



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.

- * 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 ±0.05 / 0.35 ±0.05		
Low idling rpm		rpm	725 ±25		
No load max. rpm		rpm	Below 2,070	Below 2,415	Below 2,645
Mean effective pressure		kg/cm ²	16.42	15.84	18.21
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		
Max. firing pressure of cylinder		kg/cm ²	130	128	150
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	155	163	185
		liter/h	90	106	152
Injection timing (B.T.D.C)		deg	15 ±1°	16 ±1°	18 ±1°
Fuel inj. nozzle opening pressure		kg/cm ²	286		
Starting system			Electric starting by starter motor		
Starter motor capacity		V - kW	24 - 6.6		
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 V-belt pulley		
Sea water pump type			Bronze impeller type driven by V-belt pulley		
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		
	Propeller		Clockwise viewed from stern side		
Engine size (L x W x H)	Without M/G	mm	1,337x1,222x1,074	1,337 x 1,222 x 1,074	
	With M. gear	mm	1,777x1,222x1,115	1,872 x 1,222 x 1,111	
Engine dry weight	Without M/G	kg	1,300	1,300	
	With M. gear	kg	1,590	1,710	

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 ±0.05 / 0.35 ±0.05		
Low idling rpm		rpm	725 ±25		
No load max. rpm		rpm	Below 2,070	Below 2,415	Below 2,645
Mean effective pressure		kg/cm ²	16.42	15.25	18.56
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		
Max. firing pressure of cylinder		kg/cm ²	130	128	150
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	153	156	185
		liter/h	111	122	183
Injection timing (B.T.D.C)		deg	16 ±1°	18 ±1°	18 ±1°
Fuel inj. nozzle opening pressure		kg/cm ²	286		
Starting system			Electric starting by starter motor		
Starter motor capacity		V - kW	24 - 6.6		
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 V-belt pulley		
Sea water pump type			Bronze impeller type driven by V-belt pulley		
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		
	Propeller		Clockwise viewed from stern side		
Engine size (L x W x H)	Without M/G	mm	1,495 x 1,222 x 1,169		
	With M. gear	mm	2,016 x 1,222 x 1,192		
Engine dry weight	Without M/G	kg	1,550		
	With M. gear	kg	2,065		

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 ±0.05 / 0.35 ±0.05		
Low idling rpm		rpm	725 ±25		
No load max. rpm		rpm	Below 2,070	Below 2,415	Below 2,645
Mean effective pressure		kg/cm ²	16.42	15.64	17.85
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		
Max. firing pressure of cylinder		kg/cm ²	130	126	150
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	152	160	190
		liter/h	132	154	229
Injection timing (B.T.D.C)		deg	17 ±1°	18 ±1°	19 ±1°
Fuel inj. nozzle opening pressure		kg/cm ²	286		
Starting system			Electric starting by starter motor		
Starter motor capacity		V - kW	24 - 6.6		
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 V-belt pulley		
Sea water pump type			Bronze impeller type driven by V-belt pulley		
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		
	Propeller		Clockwise viewed from stern side		
Engine size (L x W x H)	Without M/G	mm	1,653 x 1,222 x 1,199		
	With M. gear	mm	2,263 x 1,222 x 1,250		
Engine dry weight	Without M/G	kg	1,750		
	With M. gear	kg	2,460		

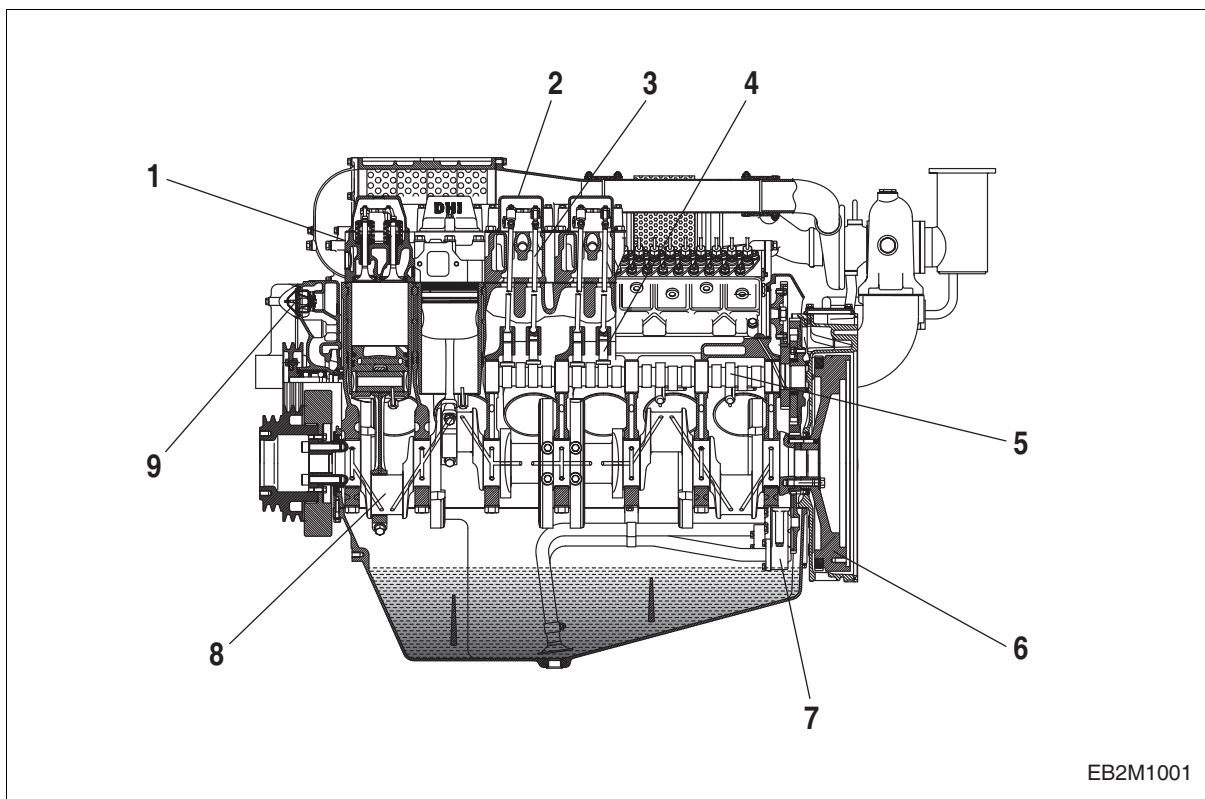
1.1.4. AD158TI / AD180TI / AD222TI

Spec. / Model		Units	DV Series		
			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		mm	0.25 ±0.05 / 0.35 ±0.05		
Low idling rpm		rpm	800 ±50		
No load max. rpm (50 Hz / 60 Hz)		rpm	Mechanical governor : 1,575 (52.5 Hz) / 1,890 (63 Hz)		
			Electric governor : 1,500 (50 Hz) / 1,800 (60 Hz)		
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.	7.10 / 8.52		
Compression ratio			14.9 : 1		15.5 : 1
Max. firing pressure of cylinder		kg/cm ²	130	130	130
Com. press. (at 200 rpm)		kg/cm ²	24 (Initial condition)		
Governor type of inj. pump			Electric governor		
Fuel consumption		g/PS.h	148 / 153	152 / 153	151 / 150
		liter/h	73 / 88	89 / 111	110 / 130
Injection timing (B.T.D.C)	TIF/TIS	deg	14 ±1° / 15 ±1°	16 ±1° / 18 ±1°	16 ±1° / 18 ±1°
Inj. nozzle opening press.		kg/cm ²	224		
Starting system			Electric starting by starter motor		
Starter motor capacity		V - kW	24V - 6.0		
Alternator capacity		V - A	24 - 80		
Battery		V - Ah	24V - 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 gear		
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)			1,295	1,545	1,735

1.2. Engine Aspects

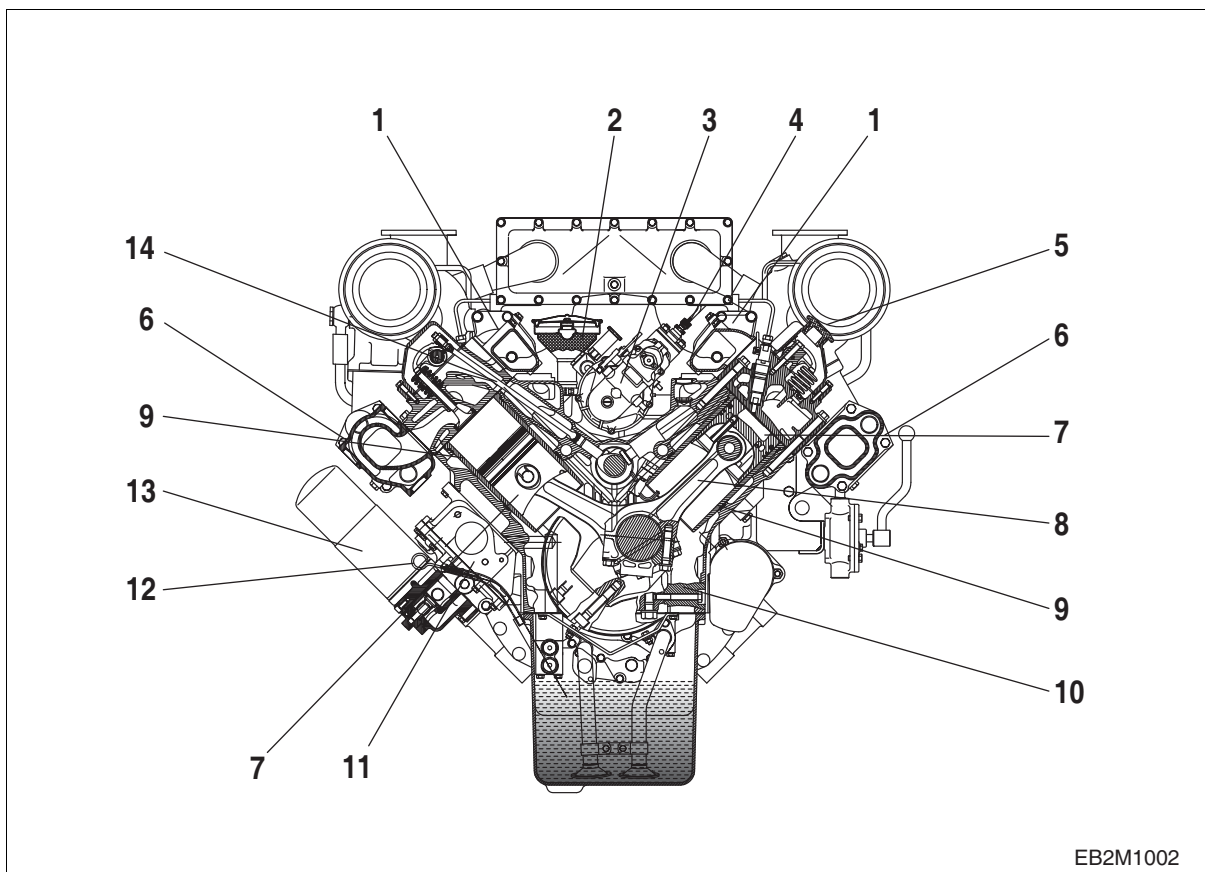
Note : The images shown represent the standard model; they do not include all models.

1.2.1. Engine sectional view (Longitudinal → V222TI)



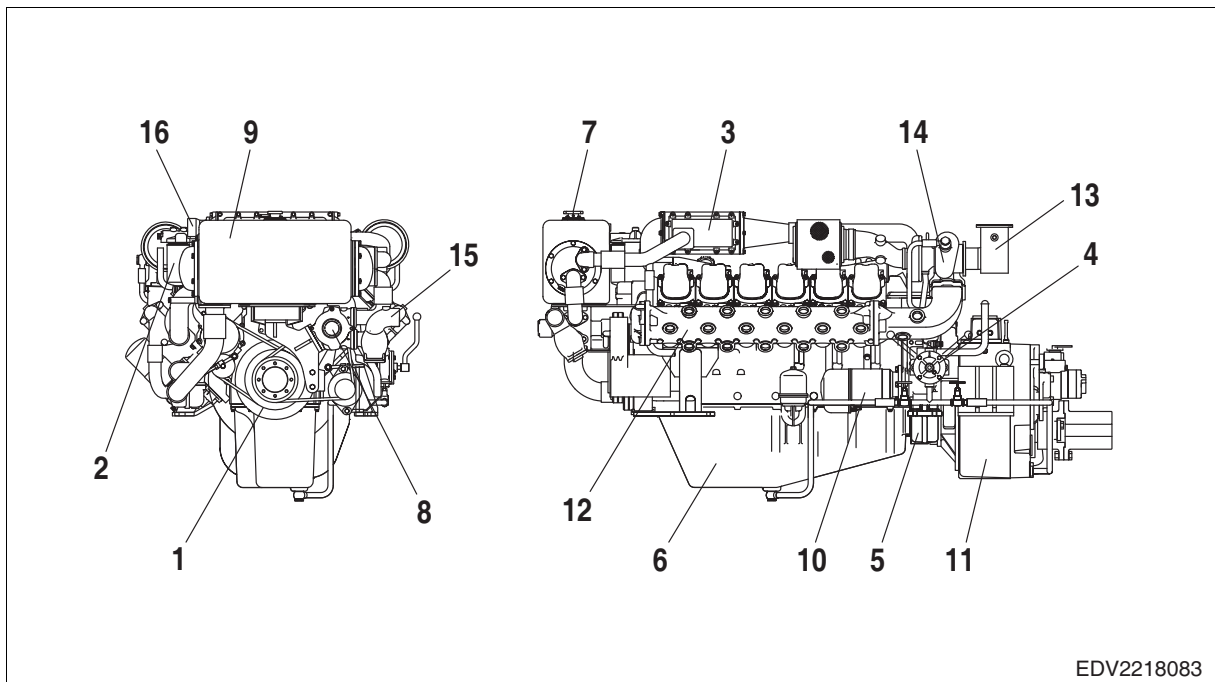
- | | | |
|------------------------|-------------|---------------|
| 1. Cylinder head | 4. Tappet | 7. Oil pump |
| 2. Cylinder head cover | 5. Camshaft | 8. Crankshaft |
| 3. Push rod | 6. Flywheel | 9. Thermostat |

1.2.2. Engine sectional view (Cross → V222TI)



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

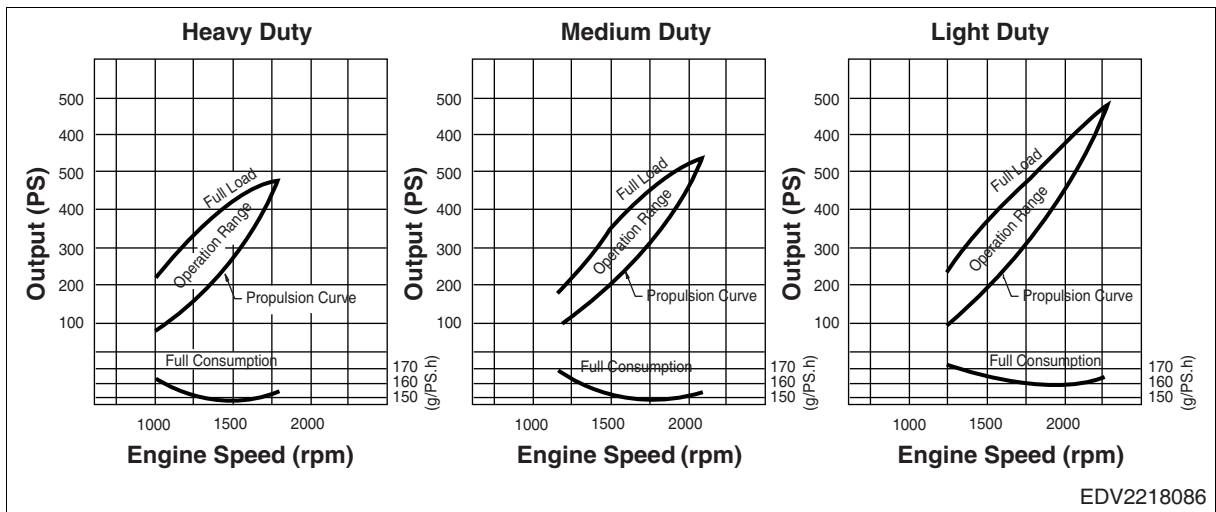
1.2.3. Engine assembly (V222TI)



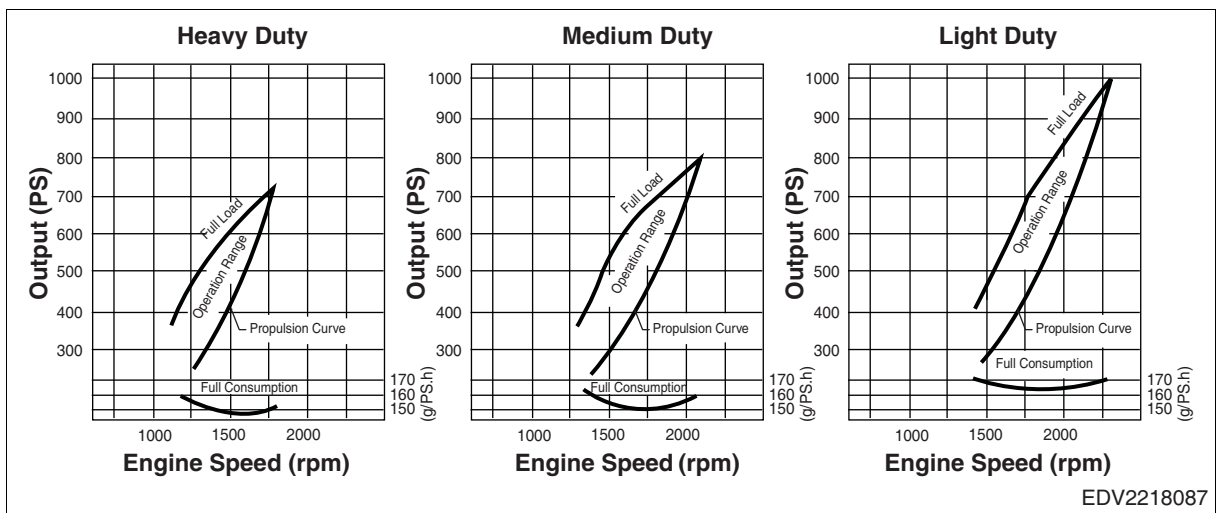
- | | | |
|---------------------|---------------------------|---------------------------|
| 1. Crank pulley | 7. Fresh water filler cap | 13. Exhaust manifold |
| 2. Fuel filter | 8. Sea water pump | 14. Turbocharger (wet) |
| 3. Intercooler | 9. Heat exchange ass'y | 15. Sea water inlet pipe |
| 4.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

1.3. Engine Performance Curve

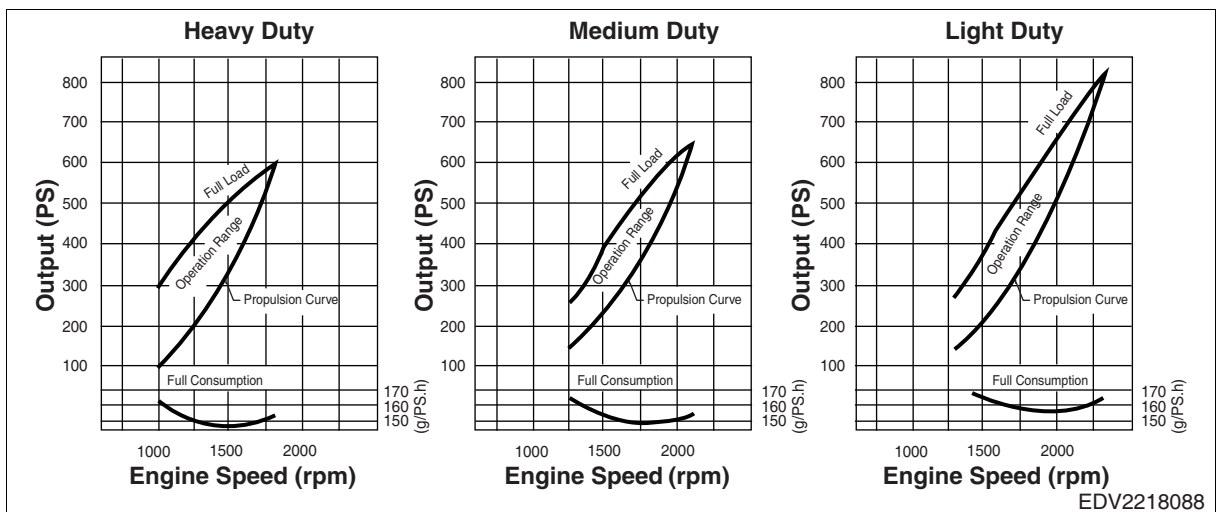
1.3.1. V158TI



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.

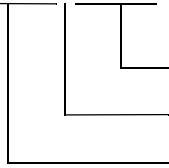


Note :

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

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

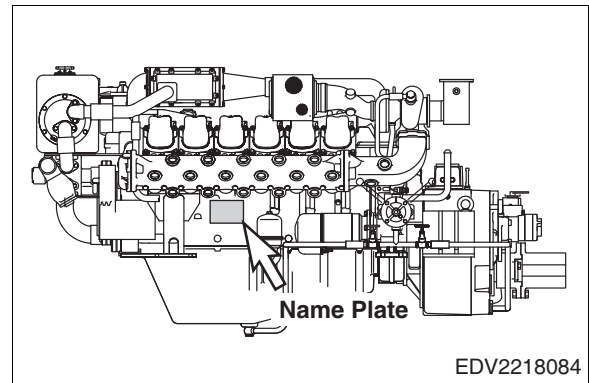
EBYKM200001



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 DOOSAN 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 DOOSAN 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 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 DOOSAN.
- (2) If faults occur, find the cause immediately and have it eliminated in order to prevent more serious damage.
- (3) Use only genuine DOOSAN spare parts. DOOSAN 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 DOOSAN 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 is switched off.

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.

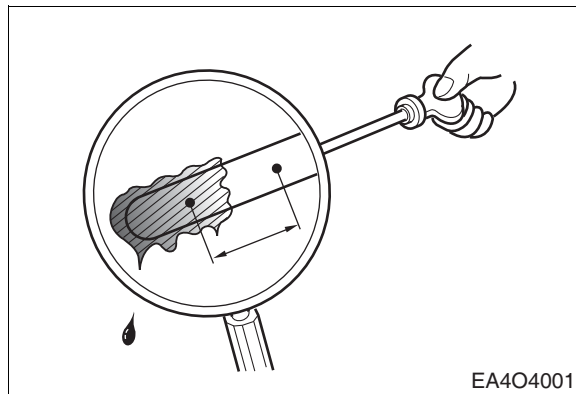
For information on collection points please contact the seller, the supplier or the local authorities.

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.

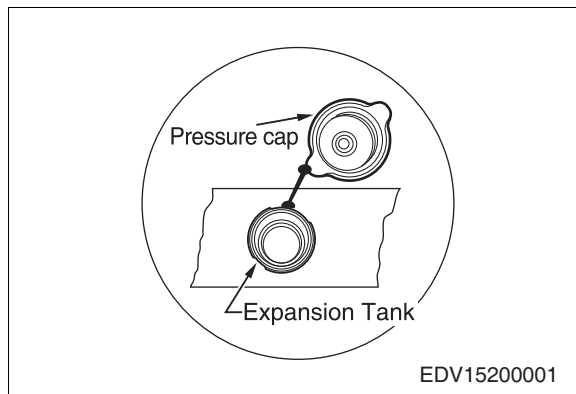


Caution :

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/cm²)



Note :

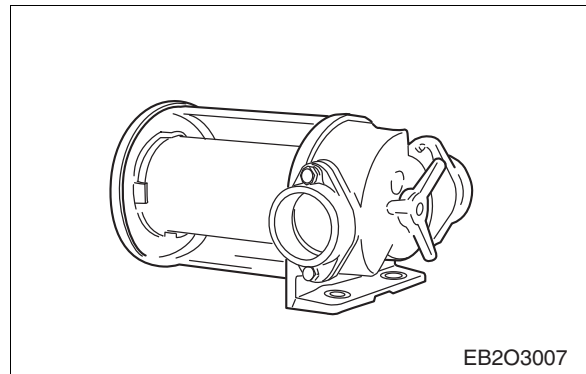
Because it is dangerous to open the pressure cap quickly when coolant is hot, after covering the cap with a cloth and then lower the inside pressure of the tank by opening slowly at first, open it up.

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. Gauge panel

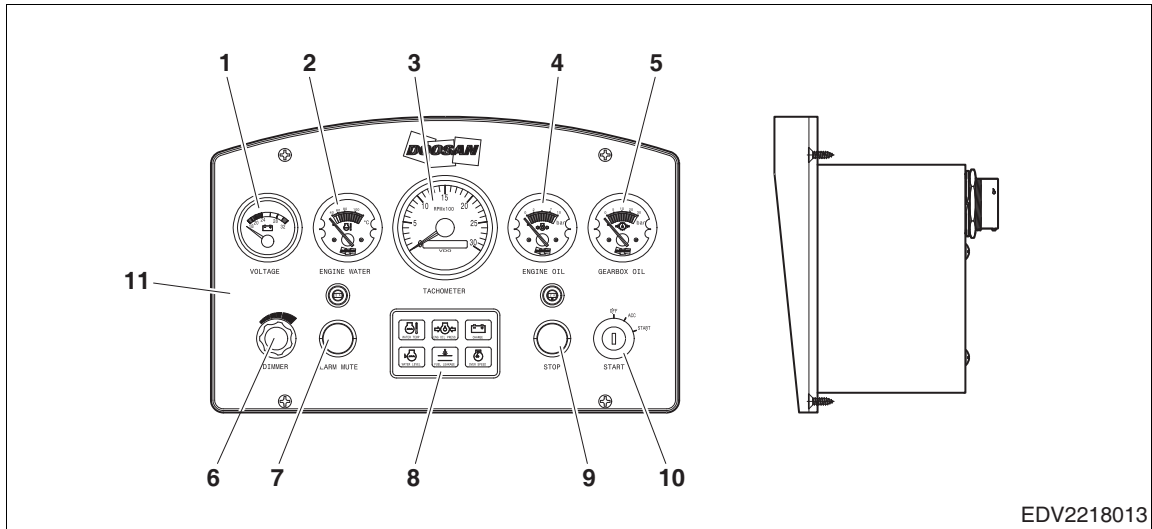
Check the all gauges of the panel whether the function is in normal or not.



Before operation your engine familiarize yourself with the instruments supplied with your boat.

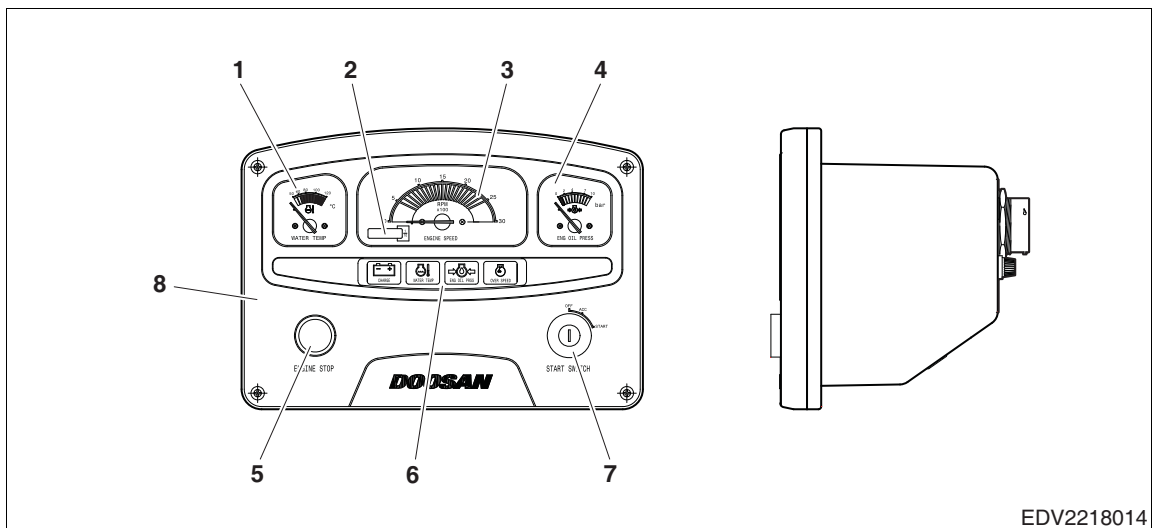
1) Analog gauge panel

- Deluxe panel



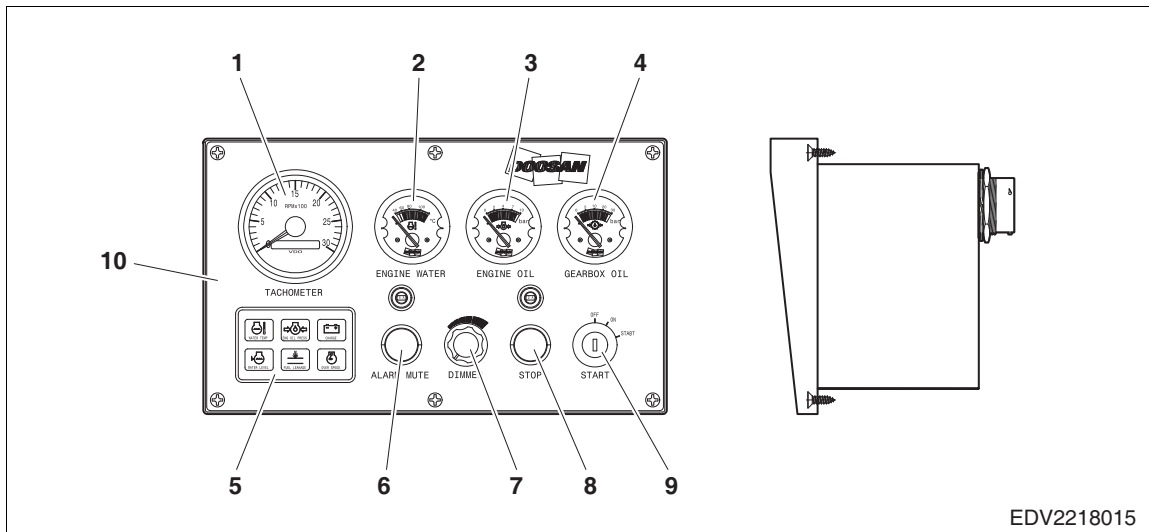
- | | | |
|-----------------------|----------------------------|----------------|
| 1. Volt meter | 5. Clutch oil press. gauge | 9. Stop button |
| 2. Water temp. gauge | 6. Rotary switch | 10. Key switch |
| 3. Tachometer | 7. Push button | 11. Panel |
| 4. Oil pressure gauge | 8. Monitor warning lamp | |

- Dutch panel



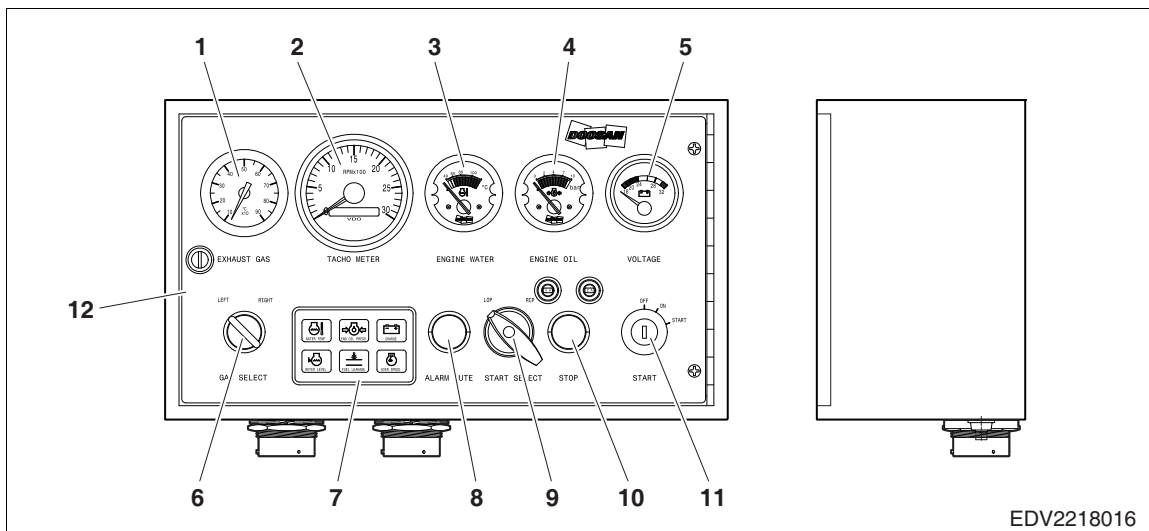
- | | | |
|----------------------|-------------------------|---------------|
| 1. Water temp. gauge | 4. Oil pressure gauge | 7. Key switch |
| 2. Hour meter | 5. Stop button | 8. Panel |
| 3. Engine speed | 6. Monitor warning lamp | |

- Single panel / Dual panel



- | | | |
|----------------------------|-------------------------|---------------|
| 1. Tachometer | 5. Monitor warning lamp | 9. Key switch |
| 2. Water temp. gauge | 6. Push button | 10. Panel |
| 3. Oil pressure gauge | 7. Rotary switch | |
| 4. Clutch oil press. gauge | 8. Stop button | |

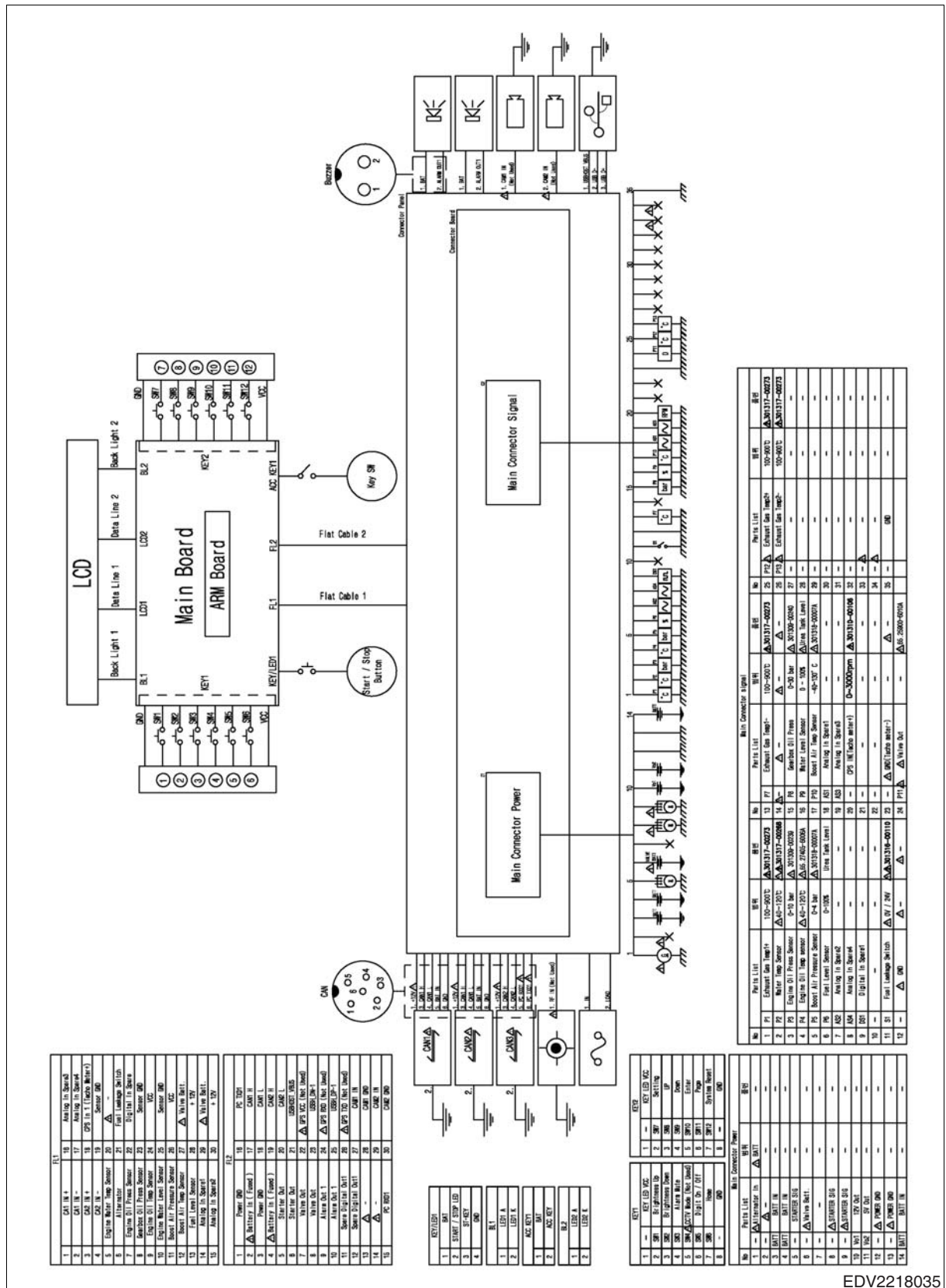
- Dual panel



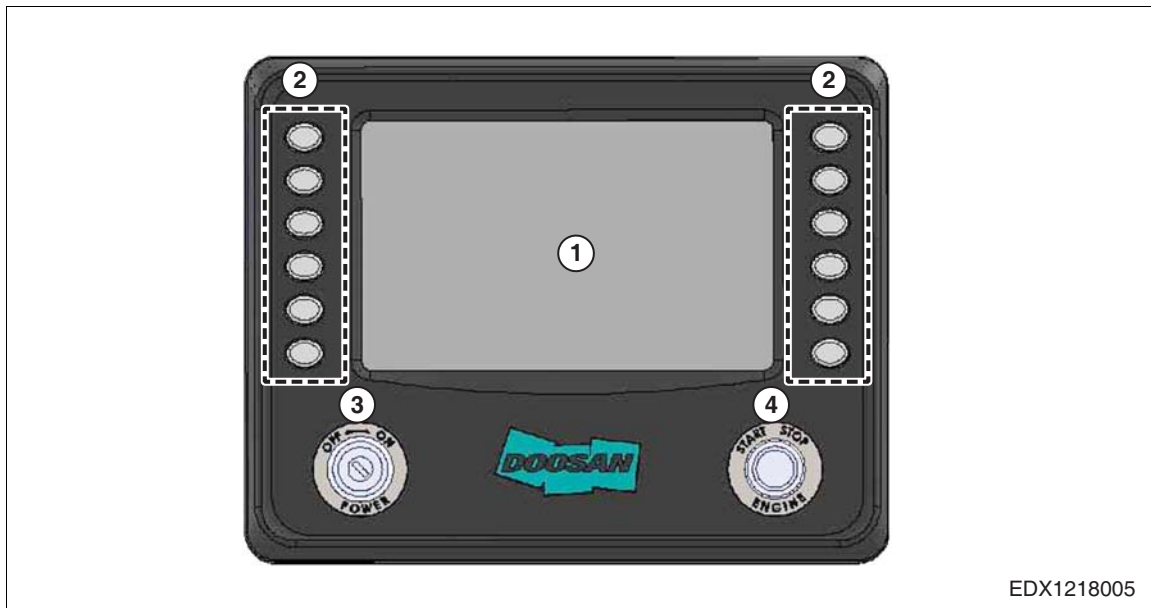
- | | | |
|-----------------------|-------------------------|------------------|
| 1. Pyrometer | 5. Volt meter | 9. Select switch |
| 2. Tachometer | 6. Select switch | 10. Stop button |
| 3. Water temp. gauge | 7. Monitor warning lamp | 11. Key switch |
| 4. Oil pressure gauge | 8. Push button | 12. Panel |

2) Digital gauge panel

- Circuit diagram

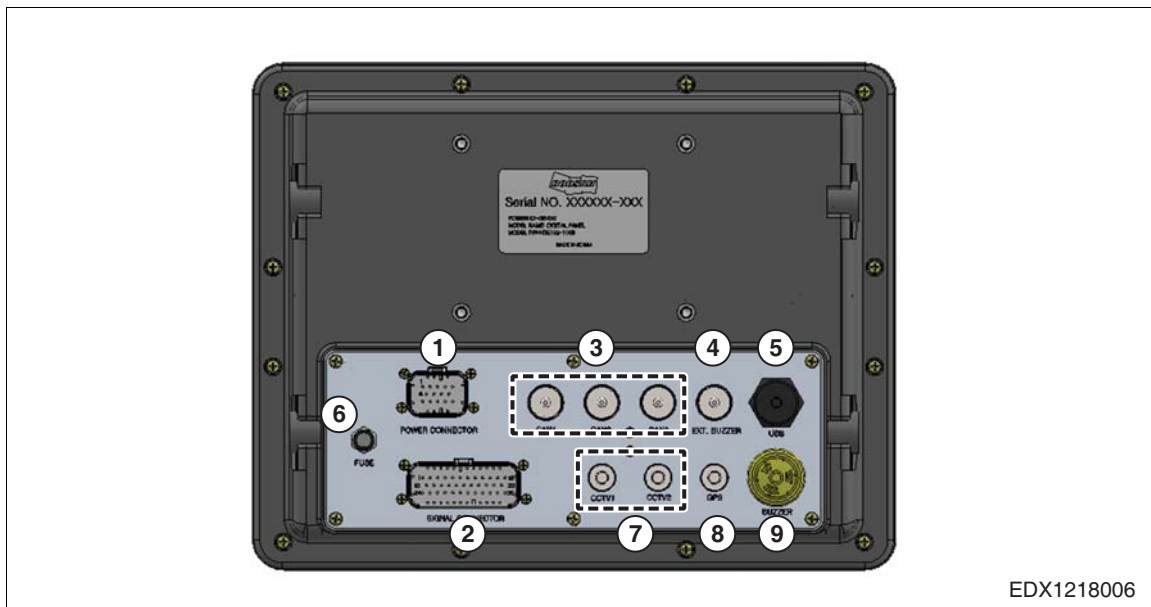


- Front



- | | |
|------------------|------------------------|
| 1. LCD | 3. Key switch |
| 2. Function Keys | 4. Start / stop button |

- Rear



- | | |
|---------------------|--------------------|
| 1. Power connector | 6. Fuse |
| 2. Signal connector | 7. CCTV (Optional) |
| 3. CAN | 8. GPS (TBD) |
| 4. Ext. buzzer | 9. Built-in buzzer |
| 5. USB | |

3.1.8. 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/cm².
- 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/cm², 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/cm², 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 DOOSAN 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 DOOSAN 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 void 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 DOOSAN 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						●	

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 DOOSAN 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.

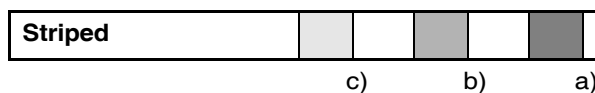
- (3) Wait for 45 seconds until color of the dipping stripe pad is turned into any colors and then compare and record the results compared with the color figure as following order.



Caution

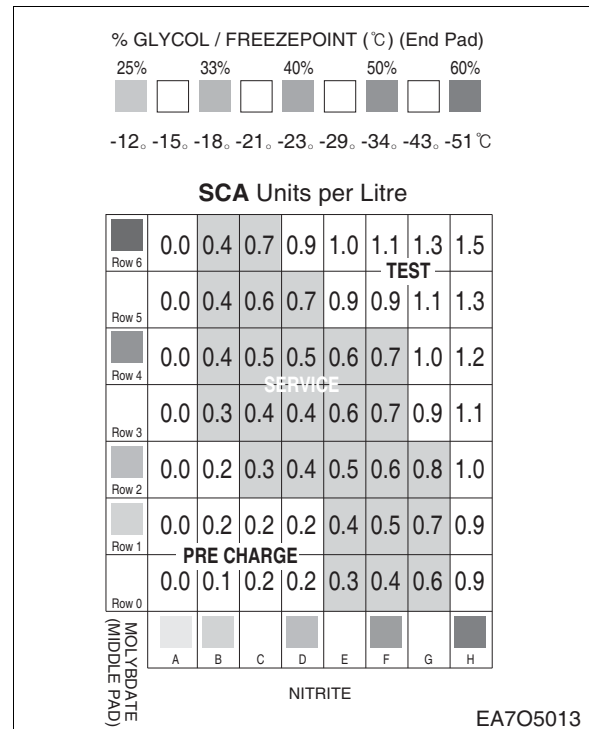
All three pad readings must be completed **no later than 75 seconds** after dipping strip.
Do not touch the stripe with fingers.

- **How to judge the strip**



- Compare FREEZEPOINT (end pad) to chart and record result.
- Next compare MOLYDATE (middle pad) to chart and record result.
- 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%).

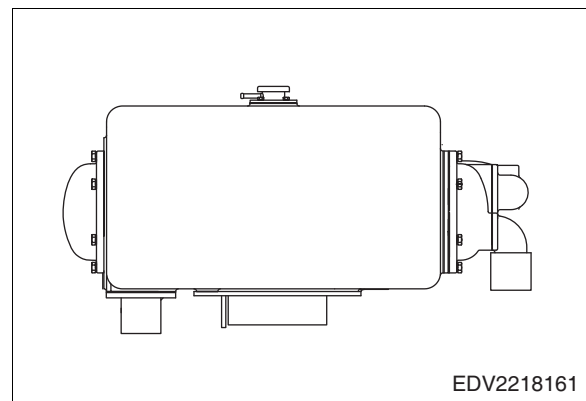
4.3.4. Heat exchanger and cooling line cleaning

(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.

- Remove the heat exchanger both left and right side covers.
- 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

4.3.5. Check and adjust of V-belt Tension

(1) V - belt condition

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

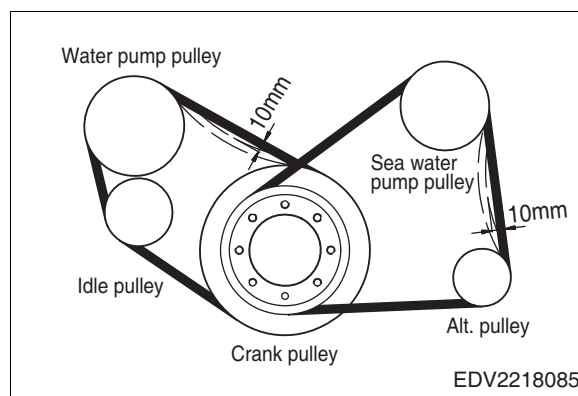
(2) V - belt Tension

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.



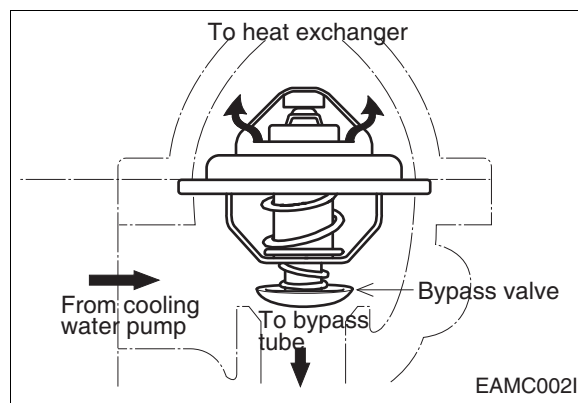
Note :

Always apply to DOOSAN 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.

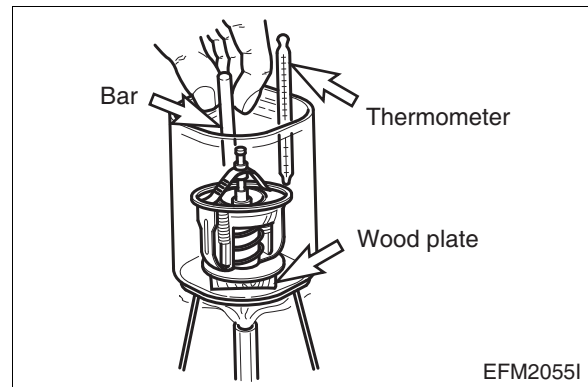
Namely, when the temperature of coolant is lower than 85°C, the thermostat valve is closed to make the coolant bypass to directly enter the water pump. When the coolant temperature rises to open wide the thermostat valve, the bypass circuit is closed and the water passage to the heat exchanger is opened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

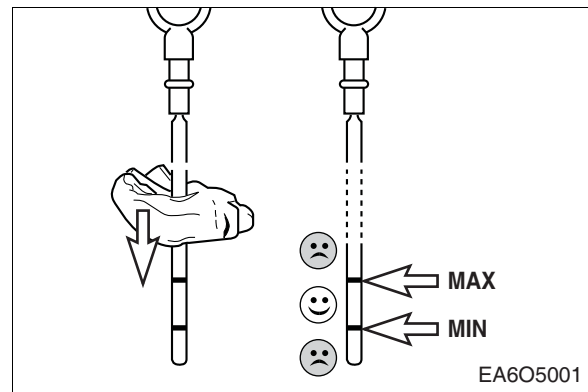
As the sea water pump is a bronze impeller type driven by V-belt, should install the sea water strainer between sea water pump and kingston valve to prevent malfunction of impeller due to clogging by any matters sucked.

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

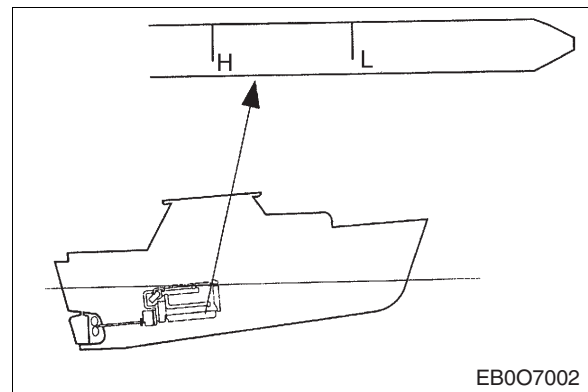
4.4.1. Oil level

- 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.

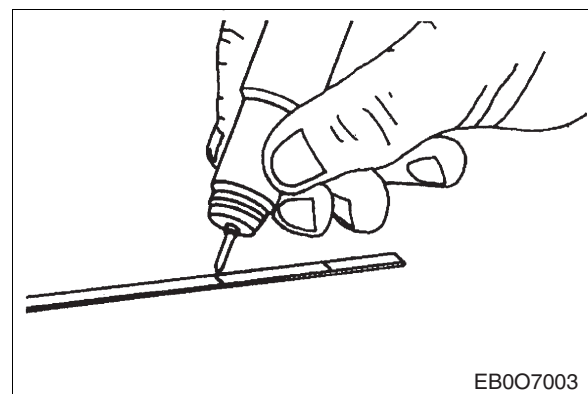


- **How to re-mark the oil dipstick**

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"

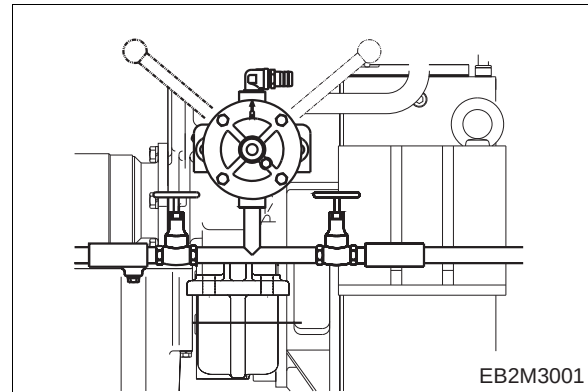


4.4.2. Exchanging of lubrication oil

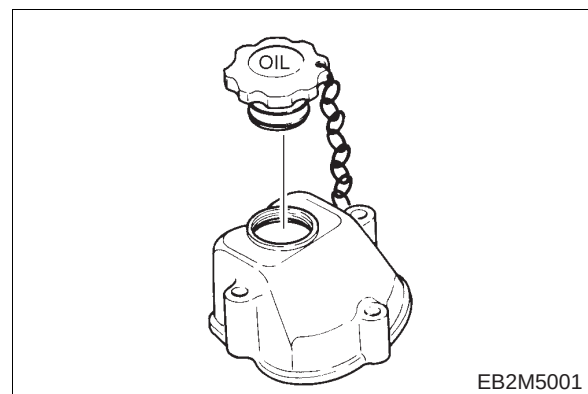
Engine oil and the oil filter is important factors affecting engine life. They affect ease of starting, fuel economy, combustion chamber deposits and engine wear. Change the engine oil at 50 hours of operation at first and next exchange will be performed every 250 hours. At the end of the break in period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

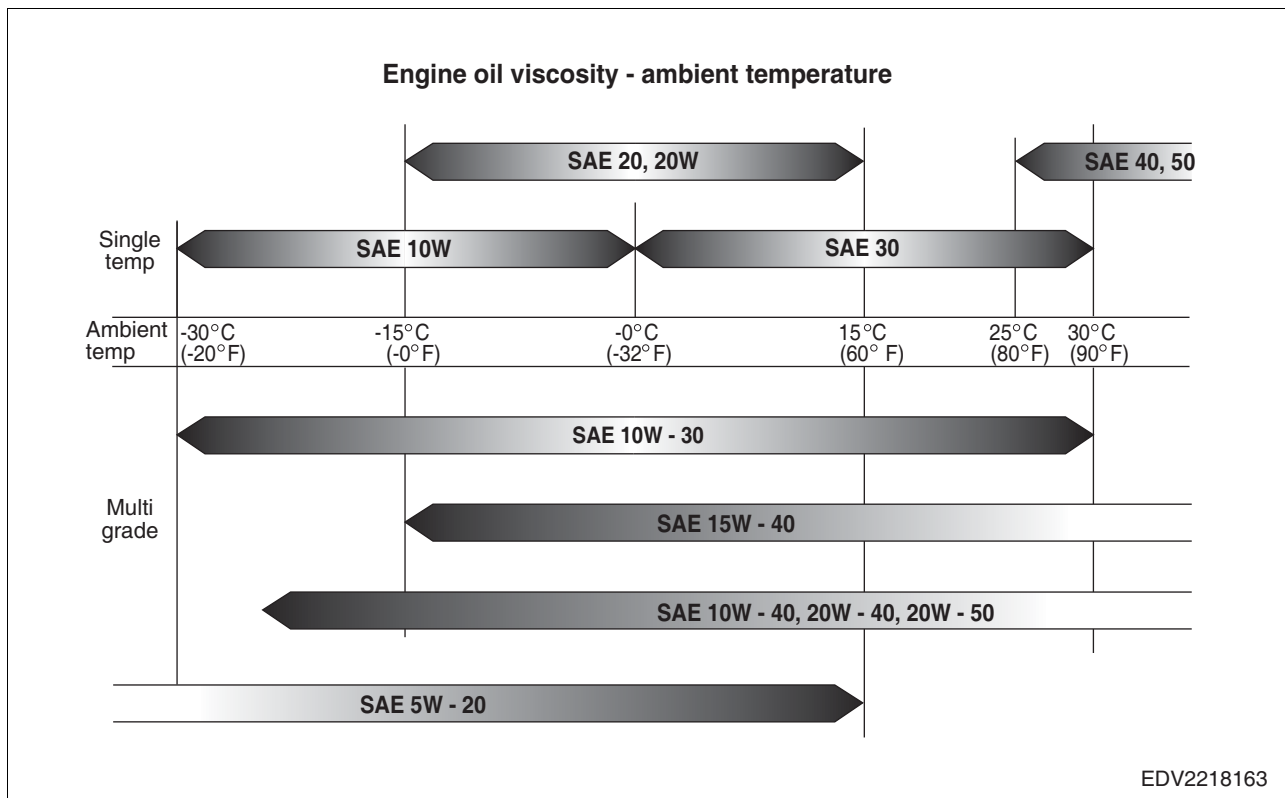


- Refill new engine oil to the filler neck on the head cover in accordance with the oil capacity of the engine.
- Be careful about the mixing of dust or contaminator during the supplement of oil. Then confirm whether the oil level gauge indicates the vicinity of its maximum level.
- For a few minutes, 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 :

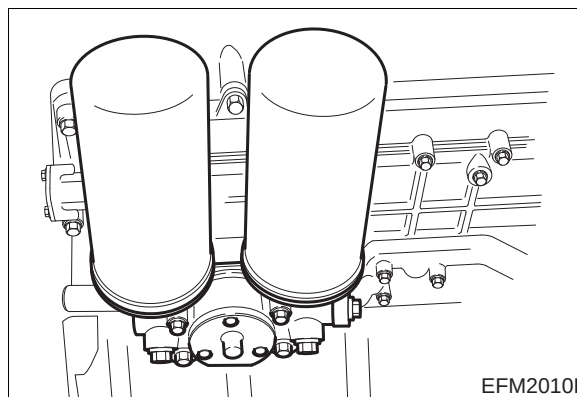
Don't forget tightening the drain plug after having drained engine oil.

- 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 :

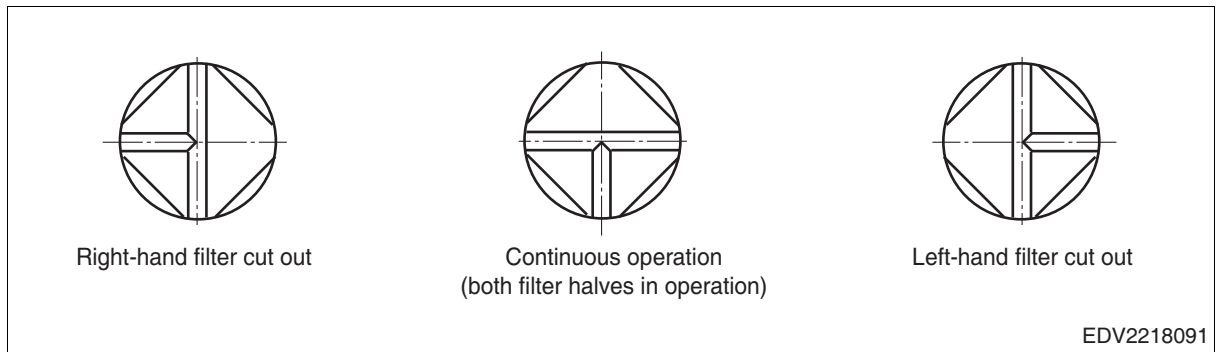
It is strongly advisable to use DOOSAN genuine oil filter cartridge for replacement.



- 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.

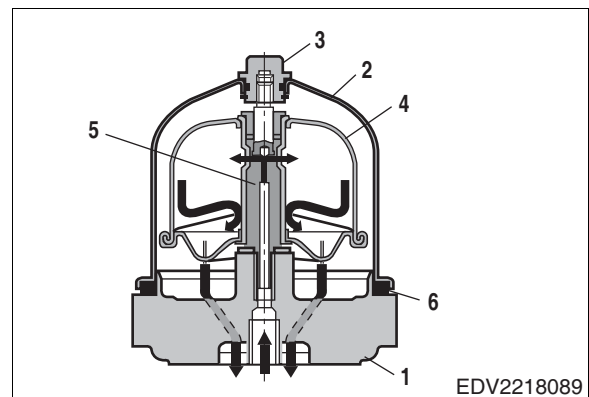


Caution :

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.



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



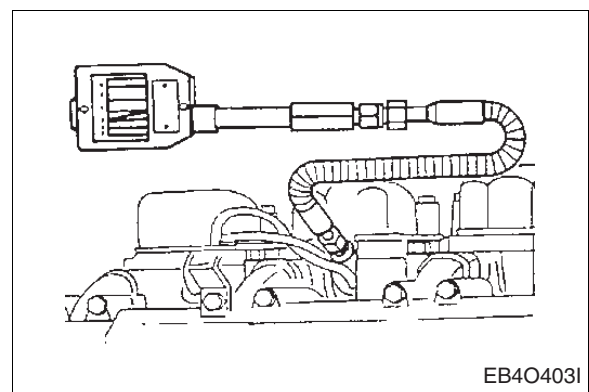
- Stop the engine after warming up, and take out nozzle holder assembly.



- Install the special tool (compression gauge adapter) at the nozzle holder hole, and connect the compression pressure gauge there.



Standard value	20 ~ 24 kg/cm ²
Limit value	20 kg/cm ² or less
Difference between each cylinder	Within $\pm 10\%$



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

4.5. Intake & Exhaust System

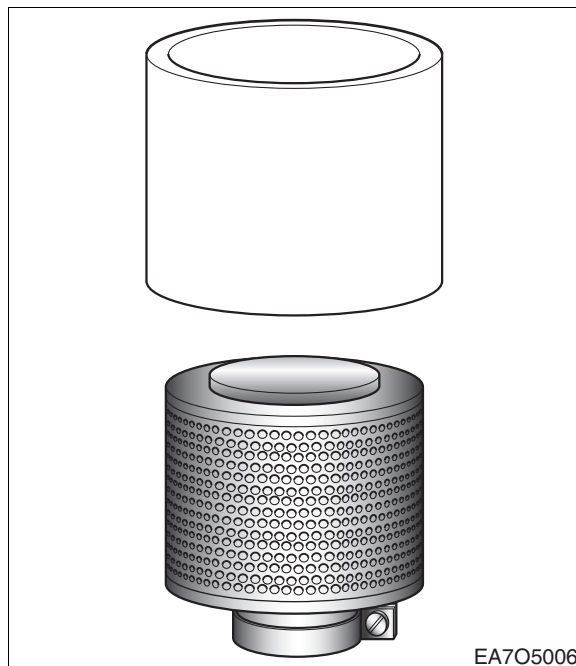
4.5.1. Cleaning & change of the air filter element

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 filter 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.

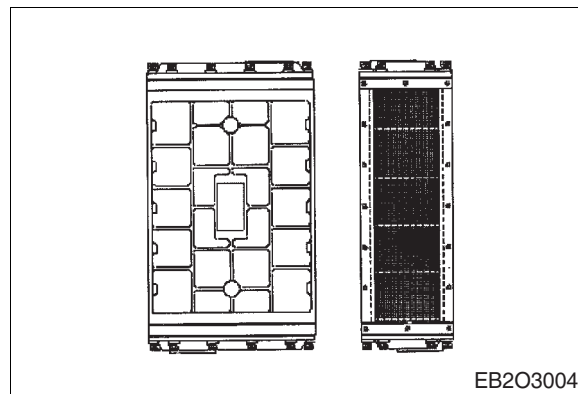
(2) Checking element



- 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.



< 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.

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.

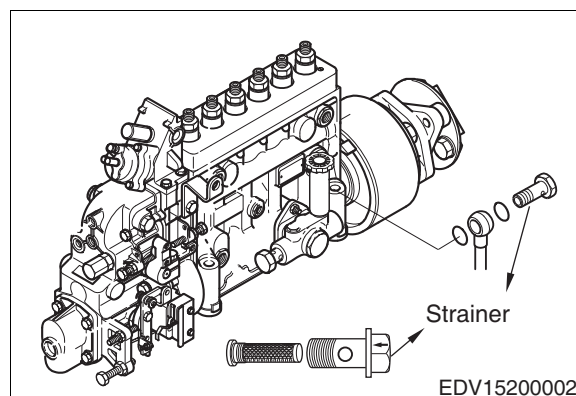
4.6. Fuel System

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. DOOSAN 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

General Fuel Classification	ASTM test	No. 1 ASTM 1-D	No. 2 ASTM 2-D	DIN 51601
Gravity, (API #)	D 287	40 ~ 44	33 ~ 37	0.815 ~ 0.855
Flash point Min. °F (°C)	D 93	100 (38)	125 (52)	131 (55)
Viscosity, kinematic CST 100 °F (40°C)	D 445	1.3 ~ 2.4	1.9 ~ 4.1	1.8 ~ 10
Cloud point °F #)	D 2,500	See note 1)	See note 1)	See note 1)
Sulfur content wt%, Max.	D 129	0.5	0.5	0.15
Carbon residue on 10%, wt%, Max.	D 524	0.15	0.35	0.1
Accelerated stability total insolubles mg/100 ml, Max. #)	D 2,274	1.5	1.5	
Ash, wt%, Max.	D 482	0.01	0.01	
Cetane number, Min. +)	D 613	45	45	> 45
Distillation Temperature, °F (°C) IMP, Typical #) 10% Typical #) 50% Typical #) 90% +) End point #)	D 86	350(177) 385(196) 45(218) 500(260) Max. 550(288) Max.	375(191) 430(221) 510(256) 625(329) Max. 675(357) Max.	680(360)
Water & Sediment %, Max.	D 1796	0.05	0.05	0.05

#) Not specified in ASTM D 975

+) Differs from ASTM D 975

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

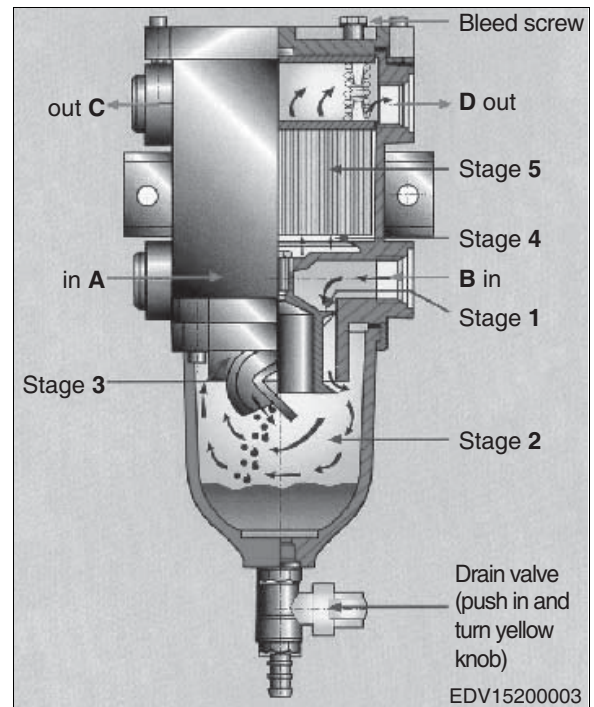
4.6.3. Water separator

DOOSAN 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.

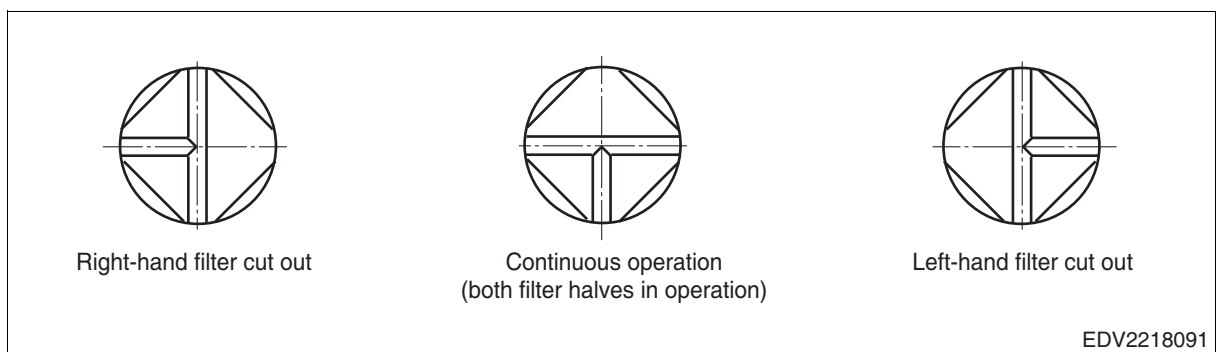
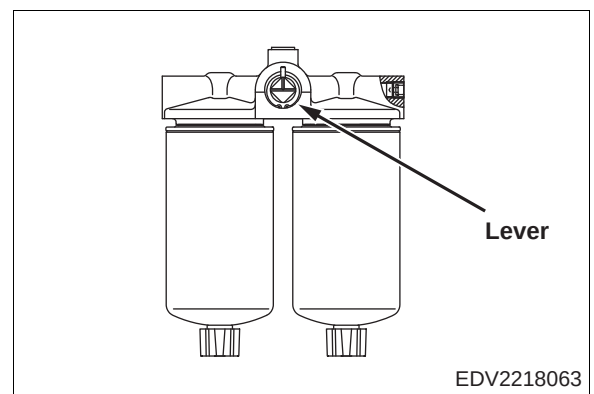
Water in the fuel will decrease the lubrication in the pump and possibly cause a failure of the pump. Injection nozzles are also lubricated by fuel and can also fail as a result of water in the fuel. Therefore, it is necessary to remove any water from the fuel before it reaches the fuel pump by using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

Fuel water separators that are available from DOOSAN 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.

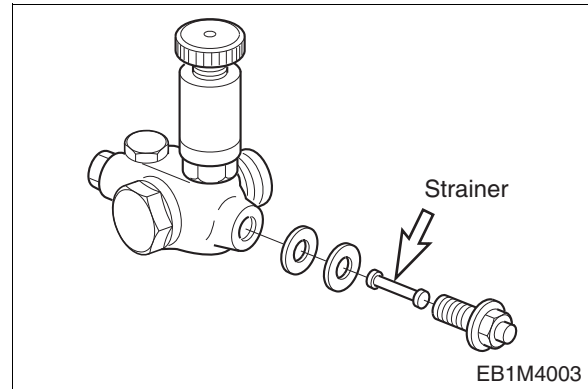


Bleeding of the fuel system

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 and 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 fresh 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 DOOSAN 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 DOOSAN 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

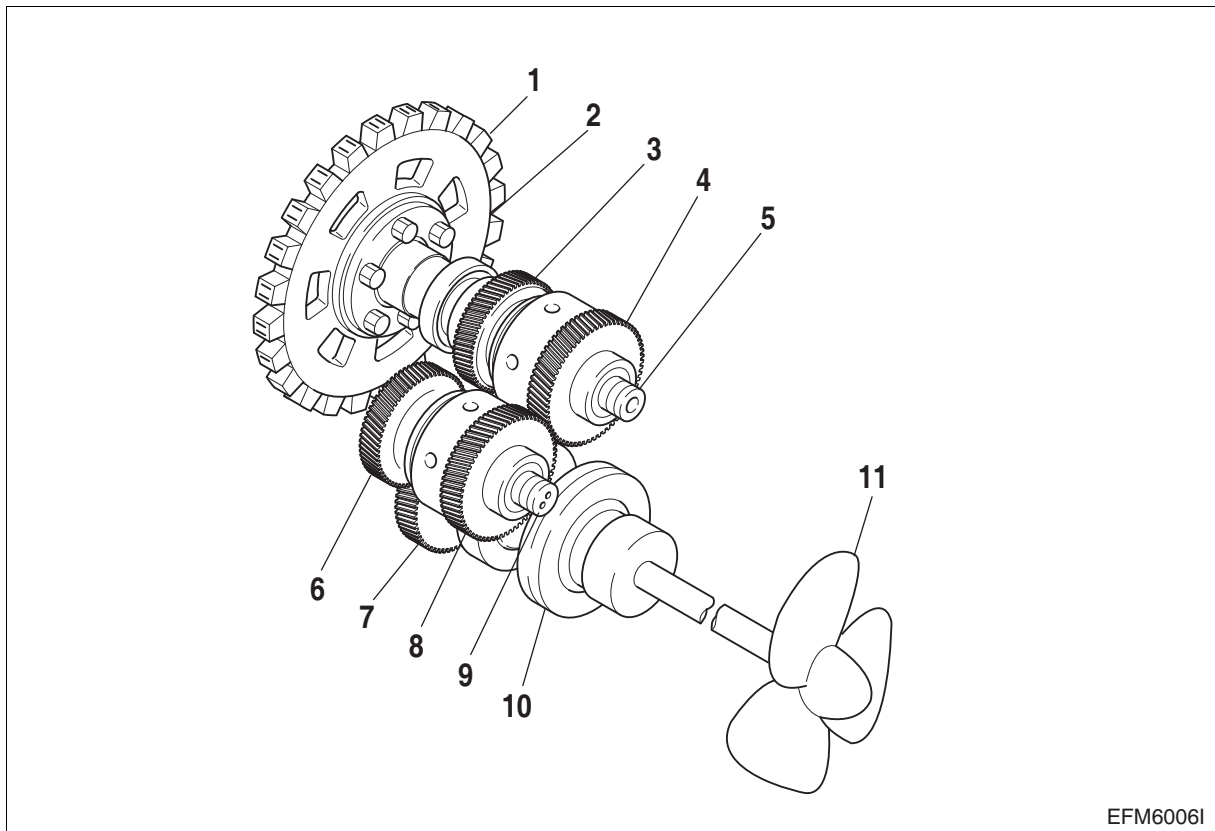
5.1. Reduction Gear

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 ;



EFM6006I

<Power line>

Neutral : 1-2-5-4-8

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

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

1. Rubber block

2. Spider

3. Forward pinion

4. Reverse drive gear

5. Input shaft

6. Reverse pinion

7. Output shaft

8. Reverse drive gear

9. Gear shaft

10. Propeller shaft

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

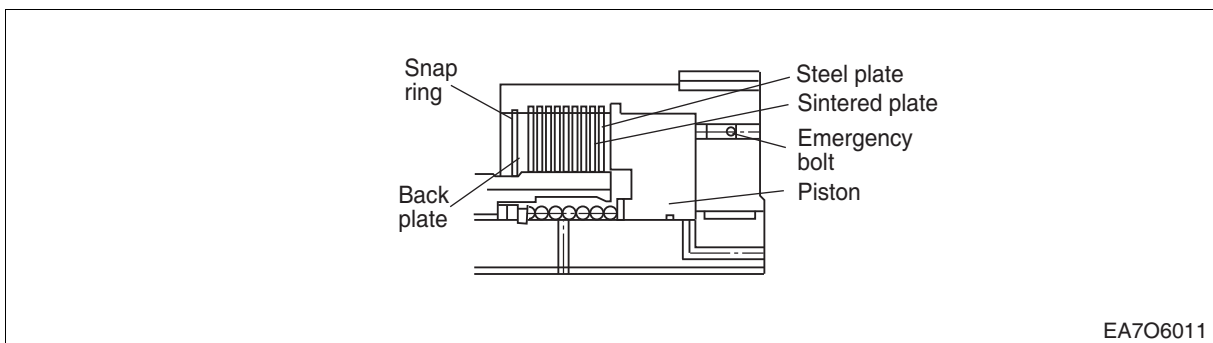
- Run the engine at idle for about 10 minutes.
- Check for oil leaks, unusual sound, temperature, etc. while idling the engine.
- While checking the clutch pressure, increase the engine rpm.

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.



