HD HYUNDAI INFRACORE

950106-159003EN

Operation & Maintenance Manual

MARINE ENGINE

4V222C, 4AD222C, 4P222C

WARNING: Breathing diesel engine exhaust exposes you to chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

- Always start and operate the engine in a well- ventilated area.
- If in an enclosed area, vent the exhaust to the outside.
- Do not modify or tamper with the exhaust system.
- Do not idle the engine except as necessary.

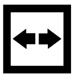
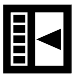
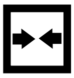
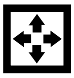
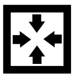
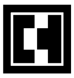
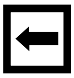
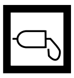
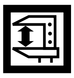
For more information go to www.P65Warnings.ca.gov.

WARNING: This product can expose you to chemicals including lead, which is known to the State of California to cause cancer and birth defects or other reproductive harm.

For more information go to www.P65Warnings.ca.gov.

Preface

This manual includes the operation and maintenance information for DX22 marine engines. The first part contains information about operating 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 operation and maintenance manual may be subject to change without notice in order to improve quality. Thank you.

2025. 07.
950106-159003EN
HD Hyundai Infracore

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

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6. Engine Service

7. Maintenance of Main Components

8. Electrical System

9. Aftertreatment System (IMO Tier3)

1. General Information

1.1. Engine Specifications

Specifications / Model		Unit	Propulsion								
			IMO Tier2								
			Continu-ous Duty	Heavy Duty					Medium Duty	Light Duty	
			4V222 CASC	4P222C ASH	4V222 CASH	4V222 CASH-II	4V222 CBSH	4V222 CCSH	4V222 CASM	4V222 CASL	4V222 CBSL
Engine type			4-stroke, V type, common rail, water-cooled turbocharger, intercooler								
Rated power (B.H.P)		kW (PS) / rpm	596 (810) / 1,800	736(1,000) / 1,800	664 (903) / 1,800	736(1,000) / 1,800	588 (800) / 1,800	530 (720) / 1,800	809 (1,100) / 2,100	908 (1,235) / 2,300	846 (1,150) / 2,300
Displacement		cc	21,927								
Number of cylinders - bore x stroke		mm	12 – Ø128 x 142								
Flywheel & housing			FWH : SAE#1 / FW : 14"								
Min. idle rpm		rpm	600								
No-load maximum rpm		rpm	1,900						2,200	2,400	
Compression ratio			17 : 1								
Firing order			1-12-5-8-3-10-6-7-2-11-4-9								
Fuel consumption		g/PS.h	149	147	151	147	151		153	158	157
Starting method			Electric starting with starter motor								
Starter motor capacity		V-kW	24–7.0								
Alternator capacity		V-A	24–80								
Battery		V-Ah	24–200								
Cooling method			Indirect raw water cooling by heat exchanger								
Coolant capacity		Liter	96.5								
Fresh water pump type			Centrifugal (pulley type)								
Raw water pump type			Rubber impeller type								
Engine oil	Pan capacity	Liter	Max. : 69, min. : 36 (including oil inside the engine : 72)								
	Pressure	kg/cm^2	Full load : 3.0, idle : 1.0								
Direction of rotation	Crank-shaft		Counterclockwise when seen from the stern								
Engine dimensions (excluding reduction gear) (L x W x H)		mm	1,912 x 1,345 x 1,346								
Engine weight (excluding reduction gear)		kg	2,020								
Type of high-pressure fuel pump			Bosch CP3.4H+ (common rail system)								
Engine control type			ECU								
Fuel injection starting pressure		bar	Controlled by ECU								
Injector nozzle type			Multi-hole type								
Fuel filter type			Cartridge								

Specifications \ Model		Unit	Propulsion							
			IMO Tier3							
			Continu-ous Duty	Heavy Duty				Medium Duty	Light Duty	
			4V222 CAKC	4V222 CAKH	4V222 CAKH-II	4V222 CBKH	4V222 CCKH	4V222 CAKM	4V222 CAKL	4V222 CBKL
Engine type			4-stroke, V type, common rail, water-cooled turbocharger, intercooler							
Rated power (B.H.P)		kW (PS) / rpm	596 (810) / 1,800	664 (903) / 1,800	736(1,000) / 1,800	588 (800) / 1,800	530 (720) / 1,800	809 (1,100) / 2,100	908 (1,235) / 2,300	846 (1,150) / 2,300
Displacement		cc	21,927							
Number of cylinders - bore x stroke		mm	12 – Ø128 x 142							
Flywheel & housing			FWH : SAE#1 / FW : 14"							
Min. idle rpm		rpm	600							
No-load maximum rpm		rpm	1,900					2,200	2,400	
Compression ratio			17 : 1							
Firing order			1-12-5-8-3-10-6-7-2-11-4-9							
Fuel consumption		g/PS.h	150	151	147	151		154	160	158
Starting method			Electric starting with starter motor							
Starter motor capacity		V-kW	24–7.0							
Alternator capacity		V-A	24–80							
Battery		V-Ah	24–200							
Cooling method			Indirect raw water cooling by heat exchanger							
Coolant capacity		Liter	96.5							
Fresh water pump type			Centrifugal (pulley type)							
Raw water pump type			Rubber impeller type							
Engine oil	Pan capacity	Liter	Max. : 69, min. : 36 (including oil inside the engine : 72)							
	Pressure	kg/cm^2	Full load : 3.0, idle : 1.0							
Direction of rotation	Crank-shaft		Counterclockwise when seen from the stern							
Engine dimensions (excluding reduction gear) (L x W x H)		mm	1,912 x 1,345 x 1,346							
Engine weight (excluding reduction gear)		kg	2,020							
Type of high-pressure fuel pump			Bosch CP3.4H+ (common rail system)							
Engine control type			ECU							
Fuel injection starting pressure		bar	Controlled by ECU							
Injector nozzle type			Multi-hole type							
Fuel filter type			Cartridge							

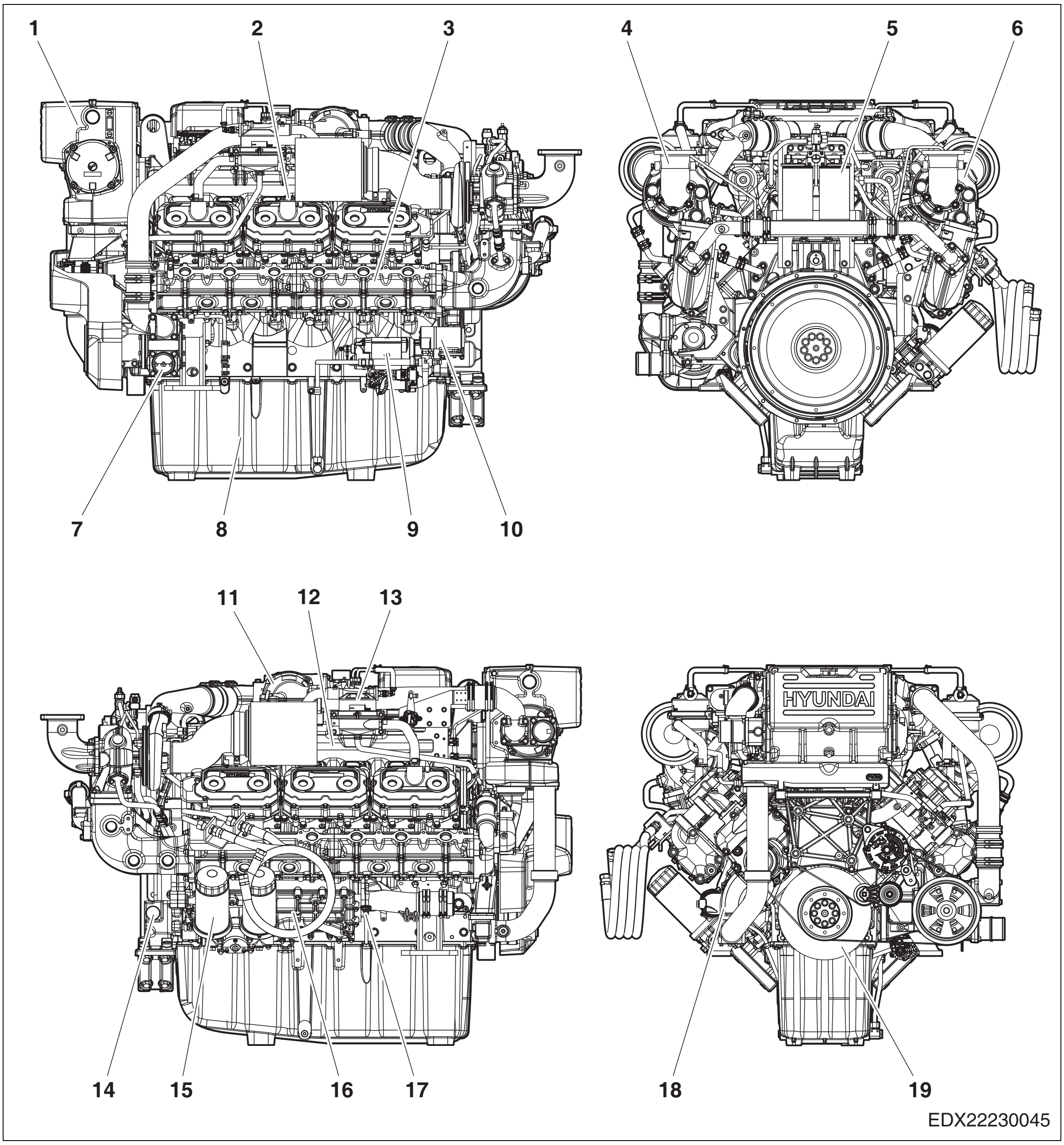
Specifications \ Model		Unit	Auxiliary						
			IMO Tier2			IMO Tier3			EPA Tier3
			50Hz	60Hz		50Hz	60Hz		60Hz
			4AD222 CASF	**4AD223 CASS**	**4AD222 CASS-II**	**4AD222 CAKF**	**4AD222 CAKS**	**4AD222 CAKS-II**	**4AD222 CBKS**
Engine type			4-stroke, V type, common rail, water-cooled turbocharger, intercooler						
Rated power (B.H.P)		kW (PS) / rpm	553 (752) / 1,500	664 (903) / 1,800	736 (1,000) / 1,800	553 (752) / 1,500	664 (903) / 1,800	736 (1,000) / 1,800	596 (810) / 1,800
Displacement		cc	21,927						
Number of cylinders - bore x stroke		mm	12 - Ø128 x 142						
Flywheel & housing			FWH : SAE#1 / FW : 14"						
Min. idle rpm		rpm	600						
No-load maximum rpm		rpm	1,800						
Compression ratio			17 : 1						
Firing order			1-12-5-8-3-10-6-7-2-11-4-9						
Fuel consumption		g/PS.h	151		147	151		147	151
Starting method			Electric starting with starter motor						
Starter motor capacity		V-kW	24–7.0						
Alternator capacity		V-A	24–80						
Battery		V-Ah	24–200						
Cooling method			Indirect raw water cooling by heat exchanger						
Coolant capacity		Liter	96.5						
Fresh water pump type			Centrifugal (pulley type)						
Raw water pump type			Rubber impeller type						
Engine oil	Pan capacity	Liter	Max. : 69, min. : 36 (including oil inside the engine : 72)						
	Pressure	kg/cm^2	Full load : 3.0, idle : 1.0						
Direction of rotation	Crank-shaft		Counterclockwise when seen from the stern						
Engine dimensions (excluding reduction gear) (L x W x H)		mm	1,912 x 1,345 x 1,346						
Engine weight (excluding reduction gear)		kg	2,020						
Type of high-pressure fuel pump			Bosch CP3.4H+ (common rail system)						
Engine control type			ECU						
Fuel injection starting pressure		bar	Controlled by ECU						
Injector nozzle type			Multi-hole type						
Fuel filter type			Cartridge						

1.2. Schematic Diagram of Engine

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

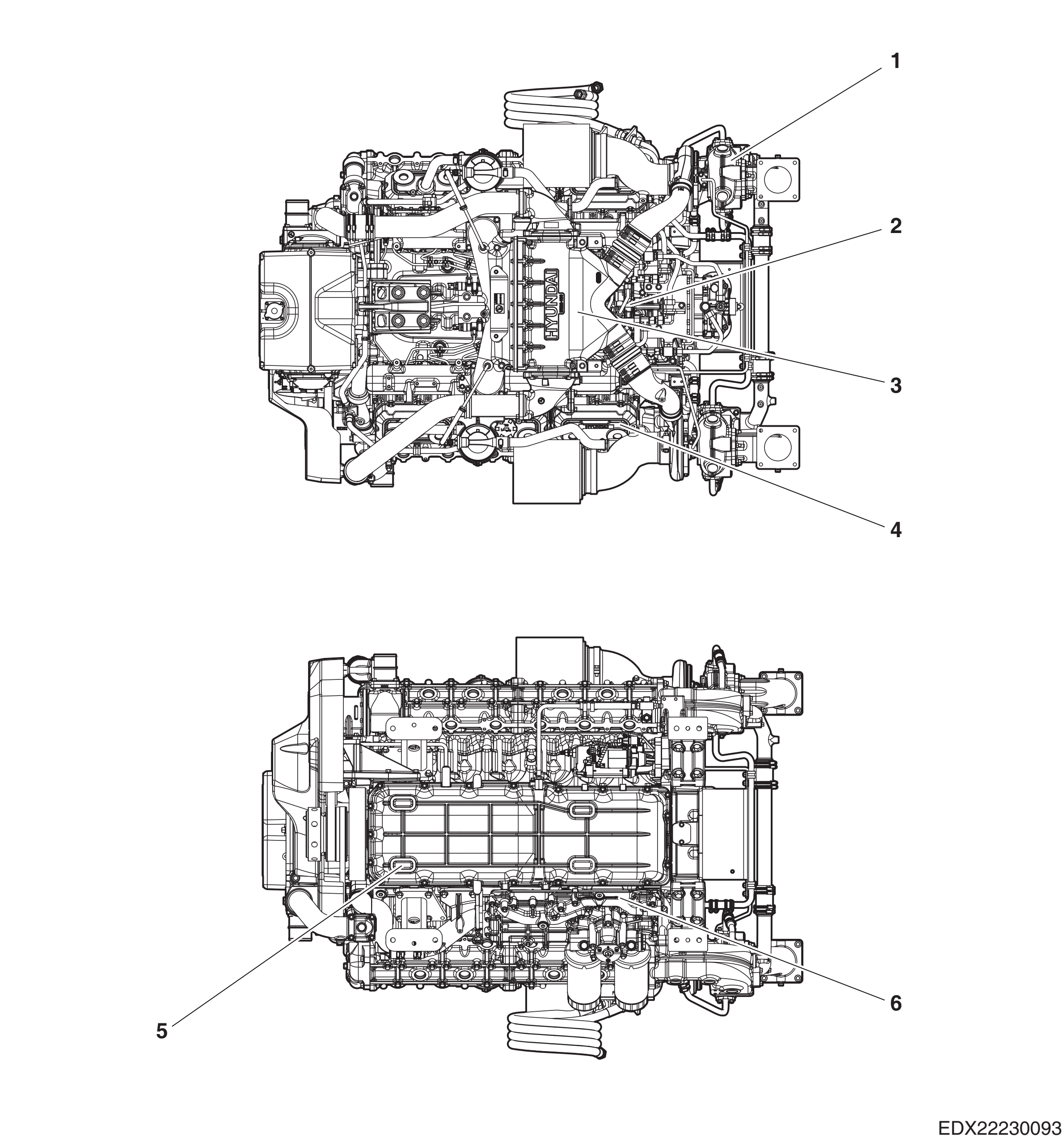
1.2.1. Outside Drawing of the Engine (Propulsion - Heat Exchanger Type)

- Plane View (Front/Rear/Left/Right)



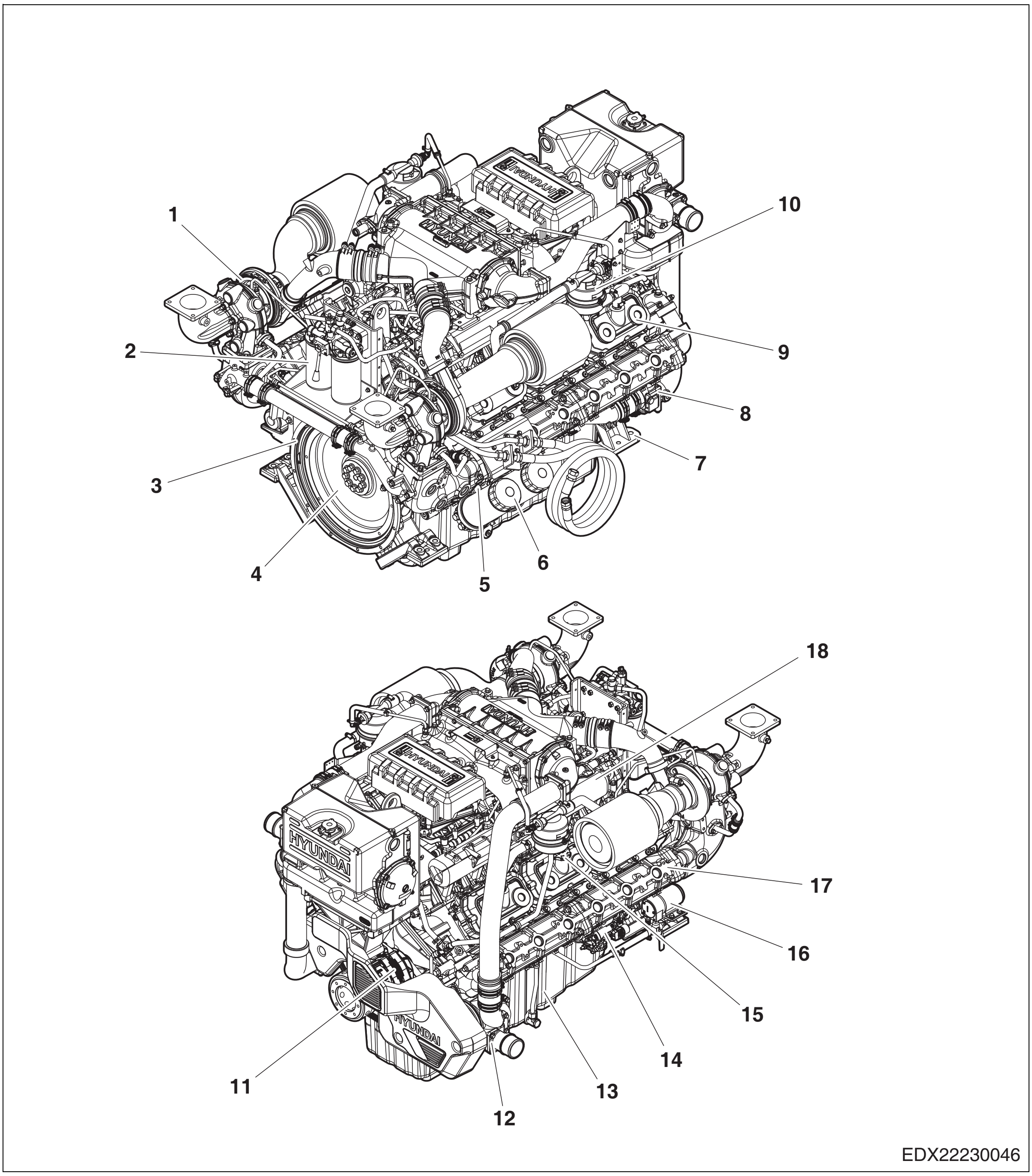
1. Heat exchanger
2. Oil filler cap
3. Exhaust manifold
4. Exhaust elbow
5. Fuel filter
6. Turbocharger
7. Raw water pump
8. Oil pan
9. Starter motor
10. Oil drain pump
11. Intercooler
12. Intake manifold
13. Breather
14. Flywheel housing
15. Oil filter
16. Oil cooler
17. Oil measuring gauge
18. Fresh water pump
19. Crankshaft pulley

● Plane View (Top/Bottom)



1. Turbocharger
2. Fuel injection pump
3. Intercooler
4. Cylinder head cover
5. Oil pan
6. Oil cooler

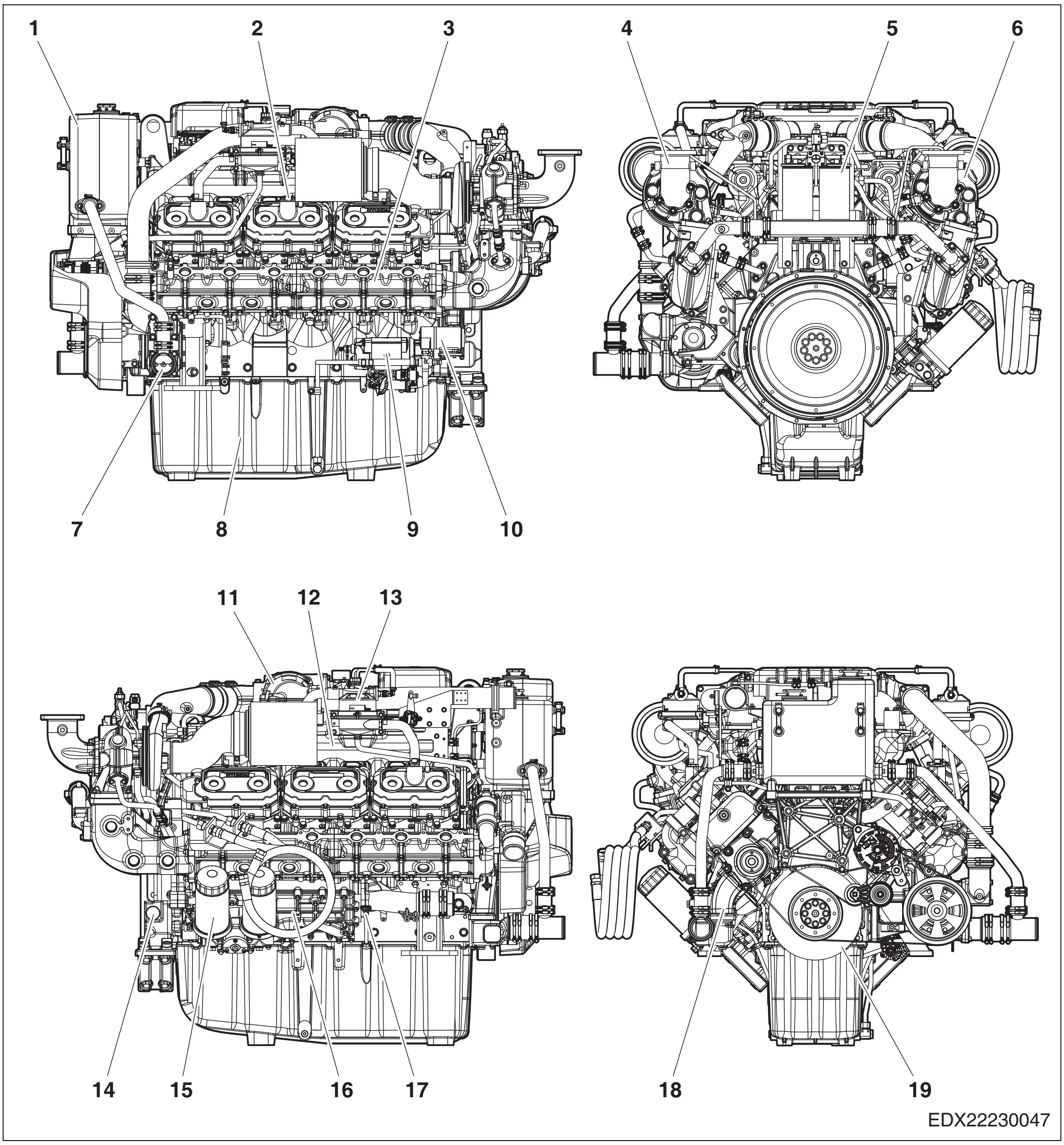
● Structural Diagram



1. Turbocharger
2. Fuel filter
3. Flywheel housing
4. Flywheel
5. Oil cooler
6. Oil filter
7. Mounting bracket
8. Fresh water pump
9. Cylinder head cover
10. Breather
11. Alternator
12. Raw water pump
13. Oil pan
14. Starter motor
15. Oil filler cap
16. Oil drain pump
17. Exhaust manifold
18. Intake manifold

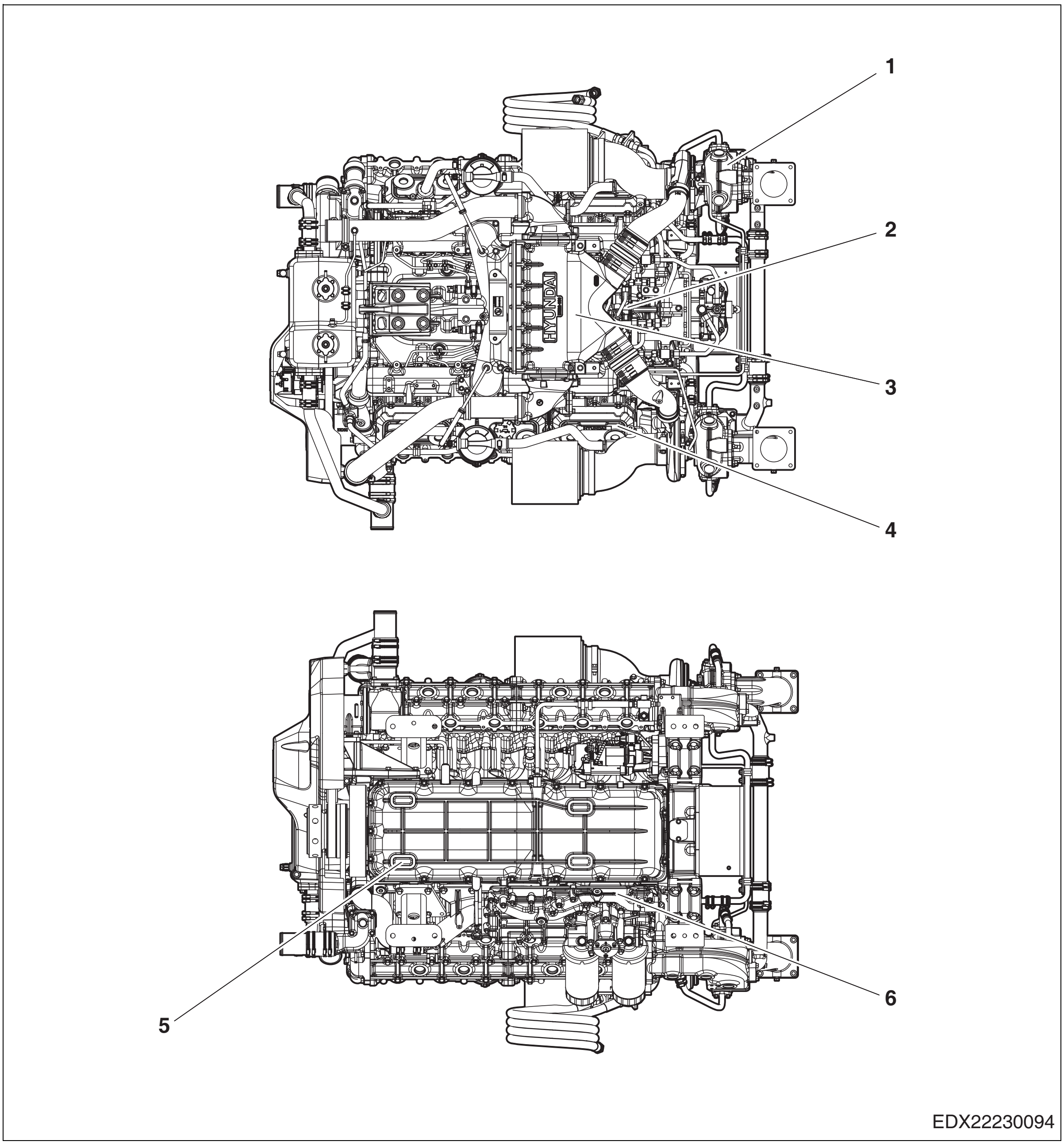
1.2.2. Outside Drawing of the Engine (Propulsion - Keel Cooling Type)

● Plane View (Front/Rear/Left/Right)



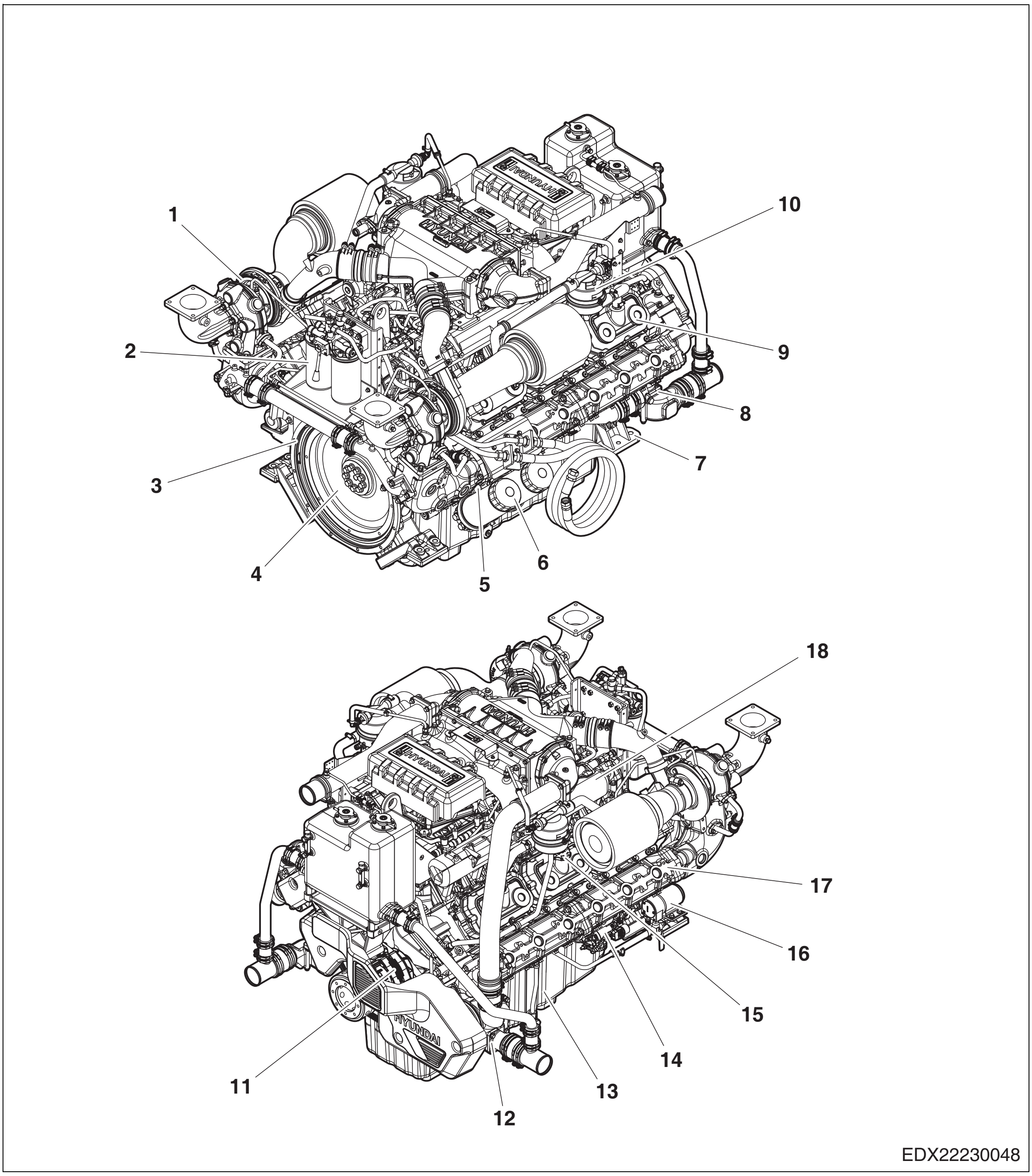
1. Keel cooling
2. Oil filler cap
3. Exhaust manifold
4. Exhaust elbow
5. Fuel filter
6. Turbocharger
7. Raw water pump
8. Oil pan
9. Starter motor
10. Oil drain pump
11. Intercooler
12. Intake manifold
13. Breather
14. Flywheel housing
15. Oil filter
16. Oil cooler
17. Oil measuring gauge
18. Fresh water pump
19. Crankshaft pulley

● Plane View (Top/Bottom)



1. Turbocharger
2. Fuel injection pump
3. Intercooler
4. Cylinder head cover
5. Oil pan
6. Oil cooler

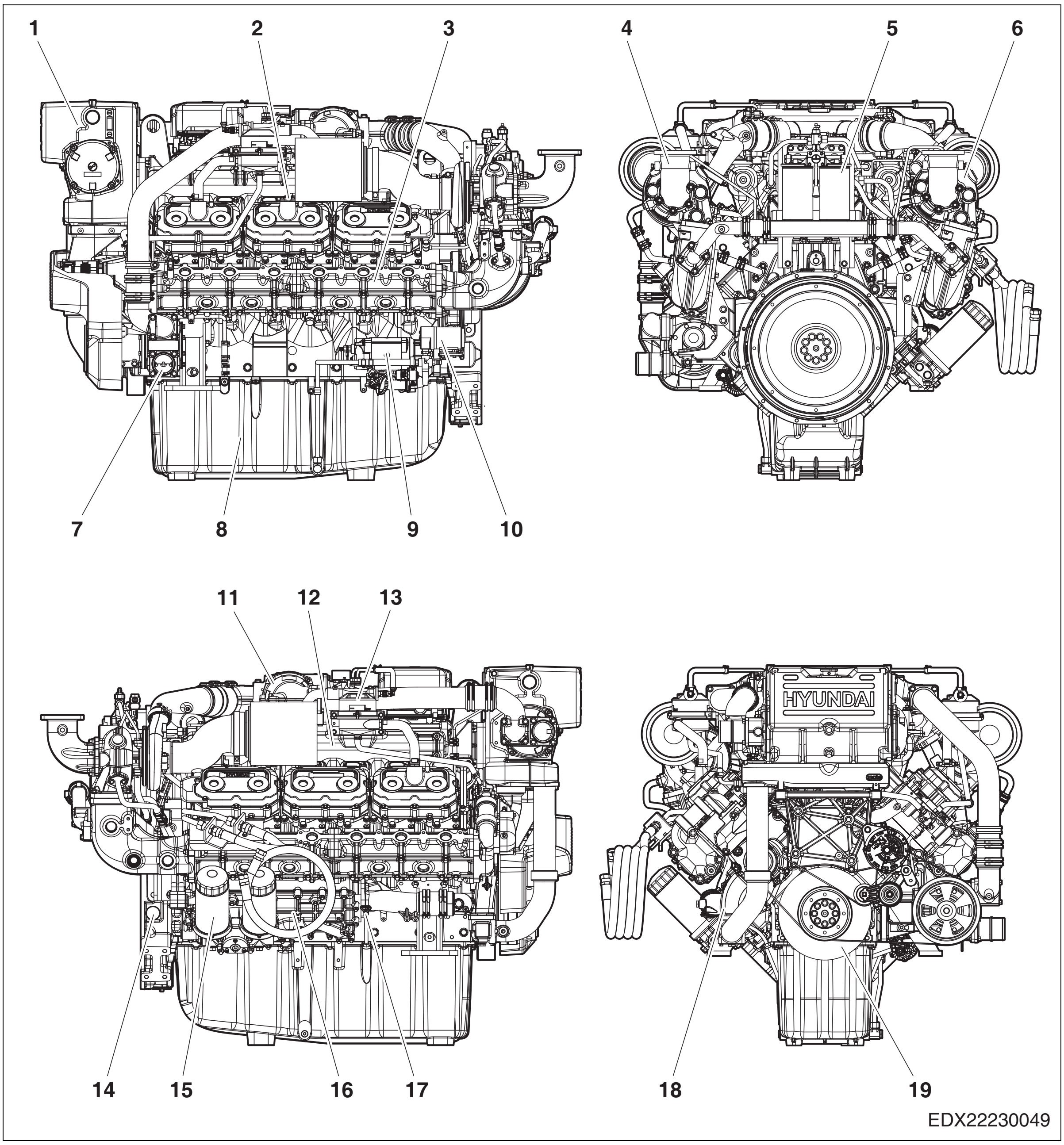
● Structural Diagram



1. Turbocharger
2. Fuel filter
3. Flywheel housing
4. Flywheel
5. Oil cooler
6. Oil filter
7. Mounting bracket
8. Fresh water pump
9. Cylinder head cover
10. Breather
11. Alternator
12. Raw water pump
13. Oil pan
14. Starter motor
15. Oil filler cap
16. Oil drain pump
17. Exhaust manifold
18. Intake manifold

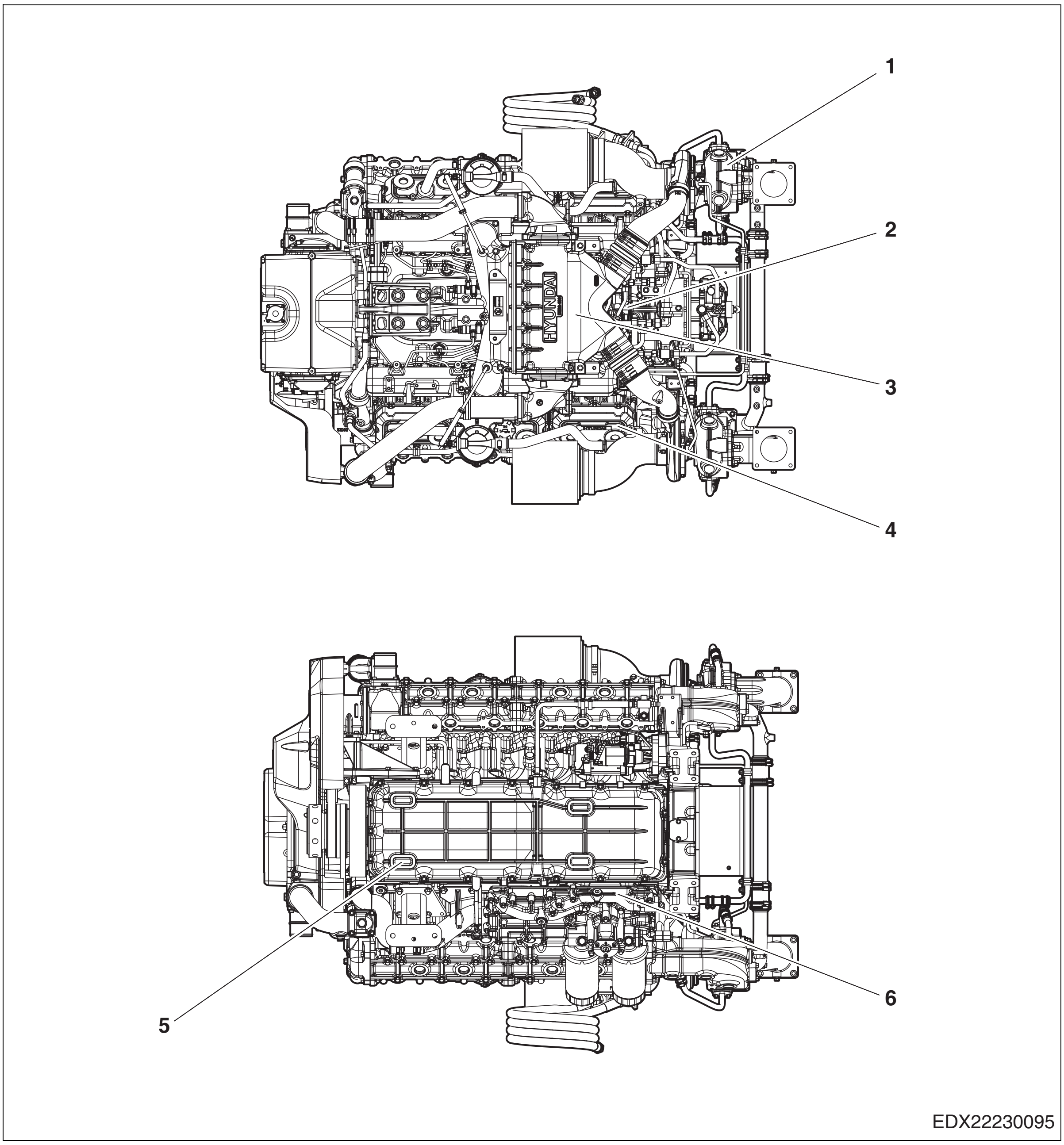
1.2.3. Outside Drawing of the Engine (Auxiliary - Heat Exchanger Type)

● Plane View (Front/Rear/Left/Right)



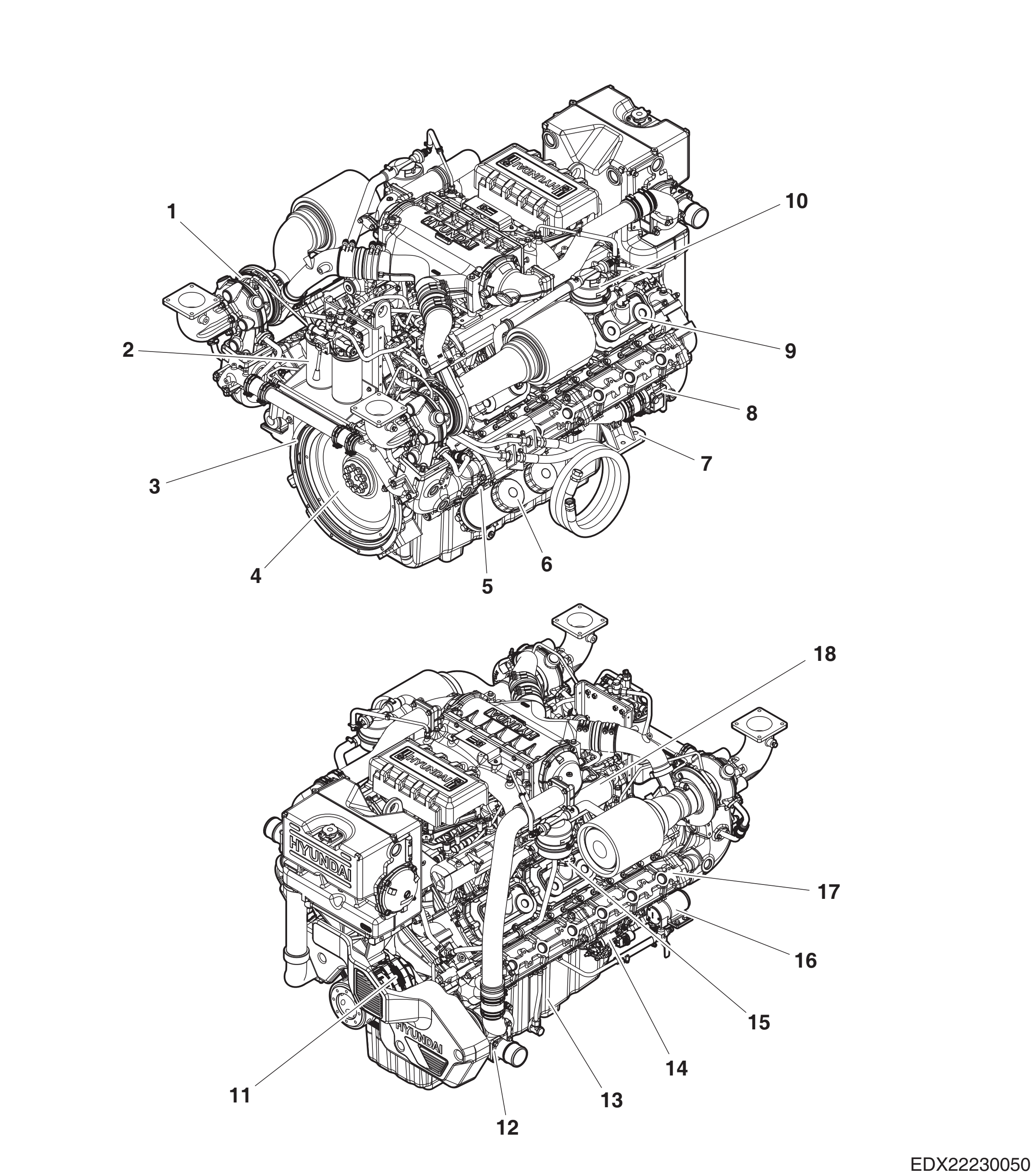
1. Heat exchanger	8. Oil pan	15. Oil filter
2. Oil filler cap	9. Starter motor	16. Oil cooler
3. Exhaust manifold	10. Oil drain pump	17. Oil measuring gauge
4. Exhaust elbow	11. Intercooler	18. Fresh water pump
5. Fuel filter	12. Intake manifold	19. Crankshaft pulley
6. Turbocharger	13. Breather	
7. Raw water pump	14. Flywheel housing	

● Plane View (Top/Bottom)



1. Turbocharger
2. Fuel injection pump
3. Intercooler
4. Cylinder head cover
5. Oil pan
6. Oil cooler

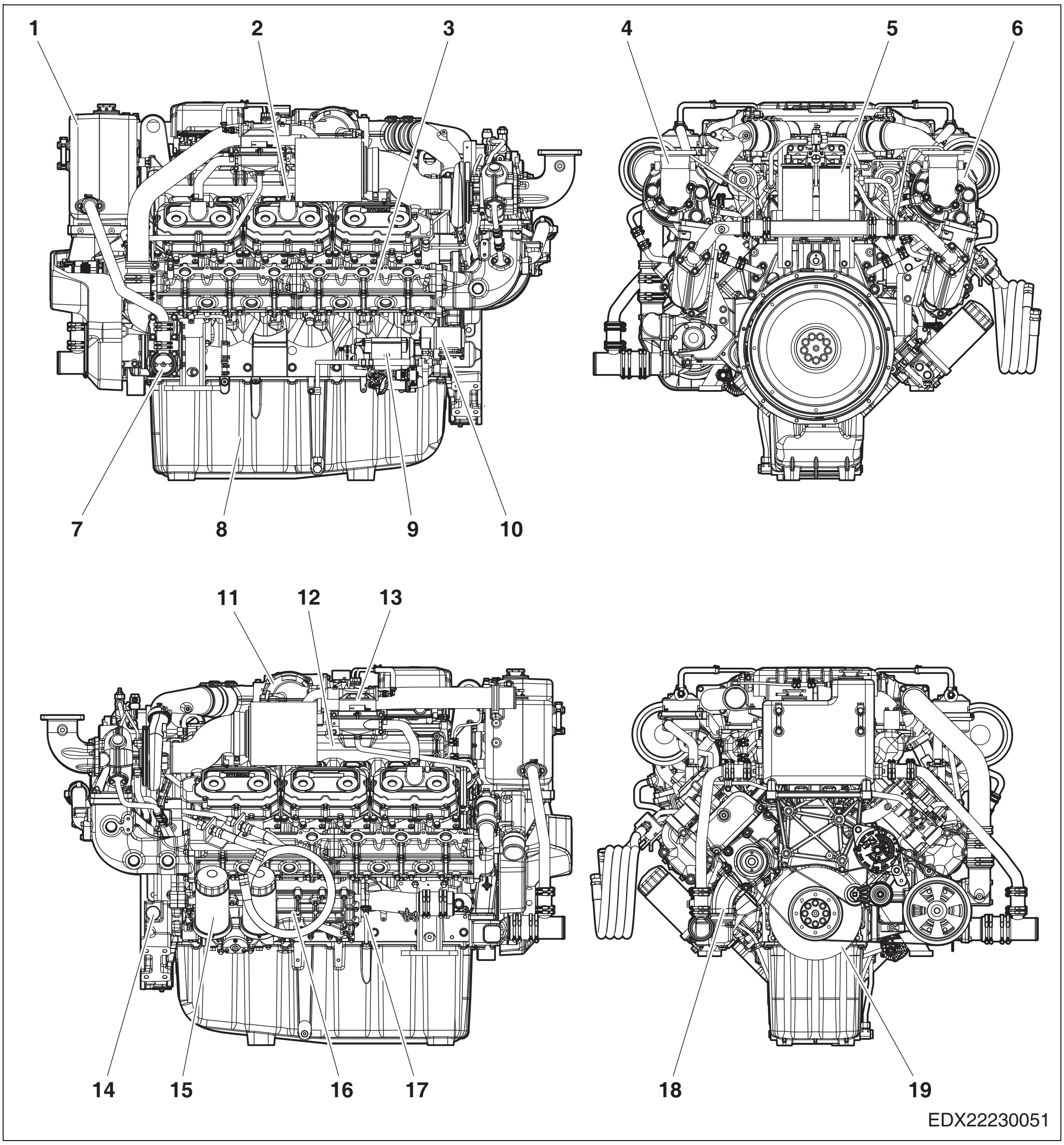
● Structural Diagram



1. Turbocharger
2. Fuel filter
3. Flywheel housing
4. Flywheel
5. Oil cooler
6. Oil filter
7. Mounting bracket
8. Fresh water pump
9. Cylinder head cover
10. Breather
11. Alternator
12. Raw water pump
13. Oil pan
14. Starter motor
15. Oil filler cap
16. Oil drain pump
17. Exhaust manifold
18. Intake manifold

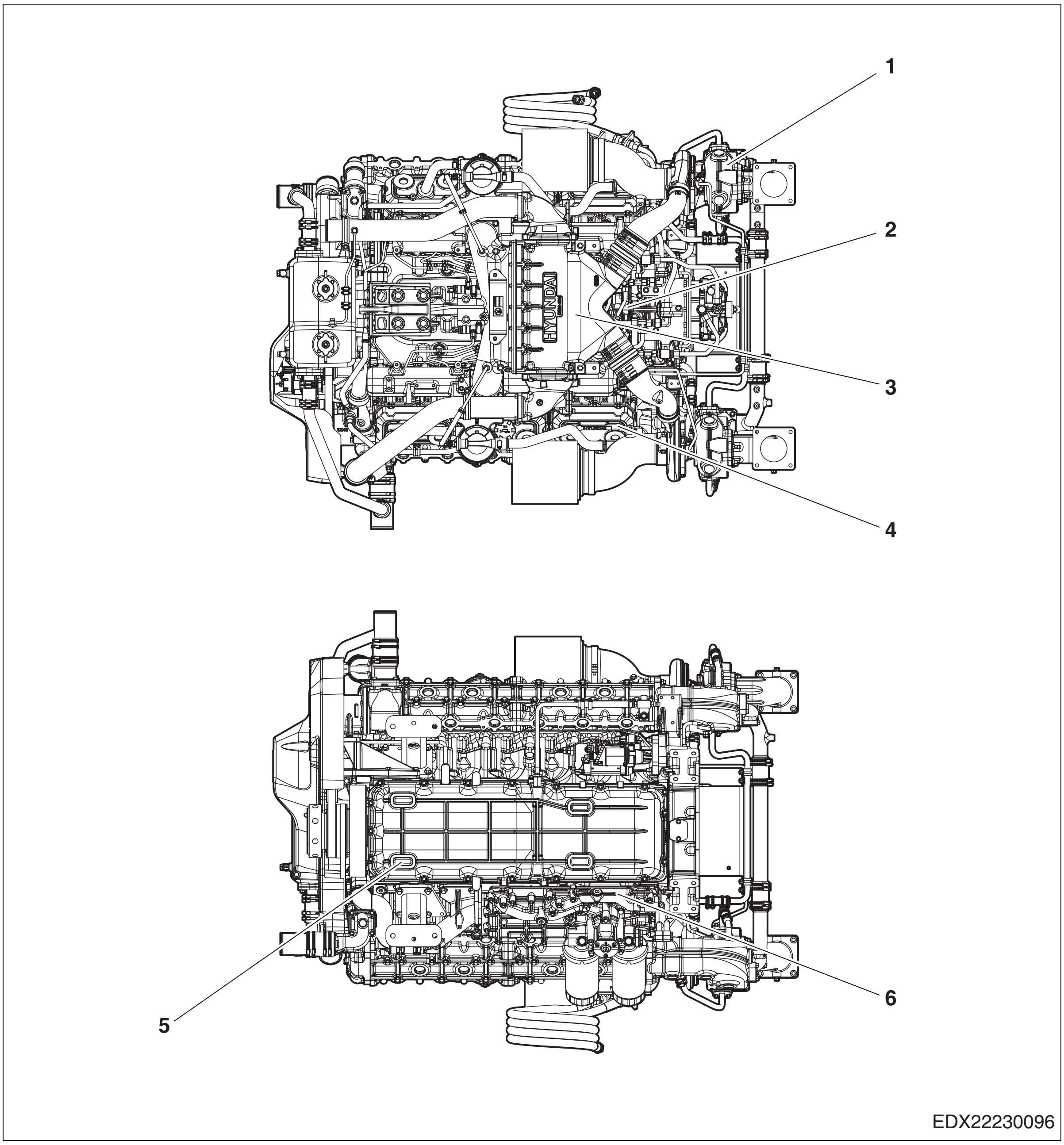
1.2.4. Outside Drawing of the Engine (Auxiliary - Keel Cooling Type)

● Plane View (Front/Rear/Left/Right)



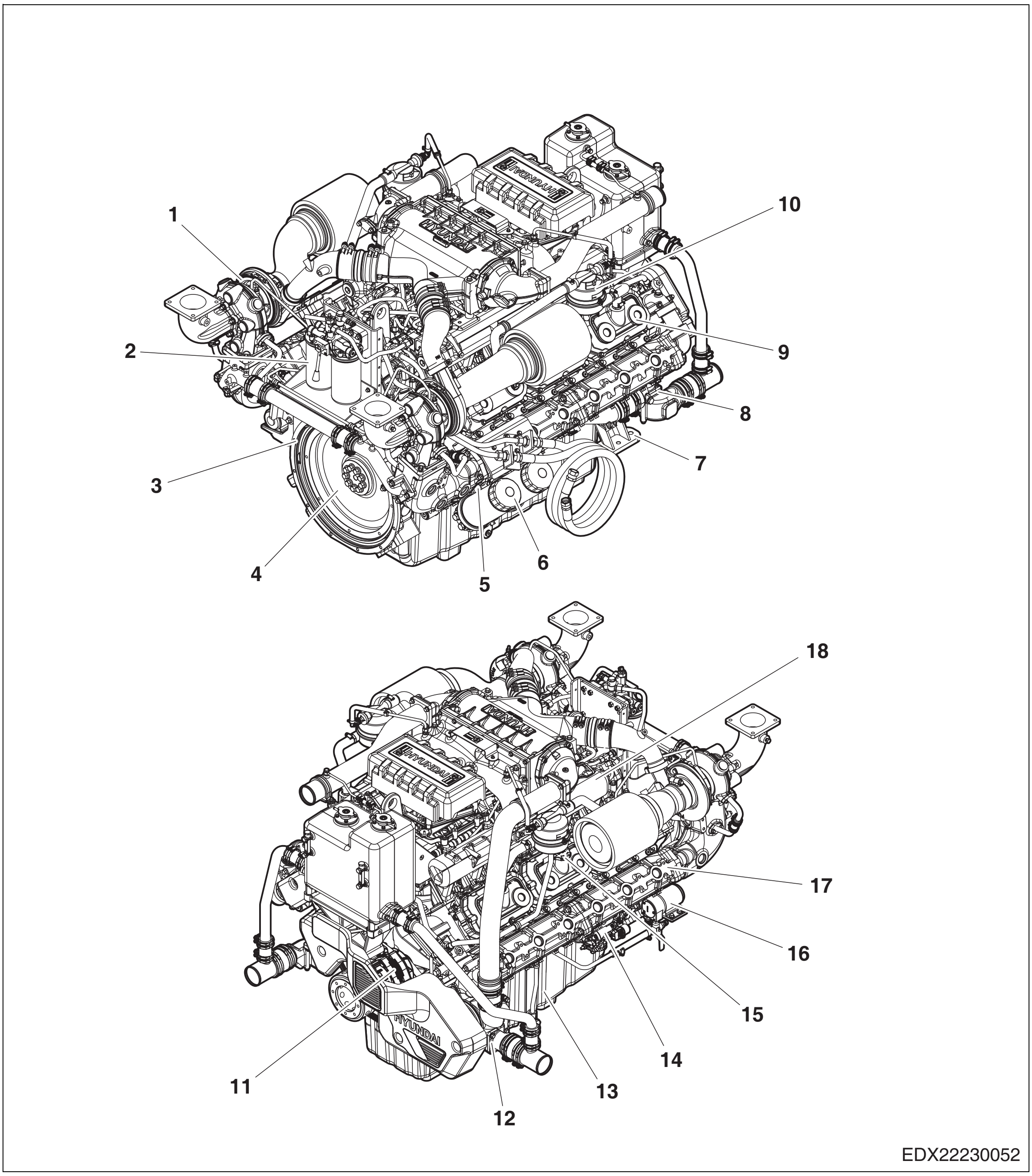
1. Keel cooling
2. Oil filler cap
3. Exhaust manifold
4. Exhaust elbow
5. Fuel filter
6. Turbocharger
7. Raw water pump
8. Oil pan
9. Starter motor
10. Oil drain pump
11. Intercooler
12. Intake manifold
13. Breather
14. Flywheel housing
15. Oil filter
16. Oil cooler
17. Oil measuring gauge
18. Fresh water pump
19. Crankshaft pulley

- Plane View (Top/Bottom)



1. Turbocharger	3. Intercooler	5. Oil pan
2. Fuel injection pump	4. Cylinder head cover	6. Oil cooler

● Structural Diagram

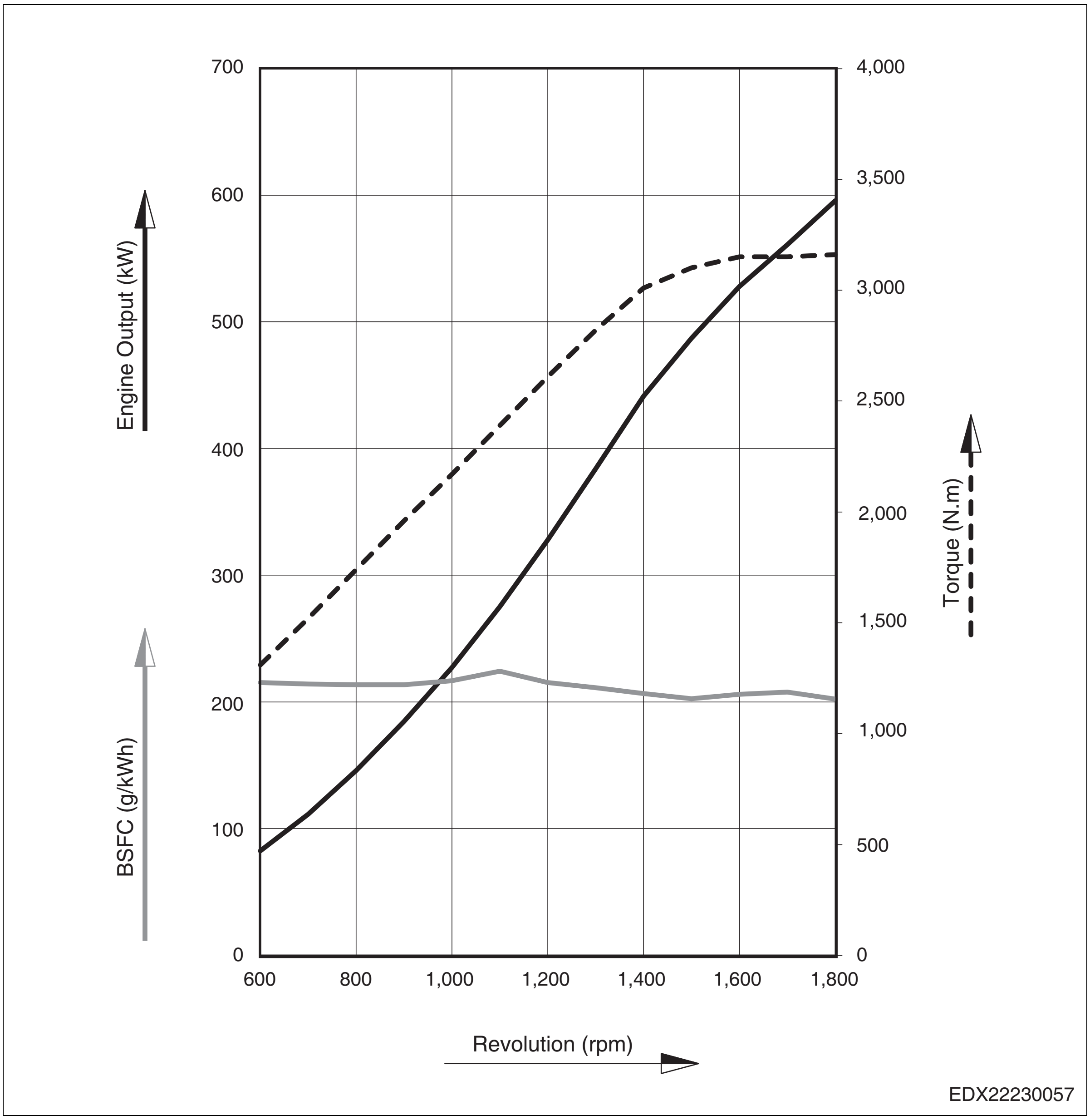


1. Turbocharger
2. Fuel filter
3. Flywheel housing
4. Flywheel
5. Oil cooler
6. Oil filter
7. Mounting bracket
8. Fresh water pump
9. Cylinder head cover
10. Breather
11. Alternator
12. Raw water pump
13. Oil pan
14. Starter motor
15. Oil filler cap
16. Oil drain pump
17. Exhaust manifold
18. Intake manifold

1.3. Engine Performance Curve

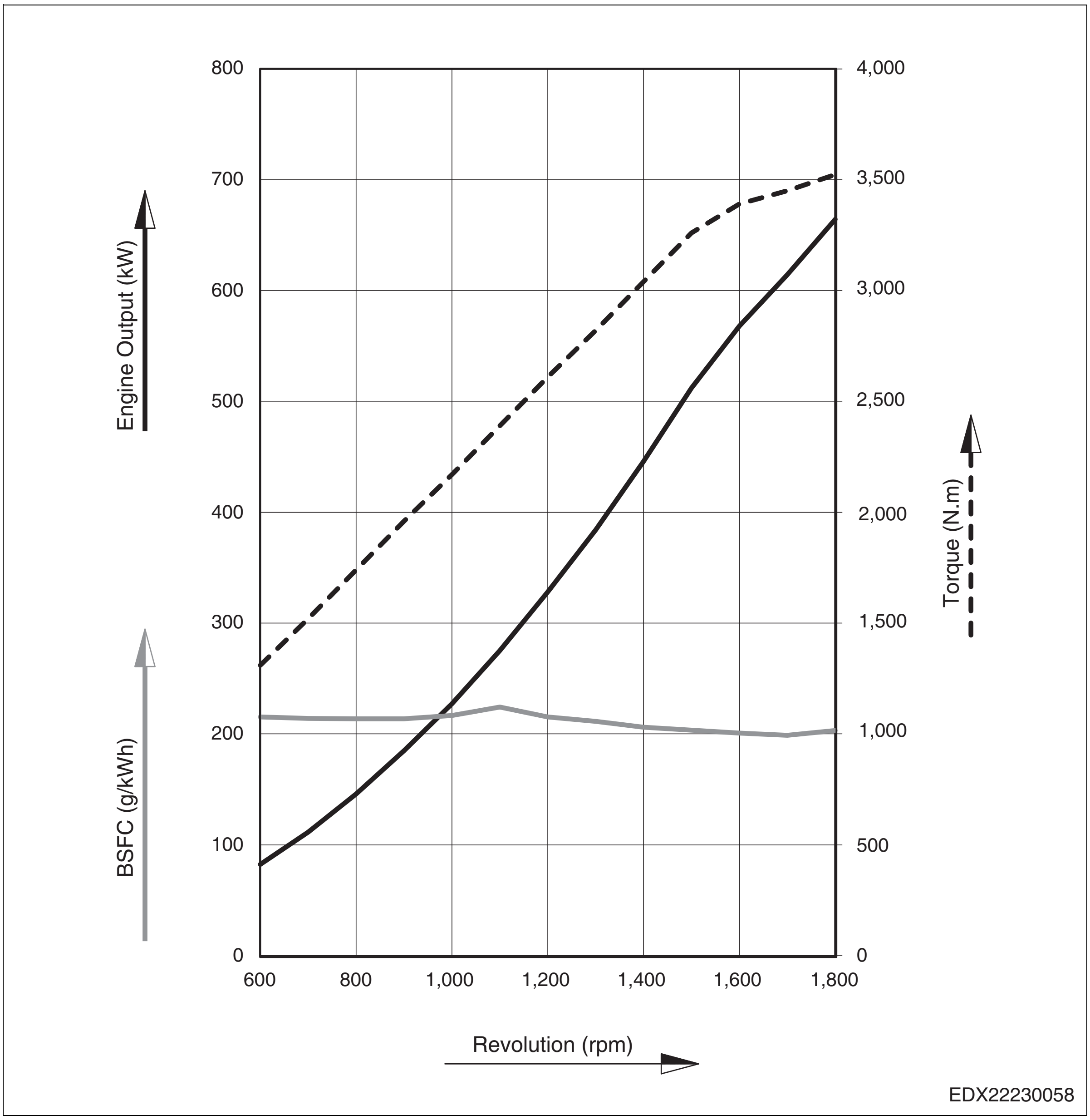
1.3.1. Performance Curve (IMO Tier2)

- 4V222CASC (Continuous Duty)



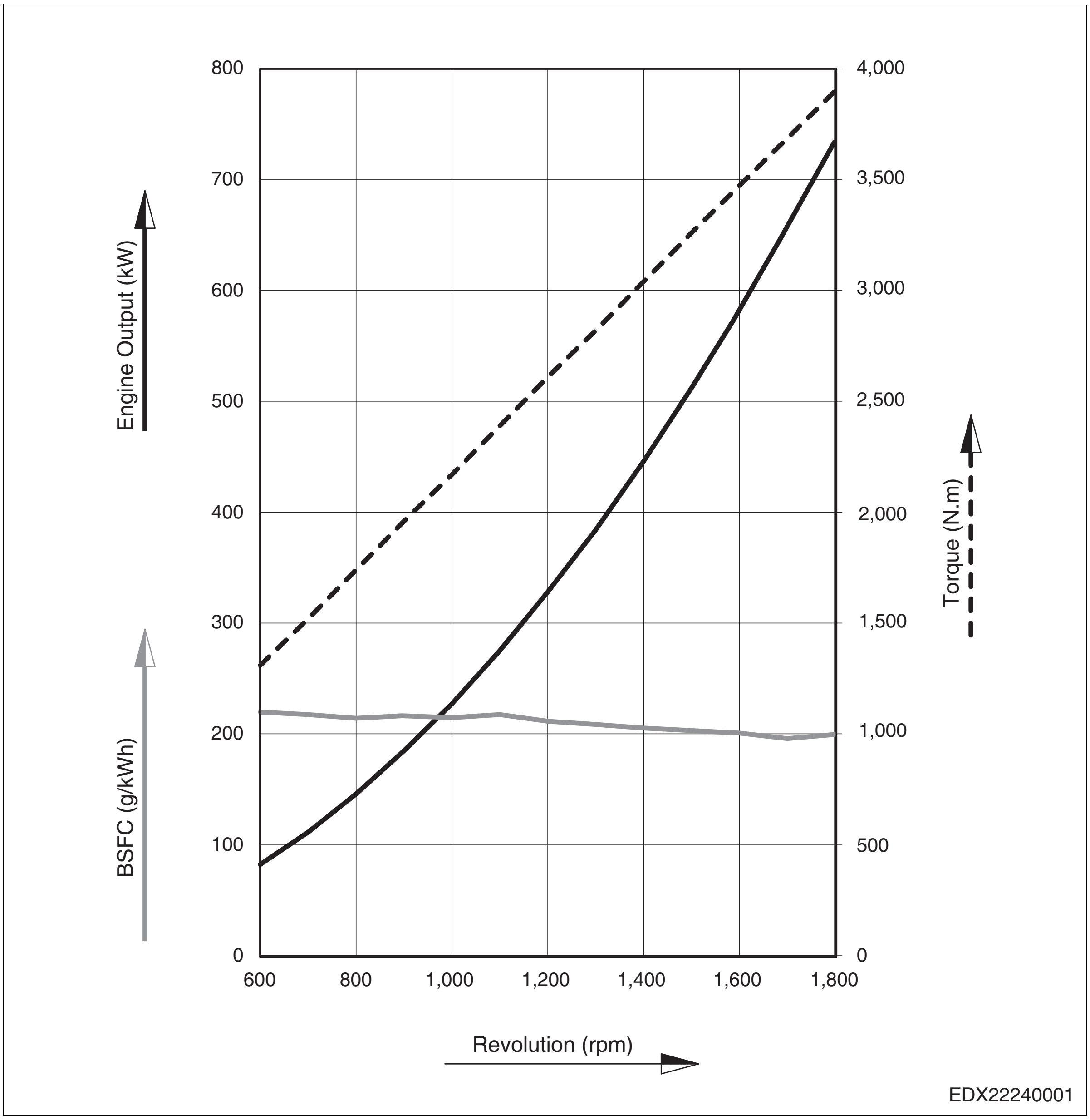
Testing and evaluation method		KS - R0071
Engine power	(max.)	810 PS (596 kW) / 1,800 rpm
Fuel consumption	(rated)	202.2 g/kWh

● 4V222CASH (Heavy Duty)



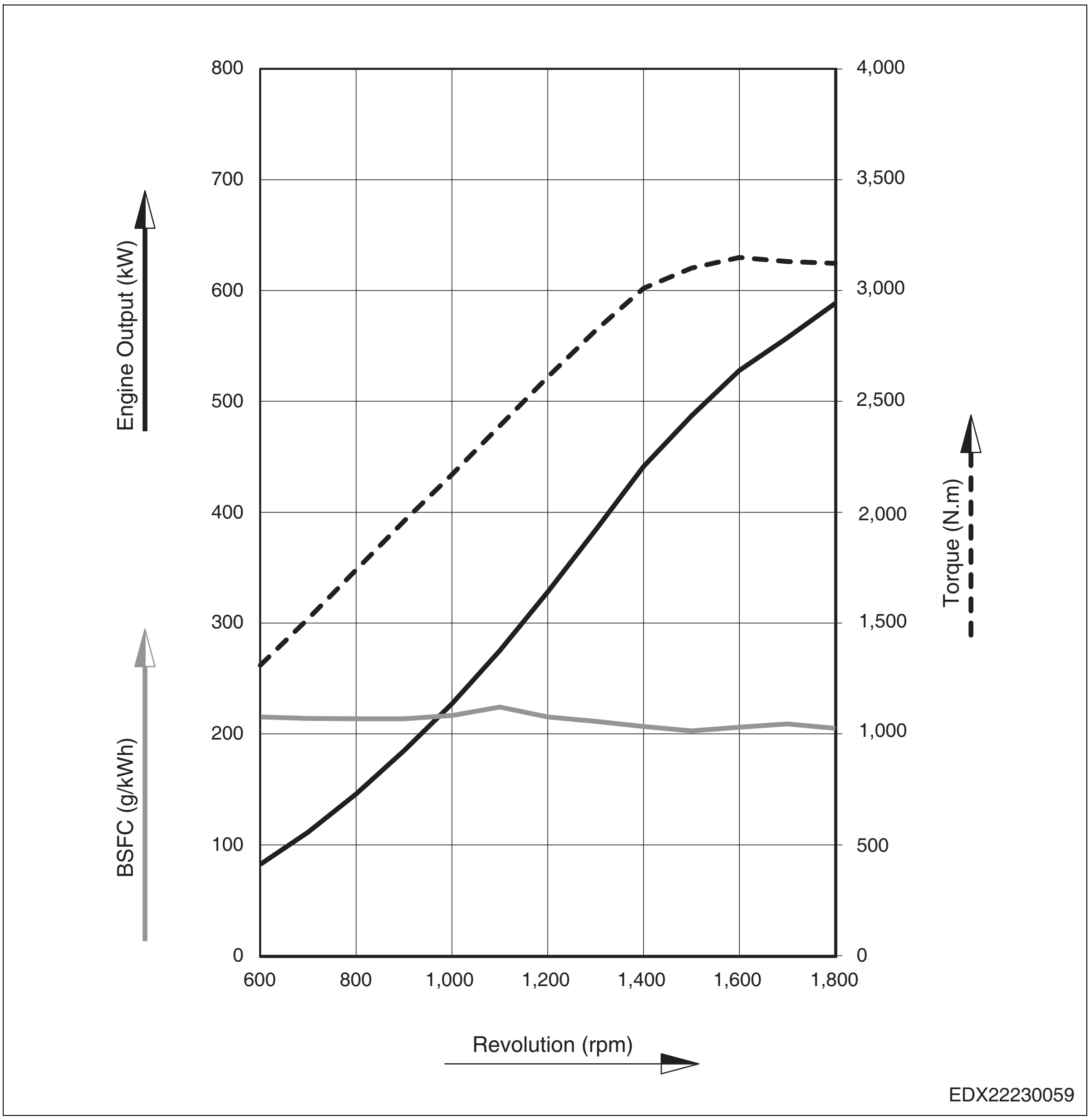
Testing and evaluation method		KS - R0071
Engine power	(max.)	903 PS (664 kW) / 1,800 rpm
Fuel consumption	(rated)	203.0 g/kWh

● 4V222CASH-II (Heavy Duty)



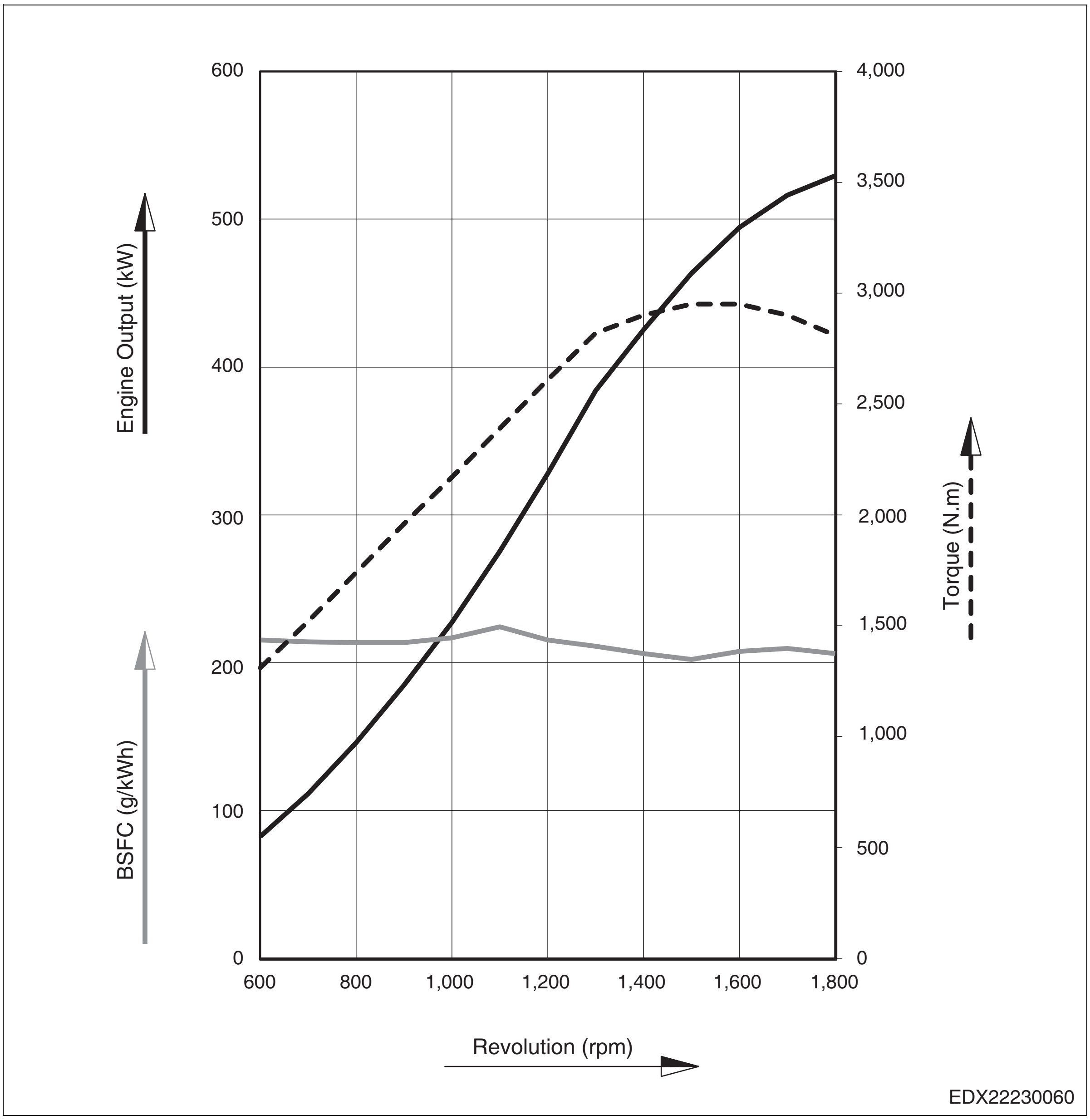
Testing and evaluation method		KS - R0071
Engine power	(max.)	1,000 PS (736 kW) / 1,800 rpm
Fuel consumption	(rated)	199.6 g/kWh

● 4V222CBSH (Heavy Duty)



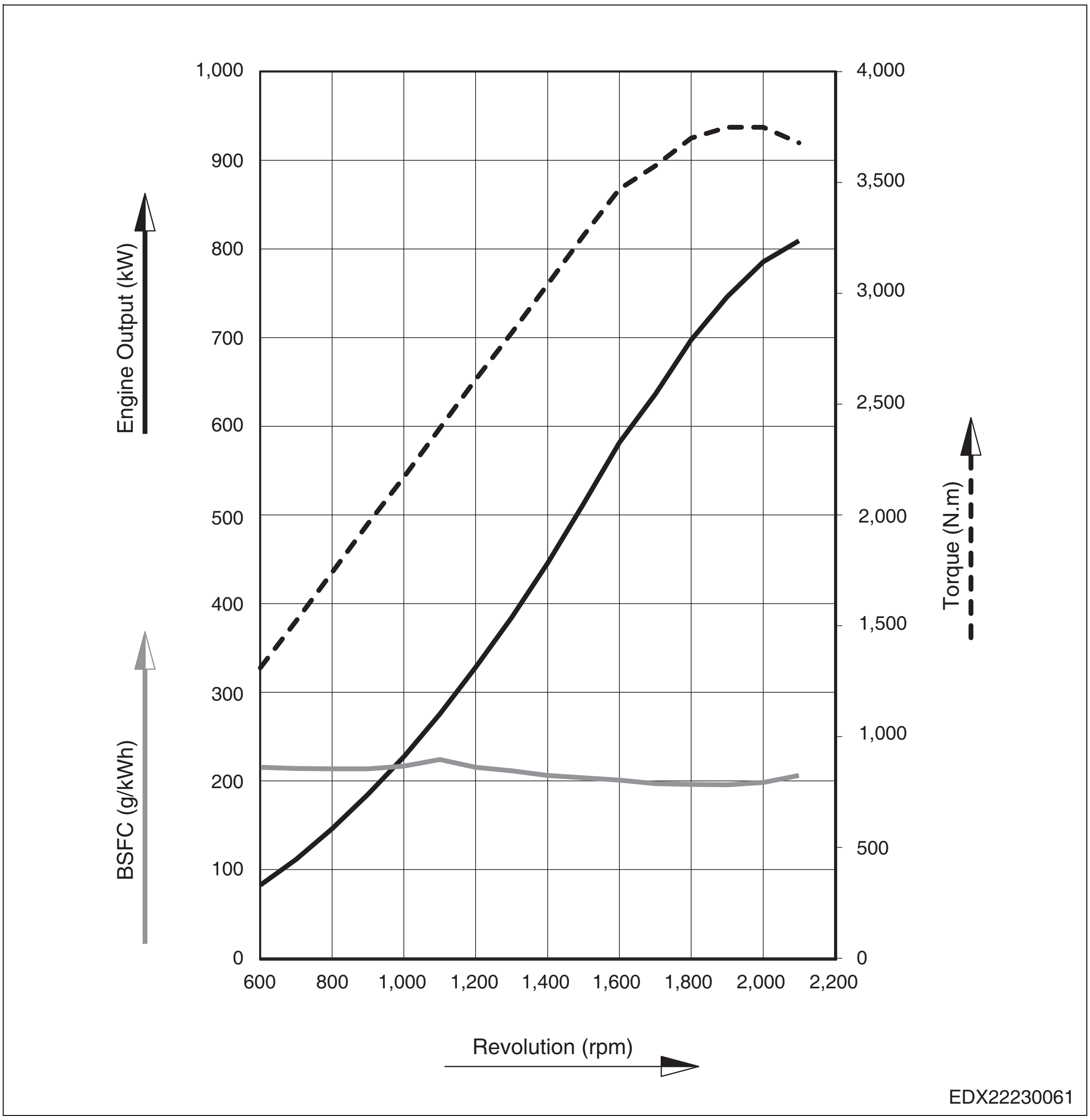
Testing and evaluation method		KS - R0071
Engine power	(max.)	800 PS (588 kW) / 1,800 rpm
Fuel consumption	(rated)	204.9 g/kWh

● 4V222CCSH (Heavy Duty)



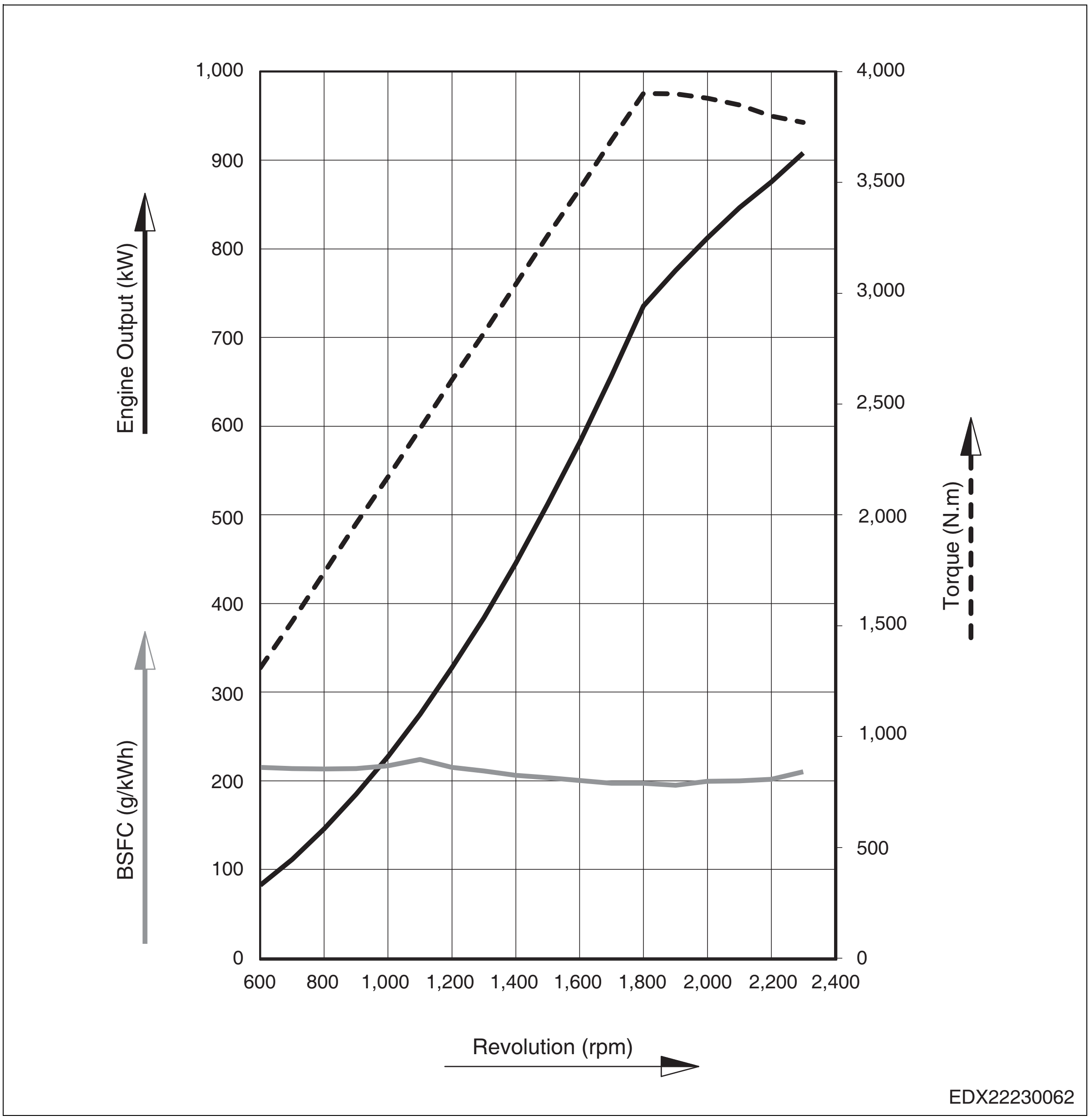
Testing and evaluation method		KS - R0071
Engine power	(max.)	720 PS (530 kW) / 1,800 rpm
Fuel consumption	(rated)	206.0 g/kWh

- 4V222CASM (Medium Duty)



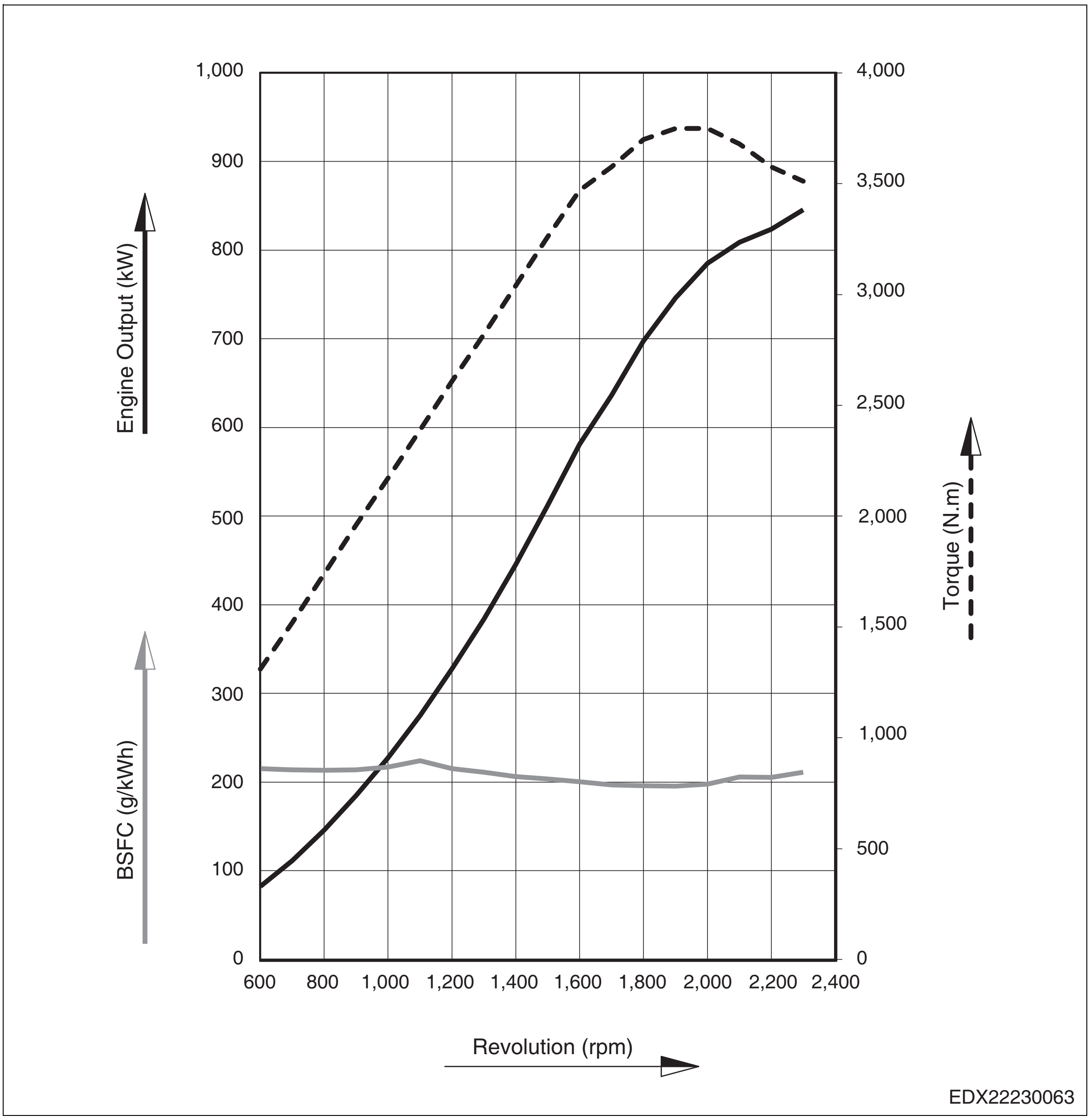
Testing and evaluation method		KS - R0071
Engine power	(max.)	1,100 PS (809 kW) / 2,100 rpm
Fuel consumption	(rated)	205.8 g/kWh

● 4V222CASL (Light Duty)



Testing and evaluation method		KS - R0071
Engine power	(max.)	1,235 PS (908 kW) / 2,300 rpm
Fuel consumption	(rated)	210.3 g/kWh

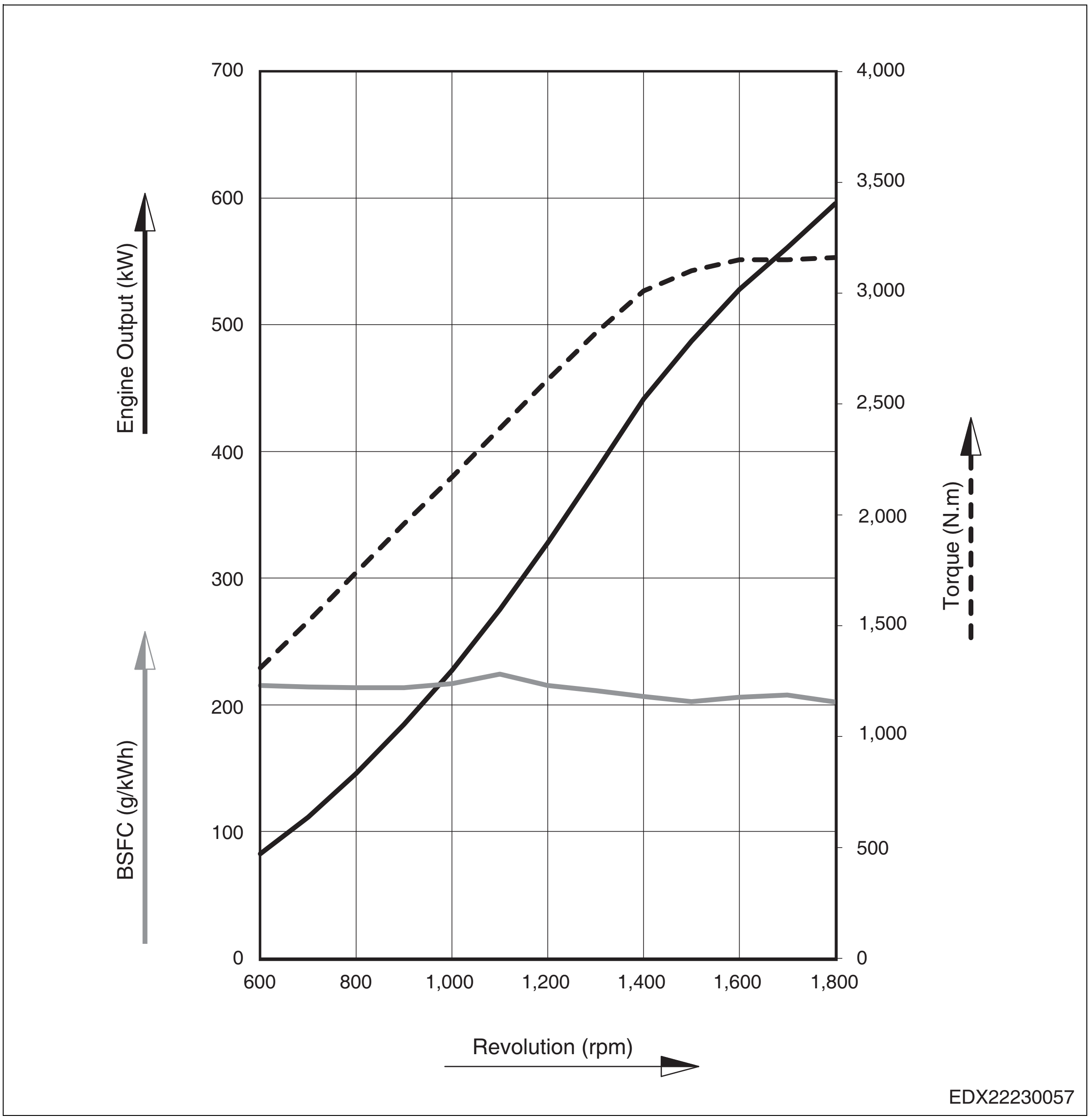
● 4V222CBSL (Light Duty)



Testing and evaluation method		KS - R0071
Engine power	(max.)	1,150 PS (846 kW) / 2,300 rpm
Fuel consumption	(rated)	211.1 g/kWh

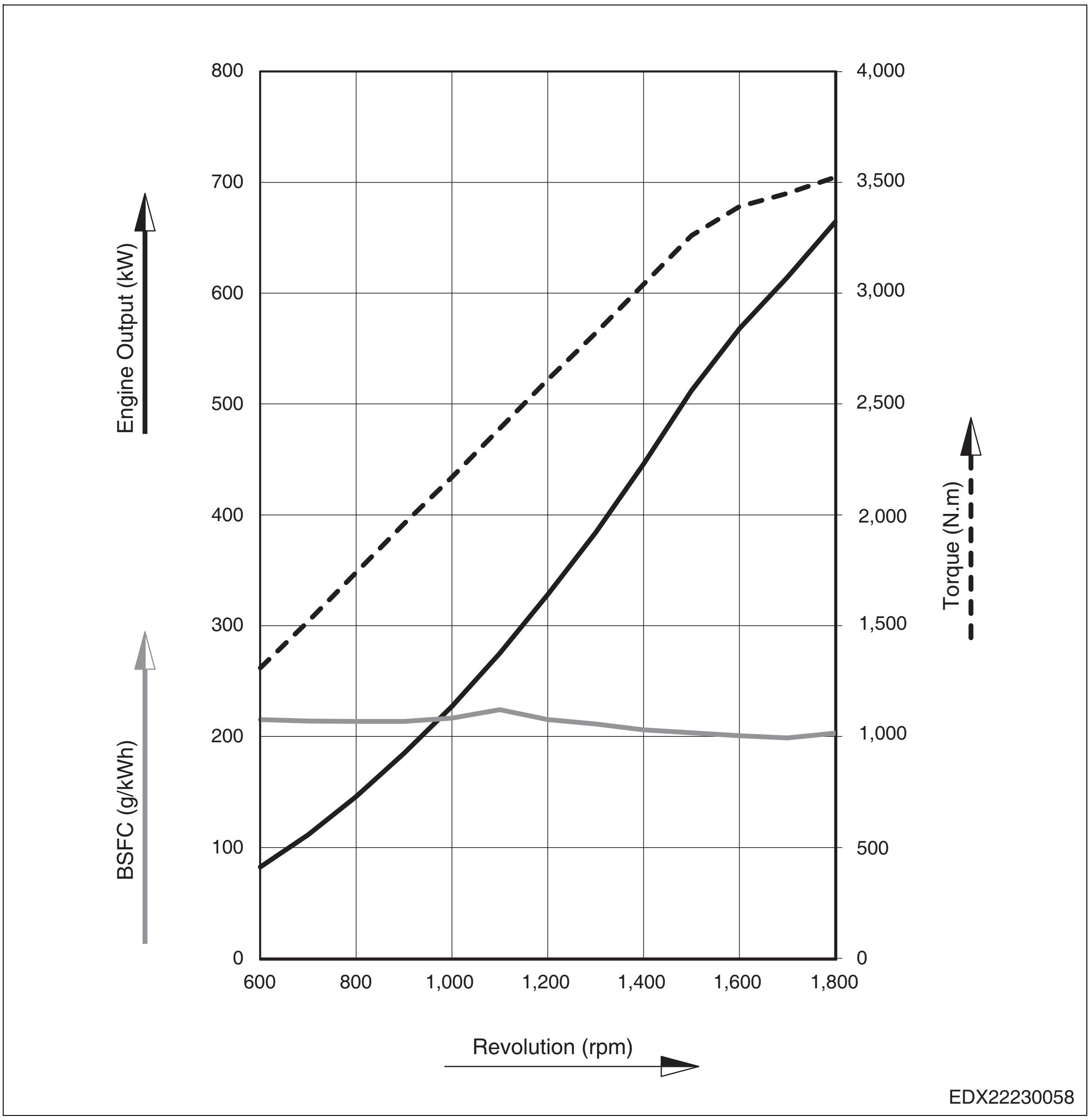
1.3.2. Performance Curve (IMO Tier3)

- 4V222CAKC (Continuous Duty)



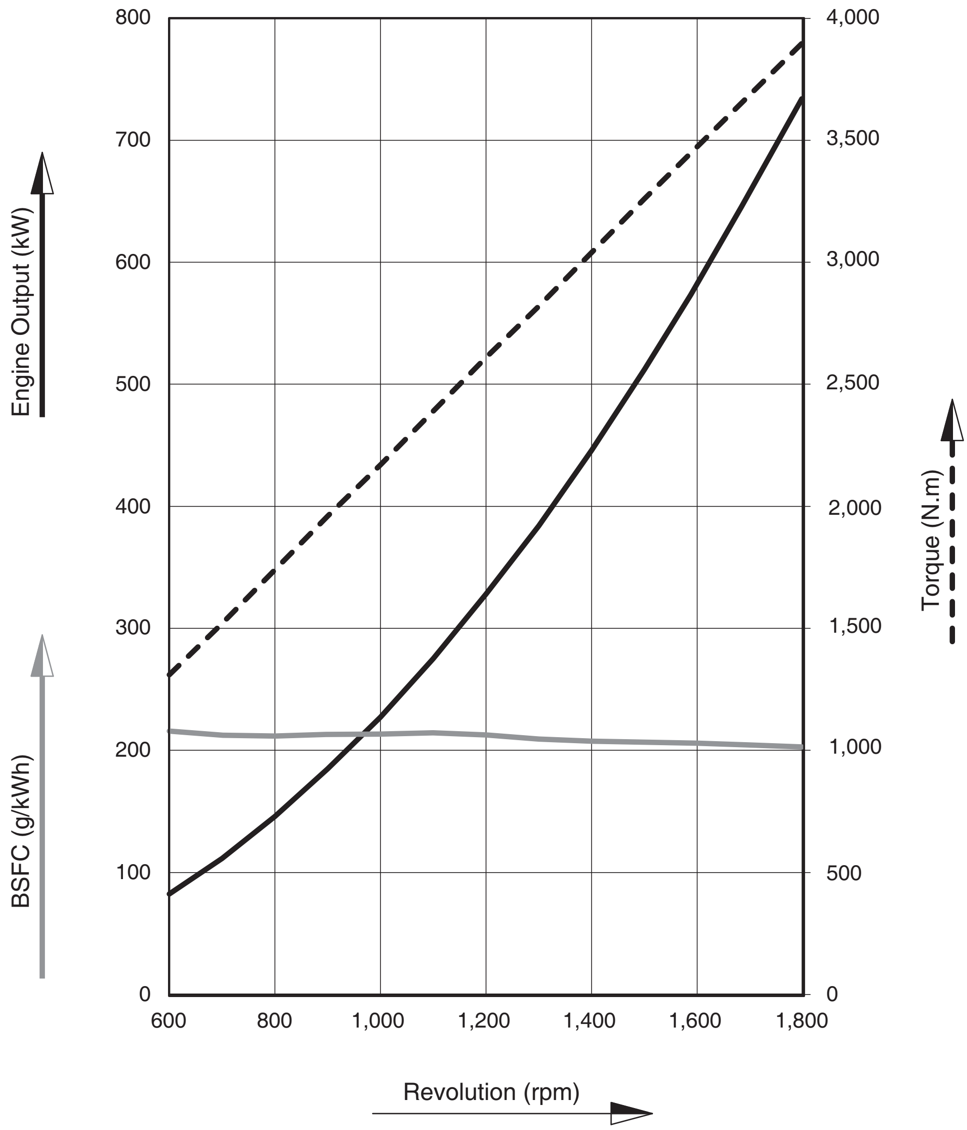
Testing and evaluation method		KS - R0071
Engine power	(max.)	810 PS (596 kW) / 1,800 rpm
Fuel consumption	(rated)	204.0 g/kWh

