DAEWOO
DAEWOO HEAVY INDUSTRIES & MACHINERY LTD.

65.99897-8067

Operation & Maintenance Manual

MARINE DIESEL ENGINE

V158TI, V180TI, V222TI

MARINE GENERATOR ENGINE

AD158TI, AD180TI, AD222TI

FOREWORD

This manual is designed to serve as a reference for the operation & Maintenance of **V158TI / V180TI / V222TI** 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


Installation


Disassembly


Reassembly


Align the marks


Directional Indication


Inspection


Measurement


Adjustment


Cleaning


Pay close attention-Important


Tighten to specified torque


Use special tools of manufacturer's


Lubricate with oil


Lubricate with grease

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.

May. 2002.

DAEWOO Heavy Industries & Machinary LTD.

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1. SPECIFICATION

1.1. Engine Specification

1.1.1. V158TI

Marine Engine Specification						
Model		**Units**	**V158TI**			
			V158TIE	**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	420(309)/1,800	480(353)/1,800	540(397)/2,10	680(500)/2,300
Displacement		cc	14,618			
Cylinder number - bore(ø) x stroke		mm	8 - ø128 x 142			
Valve clearance at cold	In / Ex	mm	0.25 / 0.35			
Low idling rpm		rpm	725 ± 25			
No load max. rpm		rpm	below 2070	below 2070	Below 2415	below 2645
Mean effective pressure		kg/cm²	14.47	16.42	15.84	18.21
Mean piston speed		m/sec.	8.52	8.52	9.94	10.89
Compression ratio			16.5 : 1	15 : 1		
Firing order			1 - 5 - 7 - 2 - 6 - 3 - 4 - 8			
Max. firing pressure of cylinder		kg/cm²	130	130	128	150
Compression pressure	at 200 rpm	kg/cm²	28 (Initial Condition)			
Governor type of injection pump			Mechanical variable speed (R.Q.V)			
Fuel consumptio n		g/PS.h	155	155	163	185
		liter/h	90	90	106	152
Injection timing (B.T.D.C)		deg	26˚ ± 1˚	24˚ ± 1˚	24˚ ± 1˚	24˚ ± 1˚
Fuel inj. nozzle opening pressure		kg/cm²	286			
Starting system			Electric Starting by starter motor			
Starter motor capacity		V - kW	24 - 6.6			
Alternator capacityV - A		24 - 50				
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/cm²	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	1337x1222x1074		1,337 x 1,222 x 1,074	
	with M. gear	mm	1777x1222x1115		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 / 0.35		
Low idling rpm		rpm	725 ± 25		
No load max. rpm		rpm	Below 2,070	Below 2,415	below 2,645
Mean effective pressure		kg/cm²	16.42	15.25	18.56
Mean piston speed		m/sec.	8.52	9.94	10.89
Compression ratio			15 : 1		
Firing order			1 - 6 - 5 - 10 - 2 - 7 - 3 - 8 - 4 - 9		
Max. firing pressure of cylinder		kg/cm²	130	128	150
Compression pressure	at 200 rpm	kg/cm²	28 (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	24˚ ± 1˚	24˚ ± 1˚	24˚ ± 1˚
Fuel inj. nozzle opening pressure		kg/cm²	286		
Starting system			Electric Starting by starter motor		
Starter motor capacity		V - kW	24 - 6.6		
Alternator capacity		V - A	24 - 50		
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/cm²	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

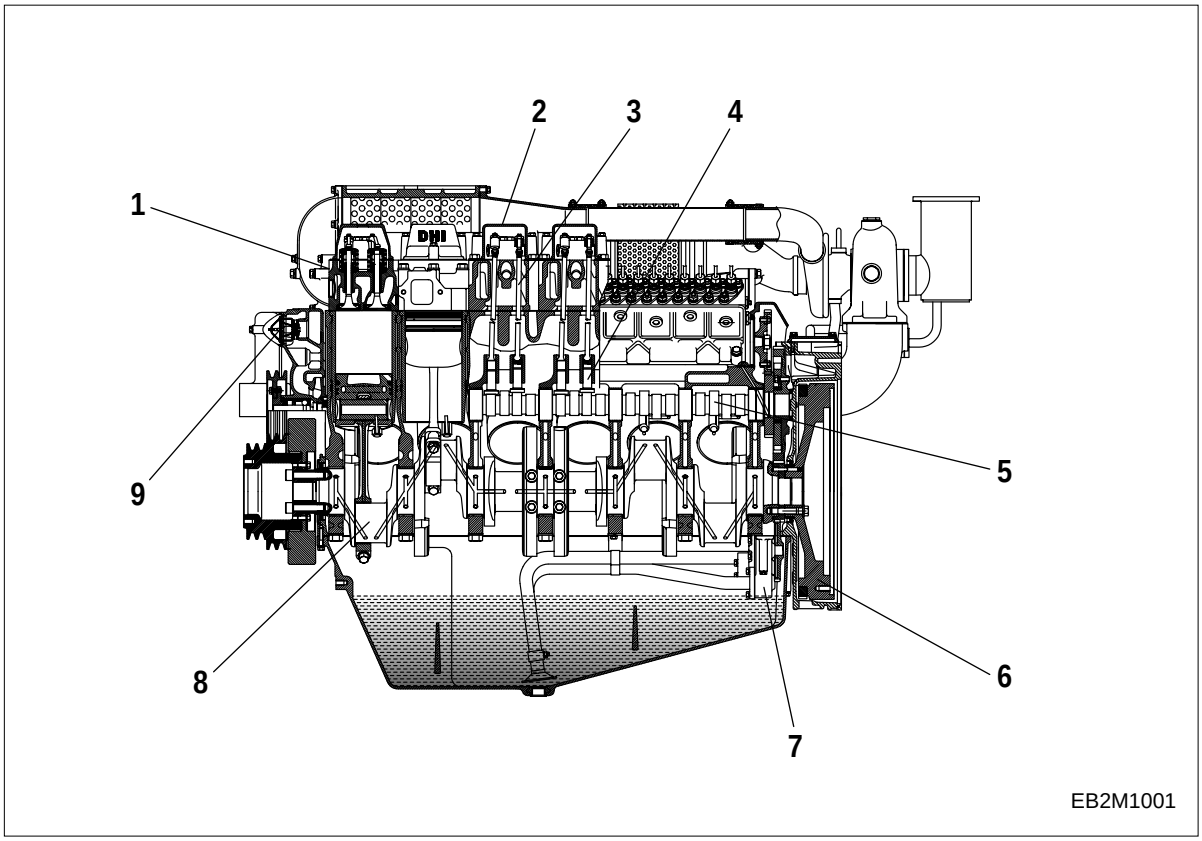
Marine Engine Specification					
Model		**Units**	**V222TI**		
			V222TIH	**V222TIM**	**V222TIL**
Engine type			4 cycle, V type, direct- injection, water cooled with wet turbo charger & inter-cooler		
Rating output (B.H.P)		PS(kW)/rpm	720(530)/1,800	800(588)/2,100	1,000(736)/2,300
Displacement		cc	21,927		
Cylinder number - bore(ø) x stroke		mm	12 - ø128 x 142		
Valve clearance at cold	In / Ex	mm	0.25 / 0.35		
Low idling rpm		rpm	725 ± 25		
No load max. rpm		rpm	Below 2070	Below 2415	Below 2645
Mean effective pressure		kg/cm²	16.42	15.64	17.85
Mean piston speed		m/sec.	8.52	9.94	10.89
Compression ratio			15 : 1		
Firing order			1 - 12 - 5 - 8 - 3 - 10 - 6 - 7 - 2 - 11 - 4 - 9		
Max. firing pressure of cylinder		kg/cm²	130	126	150
Compression pressure	at 200 rpm	kg/cm²	28 (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	22° ± 1°	22° ± 1°	22° ± 1°
Fuel inj. nozzle opening pressure		kg/cm²	286		
Starting system			Electric Starting by starter motor		
Starter motor capacity		V - kW	24 - 6.6		
Alternator capacity		V - A	24 - 50		
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/cm²	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 (AD158TIIF)	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	0.3 / 0.3		
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/cm²	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				15 : 1	
Max. firing press. of cylinder		kg/cm²	130	130	130
Com. Press. (at 200 rpm)		kg/cm²	28 (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)		deg.	24 ± 1°		22 ± 1°
Inj. nozzle opening press.		kg/cm²	224		
Starting system			Electric Starting by starter motor		
Starter motor capacity		V-kW	24V - 6.0		
Alternator capacity		V-A	24V - 50		
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/cm²	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 weightkg			1,295	1,545	1,735

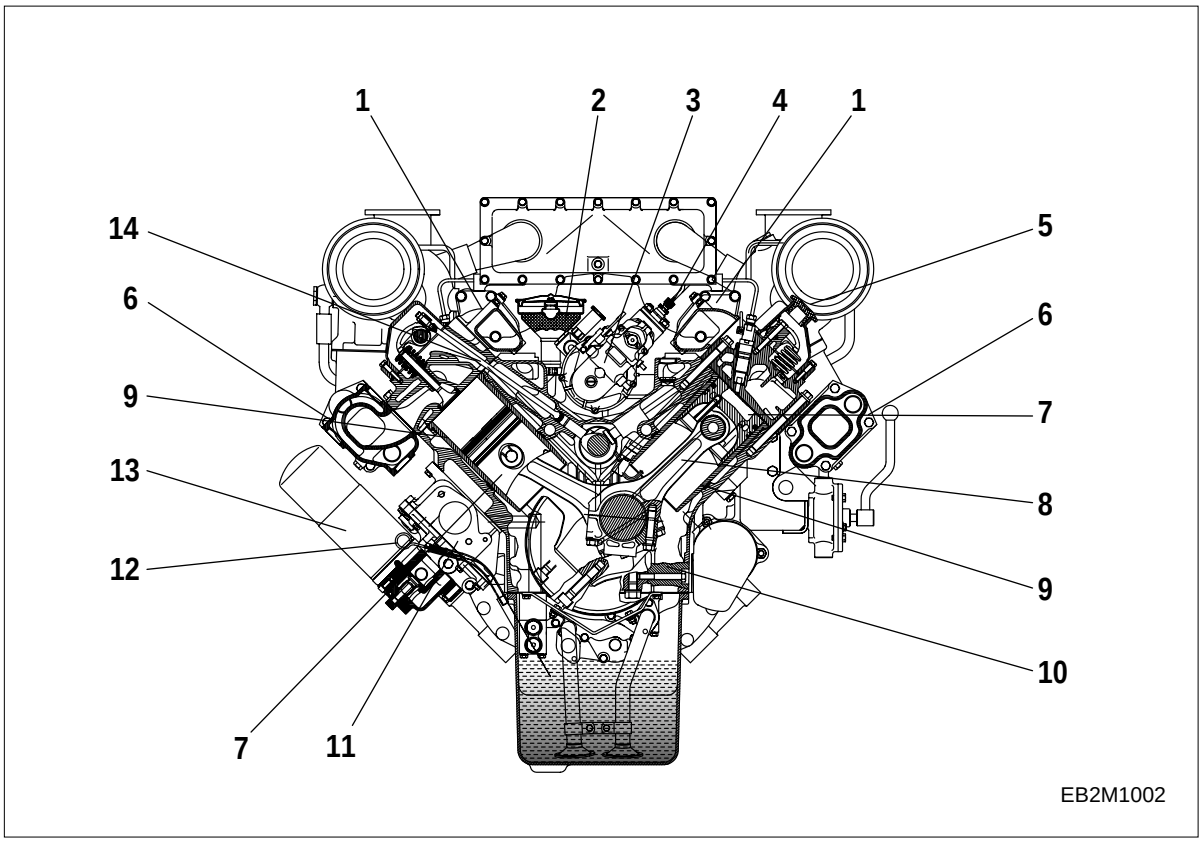
1.2. Engine Aspects

1.2.1. Engine Sectional View (Longitudinal –> V222TI)



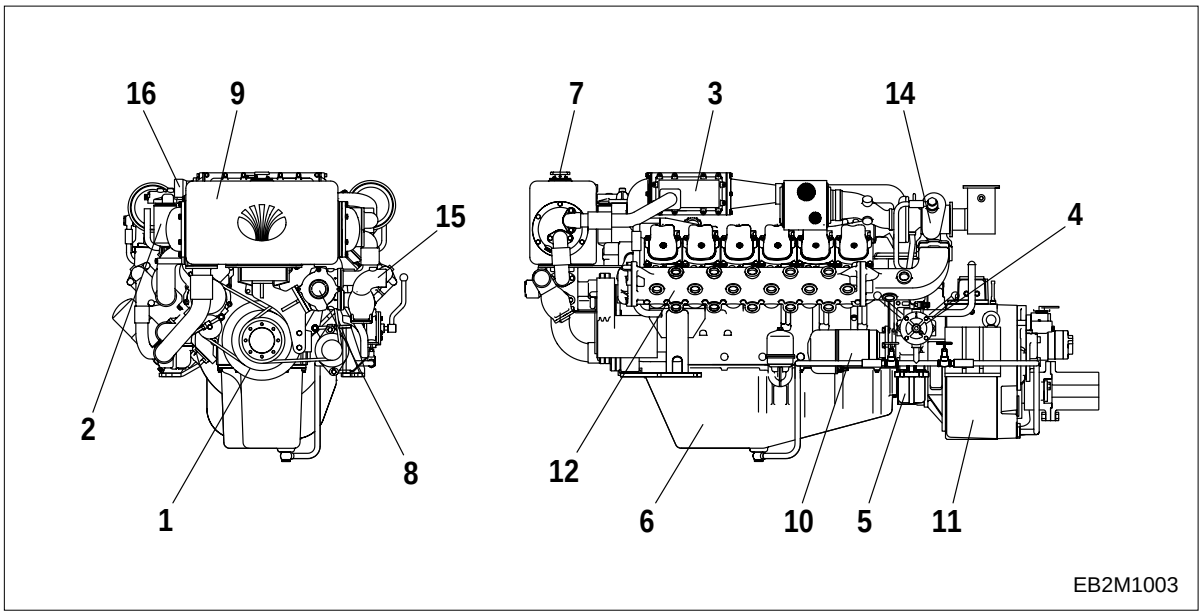
1. Cylinder head
2. Cylinder head cover
3. Push rod
4. Tappet
5. Camshaft
6. Flywheel
7. Oil pump
8. Crankshaft
9. Thermostat

1.2.2. Engine Sectional View (Cross —> V222TI)



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

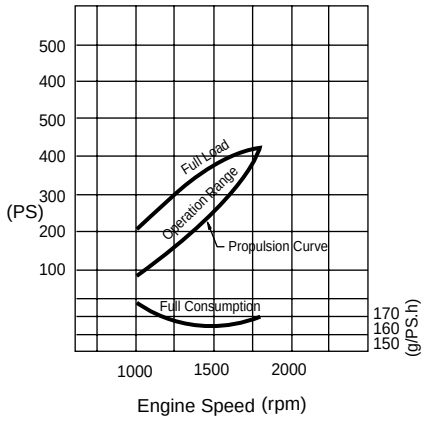
1.2.3. Engine Assembly (V222TI)



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

1.3. Engine Performance Curve

1.3.1. V158TIE



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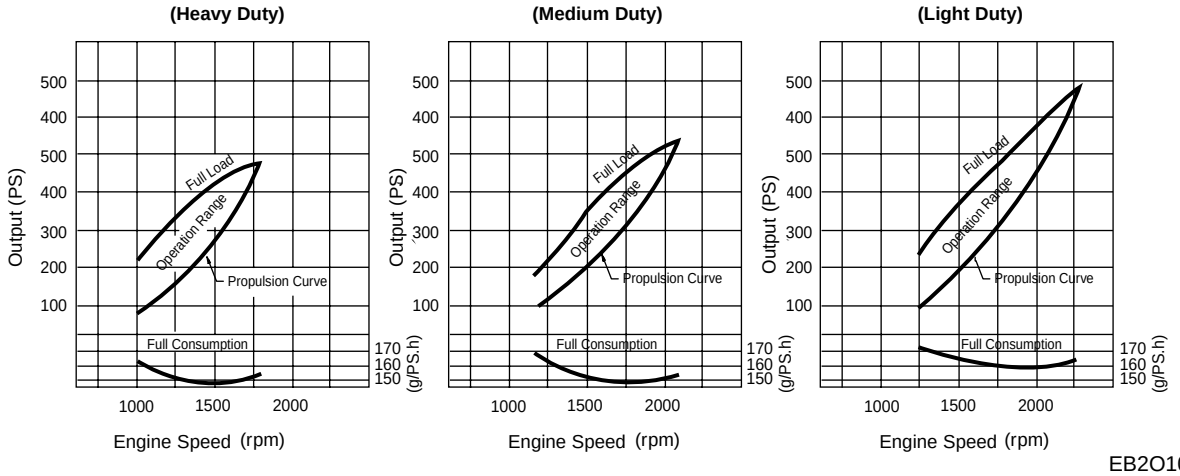
1.3.2. V158TI



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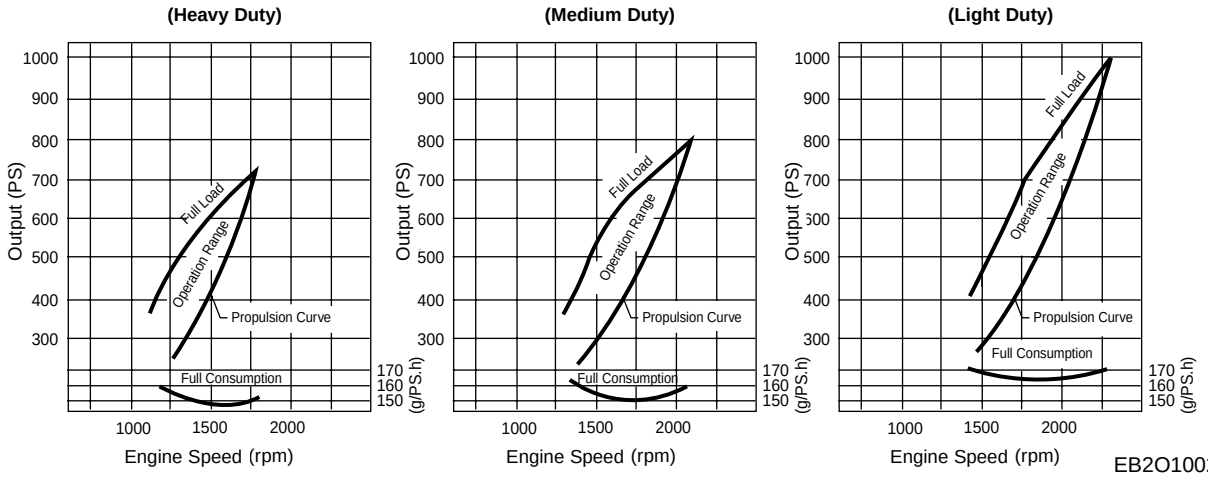
1.3.3. V180TI



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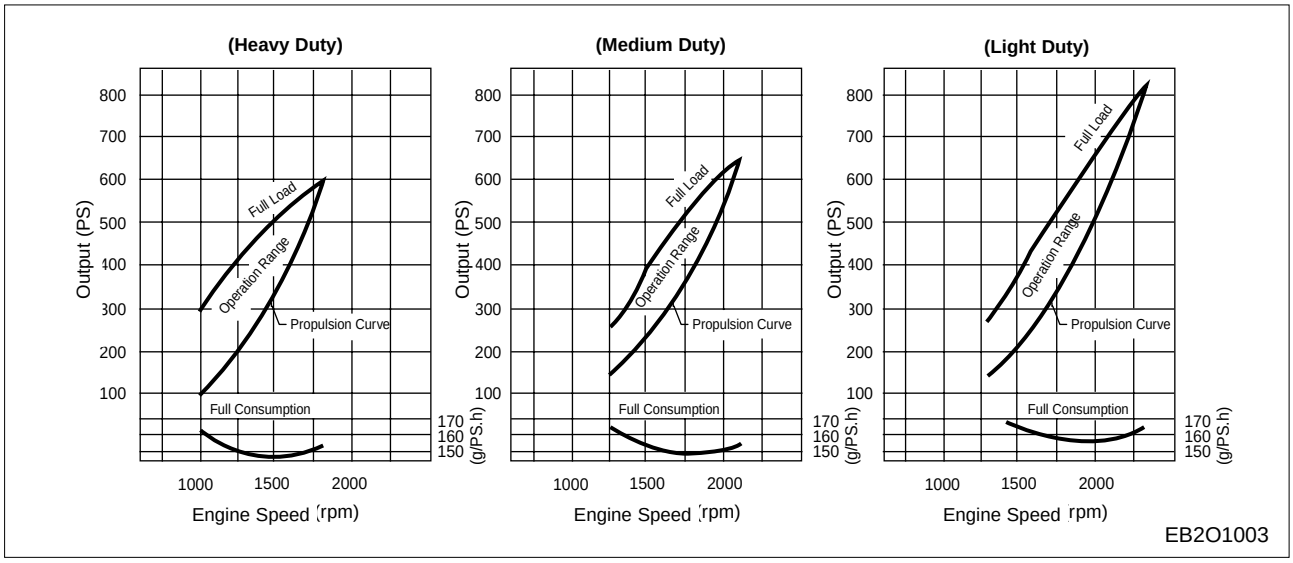
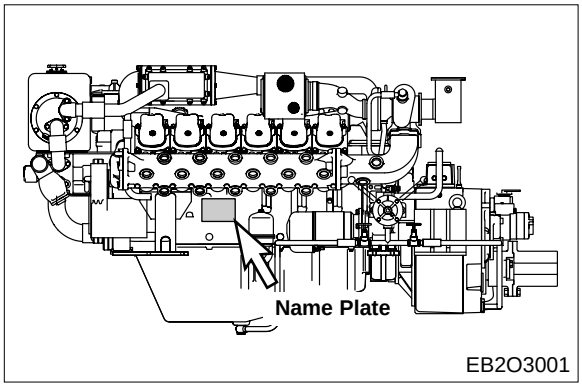
1.3.4. V222TI


(Heavy Duty)
(Medium Duty)
(Light Duty)
Output (PS)
800
700
600
500
400
300
200
100
Full Load
Operation Range
Propulsion Curve
Full Consumption
170
160
150
(g/PS.h)
1000
1500
2000
Engine Speed (rpm)
EB2O1003

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 DAEWOO 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 DAEWOO marine diesel engines which are to be operated in enclosed spaces. Ensure that there is adequate ventilation and air extraction.
- Keep vicinity of engine, ladders and stairways free of oil and grease.
  Accidents caused by slipping can have serious consequences.

2.2.2. During maintenance and care

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

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

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

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

2.2.3. When carrying out checking, setting and repair work

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

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

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

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

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

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

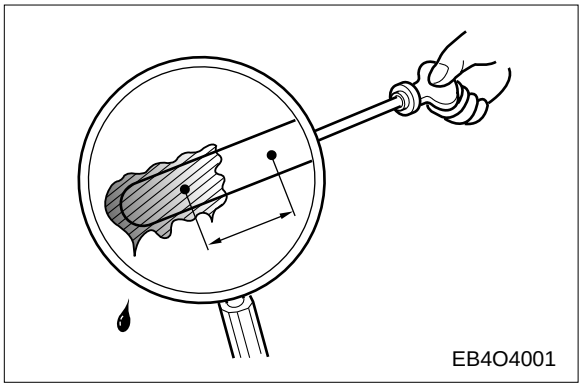
3.1. Inspections before Operation

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.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3.1.2. Cooling water

Checking the level of the cooling water in tank.

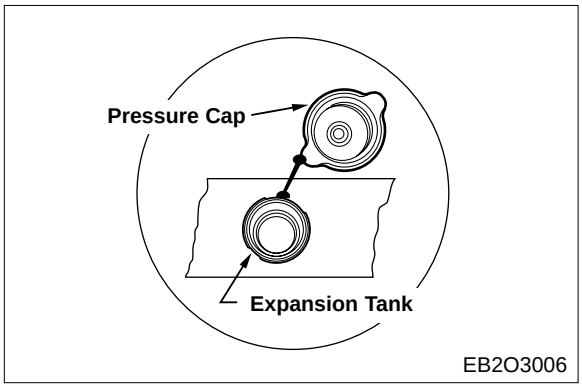
Caution

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

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

NOTE :

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



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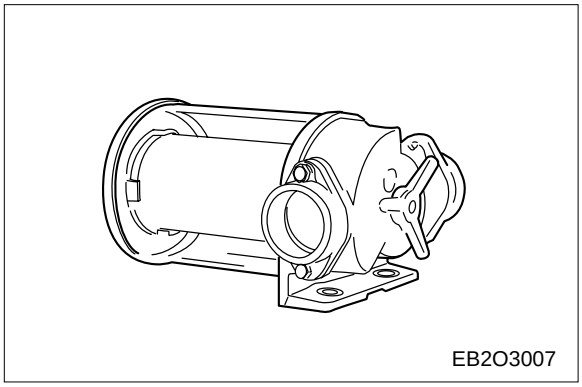
3.1.3. Sea water pump

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.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- 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.

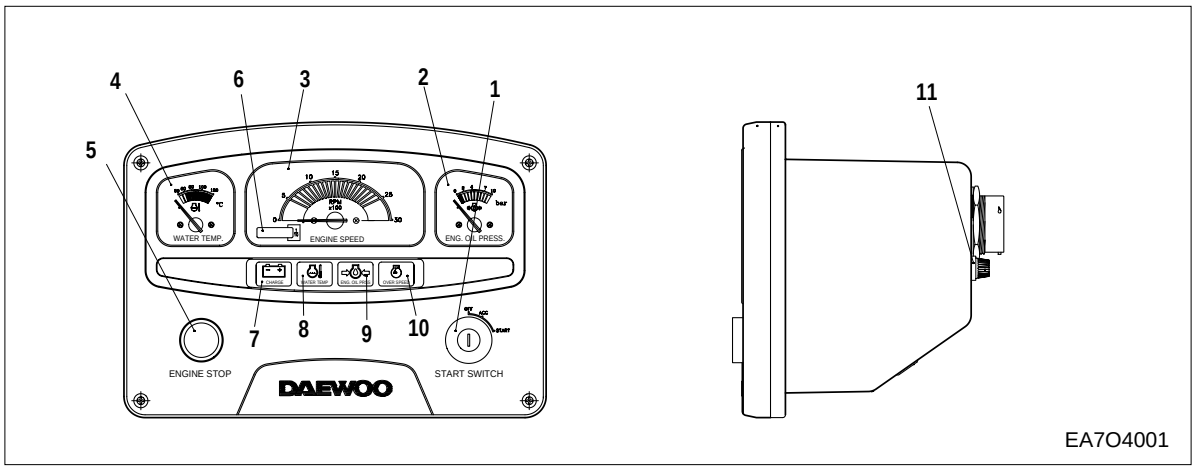
CAUTION :
The water level in the boat's bilge will increase when the boat is operated at a high inclination before rated speed is reached. Excessive water in the bilge can cause engine damage like corrosion , malfunction of engine parts.

3.1.7. Gauge Panel

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

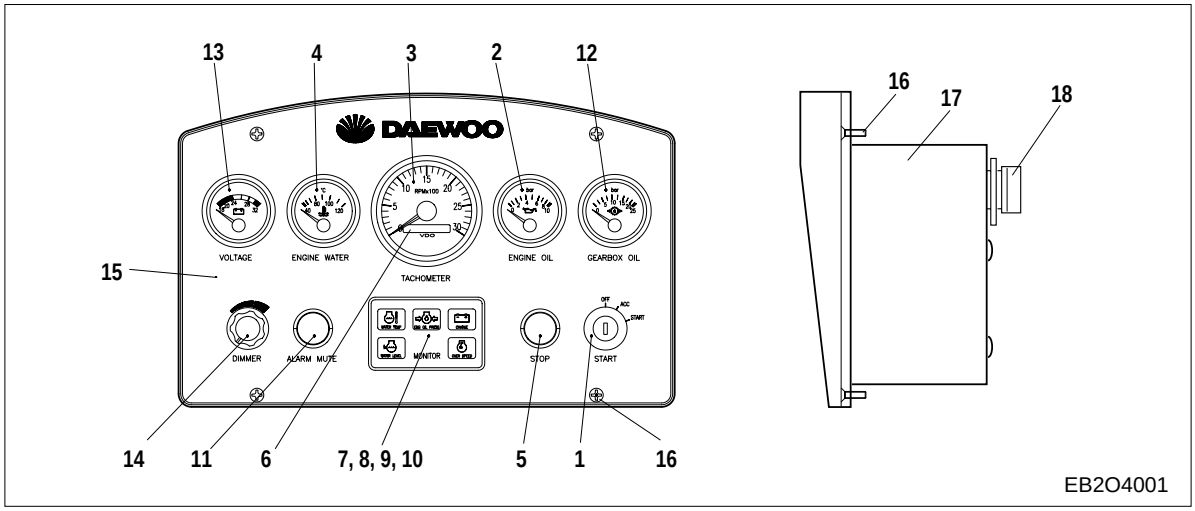
Before operation your engine familiarize yourself with the instruments supplied with your boat.

1) V158TIE



1. Key Switch
2. Engine Oil Pressure Gauge
3. Tacho-Meter
4. Water Temp. Gauge
5. Engine Stop Button
6. Hour Meter
7. Battery Warning Lamp
8. Water Temp. Warning Lamp
9. Oil Press. Warning Lamp
10. Over Speed Warning Lamp
11. Fuse

2) V158TI / V180TI / V222TI



1. Key Switch
2. Engine Oil Pressure Gauge
3. Tachometer
4. Water Temp. Gauge
5. Engine Stop Button
6. Hour Meter
7. Battery Warning Lamp
8. Water Temp. Warning Lamp
9. Oil Press. Warning Lamp
10. Over Speed Warning
11. Warning Lamp Stop Button
12. Clutch Oil Press. Gauge
13. Battery Charge Meter
14. Lamp Dimmer
15. Gauge Panel
16. Bolt
17. Connector

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)

Engine stop solenoid is operated with a warning lamp and buzzer sound at the same time as follows.

- When the engine oil pressure is less than 0.5 kg/cm^2.
- When the engine over speed becomes more than 120% of the engine rated speed but, marine generator engine becomes more than 115%.

2) Engine Warning Lamps

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

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

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

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

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

First, quickly observe the oil pressure gauge for the engine low pressure such as needle oscillation indicating low oil. If oil temperature gauge indicates below 0.5kg/cm^2, put the control lever back to the idle speed position IMMEDIATELY and shift the reduction gear control lever into the NETURAL position. Do not restart engine until the cause for the alarm has been found and corrected. Refer to “Performance Loss” in 8. Trouble Shooting Chart. Check the oil lines or switch and sensor malfunction. If the cause for the alarm cannot be found, contact your DAEWOO dealer.

3.2. Starting

3.2.1. Operation 1

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

3.2.2. Operation 2

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

3.3. Engine Brek-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 DAEWOO 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 (1500~1600rpm) for two to three minutes, then back to minimum planing speed(700~800rpm).
After the engine has reached operating temperature, momentarily reduce engine speed, then increase engine speed, to assist the break-in of rings and bearings. Maintain planing boat attitude to avoid excessive engine load.

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

3.3.3. Next 8 Hours

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

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

3.3.4. Final 10 hours

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

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

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

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

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

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

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

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

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

3.3.5. Operating after break-in 20 hours

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

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 anti-freeze is used to prevent cooling water from freeze and corrosion, it is always to be filled with the anti-freeze 35 ~ 40% of the whole coolant .

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 DAEWOO parts necessarily.
6. Used cotter pins, gaskets, O-rings, oil seals, lock washer and self-lock nuts 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 1,000hrs
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 hr 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							●
	Air filter element cleaning & change			● clean			● change	
	Inter-cooler cleaning							●
	Turbocharger cleaning							2,000 hrs
	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
Electrical System	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 DAEWOO marine engines should be mixture of fresh water and additional agent (35 ~ 40% anti-freeze and 3 ~ 5% anti-corrosion agent).
Check the quantity of anti-freeze every 600 hours. From time to time, refill the anti-freeze as much as required.
You can check the quantity of anti-freeze and anti-corrosion agent by using a FLEETGUARD test kit simply as follow. (Fleetguard CC2602M : DHI No. ; 60.99901-0038)

1) Contamination check

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

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

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

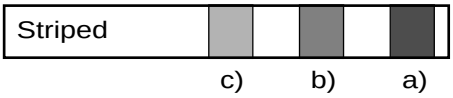
(2) Shake the bottle filled with sample coolant to mix well and take out one strip from bottle of the test kit. Then dip the strip into coolant sample for 3 ~ 5 seconds, take it out and shake it briskly to remove excess liquid.

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

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

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

● **How to judge the strip**

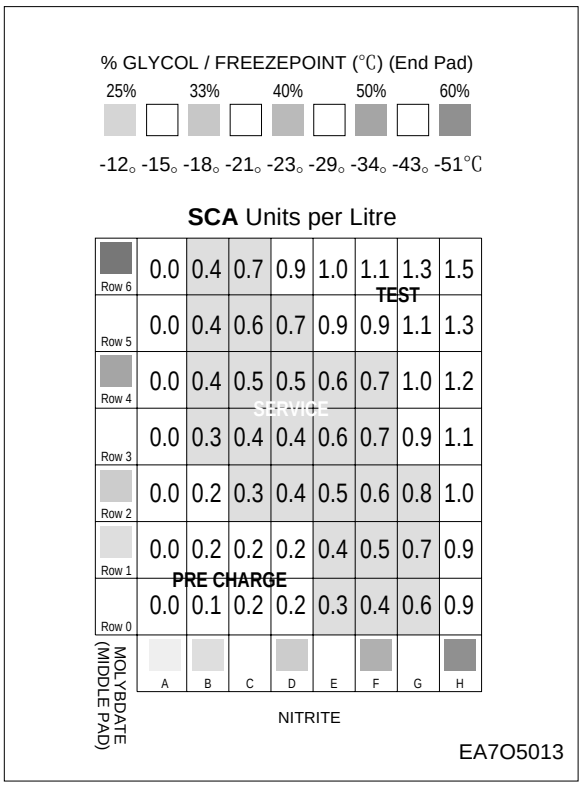


a) Compare FREEZEPOINT (end pad) to chart and record result.
b) Next compare MOLYDATE (middle pad) to chart and record result.
c) Finally compare NITRITE test to chart and record result.

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

(2) Compare the middle pad “b)” color of the strip with the color that the column block color of MOLYDATE at the left side of the table intersects the row block color of NITRITE at the bottom (pad “c)” color of the strip) on the table “SCA Units per Litre”.

(Normal range of “SCA Units per Litre” is between 0.3 and 0.8 : “green color area”)



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

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

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

4.3.3. Anti-freeze

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

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

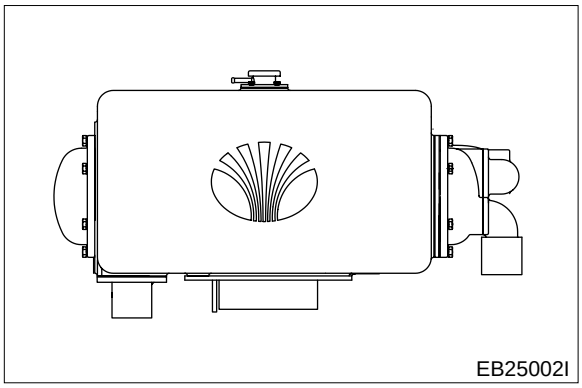
Ambient Temperature (°C)	Fresh Water (%)	Anti-freeze (%)
Over -10	85	15
-10	80	20
-15	73	27
-20	67	33
-25	60	40
-30	56	44
-40	50	50

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

4.3.4. Heat exchanger and cooling line cleaning

(1) Heat exchanger cleaning

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



a) Remove the heat exchanger both left and right side covers.
b) Remove the clogged small pieces and clean the heat-exchanger tubes.

When the heat-exchanger tubes do cleaning, clean outside and inner side of tubes with a small wire brush and pressurized water.

(2) Fresh water line cleaning

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

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

Cooling system cleaning interval : Every 1,200 hours

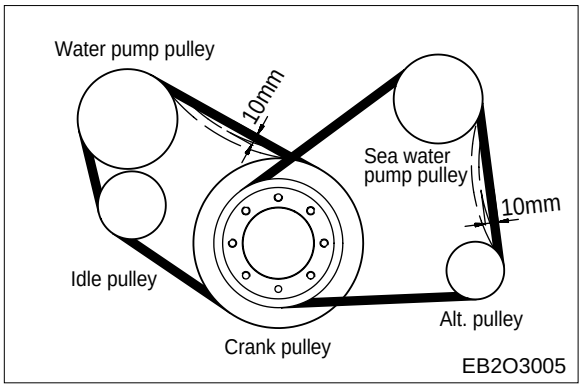
4.3.5. Check and Adjust of V-belt Tension

(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 10~15mm between the water pump pulley and the alternator pulley in normal condition. For the adjustment of the tension, loosen the adjusting bolts which support the alternator, adjust the tension and tighten the bolts again.



(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.

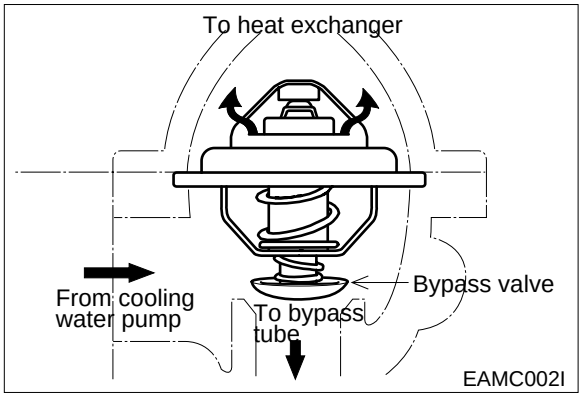
Note :

Always apply to DAEWOO 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.

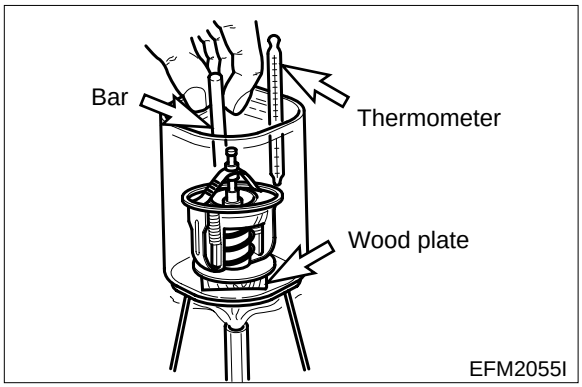


Item	Specifications
Type	Wax-pallet type
Open at	71 ˚C
Open wide at	85 ˚C
Valve lift	8 mm or more

● **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

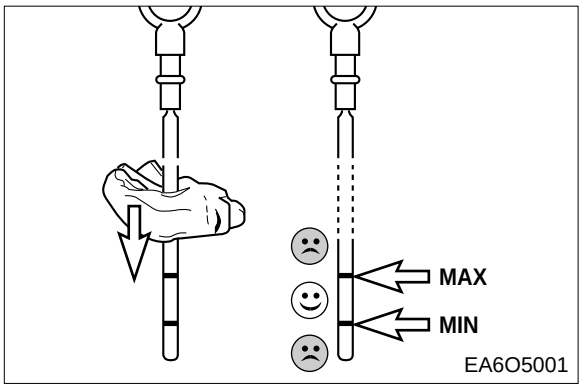
As the sea water pump is a bronze impeller type driven by V-belt, should install the sea water strainer between sea water pump and kingston valve to prevent malfunction of impeller due to clogging by any matters sucked.

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

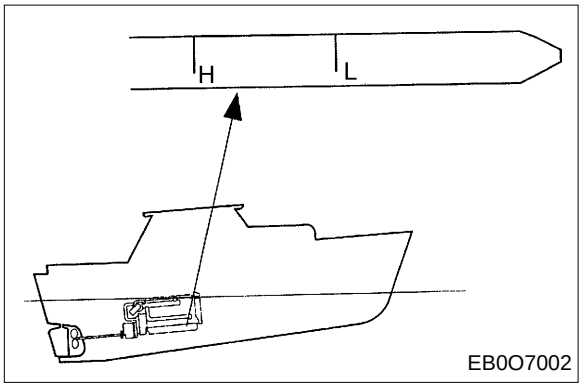
4.4.1. Oil level

- 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.

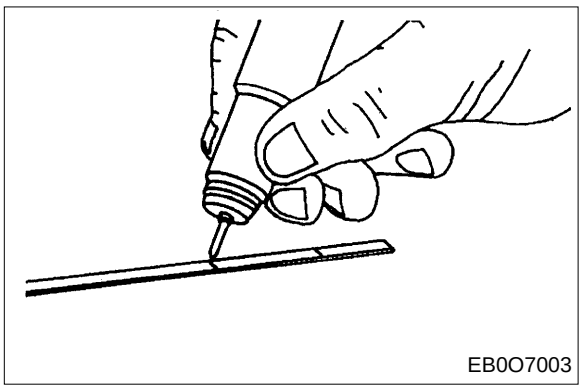


CAUTION :

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.

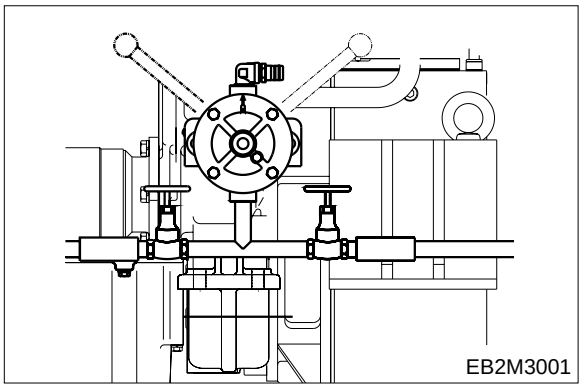
The capacity of lube oil can be referred before “1.1. Engine Specification”

4.4.2. Exchanging of lubrication oil

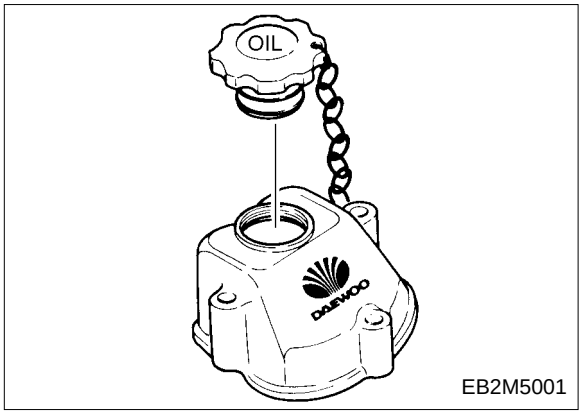
Engine oil and the oil filter is important factors affecting engine life. They affect ease of starting, fuel economy, combustion chamber deposits and engine wear. Change the engine oil at 50 hours of operation at first and next exchange will be performed every 250 hours. At the end of the break-in period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


EB2M3001

- 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.

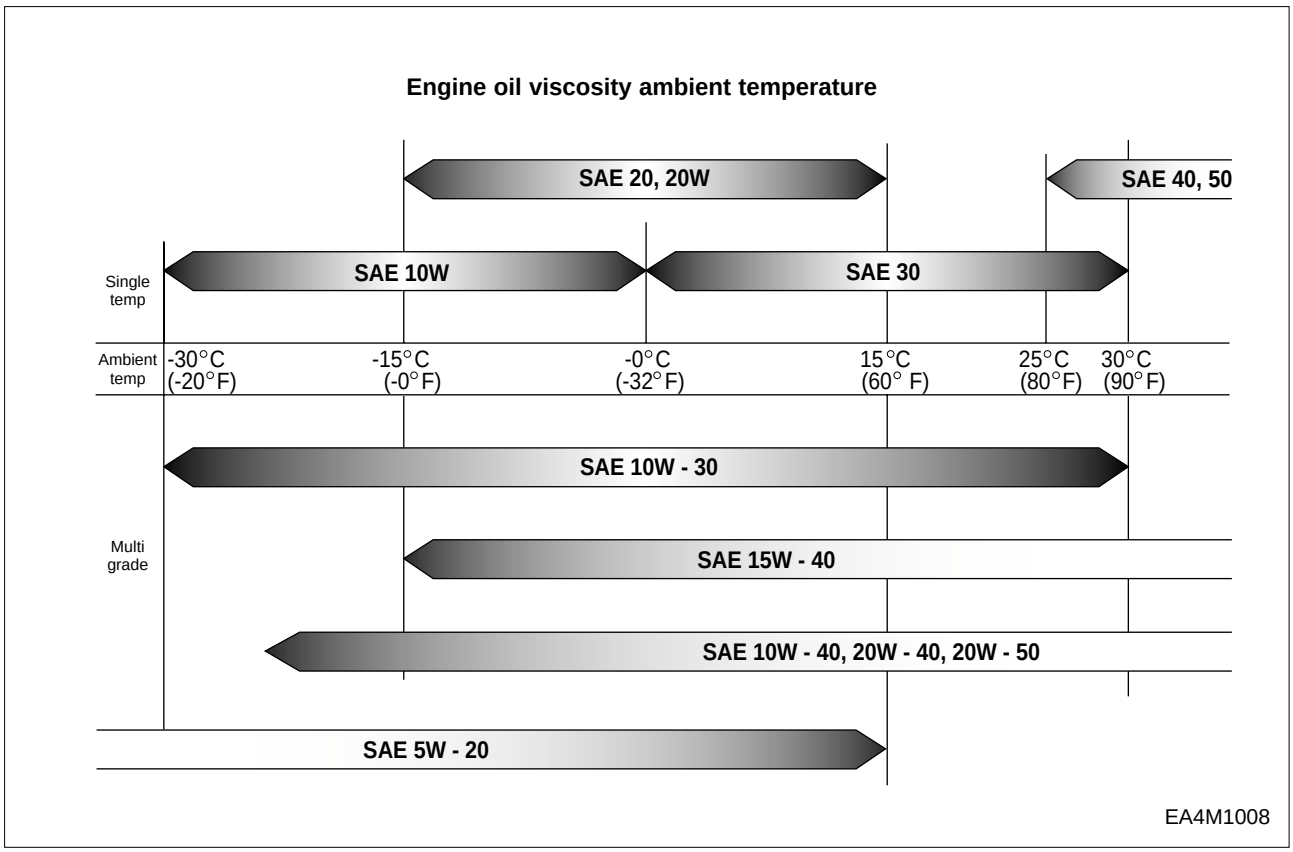


EB2M5001

- 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 CH-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-4 and SAE viscosity 15W40. Refer to oil identification symbol on the container.



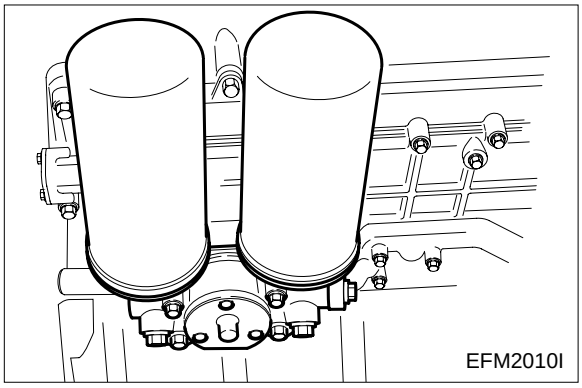
4.4.3. Replacement of oil filter cartridge

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.

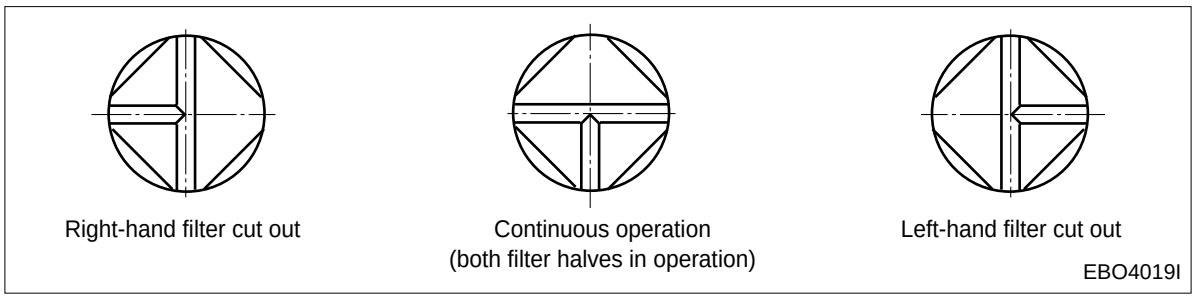
- Loosen the oil filter by turning it counter-clockwise with a filter wrench.
- With a rag wipe, clean the fitting face of the filter body and the oil filter body so that new oil filter cartridge can be seated properly.



NOTE
It is strongly advisable to use DAEWOO 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.

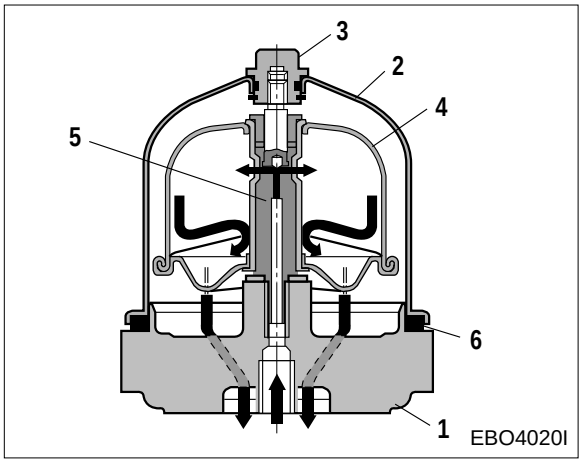
During continuous operation the selector lever that both filter halves are in operation. Observe positions of selector level.



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.

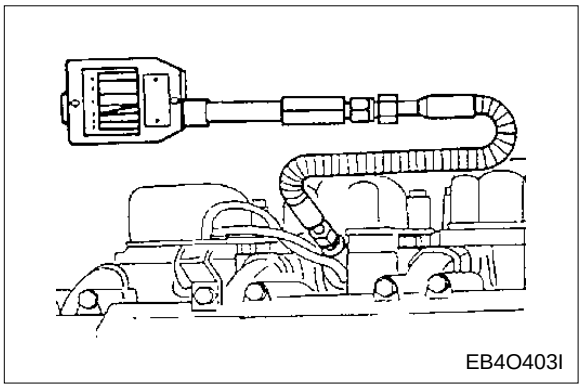


4.4.5. Marine gear oil change

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	24 ~ 28kg/cm^2
Limit value	24kg/cm^2 or less
Difference between each cylinder	Within ± 10 %

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

4.5. Intake & Exhaust System

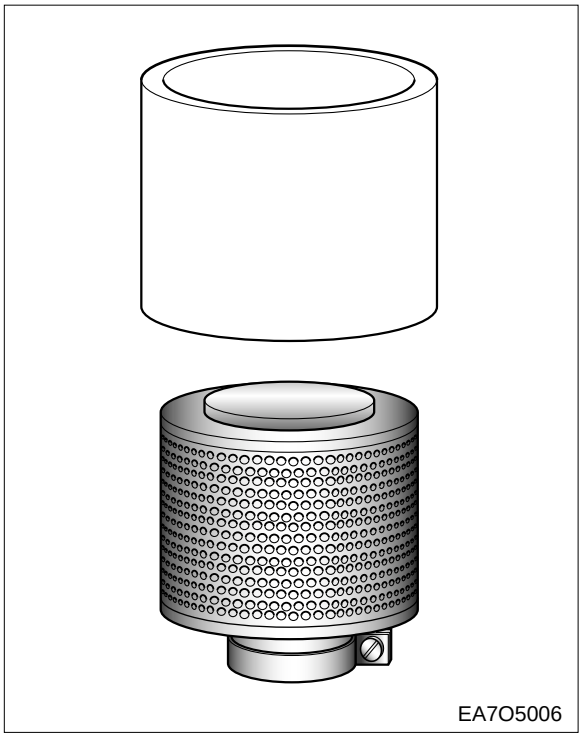
4.5.1. Cleaning & change of the air filter element

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

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

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

The air filter element should clean periodically as follow.



Cleaning of the air filter element : Every 100 hours

Exchange of the air filter element : Every 400 hours

Replace the air cleaner if deformed, broken or cracked.

(1) Air filter element cleaning

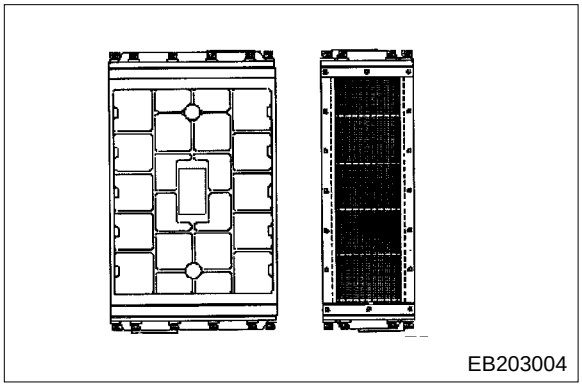
- Wash the polluted element in warm water non-sudsy household detergent.
- Rinse the element with clean water.
- Dry it thoroughly with natural air or electric fan.
  Don't use a flame or compressed air for dry.
  It makes damages to the element.

(2) Checking element

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

4.5.2. Inter-cooler

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

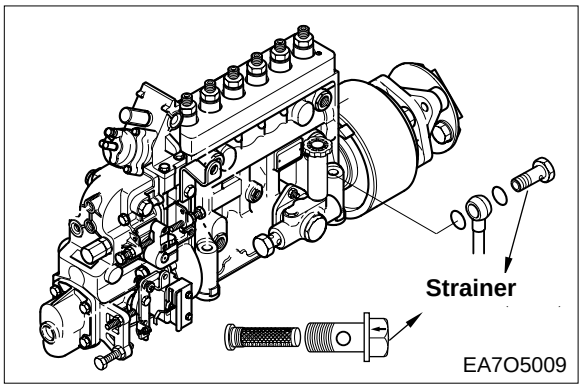
Exhaust gas depends on much or less of it shows whether combustion condition of the engine is good or not. If exhaust gas is any abnormal condition like excessive smoke, white smoke, black smoke, the engine should be serviced maintenance from specialist.

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. DAEWOO 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 2500	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 2274	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

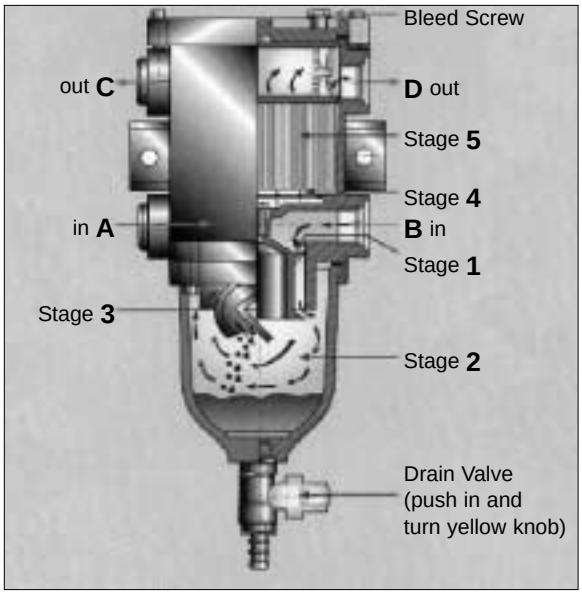
#) Not specified In ASTM D 975

+) 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 fitters by crystals.