5.2. Front Power Take Off

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

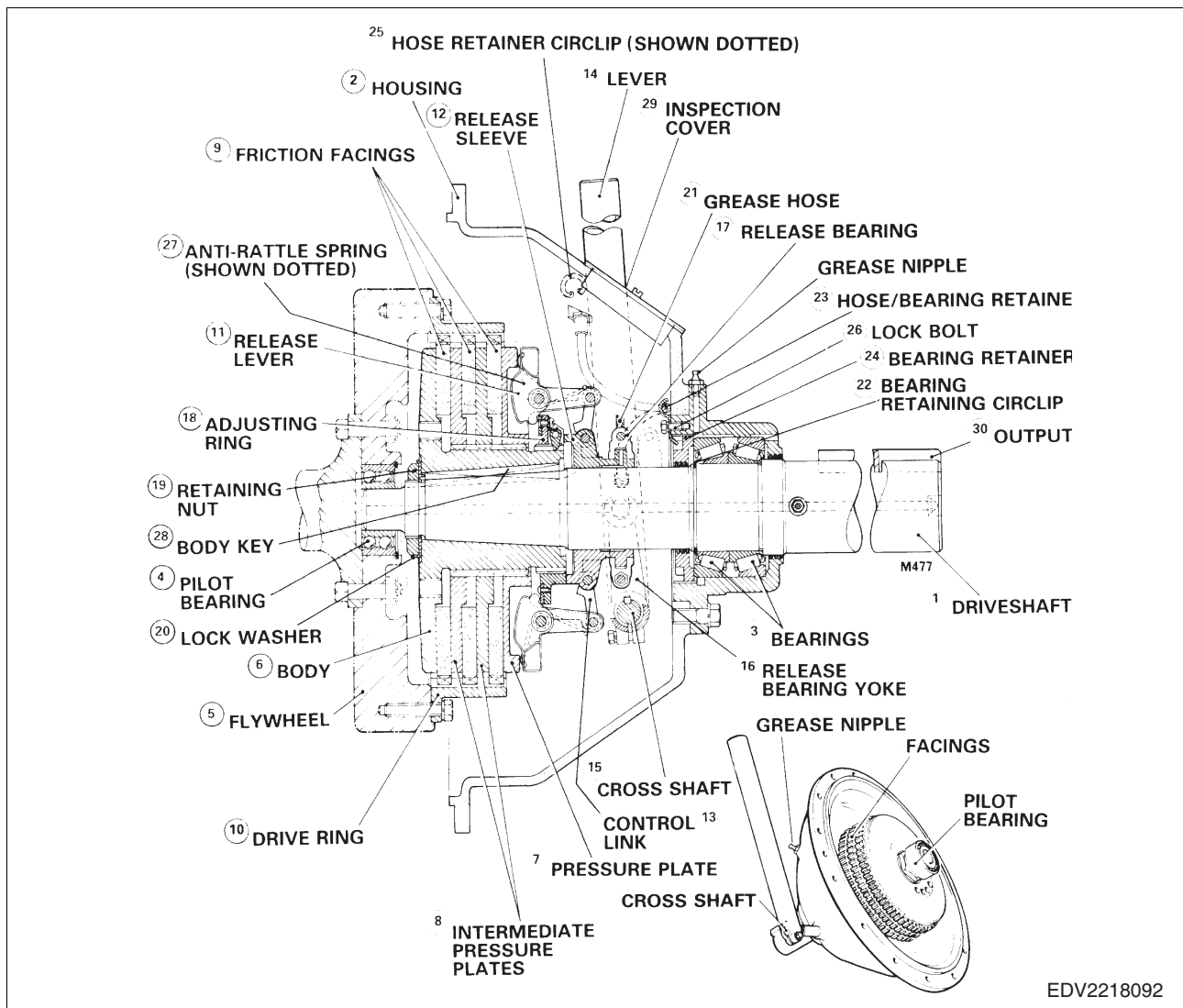
5.2.1. PTO Description and operation

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



DOOSAN 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 is not warrantable.



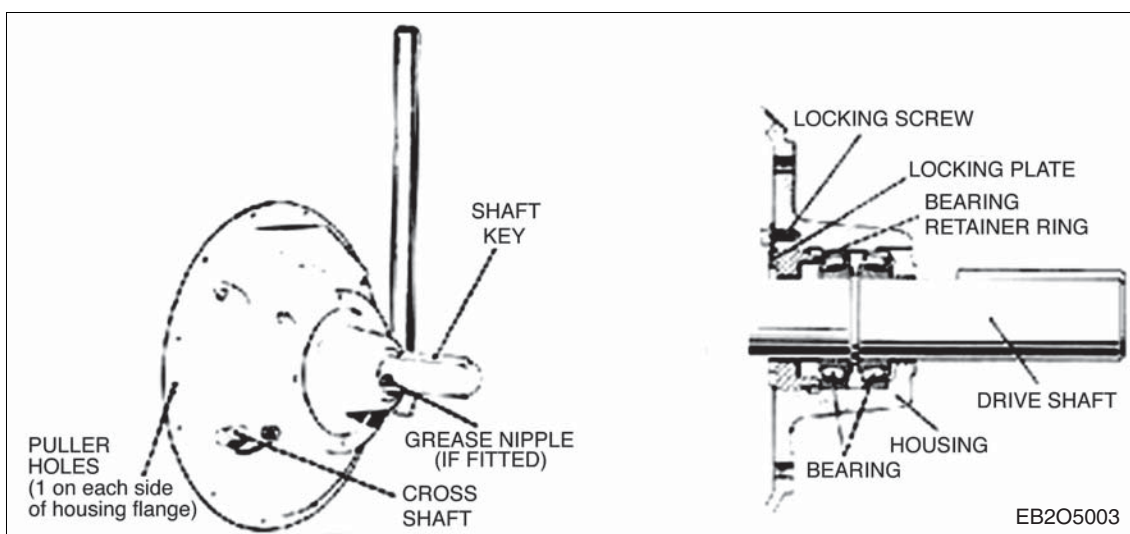
Do not adjust the PTO too tightly. Loads above the maximum quoted can cause PTO component failure.

(3) PTO adjustment

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

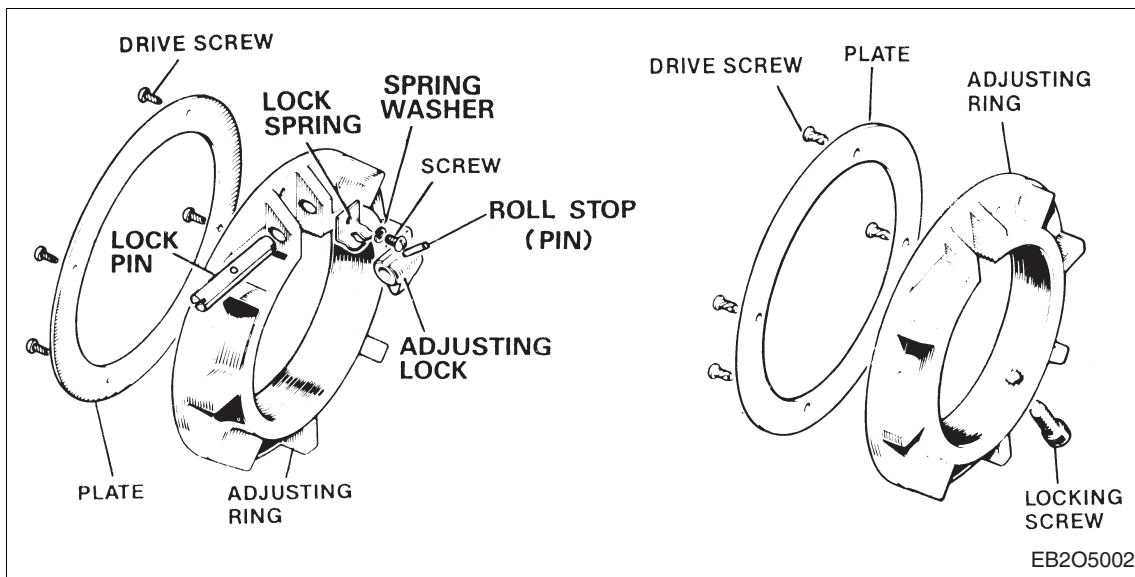
<Removing PTO from engine>

<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 appropriate over center load or cross shaft torque is obtained. (See table below 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

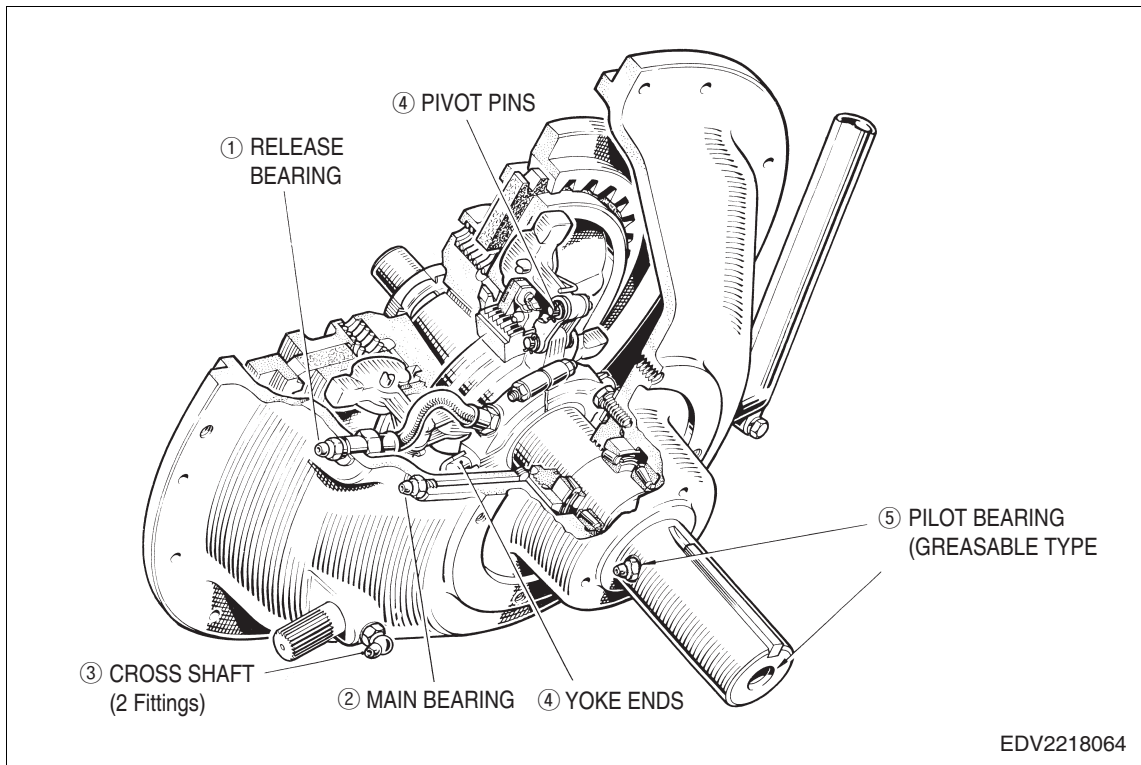
- If facings are worn, heat affected, or contaminated with lubricant they must be replaced. Severe discoloration of facings often indicates the PTO has been operating in a slipping condition, possibly due to faulty adjustment.
- In cases of severe lubricant contamination, the source of the lubrication 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 facings on over slip and over wear.
It may be resulted in any early failure.

(5) Lubrication point

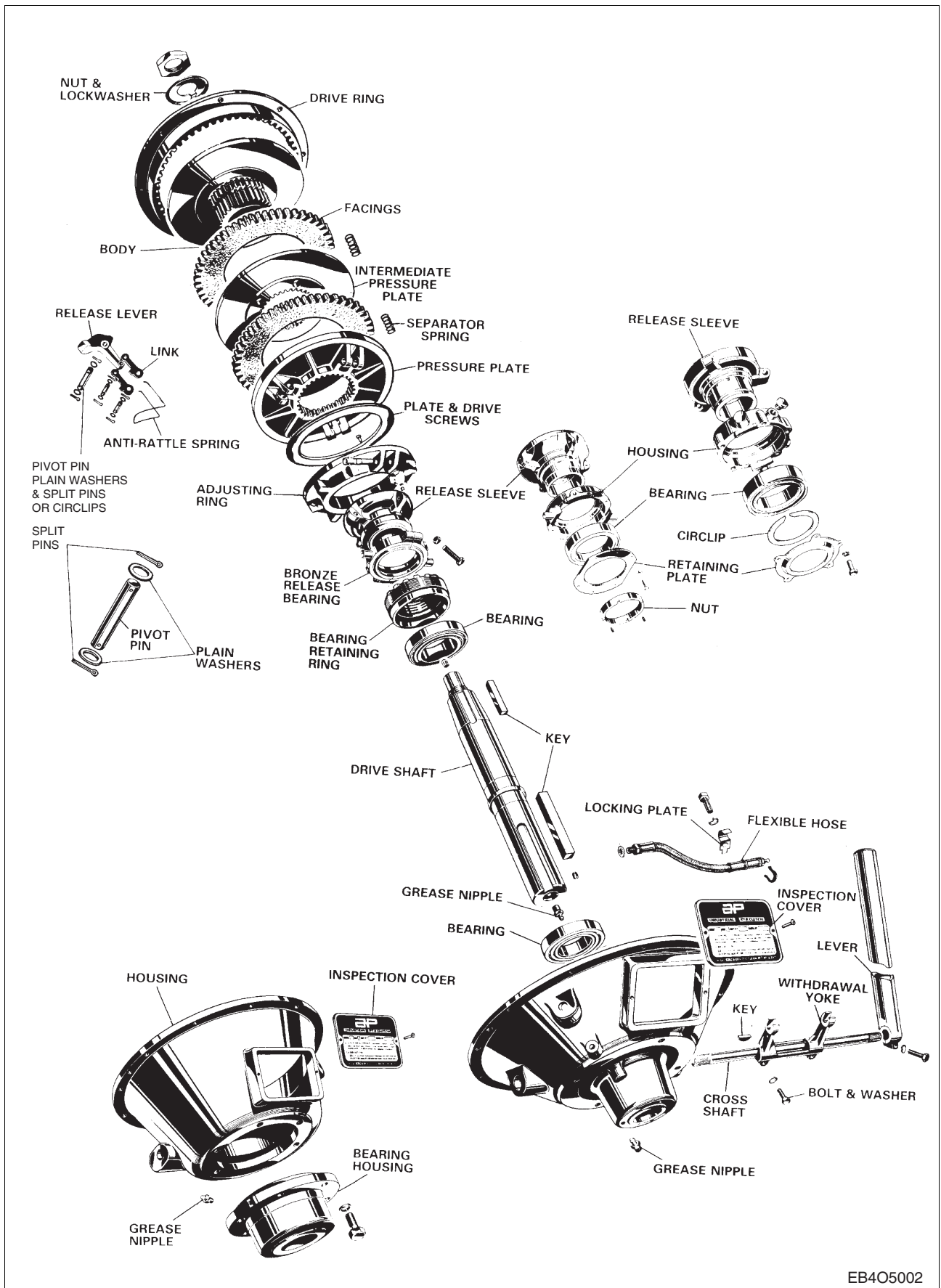
- The release bearing is lubricated through a grease nipple on the PTO housing which is connected to the bearing by a flexible hose. The drive shaft output bearings are lubricated through a grease nipple located on the PTO housing just above the bearings. Internal drillings in the housing carry the grease 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



EB4O5002

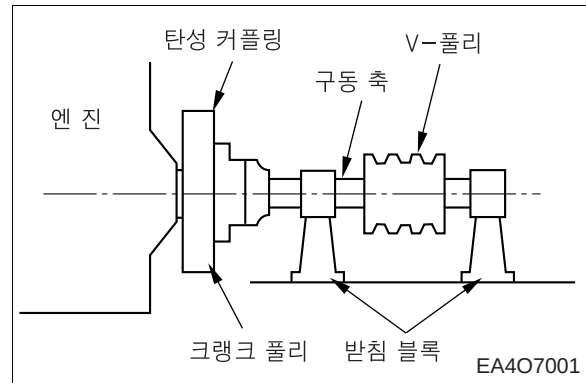
5.2.4. Front power take-off (F.P.T.O)

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.

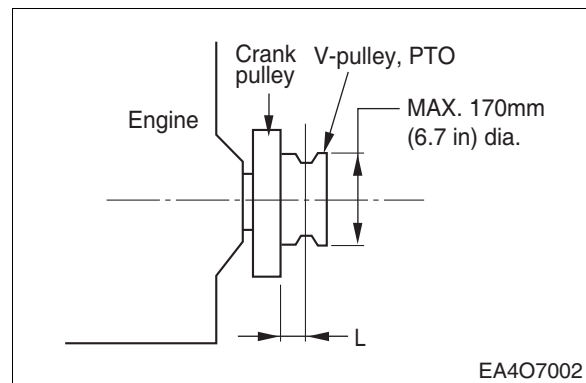
Be sure to limit the front PTO output within the maximum allowable horsepower as specified for each model in figure below. (Torque represents when there is no propeller load)



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

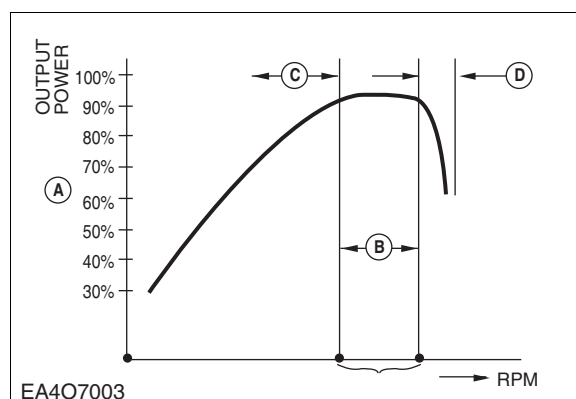
The right figure is applicable to the drive arrangement in which the distance between the end face of the engine pulley and the centerline through pulley groove is not greater than 60 mm. The distance is indicated as "L" in right figure.



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 Range (B). Refer to Specifications in Performance Curve.



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

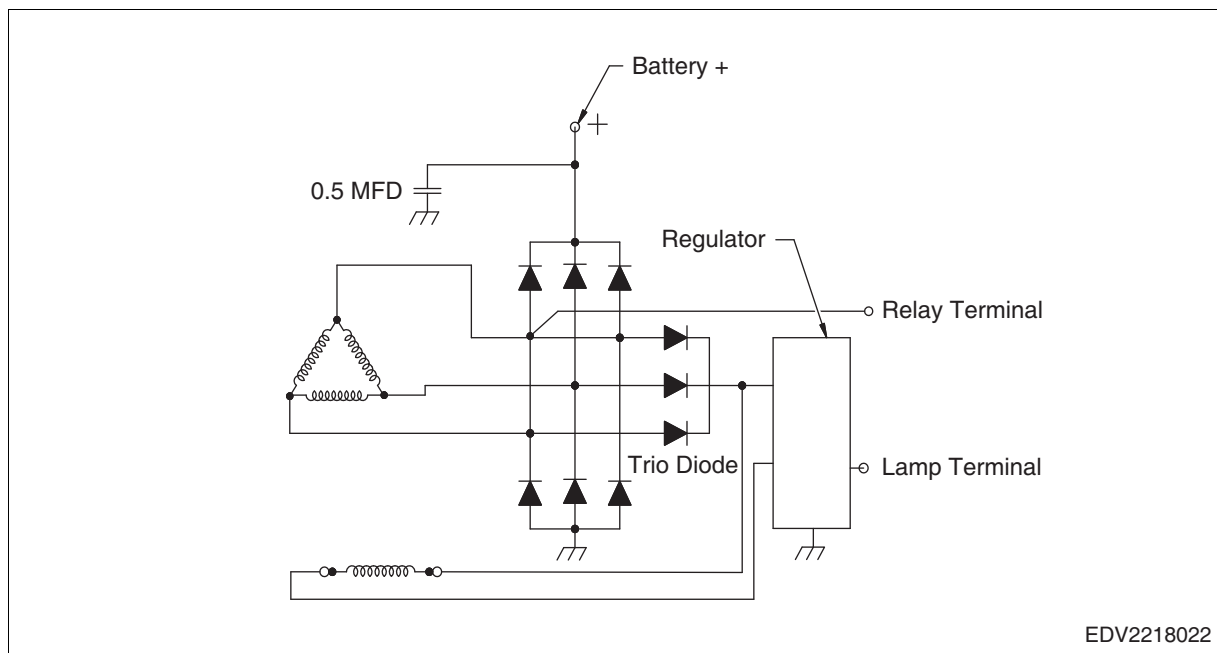
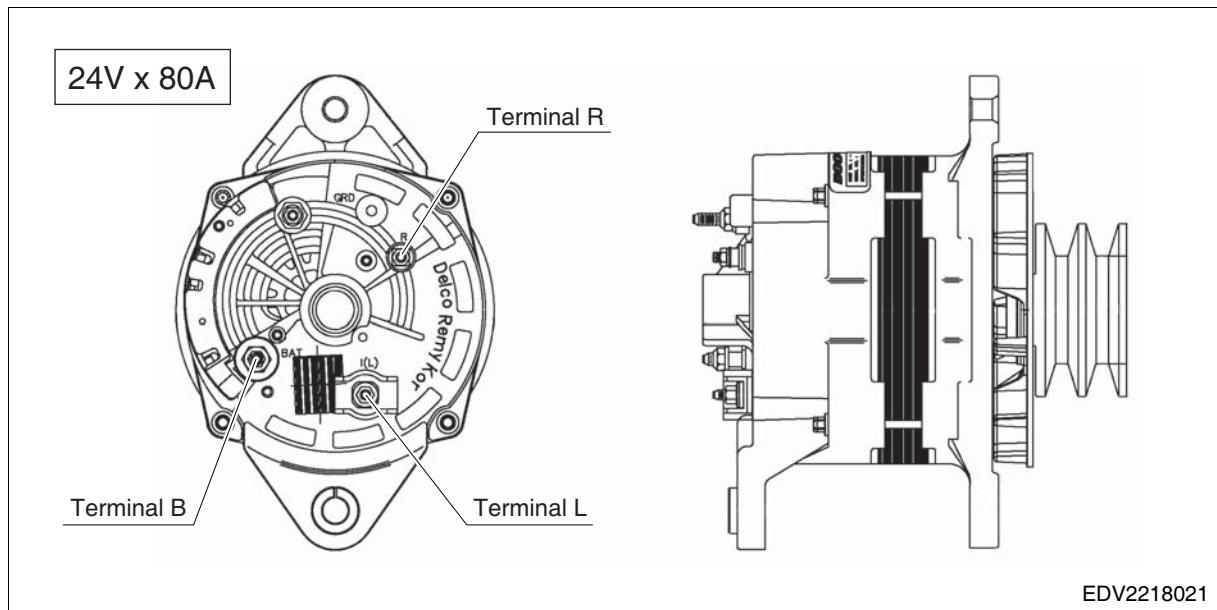


Note : Engine damage can result from incorrect propeller selection which :

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

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.

- DOOSAN 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

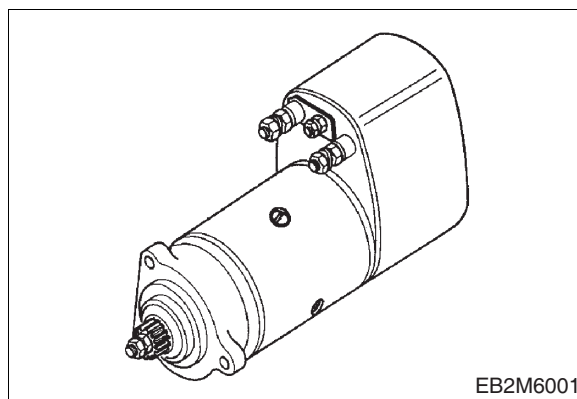
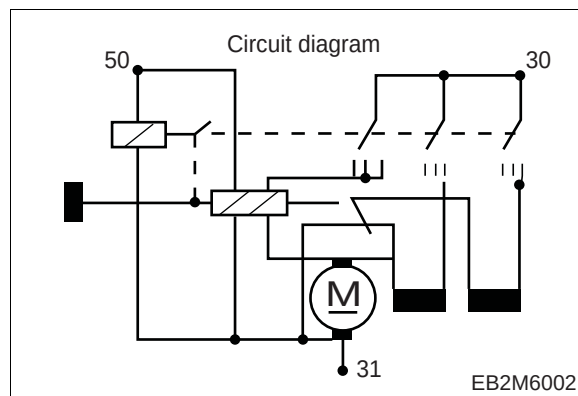
The starter motor is installed on the flywheel housing.

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

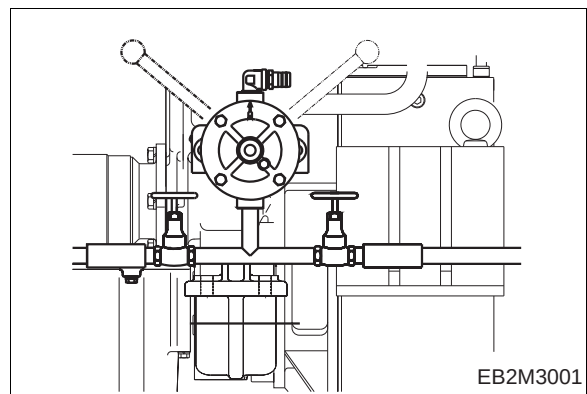
- Maintenance operation should be carried out in a bright and clean place.
- Before disassembly, provide racks for arrangement of various tools and disassembled parts.
- Arrange the disassembled parts in the disassembly sequence and use care to prevent any damage to them.

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.

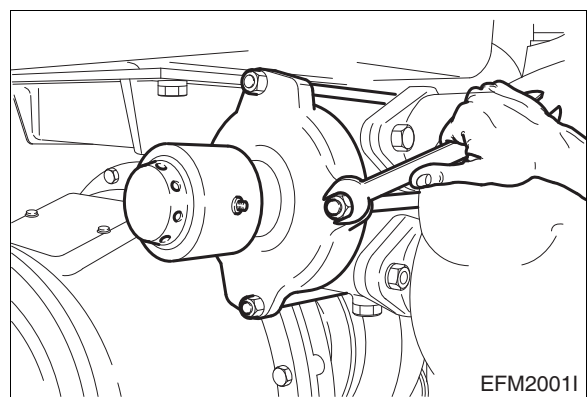
6.1.3. Engine oil

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



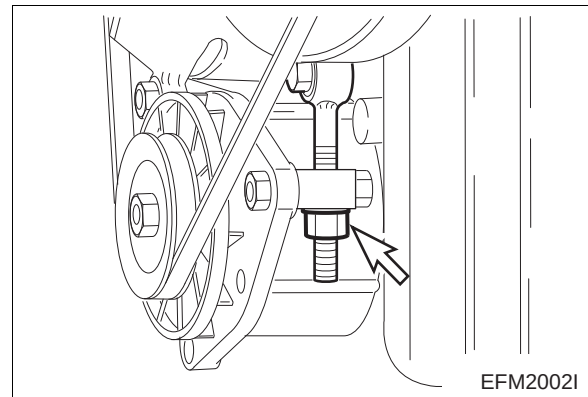
6.1.4. Sea water pump

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



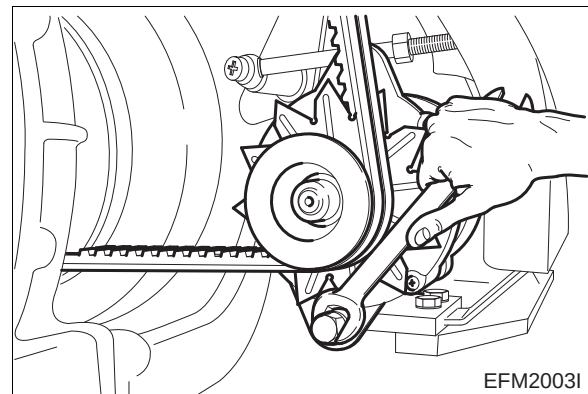
6.1.5. V-belt.

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



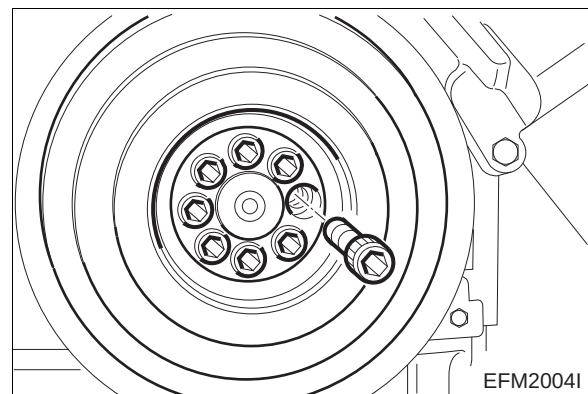
6.1.6. Alternator

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



6.1.7. Vibration damper

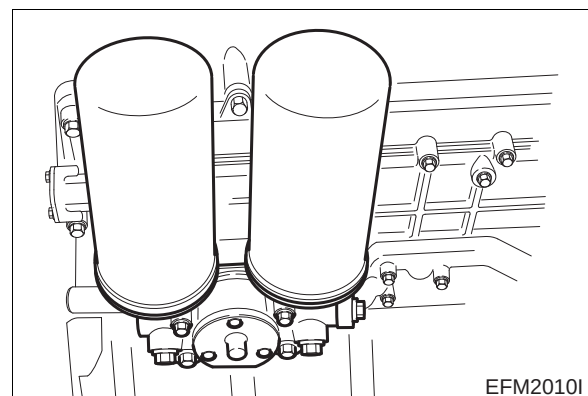
Remove the fixing bolts for crankshaft pulley in reverse order of assembly and disassemble the crankshaft pulley and vibration damper.



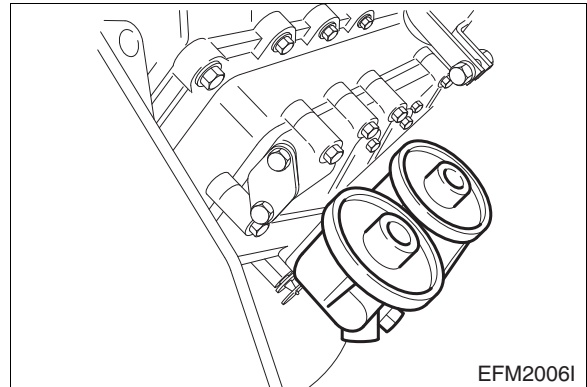
6.1.8. Oil filter assembly

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.

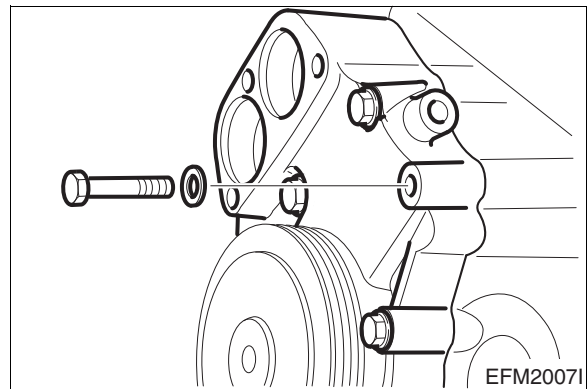


- Do not use again the cartridge removed after use.
- Remove the oil filter head fixing bolts and disassemble the filter head.



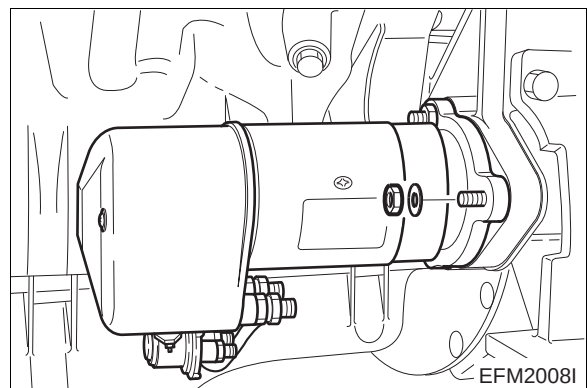
6.1.9. Cooling water pump

- 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.



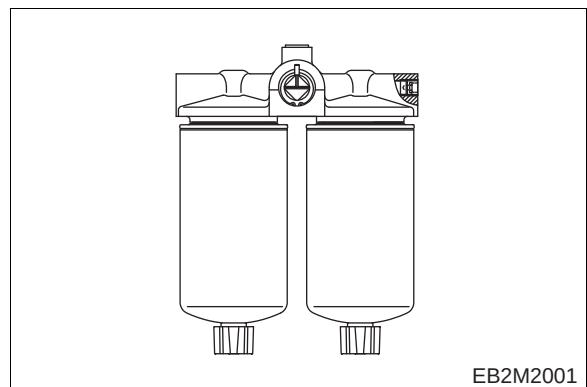
6.1.10. Starting motor

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



6.1.11. Fuel filter

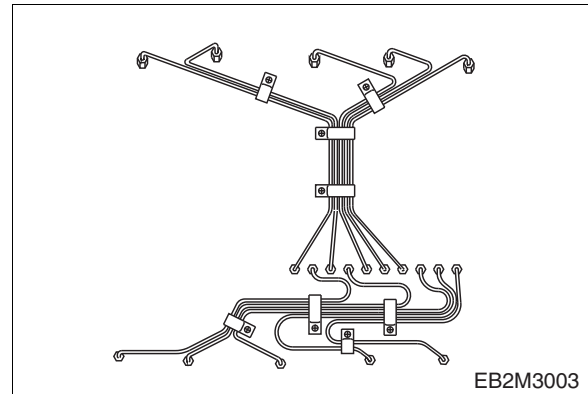
This filter is change-over type, that is the servicing procedure is for the filter side requiring to be shut off while the engine is running. During continuous operation, the selector lever should be placed in a position where both filter halves are in operation.



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

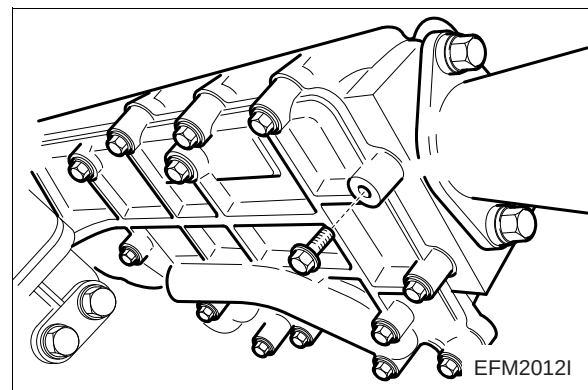
6.1.12. Injection pipe

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

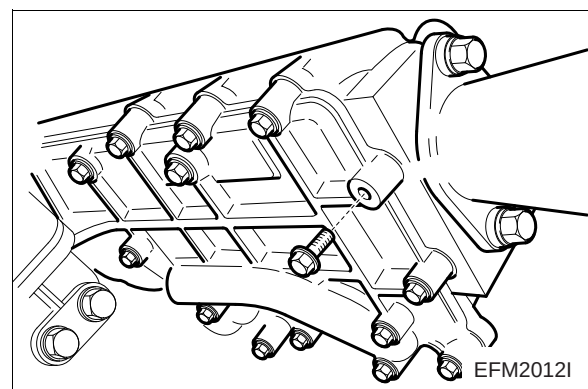


6.1.13. Oil cooler assembly

- 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.

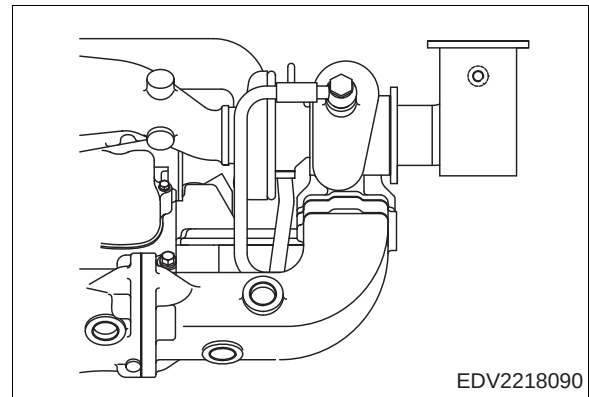


- Remove the oil cooler cover fixing bolts and disassemble the oil cooler.



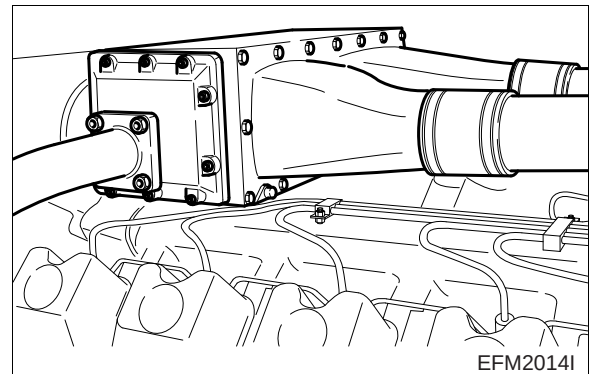
6.1.14. Turbocharger

- 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.



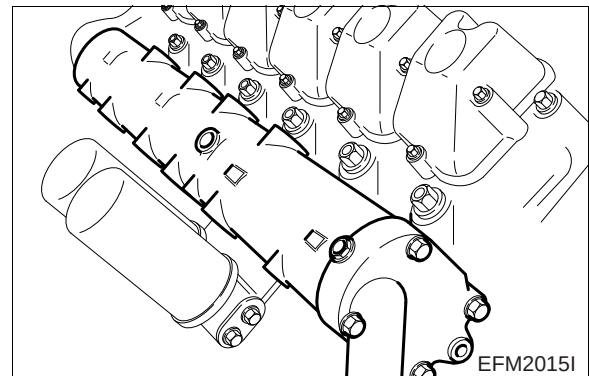
6.1.15. Inter-cooler

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



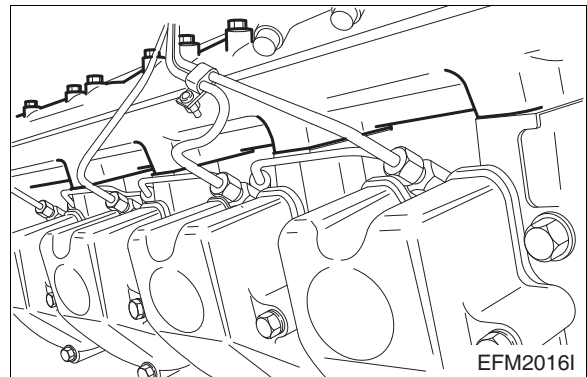
6.1.16. Exhaust manifold

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



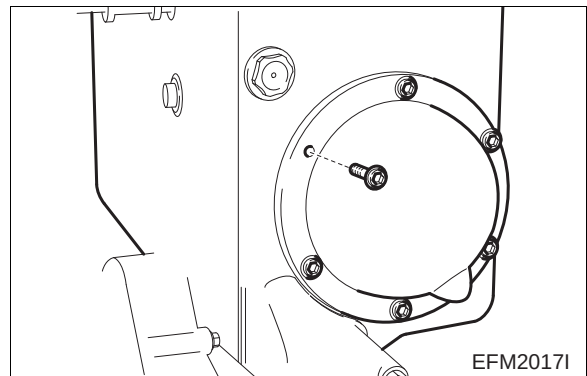
6.1.17. Intake manifold

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



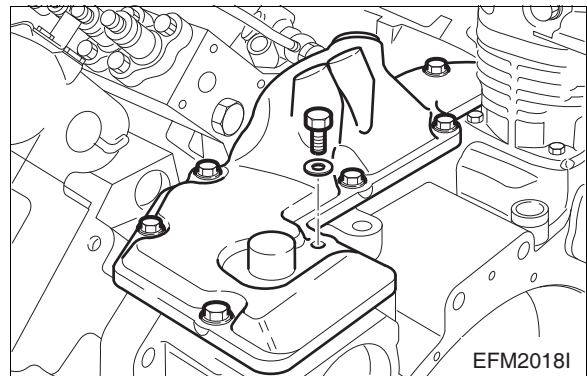
6.1.18 Heat exchanger

- 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.



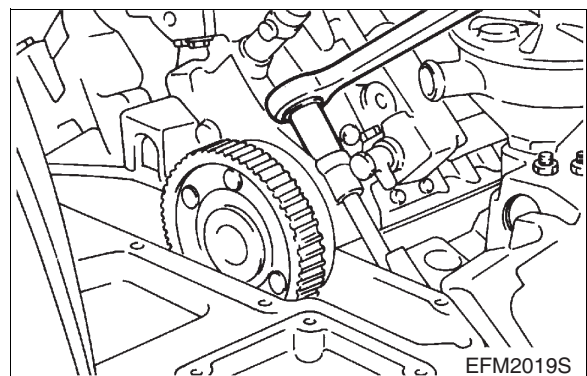
6.1.19. Flywheel housing cover

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



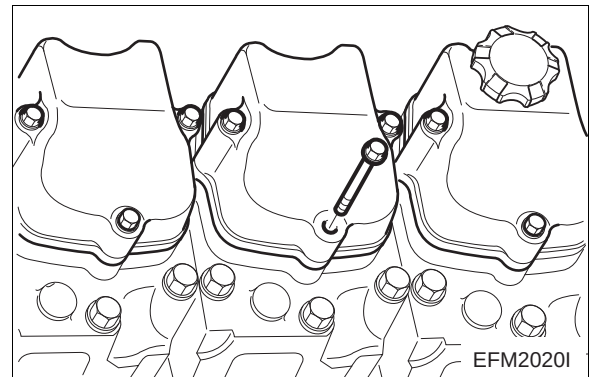
6.1.20. Fuel injection pump

- 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

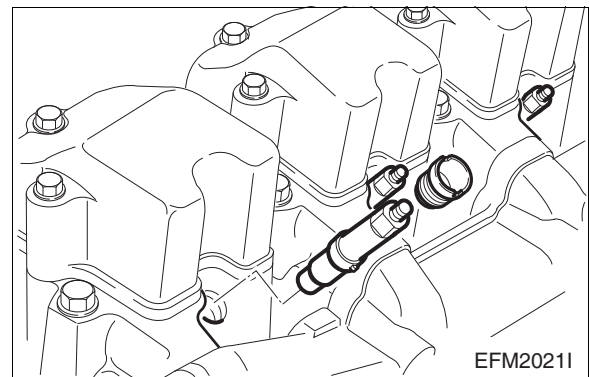
Remove the fixing bolts and tear the cylinder head cover down.



6.1.22. Nozzle holder

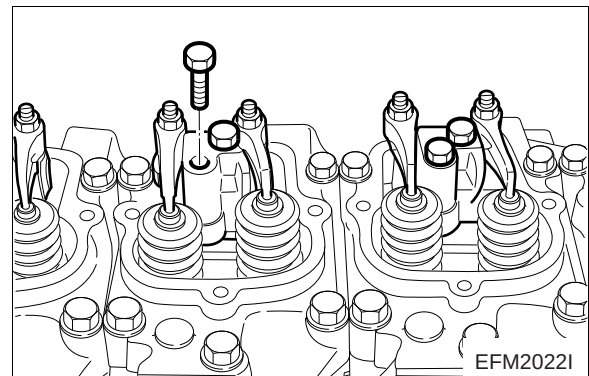


- By means of a special tool, loosen the nozzle holder assembly and take it out.



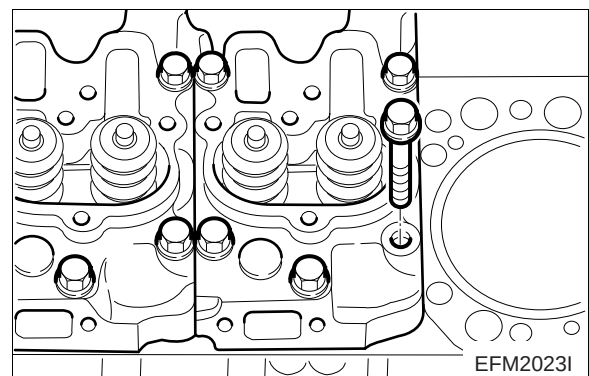
6.1.23. Rocker arm

- 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.



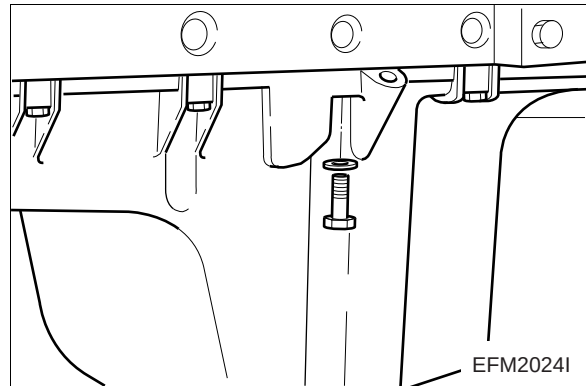


Note :

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

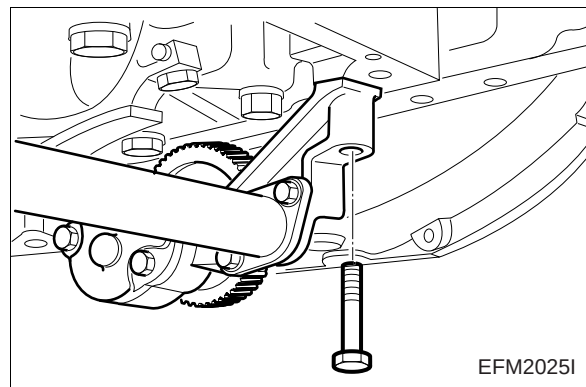
6.1.25. Oil pan

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



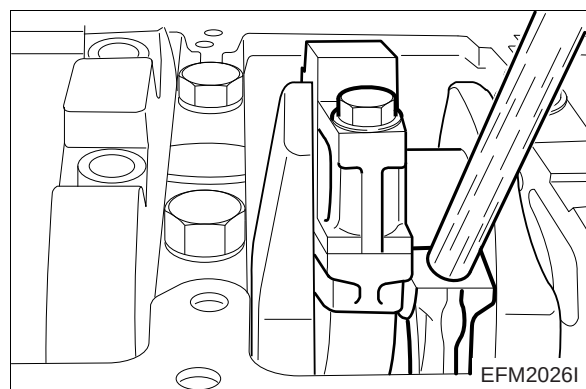
6.1.26. Oil pump

- 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.



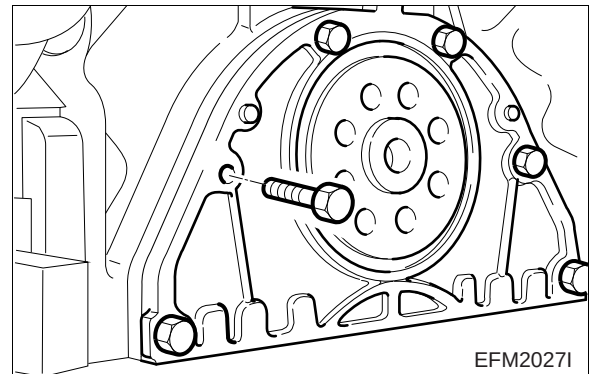
Note :

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.)

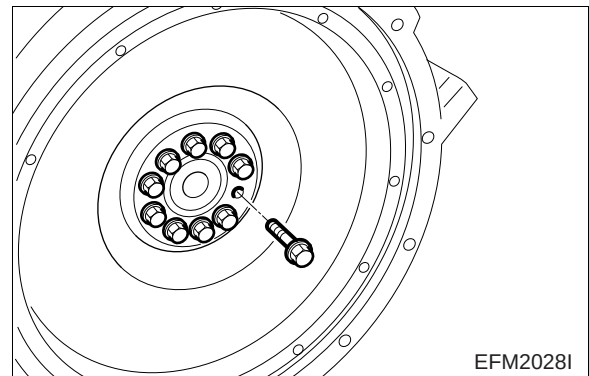
6.1.28. Front oil seal holder

- 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.



6.1.29. Flywheel

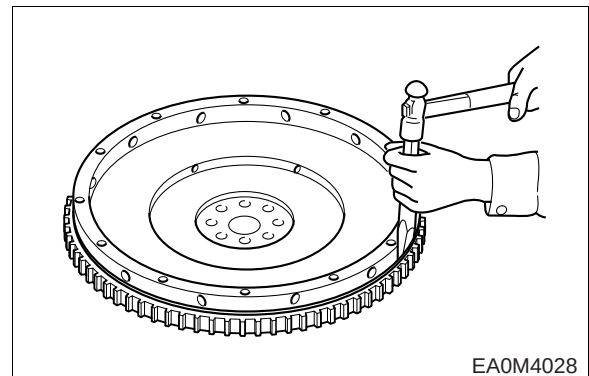
- Remove the flywheel fixing bolts in the order of disassembling and detach the flywheel.



- 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.

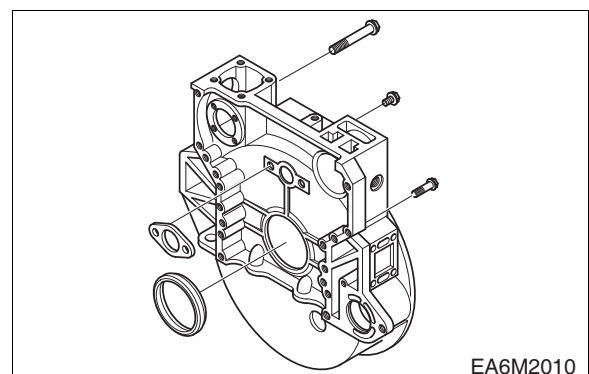


Caution :
Do not damage the flywheel.



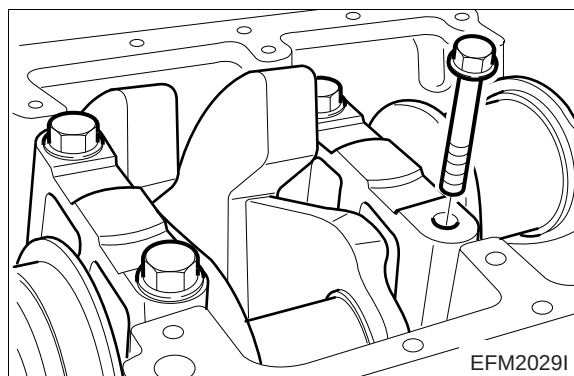
6.1.30. Flywheel housing

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



6.1.31. Crankshaft

- Loosen the bolts from bearing caps.
- Disassemble 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 :

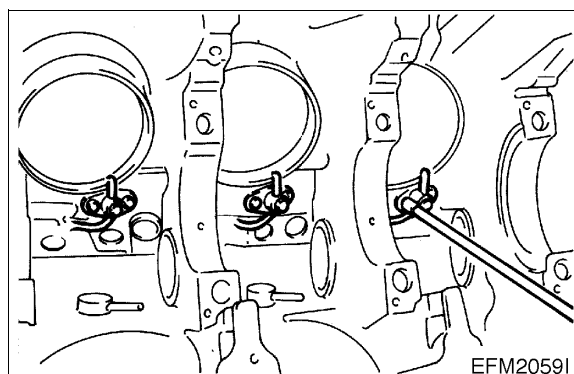
Do not mingle with the metal bearings and bearing caps randomly. To prevent mixing, temporarily assemble the metal bearings to the corresponding bearing caps in turn.

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

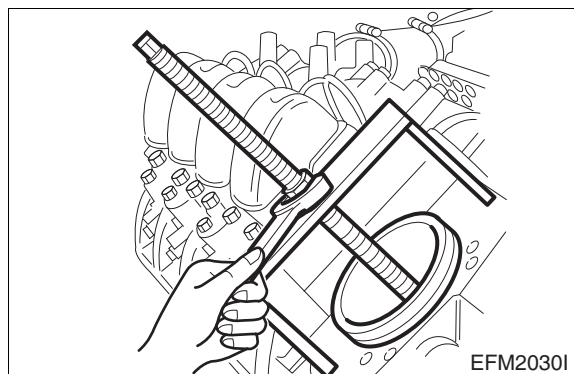
- Remove the spray nozzle fixing bolts and tear down the oil spray nozzles.



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 :

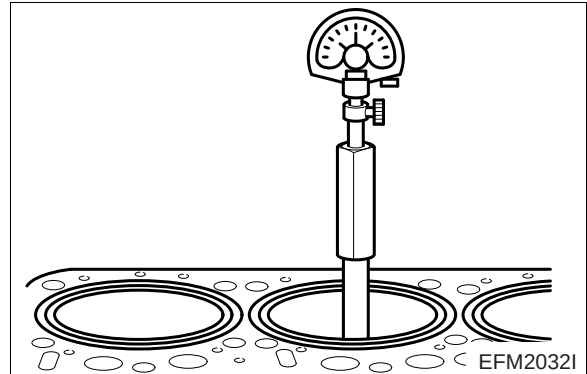
Stop up each outlet port of water and oil passages in the cylinder block, apply air pressure of about 5 kg/cm² against the inlet ports, then immerse the cylinder block in water for about 1 minute to check any leaks. (Water temperature: 70°C)

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.

Liner inner dia.	Standard	Limit
	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

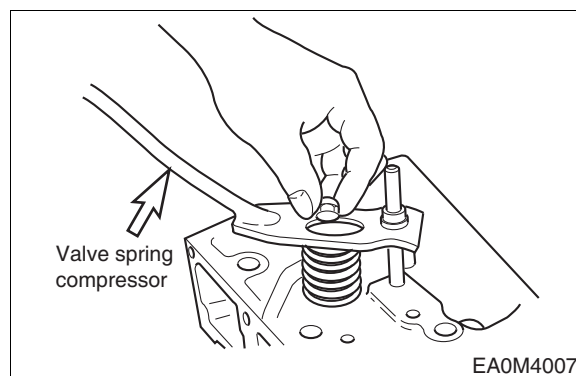


Note :

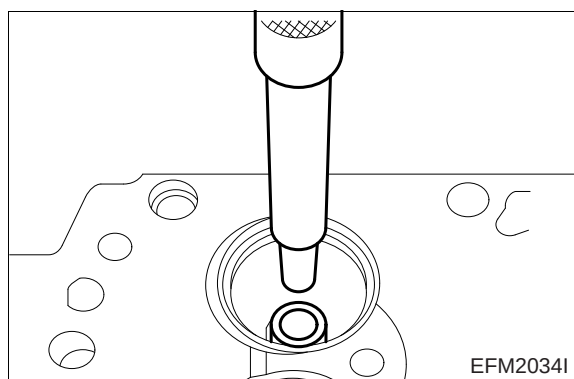
Be careful for the cylinder head gasket contact face of the cylinder head not to be damaged.



- 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

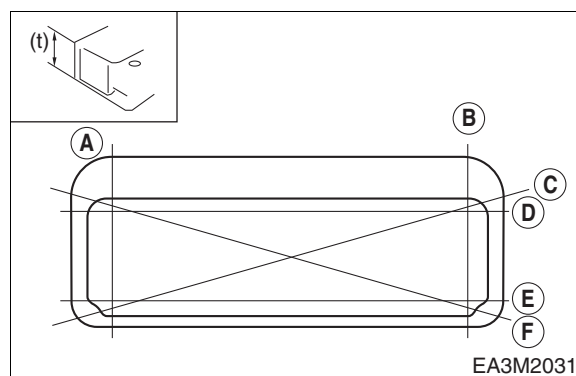
- Eliminate the carbon residue and gasket piece from the cylinder head lower face thoroughly. Then be careful for the valve seat not to be damaged.
- For cracks or damages to search difficult may be inspected by a hydraulic test or a magnetic powder test. (Hydraulic test is same as for cylinder block.)



Distortion of cylinder head bottom face

1) Distortion at the lower face

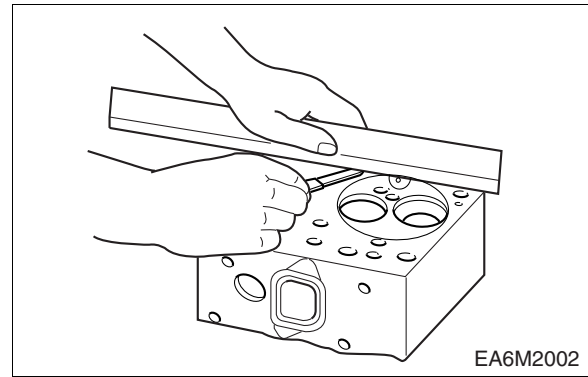
- Measure the amount of distortion using a straight edge and a feeler gauge at six positions as shown in the right figure.
- If the measured value exceeds the standard value, retrace the head with grinding paper of fine grain size to correct such defects.



- 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

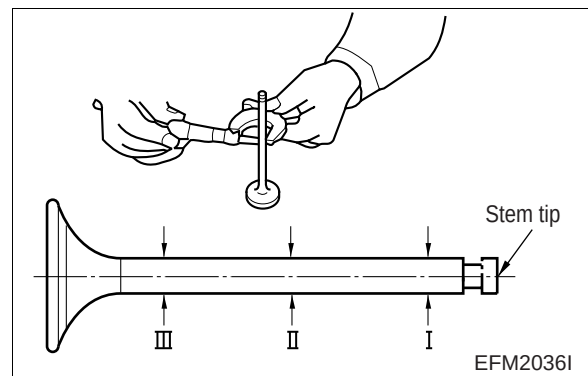
a) Valve



- 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

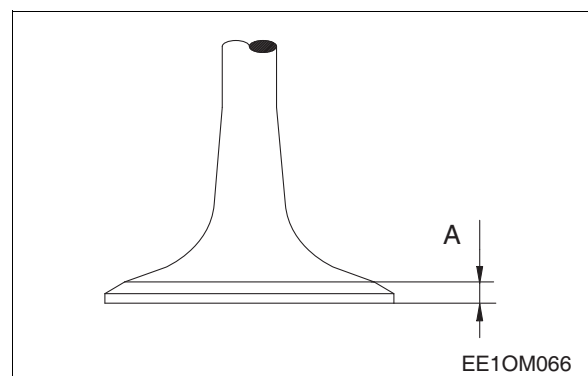


- inspect the scratch and wear of valve stem seal contacting face, and if necessary correct with the grinding paper but if severe replace it.



- 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



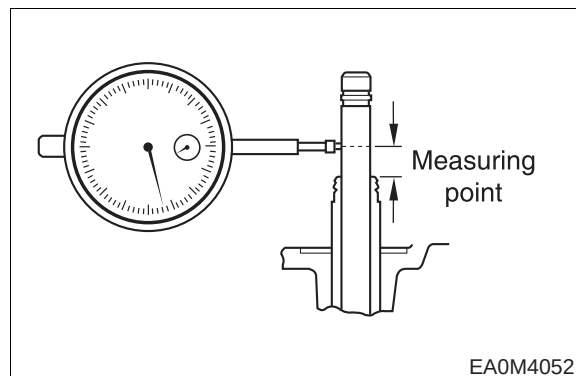
b) Check of valve guide



- 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.



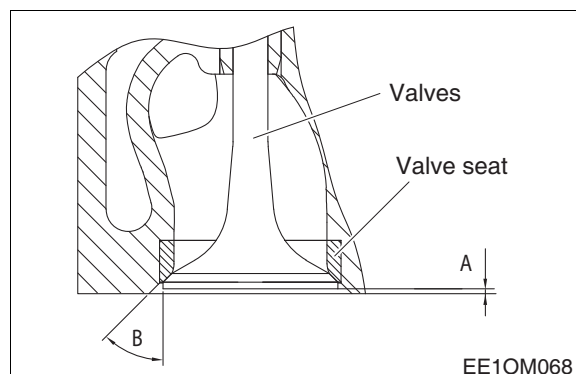
- Valve seat thickness and angle
Assemble the valves at the cylinder head and using the measuring instrument from the lower face, measure the projection amount of valve. If the measured wear is excessive, replace the valve seat.

<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°

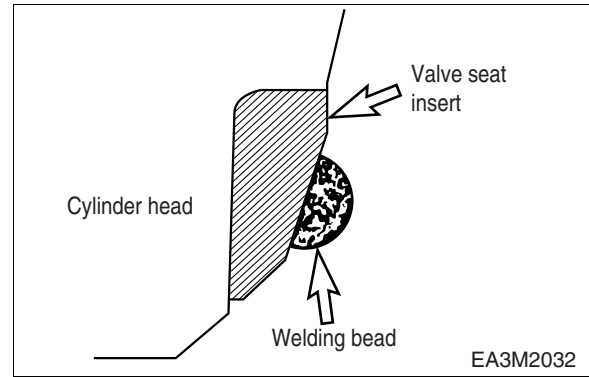




- The disassembly of valve seat can be pulled out by means of a special tool with the arc welding done at two points of valve seat rotating tool or valve seat.



- Regarding the valve seat assembling, shrink the valve seat by putting it in the dry ices for about 1 hour or so, and then press it into the cylinder head by means of a special tool.
- 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.



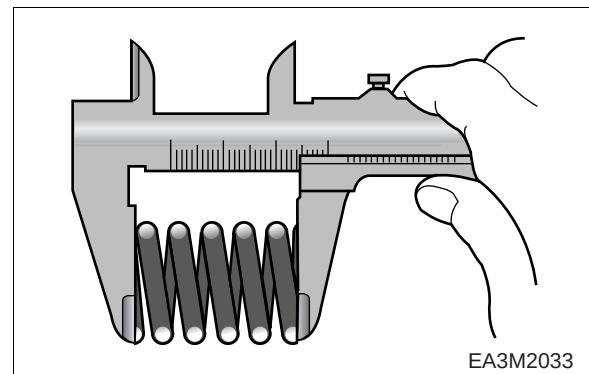
d) Valve spring



- 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>

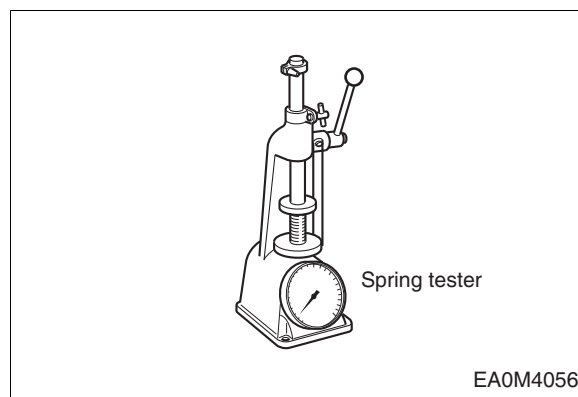
Items		Free length
Intake/	Inside	72.43 mm
Exhaust	Outside	67.17 mm

<Single spring perpendicularity regular - marine generator>

Items		Free length
Intake/	Outside	61.9 mm
Exhaust		

<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



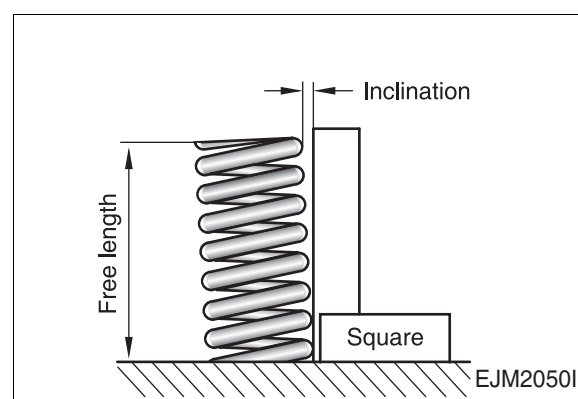
<Valve spring tension standard - marine generator>

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

- Squareness of valve spring: Measure the squareness 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/	Inside/	1.8 mm	2.0 mm
Exhaust	Outside		



<Marine - marine generator>

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

e) Assembling cylinder head

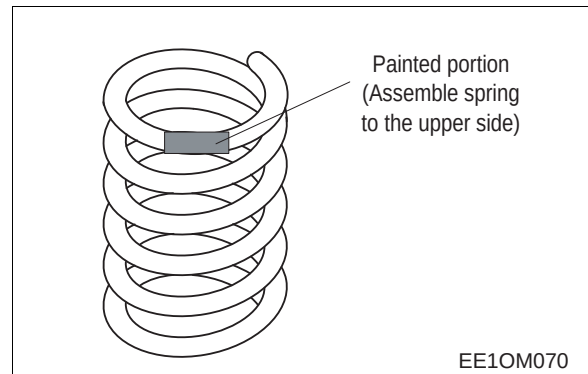


- Clean the cylinder head thoroughly.
- Coat the valve stems and valve guides with engine oil and assemble the valves.
- Replace the valve stem seals with new ones and insert the stem seals to the valve guides of cylinder head with a special tool. (Be careful for the valve stem seals not to be damaged)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

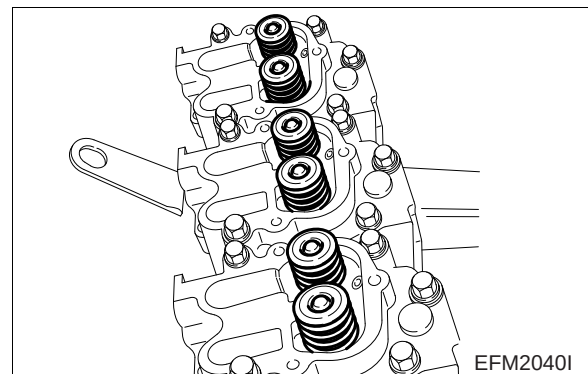


Note :

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.

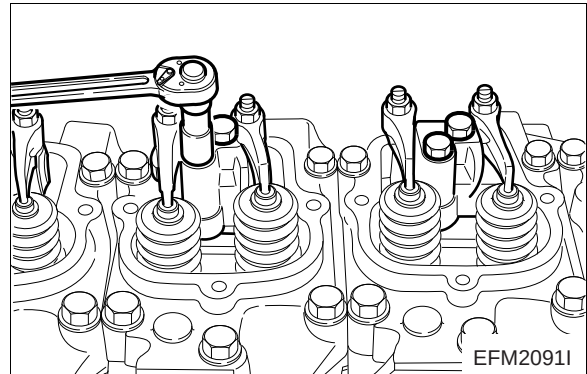


6.2.4. Rocker arm



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

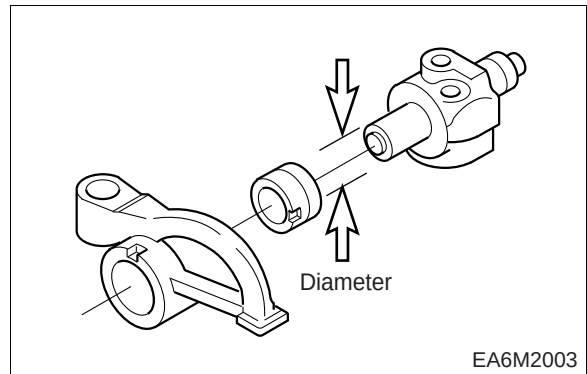
a) Rocker arm bracket



(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.	$\phi 25.005 \sim \phi 25.035$ mm	$\phi 25.083$ mm
Shaft outer Dia.	$\phi 24.967 \sim \phi 24.990$ mm	$\phi 24.930$ mm
Exhaust	$0.015 \sim 0.068$ mm	0.14 mm



b) Rocker arm



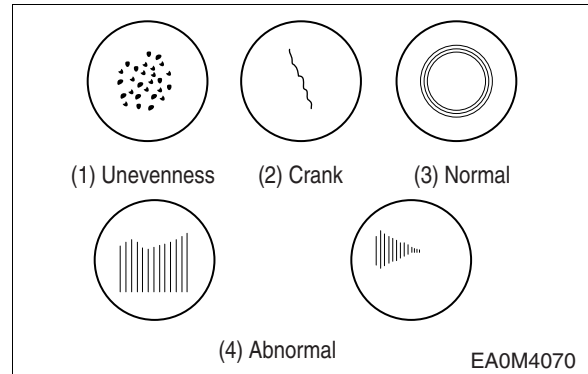
- Inspect the rocker arm surface that contacts with the valve stem for any scratch, step wear and correct the minor degree of wear with an oil stone or the fine grinding paper and replace if they are severe.



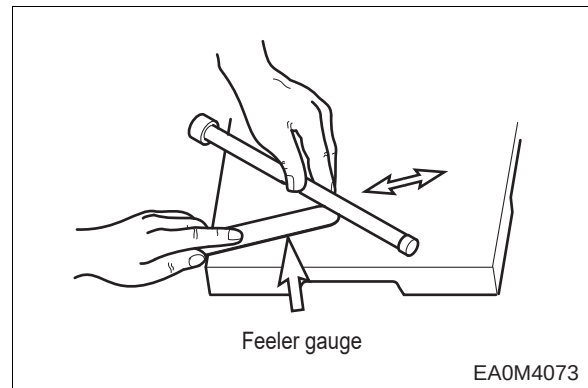
c) Tappet and push rod

- 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
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d) Rocker arm reassembling

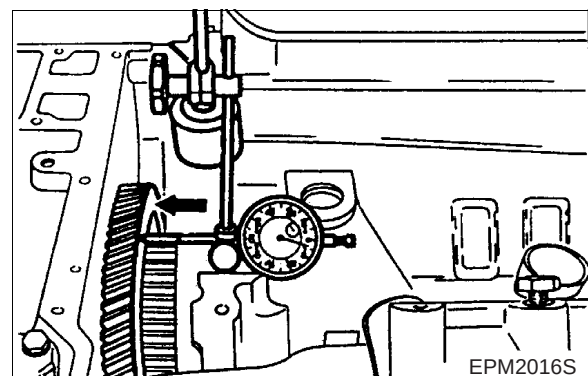
Inspect the oil passages of rocker arm and rocker arm bracket for any clogs and reassemble them in the reverse order of disassembling after thorough cleaning.

6.2.5. Camshaft



(1) Axial end play

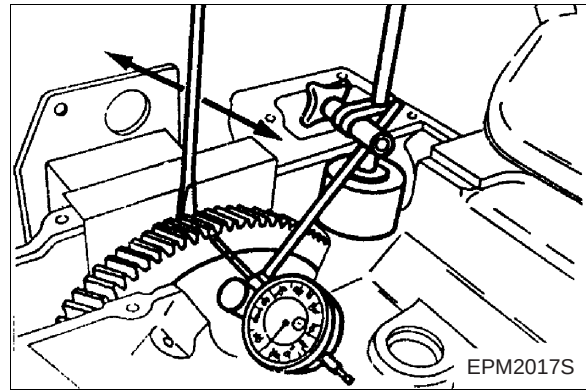
- Push the camshaft toward the pulley side.
- Place a dial gauge onto the camshaft gear.



- 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

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



(2) Inspection and measurement

• Visual check



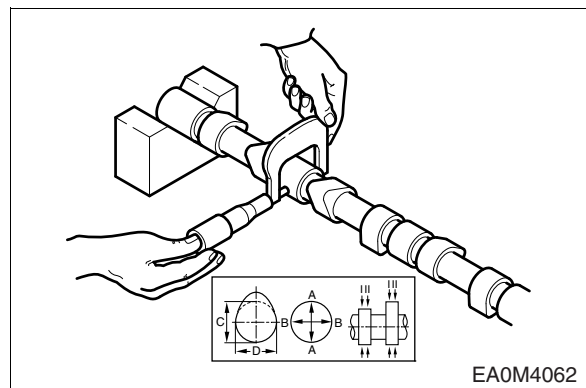
With inspecting the cam surface for any damage with naked eyes and correct any minor scratches by means of an oil stone grinding and if severe, replace it.

• 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 be replaced.

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

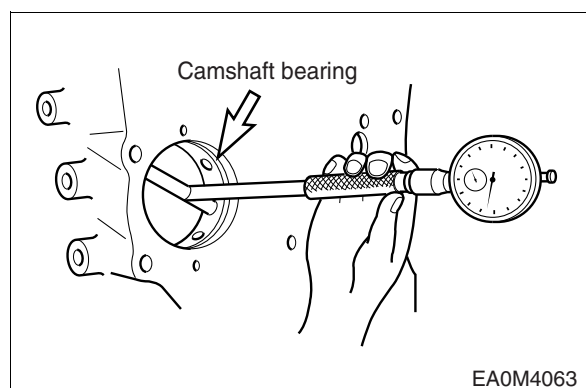


• Cam bearing diameter



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

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



- **Clearance**



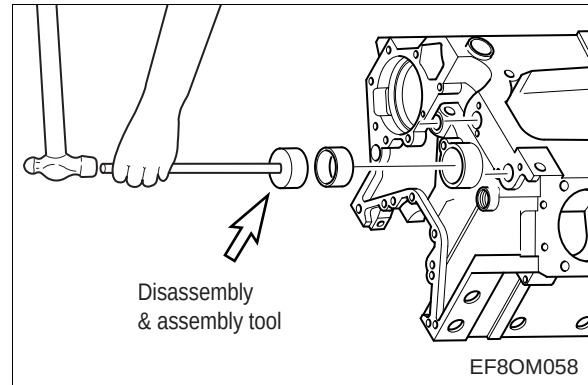
Between camshaft journal and body.

Items	Standard	Limit
Thrust	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.

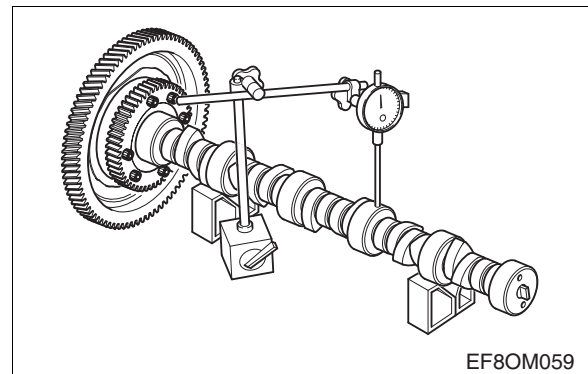


- **Camshaft run-out**



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.

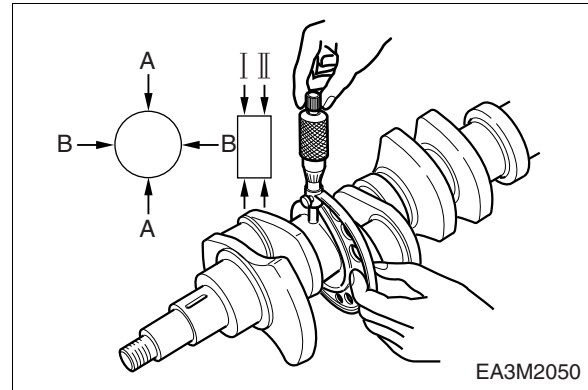
If the measured number is less than the specified limit, the camshaft must be replaced.

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.

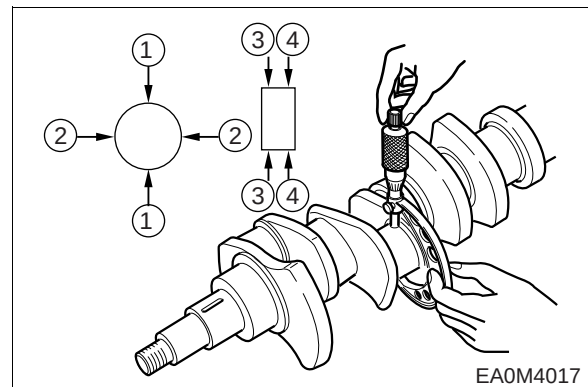
<Crankshaft journal outside diameter>

Standard	$\phi 103.98 \sim \phi 104.00$ mm
-----------------	-----------------------------------

<Crankshaft pin outside diameter>

Standard	$\phi 98.98 \sim \phi 99.00$ mm
-----------------	---------------------------------

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



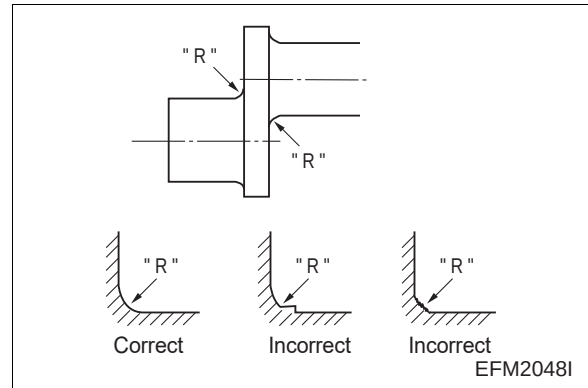
<kinds of bearings for undersize>

- Standard
- 0.10 (Inside diameter 0.10 mm less than standard)
- 0.25 (Inside diameter 0.25 mm less than standard)
- 0.50 (Inside diameter 0.50 mm less than standard)
- 0.75 (Inside diameter 0.75 mm less than standard)
- 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 :

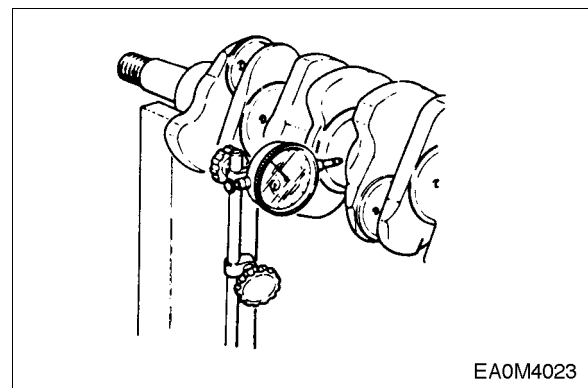
In case of crankshaft regrinding, the “R part” at the end of bearing must accurately be ground without fail and should avoid any processed jaw or coarse surface

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.

