>Testing and evaluation method</b>	<b>KS - R0071</b>
Engine power(max.)	545 ps / 2,200 rpm
Fuel consumption(rated)	173 g/ps.h

## 1.4. Engine Model and Serial Number

The engine serial number is engraved on the engine block as shown in the picture on the right. This number is required for warranty claims, ordering parts and ship inspections.

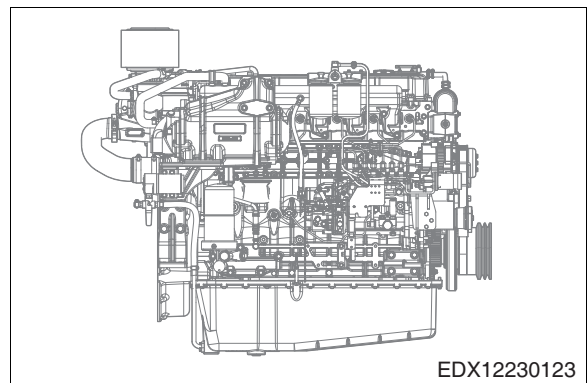
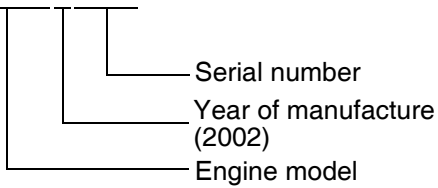


### CAUTION

The engine model name is indicated on a plate attached to the cylinder block as shown in the picture on the right.

- Engine serial number (Ex. : L126TI)

ECIKM200001



## 2. Safety Regulations

### 2.1. General Information

In order to make use of the engine safely and reliably on a daily basis, be sure to always check all engine-related matters before using it. The engine operator must familiarize themselves with the contents of this Operation and Maintenance Manual and always comply with the daily inspection and regular inspection techniques.

The contents below are a summary of the most essential rules which must be observed. The contents are divided into sections on preventing injury and property damage, as well as preventing environmental pollution. The various rules determined based on the engine specifications or region must also be followed.



Important

Seek medical assistance immediately in the event that an unanticipated accident occurs in spite of having been careful when using or servicing the engine, such as coming into contact with corrosive acid or fuel, being burnt by hot oil, or getting antifreeze in your eyes.

### 2.2. Rules for Preventing Injuries

#### 2.2.1. Starting and running the engine during test operation

Before operating the engine, read the Operation and Maintenance Manual carefully first to familiarize yourself with the "Caution" items and the main inspection items related to running and operating the engine, such as the gauge panel. Please contact a HD Hyundai Infracore service center or a local technician if further explanation of any of the contents of this manual is required.

- To ensure absolute safety, place a warning label on the door to the engine room prohibiting any unauthorized personnel from entering. Also, make sure that the engine operator understands that they are responsible for safe operation in the engine room.
- The engine should be started and run only by authorized personnel. Never let any unauthorized personnel start the engine.
- Do not approach any rotating parts while the engine is running. Be sure to wear close-fitting clothes.
- The engine becomes very hot while it is running so there is a danger of being burnt. Never touch the engine with bare hands.
- Exhaust gas contains toxic chemicals so be sure to comply with the installation standards in the chapter "Exhaust System" for HD Hyundai Infracore marine engines installed in enclosed spaces such as engine rooms. Make sure the engine room is fitted with an adequate ventilation system, such as air inlets and outlets.
- Be sure to keep the area around the engine and ladders, etc. free from oil or grease. Slipping can result in serious injury.

### 2.2.2. Cautions for service

- Make sure to perform service work only with the engine stopped. If it is necessary to perform service work with the engine running, be careful of any possible safety accidents and scalding. Do not get too close to any rotating parts if performing service work while the engine is running cannot be avoided.
- Change engine oil while it is still warm after stopping the engine.



#### CAUTION

Do not touch the oil drain plug or oil filter with bare hands while the engine is running. The engine oil is hot and may cause burns.

- Check the amount of oil in the oil pan in advance so that a suitable container with a sufficient capacity can be used for changing engine oil.
- When replacing or refilling engine coolant, cool the engine off first, then wrap the coolant pressure cap on the auxiliary tank in a cloth, turn it slowly to gradually release the high air pressure built up within the enclosed circuit, and open it. Hot coolant can cause scalding and other injuries.
- Do not tighten or disconnect any pipes or hoses (engine oil circuit, coolant circuit and hydraulic oil circuit) while the engine is running. There is a risk of damages (accidents such as fires or burns) occurring due to the liquid pouring out.
- Fuel is highly flammable. Never smoke or use fire around the engine. Fueling should be performed only while the engine is stopped.
- Be sure to wear safety goggles when performing tasks which involve using compressed air, such as cleaning the heat exchanger.
- Engine service items (such as antifreeze) should be stored in properly labeled containers so as to avoid confusing them with beverage containers.
- Follow the instructions provided by the battery manufacturer when checking or handling batteries.



#### CAUTION

The battery fluid is toxic, corrosive and explosive. Hence, it should be handled by a professional technician.

### 2.2.3. Performing inspections, adjustments and repairs

- Engine inspections, adjustments and repairs should only be performed by qualified personnel.
- Use only proper tools which are in good working condition. If using a wrench with a worn and split tip, it may slip on the parts, leading to a safety accident.
- When lifting the engine with a crane, never let anyone stand or pass below it. Check the safety condition of the crane before working with it.
- When measuring the pressure in the injection nozzles, keep hands away from the spot where fuel is injected. The high pressure may cause safety accidents. Be careful not to inhale atomized fuel in the air.
- When working on the electrical system, be sure to disconnect the battery ground cable ("-" (positive) cable) first. In order to prevent a short circuit, perform a final inspection before reconnecting it.

## 2.3. Preventing Engine Damage and Premature Wear

- 1) The customer must not attempt to exceed the set continuous maximum power of the engine provided by HD Hyundai Infracore for any other purposes.

For more details, refer to "5. Main Auxiliary Devices." Never attempt to modify the fuel injection pump without prior written consent from HD Hyundai Infracore.

- 2) If any problems occur while running the engine, find the cause and resolve the problem immediately to ensure that severe damage does not occur afterwards.
- 3) Use only genuine HD Hyundai Infracore spare and service parts for inspections and maintenance. HD Hyundai Infracore is not responsible for engine damage occurring as a result of using imitation parts.

- 4) Make sure to observe the following instructions as well as the instructions above:

- Do not operate the engine without oil or coolant.  
Use only service items (engine oil, antifreeze, anti-corrosive agents, etc.) recommended by HD Hyundai Infracore.
- Keep the engine clean. Diesel fuel must not contain any water.
- Refer to "4.6. Fuel System" in the Operation and Maintenance Manual.
- Follow the specified maintenance schedule for the engine, referring to "4.2. Daily Inspections and Regular Inspections."
- Do not stop the engine immediately while it is hot after being run. Instead, idle it for approx. 5 minutes without any load so that its temperature drops naturally, then stop the engine.
- Do not pour cold coolant into an overheated engine. Parts may be damaged.
- When adding engine oil, do not exceed the upper limit indicated on the oil gauge.  
When mounting the engine, be careful not to exceed the maximum allowable inclination angle. Failing to comply with the guidelines in this Maintenance and Operation Manual can cause severe damage to the engine.
- Check that the testing and monitoring devices (for the battery, oil pressure, coolant temperature, etc.) are always working properly.
- Do not run the saltwater pump in a dry state. Drain coolant after stopping the engine if there is a risk of it freezing.



### CAUTION

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

## 2.4. Rules for Preventing Environmental Pollution

### 2.4.1. Engine oil, filter element, fuel filter

- Used oil should be collected in an oil disposal container. Be especially careful not to allow oil to spill onto the ground or into the sea. Spilled oil can pollute sources of drinking water.
- Oil and fuel filter elements are classified as environmental pollutants and must be disposed of according to the relevant laws.

### 2.4.2. Coolant

- Undiluted anti-corrosive agents or antifreeze should be disposed of as hazardous waste.
- When disposing of used coolant, follow the applicable local regulations.

### 2.5. Safety Matters for Handling Used Engine Oil

If your skin comes in contact with engine oil for an extended period of time or repeatedly, it can lead to skin irritation.

As can be seen in the results of experiments on animals, used engine oil contains harmful substances which may cause skin cancer. When handling engine oil in the workplace, there is no cause for serious concern about health risks arising from handling oil if basic hygiene and workplace safety rules are followed.



#### Health Precautions

- Avoid repeated or prolonged skin contact with used engine oil.
- Protect the skin with a suitable skin protection product (cream, etc.) or wear protective gloves.
- If skin comes into contact with engine oil, wash it off immediately as follows.
  - Wash the skin clean with soap and water, using a brush for nails, etc.
  - Readily available commercial products for cleaning off grease easily and effectively can also be used.
  - Do not use gasoline, diesel fuel, gas oil, thinner or solvents, etc. to clean oil off skin.
- After washing the skin, apply lotion to it for protection.
- Wash fuel- or oil-stained clothes or shoes before wearing them.
- Do not carry fuel- or oil-stained rags, etc. in your pockets.



Check to ensure that used engine oil is disposed of properly.  
Improperly discarded engine oil can pollute drinking water.

Hence, never spill used engine oil into the ground, ditches or drains.

Failing to comply with disposal regulations is punishable by law, so please take care to dispose of engine contaminants (oil, fuel, antifreeze, etc.) according to the relevant regulations. For details regarding disposal procedures, contact the distributor, supplier or local agency.

### 2.6. Cause of Electrolytic Corrosion

One of the most important causes of corrosion of metal parts in salt water is interference current from the ship's electrical system. These currents may be very weak and are often hard to detect. However, if they are active over prolonged periods of time, they may cause heavy corrosion.

Electrolytic corrosion may be prevented by a suitable electrical wiring.

Marine engine installations require special grounding of electrical system components to minimize electrolytic corrosion from stray currents and to minimize radio interference.

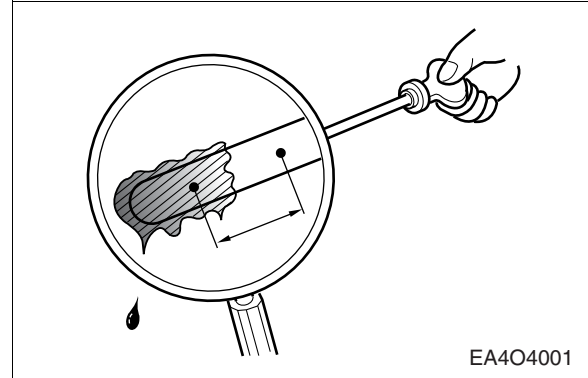
On metallic the boats the hull may serve as the common bonding conductor and a separate bonding system may not be required.

## 3. Operation

### 3.1. Inspection Items Before Running the Engine

#### 3.1.1. Lubricant

- The oil level should be between the upper and lower limits on the oil level gauge.
- The oil level must be measured in a horizontal state without any waves.
- Check the oil smeared on the oil measuring gauge for its viscosity and level of contamination. If necessary, replace or refill the engine oil.



#### CAUTION

The upper and lower limit marks indicated on the oil level gauge may differ depending on the inclination of the engine installed. When running the engine for the first time after installation, fill the engine oil to its maximum capacity and check whether it matches up with the upper limit on the gauge. If they differ from one another, readjust the upper and lower limit marks to suit the angle of inclination of the engine installed.

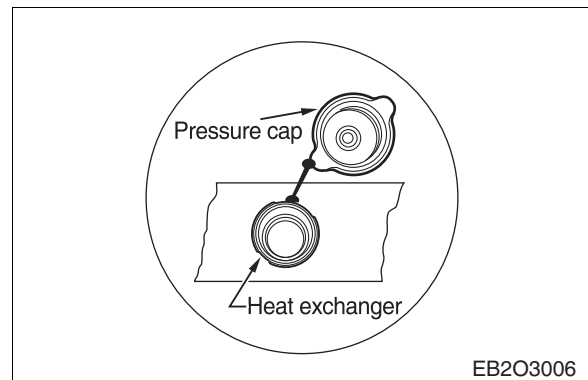
(Refer to "4.4. Lubrication System" when engraving the max./min. marks on the oil level gauge)

#### 3.1.2. Coolant

Add coolant if the level is low. The pressure cap serves to raise the boiling point and to prevent phenomena such as cavitation which create air bubbles in the engine.

Use the expansion tank cap tester to check the opening pressure of the pressure valve. If the measurement is below the standard value, replace the coolant cap.

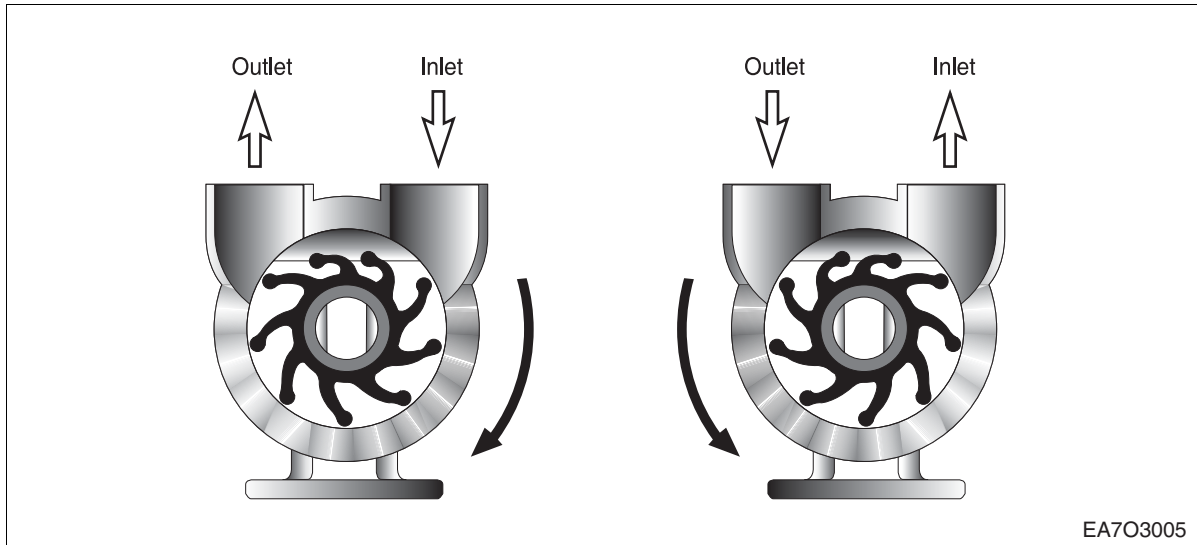
(Opening pressure of pressure valve:  
0.9 kg/cm<sup>2</sup>)



### 3.1.3. Saltwater pump

The inlet and outlet on the saltwater pump differ depending on the rotating direction of the shaft.

- The load caused by overtightening the belt or gears shortens the pump life.
- Do not run the saltwater pump in a dry state for more than 20 seconds.
- Check whether all of the valves and plugs in the saltwater system are open before running the engine.
- If there is a risk of freezing, open the rear cover on the saltwater pump and drain the water.
- Operating temperature range : 5 - 60 °C



### 3.1.4. Intake/ exhaust manifold

Check whether contamination, rust or clogging, etc. is causing excessive resistance in the intake/ exhaust manifolds.

### 3.1.5. Fuel line

Open the valve on the fuel line and check for any leaks, etc.

### 3.1.6. Inspecting the floor of the ship

Check whether there is an excessive accumulation of water on the floor of the ship in the engine room. The ship's floor should always be clean and dry. An excessive accumulation of water on the ship's floor can lead to corrosion of the engine and fires due to short circuits in the various electrical components. In order to prevent water from accumulating, install a water drain pump with an automatic adjustment switch on the ship's floor.



#### CAUTION

When the ship is run at full speed, the longitudinal inclination of the ship becomes higher, increasing the height of the water accumulated on the ship's floor.

An excessive accumulation of water on the ship's floor increases corrosion in the engine, leading to severe malfunctions.

### 3.1.7. Engine stopping and warning devices

In addition to an automatic stopping mechanism, the gauge panel is equipped with a warning lamp and warning device which warn the operator in the event that one of the following problems occurs.

#### 1) Engine stopping mechanism

The engine stops while the warning lamp blinks and a warning buzzer sounds in the following cases:

- Low engine oil pressure (0.5 kg/cm<sup>2</sup> or less)
- Overheated engine coolant (103°C or higher)
- Engine overspeeding (over 117% of the rated rpm)

#### 2) Engine warning mechanism

The engine warning lamp blinks and a warning buzzer sounds in the following cases:

- Low engine oil pressure (1 kg/cm<sup>2</sup> or less)
- Overheated engine coolant (93°C or higher)
- Battery charging problem
- Engine overspeeding (over 117% of the rated rpm)



If the warning lamp on the gauge panel above turns on after starting the engine, follow the procedure below.

First, determine which system has the problem and whether the needles on each gauge are moving abnormally. Then, immediately check each warning lamp. If the engine coolant is overheated, switch to an idling speed immediately and put the reduction gear control lever in the neutral position. Confirm the cause of the warning and do not start the engine again until it has been repaired.

Refer to the "Overheating" troubleshooting section in the service manual. If the coolant temperature gauge indicates a high coolant temperature, check whether there is not enough coolant, the heat exchanger is contaminated or the temperature sensor is malfunctioning.

If the cause of the warning cannot be determined, please contact a HD Hyundai Infracore dealership.

## 3.2. Starting

### 3.2.2. Operating techniques

This involves booting up or shutting down the digital panel system, as well as stopping the engine.

- 1) Using the key included with the product, insert it into the key switch and turn it 90° to the right (ON)  
(If the key is "ON," keep the key switch turned on)
- 2) When turned "ON," the product boots up and the gauge screen is displayed in approx. 17 seconds
- 3) When turning the system off, turn the key 90° to the left (OFF)
  - When the key is turned to the left (OFF) while the engine is running, an alarm pop-up message appears on the screen for 300 seconds. Then 300 seconds later, the engine stops and the event is saved.
  - If the key is turned to the right (ON) when the pop-up window is on the screen, the pop-up window disappears and the engine keeps running.

For details, refer to the enclosed Digital Panel Service Manual for Ships.

### 3.3. Operation

In order to achieve maximum engine performance and prolong its service life, the engine must be broken in during the initial 50 hours.

#### 3.3.1. Engine break-in

HD Hyundai Infracore marine engines are run only for a short period of time for their final test at the factory. Therefore, the break-in procedure should be performed for the initial 50 hours of operation in order to ensure optimum performance and prolonged service life.



#### CAUTION

Check to make sure that the lubricant is suitable during the engine break-in period.

After the 50-hour break-in period is complete, replace the lubricant supplied at the factory with fresh oil.

#### 3.3.2. Initial two-hour break-in

During the first 5 - 10 minutes of operation, run the engine at a high idling speed (1,500 rpm or less).

For two hours,

increase the speed of the ship gradually, then reduce the load in order to maintain the idling speed.

During this time, slowly increase the engine speed to approx. 1,500 rpm and then lower it again repeatedly at two- to three-minute intervals. Once the engine coolant reaches a suitable temperature, the engine speed will decrease slightly.

Then, increase the engine speed to start breaking in the rings (piston rings, oil rings, etc.) and bearings. During this time, be careful not to run the engine at more than 1,500 rpm.



#### CAUTION

During the initial two-hour break-in period, be sure to avoid running the engine continuously at a consistent speed without any change in the rpm.

#### 3.3.3. The following 18 hours of break-in

Following the initial two-hour break-in period, for 18 hours, take turns slowly changing the engine rpm from an idling speed to approx. 1,800 rpm (3/4 load) repeatedly. Reduce the rpm to an idling speed occasionally in order to cool the engine. During the 18-hour break-in period, the engine can be run at full speed (2,000 rpm) twice for two minutes or less.



#### CAUTION

During the 18-hour break-in period, be careful not to run the engine continuously at a consistent speed for an extended period of time.

#### 3.3.4. The final 30 hours of break-in

During the final 30 hours, the engine can be run at full speed (2,000 rpm) once for 5 - 10 minutes.

Once the engine coolant reaches a suitable temperature, the speed drops slightly for a moment. Following this, run the engine continuously at a 3/4 load (1,800 rpm).

Reduce the engine speed to an idling speed at two- to three-hour intervals occasionally in order to cool the engine.



#### CAUTION

During the break-in period, be careful not to run the engine continuously at a consistent speed for an extended period of time.

During the initial break-in period, check the engine oil level frequently. Be sure to check that the oil level remains between the "upper limit" and "lower limit" marks on the oil level gauge.



#### CAUTION

The oil pressure may fluctuate slightly following changes in the engine rpm.

Also, the oil pressure tends to be higher at the same engine speed when it is hot than when it is cold.

Replace the engine oil and filter when the break-in period (50 hours) ends.

### 3.3.5. Operation after break-in period

When running the engine in cold weather, always warm the engine up gradually.

Avoid running the engine at full speed until it reaches the normal operating temperature.

Oil consumption is high until the piston rings are seated. Hence, check the oil level frequently during the initial 50-hour break-in period.

Idling the engine for extended periods of time can cause oil leaks in the turbocharger, so avoid idling the engine continuously for more than 12 hours.

### 3.4. Inspection After Starting the Engine

Always check the engine oil pressure gauge while running the engine. If a drop in engine oil pressure is indicated on the gauge panel, stop the engine immediately. The charge warning lamp for the generator must be turned off while running the engine.

- Make sure that the '+' and '-' terminals on the battery are connected firmly without any gaps.
- If the battery charge warning lamp comes on and the engine stops suddenly while driving, check the electrical system for a wiring malfunction.
- If an abnormal condition, such as abnormal emission color, noise or odor, occurs while driving, stop the engine to find and correct the cause.

### 3.5. Inspection After 50-Hour Break-In

In order to ensure safe operation of the ship, contact a HD Hyundai Infracore marine engine dealership after the 50-hour engine break-in period to have a comprehensive inspection performed on the engine as follows.

- Replace the engine oil and oil filter
- Replace the fuel filter
- Inspect the coolant level
- Check the drive belt tension
- Check for vibrations in the brackets, etc. installed in the engine and the tightness of screws
- Parts prone to oil and water leaks, malfunction of the gauge panel, vibrations in various shafts, matters related to the ship speed, etc.

Fixing minor problems at this time can prevent major engine malfunctions caused by an accumulation of problems later, enabling the engine to be used confidently and safely.

## **3.6. Running the Engine in Winter**

### **3.6.1. Prevention of coolant freezing**

If antifreeze is not used, it may cause corrosion to spread within the engine, as well as reducing cooling efficiency and causing engine freezing in winter.

Hence, be sure to drain coolant completely after operating the engine. As frozen coolant can damage the engine severely, make sure to add antifreeze to it.

(Amount of antifreeze : 45% of coolant capacity)

### **3.6.2. Prevention of engine overcooling**

If the engine is cooled excessively, it can lead to poor heat efficiency, increased fuel consumption and increased cylinder liner wear. Therefore, the engine should not be cooled excessively. If the coolant temperature does not reach a normal level (79 - 94 °C) even after running the engine continuously, check the thermostat or various coolant lines.

### **3.6.3. Lubricant**

The viscosity of engine oil increases in cold weather, which may cause the engine speed to be unstable after the engine is started.

Using lubricant for winter (SAE 10W40 or 10W30) prevents this type of instability.

(Refer to section 4.4.)

## **3.7. Servicing and Checking Engine Parts After Prolonged Operation**

Inspecting the engine after prolonged operation restores engine performance and enhances engine durability against wear, corrosion and deterioration of its components.

Unpredictable malfunctions and defects can occur in weak points after an extended period of operation time under normal operating conditions. In such cases, repairing or correcting only one or two components cannot restore or enhance the engine performance. It is necessary to analyze the cause in detail precisely to replace or correct components that are related to or can affect the engine power and performance.

Proactive failure prevention measures for the engine can ensure long and safe operation with enhanced reliability.

It is recommended to perform preventive inspections for engine components in spring after winter has ended.

The following components need to be inspected during the preventive inspections as they can affect the engine power and performance:

- Components which affect fuel injection ;  
Nozzle, delivery valve, fuel filter, water separator, etc.
- Components which can affect intake and exhaust ;  
Air filter, intercooler, turbocharger, muffler, engine room ventilation device, etc.
- Components that can affect lubrication, cooling and vibrations ;  
Air filter, oil filter, antifreeze, heat exchanger, rubber impeller, saltwater filter, Kingston valve, central balance of axles, strength of engine mounting support, deflection of the propeller, etc.

## 4. General Inspections

### 4.1. Precautions for General Inspections

- Before performing an inspection, disconnect the cable (ground cable) from the negative (-) battery terminal in order to prevent cable damage due to short circuits.
- Place a cover over disassembled parts to avoid any external damage or contamination by foreign materials.
- There is a danger of the painted surfaces of parts being damaged if contaminated by engine oil or antifreeze so they must be handled with care.
- When servicing parts which require special tools, damage to parts can generally be prevented by using the appropriate tools or special tools.
- Make sure to use genuine HD Hyundai Infracore parts for replacements.
- Do not reuse consumable parts which have already been used during inspections, such as copper seal rings, gaskets, O-rings, oil seals, lock washers, self-locking nuts, and rubber seal rings. Be sure to replace them with new parts, while keeping disassembled parts sorted into groups to make reassembly easier.
- The tightening bolts and nuts for each part were designed with their mounting location in mind and each have a different strength and length, so they must be assembled in the correct locations.
- Be sure to clean parts before inspecting or reassembling them.  
Also, clean out oil holes, etc. using compressed air in order to prevent contamination due to foreign materials.
- Before assembly, apply a thin layer of clean oil or grease to the sliding and moving areas of parts in order to lubricate them.
- If necessary, use sealant on gaskets in order to prevent oil and water leaks.
- When tightening bolts and nuts, be sure to observe the specified tightening torque.
- When the inspection is complete, perform a final inspection to ensure that the inspection was performed properly.

## 4.2. Daily and Regular Inspections

General inspections refer to preventative maintenance. By performing maintenance in advance before problems occur in the engine, the user can keep the engine running in an optimal state and make use of the engine without any malfunctions for an extended period of time.

Preventative maintenance performed in order to prevent engine malfunction and constantly maintain optimal performance requires daily and regular inspections, as well as basic maintenance.

- The daily inspection items in the following table should be checked daily (Daily inspections)
- The regular inspection items below must be checked thoroughly at regular intervals. (Regular inspections)

Inspection Items		Daily	Regular inspection (at every interval of hours)						Remark
			50	100	250	500	600	1,000	
Cooling system	Check coolant level and refill	●							
	Check coolant and antifreeze for contamination					●			Replace every year
	Clean heat exchanger and fresh water cooling circuit								1,200 hours
	Check belt tension and replace	●							Replace every 2,000 hours
	Replace thermostat								Replace every two years
	Check saltwater discharge rate (Check opening of Kingston valve)	●							
	Rubber impeller in saltwater pump								1,200 hours
Lubrication system	Check oil level in oil pan/reduction gear	●							
	Replace engine oil		● Initial		●		●		CI-4&CH-4 CJ-4
	Replace oil filter		● Initial			●			
	Replace oil in reduction gear			● Initial			●		
	Check cylinder compression pressure							●	
Intake and Exhaust system	Adjust intake/exhaust valve clearance		● Initial			●			
	Clean or replace air filter and strainer			● Clean		● Rep-ace			
	Clean intercooler							●	
	Clean turbocharger								Every 2,000 hours
	Check concentration of exhaust gas	●							
Fuel system	Inspect for leaks in fuel line	●							
	Clean fuel strainer in fuel supply pump				●				
	Remove residue from fuel tank (Clean fuel tank)								Whenever necessary
	Drain water from separator			●					
	Change fuel filter		● Initial			●			
	Inspect fuel injection timing								Whenever necessary
	Inspect fuel injection nozzle								Whenever necessary
Electrical system	Check warning lamp	●							
	Check battery charging state	●							
	Check wiring						●		

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

## 4.3. Cooling System

### 4.3.1. Checking and refilling coolant

- Check the coolant level daily and add more if necessary. Also, coolant should be changed every 1,200 operating hours or 6 months (whichever occurs first). If coolant is contaminated, it can lead to engine overheating and overflow into the thermal expansion tank.
- Be sure to use clean water (soft water) such as tap water for the coolant used in the engine.
- Mix 45% antifreeze and 5% or less of an anti-corrosive agent into the engine coolant. (Refer to "Checking Coolant")



#### CAUTION

A suitable ratio of antifreeze and anti-corrosive agent prevents corrosion effectively in order to keep the engine running safely, but an unsuitable mixture causes cavitation, etc. in the coolant pump impeller and coolant passages within the block, leading to engine failure.

#### 1) Adding coolant

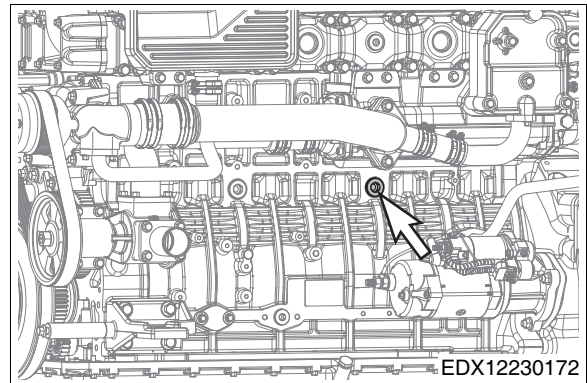
Fill the reservoir tank 2/3 with coolant. At this time, loosen the screws on the raised coolant lines or plug on top of the wet turbocharger in order to release air, then retighten them when no more air bubbles are visible.

Coolant must be poured in slowly to avoid air mixing with the coolant.

After adding coolant, idle the engine for around five minutes to circulate the coolant containing air, causing the air to be released and lowering the coolant level. At this time, stop the engine and add more coolant.

#### 2) Replacing coolant

- Open the coolant filler pressure cap to remove the pressure.
- Remove the two plugs from the bottom of the heat exchanger and the coolant suction pipe to drain the coolant.
- Tighten the coolant drain plug.
- Add more coolant according to the "Adding Coolant" section above.



#### CAUTION

When removing the coolant pressure cap while the engine is hot, wrap the cap in a cloth and loosen it slowly to release steam inside. The steam can cause burns if the coolant pressure cap is opened suddenly.

### 4.3.2. Checking coolant and antifreeze for contamination

#### 1) Checking coolant

- Engine coolant contains a mixture of clean water (soft water) such as tap water, 45% antifreeze and 5% anti-corrosive agent. The mixture concentration of antifreeze and anti-corrosive agent must be inspected every 600 hours in order to keep it at a suitable level.
- The mixture concentration of antifreeze and anti-corrosive agent can be checked with a coolant contamination measuring kit.  
(Fleetguard CC2602M : DHI No. ; 60.99901-0038)
- How to use the coolant contamination measuring kit
  - a) Collect coolant between 10 - 55 °C from the drain plug on the engine cylinder block or the pipe at the coolant pump inlet and fill the plastic container around halfway.



#### CAUTION

When gathering a coolant sample, the coolant in the reservoir tank is less contaminated and may not yield an accurate measurement of the concentration in the engine, so gather a sample of coolant from the bottom of the cylinder block.

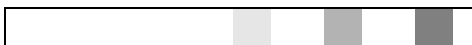
- b) After shaking the coolant sample, dip the test strip in the container, take it out after 3 to 5 seconds, then shake the moisture off the test strip.
- c) After waiting approx. 45 seconds for the colors on the test strip to change, compare the discolored test strip with the figures at the horizontal and vertical intersections on the color list label attached to the storage container for the test strip in order to determine whether the concentration and level of contamination are safe.



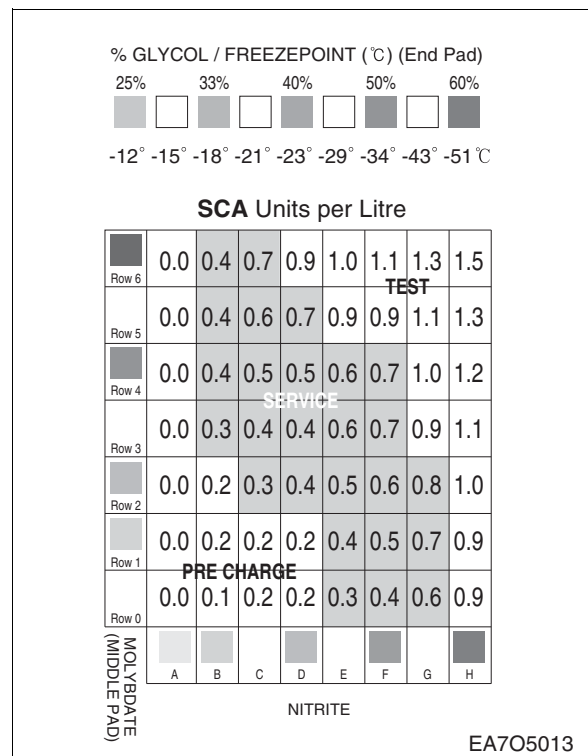
#### CAUTION

The color of the test strip may change 75 seconds after being taken out of the coolant so compare the colors and perform the inspection quickly within 75 seconds. Do not touch the colored area by hand.

- Reading the test strip



- a) Compare the FREEZEPOINT (freezing point) at the top of the storage container with the changed color on the pink end of the test strip to determine the antifreeze concentration. (The concentration must be within 33 - 50% of the color range.)
- b) Compare the discoloration on the middle and first part of the test strip with the horizontal and vertical color indications on the container. The point where they intersect indicates the state of the anti-corrosive additive. It should be maintained within the green section of 0.3 - 0.8, a suitable range.
- c) If the measured result from section (b) above is less than 0.3, add more of the anti-corrosive additive. If it is over 0.8, drain some of the coolant and add soft water to adjust the concentration.





## CAUTION

In order to prevent corrosion within the cooling system in the engine, drain the coolant every year or every 2,000 hours (whichever occurs first) and replace it with fresh coolant.

### 2) Antifreeze

It is recommended to mix coolant with 45% antifreeze. Antifreeze can prevent freezing and corrosion of the cooling system and increase the boiling point of coolant. The amount of antifreeze in winter can be adjusted according to the ambient temperature as shown in the following table. Each freezing point by antifreeze ratio in the table differs slightly depending on the type of antifreeze. For details, refer to the specifications provided by the antifreeze manufacturer.

Ambient temperature (°C)	Coolant (%)	Antifreeze
-10 or higher	85	15
-10	80	20
-15	73	27
-20	67	33
-25	60	40
-30	56	44
-40	50	50

The amount of coolant decreases naturally as the engine is operated. Adding tap water in this state can reduce the antifreeze ratio in the coolant. To maintain the specified ratio (45%), check the ratio and add the necessary amount of antifreeze.

### 4.3.3. Cleaning the heat exchanger and fresh water cooling circuit

#### 1) Cleaning the heat exchanger

If the tubes in the heat exchanger are clogged by small particles or corrosion, the amount of salt-water supplied decreases, causing the coolant to overheat and gradually reducing the cooling efficiency.

- Remove the covers on both sides of the heat exchanger and clean the tubes in the heat exchanger of any small particles clogging them.
- When cleaning the heat exchanger tubes, remove any rust from the outside and inside of the tubes using a small wire brush, then spray them with pressurized water to clean them thoroughly.

#### 2) Cleaning the fresh water cooling circuit

Cooling efficiency drops when the inside of the cooling circuit is contaminated with corrosive scale or sludge particles, etc.

Perform periodic inspections and clean the inside of the cooling circuit with a cleaning agent if necessary.



Cleaning interval for heat exchanger and cooling circuit : every 1,200 hours.

The cleaning interval must be adjusted to suit the operating environment.



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.

#### 4.3.4. Inspecting the Micro-V Belt tension and replacing the belt

The belt is equipped with an auto tensioner which automatically adjusts the belt tension so there is no need for extra adjustment of the tension.

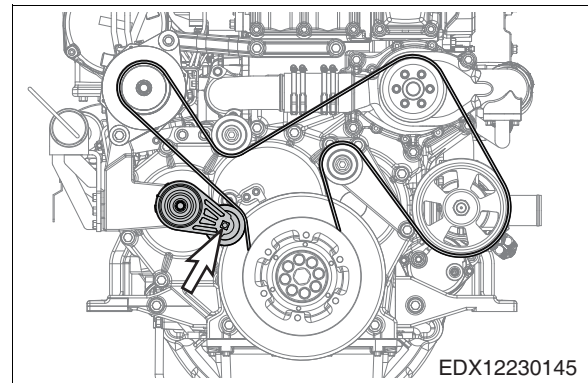
During daily inspections, be sure to inspect whether the pointer on the auto tensioner is indicating that it is time for a replacement, as well as whether there is any damage to the belt due to external factors.

1) Replacing the Micro-V Belt if necessary

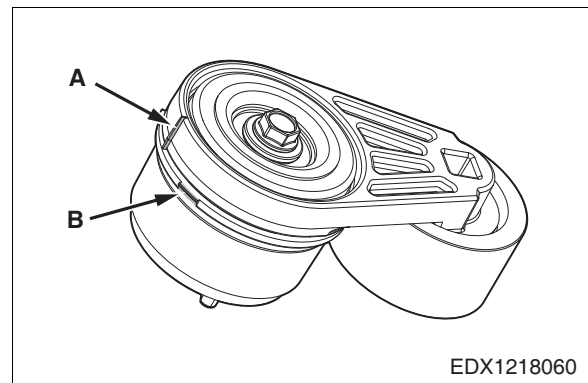
Replace the belt set in the event that the pointer on the auto tensioner indicates that it is time for a replacement, or in cases where damage to the belt from external factors has been confirmed and there are concerns of severe damage occurring.

2) Inspecting the condition of the belt

Inspect the Micro-V Belt for cracks, oil, overheating and wear.



The vertical rod (A) shown by the arrow is the "pointer," and the belt replacement period is indicated when this "pointer" enters the horizontal (B) range shown in orange.

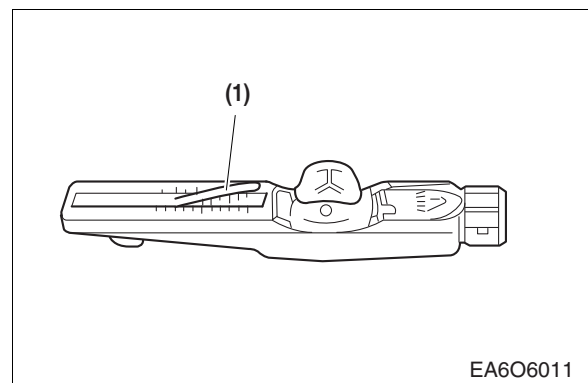


3) Measuring tension

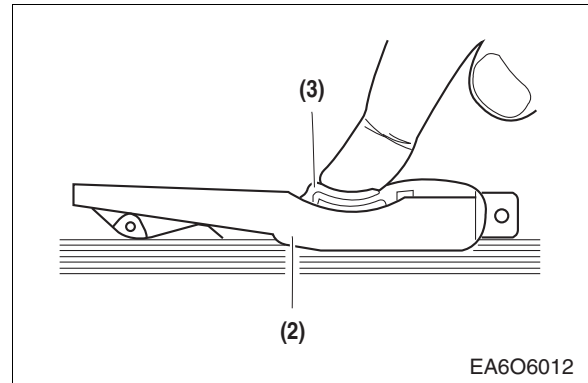
The belt is equipped with an auto tensioner which automatically adjusts the belt tension so there is no need for extra measurement of the tension. However, in the event that measuring tension is deemed necessary, measure the tension as follows.

- Lower the indicator arm (1) to within the scale.

- a) Mount the tester on the belt between the two pulleys so that the edge of the contact surface (2) is at the same height as the V-belt.



- b) Press down on the pad (3) slowly until the sound of the spring being released is heard. Then, the indicator moves upwards. If pressure is maintained even after the spring is released, you will not obtain an accurate reading.

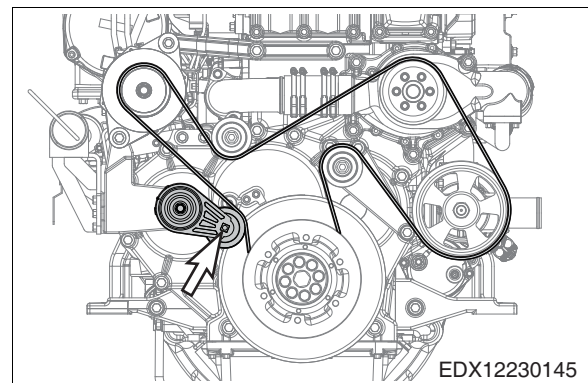


- Reading the tension value
  - a) Read the tension of the belt at the point where the top surface of the indicator arm (1) intersects with the scale.
  - b) Before reading the value, check whether the indicator arm is remaining in place.

Type	Width of drive belt	Tension of tester		
		Newly installed		Maintenance after long-term operation (replacement interval)
		Installation	10 minutes after operation	
8PK Micro V	27.61 mm	450 - 650 N	450 - 650 N	300 N

4) Adjusting tension and replacing the Micro-V Belt

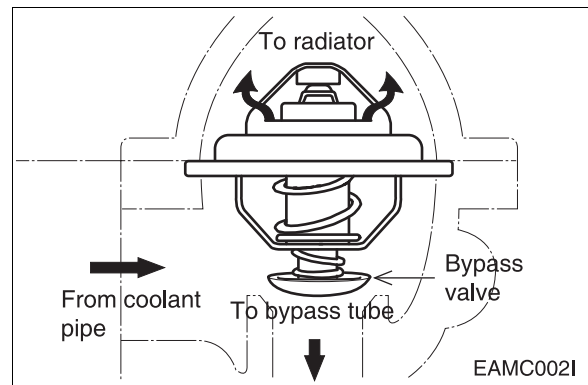
- Use the square groove located at the top of the pulley on the auto tensioner to rotate the auto tensioner clockwise.
- Remove the existing belt.
- After fitting all of the pulleys (except the auto tensioner's) with a new belt, rotate the auto tensioner clockwise one last time to wind the belt onto the auto tensioner pulley, then release the auto tensioner which was being pulled in the clockwise direction.



#### 4.3.5. Thermostat

The thermostat keeps the temperature of the engine coolant between 79 - 94 °C, thereby preventing premature wear and heat loss in the cylinders.

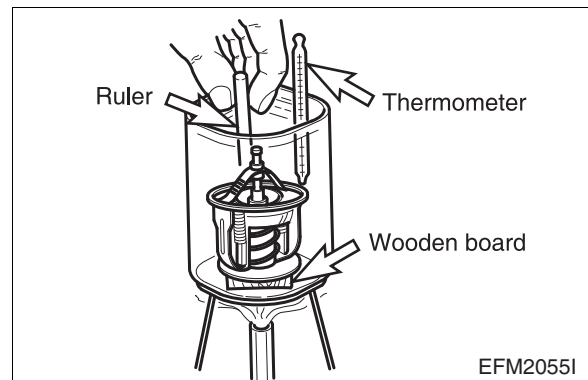
When the temperature of the coolant reaching the thermostat inlet from the cylinder head is less than 79 °C, the valve is closed, bypassing the coolant directly to the coolant pump. When the temperature is 79 - 94 °C, the coolant, heated by the open valve, passes through the heat exchanger and is cooled.



Item	Specifications
Type	Wax pellet type
Opening temp.	79 °C
Full opening temp.	94 °C
Valve lift	8 mm or higher

##### 1) Inspection

- Check the wax pellet and spring for damage.
- Submerge the thermostat in a container filled with water, heat the container, and check whether the valve lift is 0.1 mm at 79 °C and 8 mm or higher at 94 °C.



##### 2) Cautions for replacing and handling thermostat

###### ● Cautions for handling

Wax pellet-type thermostats have a slow reaction time to changes in coolant temperature, meaning that the valve does not open quickly. Thus, avoid overspeeding or operating under an excessive load after starting the engine initially.

- When draining and then refilling water in the engine cooling system, ensure that the air in the entire cooling circuit is discharged sufficiently.

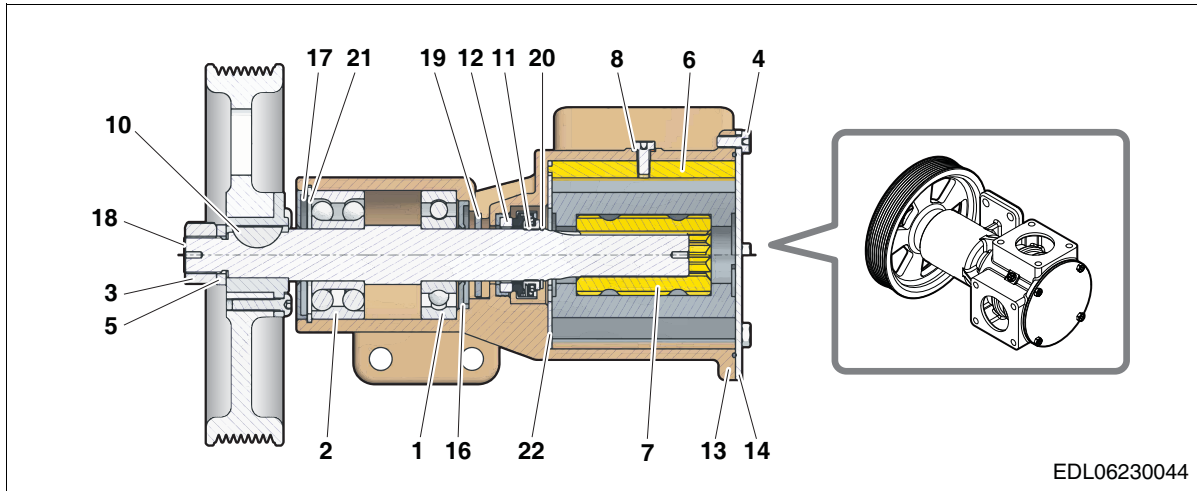
###### ● Replacing the thermostat

Replace the thermostat if a defect is discovered. There may be a slight difference depending on the level of contamination of the engine coolant, but it is usually replaced every two years.

#### 4.3.6. Checking the rubber impeller in the saltwater pump

The saltwater pump is driven by gears and employs a rubber impeller. Every time the engine is started, be sure to check that the Kingston valve installed at the bottom of the ship is open. If the valve is closed and the impeller rotates for over 20 seconds in a dry state without any saltwater, the rubber impeller can be burnt and cracked even in a short span of time since the frictional heat produced by the high rpm is not cooled, thereby damaging the rubber fins.

##### 1) Disassembling the rubber impeller



1. Bearing	7. Cover	13. O-ring	19. Sleeve
2. Bearing	8. Gasket	14. Pump casing	20. Snap ring
3. Nut	9. Impeller	15. Pulley	21. Snap ring
4. Screw	10. W/R key	16. Oil seal	22. Plate
5. Spring washer	11. Carbon	17. Oil seal	
6. Cam	12. Ceramic	18. Shaft	

- Loosen the screw on the rear cover and remove the O-ring.
- Insert two flathead screwdrivers without sharp tips as shown in the picture above on the left, using them as a lever to remove the impeller, or grab the body of the impeller firmly with pliers and turn it to the right to remove it.
- Loosen the cam mounting screw on the outer surface of the housing and remove the cam.
- Remove the wear plate inside the impeller.

##### 2) Assembling the rubber impeller

- In order to prevent rotation of the dowel pin and wear plate installed in the impeller, align it with the holes cut in a circle. However, check the amount of wear and replace it with a new one if excessively worn.
- In order to prevent water leaks and corrosion, apply sealant to the screw at the top of the cam and the cam mounting screw, then assemble it.
- Apply a thin layer of grease to the shaft mounting section on the inner side and outer surface of the impeller, then turn it to the right with the impeller inserted into the assembly shaft key and push it until it makes complete contact with the inner wear plate.



#### CAUTION

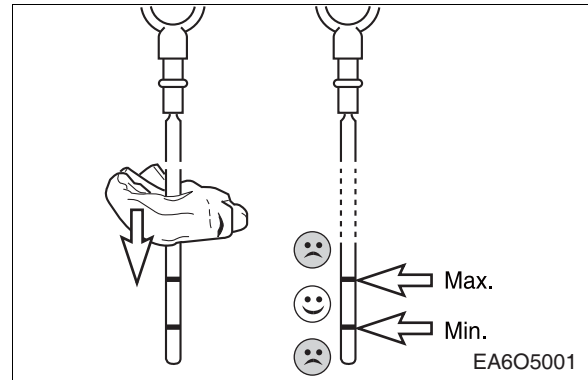
Using a hammer to force it into place against the wear plate causes the shaft to move, damaging the inner mechanical seal and causing leaks.

- Mount the O-ring and then assemble the rear cover.
- After opening the Kingston valve once the final assembly is complete, loosen the plug screw on the top of the saltwater pump to bleed the system, check for any leaks, then start the engine.

## 4.4. Lubrication System

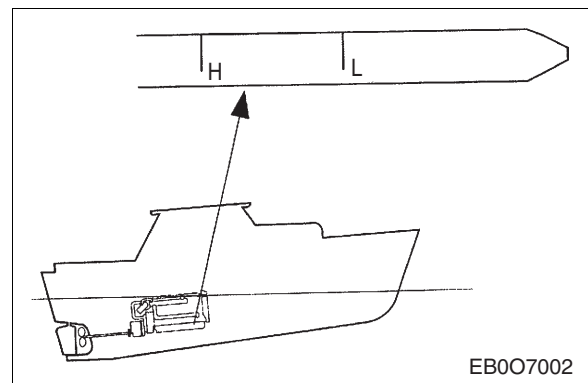
### 4.4.1. Checking the oil level

- Check the oil level in the oil pan and reduction gear daily using the oil dipstick.
- The oil level must be measured approx. 10 minutes after stopping the engine when the hull is in a horizontal state.
- Check the oil smeared on the oil dipstick, inspect the viscosity and state of contamination, and change the engine oil if necessary.

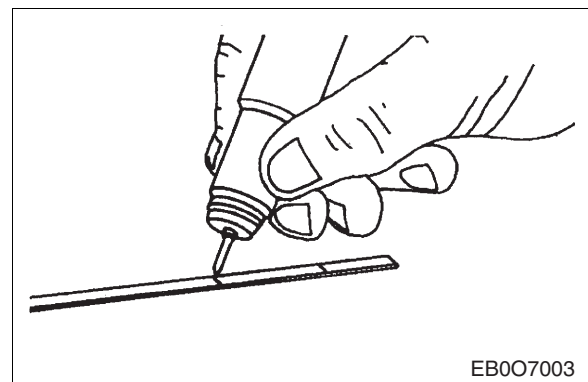


#### CAUTION

Overfilling oil past the upper limit indicated on the oil dipstick reduces the engine power and increases the amount of blow-by gas, leading to engine failure.



- Re-engraving marks on the oil dipstick  
Upon release from the factory, the oil dipstick (for the oil pan) has upper and lower limit lines engraved when installed horizontally. When running the engine initially, check the installation angle of the engine mounted in the ship. If the angle exceeds 6°, recheck the engravings and if necessary, re-engage the upper and lower limit lines on the dipstick as shown in the picture on the right to suit the inclination of the engine in the hull based on the max./min. oil capacity of the engine.  
(Refer to "1.1. Engine Specifications" for the max./min. oil capacity)



#### 4.4.2. Replacing the engine oil

The engine oil and oil filter are important factors affecting the engine life.

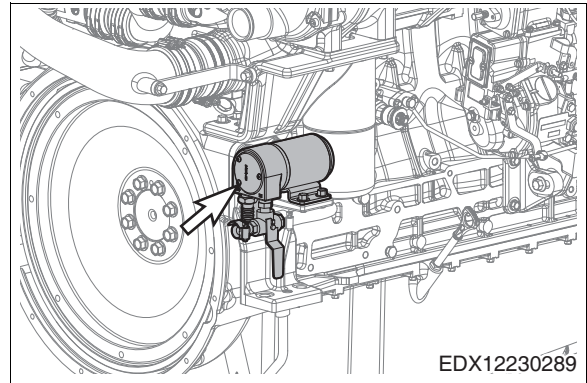
Engine oil affects startability, fuel consumption, carbon deposits in the combustion chamber, and wear to the cylinder liner, etc.

Replace the engine oil after every 500 hours of operation.

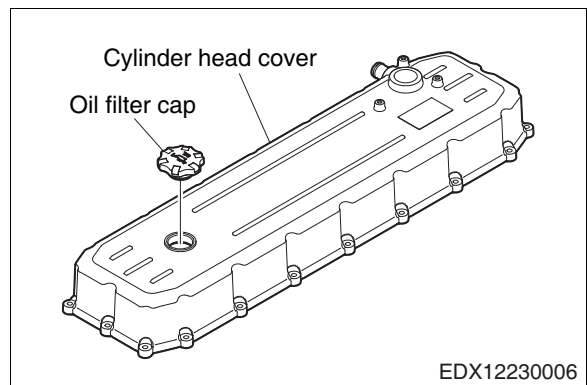
In addition, the oil filter and engine oil must be replaced after the initial 50-hour break-in period.

##### Replacement method

- Run the engine until it reaches the normal operating temperature. When the engine oil is warm, turn the drain pump to drain the oil in the oil pan (as well as the oil in the reduction gear, if necessary). Draining the engine oil while it is warm allows the oil to be drained more thoroughly, and impurities accumulated in the oil pan are also discharged along with the oil.



- Open the oil filler cap on the head cover and refill the engine oil to the appropriate level.
- While adding oil, be careful not to let dust or foreign materials enter the system.  
Check whether the oil level is near the maximum level mark on the oil dipstick.
- Idle the engine for approx. five minutes so that oil is distributed throughout the lubrication circuit.
- Then, stop the engine.  
Wait approx. 10 minutes, then check the oil level. Add more oil if necessary.



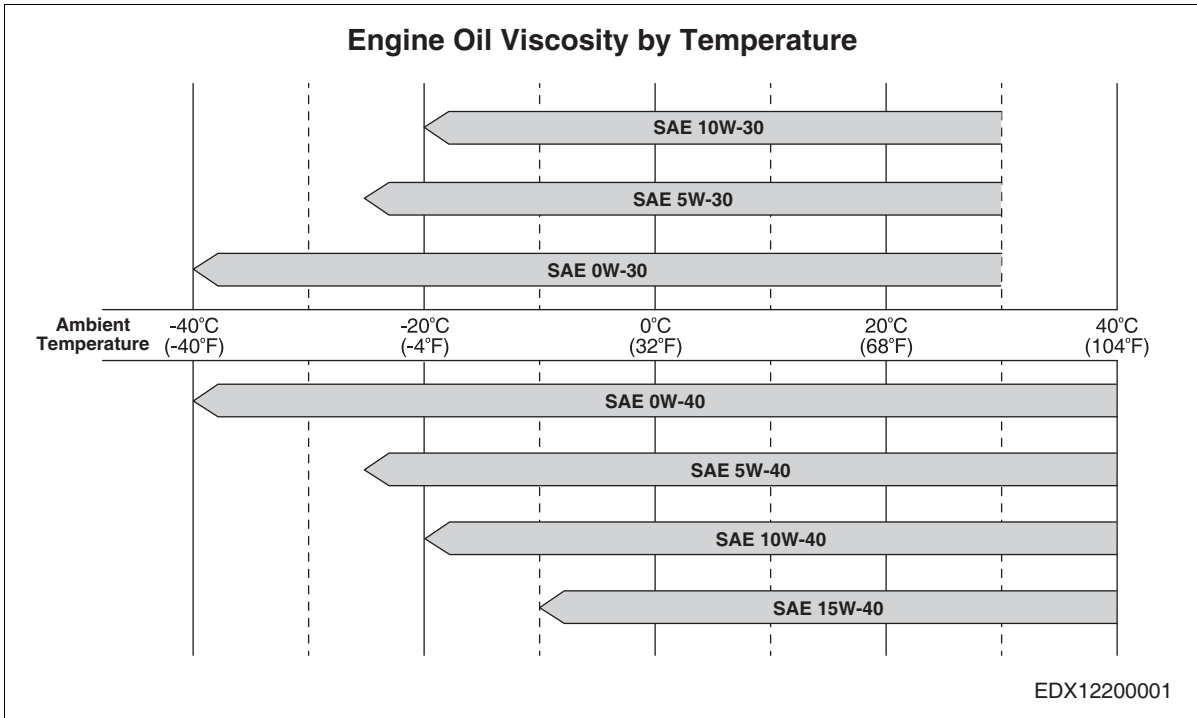
##### Recommended lubricant

Upon initial release from the factory, the engine is filled with API grade CJ-4 high-quality oil for engine break-in.

This oil should only be used during the initial 50 hours of engine break-in. Then, replace it with new oil. Be sure to check the oil level frequently during the break-in period. It is normal for the oil consumption rate to be higher than usual until the piston rings are properly seated.

When checking the oil level approx. 10 minutes after stopping the engine, the oil level must always remain between the upper and lower limit marks on the oil dipstick.

Use API grade CJ-4 or higher and SAE 10W40 engine oil in order to obtain the maximum engine performance and lifespan. Refer to the label printed on the container of the product.



● Recommended oil specifications

Manufacturer	Recommended oil	Grade
SK	SK ZIC X5000 DS 10W-40	Grade CJ-4 10W40
GS Caltex	Kixx DX EURO CJ4 10W40 / GS Caltex	
STLC	RUBIA TIR 7400	

\* If API service grade of engine oil is upper than CJ-4, Oil service interval can be 500hr. And if it's less than CI-4&CH-4 grade, oil should be changed every 250hr (1/2).

#### 4.4.3. Replacing the oil filter cartridge

Both engine oil and the oil filter are important factors affecting the engine life. Replace the oil filter cartridge as well when replacing the oil.

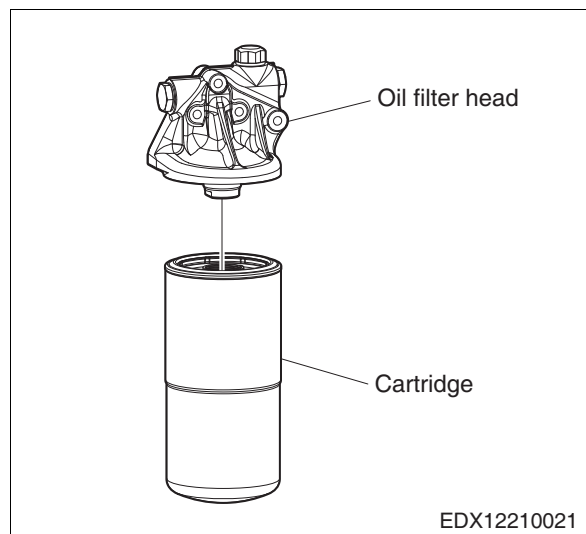
- Remove the drain plug on the head of the oil filter to drain the engine oil inside the filter first.



**CAUTION**

Do not forget to retighten the drain plug after draining the engine oil.

- Use a filter wrench to turn and loosen the oil filter in the counterclockwise direction.
- Wipe the filter and body of the packing contact surface on the oil filter with a rag thoroughly to ensure that the new filter cartridge can be seated and sealed properly.





#### CAUTION

When replacing the oil filter cartridge, make sure to use a genuine new HD Hyundai Infracore cartridge.

