HYUNDAI INFRACORE

950106-038018EN

Operation & Maintenance Manual

MARINE ENGINE

V158TI, V180TI, V222TI, AD158TI, AD180TI, AD222TI

FOREWORD

This manual is designed to serve as a reference for the operation & Maintenance of **V158TI/180TI/222TI** Marine engines and **AD158TI/180TI/222TI** marine generator engine united in one book.
The former is explained for operation and the latter is described for maintenance like parts disassembly, maintenance & inspection and re-assembly etc in order to available understanding the maintenance procedure more easily.
To maintain the engine in optimum condition and retain maximum performance for a long time, CORRECT OPERATION and PROPER MAINTENANCE is essential.
In this manual, the following symbols are used to indicate the type of service operations to be performed.


Removal


Adjustment


Installation


Cleaning


Disassembly


Pay close attention-Important


Reassembly


Tighten to specified torque


Align the marks


Use special tools of manufacturer's


Directional Indication


Lubricate with oil


Inspection


Lubricate with grease


Measurement

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

2025. 01.
950106-038018EN
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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1. SPECIFICATION

1.1. Engine Specification

1.1.1. V158TI

Marine Engine Specification					
Model		**Units**	**V158TI**		
			V158TIH	**V158TIM**	**V158TIL**
Engine type			4 cycle, V-type, direct-injection, water cooled with wet-turbo charger & inter-cooler		
Rating output (B.H.P)		PS(kW)/rpm	480(353)/1,800	540(397)/2,100	680(500)/2,300
Displacement		cc	14,618		
Cylinder number - bore (Ø) x stroke		mm	8 - Ø128 x 142		
Valve clearance at cold	In / Ex	mm	0.25 / 0.35		
Low idling		rpm	725 ±25		
No load max.		rpm	Below 2,070	Below 2,415	Below 2,645
Mean effective pressure		kg/cm^2	16.4	15.8	18.2
Mean piston speed		m/sec.	8.52	9.94	10.89
Compression ratio			15.5 : 1		
Firing order			1 - 5 - 7 - 2 - 6 - 3 - 4 - 8		
Compression pressure	at 200 rpm	kg/cm^2	24 (Initial condition)		
Governor type of injection pump			Mechanical variable speed (R.Q.V)		
Fuel consumption		g/PS.h	160	165	175
		liter/h	93	107	143
Injection timing (B.T.D.C)		deg.	15° ±1°	16° ±1°	18° ±1°
Starting system			Electric starting by starter motor		
Starter motor capacity		V - kW	24 - 7.0		
Alternator capacity		V - A	24 - 80		
Battery		V - Ah	24 - 200		
Cooling system			Indirect sea water cooling with heat exchanger		
Cooling water capacity	Max./Min.	lit.	89 / 78		
Fresh water pump type			Centrifugal type, driven by belt		
Sea water pump type			Rubber impeller type driven by belt		
Lubricating oil (Engine)	Pan capacity	lit.	Max. : 31, Min. : 25 (Engine total : 35)		
	Pressure	kg/cm^2	Full : 3.5, Idle : 1.2		
Direction of revolution	Crankshaft		Counter clockwise viewed from stern side		
Engine size (L x W x H)		mm	1,337 x 1,222 x 1,074		
Engine dry weight		kg	1,350	1,350	1,435

1.1.2. V180TI

Marine Engine Specification					
Model		**Units**	**V180TI**		
			V180TIH	**V180TIM**	**V180TIL**
Engine type			4 cycle, V-type, direct-injection, water cooled with wet-turbo charger & inter-cooler		
Rating output (B.H.P)		PS(kW)/rpm	600(441)/1,800	650(478)/2,100	820(603)/2,300
Displacement		cc	18,273		
Cylinder number - bore (Ø) x stroke		mm	10 - Ø128 x 142		
Valve clearance at cold	In / Ex	mm	0.25 / 0.35		
Low idling		rpm	725 ±25		
No load max.		rpm	Below 2,070	Below 2,415	Below 2,645
Mean effective pressure		kg/cm^2	16.4	15.2	17.6
Mean piston speed		m/sec.	8.52	9.94	10.89
Compression ratio			15.5 : 1		
Firing order			1 - 6 - 5 - 10 - 2 - 7 - 3 - 8 - 4 - 9		
Compression pressure	at 200 rpm	kg/cm^2	24 (Initial condition)		
Governor type of injection pump			Mechanical variable speed (R.Q.V)		
Fuel consumption		g/PS.h	167	179	189
		liter/h	121	141	187
Injection timing (B.T.D.C)		deg.	16° ±1°	18° ±1°	18° ±1°
Starting system			Electric starting by starter motor		
Starter motor capacity		V - kW	24 - 7.0		
Alternator capacity		V - A	24 - 80		
Battery		V - Ah	24 - 200		
Cooling system			Indirect sea water cooling with heat exchanger		
Cooling water capacity	Max./Min.	lit.	92 / 81		
Fresh water pump type			Centrifugal type, driven by belt		
Sea water pump type			Rubber impeller type driven by belt		
Lubricating oil (Engine)	Pan capacity	lit.	Max. : 35, Min. : 28 (Engine total : 38)		
	Pressure	kg/cm^2	Full : 3.5, Idle : 1.2		
Direction of revolution	Crankshaft		Counter clockwise viewed from stern side		
Engine size (L x W x H)		mm	1,495 x 1,222 x 1,169		
Engine dry weight		kg	1,550	1,550	1,630

1.1.3. V222TI

Marine Engine Specification					
Model		**Units**	**V222TI**		
			V222TIH	**V222TIM**	**V222TIL**
Engine type			4 cycle, V-type, direct-injection, water cooled with wet-turbo charger & inter-cooler		
Rating output (B.H.P)		PS(kW)/rpm	720(530)/1,800	800(588)/2,100	1,000(736)/2,300
Displacement		cc	21,927		
Cylinder number - bore (Ø) x stroke		mm	12 - Ø128 x 142		
Valve clearance at cold	In / Ex	mm	0.25 / 0.35		
Low idling		rpm	725 ±25		
No load max.		rpm	Below 2,070	Below 2,415	Below 2,645
Mean effective pressure		kg/cm^2	16.4	15.6	17.9
Mean piston speed		m/sec.	8.52	9.94	10.89
Compression ratio			15.5 : 1		
Firing order			1 - 12 - 5 - 8 - 3 - 10 - 6 - 7 - 2 - 11 - 4 - 9		
Compression pressure	at 200 rpm	kg/cm^2	24 (Initial condition)		
Governor type of injection pump			Mechanical variable speed (R.Q.V)		
Fuel consumption		g/PS.h	171	179	183
		liter/h	148	173	221
Injection timing (B.T.D.C)		deg.	20° ±1°		
Starting system			Electric starting by starter motor		
Starter motor capacity		V - kW	24 - 7.0		
Alternator capacity		V - A	24 - 80		
Battery		V - Ah	24 - 200		
Cooling system			Indirect sea water cooling with heat exchanger		
Cooling water capacity	Max./Min.	lit.	98 / 87		
Fresh water pump type			Centrifugal type, driven by belt		
Sea water pump type			Rubber impeller type driven by belt		
Lubricating oil (Engine)	Pan capacity	lit.	Max. : 40, Min. : 33 (Engine total : 43)		
	Pressure	kg/cm^2	Full : 3.5, Idle : 1.2		
Direction of revolution	Crankshaft		Counter clockwise viewed from stern side		
Engine size (L x W x H)		mm	1,653 x 1,222 x 1,199		
Engine dry weight		kg	1,750	1,750	1,830

1.1.4. AD158TI / AD180TI / AD222TI

Spec. \ Model		Units	Auxiliary		
			AD158TI	AD180TI	AD222TI
Engine type			4 cycle, V-type, direct-injection, water cooled with wet-turbo charger & inter-cooler		
Rating output (B.H.P)	50 Hz	PS(kW) / rpm	410(302)/1,500 (AD158TIF)	485(357)/1,500 (AD180TIF)	606(446)/1,500 (AD222TIF)
	60 Hz		480(353)/1,800 (AD158TIS)	600(441)/1,800 (AD180TIS)	720(530)/1,800 (AD222TIS)
Displacement		cc	14,618	18,273	21,927
Cyl. No - bore (Ø) x stroke		mm	8 - Ø128 x 142	10 - Ø128 x 142	12 - Ø128 x 142
Valve clearance at cold	In / Ex	mm	0.3 / 0.3		
Low idling		rpm	800 ±50		
No load max. (50 Hz / 60 Hz)		rpm	1,500 / 1,800		
Mean effective press. (Initial)		kg/cm^2	16.83 / 16.42	15.93 / 16.42	16.58 / 16.42
Mean piston speed (50 Hz / 60 Hz)		m/sec.	7.1 / 8.52		
Compression ratio			15.5 : 1		
Governor type of inj. pump			Electric governor		
Fuel consumption (SG: 0.832 g/cc)		g/PS.h	153 / 157	155 / 156	155 / 154
		liter/h	76 / 91	91 / 113	113 / 134
Injection timing (B.T.D.C)	50 Hz	deg.	14° ±1°	16° ±1°	16° ±1°
	60 Hz	deg.	15° ±1°	18° ±1°	18° ±1°
Starting system			Electric starting by starter motor		
Starter motor capacity		V - kW	24 - 7.0		
Alternator capacity		V - A	24 - 80		
Battery		V - Ah	24 - 200		
Cooling system			Indirect cooling by sea water with heat exchanger		
Cooling water capacity		lit.	Max. : 89, Min. : 78	Max. : 92, Min. : 81	Max. : 98, Min. : 87
Fresh water pump type			Centrifugal type, driven by V-belt		
Sea water pump type			Rubber impeller type driven by V-belt		
Lub. oil (Engine)	Pan capacity	lit.	Max. : 31, Min. : 25 (Engine total : 35)	Max. : 35, Min. : 28 (Engine total : 38)	Max. : 40, Min. : 33 (Engine total : 43)
	Pressure	kg/cm^2	Full : 3.5, Idle : 1.2		
Revolution of crankshaft			Counter clockwise viewed from stern side		
Engine size (L x W x H)		mm	1,037 x 1,222 x 1,074	1,195 x 1,222 x 1,169	1,353 x 1,222 x 1,199
Engine dry weight (kg)		kg	1,295	1,545	1,735

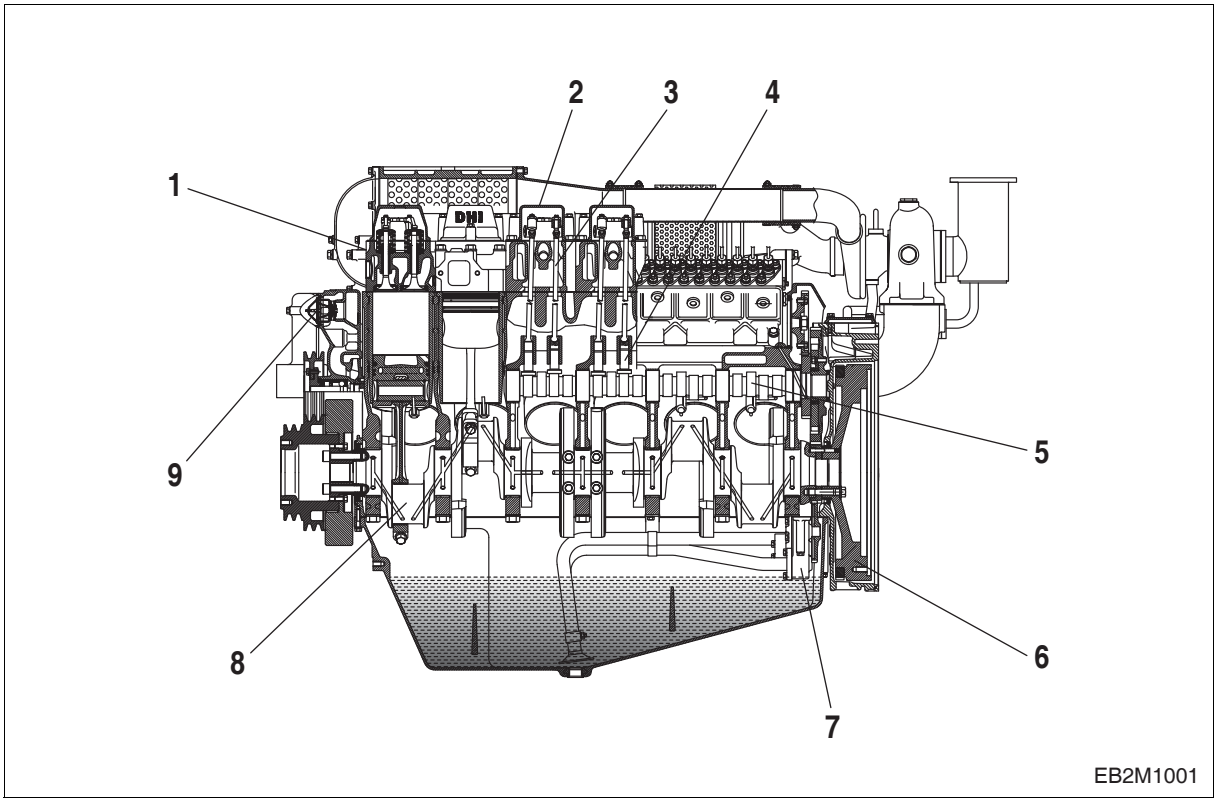
1.1.5. AD158TI / AD180TI / AD222TI

Spec. \ Model		Units	Emergency		
			AD158TI	AD180TI	AD222TI
Engine type			4 cycle, V-type, direct-injection, water cooled with wet-turbo charger & inter-cooler		
Rating output (B.H.P)	60 Hz		480(353)/1,800 (AD158TIS)	600(441)/1,800 (AD180TIS)	720(530)/1,800 (AD222TIS)
Displacement		cc	14,618	18,273	21,927
Cyl. No - bore (Ø) x stroke		mm	8 - Ø128 x 142	10 - Ø128 x 142	12 - Ø128 x 142
Valve clearance at cold	In / Ex	mm	0.3 / 0.3		
Low idling		rpm	800 ±50		
No load max. (50 Hz / 60 Hz)		rpm	1,500 / 1,800		
Mean effective press. (Initial)		kg/cm^2	16.83 / 16.42	15.93 / 16.42	16.58 / 16.42
Mean piston speed (50 Hz / 60 Hz)		m/sec.	7.1 / 8.52		
Compression ratio			16.0 : 1		
Governor type of inj. pump			Electric governor		
Fuel consumption (SG: 0.832 g/cc)		g/PS.h	160	160	158
		liter/h	92	115	137
Injection timing (B.T.D.C)	50 Hz	deg.	14° ±1°	16° ±1°	16° ±1°
	60 Hz	deg.	15° ±1°	18° ±1°	18° ±1°
Starting system			Electric starting by starter motor		
Starter motor capacity		V - kW	24 - 7.0		
Alternator capacity		V - A	24 - 80		
Battery		V - Ah	24 - 200		
Cooling system			Indirect cooling by sea water with heat exchanger		
Cooling water capacity		lit.	Max. : 89, Min. : 78	Max. : 92, Min. : 81	Max. : 98, Min. : 87
Fresh water pump type			Centrifugal type, driven by V-belt		
Sea water pump type			Rubber impeller type driven by V-belt		
Lub. oil (Engine)	Pan capacity	lit.	Max. : 31, Min. : 25 (Engine total : 35)	Max. : 35, Min. : 28 (Engine total : 38)	Max. : 40, Min. : 33 (Engine total : 43)
	Pressure	kg/cm^2	Full : 3.5, Idle : 1.2		
Revolution of crankshaft			Counter clockwise viewed from stern side		
Engine size (L x W x H)		mm	1,037 x 1,222 x 1,074	1,195 x 1,222 x 1,169	1,353 x 1,222 x 1,199
Engine dry weight (kg)		kg	1,295	1,545	1,735

1.2. Engine Aspects

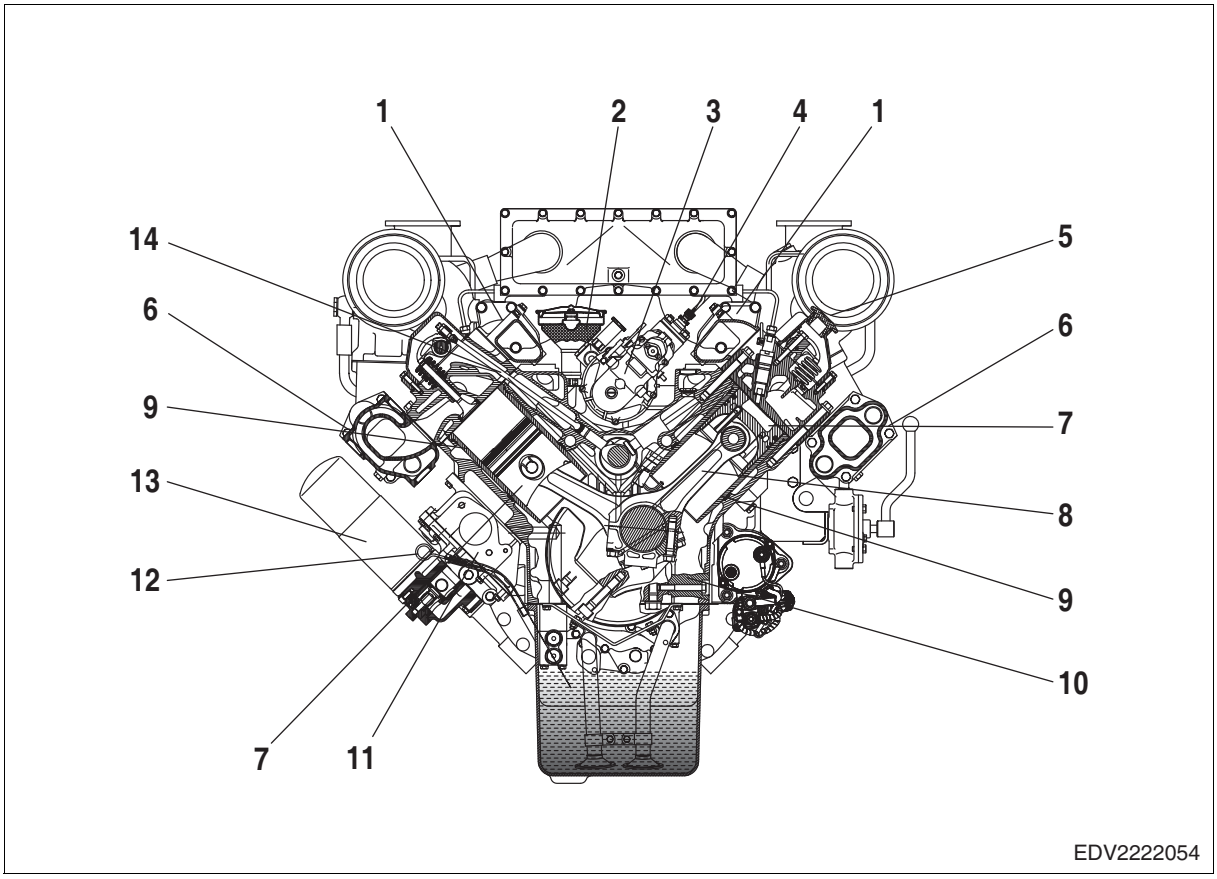
Note : The images shown represent the standard model; they do not include all models.

1.2.1. Engine sectional view (Longitudinal → V222TI)



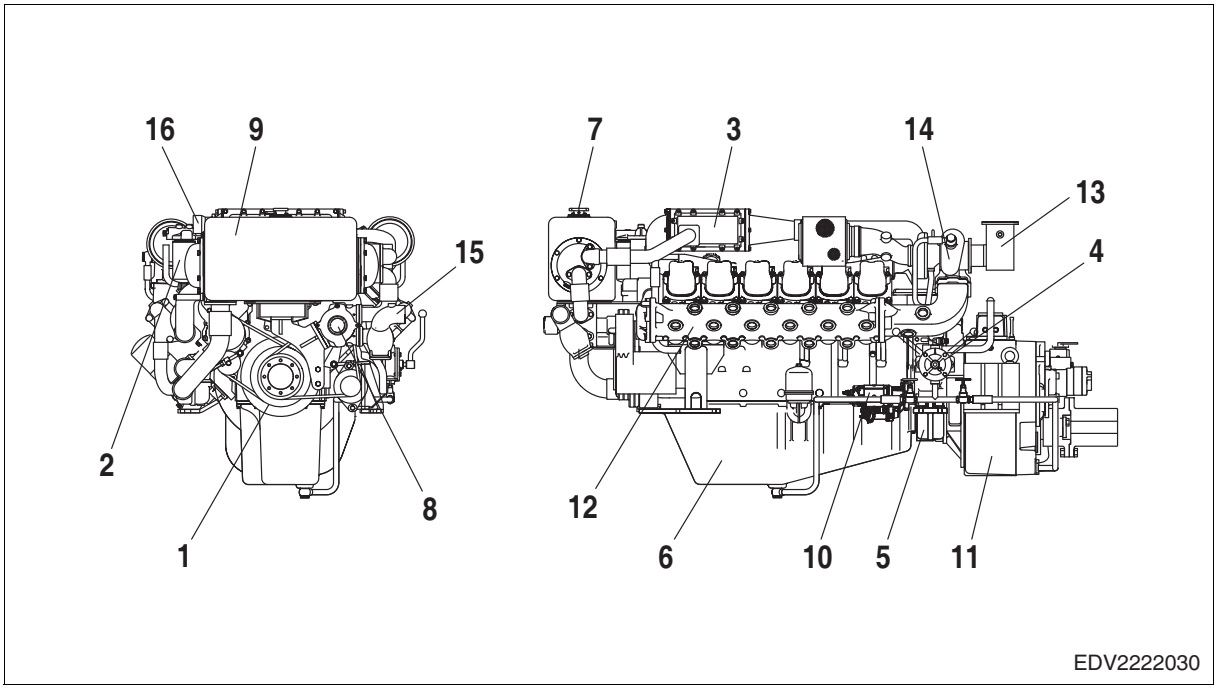
1. Cylinder head
2. Cylinder head cover
3. Push rod
4. Tappet
5. Camshaft
6. Flywheel
7. Oil pump
8. Crankshaft
9. Thermostat

1.2.2. Engine sectional view (Cross → V222TI)



1. Intake manifold
2. Breather assembly
3. Injection pump
4. Injection pipe
5. Oil filler cap
6. Exhaust manifold
7. Piston
8. Connecting rod
9. Cylinder liner
10. Cylinder block
11. Oil cooler
12. Oil level gauge
13. Oil filter
14. Push rod

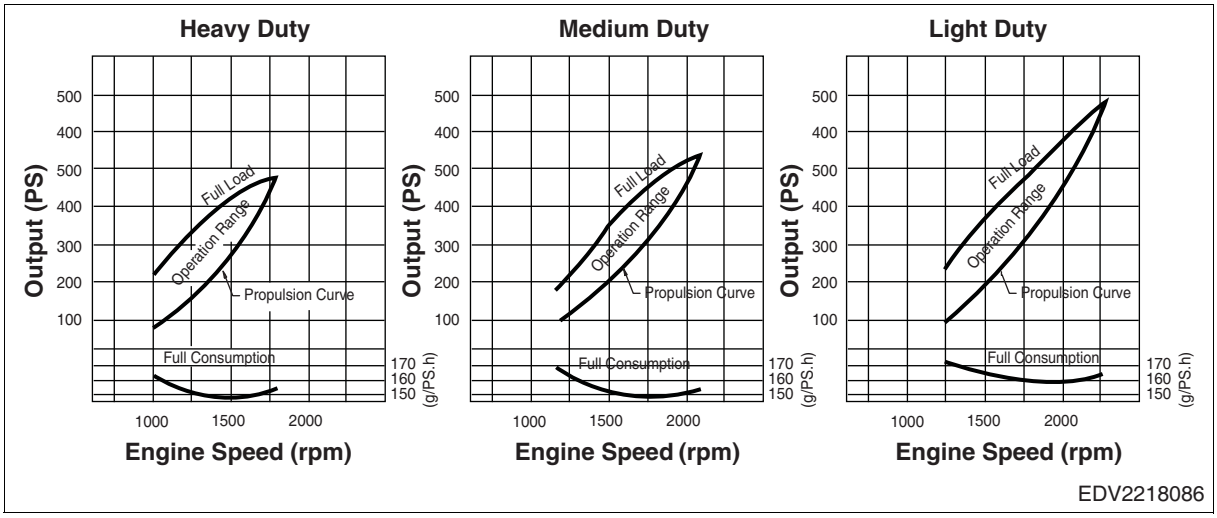
1.2.3. Engine assembly (V222TI)



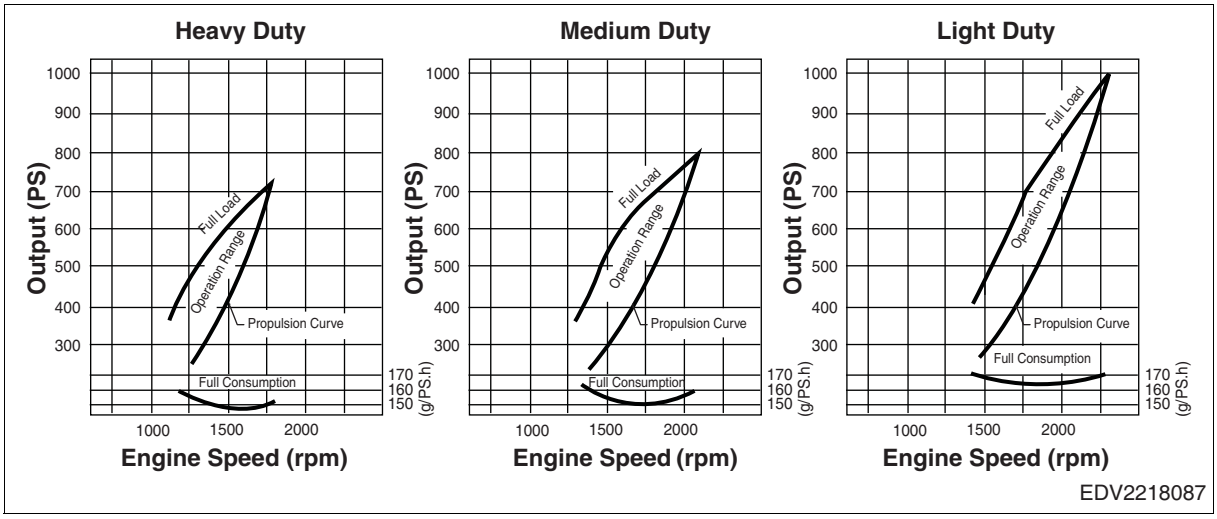
1. Crank pulley
2. Fuel filter
3. Intercooler
4. Oil drain pump
5. Flywheel housing
6. Oil pan
7. Fresh water filler cap
8. Sea water pump
9. Heat exchange ass′y
10. Starter
11. Marine gear ass′y
12. Exhaust manifold
13. Exhaust manifold
14. Turbocharger (wet)
15. Sea water inlet pipe
16. Sea water outlet pipe

1.3. Engine Performance Curve

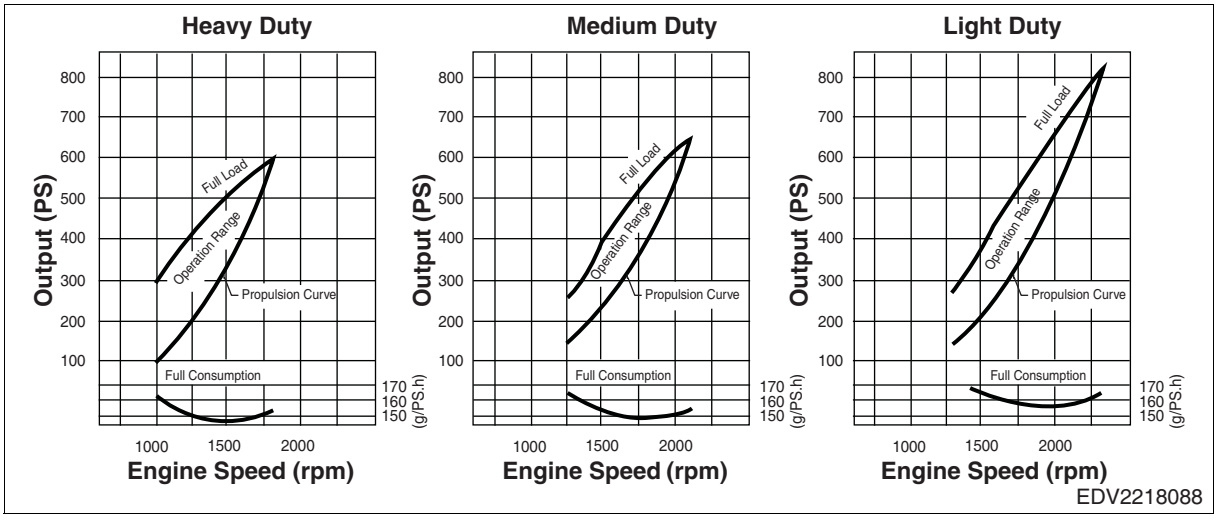
1.3.1. V158TI



1.3.2. V180TI

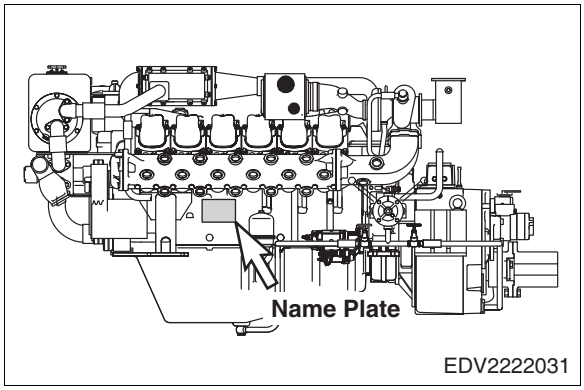


1.3.3. V222TI



1.4. Engine Model & Serial Number

The engine serial number is inscribed on the engine as illustrated. This number is required when requesting warranty and ordering parts. It is also referred to as engine model and serial number because of their location.



Note :
The engine model name (V222TI) is described in the name plate on the cylinder block.

- **Engine serial No. (Example : V222TI)**

EBYKM200001

- Serial No.
- Production Year (2002)
- Engine Model Suffix

2. SAFETY REGULATIONS

2.1. General Notes

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

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

IMPORTANT.

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

2.2. Regulations Designed to Prevent Accidents with Injury to Persons

2.2.1. During commissioning, starting and operation

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

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

2.2.2. During maintenance and care

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

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

- Take into account the amount of oil in the sump. Use a vessel of sufficient size to ensure that the oil will not overflow.
- Open the coolant circuit only when the engine has cooled down. If opening while the engine is still warm unavoidable, comply with the instructions in the chapter entitled ″4.3. Cooling System″.
- Neither tighten up nor open pipes and hoses (lube oil circuit, coolant circuit and any additional hydraulic oil circuit) during the operation. The fluid which flow out can cause injury.
- Fuel is inflammable. Do not smoke or use naked lights in its vicinity. The tank must be filled only when the engine is switched off.
- When using compressed air, e.g. for cleaning the heat exchanger, wear goggles.
- Keep service products (anti-freeze) only in containers which can not be confused with drinks containers.
- Comply with the manufacturer′s instructions when handling batteries.

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

2.2.3. When carrying out checking, setting and repair work

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

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

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

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

(3) Use only genuine HD Hyundai Infracore spare parts. HD Hyundai Infracore will accept no responsibility for damage resulting from the installation of other parts which are supposedly ″just as good″.

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

- Never let the engine run when dry, i.e. without lube oil, fuel or coolant. Use only HD Hyundai Infracore approved service products. (engine oil, anti-freeze and anti-corrosion agent)
- Pay attention to cleanliness. The diesel fuel must be free of water. See ″4.6. Fuel System″.
- Have the engine maintained at the specified intervals.
- Do not switch off the engine immediately when it is warm, but let it run without load for about 5 minutes so that temperature equalization can take place.
- Never put cold coolant into an overheated engine.
- Do not add so much engine oil that the oil level rises above the max. marking on the dipstick. Do not exceed the maximum permissible tilt of the engine. Serious damage to the engine may result if these instructions are not adhered to.
- Always ensure that the testing and monitoring equipment (for battery charge, oil pressure, and coolant temperature) function satisfactorily.
- Do not let the sea water pump run dry. If there is a risk of frost, drain the water when the engine switched off.

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

2.4. Regulations Designed to Prevent Pollution

2.4.1. Engine oil, filter element, fuel filter

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

2.4.2. Coolant

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

2.5. Notes on Safety in Handling Used Engine Oil

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

Health precautions

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

Ensure that used engine oil is disposed of properly.
- Engine oil can endanger the water supply -

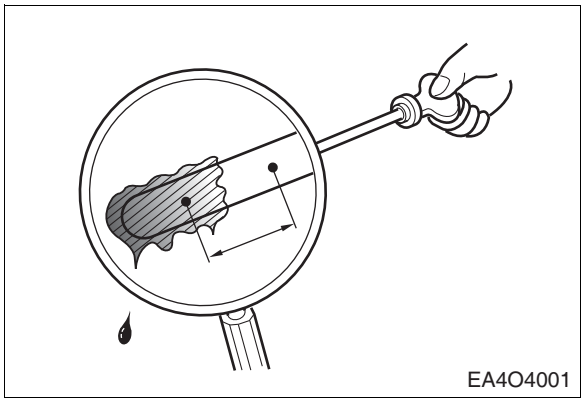
For this reason do not let engine oil get into the ground, waterways, the drains or the sewers.
Violations are punishable. Collect and dispose of used engine oil carefully.
For information on collection points please contact the seller, the supplier or the local authorities.

3. COMMISSIONING AND OPERATION

3.1. Inspections before Operation

3.1.1. Lubricating oil

a) The notches in dipstick must indicate the oil level between max. and min. permissible.
b) The measurement of the oil level must be done on a even water line and in 10 minutes after engine operating.
c) Examining the viscosity and the contamination of the oil smeared at the dipstick, replace the engine oil if necessary.

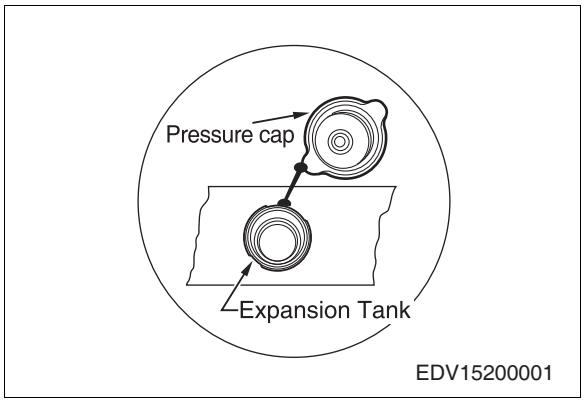


3.1.2. Cooling water

Checking the level of the cooling water in tank.

Caution :
If the installation angle of the engine exceeds 6 degrees, please remark the maximum and minimum level of the oil dipstick by engraving on the lube oil capacity of the engine. (Refer to 4.4. ″Lubrication system″)

Check the opening pressure of the pressure valve using cap tester. Replace the filler cap assembly if the measured valve does not reach the specified limit.
(Opening pressure of valve : 0.9 kg/cm^2)

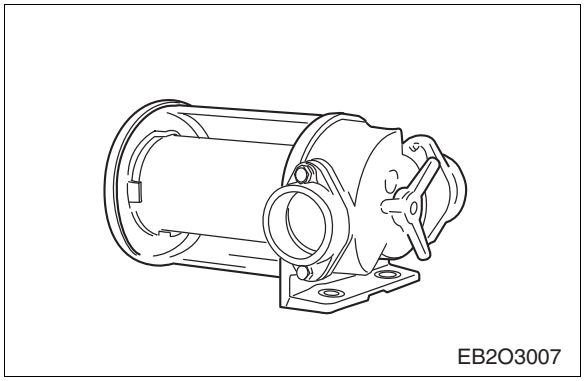


Note :
Because it is dangerous to open the pressure cap quickly when coolant is hot, after covering the cap with a cloth and then lower the inside pressure of the tank by opening slowly at first, open it up.

3.1.3. Sea water pump

Impeller of the sea water pump is a bronze type, therefore you should install the sea water strainer as right figure in order not to suck in any hard pieces and sharp scales.

Install the sea water strainer in adequate size for the engine between kingston valve and sea water pump.



- Over-tightened belt or over loaded gear will reduce the bearing life of the sea water pump.
- If sea water is not sucked in sea water pump at starting, restart the engine after filling water in the sea water pump housing and inlet hose.
- Make sure that all valves/cocks in the sea water line are opened before run.
- If there is a risk of freezing weather, drain the water by loosening bolts of end cover.
- Temperature range : 5°C (41°F) ~ 60°C (140°F)

3.1.4. Intake & exhaust Line

Make sure that intake & exhaust piping lines are properly designed and air filter element is fouled and worn severely. If so, correct and clean or replace it.

3.1.5. Fuel line

Check the fuel line leaking on opening the valve.

The contamination of fuel may cause the nozzle clogging or the sticking of the injection pump components. Therefore, cleanness of fuel system should be maintained at any time.

3.1.6. Bottom of the engine room

(1) Always keep the bottom clean.

Check the bilge for excessive water accumulation. Always keep the bilge clean and dry. Never allow the water depth in the bilge to exceed the bottom of the engine.

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

Caution :

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

3.1.7. Engine stop & warning devices

V158TI/V180TI/V222TI gauge panel is equipped with an audible alarm to alert the operator to the following.

1) Engine stop device (Stop solenoid)

- When the engine oil pressure is less than 0.5 kg/cm^2.
- When the engine over speed becomes more than 117% of the engine rated speed but, marine generator engine becomes more than 115%.

2) Engine warning lamps

Engine warning lamp is turned on with buzzer sound at the same time.

- When the engine oil pressure is less than 1 bar (1st stage) and 0.5 bar (2nd stage).
- When the engine water temperature is more than 93°C.
- When the battery is not charged.

If a warning lamp of the gauge panel on engine operation is turned on, you will find as follows.

The alarm horn will sound when the ignition is turned on and continue to sound until the key switch is shifted into ″OFF″ position or minimum oil pressure is obtained. This provides a functional test of warning system.

If the engine oil pressure becomes to less than 0.5 kg/cm^2, the alarm horn will sound and the engine is stopped by stop solenoid at the same time automatically. Proceed as follows :

First, quickly observe the oil pressure gauge for the engine low pressure such as needle oscillation indicating low oil. If oil temperature gauge indicates below 0.5 kg/cm^2, put the control lever back to the idle speed position IMMEDIATELY and shift the reduction gear control lever into the NETURAL position. Do not restart engine until the cause for the alarm has been found and corrected. Refer to ″Performance Loss″ in Trouble Shooting Chart.

Check the oil lines or switch and sensor malfunction. If the cause for the alarm cannot be found, contact your HD Hyundai Infracore dealer.

3.2. Starting

3.2.1. Operation 1 (Analog panel)

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

Behavior - When the key switch is placed in the START position.

After the engine is cranked, convert the key switch to the ACC position quickly.

Behavior - As the engine is cranked, don't fix the key switch too long (over 4 seconds) in the ″START″ position. If you do, the starter may be malfunction.

If you fail the engine starting at first, restart the engine after waiting for 30 seconds at least to prevent the circuit malfunction of the starter.

3.2.2. Operation 2 (Digital panel)

Digital panel system boot, shutdown and the engine stop function.

1) Insert the key into key switch on the product, please rotate 90 to the right (ON) (When the key is turned ″ON″, keeping the key jammed)
2) After key on, all the system boot in 17 secs.
3) When turn off the system rotate the key 90 to the left (OFF)
   - When you rotate the key from the ignition state to the left (OFF) the 300 seconds alarm message pop-up on the window then engine shutdown after 300 seconds with saving event.
   - When a pop-up appears, if you rotate the key to the right (ON) pop-up disappears then the engine will remain on.

Refer to ″User's Manual for Digital Panel″ for details.

3.3. Engine Break-in

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

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

3.3.1. New engine break-in 20 hours

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

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

3.3.2. Initial two hours of break-in

For the first five to ten minutes of operation, operate engine at a fast idle (below 1,300 rpm) During the remaining first two hours of operation, accelerate to bring boat onto plane quickly and bring throttle back to maintain a planing attitude. During this period, vary the engine speed frequently by accelerating to approximately three-fourths throttle (1,500 ~ 1,600 rpm) for two to three minutes, then back to minimum planing speed(700 ~ 800 rpm).

After the engine has reached operating temperature, momentarily reduce engine speed, then increase engine speed, to assist the break-in of rings and bearings. Maintain planing boat attitude to avoid excessive engine load.

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

3.3.3. Next 8 hours

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

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

3.3.4. Final 10 hours

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

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

During the break-in period, be particularly observe as follows :

- Check engine oil level frequently. Maintain oil level in the safe range, between the ″min.″ and ″max.″ marks on dipstick.
- Watch the oil pressure warning lamp. If the lamp blinks whenever the boat attitude (i.e. turning, climbing on plane, etc.) is changed, it may be the oil pick-up screen is not covered with oil. Check oil dipstick. Add oil to the oil pan, if required. Do not overfill.

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

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

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

When the engine operation become to reach 50 hours in total including the break-in period 20 hours, replace the engine oil and oil filter to new ones. Fill oil pan with recommended engine oil. Refer to ″4.4. Lubricating System″.

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

3.3.5. Operating after break-in 20 hours

When starting a cold engine, always allow the engine to warm up gradually. Never run the engine at full throttle until the engine is thoroughly warmed up.

And you'd better run the engine at three-fourths throttle (about 1,600 rpm) before initial 50 hours as possible. Be sure to check the oil level frequently during the first 50 hours of operation since the oil consumption will be high until the piston rings are properly seated.

3.4. Inspections after Starting

During operation the oil pressure in the engine lubrication system must be monitored. If the monitoring devices register a drop in the lube oil pressure, switch off the engine immediately. And the charge warning lamp of the alternator should go out when the engine is running.

- Do not disconnect the battery or pole terminals or the cables!
- If, during operation, the battery charge lamp suddenly lights up, stop the engine immediately and remedy the fault in the electrical system!
- Engine should be stopped if the color, the noise or the odor of exhaust gas is not normal.
- Confirm the following things through warning lamps and gauge panel.

3.4.1. Pressure of lubricating oil

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

3.4.2. Temperature of cooling water

The cooling water temperature should be 71 ~ 85°C in normal operating conditions. Abnormally high cooling water temperature could cause the overheating of engine and the sticking of cylinder components. And excessively low cooling water temperature increases the fuel consumption, accelerates the wears of cylinder liners and shortens the engine life-time.

3.5. Check after Initial 50 Hours Operation.

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

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

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

3.6. Operation In Winter

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

3.6.1. Prevention against the freeze of cooling water

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

3.6.2. Prevention against excessive cooling

Drop of thermal efficiency caused by excessive cooling increases fuel consumption. Therefore should prevent the engine from excessive cooling. If the temperature of coolant does not reach to normal condition (71 ~ 85°C) after continuous operation, examine the thermostat or the other cooling lines.

3.6.3. Lubricating oil

As cold weather leads to the rise of oil viscosity, engine speed becomes unstable after starting. Therefore the lubricating oil for winter (SAE 15W40 or 10W30) should be used to prevent this unstableness. Refer to ″4.4. Lubricating system″.

3.7. Tuning the Engine

The purpose of an engine tune-up is to restore power and performance that's been lost through wear, corrosion or deterioration of one or more parts or components. In the normal operation of an engine, these changes can take place gradually at a number of points, so that it's seldom advisable to attempt an improvement in performance by correction of one or two items only. Time will be saved and more lasting results will be obtained by following define and thorough procedure of analysis and correction of all items affecting power and performance.

Economical, trouble-free operation can better be ensured if a complete tune-up is performed once every year, preferably in the spring. Components that affect power and performance to be checked are:

- Components affecting fuel injection ;
  Nozzle, delivery valve, fuel filter, fuel water separator, etc.
- Components affecting intake & exhaust ;
  Air filter, inter-cooler, turbo-charger, silencer, good ventilation of engine room etc.
- Components affecting lubrication & cooling ;
  Air & oil filter, anti- freeze, heat exchanger, rubber impeller, sea water filter, kingston valve, misalignment of propeller, stableness of bed frame, bent propeller blade etc.

4. GENERAL INFORMATION

4.1. General Repair Instructions

1. Before performing service operation, disconnect the grounding cable from the battery for reducing the chance of cable damage and burning due to short-circuiting.
2. Use covers to prevent the disassembled parts and components from damage or pollution.
3. Engine oil and anti-freeze solution must be handled with care. They can cause damage for painted parts.
4. The use of proper tools or specified special tools is important to perform the efficient and reliable maintenance operation.
5. Use genuine HD Hyundai Infracore parts necessarily.
6. Used cotter pins, gaskets, O-rings, oil seals, lock washer, self-lock nuts and rubber coated seal ring etc. should be discarded. New ones should be used for re-assembled parts. If these are reused, normal performance can not be maintained.
7. To facilitate reassembling, keep disassembled parts neatly in groups. Fixing bolts and nuts for reassembled parts should be reused at the original position. They are varied in hardness or length because they are designed depending on their application.
8. Clean the disassembled parts prior to inspection or re-assembly. By using compressed air, make oil ports and etc. of them free from any foreign material.
9. Lubricate the surface of rotating and sliding parts with oil or grease before installation.
10. If necessary, use sealant onto gaskets to prevent leakage.
11. Carefully obey all specified torque to tighten bolts and nuts
12. When maintenance is completed, make a final check to be sure it has been done properly.

4.2. Periodical Inspection & Maintenance

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

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

Inspection		Daily	Every 50hrs	Every 100hrs	Every 250hrs	Every 500hrs	Every 600hrs	Every 1,000 hrs
Cooling system	Coolant level check and refill	●						
	Contamination of the coolant check and the quantity of the anti-freeze						●	1 year change
	Heat-exchanger and water cooling line cleaning							1,200 hr
	V-belt check and adjustment	●						2,000 hrs change
	Thermostat check							2 years
	Impeller of sea water pump check	●						2,000 hrs change
Lubrication system	Oil level check	●						
	Lubrication oil exchange		● 1st		●			
	Oil filter cartridge replacement		● 1st		●			
	Marine gear oil exchange			● 1st			●	
	Cylinder compression pressure check							●
	Rotor for bypass filter					● change		
Intake & exhaust system	In./Ex. valve clearance adjustment		● 1st					●
	Air filter element cleaning & change			● clean			● change	
	Inter-cooler cleaning							●
	Turbocharger cleaning							2,000 hr
	Exhaust gas check	●						
Fuel system	Priming pump strainer cleaning				●			
	Fuel tank check & cleaning		●					
	Water separator cleaning			●				
	Fuel filter exchange		● 1st		●			
	Fuel Injection timing check							1 year
	Fuel Injection nozzle check							1 year
Engine adjust	Warning lamps check	●						
	Battery charging check	●						
	Wiring harness check						●	

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

4.3. Cooling System

4.3.1. Coolant level check and refill

- Replenish the deficient coolant in the expansion tank every day before running. The coolant must be changed at intervals of 1,200 hours operation or six months whichever comes first. If the coolant is being fouled greatly, it will lead engine overheat or coolant blow off from the expansion tank.
- The clean fresh water should be used for engine coolant.
- Additional agent (35 ~ 40% anti-freeze and 3 ~ 5% anti-corrosion agent) should be mixed with fresh water for engine coolant to prevent the cooling system problem like freezing, corrosion and etc.

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

(1) Coolant replenishment

Let the plug in the highest level of the water lines or the upper plug of wet turbocharger open, and fill the coolant about three forth of the expansion tank slowly until the air bubbles in water do not come out through the plug hole. Then reassemble the plug.

After filling the coolant, run the engine at the idle rpm for around 5 minutes and you will find out the engine coolant level becomes lower than before cause of escaping the air bubbles in water. Then stop the engine and replenish additional coolant properly.

(2) Coolant change

- Open the pressure cap of expansion to remove the air pressure.

Caution :
When remove the pressure of the filler cap while the engine is still hot, cover the cap with a cloth, then turn it counter-clockwise slowly to release internal steam pressure. This will prevent a person from scalding by hot steam spouted out from the filler cap.

- V-type engines have 5 places of drain plug as follows
  1) Lower part of right exhaust elbow
  2) Front part of the left exhaust manifold cover
  3) Lower part of the heat exchanger outlet pipe
  4) Lower part of oil cooler
  5) Cylinder block part of starter upper side.

- After water draining, re-assemble the drain plugs and then replenish the coolant as same as ″(1) Coolant replenishment″.

4.3.2. Contamination check of coolant and quantity of anti-freeze

- We recommend the engine coolant for HD Hyundai Infracore marine engines should be mixture of fresh water and additional agent (35 ~ 40% anti-freeze and 3 ~ 5% anti-corrosion agent).
  Check the quantity of anti-freeze every 600 hours. From time to time, refill the anti-freeze as much as required.
  You can check the quantity of anti-freeze and anti-corrosion agent by using a FLEETGUARD test kit simply as follow. (FLEETGUARD CC2602M : DHI No. ; 60.99901-0038)

1) Contamination check

- **How to use test kit (Striped pad)**

(1) Collect half of a coolant sample cup from a drain plug at the lower side of the water pump inlet pipe or cylinder block. Coolant must be between 10°C and 55°C when tested. Room temperature is preferred.

Do not collect the coolant from the expansion tank or overflow system.
The collected sample is less contaminated, so it can not be substituted for the quality of whole coolant.

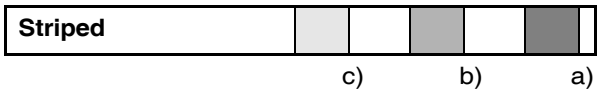
(2) Shake the bottle filled with sample coolant to mix well and take out one strip from bottle of the test kit. Then dip the strip into coolant sample for 3 ~ 5 seconds, take it out and shake it briskly to remove excess liquid.

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

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

Caution
All three pad readings must be completed **no later than 75 seconds** after dipping strip. Do not touch the stripe with fingers.

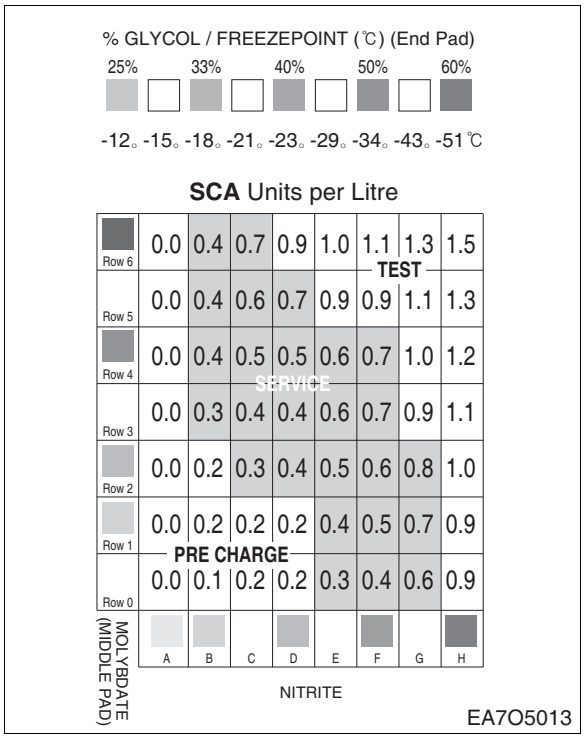
- **How to judge the strip**



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

(1) Compare the end pad ″a)″ color of the strip with color blocks of a row at the upper part of the standard color chart (below of the letter ″GLYCOL/ FREEZE POINT″). Same color in the block of the row means the content of anti-freeze in the coolant. (Normal range is between 33% and 50%.)

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



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

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

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

4.3.3. Anti-freeze

The anti-freeze, 35 ~ 40% of the whole coolant, is always to be used to prevent the cooling system from the corrosion. And in winter the amount of anti-freeze shown in the following table should be used in accordance with the ambient temperature.

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

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

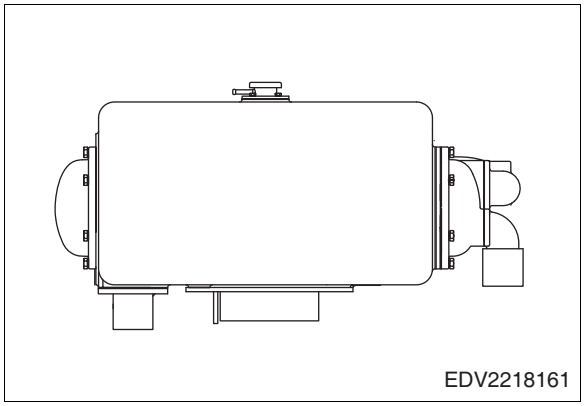
Any coolant loss due to engine operation must be replenished. But adding fresh water for coolant tends to lower the content of anti-freeze. Always replenish the coolant with a mixture of antifreeze and water, and keep the proper content of antifreeze (35 ~ 40%).

4.3.4. Heat exchanger and cooling line cleaning

(1) Heat exchanger cleaning

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

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



(2) Fresh water line cleaning

If the cooling circuits are fouled with water scales or sludge particles, the cooling efficiency will be dropped down.

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

Cooling system cleaning interval : Every 1,200 hours

Note :

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

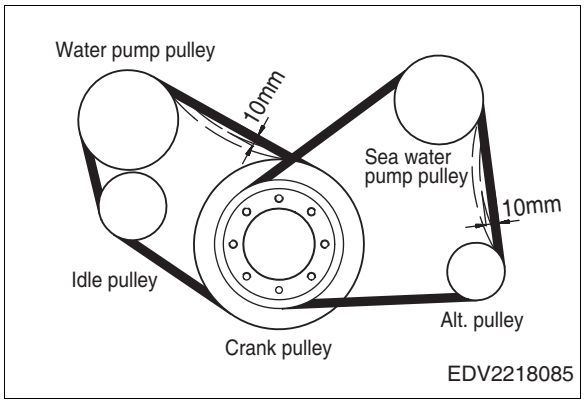
4.3.5. Check and adjust of V-belt Tension

(1) V - belt condition

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

(2) V - belt Tension

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



(3) Change the V-belt

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

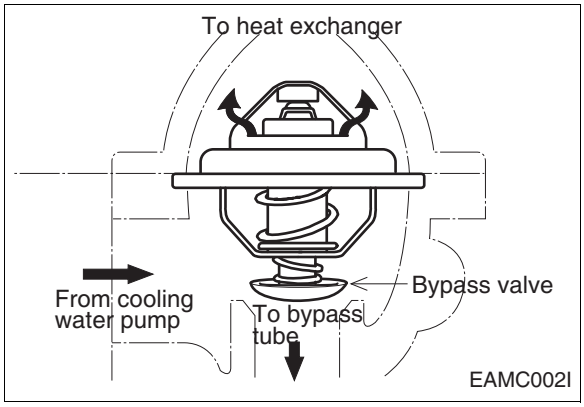
If, in the case of a multiple belt drive, wear or differing tensions are found, always replace the complete set of the belts.

Note :
Always apply to HD Hyundai Infracore genuine parts every replacement.

4.3.6. Thermostat

The thermostat maintains a constant temperature of coolant (71 ~ 85°C) and improves thermal efficiency of the engine by preventing heat loss.

Namely, when the temperature of coolant is lower than 85°C, the thermostat valve is closed to make the coolant bypass to directly enter the water pump. When the coolant temperature rises to open wide the thermostat valve, the bypass circuit is closed and the water passage to the heat exchanger is opened so that the coolant is forced to flow into the heat exchanger.

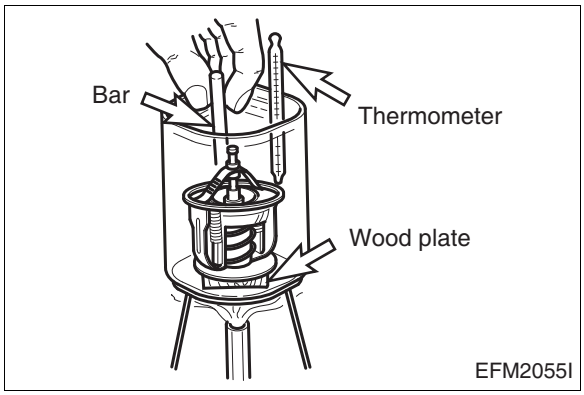


Item	Specifications
Type	Wax-pallet type
Open at	71°C
Open wide at	85°C
Valve lift	8 mm or more

- **Inspecting**

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

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



- **Replacing thermostat and precautions for handling**

  (1) Precautions for handling

  The wax pallet type thermostat does not react as quickly as bellows type one to a variation of temperature of coolant. Such relatively slow reaction is mainly due to the large heat capacity of the wax pellet type thermostat. Therefore, to avoid a sharp rise of coolant temperature, it is essential to idle the engine sufficiently before running it. In cold weather, do not run the engine at overload or overspeed it immediately after starting off.

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

  (3) Replacing thermostat

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

- Change the thermostat every 2 years.

4.3.7. Sea water pump

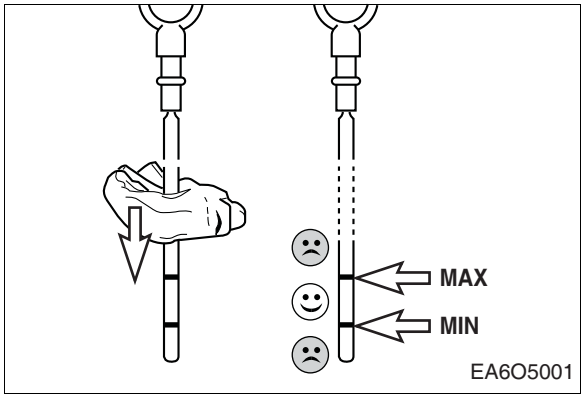
As the sea water pump is a bronze impeller type driven by V-belt, should install the sea water strainer between sea water pump and kingston valve to prevent malfunction of impeller due to clogging by any matters sucked.

Every the engine starts you should always check whether the kingston valve on the bottom of the boat is opened. If sea water does not flowed out through outlet pipe of the boat outside, fill coolant in the sea water pump inlet pipe and hose after loosening clamp.

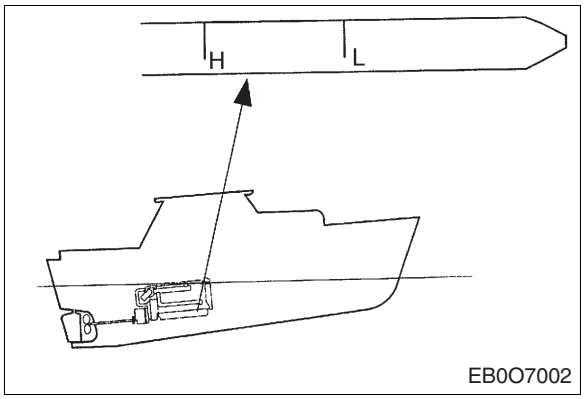
4.4. Lubrication System

4.4.1. Oil level

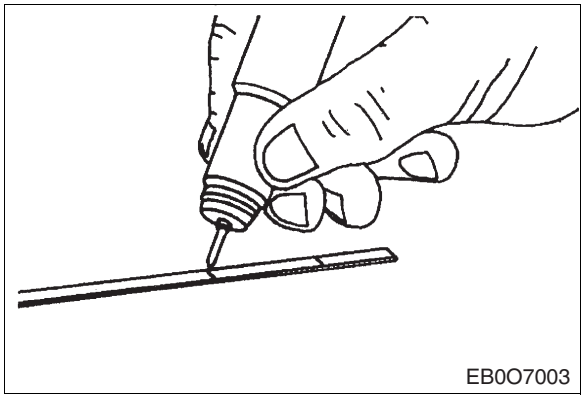
- The notches in dipstick must indicate the oil level between high and low permissible when the vessel is in the water that is at normal trim.
- The oil level should be checked at the horizontal position of the boat after waiting about 10 minutes since then the engine has been shut down.
- Examining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



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



- **How to re-mark the oil dipstick**
  Since the inclination angle of marine engine may differ greatly among vessels, the high and low oil levels on the dipstick should be also changed for over 6 degree of the engine inclination.
  Dipstick should be re-marked by engraving on the lube oil capacity of each engine. Be sure to check and mark the oil levels between **High** and **Low** when the vessel is commissioning at first. Please note that stamping or notching will weaken the dipstick and the tip of the dipstick may break off in the oil pan.
  The capacity of lube oil can be referred before ″1.1. Engine Specification″

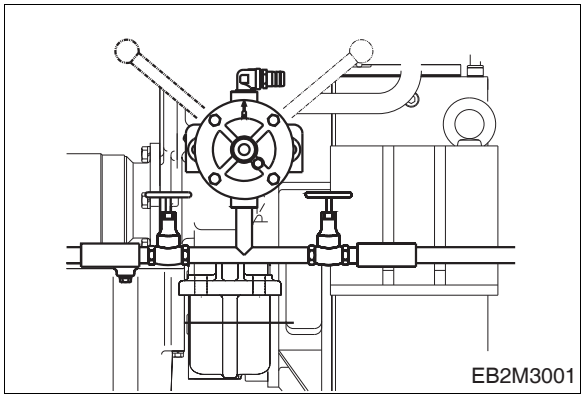


4.4.2. Exchanging of lubrication oil

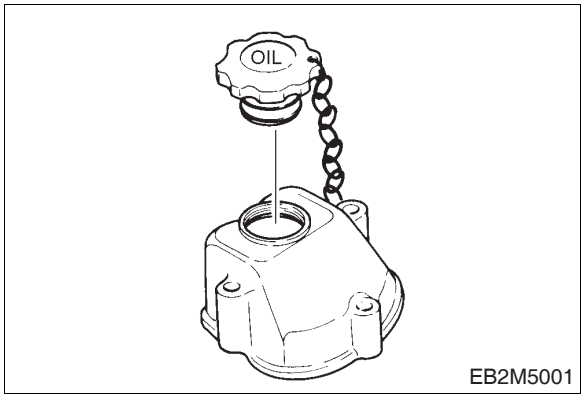
Engine oil and the oil filter is important factors affecting engine life. They affect ease of starting, fuel economy, combustion chamber deposits and engine wear. Change the engine oil at 50 hours of operation at first and next exchange will be performed every 250 hours. At the end of the break in period (50 hours), change the sump oil and replace the oil filter cartridge to new one.

1) Oil drainage

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

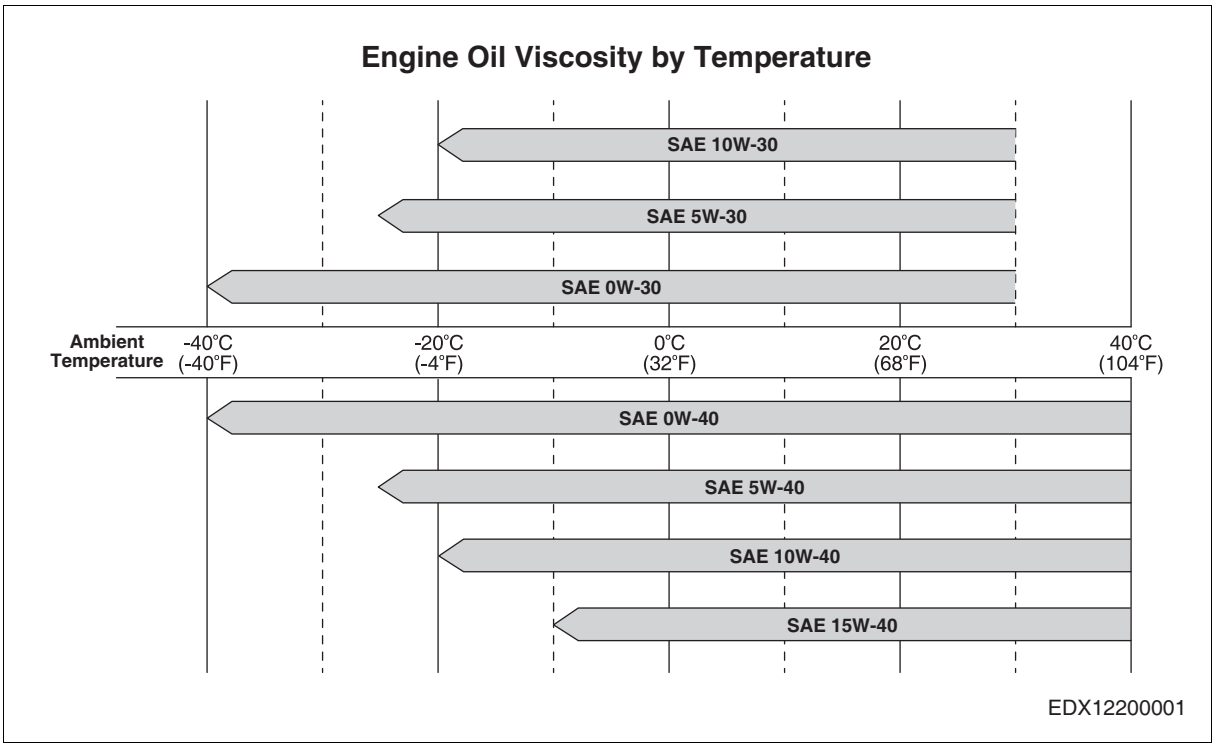


- Refill new engine oil to the filler neck on the head cover in accordance with the oil capacity of the engine.
- Be careful about the mixing of dust or contaminator during the supplement of oil. Then confirm whether the oil level gauge indicates the vicinity of its maximum level.
- For a few minutes, operate the engine at idling in order to circulate oil through lubrication system.
- Thereafter shut down the engine. After waiting for about 10 minutes measure the quantity of oil and refill the additional oil if necessary.



Recommend of lubricating oil

Initial factory fill is high quality break-in oil for API Service CI-4 grade. During the break-in period, frequently check the oil level. Somewhat higher oil consumption is normal until piston rings are seated. The oil level should be maintained in the safe range between the Min. and Max. mark on the dipstick. To obtain the best engine performance and engine life, Engine oil is specified by API service, lettered designations and SAE viscosity numbers. If the specified engine oil is not available, use a reputable brand of engine oil labeled for API Service CH or CI and SAE viscosity 10W40. Refer to oil identification symbol on the container.



4.4.3. Replacement of oil filter cartridge

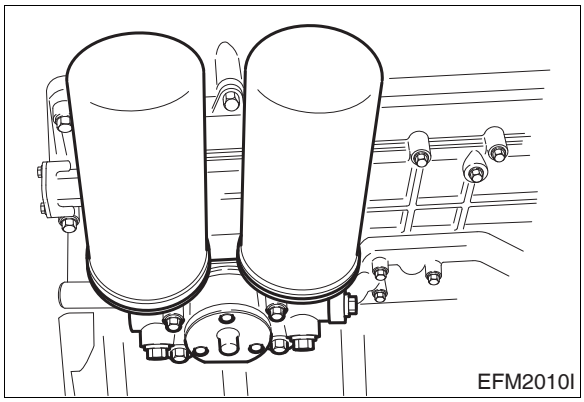
At the same time of oil exchanges, replace the oil filter cartridges.

- Drain engine oil by loosening the drain plug on the filter head.

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

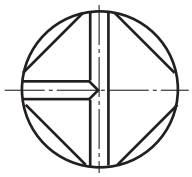
- Loosen the oil filter by turning it counter-clockwise with a filter wrench.
- With a rag wipe, clean the fitting face of the filter body and the oil filter body so that new oil filter cartridge can be seated properly.

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

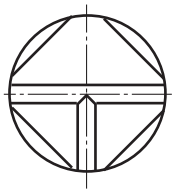


- Lightly oil the O-ring and turn the oil filter until sealing face is fitted against the O-ring. Turn 3/4 ~ 1 turns further with the filter wrench.

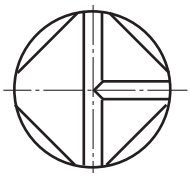
During continuous operation the selector lever that both filter halves are in operation. Observe positions of selector level.



Right-hand filter cut out



Continuous operation
(both filter halves in operation)



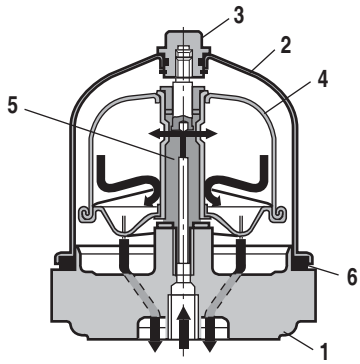
Left-hand filter cut out

EDV2218091

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

4.4.4. Oil centrifugal filter

- Oil centrifugal filter is an auxiliary filter which has a special structure able to separate some impurity from oil centrifugal by means of oil pressure, and that can be used semi-perpetually by maintaining without a necessity of replacement.
- The oil centrifugal filter should be maintained at every time of oil replacement.



EDV2218089

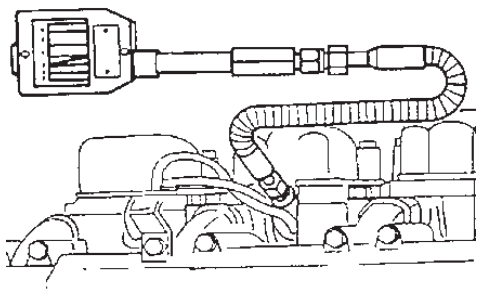
4.4.5. Marine gear oil change

Always apply to API Service SAE #30 for reduction gear oil. Change the reduction gear oil at 100 hours of operation at first and next exchange will be performed every 600 hours.

4.4.6. Cylinder compression pressure

- Stop the engine after warming up, and take out nozzle holder assembly.
- Install the special tool (compression gauge adapter) at the nozzle holder hole, and connect the compression pressure gauge there.

Standard value	24 kg/cm^2



EB4O403I

* Condition : Cooling water temperature 20°C, Engine rotation 200 rpm.(about 10 revolutions)

4.5. Intake & Exhaust System

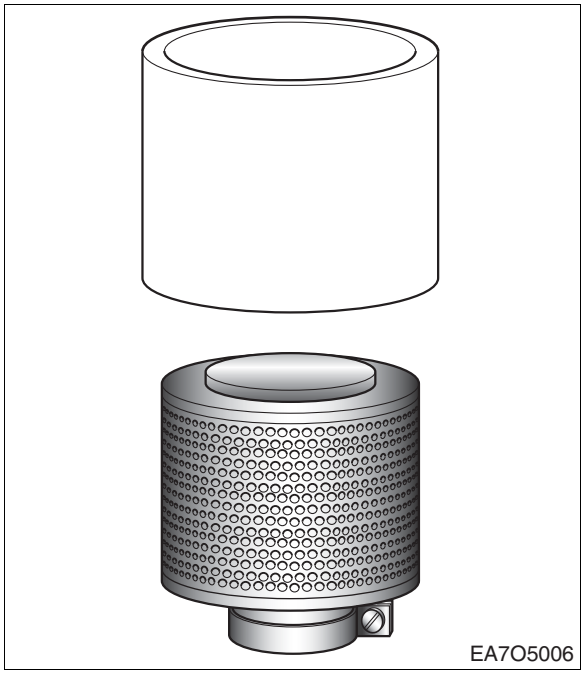
4.5.1. Cleaning & change of the air filter element

The engine life and performance depends on the intake air condition greatly.

A fouled air filter element result a decreased intake air amount leading the engine output decrease and finally may cause an engine malfunction.

Further, a damaged air filer element results wear on the cylinder component or the valve mechanism etc. leading increased engine oil consumption and decreased engine output, finally leads to shorten the engine life.

The air filter element should clean periodically as follow.



Cleaning of the air filter element : Every 100 hours
Exchange of the air filter element : Every 400 hours
Replace the air cleaner if deformed, broken or cracked.

(1) Air filter element cleaning

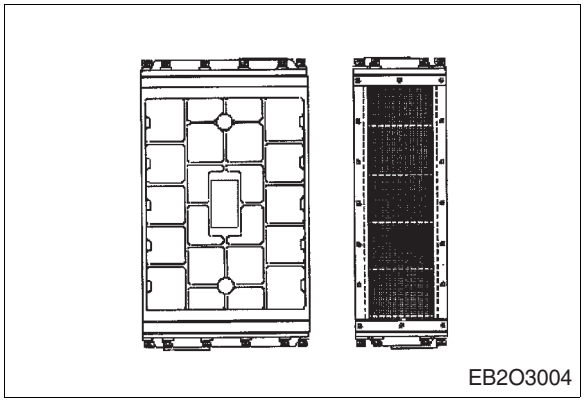
- Wash the polluted element in warm water non-sudsy household detergent.
- Rinse the element with clean water.
- Dry it thoroughly with natural air or electric fan.
  Don't use a flame or compressed air for dry.
  It makes damages to the element.

(2) Checking element

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

4.5.2. Inter-cooler

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


EB2O3004

< Inter cooler cleaning >

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

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

Observe the specified pressure when making the hydraulic test.

Cleaning of inter cooler : Every 1,000 hours.

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

4.5.3. Turbo-charger cleaning

- Turbo-charger should clean every 2,000 hours. The only points to be observed are the oil pipes which should be checked at every oil change for leakage and restrictions and should check the condition of turbo-charger like oil leaks, unusual turbo sounds periodically.
- Air cleaner element should be checked and cleaned periodically to prevent foreign matters from entering the inside of the engine.
- Should check and measure the pressure of intake air and exhaust gas periodically. If there is an air leakage, should repair the problem at once to prevent from occurring the engine power loss and over heating.
- In case of operating in highly dust or oil-laden atmospheres, cleaning of the air compressor impeller may be necessary from time to time. To this end, remove compressor casing **(Caution : Do not skew it!)** and clean in a non-acid solvent, if necessary use a plastic scraper.

If the air compressor should be badly fouled, it is recommended that the wheel be allowed to soak in a vessel with solvent and to clean it then with a stiff non-steel brush. In doing so, take care to see that only the compressor wheel is immersed and that the turbocharger is supported on the bearing casing and not on the wheel.

4.5.4. Exhaust gas checking

Exhaust gas depends on much or less of it shows whether combustion condition of the engine is good or not. If exhaust gas is any abnormal condition like excessive smoke, white smoke, black smoke, the engine should be serviced maintenance from specialist.

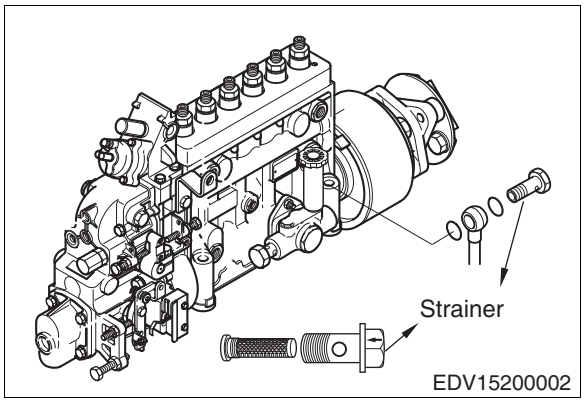
4.6. Fuel System

As fuel injection pumps and injection nozzles consist of very complicated and precise components, the contamination of fuel causes the clogging of the nozzle or the sticking of the components of injection pump. Therefore, the cleanness of the fuel system should be maintained all the time.

If the engine is equipped with a fuel water separator, drain off any water that has accumulated. Water in fuel can seriously affect engine performance and may cause engine damage.

4.6.1. Priming pump strainer cleaning

Clean the priming pump strainer every 100 hours operation. The strainer is incorporated in the priming pump inlet side joint bolt. Clean the strainer with the compressed air and rinse it in the fuel oil.



4.6.2. Fuel tank cleaning & checking

Fill the tank with recommended fuel. Keeping tanks full reduces water condensation and helps keep fuel cool, which is important to engine performance. Make sure fuel supply valves (if used) are opened. In marine environment, the most likely fuel contaminants are water and microbial growth (black ″slime″). Generally, this type of contamination is the result of poor fuel handling practices.

Black ″slime″ requires water in the fuel to form and grow, so the best prevention is to keep water content to a minimum in storage tanks.

If diesel fuel which contains moisture is used, injection system and cylinder liners, pistons will be damaged. Drain moisture and accumulated sediment from drainage device of storage tank regularly. You should change the element of the water separator or fuel filter cartridge several times until fuel of the suction line is cleaned.

Notice :

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

- **How to select fuel oil**

  Fuel quality is an important factor in obtaining satisfactory engine performance, long engine life, and acceptable exhaust emission levels. HD Hyundai Infracore engines are designed to operate on most diesel fuels marketed today. In general, fuels meeting the properties of ASTM designation D975 (grades 1-D and 2-D) have provided satisfactory performance.

  The ASTM 975 specification, however, does not in itself adequately define the fuel characteristics needed for assurance of fuel quality.

  The properties listed in the fuel oil selection chart below have provided optimum engine performance. Grade 2-D fuel is normally available for marine service. Grade 1-D fuel should not be used in pleasure craft engines, except in an emergency.

Fuel oil selection chart

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

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

Note : 1. The cloud point should be 6°C (10°F) below the lowest expected fuel temperature to prevent clogging of fuel fitters by crystals.

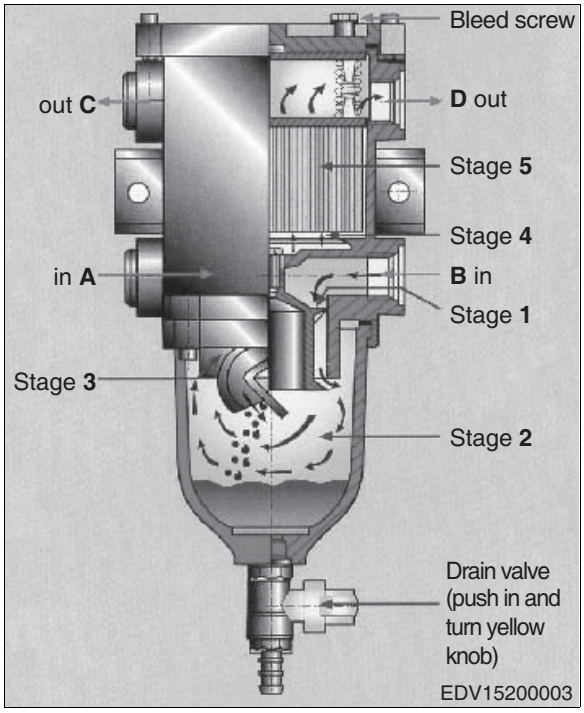
4.6.3. Water separator

HD Hyundai Infracore recommends the fuel water separator to install between fuel tank and fuel injection pump strongly.

Condensation formed in a partially filled tank promotes the growth of microbial organisms that can clog fuel filters and restrict fuel flow and cause the engine power decrease before.

Water in the fuel will decrease the lubrication in the pump and possibly cause a failure of the pump. Injection nozzles are also lubricated by fuel and can also fail as a result of water in the fuel. Therefore, it is necessary to remove any water from the fuel before it reaches the fuel pump by using a fuel water separator.

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



4.6.4. Fuel filter exchanging

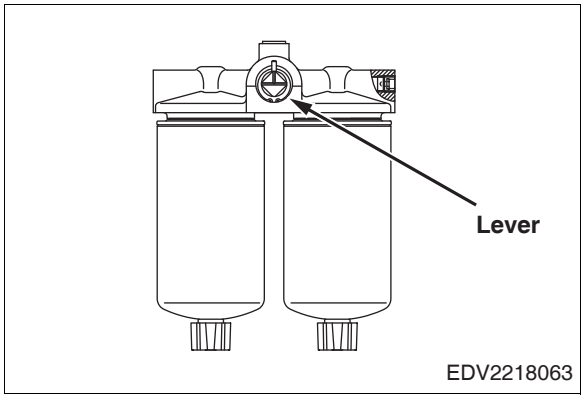
a) Loosen the fuel filter by turning it counter-clockwise with the filter wrench.
   - Discard the used filter a designated place.

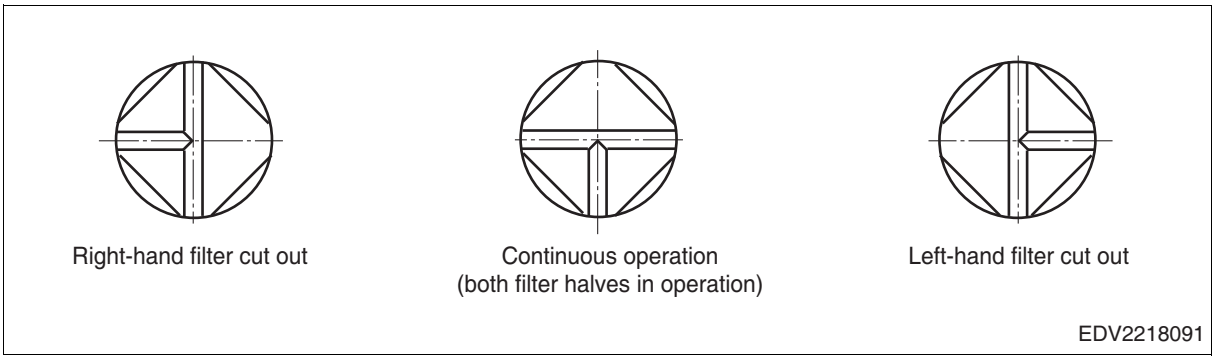
b) Wipe the filter fitting face clean.

c) Apply a light coat of engine oil to the O-ring and supply fuel to the new filters.

d) Turn the new filter until the filter O-ring is fitted against the sealing face.

e) And then turn the filter cartridge about 3/4 ~ 1 turn more with hands or filter wrench.