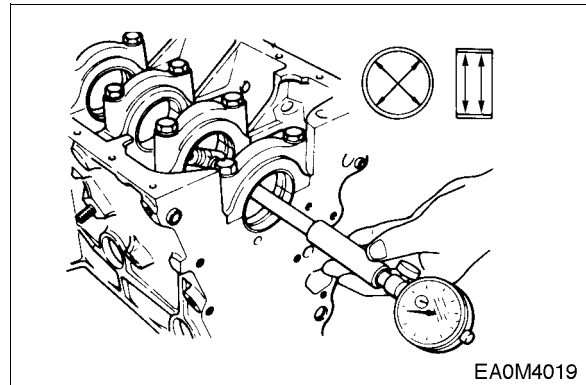
a) How to utilize the cylinder gauge



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

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

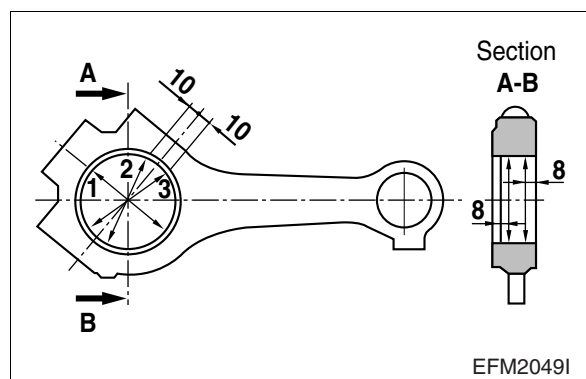
Bearing cap bolt torque	Initial 30 kg.m + angle 90°
--------------------------------	-----------------------------



- 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.

Journal bearing standard diameter	ø90.056 ~ ø90.098 mm
--	----------------------

Connecting rod bolt torque	Initial 30 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

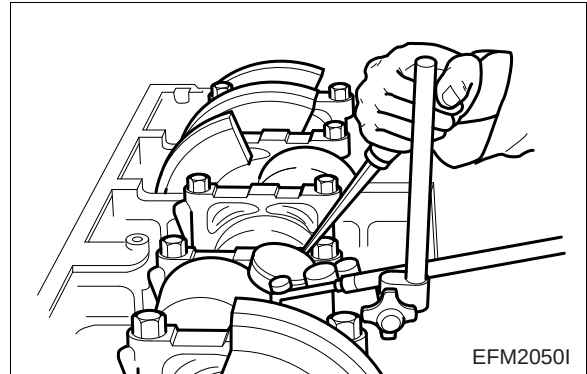
- ① Install the crankshaft in the cylinder block and place the plastic gauge on the crankshaft journal and pin at axial direction and then after tightening the bearing cap at the specified torque and again after tearing apart the bearing cap, measure the flatten plastic gauge thickness by pick it up.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



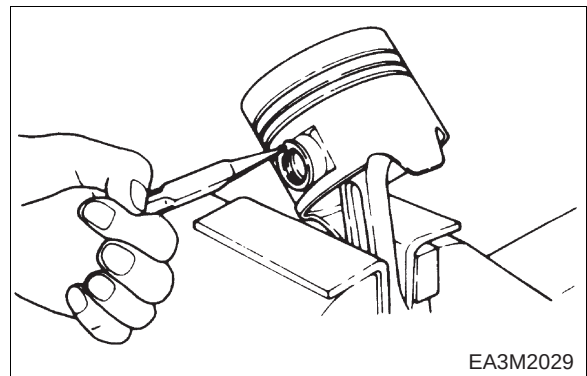
EFM2050I

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

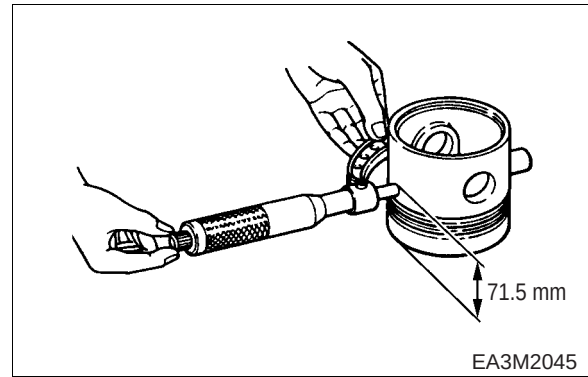


- With naked eyes, inspect the piston for any wear, crack and scratch and particularly inspect carefully at the ring grooves for any wear.



- 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	$\phi 127.739 \sim \phi 127.757 \text{ mm}$
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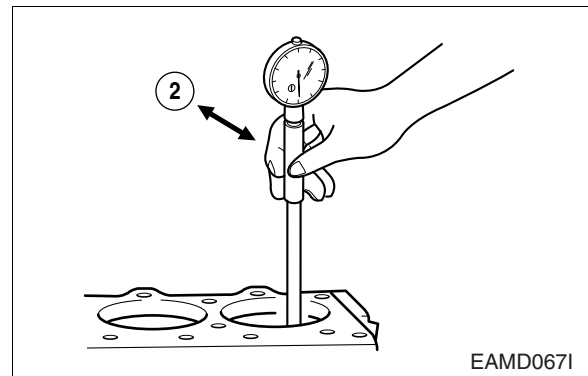


- By comparing the measured value of the piston outside diameter with the cylinder liner inside diameter, the bigger clearance is replaced.



- 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	$\phi 127.990 \sim \phi 128.010 \text{ mm}$
-----------------	---



- 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	$0.233 \sim 0.271 \text{ mm}$
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(3) Piston ring & ring groove



Inspection

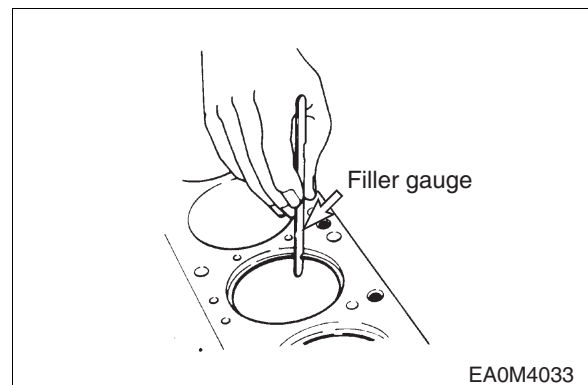
In case of piston ring's wear, damage or engine overhaul, replace piston rings.



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

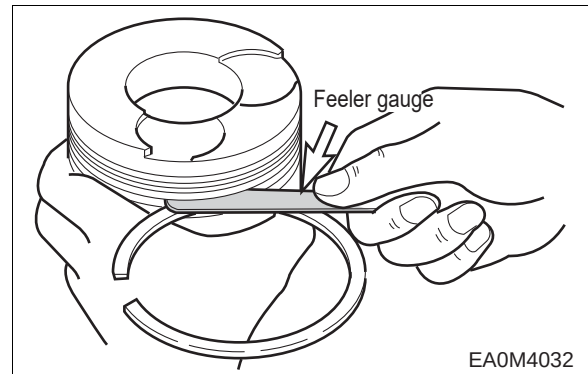
Piston ring groove clearance.



- 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



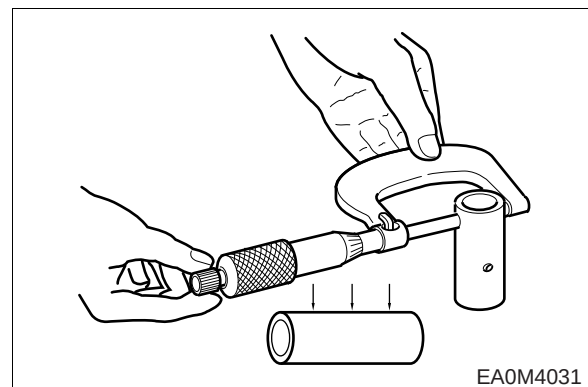
(4) Piston pin



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.

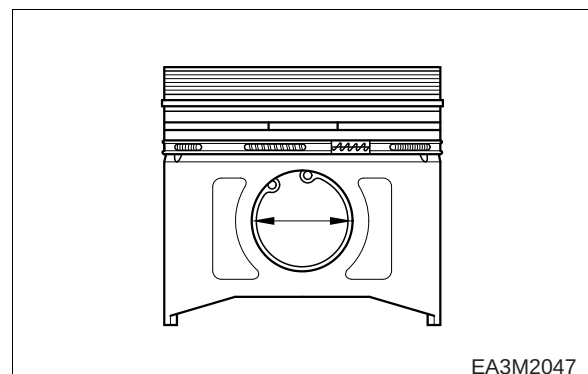
Standard	Limit
ø45.994 ~ ø46.0 mm	ø45.979 mm



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
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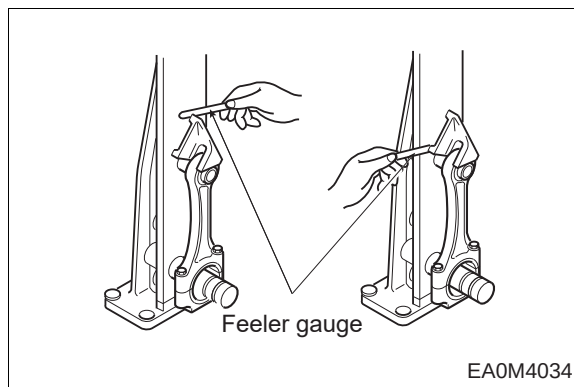
(5) Connecting rod



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

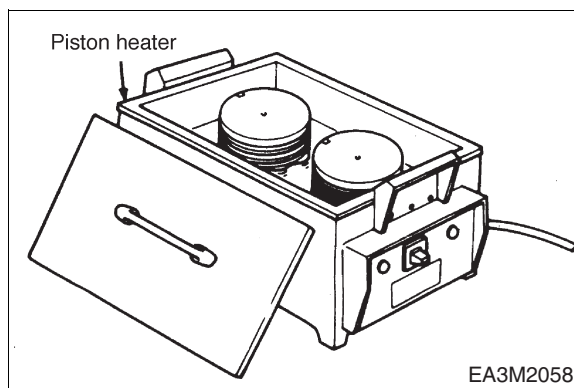


- After heating the piston at the piston heater for about 5 min (120 ~ 150°C), by aligning the piston pin hole with the pin hole of connecting rod's smaller end, insert the oil coated piston pin.



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.



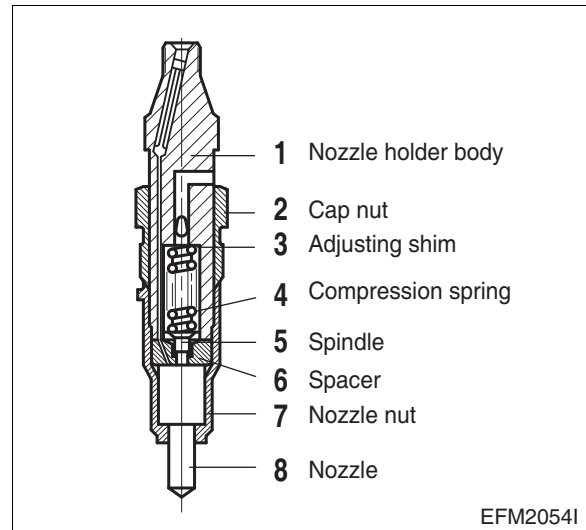
- Inspect the disassembled parts if there is any damage, replace it.



- Assembling can be done in the reverse order of disassembling.



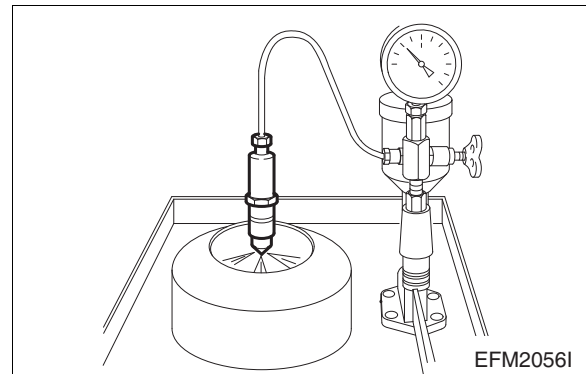
- After assembling the nozzle, set it in the injection pressure measuring tester.



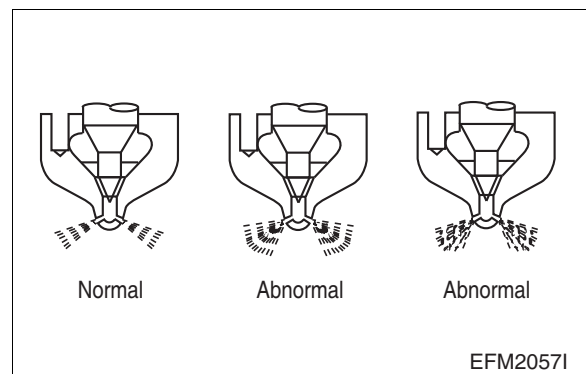
- By manipulating the tester handle, inspect the injection pressure and atomizing state.

<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

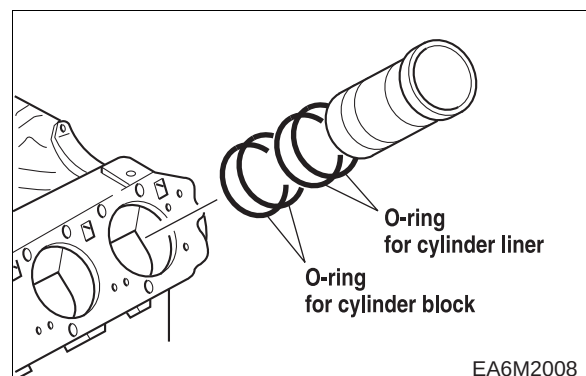
- Clean all the disassembled parts, particularly oil and water ports, using compressed air, then check that they are free from restrictions.
- Arrange the general and special tools in order for engine assembly operation.
- To wet each sliding part, prepare the clean engine oil.
- Prepare service materials 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

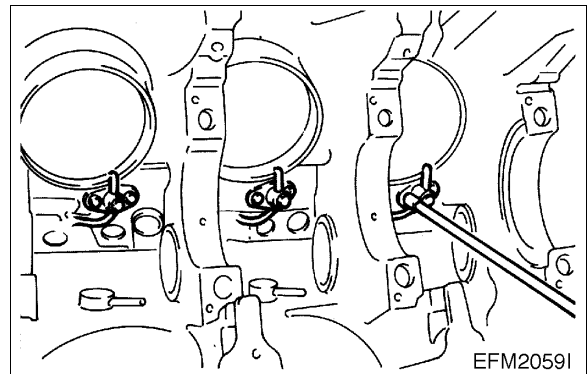
- Replace the used O-rings with new ones and insert the O-ring in the cylinder liner upper side, but the other one in the cylinder block lower side separately.
- Coat the joint parts where O-ring contacts with oil.
- After slipping the cylinder liner smoothly into the cylinder block, press it in being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



- After completion of assembling the cylinder liner, confirm no leaks with 4 kg/cm² hydraulic test.

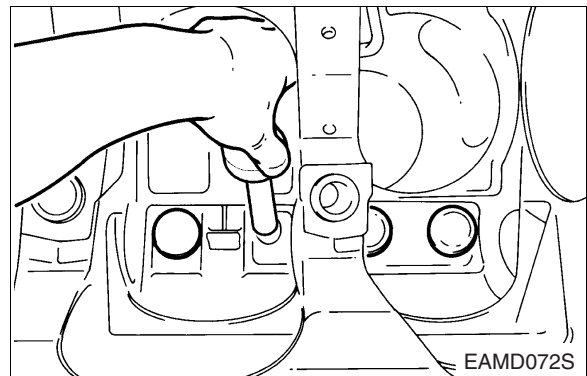
6.3.4. Oil spray nozzle

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



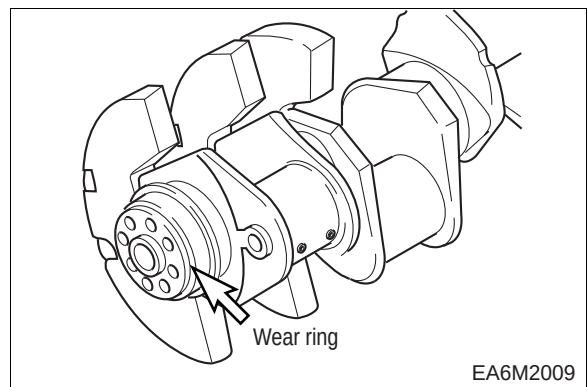
6.3.5. Tappet

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

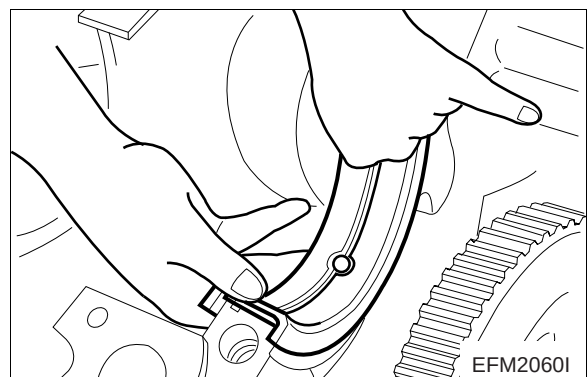


6.3.6. Crankshaft

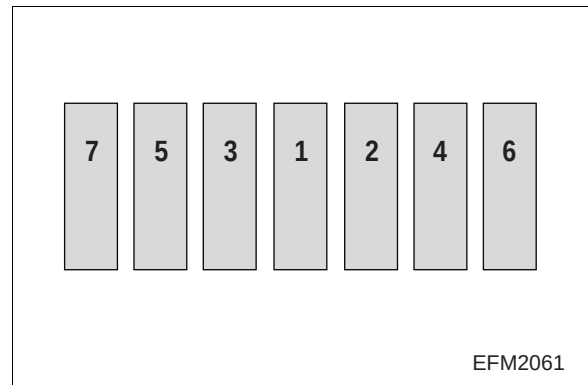
- Put the wear ring into the heater to heat it up to 150 ~ 200°C level, push it over the crankshaft by means of a jig.



- 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.

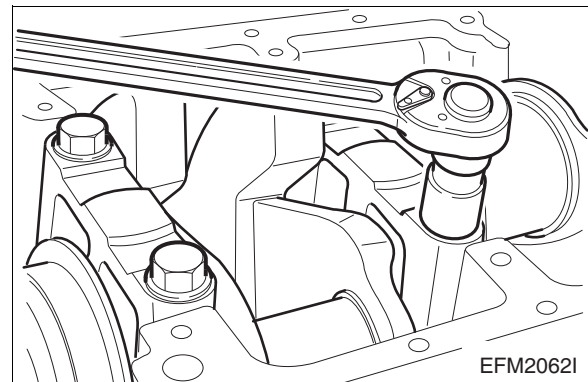


- According to the tightening order, tighten the bearing cap bolts with 30 kg.m and with rotating angle method ($90^\circ +10^\circ$) and tightening order are as follows.

< 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 $90^\circ +10^\circ$.

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



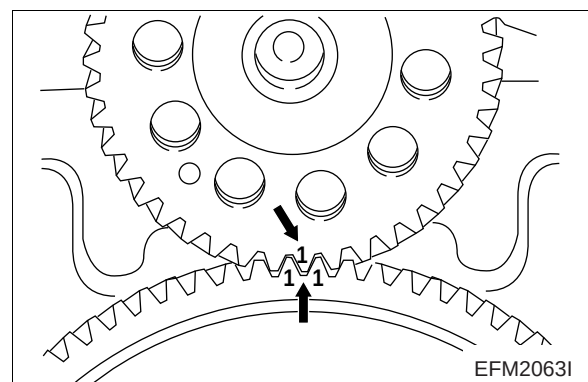
- Inspect if the crank shaft's rotation is smooth.
- Assemble the crankshaft gear on the crankshaft and coat a white paint mark on "1" part in order to find easily.

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.

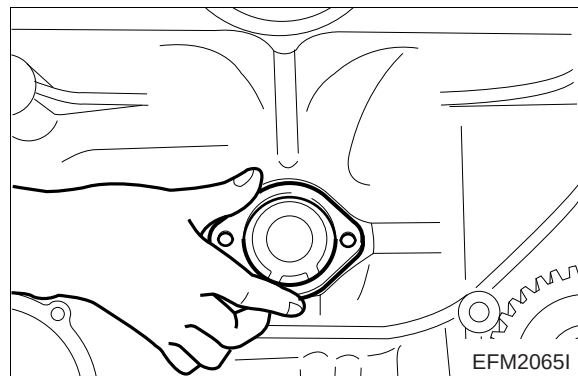


6.3.8. Flywheel housing

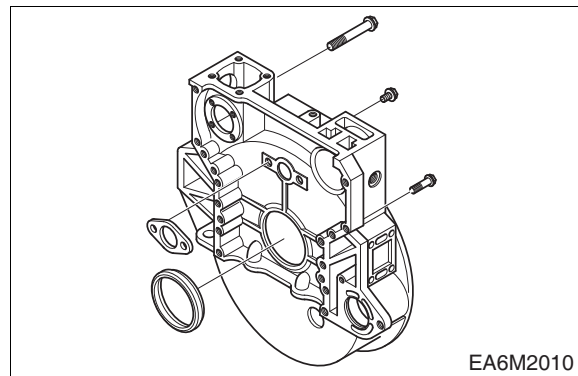


- Coat the thrust washer fixing bolt with an adhesive and tighten it with specified torque.

Torque	3.1 kg.m
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- 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.

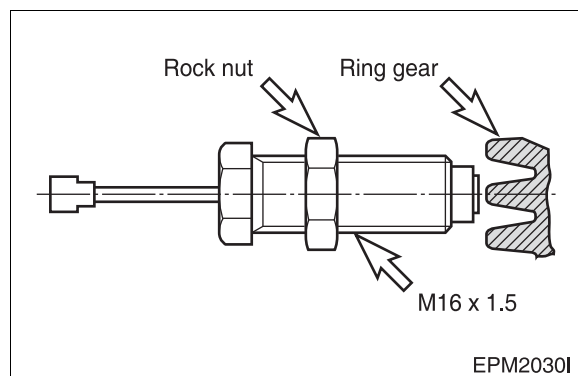


- After fitting the flywheel housing holes to the guide pins and engage temporarily 2 ~ 3 threads of fixing bolts, and according to the tightening order (zigzag method) tighten them in the specified torque.

Torque	7.5 kg.m
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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)

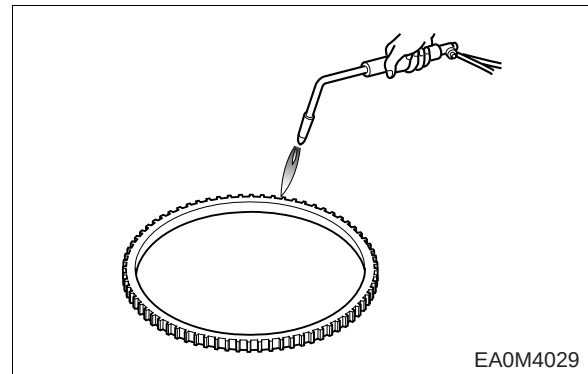


6.3.10. Flywheel

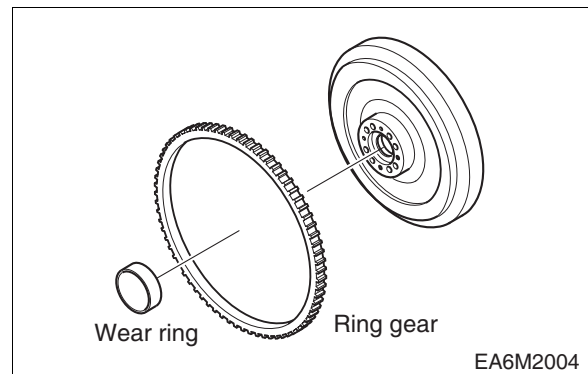
- Installation of flywheel ring gear With a gas burner, heat the ring gear evenly until heat expansion takes place, then install it using a hammer.



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

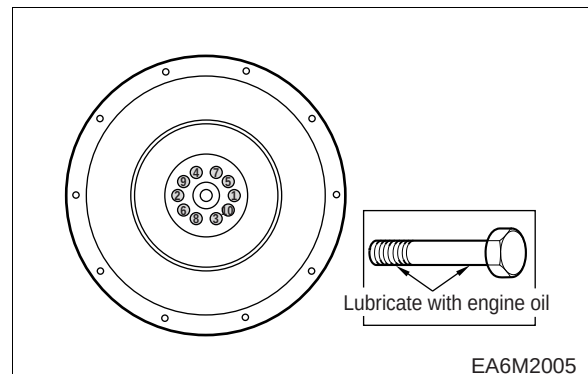


- By means of mandrel, press in the wear ring at the backward face.
- Install two guide bolts for installing the fly-wheel to the crankshaft.



- 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)

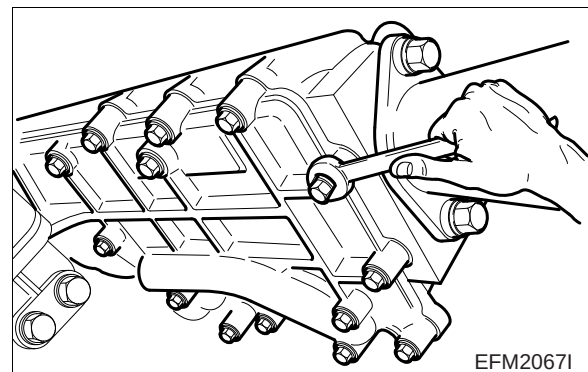
Torque	26 kg.m
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6.3.11. Oil cooler

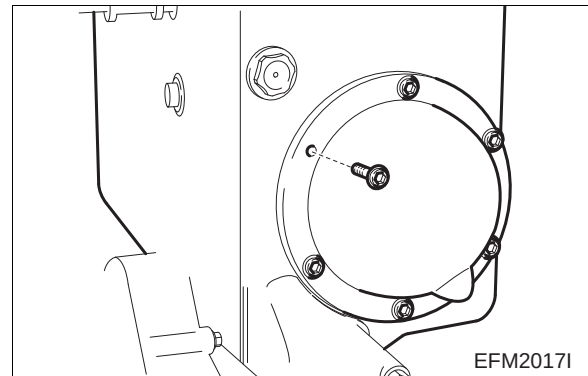
- Attach a gasket on the surface in the oil cooler housing where the oil cooler is installed.
- Tighten the oil cooler with fixing bolts.
- Install the oil cooler assembly by tightening the fixing bolts in the zigzag order.

Torque	M8	3.1 kg.m
	M10	5.5 kg.m



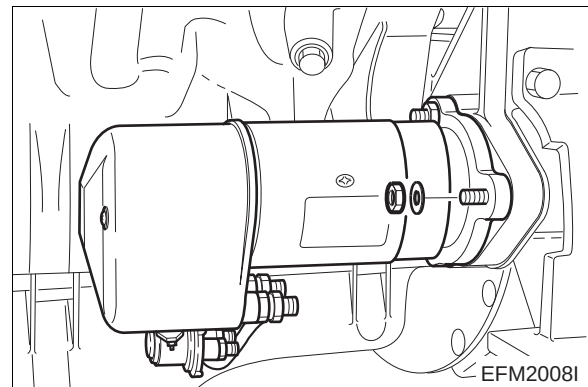
6.3.12. Heat exchanger

- 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.



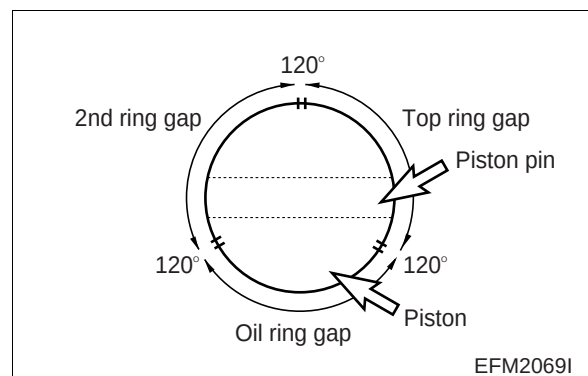
6.3.13. Starting motor

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

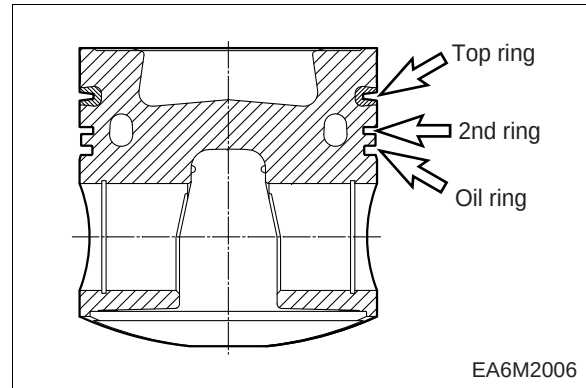


6.3.14. Piston

- 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>

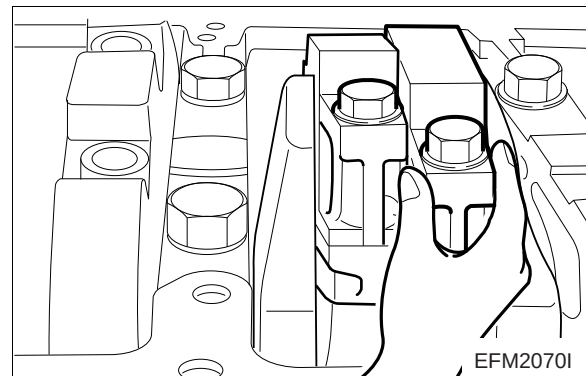
- (1) First step : Engage 2 - 3 threads by hands.
 - (2) Second step : Tighten to about 7 kg.m with wrench.
 - (3) Third step : By means of torque wrench tighten to 10 kg.m.
 - (4) Fourth step : Finally assemble by means of rotation angle method 90°+10°.
- However, according to above tightening order,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

* Standard length of bolt and use limit:

(from head seat to bolt tip)

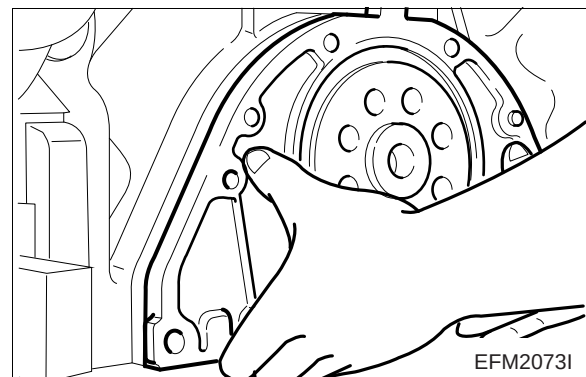
Standard length	Use limit
67.5 ^{+0.3} mm	69 mm

- 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.

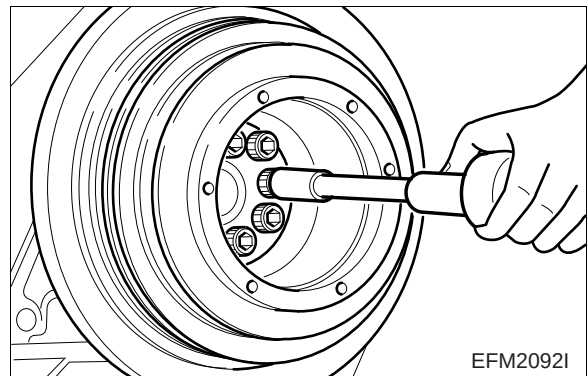
6.3.16. Vibration damper

- Assemble the vibration damper tightening firstly by the crankshaft pulley and the fixing bolts.



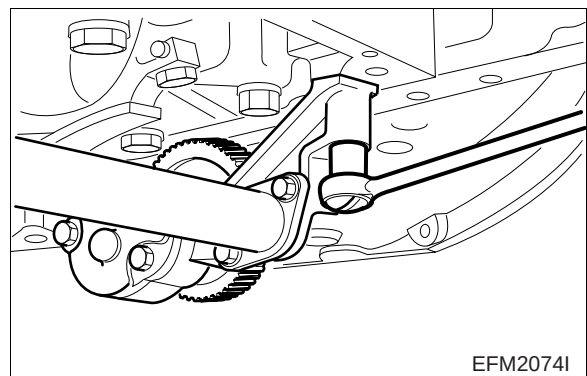
- Insert the crankshaft pulley assembly to the crankshaft and tighten the fixing bolts in the method of zigzag to the specified torque.

Torque	21 kg.m
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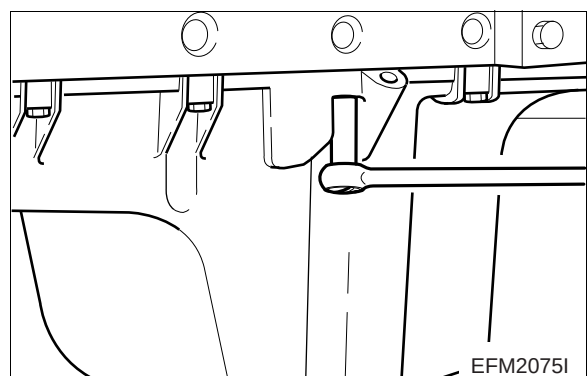
6.3.17. Oil pump

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



6.3.18. Oil pan

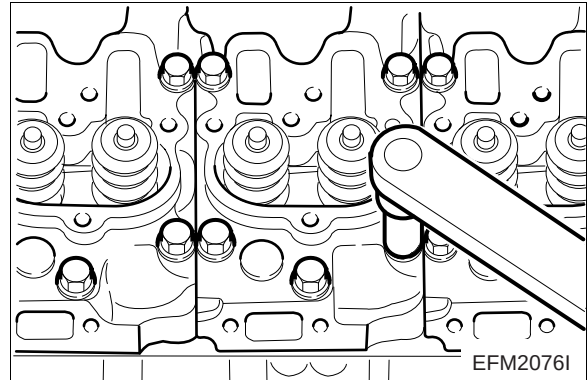
- Clean thoroughly the gasket that is projecting at the junction parts of front oil seal holder and flywheel housing of cylinder block's lower face with a scraper. In the process of gasket removal, be careful for the gasket pieces not to get into the engine inside.
- Attach the gasket to the cylinder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



- 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.)

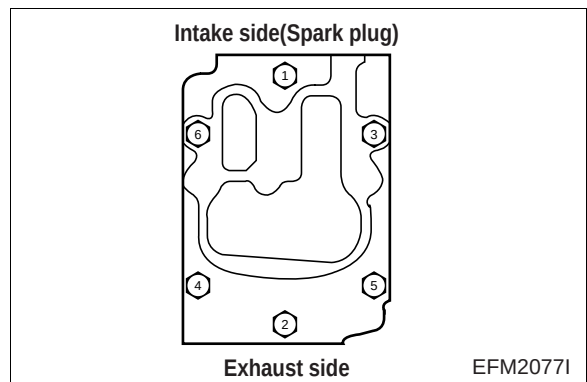


- Tighten the cylinder head bolts to the specified torque according to step by step.

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°.



* Standard length of bolt and use limit:

from the head seat face to tip

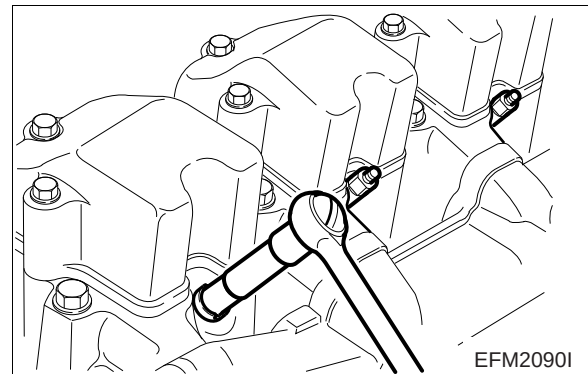
Bolt No.	Standard length	Use limit
3, 6	168 mm	171 mm
2, 4, 5	144 mm	147 mm
1	109 mm	112 mm



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.

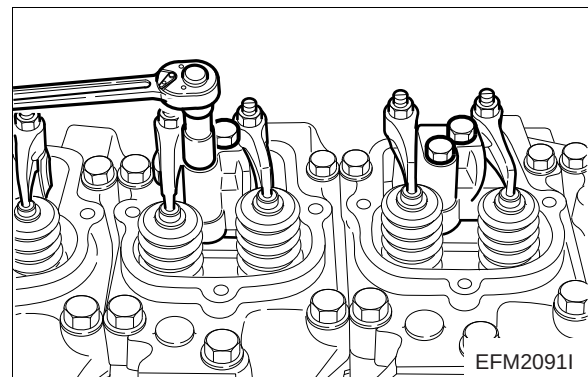


- Make a position the rocker arm assembly on the cylinder head and tighten the fixing bolts to the specified tightening torque.

Torque	6.2 kg.m
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- 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).

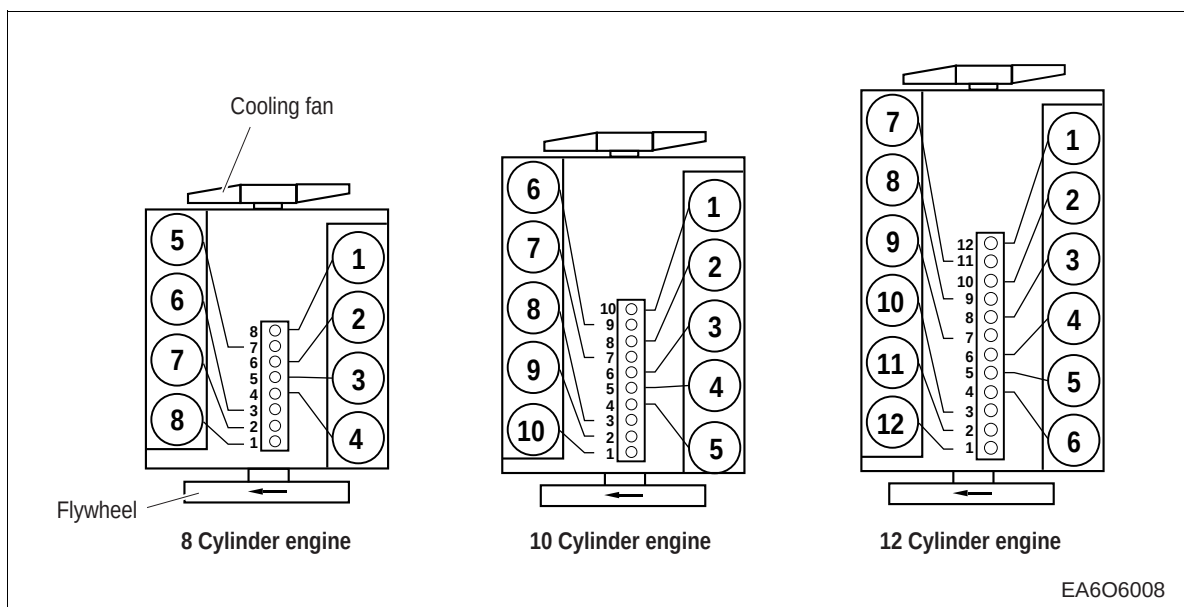


Note :

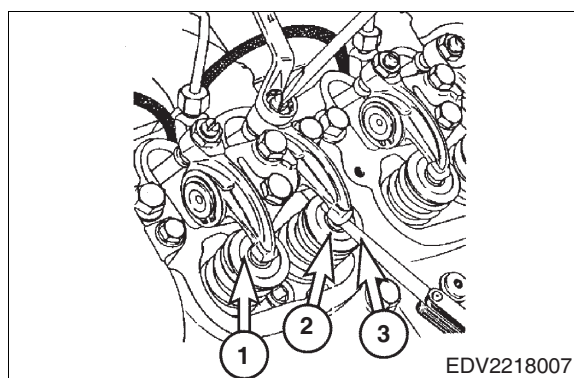
#1. Cylinder is located at the side where cooling water pump was installed.

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.

Specified Value		Measurement Tolerance	
In. Valve	Ex. Valve	In. Valve	Ex. Valve
0.25 mm	0.35 mm	±0.05 mm	

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

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

*** 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)**

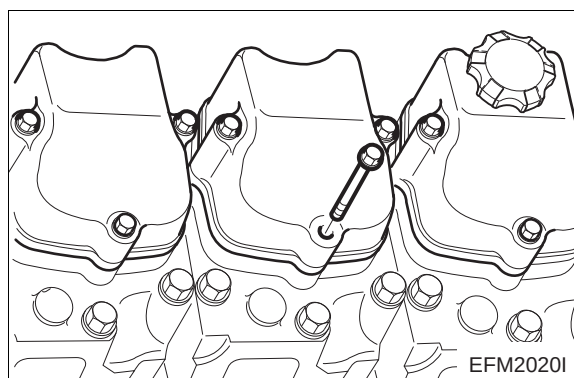
Valve overlap cylinder No.									
1	6	5	10	2	7	3	8	4	9
7	3	8	4	9	1	6	5	10	2
Adjusting valve cylinder No. (In./Ex. Valve)									

*** 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)											

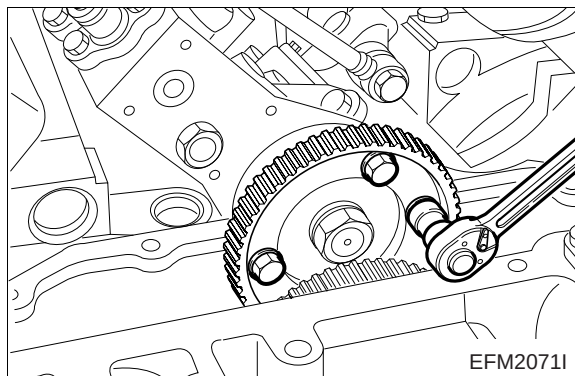
6.3.23. Cylinder head cover

- 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.

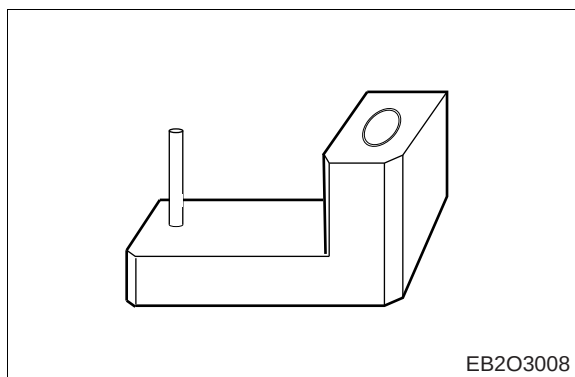


6.3.24. Fuel injection pump

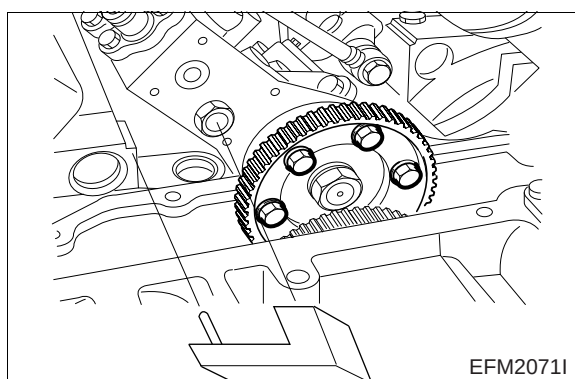
- Turn the crankshaft so as to let the cylinder No. 6 for V158TI, AD158TI, V222TI, AD222TI engines and the cylinder No. 7 for V180TI, AD180TI come to the overlap TDC (Top Dead Center).
- Rotate the crankshaft to reverse about 30° (in order to remove a backlash) and then rotate it to engine rotating direction 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.



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



- 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

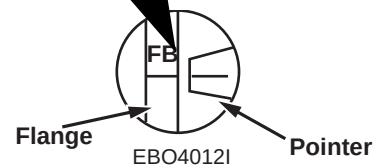
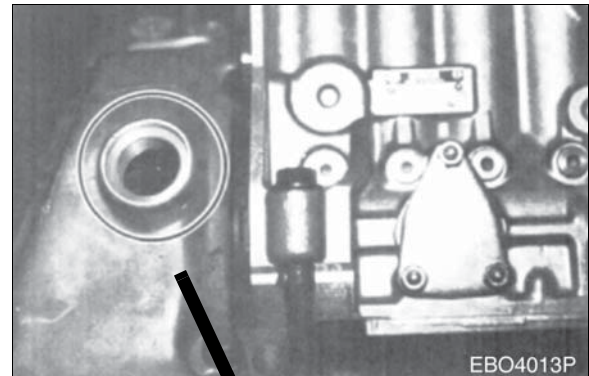
6.3.25. Injection timing

<How to check the injection timing>

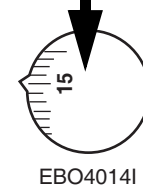
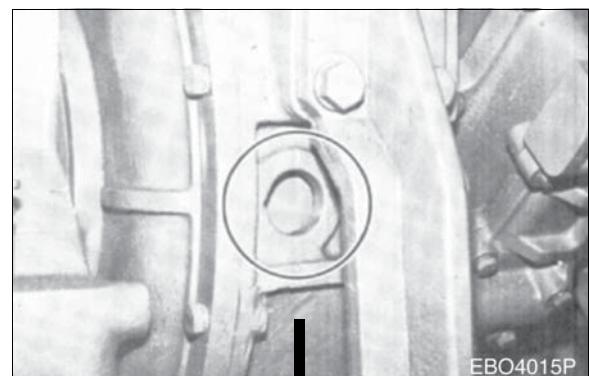
- Check the current injection timing of the engine as follows before adjusting it but if the injection timing is wrong should do it.

- 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.



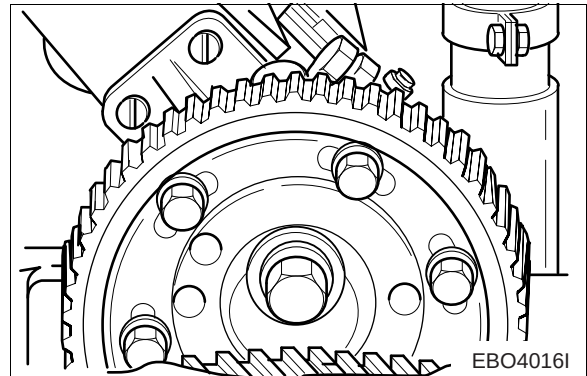
- 2) Check the injection timing degree whether the V-type edge of the flywheel housing sight hole coincides with the engine injection timing degree marked on the flywheel corresponding to fuel delivery position.



<How to adjust injection timing>

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

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



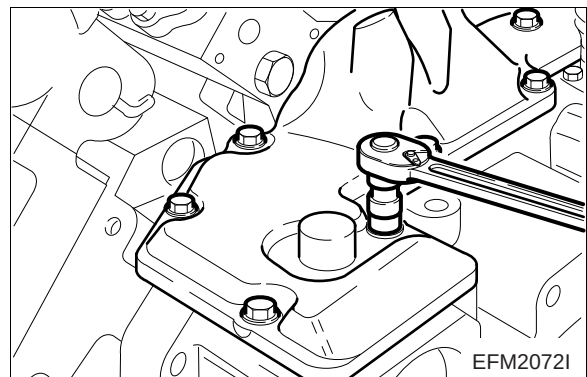
- 3) Coincide the mark on pointer provided in injection pump with the matching mark (FB) on the flange surface of the drive gear by turning the flange in the oblong holes of the drive gear.
- 4) Tighten the bolt (M8) to specified torque. (2.2 kg.m) not to move the drive gear
- 5) After confirmation that 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°

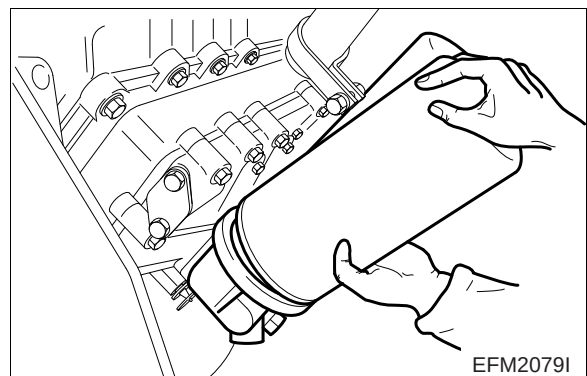
6.3.26. Flywheel housing cover

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



6.3.27. Oil filter

- Install the oil filter cartridge.

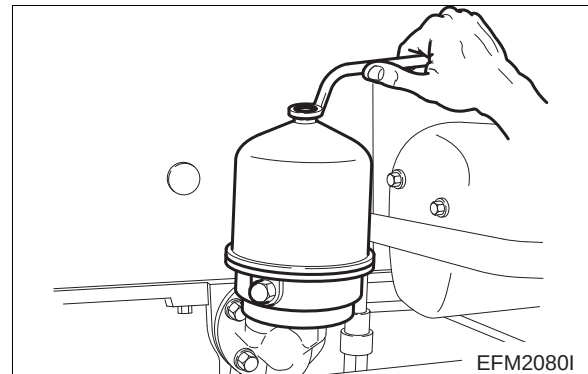


6.3.28. Oil centrifugal filter

- 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.

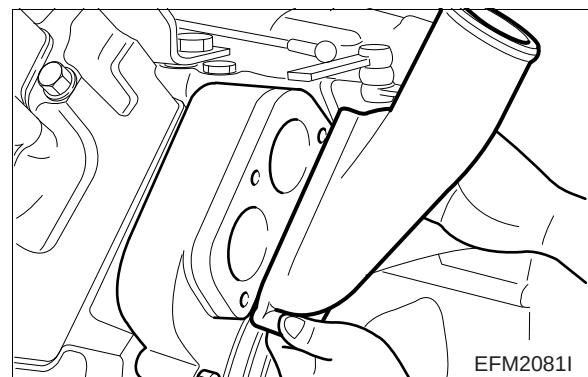


Torque	1.5 kg.m
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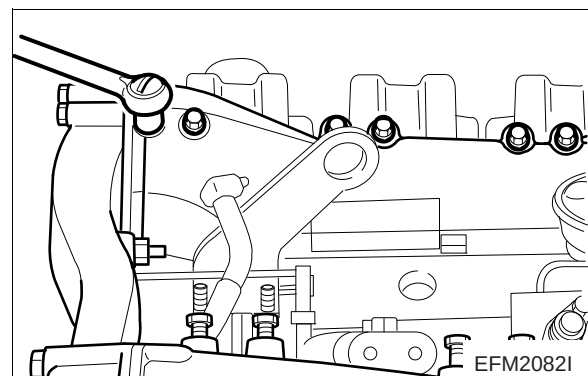
6.3.29. Fresh water pump

- 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.



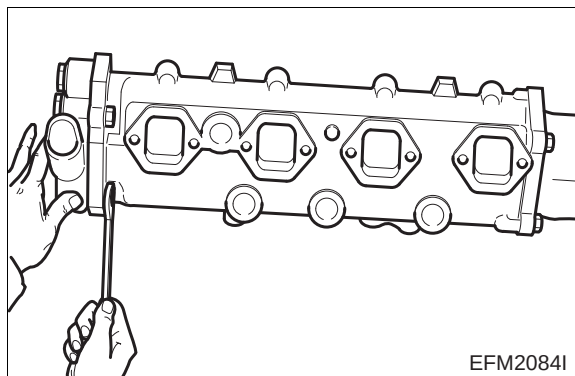
6.3.30. Intake manifold

- 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

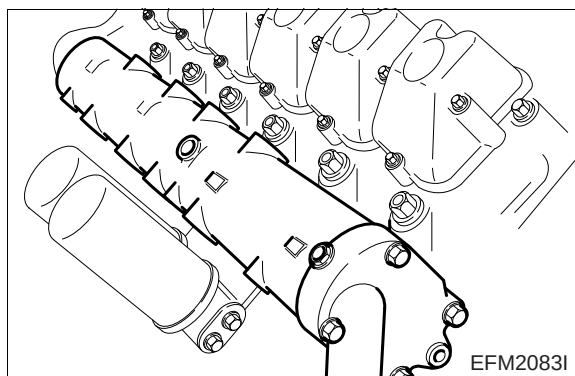
- Prior to assembling the exhaust manifold, attach the gasket firstly to the cover and elbow exhaust pipe and assemble them to the engine block tightening the bolts evenly as the right figure.



- 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.

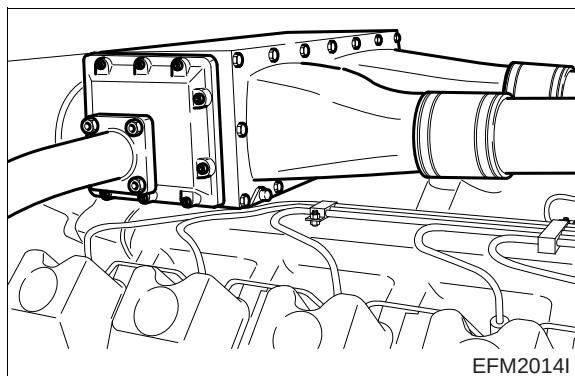


Be careful not to drop the manifold because it is very heavy.



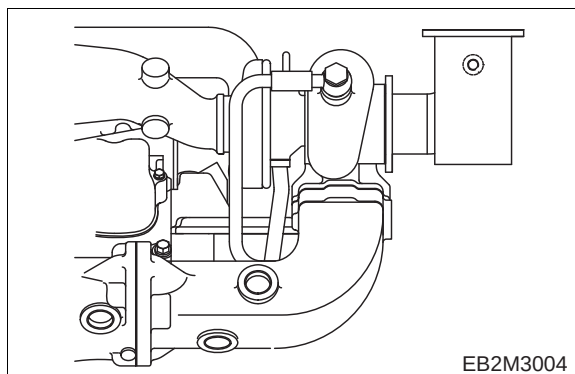
6.3.32. Inter-cooler

- 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.



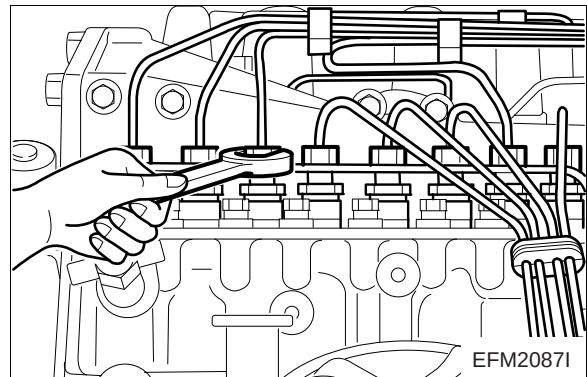
6.3.33. Turbocharger

- 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.



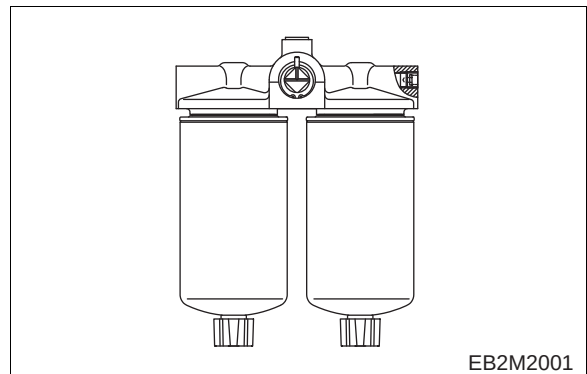
6.3.34. Fuel injection pipe

- 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.



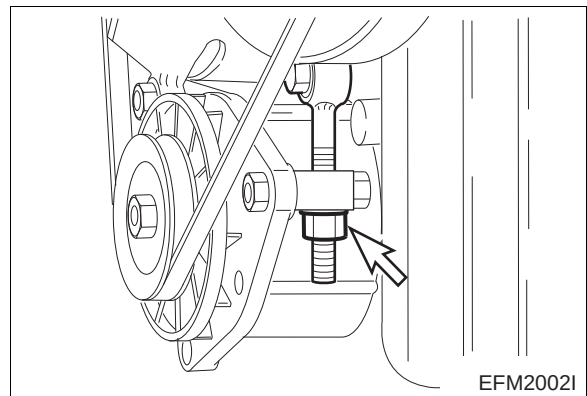
6.3.35. Fuel filter

- 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.



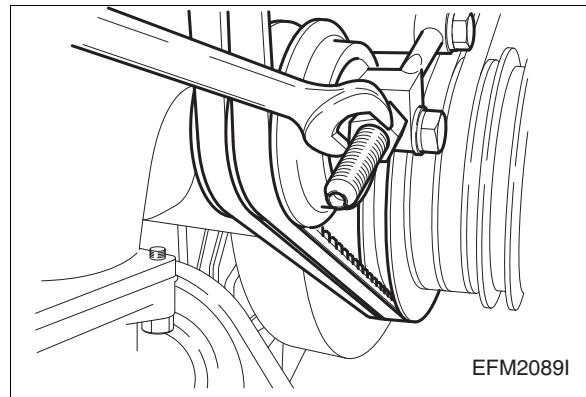
6.3.36. Alternator

- 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.



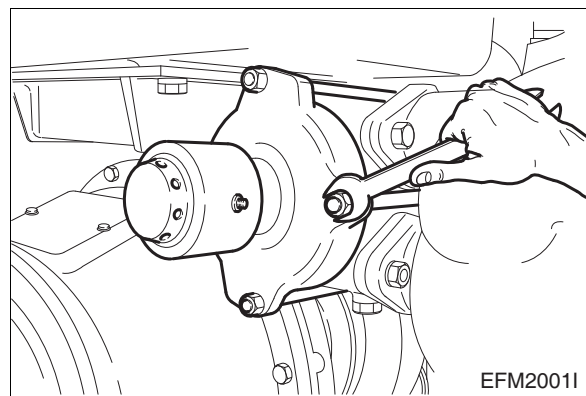
6.3.37. Idle pulley

- 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).



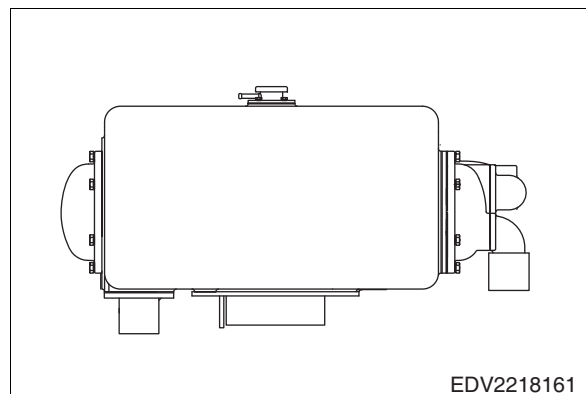
6.3.38. Sea water pump

- 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

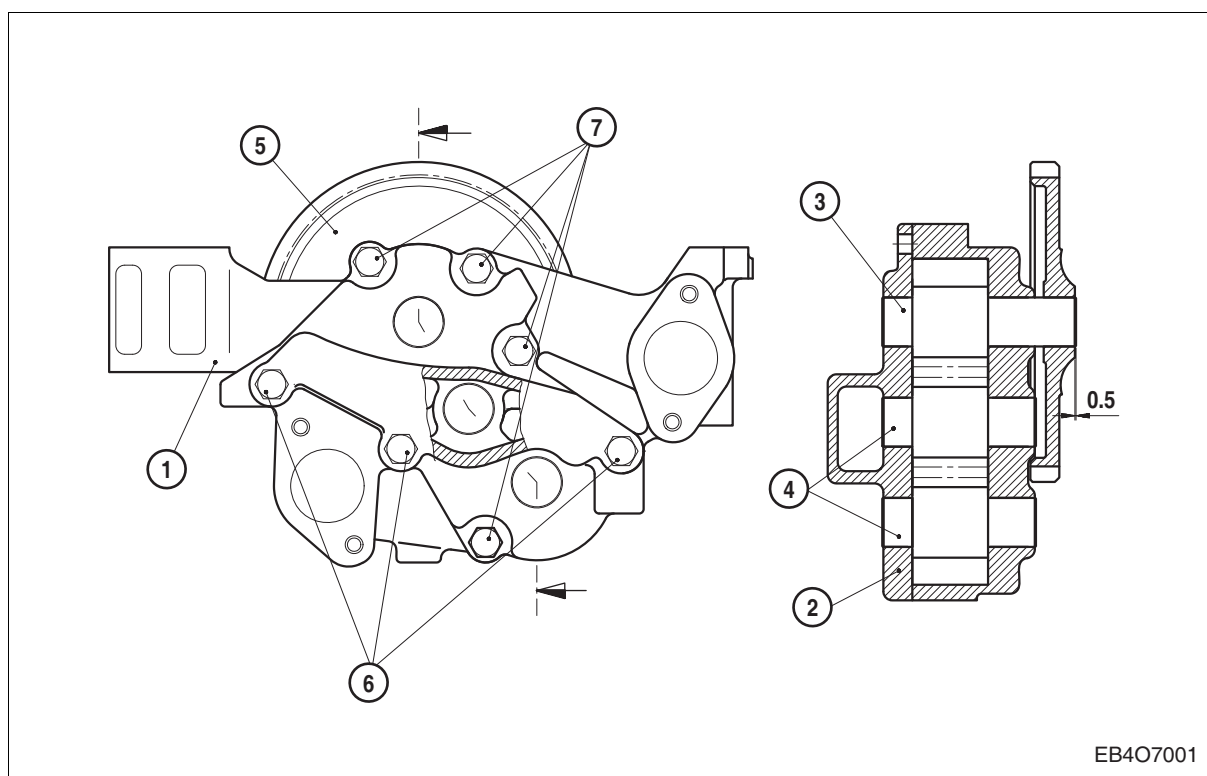
Lubricating oil pumped by the gear oil pump in the oil pan is filtrated in the oil filter.

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		

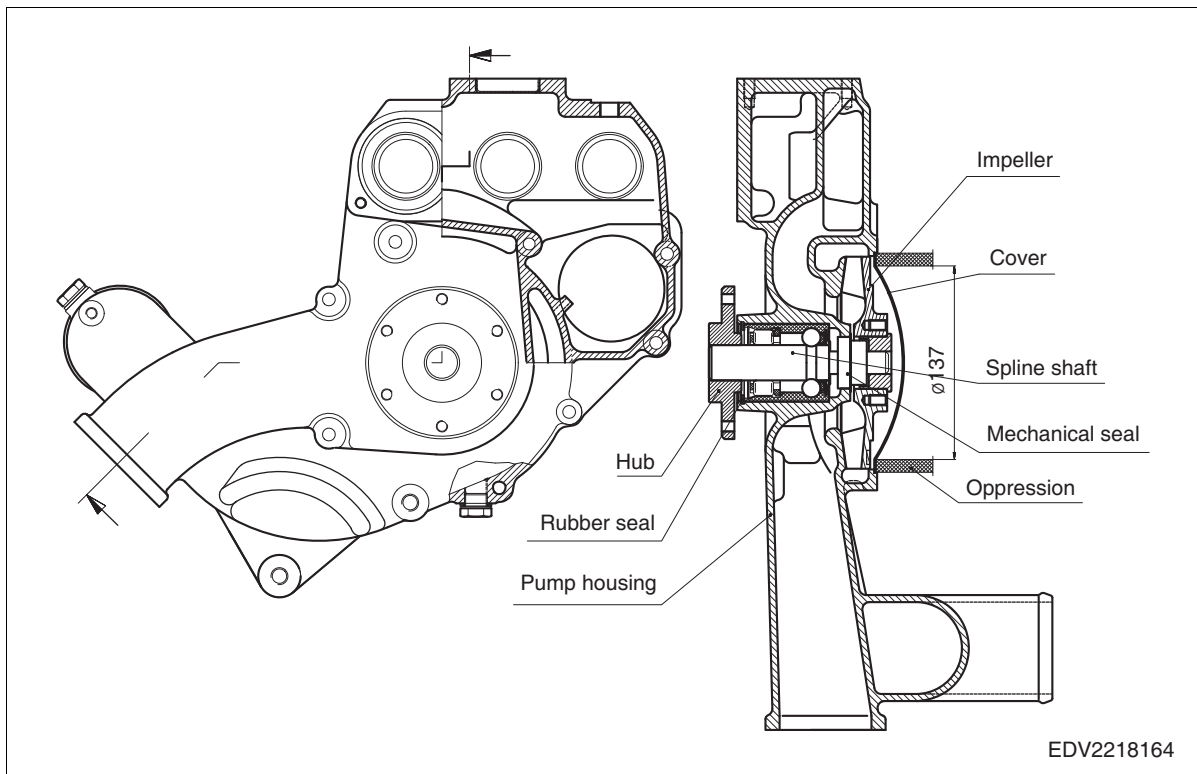
7.1.2.Oil pump



- | | |
|---------------------|------------------------|
| 1. Oil Pump Housing | 4. Oil Pump Gear |
| 2. Cover | 5. Oil Pump Drive Gear |
| 3. Oil Pump 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

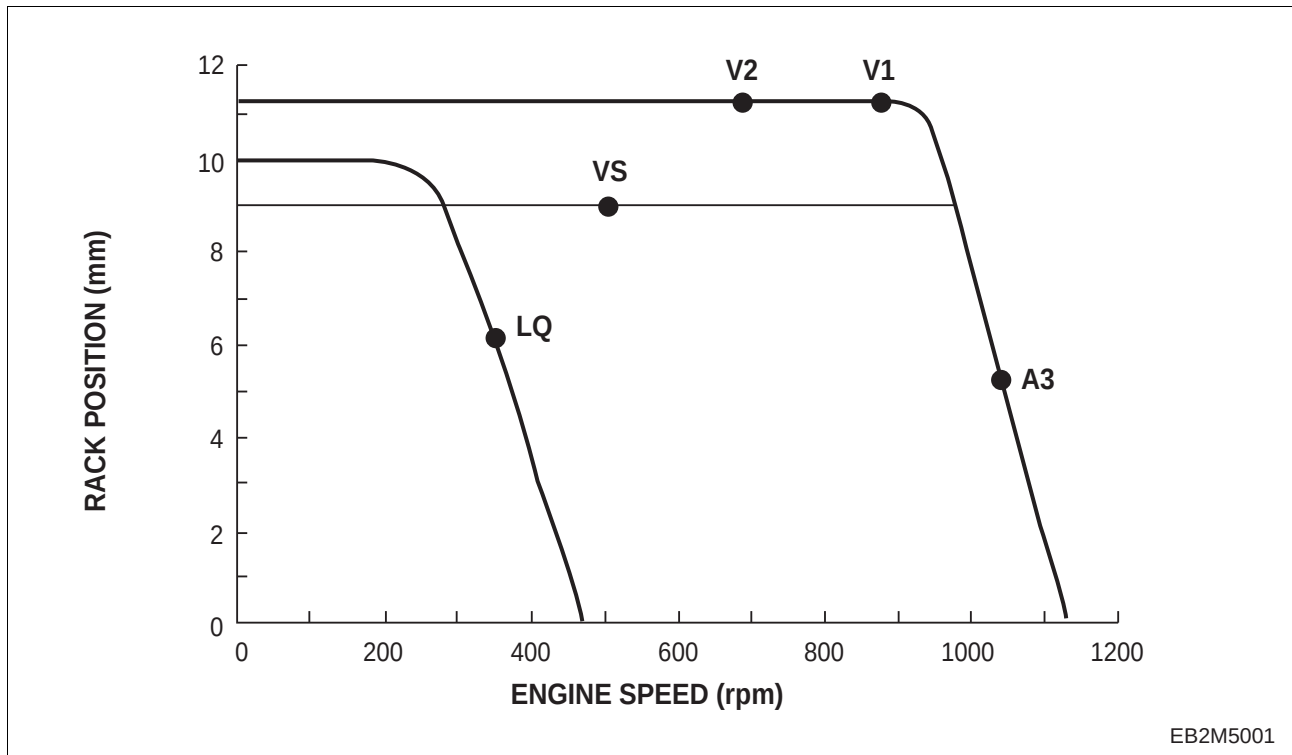
(1) Main data and specifications

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

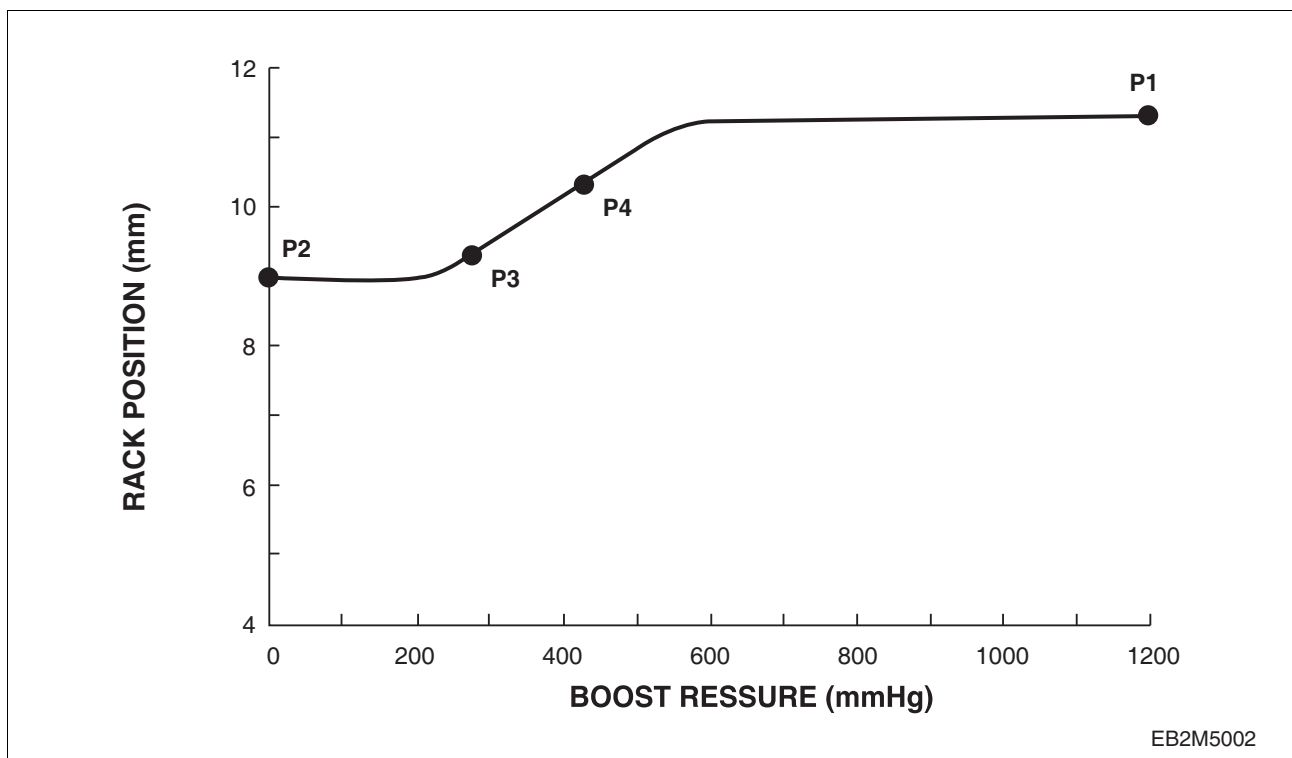
(2) Calibration data

(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						
Refer to (3) rack diagram	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	
	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)						
Refer to (4) boost pressure	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	
	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

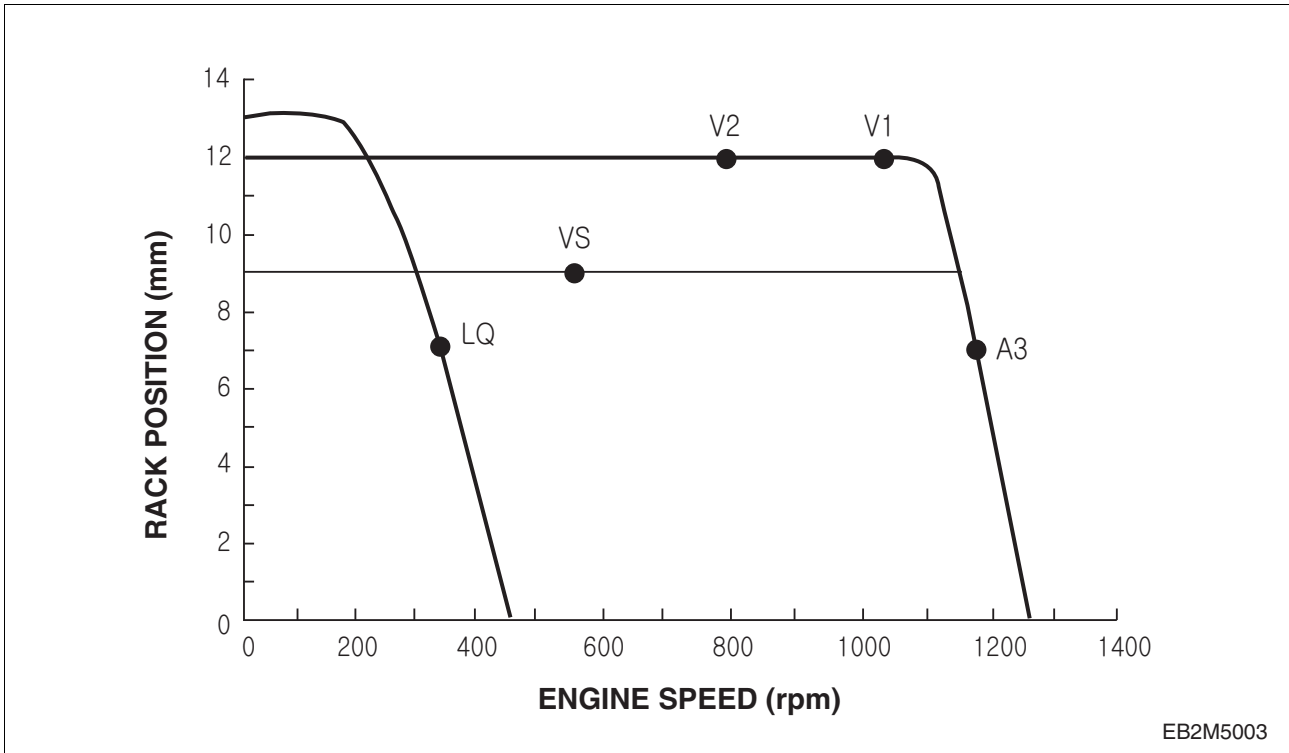
(1) Main data and specifications

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

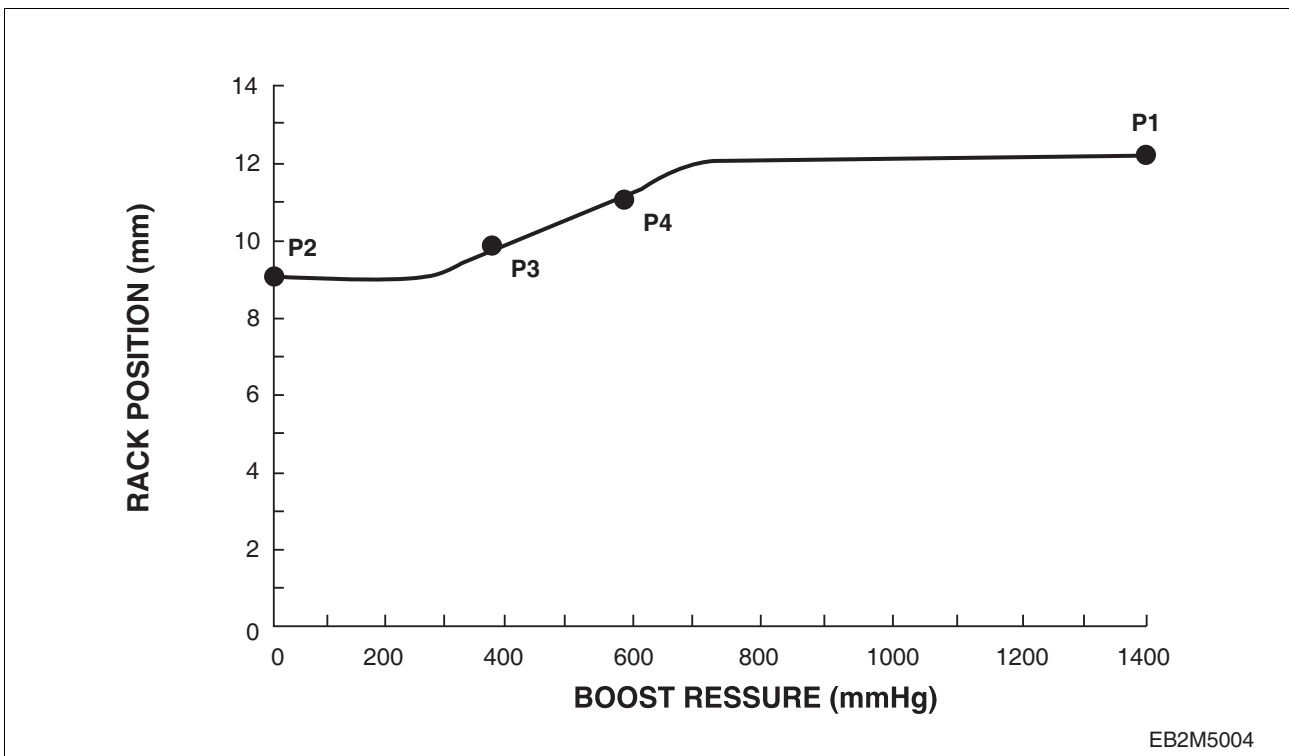
(2) Calibration data

(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)		Press. (mmHg)
				(A) Test condition for inj. pump	Remarks	
	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)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
	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

