RAYWIN

E38M571-4003108SF1

4E38T Series Diesel Engine

Operation & Maintenance Manual

Please read this manual carefully before using the engine.

Raywin Powertrain Technology Co., Ltd.

Content

Non road Diesel Engine Introduction

"Raywin" 4E38T Series of diesel engine are designed by the advice of Germany FEV Co. Ltd., and learn from the advanced technology developed for diesel engines for non-road diesel machinery products . This series diesel engine has excellent power and economic indexes, high reliability and durability and mainly applicable for construction machinery, agricultural machinery, Marine propulsion engine, Marine auxiliary engine, generator set, etc.. As required by users, by modification of partial of components (such as adjusting injection pump, replacing clutch housing, oil pan, air outlet and inlet pipe, engine support, electric appliance system), it can meet the different requirements of performance and installation of applications.

In order to ensure the normal use of diesel engine, this manual mainly introduces the technical parameters, structure, performance and other aspects of the diesel engine for non-road machinery, and provides the technical data of use, maintenance and fault analysis.

The data and description offered in the Instruction shall be based on current products solely. Please pay attention, due to continuous improvement of our products and for the purpose of satisfaction of different users, the in-kind product shall prevail if any discrepancy existed in the Instruction.

Before use, please read this instruction carefully. Use and maintain the diesel engine in strict accordance with this instruction.

Revised In April 2024

Preface

Thanks for your choosing “Raywin” diesel engine. The Instruction is prepared for your understanding its operation and maintenance. For the sake of safety of person and property, please read it carefully before using.

The mark “  ” in the Instruction shows that personal injury or other damages may be caused, please obey the instruction strictly.

The instruction marked with “**Notice**” in the Instruction shows that personal injury or slight damages on gadget may be caused, please follow the operation procedure carefully.

Important considerations in use

1. In order to guarantee the safety of person and property, please read the Instruction carefully before using and operate and maintain diesel engine according to the regulations in the Instruction strictly.
2. Diesel engine's startup, running-in, operation, shutdown shall be carried out properly according to the Instruction
3. Operators shall pay attention to the safety warning marks. Do not close to the area with safety warning during the operation of diesel engine.
4. In order to prolong the life of starter and battery, the continuous starting time of starter shall not exceed 15 seconds. If restart is required, turn the ignition key to "OFF" and restart after 1 or 2 minutes.
5. Do not remove air filter during operation. The air filter shall be cleaned as required. The upper and lower gasket rings for filter element shall be fit up for sealing in re-installation. When the filter is connected with hose, clamp shall be used to prevent the hose from loosing due to shake of diesel engine. Strictly prohibit not-filtered dusty air from entering into cylinder.
6. Oil supply system is the important system of diesel engine. The parts and components thereof shall not be removed or adjusted without permission, which shall be carried out in the technical service station authorized by Raywin.
7. When the running-in period comes to an end, please carry out maintenance in the service station as required.

SAFETY WARNING

1、When diesel engine is running, don't touch fan, pulley, belts and other region where rotating parts are exposed, to avoid damaging rotating parts.

2、Operators should not open radiator cap at once when diesel engine in hot condition. To avoid being scalded by the high temperature vapor.

3、When the diesel engine is in hot condition, don't touch the high temperature parts like exhaust pipe, to avoid being scalded.

4、 It is forbidden to fill cold water into the engine when diesel engine temperature is too high and short of water.

5、 Diesel engine would exhaust harmful gases like carbon dioxide and carbon black in operating condition, be sure it is effective ventilation when used.

6、 Must consider the influence of waste gas, smoke, noise to the surroundings, personnel and goods.

SAFETY SIGNS

Pay attention to these marks when running the engines:

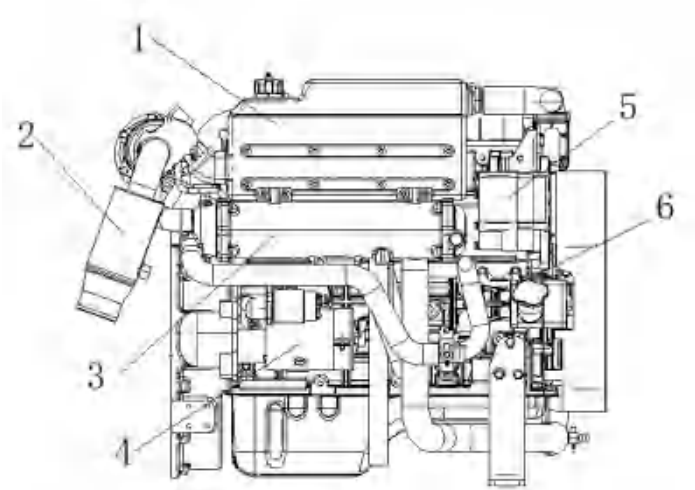
Table 1

Mark	Warning specifications	Pasting place
	1. Keep away from rotating parts when engine is running in order to avoid being hurt; 2. When engine is running or stopping for 30 minutes, keep away from exhaust pipe, turbocharger, silencer and do not open cooling water tank to avoid being scalded.	Paste in advanced cover shell in the front of diesel engine.
	Watch out for cutting your finger by Revolute Joint	Paste in fan blades.

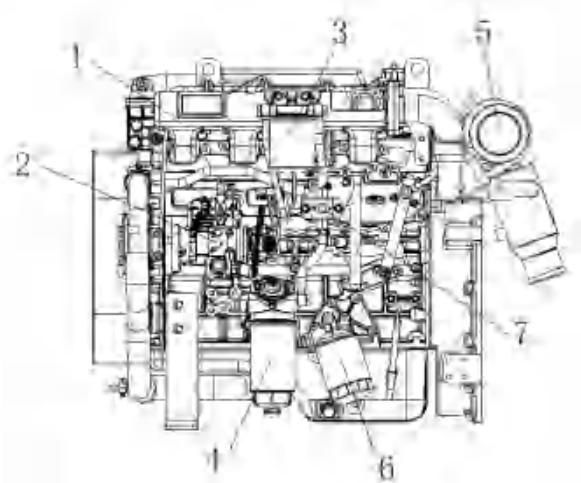
Overview

General Puerpose Machinery engine

Engine schematic diagram

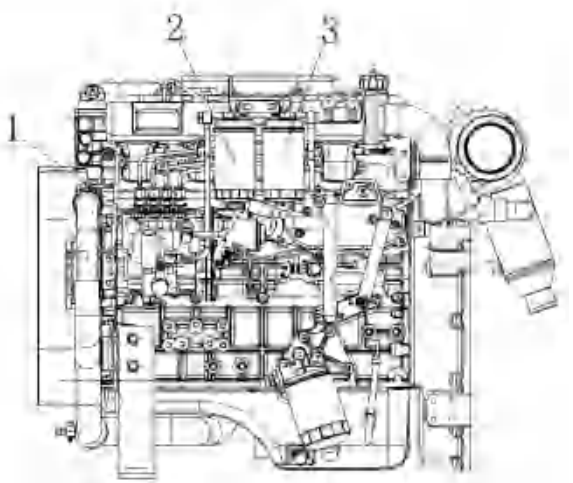


1.Exhaust manifold(Water-cooled) 2.Smoke and water mixer 3.Heat exchanger
4.Starter motor 5.Alternator 6.Seawater pump



(DB pump)

1.Intake pipe 2.Fuel injection pump 3.Fuel filter
4.Pre-fuel filter 5.Turbocharger 6.Oil filter
7.Electric Lift pump

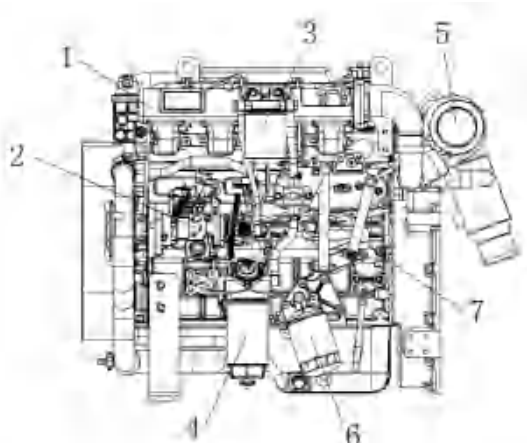


(In-line pump)

1.Fuel injection pump 2.Pre-fuel filter
3.Fuel filter

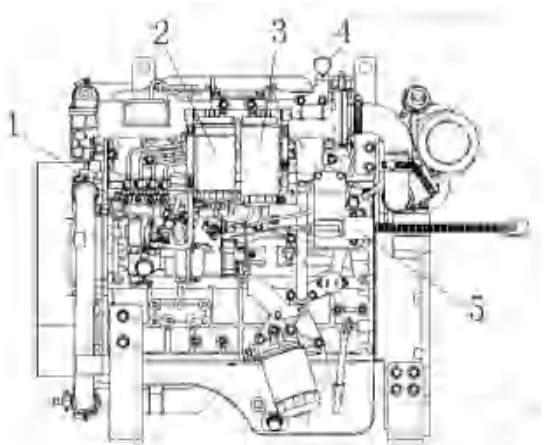
Model characters explanation（Marine G-drive）

4E38TG0-FW 4E38TG0-FS
4-----4 cylinders E-----series code 38-----3.8 liters displacement
T-----turbocharged G-----G-drive 0-----Spectrum code FW-----In-line pump FS-----DB pump



(DB pump)

1.Intake pipe 2.Fuel injection pump 3.Fuel filter
4.Pre-fuel filter 5.Turbocharger 6.Oil filter
7.Electric Lift pump