● 4V222CAKH (Heavy Duty)



Testing and evaluation method		KS - R0071
Engine power	(max.)	903 PS (664 kW) / 1,800 rpm
Fuel consumption	(rated)	206.1 g/kWh

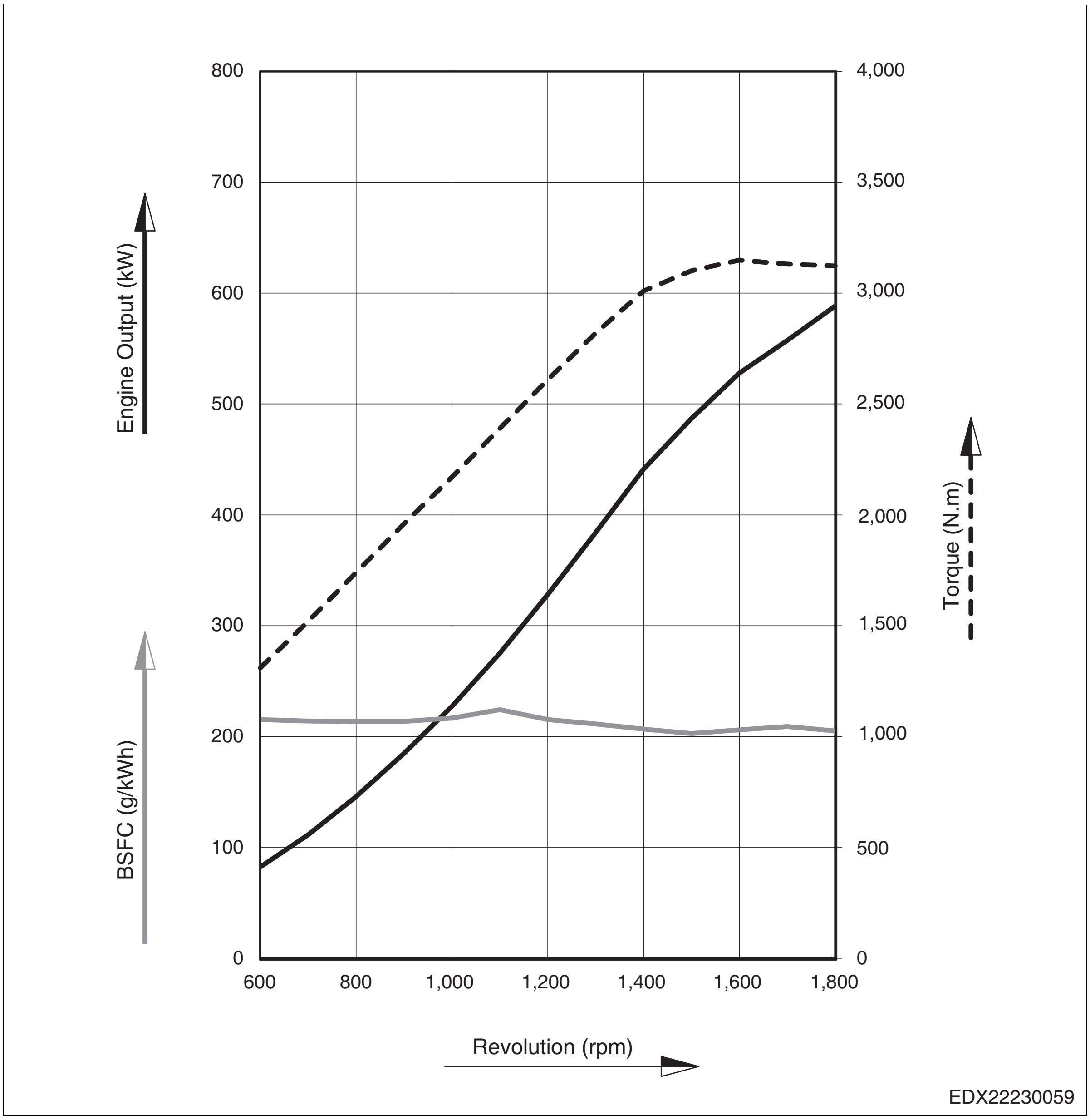
● 4V222CAKH-II (Heavy Duty)



EDX22240002

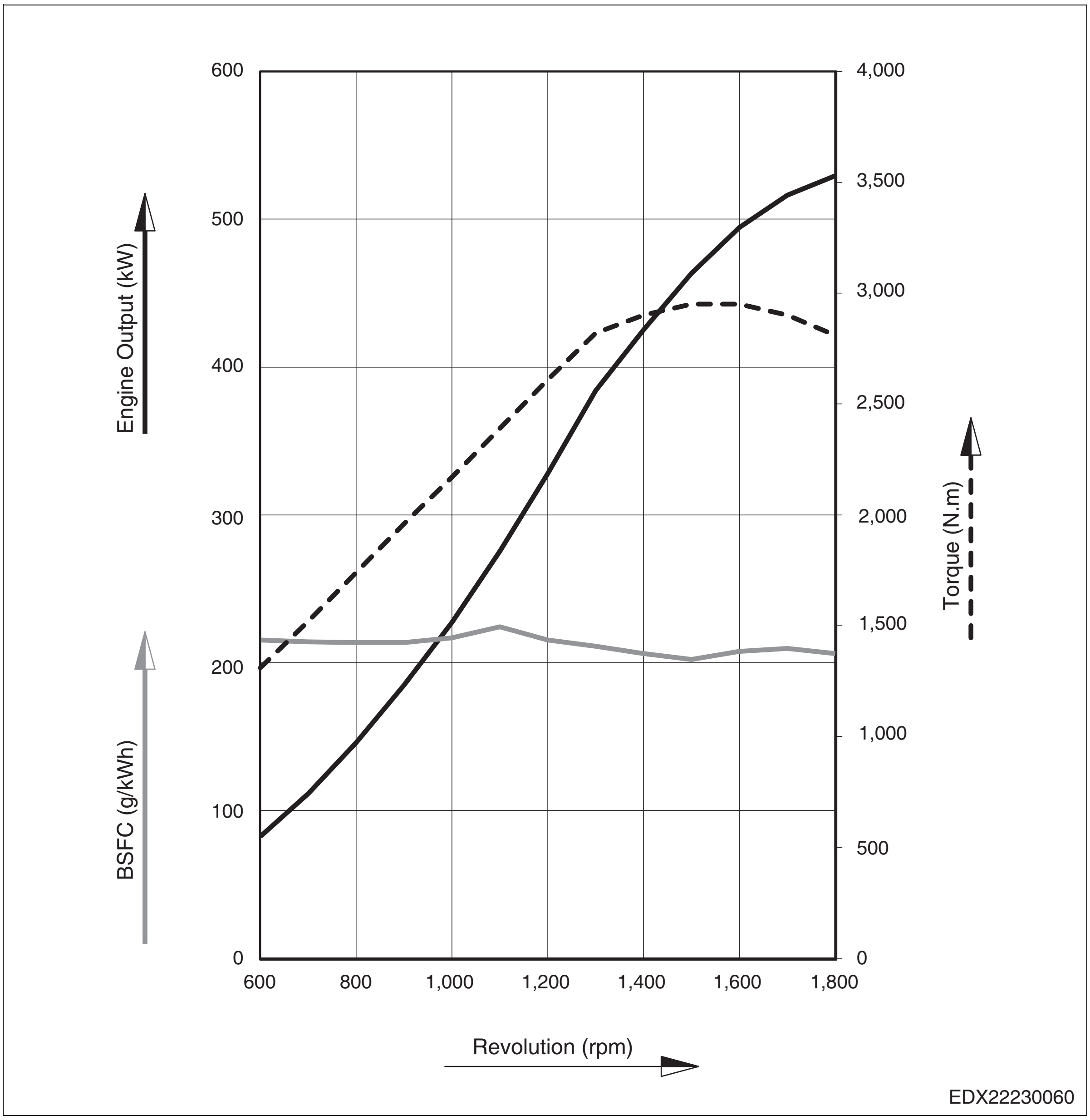
Testing and evaluation method	KS - R0071
Engine power (max.)	1,000 PS (736 kW) / 1,800 rpm
Fuel consumption (rated)	203.6 g/kWh

● 4V222CBKH (Heavy Duty)



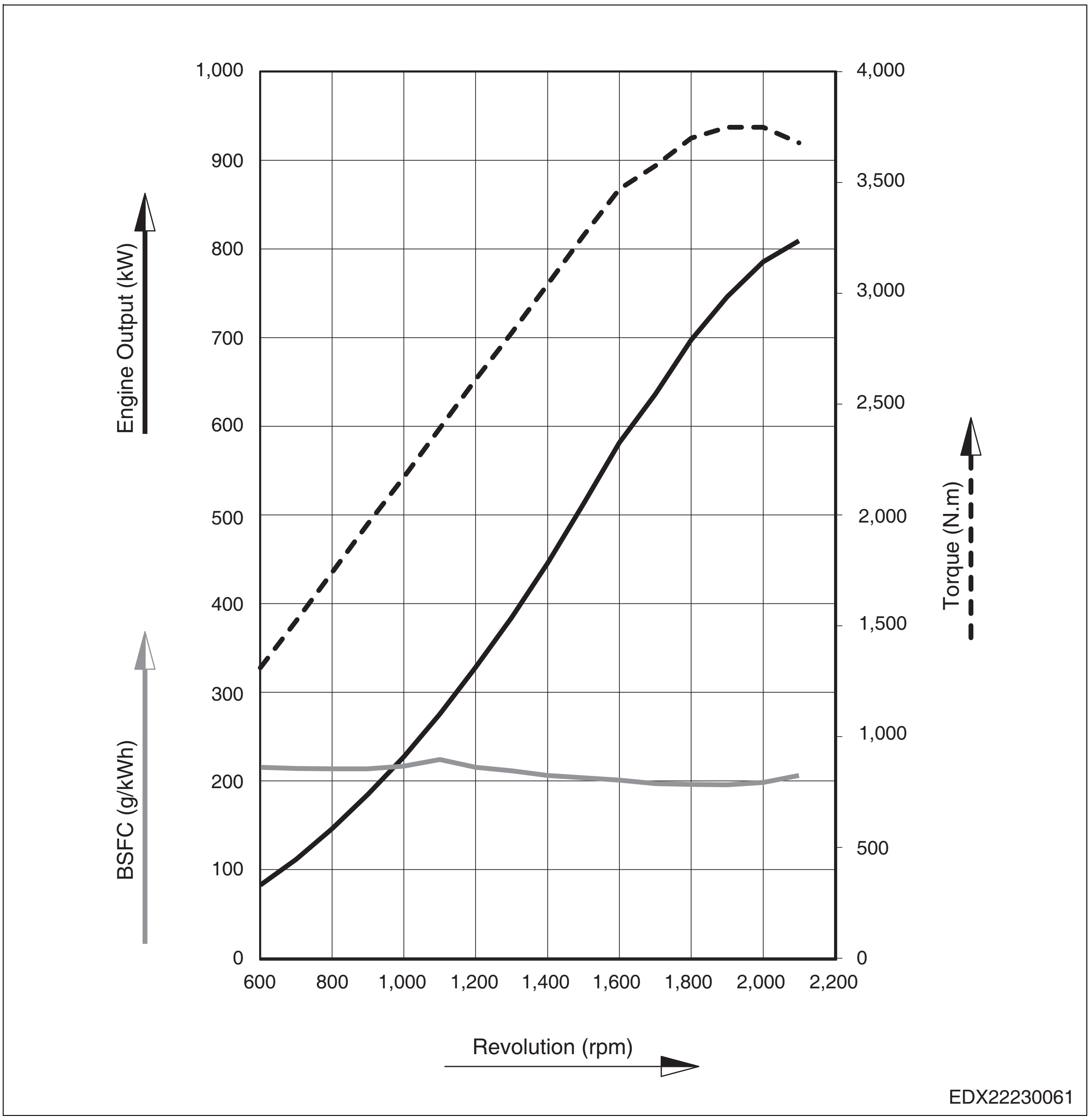
Testing and evaluation method		KS - R0071
Engine power	(max.)	800 PS (588 kW) / 1,800 rpm
Fuel consumption	(rated)	205.5 g/kWh

● 4V222CCKH (Heavy Duty)



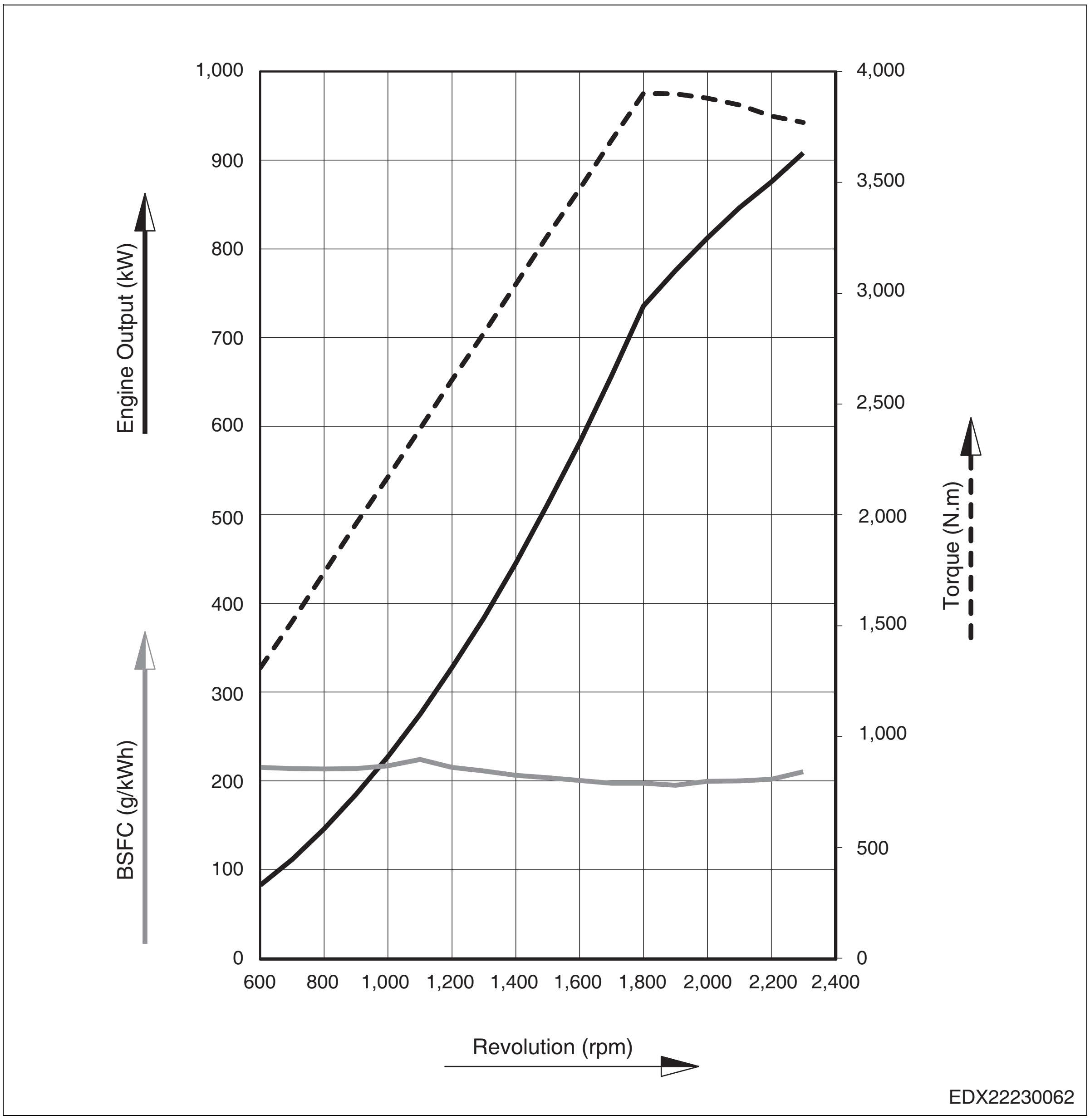
Testing and evaluation method		KS - R0071
Engine power	(max.)	720 PS (530 kW) / 1,800 rpm
Fuel consumption	(rated)	206.4 g/kWh

● 4V222CAKM (Medium Duty)



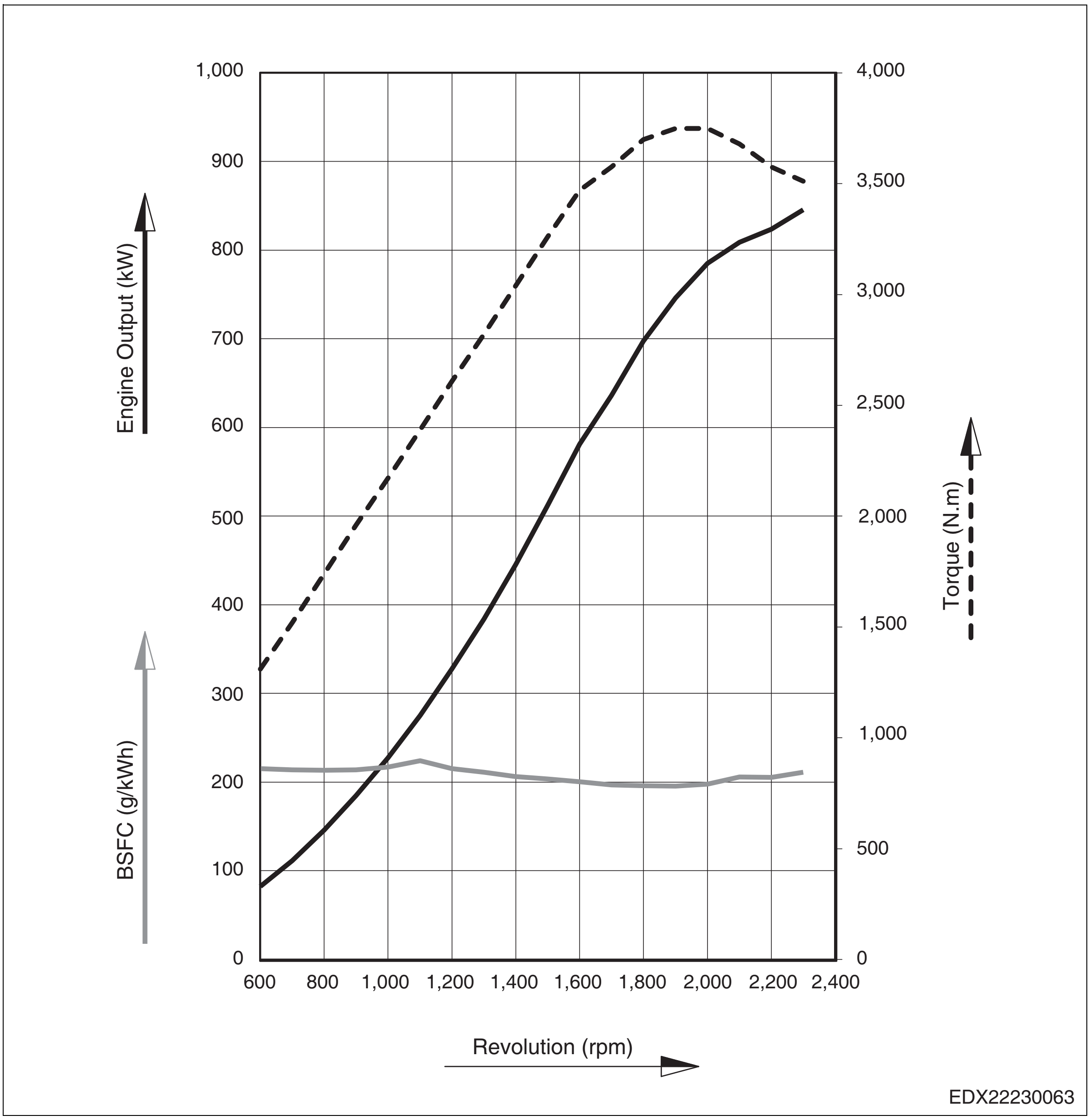
Testing and evaluation method		KS - R0071
Engine power	(max.)	1,100 PS (809 kW) / 2,100 rpm
Fuel consumption	(rated)	208.7 g/kWh

● 4V222CAKL (Light Duty)



Testing and evaluation method		KS - R0071
Engine power	(max.)	1,235 PS (908 kW) / 2,300 rpm
Fuel consumption	(rated)	213.5 g/kWh

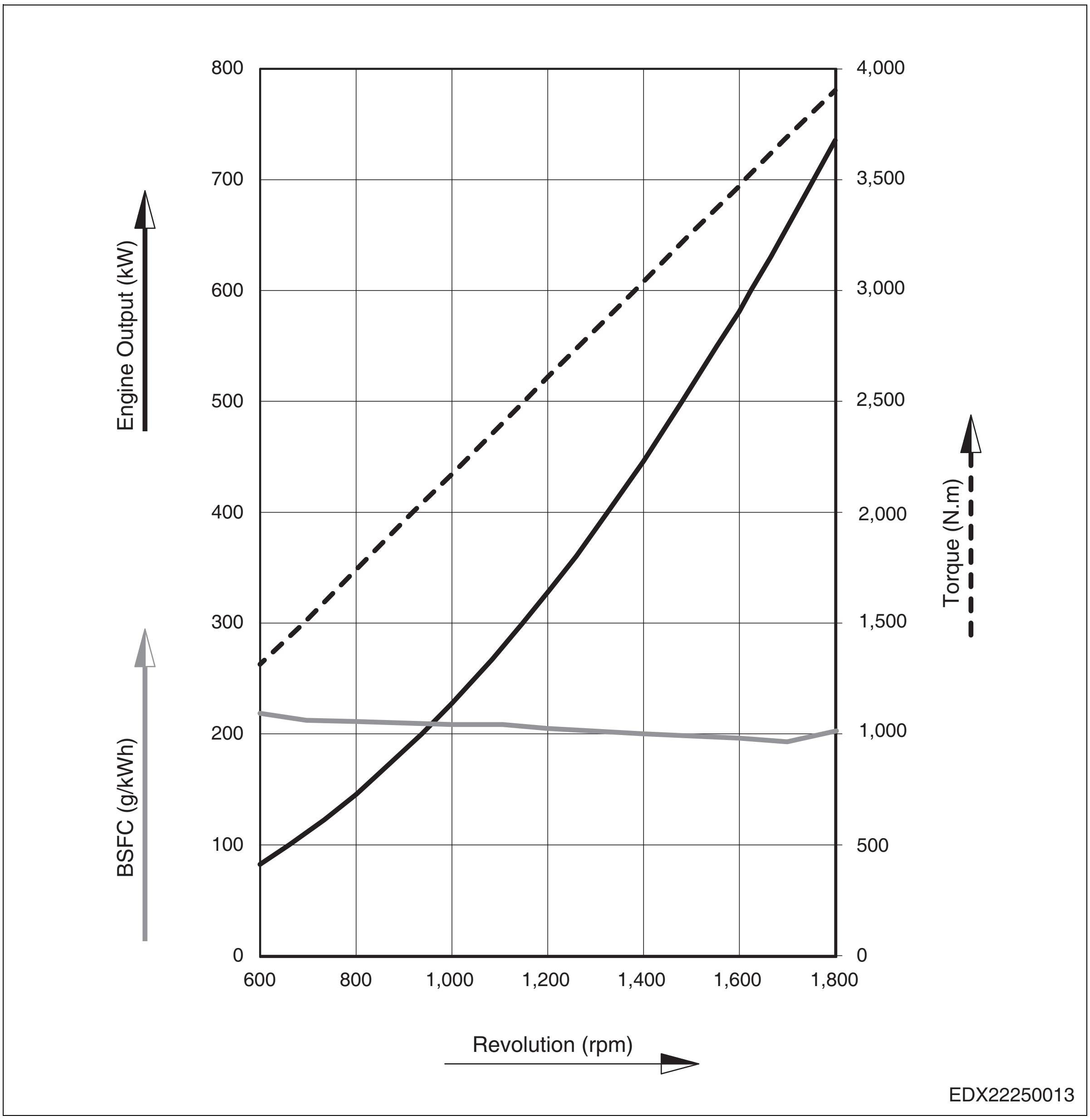
● 4V222CBKL (Light Duty)



Testing and evaluation method		KS - R0071
Engine power	(max.)	1,150 PS (846 kW) / 2,300 rpm
Fuel consumption	(rated)	213.4 g/kWh

1.3.3. Performance Curve (Power Unit)

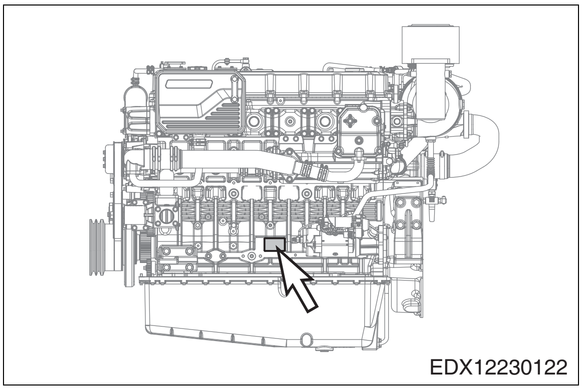
● 4P222CASH (IMO Tier2)



Testing and evaluation method		KS - R0071
Engine power	(max.)	1,000 PS (736 kW) / 1,800 rpm
Fuel consumption	(rated)	202.2 g/kWh

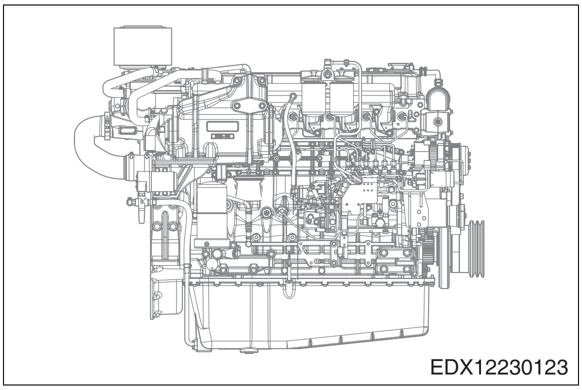
1.4. Engine Model and Serial Number

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.



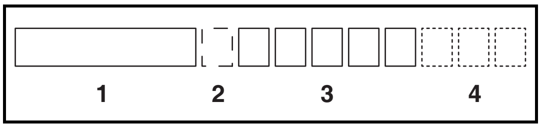
EDX12230122

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



EDX12230123

● Engine Serial Number



1	Suffix
2	Last digit of production year
3	Number (serial number)
4	N/A

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 oil level in the oil pan in advance so that a suitable container with 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.
- Before working on any electrical system, be sure to disconnect the negative ('–') battery cable (ground 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 Components." 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 raw water 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.

   - Only use clean fuel with the specified grade. Please use the fuel recommended in this Operation and Maintenance Manual.

CAUTION
Using imitation or unspecified fuel may cause severe faults in the engine.

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. Electrolytic Corrosion Prevention

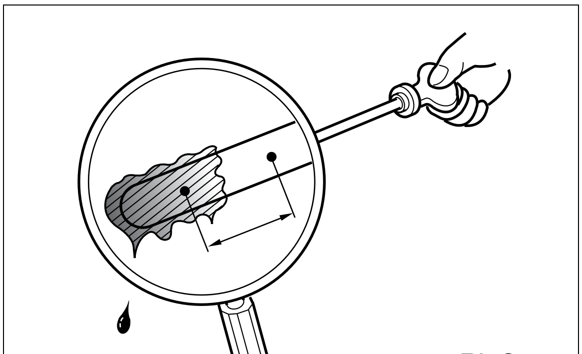
One of the most important causes of the corrosion of metal parts that occurs when they come into contact with seawater is the electrolytic corrosion caused by current in the electrical circuit of the ship. This current is very weak and difficult to detect. However, if this weak current continues to flow for an extended period of time, it can cause significant corrosion. This electrolytic corrosion can be prevented with proper wiring.
To prevent the electrolytic corrosion of the engine, the engine and reducer as well as their pipes need to be connected to the hull with ground wires.
The ground wires need to be copper wires with low electrical resistance and the cross-sectional area of the wires must be at least 16 mm^2.

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.



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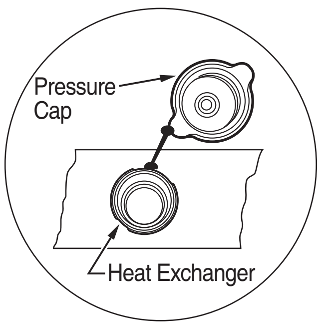
CAUTION
The upper and lower limit marks indicated on the oil level gauge may differ depending on the inclination of the engine installed. When running the engine for the first time after installation, fill the engine oil to its maximum capacity and check whether it matches up with the upper limit on 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.
(Engrave the maximum and minimum markings on the oil level gauge while referring to 4.4 "Fuel System.")

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^2)



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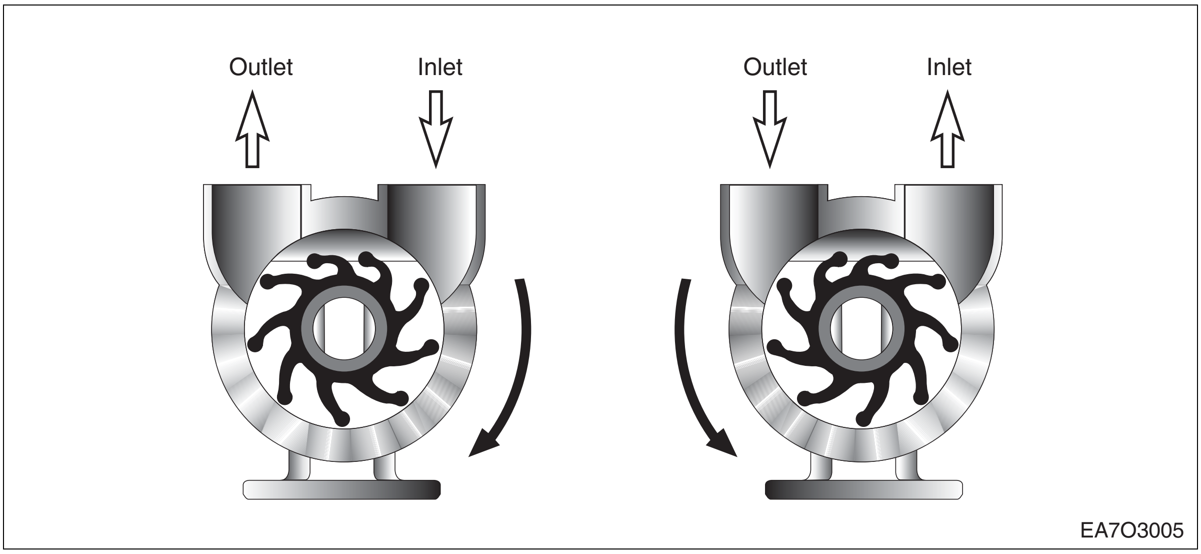
3.1.3. Raw Water Pump

The inlet and outlet on the raw water pump differ depending on therotating direction of the shaft.

- The load caused by overtightening the belt or gears shortens the pump life.
- Do not run the raw water pump in a dry state for more than 20 seconds.
- Check whether all of the valves and plugs in the raw water system are open before running the engine.
- If there is a risk of freezing, open the rear cover on the raw water 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 (1 bar or less @ 600 rpm, based on gauge pressure)
   - High engine coolant temperature (105°C or higher)
   - Engine overspeeding (over 117% of the rated rpm)
   - Abnormal common rail pressure (open common rail relief valve, max. common rail pressure exceeded, etc.)
   - Leaking fuel line

2) Speed limiter (propulsion engine), torque limiter (auxiliary engine)

   The engine warning lamp turns on, a warning buzzer sounds, and the speed and torque of the propulsion engine and auxiliary engine are limited, respectively.
   Speed limit of propulsion engine : Limited to MD 1,900 rpm, HD 1,800 rpm, CD 1,600 rpm.
   Torque limit of auxiliary engine: Limited to 50% of the rated power.
   - Abnormal sensor voltage (coolant temperature sensor, cam sensor, oil pressure sensor)
   - High fuel temperature (70°C or higher)
   - High oil temperature (130°C or higher)
   - High turbocharger air temperature (90°C or higher)
   - Turbocharger air leak (leak in rear of turbocharger)
   - Faulty CP metering unit
   - High SCR pressure difference (clogged SCR)
   - Abnormal common rail pressure

3) Engine warning mechanism

   The engine warning lamp blinks and a warning buzzer sounds.
   - Refer to the list of fault codes for engine warning devices

⚠ 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

3.2.1. 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's 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
- Check 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.)

3.6.4. Running the Primary Fuel Filter (Oil-Water Separator) Heater

In winter and in cold temperatures, the paraffin in diesel forms a gel and blocks the surface of the cartridge in the primary fuel filter, resulting in restricted fuel flow. In such cases, engine start-up may be delayed/impossible, the engine rpm may be unstable after engine start-up, or the engine may turn off. To prevent this phenomenon, turn the key on and run the heater mounted on the primary fuel filter (oil-water separator) three minutes before starting the engine to remove the paraffin from inside the primary fuel filter and the paraffin gel entering continuously from the fuel tank.

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 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, raw water filter, Kingston valve, central balance of axles, strength of engine mounting support, deflection of the propeller, etc.

1) Fuel tank
   Sludge resulting from chemical reactions among foreign matter such as condensate and moisture, various acidic substances, and microbes which breed in such environments form continuously in the tank. Accordingly, make sure to remove contaminants and wash the tank periodically; otherwise, foreign matter may enter the high-pressure fuel injection system of the engine, causing critical damage such as wear, corrosion and clogging in the engine injection system, as well as excessive maintenance expenses.
   - Condensate: Occurs when moisture in the air condenses on the inner wall of the tank due to the temperature difference between the fuel and the air
   - Foreign matter: Constantly enters through the fuel container and the air ports on the tank
   - Microbes: Constantly enter through the air port on the tank
2) Primary fuel filter and cartridge (oil-water separator)
   Make sure to use genuine parts, comply with the specified replacement intervals, and periodically remove moisture stored in the filter to prevent it from entering the high-pressure fuel injection system of the engine.
3) Secondary fuel filter and element
   Make sure to use genuine parts, comply with the specified replacement intervals, and take care to prevent foreign matter from entering the high-pressure fuel injection system of the engine.
4) Normal state of common rail and high-pressure pump wiring fasteners
   If the fasteners for the common rail pressure sensor (RPS) and high-pressure pump fuel metering unit (FMU) wiring on the engine are loose, wire movement during engine operation causes wear on the metal pins of the connectors attached to the sensor and metering unit. If the amount of wear increases and the contact between the metal pins of the connectors lifts occasionally while the engine is running, the ECU registers this as an open circuit, displays a fault code and restricts engine power; for the sake of safety, the high-pressure pump maintains the maximum amount of fuel delivery to the common rail without any control of the amount of fuel by the ECU; and in the common rail, the pressure adjustment valve opens and is permanently damaged due to excessive pressure, causing large amounts of fuel to be returned to the fuel tank. Make sure that the various wires remain connected firmly during engine delivery.

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. Make sure to replace them with new parts, and sort disassembled parts 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)						Remarks
			50	100	250	500	600	1,000	
Cooling system	Checking and refilling coolant	●							
	Checking coolant and anti-freeze for contamination						●		Replace every year
	Clean heat exchanger and fresh water cooling circuit								1,200 hours
	Check belt tension and replace	●						●	Note)
	Replace the thermostat								Replace every two years
	Check raw water discharge rate (Check opening of Kingston valve)	●							
	Check impeller and cam					●			
Lubrication system	Check oil level in oil pan/ reduction gear	●							
	Replacing the engine oil		● Initial			●			CI–4
	Replace the oil filter		● Initial			●			
	Replacing the oil in the reduction gear			● Initial			●		
	Check cylinder compression pressure							●	
Intake and exhaust system	Adjust the intake/exhaust valve clearance		● Initial			●			
	Clean intercooler							●	
	Clean or replace air filter element			●					Replace every 600 hours
Fuel system	Inspect for leaks in fuel line	●							
	Remove residue from fuel tank (Clean the fuel tank)								When necessary
	Drain water from oil-water separator	●							
	Replace the primary & secondary fuel filter cartridge					●			250 hours when bio-diesel is used
Electrical system	Checking the warning lamp	●							
	Check battery charging state	●							
	Checking the wiring						●		

* If the sulfur content of the fuel exceeds 0.5%, reduce the replacement and inspection intervals by half.
Note) Replace it when the tensioner pointer enters the horizontal line zone.

4.3. Cooling System

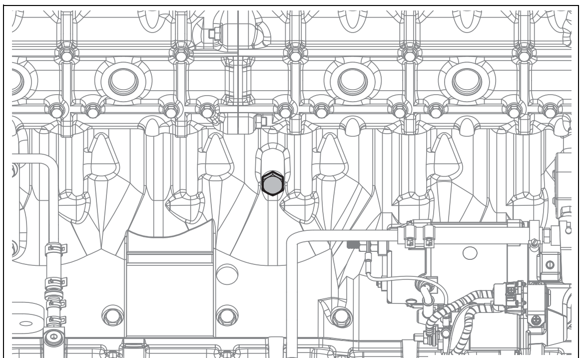
4.3.1. Checking and Refilling Coolant

- 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 raised coolant lines or the plug screw 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.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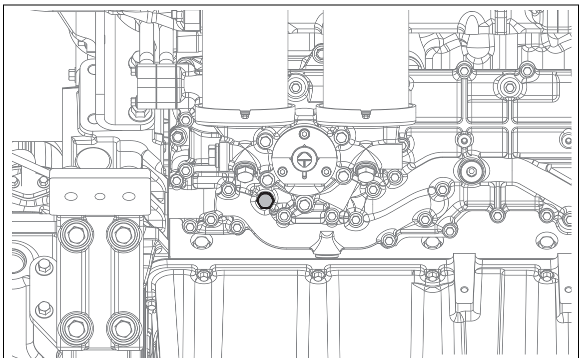
CAUTION
When removing the coolant pressure cap while the engine is hot, wrap the cap in a cloth and loosen it slowly to release steam inside. The steam can cause burns if the coolant pressure cap is opened suddenly.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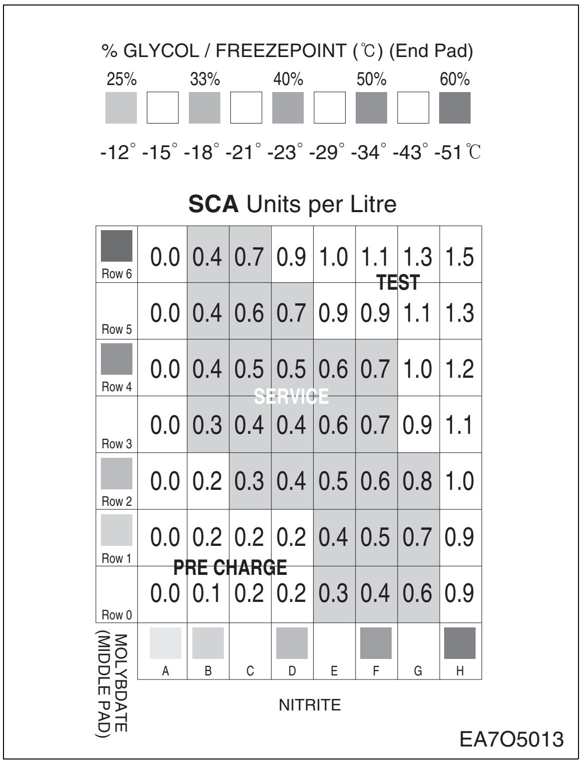
4.3.2. Checking Coolant and Antifreeze for Contamination

1) Coolant inspections

- Engine coolant is a mixture of clean water (soft water) such as tap water with 45% antifreeze and 5% anticorrosive agent added. 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.

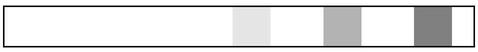
CAUTION
When gathering a coolant sample, the coolant in the reservoir tank is less contaminated and may not yield an accurate measurement of the concentration in the engine, so gather a sample of coolant from the bottom of the cylinder block.

b) After shaking the coolant sample, dip the test strip in the container, take it out after 3 ~ 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) Anti-freeze
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 (%)	Anti-freeze
-10 or more	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 raw 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 the corrosion of the cooling system, a plug screw type anti-corrosion rod (zinc anode) has been introduced. Ensure to check it regularly (every month) and replace it when corroded.

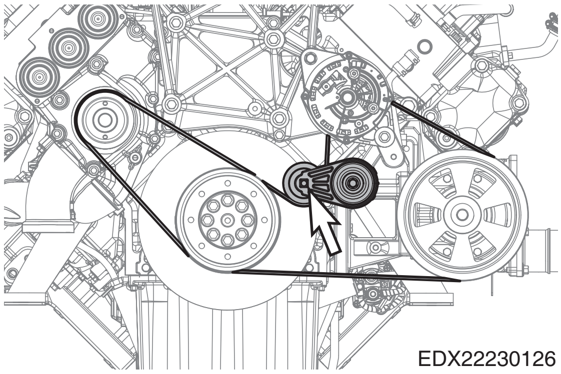
4.3.4. Inspecting the Micro-V Belt Tension and Replacing the Belt

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.



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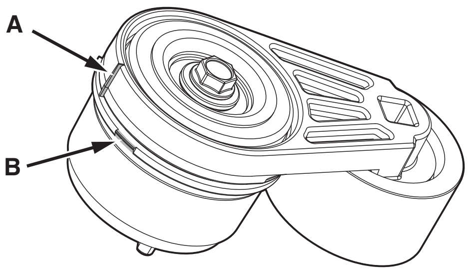
2) Inspecting the condition

   Inspect the Micro V-belt for cracks, contamination, 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.



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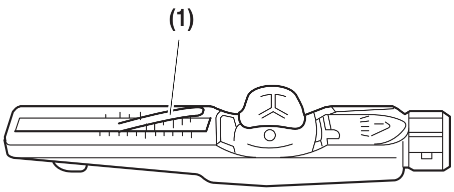
3) Measuring tension

   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.

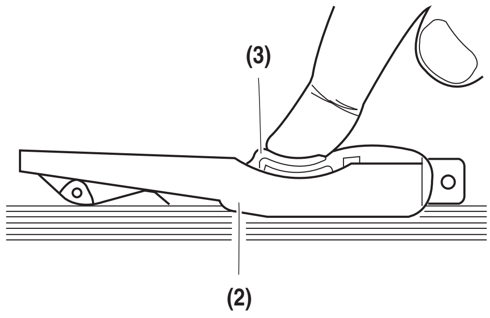
   ● Lower the indicator arm (1) to within the scale.

     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.



EA6O6011

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.



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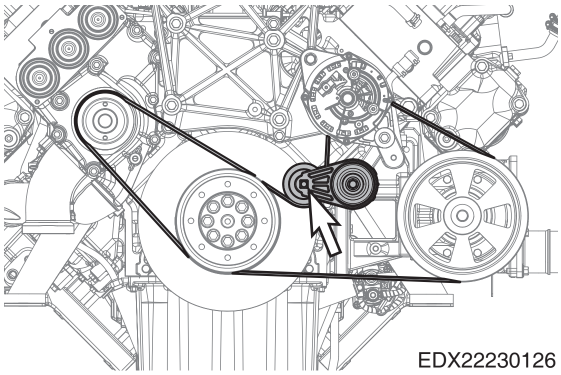
- Reading the tension value
  a) Read the tension of the belt at the point where the top surface of the indicator arm (1) intersects with the scale.
  b) Before reading the value, check whether the indicator arm is remaining in place.

Type	Drive belt width	Tension on the tester		
		Newly installed		During service after prolonged 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.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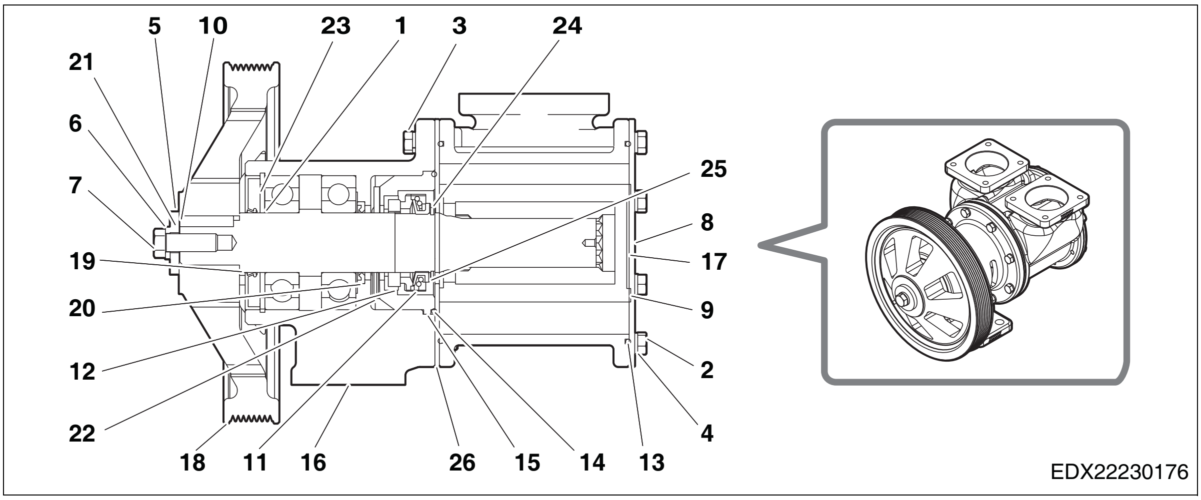
4.3.5. Checking the Rubber Impeller in the Raw Water Pump

The raw water pump is driven by belt 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 raw water, 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. Bolt	13. O-ring	19. Retainer	25. Spacer
2. Bolt	8. Cover	14. O-ring	20. Retainer	26. Washer plate
3. Bolt	9. Impeller	15. Seal casing	21. Shaft	
4. Washer	10. Key	16. Bearing casing	22. Slinger	
5. Washer	11. M/S	17. Impeller casing	23. Snap ring	
6. Washer	12. M/S	18. Pulley	24. Snap ring	

- Loosen the bolt on the 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

- To prevent the dowel pins and wear plate mounted inside the impeller from rotating, align them with the circle of holes. 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.
- For the impeller, as its aging occurs due to the nature of rubber, it is recommended to replace them every six months to one year.

CAUTION

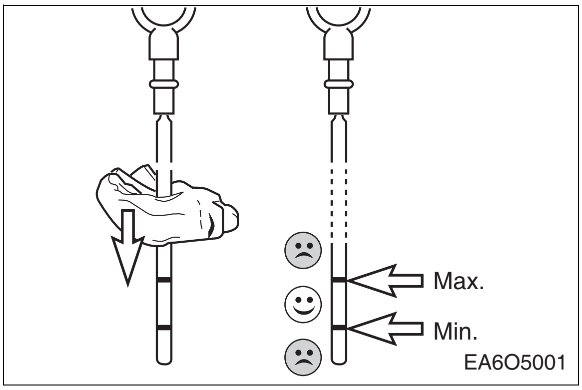
Make sure that the impeller makes contact with the inner wear plate. Please note that using a hammer to force the impeller into place may cause the shaft to move and damage the internal mechanical seal, resulting in leaks.

- 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 raw water pump to bleed the system, check for any leaks, then start the engine.

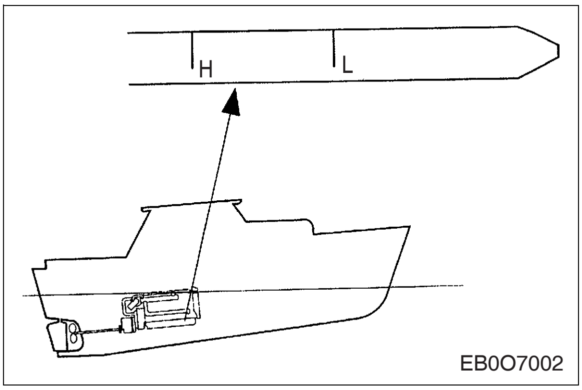
4.4. Lubrication System

4.4.1. Checking the Oil Level

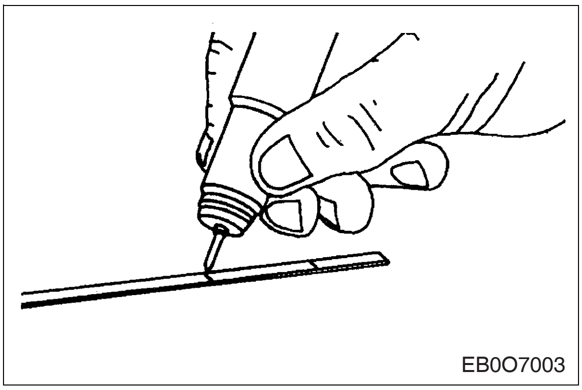
- Check the oil level in the oil pan and reduction gear daily using the oil dipstick.
- The oil level must be measured approx. 10 minutes after stopping the engine when the hull is in a horizontal state.
- Check the oil smeared on the oil dipstick, inspect the viscosity and state of contamination, and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

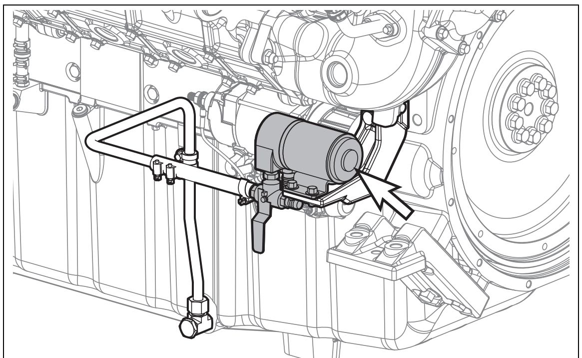
Engine oil affects startability, fuel consumption, carbon deposits in the combustion chamber, and wear to the cylinder liner, etc.

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.



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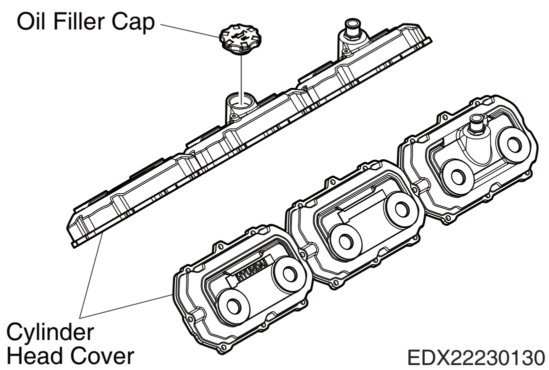
- Open the oil filler cap on the head cover and refill the engine oil to the appropriate level.
- While adding oil, be careful not to let dust or foreign materials enter the system. Check whether the oil level is near the maximum level mark on the oil dipstick.
- Idle the engine for approx. five minutes 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.



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⚠ Recommended lubricant

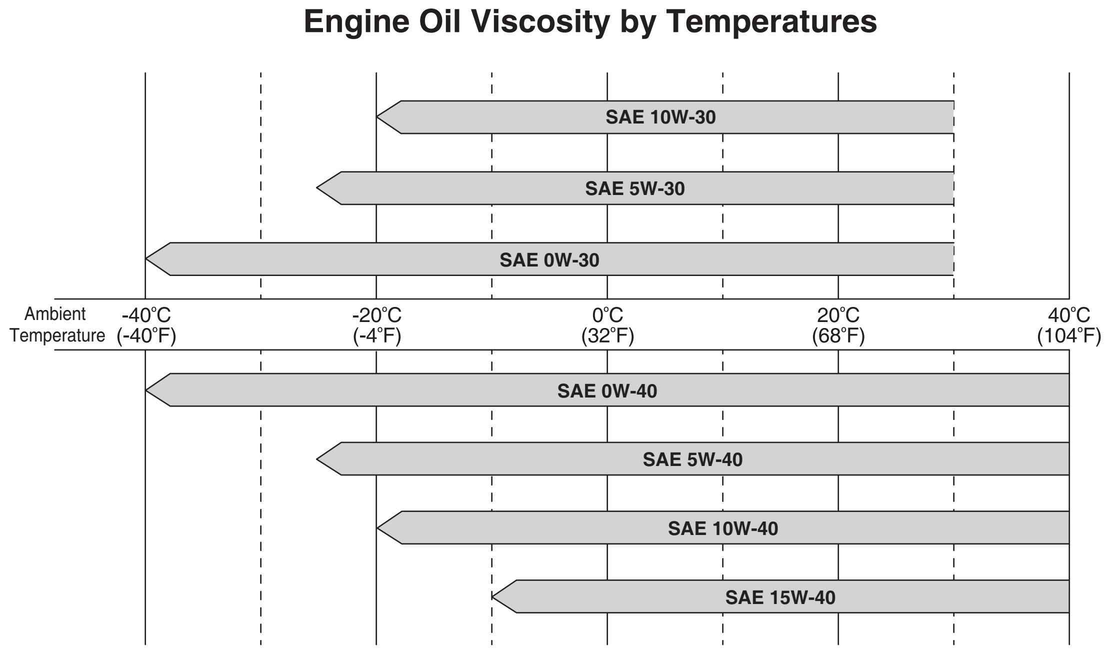
Upon initial release from the factory, the engine is filled with API grade CJ-4 high-quality oil for engine break-in.

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 CI-4 grade or higher and SAE 10W40 engine oil in order to obtain maximum engine performance and service life. Refer to the label printed on the container of the product.



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- Recommended oil specifications

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

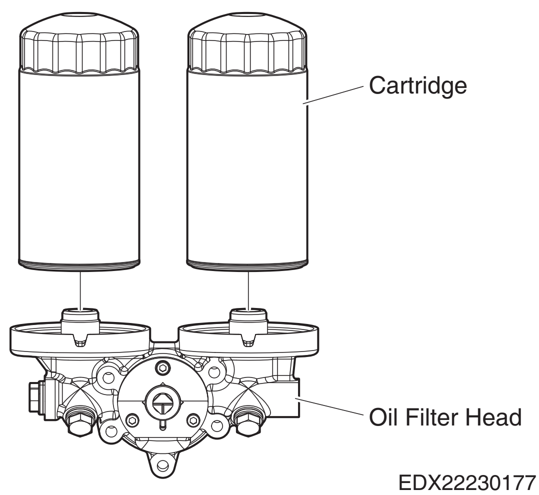
* CI–4 grade must be replaced every 500 hours, while CH–4 grade must be replaced every 250 hours.

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.

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.



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CAUTION

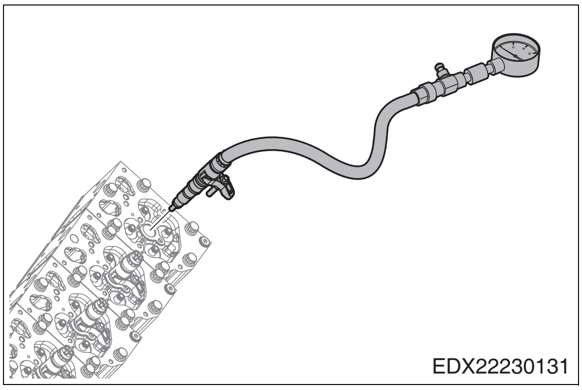
When replacing the oil filter cartridge, make sure to use a genuine new HD Hyundai Infracore cartridge.

- 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 ~ 1 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



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- 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
DX22	35 bar

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

4.5. Intake and Exhaust System

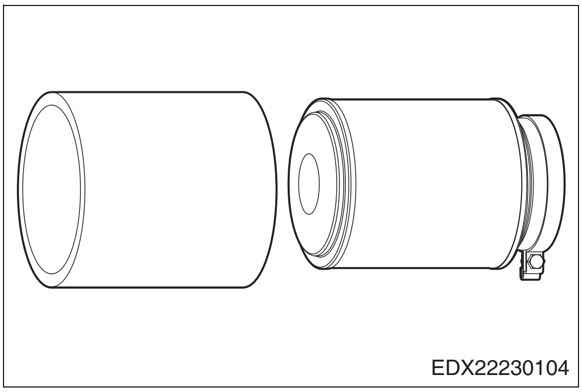
4.5.1. Adjusting the Intake/Exhaust Valve Clearance

The valve clearance must generally be inspected after every 500 hours of engine operation.
For more details, refer to "Adjusting sequence of valve clearance" in "7.4.3. Valves"

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. Air Filter



- The engine life and performance are affected significantly by the quality of the intake air. A contaminated air filter 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.

- Cleaning the metal type air filter
  - 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.

Important
Check the air filter regularly, and if the surface of its element is contaminated, clean or replace the element.

Cleaning the air cleaner element	Every 100 hours
Replacing the air cleaner element	Every 600 hours

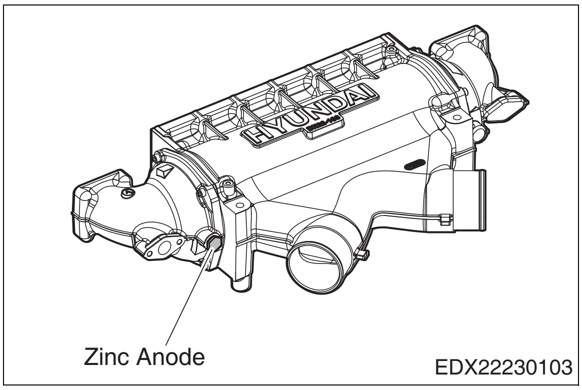
- Check whether the inside of the element is clean and dry.
- Replace the element with a new one if it is torn or damaged.

4.5.3. Cleaning the Intercooler

The intercooler installed in the DX22 model is a raw water cooling-type intercooler whose service life 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 raw water 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 the corrosion of the cooling system, a plug screw type anti-corrosion rod (zinc anode) has been introduced. Ensure to check it regularly (every month) and replace it when corroded.

4.5.4. 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 common rail fuel injection system operates at high pressures (1,800 bar). Accordingly, the system must be handled and serviced with care, and the safety regulations must always be followed.
- The common rail fuel injection system should never be removed, installed or inspected while the engine is running or immediately after stopping the engine; inspections and service work should be performed at least 30 seconds to one minute after stopping the engine.
- During service work and inspections, make sure that the workspace is clean before performing any work to prevent foreign matter from entering the fuel system; keep any unnecessary removal and installation to a minimum; and in the case of parts which must be reused during removal and installation, take the necessary measures to prevent foreign matter from entering the parts after removing them and clean them before reusing them for installation.
- The normal performance of O-rings and sealing washers used on high-pressure fuel pipes and in the fuel system cannot be guaranteed if they are reused; make sure to use new parts.
- When assembling high-pressure fuel pumps, common rails, injectors, and high-pressure fuel pipes, take care to prevent damage due to impacts, etc. resulting from carelessness and make sure to assemble them precisely.

4.6.1. Fuel Tank

The fuel tank must be able to store fuel cleanly and safely and must be structured to satisfy the following requirements so as not to affect the components of the engine injection system.

- Material
  Zinc (Zn), copper (Cu), lead (Pb), sodium (NA) and calcium (CA) cause chemical reactions with water in fuel and biodiesel, thereby forming various corrosive acids, sludge and viscous substances. When this occurs, it causes premature clogging of the primary fuel filter, seizure of injectors, corrosion and wear of fuel system components, including the injection system, leading to excessive maintenance expenses resulting from engine failure. Hence, when the use of these materials cannot be avoided, make sure to apply a phosphate film or trivalent chromium plating to prevent the materials from coming into direct contact with fuel.
- Air intake/discharge system
  When fuel is delivered to the engine, a reduction in pressure equivalent to the volume occupied by the fuel in the tank occurs, leading to a fluctuation in the volume of fuel as a result of a change in the fuel temperature. Hence, if the fuel tank is an enclosed structure, excessive static/negative pressure is formed, causing abnormal engine operation. Accordingly, the fuel tank must be equipped with an air intake/discharge system to constantly maintain atmospheric pressure, while the ports through which air is drawn in or discharged must be connected by means of extension hoses or tubes to a clean environment with minimal dust, moisture, insects, etc. or a suitable air filter must be installed to prevent such foreign matter from entering the system. When air inlets and outlets are installed in extremely dusty or humid areas, the service life of the primary and secondary fuel filters is severely reduced, while wear and corrosion of injection system components are accelerated, resulting in a shortened service life and excessive maintenance expenses.
- Port for draining condensate and cleaning foreign matter
  Inside the fuel tank, foreign matter entering through the air inlet and outlet ports as well as condensate on the inner wall of the tank resulting from the difference in temperature between fuel and ambient air form deposits continuously. The fuel tank must be equipped with a cleaning port for periodically removing and cleaning condensate and foreign matter to prevent foreign matter and condensate deposits in the tank from entering the engine fuel system.
- 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.

CAUTION
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.

4.6.2. Fuel Requirements

Allowable Fuel Under Warranty

1) Korea: Article 115 Schedule 33 "Ultra Low Sulfur Diesel" of the Clean Air Conservation Act
2) Europe: EN590:2013 AC:2014, EN16734:2016
3) North America: ASTM D975–15C Grade 1D or 2D
4) Japan: JIS K2204:2007 (lubricity ≤ 520 µm, FAME Max. 5%)
5) China: GB252:2015 and GB19147:2013
6) India: IS 1460 2005 Amm. 10 BS Ⅲ or BS Ⅳ
7) Brazil: ANP69/2014
8) Russia: GOST R32511-2013 (excluding Articles 3 and 4)

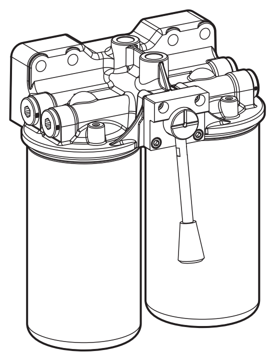
4.6.3. Fuel Filter

The fuel filter consists of a primary and secondary filter; the primary filter serves to filter out water and large particles of foreign matter, while the secondary filter is used to filter out smaller particles of foreign matter.
If you do not regularly inspect the fuel filter and discharge the water in the fuel filter, water enters the fuel system of the engine and can cause severe faults in the fuel injection pump, fuel injection pipe, common rail and injector. In addition, the fuel filter performance can be degraded or damaged.

- When draining the water in the fuel filter, fuel may also be drained as well. Fuel is a highly flammable substance. Hence, smoking or using an open flame near the engine may cause a fire.
- Only use clean fuel with the specified grade. Using imitation or unspecified fuel may increase the amount of water in the fuel filter.
- If you do not drain the water in the fuel filter when the fuel filter warning lamp is illuminated, water may enter the fuel system and cause the engine to turn off.
- New fuel filters must be assembled without any fuel in them. Do not use the fuel in replaced fuel filters or the fuel in the fuel tank in new fuel filters.

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 ~ 1 turn.



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Note
For detailed information, refer to 7.3. Fuel System.

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 completely tightening the fuel tank valve or cock, remove the fuel filter and oil-water separator and clean them or replace the element; then, tighten them enough to prevent 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 raw water pipe firmly. If the weather is exceptionally cold, open the drain plugs on the heat exchanger, intercooler, reduction gear oil cooler, etc. to drain the raw water completely, then leave the plugs removed on the engine components open. Also, be sure to remove the rubber impeller in the raw water 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 raw water 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.

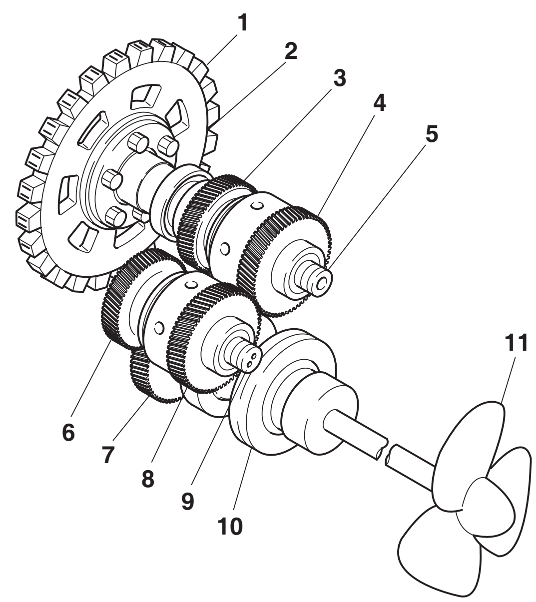
5. Main Components

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 use in high-speed engines and is composed for 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.



EFM6006I

<Power line>

Neutral : 1 - 2 - 5 - 4 - 8

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

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

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

5.1.2. 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.

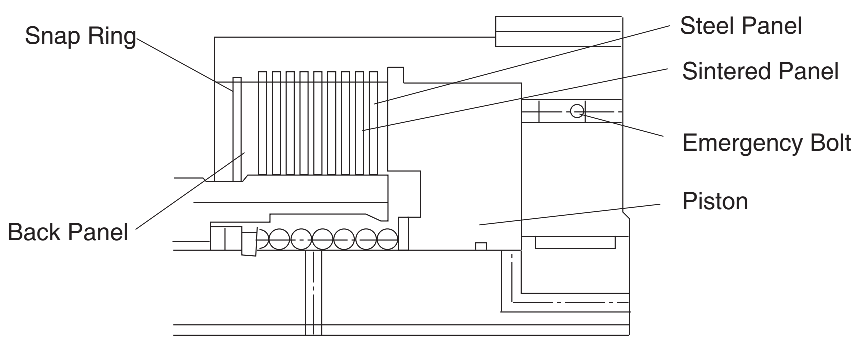
4) Emergency bolt

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.



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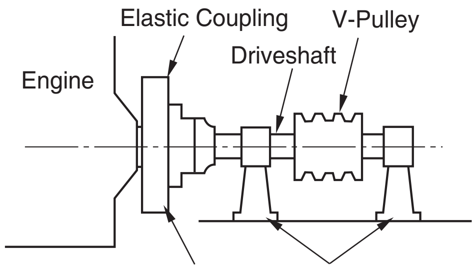
5.2. Front of Engine Power Takeoff (FPTO)

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.



EA4O7001

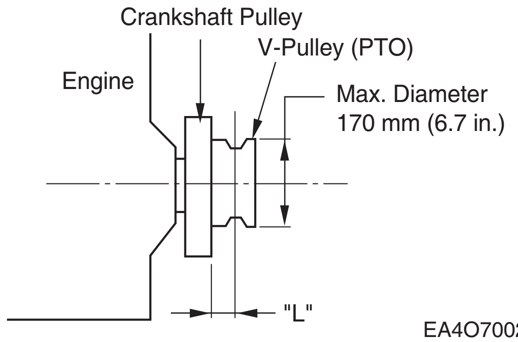
⚠ When using the FPTO to install the driveshaft of attachments, the deviation of the shaft from the central axis and the gap between the contact surface must each be less than 0.02 mm.

Engine model	Rotational torque
DX22	140 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.



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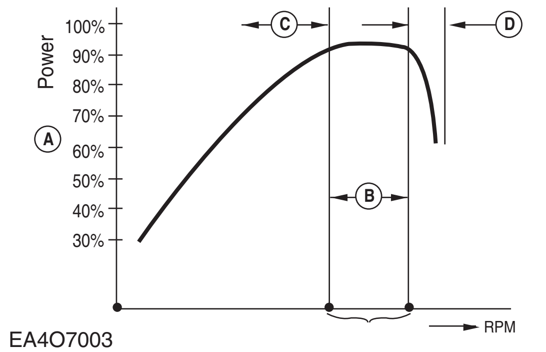
Engine model	Rotational torque
DX22	88 kg·m

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.



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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.

6. Engine Service

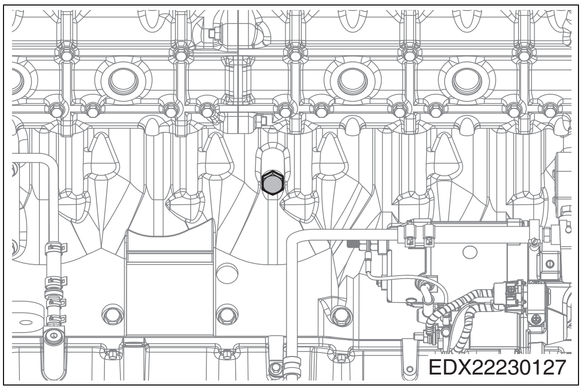
6.1. Disassembly

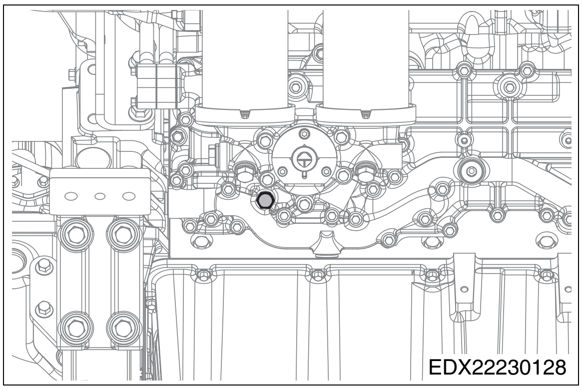
6.1.1. Preparation

- Before disassembly, prepare a shelf for parts to store various tools and disassembled parts.
- When performing disassembly, make sure to use clean, bare hands and keep the workspace and its surroundings clean.
- Make sure to store parts in such a way that they do not bump into one another after being disassembled.
- Store the disassembled parts in the order of disassembly.
- Before disassembling parts, remove the ground power source of the battery.

6.1.2. Coolant

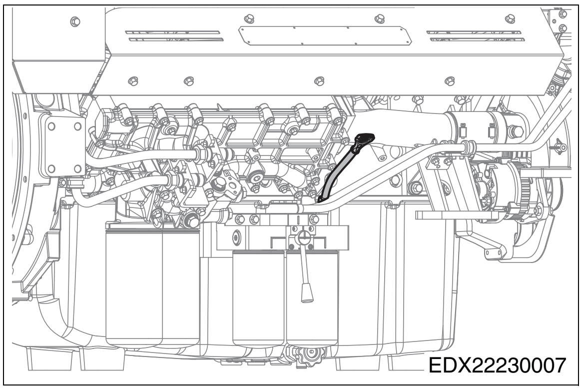
- Remove the coolant drain plug from the cylinder block and drain coolant into a suitable container.





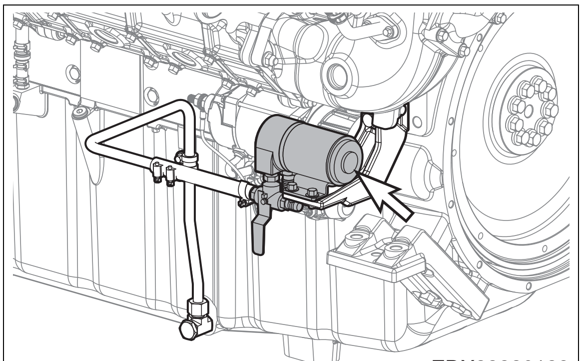
6.1.3. Oil Level Gauge

- Remove the oil level gauge from the oil pan guide tube.



6.1.4. Engine Oil

- Drain the engine oil from the oil pan through the drain pump and collect this oil in a previously prepared container.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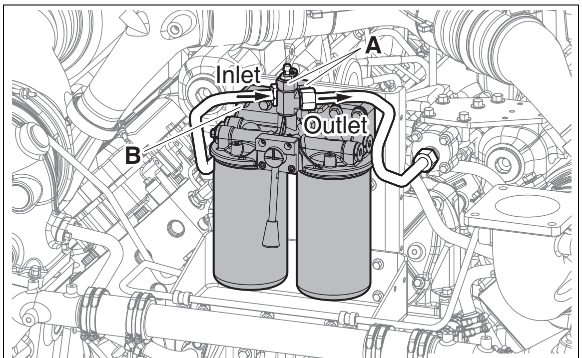
6.1.5. Fuel Filter

- Unscrew hollow screws (A) on the fuel filter and disconnect the fuel pipes.
- Unscrew fuel filter mounting bolts (B) and remove the fuel filter assembly.



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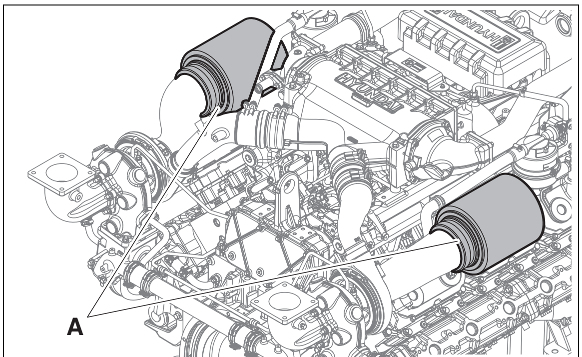
6.1.6. Air Filter and Exhaust Elbow

- Unscrew the mounting bolts and remove the air filter, intake stake and exhaust elbow.
- Be careful not to allow foreign matter to enter the turbocharger.

A	Air filter
B	Intake stake
C	Exhaust elbow



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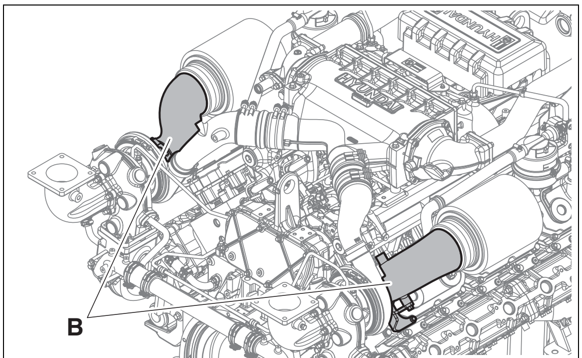

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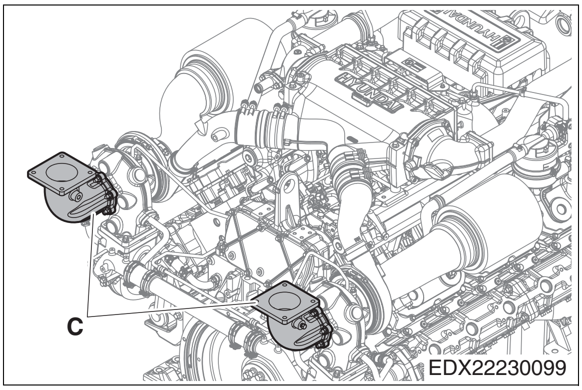
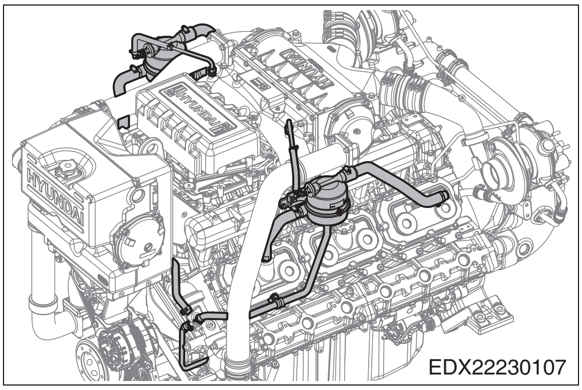


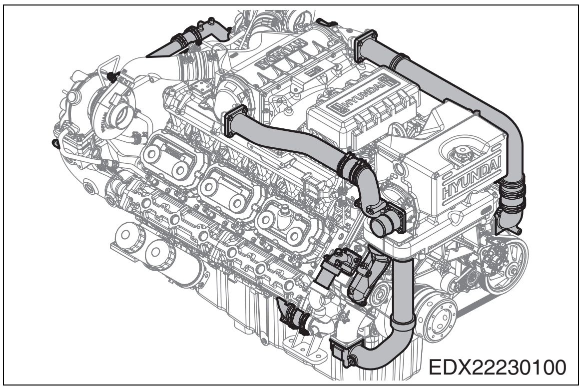
6.1.7. Breather

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



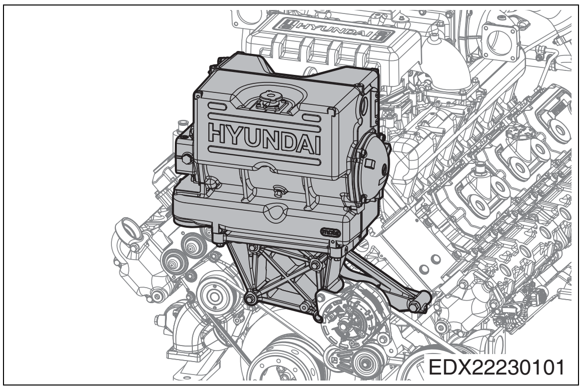
6.1.8. Coolant Pipe

- Unscrew the mounting bolts and remove the coolant pipe.
- Be careful not to allow foreign matter to enter the raw waterwater pump and intercooler.



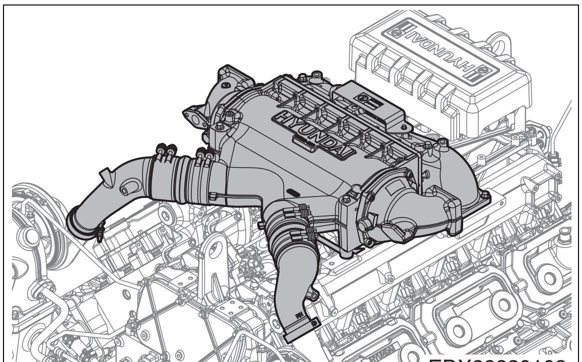
6.1.9. Heat Exchanger

- Disconnect the hose and coolant pipe from the heat exchanger.
- Unscrew the heat exchanger mounting bolts and remove the heat exchanger.



6.1.10. Intercooler

- Disconnect the hose and coolant pipe from the intercooler.
- Unscrew the intercooler mounting bolts and remove the intercooler.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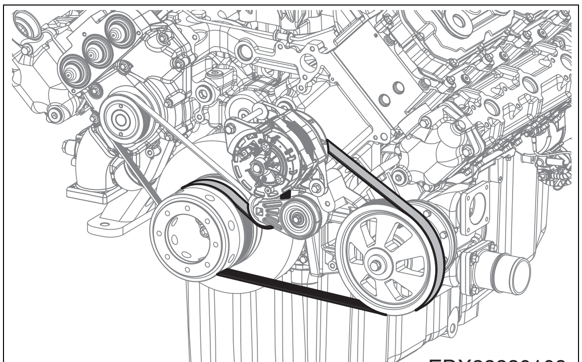
6.1.11. Raw Water Pump Belt

- Unscrew the belt tension adjusting bolt and remove the raw water pump belt.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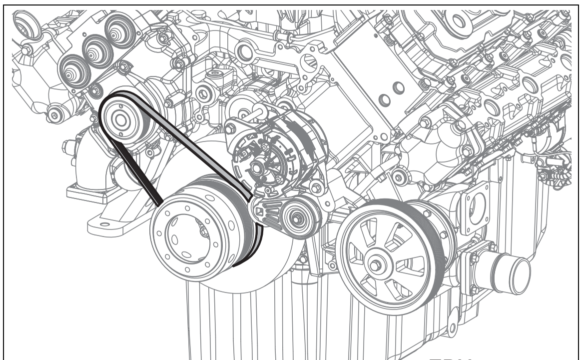
6.1.12. Water Pump Belt

- Support the driver and turn the crank to remove the belt.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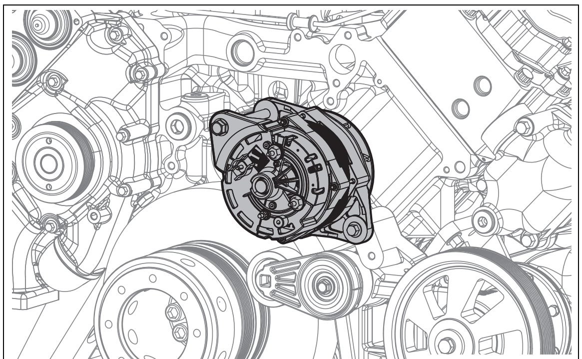
6.1.13. Alternator

- Unscrew the alternator bracket bolts and hinge bolts and remove the alternator.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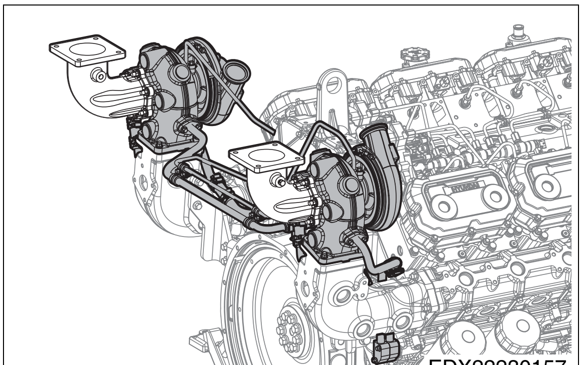
6.1.14. Turbocharger

- Loosen the intake manifold hose clamp and disconnect the air pipe.
- Unscrew the hollow screws on the turbocharger lubricating oil supply and disconnect the oil pipe and coolant pipe.
- Unscrew the turbocharger mounting nuts and remove the turbocharger from the exhaust manifold.



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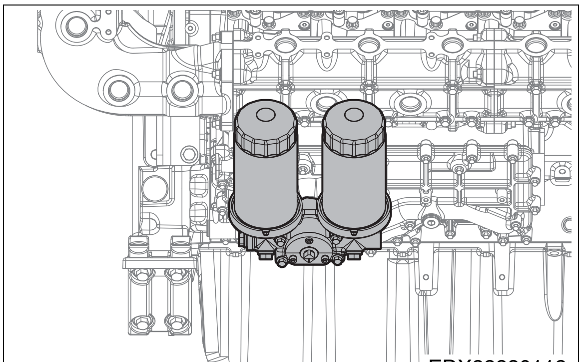
6.1.15. Oil Filter

- Use an oil filter wrench to remove the oil filter cartridge.
- Do not reuse the cartridge.



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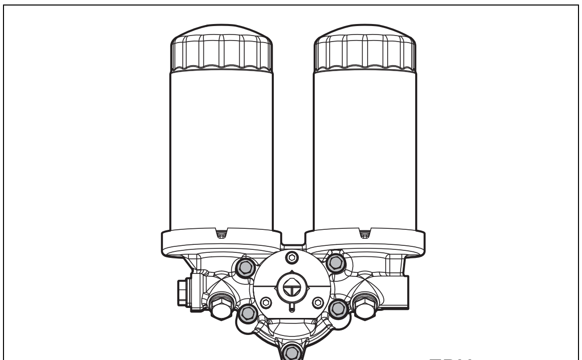
- Loosen the oil filter mounting bolts and remove the filter head.



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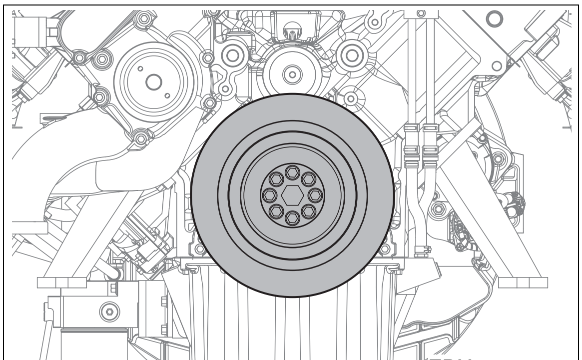
6.1.16. Vibration Damper

- Unscrew the crankshaft pulley mounting bolts and remove both the crankshaft pulley and the vibration damper.



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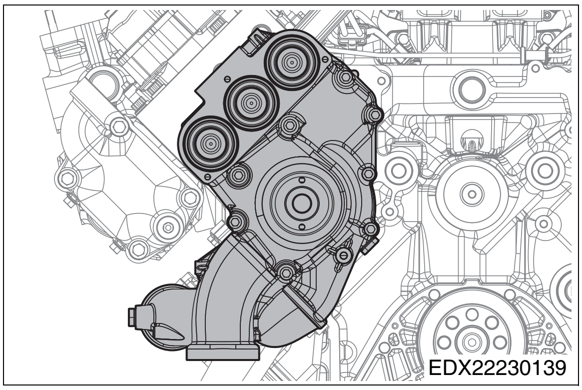
6.1.17. Coolant Pump and Thermostat

- Loosen the various connecting hose clamps.
- Loosen the coolant drain pipes and remove the thermostat.
- Unscrew the coolant pump mounting bolts and remove the coolant pump.



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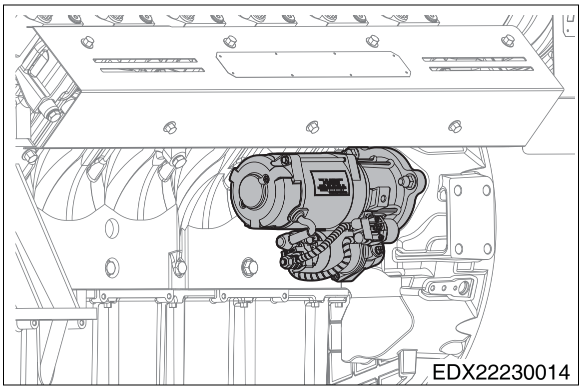
6.1.18. Starter Motor

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



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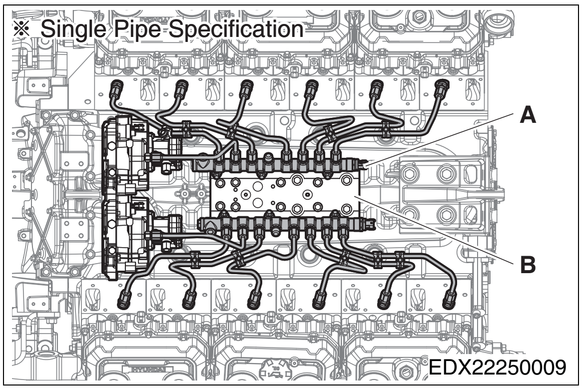
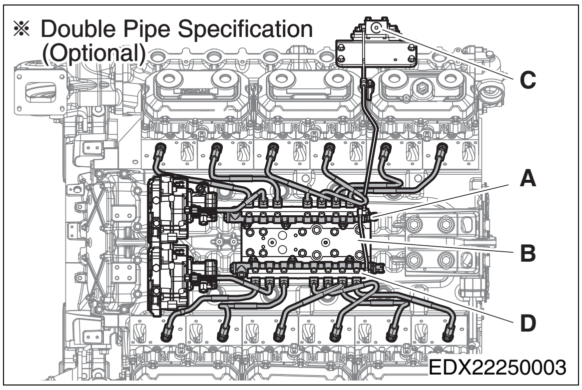
6.1.19. Common Rail and Fuel Injection Pipes

- Disconnect the fuel pipe.
- Loosen common rail fixing bolts (6ea) and disconnect common rail (A).
- Unscrew the bracket mounting bolts and remove the bracket (B).



EDX22250009

- Disconnect the fuel pipe.
- Disconnect the fuel tank fuel switch (C) and bracket.
- After removing the terminal block (D) and loosen the common rail fixing bolts (6ea) and disconnect the common rail (A).
- Unscrew the bracket mounting bolts and remove the bracket (B).
- Loosen the fuel hose fixing bolt and disconnect the fuel hose.



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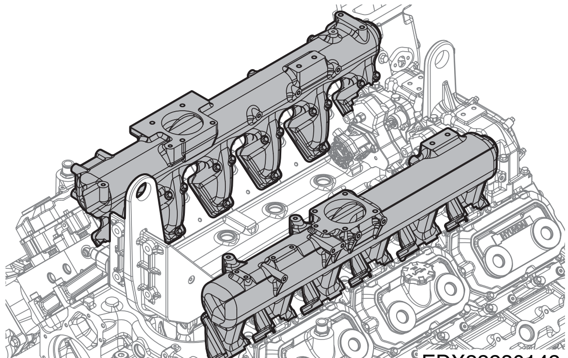
6.1.20. Intake Manifold

- Loosen the hose clamps connected to the oil-water separator.
- Unscrew the oil-water separator bracket mounting bolts and remove the bracket.
- Unscrew the intake manifold mounting bolts and remove the intake manifold from the cylinder head.



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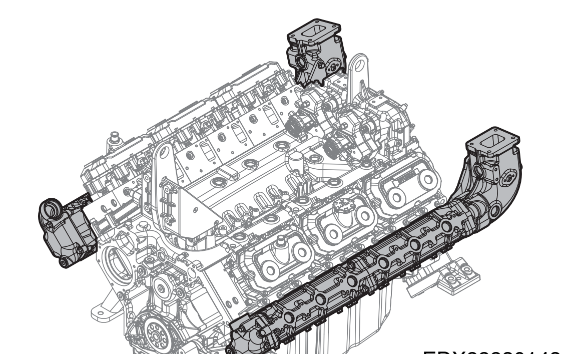
6.1.21. Exhaust Manifold

- Unscrew the exhaust manifold mounting bolts and remove the exhaust manifold from the cylinder head.



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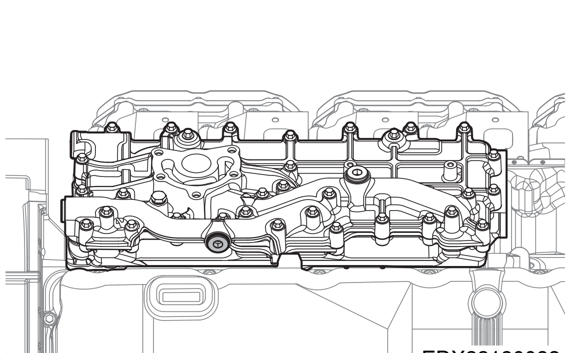
6.1.22. Oil Cooler

- Remove the coolant drain plug and drain the coolant.
- Unscrew the oil cooler cover mounting bolts and remove the oil cooler.



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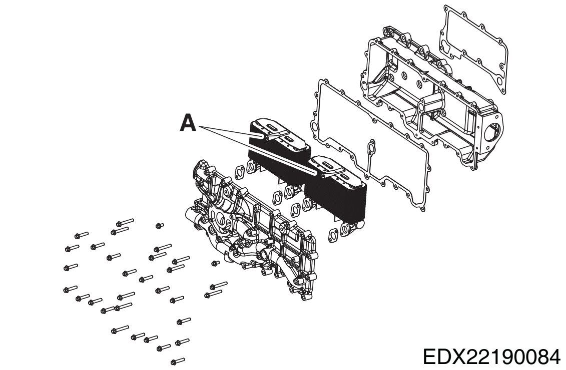
- Secure the oil cooler in a vice and remove the oil cooler mounting bolts; then, insert and reassemble cooler (A).



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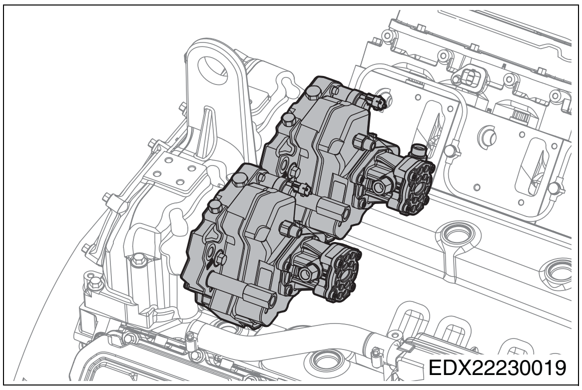
6.1.23. Fuel Injection Pump

- Loosen the high-pressure fuel pump mounting bolts and remove both high-pressure pumps from the timing gear case.



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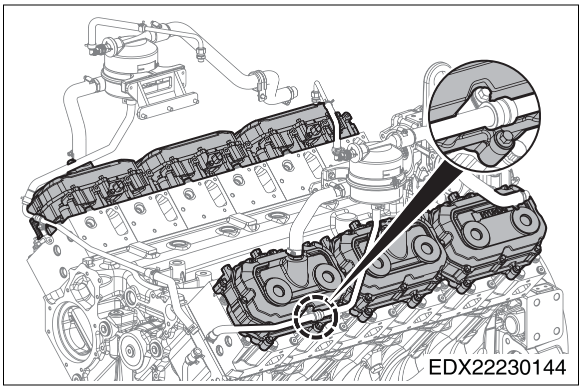
6.1.24. Cylinder Head Cover

- Unscrew the oil drain pipe mounting bolts and remove the oil drain pipe.
- Unscrew the mounting bolts and remove the cylinder head cover.



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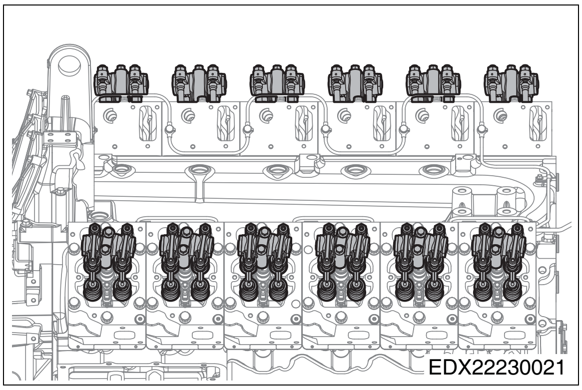
6.1.25. Rocker Arm

- Loosen the rocker arm bracket mounting bolts and remove the rocker arm assembly.
- Remove the calipers and pushrods.



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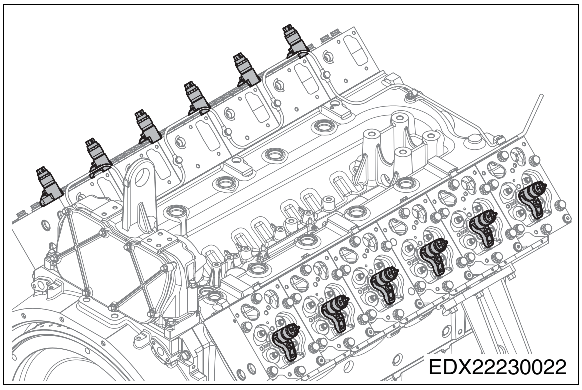
6.1.26. Injector

- Loosen the high-pressure fuel connector mounting nuts and remove the high-pressure fuel connector.
- Do not reuse high-pressure fuel connectors.
- Remove the harness connected to the injector, unscrew the injector mounting bracket bolt, and remove the injector.
- Be careful not to damage the nozzle while removing the injector.



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- Pull out the seal ring from the nozzle hole on the cylinder head and discard it.

CAUTION

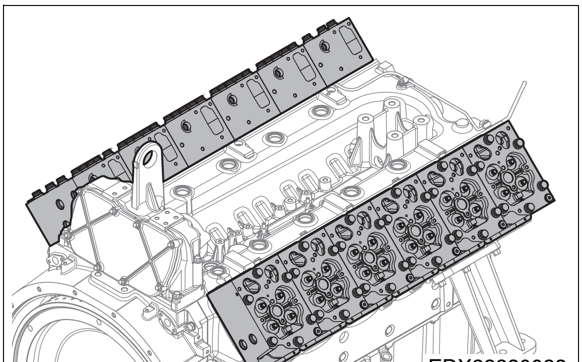
- When removing the injector, unscrew the high-pressure fuel connector mounting nut and completely disconnect the high-pressure fuel connector; then, unscrew the caliper mounting bolt on the injector and remove the injector.
- After disassembly, seal the injector and high-pressure fuel connector to prevent foreign matter from entering them.

6.1.27. Cylinder Head

- Unscrew the cylinder head mounting bolts in the reverse order of assembly and remove the cylinder head.
- Remove and discard the cylinder head gasket.
- Remove the residue on the contact surface between the cylinder head and cylinder block.

CAUTION

Be careful not to damage the cylinder head gasket contact surface.



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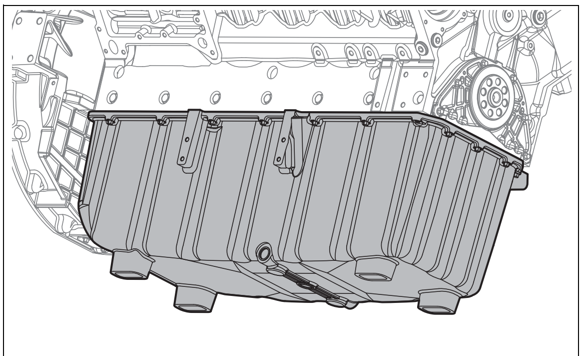
6.1.28. Oil Pan

- Loosen the oil pan mounting bolts and remove the oil pan.
- Remove and discard the oil pan gasket.



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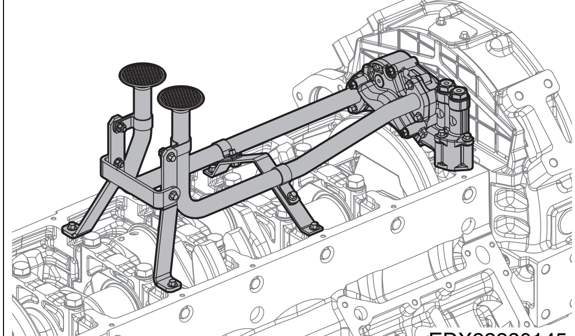
6.1.29. Oil Pump

- Remove the oil suction pipe mounting bolts and remove the oil suction pipes.
- Remove the oil pump mounting bolts and remove the oil pump.



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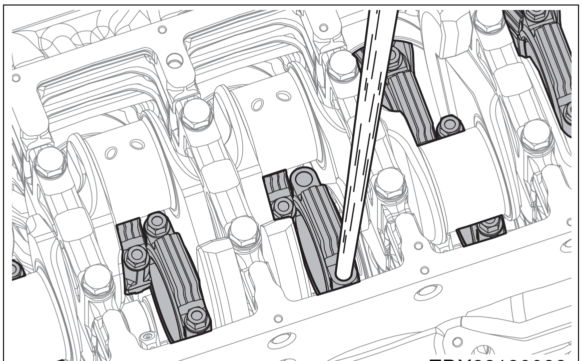
6.1.30. Piston

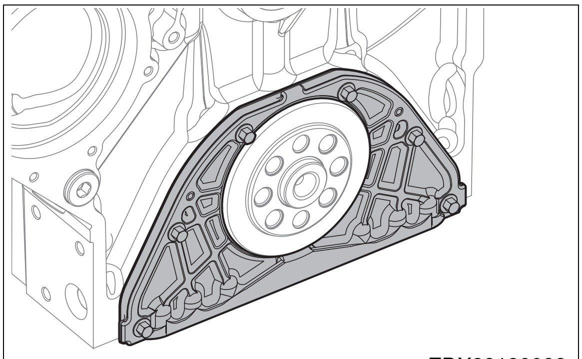
- Unscrew the connecting rod cap bolts in the reverse order of assembly; then, tap lightly on the top and bottom of the connecting rod cap with a urethane hammer to remove the cap and pull out the bearing.
- Push a wooden stick into the bottom of the piston and remove the piston in the direction of the cylinder head.


EDX22190092

CAUTION
Make sure that removed pistons do not bump into other pistons or parts.
Store pistons in order of their cylinders. (Temporarily assemble the connecting rods to avoid mixing up the connecting rod caps.)

6.1.31. Front Oil Seal Holder

- Unscrew the oil seal holder mounting bolts and remove the oil seal holder.
- Remove the oil seal and gasket from the oil seal holder and discard it.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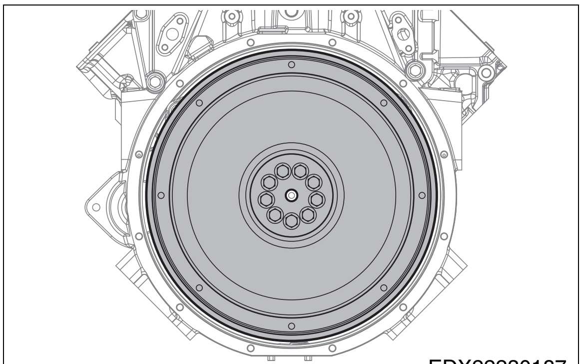
6.1.32. Flywheel

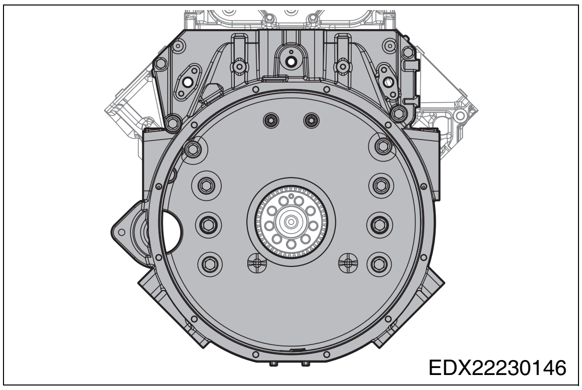
- Unscrew the flywheel mounting bolts in the reverse order of assembly and remove the flywheel.
- Remove the flywheel ring gear.
  - Heat the ring gear (up to 200°C) with a gas burner to expand it.
  - Tap around the ring gear with a hammer and brass rod to remove the ring gear.


EDX22230187

CAUTION
Take care not to damage the flywheel.

6.1.33. Flywheel Housing

- Unscrew the flywheel housing mounting bolts and remove the flywheel housing.
- Remove the oil seal from the flywheel housing.