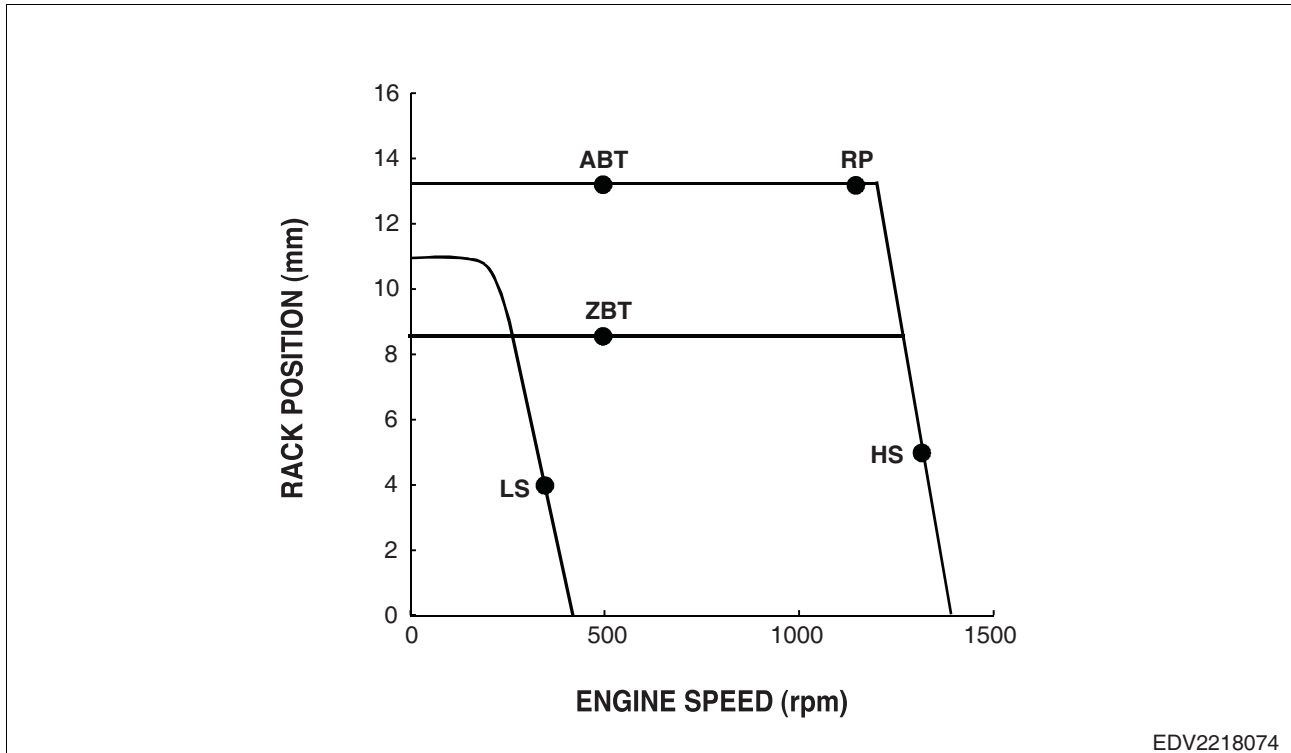
(1) Main data and specifications

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

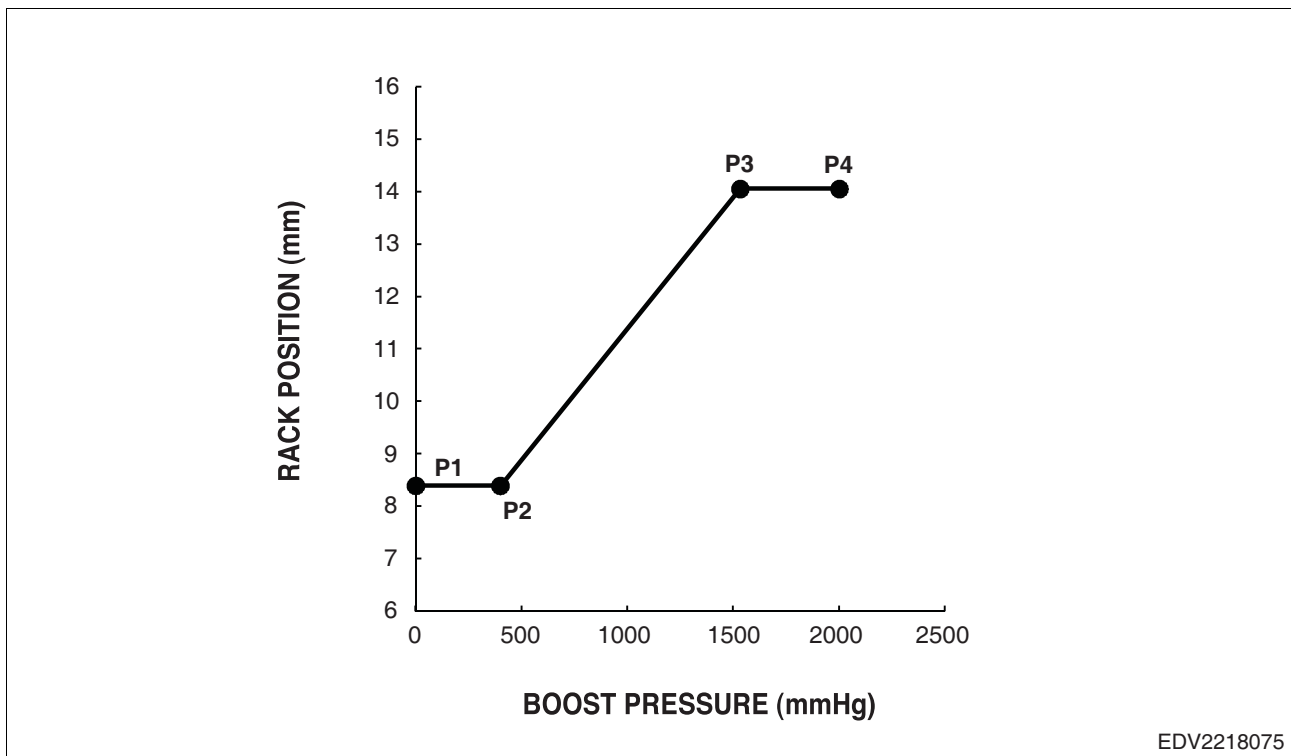
(2) Calibration data

(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						
Refer to (3) rack diagram	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	
	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)						
Refer to (4) boost pressure	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	
	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

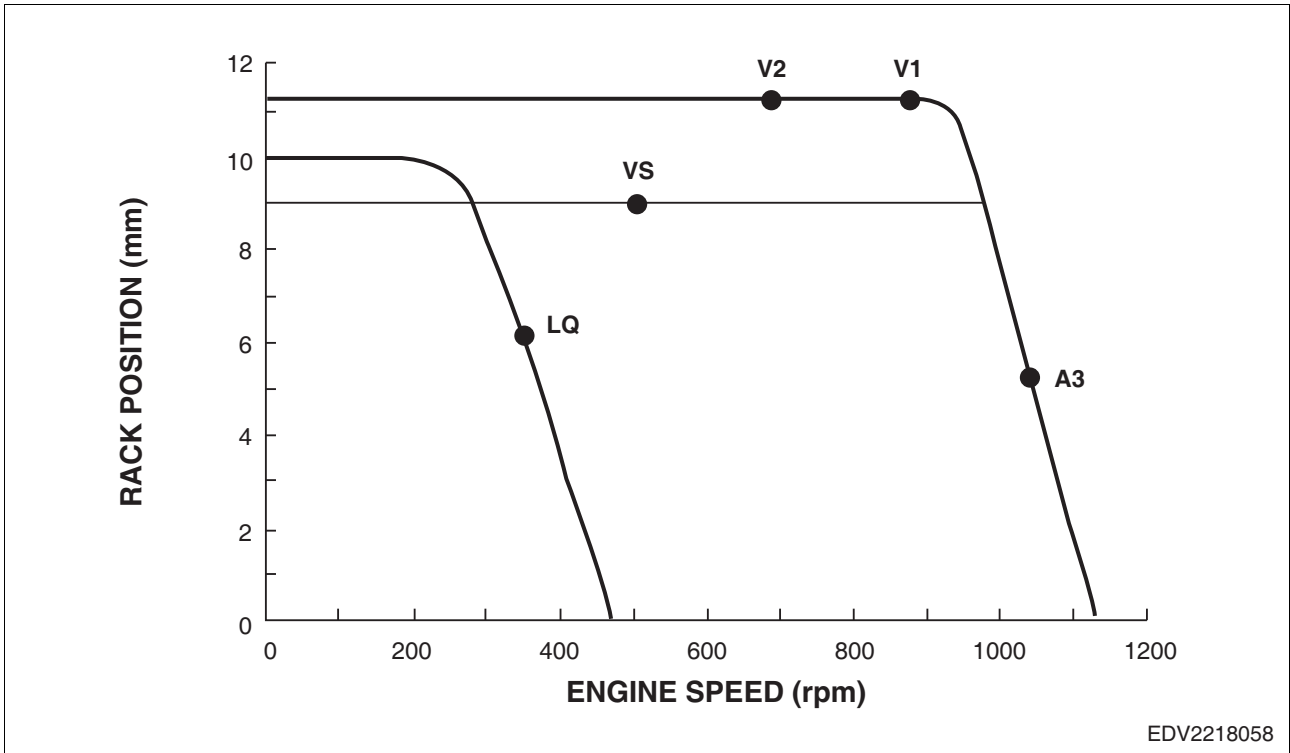
(1) Main data and specifications

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

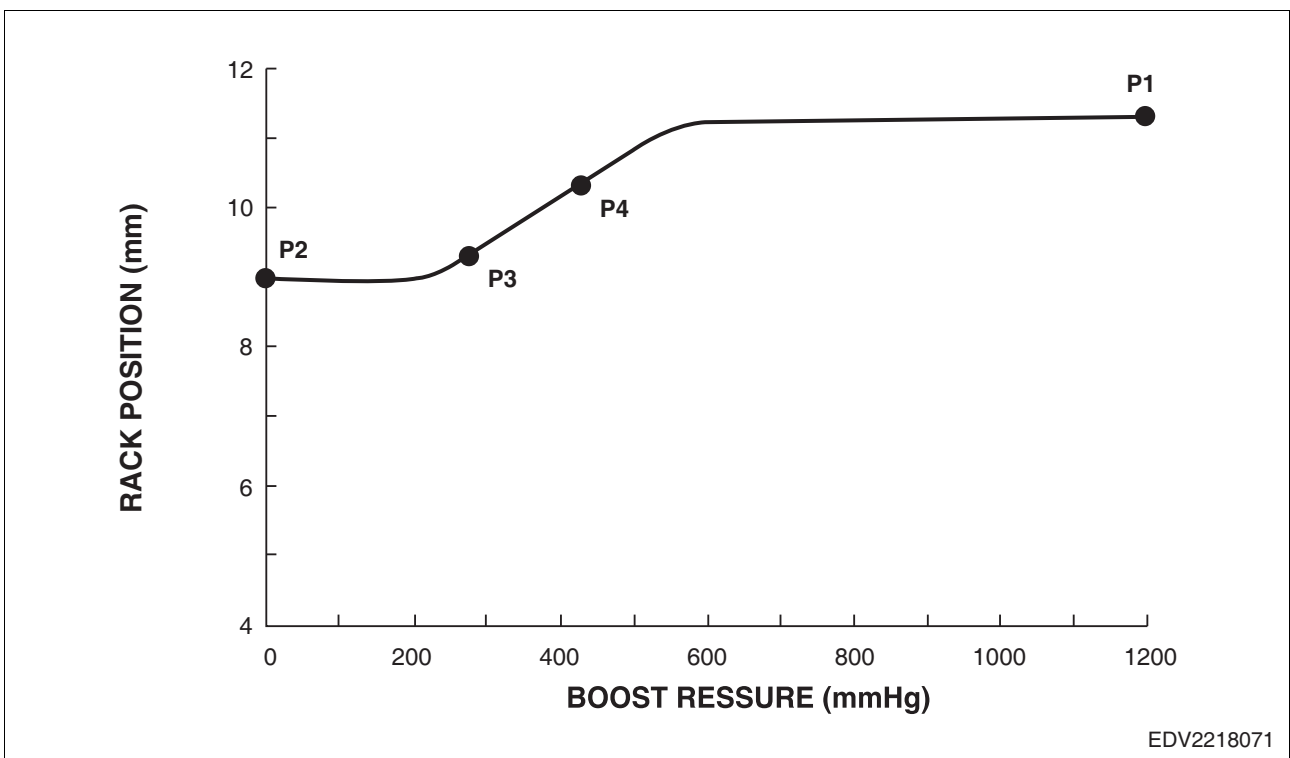
(2) Calibration data

(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)		Press. (mmHg)
				(A) Test condition for inj. pump	Remarks	
	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)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
	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

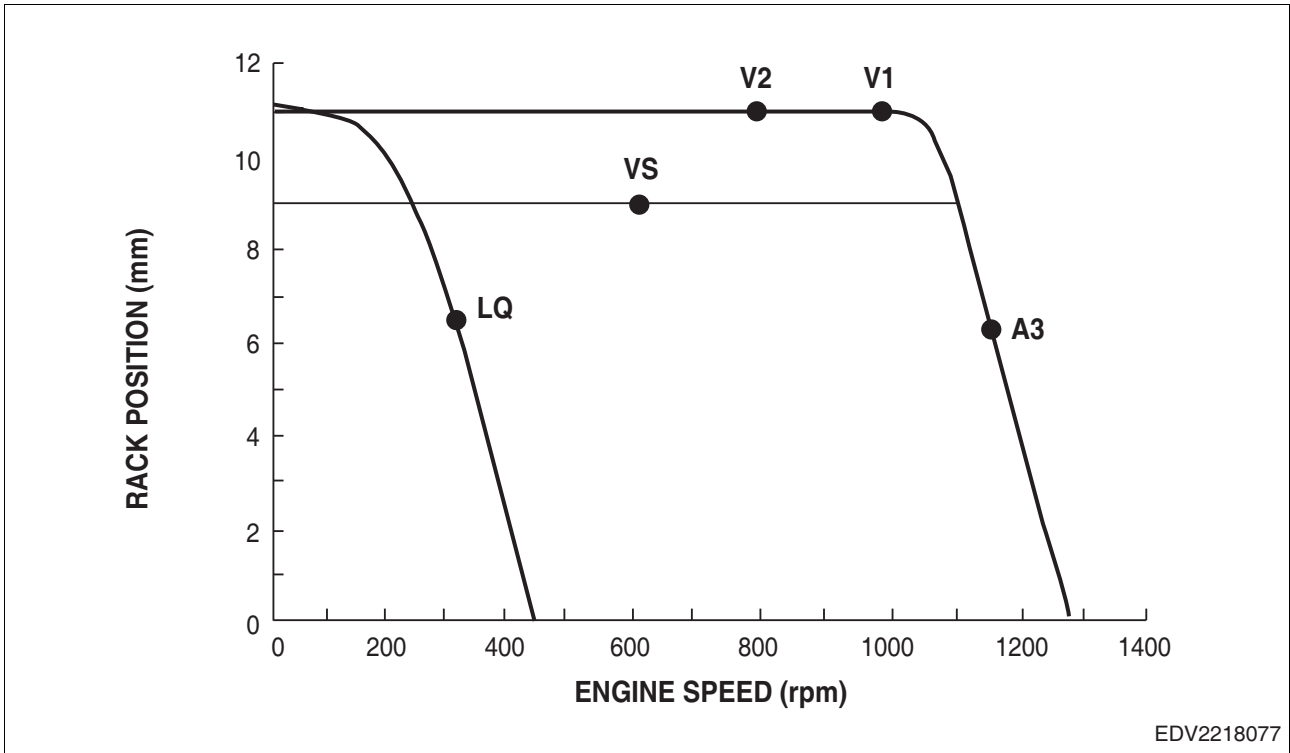
(1) Main data and specifications

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

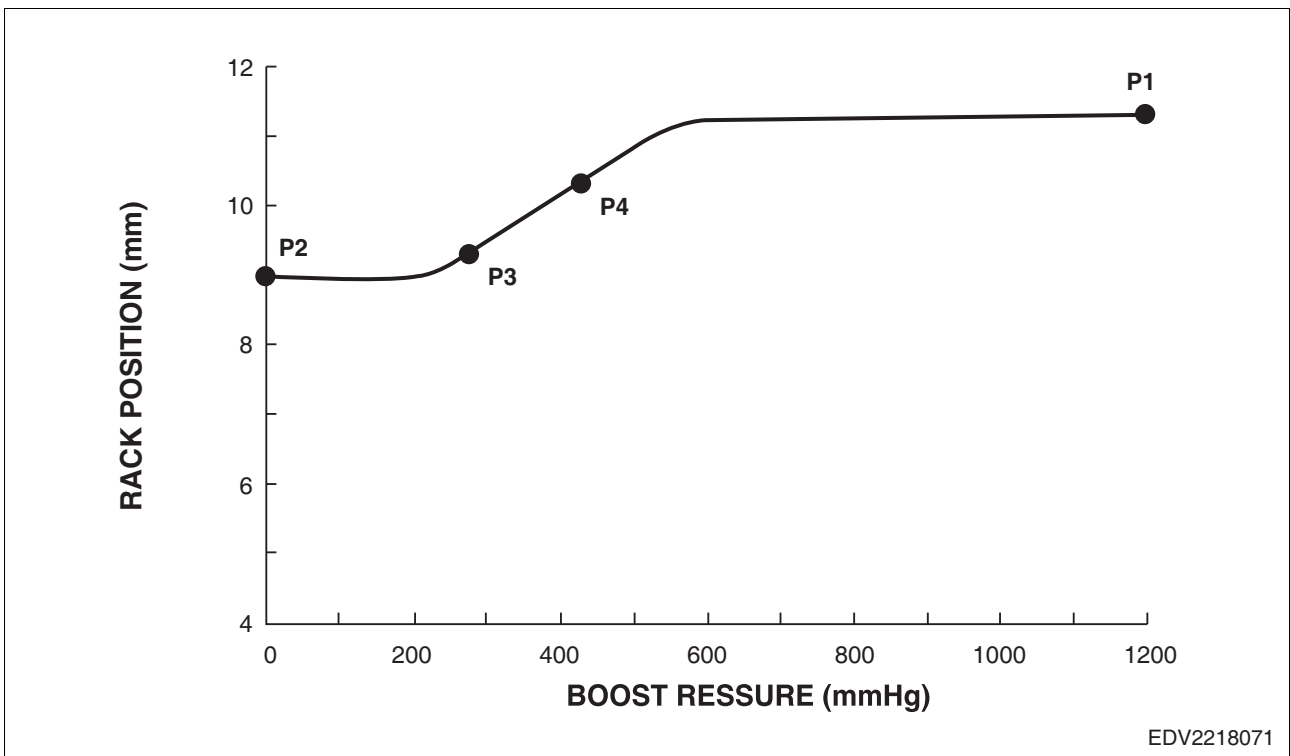
(2) Calibration data

(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)		Press. (mmHg)
				(A) Test condition for inj. pump	Remarks	
	V1	11.55 ±0.05	1,050	243.0 ±3.0	Max. power	1,500
	V2	11.55 ±0.10	800	240.4 ±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	1,150	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)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
	P1	11.55 ±0.05	500	-	-	1,500
	P2	8.96 ±0.05	500	-	-	0
	P3	9.9 ±0.10	500			275
	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	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

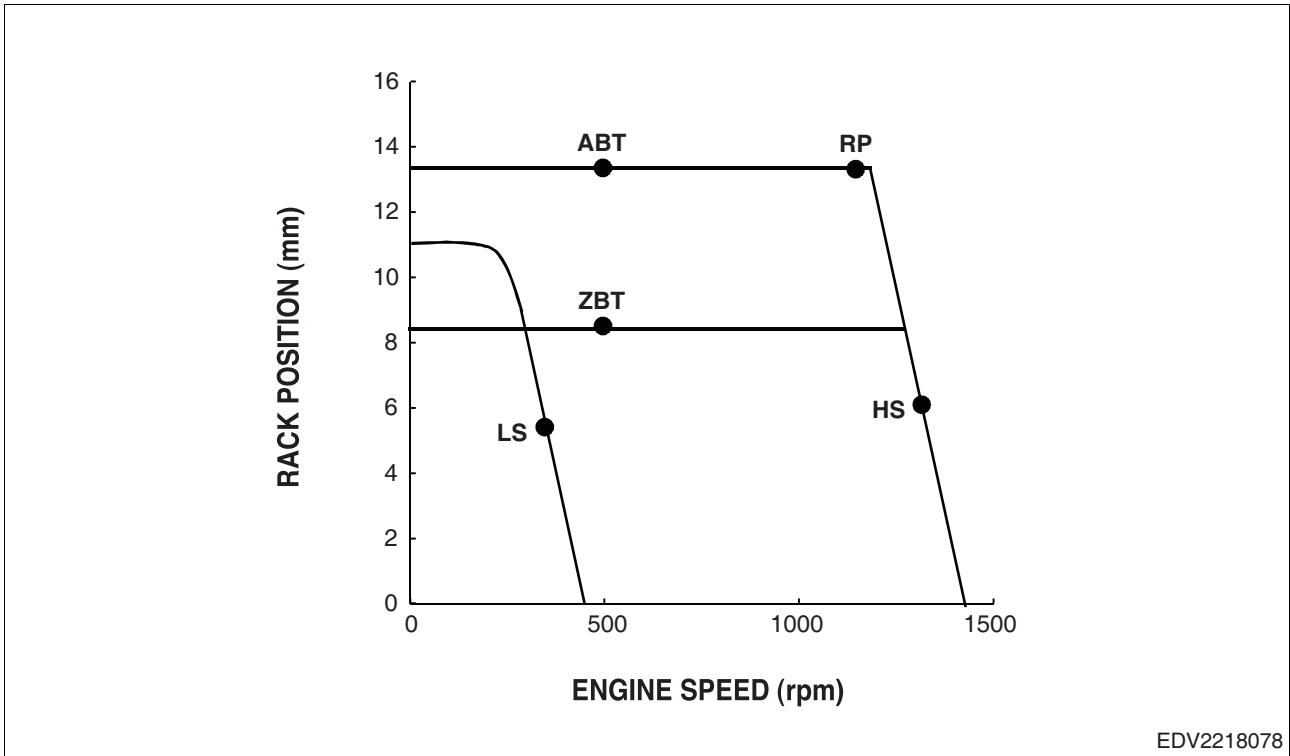
(1) Main data and specifications

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

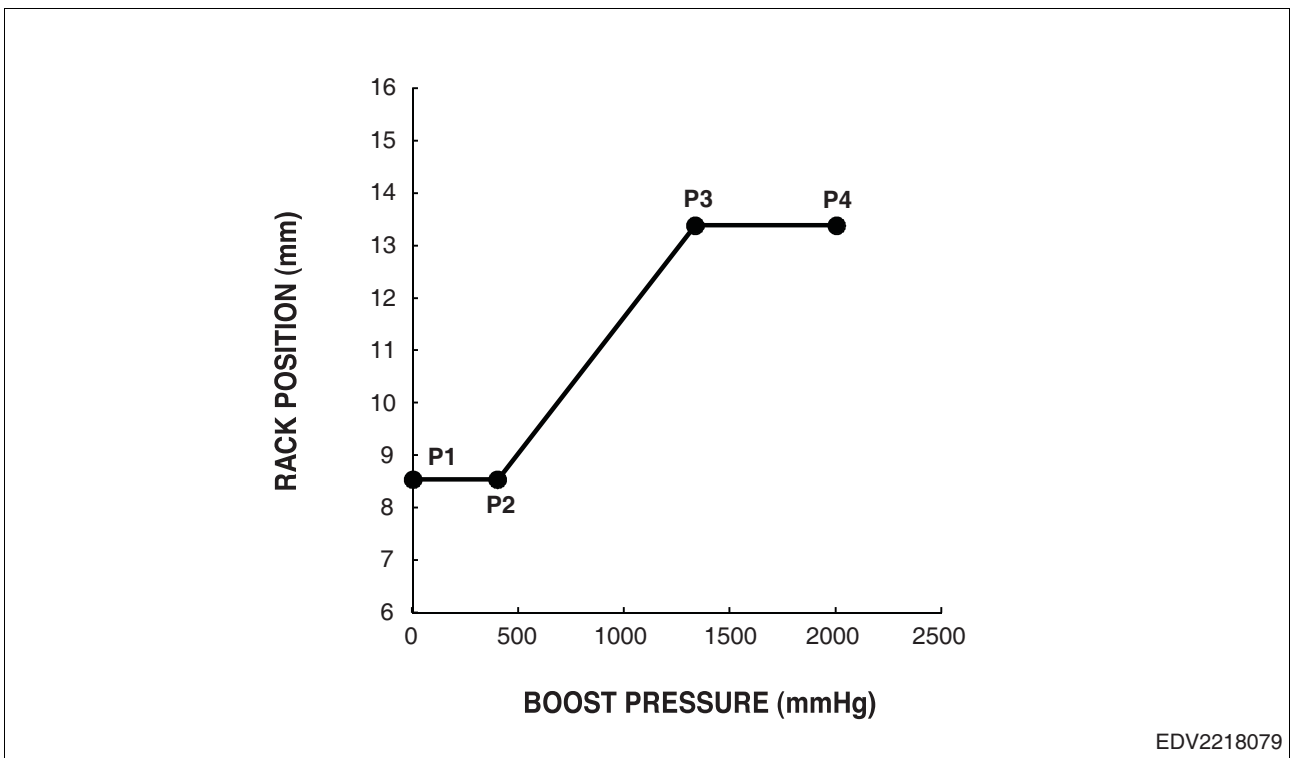
(2) Calibration data

(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)		Press. (mmHg)
				(A) Test condition for inj. pump	Remarks	
	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)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
	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=30.50N/mm	Delivery valve spring			k = 7.2N/mm	
Feed spring	Double action	Timer			None	

(3) Rack diagram



(4) Boost compensator pressure



7) V222TIH

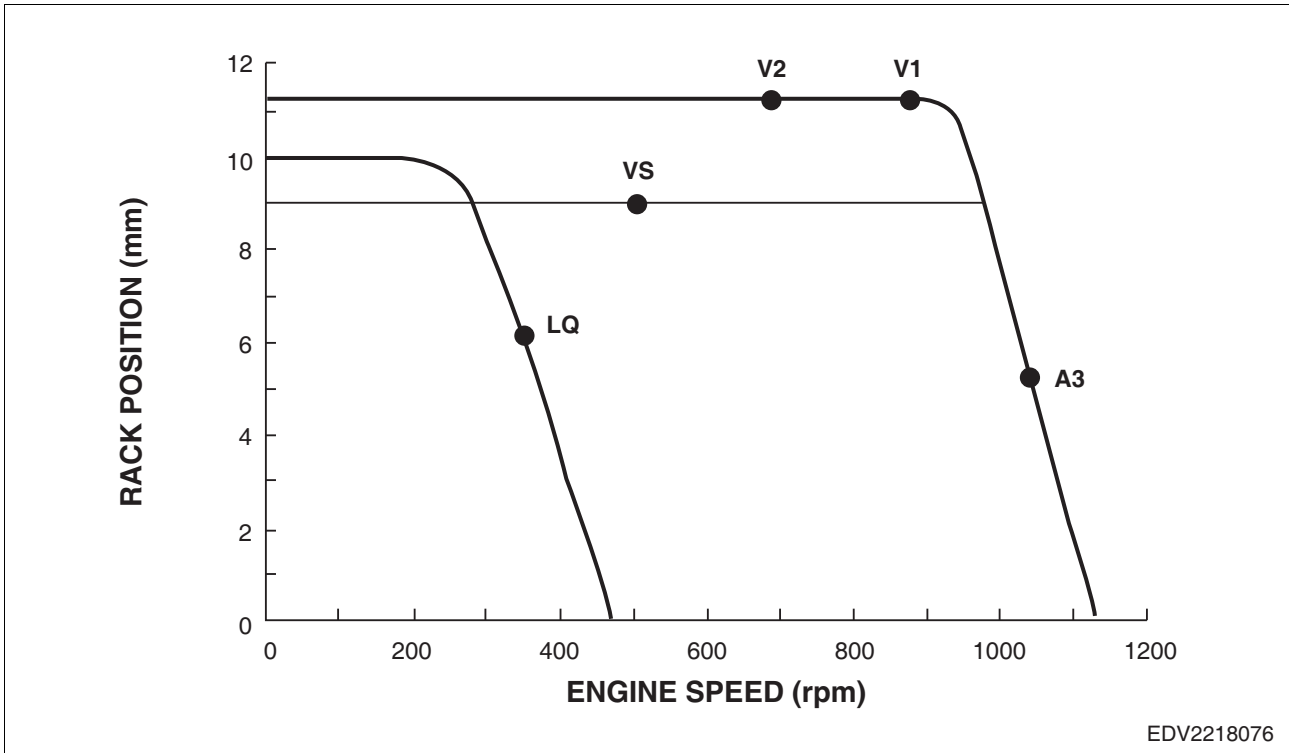
(1) Main data and specifications

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 17 ±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

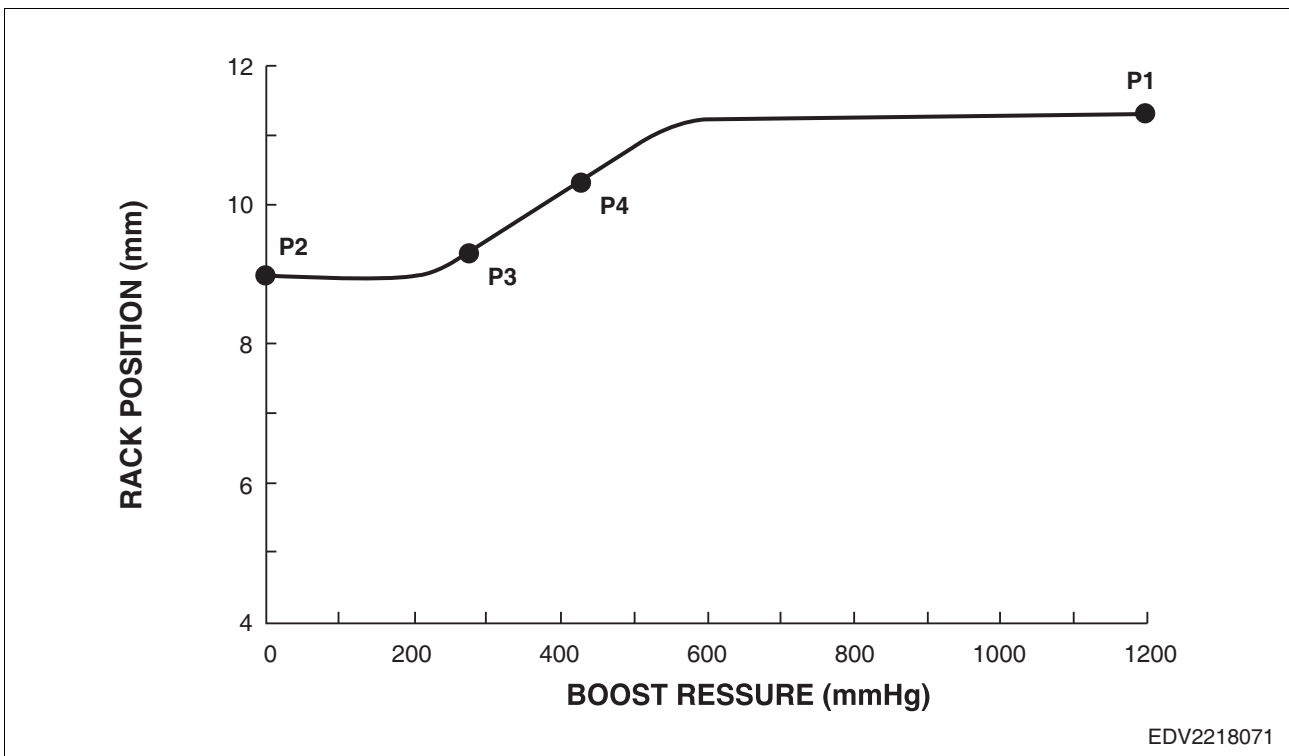
(2) Calibration data

(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)		Press. (mmHg)
				(A) Test condition for inj. pump	Remarks	
	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)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
	P1	11.55 ±0.05	500	-	-	1,500
	P2	8.96 ±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



8) V222TIM

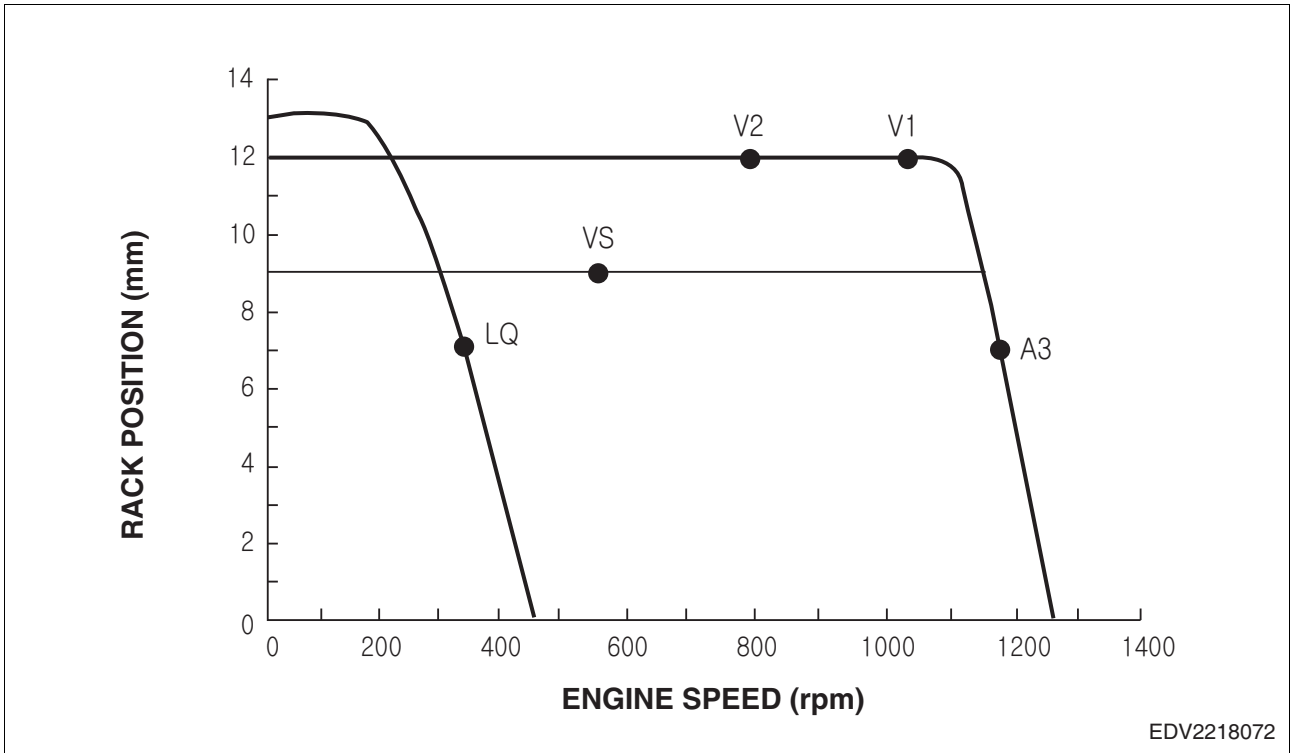
(1) Main data and specifications

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 18 ±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

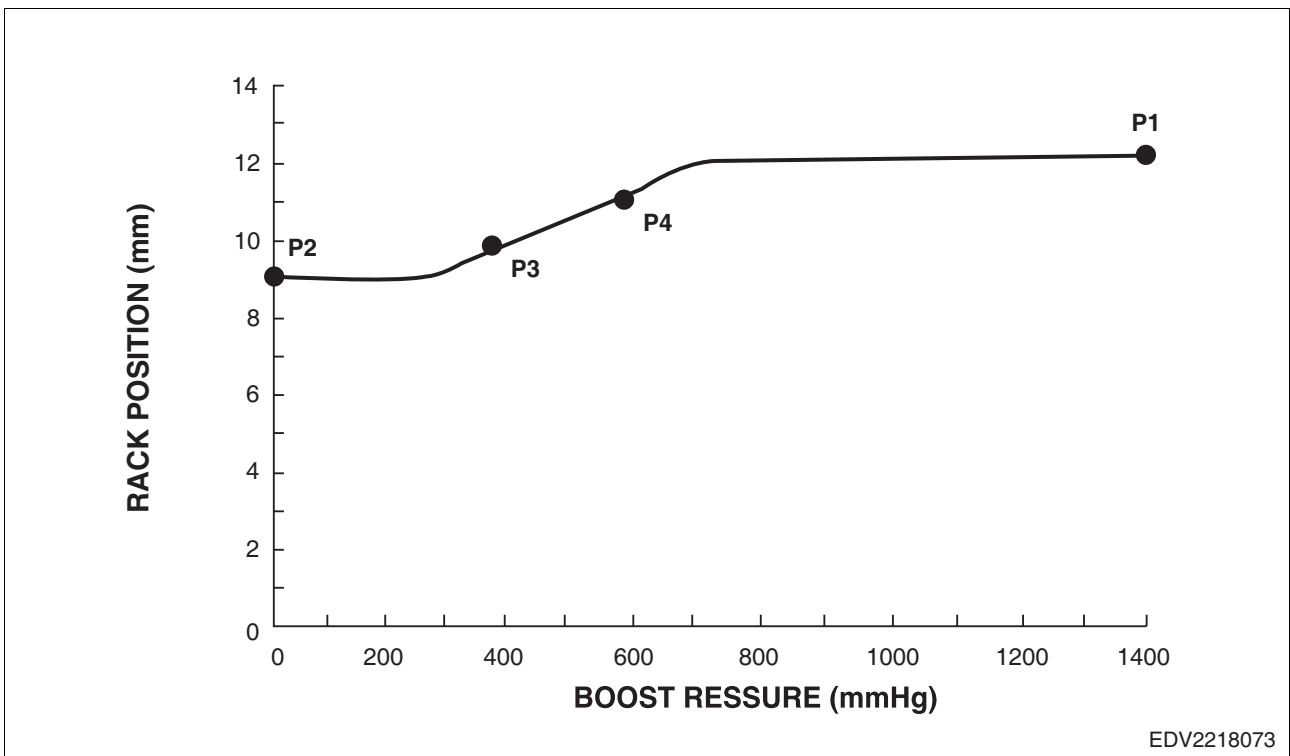
(2) Calibration data

(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)		Press. (mmHg)
				(A) Test condition for inj. pump	Remarks	
	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)		Press. (mmHg)
				(A) Test condition for inj. pump	(B) Engine standard parts	
	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

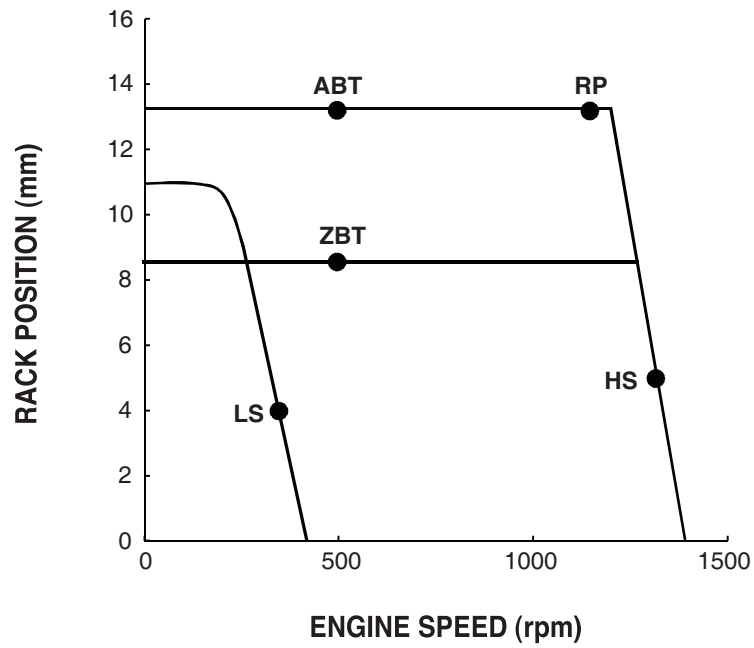
(1) Main data and specifications

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 19 ±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

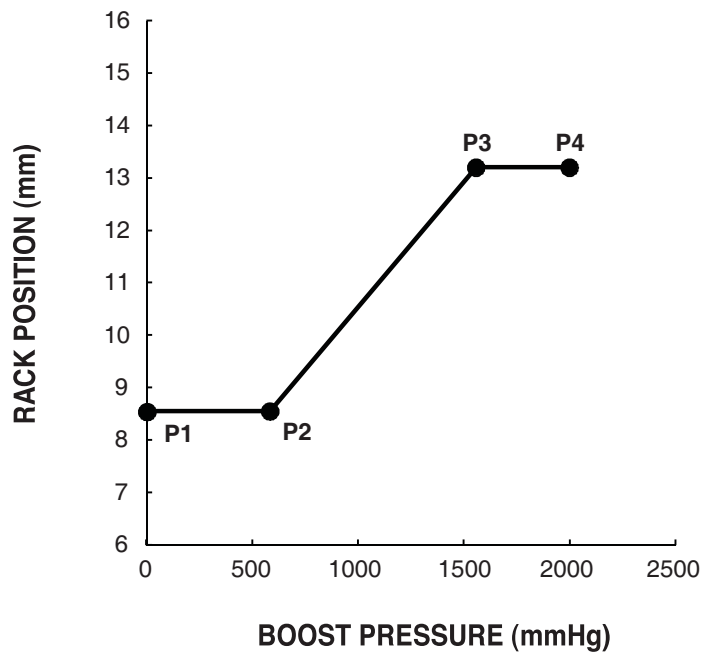
(A) Test condition for injection pump	Nozzle & Holder ass'y		1 688 901 019	Opening pressure : 212.6 bar		
	Injection pipe (OD, ID, L)		1 680 750 075	ø3.0 x ø8.0 x 1,000 mm		
	Test oil		FUSUS	Temperature : 40 ±5°C		
(B) Engine standard parts	Nozzle & Holder ass'y		65.10101-7053	Nozzle (5 × ø0.418)		
			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						
Refer to (3) rack diagram	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	
	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)						
Refer to (4) boost pressure	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	
	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



EDV2218074

(4) Boost compensator pressure



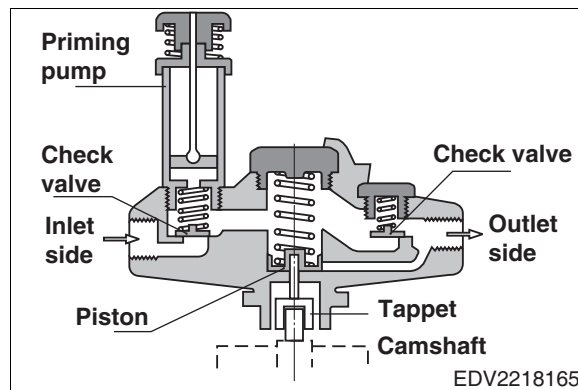
EDV2218081

7.3.2. Fuel feed pump

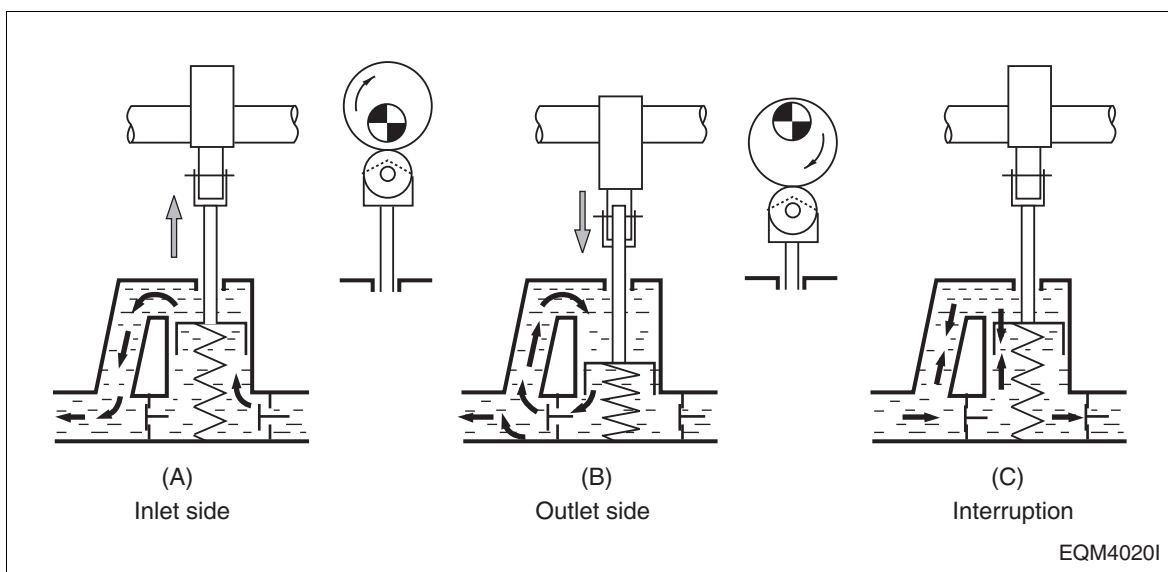
1) General descriptions and construction

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.

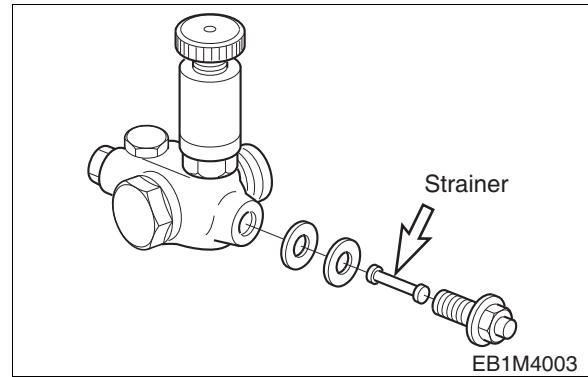


When the cam reaches the Bottom Dead Center as shown in the figure, the fuel is drawn in through the check valve on the inlet side. The fuel pressurized as the cam rotates on flows through the check valve on the outlet side as shown in (B). If feeding pressure increases abnormally, the spring is compressed,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

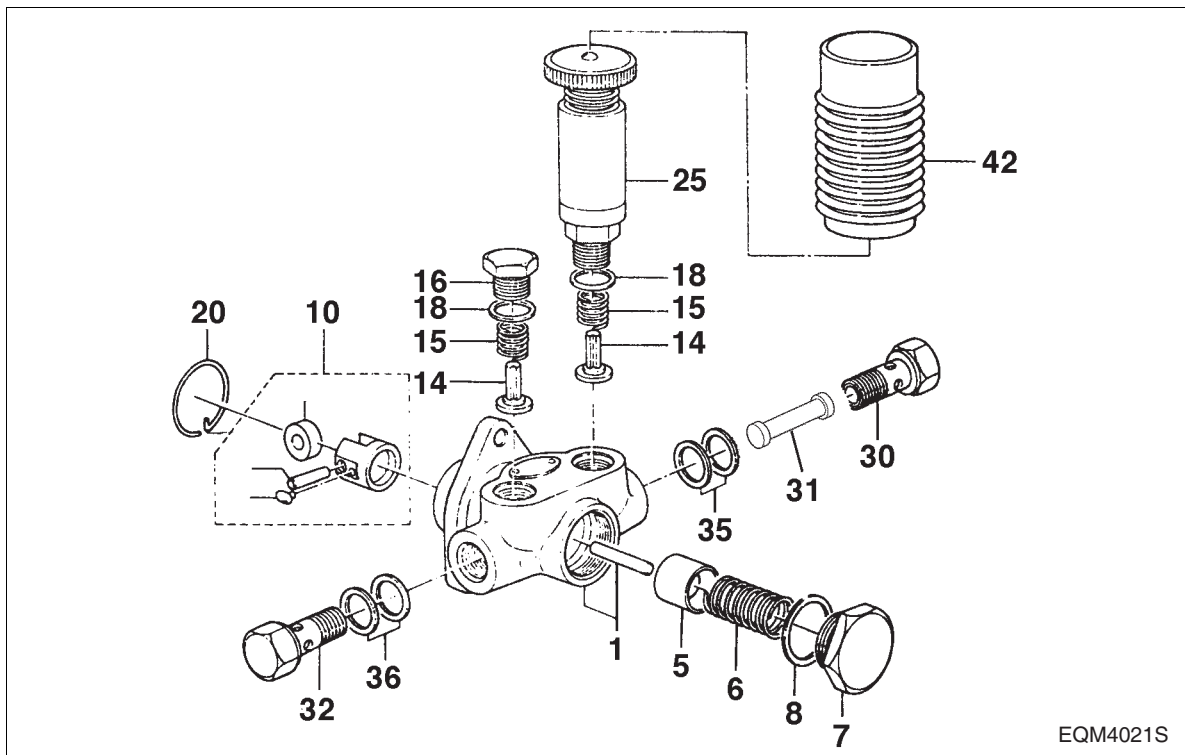


This feed pump is mounted with a priming pump designed to permit manual feeding of fuel from the fuel tank with the injection pump mounted in the engine. During the manual feeding operation, air must be bled from the fuel lines. When using the priming pump, fix it securely to prevent the possible entry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

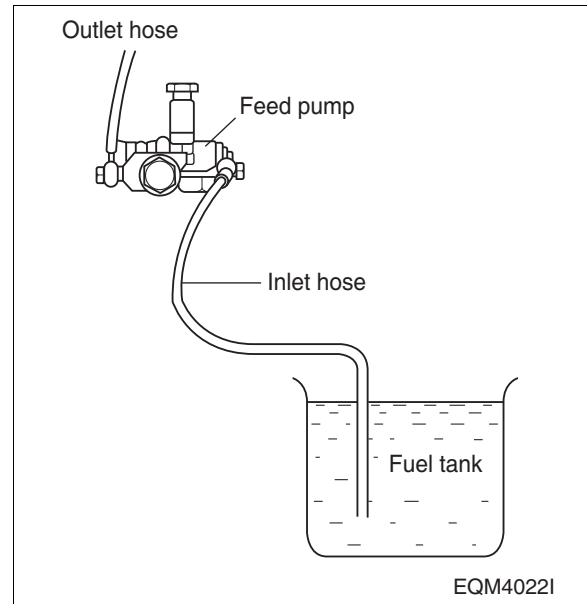
- Re-assembly operation is performed in reverse order of disassembly. All the gaskets must be replaced with new ones at re-assembly.

5) Testing

- Suction capacity test

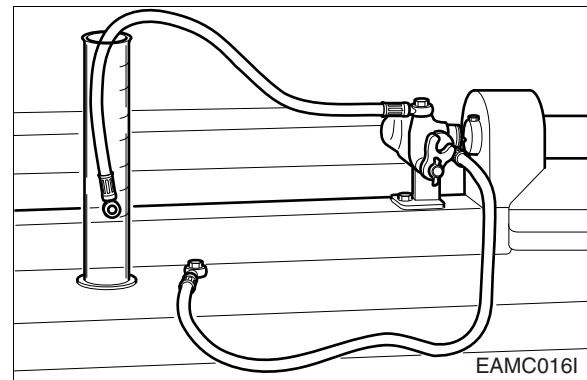
Connect one end of a hose to the inlet side of the feed pump and immerse the other end of it into the fuel tank as illustrated.

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.



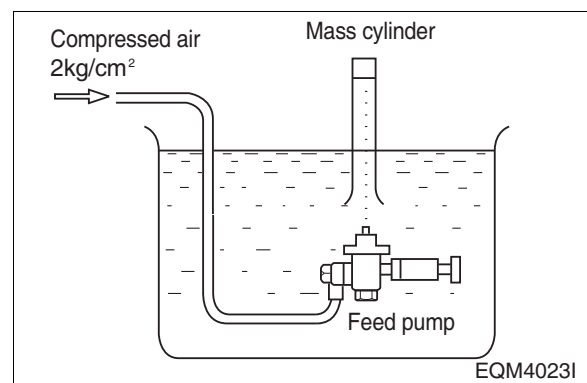
- Delivery test

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

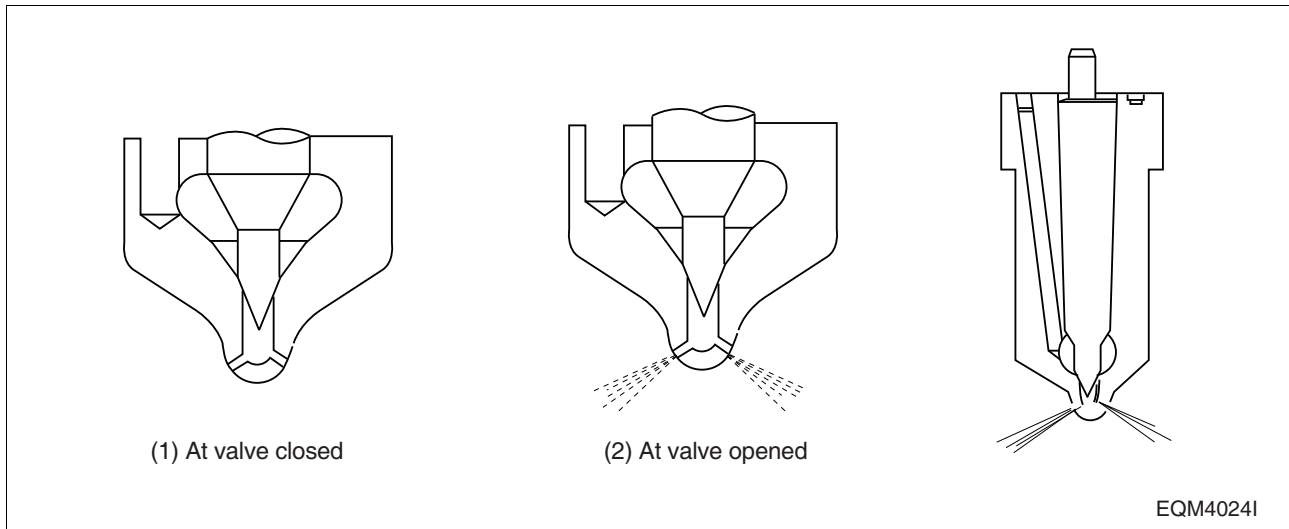
Plug up the delivery port on the feed pump and apply compressed air of 2 kg/cm² into the inlet side. Submerge the feed pump in a container of diesel fuel and check for air leak.



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.

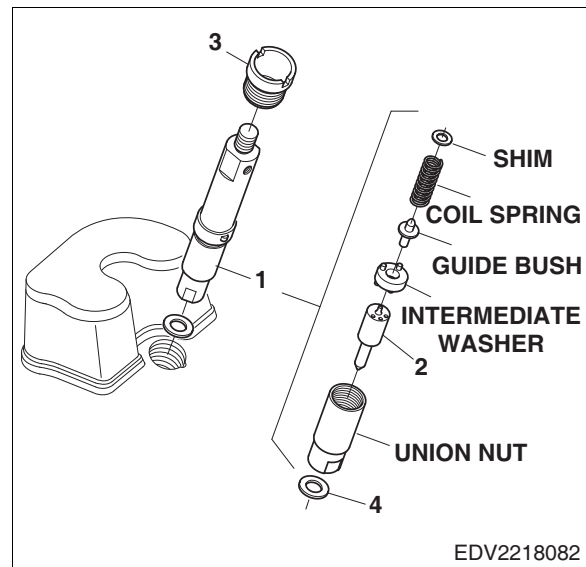
The fuel injected should necessarily be ignited immediately and combusted in a short period of time as too long a combustion period will prevent the high speed operation of the engine and can cause serious engine knocking.



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

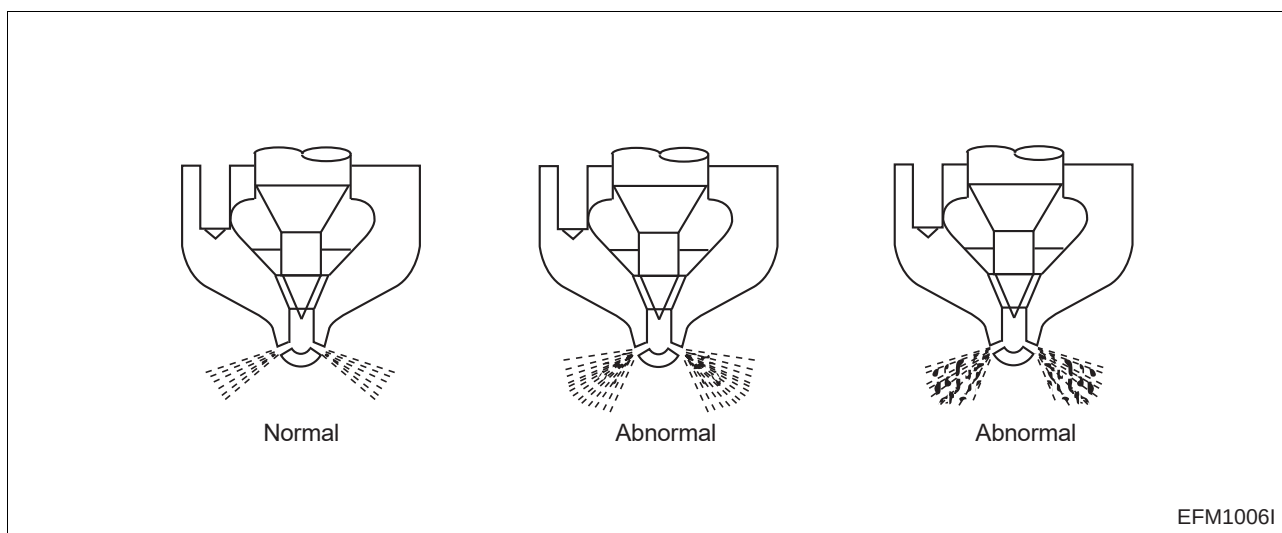
- After removing carbon deposit, submerge the nozzle in diesel oil and clean it.
- Replace all the gaskets with new ones.
- Assemble the parts and tighten them to specified torque.

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.



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

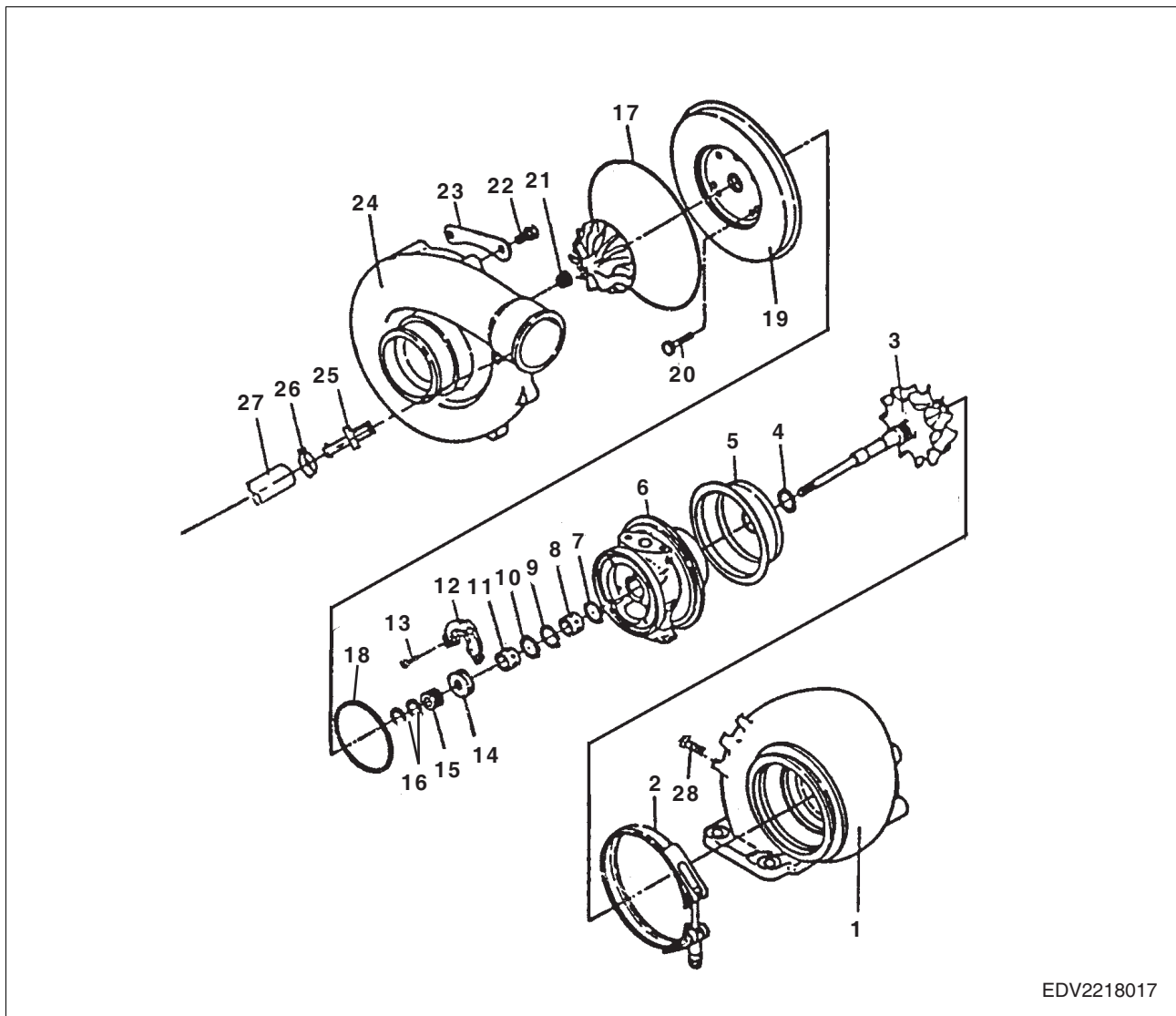
7.4.1. Specification

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



EDV2218017

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

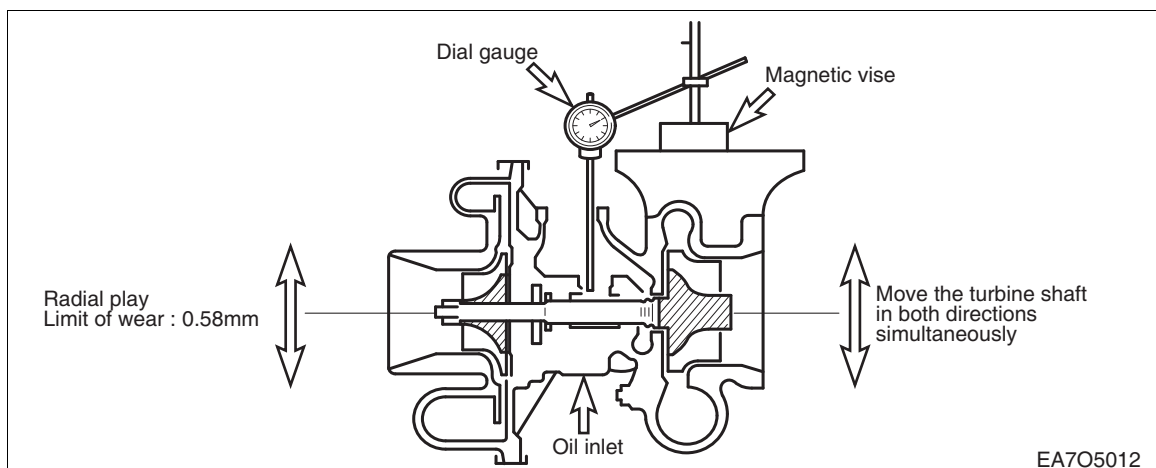
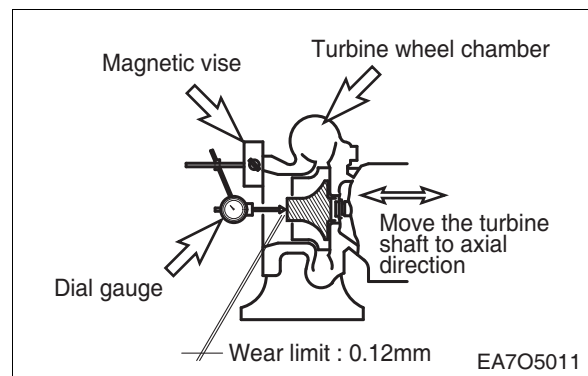
- (1) When disassembling the turbocharger, be sure to plug the oil inlet and outlet ports
- (2) If the measured axial and radial plays are beyond the limit of wear, replace or repair the turbocharger.

● Measuring rotor axial clearance

Axial clearance	0.12 mm
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● Measuring radial clearance

Radial clearance	0.58 mm
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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.

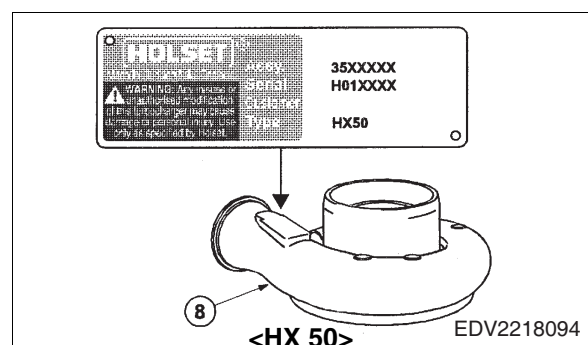
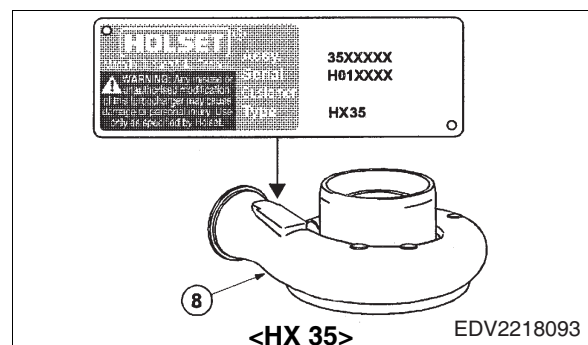
(3) Exhaust system

- 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.

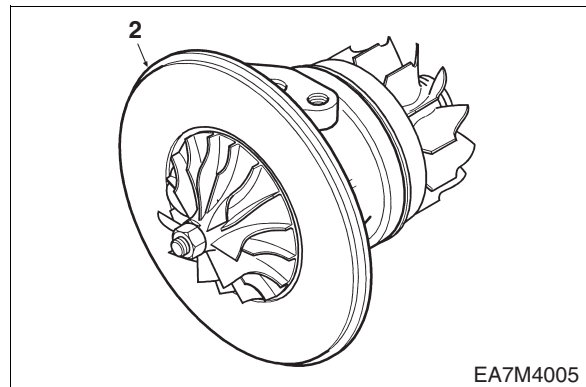
7.4.4. Component Identification

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.

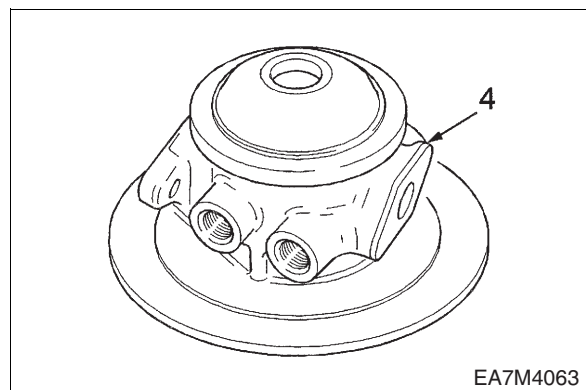


2) Center housing rotating assembly



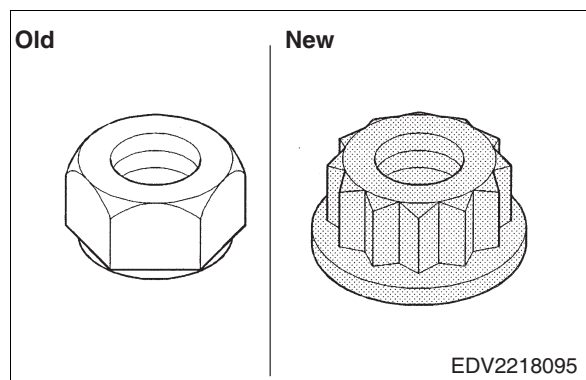
3) Watercooled bearing housing (4)

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 turbo-charger 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 Ins
New lock nut	17	150
Old lock nut	16	160

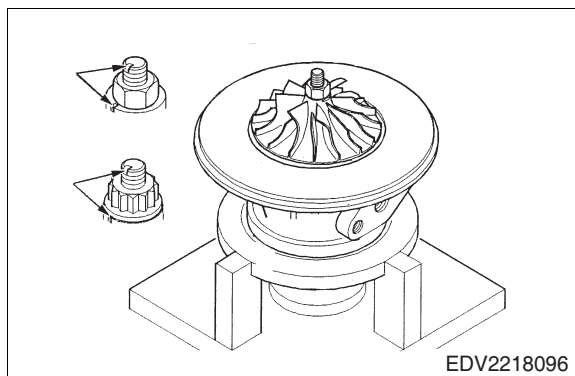


Caution :

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

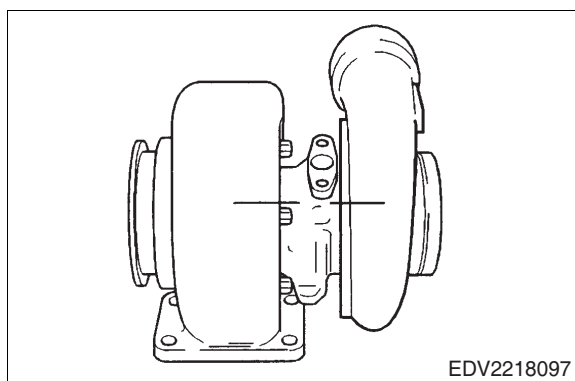
If no marks exist, scribe the shaft and compressor wheel (as shown) before removing the compressor wheel lock nut.

Always check balance the rotor before rebuild.

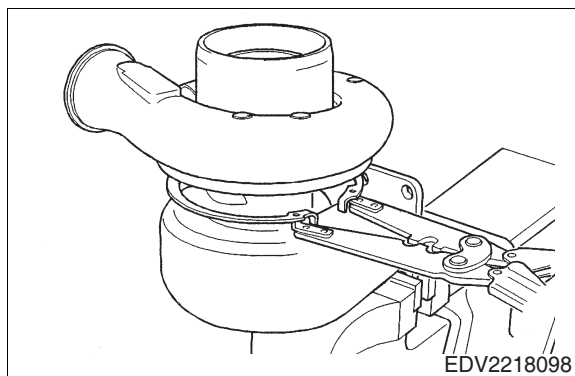


7.4.5. Disassembly

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

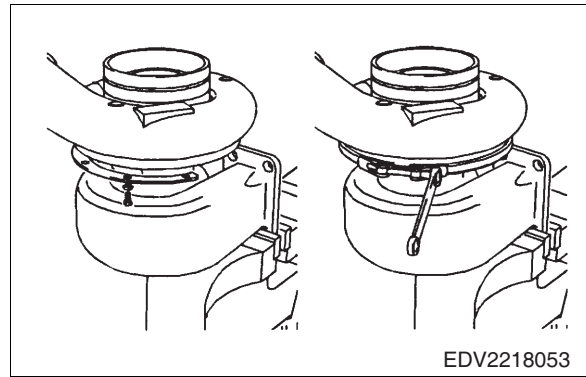


- Secure the turbine housing (5) in a vice.
HX35 : Remove the compressor cover circlip (91) using circlip pliers.



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).

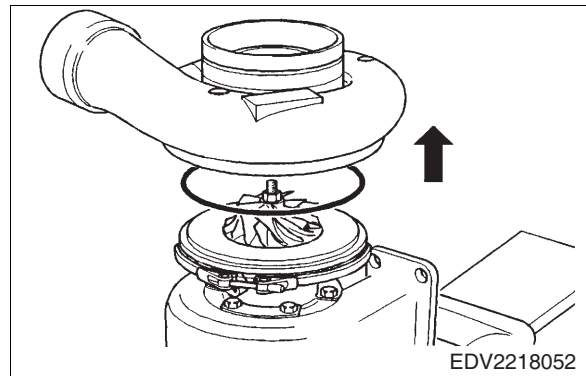


- Gently remove the compressor cover (8), and if fitted, remove the O-ring seal (41).

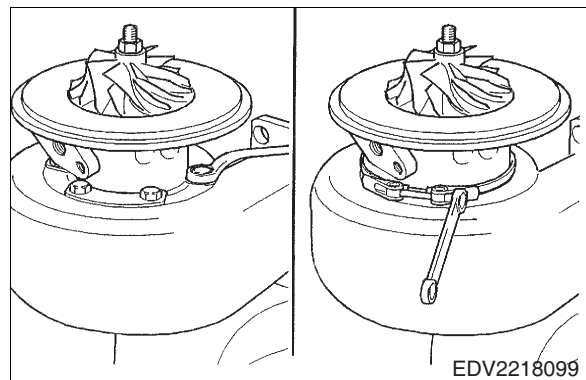


Caution :

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



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

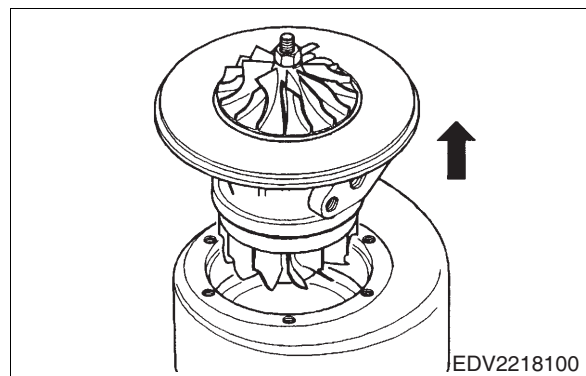


- Remove the CHRA from the turbine housing.



Caution :

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



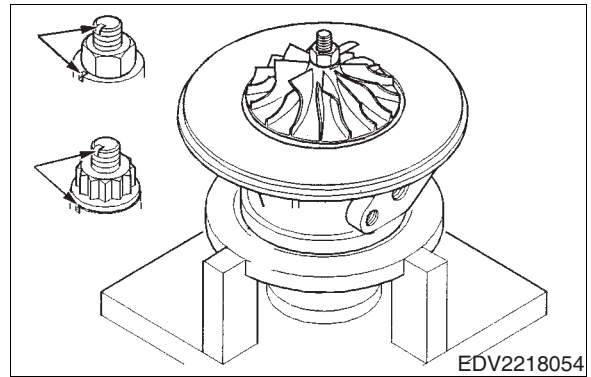
- Locate the Center Housing Rotating Assembly (CHRA) onto a 19 mm socket clamped in the jaws of a vice or a suitable fixture.