Caution :

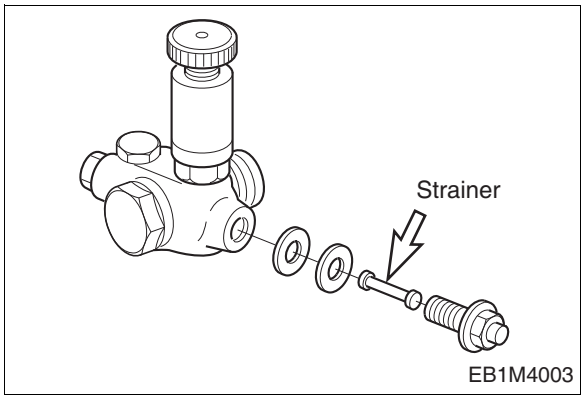
Do not leave selector lever in any intermediate position because this would be liable to interfere with oil supply.

Bleeding of the fuel system

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

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

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



Note :

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

4.6.5. Checking the fuel injection timing (by authorized specialist personnel)

Check the fuel injection timing every year. Refer to details ″6.3.15. Injection pump & injection timing″.

Caution :

- Check the fuel injection pump housing for cracks or breaks, and replace if damaged.
- Check whether the lead seal for idling control arid speed control levers have been removed or not.
- No alterations must be made to the injection pump. If the lead seal is damaged the warranty on the engine will become null and void.
- We strongly recommend that any faults developing in the injection pump should be taken care of by authorized specialist personnel.

4.6.6. Injection nozzle maintenance (by authorized specialist personnel)

Check the fuel injection nozzle every year or increasing the smoke excessively.

Refer to details ″7.3.3. Fuel injection nozzle″

4.7. Electric System

4.7.1. Warning lamp check

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

4.7.2. Battery charging check

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

4.7.3. Engine wiring check

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

4.8. Valve Clearance

The valve clearances are to be adjusted at the times of the following situations.

- After initial 50 hours operation.
- When the engine is overhauled and the cylinder heads are disassembled.
- When severe noise comes from valve train.
- When the engine is not normally operated, even though there is no trouble in the fuel system.

  The valve clearance of the cold engine are as follows ;

  - Intake valves : 0.25 ±0.05 mm
  - Exhaust valves : 0.35 ±0.05 mm

4.8.1. When the engine is not used long time

In case of the engine is not used long time, preserve the engine from corrosion, faulty matters in order to run the engine operation easy and keep it long maintenance.

Especially the main external and internal components of the engine are likely to corrode as follows.

- Drain the coolant of the engine completely and refill the new flesh water in the engine and run it until the water line is cleaned quite.

  After draining the coolant refill the anti-freeze 35 ~ 40% with the fresh water again.
- Run the engine until engine coolant is up to normal temperature 71 ~ 85°C and then stop the engine.
- Change the oil and oil filter cartridge new one after running the engine for 10 ~ 15 minutes in order to drain the faulty matters in the oil pan as clearly as possible.
- Close the valve or cock of the fuel tank and clean the fuel filter and water separator.
- Run the engine about 5 minutes in order to circulate the new fuel through the all lines fully.
- Clean the air filter element and If worn severely change it new one.

- Drain the reduction gear oil completely and clean the strainer inserted in the inner side of it and then refill the specified oil (SAE #30) up to the maximum level of the oil dipsticks.
- Run the engine on idle rpm for 5 minutes and then shift the control lever of the reduction gear Neutral to Forward, Neutral to Reverse position in turn to circulate the oil around the all lines of it.
- Put the engine throttle lever on idle position then reduction gear and FPTO lever on switch off position (Neutral & OFF).
- Drain the engine coolant completely and remove the drain plugs.
- Close the kingston valve of the sea water line tightly, Specially likely to freeze, drain the water of the heat exchanger, inter cooler, reduction gear oil cooler and keep the plugs opened. At last don't forget to detach the sea water pump impeller and preserve it a dark place.
- First of all detach the battery wire (-) and then the other wires and clean the wires. If the battery is refilled with the distilled water, refill it but HD Hyundai Infracore batteries need not. And apply the grease on the surface of the wire terminals to protect corrosion.
- Loosen the V-belt to prevent its tension and push the paper sheet in the pulley homes under the V-belts.
- Run the engine on idle rpm or some more for 10 minutes once 10 days at least to lubricate all lubrication system and charge the batteries of the engine.
- The engine not used for a long time should check the condition of it regularly. Specially apply the grease on the engine parts likely to corrode.

4.9. When the Engine is Sunk

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

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

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

5. MAIN ACCESSORY PARTS

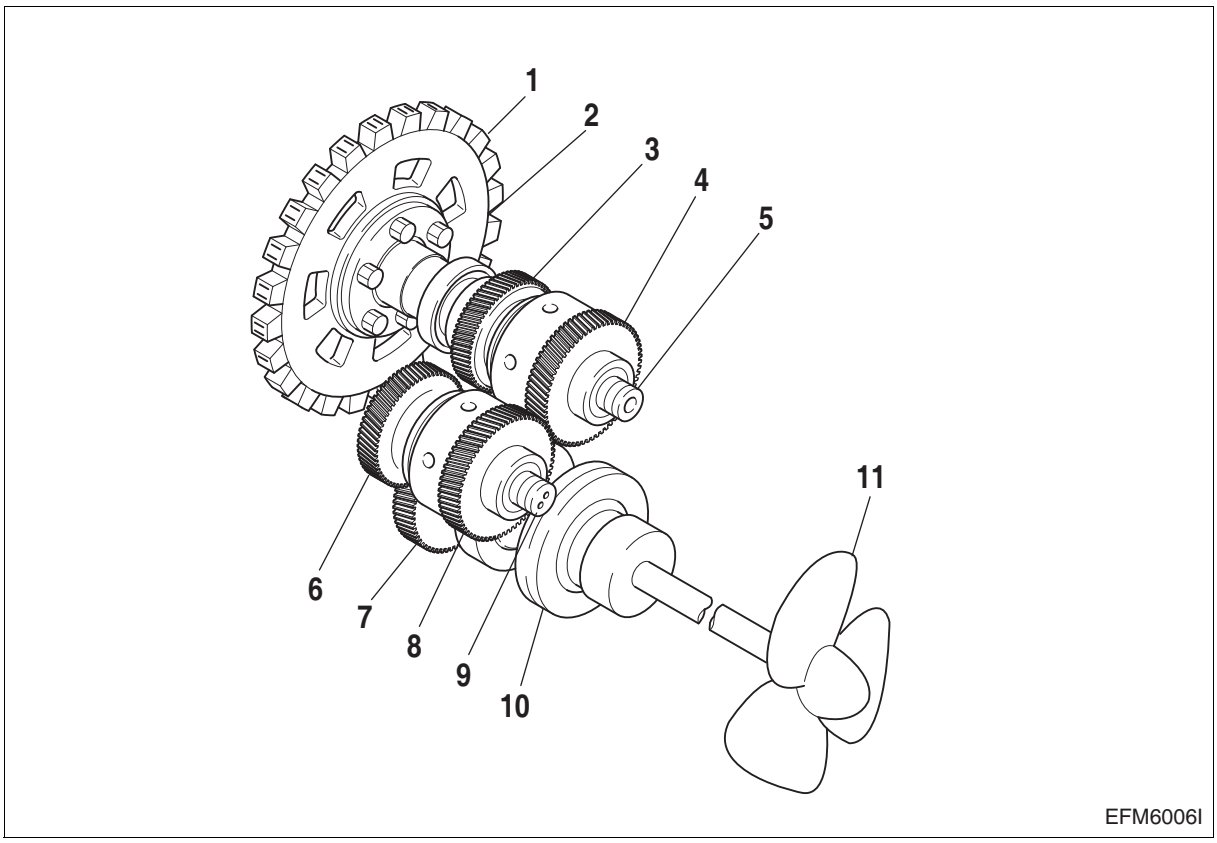
5.1. Reduction Gear

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

5.1.1. Construction and operation

The reduction gear is used for high-speed engine and consists of 4 major components such as input shaft, gear shaft, output shaft, and housing.

The clutch for forward and reverse movements is composed of a hydraulic wet-type and multi-plate type, and the construction and power line is as follows ;



<Power line>

Neutral : 1-2-5-4-8

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

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

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

The hydraulic-type clutch is composed of forward main body, reverse main body, output shaft, and selector valve.

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

5.1.2. Operation

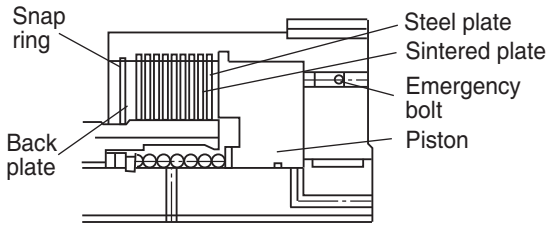
1) Before operation
   - Check the tightening bolts and nuts on the components as a whole for looseness.
   - Check the oil level with the oil level gauge.
     (Run the engine at idle for a few minutes, then stop it before checking the oil level.)
   - Place the control lever in the neutral position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

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

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

4) Emergency bolt

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



EA7O6011

5.2. Front Power Take Off

Refer to Service and Operation manual of AP Power Take Off company for detail operation and maintenance.

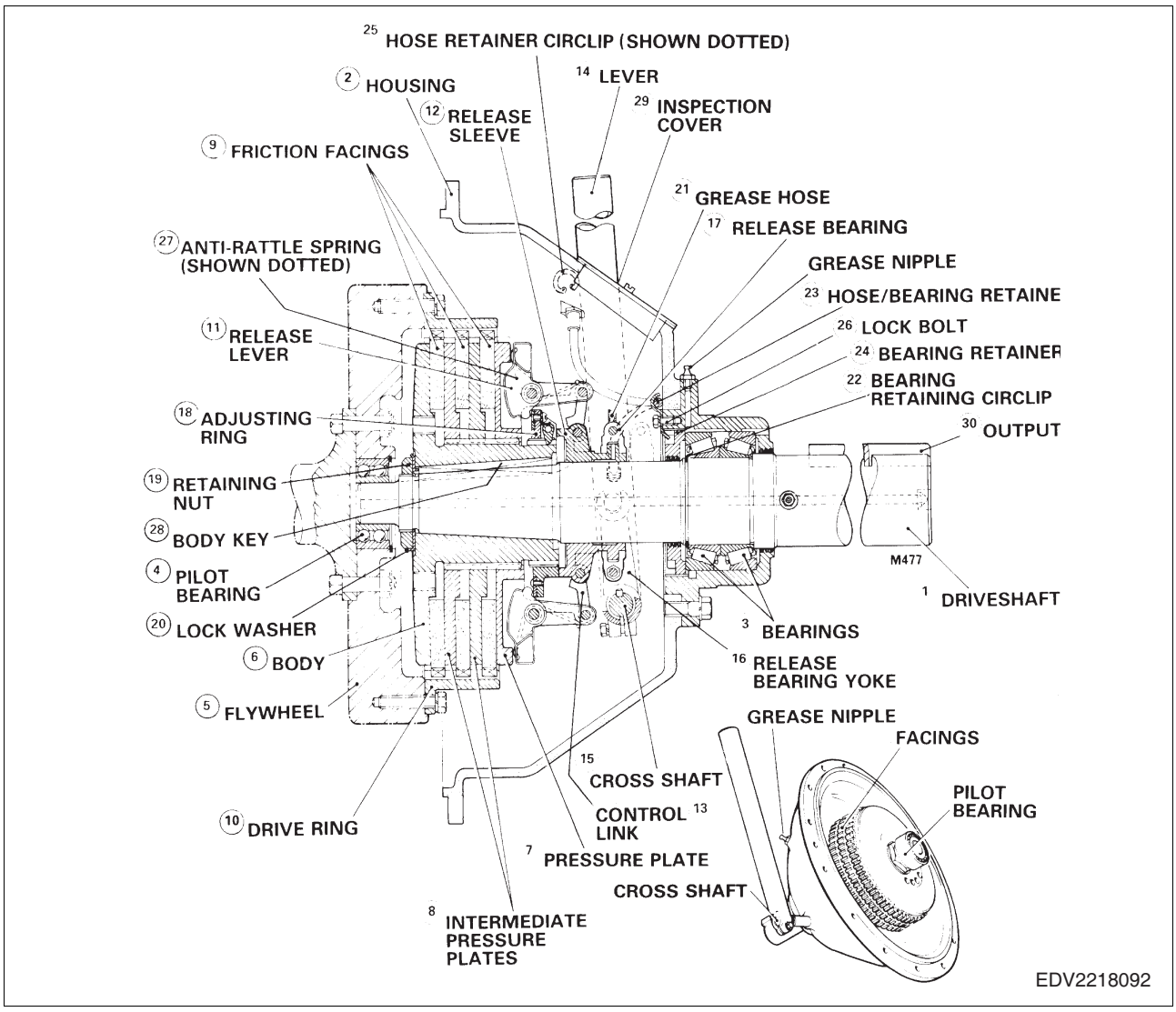
5.2.1. PTO Description and operation

Below figure shows a section view of a typical multiple-plate PTO.

A driveshaft(1) is carried in a cast iron housing(2). The tapered roller bearing(4) locates in the flywheel(5) (various types of bearing can be specified) to support the input end of the drive shaft. The body(6) is pressed on the drive shaft and retained by a key(28). External (male) splines on the body are mated to internal splines on the pressure plate(7). With double and triple plate PTO there are intermediate pressure plates(8) which also slide on the body.

Between the body and pressure plates are the friction facings(9) which (as shown on the lower figure) are molded with gear teeth along the outside diameter. The gear teeth on the facings engage with gear teeth on the drive ring(10) which is in turn bolted to the engine flywheel.

Power flow is from the engine flywheel to the drive ring, through the drive ring gear teeth to the friction facings. With the PTO engaged, the facings are clamped between the pressure plates and transmit power through the splines on the pressure plates to the body. Finally, power is transmitted to the drive shaft through the key(28).



Release levers(11) carried on the pressure plate are connected to a release sleeve(12) by control links(13). The PTO is engaged by moving the lever(14) in the direction of the engine. The lever is attached to a cross-shaft(15) in the PTO housing and a release bearing yoke(16). As the lever moves toward the engine, the bearing yoke rotates with the cross shaft and moves the release bearing(17) and sleeve(12) to contact with the adjusting ring assembly(18). As pressure is applied to the adjusting ring, the control links force the release levers against the pressure plate. When sufficient pressure has been applied through the lever, the release levers and control links snap ″over-center″ thus locking the pressure plates and friction facings together in the engaged position.

Regular adjustment is required to maintain the over-center load as friction faces wear during service.(see adjustment procedure).

5.2.2. How to use PTO

(1) PTO engagement procedure

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

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

(2) Checking engagement load

Check PTO adjustment as follow :

- Using a torque wrench and 1-1/4″ (32 mm) socket on the hex fitting on the PTO operating handle, check torque on cross shaft required to engage PTO.

Note :
If the PTO handle does not have a hex fitting, use special service tool on the cross shaft spline. (Refer to the ″Service & Operation Manual of AP POWER TAKE OFF″)

- Readjust PTO with adjusting ring if necessary. (Refer to ″5.9.3. PTO engagement procedure″.)

<Engagement load at end of standard perating Lever 63.5 cm (25″)>

PTO Size	Over-center load at end of lever		Equivalent torque at cross shaft	
	lbs.	Kg	lb.ft.	Nm
10″ & 11.5″	75 ~ 90	34 ~ 41	156 ~ 187	211 ~ 254
14″	80 ~ 100	36 ~ 45	167 ~ 208	226 ~ 282

HD Hyundai Infracore engines only apply to 11.5″ PTO size.
Do not adjust the PTO too tightly. Loads above the maximum quoted can cause PTO component failure.

- Re-adjust PTO with adjusting ring if necessary.(Refer to PTO adjustment 5.2.2.)
- Recheck cross shaft torque.
- Repeat adjustment until correct torque is achieved at cross shaft.

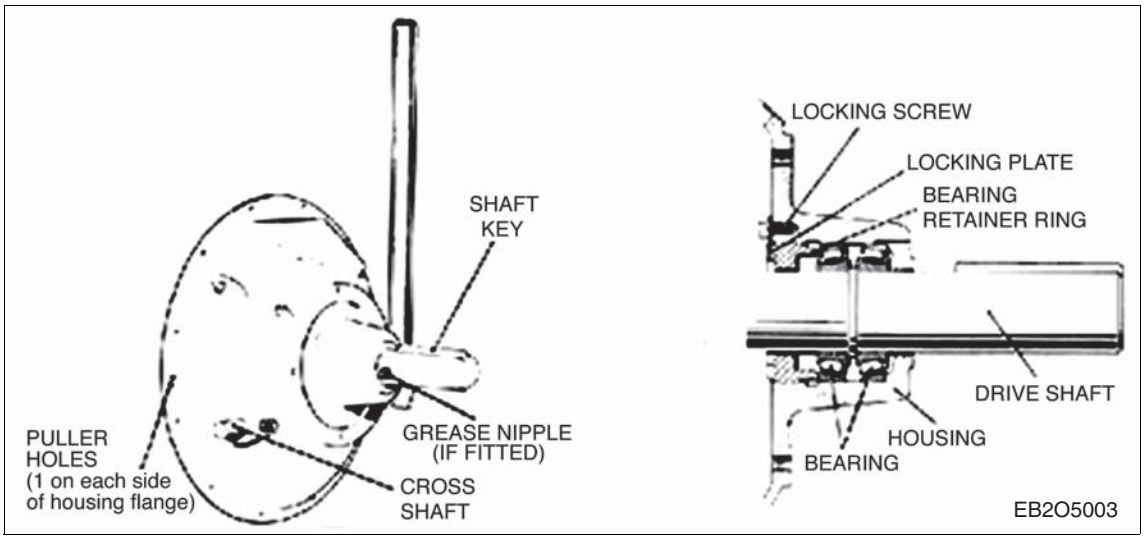
Note :
After installation and during ″wear in″ frequent adjustment may be necessary to maintain correct over center loads. Failure to do this adjustment will result in excessive wear and/or burn out which in not warrantable.

Do not adjust the PTO too tightly. Loads above the maximum quoted can cause PTO component failure.

(3) PTO adjustment

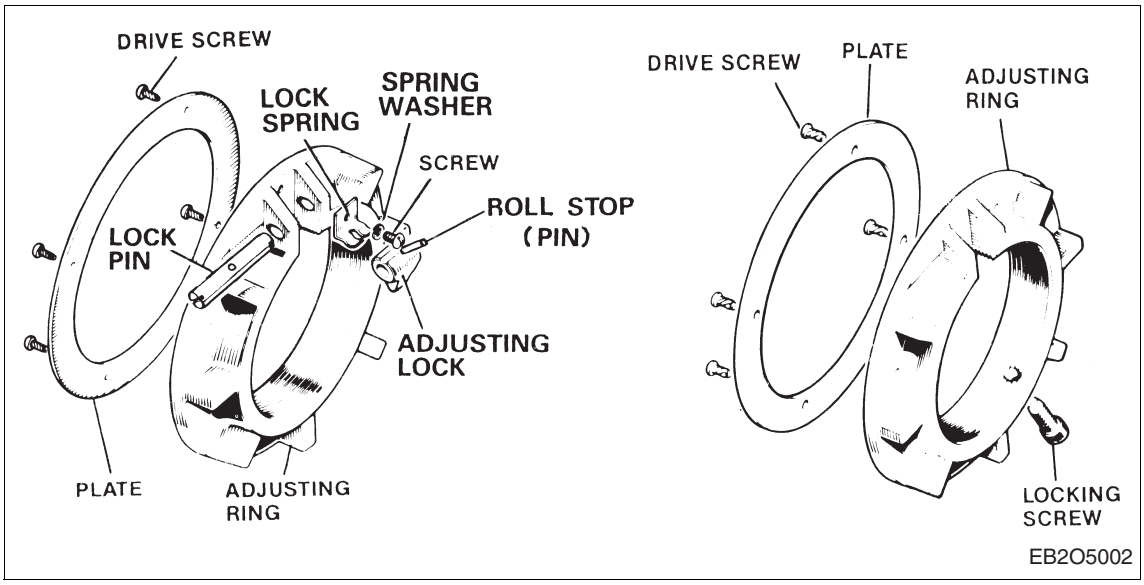
- Do not attempt to adjust PTO with the engine running.

<Removing PTO from engine> **<Shaft bearing adjustment>**



- To adjust the PTO remove the inspection cover and release either the adjuster lock or socket head screw in the red adjuster ring from the splines in the clutch body. Once the lock or socket screws are disengaged turn the adjuster ring by hand, or by tapping it with a soft metal drift and a hammer until the approriate over center load or cross shaft torque is obtained.
  (See table bow or inspection cover).

<Adjusting rings>



- Relocate lock or socket screw, turning adjuster ring clockwise if required, to ensure engagement of the screw or lock in the nearest spline space. The socket screw should be tightened with a torque of 10-13 lbs.ft.(14 ~ 18 Nm)
- Remove all foreign objects (tools etc.) from the PTO housing and replace the inspection cover.

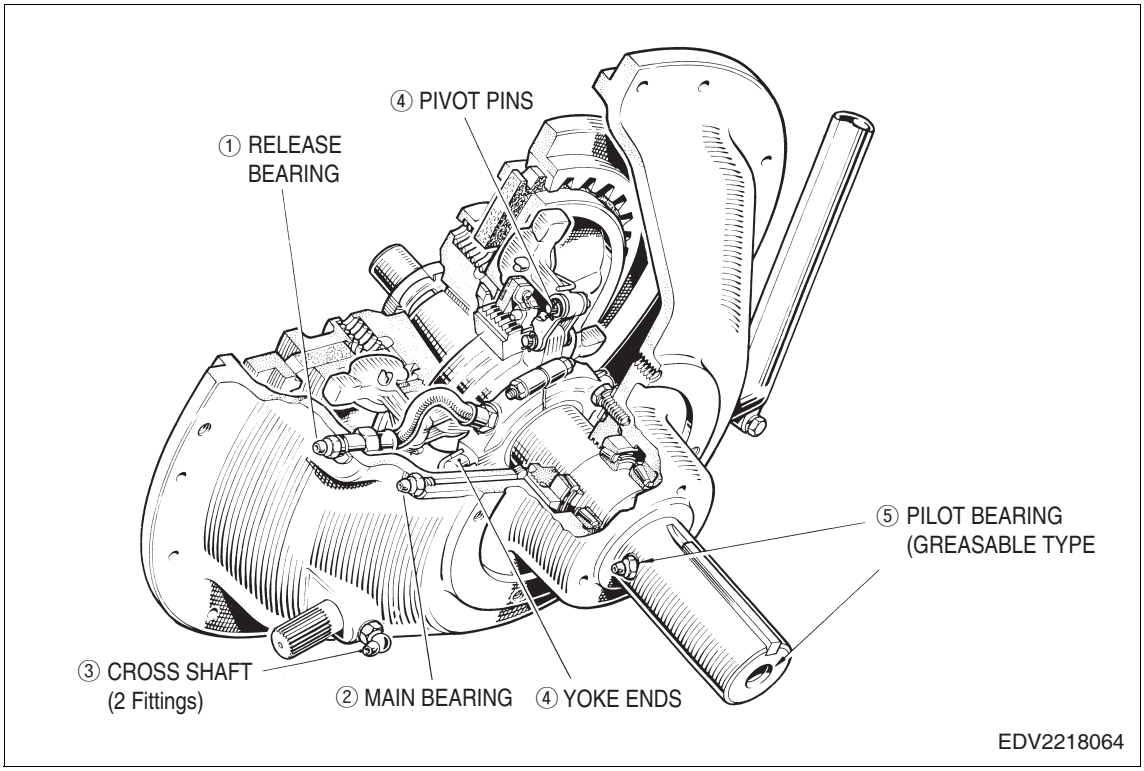
(4) Facing check

- If facings are worn, heat affected, or contaminated with lubricant they must be replaced. Severe discoloration of facings often indicates the PTO has been operating in a slipping condition, possibly due to faulty adjustment.
- In cases of severe lubricant contamination, the source of the lubrication must be found and rectified. Examine the teeth for wear or cracks, replace as required.
- New PTO assemblies and those serviced with new friction facings will require frequent adjustment until the facings are fully bedded in.

Do not use the PTO friction factions on over slip and over wear.
It may be resulted in any early failure.

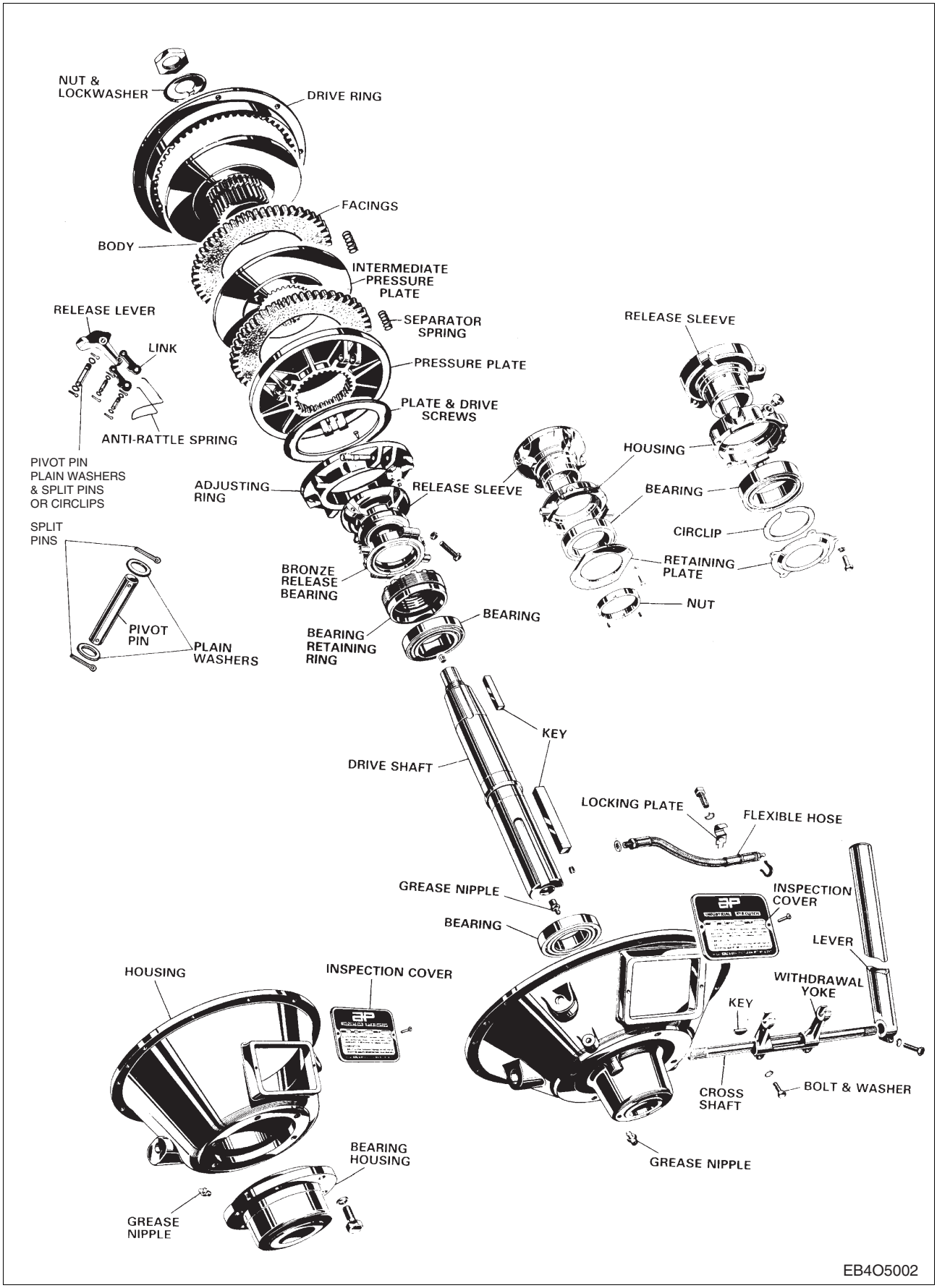
(5) Lubrication point

- The release bearing is lubricated through a grease nipple on the PTO housing which is connected to the bearing by a flexible hose. The drive shaft output bearings are lubricated through a grease nipple located on the PTO housing just above the bearings. Internal drillings in the housing carry the grease to the bearings.
- Do not over grease. Excess lubrication at any of the points can result in contamination of the friction facings which will cause immediate PTO failure.



Note :
Refer to the ″Service & Operation Manual of AP POWER TAKE OFF″ attached with AP Co. clutch itself for all detail contents.

5.2.3. Exploded view of typical 11-1/2″ ~ 14″ twin clutch



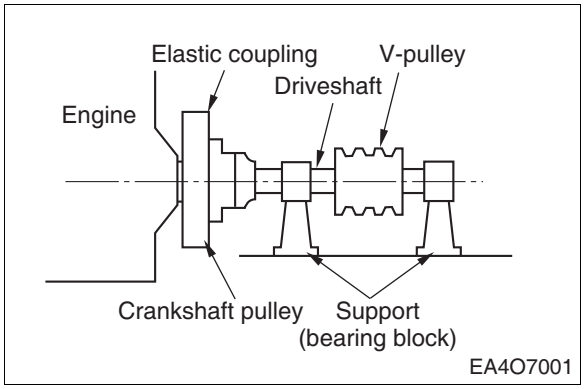
5.2.4. Front power take-off (F.P.T.O)

1) For medium power

For front power take-off in line with crankshaft, it is a standard procedure to support drive shaft and V-pulley by two pillow blocks by using flexile coupling for connection to engine.

When the front PTO is installed, be sure to take deflection reading. Radial run-out should be no more than 0.02 mm.

Be sure to limit the front PTO output within the maximum allowable horsepower as specified for each model in figure below. (Torque represents when there is no propeller load)

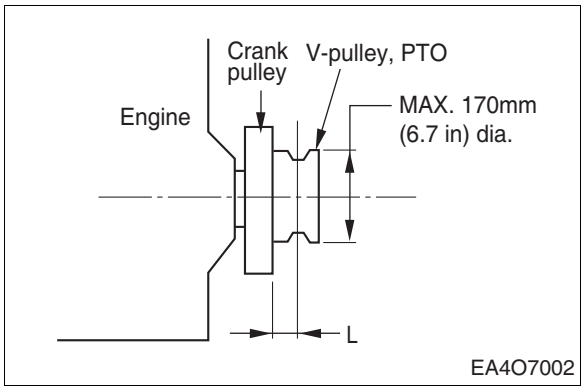


Model	Load(kW)	rpm	Model	Load(kW)	rpm
V158TIE	162	1,500	V180TI	220	1,500
V158TI	176	1,500	V222TI	265	1,500

2) For small power

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

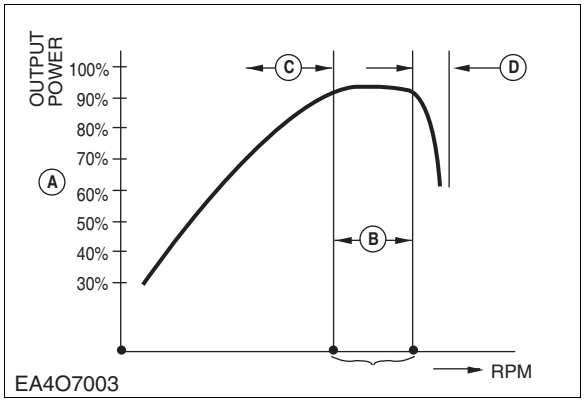
as ″L″ in right figure.



Model	L mm	Belt driven side load(kW)	rpm
V158TIE	60	91	1,500
V158TI		95	
V180TI		115	
V222TI		125	

5.3. Propeller Selection

Your dealer has chosen a propeller designed to deliver top performance and economy under most conditions. To obtain the maximum percentage of available horsepower (A), the engine RPM at Full Throttle should be in the specified Full Throttle Operating Rage (B).
Refer to Specifications in Performance Curve.



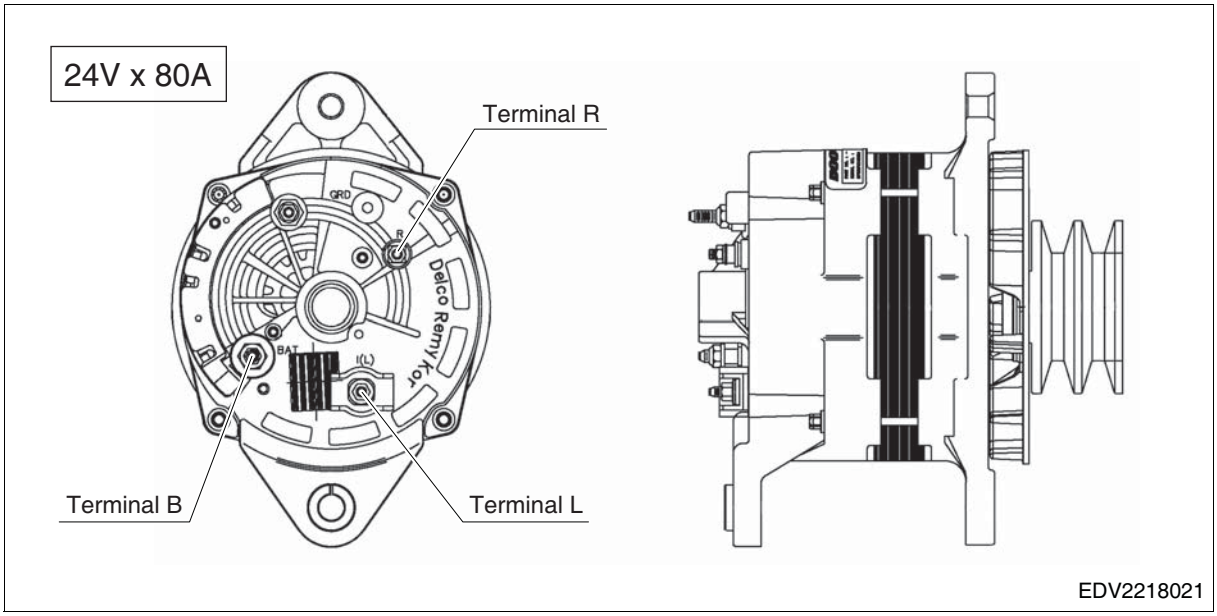
If the engine′s full throttle RPM on normal
load is below the specified on the low side of the range, use a propeller with less pitch to increase the RPM. Should the engine′s full throttle RPM want to exceed the specified range (B), the engine RPM is limited by the governor. Use a propeller of higher pitch to stop the limiting by the governor.

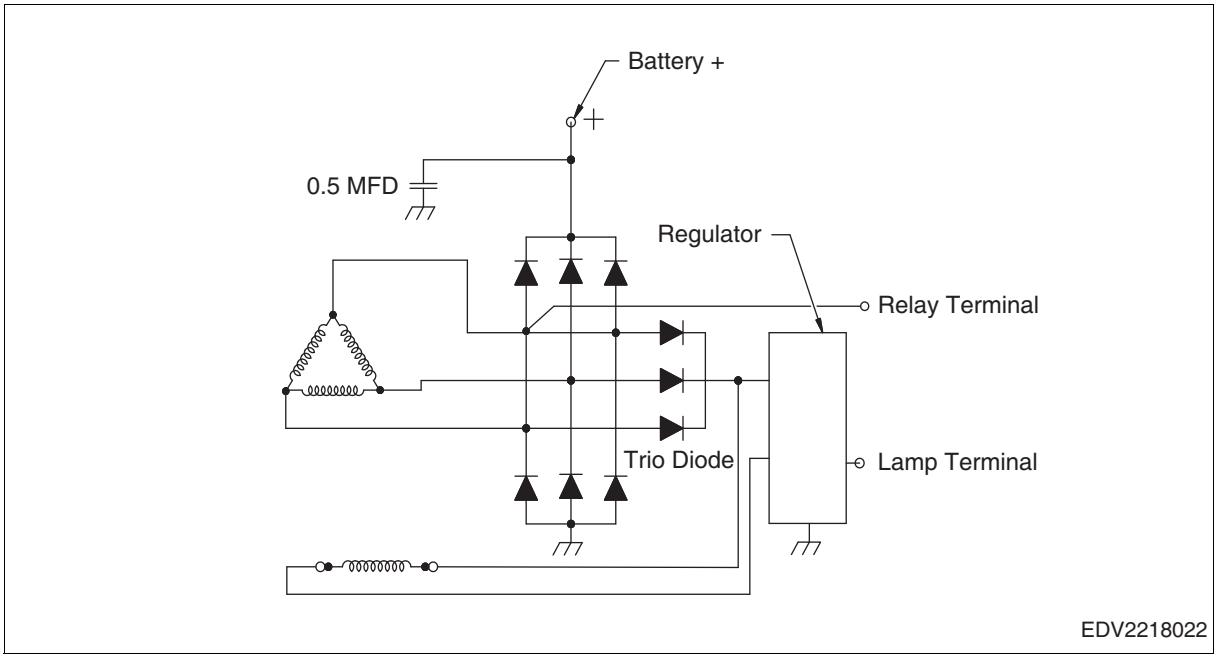
Note : Engine damage can result from incorrect propeller selection which :

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

5.4. Electric System

5.4.1. Alternator





The alternator is fitted with integral silicon rectifiers. A transistorized regulator mounted on the alternator controls the alternator voltage evenly. The alternator should be operated with the regulator and battery connected in circuit to avoid the damage of the rectifier and regulator.

The alternator is maintenance free, but it must be protected against dust and above all against moisture therefore it must be mounted a cover for protector properly.

5.4.2. Precautions in use

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

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

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

5.4.3. Starter motor

The starter motor is installed on the flywheel housing.

When the starting key switch is turned on, the starter motor pinion flies out and engages the ring gear of the flywheel. Then the main contact is closed, current flows, and the engine is started.

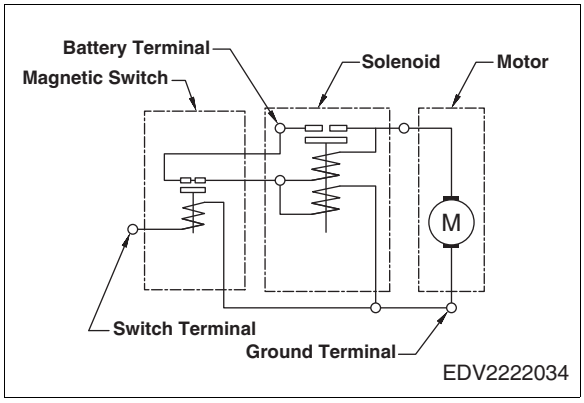
After the engine starts, the pinion automatically returns to its initial position when the starting key switch is released. Once the engine starts, the starting key switch should be released immediately.

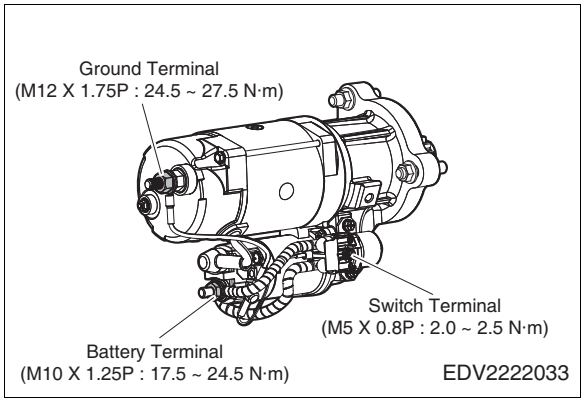
Otherwise, the starter motor may be damaged or burned out.

In case of repairing the engine, dip the pinion of the starter and ring gear into the fuel and remove the corrosion with brush.

After that apply the grease on them to protect the corrosion.

Whenever you clean the starter, always pay attention not to occur the electric short due to entering the water etc.





Starter motor always should be prevented from humid.

Precaution

Before working the electric system of the engine be sure to detach the battery wire (-) to prevent from electric short.

6. DISASSEMBLY AND ASSEMBLY OF MAJOR COMPONENTS

6.1. Disassembly

6.1.1. General precautions

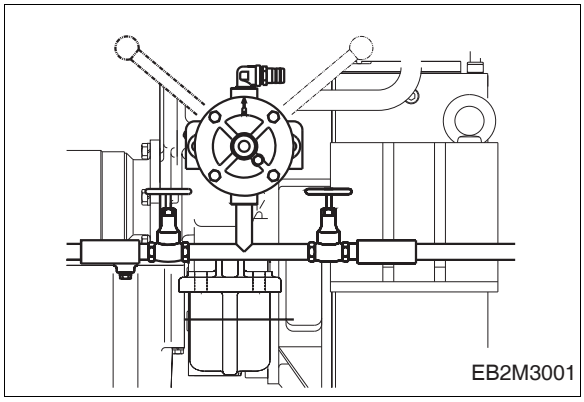
- Maintenance operation should be carried out in a bright and clean place.
- Before disassembly, provide racks for arrangement of various tools and disassembled parts.
- Arrange the disassembled parts in the disassembly sequence and use care to prevent any damage to them.

6.1.2. Cooling water

- Open the pressure cap of heat exchanger tank to remove the air pressure.
- Loosen the drain plugs as follows and then drain out the cooling water into a container.
  1) Below the right wet turbocharger elbow
  2) Below the left exhaust manifold cover
  3) Below the heat exchanger inlet pipe.
  4) Below the oil cooler housing
  5) Cylinder block face upper the starter.

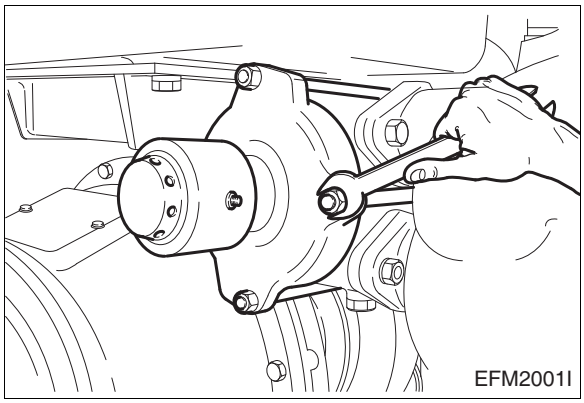
6.1.3. Engine oil

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



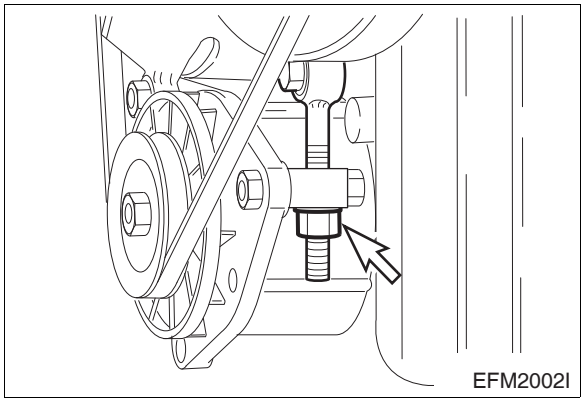
6.1.4. Sea water pump

- Remove sea water pipes connected to the inlet and outlet pipes.
- Remove the sea water pumps.



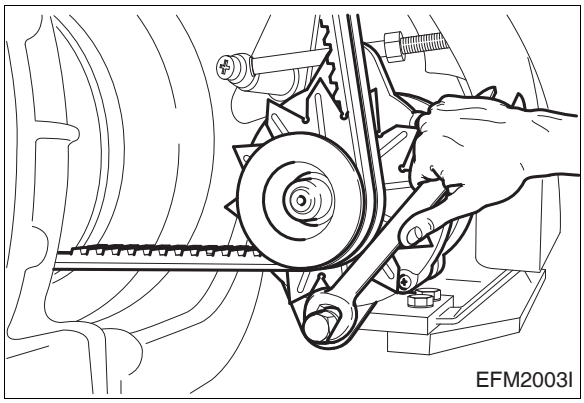
6.1.5. V-belt.

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



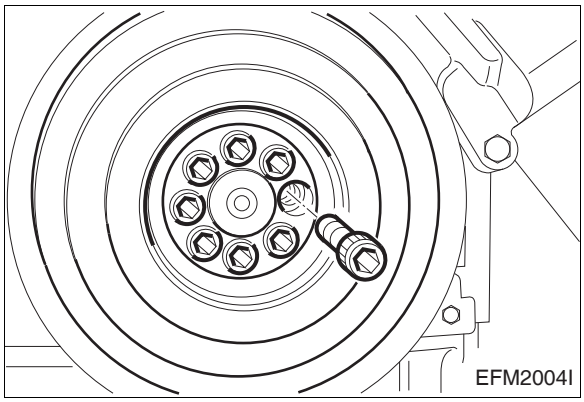
6.1.6. Alternator

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



6.1.7. Vibration damper

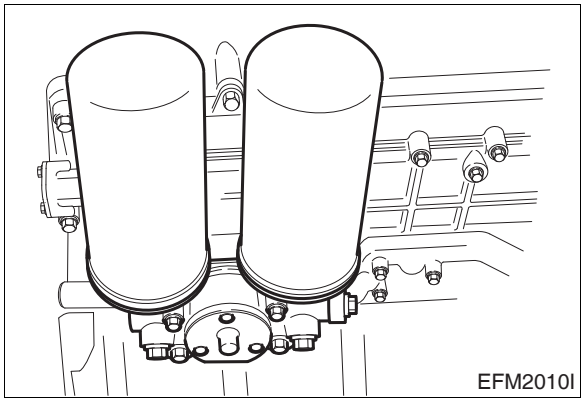
Remove the fixing bolts for crankshaft pulley in reverse order of assembly and disassemble the crankshaft pulley and vibration damper.



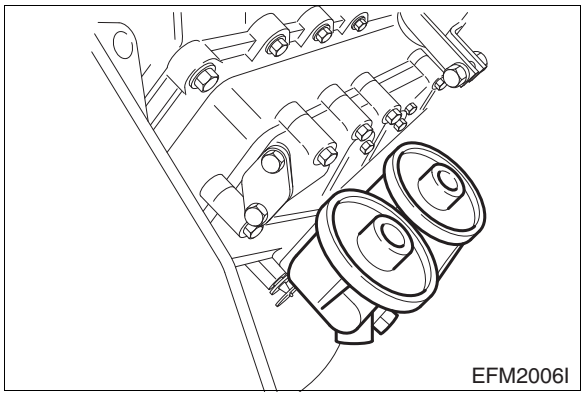
6.1.8. Oil filter assembly

This filter is change-over type, that is the servicing procedure is for the filter side requiring to be shut off while the engine is running.
During continuous operation, the selector lever should be placed in a position where both filter halves are in operation.

- Disassemble the oil filter cartridge using a filter wrench.

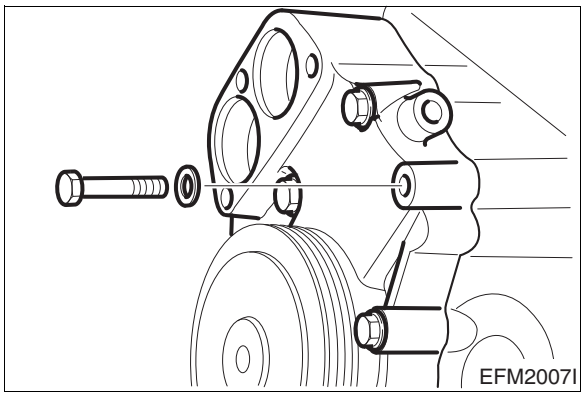


- Do not use again the cartridge removed after use.
- Remove the oil filter head fixing bolts and disassemble the filter head.



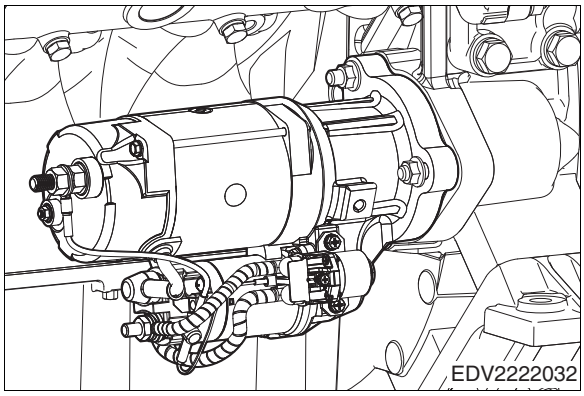
6.1.9. Cooling water pump

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



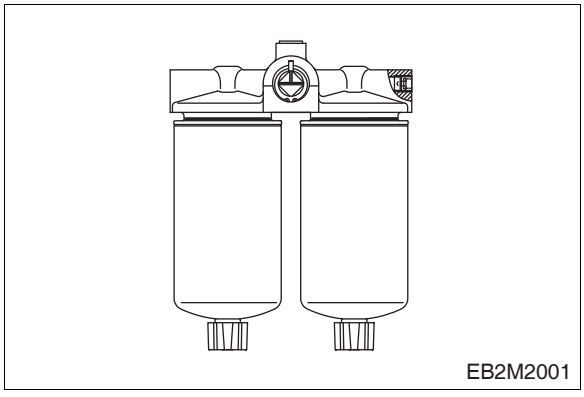
6.1.10. Starting motor

Loosen the starting motor fixing nuts and dismantle the starting motor.



6.1.11. Fuel filter

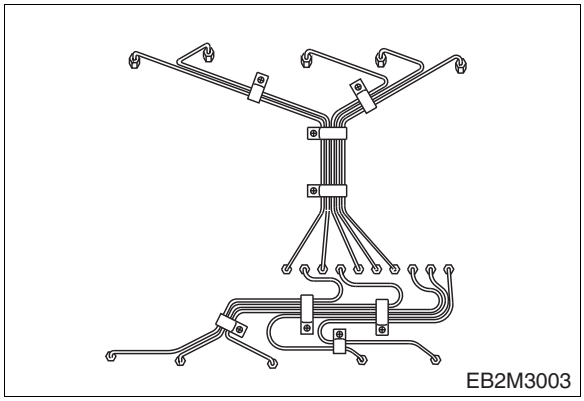
This filter is change-over type, that is the servicing procedure is for the filter side requiring to be shut off while the engine is running.
During continuous operation, the selector lever should be placed in a position where both filter halves are in operation.



- Disassemble the rubber hoses of the fuel supply and discharge.
- Remove the fuel filter fixing bolts and disassemble the filter.

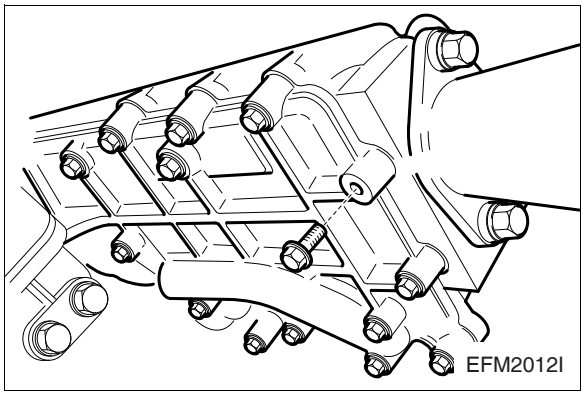
6.1.12. Injection pipe

- Disassemble the injection pipe from the nozzle holder and fuel injection pump.
- Disassemble various fuel pipe and hose.

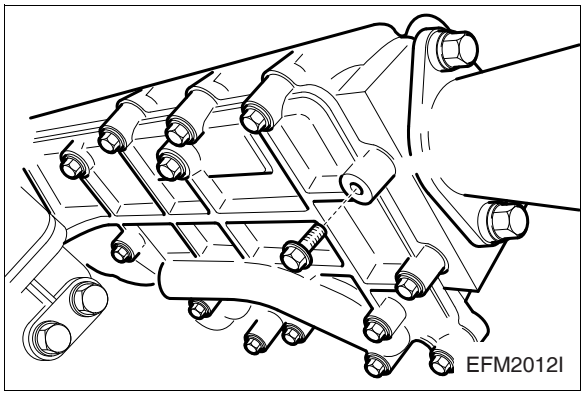

EB2M3003

6.1.13. Oil cooler assembly

- By removing the plug screw of cooling water discharge port, the cooling water is discharged.
- By removing the cooler housing fixing bolts and detach the oil cooler housing from the cylinder block.

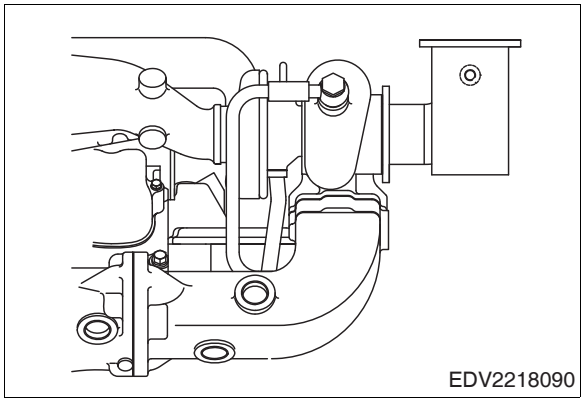

EFM2012I

- Remove the oil cooler cover fixing bolts and disassemble the oil cooler.


EFM2012I

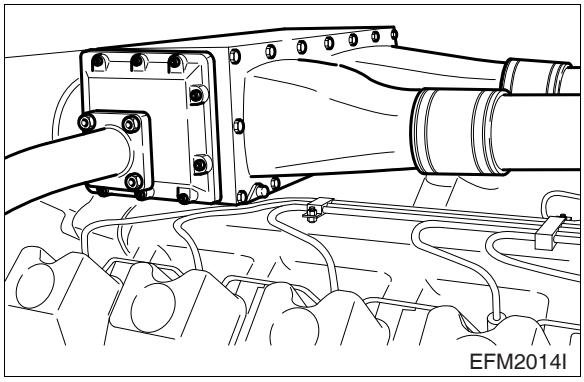
6.1.14. Turbocharger

- Loosen the hose clamp for connecting the intake stake and tear down the air intake stake.
- Loosen the clamp for connecting the air intake manifold.
- Remove the hollow screw of the turbocharger inlet & outlet pipe for lubricating, and tear the pipes down.
- Loosen the turbocharger fixing nuts and detach the turbocharger from the exhaust manifold elbow.


EDV2218090

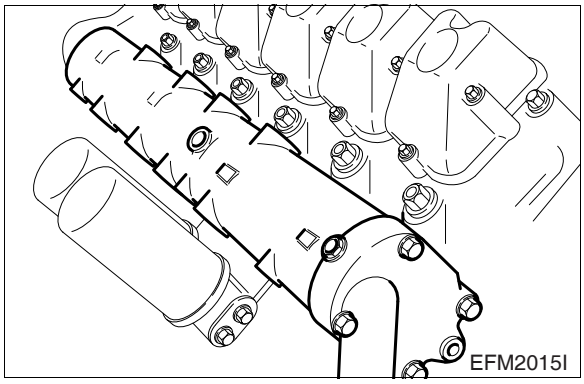
6.1.15. Inter-cooler

- Tear down the various hoses and pipes from the inter cooler.
- Remove the inter-cooler fixing bolts and detach it.


EFM2014I

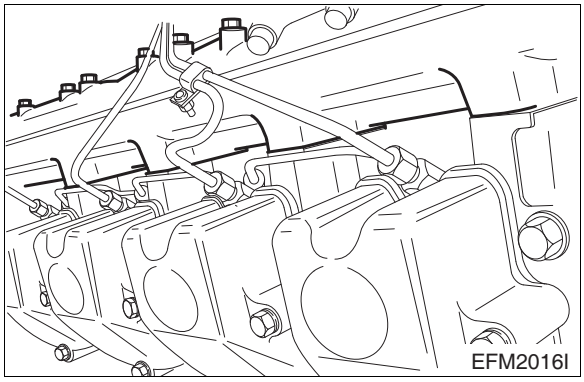
6.1.16. Exhaust manifold

- Loosen the exhaust manifold fixing bolts and dismantle the manifold from the cylinder head.


EFM2015I

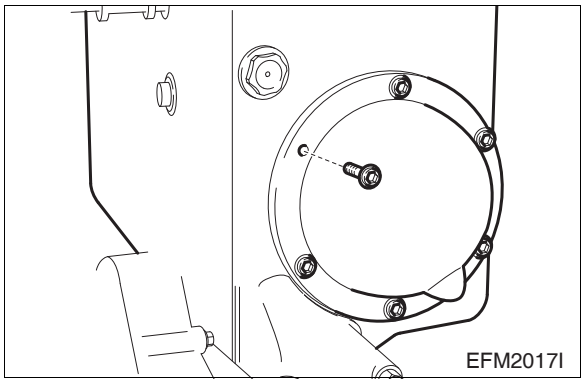
6.1.17. Intake manifold

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



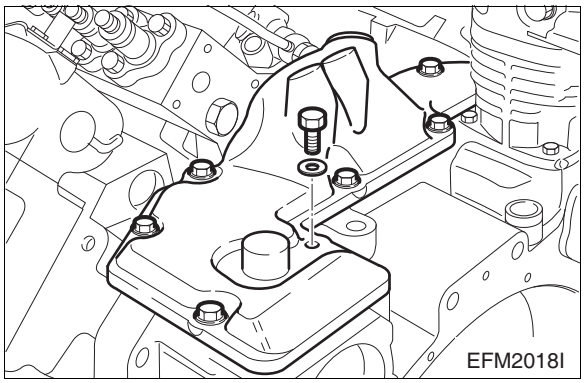
6.1.18 Heat exchanger

- Remove the hoses and the pipes.
- Remove the cover bolts
- Remove the 4 fixing bolts from the lower plate.
- Pull out the heat exchanger tube bundle.
- Clean the tubes.



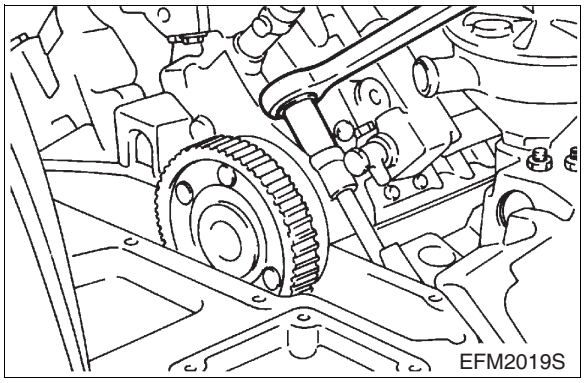
6.1.19. Flywheel housing cover

- Detach the side cover.
- Disassemble the flywheel housing cover.



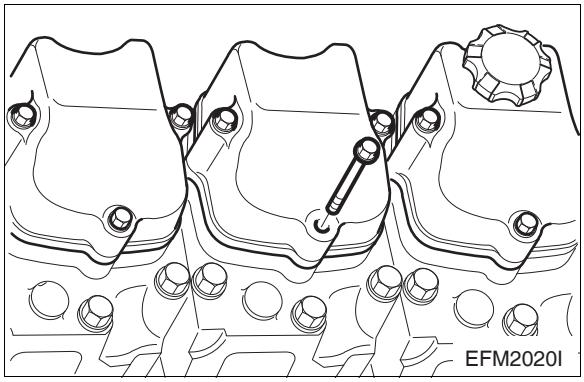
6.1.20. Fuel injection pump

- Remove the oil hoses for lubrication and the fuel hoses.
- Loosen the fixing bolts of fuel injection pump and detach the fuel Injection pump.



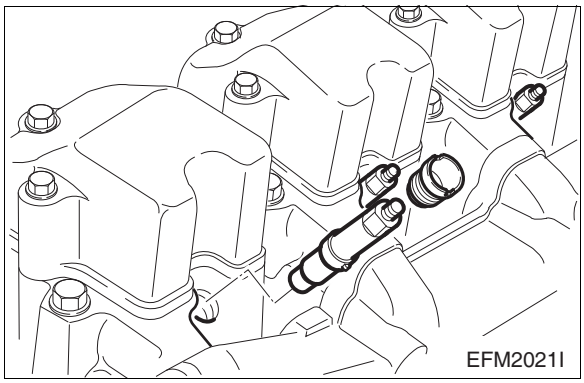
6.1.21. Cylinder head cover

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



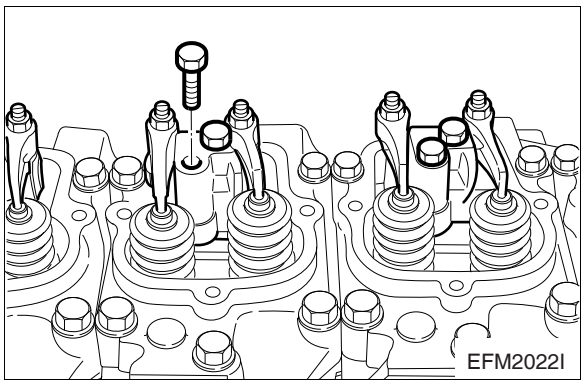
6.1.22. Nozzle holder

- By means of a special tool, loosen the nozzle holder assembly and take it out.



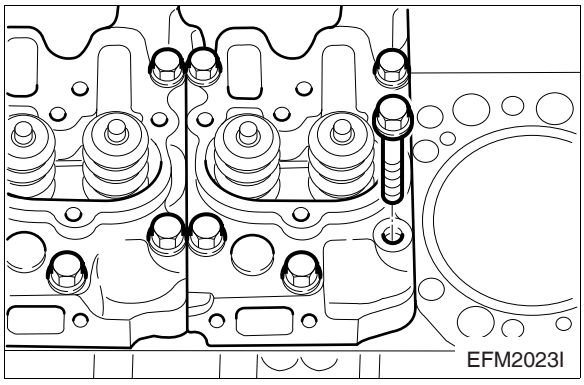
6.1.23. Rocker arm

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



6.1.24. Cylinder head

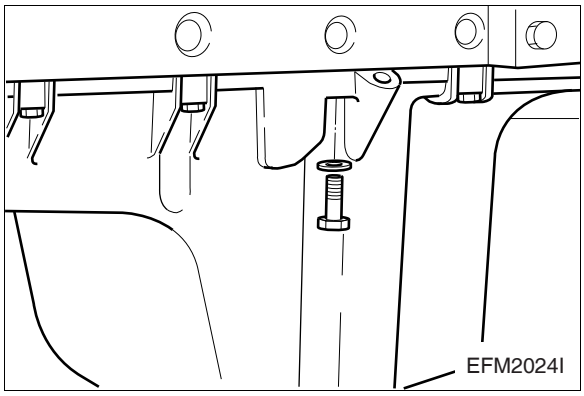
- Loosen the cylinder head fixing bolts in the reverse order of assembling, and remove them all and then take the cylinder head out.
- Remove the cylinder head gasket and scrap it.
- Eliminate the residue from the cylinder head face and cylinder block face.



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

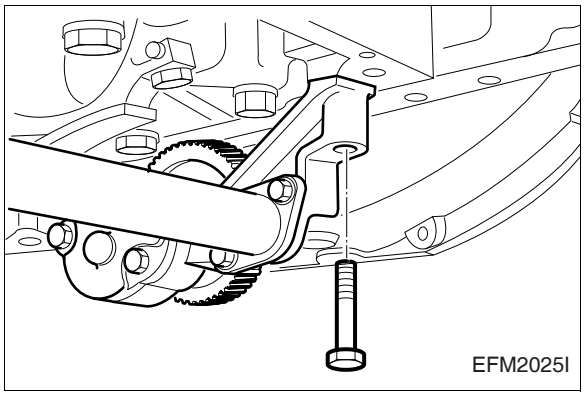
6.1.25. Oil pan

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



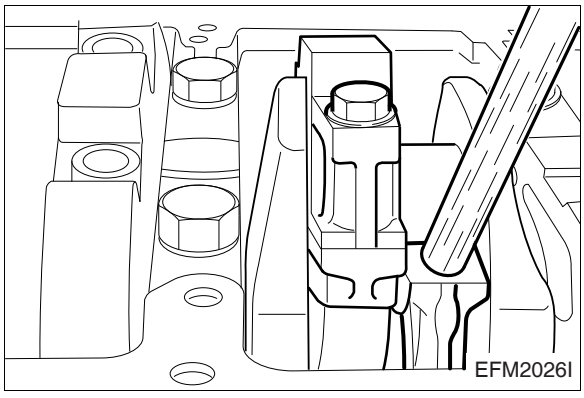
6.1.26. Oil pump

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



6.1.27. Piston

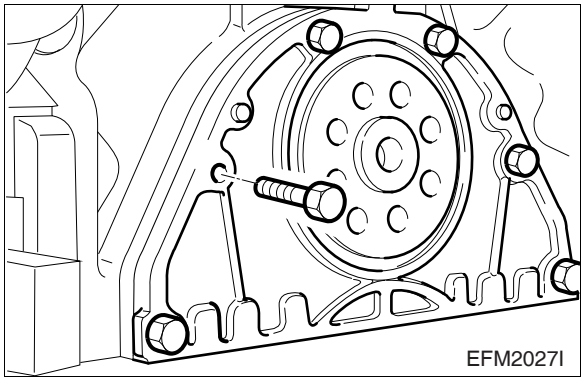
- Remove the connecting rod cap bolts in the reverse order of assembling and follow the similar method as in the cylinder head bolt removal.
- Tapping the upper and lower connecting rod caps lightly with a non steel hammer, detach them and take the bearings out.
- By pushing the piston assembly with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



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

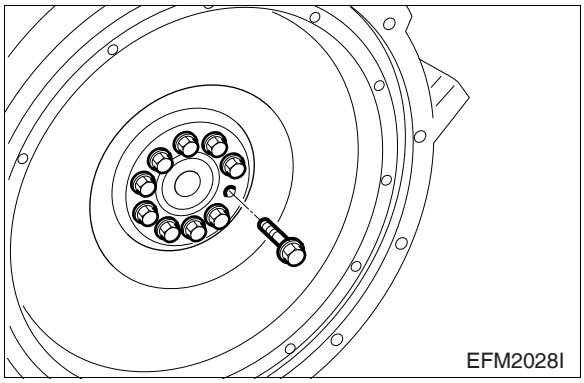
6.1.28. Front oil seal holder

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


EFM2027I

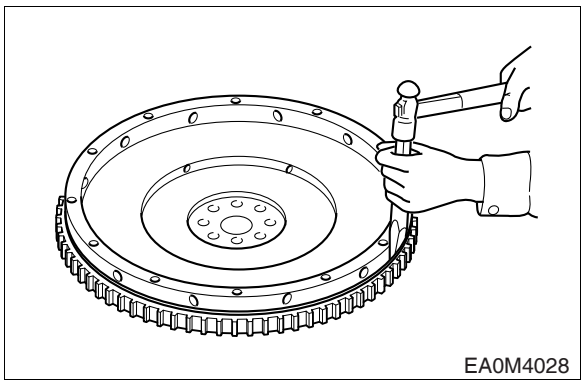
6.1.29. Flywheel

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


EFM2028I

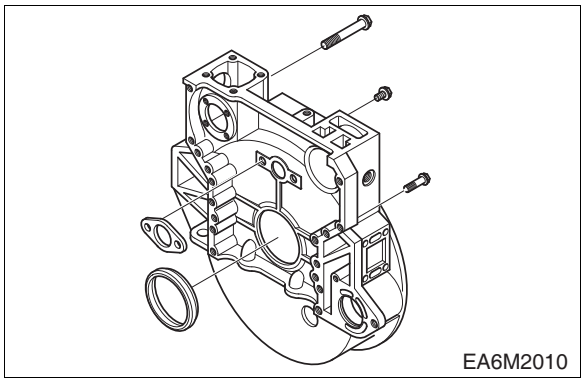
- Remove the flywheel ring gear.
  - Heat the ring gear evenly with a gas burner (up to 200°C) to invite volumetric expansion.
  - Tapping around the edges of the ring gear with a hammer and brass bar to remove it.

Caution :
Do not damage the flywheel.


EA0M4028

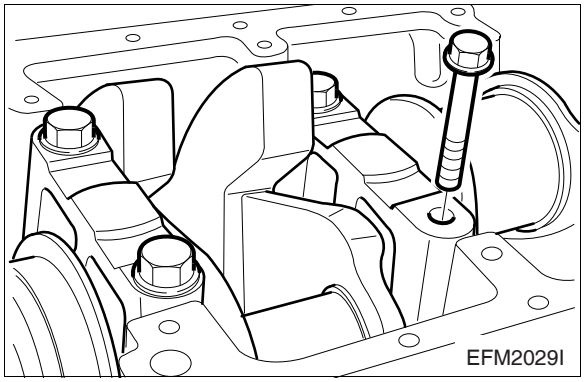
6.1.30. Flywheel housing

- Loosen the housing fixing bolts and detach the flywheel housing.
- Remove the oil seal from the flywheel housing.


EA6M2010

6.1.31. Crankshaft

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



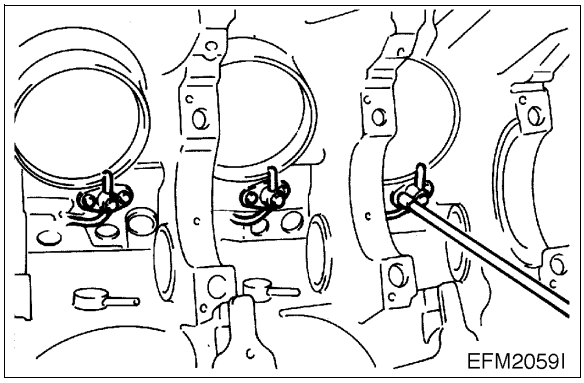
Note :
Do not mingle with the metal bearings and bearing caps randomly. To prevent mixing, temporarily assemble the metal bearings to the corresponding bearing caps in turn.

6.1.32. Camshaft and tappet

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

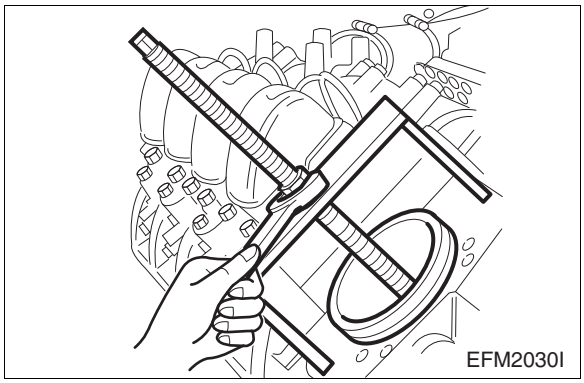
6.1.33. Oil spray nozzle

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



6.1.34. Cylinder liner

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



6.2. Inspection

6.2.1. Cylinder block

1) Clean the cylinder block thoroughly and check a visual inspection for cracks or damage.
2) Replace if cracked or severely damaged, and correct if slightly damaged.
3) Check the oil and water passing lines for restriction or corrosion.
4) Inspect the cylinder block's camshaft bush to any damage and the alignment of oil supply holes and if abnormal or severe wears, replace it.
5) Make a hydraulic test to check for any cracks or air leaks.

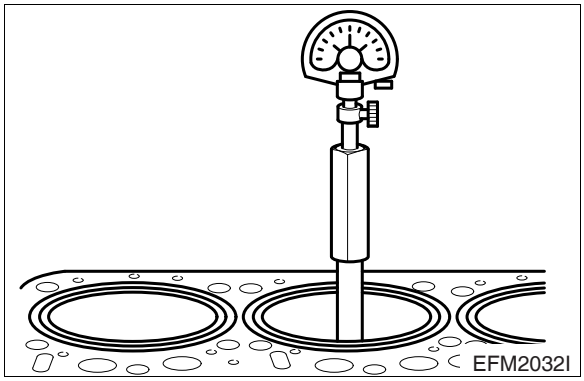
Hydraulic test :

Stop up each outlet port of water and oil passages in the cylinder block, apply air pressure of about 5 kg/cm^2 against the inlet ports, then immerse the cylinder block in water for about 1 minute to check any leaks. (Water temperature: 70°C)

6.2.2. Cylinder liner measurement

- Assemble the cylinder liner at the cylinder block and measure inner diameter at upper, middle, lower that is, 3 steps by 45° interval and calculate the average values after eliminating the maximum and minimum values.
- If the measured values are very close to the limit value or beyond, replace it.

	Standard	Limit
Liner inner dia.	ø127.990 ~ ø128.010 mm	ø128.16 mm



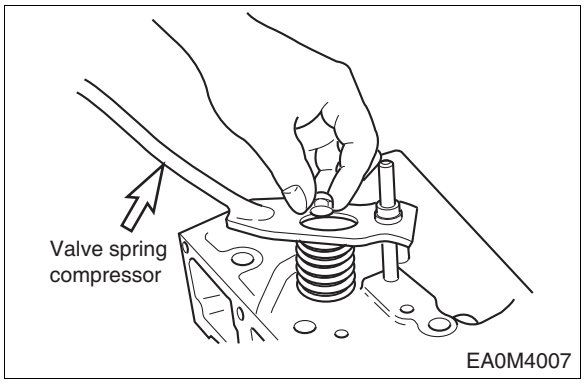
6.2.3. Cylinder head

- Carefully remove carbon from the lower face of the cylinder head using nonmetallic material to prevent scratching of the valve seat faces.
- Check the entire cylinder head for very fine cracks or damage invisible to ordinary sight using a hydraulic tester or a magnetic flaw detector.

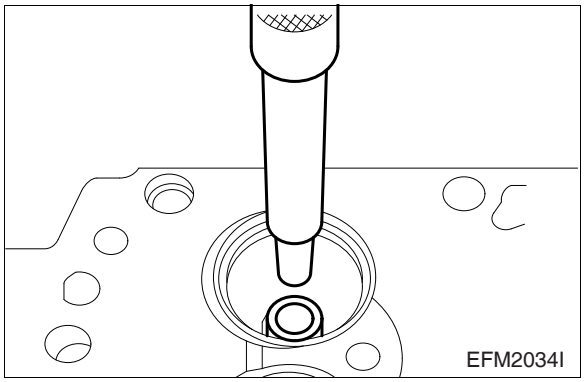
(1) Cylinder head disassembly

Note :
Be careful for the cylinder head gasket contact face of the cylinder head not to be damaged.

- Remove the cotter pin pressing the valve spring by means of a special tool.



- Take out the valve stem seal.
- Pull out the intake and exhaust valves.
- Remove the valve guides from the combustion room side of cylinder head by means of a special tool.



(2) Inspection and measurement of cylinder head

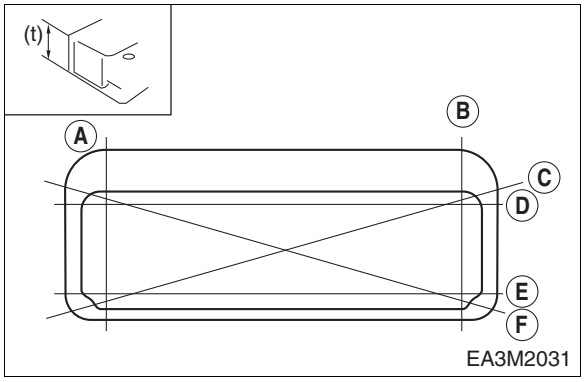
Inspection of cracks and damage

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

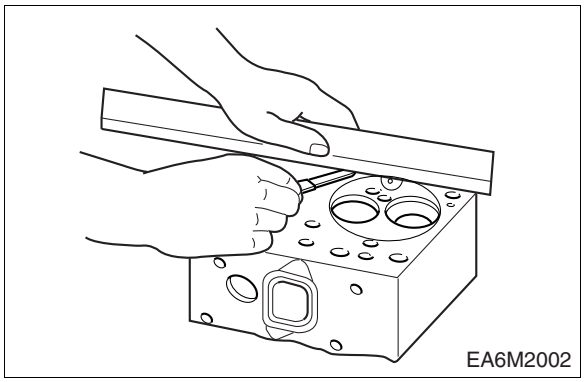
Distortion of cylinder head bottom face

1) Distortion at the lower face

- Measure the amount of distortion using a straight edge and a feeler gauge at six positions as shown in the right figure.
- If the measured value exceeds the standard value, retrace the head with grinding paper of fine grain size to correct such defects.



- If the measured value exceeds the maximum allowable limit, replace the cylinder head.



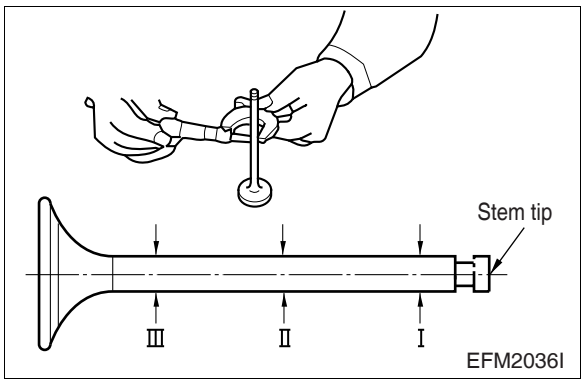
<Lower face warp and height>

War page	Standard	Limit
	0.05 mm or less	0.2 mm
Thickness : t (reference)	113.9 ~ 114.0 mm	112.9 mm

(3) Inspection and measurement of valve and valve guide

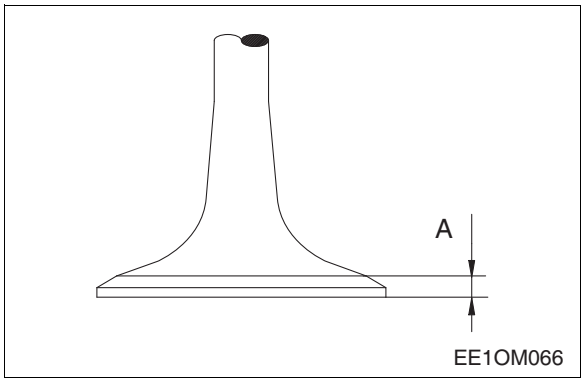
a) Valve

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



Valve	Standard	Limit
Intake	ø11.969 ~ ø11.980 mm	ø11.949 mm
Exhaust	ø11.944 ~ ø11.955 mm	ø11.914 mm

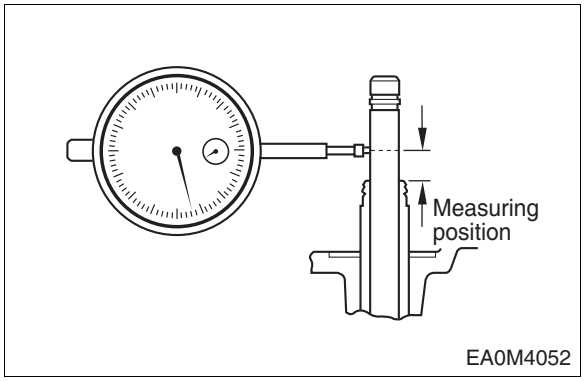
- inspect the scratch and wear of valve stem seal contacting face, and if necessary correct with the grinding paper but if severe replace it.
- If valve head thickness becomes less than limit, replace the valve.



Valve	Standard	Limit
Intake	4.6 ~ 5.0 mm	4.1 mm
Exhaust	4.33 ~ 4.83 mm	3.83 mm

b) Check of valve guide

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



Note :
Simultaneously be processed when in guide reamer process.