4.6.3. Water separator

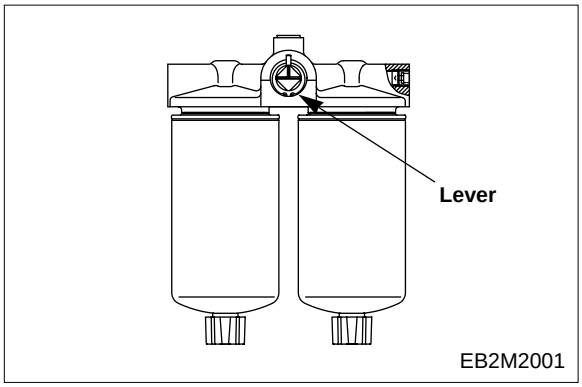
DAEWOO recommends the fuel water separator to install between fuel tank and fuel injection pump strongly.
Condensation formed in a partially filled tank promotes the growth of microbial organisms that can clog fuel filters and restrict fuel flow and cause the engine power decrease before.
Water in the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

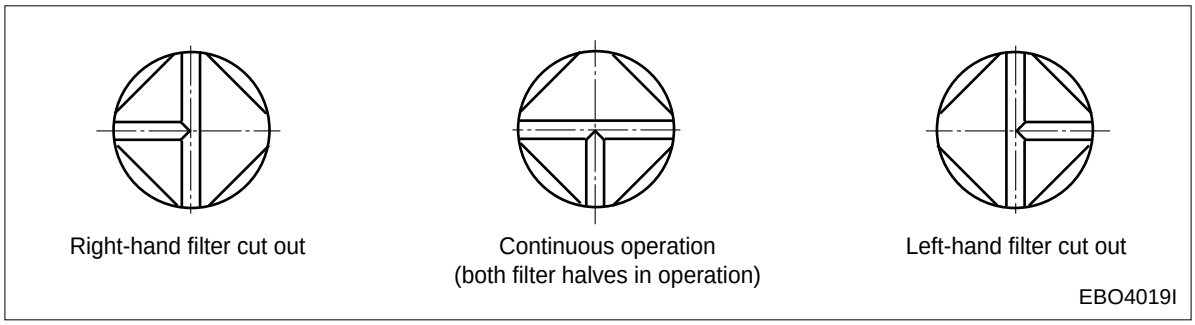


Fuel water separators that are available from DAEWOO are recommended. If another fuel water separator is to be used, it must be sized for the engine's fuel supply flow rate.

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.



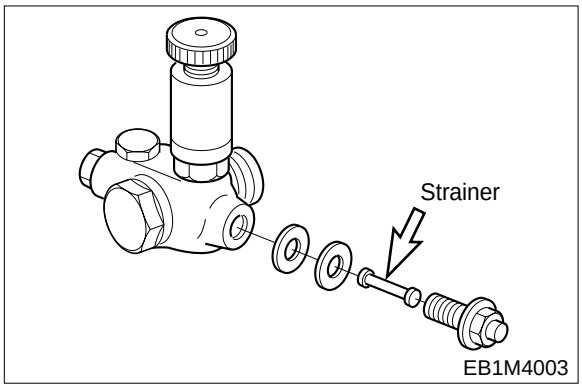


Caution : Do not leave selector lever in any intermediate position because this would be liable to interfere with oil supply.

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.



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 mm
  - Exhaust valves : 0.35 mm

4.8.1. When the engine is not used long time

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

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

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

- Drain the reduction gear oil completely and clean the strainer inserted in the inner side of it and then refill the specified oil (SAE #30) up to the maximum level of the oil dipsticks.
- Run the engine on idle rpm for 5 minutes and then shift the control lever of the reduction gear Neutral to Forward, Neutral to Reverse position in turn to circulate the oil around the all lines of it.
- Put the engine throttle lever on idle position then reduction gear and FPTO lever on switch off position (Neutral & OFF).
- Drain the engine coolant completely and remove the drain plugs.
- Close the kingston valve of the sea water line tightly, Specially likely to freeze, drain the water of the heat exchanger, inter cooler, reduction gear oil cooler and keep the plugs opened. At last don't forget to detach the sea water pump impeller and preserve it a dark place.
- First of all detach the battery wire (-) and then the other wires and clean the wires. If the battery is refilled with the distilled water, refill it but DAEWOO 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 DAEWOO dealer for service of the engine at once.
Repair man disassembles all parts of the engine and remove the salty moisture of each disassembled component then apply oil to the parts at once.
At last check whether the components of the engine is dried and eroded away or damaged especially components of the fuel system. This action must be finished quickly without delay time or maybe results engine fatal damage from salty corrosion. Be sure to install the auto bilge pump in the bottom of the boat to keep the water level below the flywheel housing and to prevent overflowing with water.

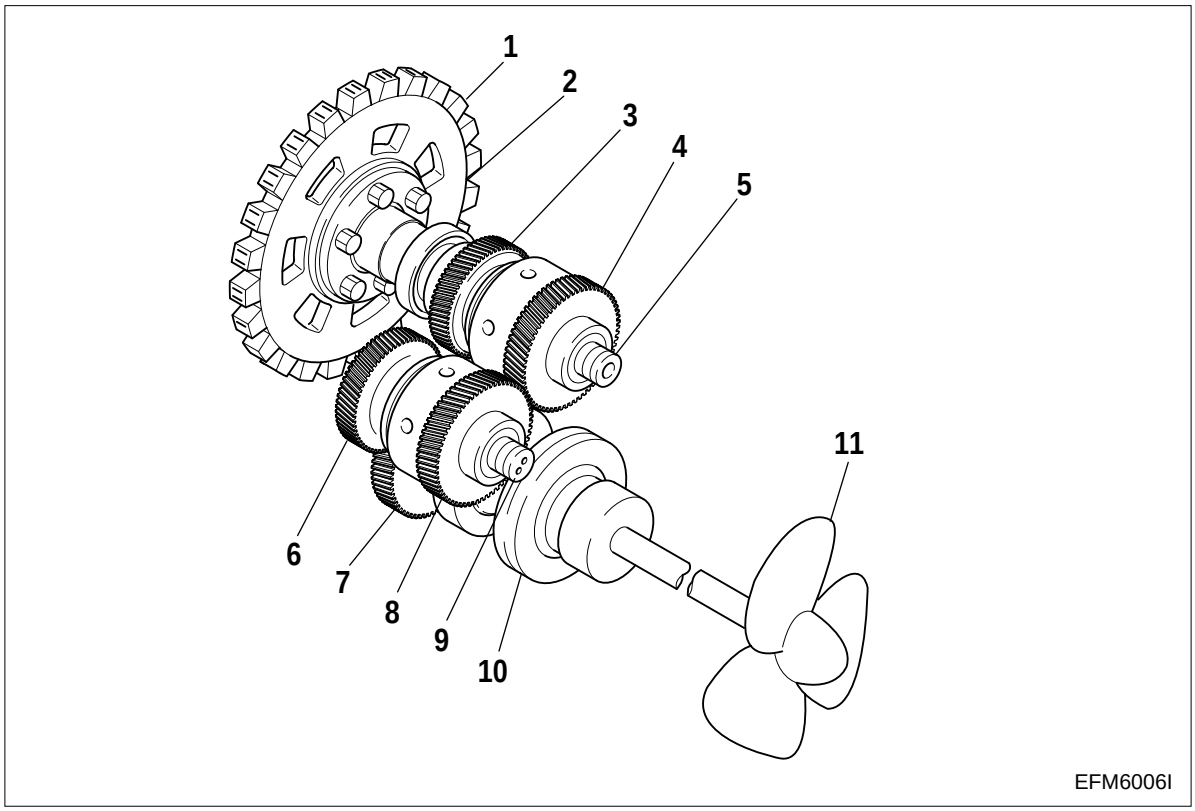
5. MAIN ACCESSORY PARTS

5.1. Reduction Gear

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

5.1.1. Construction and operation

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



<Power line>
Neutral : 1-2-5-4-8
Forward : 1-2-5-3-7-10
Reverse : 1-2-5-4-8-9-6-7-10

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

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

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

5.1.2. Operation

1) Before operation

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

2) Starting

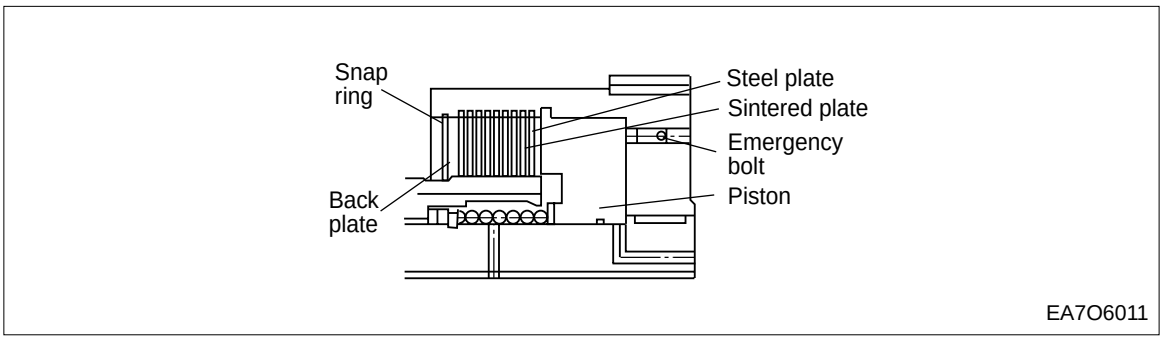
- Run the engine at idle for about 10 minutes.
- Check for oil leaks, unusual sound, temperature, etc. while idling the engine.
- While checking the clutch pressure, increase the engine rpm.

3) Driving and stopping

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

4) Emergency bolt

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



5.2. Front Power Take Off

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

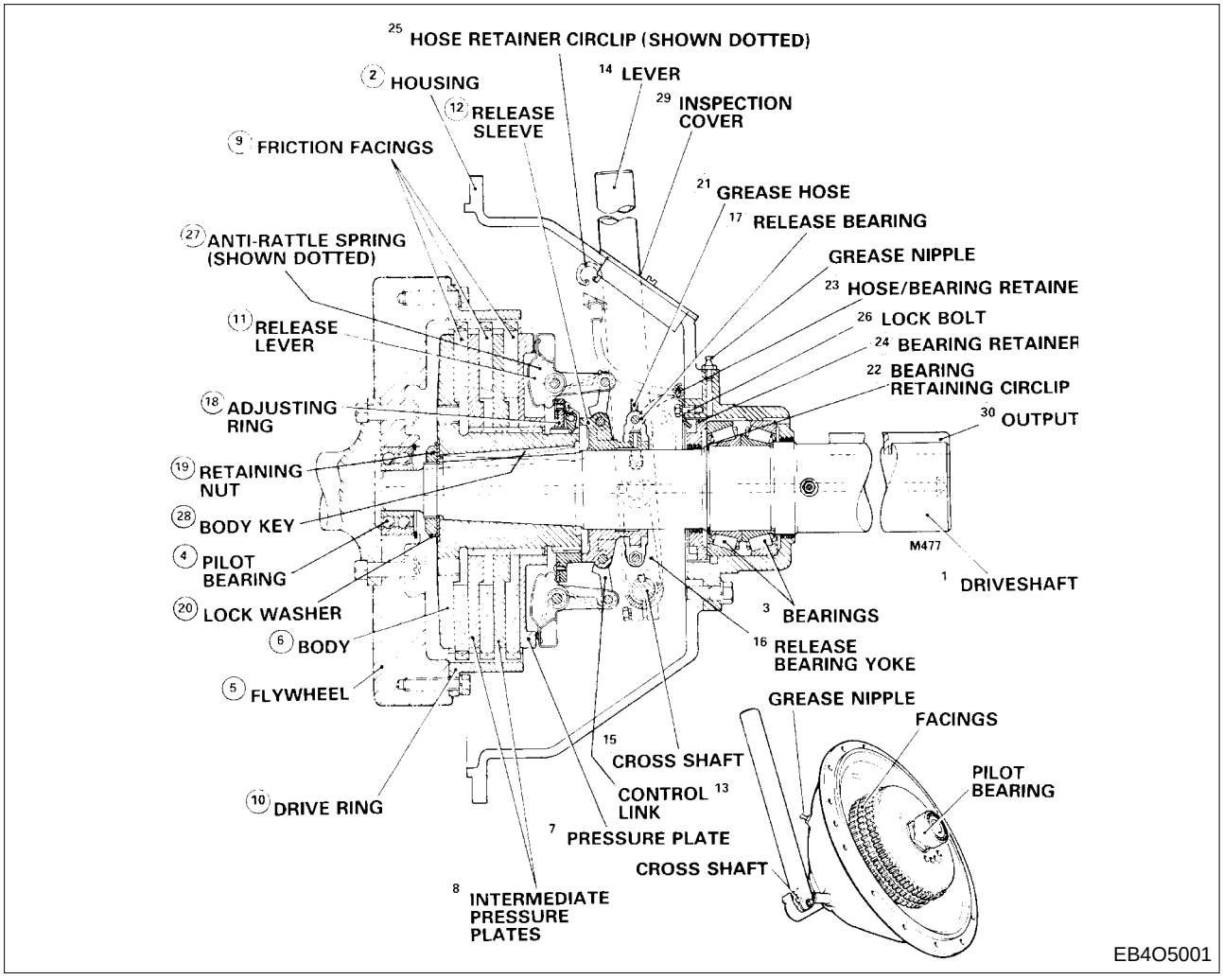
5.2.1. PTO Description and operation

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 driveshaft 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 driveshaft 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 frictionfaces 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 PperatingLever 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**

DAEWOO 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.

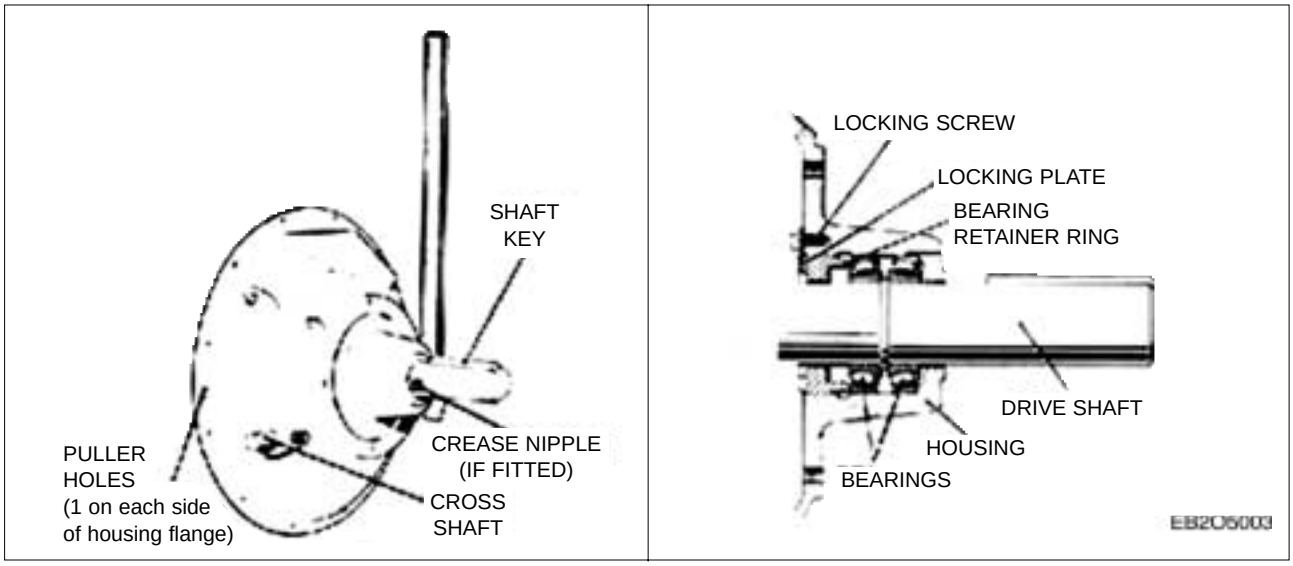
Note : After installation and during “wear in” frequent adjustment may be necessary to maintain correct overcenter loads. Failure to do this adjustment will result in excessive wear and/or burn out which in not warrantable.

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

(3) PTO adjustment

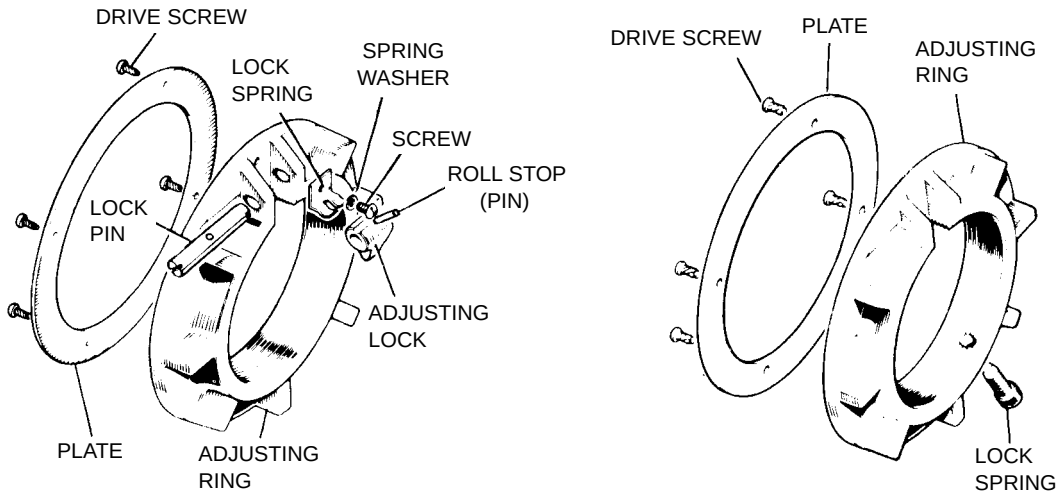
- Do not attempt to adjust PTO with the engine running.

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



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

<Adjusting rings>



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

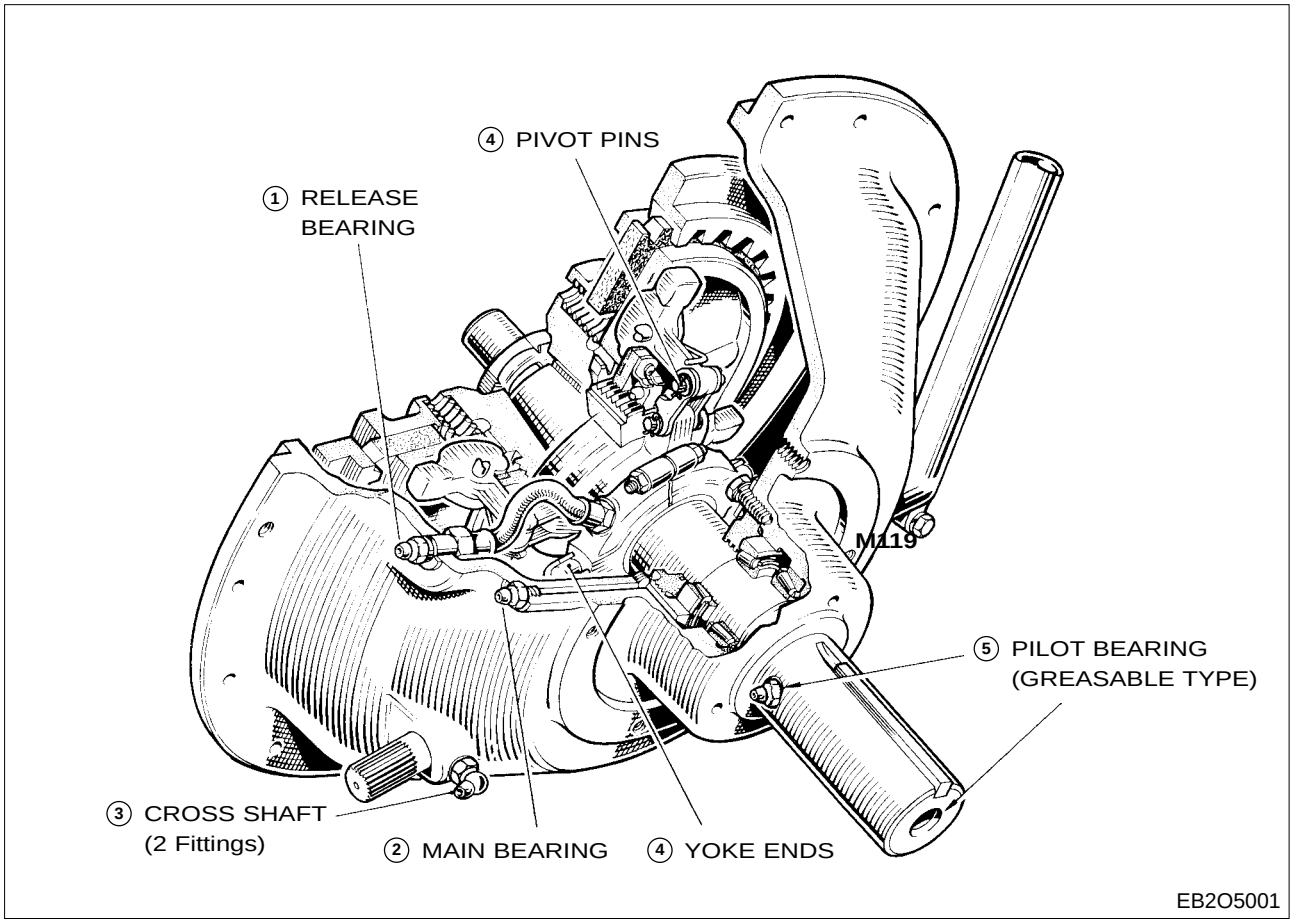
(4) Facing Check

- 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 requier frequent adjustment until the facings are fully bedded in.

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

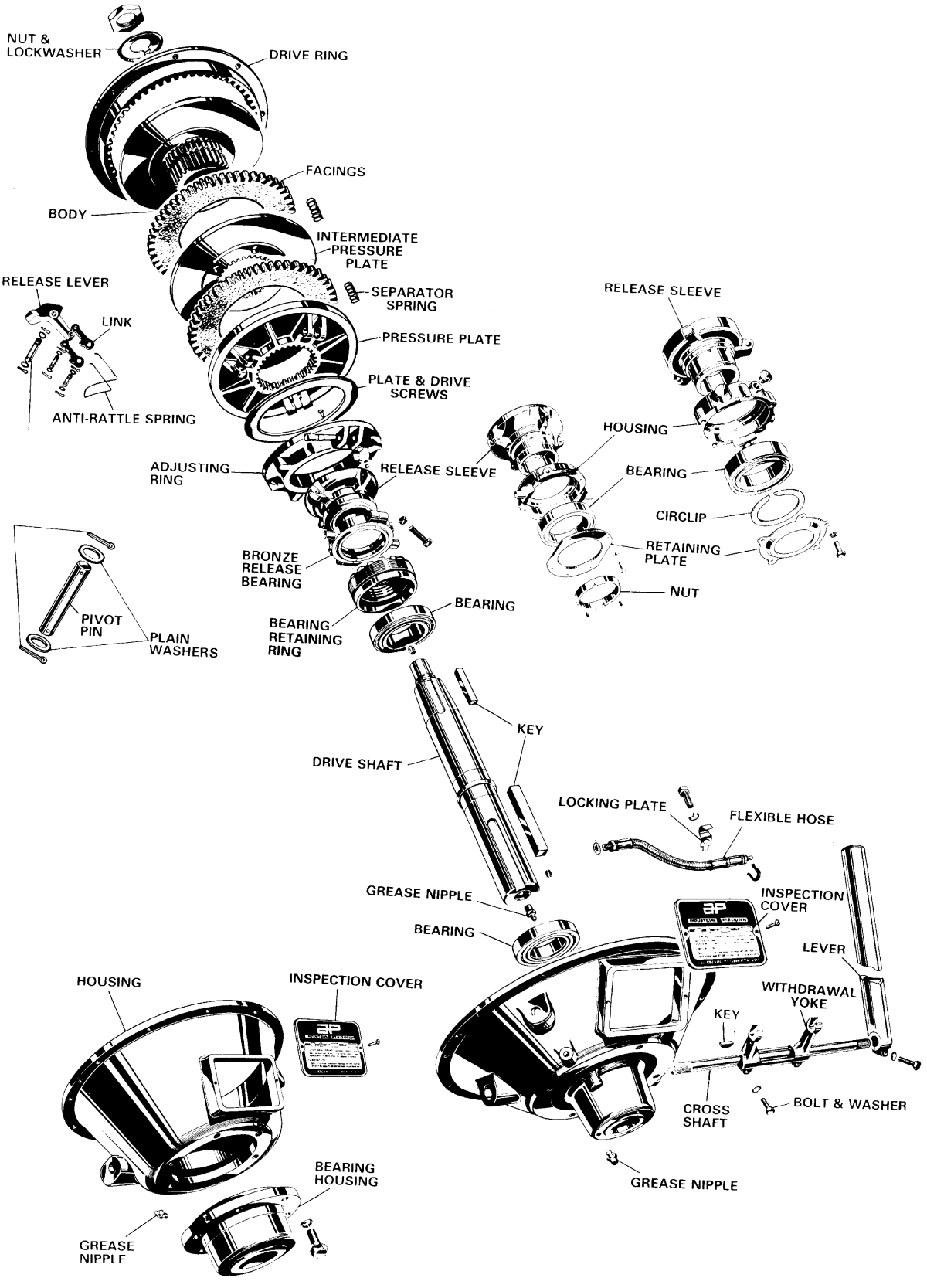
(5) Lubrication point

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



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

5.2.3. Exploded View of Typical 11-1/2” ~ 14” Twin Clutch

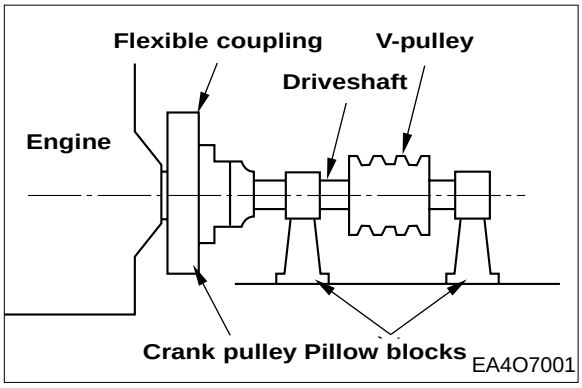


5.2.4. Front Power Take-Off (F.P.T.O)

1) For medium power

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

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

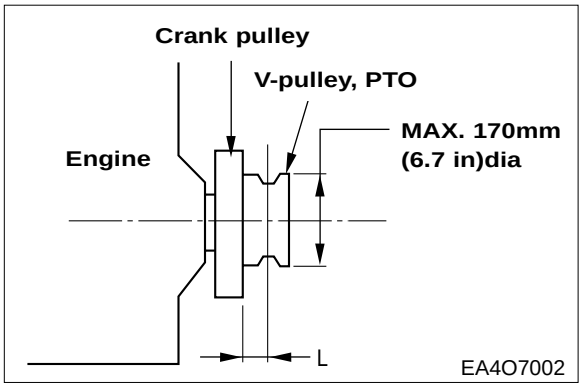


Be sure to limit the front PTO output within the maximum allowable horsepower as specified for each model in figure below. (Torque represents when there is no propeller load)

Model	Load(kW)	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

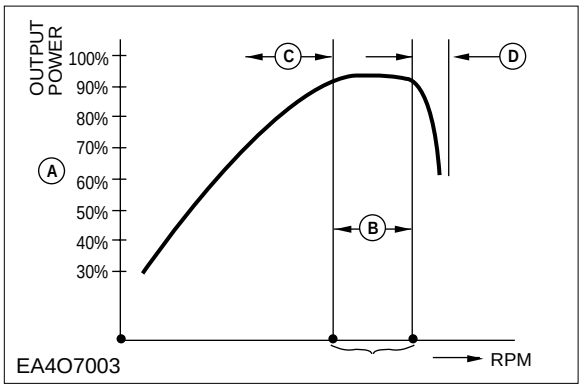
The right figure is applicable to the drive arrangement in which the distance between the end face of the engine pulley and the centerline through pulley groove is not greater than 60mm. The distance is indicated as “L” in right figure.



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

5.3. Propeller Selection

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



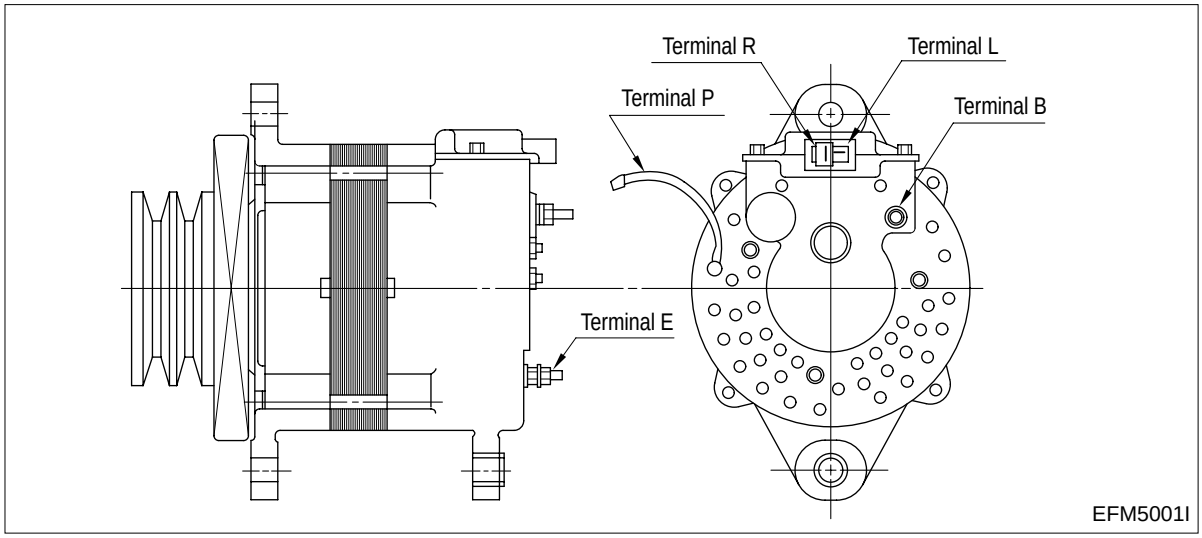
If the engine's full throttle RPM on normal load is below the specified on the low side of the range, use a propeller with less pitch to increase the RPM.
Should the engine's full throttle RPM want to exceed the specified range(B), the engine RPM is limited by the governor. Use a propeller of higher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

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

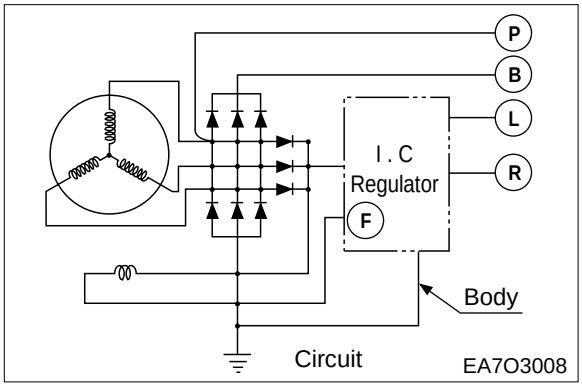
- (C) Prevents engine RPM from attaining the specified "Full Throttle Operating Range". Engine is laboring, install lower pitch propeller.
- (D) Allows engine RPM above the specified. "Full Throttle Operating Range". Engine RPM is livited by the governor, install a higher pitch propeller.

5.4. Electric System

5.4.1. Alternator



The alternator is fitted with integral silicon rectifiers. A transistorized regulator mounted on the alternator controls the alternator voltage evenly. The alternator should be operated with the regulator and battery connected in circuit to avoid the damage of the rectifier and regulator. The alternator is maintenance free, but it must be protected against dust and above all against moisture therefore it must be mounted a cover for protector properly.



(1) In case of abnormal charging

● Voltage measurement between terminal and alternator body during operation.

<Voltage during operation>

Measuring point	Voltage
Terminal B - Body	About DC28V~29V
Terminal L - Body	About DC28V~29V
Terminal R - Body	about DC28V~29V

<Voltage during stop>

Measuring point	Voltage
Terminal B - Body	about DC24V
Terminal L - Body	about DC2V
Terminal R - Body	about DC24V

※ For the confirmation of wiring state, measurement of voltage should be carried out only at each terminal during engine stop.

(2) Inspection points on the voltage regulator

<Resistance value between voltage regulator's terminals>

Terminal		Resistance Value (KΩ)
+	-	
L	E	about 2
R	E	about 53
F	E	about 50
L	B	about 50
H	L	about 50
R	B	About 168

Terminal		Resistance Value (KΩ)
+	-	
E	R	∞
L	R	∞
B	R	∞

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.

- DAEWOO 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.

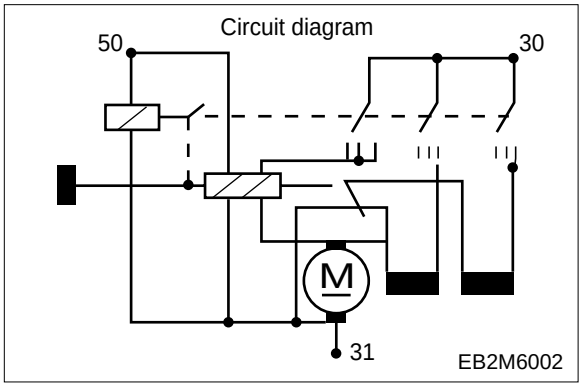
After the engine starts, the pinion automatically returns to its initial position when the starting key switch is released.

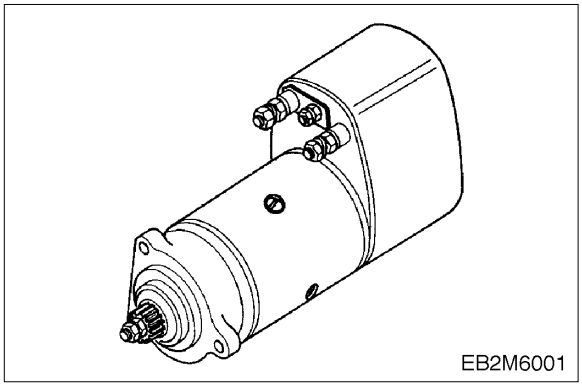
Once the engine starts, the starting key switch should be released immediately. Otherwise, the starter motor may be damaged or burned out.

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

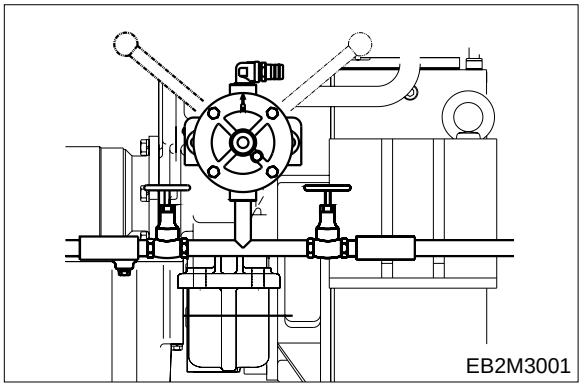
- Maintenance operation should be carried out in a bright and clean place.
- Before disassembly, provide racks for arrangement of various tools and disassembled parts.
- Arrange the disassembled parts in the disassembly sequence and use care to prevent any damage to them.

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.

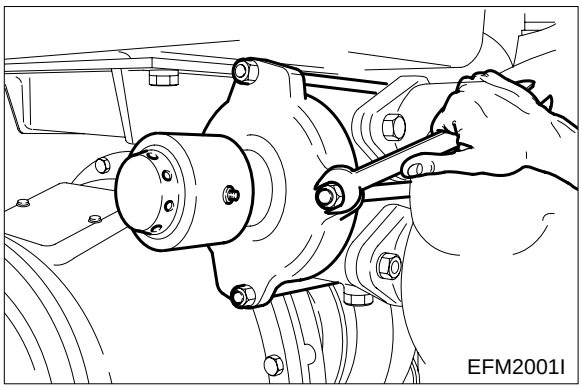
6.1.3. Engine oil

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


EB2M3001

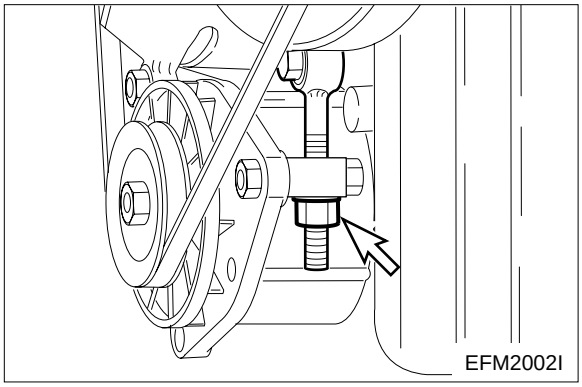
6.1.4. Sea water pump

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


EFM2001I

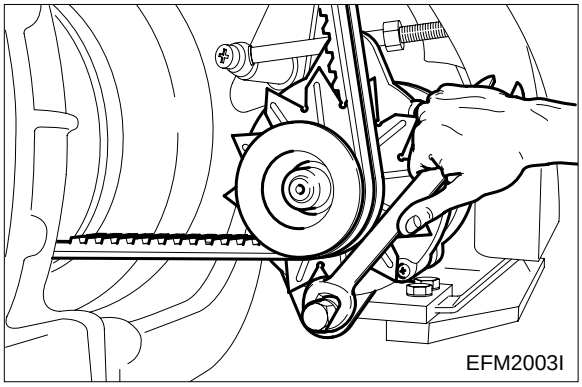
6.1.5. V-belt.

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



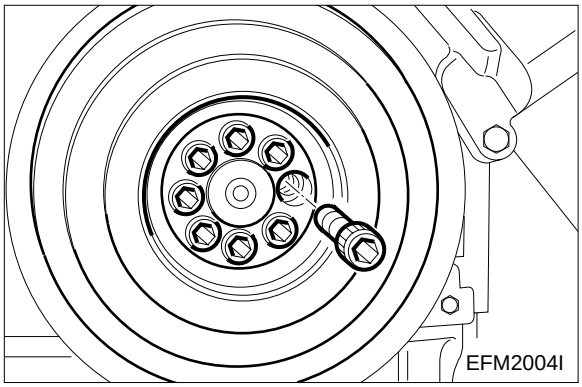
6.1.6. Alternator

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



6.1.7. Vibration damper

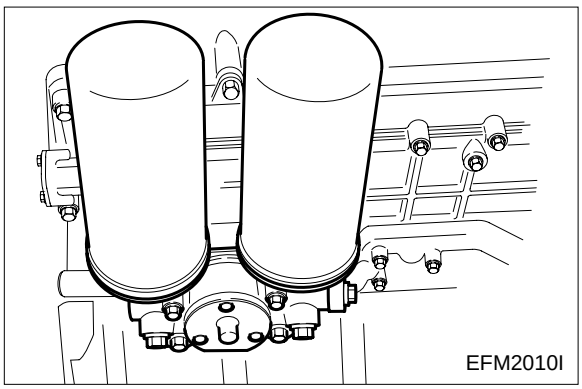
Remove the fixing bolts for crankshaft pulley in reverse order of assembly and disassemble the crankshaft pulley and vibration damper.



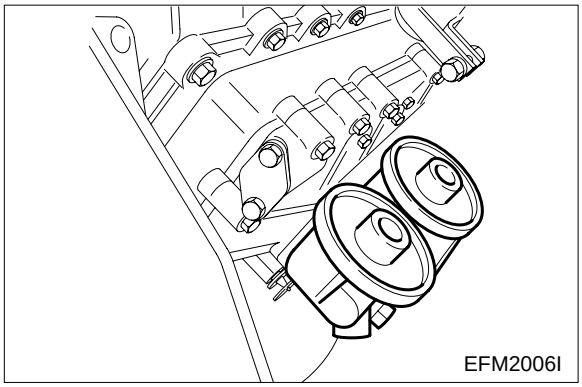
6.1.8. Oil filter assembly

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.

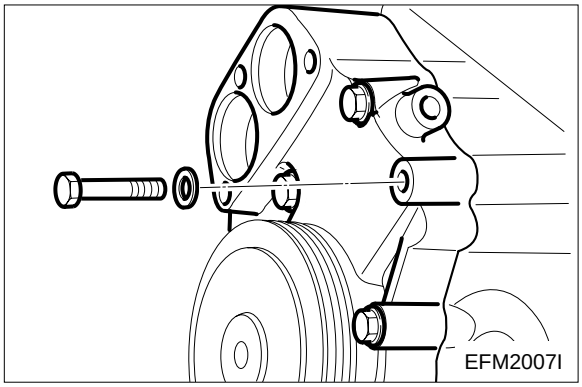


- Do not use again the cartridge removed after use.
- Remove the oil filter head fixing bolts and disassemble the filter head.


EFM2006I

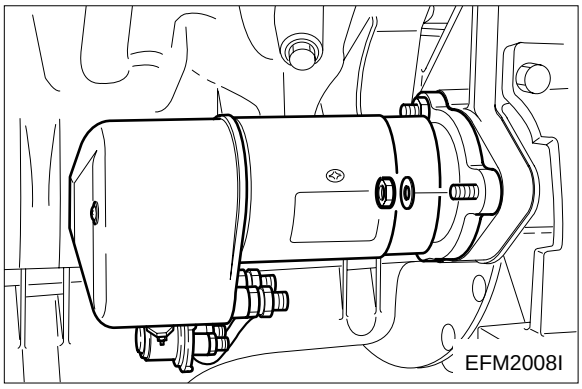
6.1.9. Cooling water pump

- 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.


EFM2007I

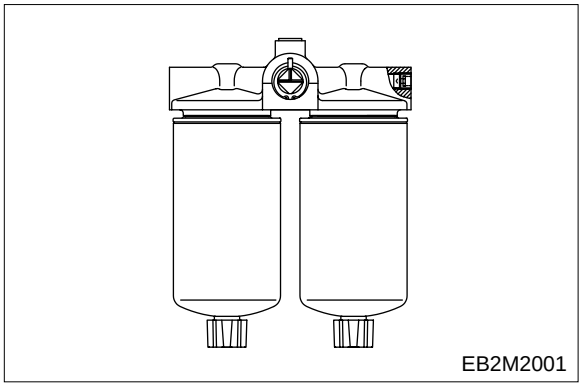
6.1.10. Starting motor

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


EFM2008I

6.1.11. Fuel filter

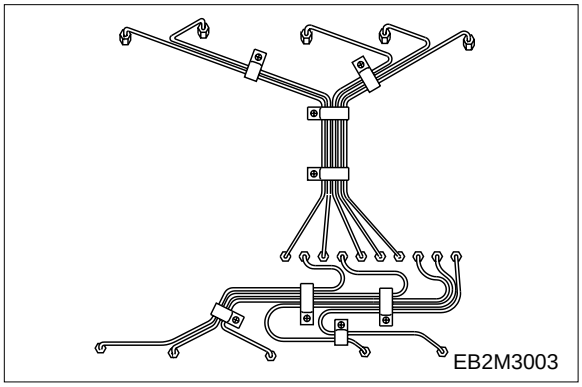
This filter is change-over type, that is the servicing procedure is for the filter side requiring to be shut off while the engine is running.
During continuous operation, the selector lever should be placed in a position where both filter halves are in operation.


EB2M2001

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

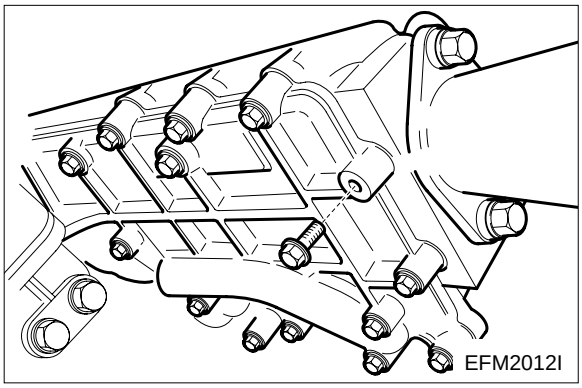
6.1.12. Injection pipe

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

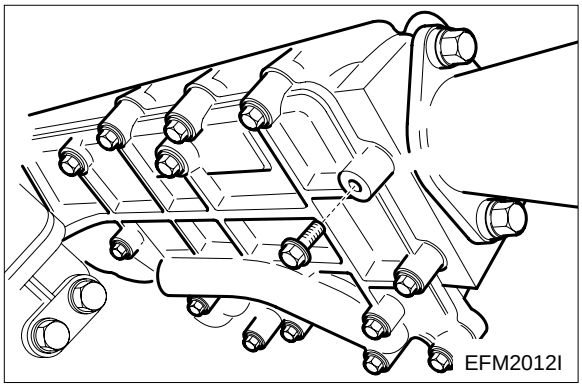


6.1.13. Oil cooler assembly

- 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.

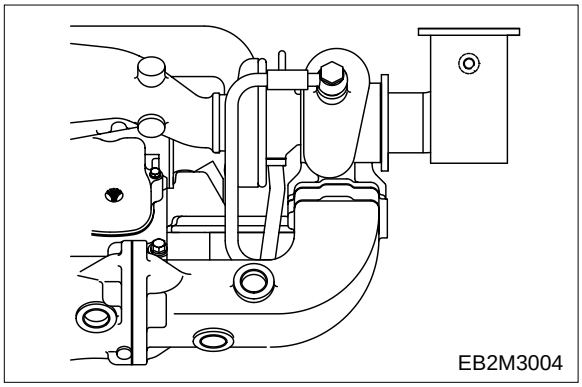


- Remove the oil cooler cover fixing bolts and disassemble the oil cooler.



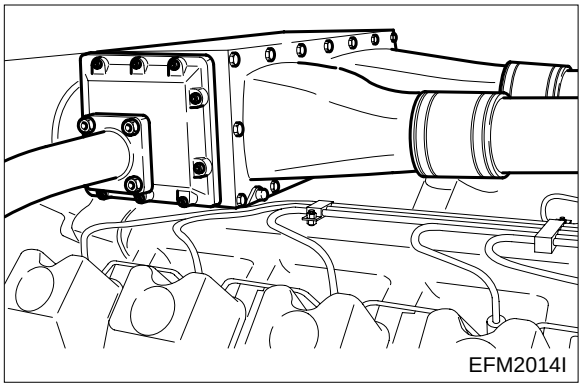
6.1.14. Turbocharger

- 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.


EB2M3004

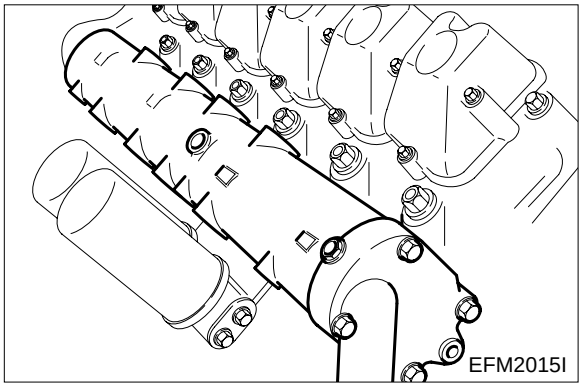
6.1.15. Inter-cooler

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


EFM2014I

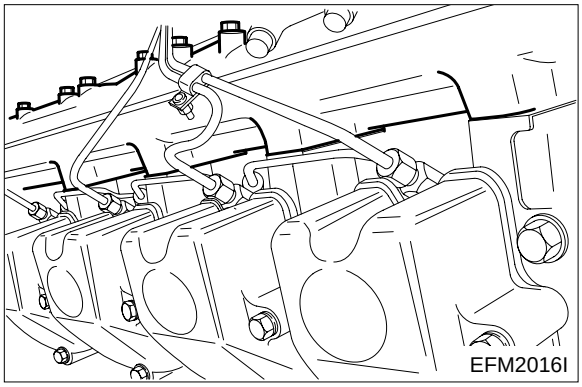
6.1.16. Exhaust manifold

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


EFM2015I

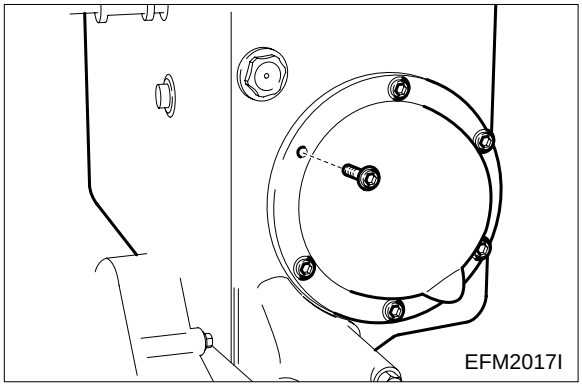
6.1.17. Intake manifold

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



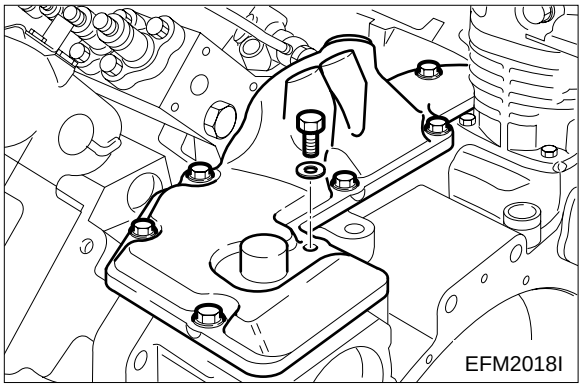
6.1.18 Heat exchanger

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



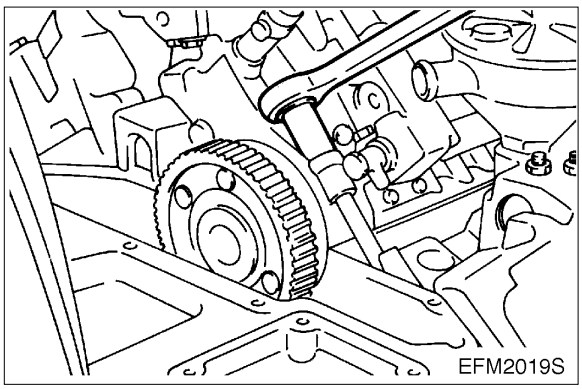
6.1.19. Flywheel housing cover

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



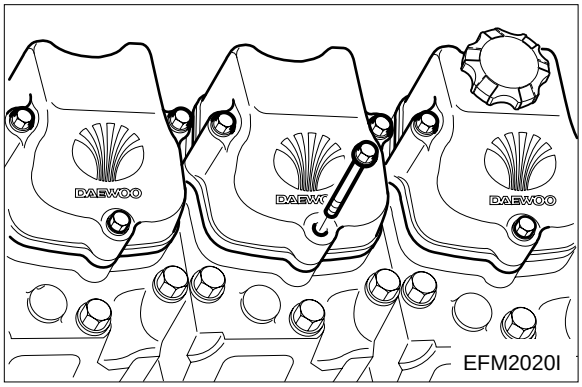
6.1.20. Fuel injection pump

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



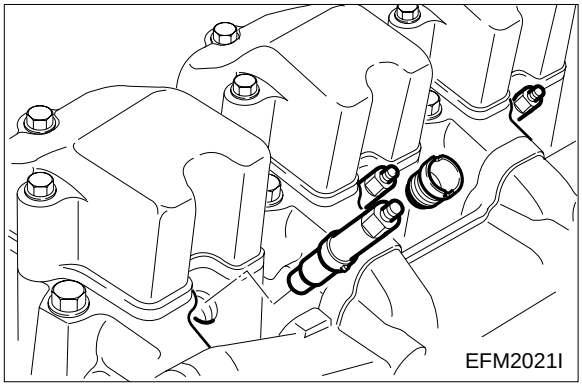
6.1.21. Cylinder head cover

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



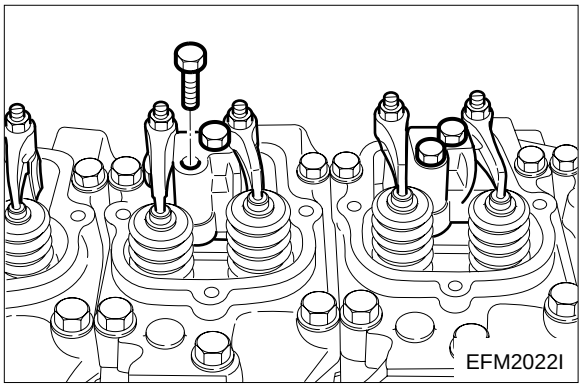
6.1.22. Nozzle holder

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



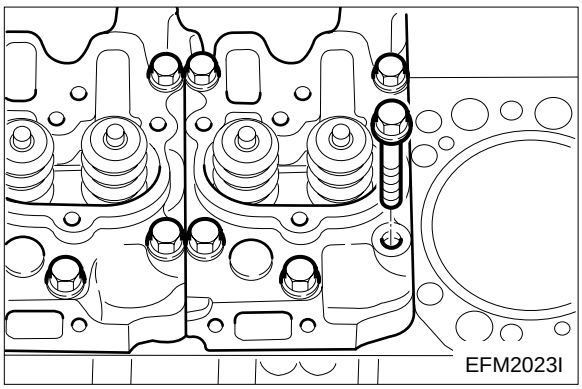
6.1.23. Rocker arm

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



6.1.24. Cylinder head

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

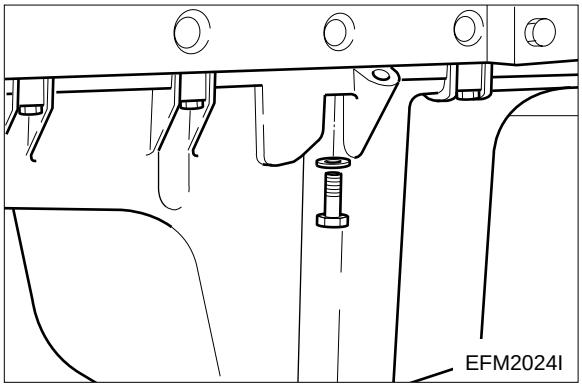


Notes :

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

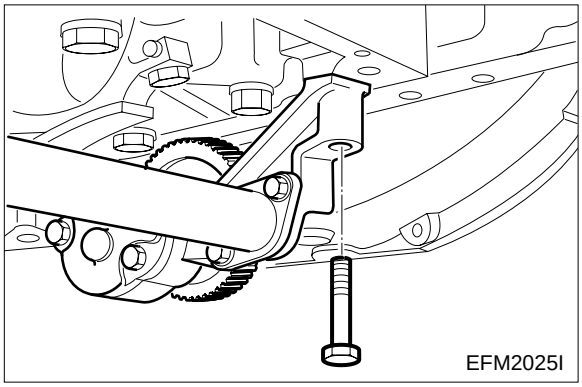
6.1.25. Oil pan

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



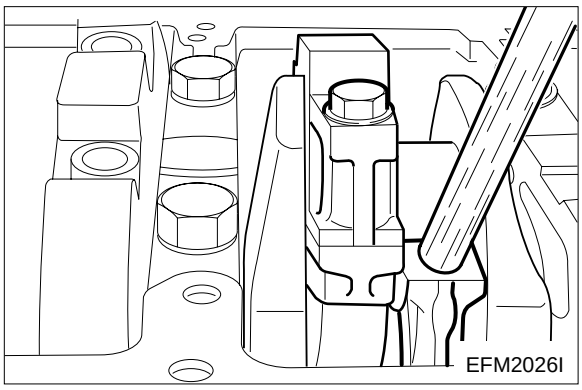
6.1.26. Oil pump

- 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.



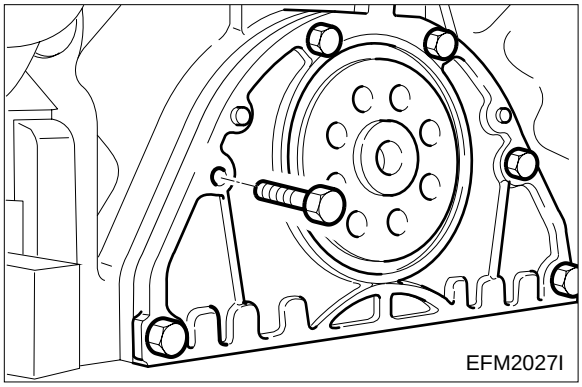
Notes :

Be careful of the removed pistons not to collide each other or with the other parts.

At the storage of pistons, maintain them in the order of cylinder number. (In order for connecting rod caps not to mix one another, temporarily assemble them to the corresponding connecting rods.)