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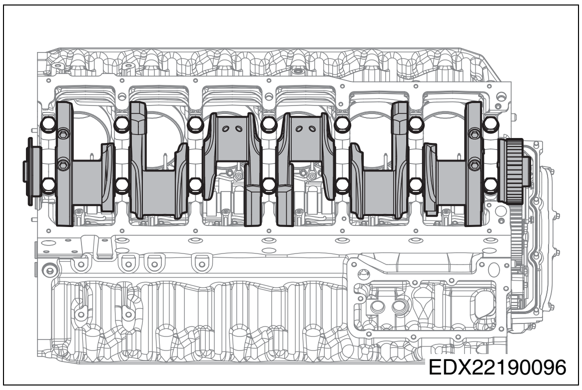
6.1.34. Crankshaft

- Remove the bolts from the bearing caps.
- Remove the main bearing cap mounting bolts in the reverse order of assembly. (Follow the same instructions to remove the cylinder head bolts.)
- Store the removed bearing caps in order of their cylinders.
- Temporarily install bolts on both sides of the crankshaft, and use ropes to lift the crankshaft.



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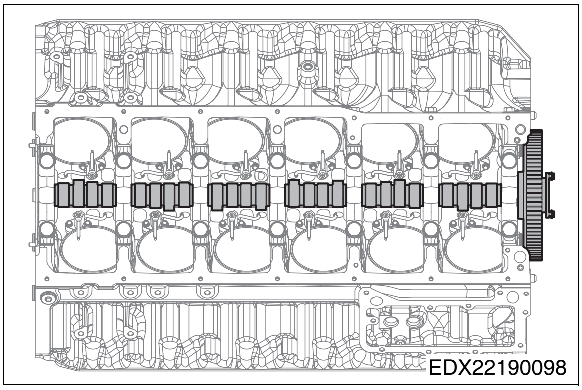
CAUTION
Take care not to mix up bearings and bearing caps from different cylinders.
(To avoid confusion, temporarily assemble the bearings in their respective caps.)

6.1.35. Camshaft and Tappet

- Pull the tappets out of the cylinder block.
- Remove the camshaft while taking care not to damage the camshaft and bear-ing.



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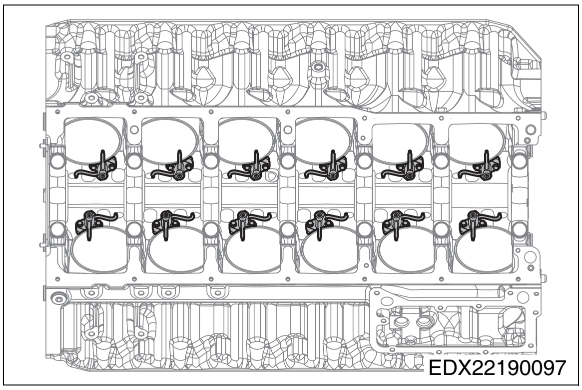
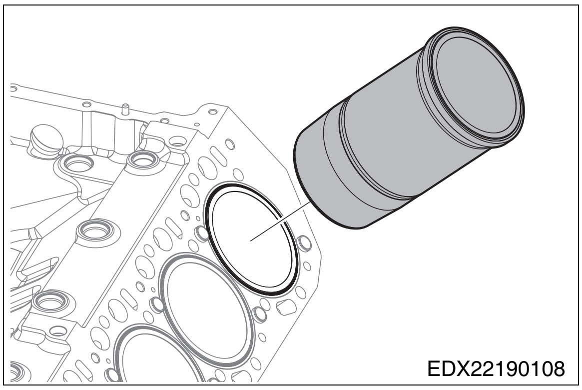
6.1.36. Oil Injection Nozzle

- Unscrew the oil injection nozzle mounting bolts and remove the oil injection nozzle.


EDX22190097

6.1.37. Cylinder Liner

- Use a special tool to pull the cylinder liner out of the cylinder block.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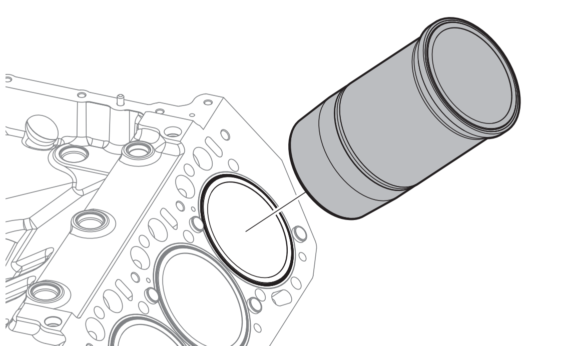
6.2. Engine Reassembly

6.2.1. General Precautions

- Clean all parts thoroughly and blow compressed air into the various oil and coolant passages to clean them out completely.
- Arrange the various special and general tools for assembly in order.
- Prepare clean engine oil to apply to each moving part.
- Prepare other materials such as sealant.
- Use ThreeBond as an adhesive in the engine oil circuit and silicone in the cooling circuit.
- Used gaskets, seal rings and other consumable parts should be discarded and replaced with new ones.
- Each bolt should be tightened to its specified torque in order and should not be overtightened.
- After assembling engine components, check to make sure that the engine moves smoothly.
- After assembly is complete, check each bolt for looseness.
- After completely assembling the engine, check for any missing or faulty parts.
- Keep your hands clean while working.

6.2.2. Cylinder Liner

- Replace the O-rings with new ones. Insert the upper O-ring into the cylinder liner and the lower O-ring into the cylinder block.
- Apply oil to the O-ring joint.
- After gently inserting the cylinder liner into the liner hole in the cylinder block, insert the O-ring while taking care not to damage it.
- After completely assembling the cylinder liner, perform a hydrostatic test (4 kg/cm^2) to check for leaks.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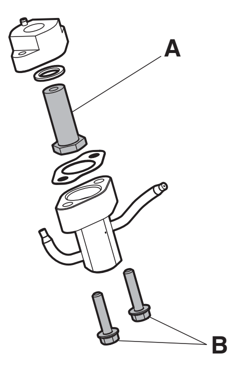
6.2.3. Oil Injection Nozzle

- Tighten the oil injection nozzle flange with hollow screw (A).
- Assemble the oil injection nozzle with mounting bolts (B).

Hollow screw torque	7 kg·m
Mounting bolt torque	1.2 kg·m



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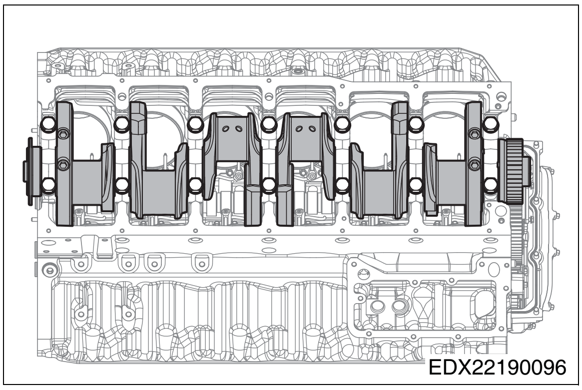
6.2.4. Crankshaft

● Place the wear ring in a heater and heat it to 150 ~ 200°C; then, use a jig to fit it onto the crankshaft.



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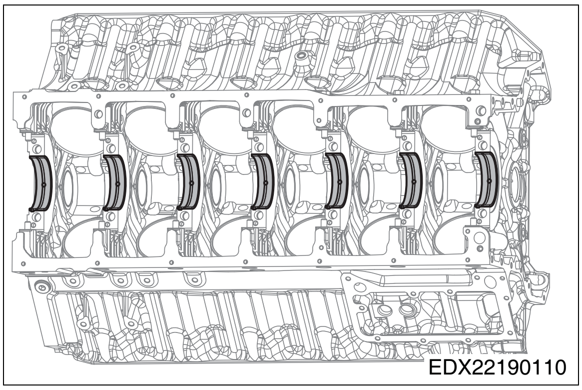
● Assemble the main bearings on the cylinder block and apply engine oil to the bearings. When doing so, assemble the bearings with holes on the cylinder block and the bearings without holes on the bearing caps, taking care not to mix them up.



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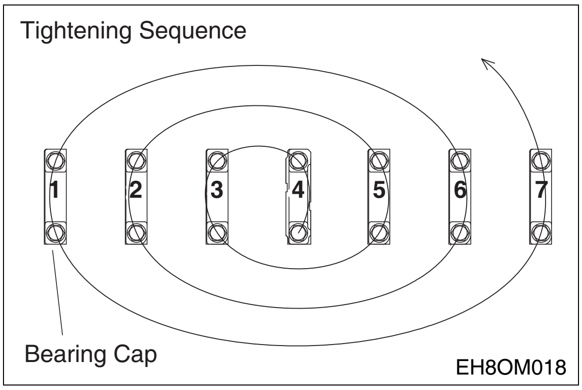
● Temporarily assemble one bolt in each bolt hole on either side of the crankshaft; then, after attaching wires, lift the crankshaft with a crane or chain block and lower it carefully onto the cylinder block.

● Apply engine oil to the crankshaft journal and pin, and fit the main bearings in the bearing caps; then, check the numbers to avoid mixing up the bearing caps and install them on the cylinder block.



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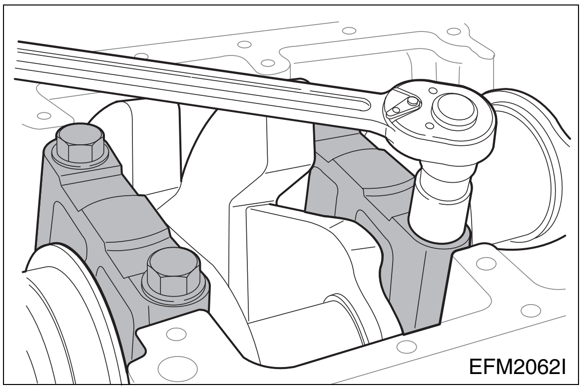
● Assemble the bearing cap bolts in the correct tightening sequence at the specified tightening torque (30 kg·m) using the rotating angle method (90° + 10°). The tightening sequence is as follows.

< Bearing cap tightening sequence >

- Step 1: Tighten the bolts one or two threads by hand
- Step 2: Use a wrench to tighten them to approx. 15 kg·m
- Step 3: Tighten them with a torque wrench (approx. 25 kg·m)
- Step 4: Tighten them with a torque wrench (approx. 30 kg·m)
- Step 5: Tighten them one last time with the rotating angle method (90° + 10°)

Make sure to tighten the bolts in several steps according to the tightening sequence above.



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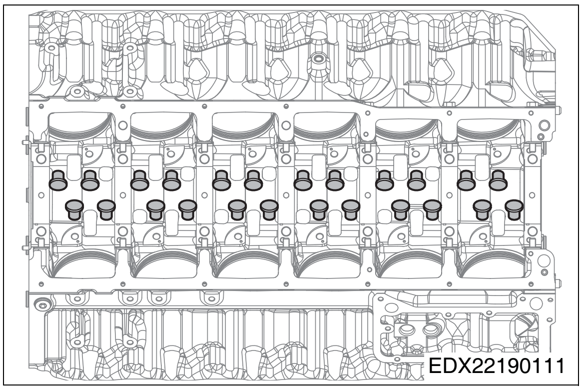
- Check whether the crankshaft rotates smoothly.
- Assemble the crankshaft gear with the crankshaft and mark gear tooth "1" with white paint to identify it easily.

6.2.5. Tappet

- Apply clean oil to the face of the tappet and insert the tappet into the tappet hole in the cylinder block.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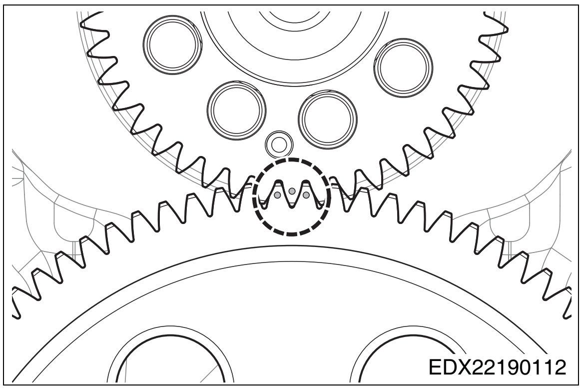
6.2.6. Camshaft

- Apply engine oil to the cylinder block cam bushing and camshaft.
- Take care not to damage the cam bushing and camshaft.
- Check to make sure that the markings on the crankshaft gear and camshaft gear are aligned when assembling them.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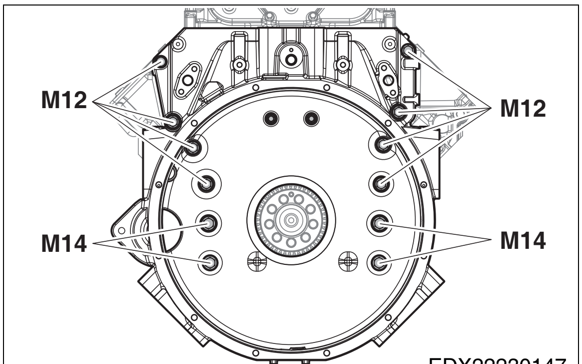
6.2.7. Flywheel Housing

- Before assembling the flywheel housing with the cylinder block, assemble the flywheel housing as follows first.
- Apply Loctite to the thrust washer mounting bolts and tighten them to the specified torque.

Torque	M14 x 1.5p (12.9T)	17.0 kg·m
	M12 x 1.5p (12.9T)	13.4 kg·m

- Apply lubricant to the oil seal and use a special tool to assemble it while taking care not to misalign or damage the seal.
- Apply a gasket to the cylinder block surface where the flywheel housing is to be mounted. (Grease the cylinder block surface to prevent the gasket from coming off.)
- Temporarily install two flywheel housing assembly guide bolts on the cylinder block.



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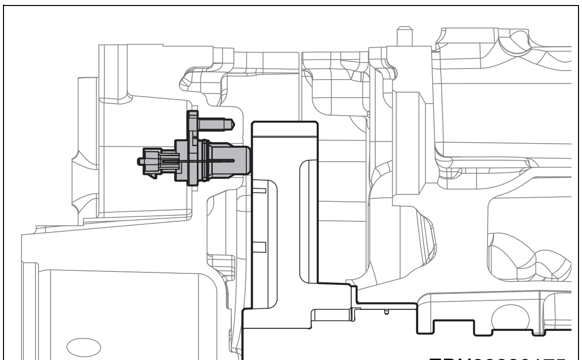
- Fit the flywheel housing holes onto the guide bolts and temporarily tighten the mounting bolts 2 ~ 3 threads; then, tighten them to the specified torque in the correct tightening sequence (zigzag pattern).

6.2.8. Cam & CRS Sensor

- After mounting the cam sensor on the sensor bracket, insert it into the mounting holes in the cylinder block and tighten the bolts.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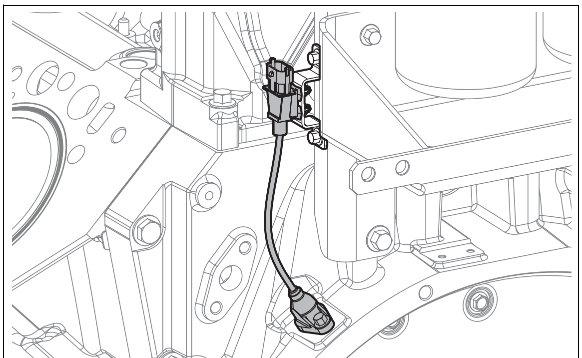
- After mounting the CRS sensor on the sensor bracket, insert it into the mounting holes in the flywheel housing and tighten the bolts.

Sensor & target wheel air gap	1.0 ±0.5 mm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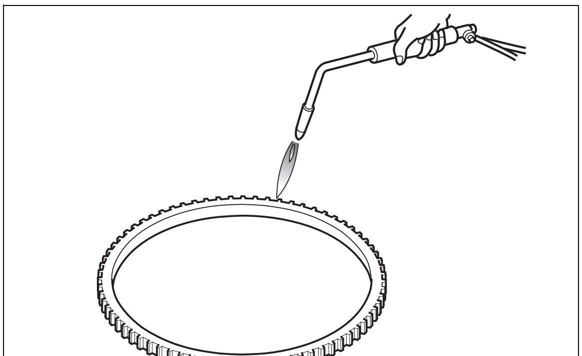
6.2.9. Flywheel

- Heat the ring gear evenly with a gas burner to expand it; then, use a hammer to install the ring gear on the flywheel.
- Do not allow the temperature of the ring gear to exceed 200°C.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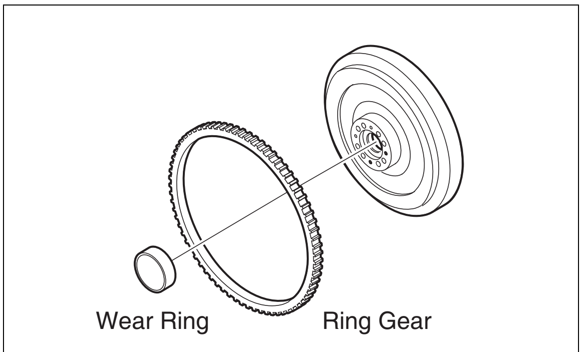
● Use an assembly jig to press fit the wear ring into the back of the flywheel so that the flywheel is aligned with the edge of the wear ring. (Apply Loctite #262 to the mounting surface)



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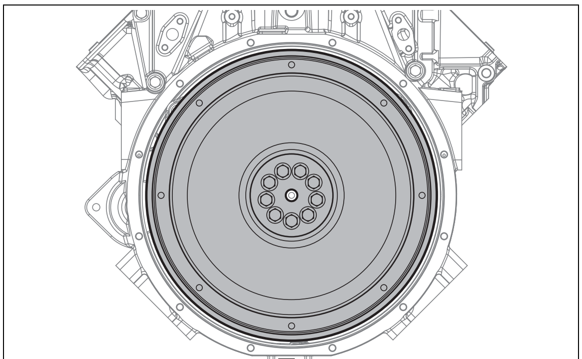
● Install the flywheel assembly guide bolts on the crankshaft.

● Fit the flywheel onto the guide bolts and temporarily tighten the mounting bolts 2 ~ 3 threads; then, tighten the bolts to a torque of 20 kg·m in the order of assembly.

● After tightening the bolts again at an angle of 90° in the order of assembly, tighten them again at 90° in the order of assembly; finally, tighten them at 55° in order.

Torque	20 kg·m + 90° + 90° + 55°



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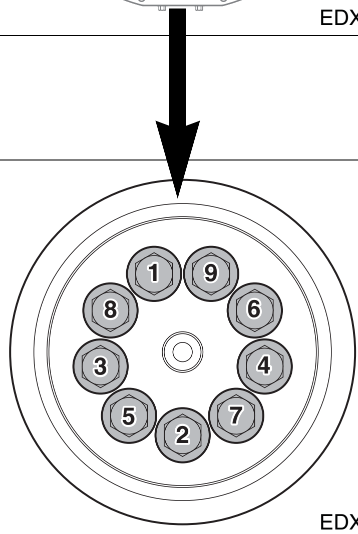

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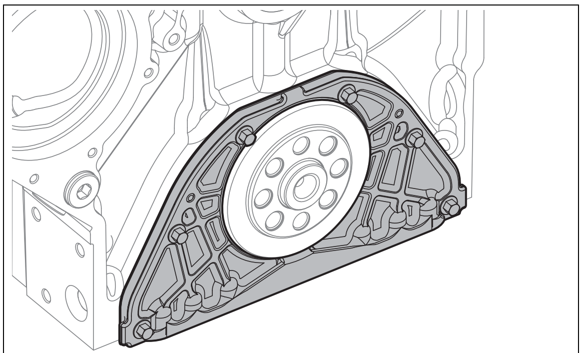
6.2.10. Oil Seal Holder (Front)

● After aligning the oil seal properly with the oil seal holder holes, use an insertion jig to install it.
(Be careful not to damage the oil seal.)

● Apply a gasket to the oil seal holder.

● Align the cylinder block reference pins with the oil seal holder reference pin holes; then, tap the reference pins gently with a urethane hammer to assemble them. Make sure that the oil seal is not damaged by the crankshaft during assembly.



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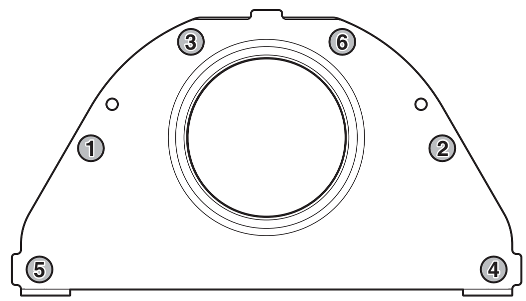
CAUTION

When inserting the oil seal into the oil seal holder, assemble it in a dry state without applying any oil or lubricant.

- Apply oil to the inside of the oil seal and tighten the oil seal holder in a zigzag pattern.

Torque	2.2 kg·m



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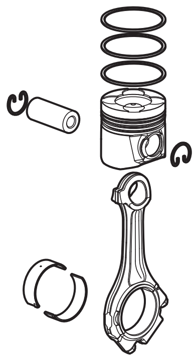
6.2.11. Piston

- Align the piston assemblies in order of their respective cylinders and insert the bearings into the connecting rods and bearing caps. Take care not to mix connecting rods and caps with those used in other cylinders.
- Apply a sufficient layer of clean engine oil to the pistons and connecting rod bearings.



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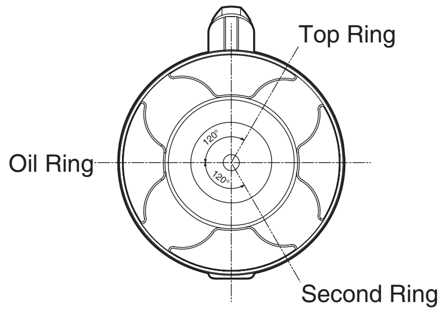
- Insert the piston rings with a special tool and adjust the gap between the piston rings to 120°.



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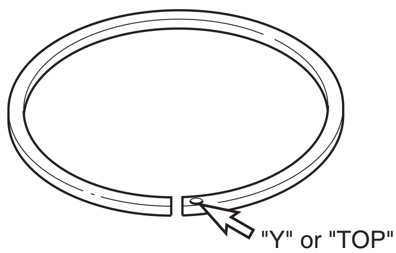
- Make sure not to install the piston ring upside down—the "Y" or "TOP" mark on top of the ring connection should face up.



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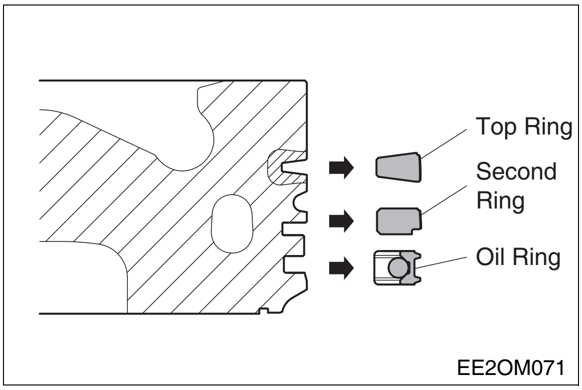
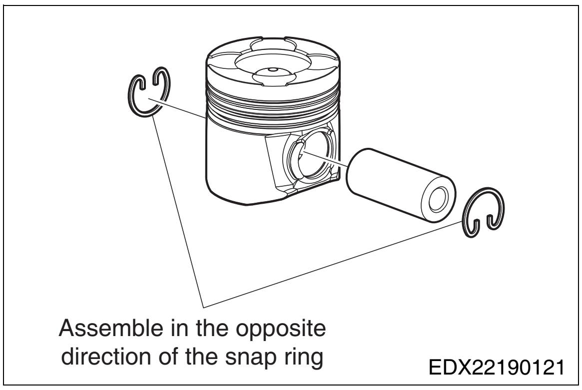
● Insert the pistons into the cylinders by hand or with a wooden stick. (Take care not to damage the piston and rings.)



● Push the piston while rotating the crankshaft approx. 180° to install the bearing cap on the connecting rod.



● Tighten the connecting rod bolts 2 ~ 3 threads; then, tighten them to the specified tightening torque (10 kg·m + 90° + 10°).

< Connecting rod bolt tightening sequence >

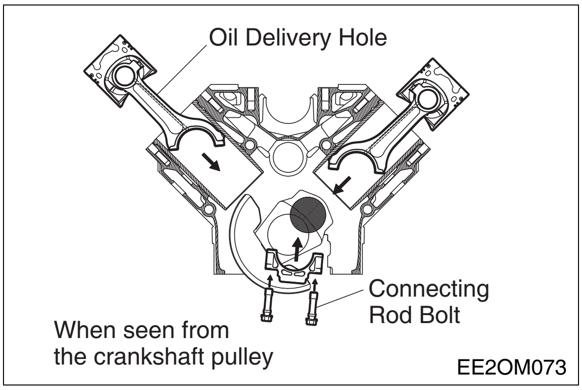
- Step 1: Tighten the bolts 2 ~ 3 threads by hand
- Step 2: Use a wrench to tighten them to approx. 7 kg·m
- Step 3 : Tighten the bolt to 10 kg·m with a torque wrench.
- Step 4: Tighten them one last time to 90° + 10° with the rotating angle method

Tighten the bolts in several stages according to the bolt tightening sequence above.

<Standard bolt length and allowable limit>

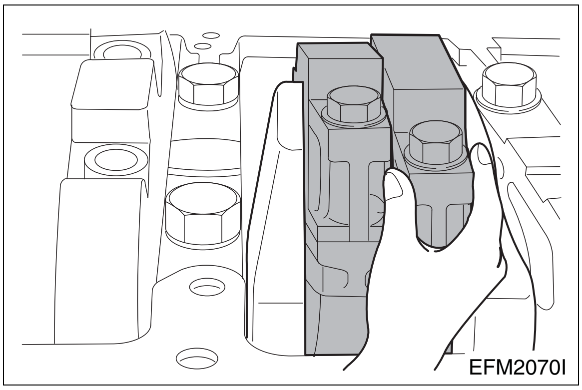
- From the seat of the head to the end of the bolt

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



● Move the connecting rod bearing caps by hand to check whether they move smoothly from side to side.

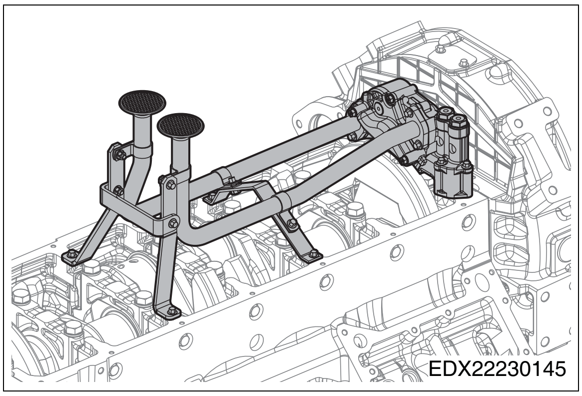
● Rotate the crankshaft in the same way as described above when mounting it on each cylinder.



6.2.12. Oil Pump

- Place the oil pump on the cylinder block mounting location.
- Tighten the oil pump and pressure adjustment valve with mounting bolts to assemble them.

Oil pump backlash	0.035 ~ 0.263 mm



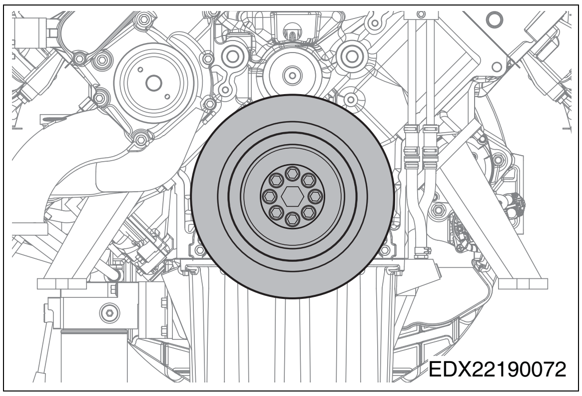
- Apply a gasket to the oil suction pipe mounting surface of the oil pump and tighten the oil suction pipe with mounting bolts to assemble it.
- Tighten the pipe bracket onto the cylinder block with bolts to assemble it.

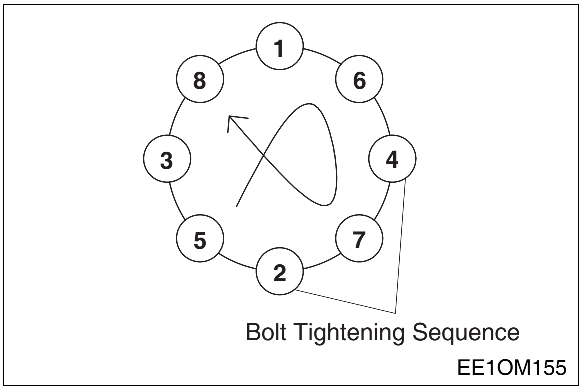
Torque	2.2 kg·m

6.2.13. Vibration Damper

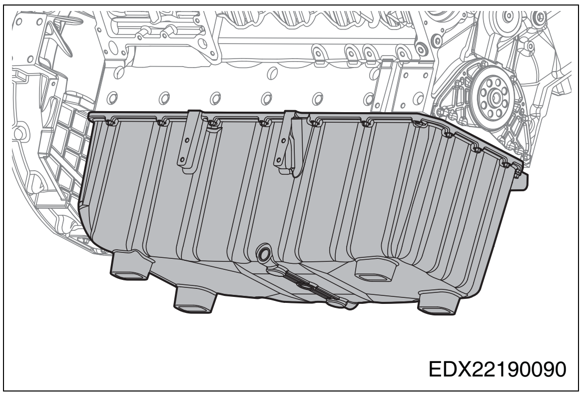
- Assemble the crankshaft pulley and vibration damper after first tightening them with mounting bolts.
- Fit the crankshaft pulley assembly onto the crankshaft and apply engine oil to the bolts; then, tighten them to the specified torque.

Torque	21 kg·m





6.2.14. Oil Pan

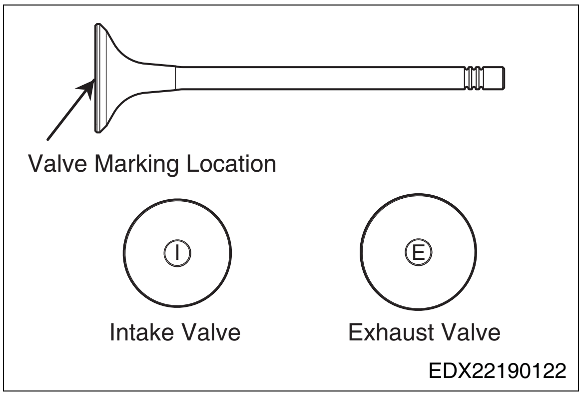


- Use a scraper to completely remove the gasket protruding from the joint between the front oil seal holder and the flywheel housing on the bottom of the cylinder block. When removing the gasket, make sure that pieces of the gasket do not enter the engine.
- Apply a gasket to the cylinder block.
- Mount the oil pan and tighten it with mounting bolts.
- Take care not to displace the gasket.

Torque	Drain plug	10 kg·m (M30-screw plug)
	Mounting bolts	3.1 kg·m

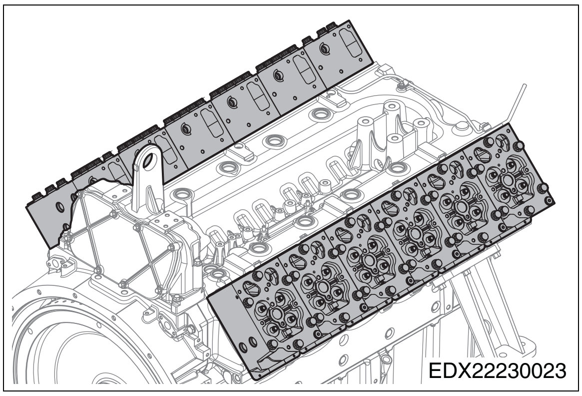
- Mount the guide tube and insert the oil level gauge.

6.2.15. Intake and Exhaust Valves



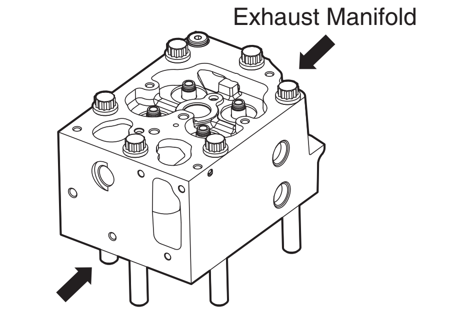
- Before installing the valves on the cylinder head, check the "I" and "E" marks on the valve head.
- Use a valve stem seal installation jig to install the valve stem seals on the valve guides.

6.2.16. Cylinder Head



- Blow into the cylinder head bolt holes with compressed air to completely remove all foreign matter.
- Thoroughly wipe the head gasket contact surface on the cylinder block.
- Make sure to check for and remove any foreign matter in the combustion chamber.
- Align the gasket with the cylinder block mounting pins and assemble it.
- Align the cylinder head with the cylinder block reference pins and mount it on the cylinder block.

(Be careful not to damage the head gasket.)



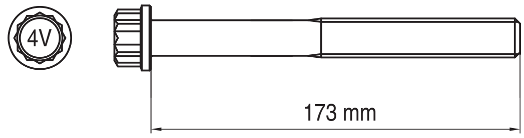
EDX22190123

- Tighten the cylinder head bolts to the specified torque in several stages. Before assembling the bolts, make sure to adjust the parallelism between the cylinder head with a long steel ruler.

Standard length	173 mm

<Cylinder head bolt tightening sequence>

- Step 1: Tighten the bolts 1 ~ 2 threads by hand
- Step 2: Use a wrench to tighten them to approx. 4 kg·m
- Step 3: Tighten them to 90° with the rotating angle method
- Step 4: Tighten them one final time by an additional 90°



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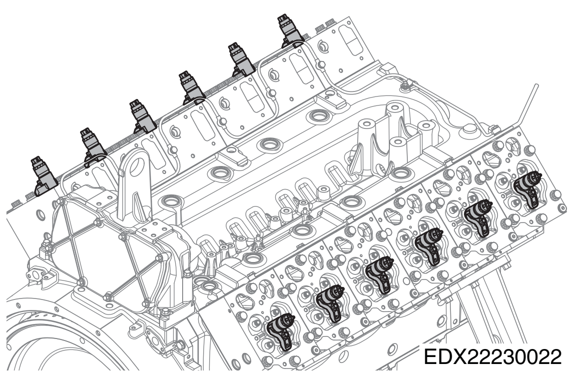
CAUTION
Take care not to allow any foreign matter to enter the cylinder head inlet passages.

6.2.17. Injector

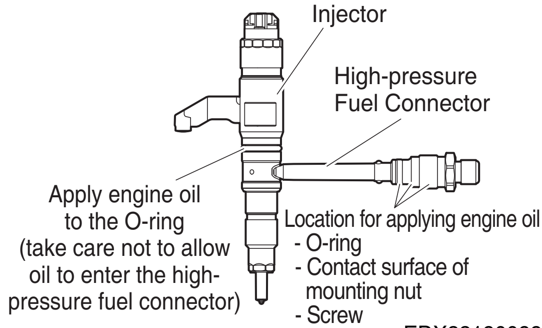
CAUTION

- When installing a new injection pipe after disconnecting the fuel injection pipe connected to a high-pressure fuel connector (HPC), make sure to retighten the HPC mounting nuts to the specified torque.
- In addition, do not reuse injection pipes as the seal for high-pressure fuel is deformed while tightening them.
  HPC nut tightening torque: 6.2 ±0.62 kg·m
  Injection pipe tightening torque: 4.0 ±0.4 kg·m
- Wash all parts thoroughly and keep them free of foreign matter.
- Fuel lines connecting the common rail to the injectors require particular cleanliness as they lack a filtration function.
- Clean and remove all foreign matter from the holes drilled in the cylinder head for inserting high-pressure fuel connectors and holes for injectors.


EDX22230022

– When the injector is disassembled, the high-pressure fuel connector must be replaced with a new one.
– If fuel remaining in a fuel return line enters the combustion chamber while disassembling the injectors, it must be drained either with a hand pump or by cranking the starter motor with the fuel shut off.

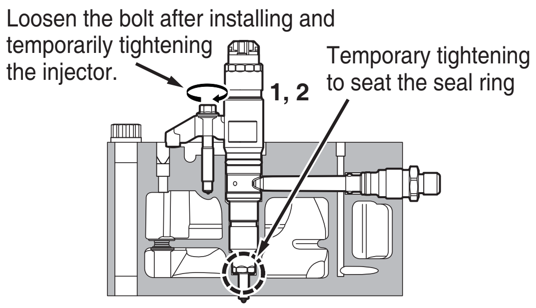
● The injectors must be assembled precisely in the following order.
● Fit an O-ring onto the injector and apply engine oil to the outer circumference.



EDX22190099

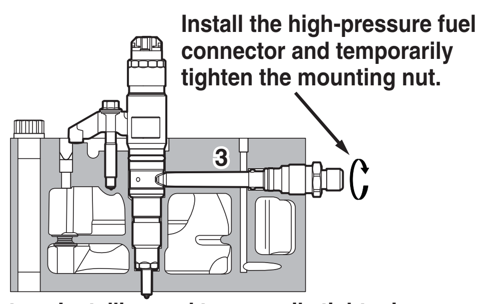
CAUTION
Be careful not to contaminate the connector hole in the high-pressure fuel connector on the side of the injector with oil or foreign matter.

● Align the seal ring with the injector hole on the cylinder head, then insert the injector carefully. Align the injector mounting bolt with the screw on the head and turn the bolt two to three threads by hand to tighten it.
● Seat the injector in the mounting position on injector mounting brackets ① and ② using the mounting bolts; then, tighten it temporarily. After tightening the injector temporarily, loosen the mounting bracket bolts enough to allow flow without applying excessive force to the injector. (Injector axial load of 0 kg·m)



Step one: Installing and temporarily tightening the injector EDX22190100

● Hold the ball on high-pressure fuel connector ③ so that it is vertical and check that it is aligned with the groove in the hole on the side of the head of the intake manifold. Then, align it with the high-pressure fuel connector using the hole in the side of the head and push the high-pressure fuel connector in as far as possible. After tightening the mounting nut (M22 × 1.5) on the high-pressure fuel connector two to three threads by hand, use a torque wrench to tighten it temporarily.

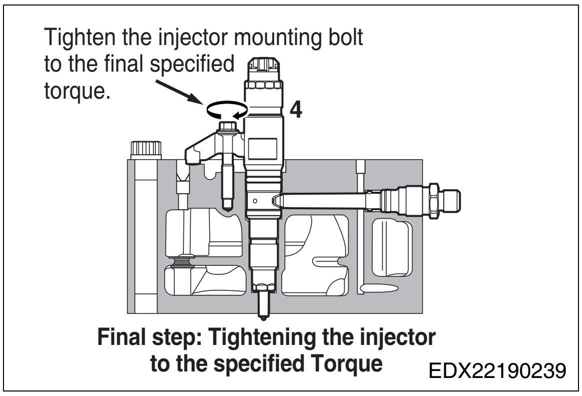


Step two: Installing and temporarily tightening the high-pressure fuel connector EDX22190238

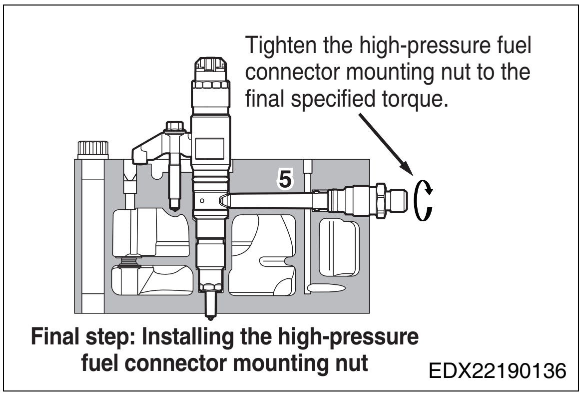
Temporary tightening torque	Injector mounting bracket bolt	High-pressure fuel connector mounting nut
	0.3 ±0.1 kg·m	0.3 ±0.1 kg·m

- Finish tightening injector mounting bracket mounting bolt ④ and high-pressure fuel connector mounting nut ⑤ to their specified torque in order.

Final torque	Injector mounting bracket bolt	High-pressure fuel connector mounting nut
	3.0 ±0.5 kg·m	5.5 ±0.55 kg·m



EDX22190239

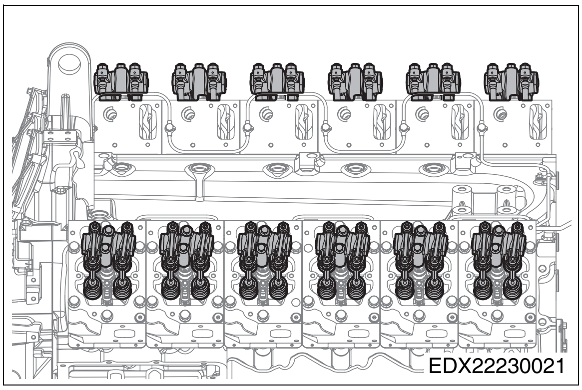


EDX22190136

6.2.18. Rocker Arm

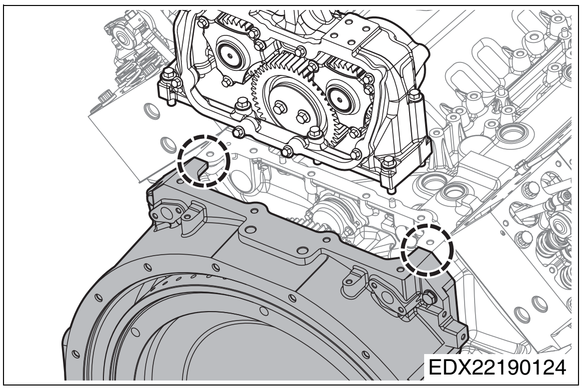
- Apply engine oil to the pushrod and insert it into the pushrod hole.
- Mount the rocker arm assemblies on the cylinder head and tighten the mounting bolts to the specified torque.

Torque	6.2 kg·m


EDX22230021

6.2.19. Timing Gear Case

- Apply a liquid gasket to the T-joint between the cylinder block and the flywheel housing.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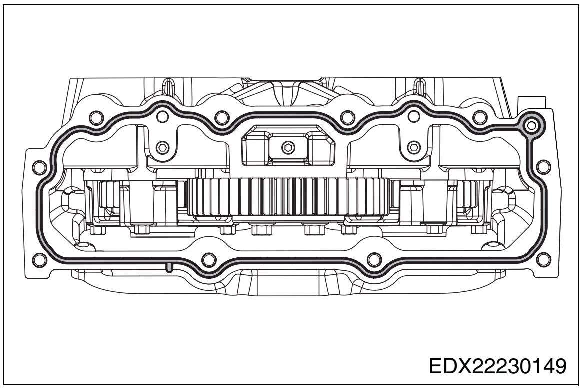
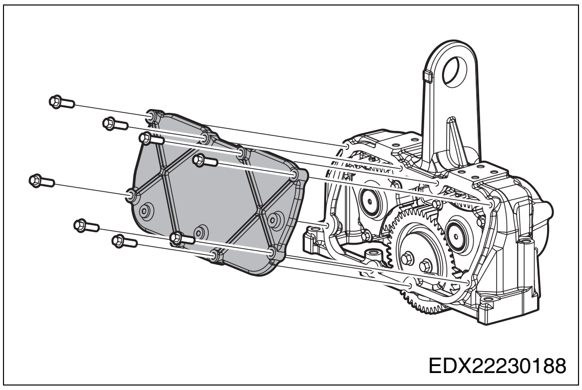
- After checking the rubber gasket on the timing gear case, seat it on the mounting surface; then, tighten the mounting bolts in a zigzag pattern.

Torque	6.2 kg·m


EDX22230149

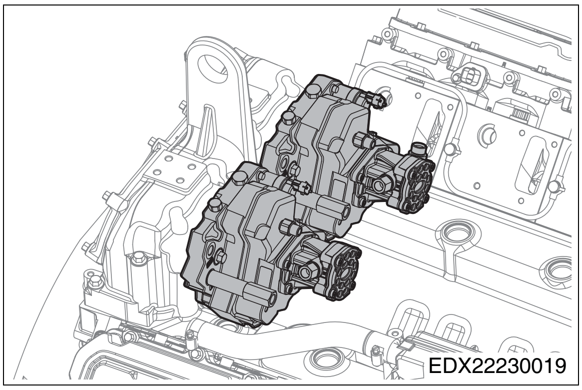
- After installing the timing gear case, install the cover (8-M8 X 1.25).

Torque	2.2 ±0.55 kg·m


EDX22230188

6.2.20. Fuel Injection Pump

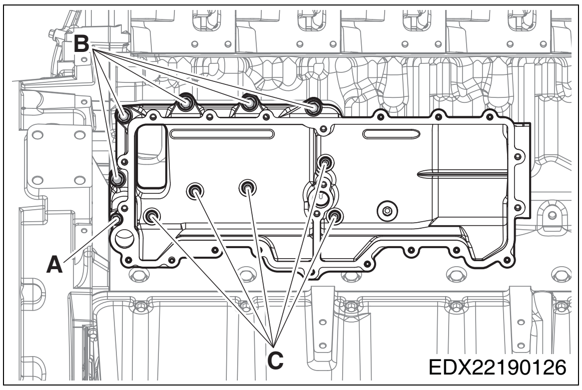
- After greasing the O-ring on the high-pressure fuel pump, align the drive gear spline teeth with the timing gear case and insert it. (Assemble the spline teeth and high-pressure pump teeth regardless of the timing.)
- After inserting the high-pressure pumps on both sides, assemble the mounting bolts.


EDX22230019

6.2.21. Oil Cooler

- Apply gaskets (B) to the surface of the oil cooler housing where the oil cooler is to be installed.
- Tighten the oil cooler with the mounting bolts.
- Tighten and assemble the oil cooler mounting bolts in a zigzag pattern.
  <Oil cooler housing mounting bolts and torque>

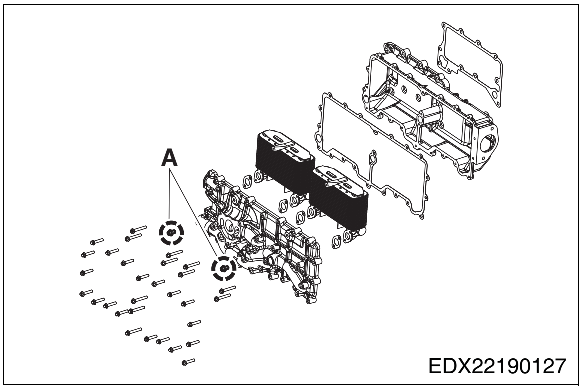
Torque	M8 hex bolt (A)	3.1 kg·m
	M10 hex bolt (B)	4.4 kg·m
	M10 wrench bolt (C)	6.2 kg·m



EDX22190126

- Tighten the oil cooler and cover with mounting bolts.
- Install washers and apply Loctite to 2 cover mounting bolts (A); then, tighten them.

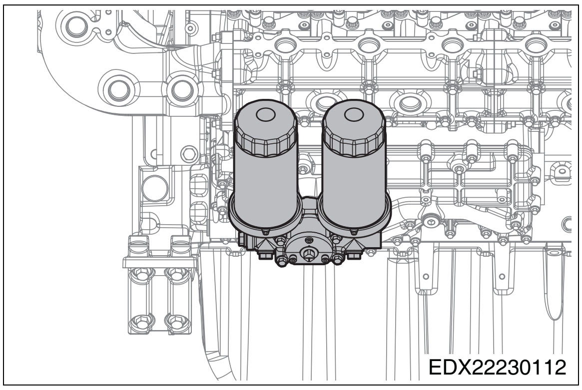
Torque	M8 hex bolt	2.2 kg·m	2 EA (A)
		3.1 kg·m	19 EA



6.2.22. Oil Filter

- Apply a gasket to the oil cooler housing surface and assemble the oil filter.
- Install the oil filter cartridge.

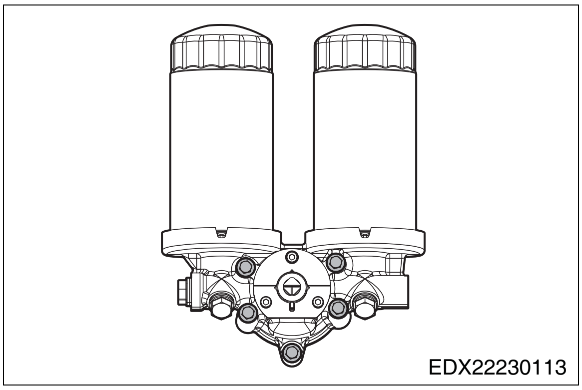
M10 hex bolt	6.2 kg·m



- Cartridge
  - Apply engine oil to the rubber packing.
  - Tighten the packing until it comes into contact with the filter head.
  - Use a filter wrench to tighten it another 3/4 ~ 1 turn.

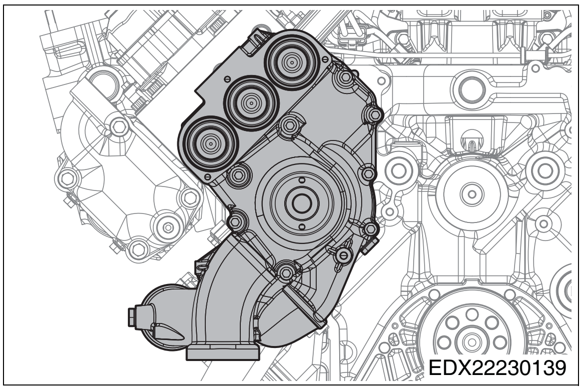
CAUTION
Do not forget to tighten the drain plug after draining the engine oil.

- Use a filter wrench to turn and loosen the oil filter in the counterclockwise direction.
- Use a rag wipe to clean the filter body and mounting surface of the oil filter body and ensure that the new oil filter cartridge is seated properly.
- Lubricate the O-ring lightly with oil and turn the oil filter until the sealing surface aligns with the O-ring. Use a filter wrench to turn it an additional 1 ~ 1/4 turn.



Torque	4.4 kg·m

6.2.23. Coolant Pump

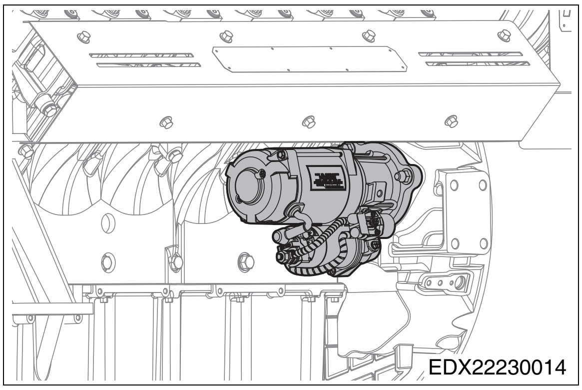


- When applying a gasket to the coolant pump, apply a sealant to the surface of both the gasket and the cylinder block. <Coolant pump and coolant pipe>

Torque	M8	2.2 kg·m

- Tighten and assemble the coolant pump with mounting bolts in a zigzag pattern.
- Fit the thermostat onto the coolant pump.
- Fit an O-ring onto the thermostat and tighten the coolant pipe with mounting bolts to assemble it.

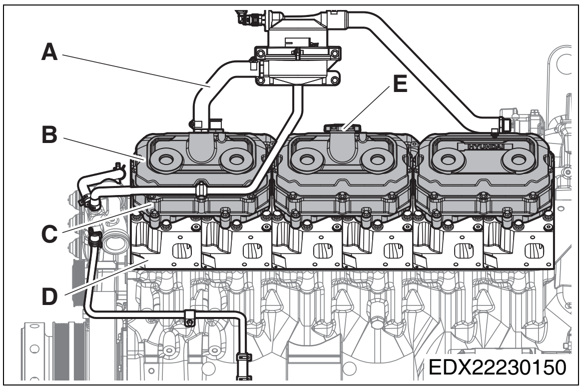
6.2.24. Starter Motor



- Tighten stud bolts in the starter motor mounting holes in the flywheel housing.
- Fit the starter motor onto the flywheel housing and tighten it with mounting nuts.

Torque	8 kg·m

6.2.25. Cylinder Head Cover and Middle Cover



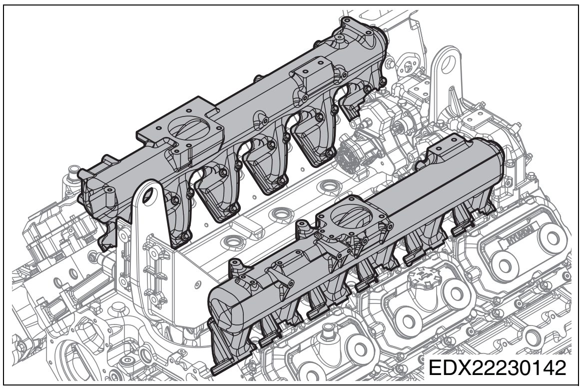
- After applying a new gasket to the middle cover mounting surface of cylinder head (D), tighten it with mounting bolts to assemble it.
- Tighten cylinder head cover (B) with mounting bolts to assemble it.
- Insert oil filler cap (E).
- Insert oil breather hose (A) and tighten it with a clamp to assemble it.

Middle cover (C) and head cover (B) mounting bolt torque	2.2 kg·m

6.2.26. Intake Manifold

- Apply a new gasket to the cylinder head surface.
- Tighten the intake manifold with mounting bolts to assemble it.

Torque	2.2 kg·m



6.2.27. Common Rail and Fuel Injection Pipes

- Assemble the common rail bracket (B) and fasten common rail (A).

Tightening torque	2.2 kg·m

- Connect the high-pressure pipes between high-pressure fuel connector (C) and the common rail, and fasten them with clips (D).

High-pressure fuel pipe nut torque	4 kg·m

- Mount the tank fuel switch bracket bolts (2ea) to the cylinder block.

Tightening torque	2.2 kg·m

- Mount the sealing (1ea), plug screw (1ea) on the bottom of the tank fuel switch (C).

Plug screw tightening torque	5 kg·m

- Mount the bolts (2ea) to the tank fuel switch (C) bracket.

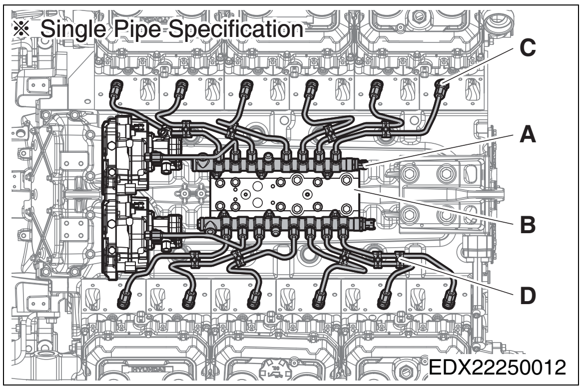
Tightening torque	2.2 kg·m

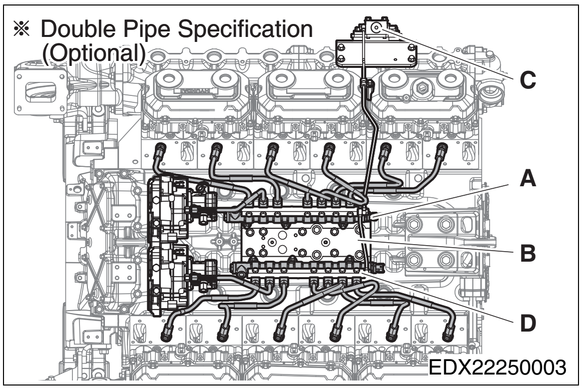
- Mount the sensor on the top of the tank fuel switch (C).

Tightening torque	8.5 kg·m

- Assemble 2 hoses to the tank fuel switch (C) with hollow screws, and tighten the fuel hoses to the terminal block (D) on the common rail (A).

Tightening torque	1.6 kg·m



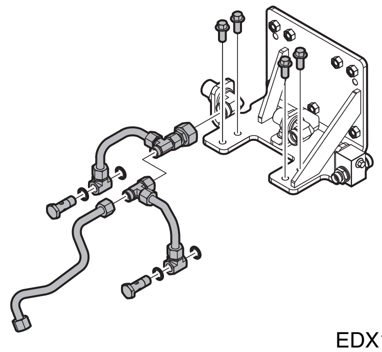


- Assemble the hose with clips (3ea), spacer (1ea), and bolts (3ea).

<Fuel pipe assembly order>

- Tighten the bracket with four bolts.

Tightening torque	6.2 kg·m



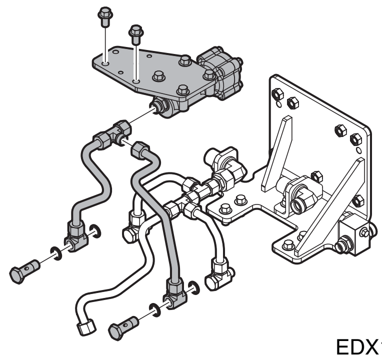
EDX15240197

- Tighten the hollow screws on three fuel pipes three to four threads by hand temporarily.
- Tighten the cap nuts on three fuel pipes until not turn any further by hand.
- Tighten two hollow screws completely.

Tightening torque	2.5 kg·m

- Tighten the cap nuts completely. (After tightening the pipes temporarily, tighten them with the rotating angle method (120° ± 30°))
- Tighten two bolts on the sub bracket.

Tightening torque	6.2 kg·m



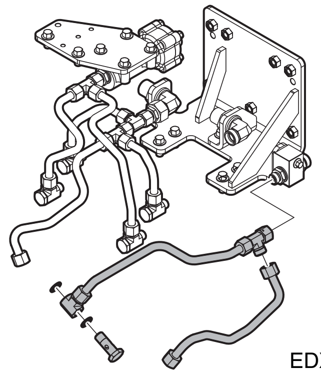
EDX15240198

- Tighten the hollow screws on two fuel pipes three to four threads by hand temporarily.
- Tighten the cap nuts on two fuel pipes until not turn any further by hand.
- Tighten two hollow screws completely.

Tightening torque	2.5 kg·m

- Tighten the cap nuts completely. (After tightening the pipes temporarily, tighten them with the rotating angle method (120° ± 30°))
- Tighten the hollow screws on two
- fuel pipes three to four threads by hand temporarily.
- Tighten the cap nuts on two fuel pipes until not turn any further by hand.
- Tighten one hollow screw completely.

Tightening torque	2.5 kg·m

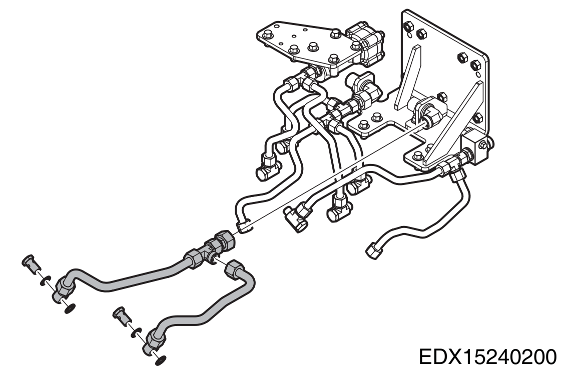


EDX15240199

- Tighten the cap nuts completely. (After tightening the pipes temporarily, tighten them with the rotating angle method (120° ± 30°))
- Tighten the hollow screws on two fuel pipes three to four threads by hand temporarily.
- Tighten the cap nuts on two fuel pipes until not turn any further by hand.
- Tighten two hollow screws completely.

Tightening torque	2.5 kg·m

- Tighten the cap nuts completely. (After tightening the pipes temporarily, tighten them with the rotating angle method (120° ± 30°))



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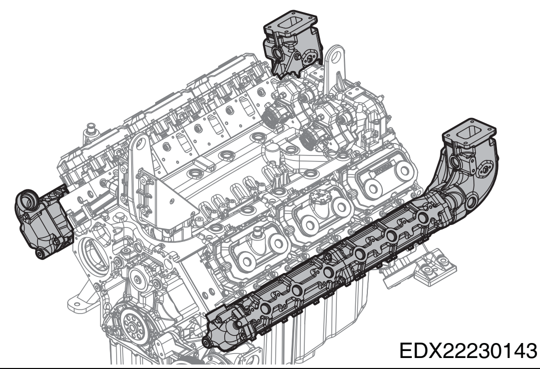
6.2.28. Exhaust Manifold

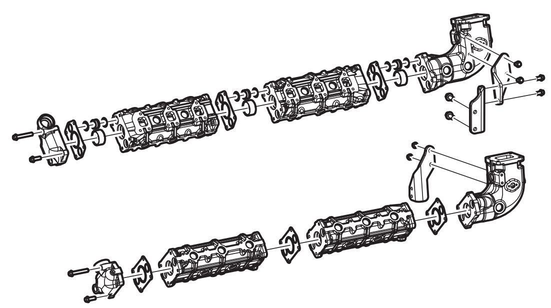
- Connect the two-part exhaust manifold by fitting a steel ring onto the connection.
- Apply a new gasket to the exhaust manifold.



EDX22230143

- Apply gasket to exhaust elbow connected to the exhaust manifold and tighten the connecting nuts to assemble it.
- Assemble both sides as described above.

Torque	8 kg·m



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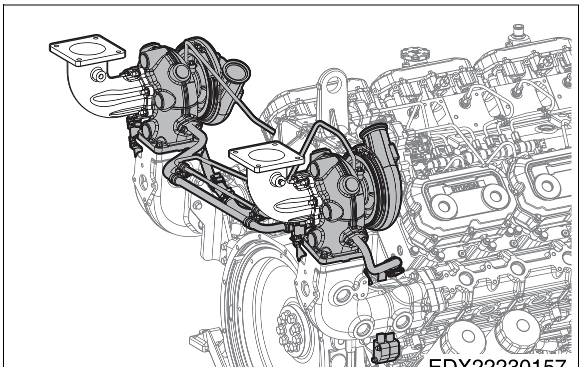
6.2.29. Turbocharger

- Apply a gasket to the exhaust elbow and assemble the turbocharger with mounting nuts.
- Apply a gasket to the oil delivery pipe and tighten the mounting bolts to assemble it.
- Apply a gasket to the oil drain pipe and tighten the bolts to assemble it.
- Assemble both sides as described above.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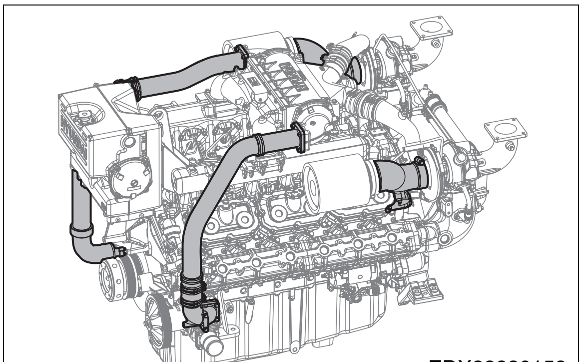
Turbocharger mounting nut torque	6.2 kg·m

6.2.30. Intake Stake and Air Pipe

- Connect the rubber hose between the intercooler and raw water pump, and then tighten the clamp to assemble it.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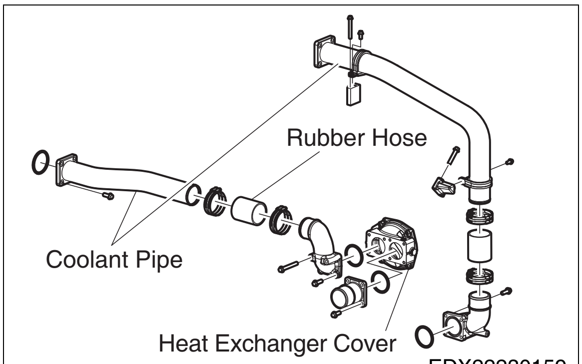

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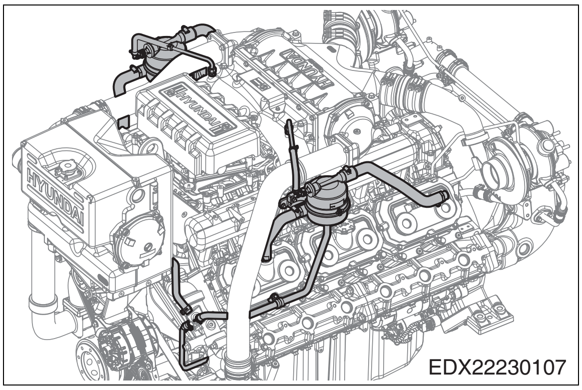
6.2.31. Breather

- Connect the breather hose to the breather assembly.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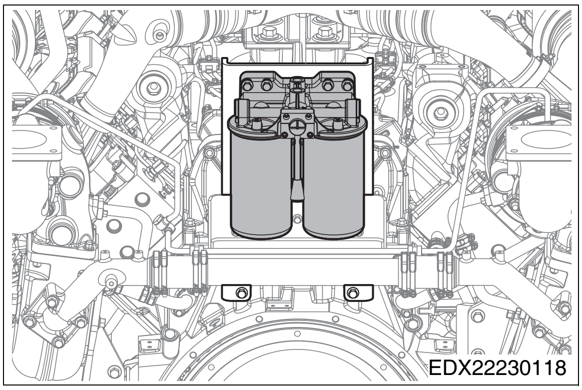
6.2.32. Fuel Filter

- Secure the bracket on the cylinder block and assemble the fuel filter.
- When replacing the fuel filter with a new one, make sure to fill the cartridge inside with fuel before installing it.

Torque	6.2 kg·m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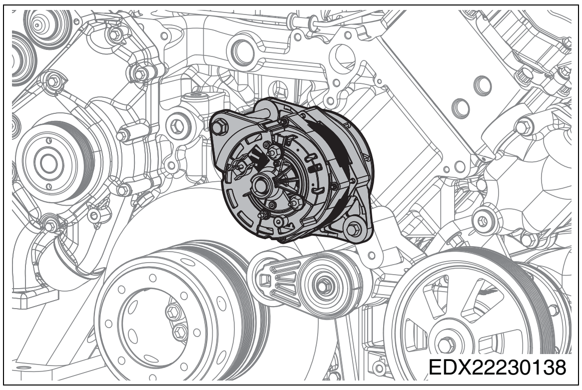
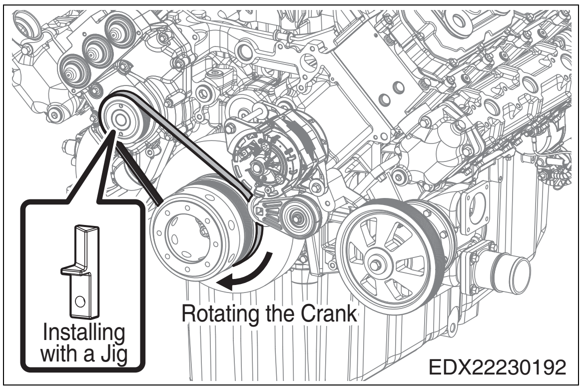
6.2.33. Alternator

- Tighten the alternator bracket onto the cylinder block with mounting bolts to assemble it.
- Mount the alternator on the bracket and fasten it with the lower bracket.


EDX22230138

6.2.34. Water Pump Belt

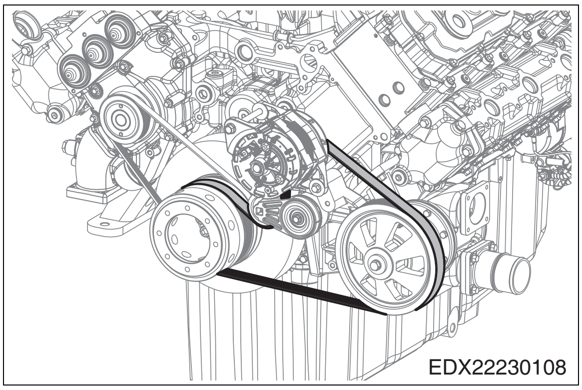
- Install a jig on the pulley and turn the crank to install the belt.



EDX22230192

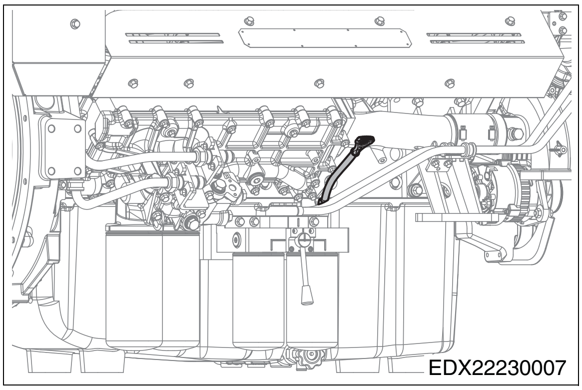
6.2.35. Raw Water Pump Belt

- Install the idler pulley bracket on the cylinder block.
- Connect the fan pulley, crank pulley, and idler pulley with the V-belt.
- Tighten the tighten adjusting bolt. (It should be deflected 10 mm ~ 15 mm when pressed with the thumb.)


EDX22230108

6.2.36. Oil Level Gauge and Guide Tube

- Assemble the guide tube and oil level gauge with the oil pan.



EDX22230007

6.2.37. Misc.

- Connect the various sensors, harnesses, fuel and oil lines.

7. Maintenance of Main Components

7.1. Lubrication System

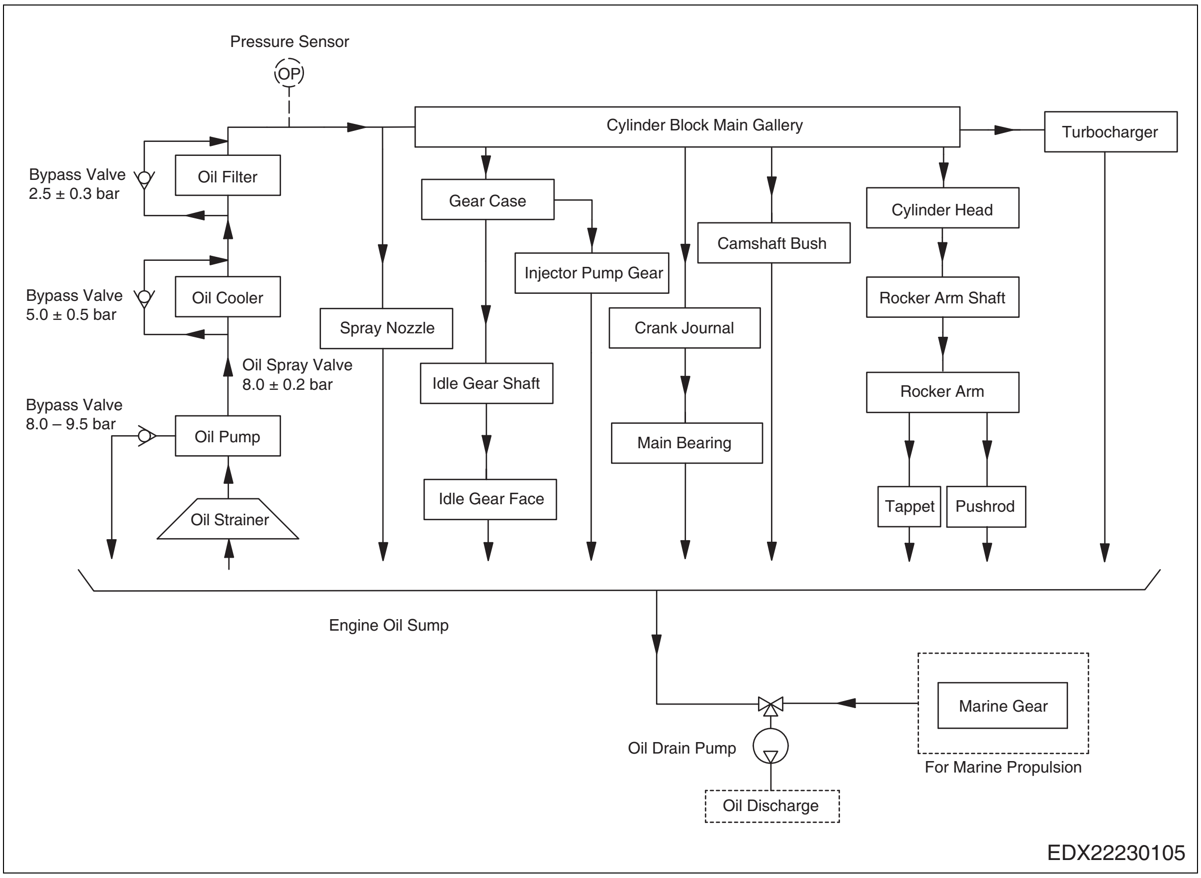
7.1.1. General Information

As engine oil is sucked and delivered from the oil pan through the gear oil pump, all of it passes through the oil cooler and oil filter to be filtered. Then, this oil flows through the main oil gallery in the cylinder block to lubricate each bearing, turbocharger, etc. in the engine in order to maintain normal engine performance.

7.1.2. Specifications

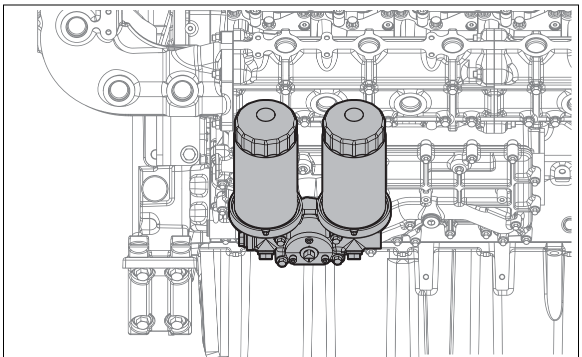
Item	Specifications	Item	Specifications
Lubrication method	Forced circulation	Oil filter type	Full flow
Oil pump type	Gear driven	Cartridge bypass	
Relief valve opening pressure	8 ~ 9.5 bar	Valve opening pressure	2.5 ±0.3 bar
Oil injection nozzle adjustment		Oil cooler bypass	
Valve opening pressure	0.6 ~ 1.0 bar	Valve opening pressure	5.0 ±0.5 bar

7.1.3. Lubrication System Circuit Diagram



7.1.4. Oil Filter

The oil filter installed in the engine is a cartridge-type filter. Make sure to replace it with a new one at the designated interval.



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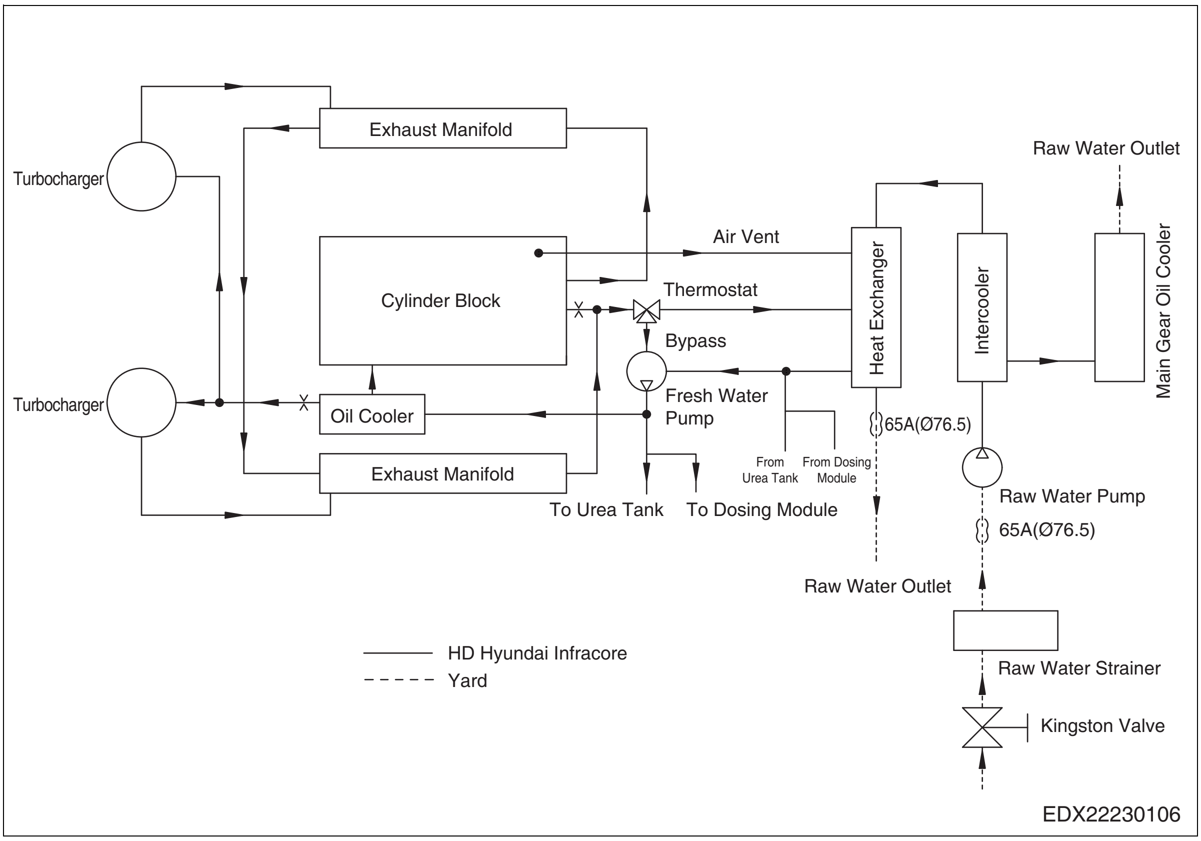
7.1.5. Troubleshooting

Symptom	Possible Cause	Troubleshooting
Excessive oil consumption	Poor oil quality	Use the specified oil
	Leaky oil seal ring and packing	Replace
	Worn piston and ring	Replace the piston and piston ring
	Worn cylinder liner	Replace the cylinder liner
	Seized piston ring	Replace the piston and piston ring
	Worn valve guide oil seal, valve guide, or valve stem	Replace
Oil pressure drop	Poor oil quality	Use the specified oil
	Seized oil pump relief valve	Replace
	Clogged oil pump strainer	Use the specified oil
	Worn oil pump gear	Replace
	Cracked oil pump delivery pipe	Replace
	Defective oil pump	Repair or replace
	Defective hydraulic system	Repair or replace
	Worn bearing	Replace
Contaminated oil	Clogged oil filter	Replace the oil filter cartridge
	Gas leak	Replace the piston ring and cylinder liner

7.2. Cooling System

7.2.1. Cooling System

- Fresh water in the engine heat exchanger is indirectly cooled using sea water. In addition, the system is designed so that the engine's coolant temperature is within the normal range of 71 ~ 81°C and the seawater inlet temperature is 32°C.
- River water or sea water is sucked in by the raw water pump and then passes through the heat exchanger where the sea water absorbs the heat generated in the freshwater coolant. The sea water then cools the intercooler and the oil cooler of the reduction gear and is discharged outside the ship. In this case, the seawater first passes through the intercooler and oil cooler of the reduction gear and then through the heat exchanger.



Note

1 Thermostat opening temperature: 71°C (85°C when fully open).

2 The raw water pump inlet limits should not exceed 0.3 bar at normal speed and 0.05 bar at maximum speed.

3 The raw water pump suction pipe must be at least Ø75 mm in size.

7.2.2. Specifications

Item		Specifications
Coolant pump	Type	Centrifugal
	Supply	Approx. 840 liter/min.
	Pump speed	4,370 rpm
	Pump back pressure	3.8 kg/cm^2
Thermostat	Operating temperature	71 ~ 85°C

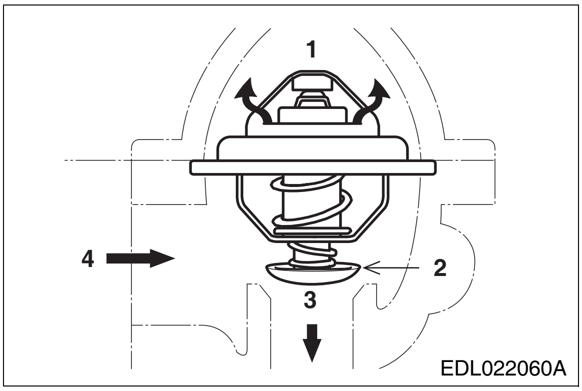
7.2.3. Thermostat

The thermostat is used to maintain a constant coolant temperature and prevent heat loss in order to enhance the engine's thermal efficiency.

When the coolant temperature is low, the thermostat valve closes and coolant is bypassed directly to the pump. When the coolant temperature rises and the thermostat valve opens completely, the bypass circuit closes and the coolant passage to the radiator opens to allow coolant to flow to the radiator.

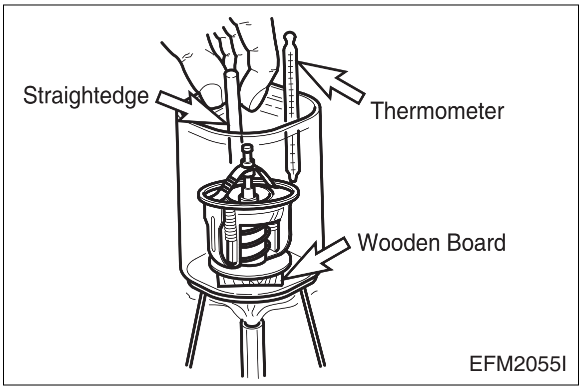
Item	**Specifications**
	Temperature regions
Type	Wax pellet
Opening temperature	71°C
Full opening temperature	85°C
Valve lift	8 mm or more

1.	Heat exchanger
2.	Bypass valve
3.	Coolant pump
4.	Coolant pipe



1) Inspection

- Check the wax pellet and spring for damage.
- Submerge the thermostat in water and heat the water slowly to check whether the thermostat operates properly.
  If the lift is 0.1 mm (start of opening) at a water temperature of 71°C and 8 mm (fully open) or more at a water temperature 85°C, the thermostat is normal.



2) Cautions for replacing and handling the thermostat

- Cautions for handling

  The reaction rate of the wax pellet type against changes in the coolant temperature is slower than that of the bellows type.

  This is because the wax pellet type has a higher thermal capacity. Therefore, the engine must first be idled sufficiently to prevent a rapid rise in the engine coolant temperature. In cold weather, avoid overloading or overspeeding immediately after starting the engine.

  When draining coolant from or adding coolant to the engine cooling system, drain or pour it slowly to allow enough air to escape from the system.

- Replace the thermostat

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

7.2.4. Troubleshooting

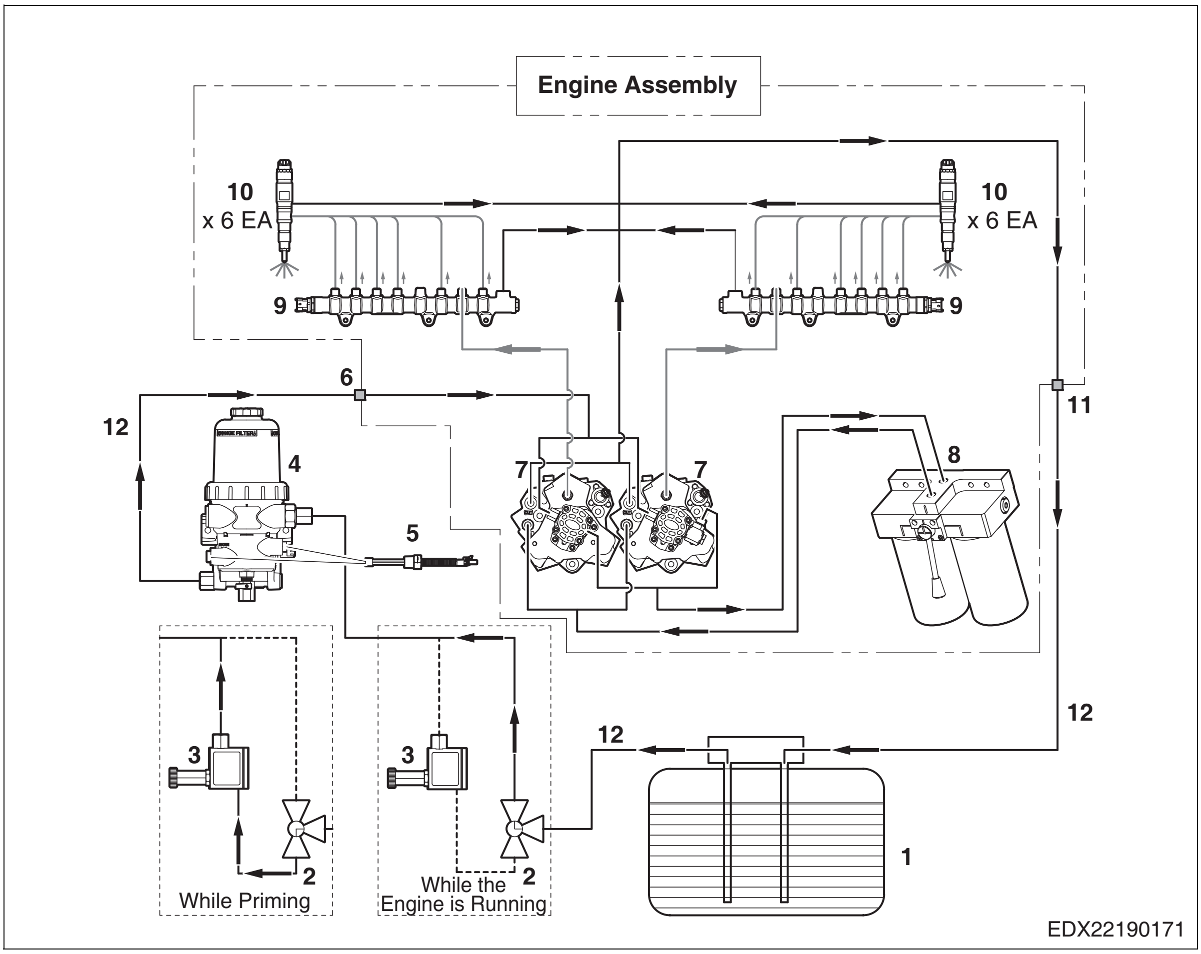
Symptom	Possible Cause	Troubleshooting
Overheated engine	Insufficient coolant	Add coolant
	Loose heat exchanger cap spring	Replace the cap
	Loose or broken belt	Adjust or replace the belt
	Belt contaminated with oil	Replace the belt
	Malfunctioning thermostat	Replace the thermostat
	Faulty coolant pump	Repair or replace
	Resistance due to contamination of coolant passage	Clean the heat exchanger and coolant passage
	Incorrect fuel injection timing	Adjust the fuel injection timing
	Contaminated or clogged heat exchanger air passage	Clean the exterior of the heat exchanger
	Coolant leakage due to damaged cylinder head gasket	Replace the cylinder head gasket
Overcooled engine	Malfunctioning thermostat	Replace the thermostat
	Excessively low ambient temperature	Cover the heat exchanger
Insufficient coolant	Coolant leaking from heat exchanger	Repair or replace
	Loose or damaged heat exchanger coolant connection	Retighten the hose clamp or replace the hose
	Loose heat exchanger cap valve spring	Replace the cap
	Leaky coolant pump	Repair or replace
	Leaky cylinder head gasket	Replace the cylinder head gasket
	Cracked cylinder head or block	Replace the cylinder head or block
Abnormal noise in cooling system	Faulty coolant pump bearing	Replace the bearing
	Faulty belt	Replace the belt

7.3. Fuel System

7.3.1. General Information

This engine is equipped with a high-pressure common rail fuel injection system and consists of the components shown in the "fuel system schematic diagram" below. The system is designed to function optimally according to the engine performance.

After leaving the fuel tank and passing through the primary fuel filter (oil-water separator), fuel is filtered of all water and large particles of foreign matter; then, the fuel is sent to the secondary fuel filter by the low-pressure gear pump installed in the high-pressure fuel pump. Here, small particles of foreign matter which may cause problems in the injection system are removed. Then, after the fuel is pressurized to a suitably high pressure for the required engine performance, the fuel is sent to the common rail where it is injected into the combustion chamber at a high pressure by injectors controlled by the ECU. The fuel remaining after combustion is complete and the fuel used to lubricate and cool the high-pressure pump, common rail and injectors are gathered together and returned to the fuel tank.



No.	Part name	Related system
1.	Fuel Tank	Shipyard
2.	Three-way valve	Shipyard
3.	Hand priming pump	Engine
4.	Primary fuel filter (Water-in-fuel sensor included)	Engine
5.	Primary fuel filter heater	Engine
6.	Engine fuel inlet port (1 1/16-12 UNF-2B SAE J516 37° MALE CONE)	Engine

No.	Part name	Related system
7.	High-pressure fuel pump	Engine
8.	Secondary fuel filter	Engine
9.	Common rail	Engine
10.	Injector	Engine
11.	Engine fuel outlet port (1 1/16-12 UNF-2B SAE J516 37° MALE CONE)	Engine
12.	Fuel hose (Coupling 1 1/16-12 UNF SAE J516 37° FLARE) 2 meters, 3 EA	Engine

7.3.2. Precautions

- The common rail fuel injection system operates at high pressures (1,800 bar). Accordingly, the system must be handled and serviced with care, and the safety regulations must always be followed.
- The common rail fuel injection system should never be removed, installed or inspected while the engine is running or immediately after stopping the engine; inspections and service work should be performed at least 30 seconds to one minute after stopping the engine.
- During service work and inspections, make sure that the workspace is clean before performing any work to prevent foreign matter from entering the fuel system; keep any unnecessary removal and installation to a minimum; and in the case of parts which must be reused during removal and installation, take the necessary measures to prevent foreign matter from entering the parts after removing them and clean them before reusing them for installation.
- The normal performance of O-rings and sealing washers used on high-pressure fuel pipes and in the fuel system cannot be guaranteed if they are reused; make sure to use new parts.
- When assembling high-pressure fuel pumps, common rails, injectors, and high-pressure fuel pipes, take care to prevent damage due to impacts, etc. resulting from carelessness and make sure to assemble them precisely.

7.3.3. Fuel Tank

The fuel tank must be able to store fuel cleanly and safely and must be structured to satisfy the following requirements so as not to affect the components of the engine injection system.

1) Materials
   Zinc (Zn), copper (Cu), lead (Pb), sodium (Na) and calcium (Ca) cause chemical reactions with water in fuel and biodiesel, thereby forming various corrosive acids, sludge and viscous substances. When this occurs, it causes premature clogging of the primary fuel filter, seizure of injectors, corrosion and wear of fuel system components, including the injection system, leading to excessive maintenance expenses resulting from engine failure. Hence, when the use of these materials cannot be avoided, make sure to apply a phosphate film or trivalent chromium plating to prevent the materials from coming into direct contact with fuel.
2) Air intake/discharge system
   When fuel is delivered to the engine, a reduction in pressure equivalent to the volume occupied by the fuel in the tank occurs, leading to a fluctuation in the volume of fuel as a result of a change in the fuel temperature. Hence, if the fuel tank is an enclosed structure, excessive static/negative pressure is formed, causing abnormal engine operation. Accordingly, the fuel tank must be equipped with an air intake/discharge system to constantly maintain atmospheric pressure, while the ports through which air is drawn in or discharged must be connected by means of extension hoses or tubes to a clean environment with minimal dust, moisture, insects, etc. or a suitable air filter must be installed to prevent such foreign matter from entering the system. When air inlets and outlets are installed in extremely dusty or humid areas, the service life of the primary and secondary fuel filters is severely reduced, while wear and corrosion of injection system components are accelerated, resulting in a shortened service life and excessive maintenance expenses.
3) Port for draining condensate and cleaning foreign matter
   Inside the fuel tank, foreign matter entering through the air inlet and outlet ports as well as condensate on the inner wall of the tank resulting from the difference in temperature between fuel and ambient air form deposits continuously. The fuel tank must be equipped with a cleaning port for periodically removing and cleaning condensate and foreign matter to prevent foreign matter and condensate deposits in the tank from entering the engine fuel system.

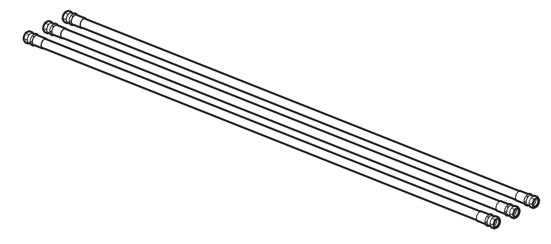
7.3.4. Fuel Lines Connected to the Engine

1) Materials

Since the fuel lines connecting the engine and the fuel tank must be flexible enough to withstand vibrations while the engine is running, it is recommended to use hoses.

The marine engine includes two 2 m fuel hoses (420103-00602) attached to the engine and the other fuel hose is packaged separately and provided along with the engine. Make sure to install and use them where necessary on the primary fuel filter, hand priming pump, and fuel tank.

When additional fuel hoses of different lengths are required, use the fuel hose specifications provided to order hoses of the desired length from a hose supplier.



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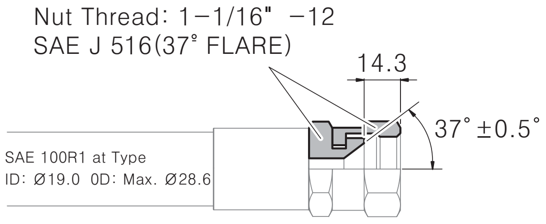
< Fuel hose specifications >

Hose	SAE 100R1 AT Type I.D. Ø19.0, O.D. max. Ø28.6
Hose coupling	SAE J516 37° Flare, 1 1/16" – 12 UNF



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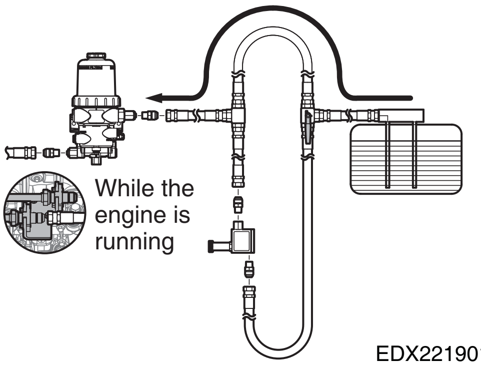
2) Pipe configuration

The fuel lines connecting the fuel tank and primary fuel filter and the piping connected to the hand priming pump must be configured as shown in the figure on the right. When the engine is running with a three-way valve installed, make sure to configure the piping so as to prevent fuel from passing unnecessarily through the hand priming pump and causing a loss of suction pressure.



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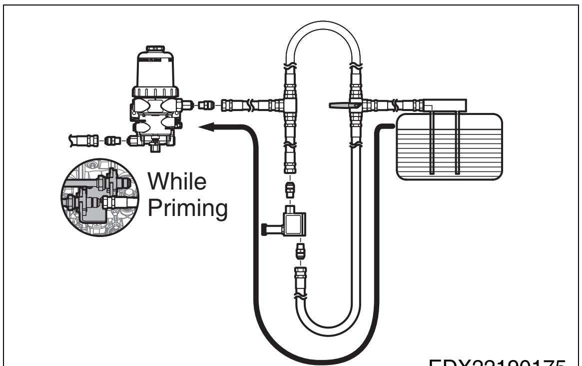

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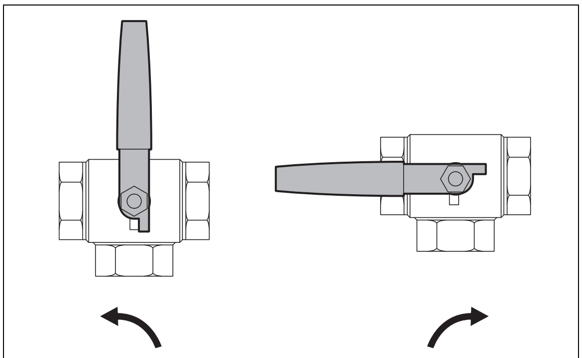
7.3.5. Three-Way Valve

1) Materials and specifications

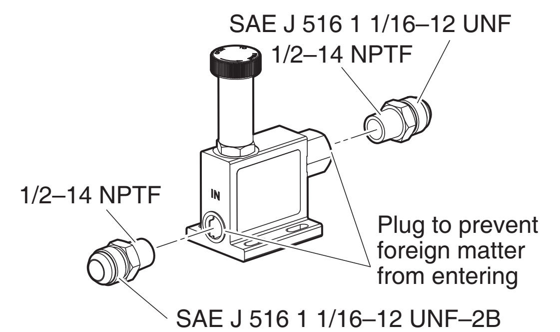
   Zinc (Zn), copper (Cu), lead (Pb), sodium (Na) and calcium (Ca) cause chemical reactions with water in fuel and biodiesel, thereby forming various corrosive acids, sludge and viscous substances.
   When this occurs, it causes premature clogging of the primary fuel filter, seizure of injectors, corrosion and wear of fuel system components, including the injection system, leading to excessive maintenance expenses resulting from engine failure. Hence, in addition to using stainless materials, please refer to the figure on the right to purchase and install threaded products among the commercially available L-type three-way valves to enable piping to be connected easily.


EDX22190176

7.3.6. Hand Priming Pump and Connecting Adapter

1) Configuration

A hand priming pump and two piping connecting adapters are provided as separate accessories along with the engine.



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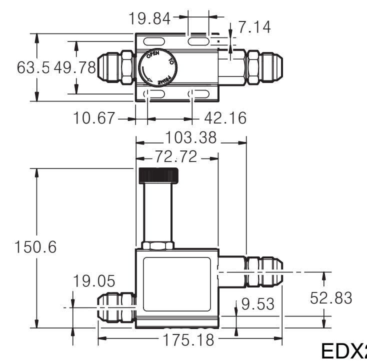
2) Installation

Remove the plug for preventing foreign matter from entering the hand priming pump and tighten the connecting adapters provided to the specified torque.



EDX22190178

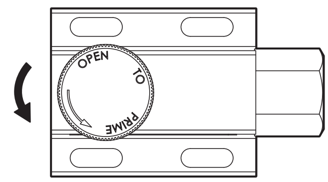
Torque	5 ±0.5 kg·m

As illustrated by the installation location in the fuel system schematic diagram, the hand priming pump must be located between the three-way valve and primary fuel filter, and four M6 bolts should be installed firmly in locations which do not disrupt the generator set controls in order to prevent looseness and unnecessary movement during operation.
When tightening piping couplings, tighten the coupling with the connecting adapter on the hand priming pump secured with a 27 mm spanner to prevent the adapter from turning along with the coupling.
Make sure that the tightening torque of piping being connected does not exceed a maximum of 9.5 kg·m.

3) Usage

The hand priming pump is used for priming to remove air remaining in the fuel passages after service work which requires the removal and installation of engine fuel system components and the primary/secondary fuel filters.

- Turn the handle on the hand priming pump counterclockwise by hand to unlock the pump.



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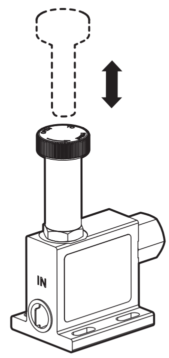
- Pump the handle up and down by hand to prime the pump.



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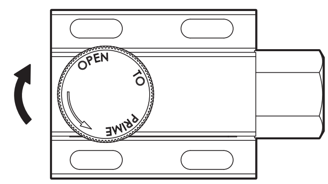
- After priming is complete, press the handle into the compressed position by hand; then, wind it in the clockwise direction to lock it.