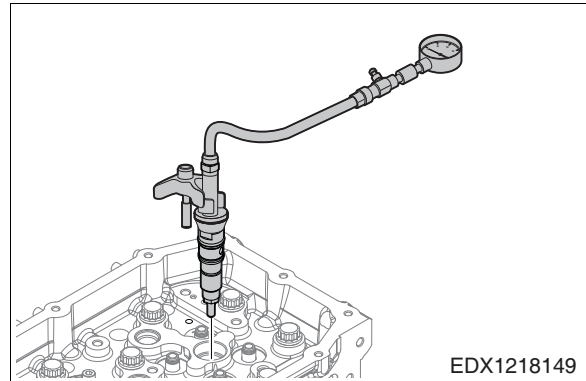
- Before installing the new cartridge, apply a thin layer of clean engine oil to the O-ring, then tighten it until the sealing surface makes contact with the O-ring and turn it an additional 3/4 to one turn in order to create an airtight seal.

#### 4.4.4. Replacing the oil in the reduction gear

Always use SAE 30 oil (not multi-grade oil) in the reduction gear, regardless of the season. The oil in the reduction gear must be replaced after the initial 100 hours of engine operation, then every 600 hours afterwards.

#### 4.4.5. Cylinder compression pressure

- After performing a test run of the engine, stop the engine and disassemble the nozzle assembly.
- Install a special tool (gauge adapter) in the nozzle holder mounting hole on the cylinder and connect the compression pressure gauge to the adapter on the opposite side.
- After shutting off the fuel circuit, run the starter motor and measure the compression pressure sequentially in each cylinder.



Model	Standard
DX12	37.7 kg/cm <sup>2</sup>

Test conditions : Coolant temperature of 20 °C and speed of 200 rpm (approx. 10 rotations)

## 4.5. Intake and Exhaust System

### 4.5.1. Adjusting the intake/exhaust valve clearance

The valve clearance must generally be inspected after every 1,000 hours of engine operation.  
For details, refer to "Valve Clearance Adjustment Procedure" in the section "6.3.21. Cylinder Head."



#### CAUTION

The valve clearance must be adjusted in the following cases.

- When servicing internal engine parts (pistons, rings, etc.) or disassembling the cylinder head
- When severe abnormal noise is coming from the valves
- When there is an excessive amount of exhaust gas or the engine is not running properly in spite of there being no problems in the fuel system.

### 4.5.2. Cleaning and replacing the air filter element

The engine life and performance are affected significantly by the quality of the intake air. A contaminated air filter element reduces the amount of intake air affecting the engine power, leading to premature engine failure.

Furthermore, a damaged air filter accumulates foreign materials in the cylinder components or valves, causing uneven valve operation and wear to the pistons and liner. This increases oil consumption, reduces engine power and ultimately shortens the engine life. Hence, the air filter element must be cleaned and replaced periodically.

- Air filter element cleaning : Every 100 hours
- Air filter element replacement : Every 400 hours

#### 1) Cleaning the element

Clean the element in warm water and a foam-less detergent.

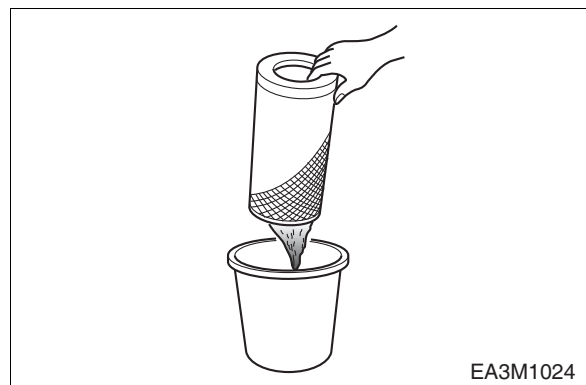
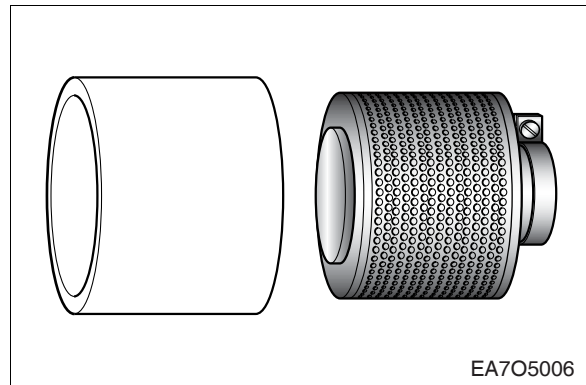
Rinse the element in clean water.

Air-dry it naturally or dry it thoroughly using an electric fan. Using a flame or compressed air to dry the element can damage it.

#### 2) Inspecting the element

Check whether the inside of the element is clean and dry.

Replace the element with a new one if it is torn or damaged.



### 4.5.3. Cleaning the intercooler

The intercooler installed in the DX12 model is a saltwater cooling-type intercooler whose lifespan and performance are affected significantly by the quality of the intake air. Contaminated, dirty air contaminates and clogs the air fins in the intercooler, reducing engine power and ultimately causing engine failure. Hence, the air filter element must be inspected daily and always kept clean.

The anode must be replaced periodically in order to prevent corrosion of the tubes in the intercooler.

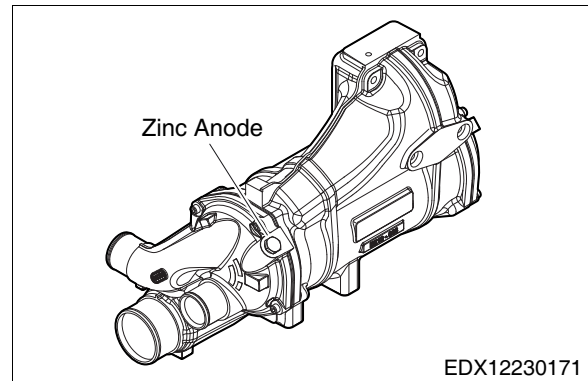
The replacement interval may vary depending on the engine operating conditions and saltwater quality so perform inspections and replacements according to the operating conditions.

#### <Cleaning the intercooler>

Regular cleaning is required in order to maintain the maximum efficiency of the intercooler.

To clean the intercooler, remove the cover and clean it in a hot alkaline solution, i.e. a 3 - 5% P3-FD solution.

If there are hard deposits of scale stuck to the intercooler even after doing so, pour a solvent on it which is capable of removing scale without corroding the intercooler fan. Repeat this until the deposits are removed. When reassembling the intercooler, use a new O-ring, and before installing the O-ring, check to make sure that the contact surface is clean.



Intercooler cleaning : 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.

### 4.5.4. Cleaning the turbocharger

- The turbocharger must be serviced every 2,000 hours. However, in order to be used long-term without any malfunctions, be sure to check the oil pipes for leakage or clogging every time the engine oil is replaced, and check periodically whether the turbocharger is producing abnormal noises while driving.
- Inspect the air filter element frequently, and clean it to ensure that foreign materials do not enter or clog it.
- The pressure of compressed air and exhaust gas must be measured and inspected periodically. Air leaks should be repaired immediately since they can cause drops in engine power and overheating.
- Clean the impeller frequently when driving in regions with air containing a large amount of dust or oil. When disassembling the impeller case in order to clean the impeller, be careful not to bend the shaft.

Use a non-acidic solvent when cleaning the impeller. If necessary, remove deposits using a plastic scraper.

If the impeller is severely contaminated, soak it in solvent and clean it with a bristle brush. When doing so, ensure that only the impeller comes into contact with the solvent. Be careful not to allow the impeller to make direct contact with the bottom in order to prevent deformation of the impeller.

#### 4.5.5. Checking the concentration of exhaust gas

Exhaust gas being discharged from the engine's exhaust pipe means that combustion is occurring within the engine. Observe the state of exhaust gas daily. If abnormal exhaust is discharged (excessive exhaust gas, white smoke, black smoke, etc.), there is a problem with the engine combustion. This requires a professional inspection or maintenance.

### 4.6. Fuel System

The core of the fuel system is the fuel injection pump and injection nozzles. These are very complex and precise parts, meaning that the nozzles can be clogged and cause the components of the injection pump to seize up if the fuel is contaminated or there is water in the fuel. Hence, always keep the fuel system clean and free of water.

#### 4.6.1. Cleaning and maintaining the fuel tank

After filling the tank with the recommended fuel, draining any condensation accumulated on the bottom of the tank completely and keeping the fuel full help to enhance engine performance.



Check whether the fuel supply valve is open. (If used)

As the fuel tank cools after stopping the engine, condensation forms and can contaminate the fuel. In order to prevent this, add fuel to the tank after running the engine each day.

In maritime regions, most fuel contamination is caused by moisture and the reproduction of microorganisms. Generally, contamination arises from handling fuel improperly and not following common sense. If fuel contains moisture, it is easy for microorganisms to reproduce and coat the bottom of the tank in a black slime. Hence, it is important to keep the amount of moisture in the fuel storage tank to a minimum.

In order to remove contaminated fuel from the fuel tank, install a water separator to gather the moisture and foreign materials in the tank. Drain the contaminated, foreign matter accumulated here every day and change the engine fuel filter several times until the fuel system is clean.



#### CAUTION

Do not use a tank made of galvanized steel for fuel storage. Fuel produces a chemical reaction with the zinc coating, causing it to peel off. These fragments clog the fuel filter quickly and contaminate the fuel pump and nozzles.

#### 4.6.2. Allowed Fuel

Diesel fuel must comply with EN590/ASTM D975 grade 2.

● Selection table for recommended fuels

The characteristics in the recommended fuel selection table below are intended to provide optimum engine performance.

<Low sulfur diesel fuel components>

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%	D86	65%: 250°C	EN ISO 3405
	2D 282-338°C		85%: 350°C	
Kinematic viscosity (at 40°C)	2D 1.9-4.1 mm <sup>2</sup> /s	D445	2.0-4.5 mm <sup>2</sup> /s	EN ISO 3104
Density (at 15°C)			820-845 kg/m <sup>3</sup>	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 <sup>2</sup>	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:	Report	D2500		
- Cloud point		D4539		
- LTFT/CFPP		D6371		
Cloud point			Location & season dependant	EN 23015
CFPP			Location & season dependant	EN 116
Carbon residue on 10% distillation residue, max.		D524	0.30% wt	EN ISO 10370
	2D: 0.35% wt			
Oxidation stability, max.			25 g/m <sup>3</sup>	EN ISO 12205
Lubricity (at 60°C), max.	520 μm	D6079 D7688	460 μm	ISO 12156-1
Conductivity, min.	25 pS/m	D2624 D4308		

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



**CAUTION**

In order to prevent fuel from freezing and clogging the fuel filter mesh, the cloud point of the fuel used must be 6°C below the lowest temperature at which fuel starts to freeze.

#### 4.6.3. Removing moisture from the oil-water separator

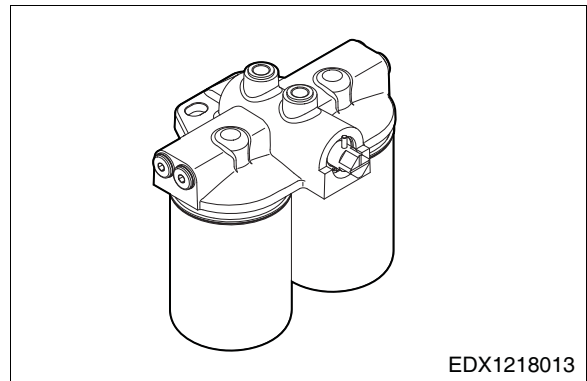
We strongly recommend installing an oil-water separator in the ship's fuel line.

The reason for this is that microorganisms reproduce and grow in partially accumulated condensation in the fuel tank, thereby contaminating the fuel. This clogs the fuel filter, disrupts the flow of fuel and reduces engine power. If there is an oil-water separator installed in the fuel line, remove the condensation periodically.

If moisture enters the fuel, it can seriously affect engine performance and damage the engine.

#### 4.6.4. Replacing the fuel filter

- Turn the fuel filter cartridge counterclockwise with a filter wrench to loosen it. Discard the used filter in the designated place.
- Wipe the filter contact surface clean.
- Apply a thin layer of engine oil to the O-ring and add fuel to the new filter.
- Install the O-ring on the sealing surface and tighten the cartridge another 3/4 to one turn.

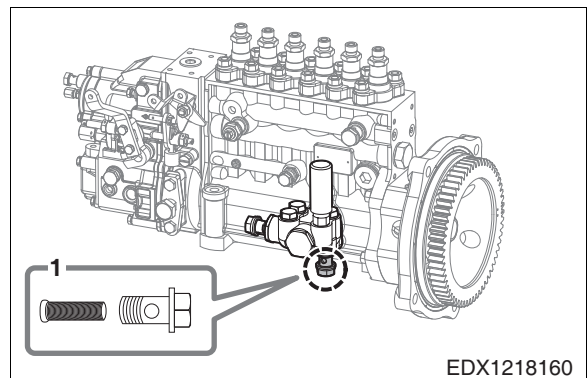


#### 4.6.5. Cleaning the priming pump strainer

Clean the priming pump strainer(1) every 250 hours of operation.

The strainer(1) is mounted on the joint bolt by the priming pump inlet.

Clean the strainer(1) with compressed air and then rinse it with fuel.

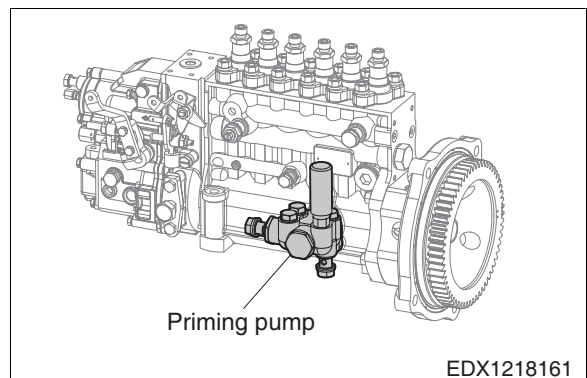


#### 4.6.6. Bleeding the fuel system

Whenever the fuel filter is replaced or the engine stalls due to insufficient fuel, remove the air from the fuel line as follows.

With the joint bolt on the fuel filter outlet and injection pump bleeder screw loosened, operate the priming pump manually to remove the air from the fuel.

- Push down on the supply pump cap repeatedly until fuel free of bubbles flows out of the bleeding plug screw.
- After all of the air has been discharged, close the plug screws on the filter and pump.
- Push down on the fuel pump cap repeatedly to check the resistance of fuel delivery.

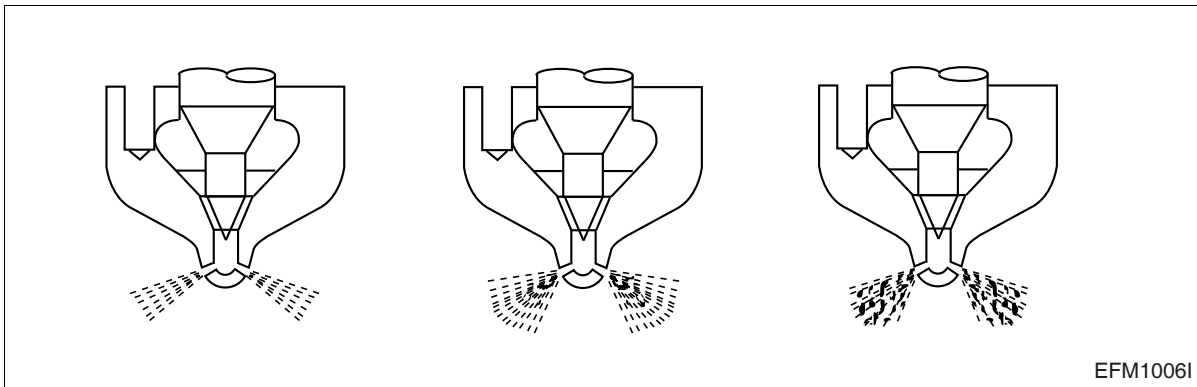
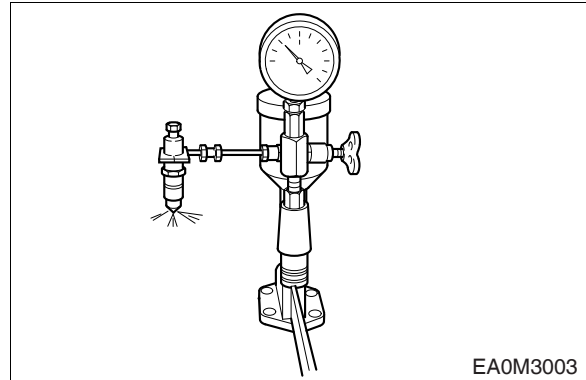


#### 4.6.7. Injection pump

- Check the housing of the fuel injection pump for cracks or damage and replace if damaged.
- Inspect and check whether the lid seal for the idling control and speed control lever has come loose.
- Do not modify the injection pump. In the event that the lid seal is damaged, the engine warranty is void.
- We strongly recommend having any defects in the injection pump handled by a certified technician.

#### 4.6.8. Injection nozzle maintenance (to be performed by a certified technician)

The injector is designed so that fuel supplied from the injection pump is injected directly into the round combustion chamber in the piston crown. The injector is composed of a nozzle and nozzle holder. The copper seal installed on the injector maintains airtight seating and proper thermal diffusion. The opening pressure of the nozzle is adjusted using the shim of the compression spring.



- Install the nozzle on the nozzle tester.
- Check the injection pressure. If the pressure does not reach the designated limit, use the adjustment shim to adjust the nozzle.
- Inspect the nozzle injection pattern and replace if damaged.

	<b>DX12</b>
<b>Opening pressure</b>	300 bar



Note:

Never use tanks made of galvanized steel for fuel storage. The fuel reacts chemically with the zinc coating to produce powdery fragments which clog the fuel filter and may damage the fuel pump and injection nozzle.

#### 4.6.9. Injection pipe

- When installing pipes in the engine, make sure they are properly aligned.
- Do not bend or permanently deform the pipes (in the event that the nozzle is not being replaced).
- Do not install severely bent pipes.
- Do not bend pipes more than 2-3° from the end.

In the event that a defect which may cause excessive operating pressure occurs in the injection system, replace both the defective part as well as the injection line.

## 4.7. Electrical System

### 4.7.1. Checking the warning lamp

Pay careful attention to whether the lamp on the gauge panel malfunctions during daily use. It is normal for the oil warning lamp to turn on before starting the engine.

### 4.7.2. Checking the battery charging state

Check whether the battery is discharged or damaged before using the engine.

### 4.7.3. Checking the wiring

Every 600 hours, be sure to check whether the electrical wiring connected to or in contact with the hull has come loose or whether there is any damage (open circuit, short circuit, etc.) in the wires themselves.

## 4.8. Long-Term Engine Storage and Maintenance

When storing the engine for an extended period of time, it must be stored and maintained properly in order to prevent contamination or corrosion in the parts. By doing so, one can expect even smoother engine operation than usual and a long service life free of malfunctions. The parts inside and outside the engine are particularly prone to rusting so be sure to maintain the engine as follows.

- Drain the coolant completely, pour in clean fresh water (soft water), run the engine until the internal coolant circuit is cleaned out sufficiently, then drain the coolant again. After doing so, add the specified coolant (mixed with 45% antifreeze).
- Run the engine until the coolant reaches the normal operating temperature of 79 - 94 °C, then stop the engine.
- Either turn and remove the drain plug on the oil pan or turn the drain pump to drain the lubricant, then replace the oil filter cartridge with a new one and add fresh oil up to the upper limit line. When draining oil, run the engine for around 10 - 15 minutes until it is hot, then stop it and drain the oil immediately in order to discharge the foreign matter sitting on the bottom of the oil pan.
- After tightening the fuel tank valve or plug completely, disassemble the fuel filter and oil-water separator and clean them or replace the element, then tighten them so that there are no leaks.
- Run the engine for approx. 5 minutes until clean fuel has been circulated sufficiently in the fuel line.
- Disassemble and thoroughly clean the air filter. If it is severely contaminated, replace the element with a new one.
- Drain the oil in the reduction gear completely, disassemble and clean the strainer inside the reduction gear, then add the specified oil (SAE #30, API grade CC or higher).
- Idle the engine for approx. 10 minutes while switching between neutral/ forward, neutral/ reverse to enable clean oil to be distributed throughout the inside of the engine.
- Place the engine's throttle lever in the "Idle" position and shut off the power (neutral or OFF) to the reduction gear and FPTO, etc.
- Drain the coolant completely and keep the drain plug removed.
- Close the valve on the saltwater pipe firmly. If the weather is exceptionally cold, open the drain plugs on the heat exchanger, air cooler (intercooler), reduction gear oil cooler, etc. to drain the saltwater completely, then leave the plugs removed on the engine components open. Also, be sure to remove the rubber impeller in the saltwater pump and store it in a shaded place.

- Disconnect the negative (-) battery cable first, then disconnect all the rest of the cables. After wiping the battery and cables clean, add distilled water to the battery. (If required)
- Clean each part thoroughly, apply grease to parts with a risk of rusting (moving parts, etc.), and spread wax on painted surfaces.
- Loosen the belts so that no force is applied to the bearings and insert thick pieces of cardboard between the grooves in pulleys with belts attached.
- Turn on the starter motor at least once a week to run the engine, enabling parts in contact with one another (pistons, rings and bearings, etc.) to change positions.
- Engines in storage must be inspected periodically. If there are signs of rust or corrosion occurring, remove the rust and apply grease.
- Check the overall state of safety of the ship thoroughly.

#### **4.9. Measures to Take if the Engine is Submerged in Water**

If the engine is submerged in water, remove the water from the engine as quickly as possible and contact a local HD Hyundai Infracore engine dealership to have the engine serviced.

Service technicians disassemble the engine to remove the salt from all components and reapply lubricant to all internal parts immediately.

Also, all electrical components are dried and damage due to corrosion from saltwater is inspected.

Such measures must be taken as quickly as possible. Delays may cause critical damage to the engine.

In particular, check whether there is salt or excessive moisture in the engine's fuel line system and install an automatic bilge pump to keep the depth of the water accumulated on the floor of the ship with the engine installed below the flywheel housing.

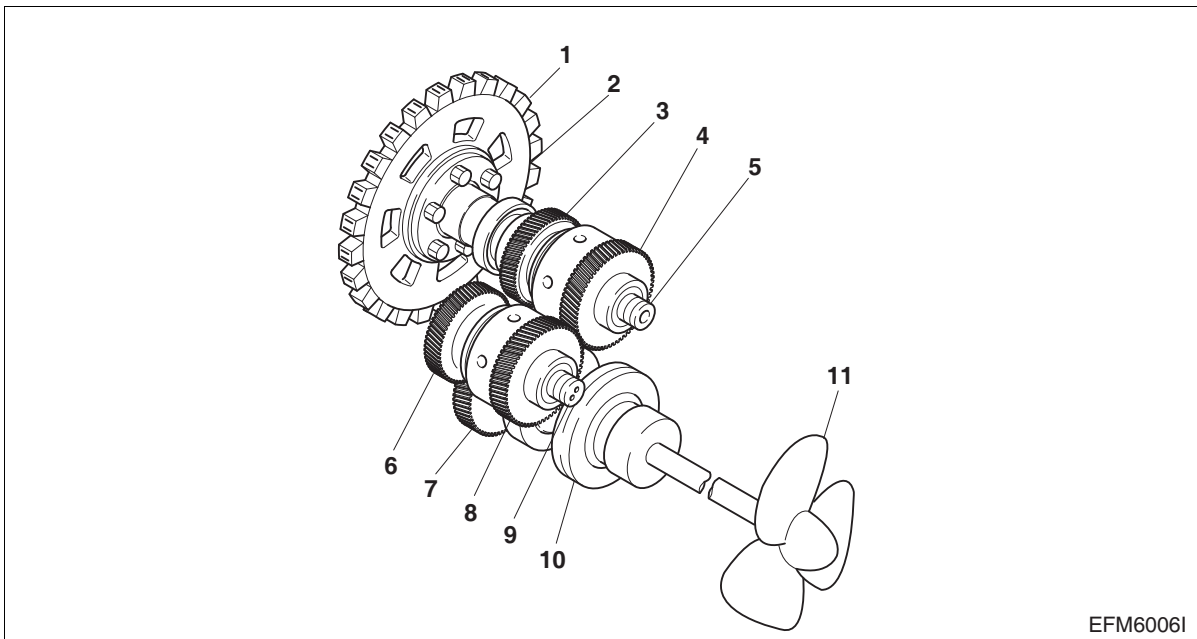
## 5. Main Components

### 5.1. Reduction Gear

For details about maintenance and handling techniques, refer to the reduction gear booklet provided separately.

#### 5.1.1. Structure and operating principles

The reduction gear is used in high-speed engines and is composed of four main parts: an input shaft, gear shaft, output shaft and housing. The clutch for forward and reverse drive is a hydraulic, wet, multi-plate type. The structure and power transmission process are 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       | 6. Reverse pinion     |
| 2. Spider             | 7. Output shaft       |
| 3. Forward pinion     | 8. Reverse drive gear |
| 4. Reverse drive gear | 9. Gear shaft         |
| 5. Input shaft        | 10. Propeller shaft   |

#### 5.1.2. Characteristics

The reduction gear is composed of a forward shaft, reverse shaft, output shaft and valve body.

The valve body installed on the exterior is a device which controls the forward, neutral and reverse modes. It can also be adjusted remotely.

The oil delivered to the oil pump is supplied to the clutch assembly and the lubricated parts of the each gear and bearing. When installing the reduction gear, take care to ensure that the power transmission shaft is aligned precisely in a straight line with the engine driveshaft.

### 5.1.3. Operation

#### 1) Before operation

- Check the tightness of bolts and nuts in all components.
- Check the oil level with the oil dipstick.  
(Before checking the oil level, idle the engine for several minutes and then stop the engine.)
- Place the reduction gear control lever in the neutral position before starting the engine.

#### 2) Starting

- Idle the engine for 10 minutes.
- Check for leaks, abnormal sounds, temperature, etc. while idling the engine.
- Increase the engine rpm and check whether the clutch pressure is normal.

#### 3) Driving and stopping

- Check whether the specified pressure is obtained while the clutch is engaged.  
The pressure drops slightly at a low engine rpm but it does not affect the engine operation.  
(Specified pressure : Refer to the attached drawing)
- When changing the gear to forward to reverse mode, idle the engine first before changing it.
- When the engine is running, the oil temperature must be maintained at 60 - 90°C.
- To stop the engine, place the control lever in the neutral position and then stop it.

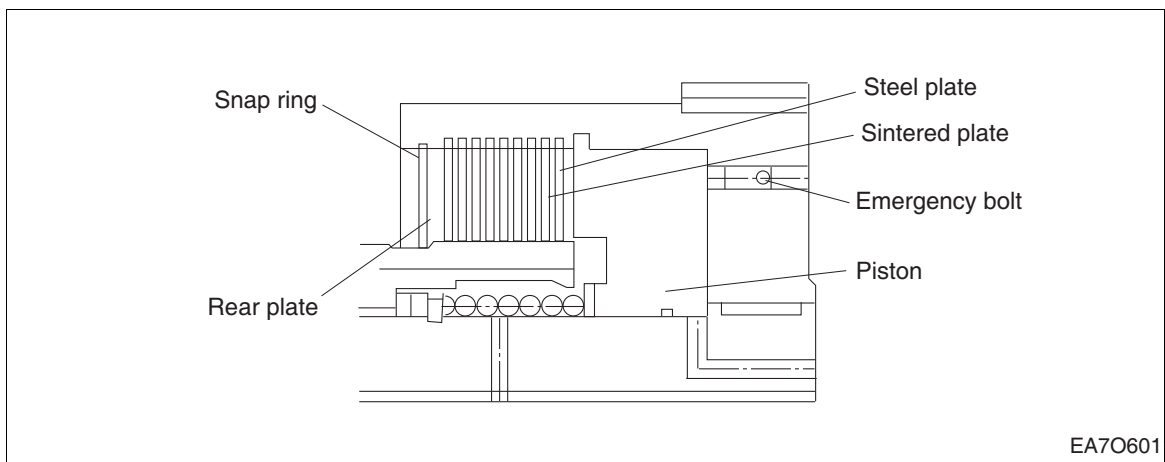
#### 4) Emergency bolt

The emergency bolt is used as an emergency measure when the clutch slips while at sea and power is not transmitted to the propeller. Tightening the emergency bolt located on the forward clutch delivers power mechanically but only for driving forward. When using the emergency bolt, loosen the cover bolt first and disassemble the control block. Then, use a 5 mm L-wrench to tighten the 8 mm wrench bolt on top of the disk pack.

Next, reassemble the control block in the reverse order.

When the engine is started after tightening the bolt is complete, the propeller runs immediately and the ship moves forward.

At this time, take care to drive at less than half the usual speed.



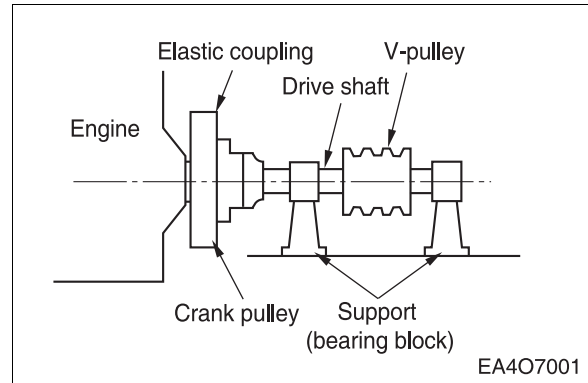
## 5.2. Front of Engine Power Takeoff (F.P.T.O.)

All auxiliary devices connected to and driven directly by the engine's crank pulley affect mostly warpage and vibrations in the engine. Excessive warpage and vibrations not only cause noise, gear malfunction and premature wear of the main bearing, but can even cause damage to the crankshaft in severe cases. Take care not to exceed the maximum usable limit for the front power takeoff recommended for each of the following models. These are the maximum values for power which can be transmitted by each clutch.

### 5.2.1. Maximum capacity of front power takeoff

In order to use the front power takeoff properly, install an elastic coupling on the front of the crank pulley as shown in the picture, connecting the engine with the PTO pulley (V-pulley) and driveshaft. Then, install two bearing blocks able to firmly support the PTO pulley and driveshaft on the front and back.

HD Hyundai Infracore recommends installing the front power takeoff (FPTO) in this way in order to prevent engine warpage and vibrations.

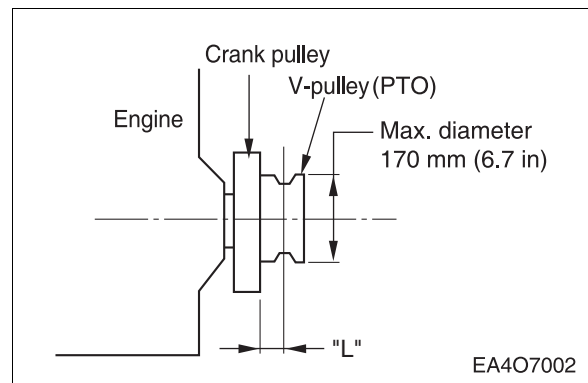


When using the FPTO to install the driveshaft of attachments, the deviation of the shaft from the central axis and the gap between the contact surface must each be less than 0.02 mm.

Engine model	Rotational torque
4L126TIM	99 kg·m
4L126TIL	104 kg·m

### 5.2.2. Maximum allowable open power takeoff in open state

In the event that a support bearing is not used on the front of the PTO pulley as shown in the picture, the usable capacity varies significantly depending on how far the PTO pulley is from the tip of the crank pulley. When obtaining power in this way, it is easy for engine parts to be damaged (cracks in the crank pulley and bolt, premature wear of the main bearing, broken clutch, etc.) depending on the size of the load. Hence, it is safer to install a support bearing on the front whenever possible. If auxiliary power is used as shown in the picture, make sure the distance (L) from the tip of the crank pulley to the center line of the groove in the V-pulley is less than 60 mm for the sake of safety.

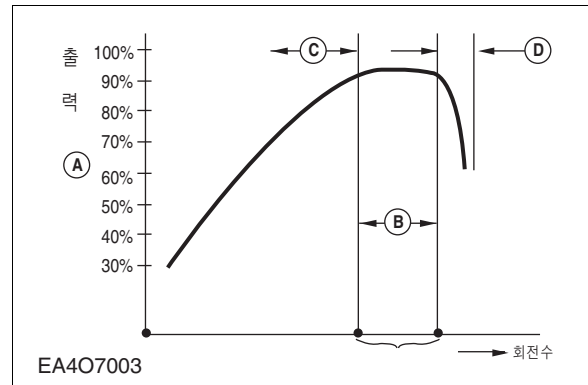


Engine model	Rotational torque
4L126TIM	62 kg·m
4L126TIL	65 kg·m

### 5.3. Propeller

In order to obtain the maximum speed from the marine engine installed in the ship, the propeller must be set to provide optimum performance and efficiency under optimal conditions. In order to obtain the maximum usable horsepower (A), the engine rpm must be within the full-load range (B) indicated in the picture at the speed of the continuous rated power.

Refer to the engine performance curve in the "Engine Specifications" section included earlier in this manual.



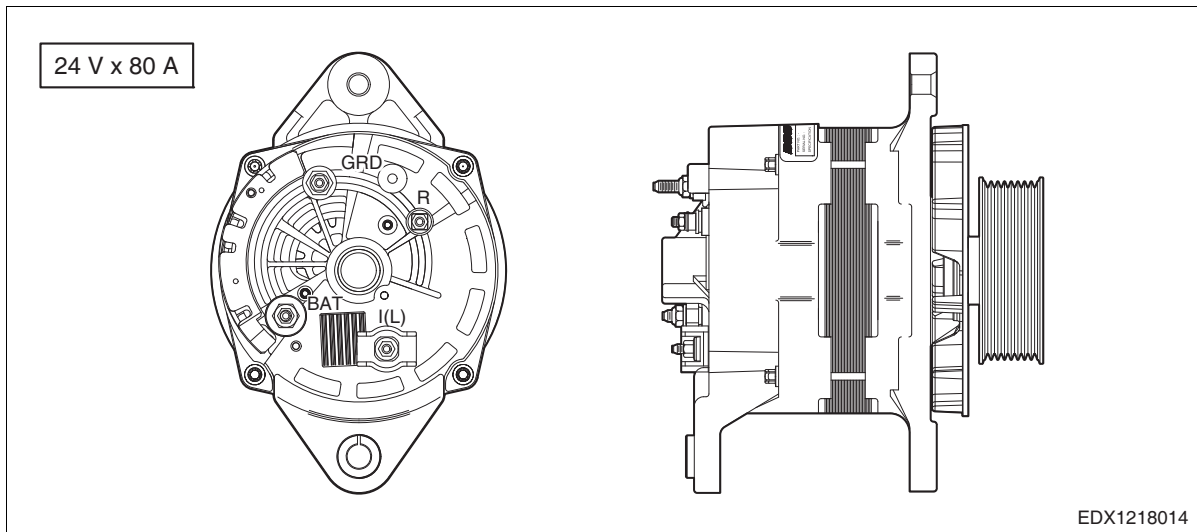
#### CAUTION

Choosing an unsuitable propeller causes damage to the engine. If the engine's continuous rated rpm exceeds the specified speed range while the hull is full, take the following measures.

- If the engine speed (rpm) fails to reach the specified "full-speed operating range" (section C), run the engine with a reduced propeller pitch.
- If the engine speed (rpm) exceeds the specified "full-speed operating range" (section D), enlarge the propeller pitch to run the engine.

## 5.4. Electrical System

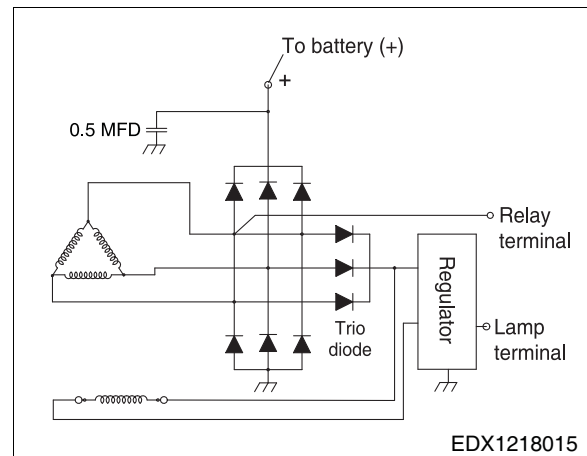
### 5.4.1. Generator



The generator is equipped with a silicon rectifier. The voltage control regulator installed in the body of the generator consistently adjusts the voltage generated inside and supplies it to the battery.

In order to prevent damage to the rectifier and regulator, the generator must be operated with the regular and battery connected.

The generator does not require maintenance. However, a protective generator cover must be installed to prevent contamination due to dust, moisture or salt in order to prevent damage to the internal circuit.



#### Cautions for usage

- Keep in mind that the battery voltage drops when not used for an extended period of time.
- Starting is occasionally difficult during winter. At such times, do not force the engine to start. Restart the engine at intervals of approx. 30 seconds.
- Before turning on the gauge panel, check the battery terminals once more.  
**(Note : The red end is the positive "+" terminal and the black end is the negative "-" terminal. )**
- When disassembling the gauge panel, there is a risk of electric shock. Hence, always disconnect the connectors on the back before working on the gauge panel.
- Using tinfoil as a fuse connection may damage components due to excess current. Hence, when a fuse is blown, resolve the cause of the problem and then replace it with a new fuse.
- The battery is sensitive to heat expansion so it must not be left in a hot place.
- Always remove the key when the engine is stopped. By doing so, fires or safety accidents due to malfunctions can be prevented.
- When disposing of the battery, be sure to observe the following rules.

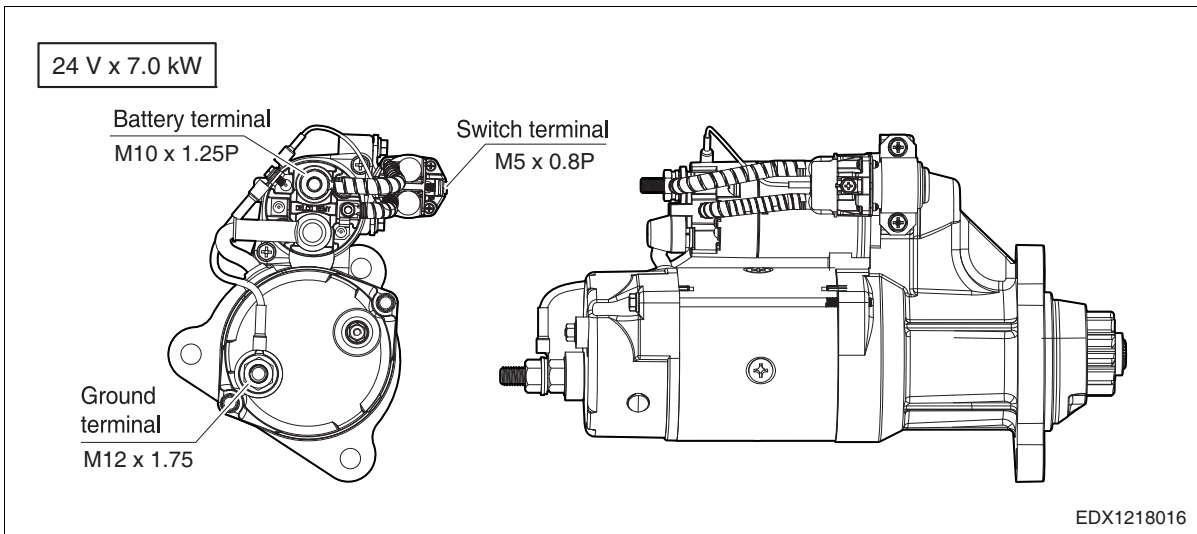


**CAUTION**

Do not dispose of the battery anywhere with flames around. Discard it in a designated place.  
Do not dispose of the battery in a place which could pollute the environment, such as streams, rivers and mountains.  
Seal the battery and dispose of it as far away as possible so that it cannot be reused.

- HD Hyundai Infracore is not responsible for problems arising as a result of the user arbitrarily disassembling parts or problems arising due to changes made to the structure of the product without prior consent from HD Hyundai Infracore.

**5.4.2. Starter motor**



The starter motor is installed on the back left side of the flywheel. When servicing the engine, soak the starter motor pinion and ring gear in fuel and clean them thoroughly with a brush. Then, apply grease to them to prevent rust.

When cleaning the starter motor, take particular care to ensure that moisture does not enter the wiring and cause a short circuit.



**CAUTION**

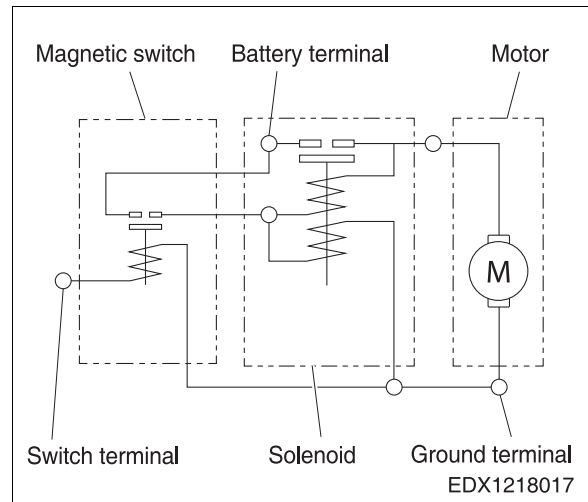
The starter motor should always be protected from moisture.



**WARNING**

Before working on the electrical systems, disconnect the negative ("-") battery cable.

To prevent a short circuit while working, reconnect the cable after the work is complete.



## 6. Engine Service

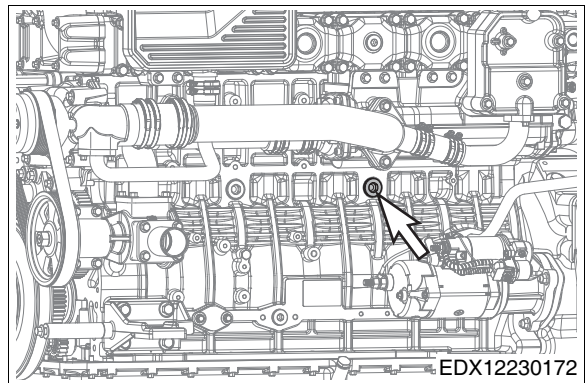
### 6.1. Disassembly

#### 6.1.1. Preparation

- Always work in a well-lit and clean environment.
- Before disassembly, prepare a shelf for the various tools and disassembled parts.
- Store disassembled parts in their disassembled order and be careful not to damage them.

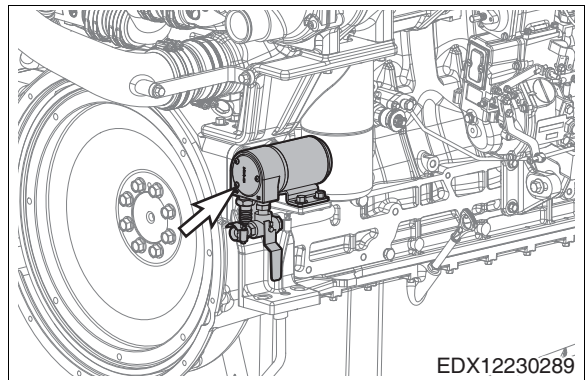
#### 6.1.2. Engine coolant

- Prepare a container, remove the coolant drain plug on the engine block and drain the coolant into the container.



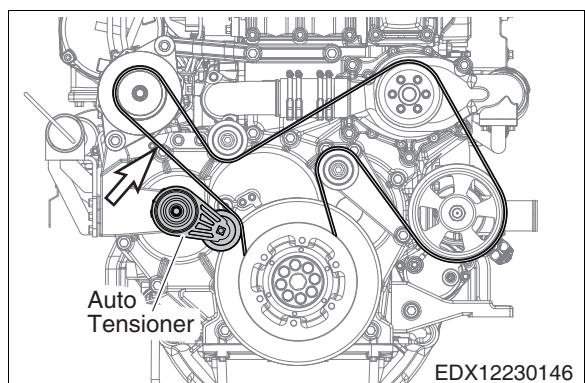
#### 6.1.3. Engine oil drain pump

- Prepare a container, run the oil drain pump and drain the engine and reduction gear oil into the container.
- Disconnect the rubber hose connected to the oil pan and reduction gear.
- Remove the oil drain pump mounting bolt and remove the oil drain pump.



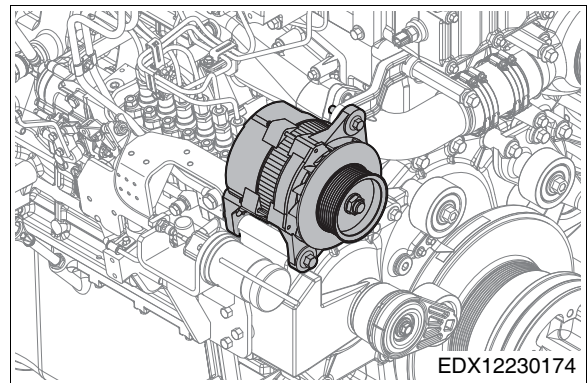
#### 6.1.4. Belt

- Rotate the auto tensioner clockwise to loosen the belt, then remove the rubber belt.



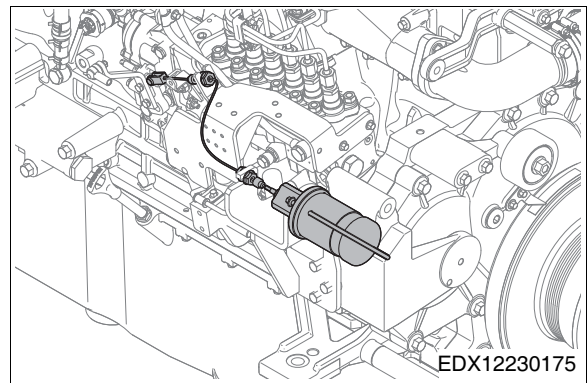
### 6.1.5. Generator

- Loosen the generator mounting bolt, then remove the protective cover and generator.



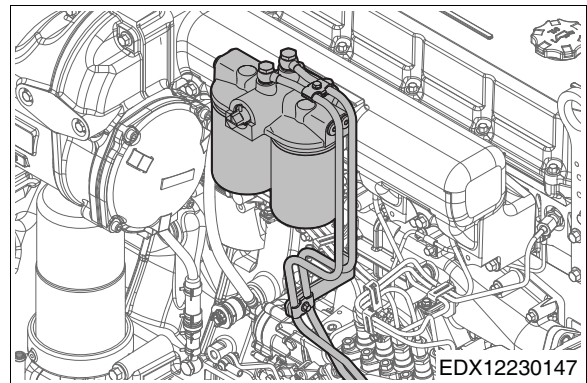
### 6.1.6. Engine stop solenoid

- Disconnect the cable connected to the solenoid and fuel stop lever.
- Disassemble the engine stop solenoid.



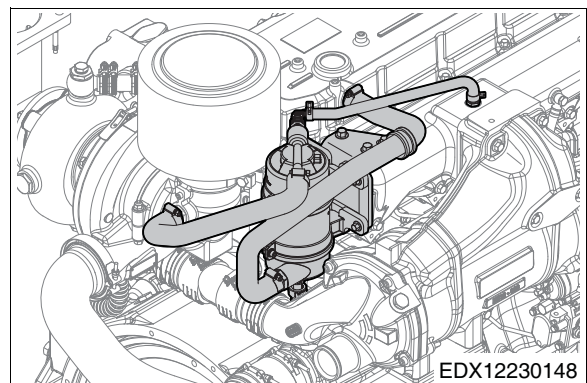
### 6.1.7. Fuel filter

- Disconnect the fuel pipe connected to the fuel injection pump and loosen the filter mounting bolt, then remove the fuel filter.



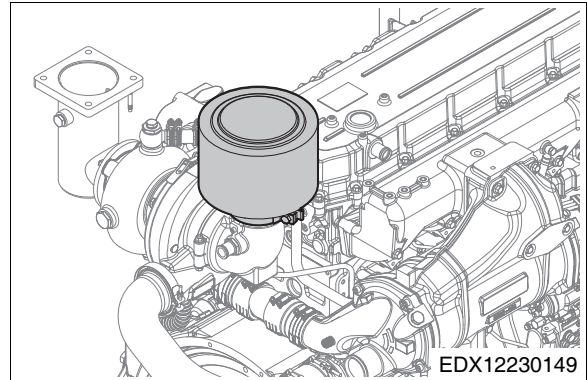
### 6.1.8. Breather

- Loosen the breather hose mounting clamp on top of the cylinder head cover and remove the rubber hose.



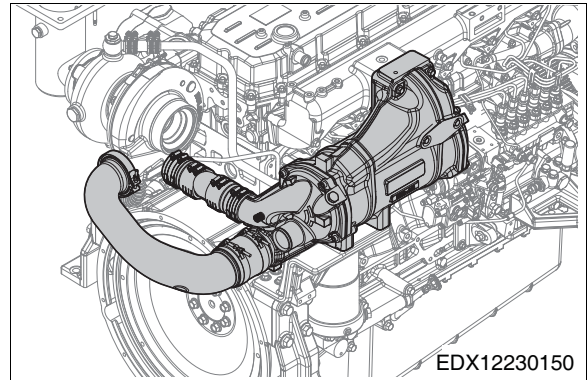
### 6.1.9. Air filter

- Detach the filter element.
- Loosen the clamp and remove the air filter.



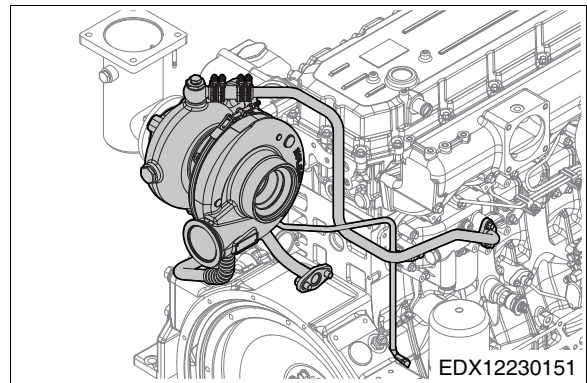
### 6.1.10. Intercooler

- Detach the coolant pipe from the intercooler.
- Remove the air pipe from the turbocharger.
- Disassemble the intercooler.



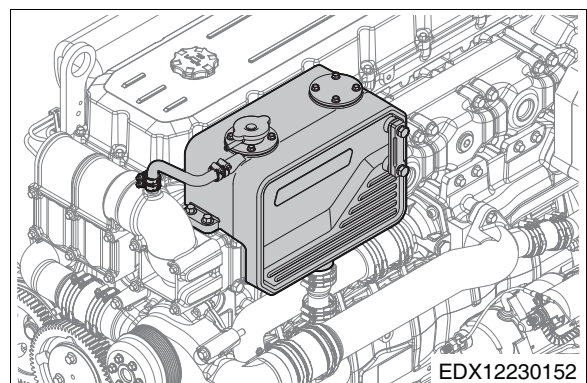
### 6.1.11. Turbocharger

- Loosen the clamp on the rubber hose connected to the turbocharger inlet and remove the intake pipe.
- Loosen the nut on the exhaust outlet pipe installed on the turbocharger and disassemble the exhaust pipe.
- Disconnect the oil supply pipe and return pipe on the turbocharger, then loosen the turbocharger mounting nut and disassemble the turbocharger.



### 6.1.12. Reservoir tank

- Disconnect the pipe connected to the reservoir tank.
- Loosen the reservoir tank bracket mounting bolt and remove the reservoir tank.



### 6.1.13. Injection Pipe

- Remove the nuts on the injection pipes for cylinders 1 to 6 (high-pressure fuel connector & injection pump).



**CAUTION:**

There may be residual fuel pressure inside the injection pipes, so beware of fuel spray when removing nuts.

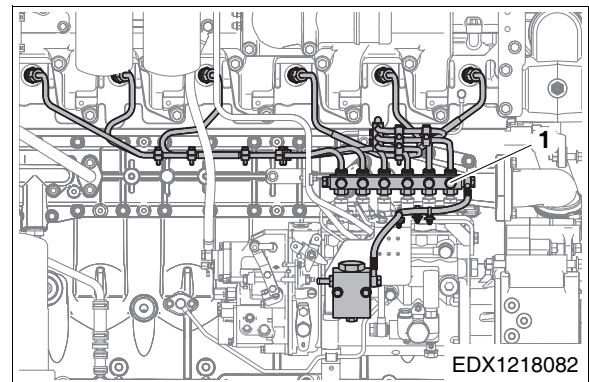
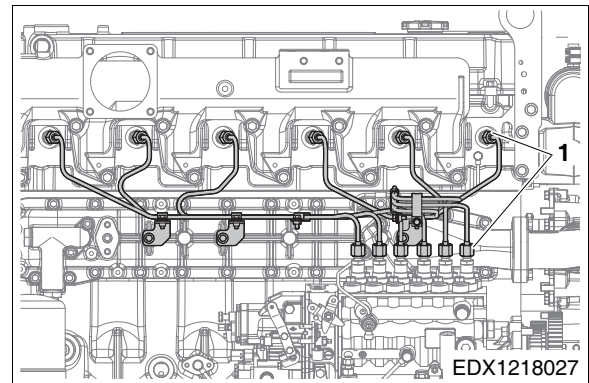
- After removing the injection pipe mounting bracket bolts (2ea) from the oil cooler side for cylinders 4 to 6, disconnect injection pipes 4 to 6 from the engine.
- After removing the injection pipe mounting bracket bolt (1ea) from the oil cooler side for cylinders 1 to 3, disconnect injection pipes 1 to 3 from the engine.



**CAUTION:**

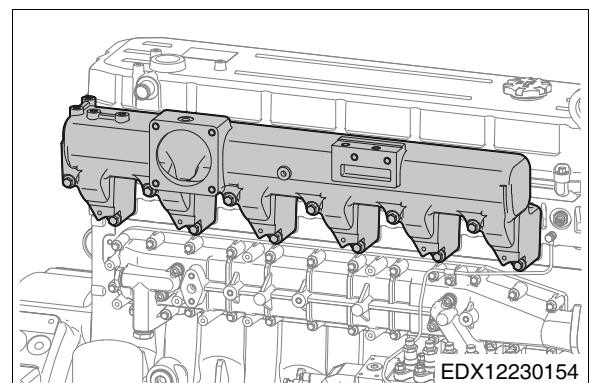
Injection pipes cannot be reused since they provide sealing for high-pressure fuel lines.

- Remove the hollow screws (1) in order to disconnect the fuel return pipe. (Only for double pipes)



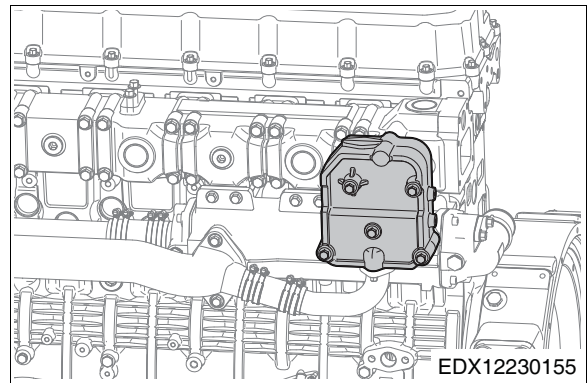
### 6.1.14. Intake manifold

- Disconnect the air hose connected to the fuel injection pump.
- Loosen the intake manifold mounting bolt and remove the intake manifold.



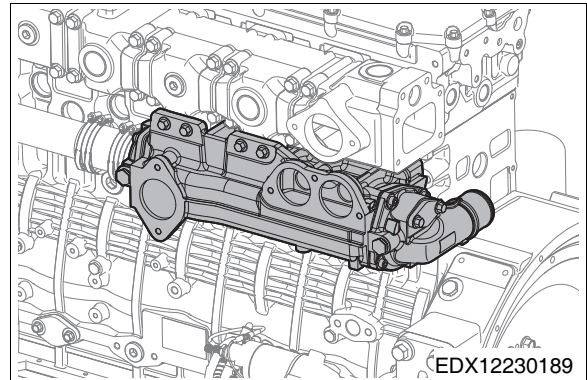
### 6.1.15. Thermostat

- Disconnect the hose and bypass pipe connected to the coolant pump. Loosen the thermostat mounting bolts connected to the exhaust manifold and heat exchanger, then remove the housing.
- Remove the thermostat.



### 6.1.16. Heat exchanger

- Loosen the rubber hose mounting clamps connected to both sides of the heat exchanger, then disconnect the rubber hose.
- After removing the exhaust manifold, loosen the heat exchanger mounting bolts connected to it and remove the heat exchanger.



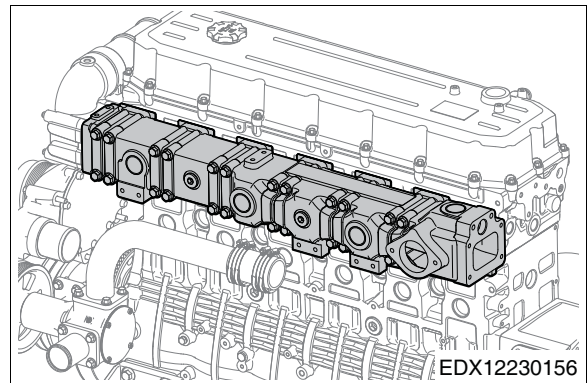
### 6.1.17. Exhaust manifold

- Loosen the exhaust manifold mounting bolts, disconnect the heat exchanger and exhaust manifold assembly, then remove the heat exchanger and gasket.



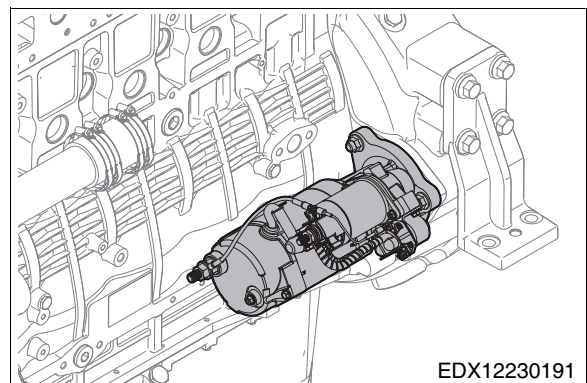
#### CAUTION

The exhaust manifold assembly is very heavy so be careful during disassembly.



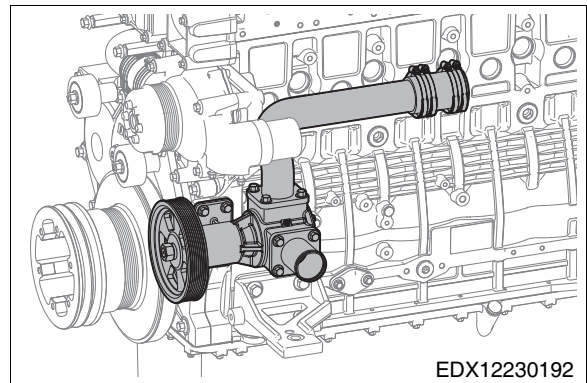
### 6.1.18. Starter motor

- Loosen the starter motor mounting bolts, then remove the starter motor.



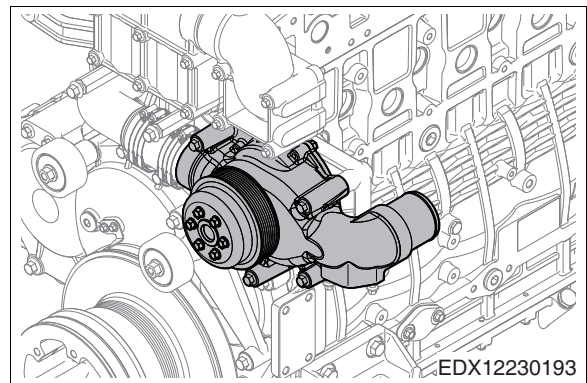
### 6.1.19. Saltwater pump

- Loosen the rubber hose mounting clamp connected to the saltwater pump, then remove the rubber hose.
- Loosen the mounting bolts on the PTO housing integrated with the saltwater pump, then remove the saltwater pump assembly.