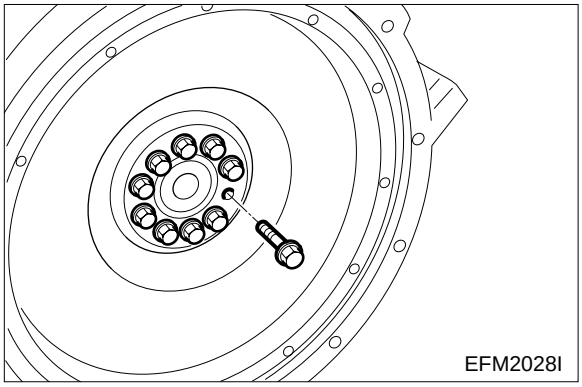
6.1.28. Front oil seal holder

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


EFM2027I

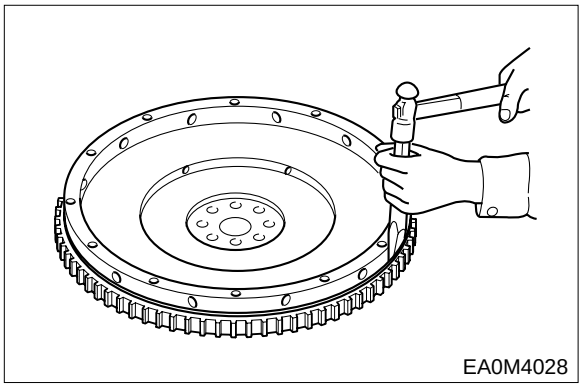
6.1.29. Flywheel

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


EFM2028I

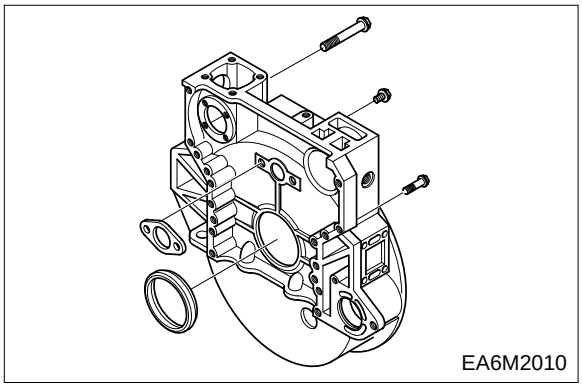
- Remove the flywheel ring gear.
  - Heat the ring gear evenly with a gas burner (up to 200 ˚C) to invite volumetric expansion.
  - Tapping around the edges of the ring gear with a hammer and brass bar to remove it.

Caution :
Do not damage the flywheel.


EA0M4028

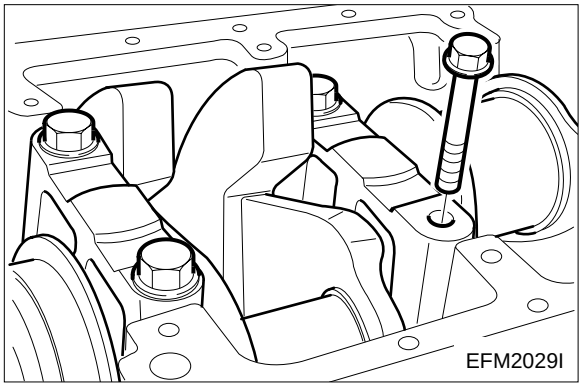
6.1.30. Flywheel housing

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


EA6M2010

6.1.31. Crankshaft

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


EFM2029I

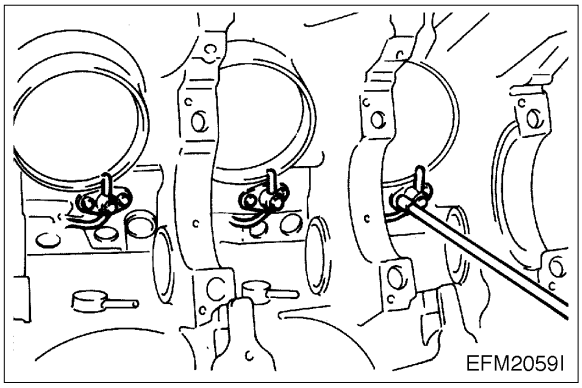
Notes :
Do not mingle with the metal bearings and bearing caps randomly. To prevent mixing, temporarily assemble the metal bearings to the corresponding bearing caps in turn.

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.

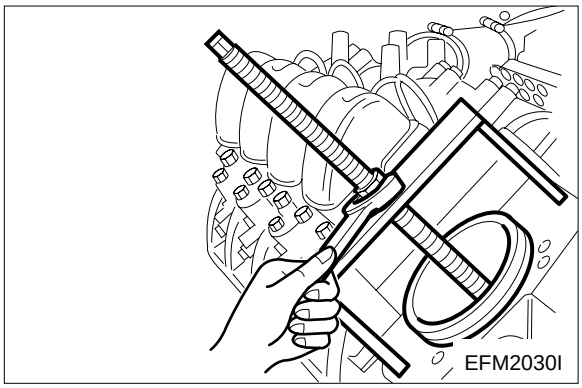
6.1.33. Oil spray nozzle

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


EFM2059I

6.1.34. Cylinder liner

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


EFM2030I

6.2. Inspection

6.2.1. Cylinder block

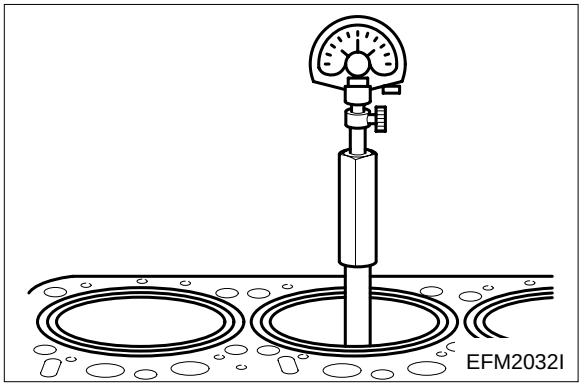
1) Clean the cylinder block thoroughly and check a visual inspection for cracks or damage.
2) Replace if cracked or severely damaged, and correct if slightly damaged.
3) Check the oil and water passing lines for restriction or corrosion.
4) Inspect the cylinder block's camshaft bush to any damage and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

Hydraulic test :

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

6.2.2. Cylinder liner measurement

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



Liner inner dia.	Standard	Limit
	∅127.990 ~ ∅128.010 mm	∅128.16 mm

6.2.3. Cylinder head

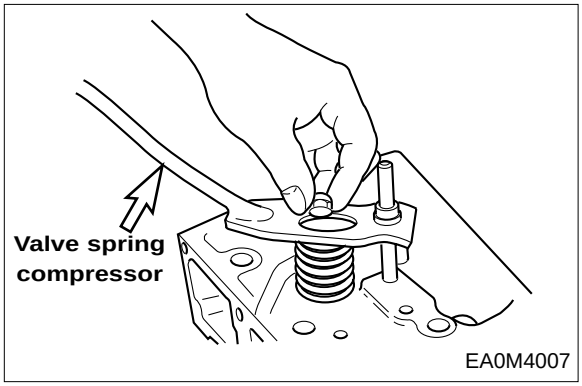
- Carefully remove carbon from the lower face of the cylinder head using nonmetallic material to prevent scratching of the valve seat faces.
- Check the entire cylinder head for very fine cracks or damage invisible to ordinary sight using a hydraulic tester or a magnetic flaw detector.

(1) Cylinder head disassembly

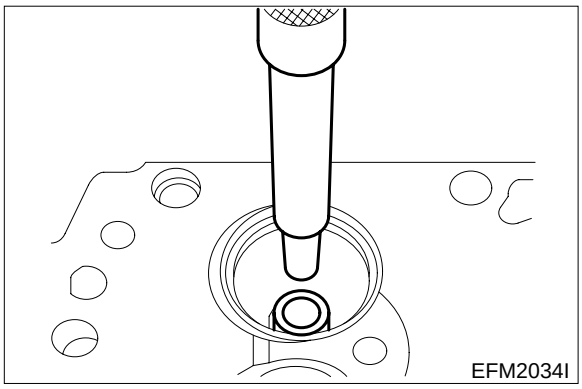
Notes :

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

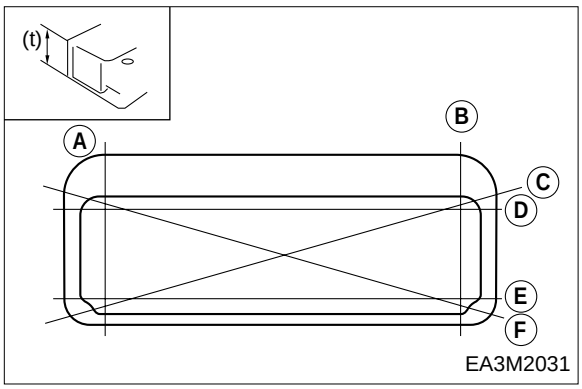
Inspection of cracks and damage

- 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

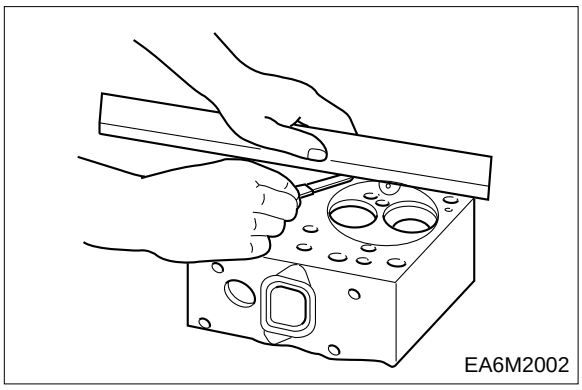
- Measure the amount of distortion using a straight edge and a feeler gauge at six positions as shown in the right figure.
- If the measured value exceeds the standard value, retrace the head with grinding paper of fine grain size to correct such defects.



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

<Lower face warp and height>

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

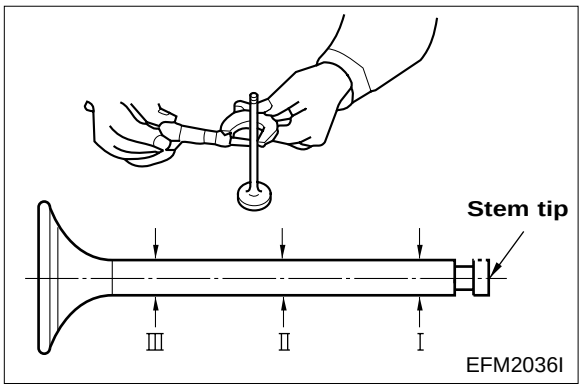

EA6M2002

(3) Inspection and measurement of valve & valve guide

a) Valve

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

Valve	Standard	Limit
Intake	ø 11.969 ~ ø 11.980 mm	ø 12.130 mm
Exhaust	ø 11.945 ~ ø 11.955 mm	ø 12.105 mm

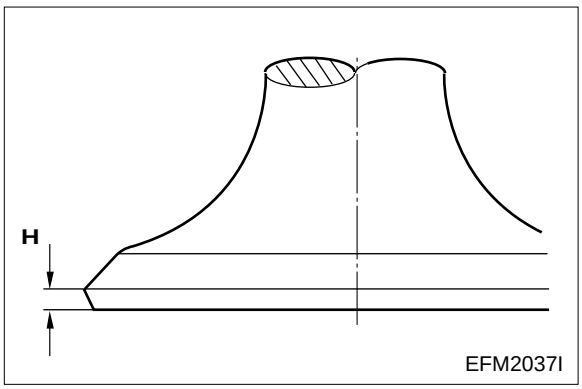


EFM2036I

● 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 (H) becomes less than 1.6mm for intake and 1.3mm for exhaust, replace the valve.

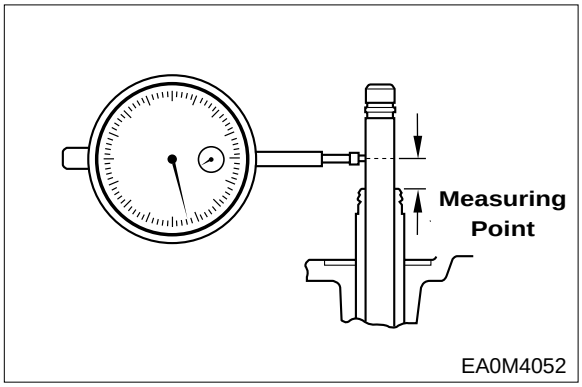
Valve	Standard	Limit
Intake	2.6 ~ 3.0 mm	1.6 mm
Exhaust	1.9 ~ 2.3 mm	1.3 mm



EFM2037I

b) 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. (Simultaneously be processed when in guide reamer process.)

Valve	Standard	Limit
Intake	0.020 ~ 0.049 mm	0.20 mm
Exhaust	0.045 ~ 0.074 mm	0.25 mm

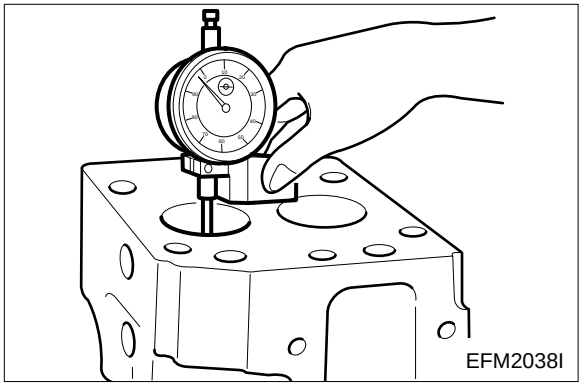
- After inserting the valves in the valve guide of the cylinder head using a special tool, measure whether the concentric circles between the valve guide and seat is aligned.

c) Valve seat

- Inspect the damage and wear of valve seat and if necessary replace.

- **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 value is more than the use limit, replace the valve seat.

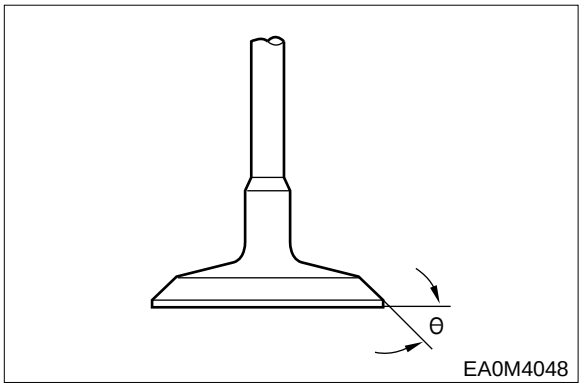


<Valve seat projection>

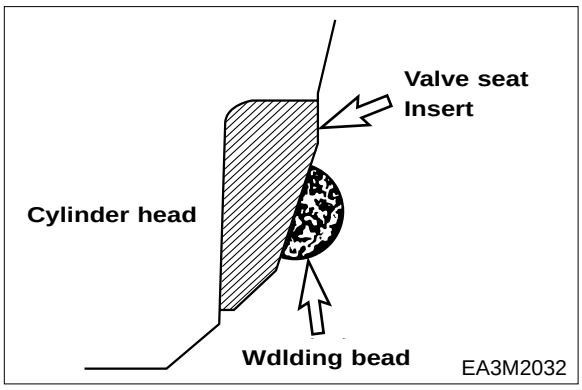
Standard	Limit
0.65 ~ 0.95 mm	2.5 mm

<Valve seat angle>

Intake Valve	30˚
Exhaust Valve	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.

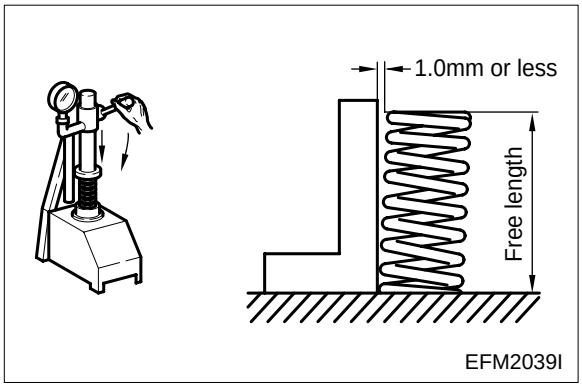
d) Valve spring

● Inspect the outlook of valve spring and if necessary replace it.

● 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.



<Tension test and Free length >

Inner Spring	Free length	65.5 mm
	When given a regular load (15 ~ 17 kg)	46.3 mm
Outer Spring	Free length	64 mm
	When given a regular load (37 ~ 41 kg)	46.3 mm

e) Assembling cylinder head

● Clean the cylinder head thoroughly.

● Coat the valve stems and valve guides with engine oil and assemble the valves.

● Replace the valve stem seals with new ones and insert the stem seals to the valve guides of cylinder head using a special tool.
(Be careful for the valve stem seals not to be damaged.)

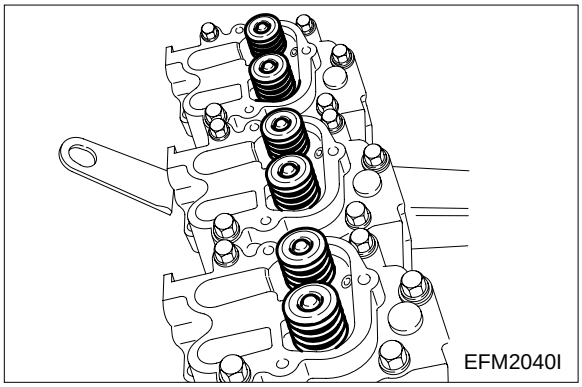
● Install the valve spring washer to valve guide.

● After putting on the inside, outside spring, install the valve spring seat on them.

NOTE :

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

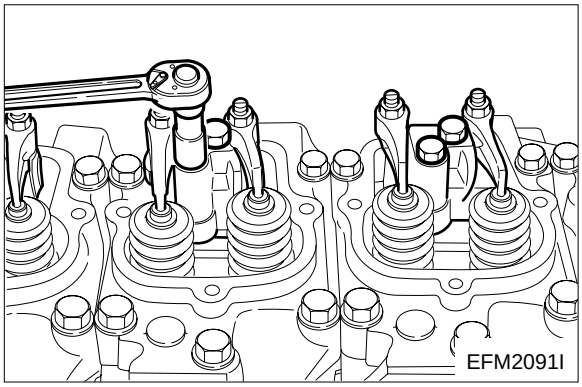
- Pressing the spring down using a special tool, assemble by inserting the valve cotter.
- After the valve is assembled, inspect the valve tapping it lightly with a urethane hammer if accurate assembly was done.


EFM2040I

6.2.4. Rocker arm

(1) Rocker arm disassembling

- 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.

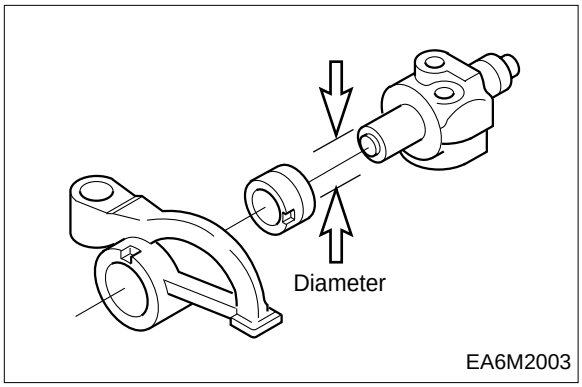

EFM2091I

(4) 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.



EA6M2003

Items	Standard	Limit
Bush Inner Dia.	∅ 25.005 ~ ∅ 25.035 mm	∅ 25.055 mm
Shaft outer Dia.	∅ 24.967 ~ ∅ 24.990 mm	∅ 24.837 mm
Clearance	0.015 ~ 0.068 mm	0.25 mm

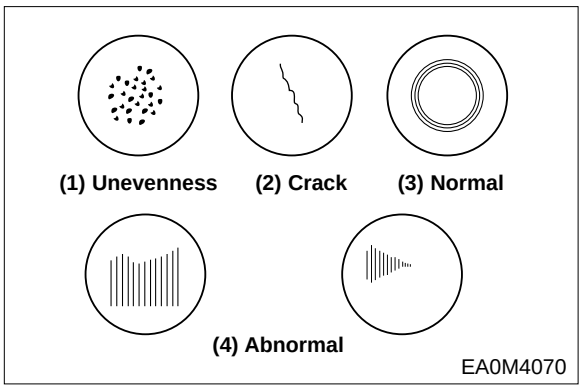
b) Rocker arm

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.

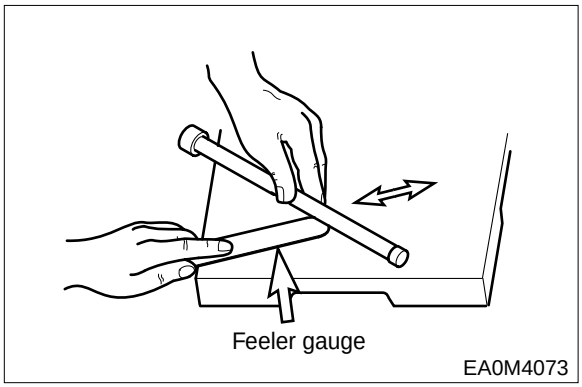
c) Tappet and push rod

- 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	0.25 mm



- By inspecting the tappet surface that contacts with the camshaft's cam for any crack and scratch etc., and if the degree is small, correct them with an oil stone or the grinding paper but if severe replace them.



- Place the push rod on the surface plate and rolling it, Inspect the curving degree with a clearance gauge and if abnormal, replace it.

<Run-out>

Limit	0.3 mm or less

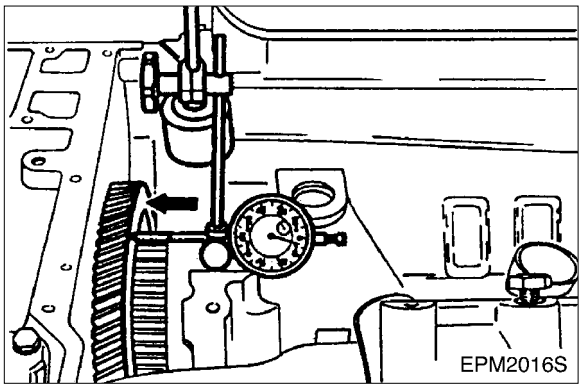
d) Rocker arm reassembling

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

6.2.5. Camshaft

(1) Axial end play

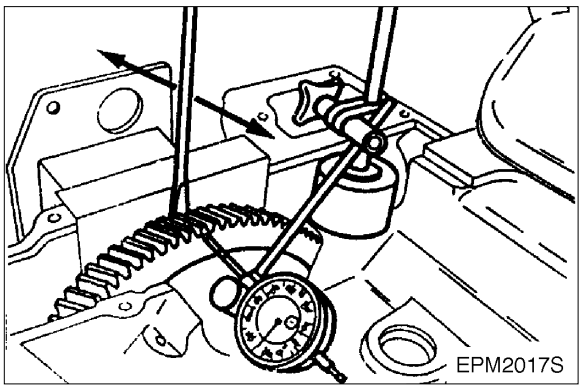
- Push the camshaft toward the pulley side.
- Place a dial gauge onto the camshaft gear.



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

Limit	0.2 ~ 0.9 mm

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



(2) Inspection and measurement

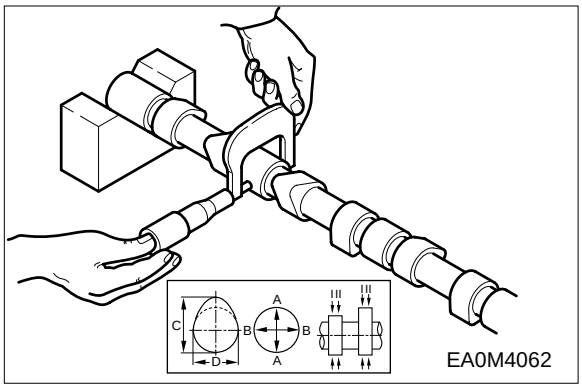
● **Visual check**

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.

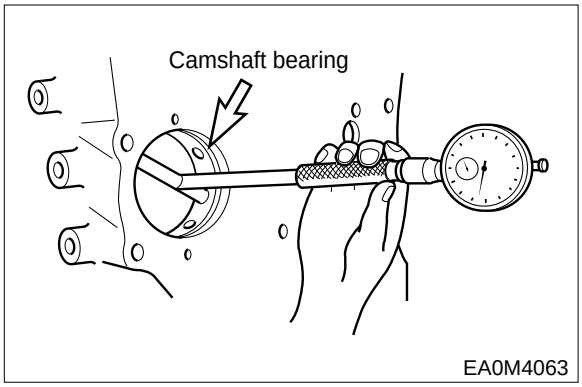
If the measured number is less than the specified limit, the camshaft must replaced.



Items		Standard	Limit
Cam lobe	Intake	56.37 mm	55.17 mm
height (C)	Exhaust	56.43 mm	55.11 mm
Cam journal diameter (A,B)		∅69.91~ 69.94 mm	-

● **Cam bearing diameter**

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



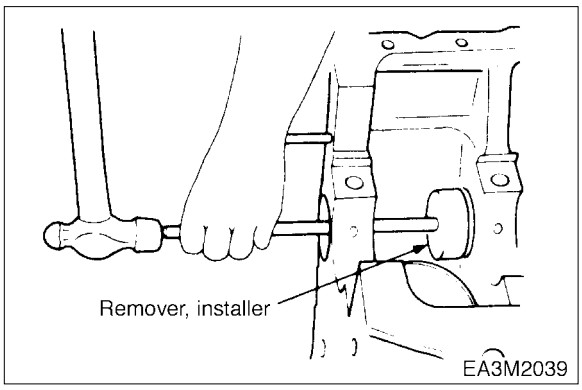
Standard	Limit
∅70.077 ~ ∅ 70.061 mm	∅69.897 mm

● **Clearance between camshaft journal and body**

Standard	Limit
0.060 ~ 0.120 mm	0.18 mm

Camshaft bearing replacement

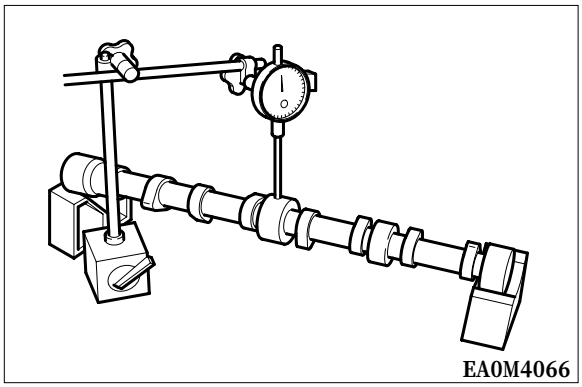
Remover, installer



Camshaft run-out

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

Limit	0.1 mm



6.2.6. Crankshaft

(1) Inspection and measurement

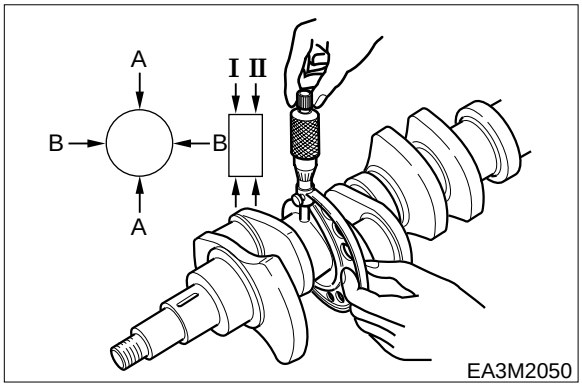
- Inspect for any scratch or damage with naked eyes, and grind to the undersize according to the damaged degree and use the undersized bearing.
- Inspect for any crack by means of magnetic powder and color check, and replace the cracked ones.

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>

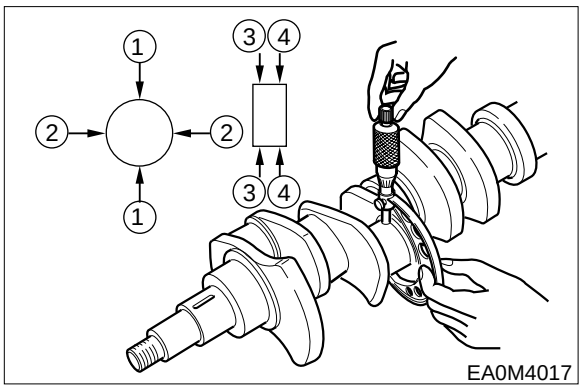
Standard	∅103.98 ~ ∅104.00 mm



<Crankshaft pin outside diameter>

Standard	∅89.98 ~ ∅90.00 mm

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



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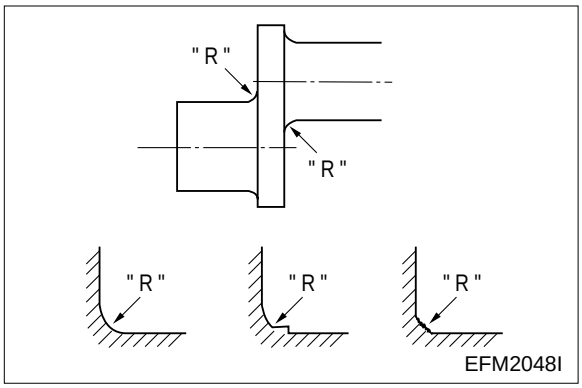
<kinds of bearings for undersize>

(a) Standard
(b) 0.25 (Inside dia. 0.25mm less than standard)
(c) 0.50 (Inside dia. 0.50mm less than standard)
(d) 0.75 (Inside dia. 0.75mm less than standard)
(e) 1.00 (Inside dia. 1.00mm less than standard)

There are 4 kinds of rounds as right figure, and the crankshaft also can be used by regrinding as above.



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<"R part" standard value>

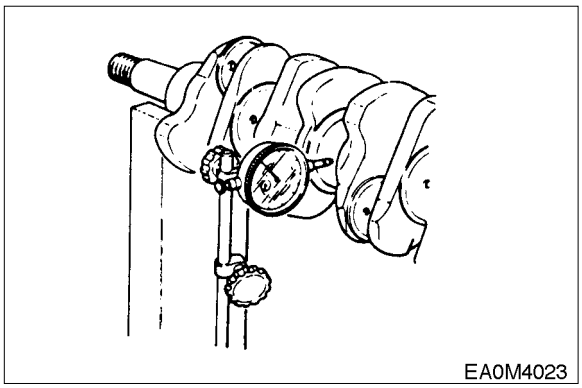
(a) Crank pin "R part" : $4.0^{0}_{-0.5}$
(b) Crank journal "R part" : $4.0^{0}_{-0.5}$

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.

Run out of crankshaft

(a) Place the crankshaft on the V-block.
(b) 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


EA0M4023

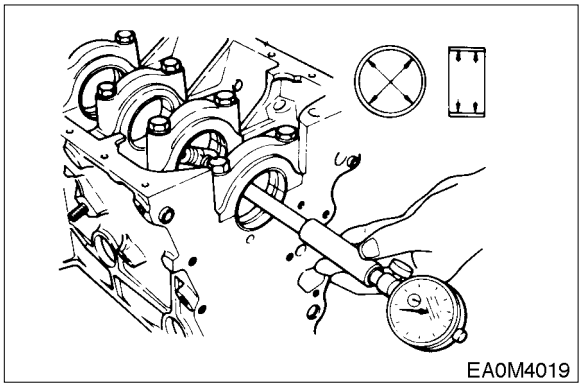
(2) Inspection on crankshaft bearing and connecting rod bearing

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

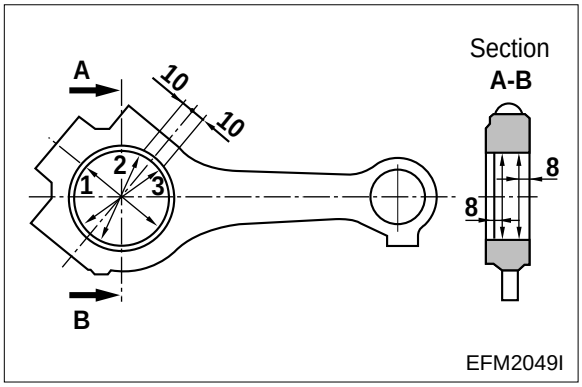
① Assemble the main bearing at the cylinder block and after tightening the bearing cap at the specified torque, measure the inside diameter.



Journal bearing nominal diameter	∅103.98 ~104.00 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.



Connecting rod bearing journal diameter	∅89.98~90.00 mm

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

③ Crankshaft pin and bearing clearance In case that this clearance value exceeds the limit value, grind the crankshaft journal and pin and then use the undersized bearing.

Standard	Limit
0.066 ~ 0.132 mm	0.166 mm

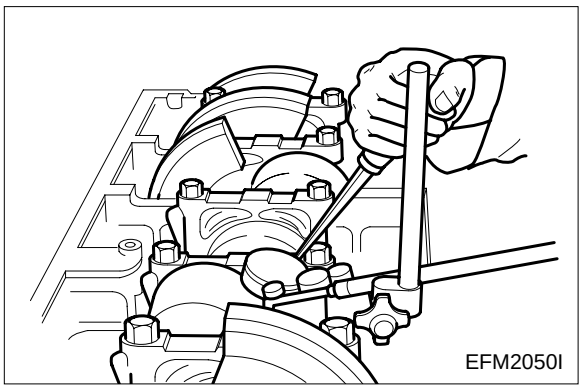
b) How to utilize plastic gauge

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.

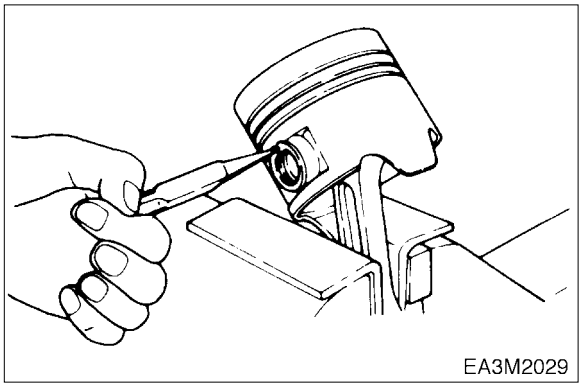


Standard	Limit
0.190 ~ 0.322 mm	0.452 mm

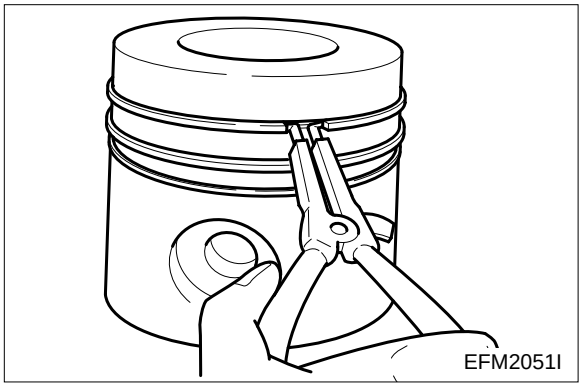
6.2.7. Piston

(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.



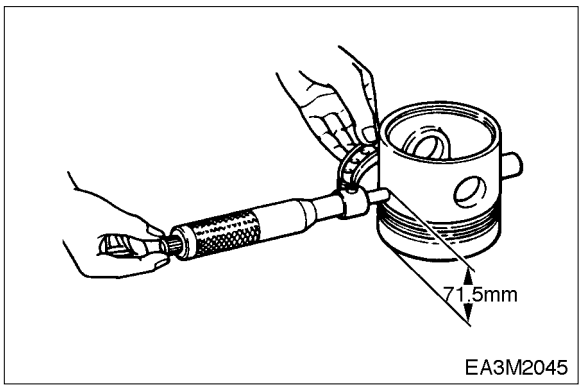
- With a pair of pliers, remove the piston rings.
- Clean the piston thoroughly.



(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.

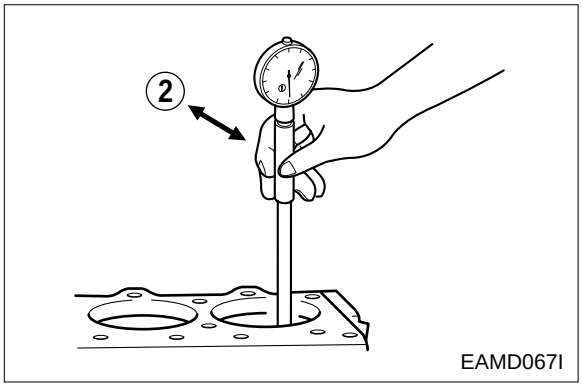
● With the outside micrometer, measure the piston's outside diameter the measuring position is 71.5mm from the piston lower end, and the direction of measurement must be perpendicular to the piston pin direction.



Standard	∅127.739 ~ ∅127.757 mm

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

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



Standard	∅127.990 ~ ∅128.010 mm

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

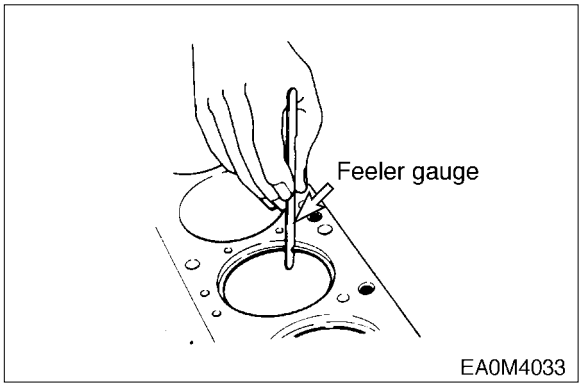
Standard	0.233 ~ 0.271 mm

(3) Piston ring & ring groove

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

Gap clearance
Measure the piston ring cut part.

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

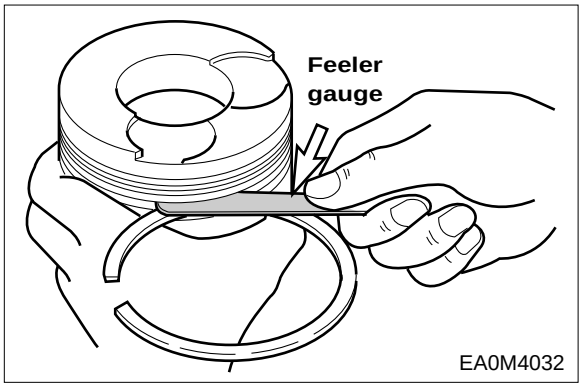


<Piston ring gap>

Division	Standard	Limit
Top ring	0.35 ~ 0.55 mm	1.5 mm
2nd ring	0.40 ~ 0.60 mm	1.5 mm
Oil ring	0.35 ~ 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.



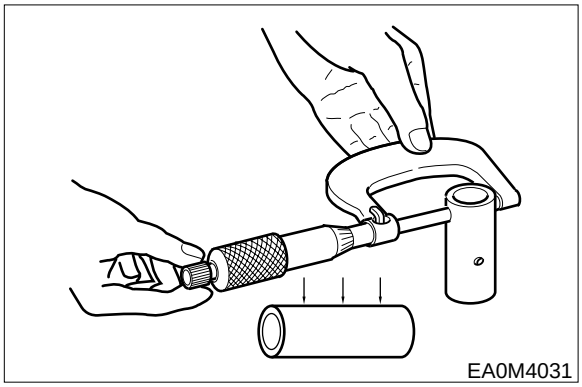
<Piston side clearance>

Division	Specified value	Limit value
Top ring	0.35 ~ 0.55 mm	0.3 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

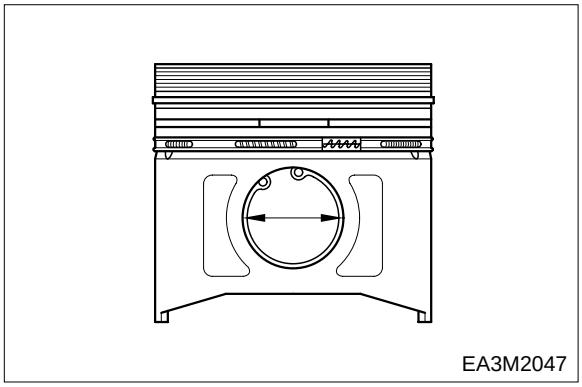
With the outside micrometer, measure the piston pin's outside diameter and if the value is same as the use limit value or less, replace it.



Standard	Limit
∅44.994 ~ ∅46.000 mm	∅44.979 mm or less

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.

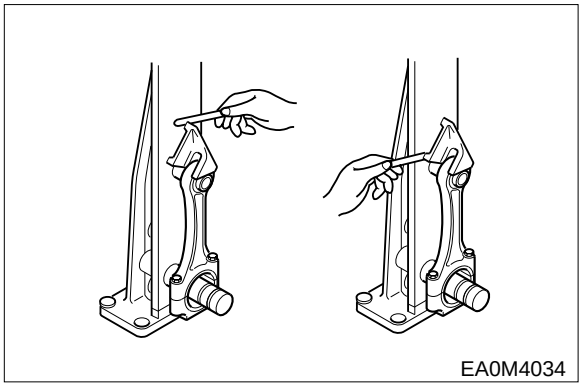


Limit	0.003 ~ 0.015 mm

(5) Connecting rod

Distortion and parallel

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



Standard	Limit
0.02 mm	0.2 mm

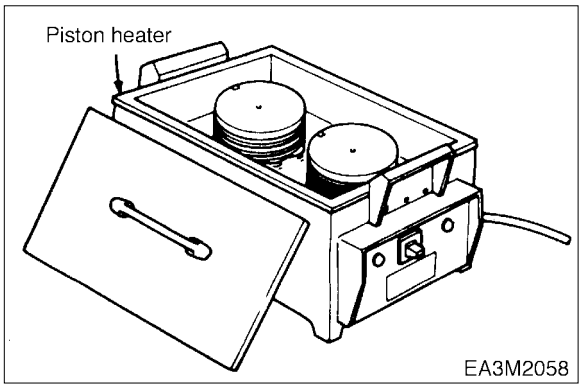
Amounts of wear

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

Standard	Limit
0.02 mm	0.2 mm

(6) Piston reassembling

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



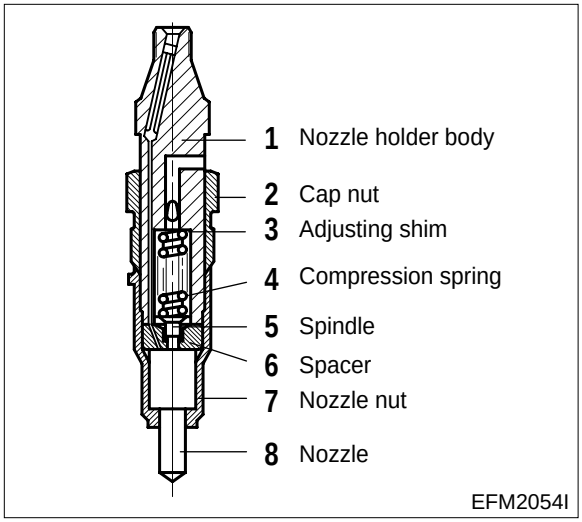
NOTE :

Confirm the direction of connecting rod and assemble.

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

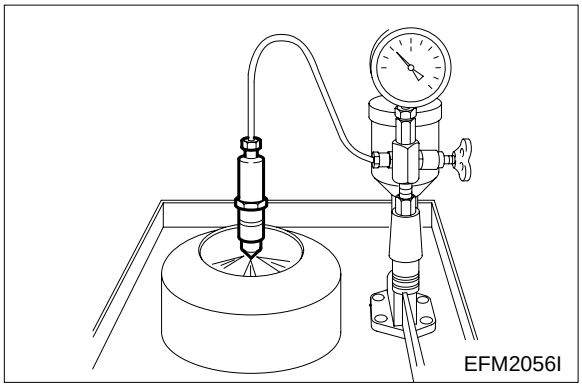
6.2.8. Injection nozzle

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

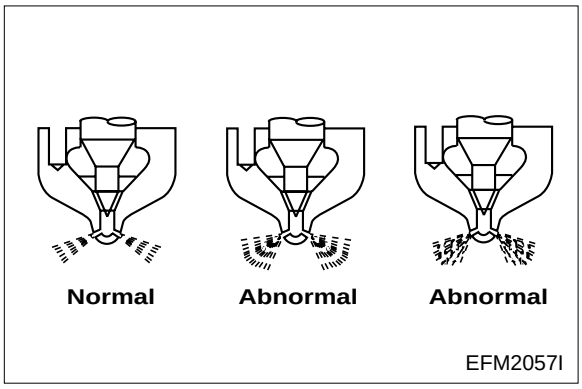


<Operating pressure>

New nozzle holder	300 + 8 kg/cm²
Used nozzle holder	285 + 8 kg/cm²



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



6.3. Engine Re-assembly

6.3.1. General Preparation

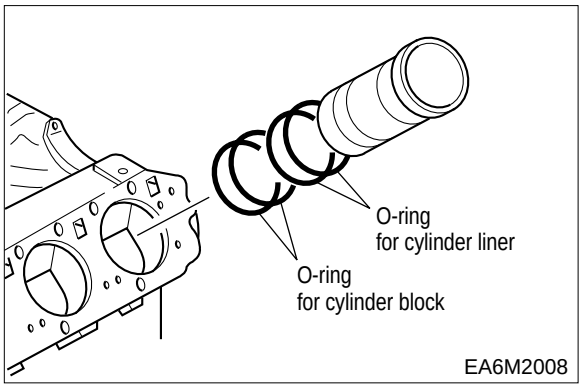
- Clean all the disassembled parts, particularly oil and water ports, using compressed air, then check that they are free from restrictions.
- Arrange the general and special tools in order for engine assembly operation.
- To wet each sliding part, prepare the clean engine oil.
- Prepare service materials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

6.3.2. Cylinder block

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

6.3.3. Cylinder liner

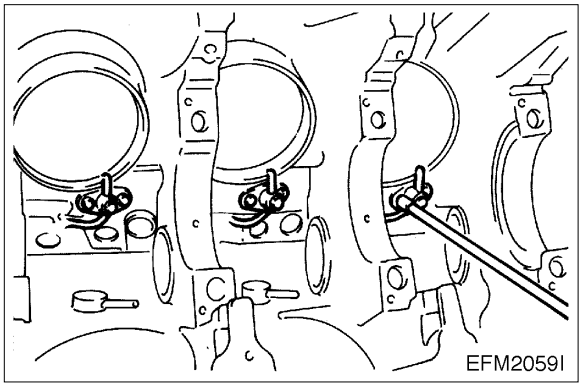
- Replace the used O-rings with new ones and insert the O-ring in the cylinder liner upper side, but the other one in the cylinder block lower side separately.
- Coat the joint parts where O-ring contacts with oil.
- After slipping the cylinder liner smoothly into the cylinder block, press it in being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



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

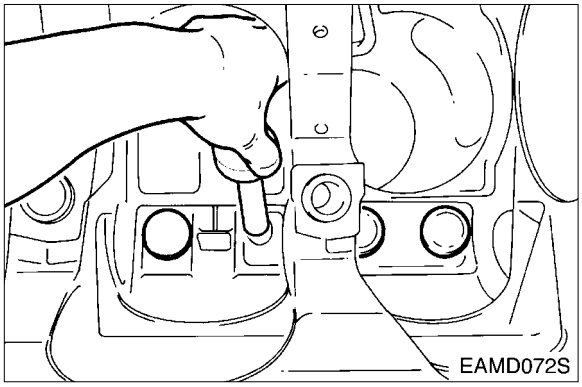
6.3.4. Oil spray nozzle

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



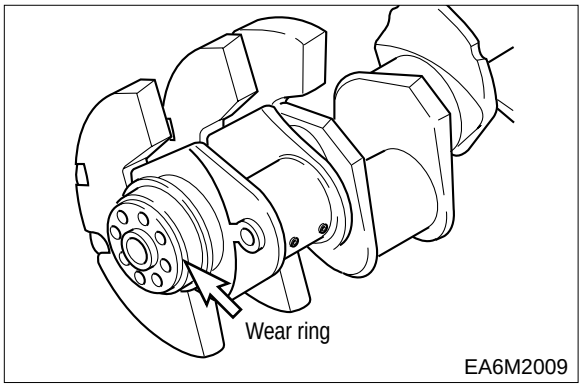
6.3.5. Tappet

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

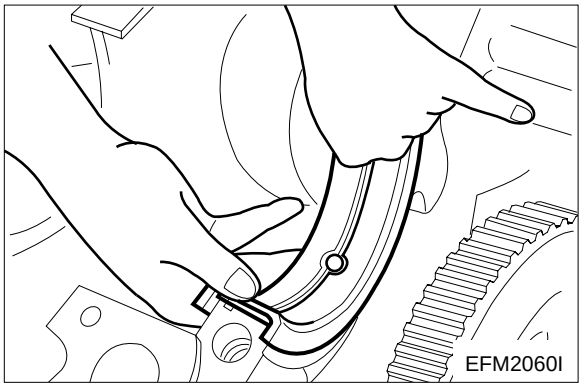


6.3.6. Crankshaft

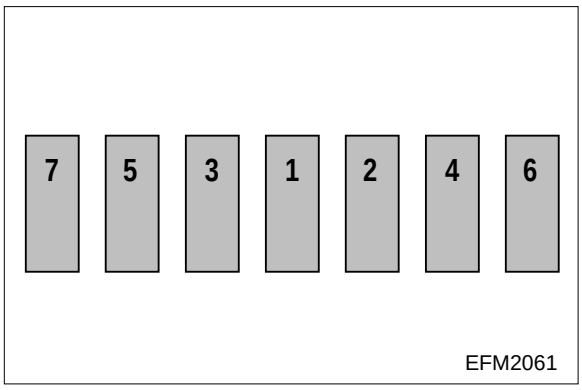
- Put the wear ring into the heater to heat it up to 150 ~ 200 ˚C level, push it over the crankshaft by means of a jig.



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



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

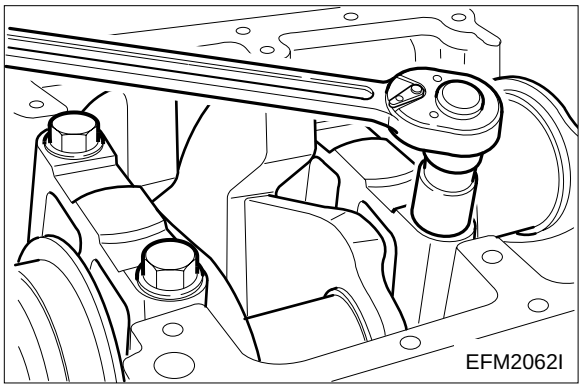


- Coat the crankshaft journal and pin parts with clean engine oil, and after fitting the main bearing into the bearing cap and assemble it to the cylinder block making sure of the number in order not to change the bearing cap.

- Coat the bearing cap bolt and its bolt seat part with engine oil necessarily and according to the tightening order, tighten them with 30 kg.m and with rotating angle method (90° $^{+10°}$) and tightening order is as follows.

<Bearing cap bolt's tightening order>

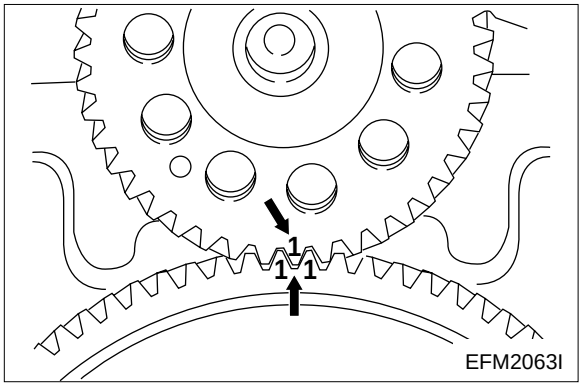
(1) First step : Coat the bolts with engine oil.
(2) Second step : Screw down 1 ~ 2 threads.
(3) Third step : Tighten with about 15 kg.m by wrench.
(4) Fourth step : Tighten with about 25kg.m by torque wrench.
(5) Fifth step: Tighten with 30kg.m by torque wrench.
(6) Sixth step: Tighten with final rotating angle method 90° $^{+10°}$.
However, according to above tightening order, tighten step by step.



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

6.3.7. Camshaft

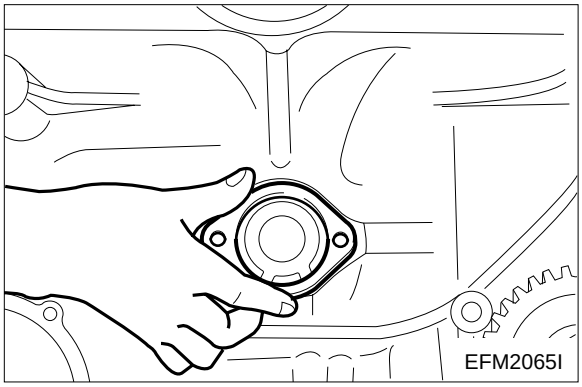
- Coat the cam bush of cylinder block and camshaft with engine oil.
- Assemble the cam bush and camshaft for them not to be damaged.
- Assemble the crankshaft gear and the camshaft gear making sure that the gear marks on both gears are aligned together as right figure.



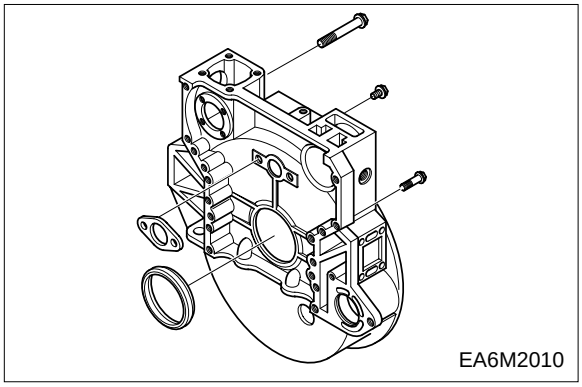
6.3.8. Flywheel housing

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

Torque	4 kg.m


EFM2065I

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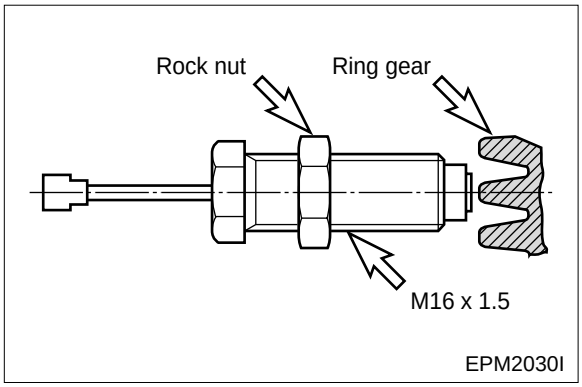
● After fitting the flywheel housing holes to the guide pins and engage temporarily 2 ~ 3 threads of fixing bolts, and according to the tightening order (zigzag method) tighten them in the specified torque.

Torque	7.5 kg.m

6.3.9. Tacho sensor

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



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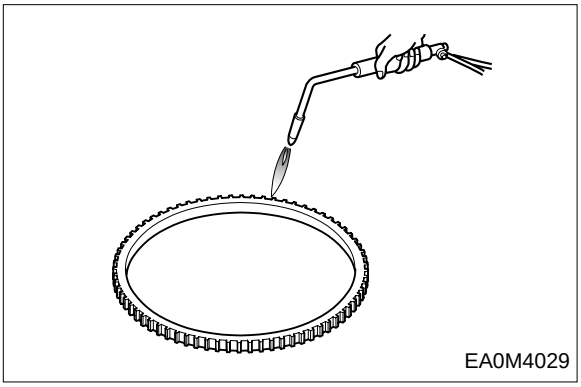
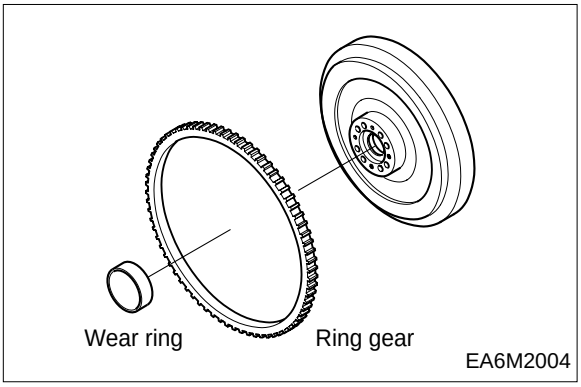
6.3.10. Flywheel

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



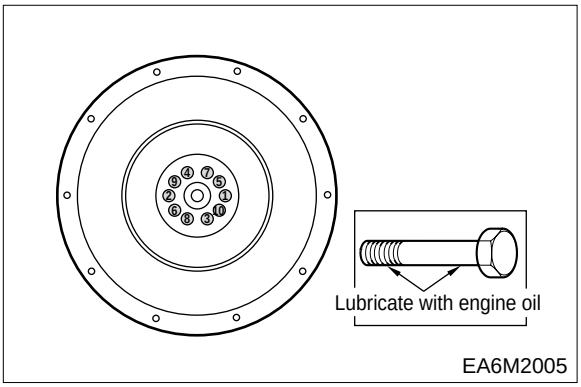
Do not allow the temperature of the ring gear to exceed 200 °C (390 °F).