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.)

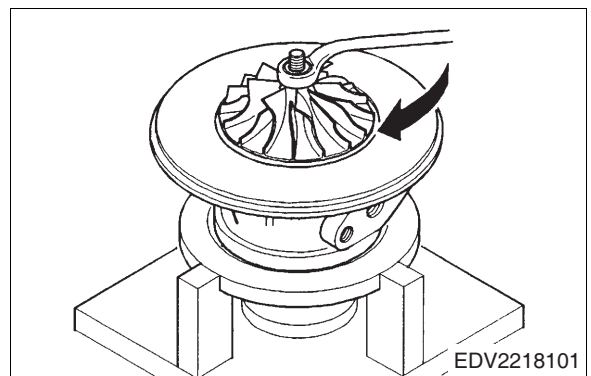


- Remove the compressor wheel lock nut (61).

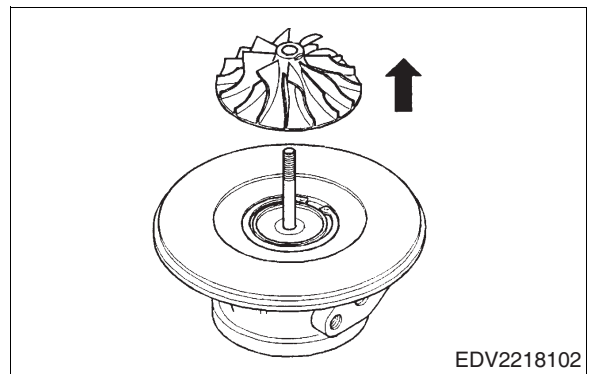


Note :

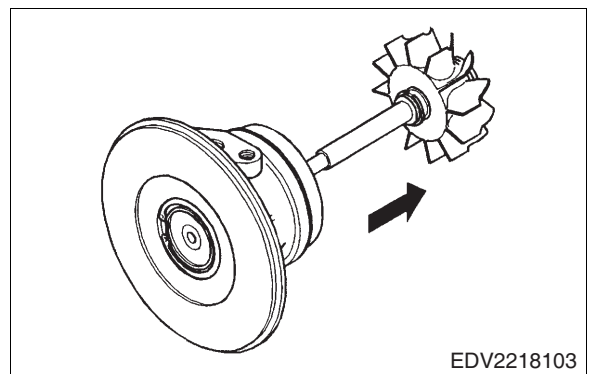
Left hand thread.



- 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).

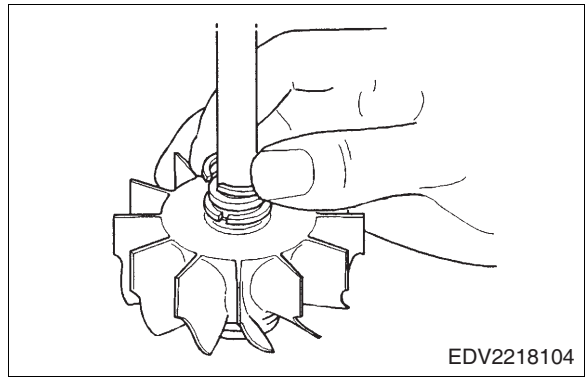
- HX35(V158TI) : 1EA

- HX50(V180TI/V222TI) : 2EA

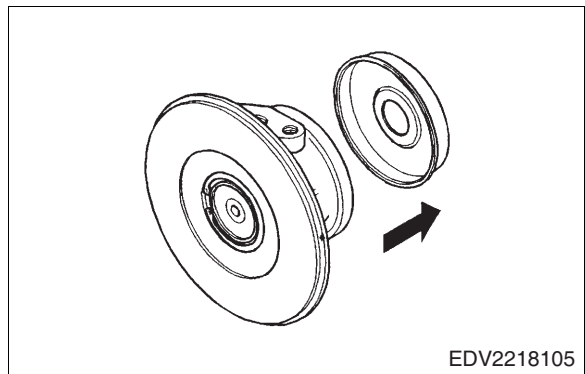


Caution :

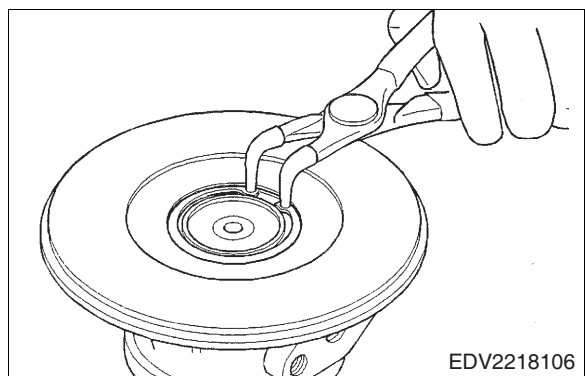
Care should be taken not to score the assembly turbine wheel shaft.



- Remove the heat shield (38).

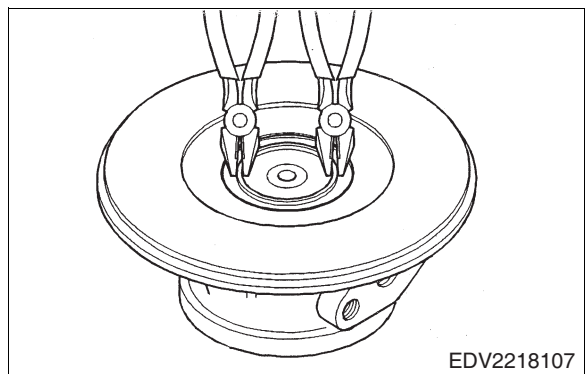


- Place the bearing housing on a flat surface and using circlip pliers, remove the insert retaining ring (66).

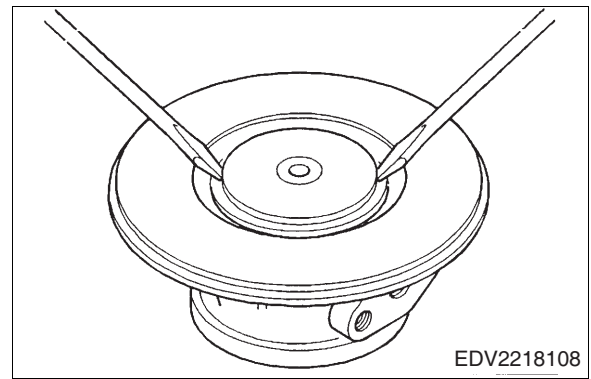


- Gently remove the oil seal plate (43) as follows.

- **HX35** : Using two flat nose pliers

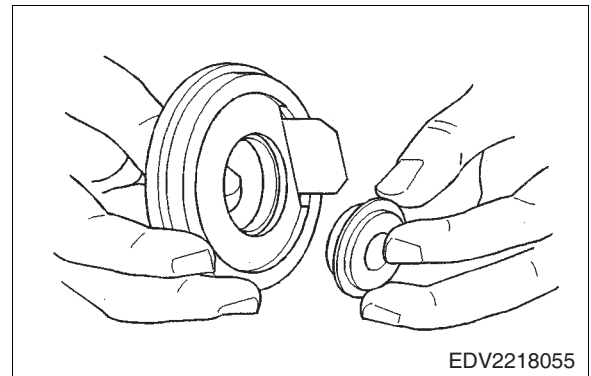


- **HX50** : Using two flat screwdrivers.

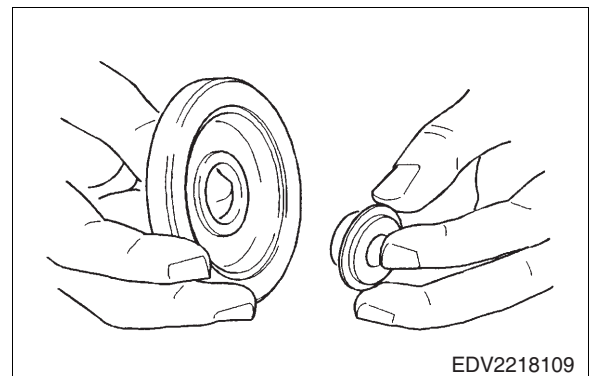


- Remove the oil slinger (31).

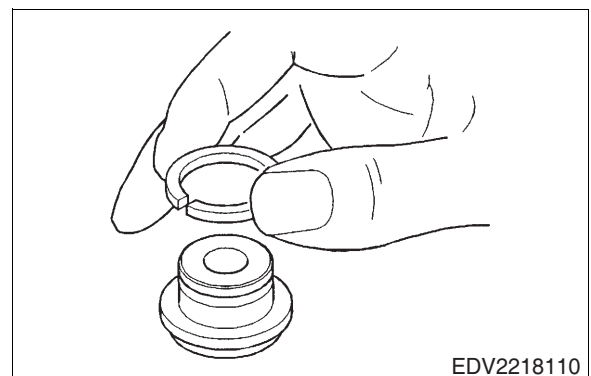
- **HX35**



- **HX50**

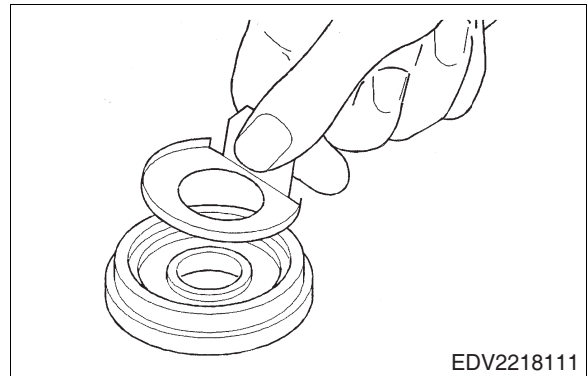


- Remove and discard the piston ring seal (16).

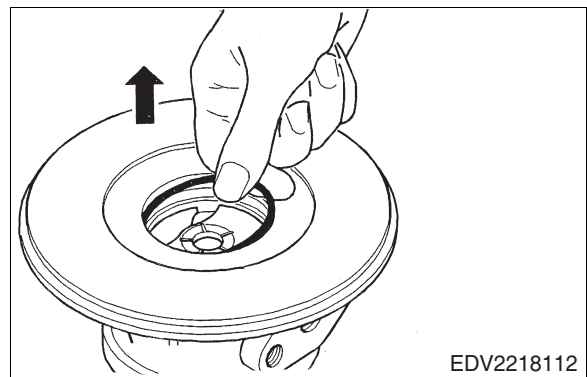


<HX35>

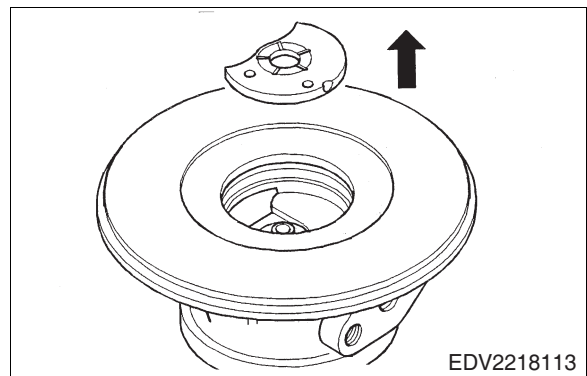
- Remove and discard the oil baffle (33).



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

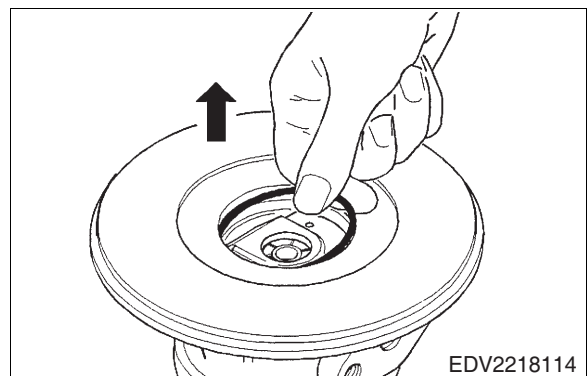


- Remove the thrust bearing (12).

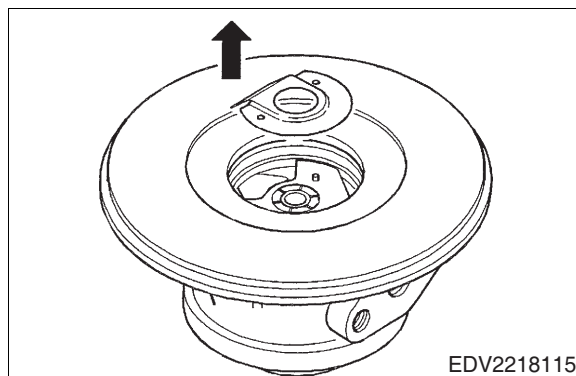


<HX50>

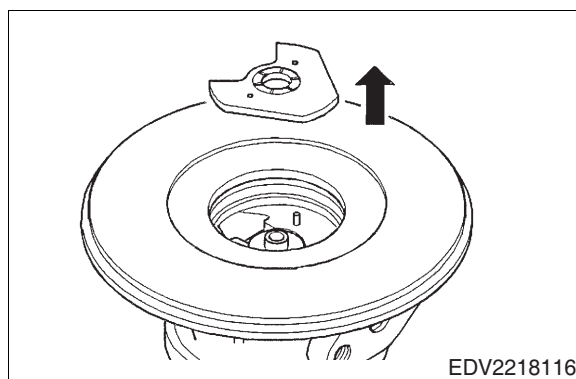
- Remove and discard the O-ring seal (32).



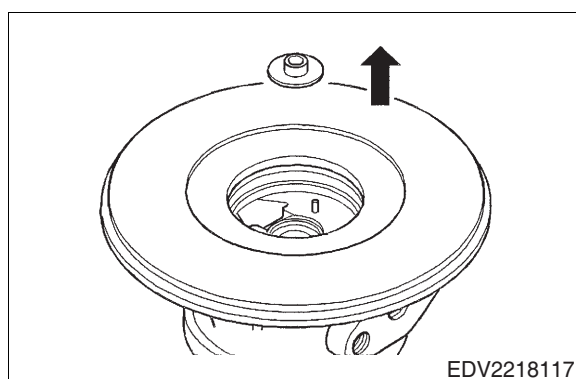
- Remove and discard the oil baffle (33).



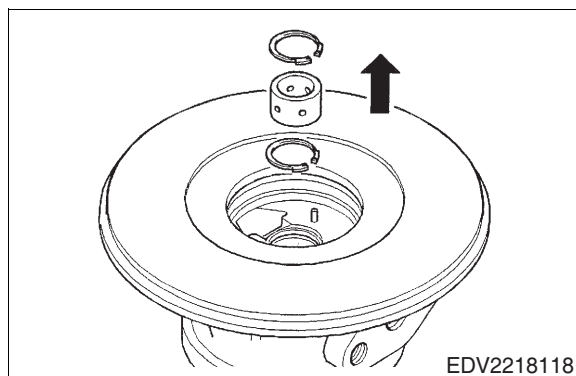
- Remove the thrust bearing (12).



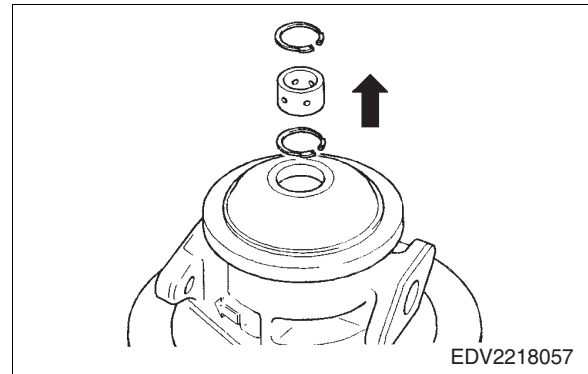
- Remove the thrust collar (36).



- 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 turbocharger 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



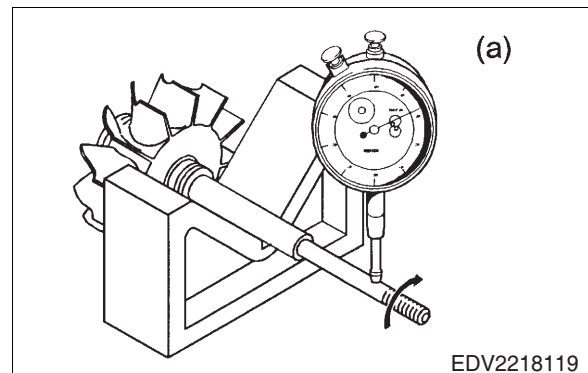
Caution :

Do not attempt to straighten the turbine shaft.



- 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)



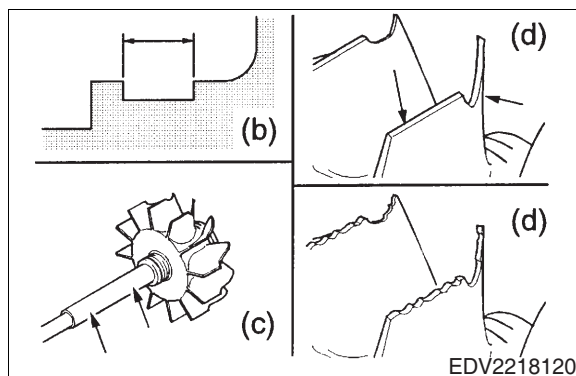
- b) Inspect the piston ring groove walls for wear.

- 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 journals (Min.)	mm	in.
	10.972	0.432

- HX50 (V180TI/ V222TI)

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



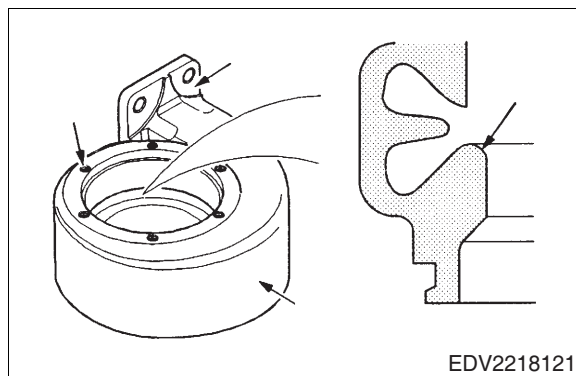
- d) Inspect for cracked, bent or damaged blades but **DO NOT ATTEMPT TO STRAIGHTEN BLADES.**

● 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.

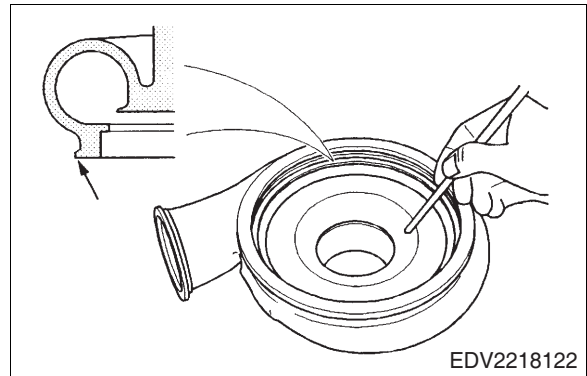


- **Compressor housing (8)**



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.



- **Bearing housing (4)**

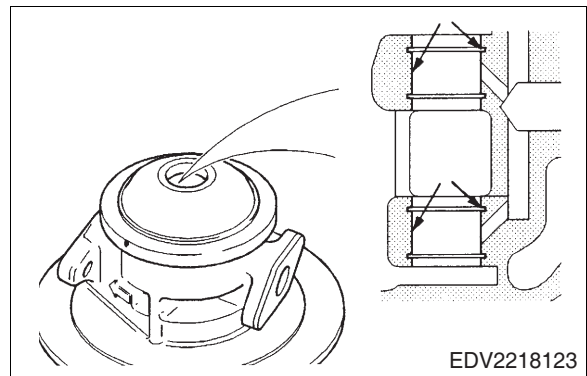


Inspect the bore for wear or score mark on both the bearing and piston ring area. Also check all tapped holes are clean and free from dirt.

Replace with new if any damage is found.

- HX35 (V158TI)

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

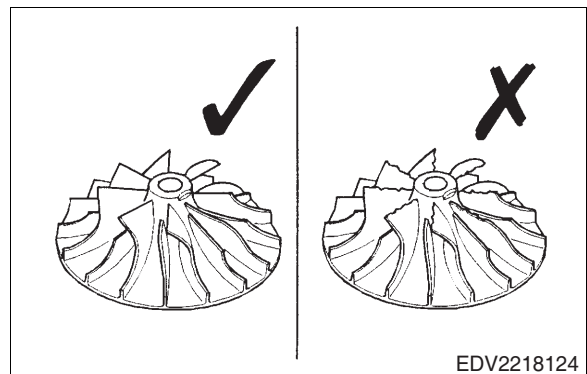


- **Compressor wheel (7)**



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

Replace with new if any damage is found.

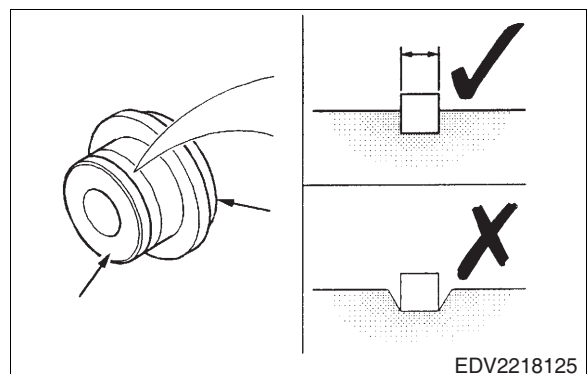


<Minor components>

- **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.

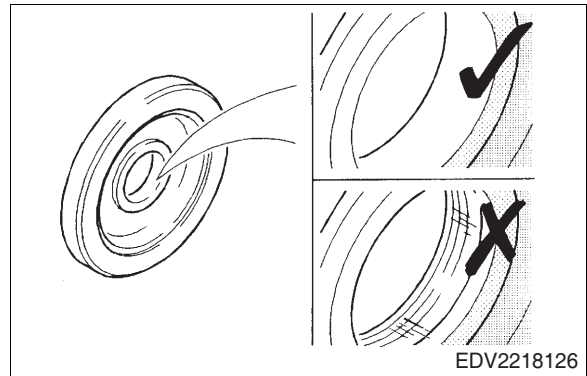
Groove Width (Max.)	mm	in.
	1.664	0.0665



- **Oil seal plate (43)**



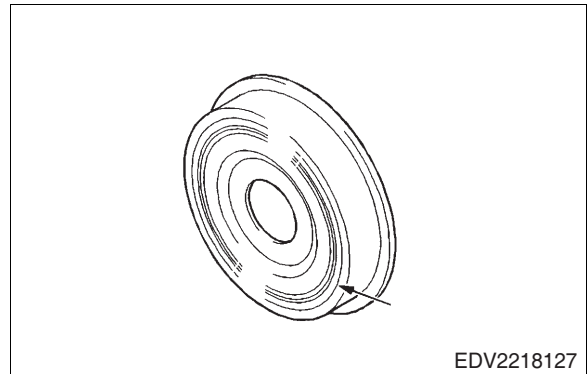
Inspect the seal bore, replace if scored or damaged.



- **Heat shield (38)**



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



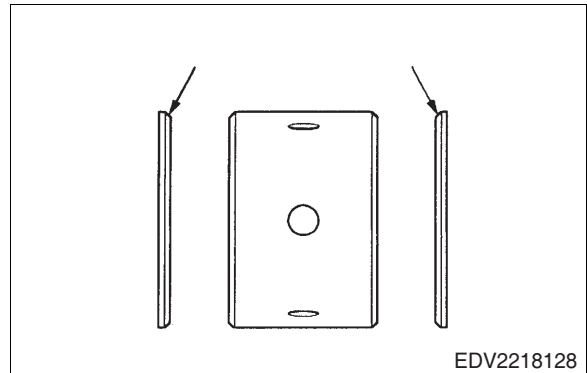
7.4.8. Assembly

- 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.



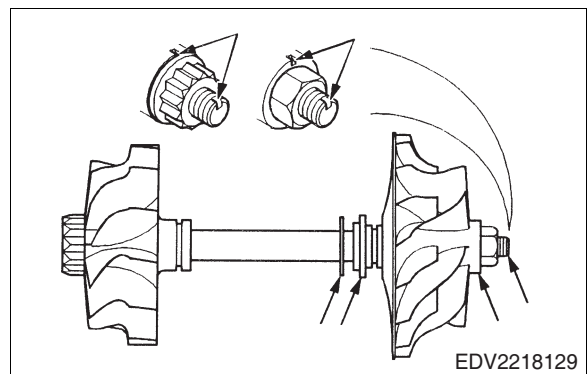
- **Rotor balance**



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.





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

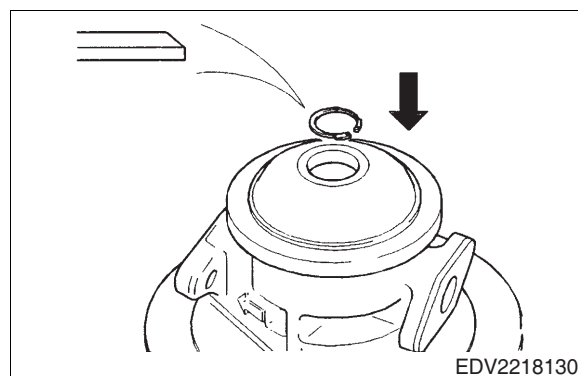
- HX35 (V158TI)

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

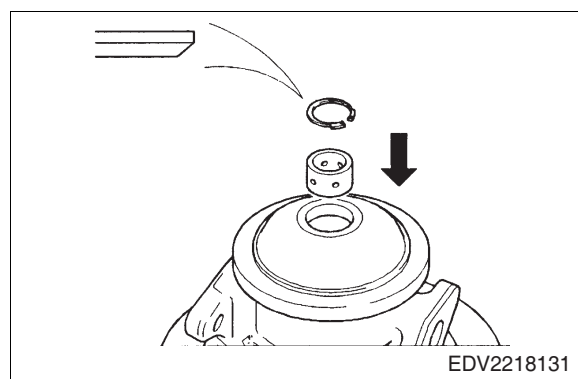
- HX50 (V188TI, V222TI)

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

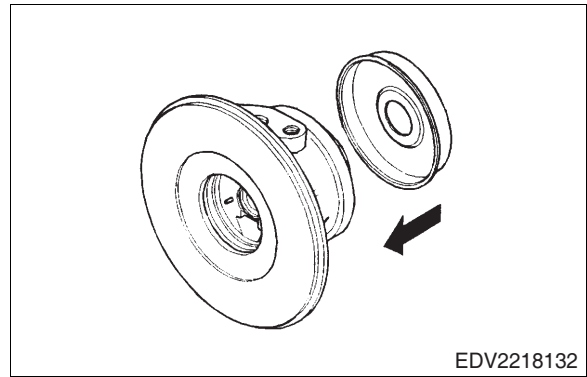
- Place the bearing housing (4) on a bench with the turbine end facing uppermost. Fit the inner circlip (64) with the bevelled edge facing upwards.



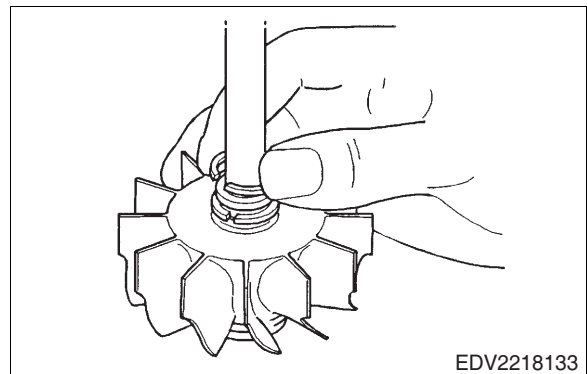
- Lubricate the journal bearing (11) and install into position. Fit the outer circlip (64) with the bevelled edge facing the bearing. Turn the bearing housing over and repeat the process.



- Install the heat shield (38).



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

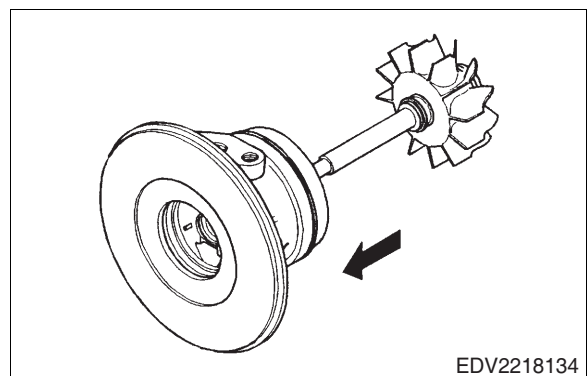


- Lubricate the shaft using clean engine oil.

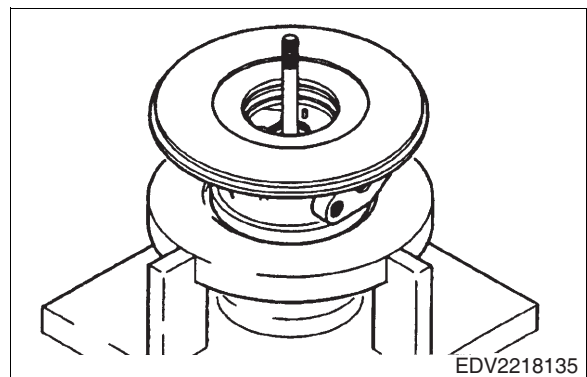


Caution :

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.

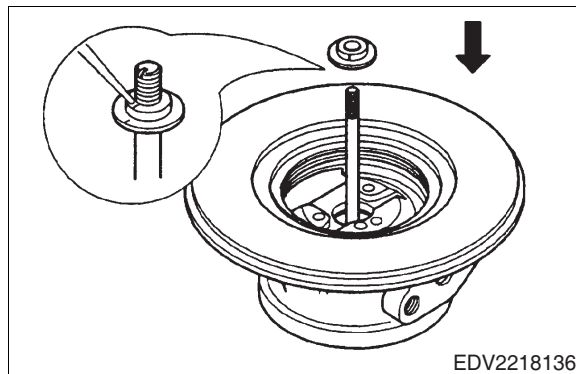


- Install the thrust collar (36).



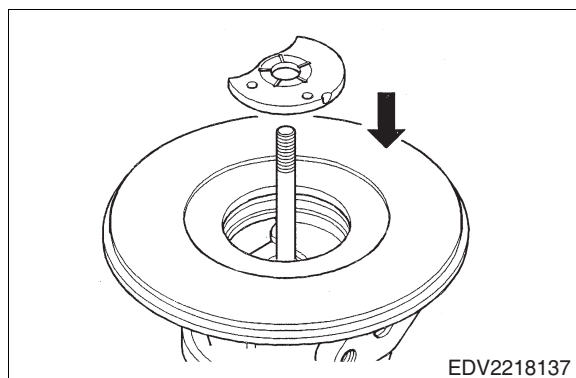
Caution :

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

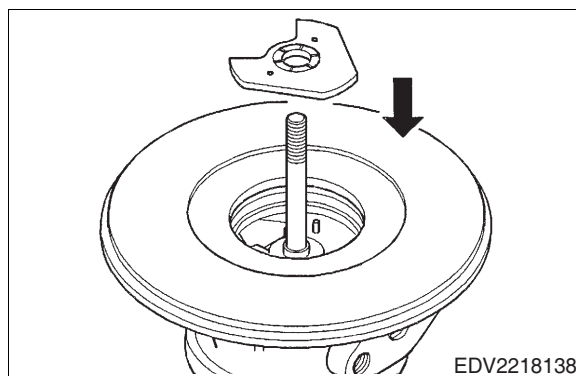


- Using clean engine oil, lubricate the thrust bearing (12).
Install the thrust bearing.

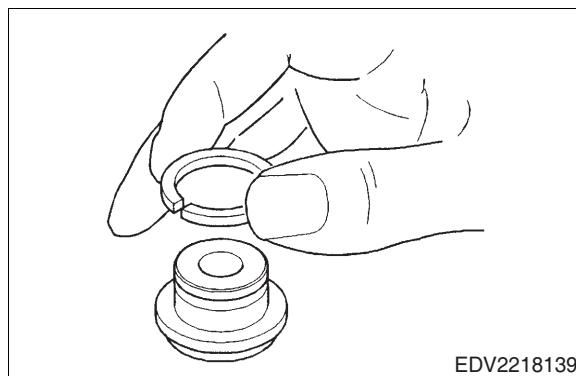
- HX35



- HX50



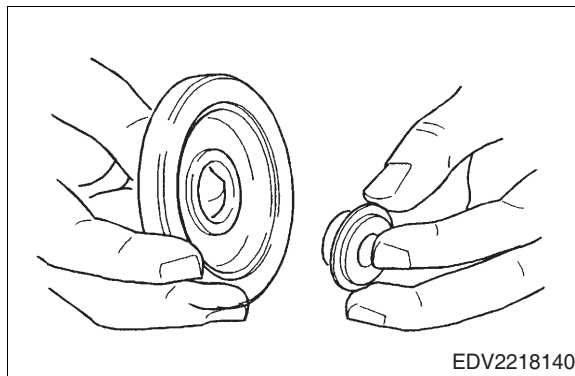
- Fit the new piston ring seal (13) to the oil slinger (31).



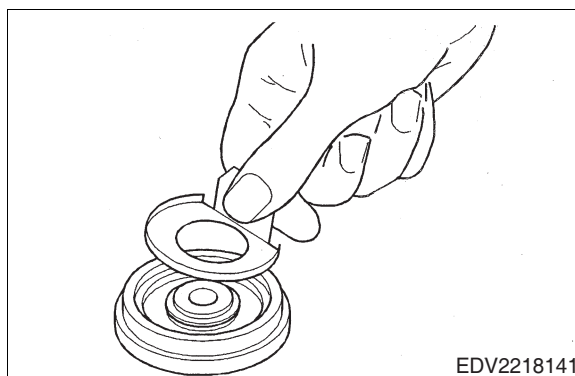
<HX35>



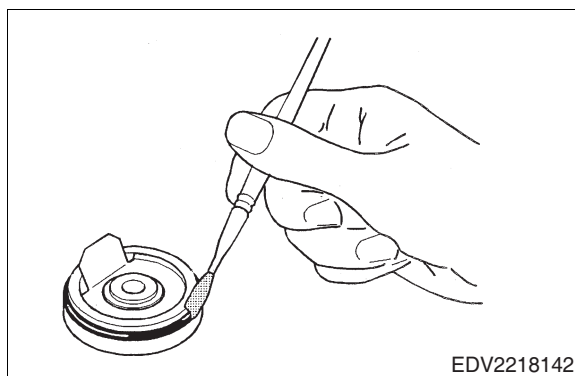
- Using clean engine oil, lubricate the oil slinger (31) and install into the oil seal plate (43).



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

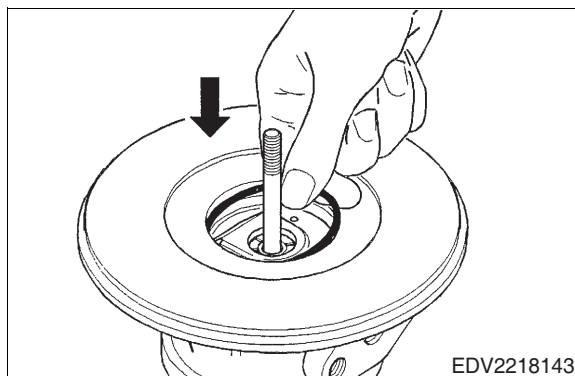


- Apply a small amount of engine oil to the oil seal plate (43) and place the O-ring seal (32) into position.

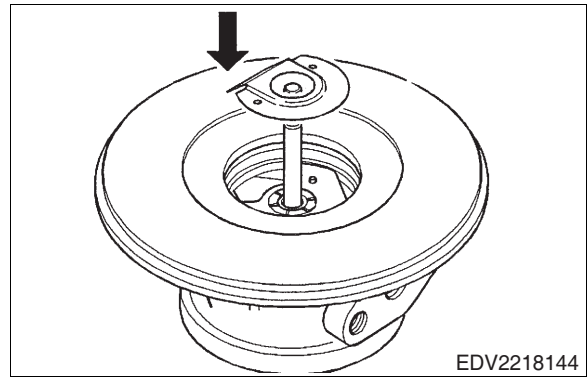


<HX50>

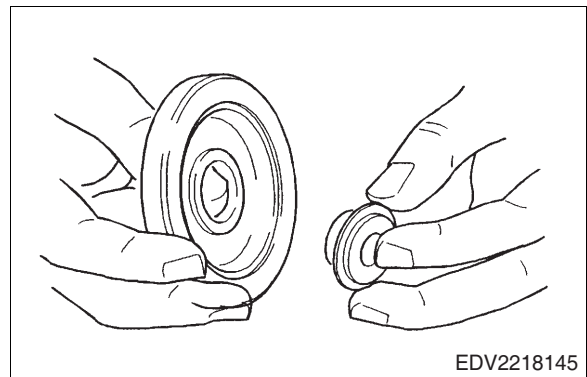
- Apply a small amount of engine oil to the O-ring seal (32), and place into position.



- 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).

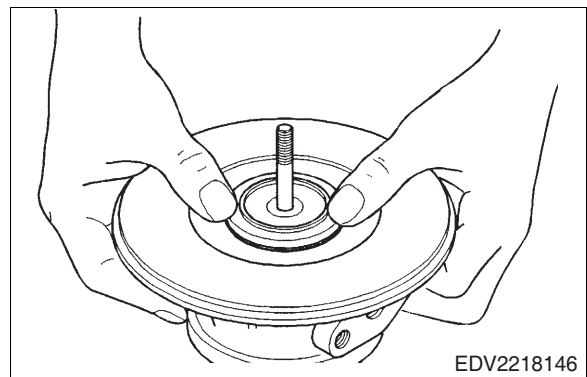


- Install the oil seal plate (43) into the bearing housing (4).

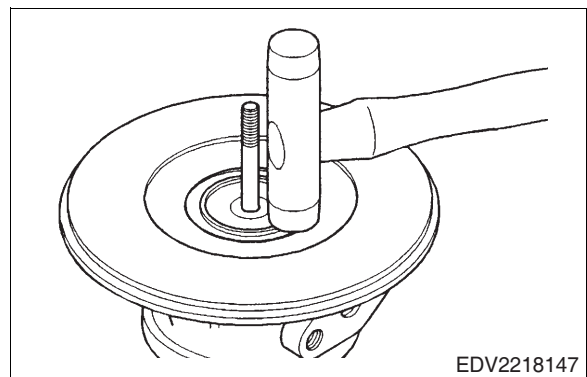


Caution :

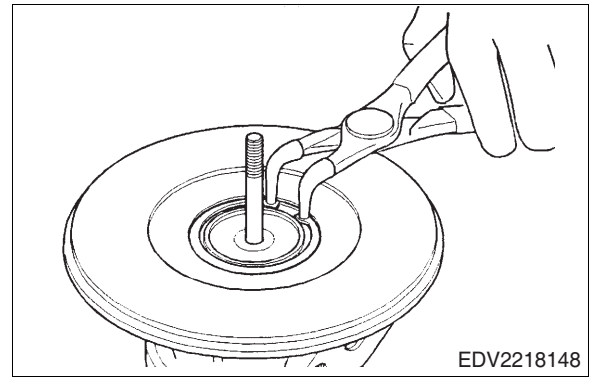
Align the balance marks on the oil slinger (31) with that on the shaft end.



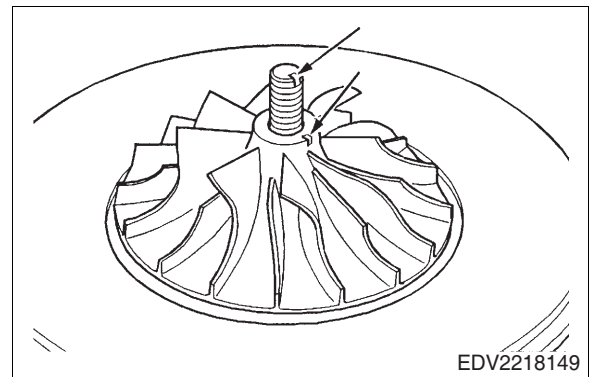
- Gently tap the oil seal plate (43) with a soft hammer to seat in position.



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



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



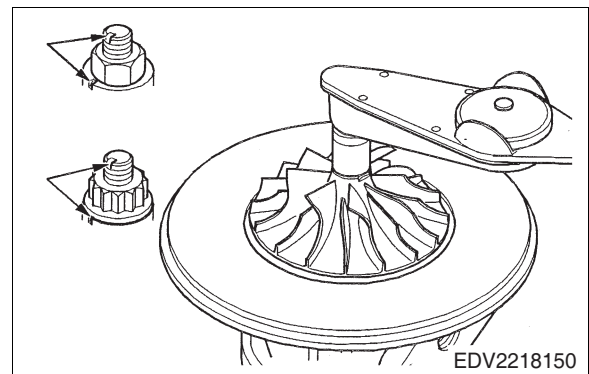
- Install the compressor wheel lock nut(61) and tighten to the torque value.



Note :

Left hand thread.

Torque value	Nm	in-lbs
	17	150



Caution :

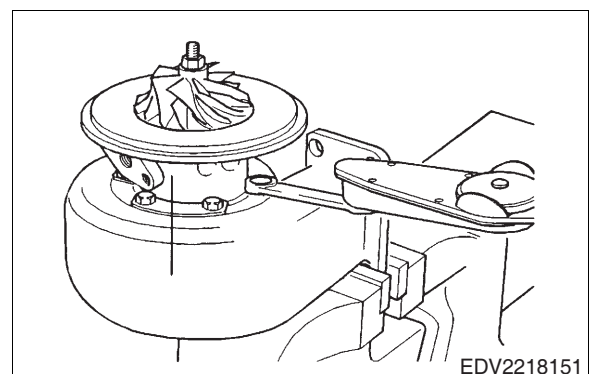
Ensure that the balance marks are aligned on the compressor wheel and the shaft.

<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

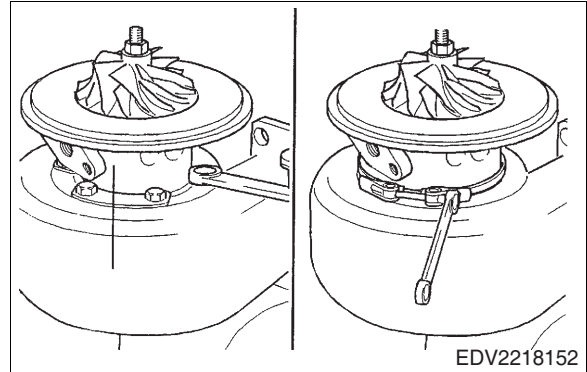
If fitted, install v-band clamp (28) and tighten the v-band lock nut.

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



Caution :

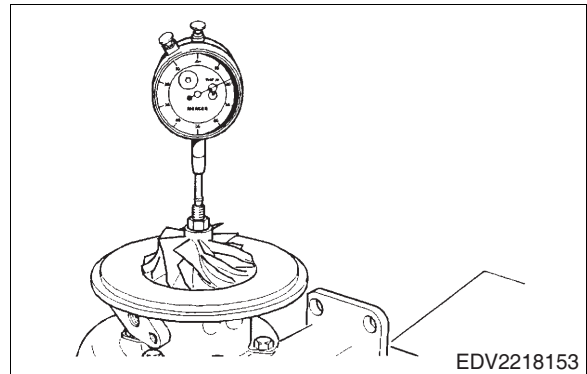
Make sure the scribe marks are aligned.



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

- HX50 (V180TI/ V222TI)

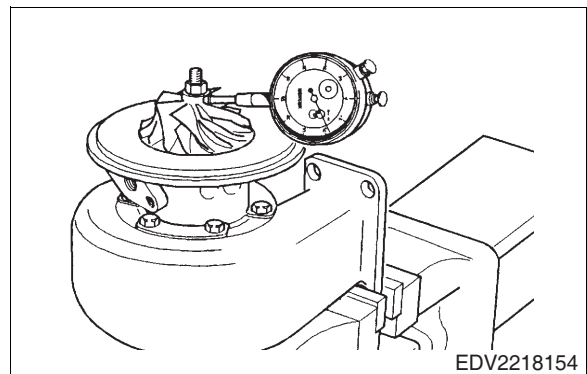
Trust clearance	mm	In
Minimum	0.038	0.0015
Maximum	0.093	0.0037



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

- HX50 (V180TI/ V222TI)

Radial clearance	mm	In
Minimum	0.394	0.0155
Maximum	0.635	0.0250



- Loosely fit the V-band clamp.



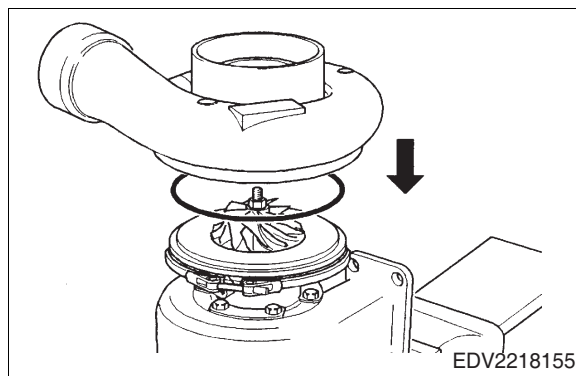
Lubricate and install the O-ring seal (41) if fitted.

Install the compressor cover (8).



Caution :

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

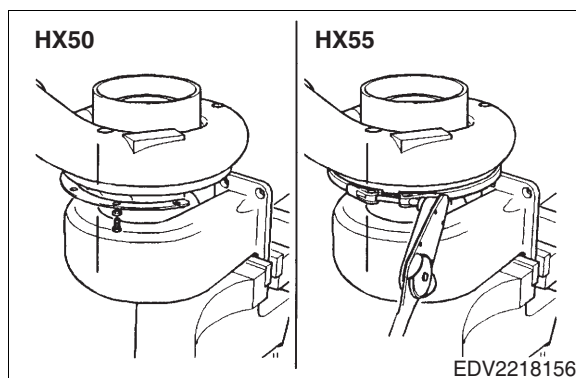


• **HX50**

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.

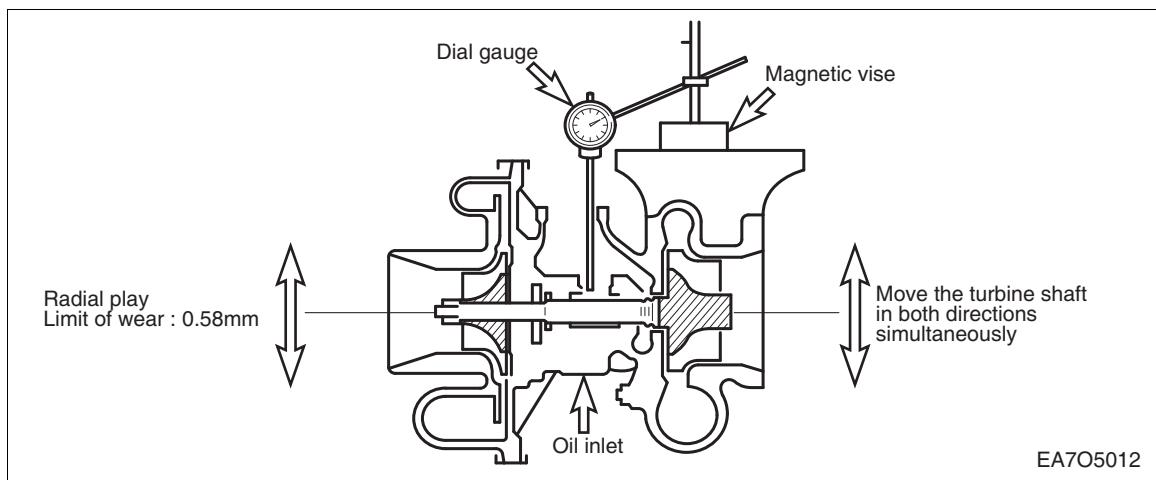
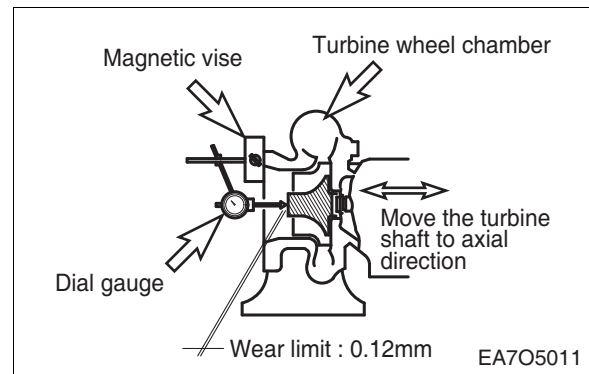
- (1) When disassembling the turbocharger, be sure to plug the oil inlet and outlet ports
- (2) If the measured axial and radial plays are beyond the limit of wear, replace or repair the turbocharger.

- **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

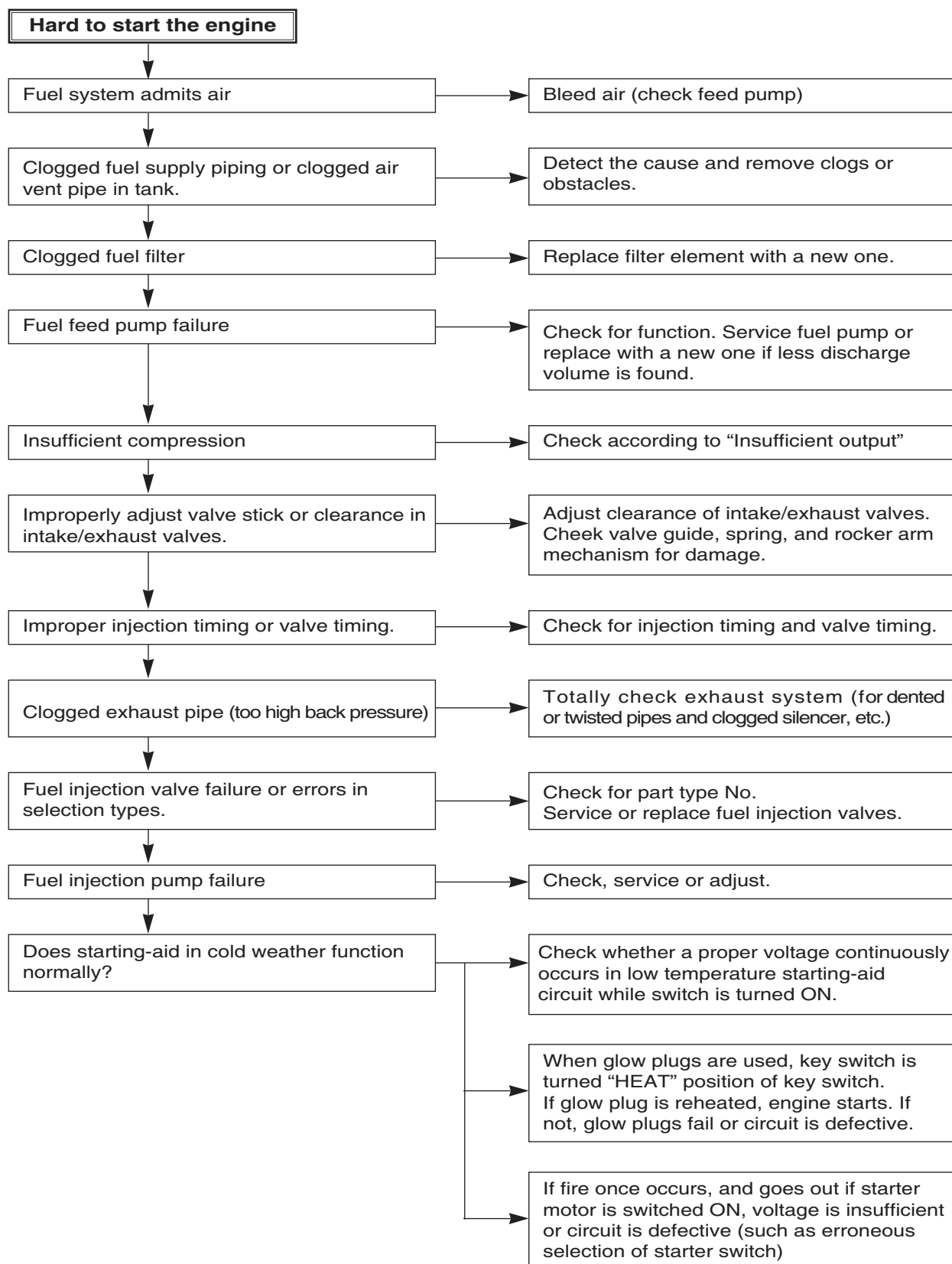
- Check the inside of the intake system for foreign matters.
- Assemble each joint on the intake duct and air cleaner securely to prevent air leaks.

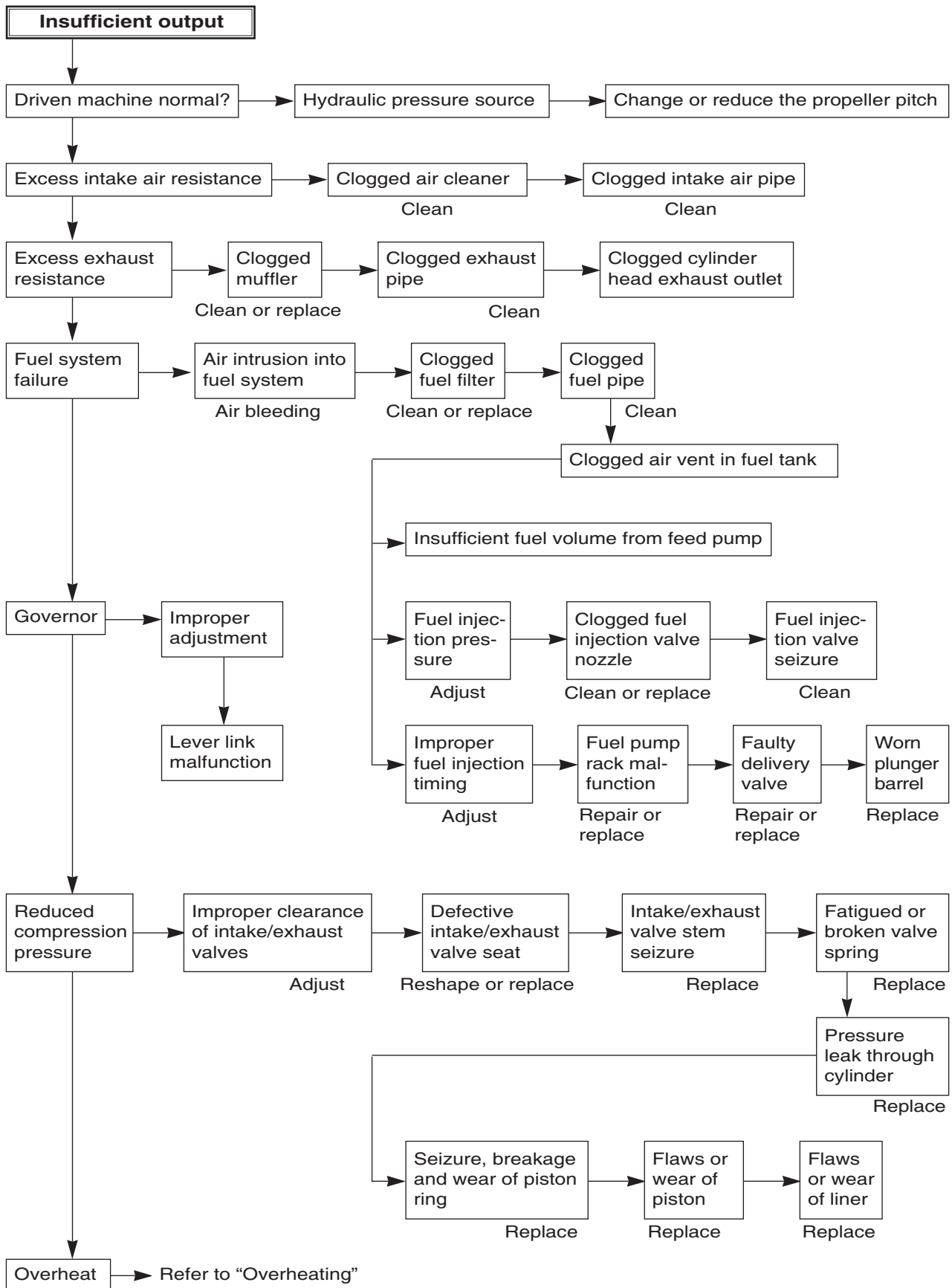
(3) Exhaust system

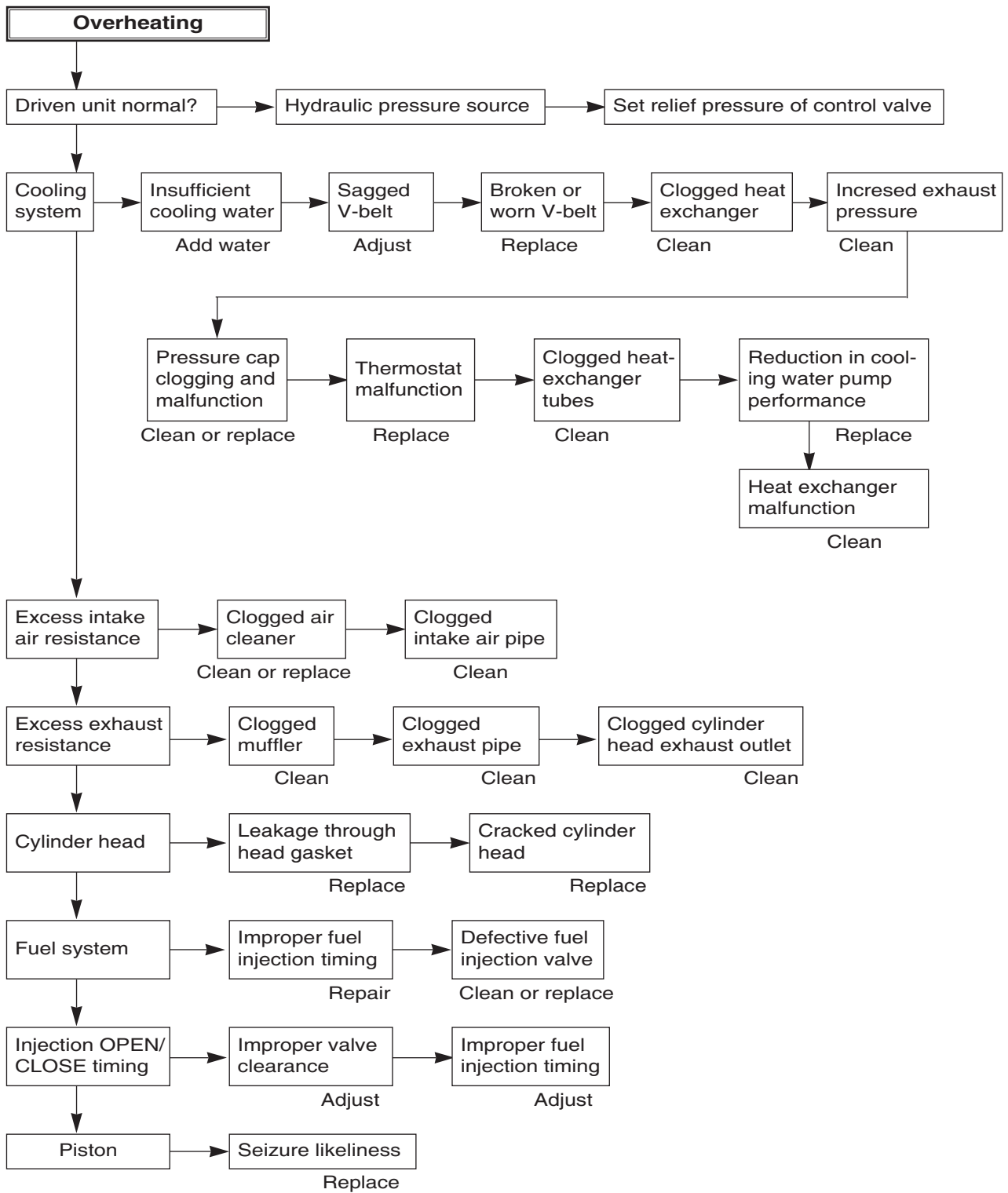
- Check the inside of the exhaust system for foreign matters.
- Be sure to use heat resisting steel bolts and nuts. Do not interchange them with ordinary steel bolts and nuts when performing re-assembly operation. Apply anti-seizure coating to the bolts and nuts.
- Assemble each joint on the exhaust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

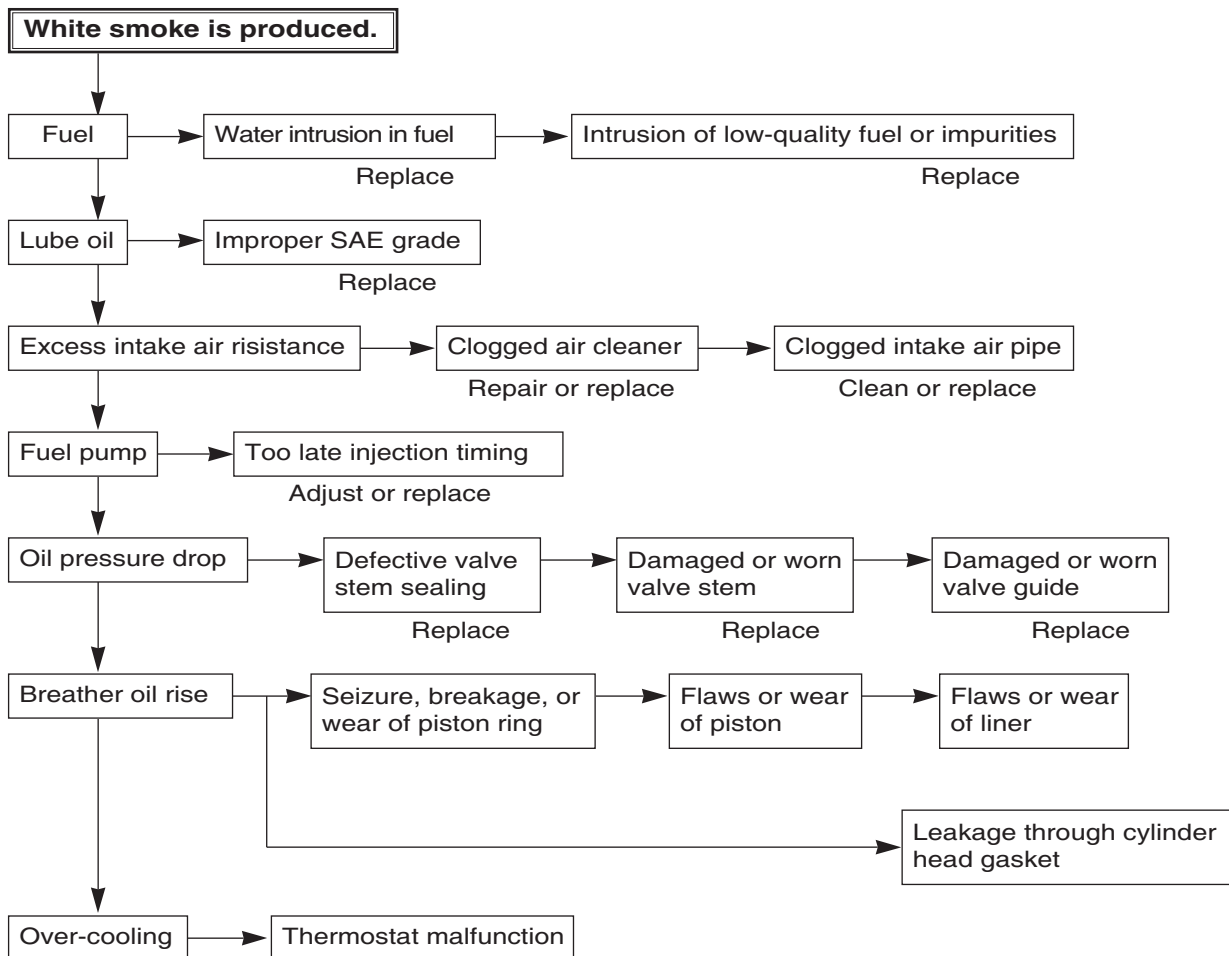
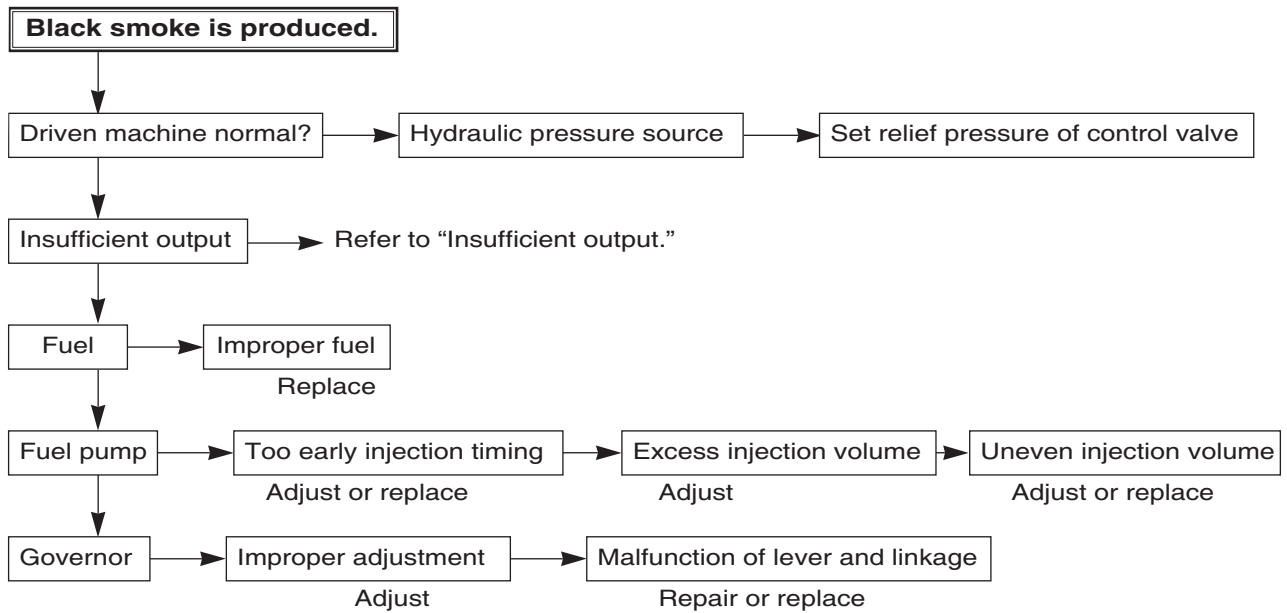
8. TROUBLE SHOOTING

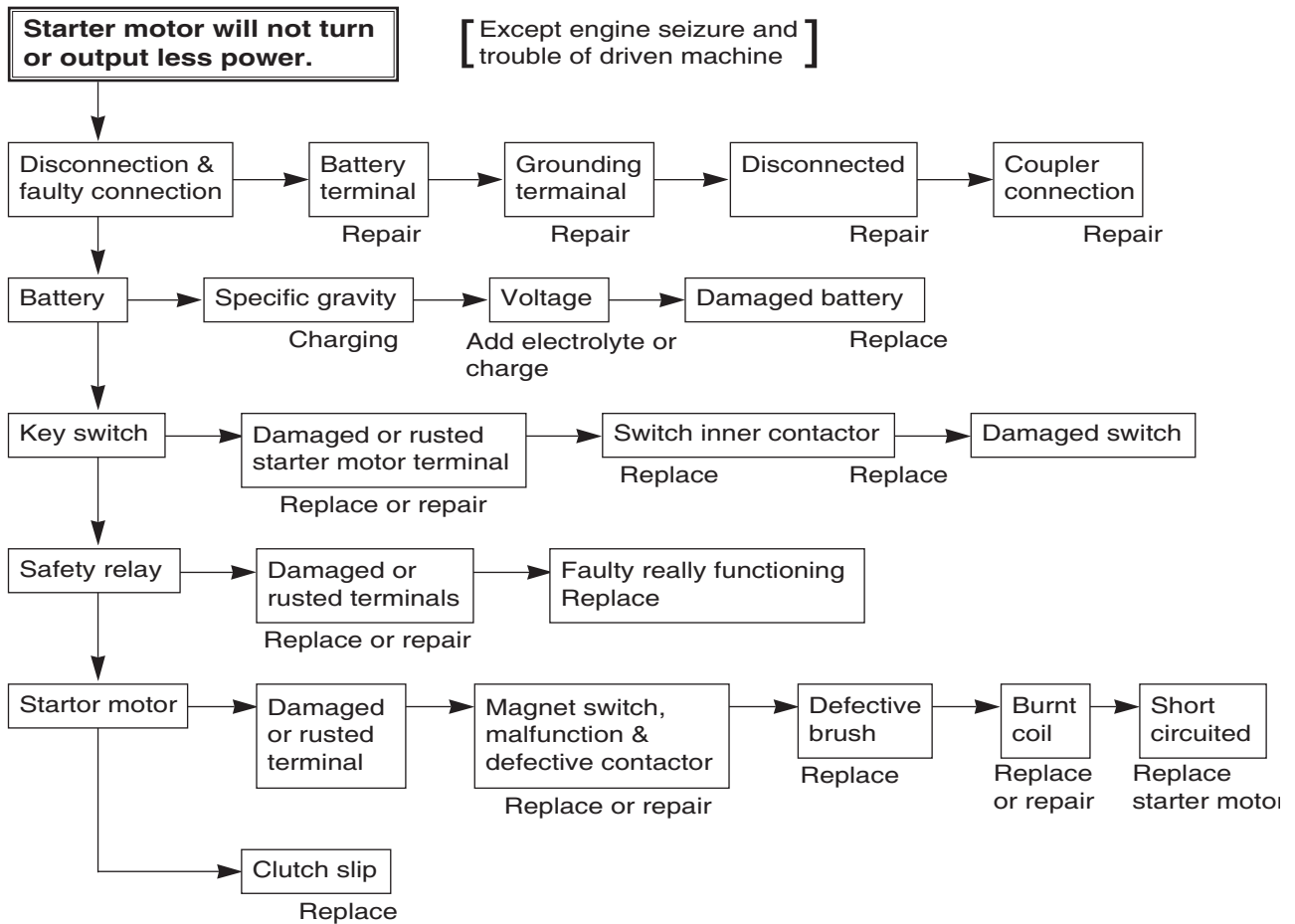
The following description summarizes the probable cause of and remedy for general failure by item. Immediate countermeasures should be taken before a failure is inflamed if any symptom is detected.



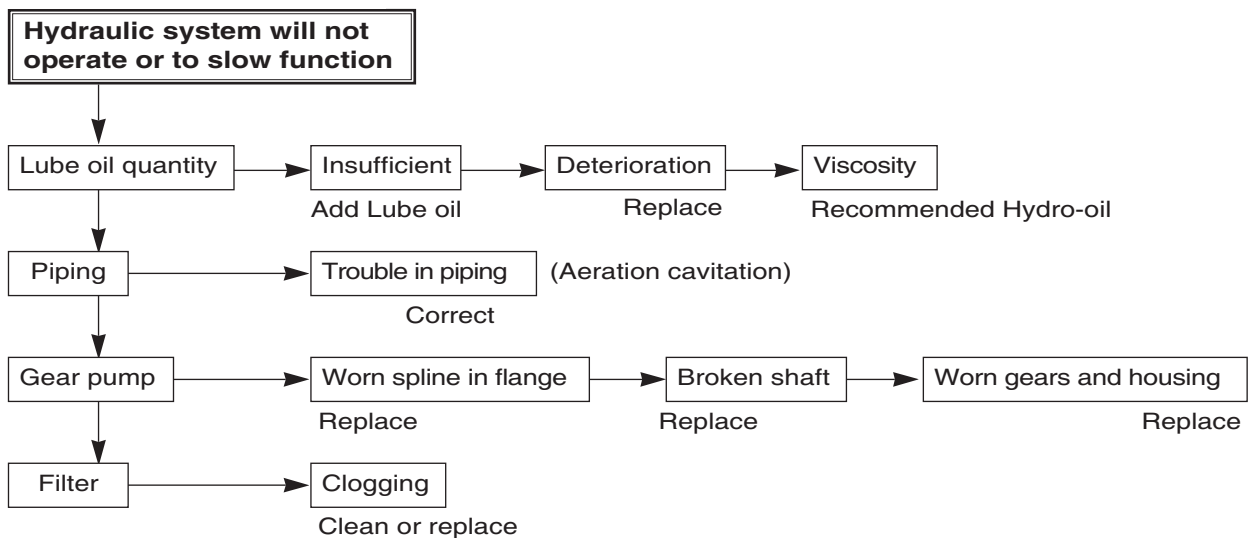


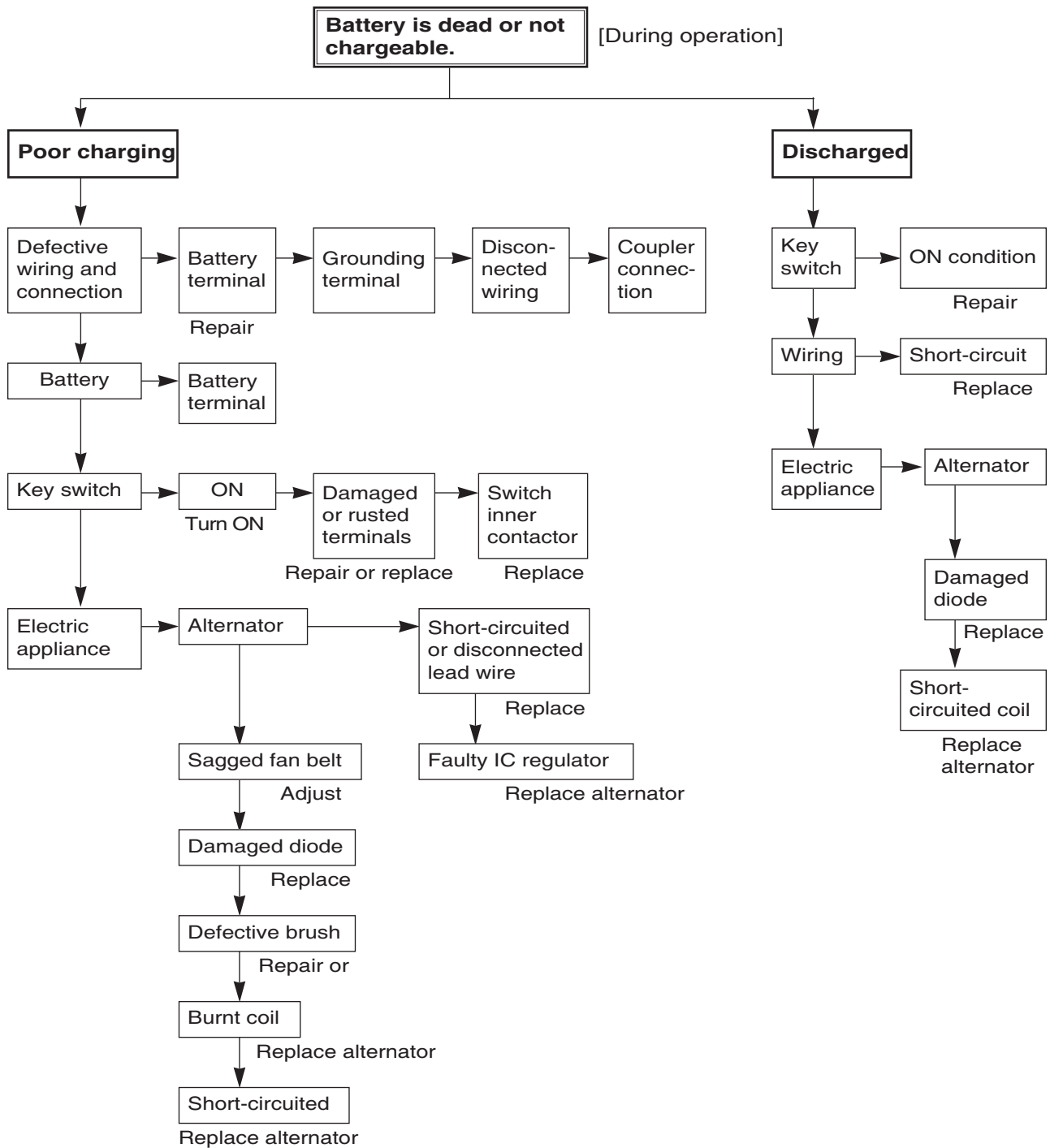






Hydraulic pressure source





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/mm ²)										
	20	24	32	30	40	36	48	54	64	90	108
	Tightening torque (kg.m)										
M5	0.15	0.16	0.25	0.22	0.31	0.28	0.43	0.48	0.5	0.75	0.9
M6	0.28	0.30	0.45	0.4	0.55	0.47	0.77	0.85	0.9	1.25	0.5
M7	0.43	0.46	0.7	0.63	0.83	0.78	1.2	1.3	1.4	1.95	2.35
M8	0.7	0.75	1.1	1	1.4	1.25	1.9	2.1	2.2	3.1	3.8
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 MoS₂ should be tightened to 60% or so of the standard value.