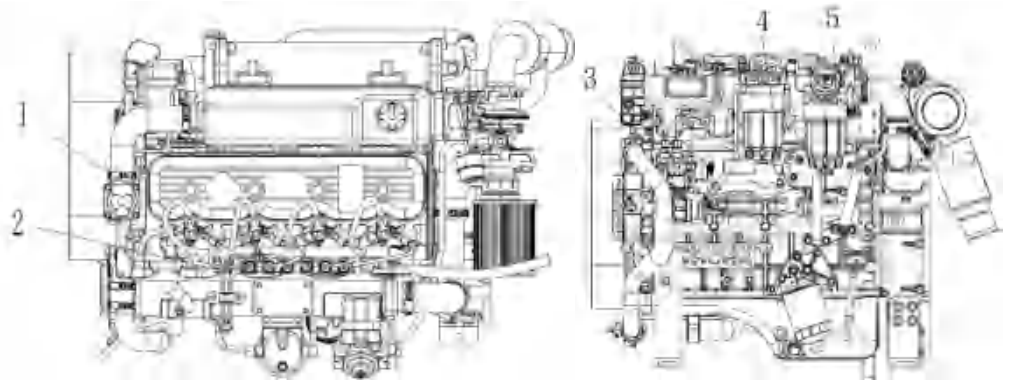


(In-line pump)

1.Fuel injection pump 2.Pre-fuel filter
3.Fuel filter 4.Manually turn off the engine and pull the wire 5. Electricity Solenoid

Model characters explanation(Marine Propulsion)

4E38T08-FW 4E38T08-FS
4-----4 cylinders E-----series code 38-----3.8 liters displacement
T-----turbocharged 08-----Spectrum code FW-----In-line pump FS-----DB pump



(High pressure diesel fuel pump)

1.High-pressure Rail 2.Rail pressure sensor 3. High pressure diesel fuel pump
4.Fuel filter 5.Pre-fuel filter

Model characters explanation(Marine Propulsion)

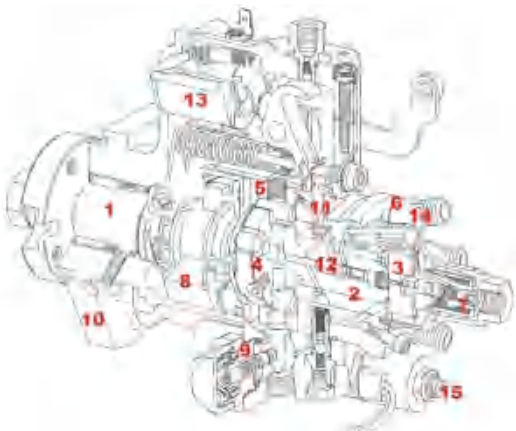
4E38T08-CB

4-----4 cylinders E-----series code 38-----3.8 liters displacement

T-----turbocharged 08-----Spectrum code CB----- High pressure diesel fuel pump

DB pump,In-line pump campare

Layout(DB pump inner)



1. Drive shaft---2. Distribution rotor---3. Fuel supply pump vane---4. Pump fuelplunger

5. Inner cam ring---6. Pump head---7. Pressure limiting component---8. Governor

9. Automatic advancer---10. Pump body ---11. Fuel volume control valve---

12. Delivery valve---13. Solenoid valve---14. Low-speed fuel quantity limiter ---

15. Solenoid valve drive cold start advancer

Feature campare

4E38TG0/FS Series

DB pump

It is suitable for 3, 4, and 6-cylinder engines, with a single-cylinder displacement of up to 1.3 liters.

The maximum speed is 3600 rpm. The maximum fuel supply is 190mm3/ trs. at 1800rpm and 160mm3/str. at 2400rpm.

The specially designed components allow the use of low-viscosity fuels such as kerosene, Jet A, and JP8.

The full-range governor has a minimum adjustment rate of 5%, while the constant-speed governor has an adjustment rate of 3-5%.

One pump can meet requirement 50Hz and 60Hz

4E38TG0/FW Series

4E38T08/FW Series

In-line pump

Characteristic: sealed pump body, integral type
plunger, the size is smaller than PW Pump, can
instead of A, AW, PL, and some kinds of VE Pump.
Parameters:
Plunger diameter: 9.5~11mm
Cam lift: 11mm
Cylinder distance: 29mm
Cylinder numbers: 2, 3, 4
Permissible Pressure: 100MPa
Max speed: 1800rpm(Fixed speed)
3000rpm(Variable speed)
Installation: riser, flange

High pressure diesel fuel pump

The high-pressure common rail fuel pump is one of the core components of the high-pressure common rail system, responsible for providing high-pressure fuel to the common rail pipe. Function: Pressurize the fuel to 1600-2500 bar (different models have different pressures) and deliver it to the common rail for storage, ensuring that the injection pressure is independent of the engine speed. Working mode: The electronic control unit (ECU) is used to regulate pressure, and the rail pressure is dynamically adjusted through the fuel metering unit to achieve precise fuel supply. Unlike traditional mechanical pumps, its driving torque is smaller, and due to the continuous high pressure in the common rail cavity, it only needs to maintain pressure instead of frequent pressure building. Structural features: Usually designed as a radial piston pump, integrated with pressure regulating solenoid valve, which can optimize oil pressure in real time according to load. Composed of a closed-loop system with a common rail and electronic fuel injectors, the injection process is completely separated from pressure generation. Advantages: Supports multiple injections (pre injection, main injection, post injection) to improve combustion efficiency and reduce emissions. Adapt to strict emission standards (such as Euro V), but require high fuel cleanliness and need to be used in conjunction with high-precision filters.

Chapter 1 Main Technical Specifications and Parameters of Diesel Engine

1. Main Technical Specifications

The parameters listed in this book are values in standard environment (atmospheric pressure: 100Kpa, inlet temperature: 298K, dry air pressure: 99Kpa, partial pressure of water vapor: 1Kpa, relative humidity: 30%).In addition, the specific value of the product is subject to change base on engines' various upgrade. Please always follow the actual engine parameters..

PS:FW-----In-line pump
FS ----- DB pump

Table 1（Marine G-drive）

Model No.	4E38TG3/FW 4E38TG3/FS	4E38TG2/FW 4E38TG2/FS	4E38TG1/FW 4E38TG1/FS	4E38TG0/FW 4E38TG0/FS
Types	four-cylinder in-line,direct injection, four-stroke,turbocharged			
bore×stroke (mm)	102×115			
Total Piston Displacement L	3.8			
Rated Power/Speed kW/r/min	50/1500	55/1800	60/1500	65/1800
Adjustable rate %	5			
Cylinders Working Sequence	1-3-4-2			
Min. Fuel Consumption Rate (g/Kw.h)	≤ 225			
Crankshaft Rotating Direction	Clockwise（from the front view of diesel engine）			
Lubricating Way	Pressure & splash combined			
Cooling Way	Forced water cooling closed cycle+sea water pump heat exchange system			
Oil capacity (L)	7			
Net Weight (kg)	380±20			

Table 2**(Marine Propulsion)**

PS:FW-----In-line pump
FS ----- DB pump

Model No.	4E38T05/FW	4E38T06/FW	4E38T07/FW	4E38T08/FW
	4E38T05/FS	4E38T06/FS	4E38T07/FS	4E38T08/FS
Types	four-cylinder in-line,direct injection, four-stroke,turbocharged			
bore×stroke (mm)	102×115			
Total Piston Displacement L	3.8			
Rated Power/Speed kW/r/min	55/2500	60/2500	65/2500	70/3000
Speed governor type	Mechanical			
Cylinders Working Sequence	1-3-4-2			
Min. Fuel Consumption Rate (g/Kw.h)	≤ 225			
Crankshaft Rotating Direction	Clockwise（from the front view of diesel engine）			
Lubricating Way	Pressure & splash combined			
Cooling Way	Forced water cooling closed cycle			
Oil capacity (L)	7			
Net Weight (kg)	380±20			

Table 3**(Marine Propulsion)** CB----- High pressure diesel fuel pump

Model No.	4E38T 08/CB	4E38T 07/CB	4E38T 06/CB	4E38T 05/CB	4E38T 47/CB	4E38T 46/CB	4E38T 45/CB	4E38T 26/CB	4E38T 25/CB
Engine Types	Vertical, inline, water-cooled and four-stroke types								
Aspiration	turbocharged								
bore×stroke (mm)	102×115								
Total Piston Displacement L	3.8								
Cylinder Working Sequence	1-3-4-2								
Rated Power/Speed kW/r/min	74/2600	67/2600	63/2600	56/2600	67/2400	63/2400	56/2400	63/2200	56/2200
Maximum Torque/Speed	353N.m/1900rpm								
Oil capacity （L）	7 (subject to the actual charge amount)								
Min. fuel consumption	≤216								
Crankshaft Rotation Direction	anticlockwise(Facing the flywheel)								
Fuel System	High-Pressure Common Rail								
Lubrication System	Pressure and Splash Lubrication								
Cooling System	Forced water-cooling closed-cycle + heat exchanger seawater external circulation system.								
Net Weight （kg）	380±20								

2. Main Technical Data

1).Valve Clearance

Table 4

Intake Valve	Cold state	0.30~0.35mm
	Hot state	0.25~0.30mm
Exhaust Valve	Cold state	0.35~0.40 mm
	Hot state	0.30~0.35mm

2). Temperature and Pressure Ranges of Diesel Engine under Normal Situation

Table 5

Max Water Temperature	≤ 95℃
Oil Pressure	196-588kPa
Oil Pressure at Min. No-load Speed	≥ 78kPa

3). Tightening Torque of Main Bolts

Table 6

Type	4E38T Series N·m(kgf·m)
Bolts for Cylinder Head	160~200 (16~20)
Bolts for Main Bearing	200~240 (20~24)
Bolts for Connecting Rod	100~140 (10~14)
Bolts for Flywheel	100~140 (10~14)
Bolts for Flywheel Housing	70~110 (7~11)
Bolts for Crankshaft Pulley	200~230 (20~23)