Valve	Standard	Limit
Intake	0.020 ~ 0.049 mm	0.10 mm
Exhaust	0.045 ~ 0.074 mm	0.15 mm

c) Valve seat

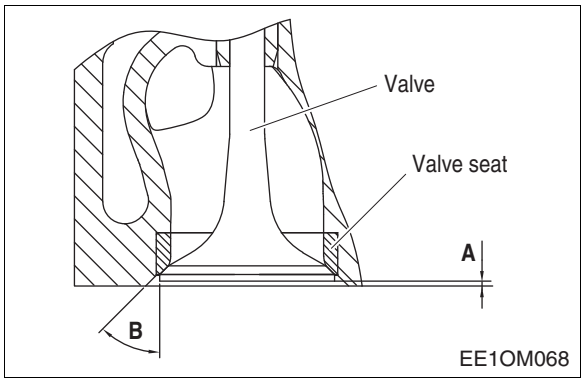
- Visual inspection
  Check if the exterior of the valve spring is damaged with the naked eye. Replace it with a new one if required.
- Valve seat thickness and angle
  Assemble the valves at the cylinder head and using the measuring instrument from the lower face, measure the projection amount of valve.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

<Valve projecting amount>

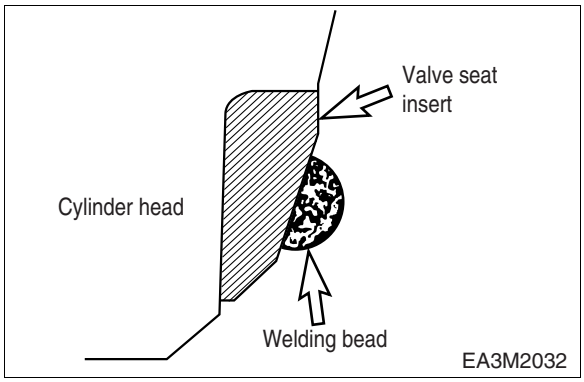
Items	Standard
Intake (A)	0.65 ~ 0.95 mm
Exhaust (B)	0.65 ~ 0.95 mm

<Valve seat angle>

Items	Standard
Intake (A)	60°
Exhaust (B)	45°

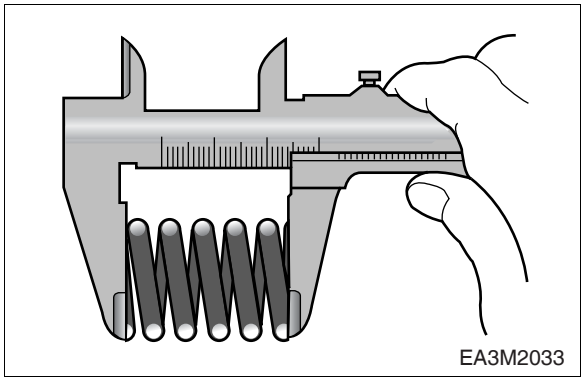


- The disassembly of valve seat cam be pulled out by means of a special tool with the arc welding done at two points of valve seat rotating tool or valve seat.
- Regarding the valve seat assembling, shrink the valve seat by putting it in the dry ices for about 1 hour or so, and then press it into the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



d) Valve spring

- Visual inspection
  Check if the exterior of the valve spring is damaged with the naked eye. Replace it with a new one if required.
- By means of spring tester, measure the tension and free length.
- Measure the perpendicularity of valve spring.
- In case that the measured value exceeds the limit value, replace it.



<Dual spring perpendicularity regular>

Items		Free length
Spring	Inside	65.5 mm
	Outside	64 mm

<Single spring perpendicularity regular - marine>

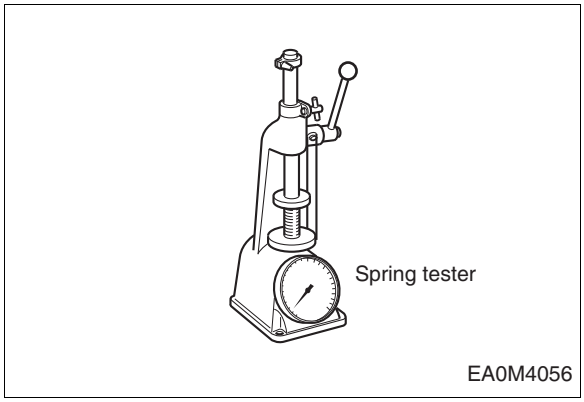
Items		Free length
Intake/ Exhaust	Inside	72.43 mm
	Outside	67.17 mm

<Single spring perpendicularity regular - marine generator>

Items		Free length
Intake/ Exhaust	Outside	61.9 mm

<Valve spring tension standard - marine>

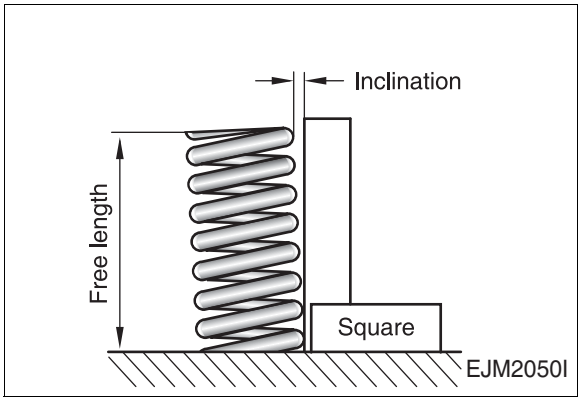
Items		Length P1/P2 (mm)	Spring tension P1/P2 (kg)	Limit P1/P2 (kg)
Intake/ Exhaust	In side	46.3/ 32.3	16.0/ 29.5	±1.0/ ±2.5
	Out side	46.8/ 32.8	39.0/ 71.5	±2.0/ ±5.0



<Valve spring tension standard - marine generator>

Items		Length P1/P2 (mm)	Spring tension P1/P2 (kg)	Limit P1/P2 (kg)
Intake/ Exhaust	Out side	46.8/ 32.8	47.0/ 90.5	±2.5/ ±4.5

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



<Marine>

Items		Standard	Limit
Intake/ Exhaust	Inside/ Outside	1.8 mm	2.0 mm

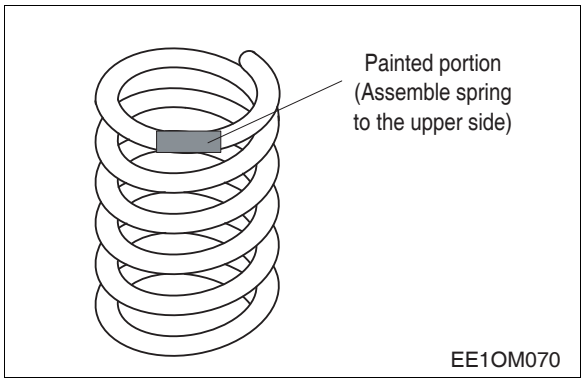
<Marine - marine generator>

Items		Standard	Limit
Intake/ Exhaust	Inside/ Outside	1.2 mm	2.0 mm

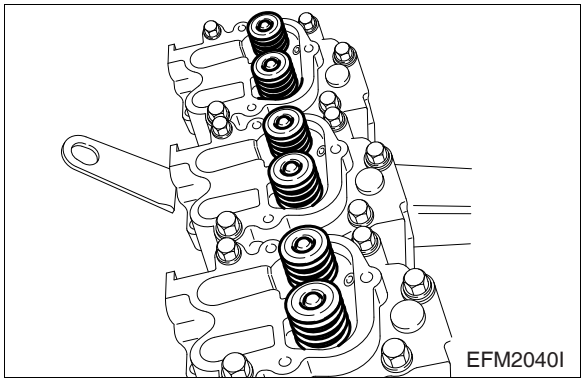
e) Assembling cylinder head

- Clean the cylinder head thoroughly.
- Coat the valve stems and valve guides with engine oil and assemble the valves.
- Replace the valve stem seals with new ones and insert the stem seals to the valve guides of cylinder head with a special tool. (Be careful for the valve stem seals not to be damaged)
- Install the valve spring washer to valve guide.
- Put in the valve spring and then attach the valve spring plate on the springs.

Note :
Install the valve spring seat with ″TOP″ (Painted in Dual spring - Yellow / Single spring - red) side up.



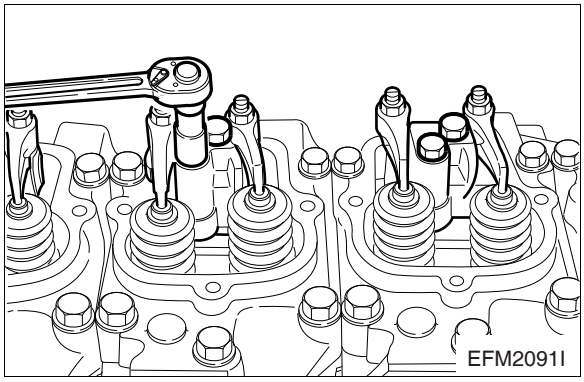
- Pressing the spring down with a special tool, assemble by inserting the valve cotter.
- After the valve is assembled, inspect the valve tapping it lightly with an urethane hammer if accurate assembling was done.



6.2.4. Rocker arm

1) Cylinder head disassembly

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

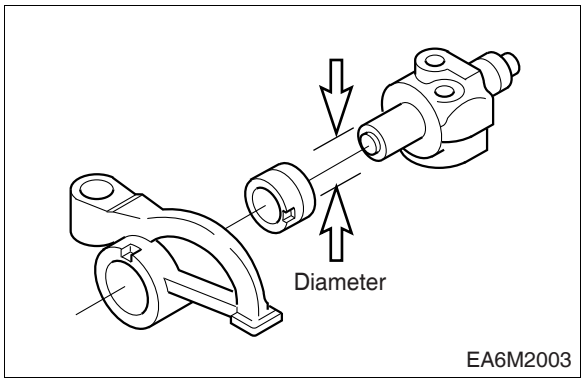


2) Inspection and measurement

a) Rocker arm bracket

(Single unit type with a shaft)

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



	Standard	Limit
Bush Inner Dia.	ø25.005 ~ ø25.035 mm	ø25.083 mm
Shaft outer Dia.	ø24.967 ~ ø24.990 mm	ø24.930 mm
Exhaust	0.015 ~ 0.068 mm	0.14 mm

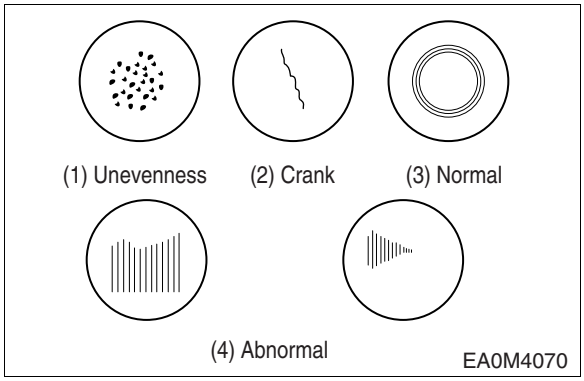
b) Rocker arm

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

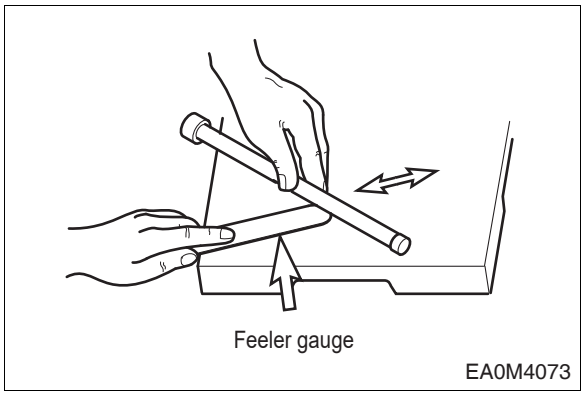
c) Tappet and push rod

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

Items	Standard	Limit
Tappet clearance	0.035 ~ 0.077 mm	0.15 mm



- By inspecting the tappet surface that contacts with the camshaft's cam for any crack and scratch etc., and if the degree is small, correct them with an oil stone or the grinding paper but if severe replace them.
- Place the push rod on the surface plate and rolling it, Inspect the curving degree with a clearance gauge and if abnormal, replace it.



<Run-out>

Limit	0.3 mm or less

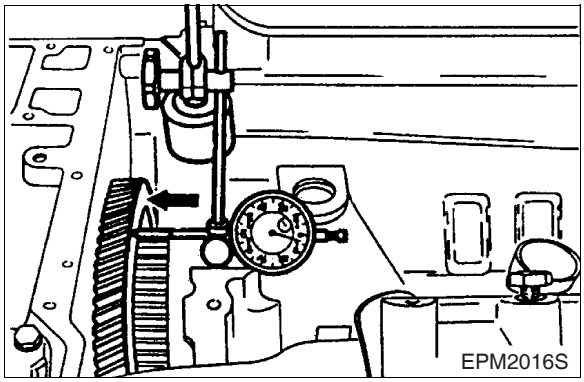
d) Rocker arm reassembling

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

6.2.5. Camshaft

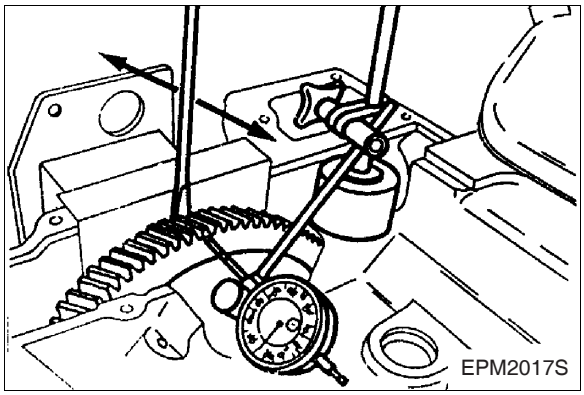
(1) Axial end play

- Push the camshaft toward the pulley side.
- Place a dial gauge onto the camshaft gear.



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

Items	Standard	Limit
End play	0.24 ~ 0.86 mm	0.9 mm


EPM2017S

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

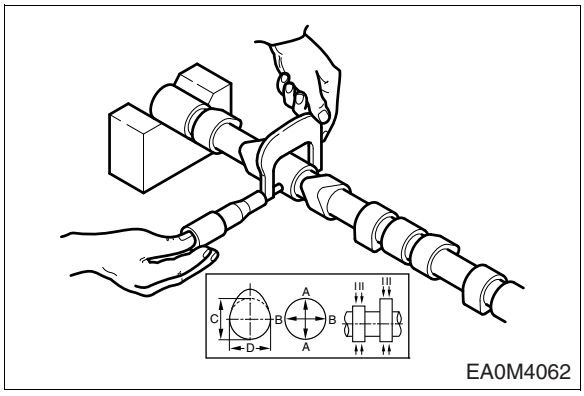
(2) Inspection and measurement

- **Visual check**

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

- **Cam lobe height**

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

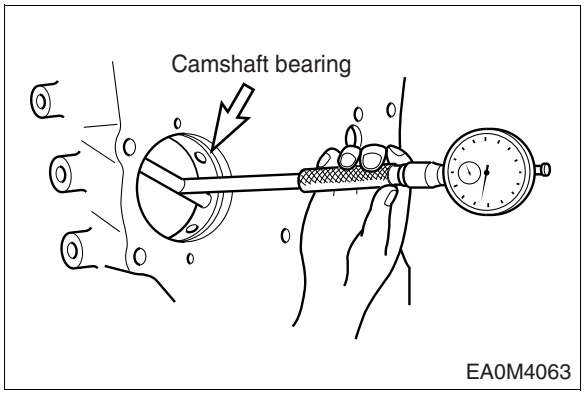


EA0M4062

Items		Standard	Limit
Cam lobe height (C)	Intake	56.370 mm	56.032 mm
	Exhaust	56.430 mm	56.091 mm
Cam Journal Diameter (A, B)		ø69.91 ~ ø69.94 mm	ø69.560 mm

- **Cam bearing diameter**

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



EA0M4063

Items	Standard	Limit
Thust	ø70.070 ~ ø70.090 mm	ø69.464 mm
Middle	ø70.000 ~ ø70.030 mm	ø69.192 mm

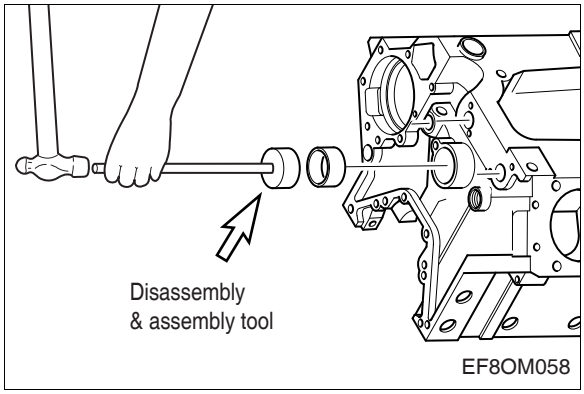
- **Clearance**

Between camshaft journal and body.

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

- **Camshaft bearing replacement**

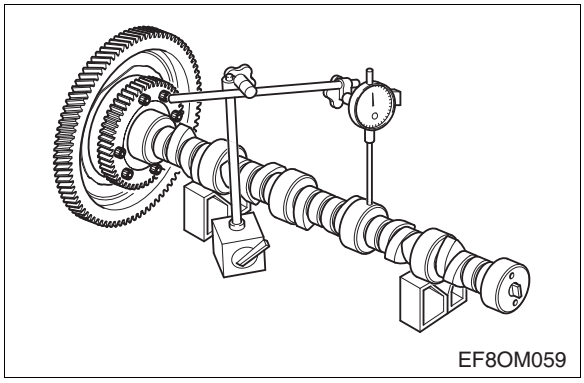
Replace the camshaft bearing with a special tool.



- **Camshaft run-out**

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

Standard	Limit
0.05 mm	0.15 mm



- **Cam lobe height**

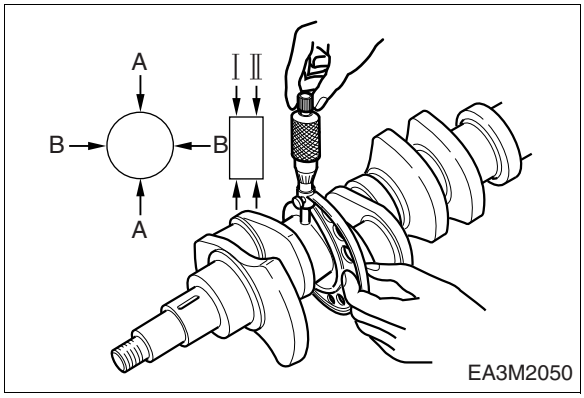
Use a micrometer to measure the cam lobe height and journal diameter.

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

6.2.6. Crankshaft

(1) Inspection and measurement

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



a) Journal and pin diameter

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

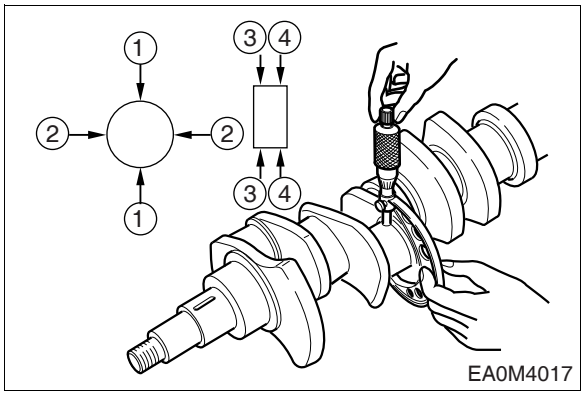
<Crankshaft journal outside diameter>

Standard	ø103.98 ~ ø104.00 mm

<Crankshaft pin outside diameter>

Standard	ø98.98 ~ ø90.00 mm

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



<kinds of bearings for undersize>

(a) Standard

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

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

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

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

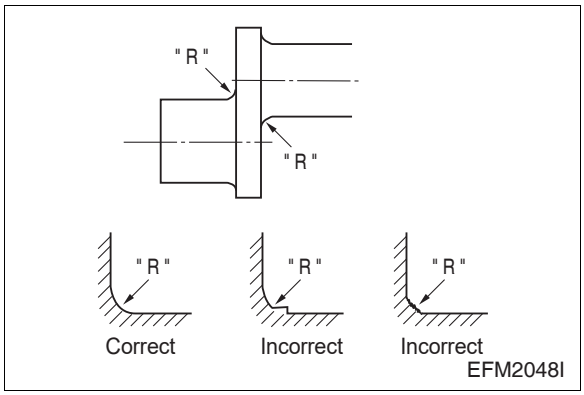
(f) 1.00 (Inside diameter 1.00 mm less than standard)

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

<"R part" standard value>

① Crank pin ′R′ : $4.0^{0}_{-0.5}$

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

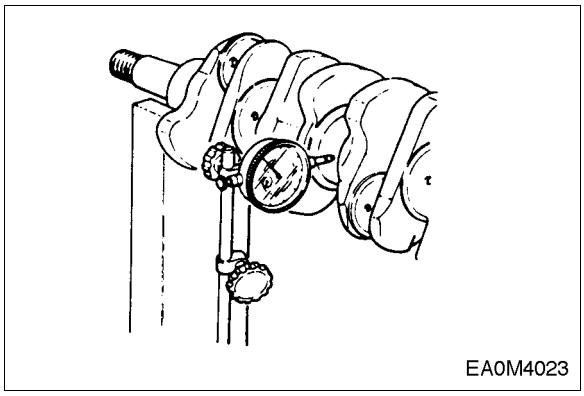


Note :
In case of crankshaft regrinding, the ″R part″ at the end of bearing must accurately be ground without fail and should avoid any processed jaw or coarse surface

b) Run out of crankshaft

- Place the crankshaft on the V-block.
- Place the dial gauge on the surface plate and measure the run out of crankshaft rotating the crankshaft

Standard	Limit
0.06 mm	0.4 mm

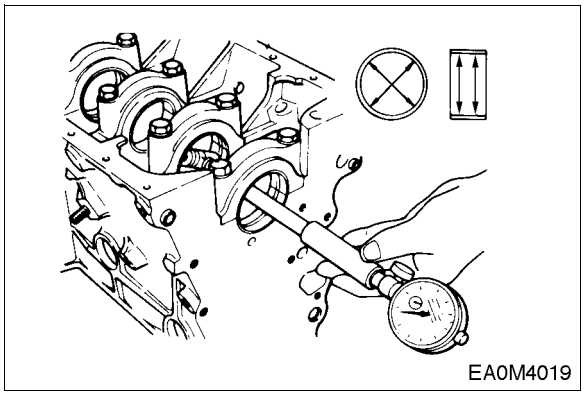


(2) Inspection on crankshaft bearing and connecting rod bearing inspection

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

a) How to utilize the cylinder gauge

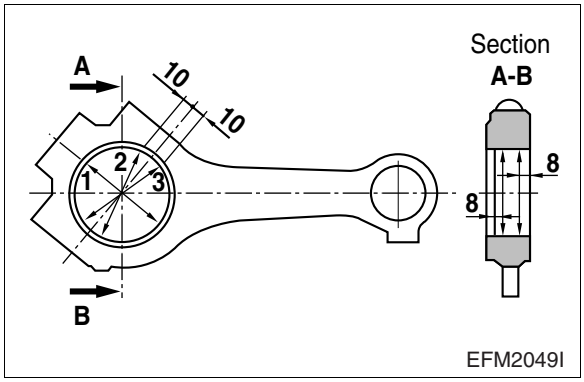
① Assemble the main bearing at the cylinder block and after tightening the bearing cap at the specified torque, measure the inside diameter.


EA0M4019

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

Bearing cap bolt torque	Initial 30 kg.m + angle 90°

② Assemble the bearing at the bigger end of connecting rod, and after tightening the bearing cap at the specified torque, measure the inside diameter.



EFM2049I

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

Connecting rod bolt torque	Initial 10 kg.m + angle 90°

③ Assemble the bearing at the bigger end of connecting rod, and after tightening the bearing cap at the specified torque, measure the inside diameter.

Standard	Limit
0.056 ~ 0.118 mm	0.143 mm

b) How to utilize plastic gauge

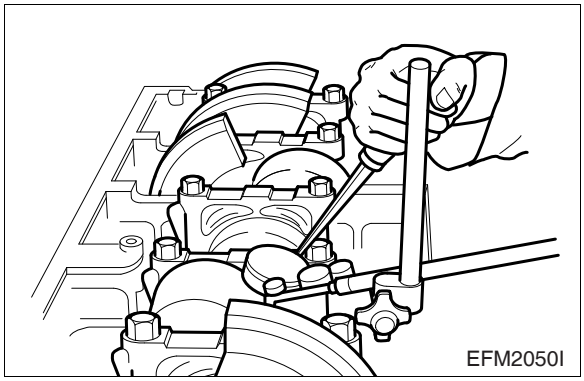
① Install the crankshaft in the cylinder block and place the plastic gauge on the crankshaft journal and pin at axial direction and then after tightening the bearing cap at the specified torque and again after tearing apart the bearing cap, measure the flatten plastic gauge thickness by pick it up. This is the oil clearance.

② With the same points, the oil clearance of connecting rod also can be measured.

End play

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

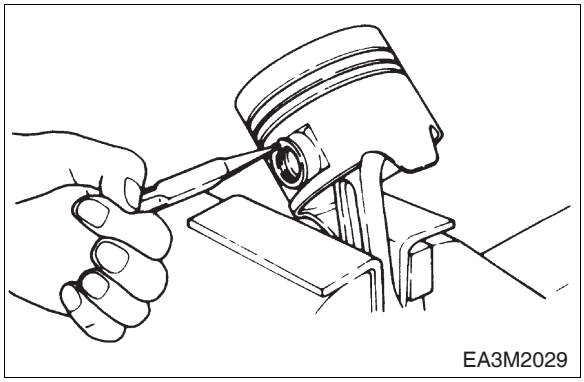
Standard	Limit
0.140 ~ 0.361 mm	0.4 mm


EFM2050I

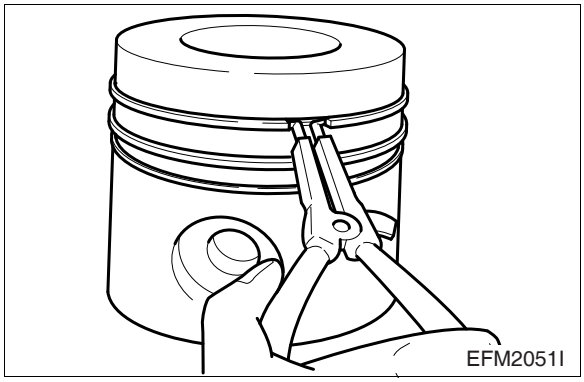
6.2.7. Piston

(1) Piston disassembling

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


EA3M2029

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

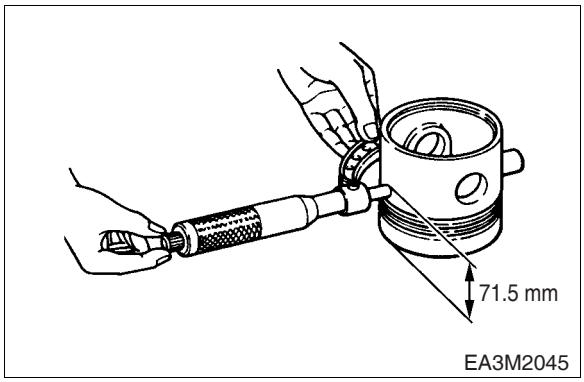

EFM2051I

(2) Inspection & measurement of the piston

- With naked eyes, inspect the piston for any wear, crack and scratch and particularly inspect carefully at the ring grooves for any wear.

- With the outside micrometer, measure the piston′s outside diameter the measuring position is 71.5 mm from the piston lower end, and the direction of measurement must be perpendicular to the piston pin direction.

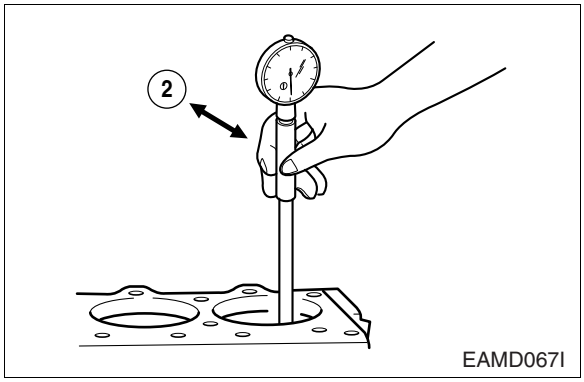
Standard	ø127.739 ~ ø127.757 mm



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

- Measurement of cylinder bore
  Assemble the cylinder liner at the cylinder block and measure inner diameter at upper, middle, lower that is, 3 steps by 45° interval and calculate the average values after eliminating the maximum and minimum values.

Standard	ø127.990 ~ ø128.010 mm



- Measure the clearance between the cylinder liner bore and the piston outer diameter, if it is more than the use limit value, replace either one that is more severe.

Standard	0.233 ~ 0.271 mm

(3) Piston ring & ring groove

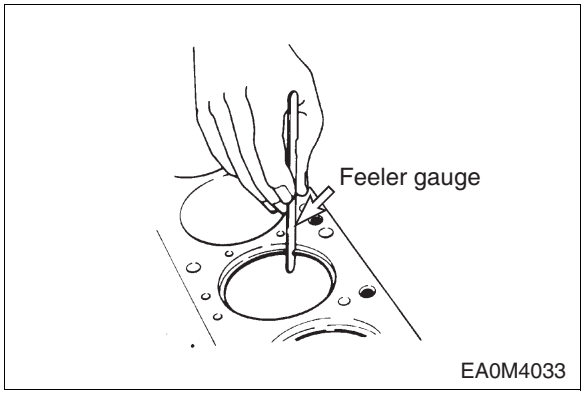
Inspection

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

Gap clearance

Measure the piston ring cut part.

- Insert the piston ring at the cylinder liner′s upper part perpendicularly.
- With a feeler gauge, measure the gap clearance of piston ring.
- If the measured value exceeds the limit value, replace it.

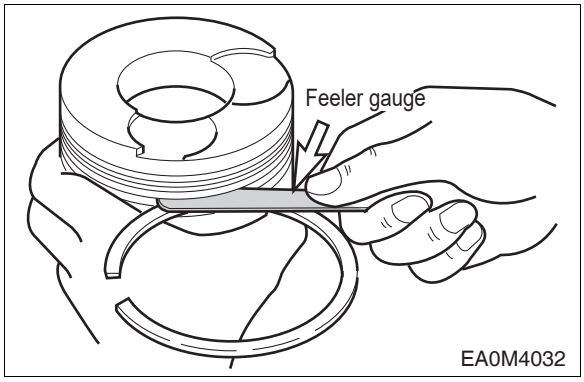


<Piston ring gap>

Division	Standard	Limit
Top ring	0.30 ~ 0.50 mm	1.5 mm
2nd ring	1.10 ~ 1.30 mm	1.5 mm
Oil ring	0.25 ~ 0.55 mm	1.5 mm

Piston ring groove clearance.

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



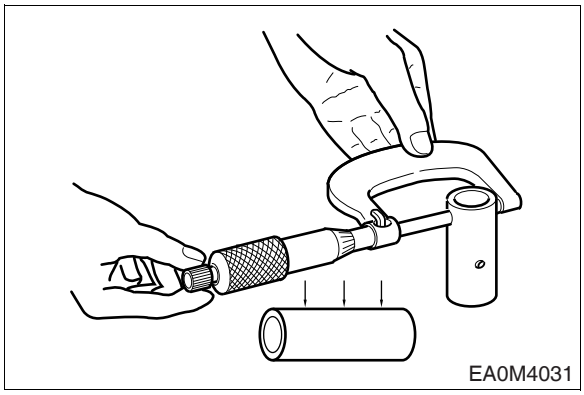
<Piston side clearance>

Division	Specified value	Limit value
Top ring	0.105 ~ 0.150 mm	1.5 mm
2nd ring	0.050 ~ 0.082 mm	0.15 mm
Oil ring	0.030 ~ 0.062 mm	0.15 mm

(4) Piston pin

Outside diameter

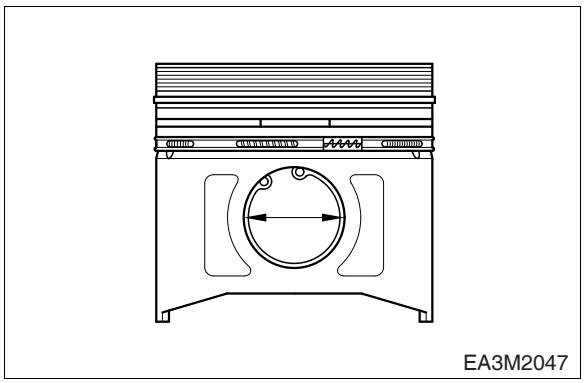
With the outside micrometer, measure the piston pin's outside diameter and if the value is same as the use limit value or less, replace it.



Standard	Limit
ø45.994 ~ ø46.0 mm	ø45.979 mm

Piston pin & connecting rod bush clearance

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

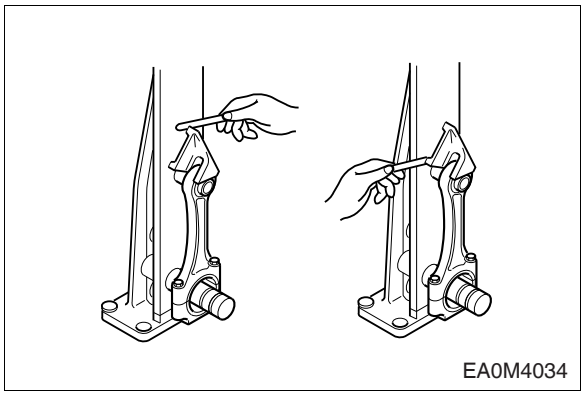


Limit	0.055 ~ 0.071 mm

(5) Connecting rod

Distortion and parallel

Install the measurement tester as figure. Measure the distortion of the bigger and smaller end bearing holes after that do as regard parallel of both holes and if abnormal, replace the connecting rod.



Standard	Limit
0.02 mm	0.2 mm

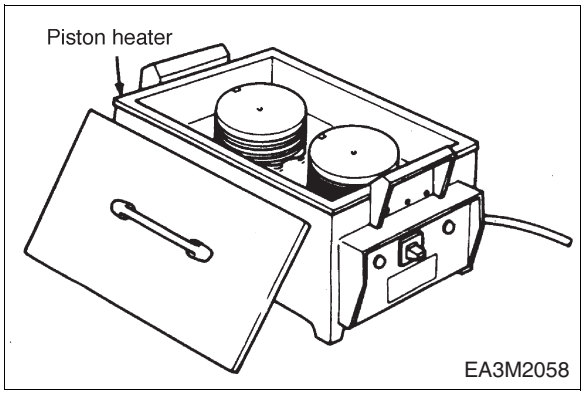
Amounts of wear

- After assembling the connecting rod in the crankshaft measure the clearance between connecting rod bigger hole and crank pin diameter using filler gauge.
- Assemble the connecting rod in the piston and then measure the clearance of these parts.
- If it is more than the use limit value, replace the connecting rod.

Standard	Limit
0.02 mm	0.2 mm

(6) Piston reassembling

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



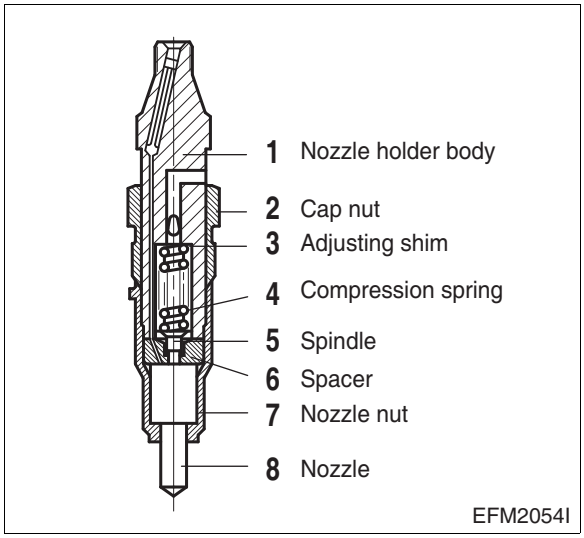
Note :

Confirm the direction of connecting rod and assemble.

- With the snap ring plier, insert the snap rings of the piston pin.
- With confirming the upper side indication of piston ring, after assembling the ring in the piston ring groove, inspect if the movement of ring is smooth.
- Arrange the assembled piston in order as the cylinder number.

6.2.8. Injection nozzle

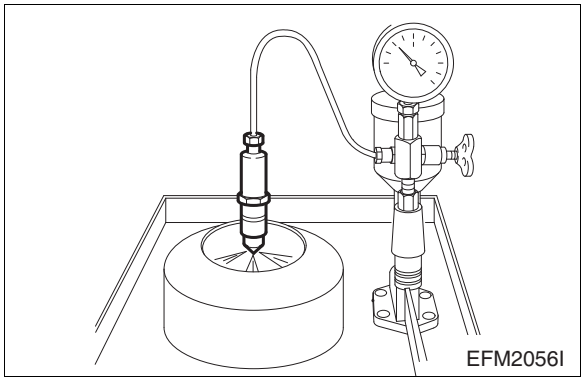
- Set the nozzle assembly between the vise holder and disassemble it.
- Remove the nozzle nuts and disassemble the inner parts.
- Inspect the disassembled parts if there is any damage, replace it.
- Assembling can be done in the reverse order of disassembling.
- After assembling the nozzle, set it in the injection pressure measuring tester.



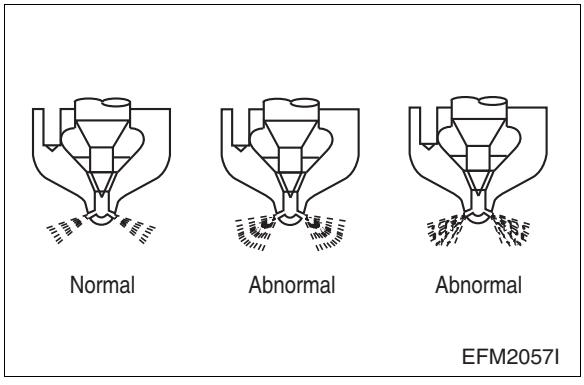
- By manipulating the tester handle, inspect the injection pressure and atomizing state.

<Operating pressure>

New nozzle holder	300 + 8 kg/cm^2
Used nozzle holder	285 + 8 kg/cm^2



- In case of low or high injection pressure, adjust by adding or reducing the spring tension adjusting shims.
- In case that atomizing state is not good, it should be replaced.



6.3. Engine Re-assembly

6.3.1. General preparation

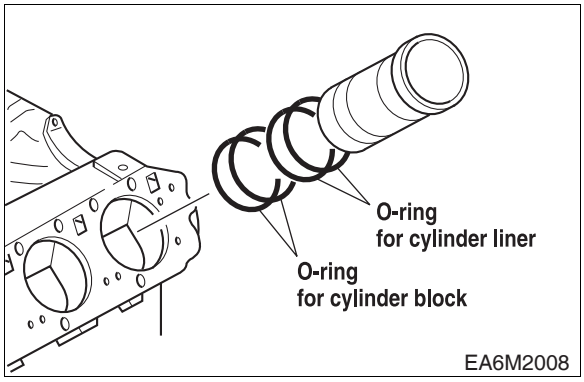
- Clean all the disassembled parts, particularly oil and water ports, using compressed air, then check that they are free from restrictions.
- Arrange the general and special tools in order for engine assembly operation.
- To wet each sliding part, prepare the clean engine oil.
- Prepare service materials such as sealant, gaskets, etc.
- Discard used gaskets, seal rings, and consumable parts, and replace with new ones.
- Apply only the specified torque for bolts in the specified tightening order and avoid over-tightening.
- Be sure to check that all the engine parts operate smoothly after being reassembled.
- Check the bolts for looseness after preliminary re-assembly.
- After completing the engine re-assembly operation, check if there is missing parts or shortage of parts.
- Keep your hands clean during the working.

6.3.2. Cylinder block

Cover the floor of the workshop with wood plate or thick paper to prevent damage to the cylinder head and place the head face of the cylinder block towards downward.

6.3.3. Cylinder liner

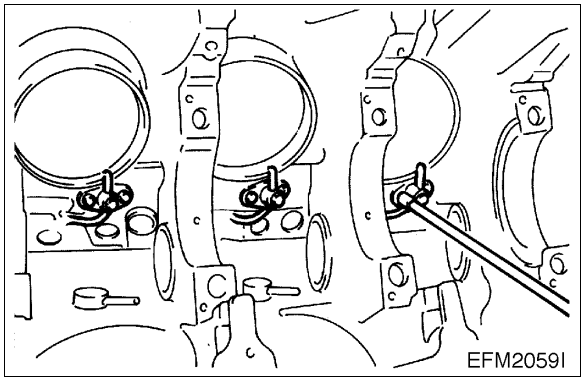
- Replace the used O-rings with new ones and insert the O-ring in the cylinder liner upper side, but the other one in the cylinder block lower side separately.
- Coat the joint parts where O-ring contacts with oil.
- After slipping the cylinder liner smoothly into the cylinder block, press it in being careful for O-ring not to damage.



- After completion of assembling the cylinder liner, confirm no leaks with 4 kg/cm^2 hydraulic test.

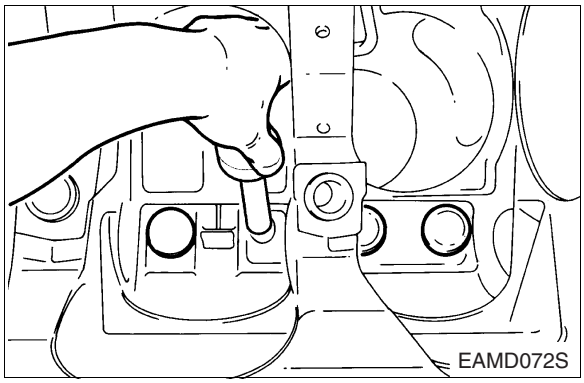
6.3.4. Oil spray nozzle

- Assemble the oil spray nozzle.
- Tighten the fixing bolts.



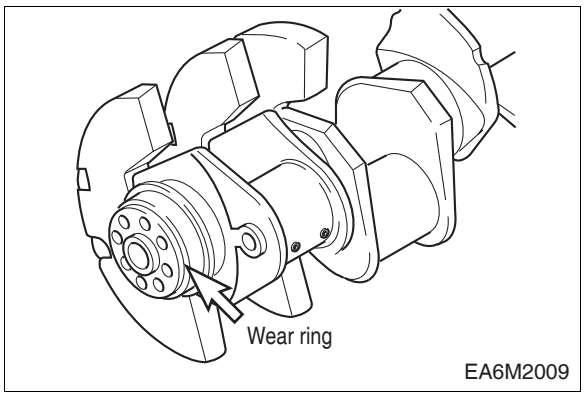
6.3.5. Tappet

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

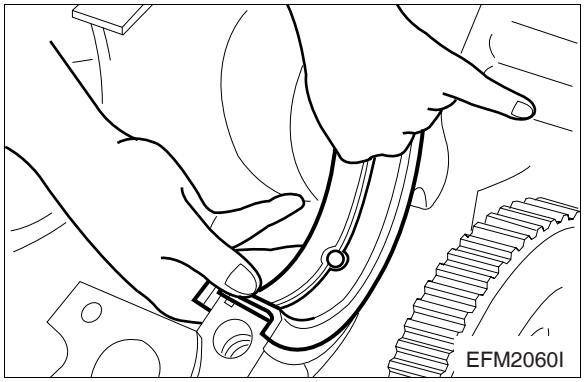


6.3.6. Crankshaft

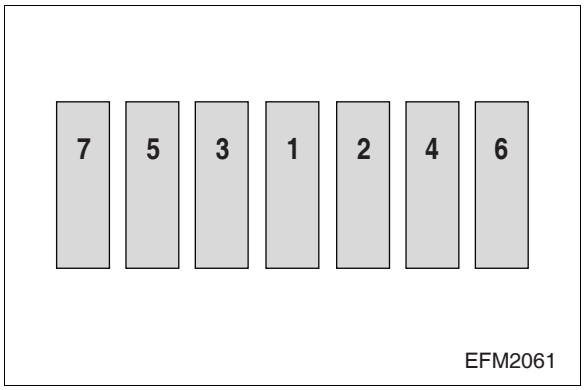
- Put the wear ring into the heater to heat it up to 150 ~ 200°C level, push it over the crankshaft by means of a jig.



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



- Assemble temporarily one bolt each at both bolt holes and by connecting the wire to the bolts, lift it with crane or chain block and put down on the cylinder block carefully.
- Coat the crankshaft journal and pin parts with engine oil, and after fitting the main bearing into the bearing cap and assemble it to the cylinder block making sure of the number in order not to change the bearing cap.



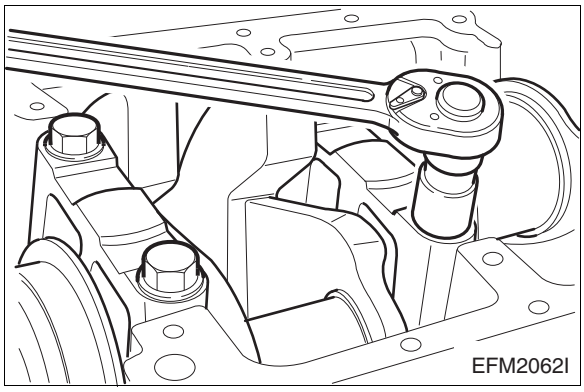
EFM2061

- **According to the tightening order,**

tighten the bearing cap bolts with 30 kg.m and with rotating angle method (90° +10°) and tightening order are as follows.

< Bearing cap bolt's tightening order >

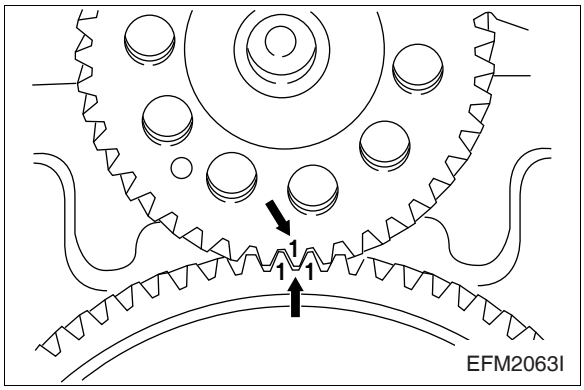
(1) First step : screw down 1 ~ 2 threads.
(2) Second step : tighten with a bout 15 kg.m by wrench.
(3) Third step : tighten with a bout 25 kg.m by torque wrench.
(4) Fourth step : tighten with 30 kg.m by torque wrench.
(5) Fifth step : tighten with final rotating angle method 90° +10°.
However, according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


EFM2062I

- Inspect if the crank shaft's rotation is smooth.
- Assemble the crankshaft gear on the crankshaft and coat a white paint mark on ″1″ part in order to find easily.

6.3.7. Camshaft

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

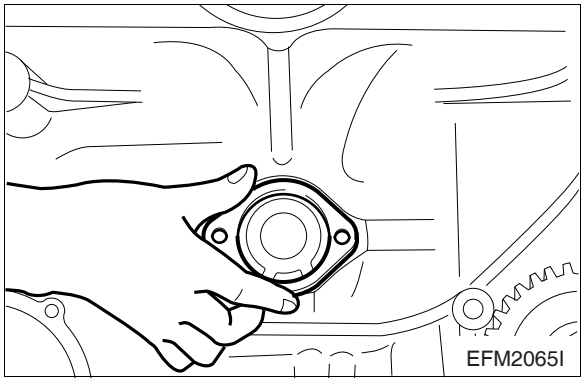


EFM2063I

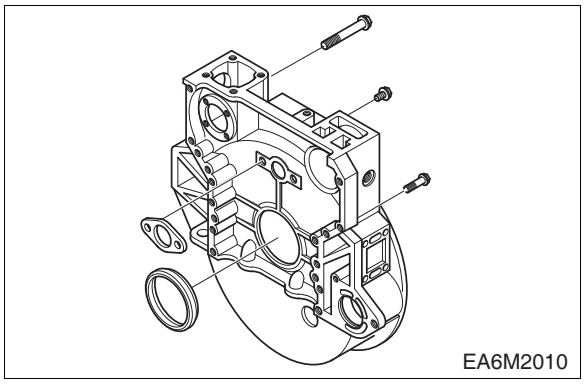
6.3.8. Flywheel housing

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

Torque	3.1 kg.m



- Coat the oil seal with lubricating oil and assemble it carefully not to be deviated or damaged by means of special tool. (Mandrel for assembling).
- Attach the gasket on the surface of cylinder block where the flywheel housing is to be installed. (In order to prevent the gasket slip down, coat a grease on the cylinder block surface.)
- Temporarily assemble 2ea of guide bolts for installing the flywheel housing to the cylinder block.

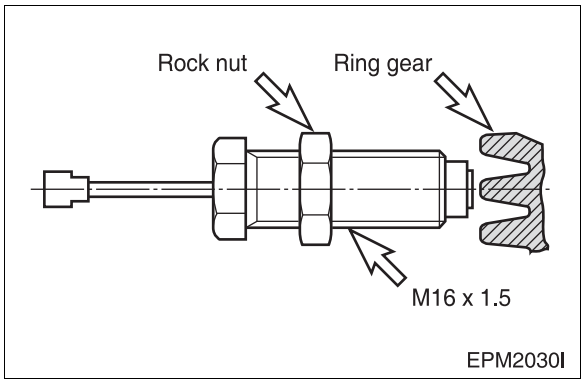


- After fitting the flywheel housing holes to the guide pins and engage temporarily 2 ~ 3 threads of fixing bolts, and according to the tightening order (zigzag method) tighten them in the specified torque.

Torque	7.5 kg.m

6.3.9. Tacho sensor

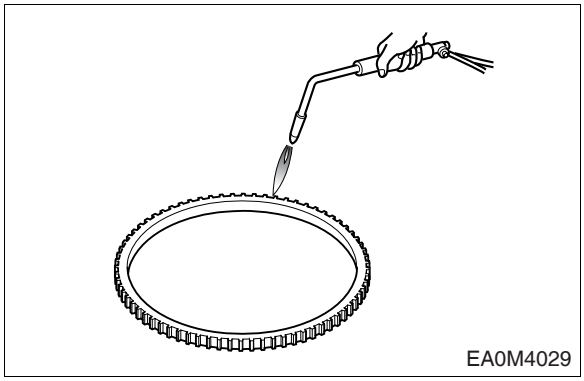
- Loosen the lock nut to hexagonal side of sensor.
- Rotate (CW) the tacho-sensor on fly wheel housing, until the end of it reach on fly wheel ring gear as figure.
- Rotate (CCW) the tacho-sensor for 270° (gap: about 1.0 mm) and fix the lock nut.
- Tolerance limit is 27° (gap ±0.1 mm)



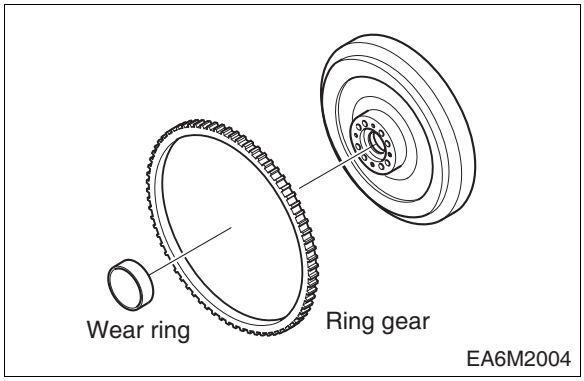
6.3.10. Flywheel

- Installation of flywheel ring gear With a gas burner, heat the ring gear evenly until heat expansion takes place, then install it using a hammer.

Do not allow the temperature of the ring gear to exceed 200°C (390°F).

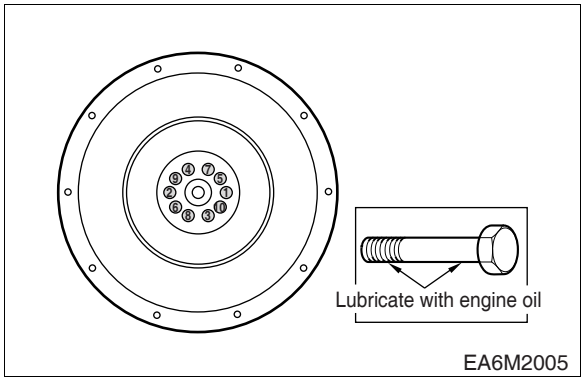


- By means of mandrel, press in the wear ring at the backward face.
- Install two guide bolts for installing the flywheel to the crankshaft.



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

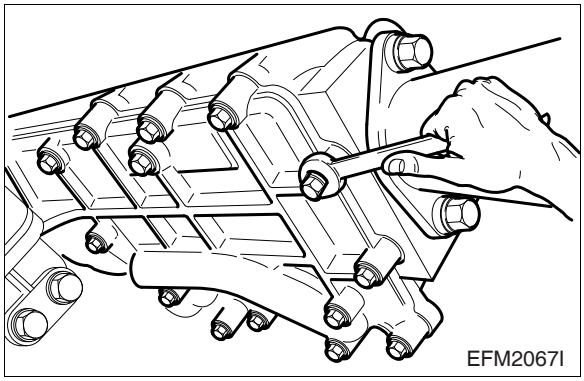
Torque	26 kg.m



6.3.11. Oil cooler

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

Torque	M8	3.1 kg.m
	M10	5.5 kg.m



6.3.12. Heat exchanger

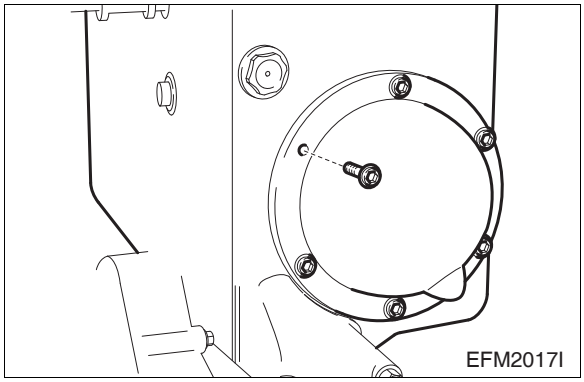
- Assemble 4ea of fixing bolts.
- Assemble the heat exchange tube.

2-baffle side of the heat exchange tube should be installed upward.

- Assemble the cover bolts.

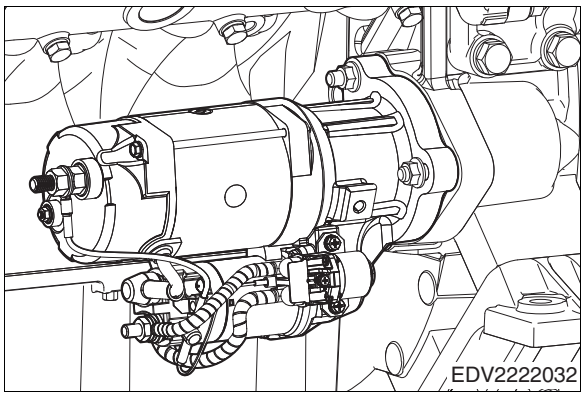
Be careful to install O-ring and gasket properly.

- Assemble the connecting hoses and pipes.



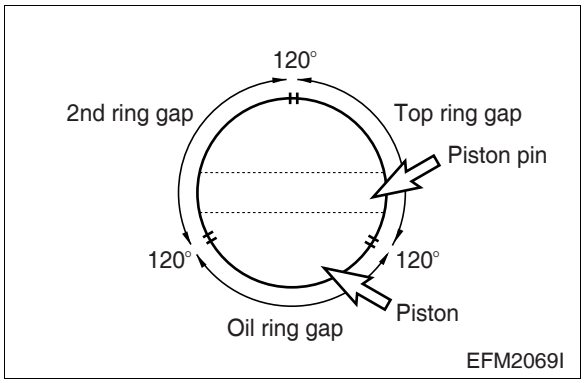
6.3.13. Starting motor

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

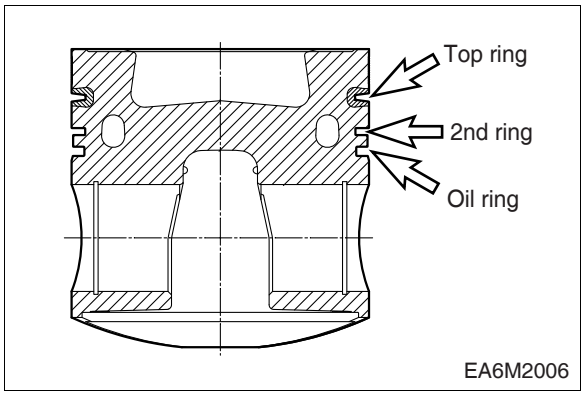


6.3.14. Piston

- Coat the pistons and connecting rod bearings sufficiently with clean engine oil.
- By means of a special tool, insert the piston rings and adjust the angles between the ring gaps at 120° as right figure.
- Push in the piston with hands or wooden bar into cylinder. (Be careful for piston and rings not to be damaged.)



- Pushing the piston down, rotate the crankshaft about 180° and fit the bearing cap to the connecting rod.
- **After engaging 2 - 3 threads of bolts primarily rind then tighten them.**



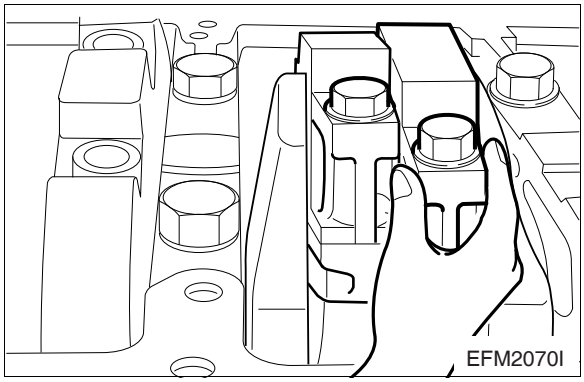
<Connecting rod bolt tightening order>

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

*** Standard length of bolt and use limit:**
(from head seat to bolt tip)

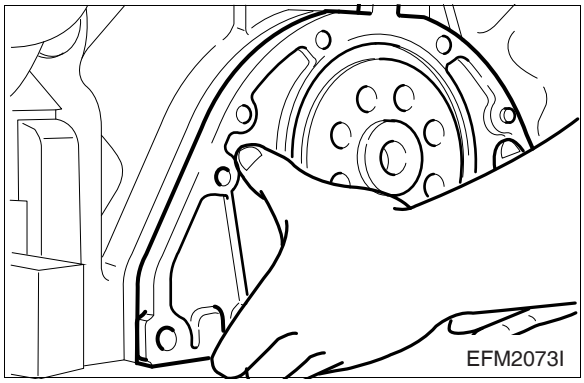
Standard length	Use limit
67.5 $^{-0.3}$ mm	69 mm

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



6.3.15. Front oil seal holder

- After placing the oil seal in the oil holder hole properly, press it in with a mandrel. (Be careful for oil seal not be damaged.)
- Attach the gasket at oil seal holder.
- Align the dowel pin with the oil seal holder dowel hole and assemble them by tapping lightly the dowel pin part with an urethane hammer.



When in assembling, take care not to hurt the oil seal by the crankshaft.

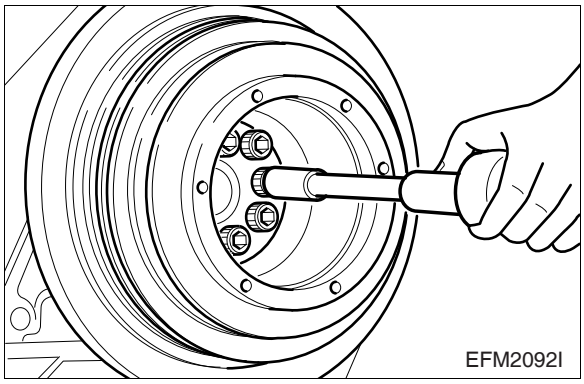
Note :
Without coating the oil seal with oil or lubricant, assemble it in the dry state.

- Tighten the fixing bolts in the zigzag method.

6.3.16. Vibration damper

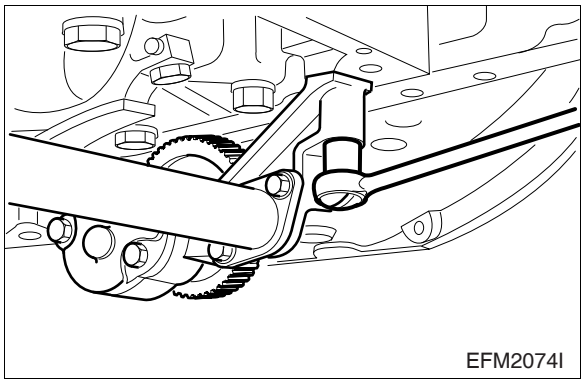
- Assemble the vibration damper tightening firstly by the crankshaft pulley and the fixing bolts.
- Insert the crankshaft pulley assembly to the crankshaft and tighten the fixing bolts in the method of zigzag to the specified torque.

Torque	21 kg.m


EFM2092I

6.3.17. Oil pump

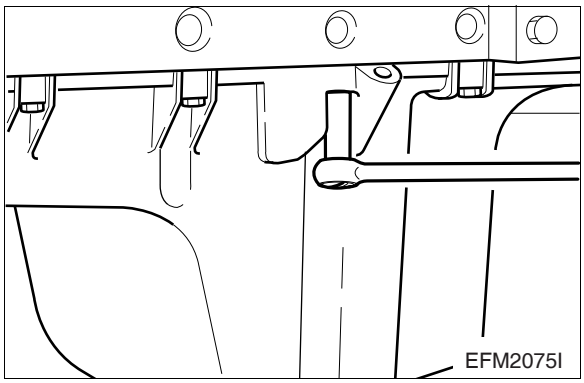
- Put the oil pump at the place to be installed on the cylinder block.
- Attach the gasket at the surface of oil pump where the pressure regulating valve is to be installed and place the regulating valve on the gasket.
- Assemble the oil pump by tightening the fixing bolts.
- Attach the gasket at the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


EFM2074I

- Assemble the pipe bracket on the cylinder block side with bolts.

6.3.18. Oil pan

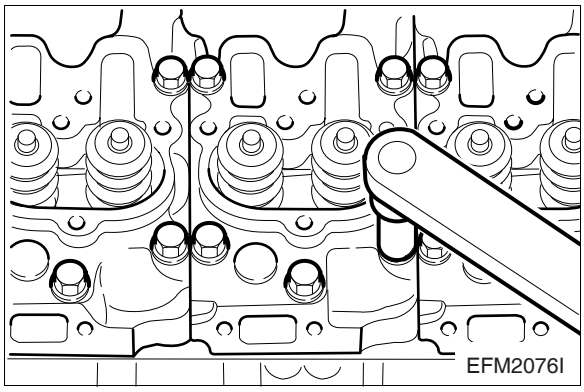
- Clean thoroughly the gasket that is projecting at the junction parts of front oil seal holder and flywheel housing of cylinder block's lower face with a scraper. In the process of gasket removal, be careful for the gasket pieces not to get into the engine inside.
- Attach the gasket to the cylinder block.


EFM2075I

- Install the oil pan and tighten the fixing bolts. T h e n take care not to squeeze out the gasket.
- Install the guide tube and insert the oil level gauge.

6.3.19. Cylinder head

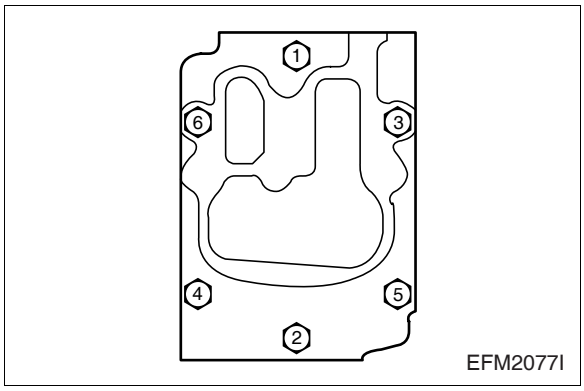
- Blow the cylinder head bolt holes with compressed air to remove the foreign material cleanly.
- Wipe off cleanly the junction part of cylinder block's head gasket.
- After confirming whether there is foreign material or not necessarily, if there is, remove it.
- Assemble a gasket fitting with the fixing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


EFM2076I

- **Tighten the cylinder head bolts to the specified torque according to step by step. However, prior to tightening the bolts, with a long steel rule, the parallel between the cylinder heads must be adjusted.**

< Cylinder head bolts tightening order >

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



EFM2077I

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

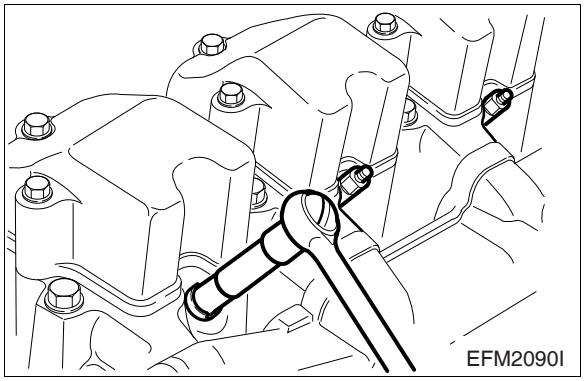
from the head seat face to tip

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

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

6.3.20. Nozzle

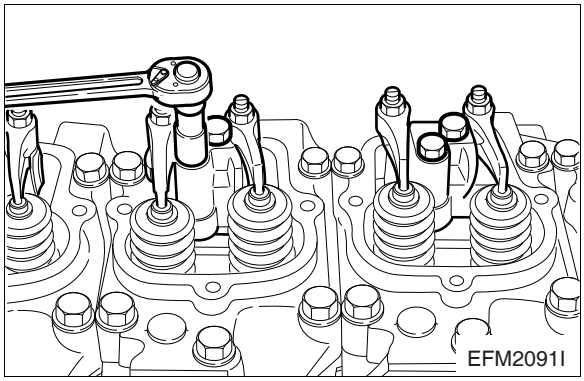
Put the new seal ring in nozzle hole of the cylinder head and after inserting the nozzle assembly, tighten it to assemble However, coat the nozzle outer part with the stuck preventing agents and assemble it.



6.3.21. Rocker arm

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

Torque	6.2 kg.m



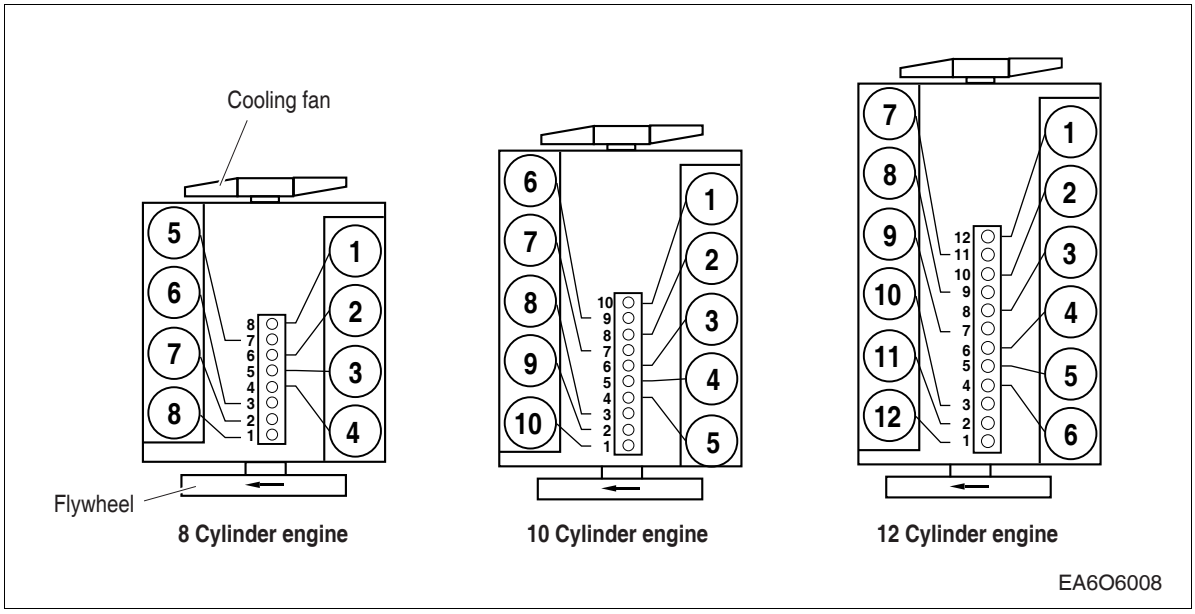
- Adjust the valve clearance.
  Regarding the adjustment, refer to the regular maintenance part.

6.3.22. Valve clearance adjust procedure

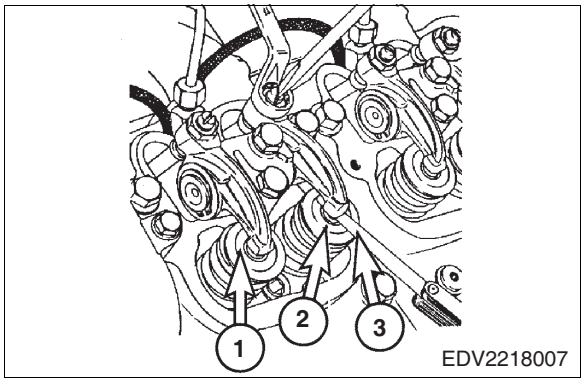
Method 1

1) Rotate the crankshaft so that #1. cylinder may be positioned at the compression TDC (Top Dead Center).

Note :
#1. Cylinder is located at the side where cooling water pump was installed.
In case of 8/12 cylinder engine, #6. cylinder is positioned at the valve overlap when #1. cylinder is positioned at the compression TDC (Top dead center).
In case of 10 cylinder engine, #7. cylinder is positioned at the valve overlap when #1. cylinder is positioned at the compression TDC (Top dead center).



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



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

Model	Specified Value	
	In. Valve	Ex. Valve
V158TI/V180TI/V222TI	0.25 mm	0.35 mm
AD158TI/AD180TI/AD222TI	3 mm	3 mm

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

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

*** 8 cylinder engine (V158TI/AD158TI)**

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

*** 10 cylinder engine (V180TI/AD180TI)**

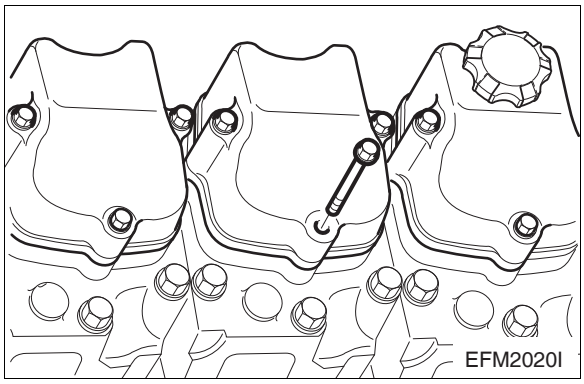
Valve overlap cylinder No.									
1	6	5	10	2	7	3	8	4	9
7	3	8	4	9	1	6	5	10	2
Adjusting valve cylinder No. (In./Ex. Valve)									

*** 12 cylinder engine (V222TI/AD222TI)**

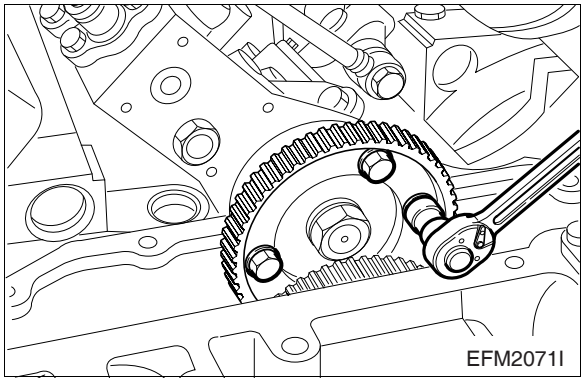
Valve overlap cylinder No.											
1	12	5	8	3	10	6	7	2	11	4	9
6	7	2	11	4	9	1	12	5	8	3	10
Adjusting valve cylinder No. (In./Ex. Valve)											

6.3.23. Cylinder head cover

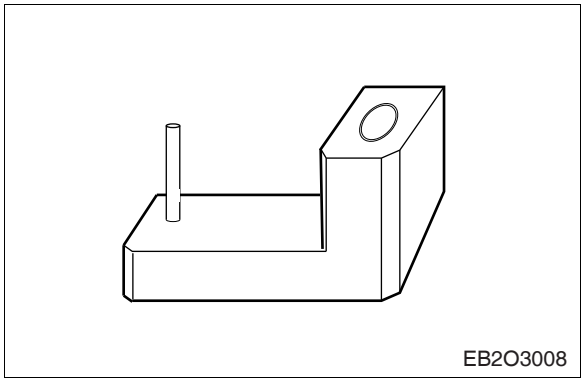
- Attach the new gasket on the surface of cylinder head where the cover is to be installed.
- Assemble the cylinder head cover by tightening the fixing bolts.
- Insert the oil filler cap.



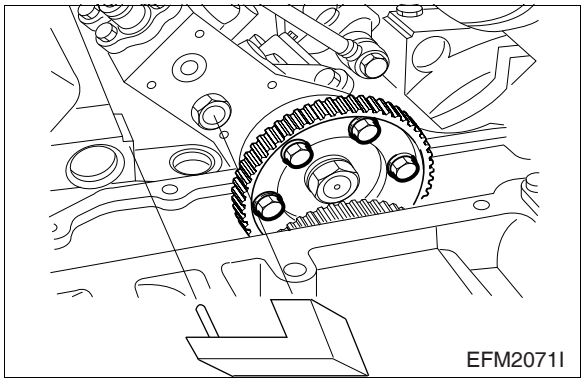
6.3.24. Fuel injection pump


EFM2071I

- Turn the crankshaft so as to let the cylinder No. 6 for V158TI, AD158TI, V222TI, AD222TI engines and the cylinder No. 7 for V180TI, AD180TI come to the overlap TDC (Top Dead Center).
- Rotate the crankshaft to reverse about 30° (in order to remove a backlash) and then rotate it to engine rotating direction to set the fuel injection timing angle.
- Coat the O-ring with grease and insert it at the lower part of fuel injection pump.
  (Be careful O-ring not to be removed)
- Prior to install the fuel pump drive gear, fit the rubber gasket first.
- Tighten temporarily the fuel injection pump drive gear with aligning the pointer on drive gear with injection pump pointer.


EB2O3008

- Fit the injection pump in the appropriate position using a special tool.(Special tool No. : **EF120-189**)


EFM2071I

- After fixing the jig hole on the limit cap of the injection pump rotate the jig counter-clockwise and align the jig pin to the machined corner of the cylinder block, then assemble the injection pump.
- After completing the preparation for injection pump assembling, install the injection pump and tighten the bolts in the zigzag method.
- After assembling the injection pump,
  find out whether the injection pump pointer and drive gear's pointer is aligned, and if aligned, tighten the fixing bolts that were temporarily tightened. However, if not aligned, loosen the fixing bolts and turn the fuel pump so as to align the pointers then tighten the fixing bolts.

In case of exchange the injection pump, should fill the engine oil in the governor of the injection pump before the engine running.

<Oil quantity of the injection pump>

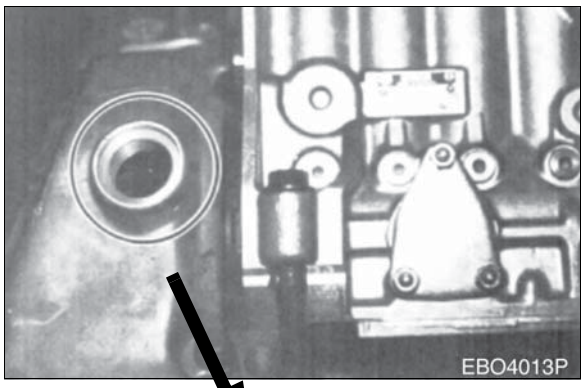
V158TIE/V158TI	V180TI	V222TI
0.95 liter	1.1 liter	1.3 liter

6.3.25. Injection timing

<How to check the injection timing>

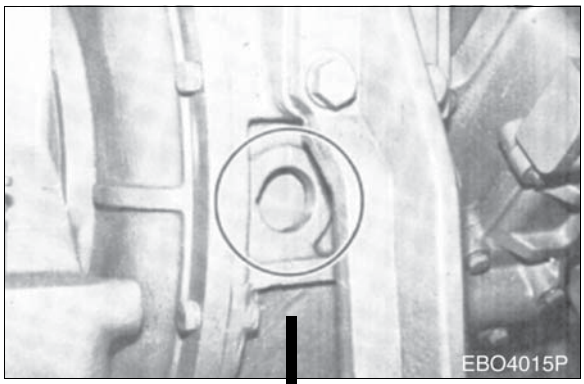
- Check the current injection timing of the engine as follows before adjusting it but if the injection timing is wrong should do it.

1) Remove the plug screw assembled in case cover on the injection pump drive gear.(Some cases are needed to remove cover assembly)
   And turn the crank pulley so that the mark on pointer provided on injection pump coincides with matching mark (FB) on the flange surface of the drive gear.



EBO4012I

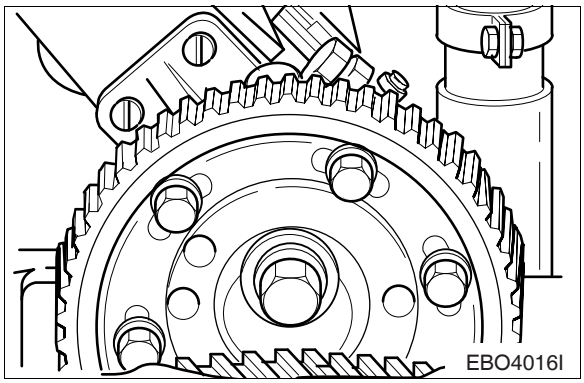
2) Check the injection timing degree whether the V-type edge of the flywheel housing sight hole coincides with the engine injection timing degree marked on the flywheel corresponding to fuel delivery position.



EBO4014I

<How to adjust injection timing>

- If upper pre-checked injection timing degree is wrong, follow as below.
  1) Loosen the fixing bolts(M8) of the injection pump driving gear in order to adjust the injection timing slightly.
  2) Turn the crank pulley clockwise until V-groove of the flywheel housing sight hole is aligned with the injection timing degree of the engine


EBO4016I

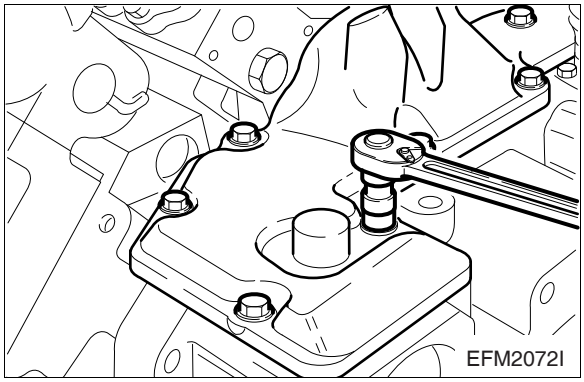
  3) Coincide the mark on pointer provided in injection pump with the matching mark (FB) on the flange surface of the drive gear by turning the flange in the oblong holes of the drive gear.
  4) Tighten the bolt (M8) to specified torque. (2.2 kg.m) not to move the drive gear
  5) After confirmation that fastening bolts are completely tightened check the start point (injection timing degree) of fuel delivery setting once more if not right repeat it again as same as upper way.

<Fuel injection timing degree>

V158TI	V158TI	V180TI	V222TI
26°	24°	24°	24°

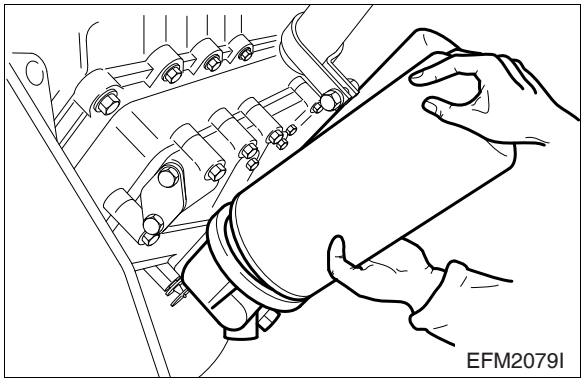
6.3.26. Flywheel housing cover

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


EFM2072I

6.3.27. Oil filter

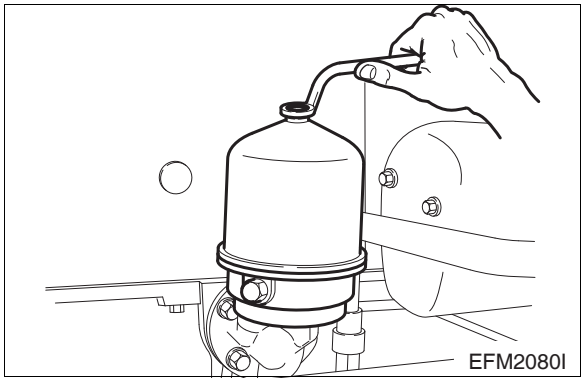
- Install the oil filter cartridge.


EFM2079I

6.3.28. Oil centrifugal filter

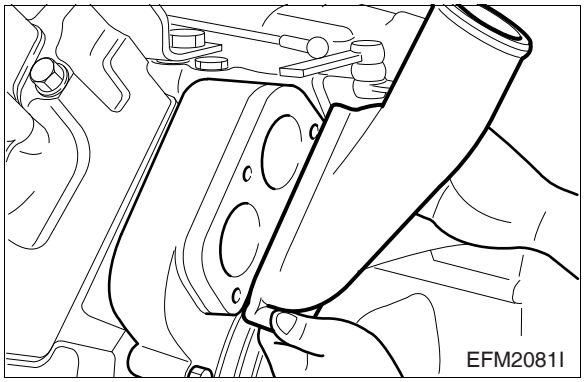
- Assembling is done in the reverse order of disassembling and take care at the state of O-ring installation.
- At the engine operation, make sure the smooth operation and no oil leaks from all the engine connections.
- Tighten the housing lock nut to specified torque.