● Tightening torque for plug screw

Item	Component	Inspection item		Specifications	Allowable Limit	Repair	Remarks
Engine parts	Cylinder block and liner	Worn inside diameter of cylinder liner		ø111 ~ ø111.022	-	-	-
		Liner projection		0.03 ~ 0.08		There must be projection	Difference in projection with nearby liner: ø0.15
		Flatness of warped upper surface of cylinder block		0.05		Repair it with a surface grinder	For a length of 200 mm
		Hydrostatic test (one minute) (kg/cm ²)		4		Replace if leaking oil	
	Cylinder head and valves	Valve seat depression	Intake	0 ~ 0.3	-	Replace the valve seat	
			Exhaust	0 ~ 0.3	-		
		Cylinder head height		109.9 ~ 110.1	108.4	Replace the cylinder head	
Main drive components	Pistons	Piston O.D.		ø110.801 ~ ø110.959		Replace the liner	Measure at a spot 13 mm from the bottom surface of the piston
		Clearance between the piston and liner		0.041 ~ 0.221	0.3	Replace if the wear exceeds the specified amount	
		Piston ring groove width	Top ring	3.50		Replace the piston if the groove width exceeds the specified amount	
			Second ring	3.06 ~ 3.08			
			Oil ring	4.04 ~ 4.06			
		Piston protrusion from the upper surface of the cylinder block		0 ~ 0.12			Measure under the edge of the top part which is not worn
		Allowable weight difference among pistons		±15 g	96 g ↓	Replace the piston	
	Piston rings	Piston ring gap	Top ring	0.30 ~ 0.50	1.5	Replace the ring	Standard gauge I.D.: ø108
			Second ring	1.10 ~ 1.30	1.5		
			Oil ring	0.25 ~ 0.55	1.5		
		Piston ring side gap	Top ring	0.105 ~ 0.150	0.3	Replace the ring or piston	Usable limit for standard gap
			Second ring	0.050 ~ 0.082	0.15		
			Oil ring	0.35 ~ 0.062	0.15		
		Ring gap direction				Install the rings at 120°C from each other	

Item	Component	Inspection item	Specifications	Allowable Limit	Repair	Remarks
Main drive components	Piston ring	Piston pin O.D.	ø41.994 ~ ø42		Replace the piston pin	
		Clearance between the piston and bushing	0.055 ~ 0.071		Replace if the wear exceeds the specified amount	
	Crank shaft	Unevenly worn journal and pin		0.01	Repair it with a grinder	Measure in vertical and horizontal directions
		Journal O.D.	ø83.966 ~ ø83.988	ø83	Use the undersize bearing	
		Pin O.D.	ø70.971 ~ ø70.990	ø70	Each (0.25, 0.5, 0.75, 1.0)	
		Ovalness of journal and pin	0.008	0.025		
		Allowable concentricity of journal and pin	0.01	0.03		
		Allowable inclination of journal and pin	0.01	0.03		
		Crankshaft and bearing clearance	0.052 ~ 0.122	0.25	Replace the valve spring	Measure on crown
		Crankshaft free play	0.15 ~ 0.325	0.25	Replace the thrust bearing	
		Deflection of crankshaft	0.1 ↓		Adjust deflection with a press	Measure at No. 4 (Supporting No. 1 and 7)
		Crankshaft balance (g.cm)	60 ↓	60 or less		
		Tightening torque of journal bearing cap bolt (kg.m)	30		Apply oil to the bolt	There should be no foreign material on the bearing cap mounting surface
		Journal bearing crush	0.08 ~ 0.110			Tighten the metal cap and unscrew one stud bolt for measurement
		Worn oil seal (Back side of crankshaft)			Replace the oil seal if there are any oil leaks	

Item	Component	Inspection item		Specifications	Allowable Limit	Repair	Remarks
Main drive components	Connecting rod	Connecting rod free play		0.170 ~ 0.248	0.50	Replace connecting rod	
		Clearance between connecting rod bearing and crank pin		0.034 ~ 0.098	0.25	Replace the bearing	
		Clearance between small end bush and piston pin		0.050 ~ 0.081	0.12		Install the bearing and loosen one bolt for measurement
		Connecting rod bearing crush Height		0.30 ~ 0.50			Tighten the bearing cap and loosen one stud bolt for measurement
		Lateral clearance of big end and small end			0.50	Replace connecting rod	
		Allowable weight difference among connecting rods		18 g ↓			
		Connecting rod bearing cap bolt torque (kg·m)		18		Apply oil to the bolt	Remove foreign materials from the connection surface
Valve system	Valves	Valve stem O.D.	Intake	ø11.969 ~ ø11.980	ø11.949	Replace valve and valve guide	Replace the guide when replacing the valve
			Exhaust	ø11.944 ~ ø11.955	ø11.914		
		Valve stem and valve guide	Intake	0.02 ~ 0.049	0.10	Replace valve and valve guide	Replace whichever one is more worn
			Exhaust	0.045 ~ 0.074	0.15		
		Valve head thickness	Intake	4.6 ~ 5.0	4.1		
			Exhaust	4.33 ~ 4.83	3.83		

Item	Component	Inspection item	Specifications	Allowable Limit	Repair	Remarks
Valve system	Valve spring (ships)	Intake - Free length of inside spring	72.43 mm	-	Replace valve spring	
		Intake - Set length of inside spring (P1/P2)	46.3 mm/32.8 mm	-		
		Intake - Load on inside spring (P1/P2)	16.0 kg/29.5 kg	±1.0 kg/±2.5 kg		
		Intake - Free length of outside spring	68.17 mm	-		
		Intake - Set length of outside spring (P1/P2)	46.3 mm/32.3 mm	-		
		Intake - Load on inside spring (P1/P2)	39.0 kg/71.5 kg	±2.0 kg/±5.0 kg		
		Exhaust - Free length of inside spring	72.43 mm	-		
		Exhaust - Set length of inside spring (P1/P2)	46.3 mm/32.3 mm	-		
		Exhaust - Load on inside spring (P1/P2)	16.0 kg/29.5 kg	±1.0 kg/±2.5 kg		
		Exhaust - Free length of outside spring	68.17 mm	-		
		Exhaust - Set length of outside spring (P1/P2)	46.3 mm/32.8 mm	-		
		Exhaust - Load on inside spring (P1/P2)	39.0 kg/71.5 kg	±2.0 kg/±5.0 kg		
	Exhaust valve spring (For marine generator model)	Intake - Free length of inside spring	-		Replace valve spring	
		Intake - Set length of inside spring (P1/P2)	-			
		Intake - Load on inside spring (P1/P2)	-			
		Intake - Free length of outside spring	61.9 mm			
		Intake - Set length of outside spring (P1/P2)	46.8 mm/32.8 mm			
		Intake - Load on inside spring (P1/P2)	47.0 kg/90.5 kg	±2.5 kg/±4.5 kg		
		Exhaust - Free length of inside spring	-			
		Exhaust - Set length of inside spring (P1/P2)	-			
		Exhaust - Load on inside spring (P1/P2)	-			
		Exhaust - Free length of outside spring	61.9 mm			
		Exhaust - Set length of outside spring (P1/P2)	46.3 mm/32.8 mm			
		Exhaust - Load on inside spring (P1/P2)	46.8 kg/32.8 kg	±2.5 kg/±4.5 kg		

Item	Component	Inspection item	Specifications	Allowable Limit	Repair	Remarks
Valve system	Timing	Rocker arm bushing I.D.	ø25.005 ~ ø25.035	ø25.083	Replace the bushing	
		Diameter of rocker arm shaft	ø24.967 ~ ø24.990	ø24.930	Replace the shaft	
		Rocker arm oil gap	0.015 ~ 0.068	0.14	Replace the bush and shaft	
		I.D. of valve tappet assembly on the block	ø20.000 ~ ø20.021	-		ø20.H7
		Tappet clearance	0.035 ~ 0.077	0.15	Replace the tappet	
		I.D. of bush assembly on the block (thrust)	ø70.070 ~ ø70.090	ø69.464	Replace the bushing	
		I.D. of bush assembly on the block (middle)	ø70.000 ~ ø70.030	ø69.192	Replace the bushing	
		Camshaft bearing diameter	ø69.910 ~ ø69.940	-		
		Camshaft bearing oil gap (thrust)	0.060 ~ 0.120	0.24	Replace the cam or bushing	
		Camshaft bearing oil gap (middle)	0.130 ~ 0.180	0.24	Replace the cam or bushing	
		Axial free play of the camshaft	0.24 ~ 0.86	-		
		Backlash (crank gear - camshaft gear)	0.143 ~ 0.292	-		
		Backlash (camshaft idler gear - camshaft gear)	0.112 ~ 0.370	-		
		Intake valve clearance	0.25 ±0.05	-		
		Exhaust valve clearance	0.35 ±0.05	-		
Lubrication system	Oil pressure	Oil pressure (normal speed) (kg/cm ²)	4.8 or below	3.5	Check for oil leaks and the clearance of each part	
		Oil pressure (no load) (kg/cm ²)	0.8 ~ 1.4	0.6	Use the recommended oil	
	Oil temperature	Max. allowable oil temperature	-	105°C		No temperatures higher than this are allowed
		Oil pressure (no load)	-	120°C		

Item	Component	Inspection item	Specifications	Allowable Limit	Repair	Remarks
Lubrication system	Oil pump	Axial clearance of oil pump gear	0.055 ~ 0.105	-	Replace the gear or cover	
		Clearance between gear shaft and oil pump cover hole	0.032 ~ 0.077	-		
		Clearance between drive gear bushing O.D. and drive hole	0.040 ~ 0.094	-	Replace the bushing or cover	
		Gear shaft O.D.	ø16.950 ~ ø16.968	ø	Replace the gear shaft	ø17e7
		Drive gear bushing O.D. (kg/cm ²)	ø28.000 ~ ø28.033	ø	Replace the bushing	ø28e7
	Valve opening pressure	Oil pressure adjustment valve	4.0 ~ 4.8	0.8	Replace the valve	
		Bypass valve for oil filter element (kg/cm ²)	1.8 ~ 2.3	0.8		
		Bypass valve for full-flow oil filter (kg/cm ²)	4.0 ~ 4.8			
		Relief valve for the oil pump (kg/cm ²)	8.5 ~ 11.5		Replace the valve	
		Adjustment valve for the spray nozzle (kg/cm ²)	1.5 ~ 1.8			
	Oil filter	Damaged oil filter cartridge			Clean and replace	

Governor Actuator Controller

DOOSAN

Governor Actuator

Definition

The governor detects the engine rpm using a magnetic pick-up sensor to adjust the flow rate of the injection pump and maintain the desired rpm.

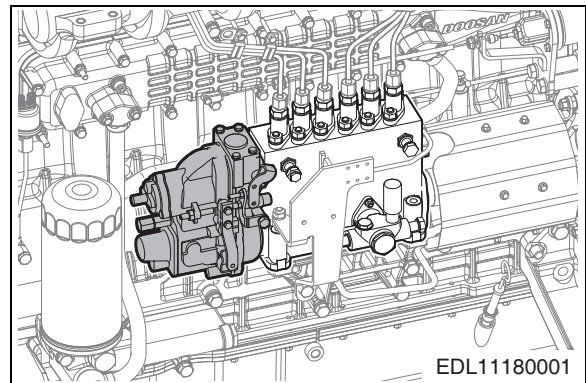
The governor activates the engine's fuel injection pump when the accelerator pedal is pressed while the vehicle is in operation and adjusts the speed of the vehicle.

The governor detects the engine speed, compares it with the set speed and sends out an output signal to open or close the fuel injection pump accordingly until the actual speed reaches the set speed.

In terms of operating the vehicle, the driver monitors the speedometer and if there is a desired speed, this corresponds to the governor's speed input, while the governor's output adjusts the accelerator in order to maintain the desired speed.

Appearance and Installation

This is a picture of the governor actuator installed which electronically controls the injection pump assembled with the generator engine.



Operating Principles

In this system, when adjusting the engine output, the controller is adjusted to set and activate the IDLE and RUN RPM, while the electronic governor is operated to adjust the injection pump and engine output.

- The moving core is activated to adjust the rpm.

Product Specifications

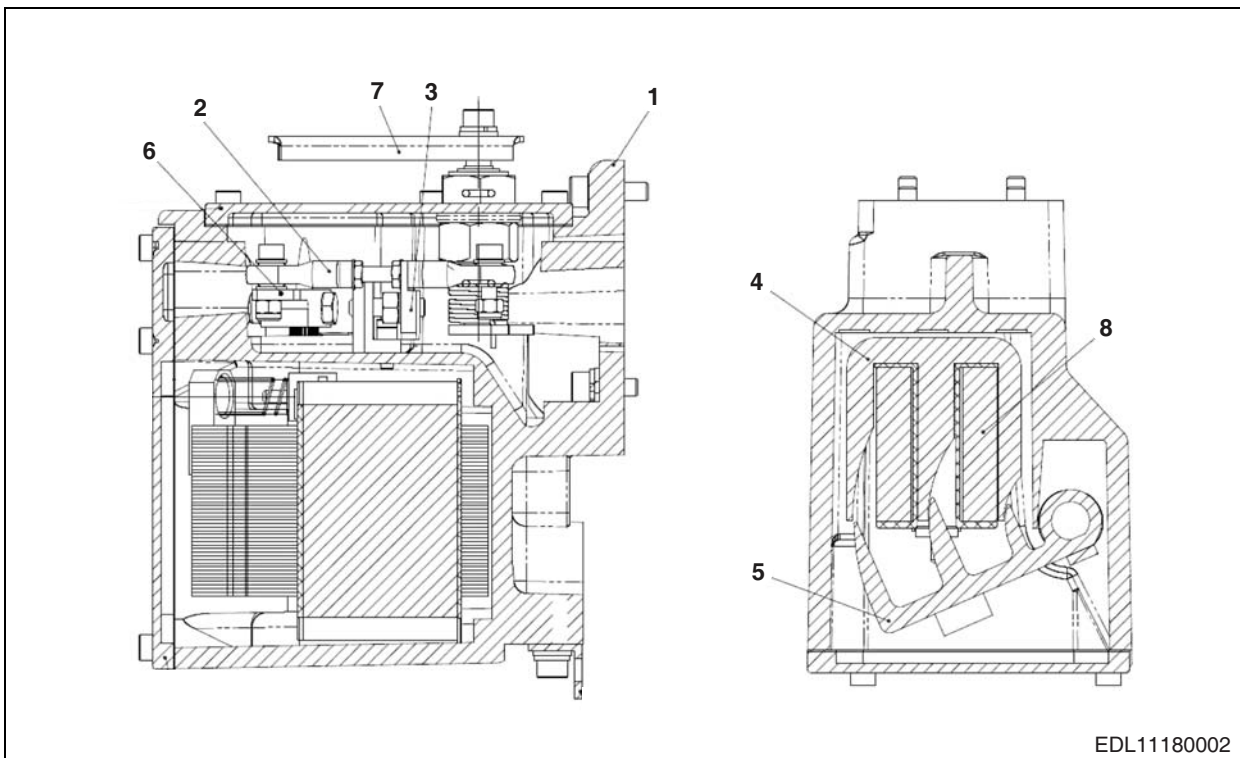
1. General specifications

Item	GN11 (DWA-2000)	GN12 (GNSA-2002)
Operating voltage (kg/lit)	DC 24V	DC 24V
Max. fuel quantity (°C)	Adjust	Adjust
Production capacity (40°C) (cst)	200 ~ 1,000 KW	150 ~ 250 KW
Allowable humidity (wt%)	100%	100%
Operating current (°C)	1.5 A	2.0 A
Max. operating current (°C)	4.5 A	3.1 A
Rack operating power (°C)	58.7 N	27.5 N
Rack operating range (ASTM)	20 mm	21 mm
Engine injection pump specs.	Right rack type	Right rack type

2. Mechanical specifications

Item	GN11 (DWA-2000)	GN12 (GNSA-2002)
Product dimensions	107.1 x 180.4 x 196.5	112 x 205 x 101
Product weight	4.9 kg	2.6 kg
Installed engine (Bosch type)	P 3000, P 7000	AD Series
Material for exterior	AL (ALDC-12)	AL (ALDC-12)
Material for core	Pure iron	Pure iron
Coil size and no. of turns	Ø0.85 / 715	Ø0.6 / 790

3. Outside view and main components of governor



- 1) Frame : The body of the governor. Made of ALDC-12 with high corrosion resistance.
- 2) Ball link assembly : A bearing assembly which connects the injection pump rack and governor actuator operating lever.
- 3) Stop plate : A part assembled with the ball link assembly. It serves to stop the engine by means of the emergency stop lever.
- 4) Static core assembly : A welded assembly composed of several layers of pure iron. A coil is wound around a bobbin, press fitted into the frame of the static core and the assembly, and then fixed in place with an epoxy resin.
- 5) Moving core assembly: A welded assembly composed of several layers of pure iron. When the governor controller adjusts the engine, the moving core assembly is activated to control the fuel and adjust the speed.
- 6) Operating lever : A lever which connects the shaft and ball link assembly.
- 7) Stop lever : An emergency stop lever which stops the engine manually when the engine cannot be stopped by the control panel. (Material: P.O. sheet)
- 8) Coil : A copper wire made of 0.85 $\varnothing$ LG B enamel and wound 715 turns around a bobbin. It is connected to the governor controller and acts as an electromagnet.

Control Unit (1)

The engine speed control unit used by Doosan is an electronic control unit designed to be able to respond quickly and accurately to changes in the instantaneous load.

This control unit is designed to receive a signal from the magnetic pick-up sensor (speed sensor) of the engine when a fluctuation occurs in the engine load and then be automatically fine-tuned to the changes in the engine rpm, thereby providing high reliability and satisfying adverse environmental engine conditions.

The main feature of this device is that it includes functions for adjusting the amount of starting fuel and the fluctuations in the speed. It thereby helps to reduce engine emissions. It also has a function for parallel engine operation, a protective function for when the battery polarity is reversed, and functions designed to ensure safety during short circuits in the actuator circuit, battery power cut-off or failure of the magnetic pick-up sensor.

Description of Functions

In order for the controller or actuator to function normally, the output signal value of the magnetic pick-up sensor must be 0.5 ~ 120V, and this signal is connected to "C" and "D" on the controller. Terminal "D" is connected to the negative ("-") battery terminal "E" inside the controller terminal.

When the signal from the magnetic pick-up sensor reaches the controller, it is converted into an analog speed signal and amplified.

In the event that the controller fails to receive the output value from the magnetic pick-up sensor during operation, the controller's output circuit shuts off all current flowing to the actuator.

The controller's integrated circuit receives the signal from the magnetic pick-up sensor based on the set speed value. This range is 8 : 1 and can be adjusted with the 25-turn potentiometer. This speed setting output value becomes the input value traveling to the dynamic control section. With the help of this dynamic control circuit, most of the engine and fuel systems perform evenly and stably.



CAUTION

For the connection to the magnetic pick-up sensor, either two wires twisted together or shielded wire should be used, but be careful that this shield is not grounded to the engine.

If grounded to the engine, an incorrect speed signal may be delivered to the speed controller.

The controller's circuit may be affected by adjustments to the gain and stability. In order to increase the operating responsiveness of the actuator within the governor, turn the gain clockwise to adjust it. The adjustment range for the gain is approximately 33 : 1.

If the stability is turned in the clockwise direction, the actuator, i.e. governor reaction time increases.

While the engine is running, the starting fuel in the controller can be adjusted from an almost closed state to a completely open state. When the engine is started, the adjusted position of the speed is determined initially by the set idle value and the speed ramping circuit. When the engine has finished speeding up, the engine is kept at the set speed while satisfying the speed fluctuation rate of the controller.

The controller's output circuit switches the current for activating the actuator at a frequency of around 500 Hz.

This is because no visible changes appear in the output curve for the actuator since the switching frequency is much higher than the natural frequency of the actuator.

The transistors in the output section are switched in order to achieve effective control of the output, thereby reducing power consumption within the controller. The output circuit delivers up to 10 A of continuous current from the 12V or 24V battery system at 25.

The actuator responds to the average value of the current based on the position of the fuel control lever.

The performance of the speed controller is stable in its standard state. In order to switch this to the droop mode, terminals "K" and "L" must be connected to one another, and the amount of change must be adjusted with the adjustment control lever. In addition, the droop range increases when terminals "G" and "H" are connected.

The engine speed controller includes functions for protecting the actuator and the engine, as well as additional functions. For example, the controller circuit includes a protective circuit for minimizing overspeeding which may occur when an excessive load is applied to the engine while starting or running the engine. The current controller also includes a load divider and automatic parallel feeder which, when used, enable parallel operation.

Specifications

Item	Details	Specifications
Performance	Simultaneous Operation / Relative Normal Stability	$\pm 0.25\%$ or less
	Speed Range / Governor	1 K ~ 7.5 KHz continuously
	Speed deviation based on changes in temp.	Max. $\pm 1\%$
	Idle Adjustment (Clockwise)	1,200 Hz or less
	Idle Adjustment (Counterclockwise)	4,100 Hz or less
	Droop Range	Adjustable between 1 ~ 5%
	Max. Droop Adjustment (With Terminals K-L Connected)	Fluctuation of 875 ± 75 Hz / 1.0 A
	Min. Droop Adjustment (with Terminals K-L Connected)	Fluctuation of 15 ± 6 Hz / 1.0 A
	Speed Trim Range	± 200 Hz
	Remote Variable Speed Range	500 ~ 7.5 Hz
Terminal Sensitivity	J	100 ± 15 Hz / Volt @ 5.0 K
	L	735 ± 60 Hz / Volt @ 65 K
	N	148 ± 10 Hz / Volt @ 1 Meg
	P	10 V DC supply @ 20 ma.
Speed Switch Adjustment Range		1,000 ~ 10,000 Hz
Environmental Conditions	Ambient Operating Temperature Range	-40 ~ 85°C
	Relative Humidity	Up to 95 %
	Surface Treatment	Corrosion resistance
Input Power	Supply	12 or 24V DC (instantaneous and back voltage protection) *
	Polarity	" - " ground
	Power Consumption	50 mA of continuous current to actuator
	Actuator Current at 25°C (Inductive Load)	Continuous min. 2.5 A, max. 10 A **
	Speed Sensor Input Voltage	0.5 ~ 120V
	Speed Switch Relay Contact (N.O. and N.C.)	10 A
Reliability	Vibrations	1 G @ 20 ~ 100 Hz
	Testing	100 % functionality test
Type	Dimensions	Refer to outside view feature
	Weight	820 g
	Installation	Installed vertically



CAUTION

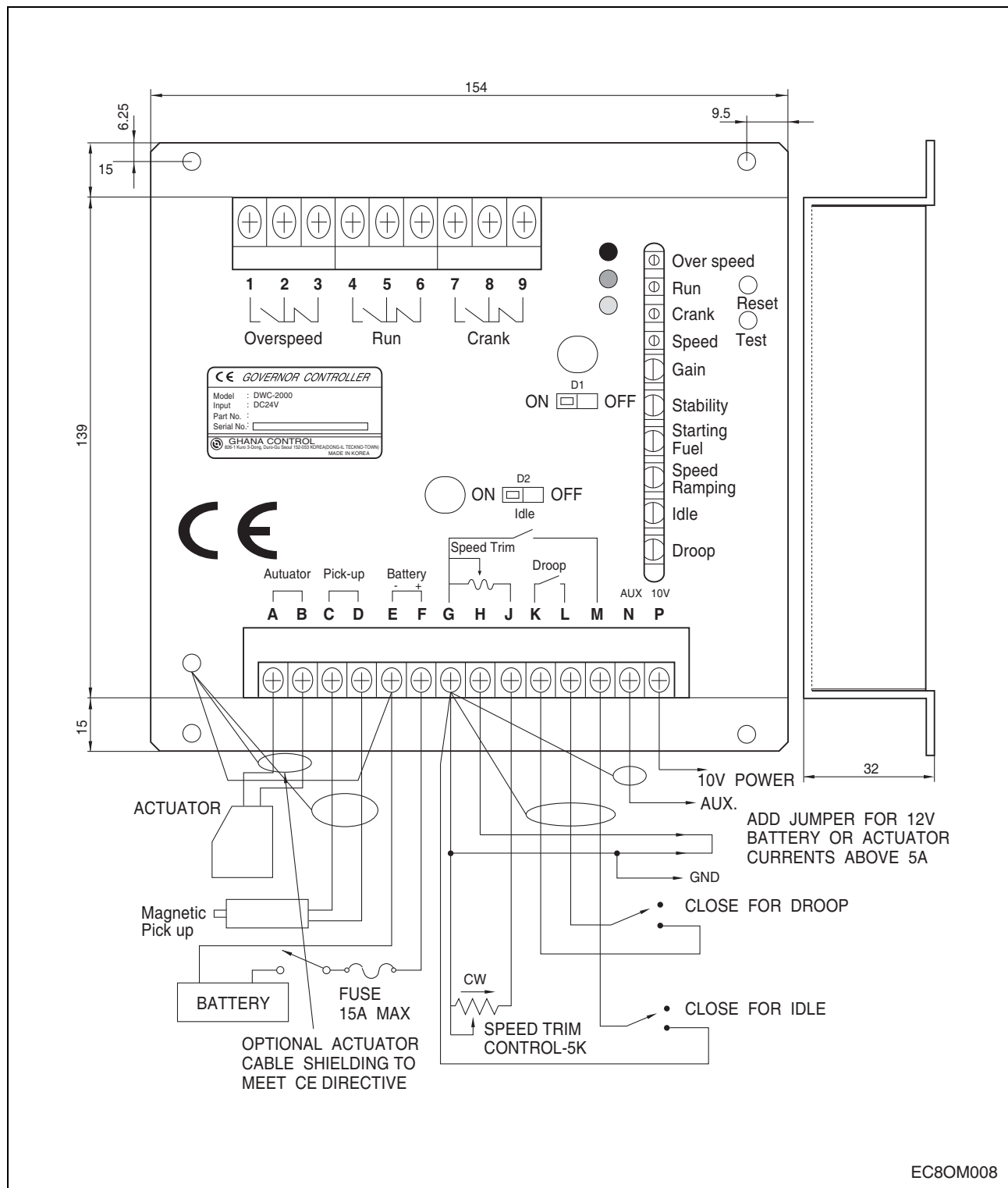
* The droop is based on the 4,000 Hz speed detection frequency from no load to full load, as well as changes of 1 A in the actuator current. When the speed sensor signal is high, the amount of droop decreases, and when the amount of change in the actuator is large, the amount of droop changes significantly. For details about droop operation, refer to the description of droop.

** Protects against back voltage using a diode. A 15 A fuse must be installed on the battery anode.

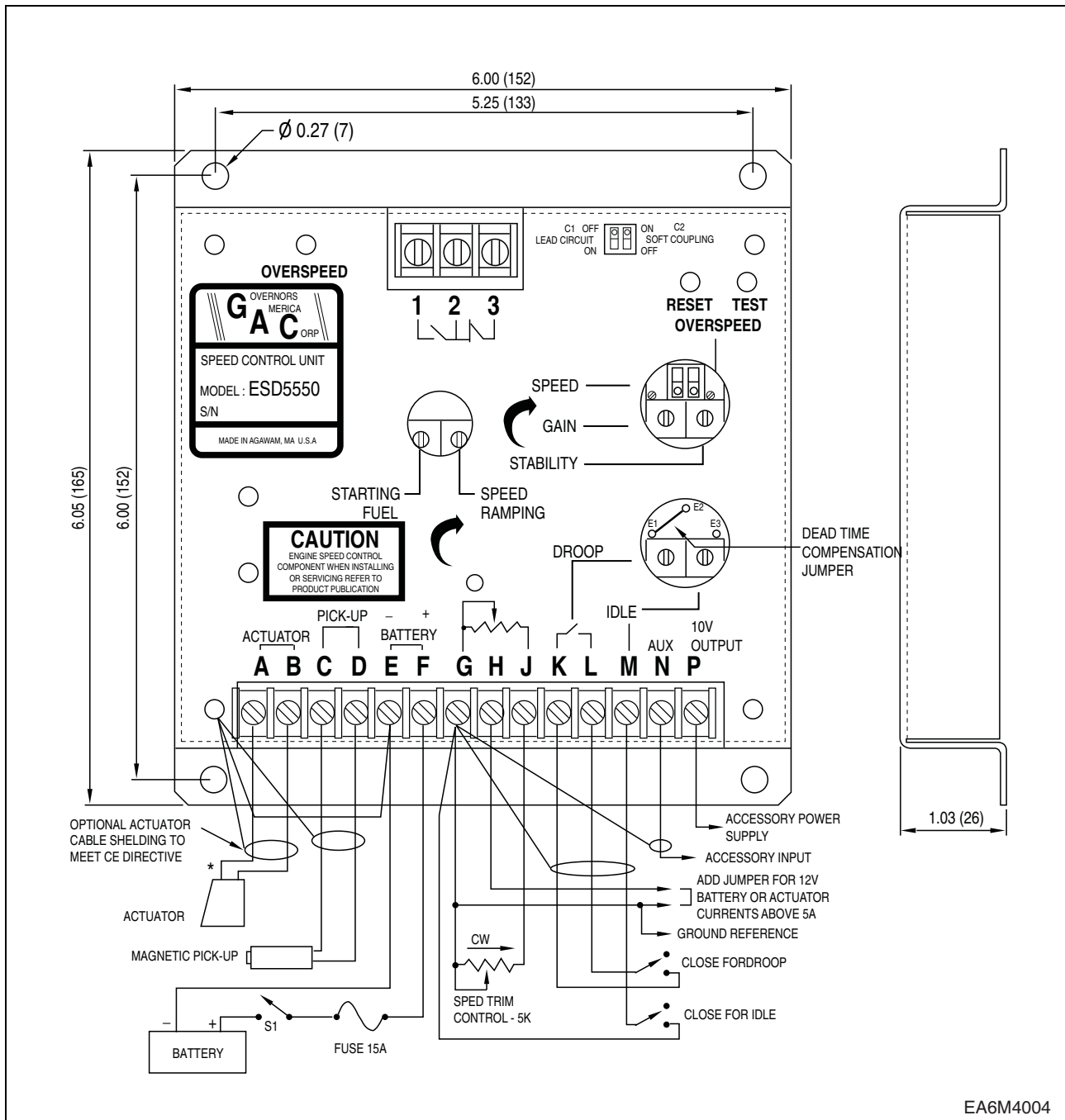
*** There is a protective device which cuts off current flowing to the actuator in the event of a short circuit. Once this short circuit is removed, the device automatically returns to normal.

Components

DWC-2000



GAC-ESD5550



EA6M4004



CAUTION

If the length of the wires is over 3 m, shielded wire must be used. One end must be grounded using shielded wire.

The speed control unit must be firmly installed in the control cabinet or engine just as with other sensitive control equipment.

If there is concern that the controller may come into contact with water or condensation, the controller must be installed vertically.

Description of Controller Terminology

1. **Starting Fuel**
Controls the amount of starting fuel during the initial ignition. When rotated clockwise, the amount of fuel increases.
2. **Speed Ramping**
Controls the time required to reach the maximum rpm. When rotated counterclockwise, the time required for reaching the rated rpm decreases.
3. **Idle**
Adjusts the idle rpm of the equipment. When rotated clockwise, the engine rpm increases.
4. **Gain**
Stabilizes fluctuations in speed occurring in the engine.
5. **Stability**
Stabilizes fluctuations in speed caused by the engine load.
6. **Speed**
Adjusts the engine rpm. When rotated clockwise, the engine rpm rises.
7. **Overspeed**
Adjusts the engine overspeed rpm. When rotated clockwise, the maximum rpm rises.
8. **Droop rpm**
Used when running the generator in parallel.
9. **Reset**
Used when resetting the overspeed controller.
10. **Test**
Used when checking or setting the overspeed.
11. **Terminals A and B**
Connected to the actuator in the engine injection pump. (No polarity)
12. **Terminals C and D**
Connected (no polarity) to the magnetic pick-up sensor.
Shielded wire must be used. It must also not be connected to the magnetic pick-up sensor for any other purposes.
13. **Terminals E and F**
Connected to the battery (E R - terminal, F R + terminal).
14. **Terminals G and M**
Terminals for maintaining the idle rpm.
15. **Terminals K and L**
Terminals for droop.
16. **Terminals H, J, N and P**
Auxiliary terminals.

Wiring

Please refer to the chart above for the basic electrical wiring. When connecting the actuator and battery to terminals A, B, E and F, the wire thickness must be at least 1.3 mm². If the wires are long, they must be thicker in order to reduce drops in voltage.

For the positive (+) battery terminal "F," a 15 A fuse must be used as shown in the picture.

The ground cable of the magnetic pick-up sensor connected to terminals "C" and "D" must either use two wires twisted together for its entire length or be shielded.

The shielded part of the wire for the magnetic pick-up sensor must be connected to terminal "D." The shielded part must be insulated so that it is not grounded to the engine. Otherwise, an incorrect frequency signal may be delivered to the speed control unit.

The voltage of the magnetic pick-up sensor must be at least 1V while the engine is running.

How to Adjust the Engine Performance (For New Controllers)

1. Before starting the engine

- (1) Set the gain and stability potentiometers of the controller to the central positions.
- (2) Starting fuel
Turn the potentiometer as far clockwise as possible. (The position in which the most fuel is supplied)
- (3) RPM ramping
Turn it as far counterclockwise as possible. (The position in which the reaction speed is quickest)
- (4) Turn the idle potentiometer as far clockwise as possible.
- (5) Connect terminals G and M. (To maintain the idle rpm after starting the engine.)

2. After starting the engine

Once the engine is started, move the actuator to the maximum fuel supply position, then maintain the idle rpm after starting it.

- (1) Check the state of ignition and adjust the starting fuel and speed ramping suitably.
- (2) If the engine appears unstable after starting it, turn the gain and stability potentiometers counterclockwise to adjust them until it stabilizes.
- (3) After disconnecting terminals G and M, use the speed potentiometer to adjust the maximum rpm.
- (4) After reconnecting terminals G and M, adjust the idle rpm to 750 rpm, disconnect the connecting wires and then check and adjust the maximum rpm.

3. Setting the engine rpm

If the speed potentiometer of the controller is turned clockwise, the setting value of the engine rpm increases. In order to do so, a 5K potentiometer must be installed between terminals "G" and "J."

4. Adjusting the characteristics of the actuator

Do the following after setting the engine to the rated no-load speed.

- (1) Turn the gain potentiometer clockwise until the engine characteristics become unstable. Slowly turn the potentiometer clockwise until the engine stabilizes again. In order to obtain an accurate setting value, turn the potentiometer counterclockwise slightly.
- (2) Turn the stability potentiometer clockwise until the engine characteristics become unstable. Slowly turn the potentiometer counterclockwise until the engine stabilizes again. In order to ensure accuracy, turn the potentiometer counterclockwise slightly.

- (3) If the engine is running with load, the gain and stability must be adjusted finely. Generally, this should be done in an unloaded, stable state.



CAUTION

In the event that it continues to appear unstable or demands higher performance in spite of being adjusted, refer to the section on troubleshooting.

5. Adjusting the starting fuel

Exhaust smoke occurring after the engine is started can be minimized as follows.

- (1) Idle the engine and connect terminals "M" and "G."
- (2) Use the idle potentiometer on the controller to adjust it to the minimum rpm at which the engine is stable.
- (3) Turn the starting fuel potentiometer counterclockwise until the engine speed drops. Increase the potentiometer slightly in order to set the idle rpm to a suitable speed.
- (4) There are two ways of increasing the engine rpm using the SPEED potentiometer on the speed controller.

Method 1) Accelerating the rated speed immediately after starting the engine (used in generators)
Disconnect terminals "M" and "G" and start the engine, then adjust the speed ramping potentiometer in order to minimize the exhaust smoke while the engine accelerates from the idle rpm to the rated rpm.

Method 2) After starting the engine, keeping the engine at the idle rpm for a certain amount of time until it is accelerated to the rated speed

- a) Use the switch to connect terminals "M" and "G." Turn the speed potentiometer counterclockwise to adjust the engine rpm. But if excessive exhaust smoke is produced while accelerating the engine, adjust the starting fuel potentiometer counterclockwise. But if it takes an excessive amount of time to start the engine, adjust the potentiometer clockwise gradually.
- b) In order to minimize the amount of exhaust smoke while accelerating from the idle rpm to the rated speed, adjust the speed ramping potentiometer with the switch open.

6. Setting the idle rpm

The idle speed increases when the idle potentiometer on the controller is turned clockwise. When the engine is set to the idle speed, this controller must be in the "droop" state in order to be able to drive stably.

7. Droop operation

Droop is used when running the engine generator in parallel, so do not use it when running the engine in isolation.

The value increases when the selection switch is set to the DROOP position and the droop potentiometer is turned clockwise.

In other words, the greater the load applied to the engine in this position, the more the speed drops.

The droop range is determined by the amount of change in the current flowing to the actuator when the engine load changes from no load to full load.

The droop range can be determined by means of internal adjustment of the controller alone and is usually set to within 10%.

After adjusting the droop range, you can reset the previously set value of the rated speed. After measuring the engine rpm, reset the speed as necessary.

8. Auxiliary input

Auxiliary terminal "N" receives signals from the load divider, automatic parallel feeder or other auxiliary devices in the governor system. Connect auxiliary devices for the speed controller directly to this "N" terminal. Use shielded wires when connecting wiring. When the automatic parallel feeder is used independently from the load divider, a 3 m resistor must be used between terminals "N" and "P" in order to adjust the voltage of the engine speed controller and parallel feeder.

The engine rpm drops when an auxiliary device is connected to terminal "N," so be sure to reset the controller.

A jumper must be used between terminals "G" and "J" or the frequency must be adjusted when the engine speed controller is operating at the maximum acceptable frequency.

When using this device, the acceptable frequency range of speed control is increased to over 7,000 Hz.

9. Auxiliary supply

Power can be supplied to auxiliary devices in the governor system at terminal "P" at an even voltage of +10 V, with a maximum current of 20 mA.

Terminal "G" is the reference potential terminal for terminal "P." If terminal "G" is short-circuited, the engine speed controller may be damaged.

10. Remote speed adjustment

A speed adjustment potentiometer is required in order to continuously adjust the engine speed remotely over a certain speed range.

Refer to the following chart in order to select a potentiometer to suit the uses based on the required speed range. If the required speed range is not in this chart, select a potentiometer for a range which is one level higher.

In order to obtain the correct speed range, additional fixed resistors can be attached to both ends of the potentiometer. Connect the potentiometer for setting the speed range according to the following wiring connection diagram.



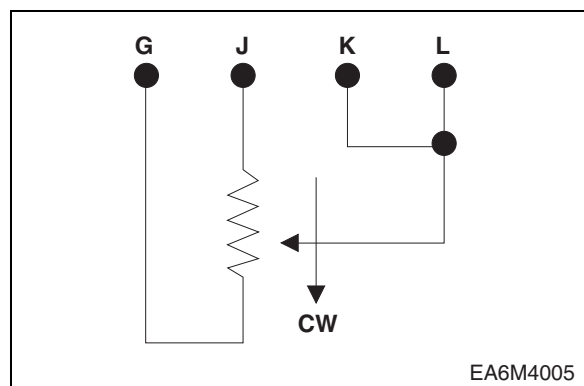
CAUTION

The generator set supplied by Doosan does not include a speed potentiometer for remote control. The consumer must install one themselves if they desire remote control. In order to obtain engine stability at a very low speed setting, a droop potentiometer can be used to obtain a small amount of droop.

On the other hand, when the speed setting is at its highest, the actuator runs almost stably regardless of the set droop value.

< Capacity and Wiring Connection Diagram for Remote Control Potentiometer >

Speed range	Potentiometer value
900 Hz	1 K
2,400 Hz	5 K
3,000 Hz	10 K
3,500 Hz	25 K
3,700 Hz	50 K



Troubleshooting

1. When the system does not work

When the engine actuator does not work, you can deduce the fault by performing the following four-step voltage test.

Be sure to check the polarity when performing measurements.

Step	Terminal	Specifications	Possible cause
1	F (+) & E (-)	Battery supply voltage (12 or 24V DC)	1. DC battery power not connected, check for damaged fuse
			2. Low battery voltage.
			3. Faulty wiring connection.
2	C & D	1.0V AC (when starting the engine)	1. Large gap between magnetic pick-up sensor and ring gear (Check gap)
			2. Faulty wiring in magnetic pick-up sensor (Check whether the resistance between terminals C and D is 30 ~ 1,200)
			3. Fault in magnetic pick-up sensor
3	P (+) & G (-)	10V DC (Internal supply voltage)	1. Short circuit in terminal P (causes fault in controller)
			2. Fault in magnetic pick-up sensor
4	F (+) & A (-)	1.0 ~ 2.0V DC (when starting the engine)	1. Low setting value for controller speed adjustment.
			2. Open or short circuit in actuator wiring.
			3. Fault in controller
			4. Fault in actuator

2. System not working properly

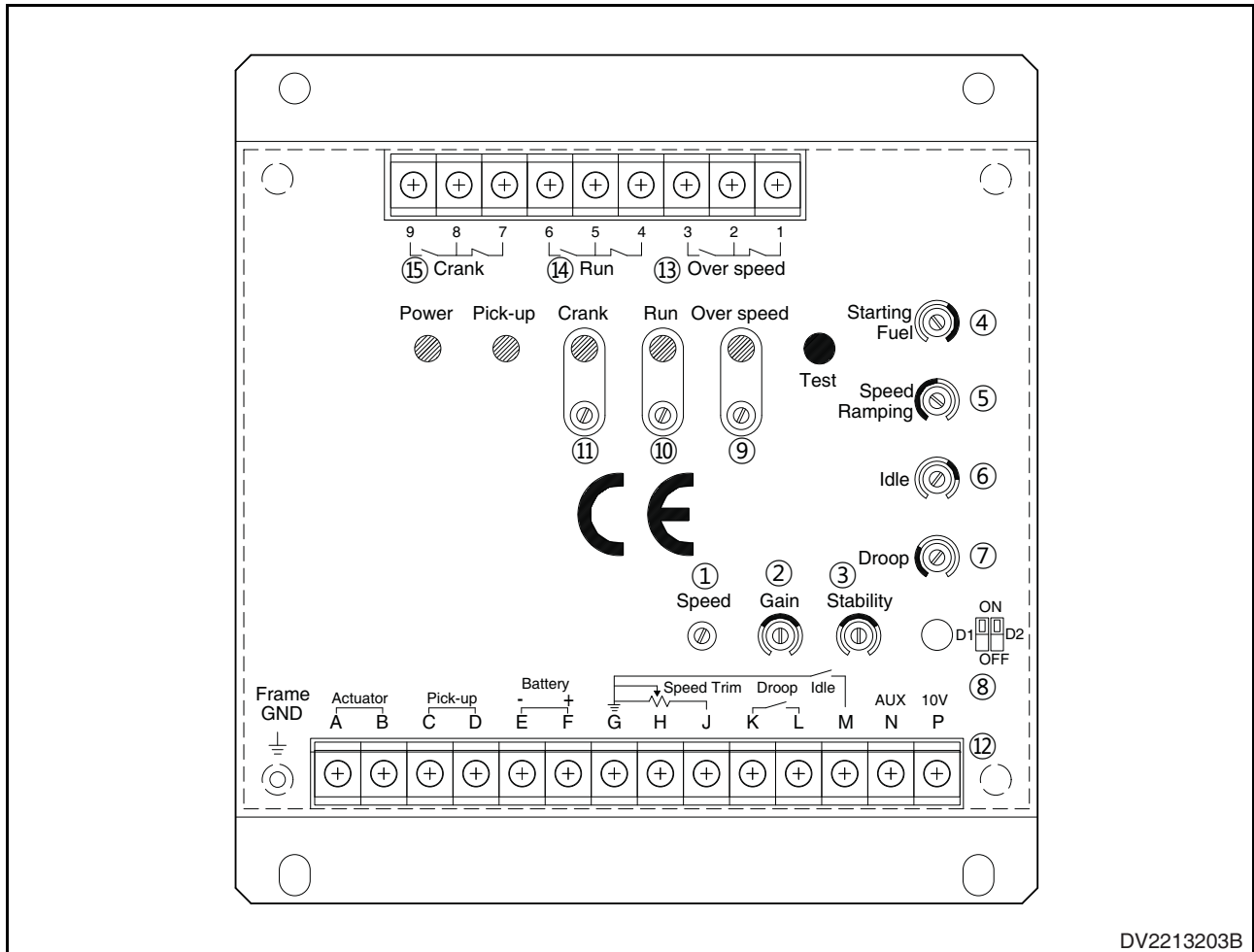
In the event that the system is not running properly, perform the following test.

Item	Details	Specifications
Engine overspeeds	- Do not run the engine - Apply a DC power supply to the actuator.	- The actuator will move to the position for maximum fuel supply. Then disconnect the magnetic pick-up sensor connected to terminals C and D. - If the actuator moves to the position for maximum fuel supply: There is a problem in the controller. - If the actuator is in a neutral fuel position: This is due to the wrong speed signal for the engine speed
	Manually maintain the speed required for engine operation. Measure the DC voltage between terminals A (-) and F (+) of the speed controller.	- When the voltage is between 1.0 ~ 2.0V DC - The speed potentiometer is set higher than the required speed. - There is a fault in the engine speed controller. - The actuator or connecting device is restricted when the voltage exceeds 2.0V DC - When the voltage is less than 1.0V DC - There is a fault in the speed controller. - The gain value is too low
The actuator is not working properly	1. Measure the battery voltage while the engine is running.	1. Replace the battery if the voltage is less than 7V in a 12V system or less than 14V in a 24V system.
	2. If terminals A and F are connected momentarily, the actuator should move to the position for maximum fuel supply.	1. Fault in the actuator or battery wiring
		2. Restricted by the actuator or connecting link
		3. Faulty actuator
Operating at a speed less than that required by the engine	1. Measure the voltage at output terminals A and B of the actuator while the engine is running.	4. Check for a blown fuse in the actuator or a short circuit in the actuator wiring.
		- If the measured voltage has a difference of less than 2V with the battery voltage, the fuel control is being obstructed such that it cannot reach the maximum fuel supply position, presumably due to interference from the actuator linkage. - The speed setting is too low

Control Unit (2)

Components

DWG-2013



Installing (Mounting) the Controller and Cautions

1. Install the controller vertically on the face of the control panel, away from water or moisture, and be careful that heat from heating elements near the controller is not transferred to it.
2. Also, in the event that it is exposed to moisture for an extended period of time (over one month or dew condensation), it may not reach the rated rpm due to a change in the resistance value of the internal circuit caused by exposure to moisture, so dry it off sufficiently before using it.
3. Do not rely exclusively on the function of the actuator in the electronic governor to prevent overspeeding. It is recommended to install a second, independent engine stopping device, such as a fuel shutoff solenoid.
4. Regarding setting each Doosan engine to the average set range depending on the type of engine, the indications for the set range on the front of each adjustable resistor recommend the settings within the set range.

EMC (Electromagnetic Compatibility)

In order to minimize damage to the controller due to unnecessary nearby electromagnetic waves, either mount the controller on a grounded metal surface or use a shielded metal case. All wires should be shielded and the shielded part should be grounded to a single point. We cannot provide guarantees for any EMC-related product quality issues arising in the case that the above-mentioned installation method for preventing electromagnetic waves is not performed.

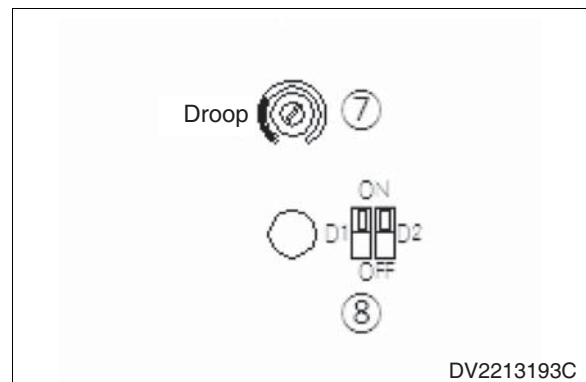
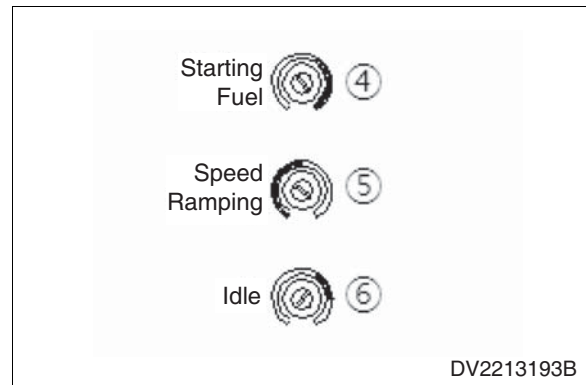
Description of Control Mode Items

In order to minimize damage to the controller due to unnecessary nearby electromagnetic waves, either mount the controller on a grounded metal surface or use a shielded metal case. All wires should be shielded and the shielded part should be grounded to a single point. We cannot provide guarantees for any EMC-related product quality issues arising in the case that the above-mentioned installation method for preventing electromagnetic waves is not performed.

1. Items for auxiliary (emergency) control mode
 - (1) Speed control resistor: Controls the engine's running speed.
 - (2) Gain control resistor: Controls the gain (sensitivity).
 - (3) Stability control resistor: Controls the stability (responsiveness).
 - (4) Starting fuel control resistor: Controls the amount of fuel when the engine is started.
 - (5) Speed ramping control resistor: Controls the time it takes to reach the rated speed after starting the engine.
 - (6) Idle control resistor: Controls the initial engine speed.
 - (7) Droop control resistor: Controls the amount of droop (%) during droop operation.
 - (8) Differential control switch (dip switch): A control switch for selecting differential functions.
 - (9) Overspeed lamp control resistor: Controls the activation timing of the engine speed lamp and relay.
 - (10) Run lamp control resistor: Controls the activation timing of the engine operation lamp and relay.
 - (11) Crank lamp control resistor: Controls the activation timing of the initial speed indicator lamp and relay.
 - (12) TB1: A terminal block for external input/output wiring connections.
 - (13) TB2: An output terminal for the engine overspeed relay contact. (Capacity - 2 A/125V AC).
 - (14) TB3: An output terminal for the engine operating speed relay contact. (Capacity - 2 A/125V AC).
 - (15) TB4: An output terminal for the initial engine speed relay contact. (Capacity - 2 A/125V AC).

Adjustment (Tuning) Order and Method

1. The potentiometer's guide range on the front of the case is the adjustment range applied to Doosan Infracore (Inc.) engines.
2. When adjusting the potentiometer, use a flat-blade precision screwdriver of the right size. (Be careful not to damage the resistor)
3. Check whether the wiring connections of all external devices are correct before starting the engine.



4. Adjusting the Engine Start-up Characteristics

- (1) Connect the G-M terminals (turn the initial engine speed (idle) switch ON). Starting Fuel



IMPORTANT

Purpose of adjustment: Adjusting to the most economical amount of fuel based on the state of the engine installed.

Recommended direction: 1 o'clock to 5 o'clock

Problems when adjusted incorrectly: In the 7 o'clock to 1 o'clock direction, there is not enough fuel, which may cause faulty starting. In the 5 o'clock or higher direction, fuel efficiency worsens during starting and the amount of exhaust gas may increase.

- (2) Adjust the speed ramping potentiometer in the 9 o'clock to 12 o'clock direction.



IMPORTANT

The farther it is turned clockwise, the longer it takes to reach the rated (run) speed. (Up to 10 seconds or more)

If the value is too low, overshoot or hunting may occur due to sudden increases in speed. Fuel efficiency may worsen and the amount of exhaust gas may increase.

- (3) Start the engine: Turn on the start motor.

5. Adjusting the engine operating speed and initial speed (idle)

- (1) Adjust the engine operating speed (frequency).



IMPORTANT

After starting the engine, disconnect the G-M terminal. (Turn the initial speed switch OFF)

Adjust the speed (frequency) with the speed potentiometer while in an unloaded state.

Clockwise: RPM increases / counterclockwise: RPM decreases

- (2) Adjusts the initial engine speed.



IMPORTANT

After turning the initial speed switch ON again, use the idle potentiometer to adjust the speed to 800 rpm.

Purpose of adjustment: Adjusting the initial amount of fuel for starting the engine and for the preheating function after starting the engine.

Recommended direction: 12 o'clock to 3 o'clock. There are differences in the direction for each engine model or rated rpm but we recommend an engine rpm of 800.



IMPORTANT

Problems when adjusted incorrectly: The initial starting performance is degraded and excessive fuel consumption occurs while preheating.

One must not overlook the fact that the idle speed is one of the main factors which determines the start-up characteristics of the engine.

Hence, after adjusting the potentiometer, the initial speed must be adjusted regardless of whether or not idle mode is used.

6. Adjusting the Governor Characteristics

- (1) After disconnecting the G-M terminal (initial speed switch OFF), adjust it when the engine reaches the operating speed (run speed).

- (2) Adjust the gain.

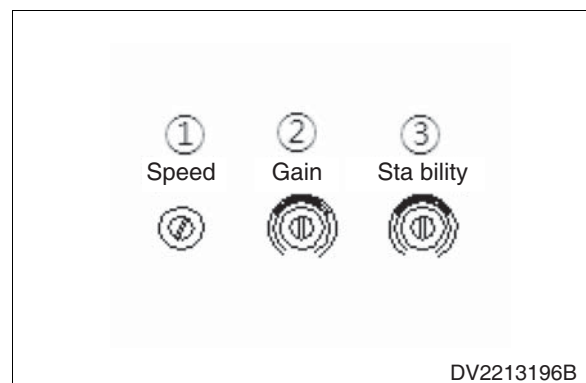


IMPORTANT

Turn the gain potentiometer clockwise until the engine becomes unstable in an unloaded state.

Slowly turn the gain potentiometer counterclockwise and set it at the position that the rpm becomes in the most stable state.

For the sake of stability, turn the gain potentiometer around 20 arcminutes (10°) in the counterclockwise direction.



7. Adjusting the stability

- (1) Turn the stability potentiometer clockwise until the engine becomes unstable in an unloaded state.
- (2) Slowly turn the stability potentiometer counterclockwise and set it at the position that the rpm becomes in the most stable state.
- (3) For the sake of stability, turn the stability potentiometer around 20 arcminutes (10°) in the counterclockwise direction.

8. Other adjustments

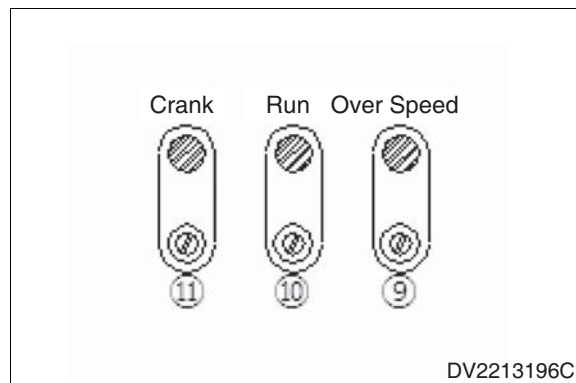
- (1) Adjusting the ON timing of the engine operation (run) lamp.



IMPORTANT

Turn the run potentiometer counterclockwise at the engine operating speed until the engine run lamp turns on.

In order to prevent the lamp from blinking (turning on/off when the load changes after setting the rated speed), turn it another 90° in the counterclockwise direction.



- (2) Adjusting the ON timing of the initial speed lamp (crank lamp).



IMPORTANT

Turn the crank potentiometer counterclockwise at the crank speed until the crank lamp turns on. In order to prevent the lamp from blinking (turning on/off when the load changes after setting the rated speed), turn it another 90° in the counterclockwise direction.

- (3) Adjusting the ON timing of the engine overspeed lamp.



IMPORTANT

Push the test button at the engine operating speed and slowly turn the overspeed potentiometer counterclockwise until the engine overspeed lamp turns on and the engine shuts off. It will be set to a speed around 15% higher than the engine operating speed.



IMPORTANT

After all adjustments are complete, restart the engine and check whether the start-up, no load and load characteristics are stable.

In order to prevent the lamp from blinking (turning on/off when the load changes after setting the rated speed), turn it another 90° in the counterclockwise direction.

9) Adjusting the starting fuel (minimizing exhaust gas)

- (1) Crank speed switch ON → adjust crank speed to 800 rpm → turn the starting fuel potentiometer counterclockwise until the engine speed drops. → For the sake of stability, turn it another 15° in the clockwise direction.



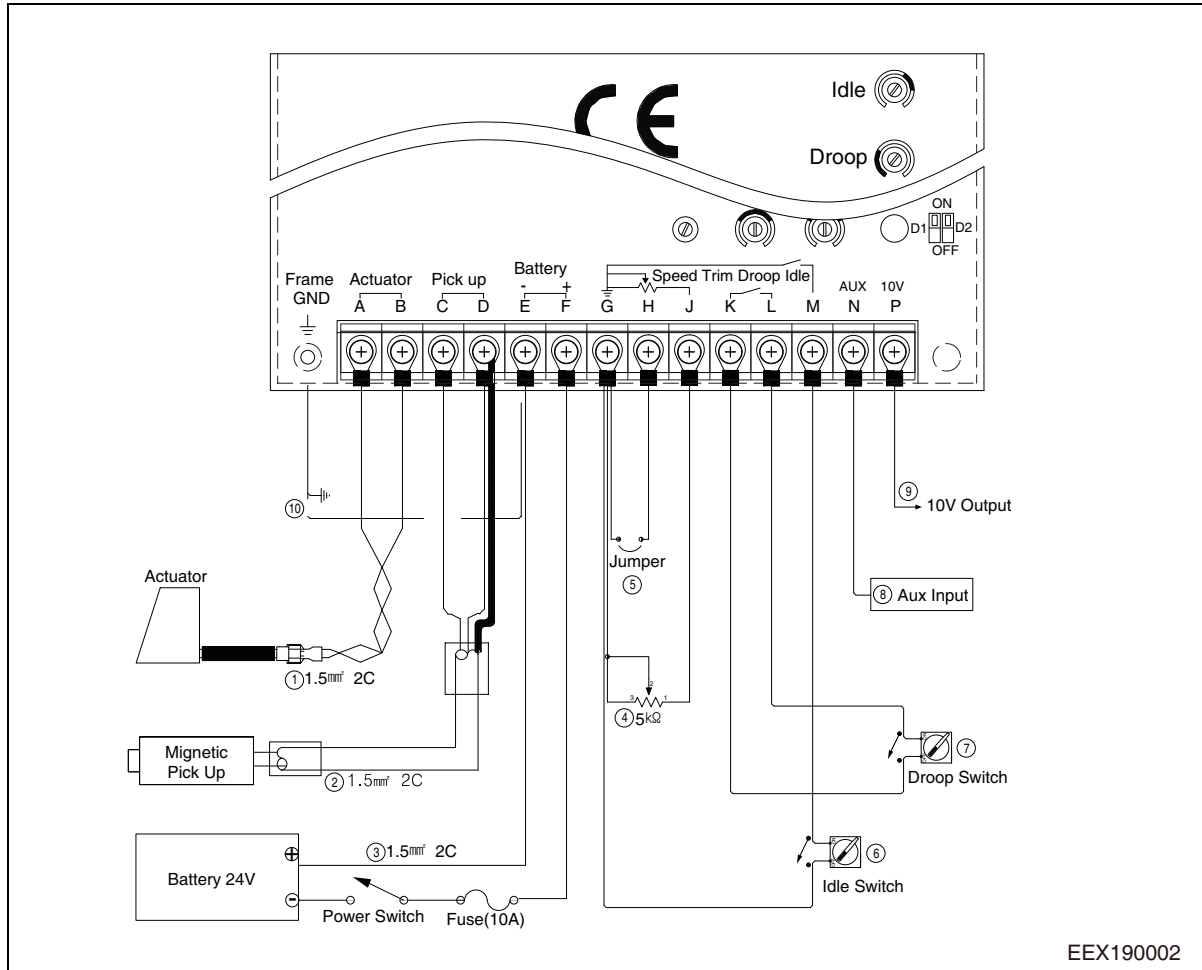
CAUTION

If the amount of exhaust gas is not excessive when starting the engine, we recommend adjusting the starting fuel potentiometer to a higher setting in the 5 o'clock direction.

If set too low, startability worsens and immediately after starting the engine, overshoot may occur and cause the engine to exceed the set overspeed value.

10) When the engine will not start

- (1) If there are no problems with the wiring connections → adjust all control values to the "factory setting."
(Refer to DV2213211A)
→ Restart the engine.
- (2) If the problem is not resolved: There may be a problem with the controller hardware so replace the controller.



External Wiring Connections

- Refer to the wiring connection diagram to connect them.
 - All wiring must be over the specified 1.5 mm² and be shielded.
 - When using shielded wiring, all shielded wires not indicated on the wiring connection diagram must be grounded to the frame.
1. Twisted cables must be used for the actuator wiring.



IMPORTANT

After connecting the wiring, the resistance between A-B must be 3.5 ~ 4.5 Ω.

2. The cables for the magnetic speed sensor must be "shielded wires," and the shielded part must be connected to terminal D as well.



IMPORTANT

If this shielded part is grounded to the engine or not grounded, a distorted speed signal may be entered and cause problems such as hunting, so be sure to ground it.

3. Be careful not to reverse the polarity of the battery connected to terminals E and F, and be sure to install a 10 A fuse between the positive (+) battery terminal and terminal F.



IMPORTANT

After connecting them, be sure to check whether the voltage between the terminals is DC 24V (±4 V). Also, ground terminal E to the frame. (Wiring connection no.10)

4. Connect a 5 kW resistor externally as shown in the picture to enable the engine speed to be fine-tuned within a range of around "set speed ± 210 Hz."
5. When using a 12V battery or an actuator with a current consumption over 5 A, use a jumper to connect terminals G and H.
6. A selection switch for switching between the crank speed mode and run speed mode.
7. The droop mode selection switch.



IMPORTANT

ON (connected): droop mode / OFF (disconnected): isochronous mode

8. Connects the signal coming from the auxiliary device used in the parallel operating system to terminal N.



IMPORTANT

Use shielded wires.

9. Accessory power supply: Terminal P, which supplies rated power of +10[V], 20[mA], can be used as a power supply for external auxiliary devices and applied in a variety of different ways.



IMPORTANT

However, it should only be used within the range of the rated capacity. Be careful to avoid short circuits, and in the event that the capacity is exceeded, it may cause critical damage to the controller.



CAUTION

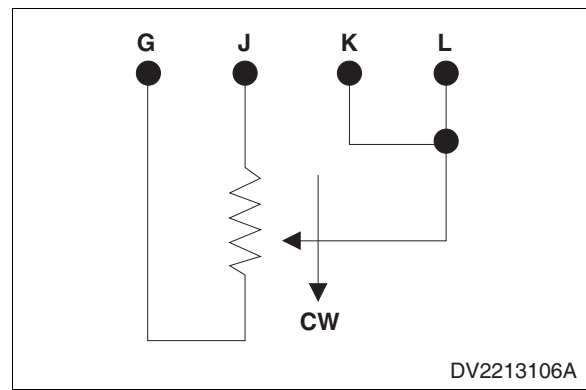
Incorrectly connected wires or abnormal battery voltage can cause critical damage to the controller so be sure to inspect them before use.

Mounting and Connecting the Magnetic Speed Sensor

1. The optimal gap between the magnetic speed sensor and ring gear is 0.45 mm. In order to achieve this, tighten the sensor until it makes contact with the ring gear, then turn it another 3/4 turns in the reverse direction to obtain a suitable gap.
2. The speed sensor signal can be checked by measuring the voltage (AC) between terminals C-D while the engine is running.
3. The sensor voltage applied to the controller must be over AC 3V.

Adjusting the Speed Externally

1. By connecting the speed adjustment potentiometer externally as shown in the picture, you can adjust the engine speed remotely and externally within a certain speed range. Refer to the chart to set the resistance value according to the required speed range.
2. When the engine speed is set to the minimum speed in remote control mode, it causes a decrease in speed due to the instability and load on the system. Hence, when using the minimum speed setting, use the droop potentiometer to adjust the amount of droop to a low level (turning the potentiometer counterclockwise), thereby enabling engine stability to be maintained.



On the other hand, when the speed setting is at its highest, the governor runs almost isochronously regardless of the set droop value.

Speed Range	Potentiometer Value	Engine rpm Converted for Number of Ring Gears		
		160	152	146
900 Hz	1 K	337 rpm	355 rpm	370 rpm
2,400 Hz	5 K	900 rpm	947 rpm	986 rpm
3,000 Hz	10 K	1,125 rpm	1,184 rpm	1,230 rpm
3,500 Hz	25 K	1,315 rpm	1,381 rpm	1,438 rpm
3,700 Hz	50 K	1,387 rpm	1,460 rpm	1,520 rpm

3. State of adjustment at time of factory release

300611-00683	
Overspeed	1,725 rpm (based on 160 gear teeth)
Run lamp	Maximum CW
Gain	Mid-range (facing 12 o'clock)
Stability	Mid-range (facing 12 o'clock)
Starting Fuel	Full CW (Maximum Fuel)
Speed Ramping	Facing 9 o'clock
Droop Full	CCW (Minimum)
E.M. Speed Adjustment	(160 gear teeth)
Speed Adjustment	4,000 Hz (1,500 rpm)
Idle Adjustment	2,133 Hz (800 rpm)

CW: Clockwise, CCW: Counterclockwise

300611-00684	
Overspeed	1,725 rpm (based on 160 gear teeth)
Run lamp	Maximum CW
Gain	Mid-range (facing 12 o'clock)
Stability	Mid-range (facing 12 o'clock)
Starting Fuel	Full CW (Maximum Fuel)
Speed Ramping	Facing 9 o'clock
Droop Full	Full CCW (Minimum)
E.M. Speed Adjustment	(160 gear teeth)
Speed Adjustment	4,800 Hz (1,800 rpm)
Idle Adjustment	2,133 Hz (800 rpm)

CW: Clockwise, CCW: Counterclockwise

300611-00685	
Overspeed	2,070 rpm (based on 160 gear teeth)
Run lamp	Maximum CW
Gain	Mid-range (facing 12 o'clock)
Stability	Mid-range (facing 12 o'clock)
Starting Fuel	Full CW (Maximum Fuel)
Speed Ramping	Facing 9 o'clock
Droop Full	Full CCW (Minimum)
E.M. Speed Adjustment	(152 gear teeth)
Speed Adjustment	3,800 Hz (1,500 rpm)
Idle Adjustment	2,026 Hz (800 rpm)

CW: Clockwise, CCW: Counterclockwise

300611-00686	
Overspeed	2,070 rpm (based on 160 gear teeth)
Run lamp	Maximum CW
Gain	Mid-range (facing 12 o'clock)
Stability	Mid-range (facing 12 o'clock)
Starting Fuel	Full CW (Maximum Fuel)
Speed Ramping	Facing 9 o'clock
Droop Full	Full CCW (Minimum)
E.M. Speed Adjustment	(152 gear teeth)
Speed Adjustment	3,800 Hz (1,500 rpm)
Idle Adjustment	2,026 Hz (800 rpm)

CW: Clockwise, CCW: Counterclockwise

Droop Parallel Operating Mode (Manual Parallel)

- Definition of droop: A reduction in the speed setting following an increase in the load

$$\text{DROOP}(\%) = \frac{(\text{No Load Speed} - \text{Full Load Rated Speed}) \times 100}{\text{Full Load Rated Speed}}$$

- Purpose of droop: Droop is used with the purpose of load sharing in the parallel operating system among generators.
- If there is no droop function in the parallel system, the generator may overload or motorize.
- Applying droop: In order to use droop, turn on the droop selection switch connected to terminals K-L.
- When in droop mode, the speed decreases due to an increased load, but you can use the "Droop" potentiometer (7) to determine the amount (%) of droop.



IMPORTANT

Turning it clockwise increases the amount of decrease. (Increases the amount (%) of droop)
The amount of droop generally used is less than 10%. In order to maintain stability in speed droop governors, the minimum amount of droop required is at least 2.5%. The value of the rated speed already set based on the adjusted amount of droop can change so check the engine speed and readjust the speed as necessary.

Accessory Input (Automatic Parallel)

- Accessory terminal N receives signals from the load sharing unit, auto synchronizer or other accessories in the governor system.
- Use shielded wires when connecting wiring.
- The engine speed drops when an accessory is connected to terminal N so the speed adjustment potentiometer must be reset.
- When the control device is operating at the maximum acceptable frequency, a jumper or frequency trim control may be required between terminals G and J. When using this device, the acceptable frequency range of speed control is increased to over 7,000 Hz.

Controller Lamp Display (Diagnosis) Functions

- **Power** : The lamp turns on when a battery power supply is connected and an internal control voltage (DC 12V) has been generated. This means that the main controller is running.
- **Pick Up** : The lamp turns on when the magnetic speed sensor signal entering terminals C-D is over AC 3.0V.
- **Crank** : The lamp turns on and the relay activates when the set rated speed (crank speed) is reached.
- **Run** : The lamp turns on and the relay activates when the set rated speed (run speed) is reached.
- **Overspeed** : When the engine speed reaches the set overspeed, the lamp turns on, the relay activates and the actuator output is blocked.

System Troubleshooting (Instability)

1. Instability at rapid intervals (hunting): Applying SW D1 and D2
 - (1) The differential function activates when D1 is placed in the ON position.
 - (2) This can increase the responsiveness to changes in speed (rpm), thereby enabling quicker response to changes in speed.
 - (3) Slight hunting may occur at rapid intervals due to sensitive response to external frequency noise. In such cases, turn D1 off and readjust the gain and stability.
 - (4) If the instability persists in spite of doing so, turning off SW D2 on the device can help to stabilize the engine.
 - (5) After taking such measures, readjust the gain and stability again in order to optimize the system. This will help to reduce and eliminate instability.
2. Instability at slow intervals (hunting)

The main factors involved in hunting at slow intervals have many causes but generally, it occurs when tuning is not optimized due to the slight differences in mechanical characteristics in each engine. Such hunting can mostly be resolved by readjusting the gain and stability within the controller.



IMPORTANT

Refer to the information on the order of adjustment.

- 3) If the problem is not resolved with the methods above
 - (1) Loss of control function due to a fault in the controller itself - replace the controller.
 - (2) Fault in an external mechanical device (actuator, fuel injection device, turbine, etc.) - adjust the mechanical device.

When the System is Not Working

In the event that the engine governor system is not working properly, you can deduce the cause by performing the test in the following chart.

Here, (+) and (-) represent the polarities of the measuring instrument. Using the method in the chart below, if the test results are normal, there may be a problem in the actuator or the actuator wiring connections so the actuator must be inspected.

Step	Measured terminals	Time of measurement	Normal value	Presumed cause of fault	Troubleshooting
1	F (+) & E (-)	E/G stopped	DC 24V	Battery failure Faulty connection	Check battery line, replace battery.
2	F (+) & E (-)	E/G starting	DC 15 or higher		
3	C & D	E/G stopped	300 ~ 1,200 Ω using test ohm-meter	Defective speed sensor Damaged or incorrectly connected speed sensor wiring	Check sensor line. Replace speed sensor.
4	C & D	E/G starting	1.5V or higher when measured with tester AC voltmeter	Gap between speed sensor and ring gear too wide. Defective speed sensor	
5	A & B	E/G stopped	3.8 ~ 4.5 Ω using test ohm-meter	Check line for short circuit if measured value is less than 3.8 Ω Check line for open circuit if measured value is over 4.8 Ω Defective actuator	Check actuator line for short or open circuit. Replace actuator
6	P (+) & G (-)	Key S/W ON	DC 9.5 ~ 10.5V	Faulty control device	Replace controller.
7	F (+) & A (-)	While in operation	DC 9 ~ 15V when normal DC 1 ~ 3V when abnormal	Low speed setting. Short or open circuit in actuator wiring connection Actuator	Check speed settings. Check actuator line. Check actuator and replace if faulty.

Digital Speed Controller

Product Overview and General Specification

1. Product information

Digital speed controller (DSC-1000) 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

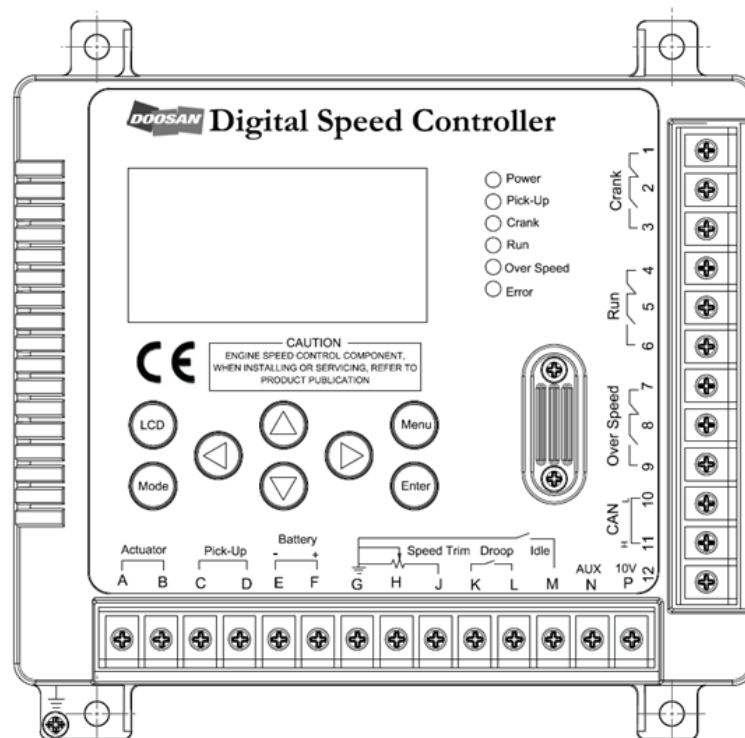
2. Product appearance

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.