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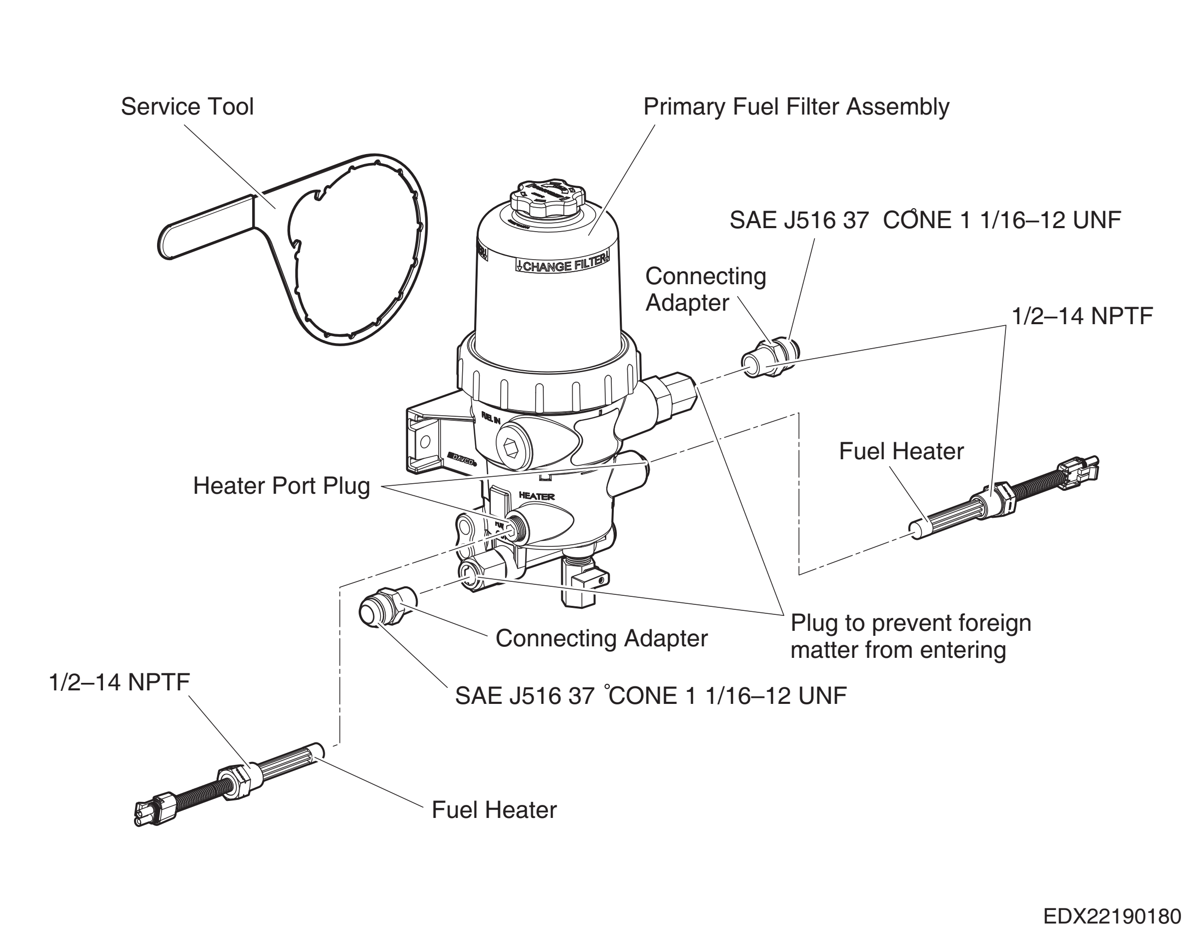
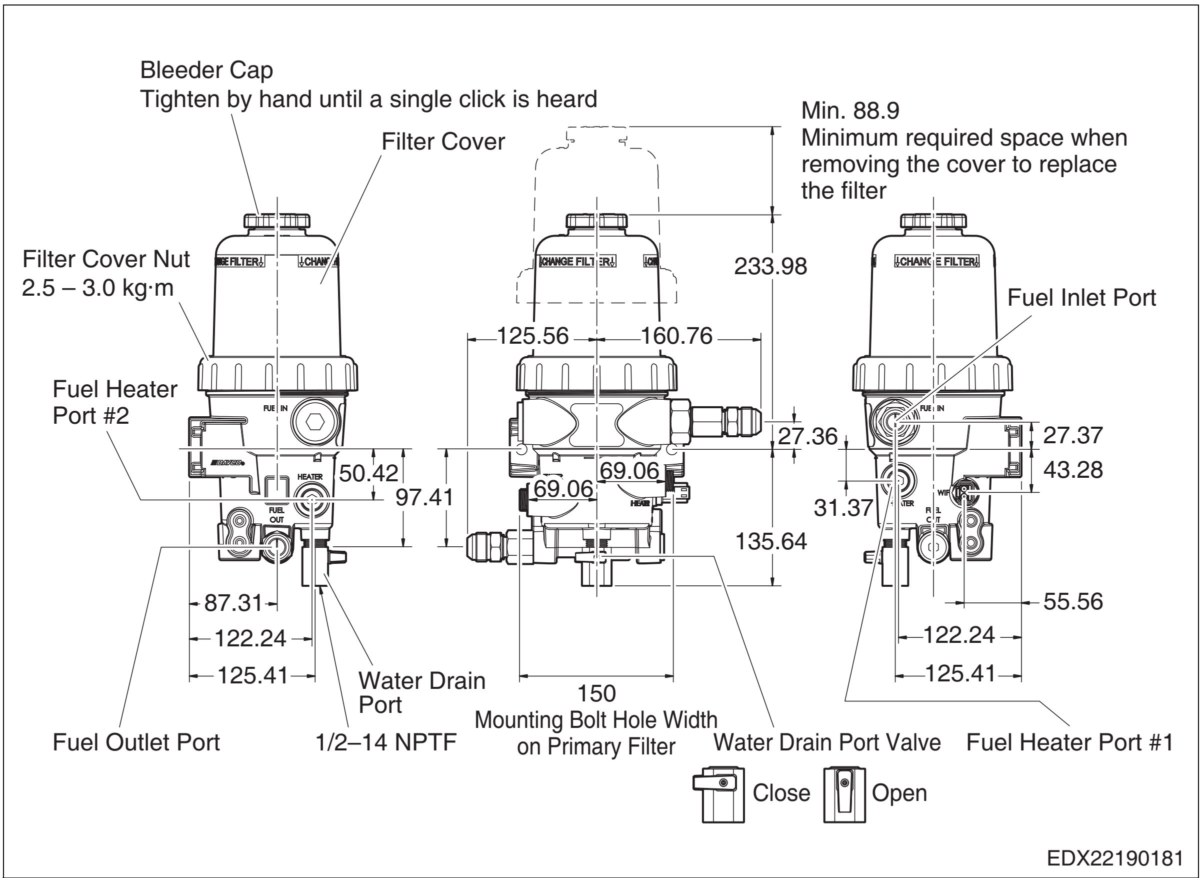
7.3.7. Primary Fuel Filter, Connecting Adapter, Fuel Heater, Service Tool

1) Configuration

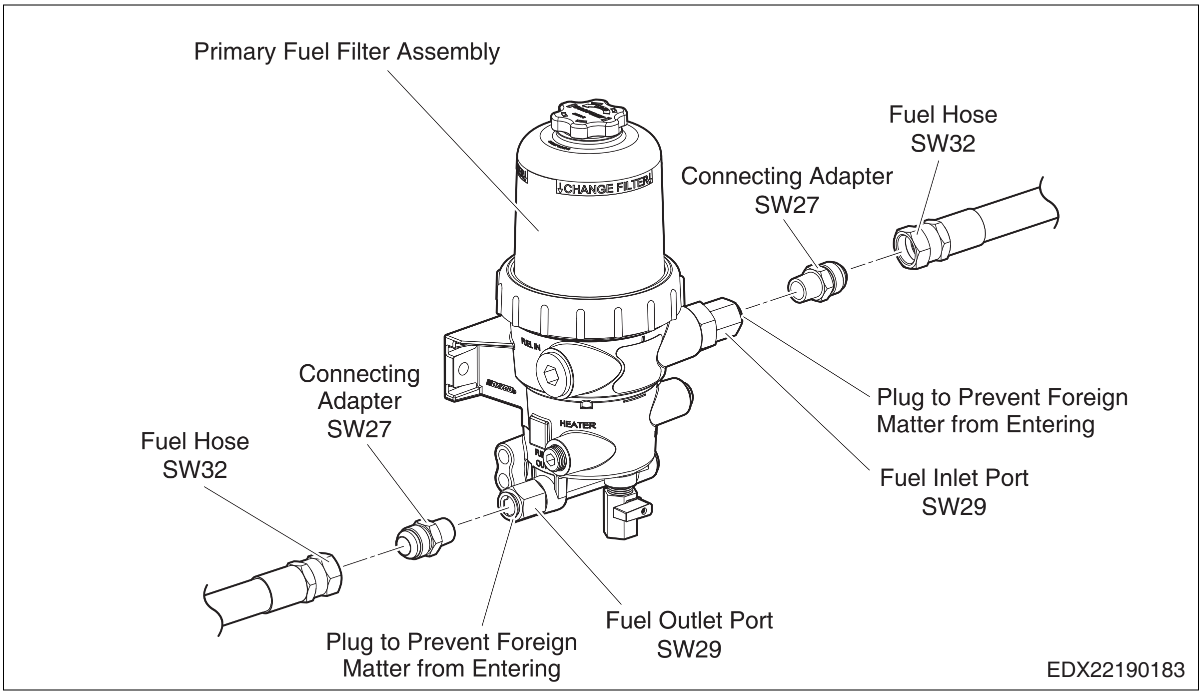
A primary fuel filter, two piping connecting adapters, fuel heater, and a service tool are provided as separate accessories along with the engine.



2) Installation

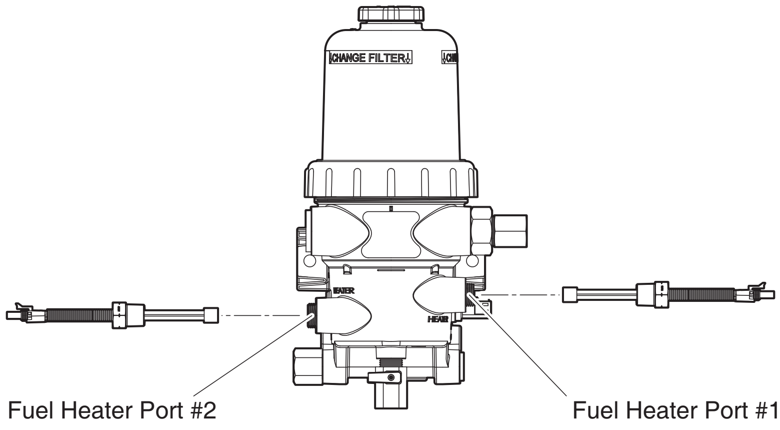


- Mounting the primary fuel filter and connecting the fuel lines



Remove the plugs for preventing foreign matter from entering the fuel inlet/outlet of the primary fuel filter and tighten the connecting adapters provided to the specified torque. (Specified tightening torque for adapters: 5 ±0.5 kg·m) When tightening the adapters, tighten them with the fuel inlet/outlet ports on the primary fuel filter secured with a 29 mm spanner to prevent the ports from turning along with the adapters.
As illustrated by the installation location in the fuel system schematic diagram, the primary fuel filter must be located between the fuel tank and the engine, and two M10 bolts should be installed firmly in locations which do not disrupt the periodic water draining and filter replacement in order to prevent looseness and unnecessary movement during operation.
When tightening piping couplings, tighten the coupling with the connecting adapter on the primary fuel filter secured with a 27 mm spanner to prevent the adapter from turning along with the coupling, and make sure that the tightening torque of piping being connected does not exceed a maximum of 9.5 kg·m.

- Fuel heater connection



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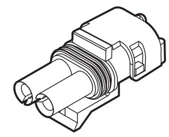
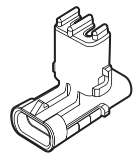
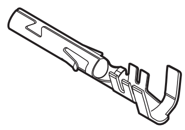
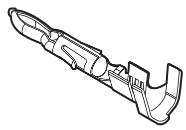
For marine engines, two fuel heaters are required regardless of whether a tropical or temperate zone.

Make sure to check the information on the wiring circuit and power consumption before installing the heater to ensure normal operation.

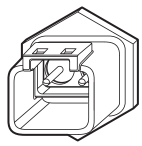
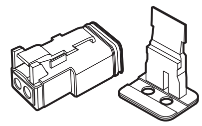
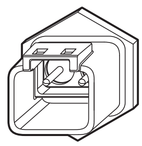
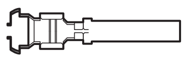
- Number of fuel heaters: 2 ea
- Fuel heater tightening torque: 2 ~ 4 kg·m
- Fuel heater specifications (for one heater)
  Operating voltage: 24 VDC
  Normal operating current: 4.5 A @ 24 V
  Maximum operating current: 14 A @ 24 V
  Operating power: 195 W
  Operating temperature: 2 ±5°C On, 24 ±5°C Off
  Resistance: 2.0 Ω ~ 3.0 Ω @ 25°C

– Wiring connector information
Polarity: Non-polar
Wiring specifications: 14 AWG
GXL Wire

Item	Heater	Harness connecting part
Connector	APTIV 12103584  Two-way brown weather pack tower sealed male connector	APTIV 12010973  Two-way black weather pack shroud sealed male connector
Terminal	APTIV 12124580  Weather pack female sealed tin plating tank terminal. Cable range 1.00 ~ 2.00 mm^2	APTIV 12124582  Weather pack male sealed tin plating tank terminal. Cable range 1.00 ~ 2.00 mm^2

● Water-in-fuel switch connection
The water in fuel sensor switch is used to notify the operator that drainage is necessary when the water collected in the primary fuel filter exceeds a certain volume. Water particles filtered out by the primary fuel filter cartridge sink to the bottom of the primary fuel filter due to the difference in weight between fuel and water particles. When a certain amount of particles accumulates and the water level reaches the probe of the water in fuel sensor switch, an electrical connection with the probe is created by the water and power is supplied to the LED lamp or buzzer to activate an alarm.

– Water storage capacity of the primary fuel filter
Start of electrical connection with water-in-fuel sensor switch: 210 ml
Maximum water capacity: 500 ml
– Water-in-fuel switch tightening torque: 0.5 ~ 0.6 kg·m
(Provided pre-assembled in the generator upon release from the factory.)
– Water-in-fuel switch specifications
Operating voltage: 5 ~ 50 VDC or VAC
Resistance: 82 kW ±2% @ 25°C

Item	Water-in-fuel switch side	Harness connecting part
Connector	DEUTSCH DT04-2PA 	DEUTSCH DT06-2S 
Terminal	Size 16 for DT04-2P  Pin	Size 16 for DT06-2S  Socket

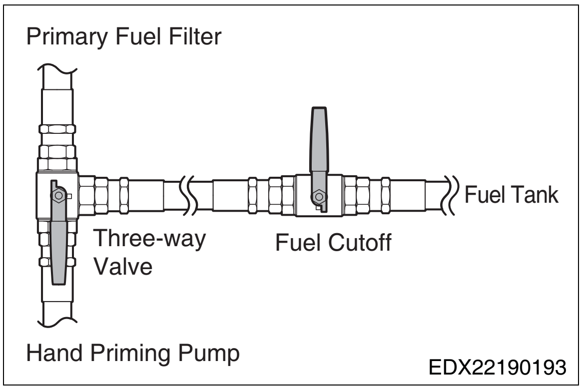
- Water-in-fuel sensor wiring circuit
- Wiring connector information
  Polarity: Non-polar
  Connectors and terminals: See table on the right

3) Usage

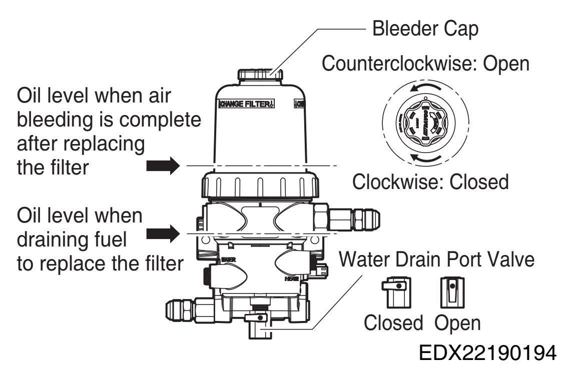
● Fuel heater operation at low temperatures
In winter and in cold temperatures, the paraffin in diesel forms a gel and blocks the surface of the cartridge in the primary fuel filter, resulting in restricted fuel flow. In such cases, engine start-up may be delayed/impossible, the engine rpm may be unstable after engine start-up, or the engine may turn off. To prevent this phenomenon, turn the key switch on to run the heater mounted on the primary fuel filter (oil-water separator) three minutes before starting the engine to remove the paraffin from inside the primary fuel filter and the paraffin gel entering continuously from the fuel tank.

CAUTION
To ensure smooth engine start-up, maintenance, and normal engine power in winter, make sure to use winter fuel.
If summer fuel is used in winter, an excessive amount of paraffin forms in the fuel and the fuel flow in the fuel lines is restricted, thereby clogging the cartridges in the primary/secondary filters and causing delayed start-up or engine shutoff.

● Replacing the cartridge of the primary fuel filter at replacement intervals
- Turn the manual valve on the fuel line supplying fuel from the fuel tank to the fuel shutoff position.



- To drain the fuel in the primary fuel filter, open the water drainage port valve on the bottom; then, open the air bleeder cap on top to enable fuel to be drained smoothly. During this step, not all of the fuel in the fuel filter must be drained. Once the fuel level decreases below the filter cover nuts, turn the valve to the locked position again to stop draining the fuel.



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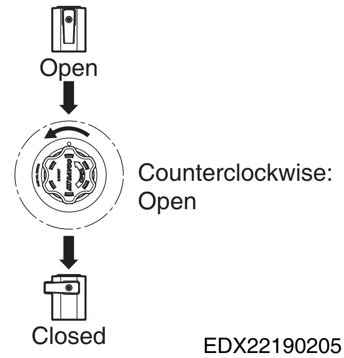
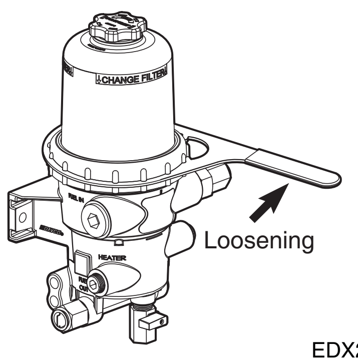


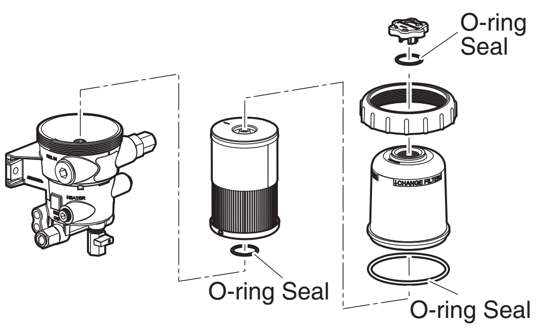
EDX22190205

- Use a service tool to remove the filter cover and cover mounting nuts.



EDX22190195

- Remove the old cartridge and replace it with a new one; then, temporarily assemble the cover, nuts and cap in the reverse order of disassembly.

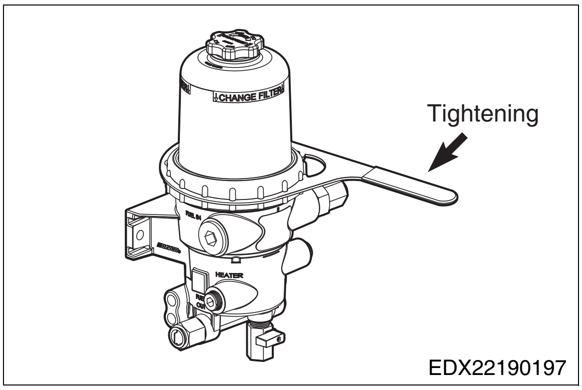


EDX22190196

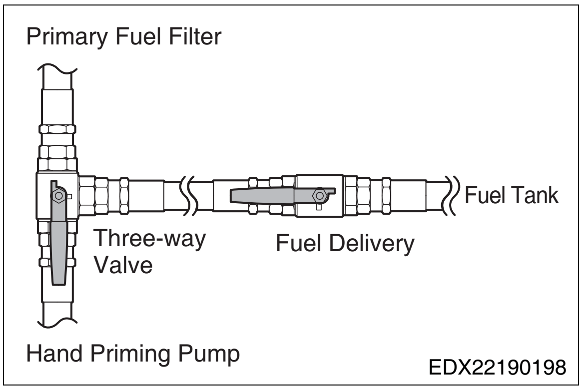
⚠ CAUTION

Before temporarily assembling the parts, make sure to check whether any O-ring seals are missing and whether there is any contamination due to foreign matter.

– Use a service tool to tighten only the filter cover mounting nuts to 2.5 ~ 3.0 kg·m while keeping the bleeder cap temporarily assembled.

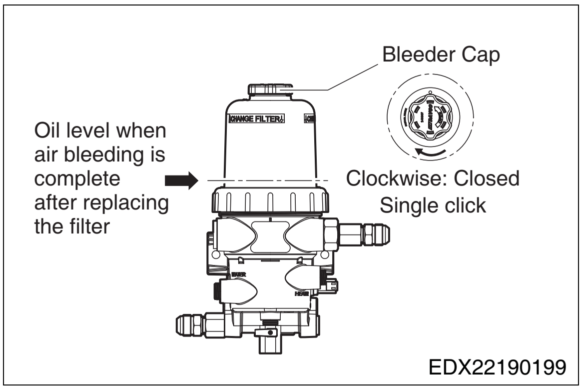


– Turn the manual valve on the fuel line supplying fuel from the fuel tank to the fuel delivery position.

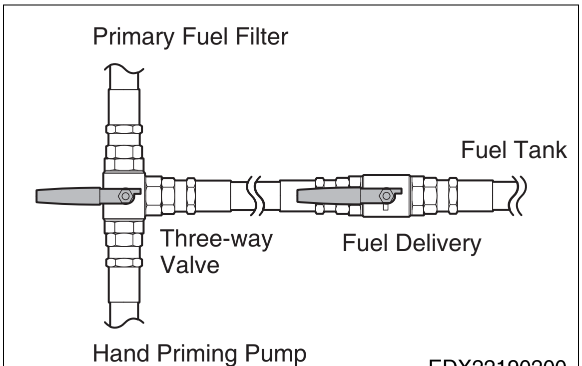


– Once the air bleeding procedure has been performed, the cartridge replacement is complete.

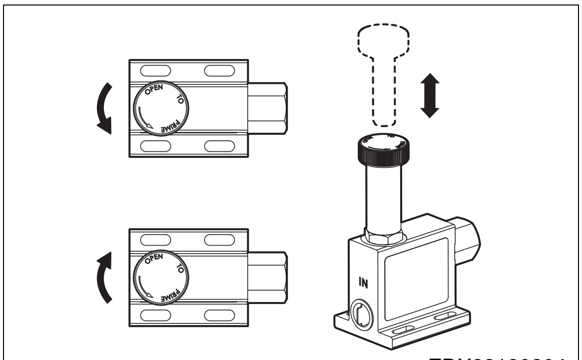
– If the fuel level in the fuel tank is higher than that of the primary fuel filter
When the filter bleeder cap is open, fuel filling and air bleeding occur automatically in the filter due to the fuel differential head. When the fuel level reaches the replacement indicator position, tighten the bleeder cap by hand until a single click is heard to finish replacing the cartridge.



- If the fuel level in the fuel tank is lower than that of the primary fuel filter
  When the filter bleeder cap is open, fuel filling and air bleeding occur automatically in the filter due to the fuel differential head. When the fuel level reaches the replacement indicator position, tighten the bleeder cap by hand until a single click is heard to finish replacing the cartridge.
  When the fuel level in the filter reaches the cartridge marking above the cover mounting nuts, tighten the bleeder cap by hand until a single click is head; then, operate the three-way valve to cause fuel to flow into the primary filter and finish replacing the cartridge.

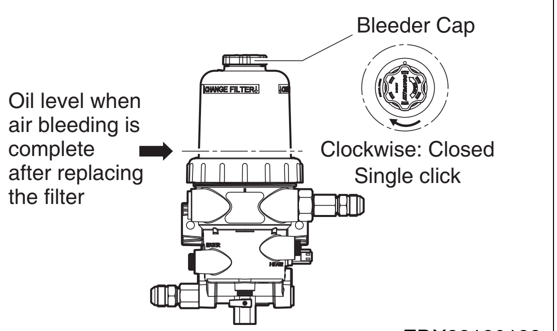


EDX22190200



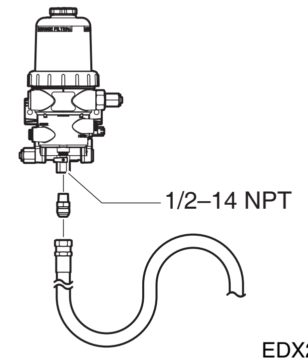
EDX22190204

CAUTION
Fuel is a flammable and toxic substance, so make sure to check for and remove any sources of heat and sparks nearby and ventilate the workspace well before replacing the filter cartridge.
When draining the fuel in the filter to replace the cartridge, drain the fuel into a fuel storage container to prevent environmental contamination and dispose of drained fuel according to the proper disposal procedures.



EDX22190199

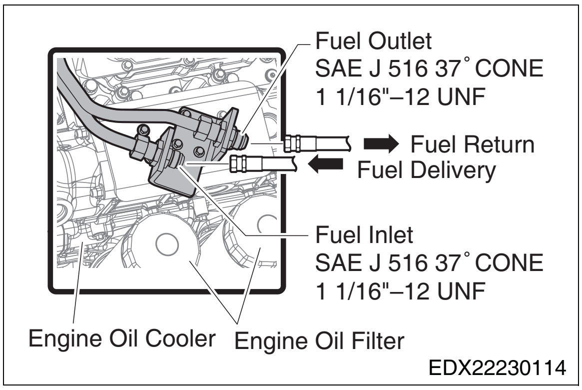
- Draining water
  - Before starting the engine each day, open the water drain valve under the primary fuel filter to drain the water collected in the filter.
  - The water drain port is equipped with a 1/2-14 NPT female screw which allows an additional hose to be installed on the generator set to extend the drain port.



EDX22190201

7.3.8. Engine Fuel Inlet/Outlet Ports

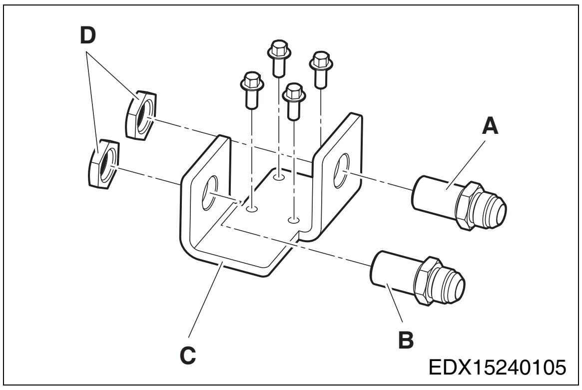
The fuel inlet/outlet ports are located on top of the engine oil filter head on the right side of the engine. Either connect the fuel hoses provided to the fuel tank and primary fuel filter or order separate fuel hoses which satisfy the specifications below and connect them. Make sure that the tightening torque of piping being connected to the fuel inlet/outlet ports does not exceed a maximum of 9.5 kg·m.



< Fuel hose specifications >

Hose	SAE 100R1 AT Type I.D. Ø19.0, O.D. max. Ø28.6
Hose coupling	SAE J516 37° Flare, 1 1/16" – 12 UNF

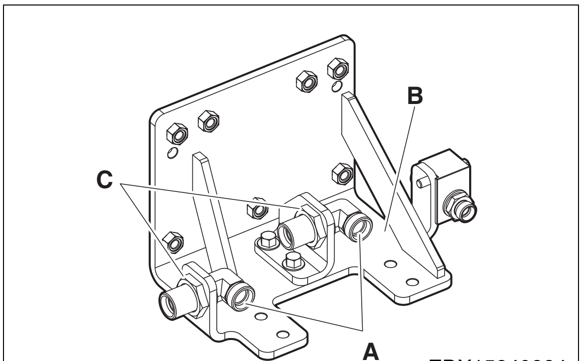
1) Configuration
   The engine fuel inlet/outlet ports consist of two pipe connecting adapters and a bracket for securing the adapters.
2) Installation
   - When tightening the adapters, note the direction of assembly to enable the adapters to slide along the grooves in the bracket joint. The engine fuel pipe inlet/outlet port bracket is installed on the engine oil filter head; use four M8 x 1.25 x 20 mm bolts to tighten it to the specified torque.



Torque	2.20 ±0.55 kg·m

A	Fuel outlet port adapter
B	Fuel inlet port adapter
C	Engine fuel inlet/outlet port bracket
D	Adapter

● Installing the upper engine fuel pipe adapters: Each upper pipe connecting adapter is secured to the upper engine fuel pipe adapter bracket with the nuts (C).
When tightening the adapters, note the direction of assembly to enable the adapters to slide along the grooves in the bracket joint. The upper engine fuel pipe port bracket is installed on the top of the engine timing gear case; use four M10 x 1.25 x 25 mm bolts to tighten it to the specified torque.

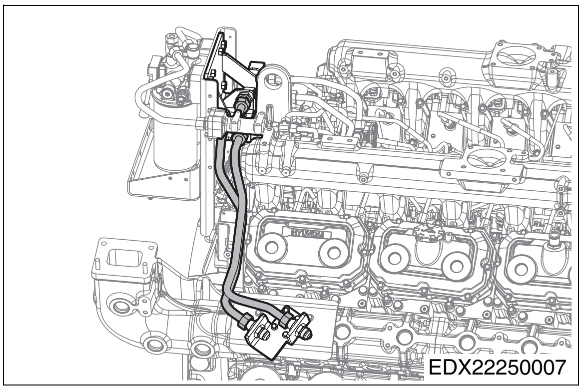


EDX15240224

Torque	6.20 ±1.55 kg·m

A	Upper engine fuel pipe adapter
B	Upper engine fuel pipe adapter bracket
C	Nut (tightening torque: 9.5 ±0.95 kg·m)

● Installing the engine fuel pipes: Install the fuel pipes from the engine fuel pipe inlet/outlet port adapters to the upper engine fuel pipe adapters at the specified torque.


EDX22250007

Torque	1 ±0.1 kg·m + 120°

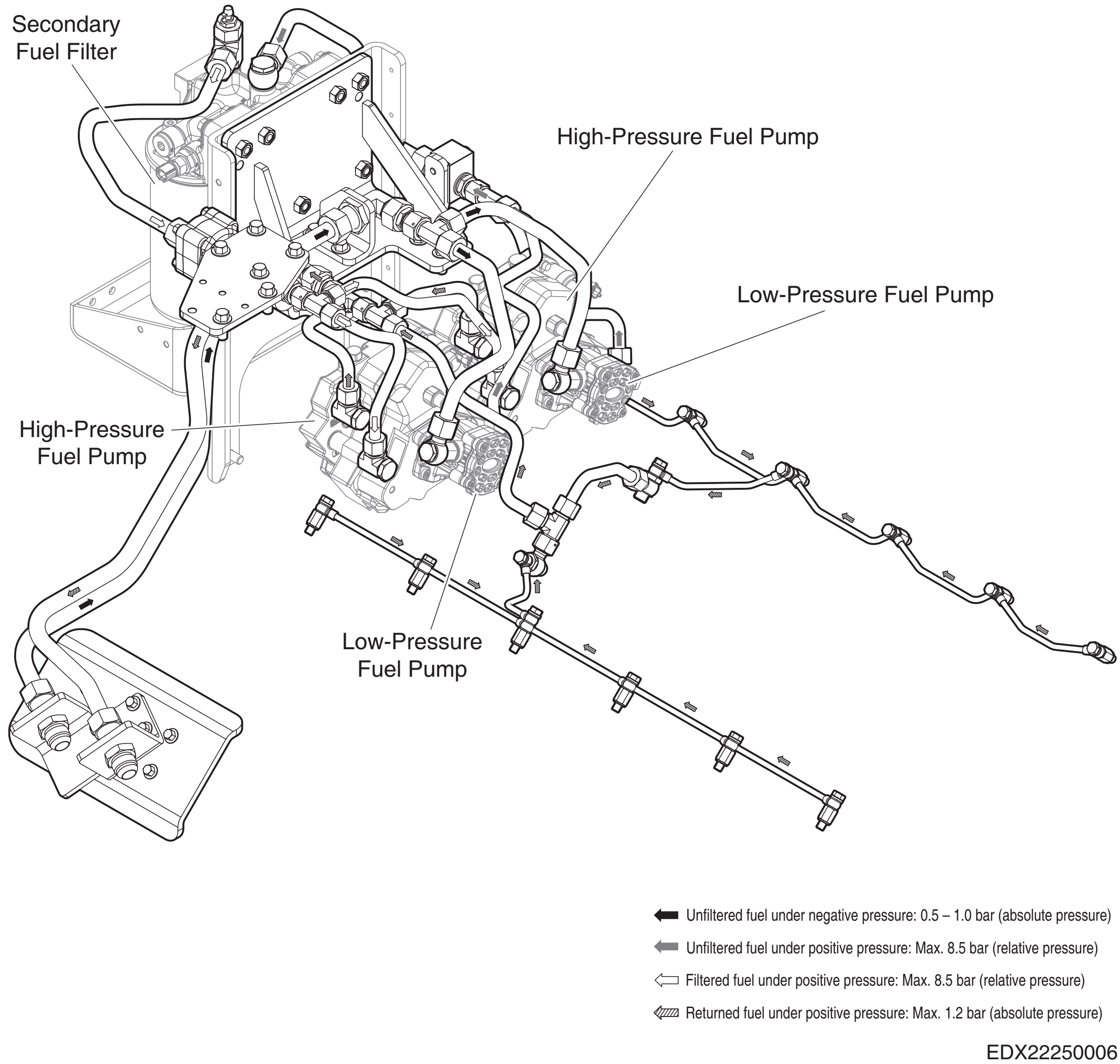
During this step, make sure to secure each pipe by tightening clips on the top of the upper engine fuel pipe adapter bracket and the side of the flywheel housing. Then, use two M8 x 1.25 x 20 mm bolts to tighten the heat shield for protecting the pipes to the specified torque.

Torque	2.20 ±0.55 kg·m

CAUTION
Note the direction when installing clips on the fuel pipes. The clips must be installed so that the bolt heads can be seated on top of the clips.

7.3.9. Low-Pressure Fuel Pump

Refer to the following figure for information on the layout of low-pressure fuel lines, the fuel flow direction, and the pressure range of each fuel line in normal operating conditions.

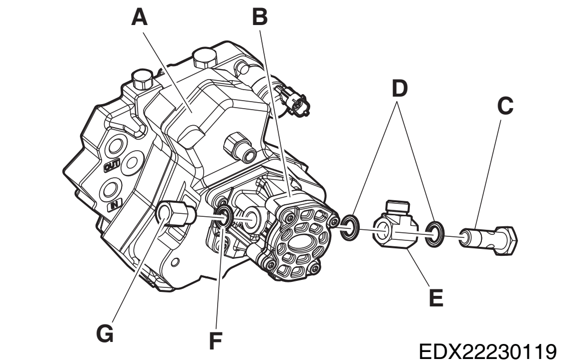


1) Configuration

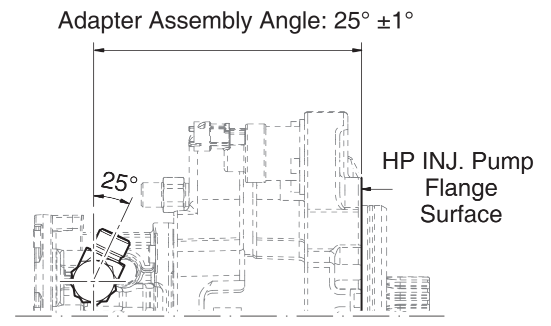
The low-pressure fuel pump is integrated with the high-pressure fuel pump. The low-pressure fuel pump on bank no. 1 consists of two sets of adapters and sealing washers for connecting fuel lines to the fuel inlet/outlet ports, while the low-pressure pump on bank no. 2 consists of one set of an adapter and sealing washer for connecting the fuel line to the fuel inlet port.

2) Installation

- Installing the low-pressure fuel pump adapter for bank no. 1
  - After temporarily tightening the fuel inlet port adapter to the low-pressure fuel pump inlet with the sealing washer, tighten it to the specified torque.
    Then, after temporarily tightening the fuel outlet port adapter to the low-pressure fuel pump outlet with the sealing washer, tighten it to the specified torque.
    During this step, make sure that the angle of the adapter port is parallel to the flange of the high-pressure fuel pump.



EDX22230119

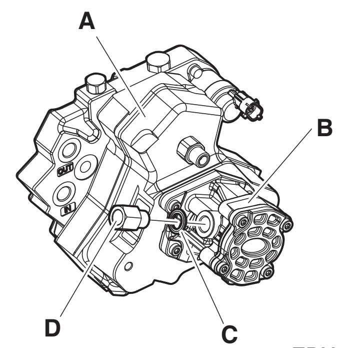


EDX22250001

Torque	Low-pressure fuel pump fuel inlet port adapter	2.5 ±0.2 kg·m
	Low-pressure fuel pump fuel outlet adapter hollow screw	2.5 ±0.2 kg·m

A	High-pressure fuel pump of bank no. 1
B	Low-pressure fuel pump of bank no. 1
C	Hollow screw of fuel outlet port of low-pressure fuel pump
D	Sealing washer of fuel outlet port of low-pressure fuel pump
E	Adapter of fuel outlet port of low-pressure fuel pump
F	Sealing washer of fuel inlet port of low-pressure fuel pump
G	Fuel inlet port adapter of low-pressure fuel pump (SW19)

- Installing the low-pressure fuel pump adapter of bank no. 2
  - After temporarily tightening the fuel inlet port adapter to the low-pressure fuel pump inlet with the sealing washer, tighten it to the specified torque.



EDX22230120

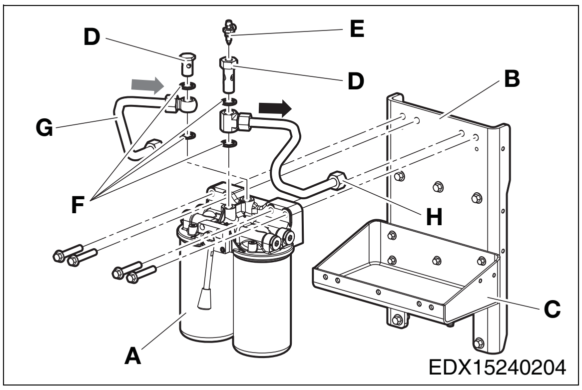
Torque	Low-pressure fuel pump fuel inlet port adapter	2.5 ±0.2 kg·m

A	High-pressure fuel pump of bank no. 2
B	Low-pressure fuel pump of bank no. 2
C	Sealing washer of fuel inlet port of low-pressure fuel pump
D	Fuel inlet port adapter of low-pressure fuel pump (SW19)

7.3.10. Secondary Fuel Filter

1) Configuration

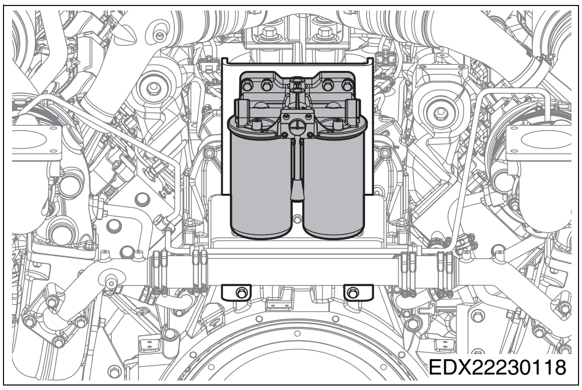
- The secondary fuel filter consists of the fuel filter head and two fuel filter cartridges.



A	Secondary fuel filter
B	Secondary fuel filter bracket
C	Secondary fuel filter fuel pan
D	Fuel pipe hollow screw
E	Bleeder nipple
F	Fuel pipe sealing washer
G	Fuel pipe on dirty side
H	Fuel pipe on clean side

2) Installation

- The fuel filter is secured to the fuel filter bracket located on the side of the engine oil pan with four M10 x 1.5 x 50 mm bolts.
  After temporarily tightening the four bolts, tighten them to the specified torque.



Torque	6.20 ±1.55 kg·m

Then, use the hollow screws and sealing washers to tighten the fuel inlet/outlet pipes in the grooves in the top of the filter head.

Torque	5.5 ±0.55 kg·m

3) Usage

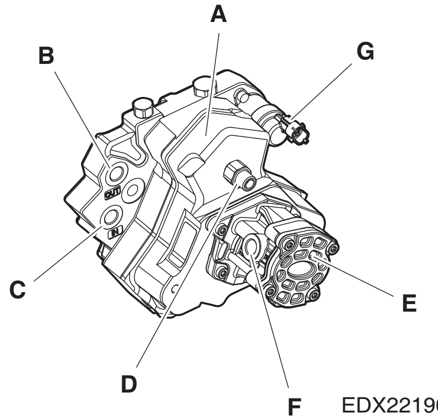
The replacement intervals of the secondary fuel filter cartridge differ depending on the ESP, PRP and COP operating conditions. Make sure to comply with the replacement intervals suited to the operating conditions.

- Use a filter wrench to turn and loosen the fuel filter cartridge in the counterclockwise direction.
- Wipe the filter contact surface thoroughly.
- 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 ~ 1 turn.

7.3.11. High-Pressure Fuel Pump

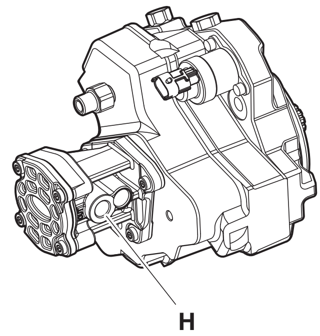
1) Components and functions

The high-pressure fuel pump consists of the pump body, the low-pressure fuel pump, and the metering unit.
The high-pressure fuel pump pressurizes fuel from the low-pressure fuel pump and secondary fuel filter to the high pressures (DX22: 1,800 bar) required for engine operation and supplies this high-pressure fuel to the common rail and injectors.
The metering unit controls the amount of fuel supplied to the common rail depending on the engine load conditions.



EDX22190213

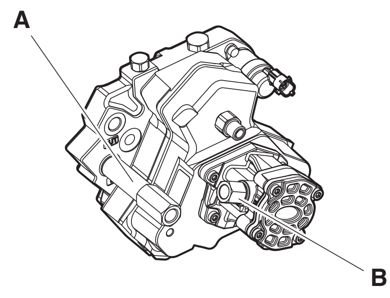
A	High-pressure fuel pump
B	High-pressure fuel pump return fuel outlet (To. Engine fuel outlet port)
C	High-pressure fuel pump inlet (From. Secondary fuel filter)
D	High-pressure fuel pump inlet (To. Common rail)
E	Low-pressure fuel pump
F	Low-pressure fuel pump inlet (From. Engine fuel inlet port)
G	Metering unit
H	Low-pressure fuel pump outlet (To. Secondary fuel filter)



EDX22190214

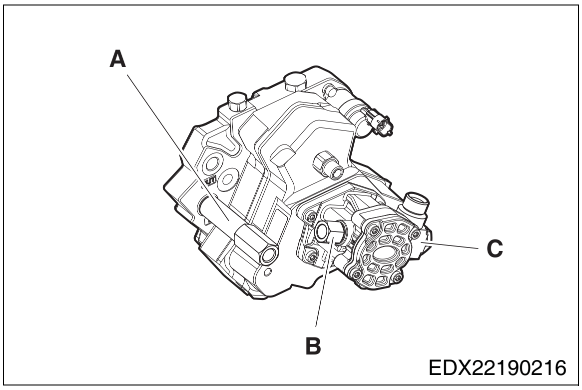
2) Installation

The pumps are secured to the timing gear case on top of the engine flywheel with three bolts each.
The high-pressure fuel pump is connected to various pipes, including the high-pressure fuel pipe and fuel return pipe. Each pipe connecting port must be connected to the correct adapter and pipe in the correct order of assembly. (Refer to the order of assembly of low-pressure fuel pipes)
The metering unit must be connected to connectors for receiving ECU signals.



EDX22190215

A	High-pressure fuel pump fuel delivery pipe adapter
B	Low-pressure fuel pump fuel drain pipe adapter
C	Low-pressure fuel pump fuel delivery pipe adapter

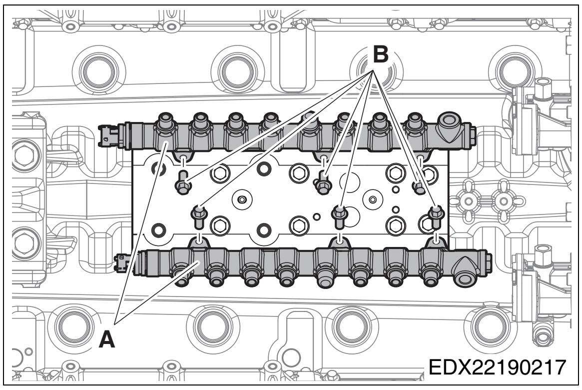


7.3.12. Common Rail

1) Components and functions

The common rail consists of the common rail body, pressure sensor, and pressure limiter valve. The common rail maintains a constant fuel pressure (DX22: 1,800 bar) required by the injectors for fuel injection regardless of the engine load and operating mode.

A	Common rail
B	Bolt (M8 x 1.25 x 20 mm)



2) Installation

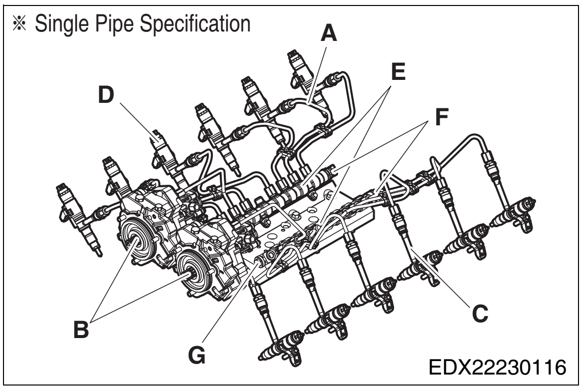
The common rails are secured to the top of the engine block with common rail brackets. Tighten the common rails securely with three bolts each.

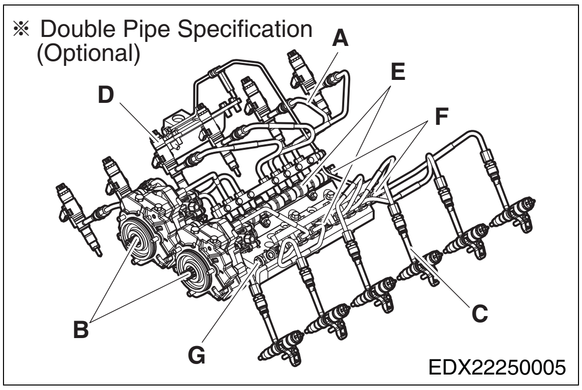
Torque	Common rail mounting bolts	2.20 ±0.55 kg·m

7.3.13. High-Pressure Fuel Pipe

1) Components and functions

The high-pressure fuel pipes consist of pipes for transporting fuel, nuts for securing the pipes, and washers for distributing stress between the nuts and pipes. They serve to deliver high-pressure fuel compressed in the common rails to the injectors.





A	High-pressure fuel pipe
B	High-pressure fuel pump
C	High-pressure fuel connector
D	Injector
E	Common rail
F	Rail Pressure Sensor
G	Rail pressure limiter valve

2) Installation

After temporarily tightening the fuel pipes for each cylinder between the common rails and high-pressure fuel connectors, tighten them to the specified torque.

Torque	High-pressure fuel pipe	4 ±0.4 kg·m
	High-pressure fuel connector	2.05 ±0.25 kg·m

After temporarily tightening the fuel pipes for each cylinder between the common rails and high-pressure fuel connectors, tighten them to the specified torque.

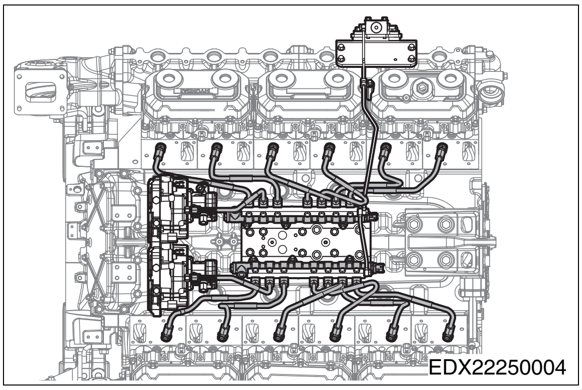
Torque	High-pressure fuel pipe clip mounting bolt	1 ±0.1 kg·m

7.3.14. Injectors, High-Pressure Fuel Connectors

1) Components and functions
   The injectors serve to inject fuel into the combustion chamber by controlling the solenoid valves based on signals from the ECU. The high-pressure fuel connectors consist of the connector body, edge filter, and O-ring for preventing leaks in the return fuel. The connectors are used to deliver fuel from the high-pressure fuel pipes to the injectors through connections between the high-pressure fuel pipes and injectors.

CAUTION
When installing a new high-pressure fuel pipe after disconnecting the high-pressure fuel pipe connected to a high-pressure fuel connector (HPC), make sure to retighten the HPC mounting nuts to the specified torque. In addition, do not reuse high-pressure fuel pipes as the seal for high-pressure fuel is deformed while tightening them.

2) Installation
   Clean all parts thoroughly, taking care not to contaminate them with foreign matter.
   - Fuel lines connecting the common rail to the injectors require particular cleanliness as they lack a filtration function.
   - Clean and remove all foreign matter from the holes drilled in the cylinder head for inserting high-pressure fuel connectors and holes for injectors.
   - When the injector is disassembled, the high-pressure fuel connector must be replaced with a new one.
   - In the event that fuel remaining in the fuel return line enters the combustion chamber while disassembling the injector, it must either be sucked out using a hand pump or discharged by cranking the starter motor with the fuel shut off.



7.4. Cylinder Block/Head

Equipped with an overhead valve and turbocharger, HD Hyundai Infracore diesel engines are electronically controlled and air-cooled by a cooling fan.

Pressurized fuel generated by the high-pressure fuel pump is stored in the common rail. When the operator uses the generator, the optimal amount of fuel and fuel injection timing are determined based on the data set in the electronic control unit (ECU) according to the vehicle speed and operating conditions, while the ECU actuates the solenoid valve for the injector installed in each cylinder of the engine to inject fuel into the cylinders.

The crankshaft is a single forged unit. The oil seals on the crankshaft and flywheel are designed to prevent oil from entering the flywheel.

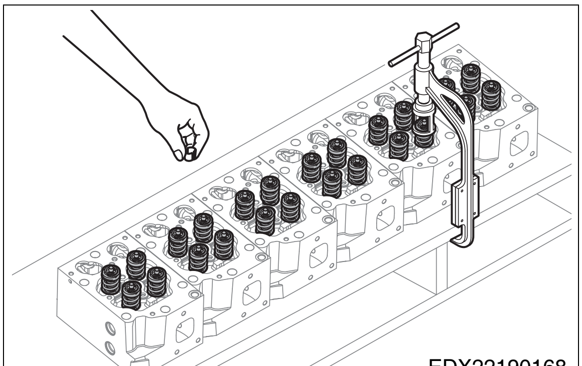
The connecting rod is a single forged unit. Its big end can be disconnected in the vertical direction, enabling it to be removed with the piston through the top of the cylinder. The moving parts of the crankshaft and connecting rod are equipped with alloy bearings.

7.4.1. Cylinder Block

- Clean the cylinder block thoroughly and check it visually for cracks or damage.
- If it is severely cracked or damaged, replace it with a new one; if the damage is minor, repair it.
- Check the oil and coolant passages for clogging and corrosion.
- Perform a hydrostatic test to check for cracks or air leaks.
- Plug the coolant and oil outlets of the cylinder block and supply approx. 4 kg/cm^2 of pressure through the inlet; then, soak the cylinder block in 70°C water for approx. one minute and check for air leaks.

7.4.2. Cylinder Head

- Disassemble the cylinder head and keep the components on a shelf for later assembly.
- Be careful not to damage the cylinder head gasket contact surface.
- Remove the valve cotter, spring and spring seat using a valve spring pressing tool.
- Pull out the intake and exhaust valves.
- Keep the removed parts in order.
- Remove the valve stem seal.

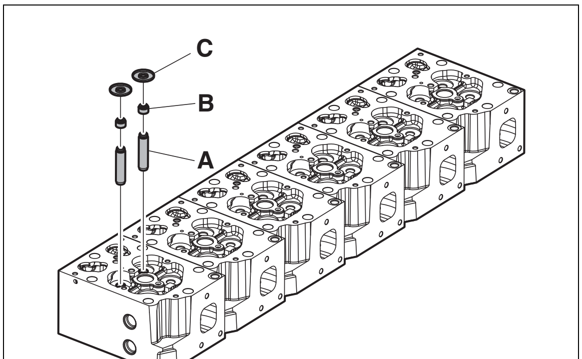


EDX22190168

1) Assembling the cylinder head
   - Clean the cylinder head thoroughly.
   - Replace the valve stem seals with new ones.
   - Use a special service tool to insert the stem seal into the valve guide of the cylinder head.
   - Apply engine oil to the valve stem and valve guide; then, install the valve.

CAUTION
Be careful not to damage the valve stem seal.
Make sure that oil does not get on the bolt.
Wipe any oil off bolts before using them.

- Install the valve stem seal (B) on the valve guides (A) on top of the cylinder head.
- Assemble the inner/outer valve springs; then, place the valve spring washer (C) on top.



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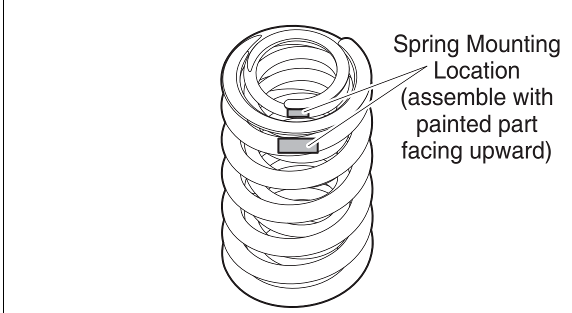
- Use a valve spring compressor to press the valve spring; then, insert the valve cotter and assemble the valve.
- After assembling the valve, tap it with a urethane hammer gently to check that it has been assembled correctly.



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2) Inspecting the cylinder head
   - Inspecting the cylinder head
     - Remove carbon residue from the bottom of the cylinder head.

CAUTION
Be careful not to scratch the valve seat surface.
Make sure that oil does not get on the bolt.
Wipe any oil off bolts before using them.

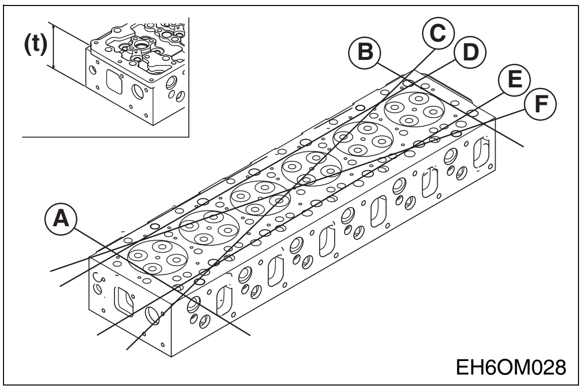
- Check the cylinder head visually for damage.
- Perform a hydrostatic test or magnetic particle test to check for small cracks or damage that cannot be identified with the naked eye.

- Bottom distortion
  - Measure the distortion of the cylinder head in the 6 directions with a feeler gauge.
  - If the measured result exceeds the allowable service limit, correct it using fine sandpaper or a grinder.
  - If the measurement exceeds the allowable limit, replace the cylinder head.

  < Cylinder head distortion and height >

(mm)

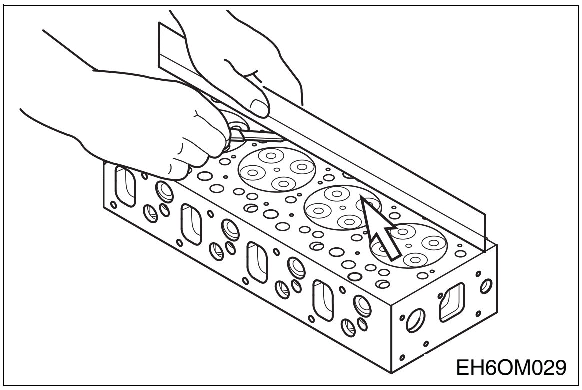
	Specified value	Allowable limit
Flatness of bottom surface of cylinder head	0.015 or less	0.03
Head height: t	116.95 ~ 117.05	116.5



- Flatness

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

Specified value	Allowable limit
0.015 mm or less	0.03 mm



- Hydrostatic test

  The hydrostatic test for the cylinder head is performed in the same way as the test for the cylinder block.

7.4.3. Valves

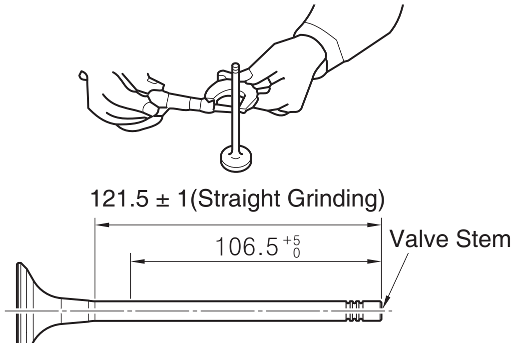
1) General information

   The overhead valve is operated by the tappet, pushrod and rocker arm on the camshaft.

2) Inspecting valves

   Wash the valve with clean engine oil and inspect it as follows.

   - Valve stem outside diameter
     - Measure the valve stem outside diameter in three places (top, middle, bottom).
     - If the amount of wear exceeds the allowable limit, replace the valve.



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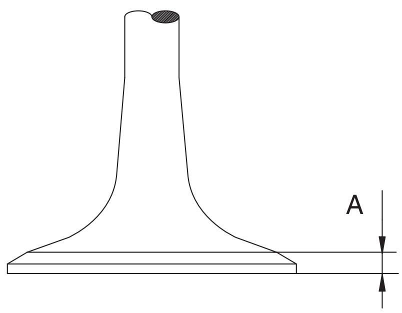
(mm)

	Specified value	Allowable limit
Intake valve stem	Ø7.963 ~ Ø7.977	Ø7.943
Exhaust valve stem	Ø7.950 ~ Ø7.964	Ø7.920

   - Valve seat contact surface
     - Check the valve seat mating surface for scratches or damage.
     - If necessary, grind the surface with sandpaper. However, if the damage is severe, replace the part.
   - Valve head thickness
     - Measure the thickness of the valve head.
     - If the measurement is below the allowable limit, replace the valve.



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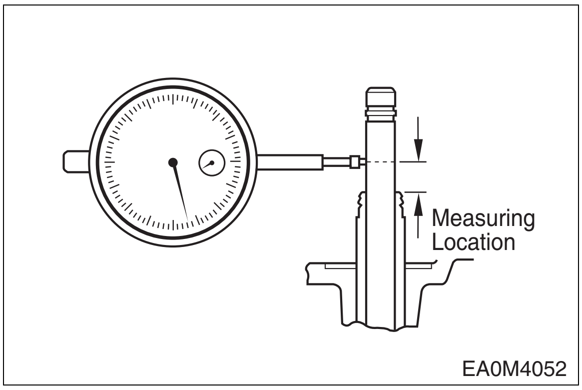
(mm)

	Specified value	Allowable limit
Intake valve (A)	3.2 ~ 3.6	2.7 or less
Exhaust valve (A)	3.9 ~ 4.3	3.4 or less

3) Inspecting the valve guide

- Install the valve on the cylinder head.
- Measure the clearance between the valve guide and valve arising from the movement of the valve.
- If the clearance is excessively large, measure the valve size. Then, replace the valve or valve guide, whichever is more worn.



<Valve stem play>

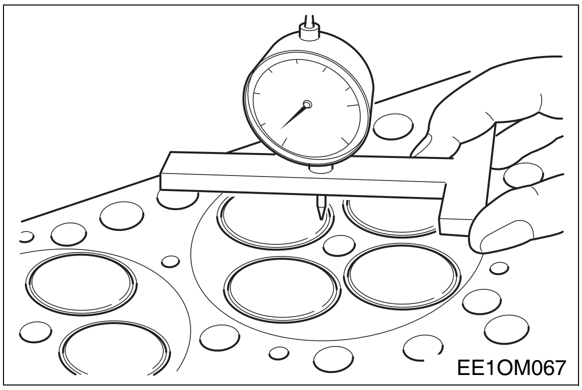
(mm)

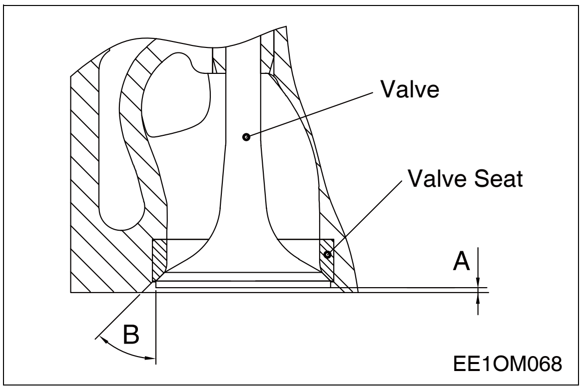
	Specified value	Allowable limit
Intake valve	0.038 ~ 0.067	0.10
Exhaust valve	0.051 ~ 0.080	0.15

- Install the valve on the cylinder head valve guide.
- Use a special service tool to check whether the valve seat is aligned with the center.

4) Inspecting the valve seat

- Amount of contact with mating surface
  - To check the amount of wear on the valve seat, measure the height of the mating surface between the intake and exhaust valve.
  - If the measurement exceeds the allowable limit, replace the part.
  - Install the valve on the cylinder head valve seat.
  - Use a dial gauge to measure the insertion length of the valve from the bottom of the cylinder head.





<Valve step height>

(mm)

	Specified value	Allowable limit
Intake valve (A)	0.9 ~ 1.1	1.3
Exhaust valve (A)	0.9 ~ 1.1	1.6

<Valve angle>

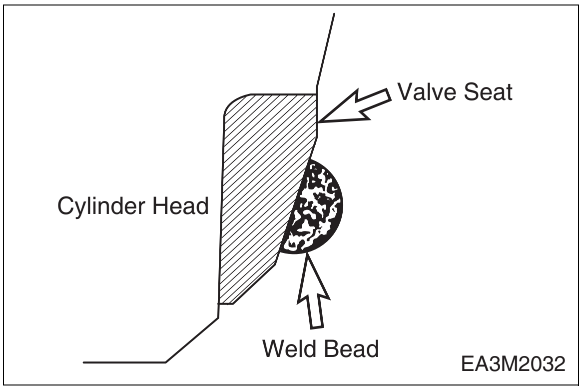
Intake valve (B)	Exhaust valve (B)
60°	45°

  - If the insertion length of the valve exceeds the allowable limit, replace the valve seat.
  - To remove the valve seat, perform arc welding in two places on the valve seat; then, use a special service tool to pull out the valve seat.

CAUTION

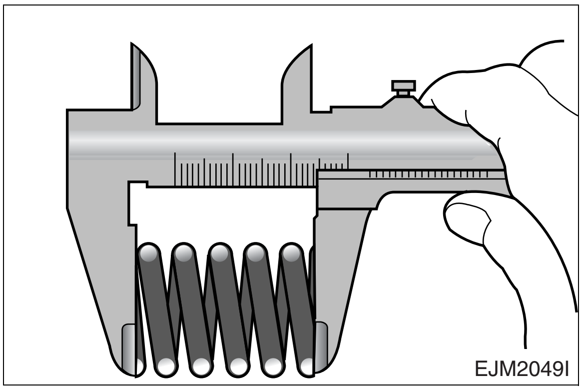
The inside diameter needs to be bored during the removal of the valve seat.

- Before assembling the valve seat, cool it in dry ice for approx. two hours.
- Use a bench press to press-fit the valve seat into the cylinder head.
- Apply abrasive to the valve head mating surface of the valve seat.
- Turn the valve to polish the valve seat surface until the valve is properly seated. Then, remove the abrasive completely.



5) Inspecting the valve spring

- Perform a visual inspection of the exterior of the valve spring.
  - Visually inspect the valve spring for external damage and replace it if necessary.
- Check the free length of the valve spring.
  - Measure the free length of the valve spring with the vernier calipers.
  - If the measurement is below the specification, replace the valve spring.

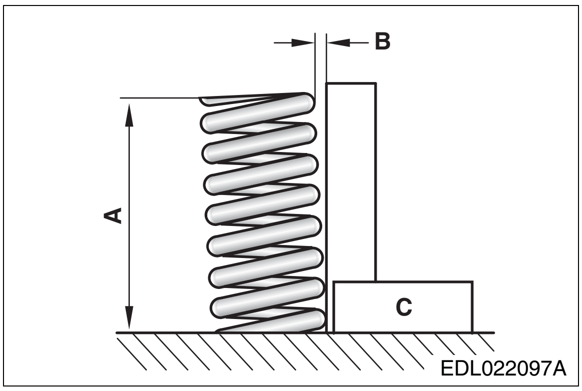


(mm)

Item		Free length
Intake	Inside	59.5
	Outside	57.0
Exhaust	Inside	59.5
	Outside	57.0

- Check the squareness of the valve spring.

A	Free length
B	Squareness
C	Straightedge

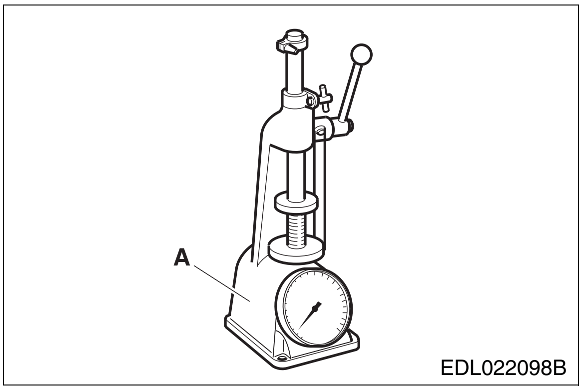


  - Use a surface plate and straightedge to measure the squareness of the valve spring.
  - If the measurement exceeds the allowable limit, replace the valve spring.

(mm)

Item		Specified value	Allowable limit
Intake	Inside	1.5 or less	2.0
	Outside	1.5 or less	2.0
Exhaust	Inside	1.5 or less	2.0
	Outside	1.5 or less	2.0

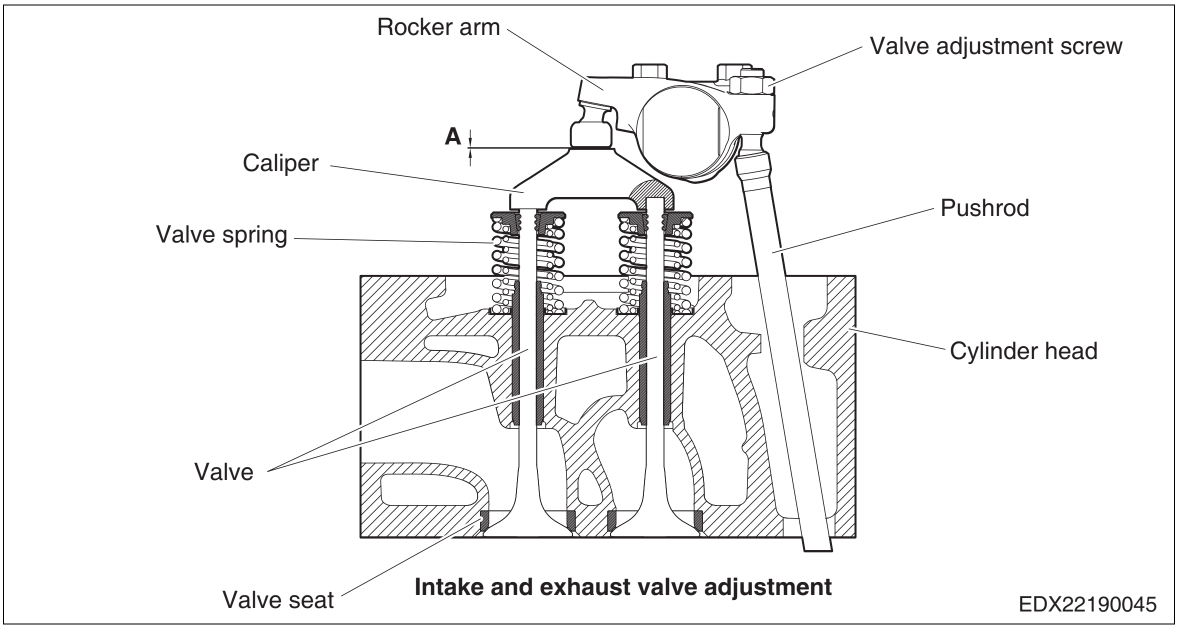
- Check the tension of the valve spring.
  - Measure the tension of the valve spring with a spring tester (A).
  - If the measurement is below the allowable limit, replace the valve spring.



Set length			Spring tension	Allowable limit
Intake	Inside	41.0/ 28.6 mm	14.8/ 25.0 kg	±1.5/ ±2.0 kg
	Outside	44.0/ 31.6 mm	25.5/ 52.3 kg	±2.0/ ±2.5 kg
Exhaust	Inside	41.0/ 28.6 mm	14.8/ 25.0 kg	±1.5/ ±2.0 kg
	Outside	44.0/ 31.6 mm	25.5/ 52.3 kg	±2.0/ ±2.5 kg

6) Adjusting the valve clearance
- Turn the crankshaft to set the piston of cylinder no. 1 at TDC of the compression stroke; then, adjust the valve clearance.
- Unscrew the rocker arm mounting nut and fit the feeler gauge between the rocker arm and valve. Adjust the clearance of each cylinder with the adjustment screw; then, tighten the mounting nut.
- Adjust the valve clearance as follows while the engine is cold:

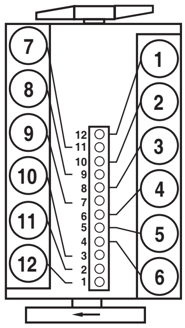
Specified Value		Measurement Tolerance	
Intake Valve	Exhaust Valve	Intake Valve	Exhaust Valve
0.4 mm	0.7 mm	±0.05 mm	



Intake and exhaust valve adjustment

7) Adjusting sequence of valve clearance

- Turn the crankshaft to set the piston of cylinder no. 1 at TDC of the compression stroke.



12-cylinder engine EDX22190246

Note

Cylinder no. 1 is where the coolant pump is installed.

Note

In a 12-cylinder engine, when cylinder no. 1 is at TDC of the compression stroke, valve overlap occurs in cylinder no. 6.

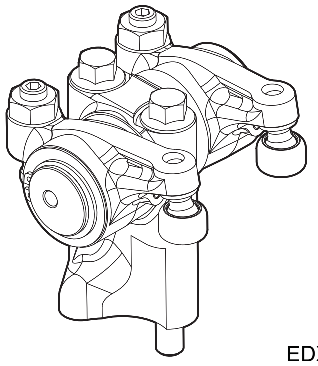
- Turn the crankshaft and adjust the valve clearance of each cylinder at TDC of the compression stroke.
- Depending on the cylinder in the valve overlap stage, adjust the valve clearance of the corresponding cylinder at TDC of the compression stroke as follows.

No. of cylinder in valve overlap stage											
1	12	5	8	3	10	6	7	2	11	4	9
6	7	2	11	4	9	1	12	5	8	3	10
Valve adjustment cylinder no. (Intake & exhaust valves)											

7.4.4. Rocker Arm

1) Checking and measuring the assemblies

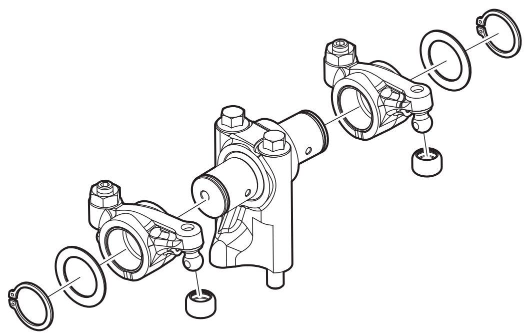
- Rocker arm bracket (integrated with shaft)
  Measure the outside diameter of the rocker arm with a micrometer at the point where the rocker arm is assembled; if the measurement exceeds the allowable limit, replace it.


EDX22230179

<Rocker arm specifications>

(mm)

Item	Specified value	Allowable limit
Bushing I.D.	Ø27.991 ~ Ø28.012	Ø28.137
Shaft O.D.	Ø27.953 ~ Ø27.976	Ø27.916
Clearance	0.015 ~ 0.059	0.12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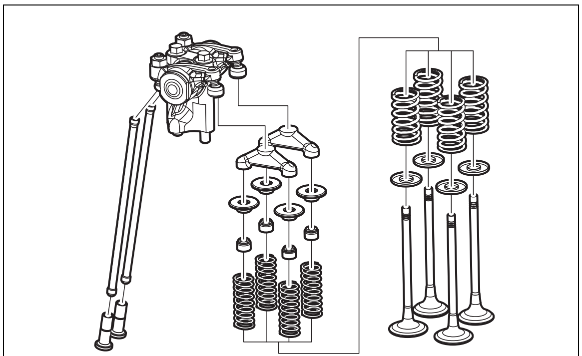
● Rocker arm

Check the surface where the rocker arm is in contact with the valve for scratches or worn pins; if the damage is minor, polish it with an oily grindstone or fine sandpaper.

CAUTION

If the damage is severe, replace the part.



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2) Assembling rocker arms

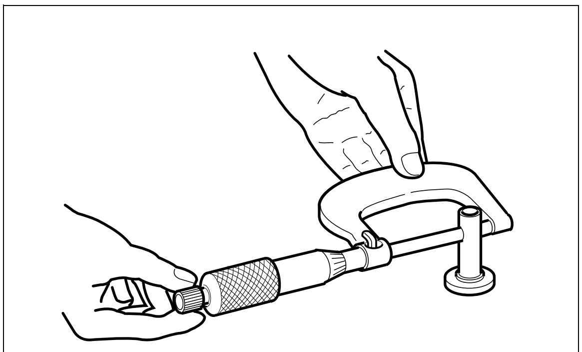
After checking the rocker arm and rocker arm bracket for clogged oil passages, clean the rocker arm thoroughly; then, reassemble the rocker arm in the reverse order of assembly.

7.4.5. Tappet and Pushrod

1) Tappet clearance

Measure the outside diameter of the tappet and the inside diameter of the cylinder block tappet hole.
If the measurement exceeds the allowable limit, replace the tappet.
<Clearance between cylinder block and tappet>

Specified value	Allowable limit
0.035 ~ 0.077 mm	0.15 mm



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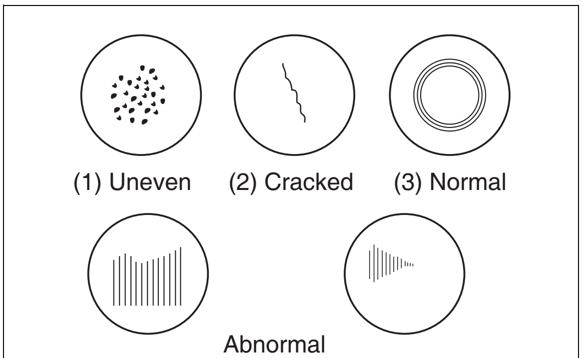
2) Inspecting the tappet visually

Check the surface of the tappet which slides in contact with the camshaft for scratches, cracks and other damage. For minor damage, use an oily grindstone or fine sandpaper to polish the surface. For severe damage, replace the tappet.



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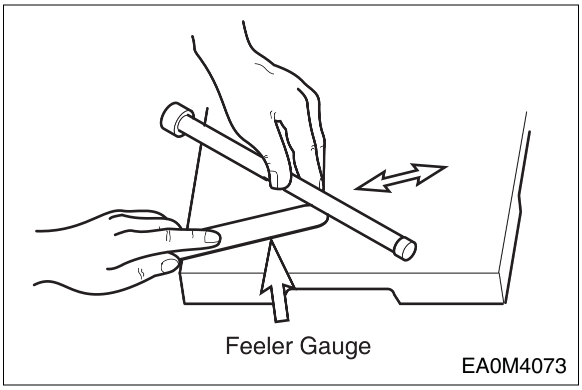
3) Pushrod deflection

Place the pushrod on a surface plate and measure its deflection with a feeler gauge while rolling it. If the measurement exceeds the allowable limit, replace it with a new one.

<Pushrod deflection>

Allowable limit	0.3 mm or less



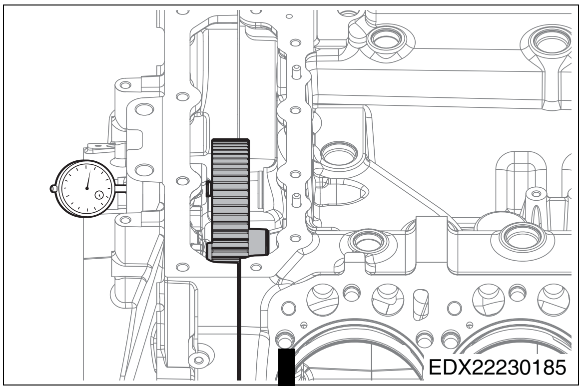
7.4.6. Camshaft

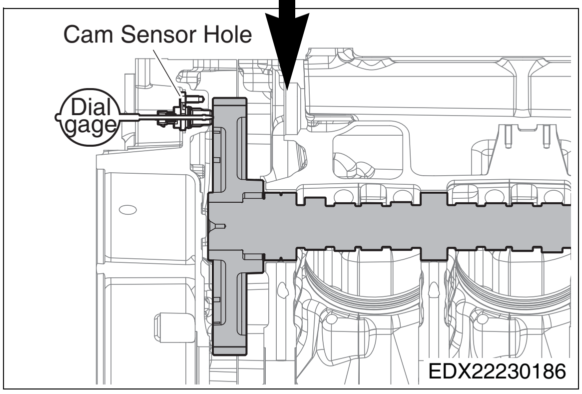
1) Camshaft play

- Push the camshaft in the direction of the pulley.
- Install a dial gauge on the camshaft gear.
- Use a screwdriver to move the side of the camshaft gear and measure the axial play of the camshaft.

Item	Minimum	Maximum
End play	0.1 mm	0.85 mm

- If there is too much free play, use a thrust washer with a different thickness to adjust it.





2) Checking and measuring the camshaft

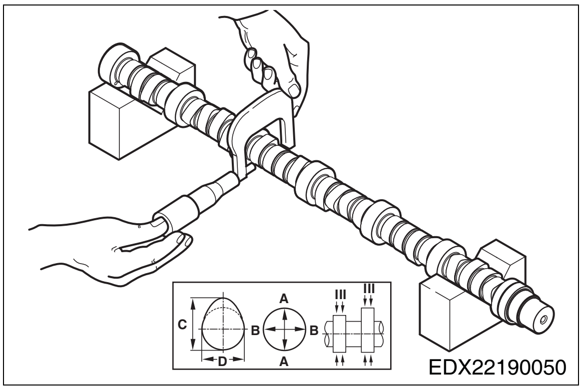
- Visual inspection

  Check the cam surface visually for damage. If any minor defects are found, polish them with an oilstone to correct them. If the damage is severe, replace the part.

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

(mm)

Item		Specified value	Allowable limit
Cam lobe height (C)	Intake	55.356	55.06
	Exhaust	56.378	56.08
Camshaft journal diameter (A, B)		Ø69.91 ~ Ø69.94	Ø69.560

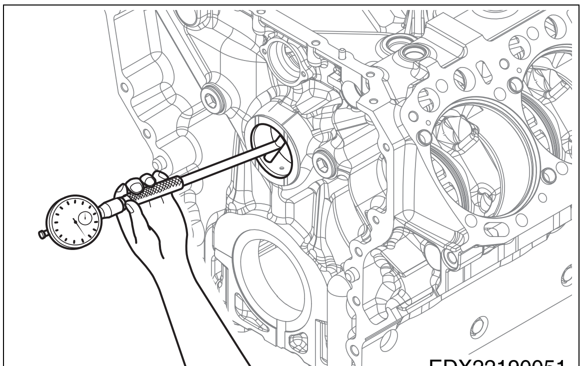


● Cam bearing diameter
Measure the inside diameter of the camshaft bushing with a cylinder gauge; then, compare the inside and outer diameters and replace the part if the measurements deviate from the normal values.

<Camshaft bearing inside diameter>

(mm)

Item	Specified value	Allowable limit
Thrust	Ø70.070 ~ Ø70.090	Ø70.19
Middle	Ø70.000 ~ Ø70.030	Ø70.19


EDX22190051

● Clearance
Clearance between the camshaft journal and camshaft body

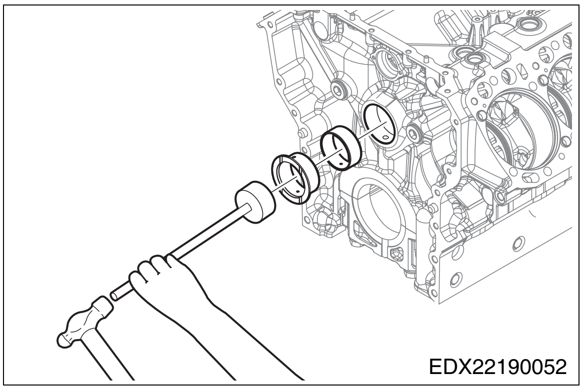
<Clearance between the camshaft journal and bushing>

(mm)

Item	Specified value	Allowable limit
Thrust	0.060 ~ 0.120	0.240
Middle	0.130 ~ 0.180	0.240

3) Replacing the camshaft bearing

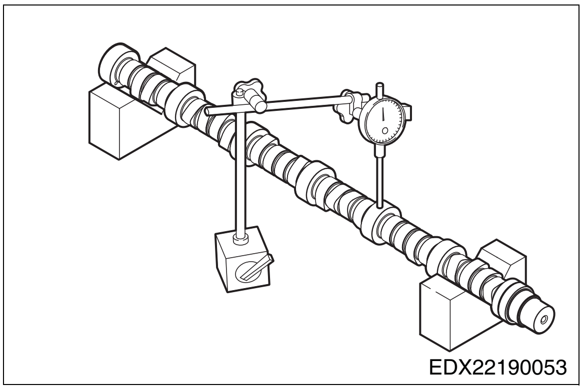
● Replacing the camshaft bearing
Use a disassembly/assembly tool to replace the camshaft bearing.


EDX22190052

● Camshaft runout
Place the camshaft on two V-blocks; then, check and adjust the camshaft runout. If severe, replace the part.

<Camshaft deflection>

Specified value	Allowable limit
0.05 mm	0.15 mm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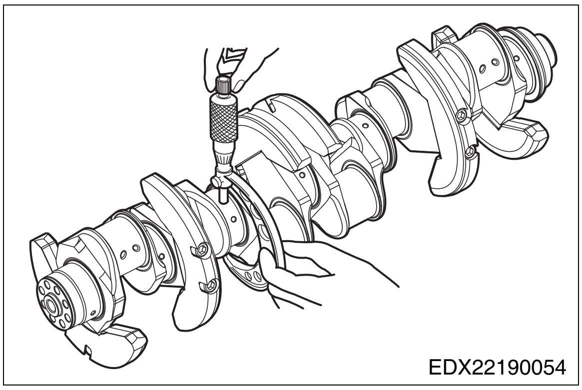
7.5. Other/Driving System

- Engine pistons are cooled by an oil gallery. The shape of the gallery, the shape and position of the nozzles, and the oil flow rate are all very important factors in lowering the temperature of the piston oil gallery. The cross sectional shape of the piston gallery is designed to achieve maximum cooling effectiveness with efficient oil flow.
- The crankshaft is a single forged unit. The crankshaft and rear oil seals are designed to prevent oil from entering the flywheel housing.
- The connecting rod is a single forged unit. Its big end can be disconnected diagonally, enabling it to be removed with the piston through the top of the cylinder. The moving parts of the crankshaft and connecting rod are equipped with alloy bearings.
- The camshaft, oil pump, and high-pressure injection pump are driven by gear connections in the timing gear case.
- The overhead valve is operated by the valve tappet, pushrod and rocker arm on the camshaft.

7.5.1. Crankshaft

1) Checking the crankshaft
   - Inspecting and measuring
     - Visually inspect the crankshaft journal and crank pin 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.
   - Journal and pin diameter
     - Using a micrometer, measure the crankshaft journal and pin O.D. in the direction shown in the figure to check the amount of wear.
     - If the amount of wear exceeds the limit, polish the crankshaft journal and crank pin and install an undersize bearing.
     - However, if the amount of wear is below the limit, polish the part with an oil stone or fine oily sandpaper. (Make sure the fine sandpaper has been soaked in oil.)



EDX22190054

<Journal and pin O.D.>

Item	Specified value
Journal diameter	Ø103.98 ~ Ø104.00 mm
Pin diameter	Ø93.98 ~ Ø94.00 mm

< Types of undersize bearings >

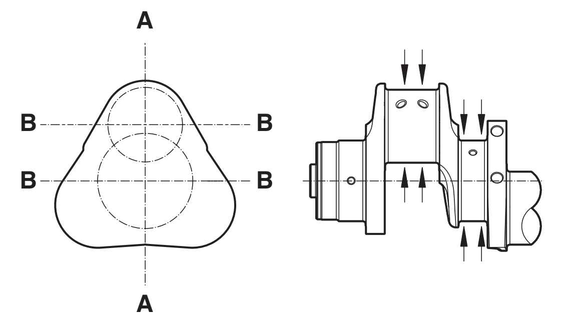
- Standard
- 0.25 (0.25 mm smaller than standard I.D.)
- 0.50 (0.50 mm smaller than standard I.D.)
- 0.75 (0.75 mm smaller than standard I.D.)
- 1.00 (1.00 mm smaller than standard I.D.)

CAUTION
As shown above, there are four types of undersize bearings. The crankshaft can be ground to the measurements above.

CAUTION
When grinding the crankshaft, make sure to grind part "R" on the end of the bearing precisely. There should not be any steps or burrs.

[Specification for section "R"]

- "R" on the crank pin: $4.5^{\ 0}_{-0.5}$
- "R" on the crank journal: $4.0^{\ 0}_{-0.5}$



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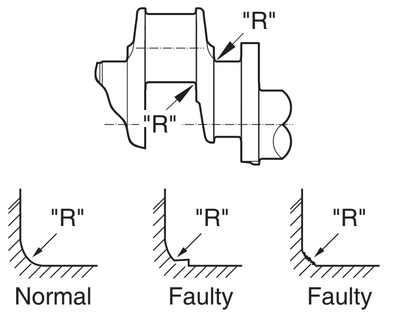

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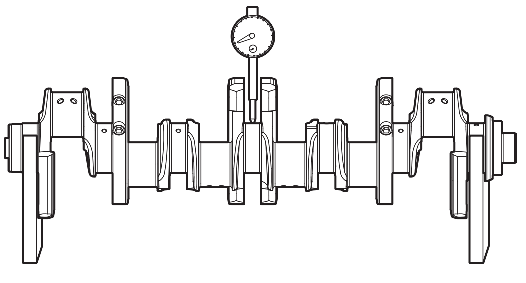
- Crankshaft deflection
  - Place the crankshaft on two V-blocks.
  - Set a dial gauge on the surface plate and roll the crankshaft to measure its deflection.

<Crankshaft deflection>

Specified value	Allowable limit
0.08 mm	0.12 mm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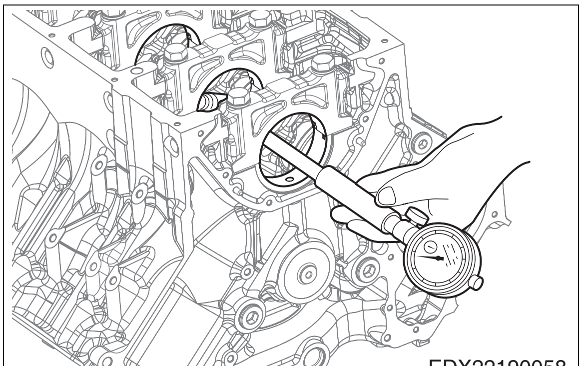
2) Inspecting the crankshaft bearings and connecting rod bearings
- Visual inspection
  Visually inspect the crankshaft journal and crank pin for scratches or damage.

- Oil clearance between crankshaft and bearing
  - Install the journal bearing on the cylinder block, tighten the bearing cap to the specified torque, and measure the inside diameter of the bearing.

Side bolt	13.4 kg·m (97 lb·ft)
Standard I.D. of journal bearing	Ø104.066 ~ Ø104.114 mm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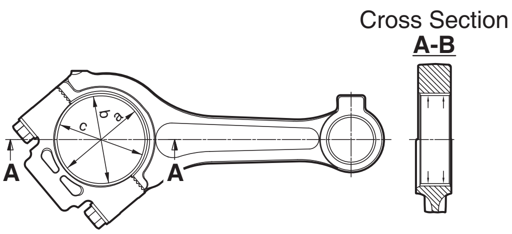
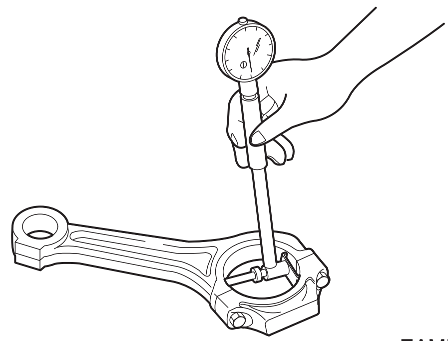
  - Install the bearing on the big end of the connecting rod, tighten the bearing cap to the specified torque, and measure the inside diameter.

Connecting rod bearing I.D.	Ø94.056 ~ Ø94.098 mm



EF8OM062


EAMD060I

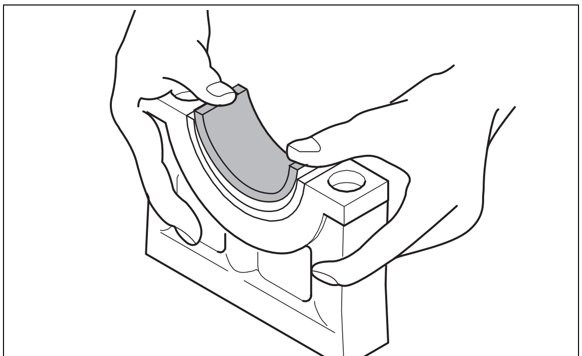
- Bearing oil clearance
  - Compare the measured bearing I.D. (journal bearing, connecting rod bearing) with the measured crankshaft journal and pin O.D. to calculate the oil clearance.

(mm)

Item	Specified value	Allowable limit
Journal bearing	0.066 ~ 0.134	0.159
Connecting rod bearing	0.056 ~ 0.118	0.143

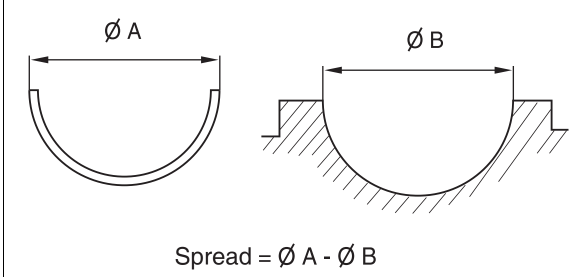
  - If the clearance is beyond the limit, grind the crank journal and crank pin and select a suitable undersize bearing to use.

- Inspecting the journal and connecting rod bearings
  - When assembling the bearing as shown in the figure, check whether the bearing is sufficiently pliable and requires a significant amount of finger pressure.



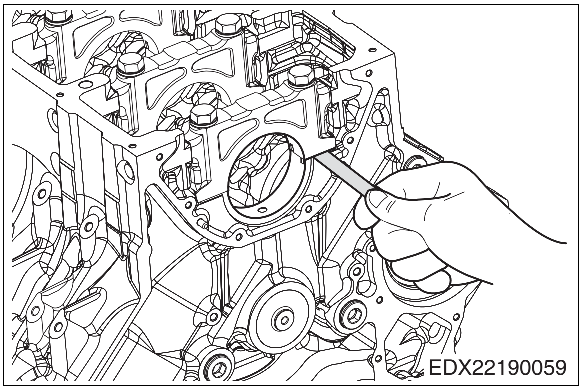
EH6OM039

  - When measuring the spread of the journal bearing and connecting rod bearing, use a dedicated jig as shown in the figure. However, perform the measurement with the parts assembled as shown below in order to facilitate the task.



EDM2047I

  - Journal bearing
    Install the bearings and caps on the cylinder block and tighten them to the specified torque; then, completely remove the bolts on one side and use a feeler gauge to measure the gap which naturally forms between the cylinder block and bearing cap.

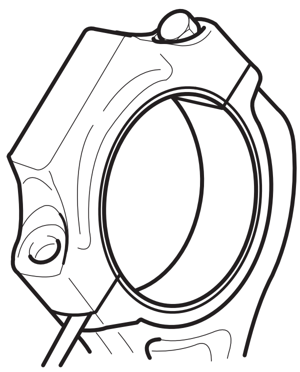


EDX22190059

<Bearing cap clearance>

Specified value	0.3 ~ 1.2 mm

  - Connecting rod bearing
    Install the bearing and cap on the connecting rod and tighten them to the specified torque; then, completely unscrew one of the bolts and use a feeler gauge to measure the gap which forms naturally between these parts due to the bearing.



EA6M064I

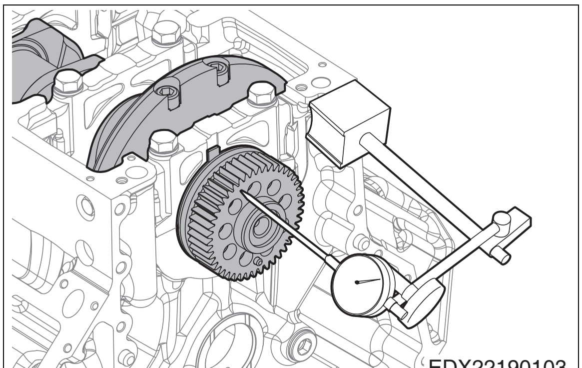
<Connecting rod bearing clearance>

Specified value	0.5 ~ 1.4 mm

- Crankshaft play
  Install the crankshaft on the cylinder block and use a dial gauge to measure the crankshaft end play.

<Crankshaft play>

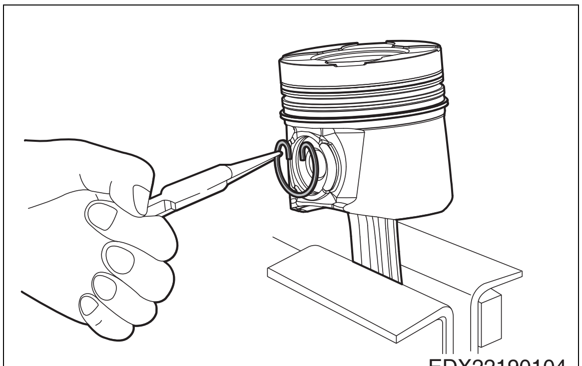
Specified value	Allowable limit
0.140 ~ 0.361 mm	0.4 mm


EDX22190103

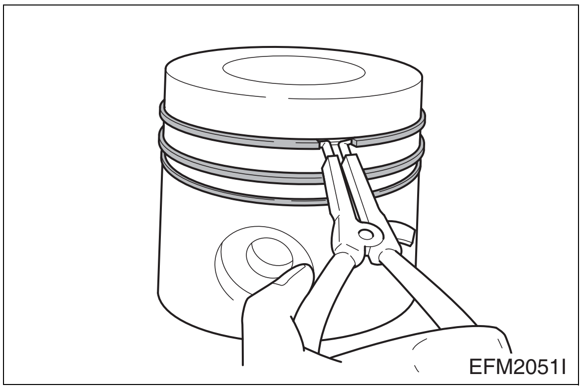
7.5.2. Piston

1) Disassembling pistons

- Disassembling piston pins
  - Remove the piston pin snap ring with snap ring pliers.
  - Remove the piston pin with a round rod.

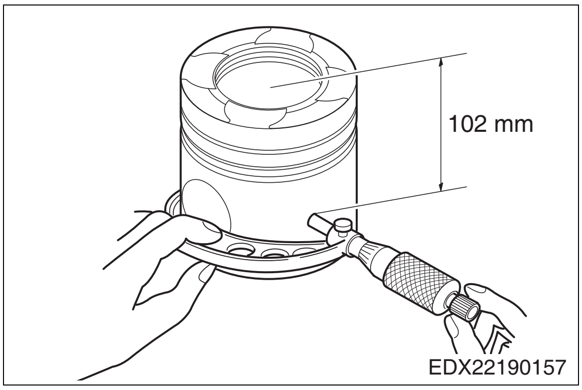

EDX22190104

- Disassembling piston rings
  - Remove the piston rings with pliers.
  - Clean the piston thoroughly.


EFM2051I

2) Inspecting and measuring

- Visual inspection
  - Visually inspect the pistons for wear, cracks or scratches, and check the piston ring grooves with particular care.
  - Use a micrometer to measure the outside diameter of the piston. Measure the piston 102 mm above the end of the piston head perpendicularly to the piston pin as shown in the figure.



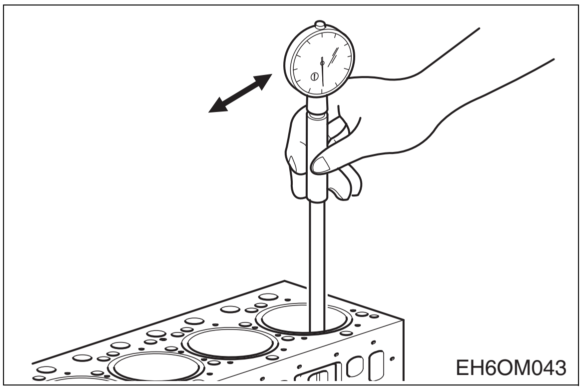
EDX22190157

<Measure perpendicularly 102 mm above the end of the piston head>

Specified value	Ø127.833 ~ Ø127.847 mm

- Cylinder bore I.D.
  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. The remainder after subtracting the maximum and minimum values is the average value.

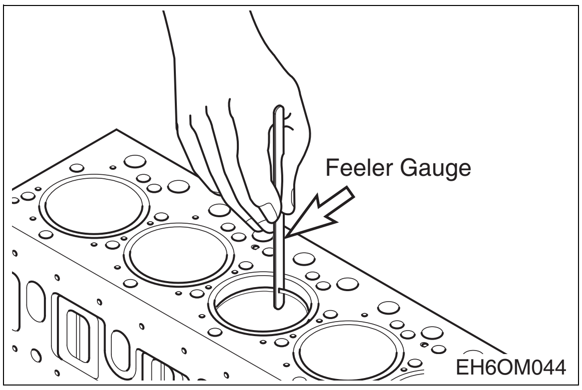
Specified value	Ø127.99 ~ Ø128.01 mm



- Clearance between the piston and cylinder liner
  The clearance is the value of the cylinder liner I.D. minus the piston O.D. If this result exceeds the allowable limit, replace either the piston or cylinder liner depending on which part is more worn.

Specified value	0.143 ~ 0.177 mm

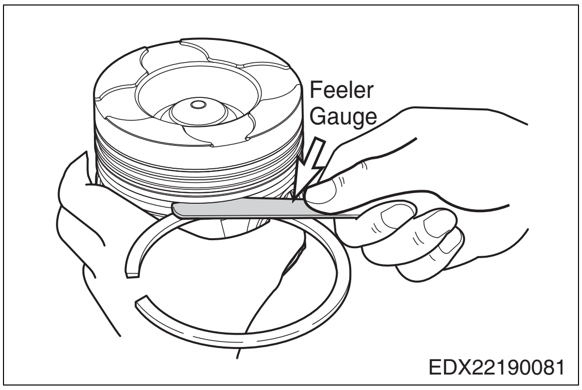
- Piston ring and piston ring groove
  After disassembling the engine, check the piston ring for wear and damage, and repair it with a new part if necessary.
- Piston ring end clearance
  - Measure the cut part of the piston ring.
  - Insert the piston ring perpendicularly into the top of the cylinder.
  - Use a feeler gauge to measure the piston ring clearance.
  - If the measurement exceeds the limit, replace the ring.



(mm)

Item	Specified value	Allowable limit
Top ring	0.30 ~ 0.40	0.7
Second ring	1.10 ~ 1.30	1.45
Oil ring	0.40 ~ 0.60	0.85

- Piston ring side gap
  - Assemble the piston rings with the piston.
  - Measure the side gap of each ring; if the measurement exceeds the allowable limit, replace the ring or the piston.



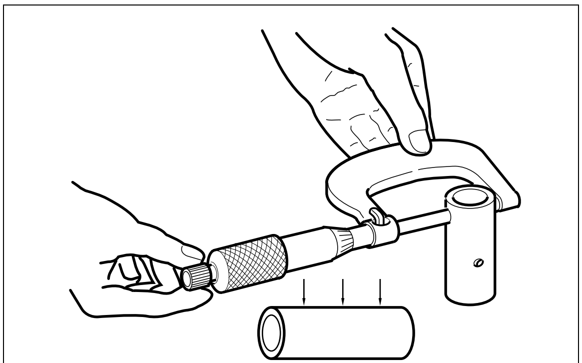
(mm)

Item	Specified value	Allowable limit
Top ring	0.105 ~ 0.150	0.30
Second ring	0.05 ~ 0.082	0.15
Oil ring	0.03 ~ 0.07	0.15

- If the measurement exceeds the allowable limit, replace the ring or the piston.

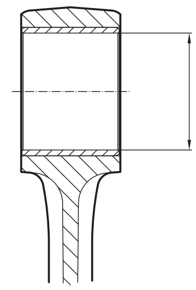
● Piston pin
Measure the outside diameter of the piston pin with an O.D. micrometer; if the measurement is equal to or less than the allowable limit, replace the pin.