Torque	1.5 kg.m



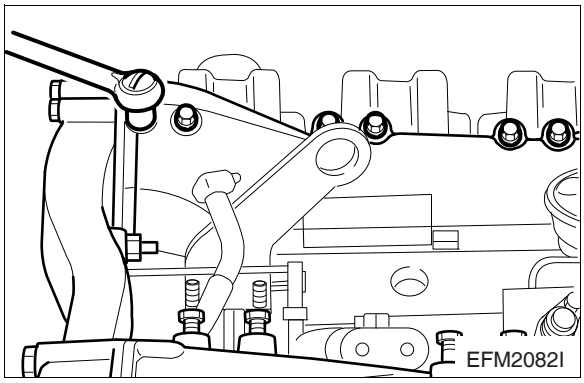
6.3.29. Fresh water pump

- Attach the gasket of the fresh water pump. (at cylinder block side)
- Assemble the fresh water pump by tightening the fixing bolts. (zigzag method)
- Insert the thermostat of fresh water pump.
- Insert the O-ring to the thermostat and assemble the cooling water pipes by tightening the fixing bolts.



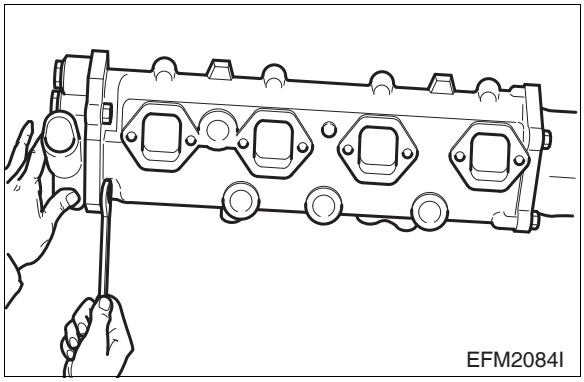
6.3.30. Intake manifold

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



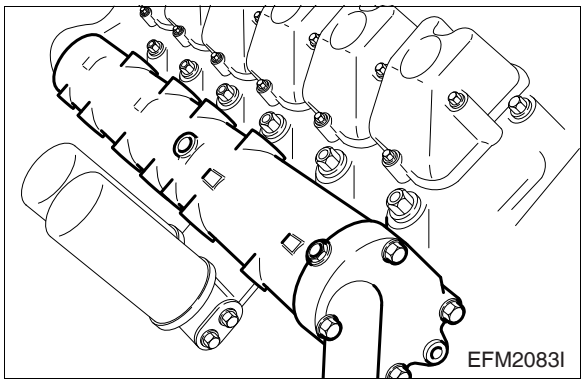
6.3.31. Exhaust manifold

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



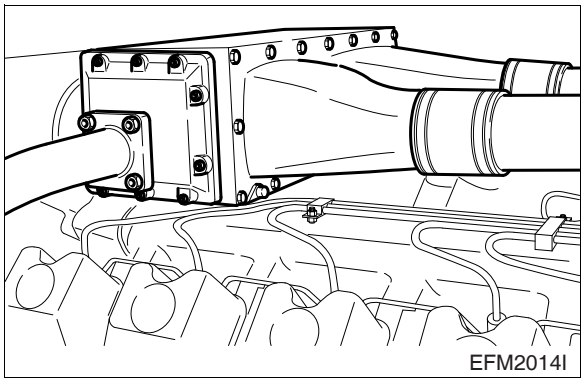
- Attach new gaskets to the exhaust manifold and then assemble the exhaust manifold with the fixing bolts.
- Attach the gasket to the exhaust elbow that is connected to the exhaust manifold, and assemble the elbow by tighten the nuts for connection.

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



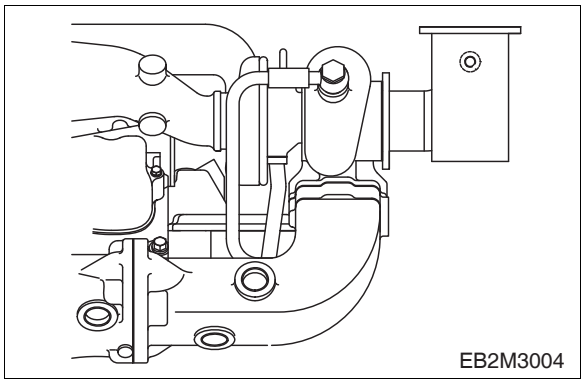
6.3.32. Inter-cooler

- After assembling the inter-cooler fixing bracket on the engine cylinder block, assemble the inter-cooler with the fixing bolts.
- Assemble the various hoses and pipes.



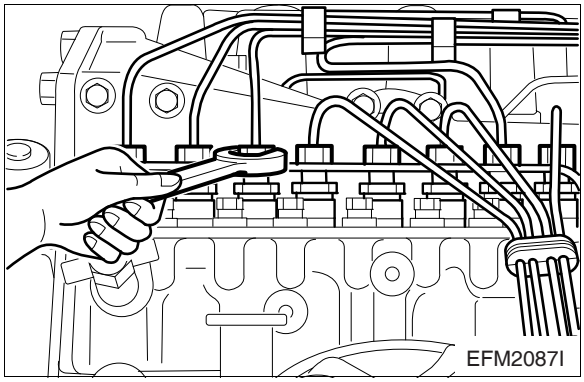
6.3.33. Turbocharger

- Attach the gasket to the exhaust elbow and assemble the turbocharger with fixing bolts.
- Attach the gasket on the oil supply and the discharge pipe and then assemble the pipes with fixing bolts.
- At the same way as above, other side can be assembled.



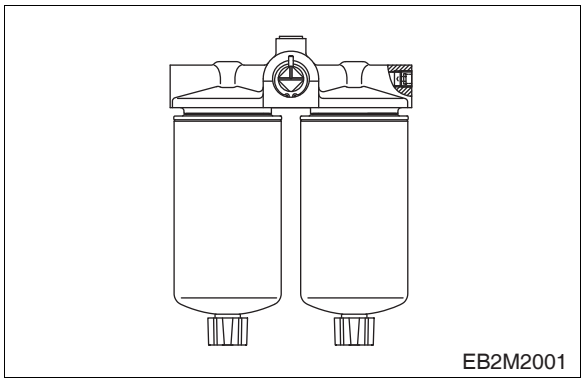
6.3.34. Fuel injection pipe

- Connect the fuel injection pipes to the fuel injection pump and the nozzle respectively and then assemble them by tightening nuts.
- Assemble the fuel return pipes by tightening fixing nuts.



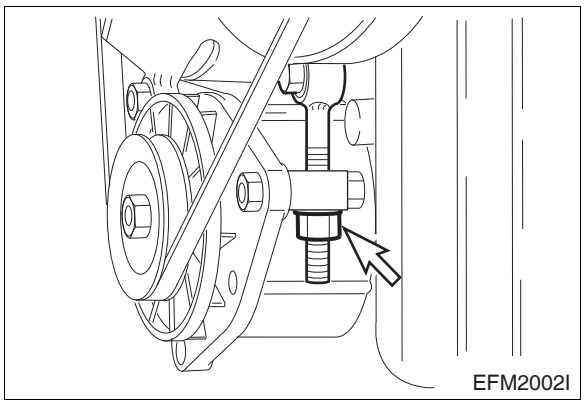
6.3.35. Fuel filter

- After installing the fuel filter in the bracket and assemble the fuel inlet and outlet hoses.
- Check the fuel adjusting cock whether its position is placed as figure in order to use both filters all the time.



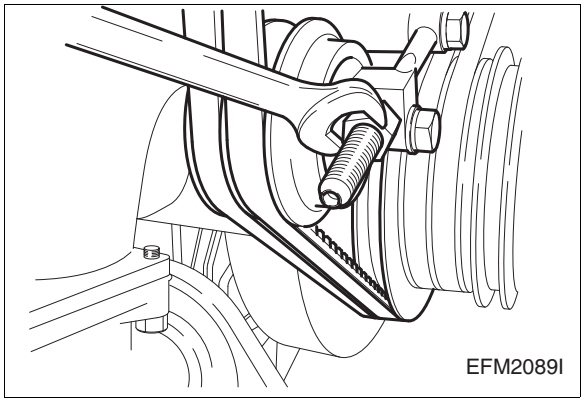
6.3.36. Alternator

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



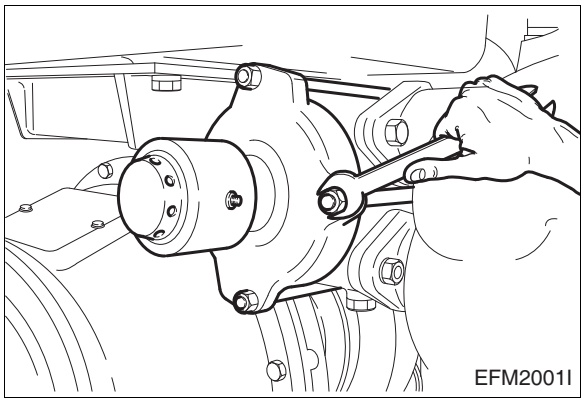
6.3.37. Idle pulley

- Install the idle pulley.
- Connect the water pump, the crank and the idle pulleys with driving V-belts.
- Tighten eye bolt and nut. (10 mm ~ 15 mm or so pushing with a thumb).



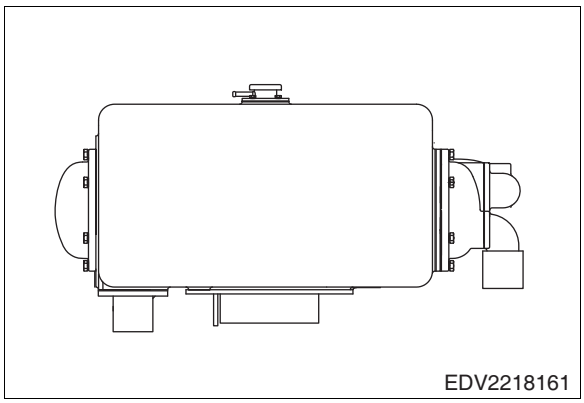
6.3.38. Sea water pump

- Assemble the sea water pump.
- Assemble the sea water filter on the inlet flange of sea water pump.
- Adjust the V-belt tension.



6.3.39. Heat Exchanger

- Assemble the heat exchanger bracket in the cylinder block.
- Install the heat exchanger on the bracket.
- Connect the inlet & outlet pipe of the heat exchanger.



6.4. Trial Test after Maintenance

Because the sliding surfaces of a maintenance engine are not lapped enough, the oil film can be destroyed easily by overload or over-speed and the engine life-time may be shortened. Therefore the following things must be obeyed by all means. (Refer to 3.3)

Up to the first 50 hours

- Engine should be run at fast idling (1,000 ~ 1,200 rpm) until the temperature of the engine becomes normal operating condition.
- Overload or continuous high speed operation should be avoided.
- High speed operation with no load should be prevented.
- Abrupt start and stop of the engine should be avoided.
- Engine speed must be under 70% of its maximum speed.
- Maintenance and inspection must be accomplished thoroughly.

7. MAIN PARTS MAINTENANCE

7.1. Lubricating System

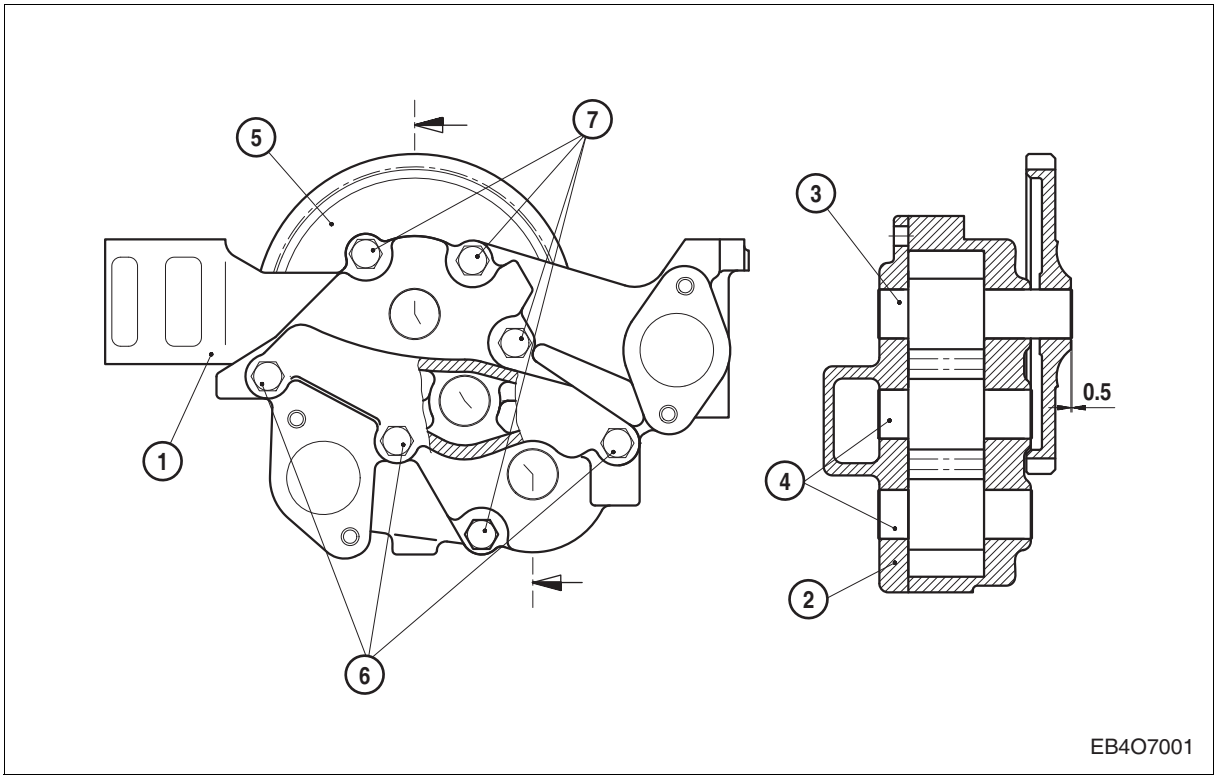
Lubricating oil pumped by the gear oil pump in the oil pan is filtrated in the oil filter.

This filtrated oil passed on the oil cooler and next the main oil gallery of the cylinder block where is distributed to lubricate the various sliding parts, fuel injection pump, and turbo-charger etc also in order to ensure normal engine performance.

7.1.1. Specifications

Item	Specifications	Item	Specifications
Lubricating system	Forced pressure circulation	Adjusting valve for spray nozzle opening pressure	1.5 ~ 1.8 kg/cm^2
Oil pump type	Gear type	Oil filter type	Full flow
Relief valve opening pressure	10 - 1.0 kg/cm^2	Bypass for filter element	Cartridge type
Bypass for oil cooler opening pressure	5 ±0.5 kg/cm^2		

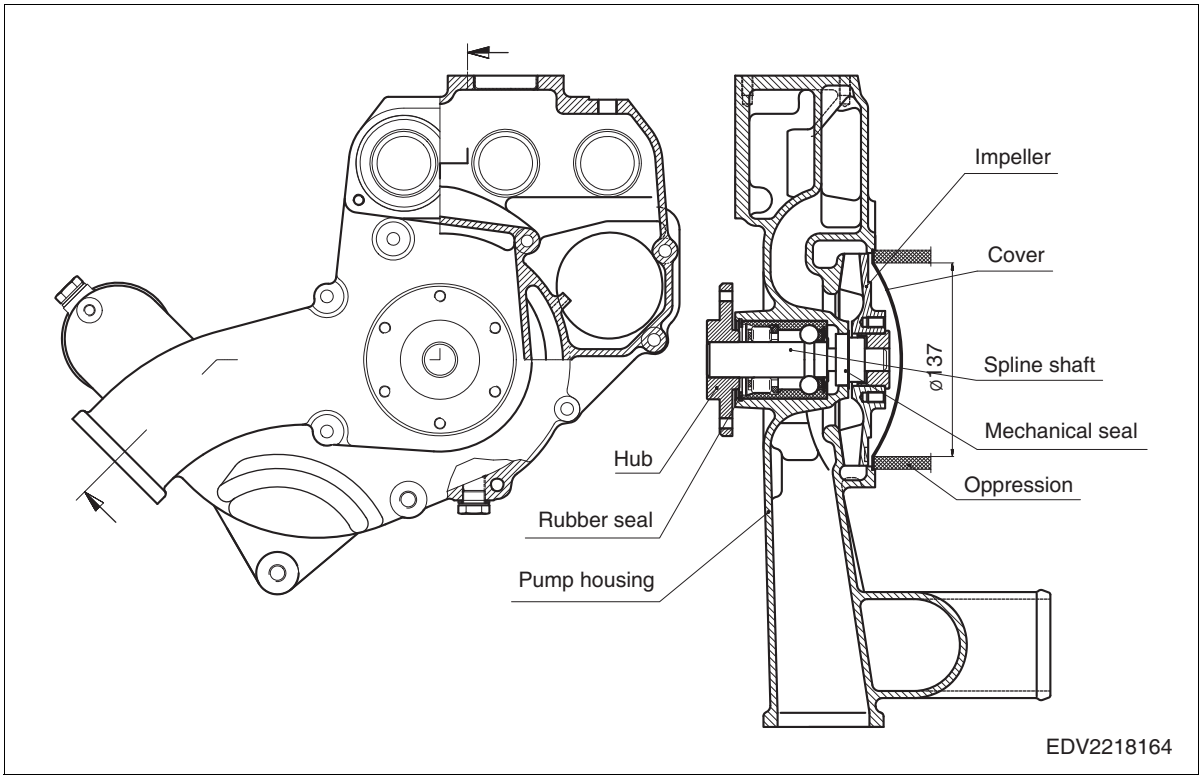
7.1.2.Oil pump



1. Oil Pump Housing
2. Cover
3. Oil Pump Gear
4. Oil Pump Gear
5. Oil Pump Drive Gear
6, 7. Bolts

7.2. Cooling System

7.2.1. Fresh water pump assembly



7.3. Fuel System

7.3.1. Injection pump

The components relating to the injection pump should be serviced at regular intervals as the plunger and delivery valve may be worn after a given length of time for use and cause the deterioration of the engine.

Make sure that servicing should be performed at the professional maintenance shop as authorized by Bosch or Zexel Company.

For adjustment of fuel injection volume, refer to the ′Specifications of fuel injection pump′ described as follows.

1) V158TIH

(1) Main data and specifications

Model : PE8P120A520LV
Injection pump : 65.11101-7680
Governor : RQV 300/900
Plunger : 2 418 455 188
Delivery valve : 2 418 552 039
Pre-stroke : 4.50 ±0.05 mm
Injection timing : BTDC 15° ±1°
Injection order : 1-5-7-2-6-3-4-8
Fuel feed pump : 0 440 008 152 (FP/KD22P78-2)
Rotating direction : C.C.W. at driving gear side

(2) Calibration data

(A) Test condition for injection pump	Nozzle & Holder ass'y	1 688 901 019	Opening pressure : 208.5 bar
	Injection pipe (OD, ID, L)	1 680 750 075	ø8.0 x ø3.0 - 1,000 mm
	Test oil	ISO4113	Temperature : 40 ±2°C
(B) Engine standard parts	Nozzle & Holder Ass'y	65.10101-7053	Nozzle (5 × ø0.418)
		0 432 131 669	Spec. : 280 bar
	Injection pipe (OD, ID, L)		ø6 x ø2.0 - 750 mm

Rack diagram and setting valve at each point

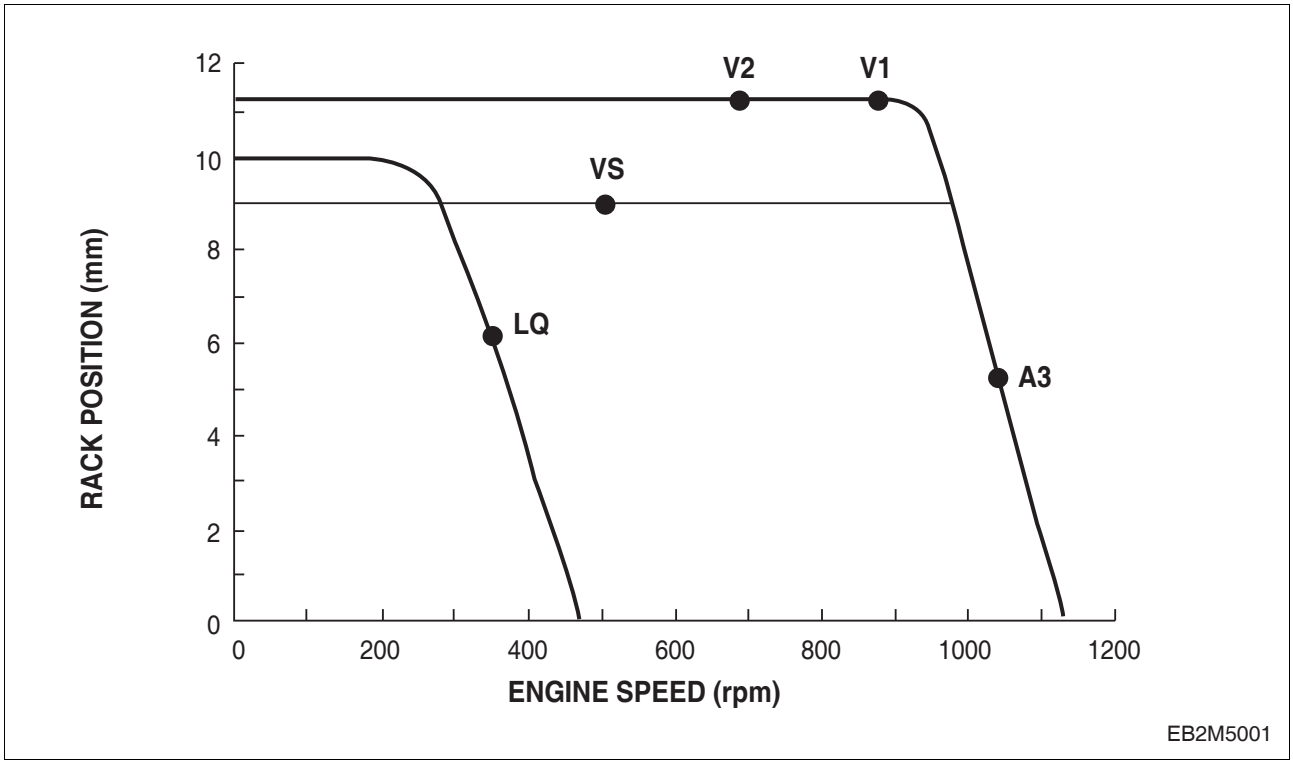
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 /1,000st)		Press. (mmHg)
				(A) Test condition for inj. pump	Remarks	
Refer to (3) rack diagram	V1	11.20 ±0.05	900	235.4 ±3.0	Max. power	1,500
	V2	11.20 ±0.10	700	230.4 ±3.0	-	1,500
	VS	8.96 ±0.20	500	159.8 ±1.0	-	0
	LQ	6.15 ±0.20	350	53.7 ±15.0	Only 2/3/4/8	0
	A3	7.10 ±0.50	1,010	109.4 ±15.0	Only 2/3/4/8	0
	ST	with Cap	100	127.5 ±10.0	Only 2/3/4/8	0

Boost pressure dependent full -load stop (boost compensator spring operation point)

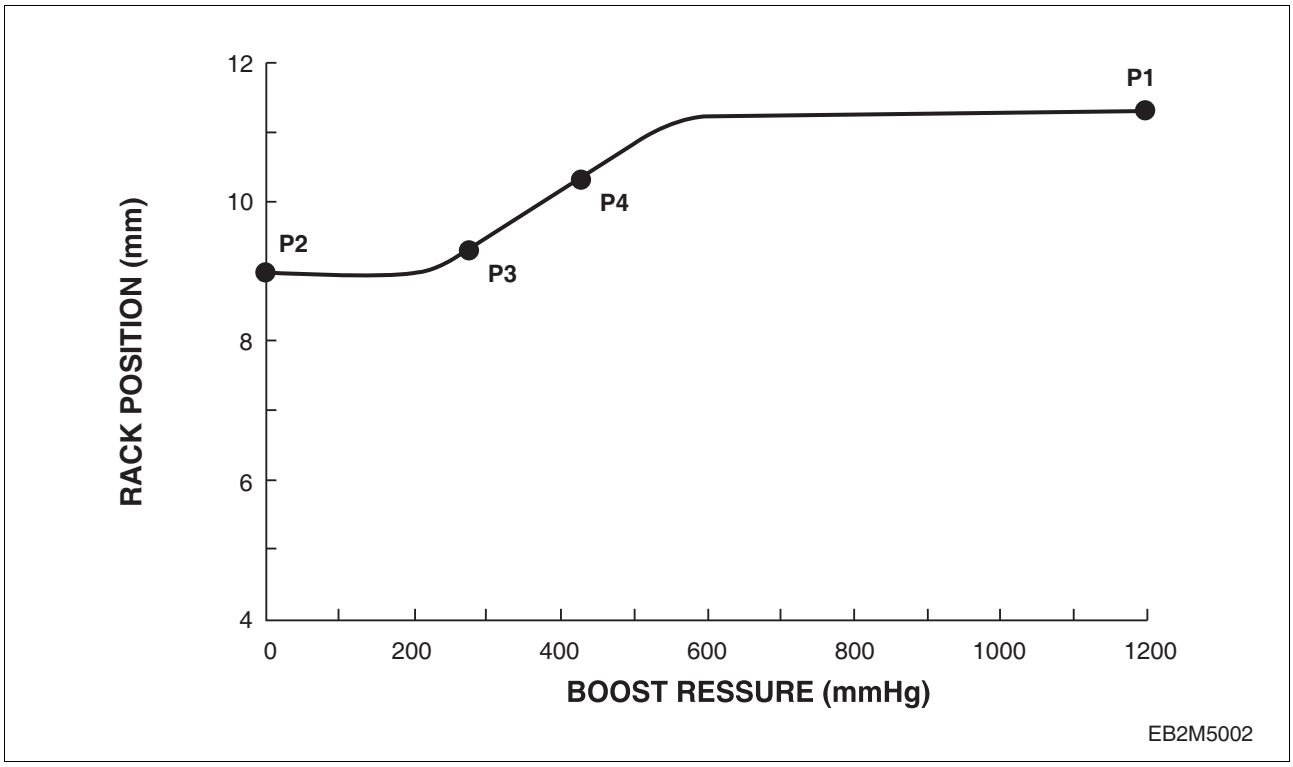
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 /1,000st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Refer to (4) boost pressure	P1	11.20 ±0.05	500	-	-	1,500
	P2	8.96 ±0.05	500	-	-	0
	P3	9.25 ±0.10	500			275
	P4	10.38 ±0.05	500	-	-	450

Weight	Weight =630g	Lever ratio (min/max)	Not fixed
Idle spring	k=14.03N/mm	Plunger	ø12
Middle spring	k=57.14N/mm	Delivery valve retraction volume	90 mm^3/st
Inner spring	None	Delivery valve opening pressure	-
LDA spring	k=30.50N/mm	Delivery valve spring	k = 7.2N/mm
Feed spring	Double action	Timer	None

(3) Rack diagram



(4) Boost compensator pressure



2) V158TIM

(1) Main data and specifications

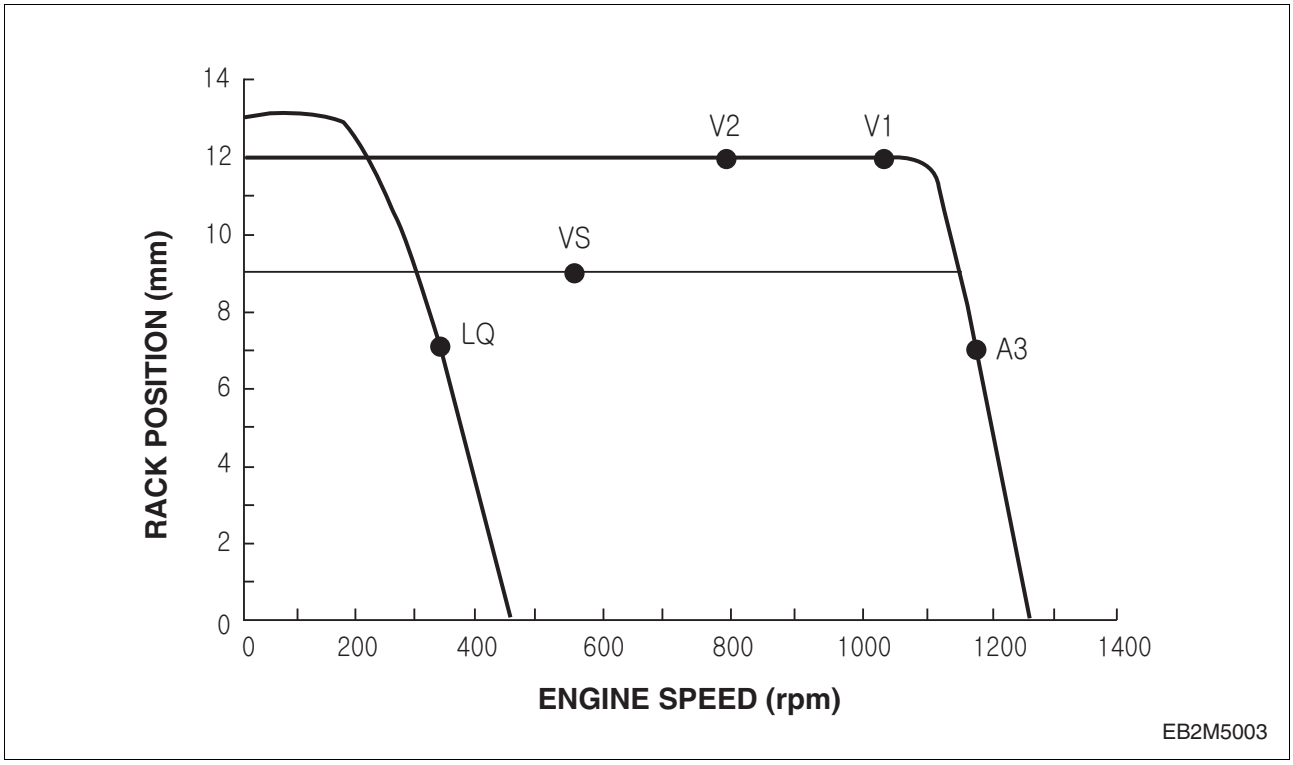
Model : PE8P120A520LV
Injection pump : 65.11101-7680
Governor : RQV 300/900
Plunger : 2 418 455 188
Delivery valve : 2 418 552 039
Pre-stroke : 4.50 ±0.05 mm
Injection timing : BTDC 16° ±1°
Injection order : 1-5-7-2-6-3-4-8
Fuel feed pump : 0 440 008 152 (FP/KD22P78-2)
Rotating direction : C.C.W. at driving gear side

(2) Calibration data

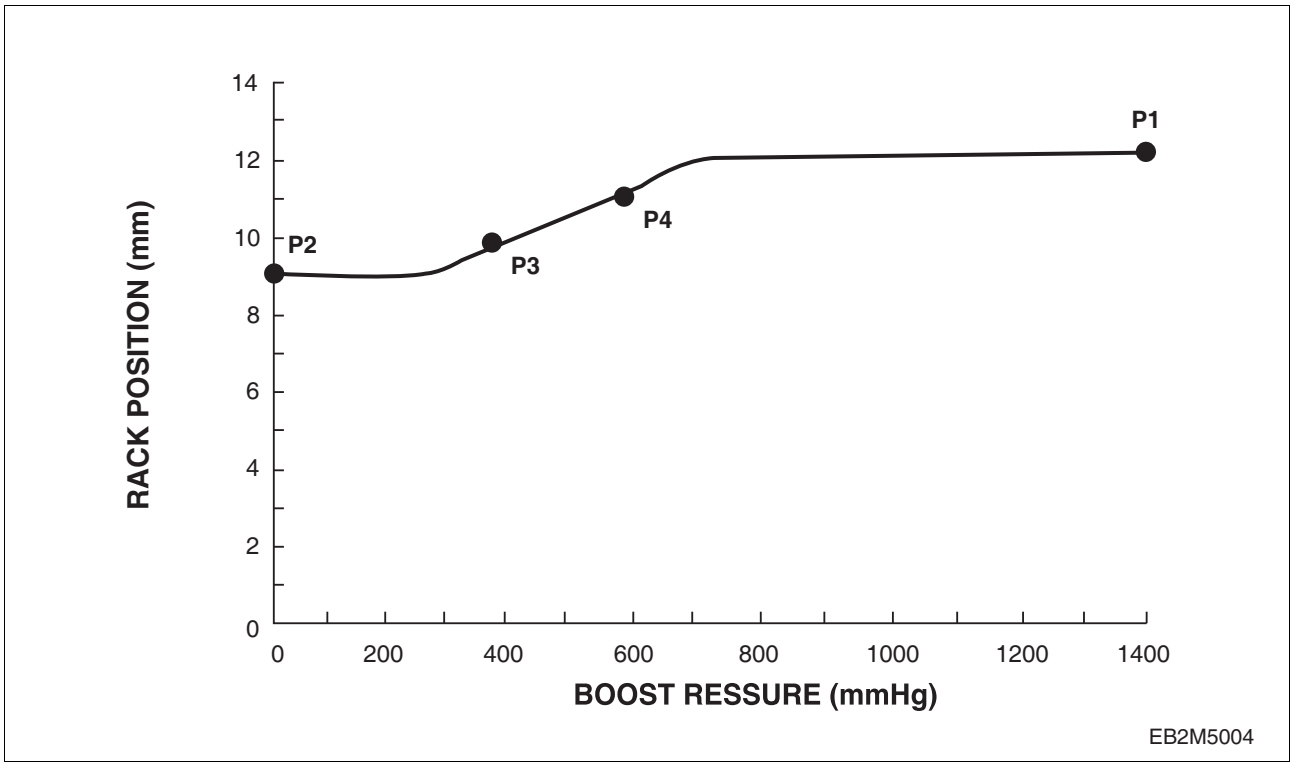
(A) Test condition for injection pump	Nozzle & Holder ass'y		1 688 901 019	Opening pressure : 212.6 bar		
	Injection pipe (OD, ID, L)		1 680 750 075	ø8.0 x ø3.0 - 1,000 mm		
	Test oil		ISO4113	Temperature : 40 ±2°C		
(B) Engine standard parts	Nozzle & Holder ass'y		65.10101-7053	Nozzle (5 × ø0.418)		
			0 432 131 669	Spec. : 285.5 bar		
	Injection pipe (OD, ID, L)			ø6 x ø2 - 750 mm		
Rack diagram and setting valve at each point						
Refer to (3) rack diagram	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 /1,000st) (A) Test condition for inj. pump	Remarks	Press. (mmHg)
	V1	12.00 ±0.05	1,050	266.0 ±3.0	Max. power	1,500
	V2	12.00 ±0.10	800	266.0 ±3.0	-	1,500
	VS	8.96 ±0.20	500	159.8 ±1.0	-	0
	LQ	6.15 ±0.20	350	53.7 ±15.0	Only 2/3/4/8	0
	A3	7.10 ±0.50	1,150	109.4 ±15.0	Only 2/3/4/8	0
	ST	with Cap	100	127.5 ±10.0	Only 2/3/4/8	0
Boost pressure dependent full -load stop (boost compensator spring operation point)						
Refer to (4) boost pressure	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 /1,000st) (A) Test condition for inj. pump	(B) Engine standard parts	Press. (mmHg)
	P1	12.00 ±0.05	500	-	-	1,500
	P2	8.96 ±0.05	500	-	-	0
	P3	9.25 ±0.10	500			275
	P4	11.20 ±0.05	500	-	-	600

Weight	Weight =630g	Lever ratio (min/max)	Not fixed
Idle spring	k=14.03N/mm	Plunger	ø12
Middle spring	k=57.14N/mm	Delivery valve retraction volume	90 mm^3/st
Inner spring	k=21.98N/mm	Delivery valve opening pressure	-
LDA spring	k=30.50N/mm	Delivery valve spring	k = 7.2N/mm
Feed spring	Double action	Timer	None

(3) Rack diagram



(4) Boost compensator pressure



3) V158TIL

(1) Main data and specifications

Model : PE8P120A520LV
Injection pump : 65.11101-7680
Governor : RQV 300/900
Plunger : 2 418 455 188
Delivery valve : 2 418 552 039
Pre-stroke : 4.50 ±0.05 mm
Injection timing : BTDC 18° ±1°
Injection order : 1-5-7-2-6-3-4-8
Fuel feed pump : 0 440 008 152 (FP/KD22P78-2)
Rotating direction : C.C.W. at driving gear side

(2) Calibration data

(A) Test condition for injection pump	Nozzle & Holder ass´y	1 688 901 019	Opening pressure : 212.6 bar
	Injection Pipe (OD, ID, L)	1 680 750 075	ø8.0 x ø3.0 x 1,000 mm
	Test oil	FUSUS	Temperature : 40 ±5°C
(B) Engine standard parts	Nozzle & Holder ass´y	65.10101-7053	Nozzle (5 × ø0.418)
		65.10102-6070	Spec. : 285.5 bar
	Injection pipe (OD, ID, L)	65.10301-6053A 65.10301-6054A	ø2.0 x ø6.35 x 750 mm

Rack diagram and setting valve at each point

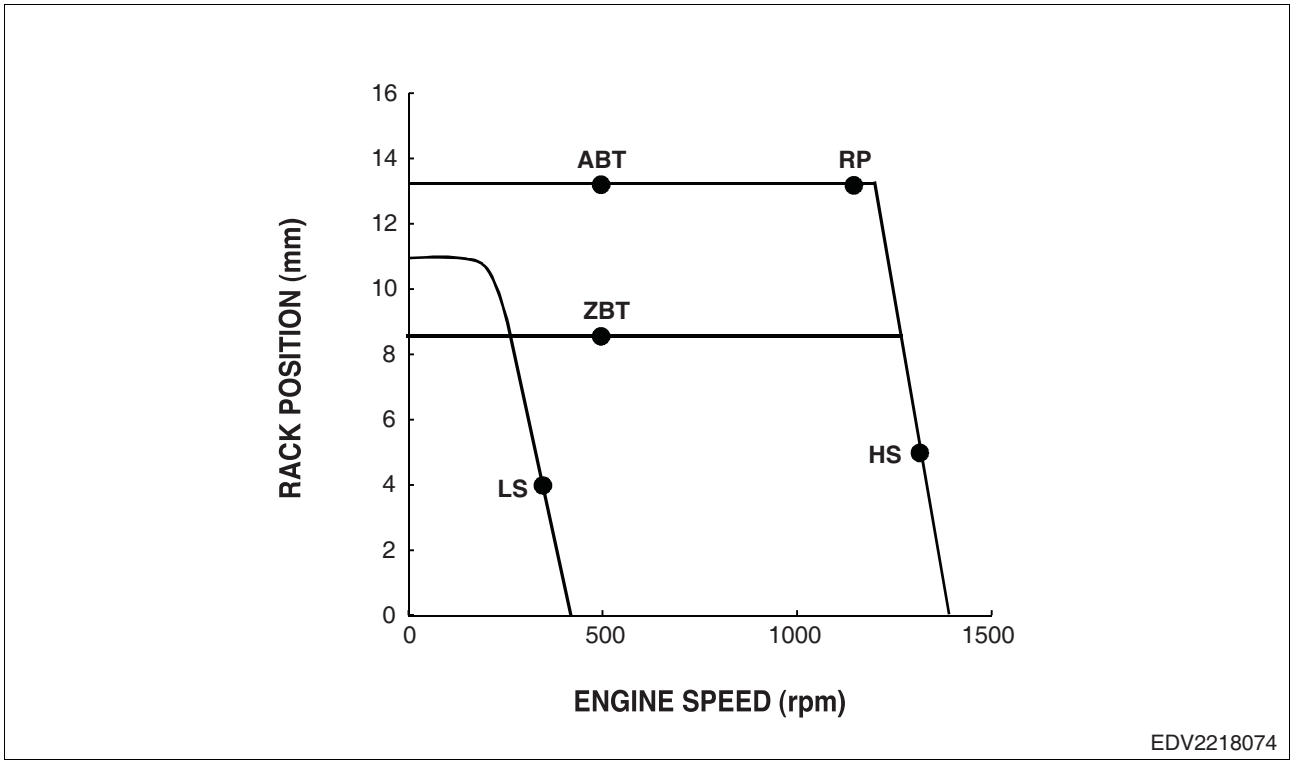
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q´ty on RIG (mm^3 /1,000st)		Press. (mmHg)
				(A) Test condition for inj. pump	Remarks	
Refer to (3) rack diagram	RP	14.02	1,150	362.3	-	1,500
	ABT	14.06	500	447.5	-	1,500
	ZBT	8,39	500	204.4	-	-
	HS	4,76	1,320	91.5	-	-
	LS	4,00	350	50.0	-	-
	ST	W/CAP	100	180.0	-	-

Boost pressure dependent full -load stop (boost compensator spring operation point)

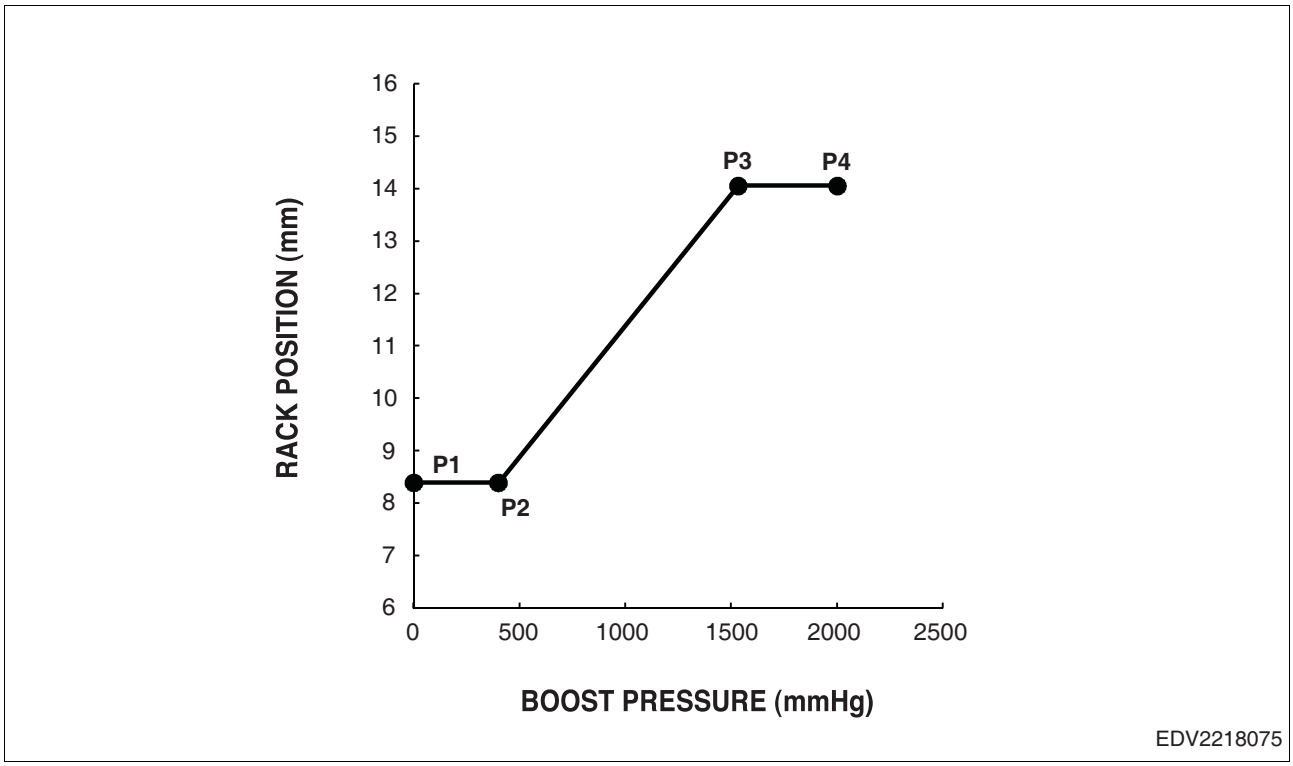
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q´ty on RIG (mm^3 /1,000st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Refer to (4) boost pressure	P1	8.39	500			0
	P2	8.39	-			300
	P3	14.06	-			1,150
	P4	14.06	-			1,500

Weight	Weight =630g	Lever ratio (min/max)	Not fixed
Idle spring	k=14.03N/mm	Plunger	ø12
Middle spring	k=57.14N/mm	Delivery valve retraction volume	90 mm^3/st
Inner spring	k=21.98N/mm	Delivery valve opening pressure	-
LDA spring	k=30.50N/mm	Delivery valve spring	k = 7.2N/mm
Feed spring	Double action	Timer	None

(3) Rack diagram



(4) Boost compensator pressure



4) V180TIH

(1) Main data and specifications

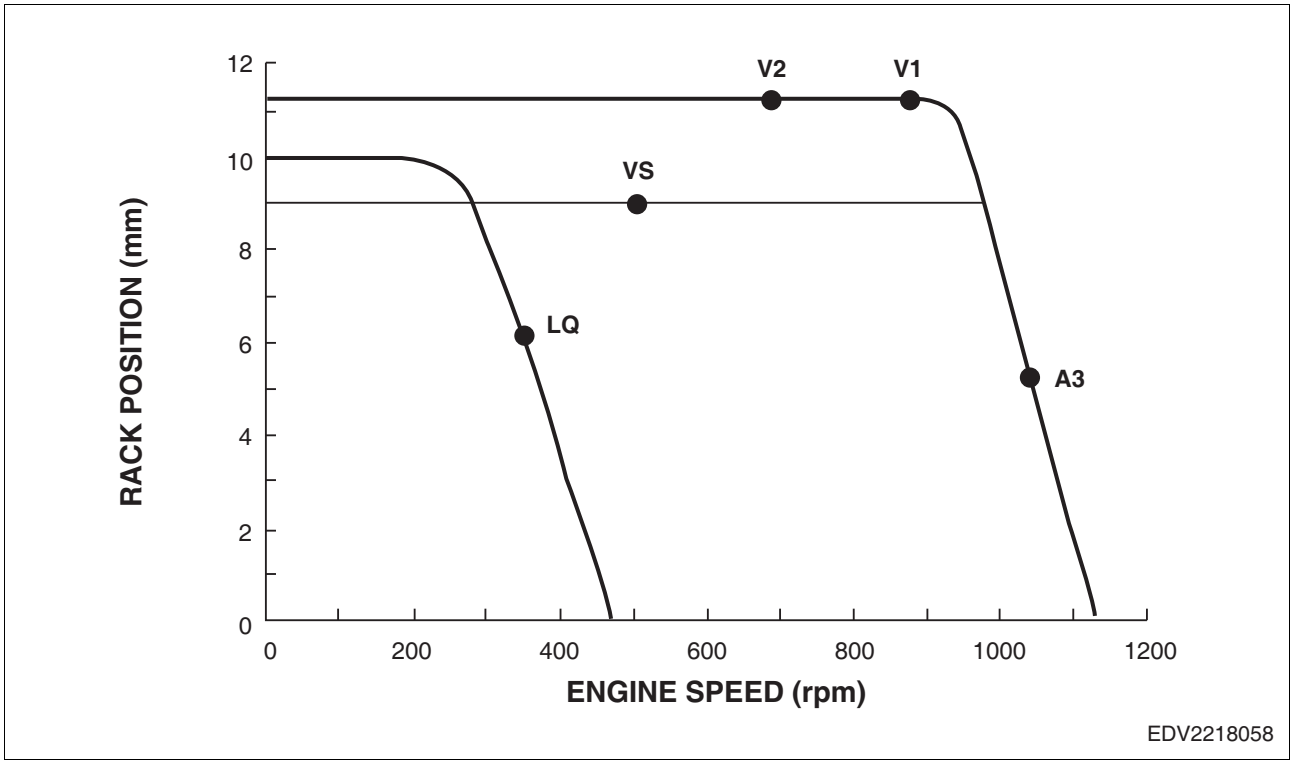
Model : PE10P120A520LV
Injection pump : 65.11101-7681
Governor : RQV 300/900
Plunger : 2 418 455 188
Delivery valve : 2 418 552 039
Pre-stroke : 4.50 ±0.05 mm
Injection timing : BTDC 16° ±1°
Injection order : 1-6-5-10-2-7-3-8-4-9
Fuel feed pump : 0 440 008 152, 0 440 008 090 (FP/KD22P78-2, KP/KD22P80-1)
Rotating direction : C.C.W. at driving gear side

(2) Calibration data

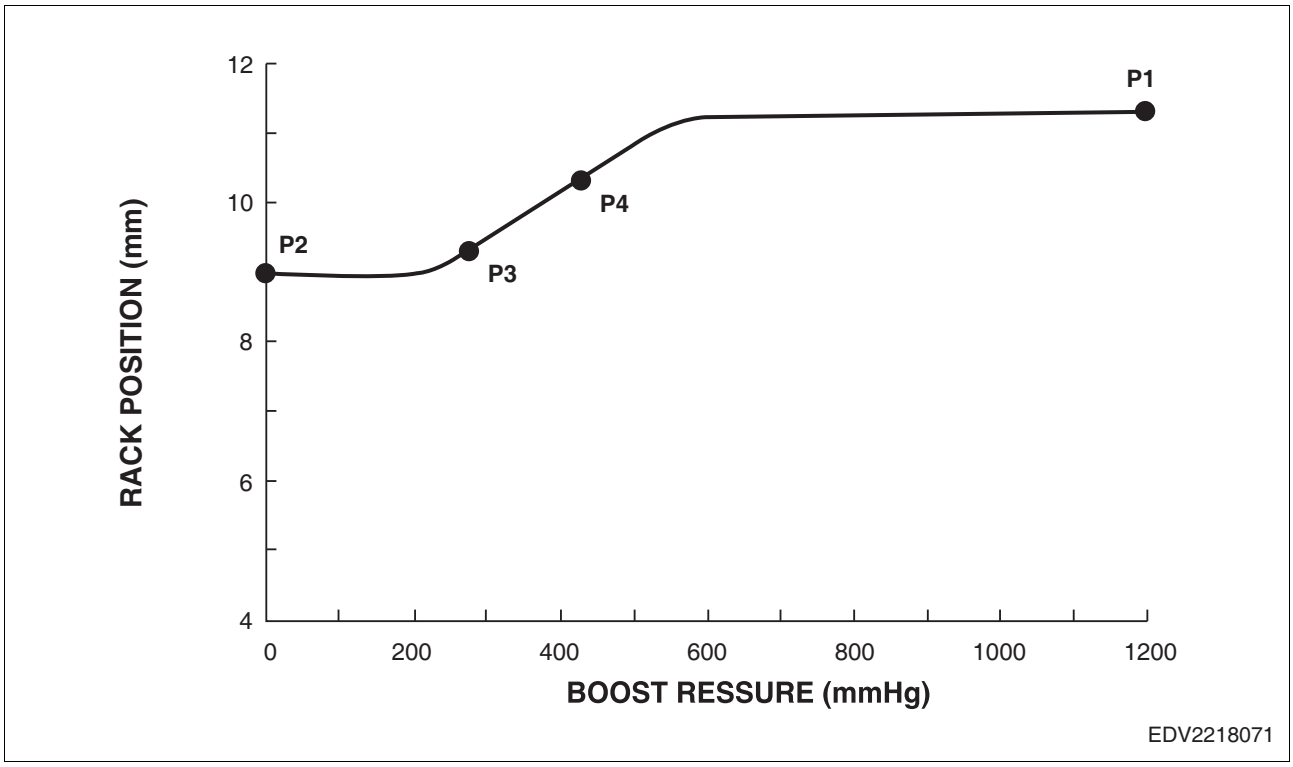
(A) Test condition for injection pump	Nozzle & Holder ass'y			1 688 901 019	Opening pressure : 208.5 bar	
	Injection pipe (OD, ID, L)			1 680 750 075	ø8.0 x ø3.0 - 1,000 mm	
	Test oil			ISO4113	Temperature : 40 ±2°C	
(B) Engine standard parts	Nozzle & Holder ass'y			65.10101-7053	Nozzle (5 × ø0.418)	
				0 432 131 669	Spec. : 280 bar	
	Injection pipe (OD, ID, L)				ø6 x ø2.0 - 750 mm	
Rack diagram and setting valve at each point						
Refer to (3) rack diagram	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 /1,000st) (A) Test condition for inj. pump	Remarks	Press. (mmHg)
	V1	11.55 ±0.05	900	244 ±3.0	Max. power	1,500
	V2	11.55 ±0.10	700	242 ±3.0	-	1,500
	VS	9.20 ±0.20	500	162 ±1.0	-	0
	LQ	6.10 ±0.20	350	48 ±15.0	Only 4/5/6/8/10	0
	A3	7.30 ±0.50	1,020	112 ±15.0	Only 4/5/6/8/10	0
	ST	with Cap	100	115 ±10.0	Only 4/5/6/8/10	0
Boost pressure dependent full -load stop (boost compensator spring operation point)						
Refer to (4) boost pressure	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 /1,000st) (A) Test condition for inj. pump	(B) Engine standard parts	Press. (mmHg)
	P1	11.55 ±0.05	500	-	-	1,500
	P2	9.20 ±0.05	500	-	-	0
	P3	9.90 ±0.10	500			300
	P4	10.90 ±0.05	500	-	-	450

Weight	Weight =630g	Lever ratio (min/max)	Not fixed
Idle spring	k=14.03N/mm	Plunger	ø12
Middle spring	k=57.14N/mm	Delivery valve retraction volume	90 mm^3/st
Inner spring	None	Delivery valve opening pressure	-
LDA spring	k=30.50N/mm	Delivery valve spring	k = 7.2N/mm
Feed spring	Double action×2	Timer	None

(3) Rack diagram



(4) Boost compensator pressure



5) V180TIM

(1) Main data and specifications

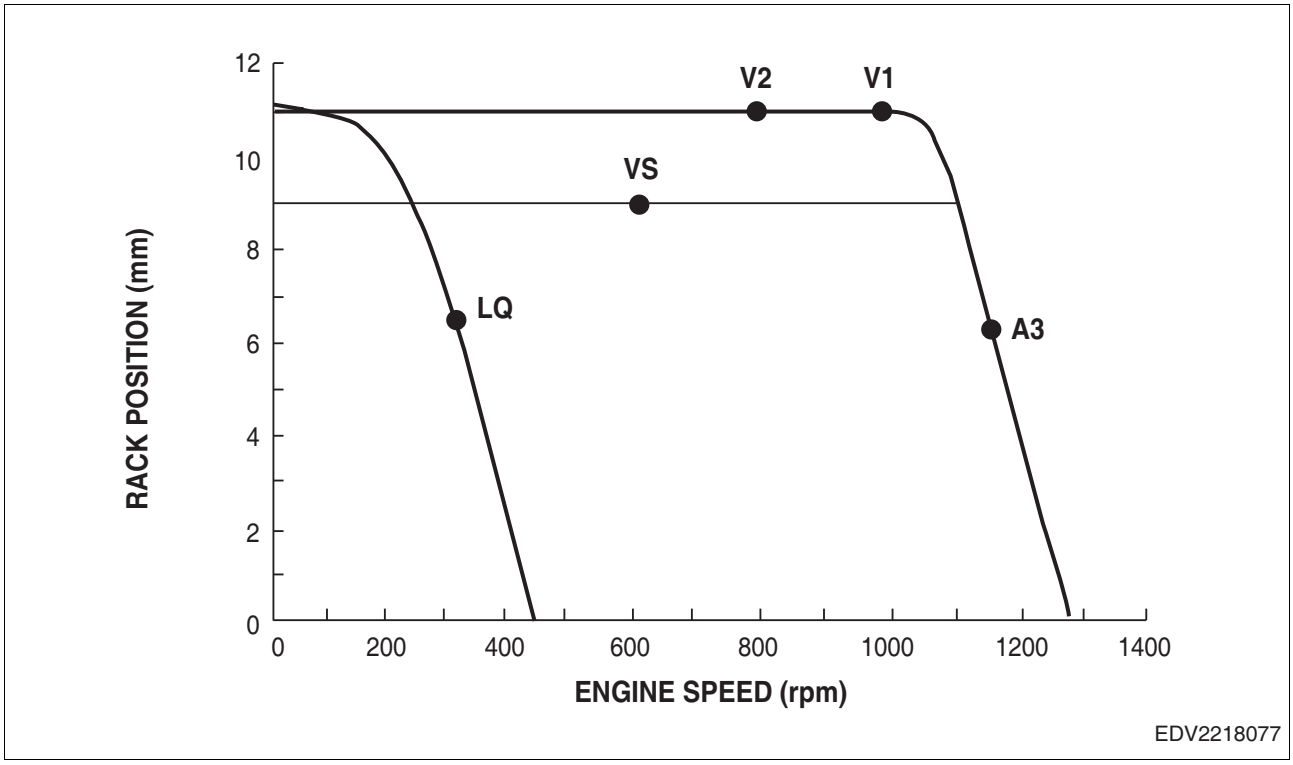
Model : PE8P120A520LV
Injection pump : 65.11101-7681
Governor : RQV 300/900
Plunger : 2 418 455 188
Delivery valve : 2 418 552 039
Pre-stroke : 4.50 ±0.05 mm
Injection timing : BTDC 18° ±1°
Injection order : 1-5-7-2-6-3-4-8
Fuel feed pump : 0 440 008 152 (FP/KD22P78-2)
Rotating direction : C.C.W. at driving gear side

(2) Calibration data

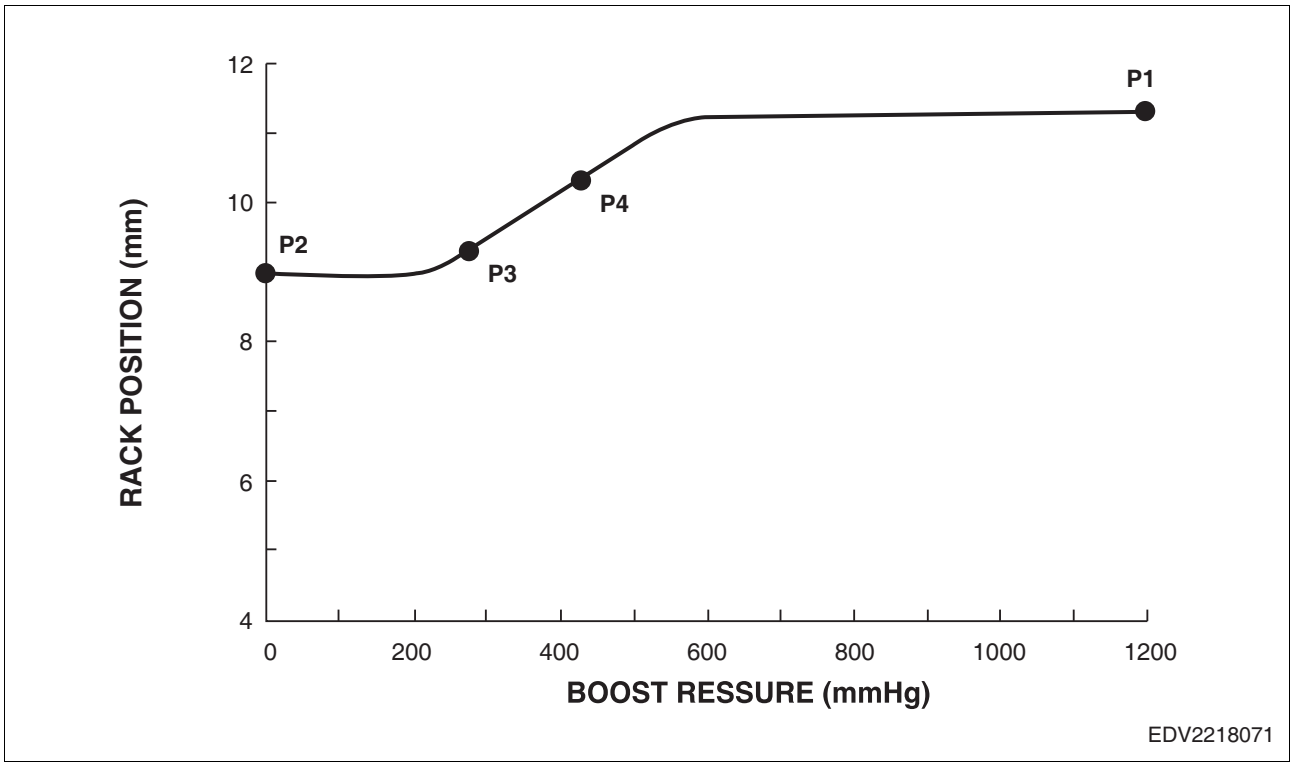
<table>
<tr><td rowspan="3">(A) Test condition for injection pump</td><td>Nozzle & Holder ass'y</td><td>1 688 901 019</td><td colspan="3">Opening pressure : 212.6 bar</td></tr>
<tr><td>Injection pipe (OD, ID, L)</td><td>1 680 750 075</td><td colspan="3">ø8.0 x ø3.0 - 1,000 mm</td></tr>
<tr><td>Test oil</td><td>ISO4113</td><td colspan="3">Temperature : 40 ±2°C</td></tr>
<tr><td rowspan="3">(B) Engine standard parts</td><td rowspan="2">Nozzle & Holder ass'y</td><td>65.10101-7053</td><td colspan="3">Nozzle (5 × ø0.418)</td></tr>
<tr><td>0 432 131 669</td><td colspan="3">Spec. : 285.5 bar</td></tr>
<tr><td>Injection pipe (OD, ID, L)</td><td></td><td colspan="3">ø6 x ø2.0 - 750 mm</td></tr>
<tr><td colspan="6">Rack diagram and setting valve at each point</td></tr>
<tr><td rowspan="8">Refer to
(3) rack diagram</td><td rowspan="2">Check point</td><td rowspan="2">Rack position (mm)</td><td rowspan="2">Pump speed (rpm)</td><td colspan="2">Injection Q'ty on RIG (mm^3 /1,000st)</td><td rowspan="2">Press. (mmHg)</td></tr>
<tr><td>(A) Test condition for inj. pump</td><td>Remarks</td></tr>
<tr><td>V1</td><td>11.55 ±0.05</td><td>1,050</td><td>243.0 ±3.0</td><td>Max. power</td><td>1,500</td></tr>
<tr><td>V2</td><td>11.55 ±0.10</td><td>800</td><td>240.4 ±3.0</td><td>-</td><td>1,500</td></tr>
<tr><td>VS</td><td>8.96 ±0.20</td><td>500</td><td>159.8 ±1.0</td><td>-</td><td>0</td></tr>
<tr><td>LQ</td><td>6.15 ±0.20</td><td>350</td><td>53.7 ±15.0</td><td>Only 2/3/4/8</td><td>0</td></tr>
<tr><td>A3</td><td>7.10 ±0.50</td><td>1,150</td><td>109.4 ±15.0</td><td>Only 2/3/4/8</td><td>0</td></tr>
<tr><td>ST</td><td>with Cap</td><td>100</td><td>127.5 ±10.0</td><td>Only 2/3/4/8</td><td>0</td></tr>
<tr><td colspan="6">Boost pressure dependent full -load stop (boost compensator spring operation point)</td></tr>
<tr><td rowspan="5">Refer to
(4) boost pressure</td><td rowspan="2">Check point</td><td rowspan="2">Rack position (mm)</td><td rowspan="2">Pump speed (rpm)</td><td colspan="2">Injection Q'ty on RIG (mm^3 /1,000st)</td><td rowspan="2">Press. (mmHg)</td></tr>
<tr><td>(A) Test condition for inj. pump</td><td>(B) Engine standard parts</td></tr>
<tr><td>P1</td><td>11.55 ±0.05</td><td>500</td><td>-</td><td>-</td><td>1,500</td></tr>
<tr><td>P2</td><td>8.96 ±0.05</td><td>500</td><td>-</td><td>-</td><td>0</td></tr>
<tr><td>P3</td><td>9.9 ±0.10</td><td>500</td><td></td><td></td><td>275</td></tr>
<tr><td>P4</td><td>10.90 ±0.05</td><td>500</td><td>-</td><td>-</td><td>450</td></tr>
</table>

Weight	Weight =630g	Lever ratio (min/max)	Not fixed
Idle spring	k=14.03N/mm	Plunger	ø12
Middle spring	k=57.14N/mm	Delivery valve retraction volume	90 mm^3/st
Inner spring	k=21.98N/mm	Delivery valve opening pressure	-
LDA spring	k=30.50N/mm	Delivery valve spring	k = 7.2N/mm
Feed spring	Double action	Timer	None

(3) Rack diagram



(4) Boost compensator pressure



6) V180TIL

(1) Main data and specifications

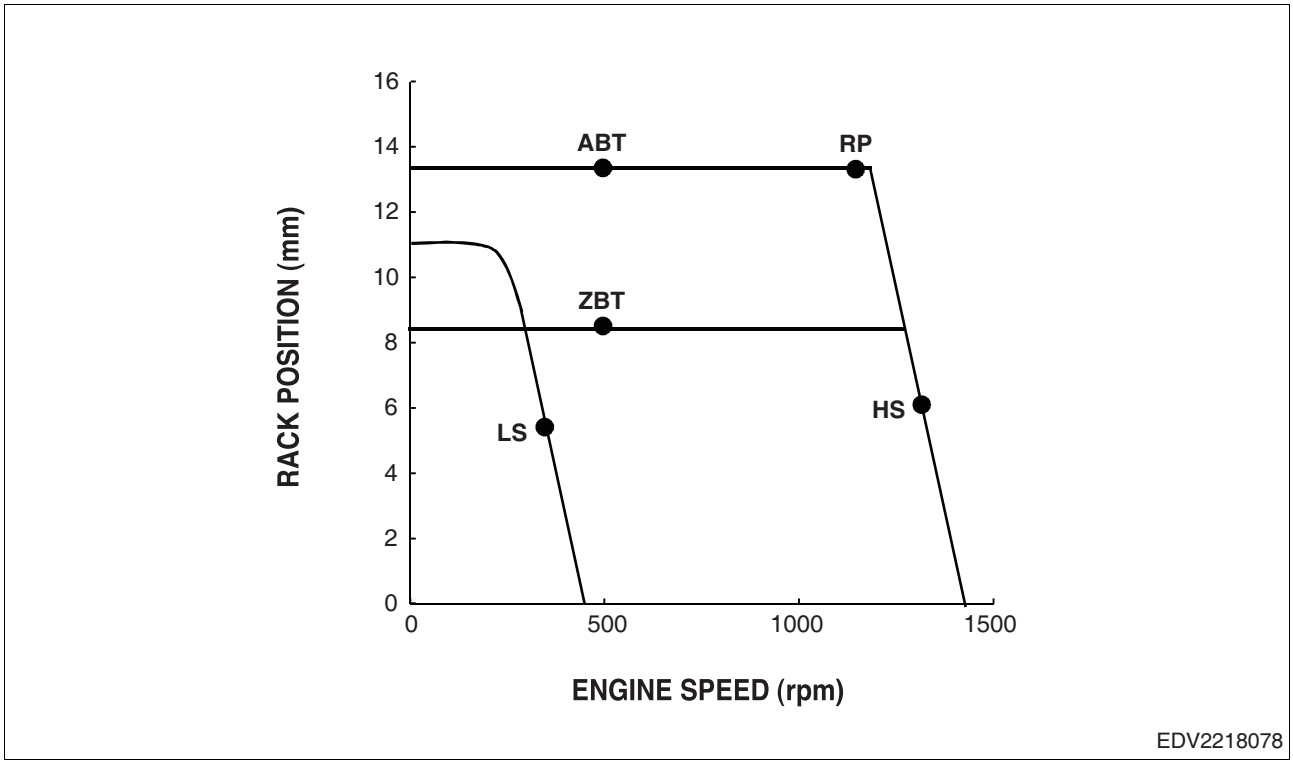
Model : PE8P120A520LV
Injection pump : 65.11101-7681
Governor : RQV 300/900
Plunger : 2 418 455 188
Delivery valve : 2 418 552 039
Pre-stroke : 4.50 ±0.05 mm
Injection timing : BTDC 18° ±1°
Injection order : 1-6-5-10-2-7-3-8-4-9
Fuel feed pump : 0 440 008 152 (FP/KD22P78-2)
Rotating direction : C.C.W. at driving gear side

(2) Calibration data

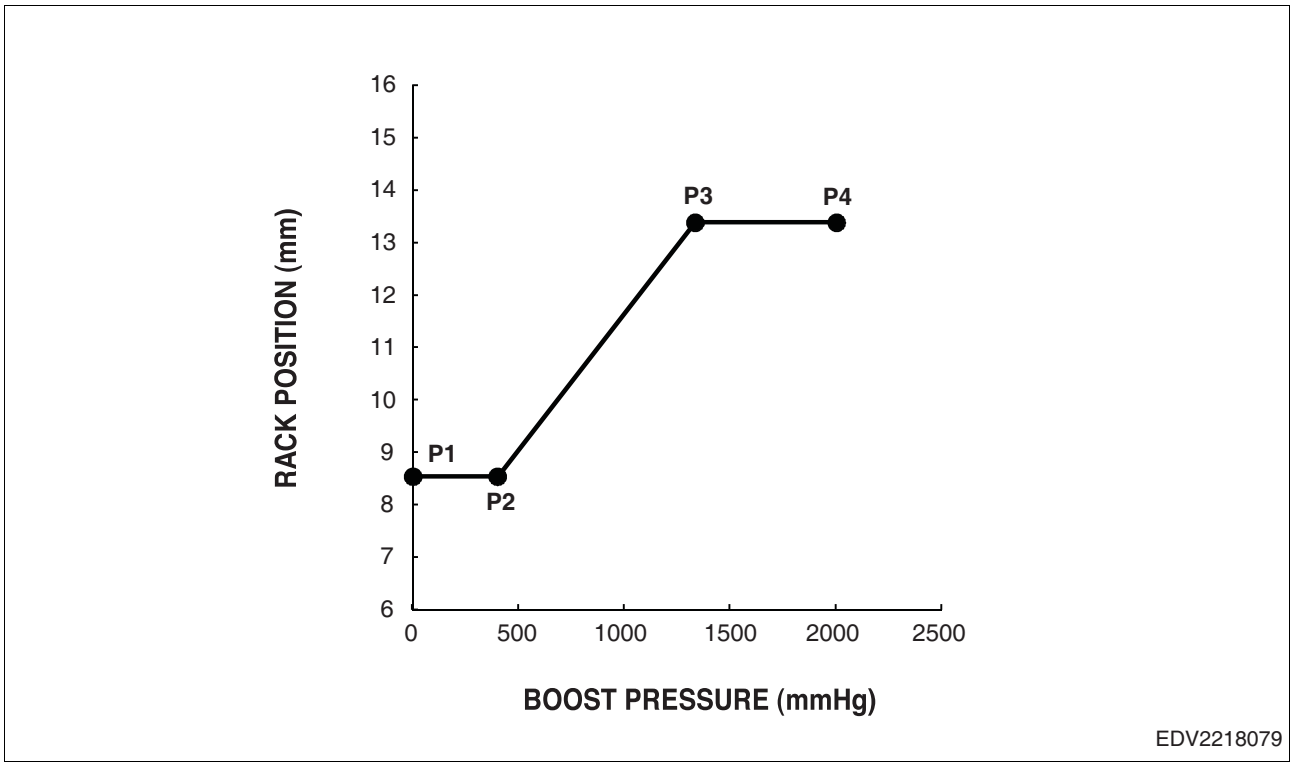
(A) Test condition for injection pump	Nozzle & Holder ass'y		1 688 901 019	Opening pressure : 212.6 bar		
	Injection pipe (OD, ID, L)		1 680 750 075	ø3.0 x ø8.0 x 1,000 mm		
	Test oil		FUSUS	Temperature : 40 ±5°C		
(B) Engine standard parts	Nozzle & Holder ass'y		65.10101-7053	Nozzle (5 × ø0.418)		
			65.10102-6070	Spec. : 285.5 bar		
	Injection pipe (OD, ID, L)		65.10301-6055B 65.10301-6056B	ø2.0 x ø6.35 x 750 mm		
Rack diagram and setting valve at each point						
Refer to (3) rack diagram	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 /1,000st) (A) Test condition for inj. pump	Remarks	Press. (mmHg)
	RP	13.33	1,150	297.3	-	1,000
	ABT	13.37	500	306.7	-	1,000
	ZBT	8,52	500	143.2	-	-
	HS	6,12	1,320	85.5	-	-
	LS	5,43	350	36.1	-	-
	ST	W/CAP	100	187.5	-	-
Boost pressure dependent full -load stop (boost compensator spring operation point)						
Refer to (4) boost pressure	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 /1,000st) (A) Test condition for inj. pump	(B) Engine standard parts	Press. (mmHg)
	P1	8.52	500			0
	P2	8.52	-			300
	P3	13.37	-			1,000
	P4	13.37	-			1,500

Weight	Weight =630g	Lever ratio (min/max)	Not fixed
Idle spring	k=14.03N/mm	Plunger	ø12
Middle spring	k=57.14N/mm	Delivery valve retraction volume	90 mm^3/st
Inner spring	k=21.98N/mm	Delivery valve opening pressure	-
LDA spring	k=30.5N/mm	Delivery valve spring	k = 7.2N/mm
Feed spring	Double action	Timer	None

(3) Rack diagram



(4) Boost compensator pressure



7) V222TIH

(1) Main data and specifications

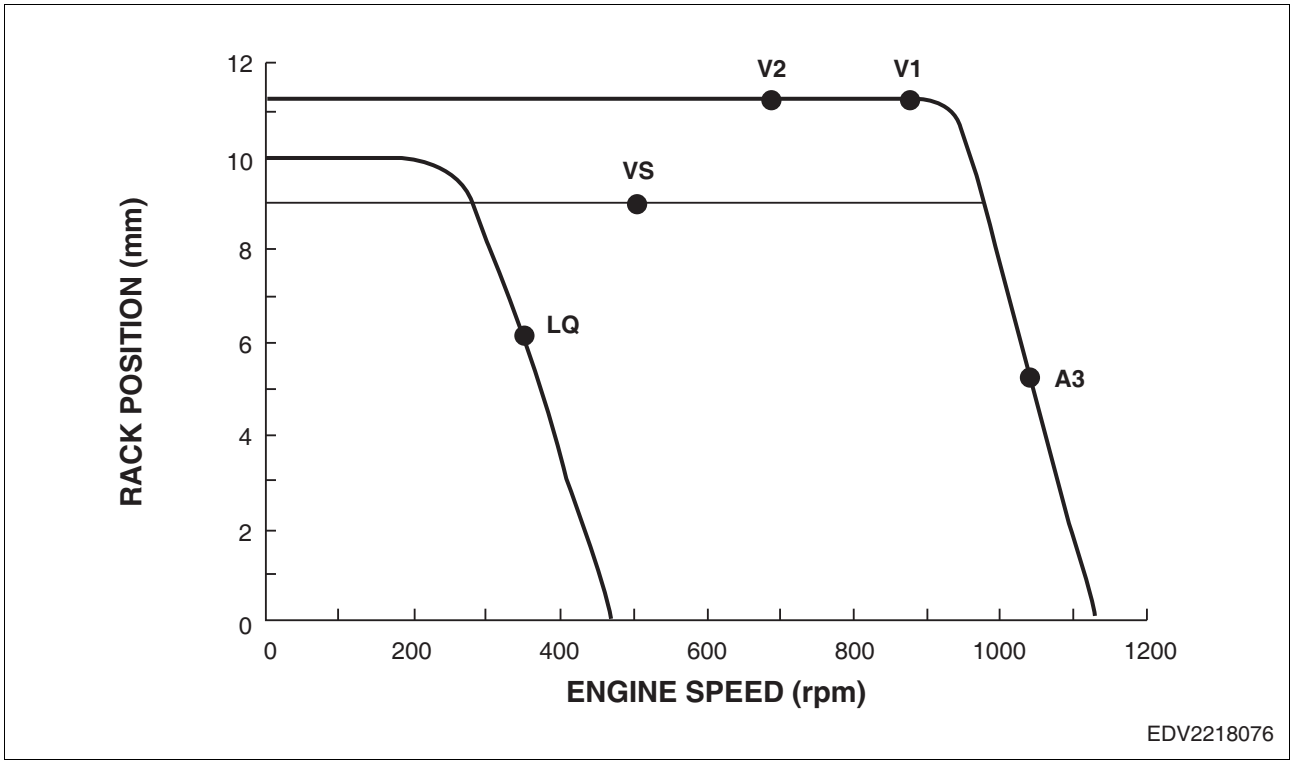
Model : PE12P120A500LV
Injection pump : 65.11101-7682
Governor : RQV 300/900
Plunger : 2 418 455 188
Delivery valve : 2 418 552 039
Pre-stroke : 4.50 ±0.05 mm
Injection timing : BTDC 20° ±1°
Injection order : 1-12-10-7-8-11-5-2-3-6-4-9
Fuel feed pump : 0 440 008 152, 0 440 008 090 (FP/KD22P78-2, KP/KD22P80-1)
Rotating direction : C.C.W. at driving gear side

(2) Calibration data

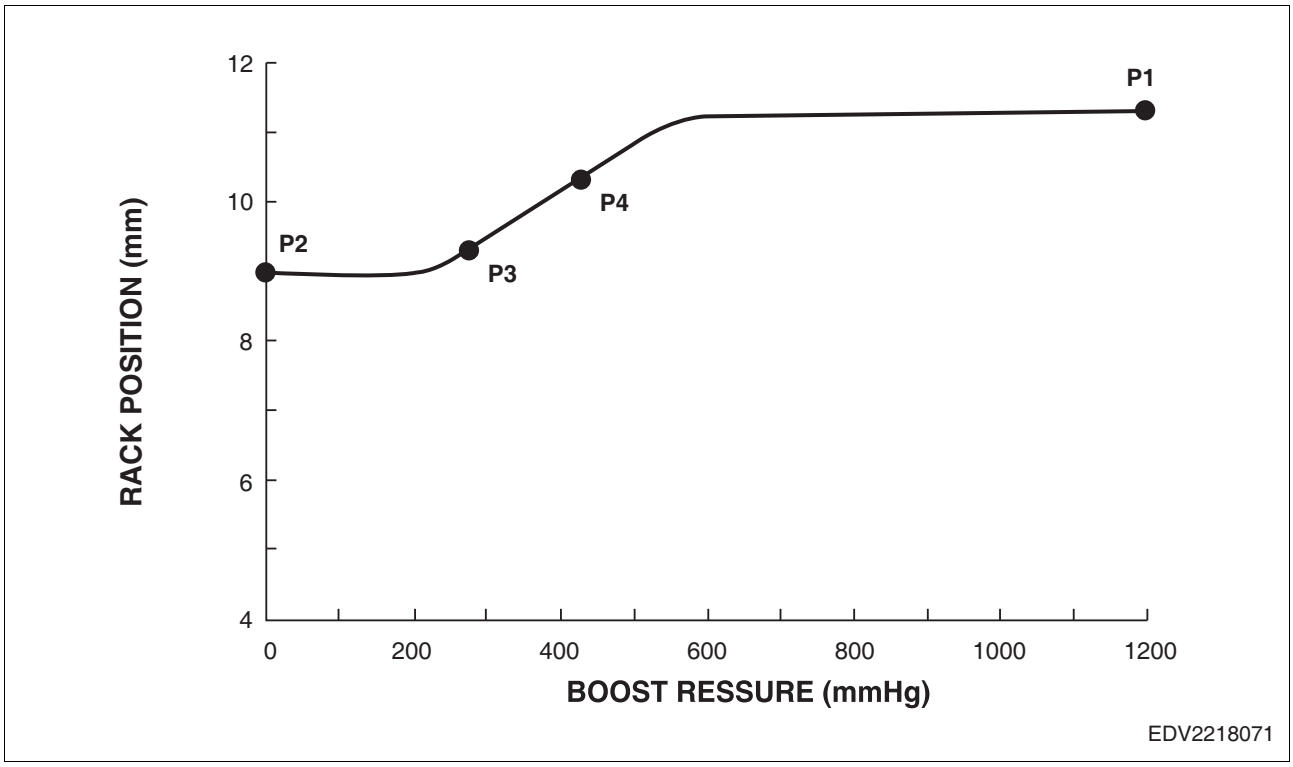
(A) Test condition for injection pump	Nozzle & Holder ass'y			1 688 901 019	Opening pressure : 208.5 bar	
	Injection pipe (OD, ID, L)			1 680 750 075	ø8.0 x ø3.0 - 1,000 mm	
	Test oil			ISO4113	Temperature : 40 ±2°C	
(B) Engine standard parts	Nozzle & Holder ass'y			65.10101-7053	Nozzle (5 × ø0.418)	
				0 432 131 669	Spec. : 280 bar	
	Injection pipe (OD, ID, L)				ø6 x ø2.0 - 750 mm	
Rack diagram and setting valve at each point						
Refer to (3) rack diagram	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 /1,000st) (A) Test condition for inj. pump	Remarks	Press. (mmHg)
	V1	11.55 ±0.05	900	244 ±3.0	Max. power	1,500
	V2	11.55 ±0.10	700	242 ±3.0	-	1,500
	VS	9.20 ±0.20	500	162 ±1.0	-	0
	LQ	6.10 ±0.20	350	48 ±15.0	Only 4/5/6/8/10/12	0
	A3	7.30 ±0.50	1,020	112 ±15.0	Only 4/5/6/8/10/12	0
	ST	with Cap	100	115 ±10.0	Only 4/5/6/8/10/12	0
Boost pressure dependent full -load stop (boost compensator spring operation point)						
Refer to (4) boost pressure	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 /1,000st) (A) Test condition for inj. pump	(B) Engine standard parts	Press. (mmHg)
	P1	11.55 ±0.05	500	-	-	1,500
	P2	8.96 ±0.05	500	-	-	0
	P3	9.9 ±0.10	500			300
	P4	10.90 ±0.05	500	-	-	450