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



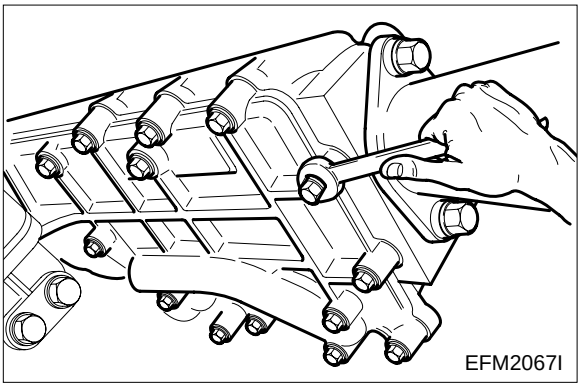
- After letting the guide pin insert through the flywheel holes and engaging the fixing bolts by 2 ~ 3 threads temporarily, tighten them to the specified torque according to lightening order. (Zigzag order)

Torque	26 kg.m



6.3.11. Oil cooler

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



6.3.12. Heat exchanger

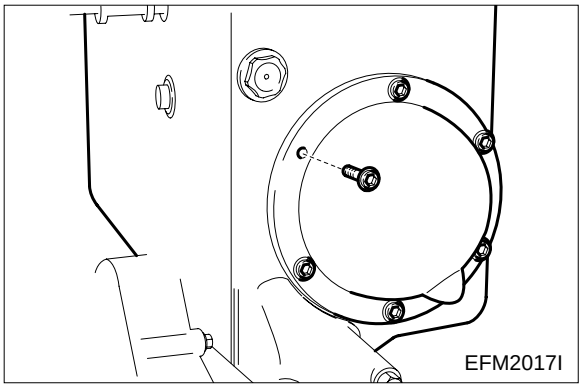
- Asemble 4ea of fixing bolts.
- Assemble the heat exchange tube.

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

- Assemble the cover bolts.

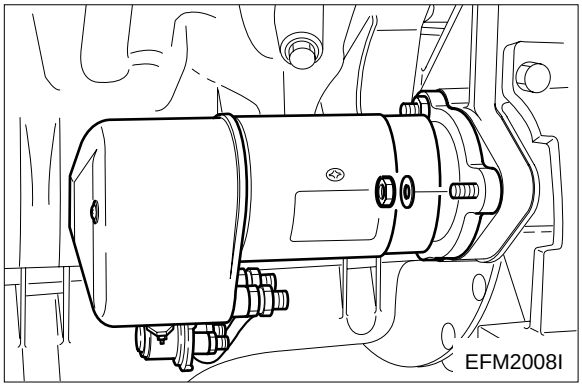
Be careful to install O-ring and gasket properly.

- Assemble the connecting hoses and pipes.



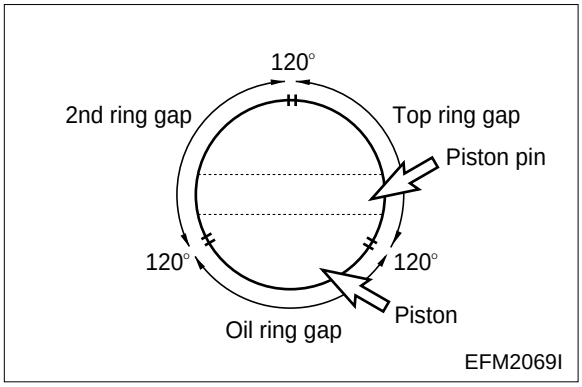
6.3.13. Starting motor

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

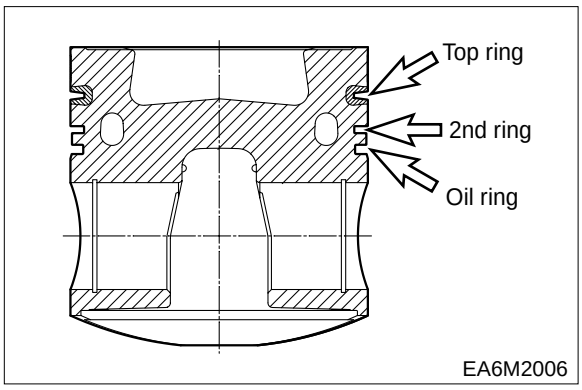


6.3.14. Piston

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



- Pushing the piston down, rotate the crankshaft about 180° and fit the bearing cap to the connecting rod.
- Coat the tap parts of connecting rod bolts and their seats with engine oil, and after engaging 2 ~ 3 threads of bolts primarily rind then tighten them to the specified torque. (10 kg.m + 90° $^{+10°}$)



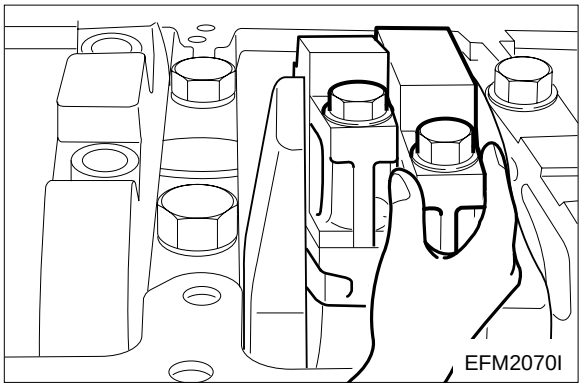
<Connecting rod bolt tightening order>

(1) First step : Coat the bolts with engine oil.
(2) Second step : Engage 2 ~ 3 threads by hands.
(3) Third step : Tighten to about 7 kg.m with wrench.
(4) Fourth step : By means of torque wrench tighten to 10 kg.m.
(5) Fifth 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)

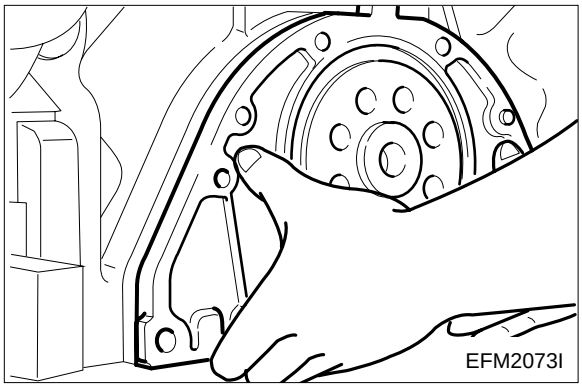
Standard length	Use limit
67.5 $^{-0.3}$ mm	69 mm

- 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.

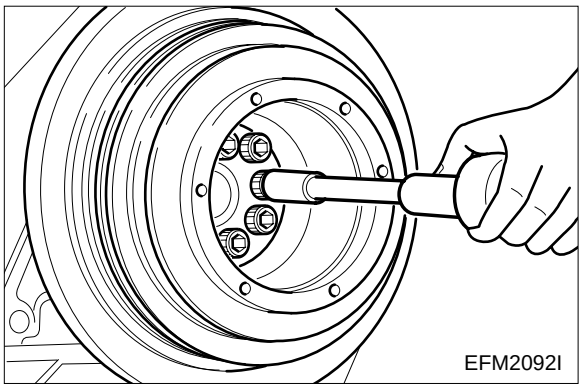
NOTE :
Without coating the oil seal with oil or lubricant, assemble it in the dry state.

- Tighten the fixing bolts in the zigzag method.

6.3.16. Vibration damper

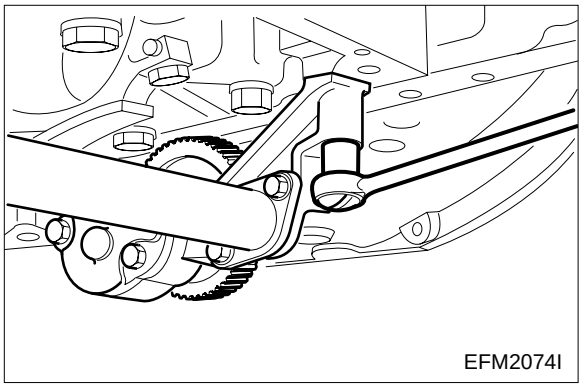
- Assemble the vibration damper tightening firstly by the crankshaft pulley and the fixing bolts.
- Insert the crankshaft pulley assembly to the crankshaft and tighten the fixing bolts in the method of zigzag to the specified torque.

Torque	20 kg.m


EFM2092I

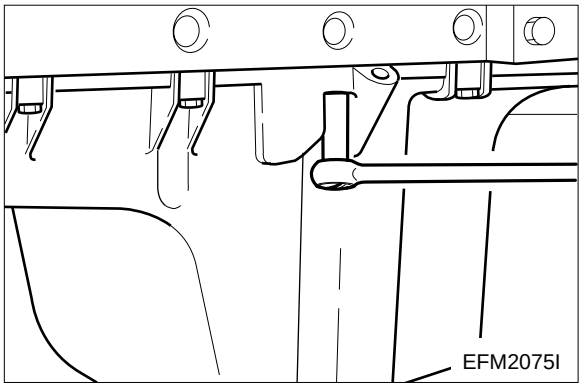
6.3.17. Oil pump

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


EFM2074I

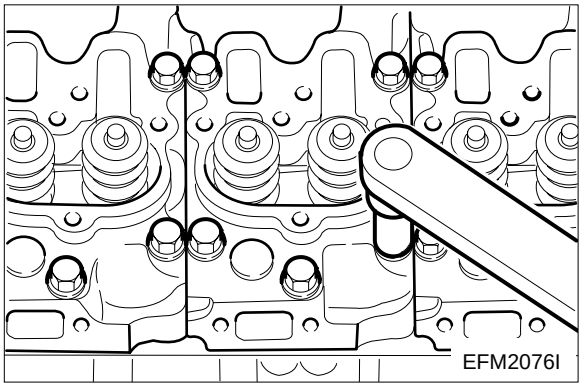
6.3.18. Oil pan

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


EFM2075I

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

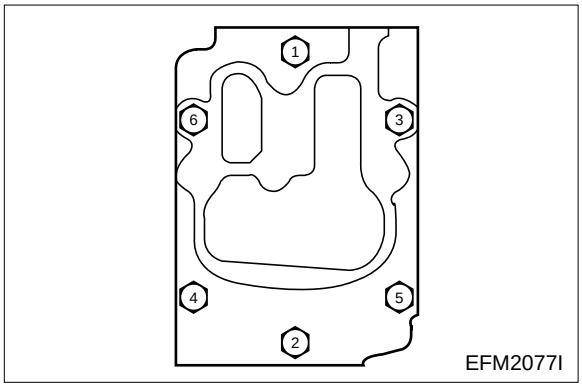
6.3.19. Cylinder head


EFM2076I

- 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 the gasket fitting with the fixing pin of the cylinder block.
- Fit the cylinder head assembly on the cylinder block aligning with its dowel pin. (Take care not to damage the head gasket.)
- Coat the cylinder head bolts with engine oil and tighten them 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 : Coat bolts with engine oil.
(2) Second step : Tighten temporarily 1 ~ 2 threads by hands.
(3) Third step : Tighten to about 8 kg.m with a wrench.
(4) Forth step : Tighten to 15kg.m with a torque wrench.
(5) Fifth step : Rotate 90° by rotation angle method.
(6) Sixth step : Finally tighten additionally rotating 90°.



EFM2077I

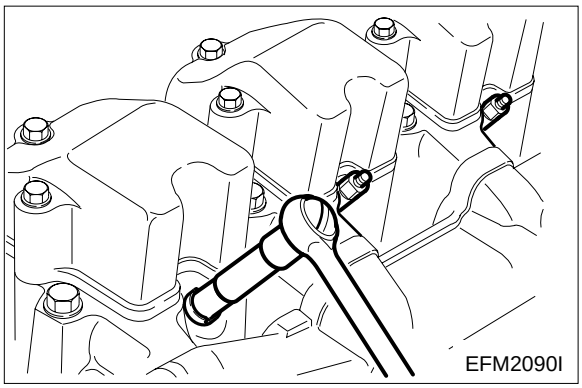
*** Standard length of bolt and use limit :**
from the head seat face to tip.

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

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

6.3.20. Nozzle

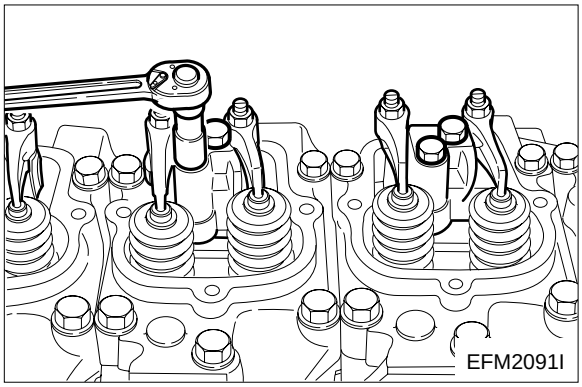
Put the new seal ring in nozzle hole of the cylinder head and after inserting the nozzle assembly, tighten it to assemble However, coat the nozzle outer part with the stuck preventing agents and assemble it.



6.3.21. Rocker arm

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

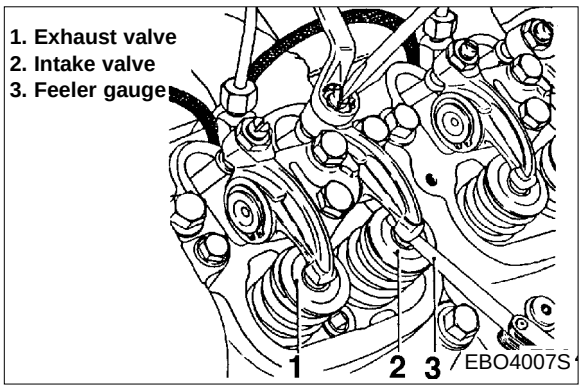
Torque	6.5 kg.m



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

6.3.22. Checking and Adjusting Valve Clearance

- After removing the head cover loosen the lock nuts of rocker arm adjusting screws using a spanner and push the filler gauge of specified value between rocker arm and valve stem.
- Tighten the adjusting screw using a driver until the inserted feeler gauge can be taken a slight resistance between the valve stem and the rocker arm. Then tighten the lock nut simultaneously on not moving the adjusting screw.
- After checking the clearance once more if necessary re-adjust it.



< How to adjust the valve clearance >

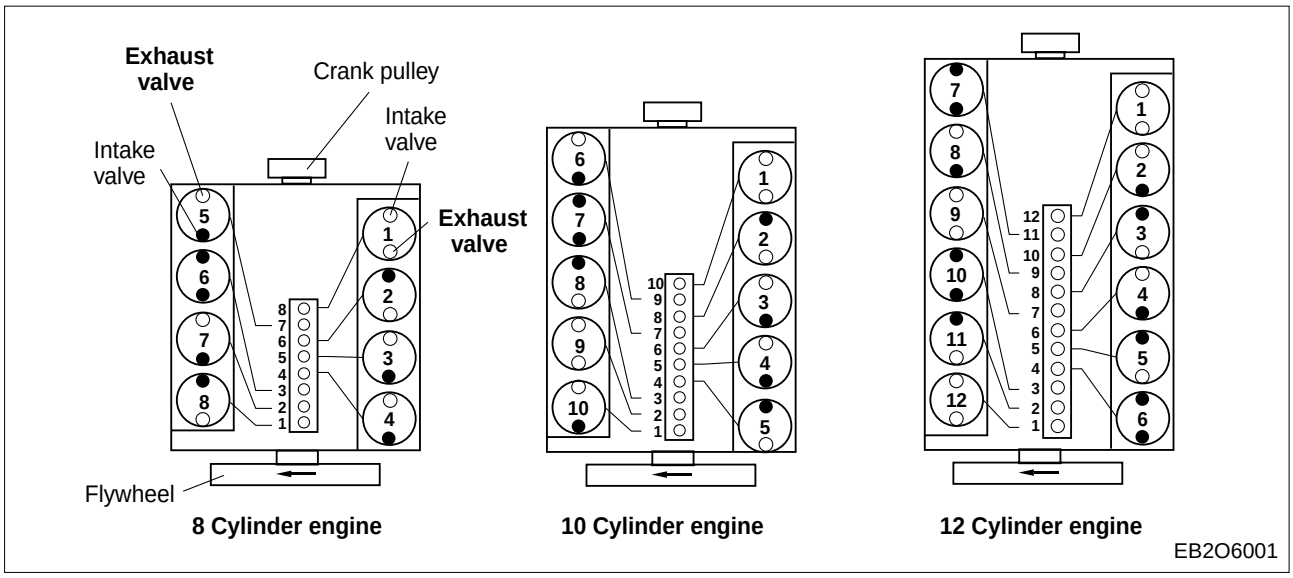
V-type Cylinder number 1 begins from the fresh water pump side on viewing front.

Be careful the intake and exhaust valve of left side is different from the right side one each other (Refer to below figure).

There are two ways adjusting the valve clearance as follows, select if you prefer one.

A) Type 1.

1) By cranking the engine, let the cylinder No. 7 on the overlap TDC in 10 cylinder engine (but 8 & 10 cylinder engine is No. 6) that is, cylinder No. 1 becomes the ignition TDC position. Then adjust the valves corresponding to mark "O" in the below figure.
2) After that, turn the crankshaft one rotation (360°) clockwise, put the cylinder No. 1 on overlap TDC position that is, cylinder No. 7 (but 8 & 10 cylinder engine is No. 6) becomes the ignition TDC position. Then adjust the valves corresponding to "●" in the below figure.



< Cylinder No. to be adjusted for intake & exhaust valves >

Engine Model	Cylinder No. 1 at :	Intake valves to be adjusted	Exhaust valves to be adjusted
V158TI Series	Overlap TDC	2, 5, 6, 7	3, 4, 6, 8
	Ignition TDC (O.T)	1, 3, 4, 8	1, 2, 5, 7
V180TI Series	Overlap TDC	2, 3, 5, 6, 7, 10	3, 4, 7, 8
	Ignition TDC (O.T)	1, 4, 8, 9	1, 2, 5, 6, 9, 10
V222TI Series	Overlap TDC	3, 5, 6, 8, 10, 12	2, 4, 6, 7, 10, 11
	Ignition TDC (O.T)	1, 2, 4, 7, 9, 11	1, 3, 5, 8, 9, 12

Note : TDC (Top Dead Center)

B) Type 2.

Above type 1 is the conventional and simple method, but if you want to adjust the valve clearance of your engine more accurately, please try type 2 sequence. This is a precise method, but it takes more time.

1) By cranking the engine, let #1 cylinder's valves overlap.
   In time, adjust the valve clearance corresponding to "No 6" of lower lists.
2) After adjusting the "No 6", turn the engine and let #5 cylinder's valves overlap as below listed again.
   At that time adjust the valve clearance corresponding to "No 3" of lower list.
3) Like this way, adjust the valve clearance in below order one by one the others respectively.

- **8 Cylinder Engine (V158TI, AD158TI)**

Valve overlapping on cylinder (Intake & Exhaust valve)	1	5	7	2	6	3	4	8
Adjusting valves on cylinder (Intake & Exhaust valve)	6	3	4	8	1	5	7	2

- **10 Cylinder Engine (V180TI, AD180TI)**

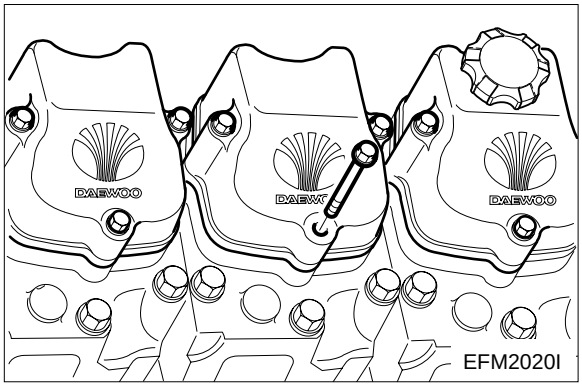
Valve overlapping on cylinder (Intake & Exhaust valve)	1	6	5	10	2	7	3	8	4	9
Adjusting valves on cylinder (Intake & Exhaust valve)	7	3	8	4	9	1	6	5	10	2

- **12 Cylinder Engine (V222TI, AD222TI)**

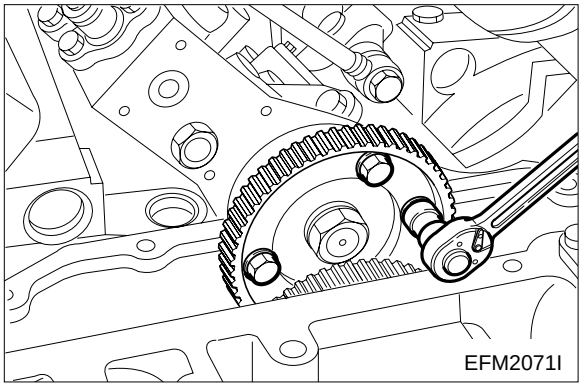
Valve overlapping on cylinder (Intake & Exhaust valve)	1	12	5	8	3	10	6	7	2	11	4	9
Adjusting valves on cylinder (Intake & Exhaust valve)	6	7	2	11	4	9	1	12	5	8	3	10

6.3.23. Cylinder head cover

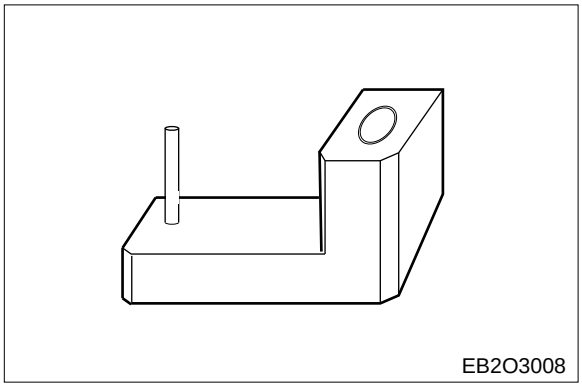
- Attach the new gasket on the surface of cylinder head where the cover is to be installed.
- Assemble the cylinder head cover by tightening the fixing bolts.
- Insert the oil filler cap.



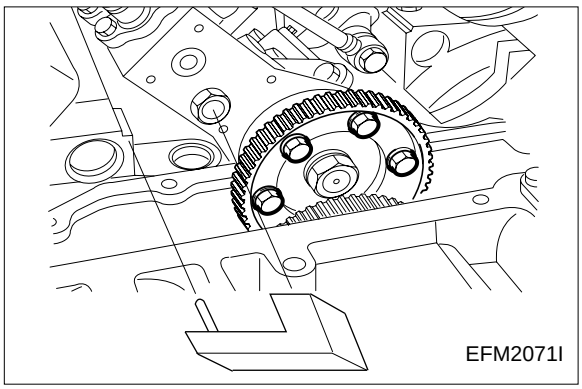
6.3.24. Fuel injection pump


EFM2071I

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


EB2O3008

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


EFM2071I

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

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

<Oil quantity of the injection pump>

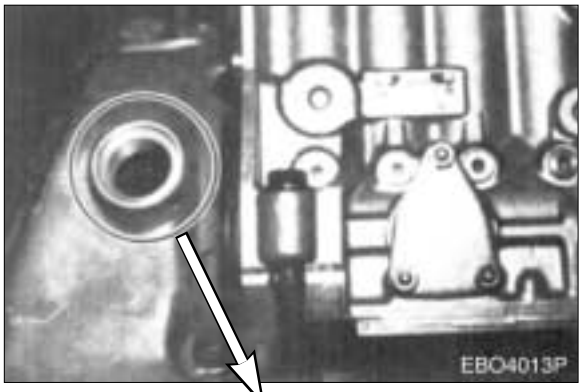
V158TIE/V158TI	V180TI	V222TI
0.95 liter	1.1 liter	1.3 liter

6.3.25. Injection timing

<How to check the injection timing>

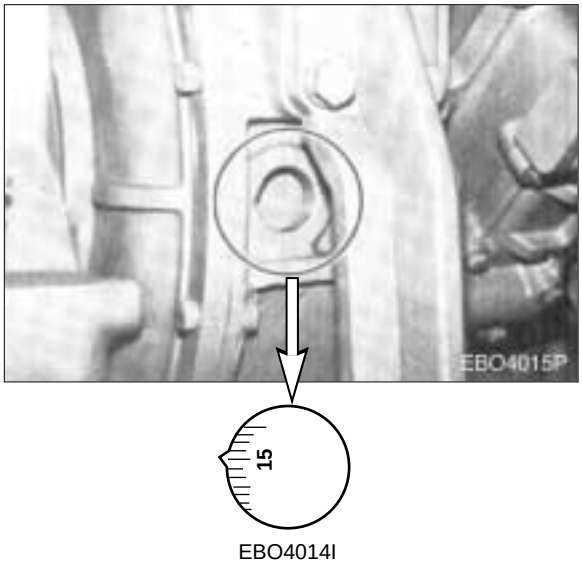
● Check the current injection timing of the engine as follows before adjusting it but if the injection timing is wrong should do it.

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



EBO4012I

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



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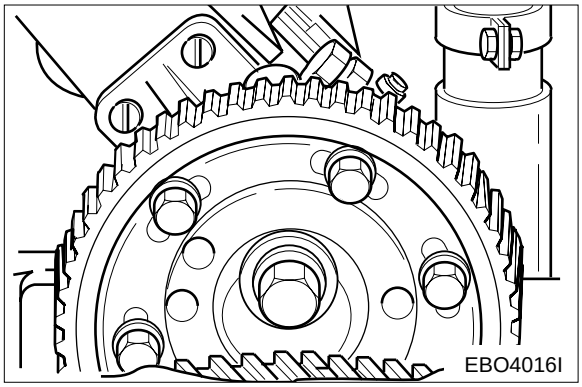
<How to adjust injection timing>



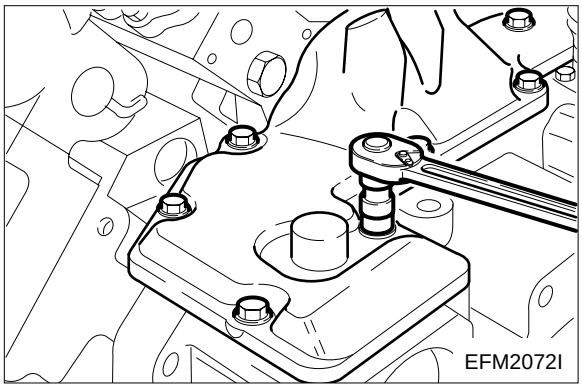
- If upper pre-checked injection timing degree is wrong, follow as below.

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. (2.2kg.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>

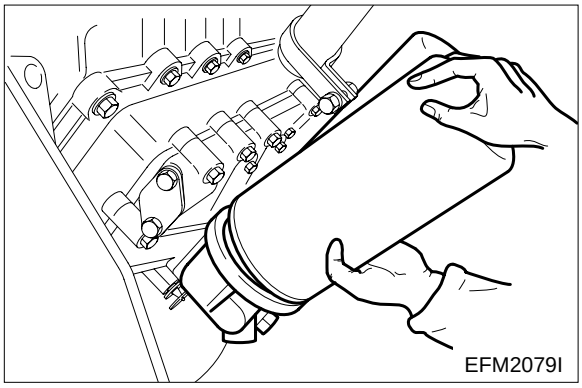
V158TI	V158TI	V180TI	V222TI
26°	24°	24°	24°

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



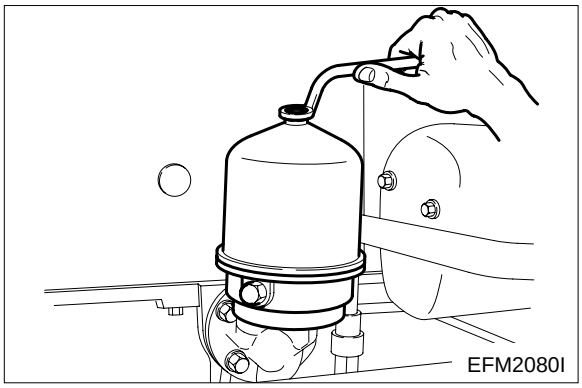
- Install the oil filter cartridge.

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.

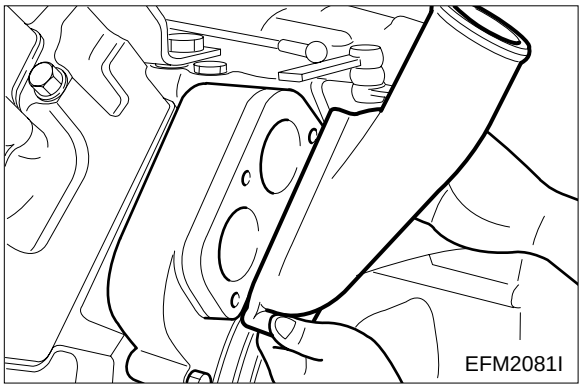
- Tighten the housing lock nut to specified torque.

Torque	1.5 kg.m


EFM2080I

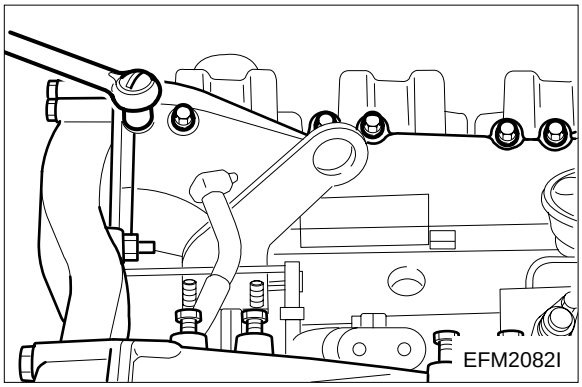
6.3.29. Fresh water pump

- 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.


EFM2081I

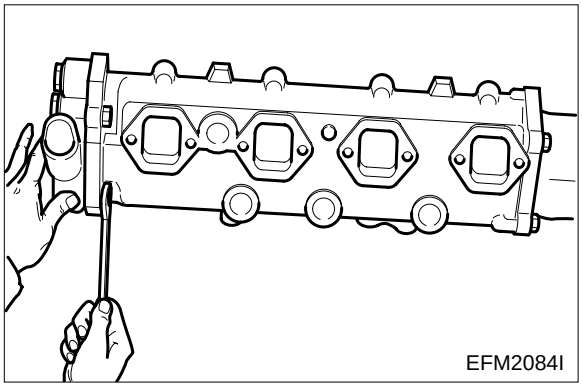
6.3.30. Intake manifold

- 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.


EFM2082I

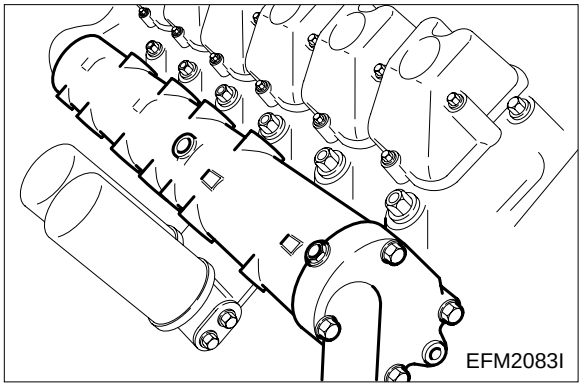
6.3.31. Exhaust manifold

- 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.


EFM2084I

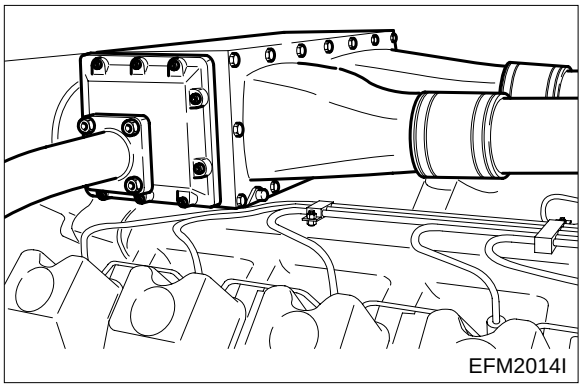
- Attach new gaskets to the exhaust manifold and then assemble the exhaust manifold with the fixing bolts.
- Attach the gasket to the exhaust elbow that is connected to the exhaust manifold, and assemble the elbow by tighten the nuts for connection.

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


EFM2083I

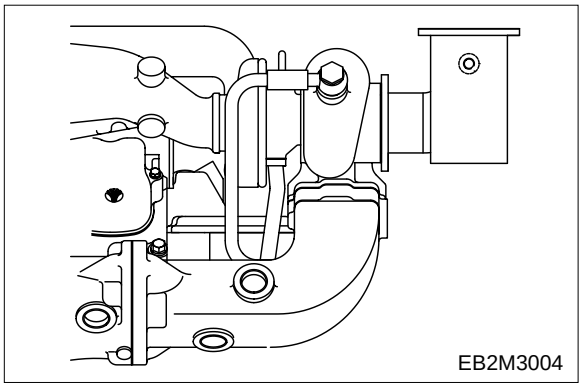
6.3.32. Inter-cooler

- 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.


EFM2014I

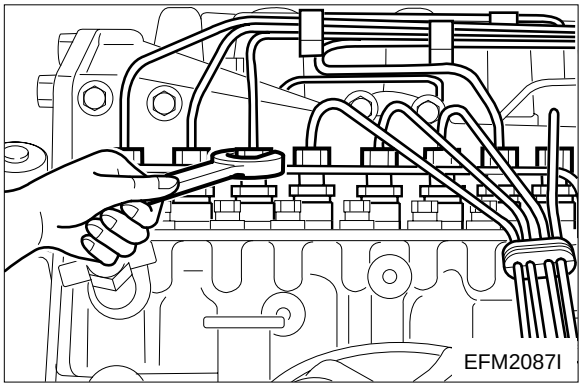
6.3.33. Turbocharger

- 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.


EB2M3004

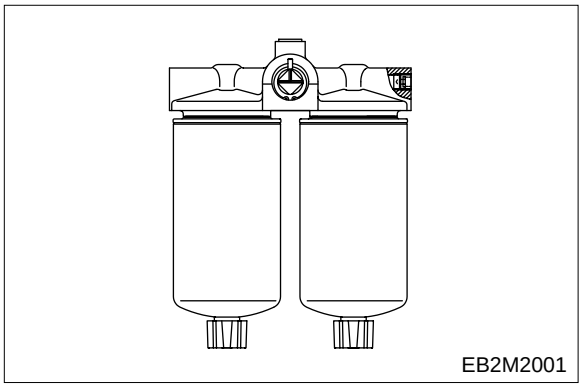
6.3.34. Fuel injection pipe

- 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.



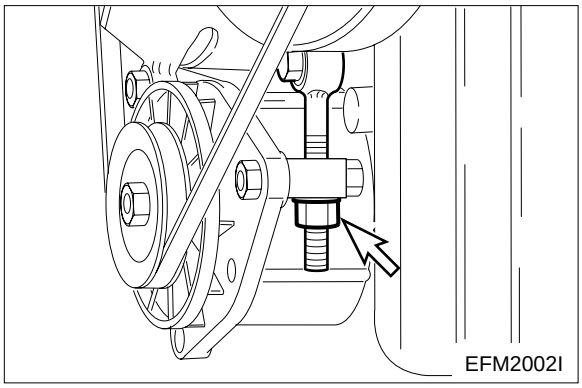
6.3.35. Fuel filter

- 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.



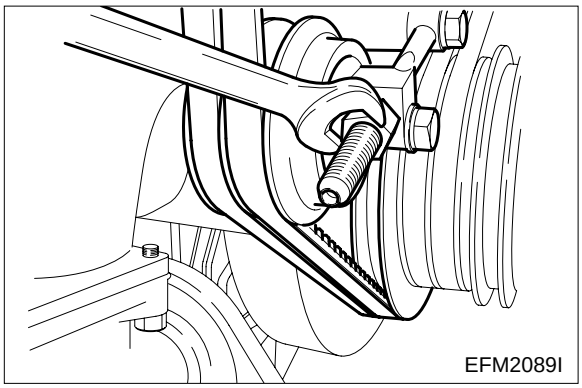
6.3.36. Alternator

- 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 10mm ~ 15mm by pushing with thumb.



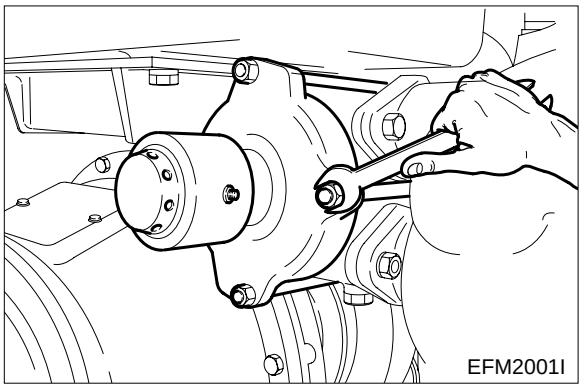
6.3.37. Idle pulley

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



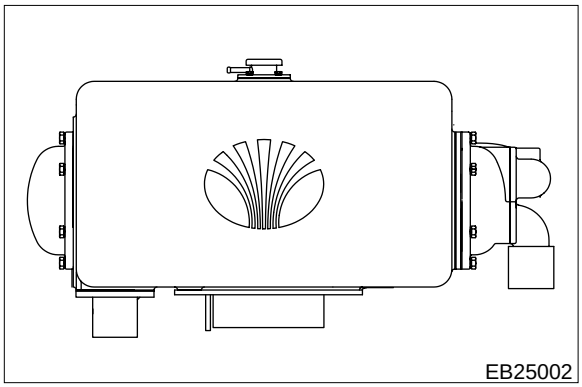
6.3.38. Sea water pump

- 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 (1000~1200rpm) 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

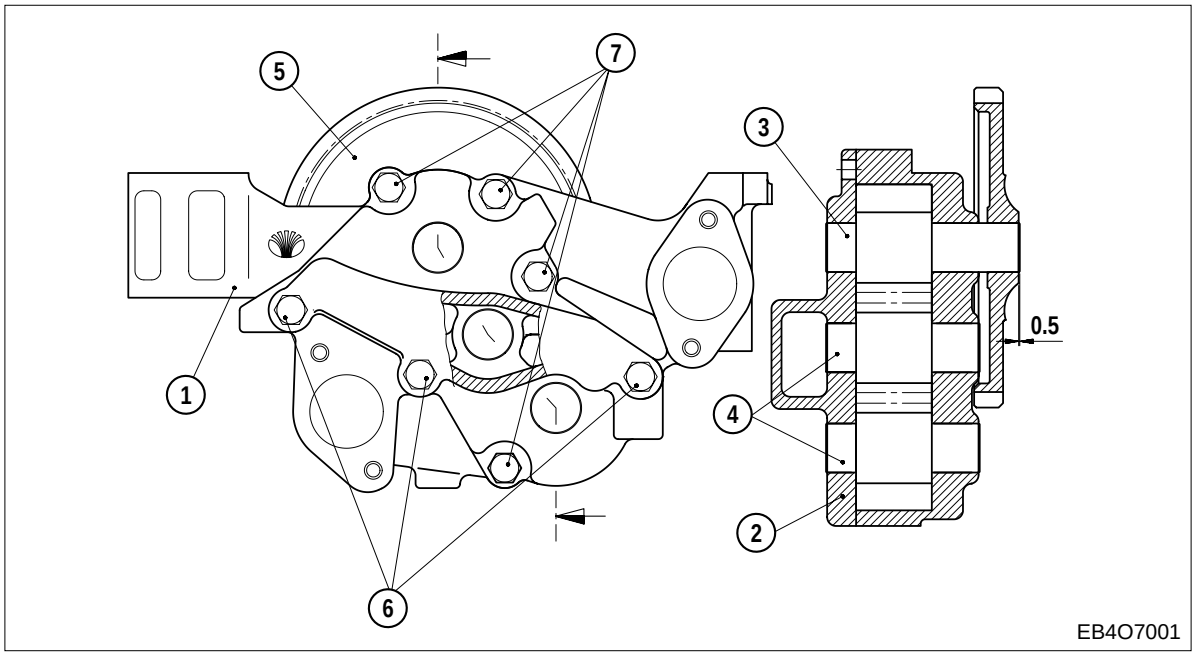
7.1. Lubricating System

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	Oil filter type	Full flow
Oil pump type	Gear type	Bypass for filter element	Cartridge Type
Relief valve opening pressure	10 kg/cm^2	Bypass valve opening pressure	2.5 ± 0.5 kg/cm^2
Bypass for oil cooler opening pressure	5 ± 0.5kg/cm^2	Bypass for entire oil filte Valve opening pressure	4.0 ~ 4.8 kg/cm^2
Adjusting valve for spray nozzle opening pressure	1.5 ~ 1.8 kg/cm^2		

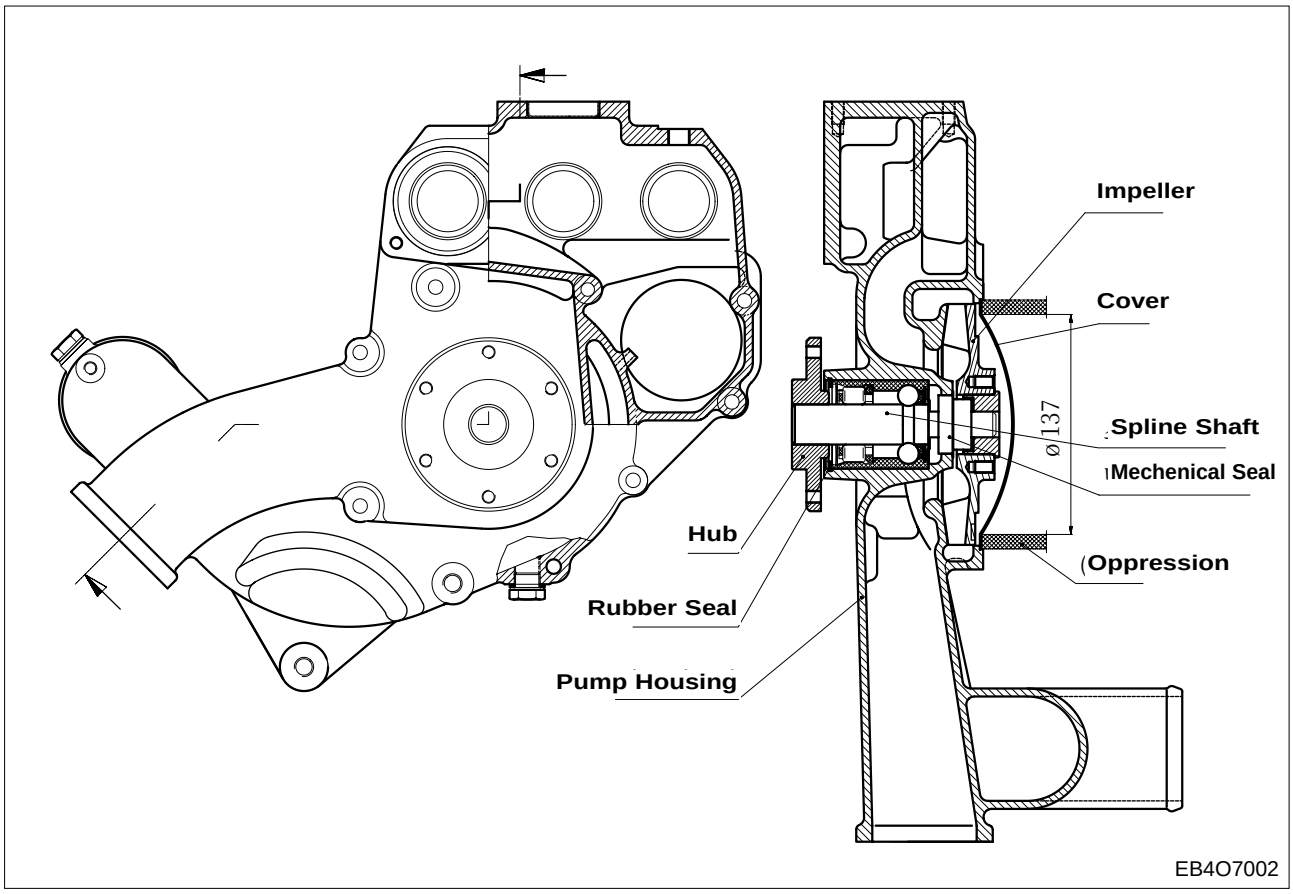
7.1.2.Oil Pump



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

7.2. Cooling System

7.2.1. Fresh water pump assembly



7.3. Fuel System

7.3.1. Injection pump

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

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

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

1) V158TIE

(1) Main data and specifications

Model : PE8P120A520/4LS3850
Injection pump : 65.11102-7355
Governor : RQV 300/900PA668-8
Plunger : 2 418 455 188
Delivery valve : 2 418 552 037
Pre-stroke : 4.50 ± 0.05 mm
Injection timing : BTDC 26°
Injection order : 1-8-7-2-6-3-5-4
Fuel feed pump : 0 440 008 152 (FP/KD22P8)
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 : 210 bar
	Injection pipe(OD ,ID ,L)	1 680 750 075	∅8.0 x ∅3.0 - 1000 mm
	Test oil	ISO4113	Temperature : 40 ± 2˚C
(B) Engine standard parts	Nozzle & holder Ass'y	65.10101-7053	Nozzle (5 x ∅0.418)
		0 432 131 669	Spec. : 285.5 kg/m²
	Injection pipe (OD, ID, L)		∅6 x ∅2 - 750 mm

Rack diagram and setting valve at each point

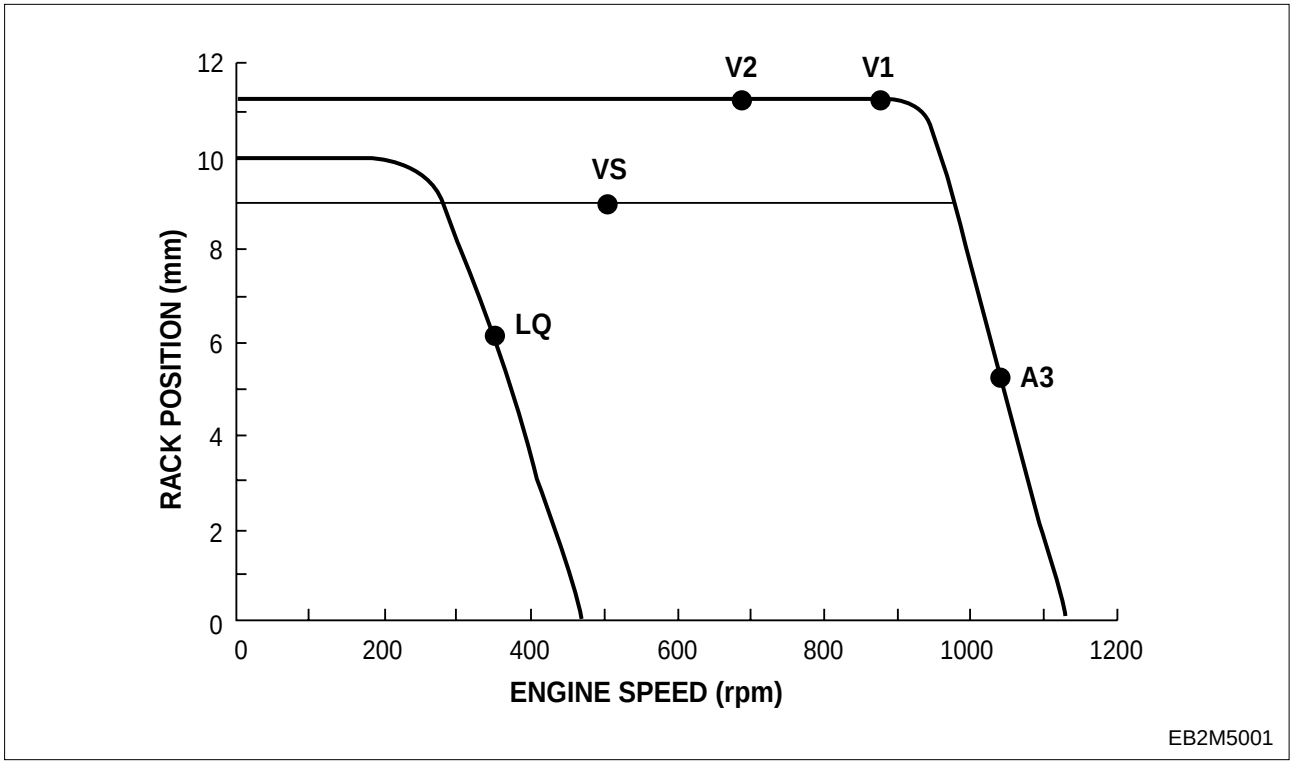
Refer to (3) Rack Diagram	Check Point	Rack position (mm)	Pump Speed (rpm)	Injection Q`ty on RIG(mm³ / 1,000st)		Press. (mmHg)
				(A) Test condition for inj. Pump	Remarks	
	V1	11.40 ± 0.05	900	218.5 ± 3.0	Max. power	-
	V2	11.50 ± 0.10	650	206.0 ± 3.0	-	-
	VS		-	-	-	-
	LQ	5.6 ± 0.20	350	25.9 ± 15.0	-	-
	A3	5.35 ± 0.50	1030	68.8 ± 15.0	-	-

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

	Check Point	Rack position (mm)	Pump Speed (rpm)	Injection Q`ty on RIG(mm³ / 1,000st)		Press. (mmHg)
				(A) Test condition for inj. Pump	(B) Engine standard parts	
	P1	-	-	-	-	-
	P2	-	-	-	-	-
	P3	-	-			-
	P4	-	-	-	-	-

Weight	Weight =630g	Lever ratio(min/max)	VWL=77 ± 4° VWV=98 ± 4°
Idle spring	k=15.74N/mm	Plunger	∅11
Middle spring	k=57.14N/mm	Delivery valve retraction volume	90mm³/st
Inner spring	None	Delivery valve opening pressure	-
LDA spring	None	Delivery valve spring	k=23.00N/mm
Feed Pump	0 440 008 005 (FP/KD22P8)	Timer	None

(3) Rack diagram



2) 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 24°
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	∅8.0 x ∅3.0 - 1000 mm	
	Test oil	ISO4113	Temperature : 40 ± 2˚C	
(B) Engine standard parts	Nozzle & holder Ass'y	65.10101-7053	Nozzle (5 x ∅0.418)	
		0 432 131 669	Spec. : 280 bar	
	Injection pipe (OD, ID, L)		∅6 x ∅2.0 - 750 mm	

Rack diagram and setting valve at each point

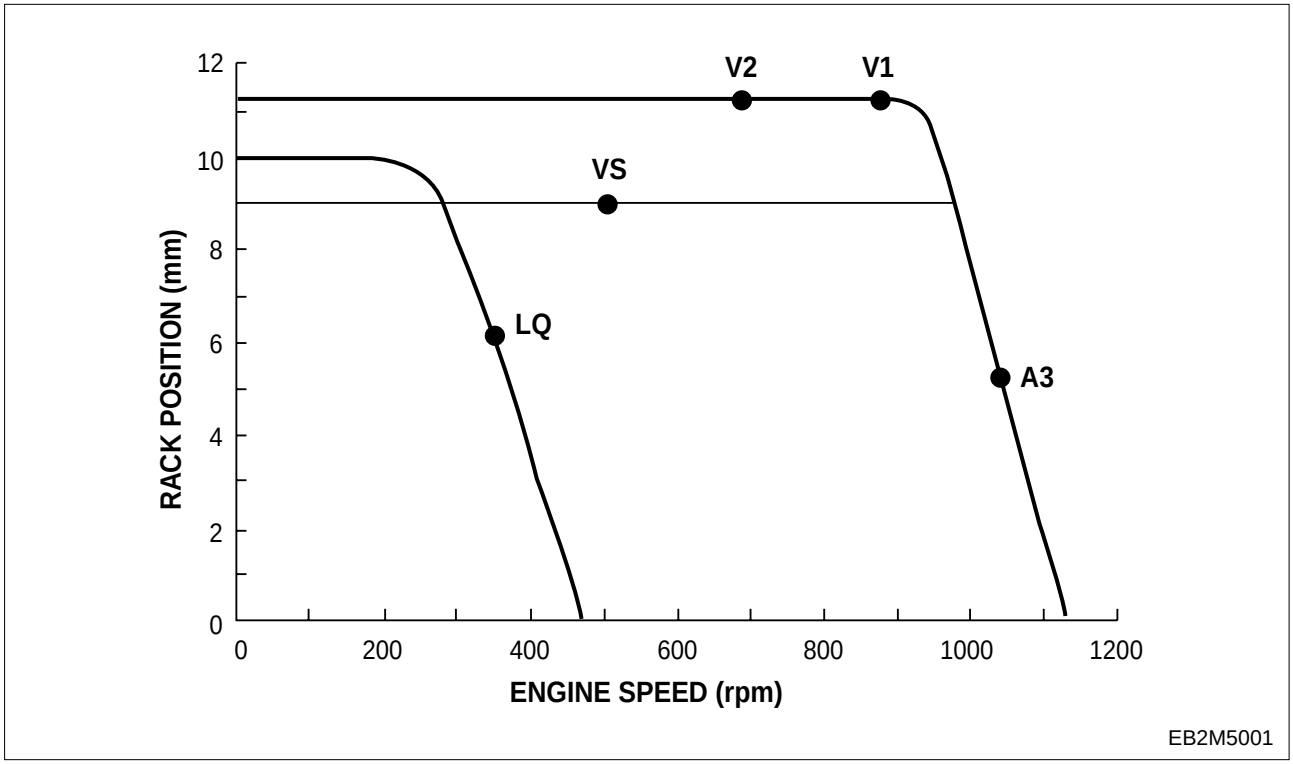
Refer to (3) Rack Diagram	Check Point	Rack position (mm)	Pump Speed (rpm)	Injection Q`ty on RIG(mm³ / 1,000st)		Press. (mmHg)
				(A) Test condition for inj. Pump	Remarks	
	V1	11.20 ± 0.05	900	235.4 ± 3.0	Max. power	1500
	V2	11.20 ± 0.10	700	230.4 ± 3.0	-	1500
	VS	8.96 ± 0.20	500	159.8 ± 1.0	-	0
	LQ	6.15 ± 0.20	350	53.7 ± 15.0	Only 2/3/4/8	0
	A3	7.10 ± 0.50	1010	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)