4). Tightening Torque of General Bolts and Nuts (For Reference)

Table 7

Strength Class of Bolt	Nominal Diameter of Bolt mm							
	6	8	10	12	14	16	18	20
	Tightening Torque N.m							
5.6	5~7	12~15	25~31	44~54	69~88	108~137	147~186	206~265
6.6	6~8	14~18	29~39	49~64	83~98	127~157	176~216	245~314
8.8	9~12	22~29	44~58	76~102	121~162	189~252	260~347	369~492
10.9	13~14	29~35	64~76	108~127	176~206	274~323	372~441	529~637
12.9	15~20	37~50	74~88	128~171	204~273	319~425	489~565	622~830

5). Recommended Value of Tightening Torque of Screw Plug

Table 7

Thread Size	NPT1/8	NPT1/4	NPT3/8	NPT1/2	NPT3/4	NPT1
Tightening Torque N.m	8~14	24~34	47~68	68~95	88~102	

Chapter 2 Operation of Diesel Engine

1. Fuel

In order to guarantee the reliability of supply system, we recommend to use the the clean diesel produced by regular fuel company. In the country or region where there is a special request about environment protection, please use the request fuel which suitable for environment regulations. The fuel holder should be clean and exclusively used. The fuel must be precipitated for at least 48 hours, and please fill the upper part of the fuel into the fuel tank.

The selected diesel brand is related to ambient temperature. When the temperature is low, the paraffin wax will be separated from diesel fuel. Then diesel fuel viscosity will decrease. Engine will be startup difficult with black smoke. On the other hand, if the diesel fuel for winter be used in summer, its viscosity will decrease due to high temperature. Fuel pipeline lubrication will be poor. Fuel injection pump and injector will be broken. Engine will be lack of power with white smoke due to delay of startup.

Please select diesel fuel base on below conditions:

Table 8

Ambient Temp.	T≥5℃	-10℃≤T<5℃	-20℃≤T<-10℃	T>-20℃
Diesel Brand to be used	No. 0 diesel	No. -10 light diesel	No. -20 light diesel	No. -35 light diesel

• Notice:

(1) Before fill the fuel, please check the fuel tank and pre-filter's bottom level, make sure to remove the excessive water in time since excessive water will cause engine can't start.

(2) Do not running the engine until fuel tank run out of fuel. Otherwise, air will be into the fuel pipeline, engine will stop due to fuel supply is not stable.

Please fill diesel in the Compliant service station. The failure of engine caused by low-grade diesel will make you lose the guarantee of quality assurance.

1.1 Fuel System Air Deflation(High pressure diesel fuel pump)

Air entering the fuel system can lead to engine starting difficulties and other engine failures. During use or maintenance, if air enters the fuel system, it is necessary to refill the fuel and then deflate the air from fuel system.

Air Deflation Procedures:

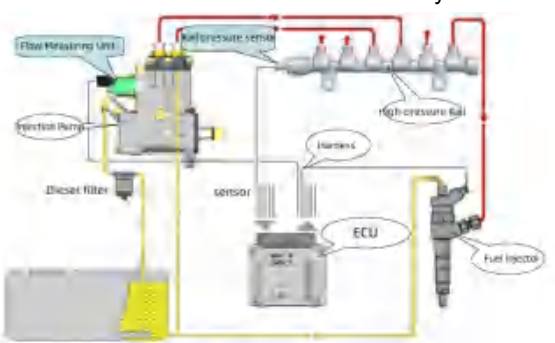
High pressure common rail fuel system air deflation

a. Turn on the power supply switch to power the ECU;

b. Loosen the high-pressure fuel pipe of any cylinder injector.

c. Press the manual pump on diesel fuel filter to remove the diesel with bubbles from the high-pressure fuel pipe. In case that the manual pump does not work, start the engine and let the high-pressure fuel pipe inject.

d. After tightening the high-pressure fuel pipe and checking that there is no leakage in each pipeline, start the engine and idle for 3~5 minutes.



2. Lubricating Oil

Diesel engine shall use the lubricating oil at CF level or above

The viscosity grade of selected oil is related to ambient temperature. The lubricant viscosity will change when ambient temperature change. It will lead engine difficult to achieve start speed or lubrication not good working. Engine difficult to startup or be damage. Therefore, the engine which work at different seasons,regions and ambient temperature, different grade of lubricant should be used.

Table 9

Ambient Temp.	Lubricating Oil Brand	Corresponding SAE Number
＞-10℃	15W/40 CF-4 level	15W/40 CF-4 level
-20℃～-5℃	10W/30 CF-4 level	10W/30 CF-4 level
＞-20℃	5W/30 CF-4 level	5W/30 CF-4 level

1).It is not allowed to use mixture oil from different brands or different manufacturers;

2). The oil to be filled is not allowed to contain foreign article or water.

3. Coolant

Diesel engine shall use antifreeze coolant fluid (which may use alcohol and glycerin mixture or glycol). It has the necessary performance of antifreeze, anticorrosion, antiscale and increasing boiling point.

Use antifreeze fluid or clean soft water which with less mineral composition and little scale deposit. The cooling system will not be clogged easily and affect heat dissipation.

- **Notice:**

1).Constantly use coolant fluid and pay attention to the continuity of the usage. Please notice that coolant fluid has not only the function of antifreeze but also the roles of anticorrosion, antiboiling and antiscale.

2) Select coolant fluid with different freezing point based on the air temperature of the region where the engine to be used. The freezing point shall be at least 10℃ lower than the min. temperature of this region so as to avoid malfunctioning.

3) Purchase qualified product and do not buy inferior one so as to avoid damages on engine and cause unnecessary loss.

4) Different brands of coolant fluid are not allowed to be used together so as to prevent chemical reaction and destroy the comprehensive performance of anticorrosion.

5) Do not add hard water, such as well water, tap water; once the coolant fluid is found to have any suspended or deposited matter, or has been stunk, it is demonstrated that it has been reacted chemically and deteriorated and malfunctioned; at this time, the cooling system should be cleaned in time and the coolant fluid should be replaced completely.

6) Glycol coolant fluid is poisonous, which shall be prevented from being contacted or inhaled; in case of skin contact, wash with water immediately and completely; furthermore,

anticorrosive additive of nitrite in this coolant fluid has carcinogenicity so that the waste is not allowed to poured randomly to avoid environment pollution.

4. Diesel Engine startup steps

Preparation and Inspection before First Startup:

1).Fill lubricating oil into oil pan till reaching upper mark on dipstick.

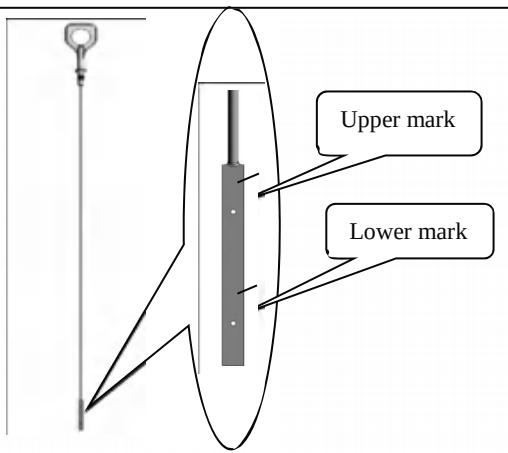
2). Add coolant fluid till reaching water tank filler, and then cover the filler cap.

3).Fill clean diesel into the tank, check the pipeline and exhaust the inside air.

4).Check the connections between battery and electrical system is correct and firm.

5).Check the pipelines and joint locaion whether there is oil and water leakage points.

6).Check the belt for its tensioning force and if any other abnormal.



Attention:when measuring the oil level, the engine must be placed horizontally with the engine in a cold state.

Preparation and Inspection before Daily Startup.

Place the engine on flat ground and keep engine in safety conditions

1).Pull out dipstick.
2).Wipe the dipstick with clean cloth, then insert it again down to the bottom.
3).Pull out the dipstick again and check the oil level.
4).Check the oil level and confirm whether it is between upper and lower mark on the dipstick;
5).If it is below the lower mark, add required grade oil.

- **Notice:**

1).The oil level check shall be carried out after engine shutdown for 15~20min
2). Check radiator coolant and add properly if required.
3). Check oil tank and add properly if required.
4). Check the pipeline/hose/joints whether there is leakage points.
5). The engine should be under the no load condition.

Starting procedure of cold engine (ambient temp is higher than 0℃):

1. Switch on with the key and check each electrical instrument is in normal indication.
2. Turn the ignition key to "ON".(If equipped with a pre-heater, then turn the ignition key to "ON" till the preheating indicator light is off.).
3.After the heating indicator disappear, turn on the engine start button to start the engine;

Warming up and inspection after startup:

1). Diesel engine shall be running at idling speed for 3~5min after startup for warming up, but cold engine shall be prevented from running at idling speed for long time.

2). The followings shall be checked during warming up:

(1). Oil pressure (the alarm light is off after warming up)

(2). Oil pressure (the alarm light is off after warming up)

(3). Pay attention to abnormal sound of engine; if any abnormal sound is heard, check the engine immediately and eliminate the fault in time.

(4). he color of the exhaust.