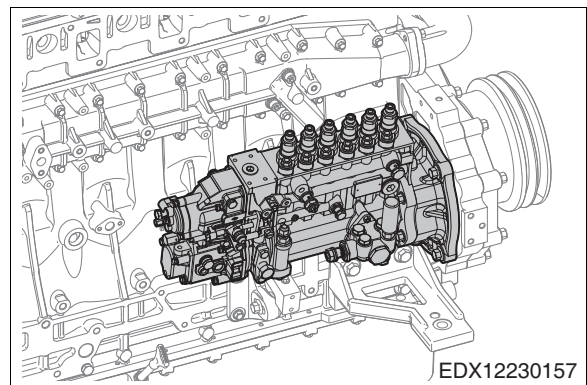
### 6.1.20. Coolant pump

- Remove the coolant pipe connected to the oil cooler.
- Disconnect the coolant pipe and hose connected to the heat exchanger.
- Unscrew the coolant pump mounting bolts and remove the coolant pump.



### 6.1.21. Injection pump

- Disconnect the oil feed pipe and return pipe connected to the fuel injection pump.
- Loosen the bolt fastening the flange on the driving end of the pump and remove the injection pump mounting bolts, then remove the injection pump.



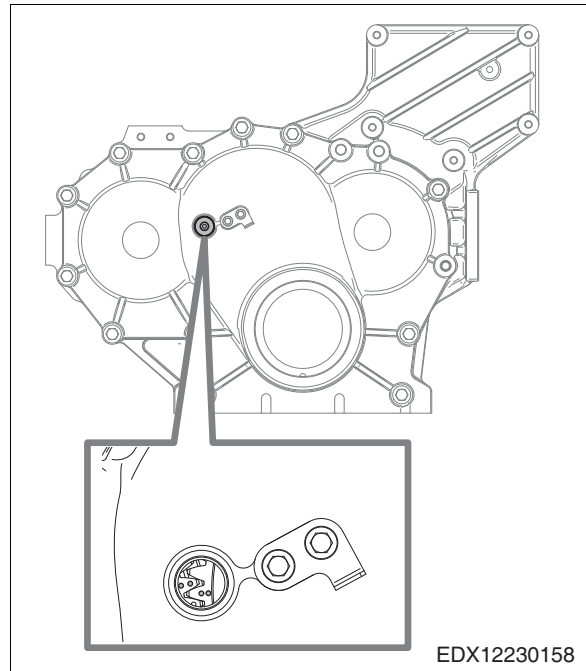


#### Note

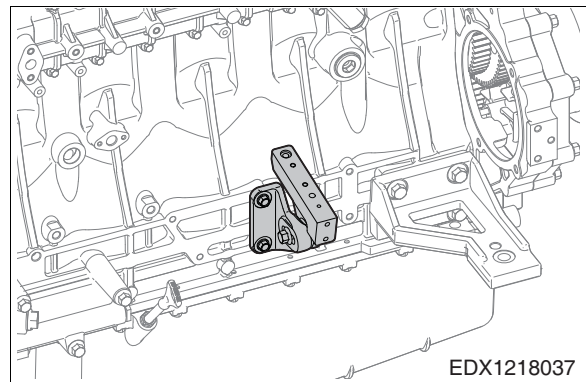
Turn the crankshaft to align cylinder no.1 with the 'OT' position, then remove the injection pump.

#### \*How to check the 'OT' position

- Remove the plug screw from the part of the timing gear case shown in the picture.
- Check the hole from which the screw was removed and turn the crankshaft to check the engraving on the gear.
- The place where the engraving on the idler gear and injection pump gear align as shown in the picture is the engine 'OT' position.

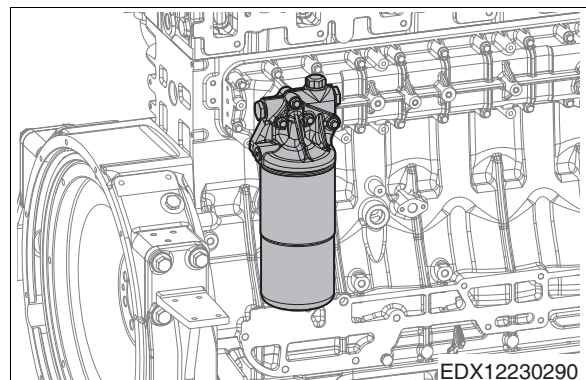


- Loosen the pump mounting bracket bolts to remove the bracket from the cylinder block.



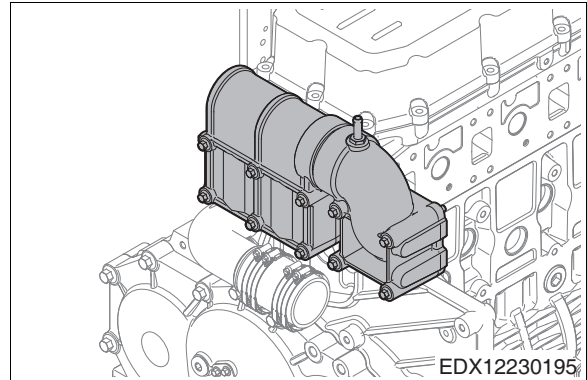
#### 6.1.22. Oil filter

- Use a filter removal wrench to remove the cartridge.
- Disconnect the pipe connected to the oil cooler.
- Loosen the oil filter mounting bolts and remove the oil filter housing from the cylinder block.



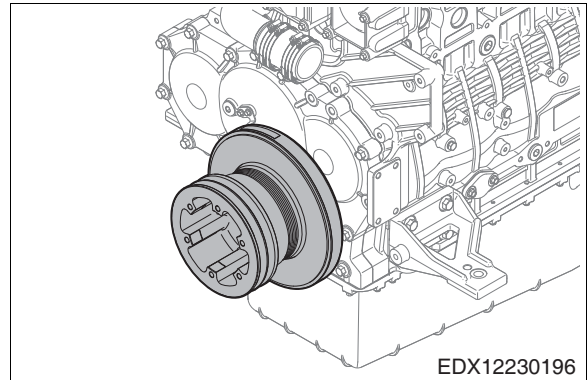
### 6.1.23. Water chamber

- Remove the 10 bolts installed on the water chamber, then remove the water chamber.



### 6.1.24. Vibration damper

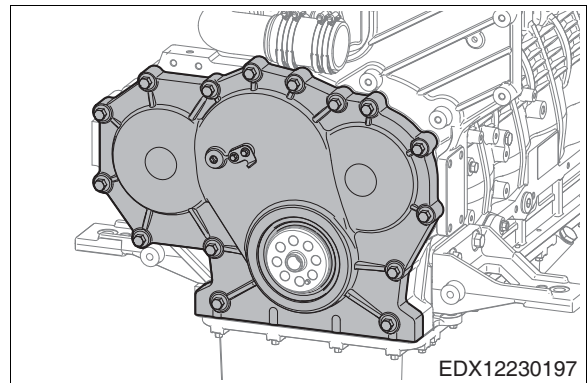
- Unscrew the pulley mounting bolts and remove the vibration damper assembly.
- Unscrew the vibration damper mounting bolts and remove the vibration damper from the pulley.



### 6.1.25. Timing gear case cover

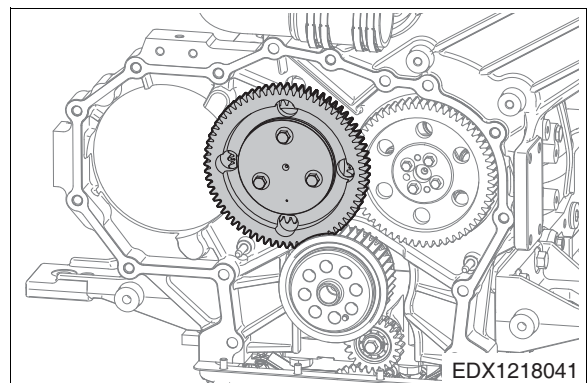


- Use an oil seal removal jig to remove the oil seal.
- Unscrew the cover mounting bolts and remove the cover from the timing gear case.



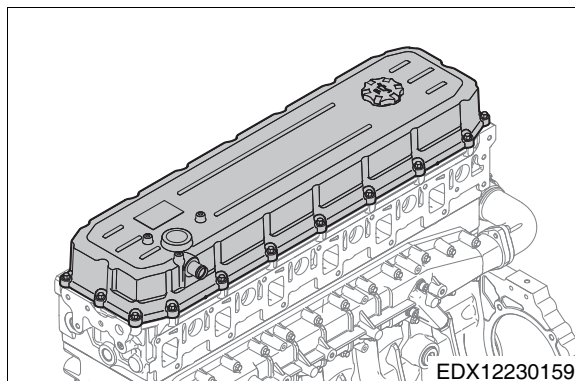
### 6.1.26. Idler gear

- Loosen the idler gear mounting bolts and remove the idler gear pin and gear.
- Use a rubber hammer to remove the idler pin without damaging it.



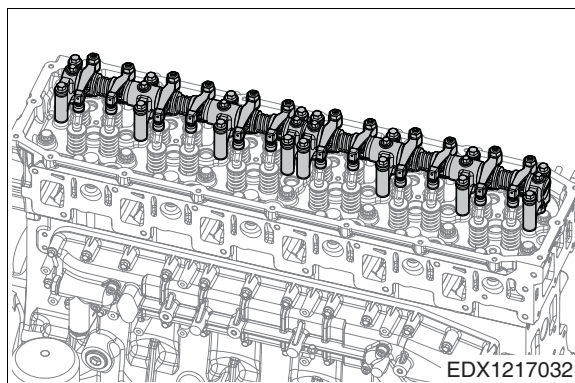
### 6.1.27. Cylinder head cover

- Unscrew the cover mounting bolts and remove the cover.

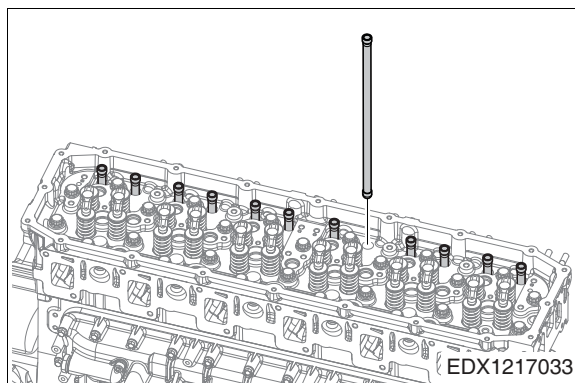


### 6.1.28. Rocker arm assembly

- Unscrew the rocker arm bracket bolts and remove the rocker arm assembly.
- Remove the calipers after removing the rocker arm assembly.

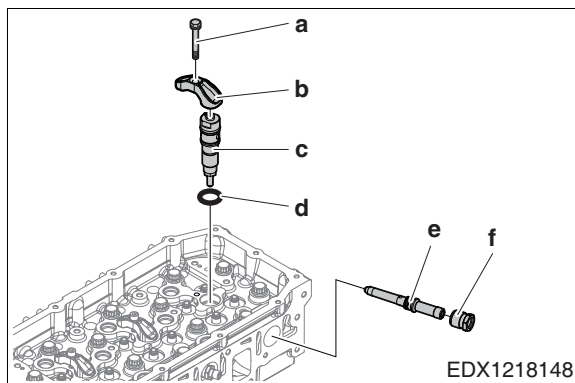


- Remove the pushrods.



### 6.1.29. Injector

- The O-rings on the injector (c) and high-pressure fuel connector (e) are always assembled; they do not require any extra assembly.



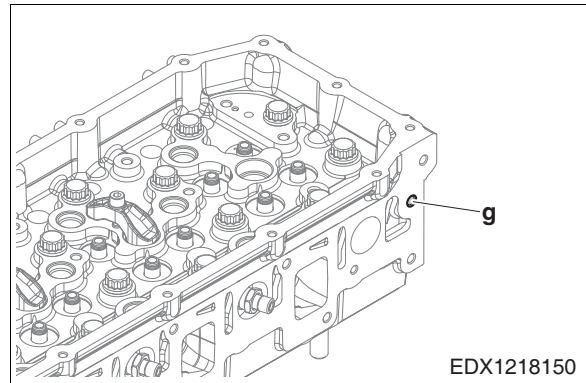
- Disconnect the in/out fuel hoses from the fuel tank and drain (g) the return fuel in the cylinder head.



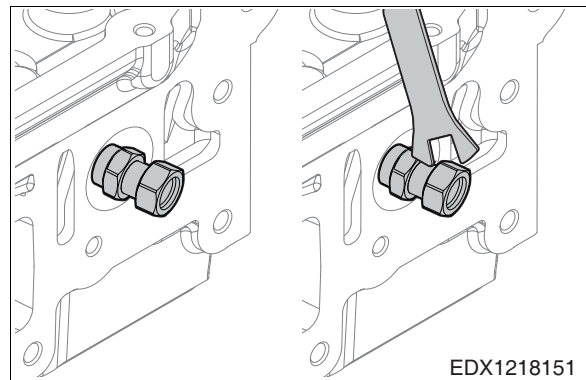
**CAUTION:**

Removing the injectors & high-pressure fuel connectors (HPC) without draining the return fuel in the cylinder head can cause return fuel to enter the combustion chamber, thereby producing white smoke or damaging the pistons.

- After removing the injection pipe, loosen the fixture bolt (a) and remove the fixture (b).
- Slightly loosen the high-pressure fuel connector nut (f) and reduce the tightening torque; then, loosen it by five turns.
- After tightening an M14x1.5P nut onto the injection pipe joint on the high-pressure fuel connector (e), use a spanner to unscrew it partially so that the high-pressure fuel connector O-ring detaches from the sealing surface of the cylinder head.
- Completely loosen the high-pressure fuel connector nut (f) and remove the high-pressure fuel connector from the cylinder head.



EDX1218150



EDX1218151



**CAUTION:**

Use a special tool (refer to the list of special tools) for assembling/removing injectors to remove the injector from the cylinder head.

- Check whether the injector sealing washer (d) is still on the hole in the cylinder head; if it is, use tweezers or a suitable tool to remove it.

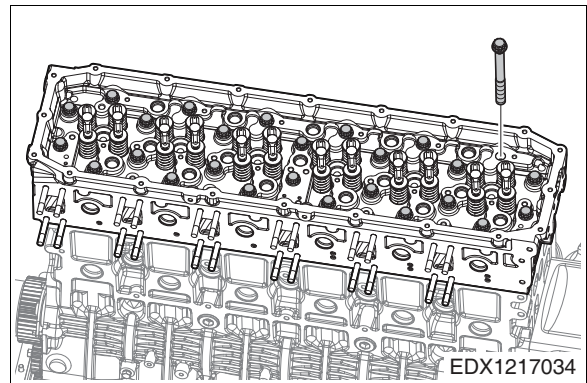


**CAUTION:**

Only remove an injector after the high-pressure fuel connector (HPC) has been removed completely.

### 6.1.30. Cylinder head

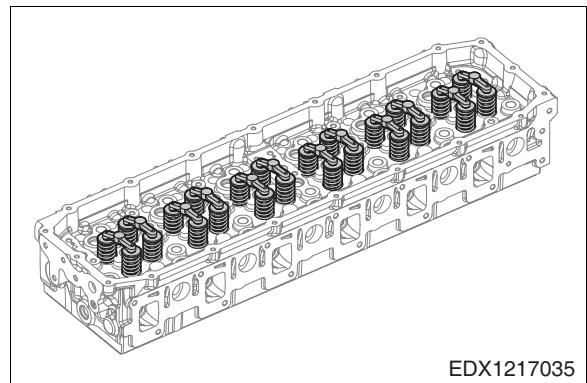
- Unscrew the cylinder head mounting bolts and remove the cylinder head.
- Remove the cylinder head gasket.



### 6.1.31. Valve and valve stem seal

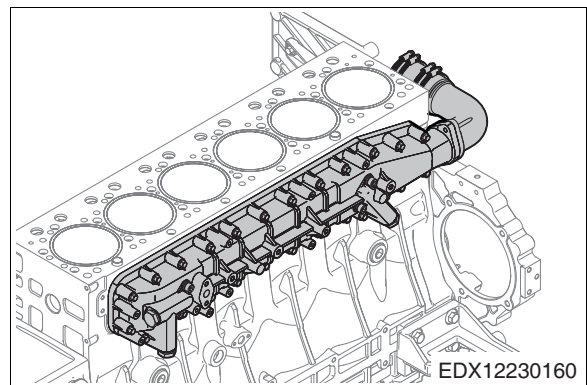


- Apply pressure to the valve spring retainers with a jig to remove the valve cotter pins.
- Remove the valve springs and retainers.
- Remove the valves.
- Use regular tools for removal. Dispose of the valve stem seals so that they cannot be reused.



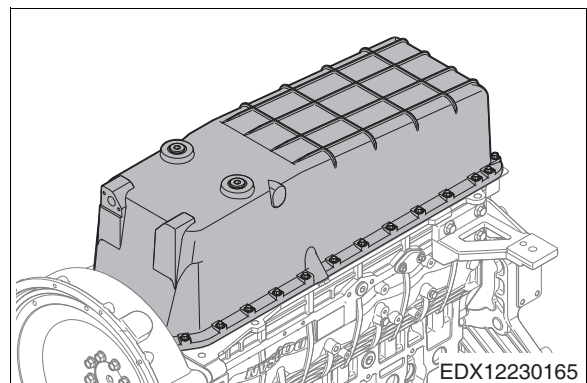
### 6.1.32. Oil cooler

- Remove the coolant pipe connected to the fresh water pump.
- Unscrew the oil cooler cover mounting bolts and remove the oil cooler assembly from the cylinder block.
- Unscrew the oil cooler mounting bolts and remove the oil cooler from the cover.



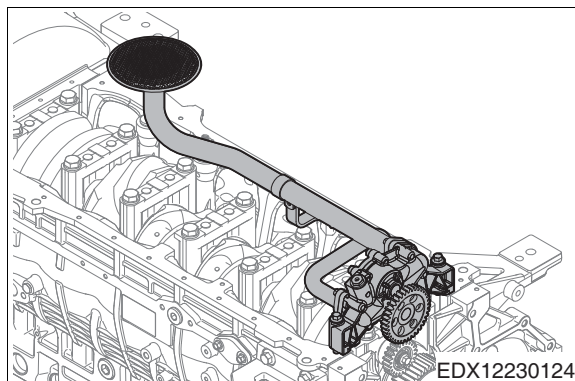
### 6.1.33. Oil pan

- Position the engine so that the flywheel faces the ground.
- Unscrew the oil pan mounting bolts to remove the oil pan and gasket.



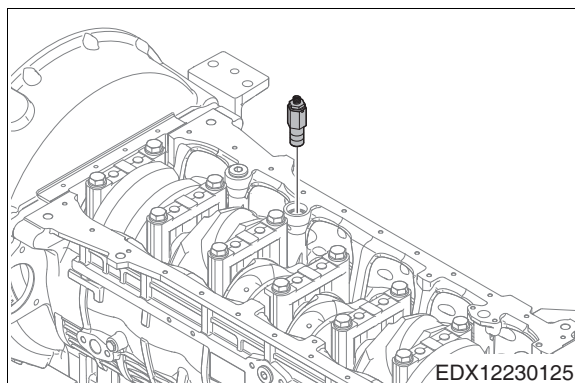
#### 6.1.34. Oil pump oil pipe

- Loosen the oil suction pipe mounting bracket and support bolts to remove the oil suction pipe assembly.
- Disconnect the oil pipe which supplies oil from the oil pump to the cylinder block.
- Unscrew the oil pump mounting bolts and remove the oil pump.



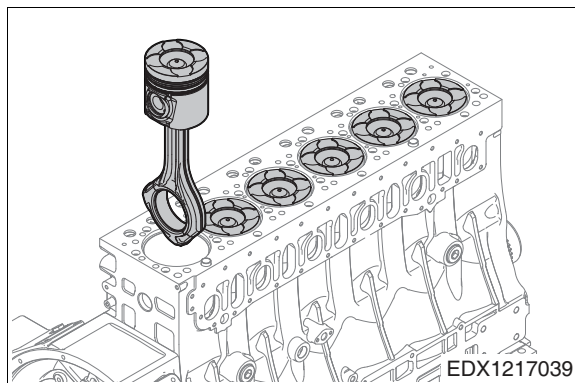
#### 6.1.35. Relief valve

- Remove the relief valve installed on the bottom of the cylinder block.

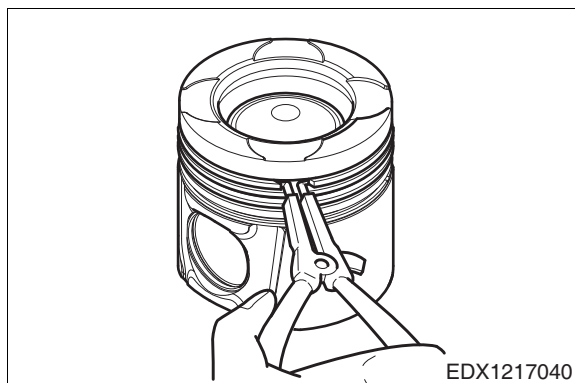


#### 6.1.36. Pistons and connecting rods

- Turn the crankshaft and remove the pistons two at a time.
- Unscrew the connecting rod bolts to remove the bearing caps, then disassemble the pistons and connecting rods in the direction of the pistons as shown in the picture.

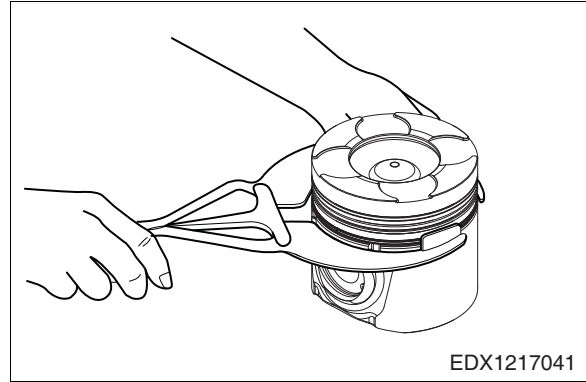


- Remove the piston pin snap rings to remove the piston pins, then remove the connecting rods and pistons.



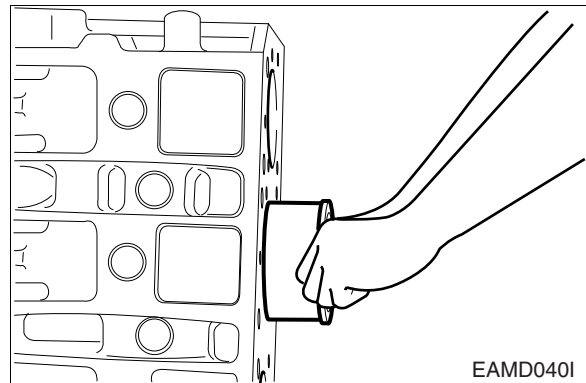


- Use ring pliers to remove the piston rings.
- Be careful not to mix up disassembled parts. Store the parts for each cylinder in order.



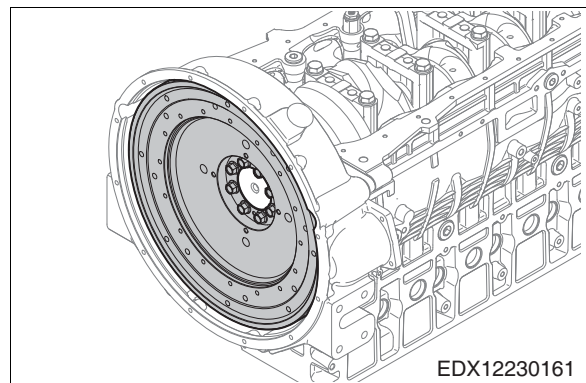
#### 6.1.37. Cylinder liner

- Using a wooden or plastic rod, push up on the bottom of the cylinder liner underneath the engine to lift it slightly and remove the cylinder liner.



#### 6.1.38. Flywheel

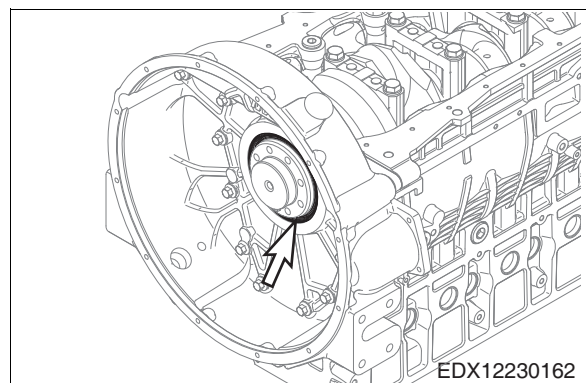
- Position the engine so that the head assembly surface on the cylinder block faces downwards.
- Install the flywheel removal stud bolts in the bolt holes drilled into the flywheel and remove the flywheel.



#### 6.1.39. Oil seal

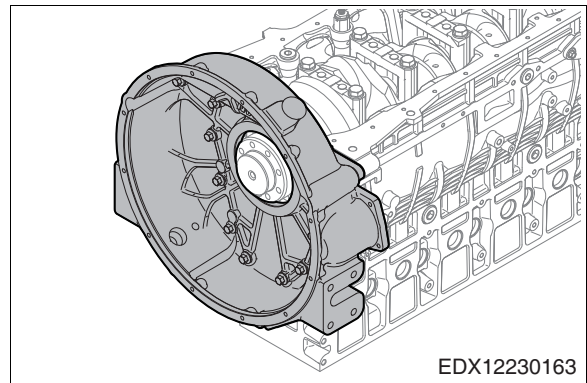


- Use an oil seal removal jig to remove the rear oil seal.



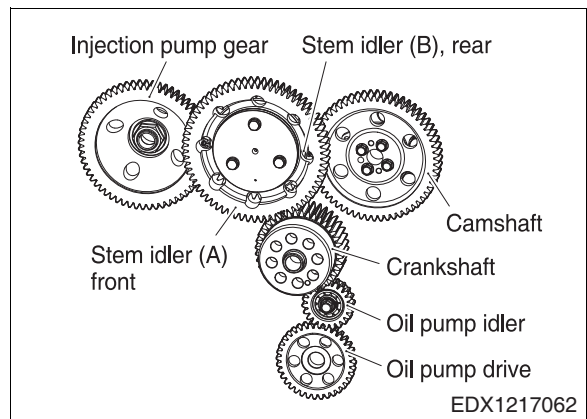
#### 6.1.40. Flywheel housing

- Unscrew the housing mounting bolts and remove the flywheel housing.



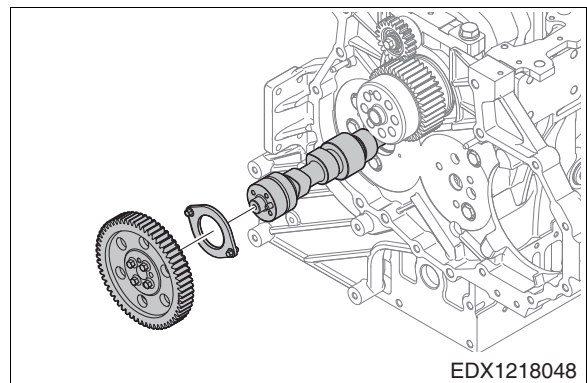
#### 6.1.41. Camshaft idler gear and cam gear

- Unscrew the idler gear mounting bolts and remove the idler gear pin.
- Remove the camshaft gear mounting bolts to remove the camshaft gear.



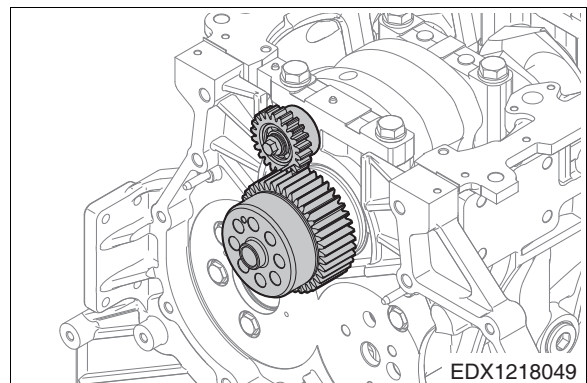
#### 6.1.42. Camshaft and tappet

- Remove the camshaft gear.
- Remove the camshaft gear thrust washer.
- Remove the camshaft while taking care not to damage it.
- Push the tappet out by hand.



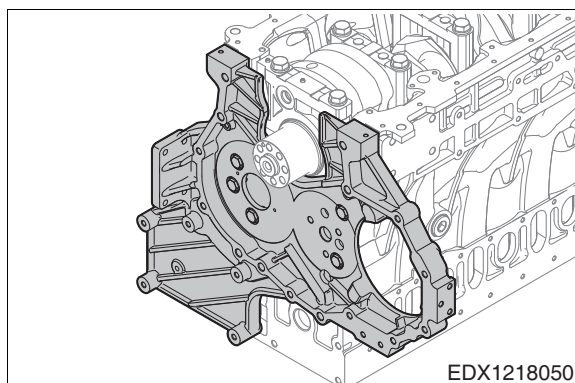
#### 6.1.43. Crankshaft gear and oil pump idler gear

- Unscrew the bolt and remove the oil pump idler gear.
- Use a puller to remove the crankshaft gear.



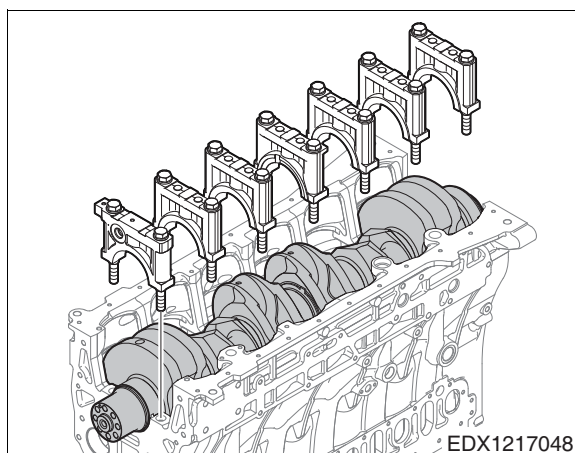
#### 6.1.44. Timing gear case

- Unscrew the case mounting bolts and remove the timing gear case.
- Tap the rear left and right sides on the contact surface of the timing gear case with a urethane hammer gently to remove the timing gear case.



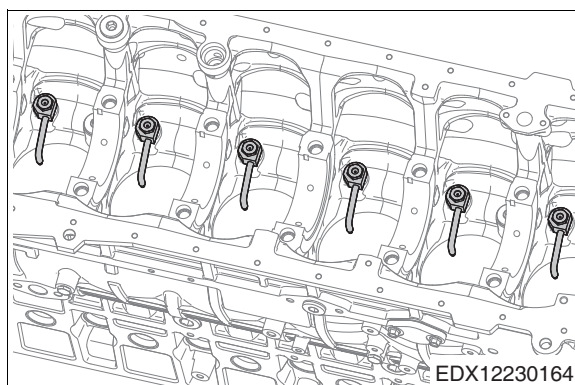
#### 6.1.45. Crankshaft

- Unscrew the main bearing cap mounting bolts to remove the bearing caps.
- Lift the crankshaft to remove it.
- Remove the main bearings.



#### 6.1.46. Oil injection nozzles

- Unscrew the oil spray nozzle mounting bolts on the inside of the cylinder block to remove the oil injection nozzles.



## 6.2. Checking the Main Components

### 6.2.1. Cylinder block



- 1) Clean the cylinder block thoroughly and check for any cracks or damage.
- 2) If it is severely cracked or damaged, replace it with a new one. Correct any minor damage.
- 3) Check the oil and coolant passages for clogging or corrosion.

Perform a test for cracks or gas leaks.

**Hydrostatic test :** Plug the various outlets (coolant and oil passages, etc.) in the cylinder block and apply approx. 4 kg/cm<sup>2</sup> of air pressure to the inlet. Then, submerge it in water for approx. one minute and check for air leaks. (Water temperature : 70°C)

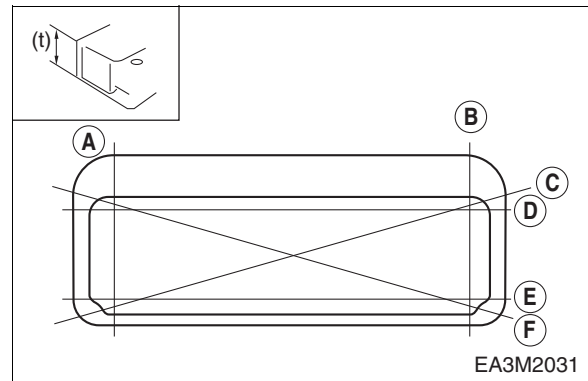
### 6.2.2. Cylinder head



- 1) Checking for cracks or damage
  - Using a non-metallic tool, remove any carbon residue from the bottom surface of the cylinder head.  
Be careful not to scratch the valve seat surface while doing so.
  - Perform a hydrostatic test or magnetic particle test to check for small cracks or damage that cannot be identified with the naked eye.



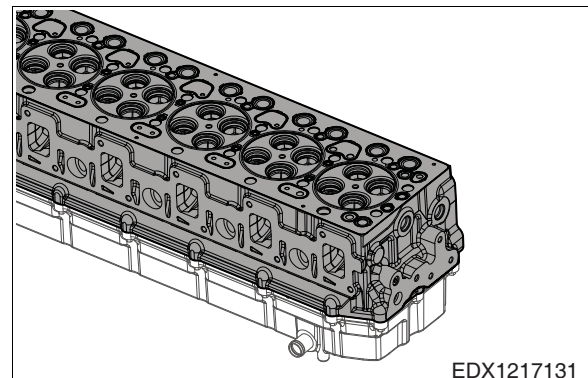
- 2) Checking the warpage of the bottom surface
  - Use a straightedge and feeler gauge to measure the warpage of the head in six directions as shown in the picture on the right.
  - If the measured value exceeds the standard value, use fine grinding paper or a fine surface grinder to correct it.
  - If the measured value exceeds the maximum allowable limit, replace the cylinder head.



<Deflection and thickness of the bottom of the cylinder head>

(mm)

	Standard	Limit
Deflection	0.2 or less	0.3
Thickness : t (Standard)	154.7 ~ 155.3	153.9





### 3) Flatness

Measure the flatness of the intake/exhaust manifold mounting surface on the cylinder head with a straightedge and feeler gauge.

<Measuring the deflection and thickness of the bottom of the cylinder head>

Standard	Limit
0.05 mm	0.2 mm



### 4) Hydrostatic test

Perform the hydrostatic test for the cylinder head in the same way as the test for the cylinder block.

## 6.2.3. Valve and valve guide

### 1) Replacing valves

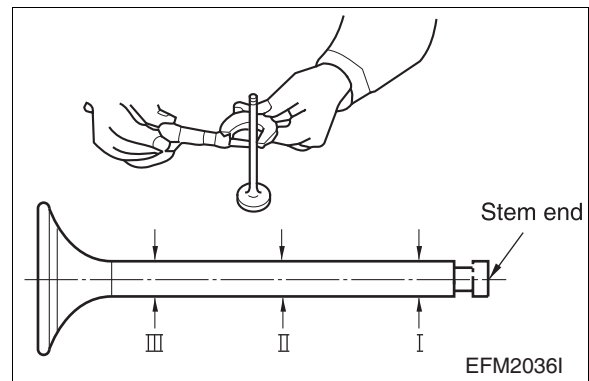


After cleaning the valve with diesel fuel, measure the outer diameter of the valve stem at the top, middle and bottom as shown in the picture to check for wear. Repair slightly damaged parts. Replace valves whose wear exceeds the limit.

<Valve stem O.D.>

(mm)

Dimensions Description	Standard	Limit
Intake valve stem	Ø7.963 - Ø7.977	Ø7.943
Exhaust valve stem	Ø7.950 - Ø7.964	Ø7.920



### ● Valve seat contact surface

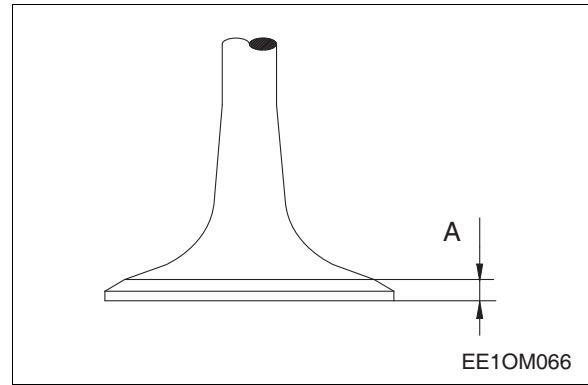
Check for scratches or wear on the valve seat contact surface and polish the contact surface with sandpaper if necessary. Replace if severely damaged.



- Valve head thickness  
Measure the thickness of the valve head and replace the valve if the measured value exceeds the limit.

(mm)

Dimensions Description	Standard	Limit
Intake valve	3.3 - 3.7	2.8
Exhaust valve	4.0 - 4.4	3.5



## 2) Valve guide

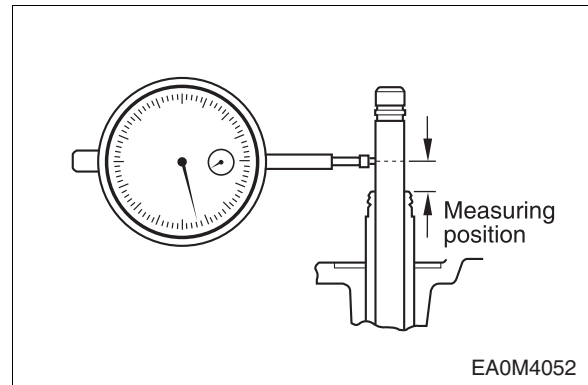
- Install the valve and valve guide and measure the clearance between the valve and valve guide resulting from valve movement. If the clearance is too great, measure the valve and replace either the valve or valve guide (whichever part is more severely worn).



<Valve stem end play>

(mm)

	Standard	Limit
Intake valve	0.023 - 0.052	0.10
Exhaust valve	0.036 - 0.065	0.15



- Assemble the valve with the cylinder head valve guide and use a special tool to measure whether the central line of the valve guide and valve seat is aligned.

## 3) Valve seat

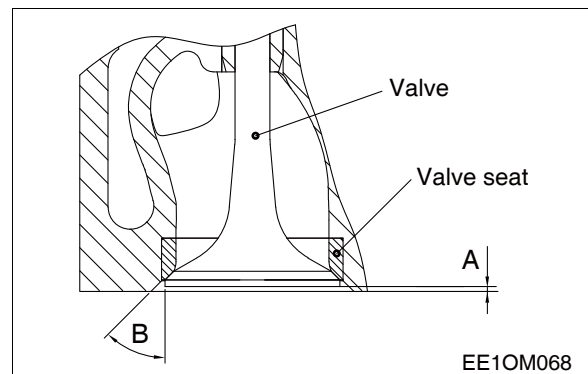


- Check the valve seat for wear or damage and replace if necessary.
- Assemble the valve with the cylinder head valve seat and use a measuring instrument on the bottom surface of the cylinder head to measure the projection of the valve. Replace the valve seat if the measured value exceeds the limit.

<Valve protrusion>

(mm)

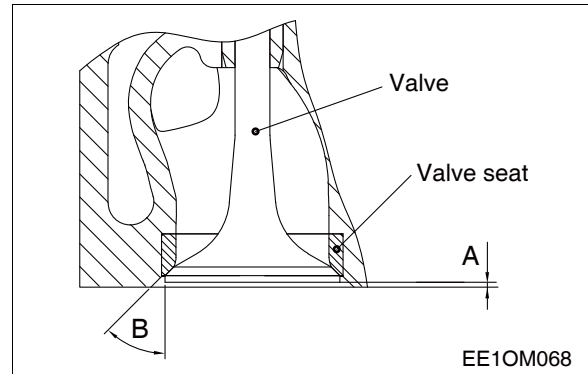
	Standard
Intake valve (A)	0.66 - 0.96
Exhaust valve (A)	0.60 - 0.90



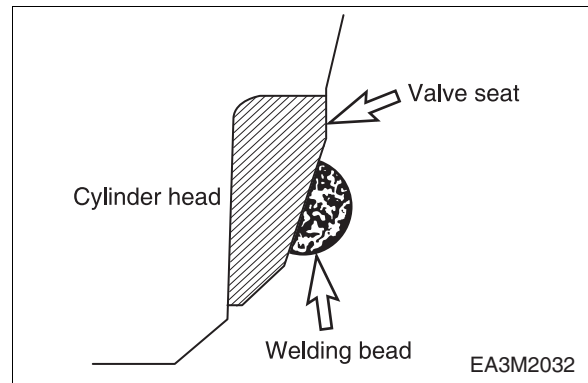
<Valve angle>

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

- When removing the valve seat, weld beads onto the seat inserted into the head and use a special tool to remove it.



- Cool and contract the valve seat in dry ice for around one hour. Then, use a special tool to insert it into the cylinder head. (The bore of the inner diameter requires drilling when replacing the valve seat)
- Spread an abrasive on the valve head contact surface of the valve seat and rotate the valve to polish it until it fits in place. Then, wipe off any abrasive remaining on the valve and head surface with oil.



Note :

When the valve seat has been prepared, use diesel fuel or an equivalent product to clean the valve and cylinder head and check for any abrasive remaining.

4) Valve Spring



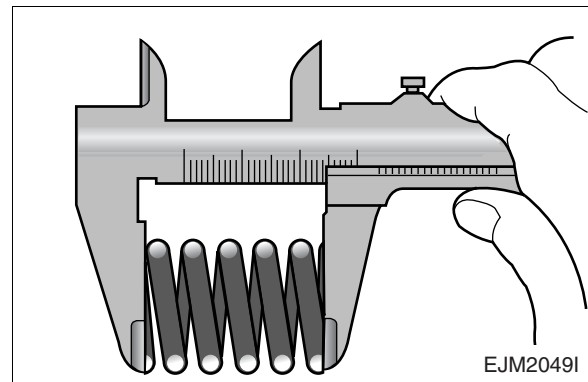
- Check the exterior for any scratches on the valve spring and replace the spring if necessary.



- Measure the free length and tension of the valve spring.

(mm)

		Free length
Intake valve	Inside	-
	Outside	62.5
Exhaust valve	Inside	-
	Outside	62.5



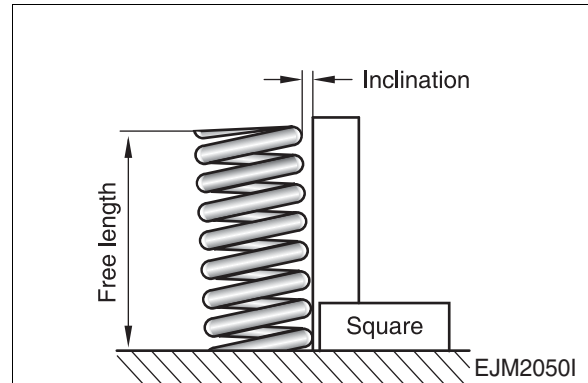
- Measure the squareness of the valve spring.
- Compare the measured value with the standard value.



- Valve spring squareness  
Use a surface plate and square to measure the squareness of the valve spring.  
If the measurement exceeds the allowable limit, replace the valve spring.

(mm)

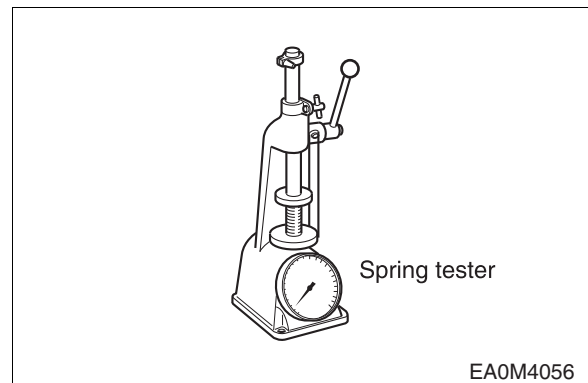
		Standard	Limit
Intake valve	Inside	-	-
	Out-side	1.6	2.0
Exhaust valve	Inside	-	-
	Out-side	1.6	2.0



- Measure the squareness of the valve spring.
- Compare the measured value with the standard value.

<Valve spring tension>

		Set length (P1/P2)	Spring force (P1/P2)	Limit (P1/P2)
Intake valve	Inside	44.0 mm/	39.4 kg/	±2.0 kg/
		31.6 mm	65.8 kg	±2.5 kg
Exhaust valve	Outside	44.0 mm/	39.4 kg/	±2.0 kg/
		31.6 mm	65.8 kg	±2.5 kg



#### 6.2.4. Rocker arm shaft assembly

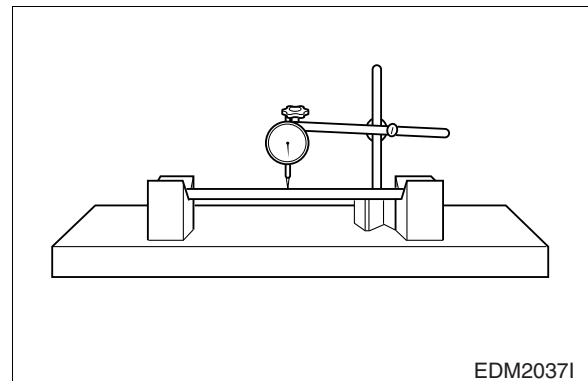
##### 1) Rocker arm shaft



- Rocker arm shaft runout  
Place the rocker arm shaft on two V-blocks and use a dial gauge to check whether the shaft is bent.  
If the runout value is small, apply pressure to the shaft with a bench press to correct the runout. Replace the shaft if the measured value exceeds the limit.

(mm)

Limit	0.2
-------	-----

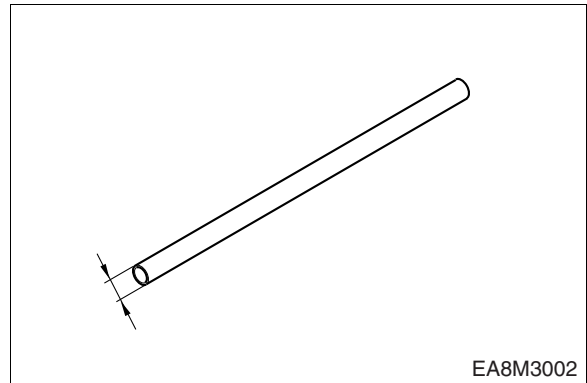




- **Rocker arm shaft diameter**  
Use an outside micrometer to measure the diameter of the rocker arm shaft at the place where the rocker arm is installed.  
Replace the rocker arm if the amount of wear exceeds the specified limit.

(mm)

Standard	Limit
Ø24.953 - Ø24.976	Ø24.916



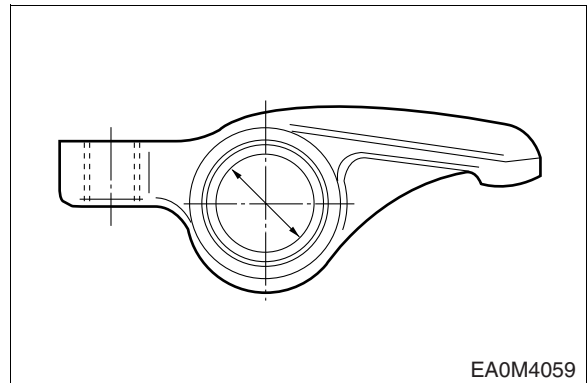
## 2) Rocker arm



- **Visual inspection**  
Perform a visual inspection for wear such as scratches or bumps on the surface of the rocker arm where it makes contact with the front end of the valve stem. If the wear is minimal, use fine sandpaper or an oil stone to correct it. Rocker arms with severe bumps must be replaced.



- **Rocker arm bushing diameter**  
Use an inside micrometer or vernier caliper to measure the inside diameter of the rocker arm bushing and compare the measured value with the diameter of the rocker arm shaft. If the clearance exceeds the limit, replace either the bushing or the shaft (whichever part is more severely worn).



<Clearance>

(mm)

Standard	Limit
0.015 - 0.059	0.12

### 3) Tappet and pushrod



#### ● Clearance

Measure the clearance between the tappet and tappet hole on the cylinder block. Replace the tappet if the value exceeds the specified limit.

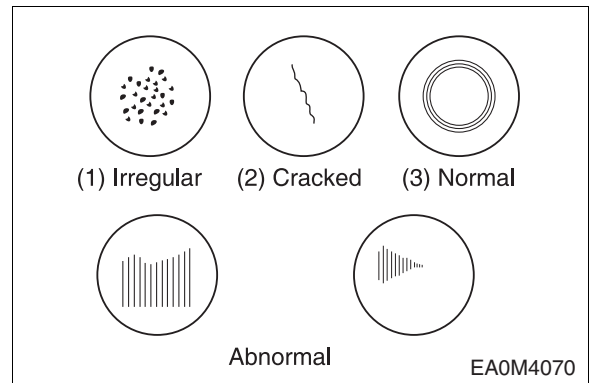
(mm)

Standard	Limit
0.035 - 0.077	0.15



#### ● Inspecting the tappet visually

Inspect the tappet surface in contact with the cam visually for pitting, scratches or cracks and replace if severely damaged. If the cracks or pitting are minor, use an oil stone or sandpaper to fix them.

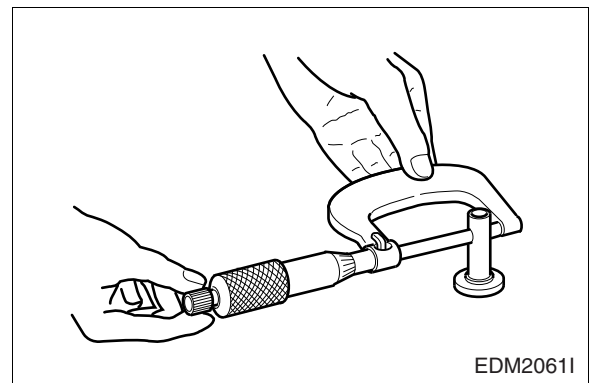


#### ● Tappet O.D.

Use an outside micrometer to measure the outside diameter of the tappet. Replace the tappet if the measured value exceeds the limit.

(mm)

Tappet diameter	Ø19.944 - Ø19.965
-----------------	-------------------



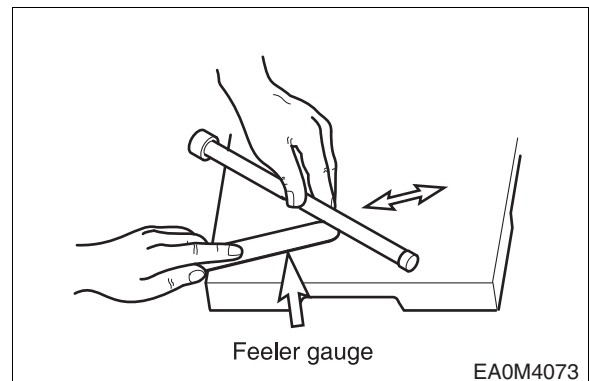
#### ● Pushrod runout

(mm)

Limit	0.3 or less
-------	-------------

Use a feeler gauge to measure the pushrod runout.

Roll the pushrod over a smooth surface as shown in the picture.



## 6.2.5. Camshaft

### 1) Cam



- Cam journal diameter and lobe height

(mm)

		Standard	Limit
Cam journal diameter (A, B)		Ø59.86 – Ø59.88	Ø59.56
Cam lobe height (C)	Intake	50.27	49.97
	Exhaust	50.30	50.00

Use a micrometer to measure the cam journal diameter. The camshaft must be replaced if the measured value is lower than the specified limit.



- Cam surface  
Use a micrometer to measure the cam journal diameter. The camshaft must be replaced if the measured value is lower than the specified limit. For minor layered wear or damage, use an oily grindstone or fine sandpaper to polish the surface. For severe damage, replace the cam.

### 2) Camshaft



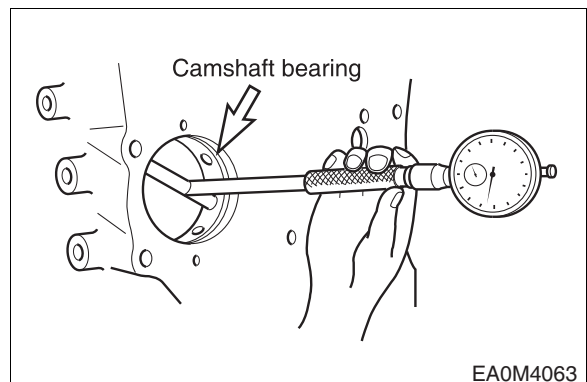
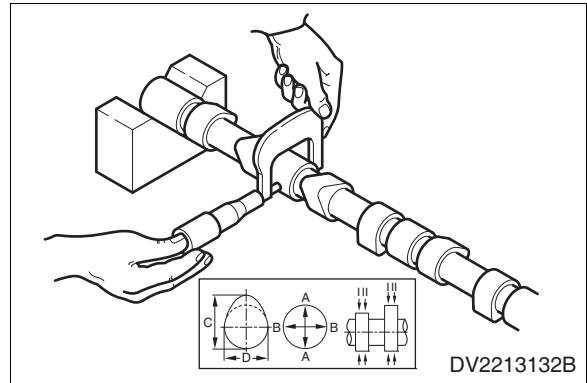
- Clearance between the camshaft journal and camshaft bushing
  - Use an outside micrometer to measure the camshaft journal diameter.
  - Use a cylinder bore indicator to measure the inside diameter of the cylinder block camshaft bushing. Then, compare the measured value with the camshaft O.D. to check the clearance.

<Clearance>

(mm)

Standard	Limit
0.045 - 0.100	0.2

Replace the bushing if the measured value exceeds the specified limit.

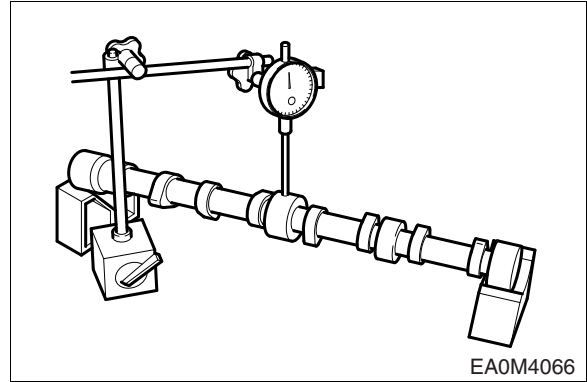




- Runout  
Support the camshaft on two V-blocks and use a dial indicator to check the runout. If the measured value indicates that the runout exceeds the limit and requires maintenance, fix or replace the camshaft.

(mm)

Standard	Limit
0.05	0.15



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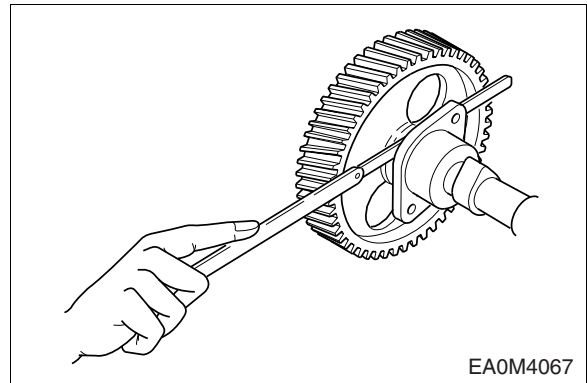
### 3) Camshaft and free play



- Push the thrust plate towards the cam gear.
- Use a feeler gauge to measure the clearance between the thrust plate and camshaft journal.
- If there is excessive end play, replace the thrust plate.

(mm)

Standard	Limit
0.14 - 0.25	0.5



EA0M4067

## 6.2.6. Crankshaft

### 1) Checking the exterior

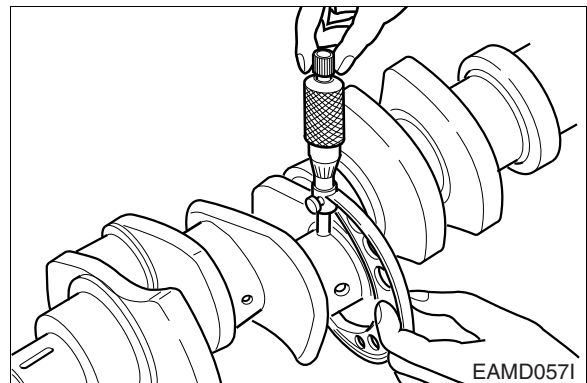


- Visually inspect the crankshaft journal and crankpin for scratches or damage.
- Perform a magnetic particle test or liquid penetrant test (color check) to check for cracks in the crankshaft. Replace if cracked.

### 2) Measuring crankshaft wear



- Using a micrometer, measure the crankshaft journal and pin O.D. in the direction shown in the picture to check the amount of wear.



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- If the wear amount exceeds the limit, polish the crankshaft and install an undersized bearing on it. However, if the wear does not exceed the limit, use an oil stone or fine sandpaper to correct the worn part and continue using it.  
(Make sure the fine sandpaper has been soaked in oil.)

(mm)

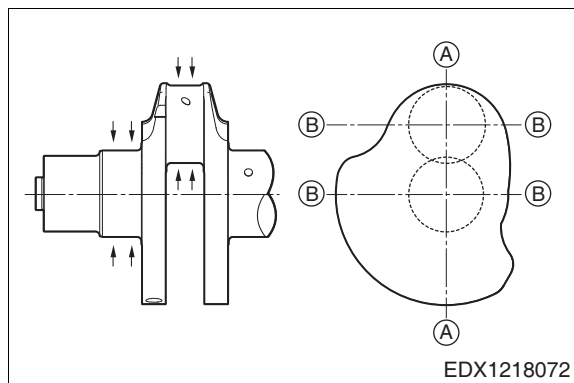
Item	Standard	Limit
Journal diameter	Ø95.966 - Ø95.988	Ø94.966
Pin diameter	Ø85.966 - Ø85.988	Ø81.966

### < Undersized bearings >

- Standard (STD)
- 0.25 (I.D. 0.25 mm smaller than standard)
- 0.50 (I.D. 0.50 mm smaller than standard)

Undersized bearings come in the two types above.

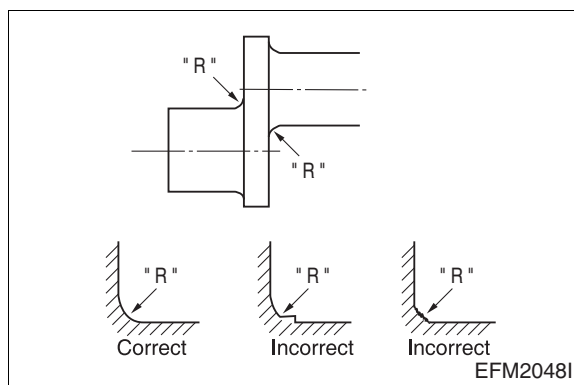
The crankshaft can be polished to the sizes above and reused.



### CAUTION

When polishing the crankshaft, the 'R' sections in the corners of the bearing must be polished precisely. Be sure to completely remove any bumps or rough spots.