Specified value	Allowable limit
Ø45.994 ~ Ø46.000 mm	Ø45.979 mm or less


EA0M4031

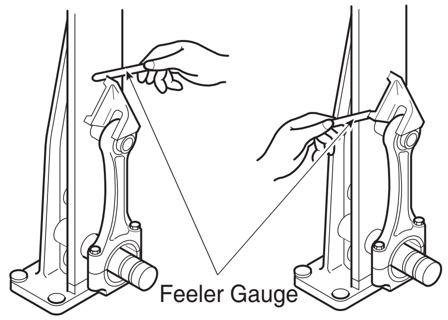
● Clearance between piston pin and connecting rod bushing
Measure the clearance between the piston pin and connecting rod bushing. If the measurement exceeds the usable limit, replace whichever part is more worn.

Specified value	Allowable limit
0.055 ~ 0.071 mm	0.13 mm


EE2OM064

● Connecting rods
- Install the connecting rod on a connecting rod measuring device as shown in the figure; then, use a feeler gauge to measure the distortion.
  If the connecting rod is distorted, do not attempt to correct and reuse it; replace it with a new one.
- Check the parallelism of the piston ring bushing hole on the connecting rod and the bearing groove at the big end of the connecting rod. Install the connecting rod on a connecting rod tester and measure it with a feeler gauge as described above.

Specified value	Allowable limit
0.02 mm	0.1 mm



EA0M4034

- Install the connecting rod on the crankshaft and use a feeler gauge to measure the clearance between the big end of the connecting rod and the crank pin.

Specified value	Allowable limit
0.056 ~ 0.118 mm	0.143 mm

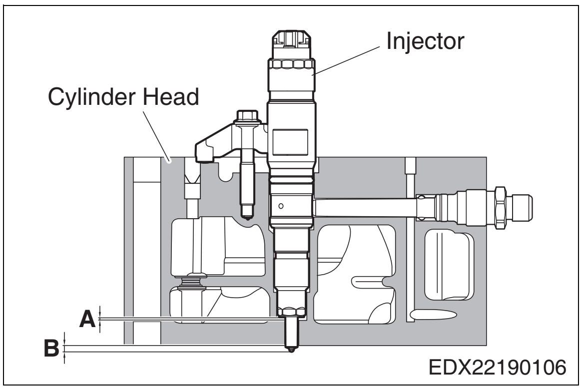
- Install the piston on the connecting rod and measure the clearance between the two assemblies.
- If the measured clearance exceeds the limit, replace the connecting rod.

7.5.3. Injector

1) Injector protrusion

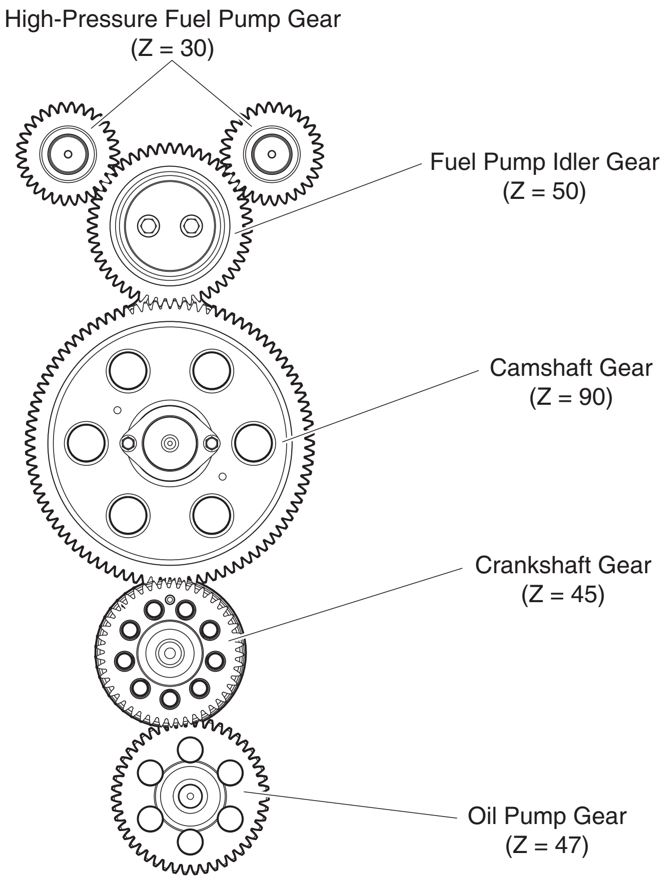
- Insert a seal ring into the cylinder head and assemble the injector.
- Check the protrusion of the injector from the cylinder head; correct if necessary.

Item	Specified value
A (thickness of seal ring)	2.0 mm
B (injector protrusion)	2.18 ~ 3.03 mm



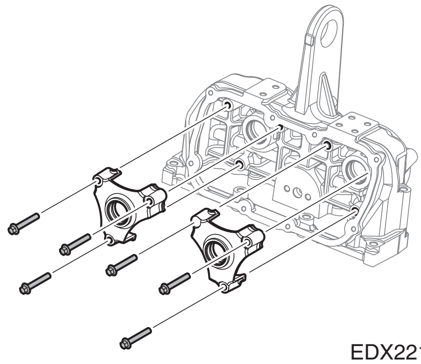
7.5.4. Others

1) Engine timing



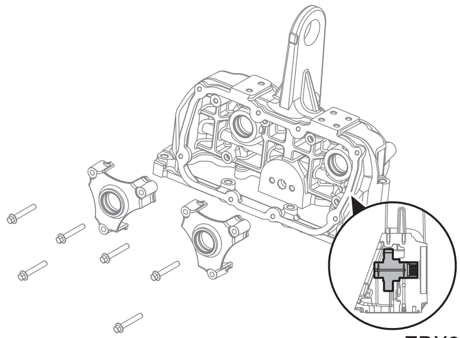
2) Timing gear train

● Unscrew six M8 bolts and remove the brackets.



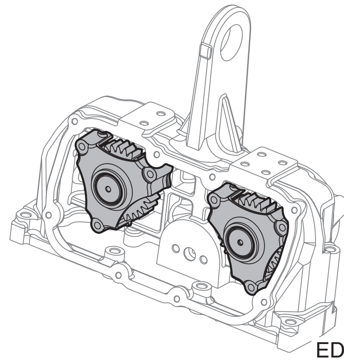
EDX22190158

● Insert the high-pressure fuel pump gears (2 EA) into the case bushing holes and seat them on the case seat.



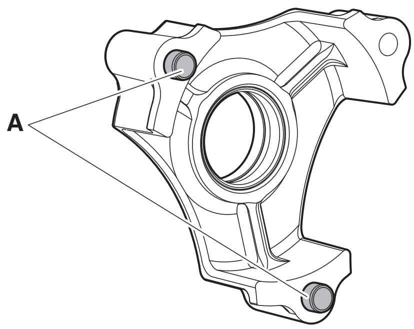
EDX22190159

● Assemble the brackets.



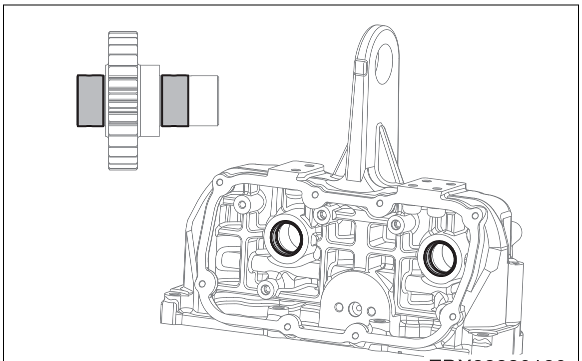
EDX22190160

– Assemble bracket pins (A) while taking care not to damage them, and seat the brackets on the case seat.
(Use a copper hammer)



EDX22190161

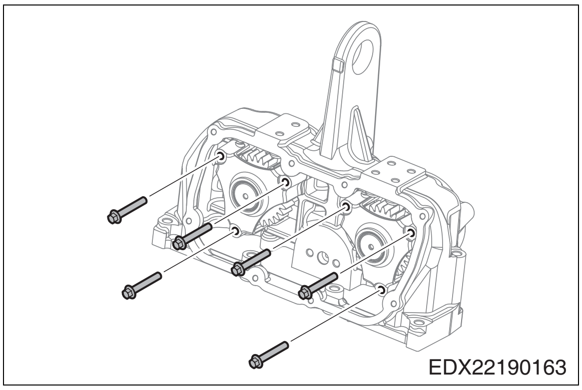
- During assembly, apply oil around the entire circumference of the bushing and shaft with a silicone brush at least once.



EDX22230190

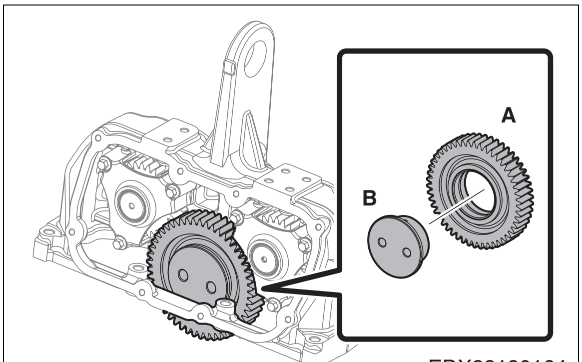
- Tighten the M8 bolts onto the brackets.

Tightening torque	2.2 ±0.55 kg·m



EDX22190163

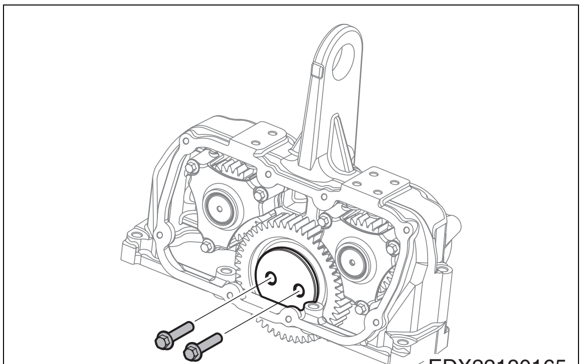
- Assemble fuel pump idler gear (A) and gear shaft (B).



EDX22190164

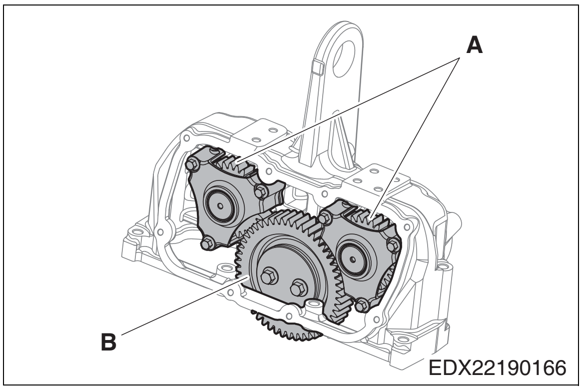
- Tighten the M10 bolts onto the gear shaft.

Tightening torque	6.2 ±1.55 kg·m



EDX22190165

- After completing the assembly, rotate gears (A) and (B) to make sure that they rotate properly.

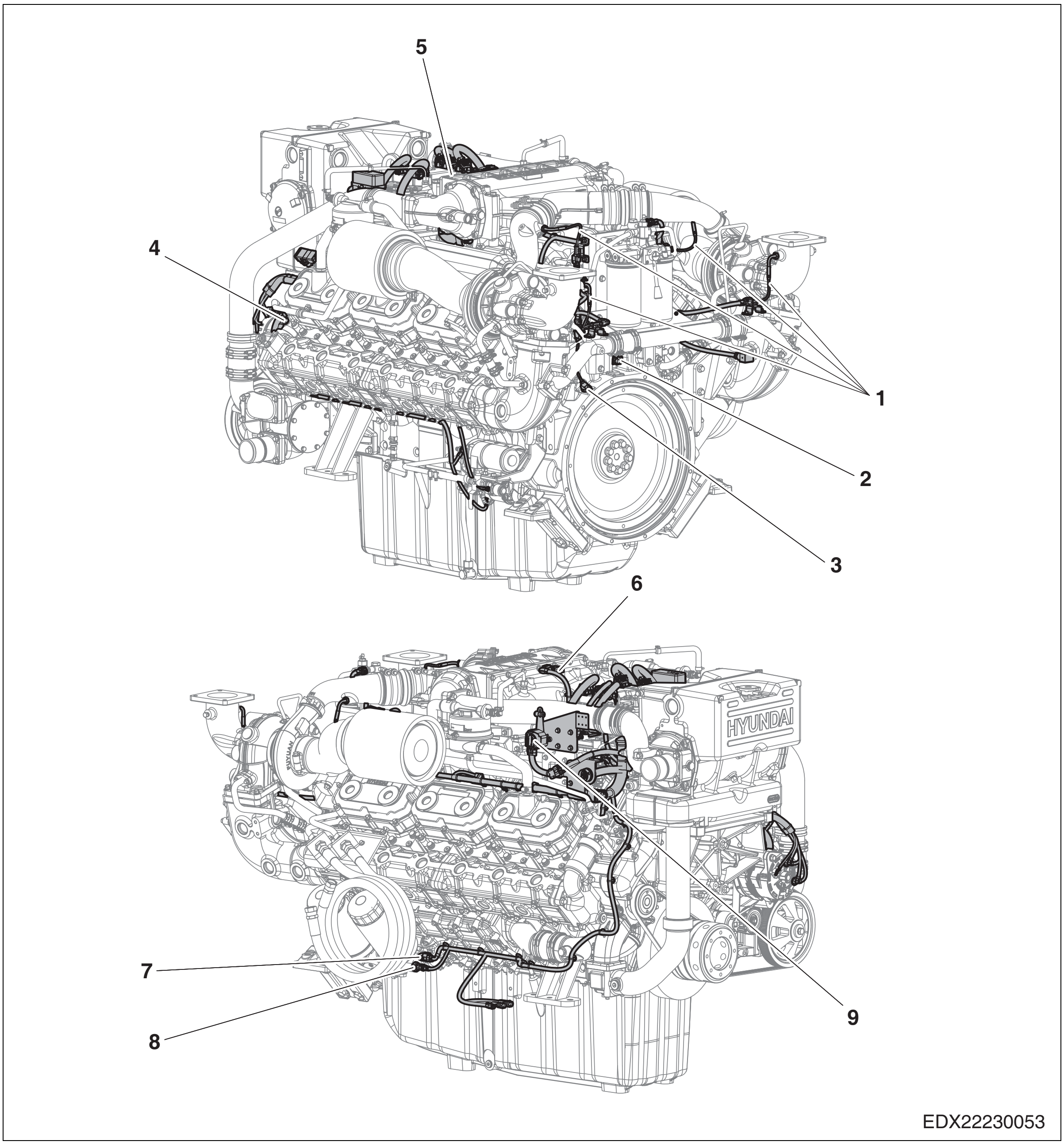


8. Electrical System

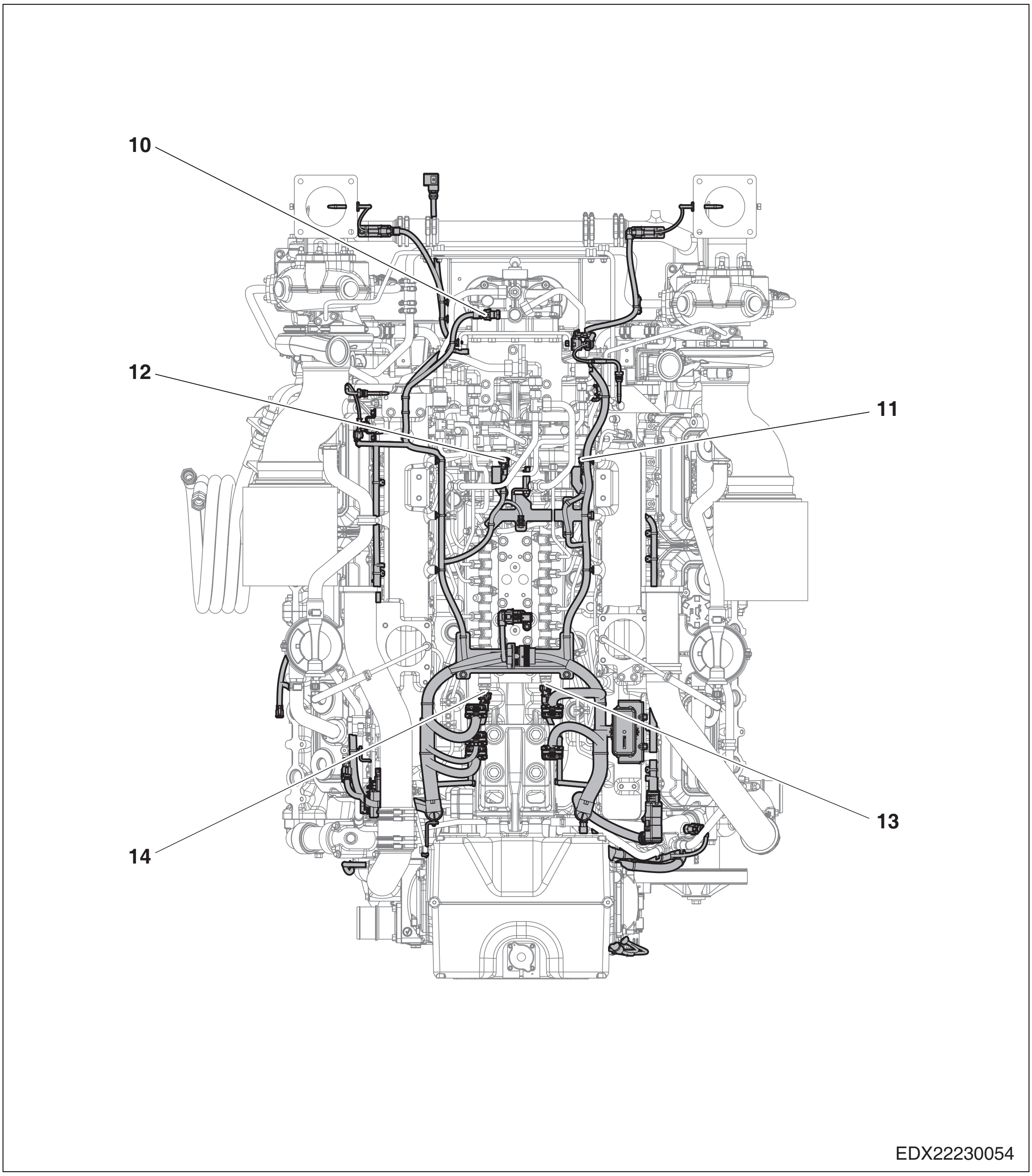
8.1. Circuit Diagram

8.1.1. Electronic Components

- Propulsion

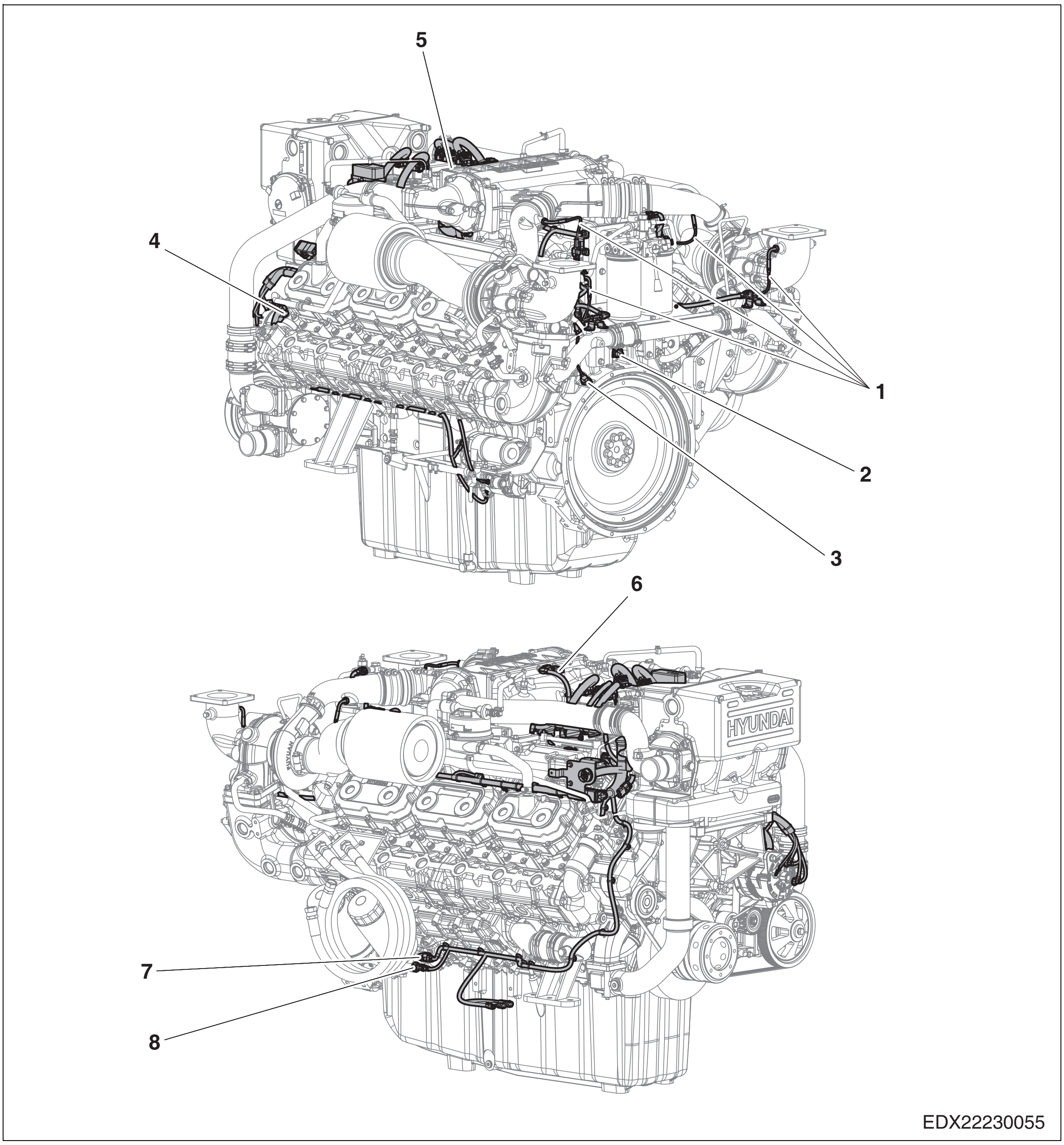


1. Exhaust temperature sensor
2. CAM sensor
3. CRS sensor
4. Coolant temperature sensor
5. Ambient temperature sensor (IMO-T3 Only)
6. TMAP sensor
7. Oil temperature sensor
8. Oil pressure sensor
9. Position sensor

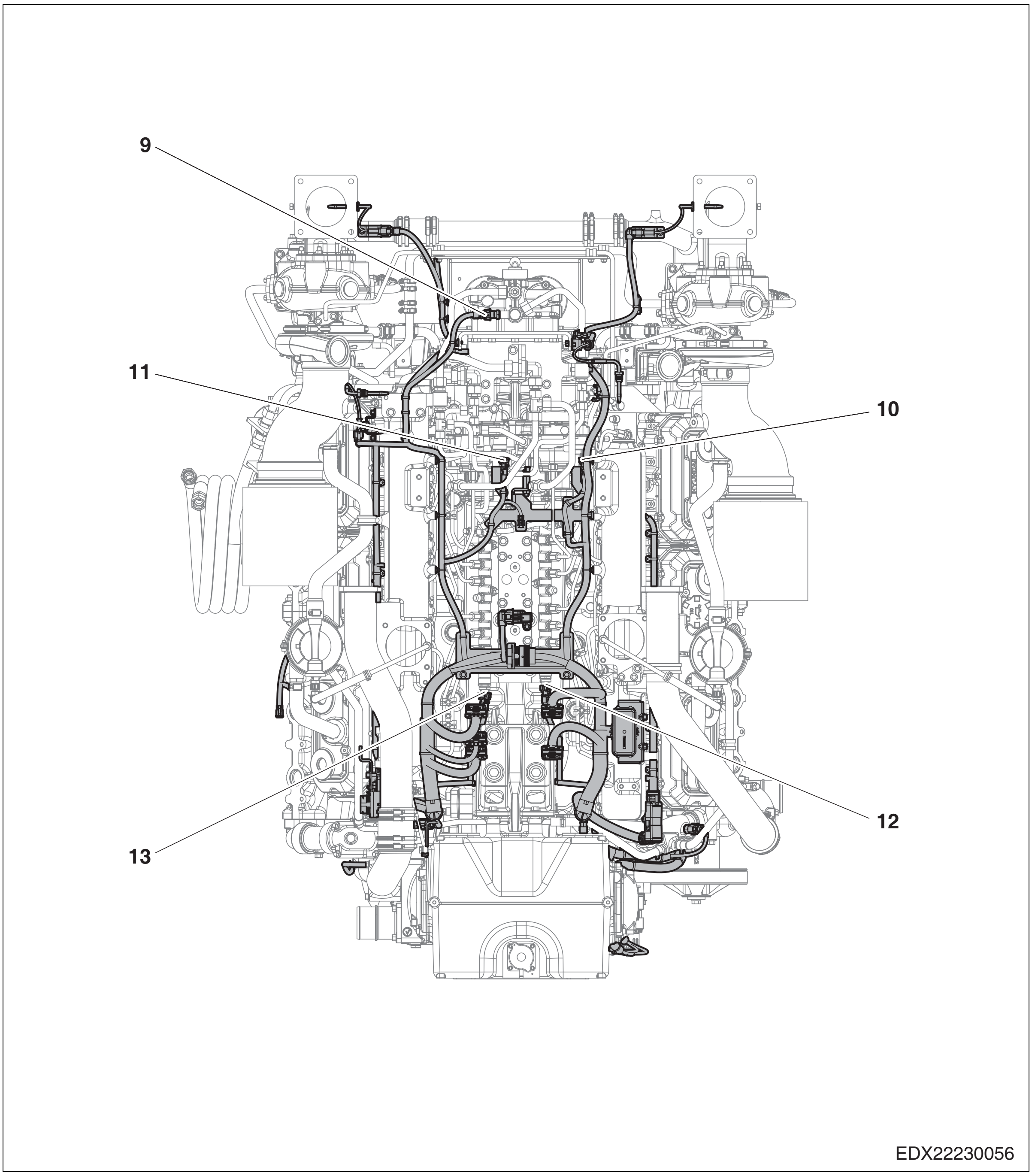


10. Fuel temp. sensor
11. Rail pressure sensor #1
12. Rail pressure sensor #2
13. Fuel metering unit #1
14. Fuel metering unit #2

● Auxiliary



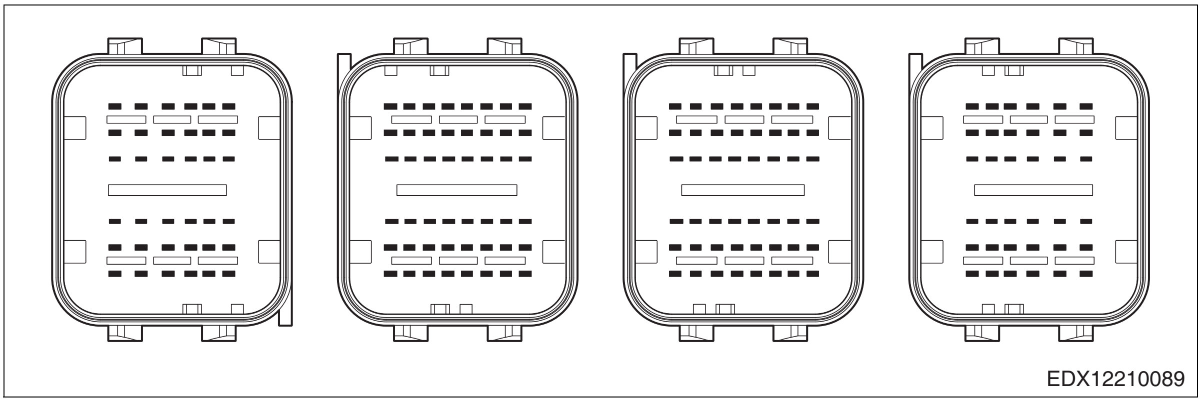
1. Exhaust temperature sensor
2. CAM sensor
3. CRS sensor
4. Coolant temperature sensor
5. Ambient temperature sensor (IMO-T3 Only)
6. TMAP sensor
7. Oil temperature sensor
8. Oil pressure sensor



9. Fuel temp. sensor
10. Rail pressure sensor #1
11. Rail pressure sensor #2
12. Fuel metering unit #1
13. Fuel metering unit #2

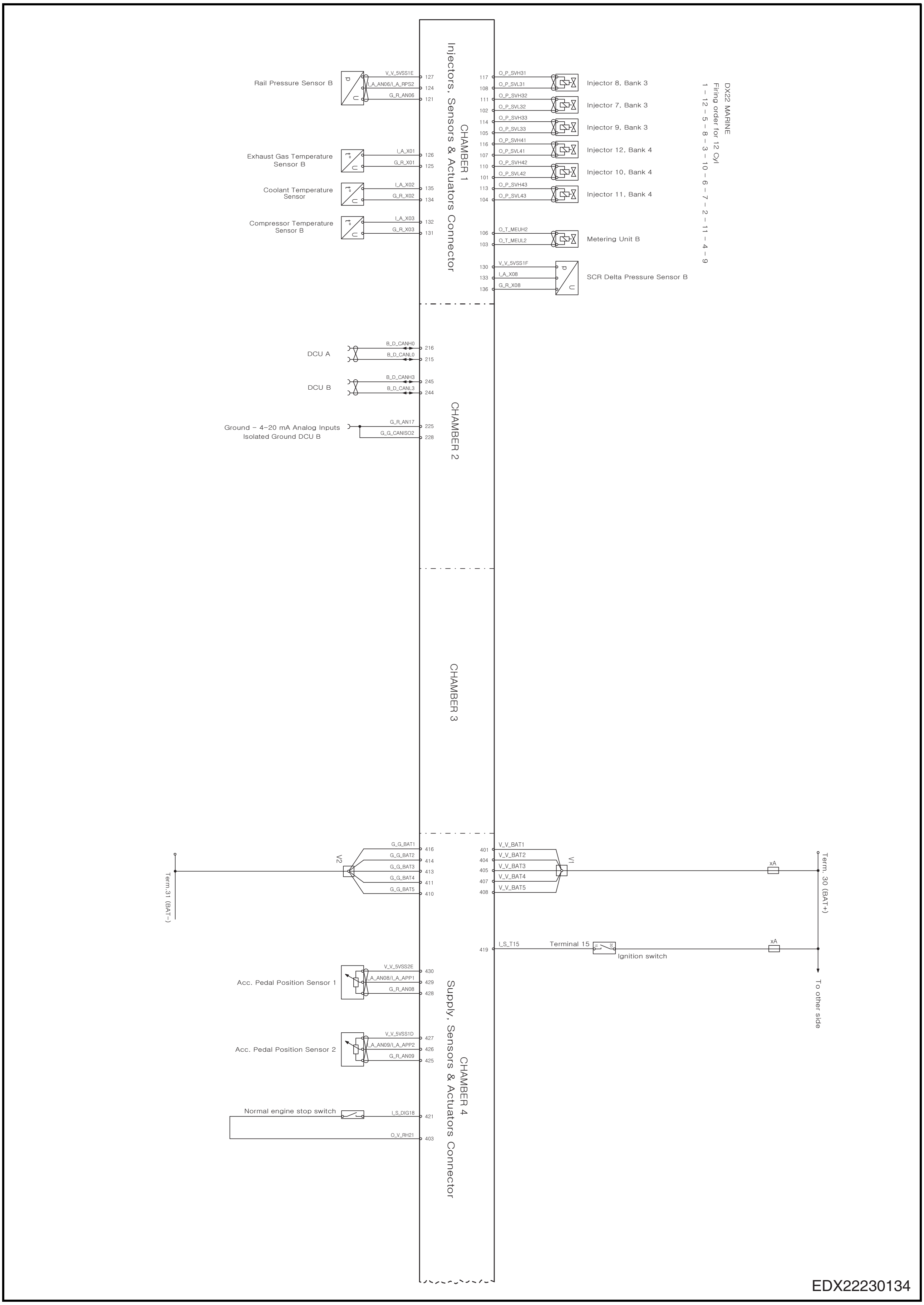
8.1.2. General Information

1) This section provides information on the engine wire harnesses and the circuit number of connectors.

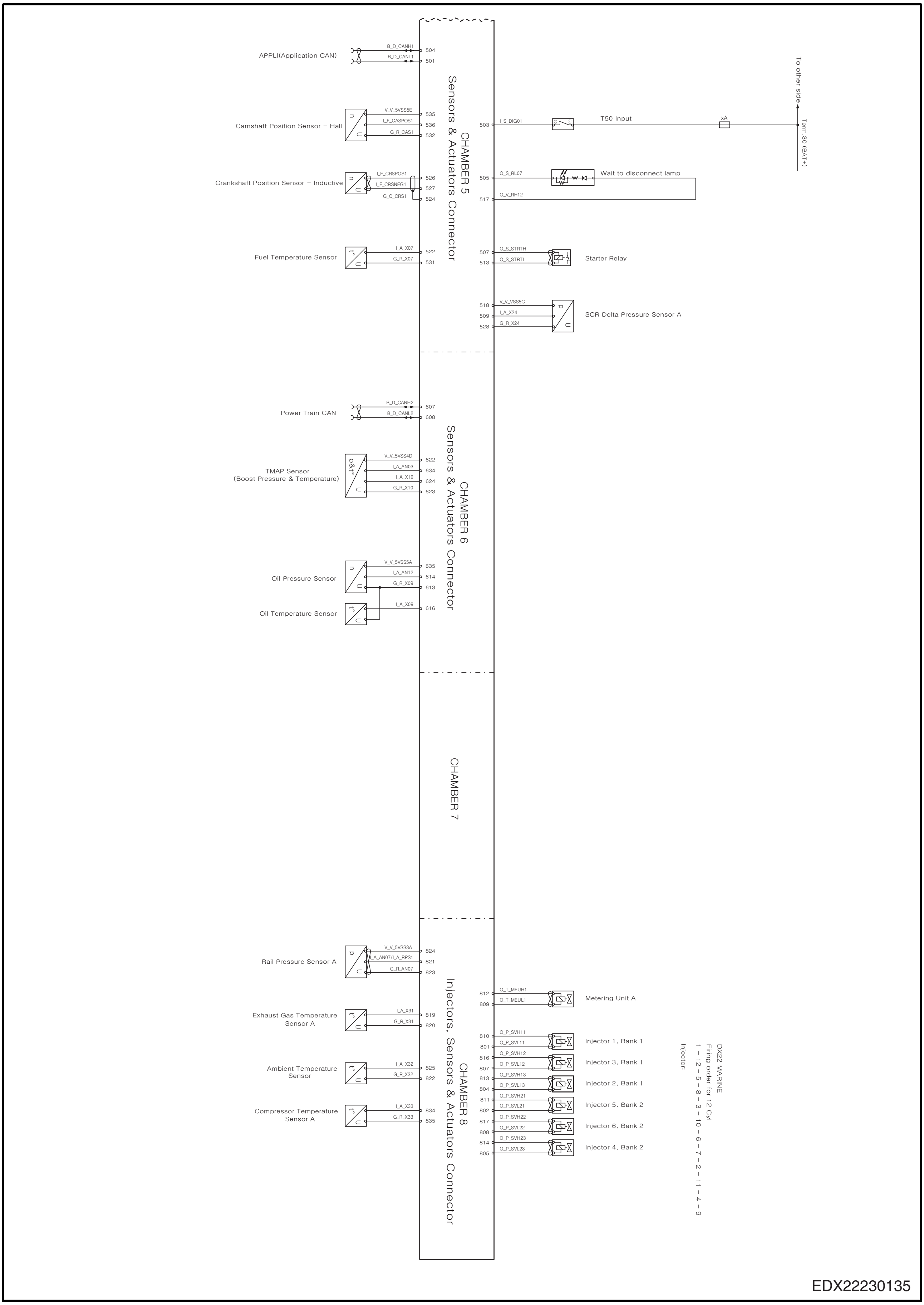


2) The wire colors are as follows.
   - B : Black
   - Brn : Brown
   - G : Green
   - Gra : Gray
   - L : Blue
   - O : Orange
   - W : White
   - Y : Yellow
   - R : Red
3) The ECU pin no. refers to the pin number of each engine connector.
4) The sensor pin no. refers to the pin number of each sensor connector.

8.1.3. Engine Connectors



EDX22230134



APPLI(Application CAN)
Camshaft Position Sensor - Hall
Crankshaft Position Sensor - Inductive
Fuel Temperature Sensor
CHAMBER 5
Sensors & Actuators Connector
T50 Input
Wait to disconnect lamp
Starter Relay
SCR Delta Pressure Sensor A
To other side
Term.30 (BAT+)
Power Train CAN
TMAP Sensor
(Boost Pressure & Temperature)
Oil Pressure Sensor
Oil Temperature Sensor
CHAMBER 6
Sensors & Actuators Connector
CHAMBER 7
Rail Pressure Sensor A
Exhaust Gas Temperature Sensor A
Ambient Temperature Sensor
Compressor Temperature Sensor A
CHAMBER 8
Injectors, Sensors & Actuators Connector
Metering Unit A
Injector 1, Bank 1
Injector 3, Bank 1
Injector 2, Bank 1
Injector 5, Bank 2
Injector 6, Bank 2
Injector 4, Bank 2
DX22 MARINE
Firing order for 12 Cyl
1 - 12 - 5 - 8 - 3 - 10 - 6 - 7 - 2 - 11 - 4 - 9
Injector:
EDX22230135

8.1.4. Engine Control Unit (ECU) Engine Connectors

Marine Propulsion LH

No.	Wire Label	Size (mm^2)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
1	125	0.75	B	FLR91X-A	EGT Sensor LH GND	ECU 1	25	E/P EGT Sensor LH (E/P EGTI)	1	
2	126	0.75	Y	FLR91X-A	EGT Sensor LH Signal	ECU 1	26	E/P EGT Sensor LH (E/P EGTI)	2	
3	131	0.75	B	FLR91X-A	Compressor Temp Sensor LH GND	ECU 1	31	T/C EGT Sensor LH (T/C EGTI)	1	
4	132	0.75	W	FLR91X-A	Compressor Temp Sensor LH Signal	ECU 1	32	T/C EGT Sensor LH (T/C EGTI)	2	
5	127	0.75	P	FLR91X-A_T09	Rail Press Sensor LH PWR	ECU 1	27	Rail Press Sensor LH (RPSL)	3	Twist Pair (121/124/127)
6	124	0.75	O	FLR91X-A_T09	Rail Press Sensor LH Signal	ECU 1	24	Rail Press Sensor LH (RPSL)	2	Twist Pair (121/124/127)
7	121	0.75	B	FLR91X-A_T09	Rail Press Sensor LH GND	ECU 1	21	Rail Press Sensor LH (RPSL)	1	Twist Pair (121/124/127)
8	111	1.5	W	FLR91X-A_T01	Injector 7 "High"	ECU 1	11	Injector Inline LH (INJL)	1	Twist Pair (102/111)
9	102	1.5	Y	FLR91X-A_T01	Injector 7 "Low"	ECU 1	2	Injector Inline LH (INJL)	2	Twist Pair (102/111)
10	117	1.5	Grl	FLR91X-A_T02	Injector 8 "High"	ECU 1	17	Injector Inline LH (INJL)	3	Twist Pair (108/117)
11	108	1.5	G	FLR91X-A_T02	Injector 8 "Low"	ECU 1	8	Injector Inline LH (INJL)	4	Twist Pair (108/117)
12	114	1.5	W	FLR91X-A_T03	Injector 9 "High"	ECU 1	14	Injector Inline LH (INJL)	5	Twist Pair (105/114)
13	105	1.5	Y	FLR91X-A_T03	Injector 9 "Low"	ECU 1	5	Injector Inline LH (INJL)	6	Twist Pair (105/114)
14	110	1.5	Grl	FLR91X-A_T04	Injector 10 "High"	ECU 1	10	Injector Inline LH (INJL)	7	Twist Pair (101/110)
15	101	1.5	G	FLR91X-A_T04	Injector 10 "Low"	ECU 1	1	Injector Inline LH (INJL)	8	Twist Pair (101/110)
16	113	1.5	W	FLR91X-A_T05	Injector 11 "High"	ECU 1	13	Injector Inline LH (INJL)	9	Twist Pair (104/113)
17	104	1.5	Y	FLR91X-A_T05	Injector 11 "Low"	ECU 1	4	Injector Inline LH (INJL)	10	Twist Pair (104/113)
18	116	1.5	Grl	FLR91X-A_T06	Injector 12 "High"	ECU 1	16	Injector Inline LH (INJL)	11	Twist Pair (107/116)
19	107	1.5	G	FLR91X-A_T06	Injector 12 "Low"	ECU 1	7	Injector Inline LH (INJL)	12	Twist Pair (107/116)
20	106	1.5	G	FLR91X-A_T07	Fuel Metering Unit LH High	ECU 1	6	Fuel Metering Unit LH (FMUL)	1	Twist Pair (103/106)
21	103	1.5	L	FLR91X-A_T07	Fuel Metering Unit LH Low	ECU 1	3	Fuel Metering Unit LH (FMUL)	2	Twist Pair (103/106)
22	135	0.75	Brn	FLR91X-A	Coolant Temp Sensor Signal	ECU 1	35	Coolant Temp Sensor (CTS)	1	
23	134	0.75	B	FLR91X-A	Coolant Temp Sensor GND	ECU 1	34	Coolant Temp Sensor (CTS)	2	
24	130	0.75	R	FLR91X-A	SCR DP Sensor B PWR	ECU 1	30	Inter CONN SCR (INT SCR)	5	
25	136	0.75	B	FLR91X-A	SCR DP Sensor B GND	ECU 1	36	Inter CONN SCR (INT SCR)	6	
26	133	0.75	G	FLR91X-A	SCR DP Sensor B Signal	ECU 1	33	Inter CONN SCR (INT SCR)	7	

No.	Wire Label	Size (mm^2)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
27	225	0.75	B	FLR91X-A	DCU CAN Ground	ECU 2	25	ECU 2	28	
28	245	0.75	L	FLR91X-A_T10	CAN 3H	ECU 2	45	Inter CONN SCR (INT SCR)	14	Twist Pair (244/245)
29	244	0.75	O	FLR91X-A_T10	CAN 3L	ECU 2	44	Inter CONN SCR (INT SCR)	15	Twist Pair (244/245)
30	216	0.75	Y	FLR91X-A_T11	CAN 0H	ECU 2	16	Inter CONN SCR (INT SCR)	16	Twist Pair (215/216)
31	215	0.75	W	FLR91X-A_T11	CAN 0L	ECU 2	15	Inter CONN SCR (INT SCR)	17	Twist Pair (215/216)
32	416	1.5	B	FLR91X-A	BAT GND 1	ECU 4	16	SP01		Splice 01
33	414	1.5	B	FLR91X-A	BAT GND 2	ECU 4	14	SP01		Splice 01
34	413	1.5	B	FLR91X-A	BAT GND 3	ECU 4	13	SP01		Splice 01
35	411	1.5	B	FLR91X-A	BAT GND 4	ECU 4	11	SP01		Splice 01
36	410	1.5	B	FLR91X-A	BAT GND 5	ECU 4	10	SP01		Splice 01
37	G01	2	B	FLR91X-B	ALT GND	SP01		SP02		Splice 01, Splice 02
38	401	1.5	R	FLR91X-A	BAT PWR 1	ECU 4	1	SP03		Splice 03
39	404	1.5	R	FLR91X-A	BAT PWR 2	ECU 4	4	SP03		Splice 03
40	405	1.5	R	FLR91X-A	BAT PWR 3	ECU 4	5	SP03		Splice 03
41	407	1.5	R	FLR91X-A	BAT PWR 4	ECU 4	7	SP03		Splice 03
42	408	1.5	R	FLR91X-A	BAT PWR 5	ECU 4	8	SP03		Splice 03
43	P01	2	R	FLR91X-B	ALT PWR	SP03		Junction Box (JBOX) F4 (5A)	2	Splice 03
44	419	0.75	Y	FLR91X-A	Key-on (T15)	ECU 4	19	Junction Box (JBOX) E/G Stop Relay	30	Splice 419
45	425	0.75	B	FLR91X-A_T13	ACC.Pedal Position Sensor 2 GND	ECU 4	25	Inter CONN 2 (INT 2)	6	Twist Pair (425/426/427)
46	426	0.75	W	FLR91X-A_T13	ACC.Pedal Position Sensor 2 Sig	ECU 4	26	Inter CONN 2 (INT 2)	5	Twist Pair (425/426/427)
47	427	0.75	R	FLR91X-A_T13	ACC.Pedal Position Sensor 2 PWR	ECU 4	27	Inter CONN 2 (INT 2)	4	Twist Pair (425/426/427)
48	428	0.75	B	FLR91X-A_T14	ACC.Pedal Position Sensor 1 GND	ECU 4	28	Inter CONN 2 (INT 2)	3	Twist Pair (428/429/430)
49	429	0.75	Y	FLR91X-A_T14	ACC.Pedal Position Sensor 1 SIG	ECU 4	29	Inter CONN 2 (INT 2)	2	Twist Pair (428/429/430)
50	430	0.75	R	FLR91X-A_T14	ACC.Pedal Position Sensor 1 PWR	ECU 4	30	Inter CONN 2 (INT 2)	1	Twist Pair (428/429/430)
51	526	0.75	O	FLR91X-A_BS01	Crank Shaft Position Sensor POS	Inter CONN 2 (INT 2)	18	Crank Shaft Position Sensor (Crank)	2	Shield Pair (526/527), Twist Pair (526/527)
52	527	0.75	P	FLR91X-A_BS01	Crank Shaft Position Sensor NEG	Inter CONN 2 (INT 2)	17	Crank Shaft Position Sensor (Crank)	1	Shield Pair (526/527), Twist Pair (526/527)
53	524	0.75	B	FLR91X-A	Crank Shaft Position Sensor GND	Inter CONN 2 (INT 2)	19	Crank Shaft Position Sensor (Crank)	3	Shield Drain (526/527)
54	507	1.5	Brn	FLR91X-A_T08	Starter Relay High	Inter CONN 2 (INT 2)	15	Junction Box (JBOX) Starter Relay	86	Twist Pair (507/513)
55	513	1.5	W	FLR91X-A_T08	Starter Relay Low	Inter CONN 2 (INT 2)	16	Junction Box (JBOX) Starter Relay	85	Twist Pair (507/513)

No.	Wire Label	Size (mm^2)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
56	518	1.5	R	FLR91X-A	SCR DP Sensor A PWR	Inter CONN SCR (INT SCR)	11	Inter CONN 2 (INT 2)	20	
57	528	0.75	B	FLR91X-A	SCR DP Sensor A GND	Inter CONN SCR (INT SCR)	12	Inter CONN 2 (INT 2)	21	
58	509	1.5	G	FLR91X-A	SCR DP Sensor A Signal	Inter CONN SCR (INT SCR)	13	Inter CONN 2 (INT 2)	22	
59	P02	2	R	FLR91X-B	ALT PWR	SP04		Junction Box (JBOX) F4 (5A)	1	Splice 04
60	P03	1.5	R	FLR91X-A	ALT PWR	SP04		Junction Box (JBOX) F3 (25A)	1	Splice 04
61	P04	3	R	FLR91X-B	ALT PWR	SP04		SP05		Splice 04, Splice 05
62	P05	3	R	FLR91X-B	ALT PWR	SP06		SP05		Splice 05, Splice 06
63	P06	2	R	FLR91X-B	ALT PWR	SP06		Junction Box (JBOX) Starter Relay	30	Splice 06
64	13a	2	W	FLR91X-B	Start S	Start Signal (STS)	1	Junction Box (JBOX) Starter Relay	87	
65	P07	3	R	FLR91X-B	BAT PWR	SP06		Junction Box (JBOX) Fuel Heater Relay	30	Splice 06
66	P09	3	R	FLR91X-B	Fuel Heater PWR	SP07		Junction Box (JBOX) Fuel Heater Relay	87	Splice 07
67	419a	0.75	Y	FLR91X-A	Key-on (T15)	419		Junction Box (JBOX) Fuel Heater Relay	86	Splice 419
68	G02	0.75	B	FLR91X-A	BAT GND	SP02		Junction Box (JBOX) Fuel Heater Relay	85	Splice 02
69	G03	8	B	FLR91X-C	ALTernator GND	ALT E2 (GND2)	1	SP02		Splice 02
70	P08	8	R	FLR91X-C	ALTernator PWR	SP05		ALT B2 (PWR2)	1	Splice 05
71	9a	1.5	W	FLR91X-A	ALTernator I	ALT I(I)	1	Inter CONN 2 (INT 2)	8	
72	G04	1.5	B	FLR91X-A	ALT GND	SP02		Inter CONN 2 (INT 2)	9	Splice 02
73	G05	1.5	B	FLR91X-A	ALT GND	SP02		Inter CONN 2 (INT 2)	10	Splice 02
74	P15	1.5	R	FLR91X-A	Panel PWR	Inter CONN 2 (INT 2)	11	Junction Box (JBOX) F3 (25A)	2	
75	P11	1.5	R	FLR91X-A	Fuel Heater 1 PWR	SP07		Junction Box (JBOX) F1 (25A)	1	Splice 07
76	P12	1.5	R	FLR91X-A	Fuel Heater 2 PWR	SP07		Junction Box (JBOX) F2 (25A)	1	Splice 07
77	P13	1.5	R	FLR91X-A	Fuel Heater 1 PWR	Inter CONN 2 (INT 2)	13	Junction Box (JBOX) F1 (25A)	2	
78	P14	1.5	R	FLR91X-A	Fuel Heater 2 PWR	Inter CONN 2 (INT 2)	12	Junction Box (JBOX) F2 (25A)	2	
79	B01	8	R	FLR91X-C	Start PWR	SP08		Start B2 (SPWR 2)	1	Splice 08
80	B06	1.5	R	FLR91X-A	Hose Heater B PWR	Inter CONN SCR (INT SCR)	1	SP08		Splice 08
81	B07	1.5	R	FLR91X-A	Hose Heater A PWR	Inter CONN SCR (INT SCR)	2	SP08		Splice 08
82	B08	2	R	FLR91X-B	DCU B PWR	Inter CONN SCR (INT SCR)	3	SP08		Splice 08
83	B09	2	R	FLR91X-B	DCU A PWR	Inter CONN SCR (INT SCR)	4	SP08		Splice 08
84	E01	8	B	FLR91X-C	Start GND	SP09		Start E2 (SGND 2)	1	Splice 09

No.	Wire Label	Size (mm^2)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
85	E02	2	B	FLR91X-B	DCU B GND	SP09		Inter CONN SCR (INT SCR)	8	Splice 09
86	E03	2	B	FLR91X-B	DCU A GND	SP09		Inter CONN SCR (INT SCR)	9	Splice 09
87	G06	2	B	FLR91X-B	ALT GND	SP02		Inter CONN SCR (INT SCR)	10	Splice 02
88	419B	0.75	Y	FLR91X-A	Key-on (T15)	419		Inter CONN SCR (INT SCR)	18	Splice 419
89	G07	0.75	B	FLR91X-A	BAT GND	SP02		Junction Box (JBOX) E/G Stop Relay	85	Splice 02
90	P16	2.5	R	FLR91X-B	Key-on (T15)	Inter CONN 2 (INT 2)	14	Junction Box (JBOX) E/G Stop Relay	87a	
91	S01	0.75	Y	FLR91X-A	Emergency Stop Switch Signal	Inter CONN 2 (INT 2)	7	Junction Box (JBOX) E/G Stop Relay	86	

Marine Propulsion RH

No.	Wire Label	Size (mm²)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
92	419	0.75	Y	FLR91X-A	Key-on (T15)	Inter CONN 1 (INT 1)	20	Inter CONN 2 (INT 2)	14	Splice 419
93	S01	0.75	Y	FLR91X-A	Emergency Stop Switch	Inter CONN 1 (INT 1)	14	Inter CONN 2 (INT 2)	7	
94	425	0.75	B	FLR91X-A_T01	ACC.Pedal Position Sensor 2 GND	Position Sensor (PSS)	A	Inter CONN 2 (INT 2)	6	Twist Pair (425/426/427)
95	426	0.75	W	FLR91X-A_T01	ACC.Pedal Position Sensor 2 SIG	Position Sensor (PSS)	B	Inter CONN 2 (INT 2)	5	Twist Pair (425/426/427)
96	427	0.75	R	FLR91X-A_T01	ACC.Pedal Position Sensor 2 PWR	Position Sensor (PSS)	C	Inter CONN 2 (INT 2)	4	Twist Pair (425/426/427)
97	428	0.75	B	FLR91X-A_T02	ACC.Pedal Position Sensor 1 GND	Position Sensor (PSS)	D	Inter CONN 2 (INT 2)	3	Twist Pair (428/429/430)
98	429	0.75	Y	FLR91X-A_T02	ACC.Pedal Position Sensor 1 SIG	Position Sensor (PSS)	E	Inter CONN 2 (INT 2)	2	Twist Pair (428/429/430)
99	430	0.75	R	FLR91X-A_T02	ACC.Pedal Position Sensor 1 PWR	Position Sensor (PSS)	F	Inter CONN 2 (INT 2)	1	Twist Pair (428/429/430)
100	501	1.5	L	FLR91X-A_T03	CAN 1L	ECU 5	1	OBD CONN (OBD)	1	Splice 501, Twist Pair (501/504)
101	504	1.5	GrL	FLR91X-A_T03	CAN 1H	ECU 5	4	OBD CONN (OBD)	2	Splice 504, Twist Pair (501/504)
102	501A	1.5	L	FLR91X-A_T16	CAN 1L	501		Inter CONN 1 (INT 1)	12	Splice 501, Twist Pair (501A/504A)
103	504A	1.5	GrL	FLR91X-A_T16	CAN 1H	504		Inter CONN 1 (INT 1)	11	Splice 504, Twist Pair (501A/504A)
104	503	1.5	Y	FLR91X-A	Key Sw Start (T50)	ECU 5	3	Inter CONN 1 (INT 1)	29	
105	522	0.75	Y	FLR91X-A	Fuel Temp Sensor Signal	ECU 5	22	Fuel Temp Sensor (FTS)	1	
106	531	0.75	B	FLR91X-A	Fuel Temp Sensor GND	ECU 5	31	Fuel Temp Sensor (FTS)	2	
107	536	0.75	O	FLR91X-A_T15	Cam Shaft Position Sensor Signal	ECU 5	36	Cam Shaft Position Sensor (CAM)	2	Twist Pair (532/535/536)
108	535	0.75	R	FLR91X-A_T15	Cam Shaft Position Sensor PWR	ECU 5	35	Cam Shaft Position Sensor (CAM)	3	Twist Pair (532/535/536)
109	532	0.75	B	FLR91X-A_T15	Cam Shaft Position Sensor GND	ECU 5	32	Cam Shaft Position Sensor (CAM)	1	Twist Pair (532/535/536)
110	526	0.75	O	FLR91X-A_BS02	Crank Shaft Position Sensor POS	ECU 5	26	Inter CONN 2 (INT 2)	18	Shield Pair (526/527), Twist Pair (526/527)
111	527	0.75	P	FLR91X-A_BS02	Crank Shaft Position Sensor NEG	ECU 5	27	Inter CONN 2 (INT 2)	17	Shield Pair (526/527), Twist Pair (526/527)
112	524	0.75	B	FLR91X-A	Crank Shaft Position Sensor GND	ECU 5	24	Inter CONN 2 (INT 2)	19	Shield Drain (526/527)
113	507	1.5	Brn	FLR91X-A_T04	Starter Relay High	ECU 5	7	Inter CONN 2 (INT 2)	15	Twist Pair (507/513)
114	513	1.5	W	FLR91X-A_T04	Starter Relay Low	ECU 5	13	Inter CONN 2 (INT 2)	16	Twist Pair (507/513)

No.	Wire Label	Size (mm²)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
115	518	1.5	R	FLR91X-A	SCR DP Sensor A PWR	ECU 5	18	Inter CONN 2 (INT 2)	20	
116	528	0.75	B	FLR91X-A	SCR DP Sensor A GND	ECU 5	28	Inter CONN 2 (INT 2)	21	
117	509	1.5	G	FLR91X-A	SCR DP Sensor A Signal	ECU 5	9	Inter CONN 2 (INT 2)	22	
118	607	0.75	W	FLR91X-A_T05	CAN 2H	ECU 6	7	Inter CONN 1 (INT 1)	3	Splice 607, Twist Pair (607/608)
119	608	0.75	Y	FLR91X-A_T05	CAN 2L	ECU 6	8	Inter CONN 1 (INT 1)	2	Splice 608, Twist Pair (607/608)
120	614	0.75	Brn	FLR91X-A	Oil Press Sensor Signal	ECU 6	14	Oil Press Sensor (OPS)	1	
121	613	0.75	B	FLR91X-A	Oil Press Sensor GND	ECU 6	13	Oil Press Sensor (OPS)	2	Splice 613
122	635	0.75	R	FLR91X-A	Oil Press Sensor PWR	ECU 6	35	Oil Press Sensor (OPS)	3	
123	616	0.75	Y	FLR91X-A	Oil Temp Sensor Signal	ECU 6	16	Oil Temp Sensor (OTS)	1	
124	613A	0.75	B	FLR91X-A	Oil Temp Sensor GND	613		Oil Temp Sensor (OTS)	2	Splice 613
125	622	0.75	R	FLR91X-A	Boost Press/Temp Sensor PWR	ECU 6	22	Boost Press/Temp Sensor (BPTS)	3	
126	634	0.75	W	FLR91X-A	Boost Press Sensor Signal	ECU 6	34	Boost Press/Temp Sensor (BPTS)	4	
127	624	0.75	O	FLR91X-A	Boost Temp Sensor Signal	ECU 6	24	Boost Press/Temp Sensor (BPTS)	2	
128	623	0.75	B	FLR91X-A	Boost Press/Temp GND	ECU 6	23	Boost Press/Temp Sensor (BPTS)	1	
129	812	1.5	G	FLR91X-A_T06	Fuel Metering Unit RH High	ECU 8	12	Fuel Metering Unit RH (FMUR)	1	Twist Pair (809/812)
130	809	1.5	L	FLR91X-A_T06	Fuel Metering Unit RH Low	ECU 8	9	Fuel Metering Unit RH (FMUR)	2	Twist Pair (809/812)
131	825	0.75	Y	FLR91X-A	Ambient Temp Sensor Signal	ECU 8	25	Ambient Temp Sensor (ATS)	1	
132	822	0.75	B	FLR91X-A	Ambient Temp Sensor GND	ECU 8	22	Ambient Temp Sensor (ATS)	2	
133	824	0.75	R	FLR91X-A_T07	Rail Press Sensor RH PWR	ECU 8	24	Rail Press Sensor RH (RPSR)	3	Twist Pair (821/823/824)
134	821	0.75	W	FLR91X-A_T07	Rail Press Sensor RH Signal	ECU 8	21	Rail Press Sensor RH (RPSR)	2	Twist Pair (821/823/824)
135	823	0.75	B	FLR91X-A_T07	Rail Press Sensor RH GND	ECU 8	23	Rail Press Sensor RH (RPSR)	1	Twist Pair (821/823/824)
136	819	0.75	Y	FLR91X-A	EGT Sensor RH Signal	ECU 8	19	E/P EGT Sensor RH (E/P EGTR)	2	
137	820	0.75	B	FLR91X-A	EGT Sensor RH GND	ECU 8	20	E/P EGT Sensor RH (E/P EGTR)	1	
138	834	0.75	W	FLR91X-A	Compressor Temp Sensor RH Signal	ECU 8	34	T/C EGT Sensor RH (T/C EGTR)	2	
139	835	0.75	B	FLR91X-A	Compressor Temp Sensor RH GND	ECU 8	35	T/C EGT Sensor RH (T/C EGTR)	1	
140	810	1.5	W	FLR91X-A_T09	Injector 1 "High"	ECU 8	10	Injector Inline RH (INJR)	1	Twist Pair (801/810)
141	801	1.5	Y	FLR91X-A_T09	Injector 1 "Low"	ECU 8	1	Injector Inline RH (INJR)	2	Twist Pair (801/810)
142	813	1.5	GrL	FLR91X-A_T10	Injector 2 "High"	ECU 8	13	Injector Inline RH (INJR)	3	Twist Pair (804/813)

No.	Wire Label	Size (mm^2)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
143	804	1.5	G	FLR91X-A_T10	Injector 2 "Low"	ECU 8	4	Injector Inline RH (INJR)	4	Twist Pair (804/813)
144	816	1.5	W	FLR91X-A_T11	Injector 3 "High"	ECU 8	16	Injector Inline RH (INJR)	5	Twist Pair (807/816)
145	807	1.5	Y	FLR91X-A_T11	Injector 3 "Low"	ECU 8	7	Injector Inline RH (INJR)	6	Twist Pair (807/816)
146	814	1.5	GrL	FLR91X-A_T12	Injector 4 "High"	ECU 8	14	Injector Inline RH (INJR)	7	Twist Pair (805/814)
147	805	1.5	G	FLR91X-A_T12	Injector 4 "Low"	ECU 8	5	Injector Inline RH (INJR)	8	Twist Pair (805/814)
148	811	1.5	W	FLR91X-A_T13	Injector 5 "High"	ECU 8	11	Injector Inline RH (INJR)	9	Twist Pair (802/811)
149	802	1.5	Y	FLR91X-A_T13	Injector 5 "Low"	ECU 8	2	Injector Inline RH (INJR)	10	Twist Pair (802/811)
150	817	1.5	GrL	FLR91X-A_T14	Injector 6 "High"	ECU 8	17	Injector Inline RH (INJR)	11	Twist Pair (808/817)
151	808	1.5	G	FLR91X-A_T14	Injector 6 "Low"	ECU 8	8	Injector Inline RH (INJR)	12	Twist Pair (808/817)
152	9A	1.5	W	FLR91X-A	Alternator I	Inter CONN 1 (INT 1)	19	Inter CONN 2 (INT 2)	8	
153	G04	1.5	B	FLR91X-A	ALT GND	Fuel Heater 2 (FH 2)	B	Inter CONN 2 (INT 2)	9	Splice G04
154	G05	1.5	B	FLR91X-A	ALT GND	Fuel Heater 1 (FH 1)	B	Inter CONN 2 (INT 2)	10	Splice G05
155	P08	1.5	R	FLR91X-A	Alt PWR	Inter CONN 2 (INT 2)	11	Inter CONN 1 (INT 1)	17	Splice P08
156	P13	1.5	R	FLR91X-A	Fuel Heater 1 PWR	Inter CONN 2 (INT 2)	13	Fuel Heater 1 (FH1)	A	
157	P14	1.5	R	FLR91X-A	Fuel Heater 2 PWR	Inter CONN 2 (INT 2)	12	Fuel Heater 2 (FH2)	A	
158	419A	0.75	Y	FLR91X-A	Key-on (T15)	419		OBD CONN (OBD)	6	Splice 419
159	G05A	0.75	B	FLR91X-A	ALT GND	G05		OBD CONN (OBD)	3	Splice G05
160	P08A	0.75	R	FLR91X-A	Alt PWR	P08		OBD CONN (OBD)	4	Splice P08
161	P08B	0.75	R	FLR91X-A	E/G Emergency Stop S/W PWR	P08		Inter CONN 1 (INT 1)	22	Splice P08
162	P08C	1.5	R	FLR91X-A	Alt PWR	P08		Inter CONN 1 (INT 1)	27	Splice P08
163	G04A	1.5	B	FLR91X-A	ALT GND	G04		Inter CONN 1 (INT 1)	6	Splice G04
164	G04B	1.5	B	FLR91X-A	ALT GND	G04		Inter CONN 1 (INT 1)	13	Splice G04
165	1S	0.75	Y	FLR91X-A	Water In Fuel Sensor Signal	Inter CONN 1 (INT 1)	4	Water In Fuel Sensor (WIF)	1	
166	1G	0.75	B	FLR91X-A	Water In Fuel Sensor GND	Inter CONN 1 (INT 1)	5	Water In Fuel Sensor (WIF)	2	
167	7D	0.75	O	FLR91X-A_BS03	Gearbox Oil Press Sensor PWR	Inter CONN 1 (INT 1)	30	Gearbox Oil Press Sensor (GOPS)	1	Shield Pair (7D/15A)
168	15A	0.75	P	FLR91X-A_BS03	Gearbox Oil Press Sensor Signal	Inter CONN 1 (INT 1)	31	Gearbox Oil Press Sensor (GOPS)	2	Shield Pair (7D/15A)
169	7D#	0.75	B	FLR91X-A	Shield Drain	BLUNT (NO USE)		BLUNT (No Use)		Shield Drain (7D/15A)
170	607A	0.75	W	FLR91X-A_T08	CAN 2H	607		OBD CONN (OBD)	8	Splice 607, Twist Pair (607/608)

No.	Wire Label	Size (mm^2)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
171	608A	0.75	Y	FLR91X-A_T08	CAN 2L	608		OBD CONN (OBD)	7	Splice 608, Twist Pair (607/608)
172	2G	0.75	B	FLR91X-A	Fuel Leakage Switch GND	Inter CONN 1 (INT 1)	24	Fuel Leakage Switch (FLS)	1	
173	2S	0.75	W	FLR91X-A	Fuel Leakage Switch Signal	Inter CONN 1 (INT 1)	10	Fuel Leakage Switch (FLS)	2	
174	505	0.75	B	FLR91X-A	Wait to Disconnect LED Lamp Ground	ECU 5	5	Inter CONN 1 (INT 1)	7	
175	517	0.75	R	FLR91X-A	Wait to Disconnect LED Lamp Supply	ECU 5	17	Inter CONN 1 (INT 1)	8	

Auxiliary LH

No.	Wire Label	Size (mm^2)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
1	125	0.75	B	FLR91X-A	EGT Sensor LH GND	ECU 1	25	E/P EGT Sensor LH (E/P EGTI)	1	
2	126	0.75	Y	FLR91X-A	EGT Sensor LH Signal	ECU 1	26	E/P EGT Sensor LH (E/P EGTI)	2	
3	131	0.75	B	FLR91X-A	Compressor Temp Sensor LH GND	ECU 1	31	T/C EGT Sensor LH (T/C EGTI)	1	
4	132	0.75	W	FLR91X-A	Compressor Temp Sensor LH Signal	ECU 1	32	T/C EGT Sensor LH (T/C EGTI)	2	
5	127	0.75	P	FLR91X-A_T09	Rail Press Sensor LH PWR	ECU 1	27	Rail Press Sensor LH (Rpsl)	3	Twist Pair (121/124/127)
6	124	0.75	O	FLR91X-A_T09	Rail Press Sensor LH Signal	ECU 1	24	Rail Press Sensor LH (Rpsl)	2	Twist Pair (121/124/127)
7	121	0.75	B	FLR91X-A_T09	Rail Press Sensor LH GND	ECU 1	21	Rail Press Sensor LH (Rpsl)	1	Twist Pair (121/124/127)
8	111	1.5	W	FLR91X-A_T01	Injector 7 "High"	ECU 1	11	Injector Inline LH (INJL)	1	Twist Pair (102/111)
9	102	1.5	Y	FLR91X-A_T01	Injector 7 "Low"	ECU 1	2	Injector Inline LH (INJL)	2	Twist Pair (102/111)
10	117	1.5	GrL	FLR91X-A_T02	Injector 8 "High"	ECU 1	17	Injector Inline LH (INJL)	3	Twist Pair (108/117)
11	108	1.5	G	FLR91X-A_T02	Injector 8 "Low"	ECU 1	8	Injector Inline LH (INJL)	4	Twist Pair (108/117)
12	114	1.5	W	FLR91X-A_T03	Injector 9 "High"	ECU 1	14	Injector Inline LH (INJL)	5	Twist Pair (105/114)
13	105	1.5	Y	FLR91X-A_T03	Injector 9 "Low"	ECU 1	5	Injector Inline LH (INJL)	6	Twist Pair (105/114)
14	110	1.5	GrL	FLR91X-A_T04	Injector 10 "High"	ECU 1	10	Injector Inline LH (INJL)	7	Twist Pair (101/110)
15	101	1.5	G	FLR91X-A_T04	Injector 10 "Low"	ECU 1	1	Injector Inline LH (INJL)	8	Twist Pair (101/110)
16	113	1.5	W	FLR91X-A_T05	Injector 11 "High"	ECU 1	13	Injector Inline LH (INJL)	9	Twist Pair (104/113)
17	104	1.5	Y	FLR91X-A_T05	Injector 11 "Low"	ECU 1	4	Injector Inline LH (INJL)	10	Twist Pair (104/113)
18	116	1.5	GrL	FLR91X-A_T06	Injector 12 "High"	ECU 1	16	Injector Inline LH (INJL)	11	Twist Pair (107/116)
19	107	1.5	G	FLR91X-A_T06	Injector 12 "Low"	ECU 1	7	Injector Inline LH (INJL)	12	Twist Pair (107/116)
20	106	1.5	G	FLR91X-A_T07	Fuel Metering Unit LH High	ECU 1	6	Fuel Metering Unit LH (FMUL)	1	Twist Pair (103/106)
21	103	1.5	L	FLR91X-A_T07	Fuel Metering Unit LH Low	ECU 1	3	Fuel Metering Unit LH (FMUL)	2	Twist Pair (103/106)
22	135	0.75	Brn	FLR91X-A	Coolant Temp Sensor Signal	ECU 1	35	Coolant Temp Sensor (CTS)	1	
23	134	0.75	B	FLR91X-A	Coolant Temp Sensor GND	ECU 1	34	Coolant Temp Sensor (CTS)	2	
24	130	0.75	R	FLR91X-A	SCR DP Sensor B PWR	ECU 1	30	Inter CONN SCR (INT SCR)	5	
25	136	0.75	B	FLR91X-A	SCR DP Sensor B GND	ECU 1	36	Inter CONN SCR (INT SCR)	6	
26	133	0.75	G	FLR91X-A	SCR DP Sensor B Signal	ECU 1	33	Inter CONN SCR (INT SCR)	7	
27	225	0.75	B	FLR91X-A	DCU CAN Ground	ECU 2	25	ECU 2	28	
28	245	0.75	L	FLR91X-A_T10	CAN 3H	ECU 2	45	Inter CONN SCR (INT SCR)	14	Twist Pair (244/245)
29	244	0.75	O	FLR91X-A_T10	CAN 3L	ECU 2	44	Inter CONN SCR (INT SCR)	15	Twist Pair (244/245)

No.	Wire Label	Size (mm^2)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
30	216	0.75	Y	FLR91X-A_T11	CAN 0H	ECU 2	16	Inter CONN SCR (INT SCR)	16	Twist Pair (215/216)
31	215	0.75	W	FLR91X-A_T11	CAN 0L	ECU 2	15	Inter CONN SCR (INT SCR)	17	Twist Pair (215/216)
32	416	1.5	B	FLR91X-A	BAT GND 1	ECU 4	16	SP01		Splice 01
33	414	1.5	B	FLR91X-A	BAT GND 2	ECU 4	14	SP01		Splice 01
34	413	1.5	B	FLR91X-A	BAT GND 3	ECU 4	13	SP01		Splice 01
35	411	1.5	B	FLR91X-A	BAT GND 4	ECU 4	11	SP01		Splice 01
36	410	1.5	B	FLR91X-A	BAT GND 5	ECU 4	10	SP01		Splice 01
37	G01	2	B	FLR91X-B	ALT GND	SP01		SP02		Splice 01, Splice 02
38	401	1.5	R	FLR91X-A	BAT PWR 1	ECU 4	1	SP03		Splice 03
39	404	1.5	R	FLR91X-A	BAT PWR 2	ECU 4	4	SP03		Splice 03
40	405	1.5	R	FLR91X-A	BAT PWR 3	ECU 4	5	SP03		Splice 03
41	407	1.5	R	FLR91X-A	BAT PWR 4	ECU 4	7	SP03		Splice 03
42	408	1.5	R	FLR91X-A	BAT PWR 5	ECU 4	8	SP03		Splice 03
43	P01	2	R	FLR91X-B	ALT PWR	SP03		Junction Box (JBOX) F4 (5A)	2	Splice 03
44	419	0.75	Y	FLR91X-A	Key-on (T15)	ECU 4	19	Junction Box (JBOX) E/G Stop Relay	30	Splice 419
45	526	0.75	O	FLR91X-A_BS01	Crank Shaft Position Sensor POS	Inter CONN 2 (INT 2)	18	Crank Shaft Position Sensor (Crank)	2	Shield Pair (526/527), Twist Pair (526/527)
46	527	0.75	P	FLR91X-A_BS01	Crank Shaft Position Sensor NEG	Inter CONN 2 (INT 2)	17	Crank Shaft Position Sensor (Crank)	1	Shield Pair (526/527), Twist Pair (526/527)
47	524	0.75	B	FLR91X-A	Crank Shaft Position Sensor GND	Inter CONN 2 (INT 2)	19	Crank Shaft Position Sensor (Crank)	3	Shield Drain (526/527)
48	507	1.5	Brn	FLR91X-A_T08	Starter Relay High	Inter CONN 2 (INT 2)	15	Junction Box (JBOX) Starter Relay	86	Twist Pair (507/513)
49	513	1.5	W	FLR91X-A_T08	Starter Relay Low	Inter CONN 2 (INT 2)	16	Junction Box (JBOX) Starter Relay	85	Twist Pair (507/513)
50	518	1.5	R	FLR91X-A	SCR DP Sensor A PWR	Inter CONN SCR (INT SCR)	11	Inter CONN 2 (INT 2)	20	
51	528	0.75	B	FLR91X-A	SCR DP Sensor A GND	Inter CONN SCR (INT SCR)	12	Inter CONN 2 (INT 2)	21	
52	509	1.5	G	FLR91X-A	SCR DP Sensor A Signal	Inter CONN SCR (INT SCR)	13	Inter CONN 2 (INT 2)	22	
53	P02	2	R	FLR91X-B	Alt PWR	SP04		Junction Box (JBOX) F4 (5A)	1	Splice 04
54	P03	1.5	R	FLR91X-A	Alt PWR	SP04		Junction Box (JBOX) F3 (25A)	1	Splice 04
55	P04	3	R	FLR91X-B	Alt PWR	SP04		SP05		Splice 04, Splice 05
56	P05	3	R	FLR91X-B	Alt PWR	SP06		SP05		Splice 05, Splice 06
57	P06	2	R	FLR91X-B	Alt PWR	SP06		Junction Box (JBOX) Starter Relay	30	Splice 06
58	13A	2	W	FLR91X-B	Start S	START SIGNAL (STS)	1	Junction Box (JBOX) Starter Relay	87	
59	P07	3	R	FLR91X-B	BAT PWR	SP06		Junction Box (JBOX) Fuel Heater Relay	30	Splice 06

No.	Wire Label	Size (mm^2)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
60	P09	3	R	FLR91X-B	Fuel Heater PWR	SP07		Junction Box (JBOX) Fuel Heater Relay	87	Splice 07
61	419A	0.75	Y	FLR91X-A	Key-on (T15)	419		Junction Box (JBOX) Fuel Heater Relay	86	Splice 419
62	G02	0.75	B	FLR91X-A	BAT GND	SP02		Junction Box (JBOX) Fuel Heater Relay	85	Splice 02
63	G03	8	B	FLR91X-C	Alternator GND	ALT E2 (GND2)	1	SP02		Splice 02
64	P08	8	R	FLR91X-C	Alternator PWR	SP05		Alt B2 (PWR2)	1	Splice 05
65	9A	1.5	W	FLR91X-A	Alternator I	ALT I (I)	1	Inter CONN 2 (INT 2)	8	
66	G04	1.5	B	FLR91X-A	ALT GND	SP02		Inter CONN 2 (INT 2)	9	Splice 02
67	G05	1.5	B	FLR91X-A	ALT GND	SP02		Inter CONN 2 (INT 2)	10	Splice 02
68	P15	1.5	R	FLR91X-A	Panel PWR	Inter CONN 2 (INT 2)	11	Junction Box (JBOX) F3 (25A)	2	
69	P11	1.5	R	FLR91X-A	Fuel Heater 1 PWR	SP07		Junction Box (JBOX) F1 (25A)	1	Splice 07
70	P12	1.5	R	FLR91X-A	Fuel Heater 2 PWR	SP07		Junction Box (JBOX) F2 (25A)	1	Splice 07
71	P13	1.5	R	FLR91X-A	Fuel Heater 1 PWR	Inter CONN 2 (INT 2)	13	Junction Box (JBOX) F1 (25A)	2	
72	P14	1.5	R	FLR91X-A	Fuel Heater 2 PWR	Inter CONN 2 (INT 2)	12	Junction Box (JBOX) F2 (25A)	2	
73	B01	8	R	FLR91X-C	Start PWR	SP08		Start B2 (SPWR 2)	1	Splice 08
74	B06	1.5	R	FLR91X-A	Hose Heater B PWR	Inter CONN SCR (INT SCR)	1	SP08		Splice 08
75	B07	1.5	R	FLR91X-A	Hose Heater A PWR	Inter CONN SCR (INT SCR)	2	SP08		Splice 08
76	B08	2	R	FLR91X-B	DCU B PWR	Inter CONN SCR (INT SCR)	3	SP08		Splice 08
77	B09	2	R	FLR91X-B	DCU A PWR	Inter CONN SCR (INT SCR)	4	SP08		Splice 08
78	E01	8	B	FLR91X-C	Start GND	SP09		Start E2 (SGND 2)	1	Splice 09
79	E02	2	B	FLR91X-B	DCU B GND	SP09		Inter CONN SCR (INT SCR)	8	Splice 09
80	E03	2	B	FLR91X-B	DCU A GND	SP09		Inter CONN SCR (INT SCR)	9	Splice 09
81	G06	2	B	FLR91X-B	ALT GND	SP02		Inter CONN SCR (INT SCR)	10	Splice 02
82	419B	0.75	Y	FLR91X-A	Key-on (T15)	419		Inter CONN SCR (INT SCR)	18	Splice 419
83	G07	0.75	B	FLR91X-A	BAT GND	SP02		Junction Box (JBOX) E/G Stop Relay	85	Splice 02
84	P16	2.5	R	FLR91X-B	Key-on (T15)	Inter CONN 2 (INT 2)	14	Junction Box (JBOX) E/G Stop Relay	87a	
85	S01	0.75	Y	FLR91X-A	Emergency Stop Switch Signal	Inter CONN 2 (INT 2)	7	Junction Box (JBOX) E/G Stop Relay	86	

Auxiliary RH

No.	Wire Label	Size (mm^2)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
86	419	0.75	Y	FLR91X-A	Key-on (T15)	Inter CONN 1 (INT 1)	20	Inter CONN 2 (INT 2)	14	Splice 419
87	S01	0.75	Y	FLR91X-A	Emergency Stop Switch	Inter CONN 1 (INT 1)	14	Inter CONN 2 (INT 2)	7	
88	501	1.5	L	FLR91X-A_T03	CAN 1L	ECU 5	1	OBD CONN (OBD)	1	Splice 501, Twist Pair (501/504)
89	504	1.5	GrL	FLR91X-A_T03	CAN 1H	ECU 5	4	OBD CONN (OBD)	2	Splice 504, Twist Pair (501/504)
90	501A	1.5	L	FLR91X-A_T16	CAN 1L	501		Inter CONN 1 (INT 1)	12	Splice 501, Twist Pair (501A/504A)
91	504A	1.5	GrL	FLR91X-A_T16	CAN 1H	504		Inter CONN 1 (INT 1)	11	Splice 504, Twist Pair (501A/504A)
92	503	1.5	Y	FLR91X-A	Key Sw Start (T50)	ECU 5	3	Inter CONN 1 (INT 1)	29	
93	522	0.75	Y	FLR91X-A	Fuel Temp Sensor Signal	ECU 5	22	Fuel Temp Sensor (FTS)	1	
94	531	0.75	B	FLR91X-A	Fuel Temp Sensor GND	ECU 5	31	Fuel Temp Sensor (FTS)	2	
95	536	0.75	O	FLR91X-A_T15	CAM Shaft Position Sensor Signal	ECU 5	36	Cam Shaft Position Sensor (CAM)	2	Twist Pair (532/535/536)
96	535	0.75	R	FLR91X-A_T15	CAM Shaft Position Sensor PWR	ECU 5	35	Cam Shaft Position Sensor (CAM)	3	Twist Pair (532/535/536)
97	532	0.75	B	FLR91X-A_T15	CAM Shaft Position Sensor GND	ECU 5	32	Cam Shaft Position Sensor (CAM)	1	Twist Pair (532/535/536)
98	526	0.75	O	FLR91X-A_BS02	Crank Shaft Position Sensor POS	ECU 5	26	Inter CONN 2 (INT 2)	18	Shield Pair (526/527), Twist Pair (526/527)
99	527	0.75	P	FLR91X-A_BS02	Crank Shaft Position Sensor NEG	ECU 5	27	Inter CONN 2 (INT 2)	17	Shield Pair (526/527), Twist Pair (526/527)
100	524	0.75	B	FLR91X-A	Crank Shaft Position Sensor GND	ECU 5	24	Inter CONN 2 (INT 2)	19	Shield Drain (526/527)
101	507	1.5	Brn	FLR91X-A_T04	Starter Relay High	ECU 5	7	Inter CONN 2 (INT 2)	15	Twist Pair (507/513)
102	513	1.5	W	FLR91X-A_T04	Starter Relay Low	ECU 5	13	Inter CONN 2 (INT 2)	16	Twist Pair (507/513)
103	518	1.5	R	FLR91X-A	SCR DP Sensor A PWR	ECU 5	18	Inter CONN 2 (INT 2)	20	
104	528	0.75	B	FLR91X-A	SCR DP Sensor A GND	ECU 5	28	Inter CONN 2 (INT 2)	21	
105	509	1.5	G	FLR91X-A	SCR DP Sensor A Signal	ECU 5	9	Inter CONN 2 (INT 2)	22	
106	607	0.75	W	FLR91X-A_T05	CAN 2H	ECU 6	7	Inter CONN 1 (INT 1)	3	Splice 607, Twist Pair (607/608)
107	608	0.75	Y	FLR91X-A_T05	CAN 2L	ECU 6	8	Inter CONN 1 (INT 1)	2	Splice 608, Twist Pair (607/608)
108	614	0.75	Brn	FLR91X-A	Oil Press Sensor Signal	ECU 6	14	Oil Press Sensor (OPS)	1	
109	613	0.75	B	FLR91X-A	Oil Press Sensor GND	ECU 6	13	Oil Press Sensor (OPS)	2	Splice 613

No.	Wire Label	Size (mm^2)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
110	635	0.75	R	FLR91X-A	Oil Press Sensor PWR	ECU 6	35	Oil Press Sensor (OPS)	3	
111	616	0.75	Y	FLR91X-A	Oil Temp Sensor Signal	ECU 6	16	Oil Temp Sensor (OTS)	1	
112	613A	0.75	B	FLR91X-A	Oil Temp Sensor GND	613		Oil Temp Sensor (OTS)	2	Splice 613
113	622	0.75	R	FLR91X-A	Boost Press/Temp Sensor PWR	ECU 6	22	Boost Press/Temp Sensor (BPTS)	3	
114	634	0.75	W	FLR91X-A	Boost Press Sensor Signal	ECU 6	34	Boost Press/Temp Sensor (BPTS)	4	
115	624	0.75	O	FLR91X-A	Boost Temp Sensor Signal	ECU 6	24	Boost Press/Temp Sensor (BPTS)	2	
116	623	0.75	B	FLR91X-A	Boost Press/Temp GND	ECU 6	23	Boost Press/Temp Sensor (BPTS)	1	
117	812	1.5	G	FLR91X-A_T06	Fuel Metering Unit RH High	ECU 8	12	Fuel Metering Unit RH (FMUR)	1	Twist Pair (809/812)
118	809	1.5	L	FLR91X-A_T06	Fuel Metering Unit RH Low	ECU 8	9	Fuel Metering Unit RH (FMUR)	2	Twist Pair (809/812)
119	825	0.75	Y	FLR91X-A	Ambient Temp Sensor Signal	ECU 8	25	Ambient Temp Sensor (ATS)	1	
120	822	0.75	B	FLR91X-A	Ambient Temp Sensor GND	ECU 8	22	Ambient Temp Sensor (ATS)	2	
121	824	0.75	R	FLR91X-A_T07	Rail Press Sensor RH PWR	ECU 8	24	Rail Press Sensor RH (RPSR)	3	Twist Pair (821/823/824)
122	821	0.75	W	FLR91X-A_T07	Rail Press Sensor RH Signal	ECU 8	21	Rail Press Sensor RH (RPSR)	2	Twist Pair (821/823/824)
123	823	0.75	B	FLR91X-A_T07	Rail Press Sensor RH GND	ECU 8	23	Rail Press Sensor RH (RPSR)	1	Twist Pair (821/823/824)
124	819	0.75	Y	FLR91X-A	EGT Sensor RH Signal	ECU 8	19	E/P EGT Sensor RH (E/P EGTR)	2	
125	820	0.75	B	FLR91X-A	EGT Sensor RH GND	ECU 8	20	E/P EGT Sensor RH (E/P EGTR)	1	
126	834	0.75	W	FLR91X-A	Compressor Temp Sensor RH Signal	ECU 8	34	T/C EGT Sensor RH (T/C EGTR)	2	
127	835	0.75	B	FLR91X-A	Compressor Temp Sensor RH GND	ECU 8	35	T/C EGT Sensor RH (T/C EGTR)	1	
128	810	1.5	W	FLR91X-A_T09	Injector 1 "High"	ECU 8	10	Injector Inline RH (INJR)	1	Twist Pair (801/810)
129	801	1.5	Y	FLR91X-A_T09	Injector 1 "Low"	ECU 8	1	Injector Inline RH (INJR)	2	Twist Pair (801/810)
130	813	1.5	GrL	FLR91X-A_T10	Injector 2 "High"	ECU 8	13	Injector Inline RH (INJR)	3	Twist Pair (804/813)
131	804	1.5	G	FLR91X-A_T10	Injector 2 "Low"	ECU 8	4	Injector Inline RH (INJR)	4	Twist Pair (804/813)
132	816	1.5	W	FLR91X-A_T11	Injector 3 "High"	ECU 8	16	Injector Inline RH (INJR)	5	Twist Pair (807/816)
133	807	1.5	Y	FLR91X-A_T11	Injector 3 "Low"	ECU 8	7	Injector Inline RH (INJR)	6	Twist Pair (807/816)
134	814	1.5	GrL	FLR91X-A_T12	Injector 4 "High"	ECU 8	14	Injector Inline RH (INJR)	7	Twist Pair (805/814)
135	805	1.5	G	FLR91X-A_T12	Injector 4 "Low"	ECU 8	5	Injector Inline RH (INJR)	8	Twist Pair (805/814)
136	811	1.5	W	FLR91X-A_T13	Injector 5 "High"	ECU 8	11	Injector Inline RH (INJR)	9	Twist Pair (802/811)

No.	Wire Label	Size (mm²)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
137	802	1.5	Y	FLR91X-A_T13	Injector 5 "Low"	ECU 8	2	Injector Inline RH (INJR)	10	Twist Pair (802/811)
138	817	1.5	GrL	FLR91X-A_T14	Injector 6 "High"	ECU 8	17	Injector Inline RH (INJR)	11	Twist Pair (808/817)
139	808	1.5	G	FLR91X-A_T14	Injector 6 "Low"	ECU 8	8	Injector Inline RH (INJR)	12	Twist Pair (808/817)
140	9A	1.5	W	FLR91X-A	Alternator I	Inter CONN 1 (INT 1)	19	Inter CONN 2 (INT 2)	8	
141	G04	1.5	B	FLR91X-A	ALT GND	Fuel Heater 2 (FH2)	B	Inter CONN 2 (INT 2)	9	Splice G04
142	G05	1.5	B	FLR91X-A	ALT GND	Fuel Heater 1 (FH1)	B	Inter CONN 2 (INT 2)	10	Splice G05
143	P08	1.5	R	FLR91X-A	ALT PWR	Inter CONN 2 (INT 2)	11	Inter CONN 1 (INT 1)	17	Splice P08
144	P13	1.5	R	FLR91X-A	Fuel Heater 1 PWR	Inter CONN 2 (INT 2)	13	Fuel Heater 1 (FH 1)	A	
145	P14	1.5	R	FLR91X-A	Fuel Heater 2 PWR	Inter CONN 2 (INT 2)	12	Fuel Heater 2 (FH 2)	A	
146	419A	0.75	Y	FLR91X-A	Key-on (T15)	419		OBD CONN (OBD)	6	Splice 419
147	G05A	0.75	B	FLR91X-A	ALT GND	G05		OBD CONN (OBD)	3	Splice G05
148	P08A	0.75	R	FLR91X-A	Alt PWR	P08		OBD CONN (OBD)	4	Splice P08
149	P08B	0.75	R	FLR91X-A	E/G Emergency Stop S/W PWR	P08		Inter CONN 1 (INT 1)	22	Splice P08
150	P08C	1.5	R	FLR91X-A	ALT PWR	P08		Inter CONN 1 (INT 1)	27	Splice P08
151	G04A	1.5	B	FLR91X-A	ALT GND	G04		Inter CONN 1 (INT 1)	6	Splice G04
152	G04B	1.5	B	FLR91X-A	ALT GND	G04		Inter CONN 1 (INT 1)	13	Splice G04
153	1S	0.75	Y	FLR91X-A	Water In Fuel Sensor Signal	Inter CONN 1 (INT 1)	4	Water In Fuel Sensor (WIF)	1	
154	1G	0.75	B	FLR91X-A	Water In Fuel Sensor GND	Inter CONN 1 (INT 1)	5	Water In Fuel Sensor (WIF)	2	
155	607A	0.75	W	FLR91X-A_T08	CAN 2H	607		OBD CONN (OBD)	8	Splice 607, Twist Pair (607/608)
156	608A	0.75	Y	FLR91X-A_T08	CAN 2L	608		OBD CONN (OBD)	7	Splice 608, Twist Pair (607/608)
157	2G	0.75	B	FLR91X-A	Fuel Leakage Switch GND	Inter CONN 1 (INT 1)	24	Fuel Leakage Switch (FLS)	1	
158	2S	0.75	W	FLR91X-A	Fuel Leakage Switch Signal	Inter CONN 1 (INT 1)	10	Fuel Leakage Switch (FLS)	2	
159	505	0.75	B	FLR91X-A	Wait to Disconnect LED Lamp Ground	ECU 5	5	Inter CONN 1 (INT 1)	7	
160	517	0.75	R	FLR91X-A	Wait to Disconnect LED Lamp Supply	ECU 5	17	Inter CONN 1 (INT 1)	8	

Urea (DCU)

No.	Wire Label	Size (mm²)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
1	B06	1.50	R	FLR91X-A	Hose Heater B PWR	Inter CONN Urea Tank LH (Urea LH)	4	Inter CONN Engine (INT ENG)	1	
2	B07	1.50	R	FLR91X-A	Hose Heater A PWR	Inter CONN Urea Tank RH (Urea RH)	4	Inter CONN Engine (INT ENG)	2	
3	B08	2.00	R	FLR91X-B	DCU B PWR	Inter CONN Urea Tank LH (Urea LH)	5	Inter CONN Engine (INT ENG)	3	
4	B09	2.00	R	FLR91X-B	DCU A PWR	SP_01		Inter CONN Engine (INT ENG)	4	Splice 01
5	B09A	2.00	R	FLR91X-B	DCU A PWR	Inter CONN Urea Tank RH (Urea RH)	5	SP_01		Splice 01
6	B09B	0.75	R	FLR91X-A	DCU A PWR	SP_01		OBD CONN 1 (OBD 1)	4	Splice 01
7	130	0.75	R	FLR91X-A	SCA DP Sensor B PWR	Inter CONN Urea Tank LH (Urea LH)	1	Inter CONN Engine (INT ENG)	5	
8	136	0.75	B	FLR91X-A	SCA DP Sensor B GND	Inter CONN Urea Tank LH (Urea LH)	2	Inter CONN Engine (INT ENG)	6	
9	133	0.75	G	FLR91X-A	SCR DP Sensor B Signal	Inter CONN Urea Tank LH (Urea LH)	3	Inter CONN Engine (INT ENG)	7	
10	E02	2.00	B	FLR91X-B	DCU B GND	Inter CONN Urea Tank LH (Urea LH)	9	Inter CONN Engine (INT ENG)	8	
11	E03	2.00	B	FLR91X-B	DCU A GND	Inter CONN Urea Tank RH (Urea RH)	9	Inter CONN Engine (INT ENG)	9	
12	G06	2.00	B	FLR91X-B	ALT GND	SP_02		Inter CONN Engine (INT ENG)	10	Splice 02
13	G06A	2.00	B	FLR91X-B	ALT GND	Inter CONN Urea Tank LH (Urea LH)	10	SP_02		Splice 02
14	G06B	2.00	B	FLR91X-B	ALT GND	Inter CONN Urea Tank RH (Urea RH)	10	SP_02		Splice 02
15	G06C	0.75	B	FLR91X-A	ALT GND	OBD CONN 1 (OBD 1)	3	SP_02		Splice 02
16	518	0.75	R	FLR91X-A	SCR DP Sensor A PWR	Inter CONN Urea Tank RH (Urea RH)	1	Inter CONN Engine (INT ENG)	11	
17	528	0.75	B	FLR91X-A	SCA DP Sensor A GND	Inter CONN Urea Tank RH (Urea RH)	2	Inter CONN Engine (INT ENG)	12	
18	509	0.75	G	FLR91X-A	SCR DP Sensor A signal	Inter CONN Urea Tank RH (Urea RH)	3	Inter CONN Engine (INT ENG)	13	
19	245	1.50	L	FLR91X-A_T01	CAN 3H	SP_04		Inter CONN Engine (INT ENG)	14	Twist Pair (244/245)
20	244	1.50	GGra	FLR91X-A T01	CAN 3L	SP_04		Inter CONN Engine (INT ENG)	15	Twist Pair (244/245)

No.	Wire Label	Size (mm^2)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
21	245A	1.50	L	FLR91X-A_T05	CAN 3H	SP_04		OBD CONN 2 (OBD 2)	1	Twist Pair (244A/245A)/ Splice 04
22	244A	1.50	GGra	FLR91X-A T05	CAN 3L	SP_04		OBD CONN 2 (OBD 2)	2	Twist Pair (244A/245A)/ Splice 04
23	245B	1.50	L	FLR91X-A_T06	CAN 3H	Inter CONN Urea Tank LH (Urea LH)	12	SP_04	14	Twist Pair (244B/245B)
24	244B	1.50	GGra	FLR91X-A T06	CAN 3L	Inter CONN Urea Tank LH (Urea LH)	11	SP_04	15	Twist Pair (244B/2458)
25	216	0.75	Y	FLR91X-A T02	CAN OH	SP_05		Inter CONN Engine (INT ENG)	16	Twist Pair (215/216)
26	215	0.75	W	FLR91X-A T02	CAN DL	SP_05		Inter CONN Engine (INT ENG)	17	Twist Pair (215/216)
27	216A	0.75	Y	FLR91X-A T07	CAN OH	SP_05		OBD CONN 3 (OBD 3)	1	Twist Pair (215A/216A)/ SPLICE 05
28	215A	0.75	W	FLR91X-A T07	CAN OL	SP_05		OBD CONN 3 (OBD 3)	2	Twist Pair (215A/216A)/ Splice 05
29	216B	0.75	Y	FLR91X-A T08	CAN OH	Inter CONN Urea Tank RH (Urea RH)	12	SP_05	16	Twist Pair (215B/2168)
30	215B	0.75	W	FLR91X-A T08	CAN OL	Inter CONN Urea Tank RH (Urea RH)	11	SP_05	17	Twist Pair (215B/216B)
31	419	0.75	Y	FLR91X-A	Key-on (T15)	SP_03		Inter CONN Engine (INT ENG)	18	Splice 03
32	419A	0.75	Y	FLR91X-A	Key-on (T15)	Inter CONN Urea Tank LH (Urea LH)	8	SP_03		Splice 03
33	419B	0.75	Y	FLR91X-A	Key-on (T15)	Inter CONN Urea Tank RH (Urea RH)	8	SP_03		Splice 03
34	419C	0.75	Y	FLR91X-A	Key-on (T15)	OBD CONN 1 (OBD 1)	6	SP_03		Splice 03
35	211A	0.75	W	FLR91X-A T03	DCU 8 CAN 1H	Inter CONN Urea Tank LH (Urea LH)	6	OBD CONN 1 (OBD 1)	8	Twist Pair (211A/212A)
36	212A	0.75	O	FLR91X-A_T03	DCU 8 CAN 1L	Inter CONN Urea Tank LH (Urea LH)	7	OBD CONN 1 (OBD 1)	7	Twist Pair (211A/212A)
37	211B	0.75	W	FLR91X-A T04	DCU A CAN 1H	Inter CONN Urea Tank RH (Urea RH)	6	OBD CONN 1 (OBD 1)	2	Twist Pair (211B/212B)
38	212B	0.75	O	FLR91X-A_T04	DCU A CAN 1L	Inter CONN Urea Tank RH (Urea RH)	7	OBD CONN 1 (OBD 1)	1	Twist Pair (211B/212B)

Aftertreatment (ATS)

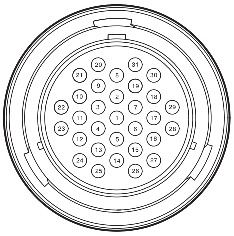
No.	Wire Label	Size (mm^2)	Color	Insulation	Circuit Description	From	No.	To	No.	Remark
1	112	0.75	W	FLR91X-A-T01	Reduction Agent Metering Valve Low	Dosing Module (DOS)	2	Inter CONN 3 (INT 3)	1	Twist Pair (112/132)
2	132	0.75	Y	FLR91X-A-T01	Reduction Agent Metering Valve High	Dosing Module (DOS)	1	Inter CONN 3 (INT 3)	2	Twist Pair (112/132)
3	133	0.75	W	FLR91X-A	SCR Upstream Signal	SCR Up Temp Sensor (SCR 1)	2	Inter CONN 2 (INT 2)	1	
4	134	0.75	B	FLR91X-A	SCR Upstream GND	SCR Up Temp Sensor (SCR 1)	1	Inter CONN 2 (INT 2)	2	
5	155	0.75	Y	FLR91X-A	SCR Downstream Signal	SCR Down Temp Sensor (SCR 2)	2	Inter CONN 2 (INT 2)	3	
6	154	0.75	B	FLR91X-A	SCR Downstream GND	SCR Down Temp Sensor (SCR 2)	1	Inter CONN 2 (INT 2)	4	
7	P01	0.75	R	FLR91X-A	NOX Sensor PWR	NOX Sensor (NOX)	1	Inter CONN 2 (INT 2)	5	
8	215	0.75	G	FLR91X-A-T02	DCU CANO Low	NOX Sensor (NOX)	2	Inter CONN 2 (INT 2)	6	Twist Pair (214/215)
9	214	0.75	W	FLR91X-A-T02	DCU CANO High	NOX Sensor (NOX)	3	Inter CONN 2 (INT 2)	7	Twist Pair (214/215)
10	G06	0.75	B	FLR91X-A	NOX Sensor GND	NOX Sensor (NOX)	4	Inter CONN 2 (INT 2)	8	
11	518	0.75	R	FLR91X-A	SCR DP Sensor A PWR	SCR DP Sensor (DPS)	1	Inter CONN 2 (INT 2)	11	
12	528	0.75	B	FLR91X-A	SCR DP Sensor A GND	SCR DP Sensor (DPS)	2	Inter CONN 2 (INT 2)	10	
13	509	0.75	G	FLR91X-A	SCR DP Sensor A Signal	SCR DP Sensor (DPS)	3	Inter CONN 2 (INT 2)	9	

8.2. Switches and Sensors

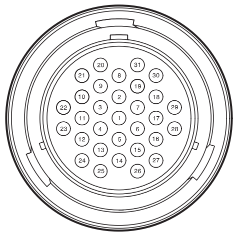
8.2.1. ECU (Engine Control Unit) Engine Connectors (Marine Propulsion LH & Auxiliary LH)