Table 10

The color of the exhaust	Combustion state	notes
No color or little blue	Normal	Good combustion state
Black smoke	Abnormal	Not good combustion state
White smoke	Abnormal	Not good combustion state

Breakdown and warranty period of key components related to environmental protection(High pressure diesel fuel pump)

Warranty period for key components related to environmental protection is 2000h or 2 years (whichever comes first)					
SN	Name	SN	Name	SN	Name
1	Fuel Injection Pump	2	Fuel Injector	3	Turbocharger

4	Common Rail Pipes	5	Electronic Control Unit,ECU		
The specific environmental protection related key components shall be subject to the actual model. For any component does not meet the emission warranty period provisions of the "*HJ 1014 -2020 Technical Requirements for Pollutant Emission Control of Non-road Diesel Mobile Machinery*", or does not meet the warranty scope and provisions in our company's service manual, should be “paid” for service.					

5.Running-in of Diesel Engine

The diesel engine must be run in before use, through which the surfaces of moving parts of the engine can reach good matching so as to avoid abnormal abrasion and damage. Its service life, reliability and economics shall depend on the quality of initial running-in to the great extent, please run it in strictly according to the specification.

The running in of diesel engine can be carried out together with end application. The running-in time is 40~60hours. When it is running-in, engine load should not be higher than the 70% of the rated load and engine speed should not be higher than the 80% of rated speed. It is not allowed that engine running at idle speed for long time. After running-in finished, the engine should be taken mandatory maintenance (follow details in Chapter III, 7th). It is been recommended that the mandatory wearing-in maintenance in professional service stations.

(1). Diesel engine is not allowed to work when coolant is “boiling”, it’s not allowed to work for long time if water temperature is too low or too high.

(2). Diesel engine is not allowed to run at idle speed for more than 10min.

6. Precautions during Operation of Diesel Engine

During diesel engine running, user must pay attention for below points:

1). **Oil Pressure**

During diesel engine running, if the alarm light of oil pressure is twinkled repeatedly, it shows the oil pressure is relatively low and the engine should be shut down for inspection.

2). Coolant Temperature

(1). The indication of water thermometer exceeds 100℃ or the indicator light is on, it shows the engine is overheated. Keep engine running at speed lower then 1000rpm for 5 min, then shutdown the engine for inspection.

(2). If water temperature can't reach to normal value, it shows that the engine is over-cooled. It will cause parts abrasion ahead of schedule. Please add cover to the radiator.

3). Engine Noise

If the engine and related parts has any abnormal sound, it shows that engine runs abnormally or the moving part has abnormal friction; thus the engine should be shut down for inspection.

4). Exhaust Smoke Color

If big volume of white or black smoke rise from the engine, it shows the inside combustion is abnormal and the engine should be shut down for inspection.

- **Notice:**

(1). Do not stop overheated engine instantly.

(2). Diesel engine is not allowed to work under overload for long time

7. Shutdown and Inspection of Diesel Engine

1).Before stopping the diesel engine, ensure that the engine is at no load status.

2).Diesel engine shall be operated at low speed for 3-5 minutes before shutdown in order to keep engine cooled down completely, during this period, user can check the engine such as abnormal noise, oil pressure, fuel/oil/coolant leakage.

3).Turn the key switch to “OFF” and disconnect the battery (if equipped).

When the ambient temperature is below 0℃, if the coolant is not antifreeze, drain the water in radiator completely, to avoid engine cylinder, water pump and radiator damage. If antifreeze coolant at proper temperature is used, the drainage is not required.

Chapter 3 Regular Inspection and Technical Maintenance

Because the working environment of most non-road machinery is bad, the status of deterioration is determined by the using time and the using state. If user ignore the degradation and performance degradation, engine structure and performance will be reduced correspondingly. It will lead an irrecoverable damage to the engine. If user want the engine work in a good condition at a long time, please follow the below technical requirements strictly.

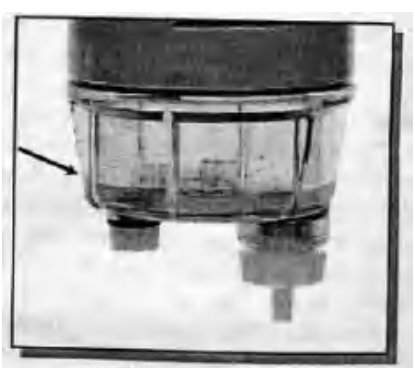
1. Fuel Supply System

The fuel pump and nozzle for injection is precise parts so that the water or impurities in the fuel will cause the piston or injector to be damaged and make the filter dirty or blocked. Thus unclean fuel will reduce the service life of the pump and the injector. Please carry out regular inspection according to the following.

1).Pre-filter(oil/water seperator) &Fuel Tank Drainage

Drain the water in oil-water separator and fuel tank regularly (every time when filling fuel). If the indicator light (if provided) on oil-water separator is on during working, shut down engine properly and drain the water.

(1). Stop engine at safe place.
(2). Place a vessel under drain plug of oil-water separator or fuel tank.
(3). Screw of the drain plug 4 or 5 turns to drain the water inside. In order to avoid the plug from dropping, do not screw it off extremely.



(4). After drainage, screw up the plug and check without leakage.
(5). Carry out air for fuel system (refer to Exhaust in Fuel System).
(6). When start the engine with oil-water separator, check whether the drain plug is leaked and whether the indicator light of the separator is off.

1.1Fuel Supply System(High pressure diesel fuel pump)

In the engine fueling system there are many precision components like the fuel pump, fuel injectors, rails etc. Moisture or impurities in the fuel can damage or fail the pump plunger, injector and various sensors, and the filter core becomes dirty or even clogged, reducing engine power output. Please conduct regular check-ups according to the following requirements.

Loosen (do not unscrew) the screw plug, drain the water and then tighten it again.

Drain water from oil-water separator or fuel tank

Drain the water from water separator or fuel tank at regular intervals (each time you fill the fuel). Stop the engine to drain the water if the water separator indicator

light up, if equipped.

a. Stop the boat or engine at a safe place.

b. Place a container under oil-water separator drain plug or fuel tank.

c. Unscrew the drain plug or fuel tank drain plug by 4 to 5 turns to drain off water. In order to avoid the drain plug from falling, do not over-unscrew the drain plug or oil drain plug.

d. Tighten the drain plug or fuel drain plug after the water is emptied, and check for leakage.

e. Deflate the air from fueling system. (Refer to fuel system air deflation).

f. A vehicle with oil-water separator should start the engine and check the drain plug for leakage. Meanwhile, check whether the oil-water separator indicator is off.

Caution: if there is need to drain the water in fuel tank frequently, please go to RAYWIN service station for further inspection.

- **Notice:**

If frequent drainage is required, please drain the water in fuel tank at the technical service station.

If the engine is not equipped with oil-water separator, consult the manufacturer to add or add oil-water separator by yourself;

2).Replacement of Diesel Filter

I Replacement Cycle

The replacement cycle for the diesel filter: Every 12 months or cumulative work at 320 hours when engine with guaranteed fuel. If the fuel with much impurities and water, reduce the replacement cycle properly.

II Replacement Procedure

(1). Screw off the diesel filter with proper tool.

(2). Wipe the joint face of the filter seat clean, fill the new filers with clean diesel fuel.

(3). Screw on filter seat till there is slight resistance, and then screw up more 2/3 circle till tightened.

(4). Exhaust the gas in fuel pipes(Exhaust in Fuel System)

(5). Start up engine and check for the leakage.

3).Exhaust air in fuel system

Air entering into the fuel system will lead to difficult startup of engine and other failures. During use or maintenance, If the fuel tank is emptied during maintenance, please exhaust the air in the fuel system after refilling of fuel.

Procedure of Exhaust in Fuel System :

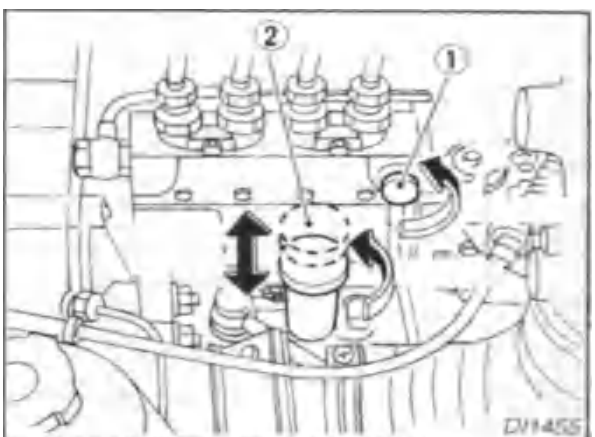
(1). Loosen the bleed screw ①

(2). Press the fuel transfer pump ② up and down with force till no bubbles could be seen in the fuel exhausted from the bleed screw ①.

(3). Tighten the bleed screw ①

(4). Press the transfer pump ② up and down with force till the resistance is increase suddenly.

(5). If the engine is not operated stably after startup, increase to the highest throttle two or three times.



- **Notice :**

1). The piston type fuel transfer pump, mounted on the side of injection pump, is driven by the eccentric wheel on the camshaft of the injection pump. When diesel engine stop running, if fuel pumping or air exhausting is required, pump fuel with manual pump and then tighten the nut on manual lever. The joint of fuel suction pipe is set at the bottom of the transfer pump; and inside the joint bolt, there is a small sieve which is mounted at the front portion of the fuel pipeline.It

filters most of the impurities. Hence do not throw this small sieve away in usual inspection; furthermore, this sieve shall be cleaned frequently, otherwise the fuel pipeline will be blocked resulting in abnormal operation of diesel engine.

2).The engine installed with a single- or double-grade spin-on filter, it with bleed screw on the top. The filter element shall be cleaned or replaced regularly. To avoid mess up inside of the filter body when doing maintenance; especially, the seal at every portion shall be noticed when in assembling. In order to guarantee diesel engine to get clean fuel,it is suggested that users or supporting manufacturers should install a primary oil-water separator or a fuel filter with less resistance before the filter.