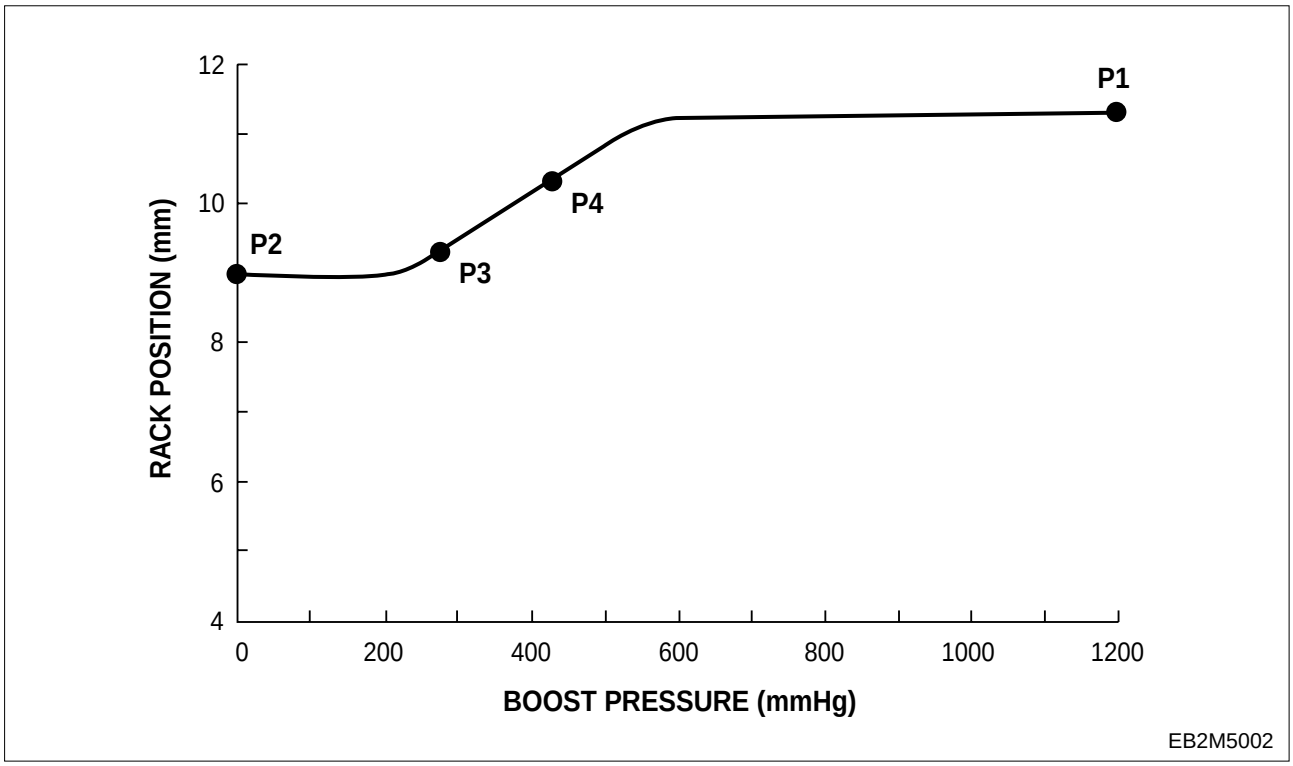
Refer to (4) Boost pressure	Check Point	Rack position (mm)	Pump Speed (rpm)	Injection Q`ty on RIG(mm³ / 1,000st)		Press. (mmHg)
				(A) Test condition for inj. Pump	(B) Engine standard parts	
	P1	11.20 ± 0.05	500	-	-	1500
	P2	8.96 ± 0.05	500	-	-	0
	P3	9.25 ± 0.10	500			275
	P4	10.38 ± 0.05	500	-	-	450

Weight	Weight =630g	Lever ratio(min/max)	Not fixed
Idle spring	k=14.03N/mm	Plunger	∅12
Middle spring	k=57.14N/mm	Delivery valve retraction volume	90mm³/st
Inner spring	None	Delivery valve opening pressure	-
LDA spring	k=30.50N/mm	Delivery valve spring	k = 7.2N/mm
Feed Pump	Double action	Timer	None

(3) Rack diagram



(4) Boost compensator pressure



3) 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 24°
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	∅8.0 x ∅3.0 - 1000 mm
	Test oil	ISO4113	Temperature : 40 ± 2˚C
(B) Engine standard parts	Nozzle & holder Ass'y	65.10101-7053	Nozzle (5 x ∅0.418)
		0 432 131 669	Spec. : 285.5 bar
	Injection pipe (OD, ID, L)		∅6 x ∅2 - 750 mm

Rack diagram and setting valve at each point

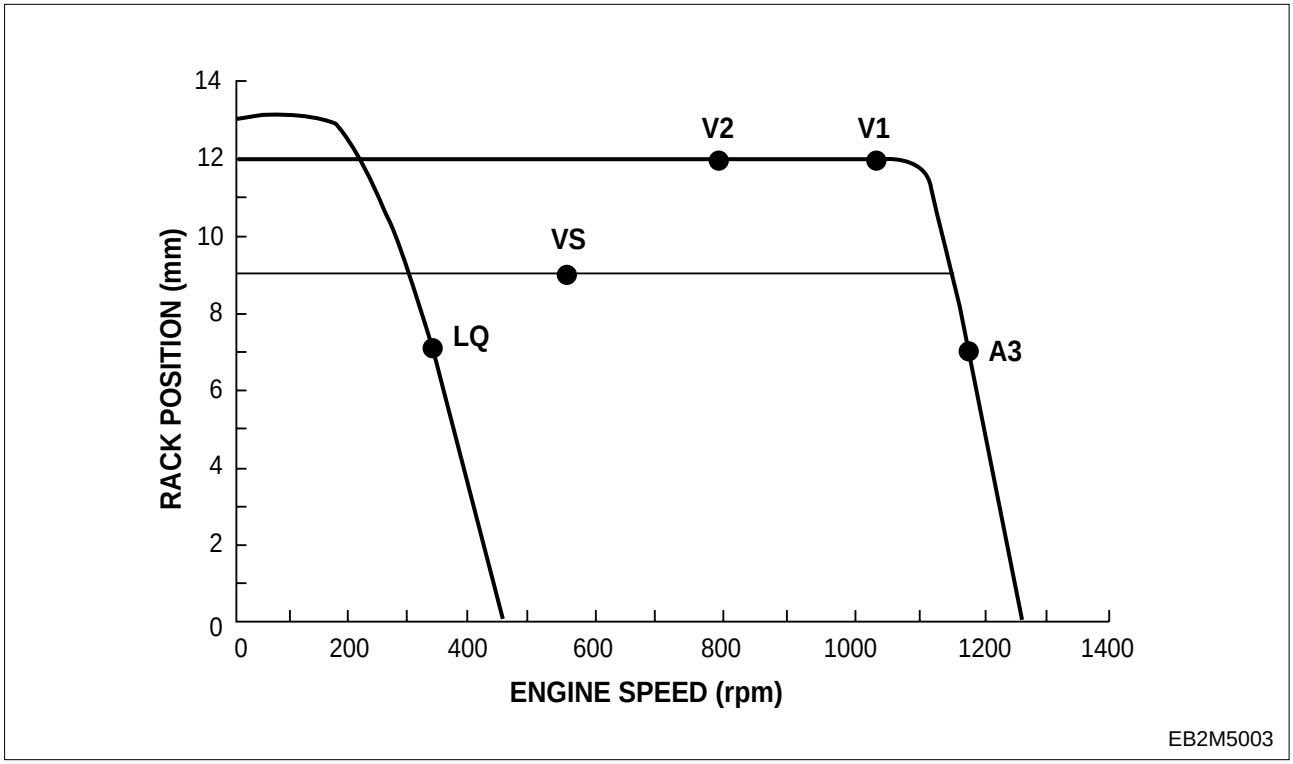
Refer to (3) Rack Diagram	Check Point	Rack position (mm)	Pump Speed (rpm)	Injection Q`ty on RIG(mm³ / 1,000st) (A) Test condition for inj. Pump	Remarks	Press. (mmHg)
	V1	12.00 ± 0.05	1050	266.0 ± 3.0	Max. power	1500
	V2	12.00 ± 0.10	800	266.0 ± 3.0	-	1500
	VS	8.96 ± 0.20	500	159.8 ± 1.0	-	0
	LQ	6.15 ± 0.20	350	53.7 ± 15.0	Only 2/3/4/8	0
	A3	7.10 ± 0.50	1150	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)

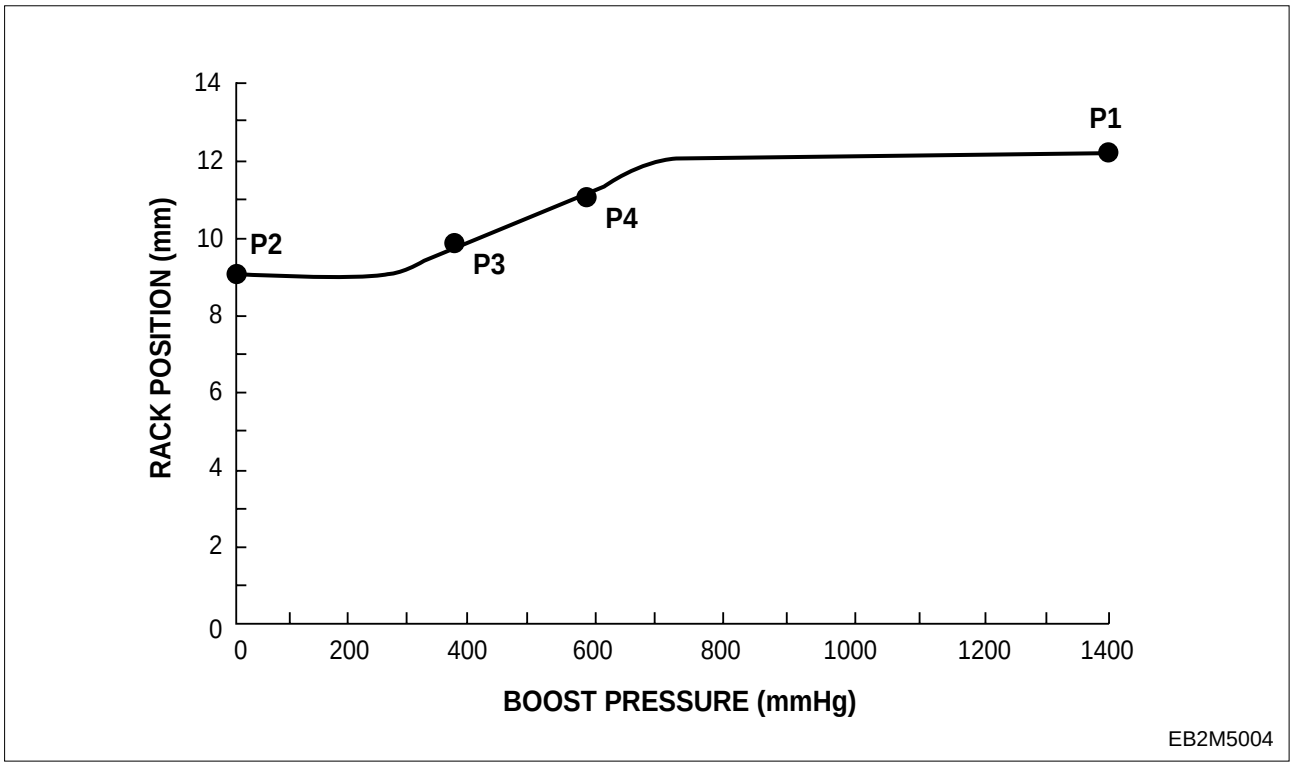
Refer to (4) Boost pressure	Check Point	Rack position (mm)	Pump Speed (rpm)	Injection Q`ty on RIG(mm³ / 1,000st) (A) Test condition for inj. Pump	(B) Engine standard parts	Press. (mmHg)
	P1	12.00 ± 0.05	500	-	-	1500
	P2	8.96 ± 0.05	500	-	-	0
	P3	9.25 ± 0.10	500			275
	P4	11.20 ± 0.05	500	-	-	600

Weight	Weight =630g	Lever ratio(min/max)	Not fixed
Idle spring	k=14.03N/mm	Plunger	∅12
Middle spring	k=57.14N/mm	Delivery valve retraction volume	90mm³/st
Inner spring	k=21.98N/mm	Delivery valve opening pressure	-
LDA spring	k=30.5N/mm	Delivery valve spring	k = 7.2N/mm
Feed Pump	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 24°
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	∅8.0 x ∅3.0 - 1000 mm
	Test oil		ISO4113	Temperature : 40 ± 2˚C
(B) Engine standard parts	Nozzle & holder Ass'y		65.10101-7053	Nozzle (5 x ∅0.418)
			0 432 131 669	Spec. : 280 bar
	Injection pipe (OD, ID, L)			∅6 x ∅2.0 - 750 mm

Rack diagram and setting valve at each point

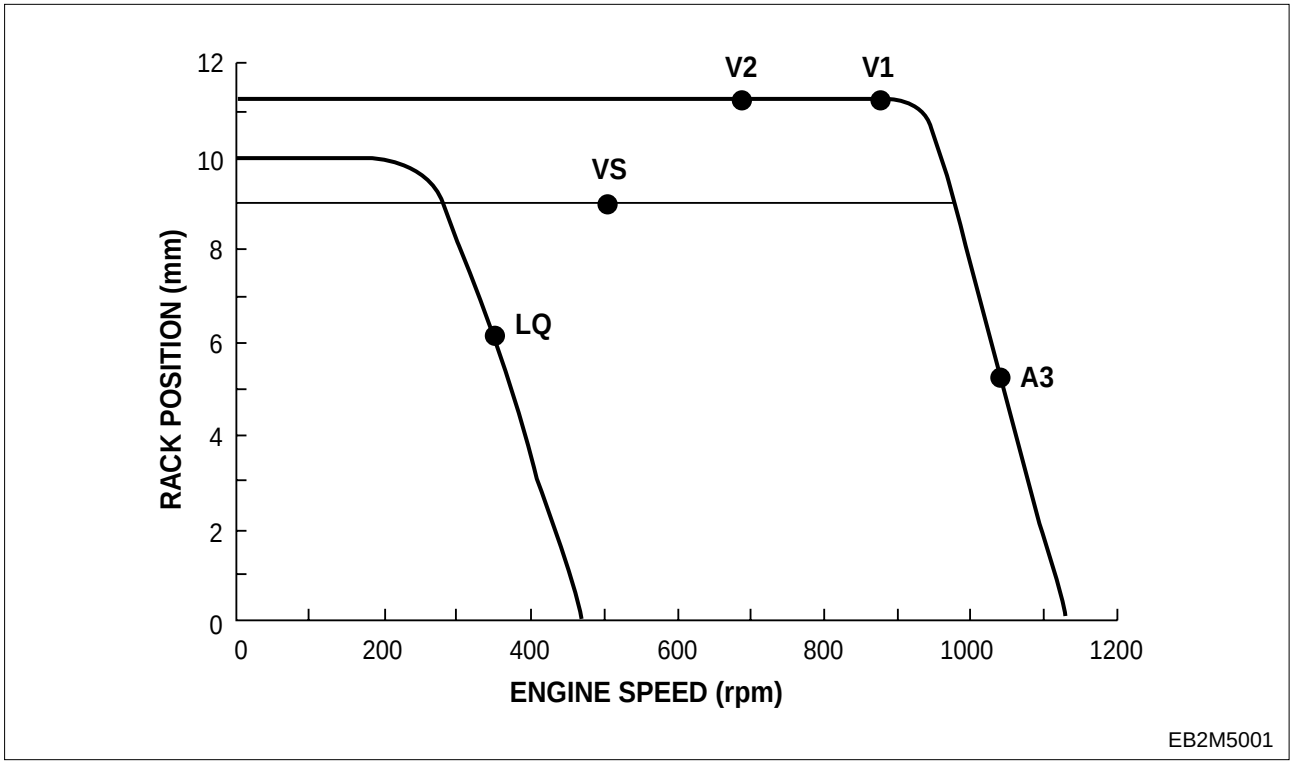
Refer to (3) Rack Diagram	Check Point	Rack position (mm)	Pump Speed (rpm)	Injection Q`ty on RIG(mm³ / 1,000st) (A) Test condition for inj. Pump	Remarks	Press. (mmHg)
	V1	11.55 ± 0.05	900	244 ± 3.0	Max. power	1500
	V2	11.55 ± 0.10	700	242 ± 3.0	-	1500
	VS	9.20 ± 0.20	500	162 ± 1.0	-	0
	LQ	6.10 ± 0.20	350	48 ± 15.0	Only 4/5/6/8/10	0
	A3	7.30 ± 0.50	1020	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)

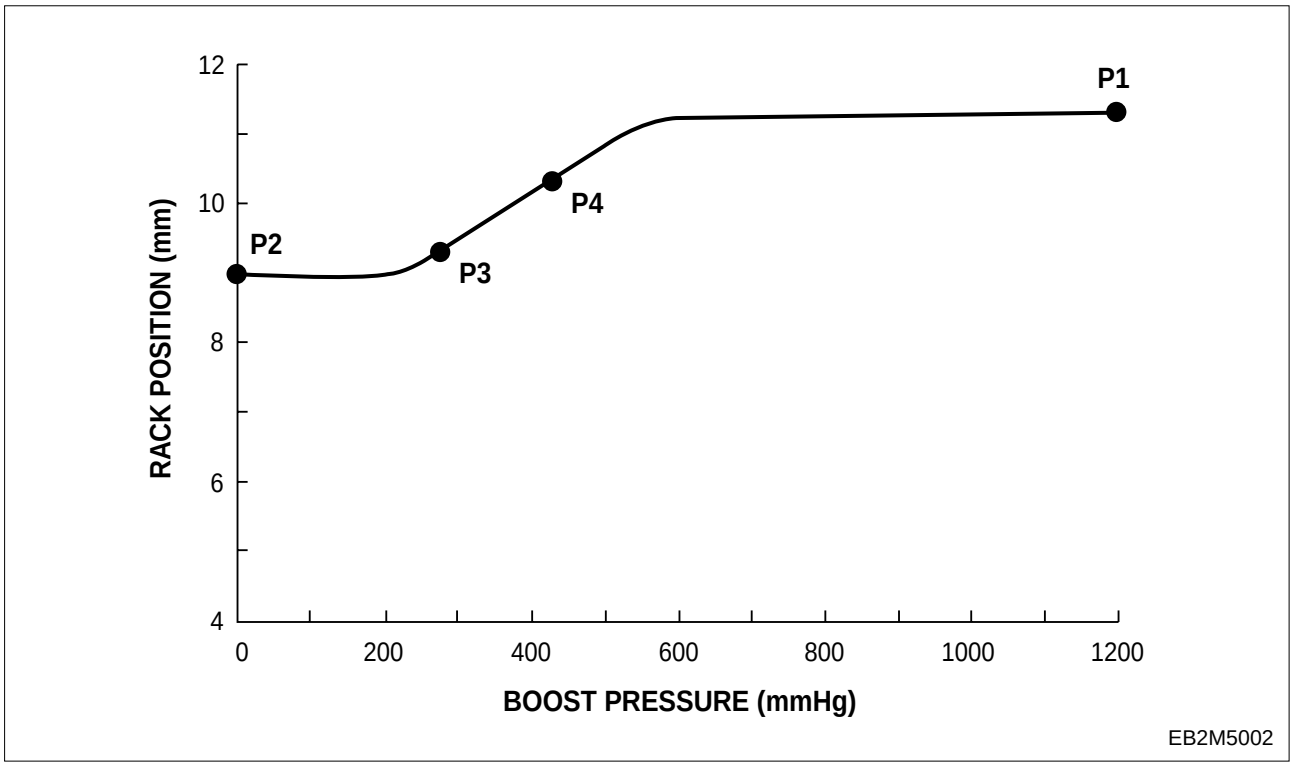
Refer to (4) Boost pressure	Check Point	Rack position (mm)	Pump Speed (rpm)	Injection Q`ty on RIG(mm³ / 1,000st) (A) Test condition for inj. Pump	(B) Engine standard parts	Press. (mmHg)
	P1	11.55 ± 0.05	500	-	-	1500
	P2	9.20 ± 0.05	500	-	-	0
	P3	9.90 ± 0.10	500			300
	P4	10.90 ± 0.05	500	-	-	450

Weight	Weight =630g	Lever ratio(min/max)	Not fixed
Idle spring	k=14.03N/mm	Plunger	∅12
Middle spring	k=57.14N/mm	Delivery valve retraction volume	90mm³/st
Inner spring	None	Delivery valve opening pressure	-
LDA spring	k=30.50N/mm	Delivery valve spring	k = 7.2N/mm
Feed Pump	Double action x 2	Timer	None

(3) Rack diagram



(4) Boost compensator pressure



5) V180TIM

(1) Main data and specifications

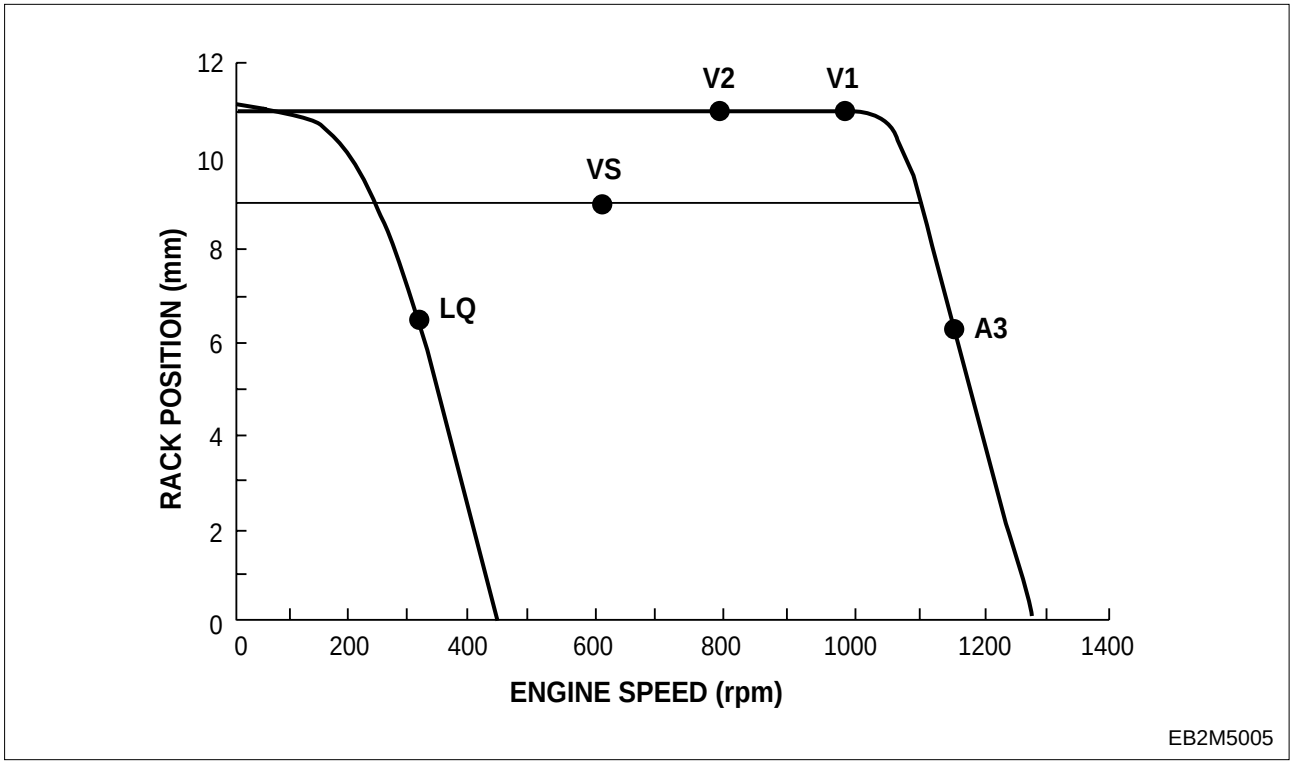
Model : PE8P120A520LV
Injection pump : 65.11101-7681
Governor : RQV 300/900
Plunger : 2 418 455 188
Delivery valve : 2 418 552 039
Pre-stroke : 4.50 ± 0.05 mm
Injection timing : BTDC 24°
Injection order : 1-6-5-10-2-7-3-8-4-9
Fuel feed pump : 0 440 008 152 (FP/KD22P78-2)
Rotating direction : C.C.W. at driving gear side

(2) Calibration data

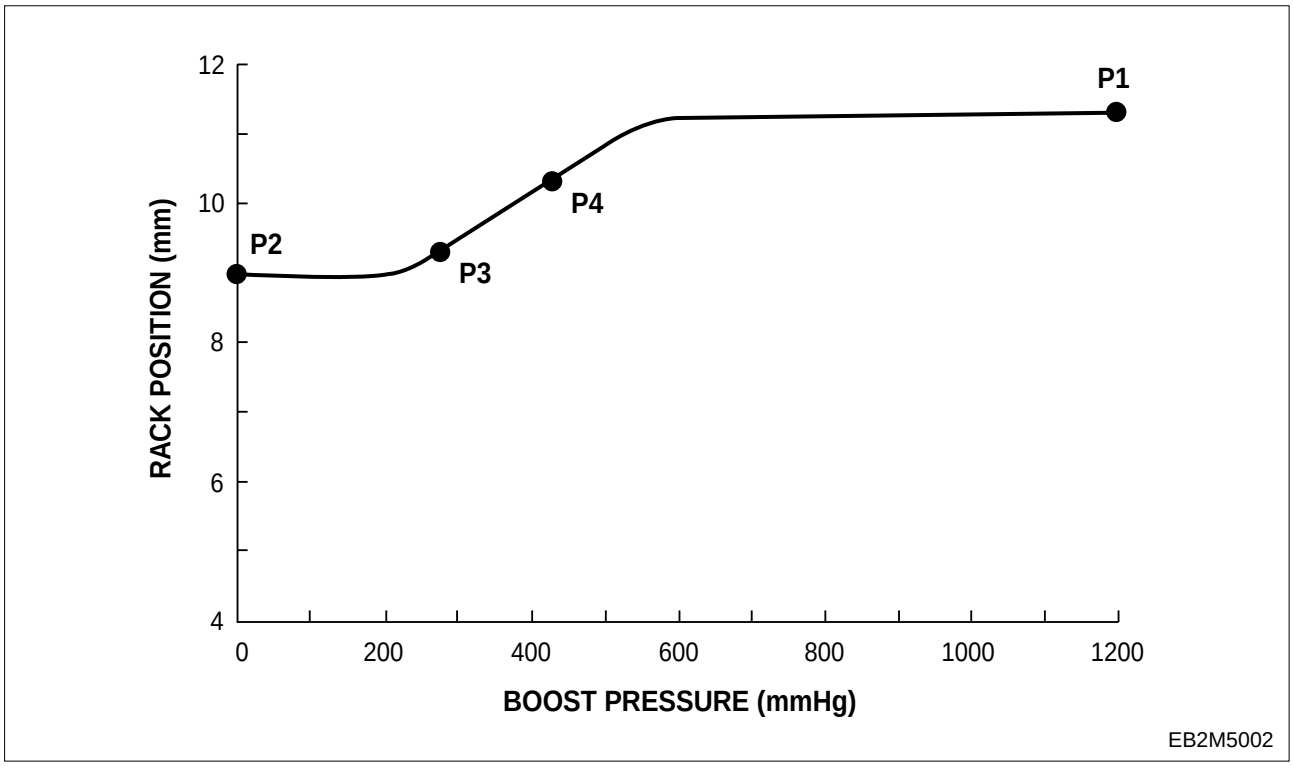
(A) Test condition for injection pump	Nozzle & Holder Ass'y		1 688 901 019	Opening pressure : 212.6 bar		
	Injection pipe(OD ,ID ,L)		1 680 750 075	∅8.0 x ∅3.0 - 1000 mm		
	Test oil		ISO4113	Temperature : 40 ± 2˚C		
(B) Engine standard parts	Nozzle & holder Ass'y		65.10101-7053	Nozzle (5 x ∅0.418)		
			0 432 131 669	Spec. : 285.5 bar		
	Injection pipe (OD, ID, L)			∅6 x ∅2.0 - 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(mm³ / 1,000st) (A) Test condition for inj. Pump	Remarks	Press. (mmHg)
	V1	11.55 ± 0.05	1050	243.0 ± 3.0	Max. power	1500
	V2	11.55 ± 0.10	800	240.4 ± 3.0	-	1500
	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	1150	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(mm³ / 1,000st) (A) Test condition for inj. Pump	(B) Engine standard parts	Press. (mmHg)
	P1	11.55 ± 0.05	500	-	-	1500
	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	∅12
Middle spring	k=57.14N/mm	Delivery valve retraction volume	90mm³/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 Pump	Double action	Timer	None

(3) Rack diagram



(4) Boost compensator pressure



6) 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 24°
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	∅8.0 x ∅3.0 - 1000 mm
	Test oil	ISO4113	Temperature : 40 ± 2˚C
(B) Engine standard parts	Nozzle & holder Ass'y	65.10101-7053	Nozzle (5 x ∅0.418)
		0 432 131 669	Spec. : 280 bar
	Injection pipe (OD, ID, L)		∅6 x ∅2.0 - 750 mm

Rack diagram and setting valve at each point

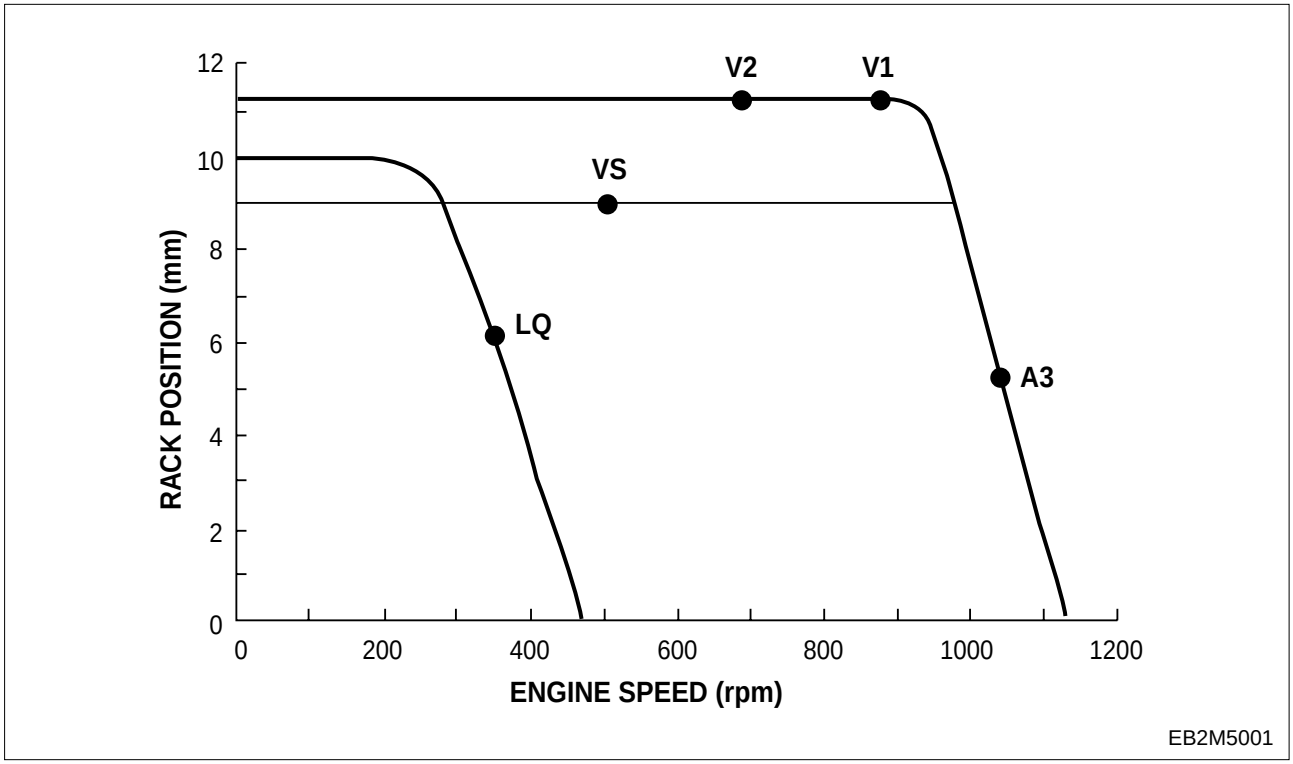
Refer to (3) Rack Diagram	Check Point	Rack position (mm)	Pump Speed (rpm)	Injection Q`ty on RIG(mm³ / 1,000st) (A) Test condition for inj. Pump	Remarks	Press. (mmHg)
	V1	11.55 ± 0.05	900	244 ± 3.0	Max. power	1500
	V2	11.55 ± 0.10	700	242 ± 3.0	-	1500
	VS	9.20 ± 0.20	500	162 ± 1.0	-	0
	LQ	6.10 ± 0.20	350	48 ± 15.0	Only 4/5/6/8/10/12	0
	A3	7.30 ± 0.50	1020	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)

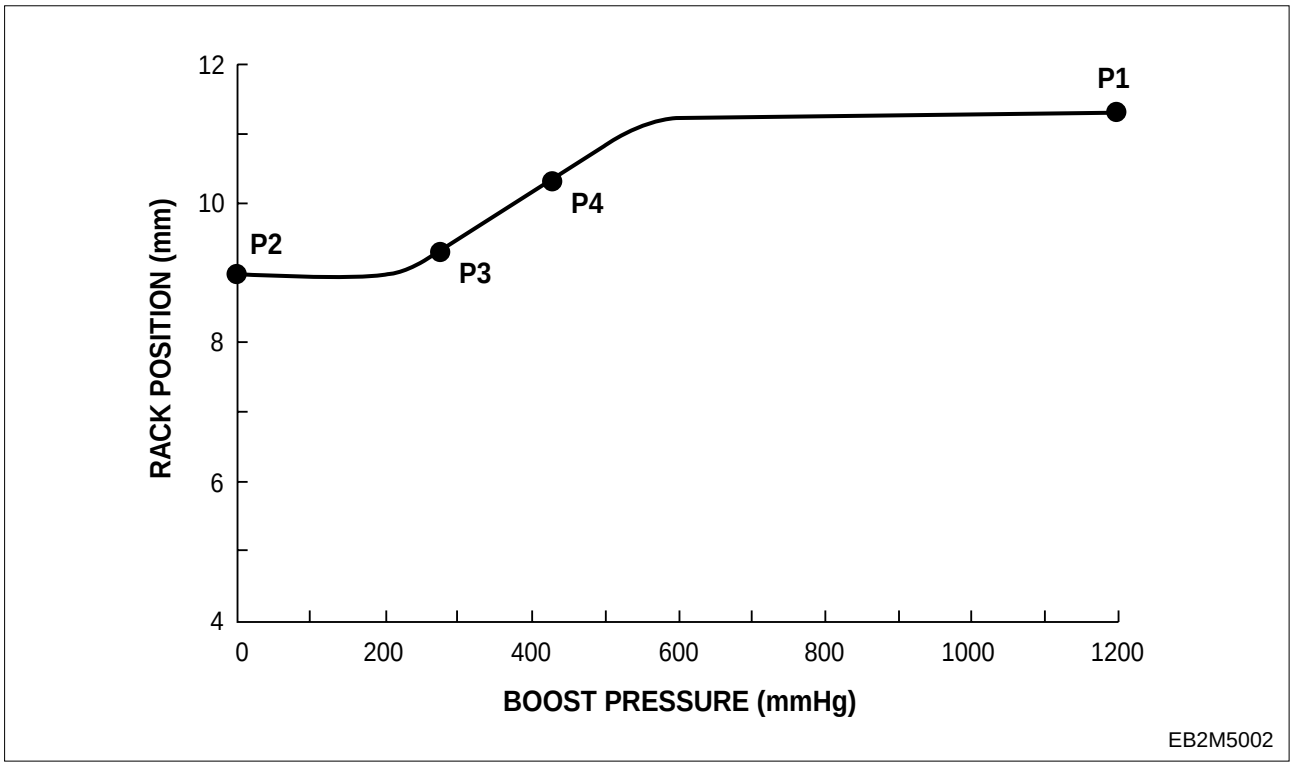
Refer to (4) Boost pressure	Check Point	Rack position (mm)	Pump Speed (rpm)	Injection Q`ty on RIG(mm³ / 1,000st) (A) Test condition for inj. Pump	(B) Engine standard parts	Press. (mmHg)
	P1	11.55 ± 0.05	500	-	-	1500
	P2	8.96 ± 0.05	500	-	-	0
	P3	9.9 ± 0.10	500			300
	P4	10.90 ± 0.05	500	-	-	450

Weight	Weight =630g	Lever ratio(min/max)	Not fixed
Idle spring	k=14.03N/mm	Plunger	∅12
Middle spring	k=57.14N/mm	Delivery valve retraction volume	90mm³/st
Inner spring	None	Delivery valve opening pressure	-
LDA spring	k=30.50N/mm	Delivery valve spring	k = 7.2N/mm
Feed Pump	Double action x 2	Timer	None

(3) Rack diagram



(4) Boost compensator pressure



7) 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 24°
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	∅8.0 x ∅3.0 - 1000 mm
	Test oil	ISO4113	Temperature : 40 ± 2˚C
(B) Engine standard parts	Nozzle & holder Ass'y	65.10101-7053	Nozzle (5 x ∅0.418)
		0 432 131 669	Spec. : 285.5 bar
	Injection pipe (OD, ID, L)		∅6 x ∅2.0 - 750 mm

Rack diagram and setting valve at each point

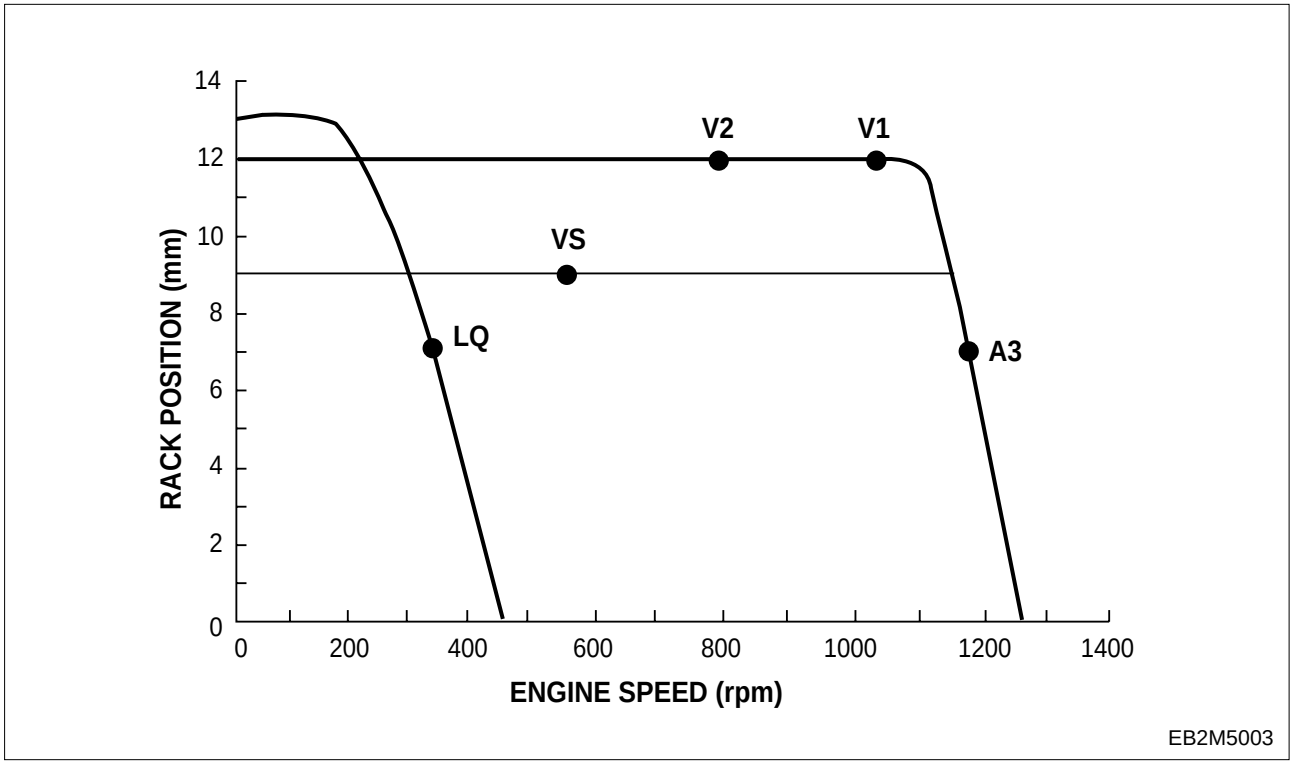
Refer to (3) Rack Diagram	Check Point	Rack position (mm)	Pump Speed (rpm)	Injection Q`ty on RIG(mm³ / 1,000st) (A) Test condition for inj. Pump	Remarks	Press. (mmHg)
	V1	12.00 ± 0.05	1050	266.0 ± 3.0	Max. power	1500
	V2	12.00 ± 0.10	800	266.0 ± 3.0	-	1500
	VS	8.96 ± 0.20	500	159.8 ± 1.0	-	0
	LQ	6.15 ± 0.20	350	53.7 ± 15.0	Only 2/3/4/8	0
	A3	7.10 ± 0.50	1150	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)

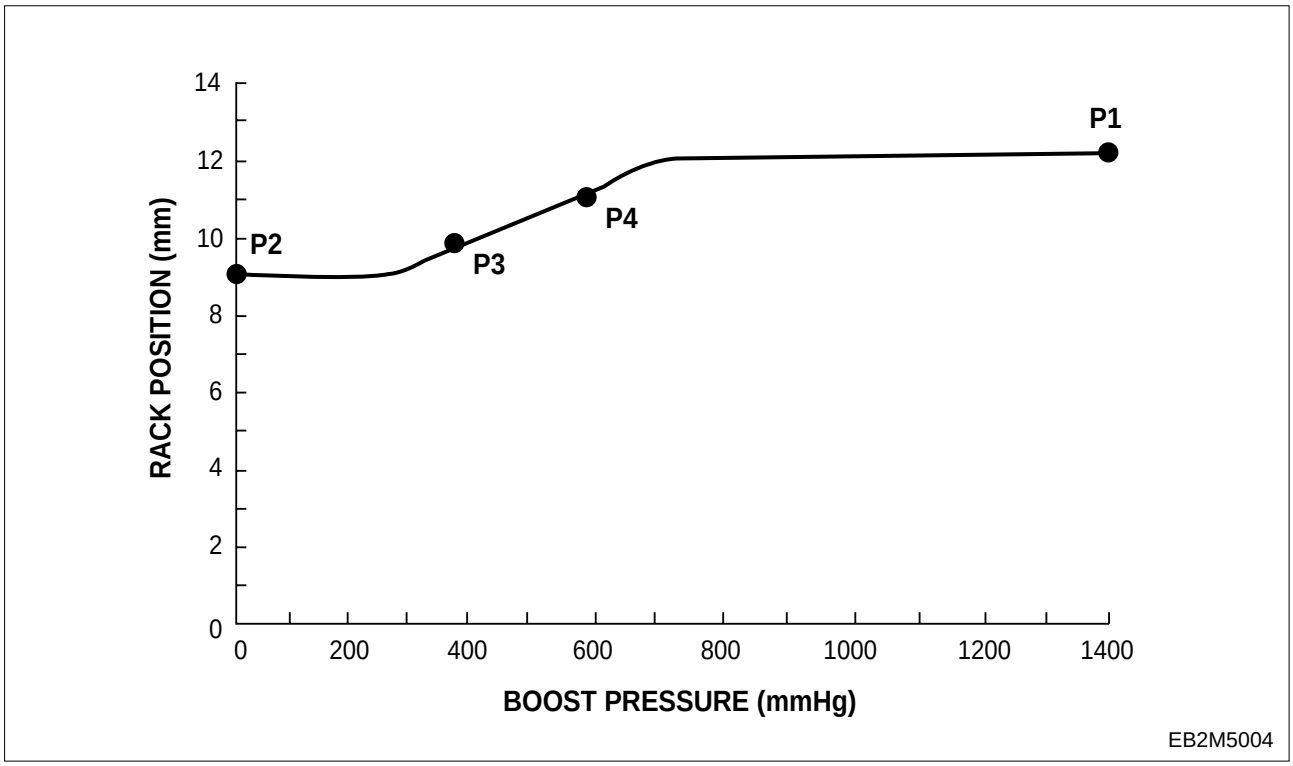
Refer to (4) Boost pressure	Check Point	Rack position (mm)	Pump Speed (rpm)	Injection Q`ty on RIG(mm³ / 1,000st) (A) Test condition for inj. Pump	(B) Engine standard parts	Press. (mmHg)
	P1	12.00 ± 0.05	500	-	-	1500
	P2	8.96 ± 0.05	500	-	-	0
	P3	9.25 ± 0.10	500			275
	P4	11.20 ± 0.05	500	-	-	600

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

(3) Rack diagram



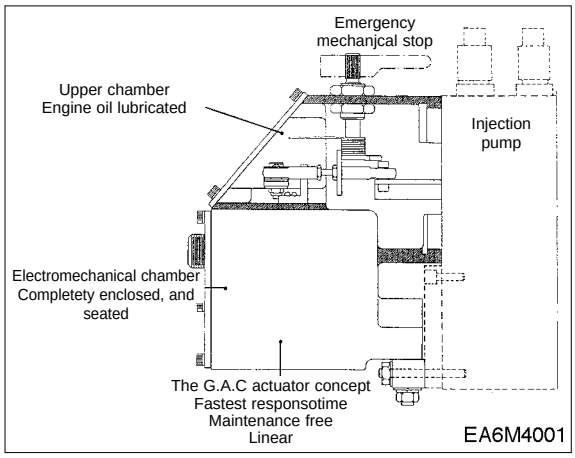
(4) Boost compensator pressure



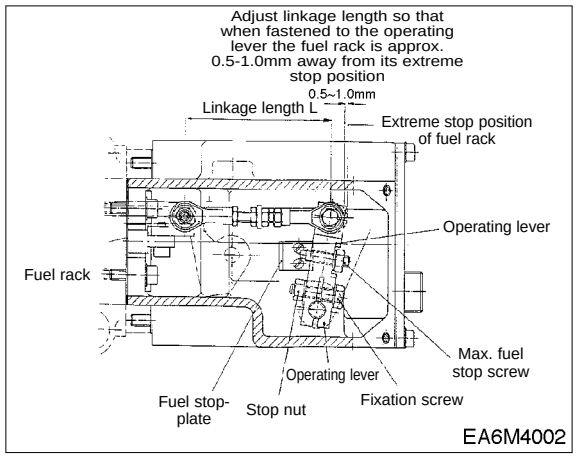
7.3.2. AD158TI / 180TI / 222TI

Governor system for fuel injection pump consists of “Integral Actuator” and “Speed Control Unit”.

1) Integral Actuator



<Side View>



<Top View>

● **Functions of Actuator’s component**

1. Emergency stop lever

It is emergency stop lever operated by manual at emergency.

2. Upper control chamber

The cover for controlling the inside is installed.

3. Electro control chamber

Operating lever is started by the electric signal generated in it.

4. Adjusting screw

As it is a part of controlling the max. fuel amount if the length which comes outside is long the torque decreases or if the length is short the torque increases.

5. Fuel stop plate

It is the plate which prevents fuel from increasing by stopping the proceeding of adjusting screw.

6. Operating lever

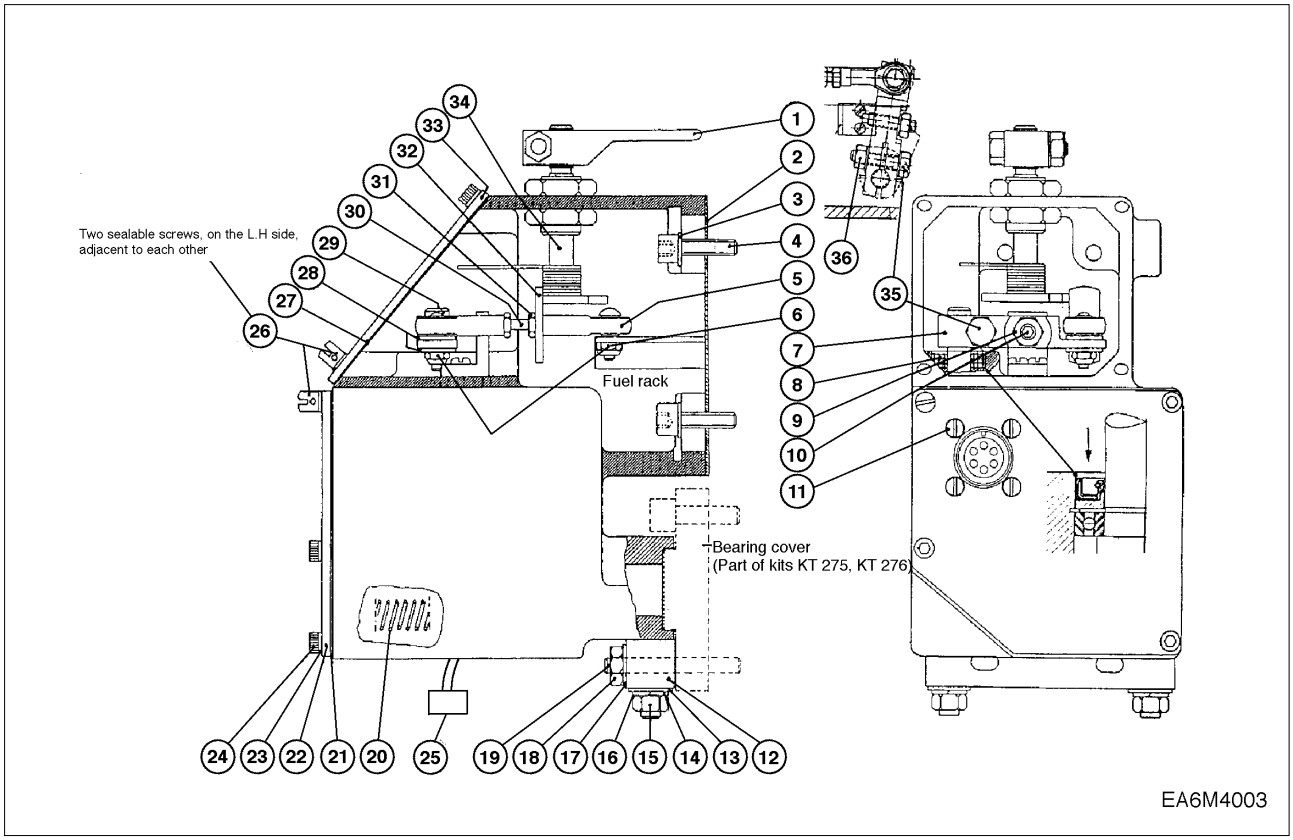
It is a connecting lever for operating the fuel rack.

7. Fuel lever

It is connected with link lever, controls fuel amount of the fuel injection pump.

Caution :

Adjusting the fuel pump is an essential part for performance and endurance of engine, therefore operation and maintenance should be performed only by specialized engineer.



No.	Description	Q'ty	Remark	No.	Description	Q'ty	Remark
1	Stop lever(emergency)	1		20	actuator spring	1	
2	pump gasket	1		21	gasket,lower cover	1	
3	washer	4		22	lower cover	1	
4	allen screw	4	7 ~ 9 N.m	23	washer	8	
5	ball link	2	*	24	allen screw	6	2.0 ± 3.0 N.m
6	stop nut	2	3.5 ~ 4.0 N.m	25	receptacle	1	
7	operating lever	1		26	sealing screw	2	3.5 ± 4.5 N.m
8	oil seal	1		27	gasket, upper cover	1	
9	counter nut	1	4.5 ~ 6.0 N.m	28	flat washer	2	
10	stop screw	1		29	screw, ball link	2	*
11	connector screw	4		30	connecting rod	1	*
12	mounting bar	1		31	nut	2	*
13	flat washer	2		32	stop plate	1	*
14	lock washer	2		33	top cover	1	
15	nut	2	17 ~ 21 N.m	34	manual stop device complete	1	
16	flat washer	2		*	linkage complete comprise pos. 5,6,28,29,30,31,32	1	
17	lock washer	2		35	fixing screw	1	12.5±13.0N.m
18	nut	2	7 ~ 9 N.m	36	stop nut	1	12.5±13.0 N.m
19	threaded bolt (part of bearing kit)	2					

2) Speed control unit for governor system (All)

a) Introduction

Series speed control unit is an all electronic device designed to control engine speed with fast and precise response to transient load changes. This closed loop control, when connected to a proportional electric actuator and supplied with a magnetic speed sensor signal, will control a wide variety of engines in an isochronous or droop mode.

The speed control unit are the engine STARTING FUEL and SPEED RAMPING adjustments. The use of these features will minimize engine exhaust smoke experienced prior to attaining engine operating speed.

Other features include adjustable droop and idle operation, inputs for accessories used in multi-engine or special applications, protection against reverse battery voltage, transient voltages, accidental short circuit of the actuator and fail safe design in the event of loss of speed sensor signal or battery supply.

	AD158TI / 180TI / 222TI
GAC actuator model	ACE 175
Speed control unit model	ESD55500

b) Description

Engine speed information for the speed control unit is usually received from a magnetic pick-up sensor Any other signal generating device may be used provided the generated frequency is proportional to engine speed and meets the voltage input and frequency range specification. The speed sensor is typically mounted in close proximity to an engine driven ferrous gear, usually the engine ring gear. As the teeth of the gear pass the magnetic sensor, a signal is generated which is proportional to engine speed.

Signal strength must be within the range of the input amplifier. An amplitude of 0.5 to 120 volts RMS is required to allow the unit to function within its design specifications. The speed signal is applied to Terminals C and D of the speed control unit. Between these terminals there is an input impedance of over 33,000 ohms. Terminal D is internally connected to Terminal E, battery negative. Only one end of the cable should be connected.

When a speed sensor signal is received by the controller, the signal is amplified and shaped by an internal circuit to provide an analog speed signal. If the speed sensor monitor does not detect a speed sensor signal, the output circuit of the speed control unit will turn off all current to the actuator.

A summing circuit receives the speed sensor signal along with the speed adjust set point input. The speed range has a ratio of 8:1 and is adjusted with a 25 turn potentiometer. The output from the summing circuit is the input to the dynamic control section of the speed control unit. The dynamic control circuit, of which the gain and stability adjustments are part, has a control function that will provide isochronous and stable performance for most engine types and fuel systems.

The speed control unit circuit is influenced by the gain and stability performance adjustments. The governor system sensitivity is increased with clockwise rotation of the gain adjustment. The gain adjustment has a range of 33:1.

The stability adjustment, when advanced clockwise, increases the time rate of response of the governor system to match the various time constants of a wide variety of engines. The speed control unit is a PID device, the “D”, derivative portion can be varied when required. (See Instability section.)

During the engine cranking cycle, STARTING FUEL can be adjusted from an almost closed, to a nearly full fuel position.

Once the engine has started, the speed control point is determined, first by the IDLE speed set point and the SPEED RAMPING circuit. After engine speed ramping has been completed, the engine will be at its governed operating speed.

At the desired governed engine speed, the actuator will be energized with sufficient current to maintain the desired engine speed, independent of load (isochronous operation).

The output circuit provides switching current at a frequency of about 500Hz to drive the actuator Since the switching frequency is well beyond the natural frequency of the actuator, there is no visible motion of the actuator output shaft.

Switching the output transistors reduces its internal power dissipation for efficient power control. The output circuit can provide current of unto 10amps continuous at 25?C for 12 and 24VDC battery systems. The actuator responds to the average current to position the engine fuel control lever.

In standard operation, the speed control unit performance is isochronous. Droop governing can be selected by connecting terminals K and L and the percent of droop governing can be varied with the droop adjustment control . The droop range can be increased by connecting Terminals G and H.

The speed control unit has several performance and protection features which enhance the governor system. A speed anticipation circuit minimizes speed overshoot on engine start-up or when large increments of load are applied to the engine.