- Standard "R" value
  - ① Crankpin "R" : 4.5
  - ② Crankshaft journal "R" : 4

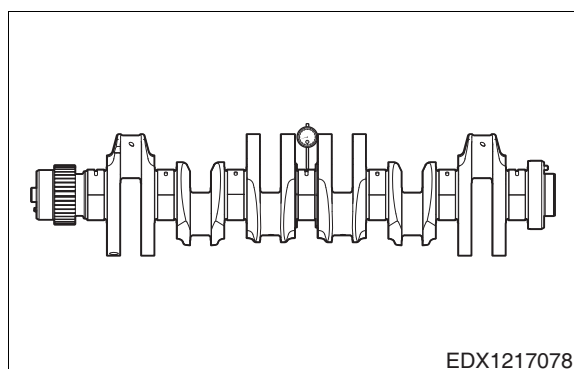


### 3) Crankshaft deflection



- Place the crankshaft on two V-blocks.
- Set a dial gauge on the surface plate and roll the crankshaft to measure its deflection.

No	Standard	Limit
4	0.1 mm	0.15 mm
3, 5	0.08 mm	0.12 mm
2, 6	0.05 mm	0.07 mm



## 6.2.7. Crankshaft bearings and connecting rod bearings

### 1) Inspecting the exterior



Check the crankshaft bearings and connecting rod bearings visually for uneven wear, scratches or damage.

### 2) Oil clearance between crankshaft and main bearing



#### ● Main bearing clearance

Install the main bearing on the cylinder block, tighten the bearing cap to the specified torque, and measure the inside diameter.



Torque	30 kg·m
--------	---------

Standard diameter	Ø96.06 - Ø96.108 mm
-------------------	---------------------

Compare the measured inside diameter of the main bearing with the outside diameter of the crankshaft journal to calculate the oil clearance between them.

#### < Main bearing oil clearance >

Standard	Limit
0.072 - 0.142 mm	0.200 mm



#### ● Connecting rod bearing clearance

Install the connecting rod bearing on the connecting rod bearing cap, tighten the bolt to the specified tightening torque, and measure the inside diameter.



Torque	8 kg·m + 60°
--------	--------------

Standard diameter	Ø86.036 - Ø86.084 mm
-------------------	----------------------

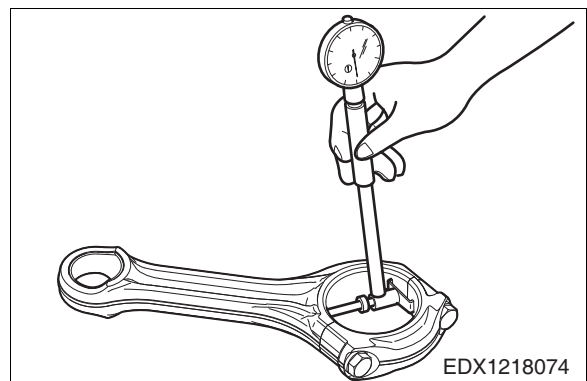
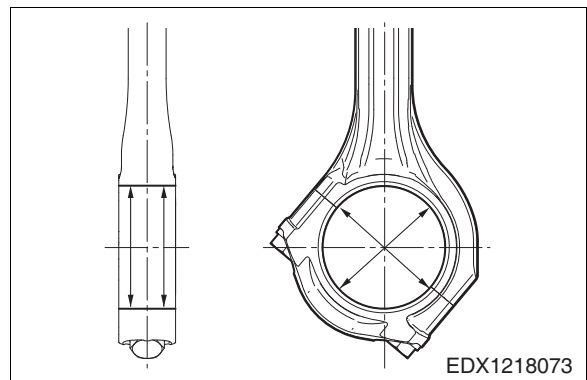
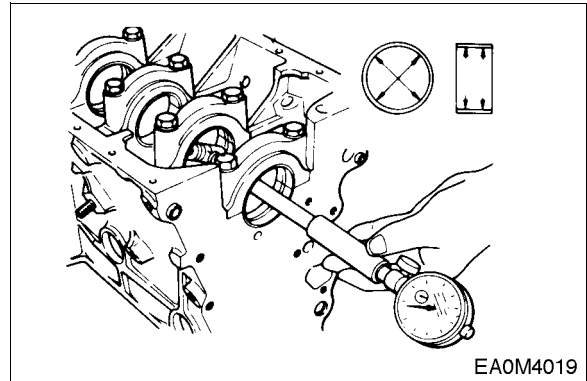
Compare the measured inside diameter of the connecting rod bearing with the outside diameter of the crankpin to calculate the oil clearance between the two parts.

#### <Connecting rod bearing oil clearance>

Standard	Limit
0.048 - 0.118 mm	0.180 mm



- If this clearance is not within the specified limit, polish the crankshaft journal and pin. Select and use an undersized bearing suited to the size of the polished crankshaft.

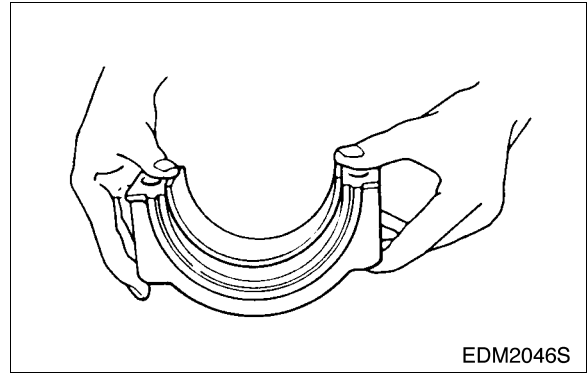


### 3) Bearing spread and crush

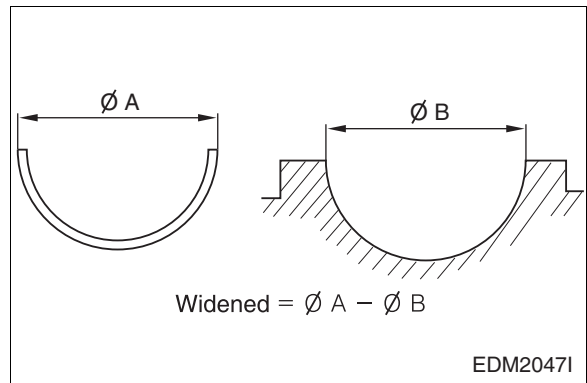


- Checking the exterior

When reassembling the bearing, check whether it needs to be pressed in firmly by hand (i.e. whether it is sufficiently flexible).



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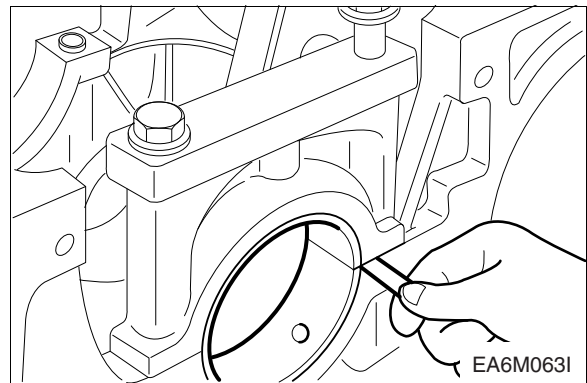


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- Crankshaft bearing crush

Install the bearing and cap on the cylinder head, tighten them to the specified torque, and unscrew the bolt on one side completely. Then, use a feeler gauge to measure the clearance between the cylinder block and bearing as shown in the picture.



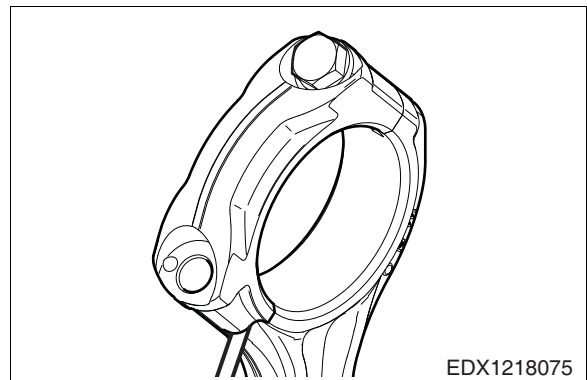
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Standard	0.16 - 0.24 mm
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- Connecting rod bearing crush

Install the bearing and cap on the connecting rod, tighten the bolts to the specified torque, and unscrew one of the bolts completely. Then, use a feeler gauge to measure the clearance between the bearing cap and connecting rod big end as shown in the picture.



EDX1218075

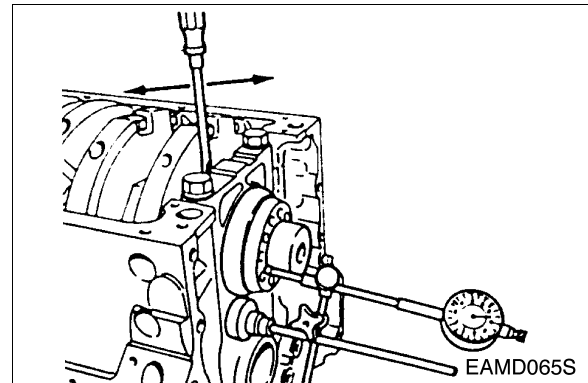
Standard	0.17 - 0.25 mm
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#### 4) Crankshaft end play

- Install the crankshaft in the cylinder block.
- Use a dial gauge to measure the crankshaft end play.



Standard	0.1 - 0.3 mm
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### 6.2.8. Pistons

#### 1) Inspecting the exterior



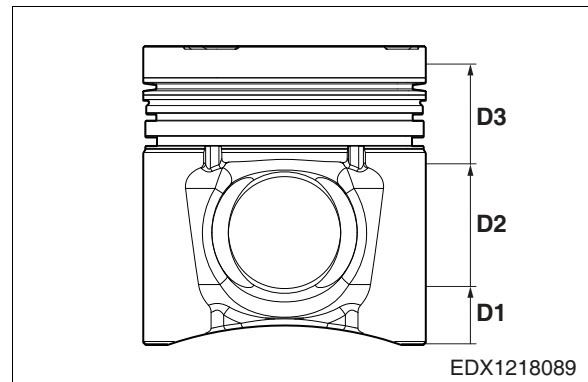
Visually inspect the pistons for wear, cracks or scratches, checking the piston ring grooves with particular care.

#### 2) Clearance between the piston and cylinder liner



- Use an outside micrometer at a right angle to the piston pin hole to measure the piston outside diameter in the places where the distance from the bottom part of the piston skirt is D1, D2 and D3.

Point	Standard diameter
D1 (25 mm)	$\varnothing 122.870 \pm 0.007$ mm
D2 (78.5 mm)	$\varnothing 122.696 \pm 0.009$ mm
D3 (122 mm)	$\varnothing 120.555 \pm 0.015$ mm



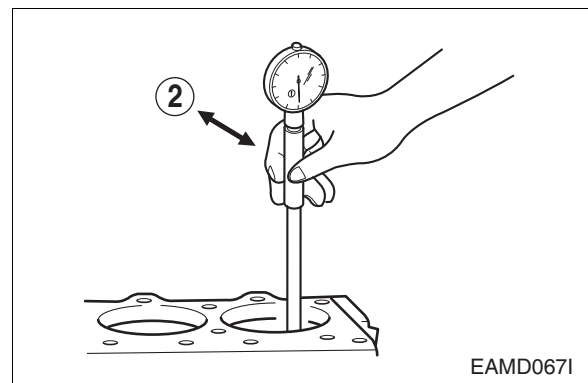
- Use a cylinder bore gauge to measure the inside diameter of the cylinder liner. Measure three places at 45° intervals: the top ring contact surface of the cylinder, the middle, and the bottom of the oil ring contact surface. Without the maximum and minimum values, calculate the average value with the remaining values.

Standard	Limit
$\varnothing 123 - \varnothing 123.025$ mm	$\varnothing 123.223$ mm

- Subtract the piston outside diameter from the cylinder liner inside diameter to calculate the clearance. If this value exceeds the limit, replace either the piston or the cylinder liner (whichever is more worn).

<Clearance between the piston and liner>

Standard	0.123 - 0.162 mm
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### 6.2.9. Piston ring



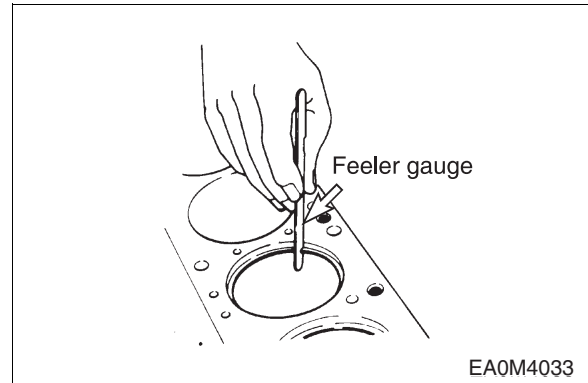
- 1) Inspecting the exterior  
If the piston ring is worn or damaged when disassembling the engine, replace it with a new one.



- 2) Piston ring clearance
  - Insert the piston ring into the top of the cylinder liner so that it is set at a right angle to the liner wall.
  - Use a feeler gauge to measure the piston ring clearance.
  - If the clearance exceeds the limit, replace the piston ring.

(mm)

Dimensions Description	Standard	Limit
Top ring	0.3 - 0.45	0.7
Second ring	1.0 - 1.2	1.45
Oil ring	0.3 - 0.45	0.7



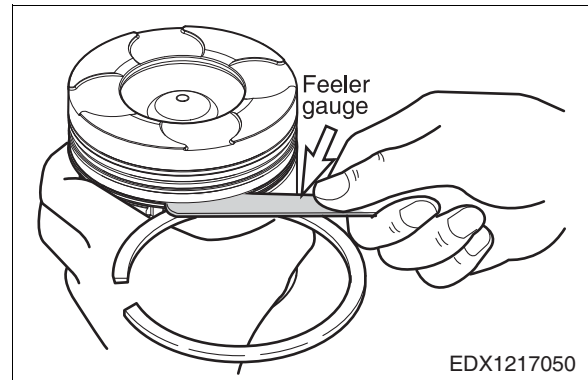
- 3) Piston ring groove clearance



- Install the compression ring and oil ring in the ring groove of the piston.
- Use a feeler gauge to measure the clearance between each ring and the width of the groove. If the measured value exceeds the limit, replace the ring or piston.

(mm)

Dimensions Description	Standard	Limit
Top ring	-	-
Second ring	Ø0.07 - Ø0.105	Ø0.125
Oil ring	Ø0.05 - Ø0.09	Ø0.11



- 4) Piston ring tension



- Use a tension tester to measure the tension of the piston ring. If the value exceeds the limit, replace the piston ring.

Item	Standard
Top ring	2.4 - 3.5 kg
Second ring	2.0 - 2.9 kg
Oil ring	6.3 - 7.7 kg

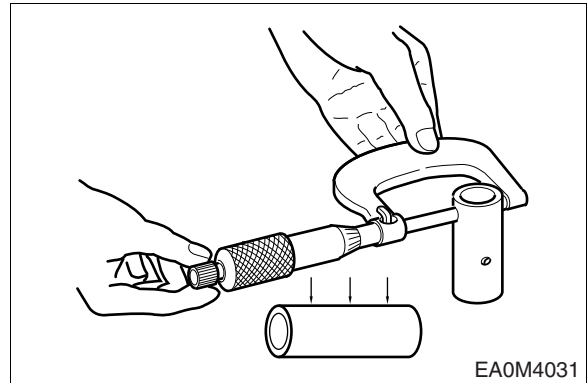
### 6.2.10. Piston pins

#### 1) Wear



Check the wear on the piston pins in the places shown in the picture. If this measured value exceeds the usable limit (0.005 mm or higher), replace the pin.

Standard	Limit
Ø48.995 - Ø49.000 mm	Ø48.990 mm or less

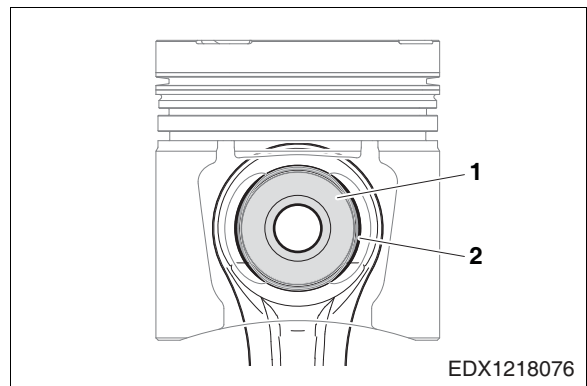


#### 2) Clearance



Measure the clearance between the piston pin (1) and connecting rod bushing (2). If this value exceeds the usable limit, replace whichever part is more worn.

Standard	Limit
0.050 ~ 0.080 mm	0.12 mm



#### 3) Inspecting the assembly



The piston is normal if the piston pin can be inserted into the pin hole after heating the piston with a piston heater.



When replacing the piston, the piston pin must also be replaced.

### 6.2.11. Connecting rods

#### 1) Distortion



Install the connecting rod on the connecting rod tester as shown in the picture. Then, use a feeler gauge to measure the distortion.

If the connecting rod is distorted, do not attempt to correct and reuse it. Be sure to replace it with a new one.

#### 2) Hole alignment (parallelism)



Check the parallelism of the piston ring bushing hole at the small end and the bearing groove at the big end of the connecting rod. Install it on a connecting rod tester and measure it with a feeler gauge as described above.

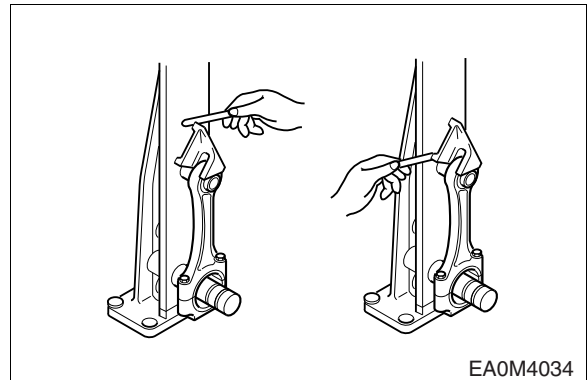
Standard	Limit
0.1875 mm	0.2 mm or less

#### 3) Wear



- Install the connecting rod on the crankshaft and use a feeler gauge to measure the clearance between the parts at the big end of the connecting rod.
- Install the piston ring on the connecting rod and measure the clearance between the parts at the small end of the connecting rod.
- If the measured value exceeds the limit, replace the connecting rod.

Limit	0.011 mm
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## 6.3. Reassembling the Engine

### 6.3.1. General precautions

- Clean all disassembled parts thoroughly. In particular, clean the inside of oil and coolant passages thoroughly using compressed air and check for any foreign matter.
- Arrange the various special and regular tools for assembly in order of engine assembly.
- Prepare clean engine oil to be applied to each sliding section.
- Prepare replacement parts for consumables such as sealant and gaskets.
- Discard all used gaskets, seal rings and consumables. Replace them with new ones.
- Tighten the various bolts to the specified tightening torque according to the tightening order. Never overtighten bolts.
- After reassembly, check to ensure that all sliding parts are working smoothly.
- After assembly is completely, be sure to check whether any bolts are loose or insufficiently tightened.
- After completely assembling the engine, check for any missing or faulty parts.
- All work must be performed with clean hands.

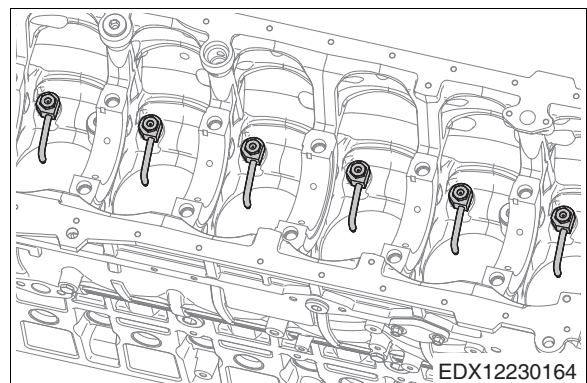
### 6.3.2. Cylinder block

- Lay wooden boards or thick cardboard on the ground so as not to damage the cylinder head assembly surface. Then, place the cylinder block on them with the head mounting surface facing the ground.

### 6.3.3. Oil injection nozzles



- Use an injection nozzle assembly jig to tighten and assemble the oil injection nozzle flanges with mounting bolts.



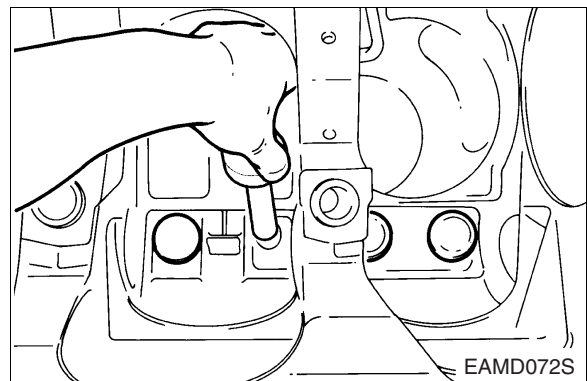
### 6.3.4. Tappets and camshaft



- Cool the new camshaft bushing in dry ice for approx. two hours. Then, use a bench press to press-fit it into the cylinder block. After press-fitting the bushing, measure the inside diameter to check for any deformation.



- Apply oil to the front of the tappets and insert them into the tappet holes on the cylinder block.

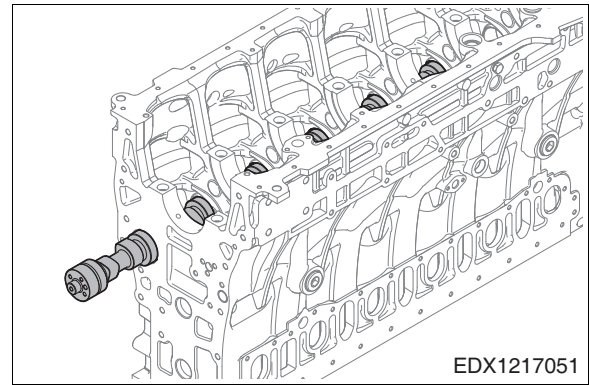




- Apply oil to the inside diameter of the cam bushing and camshaft, then assemble these parts carefully while turning the camshaft.



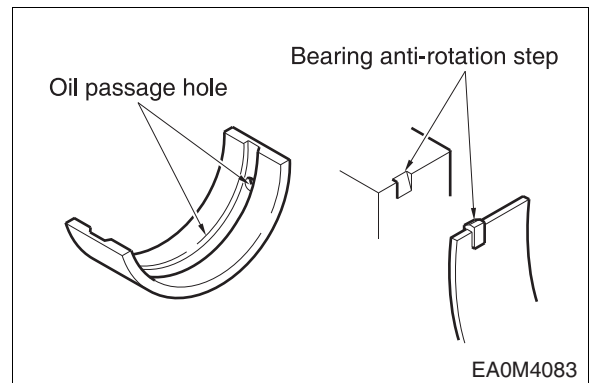
- Check whether the camshaft rotates smoothly.



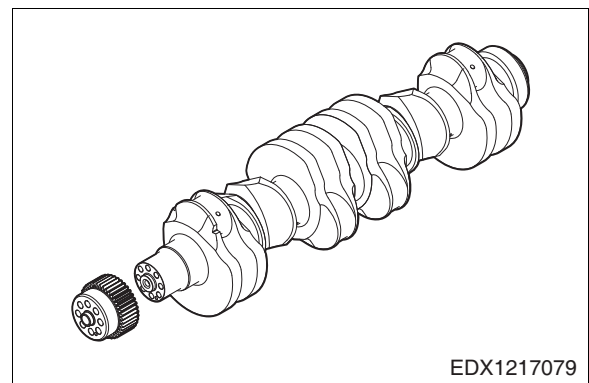
### 6.3.5. Crankshaft



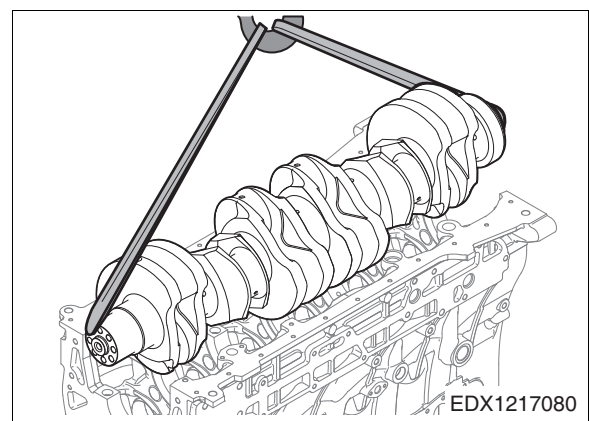
- Assemble the main bearings, aligning the key groove of the cylinder block and the key groove of the bearing with the two main bearing holes drilled into the cylinder block. Then, apply oil to the bearing surface.



- Before assembling the crankshaft, heat the crankshaft gear at 120°C for 10 minutes. Then, apply an even layer of sealant (Loctite #641) to the inside of the gear and assemble it.

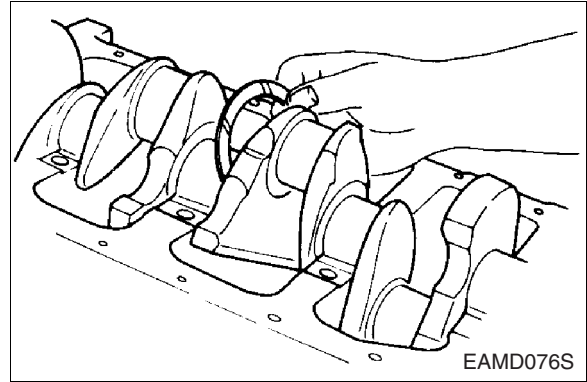


- Temporarily assemble one bolt at a time on both ends of the crankshaft, raise the crankshaft, and apply oil to the journal and pin. Then, assemble it with the cylinder block.

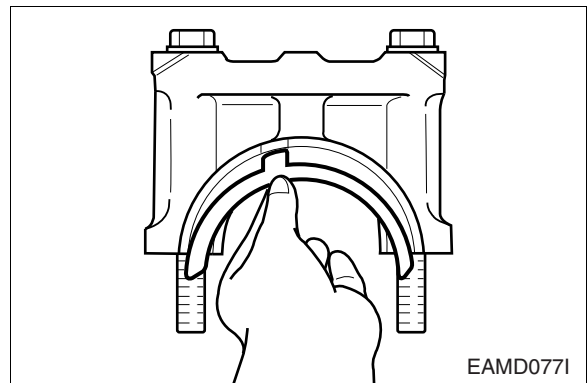




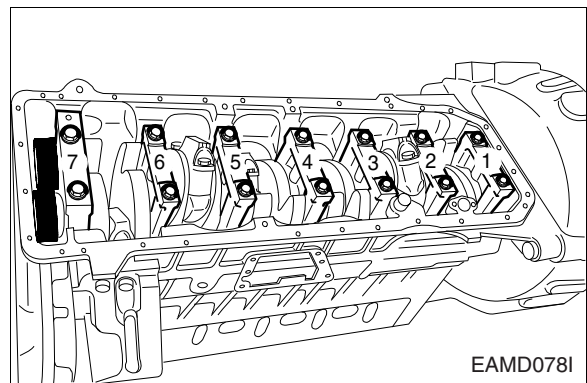
- Assemble the oil-coated thrust washers so that the oil groove in the washers faces the opposite side of the bearings as shown in the picture.



- Assemble the bearings and thrust washers with the bearing caps, then apply oil.



- Install the bearing caps, aligning the numbers on the bearing caps with the numbers engraved on the cylinder block.



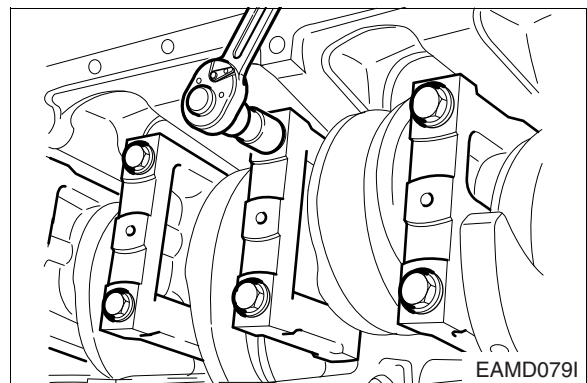
- Apply oil to the front of the bearing cap bolts and tighten them to the specified torque according to the tightening order.



Torque	30 kg·m
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- After temporarily tightening the bolts on both sides of the bearing caps evenly, tighten the bearing cap bolts sequentially in a diagonal line to approx. 15 kg·m first. Then, tighten them to 25 kg·m, and finally, tighten each bolt to the specified tightening torque of 30 kg·m.



- Tighten the bearing caps in the order 4-3-5-2-6-1-7.



- After tightening the bearing cap bolts, check whether the crankshaft rotates smoothly.

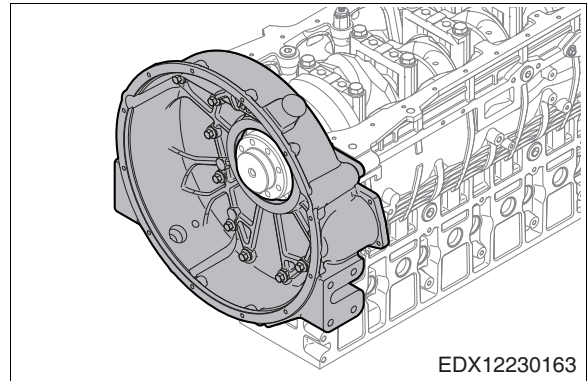
### 6.3.6. Flywheel housing

- Temporarily install the support rod on the cylinder block for removing the housing.
- Install the gasket on the cylinder block.



- Use the offset pin and support rod to attach the flywheel housing. Then, tighten the diagonal row of mounting bolts to the specified tightening torque in order.

Torque	12 kg·m
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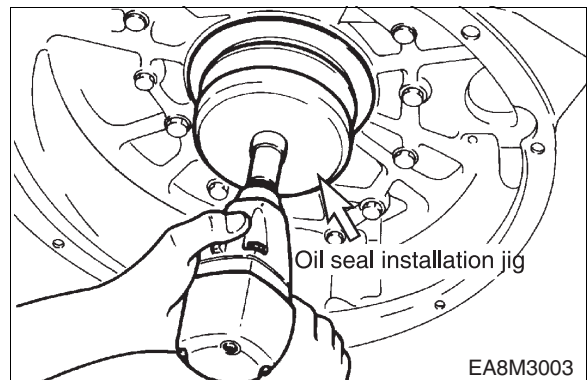
### 6.3.7. Rear oil seal



- Apply oil to the outer surface of the oil seal and the inside diameter of the flywheel housing. Then, assemble them with the crankshaft and use an assembly jig to assemble the oil seal.



- Apply oil to the outer surface of the oil seal and the inside diameter of the flywheel housing. Then, assemble them with the crankshaft and use an assembly jig to assemble the oil seal.



### 6.3.8. Flywheel



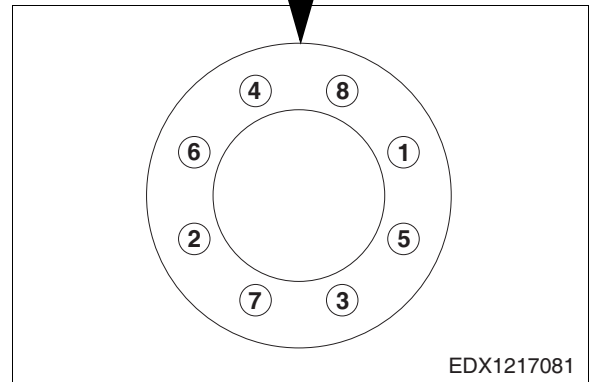
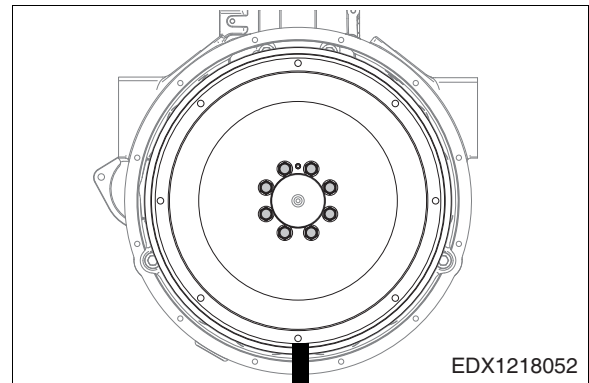
- Install a support rod in a crankshaft bolt hole, then lift the flywheel to align it with the offset pin and assemble it temporarily.

- After assembling a bolt in a bolt hole without the support rod installed, remove the support rod and assemble the remaining bolts in these holes.



- Use a torque wrench to tighten the bolts sequentially to the specified torque in a diagonal line.

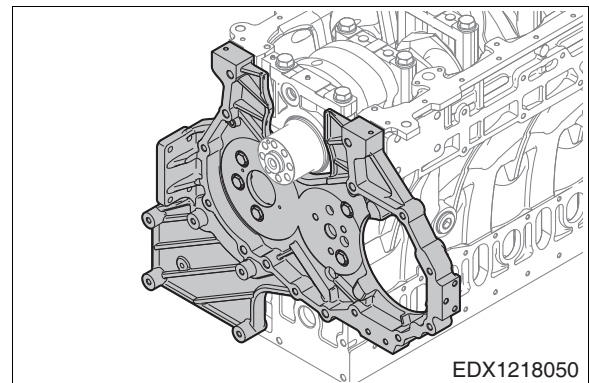
Torque	18 - 22 kg·m
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### 6.3.9. Timing gear case



- Use parallel pins to mount the gasket on the cylinder block.
- Align the dowel pins with the dowel pin holes in the timing gear case and install the timing gear case.
- Tighten the bolts to the specified torque.



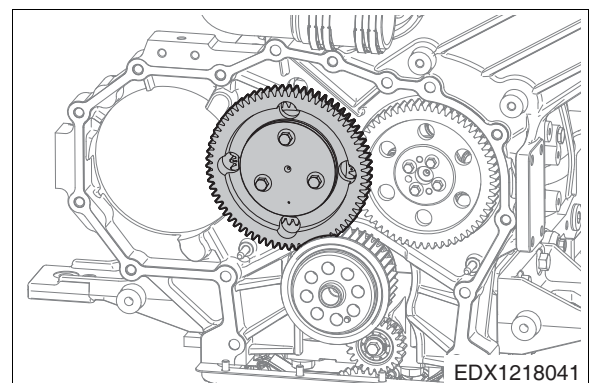
### 6.3.10. Timing gear

- Install the oil pump idler gear in bearing cap no.1.



- Install the thrust washers on the camshaft, then assemble the cam gears, aligning them with the camshaft key groove.

Camshaft thrust washers	0.9 kg·m
Camshaft gear mounting bolts	3.1 kg·m



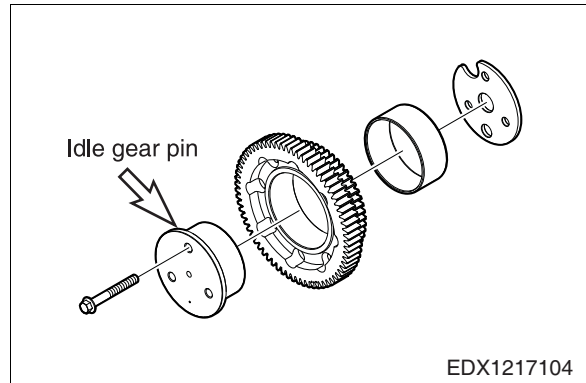


- Install the idler gear pin so that the oil port on the idler pin faces the cylinder block.



- Assemble the idler gear while aligning the engravings on the crank gear, cam gear, fuel injection pump driving gear and idler gear.

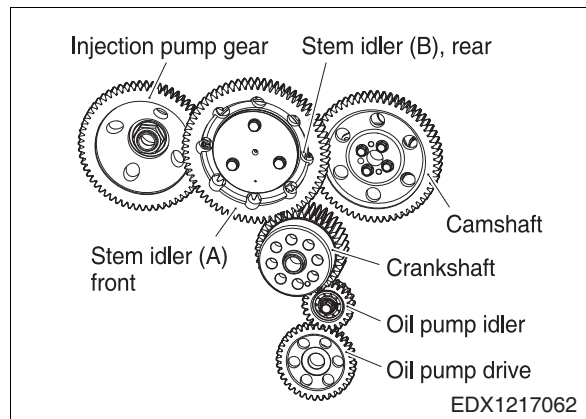
Idler gear pin mounting bolts	6.2 kg·m
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- Use a feeler gauge to check and adjust the amount of backlash between gears.

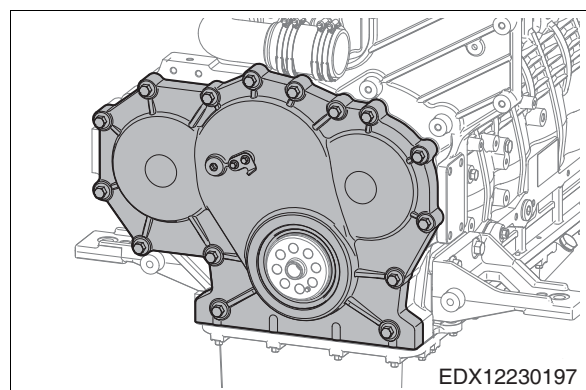
(mm)

Measuring location (between)	Backlash
Crank gear and oil pump idler gear	0.060 - 0.184
Oil pump idler gear and oil pump gear	0.020 - 0.292
Crank gear and idler gear A	0.062 - 0.194
Idler gear B and camshaft gear	0.090 - 0.236
Idler gear B and fuel injection pump gear	0.090 - 0.236



### 6.3.11. Timing gear case cover

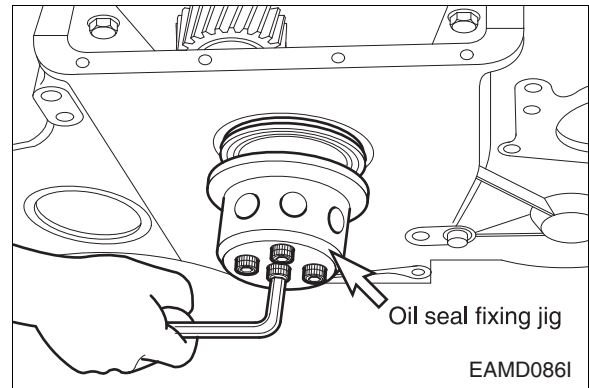
- Install the parallel pins on top of the timing gear case.
- Mount the gasket while aligning the mounting bolt holes and gasket holes.
- After aligning the cover pin holes with the parallel pins, tap the cover lightly to install it.
- Tighten the mounting bolts starting from the oil pan mounting surface.



### 6.3.12. Front oil seal

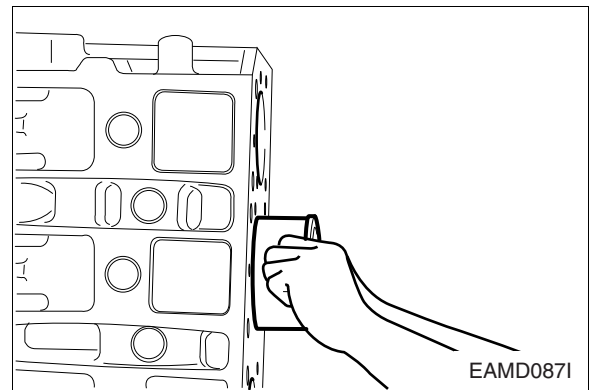


- Apply oil to the outer surface of the oil seal and the inside diameter of the timing gear case. Insert them into the top of the crankshaft to assemble them, then use an oil seal assembly jig to assemble the oil seal.



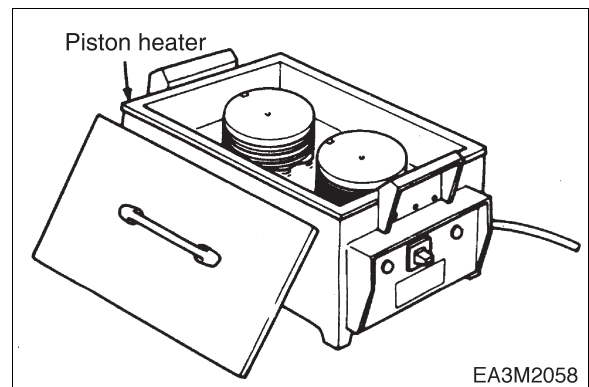
### 6.3.13. Cylinder liner

- Position the cylinder block so that the flywheel surface faces downwards.
- Use compressed air to thoroughly clean the inside of the hole on the cylinder block and the liner flange assembly surface with which the liner will be assembled.
- After cleaning and drying the liner, insert it into the cylinder block by hand.
- Apply engine oil to the inside surface of the assembled liner.

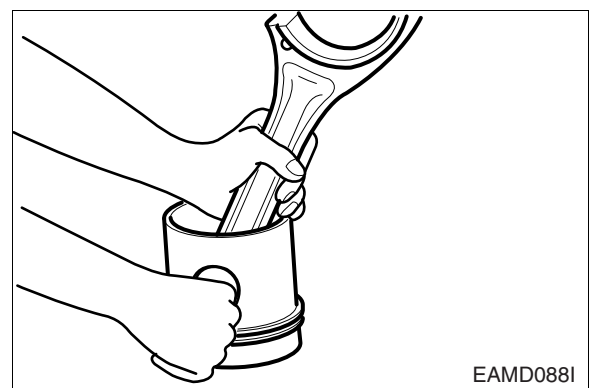


### 6.3.14. Pistons and connecting rods

- Heat the piston in a heater to approx. 100°C for five minutes.

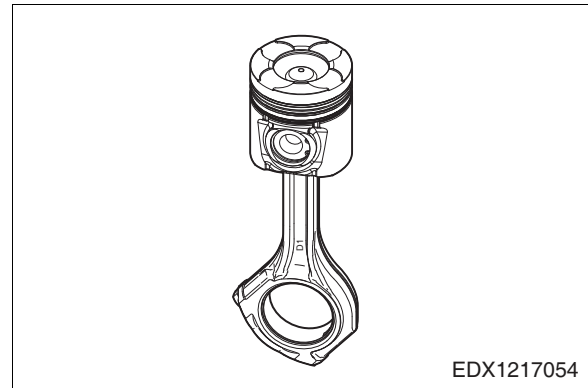


- Align the oil-coated small end bushing of the connecting rod with the piston pin hole, then tap the piston pin lightly with a rubber hammer to assemble the connecting rod and piston.





- Assemble the longer part of the connecting rod big end (the part with the groove in the bearing key) with the HD Hyundai Infracore logo engraved on the inside of the piston so that they face the opposite directions, taking care not to change the direction of the piston. As shown in the picture, the valve seat surface on the piston head should face the opposite direction of the longer part of the connecting rod. When seen from the top of the piston, it should face the same direction as the narrow clearance part of the combustion chamber.



- Install the snap ring, making sure to check that it has been installed properly.



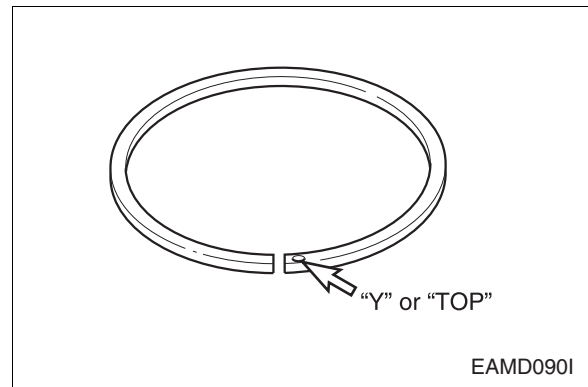
- Use piston ring assembly pliers to install the piston ring on the piston.



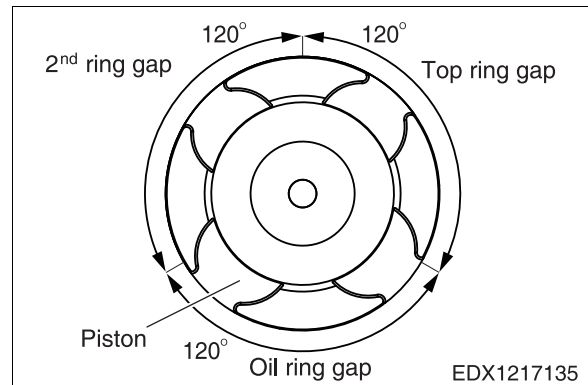
- Check the "Y" or "TOP" marking at the end of the ring to make sure that the direction of the piston ring is not switched around.



It must be installed so that the marking faces upwards.

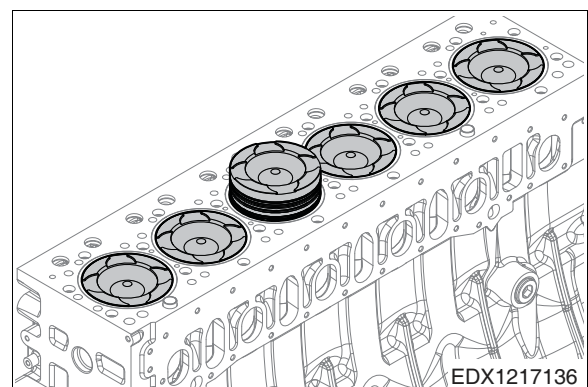


- Adjust the angle between each piston ring gap to 90°, then fit the piston into the piston assembly jig. When doing so, take care to ensure that the positions of the piston ring gaps do not align with the direction of the pins.



- Assemble the bearing, aligning it with the connecting rod key groove, then apply oil to the assembled bearing and piston.

- Push the piston in by hand, ensuring that the valve seat surface faces the tappet hole. Take care not to damage the cylinder liner and piston. Lift them slightly while inserting them in order to avoid damaging the ring on the raised part of the liner in particular.





- Assemble the bearing with the connecting rod cap and apply oil to it.



- Check whether the numbers engraved on the connecting rod cap and the side of the big end are identical. Then, install the connecting rod cap, aligning it with the offset pin.

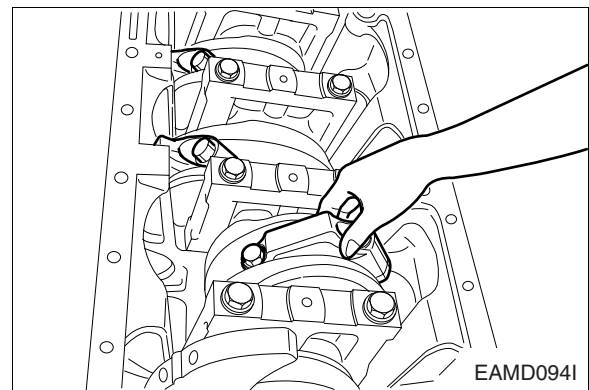
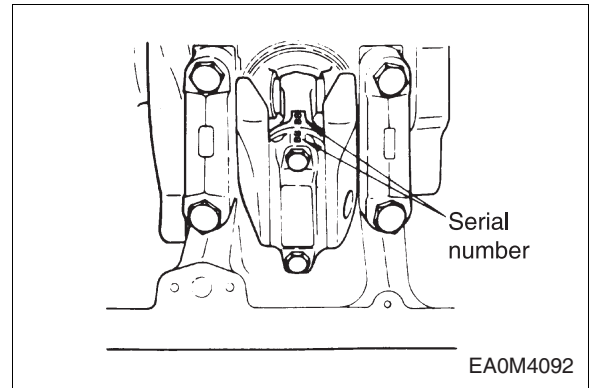


- After tightening the mounting bolts by hand, tighten them each to 15 kg·m initially and then to 22 kg·m. Finally, tighten them to the specified torque.

Torque	28 kg·m
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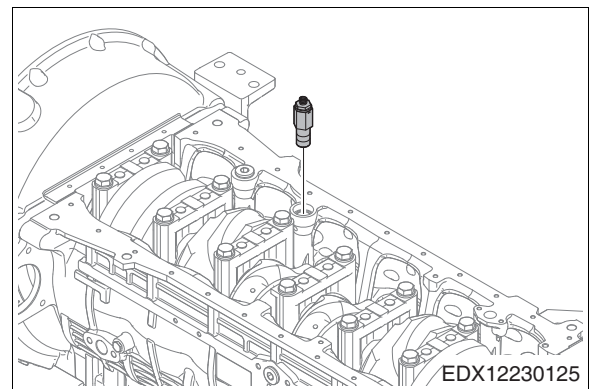


- Try moving the bearing cap by hand. If it is immobile, unscrew the mounting bolts and reassemble them.



### 6.3.15. Relief valve

- Assemble the relief valve.



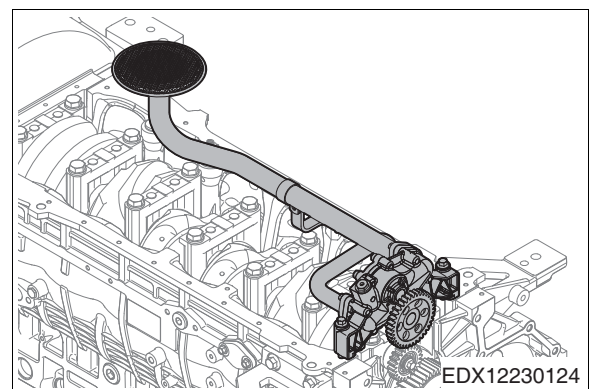
### 6.3.16. Oil pump and oil pipe



- Assemble the offset pin with bearing cap no.7. Then, tighten the oil pump to the specified torque.

Torque	4.4 kg·m
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- Connect the oil suction pipe and supply pipe. Then, assemble the support bracket with the bearing cap.

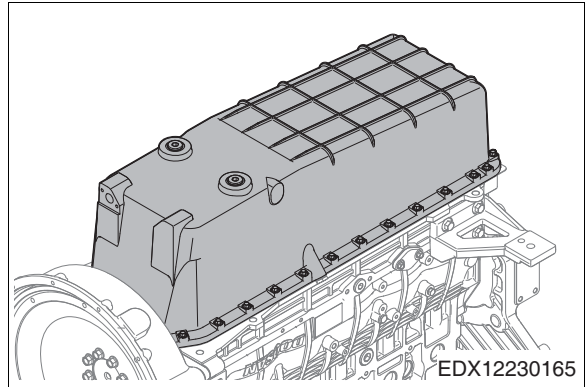


### 6.3.17. Oil pan

- Install the gasket and place the oil pan on top of it.
- Align the bolt holes and gasket holes without damaging the gasket. Then, tighten the bolts to the specified tightening torque.



Torque	3.1 kg·m
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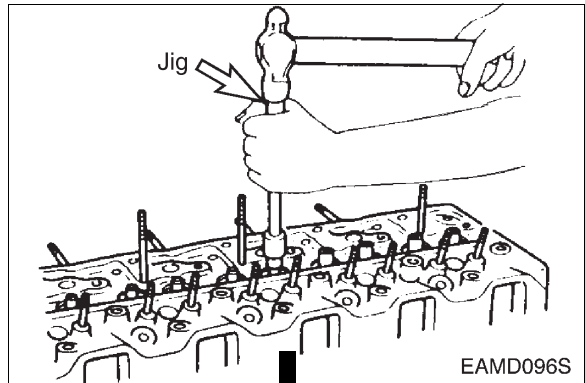
### 6.3.18. Intake/ exhaust valves



- Before assembling the valves and valve heads, find the "N (IN)" and "X (EX)" marks on the valve heads.



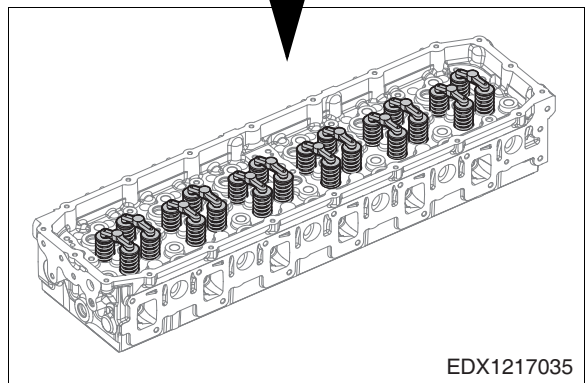
- Use a valve stem seal mounting jig to assemble the valve stem seals and valve guides.



- After installing the valve springs and spring retainers, use the jig to press down on the retainers and then install the cotter pins.



- Tap on the valve stems gently with a rubber hammer and check whether the valves have been assembled correctly.



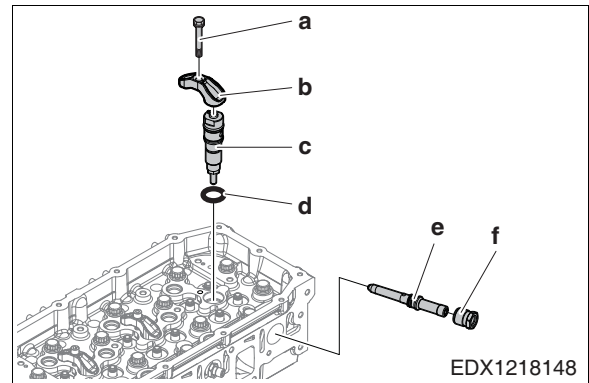
### 6.3.19. Injector



- The O-rings on the injector (c) and high-pressure fuel connector (e) are always assembled; they do not require any extra assembly.
- Clean all the parts thoroughly and be careful not to fall into the foreign material.
- Especially take deeper care on fuel line from common rail up to injector because this area has no filtering function.



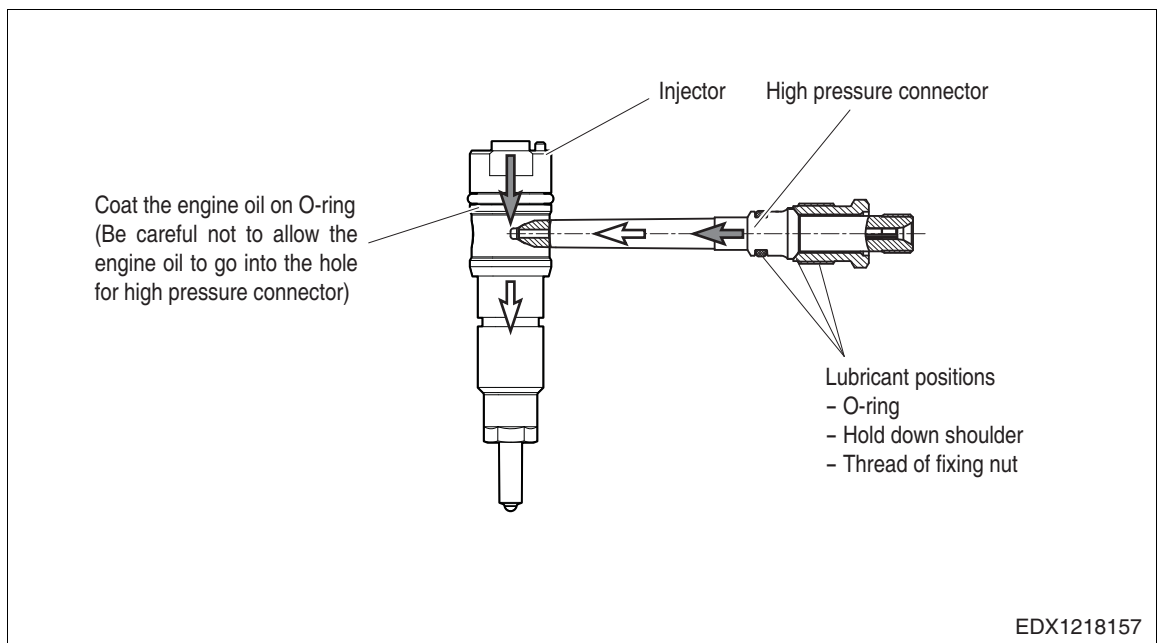
- Clean the holes which an injector and a high pressure connector will be put into before they are assembled.
- Whenever disassembling the injector, fuel high pressure connector must be replaced with a new one.
- When removing an injector, disconnect the in/out fuel hoses from the fuel tank and drain the return fuel in the cylinder head.



#### <Injector assembly procedure>



- 1) The injector must be assembled precisely in the following order.



2) Check for any foreign matter in the injector assembly hole on the cylinder head.



CAUTION:

If any foreign matter is found, remove it before assembling the injector. If an injector or sealing washer is installed when foreign matter is present, return fuel can enter the combustion chamber while the engine is running, causing pistons to melt.

3) Insert an injector sealing washer.



CAUTION:

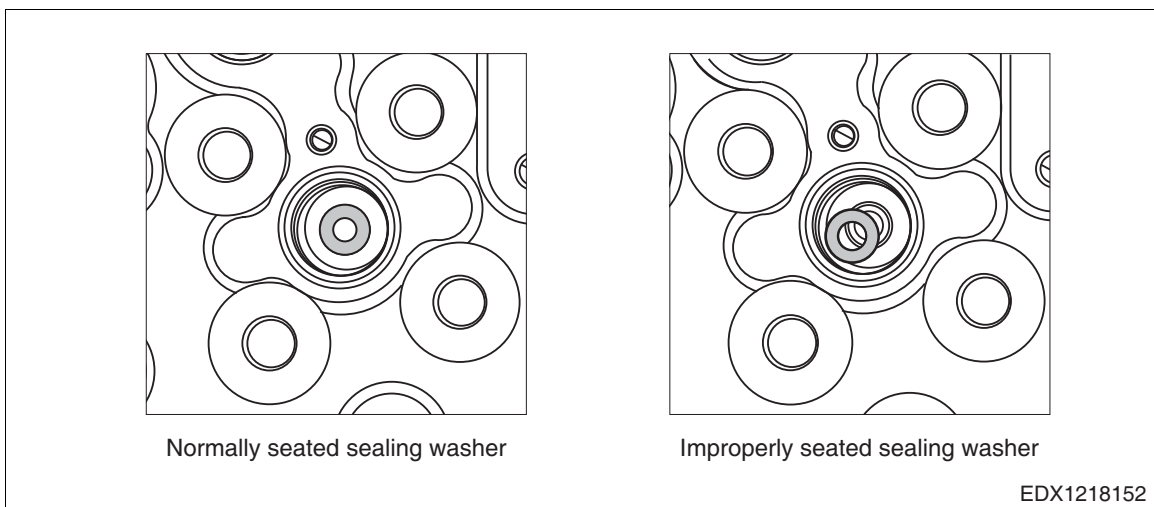
Be sure to replace removed parts with new ones. 2 mm thick copper washers are intended for single use; reusing them may lead to return fuel entering the combustion chamber, causing pistons to melt.

4) Check whether the injector sealing washer is seated securely.



CAUTION:

If the washer is tilted and not seated on the surface of the cylinder head  
(Normally seated sealing washer/Improperly seated sealing washer)



5) Apply oil to the injector O-ring seal.



CAUTION:

Be careful not to allow oil to enter the high-pressure fuel hole.

6) After aligning the pins on the fixtures with injectors ① and ②, insert the injectors / fixtures into the cylinder head.



CAUTION:

Tightening fixture bolts without aligning the position pin on an injector with the position hole on a fixture can damage pins, while assembling a high-pressure fuel connector in this state can damage the injectors and high-pressure fuel connectors.