3).Injection pump is the heart of diesel engine, so the engine performance depends on the pump. The pump has been adjusted properly before delivery and sealed with lead already. Do not unseal. Maintenance and adjustment is required to be carried out on special test stand by professional people.

2. Lubricating System

If no maintaining to the engine lubrication system, it will greatly affect the service life of the engine.

Please replace lubricating oil and the filter in accordance with the specified maintenance cycle.

Replace lubricating oil and the filter

following below steps to change lubricating oil and oil filter.

The warning light for oil pressure is on during operation of the engine indicating filter blocked. Replace it immediately regardless of the specified maintenance cycle.

1).Replacement Cycle

Lubricating oil: 6 months or the accumulative work 100 hours

Oil filter: 6 months or the accumulative work 100 hours

2).Replace lubricating oil

(1). The engine in normal temperature.

(2). Stop engine on horizontal plane with parking brake

(3). Stop the engine. Cut off the power and wait at least 10 to 15 minutes

(4). Use a large oil pan (about 8 liters) to catch the oil outlet of the engine oil sump

(5). Open the refueling port cover (on the top cylinder cover of the engine).

(6). Unscrew the oil drain plug on the oil sump and drain the oil thoroughly.If you need to change the oil filter, you can remove the oil filter and replace it with the above steps. See "change the oil filter" section.

(7). wash the drain screw plug and install it together with the gasket, then tighten it with a wrench(tightening torque of drain screw plug: 54-59n •m(5.5-6.0kg•m), be careful not to overexert).

(8). Add the required oil and cover the filler cap.

Oil filling capacity :

Oil gauge's upper grade(when change oil filter element)

Oil gauge's middle grade(when not change oil filter element)

Note: use the recommended engine oil (see chapter 2 "lubricating oil" for details)

(9). Start the engine and check whether there is oil leakage around the drain plug and oil filter.

(10). Run the engine for 3-5 minutes and then shut down.After 10 minutes, check the oil level to meet the requirements.

(11). Proper disposal of waste oil

- **Notice：**

a).The used oil must not be poured into the ground, ditches or rivers.Disposal should be carried out at properly equipped dumps. We suggest that the engine oil be replaced by the service centre. Be sure to follow the rules when dealing with waste oil. Make sure local regulations are in place first (regulations on environmental pollution vary from country to country).
b).long-term and frequent contact with oil can cause serious skin diseases, including dermatitis and cancer.
c).Avoid contact with skin as much as possible and wash thoroughly after contact.
d).Keep out of reach of children.
e).It is illegal to pollute sewers, waterways and land. Approved waste collection equipment is to be used, including sites in the city where waste oil and filters can be properly treated and garages.If in doubt, seek advice from local authorities.

Be careful not to burn yourself when the engine oil is hot.

3). Change engine oil filter

Used oil filter should be handled with appropriate device in the garbage dump. We advice that changing oil filter in the service station.

(1). Engine should be placed on a flat road in the safe condition
(2). Using the filter wrench to loosen the filter. (according to the type of engine, you may need a special cap-type wrench. If you have some question, you can inquire Raywin maintenance station.) then you can use the filter wrench unscrew the filter.

Attention: be ware of hand burns by hot oil.

(3). Use a cloth to wipe the mounting surface of the filter cleanly.
(4). Hand tight until the packing contacts the sealing face and tighten filter 2/3 turn.

(5). Start engine, check for the surrounding of filter whether oil leaks, then adjust it if it is necessary.

(6). Turn off the engine, check for the oil height level, make it meet the requirement.

3. Cooling system

1). Check for drive belt

(1).Check belt if any cracks, wear or oil/water adsorption. Replace it if necessary. The belt is not allowed to contact the bottom of the groove.

(2).Pressing the middle of the two pulley belt to check for the offset of the belt. When the fan belt exceeds the prescribed value of the offset, replace the fan belt, and adjust the fan belt tension as below table

Table 11 Belt Deviation： Unit：mm

Driving belt	Deviation of used belt		Deviation of new belt
	Limit	Deviation after adjustment	
Fan belt	12-13	8-9	7-8
Pressure applied	98N(10kg)		

2). Engine cooling fluid

Check coolant level height

After the engine is cooled, please check the coolant level in the radiator. If the coolant position is low, add coolant to the radiator cover.

Notice:

If the cooling system requires frequent supplement of coolant fluid, please make a

check in maintenance service center.

Replacement of Coolant Fluid in Engine

(1). Open both drain plug and radiator cap.
(2). Open the drain valve on the engine block.
(3). Drain the coolant and tighten the drain valve on the cylinder block.
(4). Add coolant to the radiator
(5). Keep the engine running for about a minute to clear the air.
(6). Stop the machine and wait for it to cool down, check the coolant and, in case of shortage, supplement the coolant to the radiator.

4. Air Intake System

The working condition of the intake system greatly affects the service life and performance of the engine.

Dirty air filter elements can cause insufficient intake of air into the engine, resulting in engine power loss and ultimately engine failure, shortening the service life of the engine.

For the air filter of diesel engine, please follow the "regular technical maintenance" to maintain the air filter.

5. Battery

1) The surface of battery shall be kept clean and dry. Any corrosive liquid shall be washed away with alkaline water.
2) The joint of battery shall be ensured clean and firm.

3) If engine not work for more than 30days, please cut off the battery to be negative "-" (or cut off the power switch) to avoid leakage.

NOTICE :

Do not let the battery near to fireworks or electric spark since the hydrogen released during the reaction of battery would explode. Do not let battery fluid contact skin, eyes, textile, or paintwork. After touch the battery by hand, do not rub eyes with this hand and clean it completely. Once the acid fluid contacts eyes, skin or clothes, wash with clean water for at least 15 minutes immediately and go to see a doctor in time.

6. Usage and Technical Maintenance in Winter

When the temperature is below 5℃ in winter, the diesel fuel may be frozen due to low temperature of diesel engine body and increased viscosity of lubricating oil, which results in difficult startup of the engine. Hence it is better be carried out comprehensive technical maintenance before entering into winter and the followings shall be noticed in usage:

Fuel

1) Choice of the fuel

(1). Select proper fuel as appropriate (Refer to the section of "Fuel" in Chapter 2 for details).

(2). Please go to service station to make sure you use the right fuel.

2) The supply of fuel and eliminate water

(1). Pay attention to the supply of fuel.

(2). Pay attention to loose the drain plug of the fuel tank to exhaust the deposited water content

before startup.

- **Notice：**

(1). If the liquid surface of Fuel tank is low, it will increase the cubage of air. So that it will increase the amount of air in the fuel tank.

(2). Damp amassment may cause the fuel tank rust, and it may lead engine start difficult or engine malfunction.

Coolant Fluid

When the temperature decreases below 0℃, the water in the cooling system shall be drained after shutdown. In order to avoid draining and filling water repeatedly, we recommend to use antifreeze coolant fluid (refer to the section of “Coolant Fluid” in Chapter 2 for details).

- **Notice：**

(1). Carbinol base antifreeze is not recommended because it will affect the non-metal material in the cooling system and decrease the boiling point of the coolant fluid.

(2). High silicate antifreeze is not recommended because it will lead to serious deposits.

(3). Please use antifreeze as the proper proportion recommended by related manufacturer.

Lubricating Oil

When the temperature decreases, the viscosity of the oil increases resulting in difficult startup of the engine, and the viscosity affects the stability of the engine; hence it is very important to select lubricating oil with appropriate viscosity based on the temperature. (Refer to the section of “Lubricating Oil” in Chapter 2 for details)

Battery

The battery capacity decreases pending on the temperature and its discharge rate reduces

rapidly. Therefore it is proposed to check the battery in chartered service station before winter and replace it if necessary.

1) Pay attention to charge the battery fully in cold winter.
   (1). Cold startup requires a large current consumption, thus comparing to normal temperature, more time is needed for recharge after startup.
   (2). The electrolyte of undercharged battery has low specific density so that it is easy to be iced up and damaged
2) Pay attention to cold-proof for battery in winter.
3) Refill distilled water to battery shortly after starting the engine. If it is done after the engine begins to work, the supplemented water can not mix with the original electrolyte and the unmixed water may stay in the upper layer and cause ice.

Engine Startup in Winter

The followings shall be paid attention to in starting the engine below 0℃**:**

(1). Preheated before starting the engine.
(2). If the first start is not succeed, please wait 30 seconds to restore power to the battery and then re-warm start.
(3). Please make sure each starting time must not exceed 15 second to protect the starter.
(4). When starting, if the starter pinion and flywheel collidere peatedly, it indicates that the battery is low and the battery should be charged.
(5). When the temperature is low, turn on the pre-heater device(in installed), increase the diesel fuel temperature to make sure fuel supply is properly. When starting at a very low temperature, set the throttle to the fuel cut-off position and let the engine running at idlespeed for a while, so that all moving parts of the engine loosen a properly, it will reduce the adhesion

of cold lubricating oil, and then warm up and start the engine.

- **In the winter, you should pay particular attention to:**

When the temperature is below 0℃,the diesel will separate out wax ,which make oil becomes thick and if summer diesel is used in winter , failure is highly likely. As a result, engine must be used for special maintenance.

(1). Fuel and oil for winter must be used and pay attention to the water content in the fuel to avoid freezing

(2). Cooling system must fill antifreeze that be compatible with temperature

(3). In the cold season and region vehicles should not stop in the open as much as possible.

(4). During cold starting, please start the pre-heater device, and start the engine when pre-heater light is off.

(5). When the temperature is low, turn on the pre-heater device (in installed), increase the diesel fuel temperature to make sure fuel supply is good.

7.Regular Technical Maintenance

Regular technical maintenance is the important things for using diesel engine reasonably. If you want to keep your diesel engine in good technical status and long-term reliably, you must always follow the standard seriously and make technical maintenance strictly.