Engine idle speed can be remotely selected and is adjustable. Accessory inputs to achieve variable speed operation and multi-engine control can be accepted by the speed control unit from GAC load sharing modules, automatic synchronizers.

c) Specification

PERFORMANCE		
Isochronous Operation/steady State Stability		± 0.25% or better
Speed Range/Governor		1 K ± 7.5 KHz continuous
Speed Drift with Temperature		± 1% Maximum
Idle Adjust CW		60% of set speed
Idle Adjust CCW		Less than 1,200 Hz.
Droop Range		1 ± 5 % regulation*
Droop Adj. Max. (K-L Jumpered)		400 Hz ± 75 Hz per 1.0 A change
Droop Adj. Min. (K-L Jumpered)		15 Hz ± 6 Hz. per 1.0 A change
Speed Trim Range		± 200 HZ
Remote Variable Speed Range		500 ± 7.5 Hz or any part thereof
Terminal Sensitivity	J	100 Hz ± 15 Hz/Volt @ 5.0 K Impedance
	L	735 Hz ± 60 Hz/Volt @ 65 K Impedance
	N	148 Hz ± 10 Hz/Vo1t @ 1 Meg. Impedance
	P	10 VDC Supply @ 20 ma Max.
Speed switch adjustment range		1,000 ~ 10,000 Hz
ENVIRONMENTAL		
Ambient Operating Temperature Range		- 40 ° to 180 °F (- 40 ° to + 85 °C)
Relative Humidity		up to 95 %
All Surface Finishes		Fungus Proof and Corrosion Resistant
INPUT POWER		
Supply		12 or 24 VDC Battery Systems (Transient and Reverse Voltage Protected)**
Polarity		Negative Ground (Case Isolated)
Power Consumption		50 mA continuous plus actuator current
Actuator Current Range @ 77 ?F (25 ?C) - (Inductive Load)		Min.2.5 Amps/ Max. 10 Amps continuous ***
Speed Sensor Signal		0.5 ~ 120 Volts RMS
Speed switch relay contacts (N.O. and N.C.)		10 Amps
RELIABILITY		
Vibration		1G @ 20 ~ 100 Hz
Testing		100% Functionally Tested
PHYSICAL		
Dimensions		See Outline
Weight		1.8 lbs (820 grams)
Mounting		Any Position, Vertical Preferred

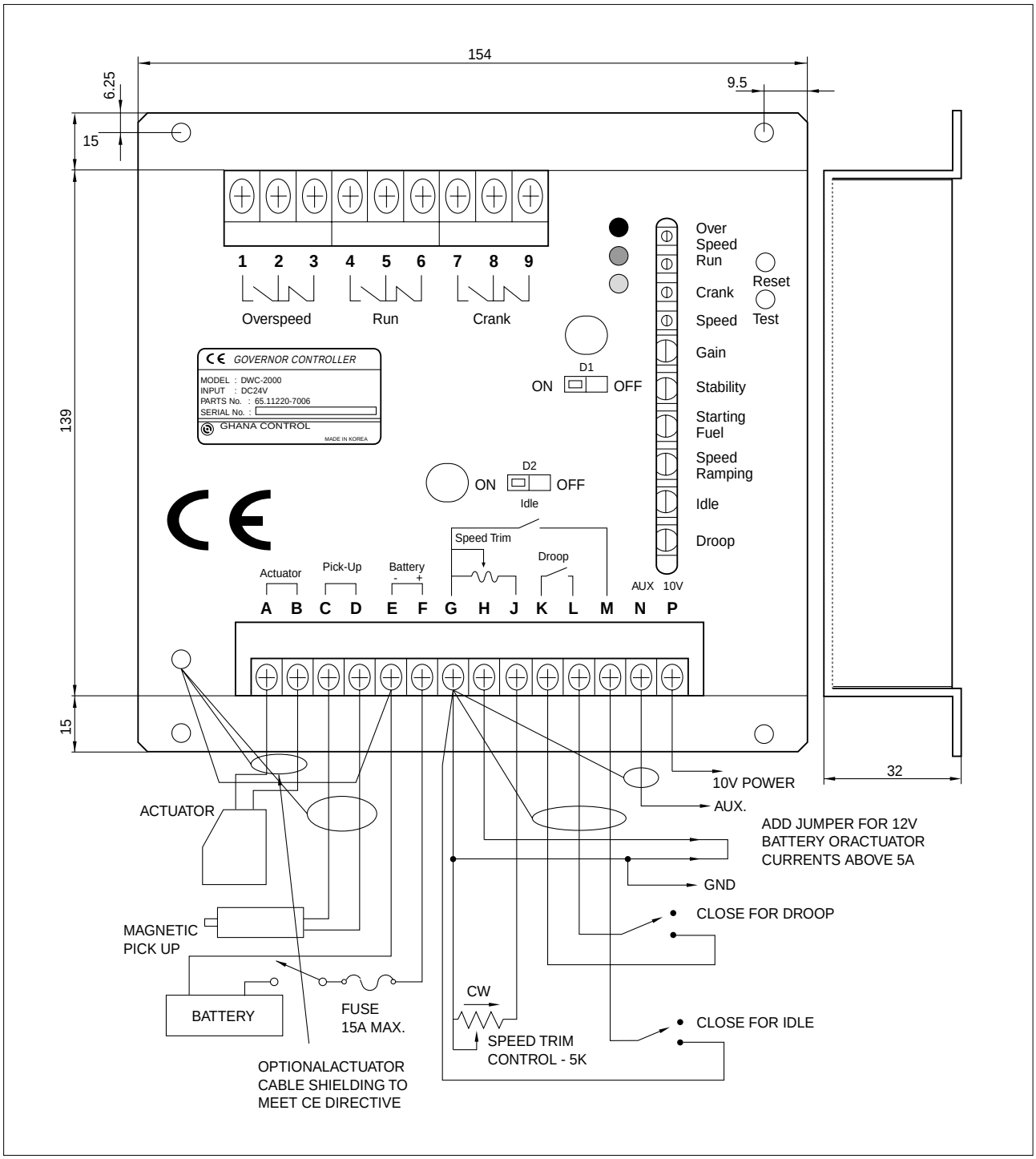
Note :

** Droop is based on a speed sensor frequency of 4,000 Hz and an actuator current. Change of 1 amp from no load to full load. Applications with higher speed sensor signals will experience less percentage of droop. Applications with more actuator current change will experience higher percentages of droop. See droop description for specific details on operation of droop ranges.*

*** Protected against reverse voltage by a series diode. A 15 Amp. fuse must be Installed in the positive battery lead.*

**** Protected against short circuit to actuator (shuts off current to actuator), unit automatically turns back on when shorts is removed.*

d) Wiring Diagram and outline (AD158TI / 180TI / 222TI)



Note :

- *If wire leads are longer than 3 meters (10 ft), a shielded cable should be used. Ground shield at one end only.*
- *The speed control unit is rugged enough to be placed in a control cabinet or engine mounted enclosure with other dedicated control equipment. If water, mist, or condensation may come in contact with the controller, it should be mounted vertically. This will allow the fluid to drain away from the speed control unit.*
- *Extremely heat should be avoided.*

Caution :

An overspeed shutdown device, independent of the governor system, should be provided to prevent loss of engine control which may cause personal injury or equipment damage. Do not rely exclusively on the governor system electric actuator to prevent overspeed. A secondary shutoff device, such as a fuel solenoid must be used.

e) Functions of the Control unit

1. STARTING FUEL : When starting engine at first, it controls the amount of starting fuel. If you turn it clockwise, the amount of fuel increases.

2. SPEED RAMPING : It controls time to be taken for the max. speed. If you turn it counter clockwise, the time to be reached the rating speed is reduced.

3. IDLE : Adjust the idle speed of the engine. If the engine rotates clockwise, the speed of the engine increases.

4. GAIN : It makes fluctuant rate of speed which generated from engine stable.

5. STABILITY : It makes fluctuant rate of speed according to the engine mounting stable.

6. SPEED : Adjust the engine speed. If engine rotates clockwise, engine speed increases.

7. OVER SPEED : Adjust engine over speed. If engine rotates clockwise, engine speed increases.

8. DROOP SPEED : It is used in parallel operation of generator.

9. RESET : It is used for initializing the over speed controller.

10. TEST : It is used for confirming and setting the over speed.

11. A, B TERMINAL : They are connected with actuator of the injection pump.

12. C, D TERMINAL : They are connected with magnetic pickup sensor, shield wire should be used. Don't use magnetic pickup sensor connected with them for other purpose.

13. E, F TERMINAL : They are connected with battery (E ⟶ - polar, F ⟶ + polar)

14. G,M TERMINAL : They are terminals for maintaining the idle speed.

15. K, L TERMINAL : They are terminals for droop.

16. H, J, N, P TERMINAL : They are subsidiary terminals.

f) Wiring

Basic electrical connections are illustrated above. Actuator and battery connections to Terminals A, B, E, and F should be #16AWG (1.3 mm^2) or larger.

Long cables require an increased wire size to minimize voltage drops.

The battery positive (+) input, Terminal F, should be fused for 15 amps as illustrated.

Magnetic speed sensor connections to Terminals C and D MUST BE TWISTED AND/OR SHIELDED for their entire length. The speed sensor cable shield should only be connected to terminal D. The shield should be insulated to insure no other part of the shield comes in contact with engine ground, otherwise stray speed signals may be introduced to the speed control unit. With the engine stopped,

adjust the gap between the magnetic speed sensor and the ring gear teeth. The gap should not be any smaller than 0.020 in, (0.45 mm). Usually, backing out the speed sensor 3/4 turn after touching the ring gear tooth will achieve a satisfactory air gap. The magnetic speed sensor voltage should be at least 1 VAC RMS during cranking.

g) Adjustments (Used new controller)

1. Before Starting Engine

① The GAIN and STABILITY adjustments are set to mid position.
② STARTING FUEL : FULL CW (Maximum Fuel)
③ SPEED RAMPING : FULL CCW (Fastest)
④ IDLE : FULL CW (Idle speed increase position)
⑤ Place the engine in idle by connecting Terminals M & G.

2. After Starting Engine

When starting engine at first, actuator activates forward “maximum fuel” position. After starting engine, adjust to maintain idle speed. The speed control unit governed speed setting is factory set at approximately engine idle speed. (1000 Hz, speed sensor signal)

① Adjust STARTING FUEL and SPEED RAMPING depending on engine running status.
② If the engine is unstable after starting, turn the GAIN and STABILITY adjustments counter-clockwise until the engine is stable.
③ After disconnecting Terminals M & G, turn SPEED to adjust maximum engine speed.
④ After connecting Terminals turn IDLE to set idle speed at 750 rpm. Then disconnect Terminal M & G, to recheck and readjust maximum engine speed.

3. Governor Speeding Setting

The governed speed set point is increased by clockwise rotation of the SPEED adjustment control. Remote speed adjustment can be obtained with an optional 5KΩ Speed Trim Control

4. Governor Performance

Once the engine is at operating speed and at no load, the following governor performance adjustment can be made.

① Rotate the GAIN adjustment clockwise until instability develops.
Gradually move the adjustment counterclockwise until stability returns.
Move the adjustment one division further counterclockwise to insure stable performance.
② Rotate the STABILITY adjustment clockwise until instability develops.
Gradually move the adjustment counterclockwise until stability returns.
Move the adjustment one division further to insure stable performance.
③ Gain and stability adjustments may require minor changes after engine load is applied. Normally, adjustments made at no load achieve satisfactory performance. A strip chart recorder can be used to further optimize the adjustments.

Note :
If instability cannot be corrected or further performance improvements are required, refer to the section on SYSTEM TROUBLESHOOTING.

5. Starting Fuel Adjustment

The engine's exhaust smoke at start-up can be minimized by completing the following adjustments.

① Place the engine in idle by connecting Terminals M & G.

② Adjust the IDLE speed for as low a speed setting as the application allows.

③ Adjust the STARTING FUEL CCW until the engine speed begins to fall, Increase the STARTING FUEL slightly so that the idle speed is returned to the desired level.

④ Stop the engine.

One of two methods of operation for the ESD5550 may now be selected.

Method 1) : Start the engine and accelerate directly to the operating speed (Generator Sets, etc.)

① Remove the connection between Terminals M & G. Start the engine and adjust the SPEED RAMPING for the least smoke on acceleration from idle to rated speed.

② If the starting smoke is excessive, the STARTING FUEL may need to be adjusted slightly CCW. If the starting time is too long, the STARTING FUEL may need to be adjusted slightly CW.

Method 2) : Start the engine and control at an idle speed for a period of time prior to accelerating to the operating speed. This method separates the starting process so that each may be optimized for the lowest smoke emissions.

① Replace the connection between Terminals M & G with a switch, usually an oil pressure switch. Start the engine. If the starting smoke is excessive, the STARTING FUEL may need to be adjusted slightly CCW. If the starting time is too long, the STARTING FUEL may need to be adjusted slightly CW.

② When the switch opens, adjust the SPEED RAMPING for the least amount of smoke when accelerating from idle speed to rated speed.

6. Idle Speed Setting

If the IDLE speed setting was not adjusted as detailed in "Starting Fuel Adjustment" section, then place the optional external selector switch in the IDLE position. The idle speed set point is increased by clockwise rotation of the IDLE adjustment control. When the engine is at idle speed, the speed control unit applies droop to the governor system to insure stable operation.

7. Speed Droop Operation

Droop is typically used for the paralleling of engine driven generators.

Place the optional external selector switch in the DROOP position, DROOP is increased by clockwise rotation of the DROOP adjustment control. When in droop operation, the engine speed will decrease as engine load increases.

The percentage of droop is based on the actuator current change from engine no load to full load. A wide range of droop is available with the internal control. Droop level requirements above 10% are unusual.

If droop levels experienced are higher or lower than those required, contact the factory for assistance.

After the droop level has been adjusted, the rated engine speed setting may need to be reset. Check the engine speed and adjust the speed setting accordingly.

8. Accessory input

The Auxiliary Terminal N accepts input signals from load sharing units, auto synchronizers, and other governor system accessories, accessories are directly connected to this terminal It is recommended that this connection from accessories be shielded as it is a sensitive input terminal.

If the auto synchronizer is used alone, not in conjunction with a load sharing module, a 3M ohm resistor should be connected between Terminals N and P This is required to match the voltage levels between the speed control unit and the synchronizer.

When an accessory is connected to Terminal N, the speed will decrease and the speed adjustment must be reset.

When operating in the upper end of the control unit frequency range, a jumper wire or frequency trim control may be required between Terminals G and J. This increases the frequency range of the speed control to over 7000 Hz.

9. Accessory Supply

The +10 volt regulated supply, Terminal P, can be utilized to provide power to governor system accessories. Up to 20mA of current can be drawn from this supply. Ground reference is Terminal G. A short circuit on this terminal can damage the speed control unit.

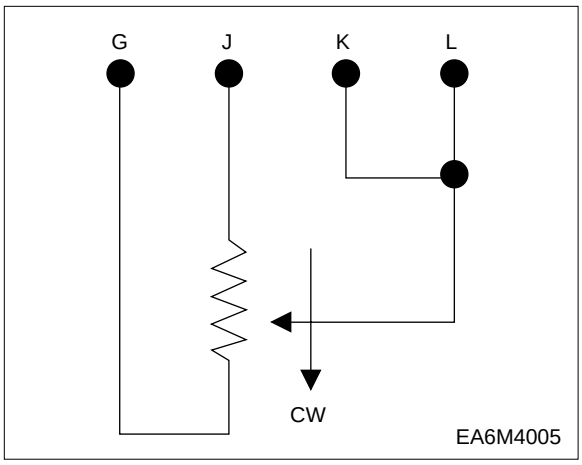
10. Wide Range Remote Variable Speed Operation

A single remote speed adjustment potentiometer can be used to adjust the engine speed continuously over a specific speed range. Select the desired speed range and the corresponding potentiometer value. (Refer to “Speed Range Potentiometer Value”) If the exact range cannot be found, select the next higher range potentiometer. An additional fixed resistor may be placed across the potentiometer to obtain the exact desired range. Connect the speed range potentiometer as shown in the next diagram.

<Speed Range Potentiometer Value>

Speed Range	Potentiometer Value
900 Hz.	1K
2,400 Hz.	5K
3,000 Hz.	10K
3,500 Hz.	25K
3,700 Hz.	50K

* Select Proper Potentiometer Value



Caution :

To maintain engine stability at the minimum speed setting, a small amount of droop can be added using the DROOP adjustment. At the maximum speed setting the governor performance will be near isochronous, regardless of the droop adjustment setting.

Contact the factory for assistance if difficulty is experienced in obtaining the desired variable speed governing performance.

h) System Trouble shooting

1. System Inoperative

If the engine governing system does not function, the fault may be determined by performing the voltage tests described in Steps 1, 2, 3, and 4.Be careful of the meter polarities measuring. Should normal values be indicated as a result of following the trouble shooting steps, the fault may be with the actuator or the wiring to the actuator See the actuator publication for testing details.

STEP	TERMINALS	NORMAL READING	PROBABLE CAUSE OF ABNORMAL READING
1	F(+) & E(-)	Battery supply voltage (12 or 24 VDC)	1. DC battery power not connected. Check for blown fuse 2. Low battery voltage. 3. Wiring error.
2	C & D	1.0 VAC RMS min., while cranking	1. Gap between speed sensor and gear teeth too great. Check gap. 2. Improper or defective wiring to the speed sensor. Resistance between terminals C and D should be 30 to 1,200 ohms. 3. Defective speed sensor.
3	P(+) & G(-)	10 VDC, Internal Supply	1. Short on terminal P (This will cause a defective unit.) 2. Defective Speed Control.
4	F(+) & A(-)	1.0 ~ 2.0 VDC while cranking	1. **SPEED** adjustment set too low 2. Short/open in actuator wiring. 3. Defective speed control. 4. Defective actuator.

2. Unsatisfactory Performance

If the governing system functions poorly, perform the following tests.

SYMPTOM	TEST	PROBABLE FAULT
Engine overspeeds	**1. Do not crank.** Apply DC power to the governor system.	**1.** Actuator goes to full fuel. Then, disconnect speed sensor at Terminals C & D. If actuator still at full fuel speed control unit defective. If actuator at minimum fuel position - erroneous speed signal. Check speed sensor data.
	2. Manually hold the engine at the desired running speed. Measure the DC voltage between Terminals A(-) & F(+) on the speed control unit.	**1.** If the voltage reading is 1.0 to 2.0 VDC. a) **SPEED** adjustment set above desired speed. b) Defective speed control unit.
		2. If the voltage reading is above 2.0 VDC, a) Actuator or linkage binding.
		3. If the voltage reading is below 1.0 VDC, a) Defective speed control unit.
		4. Gain set too low.
Actuator does not energize fully.	**1.** Measure the voltage at the battery while cranking.	**1.** If the voltage is less than 7V for a 12V system, or14V for a 24V system, replace the battery if it is weak or undersized.
	2. Momentarily connect Terminals A and F The actuator should move to the full fuel position.	**1.** Actuator or battery wiring in error.
		2. Actuator or linkage binding.
		3. Defective actuator.
		4. Fuse opens. Check for short in actuator or actuator wiring harness.
Engine remains below desired governed speed.	**1.** Measure the actuator output. Terminals A & B, while running under governor control.	**1.** If voltage measurement is within approximately 2 volts of the battery supply voltage, then fuel control restricted from reaching full fuel position. Possibly due to interference from the mechanical governor, carburetor spring or linkage alignment.
		2. Speed setting too low.

3. Insufficient Magnetic speed Sensor Signal

A strong magnetic speed sensor signal will eliminate the possibility of missed or extra pulses. The speed control unit will govern well with 0.5volts RMS speed sensor signal. A speed sensor signal of 3volts RMS or greater at governed speed is recommended. Measurement of the signal is made at Terminals C and D.

4. Electromagnetic Compatibility (EMC)

The governor system can be adversely affected by large interfering signals that are conducted through the cabling or through direct radiation into the control circuits.

All speed control units contain filters and shielding designed to protect the units sensitive circuits from moderate external interfering sources.

Although it is difficult to predict levels of interference, applications that include magnetos, solid state ignition systems, radio transmitters, voltage regulators or battery chargers should be considered suspect as possible interfering sort traces.

If it is suspected that external fields, either those that are radiated or conducted, are or will affect the governor systems operation, it is recommended to use shielded cable for all external connections.

Be sure that only one end of the shields, including the speed sensor shield, Is connected to a single point on the case of the speed control unit. Mount the speed control unit to a grounded metal back plate or place it in a sealed metal box.

Radiation is when the interfering signal is radiated directly through space to the governing system To isolate the governor system electronics from this type of interference sort roe, a metal shield or a solid metal container is usually effective.

Conduction is when the interfering signal is conducted through the interconnecting wiring to the governor system electronics. Shielded cables and installing filters are common remedies.

As an aid to help reduce the levels of EMI of a conductive nature, a battery line filter and shielded cables are conveniently supplied by KT130. To reduce the levels of EMI of a radiated nature, a shielded container P/N CA114 can be sourced from GAC and its distributors.

In severe high energy interference locations such as when the governor system is directly in the field of a powerful transmitting source, the shielding may require to be a special EMI class shielding. For these conditions, contact GAC application engineering for specific recommendations.

5. Instability

Instability in a closed loop speed control system can be categorized into two general types.

① PERIODIC appears to be sinusoidal and at a regular rate.

② NON-PERIODIC is a random wandering or an occasional deviation from a steady state band for no apparent reason

Switch C1 controls the “Lead Circuit” found. The normal position is “ON “ Move the switch to the “OFF” position if there is fast instability in the system.

Switch C2 controls an additional circuit added is designed to eliminate fast erratic governor behavior, caused by very soft or worn couplings in the drive train between the engine and generator.

The normal position is “OFF”. Move to the “ON” position if fast erratic engine behavior due to a soft coupling is experienced.

The PERIODIC type can be further classified as fast or slow instability. Fast instability is a 3Hz. or faster irregularity of the speed and is usually a jitter Slow periodic instability is below 3Hz., can be very slow, and is sometimes violent.

If fast instability occurs, this is typically the governor responding to engine firings.

Raising the engine speed increases the frequency of Instability and vice versa.

In this case, placing switch C1 in the “OFF” position will reduce the speed control unit’s sensitivity to high frequency signals.

Readjust the GAIN and STABILITY for optimum control Should instability still be present, the removal of E1 to E2 jumper may help stabilize the engine. Post locations are illustrated. Again, readjust the GAIN and STABILITY for optimum control. Interference from powerful electrical signals can also be the cause. Turn off the battery chargers or other electrical equipment to see if the system disappears.

Slow instability can have many causes. Adjustment of the GAIN and STABILITY usually cures most situations by matching the speed control unit dynamics. If this is unsuccessful, the dead time compensation can be modified. Add a capacitor from posts E2 to E3 (negative on E2). Post locations are illustrated. Start with 10mfds. and increase until instability is eliminated. The control system can also

be optimized for best performance by following this procedure.

If slow instability is unaffected by this procedure, evaluate the fuel system and engine performance. Check the fuel system linkage for binding, high friction, or poor linkage. Be sure to check linkage during engine operation. Also look at the

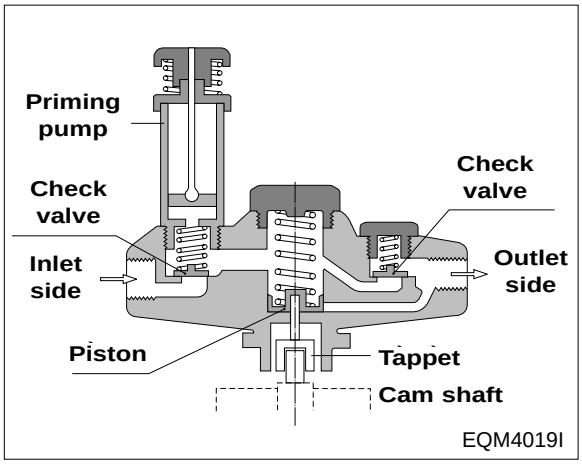
engine fuel system. Irregularities with carburetion or fuel injection systems can change engine power with a constant throttle setting Th is can result in speed deviations beyond the control of the governor system. Adding a small amount of droop can help stabilize the system for troubleshooting.

NON-PERIODIC instability should respond to the GAIN control. If increasing the gain reduces the instability, then the problem is probably with the engine. Higher gain allows the governor to respond faster and correct for disturbance. Look for engine misfirings, an erratic fuel system, or load changes on the engine generator set voltage regulator If the throttle is slightly erratic, but performance is fast, move switch C1 to the “OFF” position. This will tend to steady the system.

If unsuccessful in solving Instability, contact the factory for assistance.

7.3.3. Fuel feed pump

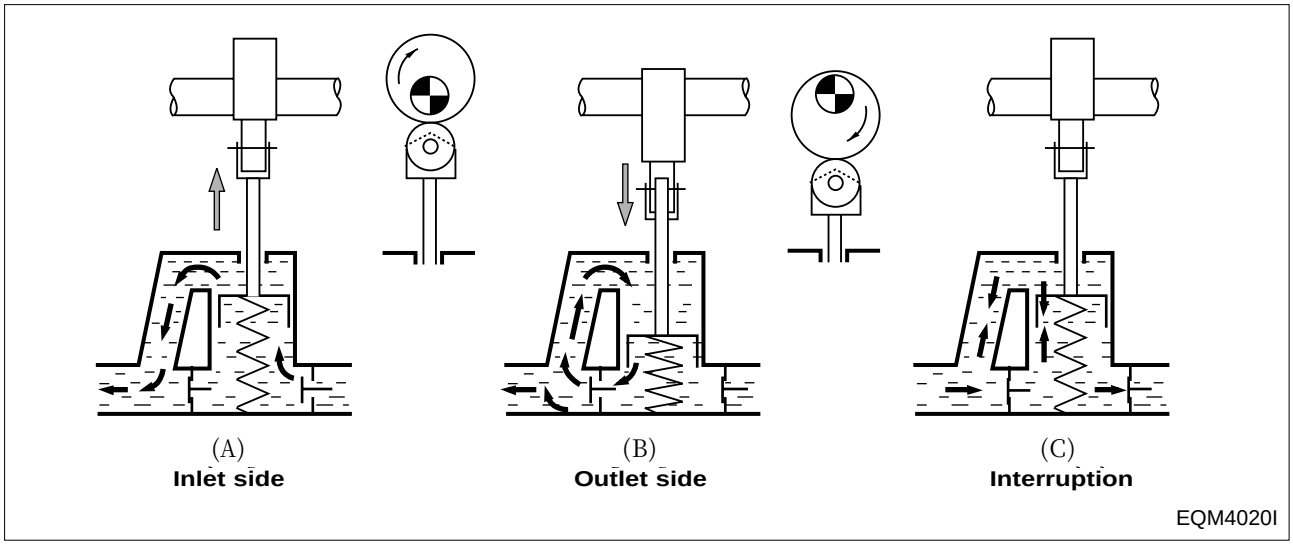
1) General descriptions and construction



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 :

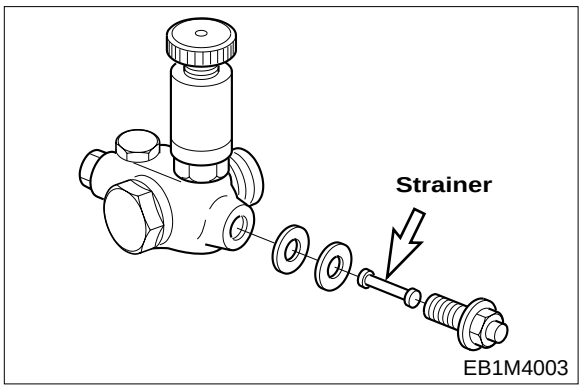
The figures show its construction (right figure) and operation (below figure). The piston in the fuel feed pump is driven by the push rod and tappet via the camshaft of injection pump and performs reciprocating operation to control the suction and delivery of fuel. When the cam reaches the Bottom Dead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

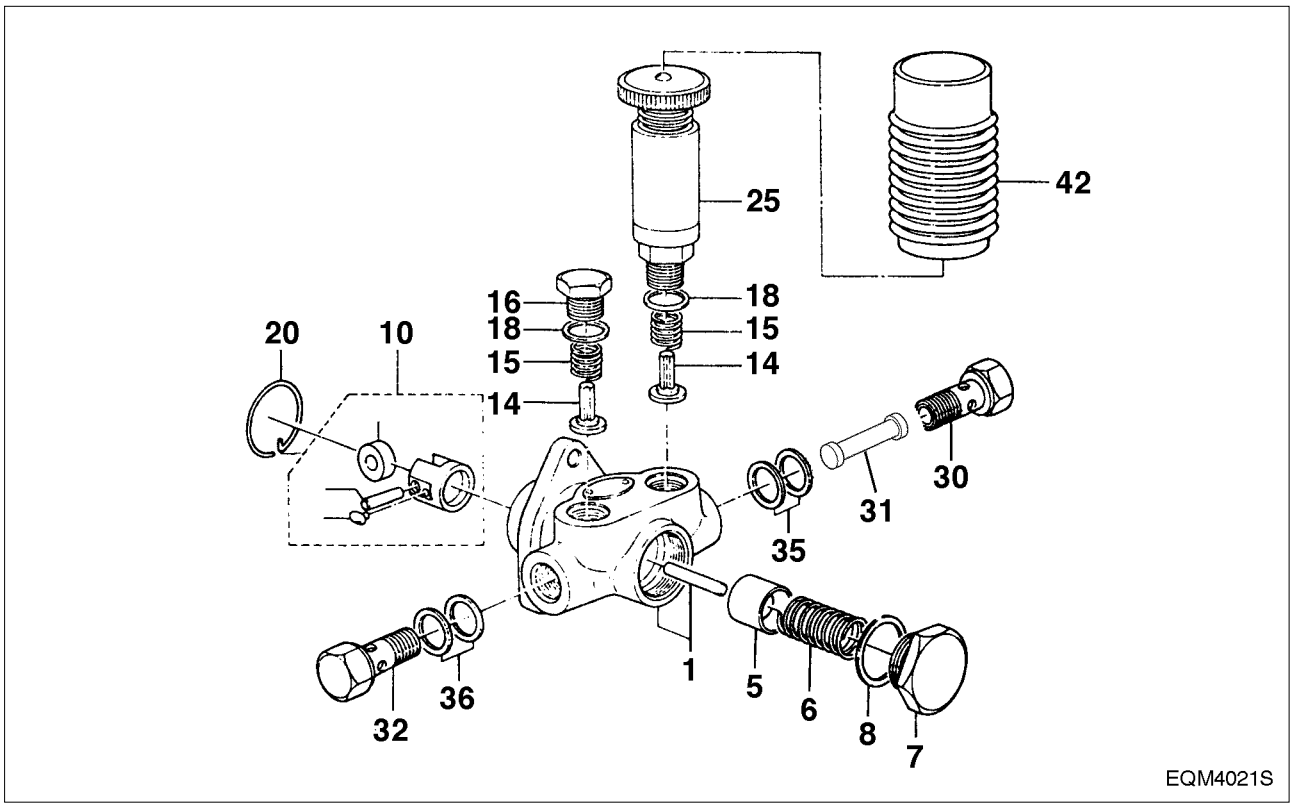


This feed pump is mounted with a priming pump designed to permit manual feeding of fuel from the fuel tank with the injection pump mounted in the engine. During the manual feeding operation, air must be bled from the fuel lines. When using the priming pump, fix it securely to prevent the possible entry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

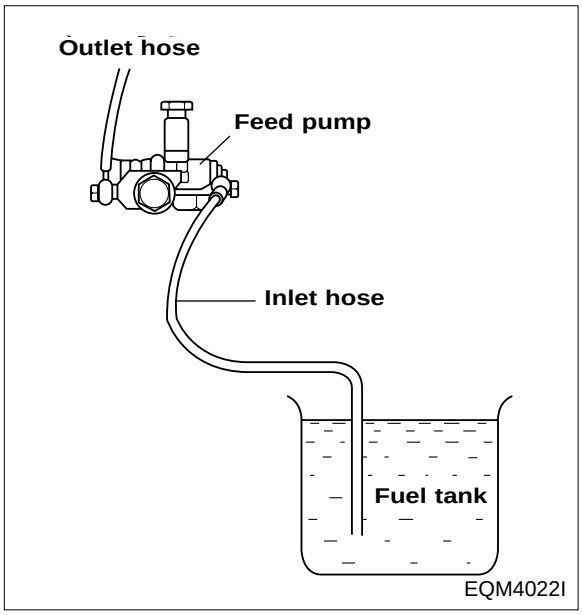
4) Re-assembly

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

5) Testing

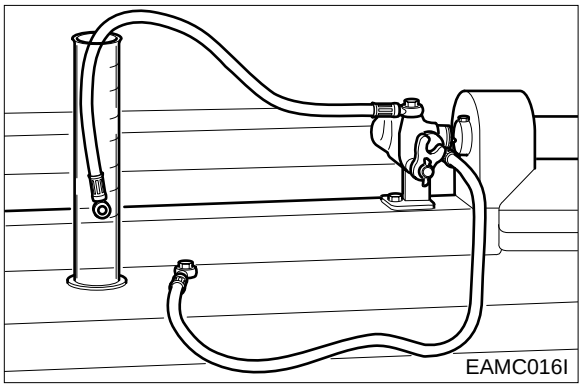
(1) Suction capacity test

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.



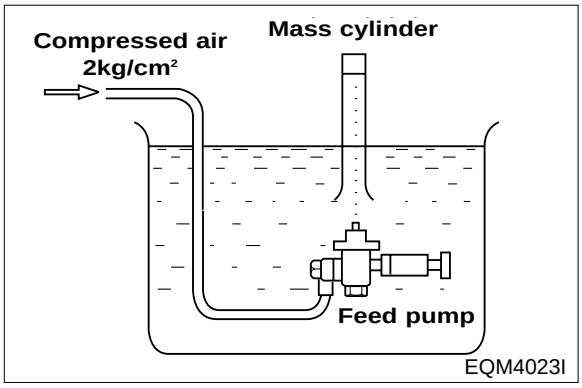
(2) Delivery test

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.



(3) Sealing test

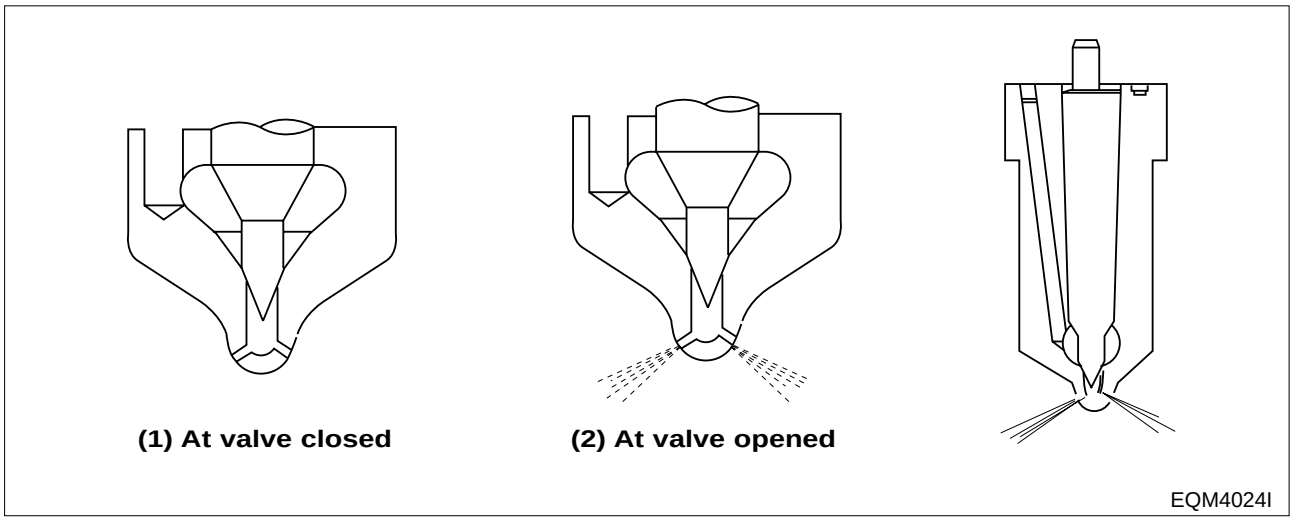
Plug up the delivery port on the feed pump and apply compressed air of 2 kg/cm^2 into the inlet side.
Submerge the feed pump in a container of diesel fuel and check for air leak.



7.3.4. Injection nozzle

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

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

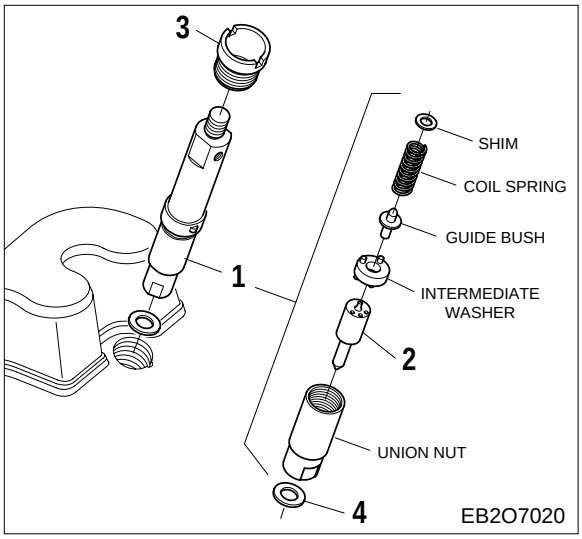


1) Structure

A copper seal fitted to the injector ensures gas-tight seating and good heat dissipation.

The opening pressure of the nozzle is adjusted by means of shims at the compression spring.

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



2) Maintenance

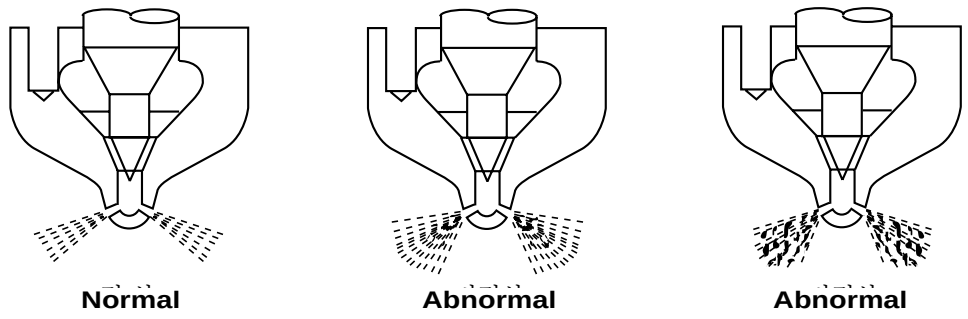
- After removing carbon deposit, submerge the nozzle in diesel oil and clean it.
- Replace all the gaskets with new ones.
- Assemble the parts and tighten them to specified torque.

3) Inspection and Adjustment

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

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

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



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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

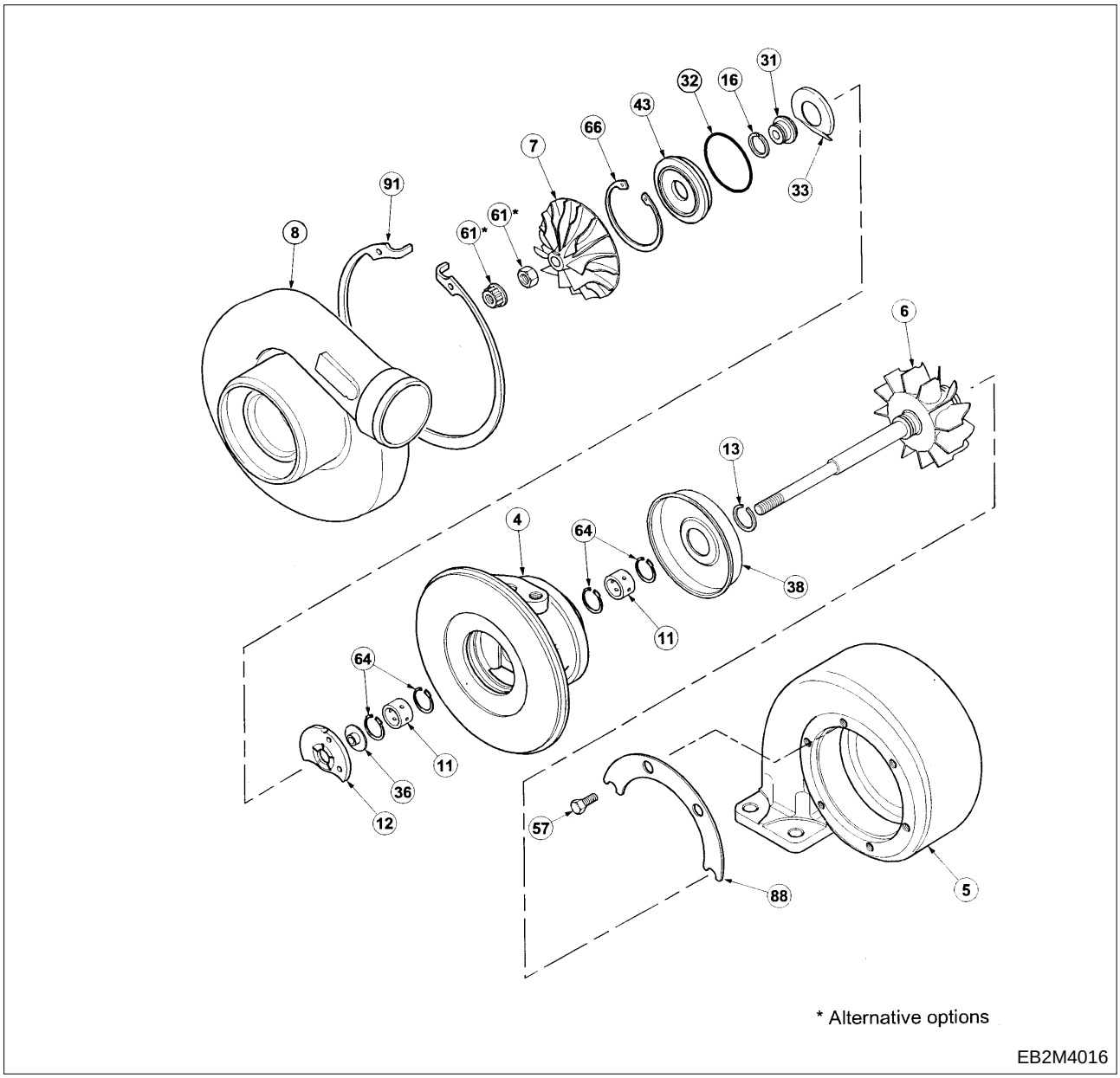
7.4.1. Specification

Items		Specification		
Engine Model		**V158TIE/V158TI**	**V180TIH**	**V222TIH**
Turbo-charger (HOLSET)		HX35M	H2DM	
At continuous output	Air pressure at compressor outlet	≈ 1.05 kg/cm²	≈ 1.15 kg/cm²	
	Air suction volume	≈ 11.0 m³/min	≈ 13.5 m³/min	
	Turbine speed	≈ 83,000 rpm	≈ 80,000 rpm	
Maximum allowable speed		≈ 130,000 rpm	≈ 115,000 rpm	
Maximum allowable exhaust gas temperature (Turbine Inlet)		700 ˚C		
Lubricating system		External oil supply		
Weight		≈ 17 kg	≈ 18 kg	

Items		Specification		
Engine Model		**V158TIM**	**V180TIM**	**V222TIM**
Turbo-charger (HOLSET)		HX35M	H2DM	
At continuous output	Air pressure at compressor outlet	≈ 1.15 kg/cm²	≈ 1.45 kg/cm²	
	Air suction volume	≈ 14.0 m³/min	≈ 18.5 m³/min	
	Turbine speed	≈ 106,000 rpm	≈ 94,000 rpm	
Maximum allowable speed		130,000 rpm	115,000 rpm	
Maximum allowable exhaust gas temperature (Turbine Inlet)		700 ˚C		
Lubricating system		External oil supply		
Weight		17 kg	18 kg	

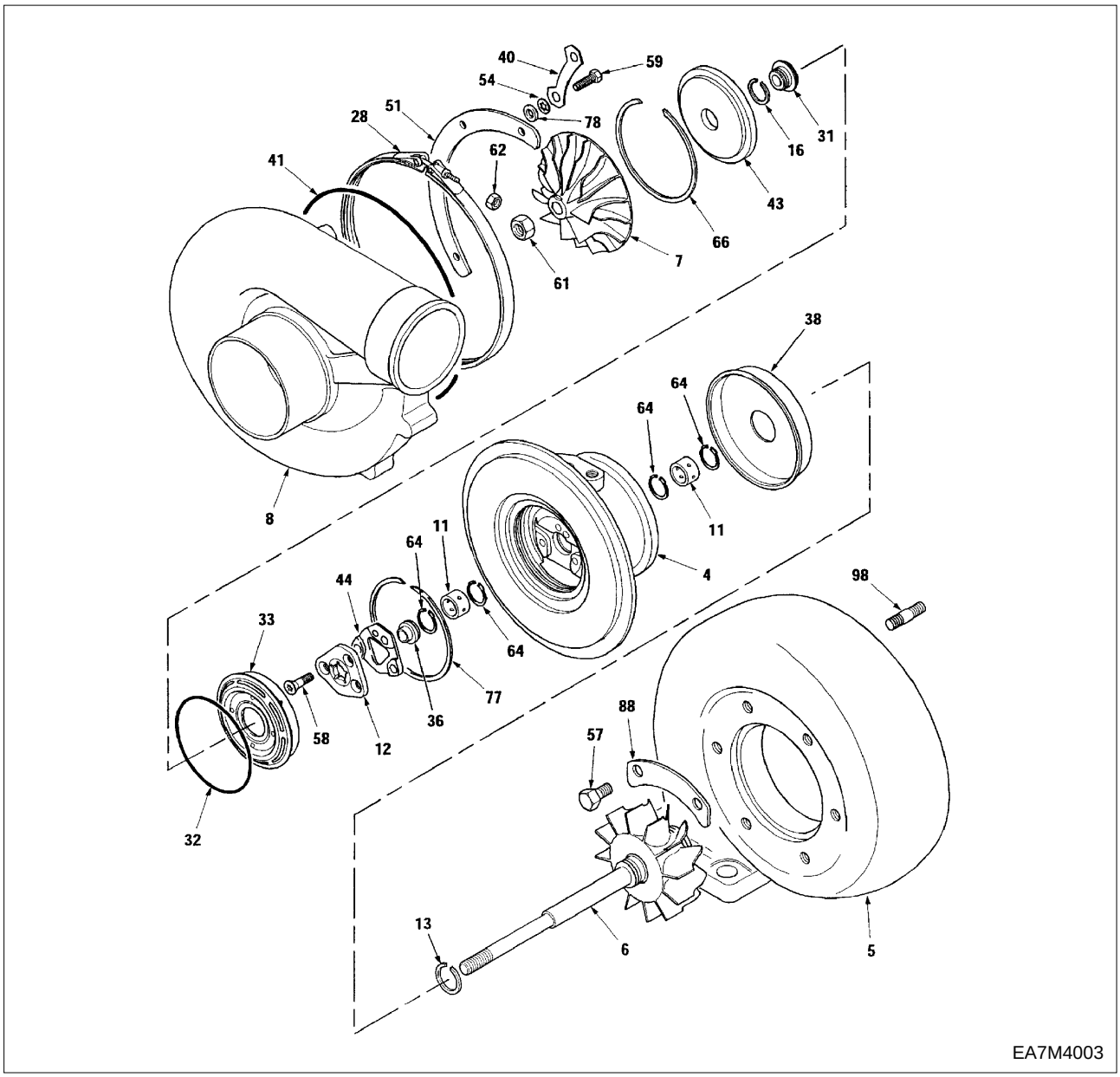
7.4.2. Construction of the turbo-charger

1) HX35M (for V158TIE, V158TIH, V158TIM)



4. Bearing housing
5. Turbine housing
6. Assembly turbine wheel
7. Compressor wheel
8. Compressor housing
11. Journal bearing
12. Thrust bearing
13. Piston ring seal, turbine
16. Piston ring seal, compressor
22. Retaining ring
31. Oil slinger
32. O ring seal, bearing housing
33. Oil baffle
34. Inlet baffle
36. Thrust collar
38. Heat shield
43. Oil seal plate
57. Bolt, turbine housing (HX35/40)
61. Lock nut, compressor wheel
64. Ring retainer bearing (Snap ring)
66. Insert, retaining ring
88. Clamp plate, turbine housing
91. Compressor cover retaining ring

2) H2DM (for V180TIH, V180TIM, V222TIH, V222TIM)



2. Center housing rotating assembly
4. Bearing Housing
5. Turbine housing
6. Assembly turbine wheel
7. Compressor wheel
8. Compressor housing
11. Journal bearing
12. Thrust bearing
13. Piston ring seal, turbine
16. Piston ring seal, compressor
29. V-band clamp
31. Oil slinger
32. O ring seal, bearing housing
33. Oil baffle
36. Thrust collar
38. Heat shield
40. Lock plate compressor
41. O ring seal, compressor
43. Oil seal plate
44. Thrust bearing spacer
51. Clamp plate, compressor cover
54. Lock washer, compressor
57. Bolt, turbine housing
58. Screw thrust bearing
59. Bolt compressor cover
61. Lock nut, compressor wheel
62. V-band lock nut
64. Ring retainer bearing
66. Insert, retaining ring
77. Flat retaining ring
78. Washer, compressor
88. Clamp plate, turbine

7.4.3. Inspection

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

1) Checking of the rotor for rotating condition

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

2) Checking of the rotor end play

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

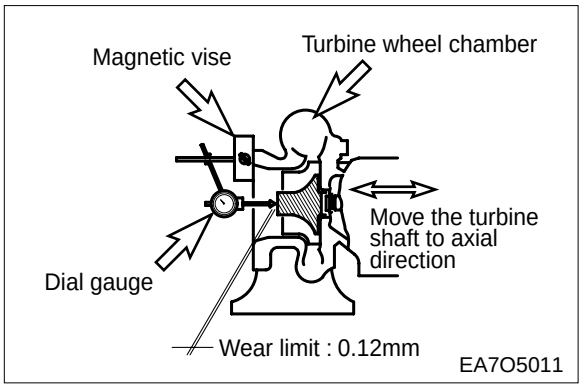
Disassemble the turbocharger from the engine, then check the rotor axial play and radial play.

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

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

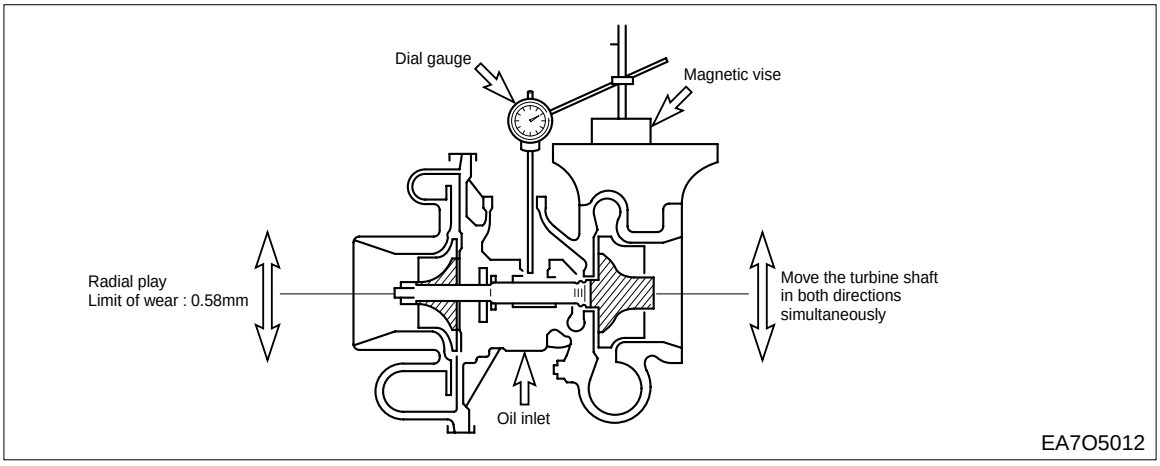
● **Measuring rotor axial clearance**

Axial clearance	0.12 mm



● **Measuring radial clearance**

Radial clearance	0.58 mm



3) Precautions for reassembling the turbocharger onto the engine

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

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

(1) Lubricating system

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

(2) Intake system

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

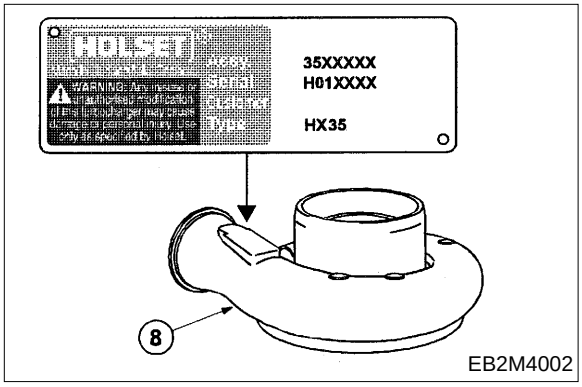
(3) Exhaust system

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

7.4.4. Component Identification

1) Turbocharge identification

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



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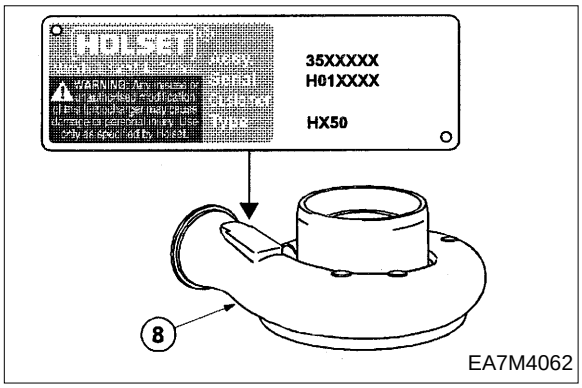

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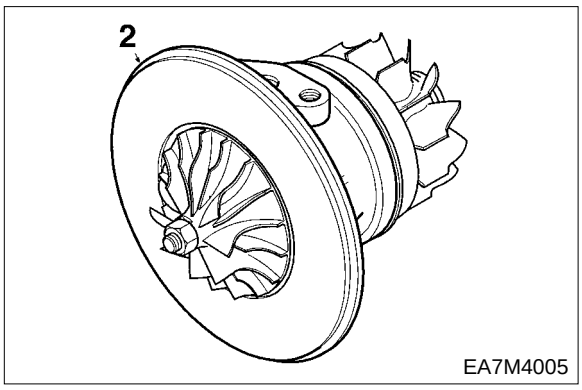
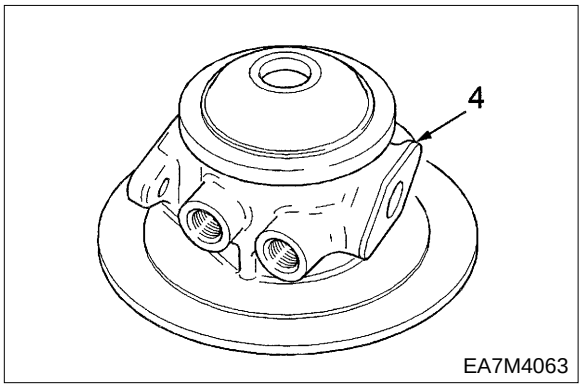
2) Center housing rotating assembly



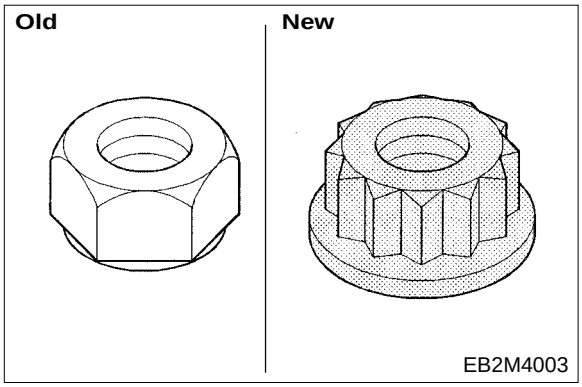
3) Watercooled bearing housing (4)

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



4) New compressor wheel lock nut (61)

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



Caution :

Always use specified torque.

Failure to do so may result in turbocharger/ engine failure.