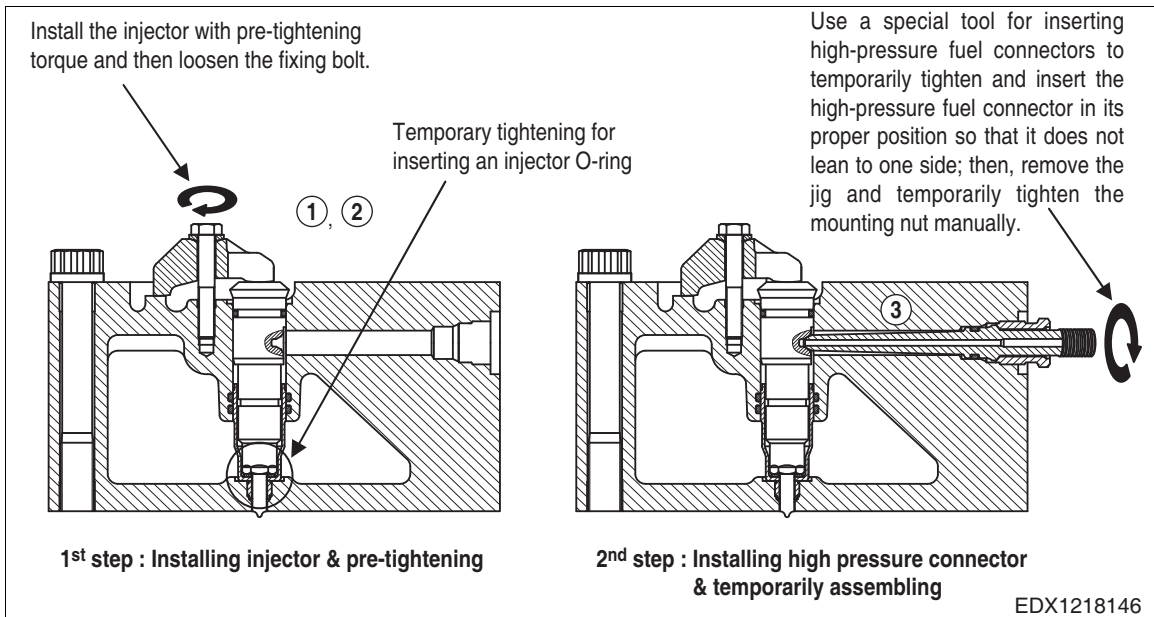
- 7) Temporarily tighten the injector fixture bolt and insert the injector into its proper position; then, loosen the injector fixture bolts by at least five turns.



**CAUTION:**

Inserting a high-pressure fuel connector without sufficiently loosening the fixture bolts produces an imperfect alignment and sealing surface between the high-pressure hole in the injector and the end of the high-pressure fuel connector, causing a drop in power.

- 8) Use a special injector alignment tool (assembly/removal jig) to adjust the high-pressure hole in the injector so that it is aligned with the hole in the ③ high-pressure fuel connector.
- 9) Check for foreign matter in the hole in the high-pressure fuel connector and remove any foreign matter completely; then, assemble the high-pressure fuel connector.
- 10) Apply oil to the O-ring on the high-pressure fuel connector.
- 11) Align the anti-rotation ball on the high-pressure fuel connector laterally; then, insert it into the anti-rotation slot in the hole in the high-pressure fuel connector on the cylinder head.
- 12) Use a high-pressure fuel connector insertion adapter (assembly jig) to temporarily tighten and insert the high-pressure fuel connector in its proper position so that it does not lean to one side; then, remove the special tool (assembly/removal jig).
- 13) Manually move the high-pressure fuel connector to the left/right/up/down, checking whether the fixture and injector move together with it, and adjust the central alignment.



Temporarily torque	Injector fixing bracket bolt	Fuel high pressure connector fixing nut
	0.3 kg·m	1.5 +0.5 kg·m

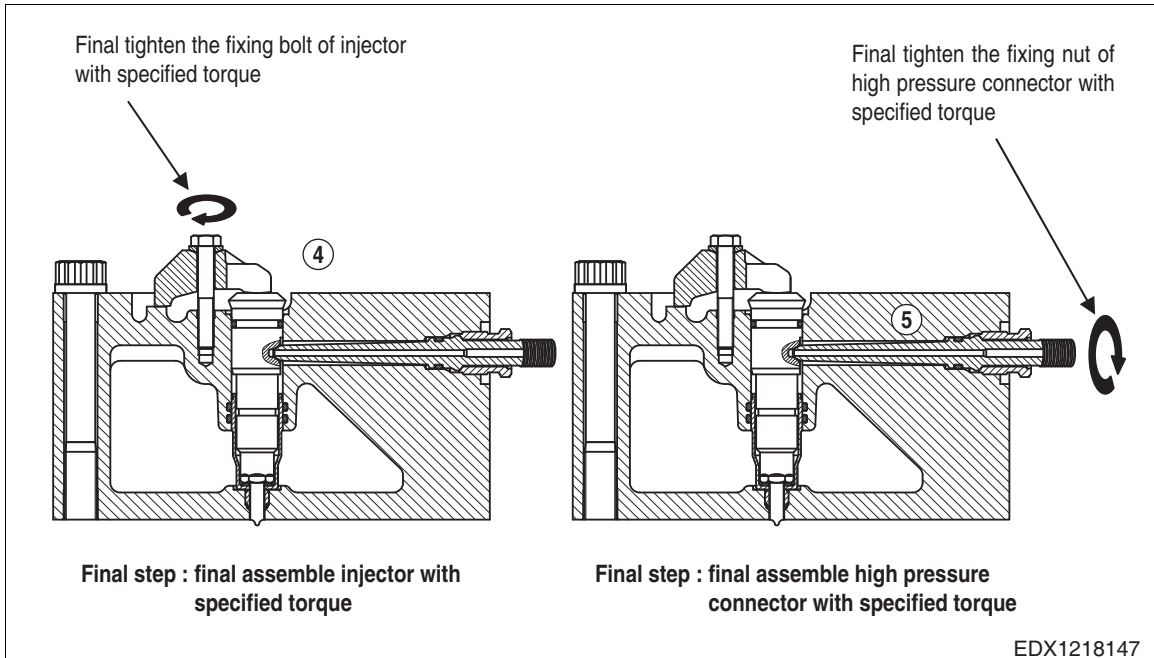


14) The injector and high pressure connector should be assembled correctly by the following order.

④ Finally tighten the fixing bolt of injector up to the specified torque while the high pressure connector is still pre-tightened.



15) ⑤ Finally assemble the high pressure connector. Tighten the fixing nut of high pressure connector according to the specified torque by the torque wrench. Please keep and obey this procedure and work order.



	Injector fixing bracket bolt	Fuel high pressure connector fixing nut
Final torque	3.5 kg·m	Manual mechanical torque wrench: 3.5 ±0.35 kg·m Manual digital torque wrench: 4.25 ±0.25 kg·m

### 6.3.20. Cylinder head

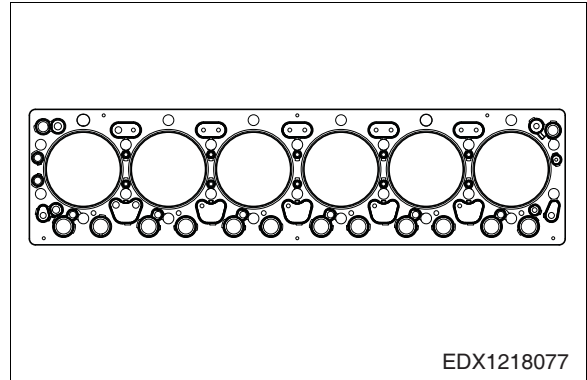
- Install the injection nozzle mounting stud bolts and coolant pipe mounting stud bolts.



- Remove any foreign matter from the head bolt hole on top of the cylinder block using compressed air. Then, wipe the cylinder block surface with which the head gasket will be assembled thoroughly.



- Make sure that the head gasket faces upwards and assemble the gasket, aligning it with the retaining pin on the cylinder block.



- Check the inside of combustion chamber for foreign substances, and carefully mount the cylinder head in the block by aligning the dowel pin with the dowel pin hole.



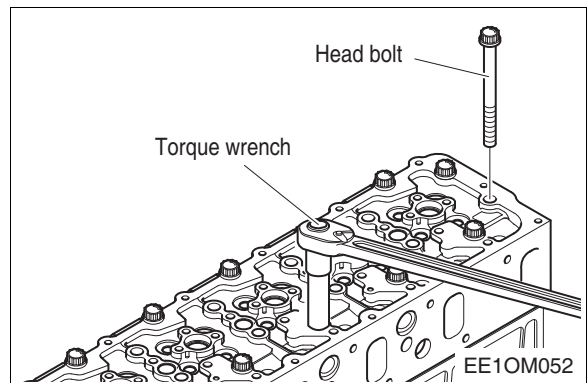
- Be careful not to damage the cylinder head gasket. If the dowel pin is not in alignment, lift the cylinder head again and then remount it.




- After tightening the cylinder head bolts, even at disassembling, the cylinder head gasket should be changed a new one.

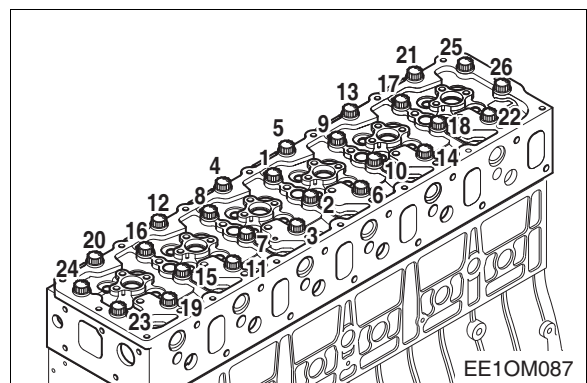


- Tighten them to the specified tightening torque in the order of assembly.



#### < Cylinder head bolts >

Specification	 <b>M16 × 1.5 × 161</b>
Torque	1st : 6 kg·m 2nd : 90° + 90° Final tightening : 30°





- Adjust the valve clearance according to the following procedure and clearance adjustment method.

**<Valve clearance adjustment guide>**



- Turn the crankshaft to set the piston of the cylinder No. 1 at the TDC of the compression stroke. Then, adjust the valve clearance. (Cylinder no.1 starts at the front of the engine while cylinder no.6 starts at the back where the flywheel is mounted.)

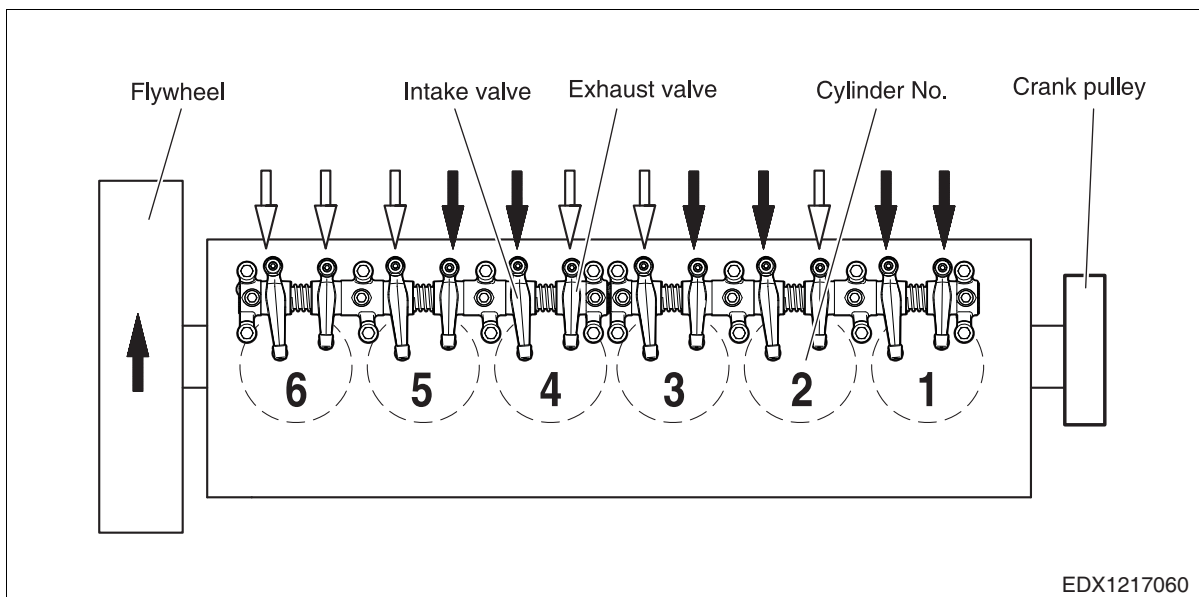


- Unscrew the rocker arm mounting nut and fit the feeler gauge between the rocker arm and valve. Adjust each clearance with the adjusting screw, then tighten the mounting nut.
- Adjust the valve clearance as follows when the engine is cold:

Specified value	
Intake valve	Exhaust valve
0.4 mm	0.7 mm

**< Valve clearance adjustment method no.1 >**

- After turning the crankshaft to align cylinder no.1 with the TDC position, adjust the valve in position "O" in the following picture. At this time, cylinder no.1 must be in the TDC position of the ignition stroke (O.T.).



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Valve adjustment	Cylinder number 1		2		3		4		5		6	
	Exhaust	Intake	Exhaust	Intake	Exhaust	Intake	Exhaust	Intake	Exhaust	Intake	Exhaust	Intake
Cylinder #1 TDC (Cylinder #6 valve overlap)	●	●		●	●			●	●			
Rotate 360°			●			●	●			●	●	●

**< Valve clearance adjustment method no.2 >**

- Valve adjustments for the valve overlap of each cylinder are to be performed as follows.

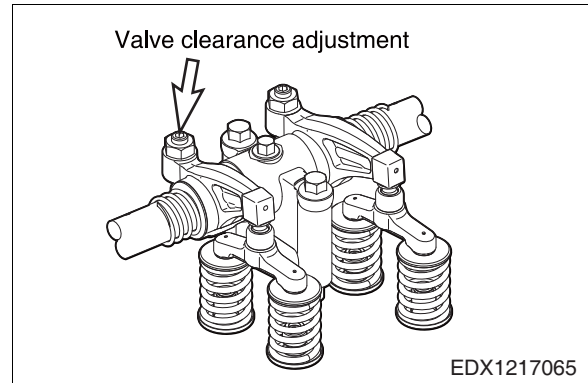
Valve overlap of each cylinder (Cylinder firing order)	1	5	3	6	2	4
Valve adjustment cylinder number	6	2	4	1	5	3



- Use a feeler gauge to adjust the valve clearance and tighten the mounting nuts to the specified torque.



Torque	4.4 kg·m
--------	----------



### 6.3.21. Rocker arm assembly

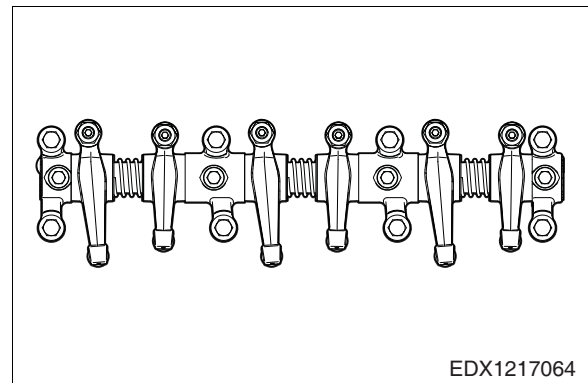


- Apply oil to the rocker arm bushing and shaft, use mounting bolts to align the parallel pins installed on the bracket with the top of the cylinder head, then tighten the bolts.



- When tightening bolts, tighten them to the specified torque in a zig-zag tightening pattern.

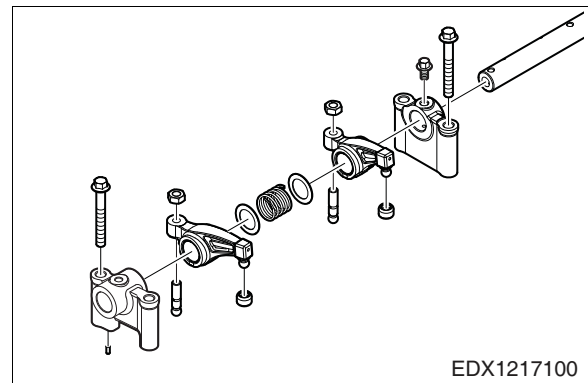
Torque	M10 (x8) : 6.2 kg·m M8 : 2.2 kg·m
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- Temporarily fit the valve clearance adjustment screw into the rocker arm.
- Install the spring, rocker arm, bracket, rocker arm, spring, washer and snap ring in the sequence described.

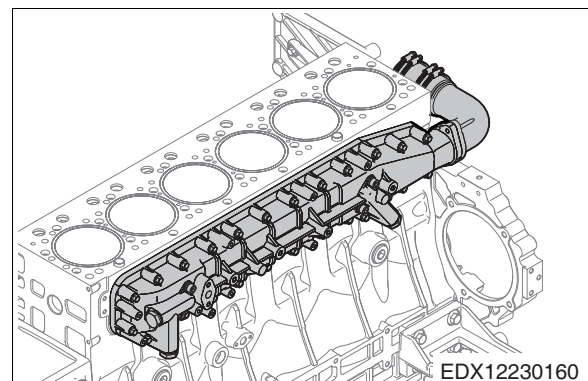


- Install the rocker arm and bracket in the same direction.



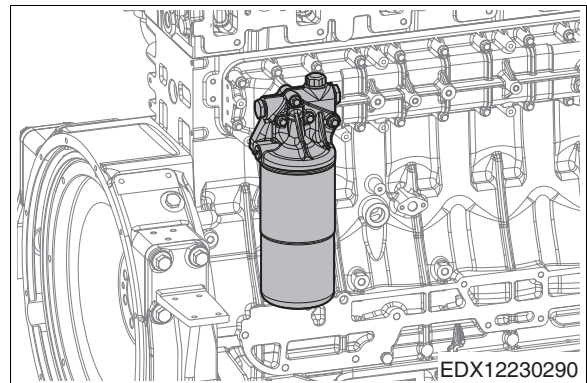
### 6.3.22. Oil cooler

- Insert the gasket, taking care to avoid oil leaks. Then, assemble the oil cooler with the oil cooler cover.
- Assemble the oil cooler cover assembly with the cylinder block, taking care not to damage the gasket.
- Assemble the connecting pipe between the coolant pump and oil cooler.



### 6.3.23. Oil filter

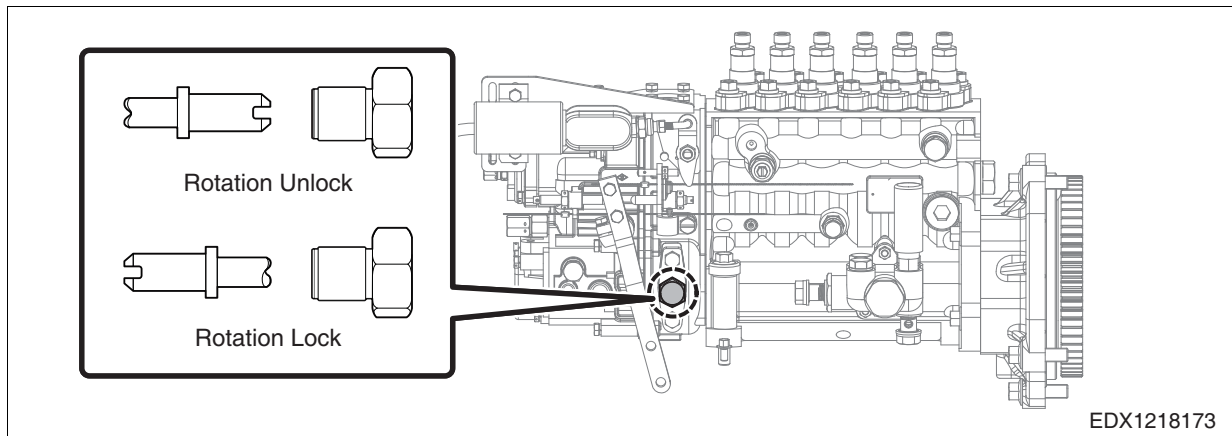
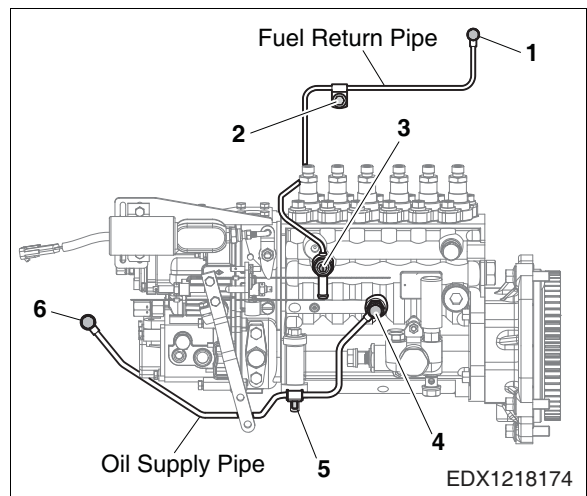
- Assemble the oil filter after inserting the gasket into the cylinder block.
- Install the oil packing and use a filter wrench to bring the surface of the O-ring on the oil filter cartridge into contact with the head seating surface. Then, tighten it an additional 3/4 to one turn.



### 6.3.24. Injection pump

- Prepare the injection pump assembly with the injection pump, flange, gear, and O-ring installed.
- Install the oil supply pipe and return pipe.

No.	Torque
1	0.8 ±0.1 kg.m
2	2.2 ±0.2 kg.m
3	2.5 ±0.5 kg.m
4	1.35 ±0.15 kg.m
5	0.9 ±0.1 kg.m
6	1.35 ±0.15 kg.m

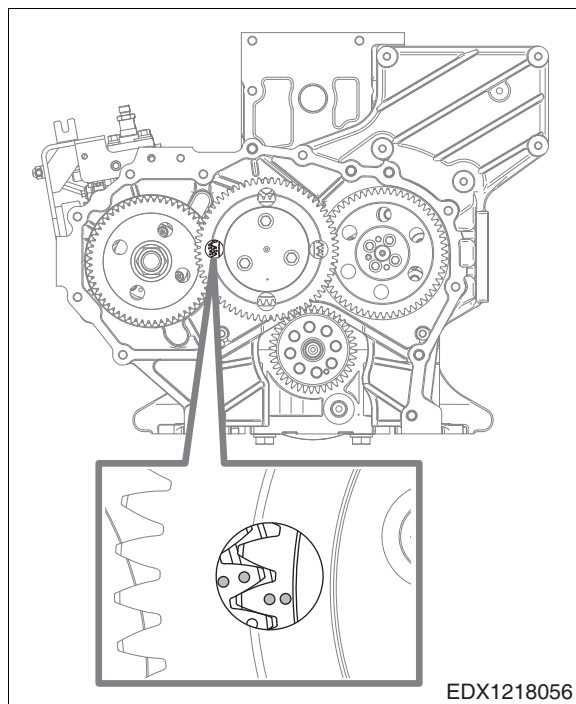


Note:

When replacing the injection pump, replace the lock pin on the mechanical governor (RQV-K) to release the lock.

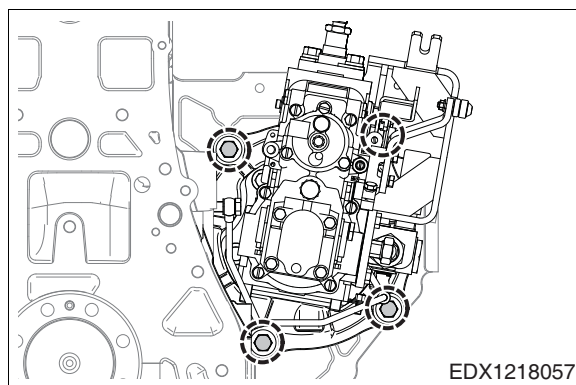
Engine cranking without lock position change can damage the injection pump.

- Insert the fuel injection pump assembly so that the engravings on the idler gear and injection pump gear are aligned.

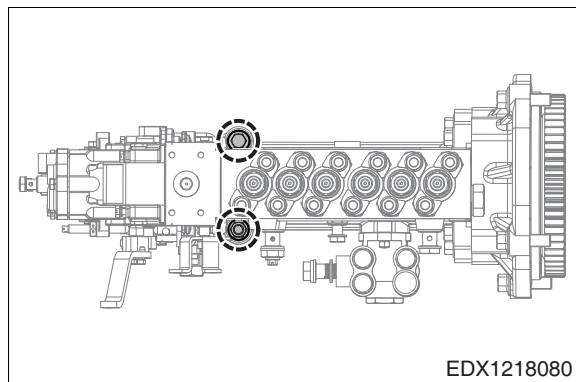


- Install the flange bolt in the inserted assembly.

Torque	11.2 ±1.1 kg·m
--------	----------------



Torque	4.4 ±0.4 kg·m
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- Assemble the bracket with the block.

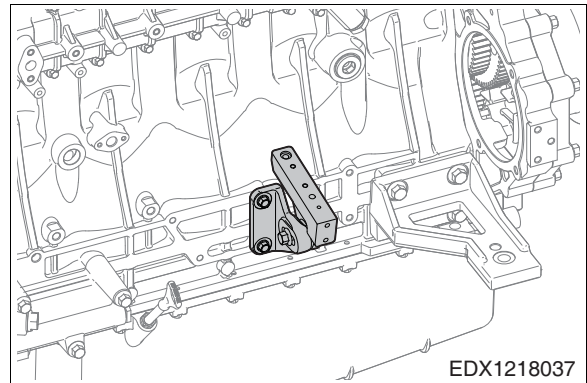
Torque	6.2 ±1.0 kg·m
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- Insert the bolts into the slots on the assembled bracket and connect them with the pump mounting bracket to assemble them.

Torque	11.2 ±1.1 kg·m
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- Install the oil supply pipe and return pipe.

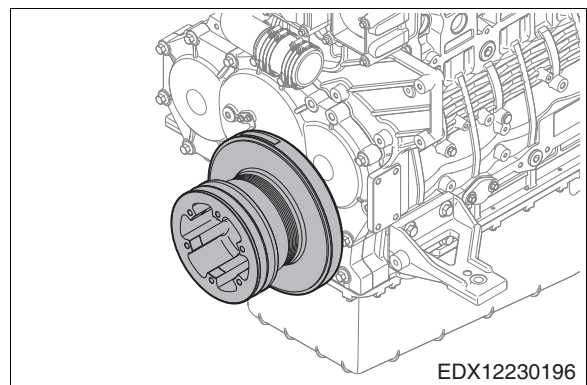


### 6.3.25. Vibration damper and crank pulley

- Assemble the vibration damper with the crankshaft pulley separately.



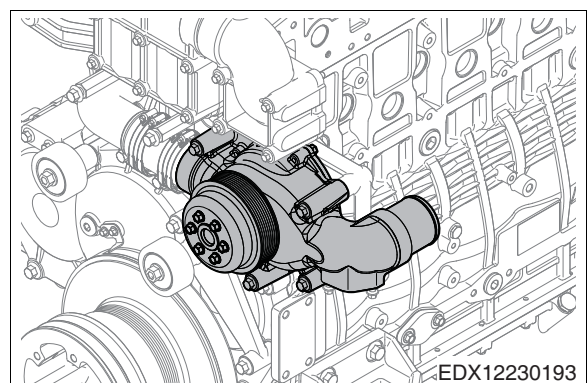
- After installing this assembly on the crankshaft, attach the thrust washers and tighten the bolts to the specified torque.



Part number	Specifications	Tightening torque	Shape	Remarks
65.90030-0013A	M12 × 1.5 × 70	10.5 ±1.5 kg·m		Discontinued
06.02106-0622	M12 × 1.5 × 65	13.4 ±2.0 kg·m		New

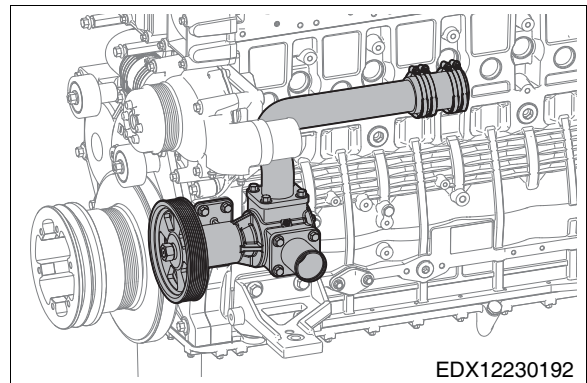
### 6.3.26. Fresh water pump

- Use the mounting bolts to assemble the fresh water pump with the TGC.
- Connect and assemble the coolant supply pipe with the bypass pipe and hose connected to the reservoir tank.



### 6.3.27. Saltwater pump

- Assemble the saltwater pump with the TGC, insert a new O-ring into the O-ring groove on the inlet/ outlet pipe flange, then assemble the pipe and hose.

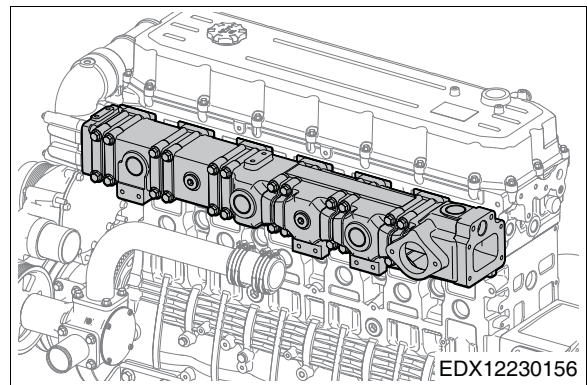


### 6.3.28. Exhaust manifold

- After temporarily assembling the heat exchanger and exhaust manifold, assemble the thermostat housing first in order to achieve the correct level of flatness of these parts. Then, adjust the flatness to the correct level and finally, tighten the mounting bolts on the heat exchanger.

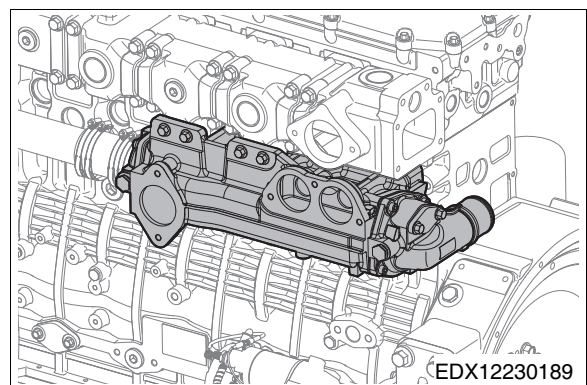


- Assemble the exhaust manifold and heat exchanger assembly with the cylinder head. These parts are heavy so be especially careful when handling them. Assemble the exhaust manifold and coolant pipe. Then, assemble the hose connecting the heat exchanger to the saltwater pump.



### 6.3.29. Heat exchanger

- Tighten the mounting bolts to install the heat exchanger.
- Connect the coolant hose to the heat exchanger.

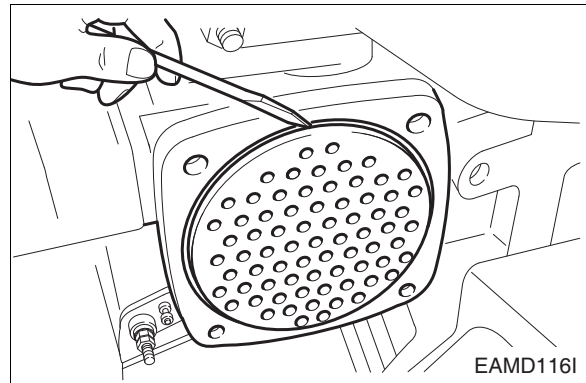




#### CAUTION

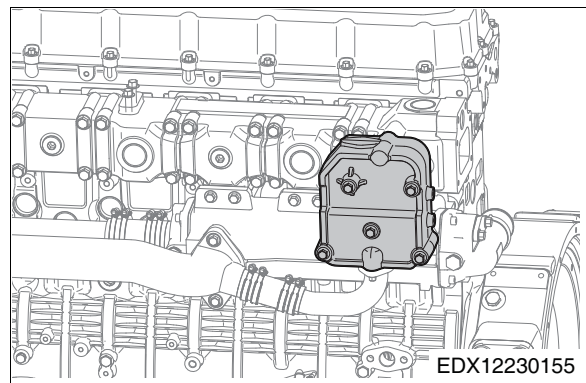
Assemble the heat exchanger tube so that the mark on top of the tube faces upwards.

This is to secure a suitable baffle position for the heat exchanger tube, enabling smooth distribution of fresh water.



#### 6.3.30. Thermostat

- Mount the thermostat in the thermostat housing along with a new gasket and O-ring.
- Assemble this assembly with the exhaust manifold and the body of the heat exchanger. Then, assemble them with the coolant bypass pipe.



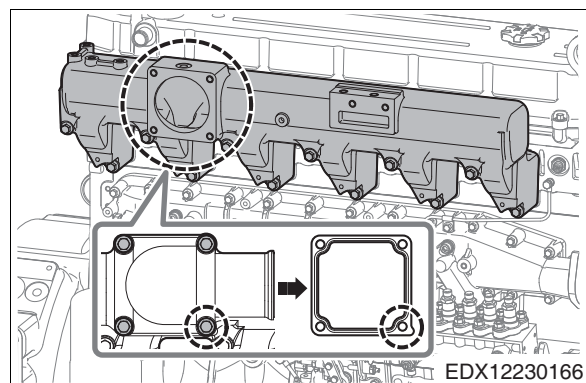
#### 6.3.31. Intake manifold

- Attach the gasket and install the intake manifold.
- Install the fuel injection pump's negative pressure operated air hose on the intake manifold.



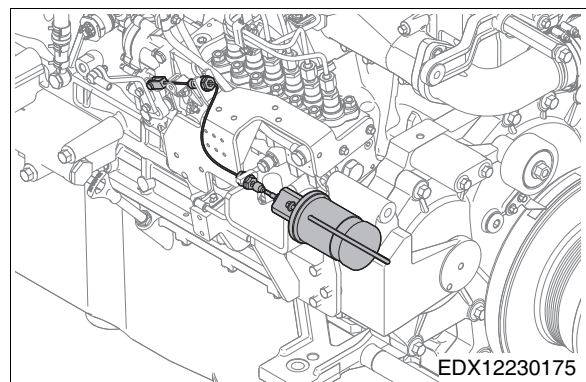
Note :

Ensure to install the steel gasket correctly with its projection facing the correct direction.



#### 6.3.32. Engine stop solenoid

- After mounting the bracket, assemble the solenoid as shown in the picture and tighten the solenoid mounting bolts.
- Connect the stop lever and solenoid on the fuel injection pump with a cable and adjust the length of the cable.



### 6.3.33. Injection pipe and fuel return pipe

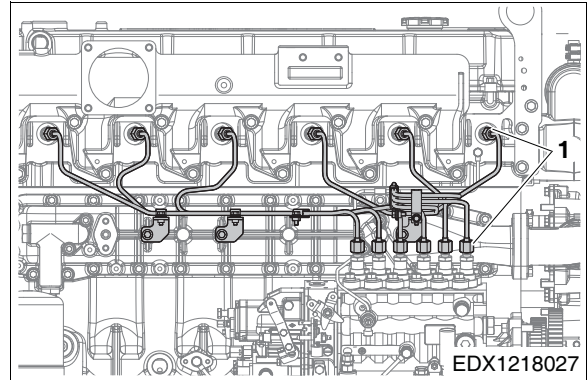


#### CAUTION:

Be sure to check the tightening torque of the nut on the high-pressure fuel connector before assembling the injection pipe.



- Temporarily tighten the nuts on the injection pipes for cylinders 1 to 3 (high-pressure fuel connector & injection pump) by hand.
- Temporarily tighten the bolt (1ea) on the injection pipe mounting bracket on the oil cooler.
- Finish tightening the nuts on the injection pipes for cylinders 1 to 3 (high-pressure fuel connector & injection pump) using a torque wrench.
- Temporarily tighten the nuts on the injection pipes for cylinders 4 to 6 (high-pressure fuel connector & injection pump) by hand.
- Temporarily tighten the bolts (2ea) on the injection pipe mounting bracket on the oil cooler.
- Finish tightening the nuts on the injection pipes for cylinders 4 to 6 (high-pressure fuel connector & injection pump) using a torque wrench.



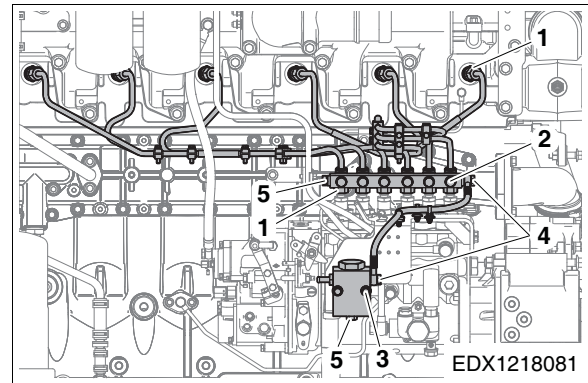
Name	Torque
Cap nut	4.0 ±0.4 kg·m
Bracket bolts	2.2 ±0.2 kg·m



- Double pipes  
Tighten the 12 cap nuts (1) on the double pipes to the specified torque as follows. Then, tighten the terminal block to the double pipes with the six hollow screws (2).

After assembling the control bracket with the injection pump, assemble the rubber piece and fuel tank body with the two bolts (3).

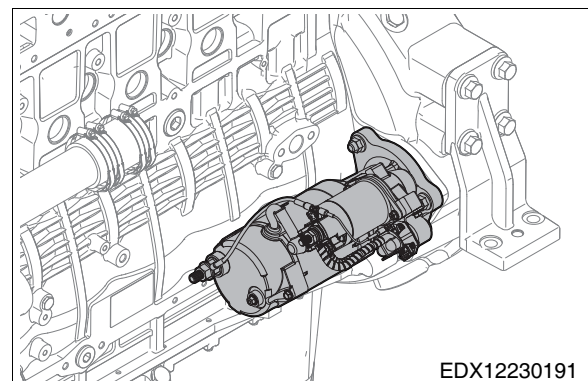
Assemble the screw plugs (4) and adapter (5) with the terminal block and fuel tank. Then, fasten the hose to the bracket.



Number	Name	Torque
1	Cap nut	4.0 ±0.4 kg·m
2	Hollow screw	1.6 ±0.4 kg·m
3	Bolt	2.2 ±0.55 kg·m
4	Screw plug	1.63 ±0.4 kg·m
5	Adapter	5.0 ±0.5 kg·m

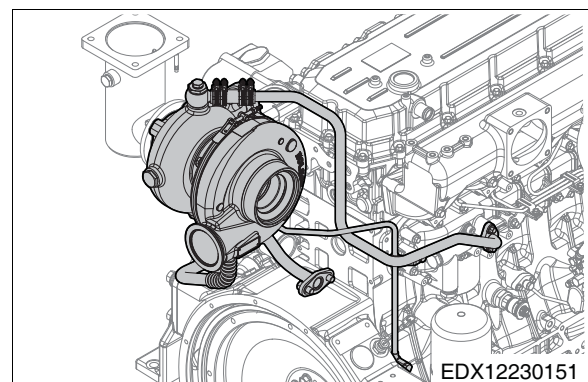
#### 6.3.34. Starter motor

- Assemble the starter motor with the flywheel housing.



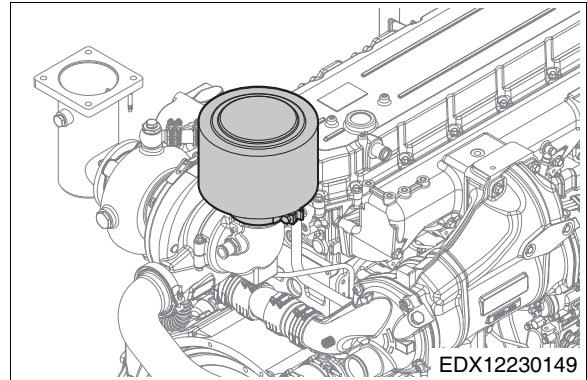
#### 6.3.35. Turbocharger

- Install a new gasket on the exhaust manifold stud bolts, install a turbocharger mounting spacer and insert a turbocharger gasket on top of it. Then, assemble the turbocharger with the mounting bolts.
- Assemble the oil supply pipe and return pipe with the top and bottom of the turbocharger.
- Install the gasket on the turbocharger exhaust outlet and assemble the exhaust elbow.



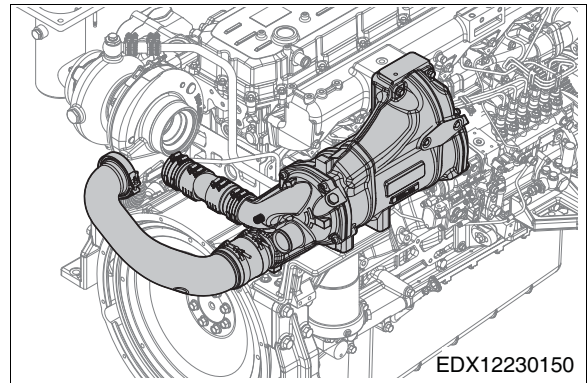
### 6.3.36. Air filter

- Assemble the air filter with the turbo-charger air inlet. Then, install the filter element on top of it as shown in the picture.



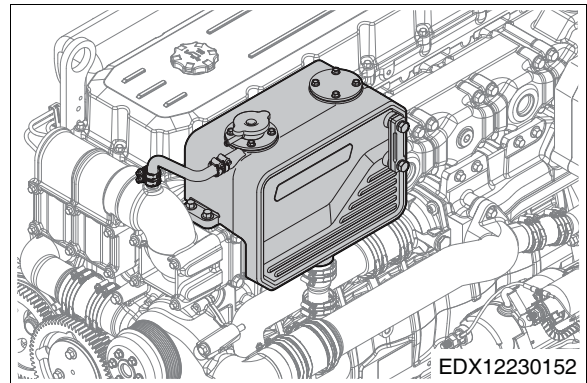
### 6.3.37. Intercooler

- Mount the intercooler bracket and assemble the intercooler.
- Connect the intake stake to the intake manifold.
- Assemble the pipe and hose connected to the intercooler and turbo-charger inlet as shown in the picture.
- Install a support bracket so that the connecting pipe does not detach from the turbocharger inlet.



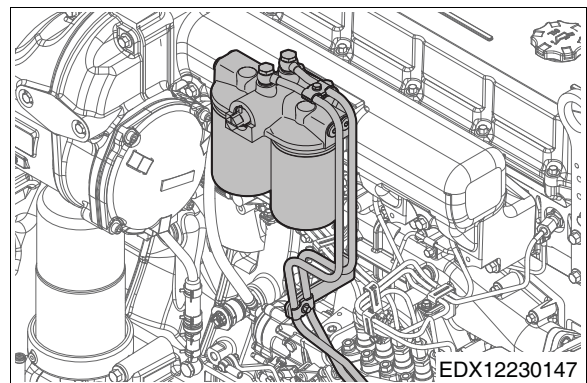
### 6.3.38. Reservoir tank

- Assemble the fresh water reservoir tank, assemble the rubber connecting hose and air bleeding hose with the bypass pipe, then tighten them with the clamps.



### 6.3.39. Fuel filter

- Assemble the fuel filter and intake manifold.
- Assemble the fuel supply hose in the direction indicated on the fuel filter head in order for fuel to be delivered in the following order: **primary fuel filter** → **fuel supply pump** → **secondary fuel filter** → **fuel injection pump**.



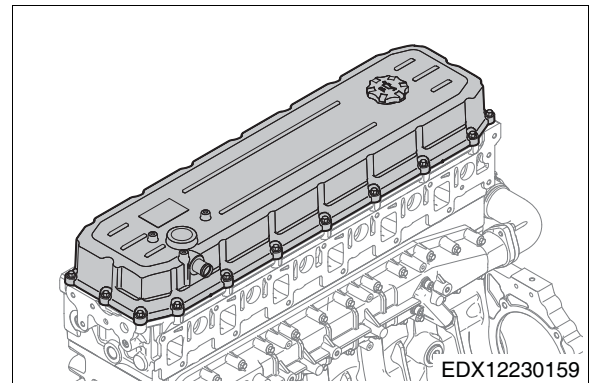
### 6.3.40. Cylinder head cover



- Assemble the cover packing with the cover and temporarily assemble the cover on top of the cylinder head. Then, tighten the mounting bolts to the specified tightening torque in the usual tightening order, starting from the inside and working outwards.

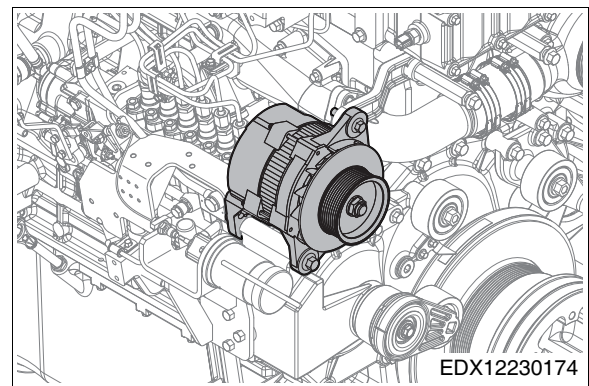
Torque	2.2 ±0.2 kg·m
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- Assemble the breather hose with the breather assembly.



### 6.3.41. Generator

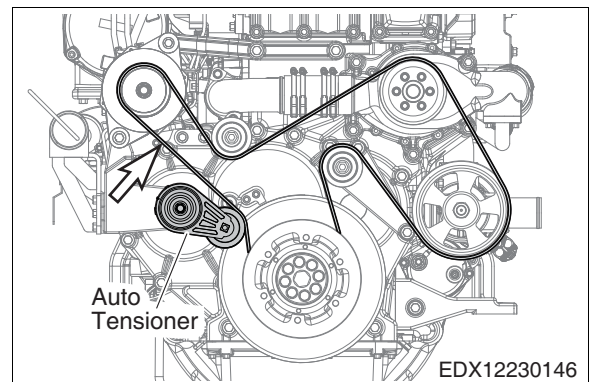
- Assemble the generator mounting bracket.
- Assemble the generator and the generator's protective cover with the bracket using mounting bolts.



### 6.3.42. V-belt



- Use a tool in the square groove of the auto tensioner to rotate the tensioner clockwise. Then, install the Micro-V Belt on the crank pulley, generator pulley and fan drive pulley.



## 6.4. Test Operation After Maintenance

After performing maintenance and replacing (boring) the parts in the engine, the various lubricated drive components reassembled within the engine have not been broken in sufficiently. Hence, if the engine is initially operated at a high speed or under an excessive load, the oil film is easily destroyed, causing premature or uneven wear in lubricated drive components. This can lead to premature breakdown within the engine, making it difficult to guarantee longterm durability.

In order to prevent this danger, the operator must follow the instructions in the section "3.3 Operating the Engine."

## 7. Maintenance of Main Components

### 7.1. Lubrication System

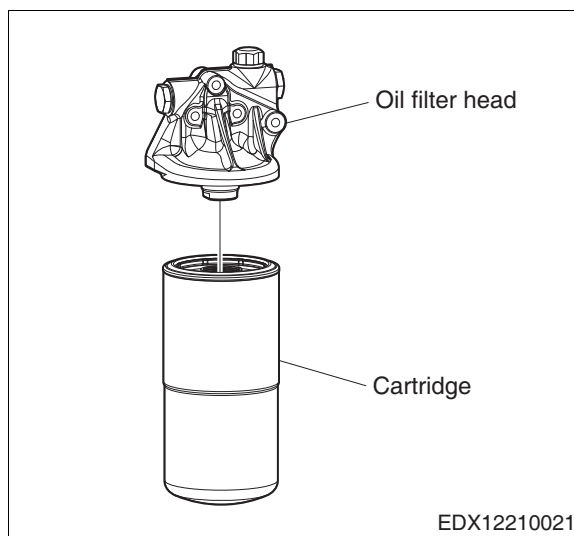
Foreign matter in the engine oil pumped from the oil pan by the gear-type oil pump is filtered out by the oil filter. Then, the oil passes through the oil cooler to be cooled before arriving in the main oil passage in the cylinder block. Having arrived here, the oil is delivered to the various sliding parts of the engine, as well as the fuel injection pump, turbocharger and saltwater pump to lubricate the relevant parts. Next, it is returned to the oil pan to keep the engine functioning normally.

#### 7.1.1. Specifications

Item	Specifications	Item	Specifications
Lubrication method	Forced circulation	Oil strainer type	Full flow
Oil pump type	Gear	Filter	Cartridge type
Oil pump relief valve opening pressure	11 ±1.5 kg/cm <sup>2</sup>	Opening pressure of bypass valve	3.2 ±0.3 kg/cm <sup>2</sup>
Opening pressure of valve for oil spray nozzle	2.0 ±0.1 kg/cm <sup>2</sup>	Opening pressure of oil filter bypass valve	5.0 + 1.0 kg/cm <sup>2</sup>

#### 7.1.2. Oil filter

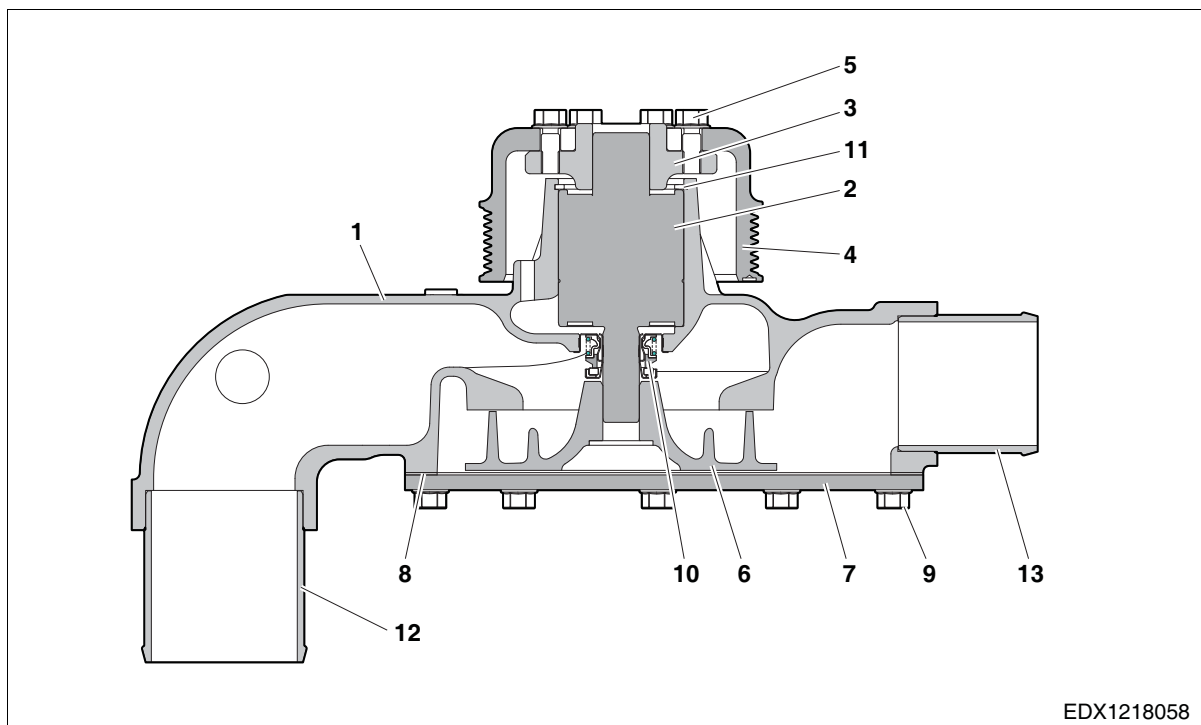
The oil filter is a cartridge-type filter. It must be replaced regularly along with the oil.



## 7.2. Cooling System

### 7.2.1. Coolant pump

- Loosen the bolts (5) and disconnect the pulley (4).
  - After slightly heating the hub (4), use a puller jig to remove it.
  - Loosen the bolts (9) and remove the housing cover (7).
  - After slightly heating the impeller (6), use a puller jig to remove it.
  - Remove the mechanical seal (10).
  - Remove the snap ring (14) and the unit bearing (2).
  - Reassemble in the reverse order.
  - In order to reassemble the impeller (6), use a gauge to maintain a consistent clearance (5 ~ 9).
- \* The water pump assembly and disassembly processes involve a significant amount of press-fitting, making them difficult to do without the necessary tools and jigs.

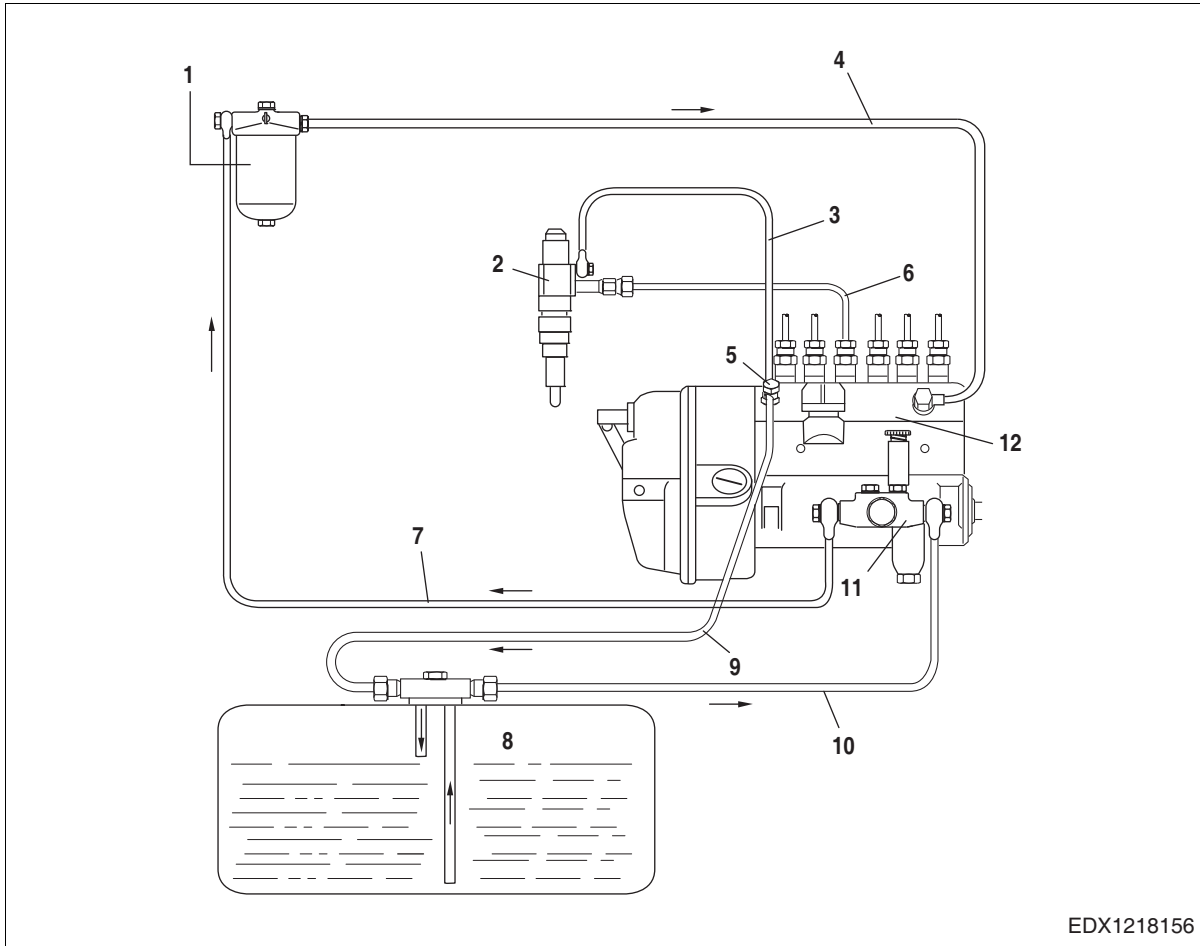


- |                             |                        |                 |
|-----------------------------|------------------------|-----------------|
| 1. Fresh water pump housing | 6. Impeller            | 11. Snap ring   |
| 2. Unit bearing             | 7. Housing cover       | 12. Outlet pipe |
| 3. Hub                      | 8. Gasket              | 13. Inlet pipe  |
| 4. Pulley                   | 9. Cover mounting bolt |                 |
| 5. Pulley mounting bolt     | 10. Mechanical seal    |                 |

## 7.3. Fuel Injection Pump

### 7.3.1. General fuel system information

The fuel system is composed of a fuel tank, injection pump, injection nozzle and fuel filter, as well as fuel lines such as pipes and hoses required for connecting these components.



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- |  |                                   |
|--|-----------------------------------|
| 1. Fuel filter                         | 7. Fuel pipe (hand pump → filter) |
| 2. Injection nozzle                    | 8. Fuel tank                      |
| 3. Overflow pipe                       | 9. Fuel return pipe               |
| 4. Fuel pipe (filter → injection pump) | 10. Suction pipe                  |
| 5. Overflow valve                      | 11. Feed pump                     |
| 6. Feed pipe                           | 12. Injection Pump                |

### 7.3.2. Injection pump

After being used for a certain amount of time, the plunger and delivery valve wear out and may degrade the engine performance, so the components of the injection pump must be serviced regularly.

Service must be performed at a WEIFU-accredited professional maintenance center.

To adjust the amount of fuel injected, refer to the 'Fuel Injection Pump Specifications' described on the next page.

#### 1) DX12

##### (1) Main data and specifications

###### Part number

Light-duty propulsion engine	: 400912-00490
Medium-duty propulsion engine	: 400912-00487A
Heavy-duty propulsion engine	: 400912-00484A
Continuous duty propulsion engine	: 400912-00628A
Auxiliary engine	: 400912-00498
Emergency generator	: 400912-00498 (electric gov.), 400912-00500 (mechanical gov.)