At the time of maintenance, you should pay attention to the parts cleaning specially. Therefore, Reinstalling the parts, you should ensure the parts be cleaned and be installed correctly, and then check whether the engine running on normally or not.

■ **Technical maintenance included :**

I Daily maintenance(work 8 ~ 10 hours);

II First mandatory runing-in maintenance(work 50 hours cumulatively or 3 months);

III Grade I Technical maintenance(work 100 hours cumulatively or 6 months)；

IV Grade II Technical maintenance(work 300 hours cumulatively or 12 months)；

■ **Daily maintenance：**

1).Check it that whether the sump oil level between two scribed line of oil scale. If not ,you should add oil. If you find oil level suddenly raise or lower,check out the reason immediately.
2).Check the coolant ,if not sufficient,you should add.
3).Check the height of battery electrolyte liquid surface, liquid surface should maintain higher than plates 10 ~ 15 millimeter ,insufficient should add distilled water.
4.Check the fuel quantity within fuel tank, if it's shortage ,you should add fuel.
5).Check whether each part of the diesel engine is loose and reliable connect or not, If it is loose, tighten it.
6).Eliminate the abnormal phenomenon that diesel engine occur during operation fault and fuel/oil/coolant leakage.

7).Clean the dirt and debris on the radiator surface。

■ **First running-in maintenance:**

1) Check coolant's level and all joints of the water pipes for coolant fluid shall have no leakage.
2) Check battery, check color marked holes are in green color, confirm the connection of positive and negative pole is reliable and installed correctly. check whether there is the battery

electrolyte leakage around.
3) Check the tightness and abnormal abrasion of the belt by sight.
4) Check all parts of the diesel engine to be connected reliably and firmly.
5) Clean away the dirt on the radiating surface of the surface of radiator.
6) Use compressed air clean air filter element.
7) Completely release the engine oil.
8) Replace engine oil filter element.
9) Fill in oil, check the oil level should be in between the fluctuation scale ruler and partial limit position.
10) Check whether there is water in bottom of pre-filter, remove the water if there are excessive water.
11) Check engein status at idling speed, slowly throttle up the engine and listen whether there is abnormal sound of engine
12) Slowly throttle up the engine, after temperatures rising, you can use your ears to hear whether the fan is normal operation

■ **Grade I Technical maintenance :**

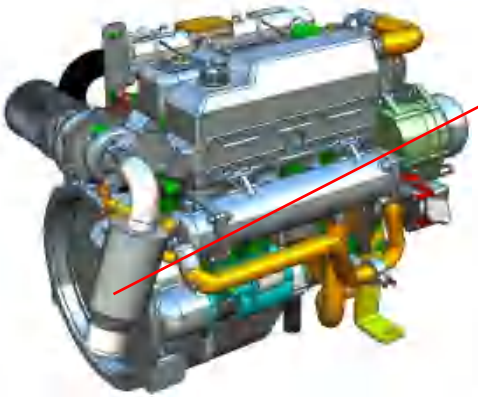
Except the lucubration oil and oil filter no need change, follow the same process as First running-in maintenance

■ **Grade II Technical maintenance :**

After " First running-in maintenance " , we still must do the followings:

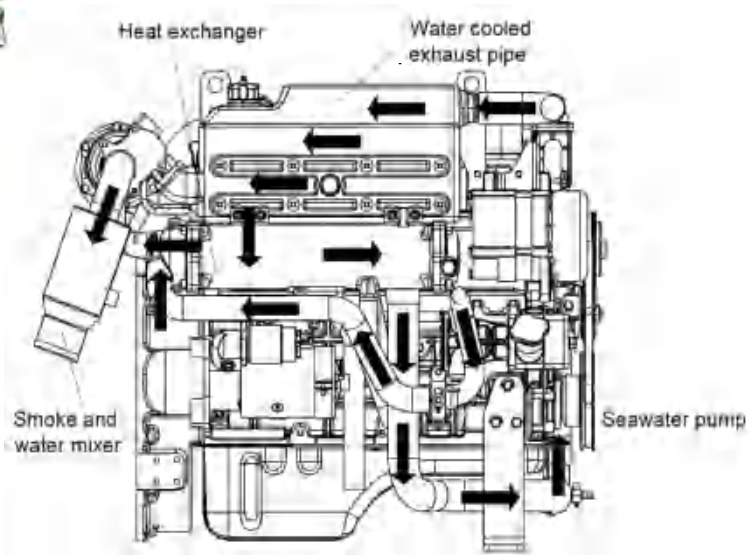
1) Replace the fuel filter.
2) Replace the air filter element.

■ **Wet exhaust pipe(smoke water mixer) :**

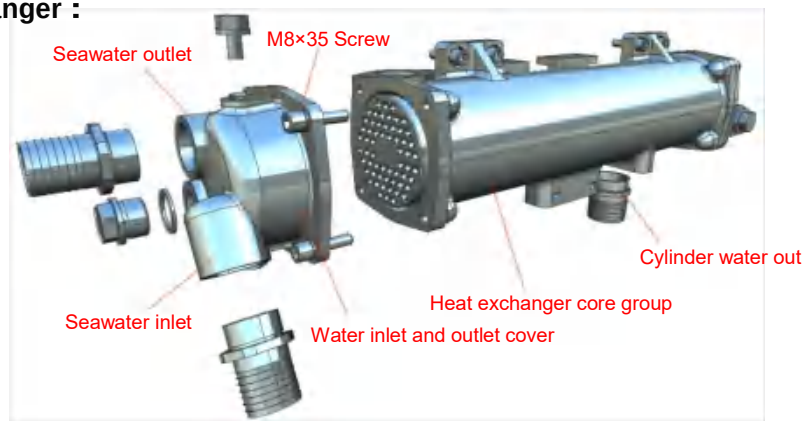


Smoke and water mixer (refer to the shape diagram of each model for the outer diameter of the interface)

■ **Heat exchange system :**



■ **Heat exchanger：**

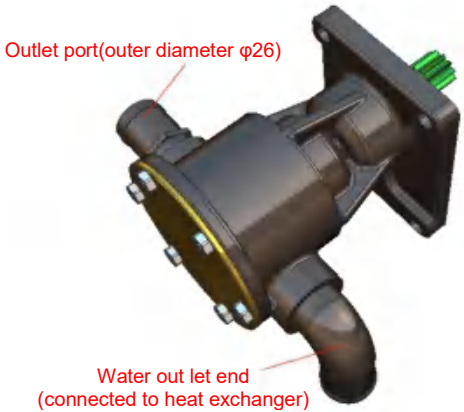


The core of the heat exchanger is a tubular structure. Seawater flows inside the pipe, while fresh water flows through the guide plate outside the pipe, exchanging heat through the cooling pipe to dissipate heat from the cylinder liner water. Zinc rods are installed on the end cover to slow down the corrosion of cooler components by seawater. After a period of use, a layer of scale will form on the surface of the zinc rod, which should be cleaned regularly, otherwise it will lose its anti-corrosion effect. After the zinc rod itself is corroded, it should be replaced with a new one.

1. Due to the corrosiveness of seawater, it can damage the surface of the protective layer, causing pipes to corrode and form dirt, reducing the flow area of seawater and reducing the cooling effect. Therefore, it should be cleaned regularly and frequently. Disassemble the inlet and outlet end covers of the heat exchanger, remove the cooling core,
and immerse it in water containing detergent. Use a non-metallic brush to clean the inner diameter of the heat dissipation pipe. After removing the scale for 15 minutes, remove the water pipe bundle and thoroughly rinse it with water. Check the corrosion of the inlet and outlet end covers and zinc rods. All sealing rings/gaskets must be replaced.

2. It is recommended to replace the anti-corrosion zinc rod every 3 months

■ Seawater pump：



The seawater pump is equipped with a high flexibility plastic impeller. Please use and maintain the seawater pump correctly, otherwise it may cause a decrease in the pumping capacity or damage.
Maintenance precautions:
1. The seawater pump should not idle, otherwise it may cause severe impeller wear Loss;
2. Please install a seawater filtration device at the front end of the seawater pump inlet to prevent debris from entering the seawater pump, which may cause damage to the impeller of the water pump and damage to the water seal;
3. Regularly replace the impeller to ensure the pumping capacity of the seawater pump, otherwise it may cause poor engine cooling; When replacing the impeller, first remove the end cover, and then use tools to remove the rubber impeller. The impeller replacement cycle is 500 hours for inspection and 800 hours for replacement;When the engine is stopped for a long time, the seawater pump and pipeline should be drained of seawater, and compressed air should be used to
blow dry any remaining water inside.

■ Maintenance of diesel engine：

Correct, timely and careful maintenance can guarantee diesel engine working smoothly for a long time, to prevent the occurrence of fault, reduce wear, prolong the service life. The user should according to the content listed in diesel engine maintenance, specific classification as follows:

Note: the use of harsh conditions (minimum temperatures below - 20℃, or the highest temperatures higher than 35℃, or environmental dust content in the high desert, mine site, construction sites, coal yards, etc.), it isnecessary to shorten the replacement cycle of engine oil.