Weight	Weight =630g	Lever ratio (min/max)	Not fixed
Idle spring	k=14.03N/mm	Plunger	ø12
Middle spring	k=57.14N/mm	Delivery valve retraction volume	90 mm^3/st
Inner spring	None	Delivery valve opening pressure	-
LDA spring	k=30.50N/mm	Delivery valve spring	k = 7.2N/mm
Feed spring	Double action×2	Timer	None

(3) Rack diagram



(4) Boost compensator pressure



8) V222TIM

(1) Main data and specifications

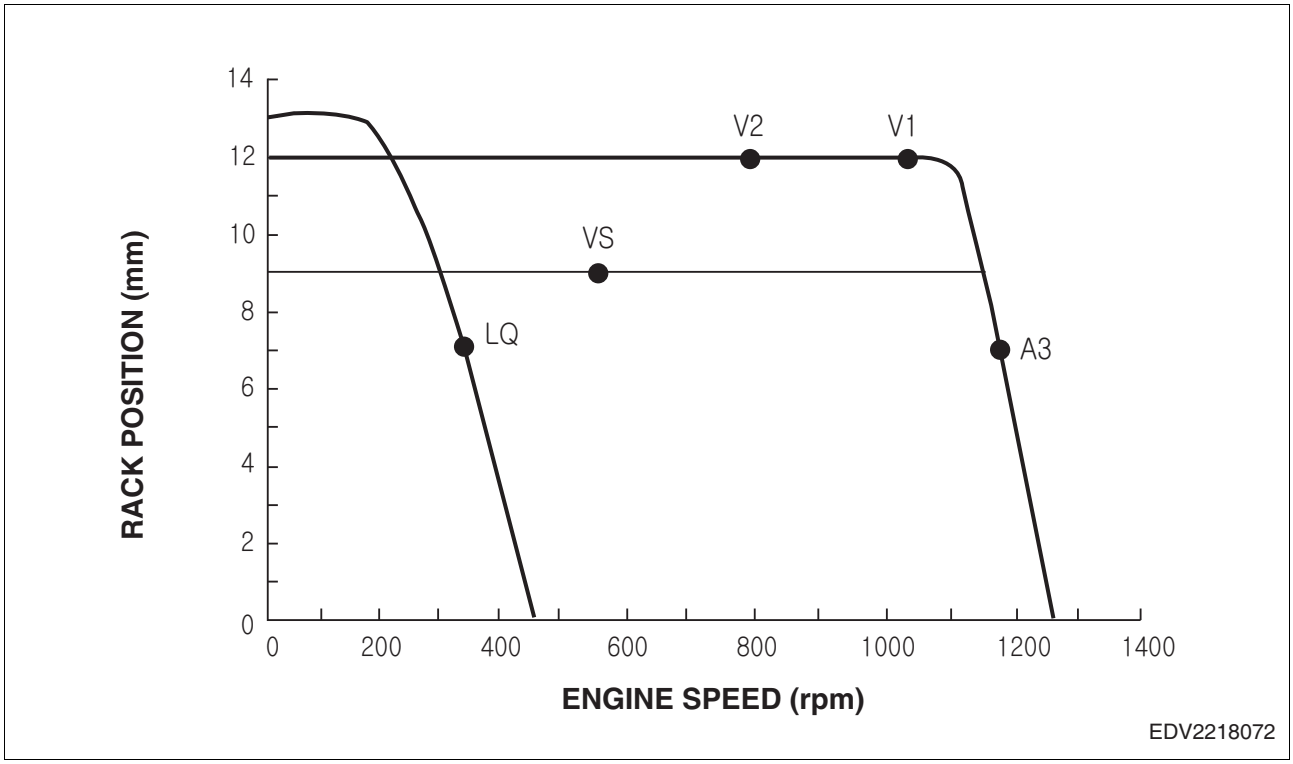
Model : PE12P120A500LV
Injection pump : 65.11101-7682
Governor : RQV 300/900
Plunger : 2 418 455 188
Delivery valve : 2 418 552 039
Pre-stroke : 4.50 ±0.05 mm
Injection timing : BTDC 20° ±1°
Injection order : 1-12-10-7-8-11-5-2-3-6-4-9
Fuel feed pump : 0 440 008 152, 0 440 008 090 (FP/KD22P78-2, KP/KD22P80-1)
Rotating direction : C.C.W. at driving gear side

(2) Calibration data

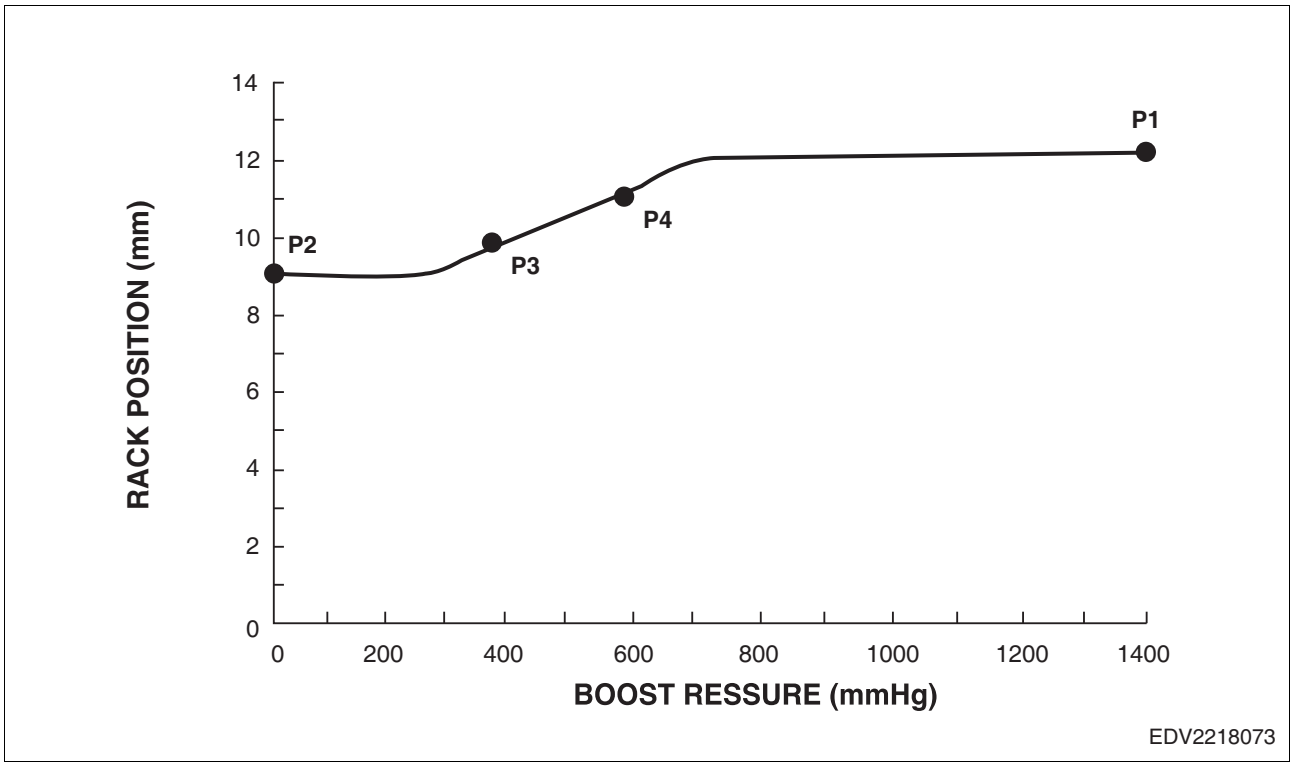
(A) Test condition for injection pump	Nozzle & Holder ass'y		1 688 901 019	Opening pressure : 212.6 bar		
	Injection pipe (OD, ID, L)		1 680 750 075	ø8.0 x ø3.0 - 1,000 mm		
	Test oil		ISO4113	Temperature : 40 ±2°C		
(B) Engine standard parts	Nozzle & Holder ass'y		65.10101-7053	Nozzle (5 × ø0.418)		
			0 432 131 669	Spec. : 285.5 bar		
	Injection pipe (OD, ID, L)			ø6 x ø2.0 - 750 mm		
Rack diagram and setting valve at each point						
Refer to (3) rack diagram	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 /1,000st) (A) Test condition for inj. pump	Remarks	Press. (mmHg)
	V1	12.00 ±0.05	1,050	266.0 ±3.0	Max. power	1,500
	V2	12.00 ±0.10	800	266.0 ±3.0	-	1,500
	VS	8.96 ±0.20	500	159.8 ±1.0	-	0
	LQ	6.15 ±0.20	350	53.7 ±15.0	Only 2/3/4/8	0
	A3	7.10 ±0.50	1,150	109.4 ±15.0	Only 2/3/4/8	0
	ST	with Cap	100	127.5 ±10.0	Only 2/3/4/8	0
Boost pressure dependent full -load stop (boost compensator spring operation point)						
Refer to (4) boost pressure	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 /1,000st) (A) Test condition for inj. pump	(B) Engine standard parts	Press. (mmHg)
	P1	12.00 ±0.05	500	-	-	1,500
	P2	8.96 ±0.05	500	-	-	0
	P3	9.25 ±0.10	500			275
	P4	11.20 ±0.05	500	-	-	600

Weight	Weight =630g	Lever ratio (min/max)	Not fixed
Idle spring	k=14.03N/mm	Plunger	ø12
Middle spring	k=57.14N/mm	Delivery valve retraction volume	90 mm^3/st
Inner spring	k=21.98N/mm	Delivery valve opening pressure	-
LDA spring	k=30.50N/mm	Delivery valve spring	k = 7.2N/mm
Feed spring	Double action	Timer	None

(3) Rack diagram



(4) Boost compensator pressure



9) V222TIL

(1) Main data and specifications

Model : PE12P120A500LV
Injection pump : 65.11101-7682
Governor : RQV 300/900
Plunger : 2 418 455 188
Delivery valve : 2 418 552 039
Pre-stroke : 4.50 ±0.05 mm
Injection timing : BTDC 20° ±1°
Injection order : 1-12-10-7-8-11-5-2-3-6-4-9
Fuel feed pump : 0 440 008 152, 0 440 008 090 (FP/KD22P78-2, KP/KD22P80-1)
Rotating direction : C.C.W. at driving gear side

(2) Calibration data

(A) Test condition for injection pump	Nozzle & Holder ass'y	1 688 901 019	Opening pressure : 212.6 bar
	Injection pipe (OD, ID, L)	1 680 750 075	ø3.0 x ø8.0 x 1,000 mm
	Test oil	FUSUS	Temperature : 40 ±5°C
(B) Engine standard parts	Nozzle & Holder ass'y	65.10101-7053	Nozzle (5 × ø0.418)
		65.10102-6070	Spec. : 285.5 bar
	Injection pipe (OD, ID, L)	65.10301-6113 65.10301-6114A	ø2.0 x ø6.35 x 850 mm

Rack diagram and setting valve at each point

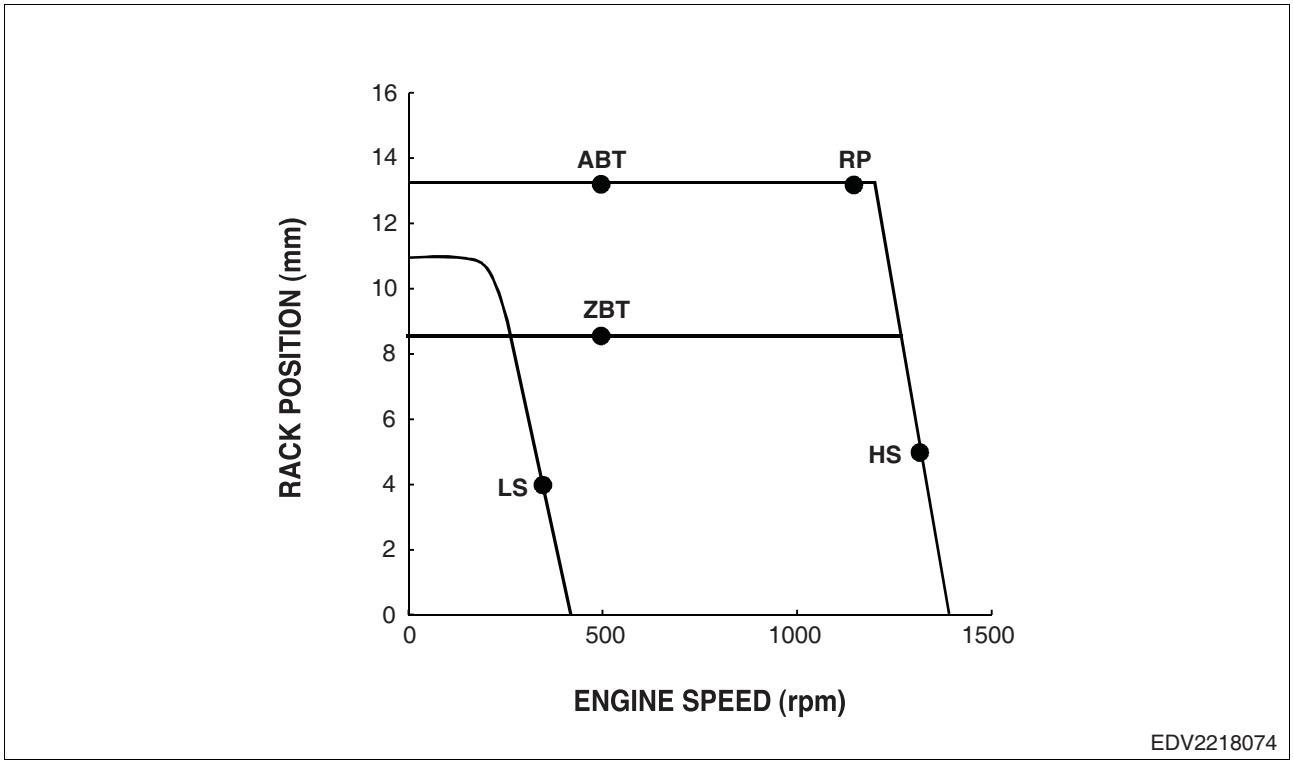
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 /1,000st)		Press. (mmHg)
				(A) Test condition for inj. pump	Remarks	
Refer to (3) rack diagram	RP	13.19	1,150	423.8	-	1,500
	ABT	13.22	500	384.4	-	1,500
	ZBT	8,56	500	161.6	-	-
	HS	5,00	1,320	80.6	-	-
	LS	4,00	350	50.0	-	-
	ST	W/CAP	100	180.0	-	-

Boost pressure dependent full -load stop (boost compensator spring operation point)

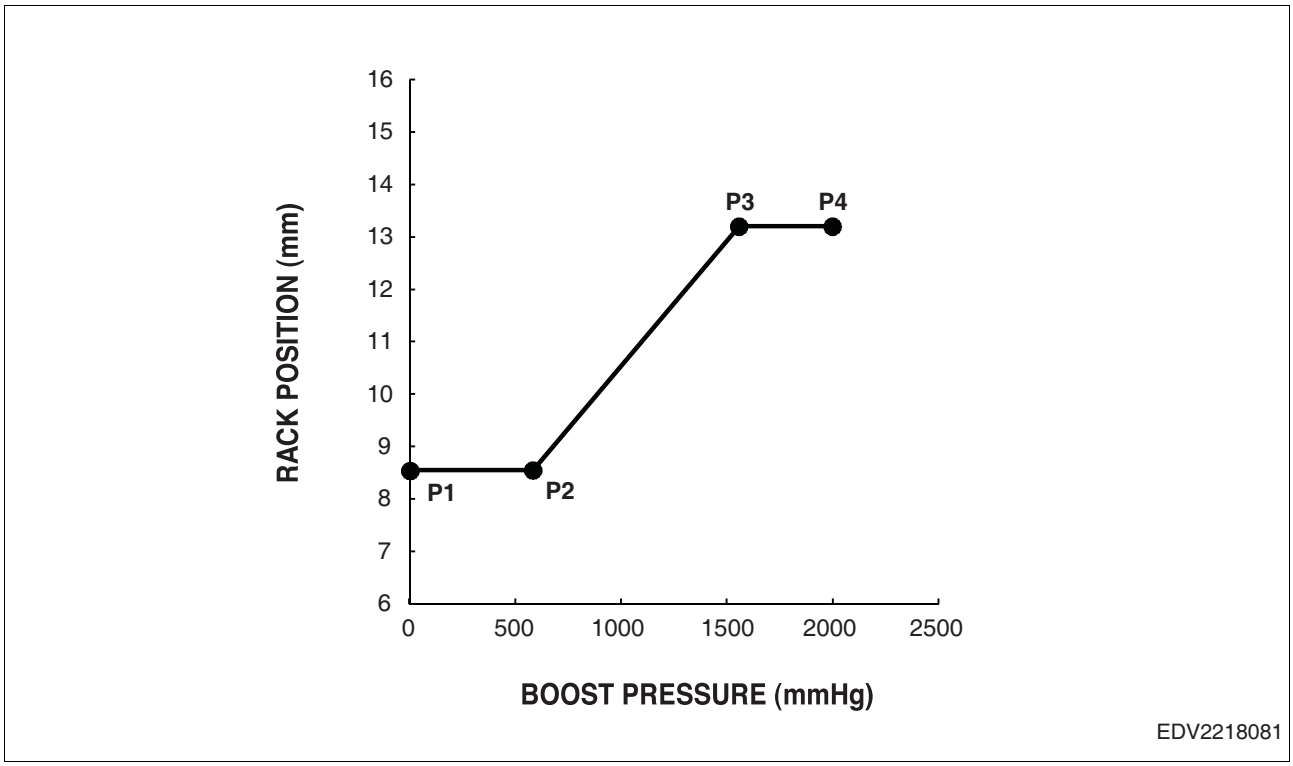
	Check point	Rack position (mm)	Pump speed (rpm)	Injection Q'ty on RIG (mm^3 /1,000st)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
Refer to (4) boost pressure	P1	8.56	500			0
	P2	8.56	-			440
	P3	13.22	-			1,170
	P4	13.22	-			1,500

Weight	Weight =630g	Lever ratio (min/max)	Not fixed
Idle spring	k=14.03N/mm	Plunger	ø12
Middle spring	k=57.14N/mm	Delivery valve retraction volume	90 mm^3/st
Inner spring	k=21.98N/mm	Delivery valve opening pressure	-
LDA spring	k=30.50N/mm	Delivery valve spring	k = 7.2N/mm
Feed spring	Double action	Timer	None

(3) Rack diagram



(4) Boost compensator pressure

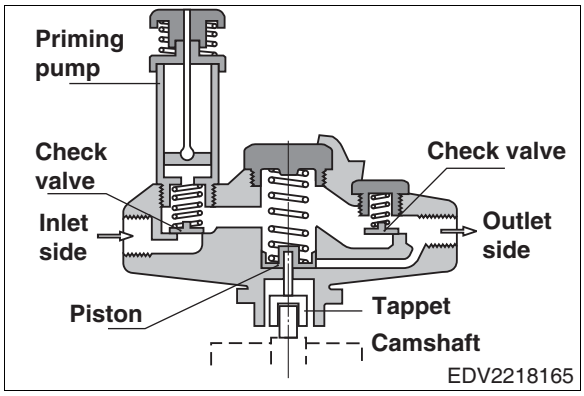


7.3.2. Fuel feed pump

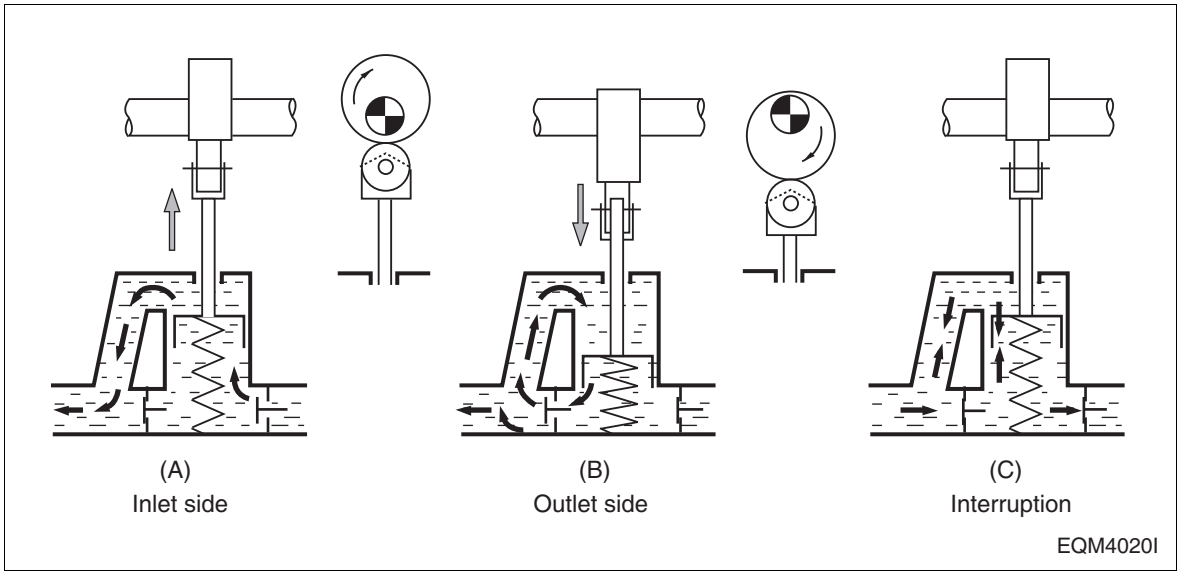
1) General descriptions and construction

The P-type injection pump is mounted with K-ADS or KP type feed pump. These pumps have the same basic construction and operation, and the general descriptions of the KP type pump are given below :

The figures show its construction (right figure) and operation (below figure). The piston in the fuel feed pump is driven by the push rod and tappet via the camshaft of injection pump and performs reciprocating operation to control the suction and delivery of fuel.

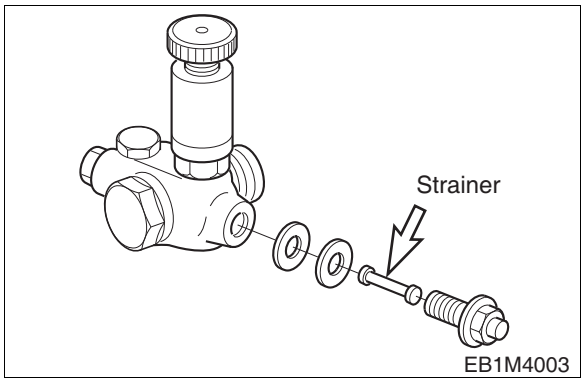


When the cam reaches the Bottom Dead Center as shown in the figure, the fuel is drawn in through the check valve on the inlet side. The fuel pressurized as the cam rotates on flows through the check valve on the outlet side as shown in (B). If feeding pressure increases abnormally, the spring is compressed, resulting in interrupting further delivery of fuel as shown in (C).

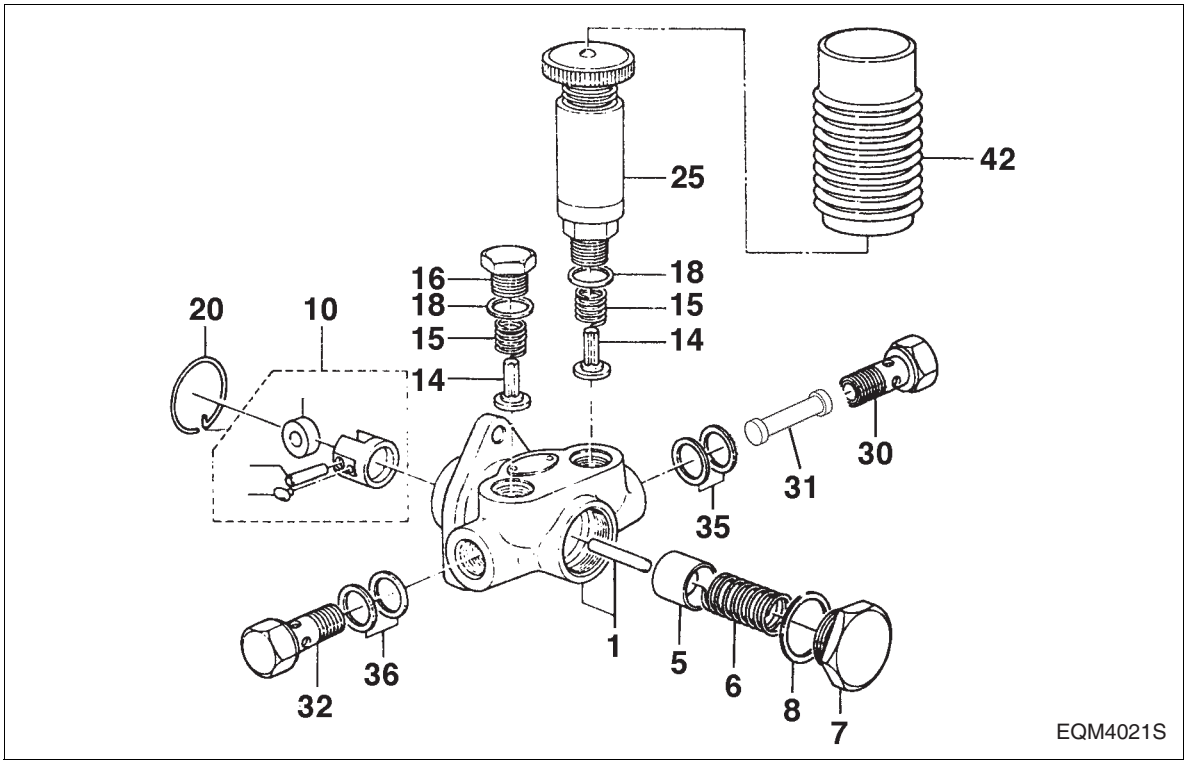


This feed pump is mounted with a priming pump designed to permit manual feeding of fuel from the fuel tank with the injection pump mounted in the engine. During the manual feeding operation, air must be bled from the fuel lines. When using the priming pump, fix it securely to prevent the possible entry of moisture or other foreign substances in the inside of the feed pump.

In addition, a strainer is fitted into joint bolt on the inlet side of the fuel feed pump to filtrate any foreign substances possibly mixed in fuel.



2) Disassembly



- Clamp the feed pump with a vise and disassemble the plugs (30, 32), strainer (31) and gaskets (35, 36).
- Take off the priming pump (25), plug (16), both gaskets (18), spring (15), and check valve (14).
- Take off the plug (7), gasket (8), spring (6), and piston (5) on the piston side.
- Pull out the snap ring (20) holding the tappet (10).
- Disassemble the snap ring, then take off the tappet (10) and push rod (1).

3) Inspection

- If the check valve is damaged or scored on its seat face, replace it with a new one.
- Inspect the piston and tappet for damage.
- Replace the push rod if excessively worn, and replace together with the pump housing if required. The inspection for wear should be performed in the same procedure as for suction pressure test described below.

4) Re-assembly

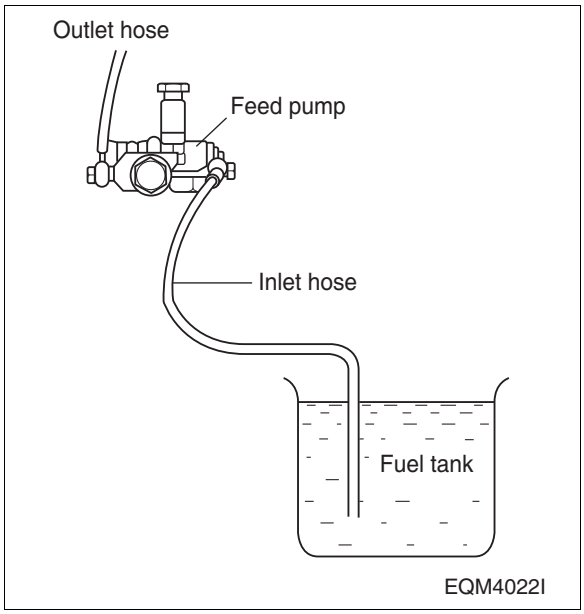
- Re-assembly operation is performed in reverse order of disassembly. All the gaskets must be replaced with new ones at re-assembly.

5) Testing

- Suction capacity test

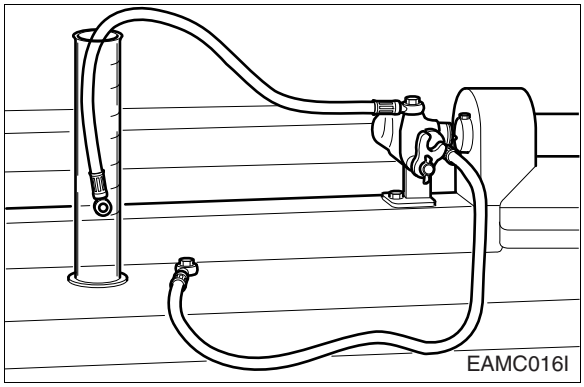
  Connect one end of a hose to the inlet side of the feed pump and immerse the other end of it into the fuel tank as illustrated.

  Hold the feed pump in position about 1 m above the fuel level of the fuel tank. Operate the tappet at the rate of 100 rpm and check to see if fuel is drawn in and delivered for 40 seconds or so.



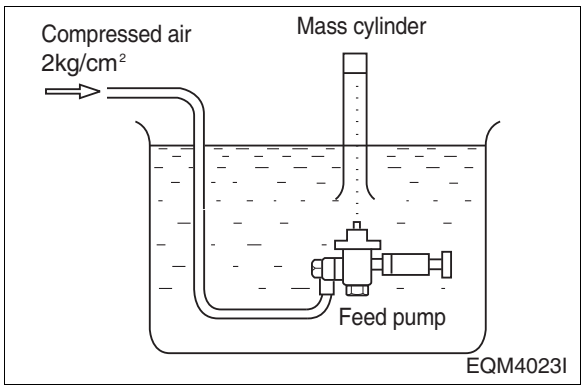
- Delivery test

  Make a test with the feed pump mounted on a pump tester as illustrated. Operate the pump at the rate of 1,000 rpm and check to see if the pump delivery is more than 405 cc/15 seconds.



- Sealing test

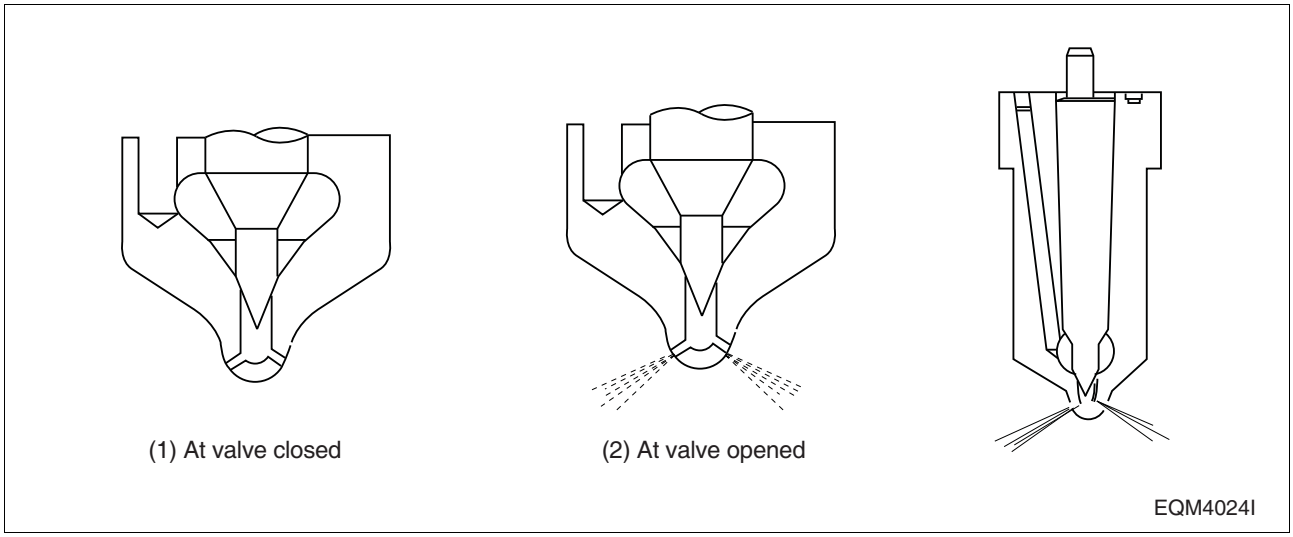
  Plug up the delivery port on the feed pump and apply compressed air of 2 kg/cm^2 into the inlet side. Submerge the feed pump in a container of diesel fuel and check for air leak.



7.3.3. Injection nozzle

The injection nozzle assembly consists of the nozzle body and needle valve assembly. Pressurized fuel delivered from the fuel injection pump is sprayed into the combustion chamber past the injection nozzle at proper spray pressure and spray angle, then burnt completely to achieve effective engine performance.

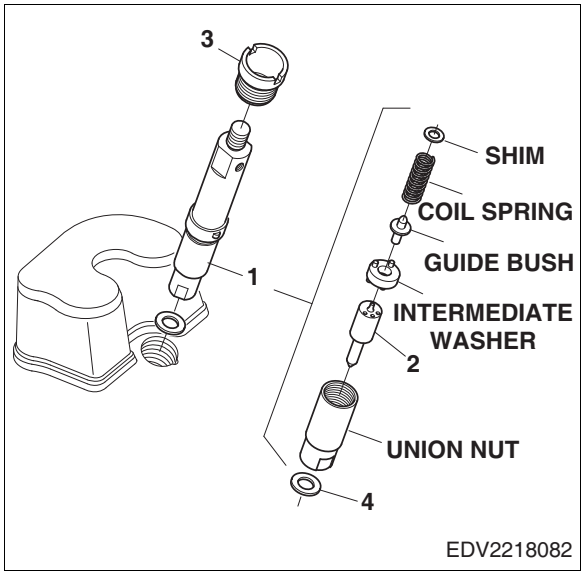
The fuel injected should necessarily be ignited immediately and combusted in a short period of time as too long a combustion period will prevent the high speedy operation of the engine and can cause serious engine knocking.



1) Structure

A copper seal fitted to the injector ensures gas-tight seating and good heat dissipation. The opening pressure of the nozzle is adjusted by means of shims at the compression spring.

1.Nozzle holder assembly
2.Nozzle tip
3.Nozzle locking nut
4.Seal ring



2) Maintenance

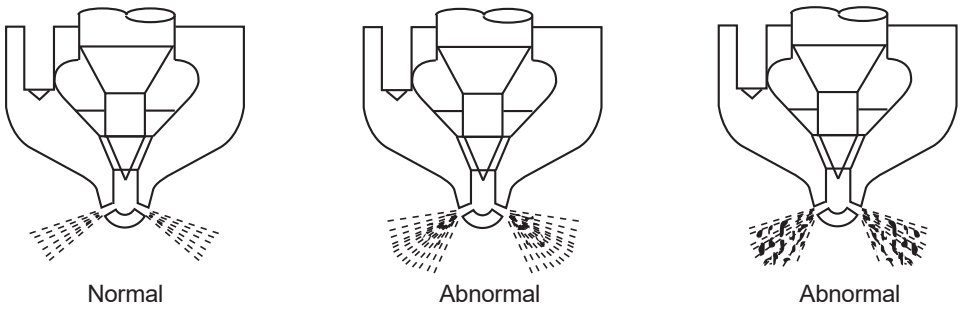
- After removing carbon deposit, submerge the nozzle in diesel oil and clean it.
- Replace all the gaskets with new ones.
- Assemble the parts and tighten them to specified torque.

3) Inspection and adjustment

- Assemble the nozzle in the nozzle tester and operate the nozzle tester 2 or 3 times to bleed air. After pressurizing it measure the nozzle pressure.

New nozzle	300 + 8 kg/cm^2
Used nozzle	285 + 8 kg/cm^2

- Re-check the injection pressure and see if the spray pattern is normal.
- Adjust the injection pressure to the standard pressure using shims if the injection pressure is poor.
- Nozzle opening pressure is adjusted by thickness of shims installed on the compress spring. Therefore in case of low or high injection pressure, adjust by adding or reducing the spring tension adjusting shims.
- In case that atomizing state is not good it should be replaced.
- After adjusting the injection pressure tighten the cap nut to specified torque.



EFM1006I

Caution
As the fuel injection line is operated by high pressure, should pay particular attention to treat.

- Fix the nozzle holder securely when assemble it.
- Do not bend the injection pipe so much it as deformed severely.
- Do not use the abnormal bending pipe preventing from cracking.
- Do not bend the end portion of injection pipe over 2 or 3 degree to assemble it easily.

7.4. Turbo-charger

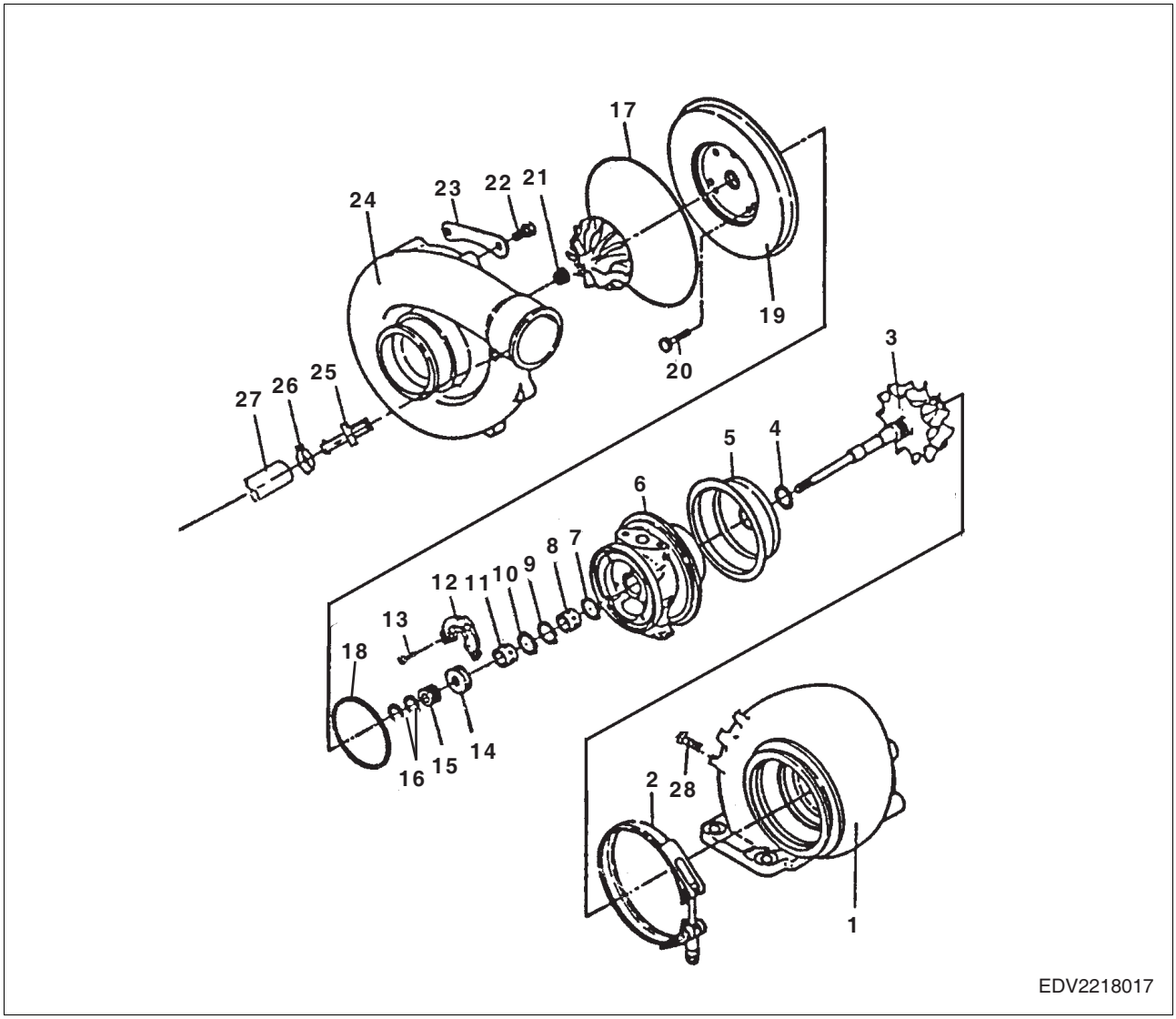
7.4.1. Specification

Model	V158TIH	V180TIH	V222TIH
Engine output (PS / rpm)	480 / 1,800	600 / 1,800	720 / 1,800
Turbo-charger model	HX35M	HX40M	HX50M
Maximum allowable exhaust gas temperature (Turbine inlet)	700		
Lubricating system	Forced oil supply		

Model	V158TIM	V180TIM	V222TIM
Engine output (PS / rpm)	540 / 2,100	650 / 2,100	800 / 2,100
Turbo-charger model	HX35M	HX40M	HX50M
Maximum allowable exhaust gas temperature (Turbine inlet)	700		
Lubricating system	Forced oil supply		

Model	V158TIL	V180TIL	V222TIL
Engine output (PS / rpm)	680 / 2,300	820 / 2,300	1,000 / 2,300
Turbo-charger model	HX40M	HX50M	HX50M
Maximum allowable exhaust gas temperature (Turbine inlet)	700		
Lubricating system	Forced oil supply		

7.4.2. Construction of the turbo-charger



1. Turbine housing
2. V-vent
3. Wheel
4. Piston ring
5. Wheel shroud
6. Center housing
7. Retaining ring
8. Bearing
9. Retaining ring
10. Retaining ring
11. Bearing
12. Thrust collar
13. Screw
14. Thrust bearing
15. Thrust spacer
16. Pistion ring
17. Seal ring
18. Seal ring
19. Rear plate
20. Bolt
21. Nut
22. Bolt
23. Clamp
24. Compressor housing
25. Elbow
26. Clamp
27. Hose
28. Bolt

7.4.3. Inspection

As the condition of turbocharger depends greatly on how well the engine is serviced, it is very important to maintain the engine in accordance with the specified maintenance procedure and pay particular attention to checking oil & air leaks, unusual sound on running.

1) Checking of the rotor for rotating condition

The inspection of the rotor assembly for rotating condition should be performed by the degree of unusual sound on running. If a sound detecting bar is used, install its tip on the turbocharger housing and increase the engine revolutions slowly. If a high-pitch sound is heard every 2 ~ 3 seconds or continuously, it means that the rotor assembly is not normal. In this case, as the metal bearing and rotor are likely to be in abnormal conditions, the turbocharger should be replaced or repaired.

2) Checking of the rotor end play

The radial and axial clearances of the rotor should check after every 2,000 hours operation. This precaution will enable measuring for any wear of axial clearance bearings to be detected in good time before serious damage is caused to the rotor and bearings. Disassemble the turbocharger from the engine, then check the rotor axial play and radial play.

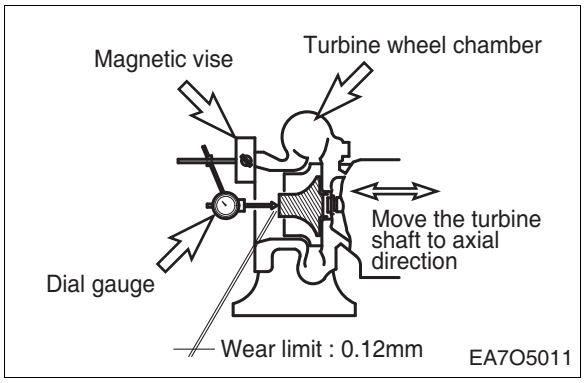
(1) When disassembling the turbocharger, be sure to plug the oil inlet and outlet ports
(2) If the measured axial and radial plays are beyond the limit of wear, replace or repair the turbocharger.

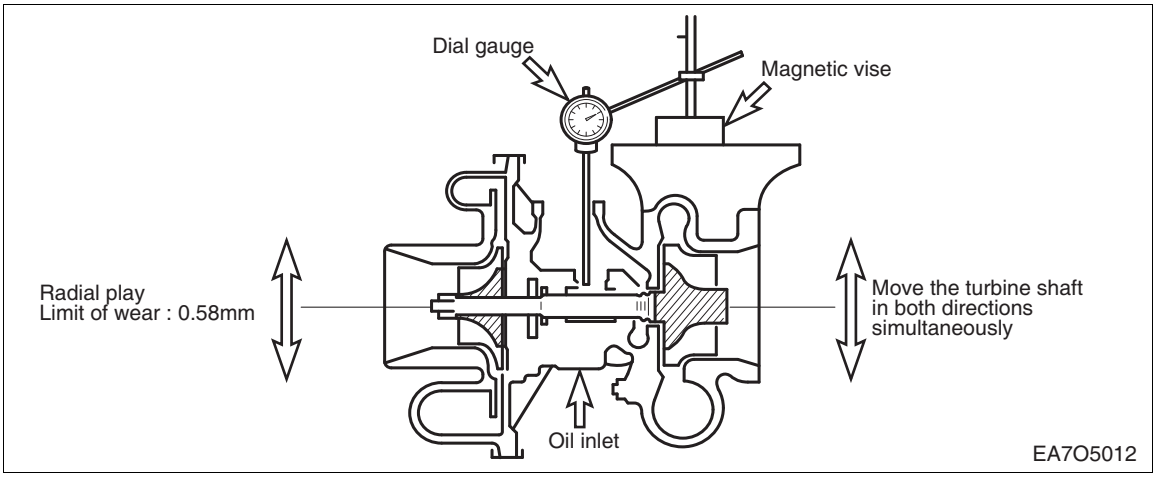
- **Measuring rotor axial clearance**

Axial clearance	0.12 mm

- **Measuring radial clearance**

Radial clearance	0.58 mm





3) Precautions for reassembling the turbocharger onto the engine

For re-assembly of the turbocharger or handling it after re-assembly operation, be sure to observe the following precautions:

Especially, pay attention to prevent foreign matters from entering the inside of the turbocharger.

(1) Lubricating system

- Before reassembling the turbocharger onto the engine, inject new oil in the oil inlet port and lubricate the journal and thrust bearings by rotating them with hand.
- Clean not only the pipes installed between the engine and oil inlet port but also the oil outlet pipe and check them for damage or foreign matters.
- Assemble each joint on oil pipes securely to prevent oil leaks.

(2) Intake system

- Check the inside of the intake system for foreign matters.
- Assemble each joint on the intake duct and air cleaner securely to prevent air leaks.

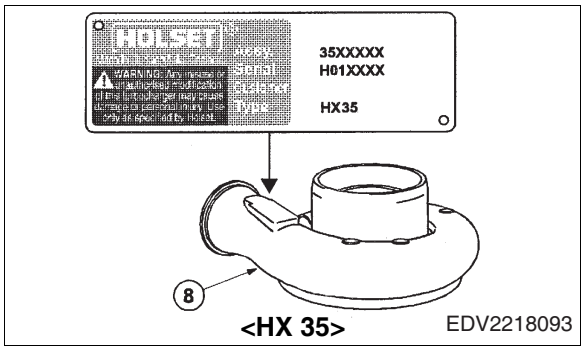
(3) Exhaust system

- Check the inside of the exhaust system for foreign matters.
- Be sure to use heat resisting steel bolts and nuts. Do not interchange them with ordinary steel bolts and nuts when performing re-assembly operation. Apply anti-seizure coating to the bolts and nuts.
- Assemble each joint on the exhaust pipes securely to prevent gas leaks.

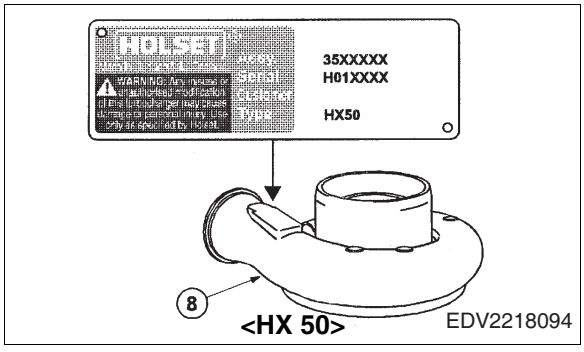
7.4.4. Component Identification

1) Turbo charge identification

A date plate is fitted to the compressor housing (8). The information on this date plate must be quoted for service and parts support.

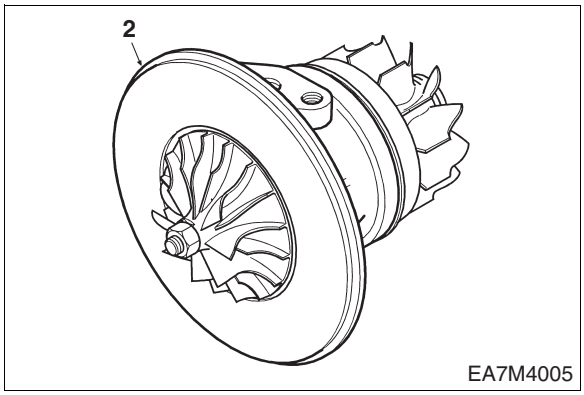


<HX 35> EDV2218093



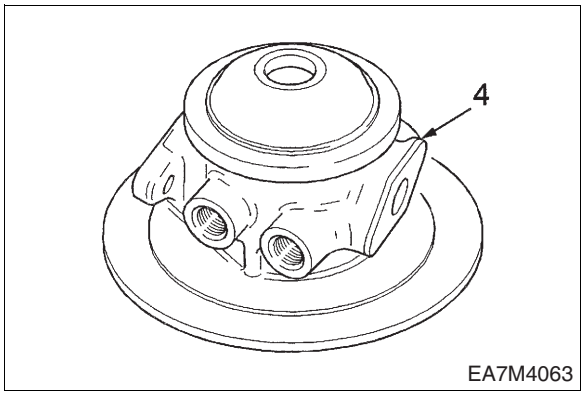
<HX 50> EDV2218094

2) Center housing rotating assembly



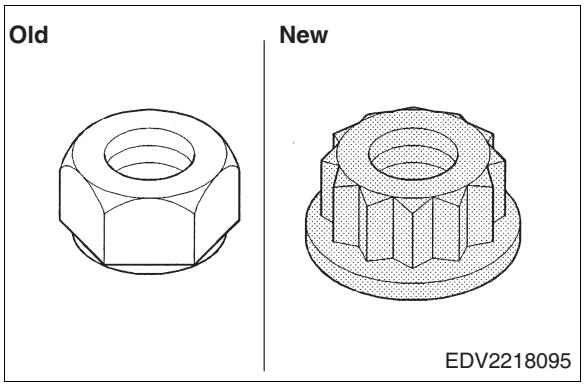
3) Watercooled bearing housing (4)

Optionally this can have additional water feed and drain plug fittings.



4) New compressor wheel lock nut (61)

Holset have introduced a new compressor wheel lock nut which is to be all new WH1C/E turbochargers. If you turbo is fitted with the new nut, it indicated that this turbocharger may have been built using the core balance process at point of manufacture rather than the traditional rotor balance process The new nut will also require a different torque process when rebuilding the turbo after service.



Caution :

Always use specified torque. Failure to do so may result in turbocharger/ engine failure.

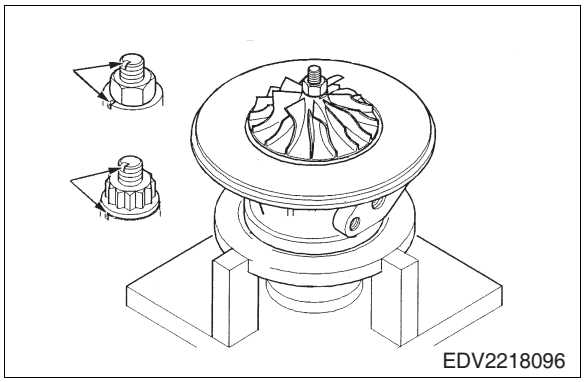
Torque value	Nm	lb lns
New lock nut	17	150
Old lock nut	16	160

Caution :

Always make sure the turbinewheel shaft end and the compressor wheel have alignment marks before disassembly of the CHRA.

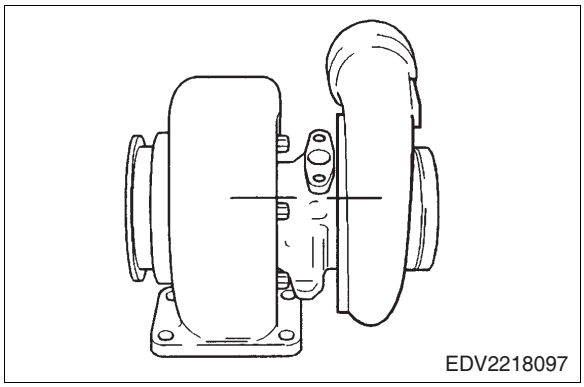
If no marks exist, scribe the shaft and compressor wheel (as shown) before removing the compressor wheel lock nut.

Always check balance the rotor before rebuild.


EDV2218096

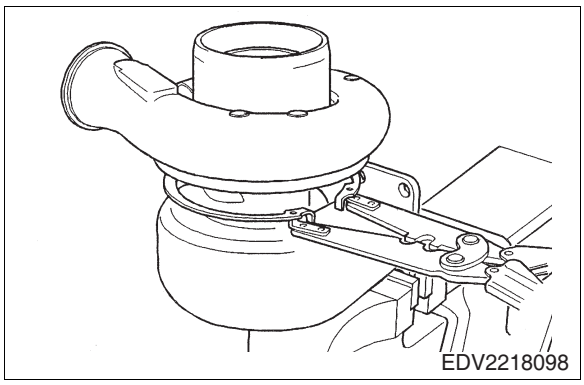
7.4.5. Disassembly

- Before disassembling the turbocharger, scribe the parts listed below to help in alignment during assembly.
  - Compressor housing (8)
  - Turbine housing (5)
  - Bearing housing (4)


EDV2218097

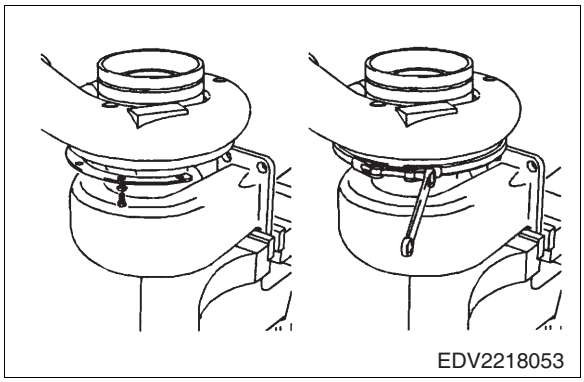
- Secure the turbine housing (5) in a vice.

  HX35 : Remove the compressor cover circlip (91) using circlip pliers.


EDV2218098

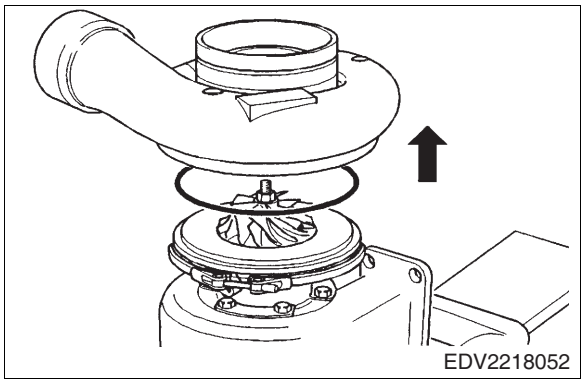
HX50 : Loosen and remove the 8 bolts (59) lock washers (54) clamp plates (51).

HX55 : Loosen and remove the compressor side V-band lock nut (62).

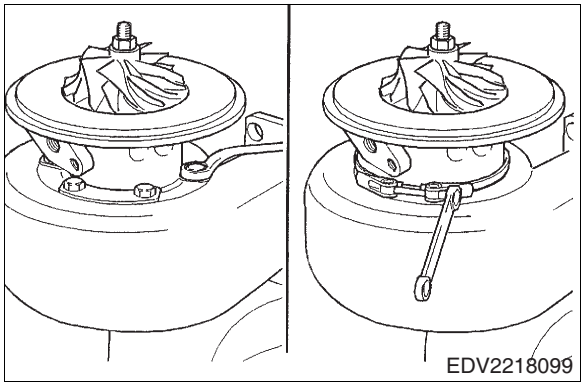

EDV2218053

- Gently remove the compressor cover (8), and if fitted, remove the O-ring seal (41).

Caution :
The compressor wheel blades can be easily damaged when the compressor housing is removed.

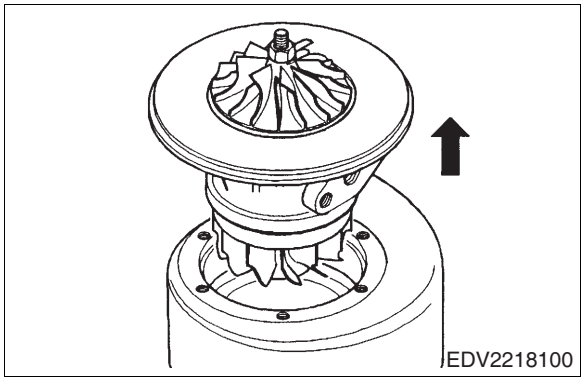

EDV2218052

- Loosen and remove the 6 bolts (57) and clamp plates (88).
  Or remove v-band lock nut and v-band if fitted.

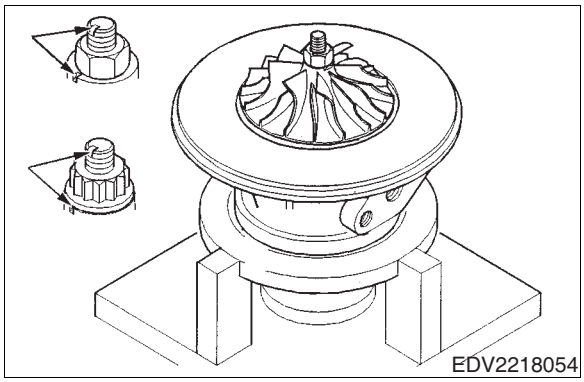

EDV2218099

- Remove the CHRA from the turbine housing.

Caution :
The turbine blades can be easily damaged when the turbine housing is removed.

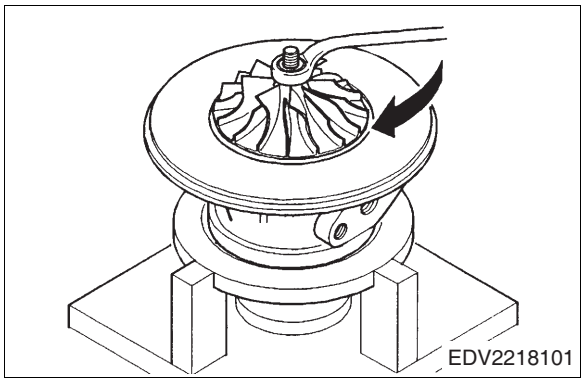

EDV2218100

- Locate the Center Housing Rotating Assembly (CHRA) onto a 19 mm socket clamped in the jaws of a vice or a suitable fixture.



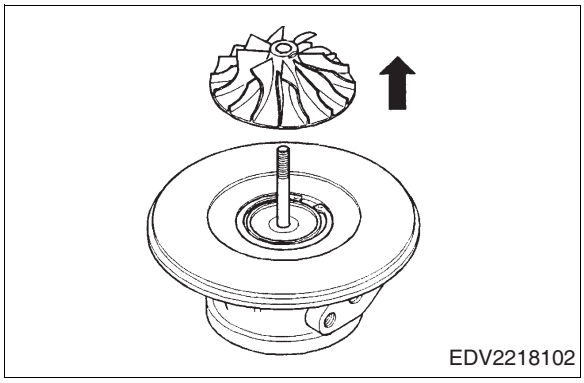
Caution :
Always make sure the turbine wheel shaft and the compressor wheel have alignment marks before disassembly of the CHRA.
If no marks exist, scribe the shaft and compressor wheel (as shown) before removing the compressor wheel lock nut. (refer to 4.3.4.)

- Remove the compressor wheel lock nut (61).

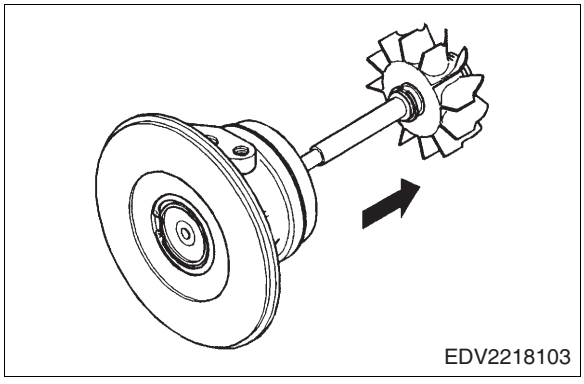


Note :
Left hand thread.

- Remove the compressor wheel (7).



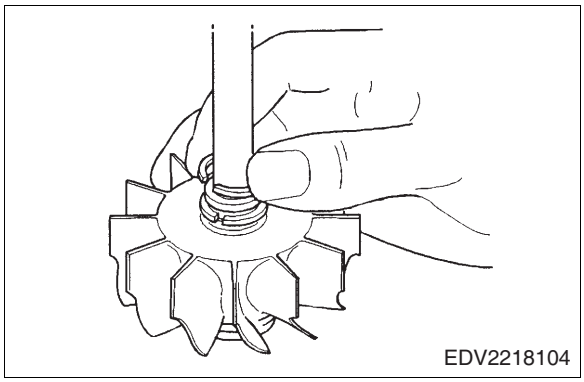
- Remove the remaining CHRA from the socket and gently slide the shaft and wheel (6) from the bearing housing (4).



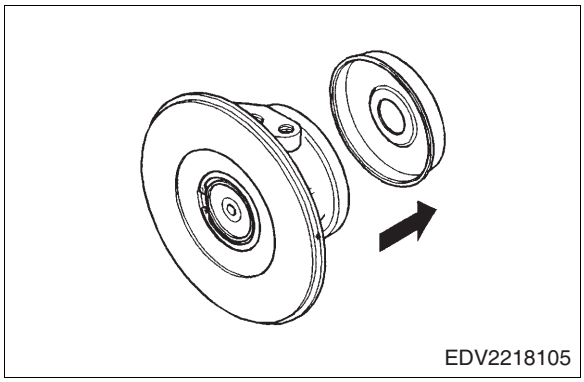
- Carefully remove and discard the piston ring seal(s) (13).

  - HX35(V158TI) : 1EA
  - HX50(V180TI/V222TI) : 2EA

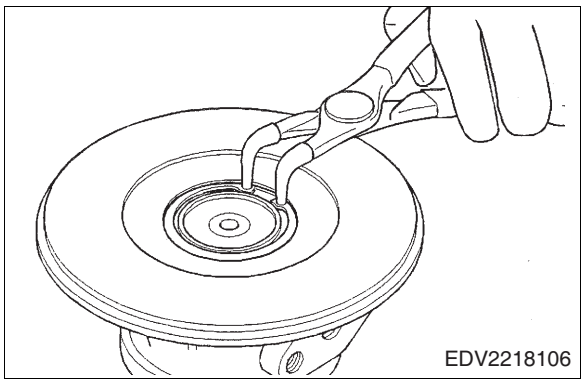
Caution :
Care should be taken not to score the assembly turbine wheel shaft.



- Remove the heat shield (38).

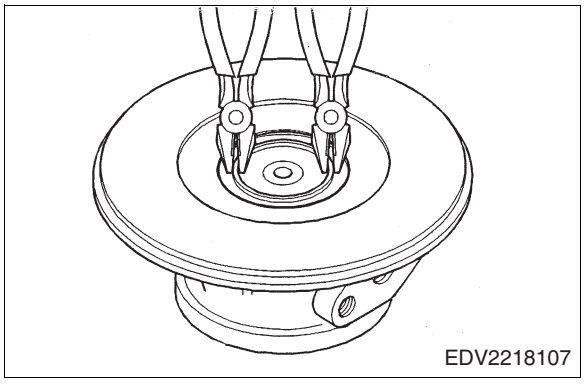


- Place the bearing housing on a flat surface and using circlip pliers, remove the insert retaining ring (66).

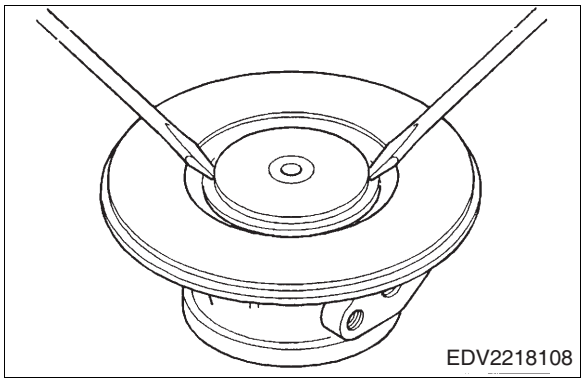


- Gently remove the oil seal plate (43) as fo lows.

  - HX35 : Using two flat nose pliers

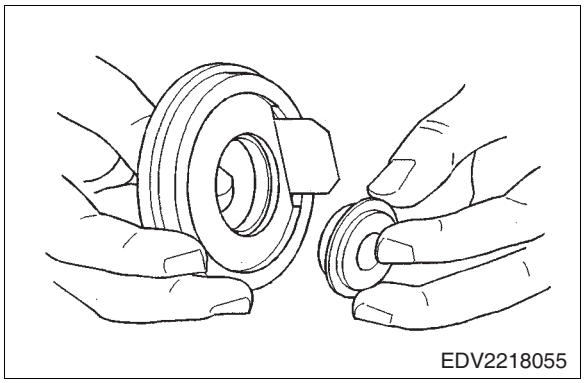


- HX50 : Using two flat screwdrivers.

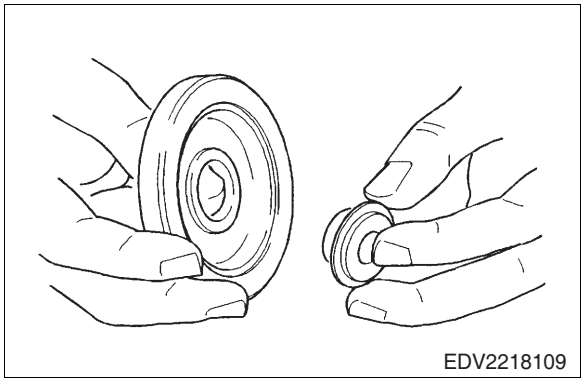


- Remove the oil slinger (31).

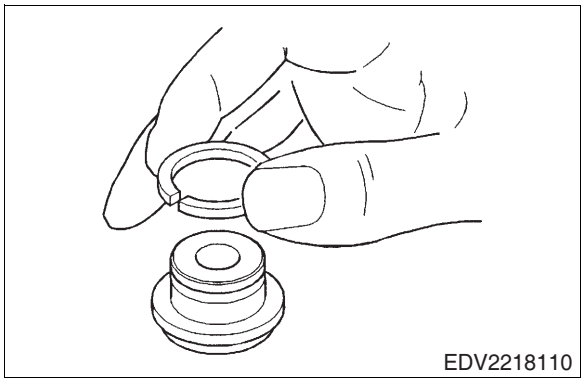
- HX35



- HX50

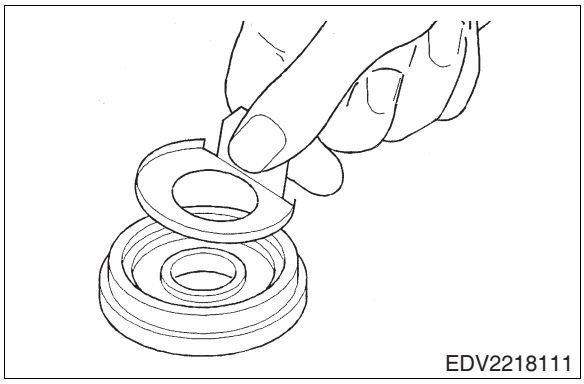


- Remove and discard the piston ring seal (16).

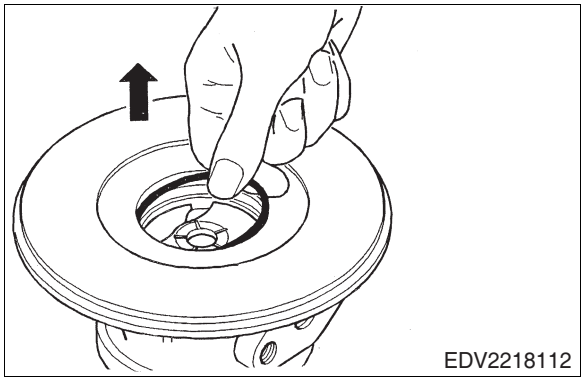


<HX35>

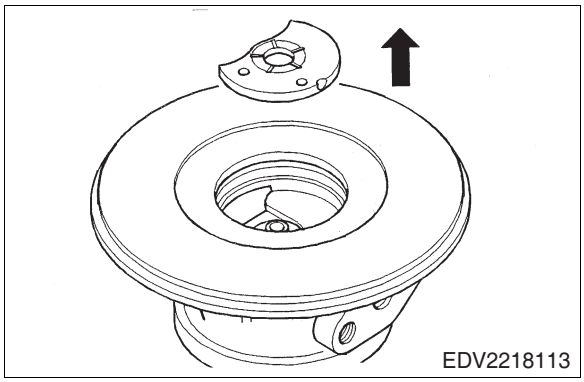
- Remove and discard the oil baffle (33).



- Remove and discard the O-ring seal (32).

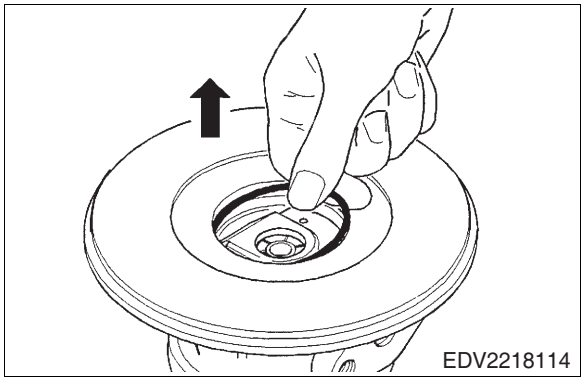


- Remove the thrust bearing (12).

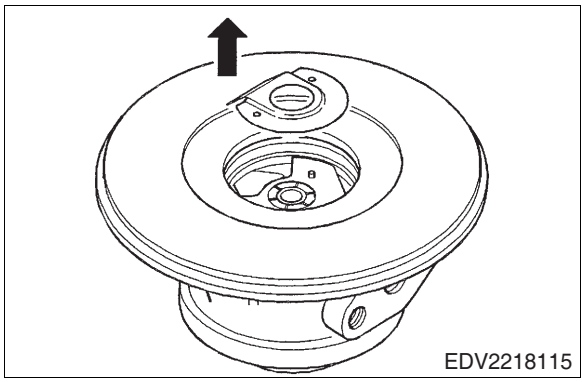


<HX50>

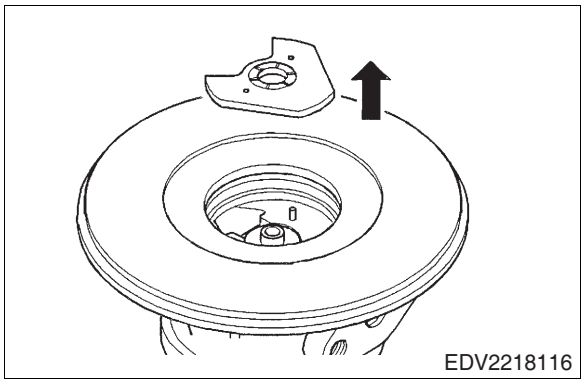
- Remove and discard the O-ring seal (32).



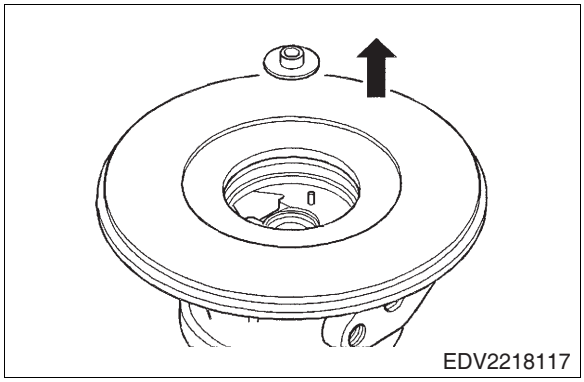
- Remove and discard the oil baffle (33).



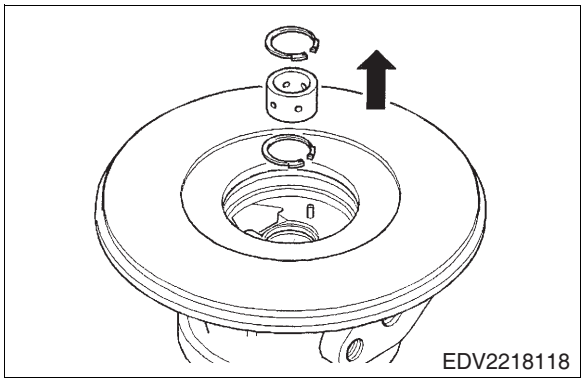
- Remove the thrust bearing (12).



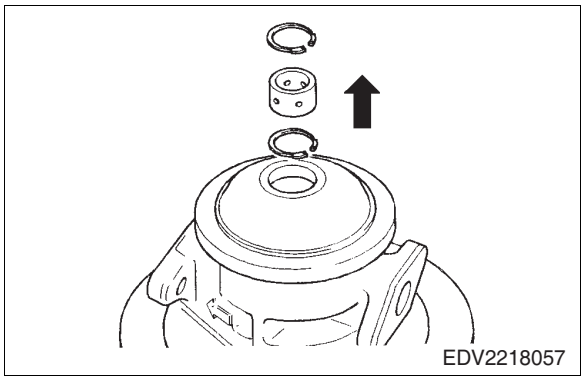
- Remove the thrust collar (36).



- Using circlip pliers, remove and discard the two circlips (64) and the journal bearing (11) from the compressor end.



- Turn the bearing housing over and repair the process.



7.4.6. Cleaning

With the turbocharger completely dismantled for overhaul, soak all the components in a non-caustic metal cleaner to loosen deposits. Bead blast the turbine housing if chemicals do not clean sufficiently.

On aluminium parts a bristle brush can be used. Never use a wire brush or metal scraper on any turbo-charger component. Ensure that all the palls are finally cleaned with an air jet, especially drilled passages and machined apertures. Turbine Wheel: In the event of carbon build-up, it may be necessary so carefully blast the Piston Ring Groove area of the turbine wheel using low grade shot medium.

Caution :
Shot blasting specific areas for long periods of time may effect component balance.

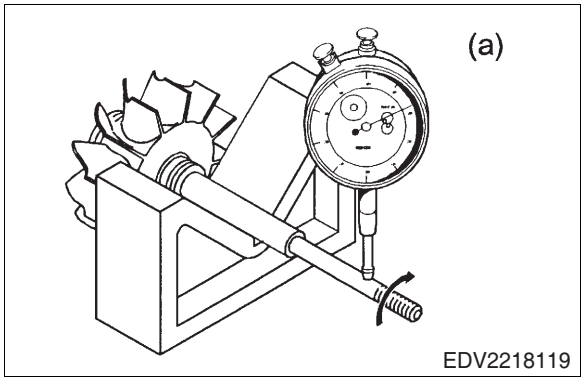
The surface adjacent to the turbine and compressor wheels on the stationary housings must be clean, smooth and free from deposits.

7.4.7. Inspection

Caution :
Do not attempt to straighten the turbine shaft.

a) Place the shaft on a V-block, using a dial gauge rotate the turbine wheel and check for movement on the dial gauge. Replace the assembly turbine wheel if it is bent. Max shaft bend allowed 0.025 mm (0.001 ins).

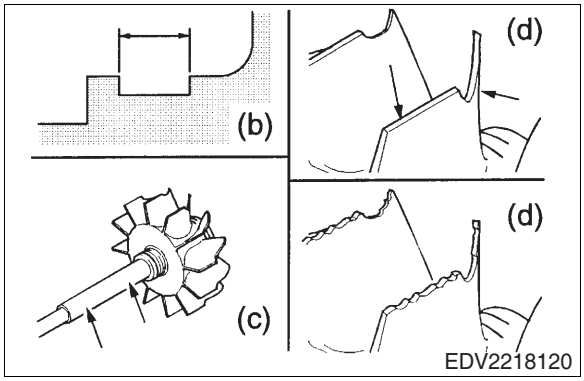
Shaft bend (Max.)	mm	in.
	0.025	0.001



<Major components>

- **Assembly turbine wheel (6)**

b) Inspect the piston ring groove walls for wear.



- HX35 (V158TI)

Turbine wheel piston ring groove (Min.)	mm	in.
	1.664	0.0665

- HX50 (V180TI/ V222TI)

Turbine wheel piston ring groove	mm	in.
Single ring (Min.)	1.664	0.0665
Twin ring (Min.)	3.538	0.1393

c) Inspect the bearing journals for excessive scratches and wear. Minor light scratches may be tolerated.

- HX35 (V158TI)

Assembly turbine wheel jounals (Min.)	mm	in.
	10.972	0.432

- HX50 (V180TI/ V222TI)

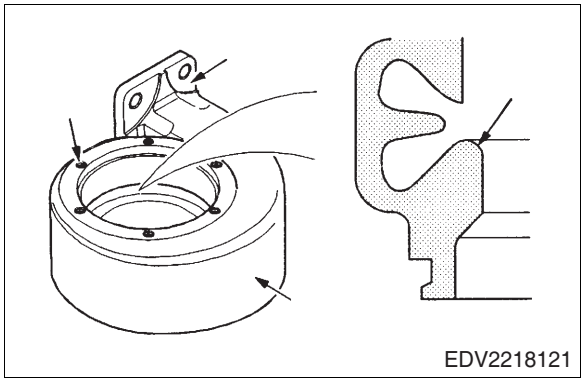
Assembly turbine wheel jounals (Min.)	mm	in.
	3.538	0.1393

d) Inspect for cracked, bent or damaged blades but **DO NOT ATTEMPT TO STRAIGHTEN BLADES.**

- **Turbine housing (5)**

Inspect the profile for damage caused by possible contact with the rotor. Check all threads for damage. Inspect the outer and internal walls for cracks or flaking caused by overheating also check mounting flanges for signs of distortion.

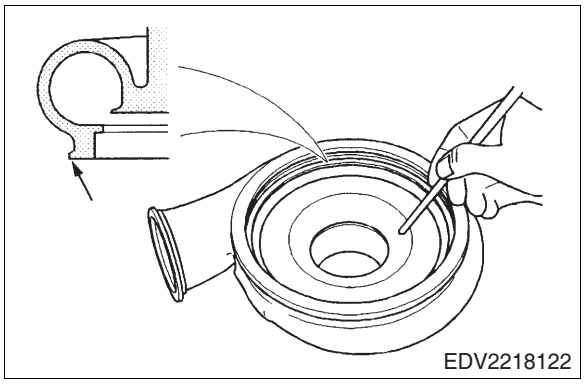
Replace with new if any of the above are visible.



- **Compressor housing (8)**

Inspect the profile for damage due to possible contact with the rotor. Check the V-band groove.

Replace with new if any of the above are visible.