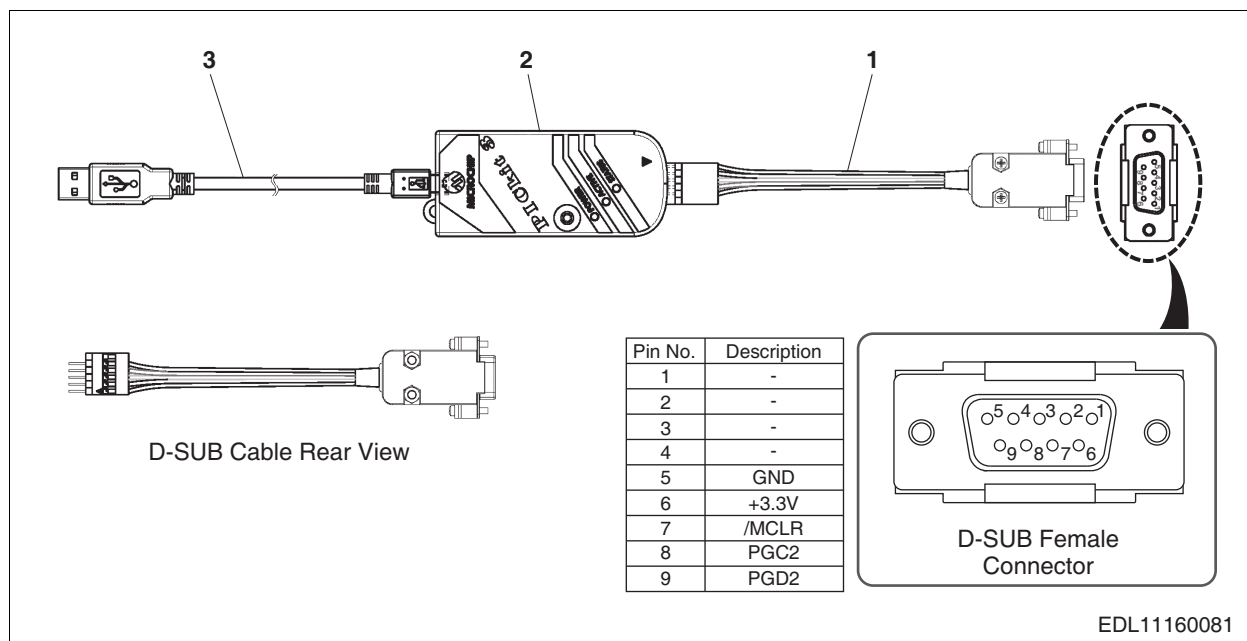


Product Front View

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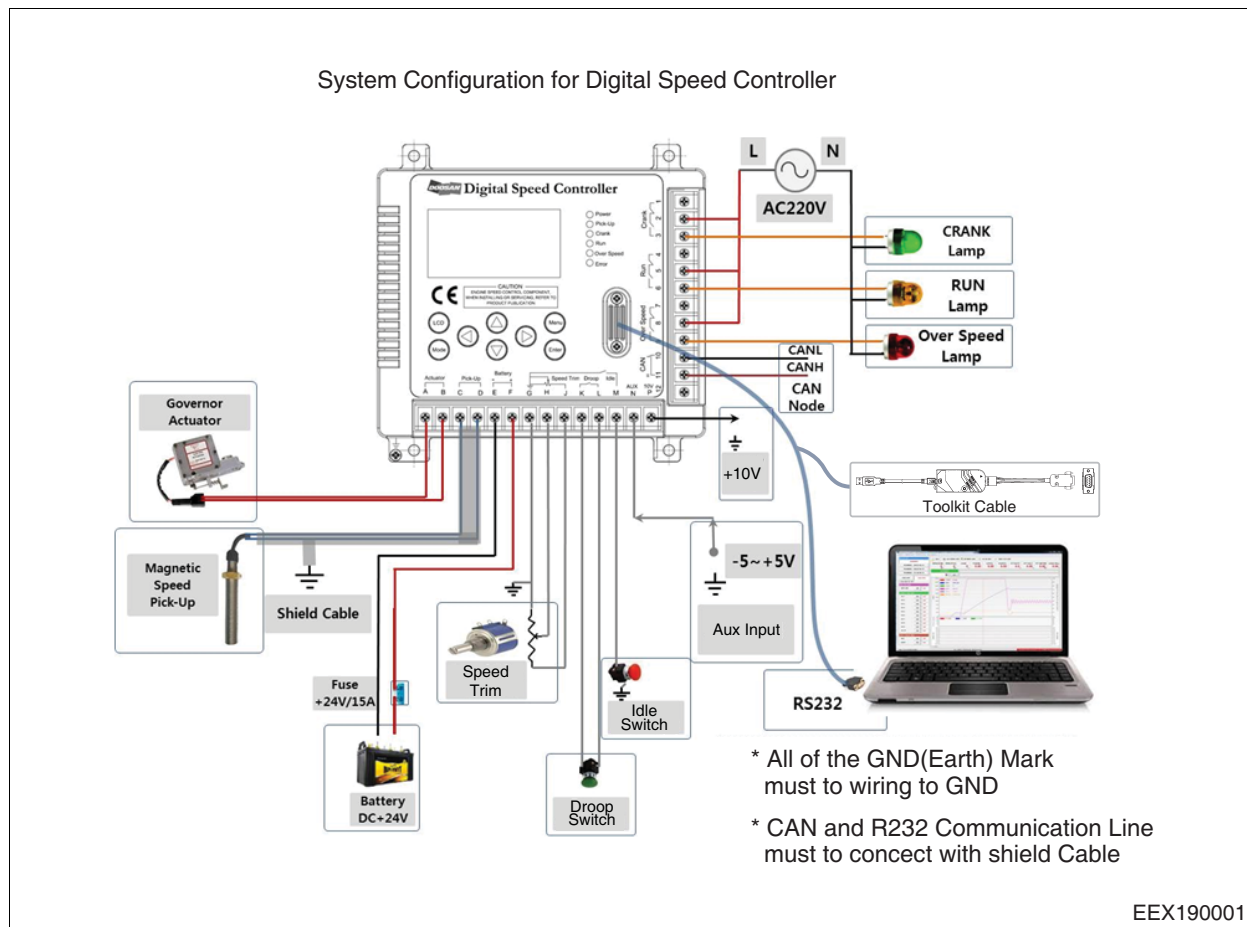
3. Product specification

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	128 Mb
7	Communication	RS232 57600 bps
		CAN (J1939)/250 kbps
8	Rated Power	DC 24V (12V ~ 30V)
9	Current Consumption	120 mA
10	Operating Temperature	-20 ~ 70°C
11	Storing Temperature	-30 ~ 80°C
12	Operating Humidity	0 ~ 95%



No.	Item	Part No.	Name
1	D-SUB Cable	850329-00502	Toolkit Cable
2	Pick It		
3	USB Cable		

4. Product system diagram

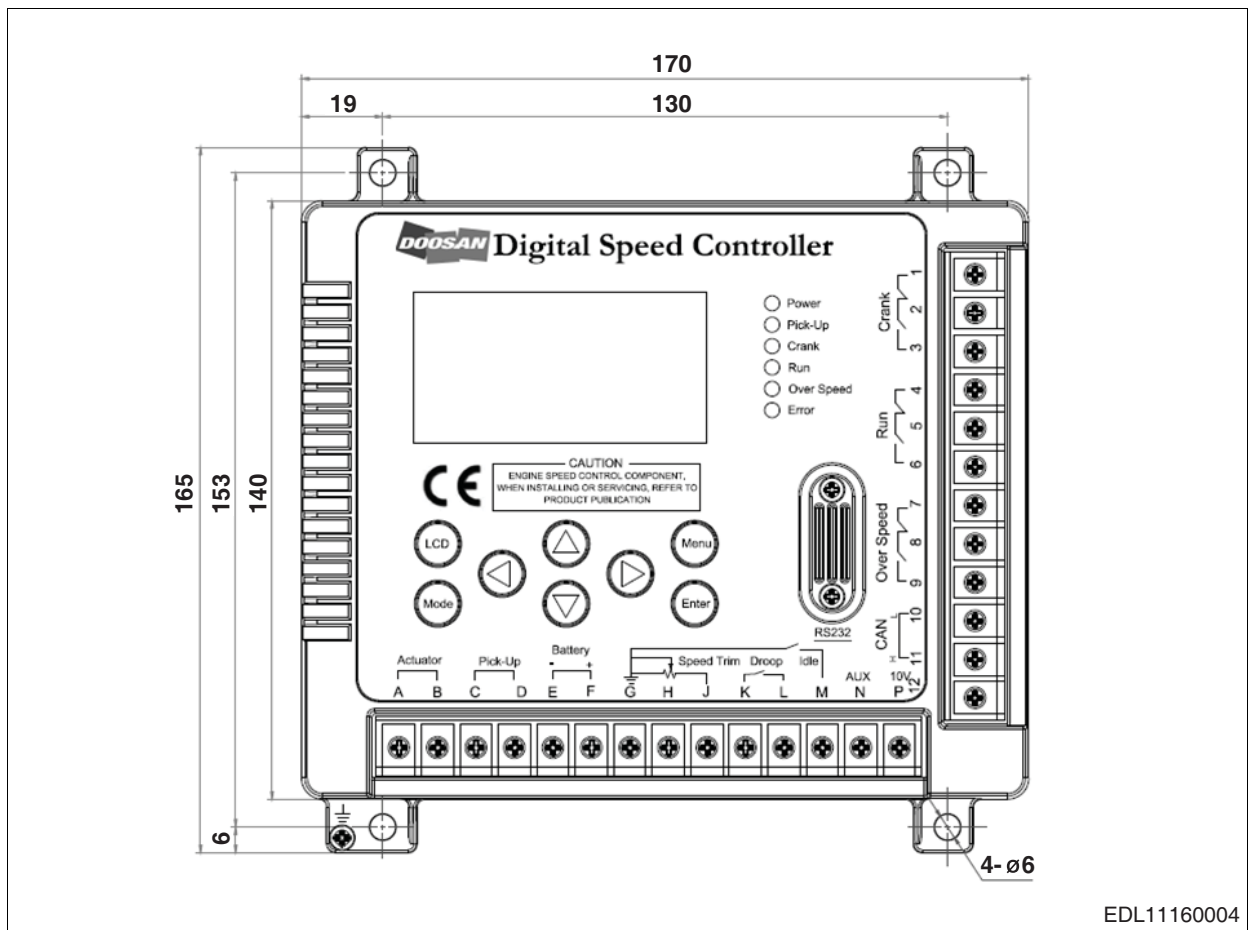


5. Product I/O signals

No.	Terminal	I/O Type	Terminal Functions
1	Actuator (A, B)	Output	Outputs are actuator control signals. Wiring should be 18AWG (105°C) or better. (However, terminals A and B can be used regardless of their polarities)
2	Pick-Up (C, D)	Input	Inputs are RPM sensor signals. Terminal D should be connected to the ground in connection with the shield cable. Gap between the RPM sensor and the gear tooth should be adjusted between 0.9 and 1.1 mm (sensor inputs should be at least 3V AC RMS).
3	Battery Voltage (-E, +F)	Input	It is a power input terminal for the controller and inputs are DC +24V/15A. 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.

No.	Terminal	I/O Type	Terminal Functions
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/20 mA 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+24 V 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 red 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 red on the crank level when the digital speed controller reaches at the RPM delivering control signals to the actuator after the engine is activated.
18	Run LED	Output	The LED turns on in red 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.
22	Ground	Ground	The GND part and the ground should be earthed in shared connection.

6. Product dimension



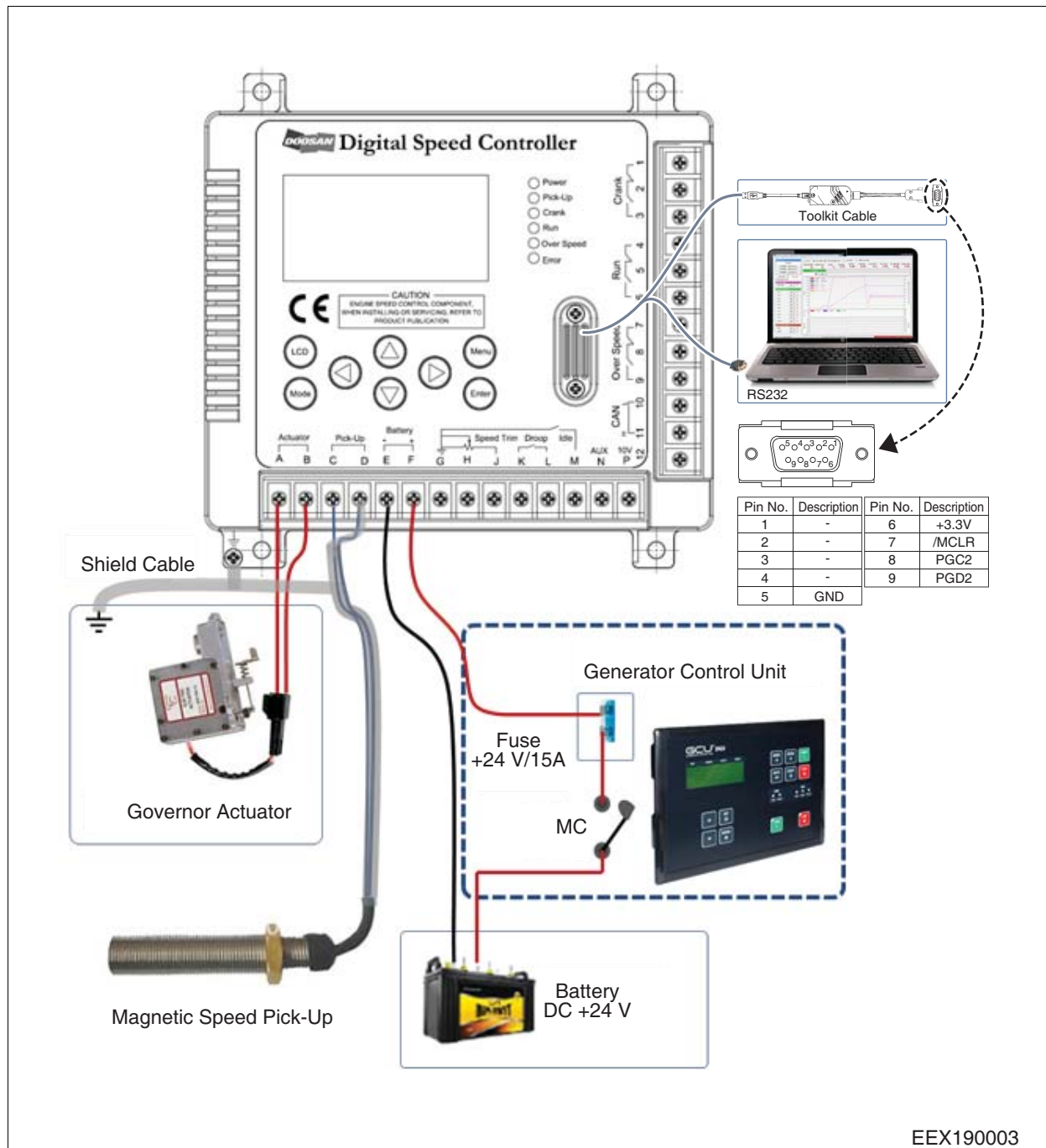
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Installation

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.

1. Connecting to the engine

(1) Battery, pick-up and actuator connection diagram



(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. Depending on cases, wiring can be done in a serial connection to the contact point a of MC and the fuse (DC +24V/15 A) when connecting to system panels or generator control devices.

(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. Wiring should be 18AWG (105°C) or better and the outside should be wrapped by plastic tubes for insulation or insulated mesh lines.

(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. Wiring should be twisted or shielded cables connected to the ground together with the terminal D. Gap between the pick-up sensor and the gear tooth should be adjusted between 0.9 and 1.1 mm.

(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

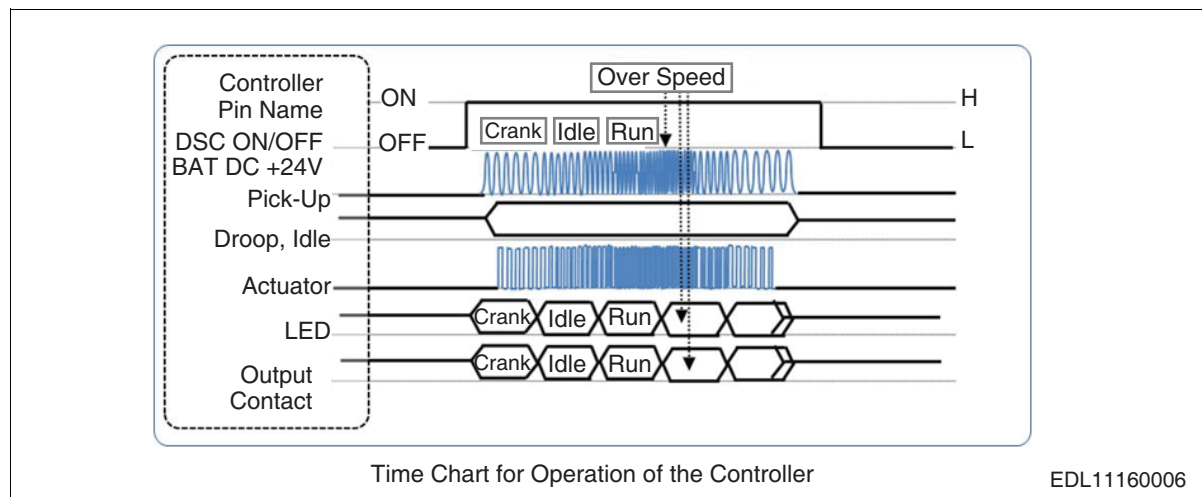
Step 1) When DC +24V power is supplied to the controller, the controller starts to operate. It indicates that power LED turns on and the power is being normally supplied.

Step 2) Inputs for speed trim, droop and idle functions are received.

Step 3) The controller checks the signals of the speed pick-up sensor.

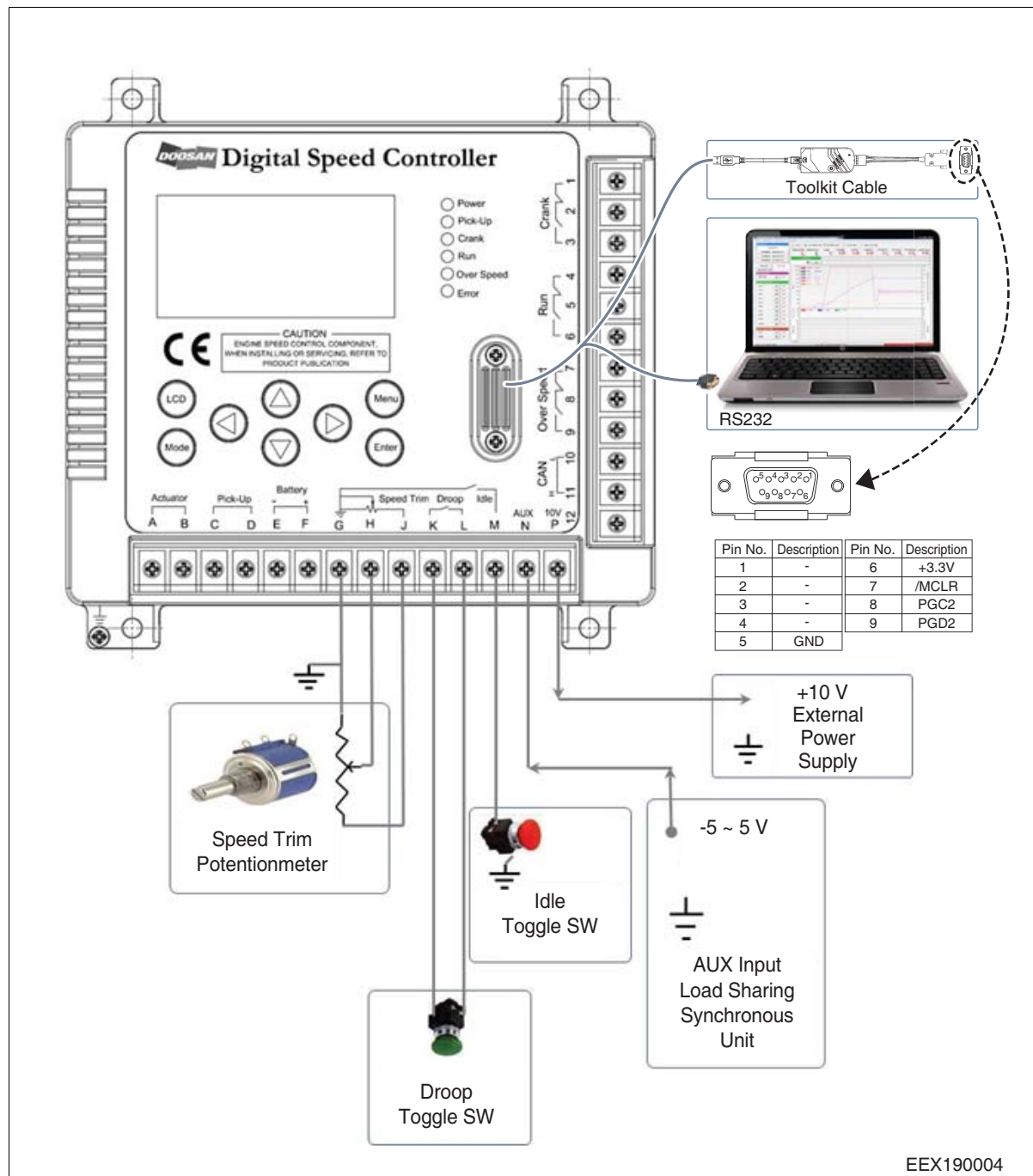
Step 4) Actuator control signals are output together with designated values of other information for crank, run and over speed functions according to the PID control values.

Step 5) The controller checks the operation condition and displays LED outputs and fault messages according to the detected information.



2. Connecting to speed trim, droop, idle and other inputs

(1) Speed trim, droop, idle and other inputs diagram



(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 connected to G depending on the current consumption of the actuator (for actuators with 5A or higher). J is an input terminal for fine-tuned voltage values between 0 to 5V.

(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.

(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.

(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 5 V and it is recommended to use shielded cables for signal wires.

(6) Connecting power to external devices

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

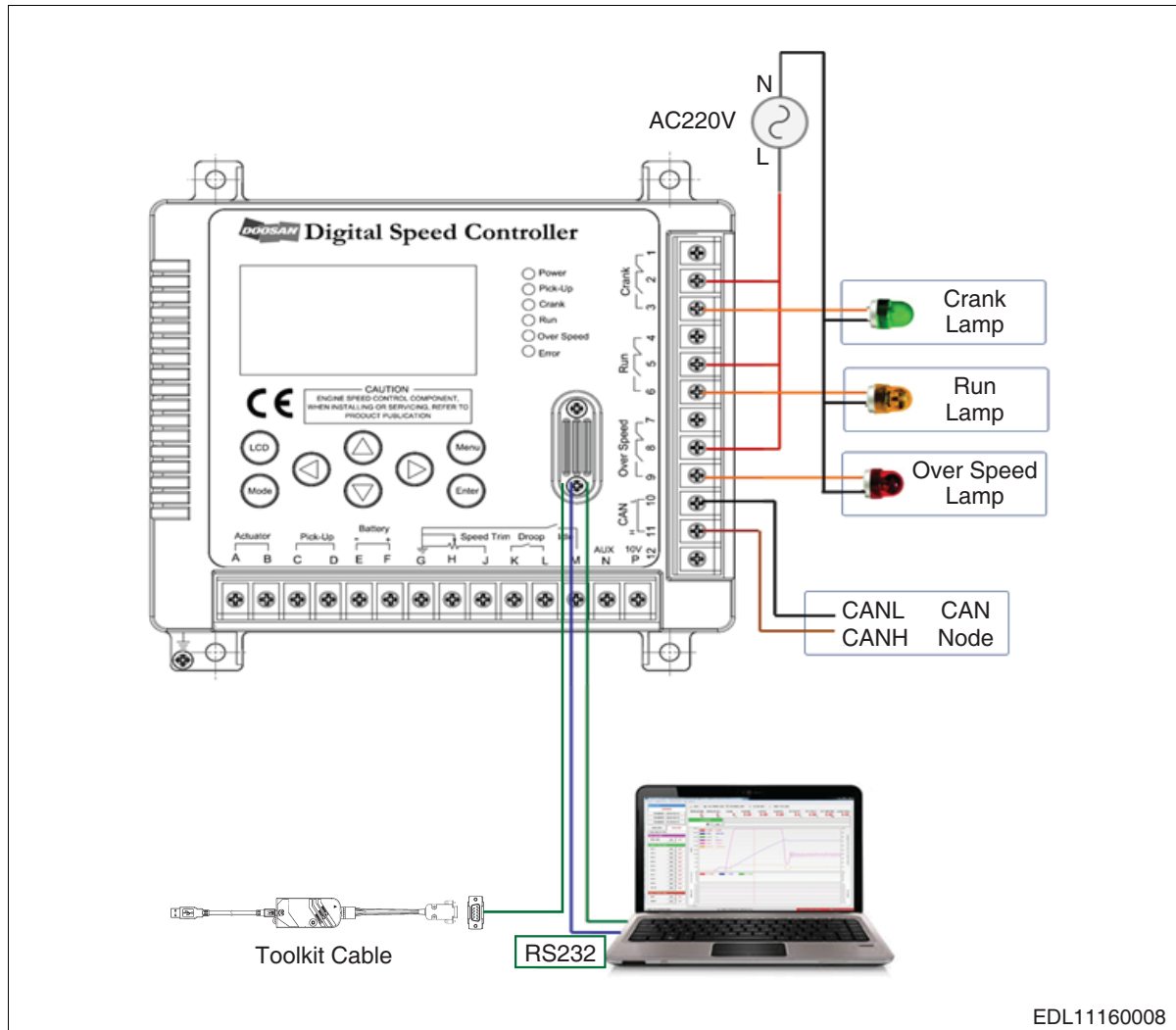
However, power supply of 20 mA or higher should not be used and care should be given to prevent short circuits.

3. Connecting to crank, run, over speed and communication

(1) 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) 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.

(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.

(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.

(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.

(6) Connecting to RS232 communication

D-SUB 9pin (female) is for RS232 communication for connection to external PCs or hosts.

It can configure system parameters of the controller or communicate with analytic applications.

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.

1. Input keys

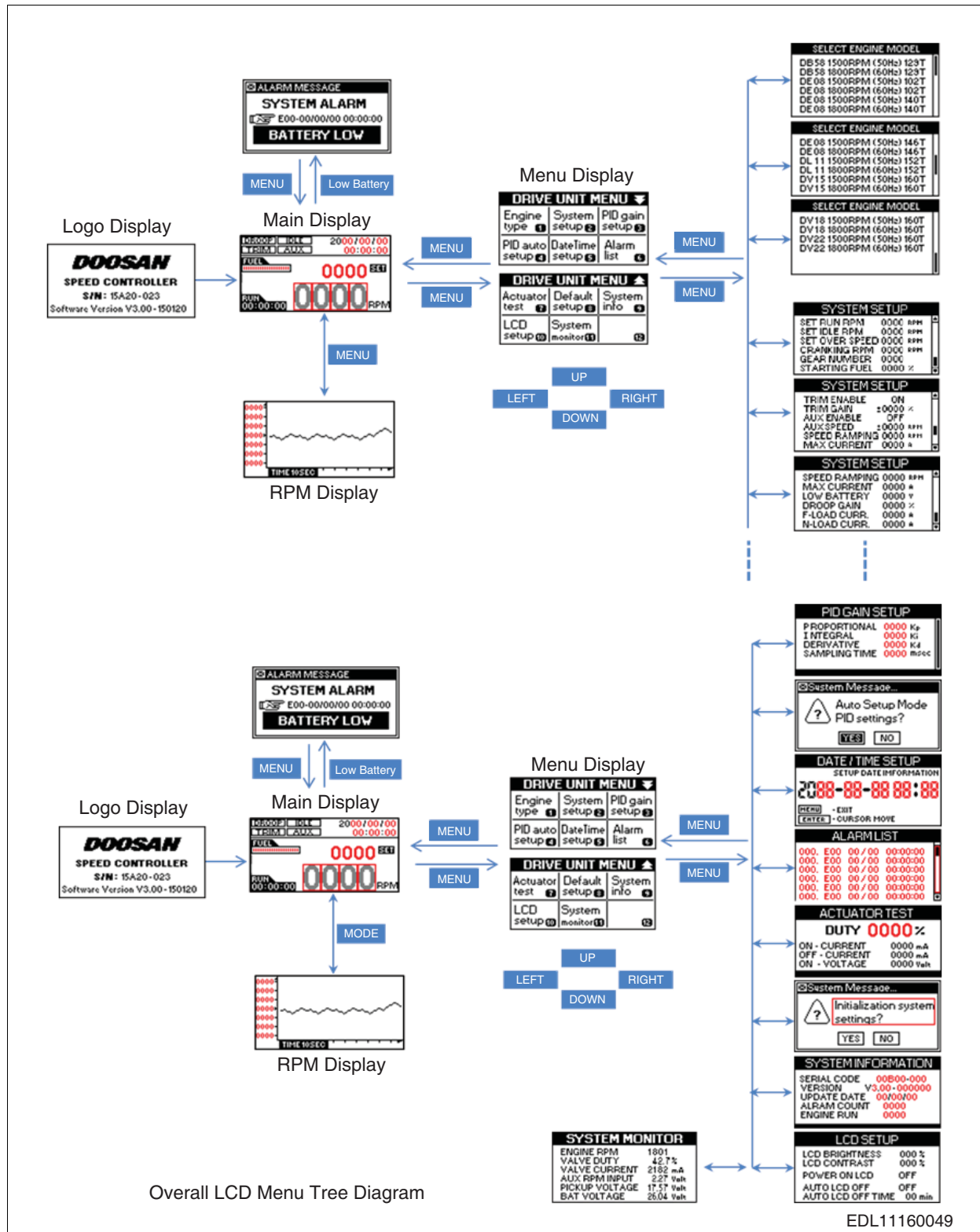
The controller has 8 input keys including LCD, Mode, Menu, Enter, Up, Down, Left and Right.

Each key as respective functions as follows:

LCD	LCD key turns on and off the display.
Mode	Mode key switches the display to either operation mode or wave form display.
Menu	Menu key lets users change the menu display and go back to the previous menu.
Enter	Enter key applies designated values on the LCD display to the system.
	Up key lets users go up or increase values in the selected menu on the LCD display.
	Down key lets users go down or decrease values in the selected menu on the display.
	Left key lets users move to the left in the selected menu.
	Right key lets users move to the right in the selected menu.

2. LCD display menu

The overall menu tree of the controller is as follows:



EDL11160049

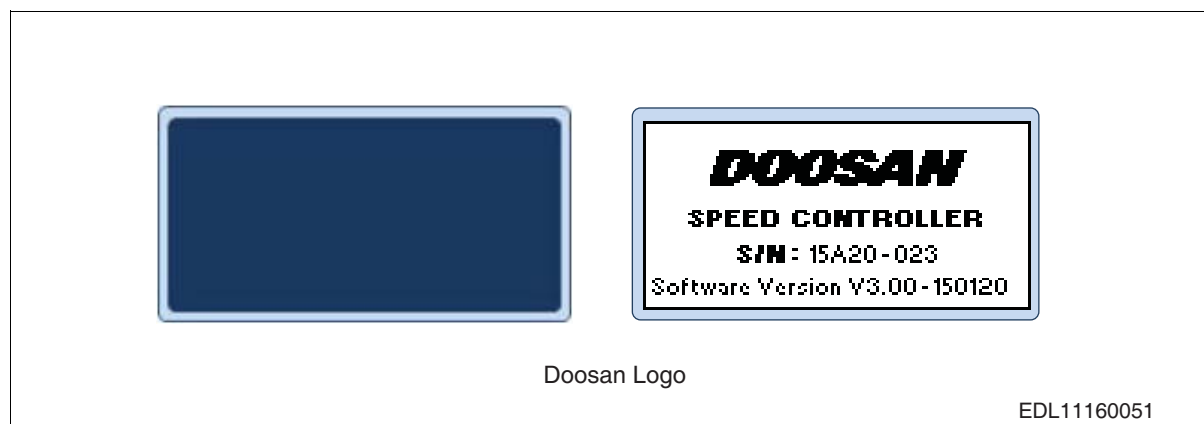
(1) LCD displays after powered on

When DC +24 V 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 Doosan logo will appear for 1 second followed by the operation display after pressing the LCD button.

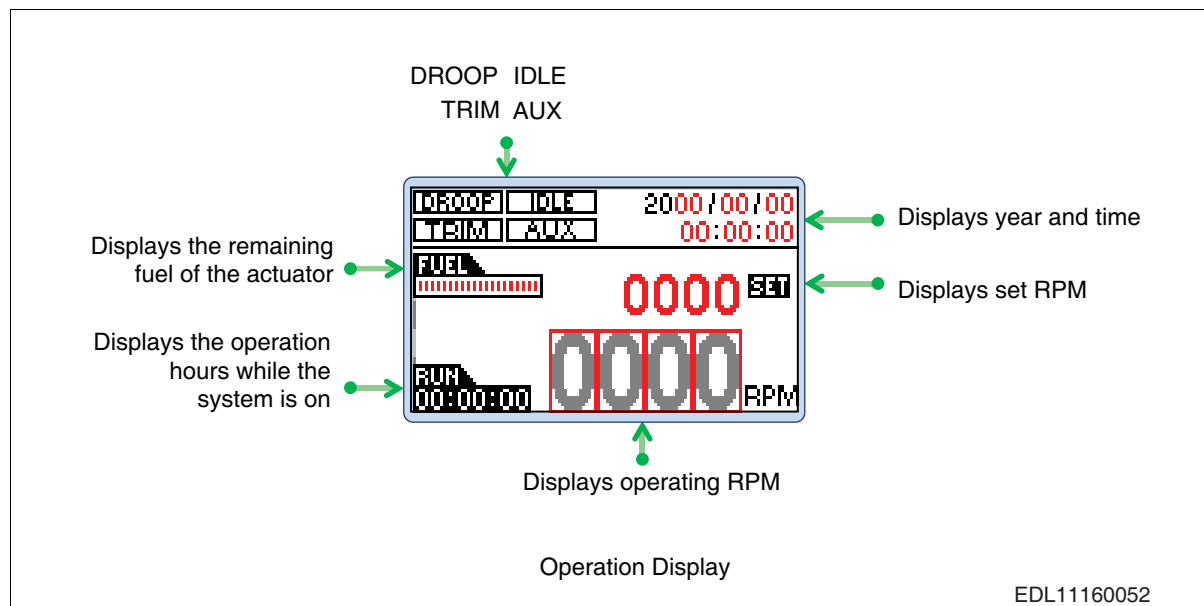
The controller will start control based on information from pick-up sensor and other input devices and designated parameter values. At this moment, where breakdowns of the surrounding devices or system errors occur, the LCD display will show such errors and processing messages.

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, Doosan 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.



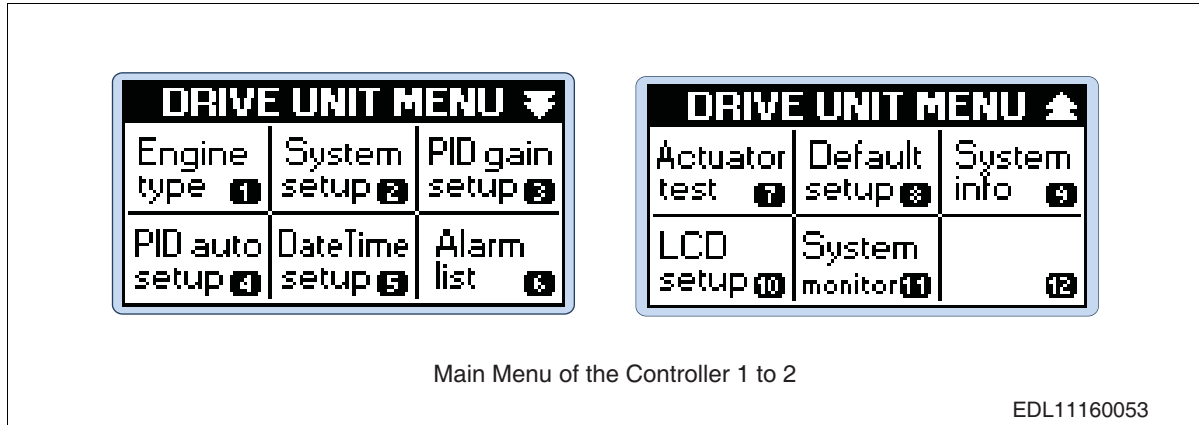
Step 2) The operation display will show 1 second after the logo appears.



(2) LCD main menu display

Displays main menu screen of the controller

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



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 Date/Time 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 (XL) 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

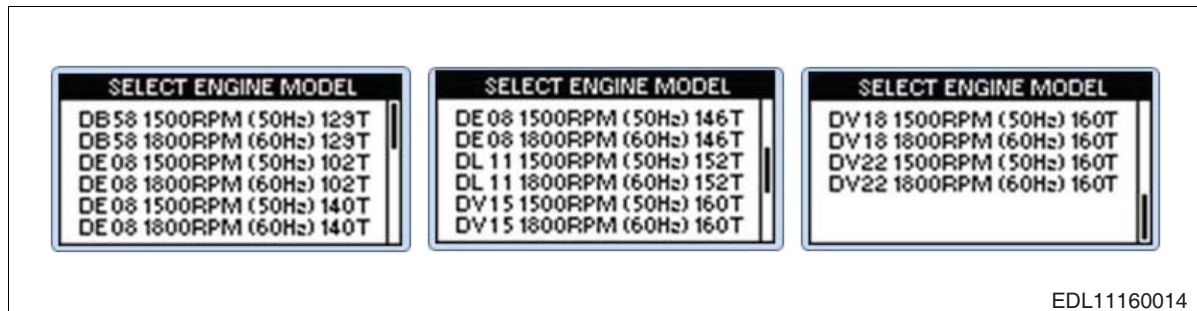
It offers menu to configure LCD operating conditions including brightness, auto on/off and off hours.

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) 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.



(4) 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.



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.

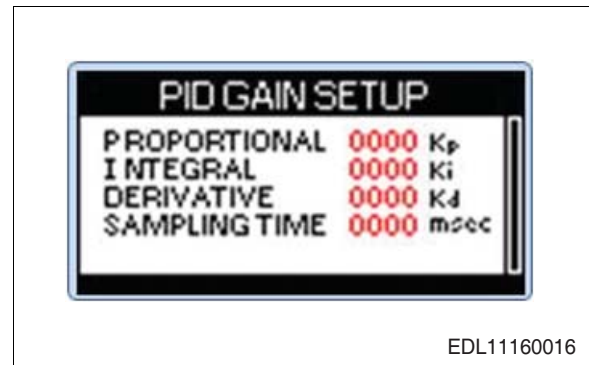
④ Cranking rpm

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.

(5) PID gain setup menu

Users can input K_p , K_i and K_d values as inputs to the PID control of the engine. K_p means proportional values while K_i means integral of the proportional values and K_d means differential of the proportional values.



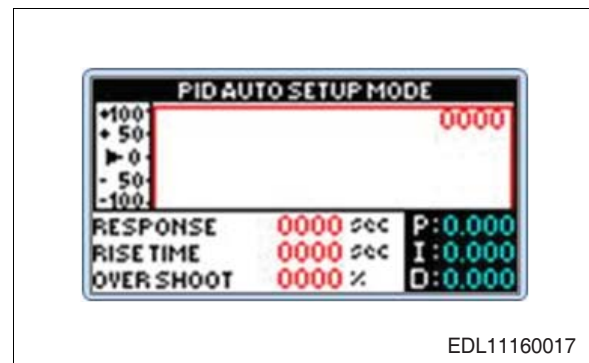
(6) PID auto setup menu

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.

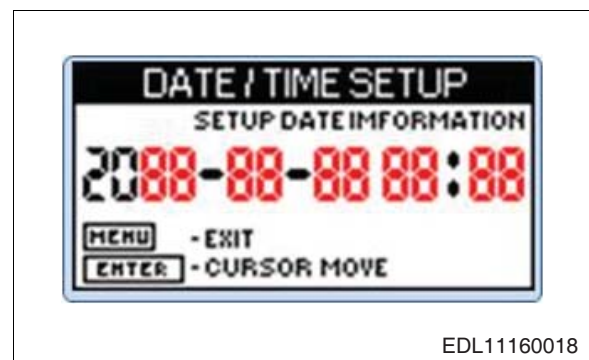
If the controller identifies the optimized P, I and D values within 30 cycles, it will display "PID Auto Setup Complete, OK". When you press Enter, it will apply tuned P, I and D values and close the menu.

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.



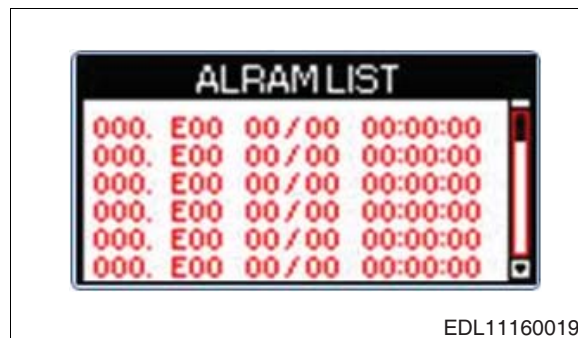
(7) Date/Time setup menu

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.



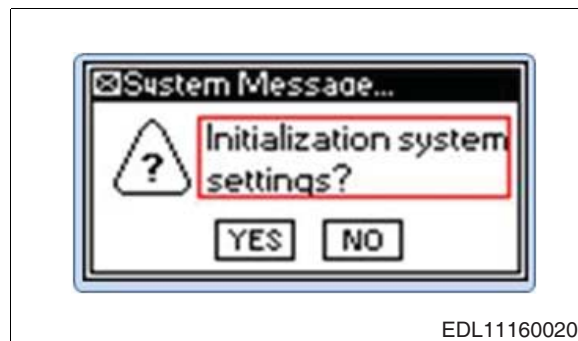
(8) Alarm list menu

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.



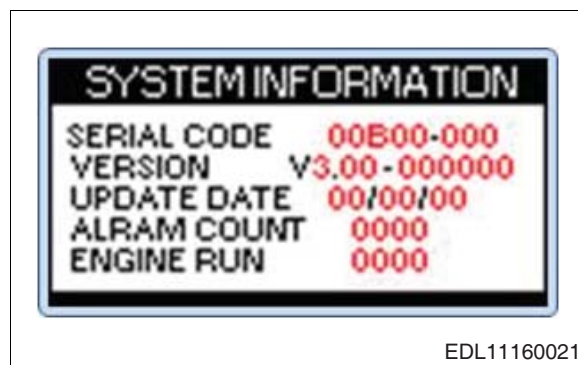
(9) Default setup menu

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.



(10) System info menu

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



3. Engine configuration

(1) Engine type configuration

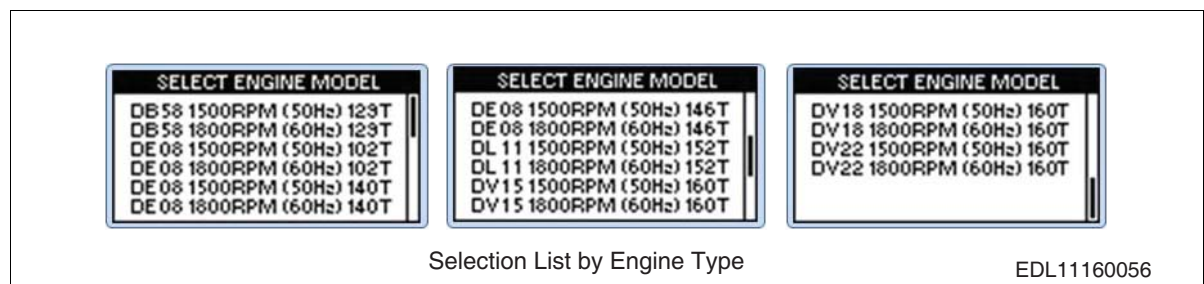
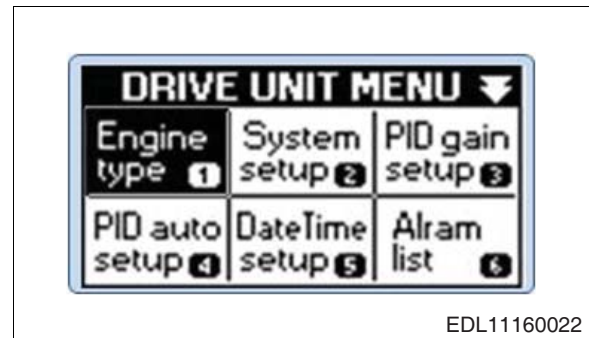
Users can store control setting information depending on types of the engines in the internal memory of the controller. If you select your engine type, applicable parameters will be automatically configured accordingly. This feature is available for 16 different types of engines.

Designated parameters by engine type (Configuration values by engine type)

No.	Menu Name	Run rpm	Over Speed	Gear Teeth	Starting Fuel	PID Value
1	DB58 1,500 rpm (50 Hz) 129T	1,500 rpm	1,725 rpm	129	65%	Optimal Value
2	DB58 1,800 rpm (60 Hz) 129T	1,800 rpm	2,070 rpm	129	65%	Optimal Value
3	DE08 1,500 rpm (50 Hz) 102T	1,500 rpm	1,725 rpm	102	65%	Optimal Value
4	DE08 1,800 rpm (60 Hz) 102T	1,800 rpm	2,070 rpm	102	65%	Optimal Value
5	DE08 1,500 rpm (50 Hz) 140T	1,500 rpm	1,725 rpm	140	65%	Optimal Value
6	DE08 1,800 rpm (60 Hz) 140T	1,800 rpm	2,070 rpm	140	65%	Optimal Value
7	DE08 1,500 rpm (50 Hz) 146T	1,500 rpm	1,725 rpm	146	65%	Optimal Value
8	DE08 1,800 rpm (60 Hz) 146T	1,800 rpm	2,070 rpm	146	65%	Optimal Value
9	DL11 1,500 rpm (50 Hz) 152T	1,500 rpm	1,725 rpm	152	65%	Optimal Value
10	DL11 1,800 rpm (60 Hz) 152T	1,800 rpm	2,070 rpm	152	65%	Optimal Value
11	DV15 1,500 rpm (50 Hz) 160T	1,500 rpm	1,725 rpm	160	65%	Optimal Value
12	DV15 1,800 rpm (60 Hz) 160T	1,800 rpm	2,070 rpm	160	65%	Optimal Value
13	DV18 1,500 rpm (50 Hz) 160T	1,500 rpm	1,725 rpm	160	65%	Optimal Value
14	DV18 1,800 rpm (60 Hz) 160T	1,800 rpm	2,070 rpm	160	65%	Optimal Value
15	DV22 1,500 rpm (50 Hz) 160T	1,500 rpm	1,725 rpm	160	65%	Optimal Value
16	DV22 1,800 rpm (60 Hz) 160T	1,800 rpm	2,070 rpm	160	65%	Optimal Value

Engine configuration procedure

- Step 1)** Press Menu button of the controller and then you can see DRIVE UNIT MENU.
- Step 2)** Select Engine Type by using Up and Down buttons in DRIVE UNIT MENU and then press Enter button.
- Step 3)** 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.

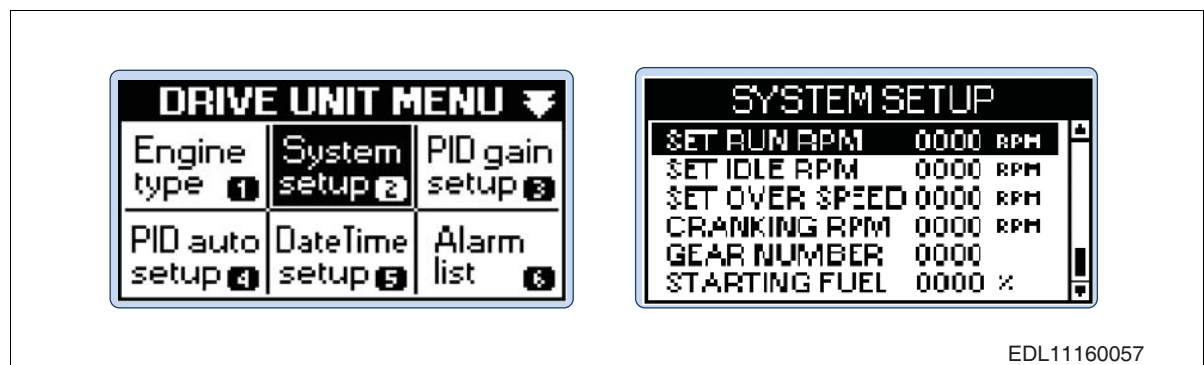


(2) System setup configuration

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.

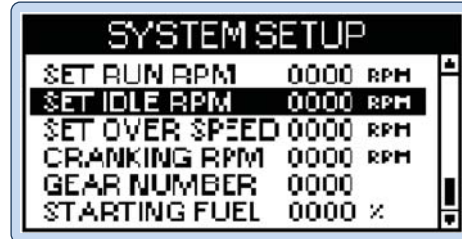
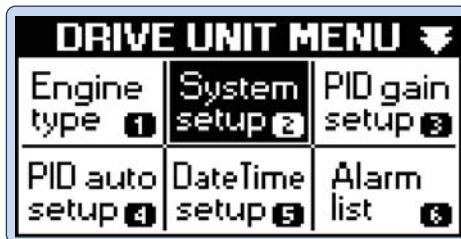
Configuring set run rpm

- Step 1)** Press Menu button of the controller and then you can see DRIVE UNIT MENU.
- Step 2)** Select System setup menu in DRIVE UNIT MENU using Up, Down, Left and Right buttons and then press Enter button.
- Step 3)** 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

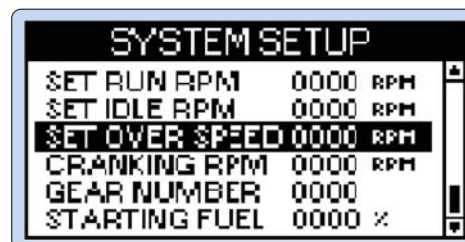
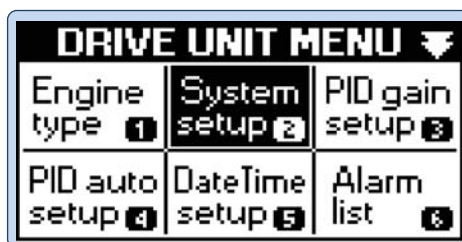
- Step 1)** Press Menu button of the controller and then you can see DRIVE UNIT MENU.
- Step 2)** Select System setup menu in DRIVE UNIT MENU using Up, Down, Left and Right buttons and then press Enter button.
- Step 3)** Select SET IDLE RPM in SYSTEM SETUP menu and then press Enter button.
Use Up and Down buttons to increase or decrease the idle operating speed of the engine and then press Enter button.



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Configuring set over speed

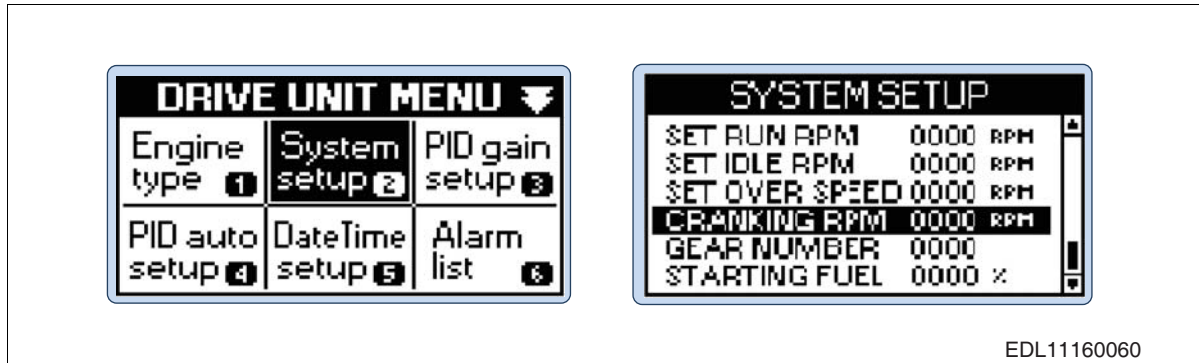
- Step 1)** Press Menu button of the controller and then you can see DRIVE UNIT MENU.
- Step 2)** Select System setup menu in DRIVE UNIT MENU using Up, Down, Left and Right buttons and then press Enter button.
- Step 3)** Select SET OVER SPEED in SYSTEM SETUP menu and then press Enter button. Use Up and Down buttons to increase or decrease the over speed values of the engine and then press Enter button.



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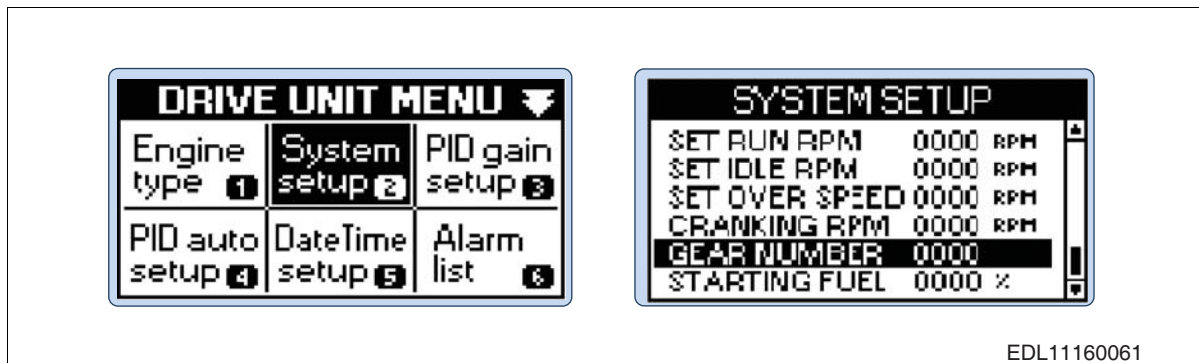
Configuring cranking rpm

- Step 1)** Press Menu button of the controller and then you can see DRIVE UNIT MENU.
- Step 2)** Select System setup menu in DRIVE UNIT MENU using Up, Down, Left and Right buttons and then press Enter button.
- Step 3)** 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.



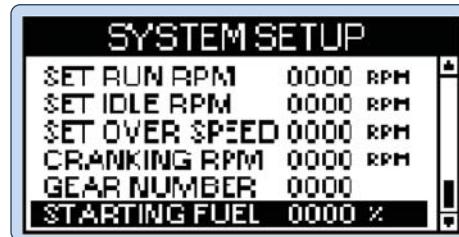
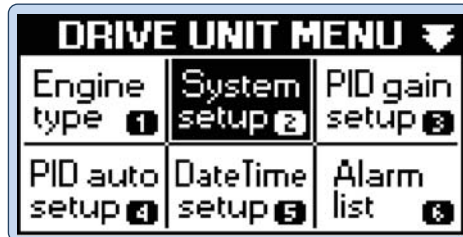
Configuring gear number

- Step 1)** Press Menu button of the controller and then you can see DRIVE UNIT MENU.
- Step 2)** Select System setup menu in DRIVE UNIT MENU using Up, Down, Left and Right buttons and then press Enter button.
- Step 3)** 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

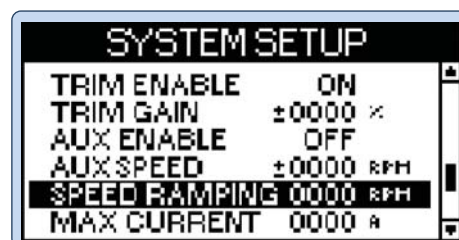
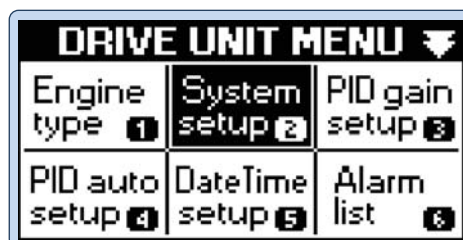
- Step 1)** Press Menu button of the controller and then you can see DRIVE UNIT MENU.
- Step 2)** Select System setup menu in DRIVE UNIT MENU using Up, Down, Left and Right buttons and then press Enter button.
- Step 3)** Select STARTING FUEL in SYSTEM SETUP menu and then press Enter button. Use Up and Down buttons to increase or decrease the percentage for the amount of fuel sprayed when the engine starts and then press Enter button.



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Configuring speed ramping

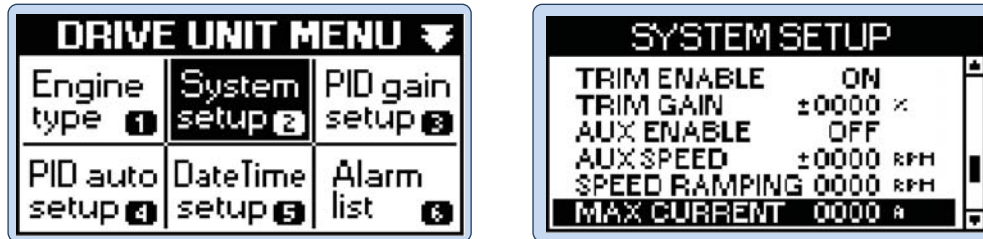
- Step 1)** Press Menu button of the controller and then you can see DRIVE UNIT MENU.
- Step 2)** Select System setup menu in DRIVE UNIT MENU using Up, Down, Left and Right buttons and then press Enter button.
- Step 3)** Select SPEED RAMPING in SYSTEM SETUP menu and then press Enter button. Use Up and 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.



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Configuring max current

- Step 1)** Press Menu button of the controller and then you can see DRIVE UNIT MENU.
- Step 2)** Select System setup menu in DRIVE UNIT MENU using Up, Down, Left and Right buttons and then press Enter button.
- Step 3)** 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. 10 A).



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Configuring low battery

- Step 1)** Press Menu button of the controller and then you can see DRIVE UNIT MENU.
- Step 2)** Select System setup menu in DRIVE UNIT MENU using Up, Down, Left and Right buttons and then press Enter button.
- Step 3)** 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.



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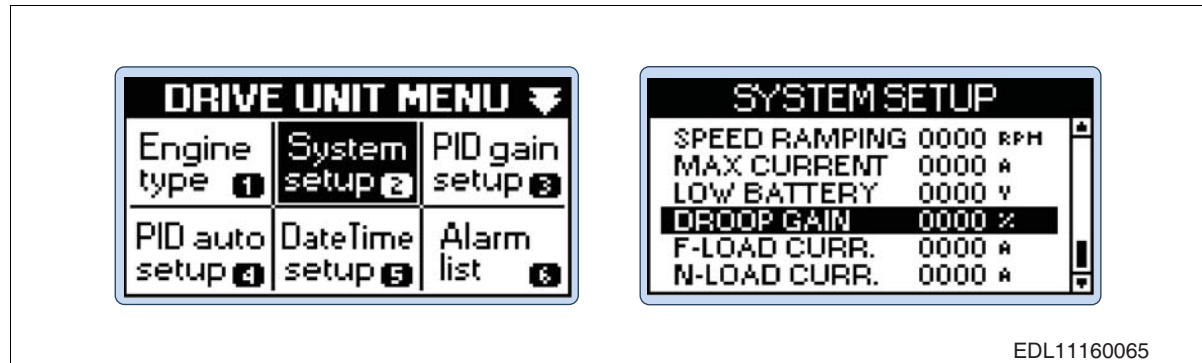
Configuring droop gain

Step 1) Press Menu button of the controller and then you can see DRIVE UNIT MENU.

Step 2) Select System setup menu in DRIVE UNIT MENU using Up, Down, Left and Right buttons and then press Enter button.

Step 3) Select DROOP GAIN in SYSTEM SETUP menu and then press Enter button.

Use Up and Down buttons to increase or decrease the RPM values with adjusted ratio to decrease at the maximum load when the generator is in parallel operation and then press Enter button.



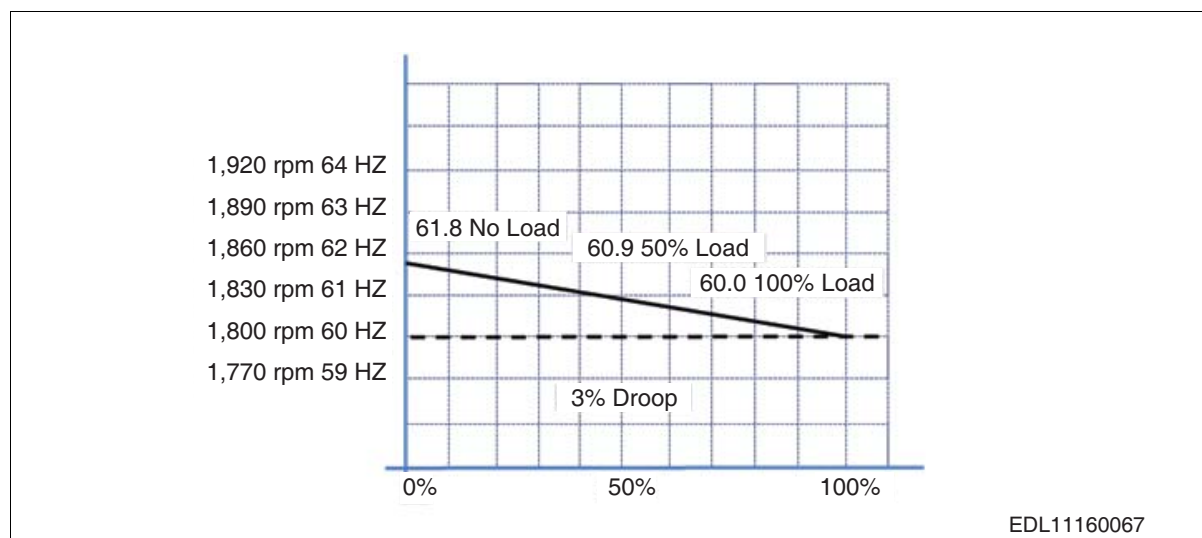
Droop Function

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

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

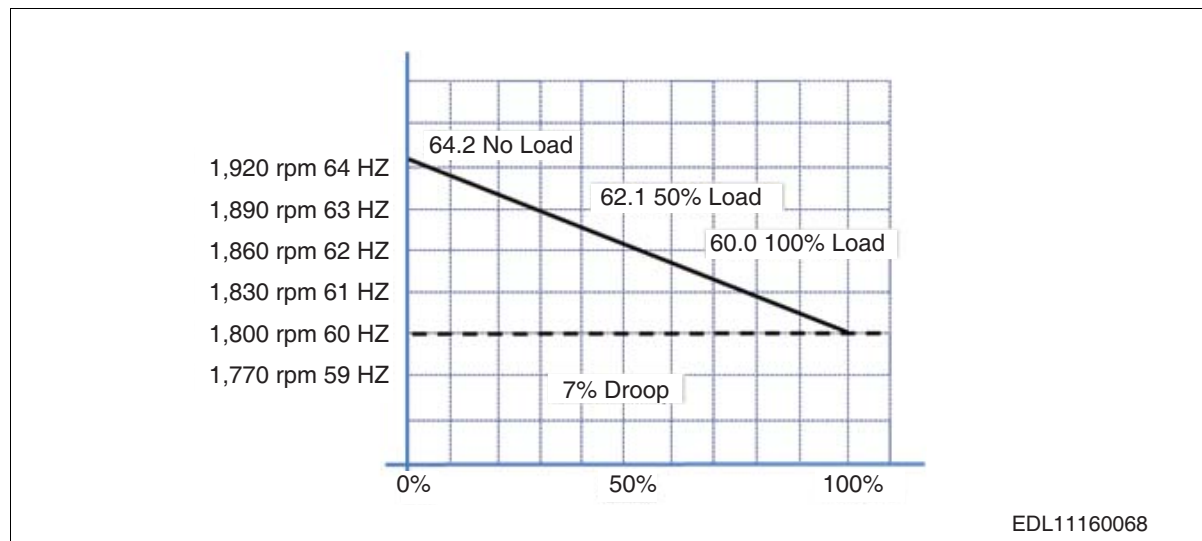
(Example for 3% droop)

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



(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 5%. It means that the generator output will be changed by 14.3% as the frequency changes by 1% due to the actuator control.

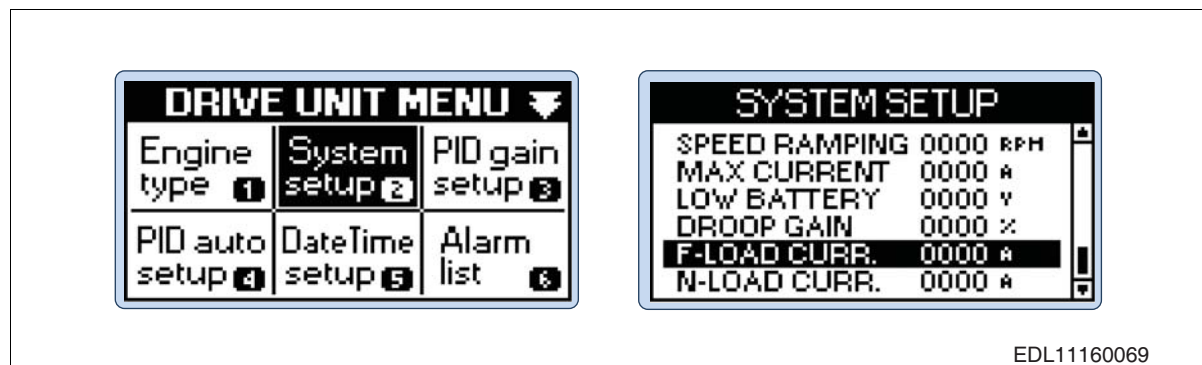


F - load curr

Step 1) Press Menu button of the controller and then you can see DRIVE UNIT MENU.

Step 2) Select System setup menu in DRIVE UNIT MENU using Up, Down, Left and Right buttons and then press Enter button.

Step 3) 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

Step 1) Press Menu button of the controller and then you can see DRIVE UNIT MENU.

Step 2) Select System setup menu in DRIVE UNIT MENU using Up, Down, Left and Right buttons and then press Enter button.

Step 3) 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.



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(3) PID gain setup configuration

Configuring PID gain Kp, Ki and Kd values

Step 1) 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.

Step 2) Use Up and Down buttons in PID GAIN SETUP to select PROPORTIONAL, INTEGRAL or DERIVATIVE and then press Enter button.



EDL11160071

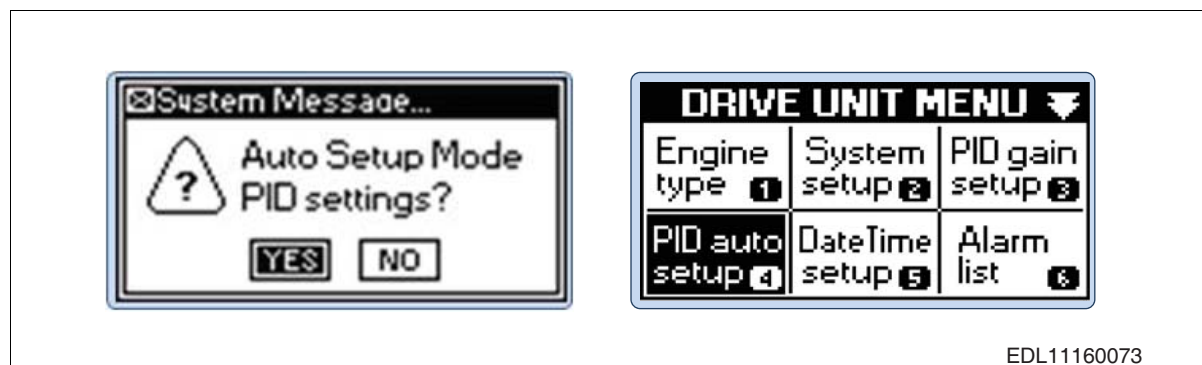
Configuring PID sampling time

- Step 1)** 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.
- Step 2)** 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.

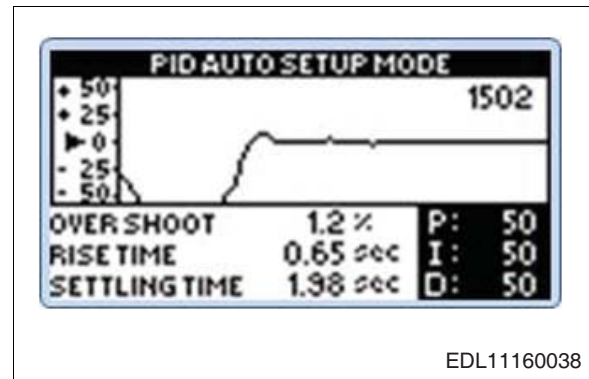


(4) PID auto setup value configuration

- Step 1)** Select your type in Engine Type menu and then start the engine with the preset configuration values maintaining it with no load.
- Step 2)** 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.
- Step 3)** 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.

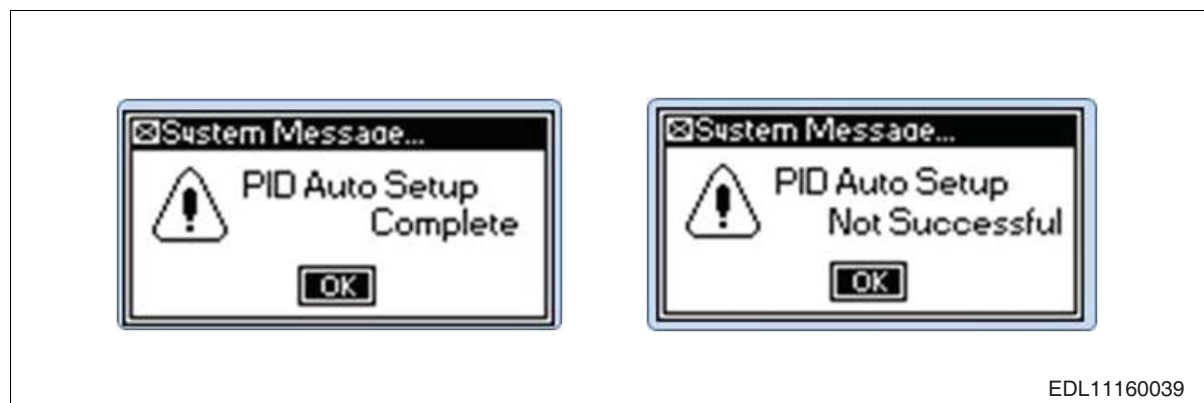


Step 4) Press YES and then the system message "PID AUTO SETUP MODE" will appear. As PID auto setup was initiated during the operation, PID auto tuning is already in progress.



Step 5) 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.

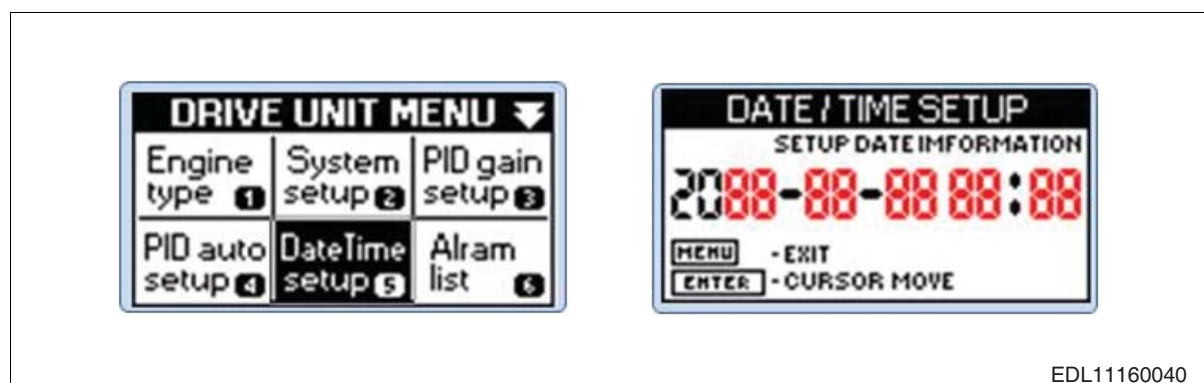
Step 6) If auto-tuning failed to identify optimized P, I and D values within 4 to 6 minutes, the system message window will display failure. If you press Enter button, you will go back to normal operation window. If you want to repeat the process, you need to start with Step 1 again.



(5) Date/Time value configuration

Step 1) Press Menu button of the controller and then you can see DRIVE UNIT MENU. Use direction buttons to select Date/Time setup menu.

Step 2) Use Up, Down, Left and Right buttons to input year, month, day and hour and then press Enter button.



(6) Alarm list

Step 1) 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.

Step 2) Use Up, Down, Left and Right buttons in ALARM LIST menu to confirm the fault messages.



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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

(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.

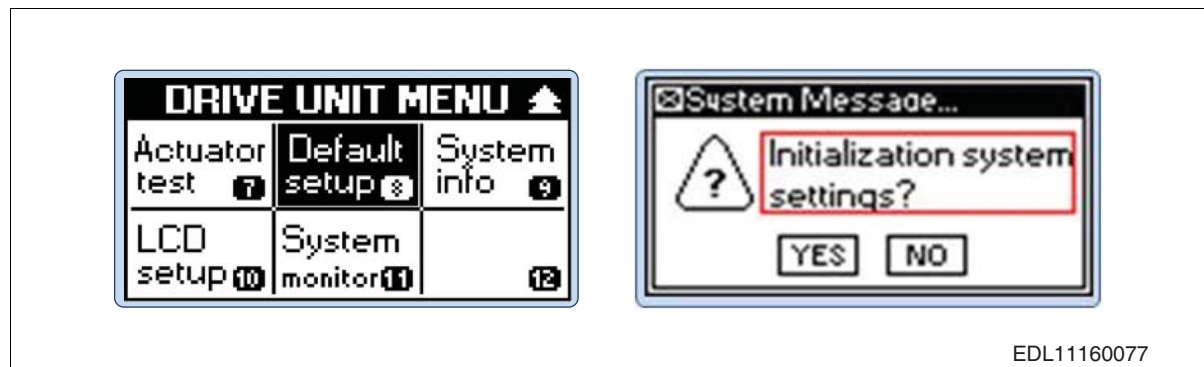
(8) Default setup functions

Step 1) 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.

Step 2) Use Left and Right buttons to select either YES or NO in System Message and then press Enter button.

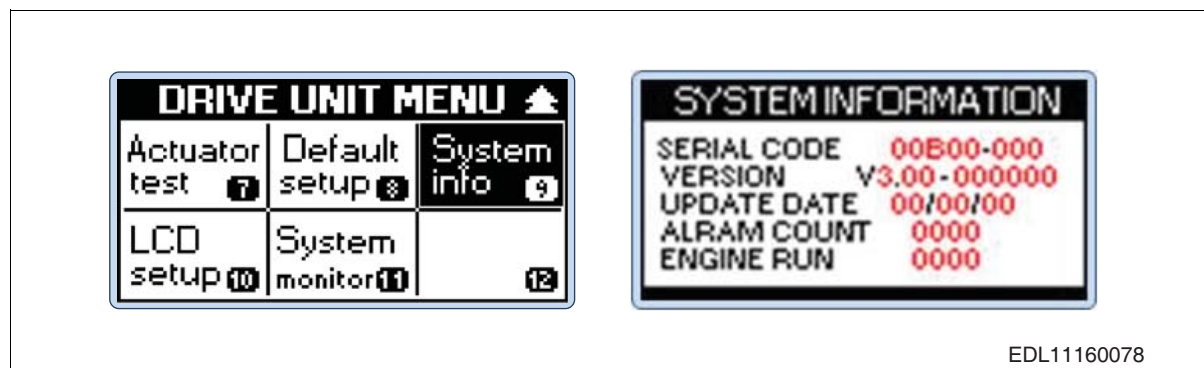


Default setup will change the configuration values of the engine to the default values. In order to initiate default setup, you need to select YES and then press Enter button. Press No button if you don't want to.

(9) System info functions

Step 1) Press menu button of the controller and then you can see DRIVE UNIT MENU.