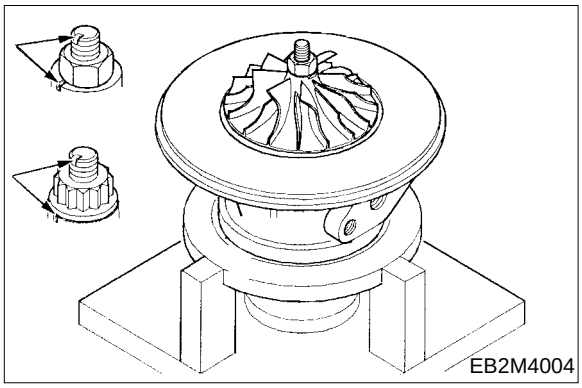
Torque value	Nm	lb ins
New lock nut	17	150
Old lock nut	16	160

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.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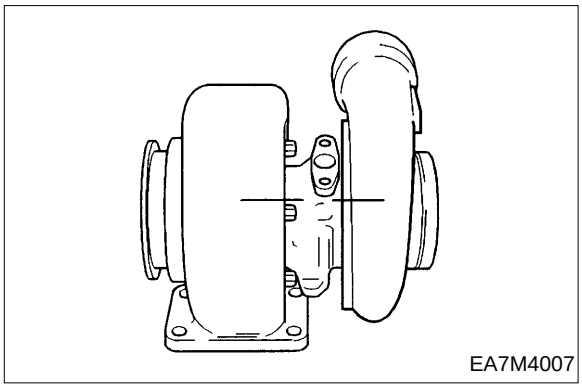
7.4.5. Disassembly

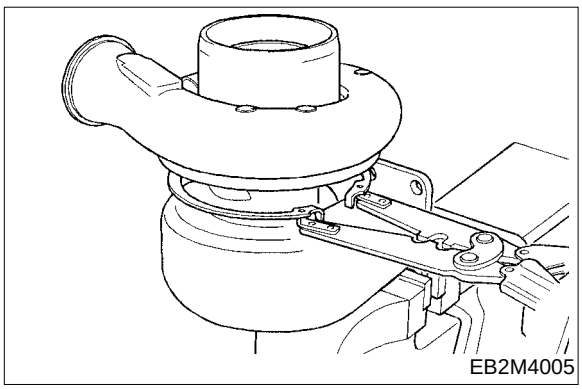
- Before disassembling the turbocharger, scribe the parts listed below to help in alignment during assembly.

  - compressor housing (8)
  - turbine housing (5)
  - bearing housing (4)


EA7M4007

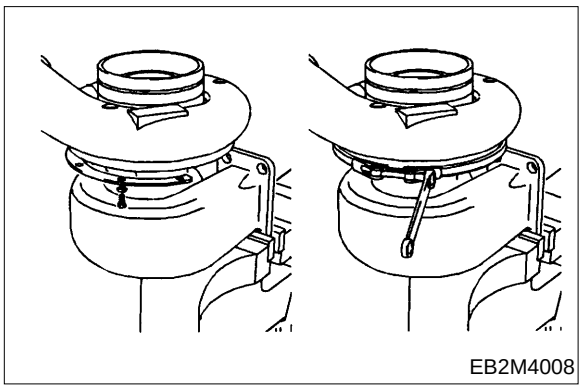
- Secure the turbine housing (5) in a vice.

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


EB2M4005

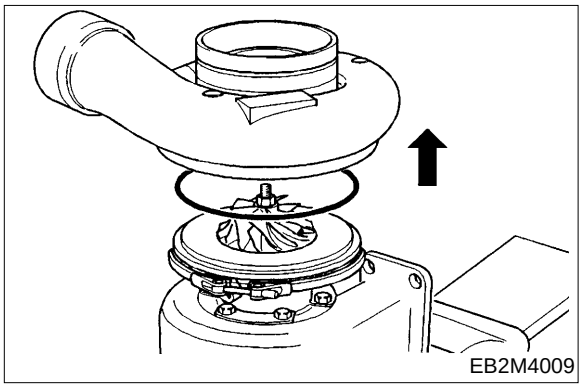
HX50 : Loosen and remove the 8 bolts (59) lock washers (54) clamp plates (51).

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

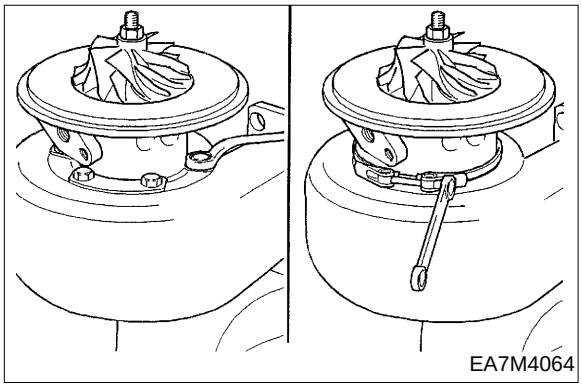

EB2M4008

- 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.

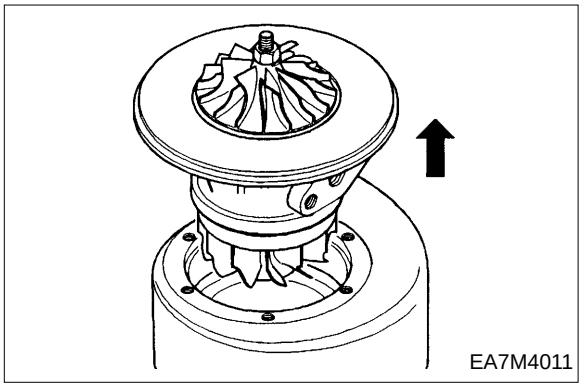

EB2M4009

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

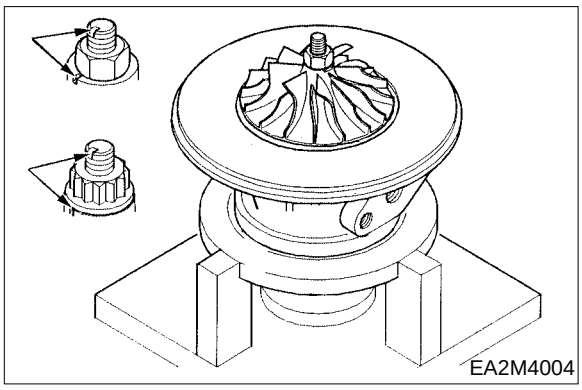

EA7M4064

- Remove the CHRA from the turbine housing.

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


EA7M4011

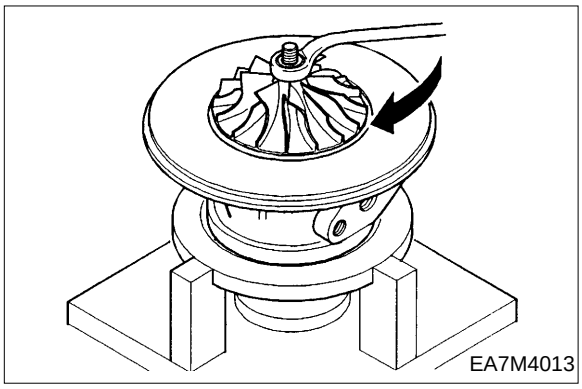
● Locate the Center Housing Rotating Assembly (CHRA) onto a 19mm socket clamped in the jaws of a vice or a suitable fixture.


EA2M4004

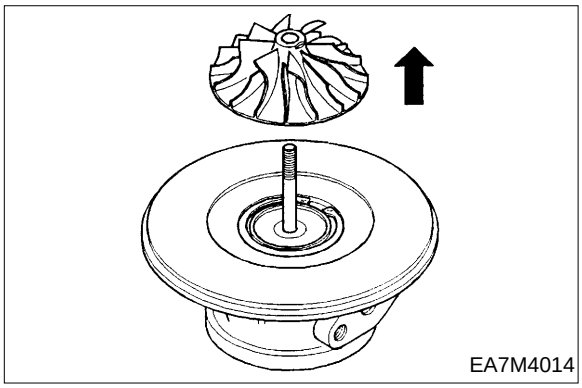
Caution :
Always make sure the turbine wheel shaft and the compressor wheel have alignment marks before disassembly of the CHRA.
If no marks exist, scribe the shaft and compressor wheel (as shown) before removing the compressor wheel lock nut. (refer to 4.3.4.)

● Remove the compressor wheel lock nut (61).

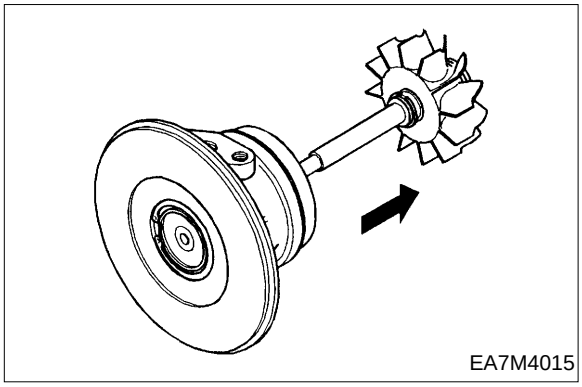
Note :
Left hand thread.


EA7M4013

● Remove the compressor wheel (7).


EA7M4014

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

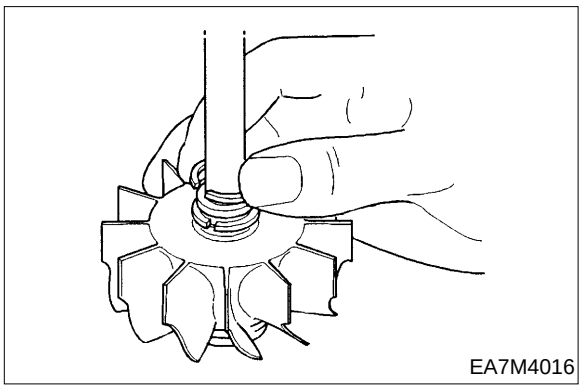

EA7M4015

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

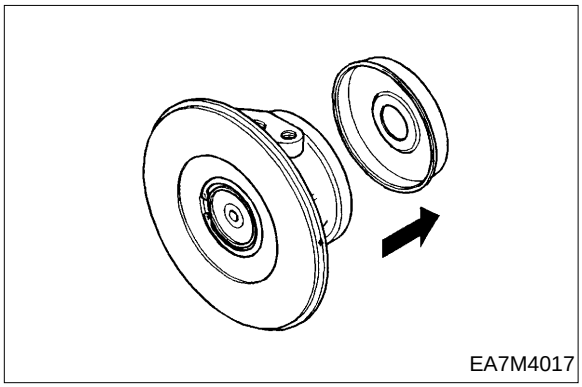
- HX35(V158TI) : 1EA

- HX50(V180TI/V222TI) : 2EA

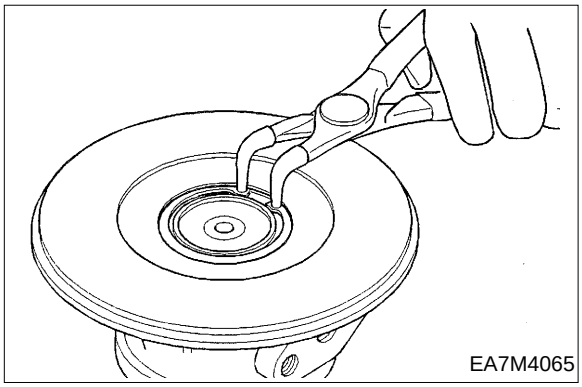
Caution :
Care should be taken not to score the assembly turbine wheel shaft.


EA7M4016

● Remove the heat shield (38).

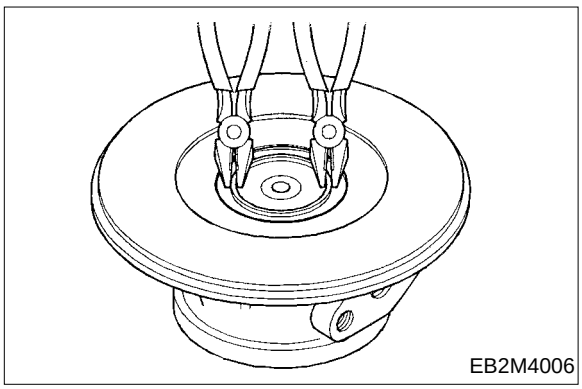

EA7M4017

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

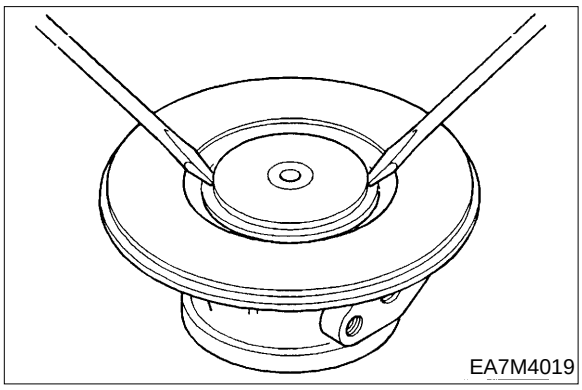

EA7M4065

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

- HX35 : Using two flat nose pliers

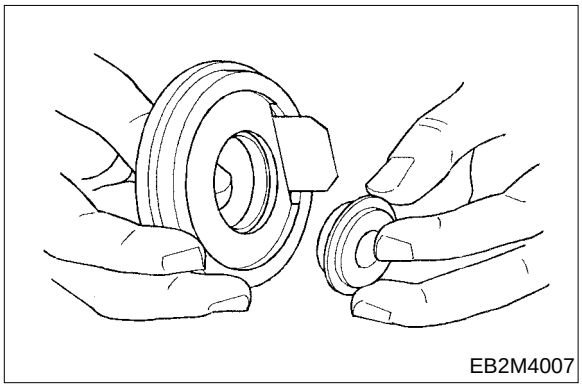

EB2M4006

- HX50 : Using two flat screwdrivers.

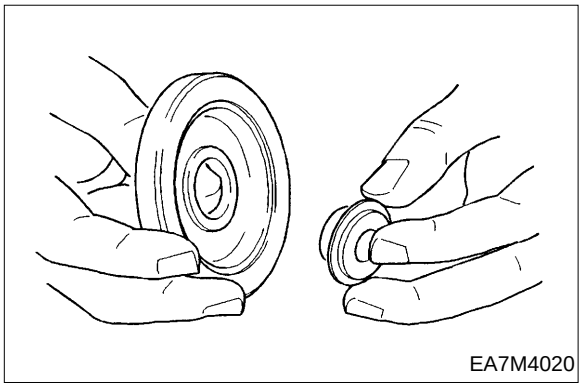

EA7M4019

● Remove the oil slinger (31).

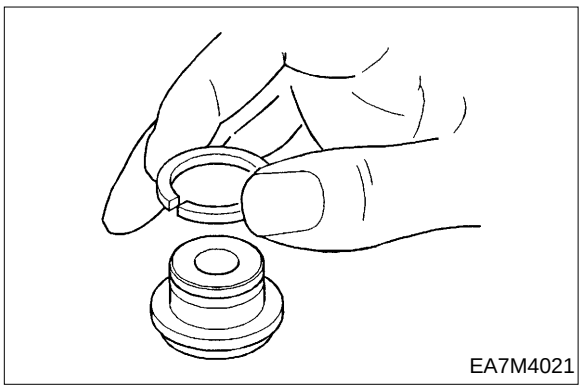
- HX35


EB2M4007

- HX50

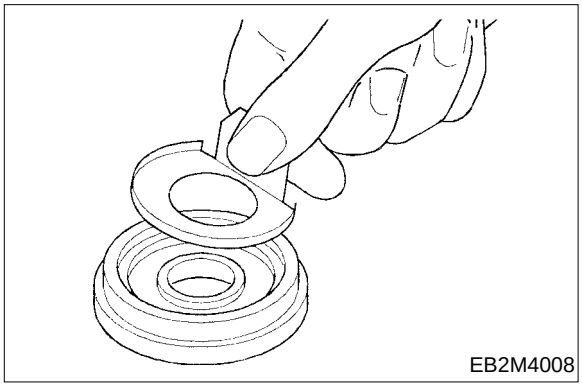

EA7M4020

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

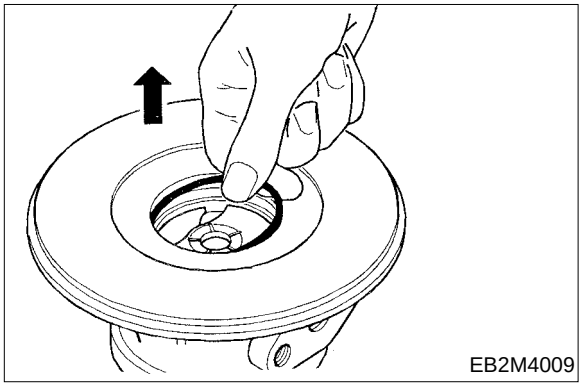

EA7M4021

<HX35>

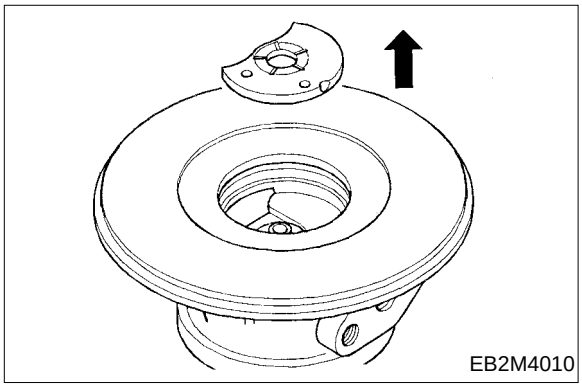
● Remove and discard the oil baffle (33).



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

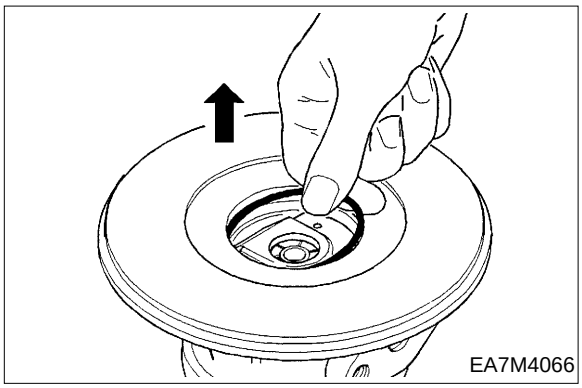


● Remove the thrust bearing (12).

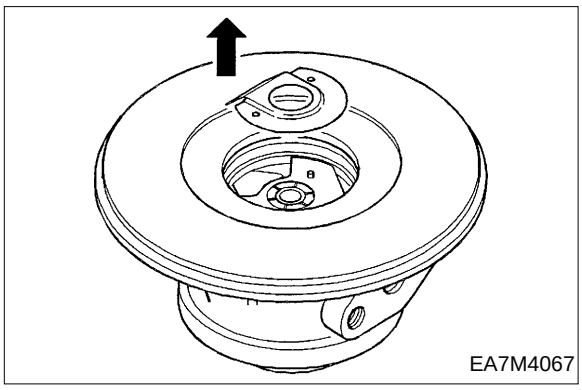


<HX50>

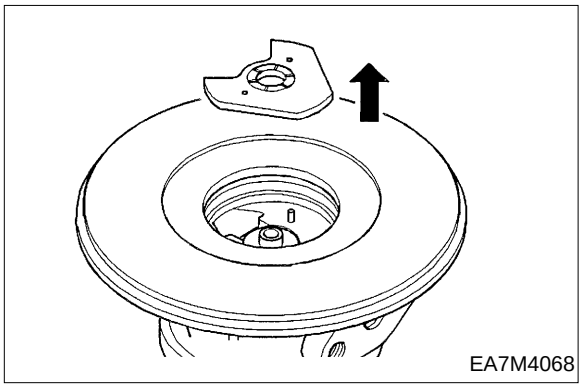
● Remove and discard the O ring seal (32).



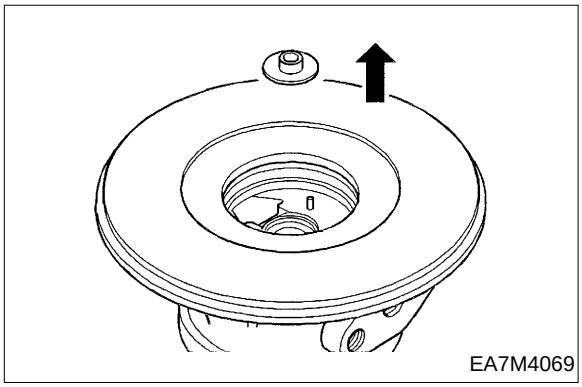
● Remove and discard the oil baffle (33).



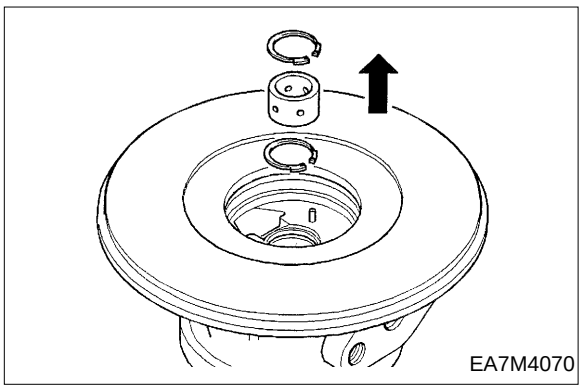
● Remove the thrust bearing (12).



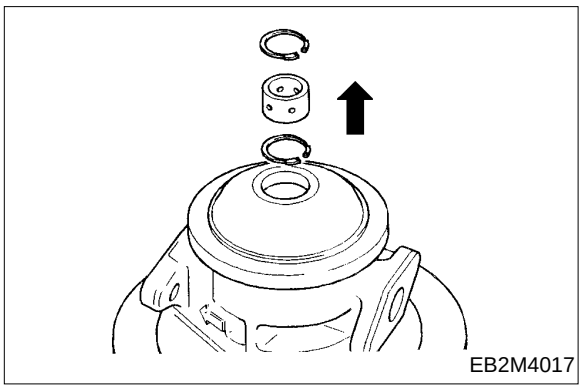
● Remove the thrust collar (36).



● 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.


EB2M4017

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.

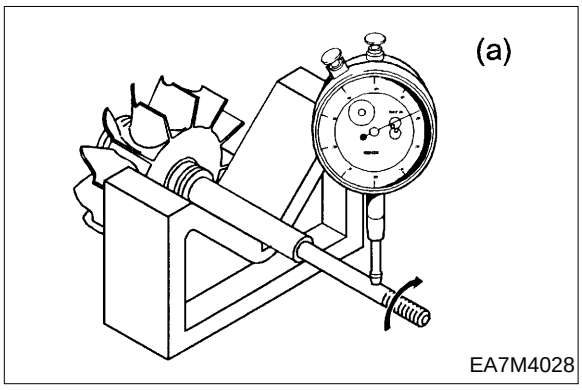
Caution :
Shot blasting specific areas for long periods of time may effect component balance.

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.

a) Place the shaft on a vee 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).



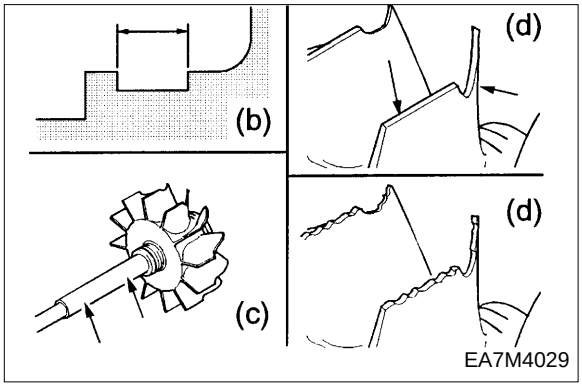
EA7M4028

Shaft Bend (Max.)	mm	in.
	0.025	0.001

<Major Components>

● Assembly Turbine Wheel (6)

b) Inspect the piston ring groove walls for wear.



- HX35 (V158TI)

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

- HX50 (V180TI/ V222TI)

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

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

- HX35 (V158TI)

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

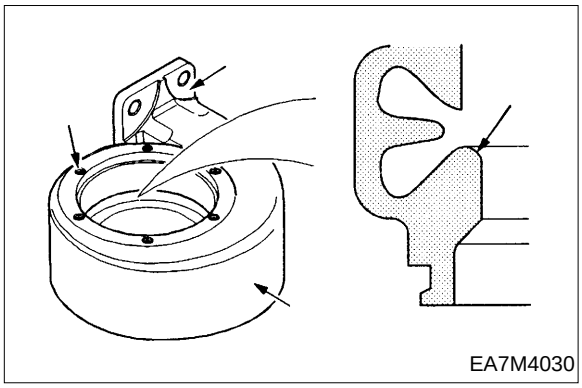
- HX50 (V180TI/ V222TI)

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

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

● Turbine Housing (5)

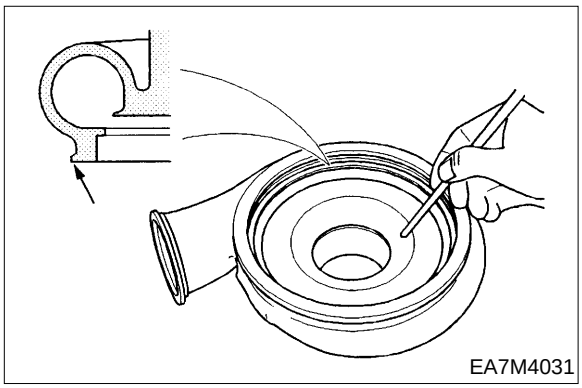
Inspect the profile for damage caused by possible contact with the rotor. Check all threads for damage. Inspect the outer and internal walls for cracks or flaking caused by overheating also check mounting flanges for signs of distortion. Replace with new if any of the above are visible.



● **Compressor Housing (8)**

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

Replace with new if any of the above are visible.


EA7M4031

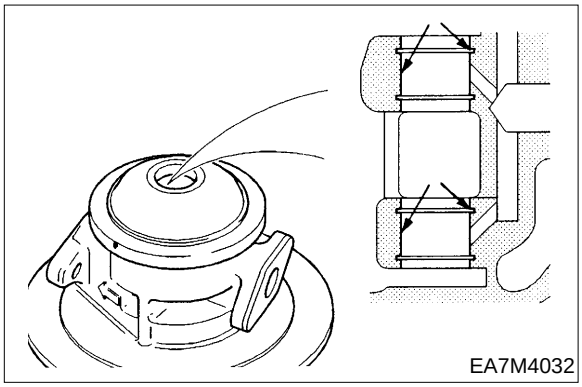
● **Bearing Housing (4)**

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)

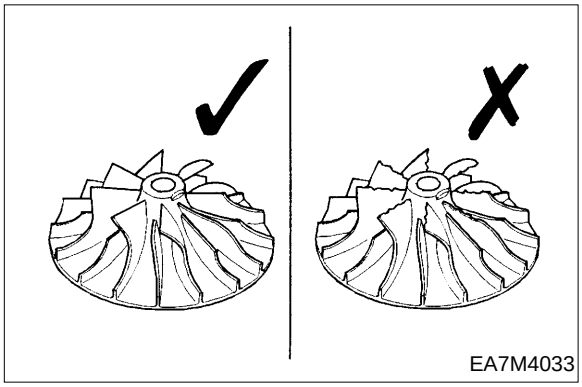
Bearing Housing Bore (Max.)	mm	in.
	15.885	0.6254


EA7M4032

● **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.

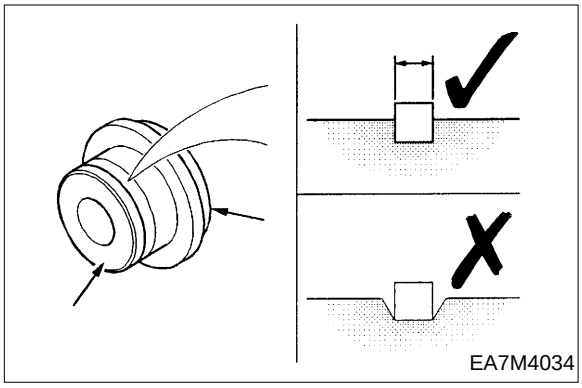

EA7M4033

<Minor Components>

● **Oil slinger (31)**

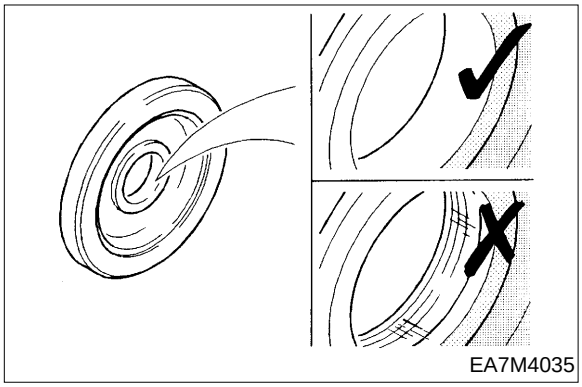
Inspect and replace if the piston ring seal groove walls are scored or damaged. Also check for signs of rubbing on the flat surfaces.

Groove Width (Max.)	mm	in.
	1.664	0.0665


EA7M4034

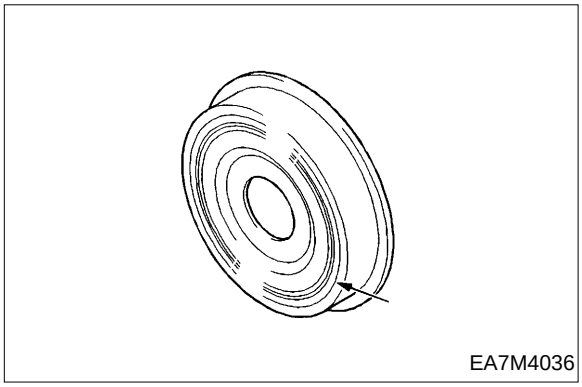
● **Oil seal plate (43)**

Inspect the seal bore, replace if scored or damaged.


EA7M4035

● **Heat shield (38)**

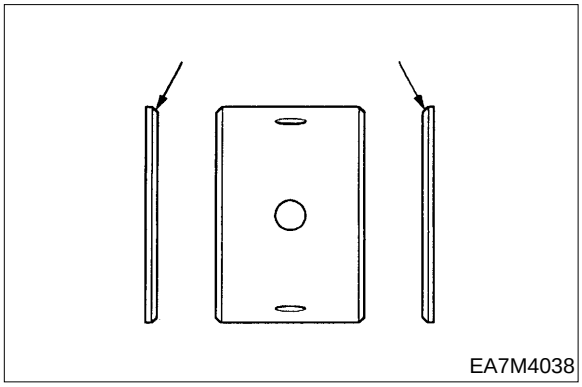
Check and replace if the heat shield id distorted or if signs of rubbing or cracking are visible.


EA7M4036

7.4.8. Assembly

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

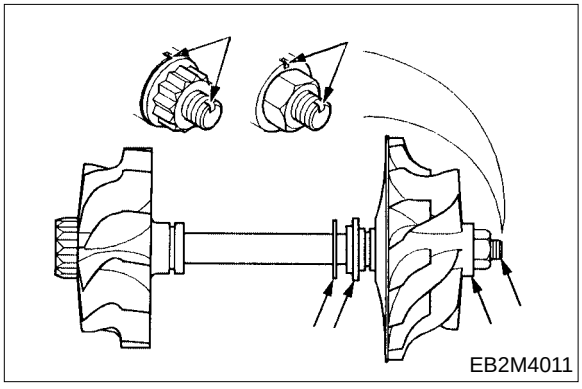
Caution :
Circlips (64). Premature failure will result if the circlips are fitted incorrectly.


EA7M4038

● **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.


EB2M4011

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

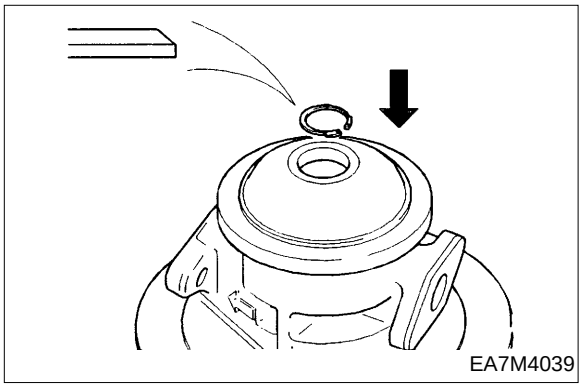
- HX35 (V158TI)

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

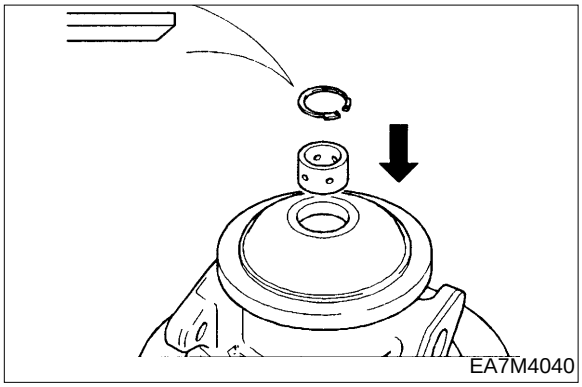
- HX50 (V188TI, V222TI)

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

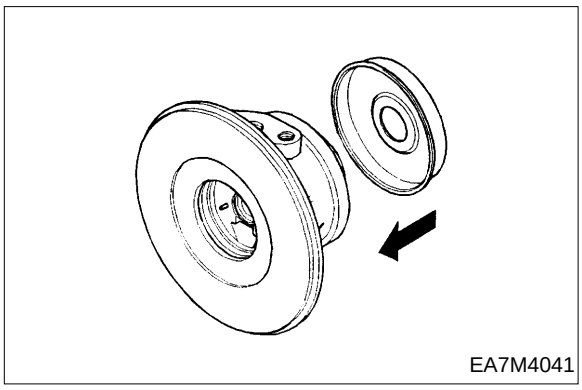
- Place the bearing housing (4) on a bench with the turbine end facing uppermost.
  Fit the inner circlip (64) with the bevelled edge facing upwards.


EA7M4039

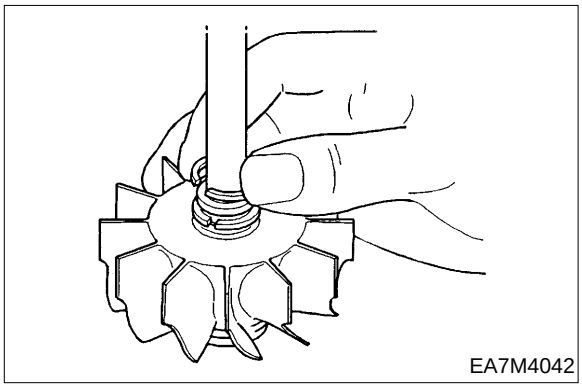
- Lubricate the journal bearing (11) and install into position.
  Fit the outer circlip (64) with the bevelled edge facing the bearing.
  Turn the bearing housing over and repeat the process.


EA7M4040

● Install the heat shield (38).

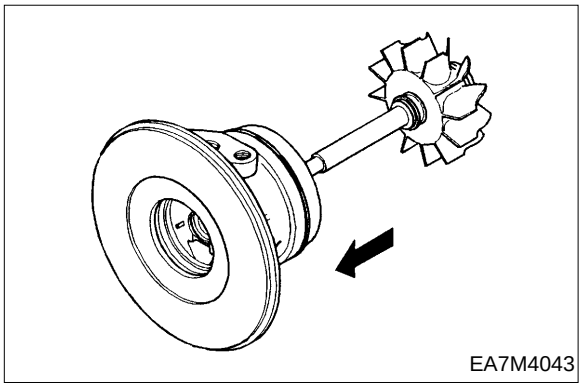

EA7M4041

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

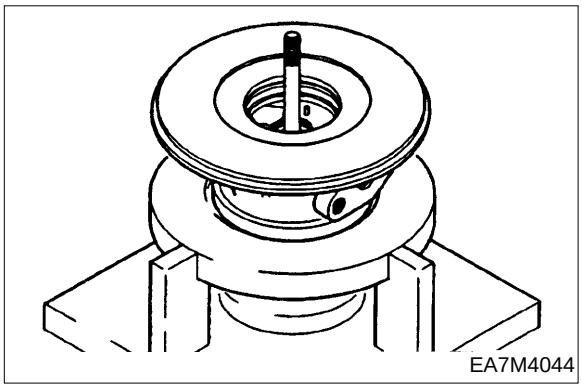

EA7M4042

● 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.

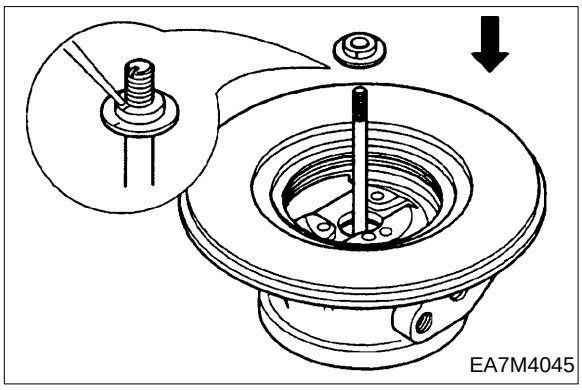

EA7M4043

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


EA7M4044

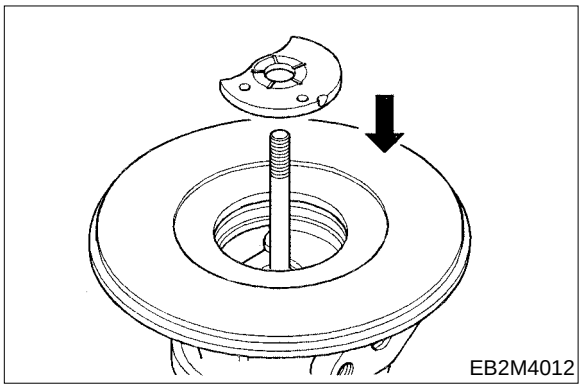
● Install the thrust collar (36).

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

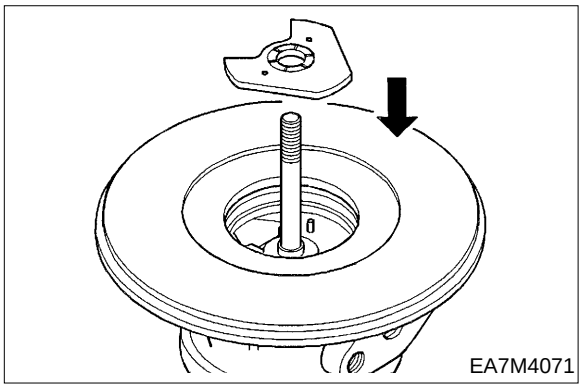

EA7M4045

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

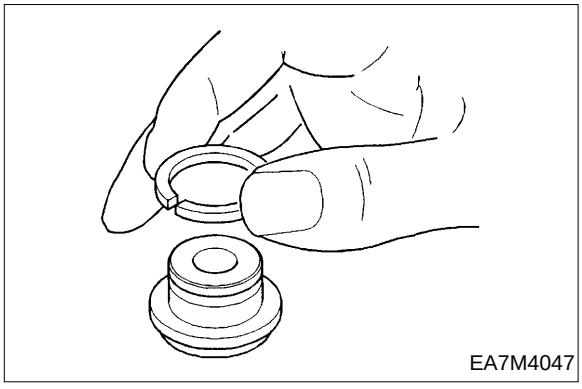
- HX35


EB2M4012

- HX50

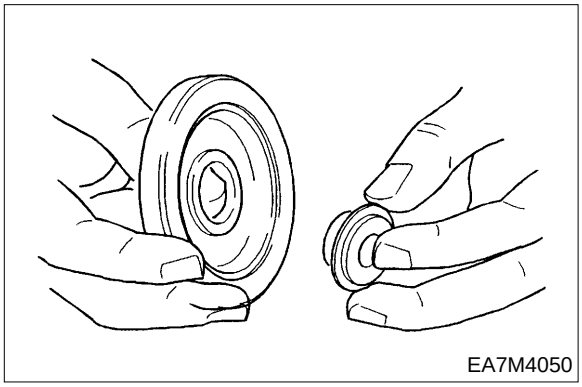

EA7M4071

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

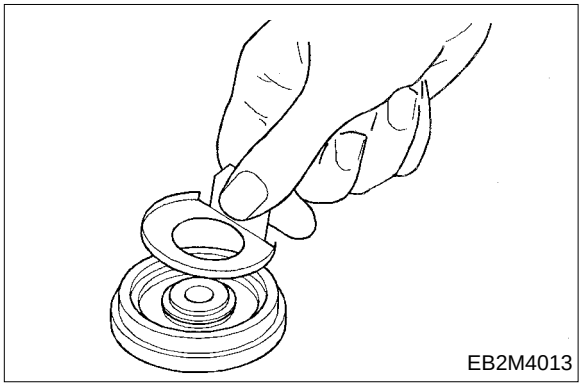

EA7M4047

<HX35>

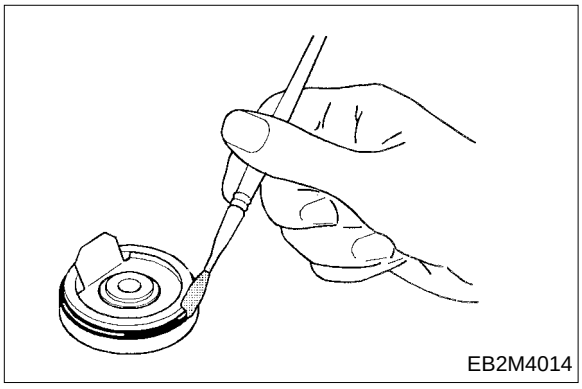
● Using clean engine oil, lubricate the oil slinger (31) and install into the oil seal plate (43).


EA7M4050

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

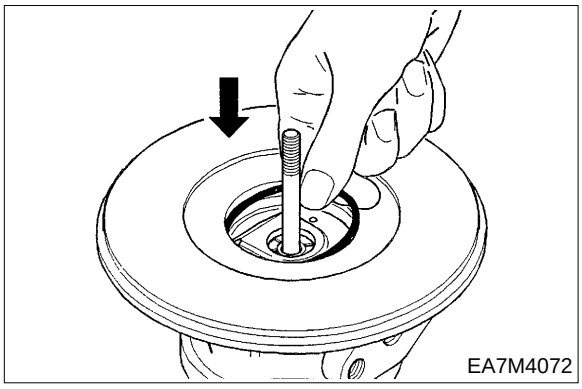

EB2M4013

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

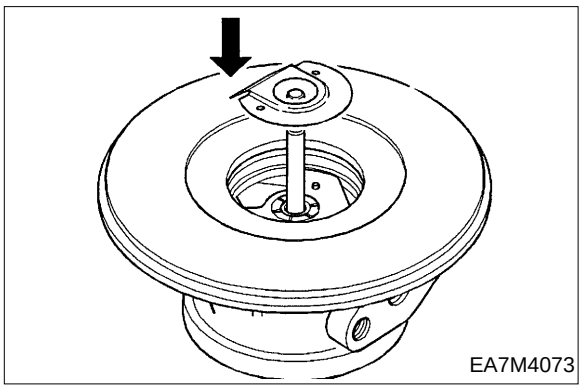

EB2M4014

<HX50>

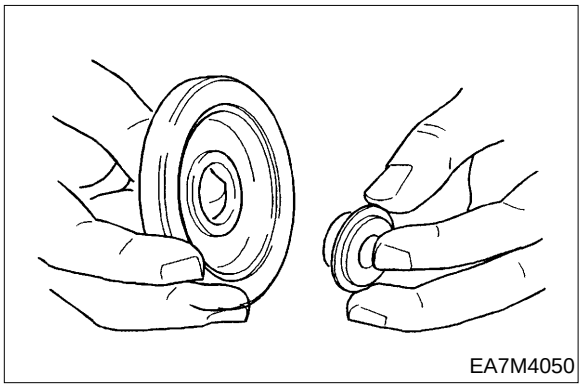
● Apply a small amount of engine oil to the O ring seal (32), and place into position.


EA7M4072

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

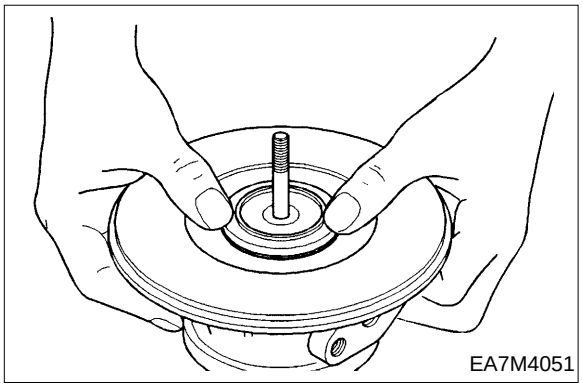


● Using clean engine oil, lubricate the oil slinger (31) and install into the oil seal plate (43).

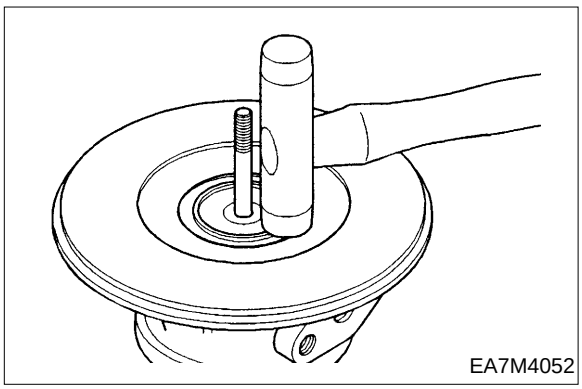


● Install the oil seal plate (43) into the bearing housing (4).

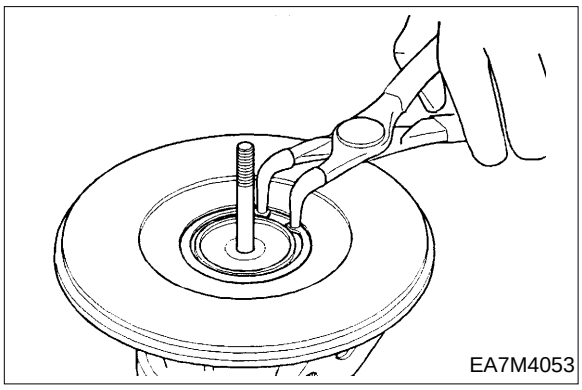
Caution :
Align the balance marks on the oil slinger (31) with that on the shaft end.



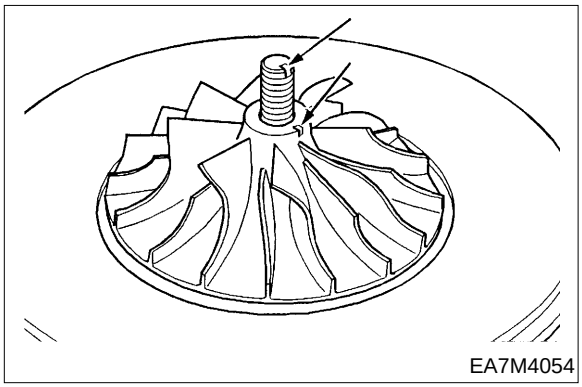
● Gently tap the oil seal plate (43) with a soft hammer to seat in position.



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


EA7M4053

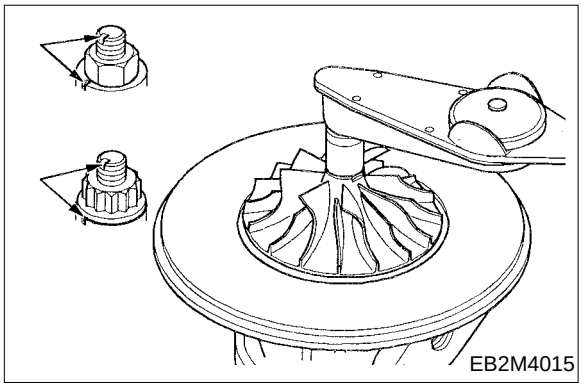
● Align the balance marks and install the compressor wheel (7).


EA7M4054

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

Note :
Left hand thread.

Torque value	Nm	in-lbs
	17	150

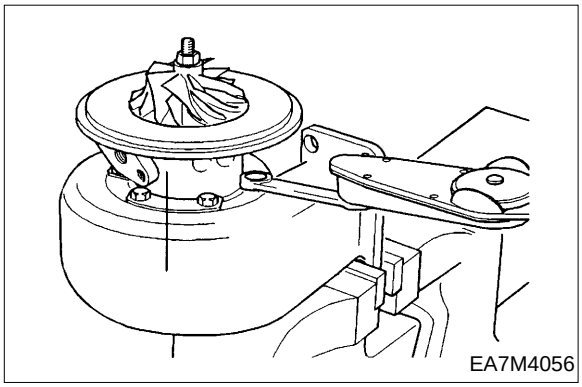

EB2M4015

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


EA7M4056

<HX50>

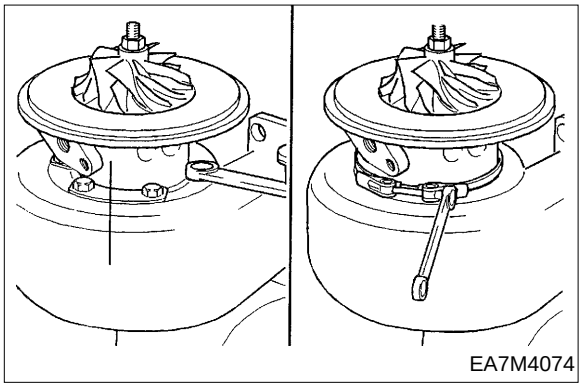
● Locate the C.H.R.A. into the turbine housing (5).
Install the 3 clamp plates (88) and tighten the 6 bolts (57) to the torque value.

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

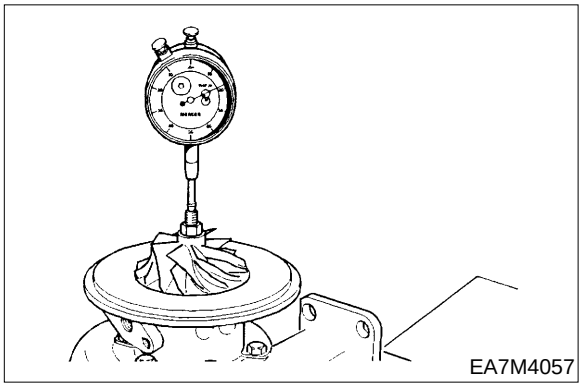
Caution :
Make sure the scribe marks are aligned.


EA7M4074

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

- HX50 (V180TI/ V222TI)

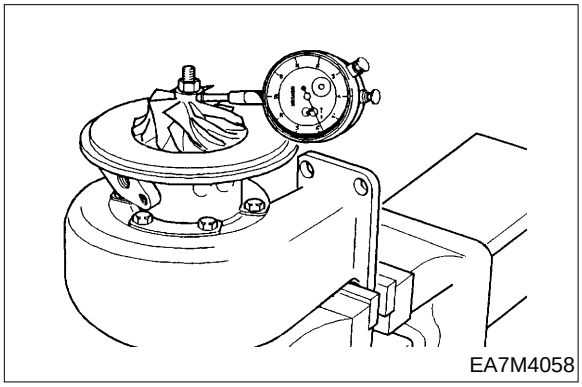
Trust clearance	mm	in
Minimum	0.038	0.0015
Maximum	0.093	0.0037


EA7M4057

● Check the radial clearance using a dial gauge.

- HX50 (V180TI/ V222TI)

Radial clearance	mm	in
Minimum	0.394	0.0155
Maximum	0.635	0.0250


EA7M4058

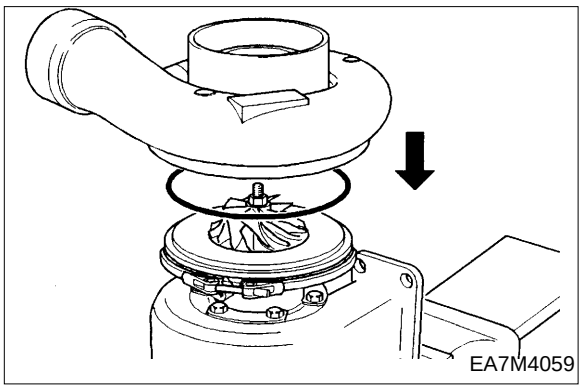
● Loosely fit the V-band clamp.

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.

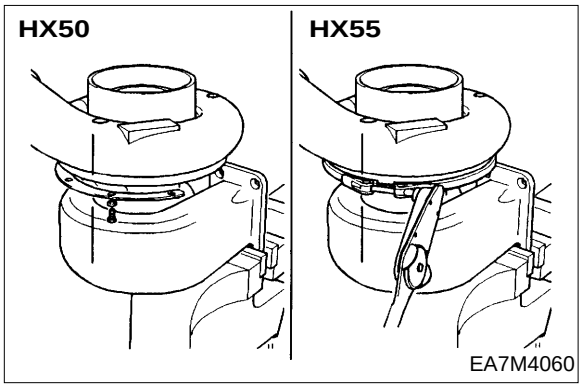


● **HX50**

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)

Torque value	Nm	in-lbs
Lock nut (62)	8.5	75
Bolts (57)	20.3	18

Caution :

Make sure the scribe marks are aligned.

7.4.3. Inspection

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

1) Checking of the rotor for rotating condition

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

2) Checking of the rotor end play

The radial and axial clearances of the rotor should check after every 2,000 hours operation.

This precaution will enable measuring for any wear of axial clearance bearings to be detected in good time before serious damage is caused to the rotor and bearings.

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

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

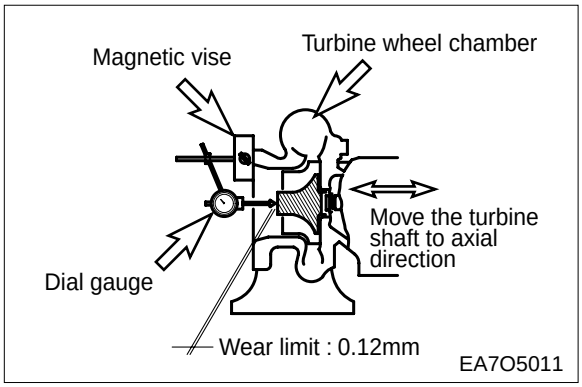
(2) If the measured axial and radial plays are beyond the limit of wear, replace or repair the turbocharger.