Model : PW8500

Governor : Mechanical / electric (Ghana Control)

Timer : No timer

##### (2) Nozzle holder assembly

###### Part number

Light-duty propulsion engine	: 400903-00167A
Medium-duty propulsion engine	: 400903-00102A
Heavy-duty propulsion engine	: 400903-00102A
Continuous duty propulsion engine	: 400903-00102A
Auxiliary engine	: 400903-00167A
Emergency generator	: 400903-00167A

(3) Nozzle : 150118-00178 (9001 212 82A)

(4) High-pressure link connector : 430230-00159 (A445120319)

##### (5) Injection pipe

Single pipe : 420208-00788, 420208-00784 (differs depending on ship class)

Double pipe : 420208-00687, 420208-00688 (differs depending on ship class)

(6) Injection sequence : 1 - 5 - 3 - 6 - 2 - 4

##### (7) Injection timing

Light-duty propulsion engine : BTDC 15° ±1°

Medium-duty propulsion engine : BTDC 15° ±1°

Heavy-duty propulsion engine : BTDC 17° ±1°

Continuous duty propulsion engine : BTDC 17° ±1°

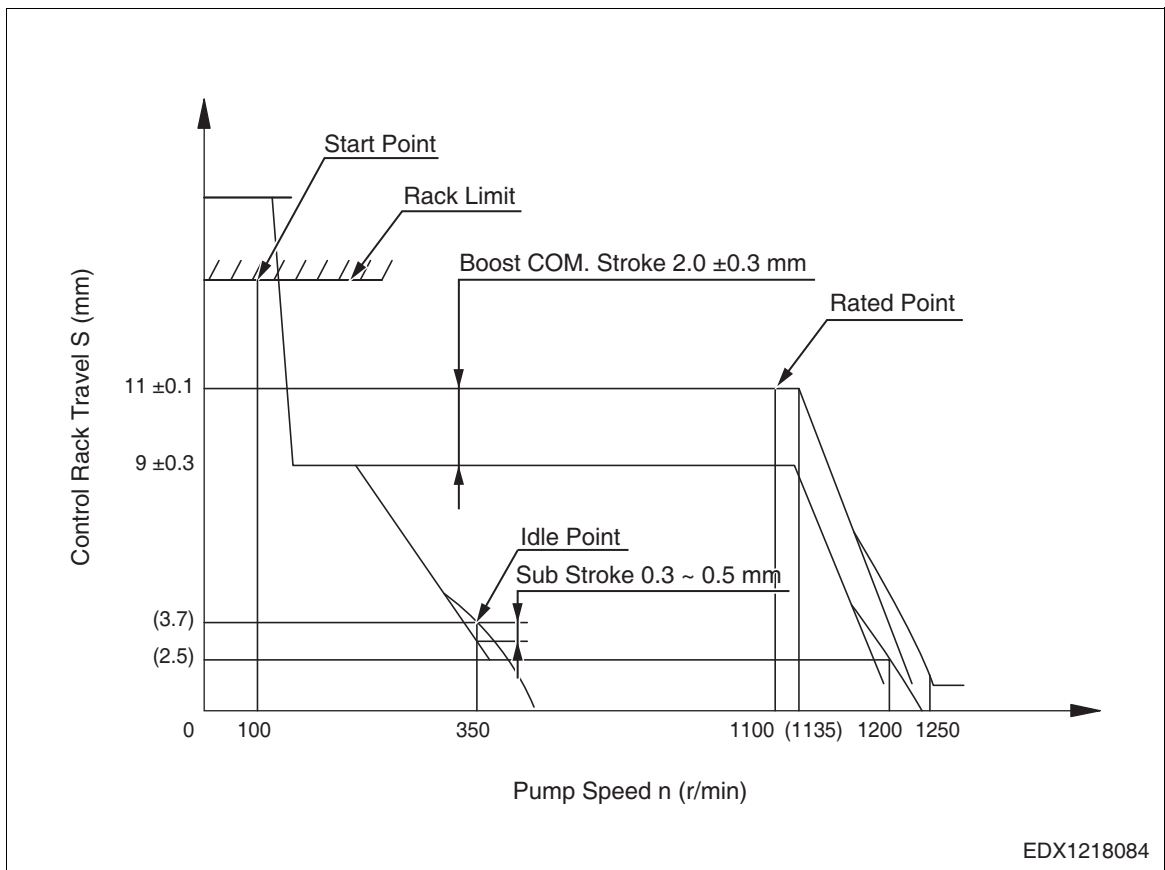
Auxiliary engine : BTDC 17° ±1°

Emergency generator : BTDC 17° ±1°

(8) Adjusting the calibration data and governor

- Light-duty propulsion engine (400912-00490)

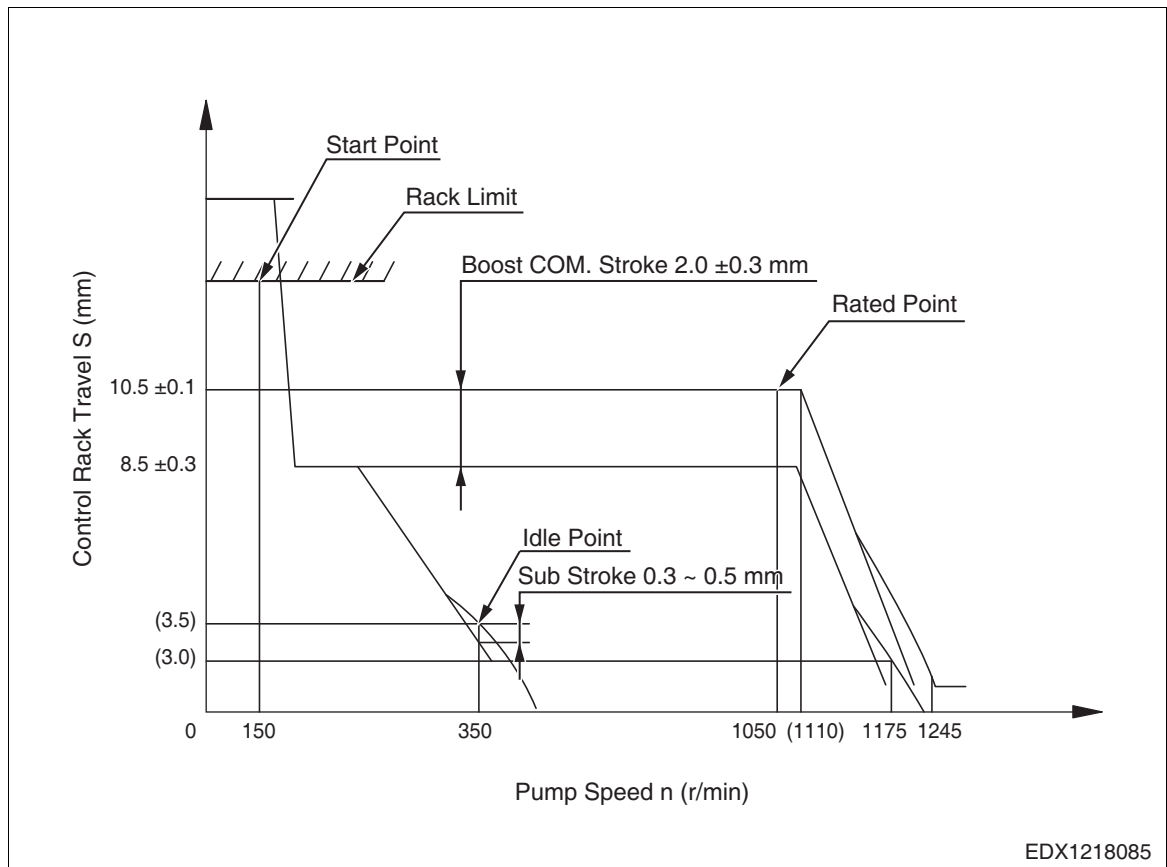
Attribute	Inspection Tolerances					
	Speed (r/min)	L.D.A. Pressure (kPa)	Fueling (mm <sup>3</sup> /st)	Fueling Tolerances (mm <sup>3</sup> /st)	Max.SP.CYL (mm <sup>3</sup> /st)	Rack Travel (mm)
Rated	1,100	180	286	±8.6	17	11 ±0.1
Torque Peak	-	-	-	-	-	-
Governor Break	1,135 ±10	180	-	-	-	10.9 ±0.2
High Idle	1,200 ±10	180	32	±6	-	(2.5)
High Idle	1,250	180	-	-	-	2.0 or below
Boost Control	500	0	240	±12	24	9 ±0.3
Start Fuel	100	0	520	±60	-	-
Low Idle	350	0	44	±8	15	(3.7)



EDX1218084

● Medium-duty propulsion engine (400912-00487A)

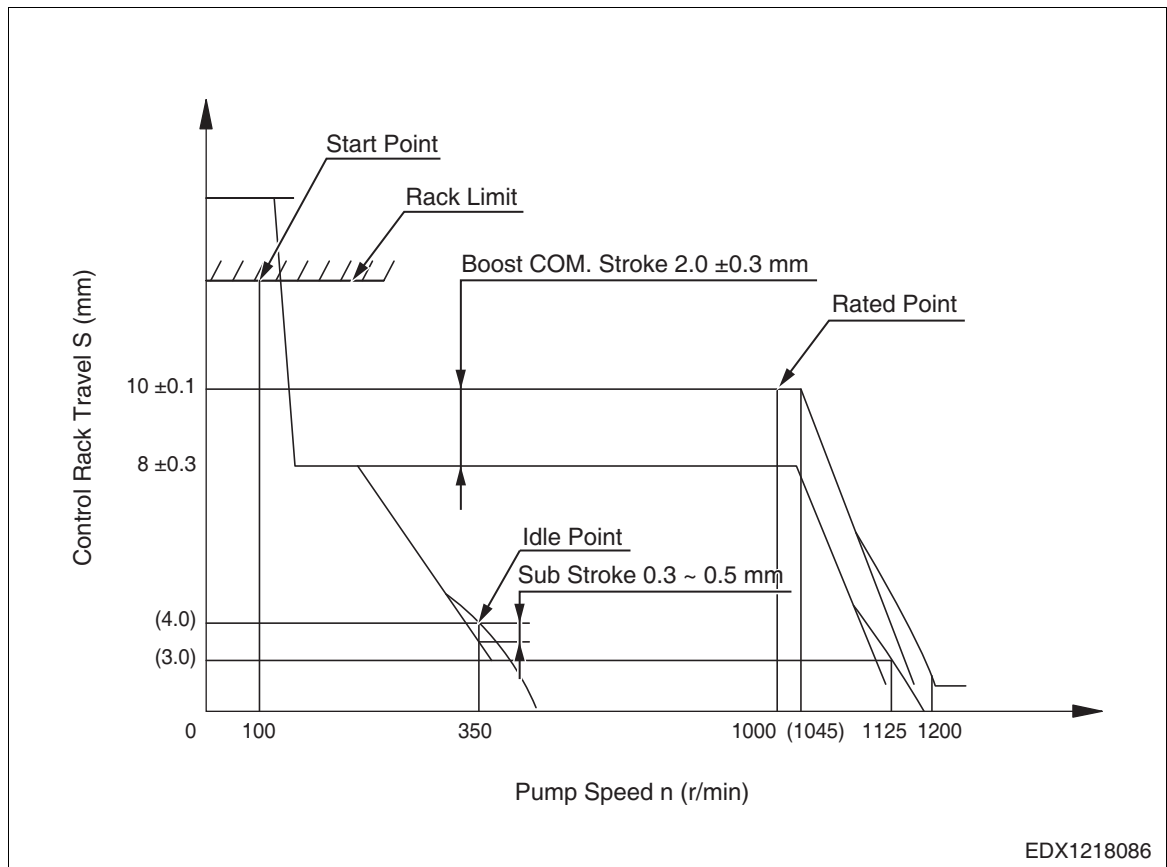
Attribute	Inspection Tolerances					
	Speed (r/min)	L.D.A. Pressure (kPa)	Fueling (mm <sup>3</sup> /st)	Fueling Tolerances (mm <sup>3</sup> /st)	Max.SP.CYL (mm <sup>3</sup> /st)	Rack Travel (mm)
Rated	1,050	180	258	±7.8	16	10.5 ±0.1
Torque Peak	-	-	-	-	-	-
Governor Break	1,110 ±10	180	-	-	-	10.4 ±0.2
High Idle	1,175 ±10	180	40	±7	-	(3.0)
High Idle	1,245	180	-	-	-	2.0 or below
Boost Control	500	0	210	±10	20	8.5 ±0.3
Start Fuel	150	0	520	±60	-	-
Low Idle	350	0	40	±7	14	(3.5)



EDX1218085

● Heavy-duty propulsion engine (400912-00484A)

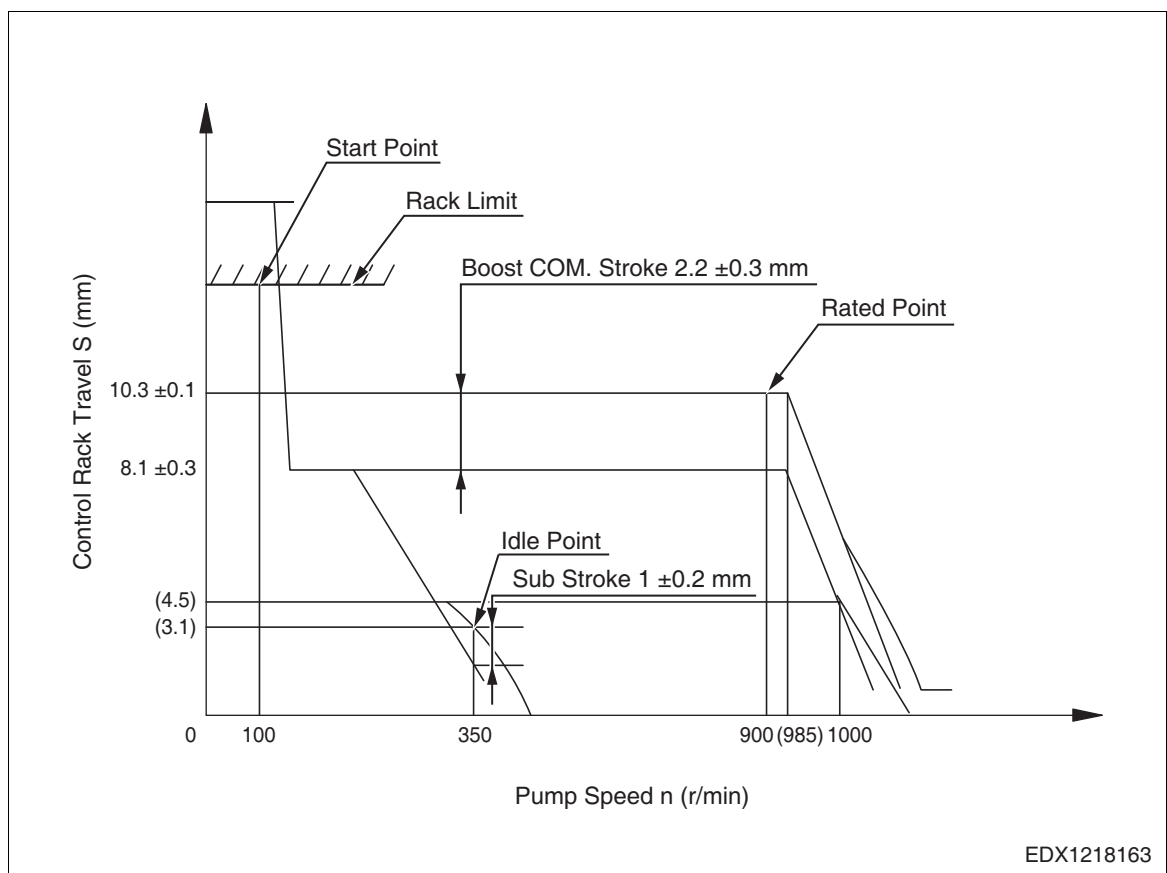
Attribute	Inspection Tolerances					
	Speed (r/min)	L.D.A. Pressure (kPa)	Fueling (mm <sup>3</sup> /st)	Fueling Tolerances (mm <sup>3</sup> /st)	Max.SP.CYL (mm <sup>3</sup> /st)	Rack Travel (mm)
Rated	1,000	180	238	±7.2	14.5	10 ±0.1
Torque Peak	-	-	-	-	-	-
Governor Break	1,045 ±10	180	-	-	-	9.9 ±0.2
High Idle	1,125 ±10	180	35	±6	-	(3.0)
High Idle	1,200	180	-	-	-	2.0 or below
Boost Control	500	0	180	±9	18	8 ±0.3
Start Fuel	100	0	520	±60	-	-
Low Idle	350	0	40	±7	14	(4.0)



EDX1218086

● Continuous duty propulsion engine (400912-00628A)

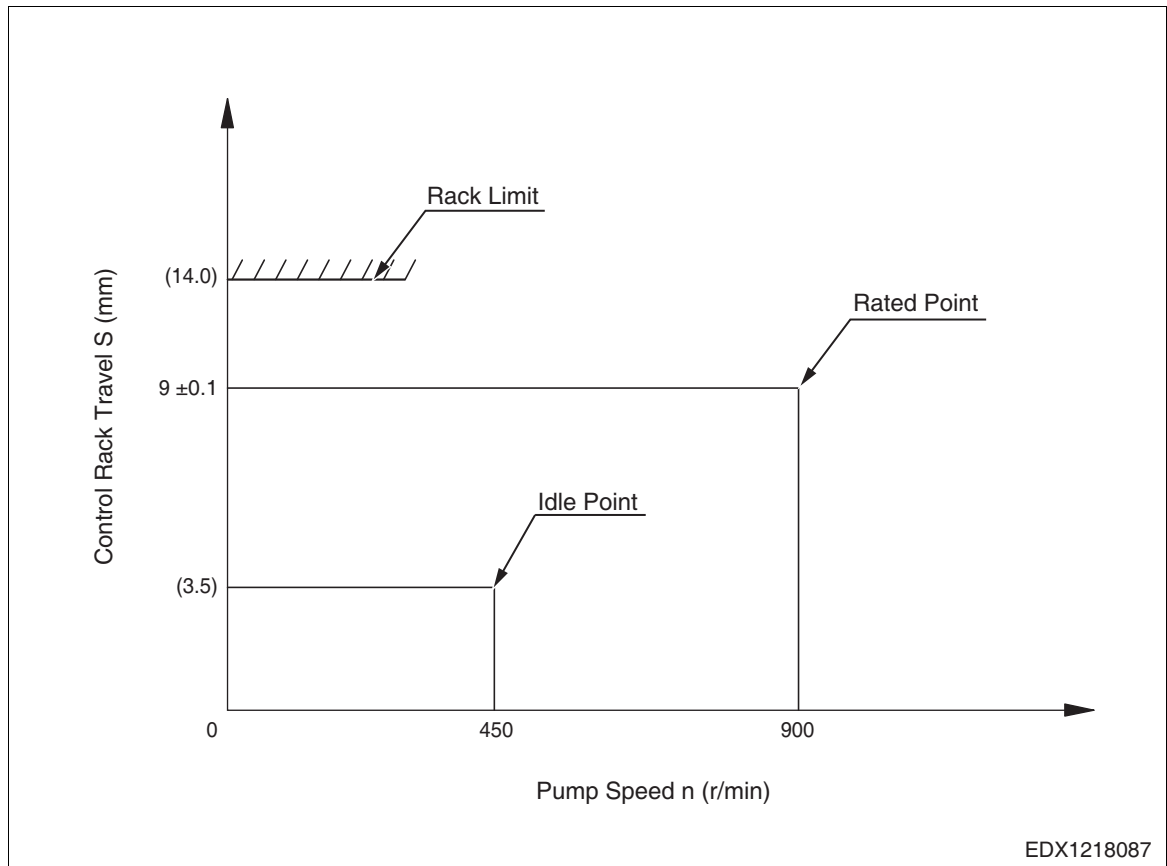
Attribute	Inspection Tolerances					
	Speed (r/min)	L.D.A. Pressure (kPa)	Fueling (mm <sup>3</sup> /st)	Fueling Tolerances (mm <sup>3</sup> /st)	Max.SP.CYL (mm <sup>3</sup> /st)	Rack Travel (mm)
Rated	900	180	270	±8	16	10.3 ±0.1
Torque Peak	-	-	-	-	-	-
Governor Break	950 ±10	180	-	-	-	10.2 ±0.2
High Idle	1,000 ±10	0	37	±6	-	(4.5)
Boost Control	500	0	190	±9.5	19	8.1 ±0.3
Start Fuel	100	0	520	±60	-	-
Low Idle	350	0	30	±6	12	(3.1)



EDX1218163

● Auxiliary engine (400912-00498)

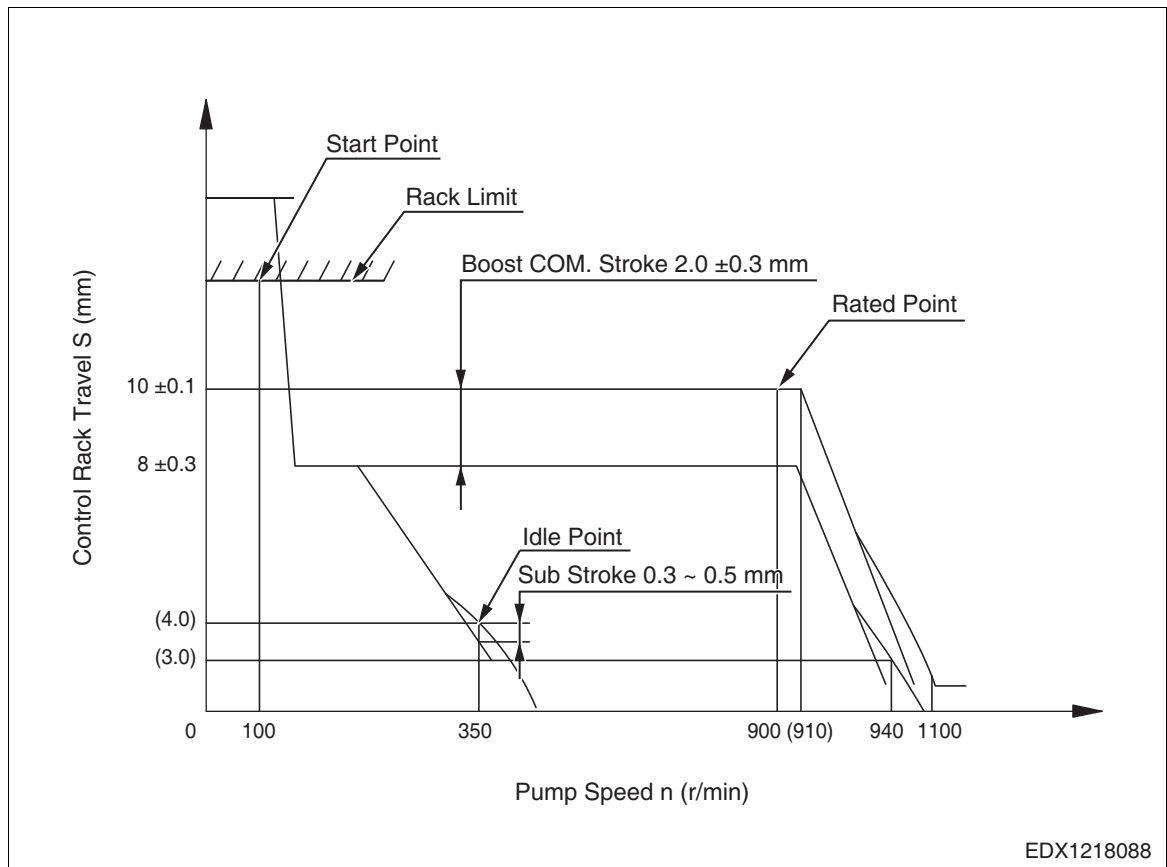
Attribute	Inspection Tolerances				
	Speed (r/min)	Fueling (mm <sup>3</sup> /st)	Fueling Tolerances (mm <sup>3</sup> /st)	Max.SP.CYL (mm <sup>3</sup> /st)	Rack Travel (mm)
Rated	900	230	±7	14	9.0 ±0.1
Start Fuel	100	(540)	-	-	(14.0)
Low Idle	450	36	±6	12	(3.5)



EDX1218087

- Emergency generator (400912-00498 (electric gov.), 400912-00500 (mechanical gov.))

Attribute	Inspection Tolerances					
	Speed (r/min)	L.D.A. Pressure (kPa)	Fueling (mm <sup>3</sup> /st)	Fueling Tolerances (mm <sup>3</sup> /st)	Max.SP.CYL (mm <sup>3</sup> /st)	Rack Travel (mm)
Rated	900	180	230	±7	14	10 ±0.1
Torque Peak	-	-	-	-	-	-
Governor Break	910 ±10	180	-	-	-	9.9 ±0.2
High Idle	940 ±10	180	45	±8	-	(3.5)
High Idle	1,000	180	-	-	-	2.0 or below
Boost Control	500	0	166	±8	16	8 ±0.3
Start Fuel	100	0	520	±60	-	-
Low Idle	350	0	40	±7	14	(4.0)

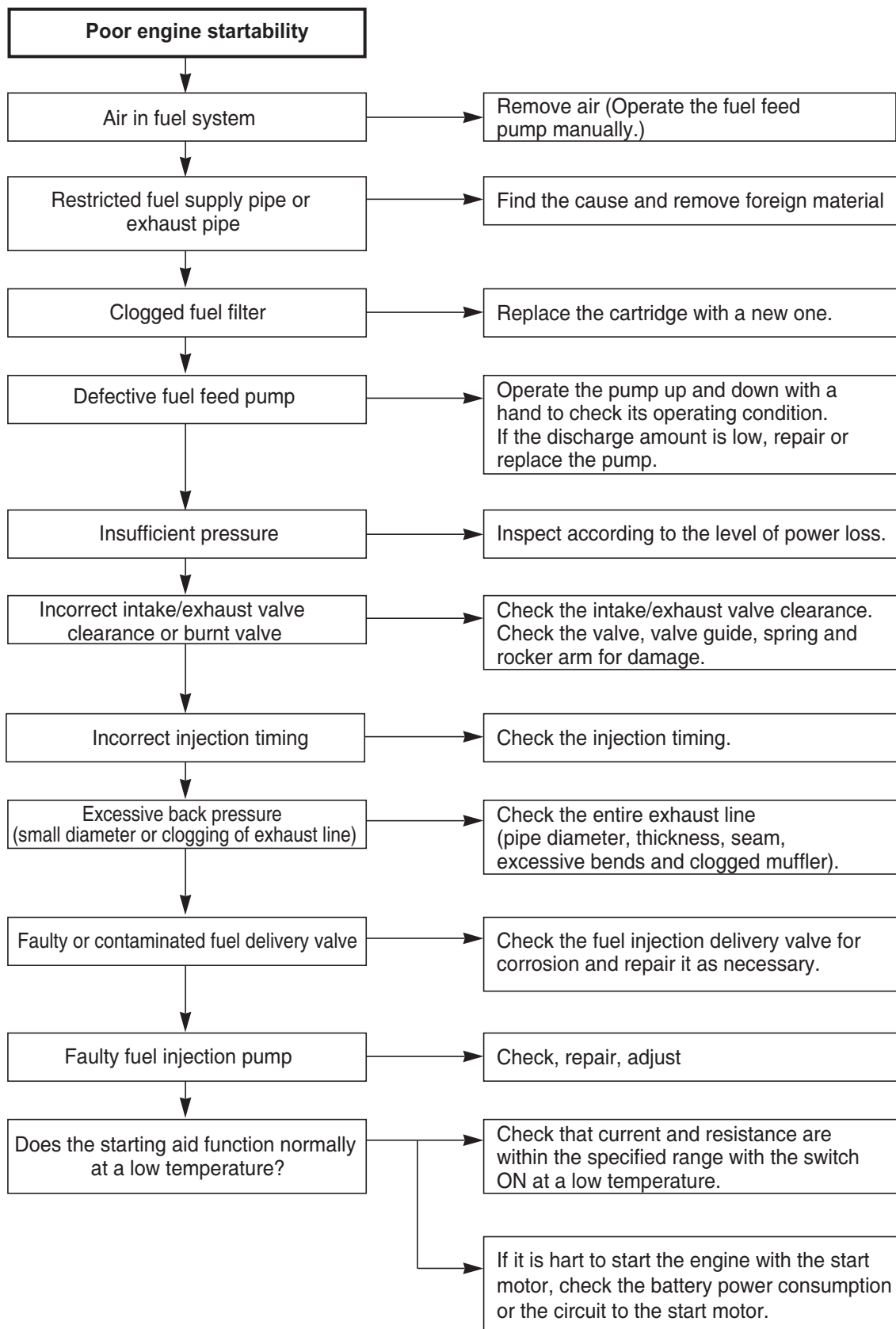


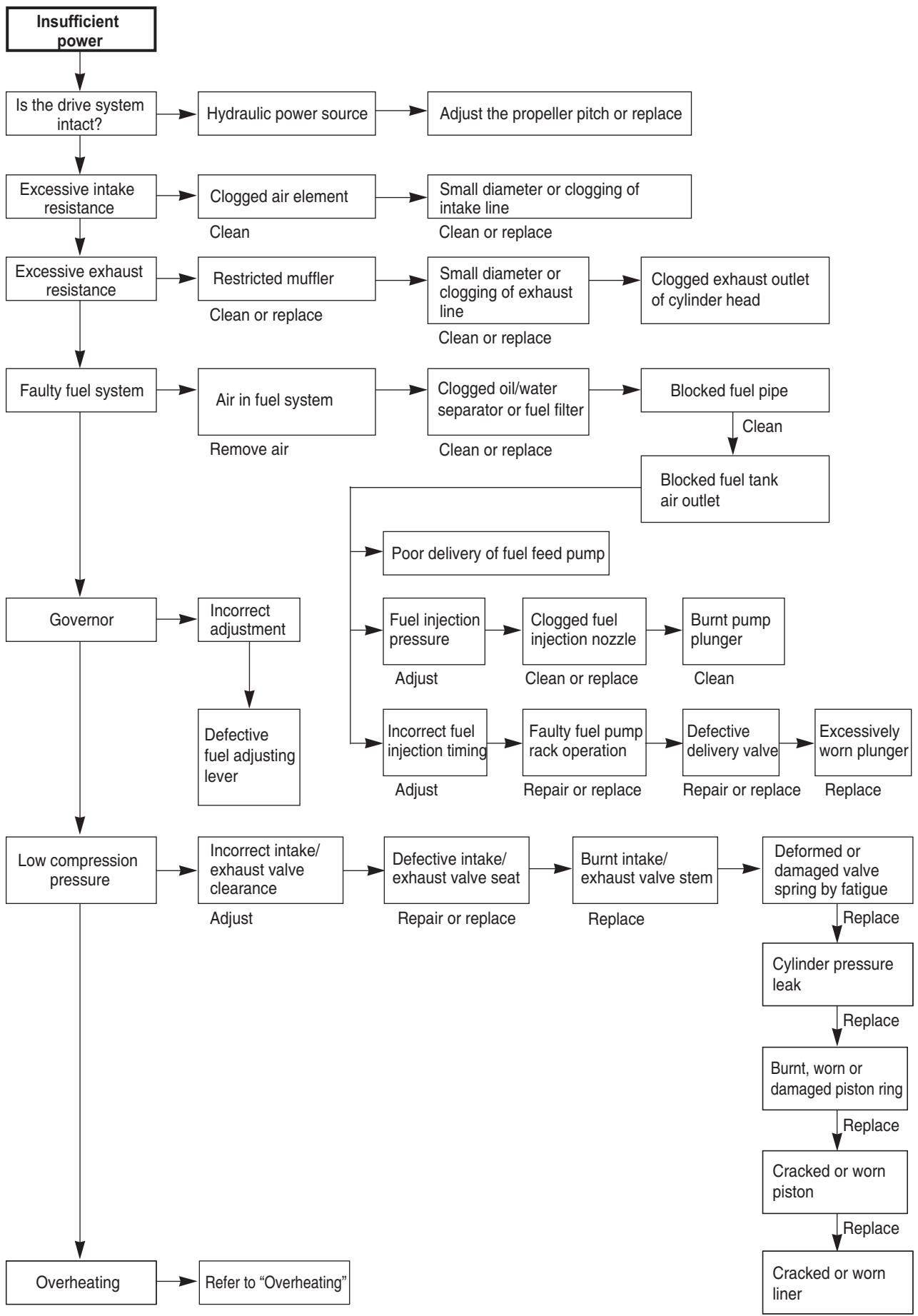
EDX1218088

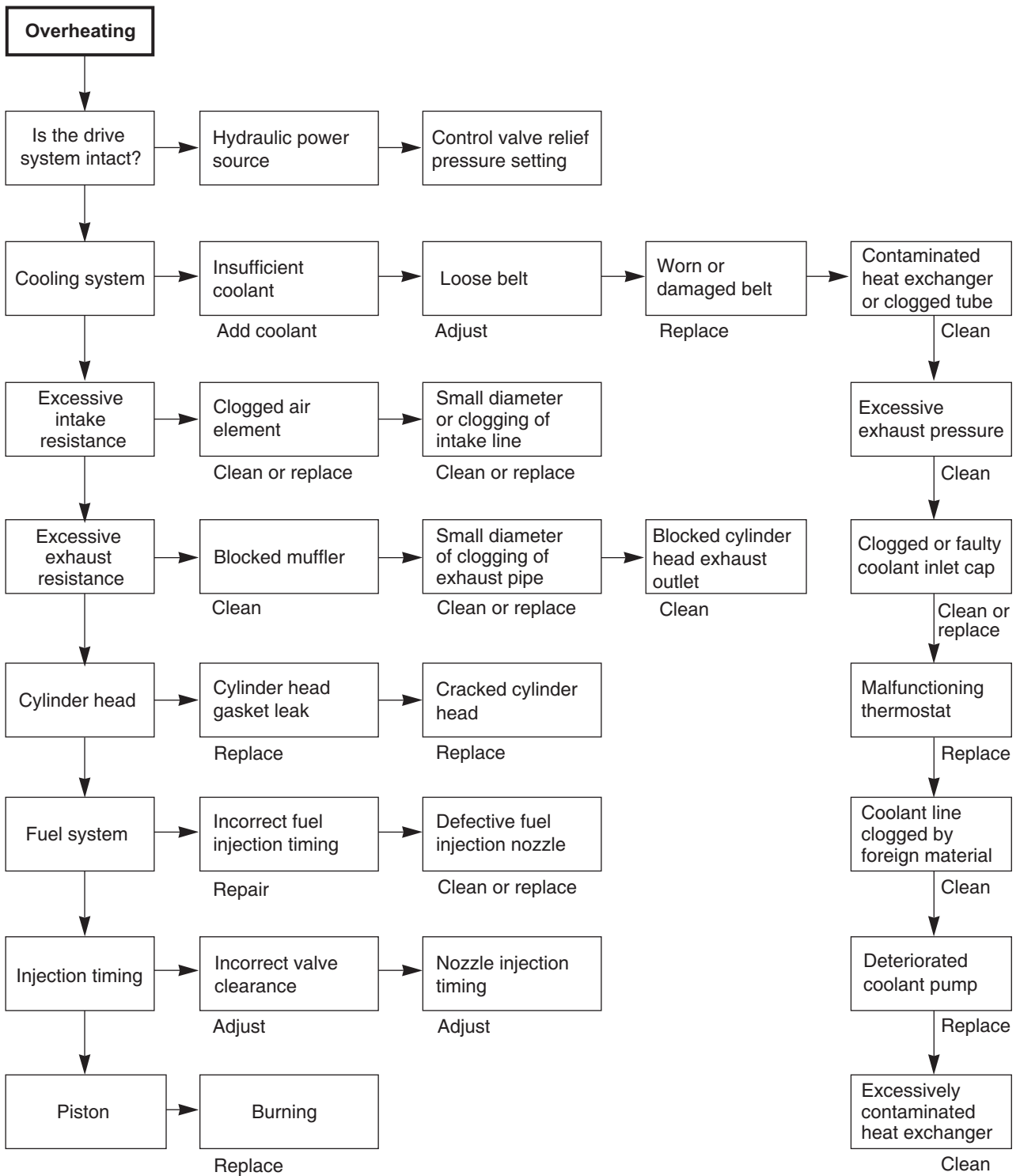
## 8. Troubleshooting

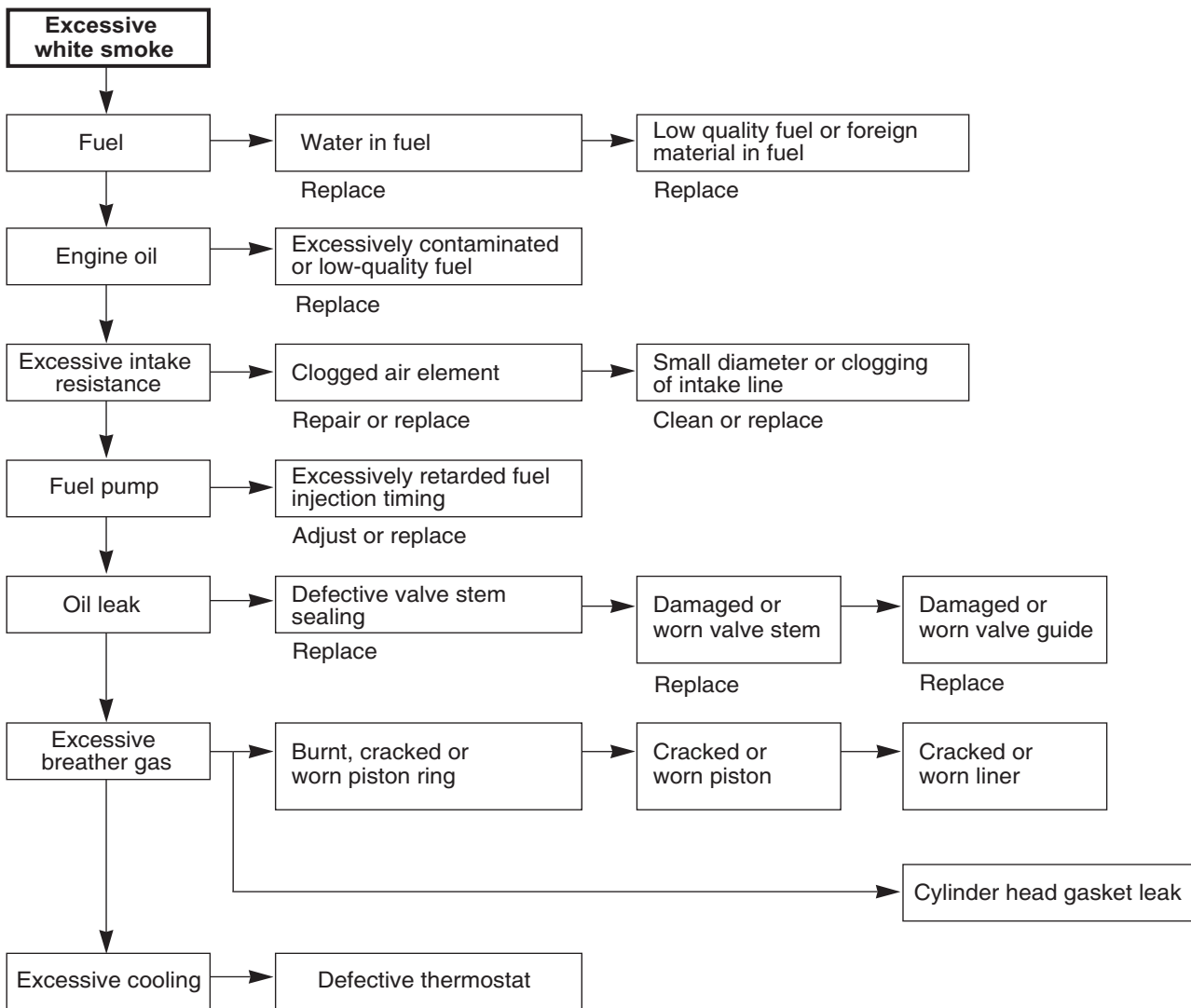
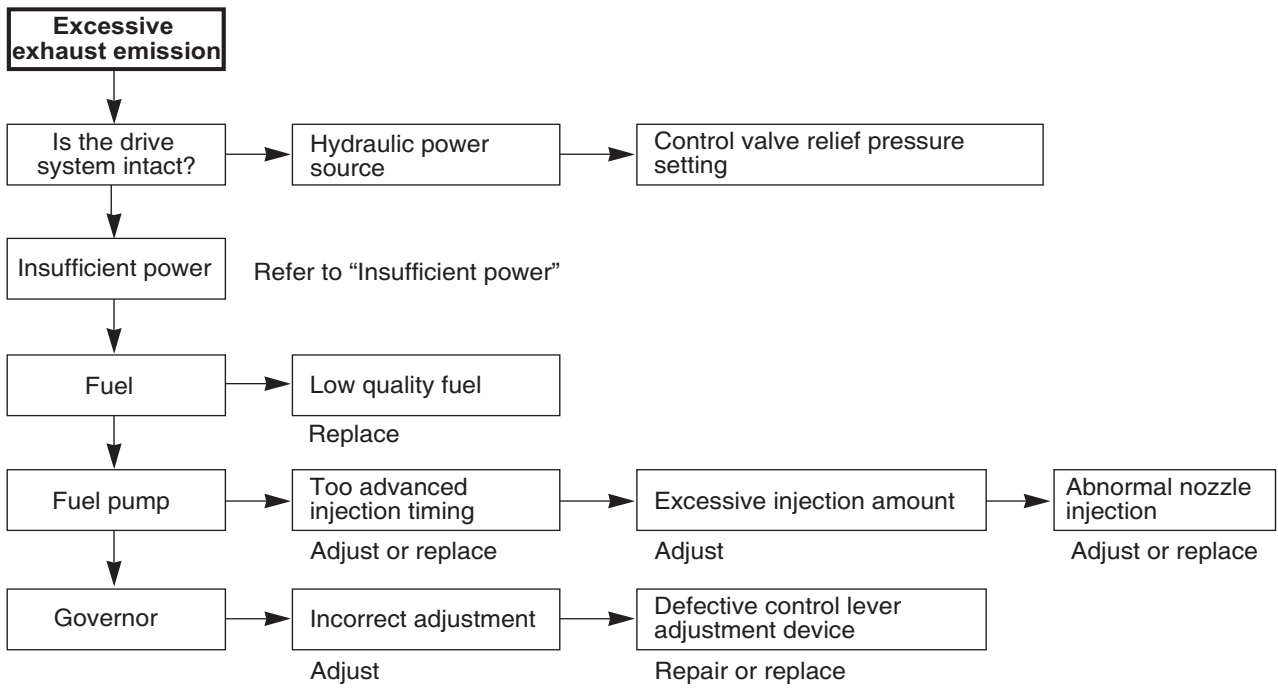
The following table is a summary of the possible causes and troubleshooting measures for faults which may occur during engine operation.

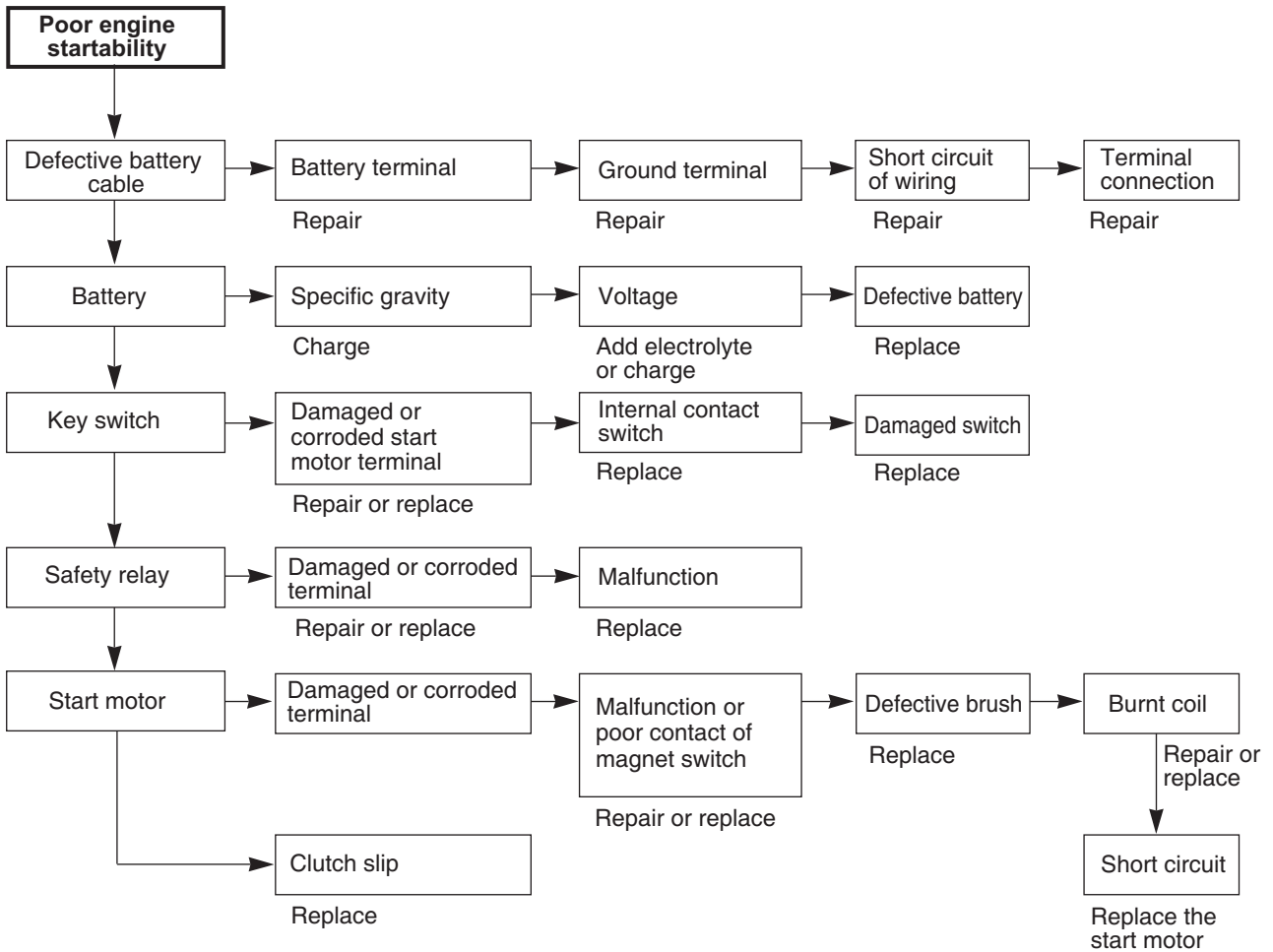
If signs of a problem are found, take action immediately before an even greater problem occurs.



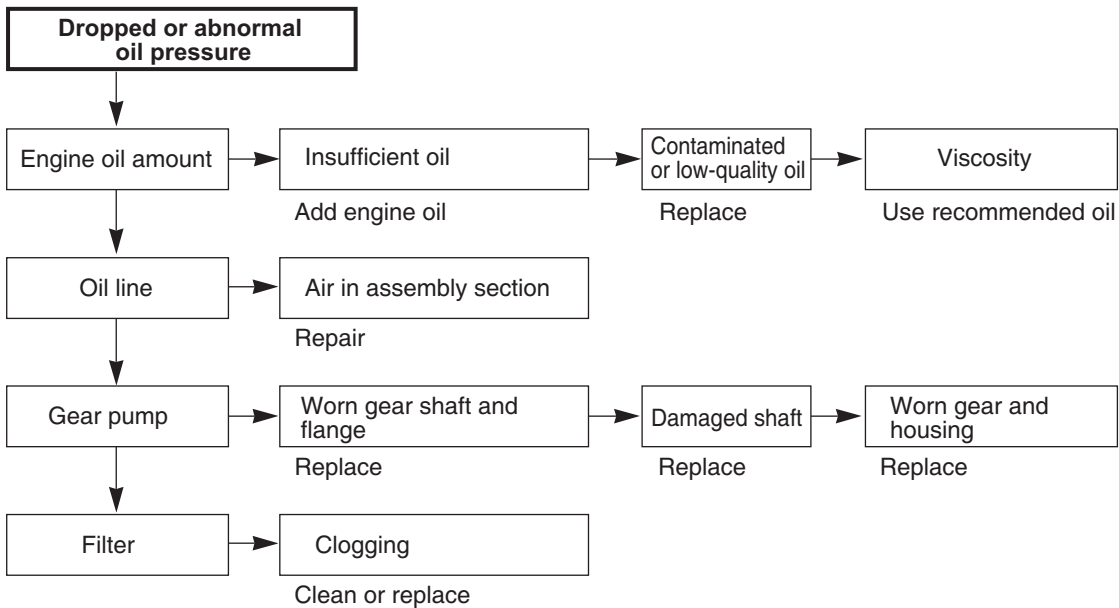


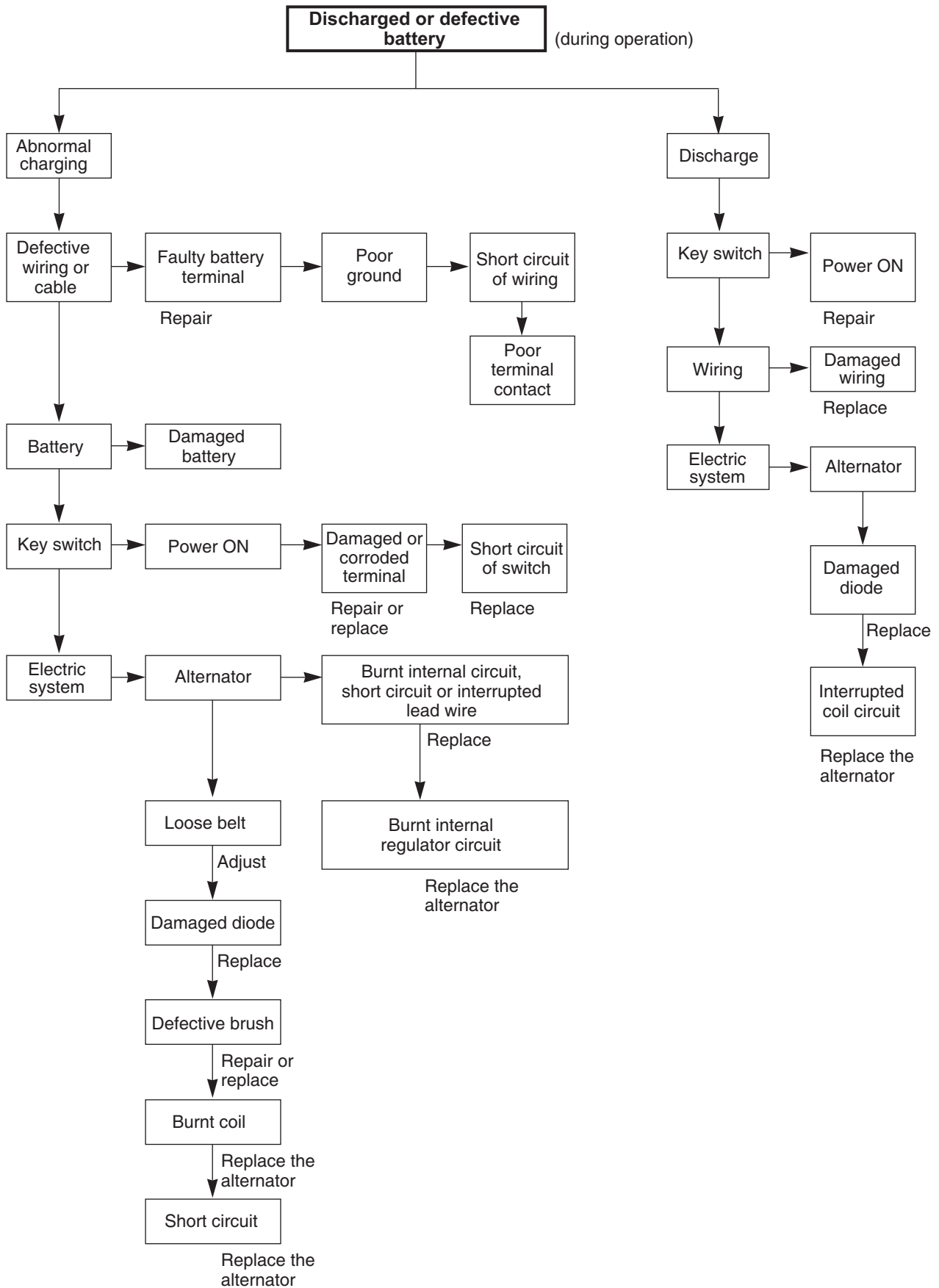






(Hydraulic power source)





## Appendix

### ● Main Tightening Torques

<Chart of Specified Tightening Torques>

Main components	Screw (dia. X pitch)	Strength (class)	Tightening torque
Cylinder head bolt	M16 × 1.5	10.9 T	6 kg·m + 90° + 90° + 30°
Connecting rod bearing cap bolt	M14 × 1.5	12.9 T	28.0 kg·m
Crankshaft main bearing cap bolt	M16 × 1.5	12.9 T	30.0 kg·m
Balance weight mounting bolt	M14 × 1.5	10.9 T	9.0 kg·m
Flywheel mounting bolt	M14 × 1.5	10.9 T	18.0 kg·m
Crankshaft mounting bolt	M12 × 1.5	10.9 T	13.4 kg·m

<Tightening Torque for Injection Pump System>

Component	Tightening torque
Injection nozzle HPC nut	3.5 kg·m

<Standard Bolt Tightening Torque by Specification>

Refer to the following table for bolts not mentioned in previous chapters.

Dia. x pitch (mm)	Strength class										
	3.6 (4A)	4.6 (4D)	4.8 (4S)	5.6 (5D)	5.8 (5S)	6.6 (6D)	6.8 (6S)	6.9 (6G)	8.8 (8G)	10.9 (10K)	12.9 (12K)
M5 x Std.	0.15	0.16	0.25	0.22	0.31	0.28	0.43	0.48	0.50	0.75	0.90
M6 x Std.	0.28	0.30	0.45	0.40	0.55	0.47	0.77	0.85	0.90	1.25	1.50
M7 x Std.	0.43	0.46	0.70	0.63	0.83	0.78	1.20	1.30	1.40	1.95	2.35
M8 x Std.	0.70	0.75	1.10	1.00	1.40	1.25	1.90	2.10	2.20	3.10	3.80
M8 x 1	0.73	0.80	1.20	1.00	1.50	1.35	2.10	2.30	2.40	3.35	4.10
M10 x Std.	1.35	1.40	2.20	1.90	2.70	2.35	3.70	4.20	4.40	6.20	7.20
M10 x 1.25	1.50	1.60	2.50	2.10	3.10	2.80	4.30	4.90	5.00	7.00	8.40
M12 x Std.	2.40	2.50	3.70	3.30	4.70	4.20	6.30	7.20	7.50	10.50	12.50
M12 x 1.25	2.55	2.70	4.00	3.50	5.00	4.50	6.80	7.70	8.00	11.20	13.40
M14 x Std.	3.70	3.90	6.00	5.20	7.50	7.00	10.00	11.50	12.00	17.00	20.00
M14 x 1.5	4.10	4.30	6.60	5.70	8.30	7.50	11.10	12.50	13.00	18.50	22.00
M16 x Std.	5.60	6.00	9.00	8.00	11.50	10.50	15.50	17.90	18.50	26.00	31.00
M16 x 1.5	6.20	6.50	9.70	8.60	12.50	11.30	17.00	19.50	20.00	28.00	35.50
M18 x Std.	7.80	8.30	12.50	11.00	16.00	14.50	21.00	27.50	28.50	41.00	43.00
M18 x 1.5	9.10	9.50	14.40	12.50	18.50	16.70	24.50	27.50	28.50	41.00	49.00
M20 x Std.	11.50	12.00	18.00	16.00	22.00	19.00	31.50	35.00	36.00	51.00	60.00
M20 x 1.5	12.80	13.50	20.50	18.00	25.00	22.50	35.00	39.50	41.00	58.00	68.00
M22 x Std.	15.50	16.00	24.50	21.00	30.00	26.00	42.00	46.00	49.00	67.00	75.00
M22 x 1.5	17.00	18.50	28.00	24.00	34.00	29.00	47.00	52.00	56.00	75.00	85.00
M24 x Std.	20.50	21.50	33.00	27.00	40.00	34.00	55.00	58.00	63.00	82.00	92.00
M24 x 2.0	23.00	35.00	37.00	31.00	45.00	38.00	61.00	67.00	74.00	93.00	103.00

Notes :

1. The torque classes specified above are based on a 70% bolt elastic limit.
2. The tensile force is the tensile strength multiplied by the cross sectional area of the screw.
3. Special screws should be tightened only to 85% of the standard value. For example, MoS2-coated screws should be tightened to 60% of the standard value.

● Specification Chart for Maintenance of Main Components

Unit : mm

Item	Component	Inspection item	Assembly standard	Usable limit	Repairs	Remarks	
Engine body	Cylinder block and liner	Worn inside diameter of cylinder liner	∅ 123 - ∅ 123.025	∅ 123.223	Replace cylinder liner.	Measure non-worn part under upper rim	
		Liner protrusion	0.03 - 0.08		There must be protrusion	0.15 ↓ difference in protrusion with nearby liner	
		Flatness of warped upper surface of cylinder block	0.05		Correct with surface grinder	For length of 200 mm	
		Hydrostatic test (one minute) (kg/cm <sup>2</sup> )	4		Replace if leaking oil		
	Cylinder head and valve	Valve seat depression	0 - 0.3	0.55	-	Replace the valve seat	
			0 - 0.3	0.55	-		
		Cylinder head height	154.7 - 155.3	153.7	Replace cylinder head		
	Hydrostatic test (one minute) (kg/cm <sup>2</sup> )	4		Replace if leaking oil	Water temperature: 70 °C		
Main drive components	Piston	Piston O.D.	∅ 122.854 - ∅ 122.886		Replace the liner	Measure at 13 mm from bottom surface of piston	
		Clearance between piston and liner	0.123 - 0.162		Replace if wear exceeds the specification		
		Piston ring groove width	3.5			Replace piston if groove width exceeds standard value	
			3.060 - 3.080				
			4.040 - 4.060				
		Piston protrusion from upper surface of cylinder block	0 - 0.12				Measure under non-worn edge of top part
	Allowable weight difference among pistons	±15 g	96 g ↓	Replace piston			
	Piston ring	Piston ring gap	Top ring	0.30 - 0.45	1.5	Replace ring	Standard gauge I.D. : ∅ 123
			Second ring	1.0 - 1.2	2.0		
			Oil ring	0.30 - 0.50	1.5		
		Piston ring side gap	Top ring			Replace ring or piston	Usable limit for standard gap
			Second ring	0.07 - 0.102	0.15		
			Oil ring	0.05 - 0.085	0.15		
		Direction of ring clearance			Install rings at 120° intervals from one another		

Item	Component	Inspection item	Assembly standard	Usable limit	Repairs	Remarks
Main drive components	Crankshaft	Unevenly worn journal and pin	0.05	0.1	Repair with grinder	Measure in vertical and horizontal directions
		Journal O.D.	Ø95.966 - Ø95.988	Ø94.966	Replace crankshaft	Ø96g6
		Pin O.D.	Ø82.966 - Ø82.988	Ø81.966	Replace crankshaft	Ø83g6
		Ovalness of journal and pin	0.008	0.025		
		Allowable concentricity of journal and pin	0.01	0.03		
		Allowable inclination of journal and pin	0.01	0.03		
		Crankshaft and bearing clearance	0.072 - 0.142	0.25	Replace bearing	Measure on crown
		Crankshaft free play	0.15 - 0.325	0.5	Replace thrust bearing	
		Deflection of crankshaft	0.05	0.1 or less	Correct deflection with press	Measure at no.4 (Supporting No. 1 and 7)
		Crankshaft balance (g.cm)	60	60 or less	Check dynamic balancing	Measure at 400 rpm
		Journal bearing cap bolt tightening torque (kg.m)	30		Apply oil to bolt	There should be no foreign material on the bearing cap mounting surface
		Journal bearing crush	0.15 - 0.25			Tighten the metal cap and unscrew one stud bolt for measurement
		Worn oil seal (Back side of crankshaft)			Replace oil seal if there are any oil leaks	Replace with new part. Use a shim
	Connecting rod	Connecting rod free play	0.22 - 0.319	0.50	Replace connecting rod	
		Clearance between connecting rod bearing and crankpin	0.049 - 0.119	0.20	Replace bearing	
		Clearance between small end bushing and piston pin	0.050 - 0.080	0.12		Install bearing, then unscrew one bolt to measure
		Height of connecting rod bearing crush	0.086 - 0.116			Tighten bearing cap, then unscrew one stud bolt to measure
		Allowable weight difference among connecting rods	±18 g			
		Connecting rod bearing cap bolt torque (kg.m)	28		Apply oil to bolt	
	Camshaft	Camshaft O.D.	Ø59.86 - Ø59.88	Ø59.56		Ø60
		Clearance between camshaft and bushing	0.045 - 0.100	0.20		
Camshaft axial play		0.14 - 0.25	0.30	Replace thrust plate		

Item	Component	Inspection item	Assembly standard	Usable limit	Repairs	Remarks		
Main drive components	Timing gear	Clearance between idler gear shaft and insertion hole	0.048 - 0.096	0.19				
		End play of idler gear shaft	0.107 - 0.203	0.25	Replace thrust collar			
		Clearance between crank gear and oil pump idler gear	0.060 - 0.184	0.26	Replace gear			
		Between oil pump idler gear and oil pump gear	0.020 - 0.292	0.41				
		Crank gear and idler gear A	0.062 - 0.194	0.27				
		Between idler gear B and camshaft gear	0.090 - 0.236	0.33				
		Between idler gear and fuel injection pump gear	0.090 - 0.236	0.33				
Valve system	Valves	Intake valve stem O.D.	Ø7.963 - Ø7.977	Ø7.943	Replace valve and guide	When replacing the valve, replace the valve guide as well		
		Exhaust valve stem O.D.	Ø7.950 - Ø7.964	Ø7.920				
		Clearance between valve stem and valve guide	Intake	0.023 - 0.052	0.10	Replace valve and guide		
			Exhaust	0.036 - 0.065	0.15	Replace		
		Valve thickness	Intake	3.3 - 3.7	2.8	Replace		
			Exhaust	4.0 - 4.4	3.5			
		Clearance between valve guide and cylinder head mounting hole		0.01 - -0.39			Apply oil to valve guide	
		Allowable radial runout between valve stem and valve head	Intake	0.04 - 0.07	0.2	Replace		
			Exhaust	0.06 - 0.09	0.25			
		Intake spring	Exterior	Free length	62.5	-	Replace valve spring	
				Spring tension (P1/P2) kg	44.0 31.6	37.4 - 41.4 63.3 - 68.3		
				Straightness (compared to free length)	1.6	2.0		
		Exhaust spring	Exterior	Free length	62.5	-	Replace valve spring	
				Spring tension (P1/P2) kg	44.0 31.6	37.4 - 41.4 63.3 - 68.3		
Straightness (compared to free length)	1.6			2.0				

Item	Component	Inspection item	Assembly standard	Usable limit	Repairs	Remarks
Valve system	Tappet	Clearance between rocker arm shaft and rocker arm bushing	0.015 - 0.059	0.12	Replace bushing or shaft	
		Rocker arm shaft wear	Ø24.953 - Ø24.976	Ø24.916	Replace	
		Allowable pushrod taper	0.3		Replace	
		Clearance between tappet and cylinder block	0.035 - 0.077	0.15	Replace tappet	
		Tappet O.D.	Ø19.944 - Ø19.965	19.89	Replace tappet	
		Contact surface of tappet and cam	-	-	Replace if excessively deformed or worn	
Lubrication system	Oil pressure	Oil pressure (normal speed) kg/cm <sup>2</sup>	4.5 or below	3.5	Oil leak Check clearance and angle	
		Oil pressure (no load) kg/cm <sup>2</sup>	0.8 - 1.4	0.6	Use recommended oil	
	Oil temperature	Max. allowable oil temp. °C (Main gallery)	-	105		No temperature higher than this are allowed
		Instant allowable oil temp. °C (Main gallery)	-	120		
	Valve opening pressure	Oil pressure adjustment valve (kg/cm <sup>2</sup> )	5.0 - 6.0	-	Replace valve	
		Bypass valve for oil filter element (kg/cm <sup>2</sup> )	1.8 - 2.4			
		Bypass valve for full-flow oil filter (kg/cm <sup>2</sup> )	4.0 - 4.8			
		Bypass valve for oil cooler bypass (kg/cm <sup>2</sup> )	5.0 - 6.0			
		Oil pump relief valve (kg/cm <sup>2</sup> )	9.5 - 12.5			
		Spray nozzle adjustment valve (kg/cm <sup>2</sup> )	1.9 - 2.1			
	Oil filter	Damaged oil filter cartridge			Clean and replace	

Item	Component	Inspection item	Assembly standard	Usable limit	Repairs	Remarks
Cooling system	Coolant pump	Displacement l/min - Engine rpm : 1,800 rpm - Water temp. : 80 °C - Negative pressure : 0.5 kg/cm <sup>2</sup>	Approx. 270		Repair or replace	
		Clearance between pump impeller and housing body	0.5 - 0.9		Replace if impeller and housing are touching one another	
	Coolant temperature	Operating temperature (suitable temperature) °C	94 - 98	95		No temperature higher than this are allowed
		Instant allowable temp. °C	105	105		
	Thermostat	Thermostat opening temperature °C (at atmospheric pressure)	79		Replace	
Fully open temperature of thermostat °C		94 or below		Replace if defective	Lift : Min. 8 mm	
Fuel system	Piping, etc.	Damaged or cracked fuel pipe, injection pipe or nozzle holder; defective packing			Repair or replace	
		Damaged fuel filter cartridge			Replace cartridge	
		Injection nozzle injection pressure (bar)	300		Replace nozzle	
		Injection pump overflow valve opening pressure (kg/cm <sup>2</sup> )	1.5		Replace valve	
		Height of nozzle protrusion from cylinder head surface (mm)	2.13		Replace cylinder head and nozzle	
Complete inspection	Engine test operation				Refer to "Test Operation Items" in the Appendix Note	Retighten head bolt after engine test operation
	Cylinder pressure	Cylinder compression pressure (kg/cm <sup>2</sup> )	24 - 28	24 or higher	Repair	At 200rpm or higher (20 °C)
		Compression pressure difference among cylinders	±10% or less compared to average		Repair	

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

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# 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.