Engine maintenance cycle time

item	Mainteranice cycle time											
	50hrs	100hrs	200hrs	250hrs	400hrs	500hrs	1 or 2 mouths	1 year	800hrs	1500hrs	3000hrs	2 years
Check fule tube and clip	☆											
※Oil change	★ first		☆									
Check position ofbattiery electrolyte		☆										
Check fan belt tension and damage		☆										
Check radiator hose and hose clamp		☆										
※Changel oil filter	★ first			☆								
Check the intake line				☆								
Change fuel filter				☆								
Clean core of air filter				☆								
Clean inner of fuel tank						☆						
Clean inside the water jacket and the radiator						☆						
Replace fan belt									☆			
Recharge battery		☆					☆					
Change core of air filter						☆						
Check valve clearance									☆			
※Check injector										☆		
Check turbocharger(if have)											☆	
Replace intake tube system												☆
Replace battery												☆
Replace radiator hose and hose clamp												☆
Replace fuel hose and clamp												☆
Replace radiator coolent(LLC)												☆
Inspecting the seawater pump impeller(marine)						☆						
Replacement of seawater pump impeller(marine)									☆			
Replacement of zinc rods(for boats)								☆				
Clean inside the water jacket and the radiator												☆
Note: After running 50 hours,please change oil and oil filter												
According U.S. EPA off road emission standard,above items listed as the important items by our company												

Chapter 4 Common Fault Analysis and Elimination Approaches for Diesel Engine

1. Difficult Startup of Diesel Engine

Fault Characteristics & Causes	Elimination Approaches
1). Fuel system a) Fuel brand is selected improperly. b) Fuel tank is out of oil or it is switched off. c) Air in fuel pipeline or fuel pump d) Water is mixed in fuel e) fuel pipeline or fuel filter is blocked. f) No fuel supply from fuel pump or advance angle is not improper.	a) Select proper fuel brand. b) Add fuel to the tank or switch it on. c) Exhaust the air in fuel system, then tighten the pipe joints. d) Replace the fuel. e).Remove the fuel pipe and filter for cleaning or replace the filter element. f) Check the lift pump or fuel pump, adjust the advance angle properly.
g) Injector no fuel spray, less fuel spay, low spray pressure, bad atomization, injector pressure adjusting spring broken, injection hole blocked h) Fuel pump injection valve leakage, spring broken, plunger coupling broken	g) Clean and polish the matching parts of the injector, adjust the injection pressure; or replace the injector assembly. h) Replace the injection pump, spring or plunger.
2). Cylinder pressure is insufficient. a) Valve clearance is too small. b) Air leaks from valve.	a) Adjust the valve clearance. b) In case of reduced elasticity of the valve

c) Air leaks from junction of cylinder head and gasket. d).Piston ring is worn, coked or the openings are overlapped. e).Abrasions of cylinder liner and piston exceed the specified limits.	spring, replace the spring; in case of bad sealing performance of the taper surface, polish the valve. c) Replace the head gasket. d) Remove the coking; replace the piston ring; adjust the opening position of the piston ring. e) Replace the cylinder liner and the piston.
3).Fuel has large viscosity and is difficult to be atomized due to too low temperature, even block fuel pipeline.	3).Heat the cooling water and use proper diesel fuel.
4).Check electric appliance system a).Battery power is low or the configuration is too small. b) Connections of electric appliance system have poor contact. c) Electromagnetic switch of starter malfunctioned. d) Gear of starter can not be engaged to ring gear of flywheel. e).Electric brush of starter and commutator has poor contact. f) Preheating device malfunctioned or preheating time is short.	a).Charge or provide with battery conforming to the requirement; b) Tighten the connections of the electric appliance system; c) Repair the electromagnetic switch of the starter or replace the starter; d) Find out the reasons and solve; e).Repair or replace the brush, clear up the commutator surface with fine emery paper, and blow off dust. f).Replace the preheating device or extend the preheating time.

2. Unstable Minimum No-load Steady Speed (Idle Speed)

Fault Characteristics & Causes	Elimination Approaches
1).The minimum no-load steady speed (idle speed) is lower than 650rpm.	1).Go to Raywin technical service station to check fuel system.
2). High-speed and idle-speed throttle in wrong positions.	2).Adjust the positions of the accelerator handles.
3).The lever is bent or has loose connection.	3).Tighten or replace the handle.
4).Air is entrained in fuel pipeline.	4).Exhaust the air.
5).Nut connecting between injection pump and diesel engine is loose.	5).Tighten the connecting nut.
6).Valve clearance is too large.	6).Adjust the valve clearance.
7).Cylinder pressure is insufficient. a) Valve clearance is too small. b) Air leaks from valve. c) Air leaks from connection of cylinder head and gasket. d).Piston ring is worn, coked or the openings are overlapped. e).Abrasions of cylinder liner and piston exceed the specified limits.	7) a) Adjust the valve clearance to specified value; b) In case of reduced elasticity of the valve spring, replace the valve spring; in case of bad sealing performance of the taper surface, polish the valve; c) Replace the head gasket; d) Replace the piston ring and adjust the opening position; e) Replace the cylinder liner and the piston.
8).Gear mark is wrong.	9). Adjust gear timing marks.
9).Internal sieve of bolt is clogged.	9).Clean the sieve.

10).Fuel pump does not work properly.	10). Replace the pump.

3. Unstable Speed of Diesel Engine

Fault Characteristics & Causes	Elimination Approaches
1). Fuel pipe a) Air exists in fuel supply system. b) Excessive water in fuel. c) Fuel pipe leaks.	a) Exhaust the air in the fuel system and tighten the connections of the fuel pipe; b) Replace the fuel; c) Tighten the connections of the fuel pipe or replace the pipe.
2). Speed governor works improperly.	2). Adjust and calibrate the speed governor.
3). Cylinder head gasket performs bad sealing.	3).Check the bolts and the gasket of the cylinder head. Tighten the bolts or replace the gasket.
4). Cylinders supply fuel differently. a) Injection pump has different fuel supplies from each cylinders; b) Injector performs badly or the matching parts are seized. c) Piston spring for injection pump is broken.	a) Adjust the fuel supply from the cylinders to injection pump; b) Check the situation of injection, clean or replace the matching parts; c) Replace the spring.

4. Diesel Engine Power shortage

Fault Characteristics & Causes	Elimination Approaches
1).Element of air filter is clogged.	1).Clean the element or replace it if necessary.
2).Inter-cooler is too dirty.	2).Clean up the stain as well as impurities and dust inside the cooler.
3).Exhaust manifold or main pipe is clogged.	3). Remove the foreign matters in the pipe.

4). Air exists in fuel pipeline.	4).Exhaust the air and tighten the connections of the pipe.
5). Fuel tank fuel reserve is insufficient and the fuel used is in poor quality.	5). Fill up fuel to the tank; select the fuel in accordance with the requirement.
6). Injection pump piston or delivery valve seat malfunctioned; or the connecting nut of high-pressure fuel pipe is loose.	6). Tighten or adjust.
7).Advance angle of fuel supply is improper.	7).Adjust the angle.
8).Injector has bad atomization.	8).Adjust the injection pressure.
9).Valve clearance is improper.	9).Adjust the clearance.
10).Compression pressure in cylinder is insufficient.	10).Refer to Item 8 in (2) “unstable idle speed”.
11).Injection timing is improper.	11).Adjust the gear to align the mark.
12).Injection pump works improperly.	12).Adjust or replace the pump.
13).Air exists in fuel pipeline.	13).Exhaust the air and tighten the connections of the pipe.

5. Exhaust Smoke Abnormal

Fault Characteristics & Causes	Elimination Approaches
1). White smoke rises. a) Water exists in cylinder. b) Water is into fuel.	a)Check and eliminate the fault. b) Replace the fuel.
2). Blue smoke rises. a) Oil flees; piston ring is on backward, seized	a) Adjust or replace piston ring.

or worn too much. b)Clearance between valve stem and valve guide is too large. c)Oil seal for valve stem is damaged.	b) Replace the valve. c) Replace the oil seal.
3).Black smoke rises. a) Diesel engine is under overload. b) Fuel supply is delayed too much. c) Fuel supply is excessive. d) Air filter and exhaust pipe is clogged. e)Valve clearance is improper; valve is sealed incompletely. f) Timing for fuel injection is improper.	a) Reduce the load. b) Adjust the advance angle of fuel supply. c) Adjust injection pump and speed governor. d) Get rid of the dust in the air filter and exhaust pipe; or replace element of the filter. e) Adjust the valve clearance; in case of bad sealing performance of the taper surface, polish the valve f) Adjust the gear of the injection pump to align the mark.

6. Diesel Engine Overheated

Fault Characteristics & Causes	Elimination Approaches
1). Cooling water in the tank is insufficient or contaminated.	1). Fill up or replace the cooling water in the tank.
2). Cooling system is impeded.	2). Get rid of the scale, foreign matters in the pipes for free flowing.
3). Water pump belt is loose.	3). Adjust the tensity of the belt.
4). Water pump works improperly.	4). Repair or replace the water pump.
5). Temperature thermostat malfunctioned.	5). Repair or replace the temperature saver.

6). Lubricating oil is in poor quality.	6). Replace the lubricating oil.
7). Water thermometer malfunctioned.	7). Replace the water thermometer.
8). Diesel engine works under overload.	8). Reduce the load.

7. Abnormal Sound during Operation of Diesel Engine

Fault Characteristics & Causes	Elimination Approaches
1). Fuel injection is too early; there is rhythmic and clear metallic rapping in cylinder.	1). Adjust the advance angle of fuel supply.
2). Fuel injection is delayed too much; there is dull and indistinct sound in cylinder.	2). Adjust the advance angle of fuel supply.
3). Clearance between piston and cylinder is too large so that there is clash in the cylinder after startup of diesel engine. The sound will be diminished with warming up of the engine.	3). Replace the piston or the cylinder liner.
4). Clearance between piston pin and pin hole is too large. The sound is soft and sharp, which will be clearer at idle especially.	4). Replace the parts to guarantee the specified clearance.
5). Clearance between main bearing and connecting rod bearing is too large so that clash of machine members can be heard when the speed of diesel engine is decreased suddenly. The sound is heavy	5). Replace the parts to guarantee the specified clearance.

and strong when the speed is low.	
6). Axial clearance of crankshaft is too large so that clash of the crankshaft's moving forward and backward can be heard in case of idle speed.	6). Replace the crankshaft thrust plate to guarantee the specified clearance.
7). Valve spring is broken; push rod is bent; valve clearance is too large; splutter or soft and rhythmic knock can be heard at cylinder head cover.	7). Replace the parts, adjust the valve clearance.
8). Top of piston bumps cylinder head or valve so that metallic rapping can be heard near the cylinder head in case of low speed.	8). Adjust the valve clearance, valve timing or replace the head gasket.
9). Gear clearance is too large due to wearing so that clash can be heard at gear box when speed is decreased suddenly.	9). Replace the gear as appropriate.