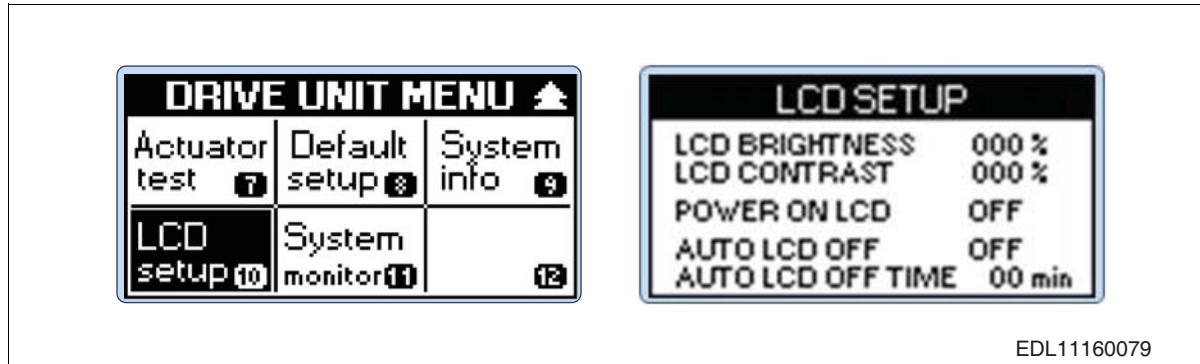
Use Up, Down, Left and Right buttons to select System info menu and then press Enter button.



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

(10) LCD setup functions

- Step 1)** 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.
- Step 2)** 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.



(11) System monitor Functions

- Step 1)** 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 and Bat Voltage.

4. How to operate

(1) Operating sequence for digital speed controller

- Step 1)** Supply DC +24V power to the battery terminals (E (-), F (+)) of the controller.
- Step 2)** Configure parameter values required for selection of the engine type and control of the engine.
- Step 3)** Install the controller on the generator system and complete circuit wiring.
- Step 4)** The controller will activate the actuator with power supply and pick-up sensor input.

(2) Detailed operating sequence

- Step 1)** Supply DC +24 V 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 (15 A/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.
- Step 2)** 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.

- Step 3)** 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.
- Step 4)** 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.

Troubleshooting

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.

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	LCD alarm message	Check the battery line
			Error LED lamp	Replace the battery
E02	Battery High	When the battery maintains its voltage exceeding 30V DC for more than 5 seconds	Alarm message pop-up on LCD	Check the battery line
			Error LED on	Replace the battery
E03	Pick-up Error	Problems in sensor signals when the engine starts.(Engine RPM lower than 600)	Alarm message pop-up on LCD	Check the RPM sensor and connecting circuits
			Error LED on	Replace the RPM sensor
			Actuator control signal off	
E04	Pick-up Error	Problems in sensor signals during the engine operation (Engine RPM 600 or higher)	Alarm message pop-up on LCD	Check the RPM sensor and connecting circuits
			Error LED on	Replace the RPM sensor
			Actuator control signal off	
E05	Actuator Current Open	Disconnection in the actuator or the connecting circuits	Alarm message pop-up on LCD	Check the disconnection in the actuator and connecting circuits
			Error LED on	Replace the actuator
E06	Actuator Current short	Short-circuits in the actuator or the connecting circuits	Alarm message pop-up on LCD	Check the disconnection in the actuator and connecting circuits
			Error LED on	Replace the actuator
E07	Over Speed	Engine RPM exceeding the configured over speed values	Alarm message pop-up on LCD	Check the speed setting
			Error LED on	Adjust PID setting values
			Actuator control off	
E08	FET Drive Error	Damages to components in the actuator output section inside the controller	Alarm message pop-up on LCD	Check the actuator and connecting circuits
			Error LED on	Replace the controller
			Actuator output power cutoff	

- (1) When problems described in alarm codes E03, E04, E07 or E08 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.

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.

- Step 1)** 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.
- Step 2)** 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.
- Step 3)** 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.
- Step 4)** Check whether the power LED turns on and Doosan 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.
- Step 5)** 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 1.1 mm and then check whether the pick-up sensor has resistance of 110 Ohms ($\pm 10\%$). If you cannot still detect no signal, replace the pick-up sensor and then operate the controller.

Digital Panel for Marine Engines Service Manual

Ver.1.0



Doosan Infracore

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1. General Information

1.1 Product Information

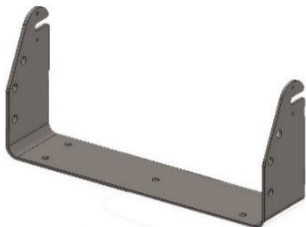
The name of the product model is a digital panel applicable to ships, generators and other various marine engines. The product is intended to improve problems of existing analog panels and allow users to check engine controls and conditions by means of a digital visualization product. It provides information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

1.2 Components and Optional Accessories

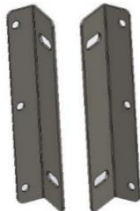
Components



① Digital Panel



② Stationary Bracket



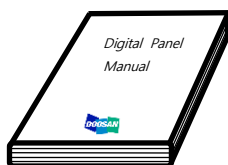
③ Mounting Bracket



④ Key x 2



⑤ Stationary 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°C to 70°C
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

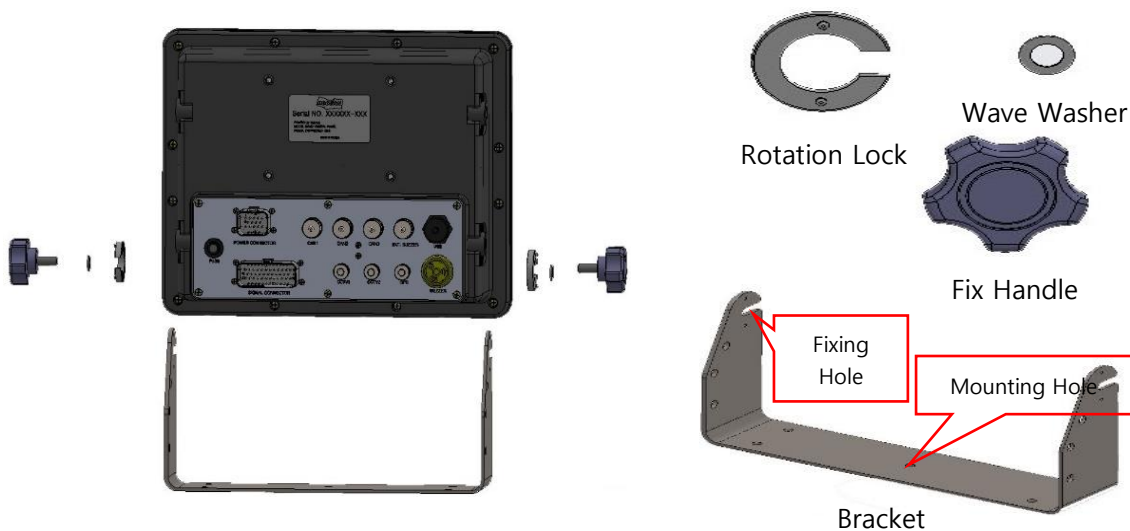
2.1 Cautions

- 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 Stationary Type

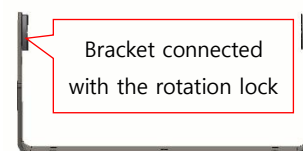
- Stationary types are installed in the steering or engine room by using stationary brackets delivered with the product.
- ※ Mounting Hole Spec: M6 bolt



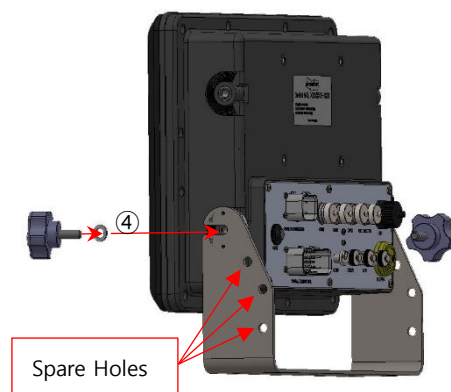
[Fig. 2-1] Stationary Type Diagram

► Installing stationary type digital panel

- ① Check whether the steering or engine room 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 Mount Type

- Mounting types are installed in a steering or engine room by using optional mounting brackets (2pcs).

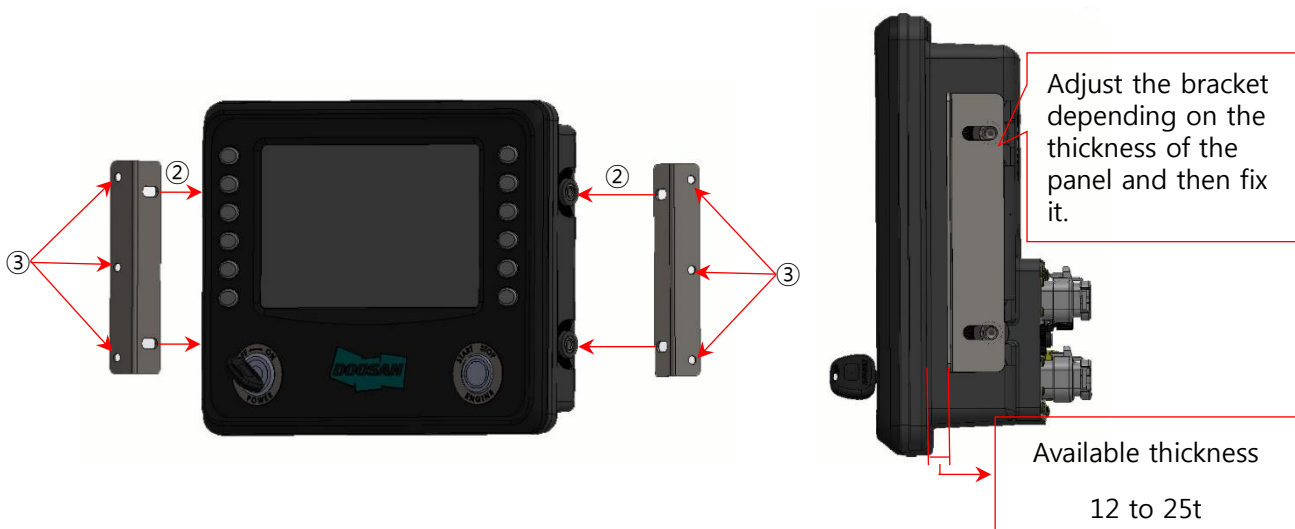
※ Bolt Spec: ① M6 ② M8, Length - 12mm



[Fig. 2-4] Mounting Type Diagram

► Installing mounting type digital panel

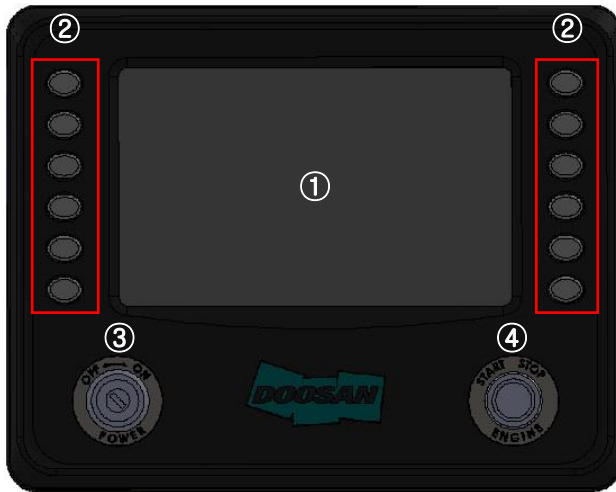
- ① Check whether the steering or engine room has engine harness wiring.
- ② As shown in Fig. 2-6, fix the mounting brackets to both sides of the panel.
- ③ Check the location within reach of the engine harness wiring and the mounting location and then mount the panel using proper bolts.
- ④ Finish gaps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

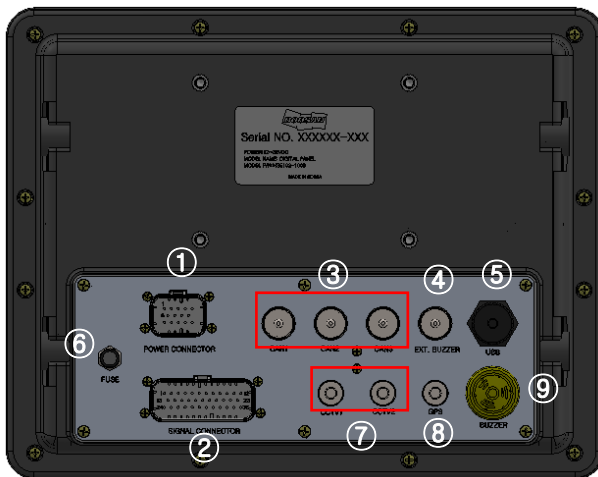


[Fig. 3-1]

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

[Table 3-1]

3.2 Back Side



[Fig. 3-2]

No.	Name	Reference
①	Power Connector	Page 9
②	Signal Connector	Page 10
③	CAN	Page 11
④	External Buzzer	Page 11
⑤	USB	Page 12
⑥	Fuse	Page 12
⑦	CCTV (Optional)	Page 11
⑧	GPS (TBC)	-
⑨	Internal Buzzer	Page 12

[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	-	-
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]

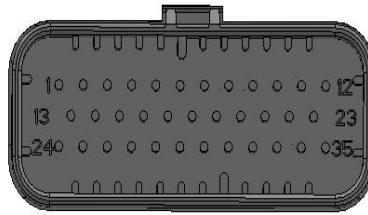


POWER CONNECTOR

[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	-	-
10	-	-	28	-	-
11	Fuel Leakage Switch	-	29	-	-
12	GND	Sensor	30	-	-
13	Exhaust Gas Temperature Sensor 1 (-)	-	31	-	-
14	-	-	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]

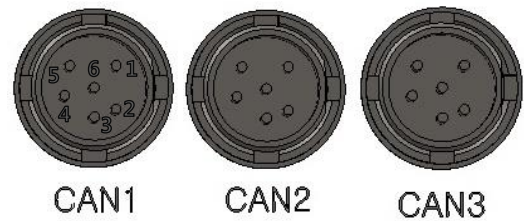
3. Part Names, Operation and Settings

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]



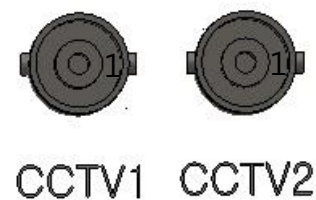
[Fig. 3-6]

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.



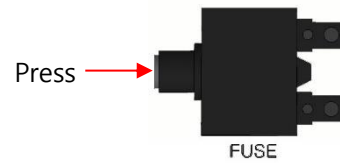
USB

[Fig. 3-8]

3.4 Fuse and Internal Buzzer

3.4.1 Fuse

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



FUSE

[Fig. 3-9]

3.4.2 Internal Buzzer

- Generate alarms for sensor problems



BUZZER

[Fig. 3-10]

3.5 Key Switch

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

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



Key

[Fig. 3-11]



Key Switch

[Fig. 3-12]

3. Part Names, Operation and Settings

3.6 Start/Stop Button

- Start/Stop button is used to start/stop control for the engine.
 - 1) Press the button for more than 3 seconds 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 3 seconds while the key is ON and the engine is in operation to stop the engine.
 - ※ You can reduce the time down to 1 second for emergency response.
 - You can change the time setting in Digital Panel Manager.



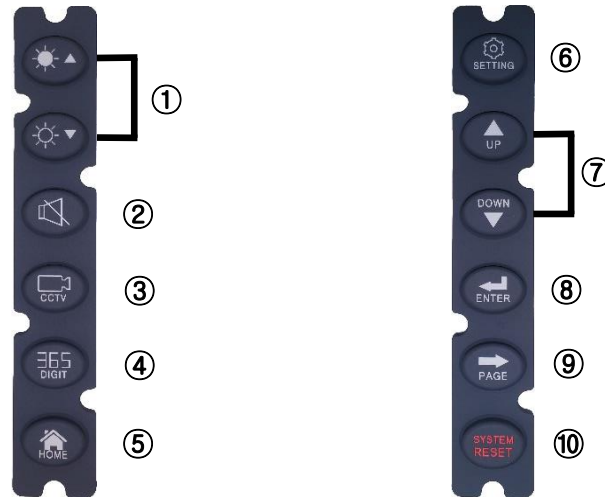
Start/Stop Button

[Fig. 3-13]

3. Part Names, Operation and Settings

3.7 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.



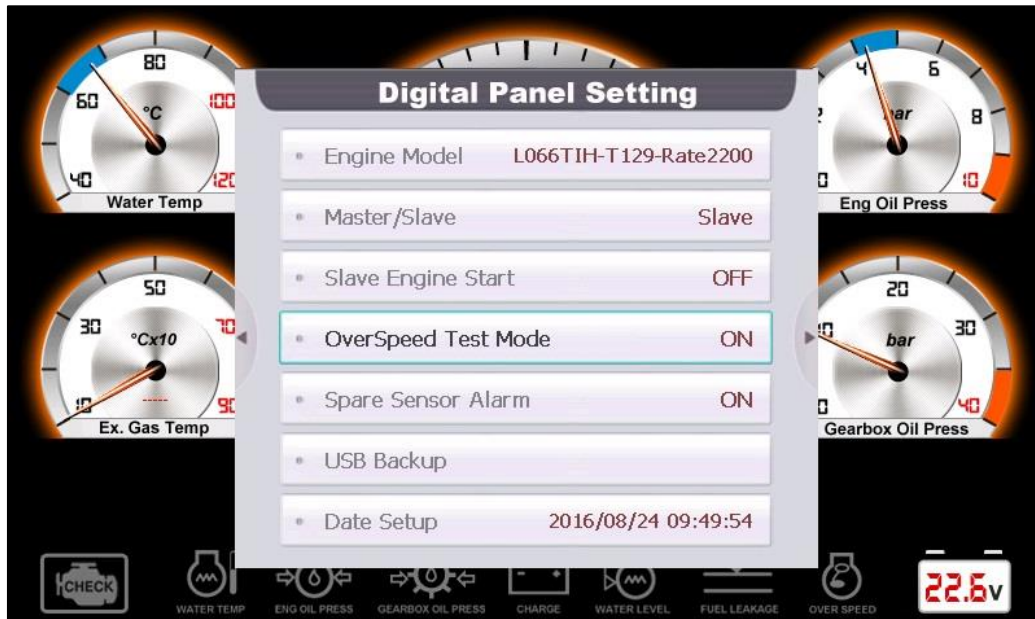
[Fig. 3-14] Function Keys

No.	Function Key	Action Feature
①	LCD Brightness Adjustment	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 Display	- Press once: number light will be on for 3 seconds and turn the display off. - Press DIGIT for 3 seconds: the number light will continue to be on - Press while the display is off: the number light will turn off.
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 - ON/OFF setting for spare sensor light - USB backup and time (year/month/hour) settings
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

3.7.1 Detailed Settings



[Fig. 3-15] Detailed Settings

► Setting Functions and Descriptions

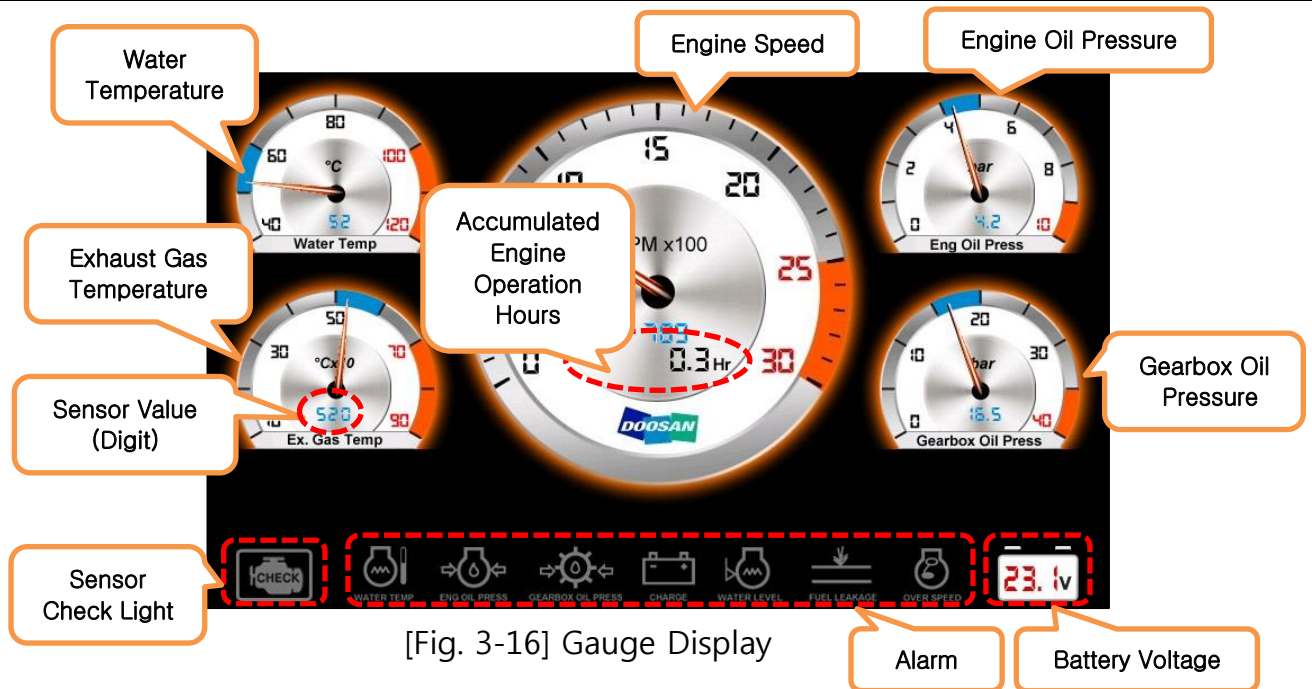
- Press  button and then use  or  button to move to functions to be changed.
- Press  button to go back to gauge display (changes will be automatically saved).

No.	Function	Description	Function Key
1	Engine Model	• Engine model setting (refer to the appendix for the list of engine models)	  
2	Master / Slave	• Master/Slave setting for multi panels	
3	Slave Engine Start	• ON/OFF setting to start the slave	
4	OverSpeed Test Mode	• ON/OFF setting for over speed (1,400RPM or faster) test	
5	Spare Sensor Alarm	• ON/OFF setting for spare check sensor light	
6	USB Back Up	• USB backup for event save files	
7	Date Setup	• Date and time setting	  

[Table 3-9]

3. Part Names, Operation and Settings

3.8 Display Structure



[Fig. 3-16] Gauge Display

- Gauge display shows various gauge data including pick up (RMP) 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, coolant level, fuel leak and overspeed alarm.

3.8.1 Engine Speed (Tachometer)

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



[Fig. 3-17]

Engine Speed Gauge

- 1) It shows the RPM indicated by the gauge hand in digital values (blue) for better accuracy (however, it is available when the 'DIGIT' button is on).
- 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 Manager).

3. Part Names, Operation and Settings

3.8.2 Engine Water Temperature

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



[Fig. 3-18]

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 when the 'DIGIT' button is on).
- 2) It shows the open/short diagnosis for sensor problems.
☞ Open: 'ERROR' / Short (GND): '-----'
- 3) It also serves as the water temperature switch.
- 4) It activates alarm and warning beep when the temperature increases up to 93°C or higher.
- 5) When the temperature increases up to 103°C or higher, the engine will stop.

3.8.3 Engine Oil Pressure

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



[Fig. 3-19]

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 when the 'DIGIT' button is on).
- 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.

3.8.4 Exhaust Gas Temperature

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



[Fig. 3-20]

Exhaust Gas Temperature

- 1) It shows the temperature indicated by the gauge hand in digital values (blue) for better accuracy (however, it is available when the 'DIGIT' button is on).
- 2) It shows the open/short diagnosis for sensor problems.
☞ Open: 'ERROR' / Short (GND): '-----'
- 3) The alarm will be activated when the temperature is 100°C or lower, or 600°C or higher while the engine is in operation.

3. Part Names, Operation and Settings

3.8.5 Gearbox Oil Pressure

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



[Fig. 3-21]

Gearbox Oil Pressure

- 1) It shows the pressure indicated by the gauge hand in digital values (blue) for better accuracy (however, it is available when the 'DIGIT' button is on).
- 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).

3.8.6 Battery Voltage

- It shows battery voltage to indicate its conditions.



[Fig. 3-22] 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).

3.8.7 Check Sensor Light

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



[Fig. 3-23] 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

3.8.8 Engine Alarm

- 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. 3-24] Engine Alarm

No.	Alarm	Action Feature
①	Coolant temperature (WATER TEMP)	• Alarm (buzzer) will be activated when the temperature is 93°C or higher
②	Engine oil pressure (ENGINE OIL PRESS)	• Alarm (buzzer) will be activated on when the pressure is 1 bar or lower
③	Gearbox oil pressure (GEARBOX OIL PRESS)	• Alarm (buzzer) will be activated when the pressure is 1 bar or lower
④	Charging (CHARGE)	• Alarm (buzzer) will be activated when the battery voltage is lower than 27V
⑤	Coolant level (WATER LEVEL)	• Alarm (buzzer) will be activated when the level is 30% or lower.
⑥	Fuel leakage (FUEL LEAKAGE)	• Alarm (buzzer) will be activated when oil leak occurs (default setting is 'disabled')
⑦	Engine over speed (OVER SPEED)	• Alarm (buzzer) will be activated when the speed exceeds 115% 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).

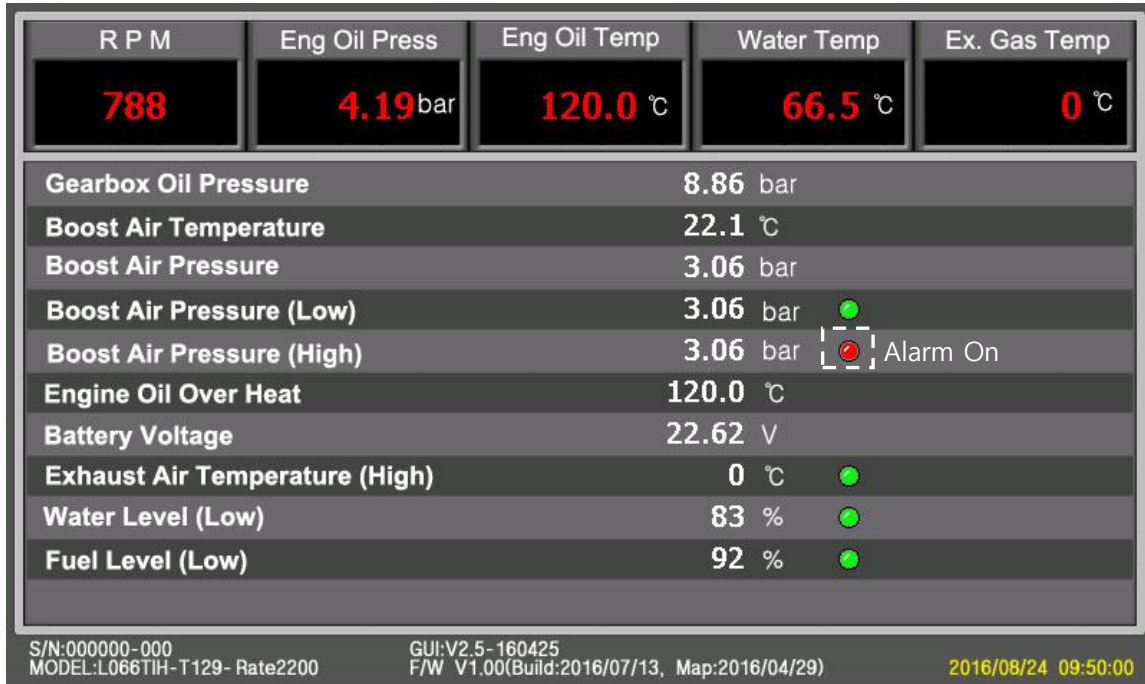
3.8.9 Engine Stop

- When the over speed exceeds **120%** of the rate speed → Enable/Disable engine stop
- When the coolant temperature exceeds **103°C** → Enable/Disable engine stop
- When the oil pressure is **0.5bar** or lower → Enable/Disable engine stop
- When fuel leakage occurs → Enable/Disable engine stop
- When the coolant level is **15%** or lower → Enable/Disable engine stop
- 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

3.9 Spare Sensor

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



[Fig. 3-25] Spare Sensor and SW 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	It is normal when the boost air pressure is between 1.1bar and 2.9bar
*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 150°C or higher
Battery Voltage	Current voltage
Exhaust Air Temperature (High)	Alarm will be activated when the exhaust air temperature is 600°C or higher
*Water Level (Low)	Alarm will be activated when the coolant level is 30% or lower
*Fuel Level (Low)	Alarm will be activated when the fuel level is 30% or lower

* Sensor for IMO Tier 3

[Table 3-11] Spare Sensor Conditions

3. Part Names, Operation and Settings

3.10 Event Summary

- It shows the numbers of normal operations, normal stops, emergency stops and sensor errors together with dates of recent errors.
- Press  button in spare sensor page to move to event summary page.

Digital Panel Alarm Information			
Engine Run Count :	2	Engine ShutDown Count :	2
Engine Stop Count :	1		
Code	Description	OC	Alarm Date
P0101	Water Temp. Over Heat	0	
P0102	Low Engine Oil Pressure	0	
P0103	Low Gearbox Oil Pressure	0	
P0104	Battery Charge(alternator)	0	
P0105	Fuel Leakage (Switch)	0	
P0106	Over Speed	1	2009/ 07/ 20/ 12: 02: 13
P0107	Low Voltage	0	
P0108	Low Water Level	0	
P0109	Low Fuel Level	0	
P0110	Engine Oil Over Heat	0	
P0111	Main Connector Removed	0	
P0112	High Exhaust Gas Temperature	0	
P0113	Low boost Air Pressure	0	
P0114	High boost Air Pressure	0	
P0115	Abnormal Engine ShutDown	1	2016/ 08/ 24/ 09: 13: 41
P0116	Low Engine Speed	0	

[Fig. 3-26] Event Summary Screen

Event List	
Water Over Heat	*Low Fuel Level
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)	*Low Boost Air Pressure
Over Speed	*High Boost Air Pressure
Low Voltage	Abnormal Engine Shutdown
*Low Water Level	Low Engine Speed

* Sensor for IMO Tier 3

[Table 3-12] Event List

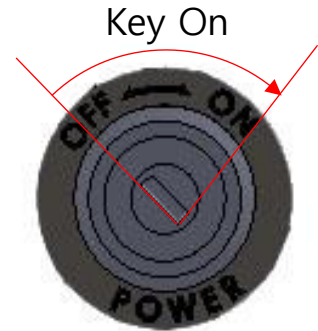
3. Part Names, Operation and Settings

3.11 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) DOOSAN 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 16V or lower.
- 4) Where the initial gauge screen is normal, press START button for 3 seconds to start the engine (the time can be reduced to 1 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 alarm is turned on.



[Fig. 3-27] Key Switch



[Fig. 3-28] DOOSAN Booting Logo

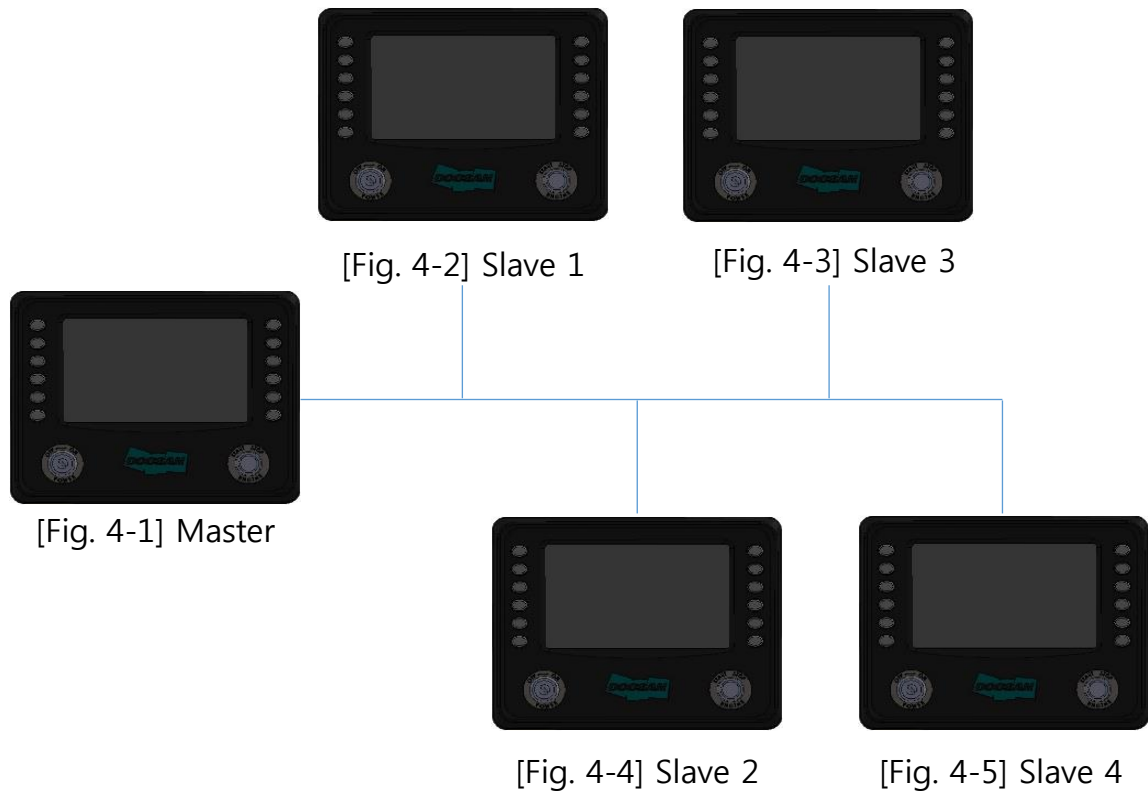


[Fig. 3-29] Gauge Display

4. Multi Panel Structure

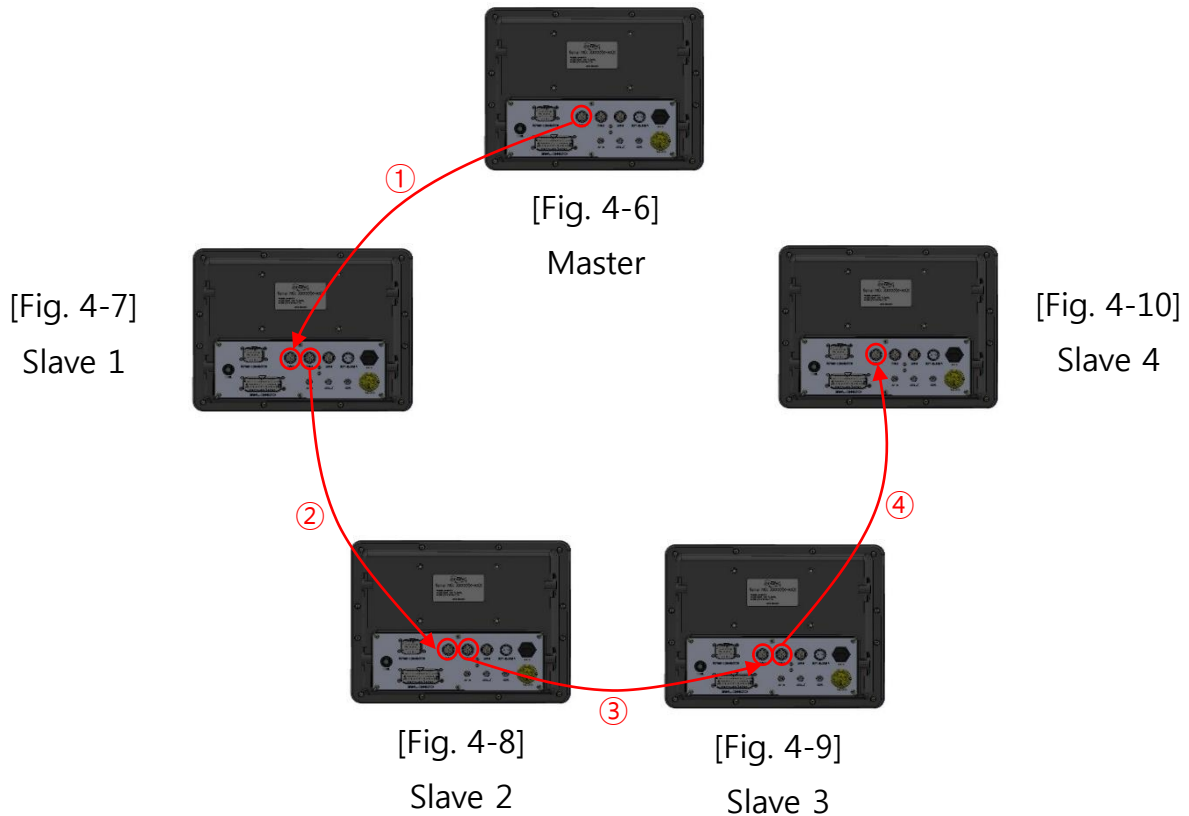
4.1 Multi Panels

- Panels can be installed up to 4 units except Master in the ship and you can check the ship conditions and control those panels at any places of installation.



4. Multi Panel Structure

4.2 How to Install Multi Panels



※ In order to install multi panels, all the necessary cables should be ready in advance (use the cables with specification recommended by DOOSAN).

(1) Connect the CAN1 terminal of the Master panel and the CAN1 terminal of the Slave 1 panel as shown in ① (2 panels).

- Master and Slave 1 connection completed

(2) Connect Slave 1 (CAN2) and Slave 2 (CAN1) as shown in ② while maintaining connection as described in ① (3 panels).

- Master, Slave 1 and Slave 2 connection completed

(3) Connect Slave 2 (CAN2) and Slave 3 (CAN1) as shown in ③ while maintaining connection as described in ② (4 panels).

- Master, Slave 1, Slave 2 and Slave 3 connection completed

(4) Connect Slave 3 (CAN2) and Slave 4 (CAN1) as shown in ④ while maintaining connection as described in ③ (5 panels)

- Master, Slave 1, Slave 2, Slave 3 and Slave 4 connection completed

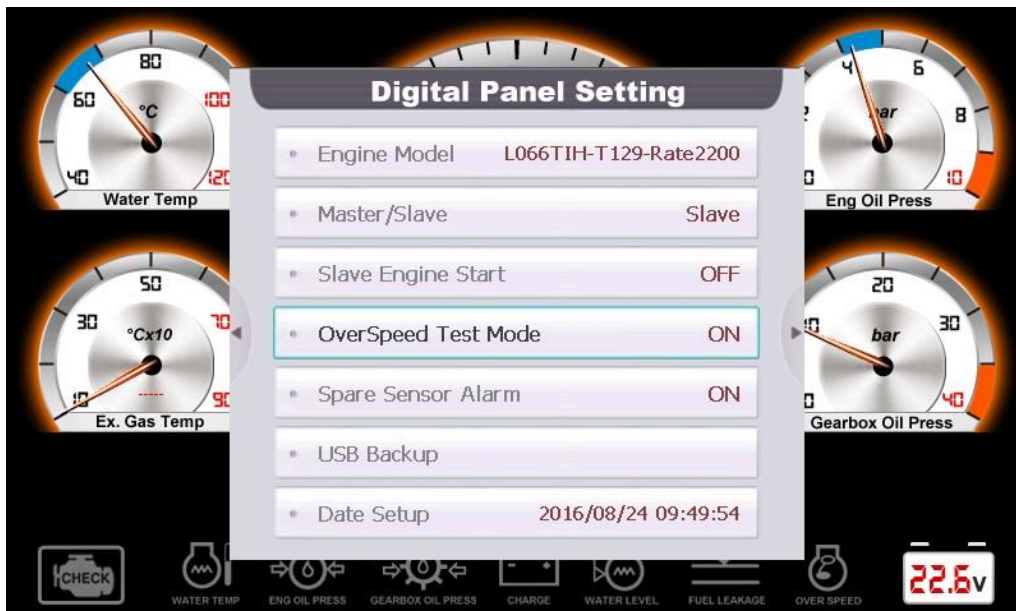
4. Multi Panel Structure

4.3 Multi Panel Settings

- (1) Press  button of the panel to be configured as Slave.
- (2) Move to ① when the setting screen appears (use  or  button to move).
- (3) Press  button to switch configuration between Master and Slave.
- (4) Configure the Master panel as described above.

※ Notes

- Master mode is available for one panel only and Slave mode is available up to 4 units.
- You can permit Slaves to start the engine with Master panel only. Where you enable Slave Engine Start setting, all Slave panels will be able to start the engine.

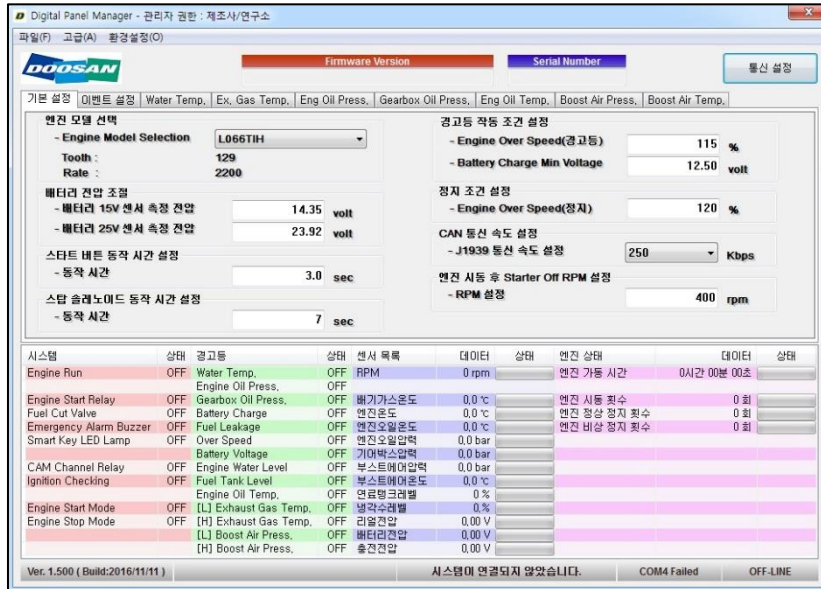


[Fig. 4-11] Multi Panel Setting Window

5. Digital Panel Manager

5.1 Digital Panel Manager

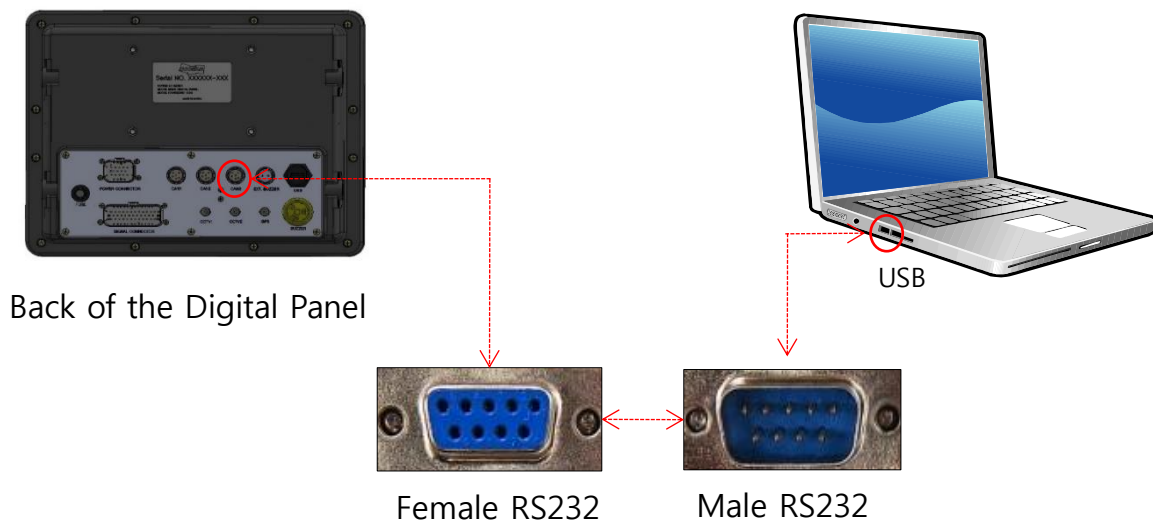
- Digital Panel Manager is a program that allows users to monitor the product conditions in real time with PC. You can configure sensor values of each sensor, engine model and over speed conditions.



[Fig. 5-1] Digital Panel Manager Initial Screen

5.2 PC Communication Connection

- Before using Digital Panel Manager, prepare CAN-RS232 cables (optional) for downloading and USB-RS232 cables (available in the market) for connection.



[Fig. 5-2] PC Communication Connection

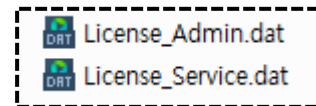
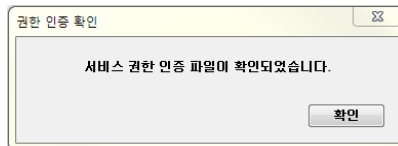
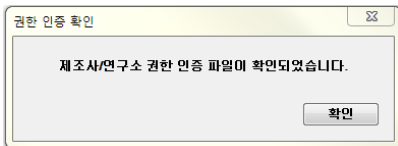
5. Digital Panel Manager

5.3 Software Installation and Execution

1. Install Digital Panel Manager on your PC.
2. Run Digital Panel Manager.



3. Permission Cert – Manufacturer or research institute cert is required as shown in Fig. 5-3 to run it.
 - ※ Cert files should be in the same folder where 'DigitalPanelManager.exe' is located.
 - ※ General users do not have cert files and they will see the screen without cert.

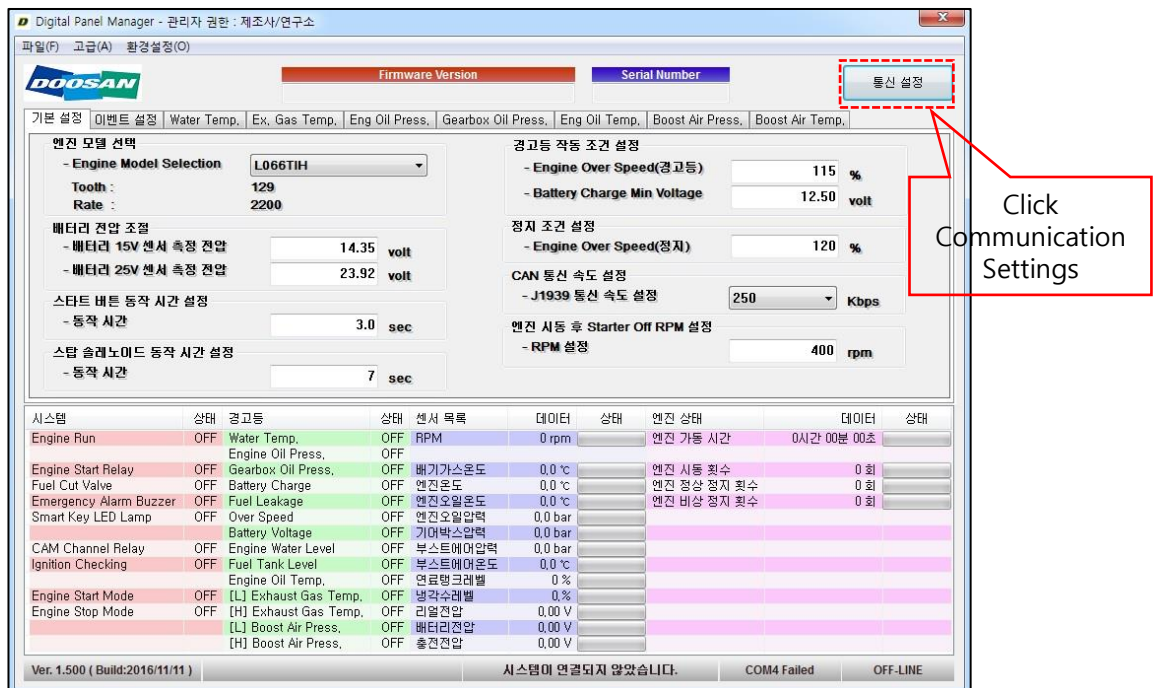


[Fig. 5-3] Permission Cert Window

<Cert Files>

4. Initial Screen – when the following initial screen appears, click Communication Settings at the top right corner for communicating settings.

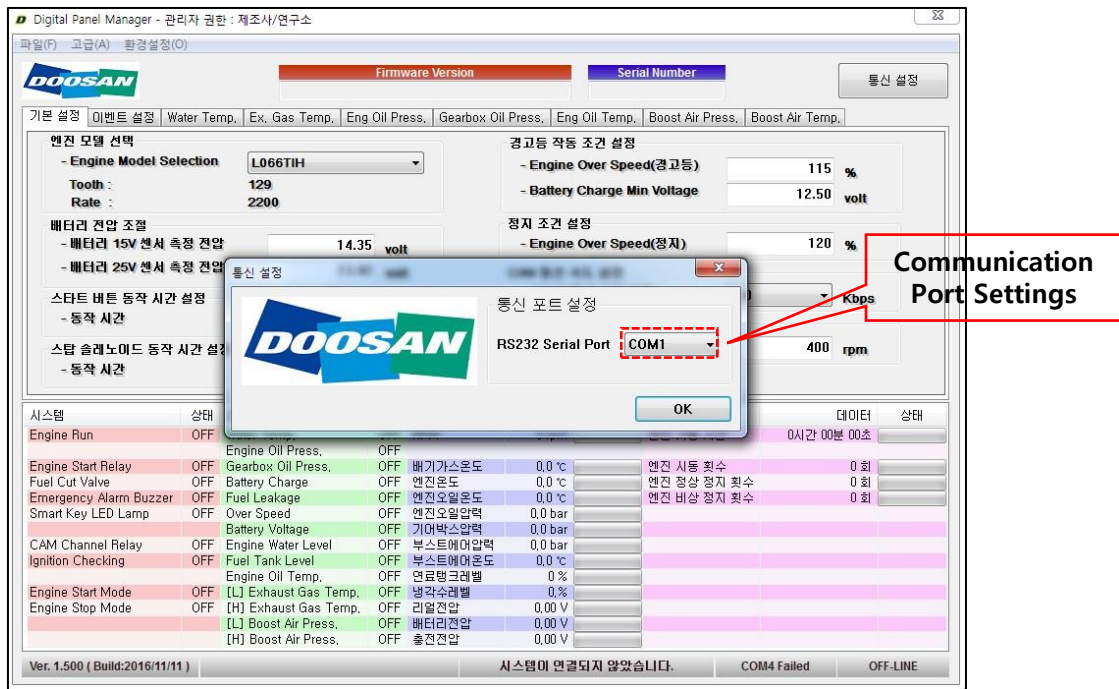
※ You can also find them in Configuration Menu at the top left corner.



[Fig. 5-4] Main Screen of the Program

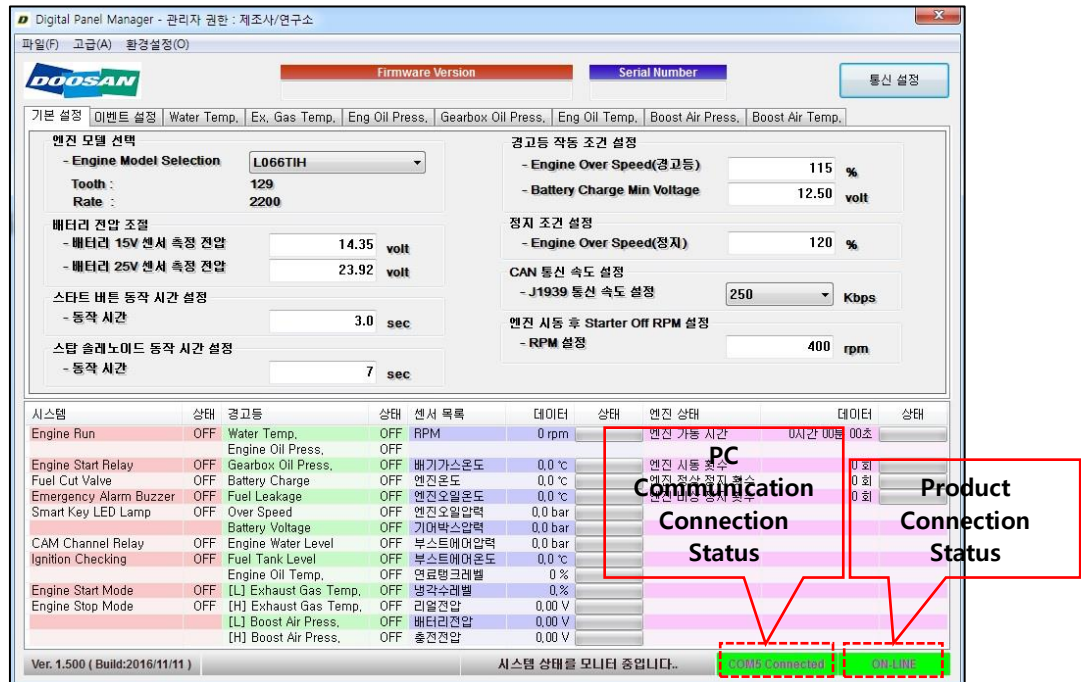
5. Digital Panel Manager

- Configure the port connected to RS232 in Communication Port Settings.



[Fig. 5-5] Communication Port Settings

- When the panel is connected to RS232, COMx Connected at the bottom right corner will turn on in green. When the product is connected to Digital Panel Manager, ON-LINE will turn on in green.



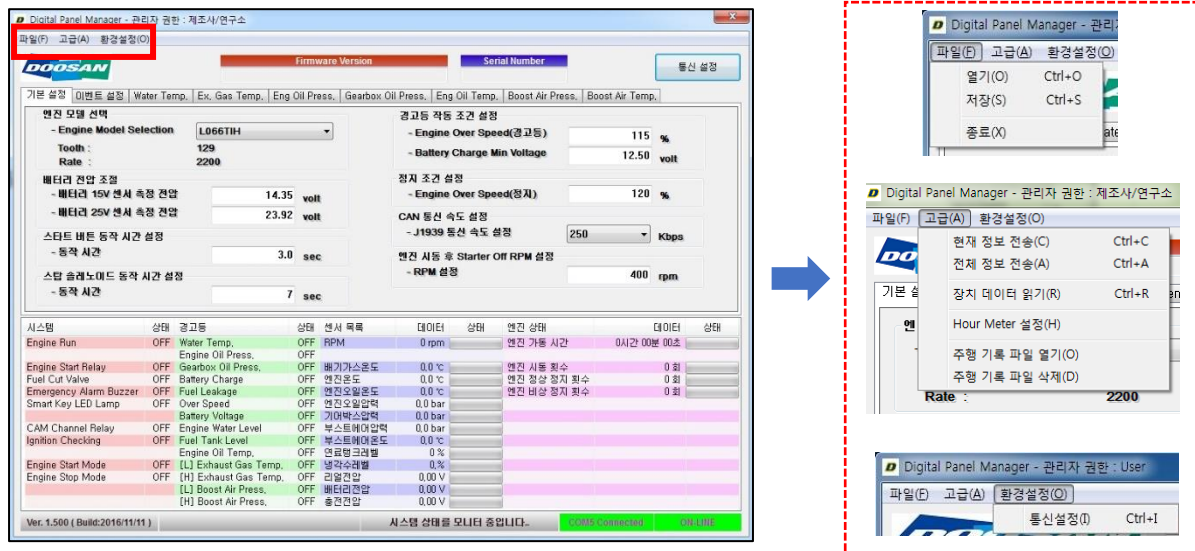
[Fig. 5-6] Communication Port and ON-LINE Connection

5. Digital Panel Manager

5.4 Display Structure and Detailed Functions

5.4.1 Menu Structure

- Descriptions of menus at the top left corner are as follows:



[Fig. 5-7] Menu Structure

	Structure	Description
Files	Open	Load setting files
	Save	Save settings as a file
	Exit	Exit the program
Advanced	Transmit Current Information	Transmit data settings in the current tab to the product
	Transmit All Information	Transmit data settings in all tabs to the product
	Read Device Data	Transmit data settings in all tabs to the product
	Hour Meter Settings	Configure the operation hours of the product
	Open Operation Record Files	Open the operation record files of the product
	Delete Operation Record Files	Delete the operation record files of the product
Configuration	Communication Settings	Configure the RS232 connection port

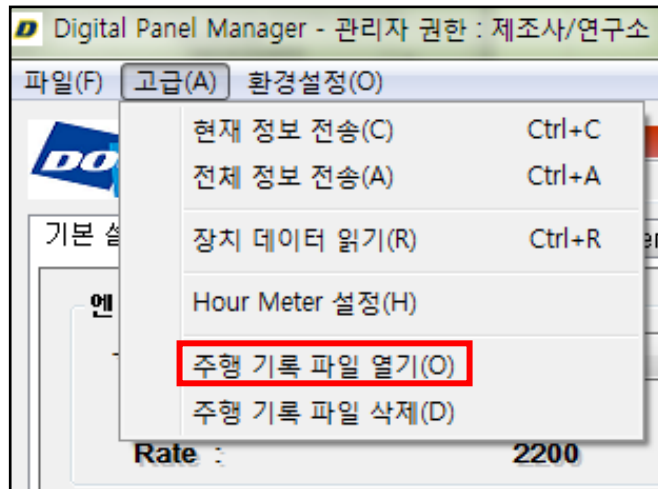
[Table 5-1] Menu Structure

5. Digital Panel Manager

5.4.2 Operation Record Files

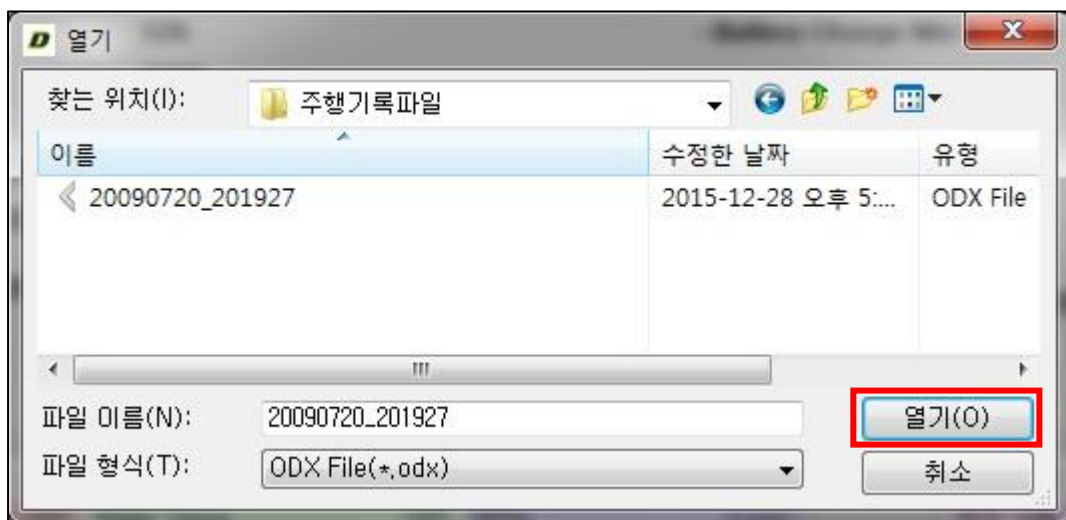
- You can check the operation record files saved in the product (users are not allowed to use this function).

1. Menu → Advanced → Click Open Operation Record Files.



[Fig. 5-8] Advanced Menu

2. Click .ODX files with dates that you want to check and then press Open button.



[Fig. 5-9] Open Operation Record Files

5. Digital Panel Manager

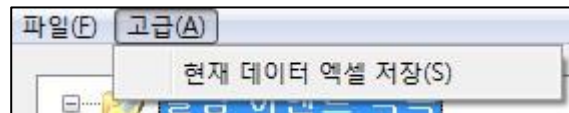
- The window in which you can check the operation records will be activated. You can see Files and Advanced Menu at the top left corner.



[Fig. 5-10] Operation Record Menu



[Fig. 5-11] Menu → Files



[Fig. 5-12] Menu → Advanced

Structure		Description
Files	Open Files	Open operation record files
	Exit	Exit the window
Advanced	Save Current Data as Excel Files	Convert current data to Excel files and save them.

[Table 5-2] Operation Record Menu

5. Digital Panel Manager

- Click + on the alarm event list at the top left corner of the operation window.



[Fig. 5-13] Activate Operation Record Window

- The list of each sensor will be activated. In order to check the records of the sensor that you want to, click + on the list (where there are records, + will appear).



[Fig. 5-14] List of the Operation Record Sensors

5. Digital Panel Manager

- When clicking the date of operation records by each sensor, you can see the graphs of those records. If you want to save those records in Excel files, select Advanced → Save current data in Excel files.



[Fig. 5-15] Operation Record Graphs

5.4.3 Setting Functions by Permission Level

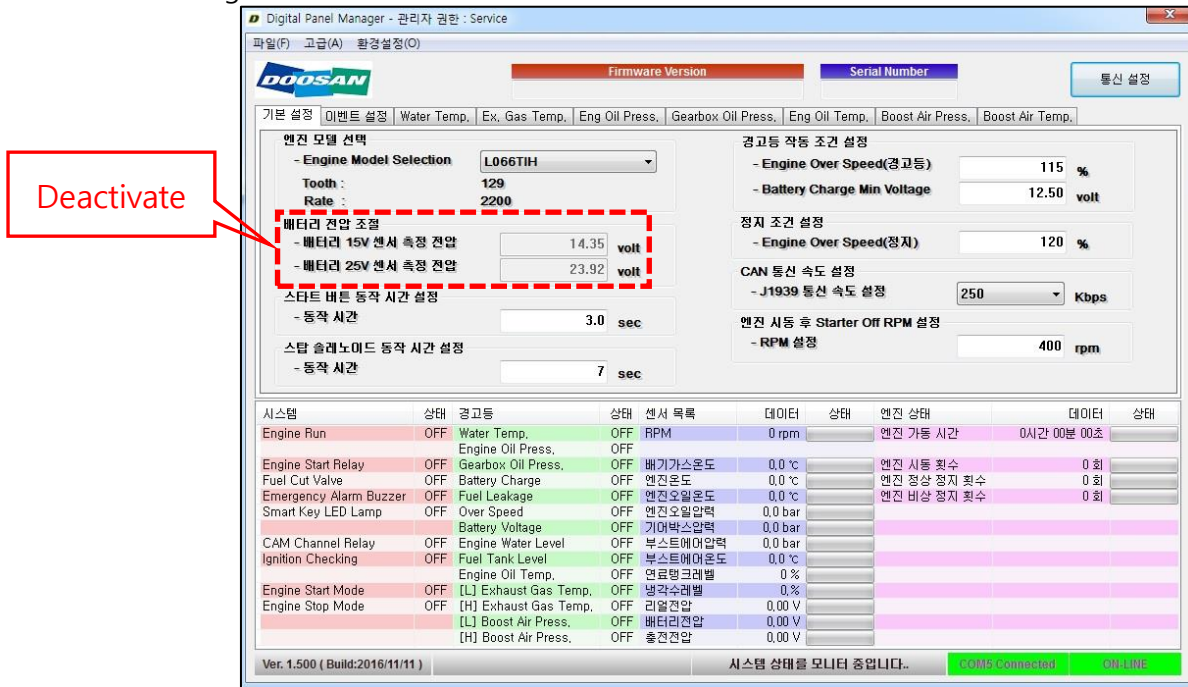
- It shows detailed descriptions about manufacturer/research institute cert.
 - ※ Where manufacturer/research institute authentication file and service cert files are in the same folder, the former will have the priority.

- Manufacturer/research institute cert – activates all tabs.

[Fig. 5-16] Manufacturer/Research Institute Cert

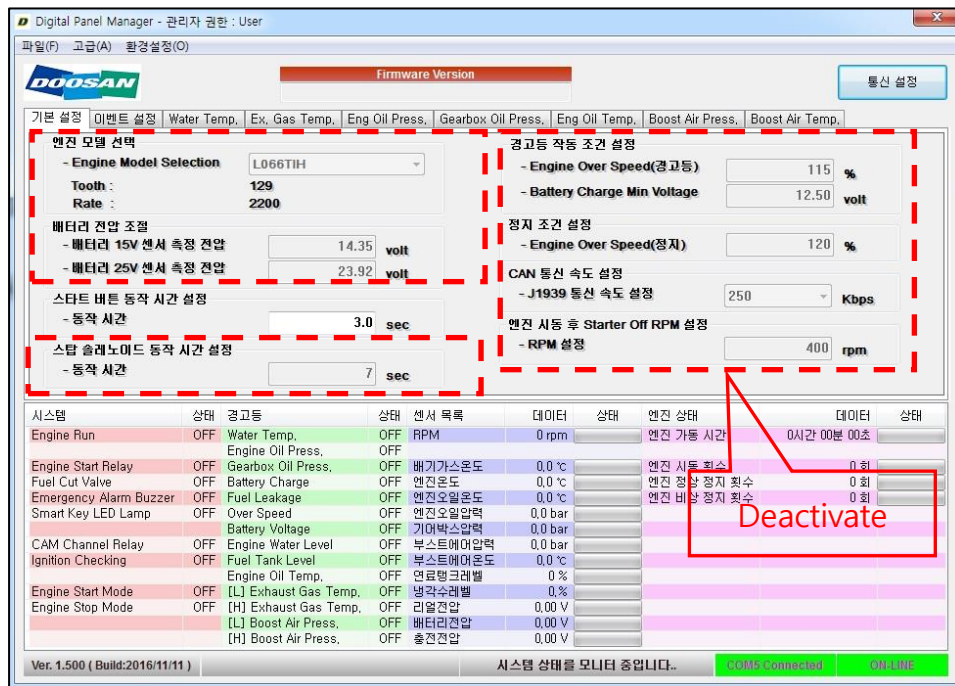
5. Digital Panel Manager

② Service Authentication – default setting (battery voltage control inactive) / Deactivate all tabs except event settings.



[Fig. 5-17] Service Authentication

③ End User Authentication – Deactivate all tabs except start button action time (you can still check the current information).

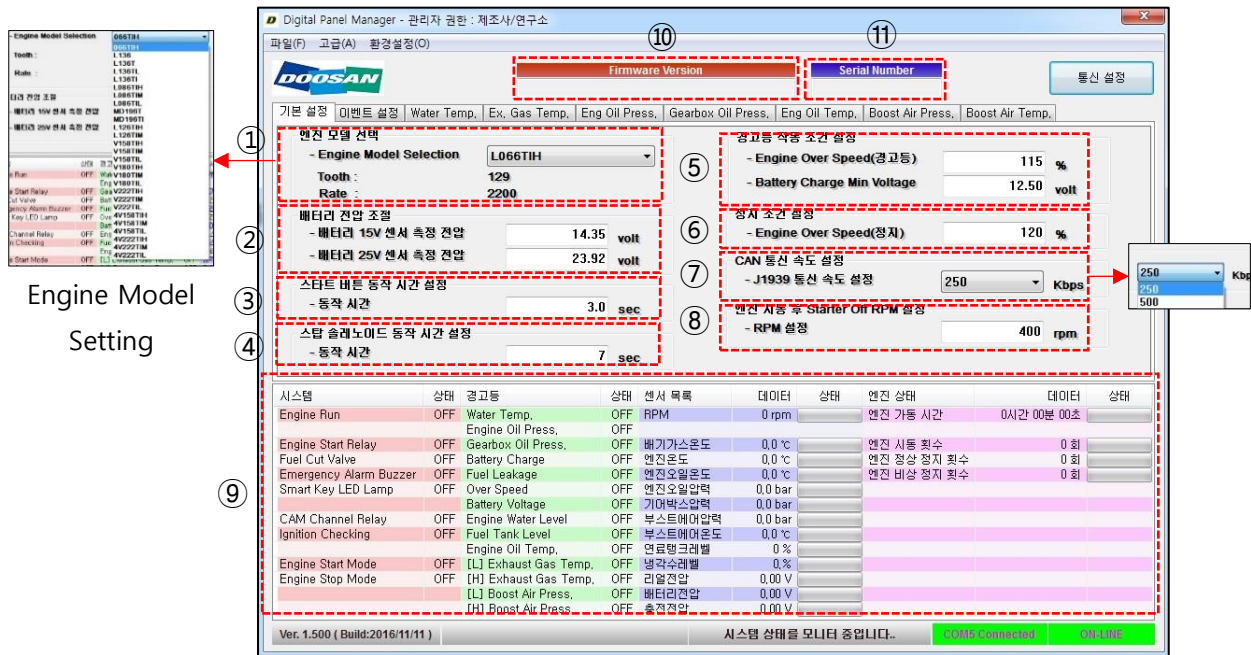


[Fig. 5-18] General User Authentication

5. Digital Panel Manager

5.4.4 Default Settings

- It shows description about the default setting tab in the initial main screen.
- ※ End users can configure start button action time only.



[Fig. 5-19] Default Setting Screen

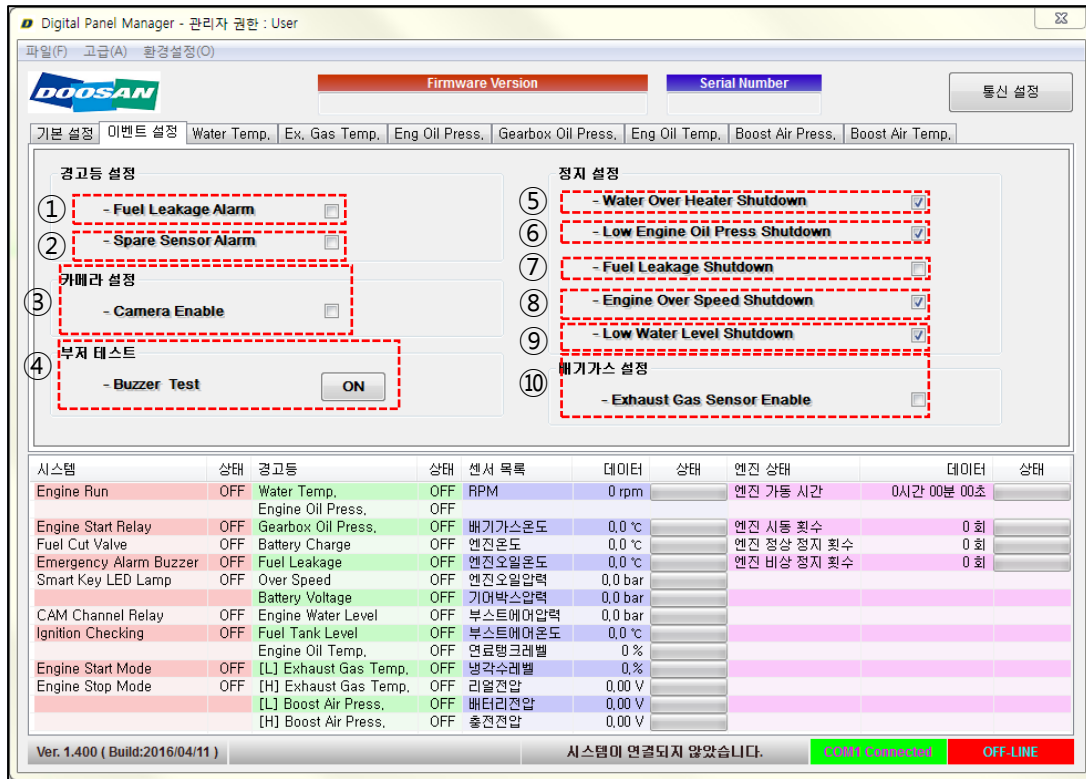
No.	Default Setting
①	Select engine models
②	Calibrate battery values after applying 15V and 25V respectively
③	Configure starting reaction time when pressing the start button (1s to 3s)
④	Timer setting for Stop Solenoid is from 7 seconds to 15 seconds
⑤	Configure alarm action conditions against engine over speed and minimum battery charging voltage
⑥	Configure engine stop conditions against engine over speed
⑦	Configure CAN communication speed
⑧	Configure criteria for starter off RPM (300 to 600RPM) when starting the engine
⑨	Monitor the engine conditions in real time
⑩	Show the current firmware version and sensor value mappings
⑪	Show the serial number of the product

[Table 5-3] Descriptions of Default Settings

5. Digital Panel Manager

5.4.5 Event Settings

- It shows description about the event setting tab.



[Fig. 5-20] Event Setting Screen

No.	Event Setting
①	ON/OFF check for fuel leakage alarm (Default: off)
②	ON/OFF check for spare sensor alarm (Default: off)
③	ON/OFF check for CCTV functions (Default: off)
④	Built-In Buzzer Test
⑤	ON/OFF check for engine stop by coolant overheating
⑥	ON/OFF check for engine stop by reduced engine oil pressure
⑦	ON/OFF check for engine stop by fuel leakage (Default: off)
⑧	ON/OFF check for engine stop for engine over speed
⑨	ON/OFF for engine stop by lack of coolant
⑩	ON/OFF check for the exhaust gas temperature sensor

[Table 5-4] Descriptions of Event Settings

5. Digital Panel Manager

5.4.6 Sensor Value Mapping Tab

- You can configure sensor values in this tap with manufacture/research institute permission only. You can only check the settings with other permissions.



[Fig. 5-21] Sensor Tab

기본 설정	이벤트 설정	Water Temp.	Ex. Gas Temp.	Eng Oil Press.	Gearbox Oil Press.	Eng Oil Temp.	Boost Air Press.	Boost Air Temp.					
엔진 온도	0	10	20	30	40	50	60	70	80	90	100	110	120
전압	4.60	4.20	3.80	3.40	3.07	2.65	2.23	1.88	1.52	1.26	1.00	0.78	0.56

[Fig. 5-22] Coolant Temperature

기본 설정	이벤트 설정	Water Temp.	Ex. Gas Temp.	Eng Oil Press.	Gearbox Oil Press.	Eng Oil Temp.	Boost Air Press.	Boost Air Temp.			
배기 온도	0	100	200	300	400	500	600	700	800	900	1000
전압	0.42	0.67	0.88	1.06	1.22	1.36	1.49	1.56	1.70	1.75	1.95

[Fig. 5-23] Exhaust Gas Temperature

기본 설정	이벤트 설정	Water Temp.	Ex. Gas Temp.	Eng Oil Press.	Gearbox Oil Press.	Eng Oil Temp.	Boost Air Press.	Boost Air Temp.			
오일 압력	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
전압	2.40	3.36	4.32	5.28	6.24	7.20	8.16	9.12	10.08	11.04	12.00

[Fig. 5-24] Engine Oil Pressure

기본 설정	이벤트 설정	Water Temp.	Ex. Gas Temp.	Eng Oil Press.	Gearbox Oil Press.	Eng Oil Temp.	Boost Air Press.	Boost Air Temp.	
오일 압력	0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0
전압	2.40	3.60	4.80	6.00	7.20	8.40	9.60	10.80	12.00

[Fig. 5-25] Gearbox Oil Pressure

기본 설정		이벤트 설정		Water Temp.	Ex. Gas Temp.	Eng Oil Press.	Gearbox Oil Press.	Eng Oil Temp.	Boost Air Press.	Boost Air Temp.			
오일 온도	0	10	20	30	40	50	60	70	80	90	100	110	120
전압	4.60	4.20	3.80	3.40	3.07	2.65	2.23	1.88	1.52	1.26	1.00	0.78	0.56

[Fig. 5-26] Engine Oil Temperature

기본 설정	이벤트 설정	Water Temp.	Ex. Gas Temp.	Eng Oil Press.	Gearbox Oil Press.	Eng Oil Temp.	Boost Air Press.	Boost A			
에어 압력	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
전압	0.00	0.50	1.07	1.64	2.21	2.79	3.36	3.93	4.50	4.70	4.90

[Fig. 5-27] Boost Air Pressure

기본 설정	이벤트 설정	Water Temp.	Ex. Gas Temp.	Eng Oil Press.	Gearbox Oil Press.	Eng Oil Temp.	Boost Air Press.	Boost Air Temp.					
에어 온도	0	10	20	30	40	50	60	70	80	90	100	110	120
전압	4.30	4.00	3.62	3.21	2.76	2.33	1.92	1.57	1.26	1.02	0.82	0.66	0.53

[Fig. 5-28] Boost Air Temperature

6. Maintenance

6.1 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

6.2 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.

7. Warranty and A/S Service

7.1 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.

7.2 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.

8. Appendix

8.1 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
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