EDV2218122

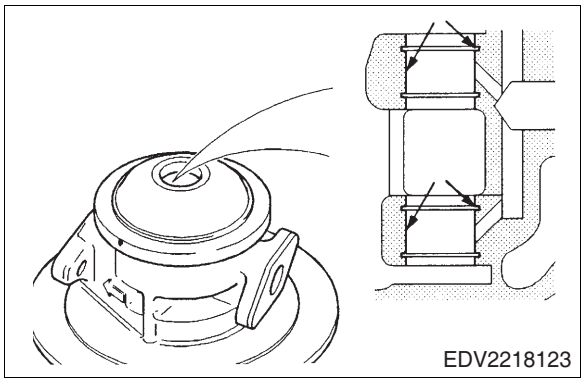
- **Bearing housing (4)**

Inspect the bore for wear or score mark on both the bearing and piston ring area. Also check all tapped holes are clean and free from dirt.

Replace with new if any damage is found.

- HX35 (V158TI)

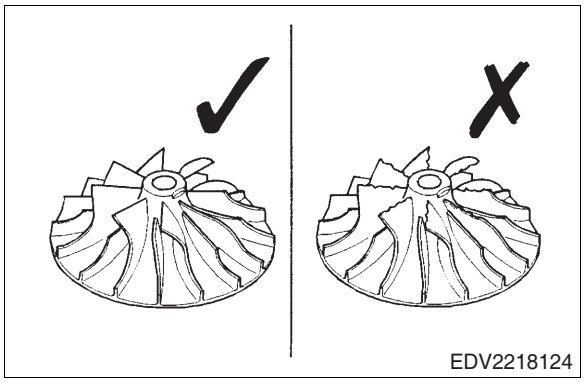
Bearing Housing Bore (Min.)	mm	in.
	15.885	0.6254


EDV2218123

- **Compressor wheel (7)**

Inspect carefully for cracked, bent or damaged blades but **DO NOT ATTEMPT TO STRAIGHTEN BLADES.**

Replace with new if any damage is found.

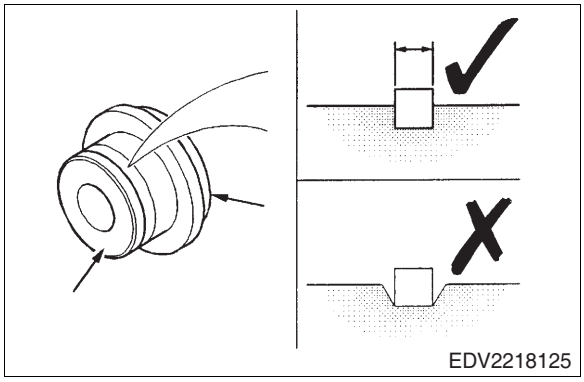

EDV2218124

<Minor components>

- **Oil slinger (31)**

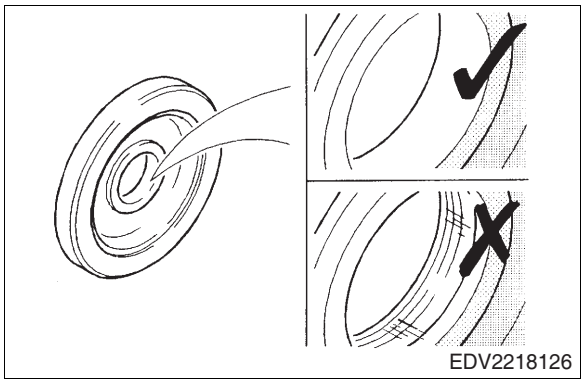
Inspect and replace if the piston ring seal groove walls are scored or damaged. Also check for signs of rubbing on the flat surfaces.

Groove Width (Max.)	mm	in.
	1.664	0.0665


EDV2218125

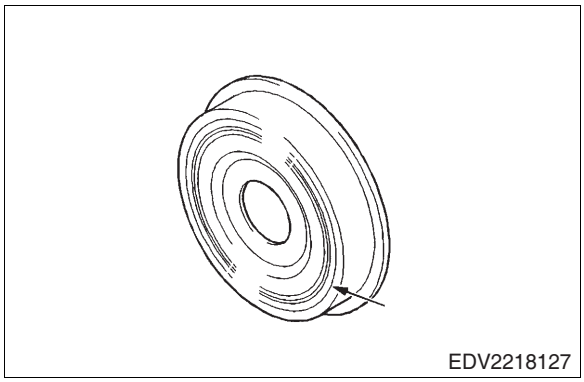
- **Oil seal plate (43)**

Inspect the seal bore, replace if scored or damaged.


EDV2218126

- **Heat shield (38)**

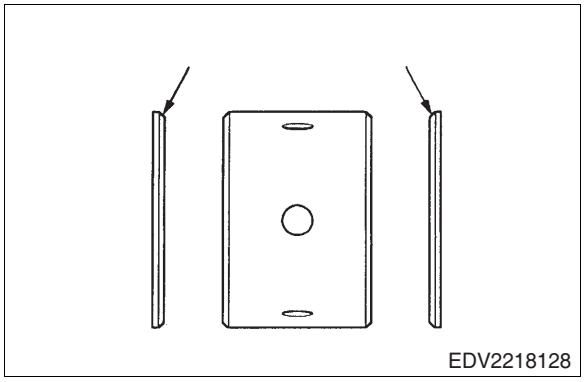
Check and replace if the heat shield id distorted or if signs of rubbing or cracking are visible.


EDV2218127

7.4.8. Assembly

- Make sure that the circlips are always fitted with the bevelled edge facing the journal bearing.

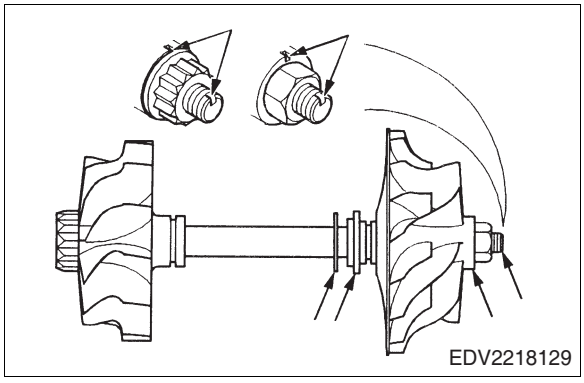
Caution :
Circlips (64). Premature failure will result if the circlips are fitted incorrectly.


EDV2218128

- **Rotor balance**

Before assembly, always make sure that both compressor wheel and assembly turbine wheel are individually balanced. **(refer to 4.3.4.)**

Then check balance of the rotor assembly to ensure it is within the required limits.


EDV2218129

Mark up each individual item to help ensure correct alignment during assembly.

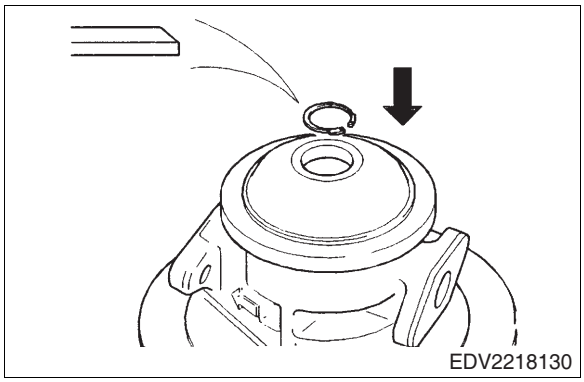
- HX35 (V158TI)

Rotor balance limits (Max.)	g.mm	oz. ins.
Turbine end	1.5	0.002
Compressor end	1.5	0.002

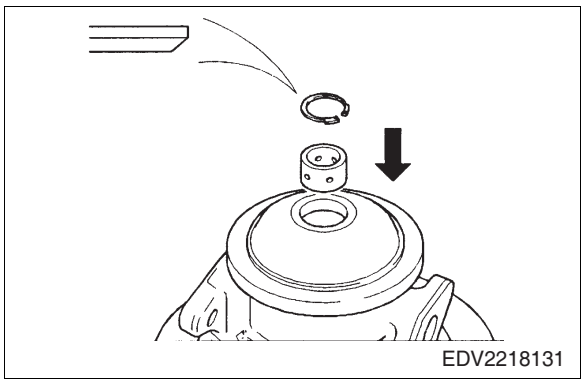
- HX50 (V188TI, V222TI)

Rotor balance limits (Max.)	g.mm	oz. ins.
Turbine end	2.2	0.003
Compressor end	4.4	0.006

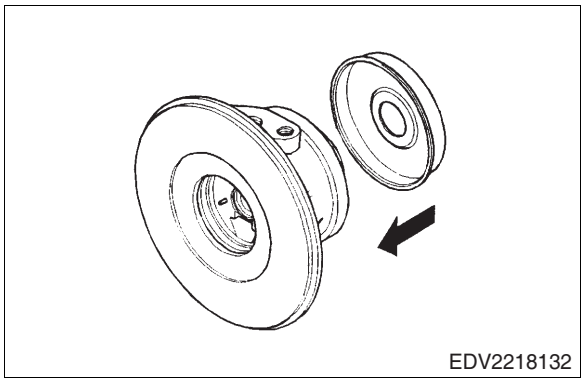
- Place the bearing housing (4) on a bench with the turbine end facing uppermost.
  Fit the inner circlip (64) with the bevelled edge facing upwards.


EDV2218130

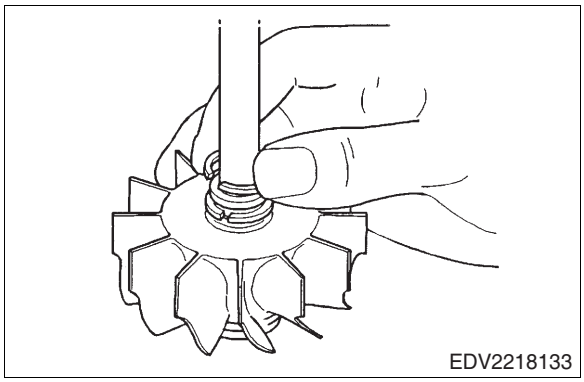
- Lubricate the journal bearing (11) and install into position.
  Fit the outer circlip (64) with the bevelled edge facing the bearing.
  Turn the bearing housing over and repeat the process.


EDV2218131

- Install the heat shield (38).

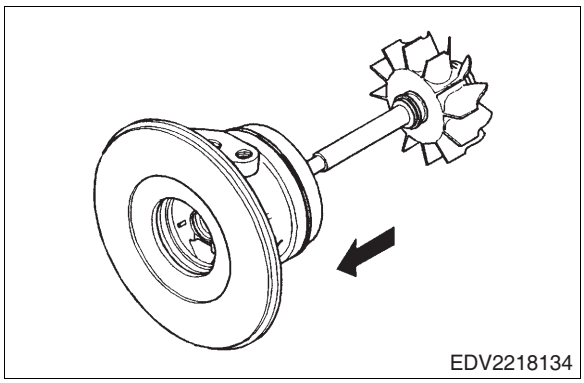


- Install the two new piston ring seals (13) to the assembly turbine wheel (6).

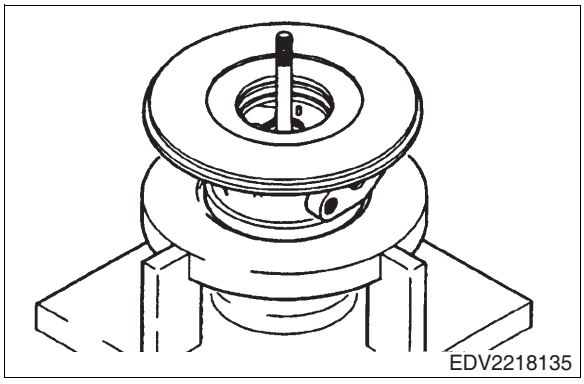


- Lubricate the shaft using clean engine oil.

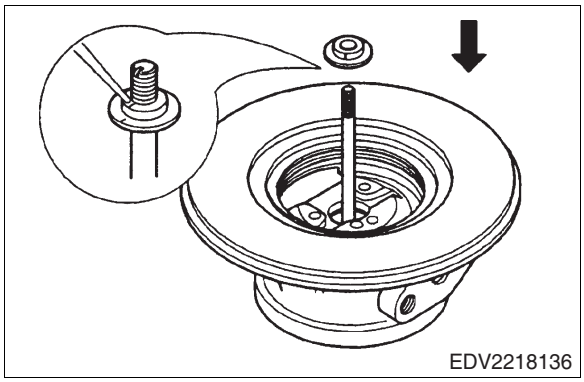
Caution :
Align the piston ring seals (16) so the gaps are positioned 180° from the oil drain hole. Gently press down on the turbine wheel - a slight rotation of the wheel will assist in properly locating the piston ring seals.



- Support the assembly turbine wheel (6) and bearing housing in a suitable fixture.



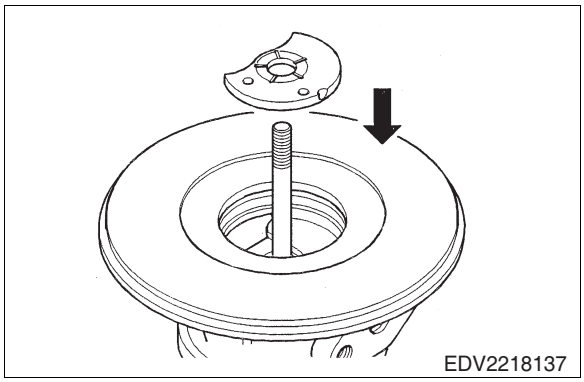
- Install the thrust collar (36).



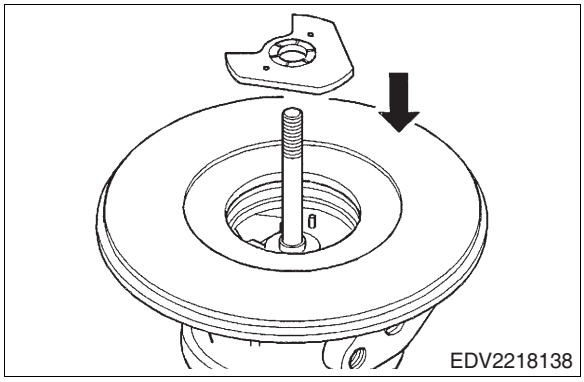
Caution :
Align the balance mark on the thrust collar with that on the shaft.

- Using clean engine oil, lubricate the thrust bearing (12). Install the thrust bearing.

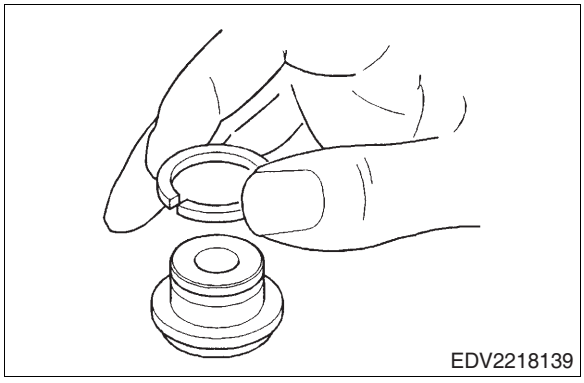
- HX35



- HX50

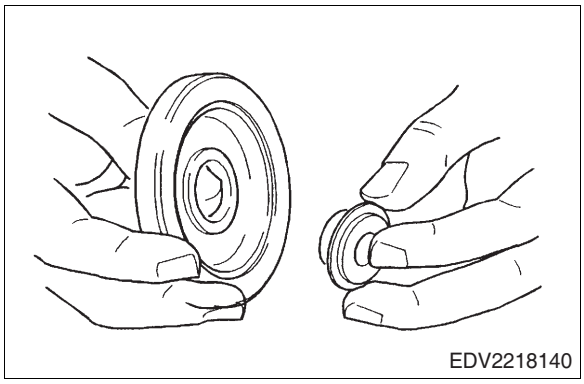


- Fit the new piston ring seal (13) to the oil slinger (31).

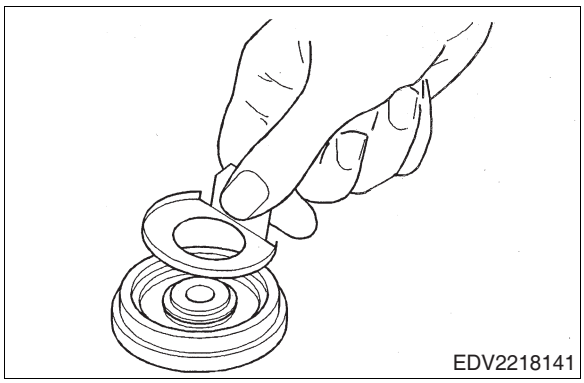


<HX35>

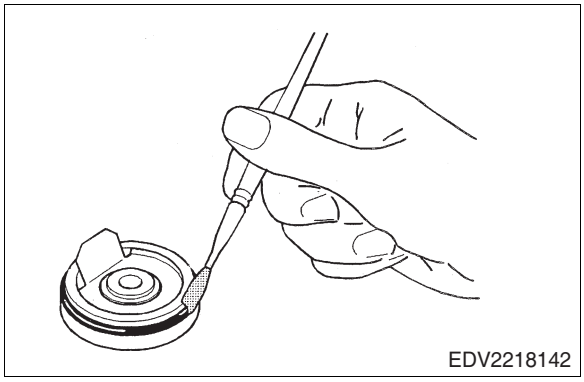
- Using clean engine oil, lubricate the oil slinger (31) and install into the oil seal plate (43).



- Install the oil baffle (33) into the oil seal plate (43).

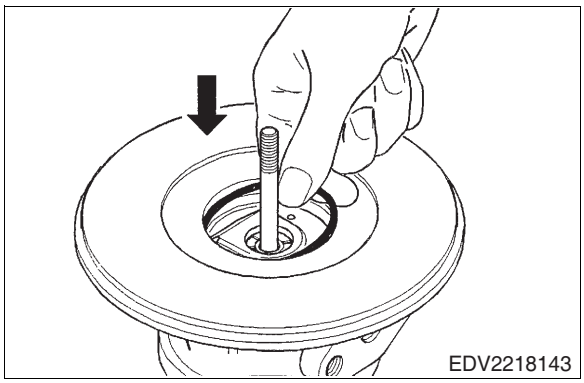


- Apply a small amount of engine oil to the oil seal plate (43) and place the O-ring seal (32) into position.

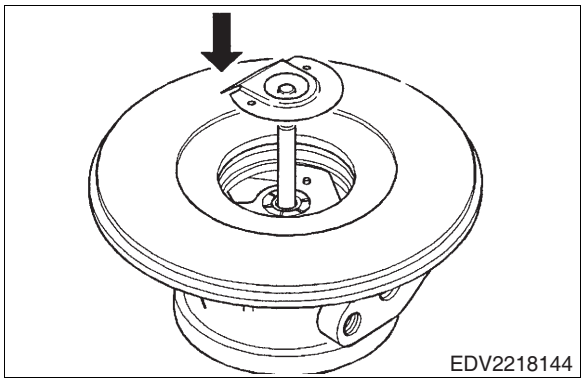


<HX50>

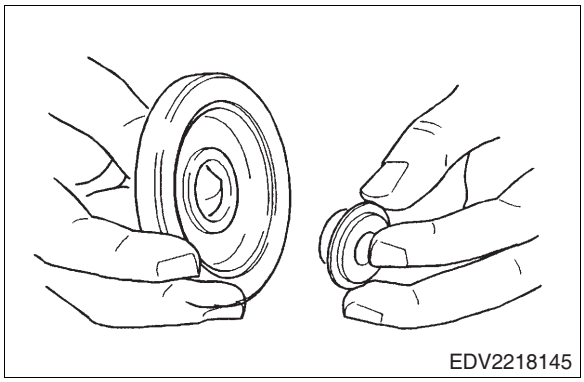
- Apply a small amount of engine oil to the O-ring seal (32), and place into position.



- Install the oil baffle (33) into the oil seal plate (43).

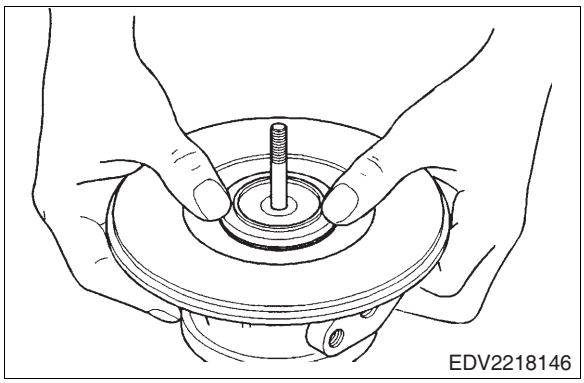


- Using clean engine oil, lubricate the oil slinger (31) and install into the oil seal plate (43).

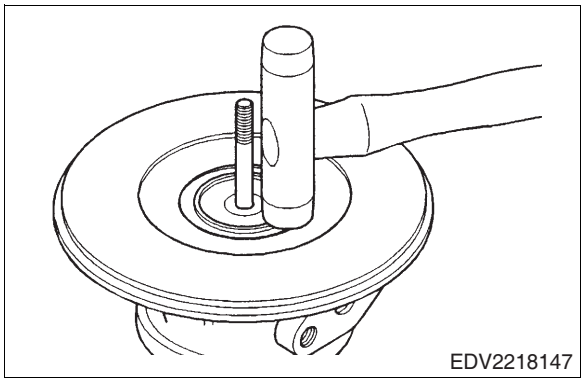


- Install the oil seal plate (43) into the bearing housing (4).

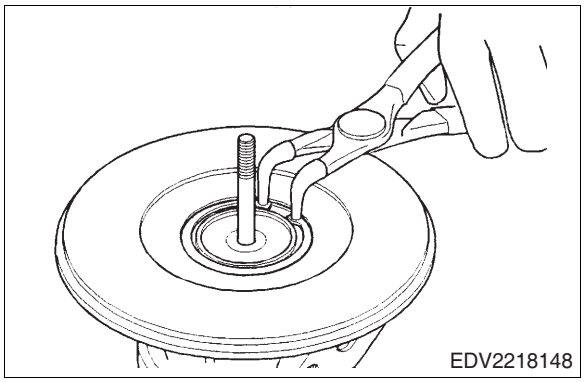
Caution :
Align the balance marks on the oil slinger (31) with that on the shaft end.



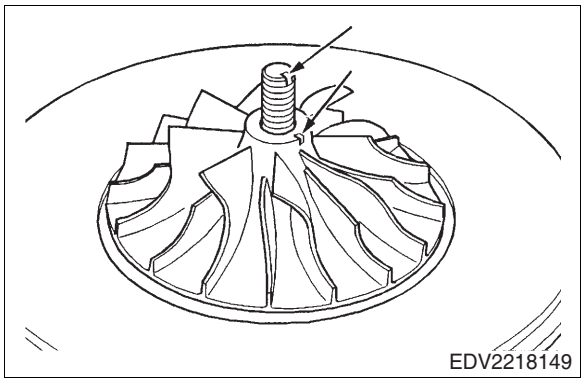
- Gently tap the oil seal plate (43) with a soft hammer to seat in position.



- Using circlip plier, install the retaining ring (66).



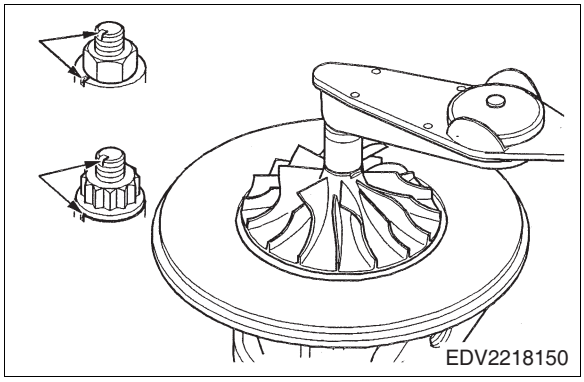
- Align the balance marks and install the compressor wheel (7).



- Install the compressor wheel lock nut(61) and tighten to the torque value.

Note :
Left hand thread.

Torque value	Nm	in-lbs
	17	150

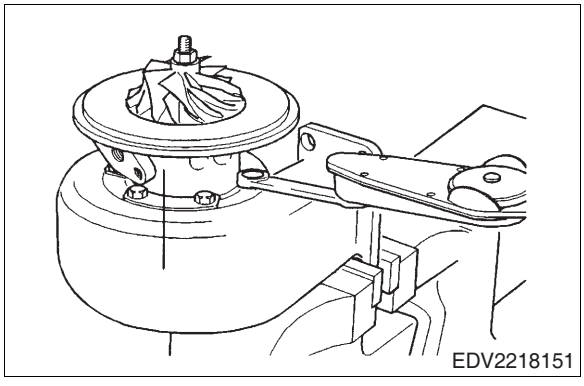


Caution :
Ensure that the balance marks are aligned on the compressor wheel and the shaft.

<HX35>

- Carefully slide the retainer ring (91) over the assembly turbine wheel (6). Locate the C.H.R.A. into the turbine housing (5).
  Install the 2 clamp plates (88) and tighten the 6 bolts (57) to the torque

Torque value bolts (57)	Nm	in-lbs
	14	120



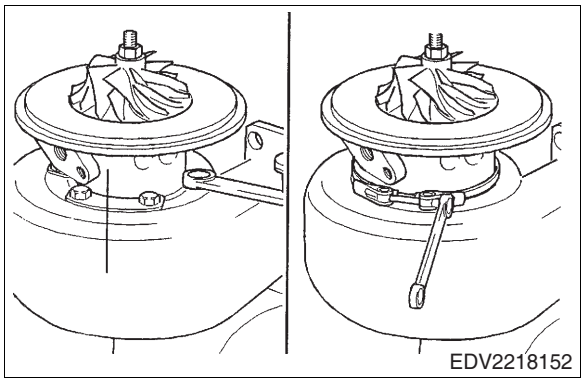
<HX50>

- Locate the C.H.R.A. into the turbine housing (5).
  Install the 3 clamp plates (88) and tighten the 6 bolts (57) to the torque value.

Torque value Bolts (57)	Nm	in-lbs
	20	180

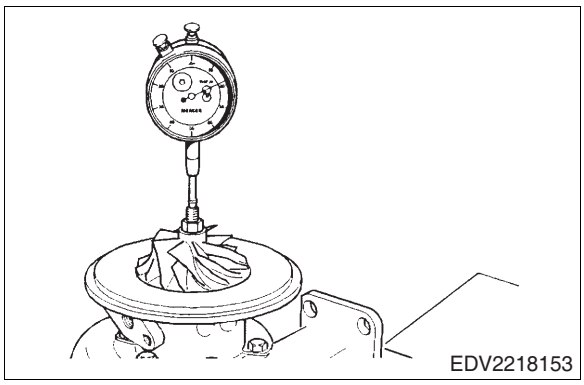
If fitted, install v-band clamp (28) and tighten the v-band lock nut.

Torque value bolts (57)	Nm	in-lbs
	8	75


EDV2218152

Caution :
Make sure the scribe marks are aligned.

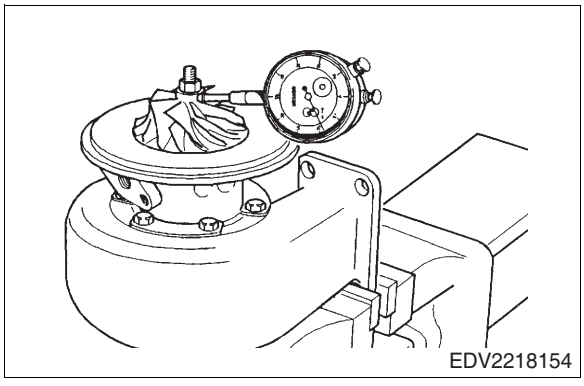
- Secure the turbine housing and check the trust clearance using a dial gauge.


EDV2218153

- HX50 (V180TI/ V222TI)

Trust clearance	mm	In
Minimum	0.038	0.0015
Maximum	0.093	0.0037

- Secure the turbine housing and check the trust clearance using a dial gauge.


EDV2218154

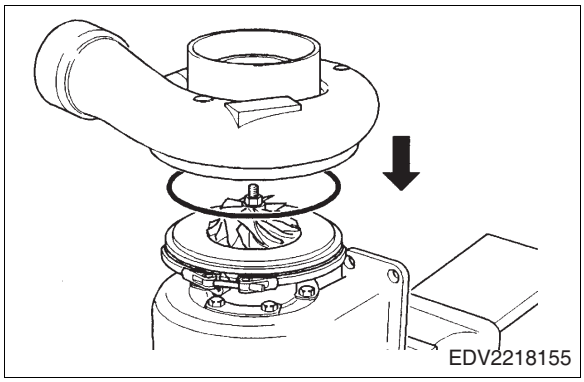
- HX50 (V180TI/ V222TI)

Radial clearance	mm	In
Minimum	0.394	0.0155
Maximum	0.635	0.0250

- Loosely fit the V-band clamp.

Lubricate and install the O-ring seal (41) if fitted.

Install the compressor cover (8).



Caution :

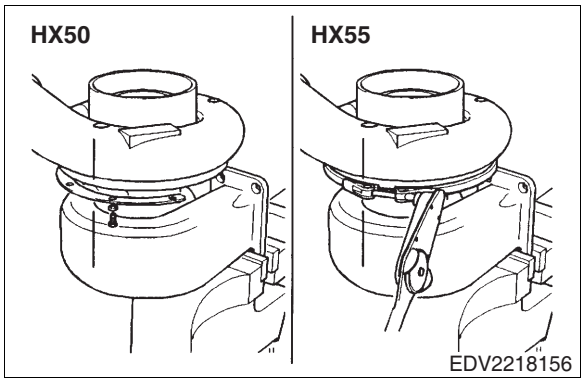
The compressor wheel blades can be easily damaged when the compressor housing is installed.

- **HX50**

Install the 2 clamp plates (51), eight lock washers (54) and tighten the 8 bolts (59) to the torque value.

- **HX55**

Install the V-band clamp (29) and tighten the lock nut (62) to the torque value.



- HX50/HX55 (V180TI/ V222TI)

Trust clearance	Nm	In-lbs
Lock nut (62)	8.5	75
Bolts (57)	20.3	18

Caution :

Make sure the scribe marks are aligned.

7.4.3. Inspection

As the condition of turbocharger depends greatly on how well the engine is serviced, it is very important to maintain the engine in accordance with the specified maintenance procedure and pay particular attention to checking oil & air leaks, unusual sound on running.

1) Checking of the rotor for rotating condition

The inspection of the rotor assembly for rotating condition should be performed by the degree of unusual sound on running. If a sound detecting bar is used, install its tip on the turbocharger housing and increase the engine revolutions slowly. If a high-pitch sound is heard every 2 ~ 3 seconds or continue, it means that the rotor assembly is not normal. In this case, as the metal bearing and rotor are likely to be in abnormal conditions, the turbocharger should be replaced or repaired.

2) Checking of the rotor end play

The radial and axial clearances of the rotor should check after every 2,000 hours operation. This precaution will enable measuring for any wear of axial clearance bearings to be detected in good time before serious damage is caused to the rotor and bearings.

Disassemble the turbocharger from the engine, then check the rotor axial play and radial play.

(1) When disassembling the turbocharger, be sure to plug the oil inlet and outlet ports

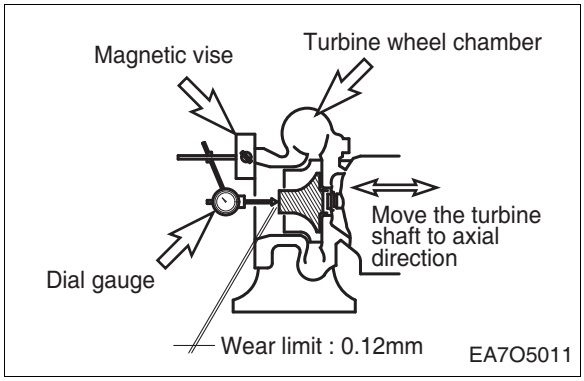
(2) If the measured axial and radial plays are beyond the limit of wear, replace or repair the turbocharger.

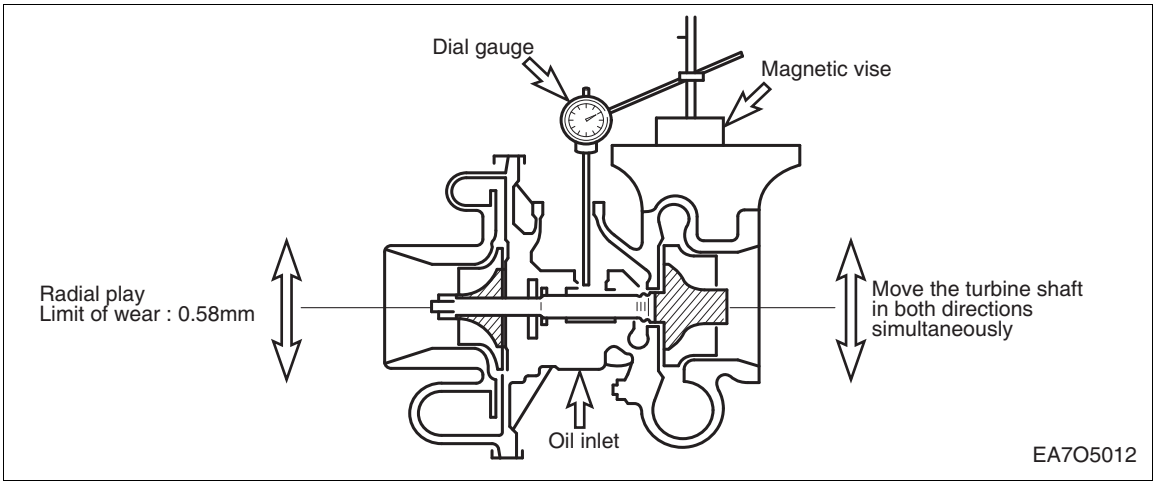
- **Measuring rotor axial clearance**

Axial clearance	0.12 mm

- **Measuring radial clearance**

Radial clearance	0.58 mm





3) Precautions for reassembling the turbocharger onto the engine

For re-assembly of the turbocharger or handling it after re-assembly operation, be sure to observe the following precautions :

Especially, pay attention to prevent foreign matters from entering the inside of the turbocharger.

(1) Lubricating system

- Before reassembling the turbocharger onto the engine, inject new oil in the oil inlet port and lubricate the journal and thrust bearings by rotating them with hand.
- Clean not only the pipes installed between the engine and oil inlet port but also the oil outlet pipe and check them for damage or foreign matters.
- Assemble each joint on oil pipes securely to prevent oil leaks.

(2) Intake system

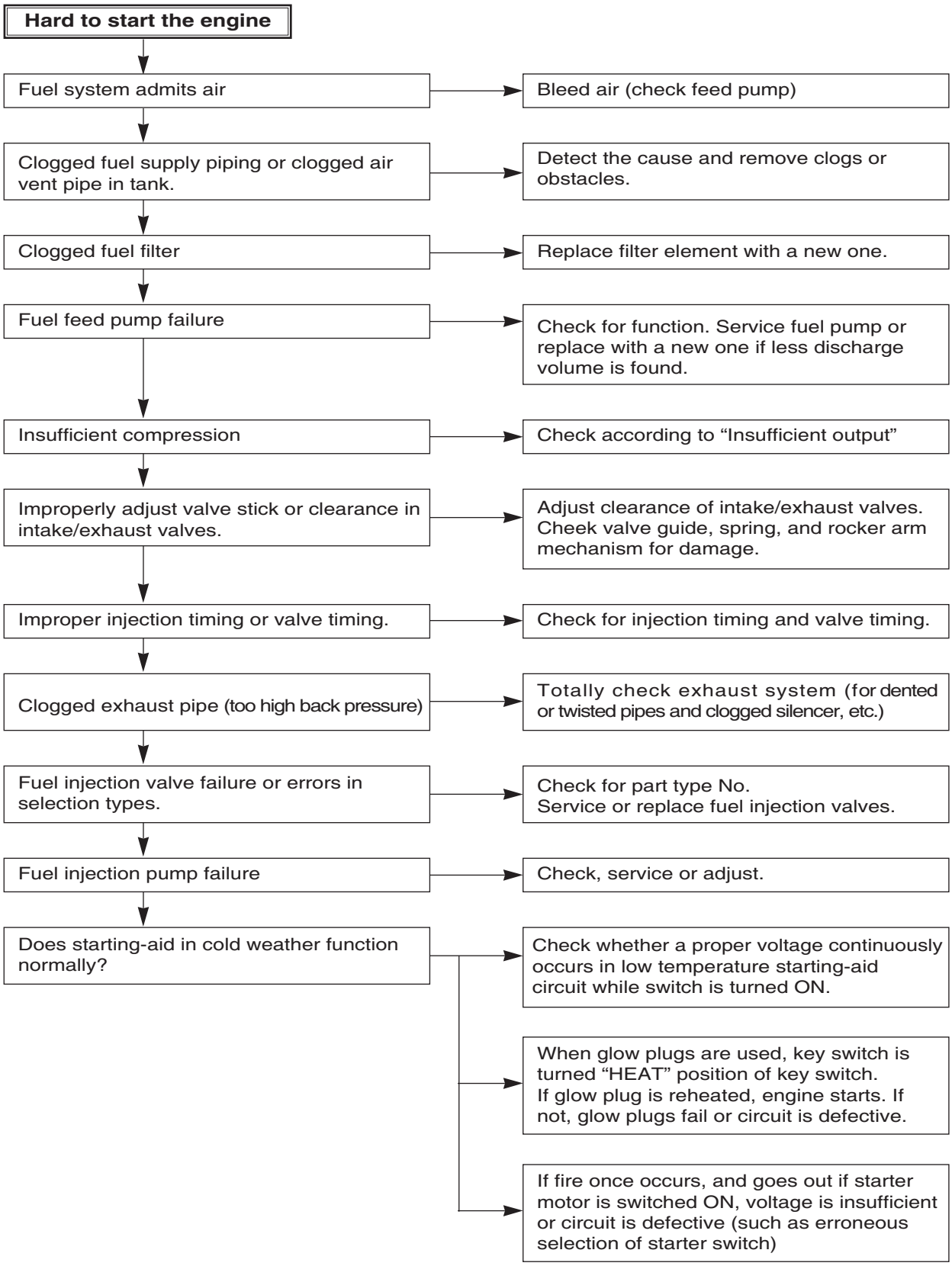
- Check the inside of the intake system for foreign matters.
- Assemble each joint on the intake duct and air cleaner securely to prevent air leaks.

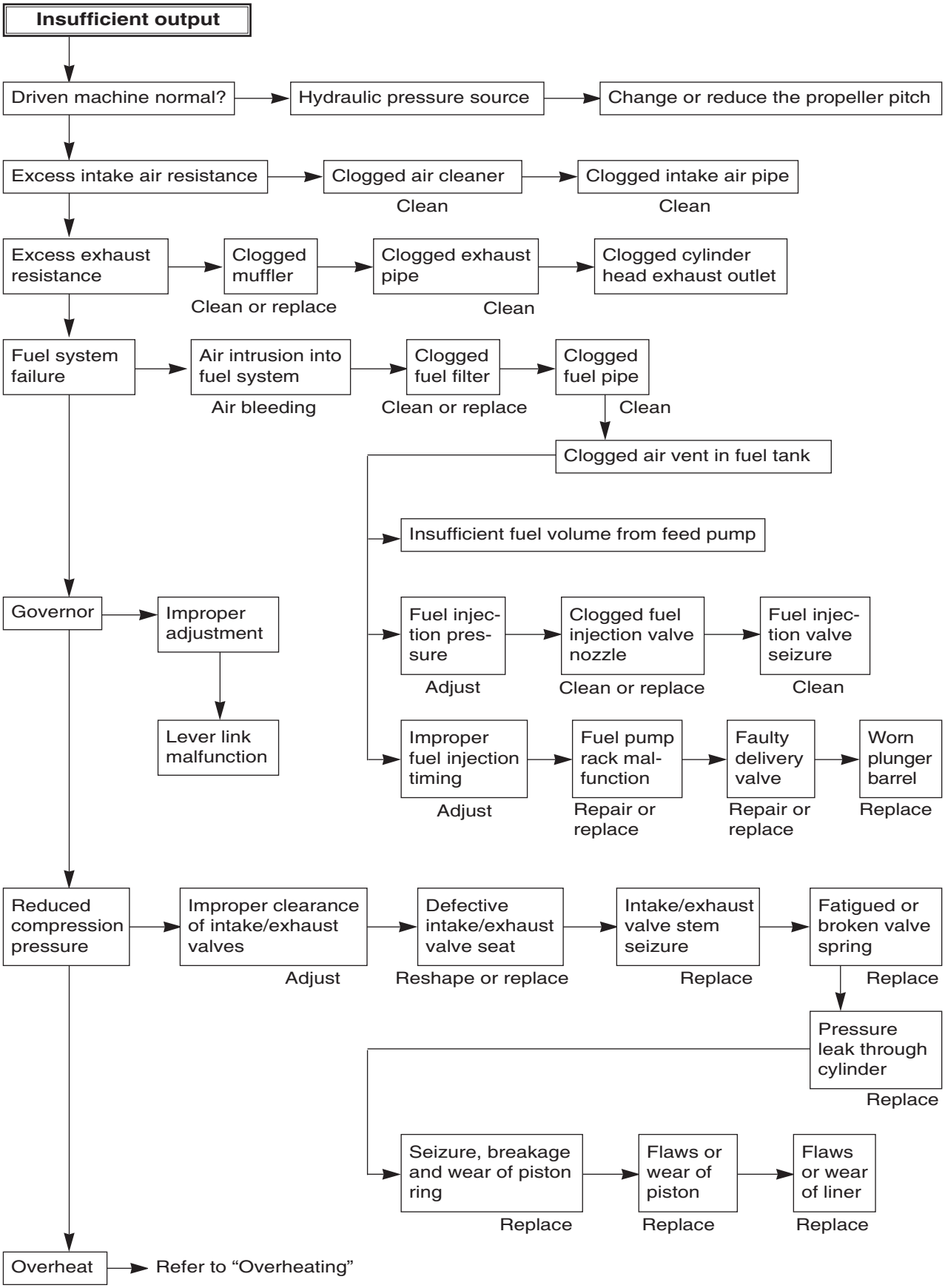
(3) Exhaust system

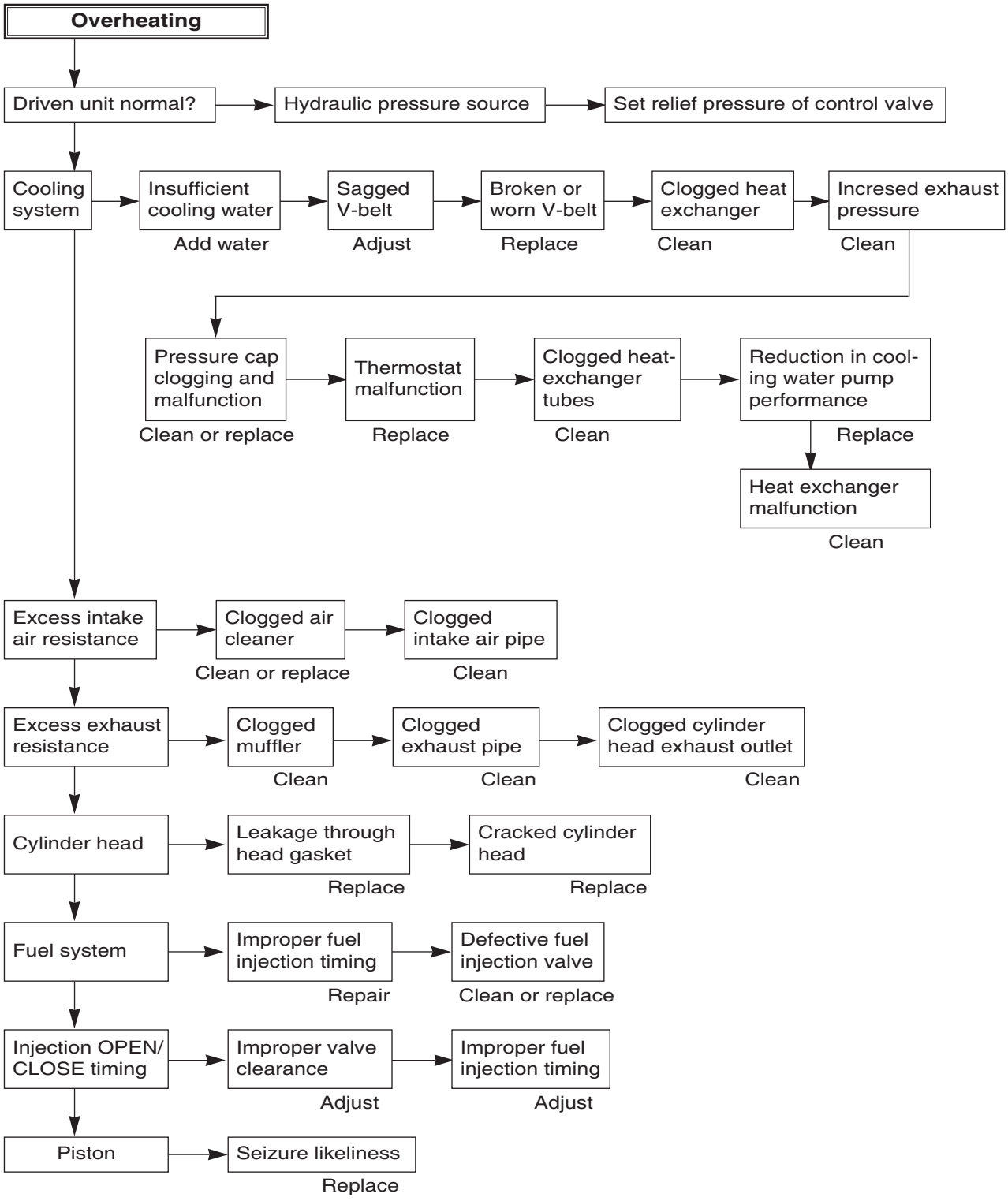
- Check the inside of the exhaust system for foreign matters.
- Be sure to use heat resisting steel bolts and nuts. Do not interchange them with ordinary steel bolts and nuts when performing re-assembly operation. Apply anti-seizure coating to the bolts and nuts.
- Assemble each joint on the exhaust pipes securely to prevent gas leaks.

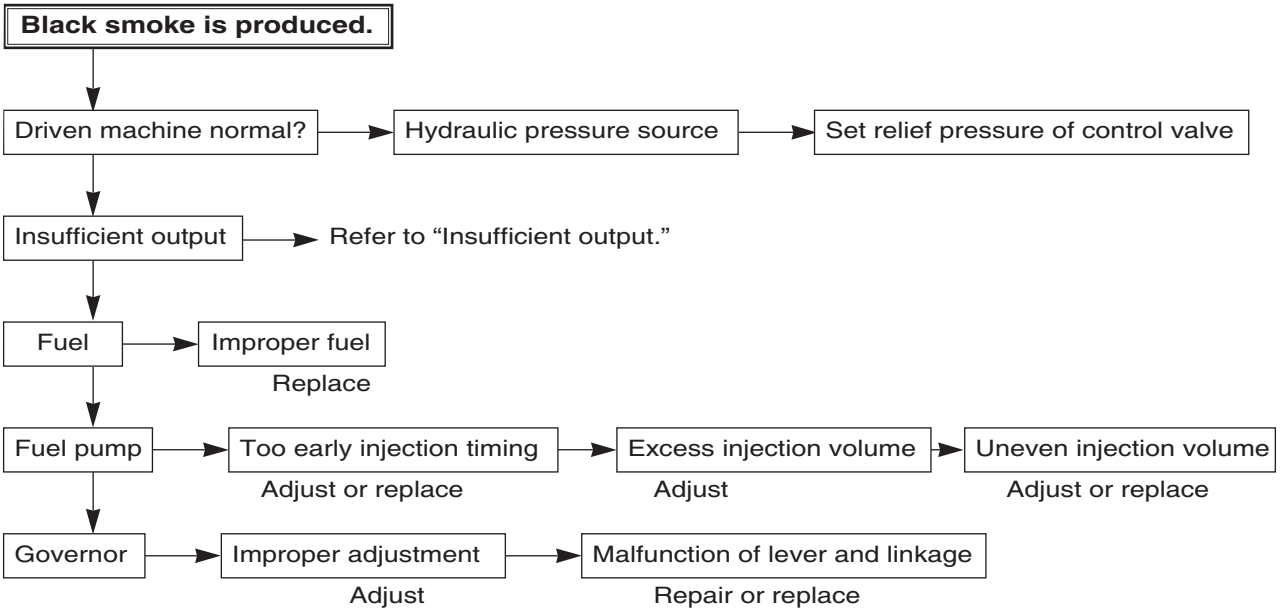
8. TROUBLE SHOOTING

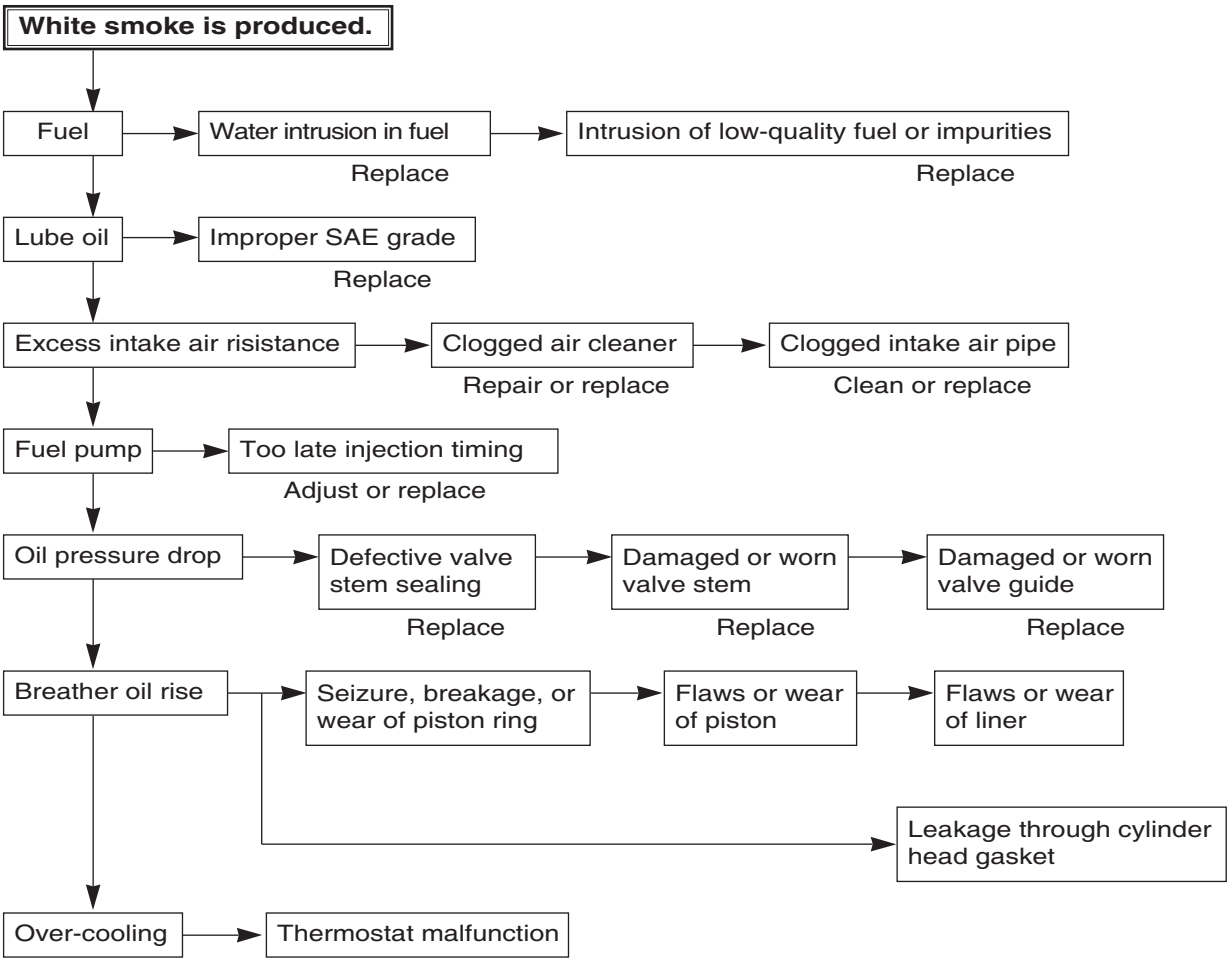
The following description summarizes the probable cause of and remedy for general failure by item. Immediate countermeasures should be taken before a failure is inflamed if any symptom is detected.

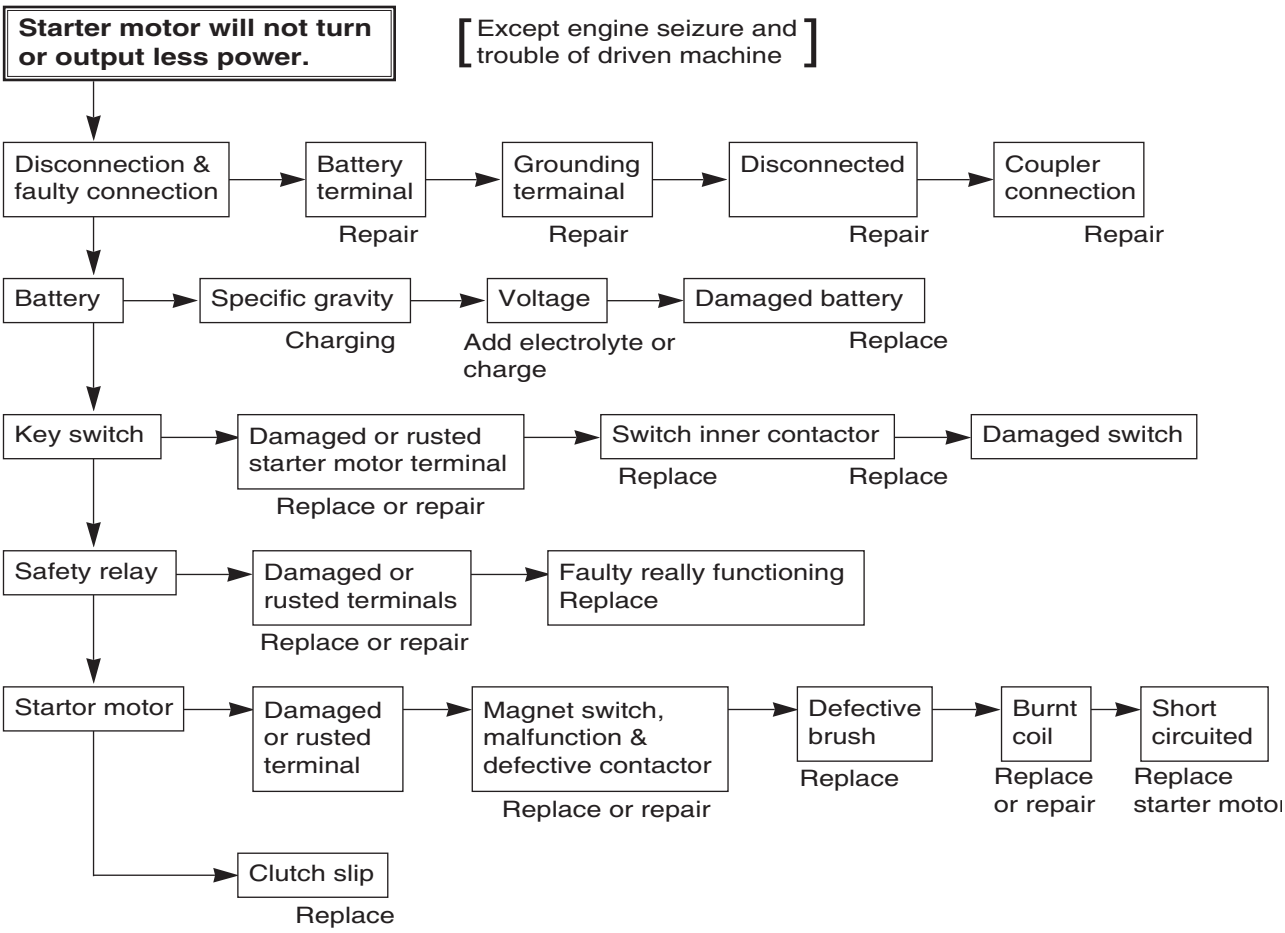



Insufficient output
Driven machine normal?
Hydraulic pressure source
Change or reduce the propeller pitch
Excess intake air resistance
Clogged air cleaner
Clean
Clogged intake air pipe
Clean
Excess exhaust resistance
Clogged muffler
Clean or replace
Clogged exhaust pipe
Clean
Clogged cylinder head exhaust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

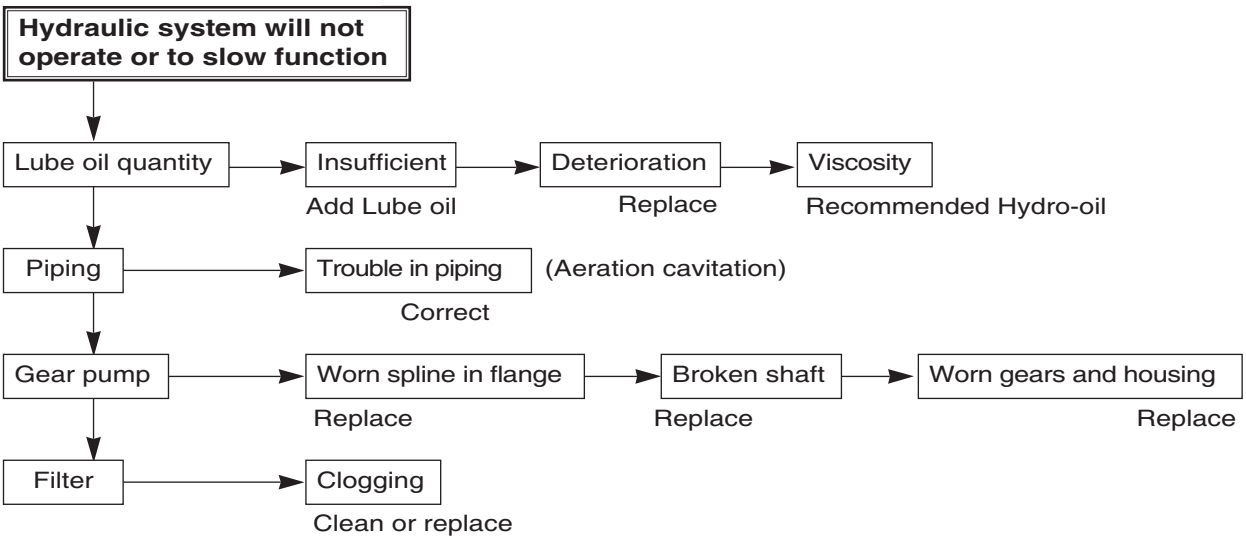

Overheating
Driven unit normal?
Hydraulic pressure source
Set relief pressure of control valve
Cooling system
Insufficient cooling water
Add water
Sagged V-belt
Adjust
Broken or worn V-belt
Replace
Clogged heat exchanger
Clean
Increased exhaust pressure
Clean
Pressure cap clogging and malfunction
Clean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

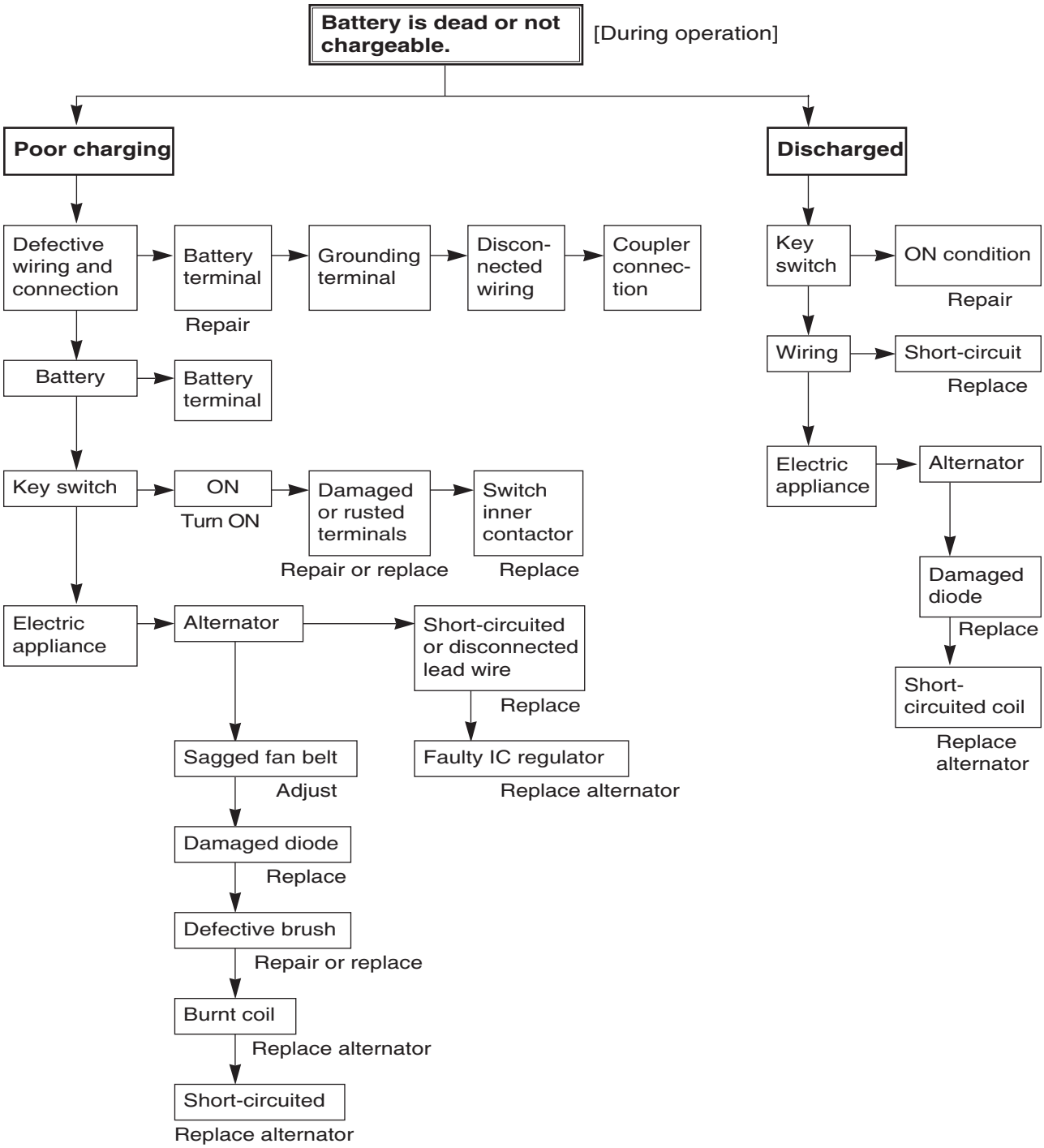

Black smoke is produced.
Driven machine normal?
Hydraulic pressure source
Set relief pressure of control valve
Insufficient output
Refer to “Insufficient output.”
Fuel
Improper fuel
Replace
Fuel pump
Too early injection timing
Adjust or replace
Excess injection volume
Adjust
Uneven injection volume
Adjust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


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



Hydraulic pressure source




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

Appendix

- **Standard table of tightening torque**

Specification	Screw	Strength	Tightening Torque kg·m
Cylinder block bearing cap			
– Main bolt	M18 × 2	12.9	Initial 30 kg.m + rotating torque 90°
– Side bolt	M12 × 1.5	10.9	8
Flywheel housing			
– Tightening bolt	M12 × 1.5	10.9	10
	M10	12.9	7.5
– Cover bolt	M8	8.8	2.2
Counter weight	M16 × 1.5	10.9	Initial 14 kg·m + rotating torque 90°
Crank pulley	M16 × 1.5	10.9	21
Vibration damper	M10	10.9	6
Flywheel	M16 × 1.5	12.9	26
Cooling fan	M8	8.8	2.2
Connecting rod cap	M16 × 1.5	10.9	Initial 10 kg·m + rotating torque 90°
Cylinder head	M15 × 2	12.9	8 kg.m + 15 kg·m + angle 90°+ angle 90°
Cylinder head cover	M8	8.8	2.2
Fuel injection nozzle holder	M28	CK60	7 ±0.5
Fuel injection pipe	M14 × 1.5		2.5
Cam shaft timer	M10	10.9	9
Rocker arm bracket	M10	10.9	6.5
Lock nut (adjusting screw)	M12 × 1	8.8	5
Oil pump cover	M8	8.8	2.2
Oil pump	M8	8.8	2.2
Oil cooler	M12	10.9	5
Oil pan	M8	8.8	2.2
Oil pan plug	M26 × 1.5	-	8
Exhaust manifold	M10	10.9	5.0
Intake manifold	M8	8.8	2.2
Fuel injection pump (cylinder block)	M10	10.9	6.5
Fuel filter	M12 × 1.5	8.8	8
Starting motor	M12 × 1.5	8	8
Alternator bracket	M14	8.8	12
Oil pressure switch	PT1/8		2
Water temperature switch	M14	8.8	2
Plug screw	M12 × 1.5		5
	M14 × 1.5		8
	M16 × 1.5		8
	M18 × 1.5		10
	M22 × 1.5		10
	M24 × 1.5		12
	M26 × 1.5		12
	M30 × 1.5		15
	AM10 × 1.0		5
	AM14 × 1.5		8

- **Standard bolt tightening torque table**

Refer to the following table for bolts other then described above

Diameter × pitch (mm)	Degree of strength										
	3.6	4.6	4.8	5.6	5.8	6.6	6.8	6.9	8.8	10.9	12.9
	(4A)	(4D)	(4S)	(5D)	(5S)	(6D)	(6S)	(6G)	(8G)	(10K)	(12K)
	Limit value for elasticity (kg/mm²)										
	20	24	32	30	40	36	48	54	64	90	108
	Tightening torque (kg.m)										
M5	0.15	0.16	0.25	0.22	0.31	0.28	0.43	0.48	0.5	0.75	0.9
M6	0.28	0.30	0.45	0.4	0.55	0.47	0.77	0.85	0.9	1.25	1.5
M7	0.43	0.46	0.7	0.63	0.83	0.78	1.2	1.3	1.4	1.95	2.35
M8	0.7	0.75	1.1	1	1.4	1.25	1.9	2.1	2.2	3.1	3.8
M8×1	0.73	0.8	1.2	1.1	1.5	1.34	2.1	2.3	2.4	3.35	4.1
M10	1.35	1.4	2.2	1.9	2.7	2.35	3.7	4.2	4.4	6.2	7.4
M10×1	1.5	1.6	2.5	2.1	3.1	2.8	4.3	4.9	5	7	8.4
M12	2.4	2.5	3.7	3.3	4.7	4.2	6.3	7.2	7.5	10.5	12.5
M12×1.5	2.55	2.7	4	3.5	5	4.6	6.8	7.7	8	11.2	13.4
M14	3.7	3.9	6	5.2	7.5	7	10	11.5	12	17	20
M14×1.5	4.1	4.3	6.6	5.7	8.3	7.5	11.1	12.5	13	18.5	22
M16	5.6	6	9	8	11.5	10.5	17.9	18.5	18	26	31
M16×1.5	6.2	6.5	9.7	8.6	12.5	11.3	17	19.5	20	28	33
M18	7.8	8.3	12.5	11	16	14.5	21	24.2	25	36	43
M18×1.5	9.1	9.5	14.5	12.5	18.5	16.7	24.5	27.5	28	41	49
M20	11.5	12	18	16	22	19	31.5	35	36	51	60
M20×1.5	12.8	13.5	20.5	18	25	22.5	35	39.5	41	58	68
M22	15.5	16	24.5	21	30	26	42	46	49	67	75
M22×1.5	17	18.5	28	24	34	29	47	52	56	75	85
M24	20.5	21.5	33	27	40	34	55	58	63	82	92
M24×1.5	23	25	37	31	45	38	61	67	74	93	103

Others:

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

   For example, a screw coated with MoS_2 should be tightened to 60% or so of the standard value.

- **Maintenance specification table**

(unit: mm)

Group	Part	Inspection item		Stand value for assembly	Limit for use	Correction	Remark
Cylinder block	Cylinder block & liner	Inside diameter of cylinder liner		ø127.99 ~ ø128.01	ø128.122	Replace liner	Measure unworn portion beneath the rim of the upper side
		Liner's roundness & columness (upper)		0.005	–		From top up to 168 mm
		Liner's roundness & columness (lower)		0.008	–		From bottom up to 85 mm
		Amount of liner projection		0.04 ~ 0.09	–		Measure at upper side of cylinder block
		The flatness of upper surface of cylinder block		0.03	–	Correct with a surface grinder	0.015 for a length of 150 mm
		Hydraulic test for 1 minute (kg/cm^2)		4	–	Replace if leaky	Temperature 70°C
	Cylinder head & valve	Valve seat depression	Intake	0.65 ~ 0.95	2.5	Replace valve seat	0.25↓ @250 hr valve clearance inspection interval
			Exhaust	0.65 ~ 0.95	2.5		
		Cylinder head height		113.9 ~ 114	113.35	Replace cylinder head	
		The flatness of lower surface of cylinder head		0.015	0.1		
		Inner diameter of valve guide	Intake	ø8.015 ~ ø8.030	–		
			Exhaust	ø8.015 ~ ø8.030	–		
		Thick of cylinder head gasket (at assembly status)		1.215 ~ 1.285	–		
		Hydraulic test for 1 minute (kg/cm^2)		4	–	Replace if leaky	Room temperature
Major moving parts	Piston	Outer diameter of piston		ø127.739 ~ ø127.757	–	Replace piston	Measure at 56.8 mm away from piston head (long diameter)
		Clearance between piston and liner		0.233 ~ 0.271	0.35	Replace one worn more	
		Inner diameter of piston pin		ø46.010 ~ ø46.016	–		Standard diameter
		Width of piston ring grooves	Top ring	3.20 ~ 3.23	–	Replace piston if groove width is beyond specified value	Measure at 125 mm of top ring groove
			2nd ring	3.040 ~ 3.060	–		
			Oil ring	4.020 ~ 4.040	–		
		Piston projection from cylinder block upper surface		0.18 ~ 0.47	–		Measure unworn portion beneath the rim of the upper side
		Permissible weight difference of each piston		50 g	50 g ↓	Replace piston	

(unit: mm)

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

(unit: mm)

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

(unit: mm)

Group	Part	Inspection item		Stand value for assembly	Limit for use	Correction	Remark
Major moving parts	Fly wheel	Ring gear assembly part's outer diameter		ø432.590 ~ ø432.700	–		Heating temperature at ring gear assembly (200 ~ 230°C)
		Ring gear inner diameter		ø432.000 ~ ø432.200	–		
		Overlap		0.390 ~ 0.700	–		
		Allowable shaking amount after assembly		0.5	–		
		Outer diameter after assembly wear ring		ø119.860 ~ ø120.000	–		
Valve system	Valve and valve guide	Exhaust valve	Stem O.D.	ø11.945 ~ ø11.955	–		
			Radial clearance	0.045 ~ 0.073	–		
			Seat angle	45°	–		
			Head diameter	ø50.9 ~ ø51.1	–		
			Valve head thickness ("H")	1.9 ~ 2.3	–		
			Valve seat head diameter	ø53.00 ~ ø53.03	–		
			Valve seat O.D.	ø53.10 ~ ø53.11	–		
		Intake valve	Stem O.D.	ø11.969 ~ ø11.980	–		
			Radial clearance	0.020 ~ 0.049	–		
			Seat angle	30°	–		
			Head diameter	ø57.85 ~ ø58.15	–		
			Valve head thickness ("H")	2.6 ~ 3.0	–		
			Valve seat head diameter	ø61.00 ~ ø61.03	–		
			Valve seat O.D.	ø61.10 ~ ø61.11	–		
		Head valve seat assembly part's depth		12.5 ~ 12.6	–		
		Valve guide I.D.		ø12.000 ~ ø12.018	–		
		Head valve guide I.D.		ø18.000 ~ ø18.018	–		
		Valve guide O.D.		ø18.028 ~ ø18.046	–		
		Valve guide mounting clamp		0.010 ~ 0.046	–		
		Valve guide play		0.04	–		
		Valve spring	Valve lift	14.1	–		
			Valve guide protrusion	17.1 ~ 17.5	–		
			Free length of inner spring	72.43	–		
			Load on inner spring	15 ~ 17 kg	–		
			Load on inner spring	27 ~ 32 kg	–		
			Free length of outer spring	68.17	–		
			Load on outer spring	37 ~ 41 kg	–		
			Load on outer spring	66.5 ~ 76.5 kg	–		

(unit: mm)

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

(unit: mm)

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

(unit: mm)

Group	Part	Inspection item		Stand value for assembly	Limit for use	Correction	Remark
Cooling system	Cooling water temperature	Operating temperature (°C)		79 ~ 95	–	Must not exceed this value	
		Permissible temperature in a short time (°C)		–	105		
	Thermostat	Operating temperature (°C)	2V TIL	71	–	Replace	
			2V TIM/TIH	79	–		
		Full opening temperature (°C)	2V TIL	85	–	Replace if defective Stroke: min. 8 mm	
			2V TIM/TIH	94	–		
Fuel system	Fuel injection pump maker			Bosch	–		
	Fuel piping & others	Fuel pipe, injection pipe & injector for damage, cracks, improper O-ring		–	–	Replace	
		Damage of fuel filter cartridge		–	–	Replace cartridge	
	Injector opening pressure (kg/cm^2)			285.5 ~ 297.8	–		
	Operating pressure of overflow valve (kg/cm^2)			1.33 ~ 1.84	–	Replace valve	
	Diameter of injector nozzle			–	–	Differs for each suffix	
	Projection height of nozzle from the cylinder head surface (mm)			3.0	–	Replace sealing	
Drive system	Gear back lash	Between crank gear & oil pump drive gear		0.099 ~ 0.451	–	Adjust back lash	
		Between crank gear & cam shaft gear		0.143 ~ 0.292	0.3		
		Between drive gear & fuel pump gear		0.102 ~ 0.338	0.45		

Paper Size : 120mmx165mm

Diesel Engine for Generators (Land/Marine)

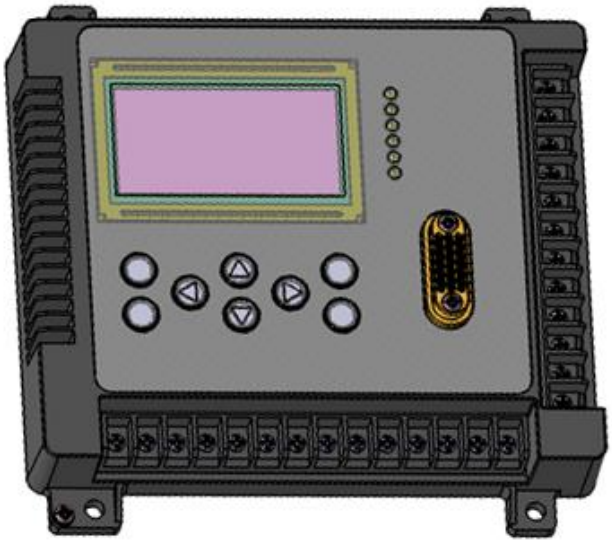
Digital Speed Controller

User Manual

Ver_1.07

300611-01127A(Land)

300611-01440(Marine)



HYUNDAI

HD Hyundai Infracore

Contents

1. Product Overview and General Specification

1.1 Product Information

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

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

[Product Features]

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

1.2 Product Appearance

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

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

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

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

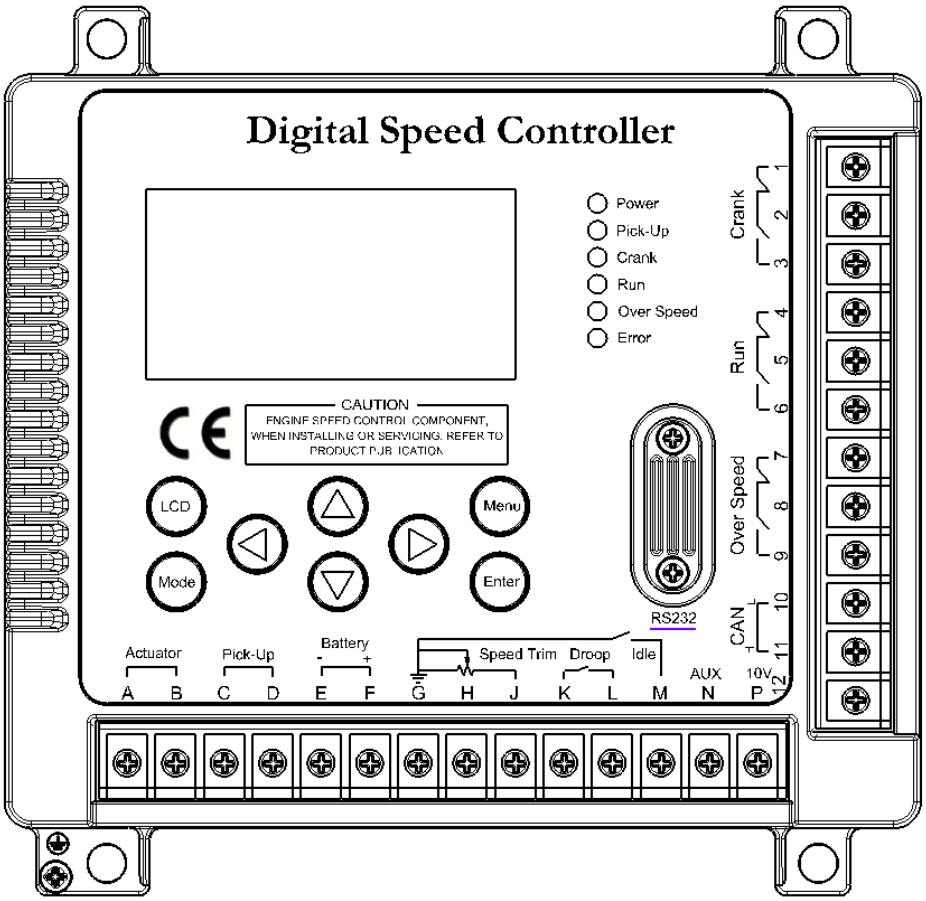


Figure 1: Product Front View

1.3 Product Specification

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

1.4 Product System Diagram

Cautions on wiring

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

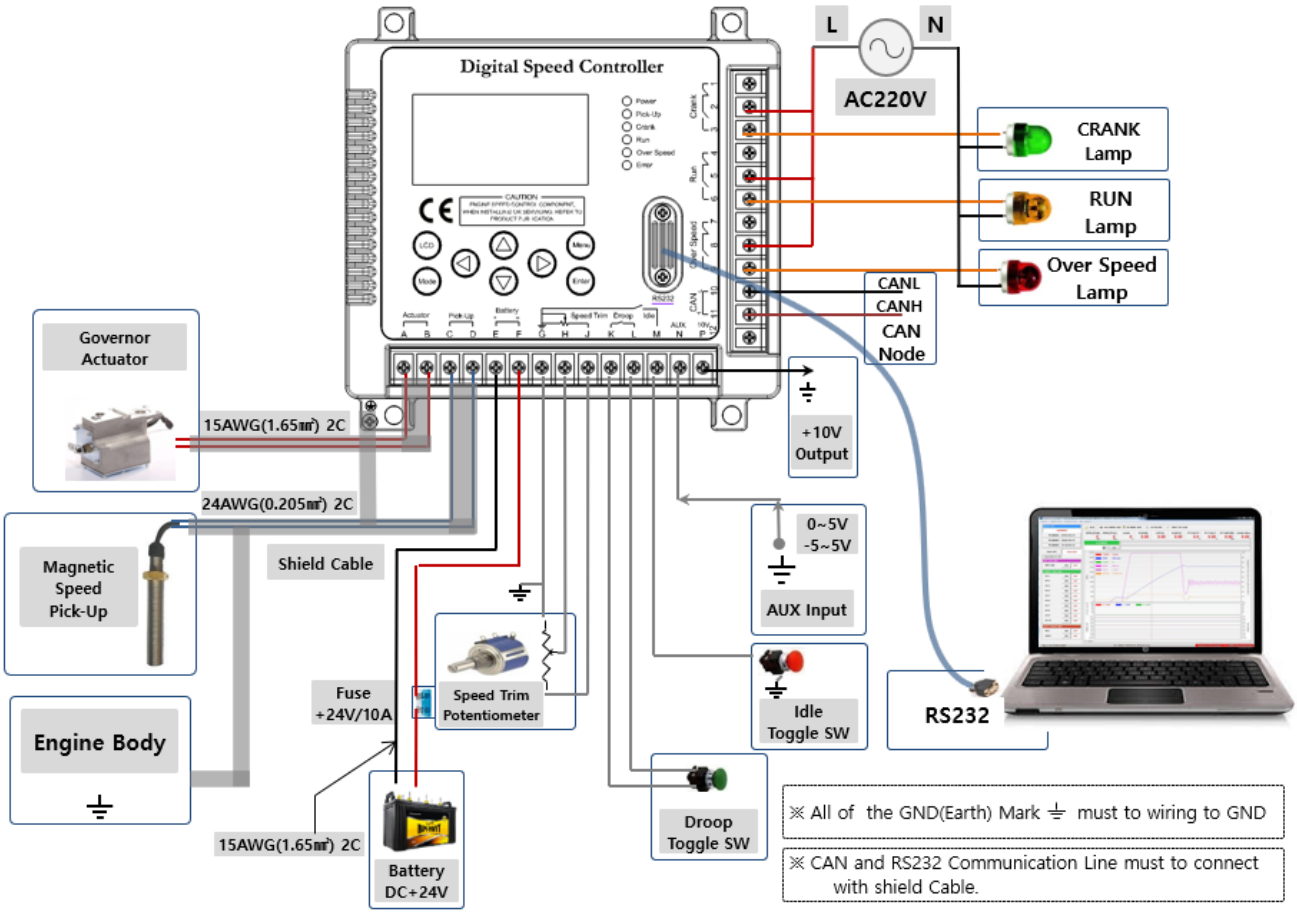


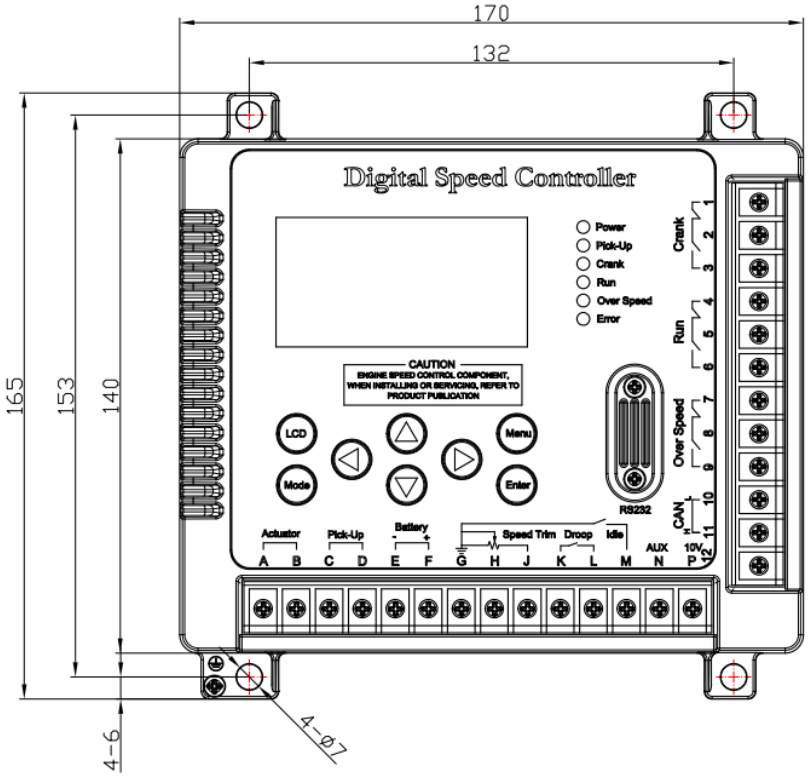
Figure 2: System Diagram for Digital Speed Controller