8. Excessive Lubricating Oil Consumption

Fault Characteristics & Causes	Elimination Approaches
1). Lubricating oil is too much or splashed excessively.	1). Drain some oil.
2). Oil leaks at drain bolt, oil filter, cylinder head, oil pan gasket, cylinder head cover gasket, front and back oil seals, oil filter gasket, end caps, and plugs.	2). Tighten the bolt, replace the gasket, replace the end cap or plug.

3). Spill port of oil control piston ring is clogged by coke.	3). Get rid of the coke at the spill port.
4). The oil is in poor quality.	4). Replace the oil.
5). Piston ring is worn or clamped.	5). Replace the piston ring.
6). Clearance between cylinder liner and piston is too large.	6). Replace the cylinder liner or the piston.
7). Oil seal for valve stem is worn.	7). Replace the oil seal.

9. Excessive Fuel Consumption

Fault Characteristics & Causes	Elimination Approaches
1). Air filter is clogged.	1). Clean or replace the filter element.
2). Inter-cooler is too dirty.	2). Get rid of impurities and dust on outside surface of the inter-cooler.
3). High-speed stop screw is not sealed up.	3). Seal up the high-speed stop screw.
4). Fuel pipeline leaks.	4). Tighten fuel pipe joints, replace the pipe.
5). Exhaust pipe is clogged.	5). Get rid of the dirt in the exhaust pipe.
6). Min. no-load steady speed is too high.	6). Adjust the min. no-load steady speed to specified value
7). Fuel is in poor quality.	7). Use specified fuel.
8). Advance angle of fuel supply is improper.	8). Adjust the advance angle.
9). Fuel out of Injector is in bad status.	9). Adjust the opening pressure of fuel injector, check and clean the nozzle or replace it.
10). Valve clearance is improper.	10). Adjust the valve clearance.
11). Injection pump works improperly.	11). Adjust or replace the injection pump.

10. Malfunctioned Lubricating System

Fault Characteristics & Causes	Elimination Approaches
1). Oil pressure is too low. a) Oil pan is short of oil. b) Oil passage is clogged. c) Oil filter is clogged. d) Diesel engine is overheated so that the oil temperature is too high and the oil is thinned.	a) Fill oil until it arrive at the marking line on the dipstick. b) Clean the oil passage and blow off by compressed air. c) Clean the oil filter or replace the filter element. d) Reduce the load, replace the oil and lower the oil temperature.
2). The oil is in poor quality.	2). Replace with the oil in conformity with the requirement.
3). Spill valve of oil filter is sticking or has excessive oil return.	3). Repair or replace the oil filter.
4). Oil pump screen is clogged.	4). Clean the screen.
5). Oil pump gear is worn or the end clearance is too large.	5). Adjust or replace the gear.
6). Oil pipe is broken or the joint gets loose.	6). Tighten the joint.
7). Oil pump malfunctioned.	7). Repair or replace the oil pump.
8). Connecting rod bearing and main bearing are worn.	8). Replace the connecting rod bearing and the main bearing.
9). Oil pressure gauge is damaged.	9). Replace the pressure gauge.

11. Malfunctioned Cooling System

Fault Characteristics & Causes	Elimination Approaches
1). Water temperature is too high. a) Cooling water is insufficient. b) Spring of radiator cap is soft. c) Belt of water pump is loose or damaged. d) Temperature thermostat malfunctioned. e) Water pump works improperly. f) Scale deposit in cooling water passage is too much. g) Radiator is clogged. h) Water leaks from radiator. i) Water leaks from water pump. j) Connecting tube of radiator is loose or broken.	 a) Fill up cooling water into the tank. b) Replace the spring. c) Tighten or replace the belt. d) Replace the temperature thermostat. e) Repair or replace the water pump. f) Clean the cooling water passage to get rid of the scale. g) Clean the pipeline of radiator for clearing. h) Repair or replace the radiator. i) Replace the gasket or packing plate. j) Tighten or replace the connecting tube.
2). Water temperature is too low. a) Temperature thermostat malfunctioned. b) Temperature thermostat is improper. c) Ambient temperature is too low.	 a) Replace the temperature thermostat. b) Use as specified. c) Set shelter from wind for protection.

12. Malfunctioned Starter

Fault Characteristics & Causes	Elimination Approaches
1). Starter does not work. a) Connection wire has poor contact. b) Battery is undercharged. c) Electric brush has poor contact. d) Starter has open circuit.	 a) Clean and tighten the contact. b) Charge up the battery. c) Clean the commutator surface. d) Repair or replace the starter.
2). Weak Start at no load a) Bearing bushing is worn. b) Electric brush has poor contact. c) Commutator is dirty or singed. d) End terminal is desoldered. e) Poor contact. f) Switch has poor contact. g) Battery is undercharged or has small capacity.	a) Replace the bearing bushing. b) Clean the commutator surface. c) Clean the oil stain and polish with fine sand cloth. d) Weld the terminal firmly. e) Clean and tighten the contact. f) Repair the switch. g) Charge up the battery or replace with the battery having enough capacity.
3).Gear withdrawal difficult; electromagnetic switch contact is burned out.	3).Replace the electromagnetic switch.

13. Malfunctioned Alternator

Fault Characteristics & Causes	Elimination Approaches
Not charged completely; undercharged; unstable charging current	a) Replace in time if damaged.

a) Measure diode or IC regulator one by one with multimeter after opening the back cover of alternator. b)Check the body, seat for cracks, core and alternator main shaft spline matching status, and internal working surface whether there is serious wear and scratch;	b) Replace in time if damaged. c) Replace in time once any damage is found; the width of the carbon brush must not be less than 2mm.

Chapter 5 Preservation of Diesel Engine

For brand new diesel engine, if long-term storage is required, shall be disposed in advance in accordance with the following requirements:

1. Drain the lubricating oil off.
2. Open water drain valve to drain the coolant fluid off inside the diesel engine.
3. Drain the diesel off inside the fuel tank and the pipeline.
4. Wipe out the oil and water stains, dust outside the diesel engine; apply anti-rust oil (add butter into drier oil and mix thoroughly after melting) on the unpainted parts and components. Rubber products as well as plastic products and parts shall not be applied with the oil.
5. The air filter (or air inlet) and the exit of exhaust pipe shall be packed well with oiled paper to prevent dust and dirt from invasion.
6. The diesel engine shall be placed in the room with good ventilation, dry and clean conditions and free of intense magnetic field (temperature: -30～60℃; humidity: 0～80%). It is strictly prohibited to be piled at the place with corrosive chemicals. Pay attention to moisture proof for the machine (especially for the electrical system).

For used diesel engine, if long-term storage is required, shall be disposed in advance in accordance with the following requirements:

1. Drain the lubricating oil off when the engine is hot after shutdown; dismantle the oil pan for cleaning.
2. Open water drain valve to drain the coolant fluid off inside the diesel engine.
3. Drain the diesel off inside the fuel tank and the pipeline.
4. Get rid of the dust on the element of air filter (paper type).

5. Dismantle the air intake pipe and fill 300g filtered HC-8 direr oil into each cylinder through air passage (heat the oil to 110～120℃ till there is no bubble at all). Turn the crankshaft so that the oil attaches to the surfaces of the valve, cylinder liner, piston and other parts uniformly. Fix the intake pipe in place.
6. Wipe out the oil and water stains, dust outside the diesel engine; apply anti-rust oil (add butter into drier oil and mix thoroughly after melting) on the unpainted parts and components. Rubber products as well as plastic products and parts shall not be applied with the oil.
7. The air filter (or air inlet) and the orifice of exhaust pipe shall be packed well with oiled paper to prevent dust and dirt from invasion.
8. The diesel engine shall be placed in the room with good ventilation, dry and clean conditions and free of intense magnetic field. It is strictly prohibited to be piled at the place with corrosive chemicals. Pay attention to moisture proof for the machine (especially for the electrical system).

- **Notice:**

The aforesaid method of preservation can be in effect for 30 months; do the same again if expired.

Chapter 6 Lifting, Installation and Depreservation of Diesel Engine

When carrying the diesel engine with packing case, use steel wire to cover the four bottom corners of the engine box. When carrying diesel engine without package, move engine by lifting lug assembly.

The installation for diesel engine must be laid properly when it is used for stationary work. It shall be fixed in the workshop with the characteristics of rain-proof, moisture-proof, good ventilation, little dust and spaciousness.

Diesel engine with oil seal had to be removed anti-rust oil before using. Continuously inject hot water into the cooling system to preheat the engine. Open the oil drain plug to drain the lubricating oil inside. Turn the crankshaft or drive it with starting dynamo (each starting time shall not be more than 15s), which shall be intermittently done several times. Finally start diesel engine according to the starting procedure; check and replace the rubber parts which require to be replaced.

Raywin Powertrain Technology Co., Ltd

Add„NO.99jiujiang Rd,Shuangfu District,Jiangjin District,Chongqing,China

Tel:+86-23-85557257

Email„ info**@raywin.cc**

Website:http://www.raywinpower.com