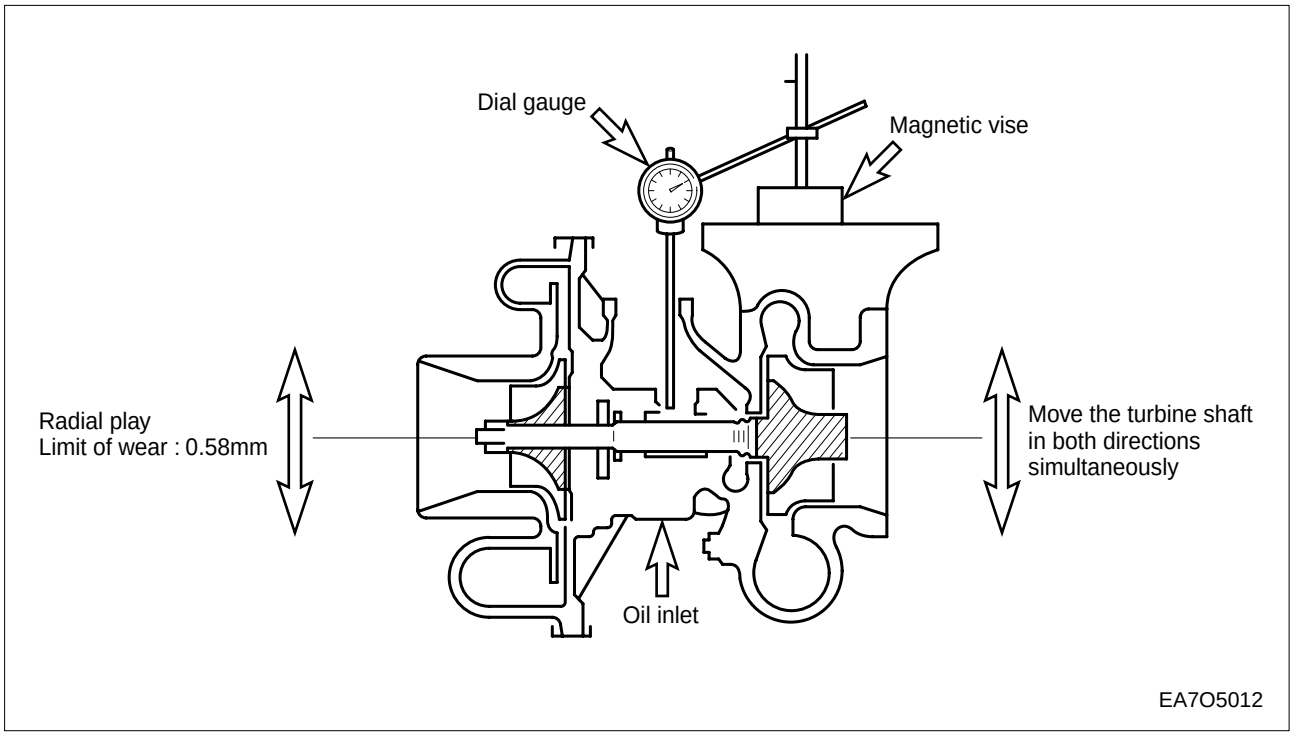
● **Measuring rotor axial clearance**

Axial clearance	0.12 mm

● **Measuring radial clearance**

Radial clearance	0.58 mm





3) Precautions for reassembling the turbocharger onto the engine

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

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

(1) Lubricating system

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

(2) Intake system

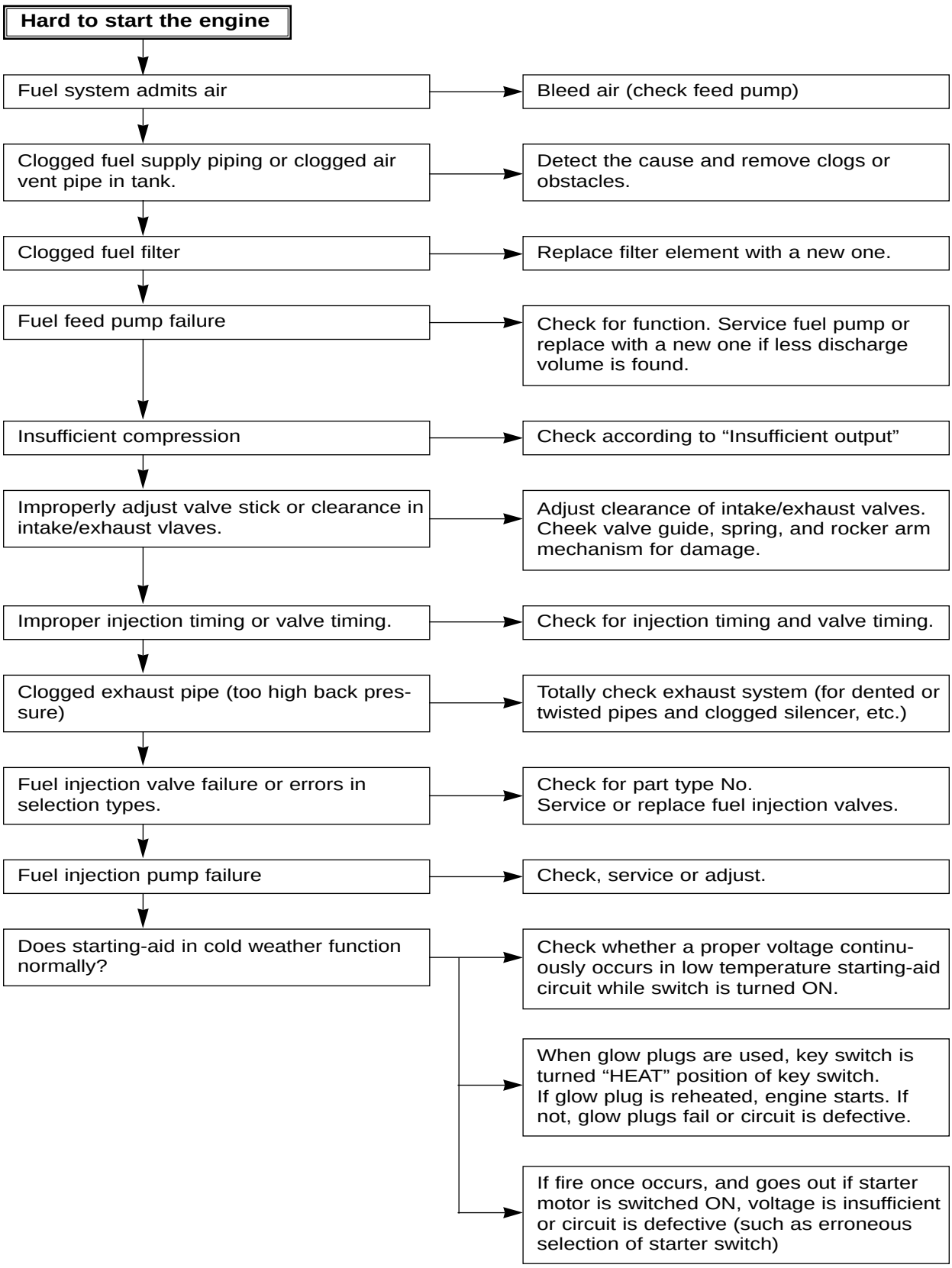
- Check the inside of the intake system for foreign matters.
- Assemble each joint on the intake duct and air cleaner securely to prevent air leaks.

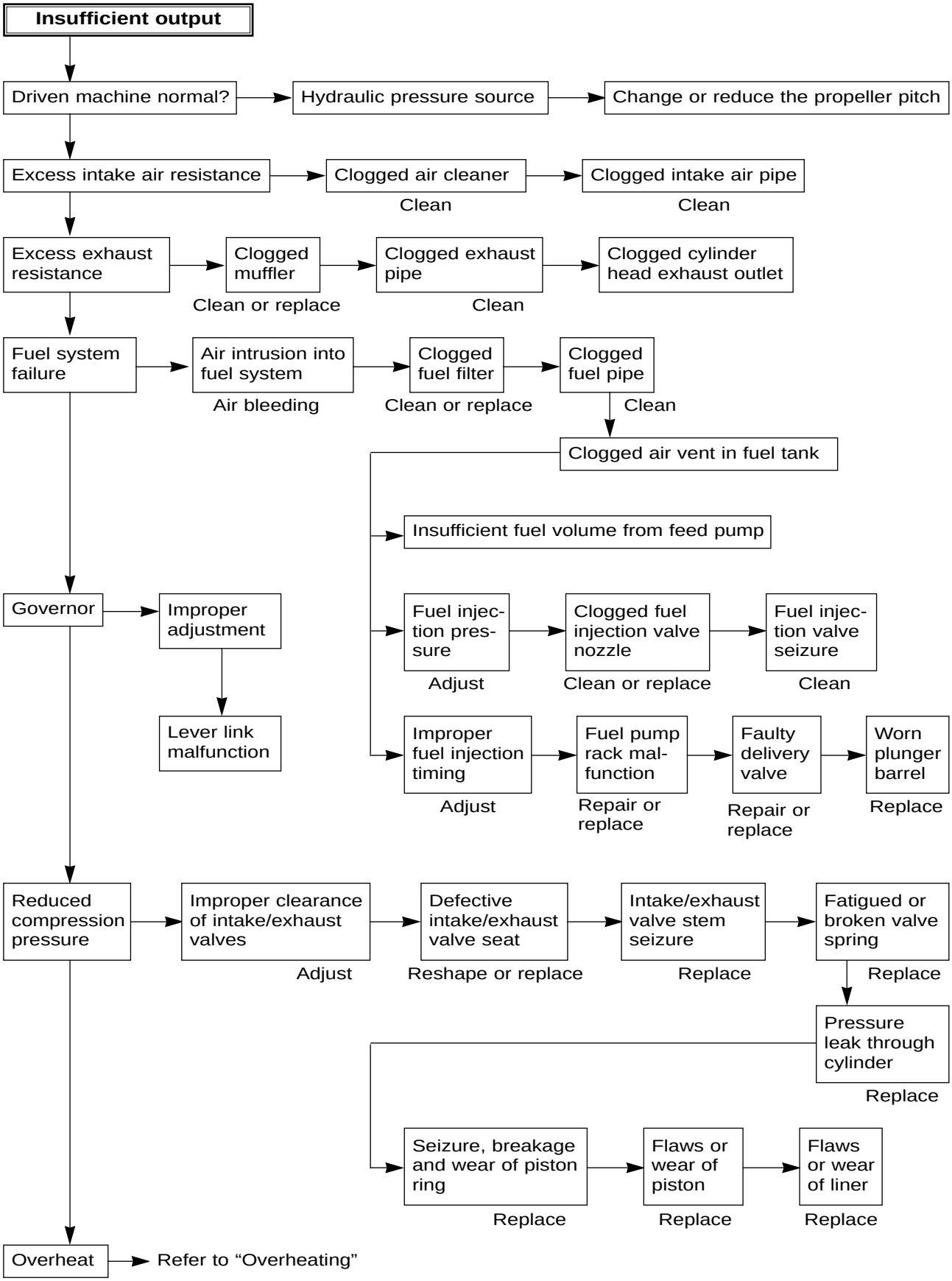
(3) Exhaust system

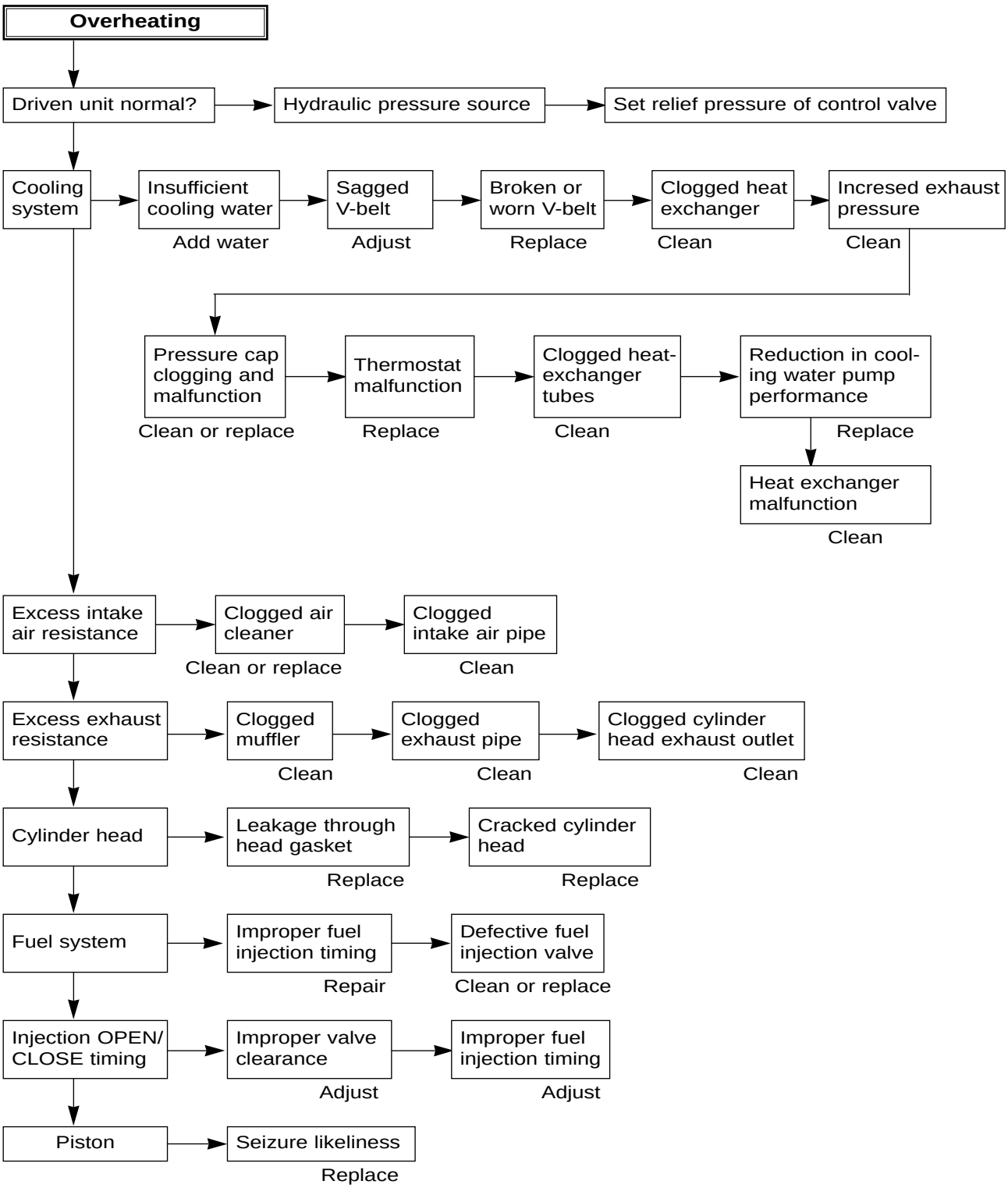
- Check the inside of the exhaust system for foreign matters.
- Be sure to use heat resisting steel bolts and nuts. Do not interchange them with ordinary steel bolts and nuts when performing re-assembly operation. Apply anti-seizure coating to the bolts and nuts.
- Assemble each joint on the exhaust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

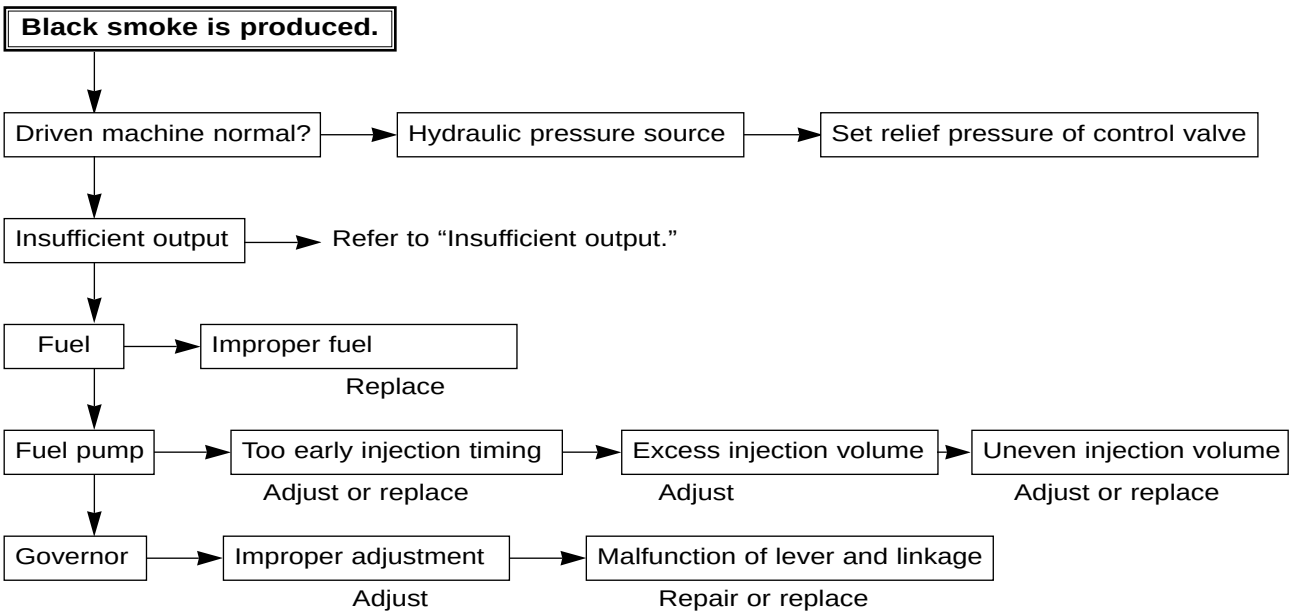
8. TROUBLE SHOOTING

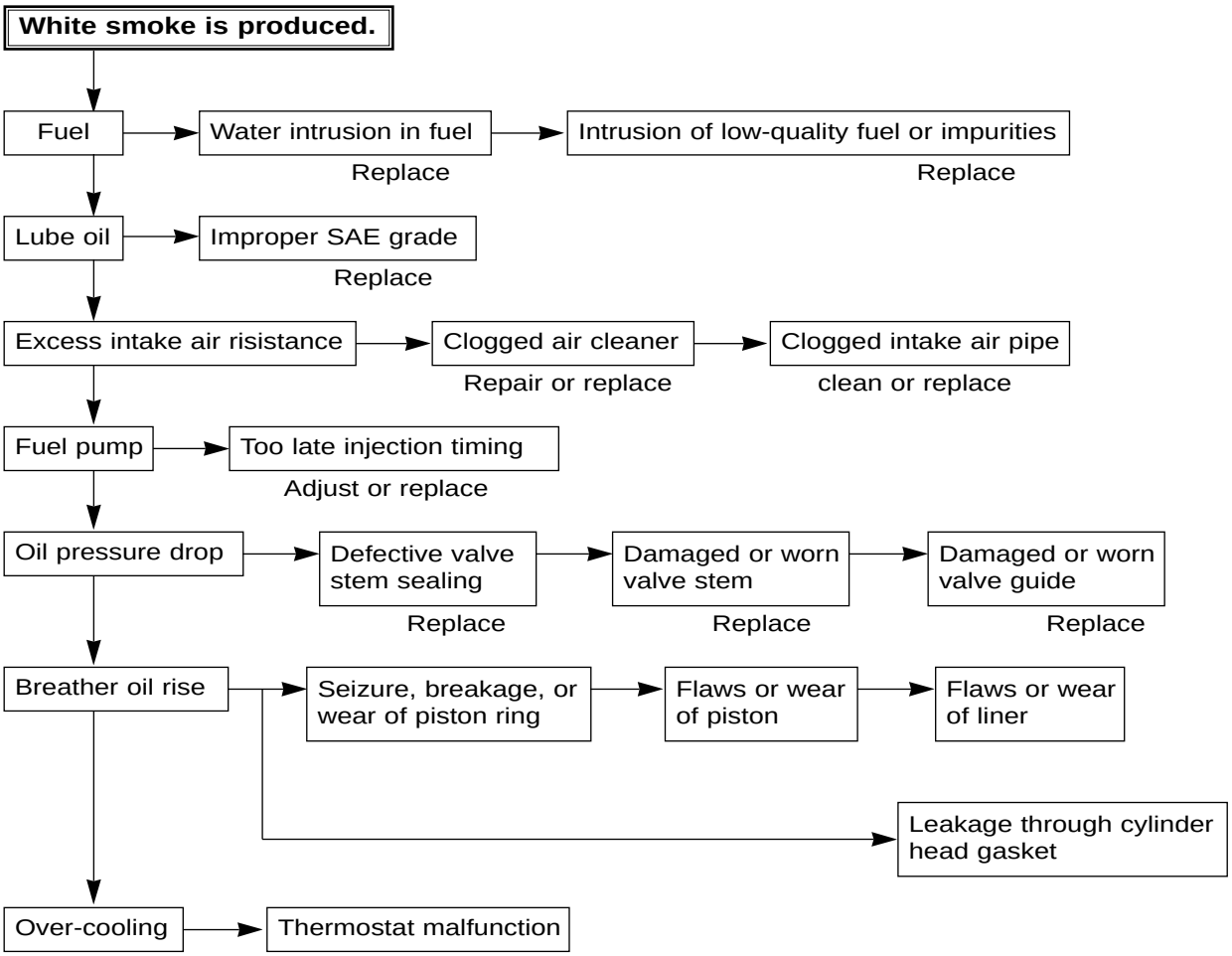
The following description summarizes the probable cause of and remedy for general failure by item. Immediate countermeasures should be taken before a failure is inflamed if any symptom is detected.

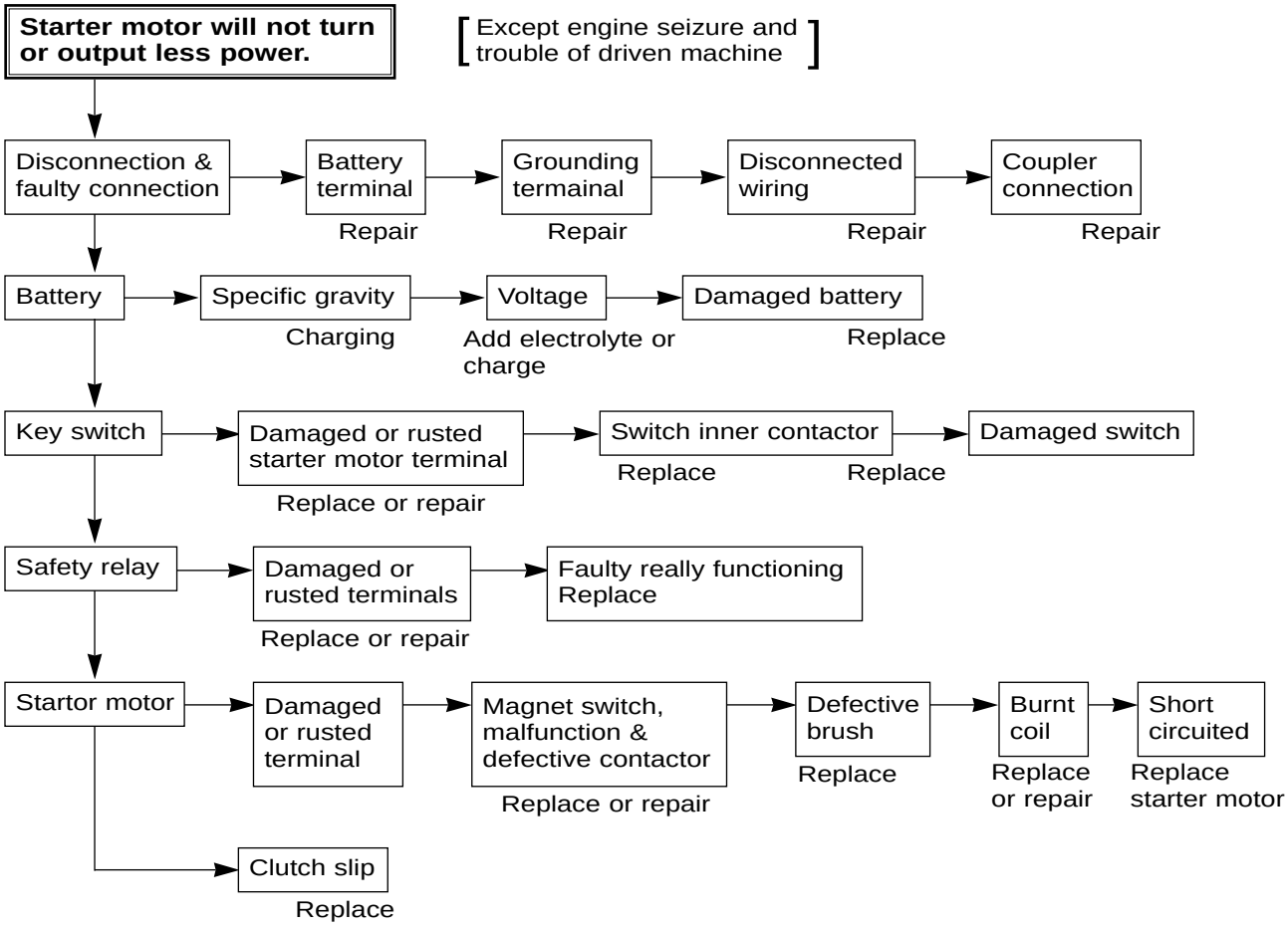



Insufficient output
Driven machine normal?
Hydraulic pressure source
Change or reduce the propeller pitch
Excess intake air resistance
Clogged air cleaner
Clean
Clogged intake air pipe
Clean
Excess exhaust resistance
Clogged muffler
Clean or replace
Clogged exhaust pipe
Clean
Clogged cylinder head exhaust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

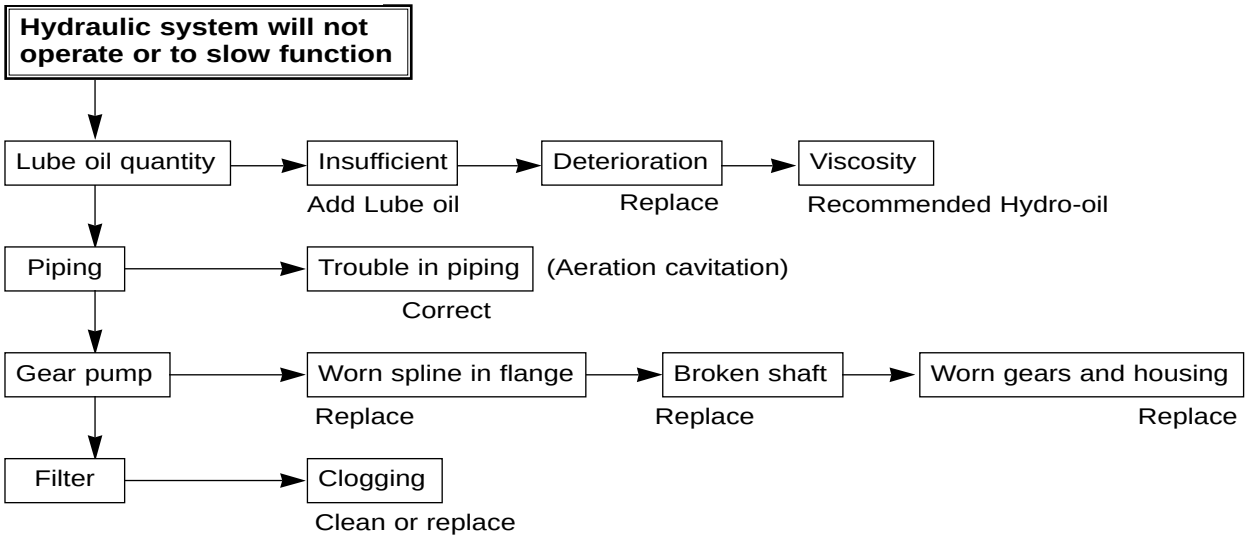

Overheating
Driven unit normal?
Hydraulic pressure source
Set relief pressure of control valve
Cooling system
Insufficient cooling water
Add water
Sagged V-belt
Adjust
Broken or worn V-belt
Replace
Clogged heat exchanger
Clean
Increased exhaust pressure
Clean
Pressure cap clogging and malfunction
Clean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

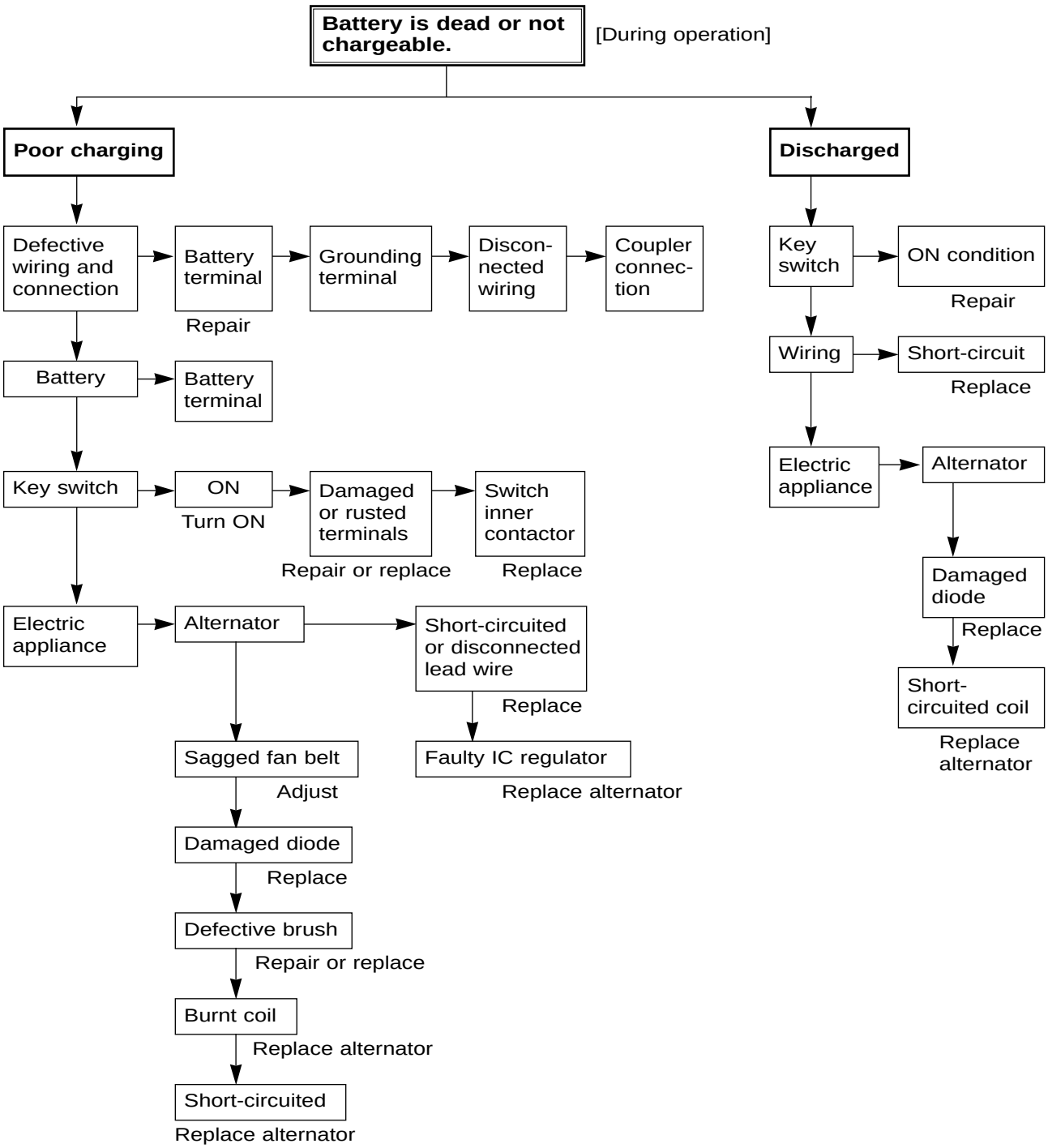

Black smoke is produced.
Driven machine normal?
Hydraulic pressure source
Set relief pressure of control valve
Insufficient output
Refer to “Insufficient output.”
Fuel
Improper fuel
Replace
Fuel pump
Too early injection timing
Adjust or replace
Excess injection volume
Adjust
Uneven injection volume
Adjust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


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

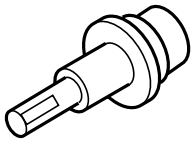
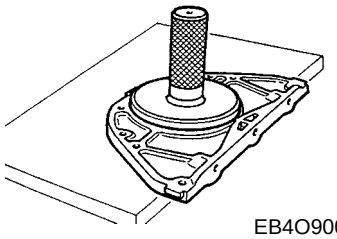
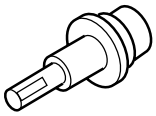
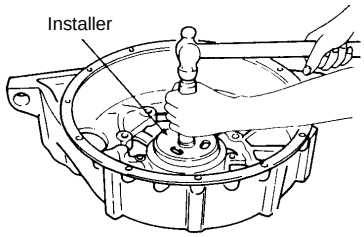
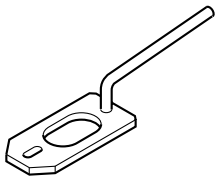
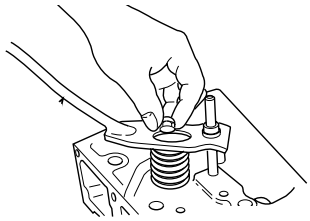
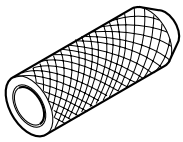
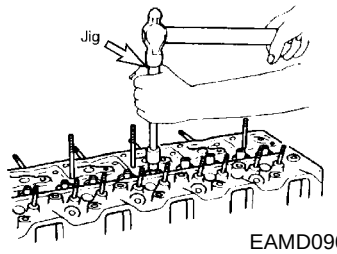
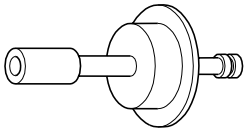
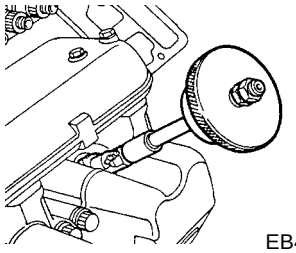
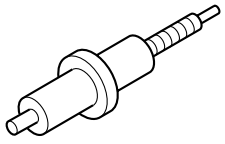
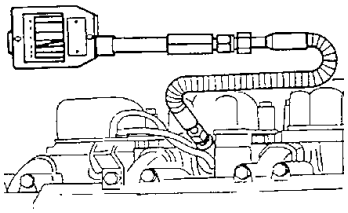


Hydraulic pressure source

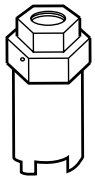
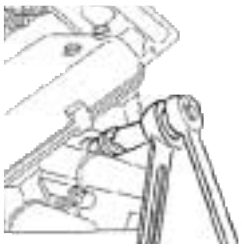
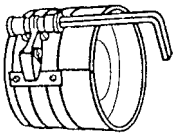
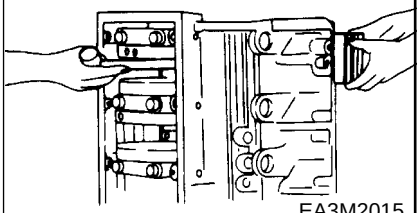
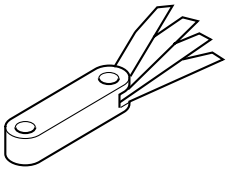
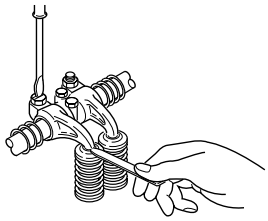
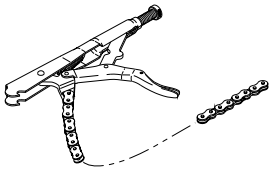
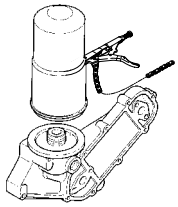
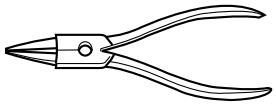
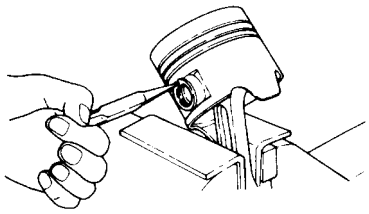
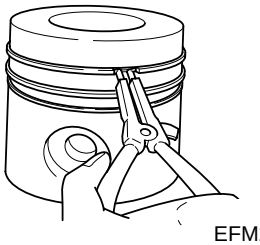



Battery is dead or not chargeable.
[During operation]
Poor charging
Discharged
Defective wiring and connection
Battery terminal
Repair
Grounding terminal
Discon-nected wiring
Coupler connec-tion
Battery
Battery terminal
Key switch
ON
Turn ON
Damaged or rusted terminals
Repair or replace
Switch inner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

9. SPECIAL TOOL LIST (1/2)

No.	Tool Names	Tool No.	Descriptions	Applications
1	Front Oil Seal Assembly Jig	EF.120-030		 EB4O9001
2	Rear Oil Seal Assembly Jig	EF.120-029		 EJM2101S
3	Valve Spring Press	EF.123-065		 EA0M4007
4	Valve Stem Seal Punch	EF.120-183		 EAMD096S
5	Inertia Extrator	E1.00308-0084		 EB4O9002
6	Adapter for Cylinder Pressure Test	EU.2-0532		 EB4O403L

SPECIAL TOOL LIST (2/2)

No.	Tool Names	Tool No.	Descriptions	Applications
7	Jig for Injection Nozzle Detatch	65.99705-0002		 EB4O9003
8	Piston Sleeve	EF.120-208		 EA3M2015
9	Filler Gauge	60.99901-0027		 EAOO4014
10	Chain Plier	EF.200-038 Vice- Grip 20R (225)		 EB1O5002
11	Snap Ring Plier	T7610001E		 EA3M2029
12	Piston Ring Plier	T7621010E		 EFM2051I

● APPENDIX

● Standard table of tightening torque

Specification	Screw	Strength	Tightening Torque kg-m
Cylinder block bearing cap			
- main bolt	M18 x 2	12.9	Initial 30 kg-m + rotating angle 90˚
- side bolt	M12 x 1.5	10.9	8
Flywheel housing			
- tightening bolt	M12 x 1.5	10.9	10
	M10	12.9	7.5
- cover bolt	M8	8.8	2.2
Counter weight	M16 x 1.5	10.9	Initial 10 kg-m + rotating angle 90˚
Crank pulley	M16 x 1.5	10.9	21
Vibration damper	M10	10.9	6
Flywheel	M16 x 1.5	12.9	26
Cooling fan	M8	8.8	2.2
Connecting rod cap	M16 x 1.5	10.9	Initial 10 kg-m + rotating angle 90˚
Cylinder head	M15 x 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 x 1.5		2.5
Cam shaft timer	M10	10.9	9
Rocker arm bracket	M10	10.9	6.5
Lock nut (adjusting screw)	M12 x 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 x 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 x 1.5	8.8	8
Starting motor	M12 x 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 x 1.5		5
	M14 x 1.5		8
	M16 x 1.5		8
	M18 x 1.5		10
	M22 x 1.5		10
	M24 x 1.5		12
	M26 x 1.5		12
	M30 x 1.5		15
	AM10 x 1.0		5
	AM14 x 1.5		8

● Engine assembly tolerance

Items		D28 series	Remarks
Cylinder block	Inside dia. of liner forced in joint part (upper part)	ø145.800~ø145.840	ø145.8 H7
	Inside dia. of liner forced in joint part (lower part)	ø144.500~ø144.540	ø144.5 H7
	Inside dia. of liner color forced in part	ø153.900~ø154.150	ø153.9 H11
	Liner colored surface depth	9.97~9.99	
Cylinder liner	Outside dia.of liner forced in joint part(upper)	ø145.741~ø145.786	ø145.8 g6
	Outside dia. of liner forced in joint part(lower)	ø144.432~ø144.457	ø144.5 f6
	Outside dia. of liner color part	ø153.65~ø153.75	ø153.8
	Liner collar height	10.03~10.05	
	Liner forced in joint part (upper)	0.014~0.099	
	Liner forced in joint part (lower)	0.043~0.108	
	Liner collar part clearance	0.150~0.500	
	Inside dia. of liner	ø127.990~ø128.010	ø128 ± ø0.01
	Liner's roundness & columness (upper)	0.01	from top up to 168mm
	Liner's roundness & columness (lower)	0.015	from bottom up to 85mm
	Liner's projection	0.04 ~ 0.08	measure at 4 place
Piston	Outside diameter of piston	ø127.739~ø127.757	measure 71.5mm part from bottom(long length)
	Inside diameter of piston pin	ø46.003~ø46.009	
	Max. allowable weight per engine	50g	
	1st ring groove width	3.5	
	2nd ring groove width	3.040 ~ 3.060	
	Oil ring home width	4.020 ~ 4.040	
Piston ring	1st ring height (thickness)	3.5	
	2nd ring height (thickness)	2.978~2.990	
	Oil ring height (thickness)	3.97~3.99	
	1st ring axial direction clearance	-	
	2nd ring axial direction clearance	0.050~0.082	
	Oil ring axial direction clearance	0.030~0.070	
	1st ring end part clearance	0.35~0.55	
	2nd ring end part clearance	0.40~0.60	
	Oil ring end part clearance	0.40~0.70	
Piston pin	Piston pin's outside diameter	ø45.994 ~ ø46.000	
	Clearance between piston pin & pin hole	0.003~0.015	
Connecting rod	Con rod small end part width	38.070~39.000	
	Con rod large end part width	35.341~35.380	35.5 C8
	Con rod cap	32.800~33.100	32.8+0.3
	Con rod axial direction clearance	0.240~0.392	
	Con rod small end part axial direction clearance	0.064~0.126	
	Con rod bush oil clearance	0.055~0.071	
	Con rod small end inside diameter (w/h bush)	ø46.055~ø46.065	
	Con rod small end inside diameter (w/o bush)	ø50.600~ø50.630	ø50.6 H7
	Con rod bush's diameter	ø50.670~ø50.700	
	Tighteness	0.04~0.10	
	Con rod large end part's inside diameter	ø95.000~ø95.022	ø95H6
	Con rod bearing spread (MIBA)	0.5~1.4	
	Con rod max. weight tolerance per engine	50g	
	Perpendicularity of large end inside diameter	0.035	reference to con rod side face
	Large end part's inside roundness & columness	0.01	
	Large end part's inside straightness	0.005	
	Parallelness of small end inside with large end	0.02	

Items		D28 series	Remarks
Crank shaft	Bearing housing diameter	ø111.000~ø111.022	ø111 H7
	Maximum shaking	0.05	
	Main bearing journal diameter		
	Standard	ø103.98~ø104.00	
	Undersize 0.10	ø103.88~ø103.90	
	Undersize 0.25	ø103.73~ø103.75	
	Undersize 0.50	ø103.48~ø103.50	
	Undersize 0.75	ø103.23~ø103.25	
	Undersize 1.00	ø102.98~ø103.00	
	Thrust bearing journal width		
	Standard	38.000~38.062	38 H9
	Undersize 1 , 2	38.500~38.562	
	Undersize 3 , 4	39.000~39.062	
	Con rod bearing journal diameter		
	Standard	ø89.98~ø90.00	
	Undersize 0.10	ø89.88~ø89.00	
	Undersize 0.25	ø89.73~ø89.75	
	Undersize 0.50	ø89.48~ø89.50	
	Undersize 0.75	ø89.23~ø89.25	
	Undersize 1.00	ø89.98~ø89.00	
	Main bearing journal's roundness	0.01	
	Main bearing journal's parallelness	0.005	
	Medium main bearing journal's shake	0.06	no 1, no 5 support
	Wear ring press in part's journal diameter	ø99.985~ø100.020	ø100 j7
	Wear ring's inside diameter	ø99.9907~ø99.942	ø100 S7
	Overlap	0.043~0.113	
	Thrust bearing width		
	Standard	37.74~37.81	
	Oversize	38.24~38.31	
	Oversize	38.74~38.81	
	Crankshaft's axial direction's clearance	0.190~0.322	
	Main bearing thickness		
	Standard	3.460~3.472	
	Oversize 0.10	3.510~3.522	
	Oversize 0.25	3.585~3.597	
	Oversize 0.50	3.710~3.722	
	Oversize 0.75	3.835~3.847	
	Oversize 1.00	3.960~3.972	
	Main bearing oil gap	0.066~0.132	
	Main bearing spread	0.3 ~ 1.2	
	Thrust bearing's spread	0.3 ~ 1.2	
Flywheel	Ring Gear assembly part's Outside diameter	ø432.490~ø432.645	
	Ring gear inside diameter	ø432.000~ø432.155	
	Overlap	0.335~0.645	
	Heat fitting temp. (˚C)	200~230	
	Allowable shaking amount after assembly	0.5	
	Outside diameter after reassembly used ring	ø114.980~ø115.015	

Items		D28 series	Remarks
Cylinder head & valve	Head gasket thickness (after tightening bolts)	1.205 ~ 1.295	
	Cylinder head height	113.9 ~ 114.0	
	Cylinder head seal surface roughness	max. 16μ	
	Valve projecting amount	- 0.65 ~ - 0.95	
	Exhaust valve		
	Stem diameter	ø11.945 ~ø11.955	
	Radius direction clearance	0.045 ~ 0.073	
	Seat angle	45°	
	Head diameter	ø50.9~ø51.1	
	"H" thickness of valve head	1.9~2.3	
	Valve seat part diameter of head	ø53.00~ø53.03	
	Outside diameter of valve seat	ø53.10~ø53.11	
	Intake valve		
	Stem diameter	ø11.969~ø11.980	
	Radius direction clearance	0.020~0.049	
	Seat angle	30°	
	Head diameter	ø57.85~ø58.15	
	"H" thickness of valve head	2.6~3.0	
	Valve seat part diameter of head	ø61.00~ø61.03	ø61 H7
	Outside dia. of valve seat	ø61.10~ø61.11	
	Depth of head's valve seat assembly part	12.5~12.6	
	Valve guide inside diameter	ø12.000~ø12.018	ø12 H7
	Valve guide's inside diameter of head	ø18.000~ø18.018	ø18 H7
	Valve guide's outside diameter	ø18.028~ø18.046	ø18.25 S7
	Valve guide assembly locking piece	0.010~0.046	
	Valve seat's shaking	0.04	reference to valve guide
Valve spring	Valve lift	14.1	
	Projecting amount of valve guide	17.1~17.5	Above valve spring
	Free length of inside spring	72.43	
	Spring load of inside spring	15~17kg	at 46.3mm
	Spring load of inside spring	27~32kg	at 32.3mm
	Free length of outside spring	68.17	
	Spring load of outside spring	37~41kg	at 46.3mm
	Spring load of outside spring	66.5~76.5kg	at32.8mm
Timing	Rocker arm bush's inside diameter	ø25.005~ø25.035	when assembled
	Rocker arm bearing journal's diameter	ø24.967~ø24.990	
	Bearing's clearance	0.015~0.068	
	Push rod's shaking	0.3	
	Valve tappet ass'y part's inside dia. of block	ø20.000~ø20.021	ø20 H7
	Push rod's outside diameter	ø19.944~ø19.965	
	Tappet clearance	0.035~0.077	
	Bush assembly's inside diameter of block	ø70.077~ø70.061	
	Camshaft diameter	ø69.910~ø69.940	ø70 e7
	Camshaft bearing oil gap	0.060~0.120	
	Camshaft axial direction play	0.20~0.90	
	Backlash (crank gear-camshaft gear)	0.118~0.242	
	Backlash (driving gear - injection pump gear)	0.102~0.338	
	Intake valve clearance	0.25	
	Exhaust valve clearance	0.35	

Items		D28 series	Remarks
Engine lubricating system	Oil pressure at idling	0.9~3.0 bar	
	Oil pressure at rated speed operation	3.0~6.5 bar	
	Oil temperature	less than 110˚C	
	Instantaneous allowable temperature	max. 100˚C	
	Bypass valve opening pressure	1.8~2.4 bar	
	Pressure regulating valve of oil pump	8.5~10 bar	
	Spray nozzle		
	Operating pressure	1.6~1.9 bar	
	Crossing pressure	1.3~1.6 bar	
	Tip diameter	∅ 2	
	Backlash (crankshaft gear-oil pump drive gear)	0.10~0.45	
	Oil pump housing's depth/gear width	43.000~43.039	43 H8
		42.910~42.950	43 e8
	Oil pump housing axial play	0.050~0.128	
Engine cooling system	Cooling water pump shaft diameter	∅21.930~∅21.950	
	Bearing gap	0.050~0.091	
	Impeller clearance (impeller - body)	1.0~1.5	
	Thermostat Operating temperature (˚C)	79˚C	
Inspection on compressed pressure	Good	above 28 bar	
	Possible to use	25~28 bar	
	Need up keep	bellow 24 bar	
	Allowable max pressure difference between cylinders	4 bar	
Fuel system	Overflow valve's operating pressure of injection pump	1.3 ~ 1.8 bar	
	Mode of fuel injection pump	Bosch	
	Governor model	GAC electronic	
	Injection nozzle's manufacture	Bosch	
	Injection nozzle hole's diameter	4-∅0.40	

● Parts & After service center

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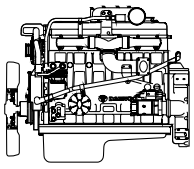
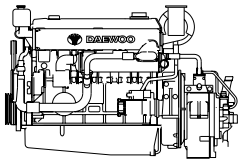
● Applications for Daewoo Engines



■ Automotive & Industrial Engines

Model		Power kW(PS)/rpm	Model	Power kW(PS)/rpm
For Vehicle	D1146	133(181)/2,500	DE12TI	250(340)/2,100
	D1146TI	158(215)/2,200	DE12TIS	250(340)/2,100
	DE08TIS	176(240)/2,300	GE12TI	250(340)/2,100
	GE08TI	191(260)/2,300	DV15T	272(370)/2,300
	DE12	169(230)/2,200	DV15TI	309(420)/2,100
	DE12T	220(300)/2,200	DV15TIS	309(420)/2,100
For Industrial	DC23	37(50)/3,000	DB58TIS	127(173)/2,000
	DC24	41(56)/3,000	D1146	115(156)/2,200
	DC24T	41(55)/2,600	D1146T	140(190)/2,200
	DB33	53(72)/3,000	D1146TI	162(220)/2,200
	DB33A	46(63)/2,300	DE08TIS	151(205)/1,900
	DB58	96(130)/2,800	DE12T	188(255)/2,000
	DB58S	75(102)/2,200	DE12TI	213(290)/2,000
	DB58T	104(142)/2,500	DE12TIS	238(323)/2,000
	DB58TI	112(152)/2,200	DV15T	238(324)/2,300



■ Marine Propulsion Engines

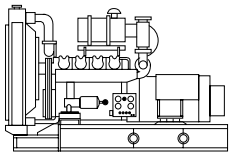
Model	Power kW(PS)/rpm	Model	Power kW(PS)/rpm
L034	51(70)/3,000	L126TIH	265(360)/2,000
L034TIH	88(120)/3,000	L126TIM	294(400)/2,100
L034TIM	107(145)/3,300	V158TIH	353(480)/1,800
L136	118(160)/2,200	V158TIM	397(540)/2,100
L136T	147(200)/2,200	V158TIL	500(680)/2,300
L136TL	177(240)/2,500	V180TIH	441(600)/1,800
L136TI	169(230)/2,200	V180TIM	478(650)/2,100
L086TIH	210(285)/2,100	V180TIL	820(603)/2,300
L086TIM	232(315)/2,300	V222TIH	530(720)/1,800
MD196T	206(280)/2,000	V222TIM	588(800)/2,100
MD196TI	235(320)/2,000	V222TIL	736(1,000)/2,300

■ Generator Set Engines (G-Drive & G-Pac)

Model	Power (Output ISO 3046)				Model	Power (Output ISO 3046)			
	@1,800rpm		@1,500rpm			@1,800rpm		@1,500rpm	
	Power (Stand-by)	Power (Prime)	Power (Stand-by)	Power (Prime)		Power (Stand-by)	Power (Prime)	Power (Stand-by)	Power (Prime)
	kW(PS)	kW(PS)	kW(PS)	kW(PS)		kW(PS)	kW(PS)	kW(PS)	kW(PS)
DC23-2	13(17)	11(15)	15(11)	14(10)	P126TI-1	288(392)	262(356)	-	-
DC23-1	18(25)	17(23)	16(22)	15(20)	P126TI	298(405)	278(378)	272(370)	241328)
DC23	24(33)	22(30)	19(26)	18(24)	P126TI-Ⅱ	342(465)	-	-	-
DC24	25(34)	23(31)	21(28)	18(25)	P158LE-2	361(491)	329(447)	321(437)	293(399)
DC24T	32(43)	29(39)	26(36)	24(32)	P158LE-1	402(546)	366(498)	362(492)	327(444)
DB33	35(47)	32(43)	29(39)	26(35)	P158LE	443(602)	402(547)	414(563)	363(494)
P034TI	60(82)	55(75)	48(65)	42(57)	P180LE-1	498(677)	454(617)	442(601)	403(548)
DB58	70(95)	64(87)	59(80)	54(73)	P180LE	540(734)	497(676)	496(674)	443(602)
D1146	105(143)	96(130)	85(116)	77(105)	P222LE-1	625(850)	563(765)	552(750)	496(675)
D1146T	138(187)	125(170)	118(160)	107(145)	P222LE	649(883)	591(803)	574(781)	532(723)
P086TI-1	191(303)	174(279)	164(270)	149(420)	GV158TIC	-	199(270)	-	169(230)
DE12T	199(270)	180(245)	166(226)	151(205)	GV180TIC	-	250(340)	-	213(289)
P086TI	223(260)	205(237)	199(223)	177(203)	GV222TIC	-	302(410)	-	257(350)

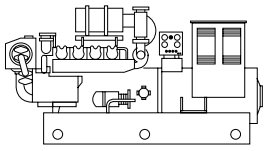
■ Marine Auxiliary Engines

Model	Power (Output ISO 3046)	Model	Power (Output ISO 3046)	Model	Power (Output ISO 3046)	Model	Power (Output ISO 3046)
	kW(PS) @ 1,500rpm		kW(PS) @ 1,500rpm		kW(PS) @ 1,800rpm		kW(PS) @ 1,800rpm
AD034F	26(35)	AD034TIF	42(57)	AD034S	32(43)	AD034TIS	55(75)
AD136F	77(105)	AD136TF	107(145)	AD136S	93(126)	AD136TS	125(170)
AD136TIF	121(165)	AD086TIF	151(205)	AD136TIS	143(195)	AD086TIS	186(253)
AD196TF	155(210)	AD196TIF	173(235)	AD196TS	181(246)	AD196TIS	199(270)
AD126TIF	206(280)	AD158TIF	302(410)	AD126TIS	247(336)	AD158TIS	353(480)
AD180TIF	357(485)	AD222TIF	446(606)	AD180TIS	441(600)	AD222TIS	530(720)



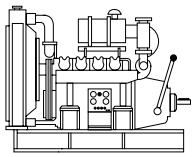
■ Generator Sets

Generator Set Model			Engine Model	Power (kW/kVA)			
				1800rpm(60Hz)		1500rpm(50Hz)	
Power (Stand-by)	Power (Prime)	Suffix		Power (Stand-by)	Power (Prime)	Power (Stand-by)	Power (Prime)
				kW/kVA	kW/kVA	kW/kVA	kW/kVA
DW10E	DW10	PIG	DC23-2	10/13	9/11	9/11	8/10
DW15E	DW15	PIH	DC23-1	15/19	14/17	13/17	12/15
DW20E	DW20	PIF	DC23	20/25	18/23	16/20	14/18
		PJF	DC24	20/25	18/23	16/20	14/18
DW26E	DW26	PII	DC24T	26/33	24/30	22/27	20/24
		PJM	DB33	26/33	24/30	22/27	20/25
DW50E	DW50	PIA	P034TI	50/63	45/56	40/50	36/45
DW60E	DW60	PJB	DB58	60/75	55/69	48/60	44/55
DW85E	DW85	PJJ	D1146	85/106	77/96	70/88	64/80
DW115E	DW115	PJK	D1146T	115/144	105/131	101/126	92/115
DW170E	DW170	PIE	P086TI-1	170/212	155/194	145/181	132/165
		PJE	DE12T	170/213	155/194	145/181	132/165
DW200E	DW200	PIL	P086TI	200/250	182/228	176/220	160/200
DW260E	DW260	PIW	P126TI-1	260/325	235/294	-	-
DW275E	DW275	PIQ	P126TI	275/344	250/313	242/303	220/275
DW320E	DW320	PIZ	P158LE-2	320/400	290/362	282/353	256/320
DW360E	DW360	PIS	P158LE-1	360/450	327/409	320/400	288/360
DW400E	DW400	PIY	P158LE	400/500	364/455	370/463	320/400
DW450E	DW450	PIO	P180LE-1	450/563	409/511	396/495	360/450
DW500E	DW500	PIM	P180LE	500/625	445/556	440/550	400/500
DW600E	DW600	PIN	P222LE	600/750	541/676	528/660	480/600



■ Marine Generator Sets

Generator Set	Engine Model	Power (kW/kVA)	
		1800rpm(60Hz)	1500rpm(50Hz)
		Power (Prime)	Power (Prime)
		kW/kVA	kW/kVA
PNM	DB33	24/30	20/25
PNB	AD034TI	50/63	36/45
PNJ	AD136	80/100	68/85
PNK	AD136T	104/130	96/120
PND	AD136TI	132/165	108/135
PNE	AD086TI	172/215	136/170
PNL	AD196TI	176/220	160/200
PNI	AD126TI	224/280	192/240
PNZ	AD158TI	328/410	276/345
PNS	AD180TI	400/500	332/415
PNY	AD222TI	500/625	408/510



■ Power Units

Model	Power kW(PS)/rpm
PU024	32(44)/2,800
PU024T	40(55)/2,600
PU034	50(68)/3,000
PU066	85(116)/2,800
PU086	116(160)/2,200
PU086T	151(205)/2,200
PU086TI	213(290)/2,200

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