1.5 Product I/O Signals

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

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

1.6 Product Dimension



2. Installation

Cautions for installing the digital speed controller

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

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

2.1 Connecting to the Engine

2.1.1 Battery, Pick-Up and Actuator Connection Diagram

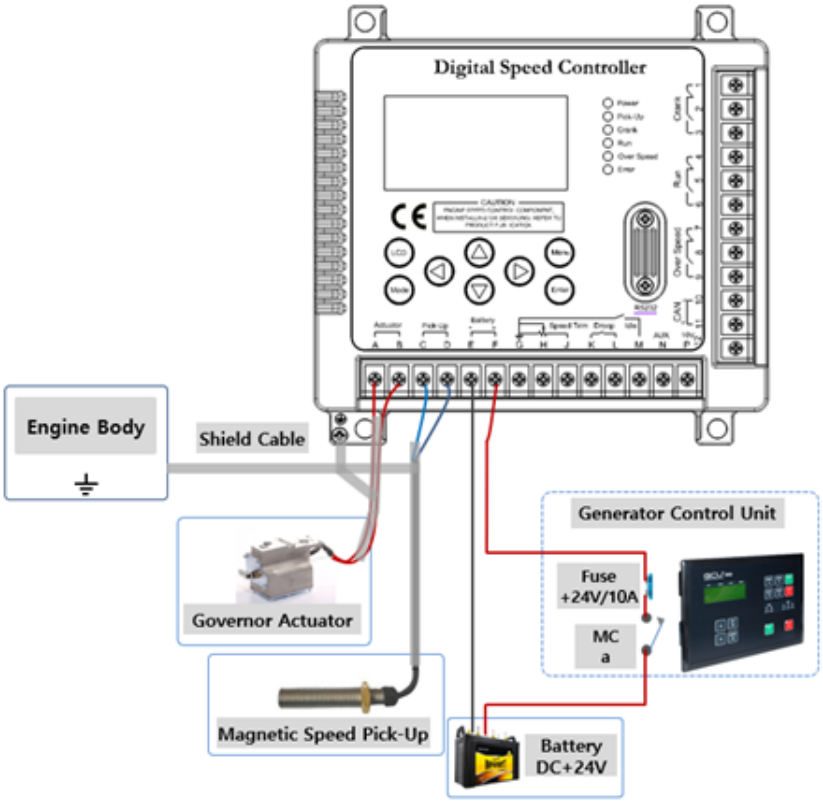


Figure 3: Battery, Pick-Up and Actuator Connection Diagram

2.1.2 Connecting to Batteries

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

2.1.3 Connecting to Actuators

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

2.1.4 Connecting to Pick-Up Sensors

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

2.1.5 Operating Sequence for Digital Speed Controller

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

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

[Operating Sequence for the Controller]

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

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

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

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

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

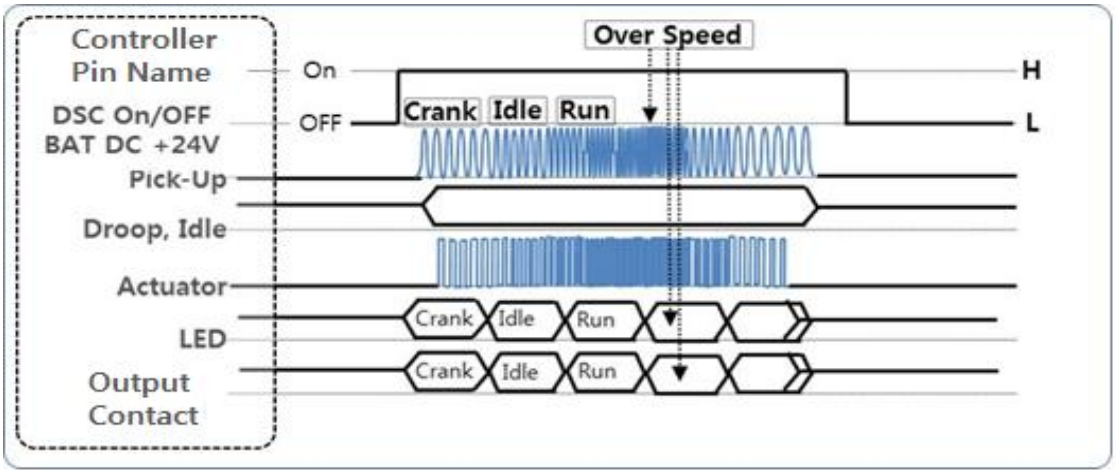


Figure 4: Time Chart for Operation of the Controller

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

2.2.1 Speed Trim, Droop, Idle and Other Inputs Diagram

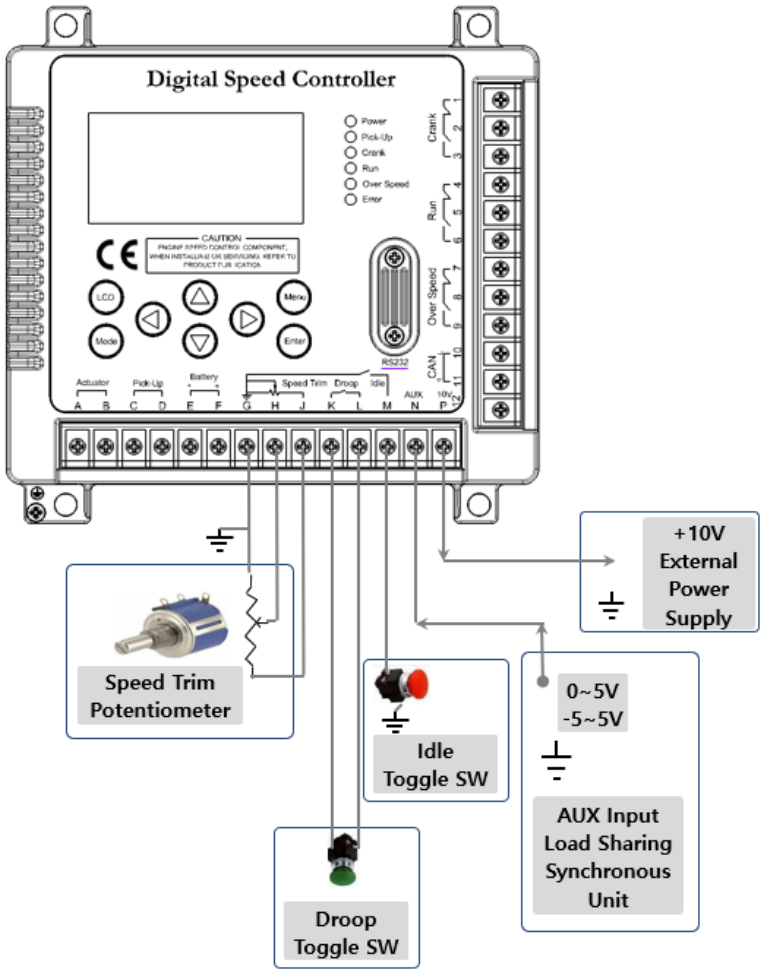


Figure 5: Speed Trim, Droop, Idle and Other Inputs Diagram

2.2.2 Connecting to Speed Trim

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

2.2.3 Connecting to Droop

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

2.2.4 Connecting to Idle

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

2.2.5 Connecting to AUX

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

2.2.6 Connecting Power to External Devices

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

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

2.3 Connecting to Crank, Run, Over Speed and Communication

2.3.1 Crank, Run, Over Speed and Communication Connection Diagram

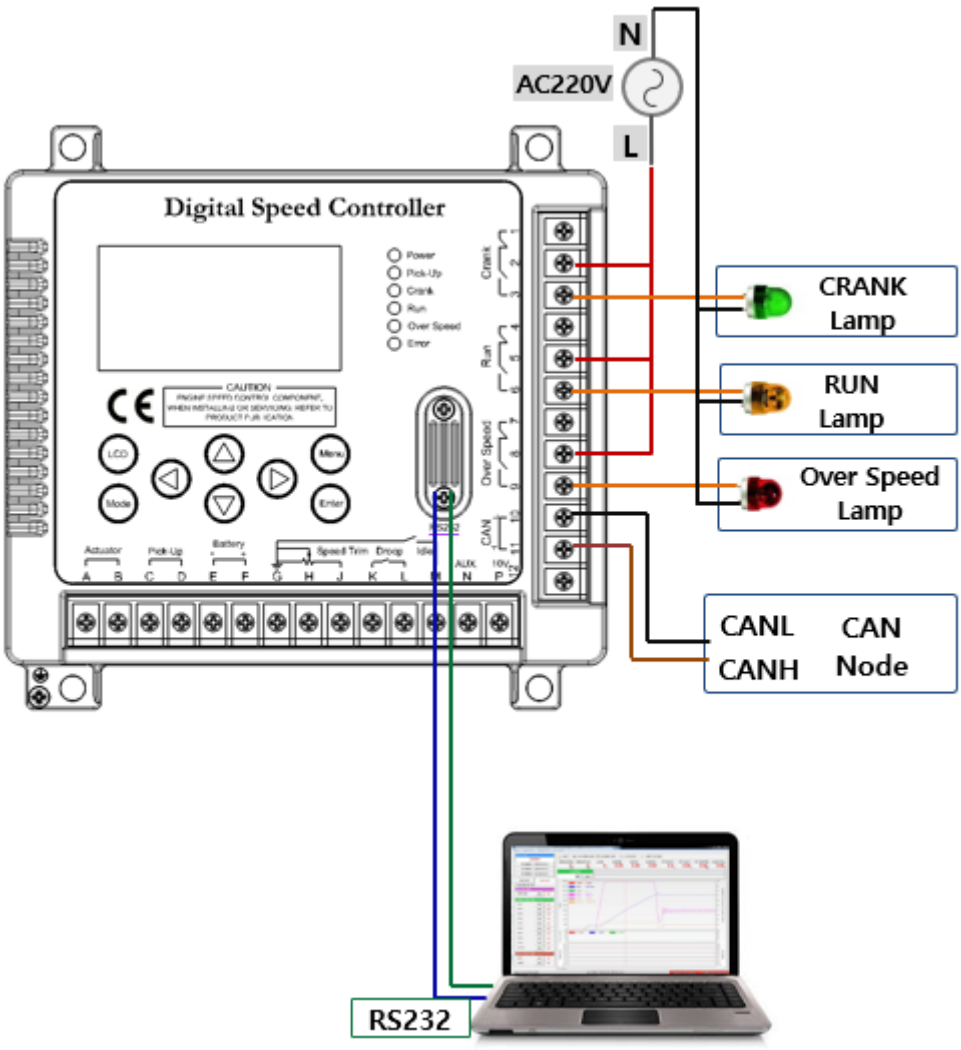


Figure 6: Crank, Run, Over Speed and Communication Connection Diagram

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

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

2.3.2 Connecting to Crank Terminals

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

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

2.3.3 Connecting to Run Terminals

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

2.3.4 Connecting to Over Speed

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

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

2.3.5 Connecting to CAN Communication

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

2.3.6 Connecting to RS232 Communication

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

3. Configuration and Operation

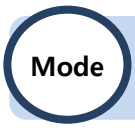
The controller can be configured and operated by input keys according to the menus on the LCD display by selecting proper ones and assigning values in the selected menu to input control information to the system. Input information should immediately apply to the controller system once updated.

3.1 Input Keys

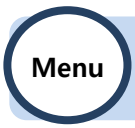
The controller has 8 input keys including LCD, Mode, Menu, Enter, Up, Down, Left and Right.

Each key as respective functions as follows:

LCD key turns on and off the display.



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



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

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

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

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

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

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

3.2 LCD Display Menu

The overall menu tree of the controller is as follows:

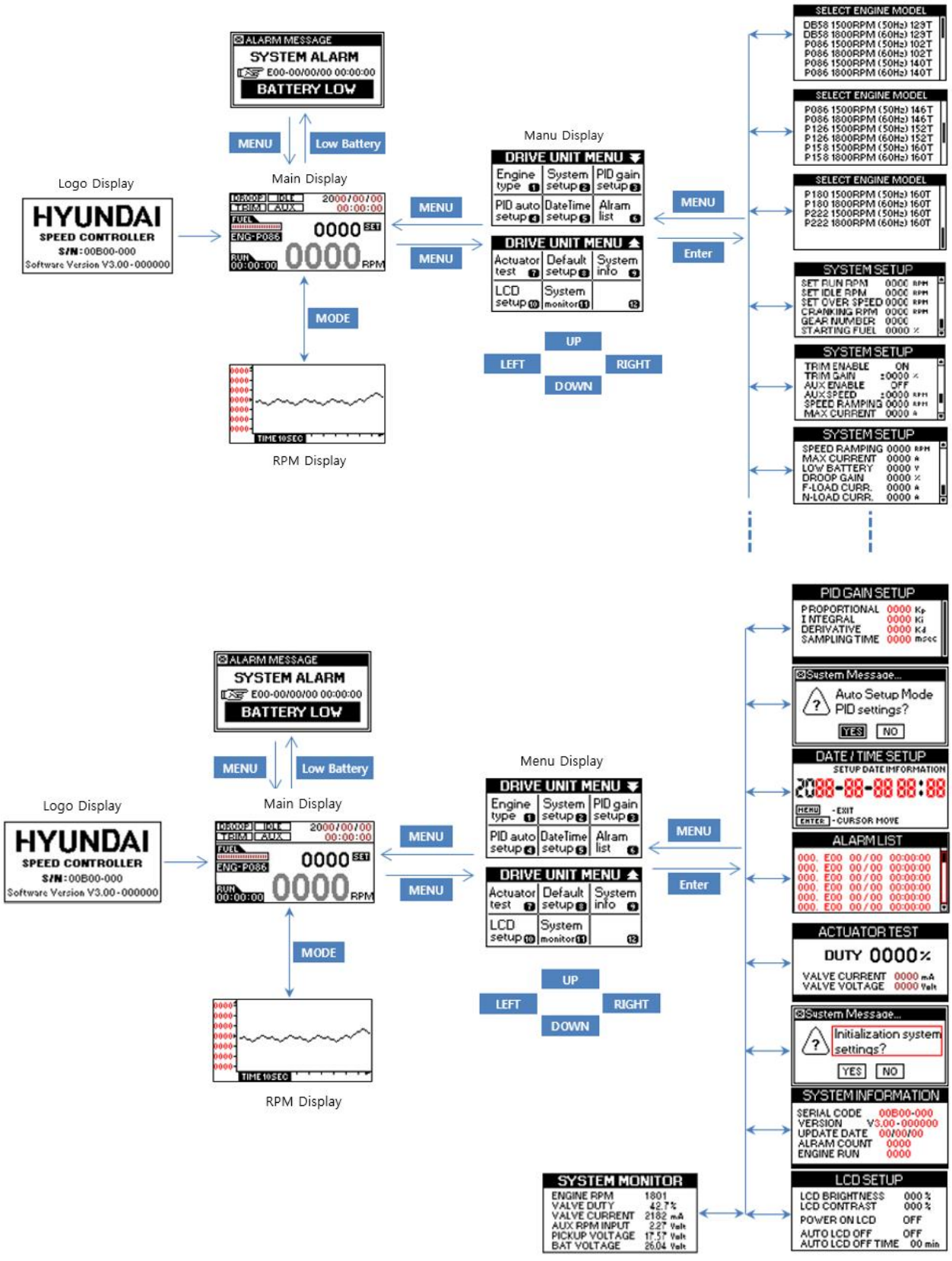


Figure 7: Overall LCD Menu Tree Diagram

3.2.1 LCD Displays After Powered On

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

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

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

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

Figure 8: HYUNDAI Logo

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

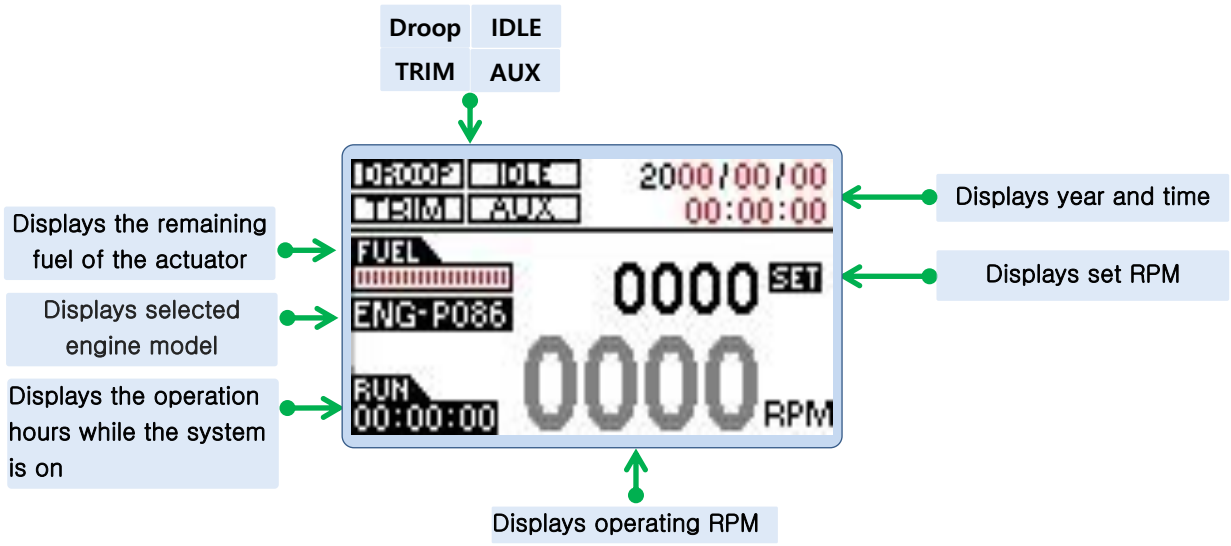
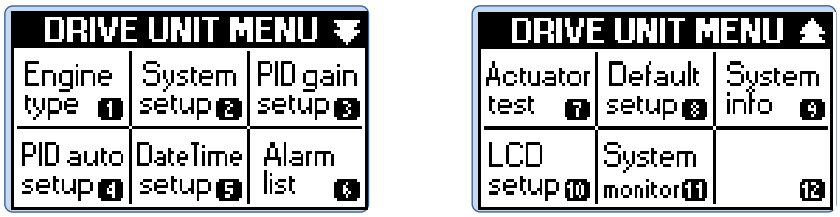


Figure 9: Operation Display

3.2.2 LCD Main Menu Display

Displays main menu screen of the controller

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



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

1) **Engine type**

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

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

2) **System setup**

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

3) **PID gain setup**

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

4) **PID auto setup**

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

5) **DateTime setup**

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

6) **Alarm list**

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

7) **Actuator Test**

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

8) **Default setup**

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

9) **System info**

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

10) **LCD setup**

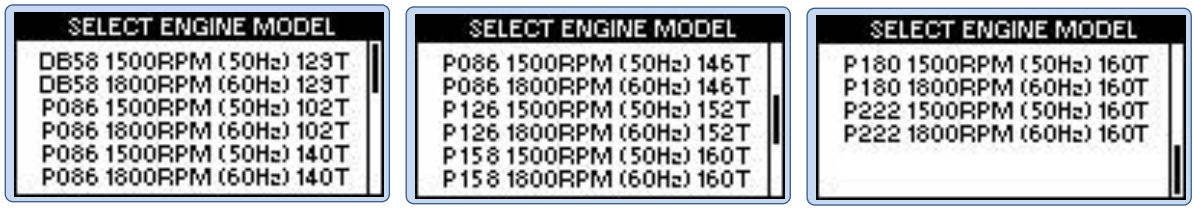
    It offers menu to configure LCD operating conditions including brightness, auto on/off and off hours.

11) **System monitor**

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

3.2.3 Engine Type Setup Menu

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

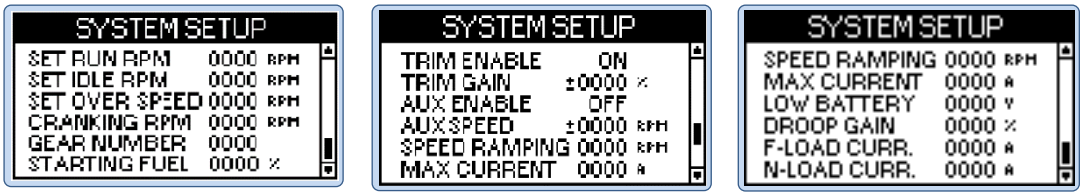


Menu 2: Engine Type Selection Menu

3.2.4 System Setup Menu

System Setup Menu Display of the Controller

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



Menu 3: System Setup Menu - 1 to 3

1) SET RUN RPM

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

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

2) SET IDLE RPM

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

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

3) SET OVER SPEED

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

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

4) CRANKING RPM

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

5) GEAR NUMBER

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

6) STARTING FUEL

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

7) AUX SPEED

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

8) SPEED RAMPING

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

9) MAX CURRENT

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

10) LOW BATTERY

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

11) DROOP GAIN

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

12) F-LOAD CURR

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

13) N-LOAD CURR

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

3.2.5 PID Gain Setup Menu

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

Menu 4: PID Gain Setup Menu

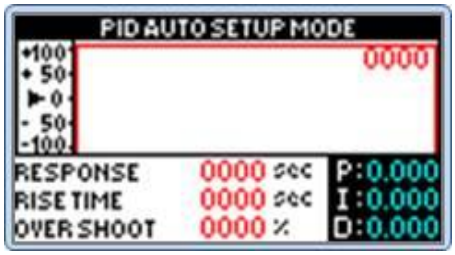
3.2.6 PID Auto Setup Menu

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

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

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

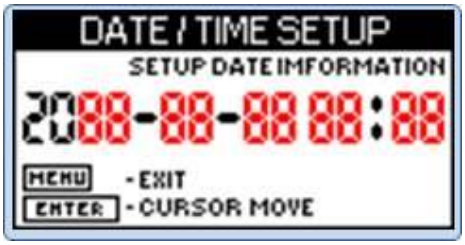
If the controller fails to identify the optimized P, I and D values within 30 cycles, it will display "PID No Successful, OK". When you press Enter, it will apply the final P, I and D values and close the menu.



Menu 5: PID auto setup menu

3.2.7 Date/Time Setup Menu

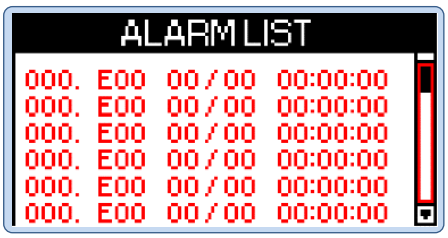
Users can designate year, month, day, hour and minute for the controller and the designated time will be used to monitor the system and manage fault messages.



Menu 6: DATE/TIME SETUP Menu

3.2.8 Alarm List Menu

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



Menu 7: ALARM LIST Menu

3.2.9 Default Setup Menu

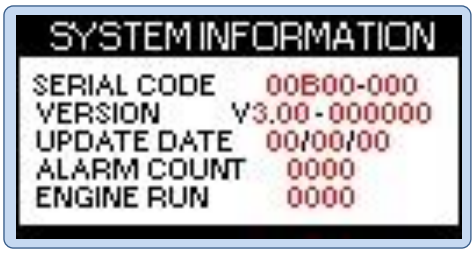
When you cannot identify the type of the control engine by the controller, this menu offers the most common parameter setting values. For default setup, select YES and then press Enter button. If you don't want to implement this function, press No button.

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

Menu 8: Default Setup Menu

3.2.10 System Info Menu

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



Menu 9: System Info Menu

3.3 Engine Configuration

3.3.1 Engine Type Configuration

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

Designated Parameters by Engine Type (Land use)

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

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

Designated Parameters by Engine Type (marine use)

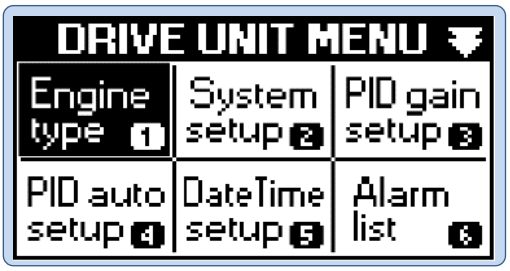
No	Menu Name	Run RPM	Over Speed	Gear Teeth	Starting Fuel	PID Value
1	AD066TI 1500RPM (50Hz) 129T	1500 RPM	1725RPM	129	60%	Optimized Value
2	AD066TI 1800RPM (60Hz) 129T	1800 RPM	2070RPM	129	60%	Optimized Value
3	AD086TI 1500RPM (50Hz) 140T	1500 RPM	1725RPM	140	60%	Optimized Value
4	AD086TI 1800RPM (60Hz)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

Table 1: Configuration Values by Engine Type

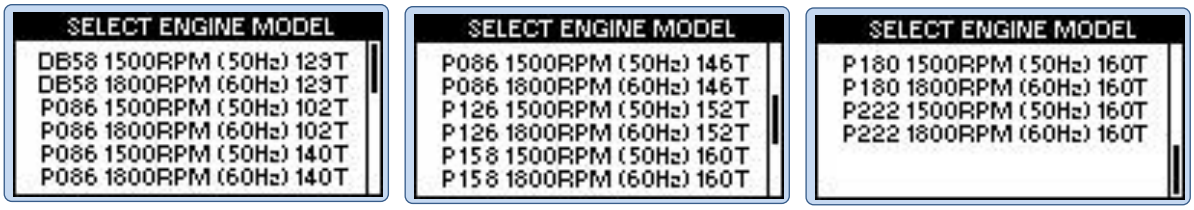
- **Engine Configuration Procedure**

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

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



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



Menu 10: Selection List by Engine Type

3.3.2 System Setup Configuration

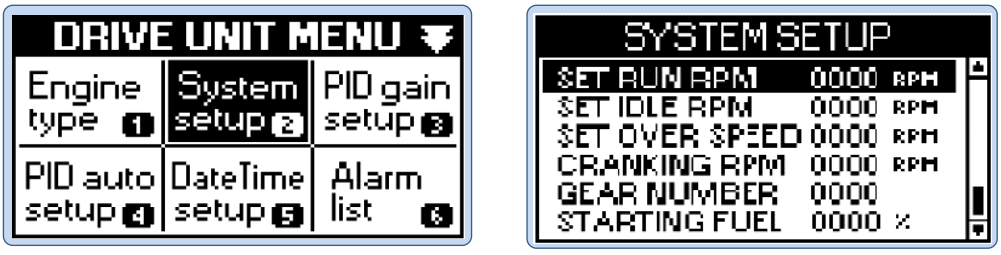
Main setting items of the controller includes **GEAR NUMBER, CRANKING RPM** and **SET RUN RPM**. You need to designate setting values to these items. Other system setup items are optional and therefore you can designate values for those items as necessary.

- Configuring **SET RUN RPM**

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

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

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

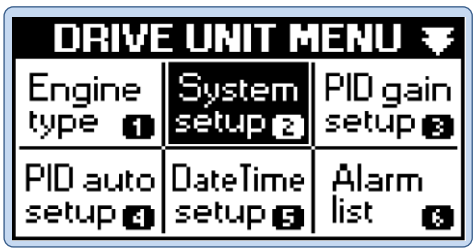


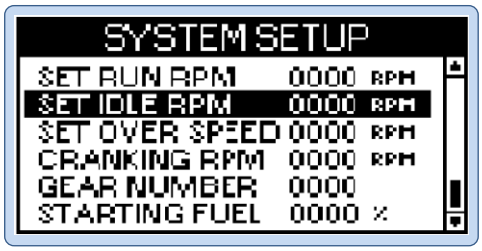
- Configuring **SET IDLE RPM**

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

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

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



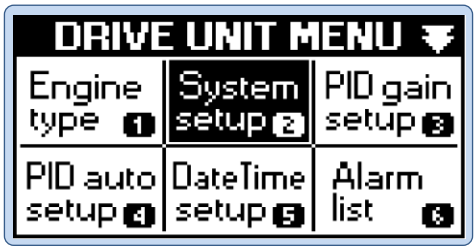


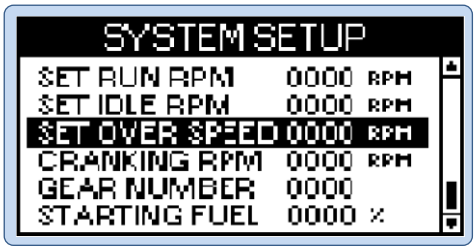
- Configuring **SET OVER SPEED**

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

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

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



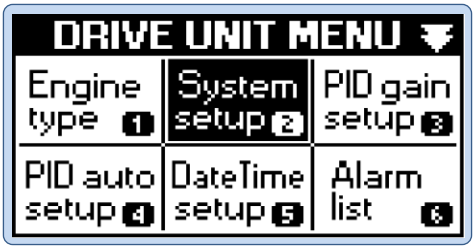


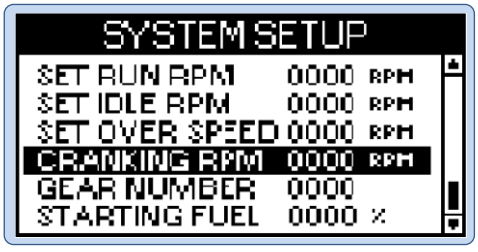
- Configuring **CRANKING RPM**

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

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

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



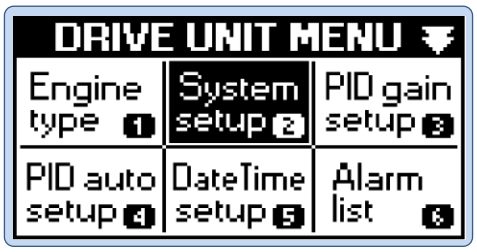


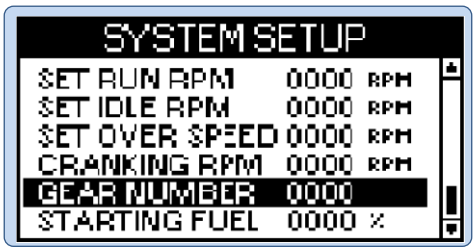
- Configuring **GEAR NUMBER**

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

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

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



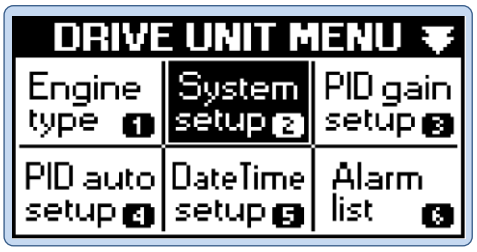


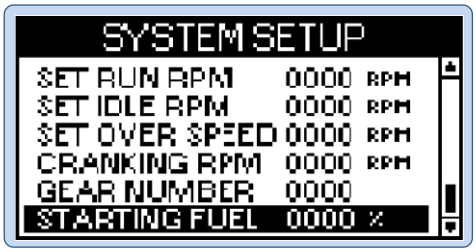
- Configuring **STARTING FUEL**

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

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

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



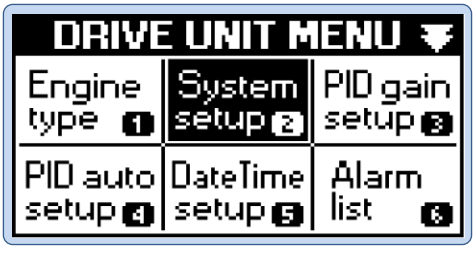


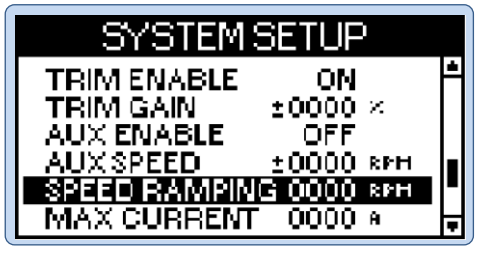
- Configuring **SPEED RAMPING**

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

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

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



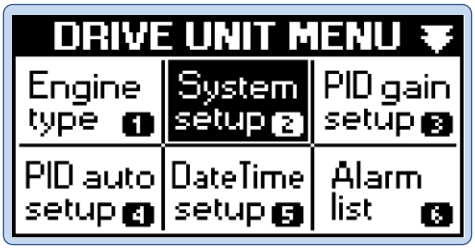


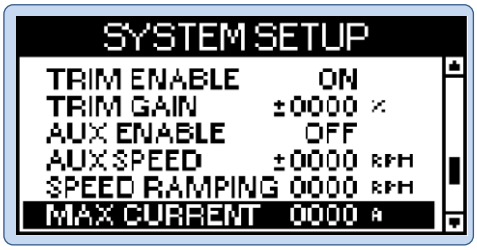
- Configuring **MAX CURRENT**

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

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

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



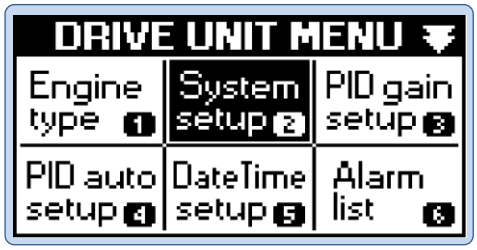


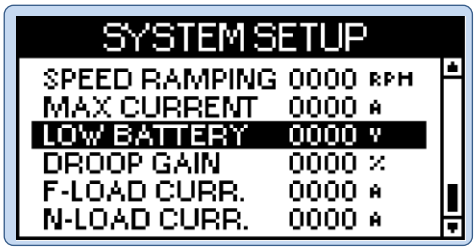
- Configuring **LOW BATTERY**

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

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

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



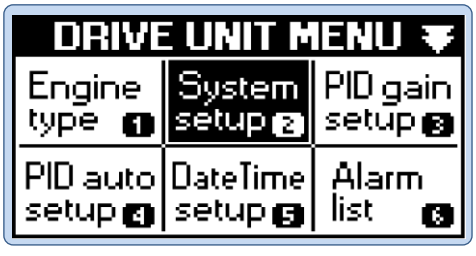


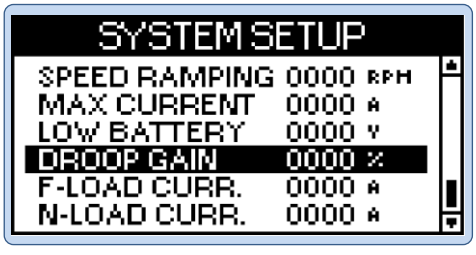
- Configuring **DROOP GAIN**

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

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

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





DROOP Function

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

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

(Example for 3% Droop)

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

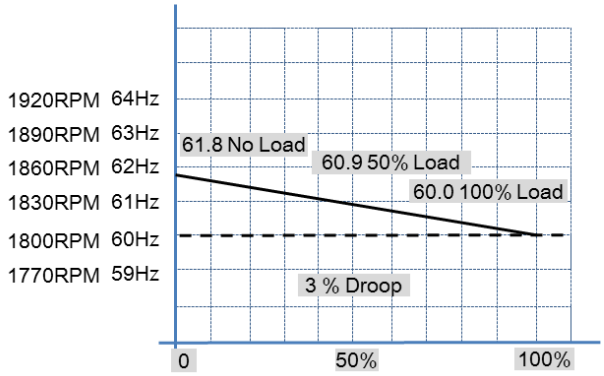


Figure 10: 3% Droop

(Example for 7% Droop)

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

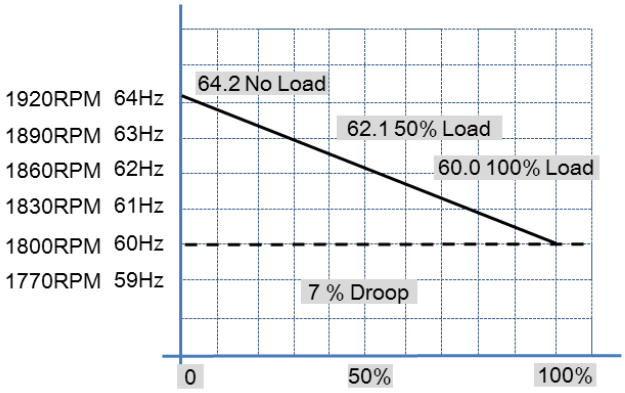


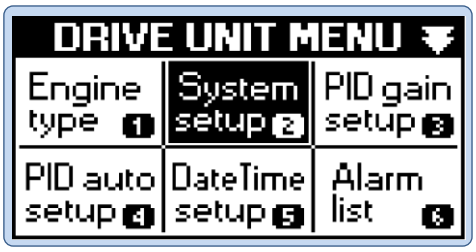
Figure 11: 7% Droop

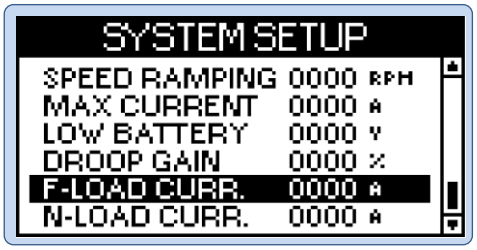
- **F-LOAD CURR.**

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

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

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



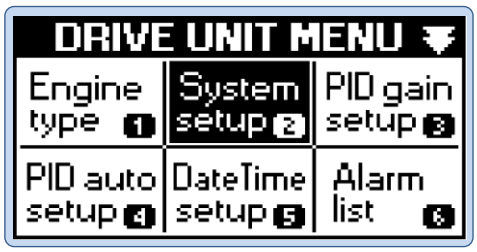


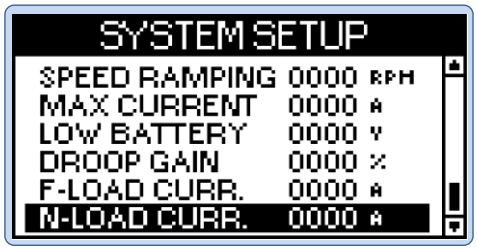
- **N-LOAD CURR.**

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

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

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





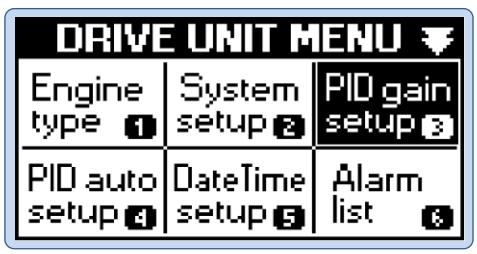
3.3.3 PID Gain Setup Configuration

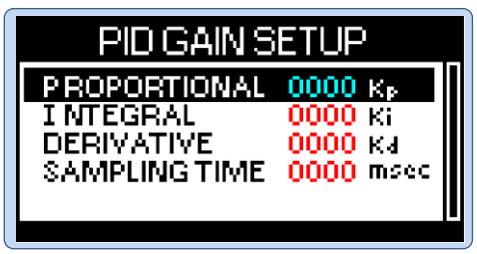
- Configuring **PID Gain Kp, Ki and Kd Values**

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

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

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

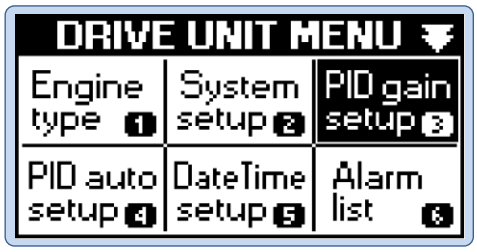


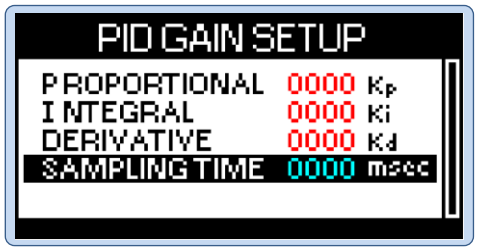


- Configuring **PID SAMPLING TIME**

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

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



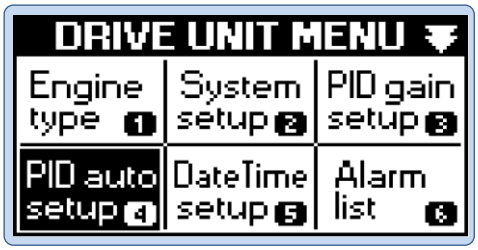


3.3.4 PID Auto Setup Value Configuration

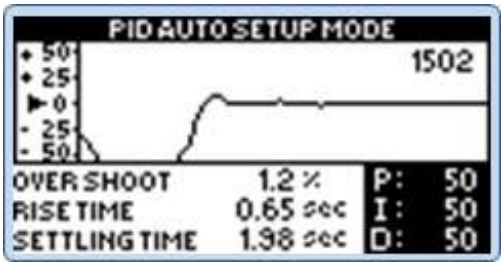
Step1) Select your type in Engine Type menu and then start the engine with the preset configuration values maintaining it with no load.

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

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



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



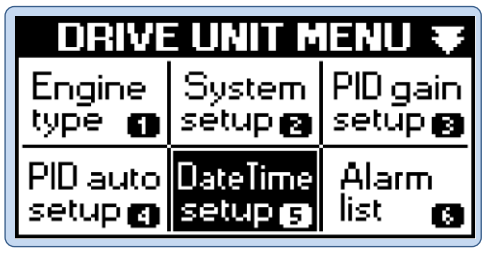
Step5) PID tuning repeats a process to obtain PID values and a window to indicate whether the process succeeded or failed will appear in several minutes (approx. 4 to 6 minutes). If the process succeeded, the system message window will appear together with OK button. If you press Enter button, you will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

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

3.3.5 DATE/TIME Value Configuration

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

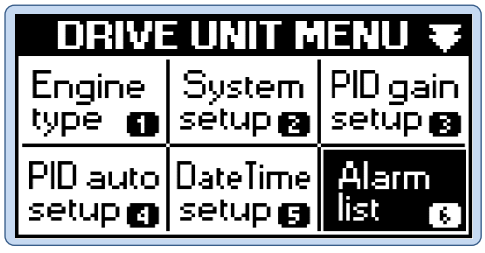
Step2) Use **Up**, **Down**, **Left** and **Right** buttons to input year, month, day and hour and then press **Enter** button.

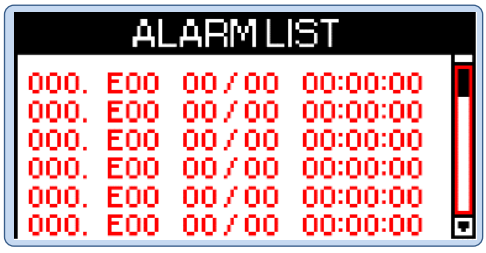


3.3.6 ALARM LIST

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

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





[Alarm Code Table]

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

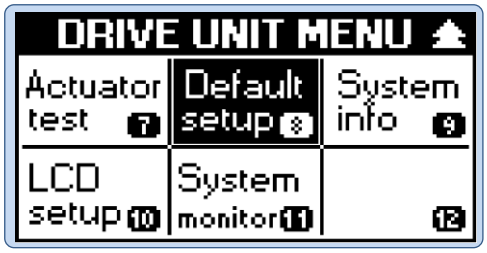
3.3.7 Actuator test

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

3.3.8 Default setup Functions

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

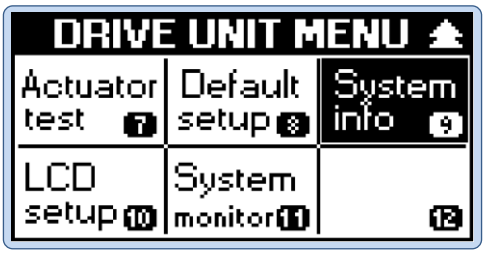
Step2) Use **Left** and **Right** buttons to select either **YES** or **NO** in **System Message** and then press **Enter** button.

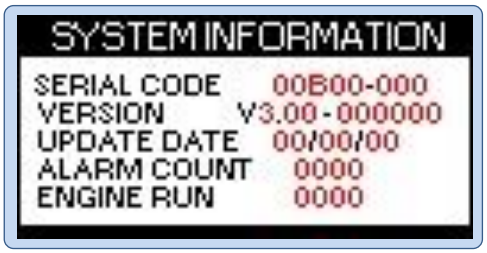


Default setup will change the configuration values of the engine to the default values. In order to initiate default setup, you need to select **YES** and then press **Enter** button. Press **No** button if you don't want to.

3.3.9 System info Functions

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



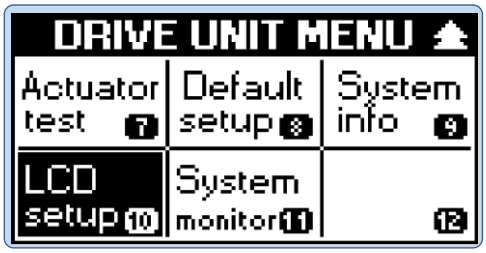


The menu displays information of the controller and the information includes the serial number, software version, last update date, alarm count and engine runs.

3.3.10 LCD setup Functions

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

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



3.3.11 System monitor Functions

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

4. How to Operate

4.1 Operating Sequence for Digital Speed Controller

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

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

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

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

4.2 Detailed Operating Sequence

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

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

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

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

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

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

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

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

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

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

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

5. Troubleshooting

5.1 Alarm List Check

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

Land/marine

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

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

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

5.2 System Checks and Measures

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

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

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

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

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

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

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

6. Warranty and A/S Service

6.1 Warranty

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

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

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

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

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

6.2 A/S Service Information

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

Digital Panel for Marine Engines

User Manual

Ver.1.2

HYUNDAI

Contents

Contents

1. General Information

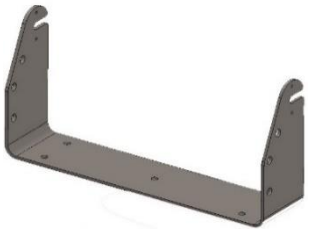
1.1 Product Information

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

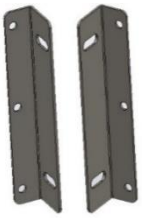
1.2 Components and Optional Accessories

Components

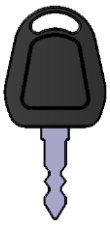
① Digital Panel



② Desk Mounting Type Bracket

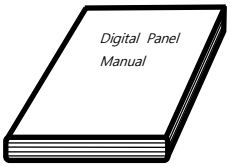


③ Flush Mounting Type Bracket



④ Key x 2

⑤ Desk Mounting Type Parts x 2



⑥ Manual

Optional Accessories

① CCTV (Analog)

② Coaxial Cable (Shielded)

1. General Information

1.3 Product Specification

Digital Panel Specification

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

[Table 1-1]

2. Product Installation

2.1 Cautions

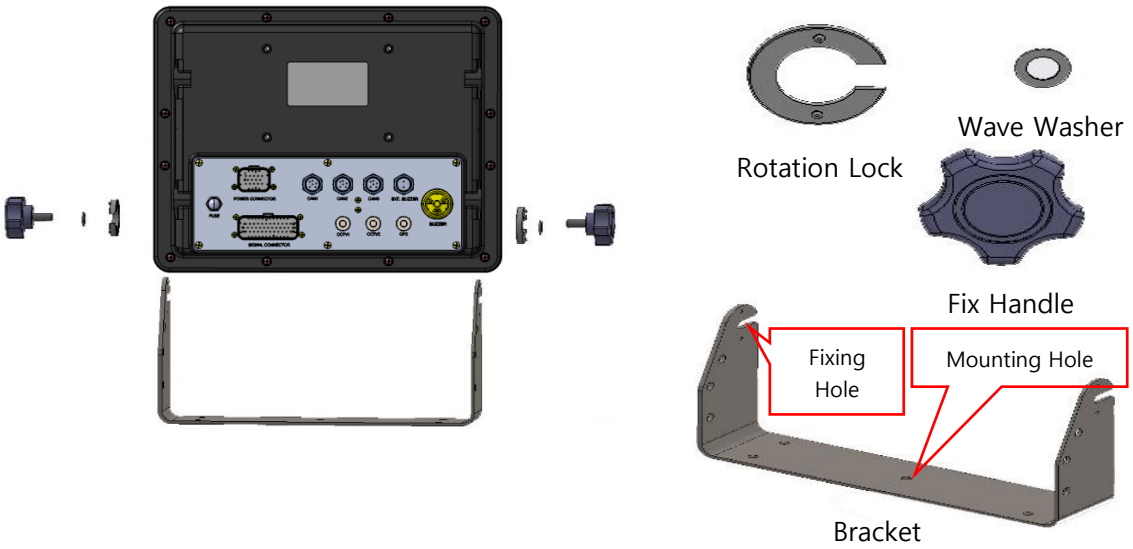
- Unskilled personnel should read this manual before use.
- Do not use or keep the product close to combustible sprays or inflammable.
- Use soft and dry cloth to clean the monitor.
- Turn off the product, pull out the harness cable and then contact our service center when you see smoke from the monitor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

2. Product Installation

2.2 Desk Mounting Type

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

※ Mounting Hole Spec: M6 bolt



[Fig. 2-1] Desk Mounting Type Diagram

▶ Installing Desk Mounting type digital panel

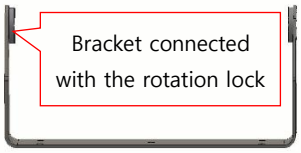
① Check whether the bridge has engine harness wiring.

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

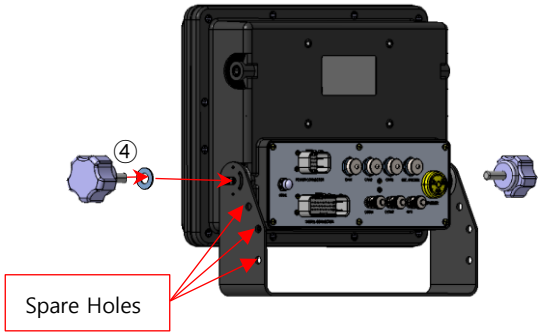
③ Place the product inside the bracket connected with the rotation lock to connect it with the rotation lock.

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

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



[Fig. 2-2]



[Fig. 2-3]

2. Product Installation

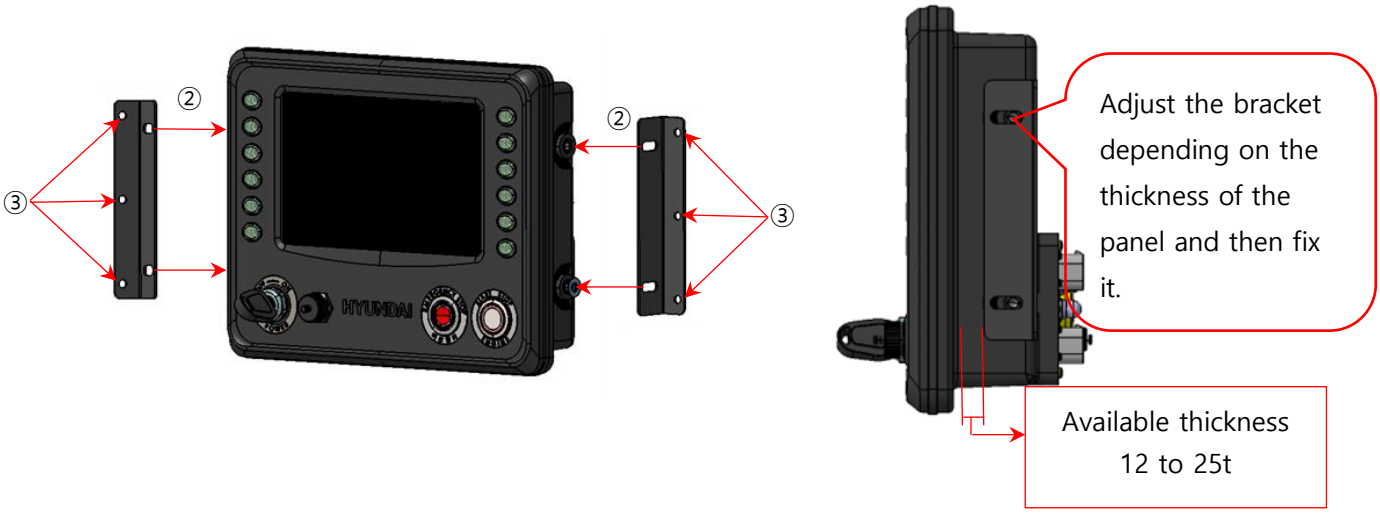
2.3 Flush Mounting Type

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

[Fig. 2-4] Flush Mounting Type Diagram

▶ Installing Flush Mounting type digital panel

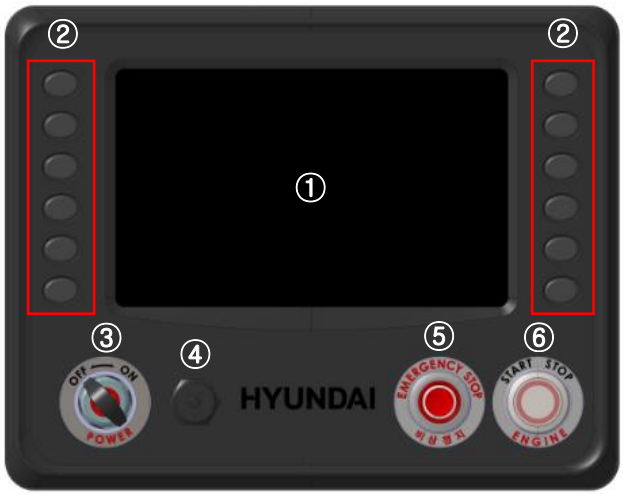
① Check whether the bridge has engine harness wiring.
② As shown in Fig. 2-6, fix the mounting brackets to both sides of the panel.
③ Check the location within reach of the engine harness wiring and the mounting location and then mount the panel using proper bolts.
④ Finish gaps between the product and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



[Fig. 2-5]

3. Part Names, Operation and Settings

3.1 Front

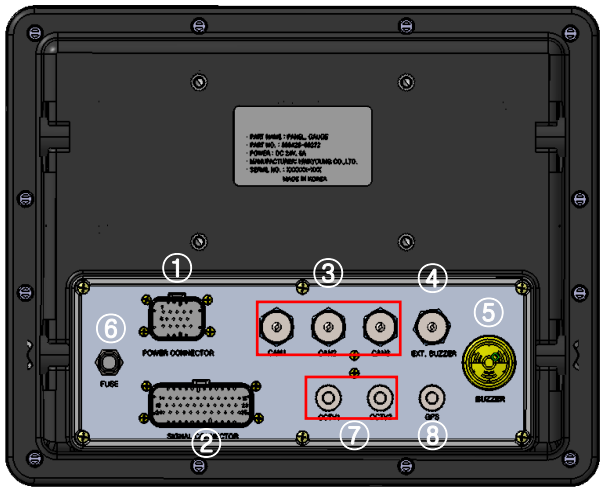


[Fig. 3-1]

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

[Table 3-1]

3.2 Rear



[Fig. 3-2]

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

[Table 3-2]

3. Part Names, Operation and Settings

3.3 External Connection Terminals

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

3.3.1 Power Connector

- Power connector supplies power and power signals.

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

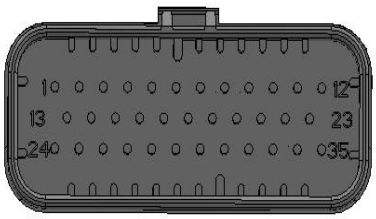
[Table 3-3]

POWER CONNECTOR

[Fig. 3-3]

3. Part Names, Operation and Settings

3.3.2 Signal Connector



SIGNAL CONNECTOR

[Fig. 3-4]

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

* Sensor for IMO Tier 3

[Table 3-4]

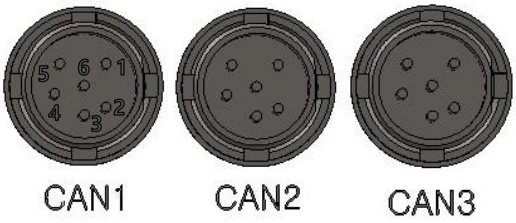
3. Part Names, Operation and Settings

3.3.3 CAN Communication Connector

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

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

[Table 3-5]



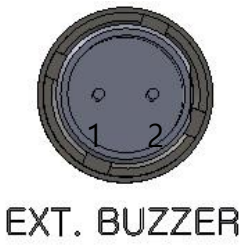
[Fig. 3-5]

3.3.4 External Buzzer Connector

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

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

[Table 3-6]



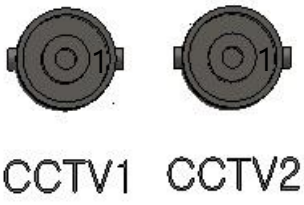
[Fig. 3-6]

3.3.5 CCTV Connector (Optional)

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

No.	Name
1	CCTV Signal In

[Table 3-7]



[Fig. 3-7]

3. Part Names, Operation and Settings

3.3.6 USB Connector

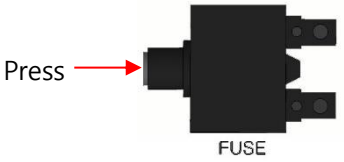
- USB memory can be inserted for data backup.
  (Only FAT32 format available)

[Fig. 3-8]

3.4 Fuse and Internal Buzzer

3.4.1 Fuse

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



[Fig. 3-9]

3.4.2 Internal Buzzer

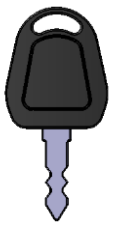
- Generate alarms for sensor problems

[Fig. 3-10]

3.5 Key Switch

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

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



Key
[Fig. 3-11]

Key Switch
[Fig. 3-12]

3. Part Names, Operation and Settings

3.6 Start/Stop Button

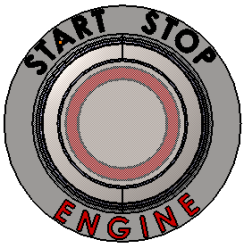
- Start/Stop button is used to start/stop control for the engine.

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

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

※ Plastic protection cover label installed.

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



Start/Stop Button

[Fig. 3-13]

3.7 Emergency Stop Button

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

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

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

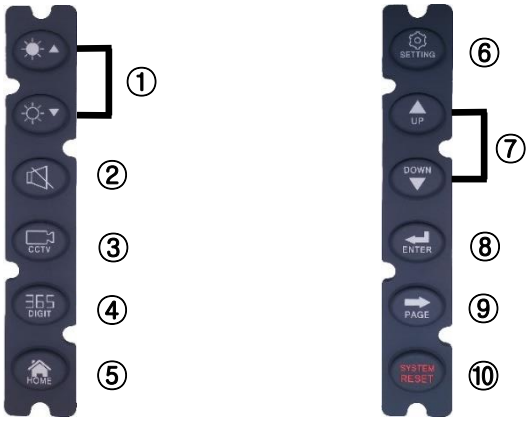
Emergency Stop Button

[Fig. 3-14]

3. Part Names, Operation and Settings

3.8 Function Keys

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



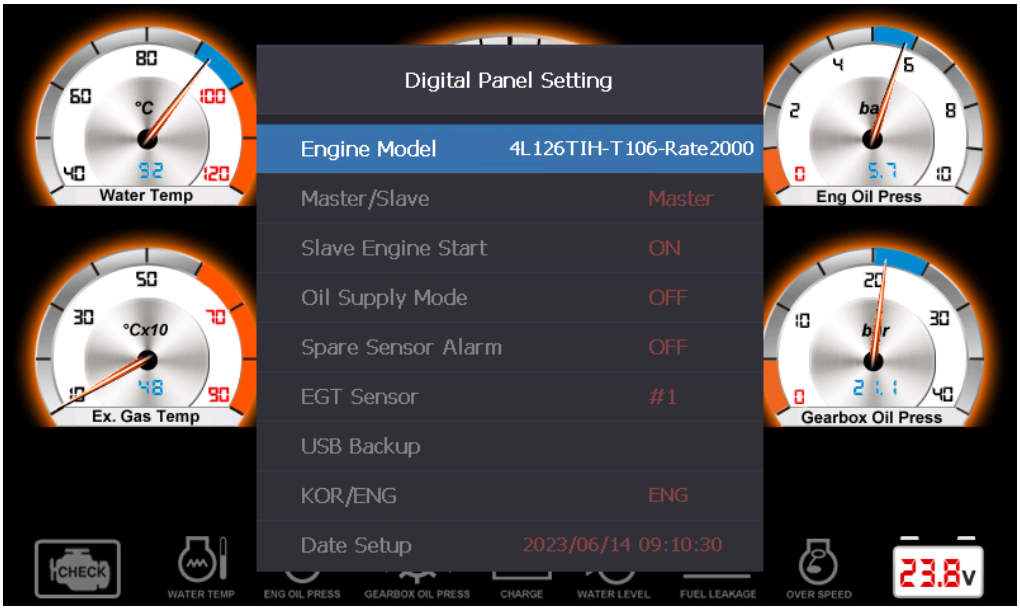
[Fig. 3-15] Function Keys

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

[Table 3-8]

3. Part Names, Operation and Settings

3.8.1 Detailed Settings



[Fig. 3-16] Detailed Settings

▶ Setting Functions and Descriptions

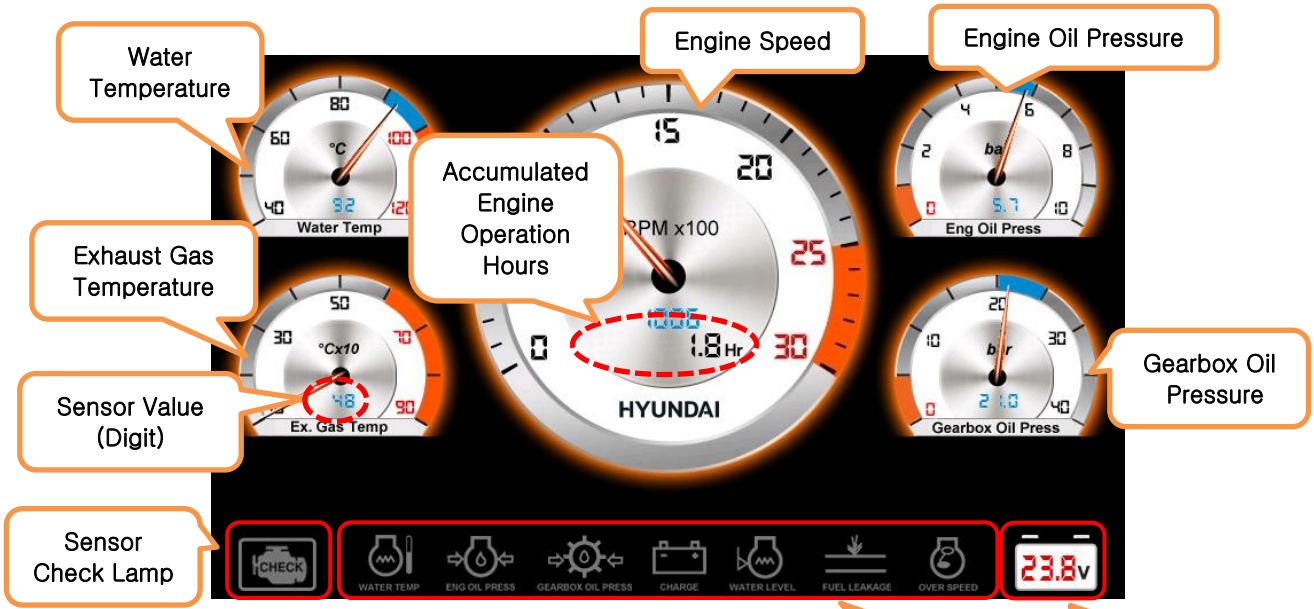
- Press SETTING button and then use UP or DOWN button to move to functions to be changed.
- Press SETTING button to go back to gauge display (changes will be automatically saved).

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

[Table 3-9]

3. Part Names, Operation and Settings

3.9 Display Structure



[Fig. 3-17] Gauge Display

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

3.9.1 Engine Speed (Tachometer)

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

[Fig. 3-18]
Engine Speed Gauge

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

3. Part Names, Operation and Settings

3.9.2 Engine Water Temperature

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

[Fig. 3-19]

Engine Water Temperature Gauge

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

3.9.3 Engine Oil Pressure

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

[Fig. 3-20]

Engine Oil Pressure Gauge

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

3.9.4 Exhaust Gas Temperature

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

[Fig. 3-21]

Exhaust Gas Temperature

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

3. Part Names, Operation and Settings

3.9.5 Gearbox Oil Pressure

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

[Fig. 3-22]
Gearbox Oil Pressure

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

3.9.6 Battery Voltage

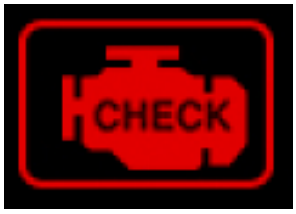
- It shows battery voltage to indicate its conditions.

[Fig. 3-23] Battery Voltage

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

3.9.7 Check Sensor Light

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



[Fig. 3-24] Check Sensor Light

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

※ Open and Short gauge displays for sensor problems

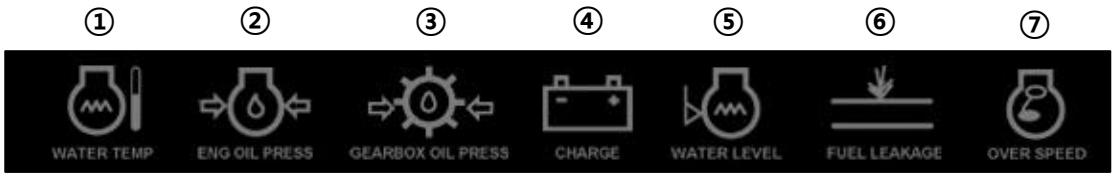
Open

Short

3. Part Names, Operation and Settings

3.9.8 Engine Alarms

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



[Fig. 3-25] Engine Alarms

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

[Table 3-10] Alarm Features

※ How to deactivate the engine alarm

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

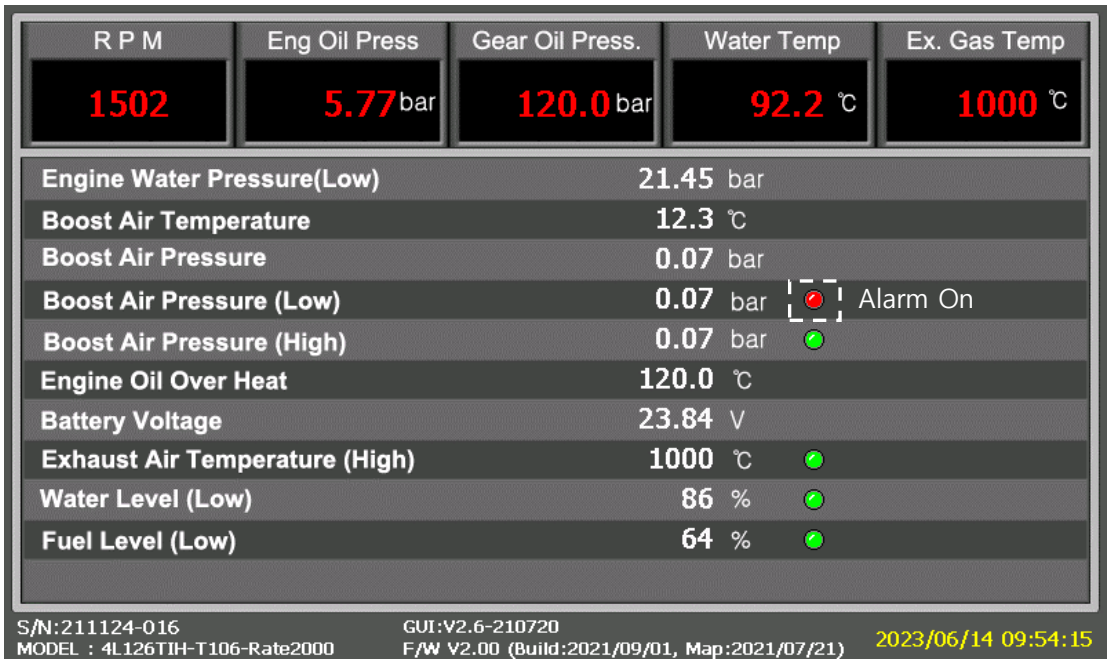
3.9.9 Engine Shutdown

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

3. Part Names, Operation and Settings

3.10 Spare Sensor

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



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

Item	Condition
Gearbox Oil Pressure	• Alarm will be activated when the gearbox oil temperature is 1bar or lower
*Boost Air Temperature	• Current temperature
*Boost Air Pressure (Low)	• Alarm will be activated when the boost air pressure is 1bar or lower
*Boost Air Pressure (High)	• Alarm will be activated when the boost air pressure is 3bar or higher
*Engine Oil Over Heat	• Alarm will be activated when the engine oil temperature is 120℃ or higher
Battery Voltage	• Current voltage
Exhaust Air Temperature (High)	• Alarm will be activated when the exhaust air temperature is 600℃ or higher
*Water Level (Low)	• Alarm will be activated when the coolant level is 30% or lower
*Fuel Level (Low)	• Alarm will be activated when the fuel level is 30% or lower

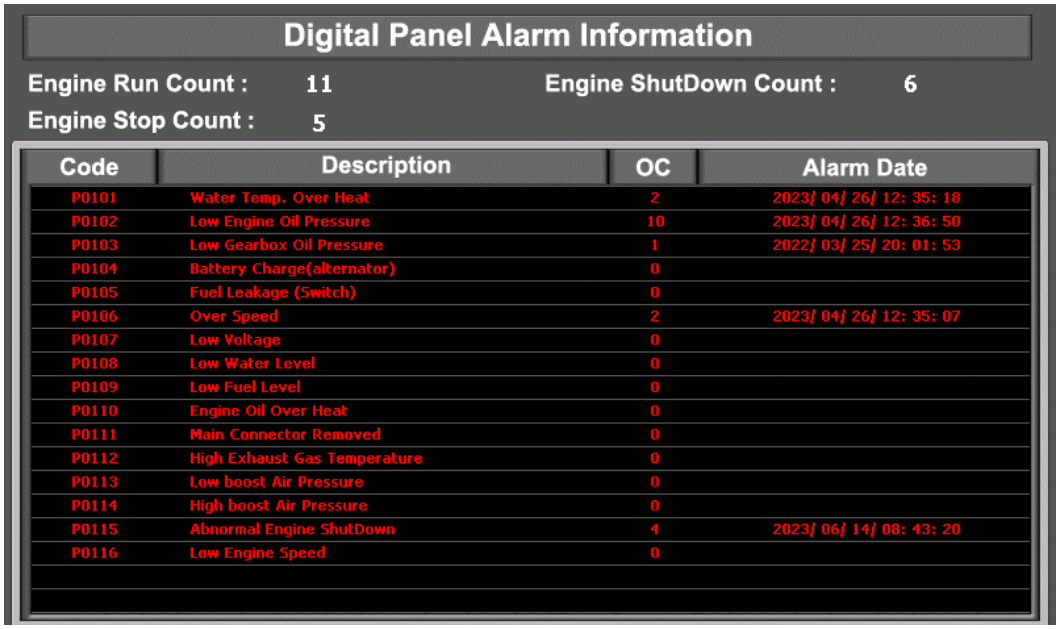
* Sensor for IMO Tier 3

[Table 3-11] Spare Sensor Conditions

3. Part Names, Operation and Settings

3.11 Event Summary

- It shows the numbers of normal operations, normal stops, emergency stops and sensor errors together with dates of recent errors.
- Press PAGE button in spare sensor page to move to event summary page.



[Fig. 3-27] Event Summary Screen

Event List			
P0101	Water Over Heat	P0109	*Low Fuel Level
P0102	Low Engine Oil Pressure	P0110	Engine Oil Over Heat
P0103	Low Gearbox Oil Pressure	P0111	Main Connector Removed
P0104	Battery Charge(Alternator)	P0112	High Exhaust Gas Temperature
P0105	Fuel Leakage(Switch)	P0113	*Low Boost Air Pressure
P0106	Over Speed	P0114	*High Boost Air Pressure
P0107	Low Voltage	P0115	Abnormal Engine Shutdown
P0108	*Low Water Level	P0116	Low Engine Speed

* Sensor for IMO Tier 3

[Table 3-12] Event List

3. Part Names, Operation and Settings

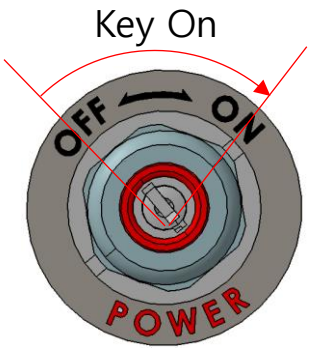
3.12 System Booting and Functional Check

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

▶ Normal System Booting

1) Insert the key into the key switch and rotate it to the right (ON).
2) HYUNDAI logo will appear for 17 seconds while the system is booting (refer to the image).
   ※ If the logo does not appear after rotating the key,
   - Rotate it to the left (OFF) and then to the right (ON) again
   - Check the harness connection at the back of the panel
   - Check whether the battery is discharged
3) The gauge display will appear after normal booting.
   - Gauge: check whether each gauge hand is within the normal range and 'ERROR' or '-----' is displayed on the screen.

   ※ Where 'ERROR' or '-----' is displayed on the screen
   - Check the harness connection
   - Function keys: check whether each function key is active on the screen by pressing them.
   - Alarm: check whether the alarm is turned on.
   - Battery: Check whether the battery is ok.
4) Where the initial gauge screen is normal, press START button for 1 second to start the engine (the time can be set to 1~3 second. Refer to Digital Panel Manager).
5) Check whether the operation is in normal RPM (initial operation in 400RPM or faster with the oil pressure of 1bar or higher) and whether is turned on.



[Fig. 3-28] Key Switch

[Fig. 3-29] Booting Logo

[Fig. 3-30] Gauge Display

4. Multi Panel Structure

4.1 Multi Panels

- Panels can be installed up to 4 units except Master in the ship and you can check the ship conditions and control those panels at any places of installation.

[Fig. 4-2] Slave 1

[Fig. 4-3] Slave 3

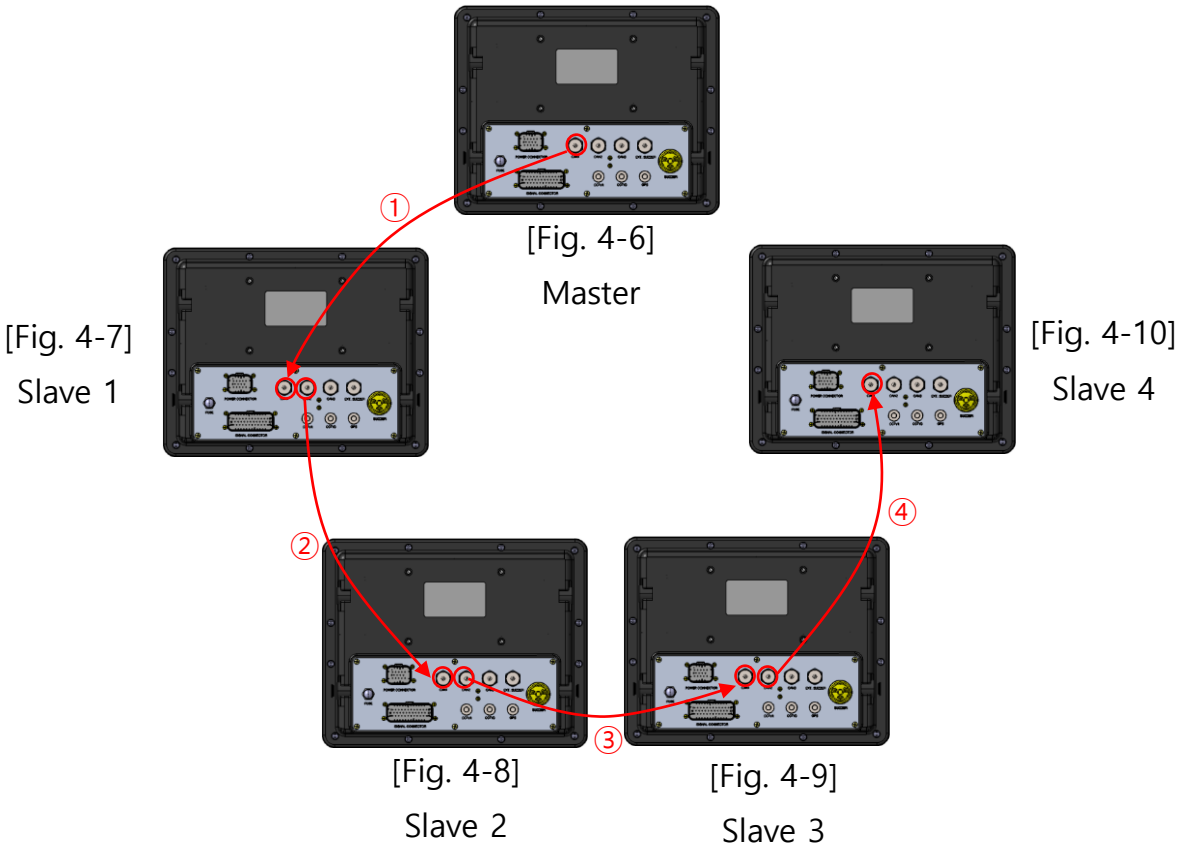
[Fig. 4-1] Master

[Fig. 4-4] Slave 2

[Fig. 4-5] Slave 4

4. Multi Panel Structure

4.2 How to Install Multi Panels



[Fig. 4-6] Master

[Fig. 4-7] Slave 1

[Fig. 4-10] Slave 4

[Fig. 4-8] Slave 2

[Fig. 4-9] Slave 3

※ In order to install multi panels, all the necessary cables should be ready in advance (use the cables with specification recommended by HYUNDAI).

(1) Connect the CAN1 terminal of the Master panel and the CAN1 terminal of the Slave 1 panel as shown in ① (2 panels).

- Master and Slave 1 connection completed

(2) Connect Slave 1 (CAN2) and Slave 2 (CAN1) as shown in ② while maintaining connection as described in ① (3 panels).

- Master, Slave 1 and Slave 2 connection completed

(3) Connect Slave 2 (CAN2) and Slave 3 (CAN1) as shown in ③ while maintaining connection as described in ② (4 panels).