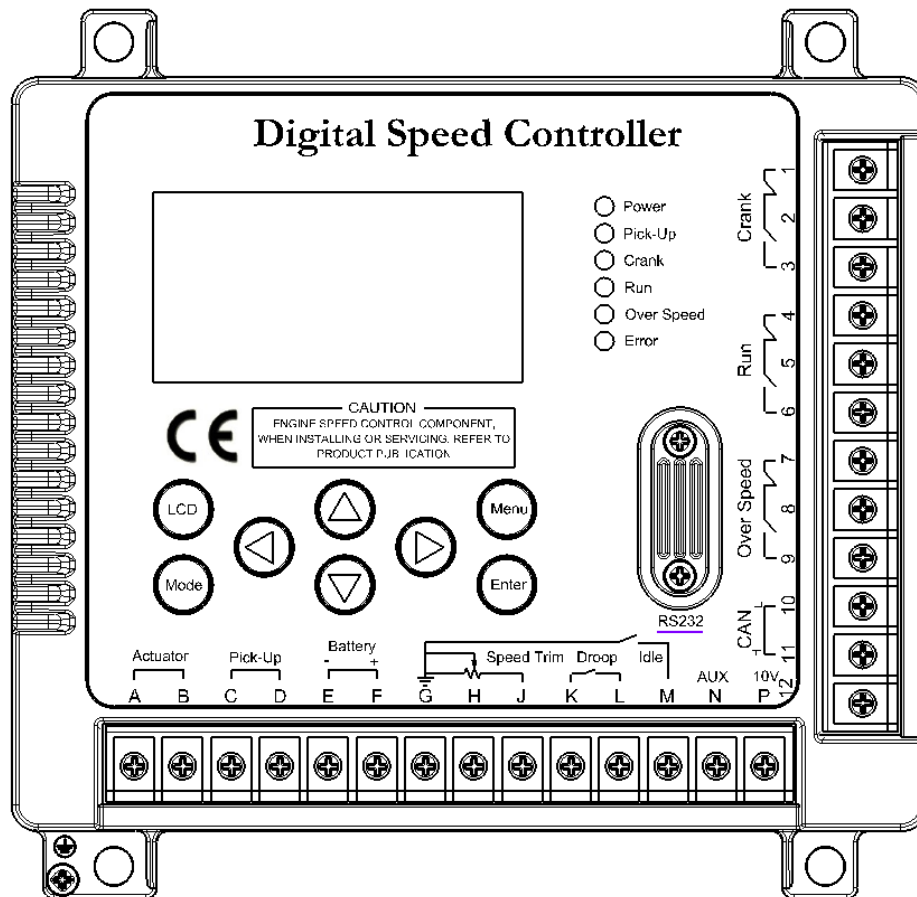


Figure 1: Product Front View

### 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°C
11	Storing Temperature	-30 to +80°C
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.

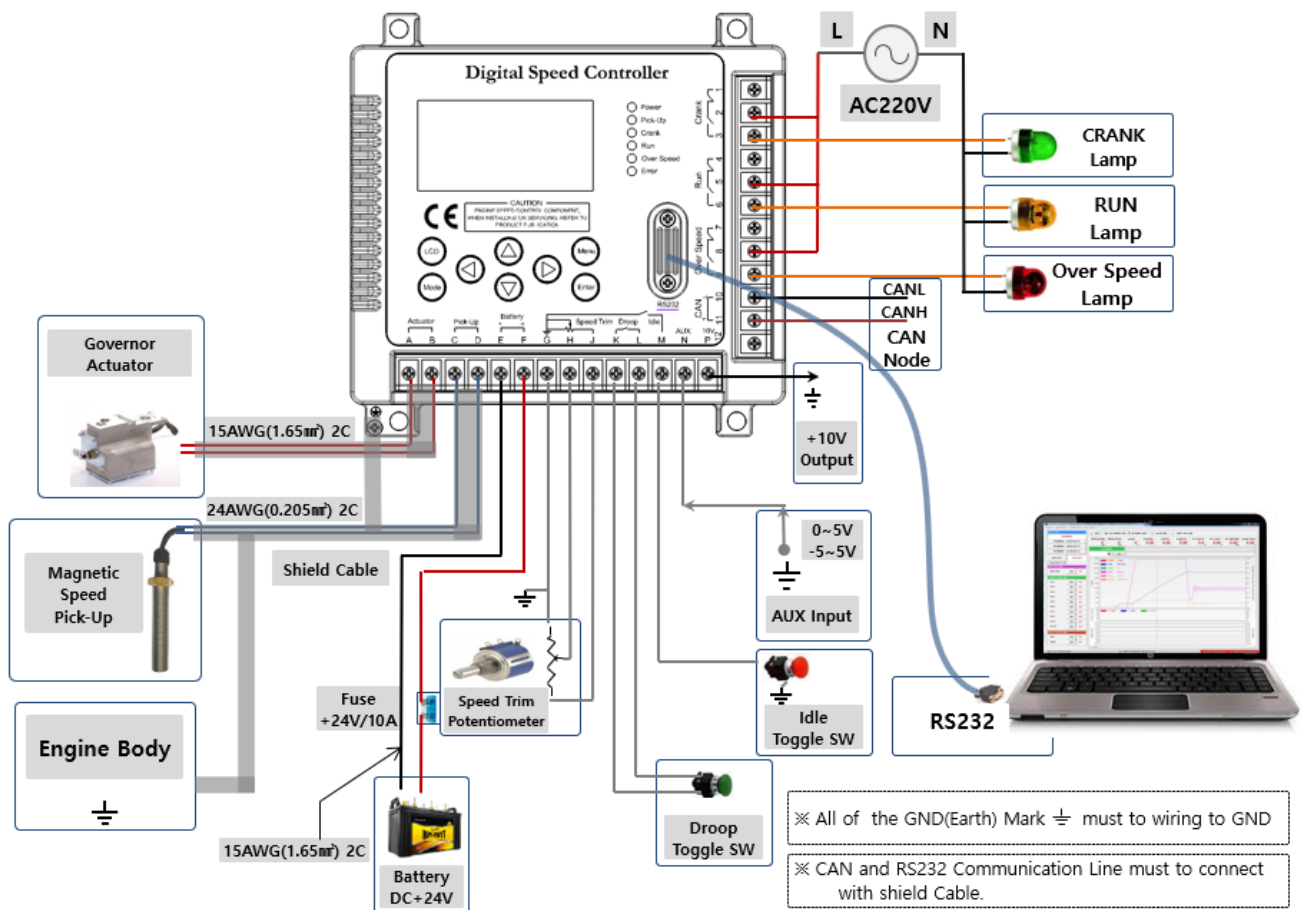


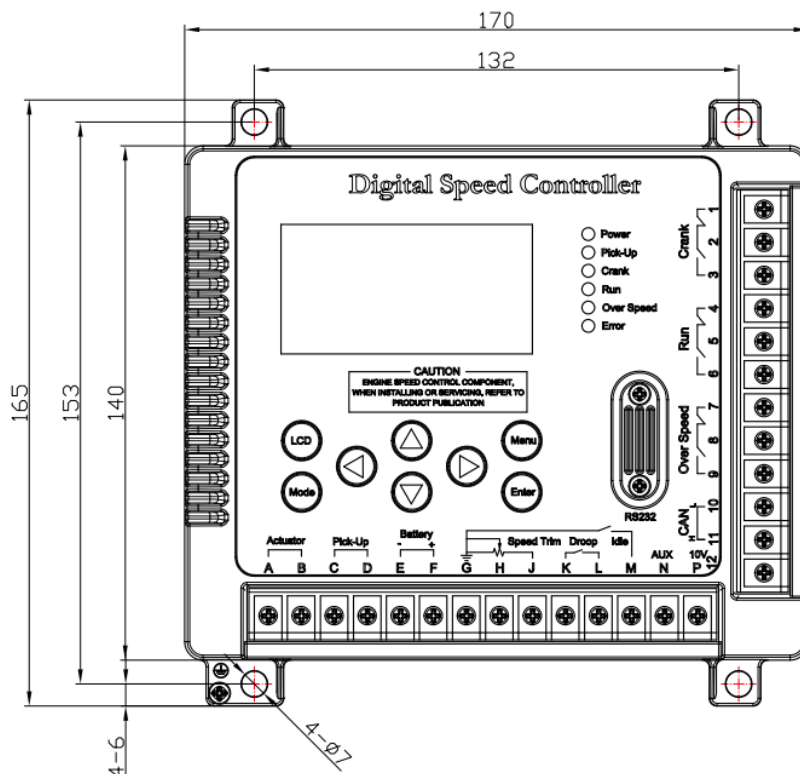
Figure 2: System Diagram for Digital Speed Controller

## 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°C) or better. (However, terminals A and B can be used regardless of their polarities. Actuator's shield 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

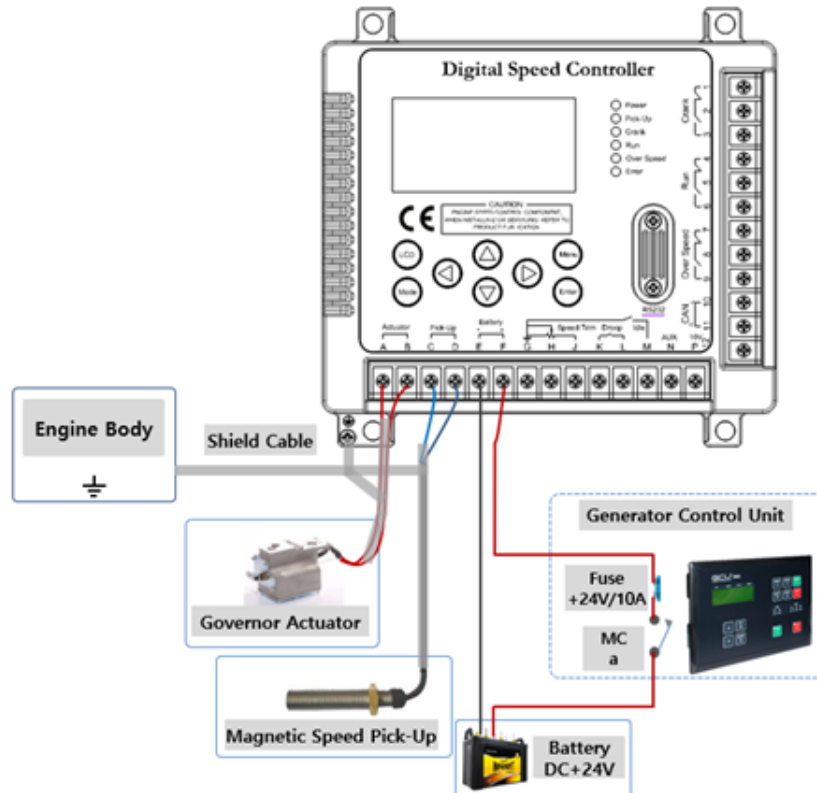


Figure 3: Battery, Pick-Up and Actuator Connection Diagram

### 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°C) 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.

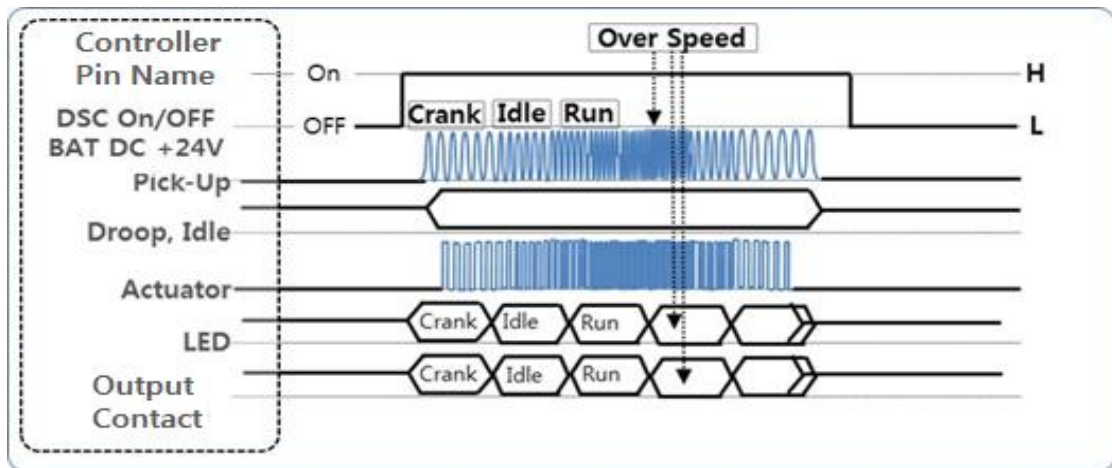


Figure 4: Time Chart for Operation of the Controller

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

### 2.2.1 Speed Trim, Droop, Idle and Other Inputs Diagram

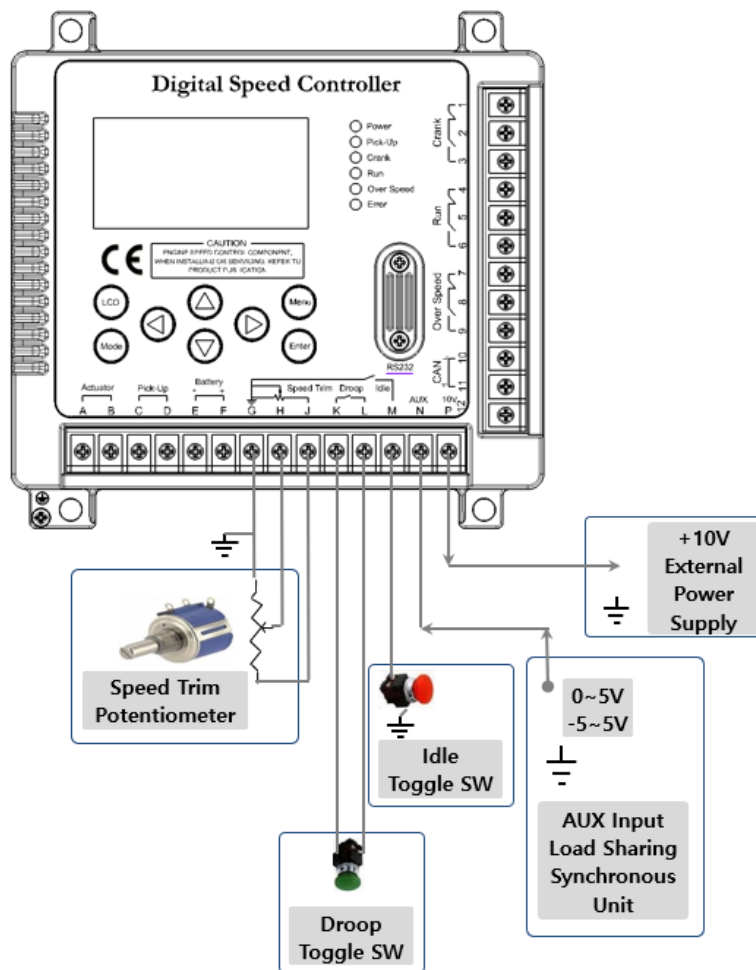


Figure 5: Speed Trim, Droop, Idle and Other Inputs Diagram

### 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.

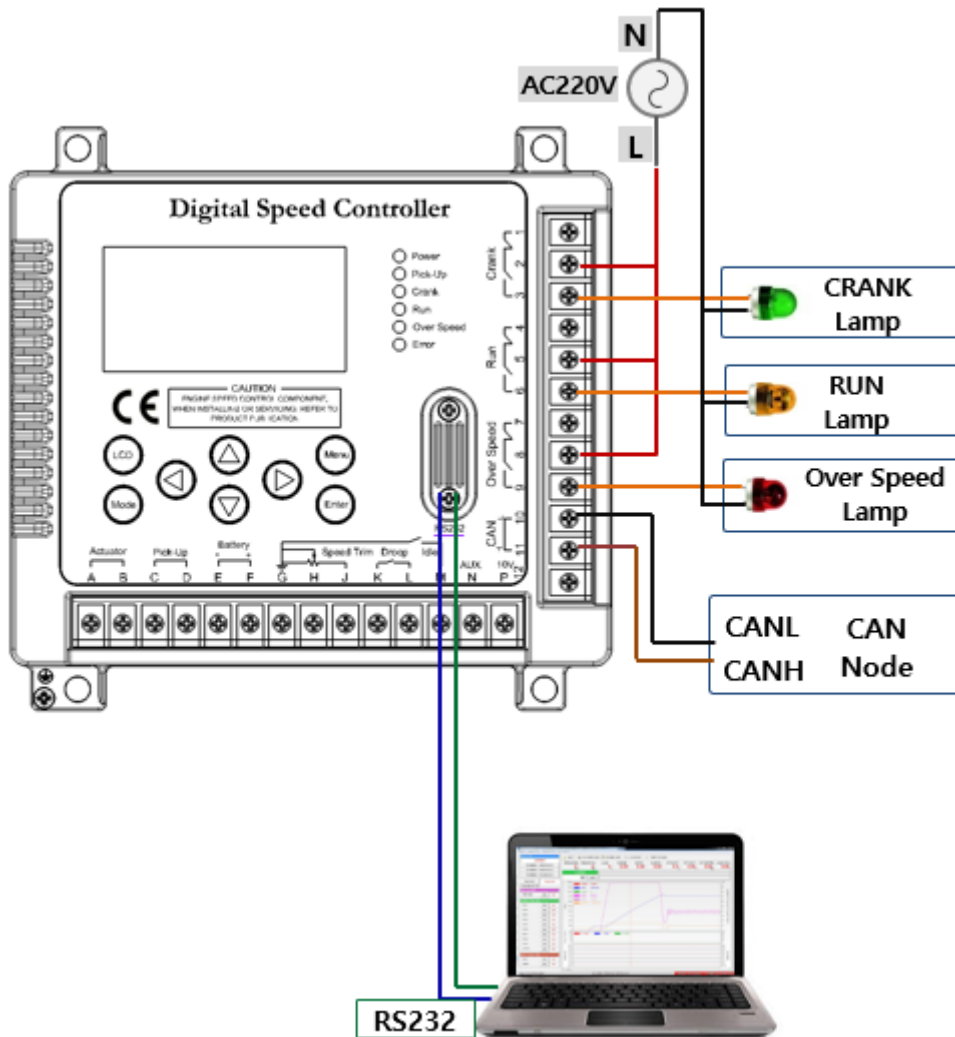
### 2.2.6 Connecting Power to External Devices

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** LCD key turns on and off the display.
-  **Mode** Mode key switches the display to either operation mode or wave form display.
-  **Menu** Menu key lets users change the menu display and go back to the previous menu.
-  **Enter** 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:

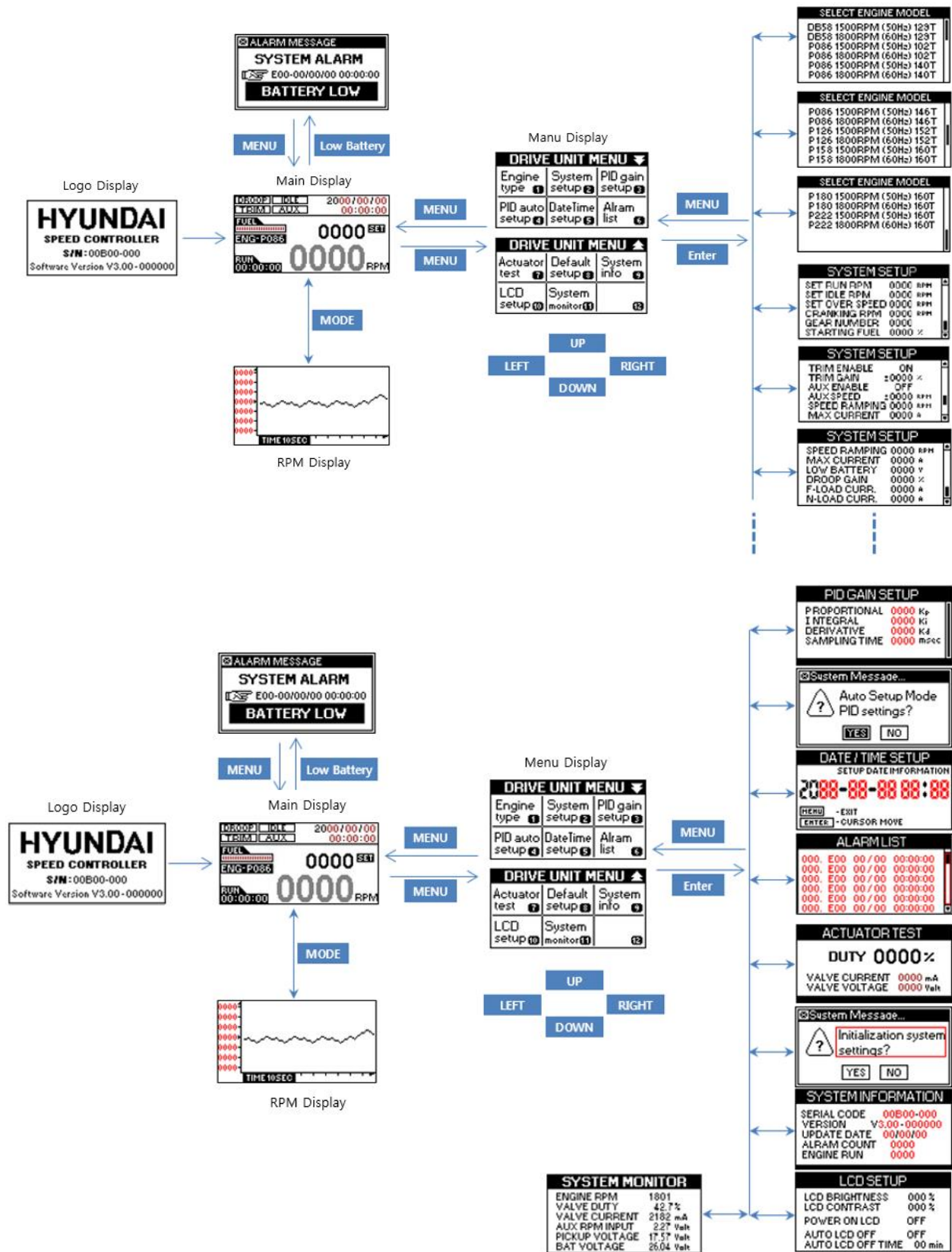


Figure 7: Overall LCD Menu Tree Diagram

### 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.**

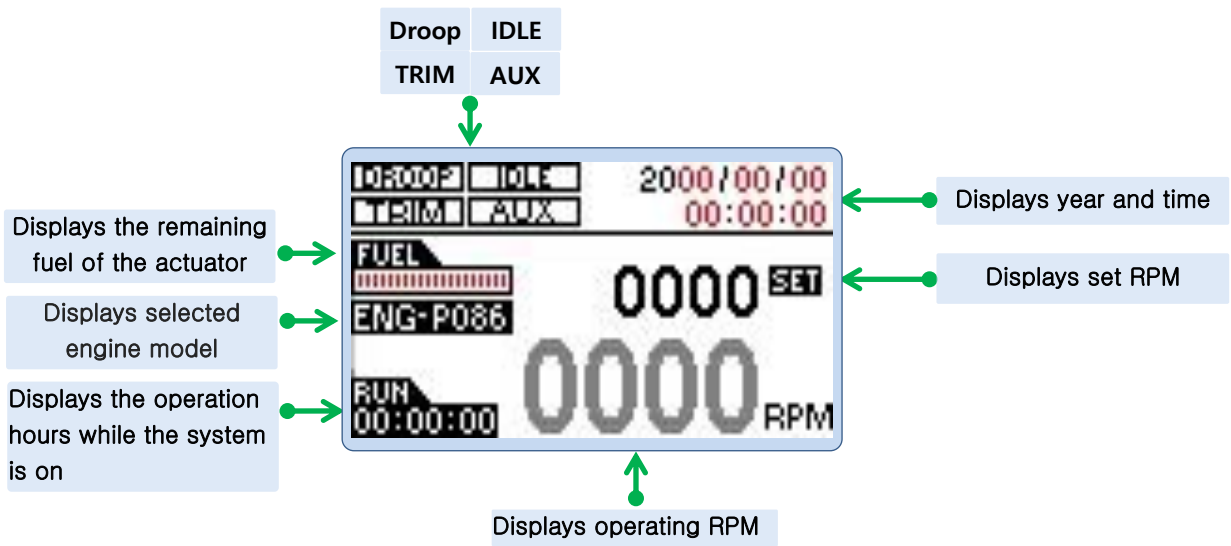
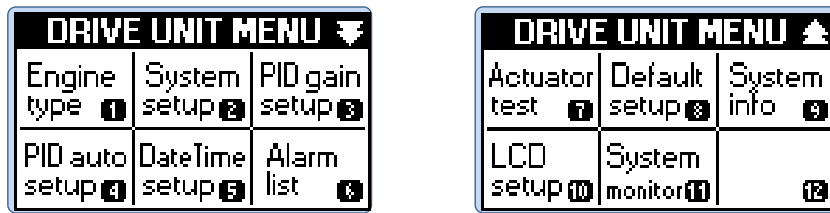


Figure 9: Operation Display

### 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/OVERSPPEED/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

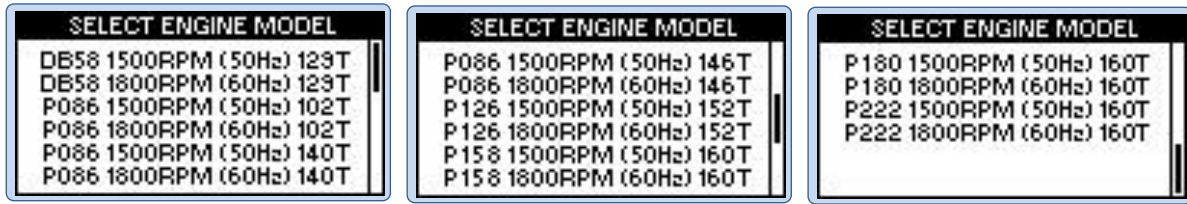
It offers menu to configure LCD operating conditions including brightness, auto on/off and off hours.

#### 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.

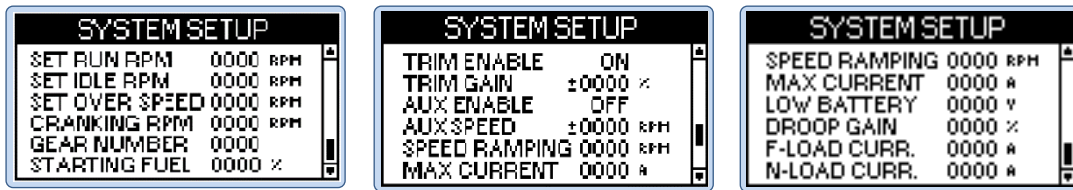


Menu 2: Engine Type Selection Menu

### 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**

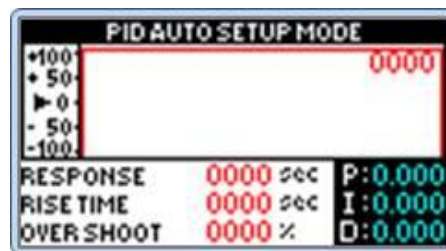
### 3.2.6 PID Auto Setup Menu

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.

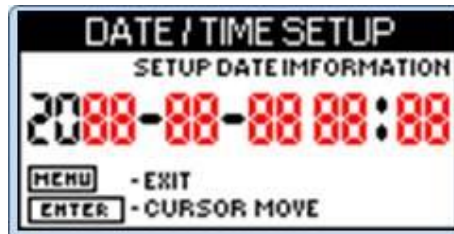
If the controller fails to identify the optimized P, I and D values within 30 cycles, it will display "PID No Successful, OK". When you press Enter, it will apply the final P, I and D values and close the menu.



Menu 5: PID auto setup menu

### 3.2.7 Date/Time Setup Menu

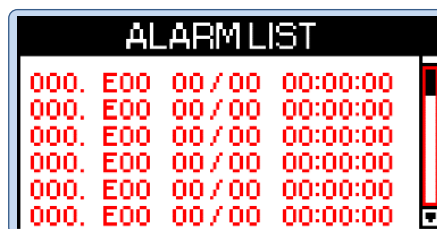
Users can designate year, month, day, hour and minute for the controller and the designated time will be used to monitor the system and manage fault messages.



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.

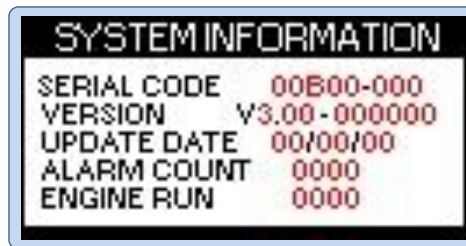
If you press YES, all the configuration values will be changed to the default ones of the engine.



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)

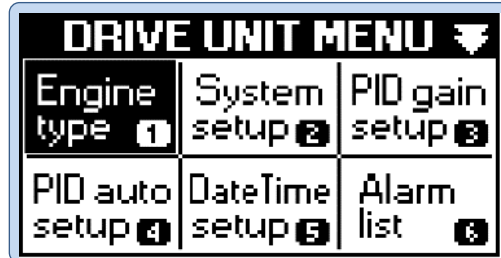
No	Menu Name	Run RPM	Over Speed	Gear Teeth	Starting Fuel	PID Value
1	AD066TI 1500RPM (50Hz) 129T	1500 RPM	1725RPM	129	60%	Optimized Value
2	AD066TI 1800RPM (60Hz) 129T	1800 RPM	2070RPM	129	60%	Optimized Value
3	AD086TI 1500RPM (50Hz) 140T	1500 RPM	1725RPM	140	60%	Optimized Value
4	AD086TI 1800RPM (60Hz) 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**

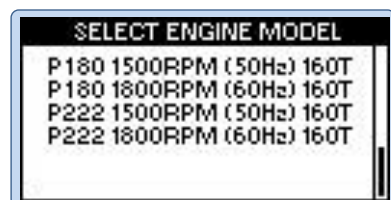
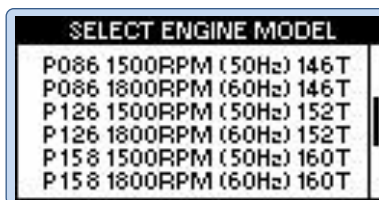
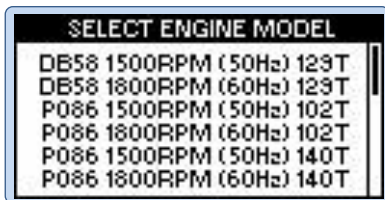
- **Engine Configuration Procedure**

**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

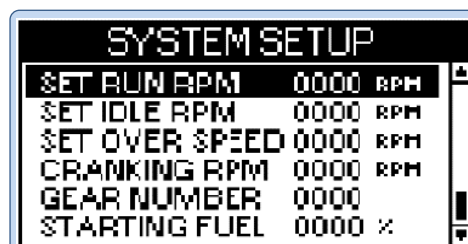
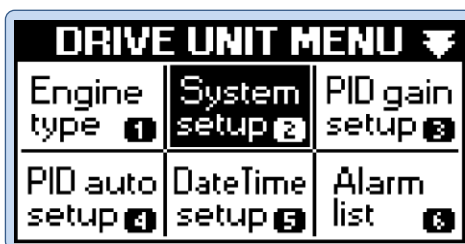
Main setting items of the controller includes **GEAR NUMBER**, **CRANKING RPM** and **SET RUN RPM**. You need to designate setting values to these items. Other system setup items are optional and therefore you can designate values for those items as necessary.

- **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.

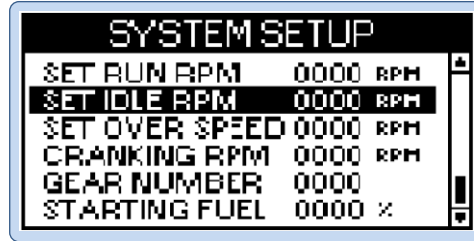
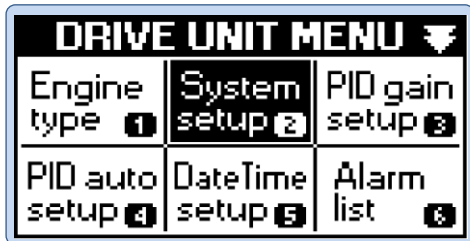


- **Configuring SET IDLE RPM**

**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.

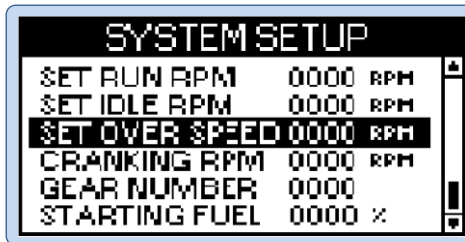
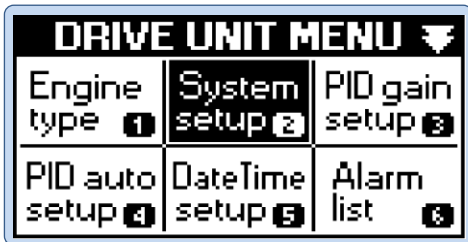


- **Configuring SET OVER SPEED**

**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.

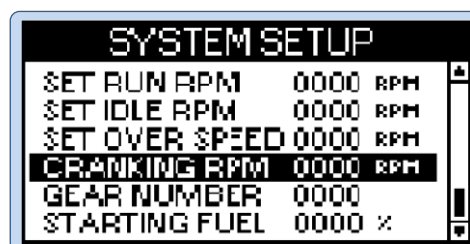
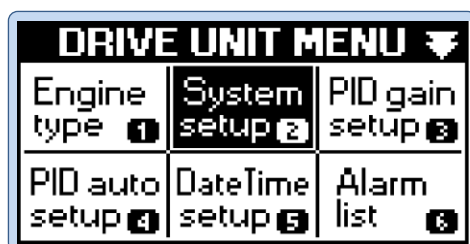


- **Configuring CRANKING RPM**

**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.

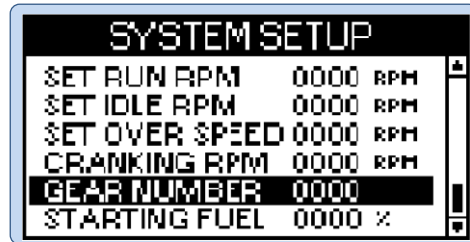
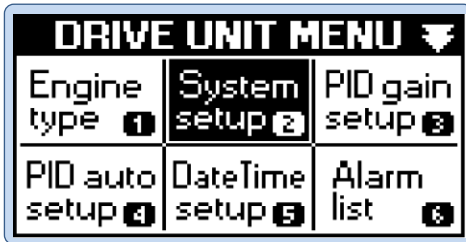


- Configuring **GEAR NUMBER**

**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.

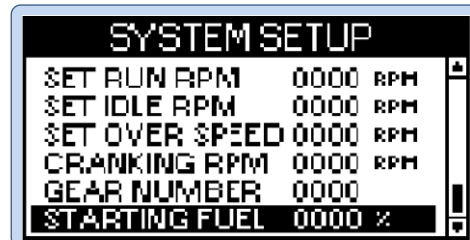
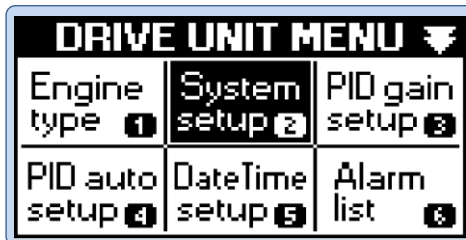


- Configuring **STARTING FUEL**

**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.

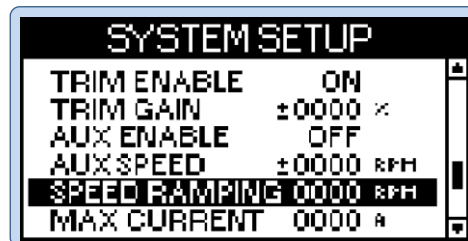
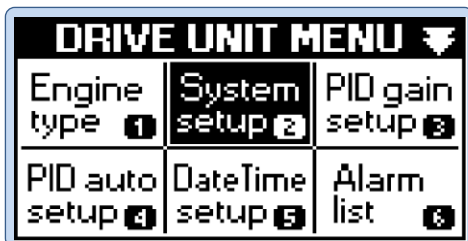


- Configuring **SPEED RAMPING**

**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.

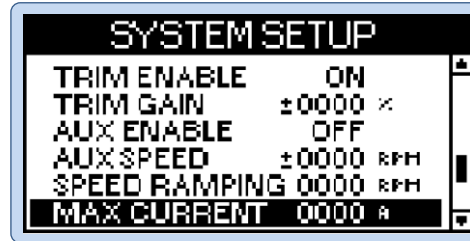
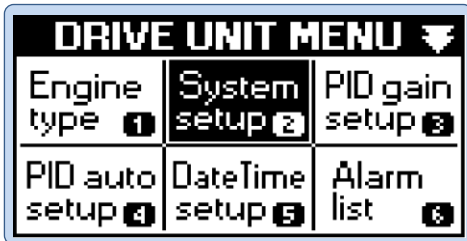


- Configuring **MAX CURRENT**

**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).

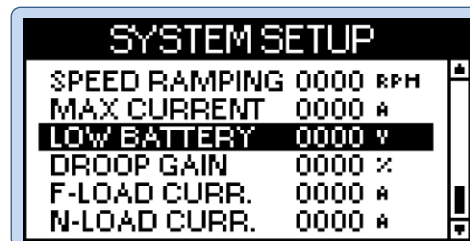
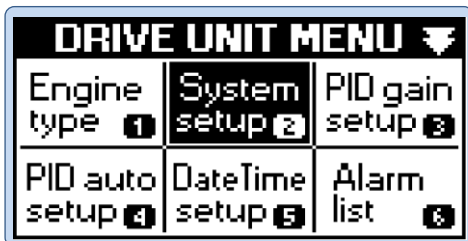


- Configuring **LOW BATTERY**

**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.

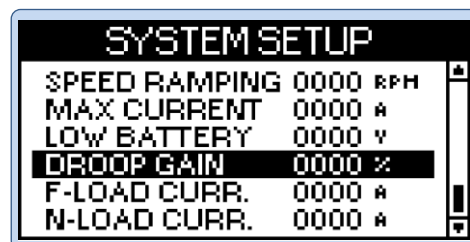
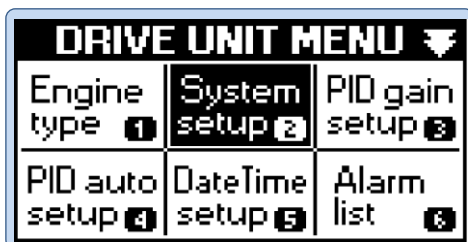


- Configuring **DROOP GAIN**

**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.



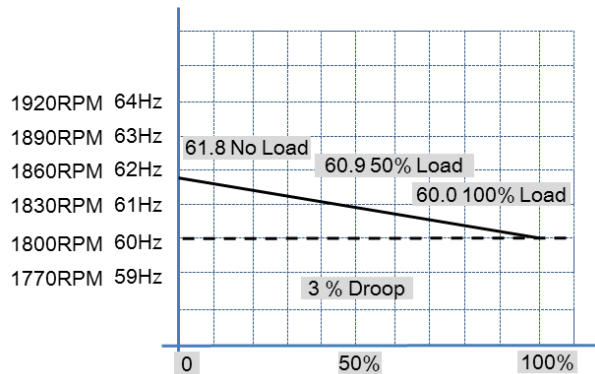
**DROOP Function**

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.

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

**(Example for 3% Droop)**

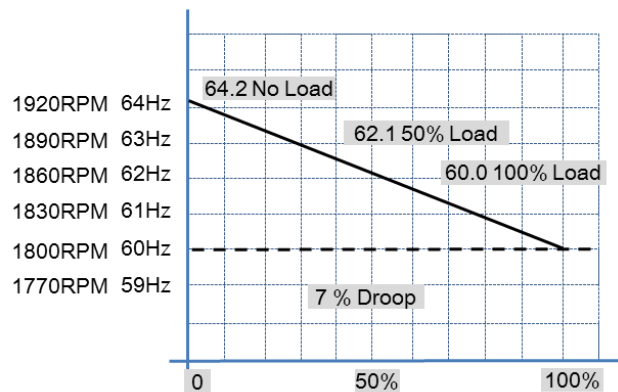
Assuming that RPM with no load is 1,800 and RPM with maximum load is 1,854 then the percentage will be 3%. It means that the generator output will be changed by 33.3% as the frequency changes by 1% due to the actuator control.



**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.



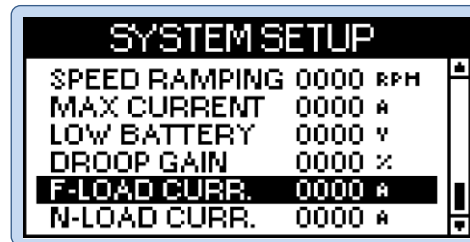
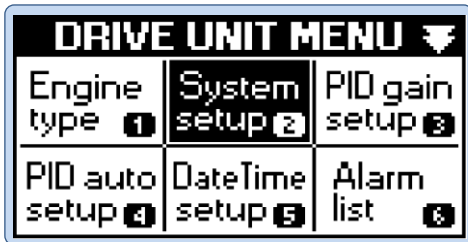
**Figure 11: 7% Droop**

- **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.

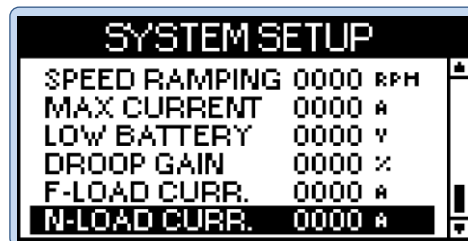
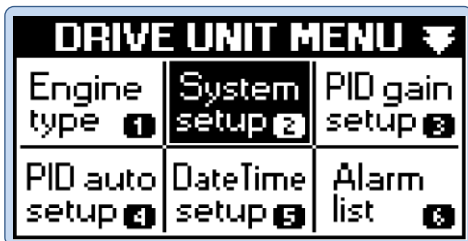


- **N-LOAD CURR.**

**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.



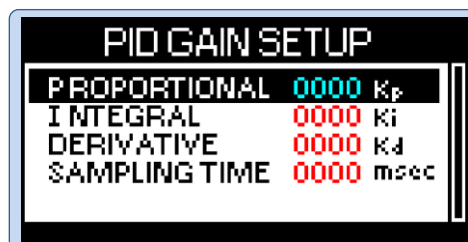
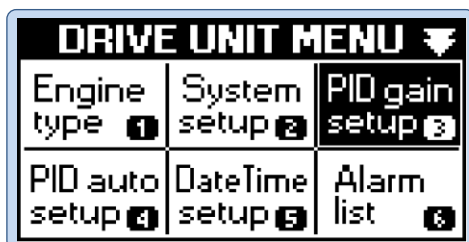
### 3.3.3 PID Gain Setup Configuration

- **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.

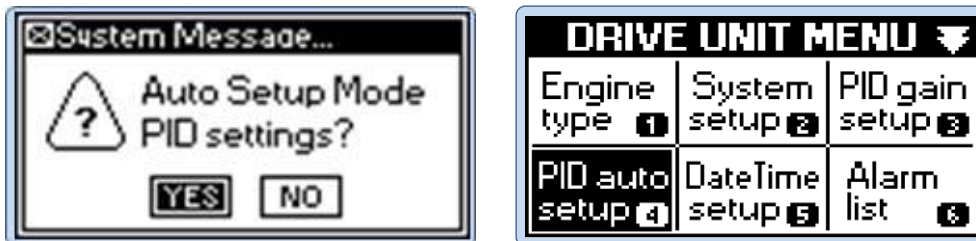


### 3.3.4 PID Auto Setup Value Configuration

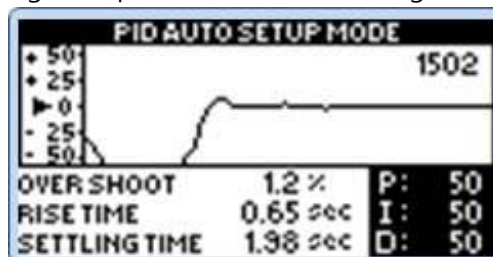
**Step1)** Select your type in Engine Type menu and then start the engine with the preset configuration values maintaining it with no load.

**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 settings?" 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

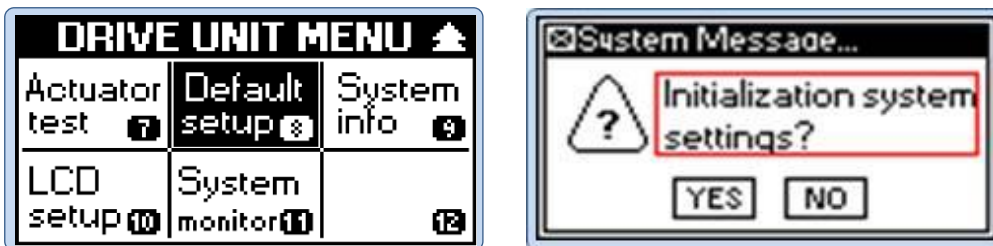
**3.3.7 Actuator test**

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 settings?”** 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.

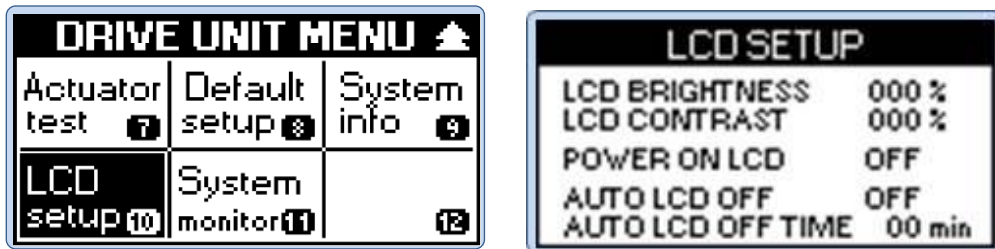


The menu displays information of the controller and the information includes the serial number, software version, last update date, alarm count and engine runs.

### 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 ( $\pm 10\%$ ). 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

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# 1. General Information

## 1.1 Product Information

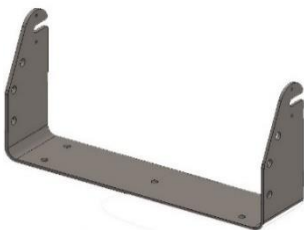
The name of the product model is a digital panel applicable to ships, generators and other various marine engines. The product is intended to improve problems of existing analog panels and allow users to check engine controls and conditions by means of a digital visualization product. It provides information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

## 1.2 Components and Optional Accessories

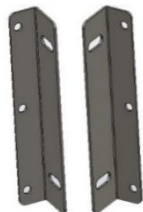
### Components



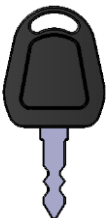
① Digital Panel



② Desk Mounting Type Bracket



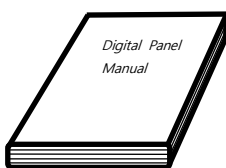
③ Flush Mounting Type Bracket



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	<ul style="list-style-type: none"><li>Cortex-A8, dsPIC33FJ256</li></ul>
2	Software	<ul style="list-style-type: none"><li>Windows CE 6.0 R2</li></ul>
3	Display	<ul style="list-style-type: none"><li>10.2" Color TFT LCD</li><li>800 * 480 (Pixels)</li><li>16:9</li></ul>
4	Flash Memory	<ul style="list-style-type: none"><li>256MB (Flash)</li><li>8GB (MicroSD card)</li></ul>
5	RAM	<ul style="list-style-type: none"><li>512MB</li></ul>
6	Operating Voltage	<ul style="list-style-type: none"><li>DC 24V (16 to 30V)</li></ul>
7	USB	<ul style="list-style-type: none"><li>USB 2.0 1 Port</li></ul>
8	Operating Temperature	<ul style="list-style-type: none"><li>- 20°C to 70°C</li></ul>
9	Internal Buzzer	<ul style="list-style-type: none"><li>Piezo Buzzer 98dB</li></ul>
10	Communication	<ul style="list-style-type: none"><li>J1939 CAN Communication</li><li>RS232</li></ul>
11	Dimensions	<ul style="list-style-type: none"><li>W 343.5 x H 270.5 x D 120</li></ul>

[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

### 2.3 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

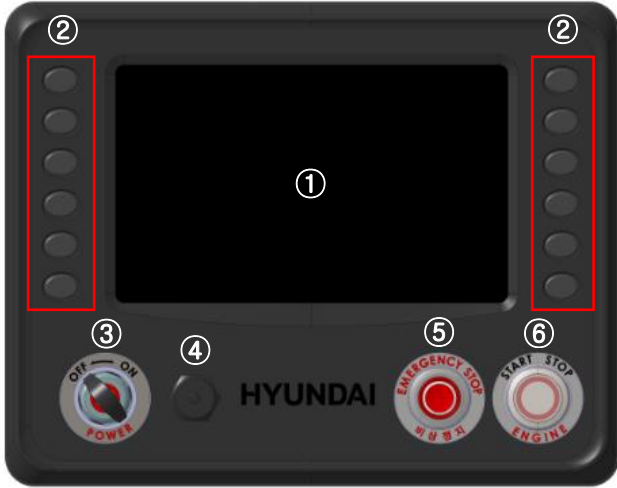
- ① Check whether the bridge has engine harness wiring.
- ② As shown in Fig. 2-6, fix the mounting brackets to both sides of the panel.
- ③ Check the location within reach of the engine harness wiring and the mounting location and then mount the panel using proper bolts.
- ④ Finish gaps between the product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

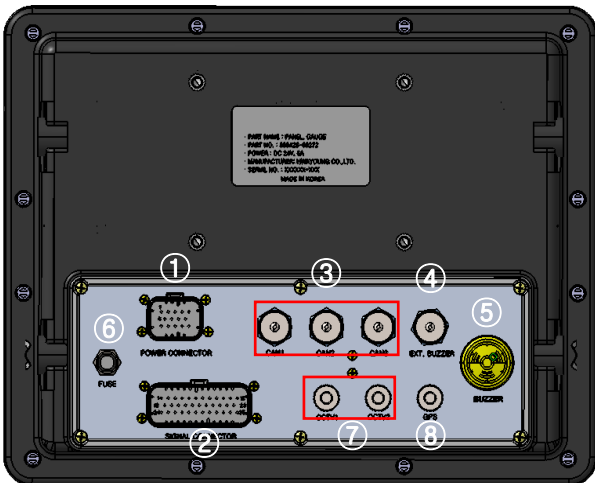


[Fig. 3-1]

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]

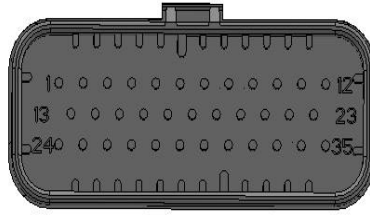


POWER CONNECTOR

[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



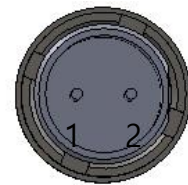
[Fig. 3-5]

[Table 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



EXT. BUZZER

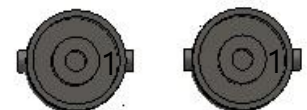
[Fig. 3-6]

[Table 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



CCTV1 CCTV2

[Fig. 3-7]

[Table 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)



USB

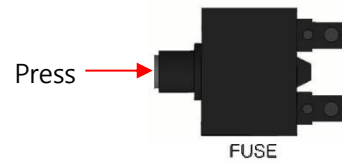
[Fig. 3-8]

## 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.



FUSE

[Fig. 3-9]

### 3.4.2 Internal Buzzer

- Generate alarms for sensor problems



BUZZER

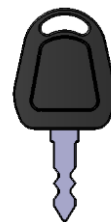
[Fig. 3-10]

## 3.5 Key Switch

---

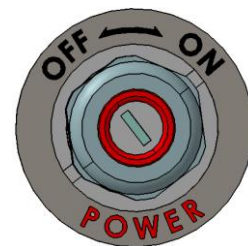
- Key switch is used to boot and turn off the digital panel system or stop the engine.

- 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

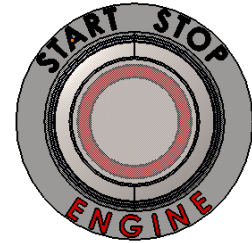
[Fig. 3-12]

## 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.



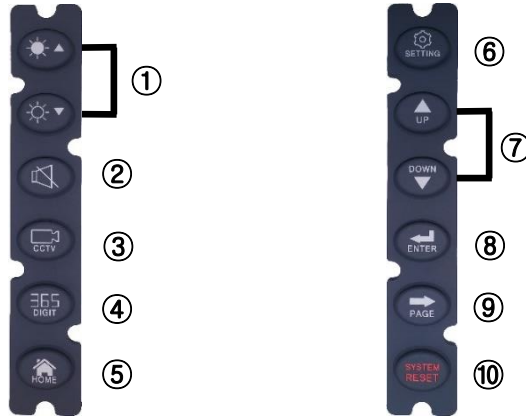
Emergency Stop Button

[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.