Marine Propulsion LH & Auxiliary LH

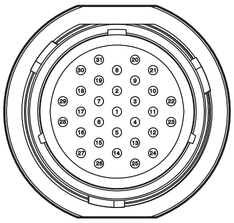
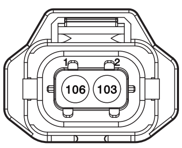
Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
Inter CONN (INT 2) (Propulsion)	425	0.75	B	FLR91X-A_T13	ACC.Pedal Position Sensor 2 GND	ECU 4	25	Inter CONN 2 (INT 2)	6
	426	0.75	W	FLR91X-A_T13	ACC.Pedal Position Sensor 2 SIG	ECU 4	26	Inter CONN 2 (INT 2)	5
	427	0.75	R	FLR91X-A_T13	ACC.Pedal Position Sensor 2 PWR	ECU 4	27	Inter CONN 2 (INT 2)	4
	428	0.75	B	FLR91X-A_T14	ACC.Pedal Position Sensor 1 GND	ECU 4	28	Inter CONN 2 (INT 2)	3
	429	0.75	Y	FLR91X-A_T14	ACC.Pedal Position Sensor 1 SIG	ECU 4	29	Inter CONN 2 (INT 2)	2
	430	0.75	R	FLR91X-A_T14	ACC.Pedal Position Sensor 1 PWR	ECU 4	30	Inter CONN 2 (INT 2)	1
	526	0.75	O	FLR91X-A_BS01	Crank Shaft Position Sensor POS	Inter CONN 2 (INT 2)	18	Crank Shaft Position Sensor (Crank)	2
	527	0.75	P	FLR91X-A_BS01	Crank Shaft Position Sensor Neg	Inter CONN 2 (INT 2)	17	Crank Shaft Position Sensor (Crank)	1
	524	0.75	B	FLR91X-A	Crank Shaft Position Sensor GND	Inter CONN 2 (INT 2)	19	Crank Shaft Position Sensor (Crank)	3
	507	1.5	Brn	FLR91X-A_T08	Starter Relay High	Inter CONN 2 (INT 2)	15	Junction Box (JBOX) Starter Relay	86
	513	1.5	W	FLR91X-A_T08	Starter Relay Low	Inter CONN 2 (INT 2)	16	Junction Box (JBOX) Starter Relay	85
	518	1.5	R	FLR91X-A	SCR DP Sensor A PWR	Inter CONN SCR (INT SCR)	11	Inter CONN 2 (INT 2)	20
	528	0.75	B	FLR91X-A	SCR DP Sensor A GND	Inter CONN SCR (INT SCR)	12	Inter CONN 2 (INT 2)	21
	509	1.5	G	FLR91X-A	SCR DP Sensor A Signal	Inter CONN SCR (INT SCR)	13	Inter CONN 2 (INT 2)	22
	9A	1.5	W	FLR91X-A	Alternator I	ALT I (I)	1	Inter CONN 2 (INT 2)	8
	G04	1.5	B	FLR91X-A	Alt GND	SP02		Inter CONN 2 (INT 2)	9
	G05	1.5	B	FLR91X-A	Alt GND	SP02		Inter CONN 2 (INT 2)	10
	P15	1.5	R	FLR91X-A	Panel PWR	Inter CONN 2 (INT 2)	11	Junction Box (JBOX) F3 (25A)	2
	P13	1.5	R	FLR91X-A	Fuel Heater 1 PWR	Inter CONN 2 (INT 2)	13	Junction Box (JBOX) F1(25A)	2
	P14	1.5	R	FLR91X-A	Fuel Heater 2 PWR	Inter CONN 2 (INT 2)	12	Junction Box (JBOX) F2 (25A)	2
	P16	2.5	R	FLR91X-B	Key-on (T15)	Inter CONN 2 (INT 2)	14	Junction Box (JBOX) E/G Stop Relay	87a
	S01	0.75	Y	FLR91X-A	Emergency Stop Switch Signal	Inter CONN 2 (INT 2)	7	Junction Box (JBOX) E/G Stop Relay	86



1	2	3	4	5
430	429	428	427	426
6	7	8	9	10
425	S01	9A	G04	G05
11	12	13	14	15
P15	P14	P13	P16	507
16	17	18	19	20
513	527	526	524	518
21	22	23	24	25
528	509	-	-	-
26	27	28	29	30
-	-	-	-	-
31				
-				

Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
Inter CONN 2 (INT 2) (Auxiliary) 	526	0.75	O	FLR91X-A_BS01	Crank Shaft Position Sensor POS	Inter CONN 2 (INT 2)	18	Crank Shaft Position Sensor (Crank)	2
	527	0.75	P	FLR91X-A_BS01	Crank Shaft Position Sensor NEG	Inter CONN 2 (INT 2)	17	Crank Shaft Position Sensor (Crank)	1
	524	0.75	B	FLR91X-A	Crank Shaft Position Sensor GND	Inter CONN 2 (INT 2)	19	Crank Shaft Position Sensor (Crank)	3
	507	1.5	Brn	FLR91X-A_T08	Starter Relay High	Inter CONN 2 (INT 2)	15	Junction Box (JBOX) Starter Relay	86
	513	1.5	W	FLR91X-A_T08	Starter Relay Low	Inter CONN 2 (INT 2)	16	Junction Box (JBOX) Starter Relay	85
	518	1.5	R	FLR91X-A	SCR DP Sensor A PWR	Inter CONN SCR (INT SCR)	11	Inter CONN 2 (INT 2)	20
	528	0.75	B	FLR91X-A	SCR DP Sensor A GND	Inter CONN SCR (INT SCR)	12	Inter CONN 2 (INT 2)	21
	509	1.5	G	FLR91X-A	SCR DP Sensor A Signal	Inter CONN SCR (INT SCR)	13	Inter CONN 2 (INT 2)	22
	9A	1.5	W	FLR91X-A	Alternator I	ALT I (I)	1	Inter CONN 2 (INT 2)	8
	G04	1.5	B	FLR91X-A	ALT GND	SP02		Inter CONN 2 (INT 2)	9
	G05	1.5	B	FLR91X-A	ALT GND	SP02		Inter CONN 2 (INT 2)	10
	P15	1.5	R	FLR91X-A	Panel PWR	Inter CONN 2 (INT 2)	11	Junction Box (JBOX) F3(25A)	2
	P13	1.5	R	FLR91X-A	Fuel Heater 1 PWR	Inter CONN 2 (INT 2)	13	Junction Box (JBOX) F1 (25A)	2
	P14	1.5	R	FLR91X-A	Fuel Heater 2 PWR	Inter CONN 2 (INT 2)	12	Junction Box (JBOX) F2 (25A)	2
	P16	2.5	R	FLR91X-B	Key-on (T15)	Inter CONN 2 (INT 2)	14	Junction Box (JBOX) E/G Stop Relay	87a
	S01	0.75	Y	FLR91X-A	Emergency Stop Switch Signal	Inter CONN 2 (INT 2)	7	Junction Box (JBOX) E/G Stop Relay	86

1	2	3	4	5
-	-	-	-	-
6	7	8	9	10
-	S01	9A	G04	G05
11	12	13	14	15
P15	P14	P13	P16	507
16	17	18	19	20
513	527	526	524	518
21	22	23	24	25
528	509	-	-	-
26	27	28	29	30
-	-	-	-	-
31				
-				

Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
Inter CONN SCR (INT SCR) 	130	0.75	R	FLR91X-A	SCR DP Sensor B PWR	ECU 1	30	Inter CONN SCR (INT SCR)	5
	136	0.75	B	FLR91X-A	SCR DP Sensor B GND	ECU 1	36	Inter CONN SCR (INT SCR)	6
	133	0.75	G	FLR91X-A	SCR DP Sensor B Signal	ECU 1	33	Inter CONN SCR (INT SCR)	7
	245	0.75	L	FLR91X-A_T10	CAN 3H	ECU 2	45	Inter CONN SCR (INT SCR)	14
	244	0.75	O	FLR91X-A_T10	CAN 3L	ECU 2	44	Inter CONN SCR (INT SCR)	15
	216	0.75	Y	FLR91X-A_T11	CAN 0H	ECU 2	16	Inter CONN SCR (INT SCR)	16
	215	0.75	W	FLR91X-A_T11	CAN 0L	ECU 2	15	Inter CONN SCR (INT SCR)	17
	518	1.5	R	FLR91X-A	SCR DP Sensor A PWR	Inter CONN SCR (INT SCR)	11	Inter CONN 2 (INT 2)	20
	528	0.75	B	FLR91X-A	SCR DP Sensor A GND	Inter CONN SCR (INT SCR)	12	Inter CONN 2 (INT 2)	21
	509	1.5	G	FLR91X-A	SCR DP Sensor A Signal	Inter CONN SCR (INT SCR)	13	Inter CONN 2 (INT 2)	22
	B06	1.5	R	FLR91X-A	Hose Heater B PWR	Inter CONN SCR (INT SCR)	1	SP08	
	B07	1.5	R	FLR91X-A	Hose Heater A PWR	Inter CONN SCR (INT SCR)	2	SP08	
	B08	2	R	FLR91X-B	DCU B PWR	Inter CONN SCR (INT SCR)	3	SP08	
	B09	2	R	FLR91X-B	DCU A PWR	Inter CONN SCR (INT SCR)	4	SP08	
	E02	2	B	FLR91X-B	DCU B GND	SP09		Inter CONN SCR (INT SCR)	8
	E03	2	B	FLR91X-B	DCU A GND	SP09		Inter CONN SCR (INT SCR)	9
	G06	2	B	FLR91X-B	ALT GND	SP02		Inter CONN SCR (INT SCR)	10
	419B	0.75	Y	FLR91X-A	Key-on (T15)	419		Inter CONN SCR (INT SCR)	18
Fuel Metering Unit LH (FMUL) 	106	1.5	G	FLR91X-A_T07	Fuel Metering Unit LH High	ECU 1	6	Fuel Metering Unit LH (FMUL)	1
	103	1.5	L	FLR91X-A_T07	Fuel Metering Unit LH LOW	ECU 1	3	Fuel Metering Unit LH (FMUL)	2

Inter CONN SCR (INT SCR) pin assignment:

1	2	3	4	5
B06	B07	B08	B09	130
6	7	8	9	10
136	133	E02	E03	G06
11	12	13	14	15
518	528	509	245	244
16	17	18	19	20
216	215	419B	-	-
21	22	23	24	25
-	-	-	-	-
26	27	28	29	30
-	-	-	-	-
31				
-				

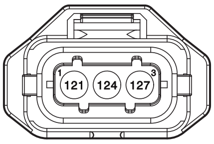
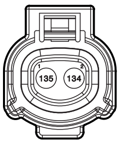
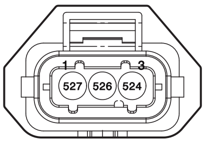
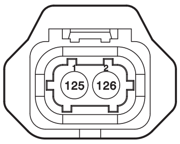
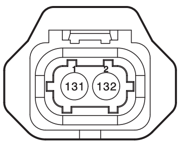
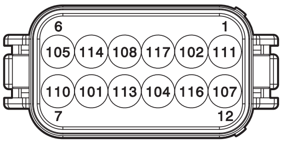
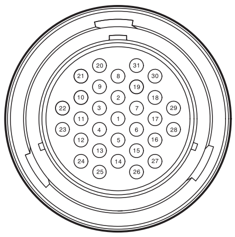
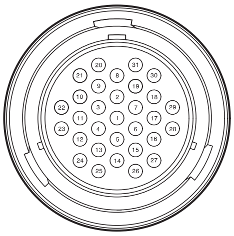
Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
Rail Press Sensor LH (RPSL) 	127	0.75	P	FLR91X-A_T09	Rail Press Sensor LH PWR	ECU 1	27	Rail Press Sensor LH (RPSL)	3
	124	0.75	O	FLR91X-A_T09	Rail Press Sensor LH Signal	ECU 1	24	Rail Press Sensor LH (RPSL)	2
	121	0.75	B	FLR91X-A_T09	Rail Press Sensor LH GND	ECU 1	21	Rail Press Sensor LH (RPSL)	1
Coolant Temp Sensor (CTS) 	135	0.75	Brn	FLR91X-A	Coolant Temp Sensor Signal	ECU 1	35	Coolant Temp Sensor (CTS)	1
	134	0.75	B	FLR91X-A	Coolant Temp Sensor GND	ECU 1	34	Coolant Temp Sensor (CTS)	2
Crank Shaft Position Sensor (CRANK) 	527	0.75	P	FLR91X-A BS01	Crank Shaft Position Sensor NEG	Inter CONN 2 (INT 2)	17	Crank Shaft Position Sensor (CRANK)	1
	526	0.75	O	FLR91X-A BS02	Crank Shaft Position Sensor POS	ECU 5	26	Inter CONN 2 (INT 2)	18
	524	0.75	B	FLR91X-A	Crank Shaft Position Sensor GND	ECU 5	24	Inter CONN 2 (INT 2)	19
E/P EGT Sensor LH (E/P EGTL) 	125	0.75	B	FLR91X-A	EGT Sensor LH GND	ECU 1	25	E/P EGT Sensor LH (E/P EGTL)	1
	126	0.75	Y	FLR91X-A	EGT Sensor LH SIGNAL	ECU 1	26	E/P EGT Sensor LH (E/P EGTL)	2
T/C EGT Sensor LH (T/C EGTL) 	131	0.75	B	FLR91X-A	Compressor Temp Sensor LH GND	ECU 1	31	T/C EGT Sensor LH (T/C EGTL)	1
	132	0.75	W	FLR91X-A	Compressor Temp Sensor LH Signal	ECU 1	32	T/C EGT Sensor LH (T/C EGTL)	2

Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
Injector Inline LH (INJL) 	111	1.5	W	FLR91X-A_T01	Injector 7 "High"	ECU 1	11	Injector Inline LH (INJL)	1
	102	1.5	Y	FLR91X-A_T01	Injector 7 "Low"	ECU 1	2	Injector Inline LH (INJL)	2
	117	1.5	GrL	FLR91X-A_T02	Injector 8 "High"	ECU 1	17	Injector Inline LH (INJL)	3
	108	1.5	G	FLR91X-A_T02	Injector 8 "Low"	ECU 1	8	Injector Inline LH (INJL)	4
	114	1.5	W	FLR91X-A_T03	Injector 9 "High"	ECU 1	14	Injector Inline LH (INJL)	5
	105	1.5	Y	FLR91X-A_T03	Injector 9 "Low"	ECU 1	5	Injector Inline LH (INJL)	6
	110	1.5	GrL	FLR91X-A_T04	Injector 10 "High"	ECU 1	10	Injector Inline LH (INJL)	7
	101	1.5	G	FLR91X-A_T04	Injector 10 "Low"	ECU 1	1	Injector Inline LH (INJL)	8
	113	1.5	W	FLR91X-A_T05	Injector 11 "High"	ECU 1	13	Injector Inline LH (INJL)	9
	104	1.5	Y	FLR91X-A_T05	Injector 11 "Low"	ECU 1	4	Injector Inline LH (INJL)	10
	116	1.5	GrL	FLR91X-A_T06	Injector 12 "High"	ECU 1	16	Injector Inline LH (INJL)	11
	107	1.5	G	FLR91X-A_T06	Injector 12 "Low"	ECU 1	7	Injector Inline LH (INJL)	12

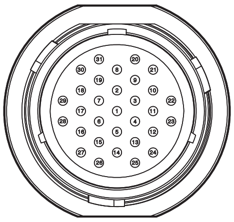
Marine Propulsion RH & Auxiliary RH

Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
Inter CONN (INT 2) (Propulsion) 	425	0.75	B	FLR91X-A_T13	ACC.Pedal Position Sensor 2 GND	ECU 4	25	Inter CONN 2 (INT 2)	6
	426	0.75	W	FLR91X-A_T13	ACC.Pedal Position Sensor 2 SIG	ECU 4	26	Inter CONN 2 (INT 2)	5
	427	0.75	R	FLR91X-A_T13	ACC.Pedal Position Sensor 2 PWR	ECU 4	27	Inter CONN 2 (INT 2)	4
	428	0.75	B	FLR91X-A_T14	ACC.Pedal Position Sensor 1 GND	ECU 4	28	Inter CONN 2 (INT 2)	3
	429	0.75	Y	FLR91X-A_T14	ACC.Pedal Position Sensor 1 SIG	ECU 4	29	Inter CONN 2 (INT 2)	2
	430	0.75	R	FLR91X-A_T14	ACC.Pedal Position Sensor 1 PWR	ECU 4	30	Inter CONN 2 (INT 2)	1
	526	0.75	O	FLR91X-A_BS01	Crank Shaft Position Sensor POS	Inter CONN 2 (INT 2)	18	Crank Shaft Position Sensor (Crank)	2
	527	0.75	P	FLR91X-A_BS01	Crank Shaft Position Sensor Neg	Inter CONN 2 (INT 2)	17	Crank Shaft Position Sensor (Crank)	1
	524	0.75	B	FLR91X-A	Crank Shaft Position Sensor GND	Inter CONN 2 (INT 2)	19	Crank Shaft Position Sensor (Crank)	3
	507	1.5	Brn	FLR91X-A_T08	Starter Relay High	Inter CONN 2 (INT 2)	15	Junction Box (JBOX) Starter Relay	86
	513	1.5	W	FLR91X-A_T08	Starter Relay Low	Inter CONN 2 (INT 2)	16	Junction Box (JBOX) Starter Relay	85
	518	1.5	R	FLR91X-A	SCR DP Sensor A PWR	Inter CONN SCR (INT SCR)	11	Inter CONN 2 (INT 2)	20
	528	0.75	B	FLR91X-A	SCR DP Sensor A GND	Inter CONN SCR (INT SCR)	12	Inter CONN 2 (INT 2)	21
	509	1.5	G	FLR91X-A	SCR DP Sensor A Signal	Inter CONN SCR (INT SCR)	13	Inter CONN 2 (INT 2)	22
	9A	1.5	W	FLR91X-A	Alternator I	ALT I (I)	1	Inter CONN 2 (INT 2)	8
	G04	1.5	B	FLR91X-A	Alt GND	SP02		Inter CONN 2 (INT 2)	9
	G05	1.5	B	FLR91X-A	Alt GND	SP02		Inter CONN 2 (INT 2)	10
	P15	1.5	R	FLR91X-A	Panel PWR	Inter CONN 2 (INT 2)	11	Junction Box (JBOX) F3 (25A)	2
	P13	1.5	R	FLR91X-A	Fuel Heater 1 PWR	Inter CONN 2 (INT 2)	13	Junction Box (JBOX) F1(25A)	2
	P14	1.5	R	FLR91X-A	Fuel Heater 2 PWR	Inter CONN 2 (INT 2)	12	Junction Box (JBOX) F2 (25A)	2
	P16	2.5	R	FLR91X-B	Key-on (T15)	Inter CONN 2 (INT 2)	14	Junction Box (JBOX) E/G Stop Relay	87a
	S01	0.75	Y	FLR91X-A	Emergency Stop Switch Signal	Inter CONN 2 (INT 2)	7	Junction Box (JBOX) E/G Stop Relay	86

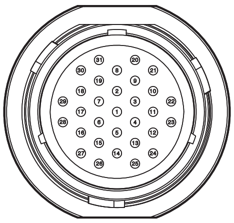
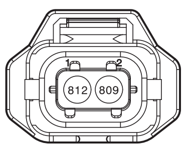
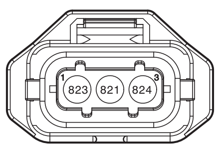
1	2	3	4	5
430	429	428	427	426
6	7	8	9	10
425	S01	9A	G04	G05
11	12	13	14	15
P15	P14	P13	P16	507
16	17	18	19	20
513	527	526	524	518
21	22	23	24	25
528	509	-	-	-
26	27	28	29	30
-	-	-	-	-
31				
-				

Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
Inter CONN 2 (INT 2) (Auxiliary)	526	0.75	O	FLR91X-A_BS01	Crank Shaft Position Sensor POS	Inter CONN 2 (INT 2)	18	Crank Shaft Position Sensor (Crank)	2
	527	0.75	P	FLR91X-A_BS01	Crank Shaft Position Sensor NEG	Inter CONN 2 (INT 2)	17	Crank Shaft Position Sensor (Crank)	1
	524	0.75	B	FLR91X-A	Crank Shaft Position Sensor GND	Inter CONN 2 (INT 2)	19	Crank Shaft Position Sensor (Crank)	3
	507	1.5	Brn	FLR91X-A_T08	Starter Relay High	Inter CONN 2 (INT 2)	15	Junction Box (JBOX) Starter Relay	86
	513	1.5	W	FLR91X-A_T08	Starter Relay Low	Inter CONN 2 (INT 2)	16	Junction Box (JBOX) Starter Relay	85
	518	1.5	R	FLR91X-A	SCR DP Sensor A PWR	Inter CONN SCR (INT SCR)	11	Inter CONN 2 (INT 2)	20
	528	0.75	B	FLR91X-A	SCR DP Sensor A GND	Inter CONN SCR (INT SCR)	12	Inter CONN 2 (INT 2)	21
	509	1.5	G	FLR91X-A	SCR DP Sensor A Signal	Inter CONN SCR (INT SCR)	13	Inter CONN 2 (INT 2)	22
	9A	1.5	W	FLR91X-A	Alternator I	ALT I (I)	1	Inter CONN 2 (INT 2)	8
	G04	1.5	B	FLR91X-A	ALT GND	SP02		Inter CONN 2 (INT 2)	9
	G05	1.5	B	FLR91X-A	ALT GND	SP02		Inter CONN 2 (INT 2)	10
	P15	1.5	R	FLR91X-A	Panel PWR	Inter CONN 2 (INT 2)	11	Junction Box (JBOX) F3(25A)	2
	P13	1.5	R	FLR91X-A	Fuel Heater 1 PWR	Inter CONN 2 (INT 2)	13	Junction Box (JBOX) F1 (25A)	2
	P14	1.5	R	FLR91X-A	Fuel Heater 2 PWR	Inter CONN 2 (INT 2)	12	Junction Box (JBOX) F2 (25A)	2
	P16	2.5	R	FLR91X-B	Key-on (T15)	Inter CONN 2 (INT 2)	14	Junction Box (JBOX) E/G Stop Relay	87a
	S01	0.75	Y	FLR91X-A	Emergency Stop Switch Signal	Inter CONN 2 (INT 2)	7	Junction Box (JBOX) E/G Stop Relay	86

1	2	3	4	5
-	-	-	-	-
6	7	8	9	10
-	S01	9A	G04	G05
11	12	13	14	15
P15	P14	P13	P16	507
16	17	18	19	20
513	527	526	524	518
21	22	23	24	25
528	509	-	-	-
26	27	28	29	30
-	-	-	-	-
31				
-				

Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
Inter CONN 1 (INT 1) (Propulsion) 	419	0.75	Y	FLR91X-A	Key-on (T15)	Inter CONN 1 (INT 1)	20	Inter CONN 2 (INT 2)	14
	S01	0.75	Y	FLR91X-A	Emergency Stop Switch	Inter CONN 1 (INT 1)	14	Inter CONN 2 (INT 2)	7
	501A	1.5	L	FLR91X-A_T16	CAN 1L	501		Inter CONN 1 (INT 1)	12
	504A	1.5	GrL	FLR91X-A_T16	CAN 1H	504		Inter CONN 1 (INT 1)	11
	503	1.5	Y	FLR91X-A	Key SW Start (T50)	ECU 5	3	Inter CONN 1 (INT 1)	29
	607	0.75	W	FLR91X-A_T05	CAN 2H	ECU 6	7	Inter CONN 1 (INT 1)	3
	608	0.75	Y	FLR91X-A_T05	CAN 2L	ECU 6	8	Inter CONN 1 (INT 1)	2
	9A	1.5	W	FLR91X-A	Alternator I	Inter CONN 1 (INT 1)	19	Inter CONN 2 (INT 2)	8
	P08	1.5	R	FLR91X-A	ALT PWR	Inter CONN 2 (INT 2)	11	Inter CONN 1 (INT 1)	17
	P08B	0.75	R	FLR91X-A	E/G Emergency Stop S/W PWR	P08		Inter CONN 1 (INT 1)	22
	P08C	1.5	R	FLR91X-A	ALT PWR	P08		Inter CONN 1 (INT 1)	27
	G04A	1.5	B	FLR91X-A	ALT GND	G04		Inter CONN 1 (INT 1)	6
	G04B	1.5	B	FLR91X-A	ALT GND	G04		Inter CONN 1 (INT 1)	13
	1S	0.75	Y	FLR91X-A	Water in Fuel Sensor Signal	Inter CONN 1 (INT 1)	4	Water in Fuel Sensor (WIF)	1
	1G	0.75	B	FLR91X-A	Water in Fuel Sensor GND	Inter CONN 1 (INT 1)	5	Water in Fuel Sensor (WIF)	2
	7D	0.75	O	FLR91X-A_BS03	Gearbox Oil Press Sensor PWR	Inter CONN 1 (INT 1)	30	Gearbox Oil Press Sensor (GOPS)	1
	15A	0.75	P	FLR91X-A_BS03	Gearbox Oil Press Sensor Signal	Inter CONN 1 (INT 1)	31	Gearbox Oil Press Sensor (GOPS)	2
	2G	0.75	B	FLR91X-A	Fuel Leakage Switch GND	Inter CONN 1 (INT 1)	24	Fuel Leakage Switch (FLS)	1
	2S	0.75	W	FLR91X-A	Fuel Leakage Switch SIGNAL	Inter CONN 1 (INT 1)	10	Fuel Leakage Switch (FLS)	2
	505	0.75	B	FLR91X-A	Wait to Disconnect LED Lamp Ground	ECU 5	5	Inter CONN 1 (INT 1)	7
	517	0.75	R	FLR91X-A	Wait to Disconnect LED Lamp Supply	ECU 5	17	Inter CONN 1 (INT 1)	8

1	2	3	4	5
-	608	607	1S	1G
6	7	8	9	10
G04A	505	517	-	2S
11	12	13	14	15
504A	501A	G04B	S01	-
16	17	18	19	20
-	P08	-	9A	419
21	22	23	24	25
-	P08B	-	2G	-
26	27	28	29	30
-	P08C	-	503	7D
31				
15A				

Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
Inter CONN 1 (INT 1) (Auxiliary) 	419	0.75	Y	FLR91X-A	Key-on (T15)	Inter CONN 1 (INT 1)	20	Inter CONN 2 (INT 2)	
	S01	0.75	Y	FLR91X-A	Emergency Stop Switch	Inter CONN 1 (INT 1)	14	Inter CONN 2 (INT 2)	
	501A	1.5	L	FLR91X-A_T16	CAN 1L	501		Inter CONN 1 (INT 1)	
	504A	1.5	GrL	FLR91X-A_T16	CAN 1H	504		Inter CONN 1 (INT 1)	
	503	1.5	Y	FLR91X-A	Key SW Start (T50)	ECU 5	3	Inter CONN 1 (INT 1)	
	607	0.75	W	FLR91X-A_T05	CAN 2H	ECU 6	7	Inter CONN 1 (INT 1)	
	608	0.75	Y	FLR91X-A_T05	CAN 2L	ECU 6	8	Inter CONN 1 (INT 1)	
	9A	1.5	W	FLR91X-A	Alternator I	Inter CONN 1 (INT 1)	19	Inter CONN 2 (INT 2)	
	P08	1.5	R	FLR91X-A	ALT PWR	Inter CONN 2 (INT 2)	11	Inter CONN 1 (INT 1)	
	P08B	0.75	R	FLR91X-A	E/G Emergency Stop S/W PWR	P08		Inter CONN 1 (INT 1)	
	P08C	1.5	R	FLR91X-A	ALT PWR	P08		Inter CONN 1 (INT 1)	
	G04A	1.5	B	FLR91X-A	ALT GND	G04		Inter CONN 1 (INT 1)	
	G04B	1.5	B	FLR91X-A	ALT GND	G04		Inter CONN 1 (INT 1)	
	1S	0.75	Y	FLR91X-A	Water in Fuel Sensor Signal	Inter CONN 1 (INT 1)	4	Water in Fuel Sensor (WIF)	
	1G	0.75	B	FLR91X-A	Water in Fuel Sensor GND	Inter CONN 1 (INT 1)	5	Water In Fuel Sensor (WIF)	
	2G	0.75	B	FLR91X-A	Fuel Leakage Switch GND	Inter CONN 1 (INT 1)	24	Fuel Leakage Switch (FLS)	
	2S	0.75	W	FLR91X-A	Fuel Leakage Switch Signal	Inter CONN 1 (INT 1)	10	Fuel Leakage Switch (FLS)	
	505	0.75	B	FLR91X-A	Wait to Disconnect LED Lamp Ground	ECU 5	5	Inter CONN 1 (INT 1)	
	517	0.75	R	FLR91X-A	Wait to Disconnect LED Lamp Supply	ECU 5	17	Inter CONN 1 (INT 1)	
Fuel Metering Unit RH (FMUL)  1 2 812 809	812	1.5	G	FLR91X-A_T06	Fuel Metering Unit RH High	ECU 8	12	Fuel Metering Unit RH (FMUR)	1
	809	1.5	L	FLR91X-A_T06	Fuel Metering Unit RH Low	ECU 8	9	Fuel Metering Unit RH (FMUR)	2
Rail Press Sensor RH (RPSL)  1 3 823 821 824	824	0.75	R	FLR91X-A_T07	Rail Press Sensor RH PWR	ECU 8	24	Rail Press Sensor RH (RPSR)	3
	821	0.75	W	FLR91X-A_T07	Rail Press Sensor RH Signal	ECU 8	21	Rail Press Sensor RH (RPSR)	2
	823	0.75	B	FLR91X-A_T07	Rail Press Sensor RH GND	ECU 8	23	Rail Press Sensor RH (RPSR)	1

1	2	3	4	5
-	608	607	1S	1G
6	7	8	9	10
G04A	505	517	-	2S
11	12	13	14	15
504A	501A	G04B	S01	-
16	17	18	19	20
-	P08	-	9A	419
21	22	23	24	25
-	P08B	-	2G	-
26	27	28	29	30
-	P08C	-	503	-
31				
-				

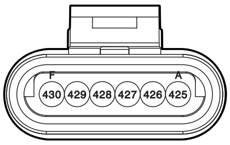
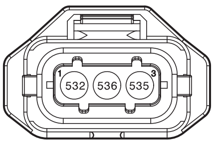
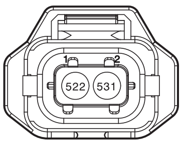
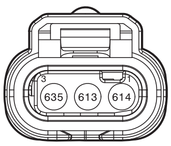
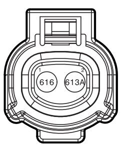
Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
Position Sensor (PSS)  	425	0.75	B	FLR91X-A_T01	ACC.Pedal Position Sensor 2 GND	Position Sensor (PSS)	A	Inter CONN 2 (INT 2)	6
	426	0.75	W	FLR91X-A_T01	ACC.Pedal Position Sensor 2 SIG	Position Sensor (PSS)	B	Inter CONN 2 (INT 2)	5
	427	0.75	R	FLR91X-A_T01	ACC.Pedal Position Sensor 2 PWR	Position Sensor (PSS)	C	Inter CONN 2 (INT 2)	4
	428	0.75	B	FLR91X-A_T02	ACC.Pedal Position Sensor 1 GND	Position Sensor (PSS)	D	Inter CONN 2 (INT 2)	3
	429	0.75	Y	FLR91X-A_T02	ACC.Pedal Position Sensor 1 SIG	Position Sensor (PSS)	E	Inter CONN 2 (INT 2)	2
	430	0.75	R	FLR91X-A_T02	ACC.Pedal Position Sensor 1 PWR	Position Sensor (PSS)	F	Inter CONN 2 (INT 2)	1
Cam Shaft Position Sensor (CAM)  	536	0.75	O	FLR91X-A_T15	Cam Shaft Position Sensor Signal	ECU 5	36	Cam Shaft Position Sensor (CAM)	2
	535	0.75	R	FLR91X-A_T15	Cam Shaft Position Sensor PWR	ECU 5	35	Cam Shaft Position Sensor (CAM)	3
	532	0.75	B	FLR91X-A_T15	Cam Shaft Position Sensor GND	ECU 5	32	Cam Shaft Position Sensor (CAM)	1
Fuel Temp Sensor (FTS)  	522	0.75	Y	FLR91X-A	Fuel Temp Sensor Signal	ECU 5	22	Fuel Temp Sensor (FTS)	1
	531	0.75	B	FLR91X-A	Fuel Temp Sensor GND	ECU 5	31	Fuel Temp Sensor (FTS)	2
Oil Press Sensor (OPS)  	614	0.75	Brn	FLR91X-A	Oil Press Sensor Signal	ECU 6	14	Oil Press Sensor (OPS)	1
	613	0.75	B	FLR91X-A	Oil Press Sensor GND	ECU 6	13	Oil Press Sensor (OPS)	2
	635	0.75	R	FLR91X-A	Oil Press Sensor PWR	ECU 6	35	Oil Press Sensor (OPS)	3
Oil Temp Sensor (OTS)  	616	0.75	Y	FLR91X-A	Oil Temp Sensor Signal	ECU 6	16	Oil Temp Sensor (OTS)	1
	613A	0.75	B	FLR91X-A	Oil Temp Sensor GND	613		Oil Temp Sensor (OTS)	2

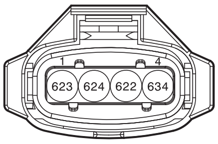
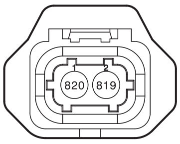
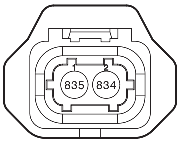
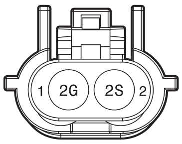
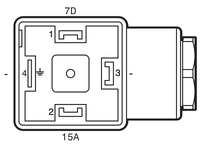
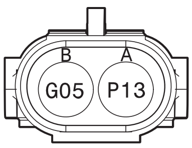
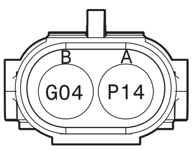
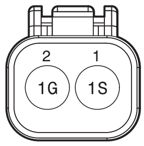
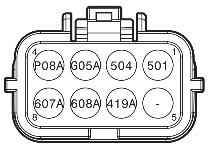
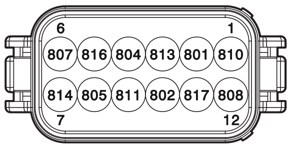
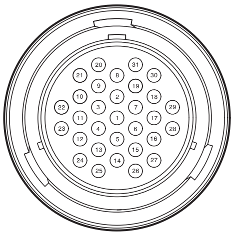
Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
Boost Press/Temp Sensor (BPTS) 	622	0.75	R	FLR91X-A	Boost Press/Temp Sensor PWR	ECU 6	22	Boost Press/Temp Sensor (BPTS)	3
	634	0.75	W	FLR91X-A	Boost Press Sensor Signal	ECU 6	34	Boost Press/Temp Sensor (BPTS)	4
	624	0.75	O	FLR91X-A	Boost Temp Sensor Signal	ECU 6	24	Boost Press/Temp Sensor (BPTS)	2
	623	0.75	B	FLR91X-A	Boost Press/Temp GND	ECU 6	23	Boost Press/Temp Sensor (BPTS)	1
E/P EGT Sensor RH (E/P EGTL) 	819	0.75	Y	FLR91X-A	EGT Sensor RH Signal	ECU 8	19	E/P EGT Sensor RH (E/P EGTR)	2
	820	0.75	B	FLR91X-A	EGT Sensor RH GND	ECU 8	20	E/P EGT Sensor RH (E/P EGTR)	1
T/C EGT Sensor RH (T/C EGTL) 	834	0.75	W	FLR91X-A	Compressor Temp Sensor RH Signal	ECU 8	34	T/C EGT Sensor RH (T/C EGTR)	2
	835	0.75	B	FLR91X-A	Compressor Temp Sensor RH GND	ECU 8	35	T/C EGT Sensor RH (T/C EGTR)	1
Fuel Leakage Switch (FLS) 	2G	0.75	B	FLR91X-A	Fuel Leakage Switch GND	Inter CONN 1 (INT 1)	24	Fuel Leakage Switch (FLS)	1
(Only for double pipe option)	2S	0.75	W	FLR91X-A	Fuel Leakage Switch Signal	Inter CONN 1 (INT 1)	10	Fuel Leakage Switch (FLS)	2
Gearbox Oil Press Sensor (GOPS) 	7D	0.75	O	FLR91X-A_BS03	Gearbox Oil Press Sensor PWR	Inter CONN 1 (INT 1)	30	Gearbox Oil Press Sensor (GOPS)	1
(Only for propulsion)	15A	0.75	P	FLR91X-A_BS03	Gearbox Oil Press Sensor Signal	Inter CONN 1 (INT 1)	31	Gearbox Oil Press Sensor (GOPS)	2
Fuel Heater 1 (FH1) 	G05	1.5	B	FLR91X-A	ALT GND	Fuel Heater 1 (FH1)	B	Inter CONN 2 (INT 2)	10
	P13	1.5	R	FLR91X-A	Fuel Heater 1 PWR	Inter CONN 2 (INT 2)	13	Fuel Heater 1 (FH1)	A
Fuel Heater 2 (FH2) 	G04	1.5	B	FLR91X-A	ALT GNO	SP02		Inter CONN 2 (INT 2)	9
	P14	1.5	R	FLR91X·A	Fuel Heater 2 PWR	Inter CONN 2 (INT 2)	12	Junction Box (JBOX) F2 (25A)	2

Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
Water in Fuel Sensor (WIF) 	1S	0.75	Y	FLR91X-A	Water in Fuel Sensor Signal	Inter CONN 1 (INT 1)	4	Water in Fuel Sensor (WIF)	1
	1G	0.75	B	FLR91X-A	Water in Fuel Sensor GND	Inter CONN 1 (INT 1)	5	Water in Fuel Sensor (WIF)	2
OBD CONN (OBD) 	501	1.5	L	FLR91X-A_T03	CAN 1L	ECU 5	1	OBD CONN (OBD)	1
	504	1.5	GrL	FLR91X-A_T03	CAN 1H	ECU 5	4	OBD CONN (OBD)	2
	G05A	0.75	B	FLR91X-A	ALT GND	G05		OBD CONN (OBD)	3
	P08A	0.75	R	FLR91X-A	ALT PWR	P08		OBD CONN (OBD)	4
	–								
	419A	0.75	Y	FLR91X-A	Key-on (T15)	419		OBD CONN (OBD)	6
	608A	0.75	Y	FLR91X-A_T08	CAN 2L	608		OBD CONN (OBD)	7
	607A	0.75	W	FLR91X-A_T08	CAN 2H	607		OBD CONN (OBD)	8
Injector Inline RH (INJL) 	810	1.5	W	FLR91X-A_T09	Injector 1 "High"	ECU 8	10	Injector Inline RH (INJR)	1
	801	1.5	Y	FLR91X-A_T09	Injector 1 "Low"	ECU 8	1	Injector Inline RH (INJR)	2
	813	1.5	GrL	FLR91X-A_T10	Injector 2 "High"	ECU 8	13	Injector Inline RH (INJR)	3
	804	1.5	G	FLR91X-A_T10	Injector 2 "Low"	ECU 8	4	Injector Inline RH (INJR)	4
	816	1.5	W	FLR91X-A_T11	Injector 3 "High"	ECU 8	16	Injector Inline RH (INJR)	5
	807	1.5	Y	FLR91X-A_T11	Injector 3 "Low"	ECU 8	7	Injector Inline RH (INJR)	6
	814	1.5	GrL	FLR91X-A_T12	Injector 4 "High"	ECU 8	14	Injector Inline RH (INJR)	7
	805	1.5	G	FLR91X-A_T12	Injector 4 "Low"	ECU 8	5	Injector Inline RH (INJR)	8
	811	1.5	W	FLR91X-A_T13	Injector 5 "High"	ECU 8	11	Injector Inline RH (INJR)	9
	802	1.5	Y	FLR91X-A_T13	Injector 5 "Low"	ECU 8	2	Injector Inline RH (INJR)	10
	817	1.5	GrL	FLR91X-A_T14	Injector 6 "High"	ECU 8	17	Injector Inline RH (INJR)	11
	808	1.5	G	FLR91X-A_T14	Injector 6 "Low"	ECU 8	8	Injector Inline RH (INJR)	12

DCU

Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
Inter CONN Engine (IMO T3) 	130	0.75	R	FLR91X-A	SCR DP sensor B PWR	ECU 1	30	Inter CONN SCR (INT SCR)	5
	136	0.75	B	FLR91X-A	SCR DP sensor B GND	ECU 1	36	Inter CONN SCR (INT SCR)	6
	133	0.75	G	FLR91X-A	SCR DP sensor B signal	ECU 1	33	Inter CONN SCR (INT SCR)	7
	245	0.75	L	FLR91X-A_T10	CAN 3H	ECU 2	45	Inter CONN SCR (INT SCR)	14
	244	0.75	O	FLR91X-A_T10	CAN 3L	ECU 2	44	Inter CONN SCR (INT SCR)	15
	216	0.75	Y	FLR91X-A_T11	CAN 0H	ECU 2	16	Inter CONN SCR (INT SCR)	16
	215	0.75	W	FLR91X-A_T11	CAN 0L	ECU 2	15	Inter CONN SCR (INT SCR)	17
	518	1.50	R	FLR91X-A	SCR DP sensor A PWR	Inter CONN SCR (INT SCR)	11	Inter CONN 2 (INT 2)	20
	528	0.75	B	FLR91X-A	SCR DP sensor A GND	Inter CONN SCR (INT SCR)	12	Inter CONN 2 (INT 2)	21
	509	1.50	G	FLR91X-A	SCR DP sensor A signal	Inter CONN SCR (INT SCR)	13	Inter CONN 2 (INT 2)	22
	B06	1.50	R	FLR91X-A	Hose heater B PWR	Inter CONN SCR (INT SCR)	1	SP08	
	B07	1.50	R	FLR91X-A	Hose heater A PWR	Inter CONN SCR (INT SCR)	2	SP08	
	B08	2.00	R	FLR91X-B	DCU B PWR	Inter CONN SCR (INT SCR)	3	SP08	
	B09	2.00	R	FLR91X-B	DCU A PWR	Inter CONN SCR (INT SCR)	4	SP08	
	E02	2.00	B	FLR91X-B	DCU B GND	SP09		Inter CONN SCR (INT SCR)	8
	E03	2.00	B	FLR91X-B	DCU A GND	SP09		Inter CONN SCR (INT SCR)	9
	G06	2.00	B	FLR91X-B	ALT GND	SP02		Inter CONN SCR (INT SCR)	10
	419B	0.75	Y	FLR91X-A	Key-on (T15)	419		Inter CONN SCR (INT SCR)	18

1	2	3	4	5
B06	B07	B08	B09	130
6	7	8	9	10
136	133	E02	E03	G06
11	12	13	14	15
518	528	509	245	244
16	17	18	19	20
216	215	149B	-	-
21	22	23	24	25
-	-	-	-	-
26	27	28	29	30
-	-	-	-	-
31				
-				

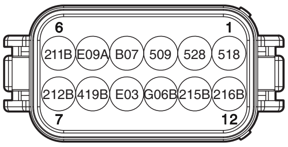
Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
Inter CONN Urea Tank RH 	518	0.75	R	FLR91X-A	SCR DP Sensor A PWR	SCR DP Sensor (DPS)	1	Inter CONN 2 (INT 2)	11
	528	0.75	B	FLR91X-A	SCR DP Sensor A GND	SCR DP Sensor (DPS)	2	Inter CONN 2 (INT 2)	10
	509	0.75	G	FLR91X-A	SCR DP Sensor A Signal	SCR DP Sensor (DPS)	3	Inter CONN 2 (INT 2)	9
	B07	1.50	R	FLR91X-A	Hose Heater A PWR	Inter CONN Urea Tank RH (Urea RH)	4	Inter CONN Engine (INT ENG)	2
	B09A	2.00	R	FLR91X-B	DCU A PWR	Inter CONN Urea Tank RH (Urea RH)	5	SP_01	
	211B	0.75	W	FLR91X-A T04	DCU A CAN 1H	Inter CONN Urea Tank RH (Urea RH)	6	OBD CONN 1 (OBD 1)	2
	215B	0.75	W	FLR91X-A T08	CAN OL	Inter CONN Urea Tank RH (Urea RH)	11	SP_05	17
	G06B	2.00	B	FLR91X-B	ALT GND	Inter CONN Urea Tank RH (Urea RH)	10	SP_02	
	E03	2.00	B	FLR91X-B	DCU A GND	Inter CONN Urea Tank RH (Urea RH)	9	Inter CONN Engine (INT ENG)	9
	419B	0.75	Y	FLR91X-A	Key-on (T15)	Inter CONN Urea Tank RH (Urea RH)	8	SP_03	
	212B	0.75	O	FLR91X-A_T04	DCU A CAN 1L	Inter CONN Urea Tank RH (Urea RH)	7	OBD CONN 1 (OBD 1)	1
	216B	0.75	Y	FLR91X-A T08	CAN OH	Inter CONN Urea Tank RH (Urea RH)	12	SP_05	16

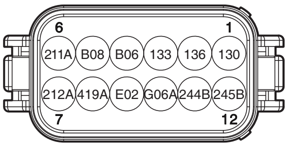
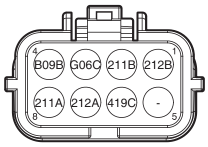
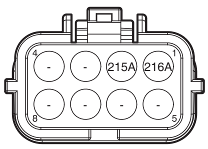
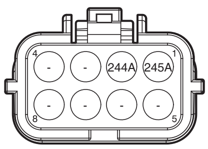
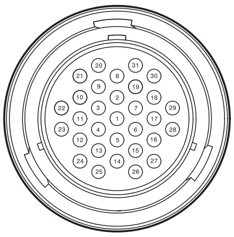
Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
Inter CONN Urea Tank LH 	130	0.75	R	FLR91X-A	SCA DP Sensor B PWR	Inter CONN Urea Tank LH (Urea LH)	1	Inter CONN Engine (INT ENG)	5
	136	0.75	B	FLR91X-A	SCA DP Sensor B GND	Inter CONN Urea Tank LH (Urea LH)	2	Inter CONN Engine (INT ENG)	6
	133	0.75	G	FLR91X-A	SCR DP Sensor B Signal	Inter CONN Urea Tank LH (Urea LH)	3	Inter CONN Engine (INT ENG)	7
	B06	1.50	R	FLR91X-A	Hose Heater B PWR	Inter CONN Urea Tank LH (Urea LH)	4	Inter CONN Engine (INT ENG)	1
	B08	2.00	R	FLR91X-B	DCU B PWR	Inter CONN Urea Tank LH (Urea LH)	5	Inter CONN Engine (INT ENG)	3
	211A	0.75	W	FLR91X-A T03	DCU 8 CAN 1H	Inter CONN Urea Tank LH (Urea LH)	6	OBD CONN 1 (OBD 1)	8
	212A	0.75	O	FLR91X-A_T03	DCU 8 CAN 1L	Inter CONN Urea Tank LH (Urea LH)	7	OBD CONN 1 (OBD 1)	7
	419A	0.75	Y	FLR91X-A	key-on (T15)	Inter CONN Urea Tank LH (Urea LH)	8	SP_03	
	E02	2.00	B	FLR91X-B	DCU B GND	Inter CONN Urea Tank LH (Urea LH)	9	Inter CONN Engine (INT ENG)	8
	G06A	2.00	B	FLR91X-B	ALT GND	Inter CONN Urea Tank LH (Urea LH)	10	SP_02	
	244B	1.50	GGra	FLR91X-A T06	CAN 3L	Inter CONN Urea Tank LH (Urea LH)	11	SP_04	15
	245B	1.50	L	FLR91X-A_T06	CAN 3H	Inter CONN Urea Tank LH (Urea LH)	12	SP_04	14

Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
OBD CONN 1 (OBD 1) 	212B	0.75	O	FLR91X-A_T04	DCU A CAN 1L	Inter CONN Urea Tank RH (Urea RH)	7	OBD CONN 1 (OBDInter1)	1
	211B	0.75	W	FLR91X-A T04	DCU A CAN 1H	Inter CONN Urea Tank RH (Urea RH)	6	OBD CONN 1 (OBD 1)	2
	G06C	0.75	B	FLR91X-A	ALT GND	OBD CONN 1 (OBD 1)	3	SP_02	
	B09B	0.75	R	FLR91X-A	DCU A PWR	SP_01		OBD CONN 1 (OBD 1)	4
	-								
	419C	0.75	Y	FLR91X-A	Key-on (T15)	OBD CONN 1 (OBD 1)	6	SP_03	
	212A	0.75	O	FLR91X-A_T03	DCU 8 CAN 1L	Inter CONN Urea Tank LH (Urea LH)	7	OBD CONN 1 (OBD 1)	7
	211A	0.75	W	FLR91X-A T03	DCU 8 CAN 1H	Inter CONN Urea Tank LH (Urea LH)	6	OBD CONN 1 (OBD 1)	8
OBD CONN 2 (OBD 2) 	216A	0.75	Y	FLR91X-A T07	CAN OH	SP_05		OBD CONN 3 (OBD 3)	1
	215A	0.75	W	FLR91X-A T07	CAN OL	SP_05		OBD CONN 3 (0BD 3)	2
OBD CONN 3 (OBD 3) 	245A	1.50	L	FLR91X-A_T05	CAN 3H	SP_04		OBD CONN 2 (OBD 2)	1
	244A	1.50	GGra	FLR91X-A T05	CAN 3L	SP_04		OBD CONN 2 (OBD 2)	2

Aftertreatment (ATS)

Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
Inter CONN Engine (IMO T3) 	130	0.75	R	FLR91X-A	SCR DP sensor B PWR	ECU 1	30	Inter CONN SCR (INT SCR)	5
	136	0.75	B	FLR91X-A	SCR DP sensor B GND	ECU 1	36	Inter CONN SCR (INT SCR)	6
	133	0.75	G	FLR91X-A	SCR DP sensor B signal	ECU 1	33	Inter CONN SCR (INT SCR)	7
	245	0.75	L	FLR91X-A_T10	CAN 3H	ECU 2	45	Inter CONN SCR (INT SCR)	14
	244	0.75	O	FLR91X-A_T10	CAN 3L	ECU 2	44	Inter CONN SCR (INT SCR)	15
	216	0.75	Y	FLR91X-A_T11	CAN 0H	ECU 2	16	Inter CONN SCR (INT SCR)	16
	215	0.75	W	FLR91X-A_T11	CAN 0L	ECU 2	15	Inter CONN SCR (INT SCR)	17
	518	1.50	R	FLR91X-A	SCR DP sensor A PWR	Inter CONN SCR (INT SCR)	11	Inter CONN 2 (INT 2)	20
	528	0.75	B	FLR91X-A	SCR DP sensor A GND	Inter CONN SCR (INT SCR)	12	Inter CONN 2 (INT 2)	21
	509	1.50	G	FLR91X-A	SCR DP sensor A signal	Inter CONN SCR (INT SCR)	13	Inter CONN 2 (INT 2)	22
	B06	1.50	R	FLR91X-A	Hose heater B PWR	Inter CONN SCR (INT SCR)	1	SP08	
	B07	1.50	R	FLR91X-A	Hose heater A PWR	Inter CONN SCR (INT SCR)	2	SP08	
	B08	2.00	R	FLR91X-B	DCU B PWR	Inter CONN SCR (INT SCR)	3	SP08	
	B09	2.00	R	FLR91X-B	DCU A PWR	Inter CONN SCR (INT SCR)	4	SP08	
	E02	2.00	B	FLR91X-B	DCU B GND	SP09		Inter CONN SCR (INT SCR)	8
	E03	2.00	B	FLR91X-B	DCU A GND	SP09		Inter CONN SCR (INT SCR)	9
	G06	2.00	B	FLR91X-B	ALT GND	SP02		Inter CONN SCR (INT SCR)	10
	419B	0.75	Y	FLR91X-A	Key-on (T15)	419		Inter CONN SCR (INT SCR)	18

1	2	3	4	5
B06	B07	B08	B09	130
6	7	8	9	10
136	133	E02	E03	G06
11	12	13	14	15
518	528	509	245	244
16	17	18	19	20
216	215	149B	-	-
21	22	23	24	25
-	-	-	-	-
26	27	28	29	30
-	-	-	-	-
31				
-				

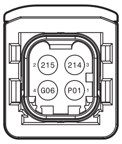
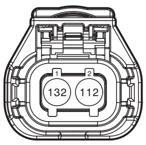
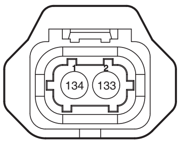
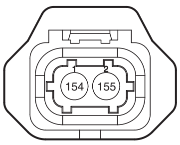
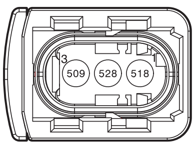
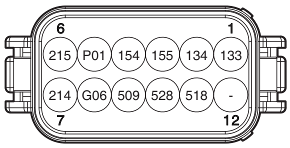
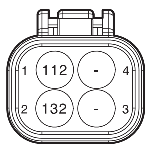
Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
NOX Sensor (NOX) 	P01	0.75	R	FLR91X-A	NOX Sensor PWR	NOX Sensor (NOX)	1	Inter CONN 2 (INT 2)	5
	215	0.75	G	FLR91X-A-T02	DCU CANO LOW	NOX Sensor (NOX)	2	Inter CONN 2 (INT 2)	6
	214	0.75	W	FLR91X-A-T02	DCU CANO HIGH	NOX Sensor (NOX)	3	Inter CONN 2 (INT 2)	7
	G06	0.75	B	FLR91X-A	NOX Sensor GND	NOX Sensor (NOX)	4	Inter CONN 2 (INT 2)	8
Dosing Module (DOS) 	132	0.75	Y	FLR91X-A-T01	Reduction Agent Metering Valve High	Dosing Module (DOS)	1	Inter CONN 3 (INT 3)	2
	112	0.75	W	FLR91X-A-T01	Reduction Agent Metering Valve Low	Dosing Module (DOS)	2	Inter CONN 3 (INT 3)	1
SCR Up Temp Sensor (SCR 1) 	134	0.75	B	FLR91X-A	SCR Upstream GND	SCRUP Temp Sensor (SCR 1)	1	Inter CONN 2 (INT 2)	2
	133	0.75	W	FLR91X-A	SCR Upstream Signal	SCRUP Temp Sensor (SCR 1)	2	Inter CONN 2 (INT 2)	1
SCR Down Temp Sensor (SCR 2) 	154	0.75	B	FLR91X-A	SCR Downstream GND	SCR DOWN Temp Sensor (SCR 2)	1	Inter CONN 2 (INT 2)	4
	155	0.75	Y	FLR91X-A	SCR Downstream Signal	SCR Down Temp Sensor (SCR 2)	2	Inter CONN 2 (INT 2)	3
SCR DP Sensor (DPS) 	518	0.75	R	FLR91X-A	SCR DP Sensor A PWR	SCR DP Sensor (DPS)	1	Inter CONN 2 (INT 2)	11
	528	0.75	B	FLR91X-A	SCR DP Sensor A GND	SCR DP Sensor (DPS)	2	Inter CONN 2 (INT 2)	10
	509	0.75	G	FLR91X-A	SCR DP Sensor A Signal	SCR DP Sensor (DPS)	3	Inter CONN 2 (INT 2)	9

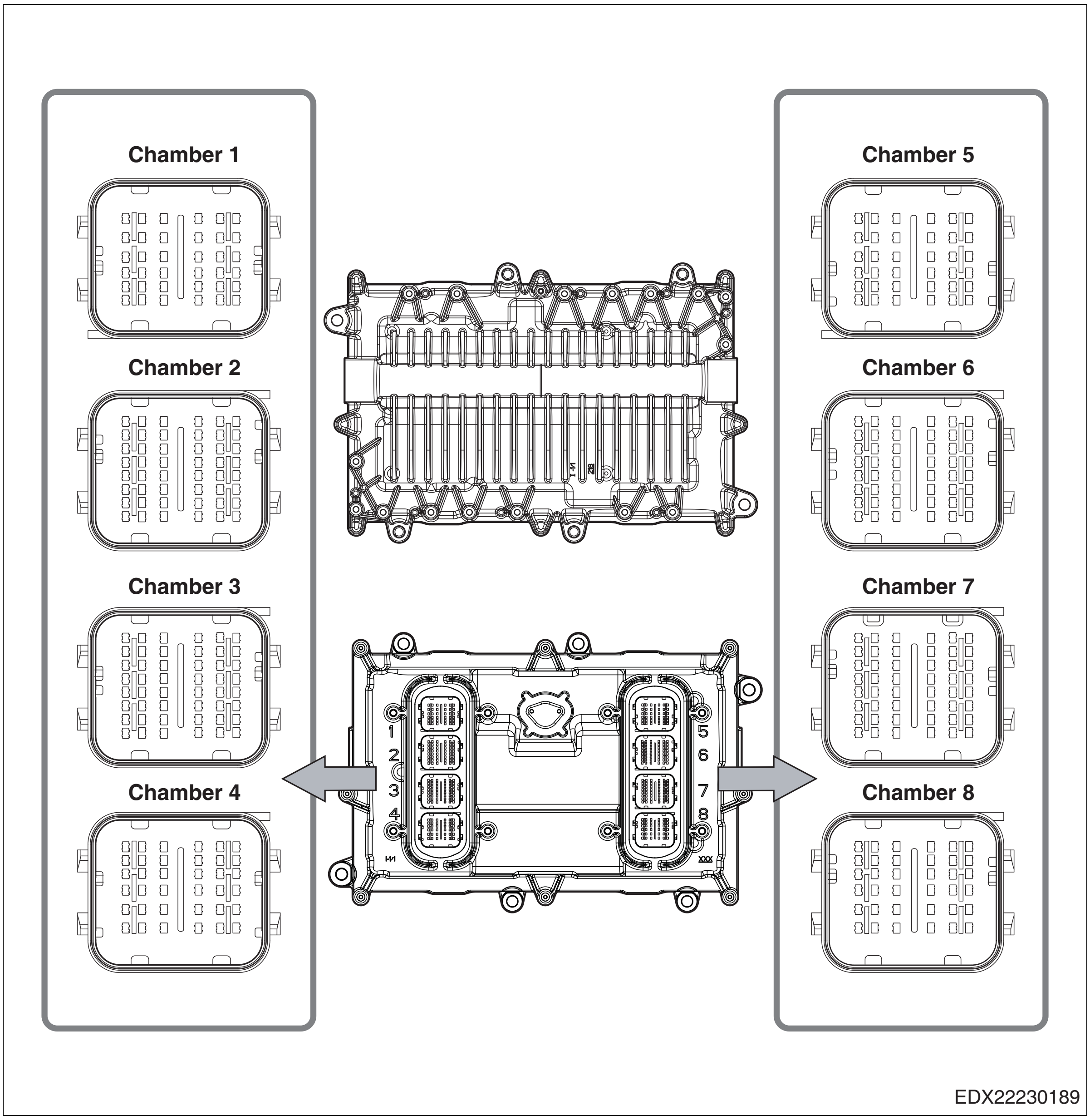
Figure	Circuit	Wire Size	Color	Insulation	Circuit Description	From	Pin	To	CONN Pin
INTER 2 (INT 2) 	133	0.75	W	FLR91X-A	SCR Upstream Signal	SCRUP Temp Sensor (SCR1)	2	Inter CONN2 (INT 2)	1
	134	0.75	B	FLR91X-A	SCR Upstream GND	SCRUP Temp Sensor (SCR1)	1	Inter CONN2 (INT 2)	2
	155	0.75	Y	FLR91X-A	SCR Downstream Signal	SCR Down Temp Sensor (SCR2)	2	Inter CONN2 (INT 2)	3
	154	0.75	B	FLR91X-A	SCR Downstream GND	SCR DOWN TEMP Sensor (SCR2)	1	Inter CONN2 (INT 2)	4
	P01	0.75	R	FLR91X-A	NOX Sensor PWR	NOX Sensor (NOX)	1	Inter CONN2 (INT 2)	5
	215	0.75	G	FLR91X-A-T02	DCU CANO Low	NOX Sensor (NOX)	2	Inter CONN2 (INT 2)	6
	214	0.75	W	FLR91X-A-T02	DCU CANO High	NOX Sensor (NOX)	3	Inter CONN2 (INT 2)	7
	G06	0.75	B	FLR91X-A	NOX Sensor GND	NOX Sensor (NOX)	4	Inter CONN2 (INT 2)	8
	509	0.75	G	FLR91X-A	SCR DP Sensor A Signal	SCR DP Sensor (DPS)	3	Inter CONN2 (INT 2)	9
	528	0.75	B	FLR91X-A	SCR DP Sensor A GND	SCR DP Sensor (DPS)	2	Inter CONN2 (INT 2)	10
	518	0.75	R	FLR91X-A	SCR DP Sensor A PWR	SCR DP Sensor (DPS)	1	Inter CONN2 (INT 2)	11
	-								
Inter 3 (INT 3) 	112	0.75	W	FLR91X-A-T01	Reduction Agent Metering Valve Low	Dosing Module (DOS)	2	Inter CONN3 (INT 3)	1
	132	0.75	Y	FLR91X-A-T01	Reduction Agent Metering Valve High	Dosing Module (DOS)	1	Inter CONN3 (INT 3)	2

8.3. Engine Control Unit (ECU)

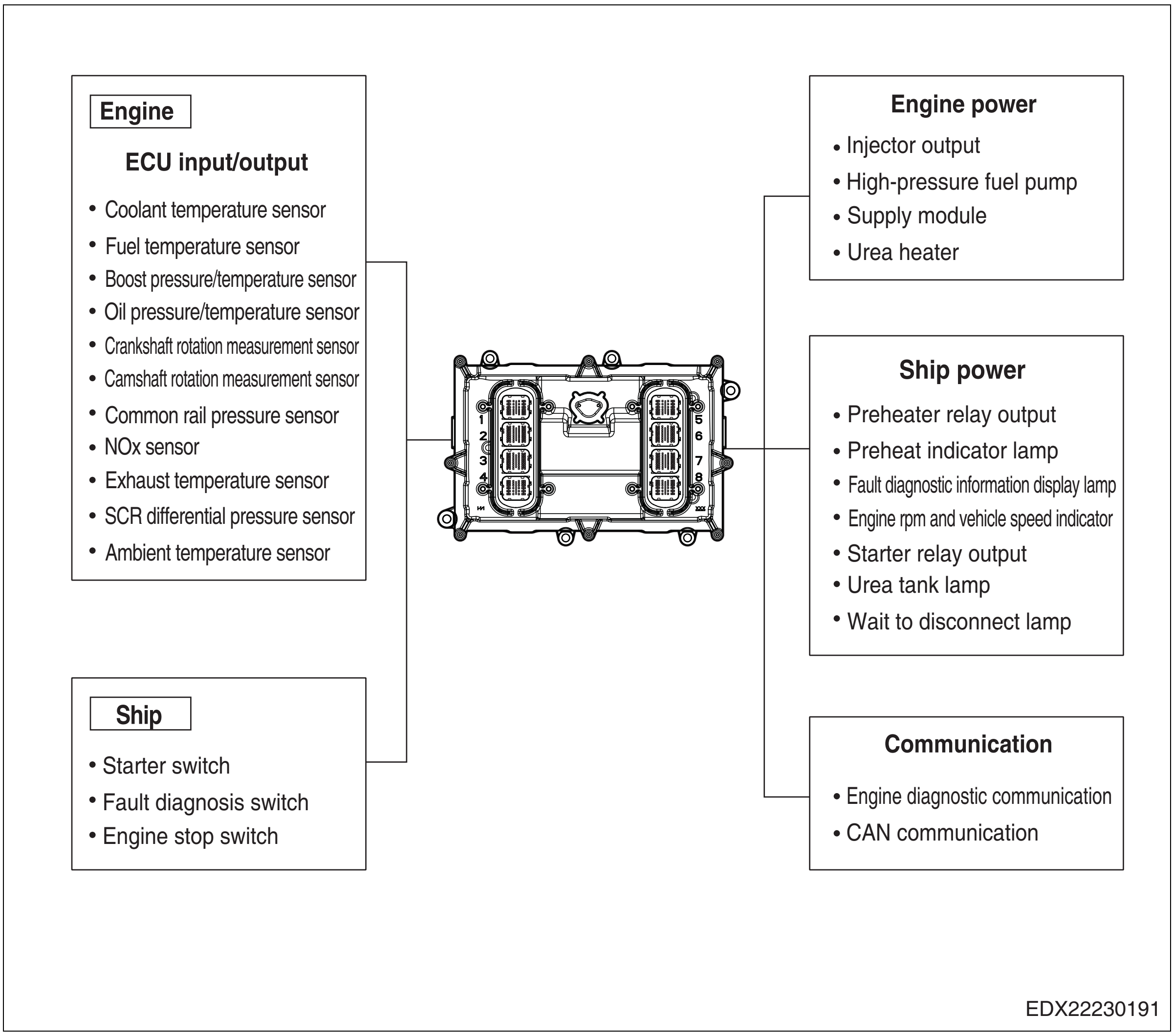
8.3.1. Engine Control Unit (ECU) Connectors

Engine control unit (ECU) connectors consist of connectors for connecting to the ship and connectors for connecting to the engine.

- ECU assembly
  1) Secure the ECU mounting plate.
  2) Install the ECU.



8.3.2. Engine Control Unit (ECU) Input/Output



8.3.3. Engine Control Unit (ECU) Operating Conditions

1) Starting the engine
   a) To set the reference temperature for determining whether or not to perform preheating, the ECU sets the lowest temperature among the coolant temperature, fuel temperature, intake air temperature, and oil temperature as the reference temperature.
   b) To set the reference temperature for determining the amount of fuel, the ECU sets the engine coolant temperature as the reference temperature.
   c) Delivers fuel to the engine after determining a suitable amount of fuel for starting the engine, then uses the crankshaft rotation sensor to measure the engine rpm signal.
2) Sailing
   a) It calculates essential data required for sailing, such as CAN data received from the ship control unit and the engine rpm, etc.
3) Adjusting the engine rpm to the needs of the driver
   a) The ECU controls the engine rpm according to the needs of the driver and controls the engine according to the engine rpm required by the ship's control unit.
4) Failure diagnosis
   a) The fault diagnosis information lamp on the gauge panel activates in the event of a fault.
   b) The fault diagnosis information lamp can be used to check the fault code.

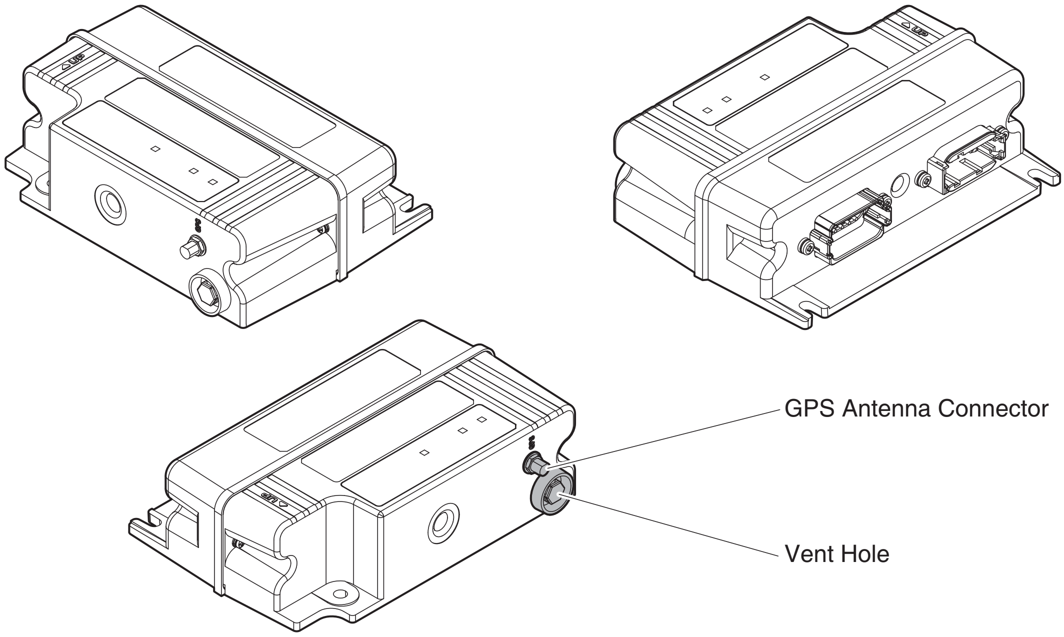
CAUTION
It can also be checked using the fault diagnosis information on the gauge panel.

   c) The type of fault can be diagnosed by connecting a diagnostic tool to the check connector on the back of the driver's seat.
5) Sailing record
   a) Sailing-related information is recorded in the engine control unit.
   b) Information such as the fuel consumption rate, engine operating time, and engine control unit operating time is recorded in the engine control unit.
   c) Information can be monitored using the ECU diagnostic system.

8.4. TMS 3.0 (Option)

8.4.1. Outside Drawing

- TMS 3.0 TYPE A (LTE)



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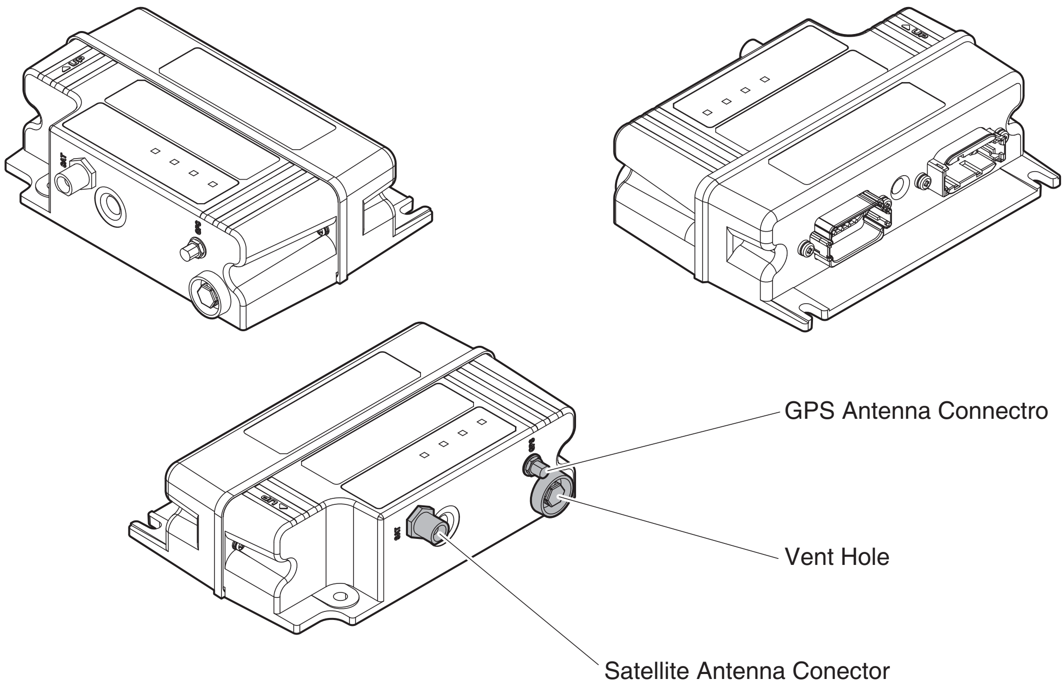
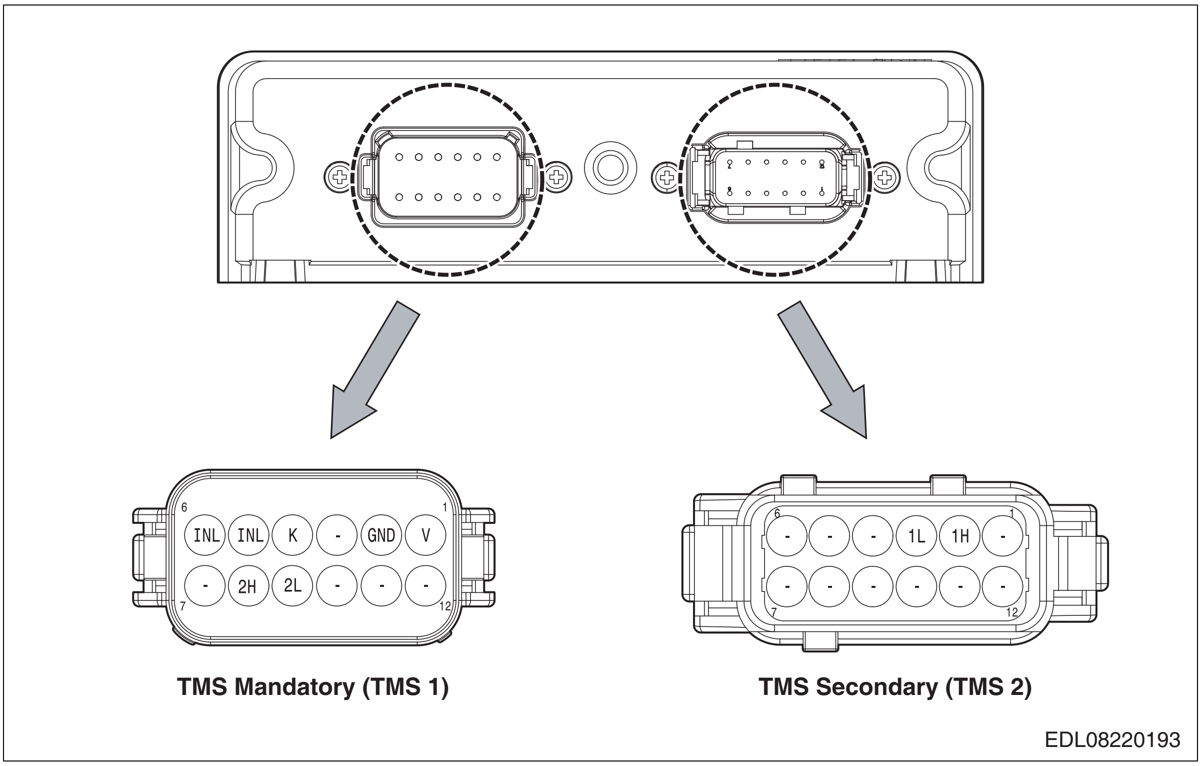
- TMS 3.0 TYPE B (LTE+SAT)



EDL06230080

8.4.2. Front PIN Map



No.	Circuit Description	Description
1	V	Power (24V)
2	GND	Ground
4	K	Key On
8	2H	CAN 2H
9	2L	CAN 2L

No.	Circuit Description	Description
2	1H	CAN 1H
3	1L	CAN 1L

8.4.3. TMS 3.0 TYPE A (LTE) Module (EG25-G) Specification

1) Key Benefits
   - LTE Cat 4 Module (Max 150 Mbps (DL), Max 50 Mbps (UL))
     Worldwide LTE, UMTS/HSPA (+) and GSM/GPRS/EDGE coverage
   - Pin Compatible with EG25-X/EC20

2) Supported Frequency Bands
   a) LTE-FDD: B1/B2/B3/B4/B5/B7/B8/B12/B13/B18/B19/B20/B25/B26/B28
   b) LTE-TDD: B38/B39/B40/B41
   c) WCDMA: B1/B2/B4/B5/B6/B8/B19
   d) GSM: 850/900/1,800/1,900 MHz

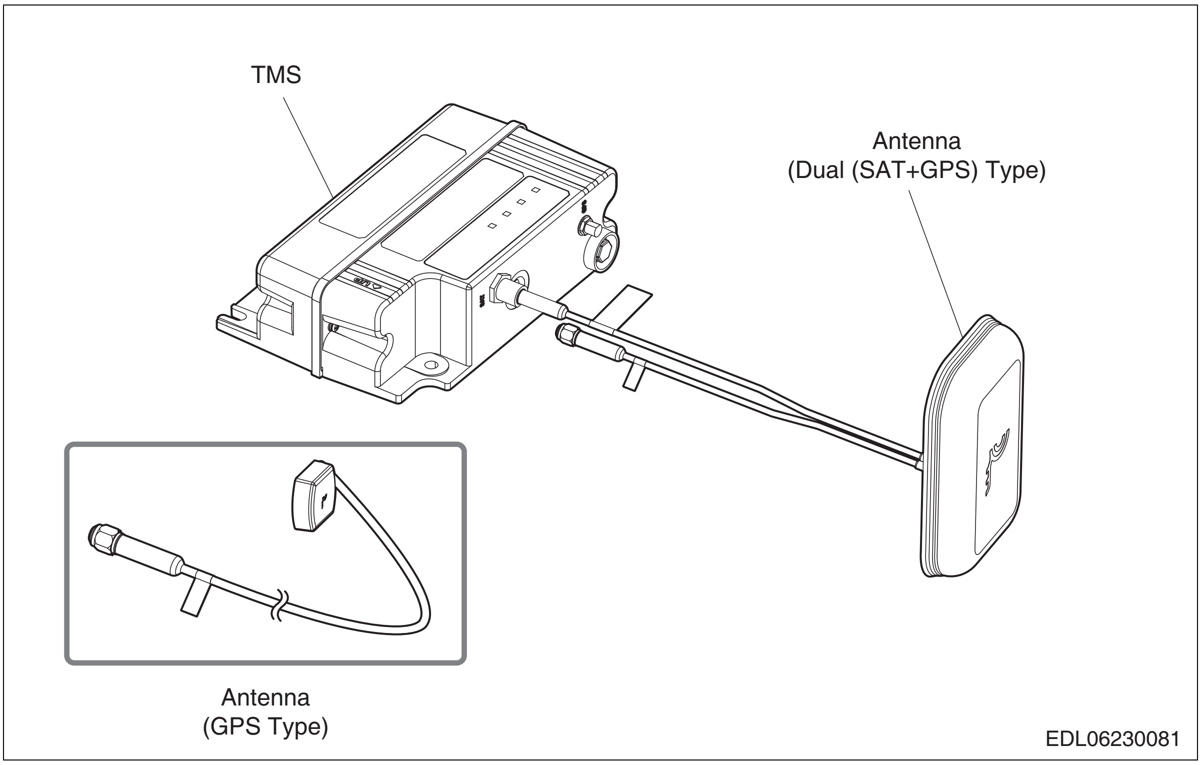
3) Internet Protocol Features
   a) Support TCP/UDP//PPP/FTP/HTTP/HTTPS/NTP/PING/QMI/NITZ
      SMTP/SPI/MQTT/CMUX/SMTPS protocols

4) Key Features
   a) (U)SIM Interface: Support USIM/SIM card: 1.8V, 3.3V
   b) Rx-diversity: Support LTE/WCDMA Rx-diversity
   c) Antenna Indication: ANT_MAIN(Main antenna interface)
      ANT_DIV(Rx-diversity antenna interface)
   d) Physical Characteristics
      Size: 29.0 (±0.15 mm) x 32.0 (±0.15 mm) x 2.4 (±0.2 mm)
      Package: LGA
      Weight: approx.4.9g
   e) Temperature Range: -40°C to +85°C

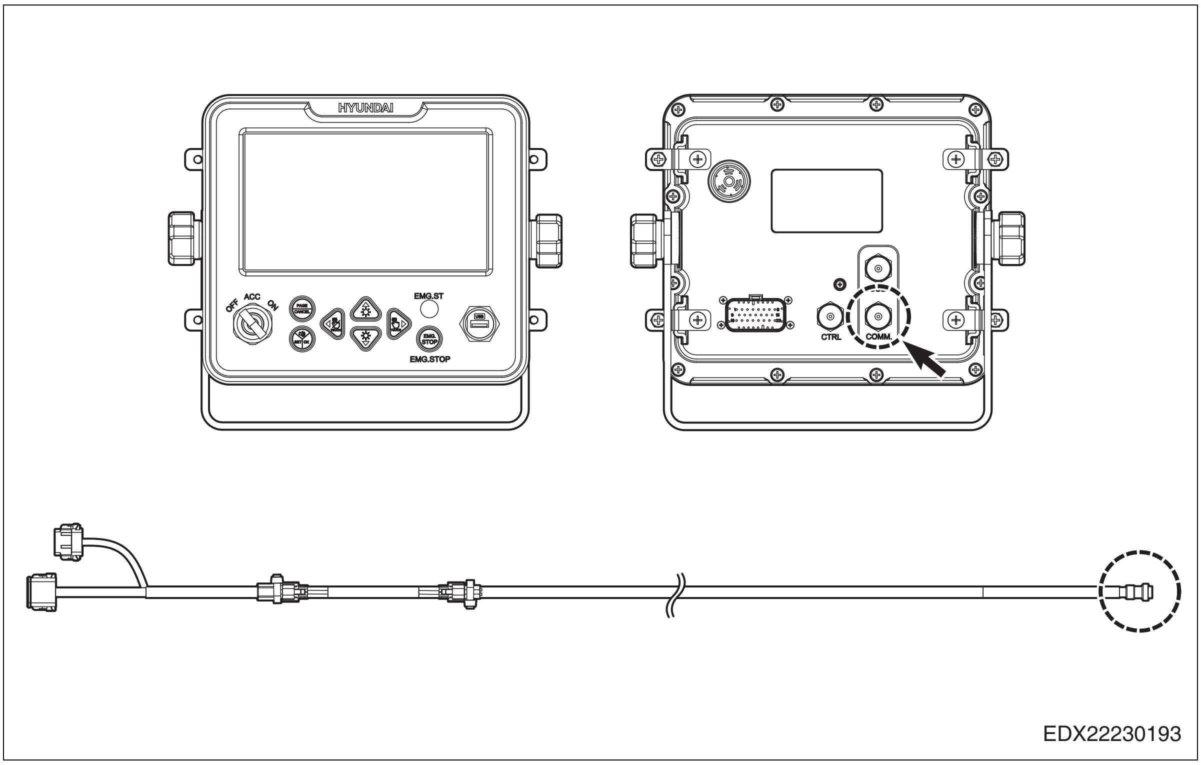
5) Approvals
   a) Carrier:
      - Deutsche Telekom (Europe)
      - Verizon/AT&T/Sprint/U.S. Cellular/T-Mobile* (North America)
      - Telus/Rogers* (Canada)
   b) Regulatory:
      - GCF (Global)
      - CE (Europe)
      - FCC/PTCRB (North America)
      - IC (Canada)
      - Anatel (Brazil)
      - IFETEL (Mexico)
      - SRRC/CCC/NAL (China)
      - KC (South korea)
      - NCC (Taiwan, China)
      - RCM (Australia & New Zealand)
      - FAC* (Russia)
      - NBTC (Thailand)
      - IMDA (Singapore)
      - ICASA (South Africa)
   c) Others:
      - RoHS
      - WHQL

8.4.4. Schematic diagram

- TMS 3.0



8.4.5. Connect DGP (Digital Gage Panel) and TMS cable



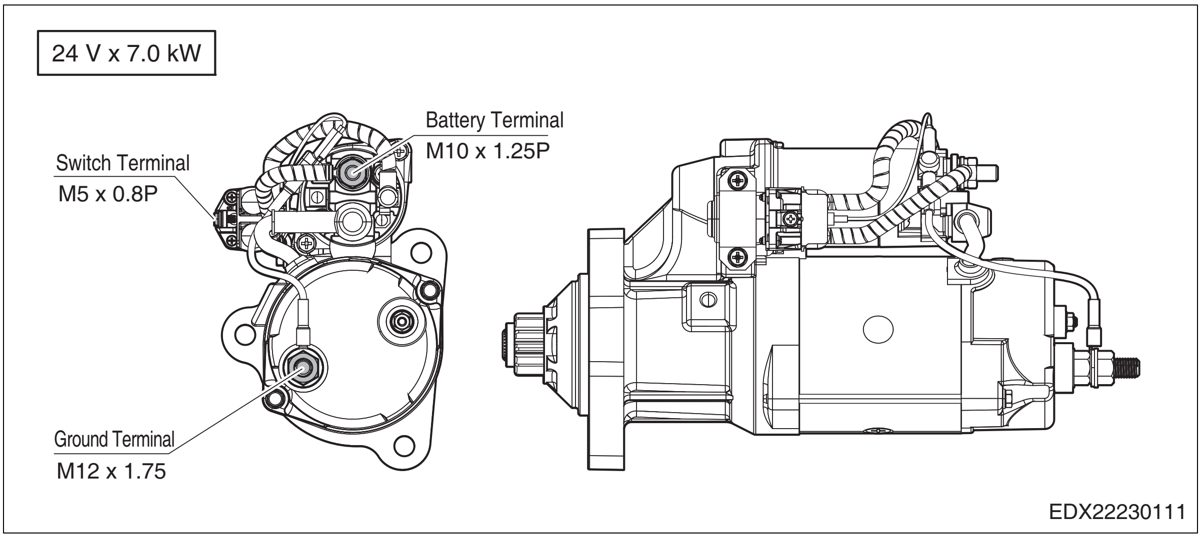
Note :

TMS cable size: 2 m, 3 m, 5 m, 7.5 m

8.5. Starter Motor

The starter motor is mounted on the back of the flywheel housing.

When disassembling the engine, soak the starter motor pinion gear and ring gear in fuel and clean them thoroughly with a brush. Then, apply grease to them to prevent rust.

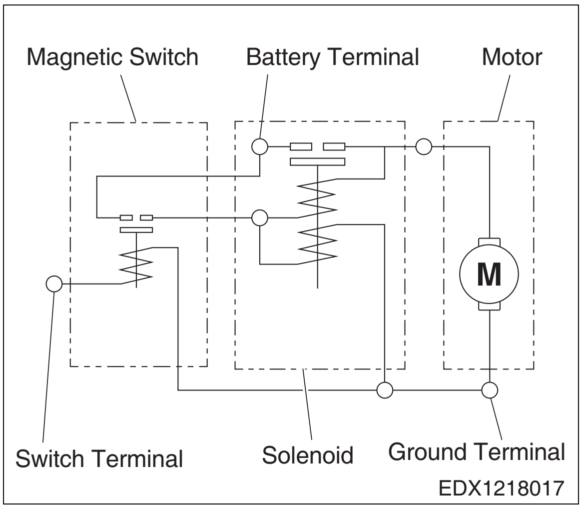


CAUTION

The starter motor should always be protected from moisture.

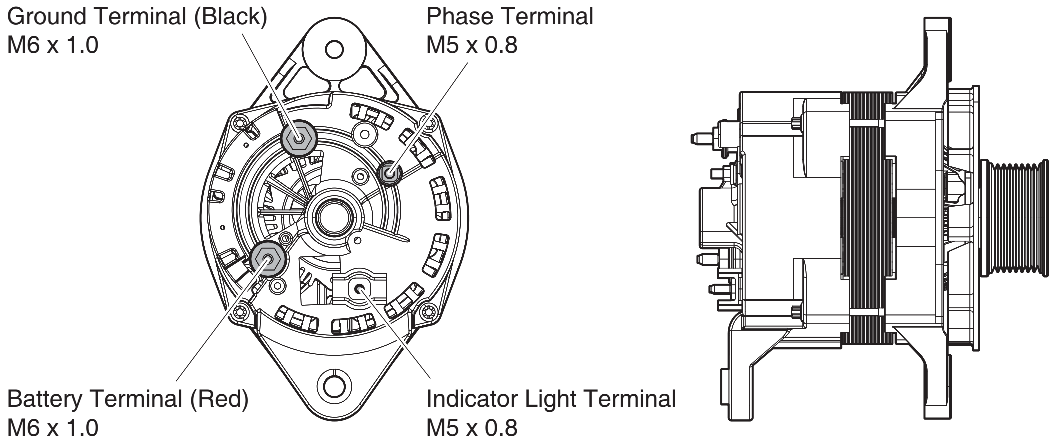
CAUTION

Before working on any electrical system, disconnect the negative ('–') battery cable (ground cable). To prevent a short circuit, connect the ground cable only after work is complete.



8.6. Alternator Motor

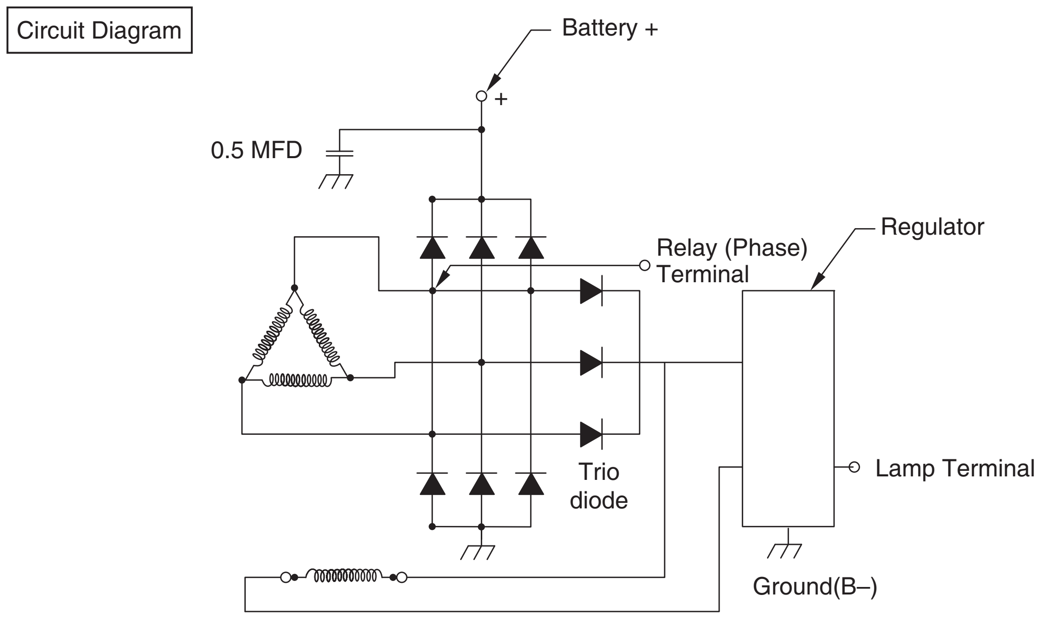
The alternator is equipped with a silicon rectifier. The transistor-type regulator installed in the body of the alternator restricts the voltage of the alternator. In order to prevent damage to the rectifier and regulator, do not run the alternator unless the regulator and battery are connected to the circuit.



EDX22230110

CAUTION

The alternator does not require maintenance, but it must be protected from dust, moisture and water.



EDX22230169

CAUTION

Run the alternator in accordance with the guidelines provided in this chapter.