- Master, Slave 1, Slave 2 and Slave 3 connection completed

(4) Connect Slave 3 (CAN2) and Slave 4 (CAN1) as shown in ④ while maintaining connection as described in ③ (5 panels)

- Master, Slave 1, Slave 2, Slave 3 and Slave 4 connection completed

4. Multi Panel Structure

4.3 Multi Panel Settings

(1) Press SETTING button of the panel to be configured as Slave.

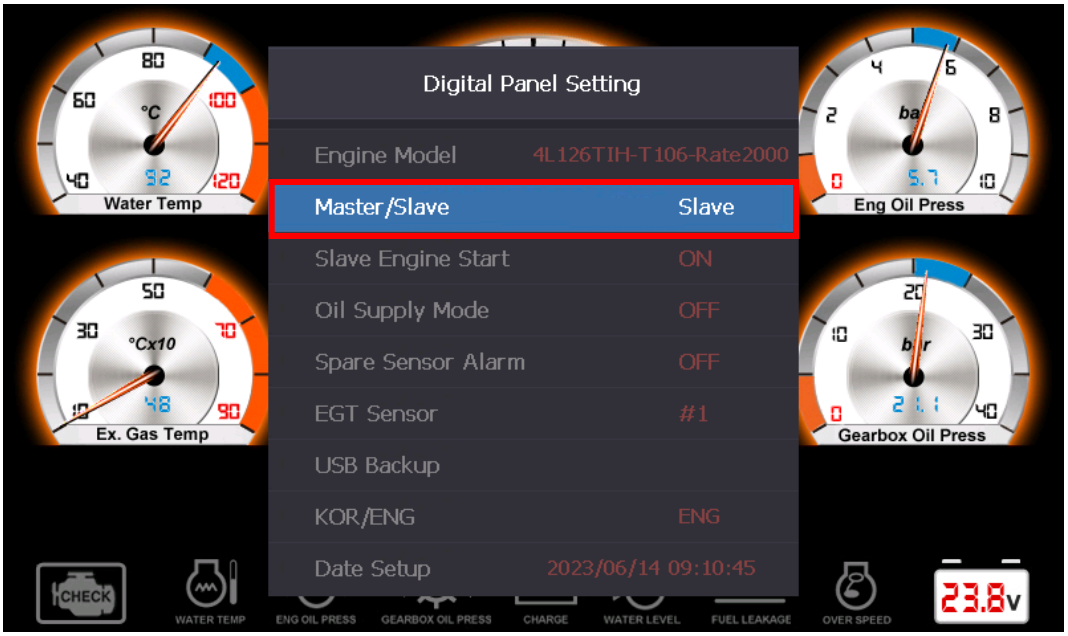
(2) Move to ① when the setting screen appears (use UP or DOWN button to move).

(3) Press ENTER button to switch configuration between Master and Slave.

(4) Configure the Master panel as described above.

※ Notes

- Master mode is available for one panel only and Slave mode is available up to 4 units.
- You can permit Slaves to start the engine with Master panel only. Where you enable Slave Engine Start setting, all Slave panels will be able to start the engine.



[Fig. 4-11] Multi Panel Setting Window

5. Maintenance

5.1 Maintenance

- To maintain the performance of the device, regular maintenance is required.

1. Use soft cloth to clean the LCD without damaging it.
    1) Clean the LCD after turning the power off.
    2) Do not use cleaners with acids or ammonia.
    3) Do not use neutral detergents to remove oil stains.
    4) Use cloth slightly wet in clean water to remove salt residuals or dust particles for natural drying. If there remain stains, clean them with soft cloth (microfibers) once again.
2. Check whether the connectors or harnesses at the back of the device are properly connected or whether they have dust or other foreign substances.
3. Check whether cables are damaged.
4. Request for checking when the software needs upgrade as follows:
   - When the manufacturer releases official software for performance improvements

5.2 Troubleshooting

- It describes possible measures for users to resolve problems while using the device.

1. The device is not turned on.
    1) Check whether harness cables at the back of the product are properly connected.
    2) Where harness cables have too much dust or moisture, remove them and clean the dust or moisture. Connect them once again after a while.
    3) Check whether the fuse button at the back of the product is pulled out.
    4) Check whether the battery is discharged.
2. You can see lines or shaking on the screen.
    1) Reboot the product.
    2) As the LCD is connected inside the product, do not disassemble it and contact the service team.
3. You can see distortions on CCTV screens.
    1) Check whether CCTV connectors or connectors at the back of the product are properly connected.
    2) Check whether cables are worn out.
4. You can see alarm or hear warning beeps at the bottom of the product screen.
    1) Check where the alarm occurs and then take measures as necessary (if you need to confirm which alarm occurs, refer to Page 20 of this manual).
5. You cannot control buttons.
    1) Check whether there are foreign substances at the panel buttons.
    2) As the button connecting parts may be damaged, do not disassemble the product and contact the service team.

6. Warranty and A/S Service

6.1 Warranty

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

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

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

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

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

6.2 A/S Service Information

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

7. Appendix

7.1 List of Engine Models

- List of compatible engine models

Engine		Number of Gear Teeth	Rate Speed	Over Speed	
DB58TI	L066TIH	129	2,200	115%	2,530
D1146	L136	140	2,200	115%	2,530
D1146T	L136T	140	2,200	115%	2,530
	L136TL	140	2,500	115%	2,875
D1146TI	L136TI	140	2,200	115%	2,530
D1146TIB	L086TIH	140	2,200	115%	2,530
	L086TIM	140	2,300	115%	2,645
	L086TIL	140	2,500	115%	2,875
DE12T	MD196T	152	2,000	115%	2,300
DE12TI	MD196TI	152	2,000	115%	2,300
DE12TIB	L126TIH	152	2,000	115%	2,300
	L126TIM	152	2,100	115%	2,415
DX12	4L126TIH	106	2,000	117%	2,340
	4L126TIM	106	2,100	117%	2,415
	4L126TIL	106	2,200	117%	2,574
D2848LB	V158TIH	160	1,800	115%	2,070
	V158TIM	160	2,100	115%	2,415
	V158TIL	160	2,300	115%	2,645
D2840LB	V180TIH	160	1,800	115%	2,070
	V180TIM	160	2,100	115%	2,415
	V180TIL	160	2,300	115%	2,645
D2842LB	V222TIH	160	1,800	115%	2,070
	V222TIM	160	2,100	115%	2,415
	V222TIL	160	2,300	115%	2,645
4VD2848LB	4V158TIH	160	1,800	115%	2,070
	4V158TIM	160	2,100	115%	2,415
	4V158TIL	160	2,300	115%	2,645
4VD2842LB	4V222TIH	160	1,800	115%	2,070
	4V222TIM	160	2,100	115%	2,415
	4V222TIL	160	2,300	115%	2,645

User Manual for 8 Inch Digital Panel and Controller for Mechanical Marine Propulsion Engine.

Ver.2.1

HYUNDAI

Contents

Contents

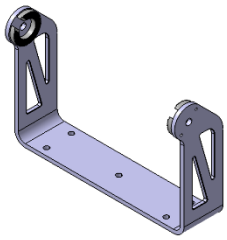
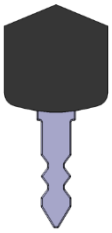
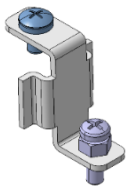
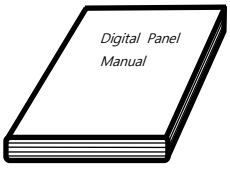
1. General Information

1.1 Product Information

This product is a digital panel for mechanical marine propulsion engines and can be applied to various small marine engines. The DACU (Data Acquisition Control Unit) acquires engine status data, and users can monitor the engine's status through the DGP (Digital Gauge Panel) feature. The product is designed with digital visualization to provide clear visibility of engine control and status information. It incorporates graphical analog gauges and digital displays to enhance user convenience and is designed to withstand harsh maritime environments.

1.2 Components and Optional Accessories

- Refer to Table 1-1 below for product components

NO	Components	Component Name	NO	Components	Component Name
1		DGP DACU	4		Desk Mounting Type Parts 1set
2		Desk Mounting Type Bracket	5		Key 2EA
3		Flush Mounting Type Bracket 4EA	6		User Manual

[Table. 1-1]

1. General Information

1.3 Product Specification

- Refer to Table 1-2 below for the hardware specifications of the digital panel for this mechanical engine.

Digital Gauge panel product Specification

No.	Item	Remark
1	Microprocessor	• NXP4330Q / S32K144
2	Software	• Linux OS GUI + F/W
3	Display	• 8″ Color TFT LCD • 1280 * 720(Pixel) • 16 : 9
4	Flash Memory	• 4GB(eMMC)
5	Ram	• 1GB
6	Operating Voltage	• DC 24V (9 ~ 32V)
7	USB	• USB 2.0 1Port
8	Operating Temperature	• - 20℃ ~ 70℃
9	Internal Buzzer	• Piezo Buzzer 98dB
10	Communication	• J1939 CAN communication • RS232
11	Dimensions	• W 287 x H 245.8 x D 108.15(DGP) • W 236 x H 186.6 x D 80(DACU)

[Table 1-2]

2. Product Installation

2.1 Cautions

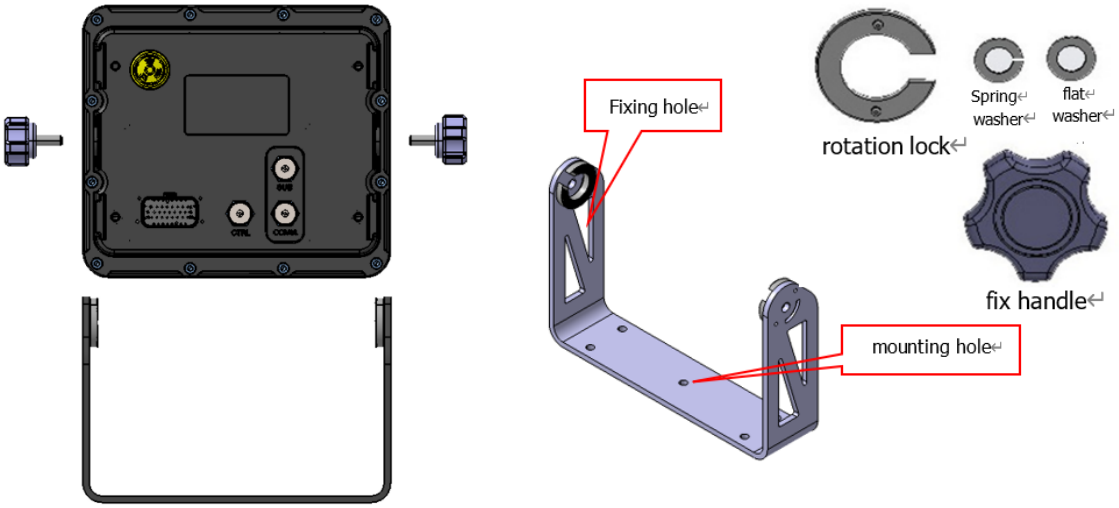
- Unskilled personnel should read this manual before use.
- Do not use or keep the product close to combustible sprays or inflammable.
- Use soft and dry cloth to clean the panel LCD.
- Turn off the product, pull out the harness cable and then contact our service center when you see smoke from the panel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

2. Product Installation

2.2 Desk Mounting Type

※ Desk Mounting Types are installed in the Bridge or engine room by using desk mounting brackets delivered with the product.

※ Mounting Hole Spec: M6 bolt

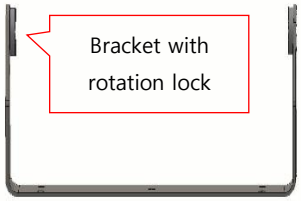


[Fig. 2-1] Desk Mounting Type Diagram

▶ Installing Desk Mounting Type digital panel

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

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

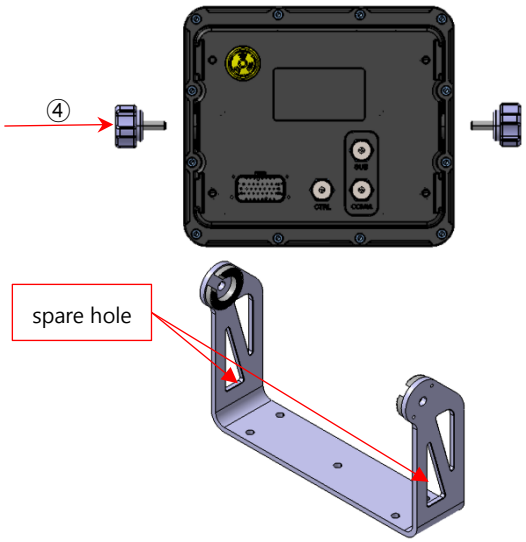


[그림 2-2]

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

④ Connect it with the fix handle to the direction indicated by an arrow and adjust the viewing angle of the LCD

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



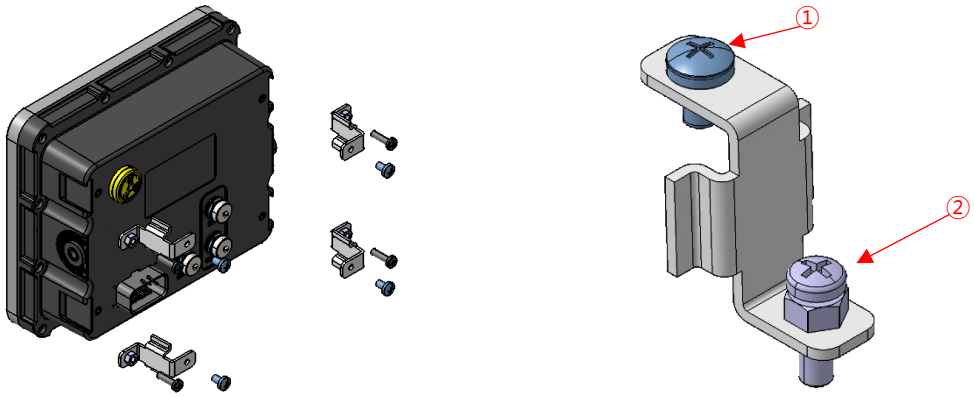
[Fig. 2-3]

2. Product Installation

2.3 Flush Mounting Type

- Flush Mounting types are installed in a **Bridge** or engine room by using optional mounting brackets (2pcs).

  ※ Bolt Spec: ① M6 X 10L ② M6 X 20L



[Fig. 2-4] Flush Mounting Type Diagram

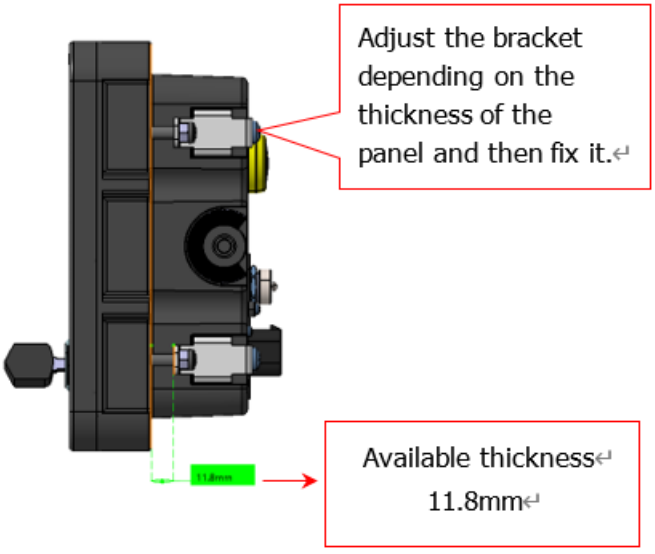
▶ Installing Flush Mounting Type digital panel

① Check the harness is wired in the Bridge or engine room.

② As shown in [Fig. 2-5], fix the mounting brackets to both sides of the panel.

③ Check the location within reach of the harness wiring and the mounting location and then mount the panel using proper bolts.

④ Finish gaps between the product and the structure depending on the mounting conditions and connect the engine harness (you may connect the engine harness first depending on conditions)



[Fig 2-5]

3. Part Names, Operation and Settings

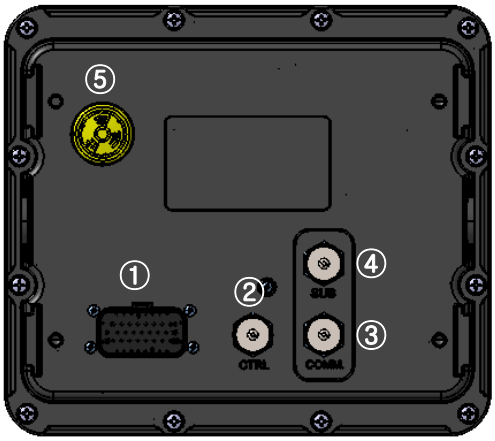
3.1 Front Side

[Fig. 3-1]

No.	Name	Reference
①	LCD	-
②	Function Keys	13 Page
③	Key Switch	11 Page
④	USB	10 Page
⑤	Emergency Stop Switch	12 Page
⑥	Emergency Start Switch	12 Page

[Table. 3-1]

3.2 Back Side



[Fig. 3-2]

No.	Name	Reference
①	Main Connector	9 Page
②	Engine Control (External Buzzer and Function for Ship Generator)	12 Page
③	COMM.	12 Page
④	SUB	12 Page
⑤	Internal Buzzer	13 Page

[Table. 3-2]

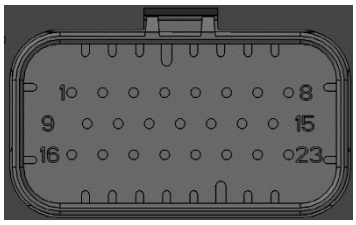
3. Part Names, Operation and Settings

3.3 External Connection Terminals

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

3.3.1 DGP 23Pin Main Connector

- Interface connector for receiving power and engine operation information from DACU and transmitting and receiving CAN signals with ECU (For Ship Generator)



[Fig. 3-3]

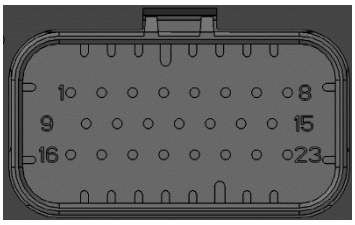
No.	Pin Description	Notes	No.	Pin Description	Notes
1	Battery In	-	13	(opt) PC RXD1	-
2	Battery In	-	14	(opt) PC TXD1	-
3	Power GND	-	15	Alternator In	Electronic panel only
4	Power GND	-	16	Wait to Disconnect Signal	
5	Key On	-	17	Wait to Disconnect Common	
6	Starter Signal	-	18	Gearbox Oil Pressure Supply	
7	Emergency Switch Power	-	19	Gearbox Oil Pressure Signal	
8	Emergency Switch Signal	-	20	Fuel Leakage Switch	
9	CAN 1 High	-	21	GND Sensor	
10	CAN 1 Low	-	22	Water In Fuel Switch	
11	(opt) CAN 2 High	Option	23	GND Sensor	
12	(opt) CAN 2 Low		-	-	-

[Table 3-3]

3. Part Names, Operation and Settings

3.3.2 DACU 23Pin Main Connector

- Interface connector to provide DGP power and engine operation information



[Fig. 3-4]

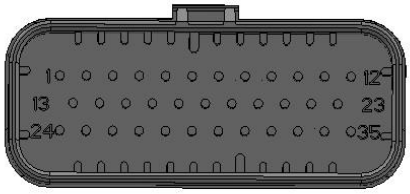
No.	Pin Description	Notes	No.	Pin Description	Notes
1	CAN 1 Low	-	13	Power GND	-
2	CAN 1 High	-	14	DSC RPM Pick-up (GND)	Generator only
3	(opt) CAN 2 High	-	15	DSC Actuator A	Generator only
4	(opt) PC TXD1	-	16	Battery In	-
5	Key On	-	17	DSC CAN 2 Low	Generator only
6	Starter Signal	-	18	DSC CAN 2 High	Generator only
7	DSC RPM Pick-up Signal	Generator only	19	Emergency Switch Signal	
8	DSC Battery	Generator only	20	Emergency Switch Power	
9	Battery In	-	21	Power GND	
10	(opt) CAN 2 Low	-	22	DSC GND	
11	(opt) PC RXD1	-	23	DSC Actuator B	Generator only
12	-	-			

[Table. 3-4]

3. Part Names, Operation and Settings

3.3.3 DACU 35Pin Main Connector

- Engine harness interface connector that is connected to the engine harness to receive power and analog sensor information of the engine and supply start control signals to the engine



[Fig. 3-5]

No.	Pin Description	Notes	No.	Pin Description	Notes
1	Alternator In	-	19	Water Pressure Signal	-
2	Stop Solenoid Signal	-	20	Stop Solenoid Power	-
3	Fuel Leakage Switch	-	21	Starter Motor Power	-
4	Engine Oil Temp Signal	-	22	-	-
5	Exhaust Gas Temp2+	-	23	Power GND	-
6	Exhaust Gas Temp1+	-	24	DSC Actuator B	Generator only
7	Engine Oil Pressure Signal	-	25	RPM Pick-up Signal	
8	Stop Solenoid Power	-	26		
9	Starter Motor Power	-	27		
10	Starter Motor Power	-	28		
11	Power GND	-	29		
12	Power GND	-	30	GND Sensor	
13	DSC Actuator A	Generator only	31	GND Sensor	
14	RPM Pick-up (GND)		32	Stop Solenoid Power	
15	Water Temp Signal	-	33	Battery In	
16	Exhaust Gas Temp2-	-	34	Battery In	
17	Exhaust Gas Temp1-		35	Battery In	
18	Gearbox Oil Pressure Signal	-	-		

[Table. 3-5]

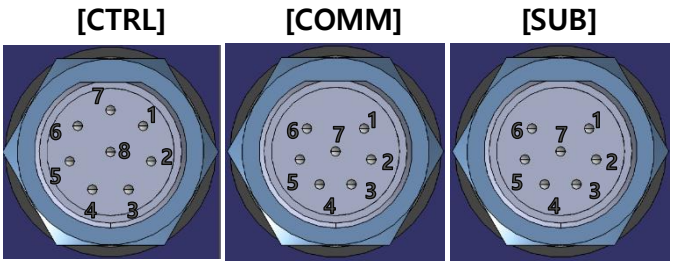
3. Part Names, Operation and Settings

3.3.4 Circular Interface Connector

- CTRL : Buzzer output connector for external buzzer connection
- COMM. : Multi-panel[OUT], communication connector for power and CAN communication
- SUB : Multi-panel[IN], communication connector for power and CAN communication

No.	CTRL	COMM.	SUB
1	Buzz Battery	Key On	Key On
2	Buzz Out	Battery In	Battery In
3	VCC	CAN2 H	CAN2 H
4	RPM_TRIM	CAN2 L	CAN2 L
5	GND	CAN1 H	CAN1 H
6	ISO_AUX+	CAN1 L	CAN1 L
7	ISO_AUX-	GND	GND
8	GND	-	-

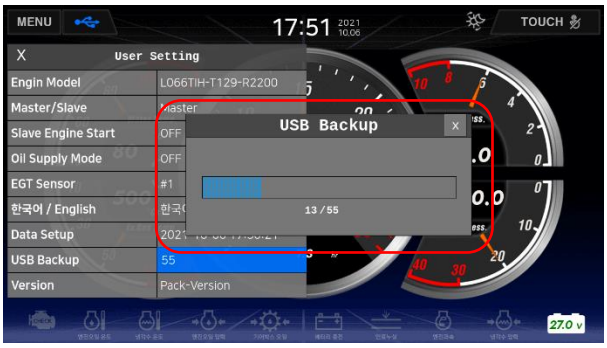
[Table. 3-6]



[Fig 3-6]

3.3.5 USB Connector

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



[Fig. 3-7-1]

[Fig. 3-7-2]

3. Part Names, Operation and Settings

3.4 Internal Buzzer

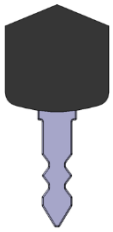
- Buzzer sound when an alarm occurs due to engine abnormality
- It operates at 98dB, and an external large-capacity buzzer can be additionally installed.

[Fig. 3-8]

3.5 Key Switch

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

1) After inserting the key included in the product in the key switch and turning it to the position of 45º to the right (ACC), the product is booted.
2) Engine starts at the position of 90º turn (ON) and it returns to 45º position (If the key is in the ON state, keep the key lock state)
3) When ACC is ON, the product boots within 5 seconds and the gauge screen is output after the introduction screen.
4) Turn the key 45º to the left (OFF) when the engine is stopped



Key
[Fig. 3-9]

Key Switch
[Fig. 3-10]

3. Part Names, Operation and Settings

3.6 Emergency Start Button

- Used to force the engine to start in an emergency situation.

1) In the OFF state of the key, rotate the key to ON while pressing it with an available device for the buttonhole.

※ Application of safety accident prevention function

※ Hole Size : Ø7

※ It should be used only in emergency situations and product life may be affected when used.

EMG. Start Button

[Fig. 3-11]

3.7 Emergency Stop Button

- Used to stop the engine in an emergency situation

1) Press immediately in case of emergency with engine running.
   → Stop solenoid actuation while pressing and warning beep.
2) Engine RPM decreases while pressed
3) Release the press when the RPM drop

※ If the button is released within a short period of time, the engine may not be stopped

※ Emergency stop should only be used in emergency situations, as it can potentially impact the lifespan of the product.

EMG.STOP

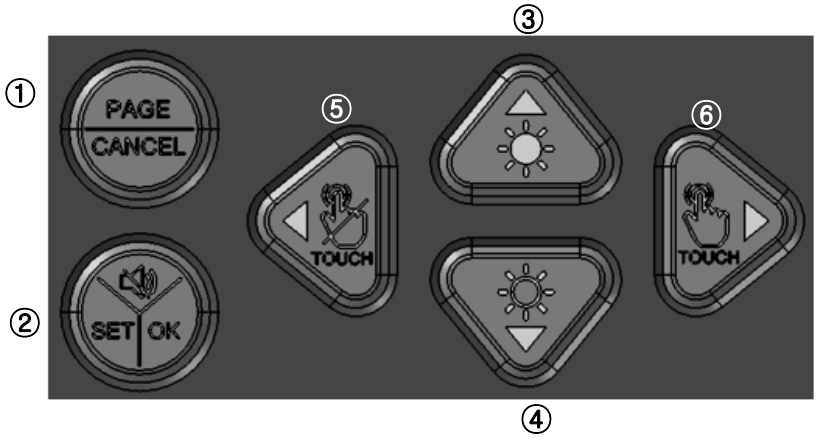
EMG. Stop Button

[Fig. 3-12]

3. Part Names, Operation and

3.8 Function Keys

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



[Fig. 3-13] Function Keys

NO.	Function	Action Characteristics
①	Page	· Switch page / cancel
②	Ok	· Enter setting, save setting value
③	Up	· Cursor movement (up), setting value change (increase), screen brightness increase
④	Down	· Cursor movement (down), setting value change (decrease), screen brightness decrease
⑤	Left	· Cursor movement (left), Lock LCD touch function
⑥	Right	· Cursor movement (right), unlock LCD touch function

[Table. 3-7]

3. Part Names, Operation and Settings

3.8.1 Detailed User Setting

[Fig. 3-14] Detailed Settings

▶ User Setting Function and Description

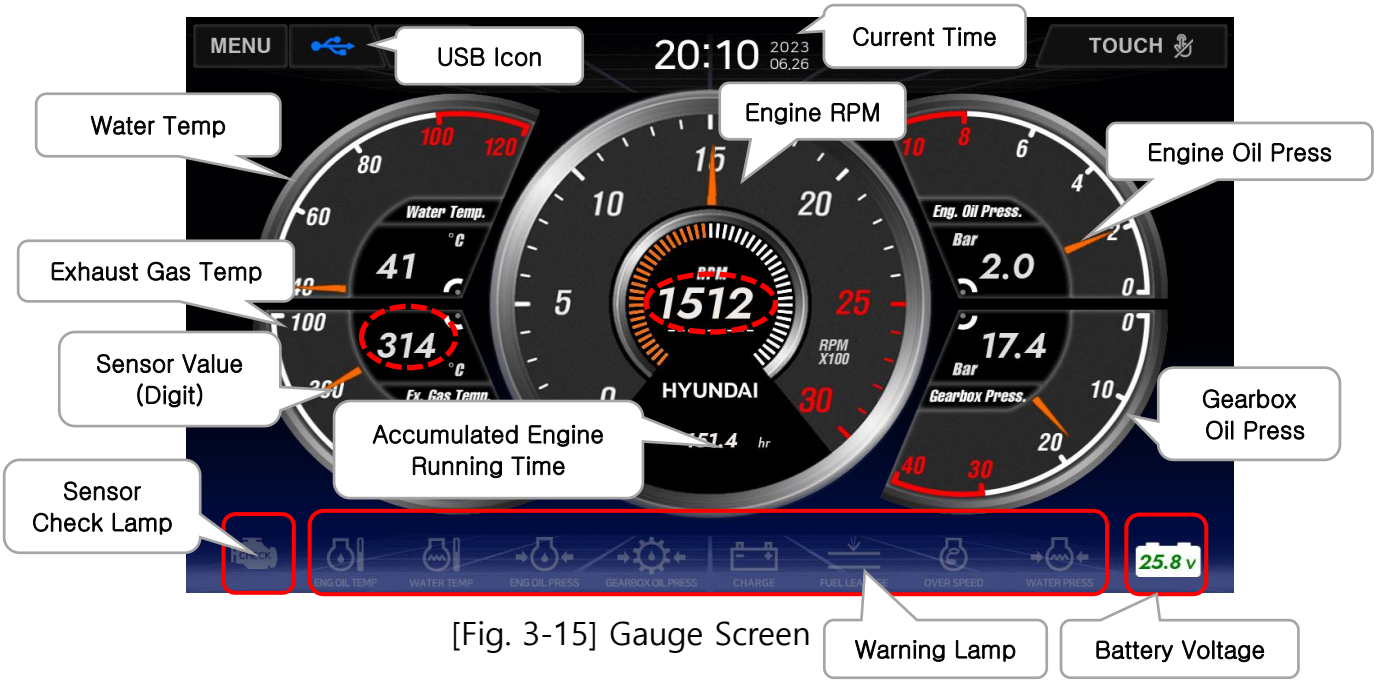
- Press and hold the settings button for 3 seconds on the main screen to enter the user settings.
- Use the arrow keys to move to the function you want to change.
- Press the Ok button to go to the gauge screen. (Auto save on change)

No.	Function	Description	Remark
1	Engine Model	· Setting the Engine Model Installed on the Ship	-
2	Master / Slave	· Master / Slave setting when using multi-panel	-
3	Slave Engine Start	· Slave start authorization On / Off	-
4	Oil Supply Mode	· On / Off function for lubrication inside the engine at idle · Can be set for a total of 5 seconds in 1 second increments	-
5	EGT Sensor	· Exhaust gas temperature sensor selection (for DX12 engine)	-
6	Korean/English	· Korean / English conversion	-
7	Date Setup	· Set date and time	-
8	USB Back up	· Backup event and driving history files to USB	-
9	Version	· Show as full integrated version of software	Select S/W update item

[Table. 3-8]

3. Part Names, Operation and Settings

3.9 Screen Layout



[Fig. 3-15] Gauge Screen

- The gauge functions include engine RPM, coolant temperature, exhaust gas temperature, engine oil pressure, gearbox oil gauge and more.
- Current time, USB detection icon, battery voltage, engine operation accumulated time, high coolant temperature, low engine oil pressure, overspeed, charging, CAN communication abnormality, moisture detection, fuel leakage and gearbox oil gauge warning lights.

3.9.1 Engine RPM

- The engine rpm is displayed as a gauge and a digital value, and the accumulated engine running time is counted.

[Fig. 3-16] Speed Gauge

1) The rpm value indicated by the needle is expressed more precisely as a digital number (digit) (The digit is always ON)
2) Displays the accumulated engine running time in 1hour increments.
   (Counts over 400rpm and is always on)
3) After starting the engine, Starter Off RPM 300 ~ 500rpm can be set

3. Part Names, Operation and Settings

3.9.2 Engine Cooling Water Temperature

- Cooling water temperature is displayed digitally with a gauge.

[Fig. 3-17]
Engine Cooling Water Temperature

1) The temperature of the coolant pointed to by the needle is more precisely expressed as a digital number (digit) (The digit is always ON)
2) In case of sensor failure, open/short diagnosis is displayed.
3) Warning lamp and warning sound when starting state is over 93℃
4) Stop the engine when the starting state is over 103 ℃

3.9.3 Engine Oil Pressure

- Displays engine oil pressure with gauge and digital.

[Fig. 3-18]
Engine Oil Pressure Gauge

1) The oil pressure value indicated by the needle is more precisely expressed as a digital value (digit) (The digit is always ON)
2) In case of sensor failure, open/short diagnosis is displayed.
3) Warning light and warning sound when less than 1 bar (Detected when holding for 10 seconds)
4) Engine stop when less than 0.5 bar (Detected when holding for 10 seconds)
5) Alarm does not work before starting, but alarm works when normal engine stops

3.9.4 Exhaust Gas Temperature

- Displays exhaust gas temperature with gauge and digital.

[Fig. 3-19]
Exhaust Gas Temperature

1) Express the exhaust gas temperature pointed by the needle more precisely as a digital number (digit) (The digit is always ON)
2) In case of sensor failure, open/short diagnosis is displayed.
3) Preliminary sensor warning light operates when the starting state is over 600 ℃

3. Part Names, Operation and Settings

3.9.5 Gearbox Oil Pressure

- Displays gearbox oil pressure with gauge and digital.

[Fig. 3-20]
Gearbox Oil Pressure

1) The gearbox oil pressure value indicated by the needle is more precisely expressed as a digital value (digit)
2) Diagnose open or short circuit when a sensor malfunction occurs.
3) When the ignition state is below 1 bar, a warning light and alarm sound are activated (if detected for more than 10 seconds).

3.9.6 Battery Voltage

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

[Fig. 3-21] Battery Voltage

1) Green for more than 24V / Red for less than 24V
2) Fault code P0562 and warning sound when battery is low voltage

➔ Low battery voltage

3.9.7 Check Sensor Light

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

[Fig. 3-22] Check Sensor Light

1) When a sensor error occurs, the check light turns on in red.
2) Lights orange when an error has ended.

※ In case of engine oil pressure sensor failure, open or short gauge screen is displayed.

Open Short

[Fig. 3-23] Check Sensor Light

3. Part Names, Operation and Settings

3.9.8 Engine Alarm

- In case of coolant temperature, engine oil pressure, gearbox oil pressure, charging, moisture detection, overspeed, or fuel leakage, warning lights flash and a buzzer sound.

[Fig. 3-24] Engine Alarm

NO.	Alarm	Action Characteristics
①	Water Temperature	· Warning light (buzzer) On when over 93℃
②	Engine Oil Pressure	· Warning light (buzzer) On when less than 1 bar
③	Gearbox Oil Pressure	· Warning light (buzzer) On when less than 1 bar
④	Charge	· Warning light (buzzer) On when battery voltage is less than about 18V
⑤	Fuel Leakage	· Warning light (buzzer) on in case of fuel leakage (Default: Disable)
⑥	Over Speed	· Warning light (buzzer) On when over 117% of Rate Speed

[Table. 3-9] Warning light characteristics

3.9.9 Engine Stop

1) When engine overspeed is more than 117% of Rate Speed → Enable/Disable engine stop
2) When the coolant temperature is over 103℃ → Enable/Disable engine stop
3) When the engine oil pressure is kept less than 0.5 bar for more than 10 seconds → Engine stop Enable/Disable possible
4) When fuel leakage occurs → Engine stop Enable/Disable possible
5) When activated Stop Valve → Stop Button is actuated by the user (at 0 RPM for 7 seconds)

※ How to turn off the engine warning light

- When the alarm condition is cleared and it is maintained for 3 seconds, the buzzer and lamp are automatically released and the lamp changes to orange color

3. Part Names, Operation and Settings

3.10 Spare Sensor

- It displays the status of other sensors, product S/N, ECU MAP VERSION, and GUI/FIRMWARE version. Pressing the menu key among the function keys moves to the spare sensor page.

[Fig. 3-25] Spare Sensor (Including Classification Applied Sensor) Information

Item	**Action Characteristics**
Exhaust Gas Temperature1 (High)	· Warning light turns on when exhaust temperature is over 600℃
Exhaust Gas Temperature2 (High)	· Warning light turns on when exhaust temperature is over 600℃
Water Pressure	· Warning light turns on when coolant pressure is less than 0.2 bar
Engine Oil Over Heat	· Warning light turns on when engine oil exceeds 120℃

[Table. 3-10] Spare Sensor

3. Part Names, Operation and Settings

3.11 Alarm Page

- The number of normal starts / number of normal stops / number of abnormal stops / number of emergency starts / number of emergency stops accumulated number of sensor alarm occurrences and information of the latest date of alarm are displayed in the digital panel itself.
- If you press the menu button on the other sensor page, the screen switches to the event summary page.

[Fig. 3-26] Fault Code List

Alarm List	
Water Temp. Over Heat	Low Voltage
Low Engine Oil Pressure	Engine Oil Over Heat
Low Gearbox Oil Pressure	Main Connector Removed
Battery Charge (Alternator)	High Exhaust Gas Temperature
Fuel Leakage (Switch)	Main Connector Removed
Over Speed	-

[Table. 3-11] Alarm List

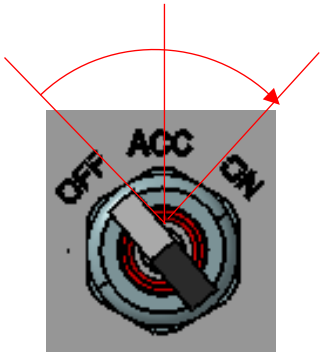
3. Part Names, Operation and Settings

3.12 System Booting and Functional Check

- A checkup is conducted to ensure the proper installation of the product.

▶ Normal System Booting

1) After inserting the key into the key switch, if the key is rotated in the ON direction (right), it returns to the central point and is fixed.



[Fig. 3-27] Key Switch

2) HYUNDAI logo is displayed when the system is booted

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

- Key OFF and then ON again
- Check the harness connection behind the panel
- Check for battery discharge

3) After booting normally, the gauge screen appears.

- Gauge : Check that each gauge needle is within the normal range and check if it is displayed on the 'OPEN' or 'SHORT' screen

※ When 'OPEN' or 'SHORT' occurs

- Check the harness connection status
- Function keys: Check whether each function key is operated normally
- Warning light: Check if the warning light is on
- Battery: Check if the battery voltage is normal

4) If there is no problem in the initial gauge screen, turn the key to start the engine.

5) Check RPM operation (initial 400RPM or higher, oil pressure 1bar or higher) and warning light on (red lamp blinks when warning light is on)

4. Multi Panel Structure

4.1 Multi Panel

- It is possible to install up to 3 additional units except for the Master in the vessel, and it is possible to check and control the vessel status at any time depending on the setting. (Be careful of the battery voltage drops as the length of the harness increases.)

[Fig. 4-1] Master

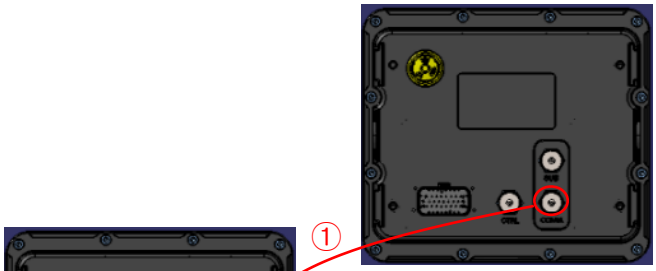
[Fig. 4-2] Slave 1

[Fig. 4-3] Slave 3

[Fig. 4-4] Slave 2

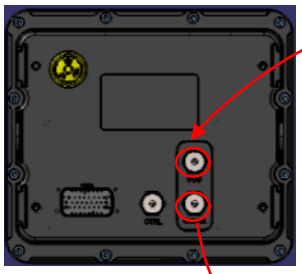
4. Multi Panel Structure

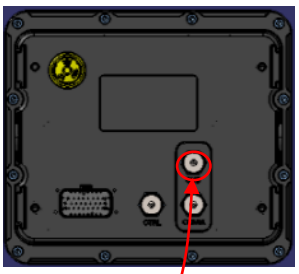
4.2 How to Install Multi Panel



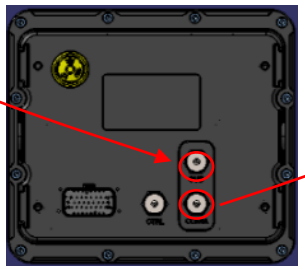
[Fig. 4-5]
Master

[Fig. 4-6]
Slave 1





[Fig. 4-8]
Slave 3



[Fig. 4-7]
Slave 2

※ Before installing the multi-panel, the necessary cables should already be prepared.
(Cables should use Hyundai's recommended specifications)

(1) Connect the SUB terminal of the Master panel to the main connector terminal of the Slave 1 panel as shown in ①. (2 panels)

● Master and Slave 1 connection completed

(2) In the state connected as in ① above, as in ②, that is, connect Slave1(COMM) to Slave2(SUB). (3 panels)

● Master and Slave 1, Slave 2 connection completed

(3) In the state connected as in ② above, as in ③, that is, connect Slave2(COMM) to Slave3(SUB). (4 panels)

● Master, Slave 1, Slave 2, Slave 3 connection completed

4. Multi Panel Structure

4.3 Multi Panel Setting

(1) Press and hold the OK button of the panel to be set in Slave mode for 3 seconds.

(2) When the Settings window opens, navigate to Figure ① (Use the directional keys to navigate).

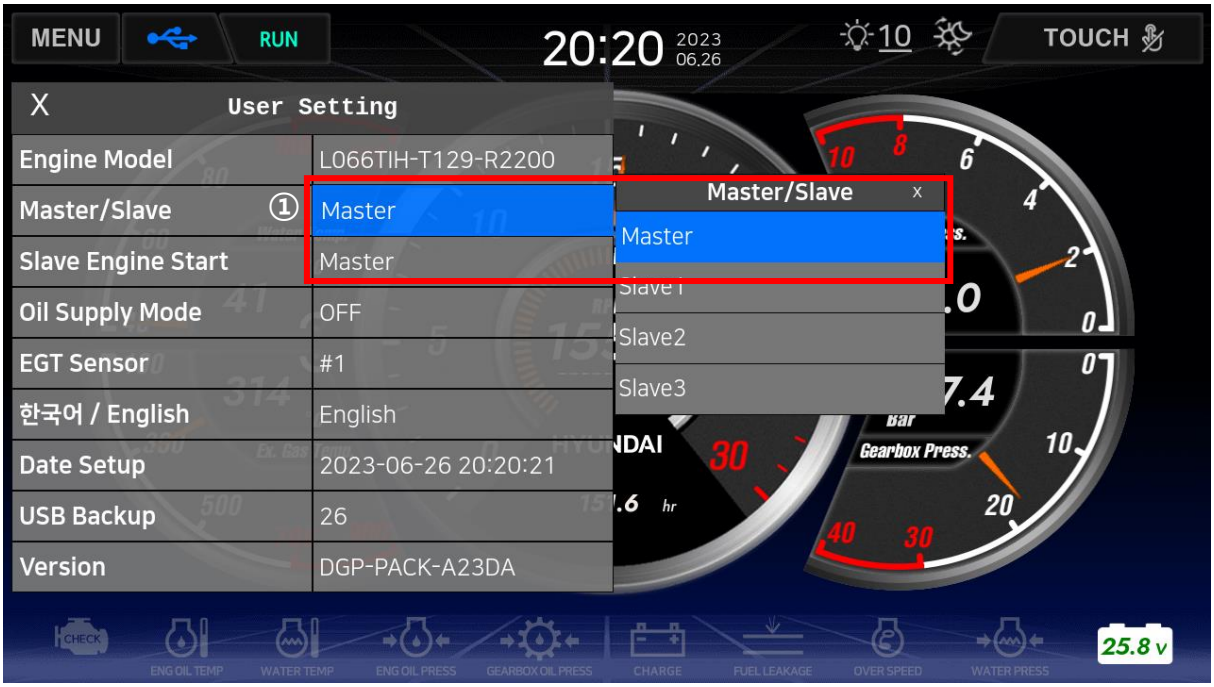
(3) Press the OK button to switch between Master / Slave1 / Slave2 / Slave3.

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

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

※ Note

- Only one product can be set in Master mode, and up to two Slaves are recommended.
- If the cable length between Master and Slaves is more than 30m, there may be a voltage drop of more than 1V, so it needs to be checked.
- Granting engine start permission to Slave panels can only be done from the Master panel and when the "slave engine start setting" is On, the selected slave panel has the starting authority.
- Emergency start is only possible from the Master panel, while emergency stop is possible from all panels.
  - The emergency stop of the Slave operates through CAN communication.
- During engine operation (RUN), re-engaging the starter is not possible.



[Fig. 4-9] Multi Panel Setting Popup

5. Maintenance

5.1 Maintenance

- To maintain the performance of the device, regular maintenance is required.

1. Use soft cloth to clean the LCD without damaging it.
    1) Clean the LCD after turning the power off.
    2) Do not use cleaners with acids or ammonia.
    3) Do not use neutral detergents to remove oil stains.
    4) Use cloth slightly wet in clean water to remove salt residuals or dust particles for natural drying. If there remain stains, clean them with soft cloth (microfibers) once again.
2. Check whether the connectors or harnesses at the back of the device are properly connected or whether they have dust or other foreign substances.
3. Check whether cables are damaged.
4. Request for checking when the software needs upgrade as follows:
    - When the manufacturer releases official software for performance improvements

5.2 Troubleshooting

- It describes possible measures for users to resolve problems while using the device.

1. The device is not turned on.
    1) Check whether harness cables at the back of the product are properly connected.
    2) Where harness cables have too much dust or moisture, remove them and clean the dust or moisture. Connect them once again after a while.
    3) Check whether the fuse button at the back of the product is pulled out.
    4) Check whether the battery is discharged.
2. You can see lines or shaking on the screen.
    1) Reboot the product.
    2) As the LCD is connected inside the product, do not disassemble it and contact the service team.
3. You can see alarm or hear warning beeps at the bottom of the product screen.
    1) Check where the alarm occurs and then take measures as necessary (if you need to confirm which alarm occurs, refer to Page 20 of this manual).
4. You cannot control buttons.
    1) Check whether there are foreign substances at the panel buttons.
    2) As the button connecting parts may be damaged, do not disassemble the product and contact the service team.

6. Warranty and A/S Service

6.1 Warranty

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

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

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

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

※ Where you use accessories or parts manufactured by other companies, please contact our service.

6.2 A/S Service Information

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

7. Appendix

7.1 List of Engine Models

- List of compatible engine models

- Engine		Gear 잇수	Rate Speed	Over Speed	
DB58TI	L066TIH	129	2,200	115%	2,530
D1146	L136	140	2,200	115%	2,530
D1146T	L136T	140	2,200	115%	2,530
	L136TL	140	2,500	115%	2,875
D1146TI	L136TI	140	2,200	115%	2,530
D1146TIB	L086TIH	140	2,200	115%	2,530
	L086TIM	140	2,300	115%	2,645
	L086TIL	140	2,500	115%	2,875
DE12T	MD196T	152	2,000	115%	2,300
DE12TI	MD196TI	152	2,000	115%	2,300
DE12TIB	L126TIH	152	2,000	115%	2,300
	L126TIM	152	2,100	115%	2,415
D2848LB	V158TIH	160	1,800	115%	2,070
	V158TIM	160	2,100	115%	2,415
	V158TIL	160	2,300	115%	2,645
D2840LB	V180TIH	160	1,800	115%	2,070
	V180TIM	160	2,100	115%	2,415
	V180TIL	160	2,300	115%	2,645
D2842LB	V222TIH	160	1,800	115%	2,070
	V222TIM	160	2,100	115%	2,415
	V222TIL	160	2,300	115%	2,645
4VD2848LB	4V158TIH	160	1,800	115%	2,070
	4V158TIM	160	2,100	115%	2,415
	4V158TIL	160	2,300	115%	2,645
4VD2842LB	4V222TIH	160	1,800	115%	2,070
	4V222TIM	160	2,100	115%	2,415
	4V222TIL	160	2,300	115%	2,645

Digital Panel for Marine Generator's

User Manual

Ver.1.2

HYUNDAI

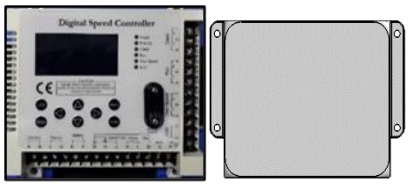
▶ Index

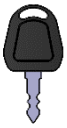
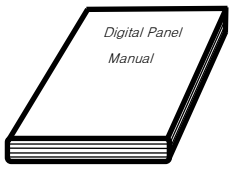
1. General Information

1.1 Product Information

The name of the product model is DGP-2000 applicable to various marine generator engines. The product is intended to improve problems of existing analog panels and allow users to check engine controls and conditions by means of a digital visualization product. It provides information in analog graphic gauges and digital displays for enhanced user experiences.

1.2 Components

Items	Image	Qty	Description	Remark
DGP-2000 ASM		1	Body of Digital Panel for Marine Gen.	
DSC-2000		1	Digital Speed Controller for Marine & Cover	
DSC Bracket		1	Assembly DGP-2000 and DSC-2000	
Desk Mounting Type Bracket		1	To install DGP-2000	

Fix handle		2	Tilting DGP-2000	
Key		2	To boot DGP-2000	
Manual		1	User manual	

[Table 1-1]

1.3 Product Specification

No.	Items	DGP-2000	DSC-2000
		Description	
1	CPU	• Cortex-A8, dsPIC33FJ256(16bit)	• dsPIC33FJ256(16bit)
2	S/W	• Windows CE 6.0 R2(OS)	• Firmware
3	Display	• 10.2" Color TFT LCD • 800 * 480(pixel) • 16 : 9	• Graphic LCD 128*64
4	Flash Memory	• 256MB(Flash) • 8GB(MicroSD card)	• 128MB
5	RAM	• 512MB	• -
6	Operating Volt.	• DC 24V (16 ~ 30V)	• DC 24V (12V~30V)
7	USB	• USB2.0 1Port	• -
8	Operating Temp.	• - 20℃ ~ 70℃	• -20~+70℃
9	Buzzer	• Piezo Buzzer 98dB	• -
10	Communication	• J1939 CAN • RS232	• RS232 57600bps • CAN(J1939)/250kbps
11	Size	• W 344 x H 271 x D 160	• W 170 x H 165 x D 30

[Table 1-2]

2. Installation

2.1 Cautions

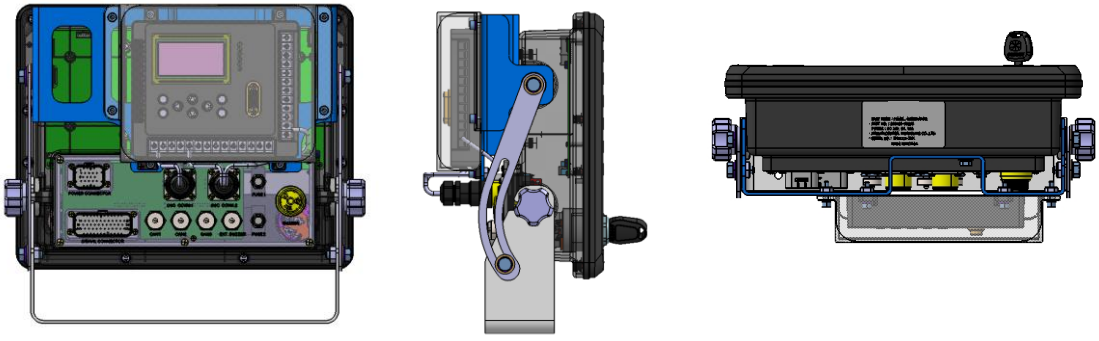
- Unskilled personnel should read this manual before use.
- Do not use or keep the product close to combustible sprays or inflammable.
- Use soft and dry cloth to clean the monitor.

  Turn off the product, pull out the harness cable and then contact our service center when you see smoke from the monitor or have strange smells.
- When you see an alarm on, you always need to check the product before operation.
- Do not disassemble the product cover at discretion (warranty does not cover unauthorized disassembly).
- Excessive impact may damage the display although a reinforced display is used.
- Use connectors matching each other when connecting them to the back of the product.

  Do not contact or remove connectors while the power is on. It may cause electric shock or lead to malfunction.
- Do not exercise excessive force when rotating to ON/OFF with the key inserted.
- Do not use the product with wet hands.
- Use protective caps for back side connectors that are not used.

2.2 Installation

- Install DGP-2000 in the engine room by using Desk Mounting brackets delivered with the product.



※ Spec. of mounting hole : M6 bolt [Fig 2-1]

▶ Installation Sequence for DGP-2000

1) Check whether the engine room has engine harness wiring.

2) Separate the temporary assembled bracket from product.

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

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

5) Put the wave washer in the fix handle and connect it with the fix handle. Then adjust the viewing angle of the LCD.

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

3. Part Names, Operation and Settings

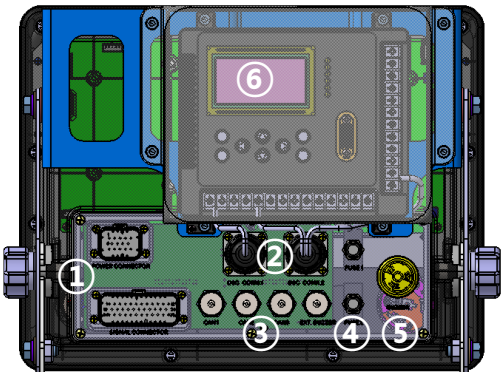
3.1 Front Side

[Fig 3-1]

No.	Name	Ref.
①	LCD	p15
②	Function Key	p13
③	Key Switch	p11
④	USB	p11
⑤	Buzzer	p11
⑥	Start/Stop Button	p12

[Table 3-1]

3.2 Back Side



[Fig 3-2]

No.	Name	Ref.
①	Main Connector(2EA)	p8
②	DSC Connector(2EA)	p10
③	CAN & PC Communication	p10
④	Fuse(6A, 10A)	p11
⑤	Buzzer	p11
⑥	DSC	-

[Table 3-2]

3.3 External Connections

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

3.3.1 Power Connector

- Power connector supplies power and power signals.

POWER CONNECTOR

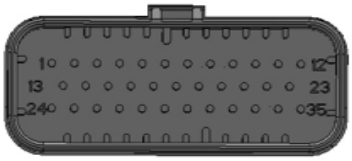
[Fig 3-3]

No.	Pin Description	Remark
1	Alternator In	Battery
2	-	-
3 4	Battery(+)(DC 24V)	Input to fuse
5	Starter Signal	-
6	-	-
7	-	-
8	Starter Signal	-
9	Starter Signal	-
10	Actuator A	-
11	Actuator B	-
12	GND	Power
13	GND	
14	Battery(+)(DC 24V)	Input to fuse

[Table 3-3]

3.3.2 Signal Connector

- Signal connector supplies sensor signals.



SIGNAL CONNECTOR

[Fig 3-4]

* : Only for IMO Tier3

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

[Table 3-4]

3.3.3 CAN Connectors

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

[Fig 3-5]

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

[Table 3-5]

3.3.4 External Buzzer Connector

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

[Fig 3-6]

No.	Pin map
1	Battery(+) – Output of fuse
2	Alarm Out

[Table 3-6]

3.3.5 DSC Connector

- Connecting DGP-2000 with DSC-2000
- Function of DSC-2000 power supply, pick-up signal transmission, actuator signal transmission and CAN communication function

[Fig 3-7]

Pin No.	Pin Name	Description	Remark
A	Actuator A	Control signal for actuator	
B	Actuator B	Power for actuator	
C	-	-	

[Table 3-7]

[Fig 3-8]

Pin No.	Pin Name	Description	Remark
1	Batt. +	Power	DSC power on(off) by engine start(stop)
2	Batt. -	Power	
3	RPM	Pick-up signal	Original pickup signal through digital panel
4	CAN H	CAN High	DSC Inform., Idle/Run Switch
5	CAN L	CAN Low	
6-7	-	-	-

[Table 3-8]

3.3.6 USB Connector

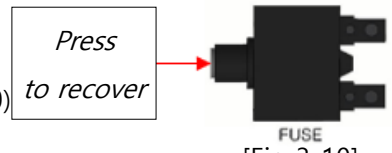
- USB memory can be inserted for data backup.

[Fig 3-9]

3.4 Fuse and Buzzer

3.4.1 Fuse

- It consists of 6A(for digital panel) fuse and 10A(DSC-2000) fuse
- 10 seconds after fuse operation, press fuse button to recover



[Fig 3-10]

3.4.2 Buzzer

- Generate alarms for sensor problems

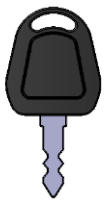
[Fig 3-11]

3.5 Key Switch

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

1) Use the key contained in the product to insert it and rotate to the right over 45° (ON) (when the key is ON, the key should remain inserted).

2) When the key is ON, the product will boot and the gauge display will

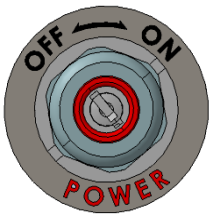


[Fig 3-12]

appear in about 15 seconds.

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

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



Key Switch
[Fig 3-13]

3.6 Start/Stop Button

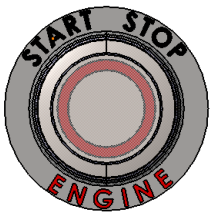
- Start/Stop button is used to start/stop control for the generator engine.

1) Press the button for more than 1 second while the key is ON,
the engine will start (the button LED will flash when pressing the button).

2) Press the button for more than 1 second while the key is ON and the engine is in operation to stop the engine.

※ The time can be set from 1 to 3 seconds. Ask for the service member.

※ Installed the protection cover to prevent object come in.



Start/Stop Button
[Fig 3-14]

3.7 Emergency Stop Button

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

1) Press immediately when an emergency situation occurs in the engine run state.
→ Red LED on while pressing

2) Release the button after the engine is completely stopped.
→ LED off when released

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

Emergency Stop Button
[Fig. 3-15]

3.8 Function Keys

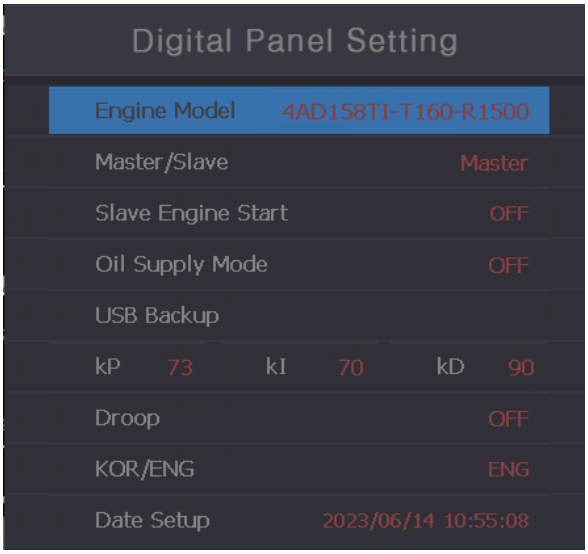
- Function keys are used to adjust LCD brightness, alarm mute, Idle/Run, Digit on/off, Home and other settings, move to and select menus, and reset the system.

[Fig 3-16]

No.	Function Key	Action Feature
①	LCD Brightness	- LCD brightness adjustable for 5 different levels (when rebooting the system, the previous setting will be maintained)
②	Alarm Mute	- Turn off the buzzer sound
③	Idle/Run	- Changing the engine status Idle to Run
④	Digit	- Digit is default on - Press **DIGIT,** the number light will be off - Press while the display is off, the number light will turn on
⑤	Home	- Move to main gauge display - Move to main display without saving when pressing it in page mode
⑥	Setting	- Engine Model setting - Master/Slave setting and ON/OFF setting to start the slave - ON/OFF oil supply mode - USB backup and date(year/month/hour) settings - Setting PID - Droop On/Off
⑦	Up/Down	- Move the cursor up and down in setting window
⑧	Enter	- Select menus or functions in the setting window
⑨	Page	- Move to spare sensor display (display page 2) / Move to event summary display (display page 3)
⑩	System Reboot	- Rebooting for system errors (press it for more than 3 seconds to reboot)

[Table 3-9]

3.8.1 Setting Items



[Fig 3-17]

▶ Setting Functions and Descriptions

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

No.	Function	Description	Remark
1	Engine Model	Engine model setting (refer to the appendix for the list of engine models)	
2	Master / Slave	Master/Slave setting for multi panels	
3	Slave Engine Start	ON/OFF setting to start by slave	
4	Oil Supply Mode	Engine cranking	
5	USB Back Up	USB backup for the saved event files	
6	Droop	Setting the engine's droop mode	
7	PID	Changing PID values	
8	Date Setup	Date and time setting	

[Table 3-10]

3.9 Display Structure

[Fig 3-18]

- Gauge display shows various gauge data including pick up(RPM) sensor, coolant temperature, exhaust gas temperature and engine oil pressure.
- DSC-2000 information icons to monitor the generator's status.
- It also includes battery voltage indication, accumulated engine operation hours, coolant temperature, engine oil pressure, gearbox oil pressure, charging, coolant level, fuel leak and overspeed alarm.

3.9.1 Engine Speed (Tachometer)

- It shows engine RPM in gauge and digital values and counts accumulated engine operation hours.
- Harness → Digital Panel → DSC → CAN → Digital Panel

[Fig 3-19]

1) It shows the RPM indicated by the gauge hand in digital values(red) for better accuracy.
2) It shows accumulated engine operation hours by hour unit. (engine speed of 400RPM or faster will be counted and the function is always on)
3) Starter Off RPM setting is available between 300 and 600RPM after the engine starts.
(The service team can configure the setting in PC Manager)
4) Engine stop(DSC function) and alarm lamp, buzzer at 115% of rate speed

3.9.2 Engine Water Temperature

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

1) It shows the temperature indicated by the gauge hand in digital values(blue) for better accuracy.

2) It shows the open/short diagnosis for sensor problems.

☞ Open: 'ERROR' / Short (GND): '-----'

3) It also serves as the water temperature switch.

4) It activates alarm and warning beep when the temperature increases up to 93℃ or higher.

5) When the temperature increases up to 103℃ or higher, the engine will stop.

[Fig 3-20]

3.9.3 Engine Oil Pressure

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

1) It shows the pressure indicated by the gauge hand in digital values (blue) for better accuracy.

2) It shows the open/short diagnosis for sensor problems.

☞ Open: '-----' / Short (Power): 'ERROR'

3) It also serves as the engine oil pressure switch.

4) It activates alarm and warning beep when the pressure is 1bar or lower (detects in 10 seconds)

5) When the pressure is 0.5bar or lower, the engine will stop

6) It will not work before the engine starts.

[Fig 3-21]

3.9.4 Exhaust Gas Temperature

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

1) It shows the temperature indicated by the gauge hand in digital values(blue) for better accuracy.

2) It shows the open/short diagnosis for sensor problems.

☞ Open: 'ERROR' / Short (GND): '-----'

3) It warning light turns on at 600 ℃ or higher (spare sensor page)

[Fig 3-22]

3.9.5 Battery Voltage

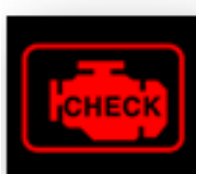
- It shows battery voltage to indicate its conditions.

1) It shows in blue for voltage of 24V or higher and red for voltage lower than 24V. [Fig 3-23]

2) It activates warning beep when the voltage is under 18V(regardless of whether the engine is in operation or not). ☞ Possible battery degradation when over 28.9V (overcharge)

3.9.6 Engine Check Lamp

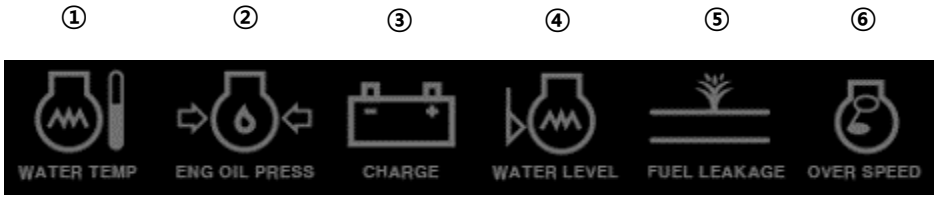
- When there are sensor errors (Open or Short), the check sensor lamp will flicker with buzzer.



[Fig 3-24]

3.9.7 Engine Alarm Lamp

- The alarm lamp will flicker with buzzer beeping when problems for coolant temperature, engine oil pressuree, charging, coolant level, fuel leakage and over speed are detected.



[Fig 3-25]

NO.	Lamp	Conditions
①	WATER TEMP(Coolant temperature)	· When the temp is **93℃** or higher
②	ENGINE OIL PRESS(Engine oil pressure)	· When the pressure is **1 bar** or lower
③	CHARGE(Battery Charge)	· When the battery voltage is lower than 18V
④	WATER LEVEL(Coolant level)	· When the level is **30%** or lower(Default 'disable')
⑤	FUEL LEAKAGE(Fuel leakage)	· When oil leak occurs(Default 'disable')
⑥	OVER SPEED(Engine over speed)	· When the speed exceeds **115%** of the rate speed

[Table 3-11]

※ How to deactivate the engine alarm

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

3.9.8 DSC-2000 information icons

[Fig 3-26]

No.	Description
①	Target RPM for generator
②	Duty rate of the current actuator for generator
③	Indication for Power on/off status of DSC-2000
④	Indication for PICK-UP signal input status
⑤	Indication for generator OVER SPEED
⑥	Indication for generator CRANK status
⑦	Indication for generator RUN status
⑧	Indication for generator ERROR status
⑨	Indication for generator IDLE ON/OFF status
⑩	Indication for generator DROOP ON/OFF status

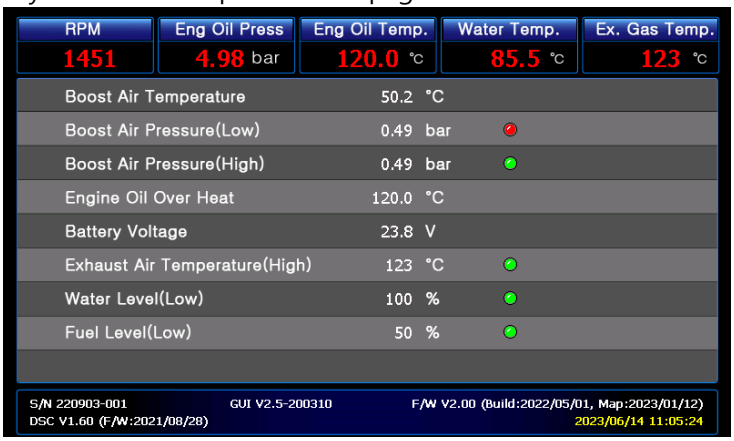
[Table 3-12]

3.9.9 Engine Stop

- When the over speed exceeds **115%** of the rate speed → **Function of DSC-2000**
- When the coolant temperature exceeds **103℃** → Enable/Disable engine stop
- When the oil pressure is lower than **0.5bar** → Enable/Disable engine stop
- When fuel leakage occurs → Enable/Disable engine stop
- When the coolant level is **15%** or lower → Enable/Disable engine stop
- When 300 seconds alarm message pop up due to key off during engine run
- When the stop button will be activated by users(Digital Speed Controller power off)

3.10 Spare Sensors

- It identifies the status of spare sensors, product S/N, S/W version and date. Press ***Page*** button of the function keys to move to spare sensor page.



[Fig 3-27]

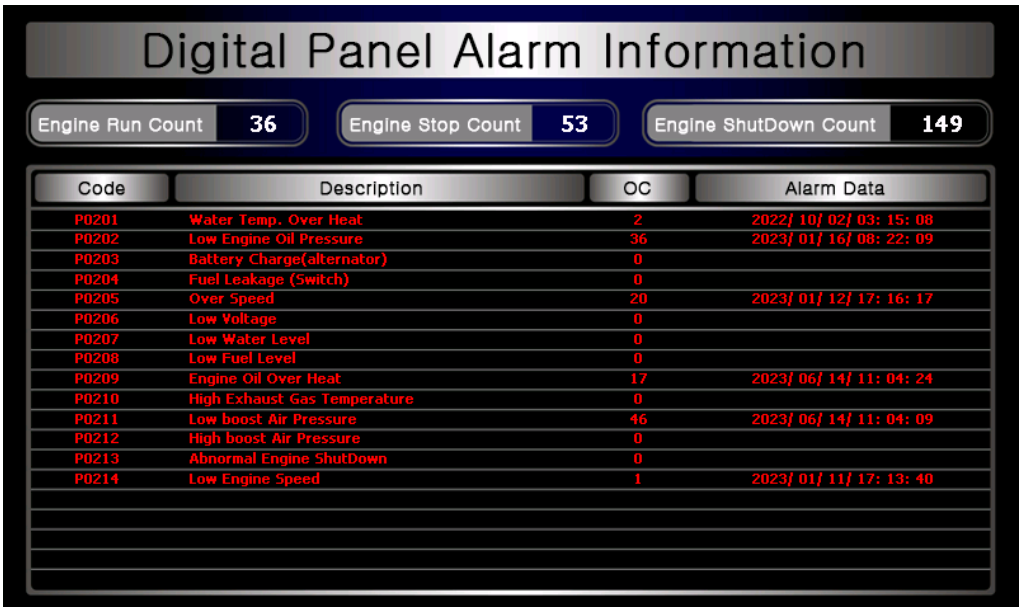
Items	Conditions
*Boost Air Temperature	• Current temperature of BATS(No alarm)
*Boost Air Pressure	• Normal when the pressure is between 1.1 and 2.9bar
*Boost Air Pressure (Low)	• Alarm when the pressure is lower than 1bar
*Boost Air Pressure (High)	• Alarm when the pressure is higher than 3bar
*Engine Oil Over Heat	• Alarm when the temperature is higher than 120℃
Battery Voltage	• Current battery voltage
Exhaust Air Temperature(High)	• Alarm when the temperature is higher than 600℃
*Water Level (Low)	• Alarm when the coolant level is lower than 30%
*Fuel Level (Low)	• Alarm when the fuel level is lower than 30%

* : Sensor for IMO Tier3

[Table 3-13]

3.11 Event Summary

- It shows the numbers of normal operations, normal stops, emergency stops and sensor errors together with dates of recent errors.
- Press ***Page*** button in spare sensor page to move to event summary page.



[Fig 3-28]

Event List			
P0201	Water Temp. Over Heat	P0208	*Low Fuel Level
P0202	Low Engine Oil Pressure	P0209	Engine Oil Over Heat
P0203	Battery Charge(Alternator)	P0210	High Exhaust Gas Temperature
P0204	Fuel Leakage(Switch)	P0211	*Low Boost Air Pressure
P0205	Over Speed	P0212	*High Boost Air Pressure
P0206	Low Voltage	P0213	Abnormal Engine Shutdown
P0207	*Low Water Level	P0214	Low engine Speed

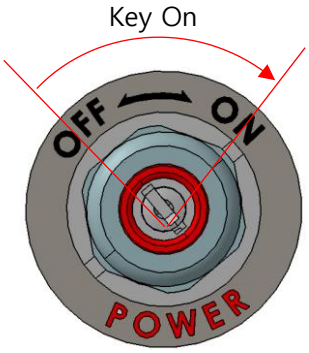
* : Sensor for IMO Tier3

[Table 3-14]

3.12 System Booting and Functional Check

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

▶ Normal System Booting



[Fig 3-29]

1) Insert the key into the key switch and rotate it to the right (ON).

2) HYUNDAI logo will appear for 17 seconds while the system is booting (refer to the image).

※ If the logo does not appear after rotating the key,

●Rotate it to the left (OFF) and then to the right (ON) again

●Check the harness connection at the back of the panel

●Check whether the battery is discharged

3) The gauge display will appear after normal booting.

●Gauge: check whether each gauge hand is within the normal range and 'ERROR' or '-----' is displayed on the screen

※ Where 'ERROR' or '-----' is displayed on the screen

●Check the harness connection

●Function keys : check whether each function key is active on the screen by pressing them

●Alarm : check whether the alarm is turned on

●Battery : check whether the battery voltage is 18V or lower

4) Where the initial gauge screen is normal, press START button for 1 second to start the engine (the time can be set from 1 to 3 seconds by the service team)

5) Check whether the operation is in normal RPM (initial operation in 400RPM or faster with the oil pressure of 1bar or higher) and whether alarm is turned on.

[Fig 3-30]

4. Multi Panel Structure

4.1 Multi Panel

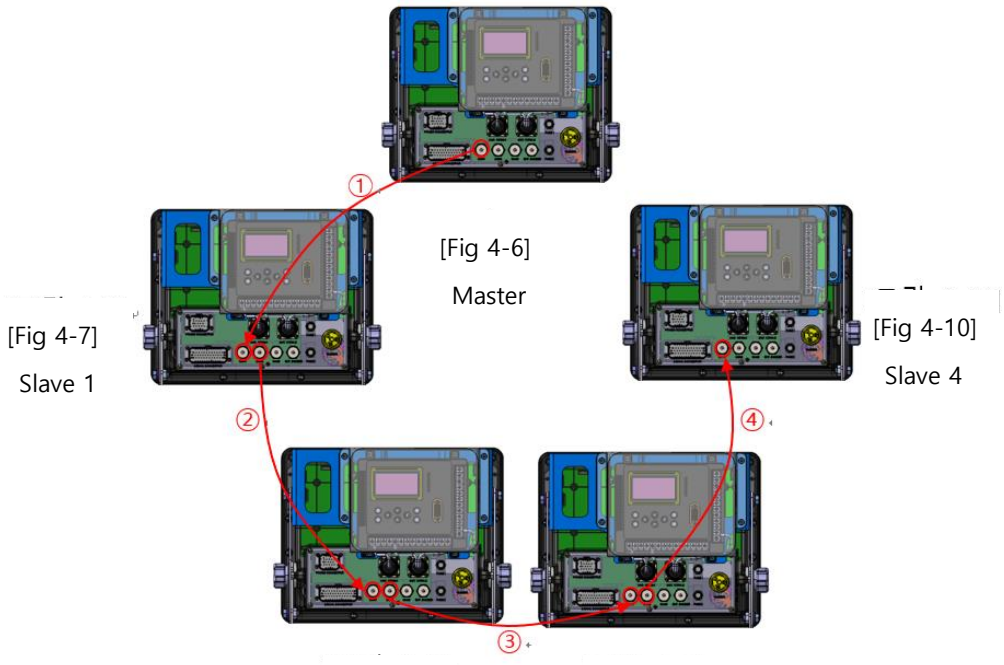
- Panels can be installed up to 4 units except Master in the ship and you can check the ship conditions and control those panels at any places of installation.

[Fig 4-2] Slave 1 [Fig 4-3] Slave 3

[Fig 4-1] Master

[Fig 4-4] Slave 2 [Fig 4-5] Slave 4

4.2 How to Install Multi Panel



[Fig 4-6] Master

[Fig 4-7] Slave 1

[Fig 4-10] Slave 4

[Fig 4-8] Slave 2

[Fig 4-9] Slave 3

※ In order to install multi panels, all the necessary cables should be ready in advance(use the cables with specification recommended by HYUNDAI).

1) Connect the CAN1 terminal of the Master panel and the CAN1 terminal of the Slave 1 panel as shown in ① (2 panels).
- ●Master and Slave 1 connection completed

2) Connect Slave 1 (CAN2) and Slave 2 (CAN1) as shown in ② while maintaining connection as described in ① (3 panels).
- ●Master, Slave 1 and Slave 2 connection completed

3) Connect Slave 2 (CAN2) and Slave 3 (CAN1) as shown in ③ while maintaining connection as described in ② (4 panels).
- ●Master, Slave 1, Slave 2 and Slave 3 connection completed

4) Connect Slave 3 (CAN2) and Slave 4 (CAN1) as shown in ④ while maintaining connection as described in ③ (5 panels).
- ●Master, Slave 1, Slave 2, Slave 3 and Slave 4 connection completed

4.3 Multi Panel Settings

1) Press ***Setting*** button of the panel to be configured as Slave.

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

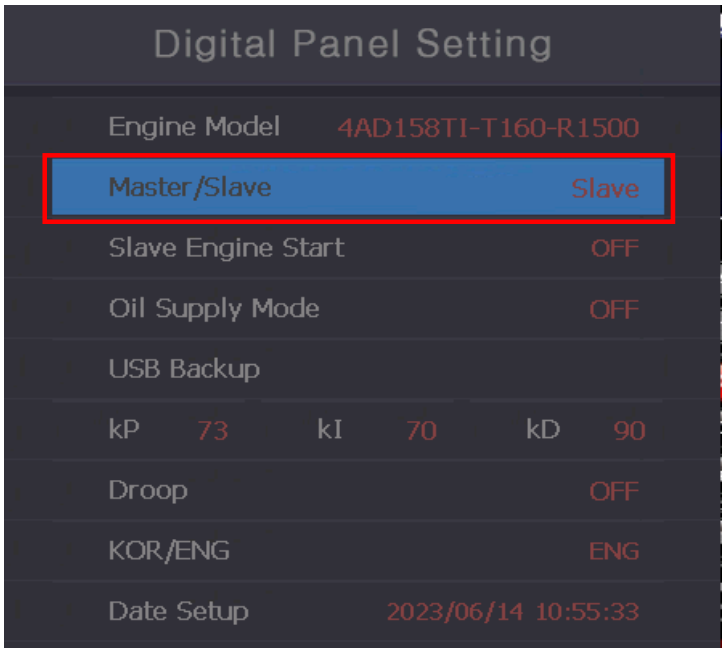
3) Press ***Enter*** button to switch configuration between Master and Slave..

4) Configure the Master panel as described above.

※ Notes

●Master mode is available for one panel only and Slave mode is available up to 4 units.

●You can permit Slaves to start the engine with Master panel only. Where you enable Slave Engine Start setting, all Slave panels will be able to start the engine.



[Fig 4-11]

5. Maintenance

5.1 Maintenance

- To maintain the performance of the device, regular maintenance is required.

1. Use soft cloth to clean the LCD without damaging it.
   1) Clean the LCD after turning the power off.
   2) Do not use cleaners with acids or ammonia.
   3) Do not use neutral detergents to remove oil stains.
   4) Use cloth slightly wet in clean water to remove salt residuals or dust particles for natural drying. If there remain stains, clean them with soft cloth (microfibers) once again.
2. Check whether the connectors or harnesses at the back of the device are properly connected or whether they have dust or other foreign substances.
3. Check whether cables are damaged.
4. Request for checking when the software needs upgrade as follows:
   - When the manufacturer releases official software for performance improvements
5. Don't give a large shock to the product.

5.2 Troubleshooting

- It describes possible measures for users to resolve problems while using the device.

1. The device is not turned on.
   1) Check whether harness cables at the back of the product are properly connected.
   2) Where harness cables have too much dust or moisture, remove them and clean the dust or moisture. Connect them once again after a while.
   3) Check whether the fuse button at the back of the product is pulled out.
   4) Check whether the battery is discharged.
2. You can see lines or shaking on the screen.
   1) Reboot the product.
   2) As the LCD is connected inside the product, do not disassemble it and contact the service team.
3. You can see alarm or hear warning beeps at the bottom of the product screen.
   1) Check where the alarm occurs and then take measures as necessary (if you need to confirm which alarm occurs, refer to Page 20 of this manual).
4. You cannot control buttons.
   1) Check whether there are foreign substances at the panel buttons.
   2) As the button connecting parts may be damaged, do not disassemble the product and contact the service team.

6. Warranty and A/S Service

6.1 Warranty

- As this manual contains important contents related to safety, use and maintenance of the product. So please read this manual carefully and then use the product in a proper manner. Those who are not familiar with the product should keep this manual close to it.

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

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

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

6.2 A/S Service Information

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

7. Appendix

7.1 Generator Engine List

Engine Name	Product Name	RPM	Tooth
DB58TI	AD066TI	1500	129
		1800	
D1146	AD136	1500	140
		1800	
D1146T	AD136T	1500	
		1800	
D1146TI	AD136TI	1500	
		1800	
D1146TIB	AD086TI	1500	
		1800	
DE12TI	AD196TI	1500	
		1800	
DE12TIB	AD126TI	1500	152
		1800	
DX12	4AD126TIF 4AD126TIS	1500	106
		1800	
D2848LB	AD158TI	1500	
		1800	
D2840LB	AD180TI	1500	
		1800	
D2842LB	AD222TI	1500	160
		1800	
4VD2848LB	4AD158TI	1500	
		1800	
4VD2842LB	4AD222TI	1500	
		1800	

[Table 7-1]