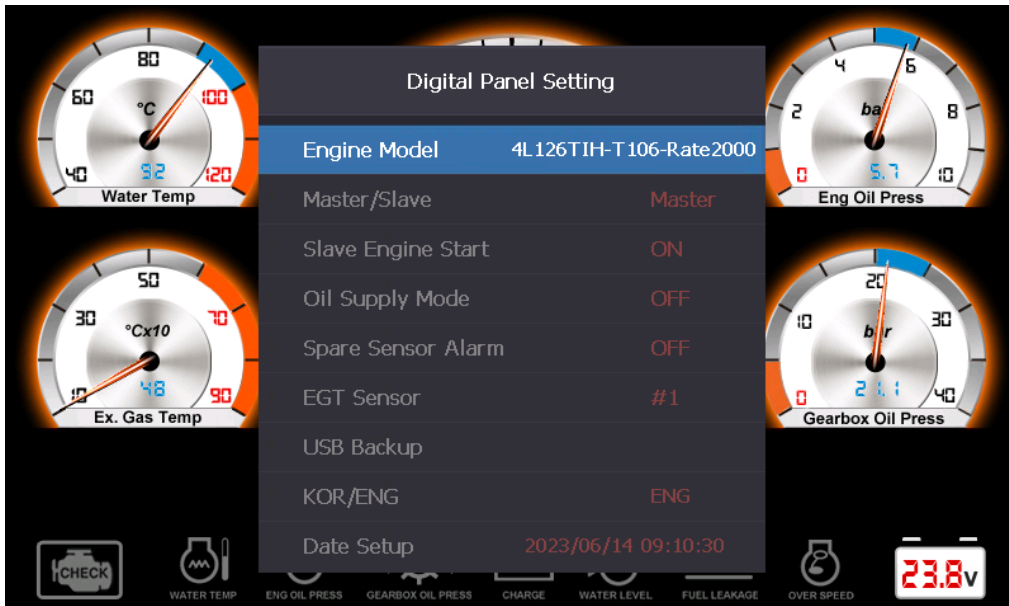
[Fig. 3-15] Function Keys

No.	Function Key	Action Feature
①	LCD dimmer	<ul style="list-style-type: none"> <li>• LCD brightness adjustable for 5 different levels (when rebooting the system, the previous setting will be maintained).</li> </ul>
②	Alarm Mute	<ul style="list-style-type: none"> <li>• Turn off the buzzer sound</li> </ul>
③	CCTV	<ul style="list-style-type: none"> <li>• Switching between CAM1 and CAM2 (optional)</li> </ul>
④	Digit On/Off	<ul style="list-style-type: none"> <li>• Default On</li> <li>• Press once : number light will be off</li> <li>• Press once again : number light will be on</li> </ul>
⑤	Home	<ul style="list-style-type: none"> <li>• Move to main gauge display.</li> <li>• Move to main display without saving when pressing it in page mode.</li> </ul>
⑥	Configuration	<ul style="list-style-type: none"> <li>• Engine Model setting</li> <li>• Master/Slave setting and ON/OFF setting to start the slave</li> <li>• ON/OFF setting for over speed testing</li> <li>• Oil Supply Mode</li> <li>• ON/OFF setting for spare sensor light</li> <li>• Select EGTS</li> <li>• USB backup and time (year/month/hour) settings</li> <li>• Convert Korean/English</li> <li>• Set date</li> </ul>
⑦	Up/Down	<ul style="list-style-type: none"> <li>• Move the cursor up and down in setting window</li> </ul>
⑧	Select	<ul style="list-style-type: none"> <li>• Select menus or functions in the setting window</li> </ul>
⑨	Page	<ul style="list-style-type: none"> <li>• Move to spare sensor display (display page 2) / Move to event summary display (display page 3)</li> </ul>
⑩	System Reboot	<ul style="list-style-type: none"> <li>• Rebooting for system errors (press it for more than 3 seconds to reboot)</li> </ul>

[Table 3-8]

### 3. Part Names, Operation and Settings

#### 3.8.1 Detailed Settings



[Fig. 3-16] Detailed Settings

#### ▶ Setting Functions and Descriptions

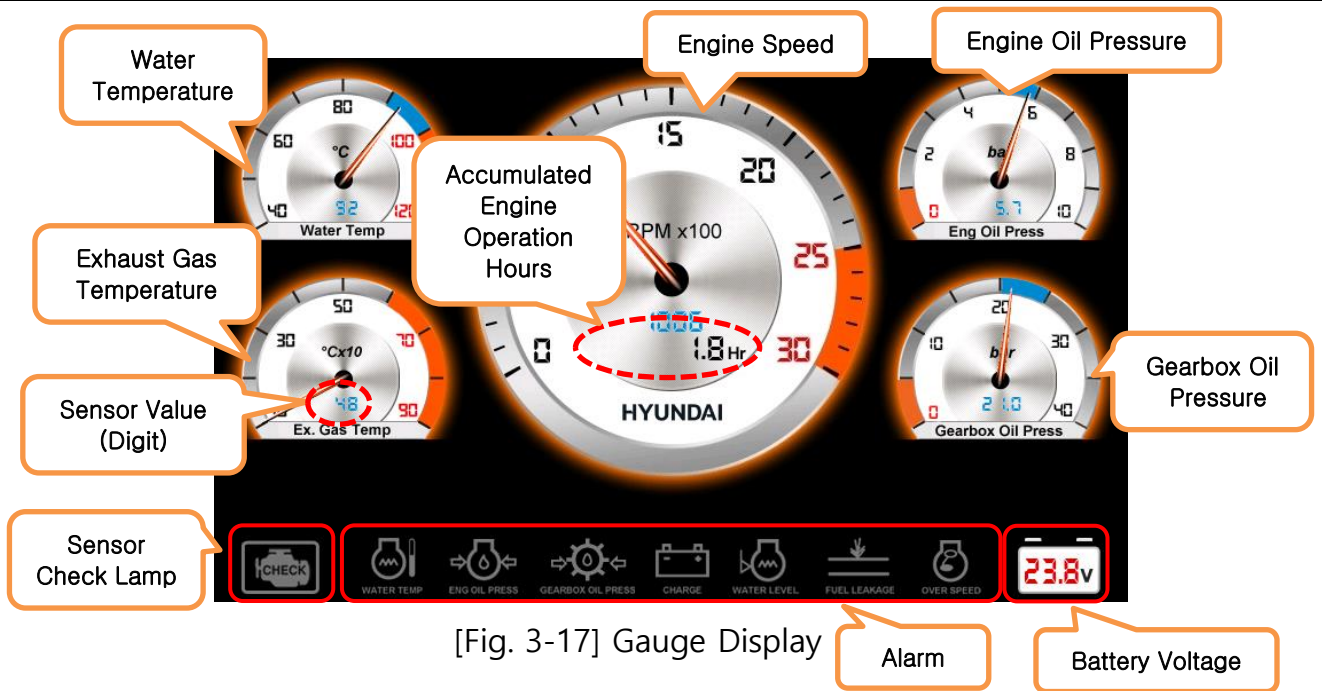
- Press button and then use or button to move to functions to be changed.
- Press button to go back to gauge display (changes will be automatically saved).

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

[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°C or higher.
- 5) When the temperature increases up to 103°C 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°C 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

※ 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 <b>93°C</b> or higher
②	Engine oil pressure	• Alarm (buzzer) will be activated on when the pressure is <b>1 bar</b> or lower
③	Gearbox oil pressure	• Alarm (buzzer) will be activated on when the pressure is <b>1 bar</b> or lower
④	Charging	• Alarm (buzzer) will be activated when the battery voltage is lower than <b>18V</b>
⑤	Water level	• Alarm (buzzer) will be activated when the level is lower than <b>30%</b>
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 <b>117%</b> 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).

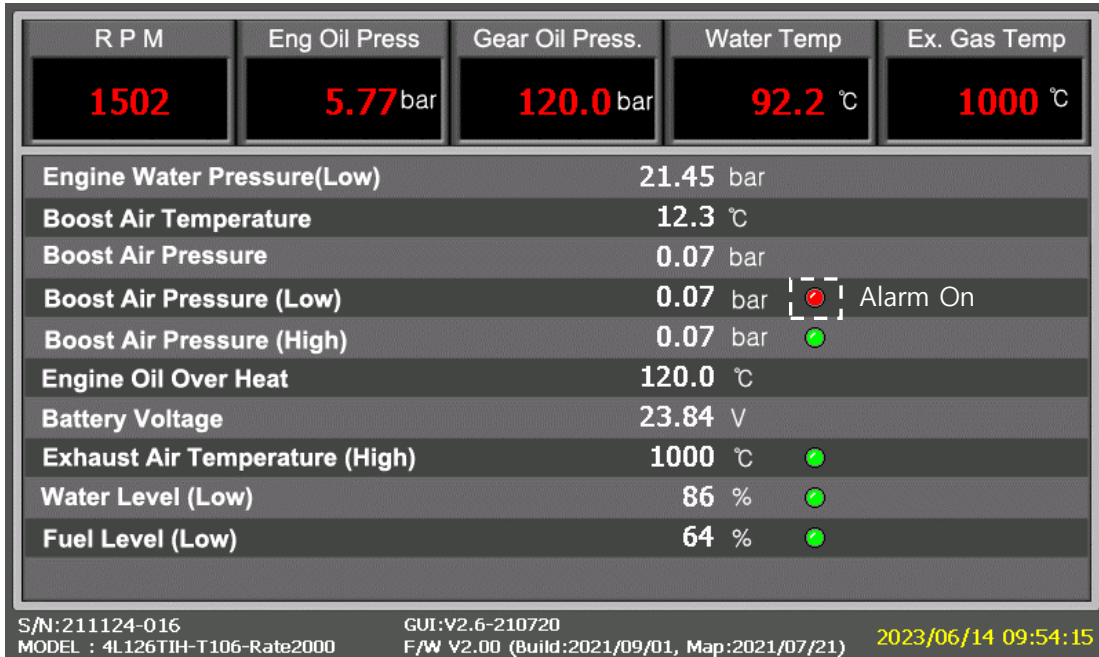
#### 3.9.9 Engine Shutdown

- 1) When the over speed exceeds **117%** of the rate speed → Enable/Disable engine stop
- 2) When the coolant temperature exceeds **103°C** → 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  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°C or higher
Battery Voltage	• Current voltage
Exhaust Air Temperature (High)	• Alarm will be activated when the exhaust air temperature is 600°C 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  button in spare sensor page to move to event summary page.

Digital Panel Alarm Information			
Engine Run Count :	11	Engine ShutDown Count :	6
Engine Stop Count :	5		
Code	Description	OC	Alarm Date
P0101	Water Temp. Over Heat	2	2023/ 04/ 26/ 12: 35: 18
P0102	Low Engine Oil Pressure	10	2023/ 04/ 26/ 12: 36: 50
P0103	Low Gearbox Oil Pressure	1	2022/ 03/ 25/ 20: 01: 53
P0104	Battery Charge(alternator)	0	
P0105	Fuel Leakage (Switch)	0	
P0106	Over Speed	2	2023/ 04/ 26/ 12: 35: 07
P0107	Low Voltage	0	
P0108	Low Water Level	0	
P0109	Low Fuel Level	0	
P0110	Engine Oil Over Heat	0	
P0111	Main Connector Removed	0	
P0112	High Exhaust Gas Temperature	0	
P0113	Low boost Air Pressure	0	
P0114	High boost Air Pressure	0	
P0115	Abnormal Engine ShutDown	4	2023/ 06/ 14/ 08: 43: 20
P0116	Low Engine Speed	0	

[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

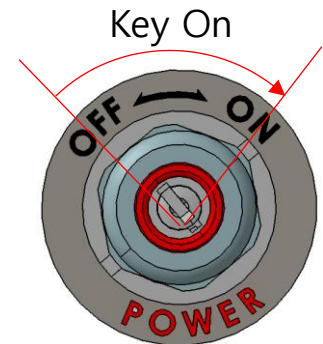
# 3. Part Names, Operation and Settings

## 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

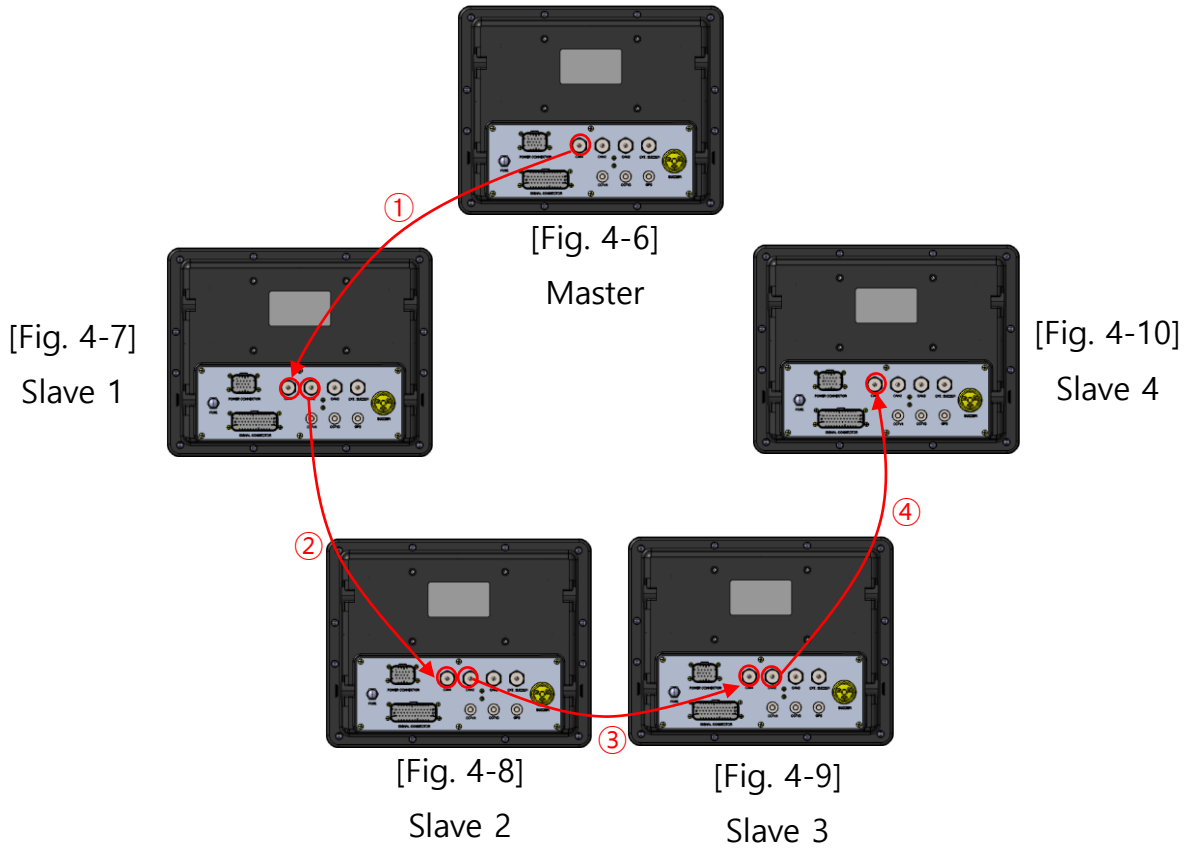
---

- 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.



# 4. Multi Panel Structure

## 4.2 How to Install Multi Panels



※ 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

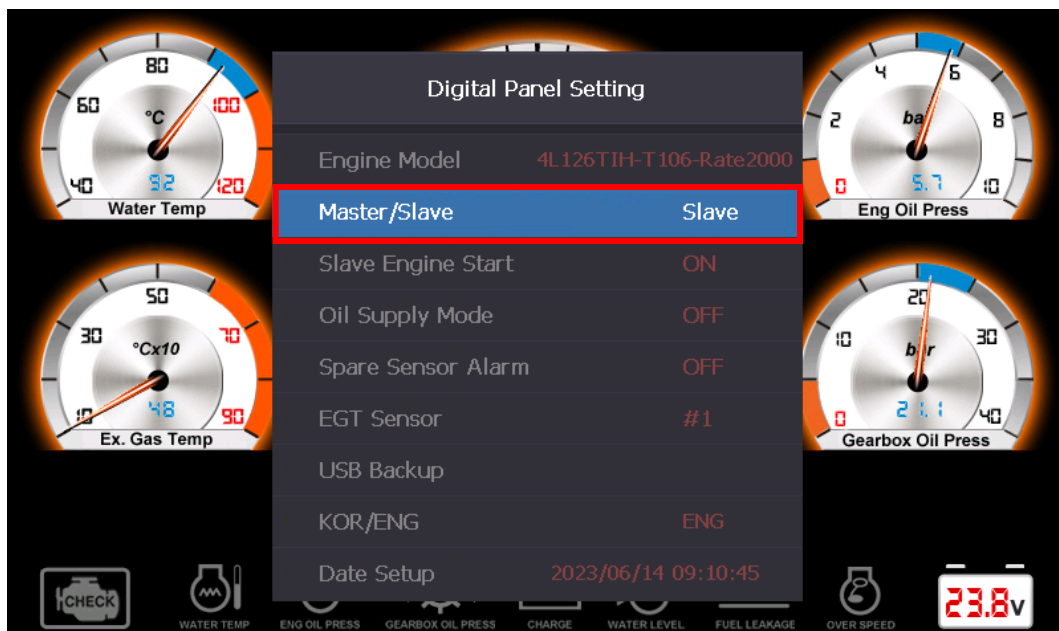
## 4. Multi Panel Structure

### 4.3 Multi Panel Settings

- (1) Press  button of the panel to be configured as Slave.
- (2) Move to ① when the setting screen appears (use  or  button to move).
- (3) Press  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

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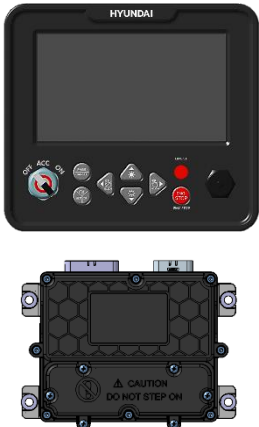

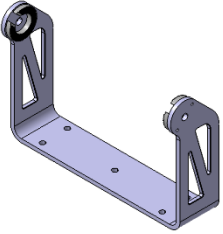
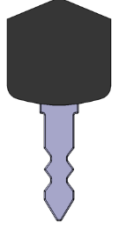
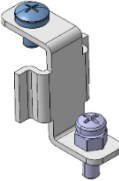
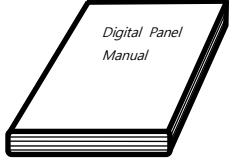
# 1. General Information

## 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	<ul style="list-style-type: none"><li>• NXP4330Q / S32K144</li></ul>
2	Software	<ul style="list-style-type: none"><li>• Linux OS GUI + F/W</li></ul>
3	Display	<ul style="list-style-type: none"><li>• 8" Color TFT LCD</li><li>• 1280 * 720(Pixel)</li><li>• 16 : 9</li></ul>
4	Flash Memory	<ul style="list-style-type: none"><li>• 4GB(eMMC)</li></ul>
5	Ram	<ul style="list-style-type: none"><li>• 1GB</li></ul>
6	Operating Voltage	<ul style="list-style-type: none"><li>• DC 24V (9 ~ 32V)</li></ul>
7	USB	<ul style="list-style-type: none"><li>• USB 2.0 1Port</li></ul>
8	Operating Temperature	<ul style="list-style-type: none"><li>• - 20°C ~ 70°C</li></ul>
9	Internal Buzzer	<ul style="list-style-type: none"><li>• Piezo Buzzer 98dB</li></ul>
10	Communication	<ul style="list-style-type: none"><li>• J1939 CAN communication</li><li>• RS232</li></ul>
11	Dimensions	<ul style="list-style-type: none"><li>• W 287 x H 245.8 x D 108.15(DGP)</li><li>• W 236 x H 186.6 x D 80(DACU)</li></ul>

[Table 1-2]

## 2. Product Installation

### 2.1 Cautions

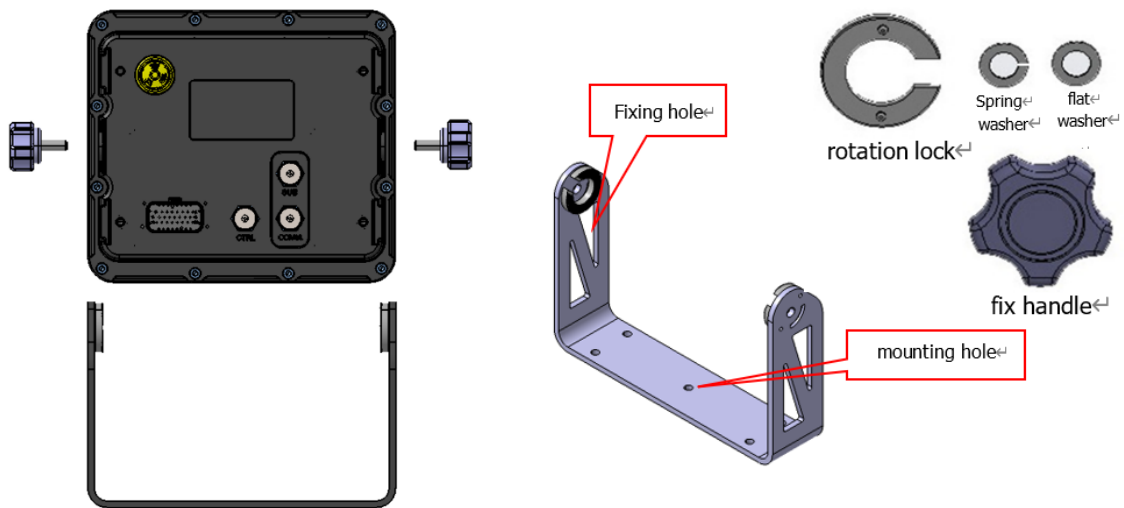
---

- 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

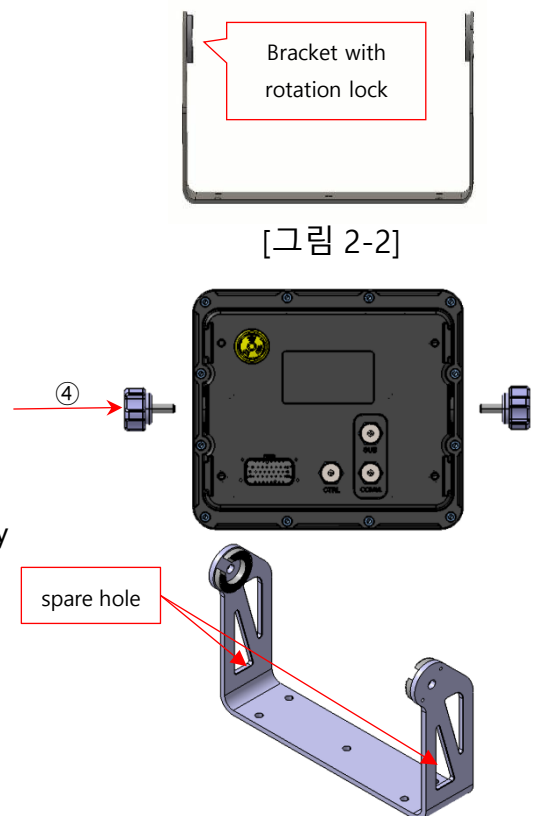


[Fig. 2-1] Desk Mounting Type Diagram

#### ▶ 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.
- 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.



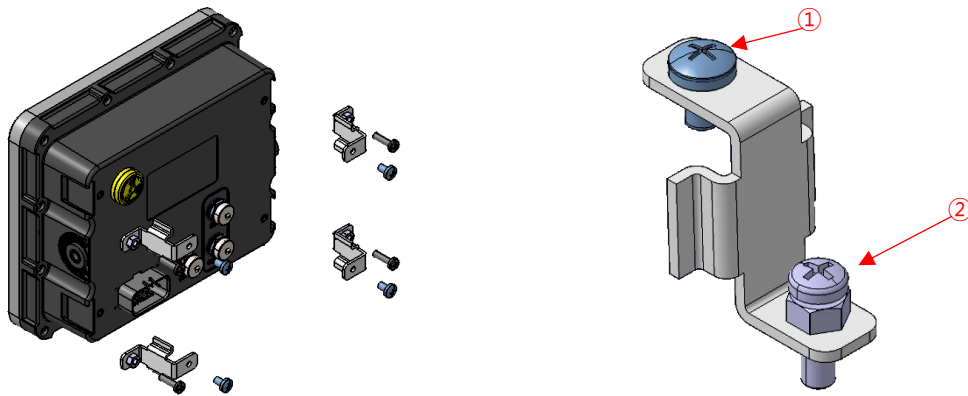
[Fig. 2-3]

## 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).

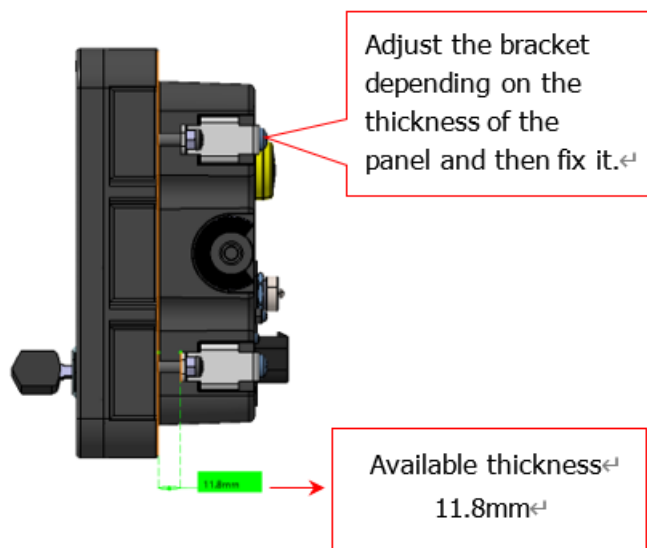
※ Bolt Spec: ① M6 X 10L ② M6 X 20L



[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

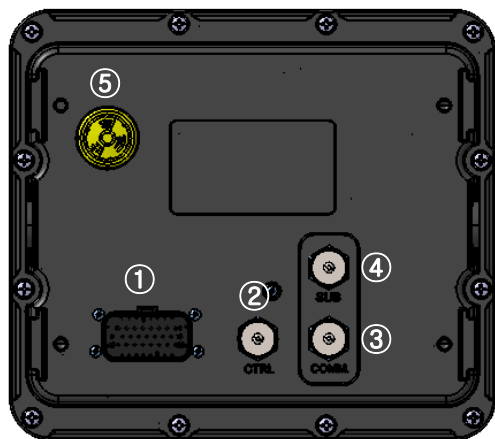


[Fig. 3-1]

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]

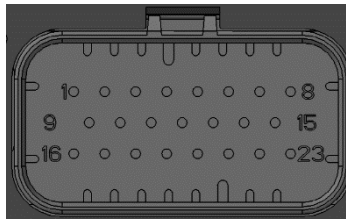
# 3. Part Names, Operation and Settings

## 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]

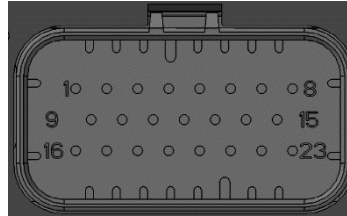
No.	Pin Description	Notes	No.	Pin Description	Notes
1	Battery In	-	13	(opt) PC RXD1	-
2	Battery In	-	14	(opt) PC TXD1	-
3	Power GND	-	15	Alternator In	Electronic panel only
4	Power GND	-	16	Wait to Disconnect Signal	
5	Key On	-	17	Wait to Disconnect Common	
6	Starter Signal	-	18	Gearbox Oil Pressure 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]

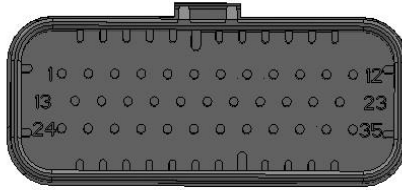
No.	Pin Description	Notes	No.	Pin Description	Notes
1	CAN 1 Low	-	13	Power GND	-
2	CAN 1 High	-	14	DSC RPM Pick-up (GND)	Generator only
3	(opt) CAN 2 High	-	15	DSC Actuator A	Generator only
4	(opt) PC TXD1	-	16	Battery In	-
5	Key On	-	17	DSC CAN 2 Low	Generator only
6	Starter Signal	-	18	DSC CAN 2 High	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]

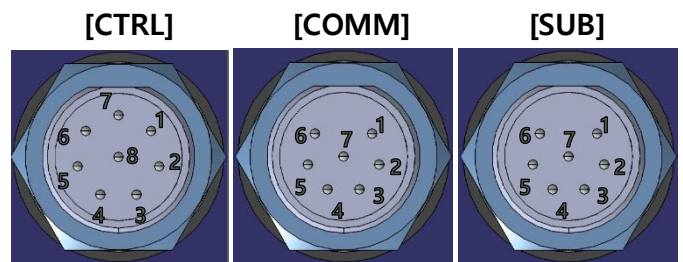
# 3. Part Names, Operation and Settings

## 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	-	-

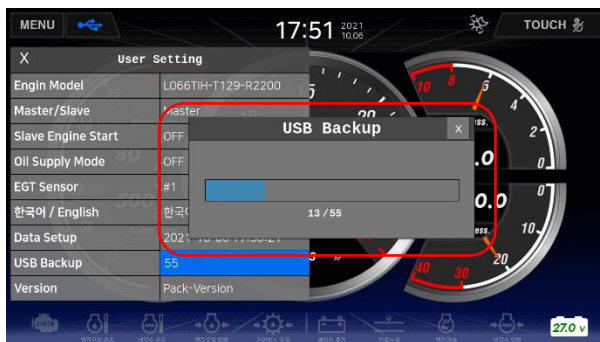
[Table. 3-6]



[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.

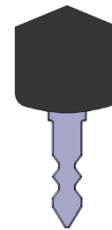


[Fig. 3-8]

### 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 45° to the right (ACC), the product is booted.
  - 2) Engine starts at the position of 90° turn (ON) and it returns to 45° 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 45° 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.



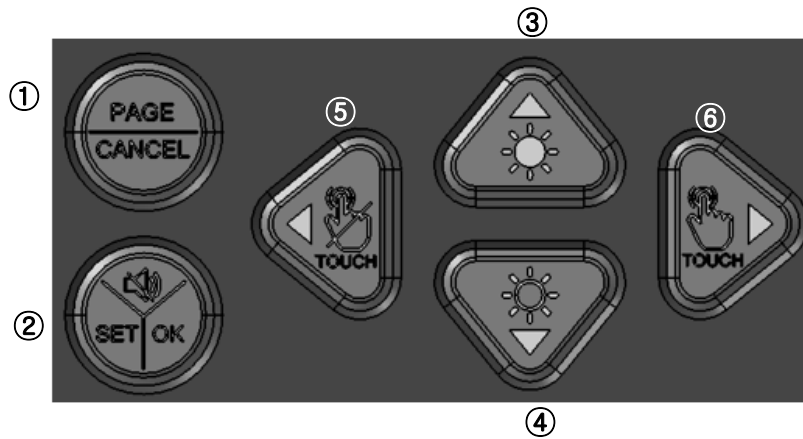
**EMG.STOP**

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

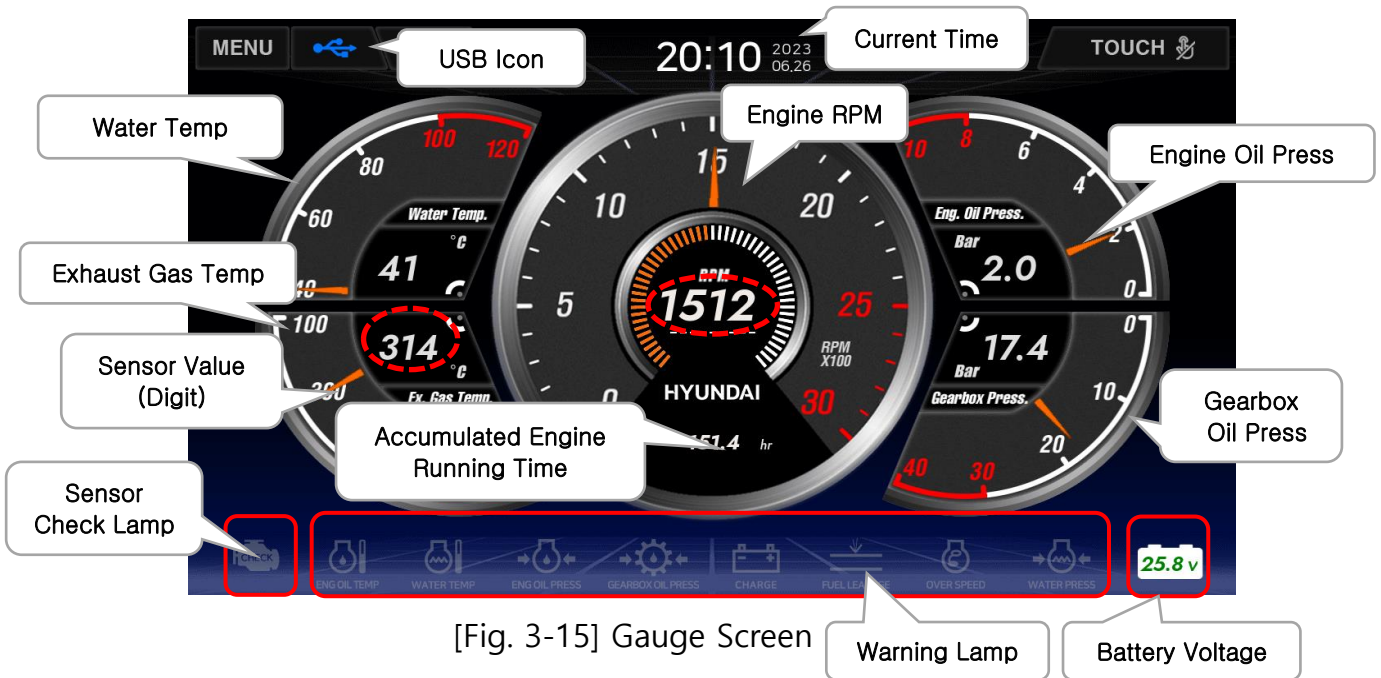
- Press and hold the settings button for 3 seconds on the main screen to enter the user settings.
- Use the arrow keys to move to the function you want to change.
- Press the Ok button to go to the gauge screen. (Auto save on change)

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



- 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°C
- 4) Stop the engine when the starting state is over 103 °C

### 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 °C

### 3. Part Names, Operation and Settings

#### 3.9.5 Gearbox Oil Pressure

- Displays gearbox oil pressure with gauge and digital.



- 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).

[Fig. 3-20]

Gearbox Oil Pressure

#### 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

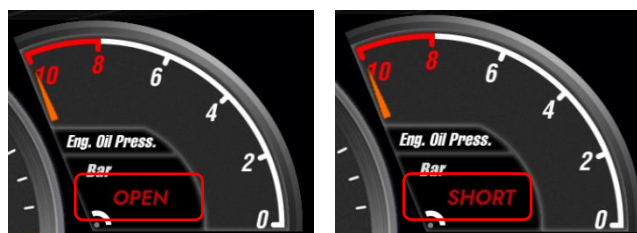
- When a sensor error (open, short) occurs or communication fault between DACU and Sensors, the sensor check light turns on.



[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°C
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°C → 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)

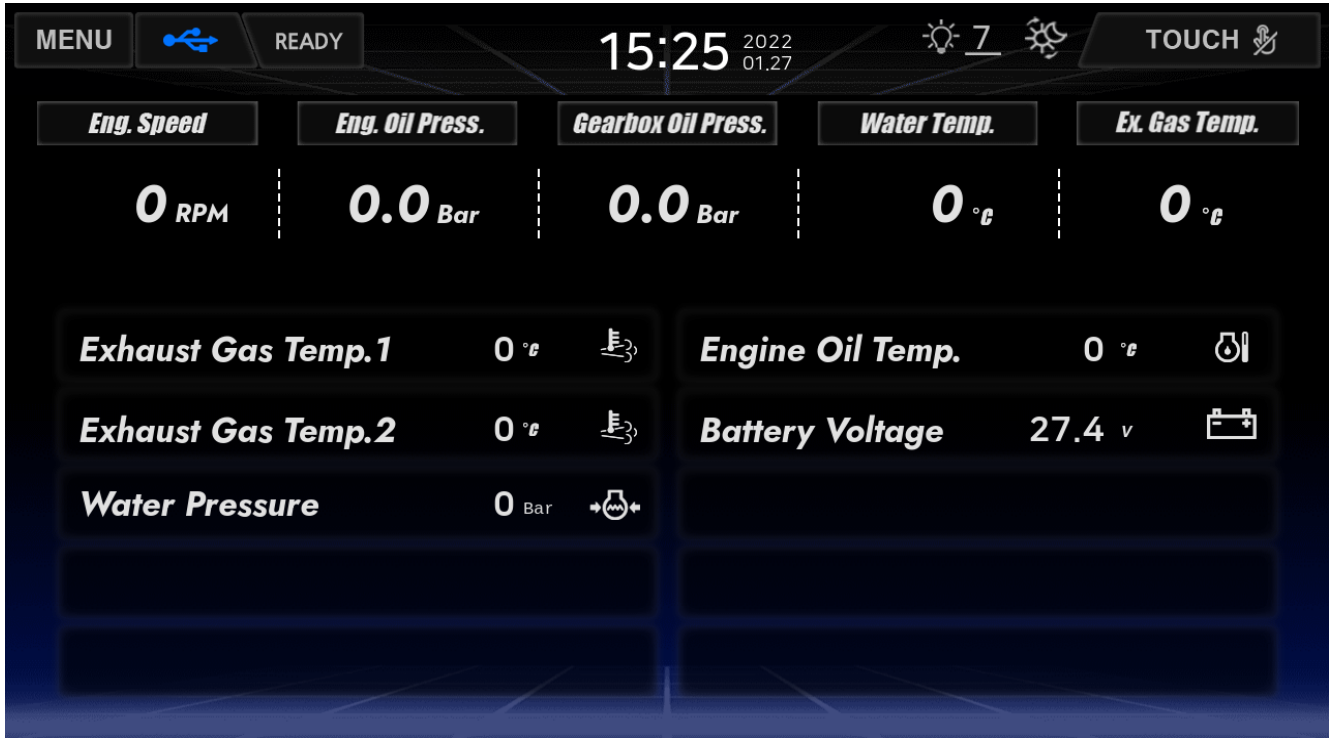
※ How to turn off the engine warning light

- 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°C
Exhaust Gas Temperature2 (High)	• Warning light turns on when exhaust temperature is over 600°C
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°C

[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.

The screenshot shows a digital panel interface with a top status bar containing 'MENU', 'READY', '15:39 2023 02.15', and 'TOUCH'. Below the status bar are five status indicators: 'ENG.RUN 0', 'ENG.STOP 0', 'ENG.Shutdown 0', 'EMG.START 0', and 'EMG.STOP 0'. The main area contains a table with the following data:

Code	Description	OC	Alarm Date
E001	Water Temp. Over Heat	0	-
E002	Low Engine Oil Pressure	0	-
E003	Low Gearbox Oil Pressure	0	-
E004	Battery Charge(Alternator)	0	-
E005	Fuel Leakage(Switch)	0	-
E006	Over Speed	0	-
E007	Low Voltage	0	-
E008	Engine Oil Over Heat	0	-
E009	Main Connector Removed	0	-
E010	High Exhaust Gas Temperature	0	-
E011	Abnormal Engine Shutdown	0	-

At the bottom of the screen, it displays 'Low Engine Speed: 0'.

[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

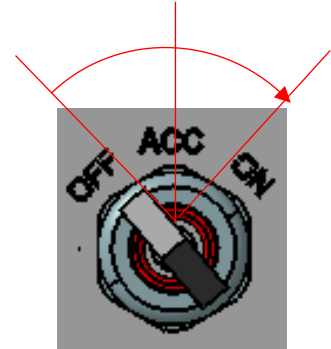
## 3.12 System Booting and Functional Check

---

- 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.
- 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)



[Fig. 3-27] Key Switch

# 4. Multi Panel Structure

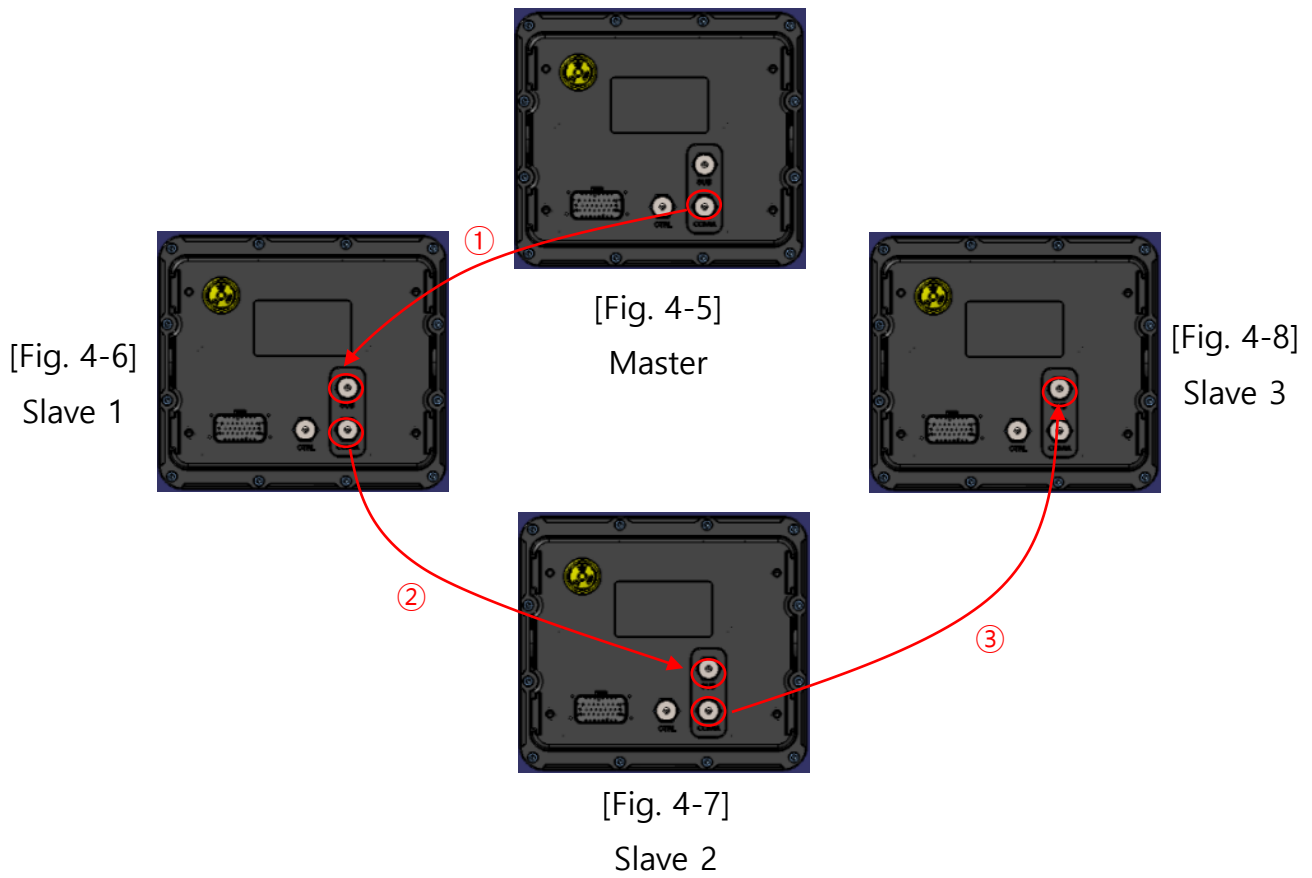
## 4.1 Multi Panel

- 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.)



# 4. Multi Panel Structure

## 4.2 How to Install Multi Panel



※ 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

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# 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°C ~ 70°C	• -20~+70°C
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).

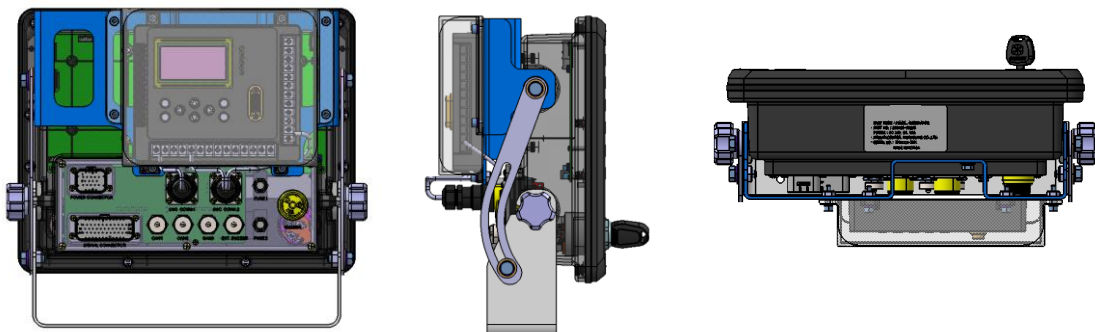
- Excessive impact may damage the display although a reinforced display is used.
- Use connectors matching each other when connecting them to the back of the product.

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

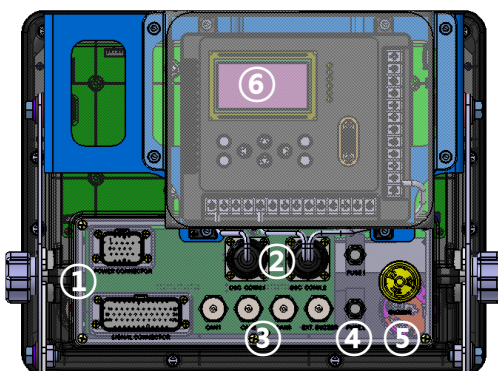


[Fig 3-1]

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**

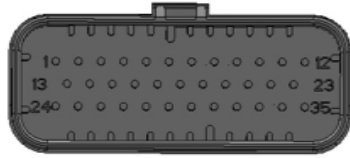
[Fig 3-3]

No.	Pin Description	Remark
1	Alternator In	Battery
2	-	-
3	Battery(+)(DC 24V)	Input to fuse
4		
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.



[Fig 3-4]

SIGNAL CONNECTOR

\* : 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.

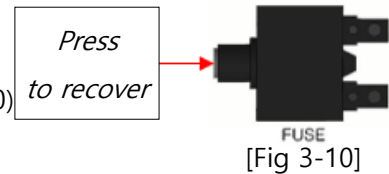


USB  
[Fig 3-9]

## 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



FUSE  
[Fig 3-10]

### 3.4.2 Buzzer

- Generate alarms for sensor problems



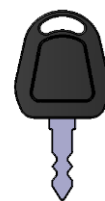
BUZZER  
[Fig 3-11]

## 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

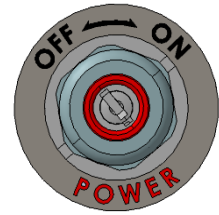


[Fig 3-12]

appear in about 15 seconds.

3) Rotate the key to the left by 45° (OFF) to turn it off.

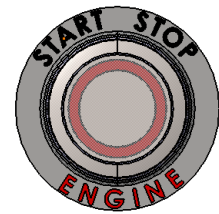
- When rotating the key to the left (OFF) while the power is on, the display will show a popup message for 300 seconds. The engine will stop and the event will be saved after 300 seconds.
- When the popup window appears, rotate the key to the right (ON) to remove the window and keep the engine on.



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 <b>DIGIT</b> , 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

Digital Panel Setting		
Engine Model	4AD158TI-T160-R1500	
Master/Slave	Master	
Slave Engine Start	OFF	
Oil Supply Mode	OFF	
USB Backup		
kP	73	kI 70 kD 90
Droop	OFF	
KOR/ENG	ENG	
Date Setup	2023/06/14 10:55:08	

[Fig 3-17]

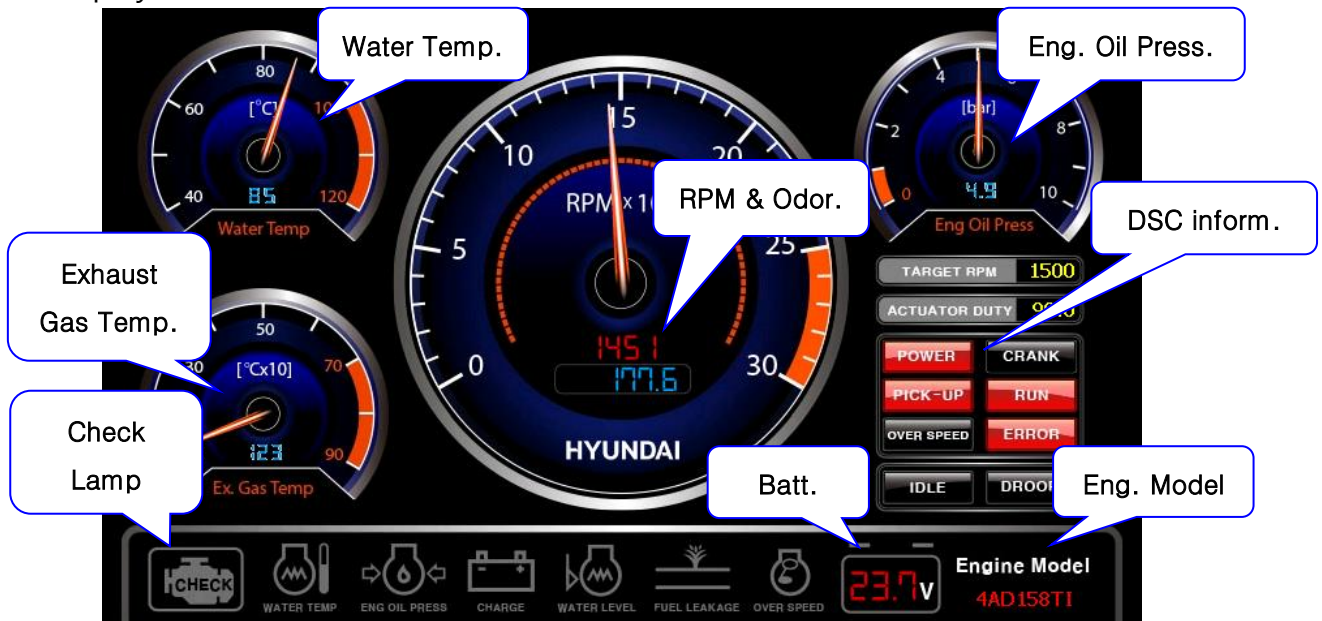
#### ► Setting Functions and Descriptions

- 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

- 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)



[Fig 3-19]

- 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°C or higher.

5) When the temperature increases up to 103°C 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 °C 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

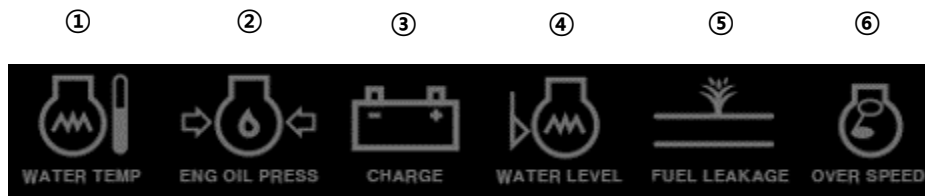
- When there are sensor errors (Open or Short), the check sensor lamp will flicker with buzzer.



[Fig 3-24]

### 3.9.7 Engine Alarm Lamp

- The alarm lamp will flicker with buzzer beeping when problems for coolant temperature, engine oil pressure, 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 <b>93°C</b> or higher
②	ENGINE OIL PRESS(Engine oil pressure)	• When the pressure is <b>1 bar</b> or lower
③	CHARGE(Battery Charge)	• When the battery voltage is lower than 18V
④	WATER LEVEL(Coolant level)	• When the level is <b>30%</b> 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 <b>115%</b> 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°C** → 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.

RPM	Eng Oil Press	Eng Oil Temp.	Water Temp.	Ex. Gas Temp.
1451	4.98 bar	120.0 °C	85.5 °C	123 °C
Boost Air Temperature		50.2 °C		
Boost Air Pressure(Low)		0.49 bar ●		
Boost Air Pressure(High)		0.49 bar ●		
Engine Oil Over Heat		120.0 °C		
Battery Voltage		23.8 V		
Exhaust Air Temperature(High)		123 °C ●		
Water Level(Low)		100 % ●		
Fuel Level(Low)		50 % ●		
<small>S/N 220903-001 GUI V2.5-200310 F/W V2.00 (Build:2022/05/01, Map:2023/01/12)                      DSC V1.60 (F/W:2021/08/28) 2023/06/14 11:05:24</small>				

[Fig 3-27]

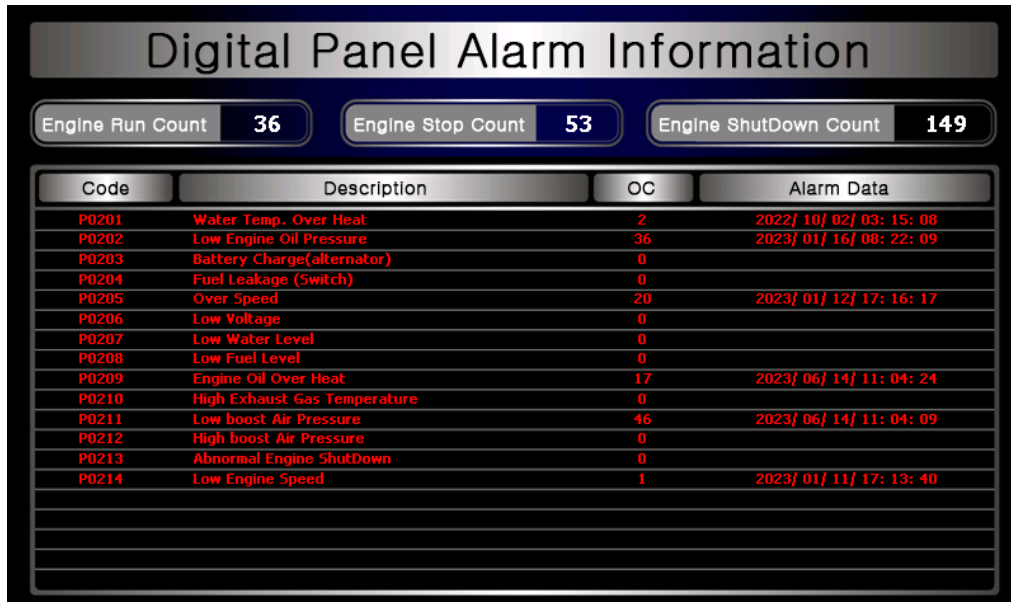
Items	Conditions
*Boost Air Temperature	• Current temperature of BATS(No alarm)
*Boost Air Pressure	• Normal when the pressure is between 1.1 and 2.9bar
*Boost Air Pressure (Low)	• Alarm when the pressure is lower than 1bar
*Boost Air Pressure (High)	• Alarm when the pressure is higher than 3bar
*Engine Oil Over Heat	• Alarm when the temperature is higher than 120°C
Battery Voltage	• Current battery voltage
Exhaust Air Temperature(High)	• Alarm when the temperature is higher than 600°C
*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

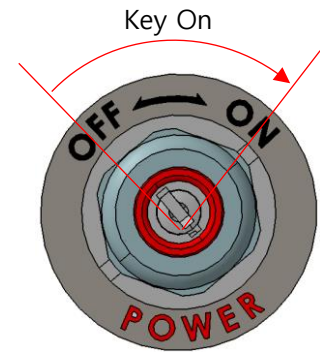
[Table 3-14]

### 3.12 System Booting and Functional Check

- You can check whether the product is properly installed or not.

#### ▶ Normal System Booting

- 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).



[Fig 3-29]

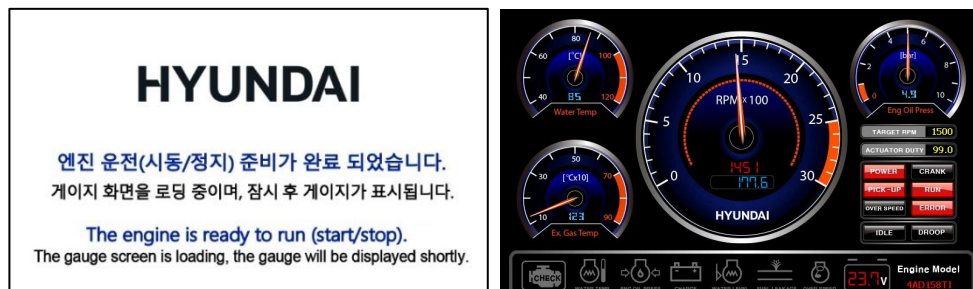
- ※ If the logo does not appear after rotating the key,
  - Rotate it to the left (OFF) and then to the right (ON) again
  - Check the harness connection at the back of the panel
  - Check whether the battery is discharged

- 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]

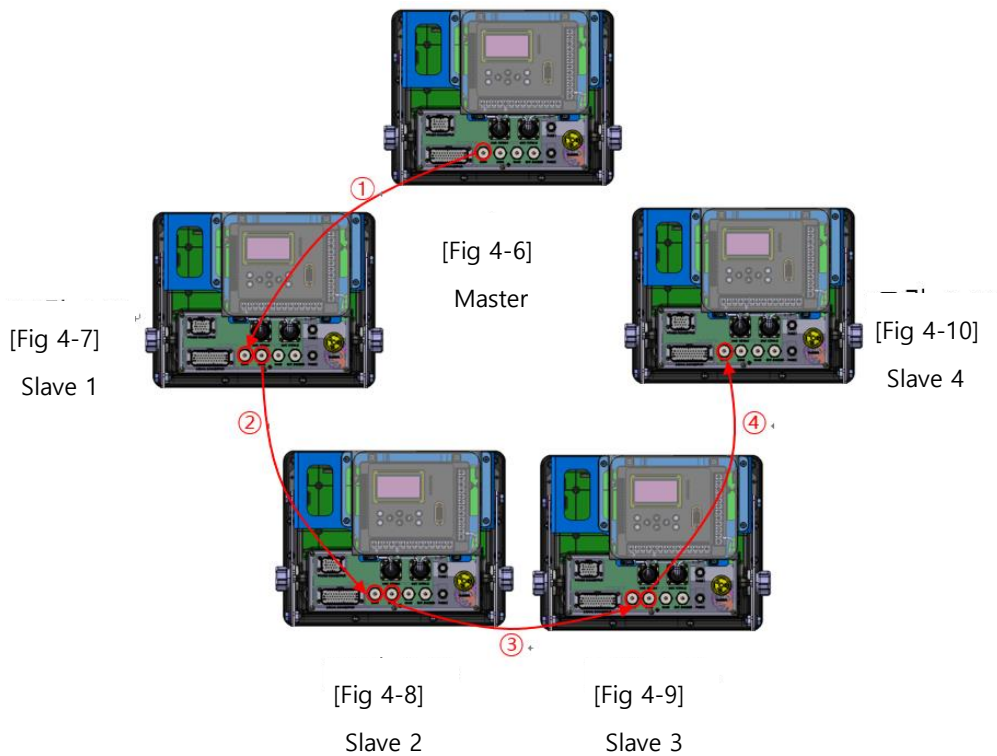
## 4. Multi Panel Structure

### 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.



### 4.2 How to Install Multi Panel



※ 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.

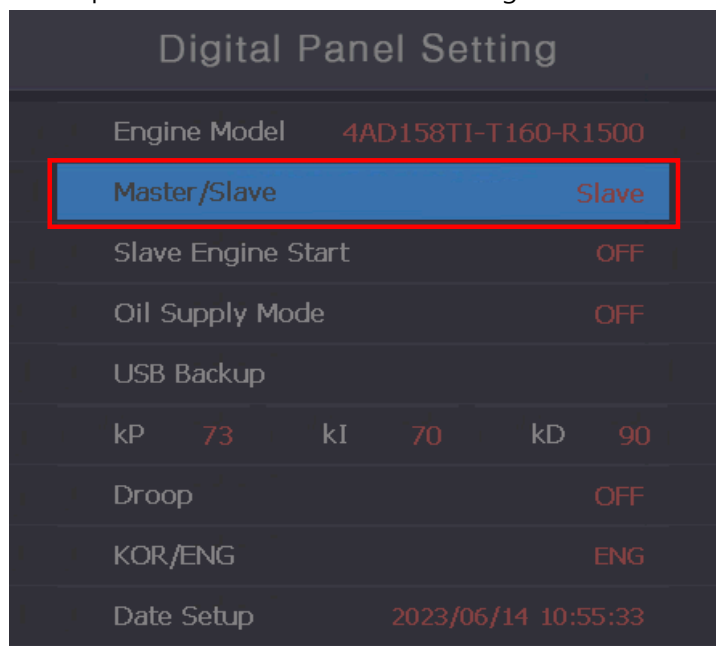
2) Move to ① when the setting screen appears (click **Up** or **Down** button to move).

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		152
		1800		
DE12TIB	AD126TI	1500		
		1800		
DX12	4AD126TIF	1500	106	
	4AD126TIS	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]