8.7. Fault Code List

No.	Fault	P-Code	SPN	FMI	EnvRef	Shutdown	Torque Limit	Speed Limit	Description
1	ARlySCB_6	P270C	520903	3	xSet2	OFF	OFF	OFF	ECU internal relay 6 short to battery (DEF tank coolant valve/hose heater)
2	ARlySCB_7	P270D	520904	3	xSet2	OFF	OFF	OFF	ECU internal relay 7 short to battery (engine stop switch/DEF overflow lamp/ ECU On lamp)
3	ARlySCB_8	P270E	520905	3	xSet14	OFF	OFF	OFF	ECU internal relay 8 short to battery (supply module/reverting valve)
4	ARlySCG_6	P271C	520908	4	xSet2	OFF	OFF	OFF	ECU internal relay 6 short to ground (DEF tank coolant valve/hose heater)
5	ARlySCG_7	P271D	520909	4	xSet2	OFF	OFF	OFF	ECU internal relay 7 short to ground (engine stop switch/DEF overflow lamp/ ECU On lamp)
6	ARlySCG_8	P271E	520910	4	xSet14	OFF	OFF	OFF	ECU internal relay 8 short to ground (supply module/reverting valve)
7	BattUHi	P0563	158	0	xSet2	OFF	OFF	OFF	Battery voltage high
8	BattULo	P0562	158	1	xSet2	OFF	OFF	OFF	Battery voltage low
9	BattUSRCMax	P1563	158	3	xSet2	OFF	OFF	OFF	High voltage in battery voltage sensor wiring
10	BattUSRCMin	P1562	158	4	xSet2	OFF	OFF	OFF	Low voltage in battery voltage sensor wiring
11	CEngDsTOverT1	P2185	110	2	xSet5	OFF	OFF	OFF	High coolant outlet temperature (alarm)
12	CEngDsTPhysRngHi	P0116	110	0	xSet5	ON	OFF	OFF	High coolant outlet temperature
13	CEngDsTSRCMax	P0118	110	3	xSet5	OFF	50% ↓	200 rpm ↓	High voltage in coolant outlet temperature sensor wiring
14	CEngDsTSRCMin	P1119	110	4	xSet5	OFF	50% ↓	200 rpm ↓	Low voltage in coolant outlet temperature sensor wiring
15	ComCSTSC1TE	U0130	520214	0	xSet2	OFF	OFF	OFF	TSC1TE CAN signal checksum error (TCU)
16	ComToA1DEFI	U0105	520824	12	xSet15	OFF	OFF	OFF	A1DEFI CAN signal error (DEF tank)
17	ComToAT1OG1	U029E	520657	12	xSet2	OFF	OFF	OFF	AT1OG1 CAN signal error (SCR downstream NOx sensor)
18	ComToAT1T1I	U0110	520201	12	xSet2	OFF	OFF	OFF	AT1T1 CAN signal error
19	ComToSMVCU	U0107	520823	12	xSet2	OFF	OFF	OFF	SMVCU CAN signal error (VCU)
20	ComToTSC1TE	U0132	520214	12	xSet2	OFF	OFF	OFF	TSC1TE CAN signal error (TCU)
21	DevLibBattUHi	P1564	520616	3	xSet2	OFF	OFF	OFF	Power diagnostics deactivated by high battery voltage
22	DevLibBattULo	P1565	520616	4	xSet2	OFF	OFF	OFF	Power diagnostics deactivated by low battery voltage
23	ECBtnStopSig	P1102	970	12	xSet2	OFF	OFF	OFF	Emergency stop switch stuck
24	ECUOnLampOL	P1161	520923	5	xSet2	OFF	OFF	OFF	Open circuit in ECU ON lamp
25	ECUOnLampSCB	P1162	520924	3	xSet2	OFF	OFF	OFF	ECU ON lamp, short to battery
26	ECUOnLampSCG	P1163	520925	4	xSet2	OFF	OFF	OFF	ECU ON lamp, short to ground
27	EngPrtOvrSpd	P0219	606	0	xSet2	ON	OFF	OFF	Engine overspeeding detected
28	EnvTPhysRngHi	P0071	171	0	xSet11	OFF	OFF	OFF	High ambient temperature
29	EnvTSRCMax	P0073	171	3	xSet11	OFF	OFF	OFF	High voltage in ambient temperature sensor wiring
30	EnvTSRCMin	P0072	171	4	xSet11	OFF	OFF	OFF	Low voltage in ambient temperature sensor wiring
31	EpmCaSI1ErrSig	P0341	520200	0	xSet30	OFF	50% ↓	200 rpm ↓	Camshaft sensor signal fault
32	EpmCaSI1NoSig	P0340	520200	2	xSet30	OFF	50% ↓	200 rpm ↓	No camshaft sensor signal
33	EpmCaSI1OfsErr	P1212	520224	12	xSet30	OFF	50% ↓	200 rpm ↓	Camshaft sensor offset angle fault
34	EpmCrSErrSig	P0336	520199	0	xSet29	OFF	OFF	OFF	Crankshaft sensor signal fault
35	EpmCrSNoSig	P0335	520199	2	xSet29	OFF	OFF	OFF	No crankshaft sensor signal
36	FuelTPhysRngHi	P0181	174	0	xSet6	OFF	50% ↓	200 rpm ↓	High fuel temperature
37	FuelTSRCMax	P0183	174	3	xSet6	OFF	OFF	OFF	High voltage in fuel temperature sensor wiring
38	FuelTSRCMin	P0182	174	4	xSet6	OFF	OFF	OFF	Low voltage in fuel temperature sensor wiring
39	HegnMntgPlausS4B1	P1206	520795	12	xSet28	OFF	OFF	OFF	SCR downstream NOx sensor is discharging air
40	InjVlv_DI_DcDc	P062B	520693	0	xSet38	OFF	OFF	OFF	Injector voltage low
41	InjVlv_DI_NoLd_0	P0201	734	5	xSet38	OFF	OFF	OFF	Open circuit in injector no. 1 wiring
42	InjVlv_DI_NoLd_1	P0202	735	5	xSet38	OFF	OFF	OFF	Open circuit in injector no. 5 wiring

No.	Fault	P-Code	SPN	FMI	EnvRef	Shutdown	Torque Limit	Speed Limit	Description
43	InjVlv_DI_NoLd_2	P0203	736	5	xSet38	OFF	OFF	OFF	Open circuit in injector no. 3 wiring
44	InjVlv_DI_NoLd_3	P0204	737	5	xSet38	OFF	OFF	OFF	Open circuit in injector no. 6 wiring
45	InjVlv_DI_NoLd_4	P0205	738	5	xSet38	OFF	OFF	OFF	Open circuit in injector no. 2 wiring
46	InjVlv_DI_NoLd_5	P120B	739	5	xSet38	OFF	OFF	OFF	Open circuit in injector no. 4 wiring
47	InjVlv_DI_ScBnk_0	P162E	520626	3	xSet38	OFF	OFF	OFF	Injection bank no. 1 wiring, short to battery
48	InjVlv_DI_ScBnk_1	P1209	520691	3	xSet38	OFF	OFF	OFF	Injection bank no. 2 wiring, short to battery
49	InjVlv_DI_ScCyl_0	P0262	734	4	xSet38	OFF	OFF	OFF	Injector no. 1 wiring, short to ground
50	InjVlv_DI_ScCyl_1	P0265	735	4	xSet38	OFF	OFF	OFF	Injector no. 5 wiring, short to ground
51	InjVlv_DI_ScCyl_2	P0268	736	4	xSet38	OFF	OFF	OFF	Injector no. 3 wiring, short to ground
52	InjVlv_DI_ScCyl_3	P0271	737	4	xSet38	OFF	OFF	OFF	Injector no. 6 wiring, short to ground
53	InjVlv_DI_ScCyl_4	P0274	738	4	xSet38	OFF	OFF	OFF	Injector no. 2 wiring, short to ground
54	InjVlv_DI_ScCyl_5	P1277	739	4	xSet38	OFF	OFF	OFF	Injector no. 4 wiring, short to ground
55	InjVlv_DI_ScHsLs_0	P086A	734	12	xSet38	OFF	OFF	OFF	Short circuit in injector no. 1 high and low side wiring
56	InjVlv_DI_ScHsLs_1	P086B	735	12	xSet38	OFF	OFF	OFF	Short circuit in injector no. 5 high and low side wiring
57	InjVlv_DI_ScHsLs_2	P086C	736	12	xSet38	OFF	OFF	OFF	Short circuit in injector no. 3 high and low side wiring
58	InjVlv_DI_ScHsLs_3	P086D	737	12	xSet38	OFF	OFF	OFF	Short circuit in injector no. 6 high and low side wiring
59	InjVlv_DI_ScHsLs_4	P086E	738	12	xSet38	OFF	OFF	OFF	Short circuit in injector no. 2 high and low side wiring
60	InjVlv_DI_ScHsLs_5	P086F	739	12	xSet38	OFF	OFF	OFF	Short circuit in injector no. 4 high and low side wiring
61	IVAdjDiaIVAdj_0	P268C	520813	2	xSet2	OFF	OFF	OFF	Adjustment value for injector no. 1 not entered
62	IVAdjDiaIVAdj_1	P2690	520814	2	xSet2	OFF	OFF	OFF	Adjustment value for injector no. 5 not entered
63	IVAdjDiaIVAdj_2	P268E	520815	2	xSet2	OFF	OFF	OFF	Adjustment value for injector no. 3 not entered
64	IVAdjDiaIVAdj_3	P2691	520816	2	xSet2	OFF	OFF	OFF	Adjustment value for injector no. 6 not entered
65	IVAdjDiaIVAdj_4	P268D	520817	2	xSet2	OFF	OFF	OFF	Adjustment value for injector no. 2 not entered
66	IVAdjDiaIVAdj_5	P268F	520818	2	xSet2	OFF	OFF	OFF	Adjustment value for injector no. 4 not entered
67	MeUnNoDiagInfo	P125A	157	2	xSet31	OFF	50% ↓	200 rpm ↓	Metering unit power supply diagnostic information unavailable
68	MeUnOlHsLs	P0255	520694	5	xSet31	OFF	OFF	OFF	Open circuit in metering unit power supply wiring
69	MeUnScbHs	P0254	520694	3	xSet31	OFF	OFF	OFF	Metering unit high side power supply wiring, short to battery
70	MeUnScbLs	P1254	520695	3	xSet31	OFF	OFF	OFF	Metering unit low side power supply wiring, short to battery
71	MeUnScgHs	P0253	520694	4	xSet31	OFF	OFF	OFF	Metering unit high side power supply wiring, short to ground
72	MeUnScgLs	P1253	520695	4	xSet31	OFF	50% ↓	200 rpm ↓	Metering unit high & low side power supply wiring, short to ground
73	MeUnScHsLs	P0256	520694	12	xSet31	OFF	OFF	OFF	Metering unit low side power supply wiring, short to battery
74	OilPSwmpPhysRngLo	P1521	100	1	xSet7	ON	OFF	OFF	Low oil pressure
75	OilPSwmpSRCMax	P1522	100	3	xSet7	OFF	50% ↓	200 rpm ↓	High voltage in oil pressure sensor wiring
76	OilPSwmpSRCMin	P1523	100	4	xSet7	OFF	50% ↓	200 rpm ↓	Low voltage in oil pressure sensor wiring
77	OilTPhysRngHi	P0196	175	0	xSet8	OFF	50% ↓	200 rpm ↓	Oil temperature high
78	OilTSRCMax	P0198	175	3	xSet8	OFF	OFF	OFF	High voltage in oil temperature wiring
79	OilTSRCMin	P0197	175	4	xSet8	OFF	OFF	OFF	Low voltage in oil temperature wiring
80	PCRGovDvtMax	P2263	5465	0	xSet13	OFF	50% ↓	200 rpm ↓	Boost system pressure deviation high_positive direction (leak)
81	PCRGovDvtMin	P1263	5465	1	xSet13	OFF	OFF	OFF	Boost system pressure deviation high_negative direction (clog)
82	PEnvRngChkMax	P2227	108	0	xSet13	OFF	OFF	OFF	High atmospheric pressure
83	PEnvRngChkMin	P1227	108	1	xSet13	OFF	OFF	OFF	Low atmospheric pressure
84	PEnvSigRngMax	P2229	108	3	xSet13	OFF	OFF	OFF	High voltage in atmospheric pressure sensor wiring

No.	Fault	P-Code	SPN	FMI	EnvRef	Shutdown	Torque Limit	Speed Limit	Description
85	PEnvSigRngMin	P2228	108	4	xSet13	OFF	OFF	OFF	Low voltage in atmospheric pressure sensor wiring
86	PEnvSnsrPlaus	P006D	108	12	xSet13	OFF	OFF	OFF	Atmospheric pressure sensor reliability error
87	PFltCharPDiffMax	P1457	520621	0	xSet18	OFF	50% ↓	200 rpm ↓	High SCR differential pressure
88	PFltCharPDiffMin	P1456	520621	1	xSet18	OFF	OFF	OFF	Low SCR differential pressure
89	PIntkVUsLineHiB1	P0238	102	3	xSet9	OFF	OFF	OFF	High voltage in boost pressure sensor wiring
90	PIntkVUsLineLoB1	P0237	102	4	xSet9	OFF	OFF	OFF	Low voltage in boost pressure sensor wiring
91	PIntkVUsPhysRngHi	P0236	102	0	xSet9	OFF	OFF	OFF	High boost pressure
92	PPFltDiffSRCMax	P2465	4767	3	xSet18	OFF	OFF	OFF	High voltage in SCR differential pressure sensor wiring
93	PPFltDiffSRCMin	P2464	4767	4	xSet18	OFF	OFF	OFF	Low voltage in SCR differential pressure sensor wiring
94	PRVctOpnMax	P0089	520203	12	xSet33	OFF	OFF	OFF	Max. no. of openings of pressure relief valve exceeded
95	PRVFrOpnPresInc	P108C	520709	12	xSet33	OFF	OFF	OFF	Pressure relief valve forced open due to increase in fuel pressure
96	PRVFrOpnPresShck	P108D	520710	12	xSet33	ON	OFF	OFF	Pressure relief valve forced open due fuel pressure impact
97	PRVOpn	P108E	520711	7	xSet33	OFF	50% ↓	200 rpm ↓	Pressure relief valve open
98	PRVQBalChk	P1036	520712	12	xSet33	OFF	OFF	OFF	Flow rate balance confirmed after successful opening of fuel pressure relief valve
99	PRVRPOutOfRng	P1037	520713	12	xSet33	OFF	OFF	OFF	Average rail pressure exceeded error range
100	PRVtiOpnMax	P108F	520714	12	xSet33	OFF	OFF	OFF	Max. opening time of pressure relief valve exceeded
101	PRVUnExptRailPDrp	P0194	129	5	xSet4	OFF	OFF	OFF	Low rail pressure error
102	RailMeUn0	P0251	520196	12	xSet4	OFF	50% ↓	200 rpm ↓	Upper limit on rail pressure deviation exceeded
103	RailMeUn10	P1251	520715	12	xSet4	OFF	50% ↓	200 rpm ↓	Fuel leak detected
104	RailMeUn2	P1252	520716	12	xSet4	OFF	50% ↓	200 rpm ↓	Rail pressure deviation limit exceeded (negative direction)
105	RailMeUn3	P0087	520717	12	xSet4	ON	50% ↓	200 rpm ↓	Minimum rail pressure limit not attained
106	RailMeUn4	P1090	520719	12	xSet4	OFF	50% ↓	200 rpm ↓	Maximum rail pressure limit exceeded
107	RailMeUn7	P1050	520720	12	xSet4	OFF	50% ↓	200 rpm ↓	Metering unit reliability fault in overrun mode
108	RailMeUn8	P1257	520721	12	xSet4	OFF	50% ↓	200 rpm ↓	Metering unit reliability fault in idling mode
109	RailPCVLimpExtd4	P1192	520722	12	xSet4	ON	OFF	OFF	Max. rail pressure exceeded in limp home mode
110	RailPGradMon	P1039	520702	2	xSet4	OFF	OFF	OFF	Rail pressure gradient monitoring fault
111	RailPOfsTstMax	P0191	129	0	xSet4	OFF	50% ↓	200 rpm ↓	Rail pressure sensor max. offset exceeded error
112	RailPOfsTstMin	P1191	129	1	xSet4	OFF	50% ↓	200 rpm ↓	Rail pressure sensor min. offset exceeded error
113	RailPSRCMax	P0193	129	3	xSet3	OFF	OFF	OFF	High voltage in rail pressure sensor wiring
114	RailPSRCMin	P0192	129	4	xSet3	OFF	OFF	OFF	Low voltage in rail pressure sensor wiring
115	RBA_IOEXTLIB_KEEPALIVE_DRV	P1123	520111	0	xSet2	OFF	OFF	OFF	Keepalive fault in ECU external unit during operation
116	RBA_IOEXTLIB_KEEPALIVE_INI	P1124	520111	1	xSet2	OFF	OFF	OFF	Keepalive fault in ECU external unit during initialization
117	rba_IoSigRtc_StopCounter	P1125	520112	2	xSet2	OFF	OFF	OFF	ECU keep counter quicker or slower than allowable value or not counting due to communication error
118	rba_MemDiag_MemReadErr	P1126	520113	0	xSet2	OFF	OFF	OFF	Read diagnostic error in ECU non-volatile memory
119	rba_MemDiag_MemWrErr	P1127	520113	1	xSet2	OFF	OFF	OFF	Write diagnostic error in ECU non-volatile memory
120	rba_MRly_Diag_Stk_Event	P1128	520114	0	xSet2	OFF	OFF	OFF	ECU main relay fault
121	rba_MultiStackTrace_Threshold	P1129	520115	0	xSet2	OFF	OFF	OFF	ECU memory critical value exceeded

No.	Fault	P-Code	SPN	FMI	EnvRef	Shutdown	Torque Limit	Speed Limit	Description
122	rba_SyC_IrrSwOffTrigEngRun_Event	P1130	520116	0	xSet2	OFF	OFF	OFF	Irregular switch off counter fault in ECU observation counter due to engine operation
123	SCRChkEta1	P10EE	520664	1	xSet34	OFF	OFF	OFF	Low SCR NOx conversion efficiency
124	SCRMonDetModeBLPlaus	P1703	520751	12	xSet34	OFF	OFF	OFF	DEF return line pressure fault
125	SCRMonDetModePresStab	P1702	520753	12	xSet34	OFF	OFF	OFF	Supply module pressure stabilization fault
126	SCRMonDetnModPDrp	P1105	520752	12	xSet34	OFF	OFF	OFF	Supply module pressure decrease fault
127	SCRMonMetCtlOvrPresErr	P20E9	520755	12	xSet34	OFF	OFF	OFF	Supply module pressure maximum limit exceeded
128	SCRMonMetCtlUndrPresErr	P20E8	520757	12	xSet34	OFF	OFF	OFF	Supply module pressure minimum limit not attained
129	SCRMonOvrPresErr	P1706	520758	12	xSet34	OFF	OFF	OFF	Excessive supply module pressure
130	SCRMonPresBuildUpErr	P1106	520209	12	xSet34	OFF	OFF	OFF	Supply module pressure build-up fault
131	SCRPODMonTnkT	P115C	3031	31	xSet16	OFF	OFF	OFF	DEF tank temperature overheating
132	SMNoAvl	P1766	520632	31	xSet34	OFF	OFF	OFF	DEF supply module temperature measurement module malfunction
133	SMPerPwm	P1767	520632	0	xSet34	OFF	OFF	OFF	DEF supply module PWM signal time outside valid range
134	SMPwm	P1768	520632	2	xSet34	OFF	OFF	OFF	Diagnostic fault check for faulty PWM signal
135	SRCHighAPP1	P0123	91	3	xSet35	OFF	OFF	OFF	High voltage in accelerator pedal no. 1 wiring
136	SRCHighAPP2	P0223	29	3	xSet35	OFF	OFF	OFF	High voltage in accelerator pedal no. 2 wiring
137	SRCLowAPP1	P0122	91	4	xSet35	OFF	OFF	OFF	Low voltage in accelerator pedal no. 1 wiring
138	SRCLowAPP2	P0222	29	4	xSet35	OFF	OFF	OFF	Low voltage in accelerator pedal no. 2 wiring
139	SRCMinUPmpP	P204C	4334	4	xSet14	OFF	OFF	OFF	High voltage in DEF pump pressure sensor wiring
140	SSpMon1	P0643	3511	7	xSet14	OFF	OFF	OFF	ECU sensor supply voltage monitoring (sensor supply 1)_DEF pressure/fan speed sensor
141	SSpMon1OT	P06B1	3511	12	xSet14	OFF	OFF	OFF	Sensor supply voltage monitoring 1 (overheating)_DEF pressure/fan speed sensor
142	SSpMon1OV	P06B2	3511	0	xSet14	OFF	OFF	OFF	Sensor supply voltage monitoring 1 (over-voltage)_DEF pressure/fan speed sensor
143	SSpMon1SCG	P06B4	3511	4	xSet14	OFF	OFF	OFF	Sensor supply voltage monitoring 1 (short to ground)_DEF pressure/fan speed sensor
144	SSpMon1UV	P06B5	3511	1	xSet14	OFF	OFF	OFF	Sensor supply voltage monitoring 1 (insufficient voltage)_DEF pressure/fan speed sensor
145	SSpMon2	P0653	3512	7	xSet18	OFF	OFF	OFF	ECU sensor supply voltage monitoring (sensor supply 2)_SCR differential pressure/camshaft sensor
146	SSpMon2OT	P06B3	3512	12	xSet18	OFF	OFF	OFF	Sensor supply voltage monitoring 2 (ECU internal chip overheating)_SCR differential pressure/camshaft sensor
147	SSpMon2OV	P16B5	3512	0	xSet18	OFF	OFF	OFF	Sensor supply voltage monitoring 2 (over-voltage)_SCR differential pressure/ camshaft sensor
148	SSpMon2SCG	P1606	3512	4	xSet18	OFF	OFF	OFF	Sensor supply voltage monitoring 2 (short to ground)_SCR differential pressure/ camshaft sensor
149	SSpMon2UV	P1610	3512	1	xSet18	OFF	OFF	OFF	Sensor supply voltage monitoring 2 (insufficient voltage)_SCR differential pressure/camshaft sensor
150	SSpMon3	P0699	3513	7	xSet4	OFF	OFF	OFF	ECU sensor supply voltage monitoring (sensor supply 3)_throttle valve/fuel rail pressure sensor

No.	Fault	P-Code	SPN	FMI	EnvRef	Shutdown	Torque Limit	Speed Limit	Description
151	SSpMon3OT	P1607	3513	12	xSet4	OFF	OFF	OFF	Sensor supply voltage monitoring 3 (overheating)_throttle valve/fuel rail pressure sensor
152	SSpMon3OV	P16B2	3513	0	xSet4	OFF	OFF	OFF	Sensor supply voltage monitoring 3 (over-voltage)_throttle valve/fuel rail pressure sensor
153	SSpMon3SCG	P1608	35	4	xSet4	OFF	OFF	OFF	Sensor supply voltage monitoring 3 (short to ground)_throttle valve/fuel rail pressure sensor
154	SSpMon3UV	P16B1	3514	18	xSet4	OFF	OFF	OFF	Sensor supply voltage monitoring 3 (insufficient voltage)_throttle valve/fuel rail pressure sensor
155	SSpMon4	P16B3	3514	12	xSet2	OFF	OFF	OFF	ECU sensor supply voltage monitoring (sensor supply 4)_boost pressure/oil pressure/VGT speed
156	SSpMon4OT	P1609	3514	7	xSet2	OFF	OFF	OFF	Sensor supply voltage monitoring 4 (overheating)_boost pressure/oil pressure/ VGT speed
157	SSpMon4OV	P16B4	3514	0	xSet2	OFF	OFF	OFF	Sensor supply voltage monitoring 4 (over-voltage)_boost pressure/oil pressure/VGT speed
158	SSpMon4SCG	P1700	3514	4	xSet2	OFF	OFF	OFF	Sensor supply voltage monitoring 4 (short to ground)_boost pressure/oil pressure/ VGT speed
159	SSpMon4UV	P1701	3514	1	xSet2	OFF	OFF	OFF	Sensor supply voltage monitoring 4 (insufficient voltage)_boost pressure/oil pressure/VGT speed
160	StrtHSSCB	P1617	520522	3	xSet1	OFF	OFF	OFF	Starter high-side relay wiring, short to battery
161	StrtHSSCG	P1616	520522	4	xSet1	OFF	OFF	OFF	Starter high-side relay wiring, short to ground
162	StrtLSOL	P0615	520523	5	xSet1	OFF	OFF	OFF	Open circuit in starter low-side relay wiring
163	StrtLSOvrTemp	P0618	520523	12	xSet1	OFF	OFF	OFF	Overheating in starter low-side relay wiring
164	StrtLSSCB	P0617	520523	3	xSet1	OFF	OFF	OFF	Starter low-side relay wiring, short to battery
165	StrtLSSCG	P0616	520523	4	xSet1	OFF	OFF	OFF	Starter low-side relay wiring, short to ground
166	SyncAPP	P2135	91	12	xSet35	OFF	OFF	OFF	Accelerator pedal synchronization fault
167	TCACDsPhysRngHi	P0110	105	0	xSet10	OFF	OFF	OFF	High boost temperature
168	TCACDsSRCMax	P0113	105	3	xSet10	OFF	OFF	OFF	High voltage in boost temperature sensor wiring
169	TCACDsSRCMin	P0112	105	4	xSet10	OFF	OFF	OFF	Low voltage in boost temperature sensor wiring
170	TECUPhysRngHi_0	P0669	1207	0	xSet2	OFF	OFF	OFF	ECU internal temperature high 1
171	TECUPhysRngHi_1	P166A	1208	0	xSet2	OFF	OFF	OFF	ECU internal temperature high 2
172	TECUPhysRngLo_0	P0668	1207	1	xSet2	OFF	OFF	OFF	ECU internal temperature low 1
173	TECUPhysRngLo_1	P166B	1208	1	xSet2	OFF	OFF	OFF	ECU internal temperature low 2
174	TECUSigRngMax	P1670	1208	2	xSet2	OFF	OFF	OFF	ECU internal temperature sensor, short to battery
175	TECUSigRngMin	P1671	1208	3	xSet2	OFF	OFF	OFF	ECU internal temperature sensor, short to ground
176	TECUSnsrPlaus	P1672	1208	12	xSet2	OFF	OFF	OFF	ECU internal temperature sensor reliability fault
177	TECUSRCMax	P1669	1207	3	xSet2	OFF	OFF	OFF	High voltage in ECU internal temperature sensor wiring
178	TECUSRCMin	P1668	1207	4	xSet2	OFF	OFF	OFF	Low voltage in ECU internal temperature sensor wiring
179	TOxiCatUsPhysRngHi	P2080	4765	0	xSet19	OFF	50% ↓	200 rpm ↓	Turbocharger downstream temperature high
180	TOxiCatUsSRCMax	P0546	4765	3	xSet19	OFF	OFF	OFF	High voltage in turbocharger downstream temperature sensor wiring
181	TOxiCatUsSRCMin	P0545	4765	4	xSet19	OFF	OFF	OFF	Low voltage in turbocharger downstream temperature sensor wiring
182	UCatDsTPhysRngHi	P043B	4363	0	xSet22	OFF	50% ↓	200 rpm ↓	SCR downstream temperature high

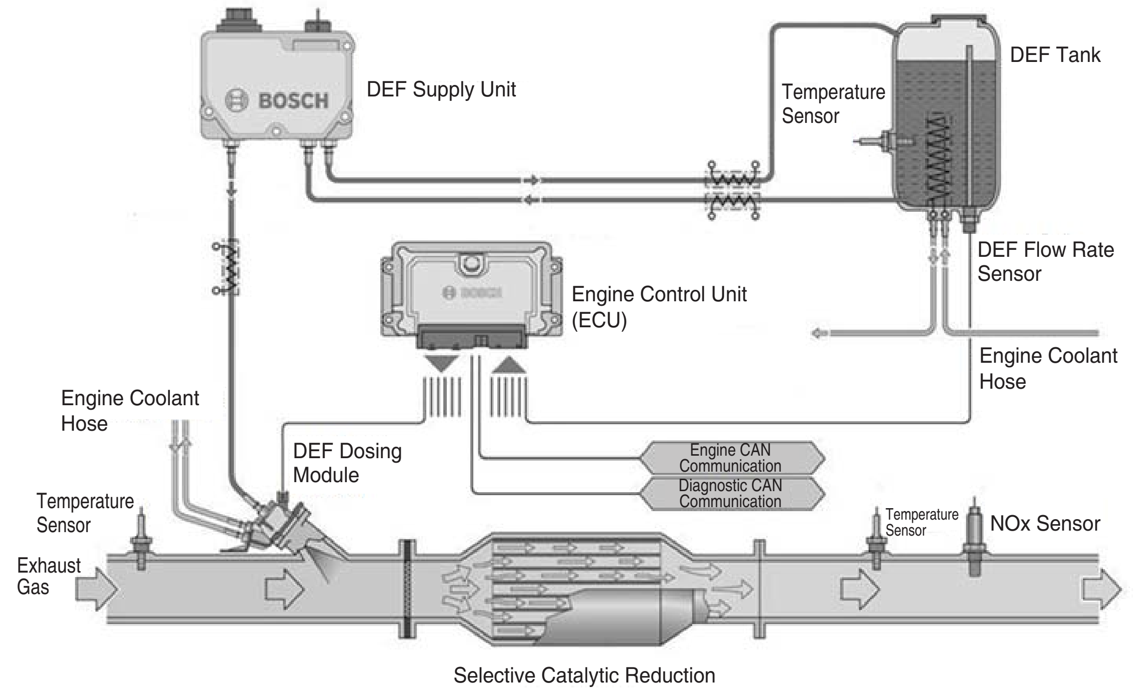
No.	Fault	P-Code	SPN	FMI	EnvRef	Shutdown	Torque Limit	Speed Limit	Description
183	UCatDsTSRCMax	P043D	4363	3	xSet22	OFF	OFF	OFF	High voltage in SCR downstream temperature sensor wiring
184	UCatDsTSRCMin	P043C	4363	4	xSet22	OFF	OFF	OFF	Low voltage in SCR downstream temperature sensor wiring
185	UCatUsTPhysRngHi	P0436	4360	0	xSet21	OFF	50% ↓	200 rpm ↓	SCR upstream temperature high
186	UCatUsTSRCMax	P0438	4360	3	xSet21	OFF	OFF	OFF	High voltage in SCR upstream temperature sensor wiring
187	UCatUsTSRCMin	P0437	4360	4	xSet21	OFF	OFF	OFF	Low voltage in SCR upstream temperature sensor wiring
188	UDCRdcAgRmn	P103C	1761	7	xSet15	OFF	OFF	OFF	SCR DEF tank level low
189	UDosVlvOL	P1739	520828	5	xSet34	OFF	OFF	OFF	Open circuit in DEF dosing valve wiring
190	UDosVlvSCB	P1718	520765	3	xSet34	OFF	OFF	OFF	DEF dosing valve wiring, short to battery
191	UDosVlvSCG	P1716	520765	4	xSet34	OFF	OFF	OFF	DEF dosing valve wiring, short to ground
192	UDosVlvSCHSLS	P1717	520766	4	xSet34	OFF	OFF	OFF	DEF dosing valve wiring, short to ground
193	UHCEnfShOffWiEmp	P1730	520822	12	xSet34	OFF	OFF	OFF	After-run carried out due to DEF pressure line heater error
194	UHtrBLOL	P20B9	4354	5	xSet25	OFF	OFF	OFF	Open circuit in DEF return line heater wiring
195	UHtrBLSCB	P20BC	4354	3	xSet25	OFF	OFF	OFF	DEF return line heater wiring, short to battery
196	UHtrBLSCG	P20BB	4354	4	xSet25	OFF	OFF	OFF	DEF return line heater wiring, short to ground
197	UHtrPLOL	P20BD	4355	5	xSet25	OFF	OFF	OFF	Open circuit in DEF pressure line heater wiring
198	UHtrPLSCB	P20C0	4355	3	xSet25	OFF	OFF	OFF	DEF pressure line heater wiring, short to battery
199	UHtrPLSCG	P20BF	4355	4	xSet25	OFF	OFF	OFF	DEF pressure line heater wiring, short to ground
200	UHtrRlyOL	P202A	4358	5	xSet25	OFF	OFF	OFF	Open circuit in DEF heating relay wiring
201	UHtrRlySCB	P202C	4358	3	xSet25	OFF	OFF	OFF	DEF heating relay wiring, short to battery
202	UHtrRlySCG	P202B	4358	4	xSet25	OFF	OFF	OFF	DEF heating relay wiring, short to ground
203	UHtrSLOL	P20C1	4356	5	xSet25	OFF	OFF	OFF	Open circuit in DEF suction line heater wiring
204	UHtrSLSCB	P20C4	4356	3	xSet25	OFF	OFF	OFF	DEF suction line heater wiring, short to battery
205	UHtrSLSCG	P20C3	4356	4	xSet25	OFF	OFF	OFF	DEF suction line heater wiring, short to ground
206	UHtrSMOL	P20C5	4357	5	xSet25	OFF	OFF	OFF	Open circuit in DEF supply module heater wiring
207	UHtrSMSCB	P20C8	4357	3	xSet25	OFF	OFF	OFF	DEF supply module heater wiring, short to battery
208	UHtrSMSCG	P20C7	4357	4	xSet25	OFF	OFF	OFF	DEF supply module heater wiring, short to ground
209	UHtrTnkOL	P20B1	3363	5	xSet25	OFF	OFF	OFF	Open circuit in DEF tank coolant valve wiring
210	UHtrTnkSCB	P20B4	3363	3	xSet25	OFF	OFF	OFF	DEF tank coolant valve wiring, short to battery
211	UHtrTnkSCG	P20B3	3363	4	xSet25	OFF	OFF	OFF	DEF tank coolant valve wiring, short to ground
212	UPmpMotNoAvl	P1723	520771	12	xSet36	OFF	OFF	OFF	DEF pump motor operation fault
213	UPmpMotOL	P208A	520772	5	xSet36	OFF	OFF	OFF	Open circuit in DEF pump motor power stage wiring
214	UPmpMotSCB	P208D	520772	3	xSet14	OFF	OFF	OFF	DEF pump motor power stage wiring, short to battery
215	UPmpMotSCG	P208C	520772	4	xSet14	OFF	OFF	OFF	DEF pump motor power stage wiring, short to ground
216	UQlSensPhyRngHi	P206D	3516	0	xSet17	OFF	OFF	OFF	DEF quality (concentration) high
217	UQlSensPhyRngLo	P206C	520811	1	xSet17	OFF	OFF	OFF	DEF quality (concentration) low
218	URevVlvOL	P20A0	4376	5	xSet34	OFF	OFF	OFF	Open circuit in DEF reverting valve wiring
219	URevVlvSCB	P20A3	4376	3	xSet34	OFF	OFF	OFF	DEF reverting valve wiring, short to battery
220	URevVlvSCG	P20A2	4376	4	xSet34	OFF	OFF	OFF	DEF reverting valve wiring, short to ground

9. Aftertreatment System (IMO Tier3)

9.1. Exhaust Gas Reduction System

9.1.1. Selective Catalytic Reduction (SCR)

- Selective catalytic reduction (SCR) is a device which injects DEF (Diesel Exhaust Fluid, urea) into the exhaust gas produced by the engine and causes a catalytic reaction with the nitrogen oxide in the exhaust gas, thereby converting it into harmless nitrogen (N_2) and water vapor (H_2O).



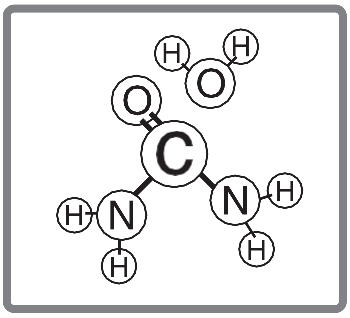
EDL06160017

- DEF (Diesel Exhaust Fluid, Urea)
  1) DEF (Diesel Exhaust Fluid, urea) is not a toxic material, but a fluid in which clean water and urea are mixed together.
     (Urea : 32.5%, water : 67.5%)
  2) In selective catalytic reduction, the following chemical reaction takes place, thereby converting nitrogen oxide (NOx) into nitrogen (N_2) and water vapor.

$$2\,CO + O_2 = 2\,CO_2$$

$$2\,C_2H6 + 7\,O_2 = 4\,CO_2 + 6\,H_20$$

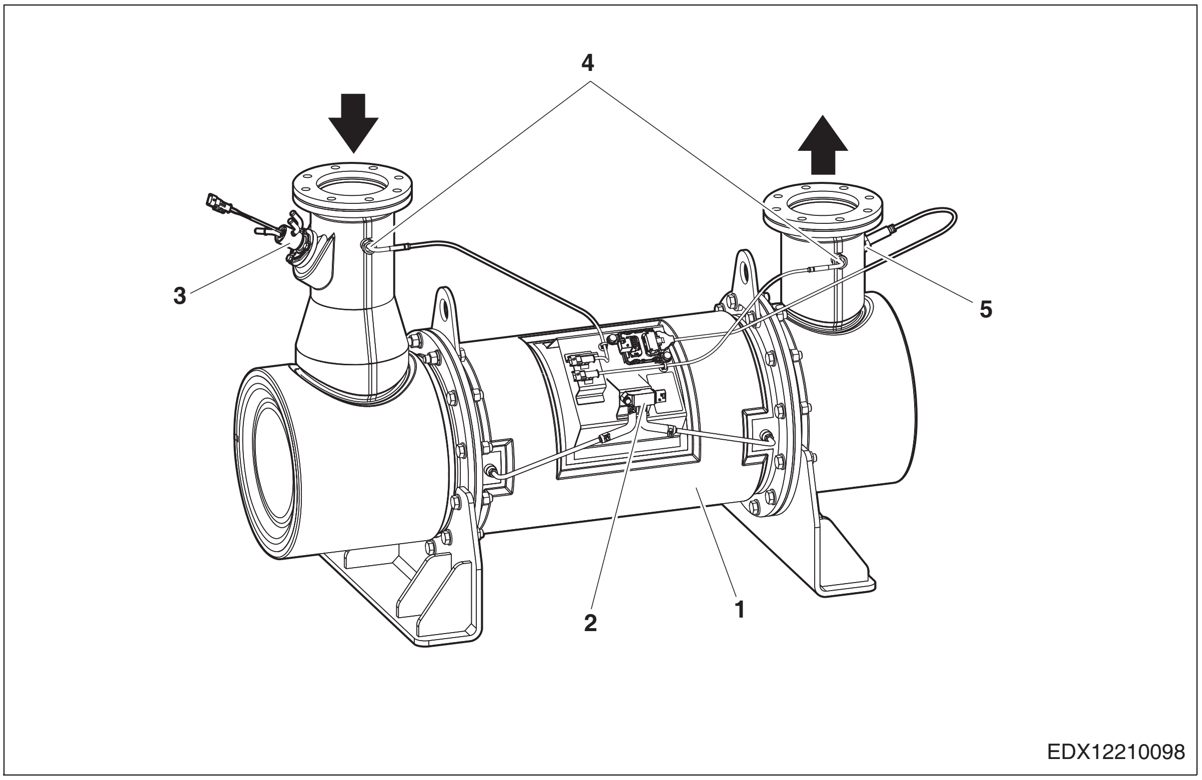
$$NO + NO_2 + 2\,NH_3 = 2\,N_2 + 3\,H_2O$$



EDL06160022

9.1.2. Aftertreatment Muffler and Catalyst

The aftertreatment muffler consists of a removable SCR (Selective Catalytic Reduction) unit and an inlet/outlet; the SCR catalyst has a sensor bracket for mounting related sensors.



1. SCR catalyst
2. DP sensor
3. Dosing module
4. Temperature sensor
5. NOx sensor

CAUTION

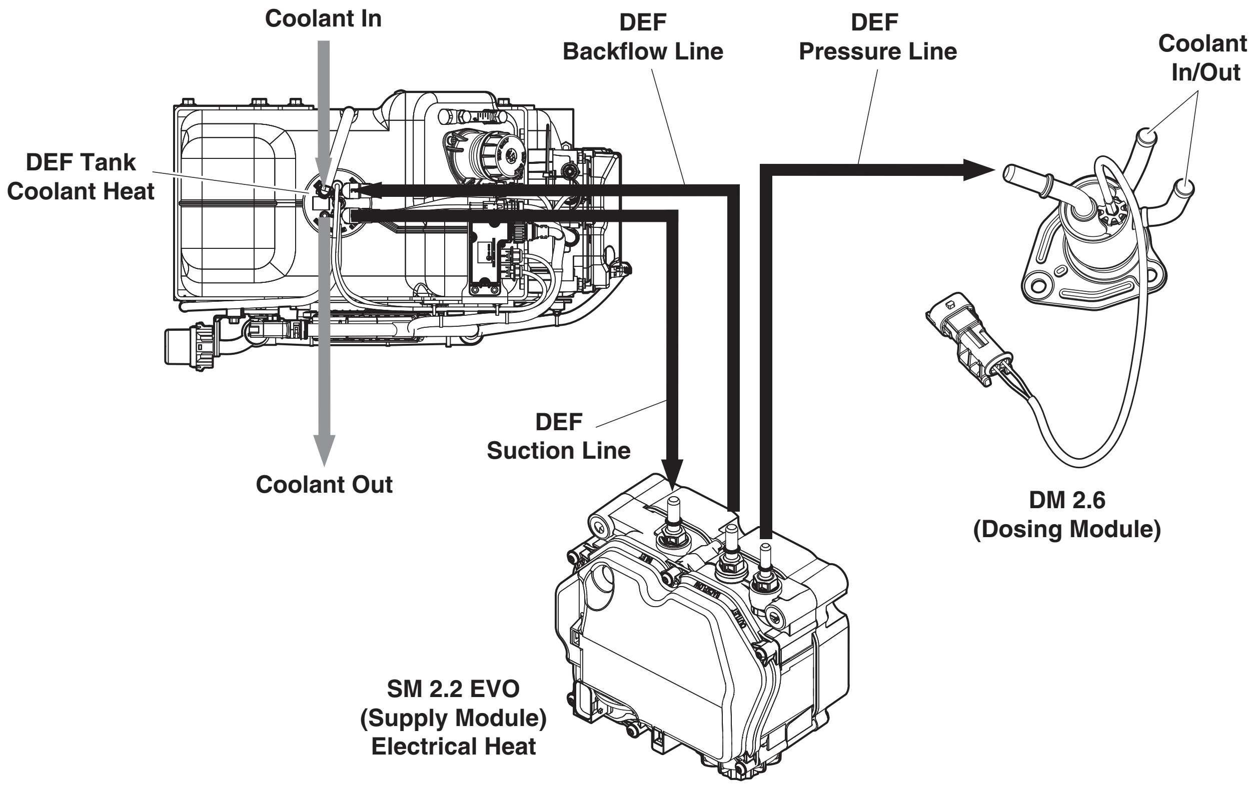
As an important part necessary for satisfying emissions regulations, the SCR catalyst requires regular yearly maintenance; if a problem occurs, the relevant measures must be taken and the SCR catalyst must be replaced.

The NOx sensor is used for monitoring any leakage of the SCR reducing agent or any decrease of the SCR efficiency. If such malfunction is detected, the code "P10EE" will be generated. This code indicates the necessity of an inspection of the SCR aftertreatment.

The DP sensor is used for monitoring internal damage or clogging of the SCR. If such a malfunction is detected, the codes "P1456" and "P1457" will be generated. They indicate the necessity of the inspection of the SCR aftertreatment.

9.1.3. DNOX 2.2 EVO System

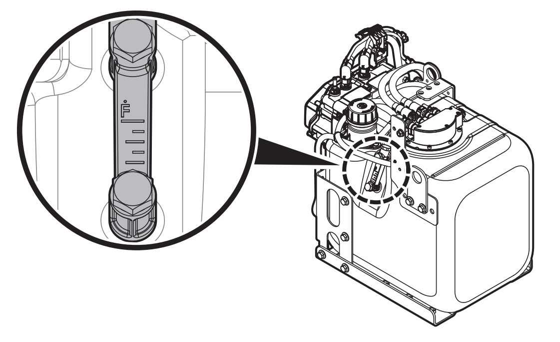
The DNOX 2.2 EVO system injects DEF (Diesel Exhaust Fluid, urea) into the SCR catalyst to reduce NOx (nitrogen oxide) emissions. The system consists of a supply module acting as a pump, a dosing module which injects DEF, an ECU which controls the entire system, a DEF tank for storing DEF, and DEF/coolant lines.



EDX22230132

CAUTION

DEF (urea) should not exceed the "F" line of the level indicator attached to the DEF tank. (Reference for models that HD Hyundai Infracore supplies DEF tank.)

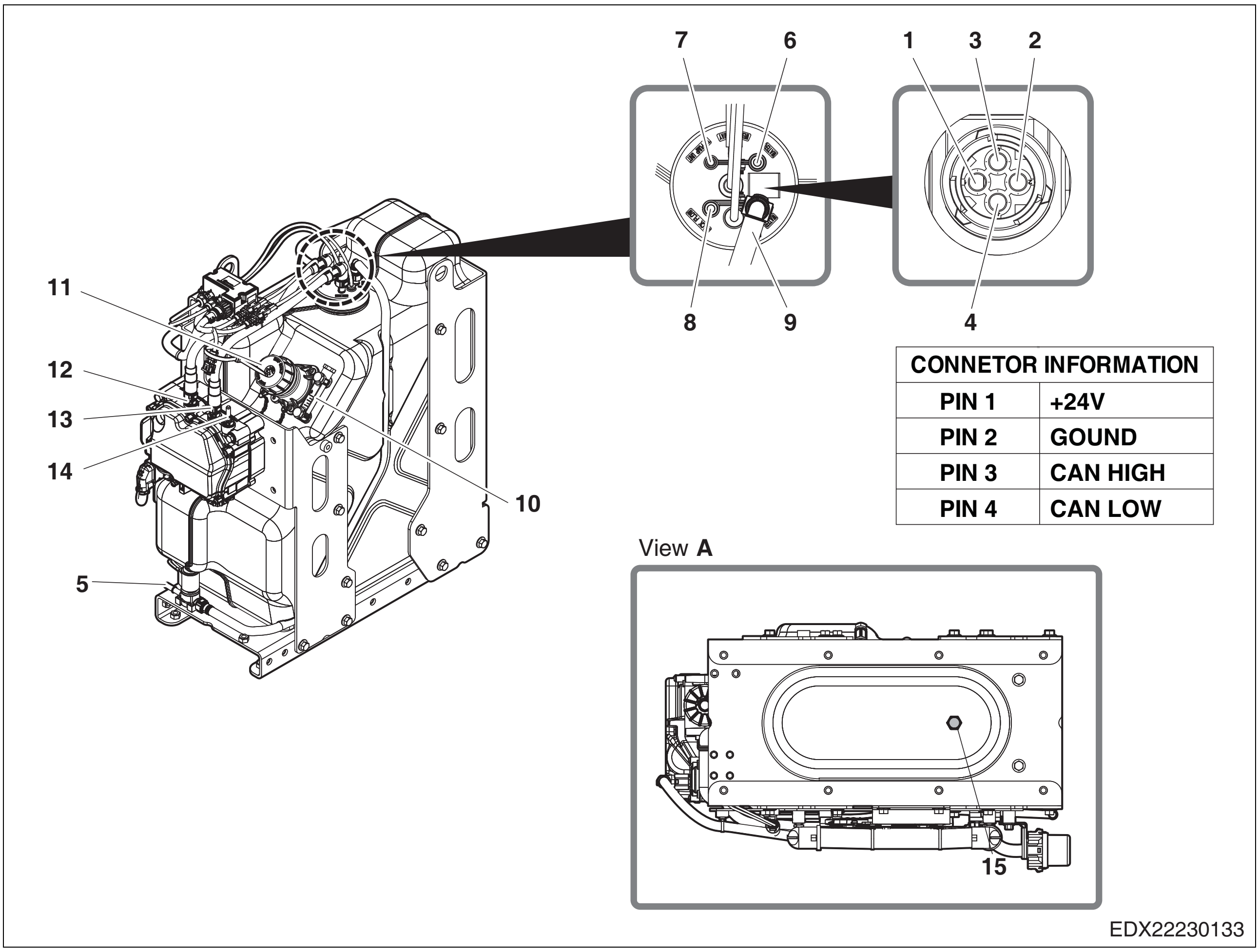


EDM03210136

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

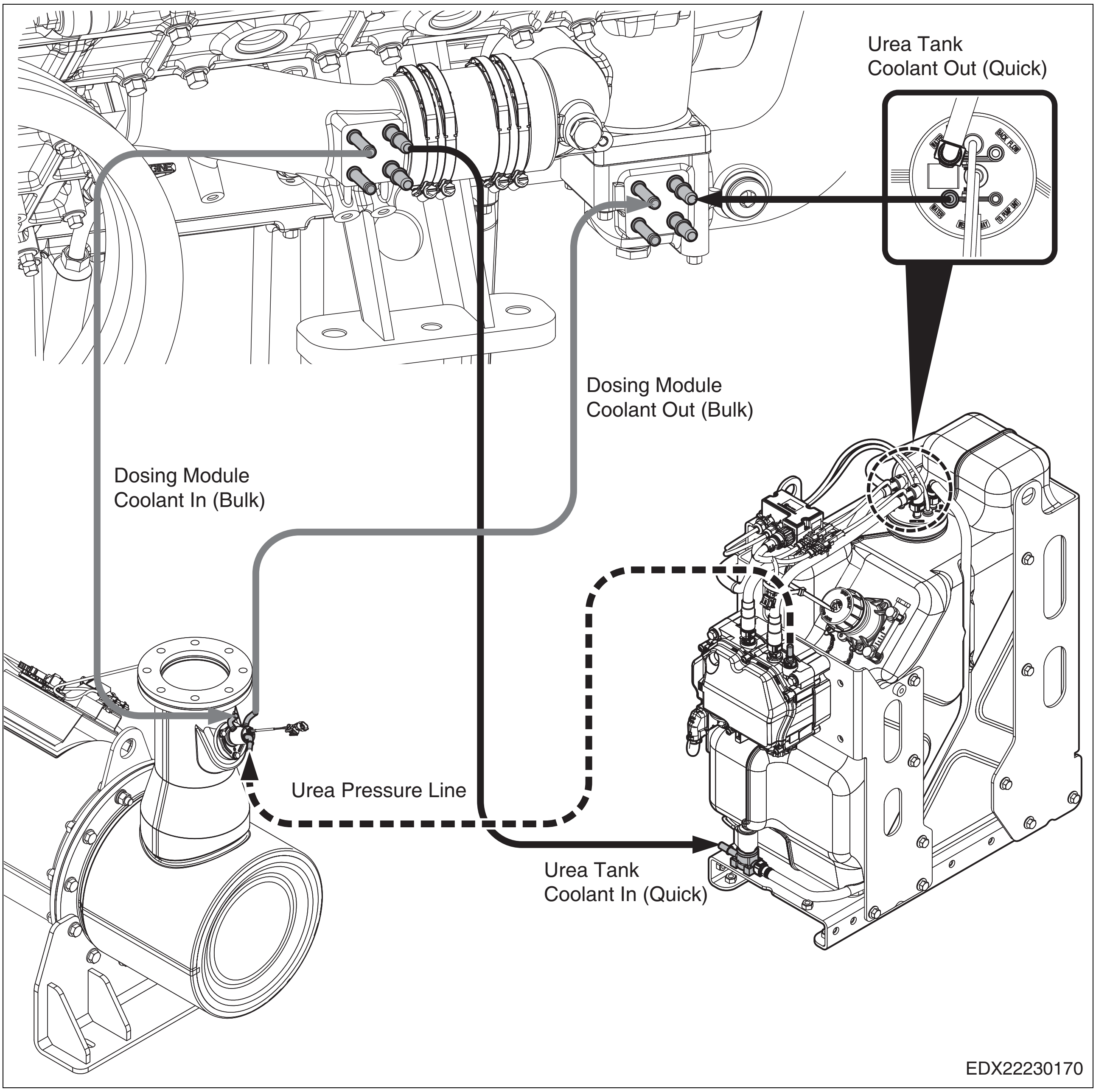
9.1.4. DEF Tank

The DEF tank is used to store DEF (Diesel Exhaust Fluid, urea). Be sure to install connecting lines in their designated positions. Take care not to apply any excessive force or shocks to the DEF tank during maintenance.



CONNETOR INFORMATION	
PIN 1	+24V
PIN 2	GOUND
PIN 3	CAN HIGH
PIN 4	CAN LOW

1. +24 V (Pin No.1)
2. Ground (Pin No.2)
3. CAN HIGH (Pin No.3)
4. CAN LOW (Pin No.4)
5. Coolant inlet
6. Coolant outlet
7. DEF outlet
8. DEF inlet
9. Coolant inlet
10. Level indicator
11. DEF tank cap
12. DEF intake (from the tank)
13. DEF return line
14. DEF pressurized outlet
15. Drain plug



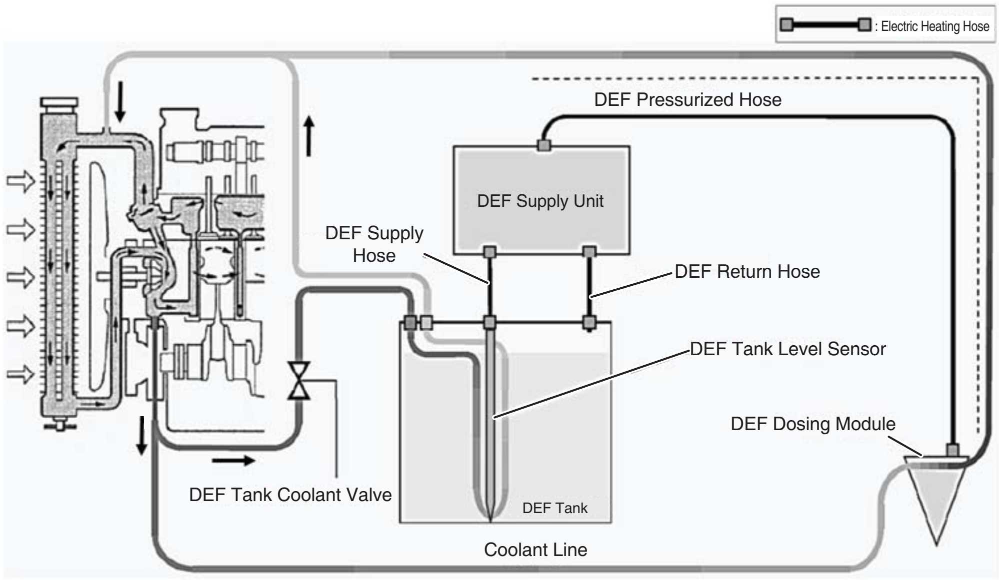
Note

Connect two aftertreatment and DEF tanks each.

This schematic diagram only shows one unit.

9.1.5 DEF (Diesel Exhaust Fluid, Urea) Pre-Heater (Heating of the Urea Solution)

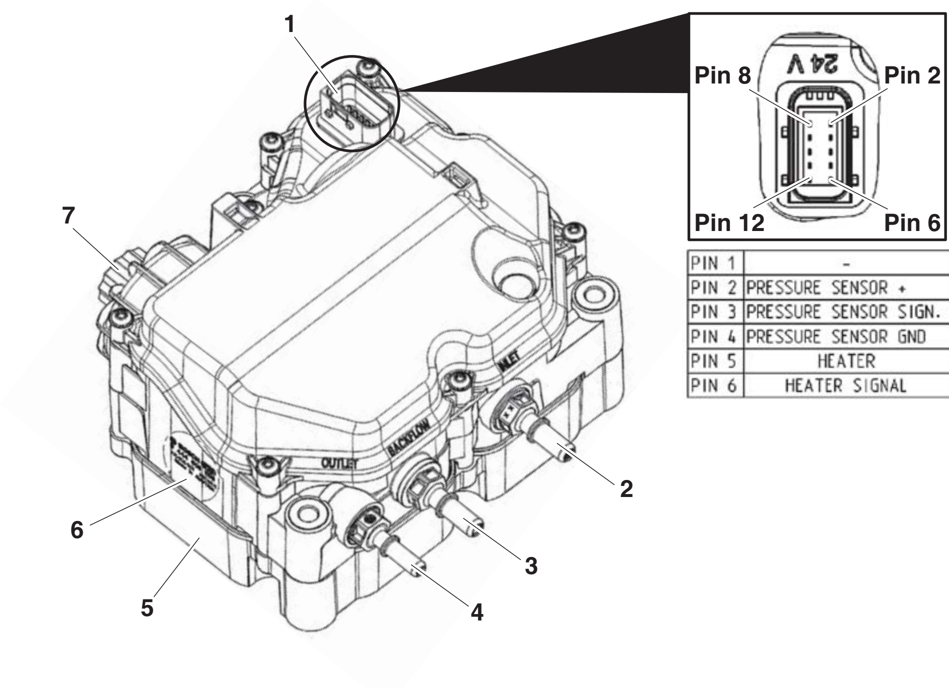
- DEF (Diesel Exhaust Fluid, urea) is frozen at or below -11°C, and therefore, the DEF tank should be heated with the engine coolant.



EDX12210003

9.1.6. Supply Module

The supply module is a device which pressurizes DEF in the DEF tank to a constant pressure and delivers it to the dosing module.



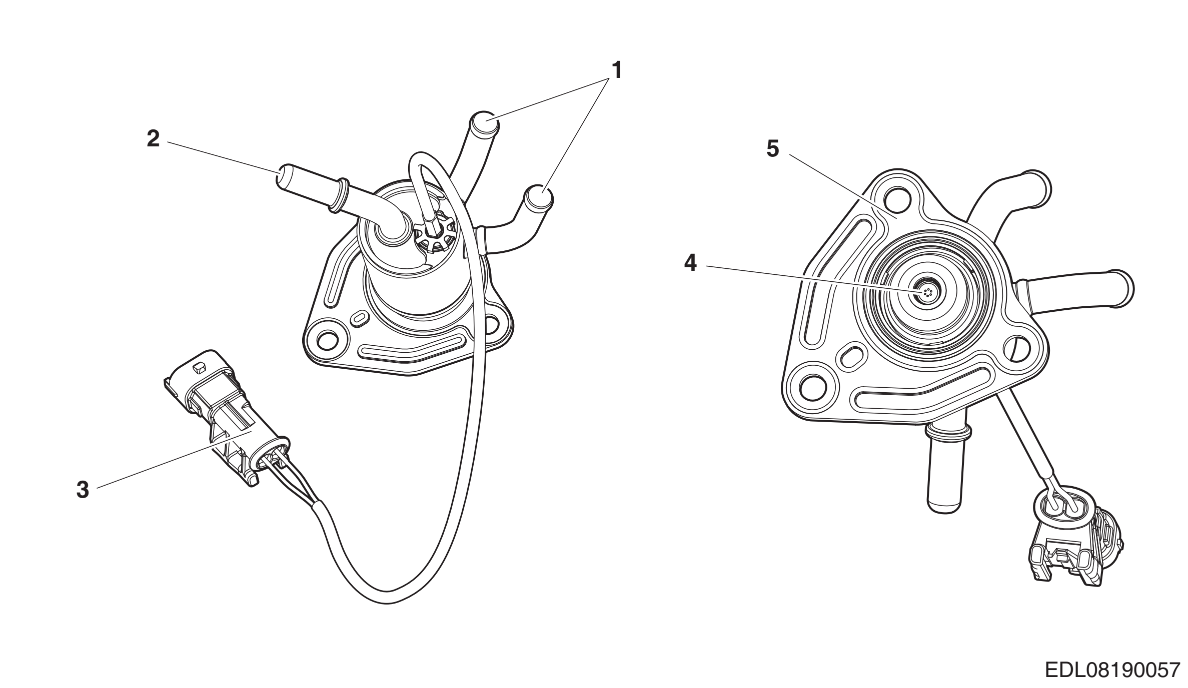
PIN 1	-	PIN 7	-
PIN 2	PRESSURE SENSOR +	PIN 8	PUMP MOTOR GND
PIN 3	PRESSURE SENSOR SIGN.	PIN 9	PUMP MOTOR +
PIN 4	PRESSURE SENSOR GND	PIN 10	PUMP MOTOR PWM
PIN 5	HEATER	PIN 11	RVV
PIN 6	HEATER SIGNAL	PIN 12	RVV SIGNAL

EK00303A

1. Connector
2. DEF inlet
3. DEF return outlet
4. DEF outlet
5. Cover plate
6. Detailed display
7. Filter cover

9.1.7. Dosing Module

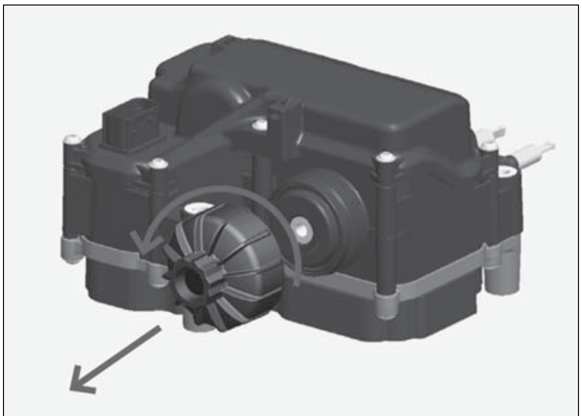
The dosing module injects the pressurized DEF from the supply module into the exhaust gas.



1. Coolant inlet/outlet
2. DEF inlet
3. Connector
4. DEF injection nozzle
5. Flange

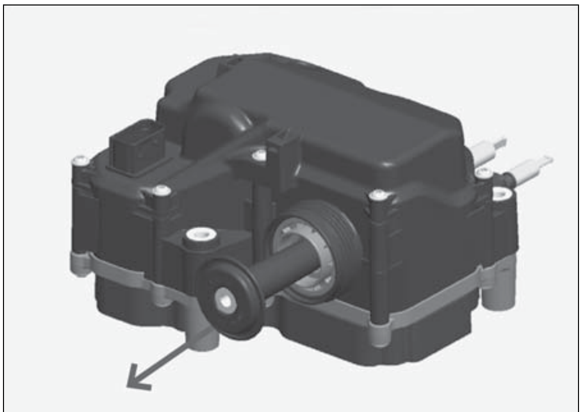
9.1.8. Replacing the DEF Filter

1) Remove the filter cover.



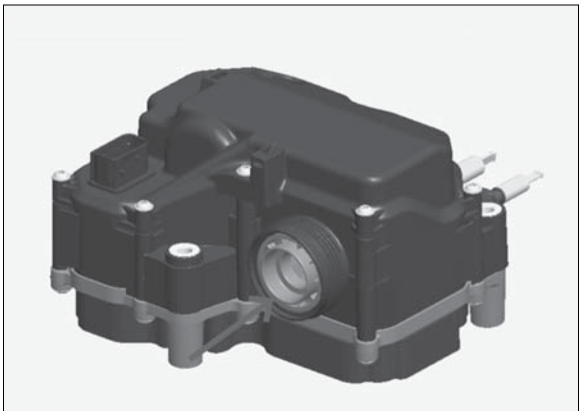
EK00305A

2) Remove the equalizing element.



EK00306A

3) Check the color of the inside of the filter (black/gray).

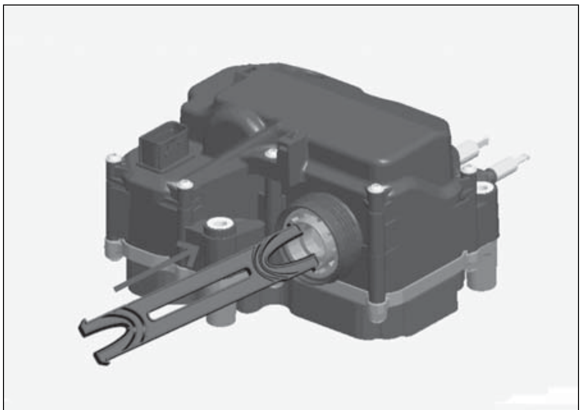


EK00307A

4) Adjust the filter removal tool so that the color on the end of the tool faces the same direction as the color of the filter.

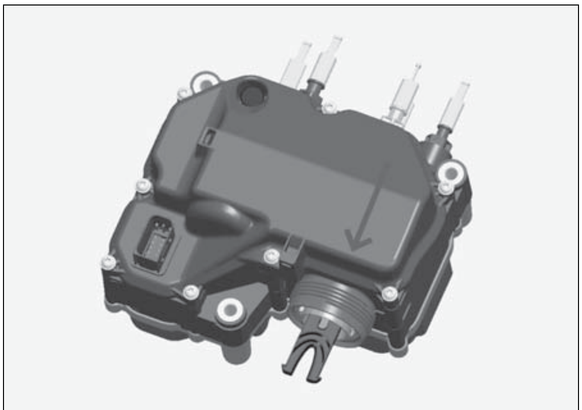
EK00308A

5) Insert the end of the filter removal tool into the filter until a click is heard or until it grips the filter.



EK00309A

6) Pull on the filter removal tool to remove the filter.



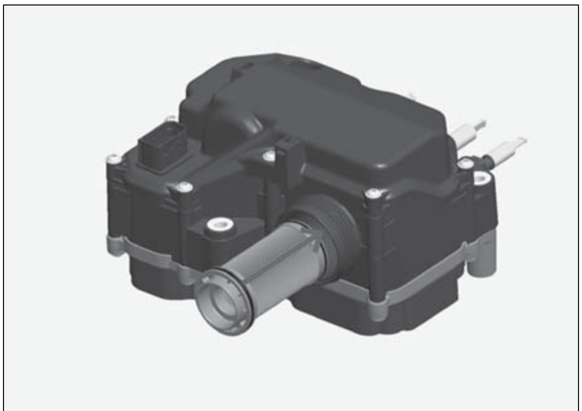
EK00310A

7) Keep the surface clean and wash the surface with water only.

EK00311A

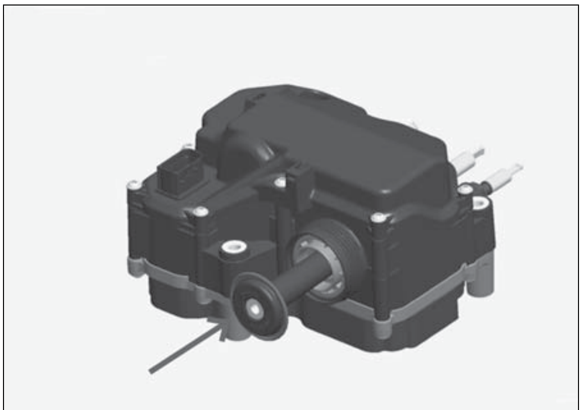
8) Apply oil to an O-ring and install a new filter.

CAUTION
Use the Mobil Velocite No.6 oil sold by Bosch.



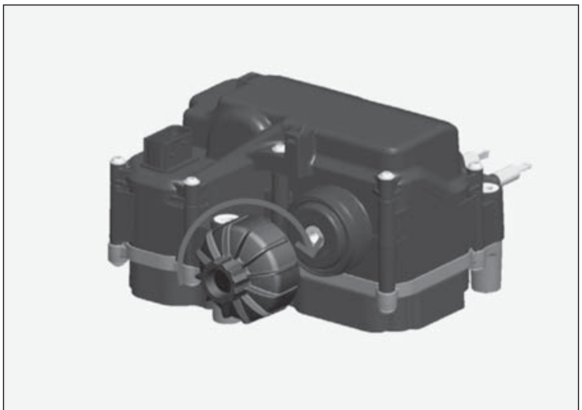
EK00312A

9) Install a new equalizing element.



EK00313A

10)Tighten the filter cover to a tightening torque of 20 +5 N·m.

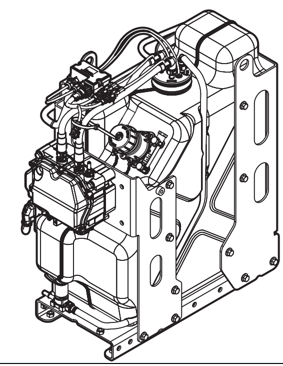


EK00314A

CAUTION
Check whether the surface of the filter cover is clean. The surface can only be washed with water.

9.1.9. Components of the DNOX 2.2 EVO System

1) The components of the DNOX 2.2 EVO are installed throughout the ship where they are most essential. Each part is designed to be protected from damage due to the surroundings.

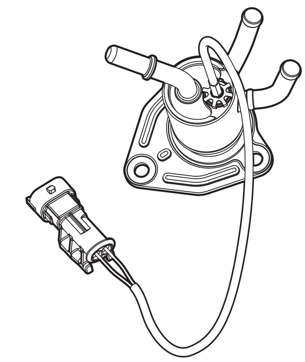


EDX22230136

CAUTION
The supply module is mounted on the DEF tank.

9.1.10. Inspecting the DNOX 2.2 EVO System for Faults

1) Dosing module
   Dosing module faults can be caused by exposure of the DEF injection nozzle tip to high temperatures, poor contact in the electric harness, and damage or poor contact in DEF hose lines, etc. The following DM faults can be inspected visually.
   a) Air leak due to insufficiently tightened bolt or DM (Dosing Module) and bolt damaged due to overtightened bolt during replacement or installation of the DM.
   b) Improperly installed electrical connector or connector contaminated by foreign matter.
   c) DEF leak due to improperly connected DEF line.
   d) Coolant leak due to improperly connected coolant line or DM exposed to high temperatures due to disconnected coolant line.
   e) DM exposed to high temperatures due to improperly installed gasket.
   f) DEF leak due to reuse of gasket.



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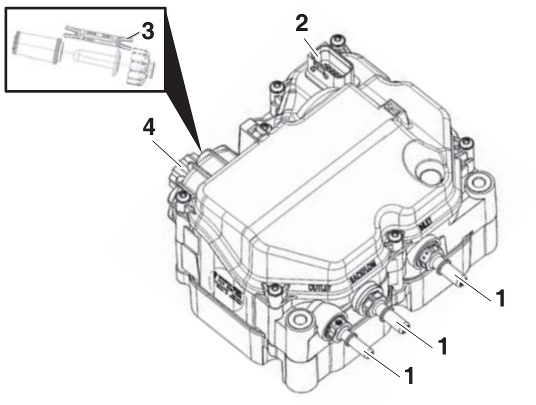
2) Supply module
   Supply module (SM) fault modes may be caused by damaged or improperly connected DEF lines and electrical connectors. Faults may occur due to incorrect installation during regular replacements of the main urea filter.



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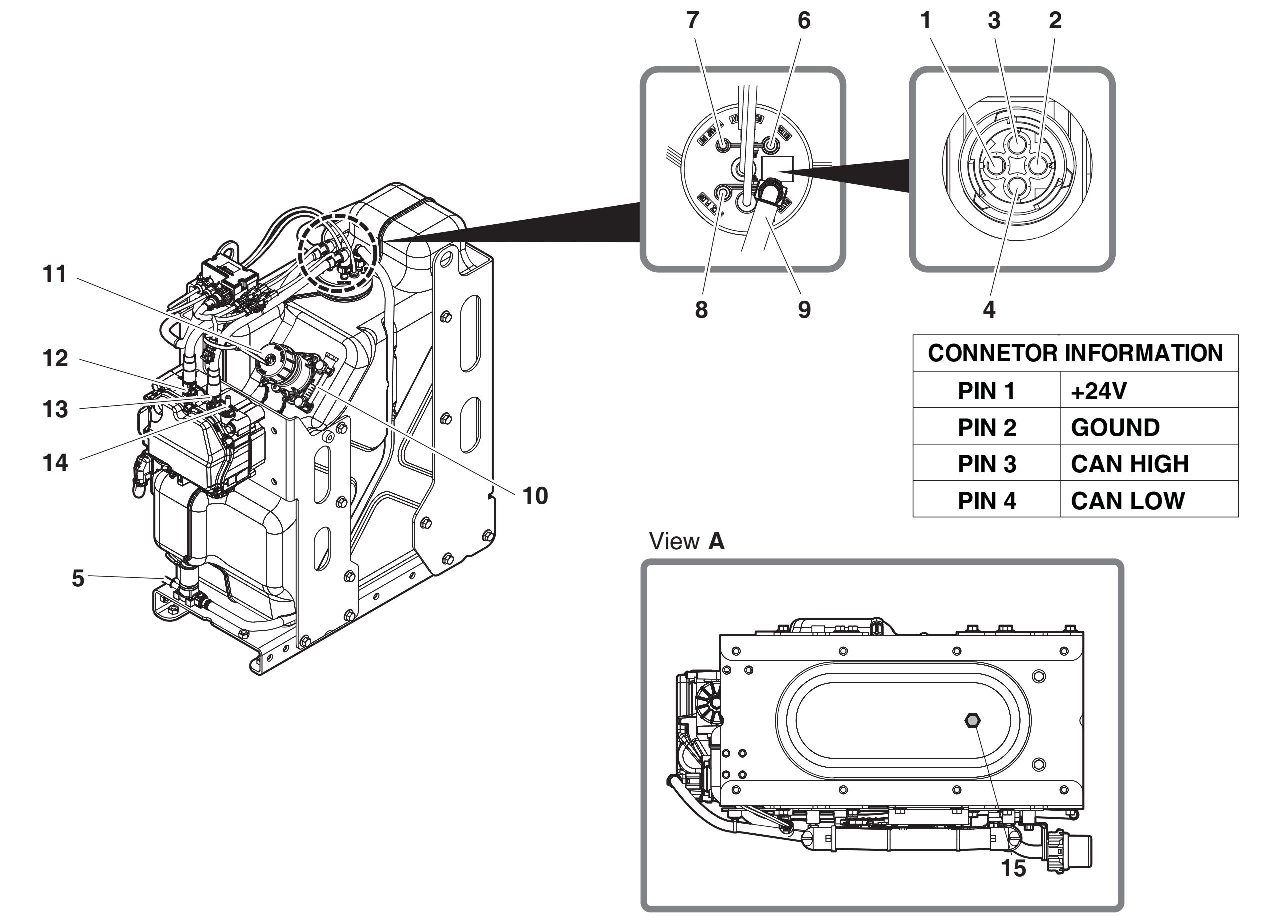
CAUTION
When replacing a filter, remove the packaging on the new filter immediately before performing the replacement.

   a) Fault due to improper assembly or improperly connected line while connecting DEF lines.
   b) Improperly installed electrical connector or connector contaminated by foreign matter.
   c) Filter damaged due to use of improper tools during replacement of SM filter or residue build-up in SM filter.
   d) Cap damaged by overtightening of DEF cap during filter replacement or filter loose due to incorrect installation.

3) DEF tank

The DEF tank is used to store DEF (Diesel Exhaust Fluid, urea).

Be sure to install connecting lines in their designated positions. Take care not to apply any excessive force or shocks to the DEF tank during maintenance.



CONNETOR INFORMATION	
PIN 1	+24V
PIN 2	GOUND
PIN 3	CAN HIGH
PIN 4	CAN LOW

EDX22230133

CAUTION

Although a DEF inlet hose and backflow hose are already installed prior to release from the factory, take care not to mix them up during removal and reassembly.

CAUTION

a) Check whether the DEF tank mounting bracket has been tightened. Failing to tighten it may lead to damage due to vibrations.

b) Check the tank temperature and the connection of the level sensor connector, taking care to avoid damaging or contaminating the connector with foreign matter.

c) Coolant lines must be installed in their proper positions. Failing to tighten coolant lines may cause coolant leakage.

d) Check the connection of the DEF line heater (2-PIN). There is a risk of freezing and bursting in winter if the heater is not working.

4) Muffler and other pipes

The preassembled muffler and various pipes do not need to be replaced, removed, or relocated unless there is a fault or problem due to external influences.

If replacement or removal is necessary due to a fault or problem, make sure to tighten each part to its specified tightening torque in order to prevent leaks.

9.1.11. DEF (Diesel Exhaust Fluid, Urea)

Component	Unit	Range		Test Method
		Min.	**Max.**	
Urea concentration[a]	% (m/m)[b]	31.8	33.2	ISO 22241-2 Annex B[c] ISO 22241-2 Annex C[c]
Density (at 20°C[d])	kg/m^3	-	1,093	ISO 3675 or ISO 12185
Deflection (at 20°C[e])	-	-	1.3843	ISO 22241 2 Annex C
Ammonia alkaline	% (m/m)[b]	-	0.2	ISO 22241 2 Annex D
Biuret	% (m/m)[b]	-	0.3	ISO 22241 2 Annex E
Aldehydes	mg/kg	-	5	ISO 22241 2 Annex F
Insoluble matter	mg/kg	-	20	ISO 22241 2 Annex G
Phosphate (PO4)	mg/kg	-	0.5	ISO 22241 2 Annex H
Calcium	mg/kg	-	0.5	ISO 22241 2 Annex I
Iron	mg/kg	-	0.5	
Copper	mg/kg	-	0.2	
Zinc	mg/kg	-	0.2	
Chrome	mg/kg	-	0.2	
Nickel	mg/kg	-	0.2	
Aluminum	mg/kg	-	0.5	
Magnesium	mg/kg	-	0.5	
Sodium	mg/kg	-	0.5	
Potassium	mg/kg	-	0.5	
Identity	-	Identical		ISO 22241 2 Annex J

a) Reference value: 32.5% (m/m).
b) The unit "% (m/m)" is used to express the mass of matter as a fraction according to international standards.
c) Calculated without subtracting nitrogen from ammonia.
d) Reference value: 1,090 kg/m^3
e) Reference value: 1.3829

DEF requires the addition of a tracer element. Take care to ensure that the quality of AUS 32 indicated in the table and the tracer element do not damage the SCR system.

CAUTION
The conditions of ISO 4259 must be applied between the maximum and minimum values within the specified range. Be sure to take the minimum difference of 4 x R (R is the reproducibility of the test method) into account. However, for the sake of maintaining high quality, 4 x R is not factored into the urea concentration.

CAUTION
The urea concentration, density and deflection are the actual values. (For the actual values, please refer to ISO 4259)

CAUTION
The values defined in notes a, d and e are standard among DEF manufacturers.

CAUTION
Be sure to check whether the DEF (Diesel Exhaust Fluid, urea) satisfies the required specifications. Be sure to apply the conditions of ISO 4259.

9.1.12. Disassembling the SCR Catalyst

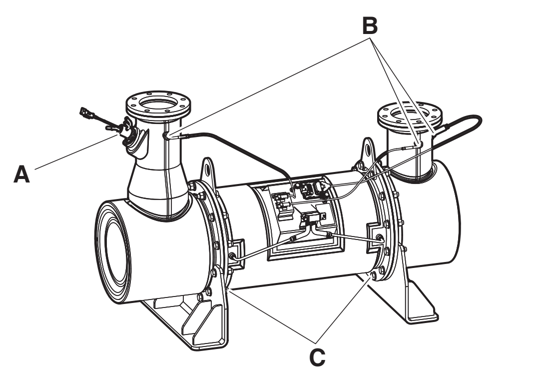
1) Disconnect dosing module (A) coolant hose and DEF hose.

CAUTION
Take care not to spill hot coolant or DEF during removal.

2) Remove temperature sensor and NOx sensor (B).
3) Unscrew flange bolts (C) and disassemble the SCR catalyst.

CAUTION
Gaskets and clamps are intended for single use only; do not reuse them.

4) Perform reassembly in the reverse order of disassembly, tightening parts to their specified tightening torque.



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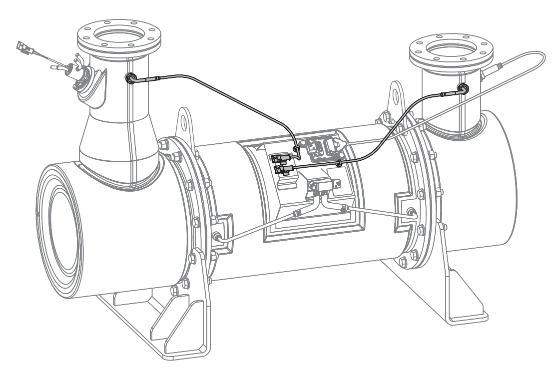
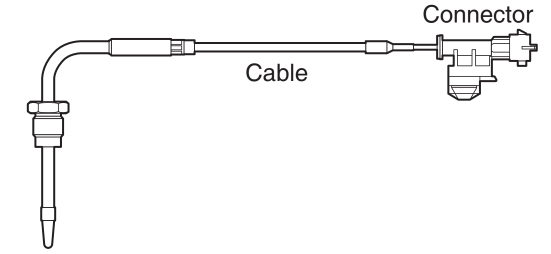
Name	Tightening torque
NOx sensor	50 ±5 Nm
Temperature sensor	45 ±5 Nm
M6 bolt (DP sensor & dosing module)	8 ±2 Nm
M14 bolt	98 ~ 117 Nm

A temperature sensor is installed in the SCR muffler inlet and outlet to measure the temperature of the aftertreatment system's SCR catalyst.


EDX12210104

- The SCR catalyst temperature sensor measures the temperature for DEF injection and serves to detect abnormal exhaust gas temperatures; the ECU monitors this data and warns the operator. In the event of a fault, suitable measures must be taken in accordance with the user's manual.



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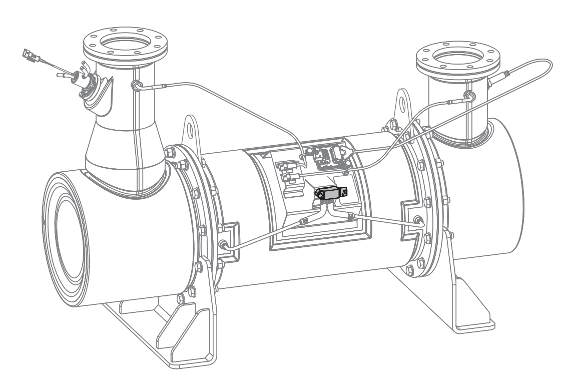
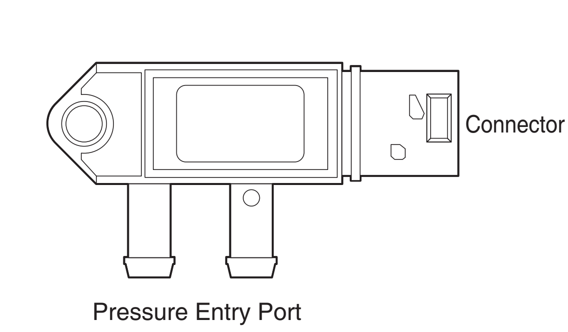
● A differential pressure sensor is installed to measure the pressure difference upstream and downstream of the SCR catalyst and check for clogging in the SCR catalyst.

Connector pin No.	Pin name
1	Supply voltage (VCC)
2	Ground
3	Output signal


EDX12210105

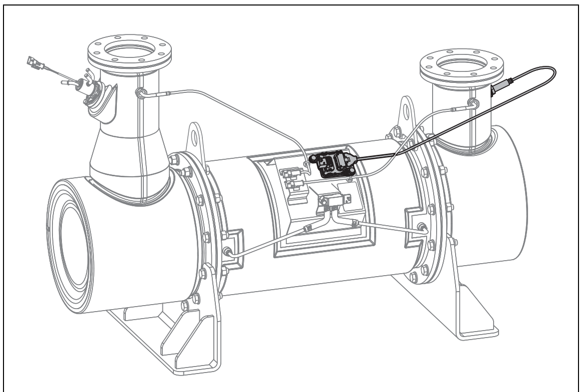
● The differential pressure sensor measures for clogging in the SCR catalyst; when abnormal differential pressure occurs, the ECU detects this and warns the operator. In the event of a fault, suitable measures must be taken in accordance with the user's manual.



EDL08190073

CAUTION
Due to high-sulfur fuel for ships, catalyst clogging can occur, and in case of excessive differential pressure, operation at maximum power for over one hour is recommended.
In case of continuous faults after that, appropriate measures should be taken according to the User Manual.

● The NOx sensor mounted downstream of the SCR muffler measures the amount of nitrogen oxide (NOx); if the NOx value increases relative to the reference value, the operator is warned.
In the event of a fault, suitable measures must be taken in accordance with the user's manual.


EDX12210106

CAUTION
In case of faults because of the degraded catalyst efficiency with the use of high-sulfur fuel for ships, operation at maximum power for over one hour is recommended.
In case of continuous faults after that, appropriate measures should be taken according to the User Manual.

9.1.13. Cautions for Handling the SCR Muffler

1) The muffler weighs around 102 kg, and the SCR catalyst is sensitive to impacts, so it must be handled with care.
2) When replacing the differential pressure sensor, take care to ensure that foreign matter does not enter the differential pressure sensor pipe. If foreign matter enters the pipe, a fault may occur due to a mis-reading of the differential pressure.
3) After removing the SCR assembly, take care to prevent foreign matter from entering the inlet/outlet. If foreign matter enters the system, the SCR catalyst may be damaged.
4) Be careful not to damage the differential pressure sensor and temperature sensor during removal and installation.
5) Reusing gaskets removed during the removal of the SCR catalyst may cause leaks, so make sure to use new gaskets.
6) Air leaks in the exhaust system can lead to violation of emissions regulations, increased noise, and increased exhaust smoke, so be sure to tighten parts to their specified tightening torque.

Appendix

● Main Tightening Torques

<Chart of specified tightening torques>

Main Components	Name (Dia. × Pitch)	Strength	Tightening Torque
Cylinder block bearing cap			
- Main bolt	M18 × 2.0	12.9T	30 kg·m + 90° (0 ~ 10°)
- Side bolt	M12 × 1.5	12.9T	13.4 kg·m
Oil spray nozzle			
- Valve	M14 × 1.5	–	7 kg·m
- Mounting bolt	M6	8.8T	1.2 kg·m
Flywheel housing	M10 × 1.5	12.9T	7.5 kg·m
	M12 × 1.5	12.9T	13.4 kg·m
	M14 × 1.5	12.9T	17 kg·m
Balance weight	M16 × 1.5	10.9T	14 kg·m + 90°
Crankshaft pulley	M16 × 1.5	12.9T	21 kg·m
Vibration damper	M12 × 1.5	12.9T	13.4 kg·m
Flywheel	M18 × 1.5	14.9T	20 kg·m (144.66 lb·ft) + 90° + 90° + 90°
Connecting rod cap	M16 × 1.5	10.9T	10 kg·m + 90°
Cylinder head	M16 × 2.0	–	4 kg·m + 90° + 90°
Cylinder center cover	M8 × 1.25	8.8T	2.2 kg·m
Cylinder head cover	M8 × 1.25	8.8T	2.2 kg·m
Rocker arm bracket	M10 × 1.5	10.9T	6.2 kg·m
Rocker arm adjustment nut	M10 × 1.0	8.8T	5.0 kg·m
Oil pump mounting	M8 × 1.25	8.8T	2.2 kg·m
Oil Filter	M10 × 1.5	8.8T	4.4 kg·m
Oil cooler	M10 × 1.5	8.8T	4.4 kg·m
Oil pan	M8 × 1.25	10.9T	3.1 kg·m
Oil pan drain plug	M30 × 1.5	–	15 kg·m
Exhaust manifold	M10 × 1.5	–	8.0 kg·m
Intake manifold	M8 × 1.25	8.8T	2.2 kg·m
Hanger bracket mounting bolt	M16 × 2.0	10.9T	26.0 kg·m
Starter Motor	M12 × 1.5	8.8T	8.0 kg·m
Alternator bracket	M12 × 1.5	8.8T	8.0 kg·m
Coolant temperature sensor	M12 × 1.5	–	2.5 kg·m
Intake temperature sensor	M10 × 1.25	–	0.8 kg·m
Fuel injector mounting bracket bolt	M8	10.9T	3.0 ~ 3.5 kg·m
High-pressure fuel pump mounting bolt	M10 × 1.5	10.9T	6.2 kg·m
High-pressure fuel connector nut	M22 × 1.5	–	5.5 kg·m
Common rail mounting bolt	M8	10.9T	2.2 kg·m
High-pressure fuel pipe - High-pressure fuel connector	M14 × 1.5	–	4.0 kg·m
High-pressure fuel pipe - Common rail	M14 × 1.5	–	4.0 kg·m
High-pressure fuel pipe - High-pressure fuel pump	M14 × 1.5	–	4.0 kg·m
Fuel filter mounting bolt	M10 × 1.5	10.9T	6.2 kg·m

<Tightening torque for injection pump system>

Component	Tightening torque
HPC nut	Temporary tightening: 0.3 ±0.1 kg·m
	Final torque: 6.2 ±0.62 kg·m
High-pressure fuel pipe	4.0 ±0.4 kg·m

<Standard bolt tightening torque by specification>

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

Unit : mm

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

Others

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 to only 85% of the standard value. For example, MoS_2-coated screws should be tightened to 60% of the standard value.

● **Specification Chart for Maintenance of Main Components**

Unit : mm

Item	Component	Check Items		Assembly Standard	Usable Limit	Repair	Remarks
Engine body	Cylinder block and liner	Worn inside diameter of cylinder liner		Ø127.990 ~ Ø128.010	Ø128.122	Replace cylinder liner.	Measure non-worn part under upper rim
		Liner protrusion		0.04 ~ 0.09		There must be projection	0.15 ↓ difference in protrusion with nearby liner
		Flatness of warped upper surface of cylinder block		0.03 (whole)		Repair it with a surface grinder	0.015 for a length of 150 mm
		Hydrostatic test (one minute) (kg/cm^2)		4		Replace if leaking oil	Water temperature: 70°C
	Cylinder head and valves	Valve seat depression	Intake	0.9 ~ 1.1	1.3	Replace the valve seat	
			Exhaust	0.9 ~ 1.1	1.6		
		Cylinder head height		116.95 ~ 117.05	116.5	Replace cylinder head	
		Hydrostatic test (one minute) (kg/cm^2)		4 bar		Replace if leaking oil	Water temperature: 70°C
Main drive components	Piston	Piston O.D.		Ø127.833 ~ Ø127.847		Replace the liner	Measure at a point 102 mm the top surface of the piston
		Clearance between piston and liner		0.143 ~ 0.177		Replace if wear exceeds the specification	
		Piston ring groove width	Top ring	3.20 ~ 3.23		Replace the piston if the groove width exceeds the specified amount	
			Second ring	3.040 ~ 3.060			
			Oil ring	4.020 ~ 4.040			
		Piston protrusion from the top surface of the cylinder block		0.18 ~ 0.47			Measure under the edge of the top part which is not worn
		Allowable weight difference among pistons		50 g	50 g ↓	Replace piston	
	Piston ring	Piston ring width	Top ring	3.075 ~ 3.095		Replace ring	
			Second ring	2.975 ~ 2.990			
			Oil ring	3.97 ~ 3.99			
		Piston ring gap	Top ring	0.30 ~ 0.40	0.7	Replace ring	Standard gauge I.D.: Ø128
			Second ring	1.10 ~ 1.30	1.45		
			Oil ring	0.40 ~ 0.60	0.85		
		Piston ring side gap	Top ring	0.105 ~ 0.150	0.30	Replace the ring or piston	Usable limit for standard gap
			Second ring	0.05 ~ 0.082	0.15		
			Oil ring	0.030 ~ 0.070	0.15		
		Direction of ring clearance				Install rings at 120˚ intervals from one another	

Unit : mm

Item	Component	Check Items		Assembly Standard	Usable Limit	Repair	Remarks
Main drive components	Crankshaft	Unevenly worn journal and pin		0.02		Repair with grinder	Lateral & longitudinal
		Journal O.D.		Ø103.98 ~ Ø104.00	Ø102.98	Use the undersize bearing (0.10, 0.25, 0.5, 0.75, 1.0)	
		Pin O.D.		Ø93.980 ~ Ø94.000	Ø92.980		Ø86g6
		Ovalness of journal and pin		0.01	0.025		
		Allowable parallelism of journal and pin		0.02	0.03		
		Clearance between crankshaft and bearing		0.066 ~ 0.134	0.159	Replace the bearing	Measure on crown
		Crankshaft play		0.140 ~ 0.361	0.4	Replace the thrust bearing	
		Crankshaft deflection		0.08	0.12 or less	Repair deflection with a press	Measure at no. 4 (supporting No. 1 and 7)
		Crankshaft levelness (g·cm)		60 ↓	60 or less	Check dynamic balancing	Measure at 400 rpm
		Journal bearing cap bolt tightening torque (kg·m)		30 kg·m + 90°		Apply oil to the bolt	There should be no foreign material on the bearing cap mounting surface
		Main bearing cap spread	Main	0.3 ~ 1.2			Tighten the metal cap and unscrew one stud bolt for measurement
			Thrust	0.3 ~ 1.2			
		Worn oil seal (Back side of crankshaft)				Replace oil seal if there are any oil leaks	Replace with new part, use a shim
	Connecting rods	Connecting rod free play	Big end	0.15 ~ 0.351	0.50	Replace connecting rod	
			Small end	1.5			
		Clearance between connecting rod bearing and crank pin		0.056 ~ 0.118	0.143	Replace the bearing	
		Clearance between small end bushing and piston pin		0.055 ~ 0.071	0.13		Install the bearing and loosen one bolt for measurement
		Height of connecting rod bearing crush		0.120 ~ 0.160			Tighten the bearing cap and unscrew one stud bolt for measurement
		Allowable weight difference among connecting rods		50 g ↓			
		Connecting rod bearing cap bolt torque (kg·m)		10 kg·m + 90°		Do not apply oil to bolt	There should be no foreign material on the bearing cap mounting surface
	Camshaft	Camshaft O.D.		Ø69.91 ~ Ø69.94	Ø69.56		
		Camshaft thrust bushing I.D.		Ø70.070 ~ Ø70.090	Ø70.19		
		Camshaft intermediate (excluding thrust) bushing I.D.		Ø70.000 ~ Ø70.030	Ø70.19		
		Clearance between camshaft and thrust bushing		0.130 ~ 0.180	0.24	Replace the cam bushing	
		Clearance between camshaft and bushing		0.060 ~ 0.120	0.24	Replace the cam bushing	
		Axial play of the camshaft		0.1 ~ 0.85	1.00	Replace thrust plate	

Unit : mm

Item	Com-ponent	Check Items			Assembly Standard	Usable Limit	Repair	Remarks
Major drive compo-nents	Timing gear	Clearance between fuel pump idler gear bushing and shaft			0.025 ~ 0.075	0.15	Replace the idler gear bushing	
		Axial play of the fuel pump idler gear			0.20 ~ 0.40	0.60	Replace the idler gear pin	
		Clearance between fuel pump gear shaft and bushing			0.025 ~ 0.075	0.15	Replace the fuel pump gear bush-ing	
		Axial play of the fuel pump gear			0.20 ~ 0.60	0.80	Replace the fuel pump gear bracket	
		Backlash between cam gear and fuel pump idler gear			0.035 ~ 0.373	0.26	Replace gear	
		Backlash between fuel pump idler gear and fuel pump gear			0.097 ~ 0.222	0.41		
		Backlash between crank gear and cam gear			0.087 ~ 0.203	0.27		
		Backlash between crank gear and oil pump gear			0.035 ~ 0.263	0.33		
Valve system	Valves	Intake valve stem O.D.			Ø7.963 ~ Ø7.977	Ø7.943	Replace valve and guide	When replac-ing 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	0.038 ~ 0.067	0.10	Replace valve and guide	
				Exhaust	0.051 ~ 0.080	0.15	Replace	
		Valve thickness		Intake	3.2 ~ 3.6	2.7	Replace	
				Exhaust	3.9 ~ 4.3	3.4		
		Clamping between valve guide and cylinder head mounting hole			0.01 ~ 0.039			Press fit after applying oil to the valve guide
		Intake/ exhaust spring	Exterior	Free length	57.0	–		
				Spring tension (P1/P2) kg	25.5 (P1/44 mm) 52.3 (P2/31.6 mm)	23.5 ~ 27.5 49.8 ~ 54.8	Replace the valve spring	
				Straightness (compared to free length)	1.5	2.0		
			Interior	Free length	59.5	–		
				Spring tension (P1/P2) kg	14.8 (P1; 41 mm) 25.0 (P2; 28.6 mm)	13.3 ~ 16.3 23.0 ~ 27.0	Replace the valve spring	
				Straightness (compared to free length)	1.5	2.0		

Unit : mm

Item	Component	Check Items		Assembly Standard	Usable Limit	Repair	Remarks
Valve system	Rocker arm and pushrod	Valve clearance	Intake	0.4 ±0.05		Adjust	
			Exhaust	0.7 ±0.05		Adjust	
		Rocker arm bushing I.D.		Ø27.991 ~ Ø28.012	Ø27.916		
		Rocker arm shaft O.D.		Ø27.953 ~ Ø27.976	Ø27.916		
		Clearance between rocker arm shaft and rocker arm bushing		0.015 ~ 0.059	0.12	Replace bushing or shaft	
		Pushrod deflection (Warpage)		0.3		Replace	
	Tappet	Clearance between tappet and cylinder block		0.035 ~ 0.077	0.15	Replace tappet	
		Tappet O.D.		Ø19.944 ~ Ø19.965		Replace tappet	
		Contact surface of tappet and cam		–	–	If it is excessively deformed or worn, replace it	
Lubrication System	Oil pressure	Oil pressure (normal speed) kg/cm^2		3.0 ~ 6.5	3.0	Check for oil leakage and clearance in each section	
		Oil pressure (idling without load) kg/cm^2		1.0 ~ 3.0	0.8 or more	Use recommended oil	
	Oil temperature	Max. allowable oil temp. °C		–	105		No temperatures higher than this are allowed
		Instant allowable oil temp. °C		–	120		
	Valve opening pressure	Bypass valve for oil filter element (bar)		2.2 ~ 2.8	–	Replace valve	
		Oil pump relief valve (bar)		8 ~ 9.5			
		Spray nozzle adjustment valve (bar)		0.6 ~ 1			
	Oil filter	Damaged oil filter cartridge				Clean and replace	
Cooling system	Coolant pump	Displacement 1/min - Engine rpm : 1,800 rpm - Water temp. : 80°C - Negative pressure : 0.5 kg/cm^2		700	600	Repair or replace	
		Clearance between pump impeller and housing body		0.5 ~ 0.9	0.1	Replace if impeller and housing are touching one another	
	Coolant Temperature	Operating temperature (suitable temperature) °C		94 ~ 98	103		No temperatures higher than this are allowed
		Instant allowable temp. °C		105	105		
	Thermostat	Thermostat opening temperature °C (under atmospheric pressure)		79	79	Replace	
		Thermostat fully open temperature °C		94 or less	94	Replace if defective	Lift : min. 8 mm
Fuel system	Piping and Other Parts	Damaged, cracked or poor packing of fuel pipe, injection pipe or nozzle holder		–		Replace	
		Damaged fuel filter cartridge		–		Replace	
	Height of nozzle protrusion from cylinder head surface (mm)			2.53		Replace the cylinder head and nozzle	

User Manual for 8 Inch Digital Panel for Electronic Marine Auxiliary Engine

Ver.1.0

HYUNDAI

HY-DGP-MANUAL-001

▶ Contents

▶ Contents

1.General Information

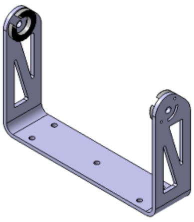
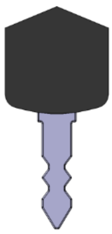
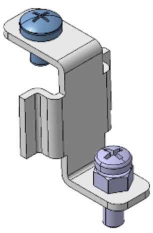
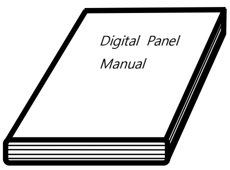
1.1 Product Information

This product is a digital panel for electronic auxiliary engine displays and can be applied to various small marine engines. The DGP model is designed to be robust for marine environments and is equipped with digital visualization to clearly monitor engine control and status information. It provides information through graphical analog gauges and digital displays, aiming to enhance user convenience.

1.2 Components and Optional Accessories

- Refer to Table 1-1 below for product components
- Reference
  DGP: Digital Gauge Panel

Components

NO	Components	Component Name	NO	Components	Component Name
1		DGP	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 electronic engine

Digital Gauge panel product Specification

No.	Item	Remark
1	Microprocessor	• NXP4330Q / S32K144
2	Software	• Linux OS GUI + F/W
3	Display	• 8" Color TFT LCD • 1280 * 720(Pixel) • 16 : 9
4	Flash Memory	• 4GB(eMMC)
5	Ram	• 1GB
6	Operating Voltage	• 9V ~ 30V DC
7	USB	• USB 2.0 1Port
8	Operating Temperature	• - 20°C ~ 70°C
9	Operating Temperature	• Piezo Buzzer 98dB
10	Internal Buzzer	• SAE J1939 CAN communication • RS232
11	Communication	• W 287 x H 245.8 x D 107.1(DGP)

[Table 1-2]

2. Product Installation

2.1 Cautions

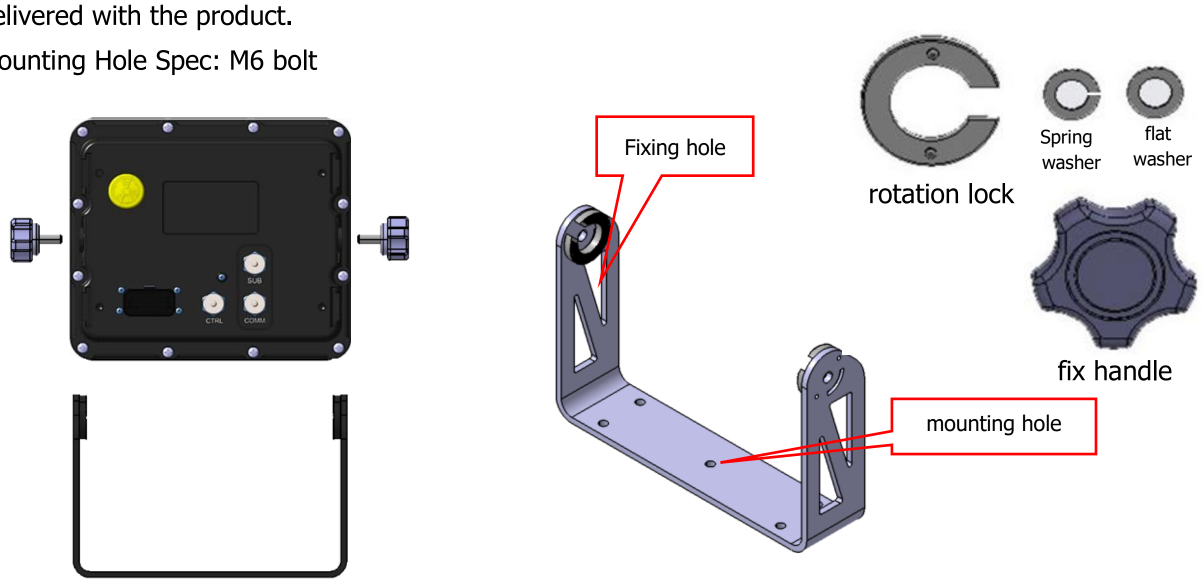
- Unskilled personnel should read this manual before use.
- Do not use or keep the product close to combustible sprays or inflammables.
- Use soft and dry cloth to clean the panel LCD.
- Turn off the product, pull out the harness cable and then contact our service center when you see smoke from the panel 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 steering 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

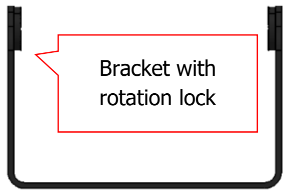
① Check if there is cable wiring available in the wheelhouse or engine room.

② Fix the bracket using mounting hole of the product at the position where the cable wiring reaches.

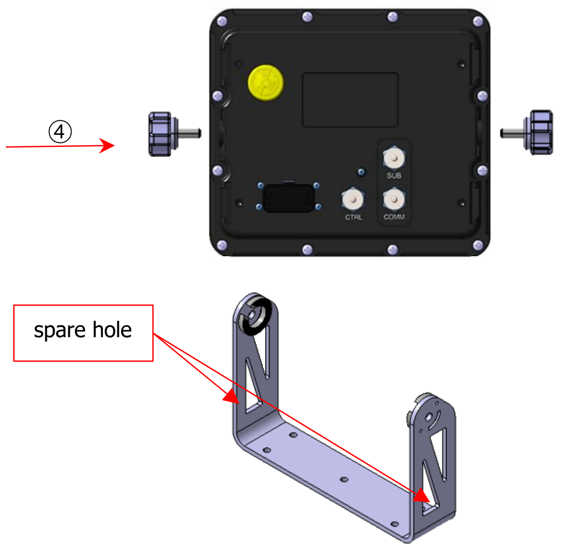
③ Place the product inside the bracket connected with the rotation lock to connect it with the rotation lock.

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. 2-2]



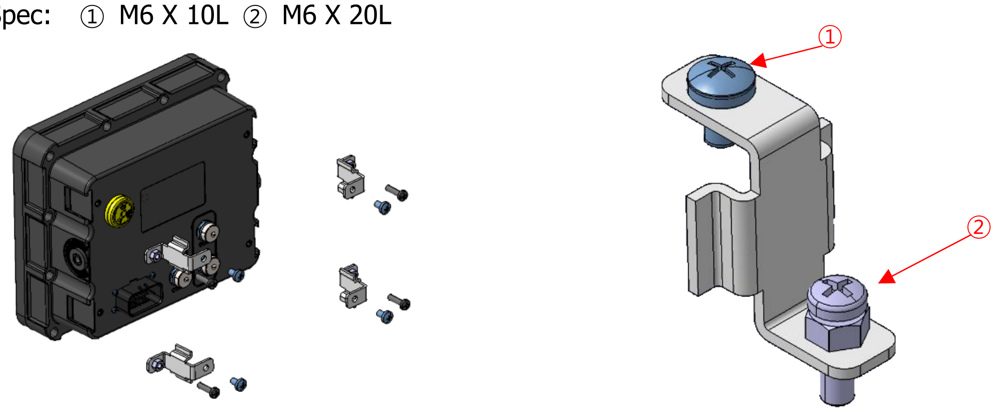
[Fig. 2-3]

2. Product Installation

2.3 Flush Mounting Type

- Flush Mounting types are installed in a steering 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

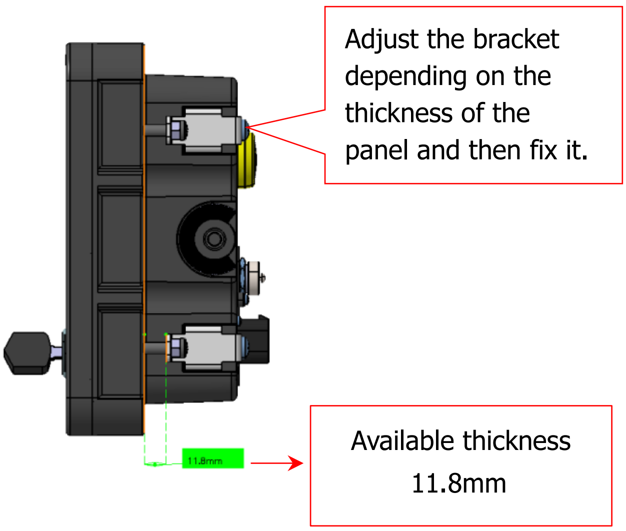
▶ Installing Flush Mounting Type digital panel

① Check the harness is wired in the steering 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

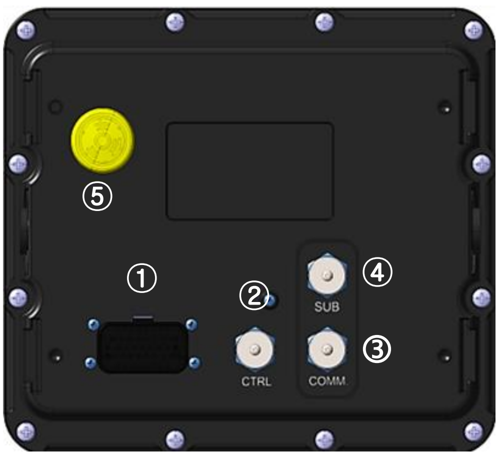
3.1 Front Side

[Fig. 3-1]

No.	Name	Reference
①	LCD	-
②	Function Keys	13 Page
③	Key Switch	11 Page
④	USB	10 Page
⑤	Emergency Start Switch	12 Page
⑥	Emergency Stop Switch	12 Page
⑦	IDLE Key	13 Page
⑧	RUN Key	13 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)	10 Page
③	COMM. (CAN / RS-232)	10 Page
④	SUB	10 Page
⑤	Internal Buzzer	11 Page

[Table 3-2]

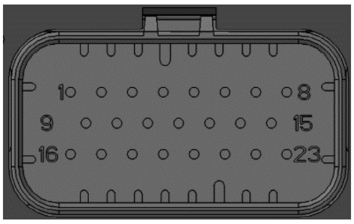
3. Part Names, Operation and Settings

3.3 External Connection Terminals

- Input/output connector connecting DGP and ECU
- Input/output connector for various control signals including sensors between ECU and engine

3.3.1 DGP 23Pin Main Connector

- Interface connector for receiving power and vessel operation information from ECU and transmitting and receiving CAN signals



[Fig. 3-3]

<table>
<tr><th>No.</th><th>Pin Description</th><th>Notes</th><th>No.</th><th>Pin Description</th><th>Notes</th></tr>
<tr><td>1</td><td>BATT IN</td><td>-</td><td>13</td><td>PC RXD1</td><td>-</td></tr>
<tr><td>2</td><td>BATT IN</td><td>-</td><td>14</td><td>PC TXD1</td><td>-</td></tr>
<tr><td>3</td><td>Power GND</td><td>-</td><td>15</td><td>Alternator IN</td><td rowspan="9">-</td></tr>
<tr><td>4</td><td>Power GND</td><td>-</td><td>16</td><td>Wait to Disconnect Signal</td></tr>
<tr><td>5</td><td>Key ON</td><td>-</td><td>17</td><td>Wait to Disconnect Common</td></tr>
<tr><td>6</td><td>STARTER Signal</td><td>-</td><td>18</td><td>-</td></tr>
<tr><td>7</td><td>Emergency Switch Power</td><td>-</td><td>19</td><td>-</td></tr>
<tr><td>8</td><td>Emergency Switch Signal</td><td>-</td><td>20</td><td>Fuel Leakage Switch</td></tr>
<tr><td>9</td><td>CAN 2(J1939) High</td><td>-</td><td>21</td><td>GND Sensor</td></tr>
<tr><td>10</td><td>CAN 2(J1939) Low</td><td>-</td><td>22</td><td>Water IN Fuel Sensor</td></tr>
<tr><td>11</td><td>CAN 1(UDS) High</td><td rowspan="2">Option</td><td>23</td><td>GND Sensor</td></tr>
<tr><td>12</td><td>CAN 1(UDS) Low</td><td>-</td><td>-</td><td>-</td></tr>
</table>

[Table 3-3]

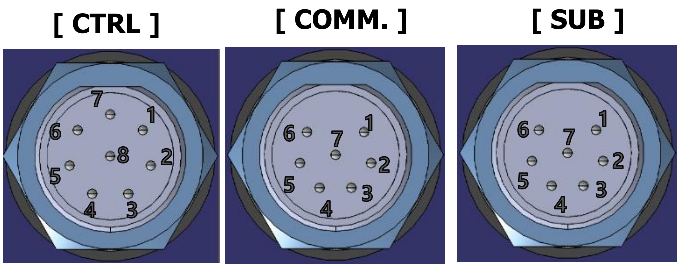
3. Part Names, Operation and Settings

3.3.2 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 BATT	Key-ON	Key-ON
2	BUZZ OUT	BATT IN	BATT IN
3	VCC	CAN1 H	CAN1 H
4	RPM_TRIM	CAN1 L	CAN1 L
5	GND	CAN2 H	CAN2 H
6	ISO_AUX+	CAN2 L	CAN2 L
7	ISO_AUX-	GND	GND
8	GND	-	-

[Table 3-4]



[Fig. 3-4]

3.3.3 USB Connector

- When backing up driving record data and upgrading software, insert a USB memory (FAT32 format is used)

[Fig. 3-5-1]

[Fig. 3-5-2]

3. Part Names, Operation and Settings

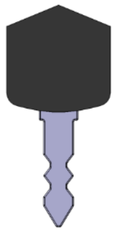
3.4 Internal Buzzer

- 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. 3-6]

3.5 Key Switch

- Digital panel system boot, engine start, and engine stop functions.
  1) After inserting the key included in the product in the key switch and turning it to the position of 45º to the right (ACC), the product is booted.
  2) Engine starts at the position of 90º turn (ON) and it returns to 45º position (If the key is in the ON state, keep the key lock state)
  3) When ACC is ON, the product boots within 5 seconds and the gauge screen is output after the introduction screen.
  4) Turn the key 45º to the left (OFF) when the engine is stopped
     - When the key is rotated to the left (OFF) position in Engine operation, in case, the panel power is turned off and the ECU is still operational, the "System Power Shutdown" alarm message window will pop up, and the engine will be shut down as shown in [Fig. 3-9].
     - When the pop-up window appears, rotate the key to the right (ON) position, then the pop-up window will disappear, and the engine will remain in the ON state.

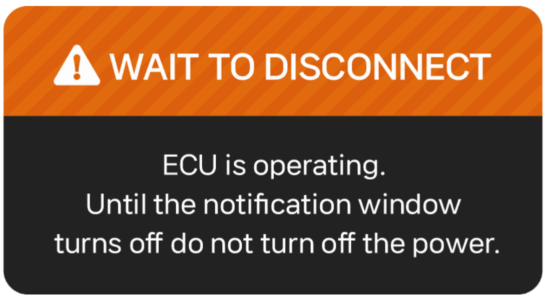


Key

[Fig. 3-7]

Key Switch

[Fig. 3-8]



[Fig. 3-9]

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. 3-10]

3.7 Emergency Stop Button

- Used to stop the engine in an emergency situation.

  1) Press immediately in case of emergency in engine running.
  2) When the emergency stop is activated, and audible alarm will sound, and the emergency stop pop up window [Fig. 3-12] will be displayed on the LCD screen, while the engine RPM decreases.
  3) The indicator will display the Shutdown icon [Fig. 3-13]
  4) Emergency stop status is not lifted until Key is off.

  ※ If the button is released within a short period of time, the engine may not be stopped.
  ※ It should be used only in emergency situations and product life may be affected when used.

EMG. STOP BUTTON
[Fig. 3-11]

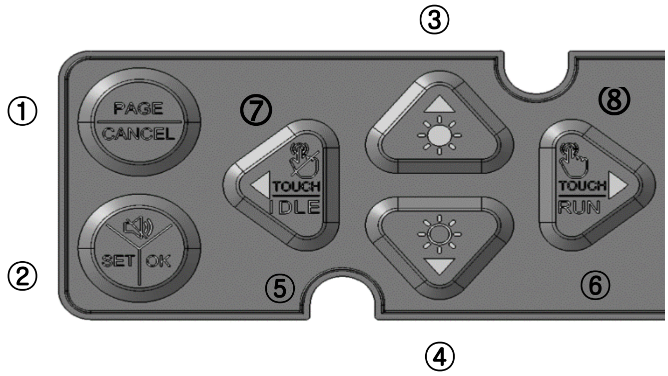
[Fig. 3-12] Emergency Stop Popup

[Fig. 3-13] Shutdown icon

3. Part Names, Operation and Settings

3.8 Function Keys

- Functions such as panel setting, alarm stop, menu movement, and selection.
- The indicator will display the IDLE icon and RUN icon [Fig. 3-15][Fig. 3-16] to indicate the operational state when the IDLE and RUN buttons are pressed.



[Fig. 3-14] 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
⑦	IDLE	· The engine is in the IDLE state(operation up to idle RPM) · The operation is performed on the digital panel with start permission
⑧	RUN	· The engine is in the RUN state(operating up to the target RPM) · The operation is performed on the digital panel with start permission

[Table 3-5]

[Fig. 3-15] IDLE Icon

[Fig. 3-16] RUN Icon

3. Part Names, Operation and Settings

3.8.1 Detailed User Setting

[Fig. 3-17] Detailed Settings

▶ User Setting Function and Description

- Press the setting button in the main screen for 3 seconds to enter the user setting.
- 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	Generator Setup	・ Setting Up Engine Control Functions ・ Fine-tuning Engine RPM with TRIM, DROOP and AUX Settings	
2	Engine Type	・ Setting the Engine Model Installed on the Ship	Reboot after changing the settings
3	Master / Slave	・ Master / Slave setting when using multi-panel(V-Type/In-Line)	-
4	Slave Engine Start	・ Master/Slave start authorization On / Off ・ The start-up authorization can only be set on the Master Panel	-
5	Korean/English	・ Korean / English conversion	-
6	Date Setup	・ Set date and time	-
7	USB BackUp	・ Backup event and driving history files to USB	-
8	Version	・ Show as full integrated version of software	Select S/W update item

[Table 3-6]

3. Part Names, Operation and Settings

3.8.2 Detailed Generator Setup

[Fig. 3-18] Generator Configuration Settings

No.	Function	Description	Remark
1	TRIM	· Current TRIM Configuration Status · OFF / Analog / Digital Mode	Display Settings Mode on the Main Screen(①, Refer to Page Page17)
2	DROOP	· DROOP Configuration Status Information	Display Settings Mode on the Main Screen (②, Refer to Page Page17)
3	AUX	· AUX Configuration Status Information · 0~5V / -5V~5V Mode	Display Settings Mode on the Main Screen (②, Refer to Page Page17))
4	SPEED RAMPING	· SPEED RAMPING Configuration Status Information	-

[Table 3-7]

▶ Generator Setup

1. Generator Settings Screen Detailed Description: Composed of TRIM ENABLE(OFF, DIGITAL, ANALOG), TRIM Range, TRIM Digital, DROOP/AUX Enable(OFF, 0~5V, -5V~5V), DROOP/AUX Range, F-LOAD TORQUE, N-LOAD TORQUE, SPEED RAMPING
2. The generator configuration items (TRIM, AUX, DROOP) are configured and applied through the digital panel set as Master, and can be viewed on the Slave digital panel with the settings made on the Master. However, the values cannot be changed on the Slave panel.
   - TRIM
     - TRIM ENABLE: The TRIM function for fine adjustment of the engine speed can be selected with digital input or analog input (OFF, ANALOG, DIGITAL).

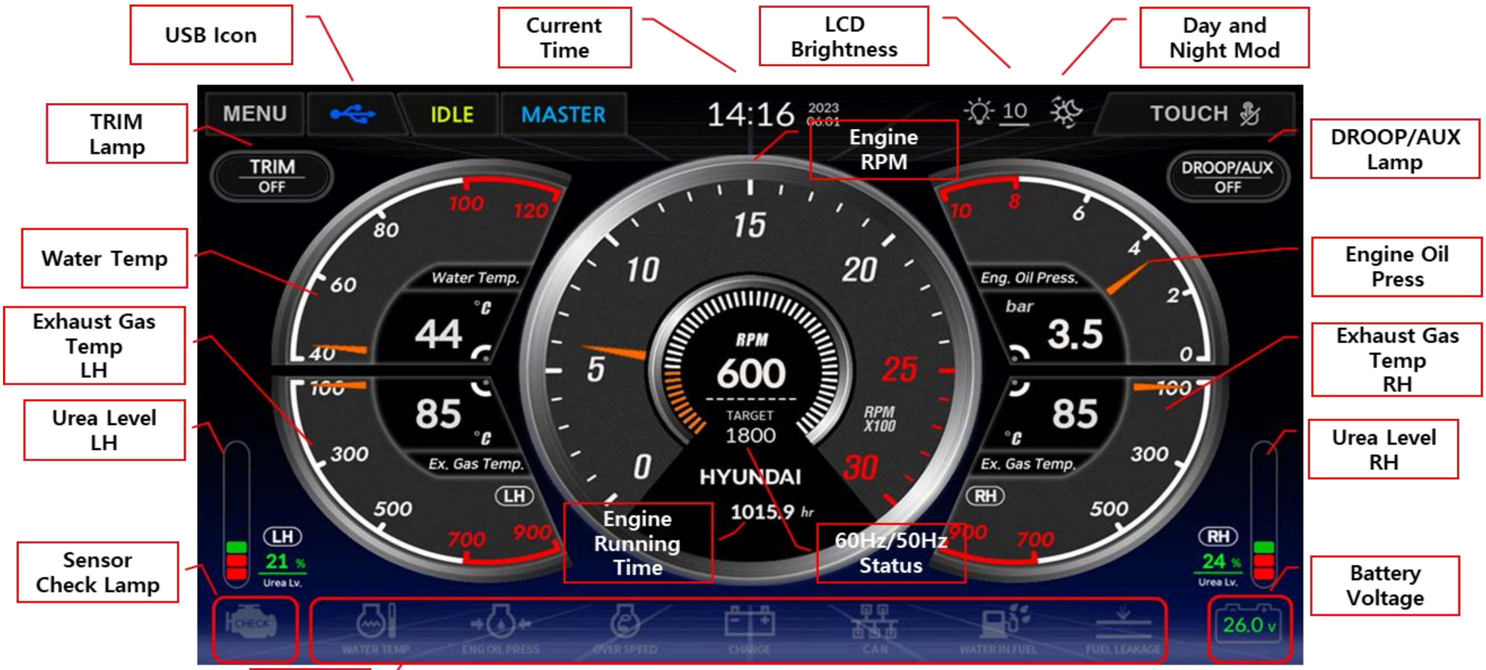
3. Part Names, Operation and Settings

- TRIM Enable「Digital」: When selected with digital input, the TRIM Digital value is applied.
  1) Set TRIM ENABLE to「Digital」and set the TRIM Digital value to 10 RPM within the TRIM Range. If the Target RPM is 60Hz 1800 (50Hz 1500), it will be output as 60Hz 1810 (50Hz 1510) (TRIM Digital value can only be set within the TRIM Range).
- TRIM Enable「Analog」: Applies the ± variation value within the TRIM Range when TRIM is an analog input from a potentiometer.
  1) Set TRIM ENABLE to「Analog」and set the TRIM Range to ±5.0 RPM. In this case, the Target RPM of 1800 (1500) can be set within the range of ±5.0 RPM.
  2) When the input voltage of the potentiometer is 0V, it will output 1795 RPM for 60Hz (1495 RPM for 50Hz). When the voltage is 2.5V, it will output 1800 RPM for 60Hz (1500 RPM for 50Hz). And when the voltage is 5V, it will output 1805 RPM for 60Hz (1505 RPM for 50Hz)

- DROOP
  - DROOP Enable: Select whether to enable the DROOP function.
    1) OFF/DOOP ON setting
  - When DROOP Range (rpm) is set to ±10rpm and the Target RPM is for 60Hz, the formula is as follows:
    1) Target RPM value (60Hz) = (F-LOAD TORQUE - Engine Torque)/(F-LOAD TORQUE - N-LOAD TORQUE) X DROOP Range (RPM) value
    2) Example: F-LOAD TORQUE = 20, N-LOAD TORQUE = 10, Engine Torque = 10, DROOP Range = ±20 RPM. In this case, the Target RPM would be calculated as follows:
       Target RPM = (20 - 10)/(20 - 10) X 20 = 1820 RPM
- AUX
  - AUX Enable: This allows the use of input signals from external load sharers or synchronization devices during parallel operation. There are two modes to choose from: -5V5V and 0V5V.
  - DROOP/AUX Range: This setting determines the speed variation of the engine for stable operation when AUX is enabled.
  - Adjustable range: 0 to 999 rpm
    1) -5V~5V Mode: When DROOP/AUX Range is set to ±10rpm, the output for -5V input would be 1790rpm (1490rpm for 50Hz) for 60Hz, 1800rpm (1500rpm for 50Hz) for 0V, and 1810rpm (1510rpm for 50Hz) for +5V input.
    2) 0V~5V Mode: When DROOP/AUX Range is set to ±10rpm, the output for 0V input would be 1790rpm (1490rpm for 50Hz) for 60Hz, and for +5V input, it would be 1810rpm (1510rpm for 50Hz)
- F-LOAD TORQUE, N-LOAD TORQUE:
  - Adjustable range: 0 to 9999 Nm
  - This setting is applicable only when DROOP is turned ON.
- SPEED RAMPING
  - The engine speed can vary up to the Target RPM based on the speed set by this setting.
  - It allows controlling the variation of the Target RPM based on the speed set in relation to the current RPM. The speed of variation is determined by the configured value. (Adjustable range: 1 to 30 seconds)

3. Part Names, Operation and Settings

3.9 Screen Layout



[Fig. 3-19] V-Type Engine Gauge Screen

[Fig. 3-20] In-Line Engine Gauge Screen

- The gauge functions include engine RPM, coolant temperature, exhaust gas temperature, engine oil pressure and more.
- In addition to the gauge elements LH/RH (for V-Type engines) or gauge element levels (for In-Line engines), there are also current time, USB detection icon, battery voltage, engine operation accumulated time, high coolant temperature, low engine oil pressure, overspeed, charging, CAN communication abnormality, water in fuel detection, and fuel leakage warning lights.

3. Part Names, Operation and Settings

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. 3-21]
Engine RPM

1) The rpm value indicated by the needle is expressed more precisely as a digital number (digit). (However, the digit is always ON)
2) Displays the accumulated engine running time in 1 hour increments.
   (Counts over 400rpm and is always on)
3) Fault Code for Overspeed Detection (V-Type Engine) B100100 / (In-Line Engine) B1001 - "Overspeed Detected" Pop-up Occurs / Indicator Displays "Shutdown" Icon.
4) For the 60Hz model, the default Target RPM is displayed as 1800.
   - Changes based on TRIM, AUX, and DROP application.
5) For the 50Hz model, the default Target RPM is displayed as 1500.
   - Changes based on TRIM, AUX, and DROP application.

3.9.2 Engine Cooling Water Temperature

- Cooling water temperature is displayed digitally with a gauge.

[Fig. 3-22]
Engine Cooling Water
Temperature

1) The temperature of the coolant pointed to by the needle is more precisely expressed as a digital number (digit). (However, the digit is always ON)
2) Fault code (V-Type Engine) P02174B / (In-Line Engine) P2185 pop-up when coolant high temperature is detected.
3) Coolant temperature warning lamp blinking and warning tone.

3. Part Names, Operation and Settings

3.9.3 Engine Oil Pressure

- Displays engine oil pressure with gauge and digital.

[Fig. 3-23]
Engine Oil Pressure Gauge

1) The oil pressure value indicated by the needle is more precisely expressed as a digital value (digit). (However, the digit is always ON)
2) Fault code received (V-Type Engine) P052484 / (In-Line Engine) P1521 pop-up occurs.
3) Warning lamp blinking and warning sounds.

3.9.4 Exhaust Gas Temperature

- Displays exhaust gas temperature with gauge and digital.

[Fig. 3-24]
Exhaust Gas Temperature

1) Express the exhaust gas temperature pointed by the needle more precisely as a digital number (digit).
(However, the digit is always ON)
2) For In-Line Engines

3.9.5 Exhaust Gas Temperature LH

- Displays exhaust gas temperature with gauge and digital.

[Fig. 3-25]
Exhaust Gas Temperature LH

1) Express the exhaust gas temperature pointed by the needle more precisely as a digital number (digit).
(However, the digit is always ON)
2) For V-Type Engines

3. Part Names, Operation and Settings

3.9.6 Exhaust Gas Temperature RH

- Displays exhaust gas temperature with gauge and digital.

[Fig. 3-26]
Exhaust Gas Temperature RH

1) Express the exhaust gas temperature pointed by the needle more precisely as a digital number (digit).
(However, the digit is always ON)
2) For V-Type Engines

3.9.7 Urea Level

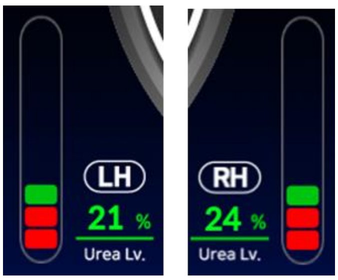
- Display urea level with gauge and digital.

[Fig. 3-27]
Urea Level

1) Express the urea level pointed by the needle more precisely as a digital number (digit).
(However, the digit is always ON)
2) When the element level gauge displays a number below 20%, it will be shown in red, and when it is 21% or above, it will be displayed in white.
3) If there is no element level for a specific suffix, it will be displayed as "----".
4) For In-Line Engines

3.9.8 Urea Level

- Display urea level with gauge and digital.



[Fig. 3-28]
Urea Level

1) The element level display bar and numeric display will be red when it is 20% or below, and green when it is 21% or above.
2) If a suffix does not have any aftertreatment, it will not be displayed on the screen.
3) For V-Type Engines

3. Part Names, Operation and Settings

3.9.9 Water In Fuel

- Indicates moisture detection when the water in fuel sensor is activated.

[Fig. 3-29] Water In Fuel

1) When "water in fuel" is detected and this condition is maintained for 10 seconds, a warning light flashes and a warning sound is emitted.
   - "Water In Fuel Detected" popup appears.
2) In case of sensor detachment (Open): "water in fuel Sensor Open Circuit Error" popup appears.
3) In case of Short: "water in fuel Sensor Short Circuit Error" popup appears.

3.9.10 Check Sensor Light

- When a sensor error (open, short) occurs, the sensor check light turns on

[Fig. 3-30] Check Sensor Light

1) If there is at least one alarm-triggering item, the indicator light will be illuminated.
2) In case of sensor error, the indicator light will be lit in red.
3) When the sensor error is resolved, the indicator light will be lit in orange.

3.9.11 Battery Voltage

- Displays the battery voltage to inform you of the battery status.

[Fig. 3-31] Battery Voltage

1) If the engine stop status is maintained at 24V or higher for 3 seconds, the indicator light will be green. If it is below 23.9V, the indicator light will be red.
2) the engine start status is maintained at 25.5V or higher for 3 seconds, the indicator light will be green. If it is below 25V, the indicator light will be red, accompanied by a warning sound.

3.9.12 TRIM, DROOP/AUX

- Depending on the TRIM, DROOP/AUX configuration, it will be illuminated or turned off, and the default setting is displayed as OFF.

[Fig. 3-32] Target RPM

1) Current TRIM (Analog, Digital) configuration status information.
3) DROOP/AUX ON, OFF configuration status information.
4) AUX 0V5V, -5V5V configuration status information
5) Setting for fine adjustment of engine speed and variation of speed for stable operation of the engine.
6) Configurable only on the digital panel set as Master.

3. Part Names, Operation and Settings

3.9.13 Engine Alarm

- When coolant temperature, engine oil pressure, gearbox oil pressure, charging, moisture detection, overspeed, fuel leakage, gearbox oil pressure, and battery voltage warning lights start flashing, an audible warning sound is triggered. (Applies to both V-Type and In-Line engine warning lights)

[Fig. 3-33] Engine Alarm

NO.	Alarm	Action Characteristics
①	COOLING WATER TEMP	· When coolant high-temperature detection occurs or when the (In-Line) P2185/(V-Type) P02174B fault code is received, the warning light will start flashing and an audible warning sound will be emitted.
②	ENGINE OIL PRESS	· When the (In-Line) P1521/(V-Type) P052484 fault code is received, the warning light will start flashing and an audible warning sound will be emitted.
③	OVER SPEED	· When the (In-Line) P0219/(V-Type) P021985 fault code is received, the warning light will start flashing, and an audible warning sound will be emitted. · When the Rate Speed exceeds 120%, the warning light will start flashing, an audible warning sound will be emitted, and the system will be shut down.
④	CHARGE	· When the (In-Line) P0562/(V-Type) P0560A2 fault code is received, the battery charging warning light will start flashing, and an audible warning sound will be emitted.
⑤	CAN	· When a CAN communication error occurs, the warning light will start flashing, and an audible warning sound will be emitted. · When the (In-Line) B1002/(V-Type) B100200 fault code is received, a "CAN Communication Error" popup will appear.
⑥	WATER IN FUEL	· When Water In Fuel detection conditions are maintained for 10 seconds (when the Water In Fuel sensor is activated), the warning light will start flashing, and an audible warning sound will be emitted.
⑦	FUEL LEAKAGE	· After 10 seconds of fuel leakage detection, the warning light will start flashing, and an audible warning sound will be emitted · (In-Line) B1005/(V-Type) B100500 When receiving fault code, "[Panel] Fuel Leak Detection" pop-up occurs
⑧	BATTERY VOLTAGE	· The display and audible warning sound will vary depending on the engine running or stopped status (refer to section 3.9.11 for details)

[Table 3-7] Warning light characteristics

3. Part Names, Operation and Settings

3.9.14 Engine Stop

1) When the engine RPM exceeds 115% of the Rate Speed (Shutdown).
2) If the current RPM is not received via CAN for 5 seconds during engine operation.
3) When the Emergency button is pressed.
4) In the event of fuel leakage.

※ 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

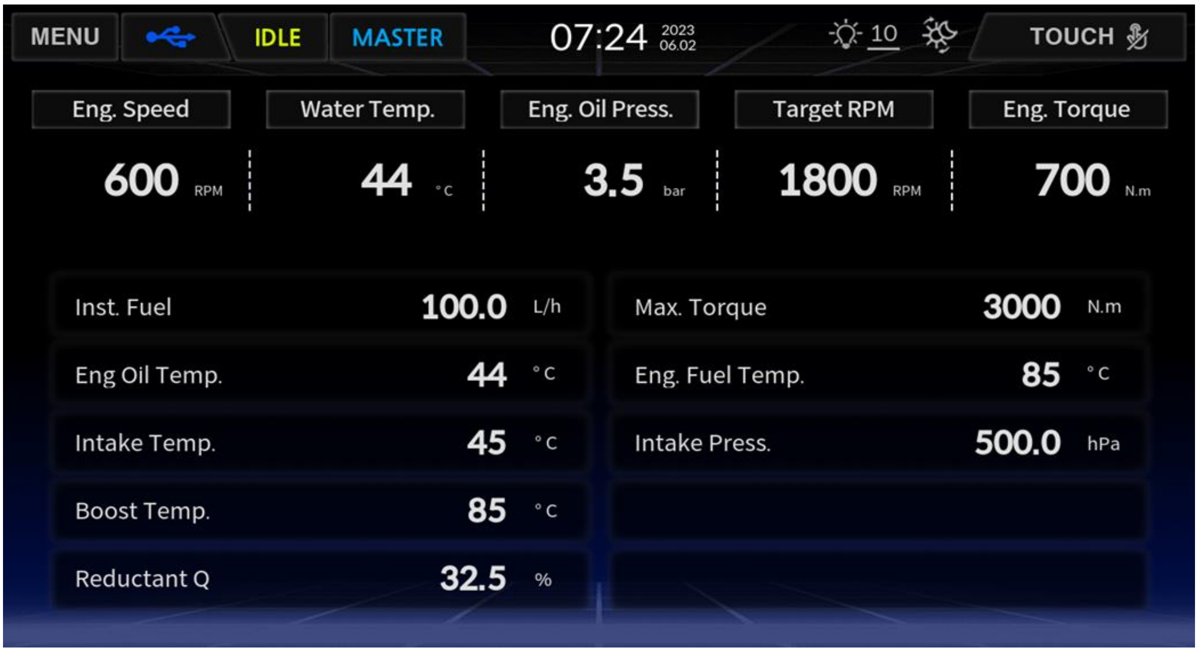
3.10 Other status

- It represents various states of the engine and the PAGE key in the function keys enable it to move to the sub-pages.

[Fig. 3-34] V-Type Engine Sub-Page Display Information

1. V-Type Engine Sub-Page Display Information
   - When operated at 60Hz, the default displayed target RPM is 1800 rpm. For 50Hz operation, the default displayed target RPM is 1500 rpm.

3. Part Names, Operation and Settings



[Fig. 3-35] In-Line Engine Sub-Page Display Information

1. In-Line Engine Sub-Page Display Information

- For In-Line engines as well, similar to V-Type engines, the default displayed target RPM is 1800 rpm when operated at 60Hz, and 1500 rpm when operated at 50Hz.

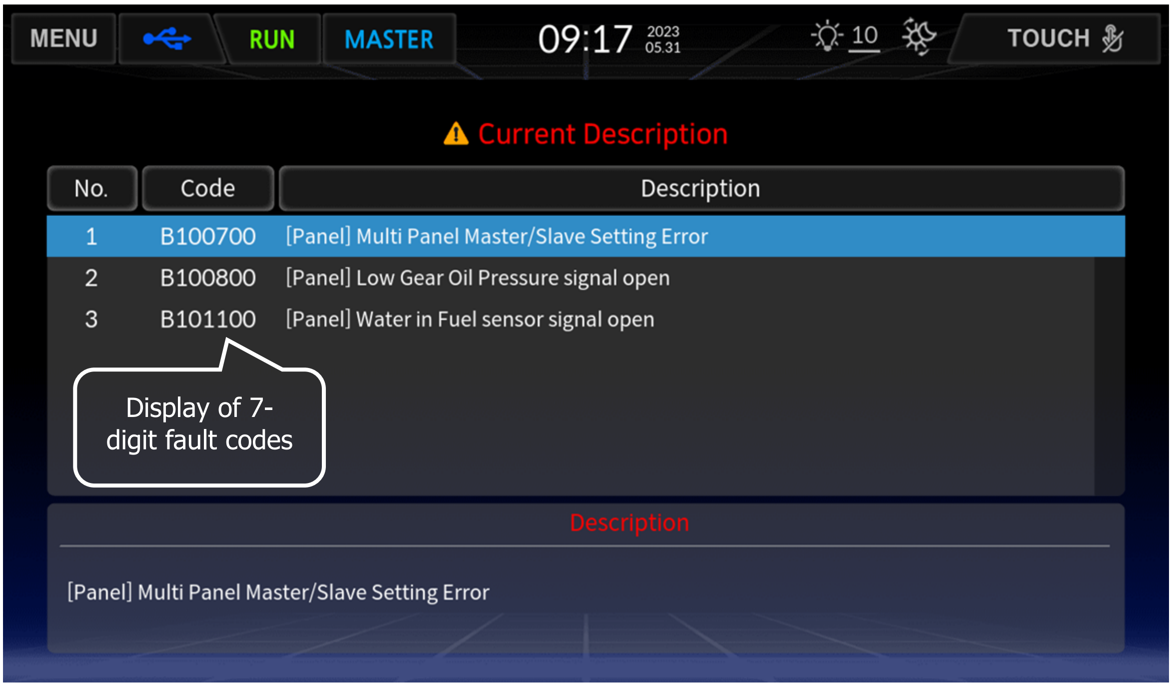
Item (V-Type Engine)	Item (In-Line Engine)
Target RPM – (RPM) unit notation	Target RPM – (RPM) unit notation
Eng. Torque - (Nm) unit notation	Eng. Torque - (Nm) unit notation
Inst. Fuel - (L/h) unit notation	Inst. Fuel - (L/h) unit notation
Eng. Oil Temp - (°C) unit notation	Eng. Oil Temp - (°C) unit notation
Intake Temp - (°C) unit notation	Intake Temp - (°C) unit notation
Boost Temp(LH) - (°C) unit notation	Boost Temp - (°C) unit notation
Reductant Q(LH) - (%) unit notation	Reductant Q - (%) unit notation
Max. Torque - (Nm) unit notation	Max. Torque - (Nm) unit notation
Eng. Fuel Temp - (°C) unit notation	Eng. Fuel Temp - (°C) unit notation
Intake Press - (hPa) unit notation	Intake Press - (hPa) unit notation
Boost Temp(RH) - (°C) unit notation	
Reductant Q(RH) - (%) unit notation	

[Table 3-8] Sub-Page Display Items

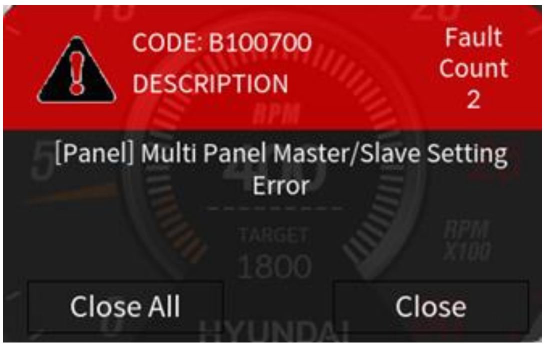
3. Part Names, Operation and Settings

3.11 Current Fault Information Page

- While the engine is running, the ECU detects any abnormalities in the engine and, when a fault condition occurs, transmits the fault code via CAN communication. This fault code is received by the digital panel, and the fault code and description are displayed on the monitor as shown in [Fig. 3-36].
- Over-speed (115% of rated speed), CAN communication error, water in fuel, fuel leakage, and other faults are detected by the digital panel, triggering pop-up notifications.
- Up to 20 real -time fault messages are displayed, as shown in [Fig. 3-34].
- The fault code alarm window shown in [Fig. 3-37] is displayed on the screen whenever a fault code occurs, regardless of which page the user is working on.
- V-Type engines display the fault codes with 7 digits, while In-Line engines display them with 5 digits.



[Fig. 3-36] Current Fault Information Page

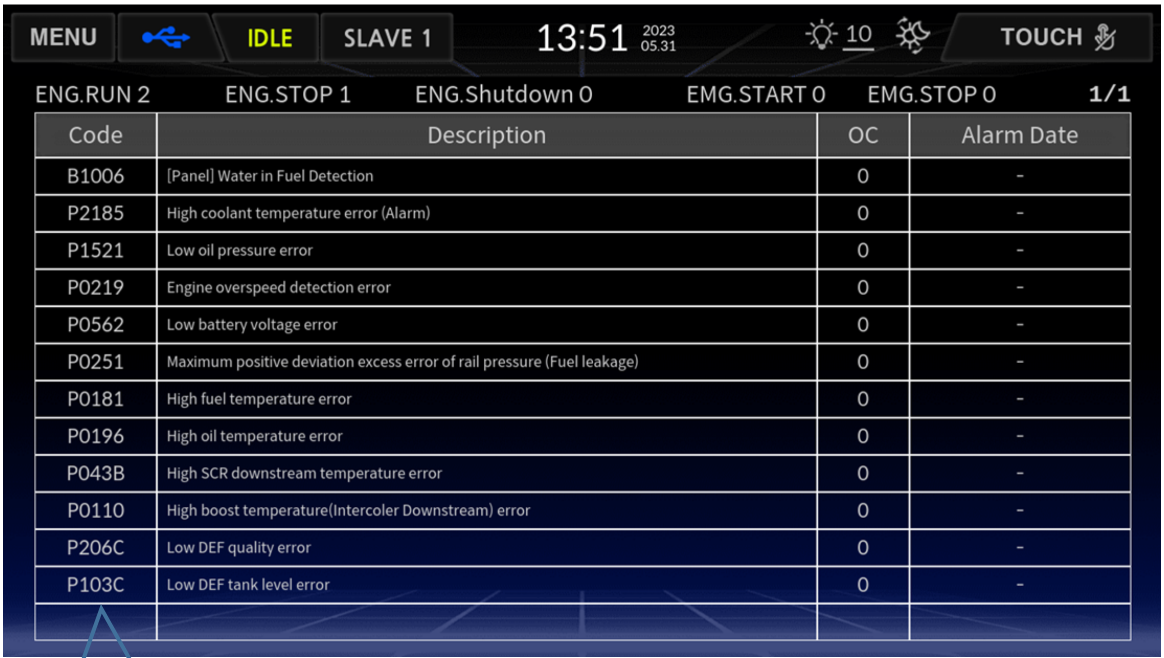


[Fig. 3-37] Fault Code Alarm Pop up

3. Part Names, Operation and Settings

3.12 Alarm Page

- It displays information about the number of engine starts, engine stops, engine abnormal stops, emergency starts, emergency stops, cumulative sensor alarm occurrences, and the date of the most recent alarm occurrence, all stored within the digital panel itself.
- Pressing the page buttons on the alarm screen will transit the display to the main page.
- V-Type engines display fault codes with 7 digits, while In-Line engines display fault codes with 5 digits.

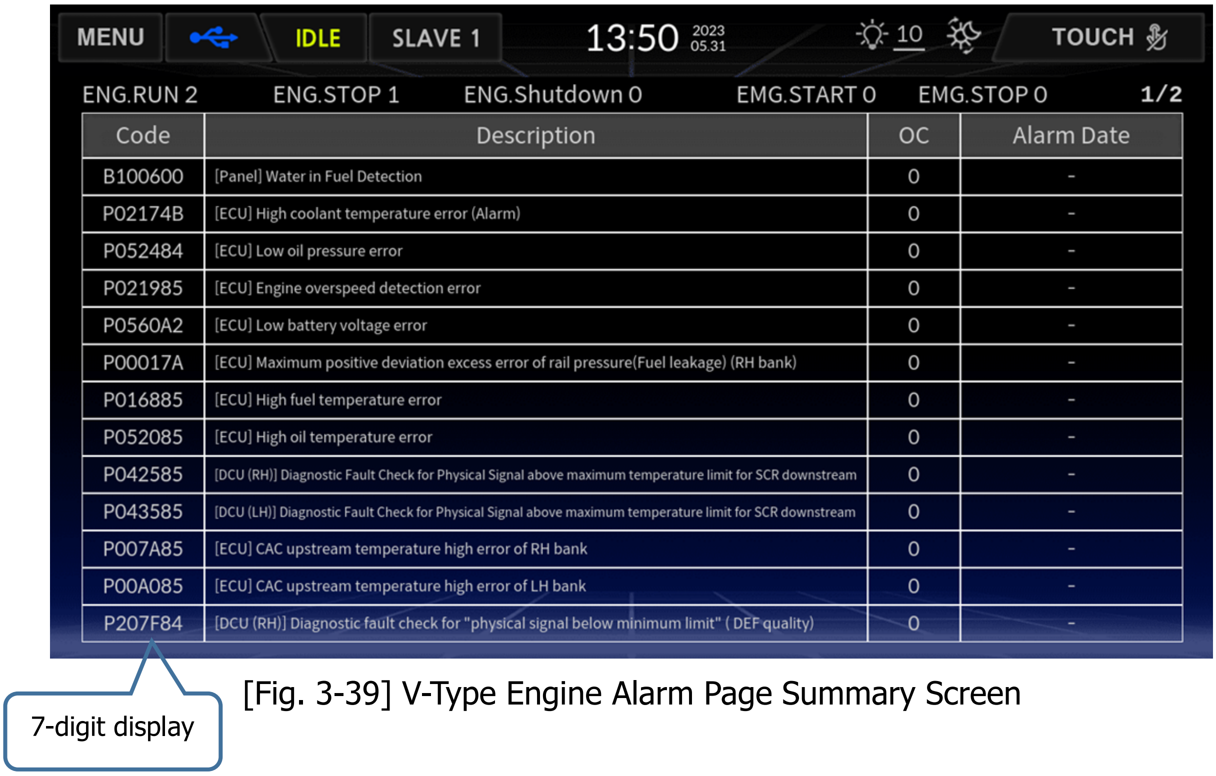


5-digit display

[Fig. 3-38] In-Line Engine Alarm Page Screen

In-Line Engine Alarm Page List			
B1006	[Panel] Water in Fuel Detection	P0181	High fuel temperature error
P2185	High coolant temperature error (Alarm)	P0196	High oil temperature error
P1521	Low oil pressure error	P043B	High SCR downstream temperature error
P0219	Engine overspeed detection error	P0110	High boost temperature
P0562	Low battery voltage error	P206C	Low DEF quality error
P0251	Maximum positive deviation excess error of rail pressure (Fuel leakage)	P103C	Low DEF tank level error

[Table 3-9] In-Line Engine Alarm Page List



[Fig. 3-39] V-Type Engine Alarm Page Summary Screen

V-Type Engine Alarm Page List			
B100600	[Panel] Water in Fuel Detection	P042585	[DCU (RH)] Diagnostic Fault Check for Physical Signal above maximum temperature limit for SCR downstream
P02174B	[ECU] High coolant temperature error (Alarm)	P043585	[DCU (LH)] Diagnostic Fault Check for Physical Signal above maximum temperature limit for SCR downstream
P052484	[ECU] Low oil pressure error	P007A85	[ECU] CAC upstream temperature high error of RH bank
P021985	[ECU] Engine overspeed detection error	P00A085	[ECU] CAC upstream temperature high error of LH bank
P0560A2	[ECU] Low battery voltage error	P207F84	[DCU (RH)] Diagnostic fault check for "physical signal below minimum limit" (DEF quality)
P00017A	[ECU] Maximum positive deviation excess error of rail pressure(Fuel leakage) (RH bank)	P32E984	[DCU (LH)] Diagnostic fault check for "physical signal below minimum limit" (DEF quality)
P016885	[ECU] High fuel temperature error	P203F00	[DCU (RH)] Status of tank level is empty
P052085	[ECU] High oil temperature error	P32B900	[DCU (LH)] Status of tank level is empty

[Table 3-10] V-Type Engine Alarm Page List

3. Part Names, Operation and Settings

3.13 System Booting and Functional Check

- After installing the product, check to see if it has been installed properly

▶ 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 [Fig. 3-41]

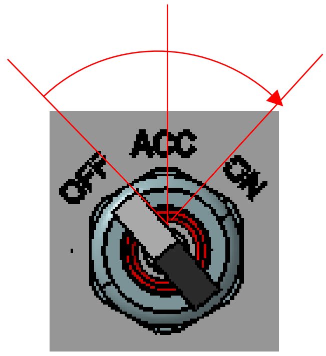
   ※ In case, the screen is not output when the key is rotated

   - 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.[Fig. 3-42]
   - 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 (initially 400RPM or higher, oil pressure 1bar or higher) and warning light on (red lamp blinks when warning light is on)



[Fig. 3-40] Key Switch

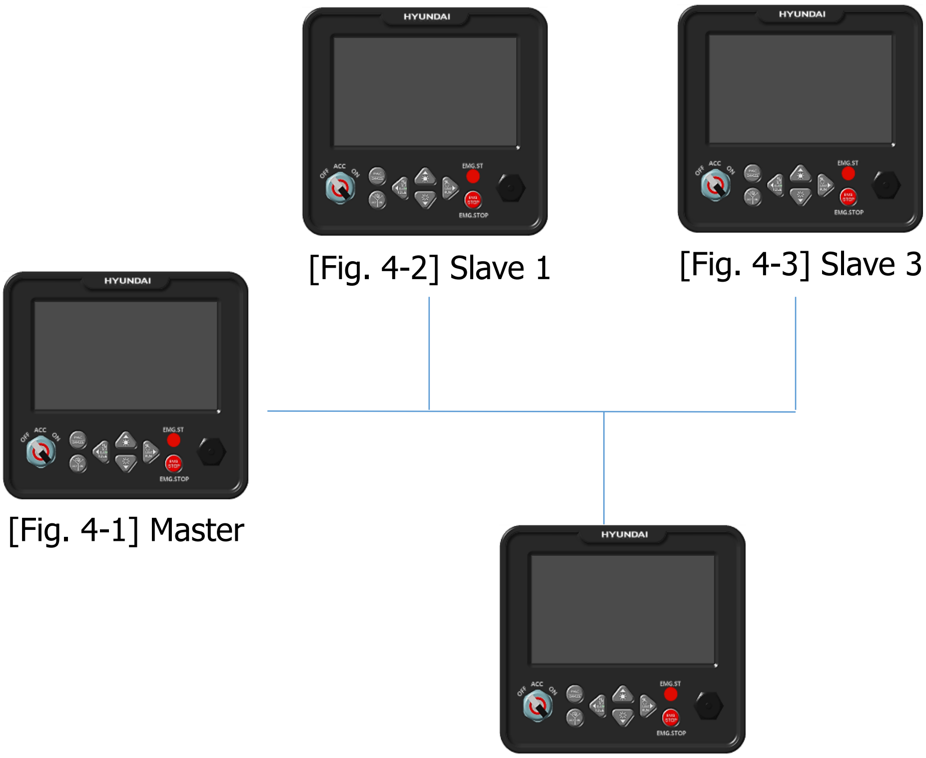
[Fig. 3-41] Boot Logo

[Fig. 3-42] Gauge Screen

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. (However, be careful of the battery voltage drops as the length of the harness increases.)



[Fig. 4-1] Master

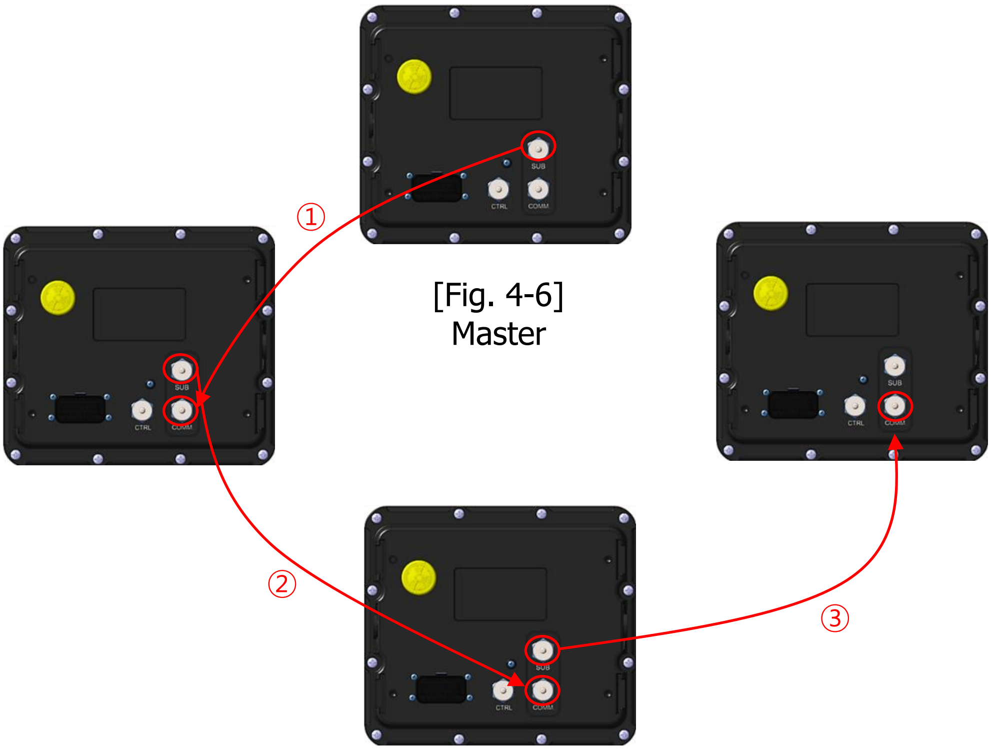
[Fig. 4-2] Slave 1

[Fig. 4-3] Slave 3

[Fig 4-4] Slave 2

4. Multi Panel Structure

4.2 How to Install Multi Panel



[Fig. 4-6]
Master

[Fig. 4-7]
Slave 1

[Fig. 4-9]
Slave 3

[Fig. 4-8]
Slave 2

※ Before installing the multi-panel, the necessary cables should already be prepared.
(Cables should use HD Hyundai InfraCore 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, Slave 1, Slave2 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.

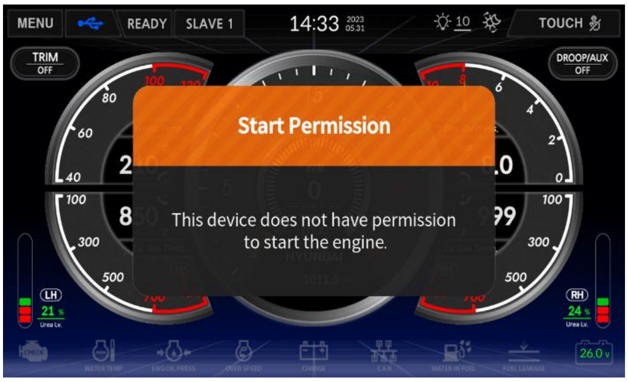
※ Note: When connecting multiple Slaves, the Slave mode settings should not overlap.

(4) Set the panel to Master mode using the same method as above.

※ Note

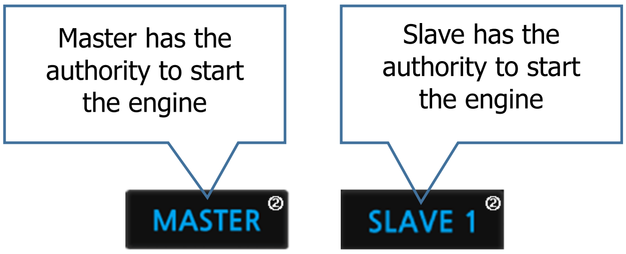
- Only one product can be set in Master mode, and up to two Slaves are recommended.
- If the cable length between Master and Slaves is more than 30m, there may be a voltage drop of more than 1V, so it needs to be checked.
- Granting engine start permission to Slave panels can only be done from the Master panel.
  - In the "Remote Engine Start" menu of the Master panel, select the Slave to grant engine start permission
  - When granting engine start permission to a Slave, the Master loses its own engine start permission.
  - Panels with engine start permission are indicated by colored icons on the indicator [Fig. 4-10 ②][Fig. 4-12].
- When a panel without engine start permission attempts to start the engine, a "No engine start permission" popup appears [Fig. 4-11].
- If both Master and Slave panels have duplicated settings for Local/Remote (e.g., Master, Master), a "[Panel] Multi Panel Local/Remote Setting Error" popup appears [Fig. 4-13].
- Emergency engine start is only possible from the Master panel, and emergency engine stop is possible from any Slave.
  - Slave emergency engine stop operates via CAN communication.
- Re-engaging the starter is not possible during engine operation (except for Emergency Start from the Master panel)

[Fig. 4-10] Multi Panel Settings Popup



[Fig. 4-11] Engine Start Authorization Popup

4. Multi Panel Structure



[Fig. 4-12] Master/Slave Start Authorization

[Fig. 4-13] Multi Panel Settings Error

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 with 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 name, breakdown conditions and your contact information.
- Please ask the seller.

User Manual for 8 Inch Digital Panel for Electronic Marine Propulsion Engine

Ver.1.0

HYUNDAI

HY-DGP-MANUAL-001

▶ Contents

▶ Contents

1.General Information

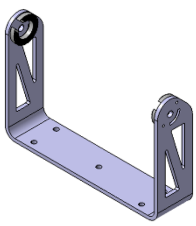
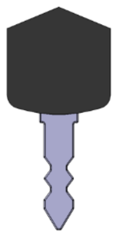
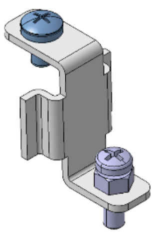
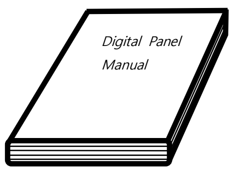
1.1 Product Information

This product is a digital panel for electronic propulsion engine displays and can be applied to various small marine engines. The DGP model is designed to be robust for marine environments and is equipped with digital visualization to clearly monitor engine control and status information. It provides information through graphical analog gauges and digital displays, aiming to enhance user convenience.

1.2Components and Optional Accessories

- Refer to Table 1-1 below for product components
- Reference
  DGP: Digital Gauge Panel

Components

NO	Components	Component Name	NO	Components	Component Name
1		DGP	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 electronic engine

Digital Gauge panel product Specification

No.	Item	Remark
1	Microprocessor	• NXP4330Q / S32K144
2	Software	• Linux OS GUI + F/W
3	Display	• 8" Color TFT LCD • 1280 * 720(Pixel) • 16 : 9
4	Flash Memory	• 4GB(eMMC)
5	Ram	• 1GB
6	Operating Voltage	• 9V ~ 30V DC
7	USB	• USB 2.0 1Port
8	Operating Temperature	• - 20°C ~ 70°C
9	Operating Temperature	• Piezo Buzzer 98dB
10	Internal Buzzer	• SAE J1939 CAN communication • RS232
11	Communication	• W 287 x H 245.8 x D 107.1(DGP)

[Table 1-2]

2. Product Installation

2.1 Cautions

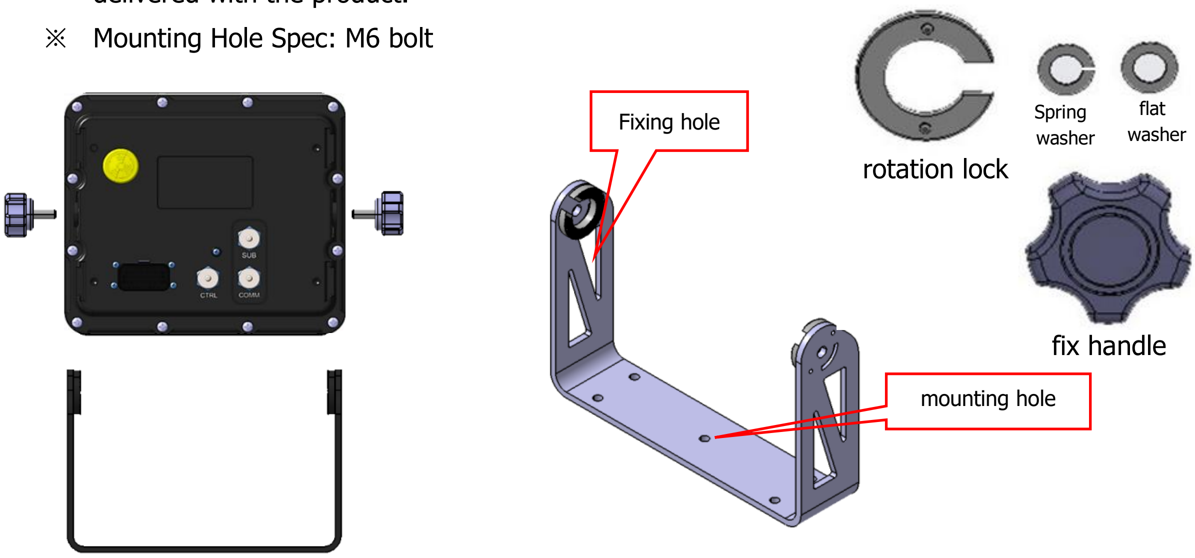
- Unskilled personnel should read this manual before use.
- Do not use or keep the product close to combustible sprays or inflammables.
- Use soft and dry cloth to clean the panel LCD.
- Turn off the product, pull out the harness cable and then contact our service center when you see smoke from the panel 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 steering 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

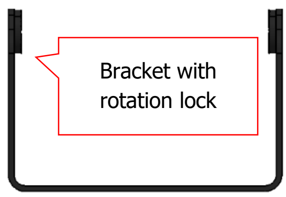
① Check if there is cable wiring available in the wheelhouse or engine room.

② Fix the bracket using mounting hole of the product at the position where the cable wiring reaches.

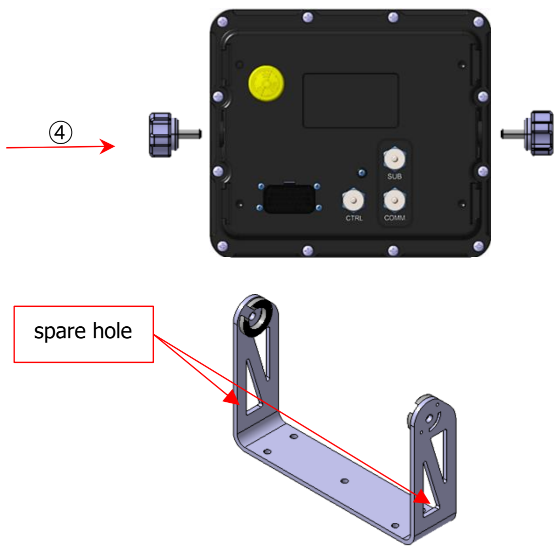
③ Place the product inside the bracket connected with the rotation lock to connect it with the rotation lock.

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. 2-2]



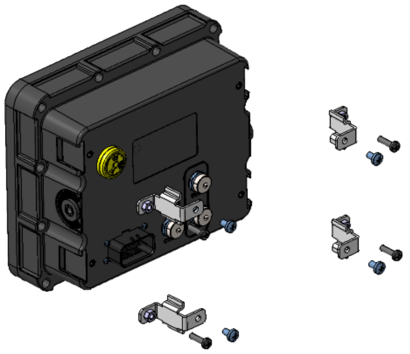
[Fig. 2-3]

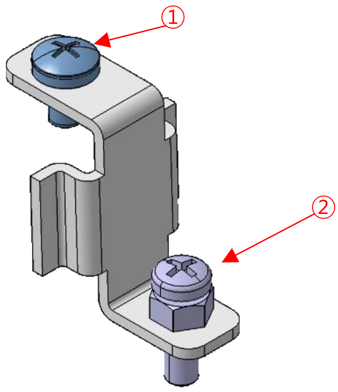
2. Product Installation

2.3 Flush Mounting Type

- Flush Mounting types are installed in a steering 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

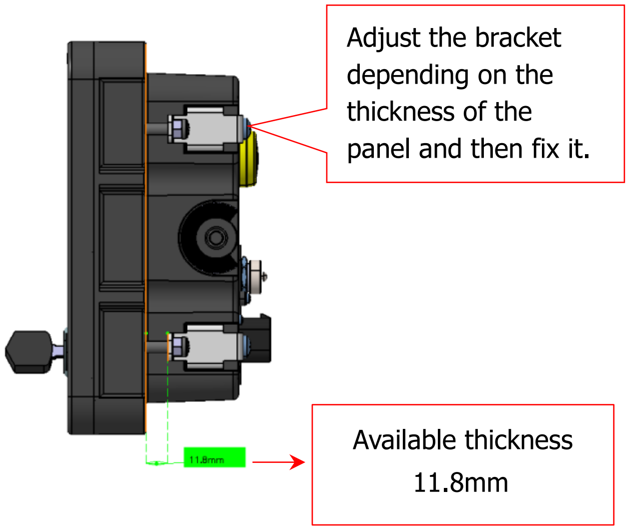
▶ Installing Flush Mounting Type digital panel

① Check the harness is wired in the steering 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

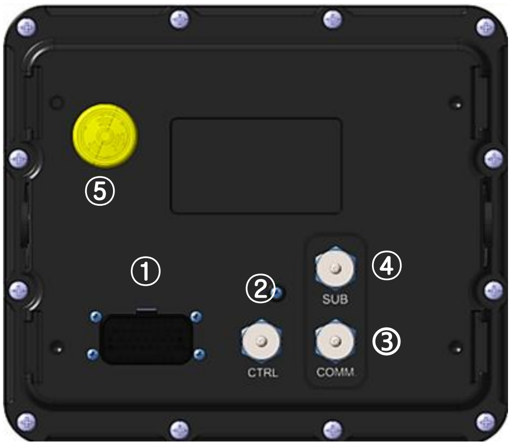
3.1 Front Side

[Fig. 3-1]

No.	Name	Reference
①	LCD	-
②	Function Keys	13 Page
③	Key Switch	11 Page
④	USB	10 Page
⑤	Emergency Start Switch	12 Page
⑥	Emergency Stop 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)	10 Page
③	COMM. (CAN / RS-232)	10 Page
④	SUB	10 Page
⑤	Internal Buzzer	11 Page

[Table 3-2]

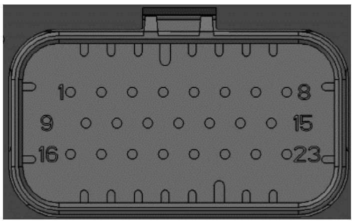
3. Part Names, Operation and Settings

3.3 External Connection Terminals

- Input/output connector connecting DGP and ECU
- Input/output connector for various control signals including sensors between ECU and engine

3.3.1 DGP 23Pin Main Connector

- Interface connector for receiving power and vessel operation information from ECU and transmitting and receiving CAN signals



[Fig. 3-3]

No.	Pin Description	Notes	No.	Pin Description	Notes
1	BATT IN	-	13	PC RXD1	-
2	BATT IN	-	14	PC TXD1	-
3	Power GND	-	15	Alternator IN	-
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 2(J1939) High	-	21	GND Sensor	
10	CAN 2(J1939) Low	-	22	Water IN Fuel Sensor	
11	CAN 1(UDS) High	Option	23	GND Sensor	
12	CAN 1(UDS) Low		-	-	-

[Table 3-3]

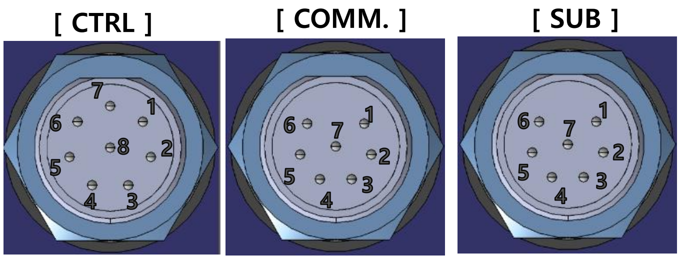
3. Part Names, Operation and Settings

3.3.2 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 BATT	Key-ON	Key-ON
2	BUZZ OUT	BATT IN	BATT IN
3	VCC	CAN1 H	CAN1 H
4	RPM_TRIM	CAN1 L	CAN1 L
5	GND	CAN2 H	CAN2 H
6	ISO_AUX+	CAN2 L	CAN2 L
7	ISO_AUX-	GND	GND
8	GND	-	-

[Table 3-4]



[Fig. 3-4]

3.3.3 USB Connector

- When backing up driving record data and upgrading software, insert a USB memory (FAT32 format is used)

[Fig. 3-5-1]

[Fig. 3-5-2]

3. Part Names, Operation and Settings

3.4 Internal Buzzer

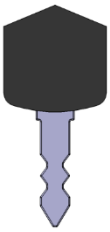
- Buzzer sound when an alarm occurs due to engine abnormality.
- It operates at 98dB, and an external large-capacity buzzer can be additionally installed.

[Fig. 3-6]

3.5 Key Switch

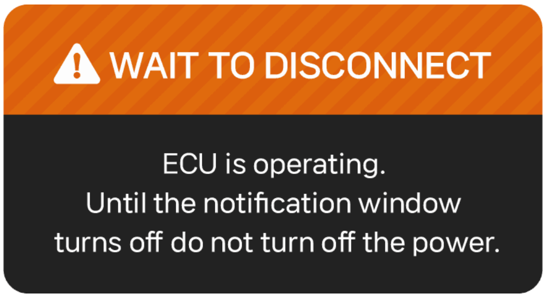
- Digital panel system boot, engine start, and engine stop functions.

1) After inserting the key included in the product in the key switch and turning it to the position of 45º to the right (ACC), the product is booted.
2) Engine starts at the position of 90º turn (ON) and it returns to 45º position (If the key is in the ON state, keep the key lock state)
3) When ACC is ON, the product boots within 5 seconds and the gauge screen is output after the introduction screen.
4) Turn the key 45º to the left (OFF) when the engine is stopped
   • When the key is rotated to the left (OFF) position in Engine operation, in case, the panel power is turned off and the ECU is still operational, the "System Power Shutdown" alarm message window will pop up, and the engine will be shut down as shown in [Fig. 3-9].
   • When the pop-up window appears, rotate the key to the right (ON) position, then the pop-up window will disappear, and the engine will remain in the ON state.



Key
[Fig. 3-7]

Key Switch
[Fig. 3-8]



[Fig. 3-9]

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. 3-10]

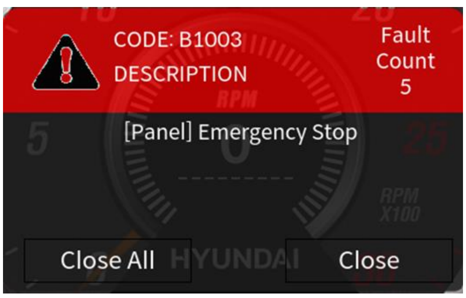
3.7 Emergency Stop Button

- Used to stop the engine in an emergency situation.

1) Press immediately in case of emergency in engine running.
2) When the emergency stop is activated, and audible alarm will sound, and the emergency stop pop up window [Fig. 3-12] will be displayed on the LCD screen, while the engine RPM decreases.
3) The indicator will display the Shutdown icon [Fig. 3-13]
4) Emergency stop status is not lifted until Key is off.

※ If the button is released within a short period of time, the engine may not be stopped.
※ It should be used only in emergency situations and product life may be affected when used.

EMG. STOP BUTTON
[Fig. 3-11]



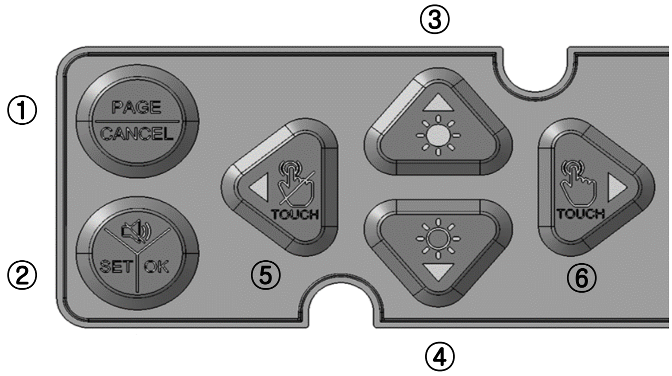
[Fig. 3-12] Emergency Stop Popup

[Fig. 3-13] Shutdown icon

3. Part Names, Operation and Settings

3.8 Function Keys

- Functions such as panel setting, alarm stop, menu movement, and selection.



[Fig. 3-14] 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 3-5]

3. Part Names, Operation and Settings

3.8.1 Detailed User Setting

[Fig. 3-15] Detailed Settings

▶ User Setting Function and Description

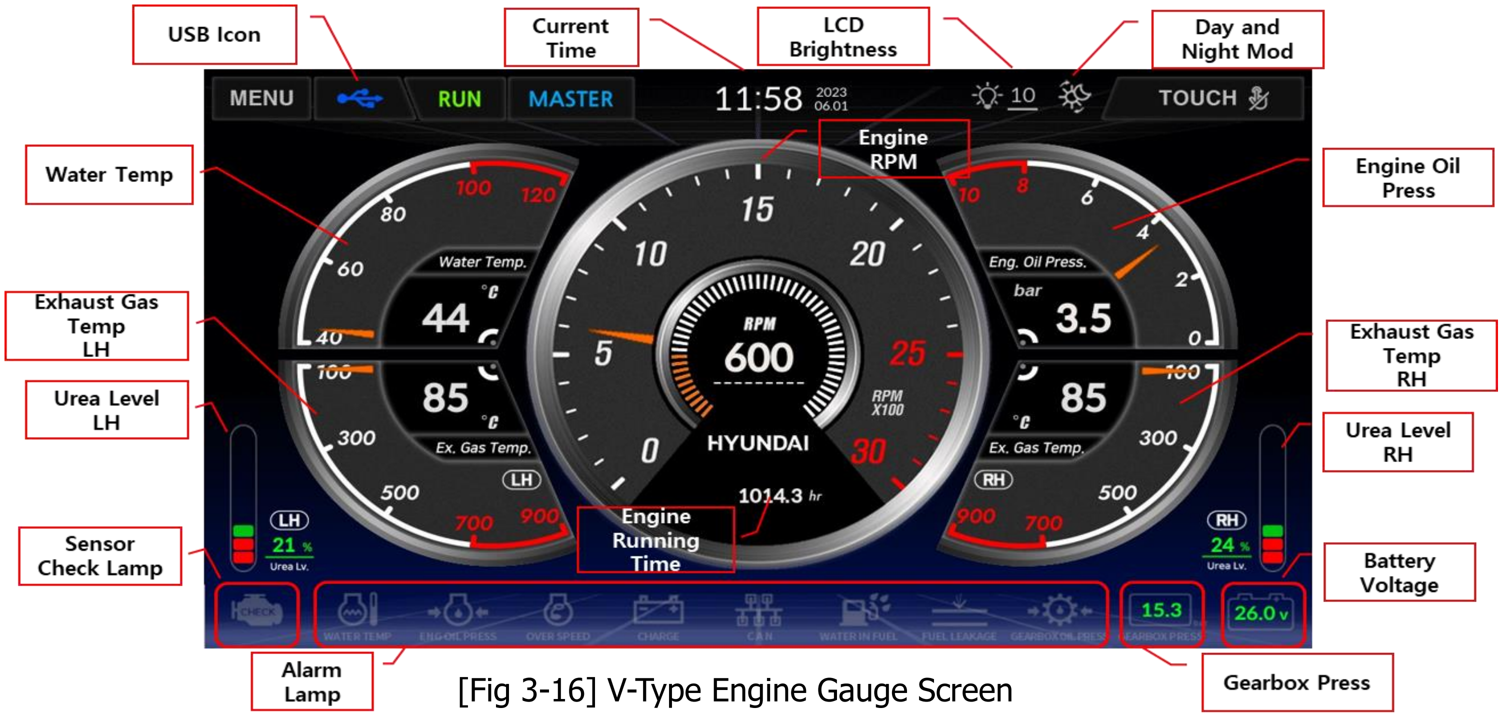
- Press the setting button in the main screen for 3 seconds to enter the user setting.
- Use the arrow keys to move to the function you want to change.
- Press the Ok button to go to the gauge screen. (Auto save on change)

No.	Function	Description	Remark
1	Engine Type	· Setting the Engine Model Installed on the Ship	Reboot after changing the settings
2	Master / Slave	· Master / Slave setting when using multi-panel(V-Type/In-Line)	-
3	Slave Engine Start	· Master/Slave start authorization On / Off · The start-up authorization can only be set on the Master Panel	-
4	Korean/English	· Korean / English conversion	-
5	Date Setup	· Set date and time	-
6	USB BackUp	· Backup event and driving history files to USB	-
7	Version	· Show as full integrated version of software	Select S/W update item

[Table 3-6]

3. Part Names, Operation and Settings

3.9 Screen Layout



[Fig 3-16] V-Type Engine Gauge Screen

[Fig. 3-17] In-Line Engine Gauge Screen

- The gauge functions include engine RPM, coolant temperature, exhaust gas temperature, engine oil pressure, gearbox oil gauge and more.
- In addition to the gauge elements LH/RH (for V-Type engines) or gauge element levels (for In-Line engines), there are also 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. Part Names, Operation and Settings

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. 3-18]
Engine RPM

1) The rpm value indicated by the needle is expressed more precisely as a digital number (digit). (However, the digit is always ON)
2) Displays the accumulated engine running time in 1 hour increments.
   (Counts over 400rpm and is always on)
3) Fault Code for Overspeed Detection (V-Type Engine) B100100 / (In-Line Engine) B1001 - "Overspeed Detected" Pop-up Occurs / Indicator Displays "Shutdown" Icon.

3.9.2 Engine Cooling Water Temperature

- Cooling water temperature is displayed digitally with a gauge.

[Fig. 3-19]
Engine Cooling Water Temperature

1) The temperature of the coolant pointed to by the needle is more precisely expressed as a digital number (digit). (However, the digit is always ON)
2) Fault code (V-Type Engine) P02174B / (In-Line Engine) P2185 pop-up when coolant high temperature is detected.
3) Coolant temperature warning lamp blinking and warning tone.

3. Part Names, Operation and Settings

3.9.3 Engine Oil Pressure

- Displays engine oil pressure with gauge and digital.

[Fig. 3-20]
Engine Oil Pressure Gauge

1) The oil pressure value indicated by the needle is more precisely expressed as a digital value (digit). (However, the digit is always ON)
2) Fault code received (V-Type Engine) P052484 / (In-Line Engine) P1521 pop-up occurs.
3) Warning lamp blinking and warning sounds.

3.9.4 Exhaust Gas Temperature

- Displays exhaust gas temperature with gauge and digital.

[Fig. 3-21]
Exhaust Gas Temperature

1) Express the exhaust gas temperature pointed by the needle more precisely as a digital number (digit).
   (However, the digit is always ON)
2) For In-Line Engines

3.9.5 Exhaust Gas Temperature LH

- Displays exhaust gas temperature with gauge and digital.

[Fig. 3-22]
Exhaust Gas Temperature LH

1) Express the exhaust gas temperature pointed by the needle more precisely as a digital number (digit).
   (However, the digit is always ON)
2) For V-Type Engines

3. Part Names, Operation and Settings

3.9.6 Exhaust Gas Temperature RH

- Displays exhaust gas temperature with gauge and digital.

[Fig. 3-23]
Exhaust Gas Temperature RH

1) Express the exhaust gas temperature pointed by the needle more precisely as a digital number (digit)
   (However, the digit is always ON)
2) For V-Type Engines

3.9.7 Gearbox Pressure

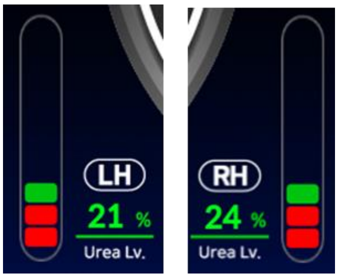
- The gearbox pressure is displayed using gauges and digitally

[Fig. 3-24]
Gearbox Pressure

1) The gearbox pressure value indicated by the needle is displayed more precisely as a digital value (digits) (Note: Digits are always ON).
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).
4) For In-Line Engines

3.9.8 Urea Level

- Display urea level with gauge and digital.



[Fig. 3-25]
Urea Level

1) The element level display bar and numeric display will be red when it is 20% or below, and green when it is 21% or above.
2) If a suffix does not have any aftertreatment, it will not be displayed on the screen.
3) For V-Type engines
4) For in-line engines, there is only one gauge available without distinguishing between RH and LH(Refer to [Fig. 3-17] In-Line Engine Gauge Screen).

3. Part Names, Operation and Settings

3.9.9 Gearbox Oil Pressure

- The gearbox oil pressure is displayed digitally.

[Fig. 3-26]
Gearbox Oil Pressure

1) The gearbox oil pressure value is represented in a more precise digital format, using digital digits. However, the digits are always displayed as ON.
2) When a fault code is received, a "Low gearbox oil pressure" popup appears.
3) If the engine is running with a pressure below 1 bar for 10 seconds, a warning light flashes with a red numerical display. If the engine maintains a pressure of 1.5 bar or above for 3 seconds, the warning is cleared, and a green display appears.
4) For V-Type Engines

3.9.10 Water In Fuel

- Indicates moisture detection when the water in fuel sensor is activated.

[Fig. 3-27] Water In Fuel

1) When "water in fuel" is detected and this condition is maintained for 10 seconds, a warning light flashes and a warning sound is emitted.
   - "Water In Fuel Detected" popup appears.
2) In case of sensor detachment (Open): "water in fuel Sensor Open Circuit Error" popup appears.
3) In case of Short: "water in fuel Sensor Short Circuit Error" popup appears.

3.9.11 Check Sensor Light

- When a sensor error (open, short) occurs, the sensor check light turns on

[Fig. 3-28] Check Sensor Light

1) If there is at least one alarm-triggering item, the indicator light will be illuminated.
2) In case of sensor error, the indicator light will be lit in red.
3) When the sensor error is resolved, the indicator light will be lit in orange.

3.9.12 Battery Voltage

- Displays the battery voltage to inform you of the battery status.

[Fig. 3-29] Battery Voltage

1) If the engine stop status is maintained at 24V or higher for 3 seconds, the indicator light will be green. If it is below 23.9V, the indicator light will be red.
2) the engine start status is maintained at 25.5V or higher for 3 seconds, the indicator light will be green. If it is below 25V, the indicator light will be red, accompanied by a warning

3. Part Names, Operation and Settings

3.9.13 Engine Alarm

- When the coolant temperature, engine oil pressure, gearbox oil pressure, charging system, moisture detection, over-speed, fuel leakage, gearbox oil pressure, and battery voltage warning lights illuminate, an audible warning sound is triggered.

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑧ ⑨

[Fig. 3-30] V-Type Engine Alarm

[Fig. 3-31] In-Line Engine Alarm

NO.	Alarm	Action Characteristics
①	COOLING WATER TEMP	· When coolant high-temperature detection occurs or when the (In-Line) P2185/(V-Type) P02174B fault code is received, the warning light will start flashing and an audible warning sound will be emitted.
②	ENGINE OIL PRESS	· When the (In-Line) P1521/(V-Type) P052484 fault code is received, the warning light will start flashing and an audible warning sound will be emitted.
③	OVER SPEED	· When the (In-Line) P0219/(V-Type) P021985 fault code is received, the warning light will start flashing, and an audible warning sound will be emitted. · When the Rate Speed exceeds 120%, the warning light will start flashing, an audible warning sound will be emitted, and the system will be shut down.
④	CHARGE	· When the (In-Line) P0562/(V-Type) P0560A2 fault code is received, the battery charging warning light will start flashing, and an audible warning sound will be emitted.
⑤	CAN	· When a CAN communication error occurs, the warning light will start flashing, and an audible warning sound will be emitted. · When the (In-Line) B1002/(V-Type) B100200 fault code is received, a "CAN Communication Error" popup will appear.
⑥	WATER IN FUEL	· When Water In Fuel detection conditions are maintained for 10 seconds (when the Water In Fuel sensor is activated), the warning light will start flashing, and an audible warning sound will be emitted.
⑦	FUEL LEAKAGE	· After 10 seconds of fuel leakage detection, the warning light will start flashing, and an audible warning sound will be emitted · (In-Line) B1005/(V-Type) B100500 When receiving fault code, "[Panel] Fuel Leak Detection" pop-up occurs

⑧	GEARBOX OIL PRESSURE	· If the engine maintains a pressure below 1 bar for 10 seconds during operation, the warning light will flash, and an audible warning sound will be emitted. · If the engine maintains a pressure of 1.5 bar or above during operation, it will be indicated in green. · For In-Line engines, this information will be displayed on the gauge. Please refer to Page 15 for more details.
⑨	BATTERY VOLTAGE	· The display and audible warning sound will vary depending on the engine running or stopped status (refer to section 3.9.12 for details)

[Table 3-7] Warning light characteristics

3.9.14 Engine Stop

1) When the engine RPM exceeds 120% of the Rate Speed (Shutdown).
2) If the current RPM is not received via CAN for 5 seconds during engine operation.
3) When the Emergency button is pressed.
4) In the event of fuel leakage.

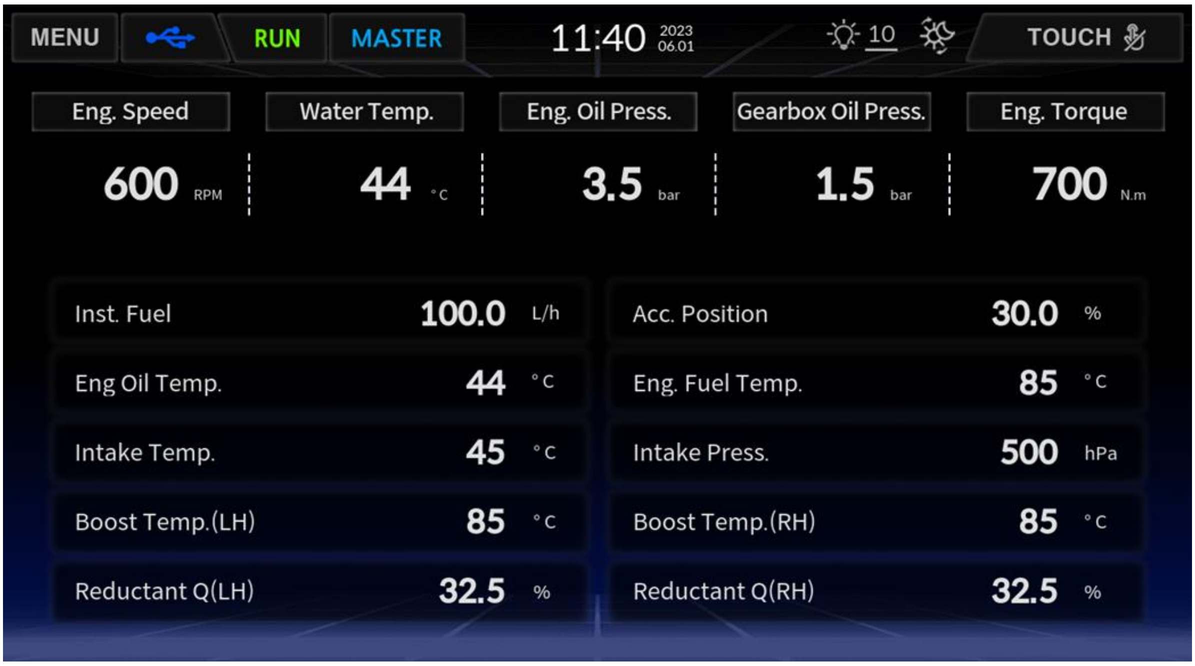
※ How to turn off the engine warning light

- 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

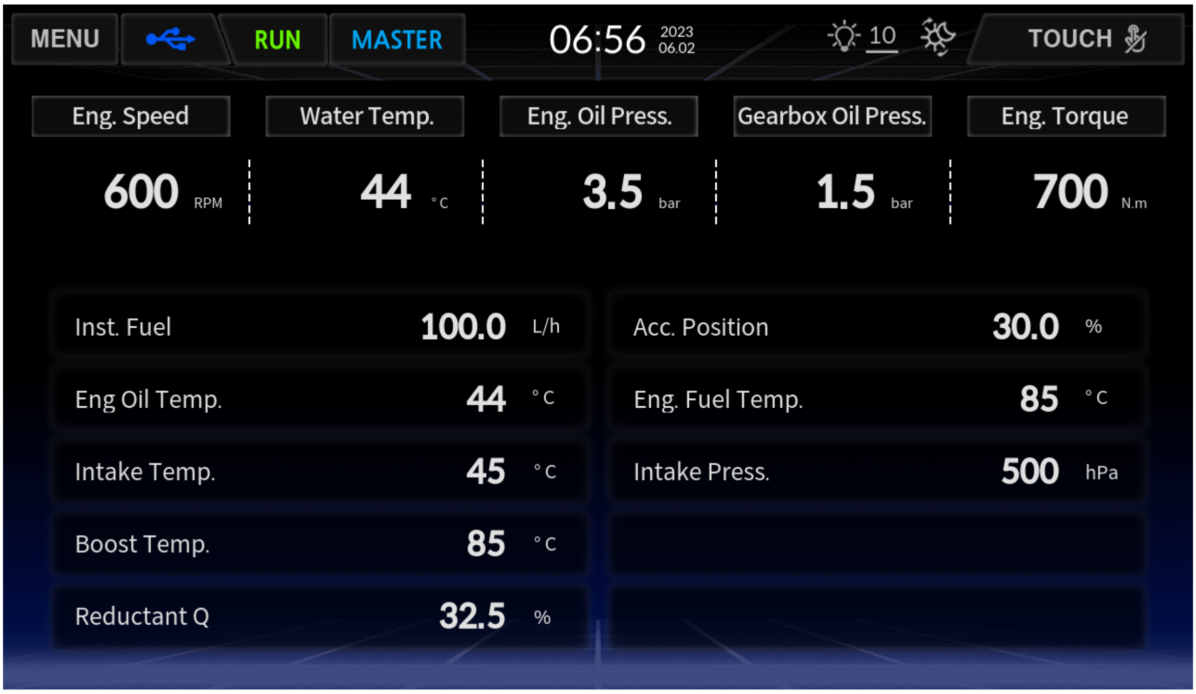
3. Part Names, Operation and Settings

3.10 Other status

- It represents various states of the engine and the PAGE key in the function keys enable it to move to the sub-pages.



[Fig. 3-32] V-Type Engine Sub-Page Display Information



[Fig. 3-33] In-Line Engine Sub-Page Display Information

3. Part Names, Operation and Settings

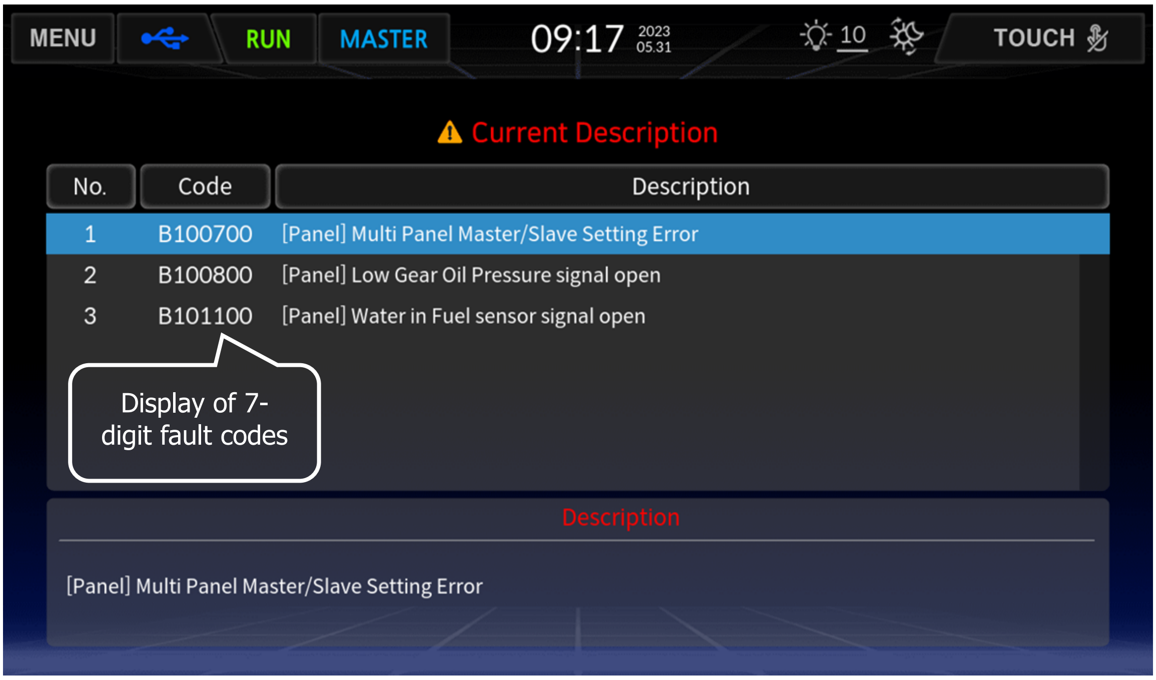
Item (V-Type Engine)	Item (In-Line Engine)
Eng. Torque - (Nm) unit notation	Eng. Torque - (Nm) unit notation
Inst. Fuel - (L/h) unit notation	Inst. Fuel - (L/h) unit notation
Eng. Oil Temp - (°C) unit notation	Eng. Oil Temp - (°C) unit notation
Intake Temp - (°C) unit notation	Intake Temp - (°C) unit notation
Boost Temp(LH) - (°C) unit notation	Boost Temp - (°C) unit notation
Reductant Q(LH) - (%) unit notation	Reductant Q - (%) unit notation
Max. Torque - (Nm) unit notation	Max. Torque - (Nm) unit notation
Eng. Fuel Temp - (°C) unit notation	Eng. Fuel Temp - (°C) unit notation
Intake Press - (hPa) unit notation	Intake Press - (hPa) unit notation
Boost Temp(RH) - (°C) unit notation	
Reductant Q(RH) - (%) unit notation	

[Table 3-8] Sub-Page Display Items

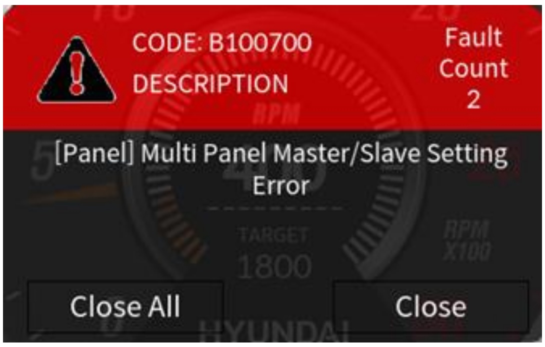
3. Part Names, Operation and Settings

3.11 Current Fault Information Page

- While the engine is running, the ECU detects any abnormalities in the engine and, when a fault condition occurs, transmits the fault code via CAN communication. This fault code is received by the digital panel, and the fault code and description are displayed on the monitor as shown in [Fig. 3-31].
- Over-speed (120% of rated speed), CAN communication error, water in fuel, fuel leakage, and other faults are detected by the digital panel, triggering pop-up notifications.
- Up to 20 real -time fault messages are displayed, as shown in [Fig. 3-34].
- The fault code alarm window shown in [Fig. 3-35] is displayed on the screen whenever a fault code occurs, regardless of which page the user is working on.
- V-Type engines display the fault codes with 7 digits, while In-Line engines display them with 5 digits.



[Fig. 3-34] Current Fault Information Page

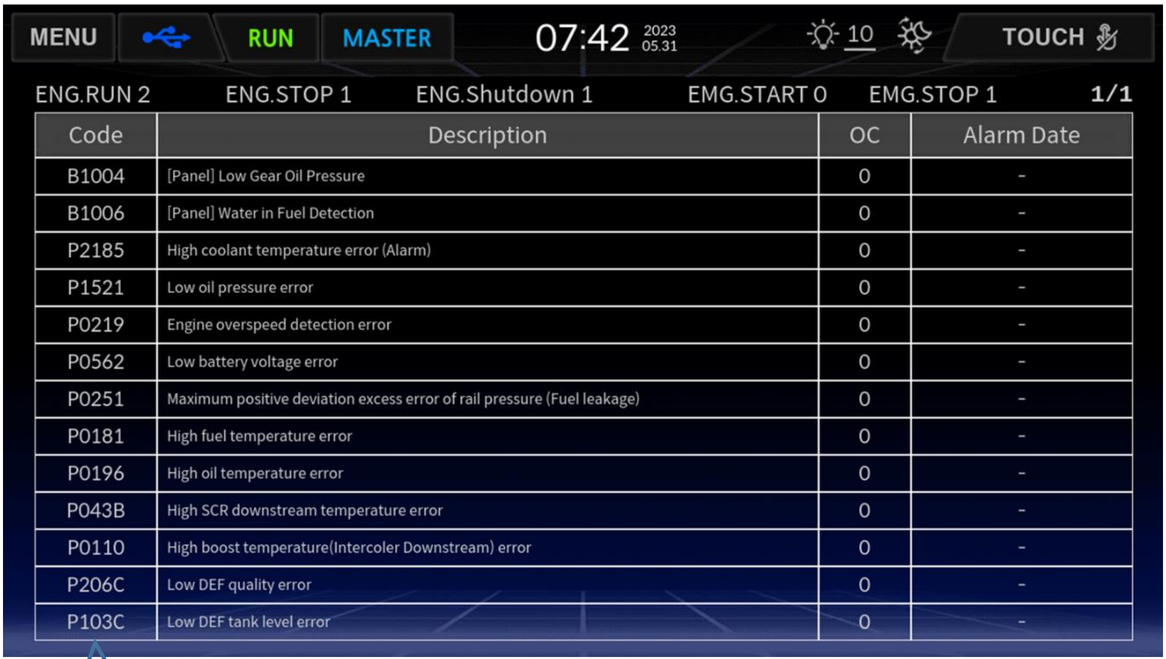


[Fig. 3-35] Fault Code Alarm Pop up

3. Part Names, Operation and Settings

3.12 Alarm Page

- It displays information about the number of engine starts, engine stops, engine abnormal stops, emergency starts, emergency stops, cumulative sensor alarm occurrences, and the date of the most recent alarm occurrence, all stored within the digital panel itself.
- Pressing the page buttons on the alarm screen will transit the display to the main page.
- V-Type engines display fault codes with 7 digits, while In-Line engines display fault codes with 5 digits.

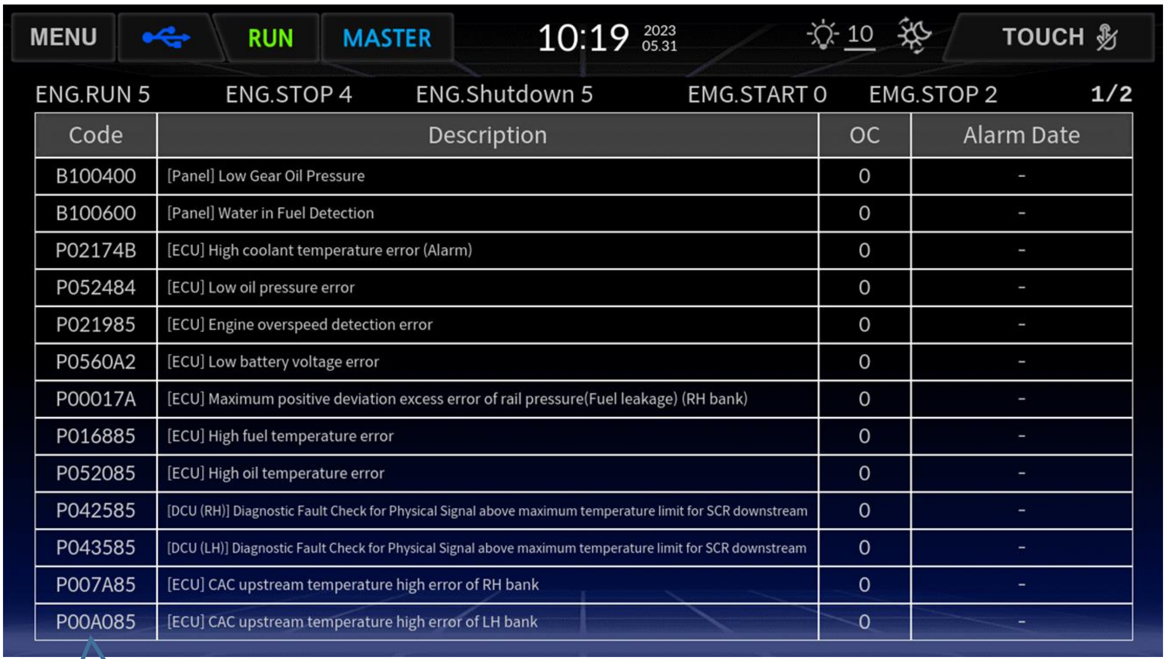


5-digit display

[Fig. 3-36] In-Line Engine Alarm Page Screen

In-Line Engine Alarm Page List			
B1004	[Panel] Low Gear Oil Pressure	P0181	High fuel temperature error
B1006	[Panel] Water In Fuel Detection	P0196	High oil temperature error
P2185	High coolant temperature error (Alarm)	P043B	High SCR downstream temperature error
P1521	Low oil pressure error	P0110	High boost temperature
P0219	Engine overspeed detection error	P206C	Low DEF quality error
P0562	Low battery voltage error	P103C	Low DEF tank level error
P0251	Maximum positive deviation excess error of rail pressure (Fuel leakage)		

[Table 3-9] In-Line Engine Alarm Page List



7-digit display

[Fig. 3-37] V-Type Engine Alarm Page Summary Screen

V-Type Engine Alarm Page List			
B100400	[Panel] Low Gear Oil Pressure	P042585	[DCU (RH)] Diagnostic Fault Check for Physical Signal above maximum temperature limit for SCR downstream
B100600	[Panel] Water in Fuel Detection	P043585	[DCU (LH)] Diagnostic Fault Check for Physical Signal above maximum temperature limit for SCR downstream
P02174B	[ECU] High coolant temperature error (Alarm)	P007A85	[ECU] CAC upstream temperature high error of RH bank
P052484	[ECU] Low oil pressure error	P00A085	[ECU] CAC upstream temperature high error of LH bank
P021985	[ECU] Engine overspeed detection error	P207F84	[DCU (RH)] Diagnostic fault check for "physical signal below minimum limit" (DEF quality)
P0560A2	[ECU] Low battery voltage error	P32E984	[DCU (LH)] Diagnostic fault check for "physical signal below minimum limit" (DEF quality)
P00017A	[ECU] Maximum positive deviation excess error of rail pressure(Fuel leakage) (RH bank)	P203F00	[DCU (RH)] Status of tank level is empty
P016885	[ECU] High fuel temperature error	P32B900	[DCU (LH)] Status of tank level is empty
P052085	[ECU] High oil temperature error		

[Table 3-10] V-Type Engine Alarm Page List

3. Part Names, Operation and Settings

3.13 System Booting and Functional Check

- After installing the product, check to see if it has been installed properly

▶ 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 [Fig. 3-39]

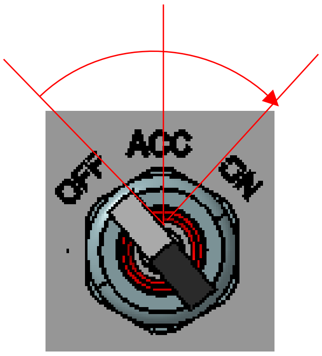
   ※ In case, the screen is not output when the key is rotated

   - 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.[Fig. 3-40]
   - 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 (initially 400RPM or higher, oil pressure 1bar or higher) and warning light on (red lamp blinks when warning light is on)



[Fig. 3-38] Key Switch

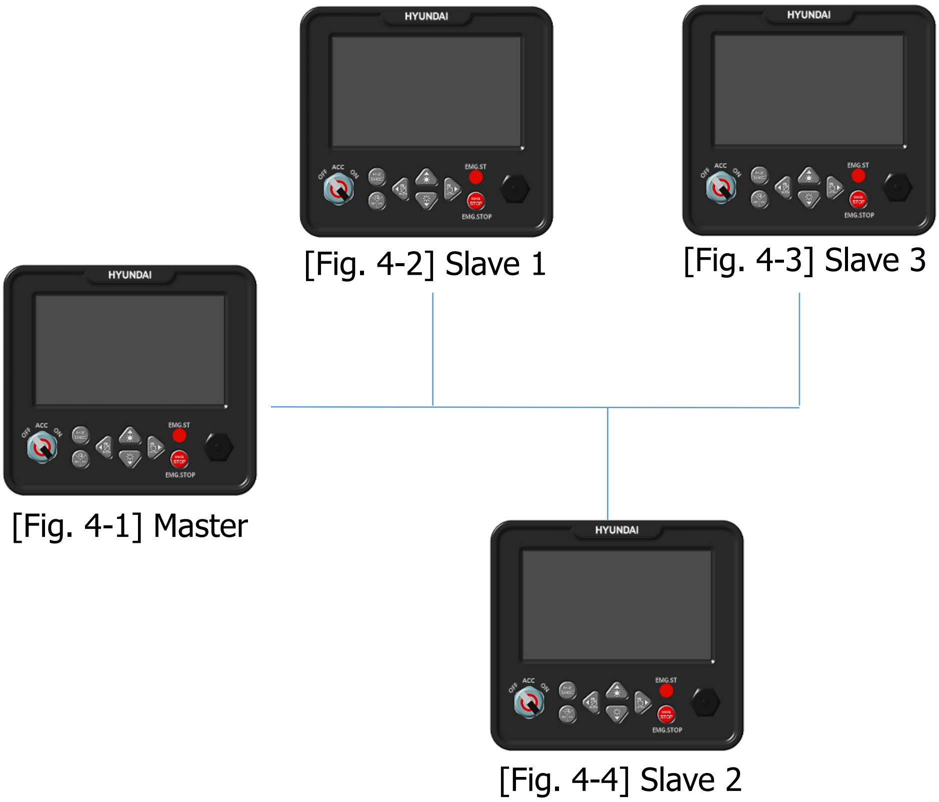
[Fig. 3-39] Boot Logo

[Fig. 3-40] Gauge Screen

4. Multi Panel Structure

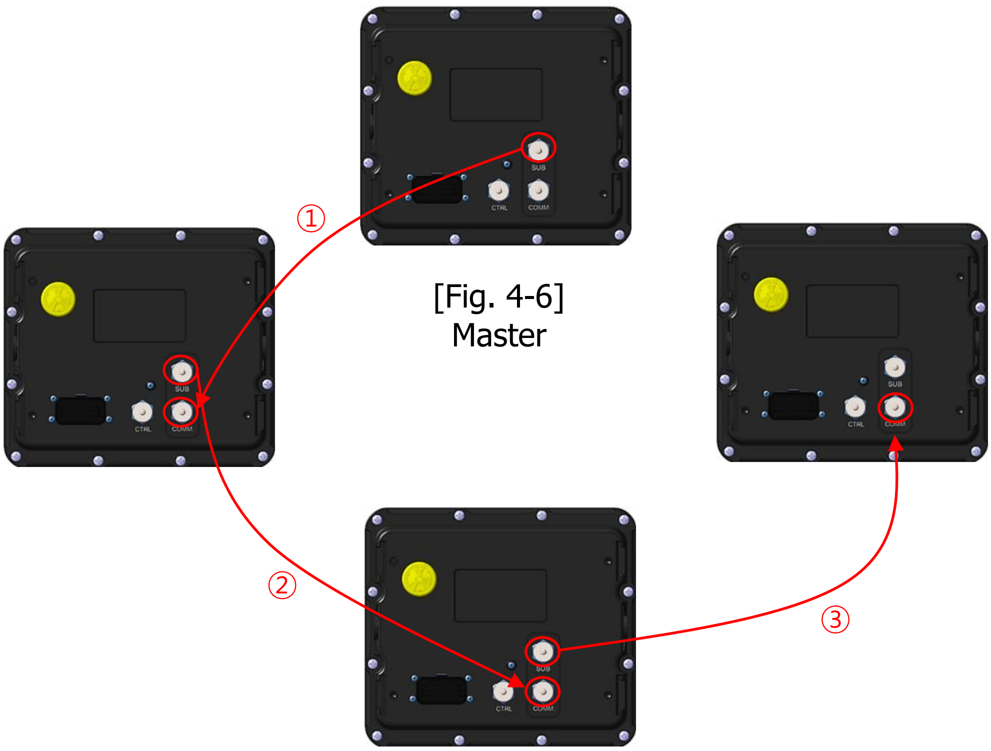
4.1 Multi Panel

- 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. (However, 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



[Fig. 4-6]
Master

[Fig. 4-7]
Slave 1

[Fig. 4-9]
Slave 3

[Fig. 4-8]
Slave 2

※ Before installing the multi-panel, the necessary cables should already be prepared.
(Cables should use HD Hyundai InfraCore 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)

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.

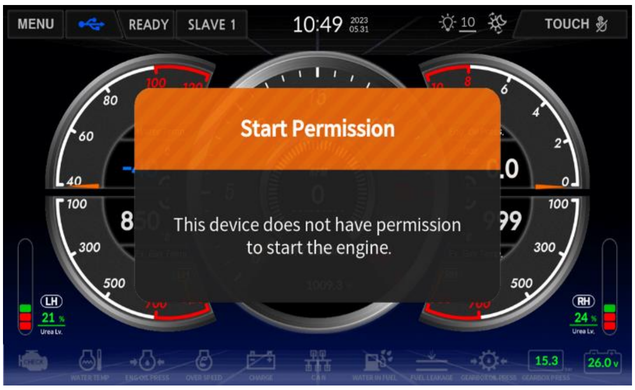
※ Note: When connecting multiple Slaves, the Slave mode settings should not overlap.

(4) Set the panel to Master mode using the same method as above.

※ Note

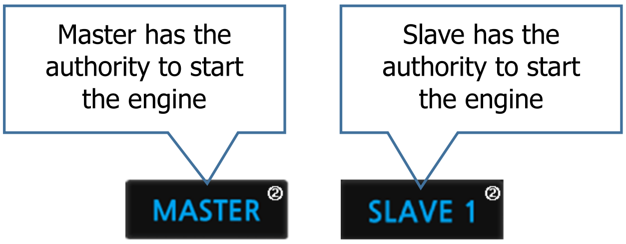
- Only one product can be set in Master mode, and up to two Slaves are recommended.
- If the cable length between Master and Slaves is more than 30m, there may be a voltage drop of more than 1V, so it needs to be checked.
- Granting engine start permission to Slave panels can only be done from the Master panel.
  - In the "Remote Engine Start" menu of the Master panel, select the Slave to grant engine start permission
  - When granting engine start permission to a Slave, the Master loses its own engine start permission.
  - Panels with engine start permission are indicated by colored icons on the indicator [Fig. 4-10 ②][Fig. 4-12].
- When a panel without engine start permission attempts to start the engine, a "No engine start permission" popup appears [Fig. 4-11].
- If both Master and Slave panels have duplicated settings for Local/Remote (e.g., Master, Master), a "[Panel] Multi Panel Local/Remote Setting Error" popup appears [Fig. 4-13].
- Emergency engine start is only possible from the Master panel, and emergency engine stop is possible from any Slave.
  - Slave emergency engine stop operates via CAN communication.
- Re-engaging the starter is not possible during engine operation (except for Emergency Start from the Master panel)

[Fig. 4-10] Multi Panel Settings Popup



[Fig. 4-11] Engine Start Authorization Popup

4. Multi Panel Structure



[Fig. 4-12] Master/Slave Start Authorization

[Fig. 4-13] Multi Panel Settings Error

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 with 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 name, breakdown conditions and your contact information.
- Please ask the seller.